OBSERVATION OF BOUNDARY LAYER EVOLUTION IN DJOUGOU, BENIN IN 2006 USING MICROWAVE RADIOMETERS

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1. INTRODUCTION

In a collaborative effort the universities of Bonn and Munich (Germany) will operate the unique microwave profiler HATPRO (Fig. 1) during the whole year 2006 in Djougou (Benin). Microwave profilers are an accurate and relatively inexpensive way to continuously observe temperature and humidity profiles of the lower troposphere as well as the liquid water path (LWP). However, such an instrument has never been used in Africa before.

Special attention will be paid to observe the planetary boundary layer by continuously observing the temperature profile with high vertical resolution using so called boundary layer scans. As a completely new application several atmospheric stability indices (e.g. CAPE, or Lifted Index) will be directly retrieved from microwave observations to study the development of convection (pre- and post-MCS developments) and thunderstorm probability.

Further information on mixing layer height, cloud base height and aerosol distribution will be gained by operating a CT25K lidar ceilometer next to HATPRO. During rainy periods information on the vertical profile of the drop size distribution will be observed by a micro rain radar. All instruments will continuously operate over all seasons with high temporal resolution (< 1 min). They will be analysed together with complementary AMMA observations at the Djougou super-site and satellite observations to also support the evaluation of mesoscale models.

2. MICROWAVE RADIOMETER HATPRO

The microwave radiometer measures the thermal emission by atmospheric components (water vapour, oxygen, cloud water) at 14 frequencies expressed as brightness temperatures. High accuracy in brightness temperatures is achieved by a combination of absolute and relative calibrations involving liquid nitrogen, noise diode standards and sky tipping. In addition. auxiliary measurements of environmental temperature, pressure and humidity as well as the presence of rain are performed. Exact time synchronization is possible via a GPS clock. Automatic observation during all weather conditions is guaranteed through a strong blower system. The radiometer is described in detail by Rose et al. (2005).

Brightness temperatures are continuously acquired in zenith direction. At prescribed intervals (for example 20 min) boundary layer scans observe the atmosphere under several angles. Assuming horizontal homogeneity the temperature profile of the boundary layer can be determined with a high vertical resolution of about 100 m.

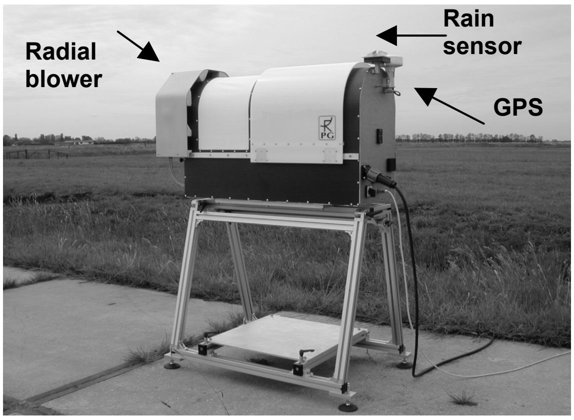


Figure 1. Photo of the microwave radiometer HATPRO

3. OBSERVED PRODUCTS

In order to derive the atmospheric parameters from the observed brightness temperatures statistical retrieval algorithms are developed on the basis of a large set of atmospheric profiles observed by radiosondes [Crewell and Löhnert, 2003]. For the zenith pointing observations the theoretical accuracy of the liquid water path (**LWP**) is about 20 gm^{-2} and below 1 kg m^{-2} for the integrated water vapor (**IWV**) content.

