Atmospheric environmental changes and a multi-objective optimization model for energy conservation and environmental protection based on improved multi-population genetic algorithm

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Abstract
With the development of computer technology and theory, cloud computing technology suitable for modern computing and large-capacity storage has emerged. Cloud computing technology depends on the Internet. The advancement and development of virtualization technologies such as cloud computing technology is the most cited of current computer technologies. With the development of cloud computing technology, this paper proposes a multi-group genetic algorithm based on interactive multi-functional processing methods, which can achieve the expectation of reducing the energy consumption of the cloud computing center to the greatest extent and at the same time ensure the stability and the running state of the server effectiveness. Through this survey, while reducing the company’s operating costs, it will also contribute to energy conservation and environmental protection. Multi-group genetic algorithms can effectively overcome the shortcomings of standard genetic algorithms, such as optimization range and efficiency, number of iterations, and premature end of iteration. The optimized result can reflect the subjective will of the decision-maker. Experimental examples show the efficiency of the algorithm, and the results show the applicability and feasibility of the algorithm. Based on the changes in the global atmospheric environment in recent years, this article discusses the reasons for the changes and focuses on the impact of human activities. In addition, the environmental issues that have received much attention today are the clues to discuss the climate issues and the harmful effects brought about by changes in the atmospheric environment, which has aroused people’s attention to energy conservation and environmental protection.

Keywords Changes in atmospheric environment · Improved multi-population genetic algorithm · Energy saving and environmental protection · Multi-objective optimization model

Introduction
Cloud computing technology is a new type of computer technology that has emerged in recent years. Its essence is to provide the remaining computing power connected to the computer through the network on demand (Esau et al. 2013). Through cloud computing technology, the remaining computing capacity widely available on the network has also become a commercial resource (Gadgil 2003). In particular, the core of the concept of cloud computing technology is to maximize the use of remaining computing resources that are widely available on the network in order to protect the environment and achieve the purpose of green computing (Chen and Chen 2014). However, according to relevant data, the total energy consumption of the cloud computing center has reached an astonishing level (Mann and Jones 2003). The power consumption of cloud computing centers in North America accounts for more than one-fifth of the total power consumption (Godfrey et al. 2009; Hansen et al. 2010). Large Internet companies are rapidly expanding their cloud computing business. The energy supply of a large number of new data centers is obtained from fossil fuels. Indirectly caused a lot of carbon emissions. For example, data centers in North America are expected to consume 2 megawatt-hours of electricity in the next 10 years (Azam et al. 2018). Genetic algorithm (GA) is a parallel computing optimization algorithm that simulates the evolution of life. For
problems that require global optimization and are difficult to analyze and process functions, GA’s probabilistic process has excellent ductility (Bansod 2005; Naidu et al. 2009). In the solution space suitable for large-scale discrete solutions and calculations, it can search for the global best solution to nonlinear problems more widely (Inman and Jeffrey 2006; Yadav 2009). By introducing a variety of genetic algorithms, the global search range is improved, the search speed is accelerated, and the search efficiency is improved (Alexeev et al. 2011). At the same time, this article uses an interactive multi-function processing method, sets a comprehensive evaluation function, and converts the multi-function into a single-purpose function for calculation (Jain et al. 2013; Zeng et al. 2007). Today, the global environment is deteriorating day by day, and all environmental crises surrounding the entire planet are taking place. As a sector of the earth’s environment, the atmospheric environment plays an extremely important role in the entire earth’s ecosystem. However, after hundreds of millions of years of changes and human activities, the atmospheric environment of our earth system has undergone tremendous changes, causing various problems (Alfarra et al. 2011). After a rough data survey and seeing these shocking data, it is not difficult for us to imagine what kind of deep and hot the earth will be in a few decades later, so we should also know that the environmental protection of the atmosphere is urgent from now on.

Materials and methods

Data source

Data comes from long-term meteorological observations data and daily average data (including total) of ground solar radiation observations of Beijing, Tianjin, Shandong, Henan, Xinjiang Uygur Autonomous Region, Qinghai and Tibet Autonomous Region of China. Selective radiation, diffuse radiation, and sunshine Time, wind speed, relative humidity, and total cloud cover, low cloud cover, where relative humidity is the average relative humidity data using interpolation. The data used to calculate the 1-month average comes from the China Meteorological Data Service Sharing Network (Rodionov and Overland 2005, Trenberth 2011). The average relative error of the observation data is 0.5%, which can meet the needs of climate analysis. According to the “Meteorological Radiation Observation Method” summarized by the China Meteorological Administration in 1996, data are strictly monitored. Due to the limitation of the consistency of the radiation data station and the data, 20 medium-sized cities representing large and small cities with continuous time series in eastern and western China were selected for analysis.

In order to emphasize changes in the atmospheric environment, the turbidity coefficient is used to reflect the changes in aerosols. The turbidity of the atmosphere is expressed by the ratio of scattered radiation and direct radiation (turbidity coefficient).

\[ \alpha = \frac{D}{S} \]  

(1)

The same turbidity coefficient depends on the aerosol content in the atmosphere. If the atmosphere is very clean, the D/S value will decrease, and if the atmosphere is clouds, it will increase.

Research methods of atmospheric environmental changes

Linear regression method

The linear method is used to analyze the evolution of climate time. In order to investigate the change trend of the total radiation on the surface, the linear tendency inference method is used to establish the linear regression equation of radiation \( y \) and time series \( x \) years. The coefficient is the trend rate and can be calculated by the least square method. \( b > 0 \) and \( b < 0 \) indicate that the radiation increases and decreases with time, respectively. \( \alpha = 0 \) indicates that there is no change.

