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Estimation of aerosol direct radiative effects on surface PAR radiation at Xianghe, Northern China

Siya Shao and Jing Zhang
College of Global Change and Earth System Sciences, Beijing Normal University, Beijing, China

In northern China, anthropogenic activities cause emissions of large amount of aerosol particles to the atmosphere. Such particles could alter the radiation balance directly by scattering and absorbing incident solar radiation, thus decrease the amount of light reaching the surface and increase the fraction of diffuse radiation. By using the aerosol data obtained from both the Aerosol Robotic Network (AERONET) and Moderate Resolution Imaging Spectroradiometer (MODIS), aerosol effects on surface photosynthetically active radiation (PAR) are explored in this study. PAR is quantitatively estimated using the NCAR Tropospheric Ultraviolet-Visible (TUV) radiation transfer model, with the influence of clouds taken into account through sunshine-duration data and the diffuse PAR calculated with diffuse radiation empirical models. This method is examined against the observations of PAR under all-sky conditions at Xianghe, northern China, and a significant linear correlation between the measured and estimated PAR is obtained with R of 0.96 and relative error of 8.47%. Aerosol effects on PAR are thus evaluated with this method. Compared with the background aerosol loading (defined as aerosol optical depth = 0.05), the monthly average PAR under present aerosol level for May, June, July and August decreases 20.65, 26.17, 17.38 and 17.84 W/m2 respectively, while the diffuse PAR for the four months increases 14.03, 21.39, 7.29, and 5.44 W/m2 respectively. The mean ratios of global and diffuse PAR under present aerosol level to that under background aerosol loading for this period are 82.9% and 130% respectively. It is found that the diffuse PAR is determined predominantly by clouds and to a lesser extent by aerosol loading. For days with high cloud transmittance, aerosols could significantly increase the diffuse PAR. In contrast, clouds with very low transmittance causes high ratio of diffuse to global PAR, and aerosols could even decrease both global and diffuse PAR. The effects of such changes induced by aerosols on plant productivity would be further studied.