Validation of GOMOS High Resolution Temperature Profiles using Wavelet Analysis - Comparison with Thule Lidar Observations

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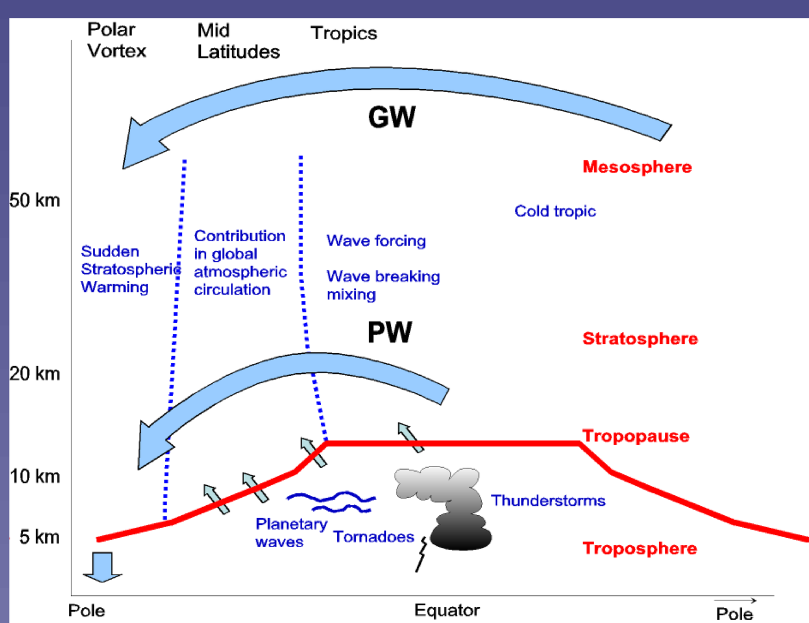
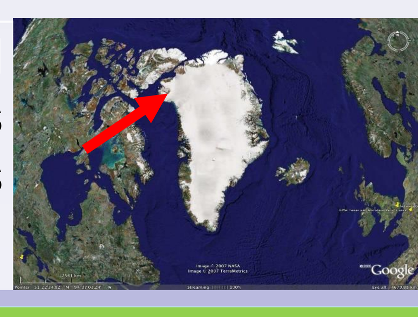
Introduction



This poster focuses on a study aimed at improving the validation of GOMOS High Resolution Temperature profiles (HRTP). In particular, we developed a method to detect and remove the influence of fluctuations associated with gravity waves from the GOMOS HRTP.

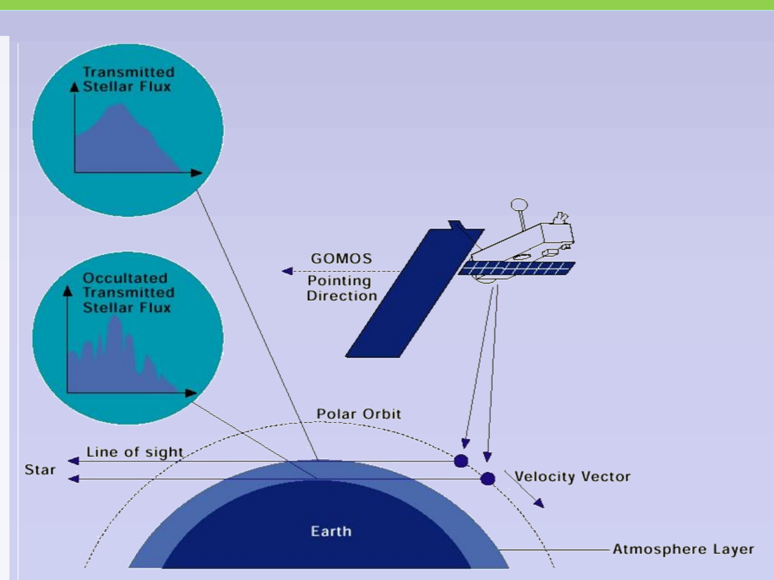
Small fluctuations have been observed by a variety of techniques including radar, lidars and satellite measurements. These wavelike motions appear as periodic oscillations in atmospheric temperature, pressure, and density, as waves propagate both vertically and horizontally. Gravity waves may carry momentum and energy from the troposphere to the middle and upper atmosphere, and are responsible for the large departure of the former from radiative equilibrium.

We employed wavelet-based analysis methods for the detection of small fluctuations present in the temperature and density vertical (stratospheric) profiles measured by the GOMOS on board Envisat, and from the Rayleigh Lidar (Light Detection and Ranging) measurements at Thule (in North Western Greenland (http://ndacc-lidar.org/). Measurements made in 2009 and 2010 are used in this study.



