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ARTICLE

Spatial and Temporal Distribution Characteristics of Solar Energy Resources in Tibet

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ABSTRACT

The Tibet Plateau is one of the regions with the richest solar energy resources in the world. In the process of achieving carbon neutrality in China, the development and utilization of solar energy resources in the region will play an important role. In this study, the gridded solar resource data with 1 km resolution in Tibet were obtained by spatial correction and downscaling of SMARTS model. On this basis, the spatial and temporal distribution characteristics of solar energy resources in the region in the past 30 years (1991–2020) are finely evaluated, and the annual global horizontal radiation resource is calculated. The results show that: 1) The average annual global horizontal radiation amount in Tibet is 1816 kWh/m^2. More than 60% of the area belongs to the "Most abundant" (GHI $\geq$ 1750 kWh/m^2) area of China's solar energy resources category A, and nearly 40% belongs to the "Quite abundant" (1400 $\leq$ GHI $<$ 1750) area of China's solar energy resource category B. 2) In space, the solar energy resources in Tibet increased gradually from north to south and from east to west. Lhasa, Central and Eastern Shigatse, Shannan, and Southwestern Ali are the most abundant cities, with a maximum annual radiation level of 2189 kWh/m^2. 3) In terms of time, the total horizontal radiation in Tibet was the highest in May and the lowest in December. 74% of the total area belongs to the "Very stable" ($R_w \geq 0.47$) area of solar resource stability category A, and 26 % belongs to the "stable" ($0.36 \leq R_w < 0.47$) area of solar resource stability category B. Solar energy resources in the region show the characteristics of both strong and stable. Average solar energy resources in the region have shown a fluctuating downward trend over the past 30 years, with an average decline of about 12.86 (kWh/m^2) per decade. 4) In terms of solar radiation resources reaching the earth's surface, the theoretical total amount of annual horizontal radiation in Tibet is about 240.07 billion tons of standard coal or 222.91 billion kilowatts on average.

KEYWORDS

Tibet; solar resource; spatiotemporal distribution

1 Introduction

Tibet is located in the southwest Qinghai-Tibet Plateau. It is located between 26°50′–36°53′N and 78°25′–99°06′E [1]. With an average altitude of more than 4000 m, it is known as the "Roof of the World". As one of the regions with the richest water, solar, and geothermal energy in China, the power supply of Tibet is dominated by clean energy such as hydropower, photovoltaic, and geothermal energy [2]. Among these clean energy sources, solar is the main contributor to the increase in the share of renewable [3]. The energy on the earth's surface mainly comes from the sun. Solar energy has become an indispensable part of global power generation structure optimization and energy structure reform. China is rich in solar energy resources and the utilization of resources is developing rapidly [4]. By the end of 2020, the total installed capacity of power in the region is more than 4 million kW, and the proportion of clean energy is nearly 90% [5]. Among them, the installed capacity of photovoltaic power generation is about 137 million kW, accounting for more than 1/3 of the total installed capacity of power [6]. It is one of the provinces with the highest installed capacity of photovoltaic power generation, after Qinghai Province (about 39%). According to the recommendations of the government of Tibet on the formulation of the "14th Five-Year Plan" for national economic and social development and the vision of the year 2035, it will accelerate the large-scale development of clean energy during the "14th Five-Year Plan" [3]. To form a clean energy, oil and gas, and other new energy complementary integrated energy system. The national demonstration area of clean and renewable energy utilization will be built in 2025. Hydropower built and under construction capacity will exceed 15 million kW, and photovoltaic power installed capacity will exceed 10 million kW. "Photovoltaic + energy storage" research and pilot projects will also be accelerated. "Water, wind and solar complementary" will be vigorously promoted.

Clean energy development, utilization, and electrification will be promoted at the forefront of the country [7–9]. Solar energy is considered a renewable resource that plays an important role in reducing greenhouse gas emissions and preventing climate change, which is essential for protecting humans, animals and ecosystems [10]. Since the 1980s, many foreign scholars have studied the variation trend of global surface solar radiation by using global site data [11]. Then the long-term changes of solar radiation at the surface were studied around the world [12–14]. Fu et al. [15] conducted a pioneering study on solar radiation. Subsequently, several scholars have studied solar radiation distribution from the perspective of China as a whole [16–20]. To realize the sustainable development of photovoltaic ecology and economy, it is very important to evaluate the photovoltaic potential worldwide. Zhou et al. [21] evaluated the temporal and spatial characteristics of solar radiation resources in Northwest China based on the data from a large number of measuring stations in Northwest China. However, due to the sparse distribution of solar observation sites, solar radiation data from measuring stations are incomplete and not always accurate. Huang et al. [22] adopted different GHI (Global Horizontal Irradiance) values and slope ranges as exclusion criteria to calculate the corresponding national power generation potential and obtain the PV suitability diagram. Liao et al. [23] described the location of photovoltaic power generation, analyzed the temporal and spatial characteristics, and measured the carbon emission reduction potential of installed photovoltaic power generation in China by province. However, a detailed description of the spatial and temporal distribution characteristics of solar energy resources in Tibet and an estimation of the development potential of solar energy resources in the region based on this still needs to be discovered in existing research.

