Profile Measurements of Aerosols and Trace Gases by DOAS during the POLARCAT Kiruna campaign

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1.Context

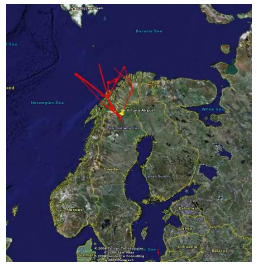


Fig. 1. Flight tracks during the POLARCAT-CNRS campaign in Kiruna

The CNRS-spring campaign took place in Kiruna, Sweden, between March the 27th and April the 14th of 2008. It was dedicated to microphysics and satellite validation. The ATR-42 from SAFIRE performed 12 flights above the Norway Sea from Kiruna and Enna airport.

2. Scientific objective

BIRA-IASB participated to this campaign with a new instrument, namely the Airborne Limb Scattering Differential Optical Apsorption Spectrometer (ALS-DOAS). Our objective was to retrieve vertical distributions of several trace gases playing a key-role in the troposphere, N2O, O3, H2CO and BrO.

Simulations with a radiative transfer model, UV-SPEC/DISORT were performed for both BrO an NO2 and shows that limb geometry is well suited to retrieve profile of small absorbers like BrO thanks to large air mass factors.

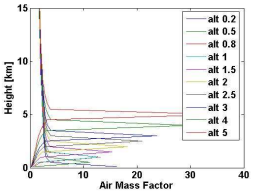


Fig. 2. Air mass factor simulations for BrO at 352 nm in the limb geometry

3. The Airborne Limb Scattering DOAS (ALS-DOAS)

Wavelength range : 332-450 nm

Spectral resolution: 0.4 to 0.6 nm

Field of View : 1.2 °

Scanning from +5 to -5° around the horizontal of the plane with a stepper

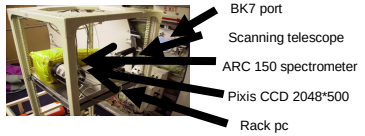


Fig 3. The ALS-DOAS onboard the ATR-42

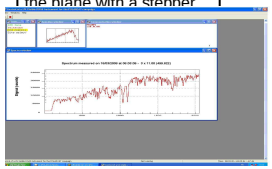


Fig. 4. The acquisition software interface, with a typical spectrum

The acquisition software controls the telescope and the CCD, calculating the integration time and saving the spectra. the program runs automatically once started. An operator is practically not needed during the flight for the ALS-DOAS.

3. Data Analysis

a. From spectra to slant columns using DOAS analysis

The spectra were evaluated with the DOAS method. Characteristic absorption structures were searched for the molecules mentionned in section 2, plus O4 and IO, compared to a reference spectrum measured when the plane was at high altitude. H2CO, BrO and IO were under the detection threshold. We thus concentrated on three molecules: O4, NO2 and O3.

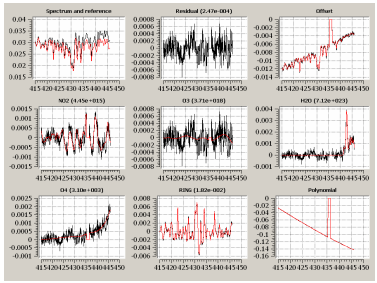
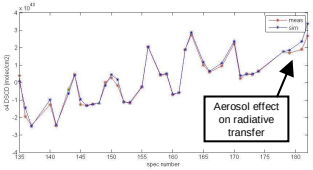
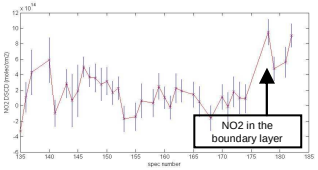


Fig 5. Exemple of a DOAS fit for NO2, between 428 and 450 nm. Interfering species are O3, H2O and O4. The Ring effect is taken into account thanks to an artificial cross-section

The result of the DOAS analysis is a differential slant column density, ie, the concentration of the molecule integrated on the line-of-sight, relative to the same quantity in the reference spectrum. This result is thus influenced by the geometry of the measurements, in particular the scanning angle of our telescope, which explains the oscillations in the DSCD series below.



O4: The profile of this absorber being know, the measurements can be compared to simulations performed with a radiative transfer model in the same geometry.This is useful to retrieve unknown parameter, in our case the aerosol extinction coefficient.



NO2: Few NO2 is present in the relatively clean arctic troposphere. Oscillations at the beginning of the series are expected to come from the stratospheric NO2, but the peak at the end corresponds to the boundary layer

Fig 6. DSCD of O4 and NO2 during the first sounding above the sea on April the 8th 2008. The planes was flying from 6 km to 250m and thus the measurements were made first in the free troposphere and then (from spectrum 172) inside the boundary layer.

3. Data Analysis

a. From slant columns to geophysical quantities

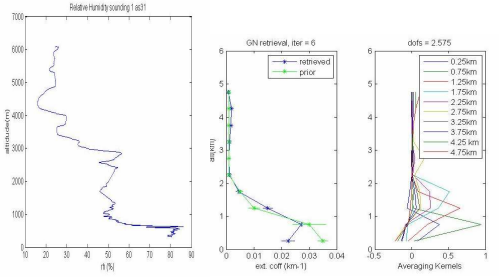


Fig 7. Exemple of retrieval of aerosol extinction coefficient, on april the 8th of 2008. The plot on the left is the relative humidity measured in-situ from the plane, closely linked to the extinction coefficient.

Arosol extinction coefficient: We use an optimal estimation to retrieve the aerosol extinction coefficient. The forward model is based on the radiative transfer code UV-spec DISORT and does not allow the calculation of weighting functions relative to the extinction coefficient so they were calculated by perturbations on a finer grid than the one used in the retrieval. The apriori used in the extinction retrieval is taken from OPAC, a software package giving optical properties of aerosols as a function of relative humidity.

NO2: Neglecting the statospheric influence, it is possible to calculate a tropospheric air mass factor corresponding to our geometry. The profile used is taken from the TM4 model and the aerosol extinction is scaled from the one derived at 360 nm with the Angström coefficient given in OPAC. This leads, for the same sounding of April the 8th above the sea, to a concentration of NO2 in the boundary layer of 60 pptv, with a detection threshold of 15 pptv

4. Future work

1. Optimize the O3 retrieval and compare it with in-situ data

2. Work on the flight of the April 11th, when long-range transport pollution was detected in the LIDAR data

Aknowledgements

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