Thermal variability at the tropopause: a view from radio occultation satellites.

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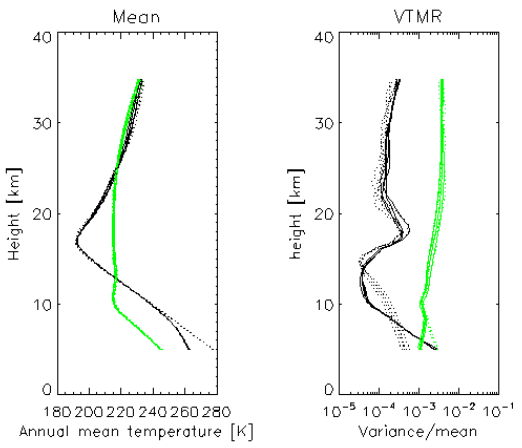
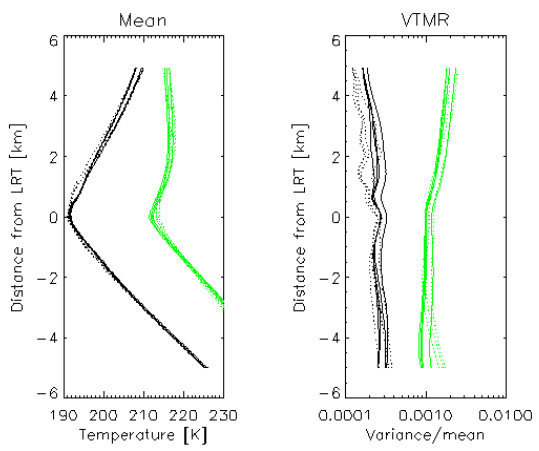
What: dry temperature profiles provided by the GPS RO mission CHAMP are compared with ECMWF colocated temperature profiles
When: the data is presented in annual averages for the period 2002-2005.

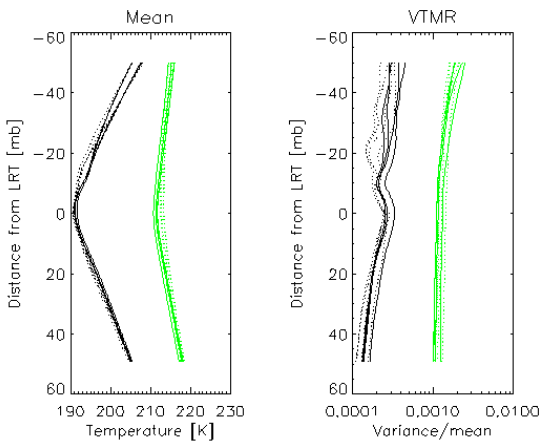
Results:
•When using a height-binning the two datasets appear to be in good agreements both in the mean values and in the variability.
•When binning the data in tropopause-based coordinates differ significantly around the tropopause. In the model tropopause appears to be smoother than in the observation but while the extra-tropical one is too cold the modelled tropical tropopause appears to warm.
•The comparison confirms the presence of a sharp tropopause transition in mid-latitude and suggests the presence of a level of enhanced stability in the tropics.



Annual means for CHAMP dry temperature (continuous) and ECMWF colocated temperature profiles (dotted) for five years namely 2002 to 2005. Right panel: variance to mean ratio for the same variables. In each panel the lines in green represent an average over all the "extra-tropical" profiles (|lat| > 40) while those in black represent the tropical profiles (|lat| < 18).

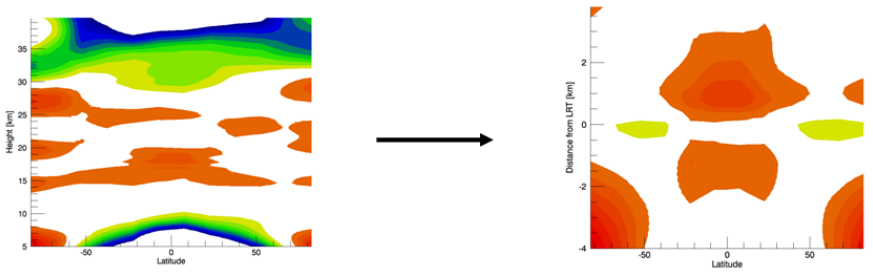


Temperature profiles in tropopause coordinate [The vertical coordinate is calculated from the position of the local lapse rate tropopause.]. Radio occultation data confirms the presence of a strong inversion layer above the extra-tropical tropopause (right in each plot). This is more pronounced in the data than in the ECMWF reanalysis. RO also suggests the presence of a broad layer of enhanced stability on top of the tropical tropopause (left in each plot).

