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Key Points:

- Daytime-dependent dimming and brightening in surface solar radiation is most clearly imprinted near sunrise and sunset over China
- Daytime shortens in the cold seasons and polluted regions of China but further prolongs in the other seasons and regions since 1993
- The 2014 APEC Blue phenomenon at Beijing induced a change in the diurnal cycle of surface solar radiation

Supporting Information:

- Supporting Information S1

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Hourly Surface Observations Suggest Stronger Solar Dimming and Brightening at Sunrise and Sunset Over China

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Abstract Exploration of the diurnal pattern of global dimming and brightening has been limited by the paucity of high-temporal resolution observations. Based on 22 years' continuous observations of hourly surface solar radiation (SSR) over 96 stations across China for 1993–2014, this study evidences higher relative changes in diurnal SSR in terms of both frequency and magnitude at sunrise and sunset, with a longer pathway for the sun passing through the atmosphere, than the hours in between. This, in general, leads to a further shortening of the days between sunrise and sunset in the cold seasons and the polluted region of north China with low radiation levels but a further extension in the other seasons and regions with sufficient sunlight. Pollution reduction by 39.4%–69.7% during the 2014 Asia-Pacific Economic Cooperation summit at Beijing are accompanied with a 10.4–80.0% rebound of diurnal SSR in the forenoon and late afternoon.

Plain Language Summary As the primary energy source for our planet, solar radiation received at the Earth's surface, i.e., surface solar radiation (SSR), has undergone significant decadal changes. But at which specific time of the day does such change mostly occur remains a question, due to the limited SSR data at hourly or shorter timescales. Since 1993, China automated its measuring instruments and started continuous hourly SSR observations. Using these historical data records, this study evidences that the largest changes in SSR occur at the hours close to sunset and sunrise, which is also known as the early morning and late afternoon rush hours. The detected dimming and brightening of SSR at sunset and sunrise could affect the period of daytime, respectively, resulting in a further shortening of the days in cold seasons and polluted regions but a further extension in the other seasons and regions with sufficient sunlight. The emission reduction campaign directed by the Chinese government during the 2014 Asia-Pacific Economic Cooperation (APEC) summit at Beijing has remarkably induced an increase in the diurnal cycle of SSR, especially in the forenoon and late afternoon as compared to the Pre-APEC period, contrary to the normal changes solely driven by solar cycle.

1. Introduction

The phenomena of “global dimming and brightening,” i.e., the transition from a decrease to an increase in the global trend of surface solar radiation (SSR) since the late 1980s as evidenced by both surface and satellite observations (Pinker et al., 2005; Wild et al., 2005), has received worldwide attention since such changes may exert profound implications on the global energy budget, climate change, as well as on Earth's water and carbon cycles (Wild, 2009). Abundant follow-up studies have confirmed SSR dimming and brightening at different regions of the world, including China, based on the observations at daily or longer timescales (see reviews, e.g., Stanhill & Cohen, 2001; Wang et al., 2015; Wang & Yang, 2014; Wild, 2009, 2012). Thus far, due to the paucity of hourly SSR observations, the evolution of SSR on the hourly basis largely remains unknown. Especially, knowledge of SSR at hourly intervals is essential for the proper design and optimization

of solar energy systems (Parishwad et al., 1997) and the accurate modeling of the physical processes at the surface and in the atmosphere (Wang et al., 2002; Yang et al., 2006).

For the global dimming phase before 1990, SSR declines over Germany and the United States were most found at high solar zenith angles, i.e., near sunrise and sunset, due to enhanced aerosol absorption along the longer optical path in clear skies, whereas a slight increase of SSR was unveiled around noon (Liepert & Kukla, 1997). Hourly sunshine duration (SD) observations, a common proxy for SSR measuring the hours of day when direct solar irradiance exceeds 120 W m^{-2} , also suggested a maximal decline near sunrise and sunset in Ankara, Turkey for 1955–1996 (Aksoy, 1999) and in Jerusalem, Israel, for the month of July between 1969 and 1995 (Cohen & Kleiman, 2005). Aksoy (1999) attributed the longest reduction in SD at low solar elevations to the corresponding increases in the relative humidity around sunrise and sunset, except for the winter months with an increase in anthropogenic emissions. In contrast, Cohen and Kleiman (2005) highlighted the direct and indirect radiative effects of the increase in tropospheric aerosol particles on the shortening of the day from sunrise to sunset. Basically, aerosols can scatter and absorb SSR depending on the nature of their composition (direct radiative forcing), or alter cloud radiative properties and lifetimes due to their role in the formation of cloud condensation nuclei (indirect radiative forcing) (Ramanathan et al., 2001; Wild, 2009).

