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

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# Overview

- Data from ATOVS, radiosondes, CHAMP.
- Methodology.
- Evaluation – GUAN radiosondes.
- Evaluation – CHAMP.
- Conclusions and future plans.

# CM-SAF products from ATOVS I

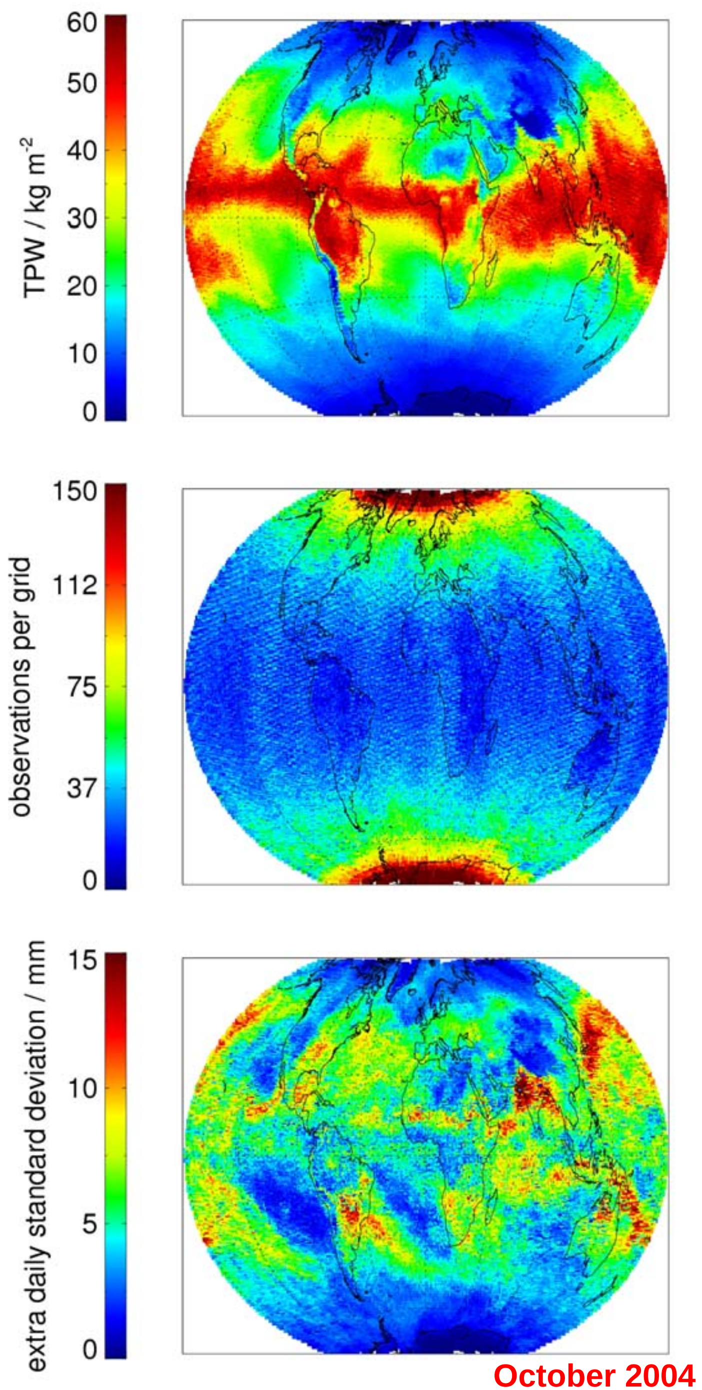
- Apply AAPP 5.3 and IAPP 2.1 to ATOVS observations from NOAA-15, -16, and -18 to get water vapour and temperature products at 42 pressure levels.

- TPW: Vertically integrated water vapour (surface – 100 hPa).
- LPW1-5, T1-5, RH1-5: Layered vertically integrated water vapour and layer mean temperature and relative humidity for 5 layers.
- T1-6, q1-6: Temperature and mixing ratio at 6 pressure levels.

| layer | 1 | 2 | 3 | 4 | 5 | -- |
|---|---|---|---|---|---|---|
| Pressure [hPa] | 300-200 | 500-300 | 700-500 | 850-700 | Surface-850 | -- |
| level | 1 | 2 | 3 | 4 | 5 | 6 |
| Pressure [hPa] | 200 | 300 | 500 | 700 | 850 | 1000 |

# CM-SAF products from ATOVS II

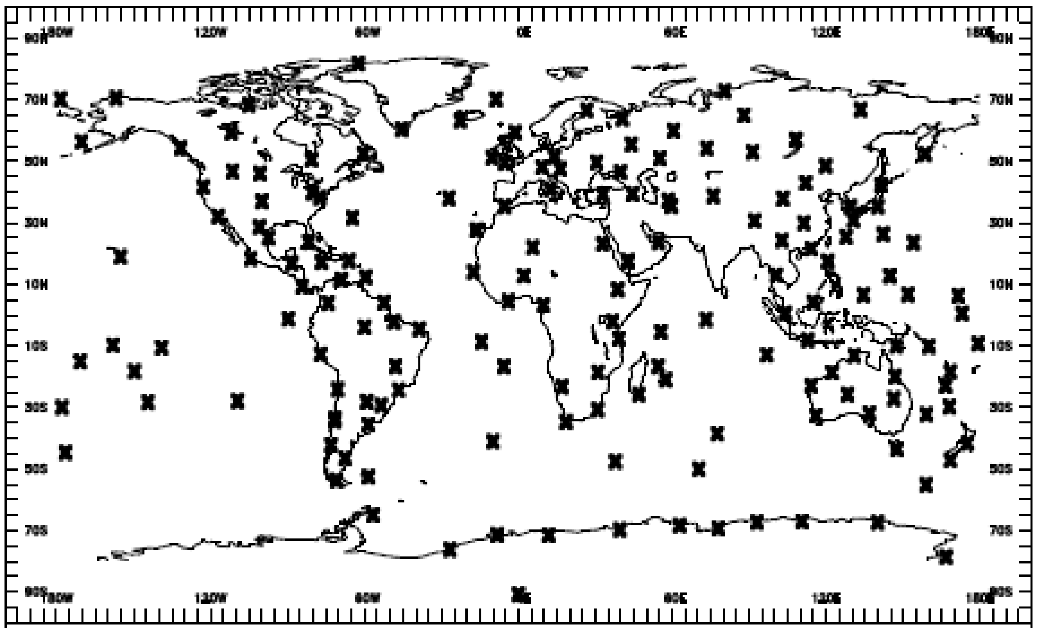
- Swath-based output of IAPP is quality controlled,
- integrated and averaged.
- A kriging routine (Lindau+Schulz, 2004) is applied to provide:
  - global products on fixed grid (90 km)$^2$ (top)
  - number of observations (middle)
  - standard deviations (bottom)
  - daily and monthly averages.
- Operational processing.



