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.

<table>
<thead>
<tr>
<th>layer</th>
<th>Pressure [hPa]</th>
<th>level</th>
<th>Pressure [hPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300-200</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>500-300</td>
<td>2</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>700-500</td>
<td>3</td>
<td>500</td>
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<tr>
<td></td>
<td>850-700</td>
<td>4</td>
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<tr>
<td></td>
<td>Surface-850</td>
<td>5</td>
<td>850</td>
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<tr>
<td></td>
<td>--</td>
<td>--</td>
<td>1000</td>
</tr>
</tbody>
</table>
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.
CHAMP

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

- TPW only.
ATOVS evaluation

- TPW -

- ATOVS – RO.

![Graph showing TPW (Total Precipitable Water) and bias correction RMSE over months from January 2004 to December 2007. The graph indicates a bias of 4.5 mm and a corrected RMSE of 1.0 mm.]
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.
A TOVS evaluation
T1-5

High quality of temperature products.
Some outliers still present.
Daily variability
- Box-Whisker plots -

**Water vapour**

- 68%

**Temperature**

- 95%

- Outliers

- Bias / mm
- Bias corr. RMSE / mm

- TPW, LPW1, LPW2, LPW3, LPW4, LPW5

- T1, T2, T3, T4, T5
## Uncertainty of kriged IAPP results

<table>
<thead>
<tr>
<th>Temperature Layer</th>
<th>Layered precipitable water</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>[K]</td>
</tr>
<tr>
<td>layer</td>
<td>bias</td>
</tr>
<tr>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>4</td>
<td>0.50</td>
</tr>
<tr>
<td>5</td>
<td>0.75</td>
</tr>
</tbody>
</table>

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.

Bias: -0.82 mm
RMSE: 4.76 mm

Bias: -0.28 mm
RMSE: 1.86 mm
Error / Uncertainty

- Island effect:
  - St Helena: 414 km²
    - 436 m
  - ATOVS: 8100 km²
    - 0 m

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

Water vapour variance within GPS data, Scandinavia (Lindau, 2000)
Evaluation - CHAMP

Bias: - 1.26 mm
RMSE: 6.15 mm

Bias: - 0.62 mm
RMSE: 4.28 mm

Larger bias and RMSE between ATOVS and CHAMP.
Evaluation - CHAMP

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

Difference in monthly mean water vapour path for JUN 2004

Monthly mean water vapour path for JUN 2004
Screening

Validation: Apply extreme outlier screening (1):

1. First bins $x$ with $0 = \text{PDF}(x)$; binsize = $\sigma / 2$
2. $Q_{1,3} \pm 3 \times \text{IQ}$
3. $3 \times \sigma$
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**

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