Despite the complex causes for global dimming and brightening (Stanhill & Cohen, 2001; Wild, 2009), anthropogenic aerosols have been increasingly proposed as the dominant factor regulating the decadal trends of SSR in China (e.g., Wang et al., 2020; Yang et al., 2019; Zhou et al., 2020). On the diurnal scale, the extinction of light by aerosols is determined not only by the changing concentrations of aerosols in the atmosphere but also the changing position of the sun through the day (Spokas & Forcella, 2006). The attenuation effect of aerosols on SSR is assumed to occur particularly when the sun is approaching the horizon, i.e., around the sunrise and sunset, due to the longer path that sunlight penetrates through the layers of aerosols (Sanchez-Romero et al., 2014). Besides, the periods of early morning and late afternoon are the typical rush hours featured by traffic congestion, thereby greatly increasing vehicle emissions and thus degrading ambient air quality (Zhang & Batterman, 2013).

Since 1993, China updated its solar radiation monitoring network by replacing the old manual instruments to automated ones (Wang et al., 2015) and started continuous and intensive hourly solar radiation observations. This provides a unique opportunity to, for the first time, reveal the decadal changes in the diurnal cycle of SSR since the 1990s. The high-temporal resolution SSR records in China can help to testify the effect of aerosols on the daytime-dependent evolution in SSR. This study therefore aims at clarifying (1) the hourly performance of dimming and brightening in SSR over China and (2) the possible connection with air pollution at different temporal and spatial scales.

2. Data and Methods

2.1. Hourly Solar Radiation Data Collection and Quality Control

Hourly solar radiation data in time intervals between 1 and 24 local time (LT) were collected from the China Meteorological Data Service Center (CMDSC, <http://data.cma.cn>) of the China Meteorological Administration (CMA) for the period of 1993–2014 measured consistently with Chinese-developed thermopile pyranometers with an uncertainty of 3.4% ($\sim 5 \text{ W m}^{-2}$) (Wang et al., 2015; Yang et al., 2012). Basic data quality controls, including tests on the climatic range, spatial consistency, and temporal continuity, have been applied by the CMA (see the Data Description Document; <http://data.cma.cn>). To further ensure the data reliability, physical thresholds for the hourly SSR observations were tested before their application, based on the criterion that hourly SSR should not exceed hourly extraterrestrial radiation R_a ($SSR < R_a$). The extraterrestrial radiation R_a ($\text{MJ m}^{-2} \text{ h}^{-1}$) at hourly scale is calculated following the FAO-56 method (Allen et al., 1998) as:

$$R_a = \frac{12 \times 60}{\pi} G_{sc} d_r \left[(\omega_2 - \omega_1) \sin \varphi \sin \delta + \cos \varphi \cos \delta (\sin \omega_2 - \sin \omega_1) \right] \quad (1)$$

$$d_r = 1 + 0.033 \cos\left(\frac{2\pi}{365}J\right) \quad (2)$$

$$\delta = 0.409 \sin\left(\frac{2\pi}{365}J - 1.39\right) \quad (3)$$

where G_{sc} is the solar constant ($0.082 \text{ MJ m}^{-2} \text{ min}^{-1}$), φ is the latitude of the location, $J \in [1, 365 \text{ or } 366]$ is the number of the day in the year, the calculated d_r and δ are the inverse relative distance Earth-Sun and solar declination, respectively.

The solar time angles at the beginning ω_1 and end of the period ω_2 are given by:

$$\omega_1 = \omega - \frac{\pi}{24} \quad (4)$$

$$\omega_2 = \omega + \frac{\pi}{24} \quad (5)$$

$$\omega = \frac{\pi}{12} \left[\left(t + 0.06667(L_z - L_m) + S_c \right) - 12 \right] \quad (6)$$

$$S_c = 0.1645 \sin 2b - 0.1255 \cos b - 0.025 \sin b \quad (7)$$

$$b = \frac{2\pi(J - 81)}{364} \quad (8)$$

where ω is solar time angle at midpoint of hourly period; L_z and L_m are the longitude of the center of the local time zone and the measurement site, respectively; S_c is the seasonal correction for solar time (hour).

