HD(CP)² Observational Prototype Experiment

Water Vapor and Temperature Measurements

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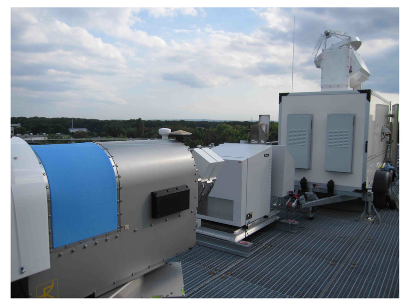
Three supersites within 5 km radius

JOYCE: Jülich Observatory for Cloud Evolution (A)



- Scanning cloud radar MIRA
- Scanning MWR HATPRO
- WV Raman lidar MPI & BASIL
- Scanning Doppler lidar
- AERI system
- Ceilometers, MRR, all-sky imager
- Aeronet station, radiation sensors

KITcube & UHOH (B)

- Cloud radar MIRA
- Scanning MWR HATPRO
- Scanning WV DIAL
- Rotational Raman Lidar
- Doppler Lidar, ceilometer
- Mobile X-band radar, rain gauges, MRR
- 2 ceilometers, MRR, 30m tower
- Surface energy balance

LACROS: Leipzig Aerosol and Cloud Remote Observations System (C)

- Multi-wavelength Raman Lidar
- Scanning cloud radar MIRA
- MWR HATPRO
- Scanning Doppler lidar
- All-sky imager, ceilometer

HOPE: April-May 2013, Jülich, Germany

HOPE area 1, 2, 5 km radius (red, yellow, green) around the Research Centre Jülich (red circle)

Objectives

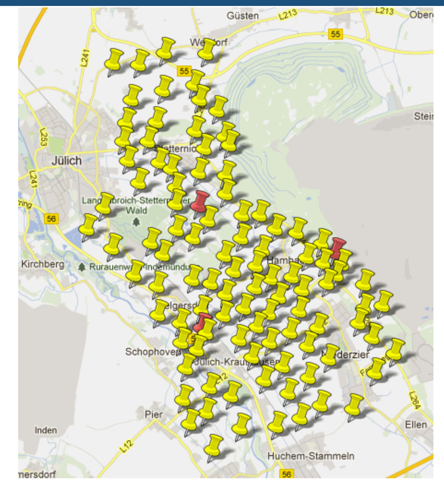
- Evaluate HD(CP)² cloud resolving model (dx=100m) over the full domain of Germany (1000 km)
- Provide information on sub grid variability

Focus

- 3D cloud and water vapor fields
- Clouds (activation) and precipitation (auto conversion) in the BL
- Cloud-overlap and 3D radiative effects
- Aerosol and cirrus cloud properties

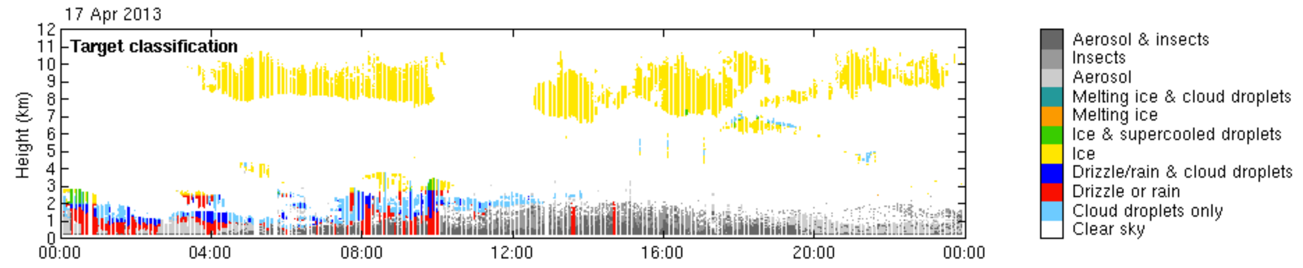
Additional measurements

- 0 and 12 UTC radiosondes
- Array of 100 surface solar irradiance stations
- MWR profiler for continuous BL temperature profiles
- 2 X-band Dual Polarization weather radars
- 3D cloudy reconstruction from all-sky cloud cameras
- EC stations and soil moisture measurements