Correlation analysis

The correlation between meteorological elements is measured by calculating the equivalent correlation number between two groups of meteorological elements. For the two sets of meteorological elements \( X_1, X_2, \ldots, X_n \) and \( Y_1, Y_2, \ldots, Y_n \), the calculation formula of the correlation coefficient is as follows:

\[ r = \frac{\sum_{i=1}^{n} (X_i - \overline{X})^2 (Y_i - \overline{Y})^2}{\sqrt{\sum_{i=1}^{n} (X_i - \overline{X})^2} \sqrt{\sum_{i=1}^{n} (Y_i - \overline{Y})^2}} \]  

(2)

The correlation coefficient ranges from \(-1.0 \) to \(+1.0 \). If \( r > 0 \) indicates that there is a positive correlation between two variables, the closer they are to \( 1.0 \), the more important the positive correlation is. \( r < 0 \) indicates that there is a negative correlation between the two variables. The closer they are to \(-1.0 \), the more important the negative correlation. \( r = 0 \) means that the two variables are independent of each other. Whether the calculated correlation coefficient is meaningful or not needs to be validated.

Improved multi-population genetic algorithm

This paper uses an improved multi-group genetic algorithm to solve the economic load dispersion problem of the power system. Through improvement, the multi-group genetic algorithm can optimize the retrieval of multiple groups at the same time,
provide different parameters for each group, and realize different retrievals. Multi-population genetic algorithm not only breaks the traditional genetic algorithm’s single-group genetic evolution idea, but also can find the best solution in a wider solution space to achieve progress and good convergence (Fig 1).

**Based on interactive multi-objective optimization model design**

**Multi-objective optimization model**

The mathematical model of the multi-objective optimization problem is expressed as follows:

\[
\begin{align*}
\text{min} & \quad F(x) = \min \{ f_1(x), f_2(x), f_3(x), \ldots \} \\
\text{s.t.} & \quad g_j(x) \leq 0 \quad (j = 1, 2, \ldots, p) \\
& \quad h_k(x) = 0 \quad (k = 1, 2, \ldots, q)
\end{align*}
\]  

(3)

Here \( x \) is the decision vector. \( X \) determines the constraint set of the vector. \( f(x) \) is the purpose function of welfare and health care. \( g(x) \) is the purpose function of the cost type. Here, \( p=1,2, \ldots, m, q=1,2,\ldots,n, m, n \) are the number of profitability objective function and cost objective function, respectively.

**Interactive multi-objective optimization method**

The interactive multi-objective optimization method completely reflects the subjective needs of decision-makers and can adjust each objective function well. Therefore, this paper adopts interactive multi-objective optimization to avoid any problem of choosing weight coefficients and reduce the cost from multi-function to single-purpose.

Consider the following multi-objective optimization problem:

\[
\begin{align*}
\max & \quad \mu(x) \\
\text{s.t.} & \quad x \in X
\end{align*}
\]  

where

\[
\begin{align*}
\mu(f_p(x)) = \frac{g_p(x) - \min g_p(x)}{\max g_p(x) - \min g_p(x)}
\mu(g_q(x)) = \frac{f_q(x) - \min f_q(x)}{\max f_q(x) - \min f_q(x)}
\end{align*}
\]  

(5)

\[
\begin{align*}
\max & \quad \mu_f(x) = (\mu(f_1(x)), \mu(f_2(x)), \ldots, \mu(f_n(x))) \\
\min & \quad \mu_g(x) = (\mu(g_1(x)), \mu(g_2(x)), \ldots, \mu(g_n(x)))
\end{align*}
\]  

(4)

Here \( x \) is the decision vector. \( X \) determines the constraint set of the vector. \( f(x) \) is the purpose function of welfare and health care. \( g(x) \) is the purpose function of the cost type. Here, \( p=1,2, \ldots, m, q=1,2,\ldots,n, m, n \) are the number of profitability objective function and cost objective function, respectively.

**Single objective satisfaction function**

In order to facilitate the comparison, we deal with each target function and number accordingly. Let \( \max \mu_f(x) \) and \( \min \mu_f(x) \) be the optimal solution and worst solution of \( f(x) \) on the constraint set \( X ; \max \mu_g(x) \) and \( \min \mu_g(x) \) are \( g(x) \), respectively. The worst solution and optimal solution in the constraint set. Remember

\[
\begin{align*}
\mu_f(x) = \frac{\mu_f(x) - \min \mu_f(x)}{\max \mu_f(x) - \min \mu_f(x)}
\mu_g(x) = \frac{\mu_g(x) - \min \mu_g(x)}{\max \mu_g(x) - \min \mu_g(x)}
\end{align*}
\]  

(5)

\[
\begin{align*}
\max & \quad \mu(x) \\
\text{s.t} & \quad x \in X
\end{align*}
\]  

(6)

Fig. 1 Schematic diagram of the structure of multi-population genetic algorithm
\[ \mu(x) = \left\{ \mu^*(f_1(x)), \mu^*(f_2(x)), \ldots, \mu^*(f_m(x)) \right\}^T, \]

which is the comprehensive objective function.

### Overall coordination degree evaluation function

The purpose of seeking the optimal solution for a multi-objective optimization problem is to obtain an ideal solution that satisfies each objective function. However, each goal has contradictions, so it is difficult to find a solution that meets all the conditions, and the calculation results need to be compromised. Therefore, in order to obtain a satisfactory solution to the multi-purpose problem as a whole, it is necessary to construct a global evaluation function that can adjust each target value. \( \mu^*(f_p(x)) \) and \( \mu^*(g_q(x)) \), respectively, represent the ideal value of the satisfaction of each objective function. When the above method is used, the ideal value is 1. If the decision vector value is found in the constraint set, the corresponding comprehensive objective function value is \( \mu(x^*) \), which is the closest to the ideal target point in this sense. Therefore, the overall adjustment degree evaluation function can be selected as follows:

\[ d(x) = \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} \left( \mu^*(f_i(x)) - f_i(x) \right)^2 + \left( \mu^*(g_j(x)) - g_j(x) \right)^2} \]

(8)

Here, \( d(x) \) is called the overall adjustment degree evaluation function.

