Preliminary results from the Lauder site of the Total Carbon Column Observing Network TCCON

V. Sherlock[1], B. J. Connor[1], S. W. Wood[1], A. Gomez[1], G. C. Toon[2], P. O. Wennberg[3] and R. A. Washenfelder[3]

[1]National Institute of Water and Atmospheric Research, Wellington, New Zealand
[2]Jet Propulsion Laboratory, Pasadena, California, USA
[3]California Institute of Technology, Pasadena, California, USA

Abstract

In this poster we give a brief description of the Total Carbon Column Observing Network (TCCON), a new network of ground-based Fourier Transform spectrometers (FTS) dedicated to measurement of greenhouse gas absorption (CO_2, CO, CH_4, N_2O) in the near infrared.

We present preliminary retrievals of CO_2 total column densities from the TCCON site in Lauder, New Zealand between July 2004 – when routine measurements began – and April 2005, and compare these retrievals with in-situ CO_2 measurements from the surface monitoring network station at Baring Head, New Zealand.

A discussion of how we plan to compare the ground-based FTS retrievals with in-situ surface observations and greenhouse gas retrievals from satellite radiances follows.

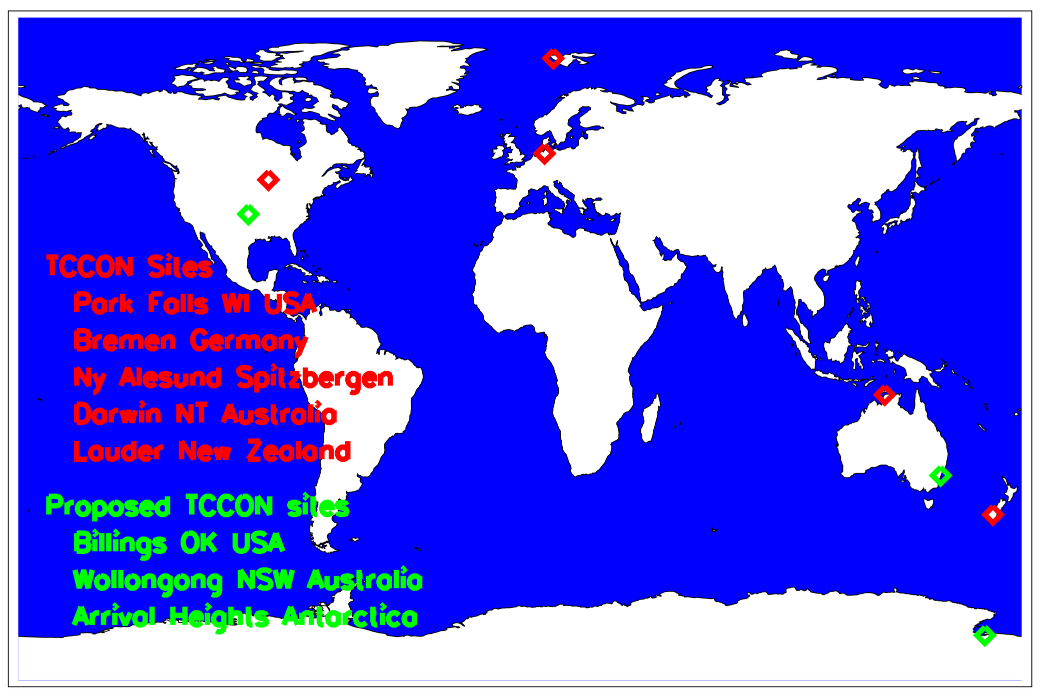
Overview of the TCCON network

TCCON is a global network of ground-based Fourier Transform spectrometers. Near infrared solar absorption spectra are acquired in the 4000–14000 cm^{-1} interval at 0.02 cm^{-1} resolution and analysed to retrieve CO_2, CO, CH_4, N_2O column densities and column average mixing ratios (denoted X_Y).

Column-integrated trace gas measurements are less sensitive to local sources and sinks and seasonal and diurnal rectifier effects than in-situ surface measurements.

