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ATMOSPHERIC CHEMISTRY AND PHYSICS

Analysis on the impact of aerosol optical depth on surface solar radiation in the Shanghai megacity, China

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2014.5.9

Outline

- Introduction
- Data and methodology
- Results
- Conclusions

Introduction

- Various studies analyzing long-term surface radiation measurements suggested a widespread decrease in SSR between the 1950s and 1980s (“global dimming”) and a partial recovery or level off beyond the 1990s.

- A number of studies which focus on the region of China discovered some similar results on SSR variations.

- Clouds and aerosols have been regarded as the most important ones to explain the dimming and brightening phenomenon. However, their interactions on SSR are strongly dependant on regional climate and pollution levels, so which one is the more important contributor for changing the SSR is not confirmed.

- Investigations on SSR and associated factors in some typical areas such as megacities or remote sites are necessary for the purpose to better understand the leading cause of SSR variations.

- The column-integrated aerosol observation such as Aerosol Optical Depth (AOD) has not been used directly to investigate its impact on SSR variation in China.

- The goal of this study is to elucidate the role of aerosol on the secular variation of SSR through analysis on AOD, DiSR and DfSR measured in Shanghai, the largest megacity of China, and to investigate a new insight into the origin of dimming and brightening in the east china monsoon region.

Data and methodology

Data

- One pyranometer (31.17° N, 121.43° E): DiSR and DfSR (from year 1961 to 2008)
- Clear-sky condition: daily mean TCC<0.10
- AOD data:

(1)550 nm from the Terra (09:00:00–10:00:00 LT) and Aqua(13:00:00–14:00:00 LT) MODIS level-2 aerosol products (MOD04_L2, MYD04_L2) (area:10×10 km) (from 2004.1.1 to 2007.12.31)

(2)A ground-based AOD monitoring (31.22° N, 121.55° E) (from year 2007)

Methodology

- Describe the temporal change of DiSR and DfSR (distinguish the dimming and brightening periods in secular variations) : 5-year moving average.

- The long term variations of DiSR and DfSR investigated under both all-sky and clear-sky conditions.

- Linear regression & t-test:

  (1) Estimate the magnitude of dimming or brightening by $Wm^{-2}decade^{-1}$.

  (2) Analyze the relationship between AOD and corresponding DiSR and DfSR under clear-sky conditions in different seasons.

- AOD and the corresponding DiSR and DfSR are examined for their weekly variations and the impact of AOD on DiSR and DfSR.(weekdays: Tue. to Fri. & weekends: Sat. to Mon.)

  All daily data for a week are converted as a percentage departure (%) from the weekly average.

Results

●The dimming and brightening characters in the secular variations of DiSR and DfSR

