Validation of high-resolution temperature profiles (HRTP) retrieved from bi-chromatic scintillation measurements by GOMOS

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Retrieval of HRTP

The GOMOS (Global Ozone Monitoring by Occultation of Stars) instrument on board Envisat is equipped with two fast photometers operating at blue (470-520 nm) and red (650-700 nm) wavelengths with a sampling frequency of 1 kHz [*http://envisat.esa.int/instruments/gomos*]. The bi-chromatic scintillations recorded by the photometers allow the determination of a refractive angle, which is proportional to the time delay between the photometer signals. The high resolution density and temperature profiles (with a **vertical resolution of about 200 m**) can be reconstructed from these data **at altitudes 18-35 km**.
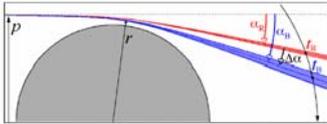

Figure 1: The schematic representation of chromatic refraction and the principle of refraction angle measurements by GOMOS.
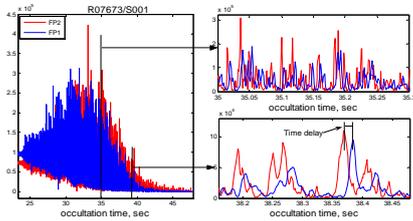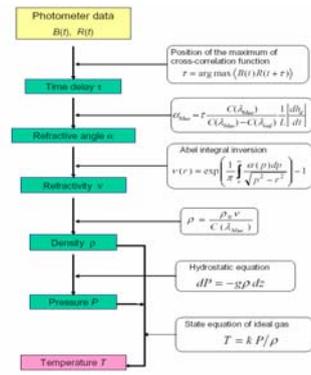

Figure 2: Signals of fast photometers.

Figure 3: Main steps of data processing

Approaches to validation of HRTP

•**Requirements for data selection:**

-Taking into spatio-temporal variability of IGW field, the the horizontal separation of collocated measurements should ideally be less **than 20 km** and the time difference between collocated profiles should **not exceed 2-3 hours**.

- There are few data satisfying the strict collocation criteria. Only radiosonde data satisfy the resolution requirements

• **Validation methods**

-Direct comparisons of profiles

•Collocated profiles are to be presented in the same vertical resolution

-Validation using spectral analysis

•Comparison of one-dimensional spatial spectra of the collocated data

•The saturated gravity waves model $V_{\delta T/T}(\kappa_z) = A\dfrac{N^4}{g^2}\kappa_z^{-3}$

GOMOS collocations
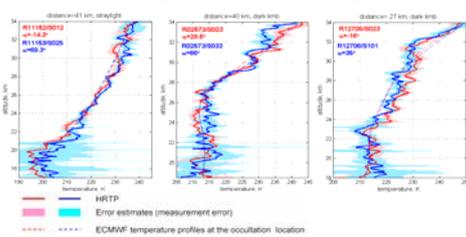
Figure 4: Examples of HRTP in GOMOS-GOMOS coincidences

Validation with radiosondes

High latitudes

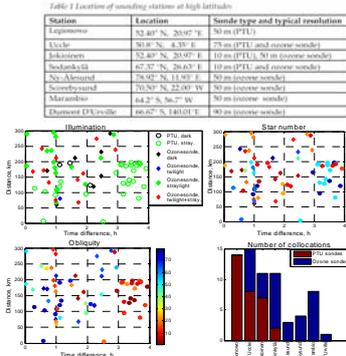*Table 1 Location of sounding stations at high latitudes*

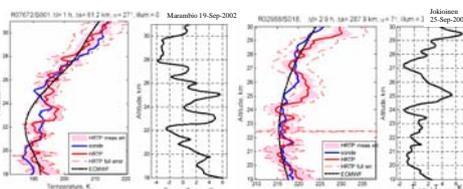*Figure 4: GOMOS data collocated with soundings at high latitudes.*

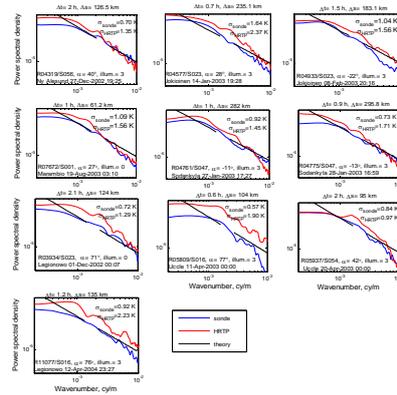*Figure 5: Examples of individual comparisons*

