Validation of atmospheric CO_2 and CH_4 retrieved from GOSAT

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1. Introduction

Human activities such as fossil fuel combustion or land use change have led to a dramatic increase in atmospheric CO_2 concentrations from a pre-industrial level of 280 parts per million (ppm) to more than 386 ppm today. Atmospheric levels of methane (CH_4) have also risen dramatically over the last 300 years from 400-700 parts per billion (ppb) to 1774 ppb [*IPCC,* 2007]**.** Satellites observations, if acquired with high accuracy and precision, have the potential to provide globally densely-sampled datasets of column CO_2 and CH_4, overcoming surface network limitations. The first observations of greenhouse gases from a dedicated satellite sensor are now available with the launch of the Japanese Greenhouse gases Observing SATellite (GOSAT) on 23 January 2009. GOSAT provides global measurements of total column CO_2 and CH_4 from its shortwave infrared (SWIR) bands and of mid-tropospheric sub-columns from its thermal-IR bands. Here we present the validation for retrievals of CO_2 and CH_4 columns from the GOSAT SWIR channels against observations of the Total Column Carbon Observation Network (TCCON).

2. Retrieval Method

The Full Physics Retrieval Algorithm, developed for the Orbiting Carbon Observatory (OCO), has been adapted for use with GOSAT SWIR observations to accurately retrieve the column-averaged dry air mole fraction of CO_2 (XCO_2) and CH_4 (XCH_4). This optimal estimation retrieval algorithm is constrained by a priori from ECMWF, LCSE and TM5 (S. Houweling)

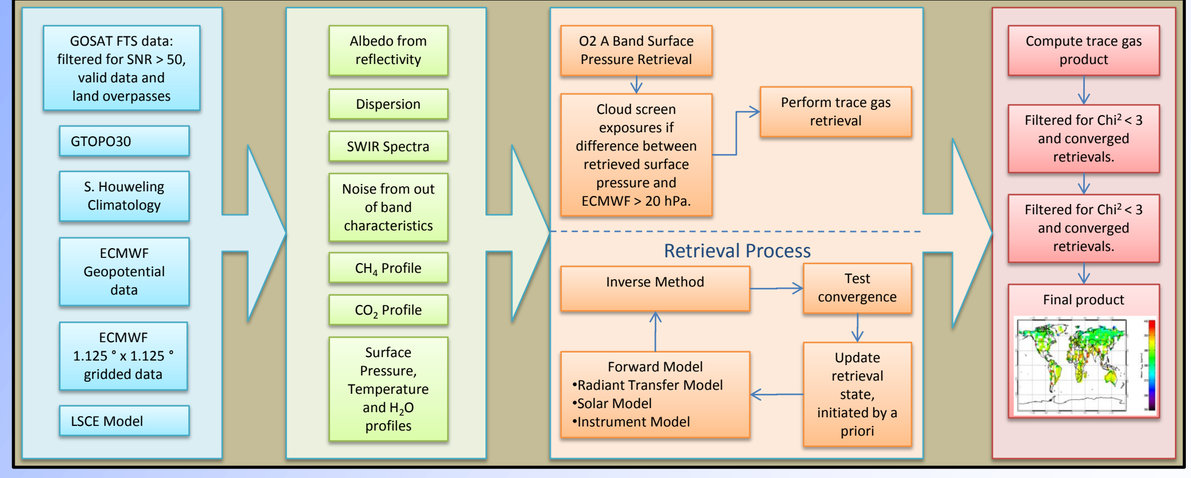

Figure 1: Flowchart depiction of the standard retrieval method. In addition to the a priori, depending on the trace gas being retrieved different aerosol inputs may be used.

3. Atmospheric CO_2

GOSAT retrievals of CO_2 have been performed for observations between April 2009 and February 2010 for overpasses over Total Carbon Column Observing Network (TCCON) sites to allow validation against retrievals from the ground-based FTS instruments. For the retrieval of XCO_2, the O_2 A band, 1.61 µm and 2.06 µm CO_2 bands were simultaneously fitted to retrieve a CO2 profile as well as temperature, water vapour, albedo, dispersion, surface pressure and aerosol optical depth. The aerosol a priori used was the same for all exposures and consisted of three aerosol profiles, each with and an optical depth of 0.05, where two were low altitude aerosol mixtures and the other allows for high altitude ice clouds.