Only the solar radiation stations with long-term hourly observations covering more than 90% of the examined period, i.e., >20 years, were considered for further analysis. Among them, three stations were combined from collocated stations to complete the recording period. After the long-term record selection, 96 stations were left with hourly SSR observations ranging between 5 and 20 LT (Figure 1). The duration of the day from sunrise to sunset at each specific site over the years for 1993–2014 can be inferred from Figure S1 of the supporting information. The analyses of hourly SSR were then performed on a monthly basis to examine the variations along the year. About 94% of the monthly average hourly data were calculated with a sampling size over >10 days per month. The missing monthly average hourly data were filled for each station based on linear regression relationships established by the available data from the same month for the whole period to minimize the effect of missing data on the overall trends without changing the original trend slopes.

2.2. Analysis Procedure

The hourly SSR trend calculations conducted in this study were all based on relative anomalies (%) of the monthly mean-hourly SSR with reference to that averaged over 1993–2014 to reduce the diurnal and seasonal differences in the absolute SSR values. More specifically, the relative SSR anomalies were calculated for each station by (1) deriving the multiyear diurnal cycles for each month, i.e., monthly mean diurnal cycles over 1993–2014, and (2) calculating the relative differences of each monthly mean-hourly SSR data from the monthly mean diurnal cycles. This was aimed to enable the comparisons among the hours of the day and the seasons of the year with different radiation levels. Then, the hourly performance of SSR dimming and brightening was compared at different temporal (annual and seasonal) and spatial (national and regional) scales over China. The seasons are defined as spring (March to May), summer (June to August), autumn (September to November), and winter (December to February). The four regions are divided by the lines of Latitude 34°N and Longitude 110°E as Northeast (NE), Southeast (SE), Northwest (NW), and Southwest (SW), respectively (Figure 1a). South and north China are divided by Latitude 34°N , which

Figure 1. Spatial patterns of (a) the decadal trends (% decade⁻¹) in surface solar radiation (SSR) and (b) and (c) the peak hours with maximum dimming and brightening over the 96 stations across China for 1993–2014. Red and blue symbols denote positive and negative trends, respectively, marked with green circles denoting significant trends at the 95% confidence level. The peak phase of diurnal SSR changes is indicated by the arrows according to the convention on the right-bottom side of the subfigures (b) and (c). The dark and light gray solid circles denote the periods during the morning and afternoon rush hours (5–8 and 17–20 LT) and in between (9–16 LT), respectively. The frequency distribution of the peak phase of diurnal SSR changes over the morning and afternoon rush hours and in between is shown on the left-bottom side of the subfigures (b) and (c), with the white bars denoting the significant changes at 95% confidence level.

approximates the 0°C January mean isotherm and the 800 mm annual precipitation isohyet in China; east and west China are divided by Longitude 110°E, which approaches the boundary between the first and second steps of China's terrain with average elevation of over 4,000 m and around 1,000–2,000 m, respectively.

To examine the effect of air pollution on the changes in the diurnal cycle of SSR, first, the hourly SSR changes were compared for the periods of morning and afternoon rush hours (5–8 and 17–20 LT) and in between (9 and 16 LT), respectively. Second, the consistency between the daytime-dependent SSR variations and the diurnal cycles of air quality index (AQI) were discussed over the seasons and regions. Third, a case study was applied to quantify the effect of stringent emission reduction for achieving blue skies during the

Asia-Pacific Economic Cooperation (APEC) summit 2014 at Beijing, the so-called “APEC Blue,” on the diurnal changes of SSR.

As the generalized mode for gauging air quality, hourly AQI information is available at the Datacenter of the Ministry of Ecology and Environment of China (<http://datacenter.mee.gov.cn/>), over 50 stations across China for 2014 (Figure S2). Quantifying the overall air quality in the monitored area, AQI is a nondimensional number within the range of 0–500 calculated from 24-h ground-measured mass concentrations of all ambient air pollutants such as SO₂, NO₂, O₃, CO, PM₁₀, and PM_{2.5} for dry conditions (Zhan et al., 2018). Though mainly representing the effect of aerosols near the surface, AQI was shown to be strongly correlated with aerosol optical depth (AOD), the measure of wavelength-dependent aerosol extinction in the atmospheric column, after corrections for aerosol seasonal vertical distribution and real-time relative humidity (Bellouin et al., 2005; Li et al., 2005; Qu et al., 2010).