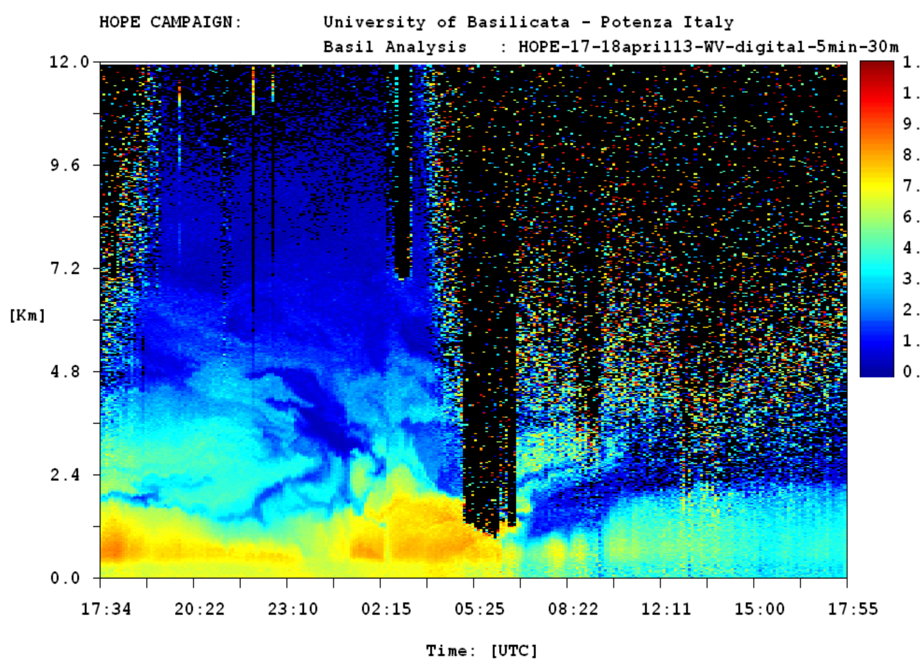
Measurement integration

- Cloudnet products: cloud classification, cloud cover, cloud microphysics
- 1DVAR retrieval of thermodynamic and cloud property profiles (IPT)
- 3D radar composites merged with satellite data

