

Name of research institute or organization:

Institute of Applied Physics, University of Bern

Title of project:

GROMOS-C: GRoundbased Ozone MOnitoring Spectrometer for Campaigns

Part of this programme:

GAW, NDACC

Project leader and team:

Prof. Dr. Niklaus Kämpfer, project leader
Susana Fernandez

Project description:

Stratospheric ozone is of major interest as it absorbs most of the harmful UV radiation from the sun, allowing life on Earth. Ground based microwave remote sensing is the only method that allows to measure ozone profiles up to the mesopause, 24-hours and under different weather conditions with high time resolution.

A novel ground based microwave radiometer, called GROMOS-C (GRound based Ozone MOnitoring System for Campaigns) has been designed to measure the vertical profile of ozone distribution in the middle atmosphere, by observing ozone emission spectra at a frequency of 110.836 GHz. The instrument is designed in a compact way which makes it transportable and suitable for outdoor use in campaigns, an advantageous feature that is lacking in present day ozone radiometers. It is operated through remote control.

GROMOS-C is a total power radiometer which uses a preamplified heterodyne receiver, and a digital Fast Fourier Transform spectrometer for the spectral analysis. Among its main new features, the incorporation of different calibration loads stands out, including a noise diode and a new type of blackbody target specifically designed for this instrument, based on Peltier elements. The calibration scheme does not depend on the use of liquid nitrogen, therefore GROMOS-C can be operated at remote places such as the Jungfrauoch with no maintenance requirements. In addition, the instrument can be switched in frequency to observe the CO line at 115 GHz.

After first successful tests on the roof of the building “Exakte Wissenschaften”, University of Bern, it has been decided to move the instrument to the terrace of the Sphinx observatory at Jungfrauoch to test in detail how the radiometer works under extreme winter conditions, as it is planned to later operate GROMOS-C from Spitzbergen under arctic environment. An impression of the instrument at Jungfrauoch is given in Figure 1. A further aim was to collect high resolution ozone spectra at high altitude, retrieve vertical profiles and validate the instrument by comparing with ozone profiles from other sources such as from a similar instrument at Bern and from satellite.

GROMOS-C has been moved to Jungfrauoch at the beginning of January 2014 and has been operational until the end of March 2014 when it was brought back to Bern for another measurement campaign on La Réunion island.

During the campaign the weather was mainly cold with minimum temperatures of -23°C and maximum close to 0°C . Wind has often been very strong, affecting the thermal regulation of GROMOS-C housing. Additional heaters were installed to solve this problem, but still on very cold and windy days the thermal stability was not as good as expected, affecting the stability of the noise diode. However, this does not pose a problem as different calibration schemas are still feasible.



Figure 1. GROMOS-C on the Sphinx terrace during the Jungfrauoch campaign. 1: Teflon window, 2: Microwave receiver, 3: Calibration targets, 4: Computer and spectrometer.

The presence of snow on the microwave window modifies its opacity. This was observed as higher brightness temperatures were measured at zenith than at lower elevations during snowfalls. A system of warm air blown on the surface of the window was designed to solve the snow problem by preventing its deposition on the surface.

The top plot of Figure 2 shows a typical one day ozone spectrum after applying the tropospheric correction. The red line corresponds to the calculated spectrum by the forward model based on the retrieved ozone profile. The bottom plot shows the residuals between the measured and the estimated spectrum. The retrievals have been run for every day, with 30 minutes integration time, from January 15 to March 4. Figure 3 shows the mean volume mixing ratio of ozone for three selected pressure levels and its evolution on time compared to the correspondent satellite measurements of MLS and to the sister radiometer located at Bern.

During a clear period at Jungfrauoch we successfully checked the feasibility of observing also the CO emission line at 115.271 GHz by shifting the LO frequency. CO is mainly present in the mesosphere, where its concentration shows a steep vertical gradient, being very low in the stratosphere. For this reason its emission spectrum results in a very narrow and rather weak broadened line.

It can be concluded that the measurement campaign of GROMOS-C at Jungfrauoch was successful. The validation campaign at Jungfrauoch proved that GROMOS-C can provide ozone profiles in the middle atmosphere, specifically between 23 to 70 km. Comparisons show a very good overall agreement with the NDACC radiometer GROMOS, as well as with MLS profiles. The accordance between the retrievals of GROMOS and GROMOS-C is within 10% at all levels, and with MLS for pressure altitudes between 30 and 0.3 hPa.