Through calculation, the original multi-purpose problem is converted into a single-purpose problem, and the process is optimized, so the best solution can be found quickly.

### Results

**Analysis of changes in the atmospheric environment throughout China**

**Analysis of ground solar radiation changes and influencing factors in the eastern region**

It can be seen from Fig. 2 that the total insolation of all observatories showed a decreasing trend from 1960 to 2011. This article selected 6 meteorological observatories in the eastern

|                | 1961–1970 | 1971–1980 | 1981–1990 | 1991–2000 | 2001–2011 |
|----------------|-----------|-----------|-----------|-----------|-----------|
| Beijing        | −22.69*** | −25.21    | −75.81*** | −60.34*   | 26.09*    | 23.47     |
| Tianjin        | −14.92*** | −21.80    | −29.86    | −23.29    | −29.2     | −8.06     |
| Jinan          | −13.58*** | −1.30     | −0.13     | −68.74*   | 9.76      | 50.83*    |
| Nanjing        | −6.34**   | −27.78    | −38.36    | −1.56     | −2.53     | 5.15      |
| Gushi          | −20.39*** | −37.92    | −10.24    | 18.35     | −58.25    | −24.98    |
| Zhengzhou      | −6.94**   | −86.5*    | 89.15*    | −17.69    | −28.59    | 0.78      |

*** means \( P < 0.001 \); >** means \( P < 0.01 \); * means \( P < 0.05 \)

Fig. 2  Interannual variation trend of total ground solar radiation in various regions of eastern China
region (Beijing, Tianjin, Jinan, Nanjing, Gushi, Zhengzhou). The annual variation of the total surface sunlight of each observatory is different. From 1961 to 2011, the annual average total surface sunshine in the eastern region was 4910.83MJ/m² (Table 1). During the 52 years from 1961 to 2011, the total surface sunshine in the 6 regions showed a decreasing trend, with Beijing decreasing the most (−22.69MJ/(m²·10a)). Then Beijing, Tianjin, Jinan, and Gushi passed. 0.001 effective level verification (** means P<0.001, 0.01 effective level verification (** means P<0.01; * means P<0.05). From 1981 to 1990, the annual average total surface sunshine in the eastern region was 4910.83mj/m2 (Table 1). During the 52 years from 1961 to 2011, the total surface sunshine in the eastern region (Beijing, Tianjin, Jinan, Nanjing, Gushi, Zhengzhou) showed a decreasing trend, with Beijing decreasing the most (−22.69MJ/(m²·10a)). Then Beijing, Tianjin, Jinan, and Gushi passed. 0.001 effective level verification (** means P<0.001, 0.01 effective level verification (** means P<0.01; * means P<0.05). From 1991 to 2000, Beijing had the largest total sunshine amount. Jinan’s sunshine is close behind.

The climate linear trend rate of the total ground solar radiation changes at various stations in eastern China is shown in Table 1.

The relationship between the amount of surface sunshine and climatic factors. Table 2 shows the correlation coefficients between total surface solar radiation and turbidity, sunshine rate, wind speed, low cloud cover, and total cloud cover in the eastern region. The turbidity coefficients of Beijing, Tianjin, Jinan, and Nanjing are negatively correlated with the amount of surface sunshine. Except for Beijing and Dinan, there is no relationship between relative humidity and the amount of sunlight on the ground. Correlation analysis of low cloud cover, total cloud cover, total surface insolation decreased from 1961 to 1970. The difference is that Zhengzhou showed the largest reduction range (P<0.05). From 1971 to 1980, the total surface sunshine in Beijing decreased the most (P<0.001), but the surface sunshine in Zhengzhou showed an increasing trend (P<0.001, 0.05). From 1981 to 1990, the changes in the amount of surface sunshine varied from station to station, with Zhengzhou having the largest reduction rate, followed by Jinan (P<0.05). From 1991 to 2000, Beijing had the largest total sunshine amount. Jinan’s sunshine is close behind.

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and total surface insolation shows that there is no relationship between total cloud cover and total surface insolation. There is a significant negative correlation between the low cloud cover in Beijing and Zhengzhou and the sunlight on the entire surface ($P<0.01$ and $P<0.05$). There is no obvious negative correlation between low cloud cover and total sunshine.

**Table 4** Correlation coefficients between total ground solar radiation and various meteorological elements in various regions of western China

| Region  | Turbidity | Percentage of sunshine | Wind speed | Low cloud cover | Total cloud cover |
|---------|-----------|-------------------------|------------|-----------------|-------------------|
| Urumqi  | −0.414**  | 0.553**                 | 0.223      | 0.173           | 0.11              |
| Turpan  | −0.162    | 0.688**                 | 0.626**    | −0.043          | −0.297*           |
| Hami    | −0.091    | 0.086                   | 0.499**    | −0.18           | 0.362**           |
| Hotan   | 0.011     | 0.409**                 | 0.182      | −0.357*         | −0.367*           |
| Altay   | −0.167    | −0.092                  | −0.219     | 0.168           | 0.084             |
| Yining  | −0.411*   | −0.104                  | 0.199      | 0.021           | −0.192            |
| Golmud  | 0.036     | 0.379**                 | 0.556**    | 0.004           | −0.442**          |
| Xining  | −0.584**  | 0.525**                 | 0.500**    | −0.441**        | 0.287*            |
| Yushu   | 0.17      | 0.207                   | −0.223     | −0.171          | −0.082            |
| Lhasa   | −0.406**  | 0.092                   | 0.243      | 0.057           | −0.414**          |
| Nagqu   | 0.329     | −0.161                  | 0.001      | −0.285*         | 0.362**           |
| Qamdo   | 0.286     | −0.121                  | 0.241      | 0.310*          | −0.061            |
| Gere    | 0.949**   | −0.125                  | 0.005      | −0.137          | −0.02             |

