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Total Carbon Column Observing Network (TCCON) activities at Izaña, Tenerife

Actividades en Izaña, Tenerife, de la red de observación de la columna de carbono (TCCON)

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ABSTRACT:

The Total Carbon Column Observing Network (TCCON) is a global network of ground-based Fourier Transform InfraRed spectrometers (FTIR). We present the first results obtained in the framework of TCCON at the Izaña Station. We find a strong correlation between the retrieved O_2 column amounts and the dry pressure column obtained from a high precision barometer. This documents the good quality of the Izaña TCCON measurements. We show the retrieved annual cycles (from 05 May, 2009 to 06 June, 2010) of CO_2 and we compare to simultaneously performed in-situ measurements.

Keywords: TCCON, FTIR, CO_2.

RESUMEN:

La red de Observación de la Columna Total de Carbono (TCCON) es una red global formada por espectrómetros de InfraRrojo de Transformada de Fourier (FTIR). Se presentarán los primeros resultados obtenidos dentro del marco de la red TCCON para la estación de Izaña. Se ha encontrado una fuerte correlación entre la columna de O_2 invertida y la columna de presión seca obtenida con un barómetro de alta precisión. Esto documenta la buena calidad de las medidas TCCON. También, se mostrará el ciclo anual invertido de CO_2 (desde el 05 de mayo de 2009 hasta el 06 de junio de 2010) comparado con medidas in-situ adquiridas simultáneamente.

Palabras clave: TCCON, FTIR, CO_2.

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1. Introduction

The Total Carbon Column Observing Network (TCCON) is a global network of ground-based Fourier transform spectrometers recording direct solar spectra in the near-infrared spectral region. With stringent requirements on the instrumentation, data processing and calibration, accurate and precise column-averaged abundance of CO_2, CH_4, N_2O, CO, HF, H_2O and HDO are retrieved. TCCON was initialized in 2004 and currently there are 19 sites affiliated around the world, Izaña being fully operational since May 2007.

The TCCON objectives are:

1. Carbon Cycle Study: In order to better understand climate change, the greenhouse gas cycles have to be investigated: exchange of CO_2, CH_4, N_2O, etc., between the atmosphere, the biosphere, and the ocean. Compared to surface in-situ measurements column measurements sample a larger portion of the atmosphere, therefore they exhibit less variability than surface data, while retaining information about surface fluxes. Greenhouse gas column observations complement the surface in-situ data and provide additional constraints to the global carbon budget [1].

2. Satellite validation: Global coverage is important for comprehensive carbon cycle research. Global monitoring of greenhouse gases requires space-based remote sensing. However, it is important to continuously document the quality of the space-based observations. In-situ measurements from the existing surface network only inform about the planetary boundary layer. They can not alone be used to validate space-based measurements, which are also sensitive at higher altitudes. Only ground-based FTIR instruments can continuously provide precise total column amounts of greenhouse gases and they are indispensable for the validation of the different satellite sensors (e.g., SCIAMACHY, GOSAT, OCO).

2. Izaña Station

Izaña is a subtropical high mountain observatory [2] located at 2370 m a.s.l., over a strong temperature inversion layer that works as a natural barrier for local pollution. It is well representative for atmospheric background conditions. Its latitudinal location complements the other mainly mid-latitudinal TCCON sites. Since many years Izaña has been a Global Atmospheric Watch (GAW) station and it has a comprehensive measurement program of a large variety of different atmospheric constituents.

The FTIR system is a Bruker Spectrometer IFS125HR housed in a container at the Izaña Station. With this instrument, Near InfraRed (NIR) spectra are recorded between 4000-9000 cm^{-1} at 0.02 cm^{-1} (optical path difference of 45 cm), with a CaF_2 beamsplitter and a room-temperature InGaAs detector. Recording of one spectrum requires between 30 seconds and a few minutes, depending on the quality needed: one scan can be performed in 30 seconds, but often several scans are co-added in order to increase the signal to noise ratio (the current study averaged 6 scans). A Fourier transformation of the recorded interferogram yields the spectrum [3]. Although the official fitting algorithm is GFIT developed at NASA/JPL, in this work the measured spectra has been processed with the nonlinear least squares fitting algorithm PROFFIT developed at the Karlsruhe Institute of Technology [4], which computes profiles and total columns of the gases of interest for every spectrum.

The CO_2 in-situ measurements are acquired with a NDIR analyzer (Li-7000) in a non commercial mode since January 2007. This analyzer is calibrated each hour with one reference and three standard tanks. The sample is cooled to -70ºC. The measurement protocol follows the GAW recommendations, leading to a precision better than 0.1 ppmV [5].