GOMOS

The GOMOS (Global Ozone Monitoring by Occultation of Stars) instrument is a spectrometer that exploited the stellar occultation technique. The species covered by GOMOS are O_3, NO_2, NO_3, neutral density, aerosols, H_2O, O_2, and High Resolution Temperature Profiles (HRTP).



The HRTP is retrieved from the scintillation observed by two GOMOS fast-photometer measurements, operating at 1 kHz sampling frequency in the blue (470-520 nm) and in the red (650-700 nm) spectral regions.

Platform: Envisat (March, 2002 – April, 2012)
Vertical resolution: 250 m
Vertical sampling:~10 m

Thule Lidar Observations

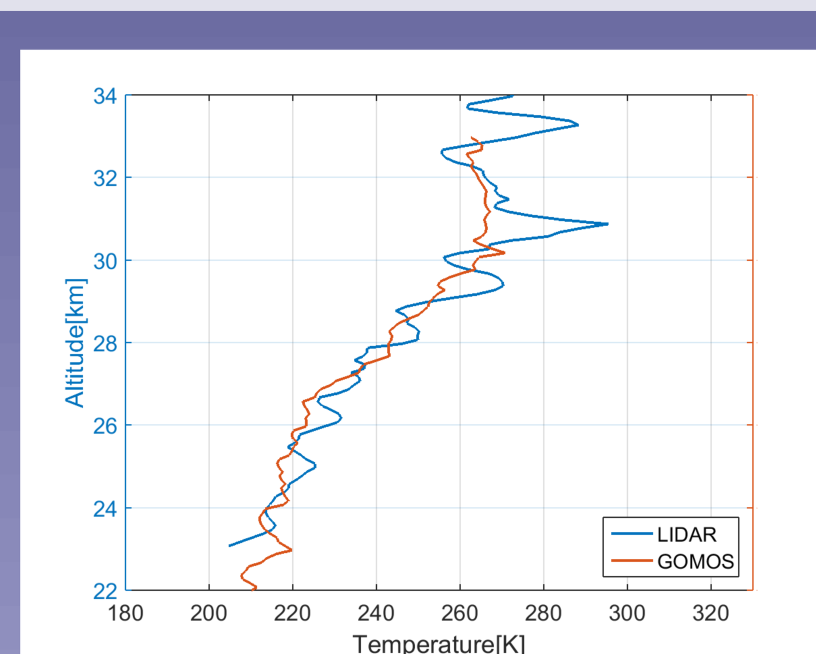
LIDAR SYSTEM

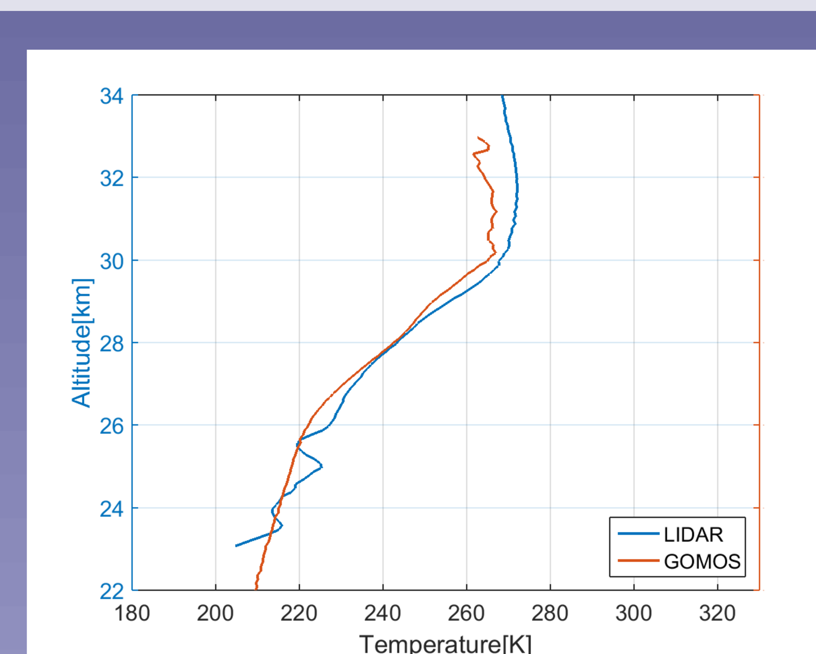
Several instruments are operational at Thule (76.5°N, 68.8°W) as part of the Network for Detection of Atmospheric Composition Change. A **lidar** was installed in 1990 and has been operational particularly during the winter season. The Lidar uses a Nd:YAG laser, three telescopes, and four receiving channels to measure the aerosol backscatter ratio and depolarization in the troposphere and lower stratosphere, and the atmospheric temperature (T) profile from 25 up to 70 km altitude.

