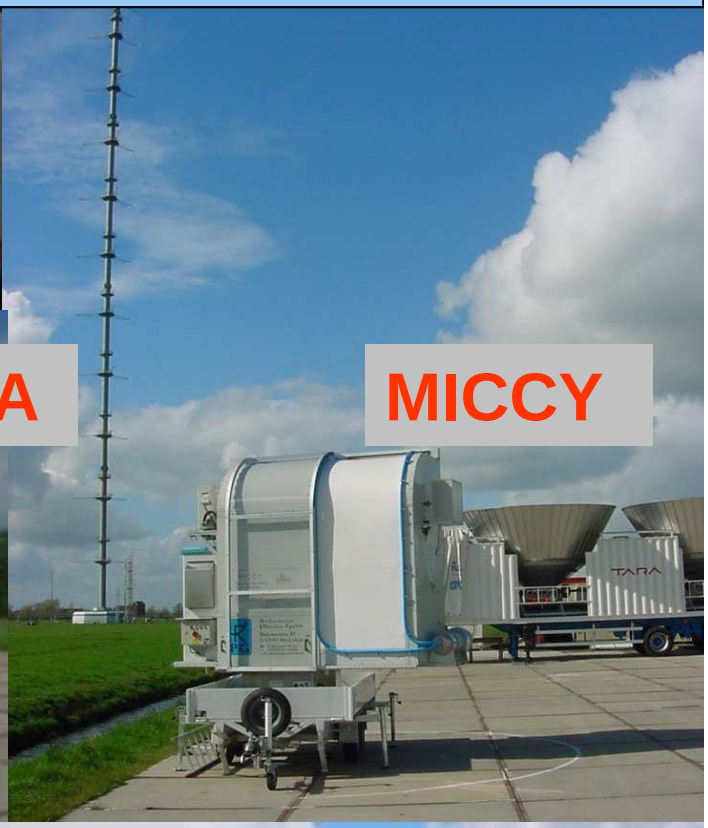
Ground-based passive remote sensing and sensor synergy

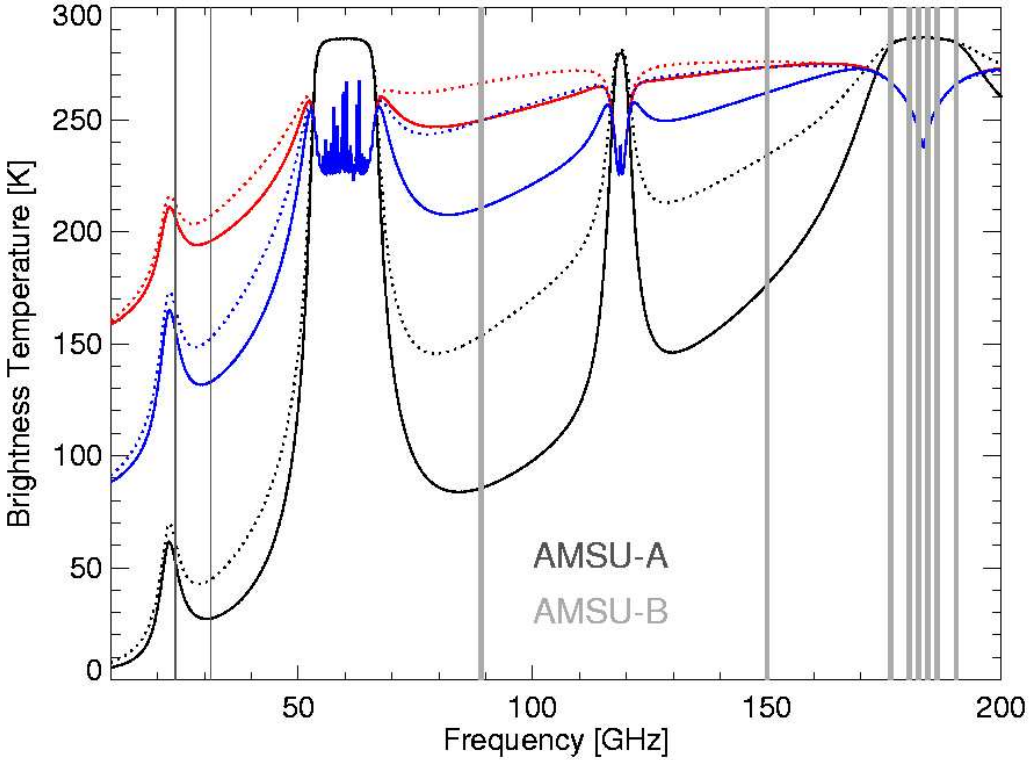
Susanne Crewell and Ulrich Löhnert
Meteorologisches Institut München

