Convective and Orographically Induced Precipitation Study – COPS

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The New Balloon-Borne Disdrometer 'Flying Parsivel'

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Fig. 1: The disdrometer Flying Parsivel. The overlay of synthetic turf prevents drops from splashing on the housing and contaminating the measurements.

In 2004 a new airborne disdrometer called Flying Parsivel was developed at IMK. It is based on the optical disdrometer PARSIVEL (Löffler-Mang and Joss, 2000) using a laser light band for the detection of

- number,
- diameter (range of 0.3–25 mm)
- and velocity (0.1–20 m s^{-1})

of hydrometeors. Different types of precipitation can be identified (rain, snow, graupel etc.) by using velocity and size information.

The sonde is launched attached to a balloon in combination with the reusable IMK radiosonde, which measures meteorological variables during the flight, manages the release of the two sondes from the balloon, and provides the GPS location for recovery after landing.

Fig. 2: Opened Flying Parsivel. The laser light sheet is located in the core of the housing.

TECHNICAL PROPERTIES OF FLYING PARSIVEL

Size of housing: 338 mm x 180 mm x 160 mm
Size of core: 180 mm x 60 mm x 160 mm
Laser diode wavelength: 680 nm; power: 1.5 W
Light sheet size: 180 mm x 30 mm x 1 mm
Measuring area: 54 cm^2
Weight: ~1.4 kg

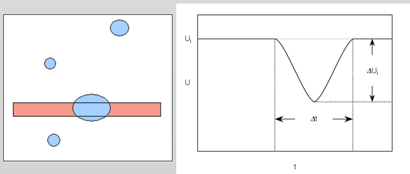


Fig. 3: Schematic of droplets falling through the light sheet (left) and resulting signal caused by a particle (right).

A MEASUREMENT FLIGHT DURING COPS

On August 21, 2007, Flying Parsivel was launched at supersite Hornisgrinde, (1160 m MSL), at 17:31 UTC. During that day, a couple of showers had developed over the Black Forest.

One hour before a shower had developed a few kilometres south of Hornisgrinde slowly moving towards the launching site. When it arrived, Flying Parsivel was launched. It ascended up to 7000 m ASL, which took 26 minutes.

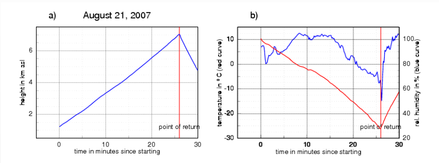


Fig. 6: a) Height ASL and b) temperature and relative humidity of Flying Parsivel measurements.

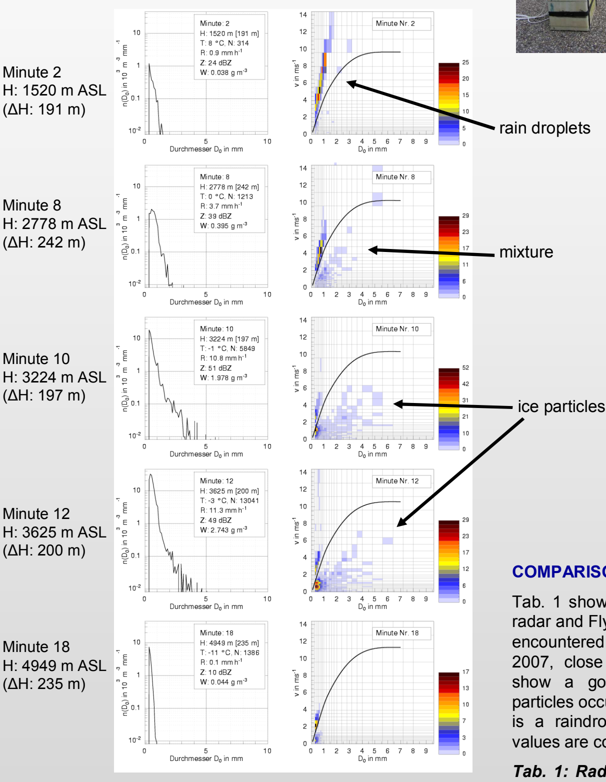


Fig. 5: Left: particle size distribution. Right: particle number as a function of size and fall velocity (color-coded) and semi-empirical curve for rain droplets (after a method by Beard). All diagrams are based on 1 minute-intervals. Note change in color coding scale. H: mean height AGL, N: particle number per m^3, R: rain intensity, Z: radar reflectivity, W: liquid water content, all parameters are calculated with the assumption that each particle is a rain droplet.

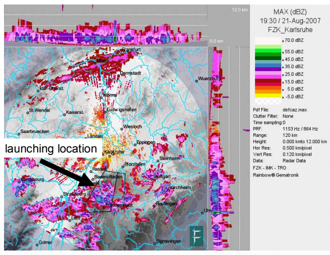
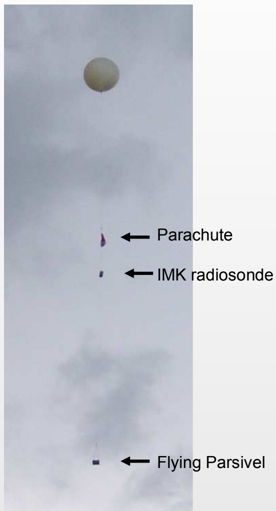


Fig. 4: Reflectivity by the C-band radar Karlsruhe.



COMPARISON WITH IMK RAIN RADAR

Tab. 1 shows reflectivity data of IMK C-band rain radar and Flying Parsivel whenever the radar beam encountered the latter (for a measurement in Feb. 2007, close to Karlsruhe). The first two values show a good agreement. Later – where ice particles occur which do not meet the "each particle is a raindrop"-assumption – the Flying Parsivel values are comprehensible too high.

Tab. 1: Radar reflectivity (Z) measured by IMK C-band rain radar and derived from Flying Parsivel measurements on Febr. 14, 2007.

Time since launching, Height, Temperature	Z (by radar)	Z (by Flying Parsivel)
1. min, 300 m, 7°C	22.8 dBZ	24 dBZ
8. min, 1650 m, 3°C	27.8 dBZ	28 dBZ
13. min, 2500 m, 0°C	20.0 dBZ	56 dBZ
17. min, 3000 m, -2°C	14.8 dBZ	44 dBZ

MEASURING PRINCIPLE

The basis of the sonde is a 680 nm laser diode that produces a flat horizontal sheet of light focused onto a single photodiode, which converts it into an electronic signal. Whenever a particle falls through the light sheet, there is a dynamic decrease in the signal (Fig. 2). The decrease depends linearly on the fraction of the light sheet blocked and thus, correlates with the particle's size. From the duration of the extinction, the velocity may be derived. Based on this concept the equivalent spherical diameter and the velocity of each particle are calculated assuming every particle to be a raindrop.

PROBLEMS

- Swinging of the disdrometer causes a permanently changing sample volume influencing the measurement results. This error can be corrected, but the built-in inclinometer proved to be not suitable for this task. It will be replaced with a gyro orientation sensor.
- As can be seen from the results, measured fall velocities are too high compared to empirical derived values. The reason is not yet clearly understood.
- In the future the photodiode's idle signal will be stored additionally to control the current status of the protective glass in front of the diodes.

OUTLOOK:

After replacing the orientation sensor and some other modifications new testings and measurements will be made. Furthermore, intercomparison measurements with other sensor systems are interesting, mainly with remote sensing based ones.

References:

Löffler-Mang, M. and J. Joss, 2000 : An Optical Disdrometer for Measuring Size and Velocity of Hydrometeors, J. Atmos. Oceanic Technol., **17**, 130-139.