Renewable and Sustainable Energy Reviews 103 (2019) 151–216

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

# Prediction of diffuse solar radiation based on multiple variables in China

Lunche Wang[a,*], Yunbo Lu[a,1], Ling Zou[a,1], Lan Feng[b], Jing Wei[c], Wenmin Qin[a], Zigeng Niu[a]

[a] Hubei Key Laboratory of Critical Zone Evolution, School of Earth Sciences, China University of Geosciences, Lumo road 388, Hongshan District, Wuhan 430074, China
[b] School of Resource and Environmental Science, Wuhan University, Wuhan, Hubei Province 430079, China
[c] State Key Laboratory of Earth Surface Processes and Resource Ecology, College of Global Change and Earth System Science, Beijing Normal University, Beijing, China

ARTICLE INFO

*Keywords:*
diffuse solar radiation
multiple variables
diffuse fraction
model comparison

ABSTRACT

The accurate knowledge of diffuse solar radiation is of vital importance for climatology, sustainable energy, agriculture and biological activities. However, the spatial coverage of diffuse solar radiation measurements is limited in many regions, due to the lack of measuring devices, high operation and maintenance costs. Therefore, numerous empirical models have been proposed in different regions and climates for predicting diffuse solar radiation. The aim of this study was to establish, test and compare various models for predicting diffuse solar radiation in China. The performances of newly proposed models were compared with empirical models in this study. Using daily observations at 17 stations during 1993-2015, 97 models with 11 independent variables were established at each station. Meanwhile, the performances of newly-established models were compared with empirical models. The results showed: (1) larger model errors were found at Ejinaqi, Wulumuqi and Kashi stations, due to the dusty air conditions. Relatively poor model performances were also observed at Sanya station, owing to the rainy weather characteristics. (2) The comparisons for the five categories of models showed that the fourth category models with four input parameters generally had higher accuracies, except the case at Wulumuqi. (3) Comparisons of $K_d$-based with $K_D$-based models showed that $k_d$-based models generally had higher accuracies , the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS for $K_d$-based models at all 17 stations were $-0.43\,MJ\,m^{-2}\,day^{-1}$, $1.5453\,MJ\,m^{-2}\,day^{-1}$, $0.2583\,MJ\,m^{-2}\,day^{-1}$, $2.1422\,MJ\,m^{-2}\,day^{-1}$, 1.7611%, 15.2127, 0.3134, 0.8111 and $1.9969\,MJ\,m^{-2}\,day^{-1}$, respectively. (4) By comparing with the models in literature, the newly-established models were better than the models in terms of model performances. The models proposed in this study were valuable for some areas without diffuse radiation record, which also supported the development and utilization of solar energy in China and other regions around the world.

## 1. Introduction

Nowadays, the potential environmental impacts of the decomposition of fossil fuels and greenhouse gas emissions were one of the biggest concerns in the world. The long-term consumption of fossil fuels led to the massive emission of greenhouse gases, which have brought global warming, climate abnormity and frequent occurrences of extreme weather. With the depletion of non-renewable energy resources and increasing energy demands, renewable energy such as solar energy, wind energy, hydroenergy, biomass energy, tidal energy and ocean thermal energy that can provide sustainable energy and reduce environmental pollution, were increasingly attracting worldwide attention.

Life on earth is mainly based on the solar radiation provided by the sun. Solar energy is environment-friendly and considered as one of the cleanest regeneration energy resource, due to the features that can be directly developed and utilized, easy to be gathered, and does not need to exploit and transport [1]. Nowadays, it has been widely used in the fields of photo-thermal utilization, power generation and photochemistry. Particular examples include plants integration on buildings [2], solar photovoltaic (PV) cells and photo voltaic power station [3]. Estimating the average incident radiation is essential for the proper design and evaluation of solar energy conversion systems [4–6]. Diffuse radiation is an important component of the surface solar radiation, and the solar elevation angle is an important factor affecting the diffuse radiation. Generally, the diffuse solar radiation reaching the land surface increases with the solar elevation angle, because global solar radiation and diffuse radiation generally increase with sunrise and

* Corresponding author.
*E-mail address:* wang@cug.edu.cn (L. Wang).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.rser.2018.12.029
Received 19 July 2018; Received in revised form 21 November 2018; Accepted 13 December 2018
1364-0321/ 

**Nomenclature**

| | |
|---|---|
| $AM$ | air mass |
| $E_o$ | correction factor of the Earth's orbit |
| $I_{SC}$ | solar constant (1367 $Wm^{-2}$) |
| $\bar{H}_d$ | the mean of diffuse solar radiation from 1993 to 2015 |
| $H_d$ | daily diffuse solar radiation on horizontal surface ($MJ\,m^{-2}\,day^{-1}$) |
| $H_g$ | daily global solar radiation on horizontal surface ($MJ\,m^{-2}\,day^{-1}$) |
| $H_o$ | daily extraterrestrial solar radiation on horizontal surface ($MJ\,m^{-2}\,day^{-1}$) |
| $K_t$ | clearness index |
| $K_d$ | diffuse fraction |
| $K_D$ | diffusion coefficient |
| MBE | Mean bias error ($MJ\,m^{-2}\,day^{-1}$) |
| MAE | Mean absolute error ($MJ\,m^{-2}\,day^{-1}$) |
| MARE | Mean absolute relative error ($MJ\,m^{-2}\,day^{-1}$) |
| MPE | Mean percentage error (%) |
| RMSE | Root mean square error ($MJ\,m^{-2}\,day^{-1}$) |
| RRMSE | Relative root mean square error |
| R | Correlation coefficient |
| RMS | centered root-mean-square ($MJ\,m^{-2}\,day^{-1}$) |
| t-stat | t-statistics |
| $n$ | daily sunshine duration hours (hr) |
| $N$ | daily maximum possible sunshine hours (hr) |
| $n_{day}$ | day number in the year |
| $R_h$ | relative humidity |
| $T_{mean}$ | daily averaged air temperature |
| $T_{max}$ | daily maximum air temperature |
| $T_{min}$ | daily minimum air temperature |
| $\Delta T$ | temperature difference |
| $\alpha$ | solar altitude at solar noon (degrees) |
| $\theta$ | solar zenith angle (degrees) |
| $\delta$ | solar declination angle (degrees) |
| $\varphi$ | latitude of the location (degrees) |
| $\omega_s$ | sunrise/sunset hour angle (degrees) |

decrease with the sunset [7], The amount of diffuse radiation is also highly sensitive to the changes in the atmospheric cloud, aerosols, water vapor content and surface conditions [8]. The changes of diffuse radiation can greatly affect the photosynthesis of plants and thus the carbon budget of terrestrial ecosystems [9]. However, many regions around the world lack reliable and long-term measured radiation data, due to the high price and maintenance costs of measuring equipment [10,11]. As a consequence, it is of great significance to develop models with high accuracy for predicting diffuse solar radiation.

In past decades, lots of methods have been proposed to estimate diffuse solar radiation in both daily and monthly scales. Meteorological parameters such as cloud cover, relative humidity, ambient temperature and clearness index were often considered as the most important input variables for developing the predicting models [12,13]. Beside these variables, some astronomical parameters, such as the solar declination angle have also been considered to affect the model accuracy [14,15]. A large number of empirical models have been developed to predict the diffuse solar radiation on horizontal surface in different scales [16]. Pandey and Katiyar [17] used radiation datasets from four regions in India to make a regression analysis between the diffuse fraction and sunshine fraction. Three statistical indicators were used to verify the model accuracy, it was concluded that the proposed All India Correlation (AIC) could be used at any locations in India. Tapakis et al. [18] used three different methods for computing diffuse fraction based on clearness index and solar altitude, the results showed that the use of solar altitude can improve the accuracy of correlations. Based on the correlations between diffuse fraction and sunshine fraction or clearness index, ten empirical models were proposed by Boukelia et al. [19], results showed that the quadratic and cubic equation was more accurate. Singh et al. [20] developed both 'local' model and 'regional' model for different climatic conditions in India and the extendibility of 'regional' model showed better performances. El-Sebaii and Trabea [21] proposed the first, second and third orders correlations using clearness index and the fraction of possible number of sunshine hours. El-Sebaii et al. [22] suggested empirical correlations to estimate diffuse radiation in horizontal surfaces for Jeddah, Saudi Arabia. A multi-location approach was proposed by Bortolini et al. [23] through the correlation between diffuse fraction and the clearness index using data from 11 European countries and 44 weather stations. Mubiru and Banda [24] employed seventeen empirical correlations, trying to find the best model for Kampala, Uganda. Khorasanizadeh et al. [25] estimated daily and monthly average diffuse radiation in the city of Kerman, Iran, the linear form of diffuse fraction model had better performance in daily scale and the linear form of diffuse coefficient model showed the highest stability for the monthly estimations. Munawwar and Muneer [26] provided multivariate models by combining daily sunshine fraction (SF) and cloudiness factor (CF) and clearness index. Many researchers have investigated the diffuse radiation through other non-empirical models. Combining the support vector machine (SVM) with wavelet transform (WT) algorithm, Shamshirband et al. [27] used the clearness index as the only input parameter to develop a coupled model for estimating horizontal diffuse solar radiation. Kambezidis et al. [28] discussed the improvements and modifications made in the Meteorological Radiation Model (MRM) algorithms for the diffuse radiation [29].

Jamil and Akhtar [30] developed 42 new models using sky-clearness index and relative sunshine duration, which were compared with other models in literature through Global Performance Index (GPI). Six empirical models were established by Sabzpooshani and Mohammadi [31] to predict monthly mean diffuse radiation in the city of Isfahan, Iran, which were compared with other 16 models. Similar methodology was conducted by Karakoti et al. [32], which proposed non-linear solar radiation models for 12 locations of India. Engerer [33] found that the new models have higher accuracies than existing modeling techniques in southeastern Australia. Bakirci [34] established 18 models in Turkey using long-term sunshine duration and global solar radiation to predict monthly mean diffuse radiation, the third-order polynomial model based on sunshine duration and clearness index was found better than other models. Karakoti et al. [35] developed seven linear and nonlinear formulas to compute the monthly average diffuse radiation in India, the models using sunshine percentage and relative humidity provided the best performances. Based on the sigmoid function using clearness index and optical air mass as the predictors, Ruiz-Arias et al. [36] presented a new regression model to predict hourly diffuse radiation. The radiation dataset at 21 stations from United States and Europe were used to investigate the model performances, which were compared against other twelve empirical models using data measured by Paulescu and Blaga [37] in Timisoara, Romania. Results showed that the model with predictor variables of clearness index and relative sunshine had the highest accuracy.

A number of models were developed in different regions; many researchers employed existing models to estimate diffuse radiation in the region of interest. Kocifaj and Kómar [38] found the Models of Homogeneous Skies (MHS) may produce large errors and the Unified Model of Radiance Patterns (UMRP) had high accuracy in various sky conditions using cloud fraction, cloud type and altitude of cloud base as inputs. Badescu et al. [39] calculated the diffuse radiation on horizontal surface using 54 models from surface meteorological data, column integrated data and satellite data. Despotovic et al. [40] used 10 statistical indicators to evaluate the performance of different models at 267 stations around the world. Khatib et al. [41] compared linear, nonlinear and artificial intelligent models, results showed that the ambient temperature, sunshine ratio and relative humidity were highly correlated with diffuse radiation. Magarreiro et al. [42] and Khorasanizadeh and Mohammadi [43] gave a review of the applicability of existing models for estimating solar radiation in different regions.

Many hybrid models were also developed for modeling diffuse radiation using multiple predictors. Khalil and Shaffie [44] used different models to estimate hourly daily diffuse solar irradiation incident for Cairo, Egypt. Aras et al. [45] established 12 hybrid models to evaluate the monthly average diffuse radiation in Central Anatolia Region of Turkey. Using diffuse fraction, diffuse coefficient, sunshine fraction, cloudiness index and clearness index, Ulgen and Hepbasli [46] proposed 32 hybrid models in three major cities of Turkey (Istanbul, Ankara and Izmir). Sanchez-Lorenzo et al. [47] established a dataset of homogeneous global solar radiation (G) and diffuse radiation (D) in Spain and analyzed the temporal changes in past decades. Cotfas et al. [48] developed a new mixed model to estimate the monthly global and diffuse horizontal radiation for Brasov, Romania using multiple parameters, including relative sunshine, clearness index, extraterrestrial radiation, latitude and longitude, which were further compared with other three known models.

In recent years, artificial intelligence technology has been widely applied in many fields because it can be used even without knowing the in-depth information of the objects [49–51]. Some investigations have been conducted to use artificial intelligence to predict the diffuse radiation. Artificial neural network models were trained and tested by Alam et al. [52] using solar radiation from 10 sites in India, results showed that the ANN model was more accurate than other empirical models. Mohammadi et al. [14] applied the adaptive neuro-fuzzy inference system (ANFIS) to study the horizontal diffuse radiation in Keramn, city of Iran. Mellit et al. [53] proposed an adaptive model for predicting hourly diffuse irradiance using sunshine duration, relative humidity and air temperature. Soares et al. [54] proposed a perceptron neural-network technique for generating a synthetic series of hourly diffuse solar radiation in São Paulo City, Brazil. One important finding was that the inclusion of atmospheric long-wave radiation as input parameter greatly improved the model performance.

As for China, Chen et al. [55] calibrated three diffuse radiation models using daily data from 16 stations, the second-degree polynomial relationship between clearness index and relative sunshine duration was more accurate for estimating diffuse radiation in China. Jiang [56] proposed an ANN model for different climatic conditions over China, which was produced higher accuracy than other empirical models. Feng et al. [57] applied the extreme learning machine (ELM), backpropagation neural networks optimized by genetic algorithm (GANN), random forests (RF) and generalized regression neural networks (GRNN) to assess diffuse radiation using global solar radiation and other meteorological parameters over North China Plain. Cao et al. [58] established a set of radiation models in northern China, which were compared with other solar radiation sources, including the measured data from China Meteorological Data Sharing System (CMDSS) and the TRNSYS database. Li et al. [59] compared the performances of different methods for estimating diffuse radiation at eight stations in China [56]. These methods were divided into two categories: H-based and non-H methods, results showed that the non-H method showed higher accuracy in regions without radiation data. Lou et al. [51] employed a machine learning algorithm to predict diffuse irradiance on a horizontal surface in Hong Kong. Li et al. [60] proposed two models for evaluating diffuse radiation using different parameters, the results showed that the proposed models had high accuracies than previous models in literature [59,60].

At present, more efforts are still needed to develop models to predict diffuse radiation in different parts of China. Most previous models had focused on the clearness index ($K_t$), relative sunshine duration (n/N), air temperature ($T_{mean}$) and relative humidity ($R_h$) as input parameters, while the models with air mass ($AM$), sunset hour angle ($\omega_s$), the day number of the year ($n_{day}$), solar declination angle ($\delta$), solar zenith angle ($\theta$), daily solar altitude at solar noon ($\alpha$) and the latitude of the location ($\varphi$) as input parameters were relatively scarce, and yet not well-rounded. Meanwhile, there were no comprehensive studies regarding diffuse radiation estimation using various empirical or physical models in different climates of China. In addition, there were no comparative studies for various diffuse radiation models using simultaneous observation data with unified criteria for model evaluation, which necessitated the diffuse radiation estimation in this study based on multiple variables in China.

The main aim of this study was to establish, test and compare 97 empirical models with new correlation coefficients for predicting diffuse radiation in China using multiple predictor variables. The proposed models in different categories with different input parameters were evaluated and compared using multiple statistical indices, including MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and RMS. The analysis in this study will provide an important reference for estimating diffuse radiation with satisfied accuracy in China.

## 2. Materials and methods

### 2.1. Sites and data

In this study, the daily radiation data ($H_d$ and $H_g$), $T_{mean}$, $T_{max}$, $T_{min}$, $n$ and $R_h$ at 17 stations in China during 1993-2015 were provided by Climatic Data Center, National Meteorological Information Center, China Meteorological Administration (CMA). Due to the presence of spurious data, instrumental errors, systematic and operational errors, it was necessary to execute a quality control analysis for the dataset according to previous studies [61,62]. The main quality control principles were as follows: the value of n/N should be greater than 0 and less than 1; some observation related data errors should be rejected, for example, the measured daily diffuse solar radiation ($H_d$) should not be larger than daily global solar radiation ($H_g$); $H_g$ should be smaller than the extraterrestrial $H_o$ in the same geographic location and $H_g$ should be larger than the minimum values for continuous overcast conditions [63,64]. After quality control, 96% of the data was accurate enough for this study [67]. The dataset was divided in two parts, 70% (random selection) of the entire dataset was used for establishing the correlations (training the model) and the remaining 30% for model validation.

The distribution of the diffuse radiation stations was shown in Fig. 1, the geographical information about the latitude, longitude and altitude for each station was given in Table 1. Geermu and Lasa stations were belonged to the Qinghai-Tibet Plateau zone, the annual mean $T_{mean}$, $T_{max}$, $T_{min}$, $\Delta T$ and $\bar{H}_d$( the mean diffuse radiation from 1993 to 2015) at Geermu station were about 6.246, 13.675, 0.175, 13.499 °C and 6.5044 MJ m$^{-2}$ day$^{-1}$, respectively. Mohe, Ejinaqi, Wulumuqi, Harbin, Lanzhou and Shenyang sites were located in the mid-temperate zone with cold and long winter, the annual mean $T_{mean}$, $T_{max}$, $T_{min}$, $\Delta T$ and $\bar{H}_d$at Harbin station were about 5.301, 10.659, 0.124, 10.536°C and 5.7811 MJ m$^{-2}$ day$^{-1}$, respectively. Beijing and Zhengzhou stations were in the warm-temperate areas, which were characterized by cold and dry winter, hot and rainy summer. The annual $T_{mean}$, $T_{max}$, $T_{min}$, $\Delta T$ and $\bar{H}_d$at Zhengzhou site were about 15.449, 20.873, 10.724, 10.149 °C and 7.9048 MJ m$^{-2}$ day$^{-1}$, respectively. Kashi, Chengdu, Kunming, Wuhan and Shanghai were located at the subtropical zone with warm summer and temperate winter, the annual $T_{mean}$, $T_{max}$, $T_{min}$, $\Delta T$ and $\bar{H}_d$at kunming station were 16.133, 21.889, 11.831, 10.059°C and 7.2047 MJ m$^{-2}$ day$^{-1}$, respectively. Guangzhou and Sanya sites were in the tropical areas, the $T_{mean}$, $T_{max}$ and $T_{min}$ values at these two sites were higher than other sites.

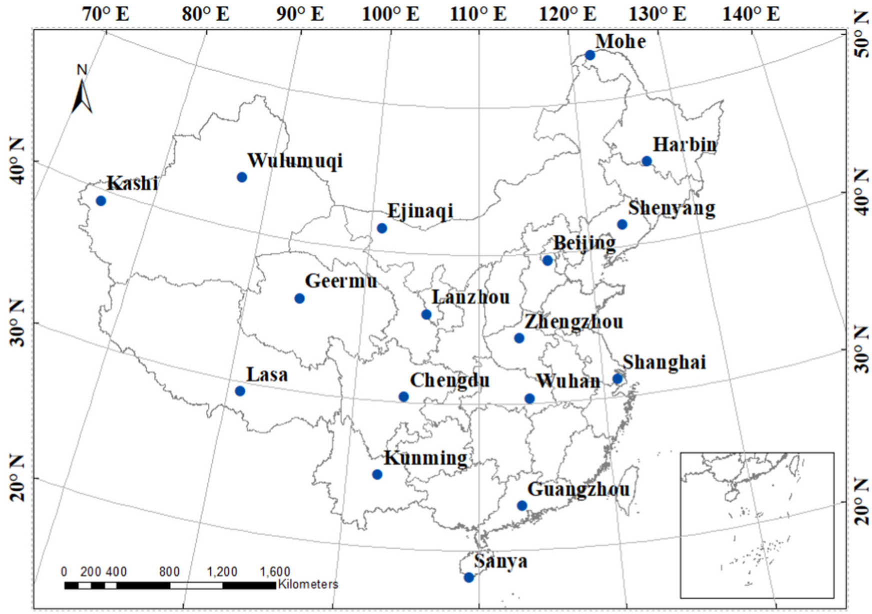


**Fig. 1.** Distributions of the diffuse radiation stations in this study. (Beijing, Chengdu, Ejinaqi, Geermu, Guangzhou, Harbin, Kashi, Kunming, Lanzhou, Lasa, Mohe, Sanya, Shanghai, Shenyang, Wuhan, Wulumuqi, Zhengzhou).

**Table 1**
The geographical locations of the diffuse solar radiation stations in China.

| Station | Longitude (deg.) | Latitude (deg.) | Altitude (m) | Climatic zone | $T_{mean}$ (°C) | $T_{max}$ (°C) | $T_{min}$ (°C) | $\Delta_T$ (°C) | $\bar{H}_d$ (MJ m$^{-2}$ day$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| Beijing | 116.283 | 39.933 | 54 | warm-temperate | 13.318 | 18.609 | 8.443 | 10.166 | 6.6149 |
| Chengdu | 104.017 | 30.667 | 506.1 | subtropical | 9.033 | 16.691 | 3.022 | 13.669 | 7.0891 |
| Ejinaqi | 101.067 | 41.950 | 940.5 | mid-temperate | 9.899 | 17.441 | 3.018 | 14.424 | 5.7587 |
| Geermu | 94.900 | 36.417 | 2807.6 | Qinghai-Tibet Plateau | 6.246 | 13.675 | 0.175 | 13.499 | 6.5044 |
| Guangzhou | 113.317 | 23.133 | 6.6 | tropical | 22.579 | 27.078 | 19.434 | 7.645 | 7.4632 |
| Harbin | 126.767 | 45.750 | 142.3 | mid-temperate | 5.301 | 10.659 | 0.124 | 10.536 | 5.7811 |
| Kashi | 75.983 | 39.467 | 1288.7 | subtropical | 12.839 | 19.01 | 6.902 | 12.107 | 6.9344 |
| Kunming | 102.683 | 25.017 | 1891.4 | subtropical | 16.133 | 21.889 | 11.831 | 10.059 | 7.2047 |
| Lanzhou | 103.883 | 36.050 | 1517.2 | mid-temperate | 7.189 | 14.49 | 1.296 | 13.194 | 6.9640 |
| Lasa | 91.133 | 29.667 | 3648.7 | Qinghai-Tibet Plateau | 9.034 | 16.717 | 3.007 | 13.71 | 6.1583 |
| Mohe | 122.367 | 53.467 | 296 | cold-temperate | −1.144 | 4.963 | −12.128 | 17.092 | 5.3244 |
| Sanya | 109.517 | 18.233 | 5.5 | tropical | 25.324 | 28.853 | 23.011 | 5.842 | 7.7296 |
| Shanghai | 121.483 | 31.400 | 3.5 | subtropical | 17.179 | 20.749 | 14.247 | 6.503 | 7.0788 |
| Shenyang | 123.450 | 41.733 | 42.8 | mid-temperate | 8.533 | 14.385 | 3.141 | 11.244 | 6.5336 |
| Wuhan | 114.133 | 30.617 | 23.3 | subtropical | 17.844 | 22.436 | 14.321 | 8.116 | 7.4668 |
| Wulumuqi | 87.617 | 43.783 | 917.9 | mid-temperate | 8.117 | 13.472 | 3.829 | 9.643 | 5.3449 |
| Zhengzhou | 113.650 | 34.717 | 110.4 | warm-temperate | 15.449 | 20.873 | 10.724 | 10.149 | 7.9048 |

### 2.2. Calculation of the solar radiation

The $K_t$ was the ratio between daily global solar radiation $H_g$ and the extraterrestrial solar radiation $H_o$. The calculation of $K_t$ was given as follows:

$$K_t = H_g/H_o \tag{1}$$

$$H_o = \left(\frac{24}{\pi}\right) \times I_{SC}E_o \times \left[\left(\frac{\pi}{180}\right)\omega_s(\sin\delta\sin\varphi) + (\cos\delta\cos\varphi\sin\omega_s)\right] \tag{2}$$

$$\delta = 23.45\sin\left(\frac{360(284 + n_{day})}{365}\right) \tag{3}$$

$$\omega_s = \cos^{-1}(-\tan\delta\tan\varphi) \tag{4}$$

where $I_{SC}$ is the solar constant, $E_o$ represents correction factor of the Earth's orbit, $\omega_s$ is the sunrise/sunset hour angle, $\delta$ is solar declination, $\varphi$ is the latitude, $n_{day}$ is day of the year starting from January 1st.

The daily solar altitude at solar noon was calculated as follows:

$$\alpha = 90^{\circ} - |\delta - \varphi| \tag{5}$$

The diffuse fraction ($K_d$) and diffusion coefficient ($k_D$) can be evaluated by following Eqs. (6) and (7) respectively[20,33]:

$$K_d = H_d/H_g \tag{6}$$

$$K_D = H_d/H_o \tag{7}$$

### 2.3. The main categories of diffuse solar radiation models

In order to investigate whether the number of input parameters will affect the model accuracy, all models for predicting diffuse solar radiation were classified into five categories according to the number of input parameters (from the first to fourth categories). Considering the periodicity of solar radiation, the fifth category was classified according to the parameter day of the year. The detailed classification information of the regression models was shown in Table 2.

**Table 2**
Categories of the developed models.

| Category | Number of input parameters | Input parameters | Mathematical representation | Number of models |
|---|---|---|---|---|
| I | 1 | $K_t$<br>$n/N$ | $K_d = f(K_t)$<br>$K_d = f(n/N)$<br>$K_D = f(K_t)$<br>$K_D = f(n/N)$ | 44 |
| II | 2 | $K_t$; $\alpha$<br>$K_t$; $n_{day}$<br>$K_t$; $AM$<br>$K_t$; $\delta$<br>$K_t$; $\omega_s$<br>$K_t$; $R_h$<br>$K_t$; $n/N$<br>$n/N$; $R_h$<br>$n/N$; $T_{mean}$<br>$T_{mean}$; $R_h$ | $K_d = f(K_t, \alpha)$<br>$K_d = f(K_t, n_{day})$<br>$K_d = f(K_t, AM)$<br>$K_d = f(K_t, \delta)$<br>$K_d = f(K_t, \omega_s)$<br>$K_d = f(K_t, R_h)$<br>$K_d = f(K_t, n/N)$<br>$K_D = f(K_t, n/N)$<br>$K_D = f(n/N, R_h)$<br>$K_D = f(n/N, T_{mean})$<br>$K_D = f(T_{mean}, R_h)$ | 35 |
| III | 3 | $K_t$; $n/N$; $\delta$<br>$K_t$; $T_{mean}$; $R_h$<br>$n/N$; $T_{mean}$; $R_h$ | $K_d = f(K_t, n/N, \delta)$<br>$K_d = f(K_t, T_{mean}, R_h)$<br>$K_D = f(n/N, T_{mean}, R_h)$ | 5 |
| IV | 4 | $K_t$; $n/N$; $\delta$; $\varphi$<br>$K_t$; $T_{mean}$; $R_h$; $\alpha$<br>$K_t$; $\theta_z$; $T_{mean}$; $R_h$<br>$K_t$; $n/N$; $T_{\max}/T_{\min}$; $R_h$ | $K_d = f(K_t, n/N, \delta, \varphi)$<br>$K_d = f(K_t, T_{mean}, R_h, \alpha)$<br>$K_d = f(K_t, \theta_z, T_{mean}, R_h)$<br>$K_d = f(K_t, n/N, T_{\max}/T_{\min}, R_h)$ | 4 |
| V | —— | $K_t$; $n/N$; $T_{mean}$; $R_h$<br>$n_{day}$; $K_t$; $T_{mean}$; $R_h$; $n/N$<br>$n_{day}$; $n/N$; $T_{mean}$; $R_h$<br>$n_{day}$; $K_t$; $T_{mean}$; $R_h$<br>$n_{day}$; $K_t$; $T_{mean}$<br>$n_{day}$; $K_t$; $R_h$<br>$n_{day}$; $K_t$<br>$n_{day}$ | $K_d = f(K_t, n/N, T_{mean}, R_h)$<br>$K_d = f(n_{day}, K_t, T_{mean}, R_h, n/N)$<br>$K_d = f(n_{day}, n/N, T_{mean}, R_h)$<br>$K_d = f(n_{day}, K_t, T_{mean}, R_h)$<br>$K_d = f(n_{day}, K_t, T_{mean})$<br>$K_d = f(n_{day}, K_t, R_h)$<br>$K_d = f(n_{day}, K_t)$<br>$K_d = f(n_{day})$ | 9 |

*2.3.1. Category I*

This category contains 44 models (model 1–model 44). Diffuse fraction and diffusion coefficient were correlated with clearness index and relative sunshine duration, respectively. The mathematical representations of these models were expressed as follows:

$$K_d = f(K_t) \tag{8}$$

$$K_d = f(n/N) \tag{9}$$

$$K_D = f(K_t) \tag{10}$$

$$K_D = f(n/N) \tag{11}$$

These models in this category I were described below

Model 1: $K_d = a + bK_t$ (12)

Model 2: $K_d = a + bK_t + cK_t^2$ (13)

Model 3: $K_d = a + bK_t + cK_t^2 + dK_t^3$ (14)

Model 4: $K_d = a + bK_t + cK_t^2 + dK_t^3 + eK_t^4$ (15)

Model 5: $K_d = a + bK_t + cK_t^2 + dK_t^3 + eK_t^4 + fK_t^5$ (16)

Model 6: $K_d = a + b\exp(1/K_t)$ (17)

Model 7: $K_d = \ln(a + bK_t)$ (18)

Model 8: $K_d = aK_t^b$ (19)

Model 9: $K_d = a + b(1/(1 + \exp(c + dK_t)))$ (20)

Model 10: $K_d = 1/(1 + \exp(a + bK_t))$ (21)

Model 11: $K_d = a + b(1/K_t)$ (22)

Model 12: $K_d = a + \exp(bK_t)$ (23)

Model 13: $K_d = a\exp(bK_t)$ (24)

Model 14: $K_d = a + b\log(K_t)$ (25)

Model 15: $K_d = a + b\exp(K_t)$ (26)

Model 16: $K_d = a + b(n/N)$ (27)

Model 17: $K_d = a + b(n/N) + c(n/N)^2$ (28)

Model 18: $K_d = a + b(n/N) + c(n/N)^2 + d(n/N)^3$ (29)

Model 19: $K_d = 1/a + b(n/N)$ (30)

Model 20: $K_d = a(n/N)^{-b} - c$ (31)

Model 21: $K_d = 1/(a + b(n/N))$ (32)

Model 22: $K_d = \ln(a + b(n/N))$ (33)

Model 23: $K_d = a + b\log(n/N)$ (34)

Model 24: $K_d = a + b\exp(n/N)$ (35)

Model 25: $K_d = a + \exp b(n/N)$ (36)

Model 26: $K_D = a + bK_t$ (37)

Model 27: $K_D = K_t\left(1 - \exp\left(a - \frac{ab}{K_t}\right)\right)$ (38)

Model 28: $K_D = a + bK_t + cK_t^2$ (39)

Model 29: $K_D = a + bK_t + cK_t^2 + dK_t^3$ (40)

Model 30: $K_D = a + bK_t + cK_t^2 + dK_t^3 + eK_t^4$ (41)

Model 31: $K_D = a\ln(K_t) + b$ (42)

Model 32: $K_D = a\exp(bK_t)$ (43)

Model 33: $K_D = aK_t^b$ (44)

Model 34: $K_D = a/K_t + b$ (45)

Model 35: $K_D = a + b\log(K_t)$ (46)

Model 36: $K_D = a + b\exp(K_t)$ (47)

Model 37: $K_D = a + \exp b(K_t)$ (48)

Model 38: $K_D = a + b(n/N)$ (49)

Model 39: $K_D = a + b(n/N) + c(n/N)^2$ (50)

Model 40: $K_D = a + b(n/N) + c(n/N)^2 + d(n/N)^3$ (51)

Model 41: $K_D = a + b\log(n/N)$ (52)

Model 42: $K_D = a\exp(b(n/N))$ (53)

Model 43: $K_D = a + b\log(n/N) + c(n/N)^2$ (54)

Model 44: $K_D = a + b\exp(n/N)$ (55)

where a, b, c, d, e and f are the empirical coefficients.

#### 2.3.2. Category II

This category contains 35 models (model 45-model 79). Diffuse fraction and diffusion coefficient were estimated. The forms of these models were described below:

$K_d = f(K_t, \alpha)$ (56)

$K_d = f(K_t, n_{day})$ (57)

$K_d = f(K_t, AM)$ (58)

$K_d = f(K_t, \delta)$ (59)

$K_d = f(K_t, \omega_s)$ (60)

$K_d = f(K_t, R_h)$ (61)

$K_d = f(K_t, n/N)$ (62)

$K_D = f(K_t, n/N)$ (63)

$K_D = f(n/N, R_h)$ (64)

$K_D = f(n/N, T_{mean})$ (65)

$K_D = f(T_{mean}, R_h)$ (66)

The models under this category were:

Model 45: $K_d = a + bK_t + c\sin\alpha$ (67)

Model 46: $K_d = aK_t + b\sin\alpha$ (68)

Model 47: $K_d = a + bK_t + c\sin(2\pi(n_{day} - 40)/365)$ (69)

Model 48: $K_d = a + b\exp(-(\exp(c + dK_t + eK_t^2 + fAM + gAM^2)))$ (70)

Model 49: $K_d = a + bK_t + c\delta$ (71)

Model 50: $K_d = a + b(\pi/180)(\omega_s - 90°) - (c + d(\pi/180)(\omega_s - 90°)) \times \cos(2(K_t - 0.9))$ (72)

Model 51: $K_d = a + b(1/K_t) + c(1/(\omega_s - 90°))$ (73)

Model 52: $K_d = a + bK_t + cR_h$ (74)

Model 53: $K_d = a + bK_t + c(n/N)$ (75)

Model 54: $K_d = a + bK_t + cK_t^2 + d(n/N) + e(n/N)^2$ (76)

Model 55: $K_d = a + bK_t + cK_t^2 + dK_t^3 + e(n/N) + f(n/N)^2 + g(n/N)^3$ (77)

Model 56: $K_d = a + bK_t + cK_t^2 + d(n/N)$ (78)

Model 57: $K_d = a + bK_t + c(n/N) + d(n/N)^2$ (79)

Model 58: $K_d = a + bK_t^2 + c(n/N)^2$ (80)

Model 59: $K_d = a + bK_t + c(n/N)^2$ (81)

Model 60: $K_d = a + bK_t^2 + c(n/N)$ (82)

Model 61: $K_d = a + bK_t^3 + c(n/N)^3$ (83)

Model 62: $K_d = a + b\log(K_t) + c\log(n/N)$ (84)

Model 63: $K_d = a + b\exp(K_t) + c\exp(n/N)$ (85)

Model 64: $K_d = a + \exp(bK_t) + \exp(cn/N)$ (86)

Model 65: $K_D = a + bK_t + c(n/N)$ (87)

Model 66: $K_D = a + bK_t + cK_t^2 + d(n/N) + e(n/N)^2$ (88)

Model 67: $K_D = a + bK_t + cK_t^2 + d(n/N)$ (89)

Model 68: $K_D = a + bK_t + c(n/N) + d(n/N)^2$ (90)

Model 69: $K_D = a + bK_t^2 + c(n/N)^2$ (91)

Model 70: $K_D = a + bK_t + c(n/N)^2$ (92)

Model 71: $K_D = a + bK_t^2 + c(n/N)$ (93)

Model 72: $K_D = a + bK_t^3 + c(n/N)^3$ (94)

Model 73: $K_D = a + b\log(K_t) + c\log(n/N)$ (95)

Model 74: $K_D = a + b\exp(K_t) + c\exp(n/N)$ (96)

Model 75: $K_D = a + b(n/N) + cR_h$ (97)

Model 76: $K_D = a + b(n/N) + c(n/N)^2 + dR_h$ (98)

Model 77: $K_D = a + b(n/N) + cT_{mean}$ (99)

Model 78: $K_D = a + b(n/N) + c(n/N)^2 + dT_{mean}$ (100)

Model 79: $K_D = a + bT_{mean} + cR_h$ (101)

#### 2.3.3. Category III

The models (model 80-model 84) in this category utilized three elements for estimating diffuse solar radiation. The mathematical equations were expressed as follows:

$K_d = f(K_t, n/N, \delta)$ (102)

$K_d = f(K_t, T_{mean}, R_h)$ (103)

$K_D = f(n/N, T_{mean}, R_h)$ (104)

These models were given as

Model 80: $K_d = a + bK_t + c(n/N) + d\cos\delta$(105)

Model 81: $K_d = a + bK_t + c(n/N) + d\delta$(106)

Model 82: $K_d = a + bK_t + cT_{mean} + dR_h$(107)

Model 83: $K_D = a + b(n/N) + c\log(n/N) + dT_{mean} + eR_h$(108)

Model 84: $K_D = a + b(n/N) + c(n/N)^2 + dT_{mean} + eR_h$(109)

### 2.3.4. Category IV

In the fourth category, the daily diffuse fraction was correlated with four different input parameters. This category contained four different forms of models (from model 85 to 88). These forms were calculated by following expressions:

$$K_d = f(K_t, n/N, \delta, \varphi) \quad (110)$$

$$K_d = f(K_t, T_{mean}, R_h, \alpha) \quad (111)$$

$$K_d = f(K_t, \theta_z, T_{mean}, R_h) \quad (112)$$

$$K_d = f(K_t, n/N, T_{\max}/T_{\min}, R_h) \quad (113)$$

The models were given as:

Model 85: $K_d = a + bK_t + c(n/N) + d\cos\delta + e\cos\varphi$ (114)

Model 86: $K_d = a + bK_t + cT_{mean} + dR_h + e\sin\alpha$ (115)

Model 87: $K_d = a + bK_t + c\cos\theta + dT_{mean} + eR_h$ (116)

Model 88: $K_d = a + bK_t + c(n/N) + d(T_{\max}/T_{\min}) + eR_h$ (117)

### 2.3.5. Category V

The sine function that took the day of the year as a variable can show the periodicity of solar radiation. Considering both the precision and the periodicity of daily diffuse solar radiation, Cao at al. [65] proposed nine models to estimate the daily diffuse solar radiation. The mathematical expression of these models were given as

$$K_d = f(K_t, n/N, T_{mean}, R_h) \quad (118)$$

$$K_d = f(n_{day}, K_t, T_{mean}, R_h, n/N) \quad (119)$$

$$K_d = f(n_{day}, n/N, T_{mean}, R_h) \quad (120)$$

$$K_d = f(n_{day}, K_t, T_{mean}, R_h) \quad (121)$$

$$K_d = f(n_{day}, K_t, T_{mean}) \quad (122)$$

$$K_d = f(n_{day}, K_t, R_h) \quad (123)$$

$$K_d = f(n_{day}, K_t) \quad (124)$$

$$K_d = f(n_{day}) \quad (125)$$

The new models (from model 89-model 97) proposed were presented as

Model 89: $K_d = a + bK_t + c(n/N) + dT_{mean} + eR_h$ (126)

Model 90: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + eK_t + fT_{mean} + gR_h + h(n/N)$ (127)

Model 91: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + e(n/N) + fT_{mean} + gR_h$ (128)

Model 92: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + eK_t + fT_{mean} + gR_h$ (129)

Model 93: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + eK_t + fT_{mean}$ (130)

Model 94: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + eK_t + fR_h$ (131)

Model 95: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right) + eK_t$ (132)

Model 96: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365}c + d\right)$ (133)

Model 97: $K_d = a + b\sin\left(\frac{2\pi n_{day}}{365} + c\right) + dK_t + eT_{mean}$ (134)

The above proposed models in this study were compared with five different empirical models for daily diffuse solar radiation to assess and validate the model accuracies. Jiang [66] recommended some models using clearness index and the fraction of possible number of sunshine hours for any locations in China. Two models were selected for comparing with the same types of models proposed in this study:

$$K_D = 0.161 + 0.132(n/N) + 0.303(n/N)^2 - 0.619(n/N)^3 \quad (135)$$

$$K_d = 0.747 + 1.502K_t - 4.956K_t^2 + 3.321K_t^3 - 1.004(n/N) + 1.747(n/N)^2 - 1.226(n/N)^3 \quad (136)$$

Chen et al. [55] proposed three models for 16 stations in China. One model from eight sites was also selected for comparative study:

$$K_D = a + b(n/N) + c(n/N)^2 \quad (137)$$

For Ejinaqi station

$$K_D = 0.2436 + 0.4801(n/N) - 0.6661(n/N)^2 \quad (138)$$

For Lanzhou station

$$K_D = 0.1498 + 0.5346(n/N) - 0.5541(n/N)^2 \quad (139)$$

For Kashi station

$$K_D = 0.2293 + 0.4496(n/N) - 0.584(n/N)^2 \quad (140)$$

For Wulumuqi station

$$K_D = 0.1793 + 0.3323(n/N) - 0.4308(n/N)^2 \quad (141)$$

For Geermu station

$$K_D = 0.2241 + 0.5459(n/N) - 0.7234(n/N)^2 \quad (142)$$

For Wuhan station

$$K_D = 0.1172 + 0.6736(n/N) - 0.654(n/N)^2 \quad (143)$$

For Beijing station

$$K_D = 0.158 + 0.6288(n/N) - 0.7226(n/N)^2 \quad (144)$$

For Kunming station

$$K_D = 0.1658 + 0.574(n/N) - 0.6823(n/N)^2 \quad (145)$$

Cao et al. [58] established the following correlation for five locations in China, giving as

$$K_d = a + b(n/N) + c(n/N)^2 + d(n/N)^3 \quad (146)$$

$$K_D = a + bK_t + cK_t^2 + d(n/N) + e(n/N)^2 \quad (147)$$

For Ejinaqi station

$$K_d = 3.764 - 13.165(n/N) + 17.633(n/N)^2 - 8.232(n/N)^3 \quad (148)$$

$$K_D = -0.710 + 2.847K_t - 2.398K_t^2 + 0.404(n/N) - 0.392(n/N)^2 \quad (149)$$

For Lanzhou station

$$K_d = 0.281 + 1.523(n/N) - 2.156(n/N)^2 + 0.476(n/N)^3 \quad (150)$$

$$K_D = 0.0715 - 1.019K_t + 1.067K_t^2 + 1.406(n/N) - 1.157(n/N)^2 \quad (151)$$

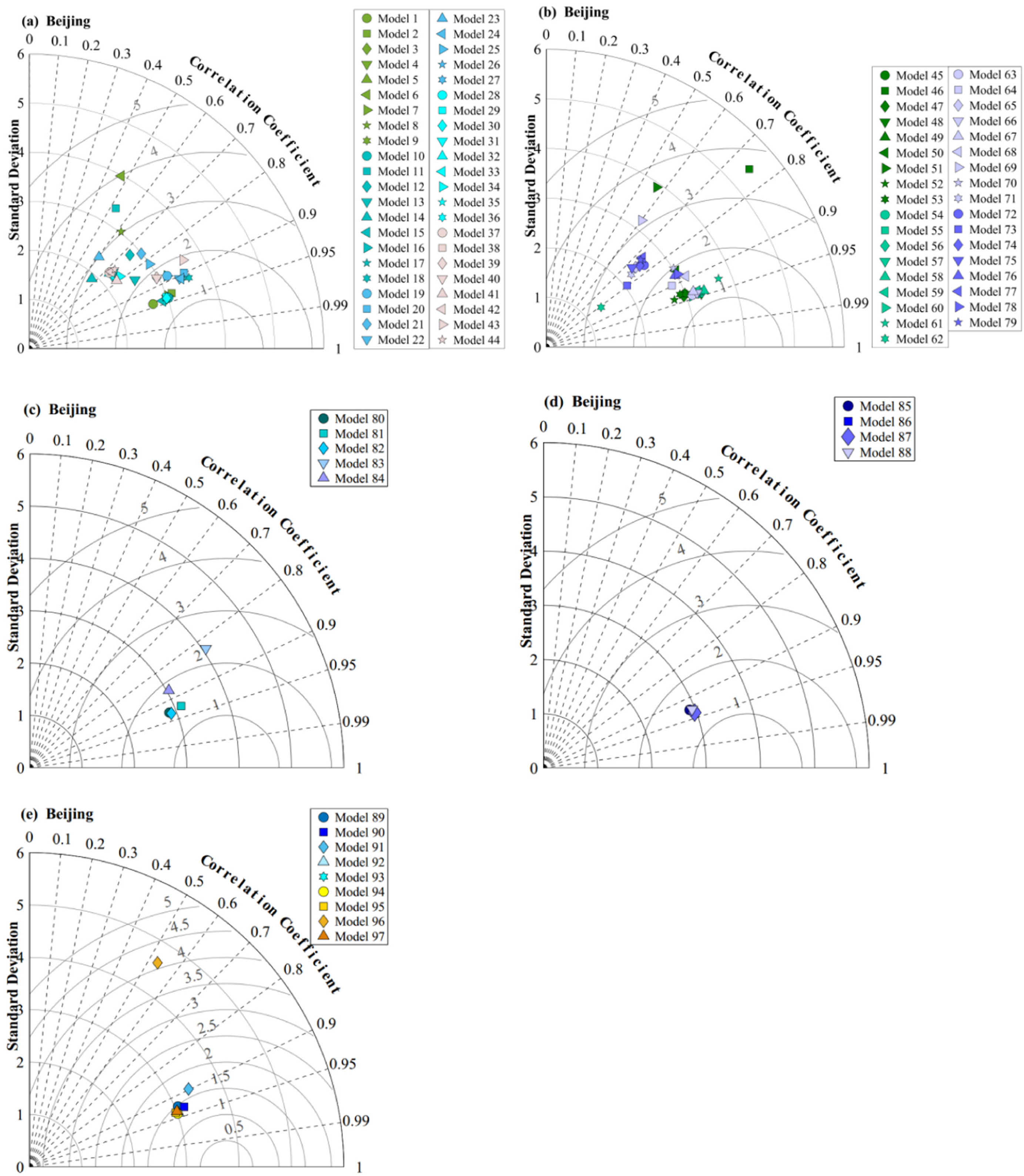


**Fig. 2.** Taylor diagram for models applied in Beijing station.

For Kashi station

$$K_d = -0.828 + 8.846(n/N) - 16.655(n/N)^2 + 9.361(n/N)^3 \tag{152}$$

$$K_D = -0.188 + 3.361K_t - 3.254K_t{}^2 - 1.207(n/N) + 0.876(n/N)^2 \tag{153}$$

For Wulumuqi station

$$K_d = -0.664 + 7.734(n/N) - 15.301(n/N)^2 + 8.918(n/N)^3 \tag{154}$$

$$K_D = -0.241 + 2.236K_t - 2.164K_t{}^2 - 0.232(n/N) + 0.0383(n/N)^2 \tag{155}$$

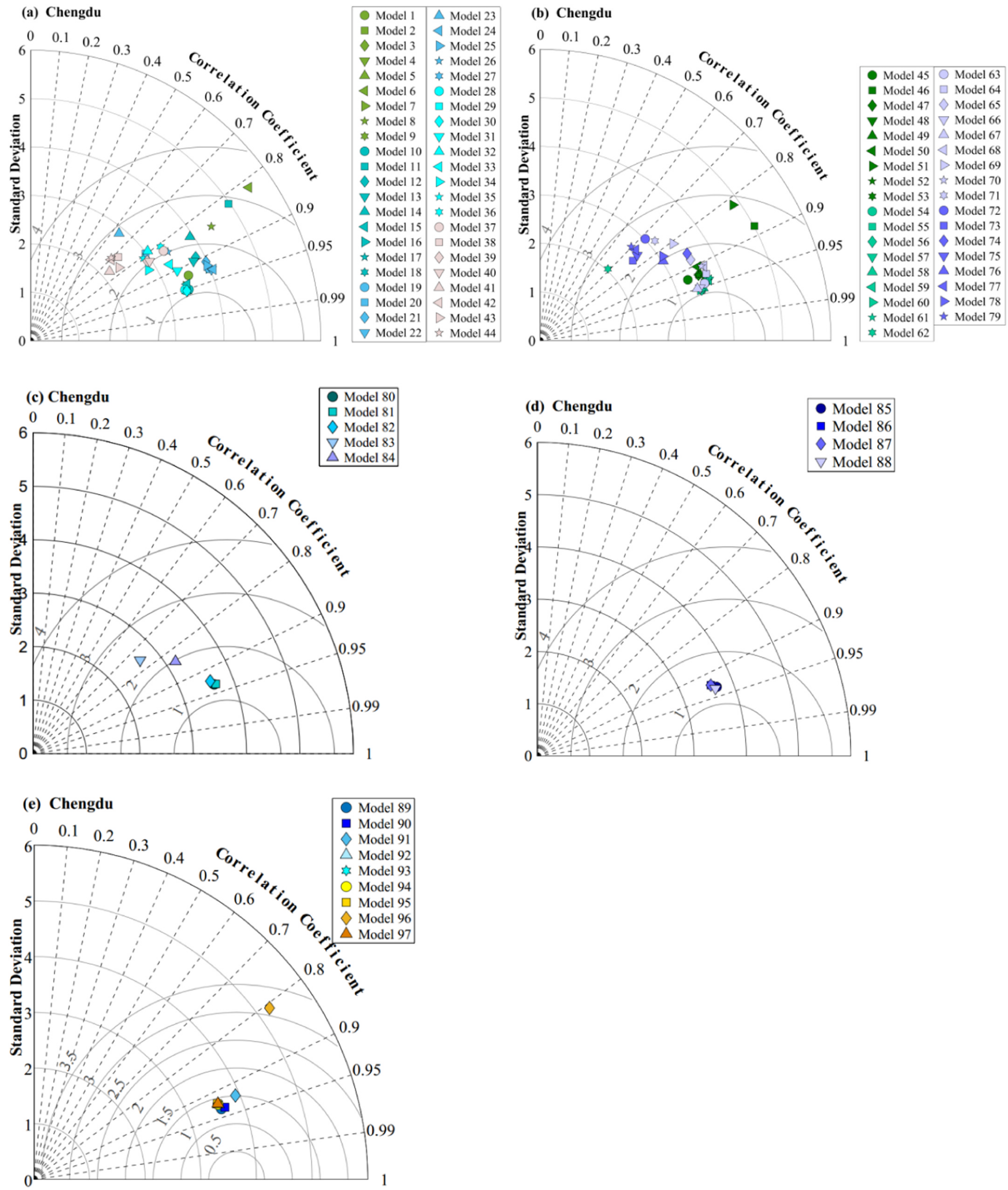


**Fig. 3.** Taylor diagram for models applied in Chengdu station.

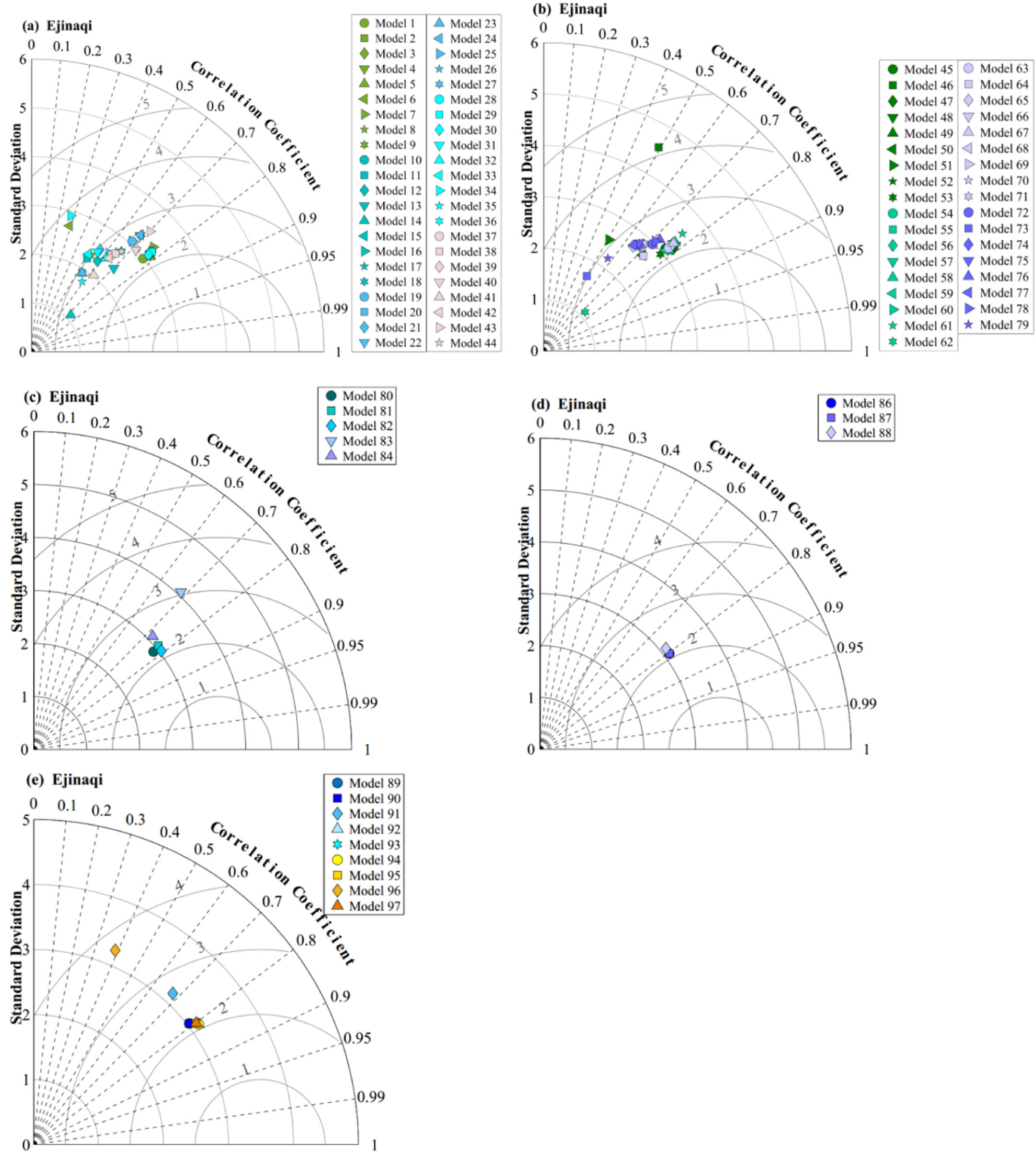


**Fig. 4.** Taylor diagram for models applied in Ejinaqi station.

For Geermu station

$$K_d = -2.112 + 10.843(n/N) - 14.541(n/N)^2 + 5.935(n/N)^3 \quad (156)$$

$$K_D = -1.247 + 4.296K_t - 3.162K_t^2 + 0.482(n/N) - 0.598(n/N)^2 \quad (157)$$

## 3. Results and discussion

### 3.1. Statistical error analysis

The measure of performance used in present study included MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and RMS, which can be expressed as

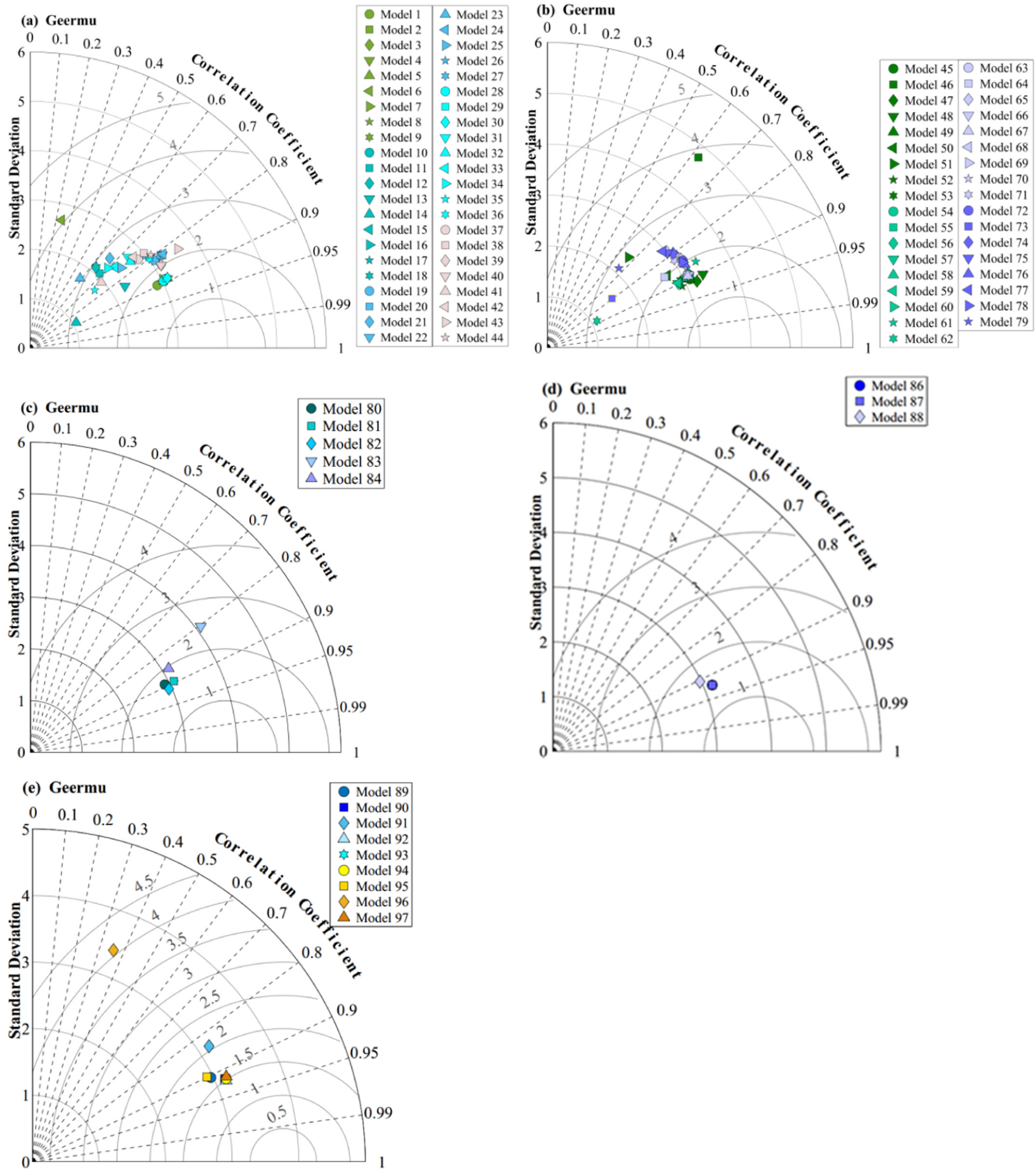


**Fig. 5.** Taylor diagram for models applied in Geermu station.

$$MBE = \frac{1}{n}\sum_{i=1}^{n}(X_{i,m} - X_{i,o}) \tag{158}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|X_{i,m} - X_{i,o}| \tag{159}$$

$$MARE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{X_{i,m} - X_{i,o}}{X_{i,o}}\right| \tag{160}$$

$$RMSE = \left(\frac{1}{n}\sum_{i=1}^{n}(X_{i,m} - X_{i,o})\right)^{\frac{1}{2}} \tag{161}$$

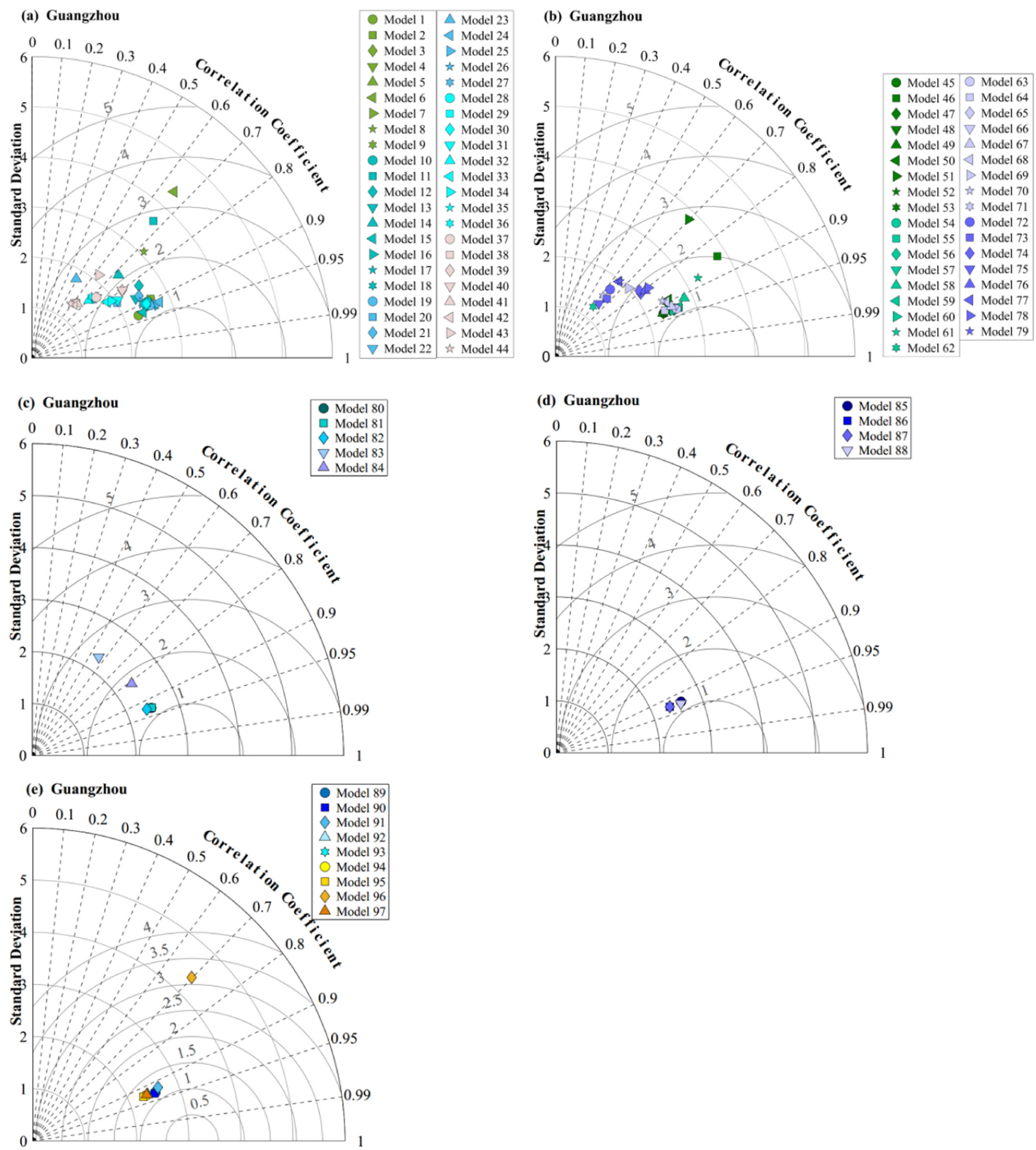


**Fig. 6.** Taylor diagram for models applied in Guangzhou station.

$$MPE(\%) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{X_{i,m} - X_{i,o}}{X_{i,o}}\right) \times 100 \tag{162}$$

$$t - stat = \left(\frac{(n-1)(MBE)^2}{(RMSE)^2 - (MBE)^2}\right)^{\frac{1}{2}} \tag{163}$$

$$RRMSE = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_{i,o} - X_{i,m})^2}}{\sum_{i=1}^{n}X_{i,o}} \tag{164}$$

$$R = \frac{\sum_{i=1}^{n}(X_{i,m} - \bar{X}_m)(X_{i,o} - \bar{X}_o)}{\sqrt{\sum_{i=1}^{n}(X_{i,m} - \bar{X}_m)^2\sum_{i=1}^{n}(X_{i,o} - \bar{X}_o)^2}} \tag{165}$$

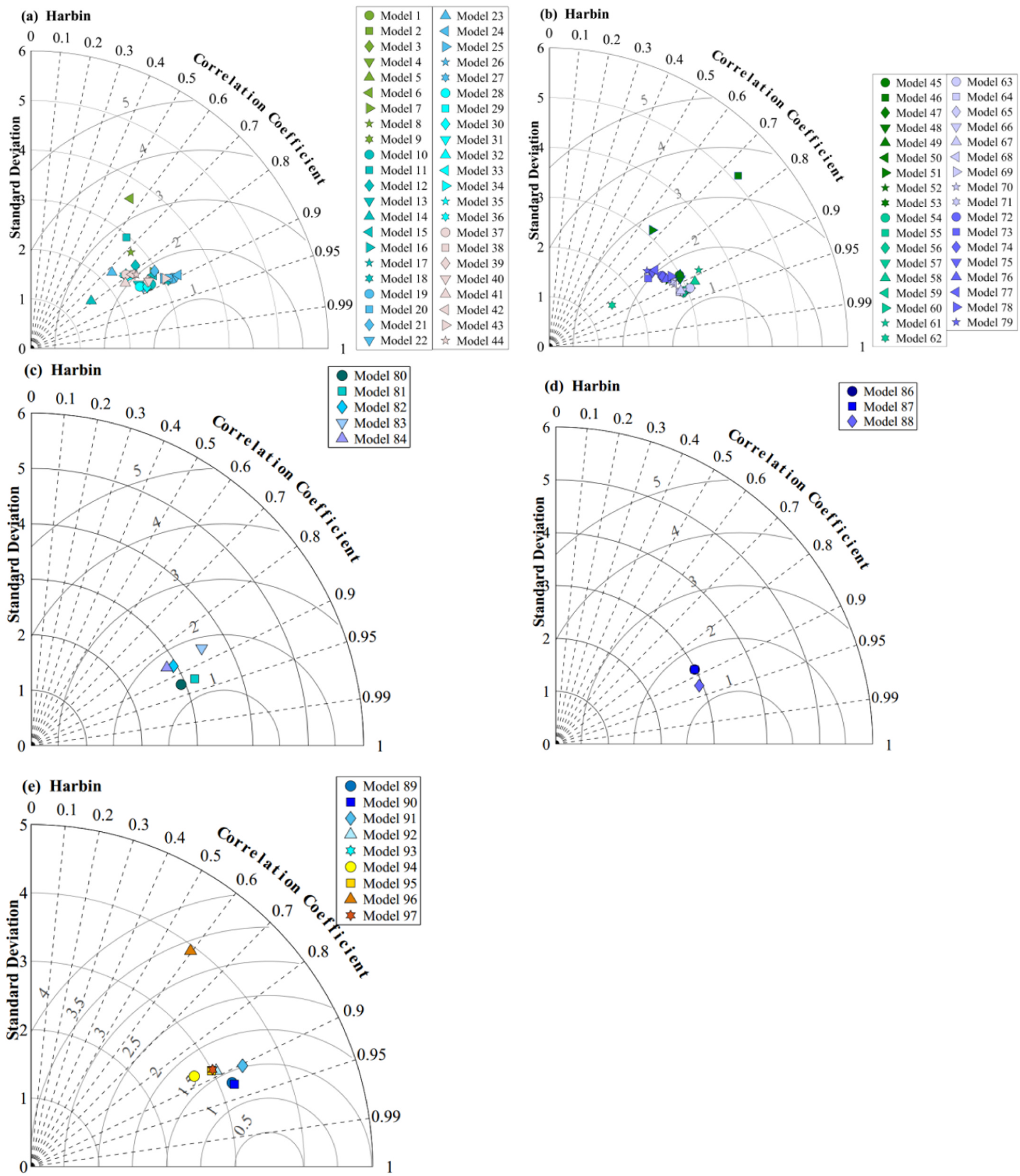


**Fig. 7.** Taylor diagram for models applied in Harbin station.

$$RMS = \sqrt{\frac{1}{n}\sum_{i=1}^{n}((X_{i,m} - \bar{X}_m) - (X_{i,o} - \bar{X}_o))^2} \quad (166)$$

where $n$ and bar indicated the number of data and mean of the variable, respectively, $X_m$ and $X_o$ were the modeled and observed daily $H_d$.

### 3.2. Model performances

In this study, the accuracy of above 97 models were compared for modeling daily $H_d$. Eleven meteorological parameters at 17 stations during 1993-2015 were used as model input elements to the applied models for estimating diffuse solar radiation in China. The regression coefficients for above 97 models at 17 stations were given in Table A1-A17. It was not convenient to reveal the accuracies of different models using error statistics in tabular form due to the huge volume of data. Taylor diagrams were especially useful in gauging the relative skills of many different models, which has been widely applied in various fields for model comparisons [64]. The correlation (R), standard deviation (STD) and centered root-mean-square difference (RMS) between measured and estimated values were combined at a single point in a two-dimensional polar diagram, which graphically displayed how close the estimated results of a particular model were to the observed data. In order to compare the performances of different categories of models, all models were used for graphical visualization based on the statistical indices. Figs. 2–18 was Taylor diagram visualizing the model accuracies at 17 radiation stations. (a)-(e) represented five categories and included 44, 35, 5, 4 and 9 models, respectively. Taylor diagrams for all stations showed that the model 6, 46, 51 and 96 gave relatively larger model errors than other models at each

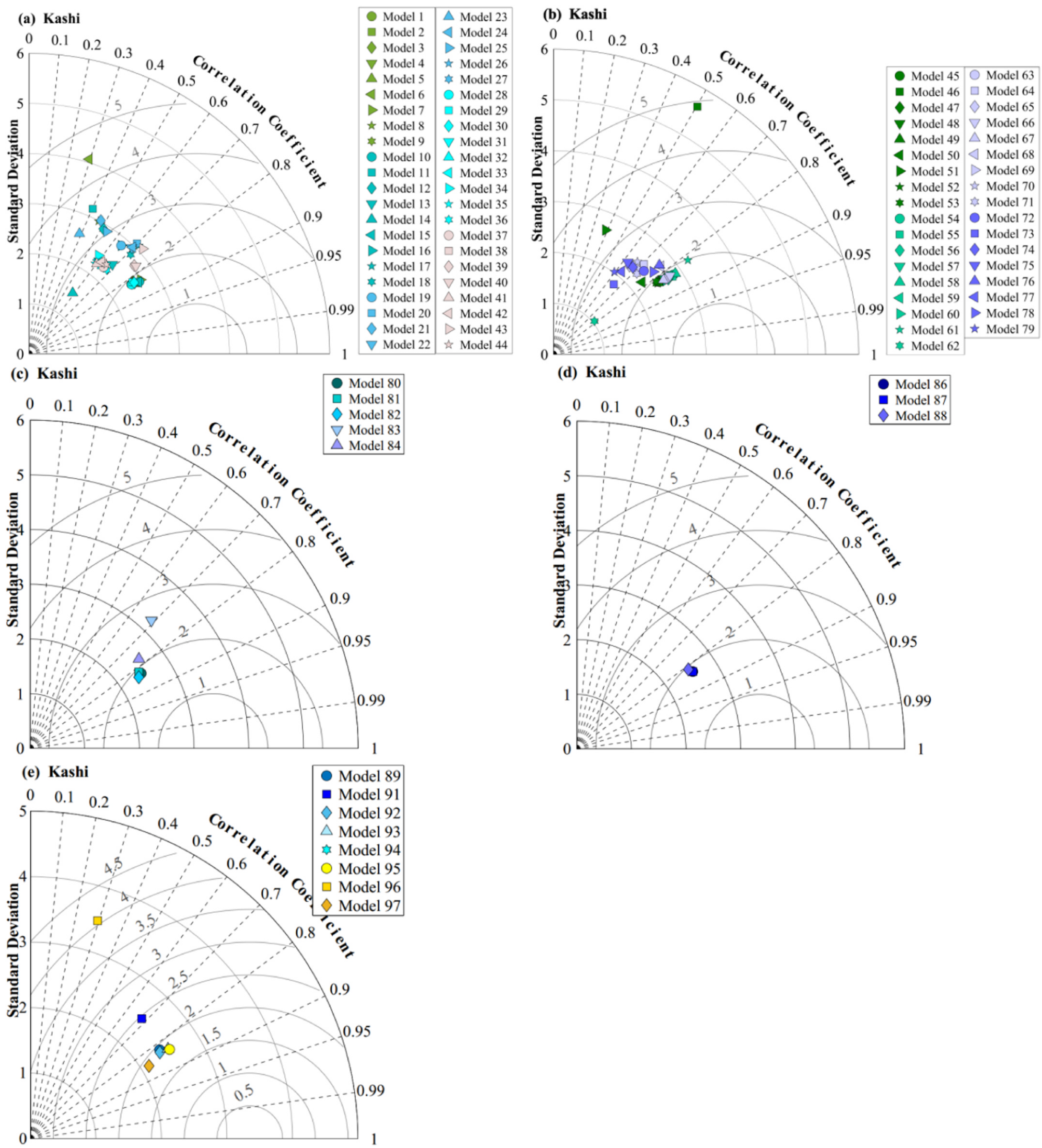


**Fig. 8.** Taylor diagram for models applied in Kashi station.

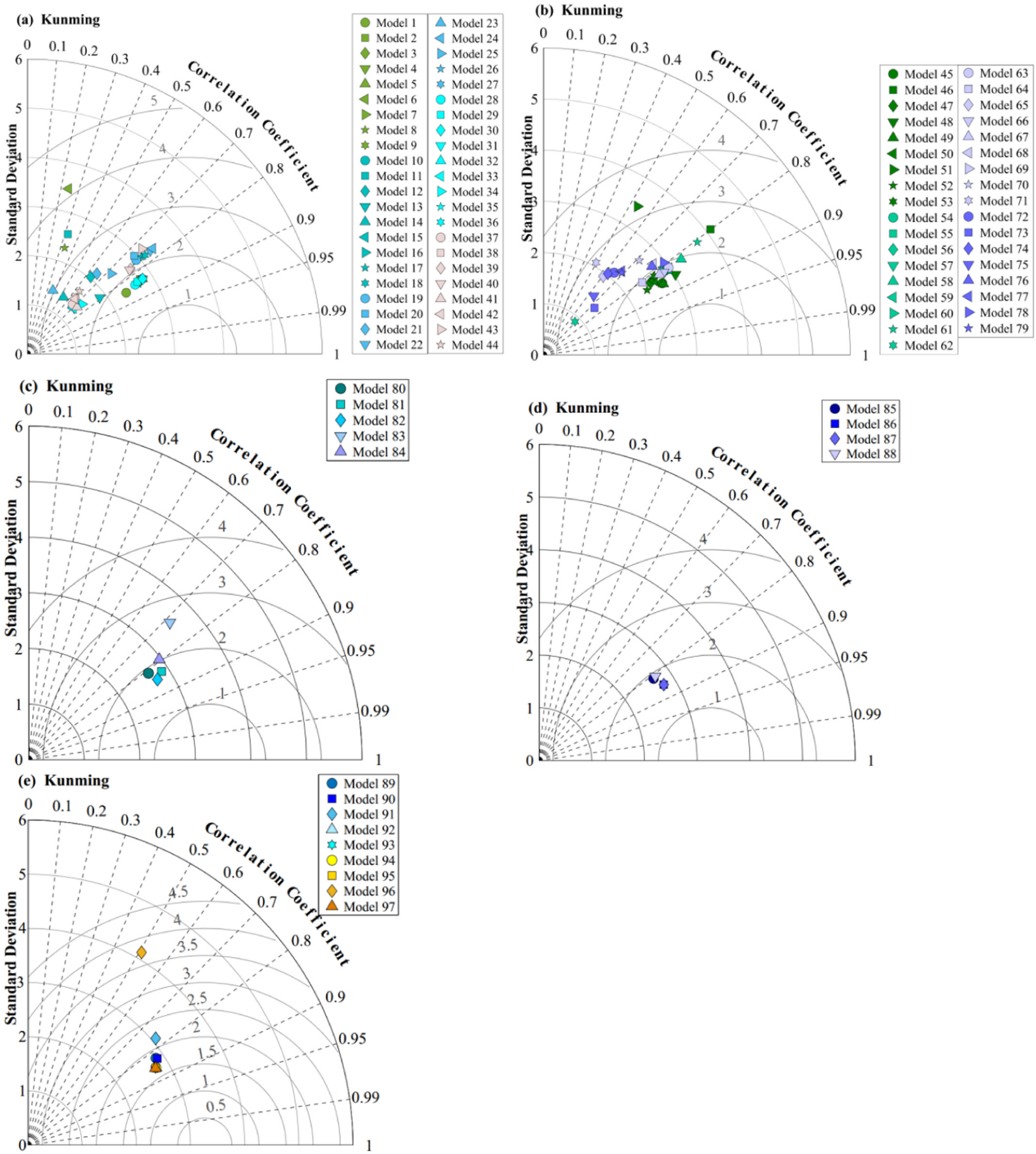


**Fig. 9.** Taylor diagram for models applied in Kunming station.

site, for example, the worst performance for model 96 was observed at Sanya station (Fig. 13) with RMS, R and STD of 3.6746 MJ m$^{-2}$ day$^{-1}$, 0.1731 and 2.8597, respectively. The representative points of some models were very close to each other (almost overlap for some cases), indicating that the statistical indices of these models were very pretty close, for example, model 3 and 29 for Chengdu station (Fig. 3) had the same R (0.9529 and 0.9529, respectively) and similar RMS error (1.108 and 1.083 MJ m$^{-2}$ day$^{-1}$, respectively) and STD (3.3922 and 3.3878 MJ m$^{-2}$ day$^{-1}$, respectively). Meanwhile, the models did not bring good estimates at some stations, such as Ejinaqi, Kashi, Sanya and Wulumuqi. For example, all models showed poor performances at Ejinaqi, Kashi and Wulumuqi sites due to the dusty air conditions. For Ejinaqi station (Fig. 4), R values were less than 0.81; R for all model were also less than 0.8 at Wulumuqi (Fig. 17).