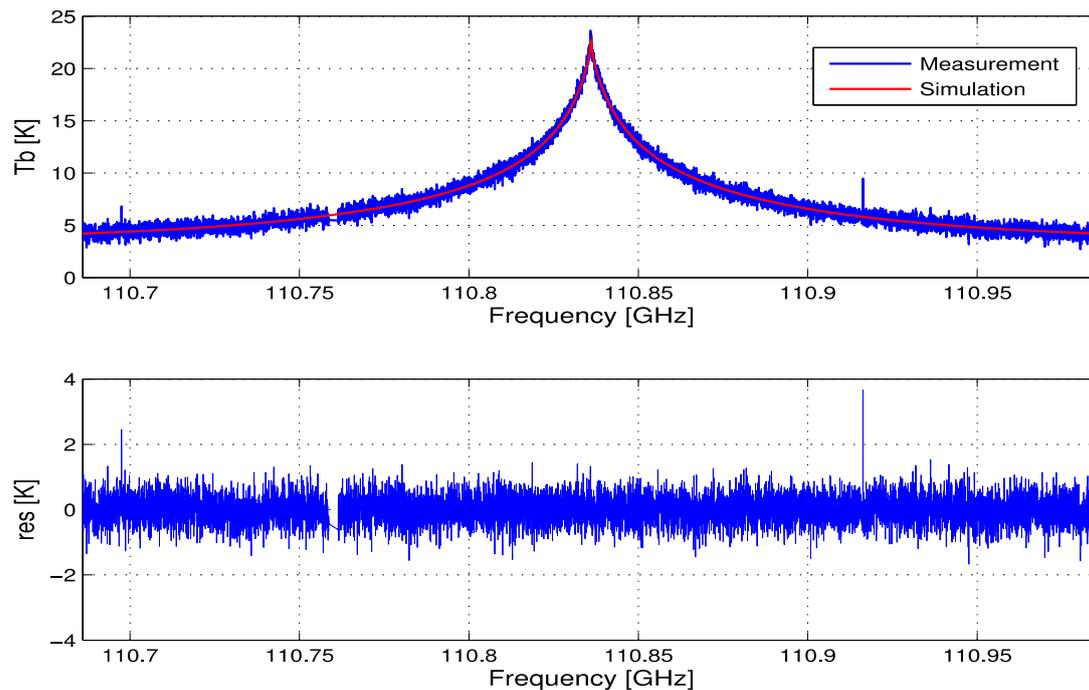


Figure 2. Above, measured and simulated one day ozone spectrum; below, residuals between simulation and measurement.

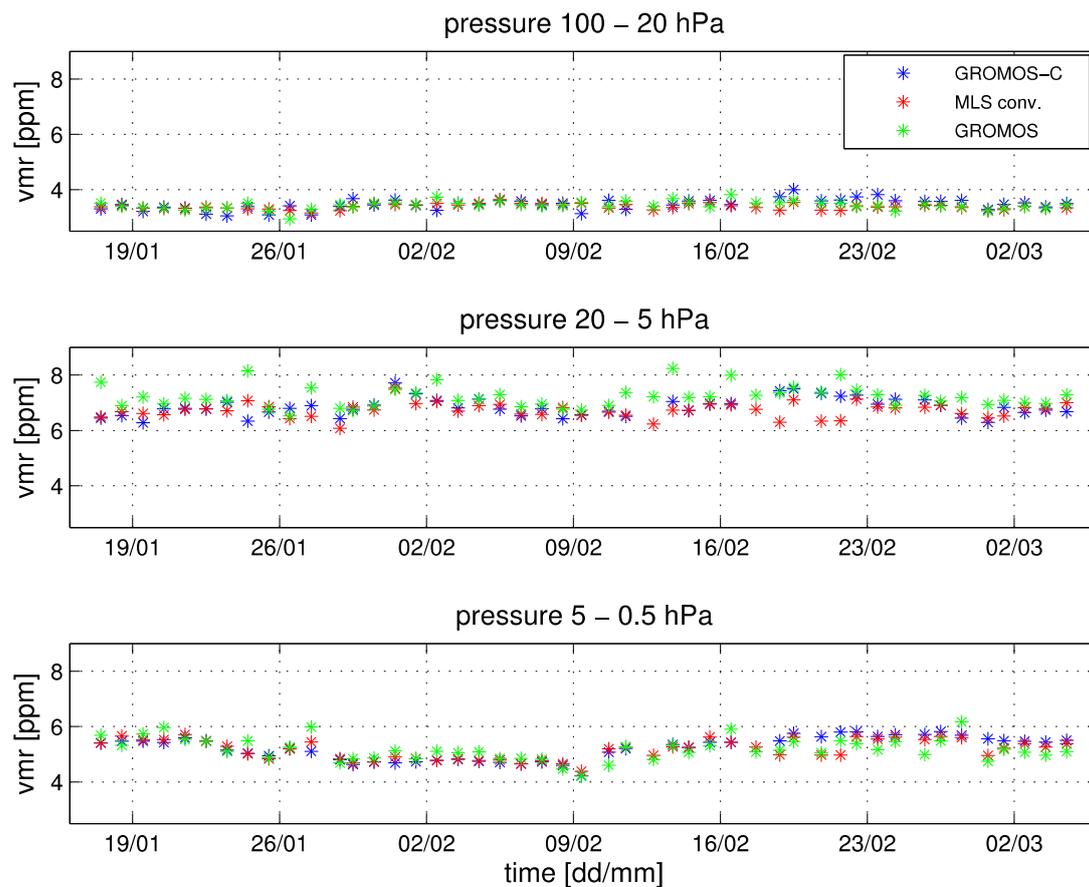


Figure 3. Time series of ozone volume mixing ratio for 3 pressure levels, retrieved by GROMOS-C and compared with MLS convolved and the instrument GROMOS at Bern.

Key words:

Stratospheric ozone, microwave radiometry, remote sensing

Collaborating partners/networks:

MeteoSwiss, NDACC (Network for the Detection of Atmospheric Composition Change)

Scientific publications and public outreach 2014:

Refereed journal articles and their internet access

Fernandez, S., A. Murk, and N. Kämpfer, GROMOS-C, a novel ground based microwave radiometer for ozone measurement campaigns, submitted to Atmos. Meas.Tech. D in December 2014.

Conference papers

Fernandez, S., A. Murk, and N. Kämpfer, GROMOS-C, the new ground based microwave radiometer for ozone measurement campaigns, WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2014), Saint Petersburg, Russia, July 10, 2014.

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