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Simultaneous retrieval of greenhouse gas concentrations and atmospheric scattering properties: first application to GOSAT observations

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The Netherlands Institute for Space Research (SRON) has developed a method for the simultaneous retrieval of greenhouse gas concentrations and atmospheric scattering properties from space-based measurements of backscattered shortwave-infrared (SWIR) sunlight [Butz et al., 2009]. The method is dedicated to current and future satellite missions such as the Japanese Greenhouse gases Observing SATellite (GOSAT) and the American Orbiting Carbon Observatory (OCO). Observations by GOSAT orbiting the Earth since January 2009 provide a promising first application for our approach. Here, we present preliminary retrieval exercises and first results for deducing the atmospheric CO_2 concentration from GOSAT's spectra in the SWIR spectral range.
The SRON-approach is based on a vector radiative transfer model (RTM) that models the backscattered sunlight in a plane parallel, multi-layered, inhomogeneous atmosphere. The RTM takes into account absorption and scattering by molecules as well as particles such as aerosols and cirrus clouds. Thereby, the RTM is capable of treating multiple scattering and polarization effects at the expense of high computational cost. We consider scattering properties of the atmosphere through 3 effective parameters that account for the amount, the size, and the height distribution of scatterers. Retrieval simulations have shown, that GOSAT's observations in the O_2 A-band, in the weakly absorbing CO_2 bands around 1.6 micron, and in the strongly absorbing CO_2 bands around 2.06 micron contain enough information to simultaneously retrieve these 3 scattering parameters and the column-average CO_2 concentration. Retrieval performance for a synthetic ensemble of aerosol and cirrus contaminated scenes is convincing since our method reduces the aerosol and cirrus induced retrieval errors for CO_2 to mostly below 1% up to scattering optical thickness 0.5. We further demonstrated that the strongly absorbing CO_2 band around 2.06 micron alone might carry sufficient information for the simultaneous retrieval of CO_2 and 2 scattering parameters effectively representing the amount and the height distribution of scatterers. Retrieval performance for such a simplified setup is comparable to using all 3 SWIR bands.
When applying our approach to real GOSAT observations, our method so far cannot achieve the performance which has been indicated by retrieval simulations. We will discuss and illustrate potential reasons for this shortcoming. In particular, we identify inaccurate assumptions about radiometric calibration and spectroscopic line parameters as major obstacles on the way toward highly accurate CO_2 retrievals.

Butz, A., Hasekamp, O. P., Frankenberg, C., and Aben, I.: Retrievals of atmospheric CO_2 from simulated spaceborne measurements of backscattered near-infrared sunlight: accounting for aerosol effects, Appl. Opt., 48, 3322, doi:10.1364/AO.48.003322, 2009