Table A1-A17 clearly showed the MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS representing the model accuracies of 97 models

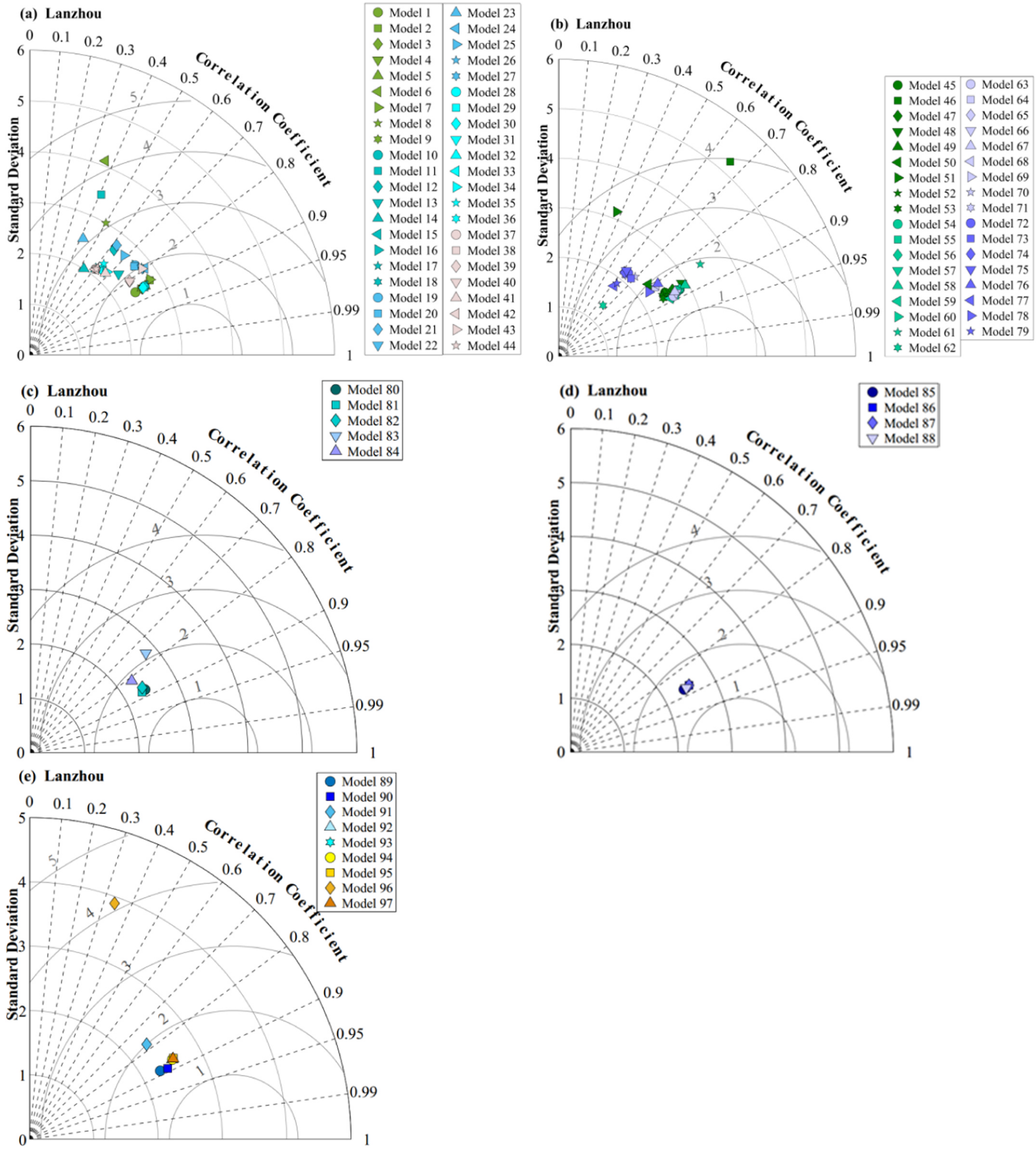


**Fig. 10.** Taylor diagram for models applied in Lanzhou station.

for above 17 stations. The bold values in each table refer to the most accurate model regarding particular statistical indicator. Based on selected statistical indicators, the most accurate models for each site were analyzed.

For Beijing station (Table A1), the statistical indicators illustrated that models 19, 48, 55 and 82 had best accuracies, the MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were −0.4917 to 0.0003 MJ m$^{-2}$ day$^{-1}$, 0.9044–1.2518 MJ m$^{-2}$ day$^{-1}$, 0.1267–0.2199 MJ m$^{-2}$ day$^{-1}$, 1.3269–1.7593 MJ m$^{-2}$ day$^{-1}$, −3.4433–8.7746%, 0.0076–17.7235, 0.1955–0.2593, 0.8849–0.9455 and 1.2513–1.7593 MJ m$^{-2}$ day$^{-1}$, respectively. Model 48 performed superior to other models at Beijing station with MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS of −0.4416 MJ m$^{-2}$ day$^{-1}$, 0.9044 MJ m$^{-2}$ day$^{-1}$, 0.1318 MJ m$^{-2}$ day$^{-1}$, 1.3269 MJ m$^{-2}$ day$^{-1}$, −3.4433%, 17.7235, 0.1955, 0.9455 and 1.2513 MJ m$^{-2}$ day$^{-1}$, respectively.

The higher model accuracies for Chengdu station shown in Table A2 were provided by models 23, 55 and 75 with MBE, MAE, MARE, RMSE,

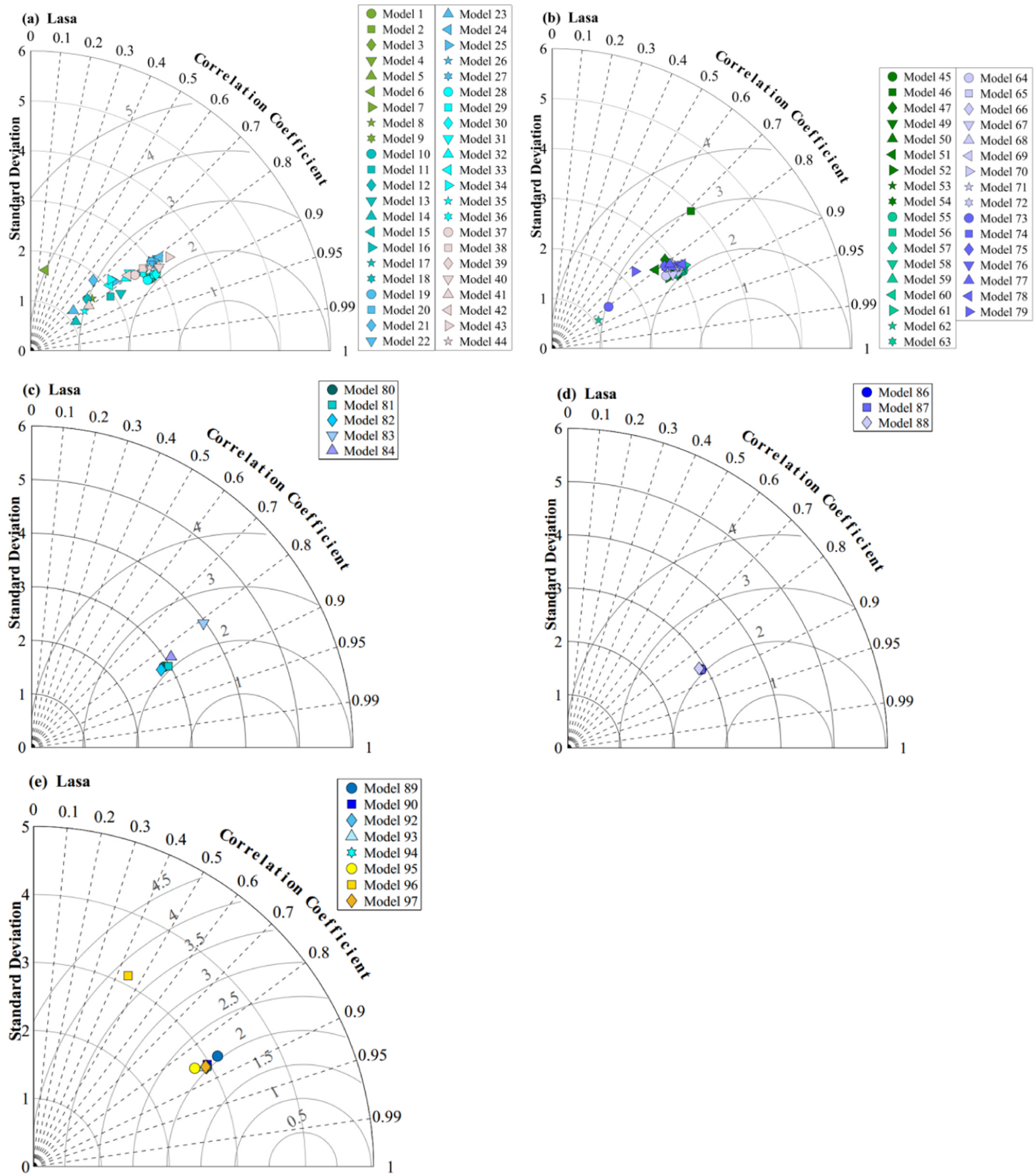


**Fig. 11.** Taylor diagram for models applied in Lasa station.

MPE, t-stats, RRMSE, R and RMS ranging from −0.3033 to 0.1556 MJ m$^{-2}$ day$^{-1}$, 0.6869 1.9200 MJ m$^{-2}$ day$^{-1}$, 0.0884–0.4278 MJ m$^{-2}$ day$^{-1}$, 1.1045–2.4935 MJ m$^{-2}$ day$^{-1}$, 0.5359–22.9653%, 0.1861–7.1634, 0.1556–0.3391, 0.6361–0.9539 and 1.0935–2.4750 MJ m$^{-2}$ day$^{-1}$, respectively. The largest R (0.9539) and smallest MAE (0.6869 MJ m$^{-2}$ day$^{-1}$), MARE (0.0884 MJ m$^{-2}$ day$^{-1}$), RMSE (1.1045 MJ m$^{-2}$ day$^{-1}$), RRMSE (0.1556) and RMS (1.0935 MJ m$^{-2}$ day$^{-1}$) were generated by Model 55.

The most accurate models for Ejinaqi station shown in Table A3 were model 55, 82, 91 and 94, the values of MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS varied from −0.6838 to −0.0099 MJ m$^{-2}$ day$^{-1}$, 1.5484 to 2.0072 MJ m$^{-2}$ day$^{-1}$, 0.3001 to 0.3871 MJ m$^{-2}$ day$^{-1}$, 2.1914 to 2.6934 MJ m$^{-2}$ day$^{-1}$, −1.2958 to 13.6705%, 0.1865 to 16.3790, 0.3559 to 0.4374, 0.6779 to 0.8082 and

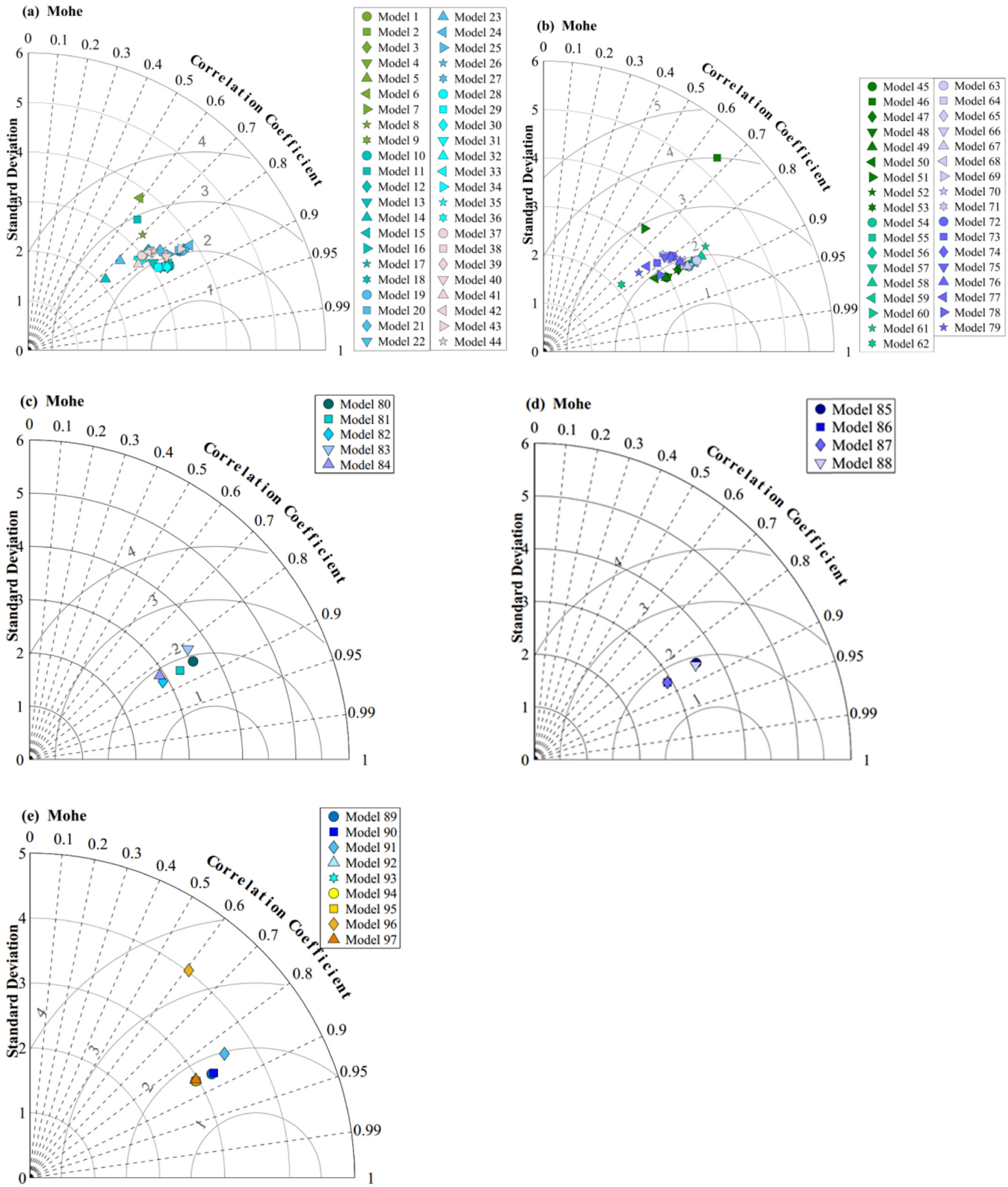


**Fig. 12.** Taylor diagram for models applied in Mohe station.

2.0797 to 2.6855 MJ m$^{-2}$ day$^{-1}$, respectively. Meanwhile, model 48 performed superior to other models with largest R (0.8082) and smallest MAE (1.5484 MJ m$^{-2}$ day$^{-1}$), RMSE (2.1914 MJ m$^{-2}$ day$^{-1}$), RRMSE (0.3559) and RMS (2.0797 MJ m$^{-2}$ day$^{-1}$).

Table A4 showed that best model performances for Geermu station were generated by model 23, 48, 82 and 86. The MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were −1.3880 to 0.0769 MJ m$^{-2}$ day$^{-1}$, 1.1542 – 2.6700 MJ m$^{-2}$ day$^{-1}$, 0.2279–0.4493 MJ m$^{-2}$ day$^{-1}$, 1.4816–3.3947 MJ m$^{-2}$ day$^{-1}$, 2.2624–13.4673%, 0.0090–22.3299, 0.2233–0.515, 0.5844–0.9235 and 1.4816–3.098 MJ m$^{-2}$ day$^{-1}$,

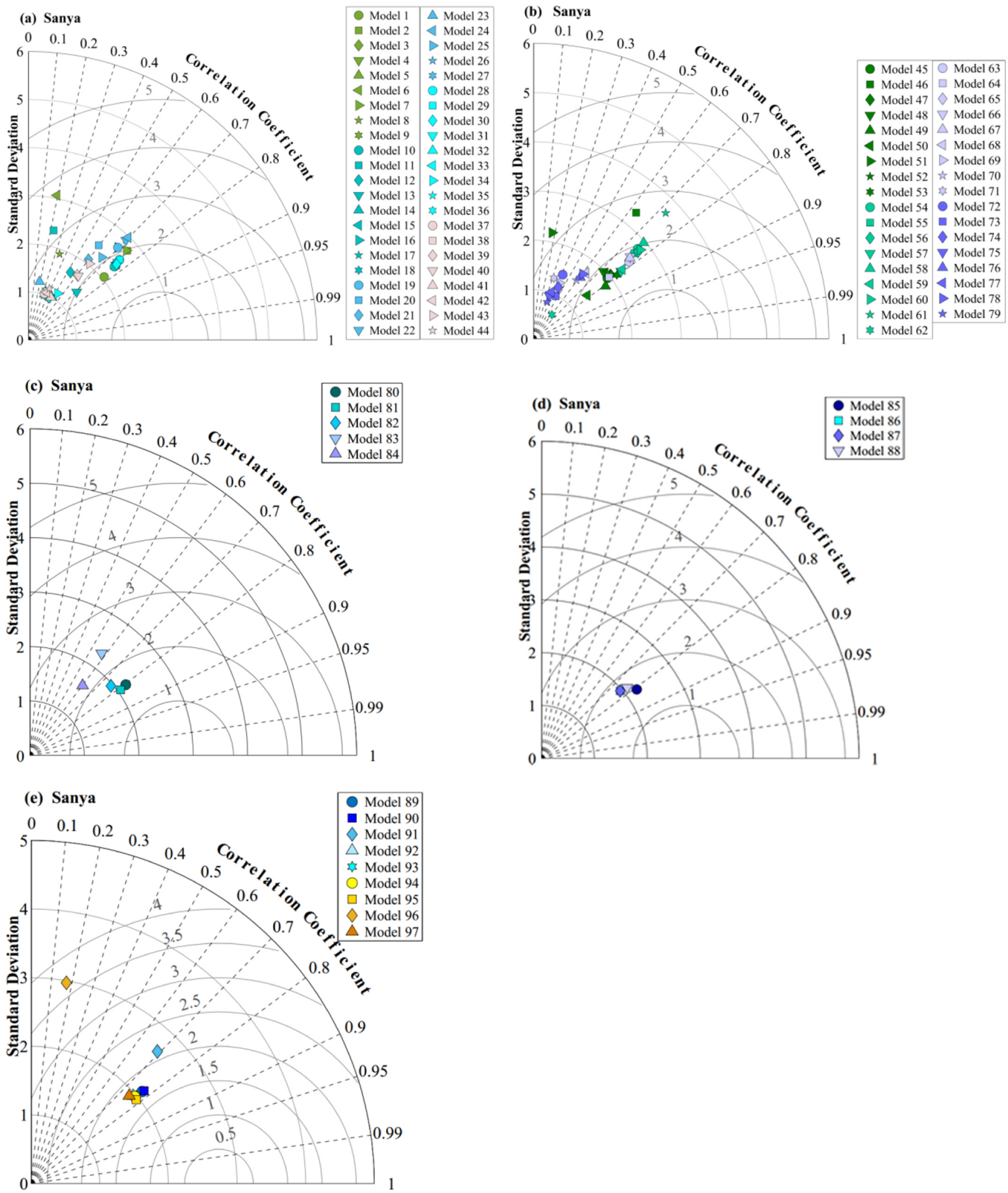


**Fig. 13.** Taylor diagram for models applied in Sanya station.

respectively. Model 86 had largest R (0.9235) and smallest MAE (1.1542 MJ $m^{-2}$ $day^{-1}$), RMSE (1.4816 MJ $m^{-2}$ $day^{-1}$), RRMSE (0.2233) and RMS (1.4816 MJ $m^{-2}$ $day^{-1}$).

Table A5 showed that model 8, 18, 31, 54, 55, 85 and 90 produced the most accurate estimates at Guangzhou station. The MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were −0.6905 to 0.0456 MJ $m^{-2}$ $day^{-1}$, 0.8245–1.7267 MJ $m^{-2}$ $day^{-1}$, 0.0948–0.2466 MJ $m^{-2}$ $day^{-1}$, 1.1997–2.2680 MJ $m^{-2}$ $day^{-1}$, −6.9522–5.9406%, 1.0038–30.1924, 0.1496–0.2828, 0.7272–0.9324 and 1.1419–2.2676 MJ $m^{-2}$ $day^{-1}$, respectively. Among these models,

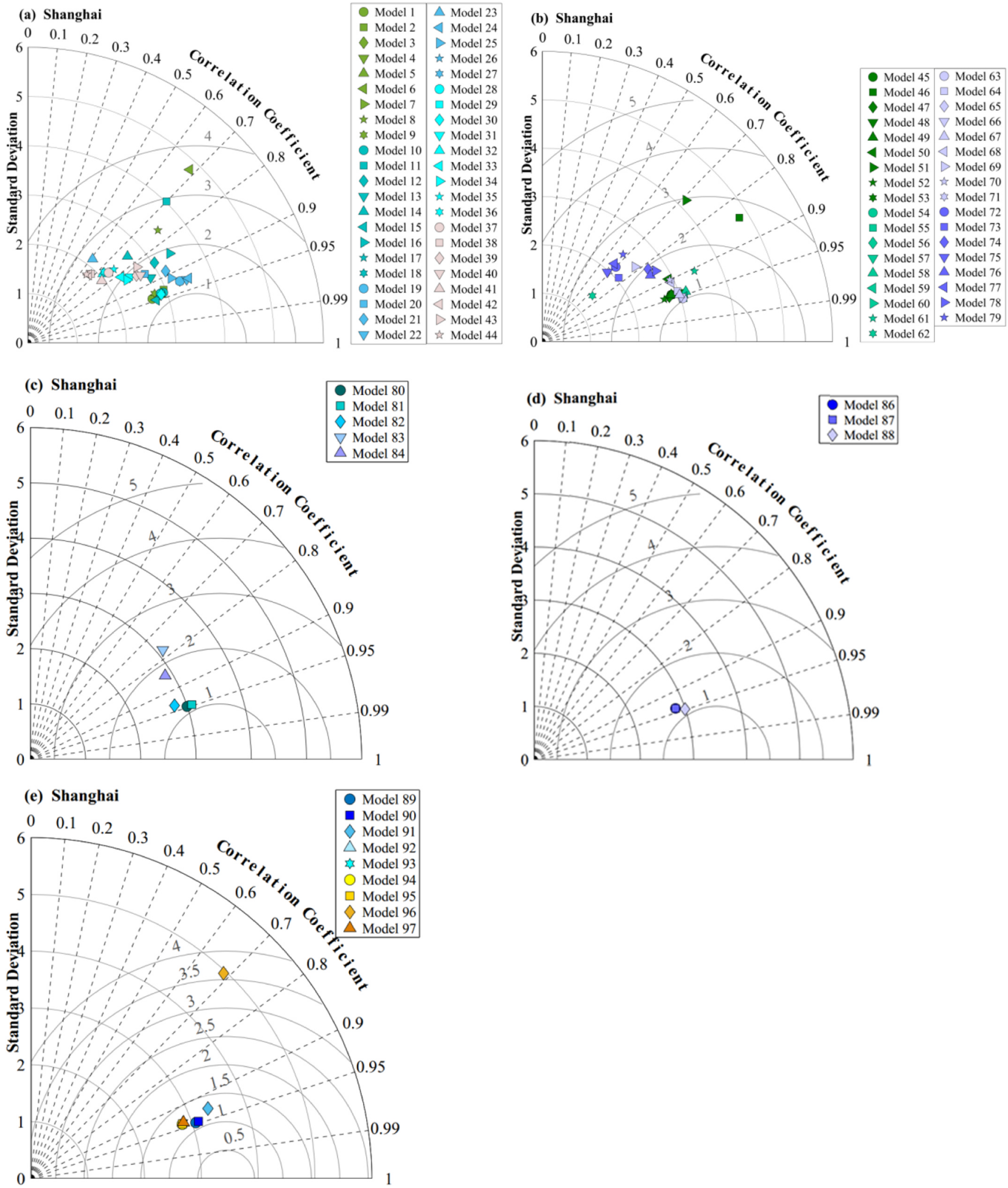

**Fig. 14.** Taylor diagram for models applied in Shanghai station.

model 90 had largest R (0.9324), model 85 had smallest RMSE (1.1997 $MJ\,m^{-2}\,day^{-1}$) and RRMSE (0.1496), model 8 had smallest MBE (0.0456 $MJ\,m^{-2}\,day^{-1}$) and t-stats (1.0038).

Table A6 showed that the most accurate models were model 8, 41 and 90 at Harbin station, the values of MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS varied from $-0.7762\sim -0.0156\,MJ\,m^{-2}\,day^{-1}$, 0.9168–1.9087 $MJ\,m^{-2}\,day^{-1}$, 0.1753–0.3818 $MJ\,m^{-2}\,day^{-1}$, 1.308–2.4337 $MJ\,m^{-2}\,day^{-1}$, $-0.7906$–14.2285%, 0.3249 – 17.1284, 0.2153 – 0.4006, 0.7207 – 0.9270 and 1.3334 – 2.4603 $MJ\,m^{-2}\,day^{-1}$, respectively. The largest R (0.927) and smallest MAE (0.9168 $MJ\,m^{-2}\,day^{-1}$),

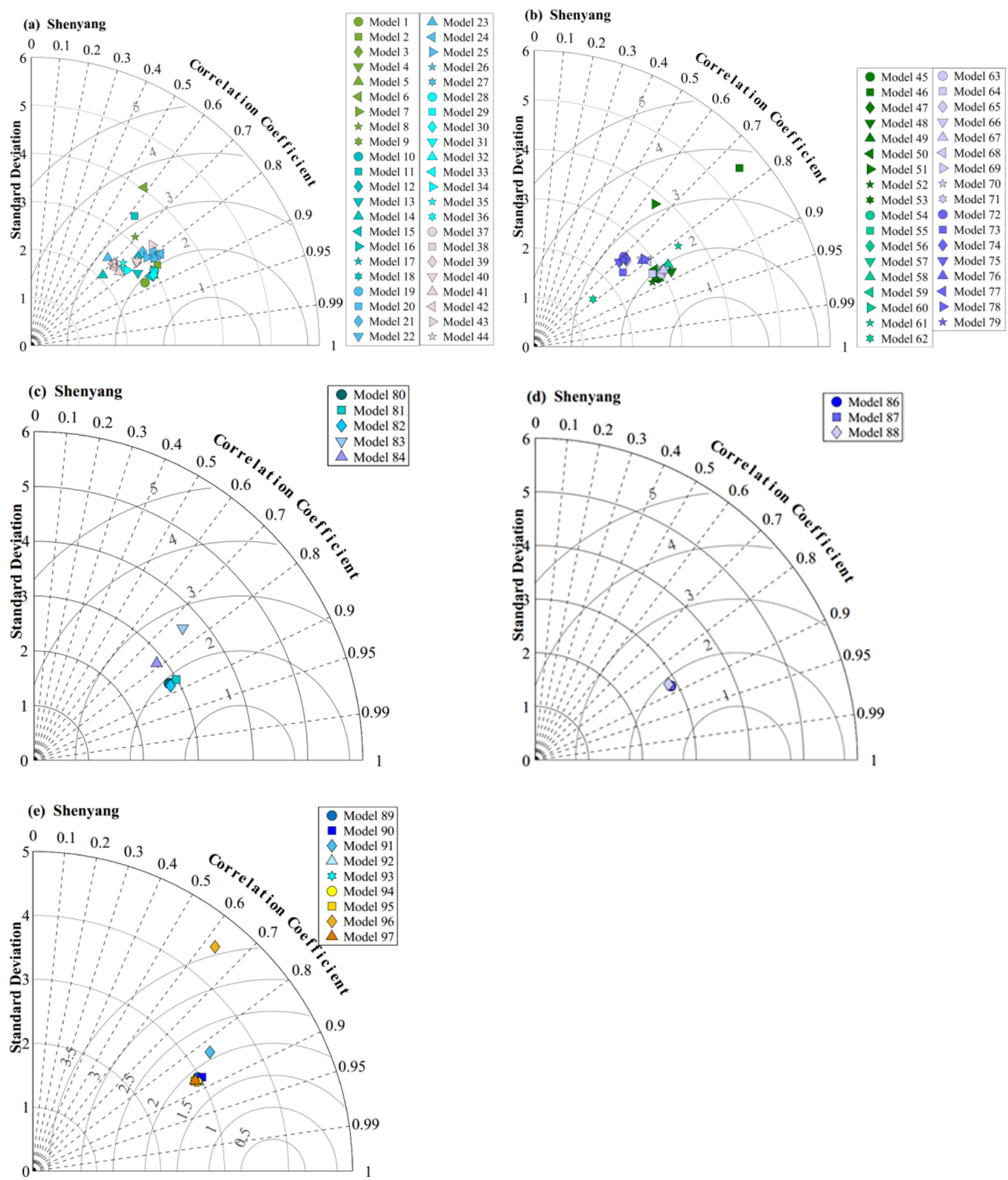


**Fig. 15.** Taylor diagram for models applied in Shenyang station.

MARE ($0.1753\,MJ\,m^{-2}\,day^{-1}$), RMSE ($1.3080\,MJ\,m^{-2}\,day^{-1}$), RRMSE (0.2153) and RMS ($1.3334\,MJ\,m^{-2}\,day^{-1}$) were produced by model 90.

Table A7 showed that model 13, 55, 57, 95 and 97 gave preferable results at Kashi station. The MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were $-0.6100$ to $0.0024\,MJ\,m^{-2}\,day^{-1}$, 1.3664–1.9320 $MJ\,m^{-2}\,day^{-1}$, 0.1906 0.3198 $MJ\,m^{-2}\,day^{-1}$, 1.8525–2.455 $MJ\,m^{-2}\,day^{-1}$, $-0.7338$ to 11.9489%, 0.0480–16.0553, 0.2571–0.3407, 0.6820–0.8525 and 1.8317 $-2.4550\,MJ\,m^{-2}\,day^{-1}$, respectively. The minimum RMSE, RRMSE and RMS were found to be 1.8525, 0.2571 and 1.8317 by model 95, while model 97 had the largest R (0.8525).

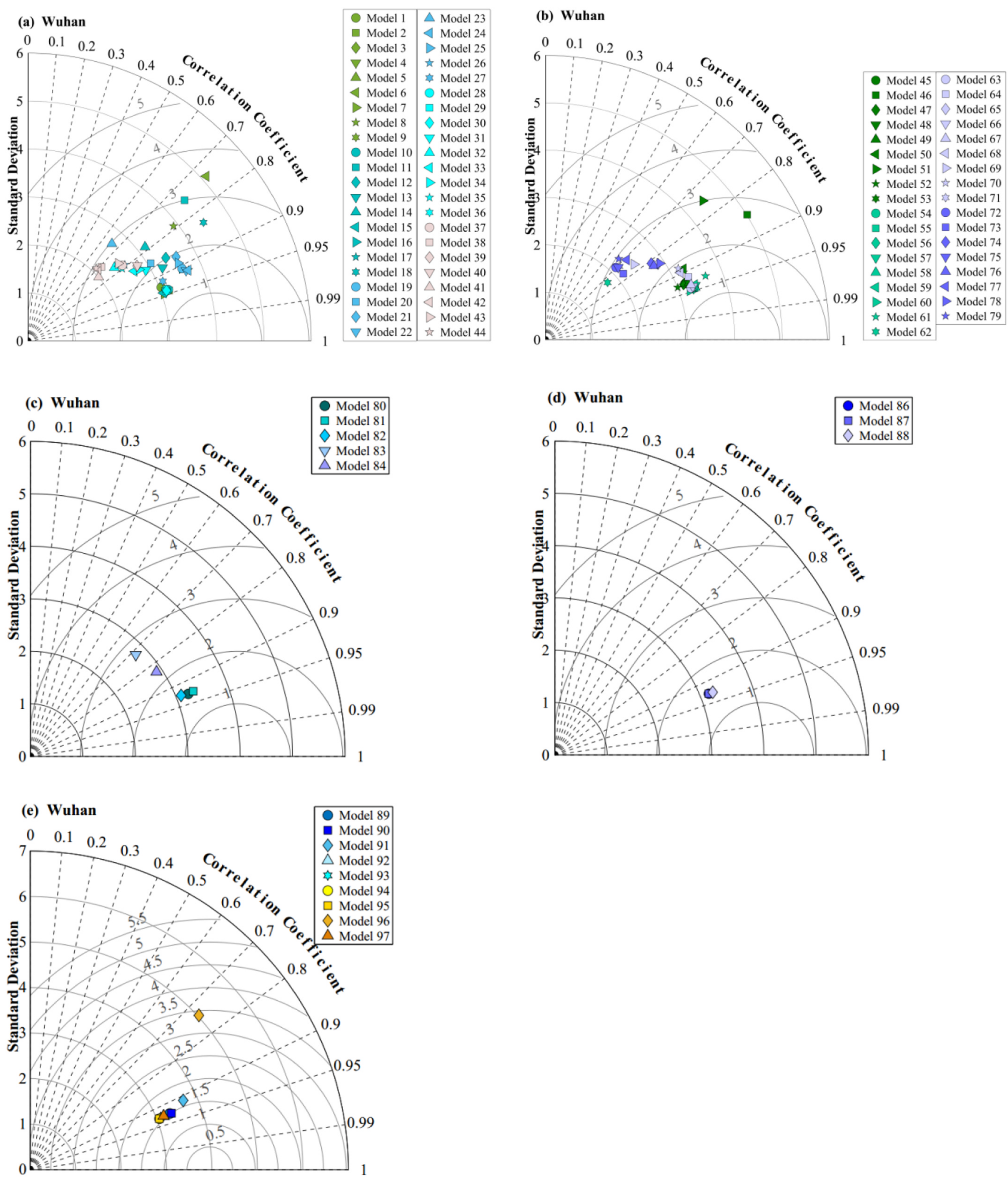


**Fig. 16.** Taylor diagram for models applied in Wuhan station.

Table A8 showed that model 24, 48, 49 and 77 produced more accurate estimates at Kunming station. The MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were −0.3661 to 0.0585 MJ m$^{-2}$ day$^{-1}$, 1.0810–1.8852 MJ m$^{-2}$ day$^{-1}$, 0.1802–0.3758 MJ m$^{-2}$ day$^{-1}$, 2.3859–1.6701 MJ m$^{-2}$ day$^{-1}$, −0.2653 to 18.1108%, 0.9194–7.9061, 0.2312–0.3303, 0.6827–0.8598 and 1.6691–2.3855 MJ m$^{-2}$ day$^{-1}$, respectively. Among these models, model 49 had the best performance with MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS of 0.0585 MJ m$^{-2}$ day$^{-1}$, 1.1184 MJ m$^{-2}$ day$^{-1}$, 0.1962 MJ m$^{-2}$ day$^{-1}$, 1.6701 MJ m$^{-2}$ day$^{-1}$, 8.4970%, 1.7135, 0.2312, 0.8598 and 1.6691 MJ m$^{-2}$ day$^{-1}$, respectively.

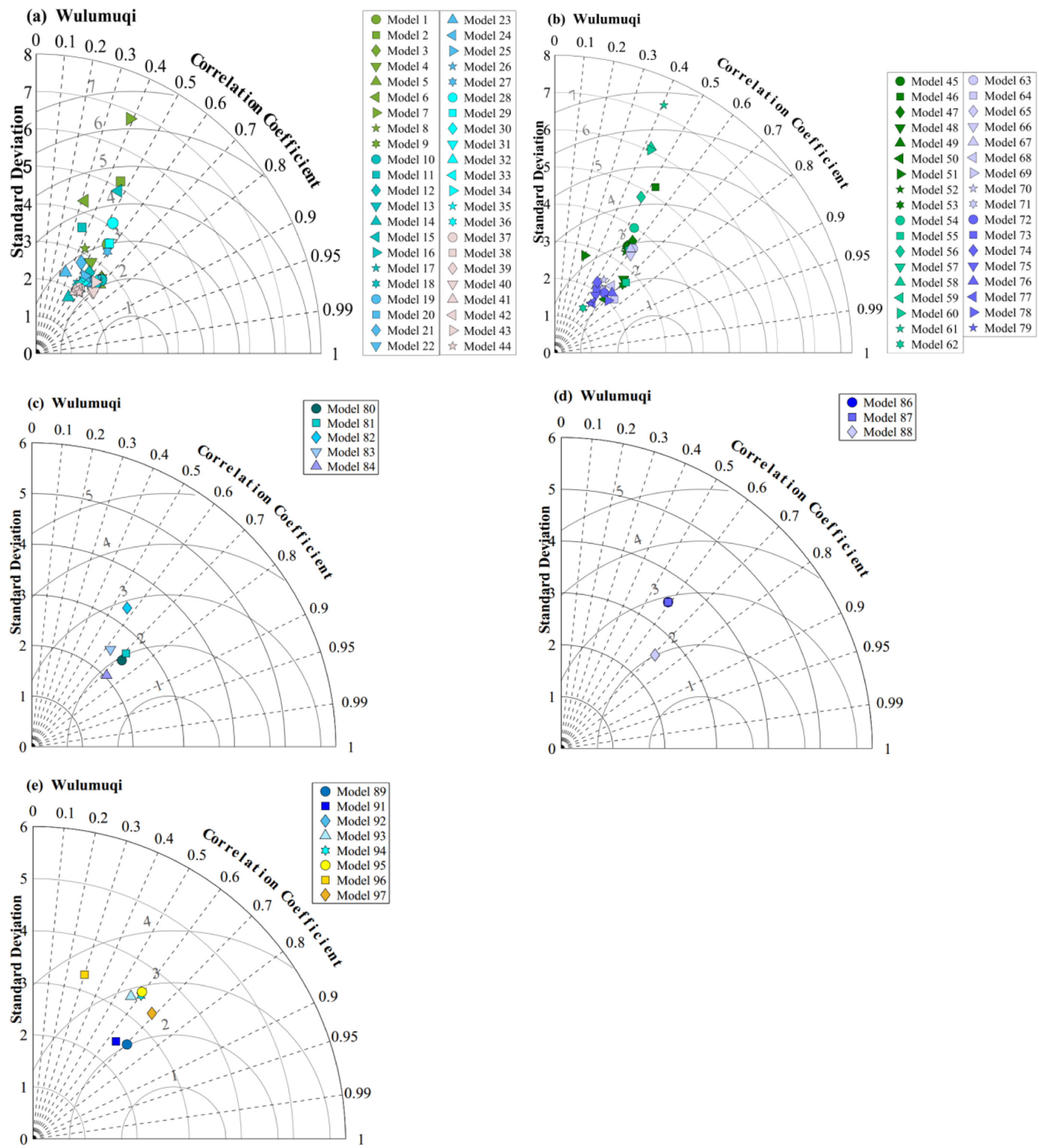


**Fig. 17.** Taylor diagram for models applied in Wulumuqi station.

Table A9 showed that the most accurate estimates were produced by model 55, 57, 59, 65 and 90 at Lanzhou station. The MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values were $-0.5568$ to $0.0012\,MJ\,m^{-2}\,day^{-1}$, $1.0879–2.0150\,MJ\,m^{-2}\,day^{-1}$, $0.1464–0.3552\,MJ\,m^{-2}\,day^{-1}$, $1.5328–2.5105\,MJ\,m^{-2}\,day^{-1}$, $-0.7111$–14.4650%, 0.0238–18.6921, 0.2169–0.3552, 0.6162–0.8902 and $1.4720–2.5105\,MJ\,m^{-2}\,day^{-1}$, respectively. Model 57 had minimum RMSE ($1.5328\,MJ\,m^{-2}\,day^{-1}$), RRMSE (0.2169) and RMS ($1.4720\,MJ\,m^{-2}\,day^{-1}$) while Model 90 had largest R (0.8902).

Table A10 showed that the accurate models for Lhasa station were model 46, 55, 68 and 94, the MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS ranged from $-0.7933$ to $0.0353\,MJ\,m^{-2}\,day^{-1}$, $1.4496–2.3284\,MJ\,m^{-2}\,day^{-1}$, $0.2609–0.4856\,MJ\,m^{-2}\,day^{-1}$, $2.0564–2.9943\,MJ\,m^{-2}\,day^{-1}$, 0.0593–11.1791%, 0.5928–18.4560, 0.3189–0.4643, 0.7108–0.8682 and $2.0302–2.9941\,MJ\,m^{-2}\,day^{-1}$, respectively. Among these models, model 94 had the highest accuracy with largest R (0.8682) and minimum MAE ($1.4496\,MJ\,m^{-2}\,day^{-1}$), RMSE ($2.0564\,MJ\,m^{-2}\,day^{-1}$), RRMSE (0.3189) and RMS

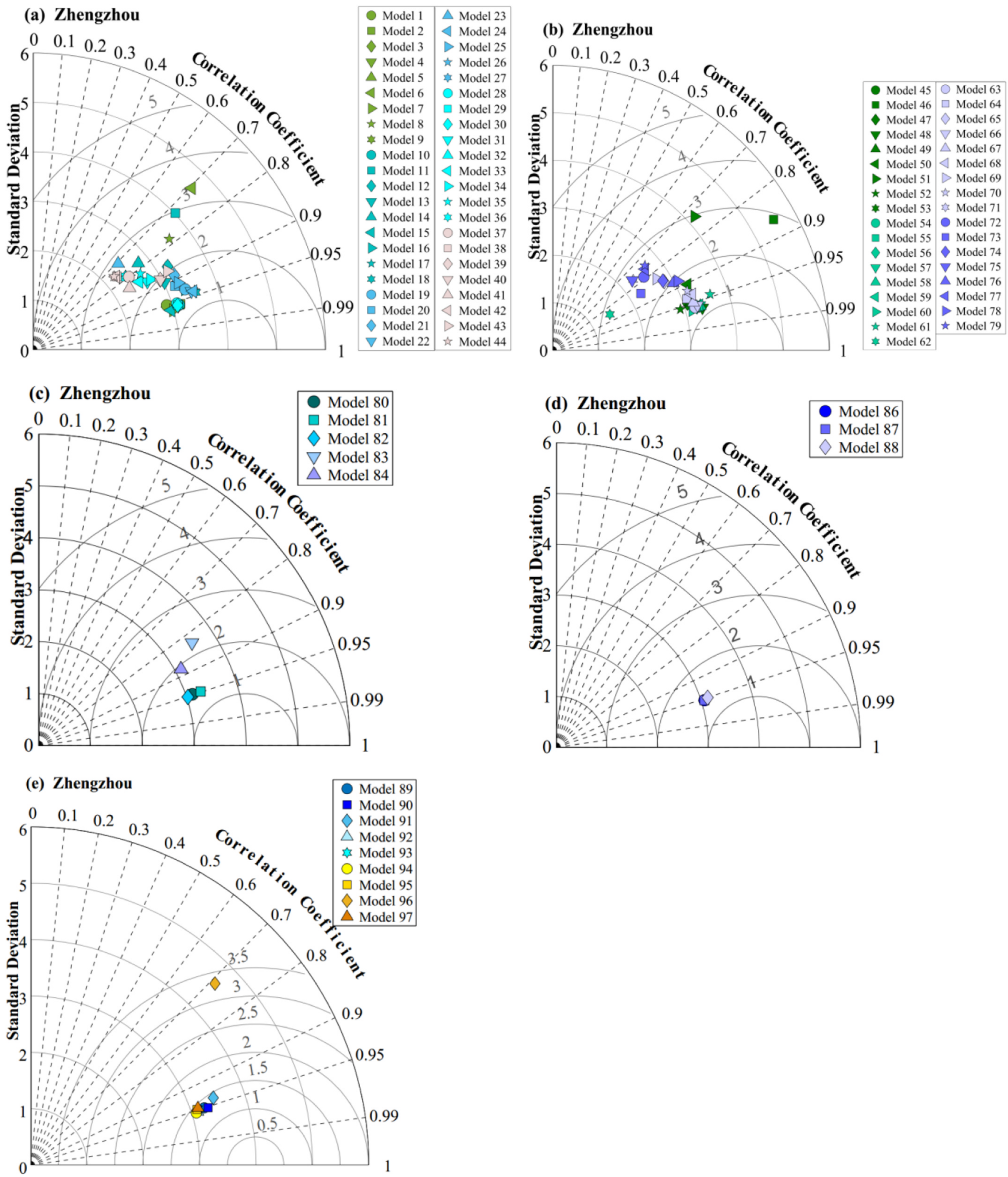


**Fig. 18.** Taylor diagram for models applied in Zhengzhou station.

($2.0302\ MJ\ m^{-2}\ day^{-1}$).

Table A11 illustrated that model 59, 82, 89 and 90 had more accurate estimates at Mohe station, the MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values ranged −0.1763 to $0.0026\ MJ\ m^{-2}\ day^{-1}$, $1.0863–1.2610\ MJ\ m^{-2}\ day^{-1}$, $0.2058–0.2475\ MJ\ m^{-2}\ day^{-1}$, $1.7478–1.8818\ MJ\ m^{-2}\ day^{-1}$, −0.3375 to 1.4024%, 0.0708–11.2518, 0.3057–0.3291, 0.8613–0.8686 and $1.7389–1.8818\ MJ\ m^{-2}\ day^{-1}$, respectively. Model 89 had smallest RMSE ($1.7478\ MJ\ m^{-2}\ day^{-1}$), RRMSE (0.3057) and RMS ($1.7389\ MJ\ m^{-2}\ day^{-1}$) while model 90 had smallest MAE ($1.0863\ MJ\ m^{-2}\ day^{-1}$), MARE ($0.2058\ MJ\ m^{-2}\ day^{-1}$) and largest R (0.8686).

Table A12 showed that the higher model accuracies for Sanya station were provided by model 85, 81, 25 and 6 with MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values varying from $-0.9223$ to $-0.0994$ MJ m$^{-2}$ day$^{-1}$, 1.1955–3.1575 MJ m$^{-2}$ day$^{-1}$, 0.1494–0.4281 MJ m$^{-2}$ day$^{-1}$, 1.6107–3.6984 MJ m$^{-2}$ day$^{-1}$, $-7.1593$ to 6.1795%, 2.9353–28.7764, 0.183–0.4214, 0.1948–0.8106 and 1.6076–3.6921 MJ m$^{-2}$ day$^{-1}$, respectively. By contrast, model 94 had the best accuracy with smallest MBE ($-0.0994$ MJ m$^{-2}$ day$^{-1}$), MAE (1.1955 MJ m$^{-2}$ day$^{-1}$), MARE (0.1494 MJ m$^{-2}$ day$^{-1}$), RMSE (1.6107 MJ m$^{-2}$ day$^{-1}$), RRMSE (0.1835) and RMS (1.6076 MJ m$^{-2}$ day$^{-1}$).

Table A13 showed that the most accurate models for Shanghai station were model 21, 50, 60 and 63, the values of MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS varies from $-0.4507$ to $-0.0052$ MJ m$^{-2}$ day$^{-1}$, 0.742–1.1579 MJ m$^{-2}$ day$^{-1}$, 0.0933–0.1575 MJ m$^{-2}$ day$^{-1}$, 1.1087–1.5906 MJ m$^{-2}$ day$^{-1}$, $-3.5308$ to 3.9818%, 0.1659–21.4281, 0.1508–0.2164, $0.887-0.9556$ and $1.0419-1.5905$ MJ m$^{-2}$ day$^{-1}$, respectively. Among these models, model 94 had the best accuracy with largest R (0.9556) and minimum MAE (0.742MJ m$^{-2}$ day$^{-1}$), RMSE (1.1087 MJ m$^{-2}$ day$^{-1}$), RRMSE (0.1508) and RMS (1.0419 MJ m$^{-2}$ day$^{-1}$).

Table A14 showed that best model performances for Shenyang station were Model 21, 22, 48 and 92 with MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values of $-0.6680$ to 0.0111 MJ m$^{-2}$ day$^{-1}$, 1.2247–1.7758 MJ m$^{-2}$ day$^{-1}$, 0.1789–0.3189 MJ m$^{-2}$ day$^{-1}$, 1.9031–2.4189 MJ m$^{-2}$ day$^{-1}$, $-5.1703$ to 13.1138%, 0.2295–18.5165, 0.2847–0.3618, 0.7665–0.8792 and 1.8096–2.4189 MJ m$^{-2}$ day$^{-1}$, respectively. The smallest MAE (1.2247 MJ m$^{-2}$ day$^{-1}$), MARE (0.1789 MJ m$^{-2}$ day$^{-1}$) and RMS (1.8096 MJ m$^{-2}$ day$^{-1}$) were provided by model 48 while the largest R (0.8792) and smallest RMSE (1.9031 MJ m$^{-2}$ day$^{-1}$) and RRMSE (0.2847) were produced by model 92.

Table A15 showed that model 7, 22, 55, 56 and 60 produced the best accuracy at Wuhan station, the MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS values ranged $-0.688\sim0.004$ MJ m$^{-2}$ day$^{-1}$, $0.8650-1.0689$ MJ m$^{-2}$ day$^{-1}$, $0.1279-0.1618$ MJ m$^{-2}$ day$^{-1}$, $1.4335-1.6033$ MJ m$^{-2}$ day$^{-1}$, $0.4160-5.5918$%, 0.1248-23.4009, $0.1855-0.2075$, $0.9156-0.9473$ and 1.3531- 1.5908 MJ m$^{-2}$ day$^{-1}$, respectively. Model 55 had smallest MAE (0.865 MJ m$^{-2}$ day$^{-1}$), RMSE (1.4335 MJ m$^{-2}$ day$^{-1}$), RRMSE (0.1855) and RMS (1.3531 MJ m$^{-2}$ day$^{-1}$) while model 60 gave the largest R (0.9473).

Table A16 showed that the more accurate models were model 5, 37 and 64 at Wulumuqi station, the values of MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS varied from $-0.4031\sim-0.0006$ MJ m$^{-2}$ day$^{-1}$, $1.4146-1.8534$ MJ m$^{-2}$ day$^{-1}$, $0.2814-0.4745$ MJ m$^{-2}$ day$^{-1}$, $1.8439-2.2925$ MJ m$^{-2}$ day$^{-1}$, 0.7923-20.6780%, 0.0129-10.6787, $0.3396-0.4223$, $0.5719-0.7471$ and $1.8026-2.2925$ MJ m$^{-2}$ day$^{-1}$, respectively. Model 64 provided

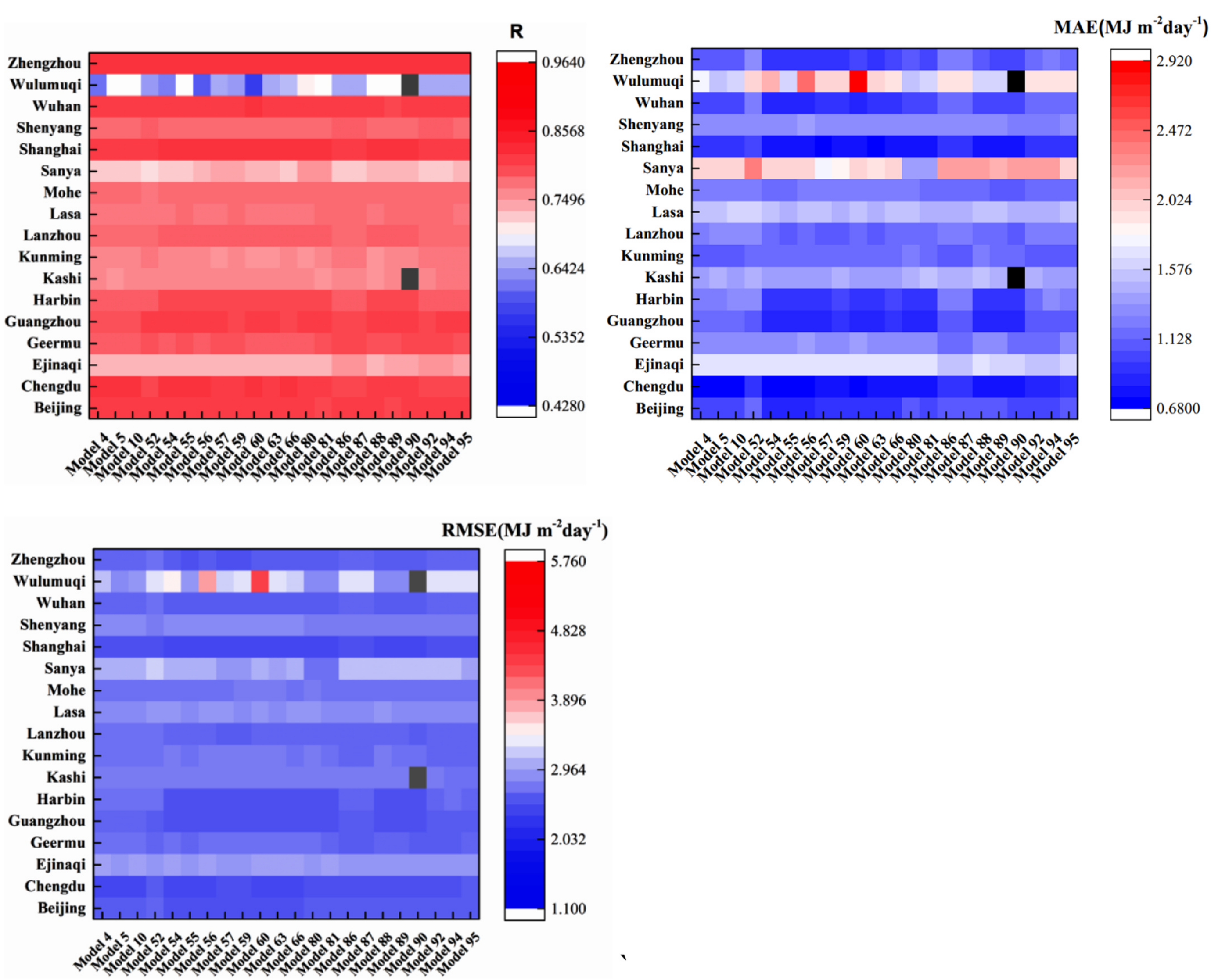


**Fig. 19.** Statistical indicators for models with better performances for all stations. Black color marks no data.

smallest MAE (1.4146 MJ $m^{-2}$ $day^{-1}$), MARE (0.2814 MJ $m^{-2}$ $day^{-1}$), RMSE (1.8439 MJ $m^{-2}$ $day^{-1}$), RRMSE (0.3396), RMS (1.8026 MJ $m^{-2}$ $day^{-1}$) and largest R (0.7471).

Table A17 showed that model 13, 18, 46 and 48 gave preferable results at Zhengzhou station, the values of MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS varied from −0.7243∼ −0.0043 MJ $m^{-2}$ $day^{-1}$, 0.9199 – 2.1306 MJ $m^{-2}$ $day^{-1}$, 0.0971 – 0.2976 MJ $m^{-2}$ $day^{-1}$, 1.3731 – 2.8697 MJ $m^{-2}$ $day^{-1}$, −6.4774 – 0.1078%, 0.0751-31.0002, 0.1638 – 0.3424, 0.8666 – 0.9637 and 1.1666 – 2.8697 MJ $m^{-2}$ $day^{-1}$, respectively. Comparisons between above these models indicated that model 48 gave better accuracy than other models with smallest MARE (0.0971 MJ $m^{-2}$ $day^{-1}$), RMSE (1.3731 MJ $m^{-2}$ $day^{-1}$), RRMSE (0.1638), RMS (1.1666 MJ $m^{-2}$ $day^{-1}$) and largest R (0.9637).

In order to determine which models can be commonly used in all sites with high accuracy, 22 models with better performances (according to the statistic indicators of R, MAE and RMSE) at all stations were selected for model comparisons. As shown in Fig. 19, the performances for selected models were relatively poor in Wulumuqi, Sanya and Ejinaqi, for example, the R values for all the 22 models were all less than 0.7496 at Wulumuqi station, and the model 60 showed the highest MAE (2.9177 MJ $m^{-2}$ $day^{-1}$) and RMSE (5.7412 MJ $m^{-2}$ $day^{-1}$) at Wulumuqi site. On the contrary, these models generally performed better in Zhengzhou, Wuhan, Shanghai, Harbin, Guangzhou, Chengdu and Beijing stations. It was worth noting that the model 55, 59, 66, 81 and 89 were generally superior to other models, for example, the R, MAE and RMSE of model 55 at Guangzhou were 0.93, 0.8845 $MJm^{-2}$ $day^{-1}$ and 1.3345 $MJm^{-2}$ $day^{-1}$, respectively. Therefore, it was recommended to use model 55, 59, 66, 81 and 89 to estimate diffuse radiation at national scale.

**Table 3**
MAE, MARE, RMSE and R for five categories of models at 17 stations in China.

| Categories | Beijing | | | | Chengdu | | | |
|---|---|---|---|---|---|---|---|---|
| | MAE | MARE | RMSE | R | MAE | MARE | RMSE | R |
| Category I | 1.6203 | 0.2905 | 2.1678 | 0.8201 | 1.2474 | 0.2077 | 1.8354 | 0.8704 |
| Category II | 1.4957 | 0.2665 | 2.0395 | 0.8560 | 1.2156 | 0.2066 | 1.7458 | 0.8764 |
| Category III | 1.2608 | 0.2101 | 1.7844 | 0.8983 | 1.1758 | 0.1860 | 1.6840 | 0.8778 |
| Category IV | 1.0678 | 0.1682 | 1.5060 | 0.9342 | 0.8677 | 0.1207 | 1.3900 | 0.9300 |
| Category V | 1.2997 | 0.2188 | 1.8012 | 0.8868 | 0.9986 | 0.1382 | 1.6314 | 0.9145 |
| | **Ejinaqi** | | | | **Geermu** | | | |
| Category I | 2.0646 | 0.8243 | 2.7772 | 0.6573 | 1.8143 | 0.3553 | 2.3458 | 0.7906 |
| Category II | 1.9998 | 0.7251 | 2.6791 | 0.7128 | 1.6487 | 0.3145 | 2.1506 | 0.8430 |
| Category III | 1.8216 | 0.6026 | 2.5090 | 0.7483 | 1.4678 | 0.2894 | 1.9349 | 0.8710 |
| Category IV | 1.5916 | 0.3110 | 2.2327 | 0.7957 | 1.1987 | 0.2423 | 1.5451 | 0.9170 |
| Category V | 1.7852 | 0.3514 | 2.4452 | 0.7409 | 1.4893 | 0.3009 | 1.9110 | 0.8432 |
| | **Guangzhou** | | | | **Harbin** | | | |
| Category I | 1.4697 | 0.2062 | 1.9176 | 0.8103 | 1.4771 | 0.2765 | 2.0119 | 0.8341 |
| Category II | 1.3590 | 0.1899 | 1.7938 | 0.8355 | 1.3211 | 0.2502 | 1.8041 | 0.8700 |
| Category III | 1.2478 | 0.1599 | 1.6764 | 0.8314 | 1.1630 | 0.2205 | 1.6242 | 0.8921 |
| Category IV | 0.9606 | 0.1126 | 1.3519 | 0.9276 | 1.1331 | 0.2097 | 1.5924 | 0.8963 |
| Category V | 1.1588 | 0.1410 | 1.6227 | 0.9019 | 1.2991 | 0.2477 | 1.8028 | 0.8623 |
| | **Kashi** | | | | **Kunming** | | | |
| Category I | 1.9724 | 0.3098 | 2.5544 | 0.6748 | 1.7479 | 0.3152 | 2.3536 | 0.7122 |
| Category II | 1.8251 | 0.2764 | 2.3686 | 0.7485 | 1.5913 | 0.2779 | 2.2225 | 0.7586 |
| Category III | 1.6126 | 0.2447 | 2.1274 | 0.7894 | 1.3790 | 0.2333 | 2.0376 | 0.8009 |
| Category IV | 1.4558 | 0.2173 | 1.9245 | 0.8261 | 1.1697 | 0.2031 | 1.8068 | 0.8330 |
| Category V | 1.7150 | 0.2698 | 2.2595 | 0.7505 | 1.3943 | 0.2496 | 2.0498 | 0.8015 |
| | **Lanzhou** | | | | **Lasa** | | | |
| Category I | 1.7604 | 0.2876 | 2.3024 | 0.7145 | 1.9710 | 0.3986 | 2.6498 | 0.7991 |
| Category II | 1.6121 | 0.2538 | 2.1232 | 0.7689 | 1.7717 | 0.3335 | 2.4594 | 0.8328 |
| Category III | 1.3475 | 0.2062 | 1.8152 | 0.8384 | 1.5806 | 0.3022 | 2.2509 | 0.8444 |
| Category IV | 1.2074 | 0.1719 | 1.6520 | 0.8736 | 1.5114 | 0.3128 | 2.1260 | 0.8598 |
| Category V | 1.4931 | 0.2329 | 1.9913 | 0.8063 | 1.6891 | 0.3637 | 2.3017 | 0.8106 |
| | **Mohe** | | | | **Sanya** | | | |
| Category I | 1.5124 | 0.3088 | 2.1608 | 0.8036 | 2.1699 | 0.2610 | 2.7086 | 0.5685 |
| Category II | 1.4502 | 0.2918 | 2.1021 | 0.8221 | 2.2154 | 0.2655 | 2.7516 | 0.6286 |
| Category III | 1.2489 | 0.2417 | 1.9160 | 0.8486 | 1.8801 | 0.2130 | 2.3777 | 0.7102 |
| Category IV | 1.1872 | 0.2342 | 1.8311 | 0.8623 | 1.9546 | 0.2168 | 2.4452 | 0.7745 |
| Category V | 1.3095 | 0.2589 | 1.9894 | 0.8332 | 2.2209 | 0.2512 | 2.7538 | 0.6917 |
| | **Shanghai** | | | | | **Shenyang** | | |
| Category I | 1.4073 | 0.2287 | 1.8819 | 0.8435 | 1.7318 | 0.3022 | 2.4237 | 0.7840 |
| Category II | 1.3092 | 0.2219 | 1.7375 | 0.8674 | 1.6802 | 0.2890 | 2.3885 | 0.8058 |
| Category III | 1.1029 | 0.1697 | 1.5309 | 0.8911 | 1.5072 | 0.2488 | 2.1905 | 0.8298 |
| Category IV | 0.9048 | 0.1191 | 1.2788 | 0.9433 | 1.2942 | 0.1989 | 1.9466 | 0.8752 |
| Category V | 1.1029 | 0.1532 | 1.5598 | 0.9118 | 1.4781 | 0.2420 | 2.1661 | 0.8427 |
| | **Wuhan** | | | | **Wulumuqi** | | | |
| Category I | 1.5589 | 0.3070 | 2.1496 | 0.8504 | 1.9594 | 0.4480 | 2.7245 | 0.5715 |
| Category II | 1.5021 | 0.3032 | 2.0524 | 0.8626 | 2.0243 | 0.4697 | 2.9891 | 0.5779 |
| Category III | 1.3573 | 0.2965 | 1.9191 | 0.8675 | 1.6311 | 0.3612 | 2.2867 | 0.6700 |
| Category IV | 1.0987 | 0.1709 | 1.6102 | 0.9295 | 1.8254 | 0.4105 | 2.7476 | 0.6301 |
| Category V | 1.2539 | 0.1937 | 1.8414 | 0.9059 | 1.9908 | 0.4545 | 2.8714 | 0.5876 |
| | **Zhengzhou** | | | | | | | |
| Category I | 1.5721 | 0.2208 | 2.0864 | 0.8758 | | | | |
| Category II | 1.5179 | 0.2152 | 2.0164 | 0.8956 | | | | |
| Category III | 1.2892 | 0.1707 | 1.7766 | 0.9120 | | | | |
| Category IV | 1.1686 | 0.1341 | 1.6086 | 0.9522 | | | | |
| Category V | 1.2842 | 0.1586 | 1.7618 | 0.9223 | | | | |

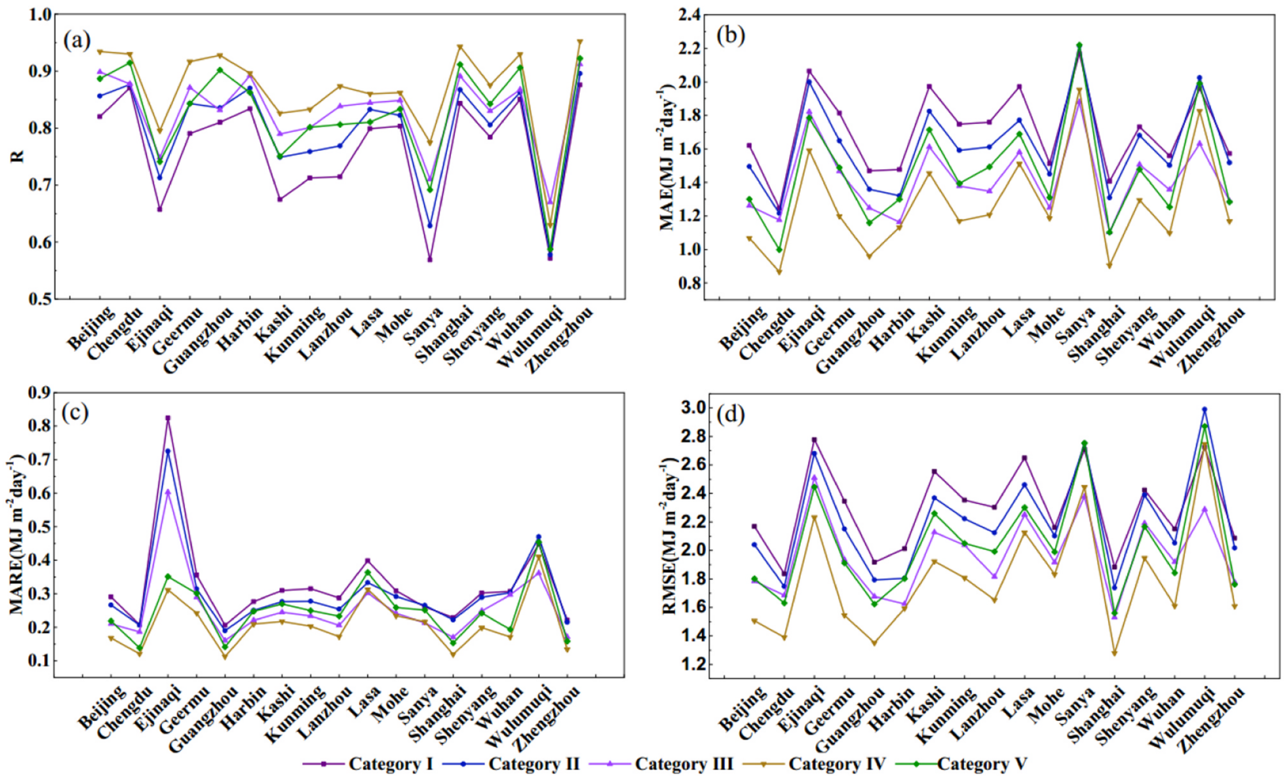


**Fig. 20.** Performance comparisons for five categories of models at 17 stations in China.

### 3.3. Performance analysis for the five categories of models

The statistical indicators for the five categories of diffuse solar radiation models were summarized in Table 3, it was also observed in Fig. 20 that the R values for the fourth category of models were greater than other categories, except the case at Wulumuqi station with R of 0.5715. On the contrary, the first category of models had lower R values at all sites than other categories, the MAE, MARE and RMSE for the first category of models at Sanya and Wulumuqi sites were higher than those from the third category. At Chengdu, Kunming, Shanghai, Shenyang, Wuhan and Zhengzhou stations, the R ranking for the five categories was Category IV, Category V, Category III, Category II and Category I. In general, the fourth category of models with four input parameters had higher model accuracy.

### 3.4. Performance analysis of the $K_d$-based and $K_D$-based models

In literature, there were very few comparative studies on $K_d$-based and $K_D$-based diffuse radiation models. In order to choose the better models for studying diffuse radiation in China, the $K_d$-based and $K_D$-based models were analyzed and the detailed statistics regarding the model performances were shown in Table 4 and Table 5. Fig. 21 also demonstrated that $K_d$-based models (model 1-25, 45-64, 80-82 and 85-97) generally had higher accuracies, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS for $K_d$-based models at all 17 stations were $-0.43\,\mathrm{MJ\,m^{-2}\,day^{-1}}$, $1.5453\,\mathrm{MJ\,m^{-2}\,day^{-1}}$, $0.2583\,\mathrm{MJ\,m^{-2}\,day^{-1}}$, $2.1422\,\mathrm{MJ\,m^{-2}\,day^{-1}}$, 1.7611%, 15.2127, 0.3134, 0.8111 and $1.9969\,\mathrm{MJ\,m^{-2}\,day^{-1}}$, respectively. In contrast, the $K_D$-based models (models 26-44, 65-79, 83 and 84) generally showed

**Table 4**
The mean MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS for $K_d$-based models (models 1-25, 45-64, 80-82 and 85-97).

| Stations | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|
| Beijing | −0.3171 | 1.3731 | 0.2273 | 1.8951 | 3.4177 | 12.9737 | 0.2784 | 0.8734 | 1.8024 |
| Chengdu | 0.2758 | 1.0034 | 0.1346 | 1.6040 | 5.5212 | 11.0892 | 0.2216 | 0.9108 | 1.5363 |
| Ejinaqi | −0.6478 | 1.9687 | 0.3945 | 2.6463 | 4.0765 | 13.9210 | 0.4298 | 0.7131 | 2.4881 |
| Germu | −0.1737 | 1.6607 | 0.3294 | 2.1300 | 12.2572 | 5.2510 | 0.3212 | 0.8327 | 2.0555 |
| Guangzhou | −0.6333 | 1.2056 | 0.1456 | 1.6618 | −4.8358 | 25.5915 | 0.2054 | 0.8801 | 1.4564 |
| Harbin | −0.2871 | 1.3436 | 0.2511 | 1.8480 | 3.0362 | 11.3747 | 0.3035 | 0.8630 | 1.7968 |
| Kashi | −0.3181 | 1.8428 | 0.2841 | 2.4143 | 4.3383 | 10.0874 | 0.3348 | 0.7314 | 2.3185 |
| Kunming | −0.0964 | 1.5147 | 0.2618 | 2.1753 | 7.9723 | 7.2607 | 0.3002 | 0.7640 | 2.1024 |
| Lanzhou | −0.2751 | 1.5770 | 0.2438 | 2.1111 | 2.5585 | 16.5243 | 0.2979 | 0.7834 | 1.9832 |
| Lasa | −0.5945 | 1.8460 | 0.3756 | 2.5024 | 10.7238 | 13.3279 | 0.3881 | 0.8155 | 2.3469 |
| Mohe | −0.1844 | 1.4210 | 0.2837 | 2.0876 | 1.3693 | 6.6824 | 0.3646 | 0.8245 | 2.0449 |
| Sanya | −1.5165 | 2.1085 | 0.2416 | 2.6500 | -14.2308 | 39.4073 | 0.3012 | 0.6834 | 2.0416 |
| Shanghai | −0.3839 | 1.1445 | 0.1534 | 1.6083 | −1.8463 | 16.8975 | 0.2161 | 0.9002 | 1.4876 |
| Shenyang | −0.5343 | 1.5776 | 0.2515 | 2.2877 | 0.3688 | 16.1424 | 0.3410 | 0.8258 | 2.1552 |
| Wuhan | −0.3926 | 1.2723 | 0.1896 | 1.8692 | 2.6087 | 14.2790 | 0.2391 | 0.8980 | 1.7612 |
| Wulumuqi | −0.5304 | 2.0704 | 0.4636 | 3.0868 | −3.7627 | 14.5822 | 0.5679 | 0.5715 | 2.9317 |
| Zhengzhou | −0.7005 | 1.3406 | 0.1598 | 1.8401 | −3.6348 | 23.2238 | 0.2174 | 0.9174 | 1.6384 |
| Mean | −0.4300 | 1.5453 | 0.2583 | 2.1422 | 1.7611 | 15.2127 | 0.3134 | 0.8111 | 1.9969 |

**Table 5**
The mean MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS for $K_D$-based models (models 26-44, 65-79, 83 and 84).

| Stations | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|
| Beijing | −0.3067 | 1.7266 | 0.3316 | 2.2866 | 11.6574 | 11.2443 | 0.3355 | 0.8049 | 2.2144 |
| Chengdu | 1.3583 | 1.9954 | 0.2716 | 3.5536 | 14.7728 | 20.8265 | 0.5005 | 0.8183 | 3.2838 |
| Ejinaqi | −0.6497 | 2.0184 | 1.2525 | 2.7344 | 83.7219 | 13.3249 | 0.4441 | 0.6634 | 2.6505 |
| Geermu | −0.2375 | 1.7286 | 0.3265 | 2.2832 | 11.9569 | 6.0833 | 0.3444 | 0.8063 | 2.2337 |
| Guangzhou | −0.5695 | 1.6445 | 0.2598 | 2.0606 | 3.5199 | 17.6599 | 0.2538 | 0.7553 | 1.9314 |
| Harbin | −0.3203 | 1.4311 | 0.2728 | 1.9420 | 6.1460 | 9.2431 | 0.3184 | 0.8410 | 1.9414 |
| Kashi | −0.3839 | 1.8915 | 0.2938 | 2.4261 | 5.1589 | 8.8802 | 0.3362 | 0.6990 | 2.3786 |
| Kunming | −0.2262 | 1.7869 | 0.3291 | 2.3478 | 11.8863 | 6.1939 | 0.3234 | 0.7177 | 2.3112 |
| Lanzhou | −0.1882 | 1.7414 | 0.2911 | 2.2346 | 8.2868 | 6.9661 | 0.3149 | 0.7084 | 2.2006 |
| Lasa | −0.7974 | 1.8289 | 0.3459 | 2.5310 | 6.5144 | 16.6660 | 0.3925 | 0.8184 | 2.3681 |
| Mohe | −0.2442 | 1.4835 | 0.3047 | 2.1143 | 1.9562 | 6.2792 | 0.3687 | 0.8064 | 2.0925 |
| Sanya | −1.5207 | 2.2669 | 0.2842 | 2.7859 | −8.8126 | 33.5961 | 0.3162 | 0.5057 | 2.3083 |
| Shanghai | −0.3076 | 1.5898 | 0.3114 | 2.0179 | 11.1260 | 11.1863 | 0.2702 | 0.8043 | 1.9598 |
| Shenyang | −0.4352 | 1.8075 | 0.3428 | 2.4798 | 9.8306 | 9.9293 | 0.3688 | 0.7642 | 2.4227 |
| Wuhan | −0.4314 | 1.8388 | 0.4579 | 2.3684 | 23.4884 | 11.8516 | 0.3014 | 0.8057 | 2.2968 |
| Wulumuqi | −0.2488 | 1.7907 | 0.4298 | 2.3618 | 10.7702 | 6.2129 | 0.4338 | 0.5999 | 2.3261 |
| Zhengzhou | −0.7049 | 1.7605 | 0.2874 | 2.2648 | 5.6372 | 18.1892 | 0.2670 | 0.8488 | 2.1230 |
| Mean | −0.4281 | 1.7560 | 0.3777 | 2.3093 | 12.9276 | 11.8998 | 0.3333 | 0.7515 | 2.2173 |

poor performances, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS at all 17 stations were −0.4281 MJ m$^{-2}$ day$^{-1}$, 1.7560 MJ m$^{-2}$ day$^{-1}$, 0.3777 MJ m$^{-2}$ day$^{-1}$, 2.3093 MJ m$^{-2}$ day$^{-1}$, 12.9276%, 11.8998, 0.3333, 0.7515 and 2.2173 MJ m$^{-2}$ day$^{-1}$, respectively. It can be summarized from above analysis that the $K_d$-based models were more suitable for estimating the diffuse radiation in China.