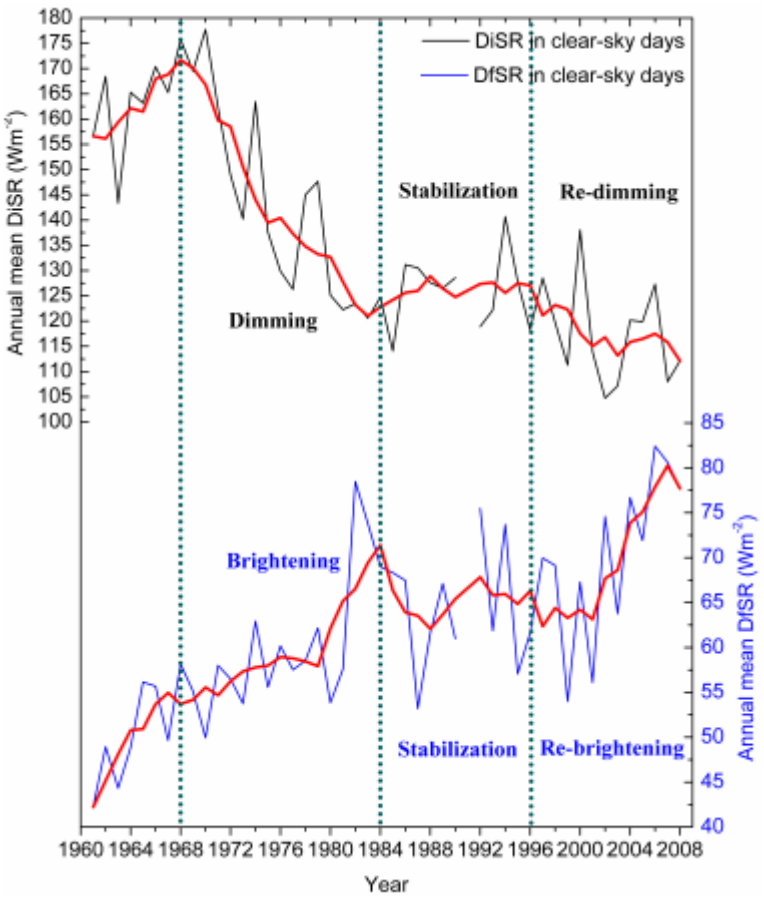

Fig. 1. Annual mean of direct surface solar radiation (DiSR, shown in black line) and diffuse surface solar radiation (DfSR, shown in blue line) observed on clear-sky days during the period of 1961–2008 in Shanghai. Five year moving averages are also shown in red lines. Units are W m^{-2}.

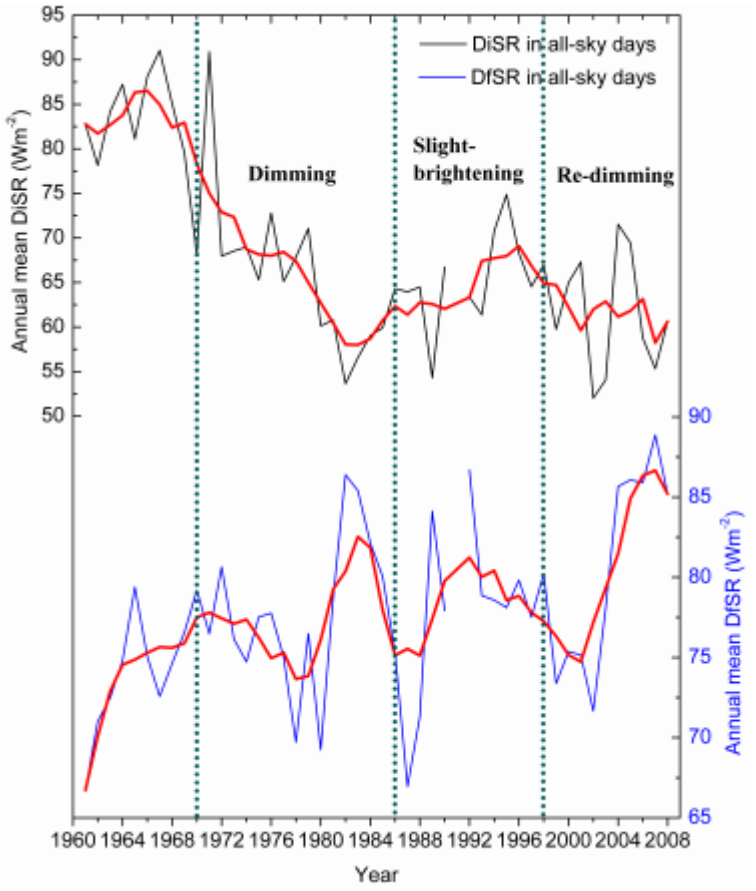

Fig. 2. Same as Fig. 1, but for all-sky days.

