Geophysical Research Abstracts,
Vol. 11, EGU2009-12144, 2009
EGU General Assembly 2009

Comparing Methods Dedicated to the Retrieval of Atmospheric CO_2 from Space Borne Observations of Backscattered Near-Infrared Sunlight

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The Orbiting Carbon Observatory (OCO) and the Greenhouse Gases Observing SATellite (GOSAT) target at inferring atmospheric CO_2 abundances with high accuracy and precision and global coverage. The observational strategy relies on measuring sunlight backscattered by the Earth's surface and atmosphere of two near-infrared CO_2 absorption bands and the O_2 A band. Several methods are proposed to retrieve the column average dry air mixing ratio XCO_2 from such measurements.

Commonly, these retrieval methods differ by the implementation of the forward model that simulates the satellite measurements and by the inverse method that infers the target quantity XCO_2 given simulated and measured radiance spectra. The forward model itself consists of a radiative transfer model that requires input from several sub-modules providing information on spectroscopic line parameters, surface properties, atmospheric state variables and aerosol properties of the sampled air masses. Differences in the implementations of the forward model and the inverse method can result in significant biases in XCO_2 retrieved from the different algorithms.

Here, we aim at comparing different retrieval approaches and identifying and characterizing (and potentially removing) differences between them. Our bottom-up-approach starts with comparing radiance spectra generated by the forward models for simple scenarios such as purely Rayleigh scattering atmospheres so that the radiative transfer model and the treatment of molecular absorption and atmospheric state variables can be verified. Then more complex scenes such as aerosol loaded atmospheres where polarization of radiation is important are considered. To this end we simulate an ensemble of radiance spectra by either of the considered retrieval methods and cross-retrieve XCO_2 among all approaches. These retrieval comparisons will then allow us to draw conclusions on differences in XCO_2 introduced by the inherent assumptions of the forward models and inverse methods, which has to be taken into account when interpreting the OCO and GOSAT XCO_2 data products.