Table 6 illustrated the mean MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS for all models at 17 sites in China, the estimated diffuse radiation from above models were generally close to the observations. However, all models had large errors at Ejinaqi, Wulumuqi, Kashi and Sanya stations. For Ejinaqi station, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS were −0.6485 MJ m$^{-2}$ day$^{-1}$, 1.9874 MJ m$^{-2}$ day$^{-1}$, 0.7162 MJ m$^{-2}$ day$^{-1}$, 2.6793 MJ m$^{-2}$ day$^{-1}$, 33.9435%, 13.6975, 0.4352, 0.6944 and 2.549 MJ m$^{-2}$ day$^{-1}$, respectively; for Wulumuqi station, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS were −0.4237 MJ m$^{-2}$ day$^{-1}$, 1.9644 MJ m$^{-2}$ day$^{-1}$, 0.4508 MJ m$^{-2}$ day$^{-1}$, 2.812 MJ m$^{-2}$ day$^{-1}$, 1.7445%, 11.4107, 0.5171, 0.5822 and 2.7022 MJ m$^{-2}$ day$^{-1}$, respectively; for Kashi station, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS were −0.3431 MJ m$^{-2}$ day$^{-1}$, 1.8612 MJ m$^{-2}$ day$^{-1}$, 0.2878 MJ m$^{-2}$ day$^{-1}$, 2.4188 MJ m$^{-2}$ day$^{-1}$, 4.6493%, 9.6299, 0.3353, 0.7191 and 2.3412 MJ m$^{-2}$ day$^{-1}$, respectively; for Sanya station, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS were −1.5180 MJ m$^{-2}$ day$^{-1}$, 2.1673 MJ m$^{-2}$ day$^{-1}$, 0.2574 MJ m$^{-2}$ day$^{-1}$, 2.7004 MJ m$^{-2}$ day$^{-1}$, -12.2199%, 37.2506, 0.3067, 0.6174 and 2.1406 MJ m$^{-2}$ day$^{-1}$, respectively. These differences in model performances were closely related to the climatic conditions in various stations, which had been discussed in detail in previous studies regarding the global solar radiation in China [62,67].

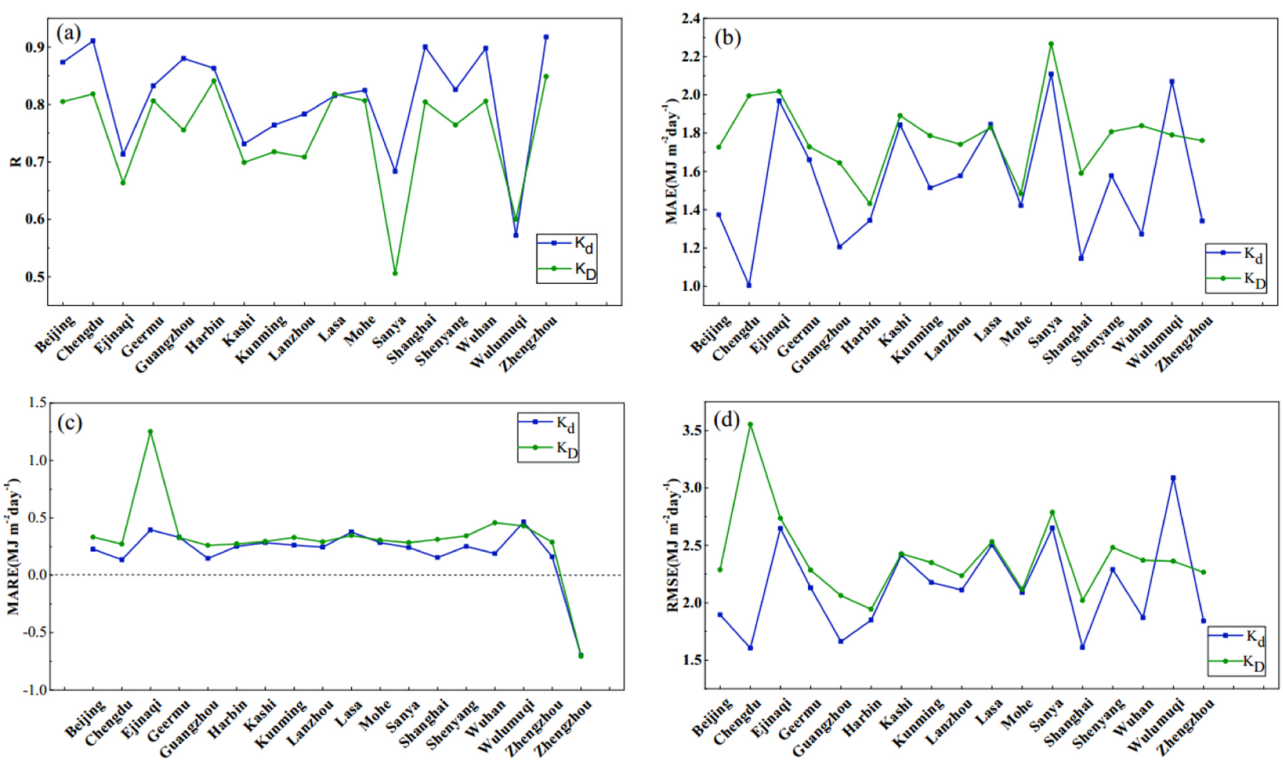


**Fig. 21.** Statistical error comparisons of $K_d$-based and $K_D$-based models at 17 stations in China.

**Table 6**
The mean MBE, MAE, MARE, RMSE, MPE, t-stats, RRMSE, R and RMS of all models at 17 stations in China.

| Stations | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|
| Beijing | −0.3132 | 1.5043 | 0.2660 | 2.0404 | 6.4757 | 12.3318 | 0.2996 | 0.8480 | 1.9553 |
| Chengdu | 0.2829 | 1.1935 | 0.1961 | 1.7580 | 9.7532 | 10.2363 | 0.2418 | 0.8795 | 1.6840 |
| Ejinaqi | −0.6485 | 1.9874 | 0.7162 | 2.6793 | 33.9435 | 13.6975 | 0.4352 | 0.6944 | 2.5490 |
| Geermu | −0.1976 | 1.6862 | 0.3283 | 2.1875 | 12.1446 | 5.5631 | 0.3299 | 0.8228 | 2.1223 |
| Guangzhou | −0.6097 | 1.3685 | 0.1880 | 1.8098 | −1.7347 | 22.6478 | 0.2234 | 0.8338 | 1.6326 |
| Harbin | −0.2995 | 1.3764 | 0.2592 | 1.8833 | 4.2024 | 10.5754 | 0.3091 | 0.8548 | 1.8510 |
| Kashi | −0.3431 | 1.8612 | 0.2878 | 2.4188 | 4.6493 | 9.6299 | 0.3353 | 0.7191 | 2.3412 |
| Kunming | −0.1446 | 1.6157 | 0.2868 | 2.2393 | 9.4249 | 6.8648 | 0.3089 | 0.7468 | 2.1799 |
| Lanzhou | −0.2429 | 1.6380 | 0.2614 | 2.1569 | 4.6845 | 12.9769 | 0.3042 | 0.7556 | 2.0639 |
| Lasa | −0.6722 | 1.8395 | 0.3642 | 2.5134 | 9.1117 | 14.6063 | 0.3898 | 0.8166 | 2.3550 |
| Mohe | −0.2066 | 1.4442 | 0.2915 | 2.0975 | 1.5871 | 6.5327 | 0.3661 | 0.8178 | 2.0626 |
| Sanya | −1.5180 | 2.1673 | 0.2574 | 2.7004 | -12.2199 | 37.2506 | 0.3067 | 0.6174 | 2.1406 |
| Shanghai | −0.3553 | 1.3114 | 0.2127 | 1.7619 | 3.0183 | 14.7558 | 0.2364 | 0.8642 | 1.6647 |
| Shenyang | −0.4971 | 1.6638 | 0.2858 | 2.3597 | 3.9170 | 13.8125 | 0.3514 | 0.8027 | 2.2555 |
| Wuhan | −0.4072 | 1.4847 | 0.2902 | 2.0564 | 10.4386 | 13.3687 | 0.2625 | 0.8634 | 1.9620 |
| Wulumuqi | −0.4237 | 1.9644 | 0.4508 | 2.8120 | 1.7445 | 11.4107 | 0.5171 | 0.5822 | 2.7022 |
| Zhengzhou | −0.7021 | 1.4980 | 0.2076 | 1.9994 | −0.1578 | 21.3358 | 0.2360 | 0.8917 | 1.8201 |

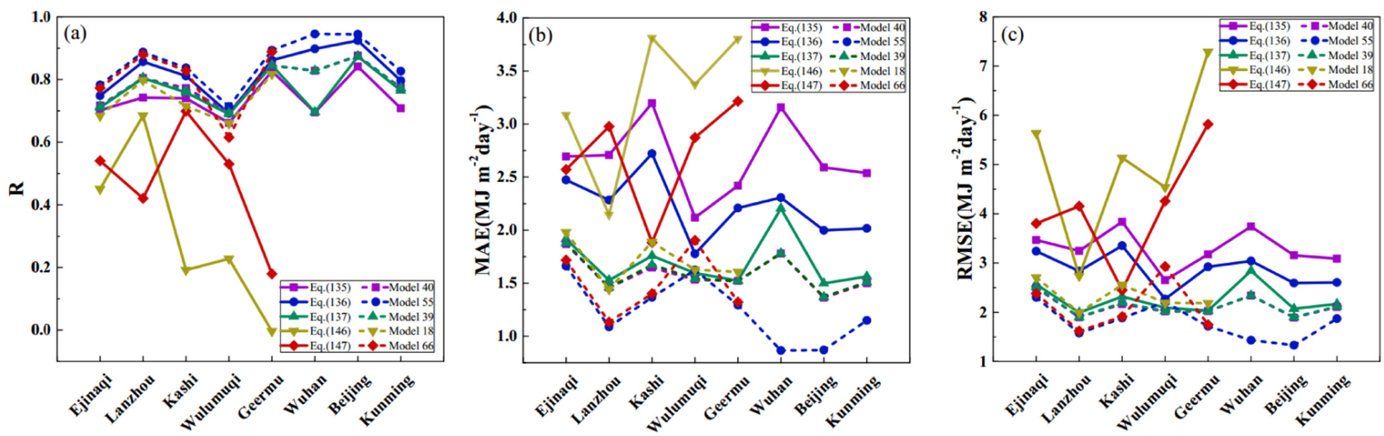

**Fig. 22.** Performance comparison between the models proposed in the literature and the model developed in this study.

### 3.5. Comparisons with previous studies

The model performance comparisons for the five diffuse radiation models chosen from literature and the proposed models were evaluated in terms of R, MAE and RMSE. For consistency, the forms of the newly-proposed models (model 40, 55, 39, 18 and 66) should be consistent with that presented in literature (Eqs. (135), (136), (137), (146) and (147)), the statistics of R, MAE and RMSE were shown in Table 7. For Fig. 22, the same color represented the same form of models; the solid and dashed lines represented the models in literature and the newly-established models, respectively. It was found from Table 7 and Fig. 22 that the models from Cao et al. [58] (Eqs. (146) and (147)) had larger statistical errors. The largest MAE and RMSE values were found at Geermu station. The R values of model 44 and model 55 were larger than the two models (Eqs. (135) and (136)) proposed by Jiang [66] at eight stations; the accuracies from the model proposed by Chen et al. [55] was not good at Wuhan station. In general, the accuracies of model 40, 55, 39, 18 and 66 were superior to the models proposed in literature. So it can be concluded that the new proposed models had better performances than the five diffuse radiation models in literature, and model 55 produced the highest model accuracy in this study.

## 4. Conclusions

The applicability of 97 models in predicting daily horizontal diffuse radiation in China was investigated in this study. Five categories of models were characterized based on the number of input variables and the periodicity of solar radiation. Each category was also subdivided into different groups based on the different input parameters ($K_t$, $\alpha$, $AM$, $R_h$, $T_{max}$, $T_{mean}$, $T_{min}$, $\Delta T$, $\delta$, $\theta$, $\varphi$, $\omega_s$, $n_{day}$, $n/N$). The major results can be concluded as:

(1) All models generally showed relatively poor performances at Ejinaqi Wulumuqi and Kashi stations, owing to the dusty air conditions, for example, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS for Ejinaqi were $-0.6485\,MJ\,m^{-2}\,day^{-1}$, $1.9874\,MJ\,m^{-2}\,day^{-1}$, $0.7162\,MJ\,m^{-2}\,day^{-1}$, $2.6793\,MJ\,m^{-2}\,day^{-1}$, 33.9435%, 13.6975, 0.4352, 0.6944 and $2.549\,MJ\,m^{-2}\,day^{-1}$, respectively. Relatively poor model performances were also observed at Sanya station due to the rainy weather characteristics, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS were $-1.518\,MJ\,m^{-2}\,day^{-1}$, $2.1673\,MJ\,m^{-2}\,day^{-1}$, $0.2574\,MJ\,m^{-2}\,day^{-1}$, $2.7004\,MJ\,m^{-2}\,day^{-1}$, -12.2199%, 37.2506, 0.3067, 0.6174 and $2.1406\,MJ\,m^{-2}\,day^{-1}$, respectively.
(2) The comparisons for the five categories of models showed that the fourth category of models with four input parameters generally had higher accuracies. Model 55, 59, 66, 81 and 89 performed well at all sites and were suitable for estimating diffuse solar radiation in any locations of China.
(3) Comparisons of $K_d$-based with $K_D$-based models showed that $k_d$-based models generally had better accuracy, except the Wulumuqi station, the mean MBE, MAE, MARE, RMSE, MPE, t-stat, RRMSE, R and centered RMS at all 17 stations were $-0.43\,MJ\,m^{-2}\,day^{-1}$, $1.5453\,MJ\,m^{-2}\,day^{-1}$, $0.2583\,MJ\,m^{-2}\,day^{-1}$, $2.1422\,MJ\,m^{-2}\,day^{-1}$, 1.7611%, 15.2127, 0.3134, 0.8111 and $1.9969\,MJ\,m^{-2}\,day^{-1}$, respectively.
(4) The accuracies for the five proposed models in this study and the models selected from the literature were evaluated. The results showed that the newly-established models had higher accuracies than these existing models. Among these models used for

**Table 7**
The MAE, RMSE and R for models in literature and the newly-proposed models at Ejinaqi, Lanzhou, Kashi, Wulumuqi, Geermu, Wuhan, Beijing and Kunming stations.

| · | **Ejinaqi** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **The models in literature** | | | **The newly-proposed models** | | | |
| | Models | MAE | RMSE | R | Models | MAE | RMSE | R |
| Jiang | Eq. (135) | 2.6944 | 3.4686 | 0.7021 | Model 40 | 1.8688 | 2.4982 | 0.7171 |
| | Eq. (136) | 2.4727 | 3.2414 | 0.7483 | Model 55 | 1.6615 | 2.3021 | 0.7826 |
| Chen | Eq. (137) | 1.9152 | 2.5690 | 0.7105 | Model 39 | 1.8781 | 2.5139 | 0.7146 |
| Cao | Eq. (146) | 3.0877 | 5.6398 | 0.4507 | Model 18 | 1.9800 | 2.7095 | 0.6838 |
| | Eq. (147) | 2.5719 | 3.8022 | 0.5406 | Model 66 | 1.7172 | 2.3820 | 0.7729 |
| | **Lanzhou** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 2.7093 | 3.2465 | 0.7424 | Model 40 | 1.4599 | 1.9003 | 0.8046 |
| | Eq. (136) | 2.2841 | 2.8341 | 0.8568 | Model 55 | 1.0879 | 1.5740 | 0.8876 |
| Chen | Eq. (137) | 1.5270 | 1.9938 | 0.8046 | Model 39 | 1.4592 | 1.8994 | 0.8049 |
| Cao | Eq. (146) | 2.1457 | 2.7370 | 0.6845 | Model 18 | 1.4426 | 1.9909 | 0.7975 |
| | Eq. (147) | 2.9777 | 4.1542 | 0.4209 | Model 66 | 1.1322 | 1.6197 | 0.8798 |
| | **Kashi** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 3.1987 | 3.8360 | 0.7405 | Model 40 | 1.6471 | 2.1675 | 0.7721 |
| | Eq. (136) | 2.7212 | 3.3528 | 0.8111 | Model 55 | 1.3664 | 1.8832 | 0.8371 |
| Chen | Eq. (137) | 1.7582 | 2.3197 | 0.7585 | Model 39 | 1.6736 | 2.1923 | 0.7655 |
| Cao | Eq. (146) | 3.8131 | 5.1391 | 0.1920 | Model 18 | 1.8877 | 2.5562 | 0.7152 |
| | Eq. (147) | 1.8824 | 2.4503 | 0.6987 | Model 66 | 1.4012 | 1.9112 | 0.8286 |
| | **Wulumuqi** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 2.1178 | 2.6488 | 0.6613 | Model 40 | 1.5324 | 2.0165 | 0.6974 |
| | Eq. (136) | 1.7770 | 2.2695 | 0.6915 | Model 55 | 1.6243 | 2.2079 | 0.7133 |
| Chen | Eq. (137) | 1.5953 | 2.0911 | 0.6896 | Model 39 | 1.5415 | 2.0220 | 0.6925 |
| Cao | Eq. (146) | 3.3749 | 4.5403 | 0.2281 | Model 18 | 1.6272 | 2.1925 | 0.6597 |
| | Eq. (147) | 2.8729 | 4.2586 | 0.5303 | Model 66 | 1.9034 | 2.9289 | 0.6154 |
| | **Geermu** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 2.4191 | 3.1786 | 0.8262 | Model 40 | 1.5218 | 2.0233 | 0.8451 |
| | Eq. (136) | 2.2090 | 2.9233 | 0.8615 | Model 55 | 1.2930 | 1.7142 | 0.8933 |
| Chen | Eq. (137) | 1.5236 | 2.0317 | 0.8448 | Model 39 | 1.5201 | 2.0241 | 0.8450 |
| Cao | Eq. (146) | 3.8056 | 7.2902 | −0.0033 | Model 18 | 1.6072 | 2.1858 | 0.8173 |
| | Eq. (147) | 3.2154 | 5.8186 | 0.1796 | Model 66 | 1.3217 | 1.7477 | 0.8886 |
| | **Wuhan** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 3.1581 | 3.7418 | 0.6951 | Model 40 | 1.7796 | 2.3384 | 0.8279 |
| | Eq. (136) | 2.3076 | 3.0410 | 0.8978 | Model 55 | 0.8650 | 1.4335 | 0.9452 |
| Chen | Eq. (137) | 2.2046 | 2.8430 | 0.6960 | Model 39 | 1.7809 | 2.3405 | 0.8279 |
| Cao | Eq. (146) | | | | Model 18 | | | |
| | Eq. (147) | | | | Model 66 | | | |
| | **Beijing** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 2.5923 | 3.1562 | 0.8414 | Model 40 | 1.3641 | 1.8918 | 0.8757 |
| | Eq. (136) | 1.9973 | 2.5943 | 0.9240 | Model 55 | 0.8700 | 1.3286 | 0.9444 |
| Chen | Eq. (137) | 1.4985 | 2.0704 | 0.8732 | Model 39 | 1.3692 | 1.8995 | 0.8744 |
| Cao | Eq. (146) | | | | Model 18 | | | |
| | Eq. (147) | | | | Model 66 | | | |
| | **Kunming** | | | | | | | |
| | | **MAE** | **RMSE** | **R** | | **MAE** | **RMSE** | **R** |
| Jiang | Eq. (135) | 2.5377 | 3.0875 | 0.7083 | Model 40 | 1.4986 | 2.1062 | 0.7735 |
| | Eq. (136) | 2.0174 | 2.6044 | 0.7961 | Model 55 | 1.1483 | 1.8721 | 0.8265 |
| Chen | Eq. (137) | 1.5629 | 2.1707 | 0.7649 | Model 39 | 1.5094 | 2.1157 | 0.7724 |
| Cao | Eq. (146) | | | | Model 18 | | | |
| | Eq. (147) | | | | Model 66 | | | |

comparative studies, model 55 was superior to other models.

This study comprehensively evaluated diffuse solar radiation models in different areas of China, which supported to find the most accurate models for estimating diffuse radiation in large regions. Actually, these models should be further validated in different climate zones around the world. Moreover, further studies are needed on the relationship between $H_d$ and more independent input parameters to acquire more accurate estimates under different climatic conditions.

## Appendix

See Tables A1–A17.


## Acknowledgements

This work was financially supported by the National Natural Science Foundation of China (No. 41601044 and No. 41801021) and the Special Fund for Basic Scientific Research of Central Colleges, China University of Geosciences, Wuhan (CUGL170401 and CUGCJ1704). We would like to thank the China Meteorological Administration (CMA) for providing the meteorological and radiation data.

**Table A1**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Beijing station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2712 | −1.4852 | — | — | — | — | — | — | −0.5709 | 1.1763 | 0.1800 | 1.6366 | 0.4544 | 18.6932 | 0.2412 | 0.9414 | 1.5338 |
| **Model 2** | 1.0505 | −0.1946 | −1.5301 | — | — | — | — | — | −0.6690 | 1.0879 | 0.1625 | 1.5619 | −5.4305 | 23.8022 | 0.2302 | 0.9330 | 1.4114 |
| **Model 3** | 0.8877 | 1.6692 | −6.8365 | 4.3271 | — | — | — | — | −0.6233 | 1.0287 | 0.1441 | 1.5324 | −3.6627 | 22.3595 | 0.2258 | 0.9400 | 1.3999 |
| **Model 4** | 1.0042 | −0.4124 | 3.3923 | -14.5029 | 11.6275 | — | — | — | −0.6123 | 1.0179 | 0.1404 | 1.5320 | −3.3136 | 21.8972 | 0.2258 | 0.9394 | 1.4043 |
| **Model 5** | 0.9973 | −0.2447 | 2.1693 | -10.7736 | 6.5894 | 2.4929 | — | — | −0.6121 | 1.0181 | 0.1405 | 1.5317 | −3.3123 | 21.8923 | 0.2257 | 0.9395 | 1.4041 |
| **Model 6** | 0.5537 | 0.0000 | — | — | — | — | — | — | 0.9475 | 3.2712 | 0.6803 | 4.1000 | 37.6280 | 11.9283 | 0.6042 | 0.4702 | 3.9890 |
| **Model 7** | 3.1566 | −2.8063 | — | — | — | — | — | — | −0.6610 | 1.1087 | 0.1666 | 1.5701 | −4.3849 | 23.3095 | 0.2314 | 0.9351 | 1.4242 |
| **Model 8** | 0.3823 | −0.4228 | — | — | — | — | — | — | 0.2782 | 2.4255 | 0.4793 | 3.0469 | 24.6947 | 4.6041 | 0.4490 | 0.6195 | 3.0342 |
| **Model 9** | 0.0365 | 0.9750 | −4.5636 | 8.8402 | — | — | — | — | −0.6162 | 1.0229 | 0.1417 | 1.5350 | −3.3772 | 22.0084 | 0.2262 | 0.9391 | 1.4060 |
| **Model 10** | −4.5631 | 8.6118 | — | — | — | — | — | — | −0.6482 | 1.0317 | 0.1428 | 1.5334 | −4.3639 | 23.4249 | 0.2260 | 0.9394 | 1.3897 |
| **Model 11** | 0.4240 | 0.0450 | — | — | — | — | — | — | 0.4228 | 2.8150 | 0.5615 | 3.5106 | 28.9374 | 6.0927 | 0.5173 | 0.5254 | 3.4850 |
| **Model 12** | 0.1638 | −2.0960 | — | — | — | — | — | — | 0.0703 | 2.0219 | 0.3872 | 2.5624 | 18.2241 | 1.3786 | 0.3776 | 0.7327 | 2.5615 |
| **Model 13** | 1.4012 | −2.0332 | — | — | — | — | — | — | −0.1760 | 1.6575 | 0.3047 | 2.1399 | 12.2908 | 4.1449 | 0.3153 | 0.8390 | 2.1326 |
| **Model 14** | 0.2117 | −0.4100 | — | — | — | — | — | — | −2.2536 | 2.8665 | 0.4019 | 3.6466 | -20.9215 | 39.4769 | 0.5374 | 0.6670 | 2.8669 |
| **Model 15** | 2.1515 | −0.9716 | — | — | — | — | — | — | −0.6346 | 1.1012 | 0.1621 | 1.5585 | −2.8182 | 22.3878 | 0.2297 | 0.9421 | 1.4234 |
| **Model 16** | 1.0267 | −0.8117 | — | — | — | — | — | — | 0.0004 | 1.2519 | 0.2199 | 1.7593 | 8.7765 | 0.0106 | 0.2593 | 0.8849 | 1.7593 |
| **Model 17** | 0.9617 | −0.2223 | −0.6337 | — | — | — | — | — | 0.0031 | 1.0146 | 0.1658 | 1.5478 | 4.7129 | 0.1013 | 0.2281 | 0.9118 | 1.5478 |
| **Model 18** | 0.9776 | −0.6900 | 0.6825 | −0.9220 | — | — | — | — | −0.0040 | 0.9892 | 0.1593 | 1.5260 | 3.9417 | 0.1332 | 0.2249 | 0.9146 | 1.5260 |
| **Model 19** | 0.9740 | −0.8117 | — | — | — | — | — | — | **0.0003** | 1.2518 | 0.2199 | 1.7593 | 8.7746 | **0.0076** | 0.2593 | 0.8849 | 1.7593 |
| **Model 20** | −0.8170 | −1.9687 | −0.9074 | — | — | — | — | — | 0.0016 | 1.1592 | 0.1869 | 1.6705 | 5.3405 | 0.0435 | 0.2368 | 0.8978 | 1.6705 |
| **Model 21** | 0.9644 | 1.7635 | — | — | — | — | — | — | 0.2640 | 1.8262 | 0.3545 | 2.4482 | 19.5153 | 5.4475 | 0.3608 | 0.7633 | 2.4339 |
| **Model 22** | 2.7267 | −1.5850 | — | — | — | — | — | — | −0.0182 | 1.0693 | 0.1766 | 1.5888 | 5.8067 | 0.5739 | 0.2341 | 0.9066 | 1.5887 |
| **Model 23** | 0.3411 | −0.2787 | — | — | — | — | — | — | −0.9522 | 2.5866 | 0.4231 | 3.1543 | 4.5089 | 14.6211 | 0.4472 | 0.6074 | 3.0072 |
| **Model 24** | 1.4907 | −0.4998 | — | — | — | — | — | — | −0.0071 | 1.0538 | 0.1747 | 1.5786 | 5.7834 | 0.2268 | 0.2326 | 0.9078 | 1.5786 |
| **Model 25** | 0.0156 | −1.1956 | — | — | — | — | — | — | 0.1110 | 1.5836 | 0.2990 | 2.1633 | 14.7641 | 2.5813 | 0.3188 | 0.8192 | 2.1604 |
| **Model 26** | 0.2410 | −0.0372 | — | — | — | — | — | — | −0.4154 | 2.0797 | 0.4234 | 2.6621 | 17.1935 | 7.9332 | 0.3923 | 0.7272 | 2.6295 |
| **Model 27** | 1.2694 | 0.8156 | — | — | — | — | — | — | −0.6354 | 1.0406 | 0.1460 | 1.5431 | −3.7736 | 22.6927 | 0.2274 | 0.9396 | 1.4062 |
| **Model 28** | −0.0369 | 1.5886 | −1.9276 | — | — | — | — | — | −0.6289 | 1.0677 | 0.1571 | 1.5512 | −4.1765 | 22.2737 | 0.2286 | 0.9374 | 1.4180 |
| **Model 29** | −0.0583 | 1.8328 | −2.6226 | 0.5668 | — | — | — | — | −0.6203 | 1.0747 | 0.1615 | 1.5604 | −4.3072 | 21.7583 | 0.2299 | 0.9357 | 1.4317 |
| **Model 30** | 0.0328 | 0.2061 | 5.3705 | -14.1477 | 9.0862 | — | — | — | −0.6139 | 1.0267 | 0.1453 | 1.5370 | −3.1462 | 21.8814 | 0.2265 | 0.9388 | 1.4091 |
| **Model 31** | 0.0244 | 0.2435 | — | — | — | — | — | — | −0.4070 | 2.0720 | 0.4022 | 2.5864 | 15.0721 | 8.0024 | 0.3811 | 0.7499 | 2.5542 |
| **Model 32** | 0.2371 | −0.1261 | — | — | — | — | — | — | −0.4132 | 2.0840 | 0.4236 | 2.6601 | 17.1811 | 7.8956 | 0.3920 | 0.7280 | 2.6279 |
| **Model 33** | 0.2391 | 0.0841 | — | — | — | — | — | — | −0.4049 | 2.0810 | 0.4092 | 2.6036 | 15.7392 | 7.9051 | 0.3837 | 0.7454 | 2.5720 |
| **Model 34** | −0.0084 | 0.2474 | — | — | — | — | — | — | −0.4146 | 1.9451 | 0.3532 | 2.4502 | 9.9427 | 8.6224 | 0.3611 | 0.7827 | 2.4149 |
| **Model 35** | 0.2435 | 0.0244 | — | — | — | — | — | — | −0.0786 | 2.0434 | 0.4322 | 2.5646 | 22.2203 | 1.5391 | 0.3779 | 0.7417 | 2.5634 |
| **Model 36** | 0.2987 | −0.0460 | — | — | — | — | — | — | −0.4247 | 2.0471 | 0.4185 | 2.6535 | 16.9790 | 8.1419 | 0.3910 | 0.7285 | 2.6193 |
| **Model 37** | −0.7601 | −0.0352 | — | — | — | — | — | — | −0.4150 | 2.0809 | 0.4235 | 2.6616 | 17.1873 | 7.9264 | 0.3922 | 0.7274 | 2.6291 |
| **Model 38** | 0.2438 | −0.0355 | — | — | — | — | — | — | −0.3770 | 2.0504 | 0.4207 | 2.6378 | 17.5448 | 7.2521 | 0.3887 | 0.7298 | 2.6107 |
| **Model 39** | 0.1714 | 0.6206 | −0.7054 | — | — | — | — | — | −0.4113 | 1.3692 | 0.2561 | 1.8995 | 5.9665 | 11.1395 | 0.2799 | 0.8744 | 1.8545 |
| **Model 40** | 0.1748 | 0.5207 | −0.4243 | −0.1969 | — | — | — | — | −0.4104 | 1.3641 | 0.2562 | 1.8918 | 5.9815 | 11.1602 | 0.2788 | 0.8757 | 1.8467 |
| **Model 41** | 0.2142 | −0.0287 | — | — | — | — | — | — | −0.7308 | 2.0004 | 0.3226 | 2.5464 | 4.8608 | 13.8346 | 0.3610 | 0.7884 | 2.4392 |
| **Model 42** | 0.2409 | −0.1331 | — | — | — | — | — | — | −0.3808 | 2.0581 | 0.4214 | 2.6403 | 17.5148 | 7.3202 | 0.3891 | 0.7300 | 2.6127 |
| **Model 43** | 0.4309 | 0.0769 | −0.3163 | — | — | — | — | — | 0.3185 | 1.3718 | 0.2212 | 1.9376 | 11.3263 | 7.6942 | 0.2747 | 0.8676 | 1.9113 |
| **Model 44** | 0.2864 | −0.0338 | — | — | — | — | — | — | −0.3604 | 1.9981 | 0.4127 | 2.6039 | 17.3856 | 7.0189 | 0.3837 | 0.7359 | 2.5788 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1485 | −1.4688 | 0.1550 | — | — | — | — | — | −0.4228 | 1.0915 | 0.1681 | 1.5042 | 0.2928 | 14.7083 | 0.2217 | 0.9340 | 1.4435 |
| **Model 46** | −0.7034 | 1.1516 | — | — | — | — | — | — | 0.6353 | 2.6054 | 0.4885 | 3.6560 | 5.6101 | 8.8615 | 0.5388 | 0.7518 | 3.6004 |
| **Model 47** | 1.2720 | −1.4869 | 0.0430 | — | — | — | — | — | −0.4498 | 1.0608 | 0.1576 | 1.4967 | −0.1323 | 15.8227 | 0.2206 | 0.9377 | 1.4275 |
| **Model 48** | 0.1545 | 0.8507 | −5.2075 | 10.3882 | −3.0307 | 0.2615 | 0.0401 | — | −0.4416 | 0.9044 | 0.1318 | **1.3269** | −3.4433 | 17.7235 | **0.1955** | **0.9455** | **1.2513** |
| **Model 49** | 1.2622 | −1.4679 | 0.0016 | — | — | — | — | — | −0.4289 | 1.0976 | 0.1690 | 1.5083 | 0.2816 | 14.8958 | 0.2223 | 0.9336 | 1.4460 |
| **Model 50** | −8.6541 | −6.3432 | -30.9462 | -20.6416 | — | — | — | — | −0.2223 | 1.4116 | 0.2332 | 1.9351 | 5.6799 | 5.8067 | 0.2852 | 0.8615 | 1.9223 |
| **Model 51** | -15.2733 | 0.0441 | -1388.2386 | — | — | — | — | — | 0.6413 | 2.8010 | 0.5480 | 3.6252 | 28.1098 | 9.0267 | 0.5342 | 0.5684 | 3.5680 |
| **Model 52** | 1.1700 | −1.3983 | 0.0011 | — | — | — | — | — | −0.5699 | 1.1728 | 0.1793 | 1.6190 | −0.1332 | 18.8858 | 0.2386 | 0.9384 | 1.5154 |

(*continued on next page*)

**Table A1** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.1697 | −0.7770 | −0.4130 | — | — | — | — | — | −0.3290 | 1.0795 | 0.1753 | 1.5414 | 3.5003 | 10.9706 | 0.2271 | 0.9306 | 1.5059 |
| **Model 54** | 0.9741 | 0.2546 | −1.2015 | −0.2515 | −0.1832 | — | — | — | −0.3969 | 0.8823 | 0.1299 | 1.3423 | −2.1564 | 15.5441 | 0.1978 | 0.9425 | 1.2822 |
| **Model 55** | 0.9338 | 0.8291 | −3.0551 | 1.5706 | −0.4236 | 0.4369 | −0.4609 | — | −0.3900 | **0.8700** | **0.1267** | 1.3286 | −1.9471 | 15.4205 | 0.1958 | 0.9444 | 1.2701 |
| **Model 56** | 0.9518 | 0.4965 | −1.5181 | −0.4089 | — | — | — | — | −0.4285 | 0.8964 | 0.1323 | 1.3659 | −2.3662 | 16.5922 | 0.2013 | 0.9418 | 1.2970 |
| **Model 57** | 1.0967 | −0.7023 | 0.0857 | −0.5773 | — | — | — | — | −0.2948 | 0.9136 | 0.1366 | 1.3630 | 0.3050 | 11.1254 | 0.2009 | 0.9380 | 1.3307 |
| **Model 58** | 0.9889 | −0.9618 | −0.4142 | — | — | — | — | — | −0.3914 | 0.8971 | 0.1333 | 1.3374 | −2.7267 | 15.3697 | 0.1971 | 0.9416 | 1.2788 |
| **Model 59** | 1.0961 | −0.6527 | −0.5168 | — | — | — | — | — | −0.2787 | 0.9168 | 0.1384 | 1.3742 | 0.8874 | 10.4025 | 0.2025 | 0.9369 | 1.3457 |
| **Model 60** | 1.0387 | −1.1045 | −0.3333 | — | — | — | — | — | −0.4647 | 0.9287 | 0.1357 | 1.3925 | −1.7826 | 17.7793 | 0.2052 | 0.9443 | 1.3127 |
| **Model 61** | 0.8995 | −1.1953 | −0.4689 | — | — | — | — | — | −0.3463 | 1.0210 | 0.1740 | 1.4506 | −4.9194 | 12.3447 | 0.2138 | 0.9294 | 1.4087 |
| **Model 62** | 0.1060 | −0.5137 | −0.0654 | — | — | — | — | — | −3.2224 | 3.3290 | 0.4037 | 4.2674 | -36.5818 | 53.1808 | 0.6050 | 0.8092 | 2.7978 |
| **Model 63** | 1.8524 | −0.4892 | −0.2636 | — | — | — | — | — | −0.3524 | 0.9221 | 0.1386 | 1.3787 | 0.4732 | 13.2774 | 0.2032 | 0.9420 | 1.3329 |
| **Model 64** | −0.8263 | −0.8551 | −0.6202 | — | — | — | — | — | −0.2008 | 1.2763 | 0.2247 | 1.7588 | 7.7372 | 5.7705 | 0.2592 | 0.8982 | 1.7473 |
| **Model 65** | 0.2074 | 0.1979 | −0.1371 | — | — | — | — | — | −0.2525 | 2.0044 | 0.4120 | 2.5472 | 18.0971 | 5.0038 | 0.3754 | 0.7466 | 2.5346 |
| **Model 66** | −0.0413 | 1.5133 | −1.5332 | 0.0623 | −0.2260 | — | — | — | −0.4201 | 0.9196 | 0.1397 | 1.3780 | −2.5605 | 16.0758 | 0.2031 | 0.9409 | 1.3124 |
| **Model 67** | −0.0688 | 1.8116 | −1.9237 | −0.1320 | — | — | — | — | −0.4723 | 1.0017 | 0.1585 | 1.4544 | −3.2734 | 17.2427 | 0.2143 | 0.9356 | 1.3756 |
| **Model 68** | 0.1152 | 0.2923 | 0.4925 | −0.7289 | — | — | — | — | −0.2288 | 1.2843 | 0.2362 | 1.7358 | 6.3941 | 6.6788 | 0.2558 | 0.8910 | 1.7207 |
| **Model 69** | 0.2501 | 0.1347 | −0.1422 | — | — | — | — | — | 2.0634 | 2.9165 | 0.7255 | 3.7631 | 64.6632 | 32.9288 | 0.5545 | 0.6014 | 3.1469 |
| **Model 70** | 0.1119 | 0.5770 | −0.3813 | — | — | — | — | — | −0.0123 | 1.4943 | 0.2992 | 1.9868 | 13.2329 | 0.3100 | 0.2928 | 0.8507 | 1.9868 |
| **Model 71** | 0.2483 | −0.4143 | 0.1439 | — | — | — | — | — | −0.6425 | 1.9288 | 0.3771 | 2.5995 | 11.9801 | 12.8094 | 0.3831 | 0.7601 | 2.5189 |
| **Model 72** | 0.2616 | 0.0059 | −0.1131 | — | — | — | — | — | −0.3309 | 1.8152 | 0.3779 | 2.4576 | 15.8228 | 6.8240 | 0.3622 | 0.7671 | 2.4352 |
| **Model 73** | 0.1802 | −0.0742 | 0.0021 | — | — | — | — | — | −1.3198 | 2.1671 | 0.3108 | 2.8136 | −5.1017 | 24.5235 | 0.3989 | 0.7964 | 2.4849 |
| **Model 74** | 0.1862 | 0.1355 | −0.0992 | — | — | — | — | — | −0.2199 | 1.9527 | 0.4065 | 2.5065 | 18.2180 | 4.4219 | 0.3694 | 0.7536 | 2.4969 |
| **Model 75** | 0.1796 | −0.0014 | 0.0008 | — | — | — | — | — | −0.4209 | 2.0298 | 0.4142 | 2.6237 | 16.2999 | 8.1617 | 0.3866 | 0.7334 | 2.5898 |
| **Model 76** | 0.1737 | 0.6209 | −0.7070 | 0.0000 | — | — | — | — | −0.4097 | 1.3690 | 0.2559 | 1.8995 | 5.9889 | 11.0921 | 0.2799 | 0.8743 | 1.8548 |
| **Model 77** | 0.2236 | −0.0303 | 0.0013 | — | — | — | — | — | −0.2472 | 2.0131 | 0.4174 | 2.5791 | 17.2035 | 4.8357 | 0.3801 | 0.7317 | 2.5672 |
| **Model 78** | 0.1673 | 0.6136 | −0.6964 | 0.0003 | — | — | — | — | −0.3792 | 1.3648 | 0.2569 | 1.8840 | 6.0248 | 10.3183 | 0.2776 | 0.8743 | 1.8454 |
| **Model 79** | 0.1753 | 0.0009 | 0.0007 | — | — | — | — | — | −0.3219 | 2.0101 | 0.4133 | 2.5799 | 16.2141 | 6.3144 | 0.3802 | 0.7345 | 2.5597 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.8748 | −0.7825 | −0.4119 | 0.3096 | — | — | — | — | −0.3285 | 1.0827 | 0.1750 | 1.5543 | 3.4989 | 10.8583 | 0.2290 | 0.9301 | 1.5192 |
| **Model 81** | 1.1689 | −0.8072 | −0.3874 | 0.0013 | — | — | — | — | −0.2314 | 1.0472 | 0.1696 | 1.4848 | 3.1747 | 7.9222 | 0.2188 | 0.9258 | 1.4667 |
| **Model 82** | 1.1835 | −1.4209 | 0.0014 | 0.0007 | — | — | — | — | −0.4917 | 1.1436 | 0.1775 | 1.5635 | **0.0845** | 16.6367 | 0.2304 | 0.9334 | 1.4842 |
| **Model 83** | 0.5538 | −0.4269 | 0.1225 | 0.0005 | 0.0004 | — | — | — | 0.7652 | 1.6669 | 0.2718 | 2.4378 | 17.6574 | 15.2656 | 0.3456 | 0.8282 | 2.3146 |
| **Model 84** | 0.1753 | 0.6131 | −0.7010 | 0.0004 | −0.0001 | — | — | — | −0.3673 | 1.3635 | 0.2565 | 1.8815 | 6.1121 | 9.9957 | 0.2773 | 0.8740 | 1.8453 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | -14.8205 | −0.7944 | −0.4047 | 0.3118 | 20.4395 | — | — | — | −0.2129 | 1.0755 | 0.1817 | 1.5276 | 5.5793 | 7.0686 | 0.2251 | 0.9293 | 1.5127 |
| **Model 86** | 0.9734 | −1.3896 | −0.0037 | 0.0011 | 0.3286 | — | — | — | −0.4526 | 1.0643 | 0.1598 | 1.4846 | −0.3739 | 16.0744 | 0.2188 | 0.9388 | 1.4139 |
| **Model 87** | 0.9734 | −1.3896 | 0.3286 | −0.0037 | 0.0011 | — | — | — | −0.4526 | 1.0643 | 0.1598 | 1.4846 | −0.3739 | 16.0744 | 0.2188 | 0.9388 | 1.4139 |
| **Model 88** | 1.0875 | −0.7191 | −0.4044 | 0.0000 | 0.0009 | — | — | — | −0.3302 | 1.0671 | 0.1715 | 1.5275 | 2.9850 | 11.1007 | 0.2246 | 0.9298 | 1.4913 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0999 | −0.7477 | −0.3987 | 0.0012 | 0.0006 | — | — | — | −0.2707 | 1.0574 | 0.1719 | 1.5045 | 3.0978 | 9.1863 | 0.2217 | 0.9263 | 1.4800 |
| **Model 90** | 1.0087 | 0.0663 | 0.9525 | 0.8797 | −0.7475 | 0.0040 | 0.0014 | −0.3789 | −0.2494 | 0.9917 | 0.1561 | 1.4256 | 1.8433 | 8.9251 | 0.2101 | 0.9322 | 1.4036 |
| **Model 91** | 0.7942 | 0.0830 | 1.0072 | 0.8352 | −0.7314 | 0.0046 | 0.0023 | — | 0.0009 | 1.1546 | 0.1935 | 1.6541 | 5.9405 | 0.0269 | 0.2437 | 0.8982 | 1.6541 |
| **Model 92** | 1.1072 | 0.0511 | 0.9003 | 0.6156 | −1.3816 | 0.0025 | 0.0015 | — | −0.4549 | 1.0365 | 0.1553 | 1.4498 | −1.1660 | 16.5965 | 0.2136 | 0.9407 | 1.3765 |
| **Model 93** | 1.2480 | 0.0355 | 0.7668 | 0.2900 | −1.4871 | 0.0015 | — | — | −0.4255 | 1.0574 | 0.1593 | 1.4792 | −0.1450 | 15.0821 | 0.2180 | 0.9370 | 1.4167 |
| **Model 94** | 1.1363 | 0.0471 | 0.8490 | −0.1008 | −1.3787 | 0.0015 | — | — | −0.4540 | 1.0375 | 0.1547 | 1.4531 | −0.9400 | 16.5161 | 0.2141 | 0.9411 | 1.3804 |
| **Model 95** | 1.2542 | −0.0540 | 0.7163 | 2.9990 | −1.4831 | — | — | — | −0.4301 | 1.0587 | 0.1591 | 1.4820 | −0.0939 | 15.2293 | 0.2184 | 0.9376 | 1.4182 |
| **Model 96** | 0.5671 | −0.0823 | 1.2099 | 0.6845 | — | — | — | — | 1.1790 | 3.2452 | 0.6604 | 4.2780 | 36.2675 | 14.3978 | 0.6304 | 0.5318 | 4.1124 |
| **Model 97** | 1.2450 | 0.0352 | −0.0949 | −1.4879 | 0.0021 | — | — | — | −0.4259 | 1.0584 | 0.1588 | 1.4842 | −0.1559 | 15.0432 | 0.2187 | 0.9359 | 1.4218 |

**Table A2**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Chengdu station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1383 | −0.9907 | — | — | — | — | — | — | 0.1699 | 0.9167 | 0.1276 | 1.4148 | 5.2533 | 6.0893 | 0.1993 | 0.9238 | 1.4046 |
| **Model 2** | 0.9895 | 0.3276 | −2.1054 | — | — | — | — | — | 0.0478 | 0.7098 | 0.0900 | 1.1126 | 2.8288 | 2.1644 | 0.1567 | 0.9524 | 1.1116 |
| **Model 3** | 0.9625 | 0.7345 | −3.5916 | 1.5057 | — | — | — | — | 0.0558 | 0.7056 | 0.0896 | 1.1094 | 3.0379 | 2.5360 | 0.1563 | 0.9529 | 1.1080 |
| **Model 4** | 0.9835 | 0.2784 | −0.8116 | −4.7406 | 4.6236 | — | — | — | 0.0570 | 0.7084 | 0.0900 | 1.1161 | 3.0722 | 2.5728 | 0.1572 | 0.9523 | 1.1147 |
| **Model 5** | 0.9949 | −0.0516 | 2.1055 | -15.4416 | 21.7853 | −9.9535 | — | — | 0.0562 | 0.7069 | 0.0897 | 1.1140 | 3.0489 | 2.5421 | 0.1569 | 0.9525 | 1.1126 |
| **Model 6** | 0.8545 | 0.0000 | — | — | — | — | — | — | 1.3583 | 1.9954 | 0.2716 | 3.5536 | 14.7728 | 20.8265 | 0.5005 | 0.8183 | 3.2838 |
| **Model 7** | 3.0567 | −2.3523 | — | — | — | — | — | — | 0.0834 | 0.8116 | 0.1122 | 1.2094 | 4.1376 | 3.4812 | 0.1703 | 0.9436 | 1.2065 |
| **Model 8** | 0.6467 | −0.1850 | — | — | — | — | — | — | 0.6350 | 1.4117 | 0.1940 | 2.4465 | 9.6890 | 13.5330 | 0.3446 | 0.8454 | 2.3626 |
| **Model 9** | 0.1423 | 0.8818 | −4.4072 | 8.5441 | — | — | — | — | 0.0559 | 0.7169 | 0.0917 | 1.1265 | 3.0914 | 2.5014 | 0.1587 | 0.9513 | 1.1251 |
| **Model 10** | −4.7991 | 8.5950 | — | — | — | — | — | — | 0.0203 | 0.7227 | 0.0922 | 1.1242 | 2.1157 | 0.9110 | 0.1583 | 0.9512 | 1.1240 |
| **Model 11** | 0.7607 | 0.0161 | — | — | — | — | — | — | 0.9370 | 1.7094 | 0.2328 | 3.0139 | 11.8788 | 16.4687 | 0.4245 | 0.8223 | 2.8646 |
| **Model 12** | 0.1492 | −1.2945 | — | — | — | — | — | — | 0.3386 | 1.0739 | 0.1486 | 1.7745 | 6.9607 | 9.7866 | 0.2499 | 0.8922 | 1.7419 |
| **Model 13** | 1.1562 | −1.1069 | — | — | — | — | — | — | 0.2997 | 1.0396 | 0.1447 | 1.6937 | 6.6755 | 9.0519 | 0.2385 | 0.8986 | 1.6669 |
| **Model 14** | 0.5809 | −0.1870 | — | — | — | — | — | — | −0.5474 | 1.6513 | 0.2420 | 2.2450 | −8.7293 | 12.6583 | 0.3162 | 0.8375 | 2.1772 |
| **Model 15** | 1.8441 | −0.7332 | — | — | — | — | — | — | 0.1139 | 0.8282 | 0.1143 | 1.2450 | 4.4356 | 4.6239 | 0.1754 | 0.9403 | 1.2398 |
| **Model 16** | 0.9845 | −0.5983 | — | — | — | — | — | — | 0.6135 | 0.8919 | 0.1206 | 1.6168 | 9.0844 | 20.6499 | 0.2277 | 0.9267 | 1.4959 |
| **Model 17** | 0.9795 | −0.4723 | −0.1862 | — | — | — | — | — | 0.6354 | 0.8960 | 0.1210 | 1.6111 | 9.0919 | 21.6076 | 0.2269 | 0.9300 | 1.4806 |
| **Model 18** | 0.9832 | −0.7787 | 0.9686 | −1.0059 | — | — | — | — | 0.6241 | 0.8874 | 0.1191 | 1.6042 | 8.9912 | 21.2631 | 0.2260 | 0.9300 | 1.4779 |
| **Model 19** | 1.0158 | −0.5983 | — | — | — | — | — | — | 0.6135 | 0.8919 | 0.1206 | 1.6168 | 9.0838 | 20.6485 | 0.2277 | 0.9267 | 1.4959 |
| **Model 20** | −0.6295 | −1.4727 | −0.9301 | — | — | — | — | — | 1.0440 | 1.4817 | 0.1827 | 2.1554 | 14.2858 | 20.5217 | 0.2303 | 0.7965 | 1.8857 |
| **Model 21** | 1.0101 | 0.9449 | — | — | — | — | — | — | 0.6088 | 0.9395 | 0.1267 | 1.7424 | 9.4087 | 18.7757 | 0.2454 | 0.9117 | 1.6326 |
| **Model 22** | 2.6640 | −1.3093 | — | — | — | — | — | — | 0.6341 | 0.8942 | 0.1207 | 1.6084 | 9.0771 | 21.5983 | 0.2265 | 0.9302 | 1.4781 |
| **Model 23** | 0.5567 | −0.1600 | — | — | — | — | — | — | −0.3033 | 1.9014 | 0.2212 | 2.4935 | **0.5359** | 4.5420 | 0.2665 | 0.6361 | 2.4750 |
| **Model 24** | 1.3918 | −0.4157 | — | — | — | — | — | — | 0.6516 | 0.9043 | 0.1219 | 1.6193 | 9.1085 | 22.1322 | 0.2281 | 0.9313 | 1.4824 |
| **Model 25** | −0.0124 | −0.7450 | — | — | — | — | — | — | 0.6039 | 0.9094 | 0.1230 | 1.6693 | 9.1904 | 19.5372 | 0.2351 | 0.9197 | 1.5563 |
| **Model 26** | 0.0859 | 0.4624 | — | — | — | — | — | — | 0.1808 | 1.4307 | 0.2719 | 2.0157 | 13.9502 | 4.5354 | 0.2839 | 0.8392 | 2.0075 |
| **Model 27** | 1.2873 | 0.8677 | — | — | — | — | — | — | 0.0768 | 0.7061 | 0.0895 | 1.1245 | 3.4429 | 3.4465 | 0.1584 | 0.9517 | 1.1218 |
| **Model 28** | −0.0348 | 1.5320 | −1.7082 | — | — | — | — | — | 0.0766 | 0.7707 | 0.1121 | 1.1509 | 2.6397 | 3.3585 | 0.1621 | 0.9494 | 1.1483 |
| **Model 29** | −0.0094 | 1.1490 | −0.3095 | −1.4170 | — | — | — | — | 0.0590 | 0.7133 | 0.0933 | 1.1099 | 2.9579 | 2.6817 | 0.1563 | 0.9529 | 1.1083 |
| **Model 30** | 0.0039 | 0.8610 | 1.4455 | −5.3603 | 2.9189 | — | — | — | 0.0563 | 0.7073 | 0.0901 | 1.1139 | 3.0560 | 2.5498 | 0.1569 | 0.9525 | 1.1125 |
| **Model 31** | 0.1162 | 0.3885 | — | — | — | — | — | — | 0.1817 | 1.0973 | 0.1813 | 1.5827 | 6.0578 | 5.8186 | 0.2229 | 0.9023 | 1.5722 |
| **Model 32** | 0.1330 | 1.6362 | — | — | — | — | — | — | 0.1854 | 1.6801 | 0.3601 | 2.2301 | 20.6734 | 4.2004 | 0.3141 | 0.7936 | 2.2223 |
| **Model 33** | 0.4544 | 0.5414 | — | — | — | — | — | — | 0.2222 | 1.2584 | 0.2293 | 1.7716 | 12.6277 | 6.3646 | 0.2495 | 0.8762 | 1.7576 |
| **Model 34** | −0.0134 | 0.2962 | — | — | — | — | — | — | 0.0875 | 1.5248 | 0.3242 | 1.8996 | 7.4647 | 2.3229 | 0.2676 | 0.8572 | 1.8976 |
| **Model 35** | 0.3885 | 0.1162 | — | — | — | — | — | — | 2.9804 | 3.0828 | 0.7948 | 3.6770 | 78.7356 | 69.6776 | 0.5179 | 0.8067 | 2.1536 |
| **Model 36** | −0.2085 | 0.3162 | — | — | — | — | — | — | 0.1722 | 1.5721 | 0.3122 | 2.1717 | 16.4004 | 4.0043 | 0.3059 | 0.8104 | 2.1648 |
| **Model 37** | −0.9030 | 0.3926 | — | — | — | — | — | — | 0.1704 | 1.4902 | 0.2913 | 2.0677 | 15.2140 | 4.1643 | 0.2912 | 0.8287 | 2.0606 |
| **Model 38** | 0.1760 | 0.1946 | — | — | — | — | — | — | −0.2460 | 2.0329 | 0.4465 | 2.5294 | 21.0434 | 4.9197 | 0.3563 | 0.7237 | 2.5174 |
| **Model 39** | 0.1575 | 0.6625 | −0.6911 | — | — | — | — | — | −0.1245 | 1.6265 | 0.3671 | 2.0636 | 17.0041 | 3.0428 | 0.2907 | 0.8252 | 2.0598 |
| **Model 40** | 0.1546 | 0.9067 | −1.6113 | 0.8015 | — | — | — | — | −0.1065 | 1.5980 | 0.3592 | 2.0265 | 16.5518 | 2.6506 | 0.2854 | 0.8318 | 2.0237 |
| **Model 41** | 0.2953 | 0.0128 | — | — | — | — | — | — | 0.1572 | 1.5088 | 0.1780 | 1.9364 | 6.4437 | 3.0197 | 0.2069 | 0.7517 | 1.9300 |
| **Model 42** | 0.1832 | 0.7271 | — | — | — | — | — | — | −0.2354 | 2.0955 | 0.4671 | 2.5982 | 23.0172 | 4.5812 | 0.3660 | 0.7063 | 2.5875 |
| **Model 43** | 0.3520 | 0.0386 | −0.1205 | — | — | — | — | — | 0.7688 | 1.5629 | 0.1928 | 2.0247 | 12.8925 | 15.2143 | 0.2164 | 0.7693 | 1.8731 |
| **Model 44** | 0.0577 | 0.1243 | — | — | — | — | — | — | −0.2600 | 2.1196 | 0.4674 | 2.6288 | 22.4757 | 5.0037 | 0.3703 | 0.6972 | 2.6159 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.0898 | −1.0071 | 0.0642 | — | — | — | — | — | −0.2557 | 0.9643 | 0.1245 | 1.4118 | −0.6551 | 9.2703 | 0.1989 | 0.9247 | 1.3885 |
| **Model 46** | −0.9842 | 1.3312 | — | — | — | — | — | — | 0.4824 | 1.7642 | 0.2613 | 2.5334 | 2.1413 | 9.7667 | 0.3568 | 0.8819 | 2.4870 |
| **Model 47** | 1.1389 | −0.9929 | 0.0021 | — | — | — | — | — | 0.1712 | 0.9165 | 0.1276 | 1.4146 | 5.2393 | 6.1375 | 0.1992 | 0.9239 | 1.4042 |
| **Model 48** | −0.0017 | 1.0146 | −5.4649 | 13.2867 | −7.0674 | −0.4993 | 0.3413 | — | 0.0624 | 0.7081 | 0.0902 | 1.1150 | 2.6148 | 2.8226 | 0.1570 | 0.9522 | 1.1132 |
| **Model 49** | 1.1423 | −1.0059 | 0.0005 | — | — | — | — | — | 0.1797 | 0.9132 | 0.1273 | 1.4135 | 5.1633 | 6.4524 | 0.1991 | 0.9247 | 1.4020 |
| **Model 50** | 12.0516 | 7.1406 | 25.4856 | 16.1612 | — | — | — | — | 0.2334 | 1.0034 | 0.1412 | 1.5900 | 6.2342 | 7.4718 | 0.2239 | 0.9055 | 1.5728 |
| **Model 51** | 10.2703 | 0.0153 | 840.4661 | — | — | — | — | — | 0.8945 | 1.6927 | 0.2305 | 2.9531 | 11.8945 | 16.0021 | 0.4159 | 0.8180 | 2.8144 |
| **Model 52** | 1.1675 | −1.0004 | −0.0003 | — | — | — | — | — | 0.1748 | 0.9131 | 0.1272 | 1.4108 | 5.3147 | 6.2857 | 0.1987 | 0.9243 | 1.4000 |

(*continued on next page*)

**Table A2** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0768 | −0.5326 | −0.3211 | — | — | — | — | — | 0.3195 | 0.8270 | 0.1139 | 1.3570 | 6.6021 | 12.1978 | 0.1911 | 0.9343 | 1.3189 |
| **Model 54** | 0.9802 | 0.3644 | −1.7400 | −0.2015 | 0.0236 | — | — | — | 0.1538 | 0.6872 | 0.0884 | 1.1049 | 4.0370 | 7.0771 | 0.1556 | 0.9538 | 1.0942 |
| **Model 55** | 0.9753 | 0.4423 | −1.9966 | 0.2565 | −0.3098 | 0.4271 | −0.3548 | — | 0.1556 | **0.6869** | **0.0884** | **1.1045** | 4.0674 | 7.1634 | **0.1556** | **0.9539** | **1.0935** |
| **Model 56** | 0.9817 | 0.3469 | −1.7127 | −0.1859 | — | — | — | — | 0.1571 | 0.6888 | 0.0886 | 1.1075 | 4.0608 | 7.2152 | 0.1560 | 0.9537 | 1.0963 |
| **Model 57** | 1.0766 | −0.5920 | −0.0250 | −0.3918 | — | — | — | — | 0.3327 | 0.8042 | 0.1102 | 1.3061 | 6.3405 | 13.2641 | 0.1840 | 0.9408 | 1.2630 |
| **Model 58** | 1.0189 | −1.2562 | −0.2319 | — | — | — | — | — | 0.1736 | 0.7166 | 0.0938 | 1.1324 | 4.2846 | 7.8102 | 0.1595 | 0.9518 | 1.1190 |
| **Model 59** | 1.0776 | −0.6034 | −0.4180 | — | — | — | — | — | 0.3311 | 0.8046 | 0.1102 | 1.3046 | 6.3001 | 13.2106 | 0.1838 | 0.9409 | 1.2619 |
| **Model 60** | 1.0247 | −1.2025 | −0.1820 | — | — | — | — | — | 0.1587 | 0.7109 | 0.0941 | 1.1157 | 4.4228 | 7.2345 | 0.1571 | 0.9529 | 1.1044 |
| **Model 61** | 0.9807 | −2.3365 | −0.1912 | — | — | — | — | — | 0.1485 | 0.7725 | 0.1008 | 1.2569 | 3.1133 | 5.9888 | 0.1770 | 0.9417 | 1.2481 |
| **Model 62** | 0.3466 | −0.3389 | −0.0611 | — | — | — | — | — | −2.2965 | 2.6790 | 0.2794 | 3.1282 | -21.5463 | 40.0737 | 0.3343 | 0.6878 | 2.1242 |
| **Model 63** | 1.7077 | −0.4500 | −0.1902 | — | — | — | — | — | 0.2711 | 0.7759 | 0.1061 | 1.2380 | 5.8372 | 11.2993 | 0.1744 | 0.9443 | 1.2079 |
| **Model 64** | −0.9263 | −0.5407 | −0.4058 | — | — | — | — | — | 0.3660 | 0.8565 | 0.1178 | 1.4422 | 7.1353 | 13.2084 | 0.2031 | 0.9278 | 1.3950 |
| **Model 65** | 0.0517 | 0.7172 | −0.1787 | — | — | — | — | — | 0.4216 | 1.1725 | 0.2122 | 1.8033 | 13.9613 | 12.1083 | 0.2540 | 0.8808 | 1.7533 |
| **Model 66** | −0.0295 | 1.4497 | −1.4612 | 0.0258 | −0.1178 | — | — | — | 0.1809 | 0.7572 | 0.1094 | 1.1580 | 3.7657 | 7.9643 | 0.1631 | 0.9495 | 1.1438 |
| **Model 67** | −0.0370 | 1.5374 | −1.5973 | −0.0525 | — | — | — | — | 0.1542 | 0.7795 | 0.1165 | 1.1552 | 3.3799 | 6.7834 | 0.1627 | 0.9494 | 1.1448 |
| **Model 68** | 0.0515 | 0.6465 | 0.1740 | −0.4666 | — | — | — | — | 0.4378 | 1.0743 | 0.1904 | 1.6173 | 11.9323 | 14.1589 | 0.2278 | 0.9105 | 1.5570 |
| **Model 69** | 0.1424 | 0.9860 | −0.2596 | — | — | — | — | — | 0.4383 | 1.5847 | 0.3476 | 2.2353 | 22.6523 | 10.0676 | 0.3148 | 0.8081 | 2.1919 |
| **Model 70** | 0.0446 | 0.7260 | −0.2845 | — | — | — | — | — | 0.4805 | 1.0530 | 0.1853 | 1.6389 | 12.7273 | 15.4403 | 0.2308 | 0.9080 | 1.5669 |
| **Model 71** | 0.1538 | 0.6645 | −0.0354 | — | — | — | — | — | 0.1829 | 1.8155 | 0.3914 | 2.4253 | 22.0775 | 3.8077 | 0.3416 | 0.7553 | 2.4184 |
| **Model 72** | 0.1772 | 1.2267 | −0.2330 | — | — | — | — | — | 0.2886 | 1.9573 | 0.4490 | 2.5782 | 27.6842 | 5.6706 | 0.3631 | 0.7192 | 2.5620 |
| **Model 73** | 0.3619 | 0.1074 | −0.0185 | — | — | — | — | — | 1.5858 | 1.9373 | 0.2495 | 2.5014 | 22.3022 | 30.3857 | 0.2673 | 0.7576 | 1.9345 |
| **Model 74** | −0.3051 | 0.5166 | −0.1346 | — | — | — | — | — | 0.4595 | 1.2923 | 0.2504 | 1.9510 | 16.7154 | 12.2006 | 0.2748 | 0.8605 | 1.8961 |
| **Model 75** | 0.3972 | 0.1573 | −0.0027 | — | — | — | — | — | **−0.0089** | 1.9200 | 0.4278 | 2.4077 | 22.9653 | **0.1861** | 0.3391 | 0.7508 | 2.4076 |
| **Model 76** | 0.3453 | 0.6109 | −0.6616 | −0.0022 | — | — | — | — | 0.0691 | 1.5542 | 0.3529 | 1.9772 | 18.7698 | 1.7609 | 0.2785 | 0.8402 | 1.9760 |
| **Model 77** | 0.1613 | 0.1884 | 0.0018 | — | — | — | — | — | −0.1298 | 2.0161 | 0.4504 | 2.5095 | 21.8077 | 2.6086 | 0.3535 | 0.7261 | 2.5061 |
| **Model 78** | 0.1461 | 0.6502 | −0.6804 | 0.0015 | — | — | — | — | −0.0332 | 1.6335 | 0.3728 | 2.0657 | 17.6888 | 0.8087 | 0.2909 | 0.8240 | 2.0654 |
| **Model 79** | 0.5681 | 0.0027 | −0.0047 | — | — | — | — | — | 0.3304 | 2.1139 | 0.5044 | 2.6385 | 31.6868 | 6.3556 | 0.3716 | 0.6969 | 2.6177 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.9377 | −0.5333 | −0.3208 | 0.1451 | — | — | — | — | 0.3195 | 0.8260 | 0.1138 | 1.3555 | 6.5991 | 12.2116 | 0.1909 | 0.9344 | 1.3173 |
| **Model 81** | 1.0801 | −0.5465 | −0.3188 | 0.0004 | — | — | — | — | 0.3252 | 0.8266 | 0.1138 | 1.3607 | 6.5288 | 12.3924 | 0.1916 | 0.9346 | 1.3212 |
| **Model 82** | 1.1678 | −1.0166 | 0.0016 | −0.0005 | — | — | — | — | 0.1979 | 0.9043 | 0.1266 | 1.4070 | 5.3743 | 7.1534 | 0.1982 | 0.9258 | 1.3930 |
| **Model 83** | 0.4512 | −0.1498 | 0.0519 | 0.0011 | −0.0008 | — | — | — | 1.2023 | 1.7634 | 0.2188 | 2.3113 | 17.2648 | 30.6652 | 0.2470 | 0.7542 | 1.9740 |
| **Model 84** | 0.3367 | 0.5969 | −0.6495 | 0.0016 | −0.0023 | — | — | — | 0.1554 | 1.5587 | 0.3568 | 1.9854 | 19.2348 | 3.9520 | 0.2796 | 0.8401 | 1.9794 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | 13.3697 | −0.5383 | −0.3181 | 0.1461 | -14.4548 | — | — | — | 0.3978 | 0.8409 | 0.1178 | 1.3968 | 7.6782 | 14.9582 | 0.1967 | 0.9332 | 1.3390 |
| **Model 86** | 1.1591 | −1.0176 | 0.0014 | −0.0004 | 0.0124 | — | — | — | 0.1971 | 0.9048 | 0.1267 | 1.4073 | 5.3532 | 7.1232 | 0.1982 | 0.9258 | 1.3934 |
| **Model 87** | 1.1591 | −1.0176 | 0.0124 | 0.0014 | −0.0004 | — | — | — | 0.1971 | 0.9048 | 0.1267 | 1.4073 | 5.3532 | 7.1232 | 0.1982 | 0.9258 | 1.3934 |
| **Model 88** | 1.0618 | −0.5270 | −0.3224 | 0.0001 | 0.0002 | — | — | — | 0.3025 | 0.8204 | 0.1118 | 1.3488 | 6.2866 | 11.5001 | 0.1895 | 0.9352 | 1.3144 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0628 | −0.5430 | −0.3183 | 0.0011 | 0.0001 | — | — | — | 0.2109 | 0.8160 | 0.1099 | 1.3157 | 4.9243 | 8.1743 | 0.1853 | 0.9358 | 1.2987 |
| **Model 90** | 1.0789 | 0.0112 | −2.0132 | 9.6575 | −0.5479 | 0.0011 | −0.0001 | −0.3192 | 0.3356 | 0.8181 | 0.1133 | 1.3552 | 6.6304 | 12.8672 | 0.1909 | 0.9356 | 1.3130 |
| **Model 91** | 0.8098 | 0.0087 | 2.0884 | −0.6438 | −0.5692 | −0.0001 | 0.0021 | — | 0.5429 | 0.9033 | 0.1232 | 1.6021 | 8.3502 | 18.1336 | 0.2256 | 0.9233 | 1.5073 |
| **Model 92** | 1.1874 | −0.0105 | −1.6912 | 5.4711 | −1.0217 | 0.0016 | −0.0007 | — | 0.2003 | 0.8966 | 0.1260 | 1.3992 | 5.4197 | 7.2816 | 0.1971 | 0.9266 | 1.3848 |
| **Model 93** | 1.1317 | −0.0037 | 0.0047 | 1.8236 | −1.0030 | 0.0015 | — | — | 0.1903 | 0.9096 | 0.1273 | 1.4123 | 5.2858 | 6.8461 | 0.1989 | 0.9251 | 1.3994 |
| **Model 94** | 1.2212 | −0.0187 | 1.2237 | 0.0327 | −1.0284 | −0.0009 | — | — | 0.1913 | 0.8979 | 0.1260 | 1.4027 | 5.3481 | 6.9310 | 0.1976 | 0.9260 | 1.3896 |
| **Model 95** | 1.1436 | −0.0156 | 1.1990 | 0.2259 | −1.0028 | — | — | — | 0.1782 | 0.9097 | 0.1273 | 1.4140 | 5.1864 | 6.3966 | 0.1992 | 0.9245 | 1.4027 |
| **Model 96** | 0.8514 | 0.0562 | 1.0791 | 1.7680 | — | — | — | — | 1.2311 | 1.9258 | 0.2637 | 3.3672 | 14.5238 | 19.7767 | 0.4743 | 0.8089 | 3.1341 |
| **Model 97** | 1.1369 | −0.0105 | 0.9350 | −1.0039 | 0.0006 | — | — | — | 0.1836 | 0.9103 | 0.1274 | 1.4137 | 5.2229 | 6.5938 | 0.1991 | 0.9248 | 1.4018 |

