Atmospheric Aerosol Measurements on Cloudy Days: a New Method

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Research Highlight

Satellites monitor the aerosol loading (or pollution level) in the atmosphere by measuring the amount of reflected sunlight. However, nearby broken clouds bounce sunlight around, making aerosols seem brighter than they really are. This, in turn "fools" satellites into thinking that the atmosphere is more polluted (has larger aerosol loading) than it really is. For example, previous studies have shown that clouds can brighten aerosols by 10-15%, overestimating the aerosol loading by 140%.

To address cloud-induced glare problem, we took advantage of the fact that clouds largely reflect almost the same amount of light regardless of its wavelength in the visible spectral range. Aerosols, on the other hand, reflect sunlight at different wavelengths to differing degrees. As a result, the three-dimensional (3D) cloud effects caused by surrounding clouds may be proportional at different wavelengths. We suggested that ratios of sunlight reflectance at different wavelengths can eliminate substantially the 3D effects of cloud and make aerosol measurements much more accurate.

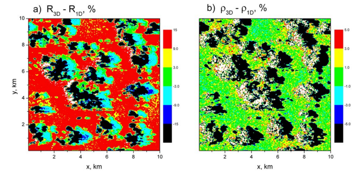
The performance of a new method, which is based on reflectance ratio, was illustrated with a model-output inverse problem. We simulated synthetic reflectances at 470, 660, and 870 nm by using the 3D fields of cumulus clouds and aerosols generated by a Large-Eddy Simulation (LES) model. The LES simulations were performed for typical summertime conditions at the ARM Climate Research Facility (ACRF) Southern Great Plains (SGP) site. Then we converted synthetic reflectance ratios (470, 660 nm) and (470, 870 nm) into retrieved values of aerosol optical depth (AOD) at three wavelengths (470, 660, and 870 nm), and compared retrieved and true AOD values. The difference was within 10% and 1% for pixel-based and domain-averaged values, respectively.

We demonstrated that the new method provides an effective way to avoid the 3D cloud effects and has the potential for accurate estimation of AOD in the presence of broken clouds. Thus, this approach could be considered as a potential research tool to study complex relationship between aerosols and clouds and estimate their impact on the regional and global climates.

Reference(s)

Kassianov, E.I., and M. Ovtchinnikov. 2008. "On reflectance ratios and aerosol optical depth retrieval in the presence of cumulus clouds." Geophys Res Lett, doi:10.1029/2008GL033231.

Working Group(s)
Aerosol



Cloud-induced glare causes 10-15% difference between 3D and 1D reflectances (470 nm) for clear patches in simulated satellite view of partly cloudy sky (left). The ratio method clears up the glare, reducing the difference to 1-2% outside the clouds and their shadows (right). R is reflectance (dimensionless) and ρ is the ratio of reflectances at two wavelengths (470 and 660 nm), in both 3D and 1D. The legend bar to the right of each panel indicates the "percentage" of glare using each method.