This study finely evaluates the solar energy resources in Tibet. Distribution map [24] and development potential of solar energy resource parameters in time and space are given. This study is to provide basic support for the large-scale development and utilization of solar resources in the region.

2 Data and Sources

The measured data of meteorological stations in this study are from the National Meteorological Information Center, and the elements include sunshine hours and sunshine percentage for solar energy resources calculation. All meteorological factors are between 1991 and 2020. The spatial distribution of meteorological stations in Tibet is shown in Fig. 1.

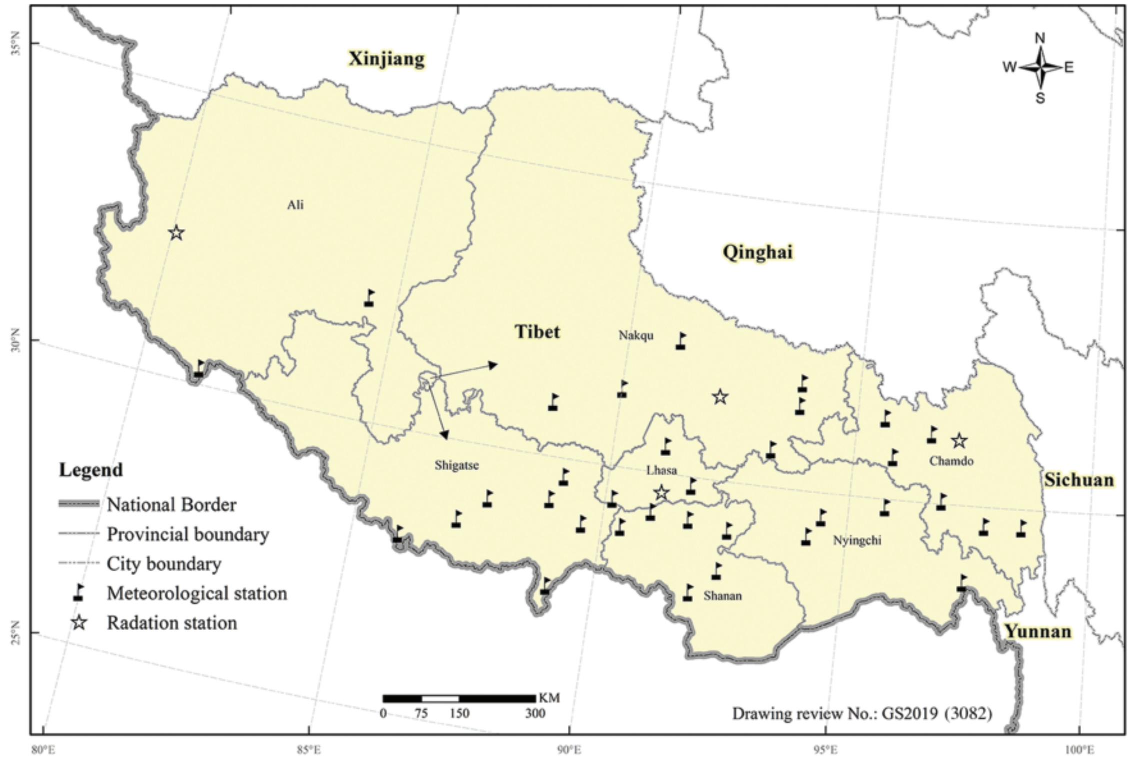

Figure 1: Spatial distribution of national meteorological stations in Tibet

3 Research Method

Solar energy resources in this study refer to horizontal solar energy resources. Horizontal solar energy resource parameters include sunshine hours, sunshine percentage, global horizontal radiation, direct horizontal radiation, and horizontal scattering radiation. The sunshine hours and percentage are drawn based on the measured data of national meteorological stations in Tibet. The global horizontal radiation, direct horizontal radiation, and horizontal scattering radiation are calculated to obtain 1 km × 1 km resolution data. The calculation flowchart is shown in Fig. 2.

According to the national standard *solar energy resource assessment method* (GB/T 37526-2019) [25], the global horizontal radiation, direct horizontal radiation and horizontal scattering radiation are calculated based on the climatic statistical method.

The calculation equation used in this study is as follows:

$$GHI = G_0 \left(a_1 s + b_1\right) \tag{1}$$

$$DBI = G_0 \left(a_2 s^2 + b_2 s + c\right) \tag{2}$$

$$DIF = GHI - DBI \tag{3}$$

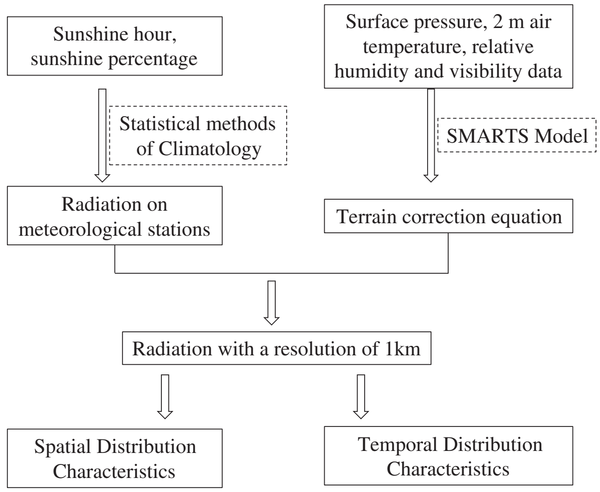

Figure 2: The calculation flowchart

In the formula, G_0 denotes extraterrestrial solar radiation (kWh/m^2), s is sunshine percentage (%), a_1, b_1 and a_2, b_2, care empirical coefficients. Through the above equation, the horizontal solar energy resource parameters of national meteorological stations in Tibet are calculated.