# Radiosonde observations (RO)

- Radiosondes: Quality controlled radiosonde observations from DWD archive, GCOS upper air network stations (173).

  - Integrate + average,
  - 2 observations per day,
  - All products,
  - Apply extreme outlier screening.

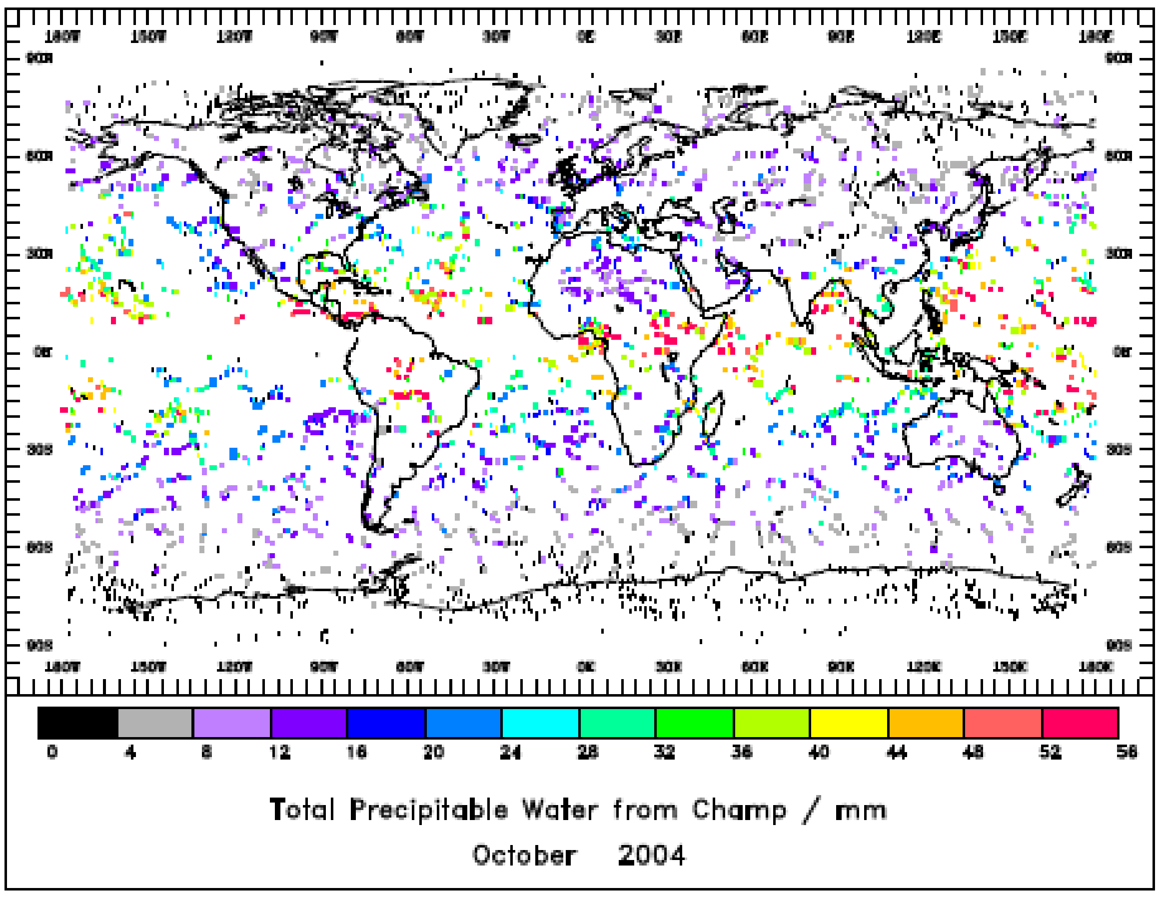


