The mini-DOAS on the NASA Global Hawk (GH mini-DOAS)

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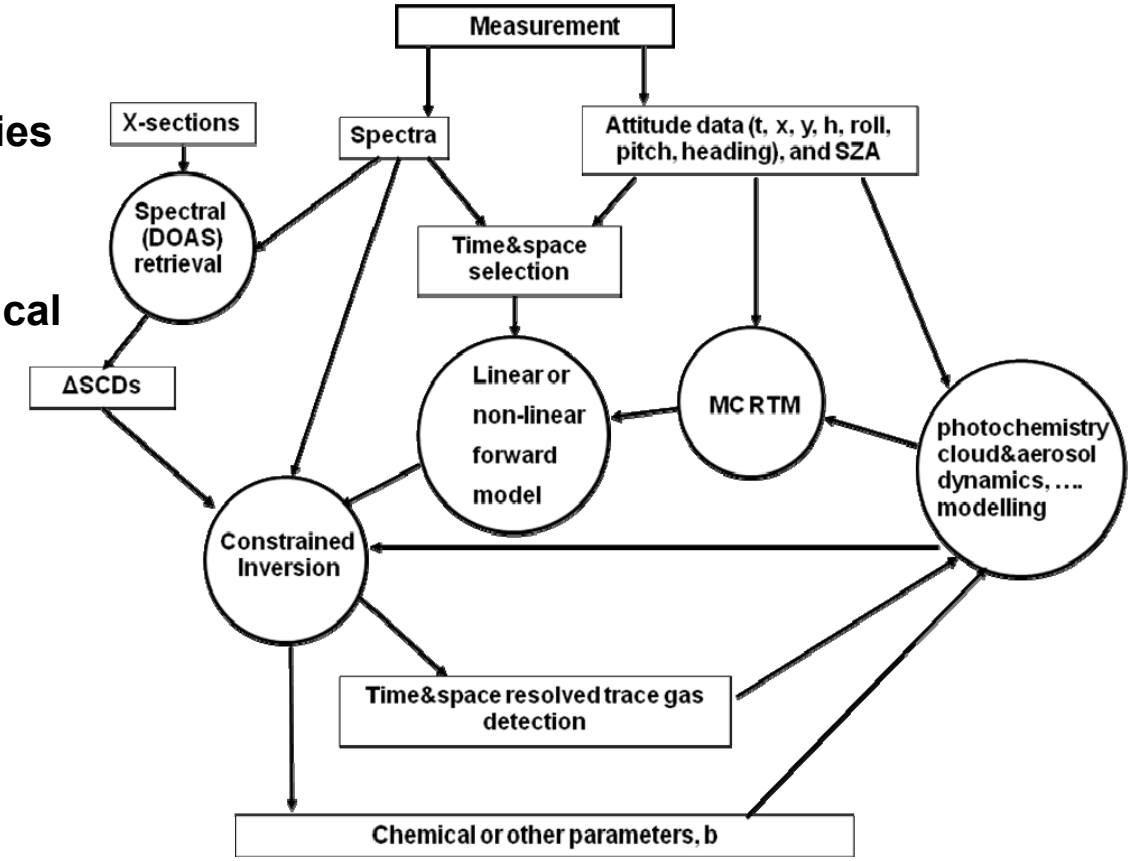
Mini-DOAS measurement technique & species

- **The mini-DOAS instrument is an UV/vis scanning double grating spectrometer (320 - 530nm) that uses limb skylight for trace gas detection, i.e. a remote sensing instrument**
- **Evaluation of the data involves**

1. **spectral retrieval (DOAS)**
2. **radiative transfer (RT) studies for each observation (McArtim)**
3. **Photochemical, microphysical and/or transport modelling depending on the scientific objectives**



Mini-DOAS measurement technique & species

Targeted species with tentative detection limits are:

Observation height	10 km	15 km	20 km
O3	35 ppb	80 ppb	140 ppb
NO2	13 ppt	28 ppt	40 ppt
BrO	0.7 ppt	1.5 ppt	2.2 ppt
OClO	3 ppt	7 ppt	10 ppt
IO	0.2 ppt	0.5 ppt	0.7 ppt
OIO	0.2 ppt	0.5 ppt	0.7 ppt
CH2O	600 ppt	1.3 ppb	2 ppb
HONO	5 ppt	10 ppt	15 ppt
O4 (*)	6.5 %	9 %	15 %
H2O (vapour) (*)	1 ppm	1.5 ppm	2 ppm
H2O (liquid) (*)	0.1 g/m^3	0.1 g/m^3	0.1 g/m^3
H2O (ice) (*)	0.15 g/m^3	0.15 g/m^3	0.15 g/m^3

