Long-term application and evaluation of IAPP using global radiosonde and CHAMP measurements

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Introduction

The major objective of the CM-SAF is the exploitation of satellite observations to derive information on key climate variables of the Earth system. The CM-SAF focuses on the atmospheric part of the Essential Climate Variables defined within the framework of the Global Climate Observing System (GCOS) and operationally applies the International ATOVS Processing Package (IAPP, Li et al., 2000) to retrieve humidity and temperature profiles from ATOVS observations onboard NOAA-15, -16, and -18. A kriging routine is utilised to determine daily and monthly averages on a global grid from the swath based retrievals. Furthermore, the profiles are vertically integrated and averaged to provide column integrated water vapour as well as humidity and temperature values for 5 layers and at 6 layer boundaries. The evaluation of global near real-time temperature and humidity monitoring products derived from ATOVS observations used for operational climate monitoring for the period 2004-2007 is carried out using global radiosonde observations that meet the quality standards of the GCOS Upper Air Network (GUAN). The evaluation is extended by utilising CHAllenging Minisatellite Payload (CHAMP) observations for the year 2004.

Data

GUAN: Quality monitored global radiosonde (RS) data from DWD archive; 173 stations in total.

ATOVS: Global temperature and humidity products, i.e., within ±180° E-W and ±80° N-S; (90km)^2 spatial resolution; sinusoidal projection.

CHAMP: Global instantaneous humidity profiles; ~4000 profiles/month.

Definitions and methods

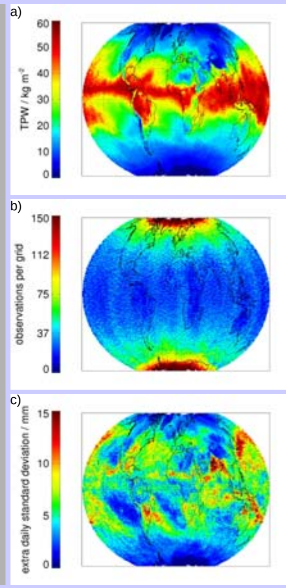


Fig. 1: Monthly (a) average total precipitable water (TPW) from ATOVS, October 2004. (b) Number of observations per grid. (c) Extra daily standard deviation.

Water vapour + temperature products (WVT products)

- TPW: surface – 100 hPa.
- Layer integrals for:

values	layer [hPa]
LPW1, T1	surface – 850
LPW2, T2	850 – 700
LPW3, T3	700 – 500
LPW4, T4	500 – 300
LPW5, T5	300 – 200

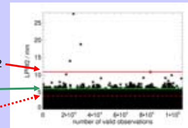
LPW: layer precipitable water, T: temperature.

- Apply kriging after (Lindau and Schulz, 2004). Output: Fig 1.
- Validation: Apply extreme outlier screening (1):

(1) first bins x with 0=PDF(x) ;binsize= σ /2

(2) Q1,3 ± 3 x IQ

(3) 3 x σ



Also available (not shown): q and T at layer boundaries and RH.

Validation with radiosondes I

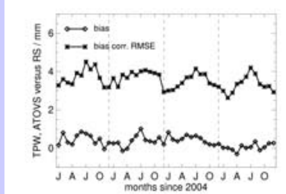


Fig. 2: TPW bias and bias corr. RMSE in 2004-2007.

- Max. TPW bias: 0.8 mm.
- LPW bias changes sign.
- Annual cycle in LPW RMSE.
- Trend in T bias.

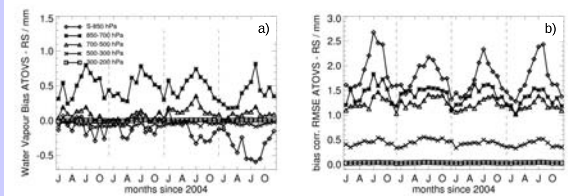


Fig. 3: LPW (a) bias and (b) bias corr. RMSE in 2004-2007.

~ 1100 valid pairs per month.

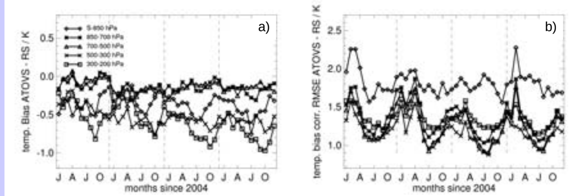


Fig. 4: T (a) bias and (b) bias corr. RMSE in 2004-2007.

