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Satellite and Ground-based evaluation of 1.61μm and 2.07μm CO_2 absorption models for the OCO-2 mission

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We describe new 1.61μm and 2.07μm CO_2 cross section models for the Orbiting Carbon Observatory-2 (OCO-2) retrieval algorithm [1,2]. Once launched, OCO-2 will use these bands to estimate column-averaged CO_2 dry air mole fraction (X_{CO_2}). The mission objective is to achieve retrieval precisions of 0.3% or better; this demands highly accurate absorption models. State of the art CO_2 line parameter databases [3] in the 2.07μm region have combined Voigt line shapes with calculated line mixing parameters. This has significantly improved spectrum fits of atmospheric data but some systematic residuals still remain [3]. An empirical fit including the speed dependence of collisions may further reduce biases in fits to atmospheric spectra. This work evaluates new candidate cross section models that combine speed-dependent line shapes and line mixing parameters. These parameters are determined from multispectrum fitting to 29 high resolution laboratory absorption spectra recorded at room temperature with a Fourier transform spectrometer (FTS) [4].

We evaluate absorption cross sections using multiple atmospheric tests. First, we use the OCO-2 CO_2 retrieval algorithm to retrieve the column averaged CO_2 dry air mole fraction, X_{CO_2}, from solar-viewing ground-based FTS spectra recorded by the Total Carbon Column Observing Network (TCCON). We used soundings from the TCCON station in Park Falls, WI, USA collected in dry winter conditions. The high signal to noise ratios and spectral resolution ($\sim$0.02 cm^{-1}) of these spectra provided a stringent test of the absorption coefficients with minimal interference from non-CO_2 absorbers or scattering. A second set of tests use data from the TANSO-FTS spectrometer aboard the Greenhouse gases Observing SATellite (GOSAT). This set of over 400 spectra evaluates performance over a wider range of conditions using sunlight reflected from the Earth's surface. Absorption and multiple scattering were tested in these retrievals. For both TCCON and GOSAT spectra, the new absorption coefficient models reduce spectral residuals and improve the RMS deviation of the fit in the 2.07μm region by approximately 10%. We find qualitatively similar benefits to both downward- and upward-looking residuals. There are also small improvements in X_{CO_2} airmass bias. The effects on the 1.61μm band are less significant but still show modest improvement. GOSAT retrieval divergence from coincident TCCON X_{CO_2} measurements for these soundings is reduced from 1.50ppm (0.39%) to 1.39ppm (0.36%). The new models will be made available to the community.

Remaining challenges in these bands include accounting for continuum absorption and H_2O broadening of CO_2. Simulations suggest water broadening of CO_2 could cause worst-case effects of similar magnitude to the changes described above. Finally, downward-looking retrievals require accurate path length estimates from spectroscopic measurements of the oxygen A-band. Spectral fits in this region currently show significant errors, making it a potential source of retrieval biases and a target of ongoing investigation.

References:

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