**Table A3**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Ejinaqi station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| Model 1 | 1.4243 | −1.6693 | — | — | — | — | — | — | −0.8194 | 1.7366 | 0.3381 | 2.4050 | −1.1852 | 18.3150 | 0.3906 | 0.7677 | 2.2559 |
| **Model 2** | 1.1486 | −0.5308 | −1.0612 | — | — | — | — | — | −0.8682 | 1.7856 | 0.3431 | 2.4853 | −4.9368 | 18.8414 | 0.4036 | 0.7643 | 2.3233 |
| **Model 3** | 0.7476 | 2.5825 | −7.9205 | 4.5846 | — | — | — | — | −0.7984 | 1.7307 | 0.3171 | 2.4064 | −3.7625 | 17.7731 | 0.3908 | 0.7719 | 2.2645 |
| **Model 4** | 1.1665 | −2.4767 | 11.1612 | -23.9500 | 14.7924 | — | — | — | −0.7513 | 1.7047 | 0.3234 | 2.3626 | −1.5880 | 16.9515 | 0.3837 | 0.7776 | 2.2345 |
| **Model 5** | 0.8888 | 2.3559 | -16.5584 | 45.8306 | -65.2356 | 34.2412 | — | — | −0.7298 | 1.6965 | 0.3174 | 2.3425 | −1.7641 | 16.5689 | 0.3804 | 0.7803 | 2.2204 |
| **Model 6** | 0.3469 | 0.0000 | — | — | — | — | — | — | 0.0492 | 2.9656 | 0.6198 | 3.6752 | 29.1590 | 0.6702 | 0.5969 | 0.2898 | 3.6533 |
| **Model 7** | 3.2133 | −2.7337 | — | — | — | — | — | — | −0.8858 | 1.8125 | 0.3525 | 2.5310 | −5.5328 | 18.8810 | 0.4110 | 0.7583 | 2.3654 |
| **Model 8** | 0.2424 | 0.7748 | — | — | — | — | — | — | −0.1090 | 2.3897 | 0.7171 | 3.0109 | 43.8403 | 1.8299 | 0.4890 | 0.5283 | 3.0018 |
| **Model 9** | −0.0405 | 1.0328 | −4.8880 | 8.3796 | — | — | — | — | −0.7784 | 1.7234 | 0.3214 | 2.3964 | −2.7812 | 17.3567 | 0.3892 | 0.7733 | 2.2610 |
| **Model 10** | −5.0411 | 8.8393 | — | — | — | — | — | — | −0.7437 | 1.7137 | 0.3207 | 2.3850 | −1.6893 | 16.5862 | 0.3873 | 0.7721 | 2.2605 |
| **Model 11** | 0.0938 | 0.1503 | — | — | — | — | — | — | −0.3184 | 2.4133 | 0.8749 | 3.0502 | 56.7491 | 5.3050 | 0.4954 | 0.5116 | 3.0299 |
| **Model 12** | 0.0363 | −1.8604 | — | — | — | — | — | — | −0.2938 | 2.2492 | 0.4761 | 2.8550 | 18.7566 | 5.2285 | 0.4637 | 0.5884 | 2.8318 |
| **Model 13** | 1.9675 | −2.7657 | — | — | — | — | — | — | −0.4197 | 1.9297 | 0.4245 | 2.5242 | 15.0097 | 8.5220 | 0.4099 | 0.7027 | 2.4824 |
| **Model 14** | 0.0144 | −0.7121 | — | — | — | — | — | — | −3.6501 | 3.6772 | 0.5671 | 4.5860 | -48.3798 | 66.4403 | 0.7448 | 0.7310 | 2.7840 |
| **Model 15** | 2.2071 | −0.9683 | — | — | — | — | — | — | −0.8623 | 1.7741 | 0.3426 | 2.4673 | −4.1651 | 18.8523 | 0.4007 | 0.7650 | 2.3063 |
| **Model 16** | 1.0450 | −0.9143 | — | — | — | — | — | — | −0.1090 | 1.9812 | 0.3773 | 2.6842 | 12.6300 | 2.0542 | 0.4359 | 0.6742 | 2.6742 |
| **Model 17** | 0.9529 | −0.4086 | −0.4654 | — | — | — | — | — | −0.0262 | 1.9772 | 0.3752 | 2.7149 | 12.5466 | 0.4876 | 0.4409 | 0.6825 | 2.7068 |
| **Model 18** | 0.9728 | −0.7714 | 0.4413 | −0.5898 | — | — | — | — | −0.0140 | 1.9800 | 0.3773 | 2.7095 | 12.7147 | 0.2605 | 0.4400 | 0.6838 | 2.7015 |
| **Model 19** | 0.9569 | −0.9143 | — | — | — | — | — | — | −0.1091 | 1.9812 | 0.3773 | 2.6842 | 12.6291 | 2.0550 | 0.4359 | 0.6742 | 2.6742 |
| **Model 20** | −0.8200 | −1.6428 | −0.8972 | — | — | — | — | — | −1.3977 | 2.4550 | 0.4140 | 3.2703 | −4.5355 | 23.5664 | 0.5314 | 0.5415 | 2.9497 |
| **Model 21** | 0.9201 | 2.7823 | — | — | — | — | — | — | −0.0194 | 2.3021 | 0.4749 | 2.9591 | 21.7593 | 0.3316 | 0.4806 | 0.5584 | 2.9504 |
| **Model 22** | 2.6560 | −1.5823 | — | — | — | — | — | — | −0.0333 | 1.9738 | 0.3751 | 2.7054 | 12.5445 | 0.6218 | 0.4394 | 0.6828 | 2.6972 |
| **Model 23** | 0.2120 | −0.4010 | — | — | — | — | — | — | −1.3977 | 2.4550 | 0.4140 | 3.2703 | −4.5355 | 23.5664 | 0.5314 | 0.5415 | 2.9497 |
| **Model 24** | 1.4809 | −0.5175 | — | — | — | — | — | — | −0.0277 | 1.9757 | 0.3753 | 2.7098 | 12.5761 | 0.5161 | 0.4401 | 0.6828 | 2.7017 |
| **Model 25** | −0.0033 | −1.4584 | — | — | — | — | — | — | −0.1604 | 2.1283 | 0.4258 | 2.7838 | 16.6618 | 2.9173 | 0.4521 | 0.6191 | 2.7711 |
| **Model 26** | 0.4578 | −0.4037 | — | — | — | — | — | — | −0.7033 | 2.0141 | 1.5412 | 2.7458 | 120.4312 | 13.3902 | 0.4459 | 0.6461 | 2.6969 |
| **Model 27** | 1.4042 | 0.8443 | — | — | — | — | — | — | −0.8353 | 1.7472 | 0.3277 | 2.4305 | −3.9098 | 18.4961 | 0.3947 | 0.7691 | 2.2770 |
| **Model 28** | −0.0491 | 1.6887 | −1.9503 | — | — | — | — | — | −0.8396 | 1.7634 | 0.3974 | 2.4465 | -15.1526 | 18.4656 | 0.3973 | 0.7676 | 2.2914 |
| **Model 29** | −0.1808 | 2.7118 | −4.2044 | 1.5066 | — | — | — | — | −0.8155 | 1.7641 | 0.7132 | 2.4364 | -46.2508 | 17.9517 | 0.3957 | 0.7692 | 2.2909 |
| **Model 30** | 0.1623 | −1.4329 | 11.4285 | -21.8706 | 12.1188 | — | — | — | −0.7460 | 1.7259 | 0.6837 | 2.3830 | 34.2135 | 16.6585 | 0.3870 | 0.7702 | 2.2661 |
| **Model 31** | −0.1371 | 0.1332 | — | — | — | — | — | — | −0.6627 | 2.1510 | 2.3693 | 2.9254 | 203.3303 | 11.7542 | 0.4751 | 0.5530 | 2.9542 |
| **Model 32** | 0.4574 | −1.3181 | — | — | — | — | — | — | −0.6558 | 2.0788 | 1.5576 | 2.7796 | 122.9519 | 12.2703 | 0.4514 | 0.6233 | 2.7416 |
| **Model 33** | 0.1660 | −0.3659 | — | — | — | — | — | — | −0.6249 | 2.2250 | 2.7000 | 3.0019 | 236.6286 | 10.7563 | 0.4875 | 0.5041 | 3.0644 |
| **Model 34** | 0.0168 | 0.1690 | — | — | — | — | — | — | −0.5627 | 2.3839 | 5.0013 | 3.5605 | 465.9730 | 8.0884 | 0.5782 | 0.2777 | 3.8698 |
| **Model 35** | 0.1332 | −0.1371 | — | — | — | — | — | — | −1.6924 | 2.4376 | 1.4395 | 3.2648 | 92.7843 | 30.6348 | 0.5302 | 0.5881 | 2.8349 |
| **Model 36** | 0.6784 | −0.2505 | — | — | — | — | — | — | −0.7196 | 1.9728 | 1.4560 | 2.6997 | 111.6087 | 13.9771 | 0.4384 | 0.6660 | 2.6406 |
| **Model 37** | −0.5442 | −0.4663 | — | — | — | — | — | — | −0.6969 | 2.0348 | 1.5416 | 2.7547 | 120.7453 | 13.2156 | 0.4474 | 0.6388 | 2.7069 |
| **Model 38** | 0.3629 | −0.2171 | — | — | — | — | — | — | −0.5091 | 2.0387 | 0.9036 | 2.7229 | 59.8038 | 9.6186 | 0.4422 | 0.6509 | 2.6761 |
| **Model 39** | 0.2291 | 0.5175 | −0.6761 | — | — | — | — | — | −0.3233 | 1.8781 | 0.9464 | 2.5139 | 66.7013 | 6.5545 | 0.4083 | 0.7146 | 2.4943 |
| **Model 40** | 0.2426 | 0.2708 | −0.0595 | −0.4010 | — | — | — | — | −0.3155 | 1.8688 | 0.9559 | 2.4982 | 67.7417 | 6.4342 | 0.4057 | 0.7171 | 2.4796 |
| **Model 41** | 0.1642 | −0.1091 | — | — | — | — | — | — | −1.1507 | 2.2190 | 0.8647 | 2.9546 | 46.1733 | 21.0786 | 0.4801 | 0.6318 | 2.7263 |
| **Model 42** | 0.3485 | −0.7610 | — | — | — | — | — | — | −0.5395 | 2.0792 | 0.9075 | 2.7511 | 59.7854 | 10.1061 | 0.4468 | 0.6381 | 2.6995 |
| **Model 43** | 0.4722 | 0.0819 | −0.3881 | — | — | — | — | — | 0.1002 | 1.9803 | 1.0207 | 2.6947 | 78.4449 | 1.8552 | 0.4379 | 0.7023 | 2.6909 |
| **Model 44** | 0.4907 | −0.1339 | — | — | — | — | — | — | −1.0515 | 1.9690 | 0.3015 | 2.6567 | −6.3273 | 21.7803 | 0.4315 | 0.6689 | 2.6286 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.3778 | −1.6626 | 0.0589 | — | — | — | — | — | −0.7418 | 1.7494 | 0.3435 | 2.4035 | −0.7401 | 16.3981 | 0.3903 | 0.7664 | 2.2806 |
| **Model 46** | −0.3407 | 0.7471 | — | — | — | — | — | — | 0.2614 | 3.3316 | 0.6816 | 4.1752 | 15.7836 | 3.1697 | 0.6781 | 0.4929 | 4.1547 |
| **Model 47** | 1.4152 | −1.6551 | 0.0388 | — | — | — | — | — | −0.6722 | 1.6735 | 0.3272 | 2.3178 | −1.3686 | 15.3134 | 0.3764 | 0.7854 | 2.2128 |
| **Model 48** | 0.0997 | 0.9306 | −3.0322 | 4.6268 | 1.5905 | −0.5721 | 0.2108 | — | −0.6701 | 1.7029 | 0.3229 | 2.3527 | −1.9585 | 15.0175 | 0.3821 | 0.7813 | 2.2495 |
| **Model 49** | 1.4200 | −1.6629 | 0.0006 | — | — | — | — | — | −0.7512 | 1.7503 | 0.3431 | 2.4068 | −0.8065 | 16.6042 | 0.3909 | 0.7660 | 2.2810 |
| **Model 50** | -42.9376 | -28.7534 | -53.9446 | -35.7851 | — | — | — | — | −0.5924 | 1.8912 | 0.3984 | 2.5082 | 8.0027 | 12.2834 | 0.4073 | 0.7190 | 2.4310 |
| **Model 51** | −5.1761 | 0.1490 | -466.17287 | — | — | — | — | — | −0.2063 | 2.4633 | 0.8815 | 3.1069 | 56.9516 | 3.3639 | 0.5046 | 0.5077 | 3.0956 |
| **Model 52** | 1.4986 | −1.7031 | −0.0016 | — | — | — | — | — | −0.6439 | 1.6744 | 0.3341 | 2.3193 | 0.5937 | 14.6053 | 0.3767 | 0.7799 | 2.2226 |

(*continued on next page*)

**Table A3** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.3607 | −1.2884 | −0.2387 | — | — | — | — | — | −0.6627 | 1.6933 | 0.3237 | 2.3413 | 1.4151 | 14.9133 | 0.3802 | 0.7705 | 2.2399 |
| **Model 54** | 1.0141 | 0.1341 | −1.2187 | −0.2535 | −0.0523 | — | — | — | −0.6622 | 1.7185 | 0.3173 | 2.3947 | −2.1143 | 14.5411 | 0.3889 | 0.7708 | 2.2954 |
| **Model 55** | 0.6741 | 3.1710 | −8.2995 | 4.7753 | −0.8932 | 1.7755 | −1.1929 | — | −0.6166 | 1.6615 | **0.3001** | 2.3021 | −1.2304 | 14.0484 | 0.3739 | 0.7826 | 2.2121 |
| **Model 56** | 0.9988 | 0.2428 | −1.3155 | −0.3138 | — | — | — | — | −0.6739 | 1.7216 | 0.3171 | 2.4006 | −2.4185 | 14.7802 | 0.3899 | 0.7702 | 2.2981 |
| **Model 57** | 1.2753 | −1.2580 | 0.1732 | −0.3937 | — | — | — | — | −0.5796 | 1.6871 | 0.3225 | 2.3360 | 1.6070 | 12.9446 | 0.3794 | 0.7728 | 2.2570 |
| **Model 58** | 0.9977 | −1.1379 | −0.2510 | — | — | — | — | — | −0.6412 | 1.7277 | 0.3215 | 2.4015 | −2.0424 | 14.0005 | 0.3900 | 0.7716 | 2.3083 |
| **Model 59** | 1.2875 | −1.1873 | −0.2760 | — | — | — | — | — | −0.5716 | 1.6854 | 0.3211 | 2.3325 | 2.0950 | 12.7740 | 0.3788 | 0.7711 | 2.2555 |
| **Model 60** | 1.0565 | −1.1343 | −0.2867 | — | — | — | — | — | −0.6861 | 1.7166 | 0.3181 | 2.3915 | −2.1696 | 15.1348 | 0.3884 | 0.7710 | 2.2851 |
| **Model 61** | 0.8534 | −1.2162 | −0.2728 | — | — | — | — | — | −0.6088 | 1.8038 | 0.3388 | 2.4978 | −3.2650 | 12.7006 | 0.4057 | 0.7642 | 2.4160 |
| **Model 62** | −0.0728 | −0.9173 | −0.0026 | — | — | — | — | — | −4.5906 | 4.5949 | 0.7696 | 5.3677 | -67.9833 | 82.2609 | 0.8723 | 0.7316 | 2.7990 |
| **Model 63** | 2.0589 | −0.7103 | −0.1586 | — | — | — | — | — | −0.6435 | 1.6976 | 0.3191 | 2.3581 | −0.3855 | 14.3357 | 0.3830 | 0.7726 | 2.2628 |
| **Model 64** | −0.6712 | −1.2496 | −0.7676 | — | — | — | — | — | −0.3957 | 1.8266 | 0.3606 | 2.4492 | 9.5643 | 8.2747 | 0.3978 | 0.7244 | 2.4103 |
| **Model 65** | 0.4491 | −0.3517 | −0.0326 | — | — | — | — | — | −0.6743 | 2.0089 | 1.4574 | 2.7334 | 112.6080 | 12.8643 | 0.4439 | 0.6497 | 2.6845 |
| **Model 66** | −0.0736 | 1.7233 | −1.7718 | 0.0362 | −0.1625 | — | — | — | −0.6573 | 1.7172 | 0.6171 | 2.3820 | -35.0285 | 14.5085 | 0.3868 | 0.7729 | 2.2847 |
| **Model 67** | −0.1211 | 2.0609 | −2.0727 | −0.1510 | — | — | — | — | −0.7135 | 1.7425 | 0.8594 | 2.4135 | -59.8287 | 15.6382 | 0.3920 | 0.7702 | 2.3057 |
| **Model 68** | 0.3062 | −0.3007 | 0.6566 | −0.6589 | — | — | — | — | −0.4694 | 1.8400 | 1.4165 | 2.5002 | 111.6764 | 9.6607 | 0.4061 | 0.7164 | 2.4857 |
| **Model 69** | 0.3748 | −0.2909 | −0.0820 | — | — | — | — | — | −0.6225 | 1.9156 | 1.1945 | 2.6164 | 87.2718 | 12.3789 | 0.4249 | 0.6918 | 2.5609 |
| **Model 70** | 0.3525 | −0.0328 | −0.2124 | — | — | — | — | — | −0.4392 | 1.9541 | 0.9631 | 2.6251 | 66.8981 | 8.5756 | 0.4263 | 0.6824 | 2.5913 |
| **Model 71** | 0.3683 | −0.5342 | 0.0786 | — | — | — | — | — | −0.8113 | 1.9513 | 1.4493 | 2.6750 | 108.7283 | 16.0855 | 0.4344 | 0.6835 | 2.5922 |
| **Model 72** | 0.3477 | −0.3413 | −0.0923 | — | — | — | — | — | −0.6179 | 1.8595 | 1.1265 | 2.5471 | 80.4919 | 12.6373 | 0.4137 | 0.7144 | 2.4878 |
| **Model 73** | 0.0578 | −0.3428 | 0.0398 | — | — | — | — | — | −2.8711 | 3.1241 | 2.4097 | 4.0712 | 158.4769 | 49.5836 | 0.6616 | 0.5021 | 3.0352 |
| **Model 74** | 0.6397 | −0.1831 | −0.0414 | — | — | — | — | — | −0.6399 | 1.9575 | 1.3053 | 2.6693 | 98.0638 | 12.4795 | 0.4335 | 0.6729 | 2.6172 |
| Model 75 | 0.3940 | −0.2242 | −0.0008 | — | — | — | — | — | −0.3702 | 2.0366 | 0.9001 | 2.6857 | 60.2043 | 7.0331 | 0.4362 | 0.6623 | 2.6602 |
| Model 76 | 0.2582 | 0.5065 | −0.6719 | −0.0007 | — | — | — | — | −0.1981 | 1.8783 | 0.9424 | 2.4958 | 67.0289 | 4.0231 | 0.4053 | 0.7226 | 2.4881 |
| Model 77 | 0.3604 | −0.2164 | 0.0002 | — | — | — | — | — | −0.4792 | 2.0517 | 0.8994 | 2.7291 | 59.2156 | 9.0133 | 0.4432 | 0.6501 | 2.6874 |
| Model 78 | 0.2272 | 0.5174 | −0.6755 | 0.0002 | — | — | — | — | −0.2993 | 1.8898 | 0.9428 | 2.5239 | 66.2290 | 6.0360 | 0.4099 | 0.7137 | 2.5068 |
| Model 79 | 0.1991 | 0.0003 | −0.0001 | — | — | — | — | — | −0.6293 | 2.2952 | 0.9341 | 2.9364 | 59.0852 | 11.0877 | 0.4769 | 0.5714 | 2.8701 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.9944 | −1.3021 | −0.2331 | 0.3867 | — | — | — | — | −0.6620 | 1.6769 | 0.3225 | 2.3196 | 1.5411 | 15.0488 | 0.3767 | 0.7744 | 2.2176 |
| **Model 81** | 1.3570 | −1.2850 | −0.2370 | 0.0006 | — | — | — | — | −0.5980 | 1.7143 | 0.3297 | 2.3504 | 1.7618 | 13.2949 | 0.3817 | 0.7679 | 2.2672 |
| **Model 82** | 1.5361 | −1.7217 | −0.0010 | −0.0020 | — | — | — | — | −0.6838 | 1.6084 | 0.3184 | 2.2624 | **0.3077** | 16.0233 | 0.3674 | 0.7914 | 2.1514 |
| **Model 83** | 0.7830 | −0.6536 | 0.1702 | −0.0001 | −0.0007 | — | — | — | 0.6568 | 2.2454 | 1.0959 | 3.1333 | 89.4851 | 10.6875 | 0.5092 | 0.6832 | 3.0579 |
| **Model 84** | 0.2650 | 0.5050 | −0.6720 | −0.0002 | −0.0008 | — | — | — | −0.2109 | 1.8630 | 0.9466 | 2.4791 | 67.7055 | 4.3155 | 0.4026 | 0.7247 | 2.4707 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.3478 | −1.7085 | −0.0042 | −0.0016 | 0.2733 | — | — | — | −0.6726 | 1.5578 | 0.3038 | 2.2081 | −0.8178 | 16.1614 | 0.3586 | 0.8035 | 2.0982 |
| **Model 87** | 1.3478 | −1.7085 | 0.2733 | −0.0042 | −0.0016 | — | — | — | −0.6726 | 1.5578 | 0.3038 | 2.2081 | −0.8178 | 16.1614 | 0.3586 | 0.8035 | 2.0982 |
| **Model 88** | 1.4342 | −1.3460 | −0.2225 | 0.0001 | −0.0015 | — | — | — | −0.5113 | 1.6593 | 0.3253 | 2.2818 | 2.8741 | 11.6091 | 0.3703 | 0.7800 | 2.2179 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.4691 | −1.3834 | −0.2086 | −0.0008 | −0.0019 | — | — | — | −0.5516 | 1.6045 | 0.3135 | 2.2347 | 2.4985 | 12.8717 | 0.3629 | 0.7894 | 2.1599 |
| **Model 90** | 1.4687 | −0.0044 | 16.2738 | -78.3972 | −1.3828 | −0.0008 | −0.0019 | −0.2085 | −0.5488 | 1.6048 | 0.3139 | 2.2327 | 2.5543 | 12.8147 | 0.3626 | 0.7897 | 2.1586 |
| **Model 91** | 1.0674 | 0.0113 | −2.4060 | -13.3035 | −0.9183 | 0.0001 | −0.0006 | — | **−0.0099** | 2.0072 | 0.3871 | 2.6934 | 13.6705 | **0.1865** | 0.4374 | 0.6779 | 2.6855 |
| **Model 92** | 1.4718 | −0.0439 | −1.0803 | −0.0340 | −1.6921 | 0.0004 | −0.0011 | — | −0.6751 | 1.5497 | 0.3038 | 2.1918 | −1.2761 | 16.3627 | 0.3560 | 0.8081 | 2.0802 |
| **Model 93** | 1.3998 | 0.0596 | 1.0952 | 0.1740 | −1.6623 | 0.0018 | — | — | −0.7357 | 1.5901 | 0.3104 | 2.2325 | −2.2294 | 17.6401 | 0.3626 | 0.8032 | 2.1029 |
| **Model 94** | 1.4795 | 0.0406 | 1.0747 | −0.1036 | −1.6936 | −0.0012 | — | — | −0.6756 | **1.5484** | 0.3031 | **2.1914** | −1.2958 | 16.3790 | **0.3559** | **0.8082** | **2.0797** |
| **Model 95** | 1.4199 | 0.0468 | 1.0605 | −0.3106 | −1.6620 | — | — | — | −0.7494 | 1.5931 | 0.3083 | 2.2424 | −2.5046 | 17.9202 | 0.3642 | 0.8020 | 2.1085 |
| **Model 96** | 0.3492 | 0.0605 | 1.0744 | -51.0232 | — | — | — | — | 0.2391 | 2.9766 | 0.6128 | 3.7461 | 28.3646 | 3.2328 | 0.6084 | 0.3883 | 3.7275 |
| **Model 97** | 1.4069 | 0.0517 | 0.3348 | −1.6614 | 0.0013 | — | — | — | −0.7371 | 1.5928 | 0.3094 | 2.2423 | −2.2937 | 17.5906 | 0.3642 | 0.8013 | 2.1127 |

**Table A4**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Geermu station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.4536 | −1.6803 | — | — | — | — | — | — | −0.1006 | 1.3494 | 0.2806 | 1.7436 | 12.8905 | 2.9147 | 0.2627 | 0.8972 | 1.7407 |
| **Model 2** | 1.1552 | −0.5102 | −1.0539 | — | — | — | — | — | −0.0717 | 1.3518 | 0.2837 | 1.7405 | 11.9304 | 2.0788 | 0.2623 | 0.8906 | 1.7390 |
| **Model 3** | 0.5390 | 3.7833 | −9.9204 | 5.6519 | — | — | — | — | −0.0943 | 1.3038 | 0.2641 | 1.7212 | 11.1393 | 2.7658 | 0.2594 | 0.8930 | 1.7186 |
| **Model 4** | 0.8729 | 0.3646 | 1.5434 | −9.9483 | 7.4560 | — | — | — | −0.0992 | 1.3034 | 0.2616 | 1.7224 | 10.7462 | 2.9084 | 0.2596 | 0.8922 | 1.7195 |
| **Model 5** | 1.1910 | −4.0063 | 22.1792 | -53.7222 | 50.3098 | -15.7536 | — | — | −0.1011 | 1.3061 | 0.2606 | 1.7291 | 10.7177 | 2.9531 | 0.2606 | 0.8912 | 1.7261 |
| **Model 6** | 0.3800 | 0.0000 | — | — | — | — | — | — | 0.4002 | 3.4230 | 0.7515 | 4.0836 | 45.1961 | 4.9661 | 0.6154 | 0.2394 | 4.0640 |
| **Model 7** | 3.2217 | −2.6939 | — | — | — | — | — | — | −0.0454 | 1.3854 | 0.2957 | 1.7605 | 12.9567 | 1.3020 | 0.2653 | 0.8884 | 1.7599 |
| **Model 8** | 0.2462 | −0.8969 | — | — | — | — | — | — | 0.3036 | 2.4529 | 0.5541 | 2.9508 | 34.9627 | 5.2156 | 0.4447 | 0.6304 | 2.9352 |
| **Model 9** | −0.0067 | 0.9657 | −5.4682 | 9.2019 | — | — | — | — | −0.0982 | 1.3086 | 0.2610 | 1.7329 | 10.7871 | 2.8629 | 0.2611 | 0.8906 | 1.7302 |
| **Model 10** | −5.1191 | 8.8159 | — | — | — | — | — | — | −0.0763 | 1.3023 | 0.2621 | 1.7315 | 11.4551 | 2.2231 | 0.2609 | 0.8911 | 1.7298 |
| **Model 11** | −0.0145 | 0.2332 | — | — | — | — | — | — | 0.0185 | 2.3120 | 0.5010 | 2.8020 | 28.0521 | 0.3330 | 0.4222 | 0.6820 | 2.8020 |
| **Model 12** | 0.0525 | −1.7970 | — | — | — | — | — | — | 0.1804 | 2.4582 | 0.5460 | 2.9383 | 32.6833 | 3.1013 | 0.4428 | 0.6324 | 2.9328 |
| **Model 13** | 2.1129 | −2.7718 | — | — | — | — | — | — | 0.1257 | 1.8137 | 0.4072 | 2.2354 | 24.8206 | 2.8412 | 0.3369 | 0.8376 | 2.2318 |
| **Model 14** | 0.0073 | −0.7792 | — | — | — | — | — | — | −3.7216 | 3.7340 | 0.4812 | 4.7063 | -47.3770 | 65.1491 | 0.7092 | 0.8752 | 2.8807 |
| **Model 15** | 2.2083 | −0.9569 | — | — | — | — | — | — | −0.0779 | 1.3479 | 0.2827 | 1.7363 | 12.1431 | 2.2652 | 0.2617 | 0.8925 | 1.7346 |
| **Model 16** | 1.0383 | −0.9374 | — | — | — | — | — | — | −0.1286 | 1.6315 | 0.3206 | 2.1768 | 13.0301 | 2.9855 | 0.3280 | 0.8171 | 2.1730 |
| **Model 17** | 0.9606 | −0.5423 | −0.3646 | — | — | — | — | — | −0.1685 | 1.6053 | 0.3054 | 2.1835 | 10.6208 | 3.9027 | 0.3290 | 0.8176 | 2.1770 |
| **Model 18** | 0.9839 | −0.8604 | 0.4143 | −0.5103 | — | — | — | — | −0.1687 | 1.6072 | 0.3065 | 2.1858 | 10.5579 | 3.9027 | 0.3294 | 0.8173 | 2.1792 |
| **Model 19** | 0.9631 | −0.9374 | — | — | — | — | — | — | −0.1776 | 1.6268 | 0.3162 | 2.1806 | 12.0457 | 4.1203 | 0.3286 | 0.8170 | 2.1733 |
| **Model 20** | −0.8708 | −1.4001 | −0.9295 | — | — | — | — | — | −0.1722 | 1.6350 | 0.3111 | 2.2036 | 10.8615 | 3.9061 | 0.3343 | 0.8144 | 2.1968 |
| **Model 21** | 0.8699 | 2.7522 | — | — | — | — | — | — | 0.2010 | 2.3064 | 0.5105 | 2.8252 | 30.1915 | 3.5962 | 0.4257 | 0.6644 | 2.8180 |
| **Model 22** | 2.6081 | −1.5766 | — | — | — | — | — | — | −0.1664 | 1.6102 | 0.3061 | 2.1883 | 10.4813 | 3.8447 | 0.3298 | 0.8171 | 2.1819 |
| **Model 23** | 0.2258 | −0.3358 | — | — | — | — | — | — | −1.3880 | 2.6700 | 0.4493 | 3.3947 | **2.2624** | 22.3299 | 0.5150 | 0.5844 | 3.0980 |
| **Model 24** | 1.4780 | −0.5308 | — | — | — | — | — | — | −0.1647 | 1.6137 | 0.3057 | 2.1931 | 10.3697 | 3.7981 | 0.3305 | 0.8165 | 2.1869 |
| **Model 25** | 0.0137 | −1.5387 | — | — | — | — | — | — | −0.0518 | 2.0024 | 0.4297 | 2.5179 | 22.2288 | 1.0371 | 0.3794 | 0.7507 | 2.5174 |
| **Model 26** | 0.4976 | −0.4461 | — | — | — | — | — | — | −0.1207 | 1.7356 | 0.3322 | 2.3589 | 14.6681 | 2.5844 | 0.3555 | 0.7806 | 2.3558 |
| **Model 27** | 1.4166 | 0.8577 | — | — | — | — | — | — | −0.1086 | 1.3160 | 0.2713 | 1.7233 | 11.5591 | 3.1840 | 0.2597 | 0.8951 | 1.7198 |
| **Model 28** | −0.0454 | 1.6833 | −1.9181 | — | — | — | — | — | −0.0800 | 1.3287 | 0.2753 | 1.7266 | 12.0114 | 2.3382 | 0.2602 | 0.8939 | 1.7248 |
| **Model 29** | −0.3122 | 3.5424 | −5.7573 | 2.4473 | — | — | — | — | −0.0874 | 1.3171 | 0.2669 | 1.7386 | 11.4039 | 2.5376 | 0.2620 | 0.8902 | 1.7364 |
| **Model 30** | 0.0945 | −0.6223 | 8.2082 | -16.5572 | 9.0830 | — | — | — | −0.1011 | 1.3079 | 0.2618 | 1.7279 | 10.7617 | 2.9562 | 0.2604 | 0.8914 | 1.7249 |
| **Model 31** | −0.1753 | 0.1288 | — | — | — | — | — | — | −0.1763 | 1.9404 | 0.3789 | 2.5688 | 16.9387 | 3.4694 | 0.3871 | 0.7334 | 2.5627 |
| **Model 32** | 0.5194 | −1.4179 | — | — | — | — | — | — | −0.1298 | 1.8882 | 0.3743 | 2.4697 | 17.5498 | 2.6541 | 0.3722 | 0.7576 | 2.4663 |
| **Model 33** | 0.1700 | −0.4602 | — | — | — | — | — | — | −0.2007 | 2.0886 | 0.4206 | 2.6410 | 19.6019 | 3.8424 | 0.3980 | 0.7214 | 2.6334 |
| **Model 34** | 0.0380 | 0.1483 | — | — | — | — | — | — | −0.2624 | 2.1893 | 0.4393 | 2.7426 | 19.8202 | 4.8462 | 0.4133 | 0.6964 | 2.7300 |
| **Model 35** | 0.1288 | −0.1753 | — | — | — | — | — | — | −1.6677 | 2.4214 | 0.3636 | 3.1927 | −7.4767 | 30.8901 | 0.4811 | 0.7457 | 2.7225 |
| **Model 36** | 0.7256 | −0.2685 | — | — | — | — | — | — | −0.1040 | 1.6577 | 0.3166 | 2.2603 | 13.9521 | 2.3223 | 0.3406 | 0.8007 | 2.2579 |
| **Model 37** | −0.4975 | −0.5401 | — | — | — | — | — | — | −0.1433 | 1.7943 | 0.3478 | 2.3976 | 15.5445 | 3.0194 | 0.3613 | 0.7728 | 2.3933 |
| **Model 38** | 0.3897 | −0.2522 | — | — | — | — | — | — | −0.1847 | 1.8200 | 0.3438 | 2.4230 | 13.5851 | 3.8563 | 0.3651 | 0.7681 | 2.4159 |
| **Model 39** | 0.2478 | 0.4694 | −0.6658 | — | — | — | — | — | −0.1796 | 1.5201 | 0.2858 | 2.0241 | 9.9502 | 4.4926 | 0.3050 | 0.8450 | 2.0161 |
| **Model 40** | 0.2600 | 0.3021 | −0.2563 | −0.2683 | — | — | — | — | −0.1776 | 1.5218 | 0.2869 | 2.0233 | 9.9827 | 4.4445 | 0.3049 | 0.8451 | 2.0155 |
| **Model 41** | 0.1755 | −0.0856 | — | — | — | — | — | — | −0.9064 | 2.2321 | 0.4016 | 2.8341 | 7.8871 | 16.8243 | 0.4300 | 0.7346 | 2.6852 |
| **Model 42** | 0.3811 | −0.8552 | — | — | — | — | — | — | −0.1763 | 1.9232 | 0.3749 | 2.4975 | 16.1299 | 3.5689 | 0.3764 | 0.7505 | 2.4913 |
| **Model 43** | 0.4488 | 0.0592 | −0.3790 | — | — | — | — | — | 0.2617 | 1.6480 | 0.3156 | 2.1707 | 16.2885 | 6.0526 | 0.3293 | 0.8304 | 2.1549 |
| **Model 44** | 0.5299 | −0.1534 | — | — | — | — | — | — | −0.1737 | 1.7196 | 0.3217 | 2.3108 | 12.2913 | 3.8018 | 0.3482 | 0.7918 | 2.3043 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.3394 | −1.6672 | 0.1366 | — | — | — | — | — | 0.0283 | 1.2747 | 0.2568 | 1.6585 | 12.1585 | 0.8611 | 0.2499 | 0.9013 | 1.6583 |
| **Model 46** | −0.6078 | 0.9560 | — | — | — | — | — | — | 0.5846 | 3.0065 | 0.5929 | 3.8698 | 16.1052 | 7.7069 | 0.5832 | 0.6214 | 3.8254 |
| **Model 47** | 1.4404 | −1.6594 | 0.0501 | — | — | — | — | — | 0.0503 | 1.1884 | 0.2353 | 1.5487 | 10.7879 | 1.6388 | 0.2334 | 0.9138 | 1.5479 |
| **Model 48** | −0.8091 | 1.7587 | −7.6650 | 15.5661 | −8.5526 | 0.1824 | 0.0041 | — | 0.0769 | 1.1995 | **0.2279** | 1.6131 | 9.5137 | 2.4073 | 0.2431 | 0.9041 | 1.6112 |
| **Model 49** | 1.4445 | −1.6665 | 0.0013 | — | — | — | — | — | 0.0179 | 1.2837 | 0.2595 | 1.6676 | 12.2290 | 0.5408 | 0.2513 | 0.9002 | 1.6675 |
| **Model 50** | -79.1989 | -52.3244 | -101.1486 | -66.4431 | — | — | — | — | −0.0027 | 1.5215 | 0.2977 | 2.0032 | 14.5576 | 0.0677 | 0.3019 | 0.8563 | 2.0032 |
| **Model 51** | −7.1482 | 0.2299 | -631.2903 | — | — | — | — | — | 0.1213 | 2.3013 | 0.4923 | 2.8107 | 27.5048 | 2.1788 | 0.4236 | 0.6679 | 2.8081 |
| **Model 52** | 1.5830 | −1.7702 | −0.0023 | — | — | — | — | — | −0.0233 | 1.2863 | 0.2713 | 1.6484 | 13.4530 | 0.7135 | 0.2484 | 0.9097 | 1.6482 |

(*continued on next page*)

**Table A4** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.3496 | −1.1797 | −0.3074 | — | — | — | — | — | −0.1409 | 1.3490 | 0.2730 | 1.7679 | 11.6451 | 4.0313 | 0.2664 | 0.8910 | 1.7622 |
| **Model 54** | 0.9715 | 0.4088 | −1.3858 | −0.4615 | 0.1133 | — | — | — | −0.1101 | 1.3319 | 0.2722 | 1.7484 | 10.6752 | 3.1828 | 0.2635 | 0.8883 | 1.7449 |
| **Model 55** | 0.4306 | 4.6216 | -10.5941 | 5.9653 | −0.9835 | 1.7226 | −1.0917 | — | −0.1231 | 1.2930 | 0.2596 | 1.7142 | 10.1056 | 3.6311 | 0.2583 | 0.8933 | 1.7097 |
| **Model 56** | 1.1221 | −0.4141 | −1.1390 | 0.0013 | — | — | — | — | −0.1992 | 1.3631 | 0.2775 | 1.7690 | 9.2262 | 5.7137 | 0.2666 | 0.8876 | 1.7578 |
| **Model 57** | 1.4500 | −1.6772 | 0.0014 | −0.0001 | — | — | — | — | −0.1118 | 1.3505 | 0.2802 | 1.7462 | 12.7308 | 3.2353 | 0.2631 | 0.8973 | 1.7426 |
| **Model 58** | 1.0133 | −1.5037 | 0.0001 | — | — | — | — | — | −0.1976 | 1.3868 | 0.2830 | 1.7901 | 8.8113 | 5.6015 | 0.2698 | 0.8831 | 1.7792 |
| **Model 59** | 1.4500 | −1.6810 | 0.0000 | — | — | — | — | — | −0.1752 | 1.3507 | 0.2750 | 1.7566 | 11.3420 | 5.0562 | 0.2647 | 0.8962 | 1.7478 |
| **Model 60** | 1.0115 | −1.5024 | 0.0015 | — | — | — | — | — | −0.2003 | 1.3874 | 0.2831 | 1.7902 | 8.8070 | 5.6782 | 0.2698 | 0.8832 | 1.7790 |
| **Model 61** | 0.8402 | −1.2206 | −0.2328 | — | — | — | — | — | −0.0386 | 1.5052 | 0.3101 | 1.8982 | 10.6782 | 1.0259 | 0.2861 | 0.8645 | 1.8978 |
| **Model 62** | −0.0187 | −0.8141 | −0.0304 | — | — | — | — | — | −3.9793 | 3.9806 | 0.5393 | 4.8920 | -53.8563 | 69.7016 | 0.7422 | 0.8799 | 2.8454 |
| **Model 63** | 2.0206 | −0.6655 | −0.1784 | — | — | — | — | — | −0.1224 | 1.3380 | 0.2698 | 1.7560 | 10.4988 | 3.5232 | 0.2646 | 0.8877 | 1.7518 |
| **Model 64** | −0.6542 | −1.1994 | −0.8489 | — | — | — | — | — | −0.1385 | 1.5672 | 0.3246 | 2.0220 | 15.1654 | 3.4619 | 0.3047 | 0.8566 | 2.0172 |
| **Model 65** | 0.4615 | −0.2720 | −0.1069 | — | — | — | — | — | −0.1409 | 1.7482 | 0.3315 | 2.3733 | 13.9727 | 2.9981 | 0.3576 | 0.7780 | 2.3692 |
| **Model 66** | −0.0634 | 1.6768 | −1.6799 | 0.0011 | −0.1462 | — | — | — | −0.1146 | 1.3217 | 0.2652 | 1.7477 | 10.5376 | 3.3126 | 0.2634 | 0.8886 | 1.7439 |
| **Model 67** | −0.1134 | 1.9979 | −1.9688 | −0.1586 | — | — | — | — | −0.1090 | 1.3176 | 0.2672 | 1.7370 | 10.9044 | 3.1704 | 0.2618 | 0.8906 | 1.7336 |
| **Model 68** | 0.3077 | −0.2182 | 0.5739 | −0.6548 | — | — | — | — | −0.1446 | 1.4826 | 0.2795 | 1.9673 | 10.3200 | 3.7156 | 0.2965 | 0.8541 | 1.9620 |
| **Model 69** | 0.3807 | −0.2045 | −0.1477 | — | — | — | — | — | −0.1267 | 1.5965 | 0.2982 | 2.1686 | 11.8649 | 2.9522 | 0.3268 | 0.8187 | 2.1649 |
| **Model 70** | 0.3307 | 0.0592 | −0.2846 | — | — | — | — | — | −0.1784 | 1.6458 | 0.3068 | 2.2093 | 11.1485 | 4.0852 | 0.3329 | 0.8118 | 2.2020 |
| **Model 71** | 0.3959 | −0.5085 | 0.0476 | — | — | — | — | — | −0.0825 | 1.5829 | 0.3046 | 2.1423 | 13.6157 | 1.9440 | 0.3228 | 0.8233 | 2.1407 |
| **Model 72** | 0.3528 | −0.2583 | −0.1457 | — | — | — | — | — | −0.1133 | 1.5123 | 0.2839 | 2.0389 | 11.1590 | 2.8071 | 0.3072 | 0.8416 | 2.0357 |
| **Model 73** | 0.0887 | −0.2892 | 0.0229 | — | — | — | — | — | −2.3146 | 2.6480 | 0.3537 | 3.5428 | -20.9882 | 43.0093 | 0.5375 | 0.7963 | 2.6822 |
| **Model 74** | 0.6380 | −0.1325 | −0.0832 | — | — | — | — | — | −0.1333 | 1.6656 | 0.3128 | 2.2691 | 12.7772 | 2.9686 | 0.3419 | 0.7995 | 2.2652 |
| **Model 75** | 0.4464 | −0.2779 | −0.0012 | — | — | — | — | — | −0.1368 | 1.7758 | 0.3389 | 2.3418 | 13.8702 | 2.9517 | 0.3529 | 0.7845 | 2.3378 |
| **Model 76** | 0.3006 | 0.4395 | −0.6598 | −0.0011 | — | — | — | — | −0.1372 | 1.4848 | 0.2822 | 1.9624 | 10.2213 | 3.5352 | 0.2957 | 0.8547 | 1.9576 |
| **Model 77** | 0.3924 | −0.2534 | −0.0003 | — | — | — | — | — | −0.2135 | 1.8234 | 0.3449 | 2.4270 | 13.5299 | 4.4543 | 0.3657 | 0.7674 | 2.4176 |
| **Model 78** | 0.2475 | 0.4698 | −0.6661 | 0.0000 | — | — | — | — | −0.1775 | 1.5196 | 0.2856 | 2.0237 | 9.9481 | 4.4398 | 0.3050 | 0.8450 | 2.0159 |
| **Model 79** | 0.1772 | 0.0004 | 0.0010 | — | — | — | — | — | −0.3112 | 2.3146 | 0.4699 | 2.8496 | 20.8990 | 5.5396 | 0.4294 | 0.6689 | 2.8326 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.9087 | −1.1940 | −0.3031 | 0.4660 | — | — | — | — | −0.1332 | 1.3395 | 0.2690 | 1.7665 | 11.5721 | 3.8131 | 0.2662 | 0.8922 | 1.7615 |
| **Model 81** | 1.3579 | −1.2424 | −0.2625 | 0.0010 | — | — | — | — | −0.0468 | 1.2981 | 0.2579 | 1.7025 | 11.3314 | 1.3870 | 0.2566 | 0.8954 | 1.7019 |
| **Model 82** | 1.5760 | −1.7668 | 0.0004 | −0.0022 | — | — | — | — | **−0.0003** | 1.2803 | 0.2691 | 1.6424 | 13.4673 | **0.0090** | 0.2475 | 0.9090 | 1.6424 |
| **Model 83** | 0.7376 | −0.6065 | 0.1254 | −0.0004 | −0.0011 | — | — | — | 0.7623 | 1.9318 | 0.3666 | 2.5970 | 24.0399 | 15.3044 | 0.3940 | 0.8039 | 2.4826 |
| **Model 84** | 0.3059 | 0.4336 | −0.6562 | −0.0003 | −0.0012 | — | — | — | −0.1603 | 1.4891 | 0.2841 | 1.9663 | 10.1789 | 4.1257 | 0.2963 | 0.8546 | 1.9597 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.2131 | −1.7197 | −0.0068 | −0.0019 | 0.4754 | — | — | — | 0.0030 | **1.1542** | 0.2308 | **1.4816** | 10.2160 | 0.1031 | **0.2233** | **0.9235** | **1.4816** |
| **Model 87** | 1.2131 | −1.7197 | 0.4754 | −0.0068 | −0.0019 | — | — | — | 0.0030 | 1.1542 | 0.2308 | 1.4816 | 10.2160 | 0.1031 | 0.2233 | 0.9235 | 1.4816 |
| **Model 88** | 1.4800 | −1.2668 | −0.3096 | −0.0001 | −0.0023 | — | — | — | −0.0563 | 1.2876 | 0.2653 | 1.6719 | 12.3897 | 1.6948 | 0.2517 | 0.9039 | 1.6710 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.4800 | −1.2668 | −0.3096 | −0.0001 | −0.0023 | — | — | — | −0.0738 | 1.2866 | 0.2647 | 1.6721 | 12.1317 | 2.2268 | 0.2520 | 0.9041 | 1.6705 |
| **Model 90** | 1.4651 | −0.1076 | −0.7641 | 0.6527 | −1.3153 | −0.0054 | −0.0020 | −0.2543 | −0.0493 | 1.1836 | 0.2335 | 1.5282 | 9.6759 | 1.6268 | 0.2303 | 0.9180 | 1.5274 |
| **Model 91** | 1.0890 | −0.1155 | −0.7199 | 0.6036 | −0.9492 | −0.0066 | −0.0013 | — | −0.1890 | 1.5514 | 0.2968 | 2.0731 | 10.0851 | 4.6164 | 0.3124 | 0.8367 | 2.0644 |
| **Model 92** | 1.5388 | −0.1121 | −0.7661 | 0.6274 | −1.7212 | −0.0051 | −0.0018 | — | 0.0116 | 1.1622 | 0.2325 | 1.4907 | 10.4287 | 0.3938 | 0.2246 | 0.9224 | 1.4907 |
| **Model 93** | 1.4401 | 0.0811 | 0.8355 | 5.6674 | −1.6514 | −0.0030 | — | — | −0.0057 | 1.1858 | 0.2335 | 1.5393 | 10.0951 | 0.1876 | 0.2320 | 0.9159 | 1.5393 |
| **Model 94** | 1.5248 | −0.0446 | 0.9510 | -16.0396 | −1.7214 | −0.0014 | — | — | 0.0571 | 1.1798 | 0.2383 | 1.5162 | 11.2775 | 1.9004 | 0.2285 | 0.9190 | 1.5152 |
| **Model 95** | 1.4597 | 0.0287 | 2.3404 | -14.9542 | −1.6847 | — | — | — | −0.0533 | 1.3131 | 0.2691 | 1.7169 | 12.6468 | 1.5659 | 0.2587 | 0.8992 | 1.7161 |
| **Model 96** | 0.3791 | −0.0750 | 0.9740 | 8.7795 | — | — | — | — | 0.6238 | 3.3538 | 0.7036 | 4.1223 | 41.4979 | 7.7206 | 0.6212 | 0.3582 | 4.0748 |
| **Model 97** | 1.4443 | 0.0543 | 18.2399 | −1.6595 | −0.0006 | — | — | — | 0.0138 | 1.1874 | 0.2361 | 1.5403 | 10.5055 | 0.4520 | 0.2321 | 0.9155 | 1.5403 |

**Table A5**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Guangzhou station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1756 | −1.3144 | — | — | — | — | — | — | −0.8135 | 1.1097 | 0.1282 | 1.5032 | −6.2089 | 32.1355 | 0.1874 | 0.9294 | 1.2640 |
| **Model 2** | 1.0228 | −0.1350 | −1.7361 | — | — | — | — | — | −1.0392 | 1.2179 | 0.1397 | 1.7165 | -11.2963 | 37.9794 | 0.2140 | 0.8958 | 1.3661 |
| **Model 3** | 0.9717 | 0.5766 | −4.1813 | 2.3738 | — | — | — | — | −0.9888 | 1.1684 | 0.1283 | 1.6562 | -10.1564 | 37.1566 | 0.2065 | 0.9046 | 1.3287 |
| **Model 4** | 0.9881 | 0.2374 | −2.2134 | −1.8804 | 3.0622 | — | — | — | −0.9806 | 1.1622 | 0.1267 | 1.6511 | −9.9480 | 36.8596 | 0.2058 | 0.9050 | 1.3284 |
| **Model 5** | 0.9792 | 0.4853 | −4.3165 | 5.5709 | −8.5721 | 6.6168 | — | — | −0.9782 | 1.1603 | 0.1262 | 1.6501 | −9.8761 | 36.7536 | 0.2057 | 0.9051 | 1.3289 |
| **Model 6** | 0.7119 | 0.0000 | — | — | — | — | — | — | 1.0258 | 2.5596 | 0.3846 | 3.4655 | 15.2907 | 15.4735 | 0.4320 | 0.6511 | 3.3101 |
| **Model 7** | 3.0604 | −2.7564 | — | — | — | — | — | — | −0.9889 | 1.1694 | 0.1326 | 1.6085 | −9.7886 | 38.9236 | 0.2005 | 0.9168 | 1.2686 |
| **Model 8** | 0.4888 | −0.2986 | — | — | — | — | — | — | **0.0456** | 1.7267 | 0.2466 | 2.2680 | 5.9406 | **1.0038** | 0.2828 | 0.7272 | 2.2676 |
| **Model 9** | −0.0507 | 1.1017 | −3.4854 | 6.9151 | — | — | — | — | −0.9751 | 1.1601 | 0.1261 | 1.6485 | −9.7792 | 36.6256 | 0.2055 | 0.9052 | 1.3293 |
| **Model 10** | −4.0801 | 8.0970 | — | — | — | — | — | — | −1.0077 | 1.1895 | 0.1311 | 1.6841 | -10.5623 | 37.2879 | 0.2100 | 0.9000 | 1.3493 |
| **Model 11** | 0.5895 | 0.0278 | — | — | — | — | — | — | 0.4003 | 2.1360 | 0.3116 | 2.8239 | 9.8371 | 7.1503 | 0.3521 | 0.6655 | 2.7954 |
| **Model 12** | 0.1914 | −2.0069 | — | — | — | — | — | — | −0.3246 | 1.3225 | 0.1776 | 1.7361 | 0.8257 | 9.5015 | 0.2164 | 0.8311 | 1.7055 |
| **Model 13** | 1.2352 | −1.6577 | — | — | — | — | — | — | −0.4951 | 1.2295 | 0.1603 | 1.6100 | −1.1861 | 16.1384 | 0.2007 | 0.8713 | 1.5319 |
| **Model 14** | 0.3638 | −0.2888 | — | — | — | — | — | — | −2.0514 | 2.5606 | 0.3294 | 2.9501 | -22.4269 | 48.3109 | 0.3678 | 0.7244 | 2.1201 |
| **Model 15** | 2.0638 | −0.9373 | — | — | — | — | — | — | −0.9244 | 1.1218 | 0.1251 | 1.5430 | −8.4969 | 37.3585 | 0.1924 | 0.9267 | 1.2354 |
| **Model 16** | 0.9783 | −0.7421 | — | — | — | — | — | — | −0.4001 | 0.8741 | 0.1037 | 1.3207 | −2.0164 | 15.8725 | 0.1647 | 0.9149 | 1.2587 |
| **Model 17** | 0.9718 | −0.6602 | −0.1030 | — | — | — | — | — | −0.3977 | 0.8599 | 0.1014 | 1.3028 | −2.2850 | 16.0056 | 0.1624 | 0.9164 | 1.2406 |
| **Model 18** | 0.9839 | −1.0912 | 1.3304 | −1.1422 | — | — | — | — | −0.3898 | **0.8245** | 0.0951 | 1.2509 | −2.4682 | 16.3721 | 0.1560 | 0.9234 | 1.1886 |
| **Model 19** | 1.0222 | −0.7421 | — | — | — | — | — | — | −0.4001 | 0.8741 | 0.1037 | 1.3207 | −2.0158 | 15.8709 | 0.1647 | 0.9149 | 1.2587 |
| **Model 20** | −0.7261 | −1.2305 | −0.9291 | — | — | — | — | — | −0.5212 | 1.0857 | 0.1253 | 1.4646 | −2.9919 | 16.8229 | 0.1628 | 0.8421 | 1.3687 |
| **Model 21** | 0.9954 | 1.4956 | — | — | — | — | — | — | −0.2510 | 1.0758 | 0.1396 | 1.5616 | 1.5214 | 8.1320 | 0.1947 | 0.8667 | 1.5413 |
| **Model 22** | 2.6119 | −1.4575 | — | — | — | — | — | — | −0.3820 | 0.8397 | 0.0985 | 1.2755 | −2.6469 | 15.6715 | 0.1590 | 0.9184 | 1.2170 |
| **Model 23** | 0.4364 | −0.1827 | — | — | — | — | — | — | −1.5162 | 2.4060 | 0.2866 | 2.7328 | -11.1839 | 29.4614 | 0.3038 | 0.4912 | 2.2737 |
| **Model 24** | 1.4359 | −0.4821 | — | — | — | — | — | — | −0.3780 | 0.8416 | 0.0986 | 1.2804 | −2.8581 | 15.4259 | 0.1596 | 0.9170 | 1.2234 |
| **Model 25** | −0.0076 | −1.0578 | — | — | — | — | — | — | −0.3521 | 0.9688 | 0.1204 | 1.4303 | −0.4023 | 12.6806 | 0.1783 | 0.8968 | 1.3863 |
| **Model 26** | 0.1319 | 0.2367 | — | — | — | — | — | — | −0.5955 | 1.8528 | 0.3086 | 2.2066 | 6.5943 | 13.9948 | 0.2751 | 0.7365 | 2.1247 |
| **Model 27** | 1.1072 | 0.8161 | — | — | — | — | — | — | −0.9242 | 1.1444 | 0.1234 | 1.6483 | −8.9518 | 33.8095 | 0.2055 | 0.8996 | 1.3649 |
| **Model 28** | −0.0317 | 1.4995 | −1.8589 | — | — | — | — | — | −0.9624 | 1.1697 | 0.1336 | 1.6495 | -10.1787 | 35.8715 | 0.2056 | 0.9037 | 1.3396 |
| **Model 29** | −0.0146 | 1.2615 | −1.0411 | −0.7939 | — | — | — | — | −0.9919 | 1.1768 | 0.1321 | 1.6623 | -10.4274 | 37.1294 | 0.2072 | 0.9034 | 1.3339 |
| **Model 30** | 0.0052 | 0.8501 | 1.3454 | −5.9529 | 3.7135 | — | — | — | −0.9820 | 1.1640 | 0.1275 | 1.6518 | −9.9636 | 36.9177 | 0.2059 | 0.9050 | 1.3281 |
| **Model 31** | 0.0780 | 0.3095 | — | — | — | — | — | — | −0.6087 | 1.5099 | 0.2114 | 1.8736 | **0.3655** | 17.1515 | 0.2336 | 0.8318 | 1.7720 |
| **Model 32** | 0.1559 | 0.8934 | — | — | — | — | — | — | −0.6009 | 1.9522 | 0.3370 | 2.3175 | 8.6206 | 13.4061 | 0.2889 | 0.7065 | 2.2382 |
| **Model 33** | 0.3211 | 0.3470 | — | — | — | — | — | — | −0.5881 | 1.6597 | 0.2602 | 2.0022 | 3.9439 | 15.3426 | 0.2496 | 0.8049 | 1.9139 |
| **Model 34** | −0.0109 | 0.2636 | — | — | — | — | — | — | −0.6629 | 1.6153 | 0.2451 | 1.9726 | −1.8429 | 17.8161 | 0.2459 | 0.8160 | 1.8579 |
| **Model 35** | 0.3095 | 0.0780 | — | — | — | — | — | — | 1.0625 | 1.8831 | 0.4158 | 2.3992 | 34.2080 | 24.6612 | 0.2991 | 0.7351 | 2.1511 |
| **Model 36** | 0.0011 | 0.1486 | — | — | — | — | — | — | −0.5972 | 1.9476 | 0.3322 | 2.3107 | 8.0909 | 13.3573 | 0.2881 | 0.7011 | 2.2322 |
| **Model 37** | −0.8625 | 0.2108 | — | — | — | — | — | — | −0.6001 | 1.8777 | 0.3153 | 2.2333 | 7.0171 | 13.9288 | 0.2784 | 0.7296 | 2.1512 |
| **Model 38** | 0.1907 | 0.0686 | — | — | — | — | — | — | −0.7749 | 2.1399 | 0.3774 | 2.5592 | 9.1184 | 15.8633 | 0.3191 | 0.6297 | 2.4391 |
| **Model 39** | 0.1494 | 0.5918 | −0.6572 | — | — | — | — | — | −0.7972 | 1.6046 | 0.2667 | 2.0060 | 1.1013 | 21.6235 | 0.2501 | 0.8027 | 1.8408 |
| **Model 40** | 0.1447 | 0.7566 | −1.2052 | 0.4367 | — | — | — | — | −0.8118 | 1.6156 | 0.2641 | 2.0108 | 0.6045 | 22.0337 | 0.2507 | 0.8030 | 1.8396 |
| **Model 41** | 0.2400 | 0.0005 | — | — | — | — | — | — | −0.9046 | 1.7580 | 0.2078 | 2.1482 | −4.2667 | 20.5123 | 0.2388 | 0.6439 | 1.9484 |
| **Model 42** | 0.1947 | 0.2732 | — | — | — | — | — | — | −0.7753 | 2.1661 | 0.3839 | 2.5910 | 9.5919 | 15.6577 | 0.3230 | 0.6159 | 2.4723 |
| **Model 43** | 0.3344 | 0.0391 | −0.1841 | — | — | — | — | — | −0.1809 | 1.5791 | 0.1920 | 2.0381 | 2.4388 | 3.9364 | 0.2266 | 0.6314 | 2.0300 |
| **Model 44** | 0.1650 | 0.0336 | — | — | — | — | — | — | −0.7829 | 2.2073 | 0.3922 | 2.6393 | 10.0170 | 15.5092 | 0.3290 | 0.5915 | 2.5205 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1269 | −1.3083 | 0.0526 | — | — | — | — | — | −0.7950 | 1.0933 | 0.1266 | 1.4790 | −6.2112 | 31.8272 | 0.1844 | 0.9283 | 1.2471 |
| **Model 46** | −0.9793 | 1.1785 | — | — | — | — | — | — | −0.3134 | 1.5356 | 0.1990 | 2.0367 | −5.4832 | 7.7760 | 0.2539 | 0.8509 | 2.0124 |
| **Model 47** | 1.1712 | −1.3017 | 0.0090 | — | — | — | — | — | −0.7966 | 1.0946 | 0.1269 | 1.4827 | −6.1634 | 31.8100 | 0.1848 | 0.9285 | 1.2504 |
| **Model 48** | 2.3991 | −2.6339 | −1.7468 | 0.4989 | −3.4570 | 2.0963 | −0.8550 | — | −0.9962 | 1.1650 | 0.1265 | 1.6661 | -10.0354 | 37.2445 | 0.2077 | 0.9053 | 1.3355 |
| **Model 49** | 1.1744 | −1.3112 | 0.0002 | — | — | — | — | — | −0.8026 | 1.1004 | 0.1273 | 1.4893 | −6.2125 | 31.9405 | 0.1857 | 0.9285 | 1.2546 |
| **Model 50** | -23.2508 | -15.7333 | -63.7347 | -41.7668 | — | — | — | — | −0.6014 | 1.1362 | 0.1395 | 1.5158 | −3.7282 | 21.5801 | 0.1890 | 0.8935 | 1.3914 |
| **Model 51** | -21.1286 | 0.0276 | -1920.5179 | — | — | — | — | — | 0.4604 | 2.1174 | 0.3040 | 2.8086 | 9.3846 | 8.2963 | 0.3501 | 0.6974 | 2.7706 |
| **Model 52** | 1.0827 | −1.2628 | 0.0010 | — | — | — | — | — | −0.7431 | 1.0669 | 0.1248 | 1.4486 | −5.4780 | 29.8394 | 0.1806 | 0.9290 | 1.2434 |

(*continued on next page*)

Table A5 (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0310 | −0.3014 | −0.5930 | — | — | — | — | — | −0.5354 | 0.8886 | 0.1019 | 1.3173 | −3.4694 | 22.2115 | 0.1642 | 0.9279 | 1.2036 |
| **Model 54** | 0.9781 | 0.1172 | −0.7958 | −0.5174 | −0.0054 | — | — | — | −0.6725 | 0.8822 | **0.0948** | 1.3418 | −6.1493 | 28.9221 | 0.1673 | 0.9302 | 1.1611 |
| **Model 55** | 1.0028 | −0.2386 | 0.9713 | −1.8750 | −0.9432 | 1.0775 | −0.7791 | — | −0.6905 | 0.8845 | 0.0983 | 1.3345 | −6.9522 | 30.1924 | 0.1664 | 0.9300 | **1.1419** |
| **Model 56** | 0.9775 | 0.1240 | −0.8055 | −0.5217 | — | — | — | — | −0.6737 | 0.8826 | 0.0949 | 1.3426 | −6.1606 | 28.9632 | 0.1674 | 0.9302 | 1.1613 |
| **Model 57** | 1.0296 | −0.3670 | −0.3966 | −0.2059 | — | — | — | — | −0.5601 | 0.8674 | 0.0971 | 1.2947 | −4.3244 | 23.9606 | 0.1614 | 0.9298 | 1.1672 |
| **Model 58** | 0.9685 | −1.0503 | −0.4370 | — | — | — | — | — | −0.7676 | 1.0109 | 0.1184 | 1.4796 | −8.7146 | 30.2985 | 0.1845 | 0.9110 | 1.2649 |
| **Model 59** | 1.0513 | −0.6346 | −0.5187 | — | — | — | — | — | −0.6438 | 0.9074 | 0.1011 | 1.3269 | −6.0771 | 27.7017 | 0.1654 | 0.9274 | 1.1603 |
| **Model 60** | 0.9952 | −0.6507 | −0.5145 | — | — | — | — | — | −0.6660 | 0.8825 | 0.0948 | 1.3355 | −5.8467 | 28.7278 | 0.1665 | 0.9321 | 1.1576 |
| **Model 61** | 0.9163 | −1.9868 | −0.3966 | — | — | — | — | — | −0.8536 | 1.1984 | 0.1582 | 1.8000 | -11.7714 | 26.8954 | 0.2244 | 0.8764 | 1.5848 |
| **Model 62** | 0.2744 | −0.2709 | −0.0984 | — | — | — | — | — | −3.0413 | 3.2578 | 0.3489 | 3.6578 | -29.6530 | 66.1230 | 0.4066 | 0.6061 | 2.0321 |
| **Model 63** | 1.6746 | −0.3155 | −0.3380 | — | — | — | — | — | −0.6150 | 0.8686 | 0.0950 | 1.3041 | −5.4433 | 26.7060 | 0.1626 | 0.9305 | 1.1499 |
| **Model 64** | −0.9497 | −0.3817 | −0.7416 | — | — | — | — | — | −0.5152 | 0.9482 | 0.1131 | 1.3697 | −2.5393 | 20.2672 | 0.1708 | 0.9221 | 1.2691 |
| **Model 65** | 0.0554 | 0.7728 | −0.3138 | — | — | — | — | — | −0.2683 | 1.4469 | 0.2252 | 1.8691 | 6.2403 | 7.2419 | 0.2330 | 0.8053 | 1.8497 |
| **Model 66** | −0.0274 | 1.3657 | −1.2280 | −0.0389 | −0.1742 | — | — | — | −0.6667 | 0.9143 | 0.1057 | 1.3625 | −6.6405 | 28.0146 | 0.1699 | 0.9259 | 1.1882 |
| **Model 67** | −0.0471 | 1.5875 | −1.5428 | −0.1772 | — | — | — | — | −0.7156 | 1.0018 | 0.1223 | 1.4347 | −7.5321 | 28.7328 | 0.1789 | 0.9189 | 1.2435 |
| **Model 68** | 0.0519 | 0.6186 | 0.1475 | −0.4837 | — | — | — | — | −0.3861 | 1.0815 | 0.1581 | 1.4327 | 0.9098 | 13.9721 | 0.1786 | 0.8975 | 1.3797 |
| **Model 69** | 0.1514 | 0.9559 | −0.3637 | — | — | — | — | — | −0.1916 | 1.7010 | 0.3067 | 2.1128 | 12.1293 | 4.5461 | 0.2634 | 0.7316 | 2.1041 |
| **Model 70** | 0.0439 | 0.7181 | −0.3673 | — | — | — | — | — | −0.3196 | 1.0857 | 0.1587 | 1.4784 | 2.1512 | 11.0550 | 0.1843 | 0.8878 | 1.4434 |
| **Model 71** | 0.1793 | 0.4384 | −0.0847 | — | — | — | — | — | −0.4963 | 2.0959 | 0.3740 | 2.4791 | 12.1653 | 10.2025 | 0.3091 | 0.6217 | 2.4289 |
| **Model 72** | 0.1875 | 1.1026 | −0.3329 | — | — | — | — | — | −0.2528 | 1.9805 | 0.3713 | 2.3932 | 15.2859 | 5.3049 | 0.2984 | 0.6343 | 2.3798 |
| **Model 73** | 0.2931 | 0.0887 | −0.0271 | — | — | — | — | — | 0.1822 | 1.5081 | 0.2054 | 1.8974 | 8.5940 | 4.2612 | 0.2109 | 0.6678 | 1.8886 |
| **Model 74** | −0.2459 | 0.5431 | −0.2145 | — | — | — | — | — | −0.2009 | 1.4907 | 0.2450 | 1.9183 | 8.3163 | 5.2585 | 0.2392 | 0.7882 | 1.9078 |
| **Model 75** | 0.2141 | 0.0615 | −0.0003 | — | — | — | — | — | −0.8074 | 2.1504 | 0.3761 | 2.5654 | 8.6133 | 16.5568 | 0.3198 | 0.6365 | 2.4350 |
| **Model 76** | 0.2408 | 0.5882 | −0.6886 | −0.0011 | — | — | — | — | −0.9200 | 1.6468 | 0.2620 | 2.0460 | −1.1698 | 25.1374 | 0.2551 | 0.8069 | 1.8275 |
| **Model 77** | 0.1124 | 0.0609 | 0.0036 | — | — | — | — | — | −0.7513 | 2.0057 | 0.3445 | 2.4526 | 6.0439 | 16.0674 | 0.3058 | 0.6483 | 2.3347 |
| **Model 78** | 0.1331 | 0.5688 | −0.6305 | 0.0008 | — | — | — | — | −0.7901 | 1.5968 | 0.2643 | 1.9938 | 0.7361 | 21.5509 | 0.2486 | 0.8038 | 1.8306 |
| **Model 79** | 0.2332 | 0.0049 | −0.0018 | — | — | — | — | — | −0.9607 | 2.0711 | 0.3347 | 2.5146 | 2.0248 | 20.6400 | 0.3135 | 0.6524 | 2.3239 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.7575 | −0.2985 | −0.5914 | 0.2836 | — | — | — | — | −0.5289 | 0.8828 | 0.1014 | 1.3074 | −3.4495 | 22.0878 | 0.1630 | 0.9289 | 1.1956 |
| **Model 81** | 1.0305 | −0.3002 | −0.5926 | 0.0001 | — | — | — | — | −0.5297 | 0.8832 | 0.1014 | 1.3077 | −3.4731 | 22.1183 | 0.1630 | 0.9284 | 1.1956 |
| **Model 82** | 1.0894 | −1.2890 | 0.0013 | 0.0006 | — | — | — | — | −0.7684 | 1.0709 | 0.1240 | 1.4551 | −6.0763 | 31.0508 | 0.1814 | 0.9274 | 1.2357 |
| **Model 83** | 0.4088 | −0.2214 | 0.0545 | 0.0009 | −0.0004 | — | — | — | 0.0906 | 1.7469 | 0.2171 | 2.2683 | 5.9502 | 1.7669 | 0.2522 | 0.5614 | 2.2665 |
| **Model 84** | 0.2350 | 0.5334 | −0.6375 | 0.0019 | −0.0015 | — | — | — | −0.9698 | 1.6554 | 0.2557 | 2.0434 | −3.1811 | 26.9234 | 0.2548 | 0.8108 | 1.7986 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | 92.9953 | −0.3290 | −0.5770 | 0.2777 | -100.3108 | — | — | — | −0.1970 | 0.8265 | 0.1040 | **1.1997** | 0.7824 | 8.3114 | **0.1496** | 0.9258 | 1.1835 |
| **Model 86** | 1.1321 | −1.3002 | 0.0025 | 0.0007 | −0.0775 | — | — | — | −0.7872 | 1.0813 | 0.1245 | 1.4738 | −6.2531 | 31.5420 | 0.1837 | 0.9271 | 1.2460 |
| **Model 87** | 1.1321 | −1.3002 | −0.0775 | 0.0025 | 0.0007 | — | — | — | −0.7872 | 1.0813 | 0.1245 | 1.4738 | −6.2531 | 31.5420 | 0.1837 | 0.9271 | 1.2460 |
| **Model 88** | 1.0110 | −0.2542 | −0.5842 | −0.0300 | 0.0006 | — | — | — | −0.5011 | 0.8533 | 0.0975 | 1.2603 | −3.7141 | 21.6379 | 0.1571 | 0.9304 | 1.1564 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 0.9525 | −0.2757 | −0.5905 | 0.0008 | 0.0007 | — | — | — | −0.4884 | 0.8590 | 0.0991 | 1.2682 | −3.1895 | 20.8378 | 0.1581 | 0.9300 | 1.1703 |
| **Model 90** | 0.8908 | 0.0470 | −0.7474 | 1.1008 | −0.3111 | 0.0049 | 0.0006 | −0.5796 | −0.5506 | 0.8650 | 0.0975 | 1.2852 | −4.0609 | 23.6760 | 0.1602 | **0.9324** | 1.1612 |
| **Model 91** | 0.8079 | 0.0352 | −0.7487 | 1.1425 | −0.7095 | 0.0031 | 0.0013 | — | −0.3689 | 0.8516 | 0.1009 | 1.2737 | −1.8842 | 15.1108 | 0.1588 | 0.9200 | 1.2191 |
| **Model 92** | 0.9860 | −0.0659 | −0.8098 | 4.5493 | −1.3081 | 0.0076 | 0.0004 | — | −0.8484 | 1.0894 | 0.1233 | 1.5042 | −7.2992 | 34.1047 | 0.1875 | 0.9266 | 1.2421 |
| **Model 93** | 1.0158 | 0.0668 | −0.7997 | 7.6668 | −1.3283 | 0.0079 | — | — | −0.8726 | 1.1061 | 0.1249 | 1.5242 | −7.6342 | 34.8608 | 0.1900 | 0.9253 | 1.2498 |
| **Model 94** | 1.0828 | −0.0029 | -84.0547 | 295.4708 | −1.2630 | 0.0010 | — | — | −0.7430 | 1.0673 | 0.1249 | 1.4490 | −5.4751 | 29.8233 | 0.1806 | 0.9289 | 1.2440 |
| **Model 95** | 1.1762 | −0.0089 | −4.1405 | −5.4066 | −1.3157 | — | — | — | −0.8143 | 1.1107 | 0.1282 | 1.5044 | −6.2373 | 32.1385 | 0.1876 | 0.9291 | 1.2650 |
| **Model 96** | 0.7040 | 0.1175 | 0.8064 | 0.2482 | — | — | — | — | 0.9358 | 2.3731 | 0.3452 | 3.2712 | 13.0483 | 14.9066 | 0.4078 | 0.6979 | 3.1345 |
| **Model 97** | 1.0098 | 0.0558 | 1.0641 | −1.3304 | 0.0076 | — | — | — | −0.8761 | 1.1067 | 0.1249 | 1.5243 | −7.6050 | 35.0730 | 0.1900 | 0.9269 | 1.2473 |