(*) Optional including a near-IR spectrometer

Major Scientific Objectives

1.) To monitor the amount of BrO and IO in the tropical TTL/LS

→ to investigate the impact of bromine and iodine for the TTL/LS photochemistry

→ to assess the total amount of stratospheric bromine and iodine

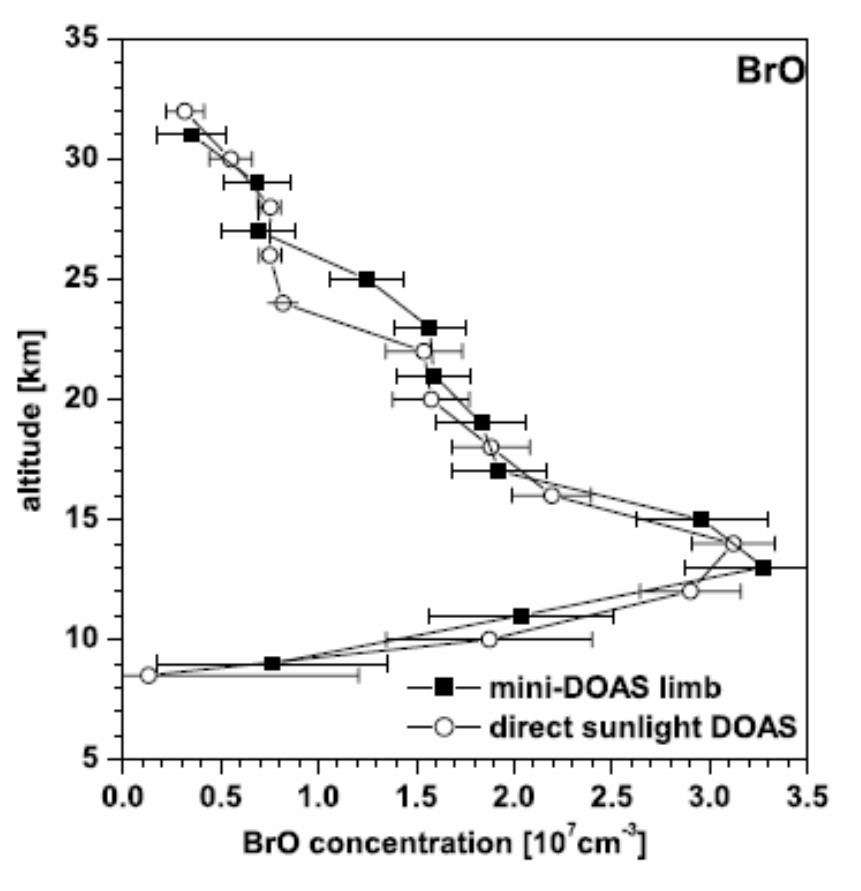
2.) To investigate the formation of NOx and HOx in deep convection

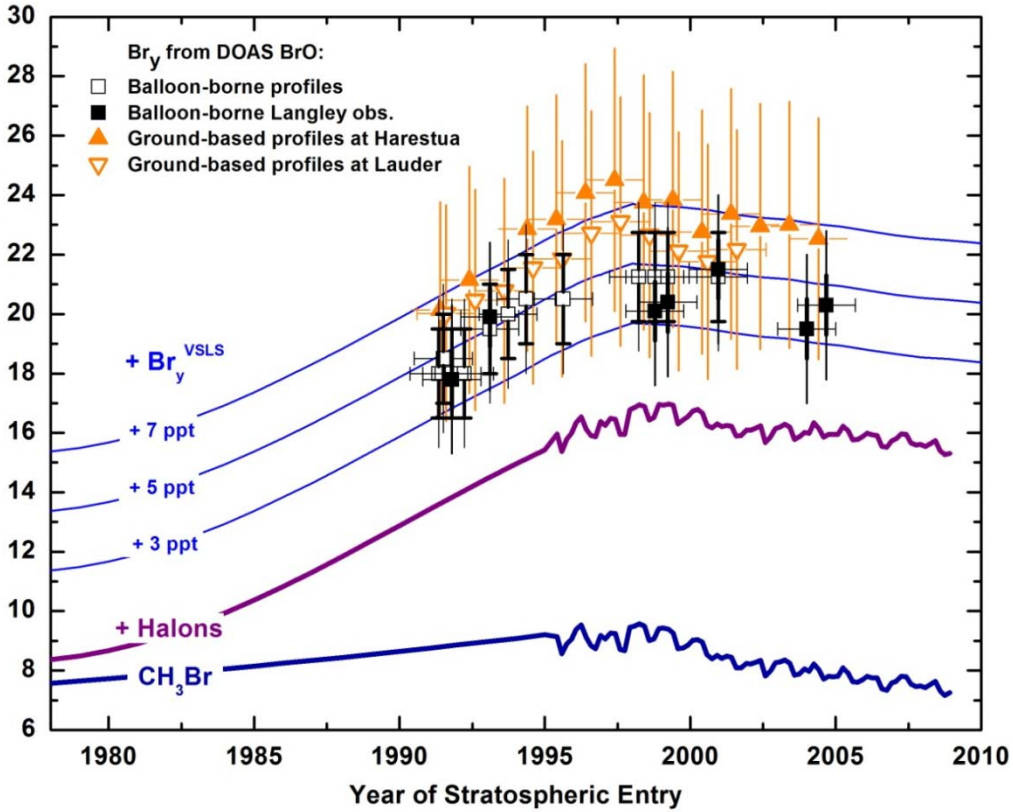
→ to assess the oxidation potential of the TTL/LS

3.) To monitor the occurrence of subvisible clouds and aerosols

→ to assess the impact of these particles in support of hetereogeneous reactions and radiative impact