All ground-based AQI observations are recorded in Beijing time (BJT) at the time zone of UTC +8. To accurately reflect the air pollution effect on the daytime-dependent SSR trends, the real local time (LT) for each AQI observation station was converted from the original observational time recorded in BJT using the following formula:

$$LT = BJT - (UTC_{+8} - UTC_{station}) \quad (9)$$

where UTC_{station} denotes the real-time zone for the given AQI observation station.

3. Results and Discussions

The decadal trend of SSR over China generally levels off since the 1990s with significant dimming and brightening trends only covering 8.3% and 19.8% of the examined 96 stations, respectively (Figure 1a). This is consistent with previous conclusions drawn on quality-controlled SSR observations (Tang et al., 2010; Wang & Wild, 2016; Yang et al., 2018). Accordingly, only 5 and 19 out of the 96 stations show consistent hourly brightening and dimming trends for 1993–2014. For the majority of the stations, the direction of SSR trends changes over different hours of the day. The hours observing the maximum hourly dimming and brightening trends over the day are indicated in Figures 1b and 1c, respectively. The peak dimming and brightening hours largely occur near sunrise and sunset, i.e., 5–8 and 17–20 LT. As shown in Figure 1b, about 83.5% of the maximum hourly relative SSR declines occur in the morning and afternoon rush hours, with 24.2% being significant at 95% confidence level. In comparison, about two-thirds of the maximum hourly brightening trends have passed the significance test (Figure 1c). The significant brightening peaks are especially prevalent in the morning and evening rush hours, accounting for 54.5% of the stations showing hourly brightening trends. Noontime peaks of dimming and brightening are generally distributed over the west part of China with less anthropogenic emissions than east China (Figure S3; Li et al., 2012; Streets et al., 2005; Tian et al., 2012).

The magnitudes of SSR dimming and brightening trends at each hour of the day averaged over the 96 stations across China are presented by the harmonic dials in Figure 2. The magnitudes of the hourly dimming and brightening trends were calculated for each hour over the stations showing negative and positive trends over 1993–2014, respectively. Consistent with the frequency distribution of the peak dimming and brightening phases, the magnitudes of the dimming trends in the morning and afternoon rush hours (−10.0% decade^{−1} on average) are stronger than those around the noontime (−3.2% decade^{−1}) over 1993–2014; the brightening trends for the periods near sunrise and sunset (14.8% decade^{−1}) are also generally larger than those around solar noon (2.9% decade^{−1}), despite that the most obvious changes in the 5 and 20 LT are mainly for the seasons and regions with longer daytime. After excluding the years of 2013–2014 affected by the implementation of the Clean Air Action Plan (Jin et al., 2016), the dimming trends on average strengthen by 2.2% decade^{−1} for the hours near sunrise and sunset, while brightening trends on average weaken by 1.8% decade^{−1}. Changes in the trends of 1993–2012 from 1993 to 2014 after excluding the effect from air pollution regulations, however, are almost invisible for the hours around solar noon. The mean magnitudes of noontime dimming and brightening trends over 1993–2012 are −3.1% decade^{−1} and 2.9% decade^{−1}, respectively, nearly the same as those over 1993–2014. Therefore, pollution-driven SSR dimming and brightening especially occur in the time periods close to sunrise and sunset rather than around solar noon with high radiation level (Figure S4).

Figure 2. 24-h harmonic dials depict the magnitudes ($\% \text{ decade}^{-1}$) of the brightening and dimming trends in hourly surface solar radiation (SSR) over 96 stations across China, respectively, for 1993–2014 and 1993–2012 (upper dials) and the absolute differences of the trends in 1993–2014 from 1993 to 2012 (lower dials).

At sunrise and sunset, i.e., at low solar elevation angle, the sun's rays penetrate through thick layers scattering or absorbing by the atmospheric aerosol and cloud particles, and then spread over a large surface area to result only in a low radiation level. Any changes in the atmospheric transmission would thus significantly affect the extinction of light along the long solar rays' path and further modify the weak sunlight at sunrise and sunset, resulting in the higher relative changes of SSR as observed. The large fractional changes in SSR in the early morning and late afternoon, though may not count much in absolute terms, are essential for the detection of dimming and brightening of a day. The gradual changes of SSR occurring when the sun is approaching the horizon would, on one hand, exert a direct effect on shortening or prolonging the length of the day (Cohen & Kleiman, 2005). On the other hand, a possible effect on plant growth can be expected since diffuse radiation and its fertilization effect on agricultural productivity are present especially after sunrise and before sunset when the response of plant photosynthesis to radiation variations is close to a linear relationship (Gueymard, 2000; Wang et al., 2002). In terms of energy input for the climate system, midday changes still might remain relevant due to their potentially larger absolute contributions despite lower percentage (relative) changes.