**Table A6**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Harbin station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1786 | −1.3658 | — | — | — | — | — | — | −0.6189 | 1.2972 | 0.2333 | 1.8258 | −2.2457 | 18.2119 | 0.3006 | 0.8750 | 1.7793 |
| **Model 2** | 1.2579 | −1.7661 | 0.4375 | — | — | — | — | — | −0.6007 | 1.2942 | 0.2312 | 1.8056 | −1.3332 | 17.8315 | 0.2972 | 0.8814 | 1.7025 |
| **Model 3** | 0.9148 | 1.1829 | −6.5285 | 4.8860 | — | — | — | — | −0.6333 | 1.2390 | 0.2133 | 1.8034 | −2.5471 | 18.9596 | 0.2969 | 0.8821 | 1.7422 |
| **Model 4** | 0.8250 | 2.3409 | -11.0338 | 11.6618 | −3.4509 | — | — | — | −0.6164 | 1.2353 | 0.2134 | 1.7904 | −2.0640 | 18.5340 | 0.2947 | 0.8846 | 1.7308 |
| **Model 5** | 1.0213 | −1.2069 | 9.4553 | -39.2558 | 53.2353 | -23.1461 | — | — | −0.6040 | 1.2381 | 0.2142 | 1.7970 | −1.6910 | 18.0407 | 0.2958 | 0.8823 | 1.7373 |
| **Model 6** | 0.5002 | 0.0000 | — | — | — | — | — | — | 0.4970 | 2.7063 | 0.5667 | 3.4018 | 25.2265 | 7.4654 | 0.5600 | 0.5531 | 3.3852 |
| **Model 7** | 2.7361 | −2.1190 | — | — | — | — | — | — | −0.5478 | 1.3519 | 0.2537 | 1.9243 | −1.3096 | 15.0094 | 0.3168 | 0.8486 | 1.9214 |
| **Model 8** | 0.3229 | −0.5406 | — | — | — | — | — | — | **−0.0156** | 1.9087 | 0.3818 | 2.4337 | 14.2285 | **0.3249** | 0.4006 | 0.7207 | 2.4603 |
| **Model 9** | 0.1752 | 0.8158 | −4.2493 | 9.5797 | — | — | — | — | −0.5952 | 1.2362 | 0.2148 | 1.7893 | −1.5195 | 17.8285 | 0.2946 | 0.8833 | 1.7341 |
| **Model 10** | −3.4604 | 6.9413 | — | — | — | — | — | — | −0.7374 | 1.2849 | 0.2218 | 1.8254 | −5.2518 | 22.3232 | 0.3005 | 0.8827 | 1.7225 |
| **Model 11** | 0.3147 | 0.0747 | — | — | — | — | — | — | 0.0251 | 2.1537 | 0.4318 | 2.7274 | 16.0020 | 0.4651 | 0.4490 | 0.6527 | 2.7494 |
| **Model 12** | 0.1474 | −2.2378 | — | — | — | — | — | — | −0.1596 | 1.6940 | 0.3313 | 2.1714 | 10.0782 | 3.7264 | 0.3575 | 0.7837 | 2.1986 |
| **Model 13** | 1.4526 | −2.2746 | — | — | — | — | — | — | −0.4024 | 1.4083 | 0.2614 | 1.8910 | 4.2847 | 11.0070 | 0.3113 | 0.8582 | 1.8916 |
| **Model 14** | 0.1320 | −0.4743 | — | — | — | — | — | — | −2.6455 | 2.7672 | 0.4069 | 3.6144 | -36.0822 | 54.2963 | 0.5950 | 0.7850 | 2.5010 |
| **Model 15** | 1.8920 | −0.8362 | — | — | — | — | — | — | −0.6223 | 1.3297 | 0.2441 | 1.9027 | −3.0319 | 17.4952 | 0.3132 | 0.8572 | 1.8679 |
| **Model 16** | 0.9042 | −0.7459 | — | — | — | — | — | — | 0.2259 | 1.0923 | 0.2212 | 1.5536 | 11.4741 | 7.4287 | 0.2558 | 0.8977 | 1.5382 |
| **Model 17** | 0.9102 | −0.7923 | 0.0496 | — | — | — | — | — | 0.2163 | 1.0912 | 0.2209 | 1.5546 | 11.4292 | 7.1024 | 0.2559 | 0.8973 | 1.5410 |
| **Model 18** | 0.9149 | −0.8978 | 0.3463 | −0.2102 | — | — | — | — | −0.0567 | 1.0526 | 0.1996 | 1.5341 | 6.1852 | 1.8699 | 0.2525 | 0.8982 | 1.5357 |
| **Model 19** | 1.1059 | −0.7459 | — | — | — | — | — | — | 0.2259 | 1.0923 | 0.2212 | 1.5536 | 11.4748 | 7.4299 | 0.2558 | 0.8977 | 1.5382 |
| **Model 20** | −0.7615 | −0.9107 | −0.9298 | — | — | — | — | — | 0.2458 | 1.2015 | 0.2393 | 1.6314 | 13.1250 | 7.0433 | 0.2593 | 0.8899 | 1.6128 |
| **Model 21** | 1.0356 | 2.2249 | — | — | — | — | — | — | 0.2325 | 1.3333 | 0.2751 | 1.8647 | 15.0736 | 6.3523 | 0.3070 | 0.8475 | 1.8662 |
| **Model 22** | 2.3797 | −1.2697 | — | — | — | — | — | — | 0.2903 | 1.1335 | 0.2303 | 1.5844 | 12.1778 | 9.4215 | 0.2608 | 0.8958 | 1.5583 |
| **Model 23** | 0.2959 | −0.2283 | — | — | — | — | — | — | −1.0554 | 2.0508 | 0.3355 | 2.6611 | −3.8752 | 19.9659 | 0.4230 | 0.7292 | 2.4429 |
| **Model 24** | 1.3034 | −0.4470 | — | — | — | — | — | — | 0.3073 | 1.1489 | 0.2327 | 1.6007 | 12.2081 | 9.8863 | 0.2635 | 0.8946 | 1.5716 |
| **Model 25** | −0.0633 | −1.1866 | — | — | — | — | — | — | 0.1668 | 1.1561 | 0.2355 | 1.6408 | 11.9929 | 5.1657 | 0.2701 | 0.8837 | 1.6406 |
| **Model 26** | 0.2380 | −0.0514 | — | — | — | — | — | — | −0.4873 | 1.6556 | 0.3157 | 2.2182 | 5.7319 | 11.3822 | 0.3652 | 0.7892 | 2.2179 |
| **Model 27** | 0.5988 | 1.0307 | — | — | — | — | — | — | −0.6346 | 1.3055 | 0.2284 | 1.8256 | −1.6821 | 18.7382 | 0.3005 | 0.8834 | 1.7650 |
| **Model 28** | 0.0881 | 0.7046 | −0.8262 | — | — | — | — | — | −0.5660 | 1.3895 | 0.2552 | 1.8806 | 0.9420 | 15.9516 | 0.3096 | 0.8696 | 1.8501 |
| **Model 29** | −0.1128 | 2.4313 | −4.9050 | 2.8609 | — | — | — | — | −0.5950 | 1.2552 | 0.2225 | 1.8071 | −1.9288 | 17.6250 | 0.2975 | 0.8800 | 1.7546 |
| **Model 30** | −0.0620 | 1.7754 | −2.3534 | −0.9766 | 1.9545 | — | — | — | −0.6097 | 1.2416 | 0.2171 | 1.7971 | −2.0978 | 18.2293 | 0.2958 | 0.8829 | 1.7405 |
| **Model 31** | 0.0055 | 0.2168 | — | — | — | — | — | — | −0.4844 | 1.6779 | 0.3184 | 2.2127 | 5.7741 | 11.3408 | 0.3642 | 0.7919 | 2.2052 |
| **Model 32** | 0.2350 | −0.2040 | — | — | — | — | — | — | −0.4858 | 1.6597 | 0.3164 | 2.2188 | 5.7910 | 11.3414 | 0.3653 | 0.7892 | 2.2180 |
| **Model 33** | 0.2159 | 0.0206 | — | — | — | — | — | — | −0.4841 | 1.6779 | 0.3186 | 2.2140 | 5.8016 | 11.3263 | 0.3645 | 0.7915 | 2.2071 |
| **Model 34** | −0.0068 | 0.2294 | — | — | — | — | — | — | −0.4920 | 1.6350 | 0.3008 | 2.1519 | 4.4114 | 11.8711 | 0.3542 | 0.8074 | 2.1344 |
| **Model 35** | 0.2168 | 0.0055 | — | — | — | — | — | — | −0.4200 | 1.6688 | 0.3213 | 2.1988 | 7.0448 | 9.8375 | 0.3620 | 0.7909 | 2.2053 |
| **Model 36** | 0.2834 | −0.0426 | — | — | — | — | — | — | −0.4916 | 1.6393 | 0.3124 | 2.2061 | 5.4949 | 11.5548 | 0.3632 | 0.7921 | 2.2065 |
| **Model 37** | −0.7627 | −0.0507 | — | — | — | — | — | — | −0.4869 | 1.6567 | 0.3159 | 2.2183 | 5.7470 | 11.3721 | 0.3652 | 0.7892 | 2.2180 |
| **Model 38** | 0.2532 | −0.0755 | — | — | — | — | — | — | −0.3584 | 1.5267 | 0.2959 | 2.0938 | 7.2191 | 8.7830 | 0.3447 | 0.8096 | 2.1230 |
| **Model 39** | 0.2028 | 0.3195 | −0.4222 | — | — | — | — | — | −0.2955 | 1.3185 | 0.2566 | 1.7917 | 5.6467 | 8.4516 | 0.2950 | 0.8663 | 1.8097 |
| **Model 40** | 0.1967 | 0.4548 | −0.8030 | 0.2698 | — | — | — | — | −0.3179 | 1.3084 | 0.2529 | 1.7811 | 4.8964 | 9.1690 | 0.2932 | 0.8683 | 1.7954 |
| **Model 41** | 0.1947 | −0.0278 | — | — | — | — | — | — | −0.7762 | 1.6491 | 0.2722 | 2.2335 | **−0.7906** | 17.1284 | 0.3550 | 0.8229 | 2.0943 |
| **Model 42** | 0.2500 | −0.3093 | — | — | — | — | — | — | −0.3711 | 1.5454 | 0.2991 | 2.1086 | 7.1640 | 9.0361 | 0.3471 | 0.8074 | 2.1349 |
| **Model 43** | 0.3262 | 0.0317 | −0.2086 | — | — | — | — | — | 0.1173 | 1.2021 | 0.2271 | 1.6386 | 10.5924 | 3.3160 | 0.2605 | 0.8870 | 1.6344 |
| **Model 44** | 0.3079 | −0.0532 | — | — | — | — | — | — | −0.3306 | 1.4813 | 0.2882 | 2.0457 | 7.3196 | 8.2777 | 0.3368 | 0.8185 | 2.0788 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1016 | −1.3713 | 0.1184 | — | — | — | — | — | −0.4966 | 1.2492 | 0.2302 | 1.7475 | −2.4481 | 14.9831 | 0.2877 | 0.8771 | 1.7285 |
| **Model 46** | −0.4092 | 0.9653 | — | — | — | — | — | — | 0.4997 | 2.6186 | 0.5299 | 3.4811 | 2.9778 | 7.3317 | 0.5731 | 0.7421 | 3.4476 |
| **Model 47** | 1.1851 | −1.3788 | 0.0394 | — | — | — | — | — | −0.5085 | 1.2126 | 0.2182 | 1.7108 | −2.8185 | 15.7342 | 0.2816 | 0.8840 | 1.6876 |
| **Model 48** | 0.2220 | 0.7927 | −3.9694 | 7.0422 | −0.3148 | 0.5206 | −0.0825 | — | −0.4618 | 1.1720 | 0.2083 | 1.6736 | −1.7289 | 14.5123 | 0.2755 | 0.8879 | 1.6415 |
| **Model 49** | 1.1800 | −1.3696 | 0.0015 | — | — | — | — | — | −0.4947 | 1.2470 | 0.2295 | 1.7455 | −2.4802 | 14.9388 | 0.2873 | 0.8773 | 1.7261 |
| **Model 50** | −1.2917 | −1.5520 | -10.4326 | −7.3540 | — | — | — | — | −0.4568 | 1.2967 | 0.2336 | 1.7711 | 0.1156 | 13.4918 | 0.2916 | 0.8749 | 1.7525 |
| **Model 51** | −3.5242 | 0.0745 | -339.4812 | — | — | — | — | — | 0.0992 | 2.1474 | 0.4299 | 2.7360 | 15.9381 | 1.8348 | 0.4504 | 0.6628 | 2.7552 |
| **Model 52** | 1.1315 | −1.3399 | 0.0005 | — | — | — | — | — | −0.5982 | 1.2893 | 0.2325 | 1.8139 | −1.7917 | 17.6580 | 0.2986 | 0.8759 | 1.7741 |

(*continued on next page*)

**Table A6** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0469 | −0.5776 | −0.4797 | — | — | — | — | — | −0.1494 | 0.9474 | 0.1795 | 1.3515 | 4.7608 | 5.6236 | 0.2225 | 0.9266 | 1.3735 |
| **Model 54** | 1.0878 | −0.8374 | 0.2573 | −0.3824 | −0.0899 | — | — | — | −0.1363 | 0.9550 | 0.1810 | 1.3543 | 5.1358 | 5.1140 | 0.2230 | 0.9265 | 1.3765 |
| **Model 55** | 0.9725 | 0.2185 | −2.3658 | 1.8258 | −0.4251 | 0.0883 | −0.1024 | — | −0.1893 | 0.9534 | 0.1778 | 1.3664 | 4.1805 | 7.0694 | 0.2249 | 0.9266 | 1.3881 |
| **Model 56** | 1.0741 | −0.7158 | 0.1428 | −0.4751 | — | — | — | — | −0.1480 | 0.9526 | 0.1804 | 1.3586 | 4.9909 | 5.5405 | 0.2236 | 0.9264 | 1.3805 |
| **Model 57** | 1.0447 | −0.5805 | −0.4555 | −0.0245 | — | — | — | — | −0.1466 | 0.9468 | 0.1795 | 1.3486 | 4.7499 | 5.5263 | 0.2220 | 0.9267 | 1.3706 |
| **Model 58** | 0.8580 | −0.6467 | −0.4678 | — | — | — | — | — | −0.0821 | 1.0456 | 0.2043 | 1.4223 | 4.3286 | 2.9221 | 0.2341 | 0.9133 | 1.4506 |
| **Model 59** | 1.0377 | −0.7787 | −0.3890 | — | — | — | — | — | −0.1964 | 1.0033 | 0.1891 | 1.3791 | 3.2036 | 7.2719 | 0.2270 | 0.9219 | 1.4000 |
| **Model 60** | 0.9275 | −0.4762 | −0.5488 | — | — | — | — | — | −0.0784 | 0.9475 | 0.1837 | 1.3482 | 5.3474 | 2.9453 | 0.2219 | 0.9235 | 1.3707 |
| **Model 61** | 0.7665 | −0.6953 | −0.5215 | — | — | — | — | — | 0.0731 | 1.2165 | 0.2439 | 1.6111 | 6.9640 | 2.2950 | 0.2652 | 0.8905 | 1.6429 |
| **Model 62** | 0.1296 | −0.3668 | −0.1079 | — | — | — | — | — | −2.6240 | 2.7284 | 0.3785 | 3.5681 | -33.7879 | 50.1554 | 0.5672 | 0.8358 | 2.4179 |
| **Model 63** | 1.6182 | −0.3588 | −0.2898 | — | — | — | — | — | −0.1066 | 0.9694 | 0.1867 | 1.3498 | 4.6538 | 4.0056 | 0.2222 | 0.9235 | 1.3746 |
| **Model 64** | −0.8931 | −0.8423 | −0.6179 | — | — | — | — | — | −0.1614 | 0.9822 | 0.1862 | 1.4023 | 5.3982 | 5.8556 | 0.2309 | 0.9230 | 1.4249 |
| **Model 65** | 0.1787 | 0.3037 | −0.2162 | — | — | — | — | — | −0.0946 | 1.3803 | 0.2776 | 1.8564 | 10.7613 | 2.5789 | 0.3056 | 0.8513 | 1.8874 |
| **Model 66** | 0.0233 | 0.9761 | −0.7195 | −0.0370 | −0.2044 | — | — | — | −0.1115 | 0.9999 | 0.1925 | 1.3885 | 6.0863 | 4.0713 | 0.2286 | 0.9225 | 1.4069 |
| **Model 67** | −0.0078 | 1.2526 | −0.9800 | −0.2479 | — | — | — | — | −0.1303 | 0.9800 | 0.1869 | 1.4060 | 5.8168 | 4.7064 | 0.2315 | 0.9208 | 1.4263 |
| **Model 68** | 0.1437 | 0.2579 | 0.1674 | −0.3873 | — | — | — | — | −0.0767 | 1.2266 | 0.2450 | 1.6246 | 8.7842 | 2.3887 | 0.2674 | 0.8889 | 1.6440 |
| **Model 69** | 0.2290 | 0.2161 | −0.1952 | — | — | — | — | — | −0.1095 | 1.3668 | 0.2763 | 1.8503 | 10.3583 | 2.9974 | 0.3046 | 0.8518 | 1.8859 |
| **Model 70** | 0.1463 | 0.3307 | −0.2533 | — | — | — | — | — | −0.0199 | 1.2306 | 0.2493 | 1.6443 | 10.2756 | 0.6104 | 0.2707 | 0.8858 | 1.6622 |
| **Model 71** | 0.2487 | 0.1031 | −0.1189 | — | — | — | — | — | −0.2648 | 1.5088 | 0.2970 | 2.0565 | 8.9558 | 6.5645 | 0.3385 | 0.8145 | 2.0938 |
| **Model 72** | 0.2402 | 0.1544 | −0.1761 | — | — | — | — | — | −0.1597 | 1.3785 | 0.2763 | 1.8809 | 9.5483 | 4.3059 | 0.3096 | 0.8468 | 1.9194 |
| **Model 73** | 0.2096 | 0.0329 | −0.0387 | — | — | — | — | — | −0.5259 | 1.5943 | 0.2778 | 2.1305 | 3.7651 | 12.8762 | 0.3387 | 0.8239 | 2.0646 |
| **Model 74** | 0.1651 | 0.1635 | −0.1252 | — | — | — | — | — | −0.0862 | 1.3736 | 0.2776 | 1.8518 | 10.8733 | 2.3551 | 0.3049 | 0.8516 | 1.8848 |
| **Model 75** | 0.2726 | −0.0817 | −0.0003 | — | — | — | — | — | −0.3671 | 1.5246 | 0.2949 | 2.0900 | 6.9472 | 9.0199 | 0.3441 | 0.8109 | 2.1170 |
| **Model 76** | 0.2263 | 0.3132 | −0.4235 | −0.0003 | — | — | — | — | −0.3058 | 1.3177 | 0.2553 | 1.7867 | 5.3113 | 8.7815 | 0.2941 | 0.8675 | 1.8011 |
| **Model 77** | 0.2523 | −0.0759 | 0.0002 | — | — | — | — | — | −0.3288 | 1.5183 | 0.2958 | 2.0779 | 7.1964 | 8.1002 | 0.3421 | 0.8104 | 2.1113 |
| **Model 78** | 0.2010 | 0.3220 | −0.4255 | 0.0003 | — | — | — | — | −0.2474 | 1.3080 | 0.2560 | 1.7709 | 5.6077 | 7.1322 | 0.2915 | 0.8660 | 1.7949 |
| **Model 79** | 0.1801 | 0.0002 | 0.0005 | — | — | — | — | — | −0.4244 | 1.6493 | 0.3171 | 2.1897 | 6.5649 | 9.9869 | 0.3605 | 0.7914 | 2.1973 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.9304 | −0.5779 | −0.4812 | 0.1224 | — | — | — | — | −0.1473 | 0.9510 | 0.1804 | 1.3581 | 4.8739 | 5.5146 | 0.2236 | 0.9261 | 1.3801 |
| **Model 81** | 1.0491 | −0.5862 | −0.4767 | 0.0014 | — | — | — | — | −0.0349 | 0.9230 | 0.1756 | 1.3200 | 4.4973 | 1.3370 | 0.2173 | 0.9256 | 1.3455 |
| **Model 82** | 1.1183 | −1.3371 | 0.0013 | 0.0006 | — | — | — | — | −0.5115 | 1.2720 | 0.2353 | 1.7799 | −1.9436 | 15.1652 | 0.2930 | 0.8727 | 1.7597 |
| **Model 83** | 0.4493 | −0.3082 | 0.0651 | 0.0004 | −0.0001 | — | — | — | 0.5515 | 1.3630 | 0.2565 | 1.8976 | 16.0455 | 14.0375 | 0.3017 | 0.8685 | 1.8157 |
| **Model 84** | 0.2236 | 0.3159 | −0.4267 | 0.0003 | −0.0003 | — | — | — | −0.2593 | 1.3059 | 0.2546 | 1.7653 | 5.2790 | 7.5067 | 0.2906 | 0.8674 | 1.7858 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 0.9830 | −1.3365 | −0.0012 | 0.0008 | 0.2039 | — | — | — | −0.4566 | 1.2252 | 0.2248 | 1.7117 | −1.7117 | 13.9896 | 0.2818 | 0.8813 | 1.7038 |
| **Model 87** | 0.9830 | −1.3365 | 0.2039 | −0.0012 | 0.0008 | — | — | — | −0.4566 | 1.2252 | 0.2248 | 1.7117 | −1.7117 | 13.9896 | 0.2818 | 0.8813 | 1.7038 |
| **Model 88** | 1.0484 | −0.5783 | −0.4795 | 0.0002 | 0.0000 | — | — | — | −0.1514 | 0.9489 | 0.1795 | 1.3537 | 4.6992 | 5.6816 | 0.2225 | 0.9263 | 1.3498 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0312 | −0.5594 | −0.4898 | 0.0016 | 0.0001 | — | — | — | −0.0336 | 0.9394 | 0.1811 | 1.3413 | 4.6812 | 1.2667 | 0.2208 | 0.9231 | 1.3671 |
| **Model 90** | 0.9968 | −0.0353 | −0.9878 | −0.9701 | −0.5759 | 0.0031 | 0.0005 | −0.4730 | −0.0252 | **0.9168** | **0.1753** | **1.3080** | 4.3403 | 0.9740 | **0.2153** | **0.9270** | **1.3334** |
| **Model 91** | 0.8104 | 0.0349 | 1.1685 | 0.6727 | −0.7285 | 0.0034 | 0.0010 | — | 0.3446 | 1.0708 | 0.2147 | 1.5639 | 11.2800 | 11.4171 | 0.2575 | 0.9028 | 1.5298 |
| **Model 92** | 1.0328 | 0.0640 | 1.0043 | 0.6033 | −1.3119 | 0.0035 | 0.0016 | — | −0.4243 | 1.1735 | 0.2149 | 1.6565 | −2.0492 | 13.3929 | 0.2727 | 0.8883 | 1.6546 |
| **Model 93** | 1.1763 | 0.0373 | 0.8856 | 0.7602 | −1.3817 | 0.0022 | — | — | −0.4984 | 1.2159 | 0.2217 | 1.7158 | −3.0586 | 15.3454 | 0.2825 | 0.8823 | 1.6945 |
| **Model 94** | 1.1327 | 0.0136 | 2.4567 | −2.2756 | −1.3418 | 0.0006 | — | — | −0.5814 | 1.2886 | 0.2322 | 1.8122 | −1.6682 | 17.1199 | 0.2983 | 0.8752 | 1.7804 |
| **Model 95** | 1.1827 | −0.0406 | 0.9273 | 2.4799 | −1.3789 | — | — | — | −0.4927 | 1.2144 | 0.2203 | 1.7082 | −2.7430 | 15.2271 | 0.2812 | 0.8834 | 1.6889 |
| **Model 96** | 0.5097 | −0.0546 | 1.6557 | −0.3745 | — | — | — | — | 0.5822 | 2.6575 | 0.5482 | 3.4041 | 24.0309 | 8.7739 | 0.5604 | 0.5957 | 3.3671 |
| **Model 97** | 1.1759 | 0.0345 | 0.1539 | −1.3803 | 0.0018 | — | — | — | −0.4965 | 1.2152 | 0.2210 | 1.7146 | −3.0445 | 15.2934 | 0.2823 | 0.8824 | 1.6931 |

**Table A7**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Kashi station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.3548 | −1.5653 | — | — | — | — | — | — | −0.3077 | 1.4731 | 0.2230 | 1.9315 | 3.7940 | 8.0595 | 0.2681 | 0.8270 | 1.9068 |
| **Model 2** | 1.2380 | −1.0111 | −0.5799 | — | — | — | — | — | −0.3104 | 1.4140 | 0.2119 | 1.8798 | 2.9313 | 8.3604 | 0.2609 | 0.8356 | 1.8540 |
| **Model 3** | 0.7434 | 3.1015 | -10.2429 | 6.8346 | — | — | — | — | −0.3656 | 1.4246 | 0.2113 | 1.9240 | 2.4359 | 9.6664 | 0.2670 | 0.8289 | 1.8890 |
| **Model 4** | 0.8034 | 2.3556 | −7.3288 | 2.3343 | 2.3949 | — | — | — | −0.3727 | 1.4207 | 0.2103 | 1.9223 | 2.2725 | 9.8688 | 0.2668 | 0.8293 | 1.8858 |
| **Model 5** | 1.1371 | −3.4481 | 26.2591 | -83.0686 | 101.0867 | -42.3714 | — | — | −0.3418 | 1.4512 | 0.2173 | 1.9571 | 3.0660 | 8.8590 | 0.2716 | 0.8206 | 1.9270 |
| **Model 6** | 0.5246 | 0.0000 | — | — | — | — | — | — | 1.1495 | 3.5251 | 0.6340 | 4.5872 | 35.0032 | 12.9271 | 0.6366 | 0.2956 | 4.4408 |
| **Model 7** | 3.1671 | −2.6950 | — | — | — | — | — | — | −0.2391 | 1.4179 | 0.2166 | 1.8764 | 3.5828 | 6.4155 | 0.2604 | 0.8322 | 1.8611 |
| **Model 8** | 0.3408 | −0.6008 | — | — | — | — | — | — | 0.4740 | 2.5870 | 0.4505 | 3.3291 | 22.1775 | 7.1833 | 0.4620 | 0.4644 | 3.2952 |
| **Model 9** | 0.1437 | 0.8779 | −5.1992 | 10.3125 | — | — | — | — | −0.3508 | 1.4567 | 0.2180 | 1.9637 | 2.9597 | 9.0675 | 0.2725 | 0.8194 | 1.9321 |
| **Model 10** | −4.6295 | 8.4060 | — | — | — | — | — | — | −0.4465 | 1.3955 | 0.2015 | 1.8942 | 0.3410 | 12.1129 | 0.2629 | 0.8370 | 1.8409 |
| **Model 11** | 0.2854 | 0.1081 | — | — | — | — | — | — | 0.4603 | 2.7989 | 0.4864 | 3.5930 | 22.8400 | 6.4505 | 0.4986 | 0.4025 | 3.5634 |
| **Model 12** | 0.1727 | −2.0735 | — | — | — | — | — | — | 0.4057 | 2.4572 | 0.4253 | 3.1418 | 20.1832 | 6.5030 | 0.4360 | 0.5112 | 3.1155 |
| **Model 13** | 1.6716 | −2.2905 | — | — | — | — | — | — | **0.0024** | 1.9320 | 0.3198 | 2.4550 | 11.9489 | **0.0480** | 0.3407 | 0.6820 | 2.4550 |
| **Model 14** | 0.1216 | −0.5803 | — | — | — | — | — | — | −3.0339 | 3.3069 | 0.4222 | 4.1021 | -34.5248 | 54.8756 | 0.5693 | 0.5822 | 2.7610 |
| **Model 15** | 2.1703 | −0.9571 | — | — | — | — | — | — | −0.3036 | 1.4061 | 0.2110 | 1.8719 | 2.7802 | 8.2091 | 0.2598 | 0.8361 | 1.8471 |
| **Model 16** | 1.0569 | −0.8164 | — | — | — | — | — | — | −0.1867 | 2.0067 | 0.3157 | 2.6455 | 7.1345 | 3.5328 | 0.3671 | 0.6477 | 2.6389 |
| **Model 17** | 0.9683 | −0.1526 | −0.6820 | — | — | — | — | — | −0.2426 | 1.7942 | 0.2693 | 2.4647 | 3.4427 | 4.9392 | 0.3421 | 0.7119 | 2.4527 |
| **Model 18** | 0.9767 | −0.3748 | −0.0820 | −0.4092 | — | — | — | — | −0.9259 | 1.8877 | 0.2630 | 2.5562 | −7.0995 | 19.4068 | 0.3548 | 0.7152 | 2.3827 |
| **Model 19** | 0.9462 | −0.8164 | — | — | — | — | — | — | −0.1867 | 2.0067 | 0.3157 | 2.6455 | 7.1342 | 3.5331 | 0.3671 | 0.6477 | 2.6389 |
| **Model 20** | −0.8066 | −1.9368 | −0.9344 | — | — | — | — | — | −0.2565 | 1.8742 | 0.2803 | 2.5223 | 3.4807 | 4.9811 | 0.3460 | 0.6984 | 2.5093 |
| **Model 21** | 0.9447 | 1.6882 | — | — | — | — | — | — | 0.2373 | 2.5256 | 0.4269 | 3.2871 | 17.5567 | 3.6145 | 0.4562 | 0.4746 | 3.2785 |
| **Model 22** | 2.7942 | −1.6151 | — | — | — | — | — | — | −0.2514 | 1.8543 | 0.2821 | 2.5008 | 4.3717 | 5.0463 | 0.3471 | 0.6950 | 2.4881 |
| **Model 23** | 0.3398 | −0.3367 | — | — | — | — | — | — | −0.9588 | 2.8638 | 0.4368 | 3.4867 | 0.2776 | 13.9389 | 0.4783 | 0.3874 | 3.3523 |
| **Model 24** | 1.5056 | −0.4933 | — | — | — | — | — | — | −0.2380 | 1.8438 | 0.2806 | 2.4963 | 4.4688 | 4.7841 | 0.3464 | 0.6969 | 2.4849 |
| **Model 25** | 0.0333 | −1.1871 | — | — | — | — | — | — | 0.0432 | 2.3309 | 0.3854 | 3.0361 | 13.3484 | 0.7103 | 0.4214 | 0.5351 | 3.0358 |
| **Model 26** | 0.3269 | −0.1628 | — | — | — | — | — | — | −0.3606 | 2.0232 | 0.3261 | 2.5539 | 7.5003 | 7.1230 | 0.3544 | 0.6565 | 2.5283 |
| **Model 27** | 1.1018 | 0.8856 | — | — | — | — | — | — | −0.3781 | 1.4566 | 0.2165 | 1.9286 | 2.4812 | 9.9830 | 0.2677 | 0.8305 | 1.8912 |
| **Model 28** | 0.0169 | 1.3076 | −1.5387 | — | — | — | — | — | −0.3220 | 1.4664 | 0.2214 | 1.9259 | 3.5326 | 8.4698 | 0.2673 | 0.8288 | 1.8988 |
| **Model 29** | −0.1794 | 2.9399 | −5.3739 | 2.7126 | — | — | — | — | −0.3415 | 1.4685 | 0.2221 | 1.9528 | 2.8304 | 8.8700 | 0.2710 | 0.8221 | 1.9227 |
| **Model 30** | −0.0290 | 1.0700 | 1.9312 | −8.5687 | 6.0035 | — | — | — | −0.3634 | 1.4301 | 0.2128 | 1.9284 | 2.4577 | 9.5837 | 0.2676 | 0.8279 | 1.8939 |
| **Model 31** | −0.0293 | 0.2202 | — | — | — | — | — | — | −0.3056 | 2.1669 | 0.3539 | 2.7112 | 9.1796 | 5.6648 | 0.3763 | 0.6015 | 2.6939 |
| **Model 32** | 0.3178 | −0.5299 | — | — | — | — | — | — | −0.3360 | 2.0690 | 0.3354 | 2.6020 | 8.1607 | 6.5023 | 0.3611 | 0.6393 | 2.5803 |
| **Model 33** | 0.2262 | −0.0879 | — | — | — | — | — | — | −0.2925 | 2.1832 | 0.3569 | 2.7294 | 9.4262 | 5.3821 | 0.3788 | 0.5951 | 2.7137 |
| **Model 34** | −0.0035 | 0.2483 | — | — | — | — | — | — | −0.2435 | 2.2305 | 0.3636 | 2.7897 | 10.0109 | 4.3750 | 0.3872 | 0.5761 | 2.7790 |
| **Model 35** | 0.2202 | −0.0293 | — | — | — | — | — | — | −0.6127 | 2.2387 | 0.3507 | 2.7847 | 4.3430 | 11.2635 | 0.3865 | 0.5903 | 2.7165 |
| **Model 36** | 0.4399 | −0.1160 | — | — | — | — | — | — | −0.3744 | 1.9607 | 0.3141 | 2.4849 | 6.8713 | 7.6104 | 0.3449 | 0.6799 | 2.4566 |
| **Model 37** | −0.6759 | −0.1651 | — | — | — | — | — | — | −0.3546 | 2.0381 | 0.3291 | 2.5694 | 7.6869 | 6.9578 | 0.3566 | 0.6510 | 2.5448 |
| **Model 38** | 0.2948 | −0.0832 | — | — | — | — | — | — | −0.3705 | 2.0979 | 0.3376 | 2.6417 | 7.4387 | 7.0742 | 0.3666 | 0.6287 | 2.6156 |
| **Model 39** | 0.2110 | 0.5452 | −0.6457 | — | — | — | — | — | −0.3569 | 1.6736 | 0.2505 | 2.1923 | 2.6556 | 8.2408 | 0.3042 | 0.7655 | 2.1630 |
| **Model 40** | 0.2177 | 0.3686 | −0.1687 | −0.3253 | — | — | — | — | −0.3691 | 1.6471 | 0.2457 | 2.1675 | 2.2265 | 8.6300 | 0.3008 | 0.7721 | 2.1358 |
| **Model 41** | 0.2192 | −0.0549 | — | — | — | — | — | — | −0.6446 | 2.2157 | 0.3374 | 2.7619 | 3.0277 | 11.6968 | 0.3789 | 0.6015 | 2.6857 |
| **Model 42** | 0.2885 | −0.2827 | — | — | — | — | — | — | −0.3507 | 2.1203 | 0.3426 | 2.6645 | 7.9379 | 6.6317 | 0.3698 | 0.6200 | 2.6413 |
| **Model 43** | 0.4575 | 0.0804 | −0.3277 | — | — | — | — | — | 0.1648 | 1.8160 | 0.2747 | 2.3655 | 9.8161 | 3.4039 | 0.3245 | 0.7342 | 2.3597 |
| **Model 44** | 0.3630 | −0.0616 | — | — | — | — | — | — | −0.3958 | 2.0293 | 0.3237 | 2.5698 | 6.4493 | 7.7851 | 0.3566 | 0.6543 | 2.5391 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.3402 | −1.5718 | 0.0243 | — | — | — | — | — | −0.2848 | 1.4760 | 0.2241 | 1.9310 | 3.9014 | 7.4460 | 0.2680 | 0.8248 | 1.9099 |
| **Model 46** | −0.6596 | 1.1007 | — | — | — | — | — | — | 0.9894 | 3.8758 | 0.6744 | 4.9948 | 18.6913 | 10.0919 | 0.6932 | 0.5026 | 4.8959 |
| **Model 47** | 1.3592 | −1.5735 | 0.0292 | — | — | — | — | — | −0.2144 | 1.4569 | 0.2217 | 1.9017 | 4.1252 | 5.6653 | 0.2639 | 0.8264 | 1.8896 |
| **Model 48** | 0.9829 | −0.8696 | 2.0052 | −4.3539 | −2.9153 | 1.0378 | −0.3720 | — | −0.3117 | 1.4302 | 0.2159 | 1.9281 | 2.8452 | 8.1822 | 0.2676 | 0.8240 | 1.9027 |
| **Model 49** | 1.3563 | −1.5682 | 0.0001 | — | — | — | — | — | −0.2973 | 1.4749 | 0.2236 | 1.9319 | 3.8461 | 7.7785 | 0.2681 | 0.8258 | 1.9089 |
| **Model 50** | 14.9634 | 8.8701 | 22.7260 | 14.0408 | — | — | — | — | −0.3188 | 1.6953 | 0.2669 | 2.1695 | 6.0896 | 7.4180 | 0.3011 | 0.7749 | 2.1460 |
| **Model 51** | 12.5445 | 0.1051 | 1083.3870 | — | — | — | — | — | 0.2429 | 2.6803 | 0.4646 | 3.3800 | 21.1727 | 3.5988 | 0.4691 | 0.3877 | 3.3713 |
| **Model 52** | 1.3607 | −1.5681 | −0.0001 | — | — | — | — | — | −0.2954 | 1.4720 | 0.2235 | 1.9286 | 3.9515 | 7.7415 | 0.2677 | 0.8269 | 1.9058 |

(continued on next page)

Table A7 (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.3024 | −1.1222 | −0.2801 | — | — | — | — | — | −0.3536 | 1.5116 | 0.2258 | 1.9860 | 3.0681 | 9.0365 | 0.2756 | 0.8157 | 1.9542 |
| **Model 54** | 1.1122 | −0.4752 | −0.5618 | 0.1093 | −0.4662 | — | — | — | −0.3973 | 1.3838 | 0.1943 | 1.8970 | −0.2956 | 10.6977 | 0.2633 | 0.8328 | 1.8549 |
| **Model 55** | 0.7982 | 2.3399 | −7.3594 | 4.7898 | −0.3173 | 0.6904 | −0.7252 | — | −0.4344 | **1.3664** | **0.1906** | 1.8832 | −0.7338 | 11.8395 | 0.2614 | 0.8371 | 1.8325 |
| **Model 56** | 1.0186 | 0.3019 | −1.3045 | −0.3923 | — | — | — | — | −0.3778 | 1.3808 | 0.1980 | 1.8784 | 0.8392 | 10.2538 | 0.2607 | 0.8362 | 1.8400 |
| **Model 57** | 1.2156 | −1.0791 | 0.2791 | −0.5956 | — | — | — | — | −0.3962 | 1.4023 | 0.1970 | 1.9156 | **−0.0023** | 10.5562 | 0.2659 | 0.8289 | 1.8742 |
| **Model 58** | 1.0246 | −0.9769 | −0.3996 | — | — | — | — | — | −0.3932 | 1.3802 | 0.1942 | 1.8964 | −0.4996 | 10.5837 | 0.2632 | 0.8330 | 1.8552 |
| **Model 59** | 1.2364 | −0.9917 | −0.3683 | — | — | — | — | — | −0.3907 | 1.4409 | 0.2063 | 1.9458 | 0.9987 | 10.2366 | 0.2700 | 0.8226 | 1.9061 |
| **Model 60** | 1.0793 | −1.0551 | −0.3567 | — | — | — | — | — | −0.3777 | 1.3910 | 0.2004 | 1.8824 | 1.1566 | 10.2275 | 0.2612 | 0.8360 | 1.8441 |
| **Model 61** | 0.9152 | −1.0591 | −0.4790 | — | — | — | — | — | −0.3483 | 1.4849 | 0.2175 | 2.0123 | −1.6948 | 8.7756 | 0.2793 | 0.8191 | 1.9820 |
| **Model 62** | 0.0059 | −0.7573 | −0.0304 | — | — | — | — | — | −4.1933 | 4.1965 | 0.5340 | 4.9473 | -53.2695 | 77.8416 | 0.6786 | 0.7763 | 2.6253 |
| **Model 63** | 2.0091 | −0.6163 | −0.2137 | — | — | — | — | — | −0.3877 | 1.4105 | 0.2021 | 1.9070 | 1.0208 | 10.3698 | 0.2647 | 0.8311 | 1.8671 |
| **Model 64** | −0.6936 | −1.2877 | −0.5624 | — | — | — | — | — | −0.2039 | 1.8396 | 0.2916 | 2.3799 | 7.4614 | 4.2945 | 0.3303 | 0.7076 | 2.3712 |
| **Model 65** | 0.3227 | −0.1274 | −0.0223 | — | — | — | — | — | −0.3683 | 2.0328 | 0.3272 | 2.5667 | 7.3603 | 7.2412 | 0.3562 | 0.6527 | 2.5402 |
| **Model 66** | −0.0204 | 1.3793 | −1.3585 | 0.1672 | −0.3264 | — | — | — | −0.3682 | 1.4012 | 0.1984 | 1.9112 | 0.7200 | 9.8037 | 0.2652 | 0.8286 | 1.8754 |
| **Model 67** | −0.0859 | 1.9233 | −1.8784 | −0.1840 | — | — | — | — | −0.3772 | 1.4386 | 0.2100 | 1.9206 | 1.4985 | 10.0040 | 0.2666 | 0.8285 | 1.8832 |
| **Model 68** | 0.2296 | −0.0813 | 0.5777 | −0.6392 | — | — | — | — | −0.3554 | 1.6455 | 0.2456 | 2.1570 | 2.6575 | 8.3434 | 0.2993 | 0.7735 | 2.1275 |
| **Model 69** | 0.3114 | −0.1095 | −0.0742 | — | — | — | — | — | −0.4159 | 1.9008 | 0.2994 | 2.4310 | 5.3729 | 8.6719 | 0.3374 | 0.6991 | 2.3951 |
| **Model 70** | 0.2727 | 0.0998 | −0.1686 | — | — | — | — | — | −0.4123 | 1.9771 | 0.3120 | 2.5229 | 5.2592 | 8.2735 | 0.3501 | 0.6721 | 2.4890 |
| **Model 71** | 0.3010 | −0.2897 | 0.0430 | — | — | — | — | — | −0.3668 | 1.8538 | 0.2950 | 2.3601 | 6.3347 | 7.8568 | 0.3275 | 0.7191 | 2.3314 |
| **Model 72** | 0.3073 | −0.1517 | −0.0951 | — | — | — | — | — | −0.4359 | 1.7888 | 0.2768 | 2.3131 | 4.0374 | 9.5818 | 0.3210 | 0.7351 | 2.2716 |
| **Model 73** | 0.1480 | −0.1616 | 0.0105 | — | — | — | — | — | −1.8122 | 2.4655 | 0.3248 | 3.1385 | -15.6021 | 34.4665 | 0.4305 | 0.6531 | 2.5624 |
| **Model 74** | 0.4155 | −0.0642 | −0.0324 | — | — | — | — | — | −0.3953 | 1.9762 | 0.3150 | 2.5085 | 6.3952 | 7.9685 | 0.3481 | 0.6734 | 2.4772 |
| **Model 75** | 0.2920 | −0.0825 | 0.0000 | — | — | — | — | — | −0.3816 | 2.0984 | 0.3370 | 2.6433 | 7.3119 | 7.2853 | 0.3668 | 0.6283 | 2.6156 |
| **Model 76** | 0.2055 | 0.5469 | −0.6459 | 0.0001 | — | — | — | — | −0.3779 | 1.6736 | 0.2494 | 2.1960 | 2.4143 | 8.7233 | 0.3048 | 0.7651 | 2.1632 |
| **Model 77** | 0.3003 | −0.0737 | −0.0009 | — | — | — | — | — | −0.4640 | 2.0725 | 0.3281 | 2.6298 | 6.8794 | 8.9510 | 0.3650 | 0.6347 | 2.5886 |
| **Model 78** | 0.2165 | 0.5569 | −0.6473 | −0.0010 | — | — | — | — | −0.4553 | 1.6387 | 0.2408 | 2.1841 | 2.0578 | 10.6431 | 0.3031 | 0.7704 | 2.1361 |
| **Model 79** | 0.2720 | −0.0016 | −0.0002 | — | — | — | — | — | −0.3899 | 2.1655 | 0.3480 | 2.7212 | 9.1567 | 7.2301 | 0.3777 | 0.5948 | 2.6931 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.6468 | −1.1128 | −0.2870 | 0.6830 | — | — | — | — | −0.3665 | 1.4750 | 0.2224 | 1.9366 | 2.7102 | 9.6254 | 0.2688 | 0.8290 | 1.9016 |
| **Model 81** | 1.2983 | −1.1086 | −0.2846 | −0.0003 | — | — | — | — | −0.3775 | 1.5071 | 0.2245 | 1.9855 | 2.9374 | 9.6721 | 0.2755 | 0.8185 | 1.9493 |
| **Model 82** | 1.4024 | −1.5519 | −0.0016 | −0.0007 | — | — | — | — | −0.2978 | 1.4482 | 0.2212 | 1.9032 | 4.4593 | 7.9127 | 0.2641 | 0.8375 | 1.8798 |
| **Model 83** | 0.7007 | −0.5093 | 0.1459 | −0.0013 | −0.0003 | — | — | — | 0.5487 | 2.0087 | 0.3127 | 2.6525 | 16.7677 | 10.3042 | 0.3639 | 0.6888 | 2.5952 |
| **Model 84** | 0.2462 | 0.5528 | −0.6466 | −0.0014 | −0.0004 | — | — | — | −0.3867 | 1.6238 | 0.2426 | 2.1593 | 3.0655 | 9.0902 | 0.2997 | 0.7732 | 2.1244 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.1196 | −1.5171 | −0.0081 | −0.0004 | 0.4493 | — | — | — | −0.2814 | 1.4272 | 0.2121 | 1.8947 | 3.4624 | 7.5003 | 0.2630 | 0.8319 | 1.8737 |
| **Model 87** | 1.1196 | −1.5171 | 0.4493 | −0.0081 | −0.0004 | — | — | — | −0.2814 | 1.4272 | 0.2121 | 1.8947 | 3.4624 | 7.5003 | 0.2630 | 0.8319 | 1.8737 |
| **Model 88** | 1.3162 | −1.1256 | −0.2822 | 0.0001 | −0.0002 | — | — | — | −0.3229 | 1.5131 | 0.2278 | 1.9839 | 3.4854 | 8.2280 | 0.2752 | 0.8144 | 1.9575 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.3648 | −1.0968 | −0.2884 | −0.0019 | −0.0009 | — | — | — | −0.3285 | 1.4851 | 0.2249 | 1.9605 | 4.0206 | 8.4880 | 0.2721 | 0.8241 | 1.9327 |
| **Model 90** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 91** | 1.1242 | −0.0382 | −2.1855 | 14.2438 | −0.7906 | −0.0038 | −0.0007 | — | −0.2999 | 1.8741 | 0.2949 | 2.4836 | 6.3291 | 6.0743 | 0.3447 | 0.6803 | 2.4654 |
| **Model 92** | 1.1634 | −0.3243 | −0.3726 | 30.9086 | −1.5245 | −0.0060 | −0.0002 | — | −0.1431 | 1.4498 | 0.2271 | 1.9079 | 7.1308 | 3.7572 | 0.2648 | 0.8322 | 1.9025 |
| **Model 93** | 1.1944 | 0.2803 | 0.3992 | 0.4404 | −1.5226 | −0.0058 | — | — | −0.3223 | 1.4144 | 0.2091 | 1.8813 | 2.8183 | 8.6855 | 0.2611 | 0.8378 | 1.8534 |
| **Model 94** | 1.3034 | −0.0444 | −0.7848 | −0.5918 | −1.5267 | 0.0006 | — | — | −0.3326 | 1.4119 | 0.2083 | 1.8680 | 2.5948 | 9.0370 | 0.2592 | 0.8408 | 1.8382 |
| **Model 95** | 1.3426 | 0.0411 | 0.7644 | 0.8539 | −1.5396 | — | — | — | −0.2763 | 1.4046 | 0.2111 | **1.8525** | 3.5682 | 7.5334 | **0.2571** | 0.8419 | **1.8317** |
| **Model 96** | 0.5253 | 0.1254 | 0.9954 | 0.8373 | — | — | — | — | 0.7607 | 3.2122 | 0.5723 | 4.1292 | 29.8800 | 9.3599 | 0.5731 | 0.2947 | 4.0585 |
| **Model 97** | 1.3656 | 0.0483 | 18.1125 | −1.5223 | −0.0027 | — | — | — | −0.6100 | 1.4679 | 0.2105 | 1.9931 | 0.5229 | 16.0553 | 0.2766 | **0.8525** | 1.8975 |

**Table A8**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Kunming station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2128 | −1.3759 | — | — | — | — | — | — | −0.0574 | 1.1812 | 0.2098 | 1.7666 | 9.2259 | 1.5882 | 0.2446 | 0.8502 | 1.7657 |
| **Model 2** | 1.0749 | −0.5807 | −0.9093 | — | — | — | — | — | −0.0408 | 1.1112 | 0.1877 | 1.7918 | 6.4506 | 1.1120 | 0.2480 | 0.8362 | 1.7914 |
| **Model 3** | 0.9137 | 1.0729 | −5.2632 | 3.3070 | — | — | — | — | −0.0682 | 1.1065 | 0.1854 | 1.7778 | 6.2797 | 1.8747 | 0.2461 | 0.8390 | 1.7765 |
| **Model 4** | 0.9596 | 0.3978 | −2.4612 | −1.0567 | 2.2748 | — | — | — | −0.0725 | 1.1063 | 0.1840 | 1.7836 | 5.8890 | 1.9877 | 0.2469 | 0.8381 | 1.7822 |
| **Model 5** | 0.9634 | 0.3233 | −2.0212 | −2.1418 | 3.4519 | −0.4617 | — | — | −0.0721 | 1.1066 | 0.1841 | 1.7837 | 5.9026 | 1.9770 | 0.2469 | 0.8381 | 1.7822 |
| **Model 6** | 0.5539 | 0.0000 | — | — | — | — | — | — | 1.7888 | 3.6689 | 0.7655 | 4.5142 | 52.8216 | 21.0904 | 0.6249 | 0.2426 | 4.1447 |
| **Model 7** | 2.9552 | −2.4123 | — | — | — | — | — | — | 0.0368 | 1.1294 | 0.1949 | 1.7869 | 8.2375 | 1.0064 | 0.2474 | 0.8370 | 1.7866 |
| **Model 8** | 0.3670 | −0.4488 | — | — | — | — | — | — | −1.5754 | 3.1506 | 0.4987 | 3.6628 | −6.3427 | 23.2821 | 0.5071 | 0.3325 | 3.3067 |
| **Model 9** | 1.0317 | −1.0892 | 3.5831 | −6.6671 | — | — | — | — | −0.0607 | 1.1130 | 0.1861 | 1.7845 | 6.2639 | 1.6636 | 0.2470 | 0.8378 | 1.7835 |
| **Model 10** | −3.9624 | 7.4792 | — | — | — | — | — | — | −0.0536 | 1.1225 | 0.1884 | 1.7868 | 6.4354 | 1.4660 | 0.2474 | 0.8373 | 1.7860 |
| **Model 11** | 0.3944 | 0.0533 | — | — | — | — | — | — | 0.9609 | 2.9308 | 0.5963 | 3.5796 | 38.8567 | 13.6175 | 0.4955 | 0.3210 | 3.4483 |
| **Model 12** | 0.1538 | −2.0936 | — | — | — | — | — | — | 0.5862 | 2.0621 | 0.4187 | 2.5875 | 27.5016 | 11.3674 | 0.3582 | 0.6358 | 2.5202 |
| **Model 13** | 1.3641 | −2.0241 | — | — | — | — | — | — | 0.2755 | 1.6607 | 0.3306 | 2.1428 | 20.3578 | 6.3350 | 0.2966 | 0.7897 | 2.1250 |
| **Model 14** | 0.1982 | −0.4117 | — | — | — | — | — | — | −2.1695 | 2.9084 | 0.4015 | 3.5271 | -16.5142 | 38.1214 | 0.4883 | 0.5365 | 2.7810 |
| **Model 15** | 1.9990 | −0.8789 | — | — | — | — | — | — | −0.0463 | 1.1132 | 0.1897 | 1.7756 | 7.0582 | 1.2750 | 0.2458 | 0.8394 | 1.7750 |
| **Model 16** | 0.9709 | −0.8338 | — | — | — | — | — | — | −0.3049 | 1.4452 | 0.2356 | 2.2005 | 4.0319 | 6.8366 | 0.3046 | 0.7574 | 2.1793 |
| **Model 17** | 0.9570 | −0.7137 | −0.1301 | — | — | — | — | — | −0.3269 | 1.4421 | 0.2321 | 2.2173 | 2.6482 | 7.2852 | 0.3069 | 0.7609 | 2.1930 |
| **Model 18** | 0.9709 | −1.0270 | 0.7842 | −0.6622 | — | — | — | — | −0.3746 | 1.4495 | 0.2341 | 2.2218 | 0.9229 | 8.3589 | 0.3076 | 0.7661 | 2.1900 |
| **Model 19** | 1.0300 | −0.8338 | — | — | — | — | — | — | −0.3049 | 1.4452 | 0.2356 | 2.2005 | 4.0322 | 6.8363 | 0.3046 | 0.7574 | 2.1793 |
| **Model 20** | −0.8259 | −1.1178 | −0.9460 | — | — | — | — | — | −0.4188 | 1.5448 | 0.2389 | 2.2823 | 1.5162 | 8.6062 | 0.3030 | 0.7364 | 2.2435 |
| **Model 21** | 0.9721 | 2.1790 | — | — | — | — | — | — | 0.2623 | 1.9139 | 0.3744 | 2.4806 | 21.2472 | 5.1964 | 0.3434 | 0.6551 | 2.4666 |
| **Model 22** | 2.5443 | −1.4812 | — | — | — | — | — | — | −0.3581 | 1.4828 | 0.2405 | 2.2629 | 0.3101 | 7.8318 | 0.3133 | 0.7660 | 2.2344 |
| **Model 23** | 0.3046 | −0.2368 | — | — | — | — | — | — | −1.2220 | 2.7743 | 0.4312 | 3.2117 | 2.1536 | 18.9710 | 0.4264 | 0.3735 | 2.9701 |
| **Model 24** | 1.4331 | −0.5070 | — | — | — | — | — | — | −0.3661 | 1.5107 | 0.2459 | 2.2924 | **−0.2653** | 7.9061 | 0.3174 | 0.7651 | 2.2630 |
| **Model 25** | −0.0050 | −1.3585 | — | — | — | — | — | — | −0.0539 | 1.6446 | 0.3014 | 2.2575 | 13.0995 | 1.1678 | 0.3125 | 0.7226 | 2.2569 |
| **Model 26** | 0.2253 | −0.0252 | — | — | — | — | — | — | −0.1589 | 2.0859 | 0.4150 | 2.5540 | 20.1056 | 3.0458 | 0.3536 | 0.6748 | 2.5490 |
| **Model 27** | 1.0209 | 0.8771 | — | — | — | — | — | — | −0.0524 | 1.1134 | 0.1887 | 1.7758 | 7.2055 | 1.4415 | 0.2458 | 0.8396 | 1.7750 |
| **Model 28** | −0.0140 | 1.3549 | −1.5781 | — | — | — | — | — | −0.0577 | 1.1187 | 0.1913 | 1.7693 | 7.3947 | 1.5950 | 0.2449 | 0.8416 | 1.7683 |
| **Model 29** | −0.0769 | 1.9999 | −3.2765 | 1.2901 | — | — | — | — | −0.0638 | 1.1578 | 0.2026 | 1.7937 | 6.4485 | 1.7394 | 0.2483 | 0.8359 | 1.7925 |
| **Model 30** | 0.0180 | 0.6027 | 2.5227 | −7.7413 | 4.7081 | — | — | — | −0.0713 | 1.1131 | 0.1859 | 1.7856 | 5.9918 | 1.9516 | 0.2472 | 0.8377 | 1.7842 |
| **Model 31** | 0.0230 | 0.2331 | — | — | — | — | — | — | −0.1172 | 2.0739 | 0.4052 | 2.4940 | 19.7010 | 2.2992 | 0.3453 | 0.7138 | 2.4912 |
| **Model 32** | 0.2228 | −0.0920 | — | — | — | — | — | — | −0.1565 | 2.0889 | 0.4155 | 2.5526 | 20.1499 | 3.0025 | 0.3534 | 0.6776 | 2.5478 |
| **Model 33** | 0.2292 | 0.0844 | — | — | — | — | — | — | −0.1229 | 2.0824 | 0.4090 | 2.5064 | 19.9470 | 2.3997 | 0.3470 | 0.7107 | 2.5033 |
| **Model 34** | −0.0087 | 0.2394 | — | — | — | — | — | — | −0.0818 | 1.9497 | 0.3685 | 2.3788 | 17.4481 | 1.6807 | 0.3293 | 0.7395 | 2.3774 |
| **Model 35** | 0.2331 | 0.0230 | — | — | — | — | — | — | 0.2382 | 2.0572 | 0.4325 | 2.4991 | 26.3622 | 4.6790 | 0.3460 | 0.7057 | 2.4877 |
| **Model 36** | 0.2702 | −0.0346 | — | — | — | — | — | — | −0.1684 | 2.0561 | 0.4097 | 2.5503 | 19.7220 | 3.2330 | 0.3530 | 0.6641 | 2.5447 |
| **Model 37** | −0.7753 | −0.0240 | — | — | — | — | — | — | −0.1586 | 2.0867 | 0.4151 | 2.5537 | 20.1115 | 3.0413 | 0.3535 | 0.6755 | 2.5487 |
| **Model 38** | 0.2355 | −0.0445 | — | — | — | — | — | — | −0.2039 | 2.0643 | 0.4093 | 2.5680 | 19.0211 | 3.8922 | 0.3555 | 0.6459 | 2.5599 |
| **Model 39** | 0.1626 | 0.5851 | −0.6818 | — | — | — | — | — | −0.3703 | 1.5094 | 0.2671 | 2.1157 | 4.7648 | 8.6874 | 0.2929 | 0.7724 | 2.0830 |
| **Model 40** | 0.1583 | 0.6816 | −0.9632 | 0.2038 | — | — | — | — | −0.3551 | 1.4986 | 0.2630 | 2.1062 | 5.2160 | 8.3575 | 0.2916 | 0.7735 | 2.0760 |
| **Model 41** | 0.2056 | −0.0192 | — | — | — | — | — | — | −0.5113 | 1.9880 | 0.3287 | 2.4333 | 8.9621 | 9.9099 | 0.3230 | 0.7289 | 2.3789 |
| **Model 42** | 0.2326 | −0.1761 | — | — | — | — | — | — | −0.1928 | 2.0709 | 0.4111 | 2.5642 | 19.3114 | 3.6842 | 0.3550 | 0.6524 | 2.5569 |
| **Model 43** | 0.3693 | 0.0498 | −0.2648 | — | — | — | — | — | 0.2915 | 1.6514 | 0.2603 | 2.3272 | 11.0231 | 5.8204 | 0.3089 | 0.7364 | 2.3089 |
| **Model 44** | 0.2797 | −0.0383 | — | — | — | — | — | — | −0.2343 | 2.0168 | 0.3980 | 2.5537 | 17.8521 | 4.5034 | 0.3535 | 0.6406 | 2.5429 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 0.9695 | −1.3361 | 0.2572 | — | — | — | — | — | 0.0622 | 1.1311 | 0.1985 | 1.6902 | 8.5936 | 1.7997 | 0.2340 | 0.8561 | 1.6890 |
| **Model 46** | −1.0219 | 1.1813 | — | — | — | — | — | — | 0.5019 | 1.8598 | 0.3281 | 2.5072 | 8.0201 | 9.9851 | 0.3471 | 0.7992 | 2.4564 |
| **Model 47** | 1.2128 | −1.3758 | 0.0200 | — | — | — | — | — | 0.6750 | 1.3699 | 0.2800 | 1.9572 | 21.7415 | 17.9539 | 0.2709 | 0.8285 | 1.8371 |
| **Model 48** | 0.0493 | 1.0008 | −4.5794 | 6.4090 | −1.4479 | 1.7975 | −0.5338 | — | **0.0359** | **1.0810** | **0.1802** | 1.7179 | 5.9184 | 1.0204 | 0.2378 | 0.8536 | 1.7176 |
| **Model 49** | 1.1918 | −1.3335 | 0.0019 | — | — | — | — | — | 0.0585 | 1.1184 | 0.1962 | **1.6701** | 8.4970 | 1.7135 | **0.2312** | **0.8598** | **1.6691** |
| **Model 50** | 6.2190 | 3.3318 | -33.7915 | -22.4381 | — | — | — | — | 0.1590 | 1.3303 | 0.2452 | 1.8300 | 12.2088 | 4.2612 | 0.2533 | 0.8301 | 1.8231 |
| **Model 51** | -54.5555 | 0.0511 | -4859.5669 | — | — | — | — | — | 1.1585 | 2.6618 | 0.5165 | 3.4360 | 33.6878 | 17.5012 | 0.4757 | 0.5350 | 3.2348 |
| **Model 52** | 1.1156 | −1.3251 | 0.0011 | — | — | — | — | — | −0.0809 | 1.1761 | 0.2088 | 1.7740 | 8.8018 | 2.2303 | 0.2456 | 0.8476 | 1.7722 |

(*continued on next page*)

**Table A8** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0851 | −0.5885 | −0.4986 | — | — | — | — | — | −0.2527 | 1.2259 | 0.2054 | 1.9096 | 5.0022 | 6.5246 | 0.2643 | 0.8148 | 1.8928 |
| **Model 54** | 0.9931 | −0.0468 | −0.7073 | −0.4761 | 0.0289 | — | — | — | −0.2149 | 1.1502 | 0.1885 | 1.8856 | 3.5865 | 5.6046 | 0.2610 | 0.8213 | 1.8733 |
| **Model 55** | 0.9093 | 0.9763 | −3.4897 | 2.0205 | −0.8140 | 1.1485 | −0.7891 | — | −0.2487 | 1.1483 | 0.1897 | 1.8721 | 2.0880 | 6.5495 | 0.2592 | 0.8265 | 1.8555 |
| **Model 56** | 0.9972 | −0.0869 | −0.6638 | −0.4486 | — | — | — | — | −0.2212 | 1.1539 | 0.1888 | 1.8885 | 3.3963 | 5.7632 | 0.2614 | 0.8212 | 1.8755 |
| **Model 57** | 1.0713 | −0.6464 | −0.2497 | −0.2337 | — | — | — | — | −0.2872 | 1.2026 | 0.1954 | 1.9194 | 2.6114 | 7.3951 | 0.2657 | 0.8163 | 1.8978 |
| **Model 58** | 0.9369 | −0.9975 | −0.3282 | — | — | — | — | — | −0.1803 | 1.2530 | 0.2143 | 1.9658 | 0.9078 | 4.4999 | 0.2721 | 0.8211 | 1.9575 |
| **Model 59** | 1.0825 | −0.8124 | −0.3930 | — | — | — | — | — | −0.2791 | 1.1982 | 0.1963 | 1.9013 | 1.6633 | 7.2529 | 0.2632 | 0.8224 | 1.8807 |
| **Model 60** | 0.9813 | −0.7338 | −0.4627 | — | — | — | — | — | −0.2208 | 1.1619 | 0.1901 | 1.9012 | 3.1726 | 5.7133 | 0.2632 | 0.8195 | 1.8883 |
| **Model 61** | 0.8486 | −1.1800 | −0.3815 | — | — | — | — | — | −0.0893 | 1.5193 | 0.2727 | 2.2240 | −0.7126 | 1.9630 | 0.3079 | 0.8064 | 2.2222 |
| **Model 62** | 0.1374 | −0.4177 | −0.0780 | — | — | — | — | — | −2.9221 | 3.2449 | 0.3909 | 3.9505 | -27.7194 | 50.6799 | 0.5244 | 0.6873 | 2.6585 |
| **Model 63** | 1.7489 | −0.4514 | −0.2611 | — | — | — | — | — | −0.2640 | 1.1891 | 0.1948 | 1.9104 | 1.9675 | 6.8194 | 0.2645 | 0.8203 | 1.8921 |
| **Model 64** | −0.8896 | −0.6938 | −0.7121 | — | — | — | — | — | −0.1824 | 1.3416 | 0.2372 | 1.9567 | 8.4813 | 4.5746 | 0.2709 | 0.8055 | 1.9482 |
| **Model 65** | 0.1483 | 0.4494 | −0.3005 | — | — | — | — | — | −0.3437 | 2.1094 | 0.3962 | 2.6228 | 14.6020 | 6.4600 | 0.3631 | 0.6048 | 2.6002 |
| **Model 66** | −0.0188 | 1.2874 | −1.1742 | −0.0003 | −0.1990 | — | — | — | −0.2471 | 1.1654 | 0.1902 | 1.8757 | 3.0904 | 6.4929 | 0.2597 | 0.8235 | 1.8594 |
| **Model 67** | −0.0469 | 1.5636 | −1.4743 | −0.1896 | — | — | — | — | −0.1807 | 1.1774 | 0.1999 | 1.8724 | 4.7630 | 4.7385 | 0.2592 | 0.8214 | 1.8637 |
| **Model 68** | 0.1110 | 0.2920 | 0.3755 | −0.6350 | — | — | — | — | −0.4498 | 1.5130 | 0.2609 | 2.1491 | 2.8718 | 10.4595 | 0.2975 | 0.7698 | 2.1015 |
| **Model 69** | 0.2172 | 0.3384 | −0.2660 | — | — | — | — | — | −0.4226 | 1.9770 | 0.3750 | 2.5561 | 12.3729 | 8.1929 | 0.3538 | 0.6354 | 2.5209 |
| **Model 70** | 0.0942 | 0.5416 | −0.3954 | — | — | — | — | — | −0.4838 | 1.6936 | 0.2952 | 2.3641 | 5.0941 | 10.2156 | 0.3273 | 0.7117 | 2.3141 |
| **Model 71** | 0.2385 | −0.2126 | 0.0630 | — | — | — | — | — | −1.8831 | 2.8162 | 0.4429 | 3.4362 | -11.2783 | 32.0151 | 0.4757 | 0.4950 | 2.8743 |
| **Model 72** | 0.2382 | 0.1783 | −0.1955 | — | — | — | — | — | −0.3929 | 1.8989 | 0.3630 | 2.5054 | 12.2895 | 7.7592 | 0.3468 | 0.6523 | 2.4744 |
| **Model 73** | 0.1937 | −0.0297 | −0.0079 | — | — | — | — | — | −0.7303 | 2.0269 | 0.3206 | 2.4912 | 5.3818 | 14.1386 | 0.3307 | 0.7348 | 2.3818 |
| **Model 74** | 0.0982 | 0.2594 | −0.1796 | — | — | — | — | — | −0.4035 | 2.0440 | 0.3837 | 2.5910 | 12.9990 | 7.7042 | 0.3587 | 0.6208 | 2.5594 |
| **Model 75** | 0.2154 | −0.0374 | 0.0002 | — | — | — | — | — | −0.2081 | 2.0588 | 0.4085 | 2.5656 | 18.9899 | 3.9758 | 0.3552 | 0.6480 | 2.5572 |
| **Model 76** | 0.2105 | 0.5778 | −0.6929 | −0.0006 | — | — | — | — | −0.3621 | 1.5023 | 0.2653 | 2.1035 | 4.6214 | 8.5405 | 0.2912 | 0.7753 | 2.0721 |
| **Model 77** | 0.1381 | −0.0384 | 0.0059 | — | — | — | — | — | 0.0449 | 1.8852 | 0.3758 | 2.3859 | 18.1108 | **0.9194** | 0.3303 | 0.6827 | 2.3855 |
| **Model 78** | 0.1100 | 0.5444 | −0.6337 | 0.0035 | — | — | — | — | −0.2112 | 1.4482 | 0.2581 | 2.0372 | 5.2260 | 5.0947 | 0.2820 | 0.7925 | 2.0262 |
| **Model 79** | 0.0517 | 0.0062 | 0.0009 | — | — | — | — | — | 0.0521 | 1.8615 | 0.3722 | 2.3637 | 18.2300 | 1.0764 | 0.3272 | 0.6900 | 2.3631 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.8629 | −0.5819 | −0.5035 | 0.2309 | — | — | — | — | −0.2482 | 1.2298 | 0.2057 | 1.9256 | 5.0344 | 6.3514 | 0.2666 | 0.8111 | 1.9095 |
| **Model 81** | 1.0794 | −0.6170 | −0.4610 | 0.0014 | — | — | — | — | −0.1537 | 1.1684 | 0.1962 | 1.8169 | 4.7890 | 4.1495 | 0.2515 | 0.8334 | 1.8104 |
| **Model 82** | 0.9962 | −1.3142 | 0.0065 | 0.0012 | — | — | — | — | 0.0478 | 1.1290 | 0.1994 | 1.7259 | 8.5501 | 1.3526 | 0.2389 | 0.8490 | 1.7252 |
| **Model 83** | 0.3965 | −0.3203 | 0.0757 | 0.0034 | 0.0002 | — | — | — | 0.8371 | 1.9184 | 0.3069 | 2.6864 | 18.6829 | 15.1198 | 0.3566 | 0.7176 | 2.5527 |
| **Model 84** | 0.1404 | 0.5413 | −0.6419 | 0.0034 | −0.0004 | — | — | — | −0.2116 | 1.4495 | 0.2583 | 2.0330 | 5.1219 | 5.1129 | 0.2814 | 0.7934 | 2.0219 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | -94.0743 | −0.5760 | −0.5064 | 0.2379 | 104.7548 | — | — | — | −0.0699 | 1.2187 | 0.2129 | 1.9012 | 8.0639 | 1.7980 | 0.2632 | 0.8132 | 1.8999 |
| **Model 86** | 0.8573 | −1.2755 | 0.0020 | 0.0014 | 0.2058 | — | — | — | 0.0482 | 1.1122 | 0.1955 | 1.6976 | 8.1193 | 1.3871 | 0.2350 | 0.8543 | 1.6969 |
| **Model 87** | 0.8573 | −1.2755 | 0.2058 | 0.0020 | 0.0014 | — | — | — | 0.0482 | 1.1122 | 0.1955 | 1.6976 | 8.1193 | 1.3871 | 0.2350 | 0.8543 | 1.6969 |
| **Model 88** | 1.1186 | −0.5902 | −0.4995 | −0.0043 | −0.0003 | — | — | — | −0.2401 | 1.2358 | 0.2086 | 1.9306 | 4.7678 | 6.1246 | 0.2673 | 0.8101 | 1.9157 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0298 | −0.6407 | −0.4678 | 0.0046 | −0.0001 | — | — | — | −0.1456 | 1.1845 | 0.2001 | 1.8497 | 5.1487 | 3.8581 | 0.2561 | 0.8266 | 1.8440 |
| **Model 90** | 1.0638 | −0.0471 | −0.6260 | 0.4222 | −0.6255 | 0.0008 | −0.0002 | −0.4607 | −0.1399 | 1.1730 | 0.1981 | 1.8280 | 5.0197 | 3.7502 | 0.2531 | 0.8311 | 1.8227 |
| **Model 91** | 0.9104 | 0.0169 | 2.3865 | -15.0997 | −0.8225 | 0.0024 | 0.0003 | — | −0.2378 | 1.4171 | 0.2321 | 2.1810 | 3.7880 | 5.3609 | 0.3019 | 0.7676 | 2.1680 |
| **Model 92** | 1.1239 | 0.0517 | 0.9571 | −1.6106 | −1.2816 | −0.0002 | 0.0006 | — | 0.0463 | 1.1125 | 0.1966 | 1.6899 | 8.2672 | 1.3396 | 0.2339 | 0.8558 | 1.6892 |
| **Model 93** | 1.1960 | −0.0587 | 1.0064 | 1.2741 | −1.2991 | −0.0012 | — | — | 0.0551 | 1.1143 | 0.1978 | 1.6870 | 8.5352 | 1.5974 | 0.2335 | 0.8564 | 1.6861 |
| **Model 94** | 1.1207 | −0.0503 | 0.9617 | 1.5164 | −1.2824 | 0.0007 | — | — | 0.0467 | 1.1126 | 0.1966 | 1.6904 | 8.2702 | 1.3516 | 0.2340 | 0.8557 | 1.6897 |
| **Model 95** | 1.1819 | −0.0506 | 1.0355 | 1.1556 | −1.3079 | — | — | — | 0.0588 | 1.1166 | 0.1981 | 1.6908 | 8.5805 | 1.7006 | 0.2341 | 0.8557 | 1.6898 |
| **Model 96** | 0.5552 | −0.1899 | 1.0069 | 0.9635 | — | — | — | — | 1.7796 | 3.2039 | 0.6296 | 4.1448 | 42.6886 | 23.2313 | 0.5738 | 0.5079 | 3.7433 |
| **Model 97** | 1.1961 | −0.0591 | 1.2970 | −1.2988 | −0.0013 | — | — | — | 0.0552 | 1.1143 | 0.1978 | 1.6870 | 8.5337 | 1.5987 | 0.2335 | 0.8564 | 1.6861 |

**Table A9**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Lanzhou station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2322 | −1.3868 | — | — | — | — | — | — | −0.6077 | 1.2876 | 0.1804 | 1.7589 | −3.2350 | 18.1974 | 0.2489 | 0.8601 | 1.6506 |
| **Model 2** | 1.0769 | −0.4716 | −1.1043 | — | — | — | — | — | −0.8994 | 1.4059 | 0.1994 | 1.9060 | -10.4360 | 26.4536 | 0.2697 | 0.8491 | 1.6804 |
| **Model 3** | 0.9431 | 1.0556 | −5.4882 | 3.6238 | — | — | — | — | −0.7089 | 1.2603 | 0.1707 | 1.7774 | −6.0179 | 21.4985 | 0.2515 | 0.8598 | 1.6299 |
| **Model 4** | 0.9220 | 1.4265 | −7.3163 | 7.0225 | −2.1268 | — | — | — | −0.7279 | 1.2647 | 0.1712 | 1.7817 | −6.4895 | 22.1245 | 0.2521 | 0.8603 | 1.6262 |
| **Model 5** | 1.0028 | −0.5502 | 7.2356 | -37.8648 | 59.2670 | -30.7732 | — | — | −0.7778 | 1.2910 | 0.1776 | 1.8072 | −7.7889 | 23.5680 | 0.2557 | 0.8585 | 1.6312 |
| **Model 6** | 0.5711 | 0.0000 | — | — | — | — | — | — | 1.5371 | 3.5137 | 0.6393 | 4.4515 | 38.3102 | 18.1863 | 0.6298 | 0.3635 | 4.1776 |
| **Model 7** | 3.0781 | −2.6413 | — | — | — | — | — | — | −0.9092 | 1.4250 | 0.2043 | 1.9223 | -10.6251 | 26.5341 | 0.2720 | 0.8467 | 1.6937 |
| **Model 8** | 0.3995 | −0.4058 | — | — | — | — | — | — | 0.6755 | 2.4898 | 0.4366 | 3.1638 | 23.5457 | 10.8017 | 0.4476 | 0.5009 | 3.0909 |
| **Model 9** | 0.0350 | 1.0268 | −3.4938 | 6.9589 | — | — | — | — | −0.6804 | 1.2593 | 0.1714 | 1.7730 | −5.2810 | 20.5416 | 0.2509 | 0.8589 | 1.6372 |
| **Model 10** | −3.9509 | 7.4059 | — | — | — | — | — | — | −0.7852 | 1.3070 | 0.1779 | 1.8083 | −7.6300 | 23.8264 | 0.2559 | 0.8591 | 1.6290 |
| **Model 11** | 0.4484 | 0.0431 | — | — | — | — | — | — | 0.9623 | 2.9557 | 0.5241 | 3.7432 | 29.2701 | 13.1492 | 0.5296 | 0.4080 | 3.6174 |
| **Model 12** | 0.1816 | −2.1165 | — | — | — | — | — | — | 0.3339 | 2.0406 | 0.3479 | 2.5907 | 16.2657 | 6.4230 | 0.3666 | 0.6250 | 2.5691 |
| **Model 13** | 1.3617 | −1.9200 | — | — | — | — | — | — | −0.0191 | 1.6750 | 0.2734 | 2.1406 | 9.4810 | 0.4409 | 0.3029 | 0.7391 | 2.1405 |
| **Model 14** | 0.2459 | −0.3872 | — | — | — | — | — | — | −1.8608 | 2.6402 | 0.3632 | 3.2861 | -17.4274 | 33.9581 | 0.4649 | 0.5323 | 2.7085 |
| **Model 15** | 2.0572 | −0.9107 | — | — | — | — | — | — | −0.8117 | 1.3373 | 0.1857 | 1.8260 | −8.1996 | 24.5257 | 0.2584 | 0.8577 | 1.6357 |
| **Model 16** | 0.9894 | −0.7073 | — | — | — | — | — | — | 0.5021 | 1.5380 | 0.2661 | 2.1390 | 16.0691 | 11.9362 | 0.3027 | 0.7622 | 2.0793 |
| **Model 17** | 0.9651 | −0.4932 | −0.2312 | — | — | — | — | — | 0.4912 | 1.4736 | 0.2532 | 2.0377 | 15.0039 | 12.2763 | 0.2883 | 0.7881 | 1.9776 |
| **Model 18** | 0.9856 | −1.0603 | 1.3794 | −1.1445 | — | — | — | — | 0.4617 | 1.4426 | 0.2436 | 1.9909 | 14.2276 | 11.7847 | 0.2817 | 0.7975 | 1.9366 |
| **Model 19** | 1.0107 | −0.7073 | — | — | — | — | — | — | 0.5022 | 1.5380 | 0.2661 | 2.1391 | 16.0698 | 11.9372 | 0.3027 | 0.7622 | 2.0793 |
| **Model 20** | −0.6728 | −1.4672 | −0.9080 | — | — | — | — | — | 0.5537 | 1.6463 | 0.2810 | 2.1548 | 16.9307 | 12.3992 | 0.2940 | 0.7631 | 2.0824 |
| **Model 21** | 0.9786 | 1.5543 | — | — | — | — | — | — | 0.6861 | 1.9768 | 0.3484 | 2.6965 | 21.7930 | 13.0036 | 0.3815 | 0.6220 | 2.6078 |
| **Model 22** | 2.6256 | −1.3724 | — | — | — | — | — | — | 0.4853 | 1.4619 | 0.2505 | 2.0202 | 14.7836 | 12.2307 | 0.2858 | 0.7920 | 1.9611 |
| **Model 23** | 0.3945 | −0.2328 | — | — | — | — | — | — | −0.1918 | 2.5892 | 0.4124 | 3.1433 | 11.6823 | 2.8516 | 0.4289 | 0.4175 | 3.1375 |
| **Model 24** | 1.3844 | −0.4316 | — | — | — | — | — | — | 0.4864 | 1.4490 | 0.2475 | 1.9963 | 14.4549 | 12.4161 | 0.2825 | 0.7987 | 1.9362 |
| **Model 25** | 0.0030 | −1.0495 | — | — | — | — | — | — | 0.5771 | 1.7620 | 0.3085 | 2.4320 | 18.8962 | 12.0734 | 0.3441 | 0.6881 | 2.3625 |
| **Model 26** | 0.2133 | 0.0443 | — | — | — | — | — | — | −0.0892 | 2.0309 | 0.3545 | 2.5291 | 13.1534 | 1.7446 | 0.3578 | 0.6094 | 2.5275 |
| **Model 27** | 1.0603 | 0.8758 | — | — | — | — | — | — | −0.7282 | 1.2627 | 0.1708 | 1.7825 | −6.5236 | 22.1220 | 0.2522 | 0.8601 | 1.6269 |
| **Model 28** | −0.0247 | 1.4475 | −1.6931 | — | — | — | — | — | −0.7679 | 1.2977 | 0.1781 | 1.8056 | −7.4850 | 23.2246 | 0.2555 | 0.8582 | 1.6342 |
| **Model 29** | −0.0331 | 1.5433 | −1.9682 | 0.2274 | — | — | — | — | −0.7501 | 1.2873 | 0.1767 | 1.7971 | −7.1626 | 22.7027 | 0.2543 | 0.8585 | 1.6331 |
| **Model 30** | −0.0167 | 1.2539 | −0.5419 | −2.4242 | 1.6594 | — | — | — | −0.7338 | 1.2714 | 0.1730 | 1.7861 | −6.6842 | 22.2716 | 0.2527 | 0.8597 | 1.6284 |
| **Model 31** | 0.0431 | 0.2706 | — | — | — | — | — | — | −0.0617 | 1.9844 | 0.3365 | 2.4543 | 12.1182 | 1.2438 | 0.3473 | 0.6379 | 2.4535 |
| **Model 32** | 0.2180 | 0.1519 | — | — | — | — | — | — | −0.0961 | 2.0263 | 0.3540 | 2.5284 | 13.0775 | 1.8805 | 0.3577 | 0.6096 | 2.5266 |
| **Model 33** | 0.2665 | 0.1553 | — | — | — | — | — | — | −0.0646 | 1.9980 | 0.3427 | 2.4701 | 12.5819 | 1.2934 | 0.3495 | 0.6316 | 2.4692 |
| **Model 34** | −0.0099 | 0.2627 | — | — | — | — | — | — | −0.0842 | 1.8737 | 0.3091 | 2.3336 | 9.9887 | 1.7840 | 0.3302 | 0.6796 | 2.3321 |
| **Model 35** | 0.2706 | 0.0431 | — | — | — | — | — | — | 0.5042 | 2.0302 | 0.3787 | 2.5355 | 22.2002 | 10.0295 | 0.3587 | 0.6310 | 2.4849 |
| **Model 36** | 0.2183 | 0.0099 | — | — | — | — | — | — | −0.1140 | 2.0174 | 0.3530 | 2.5302 | 12.8617 | 2.2301 | 0.3580 | 0.6092 | 2.5276 |
| **Model 37** | −0.7854 | 0.0412 | — | — | — | — | — | — | −0.0912 | 2.0297 | 0.3544 | 2.5289 | 13.1319 | 1.7833 | 0.3578 | 0.6094 | 2.5273 |
| **Model 38** | 0.2291 | 0.0089 | — | — | — | — | — | — | −0.1353 | 2.0152 | 0.3518 | 2.5291 | 12.5049 | 2.6484 | 0.3578 | 0.6099 | 2.5255 |
| **Model 39** | 0.1705 | 0.5247 | −0.5570 | — | — | — | — | — | −0.1986 | 1.4592 | 0.2449 | 1.8994 | 6.2590 | 5.1975 | 0.2687 | 0.8049 | 1.8890 |
| **Model 40** | 0.1700 | 0.5387 | −0.5966 | 0.0282 | — | — | — | — | −0.1978 | 1.4599 | 0.2450 | 1.9003 | 6.2659 | 5.1715 | 0.2689 | 0.8046 | 1.8900 |
| **Model 41** | 0.2351 | −0.0140 | — | — | — | — | — | — | −0.2985 | 1.8828 | 0.2916 | 2.3653 | 6.4925 | 5.9323 | 0.3228 | 0.6791 | 2.3464 |
| **Model 42** | 0.2298 | 0.0337 | — | — | — | — | — | — | −0.1349 | 2.0141 | 0.3517 | 2.5287 | 12.5135 | 2.6404 | 0.3578 | 0.6100 | 2.5251 |
| **Model 43** | 0.3753 | 0.0538 | −0.2077 | — | — | — | — | — | 0.3213 | 1.4907 | 0.2367 | 1.9929 | 11.6915 | 7.6189 | 0.2720 | 0.7923 | 1.9668 |
| **Model 44** | 0.2418 | −0.0039 | — | — | — | — | — | — | −0.1301 | 1.9951 | 0.3496 | 2.5202 | 12.5671 | 2.5553 | 0.3566 | 0.6133 | 2.5169 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.2010 | −1.3912 | 0.0427 | — | — | — | — | — | −0.5881 | 1.2851 | 0.1814 | 1.7505 | −3.4330 | 17.6324 | 0.2477 | 0.8577 | 1.6487 |
| **Model 46** | −0.7740 | 1.1535 | — | — | — | — | — | — | 0.4207 | 2.9970 | 0.4974 | 3.9657 | 3.1825 | 5.2735 | 0.5611 | 0.6615 | 3.9433 |
| **Model 47** | 1.2412 | −1.4057 | 0.0322 | — | — | — | — | — | −0.5556 | 1.2486 | 0.1771 | 1.6979 | −4.0394 | 17.1167 | 0.2402 | 0.8635 | 1.6044 |
| **Model 48** | 0.9863 | −1.3202 | 2.0896 | −5.0264 | 1.2109 | 0.5186 | −0.2415 | — | −0.7009 | 1.2969 | 0.1872 | 1.7779 | −8.1112 | 21.2023 | 0.2516 | 0.8592 | 1.6339 |
| **Model 49** | 1.2337 | −1.3903 | 0.0003 | — | — | — | — | — | −0.5932 | 1.2856 | 0.1811 | 1.7525 | −3.3959 | 17.7787 | 0.2480 | 0.8581 | 1.6490 |
| **Model 50** | -13.8894 | −9.7219 | -20.0298 | -13.5377 | — | — | — | — | −0.2952 | 1.5307 | 0.2340 | 2.0167 | 4.0344 | 7.3126 | 0.2853 | 0.7798 | 1.9950 |
| **Model 51** | 10.6524 | 0.0435 | 902.3965 | — | — | — | — | — | 0.8652 | 2.9418 | 0.5278 | 3.6468 | 29.4453 | 12.0717 | 0.5160 | 0.3726 | 3.5427 |
| **Model 52** | 1.2701 | −1.4065 | −0.0005 | — | — | — | — | — | −0.6075 | 1.2844 | 0.1804 | 1.7546 | −3.3502 | 18.2405 | 0.2483 | 0.8603 | 1.6461 |