However, if the TCCON network measurements are to provide useful additional constraints for the global carbon budget – both directly, and through validation of satellite column measurements – they must achieve a precision of 0.1% and an accuracy of 0.3%.

Accurate solar tracking, surface pressure measurements, spectroscopy and retrieval algorithms are all key to achieving



these error targets.

At each TCCON site the FTS measurement is complemented with measurements of surface pressure and in-situ surface trace gas concentrations. The FTS instrument line shape (ILS) is routinely monitored using a HCl cell.

Preliminary results from Lauder using a profile scaling retrieval algorithm

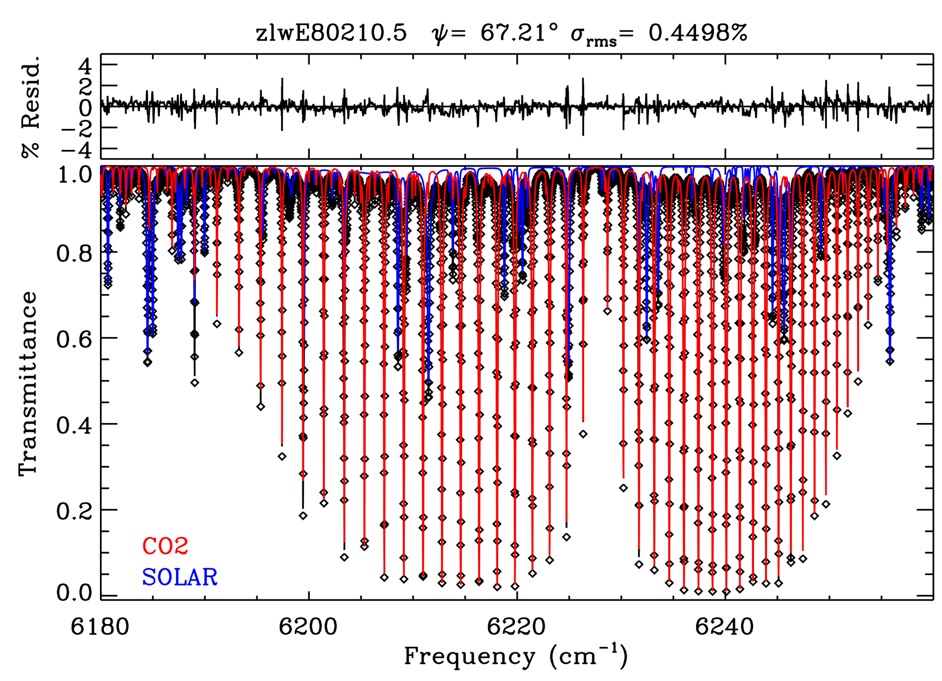


FIGURE 1: An example of simulated (solid black lines) and observed (diamonds) transmittance spectra in the 1.6 micron CO_2 band, identifying CO_2 and solar absorption lines. Fitting residuals are illustrated in the upper panel.