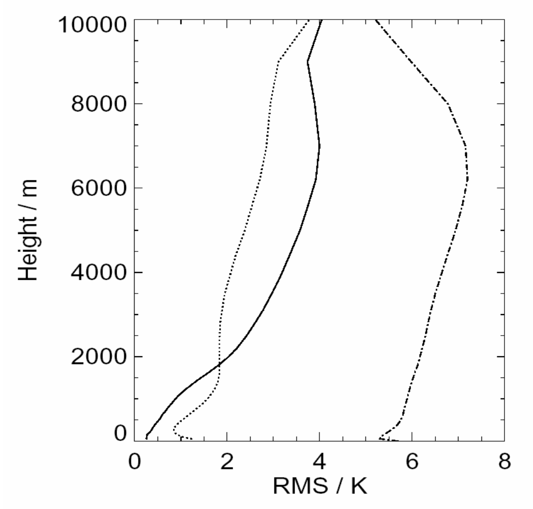
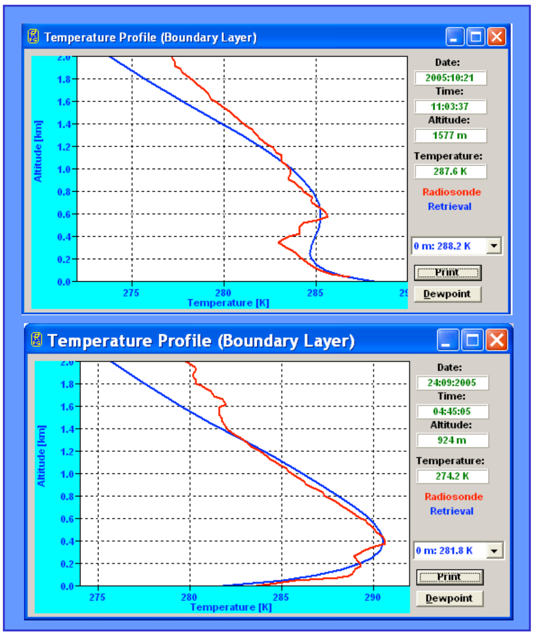


Figure 2. Theoretical accuracy of temperature profiles derived from boundary layer scans (thick line) and from zenith observations (top) The dashed lines gives the natural variability (standard deviation) of the data set used for algorithm development..

In the zenith observation mode the profiles of humidity and temperature are retrieved from the spectral characteristics of the 22 GHz water vapor line and the 60 GHz oxygen band, respectively. The accuracy for the absolute humidity is below 1 gm^{-3} and 2 K for temperature. At altitudes above about 5 km the information content of the brightness temperatures decreases strongly. This can be seen in Fig.2 by accuracy approaching the natural variability of the data set.

Boundary layer scans include angular information in addition to the spectral one. The lower the radiometer points the more information comes from the lowest atmospheric layers. For the highly opaque channels this information is only useful than the brightness temperatures can be observed at least with an accuracy of 0.1 K. If this achieved the uncertainty in the temperature profile reduces to 0.5 K in the lowest kilometer (Fig. 2). Above about 2 km the boundary layer scan can not achieve a better accuracy than the zenith pointing mode.

The high accuracy of HATPRO allows the temperature retrieval based on boundary layer scans. The comparison with radiosoundings demonstrates the ability to retrieve temperature inversions as well as more complex structures (Fig. 3).



Date: 2005:10:21
Time: 11:03:37
Altitude: 1577 m
Temperature: 287.6 K
0 m: 288.2 K

Date: 24:09:2005
Time: 04:45:05
Altitude: 924 m
Temperature: 274.2 K
0 m: 281.8 K

Figure 3. Examples of two temperature profiles retrieved from boundary layer scans (blue) and corresponding radiosonde ascents. Data from the test campaign in Lindenberg (Germany), Sept/Oct 2005.

4. CONCLUSIONS

The microwave radiometer HATPRO, a lidar ceilometer and a micro rain radar will complement the AMMA super site at Djougou, Benin. HATPRO experiences a unique accuracy which allows improved temperature retrievals for the planetary boundary layer. The performance of the radiometer has been confirmed in a test campaign at Lindenberg, Germany.

References

Crewell, S. and U. Löhnert, 2003: Accuraccy of cloud liquid water path from ground-based microwave radiometry. Part II. Sensor accuracy and synergy. *Radio Science*, 38(3), doi:10.1029/2002RS002634.

Rose, T., S. Crewell, U. Löhnert and C. Simmer, 2005: A network suitable microwave radiometer for operational monitoring of the cloudy atmosphere. *Atmos. Res.*, 75(3), 183-200, doi:10.1016/j.atmosres.2004.12.005