(*continued on next page*)

**Table A9** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.1941 | −1.0294 | −0.2238 | — | — | — | — | — | −0.3826 | 1.1826 | 0.1717 | 1.6250 | 0.4324 | 11.9730 | 0.2299 | 0.8753 | 1.5793 |
| **Model 54** | 1.0071 | 0.0952 | −1.2859 | −0.2604 | −0.0003 | — | — | — | −0.6858 | 1.1886 | 0.1657 | 1.6800 | −7.3600 | 22.1045 | 0.2377 | 0.8758 | 1.5336 |
| **Model 55** | 0.9196 | 1.2084 | −4.5824 | 2.7535 | −0.5672 | 0.9607 | −0.7029 | — | −0.5568 | **1.0879** | **0.1464** | 1.5740 | −4.4440 | 18.6921 | 0.2227 | 0.8876 | 1.4723 |
| **Model 56** | 1.0070 | 0.0956 | −1.2863 | −0.2607 | — | — | — | — | −0.6854 | 1.1884 | 0.1657 | 1.6798 | −7.3535 | 22.0904 | 0.2377 | 0.8758 | 1.5336 |
| **Model 57** | 1.1629 | −1.0616 | 0.1230 | −0.3581 | — | — | — | — | −0.4273 | 1.0911 | 0.1525 | **1.5328** | −1.7078 | 14.3467 | **0.2169** | 0.8891 | **1.4720** |
| **Model 58** | 0.9916 | −1.2351 | −0.2400 | — | — | — | — | — | −0.7092 | 1.2378 | 0.1772 | 1.7172 | −8.5082 | 22.4132 | 0.2430 | 0.8720 | 1.5639 |
| **Model 59** | 1.1679 | −1.0151 | −0.2552 | — | — | — | — | — | −0.3910 | 1.0988 | 0.1557 | 1.5392 | **−0.7111** | 12.9822 | 0.2178 | 0.8878 | 1.4887 |
| **Model 60** | 1.0234 | −1.1936 | −0.2512 | — | — | — | — | — | −0.6759 | 1.1811 | 0.1639 | 1.6696 | −7.0103 | 21.8830 | 0.2362 | 0.8771 | 1.5266 |
| **Model 61** | 0.9000 | −1.5831 | −0.2910 | — | — | — | — | — | −0.8458 | 1.5019 | 0.2384 | 2.0685 | -13.1470 | 22.1462 | 0.2927 | 0.8384 | 1.8877 |
| **Model 62** | 0.1405 | −0.5015 | −0.0485 | — | — | — | — | — | −2.9338 | 3.0989 | 0.3774 | 3.8654 | -33.1224 | 54.3652 | 0.5275 | 0.6582 | 2.5168 |
| **Model 63** | 1.9372 | −0.6750 | −0.1404 | — | — | — | — | — | −0.5459 | 1.1196 | 0.1539 | 1.5795 | −3.9280 | 18.2052 | 0.2235 | 0.8868 | 1.4822 |
| **Model 64** | −0.8078 | −1.1141 | −0.4346 | — | — | — | — | — | 0.0149 | 1.3998 | 0.2275 | 1.8571 | 8.5350 | 0.3979 | 0.2628 | 0.8135 | 1.8570 |
| **Model 65** | 0.2052 | 0.1203 | −0.0476 | — | — | — | — | — | **0.0012** | 2.0150 | 0.3552 | 2.5105 | 14.4650 | **0.0238** | 0.3552 | 0.6162 | 2.5105 |
| **Model 66** | −0.0376 | 1.5180 | −1.6086 | 0.0040 | −0.1009 | — | — | — | −0.5778 | 1.1322 | 0.1564 | 1.6197 | −5.1525 | 18.8735 | 0.2292 | 0.8798 | 1.5131 |
| **Model 67** | −0.0510 | 1.6610 | −1.7616 | −0.0981 | — | — | — | — | −0.6090 | 1.1751 | 0.1640 | 1.6615 | −5.6174 | 19.4715 | 0.2351 | 0.8741 | 1.5459 |
| **Model 68** | 0.1573 | 0.0709 | 0.4836 | −0.5485 | — | — | — | — | −0.1173 | 1.4610 | 0.2477 | 1.8865 | 7.5074 | 3.0798 | 0.2669 | 0.8063 | 1.8829 |
| **Model 69** | 0.2426 | 0.0357 | −0.0390 | — | — | — | — | — | −0.0807 | 1.9576 | 0.3462 | 2.4874 | 13.1817 | 1.6039 | 0.3519 | 0.6252 | 2.4861 |
| **Model 70** | 0.1771 | 0.2538 | −0.1438 | — | — | — | — | — | 0.1444 | 1.8203 | 0.3257 | 2.2934 | 15.1681 | 3.1174 | 0.3245 | 0.6937 | 2.2888 |
| **Model 71** | 0.2334 | −0.1507 | 0.0665 | — | — | — | — | — | −0.3369 | 1.9383 | 0.3295 | 2.4760 | 8.6432 | 6.7880 | 0.3503 | 0.6365 | 2.4530 |
| **Model 72** | 0.2528 | −0.0538 | −0.0308 | — | — | — | — | — | −0.1897 | 1.8845 | 0.3293 | 2.4456 | 10.9368 | 3.8450 | 0.3460 | 0.6430 | 2.4382 |
| **Model 73** | 0.2259 | −0.0182 | −0.0074 | — | — | — | — | — | −0.4711 | 1.8934 | 0.2857 | 2.3865 | 3.8146 | 9.3907 | 0.3257 | 0.6814 | 2.3396 |
| **Model 74** | 0.1930 | 0.0595 | −0.0296 | — | — | — | — | — | −0.0107 | 1.9973 | 0.3539 | 2.5048 | 14.3756 | 0.2104 | 0.3544 | 0.6183 | 2.5047 |
| **Model 75** | 0.2937 | −0.0109 | −0.0008 | — | — | — | — | — | −0.0945 | 2.0021 | 0.3492 | 2.5054 | 12.6027 | 1.8664 | 0.3545 | 0.6204 | 2.5036 |
| **Model 76** | 0.2150 | 0.5031 | −0.5481 | −0.0006 | — | — | — | — | −0.1702 | 1.4551 | 0.2443 | 1.8861 | 6.4241 | 4.4776 | 0.2669 | 0.8069 | 1.8784 |
| **Model 77** | 0.2389 | 0.0086 | −0.0013 | — | — | — | — | — | −0.2366 | 1.9972 | 0.3461 | 2.5127 | 12.0906 | 4.6739 | 0.3555 | 0.6186 | 2.5015 |
| **Model 78** | 0.1788 | 0.5134 | −0.5450 | −0.0009 | — | — | — | — | −0.2694 | 1.4550 | 0.2431 | 1.8954 | 6.1055 | 7.0971 | 0.2682 | 0.8144 | 1.8762 |
| **Model 79** | 0.2880 | −0.0013 | −0.0007 | — | — | — | — | — | −0.2024 | 1.9926 | 0.3447 | 2.4910 | 12.1404 | 4.0296 | 0.3525 | 0.6248 | 2.4828 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.9903 | −1.0385 | −0.2177 | 0.2132 | — | — | — | — | −0.3881 | 1.1835 | 0.1717 | 1.6256 | 0.2937 | 12.1520 | 0.2300 | 0.8759 | 1.5786 |
| **Model 81** | 1.1899 | −1.0026 | −0.2380 | −0.0004 | — | — | — | — | −0.3857 | 1.1850 | 0.1727 | 1.6293 | 0.8551 | 12.0424 | 0.2305 | 0.8788 | 1.5830 |
| **Model 82** | 1.2680 | −1.4001 | −0.0005 | −0.0004 | — | — | — | — | −0.6202 | 1.2816 | 0.1789 | 1.7544 | −3.2384 | 18.6777 | 0.2482 | 0.8639 | 1.6412 |
| **Model 83** | 0.5102 | −0.2934 | 0.0805 | −0.0010 | −0.0004 | — | — | — | 0.5353 | 1.6398 | 0.2654 | 2.1882 | 15.8244 | 11.7658 | 0.2986 | 0.7574 | 2.1217 |
| **Model 84** | 0.2220 | 0.4925 | −0.5365 | −0.0009 | −0.0006 | — | — | — | −0.2409 | 1.4473 | 0.2421 | 1.8787 | 6.2639 | 6.3897 | 0.2658 | 0.8158 | 1.8632 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | 1.0824 | −1.0381 | −0.2179 | 0.2131 | −0.1138 | — | — | — | −0.3903 | 1.1838 | 0.1717 | 1.6261 | 0.2592 | 12.2205 | 0.2301 | 0.8759 | 1.5786 |
| **Model 86** | 1.0060 | −1.3843 | −0.0062 | −0.0003 | 0.3661 | — | — | — | −0.5877 | 1.2341 | 0.1721 | 1.6823 | −3.8453 | 18.4289 | 0.2380 | 0.8716 | 1.5763 |
| **Model 87** | 1.0060 | −1.3843 | 0.3661 | −0.0062 | −0.0003 | — | — | — | −0.5877 | 1.2341 | 0.1721 | 1.6823 | −3.8453 | 18.4289 | 0.2380 | 0.8716 | 1.5763 |
| **Model 88** | 1.2651 | −1.0491 | −0.2353 | −0.0001 | −0.0009 | — | — | — | −0.3729 | 1.1775 | 0.1716 | 1.6174 | 0.3925 | 11.6815 | 0.2288 | 0.8753 | 1.5739 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.2595 | −0.9946 | −0.2592 | −0.0015 | −0.0008 | — | — | — | −0.3831 | 1.1686 | 0.1710 | 1.6070 | 1.1008 | 12.1347 | 0.2274 | 0.8863 | 1.5606 |
| **Model 90** | 1.2017 | 0.0328 | 1.0172 | 0.0740 | −1.0348 | −0.0007 | 0.0000 | −0.2243 | −0.3867 | 1.1263 | 0.1614 | 1.5546 | 0.0990 | 12.6944 | 0.2200 | **0.8902** | 1.5057 |
| **Model 91** | 0.9764 | 0.0179 | 1.4445 | −1.2067 | −0.6987 | −0.0037 | 0.0005 | — | 0.3519 | 1.5281 | 0.2681 | 2.0326 | 15.5554 | 8.6876 | 0.2876 | 0.7776 | 2.0019 |
| **Model 92** | 1.2062 | 0.0427 | 0.9095 | −0.1158 | −1.3809 | −0.0011 | 0.0005 | — | −0.5816 | 1.2193 | 0.1699 | 1.6686 | −3.9007 | 18.3790 | 0.2361 | 0.8736 | 1.5640 |
| **Model 93** | 1.2442 | 0.0540 | 0.8008 | −0.3508 | −1.3927 | −0.0027 | — | — | −0.5862 | 1.2283 | 0.1723 | 1.6743 | −3.9814 | 18.4746 | 0.2369 | 0.8726 | 1.5684 |
| **Model 94** | 1.1917 | 0.0440 | 0.9448 | 0.1585 | −1.3809 | 0.0006 | — | — | −0.5790 | 1.2177 | 0.1695 | 1.6687 | −3.8833 | 18.2849 | 0.2361 | 0.8733 | 1.5650 |
| **Model 95** | 1.2409 | 0.0392 | 0.9232 | 0.1825 | −1.4054 | — | — | — | −0.5790 | 1.2274 | 0.1722 | 1.6765 | −3.9831 | 18.1905 | 0.2372 | 0.8711 | 1.5733 |
| **Model 96** | 0.5643 | 0.0326 | 1.4638 | 0.1839 | — | — | — | — | 1.4805 | 3.5004 | 0.6416 | 4.3663 | 38.4808 | 17.8143 | 0.6178 | 0.3397 | 4.1077 |
| **Model 97** | 1.2463 | 0.0404 | −0.3792 | −1.4006 | −0.0010 | — | — | — | −0.5815 | 1.2218 | 0.1701 | 1.6728 | −3.9532 | 18.3254 | 0.2367 | 0.8722 | 1.5685 |

**Table A10**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Lasa station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2674 | −1.4532 | — | — | — | — | — | — | −0.2322 | 1.5721 | 0.3590 | 2.1515 | 17.8497 | 5.4521 | 0.3336 | 0.8564 | 2.1389 |
| **Model 2** | 1.3009 | −1.5709 | 0.0977 | — | — | — | — | — | −0.2418 | 1.5748 | 0.3594 | 2.1550 | 17.7988 | 5.6727 | 0.3342 | 0.8565 | 2.1414 |
| **Model 3** | 0.5813 | 2.7154 | −7.8344 | 4.6391 | — | — | — | — | −0.3052 | 1.5388 | 0.3385 | 2.1440 | 14.9961 | 7.2241 | 0.3325 | 0.8540 | 2.1222 |
| **Model 4** | 1.2265 | −2.8682 | 8.7891 | -15.9865 | 9.1296 | — | — | — | −0.3110 | 1.5212 | 0.3296 | 2.1356 | 14.0652 | 7.3940 | 0.3312 | 0.8540 | 2.1128 |
| **Model 5** | 1.0240 | −0.5015 | −1.2210 | 3.6368 | −8.9831 | 6.3669 | — | — | −0.3076 | 1.5211 | 0.3300 | 2.1348 | 14.1642 | 7.3126 | 0.3311 | 0.8542 | 2.1125 |
| **Model 6** | 0.3107 | 0.0000 | — | — | — | — | — | — | −0.1424 | 3.4243 | 0.8871 | 4.0112 | 55.2080 | 1.7841 | 0.6220 | 0.1802 | 4.0087 |
| **Model 7** | 2.7365 | −2.0482 | — | — | — | — | — | — | −0.1269 | 1.6017 | 0.3757 | 2.1619 | 20.1951 | 2.9542 | 0.3353 | 0.8525 | 2.1582 |
| **Model 8** | 0.1814 | −1.2011 | — | — | — | — | — | — | −0.1079 | 2.4355 | 0.6408 | 2.9296 | 40.7667 | 1.8517 | 0.4543 | 0.7618 | 2.9276 |
| **Model 9** | 0.9218 | −0.9787 | 4.0520 | −7.0104 | — | — | — | — | −0.2911 | 1.5365 | 0.3391 | 2.1395 | 15.2298 | 6.8987 | 0.3318 | 0.8542 | 2.1196 |
| **Model 10** | −3.8322 | 7.1833 | — | — | — | — | — | — | −0.2903 | 1.5774 | 0.3556 | 2.1656 | 16.7061 | 6.7944 | 0.3358 | 0.8526 | 2.1461 |
| **Model 11** | −0.2369 | 0.3412 | — | — | — | — | — | — | −0.4157 | 2.1016 | 0.5064 | 2.6370 | 26.8954 | 8.0192 | 0.4089 | 0.8272 | 2.6041 |
| **Model 12** | −0.0233 | −1.7050 | — | — | — | — | — | — | −0.2309 | 2.5155 | 0.6441 | 3.0228 | 39.0614 | 3.8480 | 0.4687 | 0.7386 | 3.0139 |
| **Model 13** | 2.4057 | −3.2200 | — | — | — | — | — | — | −0.2398 | 1.9453 | 0.4853 | 2.4585 | 28.0208 | 4.9224 | 0.3812 | 0.8432 | 2.4468 |
| **Model 14** | −0.0412 | −0.7963 | — | — | — | — | — | — | −4.2720 | 4.2723 | 0.5979 | 5.2873 | -59.7665 | 68.8806 | 0.8199 | 0.8398 | 3.1153 |
| **Model 15** | 1.8360 | −0.7833 | — | — | — | — | — | — | −0.1600 | 1.5705 | 0.3623 | 2.1432 | 18.6349 | 3.7599 | 0.3324 | 0.8536 | 2.1372 |
| **Model 16** | 0.8908 | −0.8514 | — | — | — | — | — | — | −1.1108 | 1.7934 | 0.2892 | 2.6103 | −4.7725 | 23.6200 | 0.4048 | 0.8045 | 2.3622 |
| **Model 17** | 0.8941 | −0.8646 | 0.0112 | — | — | — | — | — | −1.1108 | 1.7950 | 0.2899 | 2.6117 | −4.6675 | 23.6060 | 0.4050 | 0.8042 | 2.3637 |
| **Model 18** | 0.9541 | −1.3850 | 1.1488 | −0.7108 | — | — | — | — | −1.1137 | 1.7828 | 0.2851 | 2.6035 | −5.6583 | 23.7714 | 0.4037 | 0.8059 | 2.3533 |
| **Model 19** | 1.1226 | −0.8514 | — | — | — | — | — | — | −1.1108 | 1.7934 | 0.2892 | 2.6103 | −4.7720 | 23.6196 | 0.4048 | 0.8045 | 2.3622 |
| **Model 20** | −0.8562 | −0.9794 | −0.8978 | — | — | — | — | — | −1.1221 | 1.7912 | 0.2900 | 2.5853 | −4.6572 | 24.1753 | 0.4010 | 0.8123 | 2.3291 |
| **Model 21** | 0.7859 | 3.8182 | — | — | — | — | — | — | −0.4902 | 2.4938 | 0.5994 | 3.0951 | 31.2570 | 8.0570 | 0.4800 | 0.6642 | 3.0561 |
| **Model 22** | 2.2272 | −1.2306 | — | — | — | — | — | — | −1.0931 | 1.7683 | 0.2792 | 2.5770 | −7.0962 | 23.5286 | 0.3996 | 0.8086 | 2.3337 |
| **Model 23** | 0.1340 | −0.3816 | — | — | — | — | — | — | −2.5607 | 3.1100 | 0.4593 | 4.1093 | -15.0406 | 39.9796 | 0.6375 | 0.7291 | 3.2140 |
| **Model 24** | 1.2382 | −0.4588 | — | — | — | — | — | — | −1.0949 | 1.7681 | 0.2779 | 2.5774 | −7.8740 | 23.5691 | 0.3997 | 0.8085 | 2.3333 |
| **Model 25** | −0.0490 | −1.5997 | — | — | — | — | — | — | −0.8970 | 2.1462 | 0.4442 | 2.8172 | 13.7359 | 16.8716 | 0.4369 | 0.7713 | 2.6706 |
| **Model 26** | 0.4966 | −0.4807 | — | — | — | — | — | — | −0.4294 | 1.7772 | 0.3880 | 2.4010 | 16.7335 | 9.1295 | 0.3723 | 0.8142 | 2.3623 |
| **Model 27** | 0.9906 | 0.8965 | — | — | — | — | — | — | −0.2771 | 1.5708 | 0.3550 | 2.1597 | 16.9900 | 6.4973 | 0.3349 | 0.8555 | 2.1418 |
| **Model 28** | 0.0827 | 0.9735 | −1.2070 | — | — | — | — | — | −0.2671 | 1.5899 | 0.3618 | 2.1720 | 17.7151 | 6.2251 | 0.3368 | 0.8554 | 2.1555 |
| **Model 29** | −0.4154 | 3.9400 | −6.6968 | 3.2107 | — | — | — | — | −0.3089 | 1.5555 | 0.3429 | 2.1594 | 15.1225 | 7.2596 | 0.3349 | 0.8505 | 2.1372 |
| **Model 30** | 0.3224 | −2.4449 | 12.3127 | -20.3752 | 10.4399 | — | — | — | −0.3175 | 1.5227 | 0.3285 | 2.1384 | 13.8034 | 7.5416 | 0.3316 | 0.8530 | 2.1147 |
| **Model 31** | −0.2424 | 0.0730 | — | — | — | — | — | — | −0.5166 | 1.9344 | 0.4243 | 2.5759 | 18.2003 | 10.2816 | 0.3995 | 0.7857 | 2.5236 |
| **Model 32** | 0.6204 | −1.9149 | — | — | — | — | — | — | −0.4835 | 1.9618 | 0.4423 | 2.5671 | 20.3142 | 9.6331 | 0.3981 | 0.7949 | 2.5211 |
| **Model 33** | 0.1272 | −0.7694 | — | — | — | — | — | — | −0.5605 | 2.1735 | 0.4987 | 2.7785 | 23.5693 | 10.3445 | 0.4309 | 0.7690 | 2.7214 |
| **Model 34** | 0.0912 | 0.0338 | — | — | — | — | — | — | −0.6206 | 2.1800 | 0.4886 | 2.8285 | 21.6868 | 11.2962 | 0.4386 | 0.7468 | 2.7596 |
| **Model 35** | 0.0730 | −0.2424 | — | — | — | — | — | — | −2.5609 | 2.9474 | 0.4137 | 3.9389 | -19.0005 | 42.9815 | 0.6108 | 0.8042 | 2.9928 |
| **Model 36** | 0.7016 | −0.2678 | — | — | — | — | — | — | −0.3888 | 1.7217 | 0.3778 | 2.3358 | 16.6697 | 8.4781 | 0.3622 | 0.8254 | 2.3032 |
| **Model 37** | −0.4692 | −0.6618 | — | — | — | — | — | — | −0.4707 | 1.8424 | 0.4052 | 2.4612 | 17.5624 | 9.7863 | 0.3817 | 0.8084 | 2.4158 |
| **Model 38** | 0.3854 | −0.3013 | — | — | — | — | — | — | −0.9315 | 1.8282 | 0.3325 | 2.5585 | 3.6073 | 19.6345 | 0.3968 | 0.8058 | 2.3830 |
| **Model 39** | 0.2464 | 0.2649 | −0.4817 | — | — | — | — | — | −0.8935 | 1.6128 | 0.2694 | 2.3656 | −1.9296 | 20.4901 | 0.3668 | 0.8359 | 2.1904 |
| **Model 40** | 0.2731 | 0.0338 | 0.0236 | −0.3157 | — | — | — | — | −0.8971 | 1.6056 | 0.2662 | 2.3560 | −2.5080 | 20.6844 | 0.3654 | 0.8380 | 2.1785 |
| **Model 41** | 0.1230 | −0.1244 | — | — | — | — | — | — | −1.8360 | 2.6481 | 0.4483 | 3.4686 | −1.6482 | 31.3069 | 0.5381 | 0.7907 | 2.9428 |
| **Model 42** | 0.4106 | −1.2571 | — | — | — | — | — | — | −0.8644 | 1.9902 | 0.3989 | 2.6673 | 10.5820 | 17.2064 | 0.4136 | 0.7895 | 2.5234 |
| **Model 43** | 0.3695 | 0.0422 | −0.3312 | — | — | — | — | — | −0.5873 | 1.5762 | 0.2793 | 2.3044 | 2.9558 | 13.2252 | 0.3575 | 0.8275 | 2.2283 |
| **Model 44** | 0.5224 | −0.1693 | — | — | — | — | — | — | −0.9267 | 1.7343 | 0.3032 | 2.4782 | 1.0610 | 20.2523 | 0.3843 | 0.8194 | 2.2985 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1397 | −1.4048 | 0.1146 | — | — | — | — | — | −0.1700 | 1.5173 | 0.3336 | 2.0787 | 16.1314 | 4.1207 | 0.3223 | 0.8618 | 2.0717 |
| **Model 46** | −0.6430 | 0.8643 | — | — | — | — | — | — | **0.0353** | 2.3284 | 0.4856 | 2.9943 | 10.6917 | **0.5928** | 0.4643 | 0.7108 | 2.9941 |
| **Model 47** | 1.2399 | −1.4113 | 0.0302 | — | — | — | — | — | 1.2293 | 2.1897 | 0.6816 | 2.7528 | 59.0159 | 25.0675 | 0.4269 | 0.7860 | 2.4631 |
| **Model 48** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 49** | 1.2375 | −1.4083 | 0.0009 | — | — | — | — | — | −0.1715 | 1.5193 | 0.3353 | 2.0761 | 16.2353 | 4.1624 | 0.3219 | 0.8621 | 2.0690 |
| **Model 50** | -54.8056 | -36.4111 | -79.0573 | -52.0346 | — | — | — | — | −0.2861 | 1.6292 | 0.3407 | 2.1908 | 14.3687 | 6.6173 | 0.3397 | 0.8479 | 2.1720 |
| **Model 51** | -21.9065 | 0.3182 | -1919.4196 | — | — | — | — | — | −0.2392 | 1.9390 | 0.4331 | 2.4744 | 21.3437 | 4.8777 | 0.3837 | 0.7961 | 2.4628 |
| **Model 52** | 1.2407 | −1.4324 | 0.0003 | — | — | — | — | — | −0.4910 | 1.5873 | 0.3344 | 2.2153 | 11.9959 | 11.4167 | 0.3435 | 0.8548 | 2.1602 |

(*continued on next page*)

**Table A10** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.1318 | −0.8302 | −0.4030 | — | — | — | — | — | −0.6522 | 1.5358 | 0.2893 | 2.2046 | 5.4699 | 15.5574 | 0.3419 | 0.8561 | 2.1059 |
| **Model 54** | 1.1772 | −1.0557 | 0.1850 | −0.3250 | −0.0650 | — | — | — | −0.6679 | 1.5317 | 0.2851 | 2.2061 | 4.8233 | 15.9562 | 0.3421 | 0.8561 | 2.1026 |
| **Model 55** | 0.5319 | 3.5319 | −8.2869 | 4.8733 | −1.4075 | 2.3207 | −1.4510 | — | −0.6703 | 1.4645 | **0.2609** | 2.1596 | 2.2236 | 16.3996 | 0.3349 | 0.8603 | 2.0529 |
| **Model 56** | 1.1561 | −0.9155 | 0.0705 | −0.4028 | — | — | — | — | −0.6590 | 1.5390 | 0.2897 | 2.2089 | 5.4395 | 15.7005 | 0.3425 | 0.8560 | 2.1083 |
| **Model 57** | 1.1293 | −0.8304 | −0.3922 | −0.0091 | — | — | — | — | −0.6522 | 1.5341 | 0.2885 | 2.2033 | 5.3831 | 15.5670 | 0.3417 | 0.8562 | 2.1045 |
| **Model 58** | 0.7927 | −0.7275 | −0.3013 | — | — | — | — | — | −0.5247 | 1.4905 | 0.2804 | 2.1428 | 5.3086 | 12.6856 | 0.3323 | 0.8552 | 2.0775 |
| **Model 59** | 1.0798 | −0.9539 | −0.2754 | — | — | — | — | — | −0.5666 | 1.4837 | 0.2786 | 2.1418 | 5.3407 | 13.7779 | 0.3321 | 0.8591 | 2.0655 |
| **Model 60** | 0.8953 | −0.6086 | −0.4558 | — | — | — | — | — | −0.6466 | 1.5312 | 0.2836 | 2.2040 | 4.5485 | 15.4135 | 0.3418 | 0.8534 | 2.1070 |
| **Model 61** | 0.6646 | −0.7502 | −0.2867 | — | — | — | — | — | −0.4297 | 1.5248 | 0.2927 | 2.1645 | 6.5513 | 10.1742 | 0.3357 | 0.8465 | 2.1214 |
| **Model 62** | −0.0052 | −0.5813 | −0.1285 | — | — | — | — | — | −3.9612 | 3.9630 | 0.5228 | 5.0244 | -52.1407 | 64.3093 | 0.7794 | 0.8536 | 3.0909 |
| **Model 63** | 1.6268 | −0.4522 | −0.2154 | — | — | — | — | — | −0.5997 | 1.4998 | 0.2777 | 2.1651 | 4.4761 | 14.4794 | 0.3357 | 0.8563 | 2.0804 |
| **Model 64** | −0.7176 | −1.2702 | −0.8013 | — | — | — | — | — | −0.7948 | 1.6768 | 0.3181 | 2.3618 | 5.8959 | 17.9491 | 0.3663 | 0.8433 | 2.2241 |
| **Model 65** | 0.4115 | −0.0899 | −0.2528 | — | — | — | — | — | −0.8429 | 1.7936 | 0.3342 | 2.5016 | 5.3929 | 17.9758 | 0.3879 | 0.8114 | 2.3553 |
| **Model 66** | 0.0692 | 0.8669 | −0.7949 | 0.0339 | −0.2439 | — | — | — | −0.7160 | 1.5390 | 0.2783 | 2.2309 | 3.2169 | 17.0208 | 0.3460 | 0.8527 | 2.1129 |
| **Model 67** | −0.0100 | 1.3927 | −1.2244 | −0.2576 | — | — | — | — | −0.6860 | 1.5809 | 0.3018 | 2.2498 | 6.1774 | 16.0824 | 0.3489 | 0.8525 | 2.1426 |
| **Model 68** | 0.2751 | −0.1013 | 0.3226 | −0.4842 | — | — | — | — | −0.7933 | 1.5684 | 0.2684 | 2.3000 | **0.0593** | 18.4560 | 0.3567 | 0.8413 | 2.1589 |
| **Model 69** | 0.3293 | −0.0773 | −0.2232 | — | — | — | — | — | −0.8194 | 1.6442 | 0.2905 | 2.3687 | 1.9849 | 18.5181 | 0.3673 | 0.8322 | 2.2225 |
| **Model 70** | 0.3158 | 0.0002 | −0.2652 | — | — | — | — | — | −0.9176 | 1.6810 | 0.2877 | 2.4307 | −0.3225 | 20.4769 | 0.3769 | 0.8267 | 2.2508 |
| **Model 71** | 0.3868 | −0.1914 | −0.1770 | — | — | — | — | — | −0.6787 | 1.7099 | 0.3333 | 2.3806 | 8.3301 | 14.9411 | 0.3692 | 0.8257 | 2.2817 |
| **Model 72** | 0.3001 | −0.1085 | −0.2110 | — | — | — | — | — | −0.7645 | 1.5636 | 0.2728 | 2.2806 | 1.3689 | 17.8723 | 0.3537 | 0.8443 | 2.1487 |
| **Model 73** | 0.0844 | −0.1612 | −0.0542 | — | — | — | — | — | −2.4168 | 2.8622 | 0.4136 | 3.8184 | -15.9992 | 41.0231 | 0.5923 | 0.8046 | 2.9562 |
| **Model 74** | 0.5601 | −0.0439 | −0.1457 | — | — | — | — | — | −0.8434 | 1.7022 | 0.3053 | 2.4259 | 2.9295 | 18.6243 | 0.3762 | 0.8241 | 2.2746 |
| **Model 75** | 0.3825 | −0.2996 | 0.0000 | — | — | — | — | — | −0.9384 | 1.8275 | 0.3313 | 2.5593 | 3.3747 | 19.7970 | 0.3969 | 0.8061 | 2.3810 |
| **Model 76** | 0.2515 | 0.2632 | −0.4831 | −0.0001 | — | — | — | — | −0.8803 | 1.6133 | 0.2711 | 2.3635 | −1.5083 | 20.1598 | 0.3665 | 0.8355 | 2.1934 |
| **Model 77** | 0.3655 | −0.2900 | 0.0014 | — | — | — | — | — | −0.8277 | 1.7786 | 0.3221 | 2.4742 | 3.8300 | 17.8297 | 0.3837 | 0.8129 | 2.3317 |
| **Model 78** | 0.2400 | 0.2539 | −0.4671 | 0.0007 | — | — | — | — | −0.8400 | 1.5884 | 0.2643 | 2.3226 | −1.6580 | 19.4868 | 0.3602 | 0.8395 | 2.1653 |
| **Model 79** | 0.0868 | 0.0016 | 0.0018 | — | — | — | — | — | −0.9934 | 2.2991 | 0.4540 | 2.9444 | 10.6856 | 18.0015 | 0.4566 | 0.7329 | 2.7718 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.8911 | −0.8100 | −0.4124 | 0.2438 | — | — | — | — | −0.6620 | 1.5316 | 0.2838 | 2.2185 | 5.0186 | 15.7045 | 0.3440 | 0.8545 | 2.1174 |
| **Model 81** | 1.1220 | −0.8330 | −0.3861 | 0.0005 | — | — | — | — | −0.6027 | 1.5007 | 0.2787 | 2.1537 | 5.1578 | 14.6426 | 0.3340 | 0.8603 | 2.0676 |
| **Model 82** | 1.2402 | −1.4324 | 0.0005 | 0.0002 | — | — | — | — | −0.2435 | 1.5547 | 0.3486 | 2.1323 | 16.6080 | 5.7739 | 0.3307 | 0.8577 | 2.1183 |
| **Model 83** | 0.6239 | −0.5628 | 0.1260 | 0.0012 | −0.0003 | — | — | — | 0.1685 | 1.7317 | 0.3308 | 2.4459 | 15.2988 | 3.4653 | 0.3794 | 0.8106 | 2.4400 |
| **Model 84** | 0.2551 | 0.2441 | −0.4667 | 0.0010 | −0.0003 | — | — | — | −0.7768 | 1.5842 | 0.2691 | 2.3039 | −0.1307 | 17.9900 | 0.3573 | 0.8389 | 2.1690 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0065 | −1.3832 | −0.0047 | 0.0000 | 0.3062 | — | — | — | −0.2525 | 1.4961 | 0.3208 | 2.0867 | 14.1810 | 6.1241 | 0.3236 | 0.8623 | 2.0714 |
| **Model 87** | 1.0065 | −1.3832 | 0.3062 | −0.0047 | 0.0000 | — | — | — | −0.2525 | 1.4961 | 0.3208 | 2.0867 | 14.1810 | 6.1241 | 0.3236 | 0.8623 | 2.0714 |
| **Model 88** | 1.1603 | −0.8286 | −0.4215 | 0.0001 | −0.0004 | — | — | — | −0.6066 | 1.5419 | 0.2968 | 2.2045 | 7.0429 | 14.3530 | 0.3416 | 0.8550 | 2.1194 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.1593 | −0.8278 | −0.4219 | 0.0006 | −0.0005 | — | — | — | 0.1409 | 1.5287 | 0.3572 | 2.0578 | 21.7311 | 3.4479 | 0.3191 | 0.8577 | 2.0530 |
| **Model 90** | 1.0812 | 0.0954 | 0.4181 | 0.4888 | −0.8257 | −0.0020 | −0.0003 | −0.3900 | −0.5840 | 1.4696 | 0.2698 | 2.1403 | 5.1292 | 14.2472 | 0.3319 | 0.8622 | 2.0591 |
| **Model 91** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 92** | 1.1803 | 0.0397 | 0.7371 | 0.0826 | −1.3655 | −0.0013 | 0.0008 | — | −0.3242 | 1.4558 | 0.2977 | 2.0620 | 11.4795 | 7.9981 | 0.3198 | 0.8674 | 2.0363 |
| **Model 93** | 1.2249 | −0.0653 | 0.6505 | 3.0018 | −1.3951 | −0.0025 | — | — | −0.2071 | 1.4871 | 0.3195 | 2.0648 | 14.8815 | 5.0644 | 0.3202 | 0.8653 | 2.0544 |
| **Model 94** | 1.1685 | 0.0338 | 0.7803 | 0.4069 | −1.3652 | 0.0009 | — | — | −0.3271 | **1.4496** | 0.2943 | **2.0564** | 11.1791 | 8.0927 | **0.3189** | **0.8682** | **2.0302** |
| **Model 95** | 1.2560 | 0.0174 | 2.1656 | -25.8431 | −1.4357 | — | — | — | −0.2357 | 1.5742 | 0.3542 | 2.1630 | 17.4211 | 5.5072 | 0.3354 | 0.8541 | 2.1501 |
| **Model 96** | 0.2065 | −0.2069 | 0.5909 | 3.0560 | — | — | — | — | 0.1842 | 3.0590 | 0.6951 | 3.8092 | 39.5856 | 2.4316 | 0.5907 | 0.4449 | 3.8047 |
| **Model 97** | 1.2553 | −0.0436 | 2.0354 | −1.4023 | −0.0024 | — | — | — | −0.2086 | 1.4889 | 0.3218 | 2.0603 | 15.0003 | 5.1127 | 0.3195 | 0.8653 | 2.0497 |

**Table A11**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Mohe station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1934 | −1.2768 | — | — | — | — | — | — | −0.2403 | 1.2732 | 0.2637 | 1.8546 | 0.3426 | 6.5796 | 0.3244 | 0.8524 | 1.8390 |
| **Model 2** | 1.1968 | −1.2927 | 0.0161 | — | — | — | — | — | −0.1974 | 1.2754 | 0.2650 | 1.8553 | 1.1911 | 5.3875 | 0.3245 | 0.8519 | 1.8448 |
| **Model 3** | 0.8641 | 1.5640 | −6.4422 | 4.2701 | — | — | — | — | −0.3396 | 1.2098 | 0.2460 | 1.8372 | −2.7094 | 9.4729 | 0.3213 | 0.8591 | 1.8056 |
| **Model 4** | 0.8751 | 1.4116 | −5.8541 | 3.4178 | 0.4133 | — | — | — | −0.3406 | 1.2099 | 0.2459 | 1.8373 | −2.7596 | 9.4991 | 0.3214 | 0.8592 | 1.8055 |
| **Model 5** | 1.0710 | −2.5241 | 16.8400 | -50.9346 | 57.8738 | -22.1345 | — | — | −0.3571 | 1.2210 | 0.2473 | 1.8503 | −3.1037 | 9.9060 | 0.3236 | 0.8579 | 1.8155 |
| **Model 6** | 0.4939 | 0.0000 | — | — | — | — | — | — | 0.3809 | 2.5587 | 0.5532 | 3.3333 | 20.2615 | 5.7918 | 0.5830 | 0.5914 | 3.3115 |
| **Model 7** | 2.7813 | −2.0146 | — | — | — | — | — | — | −0.1140 | 1.3357 | 0.2781 | 1.8981 | 2.6923 | 3.0304 | 0.3320 | 0.8462 | 1.8947 |
| **Model 8** | 0.3573 | −0.4527 | — | — | — | — | — | — | 0.0674 | 1.9645 | 0.4198 | 2.6112 | 12.1180 | 1.3004 | 0.4567 | 0.7040 | 2.6103 |
| **Model 9** | 0.1549 | 0.8041 | −4.9519 | 9.6902 | — | — | — | — | −0.3399 | 1.2217 | 0.2480 | 1.8486 | −2.6945 | 9.4214 | 0.3233 | 0.8576 | 1.8170 |
| **Model 10** | −3.7606 | 6.8557 | — | — | — | — | — | — | −0.3560 | 1.2259 | 0.2483 | 1.8454 | −3.4186 | 9.9005 | 0.3228 | 0.8595 | 1.8107 |
| **Model 11** | 0.3816 | 0.0470 | — | — | — | — | — | — | 0.0920 | 2.2409 | 0.4763 | 2.9358 | 13.9251 | 1.5797 | 0.5135 | 0.6408 | 2.9343 |
| **Model 12** | 0.1288 | −1.9620 | — | — | — | — | — | — | −0.0562 | 1.6920 | 0.3594 | 2.2861 | 7.9566 | 1.2373 | 0.3998 | 0.7677 | 2.2854 |
| **Model 13** | 1.4138 | −2.0299 | — | — | — | — | — | — | −0.1693 | 1.4459 | 0.3060 | 2.0259 | 4.2208 | 4.2225 | 0.3543 | 0.8178 | 2.0188 |
| **Model 14** | 0.1978 | −0.4308 | — | — | — | — | — | — | −1.9509 | 2.3370 | 0.4092 | 3.0941 | -27.5769 | 40.9074 | 0.5412 | 0.7357 | 2.4016 |
| **Model 15** | 1.8159 | −0.7523 | — | — | — | — | — | — | −0.1699 | 1.2922 | 0.2675 | 1.8667 | 1.1396 | 4.6018 | 0.3265 | 0.8521 | 1.8590 |
| **Model 16** | 0.9534 | −0.7943 | — | — | — | — | — | — | 0.0915 | 1.3030 | 0.2536 | 2.0440 | 3.5910 | 2.2559 | 0.3575 | 0.8404 | 2.0419 |
| **Model 17** | 0.9722 | −0.9274 | 0.1360 | — | — | — | — | — | 0.0575 | 1.2951 | 0.2536 | 2.0279 | 3.4773 | 1.4293 | 0.3547 | 0.8390 | 2.0271 |
| **Model 18** | 0.9735 | −0.9540 | 0.2075 | −0.0489 | — | — | — | — | 0.0592 | 1.2952 | 0.2536 | 2.0282 | 3.5186 | 1.4706 | 0.3547 | 0.8389 | 2.0274 |
| **Model 19** | 1.0489 | −0.7943 | — | — | — | — | — | — | 0.0914 | 1.3030 | 0.2536 | 2.0440 | 3.5897 | 2.2544 | 0.3575 | 0.8404 | 2.0419 |
| **Model 20** | −0.8154 | −0.8660 | −0.9907 | — | — | — | — | — | 0.0377 | 1.3898 | 0.2715 | 2.0801 | 3.3607 | 0.8667 | 0.3548 | 0.8325 | 2.0798 |
| **Model 21** | 0.9638 | 2.2796 | — | — | — | — | — | — | 0.0551 | 1.4994 | 0.3088 | 2.1792 | 7.9052 | 1.2744 | 0.3812 | 0.7970 | 2.1785 |
| **Model 22** | 2.4673 | −1.3497 | — | — | — | — | — | — | 0.1793 | 1.3623 | 0.2626 | 2.1107 | 4.4583 | 4.2943 | 0.3692 | 0.8389 | 2.1030 |
| **Model 23** | 0.2977 | −0.2383 | — | — | — | — | — | — | −1.1375 | 2.0549 | 0.3778 | 2.7137 | -10.6211 | 22.0740 | 0.4629 | 0.7163 | 2.4638 |
| **Model 24** | 1.3569 | −0.4631 | — | — | — | — | — | — | 0.1982 | 1.3809 | 0.2649 | 2.1393 | 4.3919 | 4.6865 | 0.3742 | 0.8385 | 2.1301 |
| **Model 25** | −0.0028 | −1.3718 | — | — | — | — | — | — | −0.0056 | 1.3461 | 0.2707 | 2.0453 | 4.5062 | 0.1390 | 0.3577 | 0.8254 | 2.0453 |
| **Model 26** | 0.2680 | −0.0720 | — | — | — | — | — | — | −0.3436 | 1.6306 | 0.3434 | 2.2754 | 2.3324 | 7.6940 | 0.3980 | 0.7690 | 2.2493 |
| **Model 27** | 0.7034 | 1.0476 | — | — | — | — | — | — | −0.3384 | 1.2612 | 0.2593 | 1.8605 | −1.3194 | 9.3157 | 0.3254 | 0.8525 | 1.8295 |
| **Model 28** | 0.0709 | 0.8575 | −0.9372 | — | — | — | — | — | −0.2679 | 1.3277 | 0.2781 | 1.8996 | 0.8766 | 7.1744 | 0.3322 | 0.8434 | 1.8806 |
| **Model 29** | −0.1155 | 2.4581 | −4.5557 | 2.3925 | — | — | — | — | −0.3121 | 1.2509 | 0.2561 | 1.8635 | −1.9779 | 8.5539 | 0.3259 | 0.8535 | 1.8372 |
| **Model 30** | −0.0344 | 1.3308 | −0.2063 | −3.9104 | 3.0561 | — | — | — | −0.3321 | 1.2100 | 0.2469 | 1.8400 | −2.5239 | 9.2415 | 0.3218 | 0.8583 | 1.8098 |
| **Model 31** | 0.0082 | 0.2342 | — | — | — | — | — | — | −0.3825 | 1.6520 | 0.3464 | 2.2536 | 2.1315 | 8.6720 | 0.3942 | 0.7728 | 2.2210 |
| **Model 32** | 0.2621 | −0.2511 | — | — | — | — | — | — | −0.3492 | 1.6357 | 0.3444 | 2.2728 | 2.3474 | 7.8306 | 0.3975 | 0.7692 | 2.2459 |
| **Model 33** | 0.2328 | 0.0265 | — | — | — | — | — | — | −0.3807 | 1.6524 | 0.3466 | 2.2561 | 2.1614 | 8.6211 | 0.3946 | 0.7723 | 2.2237 |
| **Model 34** | −0.0071 | 0.2457 | — | — | — | — | — | — | −0.3726 | 1.6125 | 0.3354 | 2.1971 | 1.8339 | 8.6645 | 0.3843 | 0.7850 | 2.1653 |
| **Model 35** | 0.2342 | 0.0082 | — | — | — | — | — | — | −0.3045 | 1.6482 | 0.3489 | 2.2514 | 3.6085 | 6.8741 | 0.3938 | 0.7717 | 2.2308 |
| **Model 36** | 0.3297 | −0.0575 | — | — | — | — | — | — | −0.3286 | 1.6110 | 0.3394 | 2.2651 | 2.3123 | 7.3834 | 0.3962 | 0.7718 | 2.2411 |
| **Model 37** | −0.7336 | −0.0705 | — | — | — | — | — | — | −0.3457 | 1.6320 | 0.3436 | 2.2747 | 2.3277 | 7.7436 | 0.3979 | 0.7691 | 2.2483 |
| **Model 38** | 0.2858 | −0.0991 | — | — | — | — | — | — | −0.2372 | 1.5844 | 0.3319 | 2.2604 | 2.8773 | 5.3139 | 0.3954 | 0.7761 | 2.2479 |
| **Model 39** | 0.2311 | 0.2901 | −0.3977 | — | — | — | — | — | −0.1216 | 1.4238 | 0.2965 | 2.0257 | 2.0678 | 3.0280 | 0.3543 | 0.8262 | 2.0220 |
| **Model 40** | 0.2246 | 0.4181 | −0.7415 | 0.2349 | — | — | — | — | −0.1338 | 1.4199 | 0.2956 | 2.0175 | 1.6367 | 3.3479 | 0.3529 | 0.8283 | 2.0130 |
| **Model 41** | 0.2094 | −0.0295 | — | — | — | — | — | — | −0.6987 | 1.6491 | 0.3216 | 2.2808 | −4.7139 | 15.3867 | 0.3890 | 0.7885 | 2.1711 |
| **Model 42** | 0.2823 | −0.3758 | — | — | — | — | — | — | −0.2521 | 1.5949 | 0.3344 | 2.2636 | 2.9327 | 5.6437 | 0.3959 | 0.7743 | 2.2495 |
| **Model 43** | 0.3496 | 0.0323 | −0.2141 | — | — | — | — | — | 0.1330 | 1.4646 | 0.2877 | 2.0974 | 4.8640 | 3.0376 | 0.3578 | 0.8329 | 2.0932 |
| **Model 44** | 0.3512 | −0.0658 | — | — | — | — | — | — | −0.2045 | 1.5521 | 0.3250 | 2.2283 | 2.8747 | 4.6405 | 0.3897 | 0.7843 | 2.2189 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.2593 | −1.2894 | −0.1021 | — | — | — | — | — | −0.3926 | 1.2258 | 0.2484 | 1.8434 | −0.5194 | 10.9776 | 0.3224 | 0.8561 | 1.8011 |
| **Model 46** | −0.0490 | 0.7842 | — | — | — | — | — | — | 0.6405 | 3.0101 | 0.6412 | 4.0545 | 7.9110 | 8.0560 | 0.7092 | 0.6675 | 4.0036 |
| **Model 47** | 1.1938 | −1.2778 | 0.0081 | — | — | — | — | — | −0.2126 | 1.2751 | 0.2639 | 1.8533 | 0.3623 | 5.8159 | 0.3241 | 0.8533 | 1.8410 |
| **Model 48** | 0.2012 | 1.8126 | 0.1688 | −0.8293 | 3.9621 | −0.2296 | 0.0358 | — | −0.5114 | 1.2060 | 0.2368 | 1.8721 | −3.6524 | 14.3011 | 0.3274 | 0.8561 | 1.8009 |
| **Model 49** | 1.2009 | −1.2904 | −0.0014 | — | — | — | — | — | −0.3917 | 1.2258 | 0.2489 | 1.8436 | −0.4212 | 10.9483 | 0.3225 | 0.8561 | 1.8015 |
| **Model 50** | -22.1432 | -15.1094 | -23.1399 | -15.6067 | — | — | — | — | −0.4918 | 1.3480 | 0.2680 | 1.9803 | −0.8721 | 12.9113 | 0.3464 | 0.8360 | 1.9183 |
| **Model 51** | 2.8767 | 0.0474 | 220.7308 | — | — | — | — | — | 0.0148 | 2.2210 | 0.4713 | 2.9022 | 13.5786 | 0.2560 | 0.5076 | 0.6346 | 2.9022 |
| **Model 52** | 1.2994 | −1.3142 | −0.0012 | — | — | — | — | — | −0.2092 | 1.2636 | 0.2625 | 1.8445 | 0.9294 | 5.7495 | 0.3226 | 0.8536 | 1.8326 |

(continued on next page)

**Table A11** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0638 | −0.4446 | −0.5640 | — | — | — | — | — | −0.0411 | 1.2091 | 0.2387 | 1.8628 | 1.4854 | 1.1105 | 0.3258 | 0.8592 | 1.8624 |
| **Model 54** | 1.0052 | −0.0257 | −0.3908 | −0.7949 | 0.2166 | — | — | — | −0.0531 | 1.1962 | 0.2367 | 1.8585 | 1.5777 | 1.4381 | 0.3251 | 0.8589 | 1.8577 |
| **Model 55** | 0.8851 | 1.1306 | −3.1978 | 1.8499 | −0.9334 | 0.7147 | −0.3232 | — | −0.1118 | 1.1682 | 0.2314 | 1.8191 | 0.3966 | 3.1017 | 0.3182 | 0.8637 | 1.8157 |
| **Model 56** | 1.0267 | −0.2676 | −0.1713 | −0.5689 | — | — | — | — | −0.0246 | 1.2099 | 0.2381 | 1.8677 | 1.5746 | 0.6621 | 0.3267 | 0.8599 | 1.8675 |
| **Model 57** | 1.0757 | −0.4378 | −0.6643 | 0.0988 | — | — | — | — | −0.0638 | 1.2056 | 0.2390 | 1.8569 | 1.4317 | 1.7313 | 0.3248 | 0.8583 | 1.8559 |
| **Model 58** | 0.8813 | −0.5547 | −0.4728 | — | — | — | — | — | 0.1106 | 1.3354 | 0.2595 | 1.9825 | 2.6190 | 2.8137 | 0.3467 | 0.8564 | 1.9794 |
| **Model 59** | 1.0471 | −0.6861 | −0.4137 | — | — | — | — | — | **0.0026** | 1.2610 | 0.2475 | 1.8818 | 1.4024 | **0.0708** | 0.3291 | 0.8613 | 1.8818 |
| **Model 60** | 0.9686 | −0.3824 | −0.6005 | — | — | — | — | — | 0.0105 | 1.2229 | 0.2395 | 1.8926 | 1.9181 | 0.2797 | 0.3310 | 0.8589 | 1.8925 |
| **Model 61** | 0.7848 | −0.5798 | −0.4890 | — | — | — | — | — | 0.2724 | 1.5163 | 0.2927 | 2.1898 | 5.4565 | 6.3137 | 0.3830 | 0.8392 | 2.1728 |
| **Model 62** | 0.2013 | −0.2619 | −0.1429 | — | — | — | — | — | −1.9191 | 2.2871 | 0.3880 | 3.0446 | -26.0919 | 38.8192 | 0.5193 | 0.7590 | 2.3637 |
| **Model 63** | 1.5974 | −0.2939 | −0.3150 | — | — | — | — | — | 0.0414 | 1.2559 | 0.2452 | 1.9092 | 1.9954 | 1.0915 | 0.3339 | 0.8595 | 1.9087 |
| **Model 64** | −0.8895 | −0.5510 | −0.8290 | — | — | — | — | — | −0.0948 | 1.2219 | 0.2446 | 1.8643 | 1.6815 | 2.5653 | 0.3261 | 0.8541 | 1.8619 |
| **Model 65** | 0.2078 | 0.3144 | −0.2619 | — | — | — | — | — | −0.1503 | 1.5360 | 0.3181 | 2.1460 | 3.4965 | 3.5360 | 0.3753 | 0.7994 | 2.1407 |
| **Model 66** | −0.0074 | 1.2833 | −0.9434 | −0.1987 | −0.0885 | — | — | — | −0.0304 | 1.2146 | 0.2417 | 1.8349 | 1.9553 | 0.8339 | 0.3209 | 0.8616 | 1.8347 |
| **Model 67** | −0.0162 | 1.3821 | −1.0331 | −0.2911 | — | — | — | — | −0.0453 | 1.2265 | 0.2442 | 1.8407 | 2.0191 | 1.2385 | 0.3220 | 0.8596 | 1.8402 |
| **Model 68** | 0.1629 | 0.2884 | 0.1168 | −0.3731 | — | — | — | — | −0.0490 | 1.3806 | 0.2838 | 1.9649 | 2.6844 | 1.2559 | 0.3437 | 0.8383 | 1.9643 |
| **Model 69** | 0.2613 | 0.1584 | −0.1996 | — | — | — | — | — | −0.1274 | 1.4979 | 0.3130 | 2.1292 | 3.1270 | 3.0193 | 0.3724 | 0.8053 | 2.1254 |
| **Model 70** | 0.1679 | 0.3321 | −0.2831 | — | — | — | — | — | −0.0549 | 1.4003 | 0.2883 | 1.9883 | 2.9891 | 1.3920 | 0.3478 | 0.8332 | 1.9875 |
| **Model 71** | 0.2836 | 0.0570 | −0.1280 | — | — | — | — | — | −0.2265 | 1.5912 | 0.3331 | 2.2601 | 3.0793 | 5.0728 | 0.3953 | 0.7760 | 2.2487 |
| **Model 72** | 0.2694 | 0.0714 | −0.1655 | — | — | — | — | — | −0.1277 | 1.4874 | 0.3107 | 2.1304 | 2.9975 | 3.0244 | 0.3726 | 0.8056 | 2.1265 |
| **Model 73** | 0.2309 | 0.0584 | −0.0508 | — | — | — | — | — | −0.3992 | 1.6139 | 0.3256 | 2.2155 | 0.8718 | 8.7595 | 0.3779 | 0.7885 | 2.1792 |
| **Model 74** | 0.2338 | 0.1434 | −0.1381 | — | — | — | — | — | −0.1338 | 1.5170 | 0.3157 | 2.1379 | 3.3853 | 3.1581 | 0.3739 | 0.8022 | 2.1337 |
| **Model 75** | 0.4012 | −0.1245 | −0.0015 | — | — | — | — | — | −0.1893 | 1.5416 | 0.3238 | 2.1969 | 3.5879 | 4.3566 | 0.3842 | 0.7878 | 2.1887 |
| **Model 76** | 0.3522 | 0.2694 | −0.4039 | −0.0015 | — | — | — | — | −0.0629 | 1.3850 | 0.2883 | 1.9720 | 2.9244 | 1.6064 | 0.3449 | 0.8355 | 1.9710 |
| **Model 77** | 0.2865 | −0.1096 | −0.0012 | — | — | — | — | — | −0.4949 | 1.5488 | 0.3037 | 2.2731 | 0.9203 | 11.2328 | 0.3976 | 0.7715 | 2.2185 |
| **Model 78** | 0.2268 | 0.3134 | −0.4342 | −0.0015 | — | — | — | — | −0.4184 | 1.3007 | 0.2521 | 1.9572 | −0.3394 | 11.0209 | 0.3423 | 0.8361 | 1.9120 |
| **Model 79** | 0.2314 | −0.0009 | −0.0001 | — | — | — | — | — | −0.5845 | 1.6523 | 0.3298 | 2.3023 | 0.7152 | 13.2179 | 0.4027 | 0.7701 | 2.2268 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 1.3171 | −0.4346 | −0.5674 | −0.2676 | — | — | — | — | −0.0383 | 1.2209 | 0.2369 | 1.8878 | 1.2405 | 1.0209 | 0.3302 | 0.8577 | 1.8874 |
| **Model 81** | 1.0713 | −0.4604 | −0.5622 | −0.0013 | — | — | — | — | −0.1868 | 1.1502 | 0.2229 | 1.8040 | 0.7456 | 5.2414 | 0.3155 | 0.8611 | 1.7943 |
| **Model 82** | 1.3230 | −1.3479 | −0.0017 | −0.0014 | — | — | — | — | −0.3937 | 1.1745 | 0.2342 | 1.8054 | **−0.3375** | 11.2518 | 0.3158 | 0.8633 | 1.7620 |
| **Model 83** | 0.5894 | −0.3593 | 0.0655 | −0.0013 | −0.0014 | — | — | — | 0.2426 | 1.4229 | 0.2688 | 2.1596 | 8.8508 | 5.4050 | 0.3684 | 0.8204 | 2.1459 |
| **Model 84** | 0.3588 | 0.2918 | −0.4426 | −0.0015 | −0.0017 | — | — | — | −0.3657 | 1.2761 | 0.2457 | 1.9233 | 0.5093 | 9.7536 | 0.3364 | 0.8405 | 1.8882 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | 4.5794 | −0.4381 | −0.5657 | −0.2897 | −5.3837 | — | — | — | −0.0670 | 1.2198 | 0.2360 | 1.8848 | 0.6511 | 1.7912 | 0.3297 | 0.8578 | 1.8836 |
| **Model 86** | 1.2785 | −1.3479 | −0.0024 | −0.0013 | 0.0569 | — | — | — | −0.3914 | 1.1658 | 0.2316 | 1.7966 | −0.5780 | 11.2411 | 0.3142 | 0.8646 | 1.7535 |
| **Model 87** | 1.2785 | −1.3479 | 0.0569 | −0.0024 | −0.0013 | — | — | — | −0.3913 | 1.1657 | 0.2316 | 1.7966 | −0.5746 | 11.2393 | 0.3142 | 0.8646 | 1.7535 |
| **Model 88** | 1.2344 | −0.4839 | −0.5790 | 0.0001 | −0.0020 | — | — | — | 0.0178 | 1.1974 | 0.2376 | 1.8465 | 2.5398 | 0.4855 | 0.3232 | 0.8622 | 1.8465 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.2586 | −0.5148 | −0.5818 | −0.0018 | −0.0022 | — | — | — | −0.1763 | 1.0887 | 0.2073 | **1.7478** | 1.1400 | 5.1048 | **0.3057** | 0.8685 | **1.7389** |
| **Model 90** | 1.2428 | 0.0474 | −0.7748 | 1.3420 | −0.5241 | −0.0003 | −0.0018 | −0.5710 | −0.1740 | **1.0863** | **0.2058** | 1.7513 | 0.6578 | 5.0297 | 0.3063 | **0.8686** | 1.7426 |
| **Model 91** | 1.1189 | −0.0225 | −1.9621 | 4.8340 | −0.8420 | −0.0015 | −0.0021 | — | 0.0028 | 1.2273 | 0.2282 | 1.9711 | 3.1008 | 0.0723 | 0.3448 | 0.8433 | 1.9711 |
| **Model 92** | 1.2447 | −0.0952 | −0.9742 | −1.1279 | −1.3282 | 0.0017 | −0.0003 | — | −0.3911 | 1.1750 | 0.2327 | 1.8166 | −1.2472 | 11.1032 | 0.3177 | 0.8608 | 1.7740 |
| **Model 93** | 1.2229 | 0.0968 | −0.9849 | 8.3479 | −1.3216 | 0.0018 | — | — | −0.3943 | 1.1743 | 0.2325 | 1.8158 | −1.3719 | 11.2040 | 0.3176 | 0.8610 | 1.7724 |
| **Model 94** | 1.2472 | −0.0575 | −0.9961 | −0.8001 | −1.3339 | −0.0004 | — | — | −0.3958 | 1.1595 | 0.2280 | 1.8018 | −1.3524 | 11.3397 | 0.3151 | 0.8636 | 1.7578 |
| **Model 95** | 1.2160 | 0.0590 | −1.0143 | 2.4443 | −1.3241 | — | — | — | −0.4009 | 1.1581 | 0.2275 | 1.8000 | −1.5624 | 11.5060 | 0.3148 | 0.8641 | 1.7548 |
| **Model 96** | 0.4975 | −0.0483 | 1.8771 | −0.5109 | — | — | — | — | 0.4140 | 2.5418 | 0.5358 | 3.3837 | 19.3089 | 6.2077 | 0.5918 | 0.6082 | 3.3583 |
| **Model 97** | 1.2216 | 0.0949 | 1.0154 | −1.3219 | 0.0017 | — | — | — | −0.3939 | 1.1744 | 0.2326 | 1.8160 | −1.3592 | 11.1889 | 0.3176 | 0.8610 | 1.7728 |

**Table A12**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Sanya station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2467 | −1.5235 | — | — | — | — | — | — | −1.7852 | 2.0047 | 0.2191 | 2.5000 | -17.6729 | 51.2772 | 0.2849 | 0.7692 | 1.7502 |
| **Model 2** | 1.0452 | −0.3530 | −1.4219 | — | — | — | — | — | −1.9859 | 2.2041 | 0.2600 | 2.8012 | -22.6641 | 50.5343 | 0.3192 | 0.7428 | 1.9755 |
| **Model 3** | 0.9199 | 1.0083 | −5.3416 | 3.3105 | — | — | — | — | −1.8399 | 2.0516 | 0.2309 | 2.5988 | -19.8997 | 50.3927 | 0.2961 | 0.7562 | 1.8353 |
| **Model 4** | 0.9613 | 0.2889 | −1.7172 | −3.6487 | 4.5210 | — | — | — | −1.7912 | 2.0057 | 0.2225 | 2.5455 | -18.9965 | 49.7826 | 0.2901 | 0.7596 | 1.8087 |
| **Model 5** | 0.9454 | 0.6880 | −4.7676 | 6.1863 | −9.5919 | 7.4402 | — | — | −1.7731 | 1.9893 | 0.2194 | 2.5276 | -18.6443 | 49.4819 | 0.2880 | 0.7603 | 1.8013 |
| **Model 6** | 0.5121 | 0.0000 | — | — | — | — | — | — | −0.2156 | 3.1575 | 0.4281 | 3.6984 | 6.1795 | **2.9353** | 0.4214 | 0.1948 | 3.6921 |
| **Model 7** | 3.0708 | −2.8097 | — | — | — | — | — | — | −2.0132 | 2.2289 | 0.2641 | 2.8300 | -22.9136 | 50.8815 | 0.3225 | 0.7384 | 1.9890 |
| **Model 8** | 0.3447 | −0.4727 | — | — | — | — | — | — | −0.8289 | 2.4200 | 0.3014 | 2.8703 | −0.9472 | 15.1623 | 0.3271 | 0.3421 | 2.7480 |
| **Model 9** | −0.0791 | 1.1123 | −3.6000 | 7.0105 | — | — | — | — | −1.7894 | 2.0047 | 0.2225 | 2.5443 | -18.9774 | 49.7335 | 0.2899 | 0.7599 | 1.8087 |
| **Model 10** | −4.0025 | 7.9899 | — | — | — | — | — | — | −1.7478 | 1.9675 | 0.2163 | 2.5055 | -18.2713 | 48.9440 | 0.2855 | 0.7613 | 1.7952 |
| **Model 11** | 0.3780 | 0.0509 | — | — | — | — | — | — | −0.7059 | 2.7730 | 0.3558 | 3.2527 | 1.1811 | 11.1751 | 0.3706 | 0.2249 | 3.1751 |
| **Model 12** | 0.1519 | −2.2489 | — | — | — | — | — | — | −1.0575 | 2.1224 | 0.2498 | 2.5611 | −5.2668 | 22.7909 | 0.2918 | 0.5290 | 2.3326 |
| **Model 13** | 1.4303 | −2.2389 | — | — | — | — | — | — | −1.3315 | 1.9248 | 0.2138 | 2.4029 | −9.0990 | 33.4604 | 0.2738 | 0.7089 | 2.0003 |
| **Model 14** | 0.1515 | −0.4463 | — | — | — | — | — | — | −4.1301 | 4.2040 | 0.4462 | 4.7847 | -42.7050 | 85.9395 | 0.5452 | 0.4840 | 2.4158 |
| **Model 15** | 2.1591 | −1.0060 | — | — | — | — | — | — | −1.9117 | 2.1204 | 0.2424 | 2.6559 | -20.6638 | 52.1225 | 0.3026 | 0.7533 | 1.8437 |
| **Model 16** | 0.9408 | −0.8062 | — | — | — | — | — | — | −0.4504 | 1.5459 | 0.1810 | 2.1614 | −2.0775 | 10.7093 | 0.2463 | 0.6955 | 2.1140 |
| **Model 17** | 0.9411 | −0.8088 | 0.0031 | — | — | — | — | — | −0.4505 | 1.5454 | 0.1809 | 2.1609 | −2.0699 | 10.7147 | 0.2462 | 0.6954 | 2.1134 |
| **Model 18** | 0.9419 | −0.8282 | 0.0605 | −0.0435 | — | — | — | — | −0.4538 | 1.5465 | 0.1810 | 2.1617 | −2.1226 | 10.7935 | 0.2463 | 0.6955 | 2.1135 |
| **Model 19** | 1.0629 | −0.8062 | — | — | — | — | — | — | −0.4505 | 1.5459 | 0.1810 | 2.1614 | −2.0789 | 10.7120 | 0.2463 | 0.6955 | 2.1140 |
| **Model 20** | −0.8055 | −0.9966 | −0.9410 | — | — | — | — | — | −0.5211 | 1.7138 | 0.1986 | 2.2969 | −2.2426 | 10.9318 | 0.2516 | 0.5966 | 2.2370 |
| **Model 21** | 1.0038 | 2.1531 | — | — | — | — | — | — | −0.3940 | 1.7130 | 0.2095 | 2.2733 | 1.5760 | 8.8452 | 0.2590 | 0.5986 | 2.2389 |
| **Model 22** | 2.4671 | −1.4252 | — | — | — | — | — | — | −0.4632 | 1.6288 | 0.1951 | 2.2433 | −3.1437 | 10.6077 | 0.2556 | 0.6987 | 2.1950 |
| **Model 23** | 0.2977 | −0.2531 | — | — | — | — | — | — | −2.3353 | 2.9691 | 0.3180 | 3.4872 | -18.9488 | 42.3154 | 0.3821 | 0.1902 | 2.5898 |
| **Model 24** | 1.4007 | −0.5046 | — | — | — | — | — | — | −0.4601 | 1.6572 | 0.1996 | 2.2785 | −3.3435 | 10.3649 | 0.2596 | 0.6979 | 2.2315 |
| **Model 25** | −0.0305 | −1.2693 | — | — | — | — | — | — | −0.4498 | 1.5638 | 0.1858 | 2.1503 | −**0.4186** | 10.7537 | 0.2450 | 0.6640 | 2.1027 |
| **Model 26** | 0.2349 | −0.0467 | — | — | — | — | — | — | −1.4744 | 2.4498 | 0.3240 | 2.9811 | −4.3902 | 28.6048 | 0.3397 | 0.3263 | 2.5910 |
| **Model 27** | 1.1592 | 0.7970 | — | — | — | — | — | — | −1.7916 | 2.0234 | 0.2264 | 2.5880 | -19.0918 | 48.2222 | 0.2949 | 0.7462 | 1.8676 |
| **Model 28** | −0.0397 | 1.5476 | −1.9367 | — | — | — | — | — | −1.8759 | 2.0903 | 0.2409 | 2.6470 | -20.8362 | 50.4937 | 0.3016 | 0.7510 | 1.8675 |
| **Model 29** | −0.0355 | 1.5027 | −1.8074 | −0.1092 | — | — | — | — | −1.8829 | 2.0965 | 0.2416 | 2.6550 | -20.9131 | 50.5647 | 0.3025 | 0.7505 | 1.8719 |
| **Model 30** | 0.0117 | 0.6836 | 2.3202 | −8.0346 | 5.1487 | — | — | — | −1.8027 | 2.0180 | 0.2253 | 2.5585 | -19.1910 | 49.9101 | 0.2915 | 0.7588 | 1.8156 |
| **Model 31** | 0.0144 | 0.2240 | — | — | — | — | — | — | −1.4714 | 2.3912 | 0.3024 | 2.8843 | −5.7967 | 29.8160 | 0.3287 | 0.4290 | 2.4808 |
| **Model 32** | 0.2309 | −0.1740 | — | — | — | — | — | — | −1.4720 | 2.4456 | 0.3226 | 2.9730 | −4.4372 | 28.6476 | 0.3388 | 0.3331 | 2.5830 |
| **Model 33** | 0.2216 | 0.0527 | — | — | — | — | — | — | −1.4698 | 2.4003 | 0.3059 | 2.8977 | −5.5210 | 29.5879 | 0.3302 | 0.4142 | 2.4972 |
| **Model 34** | −0.0069 | 0.2305 | — | — | — | — | — | — | −1.4843 | 2.2835 | 0.2677 | 2.7691 | −8.9213 | 31.9174 | 0.3155 | 0.5331 | 2.3377 |
| **Model 35** | 0.2240 | 0.0144 | — | — | — | — | — | — | −1.2437 | 2.3166 | 0.3067 | 2.8067 | −2.2891 | 24.8489 | 0.3198 | 0.3955 | 2.5161 |
| **Model 36** | 0.2902 | −0.0476 | — | — | — | — | — | — | −1.4855 | 2.4538 | 0.3264 | 2.9935 | −4.4707 | 28.7330 | 0.3411 | 0.3234 | 2.5989 |
| **Model 37** | −0.7662 | −0.0451 | — | — | — | — | — | — | −1.4737 | 2.4487 | 0.3237 | 2.9790 | −4.4017 | 28.6159 | 0.3395 | 0.3281 | 2.5889 |
| **Model 38** | 0.2353 | −0.0431 | — | — | — | — | — | — | −1.3611 | 2.3722 | 0.3185 | 2.8938 | −3.1483 | 26.7924 | 0.3297 | 0.3620 | 2.5537 |
| **Model 39** | 0.1858 | 0.3700 | −0.4777 | — | — | — | — | — | −1.4230 | 2.1189 | 0.2715 | 2.6073 | −7.9473 | 32.7430 | 0.2971 | 0.6028 | 2.1847 |
| **Model 40** | 0.1800 | 0.5086 | −0.8897 | 0.3117 | — | — | — | — | −1.3878 | 2.0779 | 0.2647 | 2.5674 | −7.6379 | 32.2998 | 0.2925 | 0.6144 | 2.1599 |
| **Model 41** | 0.2000 | −0.0232 | — | — | — | — | — | — | −1.9363 | 2.4460 | 0.2599 | 2.9591 | -15.1238 | 40.6080 | 0.3242 | 0.4677 | 2.2376 |
| **Model 42** | 0.2332 | −0.1780 | — | — | — | — | — | — | −1.3712 | 2.3788 | 0.3185 | 2.8989 | −3.2787 | 26.9879 | 0.3303 | 0.3610 | 2.5541 |
| **Model 43** | 0.3289 | 0.0390 | −0.2210 | — | — | — | — | — | −0.8727 | 1.7175 | 0.1965 | 2.2021 | −5.6820 | 20.2558 | 0.2413 | 0.6249 | 2.0218 |
| **Model 44** | 0.2740 | −0.0350 | — | — | — | — | — | — | −1.3357 | 2.3408 | 0.3163 | 2.8646 | −2.9739 | 26.4969 | 0.3264 | 0.3806 | 2.5341 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.3659 | −1.5221 | −0.1313 | — | — | — | — | — | −1.8029 | 1.9969 | 0.2147 | 2.5073 | -17.5807 | 52.0124 | 0.2857 | 0.7740 | 1.7425 |
| **Model 46** | −1.2694 | 1.2179 | — | — | — | — | — | — | −1.5548 | 2.4507 | 0.3079 | 3.0643 | -16.9315 | 29.5998 | 0.3492 | 0.6320 | 2.6405 |
| **Model 47** | 1.2466 | −1.5232 | −0.0026 | — | — | — | — | — | −1.7874 | 2.0046 | 0.2187 | 2.5017 | -17.6530 | 51.3334 | 0.2851 | 0.7693 | 1.7504 |
| **Model 48** | 0.8913 | −0.6914 | -26.0911 | -10.7733 | 0.6370 | 53.2396 | -22.8544 | — | −1.5314 | 1.8374 | 0.1969 | 2.4388 | -13.9859 | 40.5569 | 0.2779 | 0.7206 | 1.8981 |
| **Model 49** | 1.2424 | −1.4520 | −0.0011 | — | — | — | — | — | −1.2432 | 1.6017 | 0.1722 | 2.0739 | -10.3371 | 37.6494 | 0.2363 | 0.8085 | 1.6600 |
| **Model 50** | -46.3893 | -30.7775 | -47.2219 | -31.2000 | — | — | — | — | −1.6143 | 1.9445 | 0.2060 | 2.4677 | -13.1991 | 43.4781 | 0.2812 | 0.7777 | 1.8664 |
| **Model 51** | 23.6807 | 0.0511 | 2060.6369 | — | — | — | — | — | −0.7534 | 2.8034 | 0.3593 | 3.2827 | 1.1948 | 11.8539 | 0.3741 | 0.1732 | 3.1950 |
| **Model 52** | 1.4234 | −1.5493 | −0.0022 | — | — | — | — | — | −2.2705 | 2.3929 | 0.2606 | 2.9181 | -23.5012 | 62.2670 | 0.3325 | 0.7428 | 1.8330 |