GUAN Radiosonde stations

# CHAMP

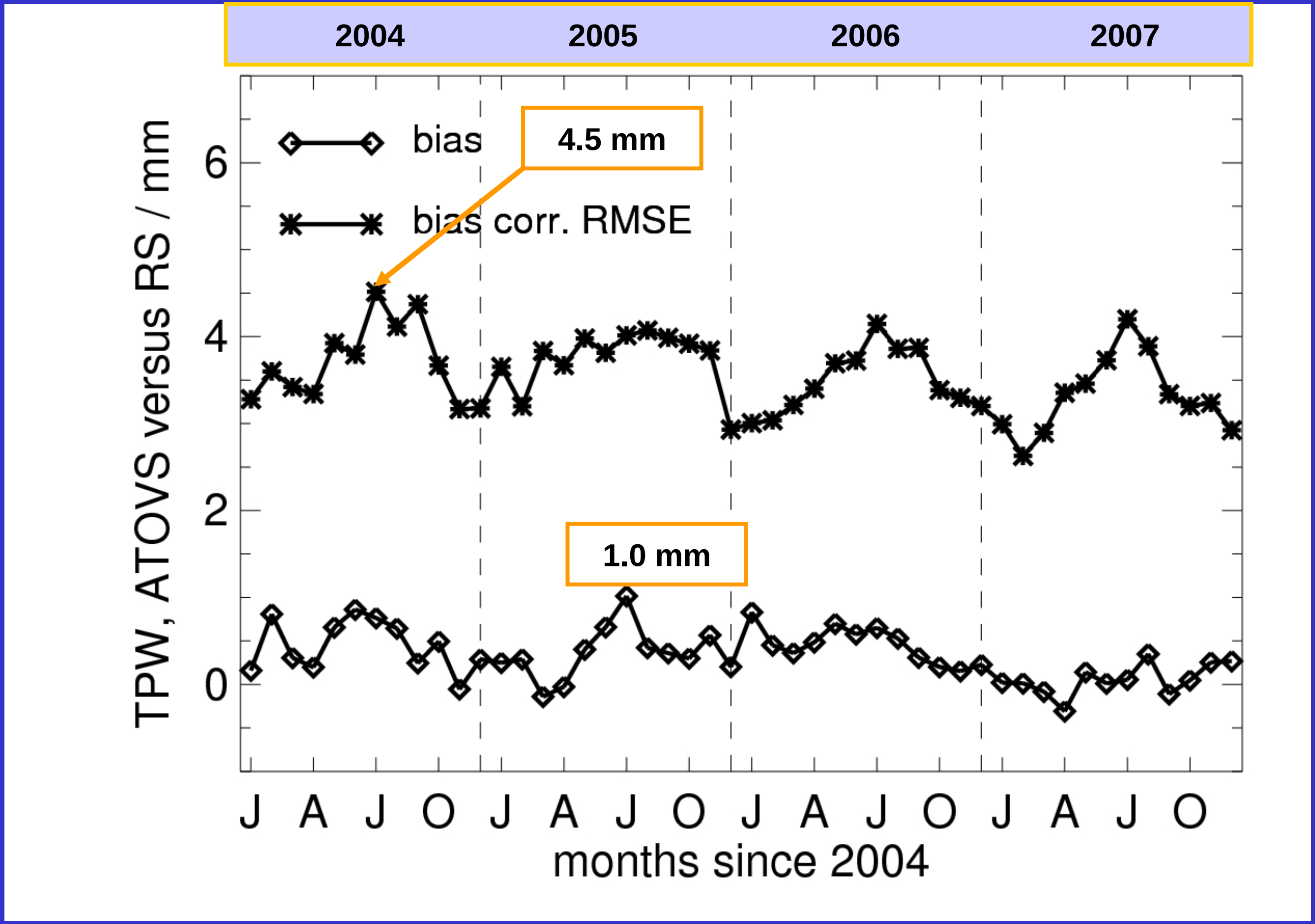
- CHAMP: CHAllenging Minisatellite Payload, GPS receiver, radio occultation method.

- TPW only.

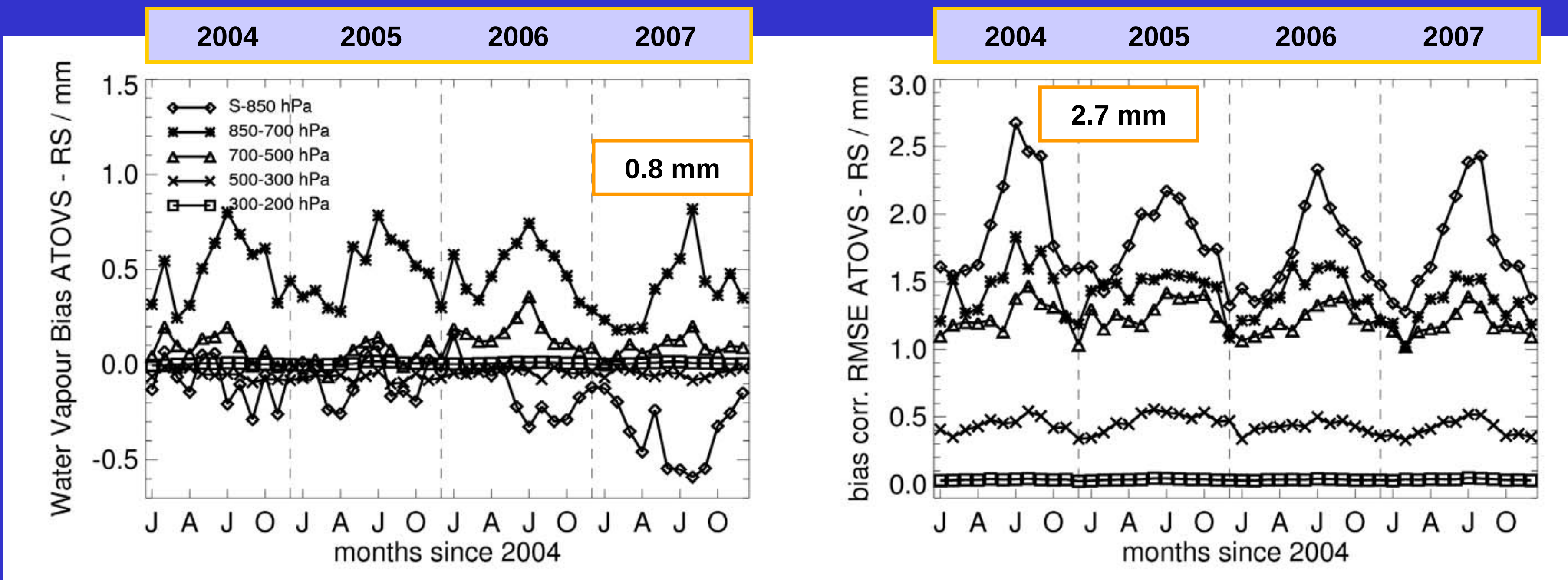


# ATOVS evaluation
# - TPW -

- ATOVS – RO.
- Evaluation: January 2004 – December 2007.



