TOOLS OF THE TRADE

Untangling aerosols from the sky with sunphotometers

Aerosols play essential roles in Earth's climate through the direct scattering and/or absorption of solar radiation, and by acting as cloud condensation nuclei (CCN) and ice nuclei (IN). In addition, aerosols can lead to environmental problems such as hazes, which impair ecosystems, pose risks to human health and decrease visibility. As aerosols are highly variable in space and time, their impact on anthropogenic climate change is difficult to quantify and requires accurate knowledge of their optical and microphysical properties. Even small errors in aerosol scattering and/or absorption measurements can change the sign of their estimated radiative effect. However, commonly used instruments for measuring aerosol parameters, such as satellite sensors, only provide limited retrieval of aerosol parameters with relatively large uncertainties. Comprehensive monitoring of aerosol properties requires measuring both direct solar radiance and scattered sky radiance, including angular and polarized signals, which can be achieved with ground-based sun-tracking photometers.

Sunphotometers are designed to automatically track the sun, providing column aerosol optical depth retrievals at several wavelength bands ranging from 340–1640 nm

at an accuracy of ± 0.01 from these data. More importantly, they are also designed to measure scattered radiance in the two different sky-radiance modes, which can be combined with sun measurements to derive other key parameters such as aerosol single scattering albedo, phase function, asymmetry parameter, complex refractive index and size distribution. Aerosol optical depth reflects total aerosol loadings, single scattering albedo is a measure of how absorptive and reflective they are, and the phase function tells us in which directions they scatter the light. All these are required to understand the perturbation that aerosols exert on the radiation budget.

Sunphotometers are used to monitor aerosol pollution in Beijing and to study the major aerosol types and their radiative effects in China. They are also used globally, such as in the Aerosol Robotic Network (AERONET) established by NASA. Continuous long-term observations by AERONET offer key information to identify aerosol types and sources, to improve climate models and to estimate their impacts on global scale. Data from AERONET are also widely used to validate and improve satellite-based aerosol measurements, advancing our understanding

Credit: Jing Li

of aerosols in the climate system. By combining these data with satellite and visibility measurements, we hope to generate a global aerosol optical parameter dataset.

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