*** means $P<0.001$; ** means $P<0.01$; * means $P<0.05$
Analysis of ground solar radiation changes and influencing factors in the western region

Figure 2 shows the historical trend of total surface sunshine in various regions of western China. It can be seen from Fig. 2 that the total insolation of Lhasa, Xining, and Urumqi showed a tendency to decrease significantly ($P<0.05$). In Kashgar, Turpan, Lhasa, and Urumqi, the total surface sunshine amount showed a low value around 1990 and then showed a tendency to increase. Yining, Golmud, and Xining’s full-surface sunlight seemed to be very low around 1980 and then showed a tendency to increase. Altai’s full sunshine was very low around 2000, and Yushu’s sunshine was very low around 2010. Generally speaking, from 1961 to 2011, the total sunlight in western China showed a tendency to decrease before and after the 1990s. After 1990, it showed an upward trend.

From 1961 to 2011, the total surface sunshine in western China was 6058.12MJ/m$^2$. As shown in Table 3, from 1961 to 2011, the 14 sites of surface sunshine decreased, and the meaningful level test was 11 sites. From 1961 to 1970, Kashgar’s surface sunshine was greatly reduced, and the other parts of the surface sunshine decreased. From 1971 to 1980, the total surface sunshine of 14 stations showed a decreasing trend. Yushu had the largest decrease rate and the largest increase in intensity. From 1981 to 1990, Golmud’s total sunshine amount decreased the most, followed by Kashgar. From 1991 to 2000, the amount of sunlight on the entire surface showed an increasing trend in most areas, and the scope of increase was different. From 2001 to 2011, the amount of sunlight on the entire surface showed a decreasing trend in most areas (Fig. 3).

The climate linear trend rate of total ground solar radiation at various sites in western China is shown in Table 3.

Comparative analysis of the change trend and influencing factors of the total solar radiation on the ground in the east and west of China

Figure 4 shows the historical trend of total insolation in various observatories in eastern and western China. The total surface sunshine in eastern and western China is the lower value observed around 1990. In the past 50 years, the total insolation in the eastern region has fluctuated more than that in the western region, and the total insolation in the eastern region has fluctuated more than that in the western region. The changes in the amount of sunlight in the east and the west are different.

Table 5 The climate linear tendency rate of the total ground solar radiation in the eastern and western regions of China (unit: MJ m$^{-2}$ (10a)$^{-1}$)

| Region | 1961–1970 | 1971–1980 | 1981–1990 | 1991–2000 | 2001–2011 |
|--------|------------|------------|------------|------------|------------|
| East   | −14.96***  | −33.42     | −27.80     | −26.26     | −14.98     | 10.36      |
| West   | −10.50***  | −0.42      | −27.87**   | −47.82***  | 47.00       | −11.36*    |

*** means $P<0.001$; ** means $P<0.01$; * means $P<0.05$
The range of changes in the total sunlight in the western region became larger in the 1990s. Therefore, the solar energy resources in the western region are abundant and can be reasonably developed and utilized.

The changing tendency of the total solar radiation on the earth’s surface is different in the east and west of China. It can be seen from Table 5 that the total surface sunshine in the east and west showed a significant decrease from 1961 to 2011 ($P<0.001$), and the decrease was greater in the east than in the west. In the 1960s, the total surface sunshine in the east and west showed a decreasing trend. In the 1970s and 1980s, the trend of total sunshine reduction in the eastern region was weaker than that in the 1960s and 1970s, but the trend of total sunshine reduction in the western region was greatly reduced. In 1990, the total surface sunshine in western China increased. After 1990, the total surface sunshine in the eastern region showed an increasing trend, and the whole surface sunshine in the western region tended to decrease significantly ($P<0.001$).

The climate linear trend rate of total ground solar radiation in the eastern and western regions of China is shown in Table 5.

Daylight is the most direct sign of sunlight, and the decrease in the proportion of sunlight reflects the decrease in sunlight. The changing tendency of sunshine hours in eastern China is similar to the changing tendency of the total sunshine amount on the ground, but the reduction range is different. The reduction range of sunshine hours in western China is smaller than the reduction range of full sunshine on the ground. Before 1980, the range of sunshine duration was very small, and the total sunshine amount on the ground tended to decrease drastically. In western China, from 1980 to 1990, the duration of sunshine and the amount of total sunshine on the ground tended to decrease significantly. After 1990, the duration of sunshine and the amount of sunshine on the whole surface showed a tendency to increase slowly. It can be seen from Table 6 that there was a significant positive correlation between the amount of sunshine and total insolation in eastern China ($P<0.01$). In western China, there is a significant relationship between the solar radiation rate and the total surface solar radiation in the 1960s and 1980s.

It can be concluded that the main reason for the decrease in sunlight in the eastern region is the sunlight rate, and the sunlight rate in the western region will also affect the ground sunlight. When there is no relationship or almost no relationship between total ground radiation and total cloud cover or low cloud cover, air pollution and pollution from other factors will become the main factors affecting the sunshine rate (Fig 5).

