The effect of GPS radio occultation data on radiometric profile retrievals

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Introduction

Current IR/MW remote sensing systems have limited skill for inferring temperature and moisture profiles in the vicinity of the tropopause and in the stratosphere. However, the Global Positioning System (GPS) radio occultation (RO) provides very accurate upper tropospheric and stratospheric refractivity profiles that are related to temperature and humidity. This study investigates the use of RO measurements to improve radiometric retrievals in the vicinity of the tropopause region.

First, the results of a simulation study are presented to illustrate the impact of the GPS data on the temperature and humidity retrievals near the tropopause. A statistical regression based on the NOAA88 radiosonde dataset is used to obtain temperature and humidity retrievals from the combination of the radiometric and geometric systems. The simulation study uses brightness temperatures from the 39 channels Advanced TIROS Operation Vertical Sounder (ATOVS) on the NOAA16 satellite.

Second, the study is repeated with real data. Preliminary results are shown: the CHAMP data is sorted according to the horizontal motion of the tangent points, and the number of collocations between CHAMP, ATOVS, and NWP data is determined. Validation of CHAMP refractivity profiles are also presented. Finally, we show preliminary results of temperature retrieval using ATOVS and GPS data.

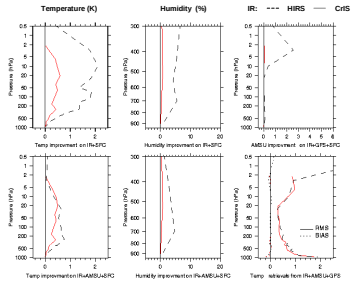
Simulation approach

Simulating observations based on:

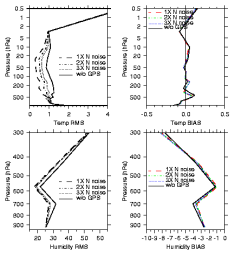
- the NOAA88B radiosonde dataset: 7547 profiles global in time and space
- IR and MW brightness temperatures (Tb) (represent HIRS, CrIS and AMSU data)
- surface temperature and humidity data
- GPS refractivity profiles at 16 pressure levels between 5 and 30 km,
- GPS simulation is based on *Healy and Eyre* (2000) and *Kursinski et al.* (1997)

Temperature and humidity retrievals:

- Both linear and quadratic terms for Tb (HIRS, AMSU), SFC obs and refractivities (GPS) are included in the regression.
- Results for ocean and land are combined in this analysis
- Regression coefficients derived from 90% of all profiles; testing is performed with remaining 10%.



GPS improvements (RMS) on temperature (first column) and humidity (second) retrievals derived from HIRS/CrIS (IR), AMSU (MW) and surface data. Retrievals with AMSU (upper panels) and without (lower panels) are shown. AMSU improvements on temperature retrievals (upper third panel). GPS + HIRS + AMSU (dashed line) and GPS + CrIS + AMSU (solid line) bias and RMS errors wrt RAOBS are shown as a reference in lower third panel.



Study of noise on temperature (upper panels) and humidity (lower panels) retrievals using ATOVS and GPS simulated data. RMS (first column) and bias (second column) errors of retrievals using GPS refractivity profiles with1X, 2X and 3X noise and without GPS data.

Results of the simulation study

This study ***yields improved tropospheric temperature and moisture profiles*** when compared to those inferred from either system alone.

•In the troposphere GPS improves:

- HIRS (representative of GOES Sounder) temperature profile retrievals near the tropopause by 1.4K and at pressure levels down to 570 hPa by 0.3K
- ATOVS (AMSU plus HIRS) temperature profile retrievals near the tropopause by 0.6K
- CrIS temperature profile retrievals near the tropopause by 0.3K

- HIRS moisture profile retrievals from 400 hPa to 700 hPa by about 5%
- ATOVS moisture profile retrievals from 570 to 700 by ~ 4%.
- Doubling GPS refractivity noise degrades the ATOVS
  - temperature profile improvement by about 0.2 K from 25 to 350 hPa and
  - humidity profile improvement by 0.6% from 570 to 700 hPa.

•In the stratosphere GPS improves:

- ATOVS temperature profile retrievals between 15 hPa and the tropopause by about 0.5K.
- CrIS temperature profile retrievals between 10 hPa and the tropopause by about 0.4K.

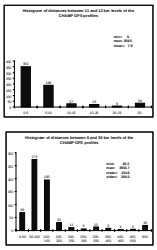
Acknowledgements

We thank GeoForschungsZentrum for providing the CHAMP data. This work was supported in part by NOAA Cooperative Agreement NAO7EC0676.

Filtering of GPS data

Data period: 05. 28 - 6. 03, 08 .26 - 27, 2001
➨ 651 occultations
Number of the profiles between 6 and 35 km
➨ 634 occultations
Horizontal motion of the profiles
➨ 583 occultations

GPS profiles are used only between 6 and 35 km, with 1 km vertical resolution and interpolated 19 levels (from 42 levels) between 7 and 400 hPa.



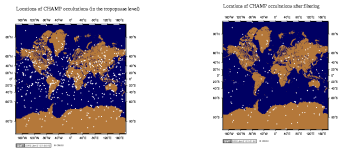
Collocation with NOAA16/ATOVS measurements

The ATOVS brightness temperatures are processed by the International ATOVS Processing Package (IAPP) developed by CIMSS/SSEC. IAPP retrievals are made on 3X3 HIRS fields of view (FOV).

Thresholds used for collocations:
For time gap: 3 hours
For geographical distance: 300 km
In multiple collocations, the selection prefers more clear pixels and closer times of observation.

ATOVS brightness temperatures are the average of clear pixel values (or average of all 9 cloudy FOV values in overcast conditions). Only the microwave channels will be used in the regression method for overcast conditions.

Locations of the CHAMP occultations before and after the collocation with ATOVS data

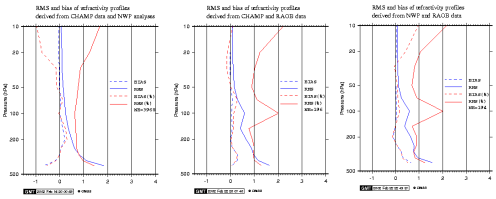


583 occultations before the collocation **190 occultations after the collocation**

Refractivity comparison of CHAMP measurements and NWP/RAOB calculations

The AVIATION numerical prediction global model analyses (00, 06, 12, 18 UTC) are used. Temperature and humidity profiles are interpolated in time and space.

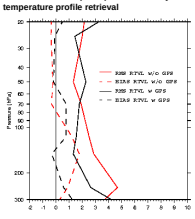
For RAOB comparison the nearest RAOB profile is chosen (3 hour time and 300 km distance gaps are chosen).



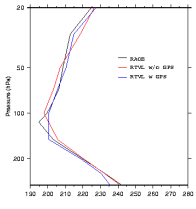
ATOVS + CHAMP profiles

In the regression method, 90% of the collocated NWP model analyses are used for the training period, and the remaining 10% of the NWP data (and one collocated radiosonde measurement) are used for validation.

RMS and bias error using ATOVS data (red) and ATOVS+GPS data (black) wrt NWP analyses for temperature profile retrieval



Comparison of temperature profiles
August 27, 2001 12 UTC, RAOB=64650, La=4.9, Fi-19.02



Future plans

Extend the dataset.

Perform more quality control of the CHAMP and RAOB datasets.

Investigate the regression method separately over land and sea and also for cloudy cases.

Repeat the study with MODIS data, thereby obtaining more collocations.

References

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