Example 1: Trend in total stratospheric bromine





Weidner et al., 2005

Including updates from

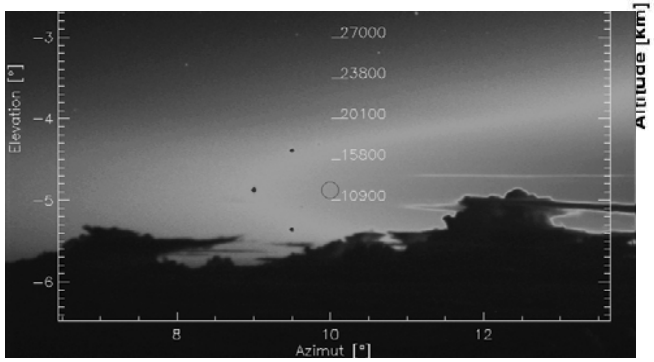
Dorf et al., 2006

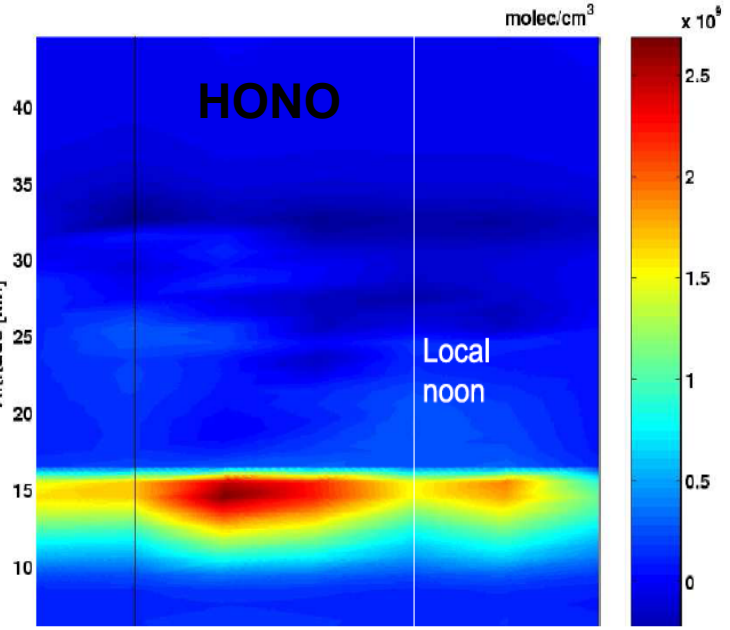
Hendrick et al., 2008

Example 2: TTL/LS NOx and HOx photochemistry & deep convection

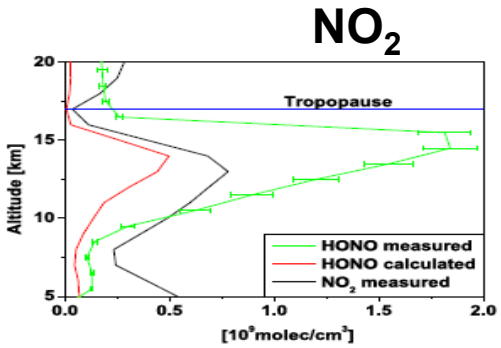
Thunderstorm related observations of NO_2 and HONO in the tropical TTL

(aboard the MIPAS-B gondola over north-eastern Brazil on June 13, 2005)