3. Results

The consistency between the retrieved O_2 column and the measured surface pressure can be used to check the instrumental stability and precision of the FTIR column retrievals. Thus, the dry pressure column (DPC) is defined by:

$$DPC = \frac{P_S}{m_{air} \cdot g} - column_{\mathrm{H_2O}}, \qquad (1)$$

where P_S is the pressure (Pa) at surface level, obtained from a high precision barometer [Setra System, Inc. Model 470 digital pressure transducer (±0.3hPa)], m_{air} is molecular mass of the dry air (28.9645 gr/mol), and $g(\varphi, h)$ is gravitational acceleration, which takes into account the latitude and altitude corrections. Column H_2O is the retrieved total water vapour column amount. The result of this comparison is shown in Fig. 1.

Using the PROFFIT algorithm CO_2 concentration profiles can be retrieved. Thus, Fig. 2 depicts the CO_2 concentrations retrieved at Izaña surface level and the one obtained from simultaneously performed in-situ measurements. Due to operational problems there is a lack of FTIR measurements during the first three months of 2010.

Although the absolute values differ (mean residual = 4.58 ± 1.31 ppm) due to the differences in the instrumental techniques, a good agreement between FTIR and in-situ measurements can be seen in Fig. 3. This comparison is only possible since at the Izaña station the surface in-situ data is well representative for the free troposphere.

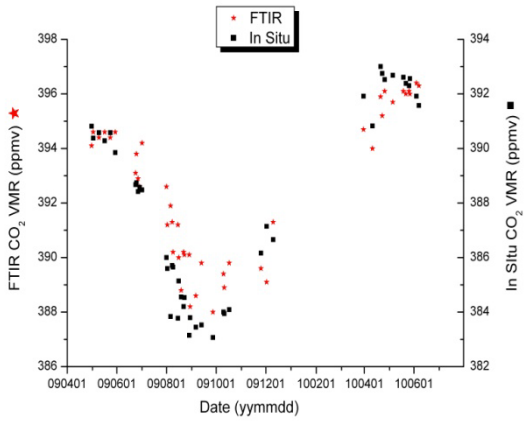

Fig. 2. Annual cycle of daily mean FTIR (red starts) and simultaneous in-situ CO2 measurements (black squares) from 05 May, 2009 to 08 June, 2010.

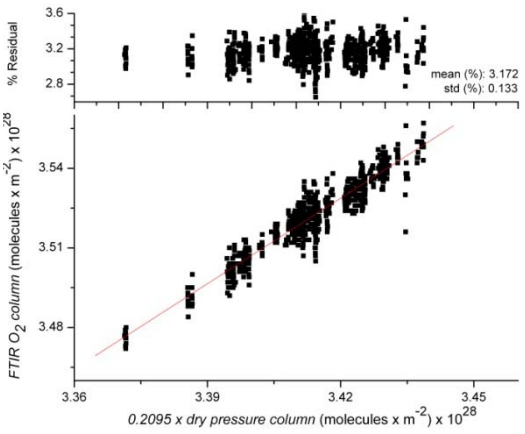

Fig. 1. Relationship between retrieved FTIR column O_2 and dry surface pressure (lower panel) and residual (%) (upper panel).

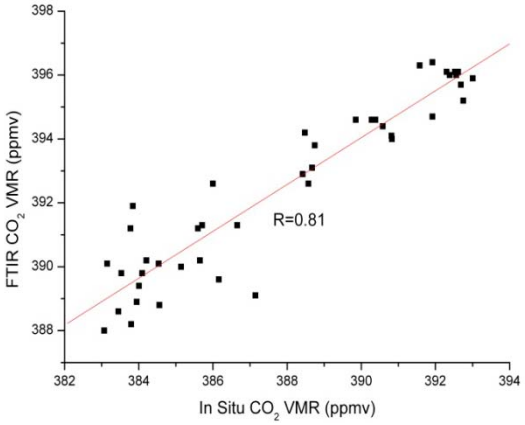

Fig. 3. Correlation between the retrieved CO_2 Volumen Mixing Ratio (VMR, ppmV) and the in-situ in dry air VMR, measured simultaneously.

4. Conclusions

We show that TCCON measurements can be used to produce a dense long-term CO_2 data set at a satisfactory quality. For the Izaña Station there is a good agreement between the TCCON data and the data obtained from simultaneously performed in-situ measurements.

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