Figure 6: Spectra of relative temperature fluctuations in sounding profiles and in HRTP.
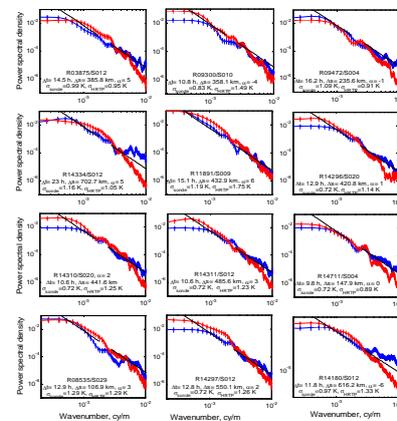
Low latitudes (SHADOZ sondes)

Figure 7: 1-D spatial spectra of relative temperature fluctuations (red: HRTP, blue: sonde, black dashed: model of the saturated gravity waves).

•In case of vertical occultations of bright stars, spectra of relative temperature fluctuations are very similar for HRTP and sonde data, as well as rms of fluctuations.

• In case of oblique occultations or dim/not-bright stars, results are ambiguous: some spectra are similar, some of them indicate significantly larger amplitude of fluctuations in HRTP than in sonde profiles.

•The actual vertical resolution of HRTP is 150-200 m (a clear cut-off in the temperature fluctuation spectra at the corresponding scales is observed).
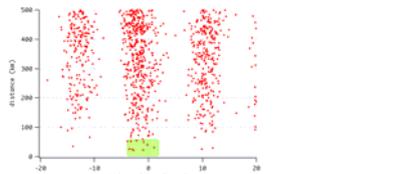
Validation with lidars

Figure 8: Available lidar data at NILU CAL/VAL database. The data satisfying the collocation criterion: distance < 60 km, time difference < 3h are highlighted.
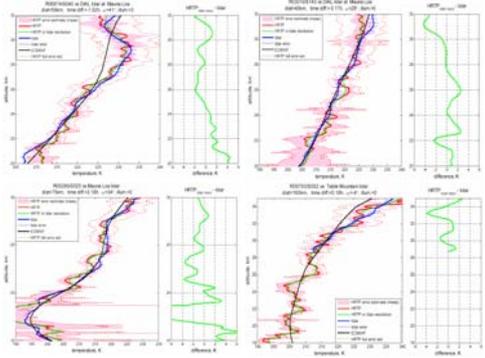

Figure 9: Comparison of HRTP and lidar temperature profiles

•In many cases, HRTP and lidar data are close to each other and may deviate significantly from ECMWF data. This demonstrates usefulness of HRTP.

•The typical deviation of smoothed HRTP from lidar temperature is smaller than 2 K. HRTP has no evident bias with respect to lidar data.

•The quality of HRTP depends weakly on star brightness.

•The reasonable HRTP can be obtained also not in full dark illumination conditions (in "stray light").

Validation with CHAMP

Radio occultation measurements provide opportunity for extensive validation of HRTP with global coverage, as they allow selection of sufficient number of collocated occultations, even using very strict collocation criteria needed for HRTP validation.
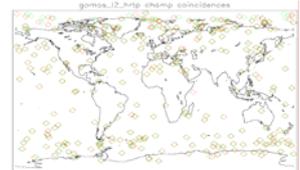

Figure 10: Collocated GOMOS and CHAMP() occultations; distance < 100 km, time difference < 3h
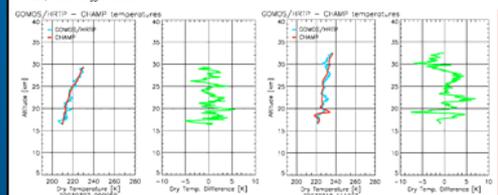

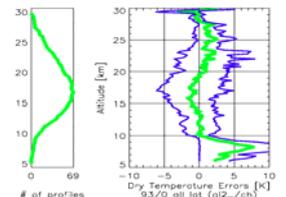*Figure 11: Examples of comparisons of HRTP and CHAMP temperature profiles*

Figure 12: Statistical analysis of deviation of HRTP from CHAMP temperature profiles; all locations. Left: number of profiles contributed to the statistics. Right: bias (mean of deviations) and standard deviation.

•The rms deviation from CHAMP profiles is ~3 K.

•A small, but altitude-dependent bias is observed.