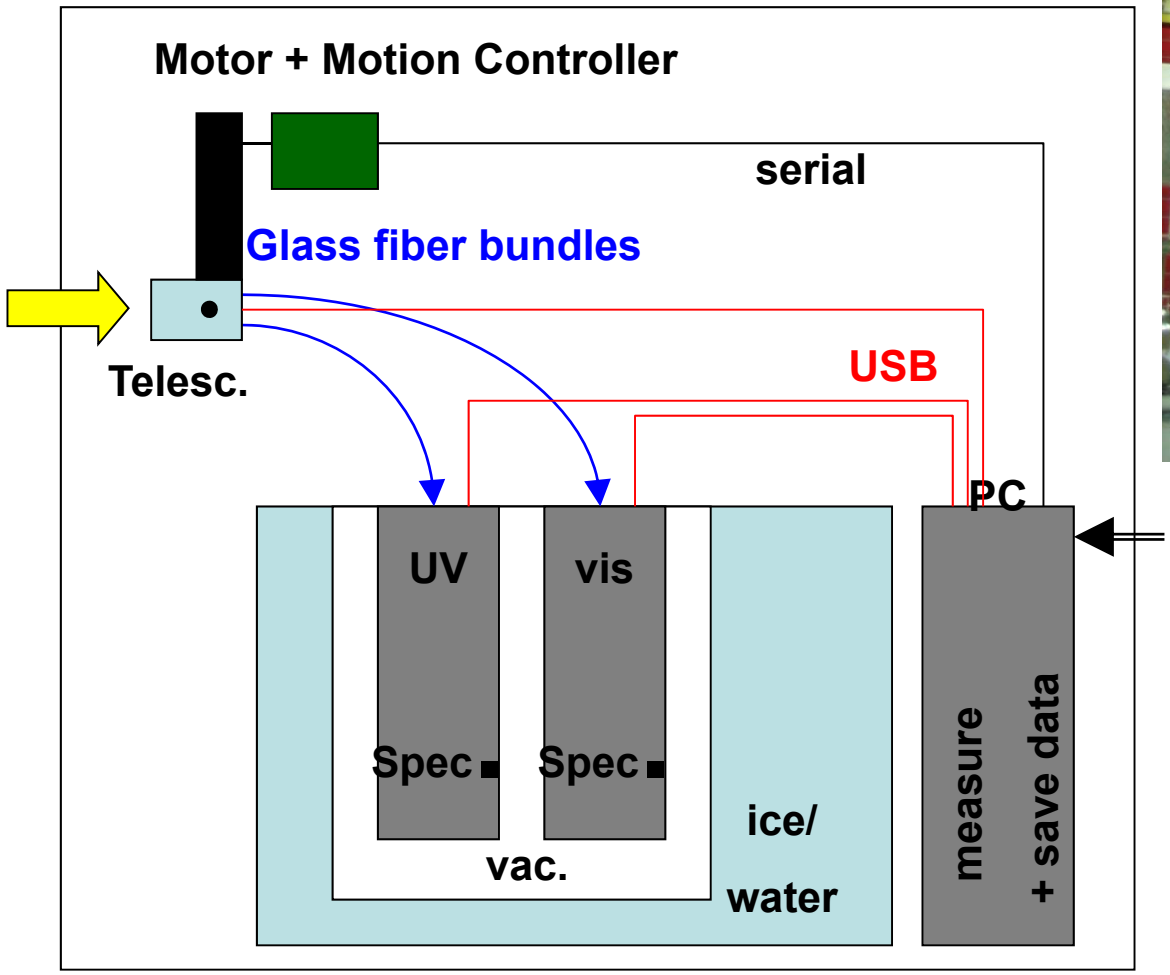




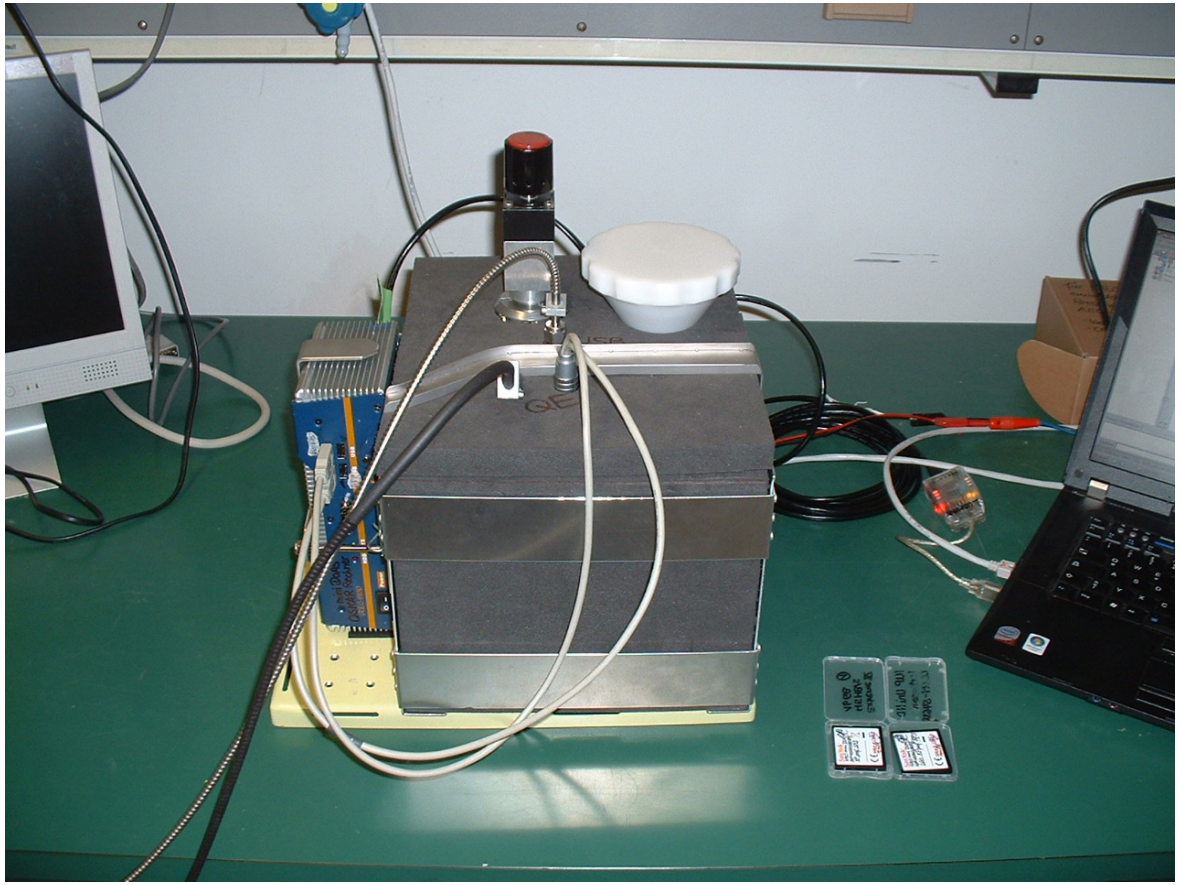
Observed NO_2 (black), calculated HONO, which is used as a priori for the inversion (red) and retrieved HONO (green), height of the tropopause (blue).



