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The Orbiting Carbon Observatory (OCO-2) L2 Retrieval Algorithm: First Tests With Greenhouse gases Observing SATellite (GOSAT) Data

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The Japanese Greenhouse gases Observing SATellite (GOSAT) and the NASA Orbiting Carbon Observatory (OCO) were the first satellites designed specifically to measure the column averaged carbon dioxide (CO_2) dry air mole fraction, X_{CO_2}, from space with the precision needed to quantify CO_2 fluxes on regional scales. GOSAT was successfully launched on 23 January 2009, and has been returning data since April 2009. The OCO mission was lost on 24 February 2009, when its launch vehicle malfunctioned and failed to reach orbit. In early 2010, NASA authorized a re-flight of OCO, called OCO-2, which is currently under development. If all goes as planned, OCO-2 will be launched by 2015.

Soon after the loss of OCO, the GOSAT Project team invited the OCO-2 science team join their effort to retrieve X_{CO_2} from GOSAT measurements. The OCO/OCO-2 retrieval algorithm was easily adapted for this task because it was designed to retrieve X_{CO_2} from high resolution spectra of reflected sunlight recorded in the same short wave infrared CO_2 and molecular oxygen (O_2) A-bands collected by the GOSAT Thermal And Near infrared Sensor for carbon Observations - Fourier Transform Spectrometer (TANSO-FTS).

The OCO/OCO-2 retrieval algorithm incorporates the following major components: (i) A pre-processing module identifies cloud-free soundings and initializes the surface-atmosphere state and observing geometry for each. (ii) The 'forward' radiative transfer model then generates polarization-dependent, synthetic spectra and radiance Jacobians for atmospheric paths including absorption and scattering by gases (CO_2, O_2, H_2O) as well as optically-thin clouds and aerosols over Lambertian or ocean glint surfaces. (iii) The synthetic spectrum is convolved with a TANSO-FTS instrument model to simulate the observed spectral resolution and polarimetric throughput. (iv) An inverse model, based on Bayesian optimal estimation, updates the surface-atmosphere state to minimize differences between the observed and simulated spectra, within the constraints imposed by the assumed a priori state vector. Steps (ii)-(iv) are repeated until convergence is reached. (v) Finally, a post-processing screening step is performed to identify and reject bad retrievals.

This algorithm has been used to retrieve X_{CO_2} from all routine GOSAT science observations collected since April 2009. These retrievals have been validated against ground based remote sensing observations of X_{CO_2} from the Total Carbon Column Observing Network (TCCON). Recent comparisons of the GOSAT and TCCON retrievals show little or no global X_{CO_2} bias and typical accuracies of $\sim$2 ppm on regional scales. This experience is continuing to provide valuable insights into the retrieval of X_{CO_2} from space based measurements, and is expected to accelerate the delivery of high quality products from OCO-2, once it is launched.