# ATOVS evaluation LPW1-5

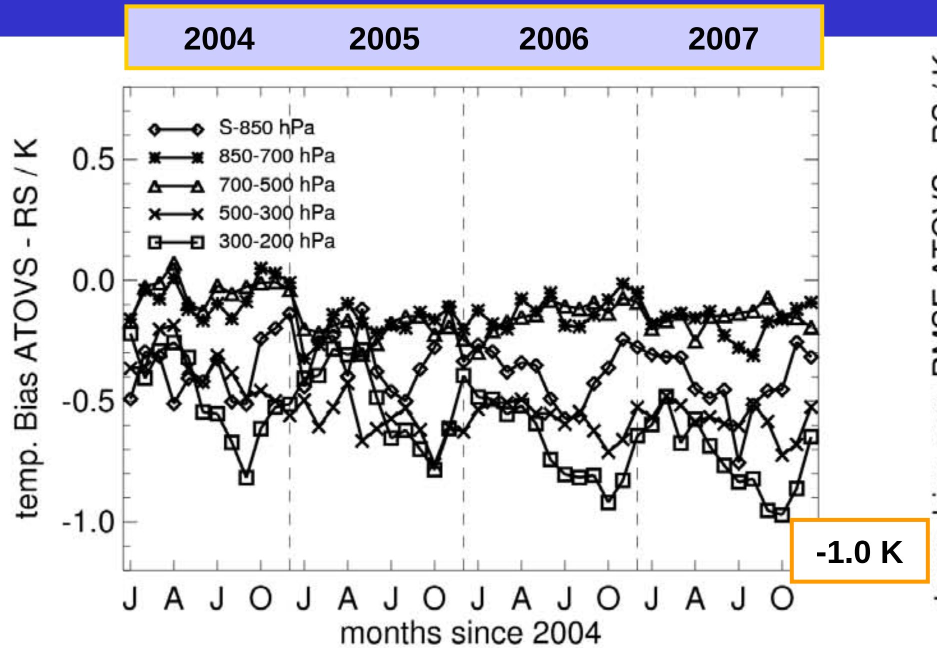


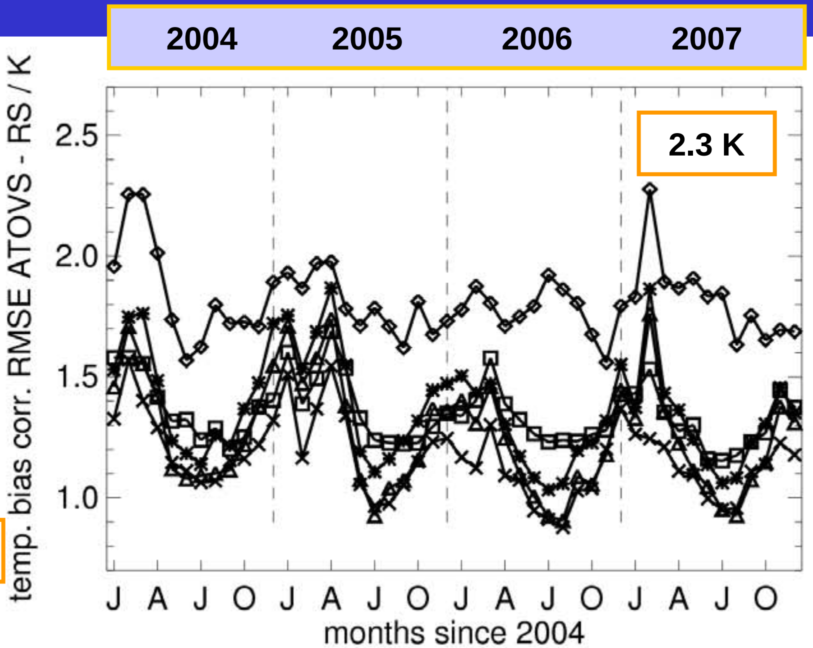

**Small biases in LPW with maximum in layer 850-700 hPa.**

**Annual cycle in RMSE in near-surface layers.**

**Decreasing RMSE for increasing layer height.**

# ATOVS evaluation
# T1-5



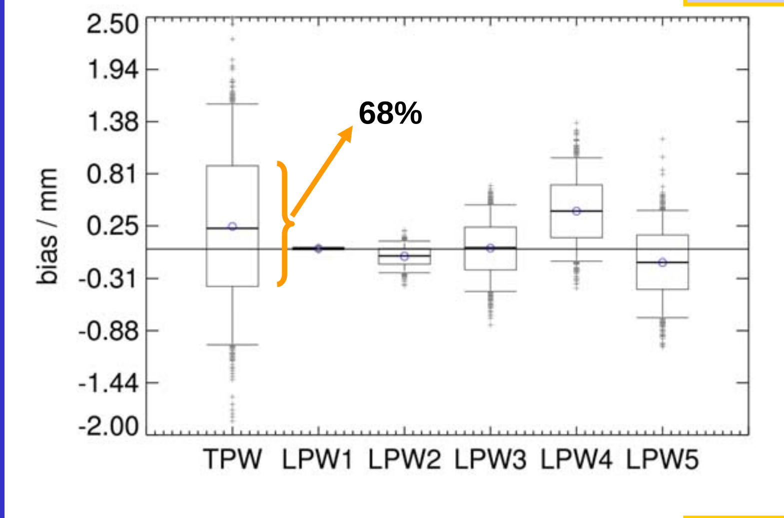



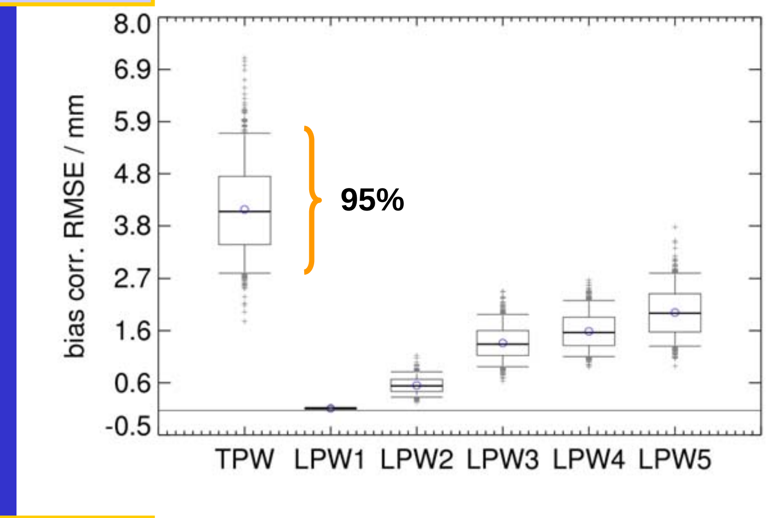

High quality of temperature products.

Some outliers still present.