The mini-DOAS instrument layout



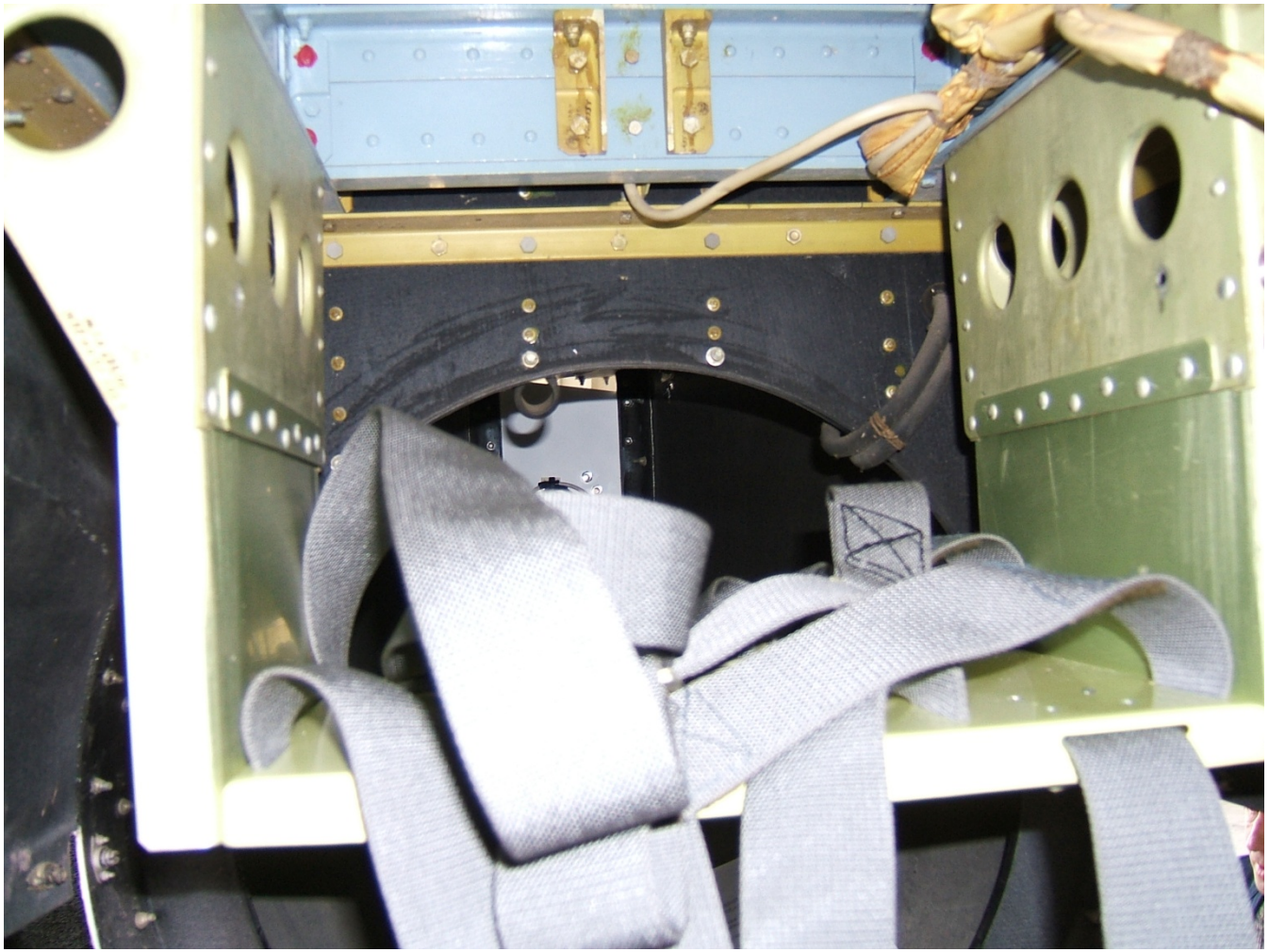
The mini-DOAS instrument integrated onto the Geophysica SIOUX plate



The mini-DOAS telescope

The mini-DOAS Geophysica housing

4. The mini-DOAS ‚rack‘ in the SIOUX cointainer



Mini-DOAS instrument characteristics

1.) Total weight: 13,5 kg

- Spectrometer: 11 kg
- Computer: 1,6 kg
- Telescope controller: 0,5 kg
- Telescopes: 0,4 kg

2.) Size:

