ESSenCe Campaign
GLORIA Measurements

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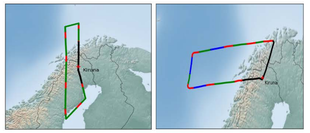
The GLORIA Instrument

The **G**imballed **L**imb **O**bserver for **R**adiance **I**maging of the **A**tmosphere is an infrared Fourier transform spectrometer (FTS/FTIR) with imaging capabilities. Incoming light is modulated by a linear Michelson interferometer and then cast on a 2D detector array with a usable area of 128x128 pixels.
The scientific goal of GLORIA is to fill the gap between in-situ observations (high spatial resolution) and remote sensing measurements (high coverage), specifically for the Upper Troposphere and Lower Stratosphere (UT/LS region).
To be able to meet various scientific requirements, GLORIA's measurement time can be adjusted. Longer interferograms yield a higher spectral resolution while shorter ones allow for more frequent measurements and better spatial resolution.
These modes of operation are designated chemistry mode and dynamics mode, respectively. The former enables us to retrieve a more diverse array of trace species from the measured data, while the latter allows for the resolution of dynamic processses and, depending on the flight path, tomographic 3D analysis.
GLORIA is mounted on a gimbal frame and can be rotated around all three principal axes. A sophisticated attitude control system stabilizes the viewing direction while measurements are recorded. Change of measurement mode, target point and even switch to nadir geometry is possible while in the air. GLORIA operations are usually preprogrammed on the ground, but manual intervention is possible at any time via a bidirectional satellite link.

The M-55 Geophysica carrier aircraft. The pictures to the left and the upper right show GLORIA deployed in the plane's forward bellypod. The aft bellypod (visible in the left image) is reserved for the MARSHALS sounder which was also mounted for ESSenCe.



2012/12/11 2012/12/16

Flight paths for the two flights performed from Kiruna Airport. The colour-coded sequences are chemistry mode (green), dynamics mode (blue), calibration (red), and parked (black.)

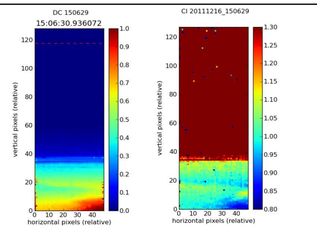
ESSenCe

ESA **S**ounder **C**ampaign took place in Kiruna (Sweden) during November and December 2011. Its main objective was to test the GLORIA instrument in the stratosphere. To this end, the Myasichshev M-55 Geophysica high altitude aircraft was used as carrier. Two flights were conducted on the 11th and 16th of December, with measurements taken from as high as 16.8 km.

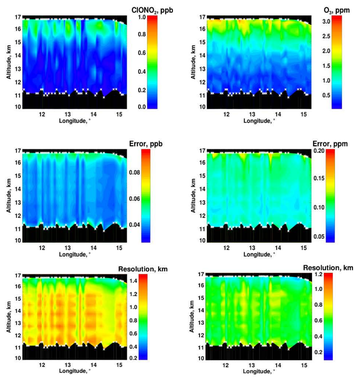
GLORIA being prepared for deployment in Arena Arctica on Kiruna Airport.

Data Analysis

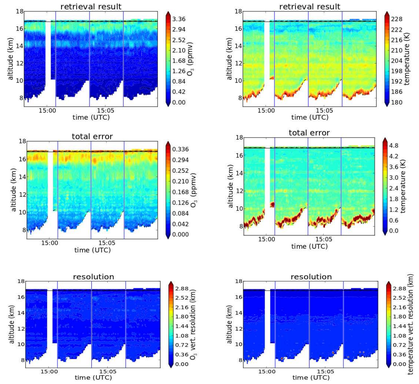
The interferograms are resampled on a spatially equidistant grid and spectrally calibrated using information from known atmospheric lines. After a Fourier transform, the resulting spectra are radiometrically calibrated using measurements from GLORIA's on-board blackbodies and deep-space measurements at 10° elevation angle.
The retrieval of trace gases, temperature etc. is performed using the L2 processors developed at Forschungszentrum Jülich (FZJ) and Karlsruher Institut für Technologie (KIT). For dynamics mode measurements, FZJ's **JU**elich **RA**pid **S**pectral **SI**mulation **C**ode (JURASSIC2) is used. Chemistry mode retrievals are performed using the **K**arlsruhe **O**ptimized and **P**recise **R**adiative transfer **A**lgorithm (KOPRAFIT). Preliminary retrieval results have been obtained for temperature and several trace gases, including $ClONO_2$, O_3 and H_2O.



Left: IR image sampled at 25 Hz from a flight 2 interferogram (dynamics mode). The pseudocolour scale is the total radiance in arbitrary units, truncated to accentuate the features visible in the lower part. Right: MIPAS-A-analogue cloud index plot for the same measurement. Lower values indicate a higher likelihood of cloud presence.



Cross-section plot of 1D $ClONO_2$ and O_3 retrievals from a chemistry mode sequence during flight 2 (14:30 to 14:49 UTC). Estimated retrieval error and vertical resolution are plotted beneath on the same grid. The spectral sampling is 0.0625 cm^{-1}. Results have been obtained using KOPRAFIT at KIT (IMK-ASF).



Cross-section plot of 1D O_3 and temperature retrievals from a dynamics mode sequence during flight 2 (14:30 to 14:49 UTC). Plotted below are the estimated retrieval error as well as the vertical resolution. Dynamics mode spectral sampling was 0.3125 cm^{-1}. The four sections represent four azimuth sweeps along the flight path. Results have been obtained using JURASSIC2 at FZJ (IEK-7).

Conclusion / Outlook

Due to GLORIA being a new instrument, the data analysis is still being refined. Preliminary results showcase GLORIA's suitability for high-resolution trace gas retrievals. At the same time, some ways of enhancing the hard- and software have been discovered during the post-campaign analysis which are currently being implemented and tested.
GLORIA's first scientific deployment will be on the combined TACTS/ESMVAL campaign on the German **H**igh **A**ltitude and **LO**ng Range Research Aircraft (HALO). This is the carrier for which GLORIA had originally been designed.
GLORIA is also a prototype instrument for the ESA Earth Explorer proposal "**PR**ocess **E**xploration through **M**easurements of **I**nfrared and Millimetre Wave **E**mitted **R**adiation" (PREMIER). The scientific objective here is to enhance our understanding of UT/LS dynamics - especially gravity (buoyancy) waves - through combined use of infrared and microwave limb sounding techniques.

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