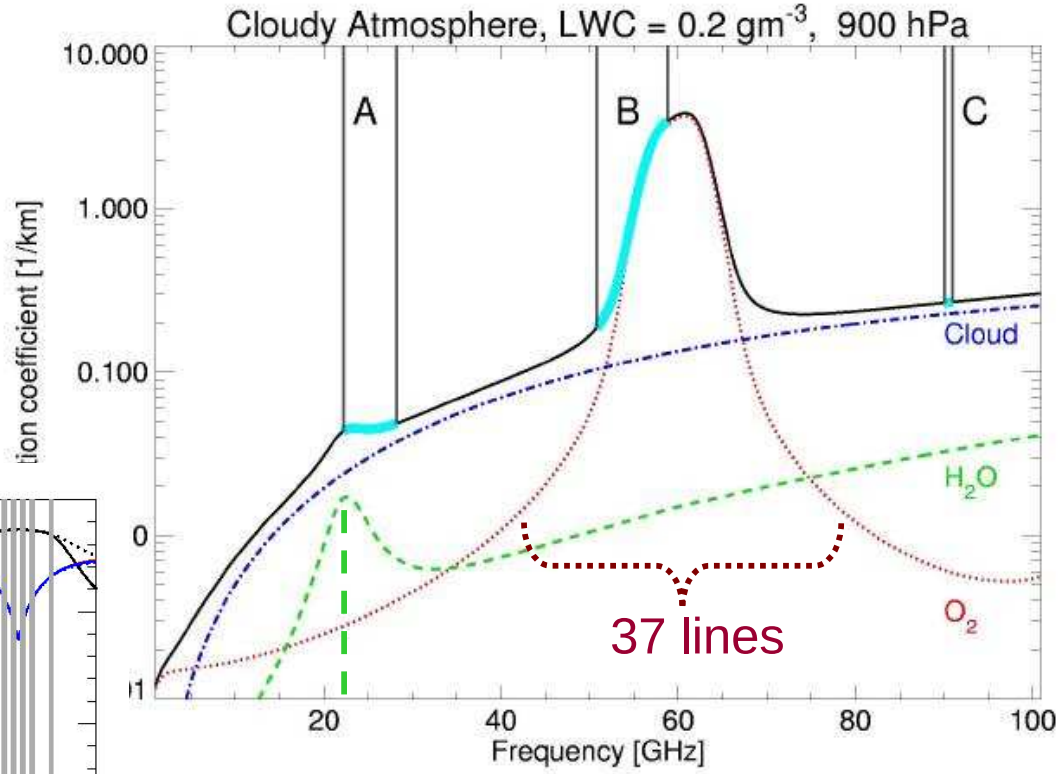
Microwave Radiometer



Microwave Spectrum

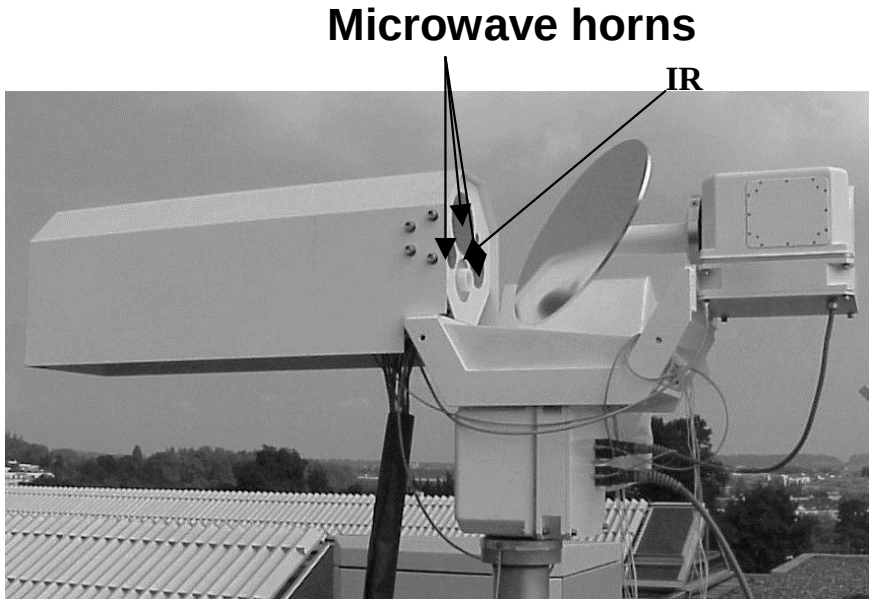
Scattering can be neglected
- frequencies <100 GHz
- non-precipitating conditions





Ground-based
satellite (vertical polarization)
satellite (horizontal polarization)

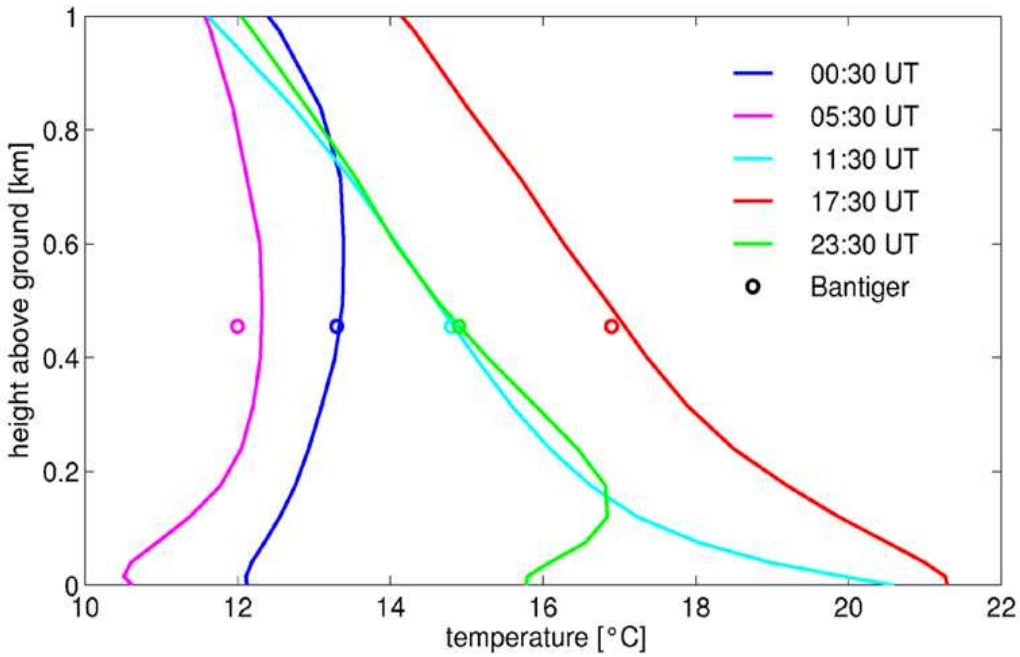
All Sky Multi-Wavelength Radiometer (ASMUWARA)



ASMUWARA in operation in Bern.
Obtains a complete sky map every 20 min

University of Bern, Ch. Mätzler

- Nine microwave channels
- Frequency range:18 to 151 GHz
- broad-band thermal IR channels
- All channels have the same view
- All channels have common full beam width of 9°



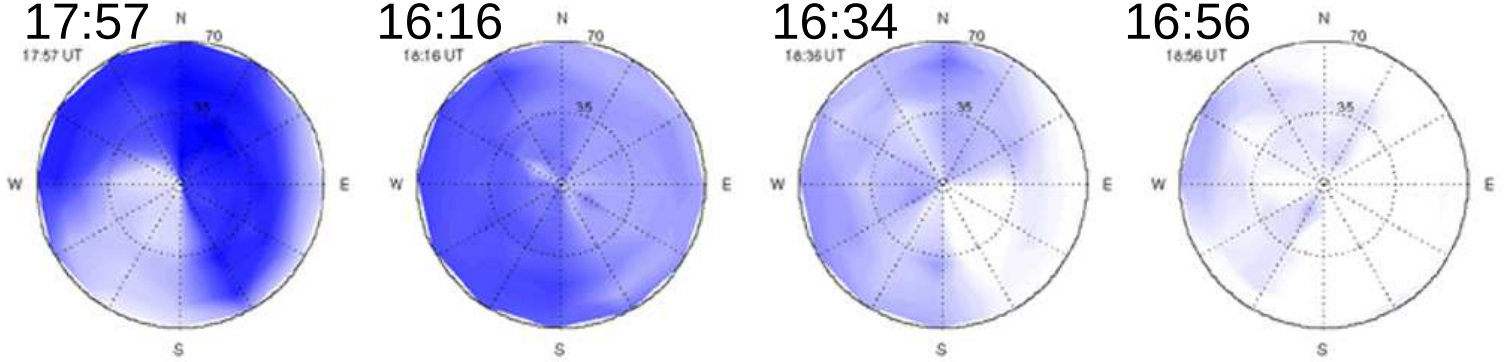
Hemispheric Observations

ASMUWARA, 8 April 2003

Liquid water path (LWP)

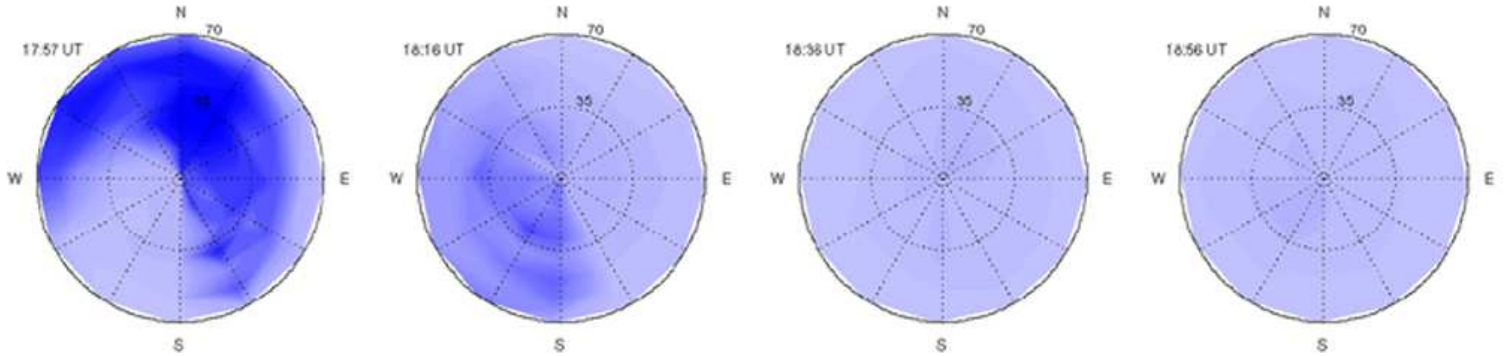
scale: blue: 0 mm, white: 0.05 mm

17:57 16:16 16:34 16:56



Infrared sensor:

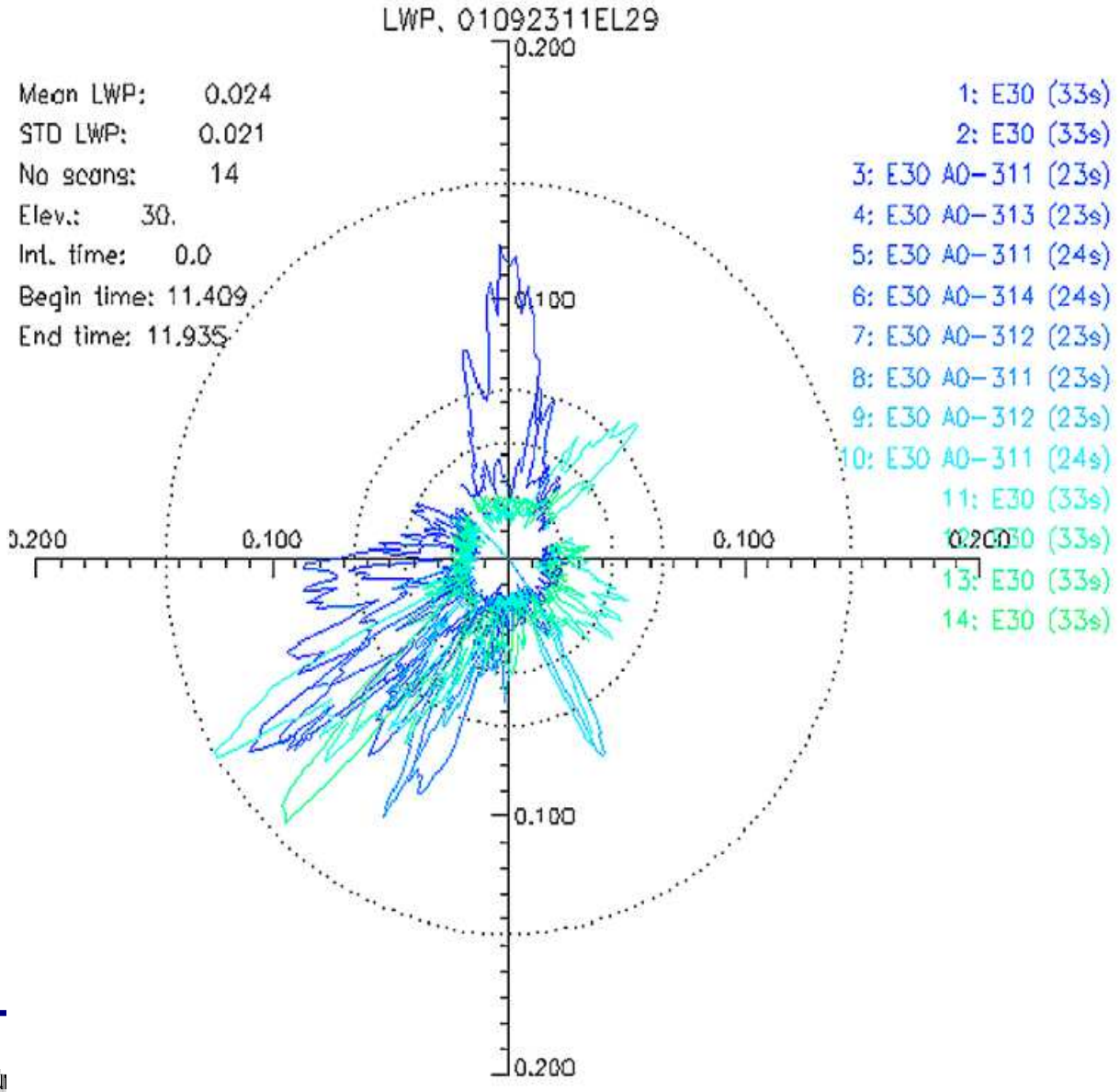
scale: blue: −70°C, white: −0°C



14 sucessive azimuth scans (30 min)

MICCY (UBonn)

high spatial resolution



Sensor Synergy: Vertical column

Cloud radar

- information on vertical cloud position
- radar reflectivity ~ $\mathbf{D^6}$
- Doppler velocity, depolarization