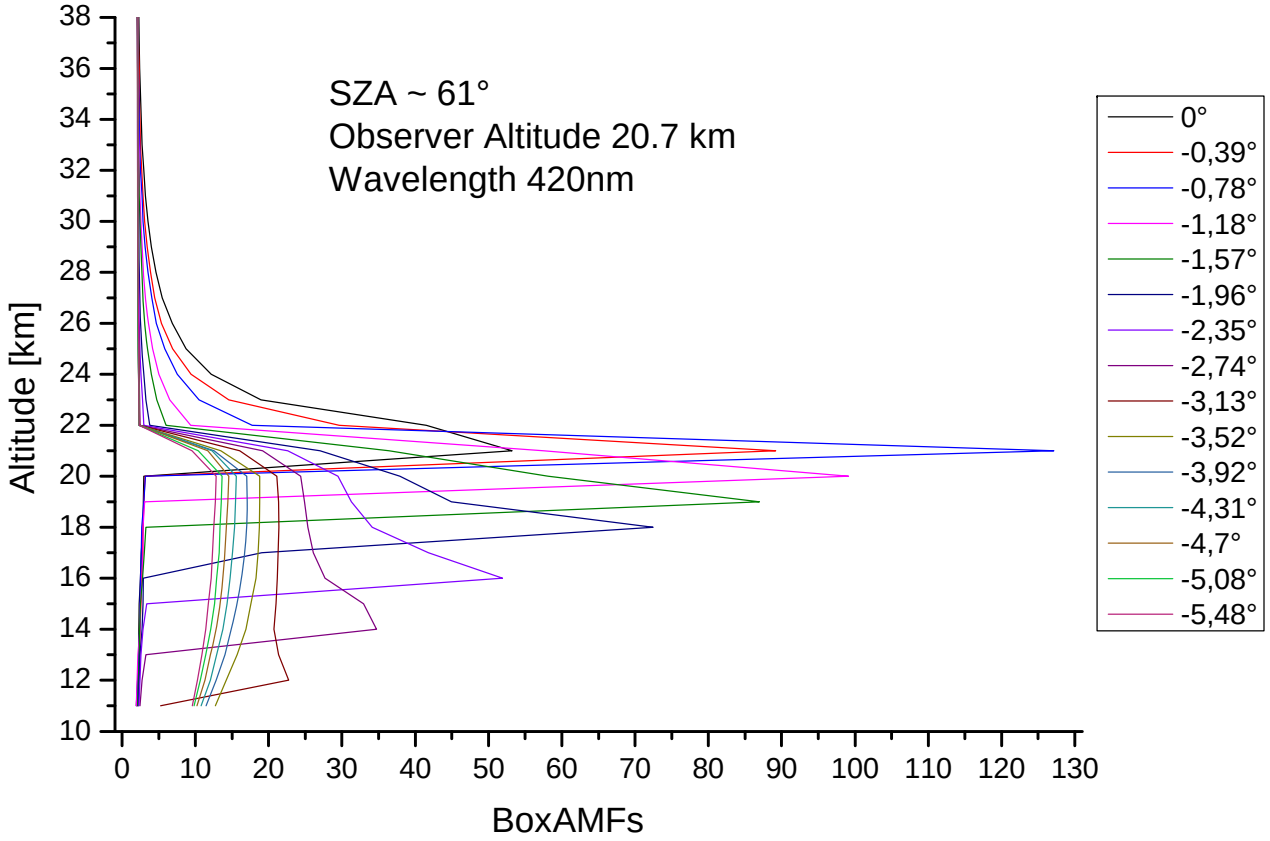
- Spectrometer housing: ~30cm times 25cm times 20cm
- Computer: ~30cm times 10cm times 12cm
- Telescopes: ~20cm times 20cm times 7cm

3.) Power consumption: 30 W (28V, 0.7 -1A), max 50W

4.) Probed air masses:

- Telescope FOV: 2.1° in the horizontal and 0.19° in the vertical
- Scanning elevation range: + 10° to - 90° in steps of ~0.05 °

Measurement characteristics: The sensitivity of looking limb!

