Observation of Boundary Layer Evolution in Djougou, Benin in 2006 using Microwave Radiometers

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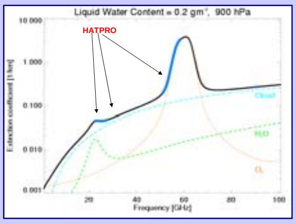
Objectives

- In a collaborative effort the universities of Bonn and Munich (Germany) will operate the unique microwave profiler **HATPRO** 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.
- 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.
- In addition a **lidar ceilometer** for aerosol and cloud information and a vertical pointing micro rain radar (**MRR**) will be deployed.
- 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.

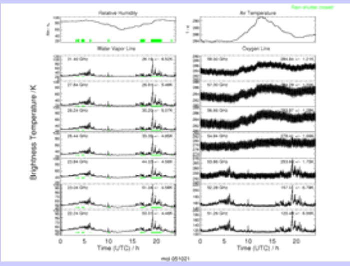
HATPRO microwave radiometer

- Continuous measurements of thermal emission by atmospheric components (water vapour, oxygen, cloud water) at 14 frequencies (see below) expressed as brightness temperatures.
- Automatic observation during all weather conditions due to hydrophopic radome coating and high power dew blower.



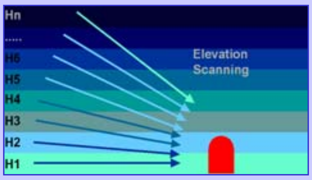
- Auxilliary measurements of environmental temperature, pressure and humidity; rain detection and GPS clock.
- High accuracy in brightness temperatures is achieved by a combination of absolute and relative calibrations involving liquid nitrogen, noise diode standards and sky tipping.

Brightness temperatures



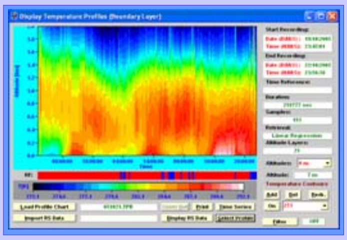
24 hours time series of brightness temperatures at Lindenberg (German Weather Service), 21 October 2005. The green times represent rain.

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



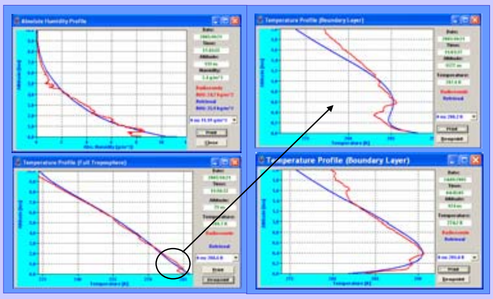
Temperature and humidity profiles

Boundary layer scans can derive the temperature profile with high accuracy (see below) and vertical resolution. The right hand figure shows a three-day time series of boundary layer temperature profiles at Lindenberg during the LAUNCH campaign. The diurnal cycle showing significant night-time inversions can be seen clearly.

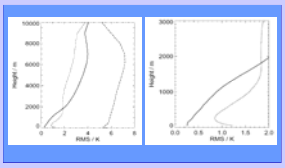


Left: Profile of absolute humidity (top) and temperature (bottom) up to 10 km height derived from one zenith pointing measurement together with corresponding radiosonde profile (red).

Right: Temperature profile of lower 2 km derive from corresponding boundary layer scan (top) and a further example for an inversion (bottom).



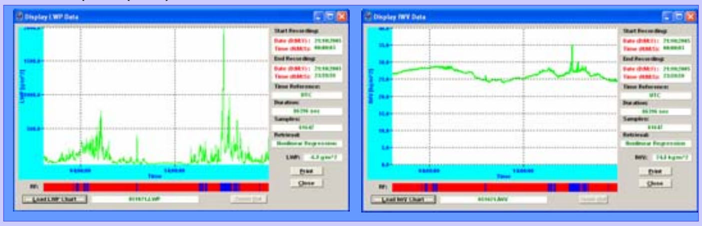
Accuracy



RMS of retrieved profiles compared to "real" profiles from radiosondes. The dotted line gives the performance of the "full-troposphere" algorithm (using zenith observation only) while the solid line gives the performance of the "boundary-layer" algorithm. Dash-dotted line represents natural variability of the dataset.

LWP,IWV

Statistical retrieval algorithms are developed on the basis of a large set of atmospheric profiles observed by radiosondes [Crewell and Löhnert, 2003]. The theoretical accuracy is about 20 gm^{-2} for LWP and <1 kg m^{-2} for the Integrated Water Vapour (IWV).



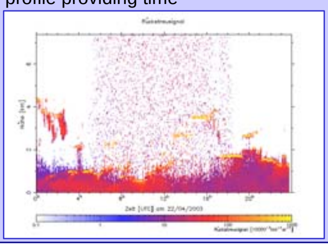
Lidar ceilometer

A LIDAR (Light Detection and Ranging) sends out laser pulses and measures the range resolved backscatter profile.

Backscatter is caused by atmospheric aerosols and hydrometeors. Due to the strong scatter of water cloud droplets the signal is extinguished within about the first 200 m of a water cloud. Ice clouds have a much lower backscatter.

The Vaisala lidar ceilometer CT25K uses a low power 905 nm laser to continuously monitor the atmospheric profile providing time height series (see bottom figure9.

- temporal resolution: 15 seconds
- vertical resolution: 30 m up to 7.5 km
- automatically detection of up to three cloud layers
- post analysis for mixing layer height detection

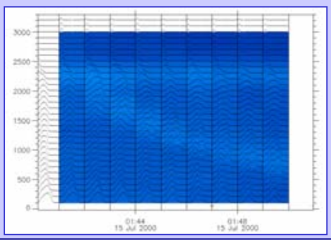


Micro Rain Radar

The Micro Rain Radar (MRR) is a small size, low power and low cost Doppler rain radar at 24.1 GHz.

It measures vertically resolved Doppler spectra in order to retrieve hydrometeor properties. The measuring principle is based on the relation between drop size and scattering cross-section and between drop size and fall velocity.

- Temporal resolution: between 10 seconds and 1 hour possible
- Variable range resolution (10 to 200 metres) in 30 range gates (300 to 6000 meters total range)
- Vertical profiles of radar reflectivity, rain rate, liquid water content (LWC), vertical velocity, and drop size distribution



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