The relationship between the amount of surface sunshine and climatic factors in the eastern and western regions. There are many factors that affect the reduction of the total solar radiation on the ground. Analyze the next cause of low cloud cover, total cloud cover, wind speed, turbidity, and sunshine rate. It can be seen from Table 7 that the turbidity in the east and west has a significant negative correlation with total

![Fig. 5](https://example.com/fig5.png) The relationship between the sunshine hours in east and west China and the total solar radiation on the ground from 1961 to 2011

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**Table 6** Correlation coefficient between total solar radiation and sunshine percentage in eastern and western regions

|               | 1961–1970 | 1971–1980 | 1981–1990 | 1991–2000 | 2001–2011 |
|---------------|-----------|-----------|-----------|-----------|-----------|
| East          | 0.851**   | 0.919**   | 0.772**   | 0.842**   | 0.845**   |
| West          | 0.348*    | 0.713*    | 0.198     | 0.704*    | 0.195     | −0.563    |

** means $P<0.01$; * means $P<0.05$
insolation \((P<0.01)\), and the correlation coefficient \((6.99/10a)\) between atmospheric turbidity and total insolation in the east is much larger than that in the west region \((3.66/10a)\). In eastern and western China, there is a significant positive correlation between wind speed and solar radiation \((P<0.01)\), and the correlation coefficient is very large. The proportion of sunshine in the eastern and western regions. The proportion coefficient \((0.851, P<0.01)\) between the sunshine rate and total sunshine in eastern China is much larger than the correlation coefficient in western China \((0.348, P<0.05)\). In the eastern and western regions, there is no relationship between total cloud cover, low cloud cover, relative humidity, and total sunshine.

**Changes in the spatial distribution of haze in a certain place**

Figures 6, 7, 8, and 9 show the spatial distribution of cavitation days in southern Jiangsu Province every 10 years. From this graph, we can see the distribution of high occurrence points and average days every 10 years. From 1980 to 1989, Yangzhou, Taicang, and Zhangjiagang became the three high-value regional centers of 67.7%, 63.8%, and 45.1%, respectively (Fig. 6).

From 1990 to 1999, Yangzhou reached the highest level of 84 days, Wuxi, Yixing, Suzhou, and Dongshan reached 50 days, and Taicang reached 69 days. However, Jindan, Yixing, Wuxi, Suzhou, Dongshan, etc. have become areas with higher prices. Changzhou on 11.2 days and Jiangyin on 15.4 days formed areas with significantly lower prices. Danu became areas with lower prices on the 24th and 25th, and Changshu and Kunshan also became areas with lower prices on the 30th and 28th (Fig. 7).

From 2000 to 2009, Dongshan ranked first in 74 days, Wuxi, Changzhou, and Zhangjiagang lasted more than 50 days, and in Kunshan, it was 45 days (Fig. 8).

The highest values from 2010 to 2013 were 95 days in Wuxi, 90 days in Dongshan, 80 days in Yangzhou, and 79 days in Changzhou (Fig. 9).

### Example calculation and analysis of energy saving and environmental protection multi-objective optimization model

**Calculation process based on interactive multi-population genetic algorithm**

1) Read the original data.
2) Initialize the population sample and calculate the target relationship value in the initial population. Use the PQ unconnected method to calculate to obtain the node voltage, power, shunt power, and other parameters.
3) Use operators to exchange information between groups, and use manual selection operators to select, crossover, and mutation operations of genetic algorithms for multiple groups such as the genetic process of personal new

| Turbidity | Percentage of sunshine | Wind speed | Relative humidity | Low cloud cover | Total cloud cover |
|-----------|------------------------|------------|-------------------|-----------------|------------------|
| East      | 0.699**                | 0.851**    | 0.680**           | 0.051           | 0.047            | 0.083            |
| West      | 0.366*                 | 0.348*     | 0.720**           | −0.070          | 0.213            | −0.019           |

**Table 7** Correlation coefficients of total ground solar radiation and various meteorological elements in eastern and western regions

**Fig. 6** Spatial distribution of average haze days from 1980 to 1989
tendencies. Each variable does not exceed the boundary, and input the best Save the overall, node voltage, power, shunt current, and other data.

4) When the variable is out of range, the control variable is out of range, and operations such as modification are performed to detect the best individual in the elite population.

5) Calculate the adaptability value.

6) Determine whether the best individual reaches the best storage algebra. If not, the genetic mutation process will be re-entered.

7) When the best individual reaches the best preservation algebra, the optimization search process ends, and the output process is the change of the best solution.

Case analysis

This article uses an interactive multi-population genetic algorithm to select the IEEE 3-node standard example (power system with 6 generating sets) for calculation and analysis. Table 8 shows the allowable effective power output limit and power generation cost characteristic coefficient of each power generation unit of the system.

The 24-h load duration is shown in Table 9.

Analysis of simulation results

1) According to the above analysis, the extreme value of each single target in a single period is obtained for the first time. The results are shown in Table 10.

2) Regardless of the emission of pollutant gas, the consumption cost is controlled to a minimum, and the improved multi-population genetic algorithm is used to solve the model. The optimization results for 24 periods are shown in Table 11.

3) Considering a 24-h optimal gas emission model, if only a 24-h optimal calculation result is considered (Table 12).
4) Considering the two purposes of consumption cost and pollutant emission control comprehensively, the interactive improved multi-population genetic algorithm is used to calculate. The optimization results are shown in Table 13.

5) Using the improved multi-group genetic algorithm, the two purposes of consumption cost and pollutant emission control in 24 periods were studied respectively. In order to obtain the optimization results of consumption cost and pollutant emission in each period, the two purposes were comprehensively considered, as shown in Fig. 10 and Fig. 11.

The optimization results of the minimum emissions are shown in Table 12.

Figure 10 shows the optimization of consumption cost in each period.