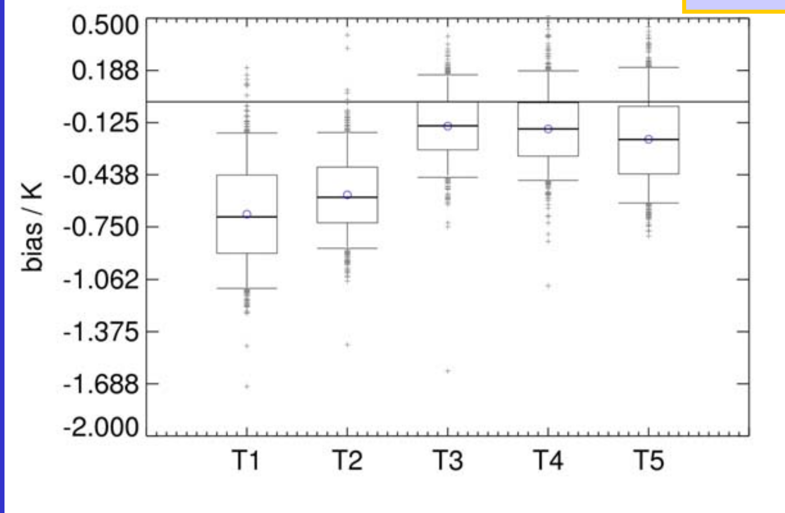
# Daily variability
# - Box-Whisker plots -

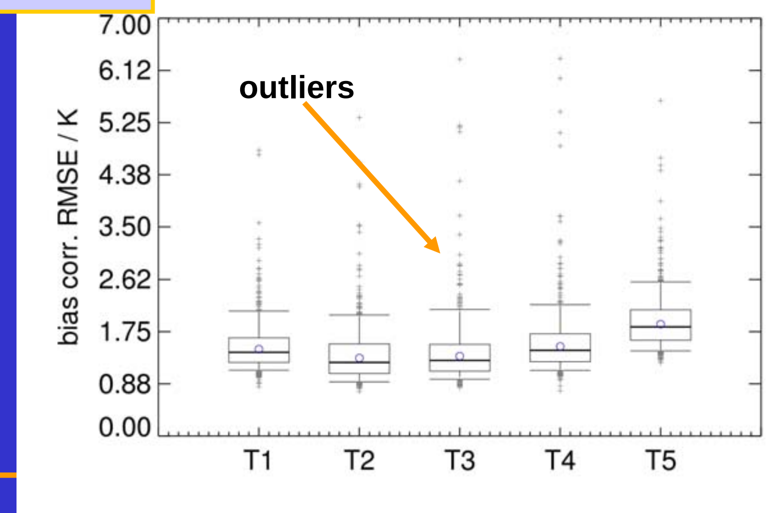
**Water vapour**




**Temperature**



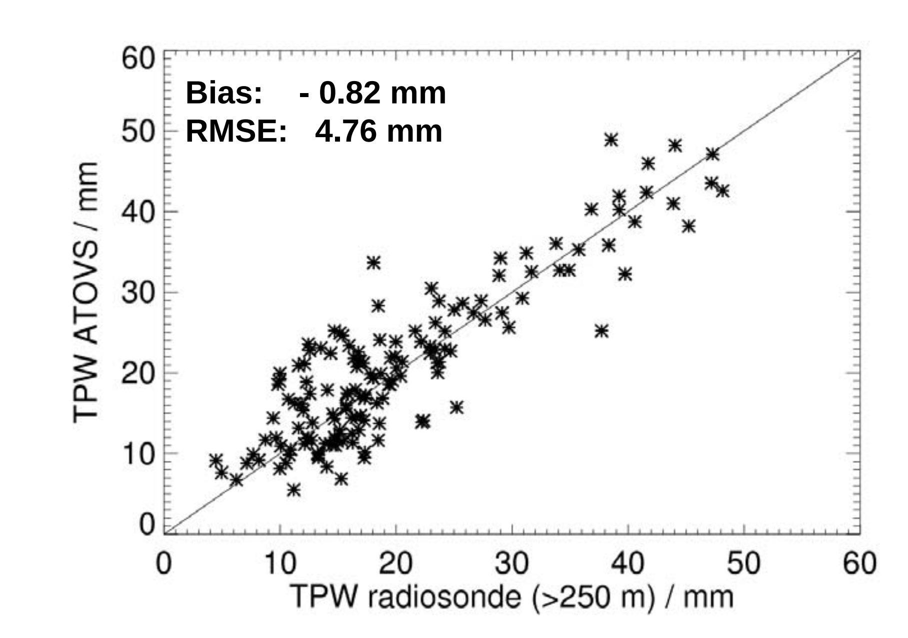
# Uncertainty of kriged IAPP results

| Temperature [K] | | | Layered precipitable water [mm] | | |
|---|---|---|---|---|---|
| layer | bias | RMSE | layer | bias | RMSE |
| 1 | 1.25 | 2 | 1 | 0.015 | 0.08 |
| 2 | 1.00 | 2 | 2 | 0.15 | 0.75 |
| 3 | 0.50 | 2 | 3 | 0.15 | 1.75 |
| 4 | 0.50 | 2.25 | 4 | 0.75 | 2.00 |
| 5 | 0.75 | 2.25 | 5 | 0.6 | 2.75 |
| | | | TPW | 1.0 | 4.50 |