On this basis, the spectral radiative transfer model SMARTS (Simple Model for Atmospheric Transmission of Sunshine) of the National Renewable Energy Laboratory is used to revise and downscale the calculation results in space, and the gridded solar resource data with 1 km resolution are obtained [26]. The SMARTS model has many advantages on various influencing factors of solar radiation, such as a variety of options, the spectral range can be set, the slope calculation function, and the diversity of output parameters. At present, this model has been widely used in sunny solar radiation calculation in China [27]. In this work, the spectral range is set to 280–4000 nm, the entire layer of water vapor content is calculated from the water vapor pressure and pressure observed by the meteorological station, the atmospheric turbidity is reflected by the visibility observed by the meteorological station, and the atmospheric ozone content is obtained from the NASA website. Model input data mainly include station latitude and longitude, altitude, hourly surface pressure, 2 m air temperature, relative humidity and visibility data. Through the analysis of the simulated monthly global horizontal radiation and altitude, it is found that both have logarithmic changes in each month. The formula is as follows:

$$GHI = \alpha \times \ln(H) + \beta \tag{4}$$

In the formula, H is the altitude (m), α and β are the empirical coefficients. By the elevation data of 1 km resolution in Tibet, the monthly solar energy resource distribution of 1 km resolution in the whole region is calculated.

Using the measured data of four national radiation observation stations in Tibet, the calculated and revised annual global radiation levels are tested. Using the method of cross validation, one station is vacated each time, and the actual measurement data is not involved in the calculation. Based on Eqs. (1)–(4), the calculated value of the station is obtained, and then the error calculation is performed on the calculated value using the actual measurement data of the station. The results are shown in Table 1. It can be seen that the calculation results of Shiquan River and Nakqu sites with high altitudes are relatively low. However, the calculation results of two sites with low altitudes in Lhasa and Chamdo have high accuracy.

Table 1: Test results of global horizontal radiation

Site name	Elevation (m)	Relative error (%)	Average absolute error (kWh/m^2)	Root mean square error (kWh/m^2)
Shiquan River	4278	−11.1	286.5	354.3
Nakqu	4507	−10.0	206.7	253.5
Lhasa	3648	0.7	67.7	94.0
Chamdo	3315	−2.3	82.3	112.2

The annual irradiation amount of all grid points in the evaluation area is added. Multiply the result to the grid point area. The annual theoretical total amount of solar energy resources (S_E) in the evaluation area (kWh, MJ, standard coal) can be obtained. Then (S_E) is divided by the year-round time to obtain the annual average theoretical total amount of solar energy resources (S_p) in the evaluation area in the unit of power (kW). The formula is as follows:

$$S_E = \sum_{i=1}^{n} S_i \cdot A_i \tag{5}$$

$$S_p = \frac{\left(\sum_{i=1}^{n} S_i \cdot A_i\right)}{T} \tag{6}$$

In the formula, S_i is the annual radiation dose per grid point in kWh/m^2, A_i is the area of each grid. The data used in this study are equal grid spacing of 1 km resolution, and the area of all grid points is 1 km^2. n is the number of grid points in the evaluation area, T is the annual hours, namely 8760 h.

4 Fine Evaluation of Solar Energy Resources

4.1 Annual Global Horizontal Radiation Grade

The amount of annual average horizontal radiation in a region reflects the abundance of solar energy resources. According to the national standard of *Classification of solar energy resources–Global radiation* (GB/T 31155-2014), the total amount of solar energy resources in China is divided into four grades. As shown in Table 2.

Table 2: Grading of annual global horizontal radiation (*GHI*) in China

Grade	Grading threshold (kWh/m^2)	Grade symbol
Most abundant	$GHI \geq 1750$	A
Quite abundance	$1400 \leq GHI < 1750$	B
Abundance	$1050 \leq GHI < 1400$	C
General	$GHI < 1050$	D

Fig. 3 shows the distribution areas of four aggregate levels in Tibet according to the above classification criteria. Table 3 is the corresponding geographical description and each level of land area of Tibet. It can be seen from the figure and table that there is no category D solar energy resource area in Tibet. Category A area accounts for 60.9% of the territory of the region. Category B area accounted for 38.9%. In terms of the abundance of solar energy resources, most regions of Tibet are suitable for the development and utilization of solar energy.

