Comparison of atmospheric water vapor measurements in Benin during AMMA

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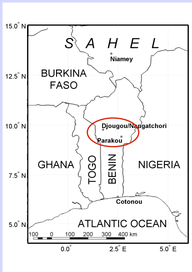
Objectives

Water vapor is a crucial parameter for the water cycle. Therefore its accurate measurement is of utmost importance. In this study we investigate the integrated water vapor (IWV), i.e. the total amount of water vapor in a column from the ground to the top of the atmosphere.

Measurements of the total column atmospheric water vapor content can be performed in various ways, each of them having its special advantages and disadvantages. During the AMMA campaign, three independent ground-based methods were used to derive IWV in Central Benin, the target area of this study. We compare radiosonde launches, a microwave radiometer and GPS wet delay measurements.



Before the AMMA campaign started in 2006, measurements of atmospheric water vapor content were very sparse in West Africa. The "classical" IWV source using radiosondes has suffered very much from the lack of data in this region.

Measurement principles

Radiosondes

Radiosondes were launched in Parakou by the University of Cologne in cooperation with ASECNA up to eight times per day during the year of 2006. The IWV can be calculated by integrating the water vapor mixing ratio over the whole ascent. The radiosonde system is manufactured by the French company MODEM.

Microwave radiometer

The Universities of Bonn and Cologne deployed a 14-channel passive microwave radiometer (HATPRO) in Nangatchori (Benin). This instrument measures atmospheric emission around the water vapor absorption line at 22.235 GHz. By using statistical retrieval algorithms it is possible to derive the IWV with an accuracy of about 1 kg/m² (Crewell and Löhnert, 2003).

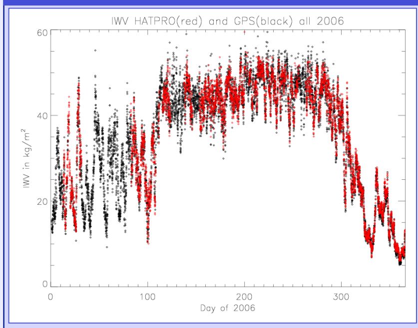
GPS

A network of 6 GPS stations was established over West Africa to measure IWV. The principle of this method is to measure the path delay between the ground and various GPS satellites which depends directly on the water vapor content of the atmosphere. One of these GPS receivers was located in Djougou (Benin).

Operations

	Temporal resolution	Number of measurements	Measurement period
Radiosondes Parakou	1 – 8 per day	632 (mainly wet season)	2006 (only few data from mid february to May)
HATPRO Nangatchori	2 sec.	Hourly mean IWV for this study	14 Jan 06 – 22 Jan 07 (no data in Feb/Mar due to mechanical problem)
GPS Djougou	Processed data: 1 hour	Hourly values for whole year	2006 (only minor data gaps)

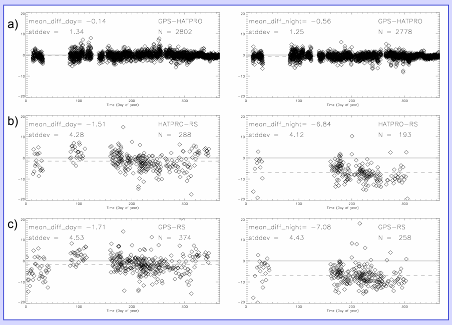
Results



The left figure presents the annual cycle of IWV and the availability of GPS and HATPRO data for the whole year 2006. It can be seen that the dry season from Jan-Apr 2006 was often interrupted by moist air outbreaks from the south. In late 2006 (Nov-Dec) remarkably drier conditions prevailed over the area.

The figure to the right shows the difference of each individual hourly measurement between (a) GPS and HATPRO, (b) HATPRO and radiosonde, and (c) GPS and radiosonde. The left column presents daytime measurements, the subplots to the right show nighttime observations. For the radiosonde comparisons, the large difference between day and night is significant.

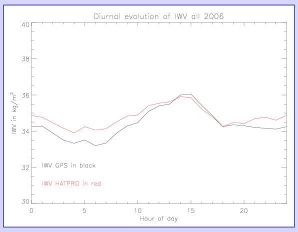
Separate studies for cloudy and cloud-free days have been performed, but showed no significant differences.

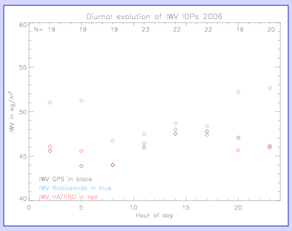


Diurnal cycle

The diurnal cycle of IWV shows a maximum around 15 UTC and a minimum at 6 UTC (left). The mean diurnal range is 2 kg/m². Differences between HATPRO and GPS with no bias during the day and GPS slightly drier (~0.5 kg/m²) during night-time are not yet completely understood.

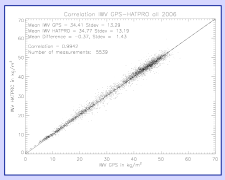
On the right plot the diurnal evolution during two periods with eight soundings per day (20-30 Jun, 1-12 Aug) can be seen. Note again the large IWV bias during the night.

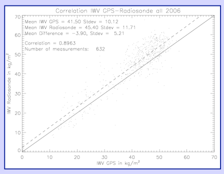




Discussion

- The comparison between IWV measurements from HATPRO microwave radiometer and GPS shows a very good agreement. These two completely independent methods to determine the atmospheric water vapor content proved to be a good means in the tropical region, both in dry and in wet season.
- A diurnal cycle of ~2 kg/m² could be observed.
- Large differences of GPS and HATPRO to radiosonde observations can be seen in the data. Especially the large night-time wet bias is significant. The higher variance may be explained by the different locations.
- This bias of ~7 kg/m² is due to a night-time wet bias of MODEM radiosondes which has been observed in 2006 at several AMMA stations. This wet bias has already been described by Miloshevich et al. (2006). Quantifying this bias is important for data correction as input to NWP models.





References: Crewell and Löhnert, 2003: Accuracy of cloud liquid water path from ground-based microwave radiometry. 2. Sensor accuracy and synergy. *Radio Science, Vol. 38, No 3*

Miloshevich et al., 2006: Absolute accuracy of water vapor measurements from six operational radiosonde types launched during AWEX-G and implications for AIRS validation. *JGR, Vol. 111*

Further information on GPS measurements see posters: Bouin et al. 4A.10, Bock et al. 4A.11, and Bock et al. 6B.18

Statistical analysis of Nangatchori observations see poster: Pospichal et al. 4A.02

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