6) The calculation of interactively improved multi-group genetic algorithm. In order to perform interactive multi-function calculations based on the evaluation function, the evolution process of the algorithm is shown in Fig. 11. When the two objectives are comprehensively considered in one cycle.

As shown in Table 14, simply pursuing the minimum consumption cost means achieving a single goal and achieving the minimum 1. The consumption cost is only 102,734.6 US dollars, and the economic benefits are considerable. The pollutant gas emissions are 13,190.12 kg, and the satisfaction level is only 0.55627. According to Table 12, if only the best emissions are pursued, consumption costs will increase. It can be seen from Table 13 that after adjusting and optimizing the two goals, the satisfaction value will reach 0.6881, and the consumption cost and emissions obtained when purely pursuing the optimization of a single goal will be in the middle respectively. The adjustment of the two is close to the satisfaction of the decision-maker’s subjective intentions. From the process of single-purpose optimization and dual-purpose adjustment optimization in Figs. 10 and 11, it can be seen that the consumption cost and emission target value under the overall adjustment of the two purposes are obtained by simply pursuing consumption cost and single-purpose optimization, respectively. Emissions. The overall adjustment of the evaluation function can achieve the goal, that is, adjust the overall balance between the individual goals, and ultimately seek the compromise of various interests.

Table 8 Generator set parameters

| Unit parameter | G1   | G2   | G3   | G4   | G5   | G6   |
|----------------|------|------|------|------|------|------|
| $P_{min}$     | 10   | 10   | 35   | 35   | 130  | 125  |
| $P_{max}$     | 125  | 150  | 225  | 210  | 325  | 315  |
| $a_i$         | 0.152| 0.106| 0.028| 0.035| 0.021| 0.018|
| $b_i$         | 38.54| 46.16| 40.40| 38.31| 36.33| 38.27|
| $c_i$         | 756.8| 451.3| 1050.0| 1243.5| 1658.6| 1356.7|
| $\alpha_i$    | 13.86| 13.86| 40.27| 40.27| 42.90| 42.90|
| $\beta_i$     | 0.328| 0.328| -0.546| -0.546| -0.511| -0.511|
| $\gamma_i$    | 0.0042| 0.0042| 0.0068| 0.0068| 0.0046| 0.0046|
From the comparison of the convergence process of the best solution in Fig. 12 and Fig. 13, it can be seen that in the evolution process of the algorithm, the iteration time of the improved multi-group genetic algorithm is greatly shortened and can converge.

### Discussion

#### Sources, hazards, and control measures of major air pollutants

**Sulfur dioxide**

1. **Source:** There are two main sources of sulfur dioxide pollution, natural factors and human activities (Kothawale and Rajeevan 2017). Among them, the sulfur dioxide pollutants caused by natural factors are mainly sulfur dioxide produced by mountain fires, volcanic eruptions, and bacterial decomposition of organic matter, as well as sulfates released from the soil. Sulfur dioxide produced by natural factors has the characteristics of wide distribution, low concentration, and easy dilution and refinement by the atmosphere, which is difficult for humans to control. Human activities are the main cause of the emission of sulfur dioxide pollutants in the atmosphere (Keevallik 2011). The emission of sulfur dioxide pollution sources is relatively concentrated in the periphery of cities and industrial zones, the main cause of acid rain. Therefore, effective control can be performed from the source.

2. **Hazard:** Sulfur dioxide is more harmful and affects human health. It will not only cause various respiratory diseases, but also have an important impact on the ecological environment. If it accumulates to a certain extent, it will produce acid rain, which will have a strong corrosive and destructive effect on the building.

3. **Prevention and management:** The source of sulfur dioxide is mainly caused by human activities, but the specific source is more complicated. As an energy-consuming city in western China, it must first actively change the energy consumption structure and actively promote the production and utilization of clean energy. Third, it is necessary to actively improve production capacity and conduct large-scale inspections of equipment and processes in relatively concentrated industrial areas in the city. In order to reduce external emissions, a good sulfur recovery rate and utilization rate must be achieved in the production process.

**Nitrogen oxides**

1. **Source:** The nitrogen oxides produced in the process of urban air pollution mainly come from three aspects (industrial pollution, household pollution, and traffic pollution).

2. **Hazard:** Nitric oxide and nitrogen dioxide are the most harmful to the human body and may cause human diseases. In addition, nitrogen oxides and hydrocarbons in the atmosphere will produce photochemical reactions under sunlight, producing highly active free radicals, aldehydes, ketones, and other pollutants, forming photochemical smog. This kind of smoke is very harmful to the human body. They can move hundreds of kilometers with air currents, which can bring chaos to people’s lives.

3. **Prevention and management:** Full consideration should be given to the city’s development planning, the city’s industrial development layout, and industrial structure, and a common prevention and management force should be formed to achieve practical results. Second, speed up the phased abolition of old cars such as cars with yellow labels, actively raise fuel standards, promote the use of clean cars and public transportation, and encourage people to travel in an environmentally friendly manner.

**Inhalable particulate matter**

1. **Source:** In recent years, China’s air pollution has become more and more serious, and human inhalable particulate matter has become one of the main pollutants in Beijing, Tianjin, Hebei, and other cities (Kripalani et al. 2003). As long as pollution sources are involved, it can be divided into natural factors and human activities (Kumar et al. 2010). The main natural origins are dust, sandstorms, etc. Human activity factors are mainly reflected in urban construction, material transportation, various soot, splash ash, construction dust, lead halide condensed particulate matter, automobile exhaust production, etc.

2. **Hazard:** Inhalable particulate matter is very
harmful to human health. Therefore, long-term production or living in an area with serious inhalable particulate matter pollution will not only cause heart and lung diseases, but may also cause various respiratory diseases. (3) Prevention and management: From the perspective of the source of inhalable particulate matter, it shows the characteristics of compound pollution of multiple pollution sources. Therefore, improve the construction environment, implement green construction, and increase the area and frequency of road sprinkling.