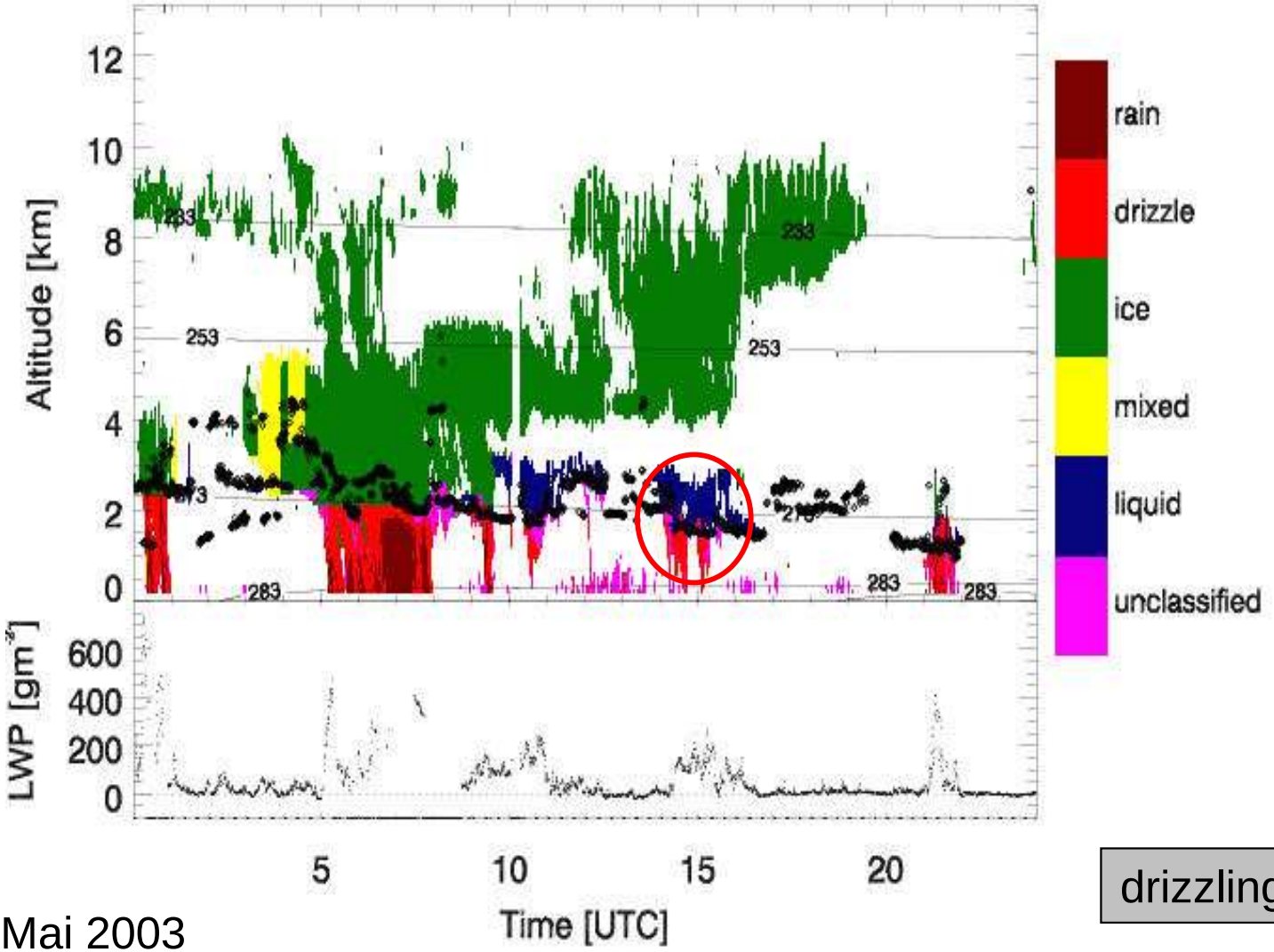
Microwave profiler

- temperature and humidity profile
- emission of cloud droplets ~ $\mathbf{D^3}$
- only limited vertical resolution

Laser Ceilometer

- backscatter due to aerosol and cloud droplets ~ $\mathbf{D^2}$
- cloud extinction proportional to droplet concentration at cloud base
- conversion of backscatter to extinction problematic

