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Simultaneous Retrieval of Atmospheric CO_2 and Effective Aerosol Properties From Simulated Space Borne Observations of Backscattered Near-Infrared Sunlight

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Forthcoming satellite missions such as the Orbiting Carbon Observatory (OCO) and the Greenhouse Gases Observing SATellite (GOSAT) target at inferring atmospheric CO_2 abundances with high accuracy and global coverage. These missions will measure spectra of near-infrared sunlight backscattered by the Earth‘s surface and atmosphere covering two near-infrared CO_2 absorption bands and the O_2 A band. For CO_2 retrievals from such measurements, light path modification due to aerosol and cirrus cloud scattering has been identified as a major source of error if not appropriately accounted for in the retrieval scheme. Neglecting aerosol and cirrus effects in the retrieval can cause errors of several percent in retrieved CO_2 strongly depending on particle amount, size, type and height distribution, ground surface properties, and viewing geometry.

Here, we present a retrieval method that simultaneously infers aerosol properties and total column CO_2 from OCO-type nadir observations over land surfaces. The goal of our approach is to account for the effect of aerosols and cirrus clouds on retrieved CO_2. The core of the retrieval scheme is a vector radiative transfer model that simulates the radiance measured by a space borne observer given input aerosol and molecular optical properties. We propose a retrieval method that infers a few effective aerosol properties of a simplified aerosols microphysical model. A Levenberg-Marquardt least-squares method is setup to test performance of our approximate aerosol forward model for an ensemble of simulated spectra.

The trial ensemble covers a wide range of aerosol types, sizes and height distributions as well as land surface scenes. Further, we consider cirrus clouds overlaying the background aerosol. Trial spectra are generated using multi-parameter aerosol and cirrus cloud models that allow for a detailed representation of aerosol and cirrus effects on spectra recorded by an OCO-like observer. Here, we aim at quantifying the residual forward model bias for retrieved CO_2 when applying the approximate retrieval model to the trial ensemble.

Preliminary results indicate that the proposed retrieval method reduces aerosol and cirrus induced CO_2 errors to mostly below 1 per cent for aerosol and cirrus optical thickness up to 0.3 and 0.1, respectively. Retrieval performance is best for aerosol-only scenes at moderate solar zenith angle (SZA) largely independent of ground surface and aerosol type. Cases including aerosol and cirrus particles are more challenging than aerosol-only scenes. In general, retrieval performance is better for moderate than for high solar zenith angles.