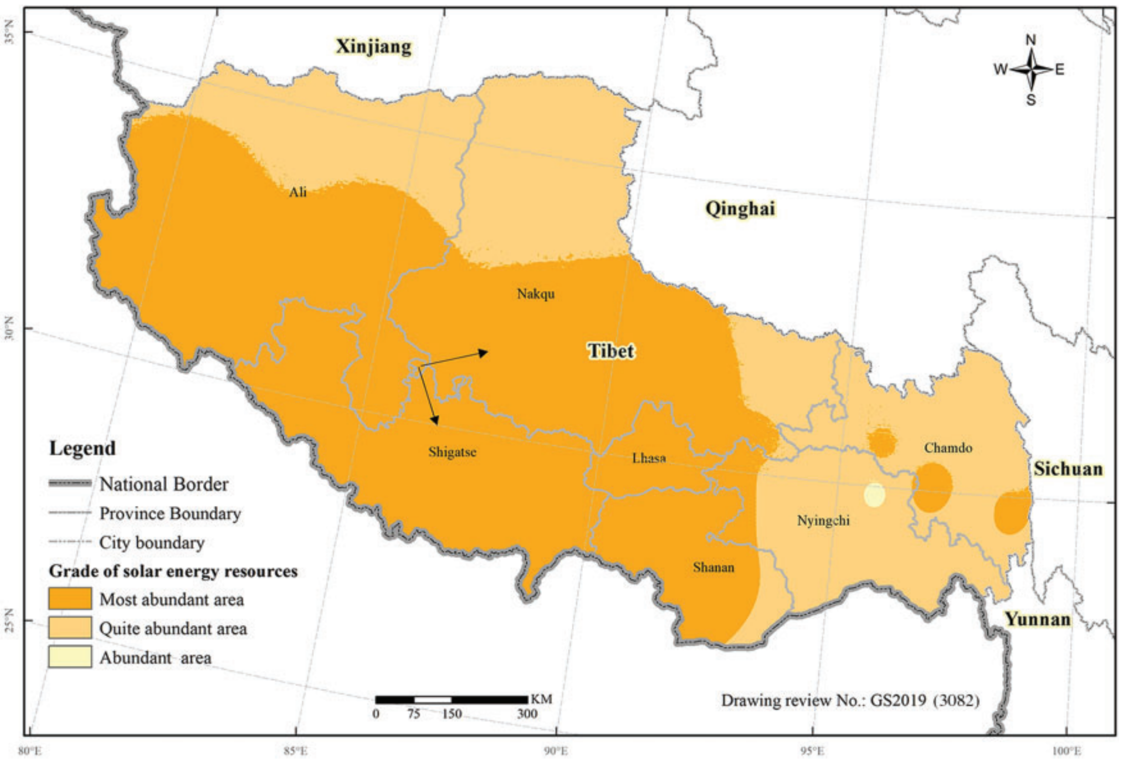

Figure 3: Grade distribution of annual global horizontal radiation in Tibet

Table 3: Graded distribution area of annual global horizontal radiation in Tibet

Grade	Main distribution areas	Area ratio (%)
Most abundant	Most areas of Shigatse, Lhasa, Shannan, the South of Ali Prefecture, the South of Nakqu, the Northwest part of Nyingchi, and part of Chamdo	60.9
Quite abundance	Northern Ali, Northern and Eastern Nakqu, most Chamdo, most Nyingchi and Southeast Shannan	38.9
Abundance	Northeast part of Nyingchi	0. 2
General	Nil	——

4.2 Stability Grade

The ratio of the minimum and maximum monthly total solar radiation in one year can characterize the stability of the annual variation of solar energy resources. In the actual atmosphere, its value changes in the (0,1] range; the closer to 1 more stable. The stability of solar energy resources in a region has an important influence on its development and utilization value. For solar power, the more stable the resource is, the more stable the output power is and the less impact on the grid. According to the national standard of *Classification of solar energy resources–Global Radiation* (GB/T 31155-2014) [28], the stability grade of solar energy resources in China is divided into four grades according to the ratio. As shown in Table 4.

Table 4: Grading of solar resource stability (R_w) in China

Grade	Grading threshold	Grade symbol
Quite stable	$R_w \geq 0.47$	A
Stable	$0.36 \leq R_w < 0.47$	B
General	$0.28 \leq R_w < 0.36$	C
Not stable	$R_w < 0.28$	D

Fig. 4 shows the distribution area of four stability levels in Tibet according to the above classification criteria. Table 5 is the corresponding geographical description and each level of land area of Tibet. It can be seen from the figure and table that there is no Category C and Category D region in the stability grade distribution of solar energy resources in Tibet. Most areas of the region belong to category A area, accounting for about 74.1%. Category B area accounted for about 25.9%.