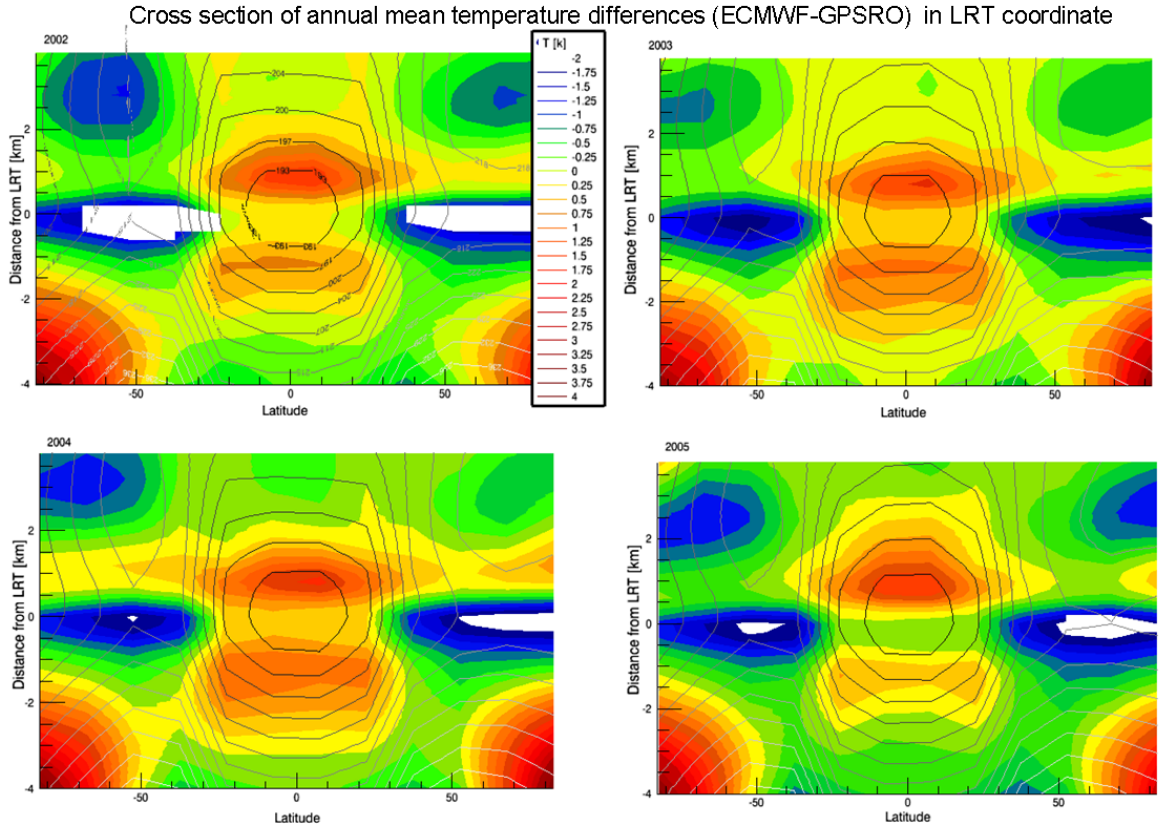


As above but in pressure LRT coordinate.

How does GPSRO work?
The RO (Radio Occultation) technique is based on the deflection of a GNSS (Global Navigation Satellite System) radio signal by the atmosphere. A receiver on board of a LEO (Low Earth Orbiter) satellite measures the phase delay induced by both the relative velocities of the two satellites and the presence of vertical variations in the refractive index of the part of the atmosphere crossed by the beam. Once the precise positions and the velocities of the two satellites are determined (Precise Orbit Determination), it is possible to isolate the atmospheric contribution to deriving atmospheric parameters. In this analysis a retrieved parameter (Tdry) has been used. This is retrieved from bending angles, which is related to pressure, temperature and humidity.



Cross section of annual mean temperature differences (ECMWF-GPSRO) in LRT coordinate



General procedure:

•The data is aggregated over 12 zonal bands

•Each profile is interpolated over 211 vertical levels from the surface up to 35 km

•For each vertical bin mean values and standard deviations of the profile are calculated.

•The dry temperature retrieval is used to identify the position of the tropopause (LRT and cold point).

•The comparisons between CHAMP data and ECMWF colocated profiles is generally good both in the tropics and in the mid-latitude.

•The data are then re-binned in tropopause based coordinate to isolate the contribution of tropopause-related processes (Birner et al 2002). This procedure avoids some of the smoothing resulting from averaging with height.

•Only the profile for which the modelled and the observed tropopause height differ for less than 2 km are used for the calculation.

•The procedure highlight some significant differences between the two datasets:

- •The tropical lower stratosphere is colder than GPSRO dry temperature
- • the extratropical tropopause is warmer in the model than in the GPSRO observations

•Repeating the procedure for different years doesn't change the overall picture. The differences are probably not just due to a misrepresentation of some climate perdiocity (e.g. QBO, MJO, ENSO,…)

There are several potential sources of differences between the two datasets. GPSRO are limb measurements and consequentially are horizontally averaged over several hundreds kilometres, ECMWF colocated profiles are grid-point vertical profile. The difference is expected to be greater in regions of large horizontal gradients.

Since 2006 GPSRO has become part of the data operationally assimilated in numerical weather models (Buontempo et al. 2007). ECMWF started assimilating GPSRO data in 2006; this is likely to have significantly reduced the biases identified in this poster (Borsche et al. 2007, Sean Healy personal communication 2008)

Conclusions

•The difference between GPSRO and ECMWF temperatures are larger when the comparison is made in tropopause-based coordinate rather than in the normal height.

•The differences between the two datasets are particularly marked around the l tropopause where discrepancies in excess of 2 k can be noticed.

•ECMWF tropopause is biased warm in the extra-tropics while around the lower tropical tropopause the bias is reversed.

•GPSRO observations indicate the presence of a layer whose vertical stability is enhanced in respect to ECMWF background situated just above the lapse rate tropopause.

•While the temperature variability of the extratropical lower stratosphere seems to be well captured by ECMWF, GPSRO profiles show a much larger variability in the tropics with respects to the model. This can probably be associate with the different representation of planetary and Kelvin waves in the model with respect to observations (Randel and Wu 2005; Borsche et al. 2007).

Bibliography:

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