●The relationships between AOD and DiSR and DfSR

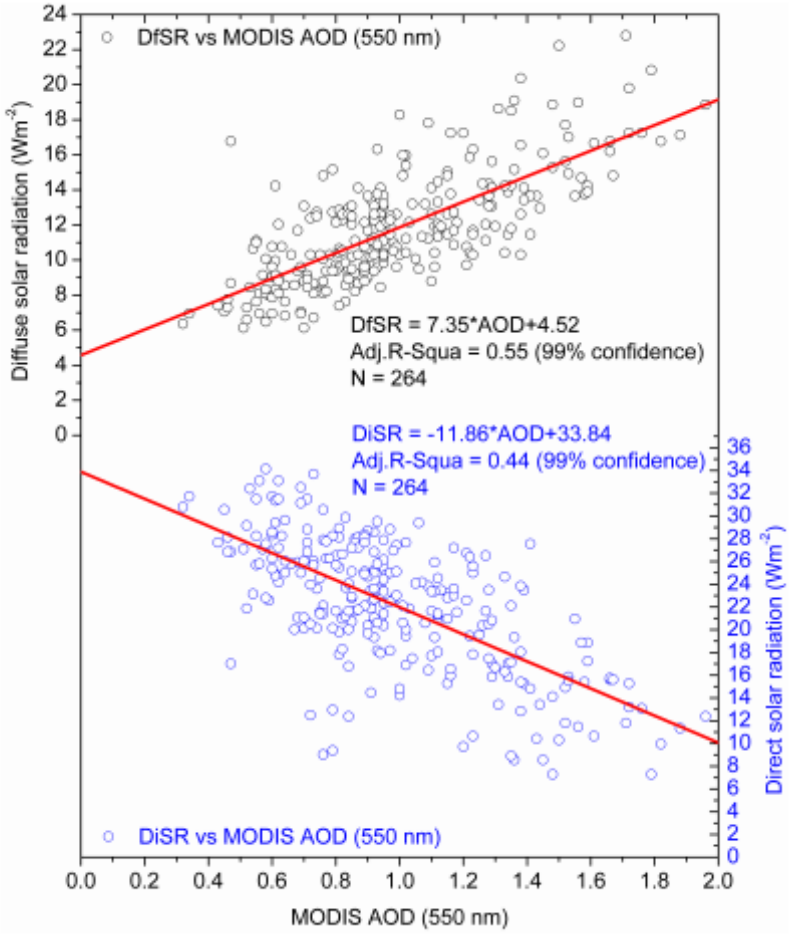

Fig. 3. Scatter plots of AOD and DfSR (denoted by black cycles on the top) and DiSR (denoted by blue cycles on the bottom) measured in spring from 2004 to 2007 in Shanghai. The AOD data is from the daily level 2 MODIS Aqua and Terra products (collection 005) at 550 nm. The DiSR and DfSR were measured during the satellite passage over this area. Linear fittings are red lines.

