Retrieval of carbon dioxide amount over boundary layer clouds
OCO methodology applied on SCIAMACHY

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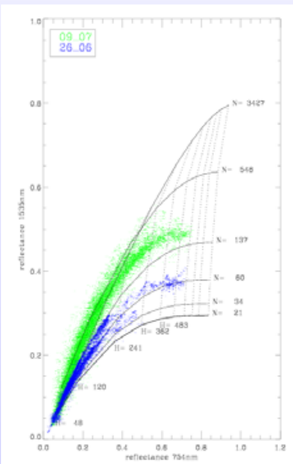
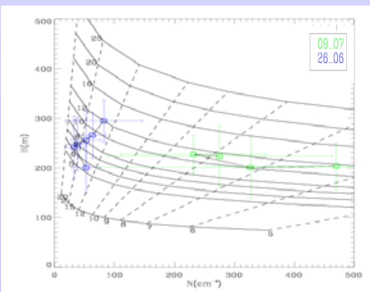
Motivation

- Approximately half of atmospheric CO2 retrieval will be rejected from OCO measurements because of cloud contamination.
- In some cases, we should be able to retrieve the column amount of CO2 over clouds.
- The Signal-to-Noise Ratio is better over clouds than in cloud-free conditions
- We expected to provide information about the vertical distribution of CO2 in the atmosphere.

Validation of Step 1

- Based on comparison with the ACE 2 campaign results **[Brenguier *et al.*, 2000]**
- Change of space from **{τ_c, r_e} to {N,H} (Droplet Number concentration, Geometrical Thickness) [Bennartz, 2007]**
- 2 studied clouds: pure marine cloud (06/26/97) and polluted cloud (07/09/97)





	06/26/1997 (marine cloud)		09/07/1997 (polluted cloud)	
Retrieval	N [cm⁻³]	H [m]	N [cm⁻³]	H [m]
In situ [from Schüller *et al.*, 2003]	40-110	70-280	220-350	80-210
Schüller *et al.*, 2003	50-70	180-210	310-370	200
OCO-like	40-80	200-300	230-480	200-230

The OCO / SCIAMACHY missions

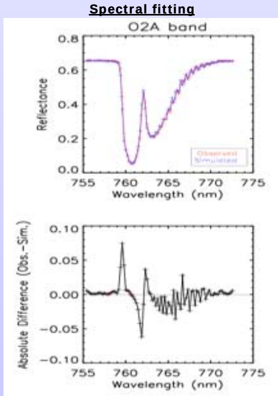
- OCO is a space-based mission solely dedicated to CO_2 measurements with precision, accuracy and resolution needed to quantify CO_2 sources and sinks (regional, monthly averaged precision of 1-2 ppm without significant coherent biases) [Crisp *et al.*, 2004].The OCO instrument incorporates 3 bore-sighted high-resolution grating spectrometers which measure spectra of reflected sunlight in the near IR CO_2 bands at 1.61 μm and 2.06 μm and in the O_2 A-band.
- SCIAMACHY is an imaging spectrometer whose primary mission objective is to perform global measurements of trace gases in the troposphere and in the stratosphere. The solar radiation transmitted, backscattered and reflected from the atmosphere is recorded at relatively high resolution (0.2 µm to 0.5 µm) over the range 240 nm to 1700 nm, and in selected regions between 2.0 µm and 2.4 µm.

Sensor	OCO		SCIAMACHY	
Band	O2A	CO2	O2A	CO2
λ [nm]	758-772	1594-1619	755-773	1562-1595
FWHM [nm]	0.045	0.08	0.4	1.34
SNR	360	250	200	200

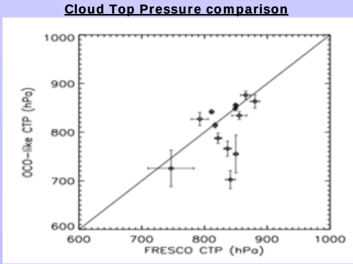
Validation of Step 2

- Based on comparison with the SCIAMACHY FRESCO standard product
- 13 SCIAMACHY images over West coast of South America
- Ozone and cloud fraction corrections

Spectral fitting

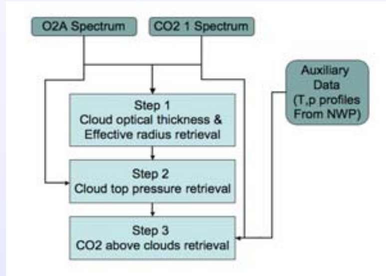


Cloud Top Pressure comparison



Retrieval Algorithm

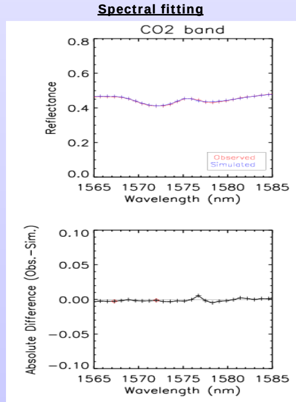
- **3 steps algorithm**
- **RTE simulations based on Successive Order of Interaction (SOI code)** [Heidinger *et al.*, 2006, O'Dell *et al.*, 2006]
- **Gaseous transmission calculation from K-binning** [Bennartz and Fischer, 2000]
- **LUT of TOA reflectance for step 1** [Nakajima and King, 1990]
- **Differential Absorption technique for steps 2 and 3**



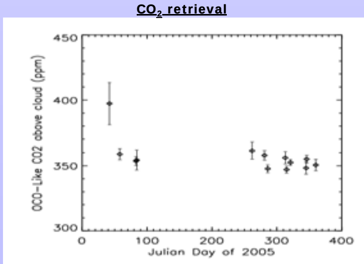
Validation of Step 3

- Based on comparison with the SCIAMACHY FRESCO standard product
- 13 SCIAMACHY images over West coast of South America in 2005
- Water vapor absorption and cloud fraction corrections

Spectral fitting



CO_2 retrieval



Open issues

- Remaining optimization and runtime issues with the CO_2 estimation over clouds should be resolved. Polarization needs to be fully integrated into the algorithm.
- Initial consistency check of the algorithm within a Observations System Simulation Experiment should be performed. This can potentially be achieved using a combination of NWP model output and CarbonTracker.
- The spectroscopic database used in the simulations needs to be updated. Currently, we use Hitran 2004. We expect to use the new CO2 line parameters created within the OCO project as soon as they become available.
- The forward modeling environment should be evaluated against other available code. This task will be performed within the framework of the model intercomparison project led by Boesch.
- Aerosols may have a strong impact on carbon dioxide retrievals above clouds. Sensitivity studies of retrievals above clouds are an outstanding issue and will be performed in the next year. The question here is in particular to what extend the response of the carbon dioxide algorithm is different from the cloud top pressure algorithm, which provides the reference airmass for carbon dioxide.

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