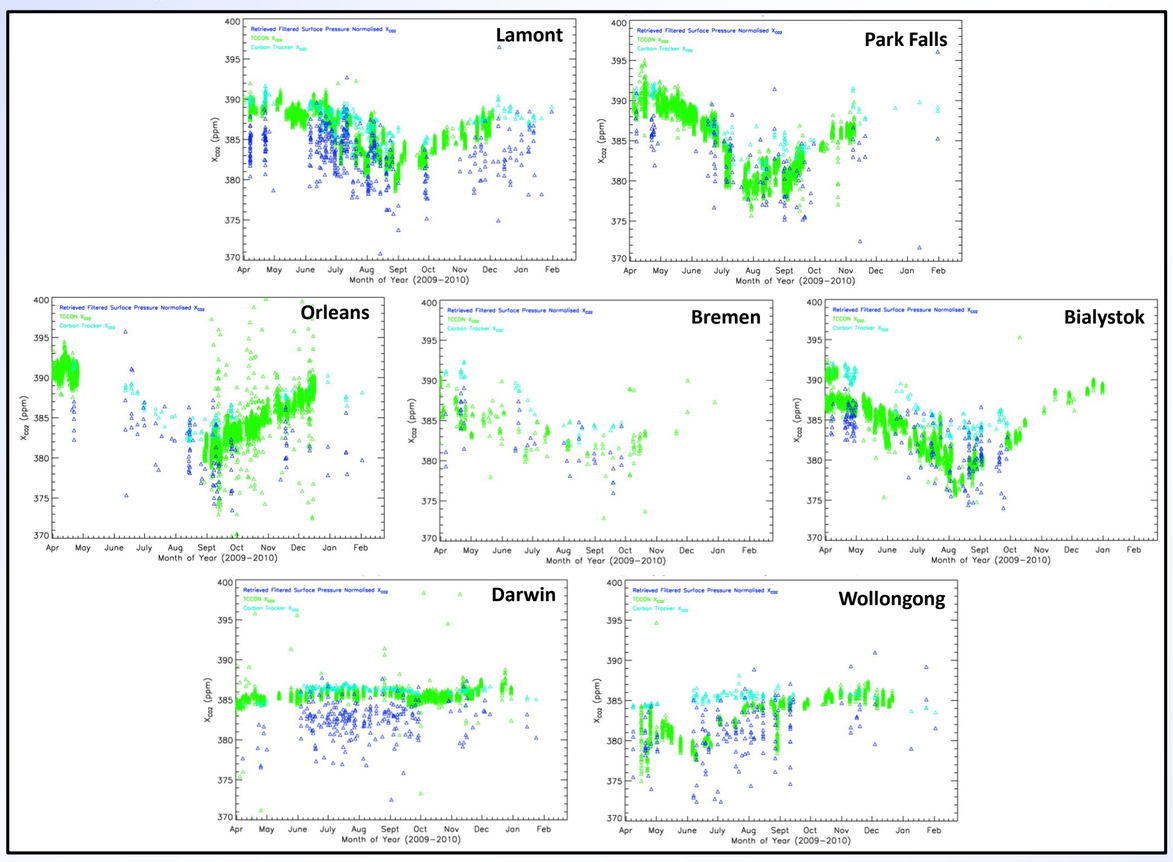

Figure 2: XCO_2 retrieved from GOSAT (blue) compared to XCO_2 retrieved from TCCON (green), Carbon Tracker CO_2 (light blue) and GEOS-Chem CO_2 (red) for different TCCON sites in North America, Europe and Australia between April 2009 and February 2010. No averaging kernels have been applied.

A bias in the retrieved GOSAT XCO_2 has been computed by comparing the closest TCCON and GOSAT observations for each GOSAT exposure time, as shown in Figure 3.

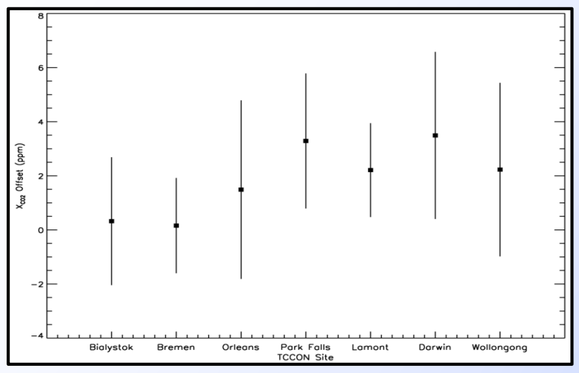

Figure 3: Retrieved XCO_2 mean offset and standard deviation for a number of TCCON sites.

