Middle – upper water vapour estimation from MSG/UTH products combined with NCEP/NCAR analysis

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Objectives of our work:

- integrate tropospheric humidity satellite observations with analysis dataset in order to estimate daily middle/upper precipitable water (MUPW)
- check its consistence with known moisture climatic fields

Atmospheric water vapour is extremely variable on almost all scales, mainly in the troposphere.

Its distribution and variation knowledge is still incomplete and long term changes, mainly in the upper troposphere, are difficult to evaluate.

Long time satellite observations, collected since several years, could be useful for a better comprehension of moisture climatology.
EUMETSAT provides two hourly tropospheric relative humidity products:

- **Channel WV6.2 μm** → Upper Tropospheric Humidity (between 300 and 600 hPa)
- **Channel WV7.3 μm** → Middle Tropospheric Humidity (between 600 and 850 hPa)

Area between 63°N - 63°S and 63°W – 63°E

Resolution: 3km

Period from February 2004 to August 2006
Estimation of Middle/Upper Precipitable Water Vapour using mixing ratio $w$ calculated from:

- **Tropospheric humidity (TH)**
  
  *comparison with averaged RH data from Integrated Global Radiosonde Archive (IGRA) has been performed*

- **Fixed level air temperature**
  
  *from NCEP/NCAR daily global analysis*

**Results**

MUPW dataset for the 850 – 300 hPa layer, for the period between February 2004 and August 2006, with a resolution of 2.5° x 2.5° (resolution lost but the clear sky restraint is reduced)
Monthly mean MUPW (02/2004 – 08/2006)
Patterns are consistent with the annual-mean specific humidity global distribution.

Precipitation-evaporation processes joint with wind-driven circulation can be noted.

Hovmöller graphs show the seasonal variability (due to the observed short time period).

Middle PW (850-600 hPa) and upper PW (600-300 hPa) patterns are similar.
- MUPW maximum follows ITCZ in its migration from the southern position in January to the northern position in July. Over the oceanic longitudes this band holds an almost stationary position north of the equator.

- Hovmöller longitude-time graphs (not reported) show only the seasonal variability.
Possible future applications

- A more extensive analysis, including upper tropospheric humidity (UTH) from Meteosat-7 (1997 - 2003) and TH from Meteosat-9 (2007 - now) might be useful to identify typical atmospheric variability modes.

- Comparison with layered precipitable water vapour directly retrieved from satellite images, already available from SAF-NWC.
Thanks for your attention

Other wv works in progress

- Water vapour retrieval from SEVIRI observations (Meteosat-9) using split-window techniques
- PW estimations from ground-based GPS measurements

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Bias 300 – 600 hPa (%)
~80% between -5% and 7%

Bias 600 – 850 hPa (%)
~80% between 5% and 20%
MSG – IGRA comparison

**rms 300 – 600 hPa (%)**

- ~82% between 13% and 22%

**rms 600 – 850 hPa (%)**

- ~61% between 16% and 28%
Middle precipitable water (MPW) latitude-time Hovmöller graph

Upper precipitable water (UPW) latitude-time Hovmöller graph
Algorithm

Saturated water vapour pressure

\[ E = 6.11 \cdot 10^{\left(\frac{7.5T}{237.7+T}\right)} \]

Mixing ratio

\[ w_{850,700,600} = 0.622 \cdot \frac{e_i}{P_i - e_i} = 0.622 \cdot \frac{E_i \cdot TH_1}{P_i - \left(\frac{E_i \cdot TH_1}{100}\right)} \]

\[ w_{600,500,400,300} = 0.622 \cdot \frac{100}{P_j - \left(\frac{E_j \cdot TH_2}{100}\right)} \]
\[
PWV = \frac{1}{g} \int_0^P w \cdot dP \quad \rightarrow \quad PWV = \sum_i PWV_i
\]

For each level

\[
PWV_{850-700} = \frac{\bar{w}_{850,700} \cdot (P_{850} - P_{700})}{g}
\]

\[PWV = PWV_{850-700} + PWV_{700-600} + PWV_{600-500} + PWV_{500-400} + PWV_{400-300}\]
1° EOF (69%): annual PWV content variability is more evident in the equatorial band than in higher latitude areas.

2° EOF (19.9%): PWV seasonality, e.g. when PWV increases in southern Africa, it decreases in northern Africa and vice-versa.
SVD method has been applied to monthly mean MUPW and precipitation fields. Precipitation data have been collected from Global Precipitation Climatology Project (GPCP).

Time series of expanded coeff. for the 1° mode of variability

Time series of expanded coeff. for the 2° mode of variability

Fraction of squared covariance (SCF):

SCF(1) = 58.4%    SCF(2) = 22.4%    SCF(3) = 5.4%
MSG MUPW annual trend
(02/2004 – 08/2006)

NCEP/NCAR PWV trend
(02/2004 – 08/2006)