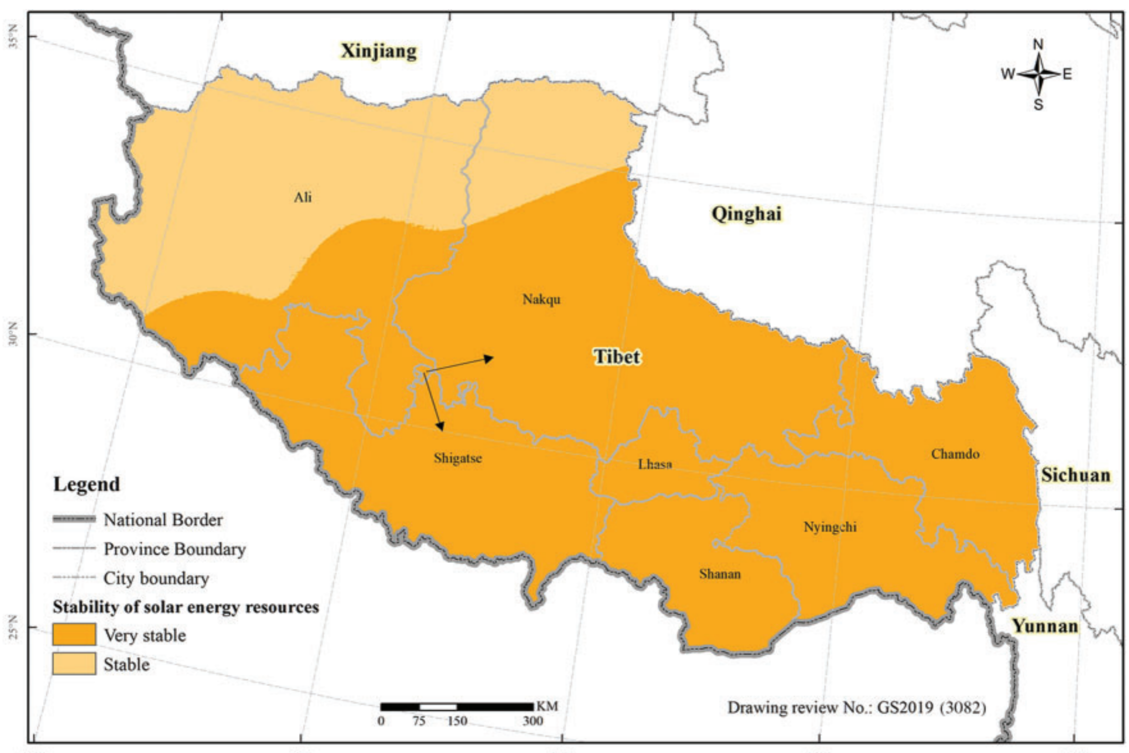

Figure 4: Grade distribution of solar energy resource stability in Tibet

Table 5: Stability grade distribution area of solar energy resources in Tibet

Grade	Main distribution areas	Area ratio (%)
Very stable	Chamdo, Nyingchi, Shannan, Lhasa, Shigatse, most areas of Nakqu, and Southeast of Ali	74.1
Stable	Most of Ali, Northwest Nakqu	25.9
General	Nil	——
Not stable	Nil	——

4.3 Grade of Direct Ratio

Horizontal total radiation consists of horizontal direct radiation and horizontal scattered radiation. The proportion of direct and diffuse radiation to total radiation varies significantly in different climate types. Different regions should develop and utilize according to the characteristics of main radiation forms. This study uses the direct ratio (the ratio of horizontal direct radiation to horizontal total radiation) to characterize this feature. In the actual atmosphere, the value of the direct ratio changes in the interval [0, 1). The closer it is to 1, the higher the proportion of direct radiation is. According to the national standard of *Classification of solar energy resources–Global Radiation* (GB/T 31155-2014), the direct ratio of solar energy resources in China is divided into four grades according to the ratio. As shown in Table 6.

Table 6: Grading of solar direct ratio (R_{DB}) in China

Grade	Grading threshold	Grade symbol	Grade definition
Very high	$R_{DB} \geq 0.6$	A	Direct radiation dominance
High	$0.5 \leq R_{DB} < 0.6$	B	More direct radiation
Mid	$0.35 \leq R_{DB} < 0.5$	C	More scattered radiation
Lower	$R_{DB} < 0.35$	D	Scattered radiation dominance

According to the above classification criteria, Fig. 5 shows the distribution area of four direct ratio grades in Tibet. Table 7 is the corresponding geographical description and the area of Tibet occupied by each level. It can be seen from the figure and table that there is no area of type D in the hierarchical distribution of solar direct radiation ratio in Tibet. The proportion of Category A and Category B in the whole area reached more than 90%, of which Category A accounted for 47.7% and Category B accounted for 43.5%. Category C accounted for only 8.8%, mainly in the southeast of Nyingchi.

4.4 Development Potential

Table 8 shows the total theoretical statistics of horizontal solar energy resources in cities (regions) of Tibet. It can be seen from the table that:

In terms of annual radiation per unit area, the average global horizontal radiation of the whole region is 1816 kWh/m^2. Among them, Lhasa is the highest, and the global horizontal radiation is 2023.0 kWh/m^2. Nyingchi is the lowest, and the global horizontal radiation is 1582.1 kWh/m^2. In terms of the theoretical total amount within the regional area, the annual global horizontal radiation of the whole region is 240.07 billion tons of standard coal or 222.91 billion kW on average. Among them, Nakqu is the highest, and the annual global horizontal radiation is 70.51 billion tons of standard coal or 65.47 billion kW on average. Lhasa is the lowest, with an annual global horizontal radiation of 6.32 billion tons of standard coal or 5.87 billion kW on average.

