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Synergetic observations of spatial and temporal cloud characteristics at the Jülich ObservatorY for Cloud Evolution (JOYCE)

The atmospheric observatory JOYCE is a specifically equipped site for investigating the processes leading to cloud formation and cloud evolution. An array of various instruments has been set up at the Research Centre Jülich to continuously monitor water vapour, clouds, and precipitation over many years. JOYCE is operated jointly by the University of Cologne, the Research Centre Jülich and the Transregional Collaborative Research Centre *Patterns in Soil-Vegetation-Atmosphere-Systems: Monitoring, Modelling and Data Assimilation*. The core instruments of JOYCE are a scanning cloud radar, a micro rain radar, a ceilometer, a pulsed Doppler lidar, a scanning 14-channel microwave radiometer (MWR) with an attached 2-channel infrared thermometer (IRT), an infrared spectrometer (AERI), a Doppler lidar, a total sky imager and radiation sensors. These measurements are supplemented by the standard meteorological measurements from the 120 m measurement tower. In addition, the polarimetric weather radar of the Research Centre Jülich provides information on the spatial distribution of precipitation. Thus, the JOYCE instrumentation is ideally suited for the analysis of water vapour variations, the development of boundary layer clouds, cloud radiation interaction, and precipitation formation.

These collocated measurements of multiple wavelength active and passive remote sensing instruments allow for the combination of the different sensors in an optimal way in order to derive the best estimate of the thermodynamic state such as temperature and water vapour profile, but also cloud properties and their associated uncertainties. Furthermore, analysing synchronous hemispheric scans of the cloud radar, the MWR and the attached IRT provides a 3D picture of water vapour and boundary layer clouds. Typical cases studies concerning the spatial and temporal development of boundary layer clouds are analysed and retrieval methodologies are discussed. These scanning measurements provide a high potential for meso-scale model evaluation, especially concerning processes such as cloud formation, cloud entrainment and auto-conversion.