Timeseries of 1.6 micron band CO_2 retrievals

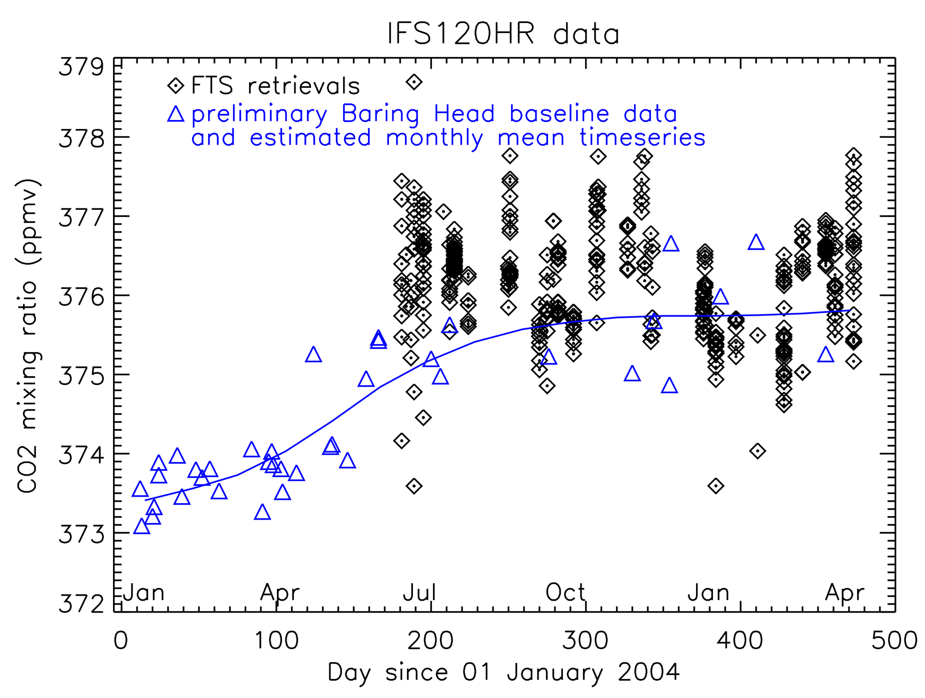


FIGURE 2: CO_2 column average volume mixing ratios derived from 1.6 micron band CO_2 retrievals. The mean mixing ratio for the timeseries is 376.2 ± 0.7 ppmv (0.2%). The standard deviation of diurnal variations range from 0.1 to 1.0 ppmv and the day-to-day variation is of the order of 0.5 ppmv. In-situ CO_2 measurements from Baring Head are illustrated for comparison. Modelling studies predict diurnal and seasonal variations in the CO_2 column of 0–0.6 ppmv and 1 ppmv respectively in the Southern Hemisphere [Olsen and Randerson, 2004].

