Vertical cloud structure over a north-eastern Brazilian coastal city using LIDAR, a microwave radiometer and a K-band hydrometeor profiler

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We observed the vertical profiles of clouds in the Brazilian coastal city of Fortaleza during 20 days of April 2011. These measurements were acquired in the frame of the Chuva project, which aims at reducing the uncertainties in the satellite-driven estimation of rainfall. Part of the project is dedicated to the collection of an extensive dataset by means of multi-instrumental campaigns through Brazil. In this poster, we aim to present preliminary cloud observations obtained with three profiling modalities participating in the project: Lidar, microwave radiometer, and a K-band profiling rain radar.

Instruments used in this study

Lidar Raymetrics LR101V-D200
Nd:YAG SH 532nm
Pulse energy 130 mJ
Pulse repetition rate 20 Hz
Pulse duration 9 ns
used with time-resolution of 1 min.

Micro rain-radar Metek MRR-2
24.230 GHz

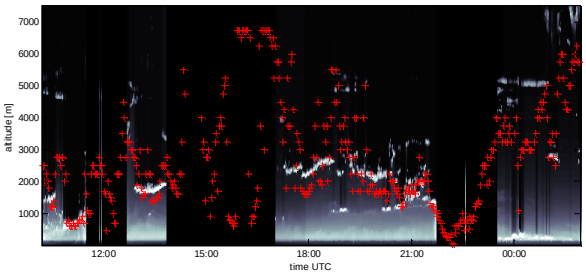
spatial resolution 50m,
time resolution 2 min.
derived quantities:
- quantitative rain rate
- drop size distribution
- Rayleigh reflectivity
- hydrometeor fall velocity

Microwave Radiometer Radiometrics MP3000
22.2 - 58.8 GHz

variable spatial resolution
time resolution 2 min.
derived quantities:
- liquid water content
- temperature
- relative humidity
- cloud base

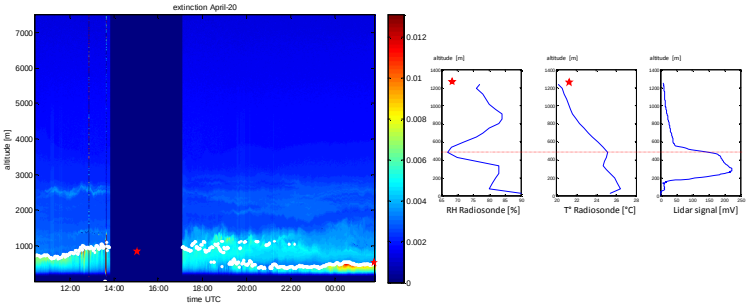
In order to perform controlled processing of the data, we are currently developing a dedicated analysis package which includes the following features:
- atmosphere USAF 1976 model, from radiosonde or from MP3000
- spatial resolution: 7.5m; time resolution: 1minute
- Backscatter data filtering using sliding window average (60m), time resolution 1min.
- Raman data spatial filtering using sliding window average (60m)
- Cloud recognition using thresholding of backscattered data

Retrieval of cloud base height



red symbols: cloud base height as retrieved from MP3000
grayscale: profiles of lidar back-scattered signal showing the height of the clouds.
There is a mismatch between these datasets: the results of the radiometer are derived from the infrared brightness temperature. For this, they seem particularly perturbated in the presence of sunlight or of a low cloud layer (around 0:00).

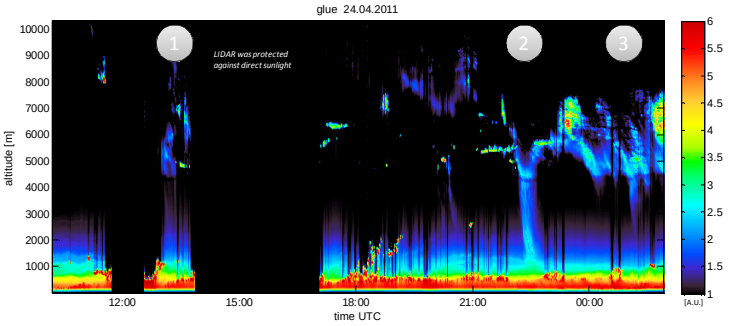
Retrieval of mixing layer height



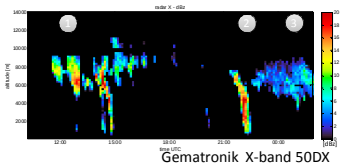
LIDAR backscatter signal overlaid with mixing layer height retrieval and 2 heights from radiosonde measurements.
LIDAR backscatter data are analysed using the gradient method applied to the backscatter coefficient profiles. We display here the mixing layer height obtained from day 24.04.2011, keeping the temporal resolution of 1 min. Results are in good agreement with the RH drop observed from 23:00 radiosonde data.