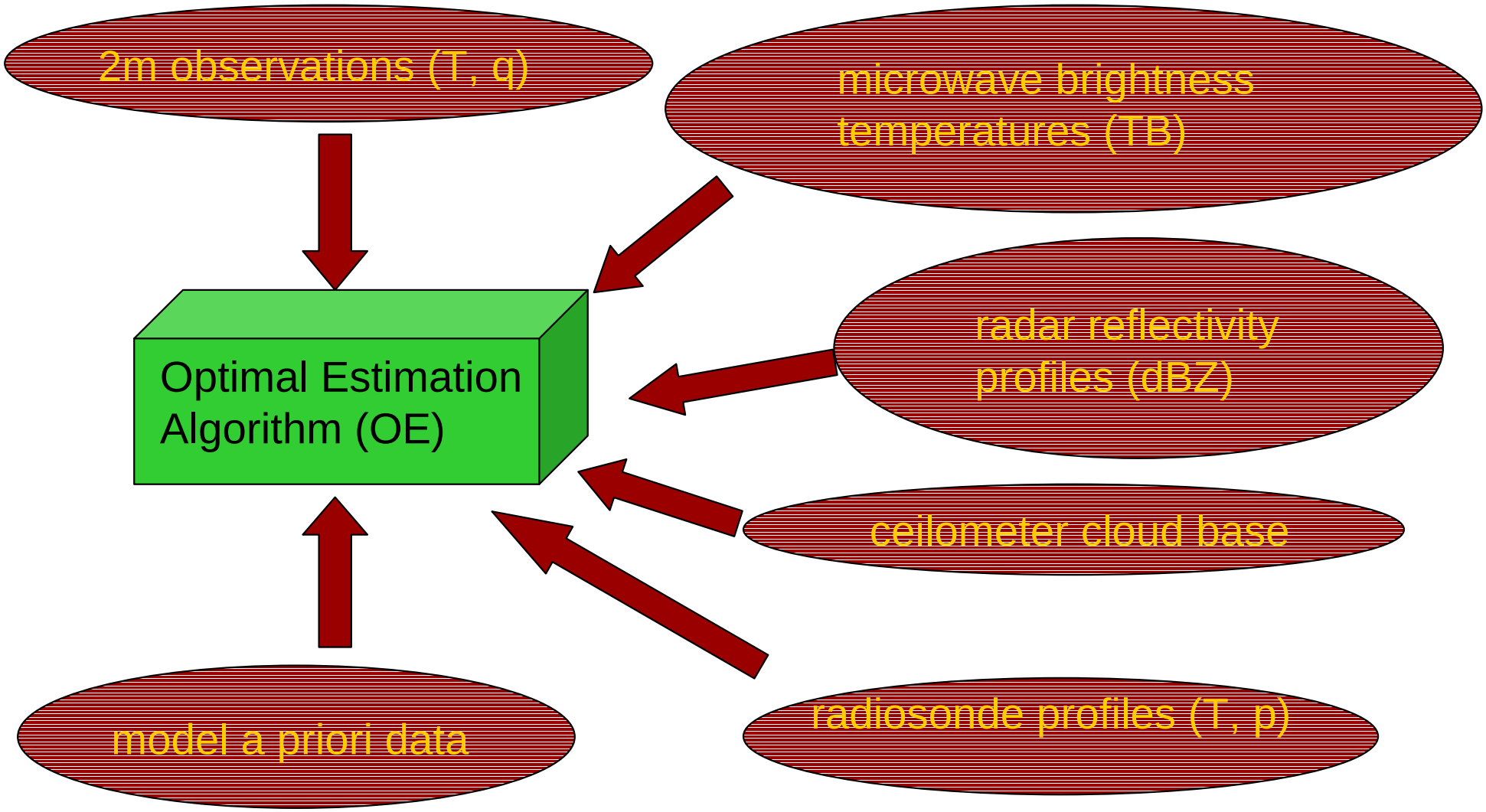
Cloud classification



drizzling clouds

Cabauw, 9. Mai 2003

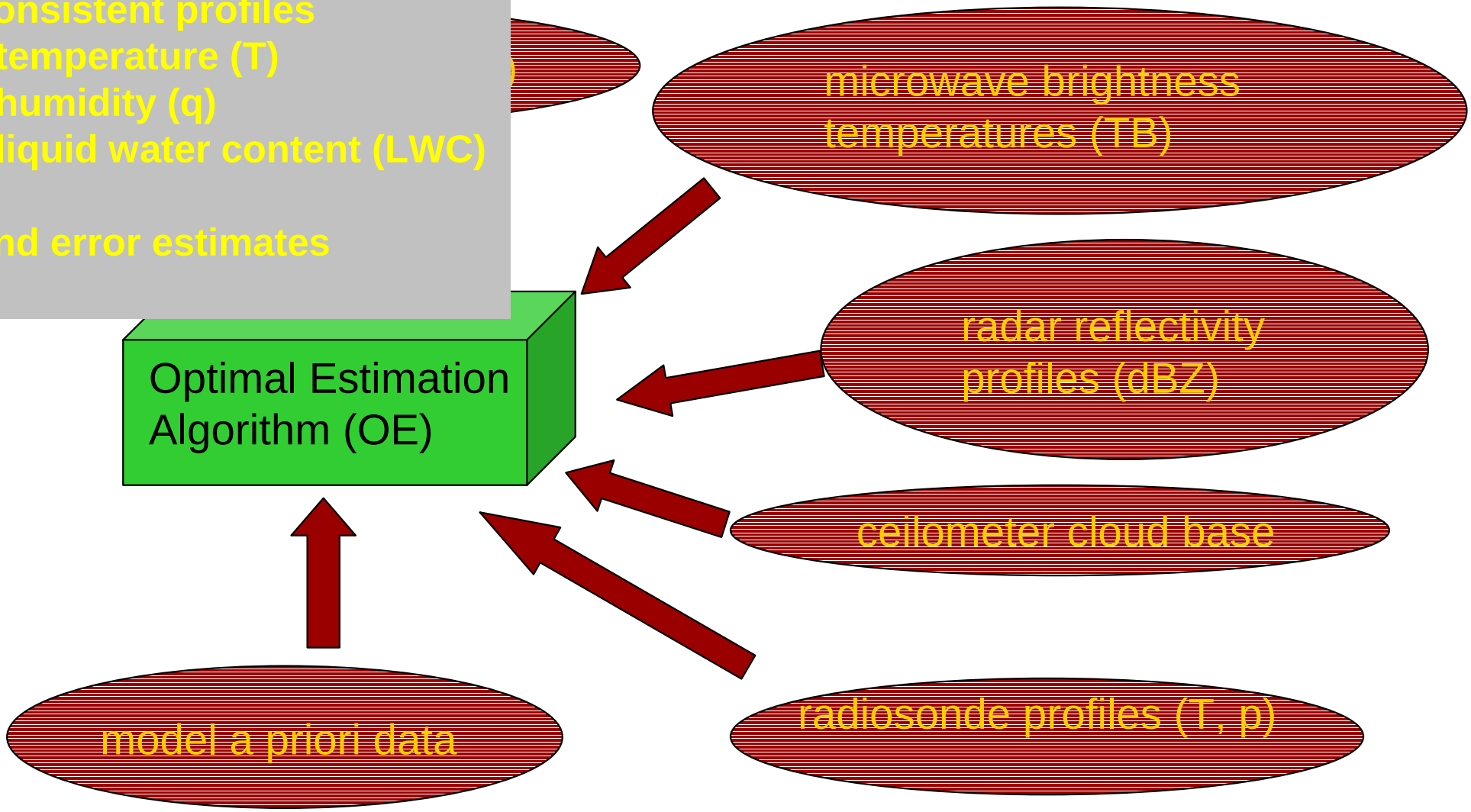
Integrated Profiling Technik (IPT)



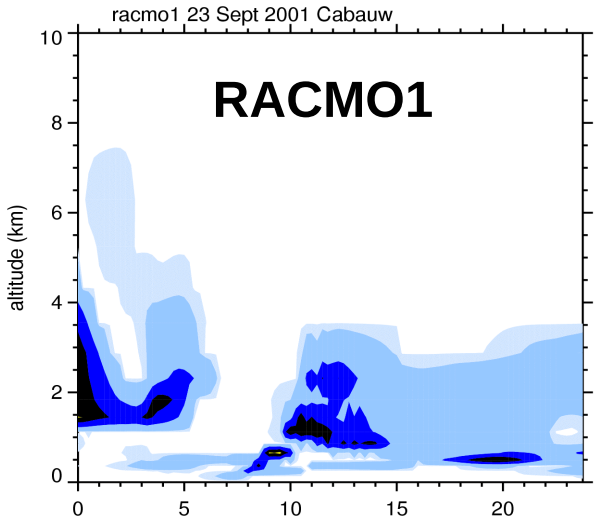
Integrated Profiling Technik (IPT)

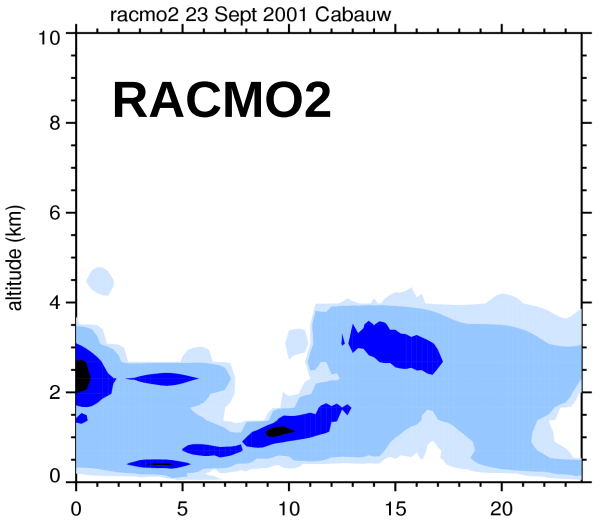
optimized, physically consistent profiles
- **temperature (T)**
- **humidity (q)**
- **liquid water content (LWC)**

