TOWARDS AN IMPROVED ESTIMATION OF CLOUD BOUNDARIES AND STRUCTURE FROM COMBINED 95 GHZ RADAR, CEILOMETER, AND MICROWAVE RADIOMETER MEASUREMENTS

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1 INTRODUCTION

An accurate geometrical cloud information like the height of the cloud base and top as well as number of layers is an essential for assessing the influence of clouds on global climate and related feedback mechanisms. Furthermore, the internal cloud structure (i.e. distribution of cloud water content) is of great importance.

Within the EU project CLIWA-NET (Cloud LIquid WAter NETwork) a network of ground-based observation sites is combined with satellite measurements to deduce highly accurate fields of the cloud liquid water path (LWP) for the entire BALTEX (Balitc sea EXperiment) area. The results will then be used for evaluation and improvement of the parameterisation of clouds, where special focus is on pure stratiform liquid water clouds, i.e. comparably low and geometrically thin clouds. For further information on the CLIWA-Net project see http://www.knmi.nl/samenw/cliwa-net/.

During the first CLIWA-NET observation period, which took place from 1 August 2000 to 30 September 2000, the GKSS Research Center in Geesthacht (Germany) hosted a ground-based site consisting of the following instrumentation

- 95 GHz cloud radar MIRACLE (GKSS, technical details are listed in table 1, further information is given in Quante et al., 1998),
- Vaisala laser ceilometer CT25K (GKSS),
- 22 channel microwave radiometer MICCY (Univ. Bonn, for technical description see Crewell et al., 2001),
- infrared radiometer (Univ. Bonn).

More detailed information about the instrumentation and additional equipment, like in-situ (aircraft) measurements during a two week intensive observation period, is given at http://w3.gkss.de/english/Radar/CNN1/.

Table 1: Technical specification of the GKSS cloud radar MIRACLE.

frequency (wavelength)	95 GHz (3.2 mm)
peak power (EIA)	1.7 kW
duty cycle	1.2 % max.
PRF	50 Hz - 80 kHz
pulse width	50 - 2000 ns
beamwidth ϑ_{3dB}	0.17°
antenna diameter	1.2 m (Cassegrain)
antenna gain	60 dB
polarization	linear (H,V)
dynamic range	> 70 dB

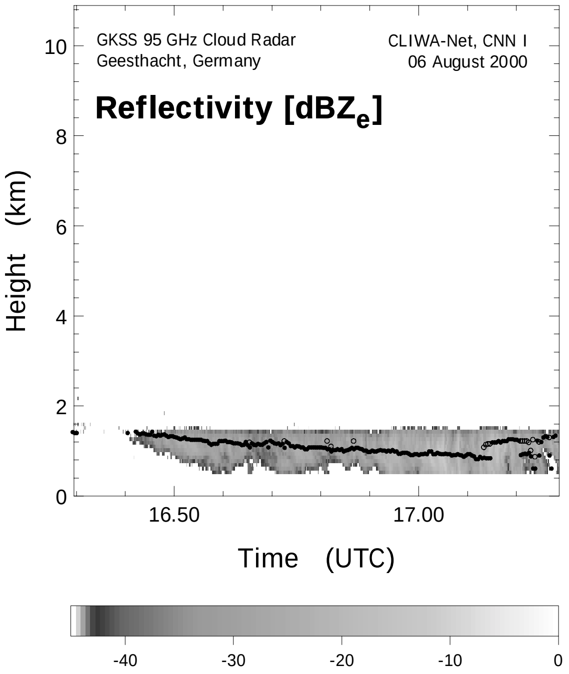

Figure 1: A one hour time series of reflecitivity profiles (time given in decimal hours, resolution: 5 s / 82.5 m). The cloud base height as derived from the CT25K ceilometer is indicated by the black dots (resolution: 15 s / 30 m).

