

Global dimming and brightening: recent developments in China

Martin Wild¹, Matthias Schwarz¹, Yawen Wang², Su Yang³,
Bart Sweerts¹, Doris Folini¹ and Jörg Trentmann⁴

(1) Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland; (2) School of Atmospheric Sciences, Sun Yat-Sen University, Zhuhai, China; (3) National Meteorological Information Centre, China Meteorological Administration, Beijing, China; (4) German Weather Service, Offenbach, Germany.

martin.wild@env.ethz.ch

Abstract

There is growing evidence that the amount of solar radiation at the Earth's surface is not stable over time but undergoes substantial multidecadal variations. Particularly, a decrease in surface solar radiation has been noted from the 1950s to the 1980s at widespread observation sites, a phenomenon popularly known as “global (solar) dimming”, followed by a partial recovery known as “brightening”. An interesting hotspot in this context is China, where surface solar radiation (SSR) underwent particularly large changes over the past decades.

Here we point to our latest studies, which shed new light on the magnitude, causes and implications of this phenomenon in China. The focus is on recent developments, which indicate, that after decades of decline in surface solar radiation, some recovery can be noted since the mid-2000s in the SSR records observed by the Chinese Meteorological Agency (Yang et al., 2018, Wang et al. 2019). This recovery is not seen in satellite derived records, which assume a constant aerosol climatology in their retrieval algorithm, suggesting the necessity for a decrease in aerosol to reconcile the diverging trends (Wang et al., 2019). This is independently supported by analyses of SSR trends specifically in the cloud-free atmosphere, which show a turn into increase in recent years both in total and direct surface solar radiation, as well as a decrease in diffuse radiation, also suggesting a recent reduction of aerosol over China (Yang et al., 2019; Wang et al. 2020).

In a further study recently published in Nature Geoscience, the combination of the Chinese SSR observations with collocated space-based measurements of the net solar exchanges at the Top of Atmosphere from CERES enabled the determination of changes in solar absorption within the atmospheric column as a residual over recent decades. The results suggest that the recent brightening in China is predominately caused by a weakening of the solar absorption within the atmosphere. This indicates that a reduction of particularly the absorbing aerosol must have taken place in recent years (Schwarz et al., 2020).

