The Total Carbon Column Observing Network (TCCON)

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ABSTRACT

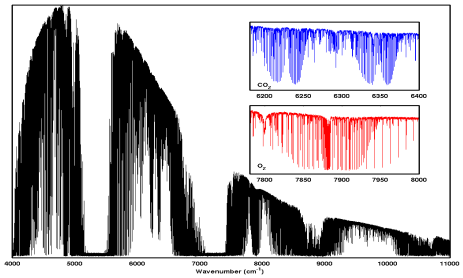
The Total Carbon Column Observing Network is a global network of ground-based Fourier transform spectrometers designed to measure column abundances of CO_2, CO, CH_4, N_2O and other molecules that absorb in the near infrared. With stringent requirements on the instrumentation, data processing and calibration, the network achieves an accuracy and precision that is unprecedented for remote sensing observations (better than 0.25%). This makes the TCCON a valuable tool for further understanding the carbon cycle, validating satellite measurements, and providing a link between satellite measurements and the extensive ground-based in situ network.

INTRODUCTION

The Total Carbon Column Observing Network (TCCON) was established in 2004 with a primary focus of measuring precise and accurate columns of CO_2. Currently, there are 19 sites affiliated with TCCON, 15 of which are currently operational.

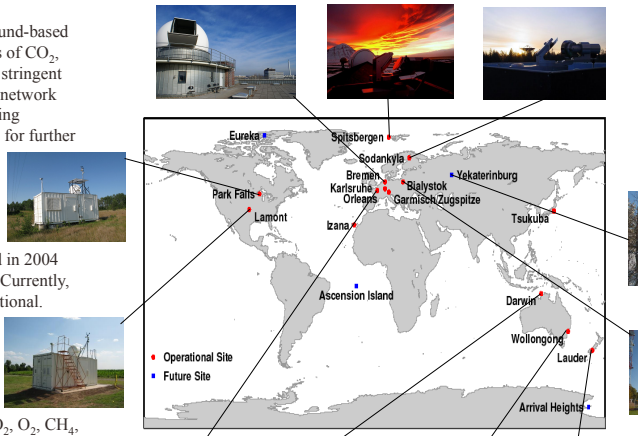
INSTRUMENTATION

The central instrument at each TCCON site is a high-quality, high-spectral-resolution Fourier transform spectrometer (FTS), into which direct solar radiation is passed by a solar tracker. The FTS instruments observe the absorption of solar radiation in the near infrared (NIR) by CO_2, O_2, CH_4, N_2O, CO and other molecules in the atmosphere.



INSTRUMENTATION

- TCCON measures total column abundances of atmospheric gases.
- Helps disentangle the effects of atmospheric mixing from the surface exchange.
- Particularly useful are column-averaged dry-air mole fractions (denoted xG for gas G). Insensitive to variations in surface pressure and atmospheric water amount.
- Because the column vertically integrates the concentration of CO_2 above the surface, horizontal gradients in measured xCO_2 are more directly related to the underlying regional-scale fluxes than is the case for the surface in situ measurements of CO_2 (Yang et al., 2007).
- The latitudinal gradients in xCO_2 are small, and to improve upon our current knowledge of the carbon cycle requires measurements with precisions better than ~0.25% in xCO_2 (Rayner and O'Brien, 2001; Miller et al., 2007).



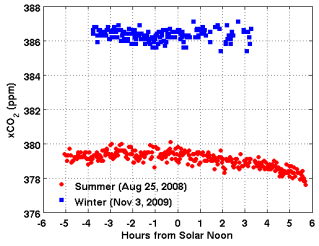
CALCULATION OF DRY-AIR MOLE FRACTIONS

Measured spectra are passed through the nonlinear least squares fitting algorithm GFIT, which computes total columns of the gases of interest for every spectrum. GFIT scales a priori VMR profiles to determine the best fit to the spectrum.

Dry-air mole fractions (denoted xG for gas G) are computed using the O_2 column to determine the total column of dry air:

$$xG = 0.2095 \frac{\text{column(G)}}{\text{column}(O_2)}$$

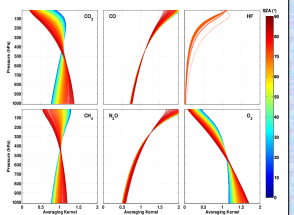
This results in very precise measurements of the DMF. The xCO_2 drawdown in Park Falls in summer (red) is clearly discernible, whereas in winter (blue), there is little variation.

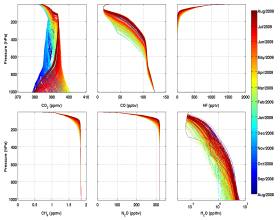


SATELLITE VALIDATION

- TCCON provides the ideal data for satellite validation. Measures column abundances, the same quantities as satellites. Measures same molecules in the same spectral regions.
- Apply Rodgers and Connor (2003) methods to compare TCCON to satellite data.

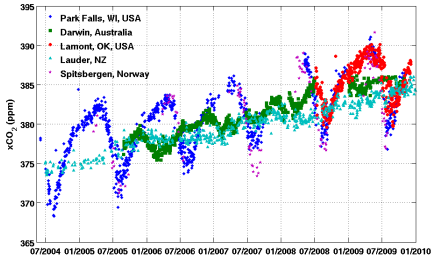
Column averaging kernels for TCCON





A priori profiles for TCCON

XCO_2 RESULTS



CONCLUSIONS

- The TCCON network includes 19 sites globally
- Produces time-resolved total column dry-air mole fractions of CO_2, CO, CH_4, N_2O, HF and H_2O.
- High accuracy (up to 0.2% in xCO_2) is achieved due to strict requirements on instrumentation, data processing and calibration
- We hope TCCON will become an increasingly valuable dataset for studies in carbon cycle science, satellite validation, and linking the satellite measurements to the ground-based in situ network.

Acknowledgments

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