DOAS measurements of NO_2 from an ultralight aircraft between Thailand and Belgium

A. Merlaud[1], C. Fayt[1], X. Toledo[2], J. van Gent[1], O. Ronveaux[3], and M. Van Roozendael[1]

Belgian Insitute for Space Aeronomy (IASB-BIRA), (2) University of Namur (FUNDP), and (3) USF-Free Sky

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Fig.1 The ultralight aircraft above Dubai during the Earth Challenge expedition

1. Context and objectives

Earth Challenge is a 27000 km expedition between Australia and Belgium, onboard 4 ultralight aircrafts, which took place in April and November 2009. The objective of the 7 pilots team, in cooperation with the World Wildlife Fund (WWF), was to draw the public's attention to the environmental problems such as sea rising, pollution and climate change. The project has been supported by BIRA-IASB.

Fig.2 Distribution of NDACC stations in the regions covered by the expedition

The expedition was a good opportunity to achieve air quality measurements in regions where few ground-based data are available(cf Fig.2), and to operate a compact instrument

2. A new instrument: the ULM-DOAS

The UV-VIS DOAS group together with the mechanical workshop team, built a new remote-sensing instrument, namely the ULM-DOAS, which was installed onboard one of the aircraft. This instrument is primarily aimed to NO_2 monitoring, but other chemical species are detectable, such as formaldehyde and sulfur dioxide.

The ULMDOAS is based on a Avantes USB2000 spectrometer controlled by a PC-104. The input optics consist only of a fiber with a baffle so the field-of-view is 25°. A GPS antenna is also connected to the computer to log the position of the measurements. The fiber head is attached under a wing of the aircraft, and pointing toward the horizon.

Atmospheric scattered light spectra between 200 and 750 nm are recorded continuioulsy with a fixed integration time, and a primary DOAS analysis (see next section) is done on-flight for quality check.

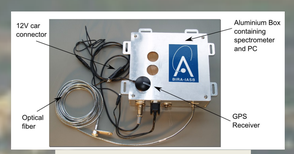


Fig.3 The ULM-DOAS

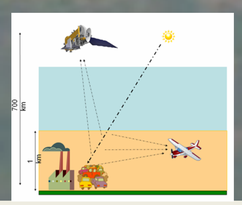


Fig 4. Principle of the measurements: the aircraft is flying at low altitude and records skylight spectra in limb-geometry with a broad field-of-view

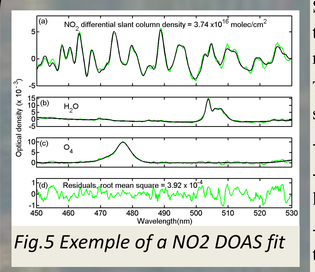


Fig.5 Exemple of a NO2 DOAS fit

3. Methods

Spectra are evaluated using the DOAS technique, yielding the integrated absorption along the line-of-sight compared to a reference spectrum, namely the differential slant column density (DSCD).

To convert DSCDs, which depend on the light path, to vertical columns, we make several assumptions:

-NO_2 amounts do not influence the light path

-NO_2 profiles can be simplified to a homogeneous concentration in the boundary layer

-We neglect the residual absorption in the reference spectrum, taken in a clean site, and the stratospheric contribution, supposed constant.

These assumptions enable to calculate air mass factors(AMF) for the measurements, and to derive vertical columns(VC) as VC = DSCD/AMF

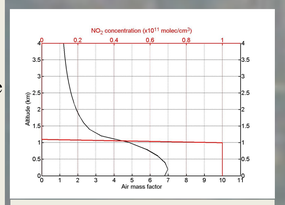
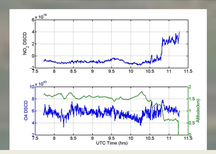


Fig.6 Air mass factor versus altitude (black) for a tipycal NO2 tropospheric profile (red)

4. Some results (preliminary)



Po Valley, Italy, 2 December 2009
Vertical column ~ 1e16 molec/cm^2

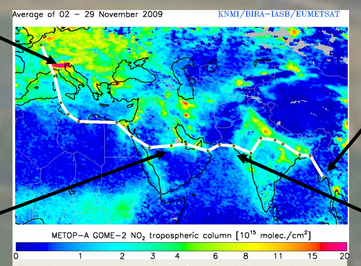
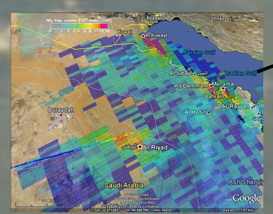


Fig.6 Average tropospheric NO2 in November 2009 from Gome-2 data, and tracks of the Earthc Challenge expedition

Chittagong, Bengladesh, 4 November 2009
Vertical column ~ 4.7e15 molec/cm^2



Riyad, Saudi Arabia, 24 November 2009, compared with OMI
Vertical column max.~ 2.3e16 molec/cm^2

Karachi, Pakistan, 16 November 2009
Vertical column ~ 1.5e16 molec/cm^2

5. Future work

Characterize visibility with O_4

Error budget

Paper in preparation for AMT

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