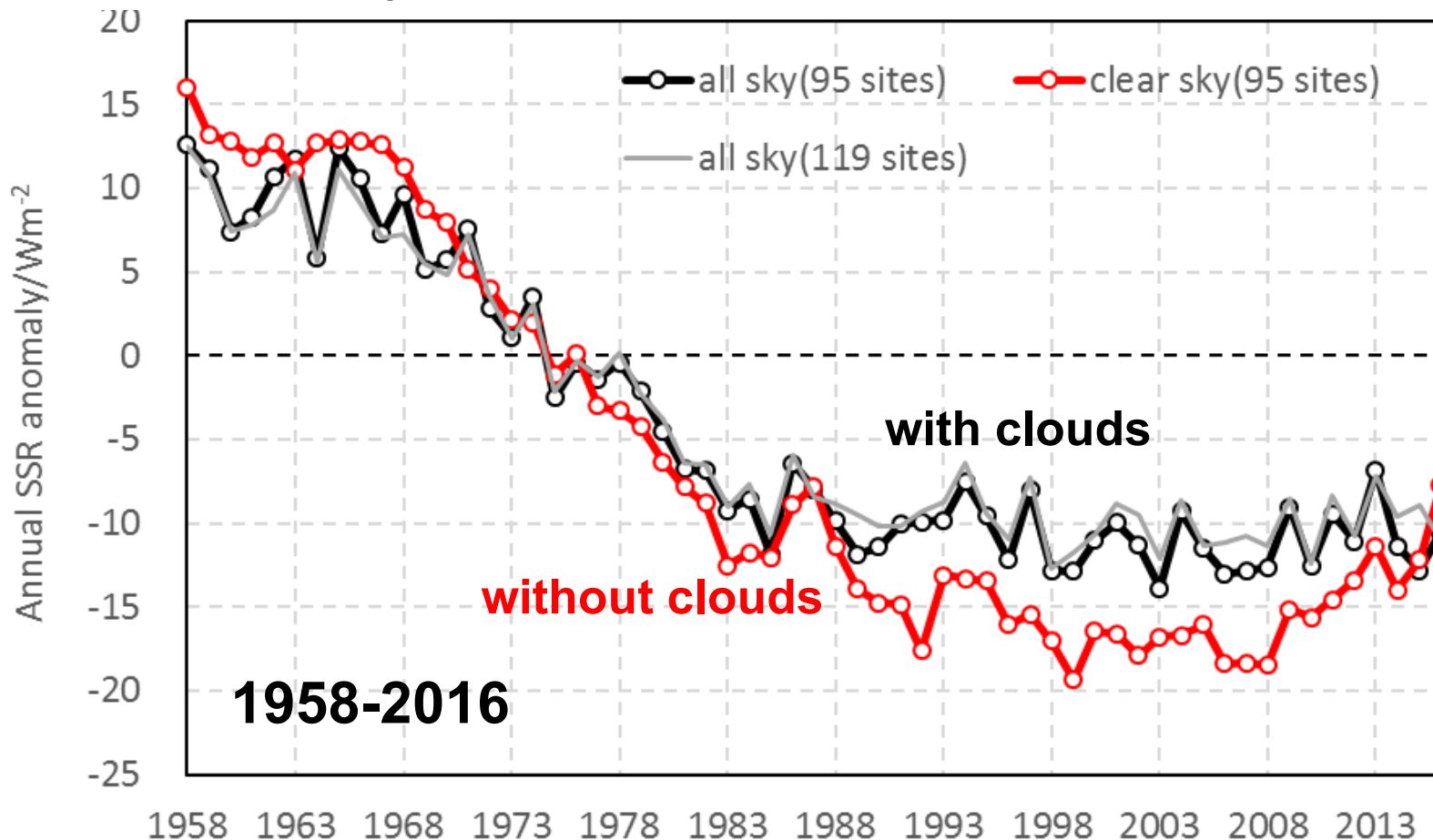
In summary, all these studies provide independent evidence that air pollution mitigation efforts in China have successfully induced a trend reversal in the amount of solar radiation reaching the Earth's surface, with some recovery in recent years after decades of dimming.

We further estimate in a study in Nature Energy that, if such a recovery could persist and air pollution levels could eventually be reduced to the pristine 1960s levels in China, this would have major benefits for Chinese photovoltaic (PV) solar power production, which could be enhanced by as much as 13 %. With the PV capacity currently installed in China, and as projected for the year 2030, this corresponds to a yearly economic benefit of 2 and 6 billion US dollars, respectively, assuming current electricity prices (Sweerts et al., 2019).

Associated references given on final slide

Surface solar radiation changes with and without clouds

Area weighed composite of 95 observations sites in **China**



Clear sky determined from cloud synop data

Our recent related publications

- Yang, S., Wang, X.L., Wild, M. (2018) Homogenization and trend analysis of the 1958-2016 in-situ surface solar radiation records in China, *J. Climate* 31, 4529-4541.
- Yang, S., Wang, X.L., Wild, M. (2019) Causes of Dimming and Brightening in China Inferred from Homogenized Daily Clear-Sky and All-Sky in situ Surface Solar Radiation Records (1958–2016), *J. Climate* 32, 5901-5913.
- Sweerts, B., Pfenninger, S., Yang, S., Folini, D., van der Zwaan, B., Wild, M. (2019) Estimation of losses in solar energy production from air pollution in China since 1960 using surface radiation data. *Nature Energy* 4, 657-663.
- Wang, Y., Trentmann, Y., Pfeifroth, U., Yuan, W., Wild, M. (2019) Improvement of air pollution in China inferred from changes between satellite-based and measured surface solar radiation, *Remote Sens.* 11, 2910.
- Schwarz, M., Folini, D., Yang, S., Allan, R.P., and Wild, M. (2020) Changes in atmospheric shortwave absorption as important driver of dimming and brightening, *Nature Geoscience* 13, pages 110–115.
- Wang, Y. Yang, S., Sanchez-Lorenzo, A., Yuan, W., and Wild, M. (2020), Revisit of Direct and Diffuse Solar Radiation in China based on Homogeneous Surface Observations: Climatology, Trends and Probable Causes, *J. Geophys. Res.* (in press)