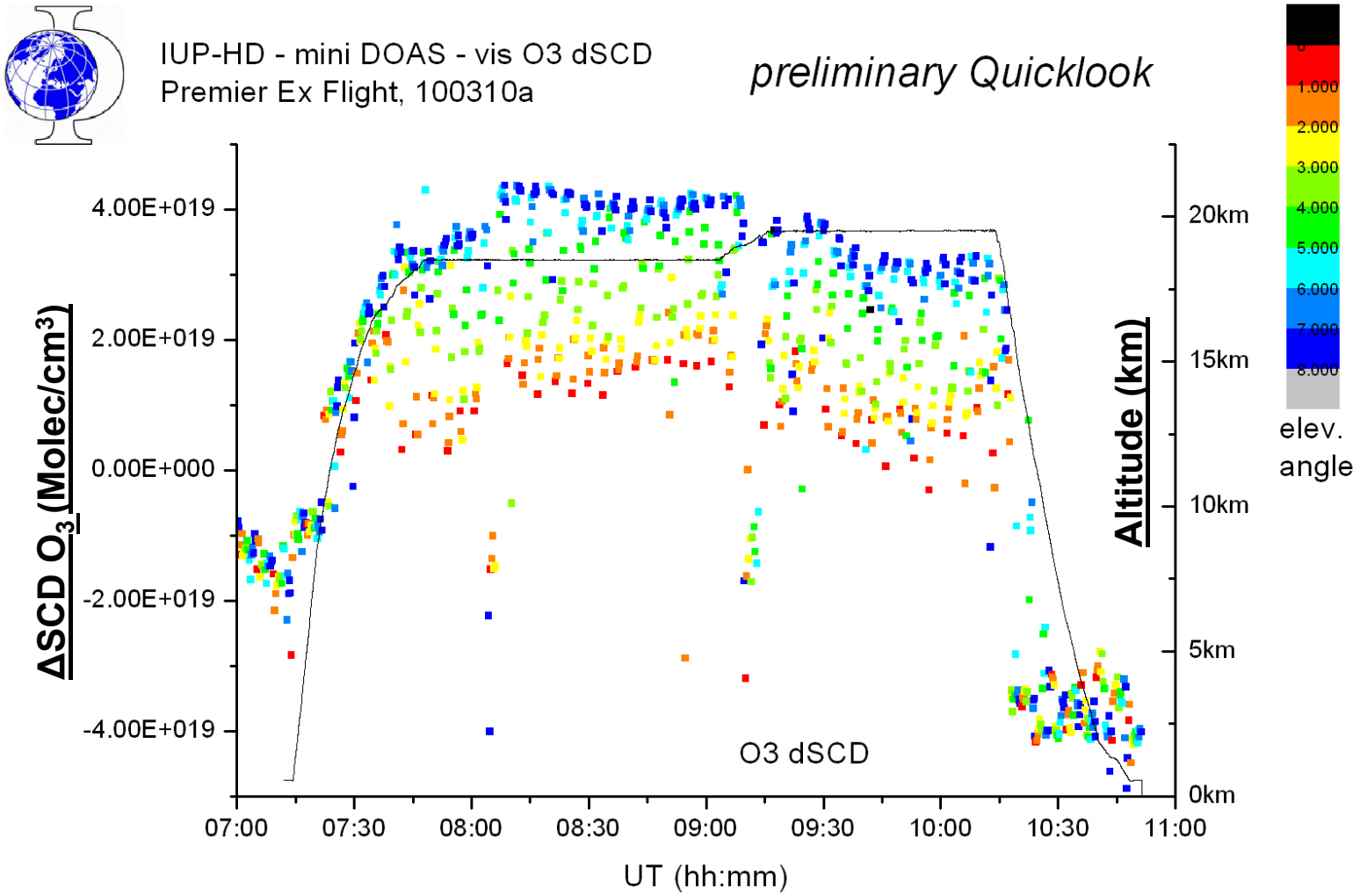


→ **for 420 nm, a FOV = 0.19° at H_{GH} = 20.7 km yields**

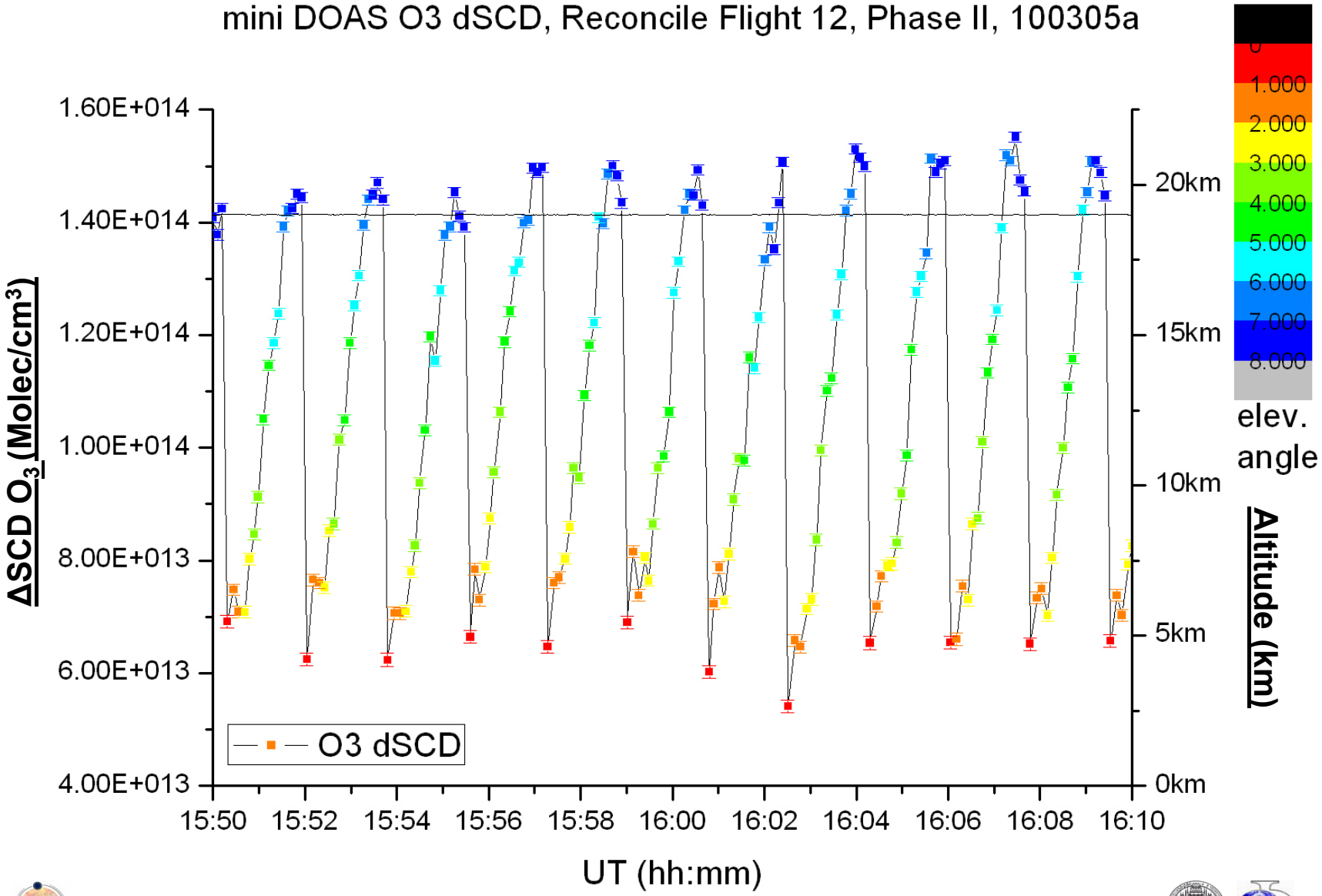
(1) A vertical resolution of Δz = 1km for a typical lightpath of 100 km

(2) Detection limit: 10^{-5}/km, or 10^{-10}/cm (in terms of extinction)