The seasonal and regional patterns of SSR dimming and brightening in the morning, noon, and afternoon phases are revealed in Figure 3. At seasonal scale, the relative SSR brightening is most obvious in the morning of winter by a rate of $6.1\% \text{ decade}^{-1}$, followed by spring, summer, and autumn. As indicated in Figures S3 and S4, winter is the season with the lowest radiation level but highest pollution level in China. Coal-dominated fossil fuel burning for domestic heating has been identified as the main reason for the severe pollution in winter (Xiao et al., 2015), which might be partially implied from the AQI peak in the midnight of the cold seasons (Figure S3a). The detected recovery of morning SSR in winter is thus possibly related to the effective control of coal fired power plant emissions in China (Jin et al., 2016). However, due to the low absolute SSR value in winter, the recovery of sunlight was mainly reported in the warm seasons of spring and summer (Wang et al., 2019; Wang & Wild, 2016) with sufficient sunlight (Figure S4a). Besides, continued dimming has greatly compensated the brightening trends in autumn and the afternoon of winter,

Figure 3. Seasonal (a) and regional (b) comparisons of the magnitudes of dimming and brightening trends (% decade⁻¹) in surface solar radiation (SSR) averaged over the time periods of morning (5–8 LT, gray circle), noon (9–16 LT, white circle), and afternoon (17–20 LT, black circle), respectively, for 1993–2014. The upper and lower error bars represent the confidence intervals for the mean magnitudes. The seasons are defined as spring (March to May), summer (June to August), autumn (September to November), and winter (December to February). The regions are divided by the lines of Latitude 34°N and Longitude 110°E as Northeast (NE), Southeast (SE), Northwest (NW), and Southwest (SW), respectively (Figure 1a).

implying a further shortening of the day in the cold seasons with relatively low radiation level and short day-length (Figure S4a).

Similar diurnal SSR dimming and brightening, with the relative changes being most obvious in the morning, followed by afternoon and noontime periods, can also be observed on a regional basis (Figure 3b). Morning brightening is notable for all regions except for NE, the main region for anthropogenic emissions reporting the highest AQI level in China (Figure S3b; Filonchik et al., 2019; Guo et al., 2017). Further weakened SSR can be observed in NE during the midday and afternoon periods. For SE, the region with more frequent overcast skies and lowest radiation levels (Figure S4), SSR tends to strengthen especially during the morning time, which would exert a beneficial effect on crop growth in this main planting area of China. Prolonged duration of sunlight is also indicated in the western part of China, i.e., NW and SW, with the most abundant solar energy reserves in China (Figure S4b).

Figure 4 depicts an increase in diurnal SSR during the 2014 Beijing APEC summit. APEC Blue serves as an example of the emission reduction campaign directed by the Chinese government to significantly improve the air quality and produce blue skies during the APEC week-long meeting. The imposed emission control measures during the APEC summit were even more intensive than during the 2008 Beijing Olympic Games (Huang et al., 2015; Sun et al., 2016). As indicated by Figure 4a, hourly AQI sharply decreased by 39.4–69.7% during the APEC submit (first-half of November 2014) as compared to the Pre-APEC period (second-half of October 2014). Afterward for the Post-APEC period (second-half of November 2014), the AQI rebounded back to a level that was even slightly higher than during the Pre-APEC period, especially at nighttime.

Figure 4. The reduction of air quality index (AQI, (a)) during the Asia-Pacific Economic Cooperation (APEC) summit period from first to 15 November 2014, largely brought surface solar radiation (SSR, (b)) back to Beijing in most hours during the day. The periods Pre-APEC and Post-APEC denotes October 16–31 and November 16–30, 2014, respectively.