Development trend of atmospheric environmental monitoring

Optimization towards digitalization

After proposing the concept of “Internet +,” all types of enterprises through the integration of “Internet +” technology not only increased the application value of data resource mining, but also brought positive effects to the company’s development. Therefore, atmospheric environmental monitoring needs to use this technology and develop steadily in the direction of digitization.

Optimizing towards intelligence

Intelligent technology has the advantages of all-weather automatic control. Through the cooperation of atmospheric environment monitoring, it can not only reduce the cost, but also avoid the influence of human factors, ensure that the atmospheric environment monitoring and management work is implemented in strict accordance with the content and regulations, and reduce the adverse effects of air pollution.

Towards systematization and legal system development

From the current atmospheric environment monitoring and management work, the relevant monitoring standards and management rules need to meet the regional atmospheric environment management needs, scientifically adjust according to specific development trends, and promote the orderly implementation of various environments. Carry out atmospheric

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**Table 11** Optimization results of minimum consumption cost

| Time   | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 |
|--------|--------|--------|--------|--------|--------|--------|
| 1:00   | 82.20  | 37.93  | 59.17  | 137.35 | 200.40 | 189.07 |
| 2:00   | 79.76  | 36.52  | 56.89  | 133.37 | 195.72 | 187.50 |
| 3:00   | 80.66  | 37.04  | 57.73  | 134.84 | 197.44 | 187.50 |
| 4:00   | 86.48  | 40.39  | 63.17  | 144.30 | 208.61 | 198.60 |
| 5:00   | 88.13  | 41.34  | 64.71  | 146.98 | 211.77 | 202.27 |
| 6:00   | 90.77  | 42.86  | 67.16  | 151.26 | 216.82 | 208.14 |
| 7:00   | 95.21  | 45.42  | 75.31  | 165.43 | 233.55 | 218.04 |
| 8:00   | 99.49  | 47.89  | 80.84  | 175.06 | 244.92 | 240.57 |
| 9:00   | 105.42 | 51.31  | 80.84  | 175.06 | 244.92 | 240.57 |
| 10:00  | 106.25 | 51.78  | 81.61  | 176.40 | 246.49 | 232.61 |
| 11:00  | 107.73 | 52.63  | 82.99  | 178.81 | 249.34 | 245.91 |
| 12:00  | 111.02 | 54.53  | 86.06  | 184.16 | 255.65 | 253.24 |
| 13:00  | 108.88 | 53.30  | 84.07  | 180.68 | 249.34 | 245.91 |
| 14:00  | 110.69 | 54.34  | 85.76  | 183.62 | 255.02 | 252.51 |
| 15:00  | 111.19 | 54.63  | 86.22  | 182.73 | 255.97 | 253.61 |
| 16:00  | 111.68 | 54.91  | 86.68  | 185.23 | 256.91 | 254.71 |
| 17:00  | 112.18 | 55.20  | 87.14  | 186.03 | 257.86 | 255.81 |
| 18:00  | 106.25 | 51.78  | 81.61  | 176.40 | 246.49 | 242.61 |
| 19:00  | 102.13 | 49.41  | 77.77  | 169.71 | 238.60 | 233.44 |
| 20:00  | 87.47  | 40.96  | 69.09  | 145.91 | 210.50 | 200.80 |
| 21:00  | 86.48  | 40.39  | 66.17  | 144.30 | 208.61 | 198.60 |
| 22:00  | 85.66  | 39.92  | 62.40  | 142.96 | 207.03 | 196.77 |
| 23:00  | 84.01  | 38.97  | 60.86  | 140.29 | 203.88 | 193.10 |
| 24:00  | 82.69  | 38.21  | 59.64  | 138.15 | 201.35 | 190.17 |

| Total cost/($/h) | $1,017,334.6 | Single goal satisfaction | $\mu_1=1$
| Total emissions/(kg/h) | 13,190.12 | $\mu_2=0.562$ |
environment monitoring and improve the actual monitoring intensity. At the same time, it can also provide a basis for improving the quality of China's atmospheric environmental protection.

Application measure of big data analysis technology in atmospheric environmental monitoring

Optimize data visualization work

In the new era, single data information in the traditional sense cannot accurately determine the characteristics of atmospheric environmental changes. The staff must propose new teaching methods based on the integration of the latest technological concepts. By using big data analysis technology in work, it helps to transform traditional data information into impressive images (Abbas et al. 2018). This not only facilitates employees to grasp the change rules more quickly, but also makes correct and effective judgments.

At the same time, with increasing attention to atmospheric environment monitoring, it is not only necessary to clarify the average fluctuation characteristics of the atmospheric environment, but also to observe the state of the atmospheric environment at various stages. Taking cities as an example, in order to meet the above requirements, it is necessary to adopt scientific reference data acquisition and analysis technology and install suitable monitoring equipment in the area, add big data to the equipment system, and build the basis of atmospheric environmental monitoring data and excellent communication. The network platform of the platform can transmit information to various weather platforms more quickly and provide users with graphic data information.

