Combining multiple scanning cloud radars for capturing the 3D structure of clouds

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1. HOPE

- In April and May 2013, the High Definition of Clouds and Precipitation for advancing Climate Prediction (HD(CP)²) Observational Prototype Experiment (HOPE) took place in Jülich, Germany.
- The mobile supersites of the Institute for Tropospheric Research of Leipzig (LACROS) and of the Karlsruhe Institute of Technology (KIT) were deployed within a radius of 4 km from the Jülich ObservatorY for Cloud Evolution (JOYCE).

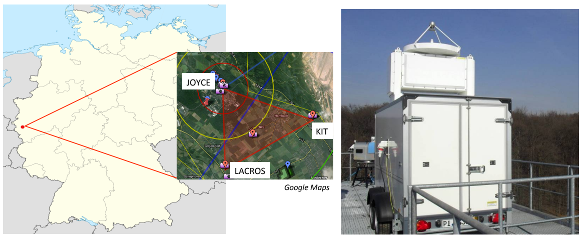

Fig. 1: Location of Jülich in Germany (left) and the MIRA36 cloud radar at JOYCE (right).

- Each of these supersites was equipped with a 35.5 GHz Doppler cloud radar with scanning capabilities, a scanning microwave radiometer and further remote sensing and in-situ sensors.

2. Scanning strategy

- The KIT radar alternately performed zenith measurements and Range Height Indicator (RHI) scans from 45° to 135° elevation angle. The azimuth angle was adjusted every hour using wind lidar data in order to scan along the cross-wind direction.
- The JOYCE cloud radar was run continuously in a hemispheric scan mode (Tab. 1), consisting of six RHI scans from 10° to 170° elevation along six different equidistant azimuth directions.
- Whenever possible, the LACROS cloud radar was run in the hemisperic scan mode using azimuth angles lying exactly in between the JOYCE scanning directions to improve the azimuth resolution (15°).

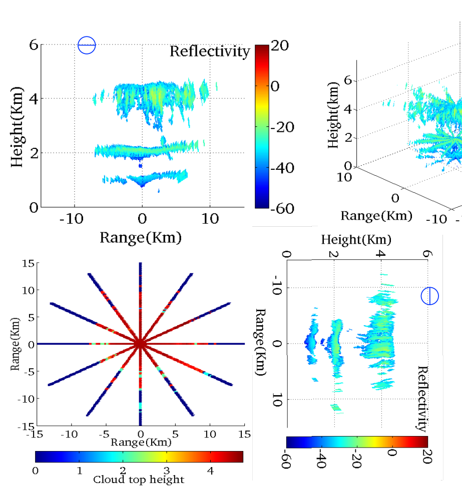

Fig. 2: Composite of a JOYCE hemispheric scan cycle performed from 3:00 to 3:06 UTC on April 14th, 2013 (right top); estimated cloud top height (left bottom) and two cross-sectional single RHI scans are shown with relative orientations indicated by the blue circles.

- Furthermore, the scanning microwave radiometer of JOYCE was synchronized with the JOYCE cloud radar to perform hemispheric scans during cloudy days, giving additional information on the liquid water path of the observed clouds.

3. Spatial inhomogeneity

- 3D information on the cloud structure allows the investigation of spatial inhomogeneities which is not feasible with zenith profiling only.
- In Fig. 3, a case of a highly spatially inhomegeneous cloud structure is presented: the radar reflectivity histogram derived from zenith profiles only does not represent the histogram derived from all angles over the 6 min time period.

Parameter	Value
PRF	5 kHz
Pulse length	200 ns
Range resolution	30 m
Range	15 km
Integration time	0.15 s
Scan speed	4.86 °/s
Sensitivity at 5 km	-45 dBZ

***Tab. 1**: Cloud radar specifications for the hemispheric scan mode.*

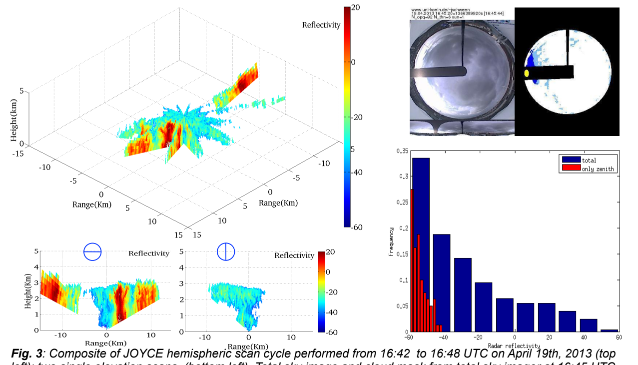

Fig. 3: Composite of JOYCE hemispheric scan cycle performed from 16:42 to 16:48 UTC on April 19th, 2013 (top left); two single elevation scans (bottom left). Total sky image and cloud mask from total sky imager at 16:45 UTC (top right). PDFs of radar reflectivity for zenith profiles only and for all angles during the 6-minute period (bottom right).

- From combined LACROS-JOYCE scans, further information on the spatial homogeneity of the clouds will be retrieved. In Fig. 4, a case of a homogeneous stratocumulus cloud is shown: the histograms of the radar reflectivitiy for the two systems strongly overlap.

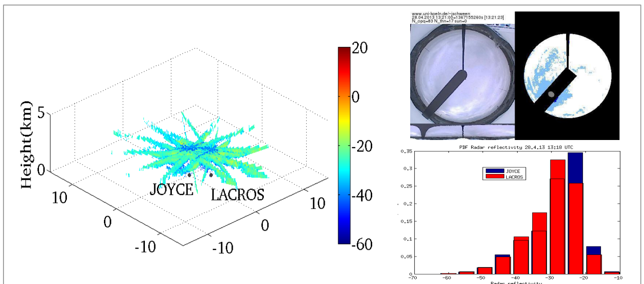

Fig. 4: Composite of combined hemispheric scan cycle performed from 13:18 to 13:24 UTC on April 28th, 2013: equivalent radar reflectivity for the two radars (left) and their PDFs (bottom right). Total sky image and cloud mask from total sky imager at 13:21 UTC (top right).

4. Conclusions and future work

- Inter-calibration among the three cloud radars will be achieved using zenith profiles during long-term homogeneous conditions.
- Combined radar elevation scans will be used to reconstruct the 3D structure of clouds and to investigate the macrophysical features such as cloud fraction, overlap and inhomogeneity.
- Further constraints on liquid water path will be provided by the synchronized JOYCE microwave radiometer measurements.
- Together with Large Eddy Simulations, the observations will provide a test bed for combined scanning strategies for future long-term observations.

HD(CP)² High definition clouds and precipitation for advancing climate prediction · JOYCE · TROPOS Leibniz Institute for Tropospheric Research · ITaRS Initial Training for atmospheric Remote Sensing

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