(continued on next page)

**Table A12** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.1901 | −1.1577 | −0.2252 | — | — | — | — | — | −1.4739 | 1.7424 | 0.1914 | 2.2210 | -14.2514 | 44.5974 | 0.2531 | 0.7950 | 1.6614 |
| **Model 54** | 0.9602 | 0.3667 | −1.8926 | −0.4987 | 0.3459 | — | — | — | −1.7670 | 1.9977 | 0.2352 | 2.6147 | -20.1213 | 46.0884 | 0.2979 | 0.7576 | 1.9273 |
| **Model 55** | 0.9204 | 0.8289 | −3.3320 | 1.2467 | −0.5064 | 0.4506 | −0.1011 | — | −1.7322 | 1.9595 | 0.2272 | 2.5479 | -19.3557 | 46.6030 | 0.2903 | 0.7627 | 1.8685 |
| **Model 56** | 1.0114 | −0.1255 | −1.3184 | −0.1925 | — | — | — | — | −1.7054 | 1.9563 | 0.2312 | 2.5276 | -19.3780 | 45.9496 | 0.2880 | 0.7696 | 1.8657 |
| **Model 57** | 1.1785 | −1.1761 | −0.0867 | −0.1495 | — | — | — | — | −1.4908 | 1.7678 | 0.1972 | 2.2429 | -14.8950 | 44.7214 | 0.2556 | 0.7913 | 1.6758 |
| **Model 58** | 0.9717 | −1.6493 | −0.1088 | — | — | — | — | — | −1.8753 | 2.1314 | 0.2586 | 2.7506 | -22.1612 | 46.8483 | 0.3134 | 0.7540 | 2.0123 |
| **Model 59** | 1.1786 | −1.2202 | −0.2195 | — | — | — | — | — | −1.5290 | 1.8048 | 0.2028 | 2.2787 | -15.5294 | 45.4932 | 0.2597 | 0.7883 | 1.6895 |
| **Model 60** | 0.9886 | −1.4476 | −0.2015 | — | — | — | — | — | −1.7065 | 1.9647 | 0.2341 | 2.5495 | -19.6249 | 45.2922 | 0.2905 | 0.7684 | 1.8941 |
| **Model 61** | 0.8682 | −2.3843 | −0.0719 | — | — | — | — | — | −2.1244 | 2.4416 | 0.3197 | 3.3234 | -27.6505 | 41.7856 | 0.3787 | 0.7247 | 2.5557 |
| **Model 62** | 0.0815 | −0.4827 | −0.0663 | — | — | — | — | — | −4.9713 | 4.9811 | 0.5175 | 5.4370 | -51.4505 | 105.9665 | 0.5957 | 0.6115 | 2.2015 |
| **Model 63** | 2.0513 | −0.8224 | −0.1095 | — | — | — | — | — | −1.6555 | 1.9028 | 0.2189 | 2.4133 | -17.8340 | 47.3918 | 0.2750 | 0.7787 | 1.7560 |
| **Model 64** | −0.8218 | −1.1892 | −0.5348 | — | — | — | — | — | −1.0465 | 1.5277 | 0.1687 | 2.0255 | −8.0146 | 30.3340 | 0.2308 | 0.7755 | 1.7342 |
| **Model 65** | 0.2082 | 0.1259 | −0.1063 | — | — | — | — | — | −1.1876 | 2.2291 | 0.3000 | 2.7220 | −1.8322 | 24.3750 | 0.3102 | 0.4487 | 2.4492 |
| **Model 66** | −0.0578 | 1.6924 | −1.9925 | −0.1057 | 0.0527 | — | — | — | −1.7185 | 1.9606 | 0.2298 | 2.5157 | -19.3471 | 47.0211 | 0.2867 | 0.7627 | 1.8372 |
| **Model 67** | −0.0500 | 1.6174 | −1.9050 | −0.0590 | — | — | — | — | −1.7103 | 1.9483 | 0.2272 | 2.4946 | -19.1498 | 47.3436 | 0.2843 | 0.7669 | 1.8160 |
| **Model 68** | 0.1720 | 0.0681 | 0.3281 | −0.4689 | — | — | — | — | −1.3282 | 2.0413 | 0.2610 | 2.5179 | −7.1495 | 31.2144 | 0.2869 | 0.6241 | 2.1391 |
| **Model 69** | 0.2390 | 0.0151 | −0.0857 | — | — | — | — | — | −1.2901 | 2.2780 | 0.3096 | 2.8000 | −2.7994 | 26.0976 | 0.3191 | 0.4211 | 2.4850 |
| **Model 70** | 0.1717 | 0.2350 | −0.2039 | — | — | — | — | — | −1.0258 | 1.9547 | 0.2601 | 2.4374 | −2.1552 | 23.3213 | 0.2777 | 0.5919 | 2.2110 |
| **Model 71** | 0.2432 | −0.2398 | 0.0571 | — | — | — | — | — | −1.6856 | 2.5588 | 0.3351 | 3.1210 | −7.2914 | 32.2583 | 0.3556 | 0.3210 | 2.6267 |
| **Model 72** | 0.2464 | −0.1404 | −0.0559 | — | — | — | — | — | −1.4403 | 2.3628 | 0.3191 | 2.8908 | −4.9133 | 28.8885 | 0.3294 | 0.4162 | 2.5064 |
| **Model 73** | 0.1893 | −0.0239 | −0.0140 | — | — | — | — | — | −2.1794 | 2.5980 | 0.2723 | 3.1278 | -17.9897 | 45.5849 | 0.3427 | 0.4642 | 2.2435 |
| **Model 74** | 0.2288 | 0.0571 | −0.0624 | — | — | — | — | — | −1.2108 | 2.2401 | 0.3037 | 2.7456 | −1.9322 | 24.7000 | 0.3129 | 0.4358 | 2.4642 |
| **Model 75** | 0.3533 | −0.0523 | −0.0015 | — | — | — | — | — | −2.0378 | 2.7320 | 0.3371 | 3.2782 | -11.9212 | 39.8907 | 0.3736 | 0.3466 | 2.5679 |
| **Model 76** | 0.2775 | 0.3517 | −0.4647 | −0.0011 | — | — | — | — | −1.9370 | 2.4096 | 0.2908 | 2.9144 | -14.5022 | 44.7169 | 0.3321 | 0.6071 | 2.1775 |
| **Model 77** | 0.2616 | −0.0400 | −0.0011 | — | — | — | — | — | −1.2540 | 2.3259 | 0.3162 | 2.8447 | −1.6447 | 24.6882 | 0.3242 | 0.3608 | 2.5534 |
| **Model 78** | 0.2049 | 0.3714 | −0.4768 | −0.0008 | — | — | — | — | −1.3440 | 2.0704 | 0.2670 | 2.5595 | −6.8321 | 31.0189 | 0.2917 | 0.6058 | 2.1782 |
| **Model 79** | 0.3096 | −0.0009 | −0.0010 | — | — | — | — | — | −1.8283 | 2.6196 | 0.3243 | 3.1510 | −9.3902 | 35.8133 | 0.3591 | 0.3535 | 2.5663 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.8722 | −0.8984 | −0.3436 | 0.2891 | — | — | — | — | −0.8851 | 1.3875 | 0.1558 | 1.8511 | −7.0846 | 27.3670 | 0.2109 | 0.8046 | 1.6258 |
| **Model 81** | 1.1560 | −0.9270 | −0.3287 | −0.0007 | — | — | — | — | −0.9223 | 1.3874 | 0.1531 | 1.8566 | −7.1593 | 28.7764 | 0.2116 | **0.8106** | 1.6112 |
| **Model 82** | 1.4423 | −1.5363 | −0.0021 | −0.0018 | — | — | — | — | −2.0713 | 2.2163 | 0.2392 | 2.7347 | -20.9340 | 58.3132 | 0.3116 | 0.7592 | 1.7856 |
| **Model 83** | 0.5263 | −0.3161 | 0.0742 | 0.0002 | −0.0011 | — | — | — | −0.7762 | 1.8283 | 0.2099 | 2.3605 | −4.6135 | 16.3386 | 0.2586 | 0.5750 | 2.2292 |
| **Model 84** | 0.2658 | 0.3456 | −0.4635 | 0.0012 | −0.0014 | — | — | — | −2.1768 | 2.5812 | 0.3072 | 3.0855 | -17.7369 | 50.0423 | 0.3516 | 0.6018 | 2.1867 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | -788.8136 | −1.0276 | −0.2647 | 0.2752 | 831.4457 | — | — | — | **−0.0994** | **1.1955** | **0.1494** | **1.6107** | 2.7269 | 3.1074 | **0.1835** | 0.8094 | **1.6076** |
| **Model 86** | 1.4442 | −1.5369 | −0.0019 | −0.0018 | −0.0095 | — | — | — | −2.0754 | 2.2195 | 0.2395 | 2.7387 | -20.9784 | 58.3843 | 0.3121 | 0.7588 | 1.7870 |
| **Model 87** | 1.4442 | −1.5369 | −0.0095 | −0.0019 | −0.0018 | — | — | — | −2.0754 | 2.2195 | 0.2395 | 2.7387 | -20.9784 | 58.3843 | 0.3121 | 0.7588 | 1.7870 |
| **Model 88** | 1.5901 | −1.1359 | −0.2401 | −0.1331 | −0.0031 | — | — | — | −2.0518 | 2.1838 | 0.2387 | 2.6926 | -21.2842 | 59.1587 | 0.3068 | 0.7710 | 1.7435 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.3648 | −1.1792 | −0.2304 | 0.0006 | −0.0023 | — | — | — | −2.0335 | 2.1702 | 0.2369 | 2.6801 | -21.0323 | 58.5547 | 0.3054 | 0.7703 | 1.7458 |
| **Model 90** | 1.3849 | −0.0169 | −2.0578 | 7.6709 | −1.1649 | 0.0002 | −0.0025 | −0.2370 | −2.0468 | 2.1805 | 0.2393 | 2.6845 | -21.3220 | 59.2371 | 0.3059 | 0.7730 | 1.7369 |
| **Model 91** | 1.0392 | 0.0180 | 3.7901 | -129.3649 | −0.8226 | 0.0019 | −0.0018 | — | −0.9487 | 1.6973 | 0.1941 | 2.3263 | −8.3219 | 22.4525 | 0.2651 | 0.6910 | 2.1241 |
| **Model 92** | 1.4383 | −0.0055 | −4.2597 | 23.9722 | −1.5355 | −0.0020 | −0.0018 | — | −2.0805 | 2.2242 | 0.2400 | 2.7436 | -21.0363 | 58.4755 | 0.3126 | 0.7582 | 1.7886 |
| **Model 93** | 1.1541 | 0.0407 | 1.0888 | 0.7894 | −1.5307 | 0.0035 | — | — | −2.0189 | 2.1553 | 0.2333 | 2.6765 | -20.4668 | 57.7570 | 0.3050 | 0.7678 | 1.7572 |
| **Model 94** | 1.3470 | 0.0245 | 1.0990 | 0.4911 | −1.5354 | −0.0013 | — | — | −2.0901 | 2.2170 | 0.2394 | 2.7370 | -21.2586 | 59.4594 | 0.3119 | 0.7651 | 1.7671 |
| **Model 95** | 1.2410 | 0.0302 | 1.1655 | 0.4371 | −1.5190 | — | — | — | −1.8077 | 1.9800 | 0.2129 | 2.4936 | -17.7701 | 52.9054 | 0.2841 | 0.7814 | 1.7176 |
| **Model 96** | 0.5025 | 0.0451 | 1.4791 | 0.1370 | — | — | — | — | −0.2602 | 3.1473 | 0.4266 | 3.6838 | 5.9307 | 3.5591 | 0.4198 | 0.1731 | 3.6746 |
| **Model 97** | 1.1424 | 0.0431 | 1.0994 | −1.5327 | 0.0041 | — | — | — | −2.0655 | 2.2166 | 0.2379 | 2.7589 | -20.6184 | 56.7677 | 0.3144 | 0.7454 | 1.8290 |

**Table A13**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Shanghai station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1833 | −1.2789 | — | — | — | — | — | — | −0.5538 | 0.9870 | 0.1280 | 1.3883 | −2.5131 | 21.9803 | 0.1889 | 0.9431 | 1.2730 |
| **Model 2** | 1.0218 | −0.0564 | −1.6653 | — | — | — | — | — | −0.6811 | 0.9631 | 0.1178 | 1.4467 | −6.3686 | 26.9611 | 0.1968 | 0.9311 | 1.2764 |
| **Model 3** | 0.9547 | 0.8604 | −4.6146 | 2.6609 | — | — | — | — | −0.6379 | 0.9197 | 0.1092 | 1.3840 | −5.5290 | 26.2440 | 0.1883 | 0.9394 | 1.2282 |
| **Model 4** | 0.9879 | 0.1834 | −0.8553 | −5.0122 | 5.1898 | — | — | — | −0.6252 | 0.9090 | 0.1072 | 1.3734 | −5.2996 | 25.8323 | 0.1868 | 0.9402 | 1.2228 |
| **Model 5** | 0.9893 | 0.1447 | −0.5364 | −6.0942 | 6.7972 | −0.8674 | — | — | −0.6256 | 0.9093 | 0.1073 | 1.3737 | −5.3074 | 25.8457 | 0.1869 | 0.9402 | 1.2229 |
| **Model 6** | 0.6630 | 0.0000 | — | — | — | — | — | — | 1.0371 | 2.6853 | 0.4244 | 3.6621 | 14.9674 | 14.9053 | 0.4982 | 0.6831 | 3.5099 |
| **Model 7** | 3.0799 | −2.6490 | — | — | — | — | — | — | −0.6639 | 0.9657 | 0.1207 | 1.3861 | −5.1133 | 27.5670 | 0.1886 | 0.9440 | 1.2168 |
| **Model 8** | 0.4581 | −0.3215 | — | — | — | — | — | — | 0.1349 | 1.7851 | 0.2631 | 2.4177 | 7.4577 | 2.8217 | 0.3289 | 0.7561 | 2.4122 |
| **Model 9** | 0.0267 | 1.0080 | −3.9146 | 7.5667 | — | — | — | — | −0.9341 | 1.1115 | 0.1300 | 1.6191 | −9.3265 | 35.6893 | 0.2203 | 0.9318 | 1.3225 |
| **Model 10** | −4.2972 | 8.0187 | — | — | — | — | — | — | −0.6643 | 0.9394 | 0.1134 | 1.3992 | −6.2805 | 27.2562 | 0.1904 | 0.9373 | 1.2315 |
| **Model 11** | 0.5375 | 0.0304 | — | — | — | — | — | — | 0.3985 | 2.1942 | 0.3295 | 2.9572 | 9.9856 | 6.8650 | 0.4023 | 0.7001 | 2.9282 |
| **Model 12** | 0.1849 | −1.9974 | — | — | — | — | — | — | −0.1435 | 1.3497 | 0.1903 | 1.8484 | 3.3528 | 3.9343 | 0.2515 | 0.8450 | 1.8428 |
| **Model 13** | 1.2465 | −1.6654 | — | — | — | — | — | — | −0.2953 | 1.2135 | 0.1699 | 1.6512 | 1.7885 | 9.1857 | 0.2246 | 0.8833 | 1.6246 |
| **Model 14** | 0.3368 | −0.3015 | — | — | — | — | — | — | −1.8342 | 2.3870 | 0.3277 | 2.9015 | -21.9403 | 41.1812 | 0.3947 | 0.7552 | 2.2472 |
| **Model 15** | 2.0170 | −0.8857 | — | — | — | — | — | — | −0.6236 | 0.9458 | 0.1181 | 1.3527 | −4.2636 | 26.2508 | 0.1840 | 0.9485 | 1.2003 |
| **Model 16** | 0.9768 | −0.7537 | — | — | — | — | — | — | 0.1894 | 1.4010 | 0.2087 | 1.9087 | 5.8752 | 5.0384 | 0.2597 | 0.8458 | 1.8993 |
| **Model 17** | 0.9761 | −0.7431 | −0.0132 | — | — | — | — | — | −0.0387 | 0.8351 | 0.1134 | 1.3004 | 1.6597 | 1.5033 | 0.1769 | 0.9267 | 1.2998 |
| **Model 18** | 0.9821 | −1.0187 | 0.8662 | −0.6758 | — | — | — | — | −0.0447 | 0.8255 | 0.1114 | 1.2873 | 1.6256 | 1.7546 | 0.1751 | 0.9281 | 1.2866 |
| **Model 19** | 1.0237 | −0.7537 | — | — | — | — | — | — | −0.0404 | 0.8362 | 0.1135 | 1.3017 | 1.6737 | 1.5675 | 0.1771 | 0.9265 | 1.3010 |
| **Model 20** | −0.7248 | −1.1215 | −0.9375 | — | — | — | — | — | −0.0856 | 1.1098 | 0.1452 | 1.5092 | 1.9860 | 2.4368 | 0.1759 | 0.8617 | 1.5067 |
| **Model 21** | 0.9990 | 1.6517 | — | — | — | — | — | — | **−0.0052** | 1.0512 | 0.1450 | 1.5906 | 3.9818 | **0.1659** | 0.2164 | 0.8870 | 1.5905 |
| **Model 22** | 2.6065 | −1.4578 | — | — | — | — | — | — | 0.0097 | 0.8386 | 0.1149 | 1.3051 | 1.5332 | 0.3754 | 0.1776 | 0.9286 | 1.3051 |
| **Model 23** | 0.3852 | −0.2140 | — | — | — | — | — | — | −1.4257 | 2.3211 | 0.2796 | 2.7475 | -10.8325 | 26.0249 | 0.3202 | 0.6118 | 2.3486 |
| **Model 24** | 1.4373 | −0.4841 | — | — | — | — | — | — | 0.0197 | 0.8516 | 0.1166 | 1.3241 | 1.4147 | 0.7516 | 0.1801 | 0.9278 | 1.3239 |
| **Model 25** | −0.0097 | −1.1100 | — | — | — | — | — | — | −0.0543 | 0.9240 | 0.1263 | 1.4163 | 2.5436 | 1.9394 | 0.1927 | 0.9114 | 1.4153 |
| **Model 26** | 0.1424 | 0.1993 | — | — | — | — | — | — | −0.3745 | 1.8911 | 0.3892 | 2.2998 | 16.0298 | 8.3386 | 0.3129 | 0.7603 | 2.2691 |
| **Model 27** | 1.1991 | 0.8418 | — | — | — | — | — | — | −0.6102 | 0.9122 | 0.1076 | 1.3838 | −5.0094 | 24.8024 | 0.1883 | 0.9375 | 1.2411 |
| **Model 28** | −0.0342 | 1.5365 | −1.8216 | — | — | — | — | — | −0.6264 | 0.9556 | 0.1307 | 1.3960 | −6.8038 | 25.3681 | 0.1899 | 0.9371 | 1.2476 |
| **Model 29** | −0.0211 | 1.3575 | −1.2460 | −0.5194 | — | — | — | — | −0.6402 | 0.9445 | 0.1225 | 1.3980 | −6.4039 | 26.0291 | 0.1902 | 0.9375 | 1.2428 |
| **Model 30** | 0.0082 | 0.7598 | 2.0720 | −7.2902 | 4.5789 | — | — | — | −0.6302 | 0.9156 | 0.1104 | 1.3766 | −5.3751 | 26.0151 | 0.1873 | 0.9399 | 1.2239 |
| **Model 31** | 0.0730 | 0.3025 | — | — | — | — | — | — | −0.4100 | 1.5394 | 0.2448 | 1.9487 | 4.9971 | 10.8667 | 0.2647 | 0.8399 | 1.9051 |
| **Model 32** | 0.1641 | 0.7409 | — | — | — | — | — | — | −0.3474 | 1.9773 | 0.4272 | 2.3937 | 19.3615 | 7.4110 | 0.3256 | 0.7367 | 2.3683 |
| **Model 33** | 0.3082 | 0.3136 | — | — | — | — | — | — | −0.3729 | 1.6851 | 0.3035 | 2.0743 | 9.4510 | 9.2347 | 0.2822 | 0.8172 | 2.0405 |
| **Model 34** | −0.0109 | 0.2684 | — | — | — | — | — | — | −0.3676 | 1.5817 | 0.2667 | 1.9435 | 4.2939 | 9.7225 | 0.2644 | 0.8447 | 1.9070 |
| **Model 35** | 0.3025 | 0.0730 | — | — | — | — | — | — | 1.0099 | 1.9645 | 0.4889 | 2.4682 | 40.0550 | 22.6335 | 0.3358 | 0.7600 | 2.2512 |
| **Model 36** | 0.0419 | 0.1188 | — | — | — | — | — | — | −0.3600 | 1.9845 | 0.4227 | 2.4034 | 18.6394 | 7.6558 | 0.3270 | 0.7315 | 2.3763 |
| **Model 37** | −0.8524 | 0.1785 | — | — | — | — | — | — | −0.3716 | 1.9123 | 0.3981 | 2.3225 | 16.7564 | 8.1888 | 0.3160 | 0.7549 | 2.2926 |
| **Model 38** | 0.1861 | 0.0813 | — | — | — | — | — | — | −0.5666 | 2.1562 | 0.4658 | 2.6326 | 19.1210 | 11.1365 | 0.3581 | 0.6746 | 2.5709 |
| **Model 39** | 0.1460 | 0.6599 | −0.7127 | — | — | — | — | — | −0.5062 | 1.4776 | 0.3188 | 1.9085 | 10.0636 | 13.9003 | 0.2596 | 0.8498 | 1.8401 |
| **Model 40** | 0.1391 | 0.9766 | −1.7230 | 0.7764 | — | — | — | — | −0.5027 | 1.4373 | 0.3047 | 1.8593 | 8.8421 | 14.1903 | 0.2529 | 0.8574 | 1.7900 |
| **Model 41** | 0.2417 | −0.0101 | — | — | — | — | — | — | −0.8200 | 1.6724 | 0.2022 | 2.0793 | −3.9848 | 18.3976 | 0.2423 | 0.7652 | 1.9108 |
| **Model 42** | 0.1913 | 0.3228 | — | — | — | — | — | — | −0.5519 | 2.1797 | 0.4771 | 2.6566 | 20.2142 | 10.7313 | 0.3614 | 0.6663 | 2.5986 |
| **Model 43** | 0.3657 | 0.0451 | −0.2126 | — | — | — | — | — | 0.1232 | 1.2592 | 0.1652 | 1.7081 | 5.1601 | 3.0992 | 0.1991 | 0.8201 | 1.7036 |
| **Model 44** | 0.1530 | 0.0417 | — | — | — | — | — | — | −0.5541 | 2.2173 | 0.4874 | 2.6974 | 20.8499 | 10.6053 | 0.3670 | 0.6508 | 2.6399 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.0895 | −1.2832 | 0.1160 | — | — | — | — | — | −0.5046 | 0.9650 | 0.1272 | 1.3374 | −2.6481 | 20.5862 | 0.1819 | 0.9398 | 1.2385 |
| **Model 46** | −0.9812 | 1.2530 | — | — | — | — | — | — | 0.0198 | 1.9548 | 0.2978 | 2.6403 | −4.5646 | 0.3783 | 0.3592 | 0.8463 | 2.6402 |
| **Model 47** | 1.1826 | −1.2771 | 0.0213 | — | — | — | — | — | −0.5160 | 0.9608 | 0.1260 | 1.3332 | −2.5672 | 21.2100 | 0.1814 | 0.9431 | 1.2293 |
| **Model 48** | −0.3799 | 1.3989 | −5.0350 | 11.1975 | −6.0973 | −0.2040 | 0.1700 | — | −0.5752 | 0.8862 | 0.1112 | 1.2929 | −5.7081 | 25.1015 | 0.1759 | 0.9429 | 1.1579 |
| **Model 49** | 1.1842 | −1.2823 | 0.0010 | — | — | — | — | — | −0.5055 | 0.9647 | 0.1270 | 1.3369 | −2.6503 | 20.6390 | 0.1819 | 0.9398 | 1.2376 |
| **Model 50** | 7.0183 | 3.8820 | −3.8646 | −2.9668 | — | — | — | — | −0.3829 | 1.1579 | 0.1575 | 1.5841 | **−0.4160** | 12.5872 | 0.2155 | 0.8957 | 1.5371 |
| **Model 51** | −8.4263 | 0.0307 | -792.5085 | — | — | — | — | — | 0.4504 | 2.1849 | 0.3269 | 2.9891 | 9.8344 | 7.6945 | 0.4066 | 0.7123 | 2.9529 |
| **Model 52** | 1.1342 | −1.2578 | 0.0006 | — | — | — | — | — | −0.5794 | 0.9922 | 0.1280 | 1.3906 | −2.9069 | 23.1614 | 0.1892 | 0.9446 | 1.2641 |

(*continued on next page*)

**Table A13** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0755 | −0.5441 | −0.4595 | — | — | — | — | — | −0.2986 | 0.7823 | 0.1036 | 1.1635 | −0.5993 | 13.4160 | 0.1583 | 0.9480 | 1.1245 |
| **Model 54** | 0.9824 | 0.2168 | −1.2767 | −0.4305 | 0.1033 | — | — | — | −0.4652 | 0.7677 | 0.0945 | 1.1779 | −3.8348 | 21.7205 | 0.1602 | 0.9514 | 1.0822 |
| **Model 55** | 0.9827 | 0.2111 | −1.0631 | −0.2582 | −0.6598 | 0.7214 | −0.4451 | — | −0.4681 | 0.7657 | 0.0945 | 1.1713 | −3.9180 | 22.0252 | 0.1594 | 0.9522 | 1.0737 |
| **Model 56** | 0.9936 | 0.0970 | −1.1300 | −0.3417 | — | — | — | — | −0.4504 | 0.7611 | 0.0941 | 1.1609 | −3.7061 | 21.2672 | 0.1579 | 0.9523 | 1.0700 |
| **Model 57** | 1.0768 | −0.6287 | −0.2187 | −0.2391 | — | — | — | — | −0.3099 | 0.7518 | 0.0984 | 1.1173 | −1.2357 | 14.5894 | 0.1520 | 0.9519 | 1.0734 |
| **Model 58** | 0.9945 | −1.2896 | −0.2547 | — | — | — | — | — | −0.5068 | 0.8327 | 0.1055 | 1.2471 | −4.9419 | 22.4722 | 0.1697 | 0.9439 | 1.1395 |
| **Model 59** | 1.0893 | −0.7670 | −0.4074 | — | — | — | — | — | −0.3454 | 0.7588 | 0.0988 | 1.1121 | −1.8899 | 16.5064 | 0.1513 | 0.9533 | 1.0572 |
| **Model 60** | 1.0078 | −1.0169 | −0.3358 | — | — | — | — | — | −0.4507 | 0.7580 | **0.0933** | 1.1543 | −3.5308 | 21.4281 | 0.1570 | 0.9536 | 1.0627 |
| **Model 61** | 0.9336 | −2.1129 | −0.2009 | — | — | — | — | — | −0.5672 | 1.0085 | 0.1392 | 1.5931 | −7.3074 | 19.2494 | 0.2167 | 0.9070 | 1.4887 |
| **Model 62** | 0.1969 | −0.3902 | −0.0842 | — | — | — | — | — | −3.2997 | 3.3824 | 0.3714 | 3.9238 | -34.5940 | 66.6287 | 0.4573 | 0.7367 | 2.1232 |
| **Model 63** | 1.7867 | −0.4898 | −0.2347 | — | — | — | — | — | −0.3791 | **0.7420** | 0.0946 | **1.1087** | −2.2984 | 18.3843 | **0.1508** | **0.9556** | **1.0419** |
| **Model 64** | −0.9225 | −0.5572 | −0.6380 | — | — | — | — | — | −0.2515 | 0.8455 | 0.1142 | 1.2478 | 0.4203 | 10.3986 | 0.1697 | 0.9372 | 1.2221 |
| **Model 65** | 0.0747 | 0.6611 | −0.2888 | — | — | — | — | — | −0.0691 | 1.4526 | 0.2800 | 1.8558 | 12.4810 | 1.8816 | 0.2525 | 0.8440 | 1.8545 |
| **Model 66** | −0.0315 | 1.4561 | −1.4729 | −0.0196 | −0.1149 | — | — | — | −0.4529 | 0.7994 | 0.1144 | 1.1843 | −5.0668 | 20.9101 | 0.1611 | 0.9507 | 1.0943 |
| **Model 67** | −0.0440 | 1.5894 | −1.6361 | −0.1183 | — | — | — | — | −0.4757 | 0.8523 | 0.1289 | 1.2347 | −5.9305 | 21.0950 | 0.1680 | 0.9463 | 1.1394 |
| **Model 68** | 0.0774 | 0.4806 | 0.2248 | −0.5099 | — | — | — | — | −0.1478 | 1.1313 | 0.2209 | 1.4565 | 8.1613 | 5.1530 | 0.1981 | 0.9084 | 1.4490 |
| **Model 69** | 0.1678 | 0.6686 | −0.2824 | — | — | — | — | — | −0.0204 | 1.7645 | 0.4083 | 2.1702 | 22.2943 | 0.4747 | 0.2952 | 0.7777 | 2.1701 |
| **Model 70** | 0.0646 | 0.6227 | −0.3370 | — | — | — | — | — | −0.0678 | 1.1385 | 0.2173 | 1.5103 | 9.0030 | 2.2695 | 0.2055 | 0.8997 | 1.5088 |
| **Model 71** | 0.1886 | 0.2162 | −0.0211 | — | — | — | — | — | −0.3172 | 2.1067 | 0.4728 | 2.5401 | 22.9023 | 6.3591 | 0.3456 | 0.6881 | 2.5203 |
| **Model 72** | 0.2003 | 0.6259 | −0.2196 | — | — | — | — | — | −0.0878 | 2.0291 | 0.4869 | 2.4629 | 26.9887 | 1.8020 | 0.3351 | 0.7014 | 2.4613 |
| **Model 73** | 0.2604 | 0.0393 | −0.0237 | — | — | — | — | — | −0.4575 | 1.5610 | 0.1977 | 1.9475 | 0.4824 | 10.3610 | 0.2270 | 0.7670 | 1.8930 |
| **Model 74** | −0.1380 | 0.4283 | −0.1835 | — | — | — | — | — | −0.0206 | 1.5505 | 0.3231 | 1.9520 | 16.1154 | 0.5324 | 0.2656 | 0.8247 | 1.9519 |
| **Model 75** | 0.2909 | 0.0543 | −0.0013 | — | — | — | — | — | −0.4115 | 2.1050 | 0.4581 | 2.5711 | 20.7378 | 8.1927 | 0.3498 | 0.6829 | 2.5379 |
| **Model 76** | 0.2159 | 0.6339 | −0.7027 | −0.0008 | — | — | — | — | −0.4001 | 1.4477 | 0.3139 | 1.8656 | 11.3444 | 11.0948 | 0.2538 | 0.8525 | 1.8222 |
| **Model 77** | 0.1615 | 0.0786 | 0.0015 | — | — | — | — | — | −0.4834 | 2.1153 | 0.4587 | 2.5728 | 18.6157 | 9.6658 | 0.3500 | 0.6787 | 2.5270 |
| **Model 78** | 0.1289 | 0.6500 | −0.7029 | 0.0011 | — | — | — | — | −0.4444 | 1.4649 | 0.3169 | 1.8780 | 9.8646 | 12.3044 | 0.2555 | 0.8485 | 1.8247 |
| **Model 79** | 0.3604 | 0.0023 | −0.0025 | — | — | — | — | — | −0.0968 | 2.0794 | 0.4665 | 2.5270 | 23.7081 | 1.9369 | 0.3438 | 0.6792 | 2.5251 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 1.0028 | −0.5451 | −0.4593 | 0.0762 | — | — | — | — | −0.2981 | 0.7821 | 0.1035 | 1.1647 | −0.5984 | 13.3807 | 0.1584 | 0.9479 | 1.1259 |
| **Model 81** | 1.0784 | −0.5618 | −0.4498 | 0.0007 | — | — | — | — | −0.2725 | 0.7778 | 0.1038 | 1.1450 | −0.7277 | 12.3802 | 0.1558 | 0.9475 | 1.1121 |
| **Model 82** | 1.1502 | −1.2798 | 0.0014 | 0.0001 | — | — | — | — | −0.5293 | 0.9843 | 0.1284 | 1.3784 | −2.6881 | 21.0144 | 0.1875 | 0.9374 | 1.2727 |
| **Model 83** | 0.4588 | −0.2855 | 0.0737 | 0.0006 | 0.0000 | — | — | — | 0.6218 | 1.5373 | 0.2025 | 2.1390 | 10.8241 | 13.0262 | 0.2493 | 0.7722 | 2.0466 |
| **Model 84** | 0.2245 | 0.6083 | −0.6846 | 0.0015 | −0.0012 | — | — | — | −0.2621 | 1.4328 | 0.3102 | 1.8277 | 11.7516 | 7.3207 | 0.2486 | 0.8503 | 1.8088 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0762 | −1.2776 | −0.0001 | 0.0001 | 0.1199 | — | — | — | −0.5120 | 0.9649 | 0.1270 | 1.3359 | −2.7411 | 20.9665 | 0.1817 | 0.9406 | 1.2339 |
| **Model 87** | 1.0762 | −1.2776 | 0.1199 | −0.0001 | 0.0001 | — | — | — | −0.5120 | 0.9649 | 0.1270 | 1.3359 | −2.7411 | 20.9665 | 0.1817 | 0.9406 | 1.2339 |
| **Model 88** | 1.0330 | −0.5267 | −0.4589 | 0.0001 | 0.0005 | — | — | — | −0.3214 | 0.7844 | 0.1032 | 1.1647 | −0.9417 | 14.5046 | 0.1584 | 0.9487 | 1.1195 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0470 | −0.5498 | −0.4554 | 0.0011 | 0.0001 | — | — | — | −0.2835 | 0.7789 | 0.1034 | 1.1543 | −0.7787 | 12.8026 | 0.1570 | 0.9471 | 1.1189 |
| **Model 90** | 1.0176 | 0.0295 | 0.9114 | 1.0437 | −0.5527 | 0.0032 | 0.0001 | −0.4538 | −0.2620 | 0.7770 | 0.1036 | 1.1473 | −0.7491 | 11.8491 | 0.1561 | 0.9465 | 1.1170 |
| **Model 91** | 0.8190 | 0.0378 | 0.9072 | 1.2406 | −0.7264 | 0.0031 | 0.0013 | — | −0.1006 | 0.8260 | 0.1113 | 1.2757 | 0.5260 | 3.9955 | 0.1736 | 0.9301 | 1.2718 |
| **Model 92** | 1.1395 | 0.0197 | 0.9537 | 0.1427 | −1.2781 | 0.0021 | 0.0001 | — | −0.5008 | 0.9633 | 0.1268 | 1.3371 | −2.6945 | 20.4120 | 0.1819 | 0.9388 | 1.2397 |
| **Model 93** | 1.1475 | 0.0197 | 0.9504 | 0.1566 | −1.2819 | 0.0022 | — | — | −0.4958 | 0.9633 | 0.1268 | 1.3379 | −2.6301 | 20.1599 | 0.1820 | 0.9383 | 1.2426 |
| **Model 94** | 1.1613 | −0.0289 | 0.7767 | 8.8539 | −1.2746 | 0.0002 | — | — | −0.5130 | 0.9620 | 0.1267 | 1.3302 | −2.7679 | 21.1219 | 0.1810 | 0.9414 | 1.2272 |
| **Model 95** | 1.1762 | −0.0300 | 0.7658 | 2.5852 | −1.2814 | — | — | — | −0.5039 | 0.9613 | 0.1268 | 1.3304 | −2.6481 | 20.6798 | 0.1810 | 0.9407 | 1.2313 |
| **Model 96** | 0.6700 | 0.0352 | 1.0109 | −0.1123 | — | — | — | — | 1.1419 | 2.7322 | 0.4271 | 3.7876 | 16.0097 | 15.9759 | 0.5153 | 0.6845 | 3.6114 |
| **Model 97** | 1.1463 | 0.0205 | 0.0396 | −1.2819 | 0.0022 | — | — | — | −0.4948 | 0.9626 | 0.1268 | 1.3373 | −2.6154 | 20.1206 | 0.1819 | 0.9383 | 1.2424 |

**Table A14**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Shenyang station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2281 | −1.3939 | — | — | — | — | — | — | −0.6554 | 1.3304 | 0.2005 | 2.0127 | −0.6976 | 17.2749 | 0.3011 | 0.8763 | 1.9030 |
| **Model 2** | 1.0014 | −0.0516 | −1.6187 | — | — | — | — | — | −0.9323 | 1.4114 | 0.2064 | 2.2246 | −8.8534 | 23.1528 | 0.3328 | 0.8435 | 2.0198 |
| **Model 3** | 0.8732 | 1.3912 | −5.7334 | 3.3917 | — | — | — | — | −0.8265 | 1.3288 | 0.1879 | 2.0992 | −6.2190 | 21.4847 | 0.3140 | 0.8611 | 1.9297 |
| **Model 4** | 0.9709 | −0.2918 | 2.4254 | -11.5494 | 9.2250 | — | — | — | −0.7924 | 1.3041 | 0.1833 | 2.0554 | −5.3589 | 20.9583 | 0.3075 | 0.8676 | 1.8965 |
| **Model 5** | 0.9649 | −0.1503 | 1.4186 | −8.5351 | 5.2136 | 1.9594 | — | — | −0.7922 | 1.3037 | 0.1833 | 2.0542 | −5.3554 | 20.9667 | 0.3073 | 0.8678 | 1.8953 |
| **Model 6** | 0.5534 | 0.0000 | — | — | — | — | — | — | 1.0513 | 2.9330 | 0.5895 | 3.7288 | 33.1534 | 14.7405 | 0.5578 | 0.5817 | 3.5775 |
| **Model 7** | 3.0848 | −2.6773 | — | — | — | — | — | — | −0.8786 | 1.3768 | 0.2009 | 2.1618 | −6.9066 | 22.3119 | 0.3234 | 0.8528 | 1.9752 |
| **Model 8** | 0.3870 | −0.4148 | — | — | — | — | — | — | 0.3477 | 2.1678 | 0.4144 | 2.7862 | 21.8138 | 6.3088 | 0.4168 | 0.6922 | 2.7644 |
| **Model 9** | 0.0195 | 0.9665 | −4.3976 | 8.2800 | — | — | — | — | −0.7952 | 1.3067 | 0.1838 | 2.0664 | −5.3881 | 20.9127 | 0.3091 | 0.8657 | 1.9072 |
| **Model 10** | −4.2027 | 7.8942 | — | — | — | — | — | — | −0.7947 | 1.3069 | 0.1838 | 2.0678 | −5.3472 | 20.8811 | 0.3093 | 0.8654 | 1.9090 |
| **Model 11** | 0.4277 | 0.0452 | — | — | — | — | — | — | 0.5496 | 2.5014 | 0.4855 | 3.1827 | 26.0690 | 8.7946 | 0.4761 | 0.6249 | 3.1349 |
| **Model 12** | 0.1591 | −2.0515 | — | — | — | — | — | — | 0.0709 | 1.8224 | 0.3334 | 2.3920 | 15.1720 | 1.4876 | 0.3578 | 0.7716 | 2.3910 |
| **Model 13** | 1.3450 | −1.9291 | — | — | — | — | — | — | −0.1850 | 1.5943 | 0.2801 | 2.1596 | 10.2787 | 4.3126 | 0.3230 | 0.8278 | 2.1517 |
| **Model 14** | 0.2342 | −0.3883 | — | — | — | — | — | — | −1.9866 | 2.5335 | 0.3595 | 3.3498 | -19.3039 | 36.9460 | 0.5011 | 0.7140 | 2.6972 |
| **Model 15** | 2.0663 | −0.9204 | — | — | — | — | — | — | −0.7994 | 1.3281 | 0.1922 | 2.0763 | −4.7352 | 20.9250 | 0.3106 | 0.8664 | 1.9163 |
| **Model 16** | 0.9570 | −0.7460 | — | — | — | — | — | — | −0.3967 | 1.5300 | 0.2512 | 2.2222 | 2.8850 | 9.1006 | 0.3324 | 0.8138 | 2.1865 |
| **Model 17** | 0.9321 | −0.5120 | −0.2644 | — | — | — | — | — | −0.4751 | 1.5138 | 0.2431 | 2.2278 | 0.4234 | 10.9489 | 0.3332 | 0.8168 | 2.1766 |
| **Model 18** | 0.9420 | −0.8087 | 0.6173 | −0.6513 | — | — | — | — | −0.5194 | 1.5140 | 0.2407 | 2.2368 | −0.6341 | 11.9756 | 0.3346 | 0.8173 | 2.1756 |
| **Model 19** | 1.0450 | −0.7460 | — | — | — | — | — | — | −0.3966 | 1.5300 | 0.2512 | 2.2222 | 2.8864 | 9.0986 | 0.3324 | 0.8138 | 2.1865 |
| **Model 20** | −0.7322 | −1.4219 | −0.8861 | — | — | — | — | — | −0.5844 | 1.7069 | 0.2689 | 2.3895 | −0.1362 | 11.6984 | 0.3392 | 0.7901 | 2.3169 |
| **Model 21** | 1.0156 | 1.7900 | — | — | — | — | — | — | **0.0111** | 1.7758 | 0.3189 | 2.4189 | 13.1138 | **0.2295** | 0.3618 | 0.7665 | 2.4189 |
| **Model 22** | 2.5409 | −1.3955 | — | — | — | — | — | — | −0.4912 | 1.5131 | 0.2420 | 2.2309 | **−0.0005** | 11.3212 | 0.3337 | 0.8171 | 2.1761 |
| **Model 23** | 0.3393 | −0.2552 | — | — | — | — | — | — | −1.0768 | 2.3816 | 0.3672 | 3.0292 | −1.0848 | 17.6378 | 0.4300 | 0.6584 | 2.8314 |
| **Model 24** | 1.3880 | −0.4656 | — | — | — | — | — | — | −0.5105 | 1.5171 | 0.2414 | 2.2409 | −0.6779 | 11.7358 | 0.3352 | 0.8168 | 2.1819 |
| **Model 25** | −0.0316 | −1.1004 | — | — | — | — | — | — | −0.2006 | 1.6348 | 0.2827 | 2.2875 | 8.1286 | 4.4151 | 0.3422 | 0.7954 | 2.2787 |
| **Model 26** | 0.2211 | 0.0187 | — | — | — | — | — | — | −0.2761 | 1.9931 | 0.4102 | 2.6237 | 17.9518 | 5.3087 | 0.3925 | 0.7253 | 2.6091 |
| **Model 27** | 1.2255 | 0.8305 | — | — | — | — | — | — | −0.7926 | 1.3288 | 0.1881 | 2.1076 | −5.3444 | 20.3580 | 0.3153 | 0.8572 | 1.9529 |
| **Model 28** | −0.0450 | 1.5941 | −1.8998 | — | — | — | — | — | −0.8312 | 1.3538 | 0.1980 | 2.1253 | −6.9013 | 21.3145 | 0.3179 | 0.8561 | 1.9561 |
| **Model 29** | −0.0493 | 1.6433 | −2.0400 | 0.1155 | — | — | — | — | −0.8262 | 1.3533 | 0.1986 | 2.1224 | −6.8656 | 21.1969 | 0.3175 | 0.8563 | 1.9550 |
| **Model 30** | 0.0292 | 0.2890 | 4.5256 | -11.9080 | 7.4236 | — | — | — | −0.7944 | 1.3109 | 0.1864 | 2.0652 | −5.2360 | 20.9043 | 0.3089 | 0.8658 | 1.9062 |
| **Model 31** | 0.0371 | 0.2606 | — | — | — | — | — | — | −0.2687 | 1.9061 | 0.3669 | 2.4734 | 14.6069 | 5.4818 | 0.3700 | 0.7650 | 2.4587 |
| **Model 32** | 0.2231 | 0.0639 | — | — | — | — | — | — | −0.2779 | 1.9939 | 0.4108 | 2.6279 | 17.9937 | 5.3334 | 0.3931 | 0.7241 | 2.6132 |
| **Model 33** | 0.2562 | 0.1323 | — | — | — | — | — | — | −0.2643 | 1.9311 | 0.3807 | 2.5096 | 15.7896 | 5.3119 | 0.3754 | 0.7562 | 2.4956 |
| **Model 34** | −0.0099 | 0.2576 | — | — | — | — | — | — | −0.3056 | 1.8032 | 0.3275 | 2.3732 | 9.1878 | 6.5144 | 0.3550 | 0.7877 | 2.3534 |
| **Model 35** | 0.2606 | 0.0371 | — | — | — | — | — | — | 0.2011 | 1.9548 | 0.4261 | 2.5280 | 25.4316 | 4.0038 | 0.3781 | 0.7443 | 2.5200 |
| **Model 36** | 0.2432 | −0.0080 | — | — | — | — | — | — | −0.2941 | 1.9964 | 0.4141 | 2.6552 | 18.1131 | 5.5893 | 0.3972 | 0.7164 | 2.6389 |
| **Model 37** | −0.7784 | 0.0175 | — | — | — | — | — | — | −0.2767 | 1.9933 | 0.4103 | 2.6248 | 17.9621 | 5.3169 | 0.3926 | 0.7250 | 2.6102 |
| **Model 38** | 0.2414 | −0.0209 | — | — | — | — | — | — | −0.3034 | 2.0034 | 0.4171 | 2.6751 | 18.1077 | 5.7253 | 0.4002 | 0.7102 | 2.6579 |
| **Model 39** | 0.1876 | 0.4864 | −0.5733 | — | — | — | — | — | −0.6143 | 1.7406 | 0.3315 | 2.4190 | 6.0271 | 13.1688 | 0.3618 | 0.7835 | 2.3397 |
| **Model 40** | 0.1881 | 0.4701 | −0.5250 | −0.0357 | — | — | — | — | −0.6173 | 1.7417 | 0.3318 | 2.4203 | 5.9816 | 13.2303 | 0.3620 | 0.7834 | 2.3403 |
| **Model 41** | 0.2212 | −0.0255 | — | — | — | — | — | — | −0.7190 | 1.9077 | 0.2989 | 2.5626 | 3.1654 | 13.5567 | 0.3638 | 0.7681 | 2.4596 |
| **Model 42** | 0.2402 | −0.0796 | — | — | — | — | — | — | −0.3007 | 2.0027 | 0.4167 | 2.6714 | 18.1270 | 5.6817 | 0.3996 | 0.7113 | 2.6544 |
| **Model 43** | 0.3813 | 0.0558 | −0.2494 | — | — | — | — | — | −0.2745 | 1.7207 | 0.2749 | 2.4468 | 5.3443 | 5.2362 | 0.3474 | 0.7696 | 2.4314 |
| **Model 44** | 0.2702 | −0.0224 | — | — | — | — | — | — | −0.3260 | 1.9991 | 0.4171 | 2.6898 | 17.7317 | 6.1236 | 0.4023 | 0.7059 | 2.6700 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1712 | −1.3878 | 0.0749 | — | — | — | — | — | −0.5799 | 1.2935 | 0.1981 | 1.9490 | −0.7405 | 15.6328 | 0.2915 | 0.8760 | 1.8608 |
| **Model 46** | −0.5026 | 1.0454 | — | — | — | — | — | — | 0.7544 | 2.7093 | 0.4873 | 3.7201 | 7.4193 | 10.3881 | 0.5565 | 0.7544 | 3.6428 |
| **Model 47** | 1.2271 | −1.3918 | 0.0266 | — | — | — | — | — | −0.5813 | 1.2819 | 0.1938 | 1.9582 | −0.9312 | 15.5929 | 0.2929 | 0.8740 | 1.8699 |
| **Model 48** | 0.1368 | 0.8457 | −5.1118 | 9.0828 | −2.2684 | 0.7902 | −0.1830 | — | −0.6680 | **1.2247** | **0.1789** | 1.9289 | −5.1703 | 18.5165 | 0.2885 | 0.8771 | **1.8096** |
| **Model 49** | 1.2240 | −1.3861 | 0.0009 | — | — | — | — | — | −0.5750 | 1.2892 | 0.1976 | 1.9436 | −0.7516 | 15.5345 | 0.2907 | 0.8761 | 1.8566 |
| **Model 50** | −6.9881 | −5.2409 | -19.3053 | -13.0596 | — | — | — | — | −0.2944 | 1.4699 | 0.2439 | 2.0638 | 5.5406 | 7.2291 | 0.3087 | 0.8423 | 2.0427 |
| **Model 51** | −8.5807 | 0.0447 | -796.6699 | — | — | — | — | — | 0.6866 | 2.4930 | 0.4782 | 3.2459 | 25.6832 | 10.8559 | 0.4855 | 0.6470 | 3.1725 |
| **Model 52** | 1.1756 | −1.3640 | 0.0006 | — | — | — | — | — | −0.6174 | 1.3177 | 0.2004 | 1.9834 | −0.1416 | 16.4295 | 0.2967 | 0.8783 | 1.8849 |

(*continued on next page*)

Table A14 (continued)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.1366 | −0.8210 | −0.3435 | — | — | — | — | — | −0.6205 | 1.3364 | 0.2041 | 2.0088 | −0.7180 | 16.2910 | 0.3005 | 0.8689 | 1.9106 |
| **Model 54** | 0.9396 | 0.3791 | −1.5425 | −0.3594 | 0.0724 | — | — | — | −0.8664 | 1.3519 | 0.1941 | 2.1167 | −7.7852 | 22.5039 | 0.3166 | 0.8586 | 1.9312 |
| **Model 55** | 0.8884 | 1.0602 | −3.5586 | 1.6522 | −0.6335 | 0.9753 | −0.6797 | — | −0.8674 | 1.3491 | 0.1930 | 2.1014 | −7.7655 | 22.7308 | 0.3143 | 0.8617 | 1.9141 |
| **Model 56** | 0.9485 | 0.2884 | −1.4338 | −0.2957 | — | — | — | — | −0.8708 | 1.3576 | 0.1950 | 2.1189 | −7.9416 | 22.6110 | 0.3170 | 0.8584 | 1.9317 |
| **Model 57** | 1.1112 | −0.8527 | −0.0239 | −0.3435 | — | — | — | — | −0.7312 | 1.3391 | 0.1977 | 2.0443 | −4.0581 | 19.2119 | 0.3058 | 0.8641 | 1.9090 |
| **Model 58** | 0.9717 | −1.2207 | −0.2580 | — | — | — | — | — | −0.9165 | 1.4057 | 0.2041 | 2.1662 | −9.2421 | 23.4213 | 0.3240 | 0.8529 | 1.9627 |
| **Model 59** | 1.1114 | −0.8646 | −0.3628 | — | — | — | — | — | −0.7379 | 1.3405 | 0.1975 | 2.0468 | −4.2435 | 19.3873 | 0.3062 | 0.8640 | 1.9092 |
| **Model 60** | 1.0006 | −1.1464 | −0.2729 | — | — | — | — | — | −0.8386 | 1.3304 | 0.1898 | 2.0824 | −6.7827 | 22.0678 | 0.3115 | 0.8637 | 1.9061 |
| **Model 61** | 0.8832 | −1.6889 | −0.2703 | — | — | — | — | — | −1.0689 | 1.6034 | 0.2522 | 2.4515 | -14.2822 | 24.3017 | 0.3667 | 0.8199 | 2.2062 |
| **Model 62** | 0.1379 | −0.4515 | −0.0835 | — | — | — | — | — | −2.9958 | 3.1262 | 0.3896 | 4.0589 | -34.0838 | 54.8694 | 0.5762 | 0.7795 | 2.7386 |
| **Model 63** | 1.8633 | −0.5896 | −0.1901 | — | — | — | — | — | −0.7720 | 1.3191 | 0.1912 | 2.0393 | −4.9315 | 20.5153 | 0.3051 | 0.8682 | 1.8876 |
| **Model 64** | −0.8690 | −0.8494 | −0.5520 | — | — | — | — | — | −0.4560 | 1.4238 | 0.2314 | 2.0623 | 3.1689 | 11.3726 | 0.3085 | 0.8507 | 2.0112 |
| **Model 65** | 0.1772 | 0.2938 | −0.1649 | — | — | — | — | — | −0.2705 | 1.9744 | 0.3969 | 2.5711 | 15.8988 | 5.3063 | 0.3846 | 0.7351 | 2.5568 |
| **Model 66** | −0.0520 | 1.5957 | −1.6940 | −0.0211 | −0.0940 | — | — | — | −0.8192 | 1.3438 | 0.1983 | 2.0857 | −7.4718 | 21.4221 | 0.3120 | 0.8613 | 1.9181 |
| **Model 67** | −0.0635 | 1.7135 | −1.8350 | −0.1038 | — | — | — | — | −0.8085 | 1.3457 | 0.2011 | 2.0846 | −7.3421 | 21.1076 | 0.3118 | 0.8610 | 1.9214 |
| **Model 68** | 0.1366 | 0.2428 | 0.3474 | −0.5508 | — | — | — | — | −0.5749 | 1.6926 | 0.3120 | 2.3349 | 4.6756 | 12.7421 | 0.3493 | 0.7990 | 2.2630 |
| **Model 69** | 0.2360 | 0.1886 | −0.1434 | — | — | — | — | — | −0.3330 | 1.9943 | 0.4139 | 2.6545 | 16.3938 | 6.3423 | 0.3971 | 0.7142 | 2.6335 |
| **Model 70** | 0.1339 | 0.4143 | −0.2712 | — | — | — | — | — | −0.4174 | 1.7986 | 0.3451 | 2.4276 | 9.2861 | 8.7542 | 0.3631 | 0.7719 | 2.3914 |
| **Model 71** | 0.2463 | −0.1270 | 0.0315 | — | — | — | — | — | −0.3514 | 1.9639 | 0.4076 | 2.6774 | 17.2424 | 6.6404 | 0.4005 | 0.7114 | 2.6542 |
| **Model 72** | 0.2531 | 0.0531 | −0.1067 | — | — | — | — | — | −0.4031 | 1.9727 | 0.4101 | 2.6905 | 15.5628 | 7.6006 | 0.4025 | 0.7068 | 2.6602 |
| **Model 73** | 0.2141 | −0.0158 | −0.0195 | — | — | — | — | — | −0.8342 | 1.9307 | 0.2962 | 2.6085 | 1.2910 | 15.6530 | 0.3703 | 0.7672 | 2.4716 |
| **Model 74** | 0.1366 | 0.1658 | −0.0999 | — | — | — | — | — | −0.2943 | 1.9897 | 0.4061 | 2.6089 | 16.1360 | 5.6955 | 0.3902 | 0.7253 | 2.5922 |
| **Model 75** | 0.2291 | −0.0168 | 0.0002 | — | — | — | — | — | −0.2847 | 1.9982 | 0.4177 | 2.6686 | 18.4508 | 5.3821 | 0.3992 | 0.7112 | 2.6533 |
| **Model 76** | 0.1872 | 0.4865 | −0.5733 | 0.0000 | — | — | — | — | −0.6135 | 1.7404 | 0.3315 | 2.4188 | 6.0408 | 13.1536 | 0.3618 | 0.7835 | 2.3397 |
| **Model 77** | 0.2376 | −0.0194 | 0.0003 | — | — | — | — | — | −0.2654 | 1.9890 | 0.4160 | 2.6498 | 17.9591 | 5.0503 | 0.3964 | 0.7140 | 2.6364 |
| **Model 78** | 0.1858 | 0.4855 | −0.5715 | 0.0002 | — | — | — | — | −0.5939 | 1.7341 | 0.3318 | 2.4056 | 5.9938 | 12.7800 | 0.3598 | 0.7849 | 2.3312 |
| **Model 79** | 0.2111 | 0.0003 | 0.0003 | — | — | — | — | — | −0.2277 | 1.9769 | 0.4143 | 2.6217 | 18.5040 | 4.3729 | 0.3922 | 0.7209 | 2.6118 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 1.2179 | −0.8218 | −0.3418 | −0.0853 | — | — | — | — | −0.6203 | 1.3327 | 0.2035 | 2.0048 | −0.7299 | 16.3206 | 0.2999 | 0.8693 | 1.9064 |
| **Model 81** | 1.1343 | −0.8219 | −0.3389 | 0.0008 | — | — | — | — | −0.5518 | 1.3101 | 0.2028 | 1.9583 | −0.7660 | 14.7310 | 0.2929 | 0.8694 | 1.8789 |
| **Model 82** | 1.1781 | −1.3644 | 0.0008 | 0.0005 | — | — | — | — | −0.5823 | 1.3011 | 0.2002 | 1.9478 | −0.4316 | 15.7123 | 0.2914 | 0.8775 | 1.8588 |
| **Model 83** | 0.4760 | −0.3370 | 0.0935 | 0.0003 | 0.0004 | — | — | — | 0.1846 | 1.8573 | 0.3058 | 2.6356 | 12.1790 | 3.2565 | 0.3742 | 0.7477 | 2.6292 |
| **Model 84** | 0.1879 | 0.4850 | −0.5717 | 0.0002 | 0.0000 | — | — | — | −0.5967 | 1.7348 | 0.3318 | 2.4061 | 5.9259 | 12.8405 | 0.3599 | 0.7849 | 2.3309 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0924 | −1.3592 | −0.0008 | 0.0006 | 0.1187 | — | — | — | −0.5383 | 1.2775 | 0.1964 | 1.9245 | −0.0244 | 14.6124 | 0.2879 | 0.8779 | 1.8476 |
| **Model 87** | 1.0924 | −1.3592 | 0.1187 | −0.0008 | 0.0006 | — | — | — | −0.5383 | 1.2775 | 0.1964 | 1.9245 | −0.0244 | 14.6124 | 0.2879 | 0.8779 | 1.8476 |
| **Model 88** | 1.0951 | −0.8009 | −0.3412 | 0.0002 | 0.0005 | — | — | — | −0.5881 | 1.3277 | 0.2040 | 1.9908 | −0.2473 | 15.4834 | 0.2978 | 0.8696 | 1.9020 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0979 | −0.7993 | −0.3425 | 0.0008 | 0.0003 | — | — | — | −0.5538 | 1.3179 | 0.2050 | 1.9614 | −0.5860 | 14.7636 | 0.2934 | 0.8693 | 1.8816 |
| **Model 90** | 1.0183 | 0.0666 | 0.9311 | 1.1821 | −0.7842 | 0.0038 | 0.0011 | −0.3334 | −0.5209 | 1.2747 | 0.1972 | 1.9166 | −0.8638 | 14.1666 | 0.2867 | 0.8740 | 1.8445 |
| **Model 91** | 0.7532 | 0.0882 | 0.9957 | 1.0302 | −0.6930 | 0.0049 | 0.0021 | — | −0.2695 | 1.4661 | 0.2403 | 2.1251 | 3.0701 | 6.4134 | 0.3179 | 0.8300 | 2.1080 |
| **Model 92** | 1.0885 | 0.0602 | 0.9465 | 0.9518 | −1.3292 | 0.0032 | 0.0013 | — | −0.5299 | 1.2480 | 0.1907 | **1.9031** | −0.6049 | 14.5417 | **0.2847** | **0.8792** | 1.8279 |
| **Model 93** | 1.2083 | 0.0538 | 0.8046 | 1.6036 | −1.3890 | 0.0031 | — | — | −0.6052 | 1.2845 | 0.1949 | 1.9543 | −1.6639 | 16.3363 | 0.2923 | 0.8754 | 1.8582 |
| **Model 94** | 1.1253 | 0.0336 | 1.0360 | −0.5661 | −1.3354 | 0.0012 | — | — | −0.5105 | 1.2487 | 0.1904 | 1.9076 | 0.0625 | 13.9325 | 0.2853 | 0.8779 | 1.8380 |
| **Model 95** | 1.2269 | 0.0268 | 1.0325 | 5.4227 | −1.3903 | — | — | — | −0.5752 | 1.2799 | 0.1940 | 1.9528 | −0.9123 | 15.4611 | 0.2921 | 0.8741 | 1.8662 |
| **Model 96** | 0.5689 | −0.0781 | 1.5807 | −0.2042 | — | — | — | — | 1.1907 | 2.8978 | 0.5706 | 3.8155 | 31.7809 | 16.4762 | 0.5707 | 0.6305 | 3.6249 |
| **Model 97** | 1.2081 | 0.0328 | 0.5486 | −1.3900 | 0.0021 | — | — | — | −0.5916 | 1.2852 | 0.1951 | 1.9580 | −1.3988 | 15.8973 | 0.2929 | 0.8738 | 1.8665 |

**Table A15**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Wuhan station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1642 | −1.2071 | — | — | — | — | — | — | −0.6052 | 1.1837 | 0.1825 | 1.7027 | 2.2301 | 18.7288 | 0.2204 | 0.9297 | 1.5915 |
| **Model 2** | 1.0057 | 0.0464 | −1.7694 | — | — | — | — | — | −0.6987 | 1.0188 | 0.1489 | 1.5875 | −0.9944 | 24.1414 | 0.2055 | 0.9433 | 1.4255 |
| **Model 3** | 0.9451 | 0.9276 | −4.7076 | 2.7283 | — | — | — | — | −0.6816 | 1.0209 | 0.1480 | 1.6061 | −0.5955 | 23.0836 | 0.2079 | 0.9426 | 1.4543 |
| **Model 4** | 0.9678 | 0.4341 | −1.8827 | −3.1684 | 4.0662 | — | — | — | −0.6806 | 1.0279 | 0.1490 | 1.6147 | −0.5441 | 22.8941 | 0.2090 | 0.9414 | 1.4643 |
| **Model 5** | 0.9880 | −0.1543 | 3.0706 | -20.1678 | 29.5045 | -13.8007 | — | — | −0.6805 | 1.0265 | 0.1488 | 1.6136 | −0.5511 | 22.9085 | 0.2089 | 0.9415 | 1.4631 |
| **Model 6** | 0.6925 | 0.0000 | — | — | — | — | — | — | 0.8879 | 2.4925 | 0.3940 | 3.5517 | 13.7440 | 12.7176 | 0.4597 | 0.7399 | 3.4389 |
| **Model 7** | 3.0584 | −2.5730 | — | — | — | — | — | — | −0.6880 | 1.0689 | 0.1618 | 1.6033 | **0.4160** | 23.4009 | 0.2075 | 0.9470 | 1.4482 |
| **Model 8** | 0.4972 | −0.2769 | — | — | — | — | — | — | 0.0243 | 1.8388 | 0.2907 | 2.5465 | 9.6067 | 0.4706 | 0.3296 | 0.7901 | 2.5464 |
| **Model 9** | 0.0820 | 0.9407 | −4.0732 | 7.9836 | — | — | — | — | −0.6812 | 1.0376 | 0.1504 | 1.6228 | −0.4389 | 22.7782 | 0.2101 | 0.9403 | 1.4729 |
| **Model 10** | −4.2665 | 7.8868 | — | — | — | — | — | — | −0.7145 | 1.0412 | 0.1517 | 1.6159 | −1.4023 | 24.2810 | 0.2092 | 0.9410 | 1.4494 |
| **Model 11** | 0.5865 | 0.0237 | — | — | — | — | — | — | 0.3171 | 2.1665 | 0.3415 | 3.0170 | 11.5221 | 5.2061 | 0.3905 | 0.7494 | 3.0003 |
| **Model 12** | 0.1698 | −1.8095 | — | — | — | — | — | — | −0.2883 | 1.4584 | 0.2253 | 2.0365 | 5.8515 | 7.0431 | 0.2636 | 0.8603 | 2.0160 |
| **Model 13** | 1.2090 | −1.5203 | — | — | — | — | — | — | −0.3937 | 1.3753 | 0.2152 | 1.9234 | 5.1800 | 10.3010 | 0.2490 | 0.8817 | 1.8826 |
| **Model 14** | 0.3945 | −0.2631 | — | — | — | — | — | — | −1.7025 | 2.4191 | 0.3345 | 2.9834 | -16.8194 | 34.2289 | 0.3862 | 0.7851 | 2.4499 |
| **Model 15** | 1.9687 | −0.8490 | — | — | — | — | — | — | −0.6582 | 1.0853 | 0.1650 | 1.6140 | 0.9352 | 21.9974 | 0.2089 | 0.9443 | 1.4738 |
| **Model 16** | 0.9937 | −0.6686 | — | — | — | — | — | — | −0.0152 | 1.0125 | 0.1494 | 1.6588 | 5.8732 | 0.4518 | 0.2147 | 0.9078 | 1.6587 |
| **Model 17** | 0.9728 | −0.3646 | −0.3676 | — | — | — | — | — | 0.0267 | 0.9622 | 0.1450 | 1.5807 | 5.5385 | 0.8326 | 0.2046 | 0.9169 | 1.5805 |
| **Model 18** | 0.9804 | −0.7370 | 0.8155 | −0.9060 | — | — | — | — | 0.9801 | 1.7694 | 0.2853 | 2.6681 | 18.4399 | 19.4534 | 0.3454 | 0.8330 | 2.4816 |
| **Model 19** | 1.0064 | −0.6686 | — | — | — | — | — | — | −0.0152 | 1.0125 | 0.1494 | 1.6588 | 5.8732 | 0.4517 | 0.2147 | 0.9078 | 1.6587 |
| **Model 20** | −0.6911 | −1.7209 | −0.9157 | — | — | — | — | — | 0.0235 | 1.2933 | 0.1643 | 1.8467 | 5.2572 | 0.5270 | 0.2032 | 0.8490 | 1.8466 |
| **Model 21** | 0.9963 | 1.2598 | — | — | — | — | — | — | 0.0334 | 1.2122 | 0.1769 | 1.9340 | 7.3833 | 0.8519 | 0.2503 | 0.8730 | 1.9337 |
| **Model 22** | 2.6735 | −1.3827 | — | — | — | — | — | — | **0.0040** | 0.9649 | 0.1442 | 1.5908 | 5.5918 | **0.1248** | 0.2059 | 0.9156 | 1.5908 |
| **Model 23** | 0.4516 | −0.2138 | — | — | — | — | — | — | −1.1426 | 2.3722 | 0.2757 | 2.8880 | −5.8256 | 17.8502 | 0.3178 | 0.6596 | 2.6523 |
| **Model 24** | 1.4072 | −0.4315 | — | — | — | — | — | — | 0.0214 | 0.9579 | 0.1442 | 1.5776 | 5.5423 | 0.6683 | 0.2042 | 0.9172 | 1.5775 |
| **Model 25** | −0.0024 | −0.9133 | — | — | — | — | — | — | −0.0088 | 1.1092 | 0.1623 | 1.7977 | 6.4649 | 0.2413 | 0.2327 | 0.8908 | 1.7977 |
| **Model 26** | 0.1272 | 0.2601 | — | — | — | — | — | — | −0.4755 | 2.0451 | 0.4825 | 2.5206 | 24.7495 | 9.4619 | 0.3263 | 0.7915 | 2.4754 |
| **Model 27** | 1.1775 | 0.8569 | — | — | — | — | — | — | −0.7222 | 1.2438 | 0.1869 | 1.8090 | −0.8162 | 21.4449 | 0.2342 | 0.9169 | 1.6587 |
| **Model 28** | −0.0319 | 1.5187 | −1.7766 | — | — | — | — | — | −0.6750 | 1.0611 | 0.1642 | 1.6273 | −2.0825 | 22.4523 | 0.2106 | 0.9394 | 1.4807 |
| **Model 29** | −0.0182 | 1.3195 | −1.1122 | −0.6169 | — | — | — | — | −0.6799 | 1.0321 | 0.1545 | 1.6055 | −1.2675 | 23.0258 | 0.2078 | 0.9426 | 1.4544 |
| **Model 30** | 0.0033 | 0.8530 | 1.5582 | −6.1914 | 3.8440 | — | — | — | −0.6807 | 1.0266 | 0.1489 | 1.6131 | −0.5706 | 22.9273 | 0.2088 | 0.9416 | 1.4624 |
| **Model 31** | 0.0834 | 0.3233 | — | — | — | — | — | — | −0.5203 | 1.6219 | 0.2823 | 2.1400 | 8.5510 | 12.3466 | 0.2770 | 0.8605 | 2.0757 |
| **Model 32** | 0.1561 | 0.9495 | — | — | — | — | — | — | −0.4442 | 2.1747 | 0.5534 | 2.6528 | 31.1906 | 8.3657 | 0.3434 | 0.7680 | 2.6154 |
| **Model 33** | 0.3378 | 0.3671 | — | — | — | — | — | — | −0.4634 | 1.8193 | 0.3938 | 2.2881 | 18.5322 | 10.1859 | 0.2962 | 0.8398 | 2.2406 |
| **Model 34** | −0.0107 | 0.2770 | — | — | — | — | — | — | −0.5378 | 1.7891 | 0.3784 | 2.2505 | 4.9510 | 12.1212 | 0.2913 | 0.8451 | 2.1853 |
| **Model 35** | 0.3233 | 0.0834 | — | — | — | — | — | — | 1.1780 | 2.1716 | 0.7323 | 2.7354 | 65.1781 | 23.5037 | 0.3541 | 0.7987 | 2.4687 |
| **Model 36** | −0.0152 | 0.1623 | — | — | — | — | — | — | −0.4654 | 2.1598 | 0.5317 | 2.6415 | 28.7726 | 8.8151 | 0.3419 | 0.7658 | 2.6002 |
| **Model 37** | −0.8660 | 0.2295 | — | — | — | — | — | — | −0.4736 | 2.0780 | 0.4988 | 2.5531 | 26.1495 | 9.2976 | 0.3305 | 0.7859 | 2.5088 |
| **Model 38** | 0.1784 | 0.1118 | — | — | — | — | — | — | −0.6393 | 2.3866 | 0.6583 | 2.9216 | 37.5459 | 11.0459 | 0.3782 | 0.7105 | 2.8508 |
| **Model 39** | 0.1400 | 0.6705 | −0.6758 | — | — | — | — | — | −0.5695 | 1.7809 | 0.5296 | 2.3405 | 29.3908 | 12.3562 | 0.3030 | 0.8279 | 2.2702 |
| **Model 40** | 0.1379 | 0.7728 | −1.0008 | 0.2489 | — | — | — | — | −0.5712 | 1.7796 | 0.5259 | 2.3384 | 28.9484 | 12.4076 | 0.3027 | 0.8279 | 2.2676 |
| **Model 41** | 0.2611 | 0.0017 | — | — | — | — | — | — | −0.6823 | 1.9594 | 0.4644 | 2.4905 | 23.7903 | 11.8078 | 0.2740 | 0.7477 | 2.3952 |
| **Model 42** | 0.1859 | 0.4399 | — | — | — | — | — | — | −0.6159 | 2.4184 | 0.6735 | 2.9536 | 39.1914 | 10.5014 | 0.3823 | 0.7038 | 2.8887 |
| **Model 43** | 0.3771 | 0.0561 | −0.1874 | — | — | — | — | — | 0.1504 | 1.6584 | 0.4630 | 2.2623 | 33.7559 | 2.7600 | 0.2489 | 0.7641 | 2.2573 |
| **Model 44** | 0.1258 | 0.0622 | — | — | — | — | — | — | −0.6261 | 2.4567 | 0.6807 | 2.9961 | 39.4852 | 10.5245 | 0.3878 | 0.6907 | 2.9299 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.0724 | −1.2168 | 0.1149 | — | — | — | — | — | −0.5524 | 1.1465 | 0.1789 | 1.6494 | 2.1294 | 17.5057 | 0.2135 | 0.9282 | 1.5542 |
| **Model 46** | −0.9804 | 1.2578 | — | — | — | — | — | — | 0.0188 | 1.8793 | 0.2993 | 2.6558 | −0.5523 | 0.3489 | 0.3438 | 0.8502 | 2.6557 |
| **Model 47** | 1.1645 | −1.2080 | 0.0235 | — | — | — | — | — | −0.5670 | 1.1561 | 0.1789 | 1.6596 | 2.0527 | 17.9036 | 0.2148 | 0.9286 | 1.5598 |
| **Model 48** | −0.1387 | 1.1465 | −4.9565 | 12.0668 | −6.4955 | −0.6687 | 0.3989 | — | −0.5987 | 0.9709 | 0.1485 | 1.4999 | −0.6031 | 21.4442 | 0.1941 | 0.9429 | 1.3752 |
| **Model 49** | 1.1670 | −1.2161 | 0.0009 | — | — | — | — | — | −0.5563 | 1.1496 | 0.1792 | 1.6553 | 2.1386 | 17.5743 | 0.2143 | 0.9278 | 1.5590 |
| **Model 50** | 1.4717 | 0.2846 | -13.0092 | −8.8788 | — | — | — | — | −0.4622 | 1.3158 | 0.2056 | 1.8797 | 3.9070 | 12.4965 | 0.2433 | 0.8897 | 1.8219 |
| **Model 51** | 0.3763 | 0.0237 | -18.5896 | — | — | — | — | — | 0.3184 | 2.1663 | 0.3414 | 3.0179 | 11.5168 | 5.2254 | 0.3906 | 0.7496 | 3.0010 |
| **Model 52** | 1.1583 | −1.2047 | 0.0001 | — | — | — | — | — | −0.6634 | 1.2048 | 0.1828 | 1.7311 | 1.4453 | 20.4346 | 0.2241 | 0.9303 | 1.5990 |