Record collected data information

Atmospheric environmental data plays a very important role in the application. Therefore, the use of big data technology to comprehensively record relevant information and produce corresponding environmental documents can not only solve the problems in the past research, but also relieve the relevant staff in the work process facing the pressure. In addition, the big data system can be connected to monitoring devices in

| Time   | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 |
|--------|--------|--------|--------|--------|--------|--------|
| 1:00   | 71.83  | 57.31  | 54.31  | 129.83 | 204.92 | 187.50 |
| 2:00   | 67.81  | 54.15  | 53.46  | 126.81 | 200.03 | 187.50 |
| 3:00   | 69.15  | 55.20  | 53.88  | 127.82 | 201.66 | 187.50 |
| 4:00   | 80.53  | 64.14  | 57.49  | 136.39 | 215.50 | 187.50 |
| 5:00   | 83.88  | 66.77  | 58.56  | 138.91 | 219.57 | 187.50 |
| 6:00   | 89.24  | 70.98  | 60.26  | 142.94 | 226.09 | 187.50 |
| 7:00   | 98.28  | 78.08  | 63.13  | 149.75 | 237.08 | 187.50 |
| 8:00   | 106.28 | 84.36  | 65.66  | 155.77 | 246.80 | 187.50 |
| 9:00   | 112.50 | 92.75  | 69.06  | 163.82 | 259.80 | 200.00 |
| 10:00  | 112.50 | 94.08  | 69.60  | 165.10 | 261.87 | 202.00 |
| 11:00  | 112.50 | 96.49  | 70.57  | 167.40 | 265.59 | 204.87 |
| 12:00  | 112.50 | 101.83 | 72.73  | 172.52 | 273.86 | 211.24 |
| 13:00  | 112.50 | 98.35  | 71.32  | 169.19 | 273.48 | 207.10 |
| 14:00  | 112.50 | 101.29 | 72.51  | 172.01 | 273.03 | 210.61 |
| 15:00  | 112.50 | 102.89 | 72.83  | 172.78 | 274.27 | 211.56 |
| 16:00  | 112.50 | 102.89 | 73.16  | 173.55 | 275.51 | 212.52 |
| 17:00  | 112.50 | 103.69 | 73.48  | 174.31 | 276.75 | 213.48 |
| 18:00  | 112.50 | 94.08  | 69.60  | 165.10 | 261.87 | 202.00 |
| 19:00  | 110.63 | 87.78  | 67.05  | 159.05 | 252.10 | 194.46 |
| 20:00  | 82.54  | 65.72  | 61.13  | 137.90 | 217.94 | 187.50 |
| 21:00  | 80.53  | 64.14  | 57.34  | 136.39 | 215.50 | 187.50 |
| 22:00  | 78.86  | 62.83  | 56.96  | 135.13 | 213.47 | 187.50 |
| 23:00  | 75.51  | 60.20  | 55.90  | 132.61 | 209.40 | 187.50 |
| 24:00  | 72.83  | 59.09  | 55.05  | 130.59 | 206.14 | 187.50 |

Total cost/($/h⁻¹) 1,030,744.2
Total emissions/(kg·h⁻¹) 12,835.64

Single goal satisfaction μ₁=0.3907
μ₂=1
other cities, so that atmospheric environmental data and information can be shared at work. In this process, big data analysis technology not only breaks the traditional concept of data processing, but also ensures the efficiency and quality of data recording. In the case of an atmospheric environment monitoring system, the most complex and most important part of the overall system is the collection of atmospheric environment monitoring data information. Therefore, analysis can only be carried out smoothly if the integrity of the data is ensured.

**Mining and sorting out atmospheric environmental data**

In essence, the basic purpose of atmospheric environment monitoring is to predict the atmospheric environment. At this stage, workers need to refer to the calculation and processing
of a large amount of data. Taking cities as an example, with
large geographic areas, climate changes and geological condi-
tions, etc., various factors need to be considered in the predic-
tion of the atmospheric environment. At present, in order to
improve the effectiveness and completeness of the prediction
work, the staff must classify and mine all kinds of data infor-
mation in combination with specific standards, and obtain it in
combination with the monitoring data of the urban atmospher-
ic environment. Using big data analysis technology, it is clear
that the urban atmospheric environment data is in different
stages and different places. In programming, staff can use
various weather equations combined with big data analysis
technology to mine valuable data information and predict
changes in the urban atmospheric environment in the future.

Predicted atmospheric environmental data

After using the big data analysis technology to complete the
above work, the staff must summarize and analyze the corre-
lation and change characteristics between the data to obtain
effective predictions. In the new era, big data analysis technol-
ogy developers must comprehensively perform program
design to ensure the rationality and standardization of the en-
tire work, so that various meteorological methods can not only
simplify data processing in the process of the program, but
also realize data processing and improve information. The
effectiveness of the work to achieve the goal of accurate forecasting.

Building an air quality early warning system

The use of big data analysis technology to monitor and predict
the atmospheric environment has broken the complexity of
traditional analysis work in the past. Through the monitoring
work form, the staff can have a more comprehensive under-
standing of the characteristics of changes in the atmospheric
environment. At this time, big data analysis technology can be
combined to build an early warning system for people’s tem-
perature. In the running state, the system connects the big
data analysis technology and the information disclosure sys-

Conclusion

The energy consumption components of the cloud computing
center are very complex. In addition to the main network
equipment and server equipment, it also includes a lot of energy consumption. Generally speaking, the annual power consumption of the IT equipment of the cloud computing center is less than half of the total power consumption, of which the power consumption of computing equipment is about 80%, and the power consumption of network communication equipment is about 20%. In order to solve the problem of economic load dispersion, this thesis proposes a multi-group genetic algorithm. By comparing numerical examples with standard genetic algorithms, it can be proved that the proposed algorithm is effective for solving multi-purpose, nonlinear, and multiple constraint problems and has strong global convergence capabilities. In the process of solving multi-objective problems, this paper adopts the interactive multi-objective comprehensive evaluation function effectively solved in the process of multi-object normalized weighting problem, scientifically adjusts the calculation results, and makes the optimization result closer to the actual situation.

**Declarations**

**Conflict of interest** The author declares that he has no competing interests.

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