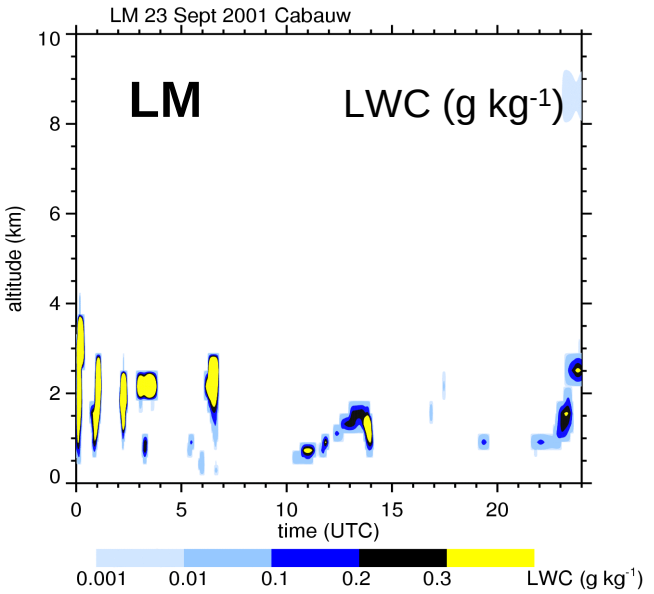
and error estimates

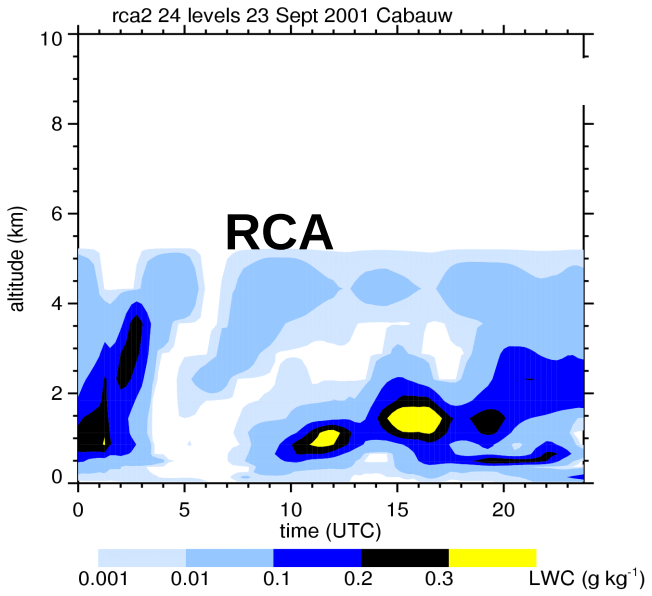


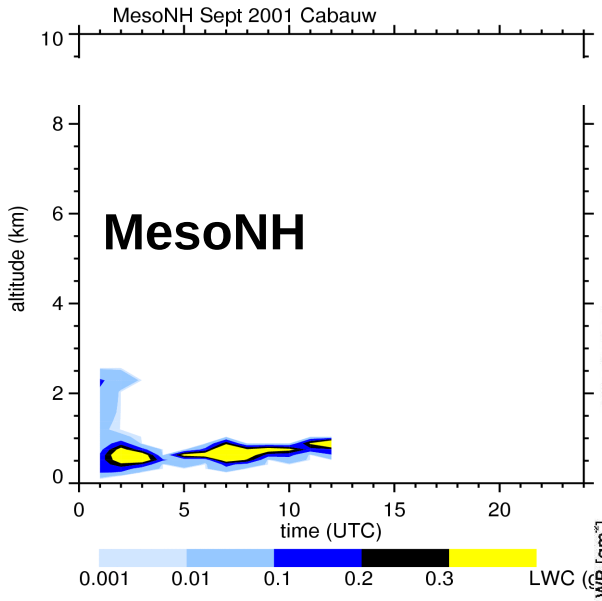
WMO Cloud Modelling Workshop, Hamburg, July 2004
BBC case 23 September 2001



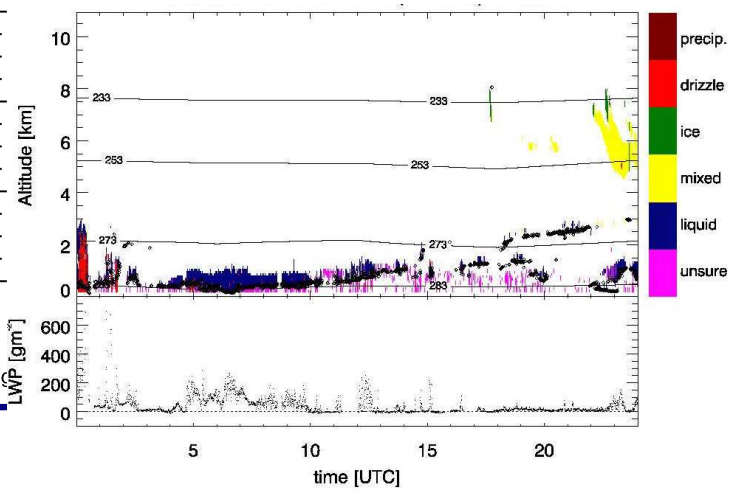








Observation



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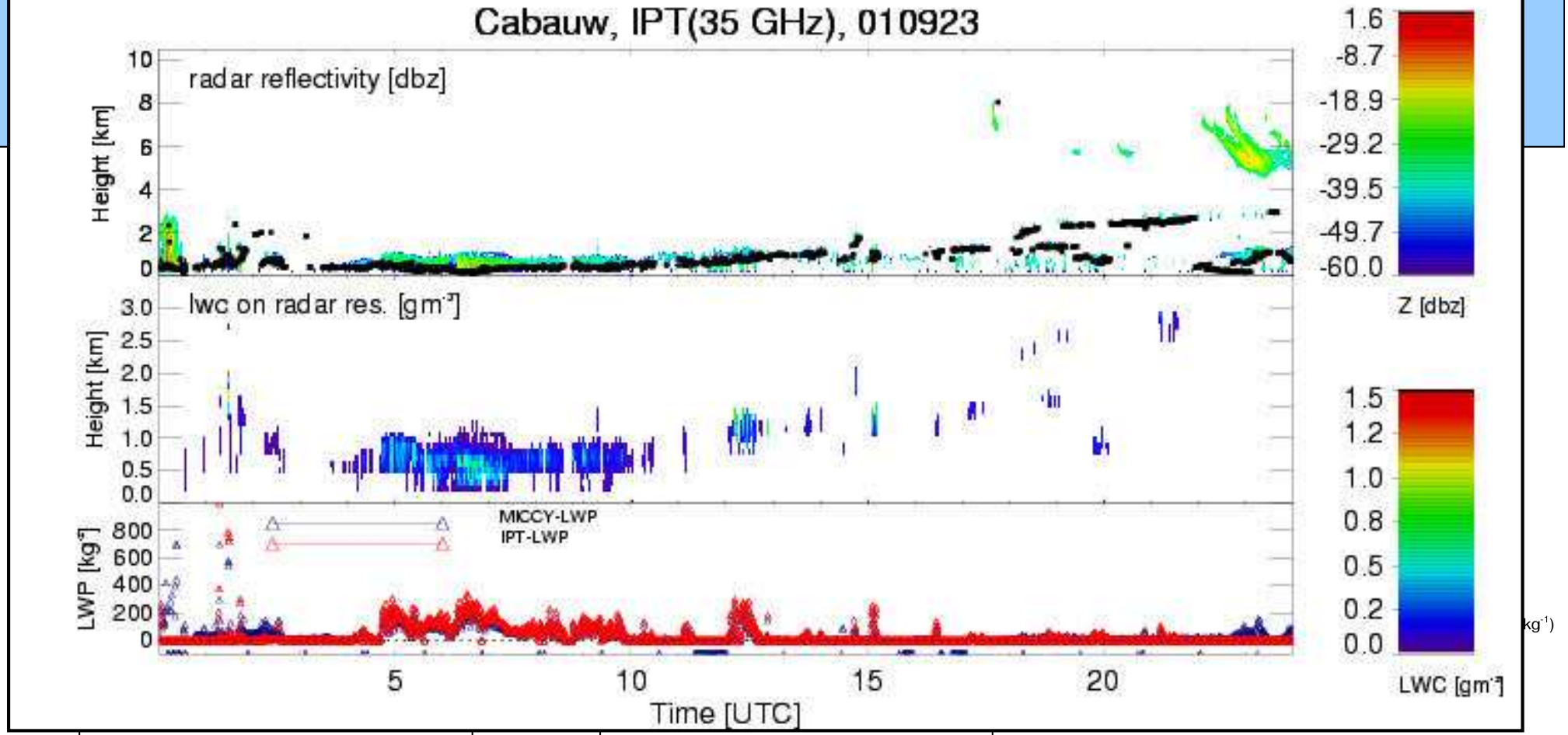

