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Effects of potential factors on changes in surface solar radiation in East China over recent decade

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Previous studies have documented that the surface solar radiation (SSR) over most regions of China has shifted from the 'global dimming' since the 1950s to the 'global brightening' after 2005. In this paper, the potential factors that affect the annual trends of SSR over East China from 2005 to 2018 based on different satellite-derived products are analyzed. Then, due to the lack of long-term various aerosol species from observation data, the focus of this study is to calculate the contributions from direct effects of different types of cloud fraction on SSR relative to the effects of total cloud fraction over East China during the same period using a BCC_RAD radiative transfer model. The results show that clouds and aerosols are the primary factors that affect the SSR over East China from 2005 to 2018, followed by water vapor and ozone.

The annual mean all-sky SSR from 2005 to 2018 is significantly increased over the North China Plain, Northeast China, Yunnan, and Eastern Sichuan provinces, with the increases up to 0.6 W m^{-2} yr^{-1}. This is probably due to the combined reductions of aerosols and clouds during this period, but clouds even play a more important role over Shanxi and northern Shaanxi. Changes in aerosols dominate the increase of SSR over Hunan, Jiangxi, and Fujian provinces, whereas clouds contribute more to the decreases of SSR over Guangdong, Guangxi, Guizhou, and Zhejiang provinces. Meanwhile, the simulations indicate that the marked annual mean decreases in high cloud fraction, especially for low cloud fraction, are the main causes of simulated increases in SSR due to total cloud fraction over most regions of East China, while the increases in high, medium-high, especially for medium-low cloud fraction, play more important roles in reductions of SSR over southern China. Moreover, the direct effects of various types of cloud fraction on changes in SSR for each season are also examined. It seems that the direct effects of low cloud fraction on SSR are likely the strongest among all kinds of clouds. Take southern China as an example, the direct effects of medium-low and low cloud fraction are stronger for spring and autumn, while contributions from low cloud fraction are largest in winter. However, the combined increases in high, medium-high, medium-low cloud fraction exceed decreases in low cloud fraction, thus causing the reduction in SSR in summer. This study highlights that different types of clouds may have different impacts on SSR not only on the annual mean scale but also on seasonal scales.

Keywords: surface solar radiation, aerosols, different types of cloud fraction