Method

The detection method is based on the continuous wavelet transform, which provides a decomposition of a signal in both the time and frequency domains. a time-frequency representation of a signal that offers very good time and frequency localization, so wavelet transforms can analyse localized intermittent periodicities of potentially great interest in the temperature signals. The 'Morlet' mother function has been selected, since it has proven to give a good resolution in time as well as in frequency.

After applying the wave screening technique, the wavy signal is estimated and subtracted from the original profile, thus providing "wave-free" profiles, as depicted in the figures below.



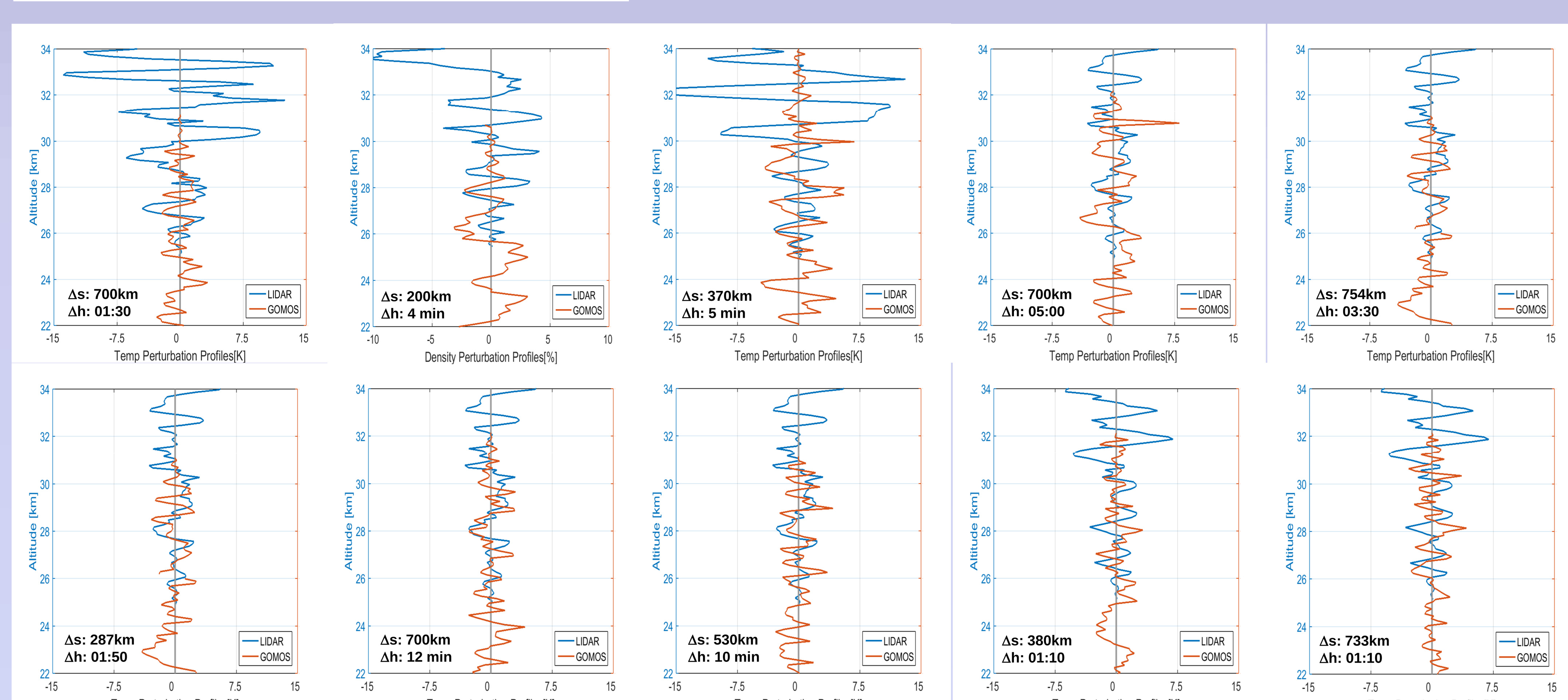


Preliminary Results: Perturbation Profiles

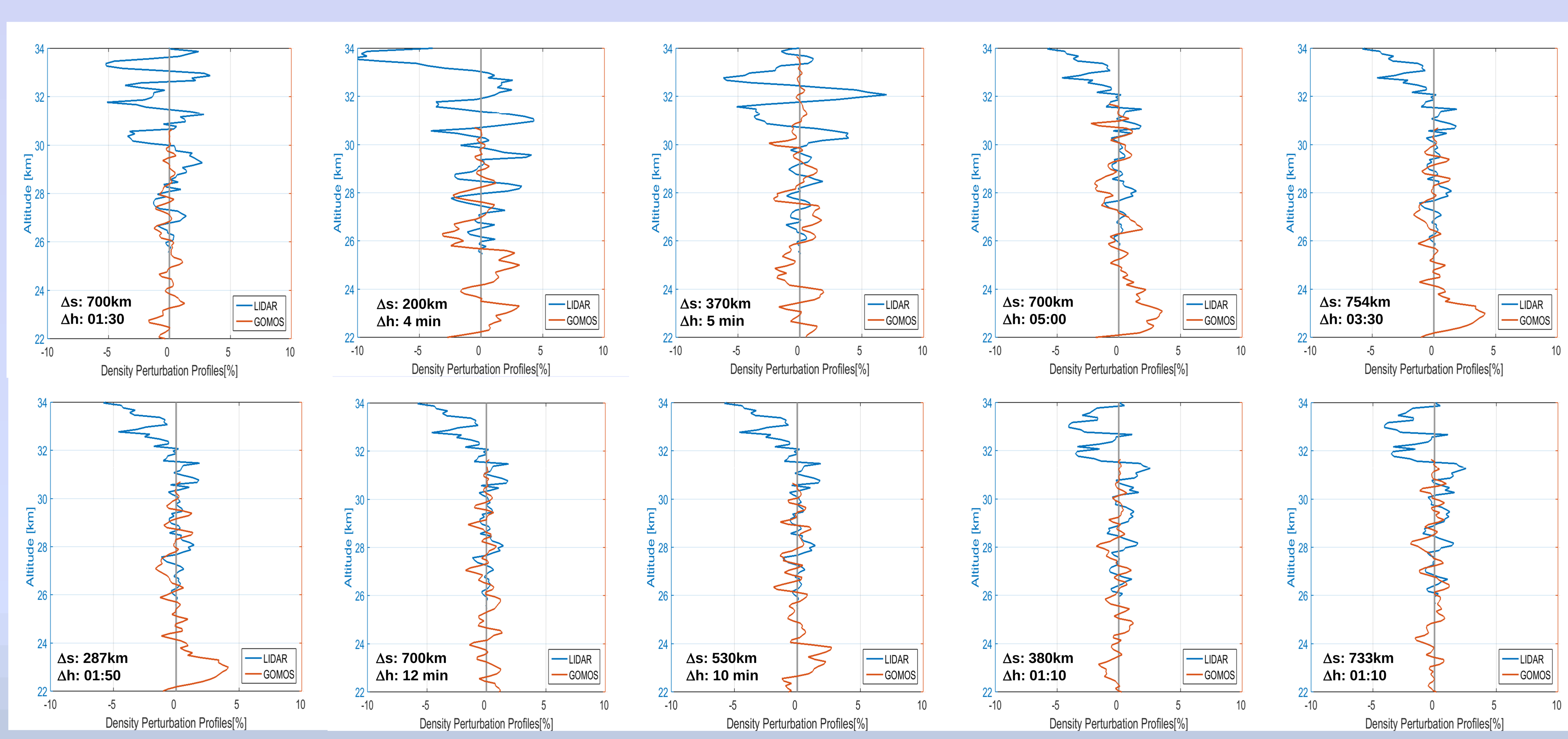
Assuming that fluctuations in temperature profiles are generated by a random ensemble of gravity waves, we can expect similar spectral properties of the temperature field at locations not far from each other (<800 km) during a time period of few hours. The fluctuations due to the gravity waves are visible also in the GOMOS air density profile since the temperature profile is derived by the air density. Where the wave signals are very similar, it could be argued that the significant phase difference between the two profiles could be due to the time and distance separation between the measurements.

Preliminary comparisons between GOMOS and Lidar measurements show a good agreement for both temperature and density perturbation profiles.

Temperature Perturbation Profiles



Density Perturbation Profiles



References

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Improvement of the statistical uncertainties on mean Temp. differences

The analysis was performed for a complete set of co-located profiles. The figure shows the average difference profiles of temperature as a function of altitude. The horizontal lines represent ±1 standard deviation (s) of the differences. The ratio between wave-free and original standard deviation of the differences indicates a ~25% reduction of s. The reduction is significant mainly above 28 km altitude.