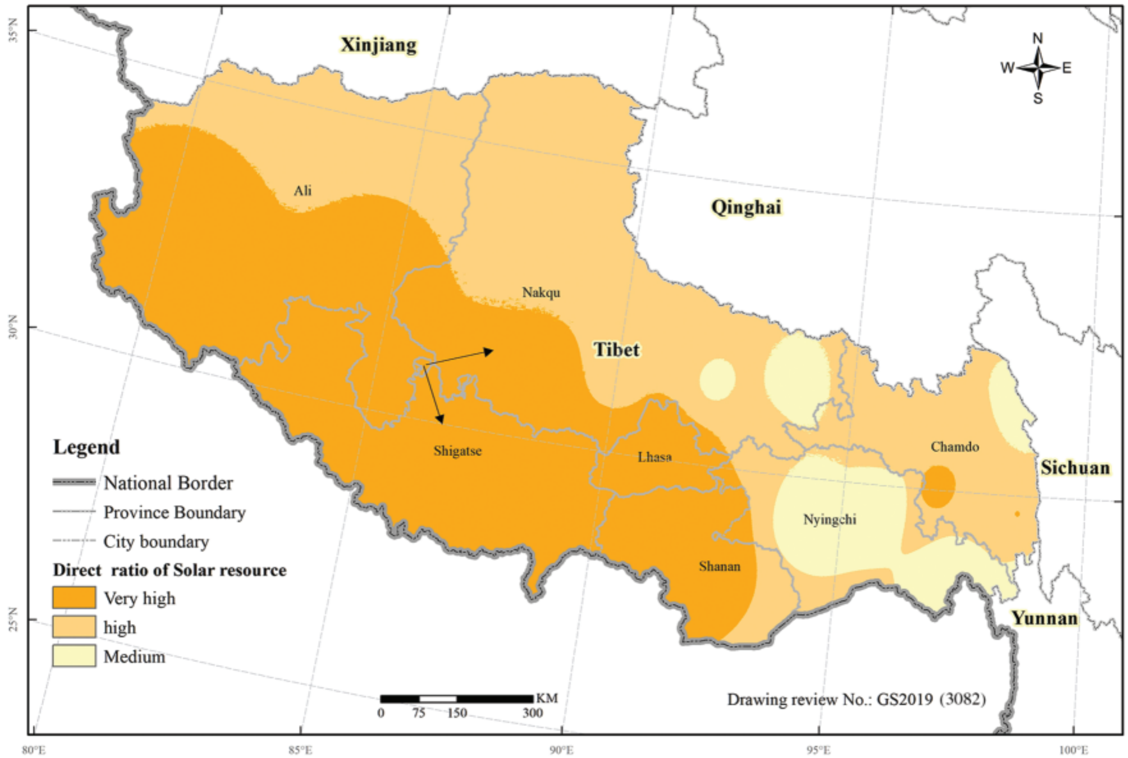

Figure 5: Grade distribution of solar direct ratio in Tibet

Table 7: Grade distribution area of solar direct ratio in Tibet

Grade	Main distribution areas	Area ratio (%)
Direct radiation dominance	Shigatse, Lhasa, most areas of Shannan, Southern Ali, Southwestern Nakqu, part of Chamdo	47.7
More direct radiation	Northern Ali, most of Nakqu, most of Chamdo, Eastern Shannan and surrounding Nyingchi	43.5
More scattered radiation	The Eastern part of Nakqu, most of Nyingchi and Northeast of Chamdo	8.8
Scattered radiation dominance	Nil	——

Table 8: Theoretical total amount of horizontal solar energy resources in cities (regions) of Tibet

(Region)	Theoretical total (Billion kW)	Total annual radiation amount in (region) (Billion tons of standard coal)	Unit area Annual irradiation amount (kWh/m^2)	(Region) Area (10000 km^2)
Shannan	151.5	163.1	1917.1	7.9
Shigatse	360.3	388.1	1979.9	18.2
Nakqu	654.7	705.1	1774.3	36.9
Nyingchi	185.1	199.4	1582.1	11.7
Lhasa	58.7	63.2	2023.0	2.9
Chamdo	191.9	206.7	1683.5	11.4
Ali region	626.9	675.2	1854.7	33.8
Total/average	2229.1	2400.7	1816.0 (average)	122.8

4.5 Interannual Changes in Solar Energy Resources

This section evaluates the interannual changes in solar energy resources in the past 30 years (1991–2020). The grid data were used to evaluate and analyze the overall solar energy resources in Tibet. Apart from that, four national radiation observation stations were selected as typical stations, including Chamdo, Shiquanhe, Lhasa and Nakqu.

4.5.1 Sunshine Hours

The sunshine hours vary fluctuating in the past 30 years. There's an upward trend in Chamdo, Lhasa and Nakqu, while a downward trend in Tibet, Shiquan River (Fig. 6). Sunshine hours increased 54.25 h per decade in Chamdo Station, with a maximum of 2597.70 h in 2015 and a minimum of 2243.00 h in 1993. In Lhasa station, it increased in rate of 52.12 h per decade, with a maximum of 3245.20 h in 2009 and a minimum of 2672.90 h in 2000. The average increase of sunshine hours in Nakqu was 8.25 h per decade, the maximum was 2878.80 h in 2015, and the minimum was 2435.00 h in 2008. The average decrease in sunshine hours in Tibet hours was 40.21 h per decade, with a maximum of 2682.24 h in 1994 and a minimum of 2399.55 h in 2019. The average decrease in Shiquan River Station was 169.78 h per decade, with a maximum of 3739.80 h in 1991 and a minimum of 3015.70 h in 2019.