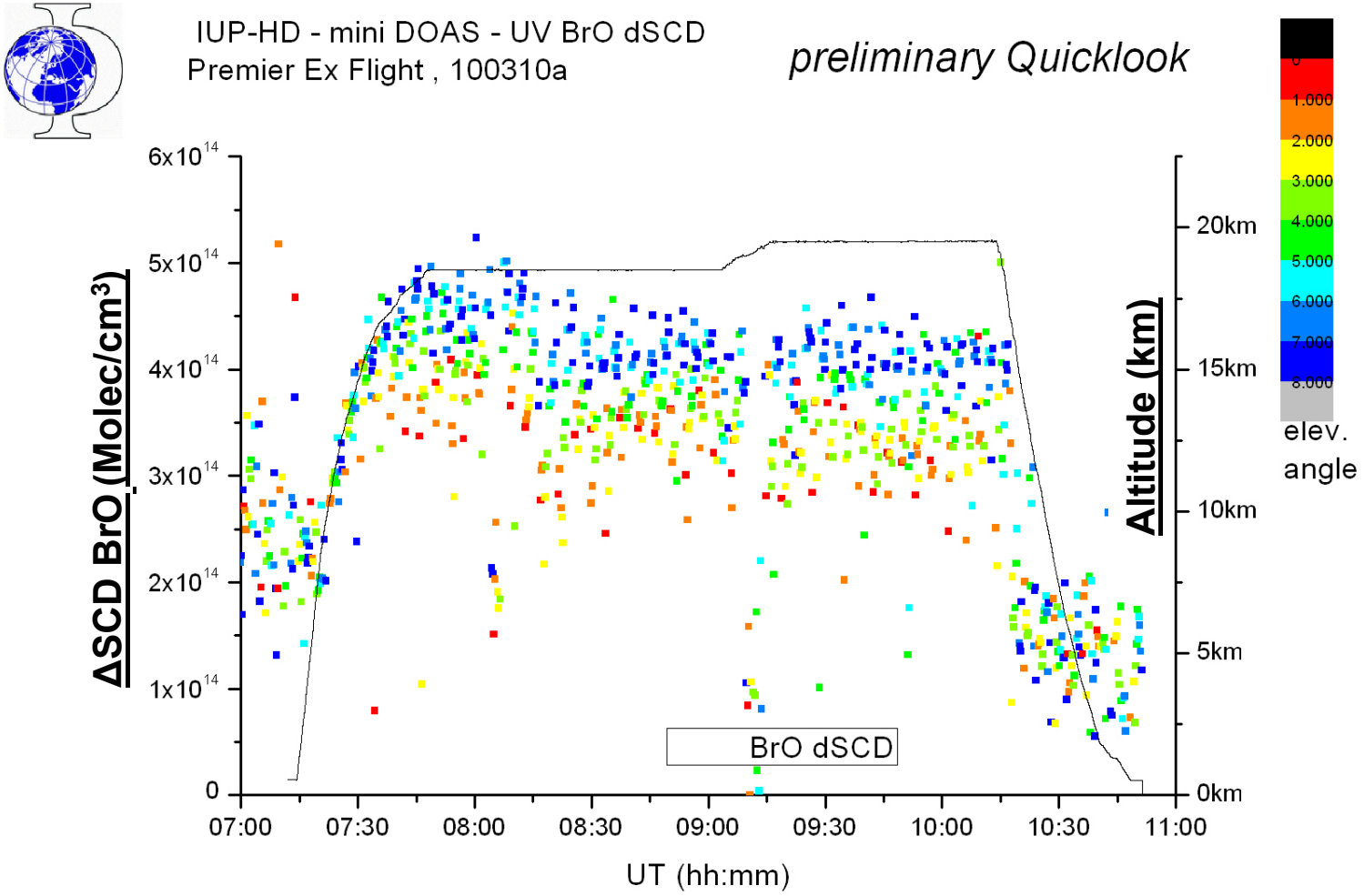
Flight 13 / March 10, 2010: ΔSCD O_3



Flight 12 / March 5, 2010: ΔSCD O_3



Flight 13 / March 10, 2010: ΔSCD BrO



Our requirements for assembly the mini-DOAS on the GH

1. **Power: 28 V, max 2 Amps**
2. **Housing: > 30 cm (length) times 60cm (depth) 25 cm (height)**
3. **unobstructed view to the horizon**
4. **online GH atitude data:**
   - **geolocation, UT time,**
   - **roll, pitch, and heading**

needed with a frequency (~ 10 Hz) somewhat depending on the flight atitude of GH, and the skylight radiance

5. Questions:

- **Is there telemetry and telecommand available, and at what rate?**
- **What are typical T‘s in the compartment?**

Pre- campaign, pre-flight, and post-flight activities

1.) Prior to a campaign:

- **Pumping and sealing (weeks)**
- **Installation of the instrument aboard (~2 days)**
- **Alignment of the telescope &relative to aircrafts data (0.5 days)**

2.) Prior to a sortie:

- **cooling/replacement of water/ice (hours)**
- **Uploading of the actual operational programme (hours)**
- **functional tests of the instrument**

3.) Postflight activities:

- **download of measured data**
- **data retrieval**
- **…**

Status & Timeline

Past/Experience:

The mini-DOAS instrument already flew on 25 DLR Falcon aircraft sorties, 10 balloon missions (MIPAS-B, LPMA/DOAS & LPMA/IASI), and 15 Geophysica sorties

Plan:

For GH we will build an upgraded copy of the existing mini-DOAS instrument

Present:

Post-doc personal (3 applicants) are just being evaluated

Fall 2010/end of 2010:

Design review and start of assembly

Mid 2011:

Final assembly and laboratory test

Sept./Nov 2011:

Attrex test integration

End of 2011:

GH mini-DOAS instrument being operational (ambitious)