~ 2800 valid pairs per month.

Validation with radiosondes II

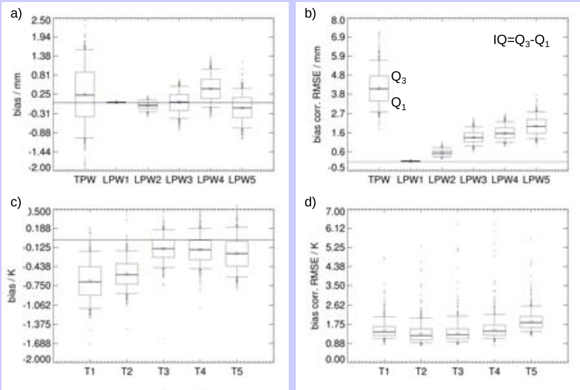


Fig. 5: Box-whisker plots of (a), (c) bias and (b), (d) RMSE for (a), (b) TPW and LPW as well as (c), (d) T in 2004-2007.

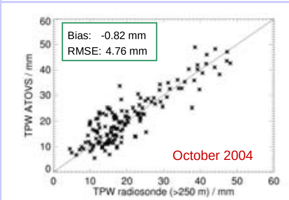


Fig. 6: Scatterplot of TPW, station height > 250 m.

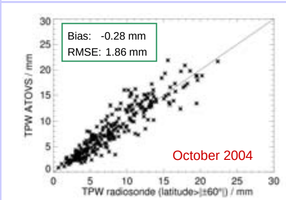


Fig. 7: Scatterplot of TPW, latitude > |± 60°|.

Validation - CHAMP

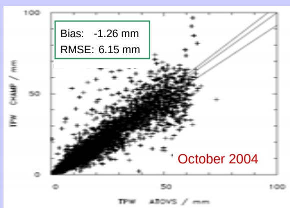


Fig. 8: Scatterplot of TPW, CHAMP, ATOVS.

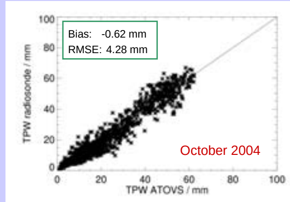


Fig. 10: Scatterplot of TPW, RS, ATOVS.

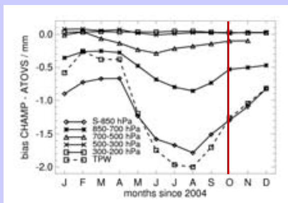


Fig. 9: TPW and LPW bias, CHAMP– ATOVS, 2004.

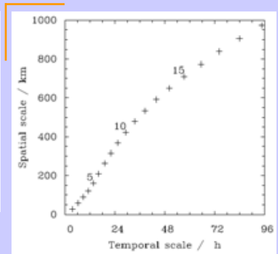


Fig. 11: Variance included within different time/space scales (Lindau, 2000). Crosses depict equal variance in steps of 1 kg/m^2.

Observational differences are not corrected for, i.e.:

- Measurements with different spatial and temporal resolution.
- Problematic geography of single stations, e.g., St. Helena: 436 m, 414 km^2.

Conclusions and outlook

Global near real-time temperature and humidity monitoring products derived from ATOVS observations used for operational climate monitoring were compared to radiosondes and CHAMP radio occultation data.

Major findings are:

- Water vapour and temperature products exhibit a very high quality.
- TPW bias fluctuates around 0 mm, with a mean value of 0.2 mm.
- LPW bias generally <0.5 mm (max. of 0.8 mm at 850-700 hPa).
- T bias usually <0.5 K (max. of -1 K at 300-200 hPa).

Spatio-temporal differences between radiosondes and ATOVS does not affect the comparisons very much.

The quality for observations at high latitudes and above high land is surprisingly good.

Although absolute bias and RMSE are larger the comparison of ATOVS to CHAMP estimates confirms the high quality of the ATOVS products.

The next step will consider the implementation of MetOp observations into the operational processing of ATOVS data.

References:

Li, J., and co-authors, 2000: Global soundings of the atmosphere from ATOVS measurements: The algorithm and validation. J. Appl. Meteor., 39, 1248-1268.

Lindau, R., J. Schulz, 2004: Gridding/merging techniques for the humidity composite product of the CM-SAF. Proceedings of the 2004 EUMETSAT Satellite Conference, Prague, Czech Republic, EUM P41, 519-526.

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