4.5.2 Sunshine Percentage

The sunshine percentage performs the same trend with sunshine hours in the five areas during the past 30 years (Fig. 7). The average increase sunshine percentage in Chamdo was 0.43 per decade, with a maximum of 63 percent in 2015 and a minimum of 53 percent in 2019 and 2020. In Lhasa Station, the average increase in sunshine percentage was 0.86% per decade, with a maximum of 72% in 2009 and a minimum of 64% in 2000. The sunshine percentage of Nakqu was 1.63 per decade, with a maximum of 57 per cent in 2019 and a minimum of 45 percent in 2008. The average decrease of sunshine percentage in Tibet was 0.24% per decade, the maximum was 58% in 2013, and the minimum was 55% in 2018.

The average decrease in Shiquan River was 1.8% per decade, the maximum was 78% in 1998, and the minimum was 67% in 2018.

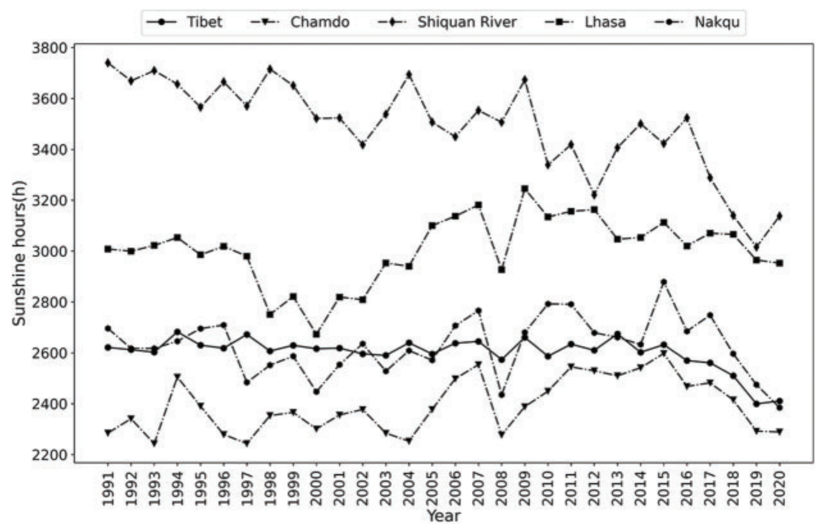

Figure 6: Variation curve of sunshine hours in recent 30 years (1991–2020)

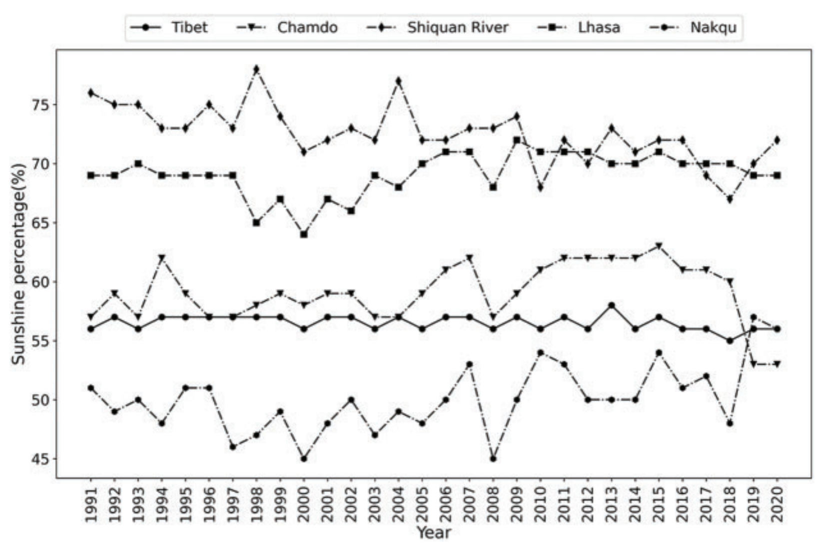

Figure 7: Sunshine percentage curve in recent 30 years (1991–2020)

4.5.3 Global Horizontal Radiation

The global horizontal radiation also performs the same with the sunshine hours and percentage during the past 30 years (Fig. 8). The average increase in global horizontal radiation of Chamdo was 21.78 (kWh/m^2) per decade, with a maximum of 1807.29 kWh/m^2 in 2015 and a minimum of 1655.83 kWh/m^2 in 1993. In Lhasa station, the average increase in global horizontal radiation was 16.07 (kWh/m^2) per decade, with a maximum of 2139.44 kWh/m^2 in 2009 and a minimum of 1975.18 kWh/m^2 in 2000. The increase of global horizontal radiation in Nakqu was 2.58 (kWh/m^2) per decade, with a maximum of 1866.77 kWh/m^2 in 2015 and a minimum of 1718.49 kWh/m^2 in 2008. The average decrease in Tibet was 12.86 (kWh/m^2) per decade, the maximum was 1770.74 kWh/m^2 in 1994, and the minimum was 1672.36 kWh/m^2 in 2019. The average decrease in Shiquan River was 63.55 (kWh/m^2) per decade, with a maximum of 2237.99 kWh/m^2 in 1991 and a minimum of 1977.48 kWh/m^2 in 2019.

