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Review of Surface Particulate Monitoring of Dust Events Using Geostationary Satellite Remote Sensing

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Abstract

The accurate measurements of natural and anthropogenic aerosol particulate matter (PM) is important in managing both environmental and health risks; however, limited monitoring in regional areas hinders accurate quantification. This article provides an overview of the ability of recently launched geostationary earth orbit (GEO) satellites, such as GOES-R (North America) and HIMAWARI (Asia and Oceania), to provide near real-time ground-level PM concentrations (GLCs). The review examines the literature relating to the spatial and temporal resolution required by air quality studies, the removal of cloud and surface effects, the aerosol inversion problem, and the computation of ground-level concentrations rather than columnar aerosol optical depth (AOD).

Determining surface PM concentrations using remote sensing is complicated by differentiating intrinsic aerosol properties (size, shape, composition, and quantity) from extrinsic signal intensities, particularly as the number of unknown intrinsic parameters exceeds the number of known extrinsic measurements. The review confirms that development of GEO satellite products has led to improvements in the use of coupled products such as GEOS-CHEM, aerosol types have consolidated on model species rather than prior descriptive classifications, and forward radiative transfer models have led to a better understanding of predictive spectra interdependencies across different aerosol types, despite fewer wavelength bands. However, it is apparent that the aerosol inversion problem remains challenging because there are limited wavelength bands for characterising localised mineralogy.

The review finds that the frequency of GEO satellite data exceeds the temporal resolution required for air quality studies, but the spatial resolution is too coarse for localised air quality studies. Continual monitoring necessitates using the less sensitive thermal infra-red bands, which also reduce surface absorption effects. However, given the challenges of the aerosol inversion problem and difficulties in converting columnar AOD to surface concentrations, the review identifies coupled GEO-neural networks as potentially the most viable option for improving quantification.

Keywords: Geostationary Earth Orbiting satellites; Aerosol Optical Depth; Particulate Matter; Thermal infra-red; spatiotemporal resolution.

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