(*continued on next page*)

**Table A15** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0944 | −0.6304 | −0.3454 | — | — | — | — | — | −0.3587 | 1.0182 | 0.1557 | 1.5639 | 3.6658 | 11.6056 | 0.2024 | 0.9295 | 1.5222 |
| **Model 54** | 0.9745 | 0.2758 | −1.4420 | −0.1997 | −0.0946 | — | — | — | −0.4755 | 0.8686 | 0.1285 | 1.4368 | 0.6462 | 17.2737 | 0.1860 | 0.9449 | 1.3559 |
| **Model 55** | 0.9593 | 0.5428 | −2.2889 | 0.7575 | −0.4671 | 0.7635 | −0.6579 | — | −0.4734 | **0.8650** | 0.1281 | **1.4335** | 0.6704 | 17.2314 | **0.1855** | 0.9452 | **1.3531** |
| **Model 56** | 0.9660 | 0.3803 | −1.5767 | −0.2817 | — | — | — | — | −0.4875 | 0.8697 | **0.1279** | 1.4453 | 0.5273 | 17.6465 | 0.1871 | 0.9450 | 1.3606 |
| **Model 57** | 1.0809 | −0.7289 | 0.1305 | −0.5144 | — | — | — | — | −0.3537 | 0.9202 | 0.1434 | 1.4395 | 2.8526 | 12.4830 | 0.1863 | 0.9398 | 1.3954 |
| **Model 58** | 1.0000 | −1.1657 | −0.2828 | — | — | — | — | — | −0.4790 | 0.8857 | 0.1323 | 1.4369 | 0.7333 | 17.4143 | 0.1860 | 0.9445 | 1.3547 |
| **Model 59** | 1.0771 | −0.6548 | −0.4082 | — | — | — | — | — | −0.3316 | 0.9222 | 0.1429 | 1.4487 | 3.1553 | 11.5822 | 0.1875 | 0.9385 | 1.4103 |
| **Model 60** | 1.0182 | −1.1689 | −0.2372 | — | — | — | — | — | −0.5189 | 0.9040 | 0.1331 | 1.4655 | 0.9233 | 18.6465 | 0.1897 | **0.9473** | 1.3706 |
| **Model 61** | 0.9436 | −1.7600 | −0.3361 | — | — | — | — | — | −0.4367 | 0.9589 | 0.1514 | 1.5258 | −0.4289 | 14.7126 | 0.1975 | 0.9292 | 1.4619 |
| **Model 62** | 0.2423 | −0.3890 | −0.0694 | — | — | — | — | — | −3.2197 | 3.4421 | 0.3617 | 4.0687 | -28.4694 | 53.6309 | 0.4477 | 0.7368 | 2.4876 |
| **Model 63** | 1.7625 | −0.4930 | −0.1986 | — | — | — | — | — | −0.4091 | 0.9237 | 0.1412 | 1.4570 | 2.5318 | 14.4079 | 0.1886 | 0.9428 | 1.3984 |
| **Model 64** | −0.9099 | −0.6348 | −0.4791 | — | — | — | — | — | −0.2784 | 1.0700 | 0.1628 | 1.6463 | 4.6058 | 8.4524 | 0.2131 | 0.9156 | 1.6226 |
| **Model 65** | 0.0968 | 0.5109 | −0.1502 | — | — | — | — | — | −0.2674 | 1.7545 | 0.3568 | 2.2610 | 16.2108 | 5.8652 | 0.2927 | 0.8300 | 2.2451 |
| **Model 66** | −0.0288 | 1.4356 | −1.4909 | 0.0597 | −0.1618 | — | — | — | −0.5237 | 0.9530 | 0.1534 | 1.5000 | −3.5369 | 18.3519 | 0.1942 | 0.9404 | 1.4056 |
| **Model 67** | −0.0433 | 1.6143 | −1.7214 | −0.0807 | — | — | — | — | −0.5567 | 1.0261 | 0.1879 | 1.5556 | −5.8310 | 18.8769 | 0.2014 | 0.9360 | 1.4525 |
| **Model 68** | 0.0812 | 0.3968 | 0.4010 | −0.5959 | — | — | — | — | −0.2889 | 1.3710 | 0.3021 | 1.8125 | 13.7847 | 7.9518 | 0.2346 | 0.8963 | 1.7894 |
| **Model 69** | 0.1758 | 0.4851 | −0.1200 | — | — | — | — | — | −0.2809 | 2.1491 | 0.5452 | 2.6335 | 32.1883 | 5.2835 | 0.3409 | 0.7625 | 2.6185 |
| **Model 70** | 0.0697 | 0.6247 | −0.2694 | — | — | — | — | — | −0.1393 | 1.3872 | 0.3153 | 1.8960 | 9.4888 | 3.6288 | 0.2454 | 0.8816 | 1.8909 |
| **Model 71** | 0.1782 | 0.0097 | 0.1082 | — | — | — | — | — | −0.6334 | 2.3838 | 0.6561 | 2.9165 | 37.4069 | 10.9576 | 0.3775 | 0.7113 | 2.8469 |
| **Model 72** | 0.2024 | 0.4071 | −0.0572 | — | — | — | — | — | −0.3793 | 2.4164 | 0.6617 | 2.9249 | 40.5634 | 6.4412 | 0.3786 | 0.6983 | 2.9002 |
| **Model 73** | 0.2838 | 0.0421 | −0.0140 | — | — | — | — | — | −0.2511 | 1.8116 | 0.4314 | 2.3237 | 25.8835 | 4.5046 | 0.2557 | 0.7635 | 2.3101 |
| **Model 74** | −0.1134 | 0.3319 | −0.0946 | — | — | — | — | — | −0.2398 | 1.8709 | 0.4072 | 2.3669 | 21.4548 | 5.0153 | 0.3064 | 0.8115 | 2.3548 |
| **Model 75** | 0.2386 | 0.0984 | −0.0007 | — | — | — | — | — | −0.7368 | 2.4069 | 0.6457 | 2.9535 | 35.2254 | 12.6886 | 0.3823 | 0.7090 | 2.8601 |
| **Model 76** | 0.1925 | 0.6572 | −0.6737 | −0.0007 | — | — | — | — | −0.6549 | 1.8077 | 0.5205 | 2.3713 | 27.3877 | 14.1546 | 0.3069 | 0.8270 | 2.2790 |
| **Model 77** | 0.1611 | 0.1047 | 0.0011 | — | — | — | — | — | −0.5992 | 2.3403 | 0.6387 | 2.8637 | 35.5547 | 10.5396 | 0.3707 | 0.7139 | 2.8003 |
| **Model 78** | 0.1283 | 0.6599 | −0.6689 | 0.0008 | — | — | — | — | −0.5412 | 1.7496 | 0.5164 | 2.2931 | 28.1005 | 11.9617 | 0.2968 | 0.8319 | 2.2283 |
| **Model 79** | 0.3476 | 0.0019 | −0.0021 | — | — | — | — | — | −0.7720 | 2.5073 | 0.6495 | 3.0468 | 33.1186 | 12.9013 | 0.3944 | 0.6727 | 2.9474 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.7943 | −0.6265 | −0.3480 | 0.3125 | — | — | — | — | −0.3546 | 1.0174 | 0.1553 | 1.5599 | 3.6617 | 11.4968 | 0.2019 | 0.9300 | 1.5191 |
| **Model 81** | 1.0980 | −0.6487 | −0.3388 | 0.0008 | — | — | — | — | −0.3237 | 0.9986 | 0.1538 | 1.5385 | 3.5646 | 10.5990 | 0.1991 | 0.9286 | 1.5041 |
| **Model 82** | 1.1549 | −1.2224 | 0.0011 | −0.0001 | — | — | — | — | −0.5948 | 1.1734 | 0.1813 | 1.6924 | 1.9944 | 18.4890 | 0.2191 | 0.9274 | 1.5844 |
| **Model 83** | 0.4450 | −0.2456 | 0.0792 | 0.0006 | 0.0001 | — | — | — | 0.4814 | 1.8183 | 0.4870 | 2.4836 | 37.4389 | 8.1903 | 0.2733 | 0.7202 | 2.4365 |
| **Model 84** | 0.1861 | 0.6436 | −0.6658 | 0.0009 | −0.0007 | — | — | — | −0.6343 | 1.7790 | 0.5052 | 2.3210 | 25.6961 | 13.9930 | 0.3004 | 0.8314 | 2.2327 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0323 | −1.2078 | −0.0017 | −0.0001 | 0.2050 | — | — | — | −0.5393 | 1.1399 | 0.1784 | 1.6352 | 2.2958 | 17.2059 | 0.2117 | 0.9295 | 1.5437 |
| **Model 87** | 1.0323 | −1.2078 | 0.2050 | −0.0017 | −0.0001 | — | — | — | −0.5393 | 1.1399 | 0.1784 | 1.6352 | 2.2958 | 17.2059 | 0.2117 | 0.9295 | 1.5437 |
| **Model 88** | 1.0838 | −0.6253 | −0.3456 | 0.0000 | 0.0001 | — | — | — | −0.3497 | 1.0164 | 0.1558 | 1.5602 | 3.7741 | 11.3151 | 0.2018 | 0.9296 | 1.5205 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0796 | −0.6429 | −0.3463 | 0.0011 | 0.0000 | — | — | — | −0.3429 | 1.0060 | 0.1542 | 1.5541 | 3.4672 | 11.1419 | 0.2012 | 0.9281 | 1.5158 |
| **Model 90** | −7.7701 | −8.8695 | −0.0236 | −1.5277 | −0.6545 | 0.0007 | 0.0000 | −0.3361 | −0.3275 | 0.9987 | 0.1531 | 1.5349 | 3.3748 | 10.7566 | 0.1987 | 0.9290 | 1.4995 |
| **Model 91** | −2.5946 | 3.4965 | 0.0328 | 1.5137 | −0.6472 | 0.0002 | 0.0012 | — | 0.0750 | 0.9954 | 0.1486 | 1.6312 | 6.4833 | 2.2666 | 0.2111 | 0.9115 | 1.6294 |
| **Model 92** | −5.6577 | 6.8555 | 0.0412 | 1.4670 | −1.2124 | −0.0003 | −0.0001 | — | −0.5542 | 1.1461 | 0.1782 | 1.6461 | 2.0522 | 17.6115 | 0.2131 | 0.9290 | 1.5500 |
| **Model 93** | 1.1513 | −0.0118 | 2.0311 | 2.2042 | −1.2202 | 0.0010 | — | — | −0.5877 | 1.1701 | 0.1807 | 1.6868 | 2.0284 | 18.3069 | 0.2183 | 0.9279 | 1.5811 |
| **Model 94** | 1.1600 | −0.0151 | 2.5191 | −0.4180 | −1.2069 | 0.0001 | — | — | −0.5872 | 1.1688 | 0.1809 | 1.6809 | 2.2746 | 18.3631 | 0.2176 | 0.9306 | 1.5750 |
| **Model 95** | 1.1670 | −0.0151 | 2.5151 | −0.3958 | −1.2098 | — | — | — | −0.5929 | 1.1718 | 0.1811 | 1.6855 | 2.2150 | 18.5084 | 0.2182 | 0.9304 | 1.5777 |
| **Model 96** | 0.6976 | 0.0468 | 0.8607 | 0.9271 | — | — | — | — | 0.8385 | 2.4784 | 0.3875 | 3.5006 | 13.2500 | 12.1511 | 0.4531 | 0.7386 | 3.3987 |
| **Model 97** | 1.1657 | −0.0243 | 2.2053 | −1.2114 | 0.0000 | — | — | — | −0.5579 | 1.1503 | 0.1786 | 1.6524 | 2.0662 | 17.6667 | 0.2139 | 0.9282 | 1.5553 |

**Table A16**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Wulumuqi station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.1786 | −1.3904 | — | — | — | — | — | — | −0.9506 | 2.0519 | 0.4739 | 3.1469 | -14.9471 | 15.7112 | 0.5796 | 0.5675 | 2.9999 |
| **Model 2** | 1.0283 | −0.5543 | −0.9608 | — | — | — | — | — | −1.5998 | 2.6366 | 0.6380 | 4.8800 | -33.8302 | 17.2032 | 0.8989 | 0.4589 | 4.6104 |
| **Model 3** | 0.8909 | 0.9637 | −5.1828 | 3.3803 | — | — | — | — | −0.5521 | 1.6302 | 0.3474 | 2.2589 | −3.4407 | 12.4967 | 0.4161 | 0.6751 | 2.1904 |
| **Model 4** | 0.9395 | 0.1242 | −1.2023 | −3.7177 | 4.2614 | — | — | — | 0.0452 | 1.7409 | 0.4008 | 2.7016 | 14.1117 | 0.8296 | 0.4976 | 0.5338 | 2.7013 |
| **Model 5** | 0.9709 | −0.6049 | 3.7679 | -17.8901 | 22.2082 | −8.3451 | — | — | −0.4031 | 1.5191 | 0.3193 | 2.1017 | **0.7923** | 9.6893 | 0.3871 | 0.6951 | 2.0627 |
| **Model 6** | 0.4791 | 0.0000 | — | — | — | — | — | — | 2.0892 | 3.5352 | 0.8370 | 4.7740 | 58.8688 | 24.1300 | 0.8794 | 0.3177 | 4.2926 |
| **Model 7** | 2.8776 | −2.4190 | — | — | — | — | — | — | −2.0843 | 3.1245 | 0.7820 | 6.6089 | -48.1611 | 16.4769 | 1.2173 | 0.3877 | 6.2716 |
| **Model 8** | 0.3303 | −0.4557 | — | — | — | — | — | — | 1.1334 | 2.5207 | 0.5947 | 3.3050 | 38.5791 | 18.0988 | 0.6088 | 0.4407 | 3.1046 |
| **Model 9** | −0.0198 | 1.0089 | −3.6104 | 7.0853 | — | — | — | — | −0.5617 | 1.6589 | 0.3574 | 2.2708 | −3.8545 | 12.6570 | 0.4183 | 0.6760 | 2.2002 |
| **Model 10** | −3.5656 | 7.1420 | — | — | — | — | — | — | −0.5042 | 1.6220 | 0.3475 | 2.2063 | −2.2582 | 11.6390 | 0.4064 | 0.6832 | 2.1479 |
| **Model 11** | 0.3590 | 0.0449 | — | — | — | — | — | — | 1.4397 | 2.9491 | 0.6960 | 3.9260 | 46.1827 | 19.5417 | 0.7232 | 0.3586 | 3.6525 |
| **Model 12** | 0.1046 | −2.0852 | — | — | — | — | — | — | 0.6289 | 1.9870 | 0.4588 | 2.5477 | 25.6823 | 12.6294 | 0.4693 | 0.5717 | 2.4689 |
| **Model 13** | 1.3421 | −2.1647 | — | — | — | — | — | — | 0.2358 | 1.6956 | 0.3817 | 2.1478 | 16.7493 | 5.4750 | 0.3956 | 0.6542 | 2.1348 |
| **Model 14** | 0.1620 | −0.4066 | — | — | — | — | — | — | −1.5277 | 2.2121 | 0.4027 | 2.7926 | -18.5927 | 32.4012 | 0.5144 | 0.5194 | 2.3376 |
| **Model 15** | 1.9749 | −0.8924 | — | — | — | — | — | — | −1.5004 | 2.5327 | 0.6097 | 4.6138 | -30.8893 | 17.0490 | 0.8498 | 0.4697 | 4.3630 |
| **Model 16** | 0.9058 | −0.7509 | — | — | — | — | — | — | −0.2023 | 1.6747 | 0.3400 | 2.2235 | 6.0311 | 4.5302 | 0.4096 | 0.6336 | 2.2143 |
| **Model 17** | 0.8917 | −0.6369 | −0.1217 | — | — | — | — | — | −0.2493 | 1.6447 | 0.3297 | 2.2007 | 4.4563 | 5.6528 | 0.4054 | 0.6466 | 2.1866 |
| **Model 18** | 0.9075 | −1.0481 | 1.0593 | −0.8444 | — | — | — | — | −0.3213 | 1.6272 | 0.3198 | 2.1925 | 2.1067 | 7.3439 | 0.4038 | 0.6597 | 2.1688 |
| **Model 19** | 1.1041 | −0.7509 | — | — | — | — | — | — | −0.2024 | 1.6747 | 0.3400 | 2.2235 | 6.0298 | 4.5316 | 0.4096 | 0.6336 | 2.2143 |
| **Model 20** | −0.7184 | −1.2254 | −0.8512 | — | — | — | — | — | −0.2732 | 1.7196 | 0.3388 | 2.2612 | 4.2774 | 5.8598 | 0.4052 | 0.6178 | 2.2447 |
| **Model 21** | 1.0515 | 2.2633 | — | — | — | — | — | — | 0.4802 | 2.1650 | 0.4840 | 2.8610 | 23.9585 | 8.4406 | 0.5270 | 0.4645 | 2.8204 |
| **Model 22** | 2.3939 | −1.2935 | — | — | — | — | — | — | −0.3055 | 1.6221 | 0.3199 | 2.1912 | 2.4052 | 6.9811 | 0.4036 | 0.6600 | 2.1698 |
| **Model 23** | 0.2659 | −0.2766 | — | — | — | — | — | — | −0.5960 | 2.3298 | 0.4673 | 2.9013 | 3.0675 | 10.1063 | 0.5198 | 0.3591 | 2.8394 |
| **Model 24** | 1.3145 | −0.4531 | — | — | — | — | — | — | −0.3340 | 1.6209 | 0.3175 | 2.1978 | 1.4033 | 7.6224 | 0.4048 | 0.6639 | 2.1722 |
| **Model 25** | −0.0730 | −1.1652 | — | — | — | — | — | — | 0.0949 | 1.8842 | 0.4047 | 2.4694 | 14.3879 | 1.9058 | 0.4549 | 0.5504 | 2.4675 |
| **Model 26** | 0.2354 | −0.0669 | — | — | — | — | — | — | −0.0096 | 1.8490 | 0.4737 | 2.2889 | 20.5182 | 0.2074 | 0.4216 | 0.5732 | 2.2889 |
| **Model 27** | 0.9694 | 0.8503 | — | — | — | — | — | — | −0.8712 | 1.9793 | 0.4491 | 2.9503 | -12.7710 | 15.3236 | 0.5434 | 0.5924 | 2.8187 |
| **Model 28** | −0.0204 | 1.3558 | −1.6349 | — | — | — | — | — | −1.1945 | 2.2461 | 0.5268 | 3.7225 | -22.2931 | 16.7971 | 0.6857 | 0.5267 | 3.5256 |
| **Model 29** | −0.0461 | 1.6401 | −2.4256 | 0.6331 | — | — | — | — | −0.9844 | 2.0612 | 0.4765 | 3.1676 | -16.7503 | 16.2096 | 0.5835 | 0.5737 | 3.0108 |
| **Model 30** | 0.0101 | 0.6697 | 2.1759 | −7.5721 | 4.9261 | — | — | — | −0.2648 | 1.5638 | 0.3387 | 2.1655 | 5.0115 | 6.1075 | 0.3989 | 0.6670 | 2.1492 |
| **Model 31** | 0.0116 | 0.2108 | — | — | — | — | — | — | 0.1568 | 1.9279 | 0.4761 | 2.3780 | 22.0618 | 3.2768 | 0.4380 | 0.5510 | 2.3728 |
| **Model 32** | 0.2288 | −0.2514 | — | — | — | — | — | — | 0.0251 | 1.8656 | 0.4767 | 2.3036 | 21.1221 | 0.5398 | 0.4243 | 0.5682 | 2.3034 |
| **Model 33** | 0.2086 | 0.0428 | — | — | — | — | — | — | 0.1465 | 1.9245 | 0.4780 | 2.3727 | 22.1704 | 3.0672 | 0.4370 | 0.5514 | 2.3682 |
| **Model 34** | −0.0066 | 0.2193 | — | — | — | — | — | — | 0.1799 | 1.8914 | 0.4377 | 2.3503 | 17.5374 | 3.8069 | 0.4329 | 0.5721 | 2.3434 |
| **Model 35** | 0.2108 | 0.0116 | — | — | — | — | — | — | 0.2746 | 1.9362 | 0.4918 | 2.3944 | 25.3033 | 5.7242 | 0.4410 | 0.5526 | 2.3786 |
| **Model 36** | 0.3042 | −0.0611 | — | — | — | — | — | — | −0.1030 | 1.8045 | 0.4618 | 2.2540 | 18.3770 | 2.2678 | 0.4152 | 0.5882 | 2.2516 |
| **Model 37** | −0.7663 | −0.0647 | — | — | — | — | — | — | **−0.0006** | 1.8534 | 0.4745 | 2.2925 | 20.6780 | **0.0129** | 0.4223 | 0.5719 | 2.2925 |
| **Model 38** | 0.2410 | −0.0692 | — | — | — | — | — | — | −0.1204 | 1.8064 | 0.4589 | 2.2549 | 18.3464 | 2.6521 | 0.4153 | 0.5812 | 2.2517 |
| **Model 39** | 0.1878 | 0.3620 | −0.4599 | — | — | — | — | — | −0.3108 | 1.5415 | 0.3637 | 2.0220 | 8.8457 | 7.7129 | 0.3724 | 0.6925 | 1.9980 |
| **Model 40** | 0.1922 | 0.2470 | −0.1297 | −0.2361 | — | — | — | — | −0.3389 | 1.5324 | 0.3609 | 2.0165 | 8.0540 | 8.4519 | 0.3714 | 0.6974 | 1.9878 |
| **Model 41** | 0.1819 | −0.0365 | — | — | — | — | — | — | −0.2869 | 1.8651 | 0.4016 | 2.3039 | 9.4468 | 6.0431 | 0.4128 | 0.5530 | 2.2860 |
| **Model 42** | 0.2375 | −0.2936 | — | — | — | — | — | — | −0.0855 | 1.8230 | 0.4634 | 2.2690 | 19.0691 | 1.8693 | 0.4179 | 0.5757 | 2.2674 |
| **Model 43** | 0.3510 | 0.0557 | −0.2466 | — | — | — | — | — | 0.0373 | 1.6035 | 0.3459 | 2.1565 | 12.1211 | 0.8339 | 0.3864 | 0.6584 | 2.1562 |
| **Model 44** | 0.2938 | −0.0499 | — | — | — | — | — | — | −0.1825 | 1.7598 | 0.4455 | 2.2121 | 16.7330 | 4.1046 | 0.4075 | 0.5997 | 2.2045 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1946 | −1.3771 | −0.0325 | — | — | — | — | — | −0.9671 | 2.0268 | 0.4659 | 3.1210 | -14.7711 | 16.1586 | 0.5749 | 0.5642 | 2.9674 |
| **Model 46** | −0.5659 | 0.9935 | — | — | — | — | — | — | 1.1617 | 3.5864 | 0.7967 | 4.6042 | 22.0569 | 12.9279 | 0.8481 | 0.5211 | 4.4553 |
| **Model 47** | 1.1576 | −1.3956 | 0.0269 | — | — | — | — | — | −1.2319 | 2.1489 | 0.4942 | 3.3019 | -22.6044 | 19.9371 | 0.6082 | 0.5736 | 3.0635 |
| **Model 48** | 0.9985 | −0.9816 | 0.6544 | −0.5657 | −4.8443 | 0.6121 | −0.1858 | — | −0.5122 | 1.6216 | 0.3487 | 2.2186 | −2.6431 | 11.7631 | 0.4087 | 0.6829 | 2.1586 |
| **Model 49** | 1.1717 | −1.3762 | −0.0004 | — | — | — | — | — | −0.9702 | 2.0230 | 0.4649 | 3.1184 | -14.7710 | 16.2295 | 0.5744 | 0.5636 | 2.9637 |
| **Model 50** | 0.8379 | −0.1381 | 9.9388 | 5.8863 | — | — | — | — | −0.0615 | 1.5427 | 0.3460 | 1.9755 | 12.8048 | 1.5442 | 0.3639 | 0.6849 | 1.9746 |
| **Model 51** | 21.5966 | 0.0422 | 1877.1394 | — | — | — | — | — | 0.9729 | 2.6239 | 0.6352 | 3.3747 | 41.1894 | 14.9270 | 0.6216 | 0.2959 | 3.2314 |
| **Model 52** | 1.0766 | −1.3100 | 0.0011 | — | — | — | — | — | −0.9579 | 1.9533 | 0.4430 | 2.9868 | -13.9629 | 16.7862 | 0.5502 | 0.5747 | 2.8291 |

(*continued on next page*)

**Table A16** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0905 | −0.8228 | −0.3475 | — | — | — | — | — | −0.7705 | 1.5963 | 0.3319 | 2.1623 | −9.2645 | 18.9059 | 0.3983 | 0.7088 | 2.0204 |
| **Model 54** | 0.9700 | −0.0745 | −0.9329 | −0.4349 | 0.1346 | — | — | — | −1.3690 | 2.1545 | 0.4935 | 3.6698 | -26.4940 | 19.9336 | 0.6760 | 0.5381 | 3.4049 |
| **Model 55** | 0.9110 | 0.7408 | −3.3280 | 1.9433 | −0.7804 | 1.2401 | −0.8142 | — | −0.8312 | 1.6243 | 0.3393 | 2.2079 | -11.2600 | 20.1469 | 0.4067 | 0.7133 | 2.0455 |
| **Model 56** | 1.0405 | −0.6384 | −0.8204 | −0.0012 | — | — | — | — | −1.2879 | 2.4440 | 0.5908 | 4.3997 | -26.2350 | 15.1775 | 0.8104 | 0.4859 | 4.2070 |
| **Model 57** | 1.1606 | −1.3344 | −0.0021 | 0.0000 | — | — | — | — | −0.6925 | 1.9811 | 0.4593 | 2.9176 | −9.1255 | 12.1134 | 0.5374 | 0.5907 | 2.8342 |
| **Model 58** | 0.9230 | −1.5523 | 0.0000 | — | — | — | — | — | −1.7999 | 2.9472 | 0.7309 | 5.8158 | -40.9719 | 16.1357 | 1.0713 | 0.4257 | 5.5303 |
| **Model 59** | 1.1797 | −1.3637 | −0.0001 | — | — | — | — | — | −0.6645 | 1.9987 | 0.4666 | 2.9681 | −8.7240 | 11.3890 | 0.5467 | 0.5869 | 2.8928 |
| **Model 60** | 0.9175 | −1.5358 | −0.0008 | — | — | — | — | — | −1.7806 | 2.9177 | 0.7227 | 5.7412 | -40.3825 | 16.1740 | 1.0575 | 0.4281 | 5.4581 |
| **Model 61** | 0.8032 | −1.4597 | −0.2511 | — | — | — | — | — | −2.4185 | 3.3814 | 0.8419 | 7.0904 | -59.3165 | 17.9895 | 1.3060 | 0.4045 | 6.6652 |
| **Model 62** | 0.1346 | −0.3200 | −0.1363 | — | — | — | — | — | −1.9728 | 2.3449 | 0.3929 | 2.9942 | -26.6574 | 42.1673 | 0.5365 | 0.5367 | 2.2525 |
| **Model 63** | 1.7773 | −0.5680 | −0.1877 | — | — | — | — | — | −1.1996 | 1.9605 | 0.4348 | 3.1046 | -22.0659 | 20.7699 | 0.5719 | 0.6023 | 2.8635 |
| **Model 64** | −0.8915 | −0.9455 | −0.5543 | — | — | — | — | — | −0.3883 | **1.4146** | **0.2814** | **1.8439** | 1.5979 | 10.6787 | **0.3396** | **0.7471** | **1.8026** |
| **Model 65** | 0.1891 | 0.2313 | −0.1826 | — | — | — | — | — | −0.0739 | 1.9308 | 0.4674 | 2.4471 | 18.0225 | 1.4981 | 0.4507 | 0.5166 | 2.4460 |
| **Model 66** | −0.0292 | 1.3879 | −1.4406 | −0.0583 | −0.0692 | — | — | — | −1.1257 | 1.9034 | 0.4220 | 2.9289 | -20.3173 | 20.6393 | 0.5395 | 0.6154 | 2.7040 |
| **Model 67** | −0.0367 | 1.4731 | −1.5470 | −0.1187 | — | — | — | — | −1.1727 | 1.9740 | 0.4454 | 3.0997 | -21.6158 | 20.2622 | 0.5710 | 0.5916 | 2.8693 |
| **Model 68** | 0.1355 | 0.2328 | 0.2485 | −0.4606 | — | — | — | — | −0.2647 | 1.6542 | 0.3740 | 2.1628 | 8.4944 | 6.1143 | 0.3984 | 0.6487 | 2.1465 |
| **Model 69** | 0.2304 | 0.1349 | −0.1598 | — | — | — | — | — | −0.1440 | 1.8156 | 0.4522 | 2.3174 | 17.0976 | 3.0858 | 0.4269 | 0.5663 | 2.3129 |
| **Model 70** | 0.1420 | 0.3374 | −0.2639 | — | — | — | — | — | −0.2062 | 1.8557 | 0.4279 | 2.4066 | 11.6776 | 4.2633 | 0.4433 | 0.5605 | 2.3978 |
| **Model 71** | 0.2449 | −0.1129 | −0.0201 | — | — | — | — | — | −0.2185 | 1.7673 | 0.4485 | 2.2252 | 15.5885 | 4.8920 | 0.4099 | 0.6027 | 2.2145 |
| **Model 72** | 0.2404 | 0.0144 | −0.1263 | — | — | — | — | — | −0.2925 | 1.6586 | 0.4133 | 2.1321 | 13.1279 | 6.8674 | 0.3927 | 0.6391 | 2.1119 |
| **Model 73** | 0.1904 | 0.0207 | −0.0455 | — | — | — | — | — | −0.1528 | 1.8701 | 0.4082 | 2.3082 | 12.0914 | 3.1939 | 0.4136 | 0.5508 | 2.3031 |
| **Model 74** | 0.1875 | 0.1305 | −0.1109 | — | — | — | — | — | −0.0798 | 1.9193 | 0.4705 | 2.4557 | 18.3022 | 1.6126 | 0.4523 | 0.5184 | 2.4544 |
| **Model 75** | 0.1965 | −0.0453 | 0.0005 | — | — | — | — | — | −0.1578 | 1.7739 | 0.4512 | 2.2300 | 18.4569 | 3.5168 | 0.4108 | 0.5817 | 2.2244 |
| **Model 76** | 0.1680 | 0.3665 | −0.4529 | 0.0003 | — | — | — | — | −0.3254 | 1.5246 | 0.3609 | 2.0077 | 9.0370 | 8.1421 | 0.3698 | 0.6936 | 1.9812 |
| **Model 77** | 0.2342 | −0.0367 | −0.0015 | — | — | — | — | — | −0.2168 | 1.7177 | 0.4345 | 2.1670 | 17.8874 | 4.9862 | 0.3992 | 0.6038 | 2.1562 |
| **Model 78** | 0.1851 | 0.3665 | −0.4383 | −0.0011 | — | — | — | — | −0.3762 | 1.4547 | 0.3448 | 1.9272 | 8.9302 | 9.8667 | 0.3550 | 0.7157 | 1.8902 |
| **Model 79** | 0.2204 | −0.0019 | −0.0001 | — | — | — | — | — | −0.1455 | 1.7374 | 0.4377 | 2.1844 | 19.3810 | 3.3086 | 0.4024 | 0.5921 | 2.1796 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.4574 | −0.7821 | −0.3817 | 0.6589 | — | — | — | — | −0.7813 | 1.5405 | 0.3179 | 2.0913 | −9.1907 | 19.9676 | 0.3852 | 0.7220 | 1.9399 |
| **Model 81** | 1.0930 | −0.8210 | −0.3539 | 0.0003 | — | — | — | — | −0.7555 | 1.6068 | 0.3353 | 2.1642 | −9.2677 | 18.4683 | 0.3986 | 0.7102 | 2.0281 |
| **Model 82** | 1.1670 | −1.3335 | −0.0019 | 0.0000 | — | — | — | — | −0.9969 | 1.9344 | 0.4405 | 3.0291 | -14.5969 | 17.2789 | 0.5580 | 0.5664 | 2.8604 |
| **Model 83** | 0.5012 | −0.3421 | 0.0946 | −0.0012 | −0.0003 | — | — | — | 0.3001 | 1.6337 | 0.3725 | 2.2433 | 19.5743 | 6.4986 | 0.4020 | 0.6282 | 2.2232 |
| **Model 84** | 0.2455 | 0.3554 | −0.4454 | −0.0019 | −0.0008 | — | — | — | −0.3734 | 1.4403 | 0.3396 | 1.9057 | 8.4110 | 9.9076 | 0.3510 | 0.7235 | 1.8687 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0065 | −1.3450 | −0.0057 | −0.0002 | 0.2981 | — | — | — | −0.9446 | 1.9443 | 0.4512 | 3.0437 | -15.6285 | 16.1856 | 0.5606 | 0.5906 | 2.8934 |
| **Model 87** | 1.0065 | −1.3450 | 0.2981 | −0.0057 | −0.0002 | — | — | — | −0.9446 | 1.9443 | 0.4512 | 3.0437 | -15.6285 | 16.1856 | 0.5606 | 0.5906 | 2.8934 |
| **Model 88** | 1.0715 | −0.8195 | −0.3394 | 0.0000 | 0.0002 | — | — | — | −0.7749 | 1.5877 | 0.3292 | 2.1553 | −9.1606 | 19.0944 | 0.3968 | 0.7091 | 2.0112 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.1107 | −0.8433 | −0.3302 | −0.0008 | −0.0002 | — | — | — | −0.7980 | 1.5863 | 0.3302 | 2.1776 | −9.6062 | 19.5269 | 0.4011 | 0.7052 | 2.0261 |
| **Model 90** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 91** | 0.7476 | 0.0729 | 1.1637 | 0.4961 | −0.7311 | 0.0053 | 0.0017 | — | −0.2235 | 1.6513 | 0.3338 | 2.1899 | 5.1328 | 5.0869 | 0.4034 | 0.6479 | 2.1784 |
| **Model 92** | 1.1680 | 0.0611 | 0.7784 | −0.3881 | −1.3418 | −0.0035 | 0.0000 | — | −0.9410 | 1.9313 | 0.4498 | 3.0196 | -15.8422 | 16.2596 | 0.5562 | 0.5971 | 2.8692 |
| **Model 93** | 1.1641 | 0.0055 | 3.2332 | −2.1578 | −1.3316 | −0.0019 | — | — | −0.9976 | 1.9356 | 0.4405 | 3.0280 | -14.6182 | 17.3004 | 0.5577 | 0.5666 | 2.8589 |
| **Model 94** | 1.1080 | 0.0422 | 0.8756 | 0.5631 | −1.3254 | 0.0007 | — | — | −0.9332 | 1.9204 | 0.4459 | 2.9728 | -15.5006 | 16.3925 | 0.5476 | 0.6022 | 2.8225 |
| **Model 95** | 1.1656 | 0.0477 | 0.8801 | 0.8015 | −1.3591 | — | — | — | −0.9475 | 1.9490 | 0.4555 | 3.0411 | -16.0052 | 16.2559 | 0.5602 | 0.5954 | 2.8897 |
| **Model 96** | 0.5200 | 0.1681 | 0.7912 | 1.9433 | — | — | — | — | 1.4463 | 2.9532 | 0.7094 | 3.8718 | 48.4772 | 19.9656 | 0.7132 | 0.2995 | 3.5915 |
| **Model 97** | 1.1764 | 0.0473 | -13.3878 | −1.3382 | −0.0031 | — | — | — | 1.0634 | 1.9994 | 0.4707 | 2.6706 | 27.9225 | 21.5215 | 0.4919 | 0.6874 | 2.4498 |

**Table A17**
Regression coefficients and statistical indicators of all models for estimating the diffuse solar radiation at Zhengzhou station.

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Category I** | | | | | | | | | | | | | | | | | |
| **Model 1** | 1.2221 | −1.2818 | — | — | — | — | — | — | −0.8125 | 1.2829 | 0.1499 | 1.7386 | −3.3810 | 26.3932 | 0.2074 | 0.9501 | 1.5371 |
| **Model 2** | 0.9988 | 0.2305 | −1.9792 | — | — | — | — | — | −0.8582 | 1.0968 | 0.1158 | 1.5878 | −6.5102 | 32.0733 | 0.1894 | 0.9562 | 1.3359 |
| **Model 3** | 0.9325 | 1.0575 | −4.5028 | 2.1946 | — | — | — | — | −0.8469 | 1.0860 | 0.1126 | 1.5930 | −6.0945 | 31.3441 | 0.1901 | 0.9582 | 1.3492 |
| **Model 4** | 0.9968 | −0.1571 | 1.8466 | -10.1815 | 8.0600 | — | — | — | −0.8439 | 1.0839 | 0.1118 | 1.5971 | −5.9589 | 31.0761 | 0.1906 | 0.9576 | 1.3560 |
| **Model 5** | 0.9747 | 0.4142 | −2.5807 | 4.0723 | -12.1601 | 10.4636 | — | — | −0.8448 | 1.0842 | 0.1117 | 1.5967 | −5.9735 | 31.1348 | 0.1905 | 0.9577 | 1.3549 |
| **Model 6** | 0.6668 | 0.0000 | — | — | — | — | — | — | 0.4702 | 2.5936 | 0.3878 | 3.3822 | 11.1285 | 7.0089 | 0.4035 | 0.7060 | 3.3493 |
| **Model 7** | 3.1843 | −2.7292 | — | — | — | — | — | — | −0.8767 | 1.1680 | 0.1282 | 1.6269 | −5.3890 | 31.9386 | 0.1941 | 0.9637 | 1.3705 |
| **Model 8** | 0.4803 | −0.3211 | — | — | — | — | — | — | −0.2612 | 1.9981 | 0.2773 | 2.5517 | 4.9894 | 5.1387 | 0.3044 | 0.7806 | 2.5382 |
| **Model 9** | 0.0081 | 1.0131 | −4.4373 | 8.0909 | — | — | — | — | −0.8452 | 1.0871 | 0.1125 | 1.5976 | −5.9432 | 31.1303 | 0.1906 | 0.9575 | 1.3557 |
| **Model 10** | −4.6998 | 8.4472 | — | — | — | — | — | — | −0.8614 | 1.0961 | 0.1142 | 1.5983 | −6.4018 | 31.9456 | 0.1907 | 0.9569 | 1.3463 |
| **Model 11** | 0.5548 | 0.0324 | — | — | — | — | — | — | −0.0354 | 2.3209 | 0.3320 | 2.9620 | 7.4834 | 0.5975 | 0.3534 | 0.7266 | 2.9618 |
| **Model 12** | 0.2019 | −1.9028 | — | — | — | — | — | — | −0.4683 | 1.6470 | 0.2152 | 2.1340 | 1.6186 | 11.2320 | 0.2546 | 0.8543 | 2.0819 |
| **Model 13** | 1.2836 | −1.5936 | — | — | — | — | — | — | −0.6089 | 1.5122 | 0.1927 | 1.9753 | **0.1078** | 16.1791 | 0.2357 | 0.8924 | 1.8791 |
| **Model 14** | 0.3612 | −0.3143 | — | — | — | — | — | — | −2.2655 | 2.8095 | 0.3373 | 3.3972 | -21.8127 | 44.6811 | 0.4053 | 0.7772 | 2.5316 |
| **Model 15** | 2.0426 | −0.8791 | — | — | — | — | — | — | −0.8488 | 1.1808 | 0.1314 | 1.6400 | −4.6788 | 30.2014 | 0.1957 | 0.9627 | 1.4033 |
| **Model 16** | 0.9914 | −0.7279 | — | — | — | — | — | — | −0.4408 | 1.0332 | 0.1240 | 1.5634 | −0.7222 | 14.6716 | 0.1865 | 0.9312 | 1.5000 |
| **Model 17** | 0.9644 | −0.3855 | −0.4226 | — | — | — | — | — | −0.4281 | 0.9416 | 0.1125 | 1.4391 | −1.8427 | 15.5584 | 0.1717 | 0.9407 | 1.3740 |
| **Model 18** | 0.9783 | −0.9536 | 1.3908 | −1.4107 | — | — | — | — | −0.4503 | **0.9199** | 0.1075 | 1.4040 | −2.3623 | 16.9075 | 0.1675 | 0.9447 | 1.3299 |
| **Model 19** | 1.0087 | −0.7279 | — | — | — | — | — | — | −0.4408 | 1.0332 | 0.1240 | 1.5634 | −0.7230 | 14.6737 | 0.1865 | 0.9312 | 1.5000 |
| **Model 20** | −0.7683 | −1.8215 | −0.8937 | — | — | — | — | — | −0.5860 | 1.1875 | 0.1371 | 1.6217 | −2.6329 | 16.9112 | 0.1726 | 0.9147 | 1.5121 |
| **Model 21** | 0.9953 | 1.4219 | — | — | — | — | — | — | −0.3301 | 1.3077 | 0.1659 | 1.8900 | 2.3901 | 8.8568 | 0.2255 | 0.8873 | 1.8610 |
| **Model 22** | 2.6588 | −1.4752 | — | — | — | — | — | — | −0.4433 | 0.9570 | 0.1133 | 1.4653 | −1.6334 | 15.8493 | 0.1748 | 0.9396 | 1.3967 |
| **Model 23** | 0.4257 | −0.2097 | — | — | — | — | — | — | −1.7225 | 2.6373 | 0.2953 | 3.1357 | -10.4265 | 28.6855 | 0.3338 | 0.7086 | 2.6202 |
| **Model 24** | 1.4445 | −0.4749 | — | — | — | — | — | — | −0.4339 | 0.9431 | 0.1123 | 1.4428 | −1.7810 | 15.7448 | 0.1721 | 0.9409 | 1.3760 |
| **Model 25** | −0.0042 | −1.0091 | — | — | — | — | — | — | −0.4015 | 1.1740 | 0.1455 | 1.7368 | 0.7910 | 11.8638 | 0.2072 | 0.9105 | 1.6898 |
| **Model 26** | 0.1710 | 0.1817 | — | — | — | — | — | — | −0.7885 | 2.1204 | 0.3616 | 2.6044 | 9.7429 | 15.8619 | 0.3107 | 0.8040 | 2.4822 |
| **Model 27** | 1.4258 | 0.8271 | — | — | — | — | — | — | −0.8267 | 1.0753 | 0.1105 | 1.5990 | −5.6528 | 30.1589 | 0.1908 | 0.9566 | 1.3687 |
| **Model 28** | −0.0517 | 1.6902 | −1.9742 | — | — | — | — | — | −0.8400 | 1.1395 | 0.1359 | 1.6297 | −7.2187 | 30.0318 | 0.1944 | 0.9532 | 1.3966 |
| **Model 29** | −0.0260 | 1.3696 | −0.9959 | −0.8508 | — | — | — | — | −0.8470 | 1.1078 | 0.1227 | 1.6027 | −6.6508 | 31.0842 | 0.1912 | 0.9569 | 1.3605 |
| **Model 30** | 0.0200 | 0.5002 | 3.5486 | −9.7088 | 5.7688 | — | — | — | −0.8407 | 1.0902 | 0.1164 | 1.5999 | −5.6835 | 30.8396 | 0.1909 | 0.9572 | 1.3612 |
| **Model 31** | 0.0763 | 0.3240 | — | — | — | — | — | — | −0.7871 | 1.8225 | 0.2532 | 2.2857 | 1.8087 | 18.3154 | 0.2727 | 0.8623 | 2.1459 |
| **Model 32** | 0.1923 | 0.5946 | — | — | — | — | — | — | −0.7827 | 2.1688 | 0.3821 | 2.6713 | 11.5730 | 15.3006 | 0.3187 | 0.7919 | 2.5541 |
| **Model 33** | 0.3264 | 0.2866 | — | — | — | — | — | — | −0.7667 | 1.9416 | 0.3049 | 2.3970 | 6.0829 | 16.8570 | 0.2860 | 0.8464 | 2.2711 |
| **Model 34** | −0.0125 | 0.2930 | — | — | — | — | — | — | −0.8134 | 1.8145 | 0.2826 | 2.2790 | −4.3779 | 19.0755 | 0.2719 | 0.8611 | 2.1290 |
| **Model 35** | 0.3240 | 0.0763 | — | — | — | — | — | — | 0.4689 | 1.8675 | 0.4082 | 2.4024 | 29.3812 | 9.9354 | 0.2866 | 0.8204 | 2.3562 |
| **Model 36** | 0.0911 | 0.1014 | — | — | — | — | — | — | −0.7910 | 2.1893 | 0.3844 | 2.6932 | 11.4722 | 15.3404 | 0.3213 | 0.7855 | 2.5744 |
| **Model 37** | −0.8233 | 0.1617 | — | — | — | — | — | — | −0.7895 | 2.1346 | 0.3672 | 2.6233 | 10.1986 | 15.7575 | 0.3130 | 0.8008 | 2.5017 |
| **Model 38** | 0.2253 | 0.0547 | — | — | — | — | — | — | −0.8556 | 2.2861 | 0.4158 | 2.8398 | 13.3028 | 15.7760 | 0.3388 | 0.7587 | 2.7079 |
| **Model 39** | 0.1754 | 0.6897 | −0.7836 | — | — | — | — | — | −0.8752 | 1.6589 | 0.2930 | 2.1631 | 4.1795 | 22.0898 | 0.2581 | 0.8789 | 1.9782 |
| **Model 40** | 0.1728 | 0.7955 | −1.1212 | 0.2627 | — | — | — | — | −0.8725 | 1.6518 | 0.2902 | 2.1567 | 4.0127 | 22.0868 | 0.2573 | 0.8795 | 1.9724 |
| **Model 41** | 0.2612 | −0.0141 | — | — | — | — | — | — | −1.1580 | 1.9316 | 0.2125 | 2.4229 | −5.0525 | 23.7424 | 0.2579 | 0.8464 | 2.1283 |
| **Model 42** | 0.2288 | 0.1923 | — | — | — | — | — | — | −0.8484 | 2.2921 | 0.4194 | 2.8504 | 13.7403 | 15.5670 | 0.3401 | 0.7561 | 2.7212 |
| **Model 43** | 0.4110 | 0.0532 | −0.2625 | — | — | — | — | — | −0.1812 | 1.3858 | 0.1617 | 1.8580 | 2.8537 | 4.2756 | 0.1978 | 0.8667 | 1.8491 |
| **Model 44** | 0.2113 | 0.0235 | — | — | — | — | — | — | −0.8414 | 2.3142 | 0.4270 | 2.8818 | 14.4513 | 15.2420 | 0.3438 | 0.7475 | 2.7563 |
| **Category II** | | | | | | | | | | | | | | | | | |
| **Model 45** | 1.1245 | −1.2875 | 0.1262 | — | — | — | — | — | −0.7336 | 1.2019 | 0.1417 | 1.6111 | −3.6744 | 25.5354 | 0.1922 | 0.9483 | 1.4344 |
| **Model 46** | −0.8069 | 1.2350 | — | — | — | — | — | — | **−0.0043** | 2.1306 | 0.2976 | 2.8697 | −6.4774 | **0.0751** | 0.3424 | 0.8666 | 2.8697 |
| **Model 47** | 1.2268 | −1.2930 | 0.0314 | — | — | — | — | — | −0.7461 | 1.2086 | 0.1418 | 1.6362 | −3.6605 | 25.5815 | 0.1952 | 0.9471 | 1.4562 |
| **Model 48** | 0.9892 | −9.4122 | 2.6440 | −3.7018 | 2.1046 | −0.1544 | 0.0269 | — | −0.7243 | 0.9286 | **0.0971** | **1.3731** | −6.3207 | 31.0002 | **0.1638** | **0.9637** | **1.1666** |
| **Model 49** | 1.2238 | −1.2871 | 0.0012 | — | — | — | — | — | −0.7209 | 1.1956 | 0.1415 | 1.5982 | −3.6649 | 25.2357 | 0.1907 | 0.9472 | 1.4263 |
| **Model 50** | −2.5417 | −2.3513 | -21.0243 | -14.1079 | — | — | — | — | −0.6334 | 1.4033 | 0.1723 | 1.8608 | −1.8777 | 18.0760 | 0.2220 | 0.9035 | 1.7497 |
| **Model 51** | −5.6936 | 0.0326 | -552.4515 | — | — | — | — | — | 0.0240 | 2.3055 | 0.3290 | 2.9665 | 7.3085 | 0.4048 | 0.3539 | 0.7369 | 2.9664 |
| **Model 52** | 1.1397 | −1.2290 | 0.0009 | — | — | — | — | — | −0.8903 | 1.2904 | 0.1472 | 1.7430 | −4.7296 | 29.6655 | 0.2080 | 0.9542 | 1.4985 |

(continued on next page)

**Table A17** (*continued*)

| Models | a | b | c | d | e | f | g | h | MBE | MAE | MARE | RMSE | MPE | t-stat | RRMSE | R | RMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model 53** | 1.0898 | −0.4842 | −0.4783 | — | — | — | — | — | −0.6131 | 1.0573 | 0.1232 | 1.5487 | −2.1408 | 21.5267 | 0.1848 | 0.9484 | 1.4221 |
| **Model 54** | 0.9783 | 0.2311 | −1.2365 | −0.1969 | −0.1817 | — | — | — | −0.6978 | 0.9384 | 0.0996 | 1.4203 | −4.9888 | 28.1633 | 0.1695 | 0.9601 | 1.2371 |
| **Model 55** | 0.9721 | 0.3237 | −1.3554 | 0.0912 | −0.5254 | 0.7703 | −0.7309 | — | −0.6922 | 0.9326 | 0.0991 | 1.4096 | −5.0853 | 28.1462 | 0.1682 | 0.9600 | 1.2279 |
| **Model 56** | 0.9566 | 0.4463 | −1.5218 | −0.3390 | — | — | — | — | −0.7064 | 0.9467 | 0.1000 | 1.4428 | −4.9087 | 28.0344 | 0.1721 | 0.9599 | 1.2580 |
| **Model 57** | 1.0798 | −0.6081 | 0.0324 | −0.5514 | — | — | — | — | −0.6405 | 0.9541 | 0.1068 | 1.4019 | −3.9627 | 25.6438 | 0.1673 | 0.9581 | 1.2471 |
| **Model 58** | 1.0030 | −1.0346 | −0.3713 | — | — | — | — | — | −0.7103 | 0.9536 | 0.1019 | 1.4166 | −5.3392 | 28.9377 | 0.1690 | 0.9597 | 1.2256 |
| **Model 59** | 1.0779 | −0.5879 | −0.5258 | — | — | — | — | — | −0.6357 | 0.9524 | 0.1067 | 1.4039 | −3.8564 | 25.3576 | 0.1675 | 0.9578 | 1.2517 |
| **Model 60** | 1.0296 | −1.0398 | −0.3050 | — | — | — | — | — | −0.7307 | 0.9885 | 0.1051 | 1.4734 | −4.4749 | 28.5161 | 0.1758 | 0.9631 | 1.2794 |
| **Model 61** | 0.9395 | −1.6613 | −0.3619 | — | — | — | — | — | −0.6977 | 1.0082 | 0.1195 | 1.4908 | −6.7746 | 26.4411 | 0.1779 | 0.9448 | 1.3175 |
| **Model 62** | 0.1522 | −0.5544 | −0.0435 | — | — | — | — | — | −4.3447 | 4.3858 | 0.4314 | 5.0526 | -41.7751 | 73.5030 | 0.5378 | 0.8530 | 2.5792 |
| **Model 63** | 1.7434 | −0.3971 | −0.2779 | — | — | — | — | — | −0.6547 | 0.9659 | 0.1071 | 1.4367 | −3.5651 | 25.5605 | 0.1714 | 0.9597 | 1.2789 |
| **Model 64** | −0.9009 | −0.5592 | −0.6004 | — | — | — | — | — | −0.5795 | 1.1371 | 0.1363 | 1.6402 | −1.1766 | 18.8590 | 0.1957 | 0.9368 | 1.5344 |
| **Model 65** | 0.0942 | 0.6452 | −0.2780 | — | — | — | — | — | −0.5195 | 1.6981 | 0.2738 | 2.2001 | 7.5879 | 12.1328 | 0.2625 | 0.8580 | 2.1378 |
| **Model 66** | −0.0355 | 1.4623 | −1.4287 | 0.0862 | −0.2520 | — | — | — | −0.7193 | 0.9947 | 0.1169 | 1.4667 | −6.1095 | 28.1006 | 0.1750 | 0.9569 | 1.2781 |
| **Model 67** | −0.0655 | 1.7608 | −1.8244 | −0.1110 | — | — | — | — | −0.7286 | 1.0894 | 0.1410 | 1.5588 | −6.7914 | 26.3985 | 0.1860 | 0.9495 | 1.3781 |
| **Model 68** | 0.0819 | 0.4927 | 0.3511 | −0.6792 | — | — | — | — | −0.6162 | 1.2514 | 0.1944 | 1.6487 | 1.0281 | 20.1185 | 0.1967 | 0.9311 | 1.5292 |
| **Model 69** | 0.1929 | 0.7049 | −0.3261 | — | — | — | — | — | −0.5355 | 1.8644 | 0.3502 | 2.3678 | 12.8561 | 11.5922 | 0.2825 | 0.8300 | 2.3064 |
| **Model 70** | 0.0610 | 0.7113 | −0.4013 | — | — | — | — | — | −0.4859 | 1.2336 | 0.1883 | 1.7231 | 2.9859 | 14.6762 | 0.2056 | 0.9183 | 1.6532 |
| **Model 71** | 0.2225 | 0.0772 | 0.0233 | — | — | — | — | — | −0.8220 | 2.2743 | 0.4137 | 2.8163 | 13.4948 | 15.2369 | 0.3360 | 0.7608 | 2.6937 |
| **Model 72** | 0.2315 | 0.6682 | −0.2845 | — | — | — | — | — | −0.6223 | 2.0872 | 0.4052 | 2.6144 | 15.5935 | 12.2362 | 0.3119 | 0.7875 | 2.5393 |
| **Model 73** | 0.2455 | −0.0317 | −0.0046 | — | — | — | — | — | −1.4474 | 2.0799 | 0.2208 | 2.5989 | −8.4034 | 29.2606 | 0.2766 | 0.8471 | 2.1585 |
| **Model 74** | −0.1155 | 0.4342 | −0.1919 | — | — | — | — | — | −0.5028 | 1.7314 | 0.2972 | 2.2296 | 9.4891 | 11.5580 | 0.2660 | 0.8521 | 2.1722 |
| **Model 75** | 0.2058 | 0.0624 | 0.0003 | — | — | — | — | — | −0.9114 | 2.2998 | 0.4161 | 2.8549 | 12.5033 | 16.8192 | 0.3406 | 0.7591 | 2.7055 |
| **Model 76** | 0.1910 | 0.6882 | −0.7897 | −0.0002 | — | — | — | — | −0.8293 | 1.6409 | 0.2911 | 2.1418 | 4.7685 | 20.9684 | 0.2555 | 0.8793 | 1.9748 |
| **Model 77** | 0.2058 | 0.0508 | 0.0014 | — | — | — | — | — | −0.7186 | 2.2013 | 0.4084 | 2.7176 | 13.1410 | 13.6903 | 0.3242 | 0.7608 | 2.6208 |
| **Model 78** | 0.1683 | 0.6779 | −0.7709 | 0.0006 | — | — | — | — | −0.8197 | 1.6161 | 0.2897 | 2.1076 | 4.2566 | 21.0785 | 0.2515 | 0.8804 | 1.9417 |
| **Model 79** | 0.2566 | 0.0017 | −0.0005 | — | — | — | — | — | −0.5462 | 2.1783 | 0.4212 | 2.7305 | 16.4630 | 10.1932 | 0.3258 | 0.7457 | 2.6753 |
| **Category III** | | | | | | | | | | | | | | | | | |
| **Model 80** | 0.8692 | −0.4812 | −0.4806 | 0.2297 | — | — | — | — | −0.6129 | 1.0535 | 0.1219 | 1.5513 | −2.1838 | 21.4724 | 0.1851 | 0.9486 | 1.4251 |
| **Model 81** | 1.0943 | −0.5076 | −0.4666 | 0.0009 | — | — | — | — | −0.5601 | 1.0063 | 0.1182 | 1.4674 | −2.3675 | 20.6178 | 0.1751 | 0.9486 | 1.3564 |
| **Model 82** | 1.1463 | −1.2503 | 0.0012 | 0.0007 | — | — | — | — | −0.8185 | 1.2435 | 0.1440 | 1.6690 | −4.3932 | 28.0955 | 0.1991 | 0.9510 | 1.4545 |
| **Model 83** | 0.4787 | −0.3145 | 0.0809 | 0.0007 | 0.0003 | — | — | — | 0.2170 | 1.5606 | 0.1831 | 2.1309 | 6.6926 | 4.4662 | 0.2268 | 0.8305 | 2.1198 |
| **Model 84** | 0.1915 | 0.6726 | −0.7774 | 0.0007 | −0.0003 | — | — | — | −0.7325 | 1.5823 | 0.2863 | 2.0645 | 5.2182 | 18.9486 | 0.2463 | 0.8811 | 1.9302 |
| **Category IV** | | | | | | | | | | | | | | | | | |
| **Model 85** | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **Model 86** | 1.0258 | −1.2400 | −0.0018 | 0.0007 | 0.2033 | — | — | — | −0.8221 | 1.2199 | 0.1405 | 1.6353 | −4.8436 | 29.0346 | 0.1951 | 0.9533 | 1.4137 |
| **Model 87** | 1.0258 | −1.2400 | 0.2033 | −0.0018 | 0.0007 | — | — | — | −0.8221 | 1.2199 | 0.1405 | 1.6353 | −4.8436 | 29.0346 | 0.1951 | 0.9533 | 1.4137 |
| **Model 88** | 1.0353 | −0.4594 | −0.4713 | 0.0001 | 0.0006 | — | — | — | −0.6738 | 1.0661 | 0.1212 | 1.5552 | −3.1594 | 23.9213 | 0.1849 | 0.9501 | 1.4016 |
| **Category V** | | | | | | | | | | | | | | | | | |
| **Model 89** | 1.0415 | −0.4807 | −0.4696 | 0.0010 | 0.0004 | — | — | — | −0.6082 | 1.0238 | 0.1185 | 1.4941 | −2.7948 | 22.2518 | 0.1783 | 0.9497 | 1.3647 |
| **Model 90** | 0.9573 | 0.0564 | 0.9706 | 0.9358 | −0.4795 | 0.0042 | 0.0010 | −0.4679 | −0.6112 | 0.9972 | 0.1139 | 1.4559 | −3.4332 | 23.0933 | 0.1737 | 0.9516 | 1.3214 |
| **Model 91** | 0.8181 | 0.0630 | 1.0432 | 0.7439 | −0.7011 | 0.0042 | 0.0015 | — | −0.5138 | 1.0008 | 0.1161 | 1.5010 | −2.7723 | 18.1918 | 0.1791 | 0.9384 | 1.4103 |
| **Model 92** | 1.0965 | 0.0396 | 0.8156 | 1.0923 | −1.2443 | 0.0027 | 0.0012 | — | −0.8176 | 1.1992 | 0.1373 | 1.6178 | −5.1061 | 29.2442 | 0.1930 | 0.9527 | 1.3960 |
| **Model 93** | 1.2030 | 0.0260 | 0.6738 | 0.7970 | −1.3016 | 0.0017 | — | — | −0.7181 | 1.1876 | 0.1396 | 1.6032 | −3.6222 | 25.0147 | 0.1913 | 0.9472 | 1.4333 |
| **Model 94** | 1.1307 | 0.0346 | 0.7732 | −0.0016 | −1.2357 | 0.0010 | — | — | −0.8352 | 1.2092 | 0.1381 | 1.6299 | −5.1989 | 29.7938 | 0.1945 | 0.9540 | 1.3997 |
| **Model 95** | 1.2110 | −0.0431 | 0.6629 | 3.1389 | −1.2926 | — | — | — | −0.7368 | 1.1941 | 0.1399 | 1.6120 | −3.7844 | 25.6597 | 0.1923 | 0.9484 | 1.4337 |
| **Model 96** | 0.6667 | −0.0305 | 2.0483 | −3.0322 | — | — | — | — | 0.4607 | 2.5528 | 0.3834 | 3.3318 | 10.9001 | 6.9711 | 0.3975 | 0.7124 | 3.2998 |
| **Model 97** | 1.2099 | 0.0253 | −0.3552 | −1.2998 | 0.0013 | — | — | — | −0.7203 | 1.1931 | 0.1406 | 1.6104 | −3.5796 | 24.9702 | 0.1921 | 0.9464 | 1.4404 |

## References


[1] Tao Q, Li Z, Zheng J, et al. Model of solar diffuse radiation transmission through circular perforated louvers and experimental verification. Energy Build 2017;142:49–55.
[2] Coma J, Perez G, Sole C, et al. New green facades as passive systems for energy savings on buildings[M]//Lentz A, Renne D. Energy Procedia. 2014:1851–9.
[3] Granqvist CG, Niklasson GA. Solar energy materials for thermal applications: A primer. Sol Energy Mater Sol Cells 2018;180:213–26.
[4] Ouria M, Sevinc H. Evaluation of the potential of solar energy utilization in Famagusta, Cyprus. Sustain Cities Soc 2018;37:189–202.
[5] Shukla K, Rangnekar S, Sudhakar K. Mathematical modeling of solar radiation incident on tilted surface for photovoltaic application at Bhopal, M.P, India. Int J Ambient Energy 2015;6(37):579–88.
[6] Shukla KN, Rangnekar S, Sudhakar K. Comparative study of isotropic and anisotropic sky models to estimate solar radiation incident on tilted surface: a case study for Bhopal, India. Energy Reports 2015;1:96–103.
[7] Li R, Ji G, Yang W, et al. The statistical characters of influencing factors of diffuse irradiance on the clear sky days in Dunhuang region. Plateau Meteorol 2004;01:116–22.
[8] Janjai S, Prathumsit J, Buntoung S, et al. Modeling the luminous efficacy of direct and diffuse solar radiation using information on cloud, aerosol and water vapor in the tropics. Renew Energy 2014;66:111–7.
[9] Misson L, Lunden M, McKay M, et al. Atmospheric aerosol light scattering and surface wetness influence the diurnal pattern of net ecosystem exchange in a semi-arid ponderosa pine plantation. Agric Forest Meteorol 2005;129(1-2):69–83.
[10] Jamil B, Akhtar N. Estimation of diffuse solar radiation in humid-subtropical climatic region of India: Comparison of diffuse fraction and diffusion coefficient models. Energy 2017;131:149–64.
[11] Jamil B, Siddiqui AT. Generalized models for estimation of diffuse solar radiation based on clearness index and sunshine duration in India: Applicability under different climatic zones. J Atmos Sol-Terrestr Phys 2017;157-158:16–34.
[12] Bailek N, Bouchouicha K, Al-Mostafa Z, et al. A new empirical model for forecasting the diffuse solar radiation over Sahara in the Algerian Big South. Renew Energy 2018;117:530–7.
[13] Charuchittipan D, Choosri P, Janjai S, et al. A semi-empirical model for estimating diffuse solar near infrared radiation in Thailand using ground- and satellite-based data for mapping applications. Renew Energy 2018;117:175–83.
[14] Mohammadi K, Shamshirband S, Petković D, et al. Determining the most important variables for diffuse solar radiation prediction using adaptive neuro-fuzzy methodology; case study: City of Kerman, Iran. Renew Sustain Energy Rev 2016;53:1570–9.
[15] Gopinathan KK, Soler A. Diffuse radiation models and monthly-average, daily, diffuse data for a wide latitude range. Energy 1995;20(7):657–67.
[16] Gutiérrez-Trashorras AJ, Villicaña-Ortiz E, Álvarez-Álvarez E, et al. Attenuation processes of solar radiation. Application to the quantification of direct and diffuse solar irradiances on horizontal surfaces in Mexico by means of an overall atmospheric transmittance. Renew Sustain Energy Rev 2018;81:93–106.
[17] Pandey CK, Katiyar AK. A comparative study to estimate daily diffuse solar radiation over India. Energy 2009;34(11):1792–6.
[18] Tapakis R, Michaelides S, Charalambides AG. Computations of diffuse fraction of global irradiance: Part 1 – analytical modelling. Sol Energy 2016;139:711–22.
[19] Boukelia TE, Mecibah M, Meriche IE. General models for estimation of the monthly mean daily diffuse solar radiation (Case study: Algeria). Energy Convers Manag 2014;81:211–9.
[20] Singh J, Bhattacharya BK, Kumar M, et al. Modelling monthly diffuse solar radiation fraction and its validity over the Indian sub-tropics. Int J Climatol 2013;33(1):77–86.
[21] El-Sebaii AA, Trabea AA. Estimation of horizontal diffuse solar radiation in Egypt. Energy Convers Manag 2003;44(15):2471–82.
[22] El-Sebaii AA, Al-Hazmi FS, Al-Ghamdi AA, et al. Global, direct and diffuse solar radiation on horizontal and tilted surfaces in Jeddah, Saudi Arabia. Appl Energy 2010;87(2):568–76.
[23] Bortolini M, Gamberi M, Graziani A, et al. Multi-location model for the estimation of the horizontal daily diffuse fraction of solar radiation in Europe. Energy Convers Manag 2013;67:208–16.
[24] Mubiru J, Banda EJKB. Performance of empirical correlations for predicting monthly mean daily diffuse solar radiation values at Kampala, Uganda. Theor Appl Climatol 2007;88(1-2):127–31.
[25] Khorasanizadeh H, Mohammadi K, Goudarzi N. Prediction of horizontal diffuse solar radiation using clearness index based empirical models; A case study. Int J Hydrog Energy 2016;41(47):21888–98.
[26] Munawwar S, Muneer T. Statistical approach to the proposition and validation of daily diffuse irradiation models. App Energy 2007;84(4):455–75.
[27] Shamshirband S, Mohammadi K, Khorasanizadeh H, et al. Estimating the diffuse solar radiation using a coupled support vector machine–wavelet transform model. Renew Sustain Energy Rev 2016;56:428–35.
[28] Kambezidis HD, Psiloglou BE, Karagiannis D, et al. Meteorological radiation model (MRMv6.1): improvements in diffuse radiation estimates and a new approach for implementation of cloud products. Renew Sustain Energy Rev 2017;74:616–37.
[29] Boland J, Ridley B, Brown B. Models of diffuse solar radiation. Renew Energy 2008;33(4):575–84.
[30] Jamil B, Akhtar N. Comparative analysis of diffuse solar radiation models based on sky-clearness index and sunshine period for humid-subtropical climatic region of India: a case study. Renew Sustain Energy Rev 2017;78:329–55.
[31] Sabzpooshani M, Mohammadi K. Establishing new empirical models for predicting monthly mean horizontal diffuse solar radiation in city of Isfahan, Iran. Energy 2014;69:571–7.
[32] Karakoti I, Pande B, Pandey K. Evaluation of different diffuse radiation models for Indian stations and predicting the best fit model. Renew Sustain Energy Rev 2011;15(5):2378–84.
[33] Engerer NA. Minute resolution estimates of the diffuse fraction of global irradiance for southeastern Australia. Sol Energy 2015;116:215–37.
[34] Bakirci K. Models for the estimation of diffuse solar radiation for typical cities in Turkey. Energy 2015;82:827–38.
[35] Karakoti I, Das PK, Singh SK. Predicting monthly mean daily diffuse radiation for India. Appl Energy 2012;91(1):412–25.
[36] Ruiz-Arias JA, Alsamamra H, Tovar-Pescador J, et al. Proposal of a regressive model for the hourly diffuse solar radiation under all sky conditions. Energy Convers Manag 2010;51(5):881–93.
[37] Paulescu E, Blaga R. Regression models for hourly diffuse solar radiation. Sol Energy 2016;125:111–24.
[38] Kocifaj M, Kómar L. Modeling diffuse irradiance under arbitrary and homogeneous skies: Comparison and validation. Appl Energy 2016;166:117–27.
[39] Badescu V, Gueymard CA, Cheval S, et al. Accuracy and sensitivity analysis for 54 models of computing hourly diffuse solar irradiation on clear sky. Theor Appl Climatol 2013;111(3-4):379–99.
[40] Despotovic M, Nedic V, Despotovic D, et al. Evaluation of empirical models for predicting monthly mean horizontal diffuse solar radiation. Renew Sustain Energy Rev 2016;56:246–60.
[41] Khatib T, Mohamed A, Sopian K. A review of solar energy modeling techniques. Renew Sustain Energy Rev 2012;16(5):2864–9.
[42] Magarreiro C, Brito MC, Soares PMM. Assessment of diffuse radiation models for cloudy atmospheric conditions in the Azores region. Sol Energy 2014;108:538–47.
[43] Khorasanizadeh H, Mohammadi K. Diffuse solar radiation on a horizontal surface: Reviewing and categorizing the empirical models. Renew Sustain Energy Rev 2016;53:338–62.
[44] Khalil SA, Shaffie AM. A comparative study of total, direct and diffuse solar irradiance by using different models on horizontal and inclined surfaces for Cairo, Egypt. Renew Sustain Energy Rev 2013;27:853–63.
[45] Aras H, Balli O, Hepbasli A. Estimating the horizontal diffuse solar radiation over the Central Anatolia Region of Turkey. Energy Convers Manag 2006;47(15-16):2240–9.
[46] Ulgen K, Hepbasli A. Diffuse solar radiation estimation models for Turkey's big cities. Energy Convers Manag 2009;50(1):149–56.
[47] Sanchez-Lorenzo A, Calbó J, Wild M. Global and diffuse solar radiation in Spain: building a homogeneous dataset and assessing their trends. Glob Planet Change 2013;100:343–52.
[48] Cotfas DT, Cotfas PA, Kaplani E, et al. Monthly average daily global and diffuse solar radiation based on sunshine duration and clearness index for Brasov, Romania. J Renew Sustain Energy 2014;6(5):507–20.
[49] Mellit A, Eleuch H, Benghanem M, et al. An adaptive model for predicting of global, direct and diffuse hourly solar irradiance. Energy Convers Manag 2010;51(4):771–82.
[50] Aler R, Galván IM, Ruiz-Arias JA, et al. Improving the separation of direct and diffuse solar radiation components using machine learning by gradient boosting. Sol Energy 2017;150:558–69.
[51] Lou S, Li DHW, Lam JC, et al. Prediction of diffuse solar irradiance using machine learning and multivariable regression. Appl Energy 2016;181:367–74.
[52] Alam S, Kaushik SC, Garg SN. Assessment of diffuse solar energy under general sky condition using artificial neural network. Appl Energy 2009;86(4):554–64.
[53] Mellit A, Eleuch H, Benghanem M, et al. An adaptive model for predicting of global, direct and diffuse hourly solar irradiance. Energy Convers Manag 2010;51(4):771–82.
[54] Soares J, Oliveira AP, Božnar MZ, et al. Modeling hourly diffuse solar-radiation in the city of São Paulo using a neural-network technique. Appl Energy 2004;79(2):201–14.
[55] Rensheng C, Ersi K, Jianping Y, et al. Estimation of horizontal diffuse solar radiation with measured daily data in China. Renew Energy 2004;29(5):717–26.
[56] Jiang Y. Prediction of monthly mean daily diffuse solar radiation using artificial neural networks and comparison with other empirical models. Energy Policy 2008;36(10):3833–7.
[57] Feng Y, Cui N, Zhang Q, et al. Comparison of artificial intelligence and empirical models for estimation of daily diffuse solar radiation in North China Plain. Int J Hydrog Energy 2017;42(21):14418–28.
[58] Cao F, Li H, Yang T, et al. Evaluation of diffuse solar radiation models in Northern China: New model establishment and radiation sources comparison. Renew Energy 2017;103:708–20.
[59] Li H, Bu X, Long Z, et al. Calculating the diffuse solar radiation in regions without solar radiation measurements. Energy 2012;44(1):611–5.
[60] Li H, Ma W, Wang X, et al. Estimating monthly average daily diffuse solar radiation with multiple predictors: a case study. Renew Energy 2011;36(7):1944–8.
[61] Tapakis R, Michaelides S, Charalambides AG. Computations of diffuse fraction of global irradiance: Part 1 – analytical modelling. Sol Energy 2016;139:711–22.
[62] Wang L, Kisi O, Zounemat-Kermani M, et al. Solar radiation prediction using different techniques: model evaluation and comparison. Renew Sustain Energy Rev

2016;61:384–97.
[63] Geiger M, Diabaté L, Ménard L, et al. A web service for controlling the quality of measurements of global solar irradiation. Sol Energy 2002;73(6):475–80.
[64] Despotovic M, Nedic V, Despotovic D, et al. Evaluation of empirical models for predicting monthly mean horizontal diffuse solar radiation. Renew Sustain Energy Rev 2016;56:246–60.
[65] Cao F, Li H, Yang T, et al. Evaluation of diffuse solar radiation models in Northern China: New model establishment and radiation sources comparison. Renew Energy 2017;103:708–20.
[66] Jiang Y. Estimation of monthly mean daily diffuse radiation in China. Appl Energy 2009;86(9):1458–64.
[67] Feng L, Lin A, Wang L, Qin W, Gong W. Evaluation of sunshine-based models for predicting diffuse solar radiation in China. Renew Sustain Energy Rev 2018;94:168–82.