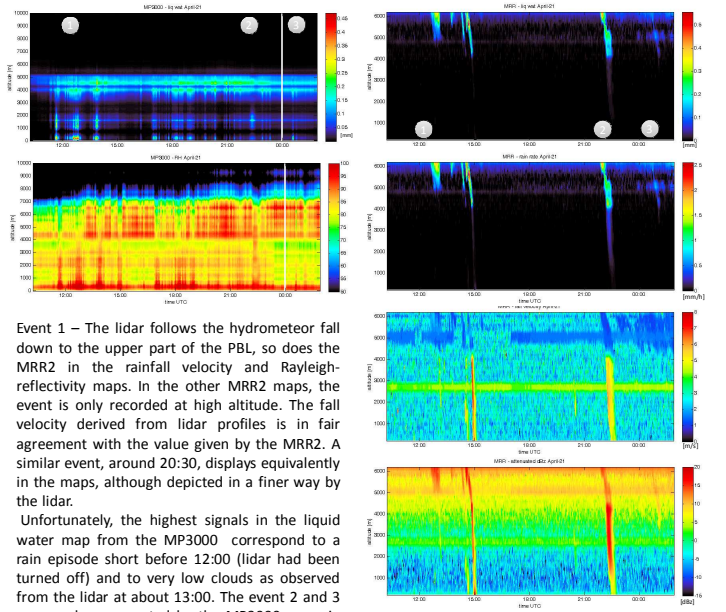
Hydrometeor events as seen from the 3 instruments

Measurements obtained on the 21st of April 2011 in Fortaleza show two different cloud layers, one of them being around the optimal range of the MRR2 and MP3000.



observed events
1. ice clouds and fall from hydrometeors (virga)
2. rain fall reaching the ground as drizzle
3. ice clouds and virga


Gematronik X-band 50DX



Event 1 – The lidar follows the hydrometeor fall down to the upper part of the PBL, so does the MRR2 in the rainfall velocity and Rayleigh-reflectivity maps. In the other MRR2 maps, the event is only recorded at high altitude. The fall velocity derived from lidar profiles is in fair agreement with the value given by the MRR2. A similar event, around 20:30, displays equivalently in the maps, although depicted in a finer way by the lidar.
Unfortunately, the highest signals in the liquid water map from the MP3000 correspond to a rain episode short before 12:00 (lidar had been turned off) and to very low clouds as observed from the lidar at about 13:00. The event 2 and 3 are poorly represented by the MP3000, even in the relative humidity map.

Event 2 - The hydrometeors clearly appear in the MRR2 rain fall velocity and Rayleigh-reflectivity maps (22:30), while the signal from the rain droplets vanishes at lower altitudes in the rain rate or liquid water maps, supposedly due to the lower sensitivity of the MRR2 when the radius of the droplets decrease by evaporation.
The fall velocity derived from lidar profiles is in fair agreement with the value given by the MRR2.

Event 3 –The MRR and the MP3000 show some signal that correlate poorly with the intensity and structure of the ice clouds seen by the lidar.

As expected, the lidar gives a much finer description of the cloud structure than the other modalities. Although the MMR2 is working in the K-band, it fails at retrieving the cloud structure located at 5500m just before and after event 2.
The MRR2 proves particularly useful in the case of hydrometeors and displays a sensitivity near to lidar in the Rayleigh-reflectivity and fall velocity maps.
Both the MRR2 and the MP3000 show difficulties for inferring the height of clouds. Their algorithms might be the cause of the mismatches found: the MP3000 uses a neural network and the MRR2 is indeed a CW apparatus; on the contrary, the lidar makes a pulsed measurement.

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Acknowledgement: CAPES; CHUVA project FAPESP grant 2009/15235-8