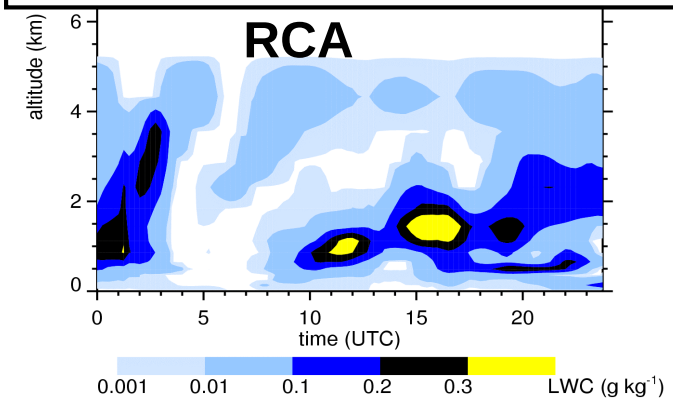

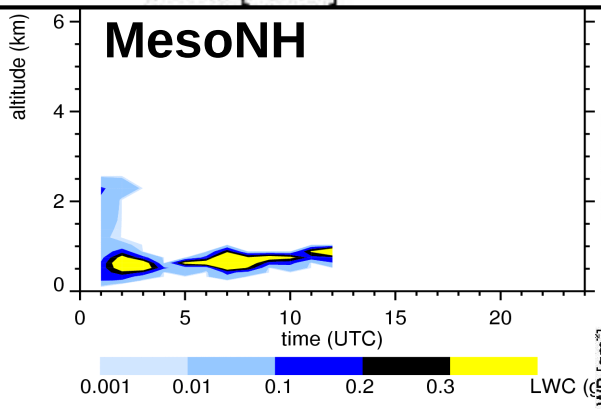

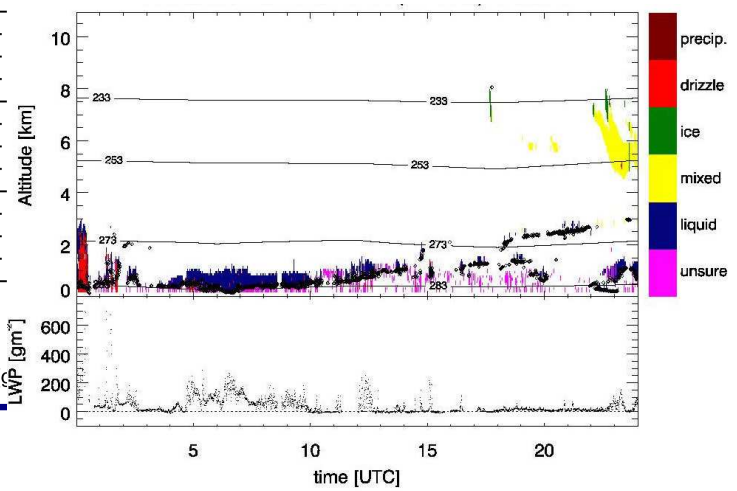

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Other methods and possible extensions

COST 720 Integrated Profiling " Retrieval of cloud microphyics"

- O'Connor et al. (UReading)
Input: LWP, Lidar extinction, profile of radar reflectivity and Doppler velocity
Output: Number concentration (const. altitude), effective radius, LWC, drizzle water content below cloud

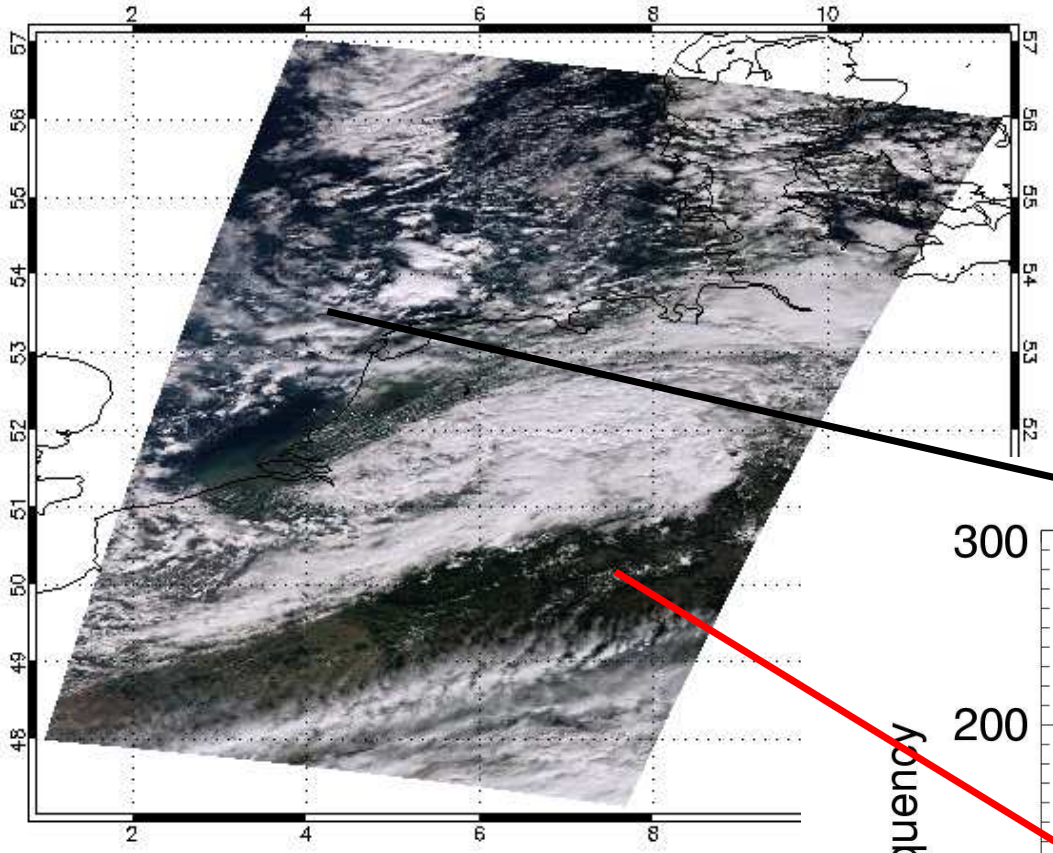
- Krasnov et al. (TUDelft)
choose Z-LWC relationship (in-situ climatology) depending on lidar/radar ratio
Output: LWC profile in drizzling and non-drizzling clouds

Ice water content
- Matrosov et al. (NOAA): cloud radar, IR
- Donovan et al. (KNMI): radar, lidar

Humidity profile
- Bianco et al. (micowave radiometer, wind profiler)

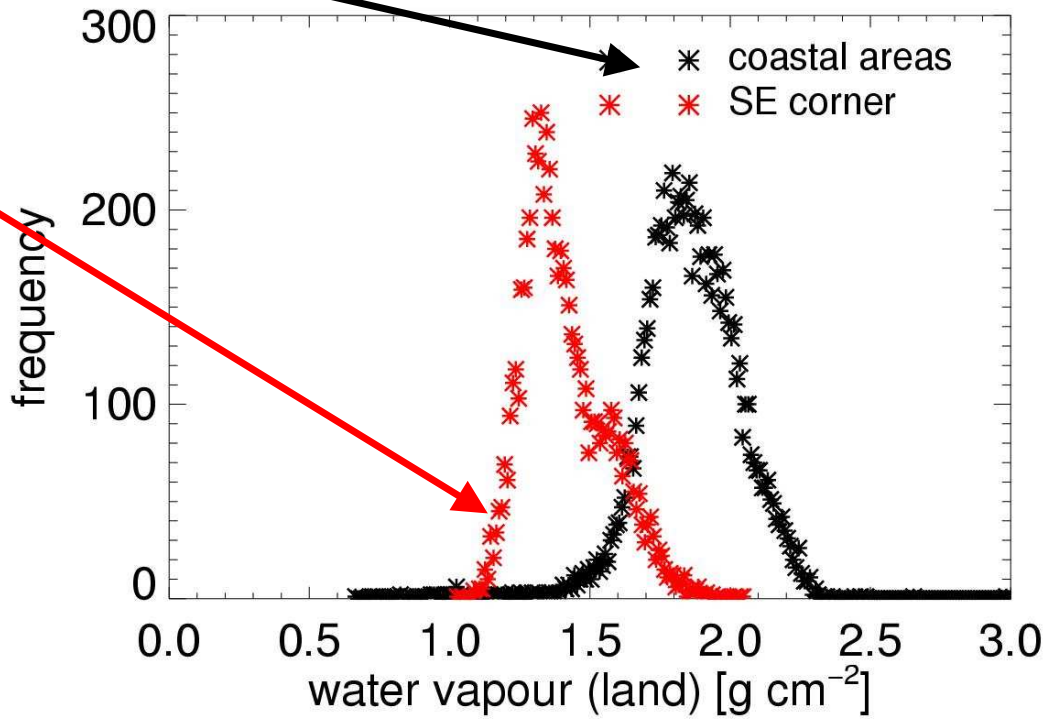
More sensors
- pyranometer
- FTIR
- ...