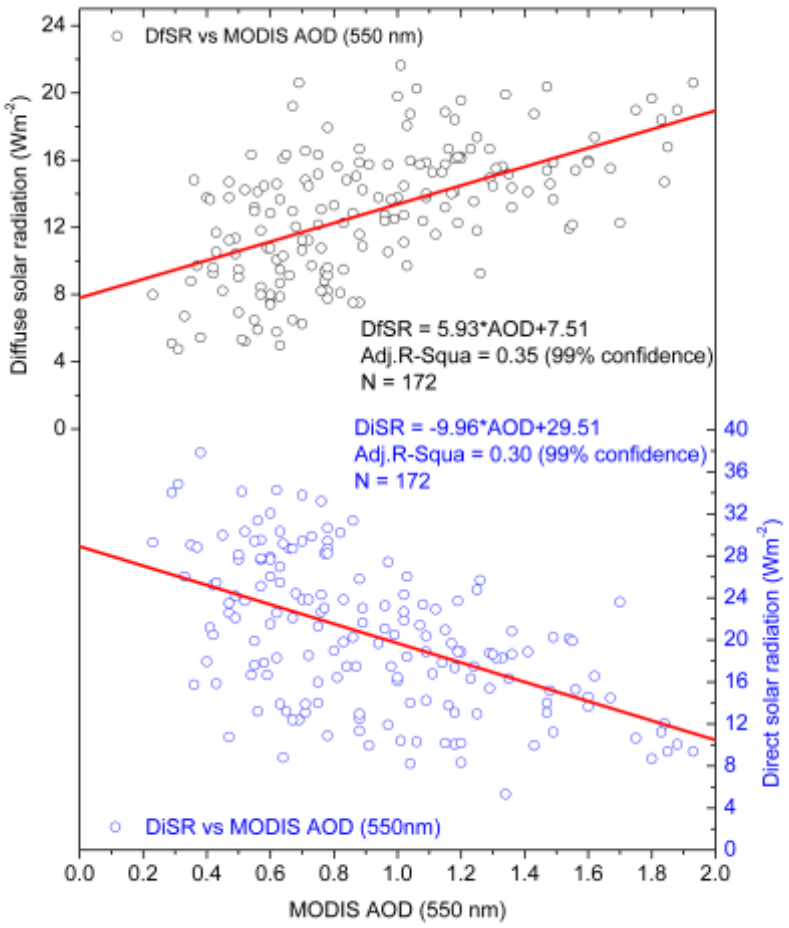

Fig. 4. Same as Fig. 3, but in summer.

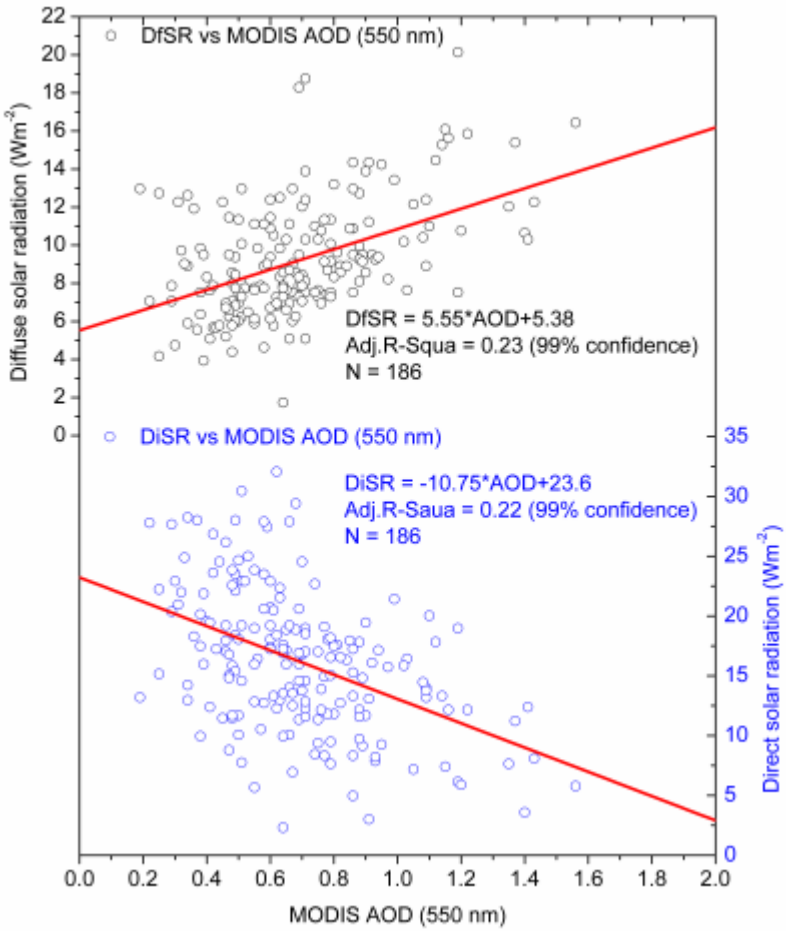

Fig. 5. Same as Fig. 3, but in autumn.