4. Atmospheric CH_4

GOSAT retrievals of CH_4 have been performed for observations between April 2009 and February 2010 for overpasses over ground based Total Carbon Column Observing Network (TCCON) sites to allow validation against retrievals from ground-based FTS instruments. For the retrieval of XCH_4, the 1.58 µm CH_4 band and 1.61 µm CO_2 band were retrieved separately. The proxy approach has been used to reduce the affects of aerosols on the retrieved XCH_4. The proxy approach can be simplified as:

$$XCH_4 = \frac{\text{Retrieved } XCH_4}{\text{Retrieved } XCO_2} \times \text{Carbon Tracker } CO_2$$

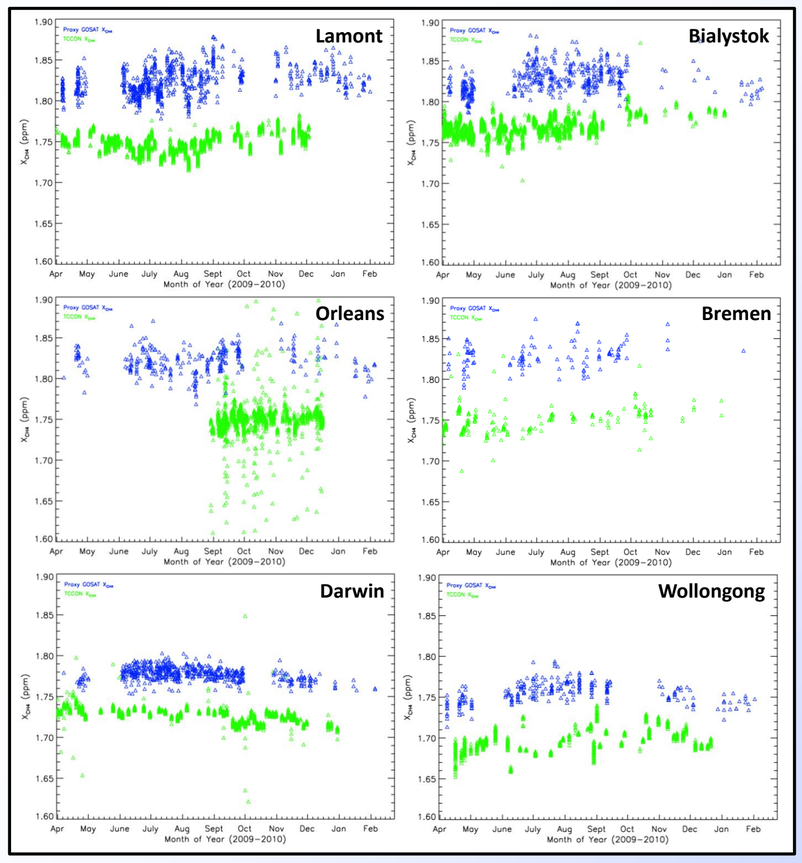

Figure 4: Proxy XCH_4 retrieved from GOSAT (blue) compared to XCH_4 retrieved from TCCON (green) for different TCCON sites in North America, Europe and Australia between April 2009 and February 2010. No averaging kernels have been applied. An offset is created when applying the proxy approach since the retrieved CO_2 is biased due to the poor spectroscopy in the 1.61 µm CO_2 band.

5. Retrieval Inter-comparisons

In addition to validation against ground based column data, retrieval inter-comparisons are an important task that can help to better understand biases and to improve the algorithms. The SWIR Carbon Observation Retrieval Model Inter-comparison Project (SCORE-MIP) was developed for this purpose and performs radiant transfer, synthetic and retrieval inter-comparisons of GOSAT data over TCCON sites.

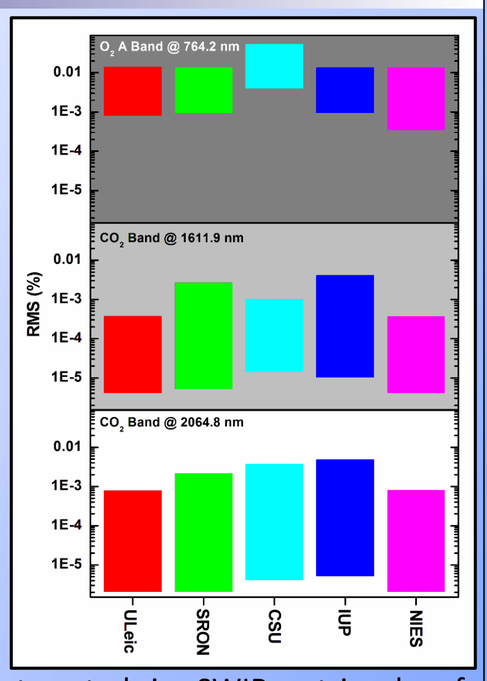

Figure 5: SCORE-MIP Task 1a RMS of three spectral bands from radiant transfer inter-comparisons of five research groups.

SCORE-MIP is open to all researchers who are interested in SWIR retrievals of greenhouse gases. Please contact the authors if you want to join the project. More details on SCORE-MIP can be found at http://sites.google.com/site/scoremip.

6. Conclusion

The XCO_2 and XCH_4 retrieved at Leicester show promising results and we expect further improvements with updates in spectroscopy and calibration. The next step will be to improve our CO_2 retrieval approach to reduce the uncertainties introduced by spectral interference from atmospheric aerosols and clouds.

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References:
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