Use of O_2 column densities as an internal network standard

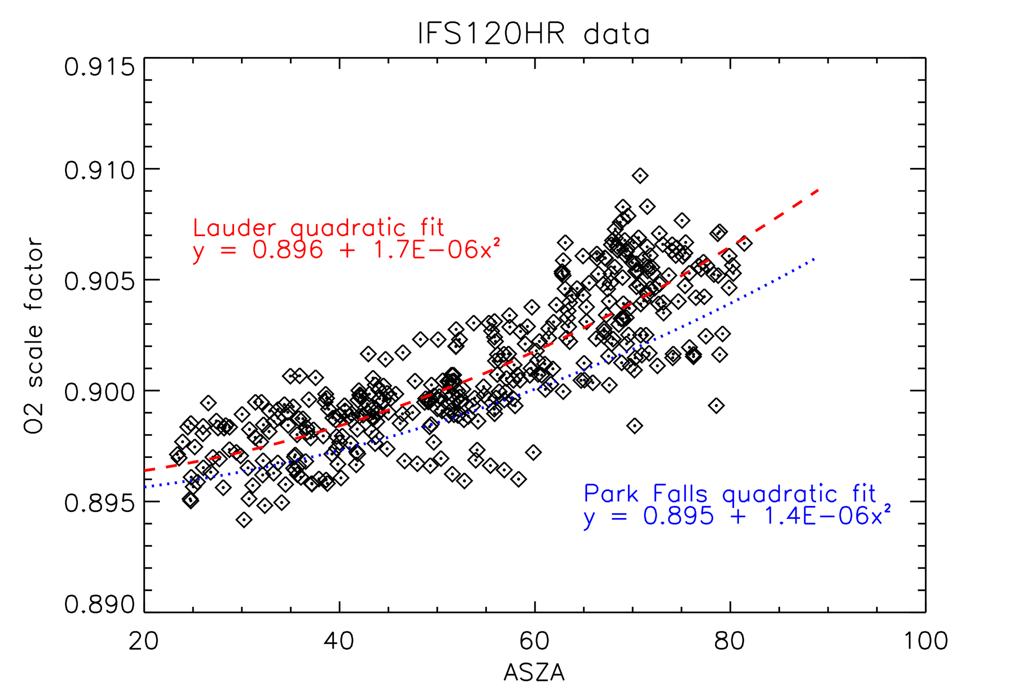


FIGURE 3: O_2 profile scale factors retrieved from the 1.27 micron band as a function of solar zenith angle. Scale factors should be unity at all zenith angles. The non-unit, zenith angle dependent character of retrievals should be corrected with improved band strength and spectroscopic parameter estimates. At a given solar zenith angle retrieval precision is of the order of 0.002 (0.2%). Target precision is 0.001 (0.1%). Lauder and Park Falls retrievals agree to within 0.1–0.3%.

Profile retrieval and applications

Profile retrieval has advantages over profile scaling algorithms

- improves precision for column retrievals due to reduced smoothing error (nearly ideal SZA-independent total column averaging kernel)
- provides some vertical resolution (typically 3–4 degrees of freedom for signal)

but it is potentially more sensitive to forward model errors e.g. specification of ILS, spectroscopy, atmospheric temperature.

Tabulated retrieval error budgets assume a signal to noise ratio of 500:1 and a perfect forward model. The a priori standard deviation of X_{CO_2} is 12 ppmv[1].

Planned comparison of ground based FTS and satellite measurements and retrievals will take retrieval errors and averaging kernels into account explicitly, following the work of Rodgers and Connor [2003]. One way of doing this is to apply satellite retrieval averaging kernels to ground based FTS profile retrievals.

Boundary layer and free troposphere partial column profile retrievals should improve comparisons with in-situ surface measurements and provide a potential link between surface and satellite measurements.

Ground based FTS CO_2 total column retrievals

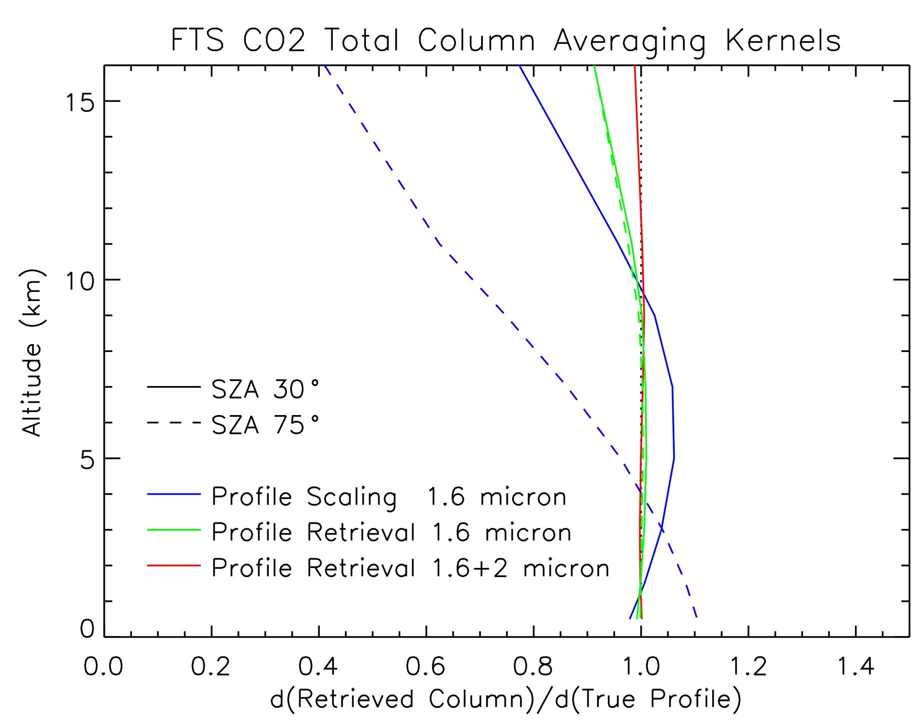


FIGURE 4: FTS CO_2 total column averaging kernels for profile retrieval and profile scaling algorithms and solar zenith angles of 30 and 75 degrees. The ideal column averaging kernel is unity at all levels.