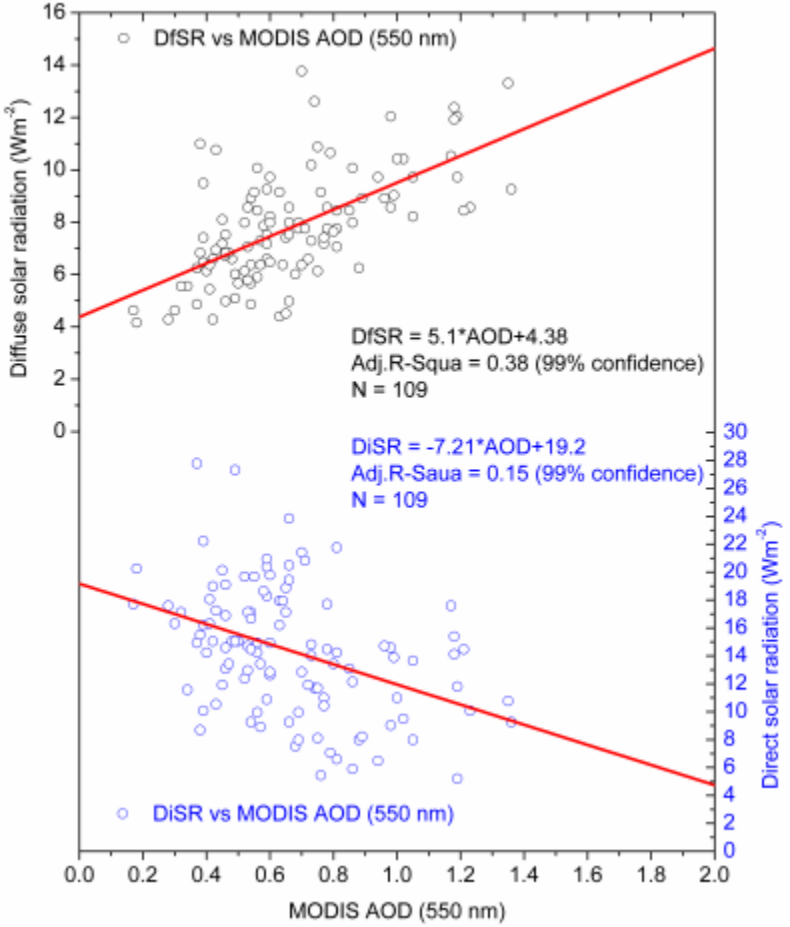

Fig. 6. Same as Fig. 3, but in winter.