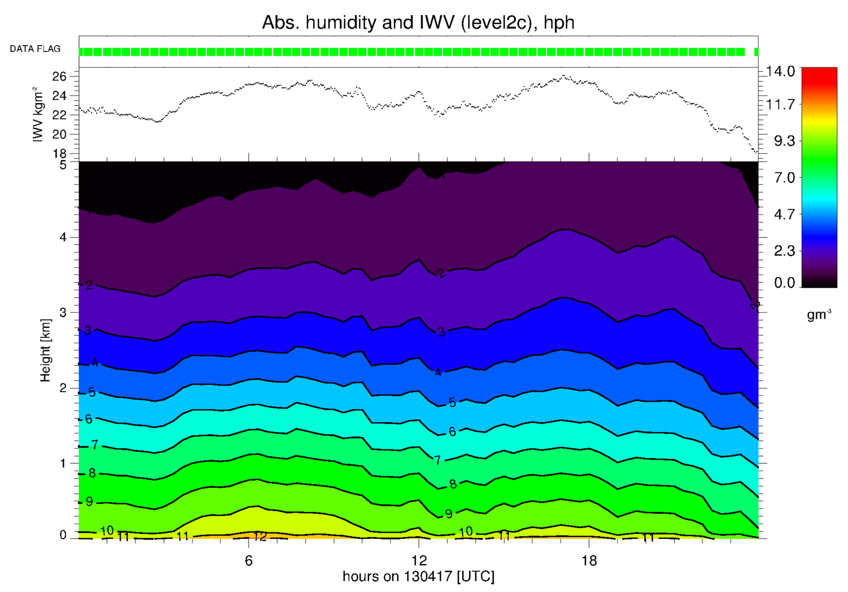


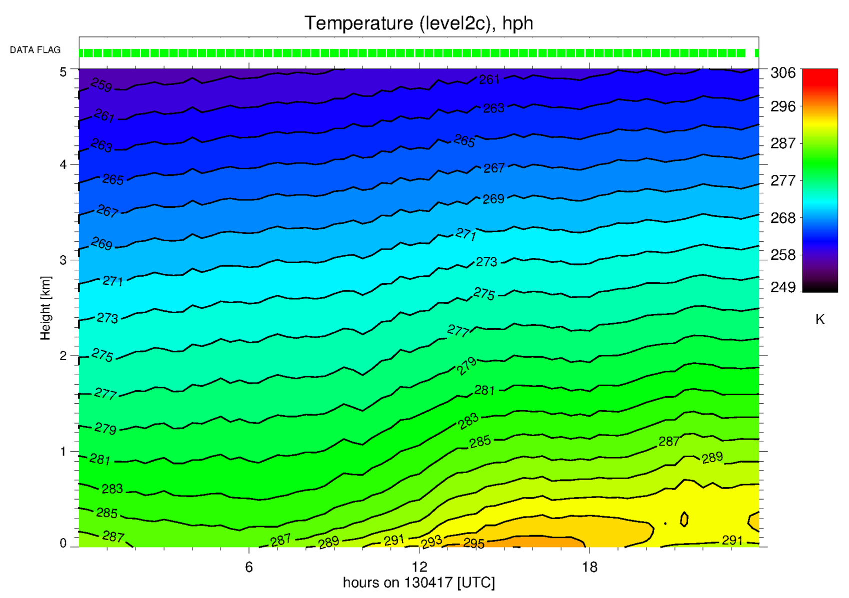
Cloudnet target categorization at JOYCE on 17 April, 2013 (www.cloud-net.org).

Raman Lidar (RL) and Microwave Radiometer (MWR)



Top: BASIL Raman Lidar measurements of water vapor mixing ratio for the 17th and 18th of April. Digital signal with 30 meters vertical resolution and 5 minutes integration time. Calibration performed with radio sounding data. Courtesy of Paolo Di Girolamo, University of Basilicata – Potenza, Italy.





Left: Microwave radiometer data (HATPRO) for the 17th of April: time series of absolute humidity (gm⁻³; top) and temperature (K; bottom) profiles from ground to 5 km height. Information is based on a statistical retrieval.

HATPRO	LIDAR
✔ calibration with internal references	✗ instability of the laser
	✗ no internal calibration
✔ continuous data acquisition	✗ opaque to clouds
✔ all weather conditions but rain	✗ can have daylight limitations
✗ limited vertical resolution	✔ very high vertical resolution

Thesis aim

- Retrieval of highly vertically resolved temperature, absolute humidity and relative humidity profiles by optimally combining MWR and Raman lidar measurements,
- Retrieval application and use for satellite validation (IASI),
- Atmospheric Process Studies of cloud formation (HOPE & Barbados).

RL and MWR joint retrieval

Optimal Estimation Scheme (OES)

$$x_{i+1} = x_i + \left(K_i^T S_e^{-1} K_i + S_a^{-1}\right)^{-1} \times \left[K_i^T S_e^{-1}\left(y - y_i\right) + S_a^{-1}\left(x_a - x_i\right)\right] ; K_i = \frac{\partial F(x_i)}{\partial x_i}$$

Atmospheric retrieved parameters: x
x=[T,q]Temperature and humidity profiles

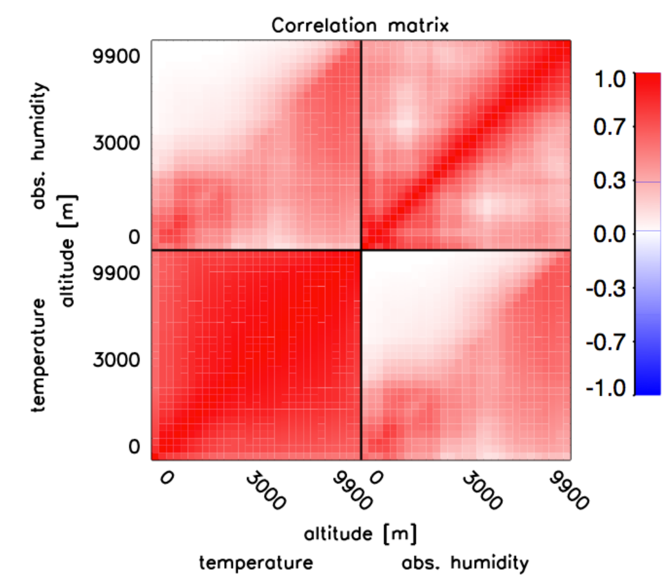
Measurements: y, S_e

From Lidar

- ✔ Water vapor mixing ratio
- ✗ Lidar temperature profiles
- ✗ Measurements error matrix

From MWR

- ✔ HATPRO TBs
- ✔ Error matrix
- ✔ Forward model: statistical approach



A priori co-variances matrix calculated from the radiosondes over the whole HOPE period

A priori information: x_a, S_a

- ✔ Co-variances matrix
- ✔ T_{prof_aver}, Q_{prof_aver} and their standard deviations

"Aerosol Remote Sensing, Processes & Applications" summer school, Sept. 23 - Oct. 4, 2013. Bucharest, Romania