Sensor Synergy: Satellite - Ground-based

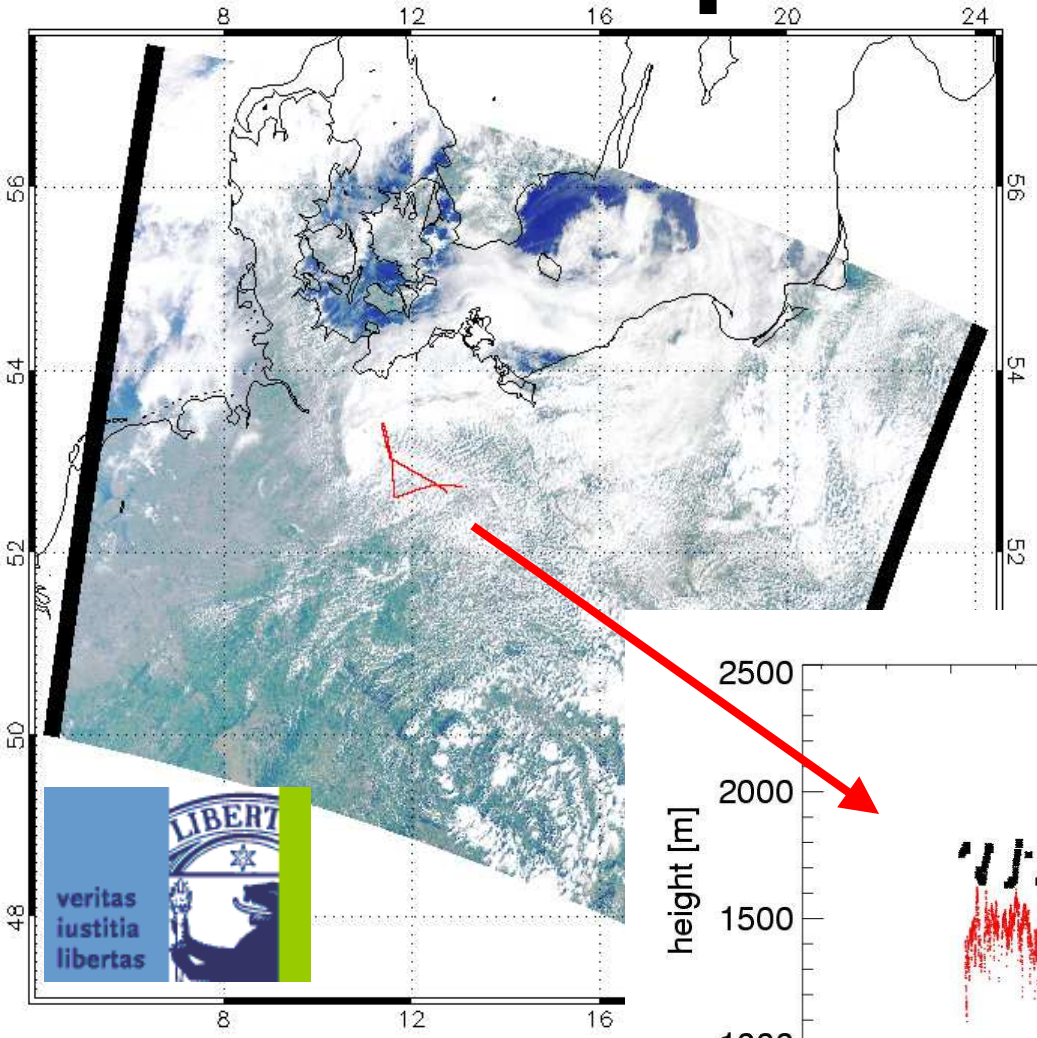


MODIS, RGB 2001-09-23

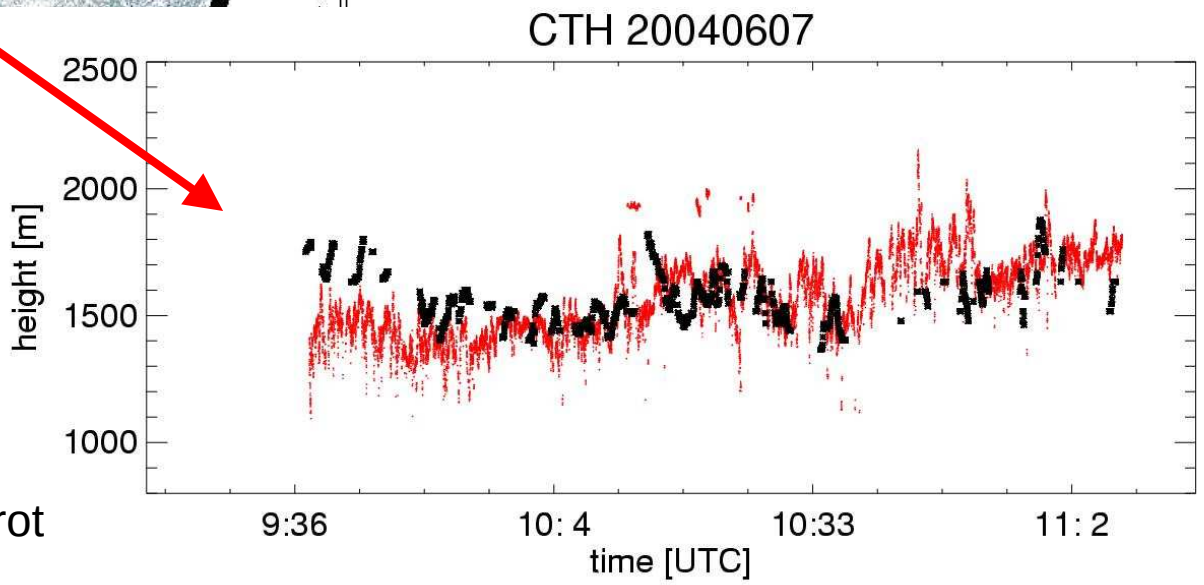
histogram: precipitable water



Cloud products: Meris



- Validation campaign: Meris / Polis (Lidar, UMunich)
- uncertainty from simulations + other: at best 20 hPa



Rene Preusker and Rasmus Lindstrot

AQUA-Radar Campaign Summer 2005

~10 micro rain radar (MRR)
- vertical profile of DSD

2 polarization radars
- RHI and sector scans

bistatic radar network

DWD Doppler raddar

AQUA RADAR

Construction of 4D-drop size distribution

Something for the shopping list ?