



Retrieval of CO₂ vertical profile information from TCCON

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Mapping the sources and sinks of carbon flux is one of the principal challenges in the current study of the carbon cycle. Both ground measurements and spacecraft observations improve our understanding of the spatial and temporal distributions of carbon dioxide (CO₂) in the atmosphere. Although the sources and sinks are located near the surface, the vertical profile of CO₂ provides important information for understanding their global transport. The Total Carbon Column Observing Network (TCCON) is a network of ground-based Fourier Transform Spectrometers recording direct sunlight in the near-infrared spectral region. Its CO₂ product provides an essential validation resource for the Orbiting Carbon Observatory-2 (OCO-2), Scanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY), and Greenhouse gases Observing SATellite (GOSAT). Because of the high-resolution and high signal to noise measurements from the TCCON instrument, the profile information of atmospheric CO₂ is recorded in the absorption line shape.

The theoretical information content analysis shows that there are at least 2.6 degrees of freedom in the CO₂ retrievals from TCCON measurements. A vertically constrained retrieval from each TCCON spectrum could provide up to 3 pieces of vertical information. The synthetic profile retrieval confirms these results, with errors in XCO₂ of less than 0.05 ppm. In real measurement retrievals, aircraft observations of the CO₂ profile are treated as a true CO₂ profile. The spectra within \pm 1-hour window are considered as simultaneous measurements with aircraft data. The error in XCO₂ from this test is less than 0.6 ppm. Further work is expected about the retrievals with a subset of optimal channels. The analysis of the averaging kernel shows that the profile information is mostly from the strong absorption lines. The success of the vertical profile retrieval will contribute to the validation of space-borne observations.