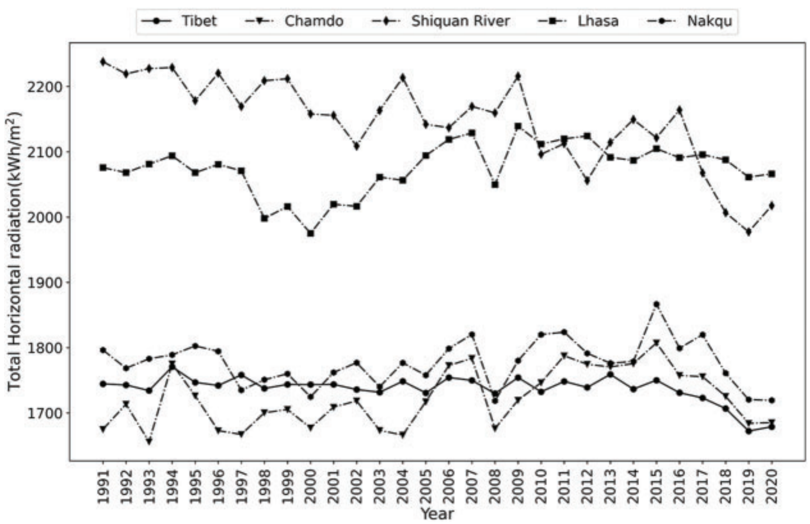

Figure 8: Annual GHI variation curve in recent 30 years (1991–2020)

5 Discussion and Suggestions

Judging from the changes in the past 30 years, the solar energy resources in Tibet and even the whole country have shown a downward trend, which has had a certain impact on photovoltaic power generation in recent years. The study [29] was a high minimum period in the 1970s, and the total volume increased significantly in the 1980s and early 1990s, but declined again after the mid-1990s. The occurrence of the high-value period in the 1970s and the low-value period in the 1980s was closely related to the cloud and rain conditions in Tibet and major global volcanic eruption events [30]. However, from the perspective of long-term climate change, interannual and interdecadal fluctuations in solar radiation are one of its inherent features. The current downward trend is only a phase of change and will not last. In addition, with the strengthening of ecological protection and the continuous improvement of air quality in China, ground-based solar radiation is also likely to gradually increase. Therefore, fluctuations in solar energy resources may have a certain impact on photovoltaic power generation in the short term, but in the long term, this impact is relatively limited. It is suggested that the development trend of solar energy resources in the next few decades and its impact on photovoltaic power generation, as well as the impact of large-scale photovoltaic power plant construction on local climate and environmental ecology should be studied. Different studies have shown that the integrated development of solar, wind and hydropower can reduce the instability and volatility of single-resource power generation. The National Wind Energy Storage Demonstration project can reduce the high-frequency fluctuations of wind power and photovoltaic output amplitude, and improve the grid's ability to absorb wind power and photovoltaic power by coordinating the power of wind power, photovoltaic and energy storage systems in real-time. Large-scale construction of photovoltaic power stations will have a certain impact on the natural environment, biodiversity and climate, and its impact exists in different life stages of photovoltaic power stations (construction, operation, scrapping). Zhai et al. [31] believed that the construction of PV stations in grassland areas will affect the local natural environment and plant community characteristics. Wang et al. [32] believed that the shading effect of photovoltaic panels is conducive to the growth of sprout-tolerant plants. The layout of photovoltaic white stations can also increase relative humidity, change wind direction, and reduce wind speed and soil temperature.

Tibet is well located in terms of solar potential, but lacks fossil energy sources. Therefore, it is wise to develop solar energy for sustainable development in Tibet. Tibet is sparsely populated and has a low density of national weather stations. At present, and Nali region only Lhasa, Qamdo, Naqu and Shiquanhe four ground solar radiation observation stations. Although the methods of climate statistics and topographic correction were used in this study to obtain the fine assessment results of solar energy resources in the whole region, there are large errors in the evaluation results in the area with fewer stations. Therefore, it is suggested to strengthen the calculation of solar energy resources in the process of developing and utilizing solar energy in Tibet, so as to provide a basis for further revising the fine evaluation results of solar energy resources in the whole region.

6 Conclusion

The average annual global horizontal radiation exposure in Tibet is 1816 kWh/m^2. More than 60% of the area belongs to the "Most abundant" area of China's solar energy resources category A, and nearly 40% belongs to the "Quite abundant" area of category B.

In space, the solar energy resources in Tibet increased gradually from north to south and from east to west. Lhasa, central and eastern Shigatse, Shannan, and Southwest Ali region are the richest. The maximum annual radiation amount of global horizontal radiation is 2189 kWh/m^2. 74% of the area belongs to the "Quite stable" area of solar resource stability category A, and 26% of the area belongs to the "Stable" area of solar resource stability category B. The solar resources in the whole area show the characteristics of "strong and stable". The average solar energy resources in the whole region have fluctuated and decreased in the past 30 years, with an average decrease of about 12.86 (kWh/m^2) per decade.

In terms of time, the global horizontal radiation in Tibet was the highest in May and the lowest in December. As far as the solar radiation resources reaching the surface are concerned, the theoretical global annual horizontal radiation in Tibet is about 240.7 billion tons of standard coal or 222.91 billion kilowatts on average.

This article analyzes the spatial and temporal distribution characteristics of solar energy in Tibet from a macro level. In the future, we will further study the solar radiation characteristics in Tibet from a micro level, such as spectral and physical characteristics, and analyze the impact of these characteristics on photovoltaic power generation, providing scientific support for improving the efficiency of solar resource utilization in the region.

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Availability of Data and Materials: Data supporting this study are included within the article.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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