1.6 micron band total column CO_2 retrieval error estimates

Retrieval	SZA	Noise	Smoothing	Total	Units
Profile scaling	30°	0.10	0.24	0.26 (0.07%)	ppmv
	75°	0.05	0.67	0.67 (0.18%)	ppmv
Profile retrieval		0.13	0.06	0.14 (0.04%)	ppmv

Ground based FTS CO_2 partial column retrievals

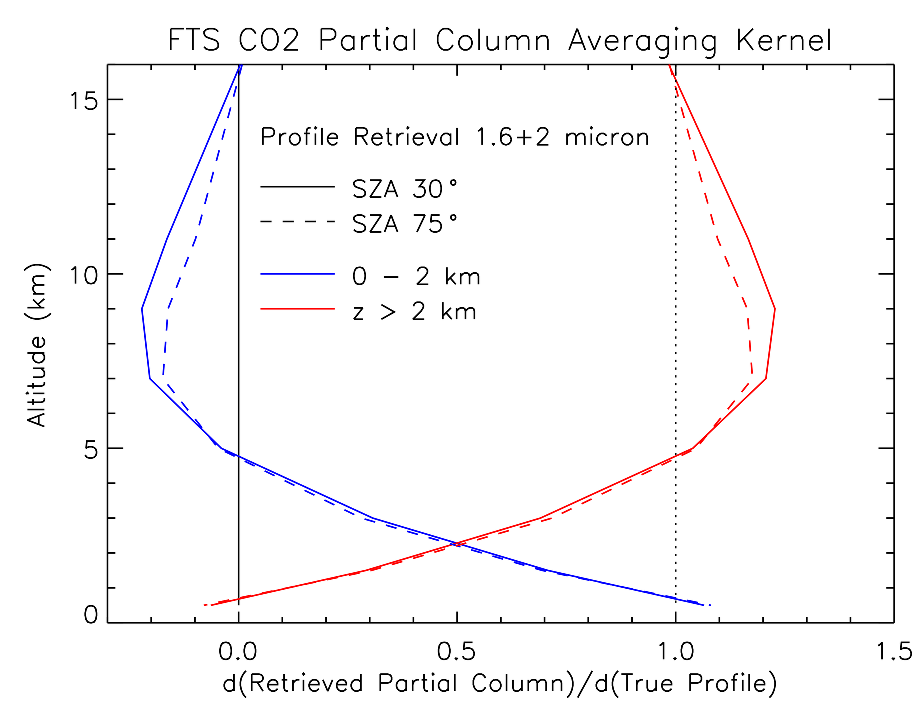


FIGURE 5: FTS CO_2 partial column averaging kernels for profile retrieval integration from 0–2 km (boundary layer) and for z > 2 km (free troposphere) and solar zenith angles of 30 and 75 degrees.

1.6 and 2 micron band profile retrieval CO_2 error estimates

Partial column	SZA	Noise	Smoothing	Total	Units
0–2 km	30°	0.7	0.3	0.7	ppmv
z>2 km	30°	0.2	0.1	0.2	ppmv
Total column		0.06	0.02	0.06 (0.02%)	ppmv

Conclusions

Preliminary results are encouraging: Lauder O_2 and CO_2 retrievals have a precision of 0.2% and O_2 retrievals are in good agreement with data from the Park Falls site.

Work is ongoing to identify the sources of observed variability and improve the precision and accuracy of retrievals to attain the TCCON error targets (0.1% precision, 0.3% accuracy).

This work will include monitoring and improving solar tracker accuracy, improving near infrared spectroscopic parameterisations (particularly O_2 collision induced absorption), the development and comparison of profile scaling and profile retrieval algorithms, with due consideration of the impact of forward model errors, and preliminary comparisons with in-situ CO_2 measurements at the Lauder site.

References

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Acknowledgements

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[1] Supplementary material is available which details the assumed CO_2 vertical error covariance.