Correspondingly, opposite to the seasonal changes in the diurnal cycles of SSR (Figure S5), APEC SSR during the early half of November reached an even higher level than the one during the late half of October (Figure 4b). The increase of SSR occurred in the forenoon and late afternoon ranging from 10.4% to 80.0%, calculated as the relative hourly SSR changes between APEC and Pre-APEC periods in 2014 (Figure 4b) minus the average changes over 1993–2014 (Figure S5) to exclude the changes driven by the solar cycle. After the closing of APEC, hourly SSR largely reduced to be less than 100 W m^{-2} (Figure 4b), which can hardly trigger the recording of sunshine duration for these days. The atmospheric conditions, e.g. changes in cloudiness, can generally be assumed to be comparable for the Pre-APEC, APEC and Post-APEC periods all in the autumn season.

The diurnal radiation level in autumn of 2014 has largely reduced from the 1993 to 2014 mean level by 55.8% on average in Beijing, when comparing Figures 4b and S5. The only exception occurred in the APEC period at sunrise and sunset, where SSR increased by 80.7% as compared to the 1993–2014 mean level, indicating an earlier lightening of the day. Note that during the autumn season of Beijing, AQI only peaks in the nighttime, which might be enhanced by the temperature inversion effect (Batlles et al., 2000). During the daytime, AQI is the highest during the early morning and late afternoon traffic, further suggesting a significant modification of SSR by air pollution at low solar elevations with longer pathlength. Such a diurnal cycle in AQI (Figure 4a) is different from the one averaged for the regions and seasons over the country (Figure S3). Varying diurnal cycles in AOD and $\text{PM}_{2.5}$ were also reported, respectively, for the AERONET AOD sites typical of different aerosol types (Smirnov et al., 2002) and the China Atmosphere Watch Network over different regions (Guo et al., 2017). Besides, the relevant meteorological parameters also possess a diurnal pattern, e.g., higher air temperature, more frequent cloud cover and cumulus clouds, lower relative humidity and higher wind speed at midday and afternoon (Aksoy, 1999; Cui et al., 2008; Eck et al., 2003). A further clarification of the diurnal climatology and changes of the relevant meteorological parameters is of high importance to understand the diurnal variabilities of SSR and aerosols and their complicated interactions.

4. Conclusions

Based on the continuous and quality-controlled hourly SSR observations over 96 stations across China for 1993–2014, this study provides a first detailed reference for understanding the characteristics of daytime-dependent SSR trends and the possible influence from air pollution. The principal conclusions drawn from this study are summarized as follows:

1. Both the frequency and magnitude indicate a higher relative decadal change of SSR at sunrise and sunset with a longer pathway for the sun passing through the atmosphere than the hours in between. Over 80% of the maximum relative decadal changes in SSR occur in the morning and afternoon rush hours. On

- average, the relative SSR dimming and brightening for the periods near sunrise and sunset are, respectively, 6.8% and 11.9% stronger than those around solar noon
2. The brightening of SSR occurs especially in the morning of 5–8 LT, accounting for 66.2% of the 77 stations observing a brightening trend in diurnal SSR, with a mean magnitude of 14.1% decade⁻¹ for 1993–2014. Dimming, on the other hand, continues largely in the afternoon of 17–20 LT, accounting for 48.4% of the 91 stations showing a dimming trend in diurnal SSR, with an average rate of -11.7% decade⁻¹
 3. At seasonal scale, dimming of SSR at sunrise and sunset indicates a further shortened daytime in the cold seasons of autumn and winter with relatively low radiation level and short day-length, but the brightening further prolongs the days in the warm seasons of spring and summer with sufficient sunlight
 4. At regional scale, the day shortening effect mainly occurs in NE, the most polluted region in China. Increased daytime can be expected in the main rice planting area of SE, and the western part of NW and SW with the highest radiation level in China beneficial for solar power generation
 5. The 2014 APEC Blue phenomenon at Beijing accompanied by stringent emission reduction has successfully brought an increase in diurnal SSR, especially at sunrise and sunset with increases of 80.7% compared to the 1993–2014 mean level. The decreases in diurnal AQI by 39.4–69.7% during the APEC summit are accompanied with increases in diurnal SSR ranging over 10.4–80.0% as compared to the Pre-APEC period especially in the forenoon and late afternoon, more than offsetting the decreases in diurnal SSR driven by solar cycle during this period

Data Availability Statement

Solar Radiation and Air Quality Index Data supporting this research are available from the China Meteorological Data Service Center (CMDC, <http://data.cma.cn/en/>) and the Data Center of the Ministry of Ecology and Environment of the People's Republic of China (<http://english.mee.gov.cn/>), respectively.

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