●Weekly cycles of AOD, DiSR and DfSR

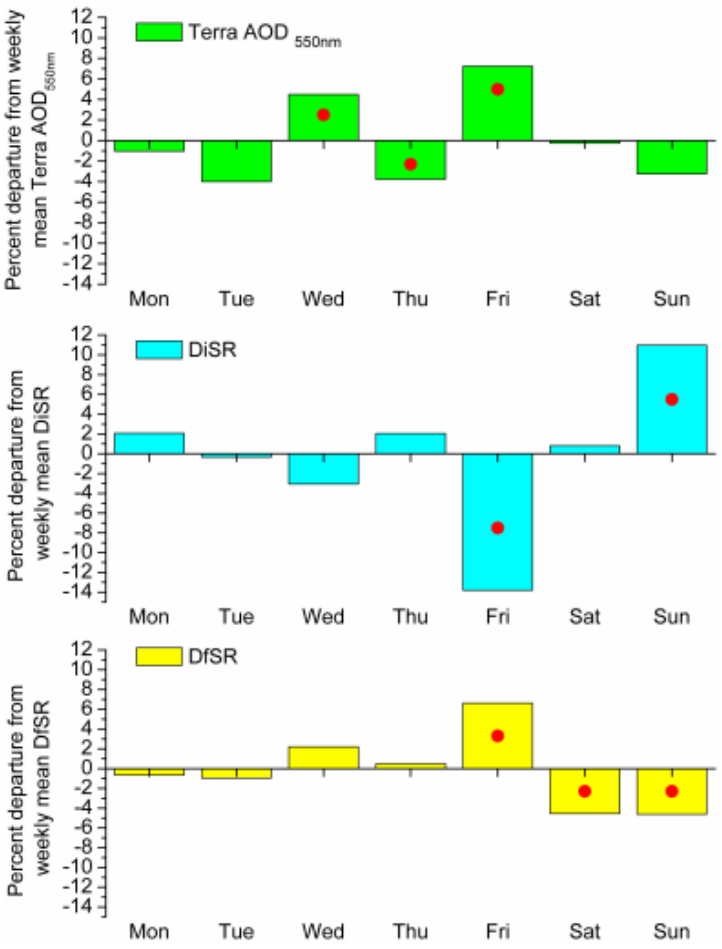

Fig. 7. Percentage departures of AOD (top), DiSR (middle) and DfSR (bottom) from their weekly averages in Shanghai. Red filled circles mean the departure from weekly average is above 90% confidence. The AOD data are from the MODIS Terra Level 2 products (collection 005) at 550 nm. Terra overpasses Shanghai between 09:00:00–10:00:00 LT each day. The DiSR and DfSR are measured from 09:00:00 to 10:00:00 LT, in line with the satellite passage. Statistical data range from 1 January 2004 to 31 December 2007.

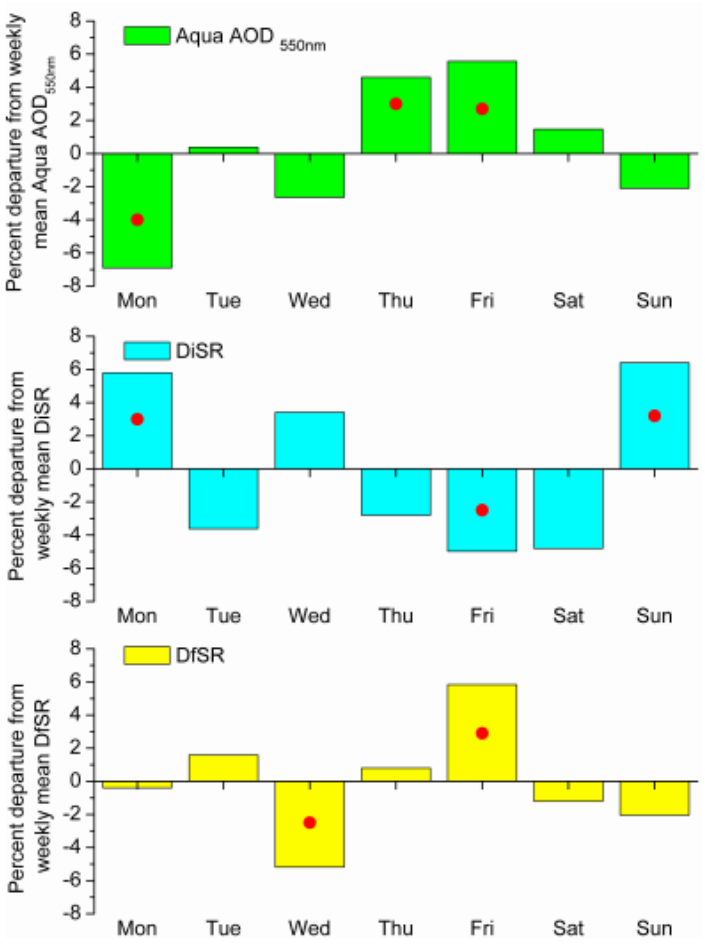

Fig. 8. Same as Fig. 7, but for the AOD data are from the MODIS Aqua products at 550 nm. Aqua overpasses Shanghai between 13:00:00–14:00:00 LT each day. The DiSR and DfSR data are measured from 13:00:00 to 14:00:00 LT, in line with the satellite passage.

Table 1. AOD Percentage Departure from Weekly Average at 440nm at Shanghai Pudong Site (%).

Mon	Tue	Wed	Thu	Fri	Sat	Sun
3.25	4.57	−2.82	15.5	−1.04	−17.6	−6.02

Conclusions

- The decadal variation of SSR, the dimming and brightening of DiSR and DfSR, respectively, on clear-sky days are the consequence of the decline in atmospheric transparency due to the change of aerosol emissions.
- Aerosol loading related to anthropogenic activities is an important modulator for decadal variation of SSR.
- In addition to aerosol loading, the aerosol composition is also related to its scattering and absorption characteristics, that is a key in understanding the contribution of anthropogenic aerosols on SSR.

Thanks!