Characterization of aerosol and cirrus cloud related errors of SCIAMACHY WFM-DOAS XCO_2 retrievals

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www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/

Introduction

Carbon Dioxide (CO_2) is the most important anthropogenic greenhouse gas. Measurements of O_2 and CO_2 absorption spectra by satellite instruments such as SCIAMACHY and retrievals of CO_2 column-averaged volume mixing ratio – denoted XCO_2 – can add important missing global information on regional CO_2 surface fluxes. This however requires to meet challenging accuracy requirements (<1%). An important error source is scattering by aerosols and undetected clouds, especially subvisuel cirrus clouds. Here we present results from a detailed analysis concerning aerosol and cirrus cloud related errors of a multi-year SCIAMACHY XCO_2 dataset (2003 – 2005) retrieved by the WFM-DOAS v2.1 algorithm developed at the University of Bremen [1].

The WFM-DOAS v2.1 algorithm is based on a least-square fit to retrieve vertical columns by scaling pre-defined vertical profiles independently in two fit windows coverging O_2-A absorption lines at 760 nm and CO_2 absorption lines at 1560 nm. The algorithm uses a fast look-up-table approach and the XCO_2 is computed from the retrieved CO_2 and O_2 columns. The algorithm handles aerosols with the DOAS polynom and by applying an Absorbing Aerosol Index (AAI) filter, which serves as an indicator for strong aerosols events such as desert dust storms. For the radiative transfer (RT) simulations a constant aerosol scenario is assumed. Cloudy pixels are identified and removed by a cloud filter.

The currently implemented WFM-DOAS approach therefore not fully considers aerosol variability and some cloud contamination also remains. Therefore it can be expected that the retrieved XCO_2 suffers at least to some extent from aerosol and cloud related errors. This study aims to characterise these errors.

Reference

[1] O. Schneising, M. Buchwitz, M. Reuter, J. Heymann, H. Bovensmann and J.P. Burrows: Long-term analysis of carbon dioxide and methane column-averaged mole fractions retrieved from SCIAMACHY, Atmos. Chem. Phys., 11, 2863-2880, 2011

Acknowledgements

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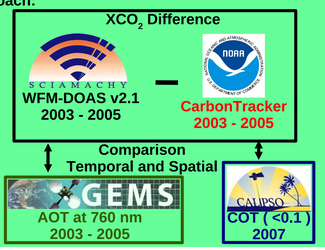
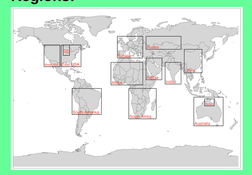
Part 1: Analysis

We compare the difference of SCIAMACHY XCO_2 and NOAA's CarbonTracker XCO_2 with global aerosol and cirrus cloud datasets. For the analysis, the aerosol optical thickness (AOT) at 760 nm from the GEMS project is used and for clouds the product of cloud optical thickness (COT) and cloud fractional coverage (CFC) from CALIPSO. The SCIAMACHY XCO_2, the CarbonTracker XCO_2 and GEMS aerosol dataset of the time period 2003 – 2005 is used. For CALIPSO we use year 2007 data (assuming negligible year-to-year variations). The comparison method is a temporal and spatial correlation analysis for pre-defined regions like Europe, Australia or China.

Analysis Approach:



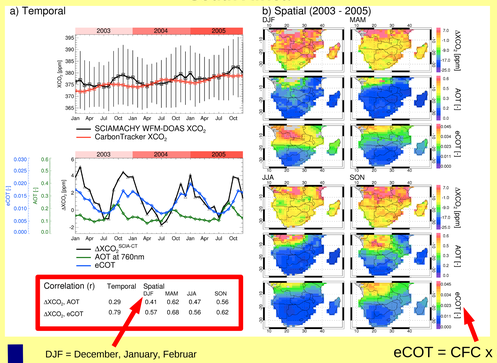
Regions:



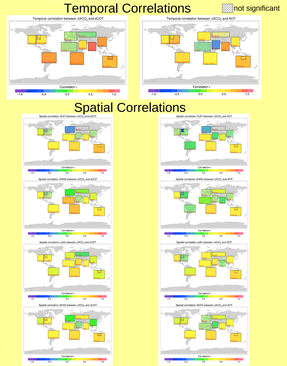
Results

Example:

South Africa



All regions:



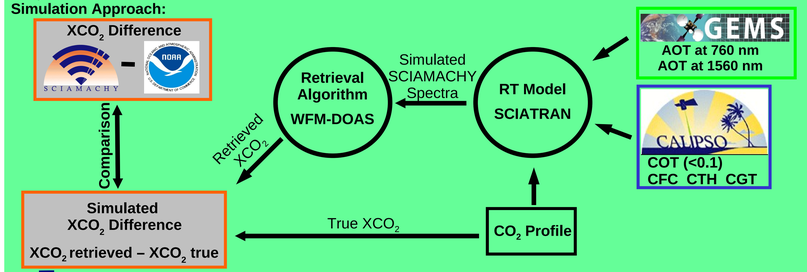
Conclusions

→ **Significant temporal and spatial correlations between SCIAMACHY - CarbonTracker XCO_2 and effective COT / AOT especially over the Southern Hemisphere**

Part 2: Simulations

In order to study if we can reproduce the observed XCO_2 differences shown in Part 1, we perform three separate simulated retrievals: (i) using GEMS aerosol (AER) as input data for the SCIATRAN RT simulations, (ii) using CALIPSO cirrus information (CIR) and (iii) using aerosol and cloud data (A&C). The simulated difference is compared by a correlation analysis with the observed differences.

Simulation Approach:



Results

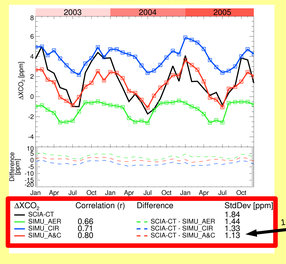
Example:

Case 1: **Aerosols only**

Case 2: **Clouds only**

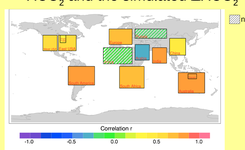
Case 3: **Aerosols and Clouds**

South Africa

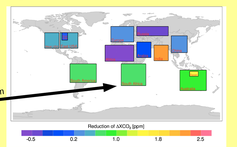


All regions: **Case 3**

Correlation r between SCIAMACHY – CarbonTracker XCO_2 and the simulated ΔXCO_2



Reduction of the SCIAMACHY - CarbonTracker ΔXCO_2 by substracting the simulated XCO_2



Conclusions

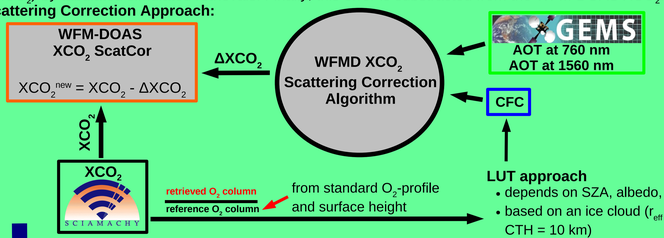
→ **Significant correlations for many regions**

→ **Good reproduction of the magnitude of aerosol and cloud related errors**

Part 3: Solutions

For the purpose of improving the SCIAMACHY WFM-DOAS XCO_2 dataset, we investigate possibilities of an a-posteriori correction of aerosol and cloud related errors. A preliminary correction algorithm is based on GEMS aerosol information and cloud information obtained from the retrieved O_2 column. An effective cloud fractional coverage (CFC) of an ice cloud with a COT of about 0.2 and a CTH of 10 km is determined from the ratio of the retrieved O_2 column and the expected O_2 column. This effective CFC and the AOT at 760 nm and 1560 nm of GEMS are used to determine the expected cloud related error (ΔXCO_2) by tabulated simulated retrievals. Finally, this error is substracted from the WFM-DOAS XCO_2.

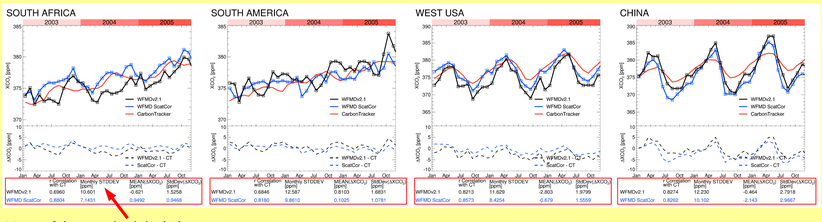
Scattering Correction Approach:



LUT approach

- depends on SZA, albedo, surface height, O_2 ratio
- based on an ice cloud (r_{eff} = 50 µm, COT = 0.2, CTH = 10 km)

First Results



Mean of the standard deviation of the monthly XCO_2 data

Next steps:

- Algorithm improvements (e.g. consider CTH)
- Investigation of spatial correlations

SCIAMACHY WFM-DOAS v2.1

SCIAMACHY WFM-DOAS ScatCor (Offset: -8.3 ppm)

CarbonTracker XCO_2

Preliminary Conclusions

→ **Improvements of the temporal characteristics of SCIAMACHY WFMD XCO_2 for many regions**