Air-mass factor formulation for spectroscopic measurements from satellites: Application to formaldehyde retrievals from the Global Ozone Monitoring Experiment

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Abstract

We present a new formulation for the air mass factor (AMF) to convert slant column measurements of optically thin atmospheric species from space into total vertical columns. Because of atmospheric scattering, the AMF depends on the vertical distribution of the species. We formulate the AMF as the integral of the relative vertical distribution (shape factor) of the species over the depth of the atmosphere, weighted by altitude-dependent coefficients (scattering weights) computed independently from a radiative transfer model. The scattering weights are readily tabulated, and one can then obtain the AMF for any observation scene by using shape factors from a three dimensional (3-D) atmospheric chemistry model for the period of observation. This approach subsequently allows objective evaluation of the 3-D model with the observed vertical columns, since the shape factor and the vertical column in the model represent two independent pieces of information. We demonstrate the AMF method by using slant column measurements of formaldehyde at 346 nm from the Global Ozone Monitoring Experiment satellite instrument over North America during July 1996. Shape factors are computed with the Global Earth Observing System CHEMistry (GEOS-CHEM) global 3-D model and are checked for consistency with the few available aircraft measurements. Scattering weights increase by an order of magnitude from the surface to the upper troposphere. The AMFs are typically 20-40% less over continents than over the oceans and are approximately half the values calculated in the absence of scattering. Model-induced errors in the AMF are estimated to be ~10%. The GEOS-CHEM model captures 50% and 60% of the variances in the observed slant and vertical columns, respectively. Comparison of the simulated and observed vertical columns allows assessment of model bias.

The full text of this paper is available as a postscript file.