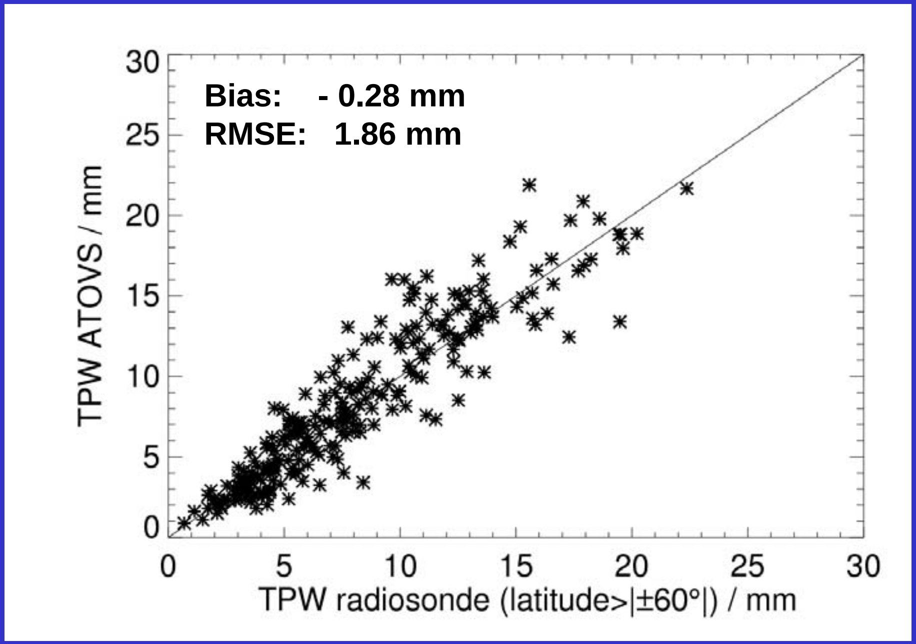
# Special issues
# - ATOVS vs. RO -

**October 2004**

**Surface height > 250 m**

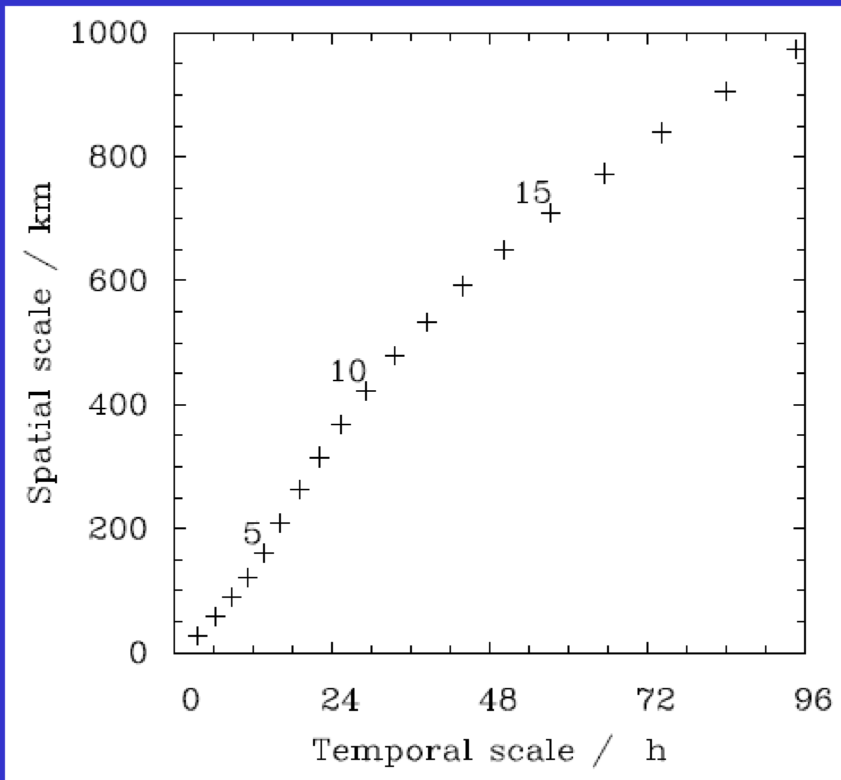



**Position either >60° or < -60° latitude**




**High quality even in problematic areas.**

# Error / Uncertainty

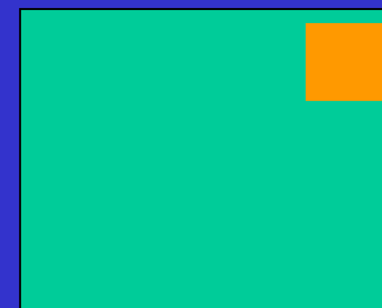



**Water vapour variance within GPS data, Scandinavia (Lindau, 2000)**

- Island effect:

**St Helena: 414 km$^2$**
**436 m**

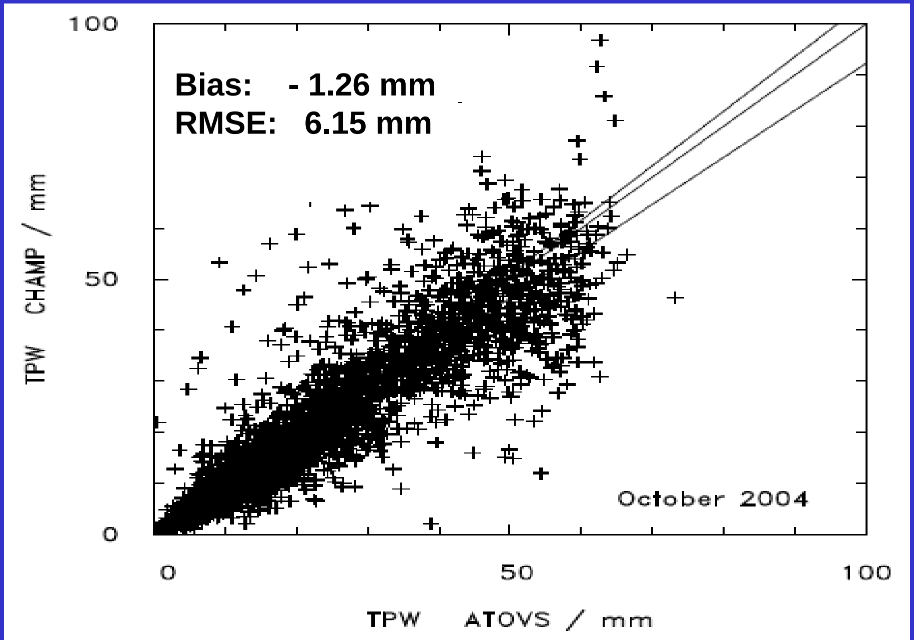
**ATOVS: 8100 km$^2$**
**0 m**

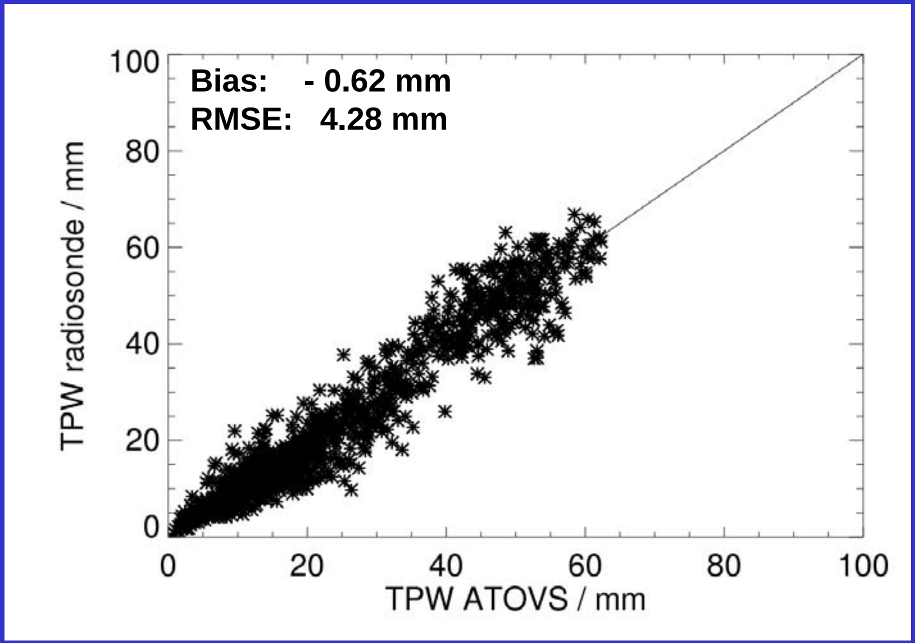


- Variable quality of RS observations (calibration / age).
- Dry bias (Miloshevich et al., 2005; Leiterer et al., 2005)

# Evaluation - CHAMP

October 2004

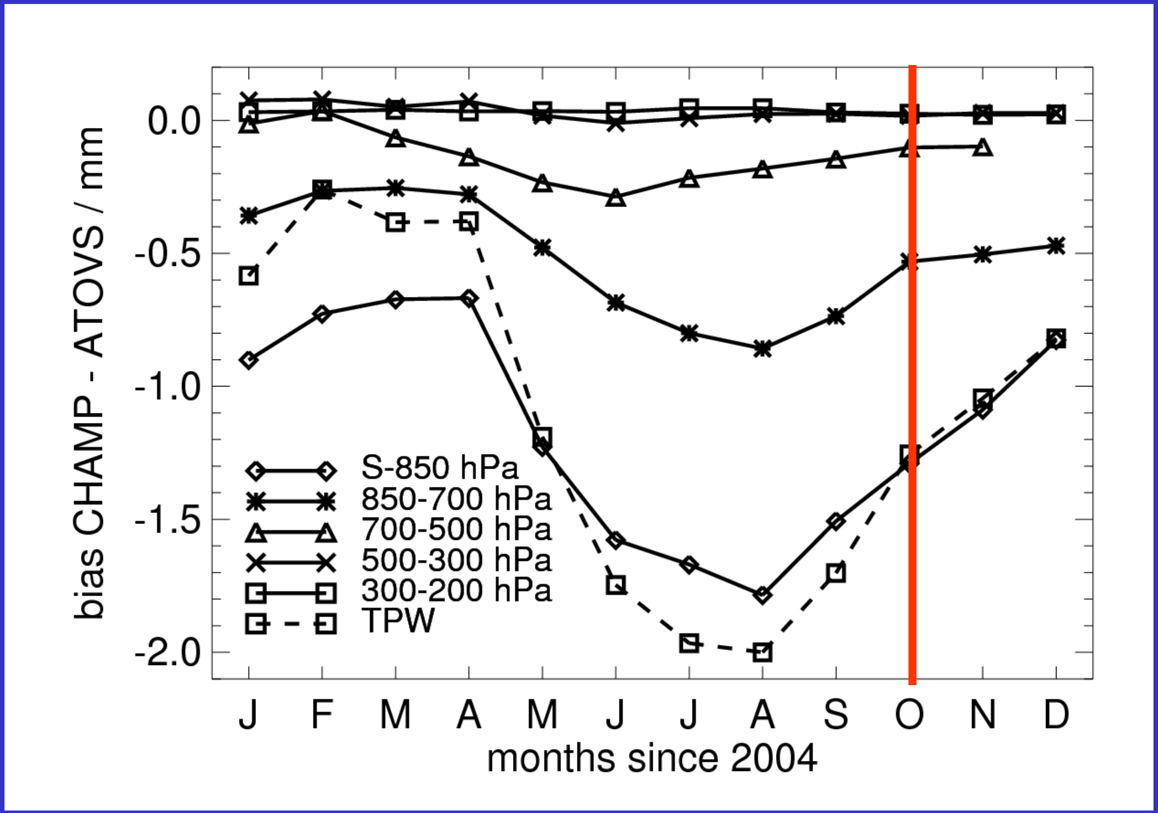



**Larger bias and RMSE between ATOVS and CHAMP.**

# Evaluation - CHAMP

2004




**TPW: maximum absolute bias: 2 mm.**

**Annual cycle in near surface layers and TPW.**

# Conclusions

- Water vapour and temperature products exhibit 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).
- Evaluation provides uncertainties. The error is most likely smaller.
- The quality for observations at high latitudes and above high land is surprisingly good.
- Comparison of ATOVS and CHAMP data gives larger bias and RMSE but still confirms the high quality of the ATOVS products.

