EGU24-17804, updated on 13 Feb 2025
https://doi.org/10.5194/egusphere-egu24-17804
EGU General Assembly 2024

Effects of long-term changes in anthropogenic aerosol emissions on shortwave radiative flux and cloud variables over the North Pacific

Jingyi Liu[1,2], Ken Carslaw[1], Daniel Grosvenor[1], Xin Huang[2], and Aijun Ding[2]
[1]Institute for Climate and Atmospheric Science, University of Leeds, Leeds, United Kingdom
[2]School of Atmospheric Sciences, Nanjing University, Nanjing, China

China's high-intensity anthropogenic emissions have strongly affected regional aerosols, weather and climate over recent decades. Affected by the typical circulations in the Asian monsoon region, aerosols over the North Pacific are closely related to emissions from China. However, how changes in aerosol emissions from China has affected changes in aerosols, clouds and radiation over the North Pacific on the timescale of decades have not been explored in detail.

In this study, using in situ and satellite observations together with model data, we investigate the long-term trends of anthropogenic emissions, aerosols, cloud properties and top-of-atmosphere (TOA) net downward shortwave radiation flux ($F_{sw\square}$) over China and the North Pacific, and discussed the potential effects of aerosol on changes in $F_{sw\square}$ over the North Pacific. Anthropogenic emissions in China have undergone significant changes in the past few decades, 1960-2020. They show a similar increasing trend before 2000 and then start to fluctuate and decline. The significant turning points of observed visibility and $PM_{2.5}$ occur around 2000 and 2013 due to the successive implementation of clean air policies. The coefficient of correlation between the two regions is 0.857 for Aerosol Optical Depth (AOD) and 0.953 for Aerosol Index (AI), indicating that aerosols in the two regions are highly correlated.

We use the MERRA-2 model outputs to investigate the $F_{sw\square}$ trends and diagnose the potential impact of aerosols on shortwave radiative fluxes. The $F_{sw\square}$ over the North Pacific shows a faster decline trend (-0.16 W m^{-2} y^{-1}) compared to the trend without aerosols (-0.11 W m^{-2} y^{-1}) during 1980-2000 (defined as the pre-2000 period), which is mainly driven by the enhanced cooling effect of increasing aerosols associated with growth in the anthropogenic emissions of East China. However, the $F_{sw\square}$shows an upward trend (+0.12 W m^{-2} y^{-1}) during 2000-2020 (the post-2000 period), accompanied by a downward trend of cloud droplet number concentration (decreased by 13.9% during 2003-2020). The cooling effect of aerosols causes an overall reduction in the annual mean values of $F_{sw\square}$ of 3.5 W m^{-2} in the pre-2000 period,and 2.9 W m^{-2} in the post-2000 period, indicating that the aerosol forcing is weakened by 17%. To understand the trends and explore the dominant driven factors of $F_{sw\square}$ in different periods, we use multiple simulations of the UK Earth System Model. We will show the contributions of anthropogenic emissions to trends in aerosol-radiation interactions (ARI) and aerosol-cloud interactions (ACI) over the North Pacific, and quantify how changes in aerosol and other climate variables have contributed to the observed

trends in $F_{sw\square}$ over the North Pacific caused by changes in cloud droplet concentrations, cloud fraction and liquid water path.