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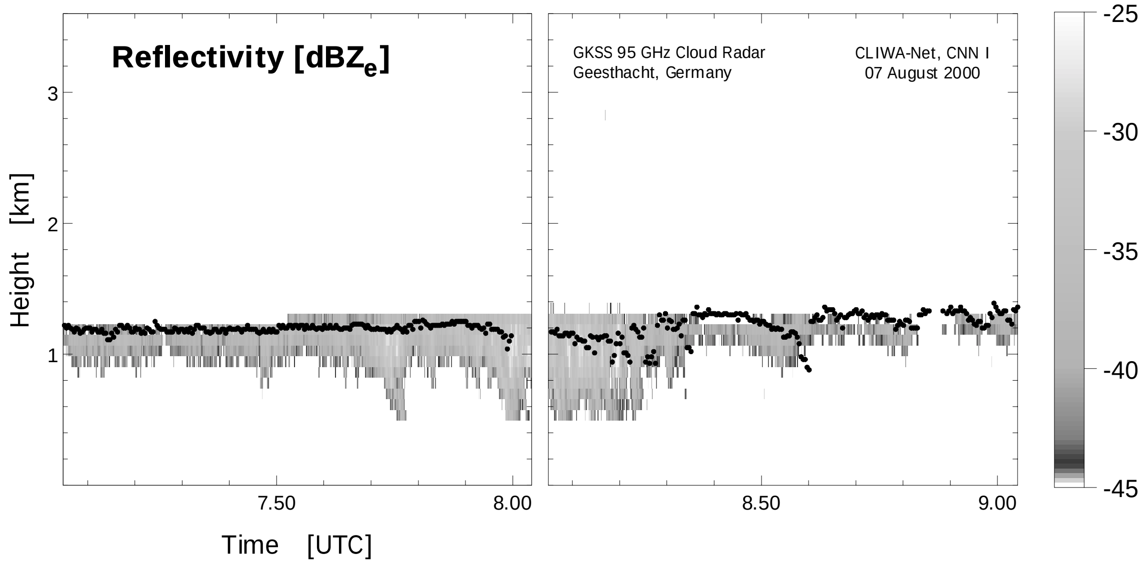

Figure 2: 1: A two hours time series of reflecitivity profiles (time given in decimal hours, resolution: 5 s / 82.5 m). Black dots indicate the cloud base height as derived from the CT25K ceilometer (resolution: 15 s / 30 m).

2 MEASUREMENT EXAMPLES

In principle, the two active instruments supply information about the vertical distribution of the hydrometeors. Scattering by cloud particles is subject to different mechanisms at radar and lidar wavelength, respectively. While the radar signal is dominated by the size of particles, the lidar signal is governed by their number. Thus, a few large particles falling out from cloud base (drizzle) can cause non-negligible radar signals, but contribute virtually nothing to the liquid water path. Because of those 'drizzle signals', the radar-estimated cloud base is often distinctively below the cloud base height as derived at optical wavelength, i.e. from measurements with ceilometer and lidar, respectively (see also Clothiaux et al., 2000; Danne et al., 1999). It should be noted that the difference between the instruments is dependent on the specified sensitivity and the algorithm for the cloud base retrieval from ceilometer data.

Figure 1 gives a clear impression of the differences in radar/lidar measurements. At the beginning of the cloud formation, radar and ceilometer start at the same height. While the cloud layer thickens, the ceilometer gives a distinctively higher cloud base height than the radar. Taking the 'optical cloud base' as reference, some large precipitating drops below the cloud cause a significant radar signal (it should be noted that these drops evaporate before reaching the ground). Nevertheless, because of their small numbers, these large particle do not contribute significantly to the LWP. Thus, the LWP measured by microwave radiometer can be assigned to the region between the 'radar cloud top' and the 'ceilometer cloud base' (Hogan et al., 1999).

The interpretation of the situation in Figure 2 less straight forward. In the beginning, the cloud seems to be very thin (1-2 radar range gates) with precipitating drops, so the apparent radar signal is for the major part from drizzle regions. After about one hour, the ceilometer signal later starts fluctuating, where at some sections the ceilometer signal is even at the top of the radar signal. In an on-going discussion different explanations for these effects are considered.

3 REFERENCES

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