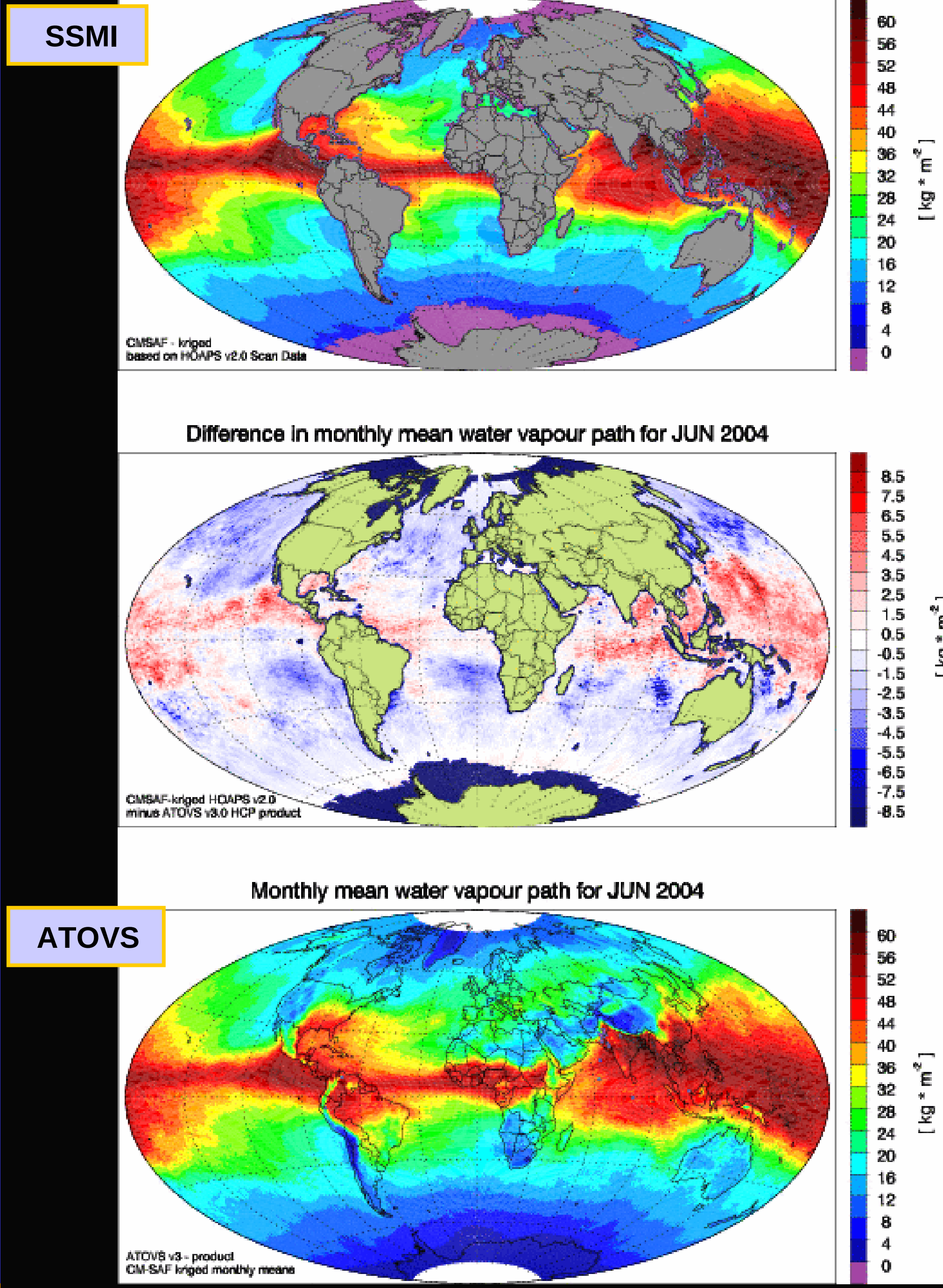
# Future plans

- Process ATOVS data from May 1998 onwards.

- Install new version of IAPP (done for new version of AAPP).
- Extend operational processing to MetOp data.
- Verify quality of extended ATOVS products.

- Error propagation study for IASI.
- Implement error covariances into ATOVS processing.
- Incorporate IASI level 2 into the ATOVS chain.

# ATOVS vs. SSMI



# Screening

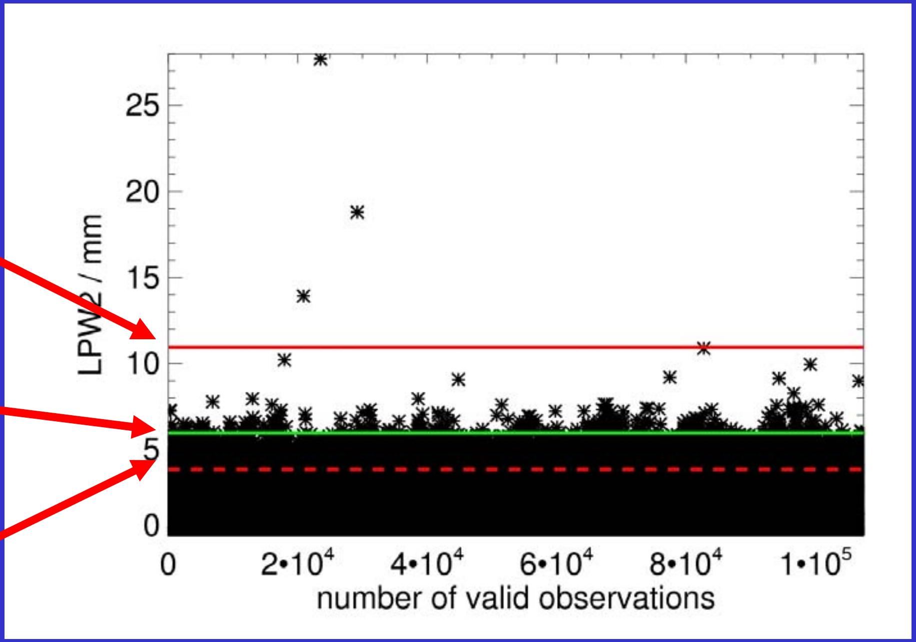
Validation: Apply extreme outlier screening (1):

(1) first bins x with

0=PDF(x) ;binsize= σ /2

(2) Q1,3 ± 3 x IQ

(3) 3 x σ



# Future plans III

## Trend analysis

- Visiting scientist at Uni Bremen.

  - Assessment of trends in the 22 GHz channel.
  - Comparison of brightness temperature differences in current, Wentz v6 and Level 1C data sets to analyse absolute intercalibration offsets.
  - Comparison of water vapour trends over global ocean: Spatial distribution and significance from SSM/I, GOME and SCIAMACHY data sets.

# STATUS OF OPERATIONAL SATELLITES (Continued)

**DRIFT RATES AND EQUATOR CROSSING NODES (ECN) As of May 2007**

| Spacecraft | Launch Date | Equator Crossing Times | Drift Rate |
|---|---|---|---|
| NOAA-18 | MAY 2005 | 1338 Ascending | -0.3 min/month |
| NOAA-17 | JUNE 2002 | 1011 Descending | -1.2 min/month |
| NOAA-16 | SEPT 2000 | 1555 Ascending | +3.9 min/month |
| NOAA-15 | MAY 1998 | 0521 Descending | -1.8 min/month |
| ~~NOAA-14~~ | ~~DEC 1994~~ | ~~2155 Ascending~~ | ~~+2.4 min/month~~ |
| NOAA-12 | MAY 1991 | 0520 Descending | +1.5 min/month |

8

International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.