Ground-based atmospheric remote sensing at the Jülich Observatory for Cloud Evolution – JOYCE-CF

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DFG Deutsche Forschungsgemeinschaft

What is JOYCE-CF?

- JOYCE-CF is an advanced setup of ground-based remote sensing observations with the focus on clouds and precipitation processes and boundary layer observations
- Cooperation of the Universities of **Bonn** and **Cologne** and the **Research Center Jülich**

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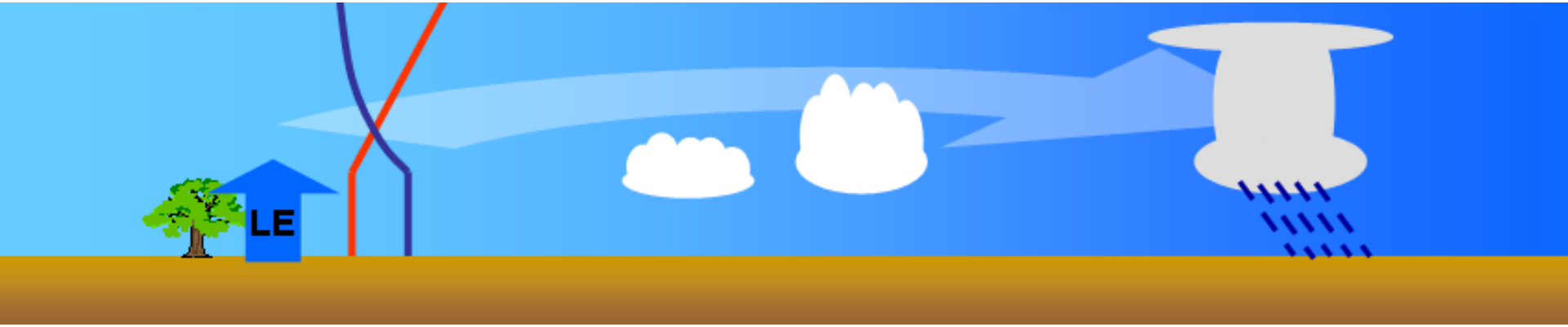
Why JOYCE-CF?

Lack of understanding: from water vapor → aerosol → clouds → precipitation under different atmospheric & surface conditions



Equally important for

→ climate research

→ forecasting applications

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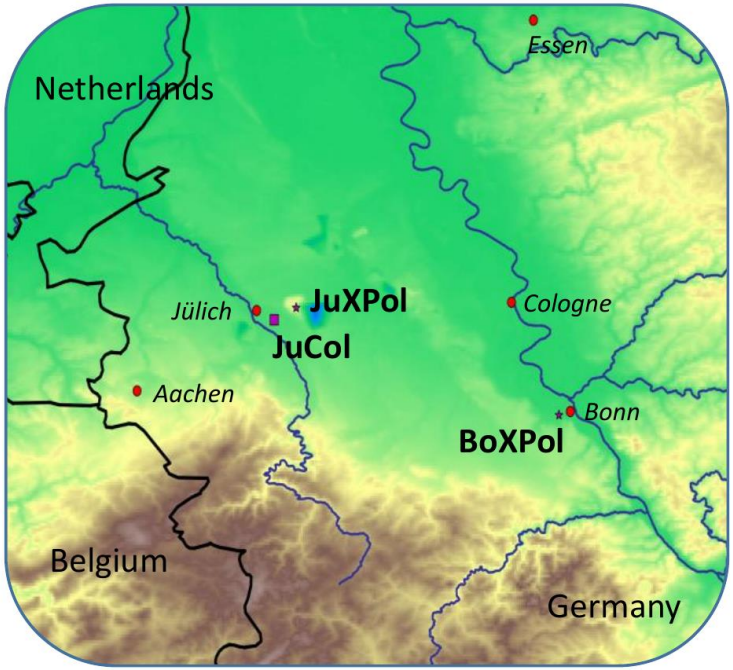
JOYCE-CF includes 3 Sites..

BoXPol: polarimetric X-band radar in Bonn

JuXPol: polarimetric X-band radar Sophienhöhe (close to Jülich)

JuCol: extended column observations at Jülich



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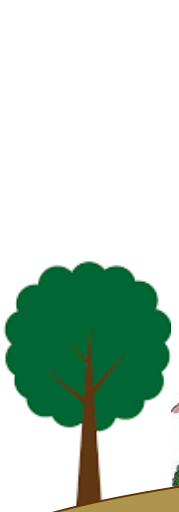
Instrumentation

Hemispheric
Cloud Camera

2 Ceilometer

120 m Mast

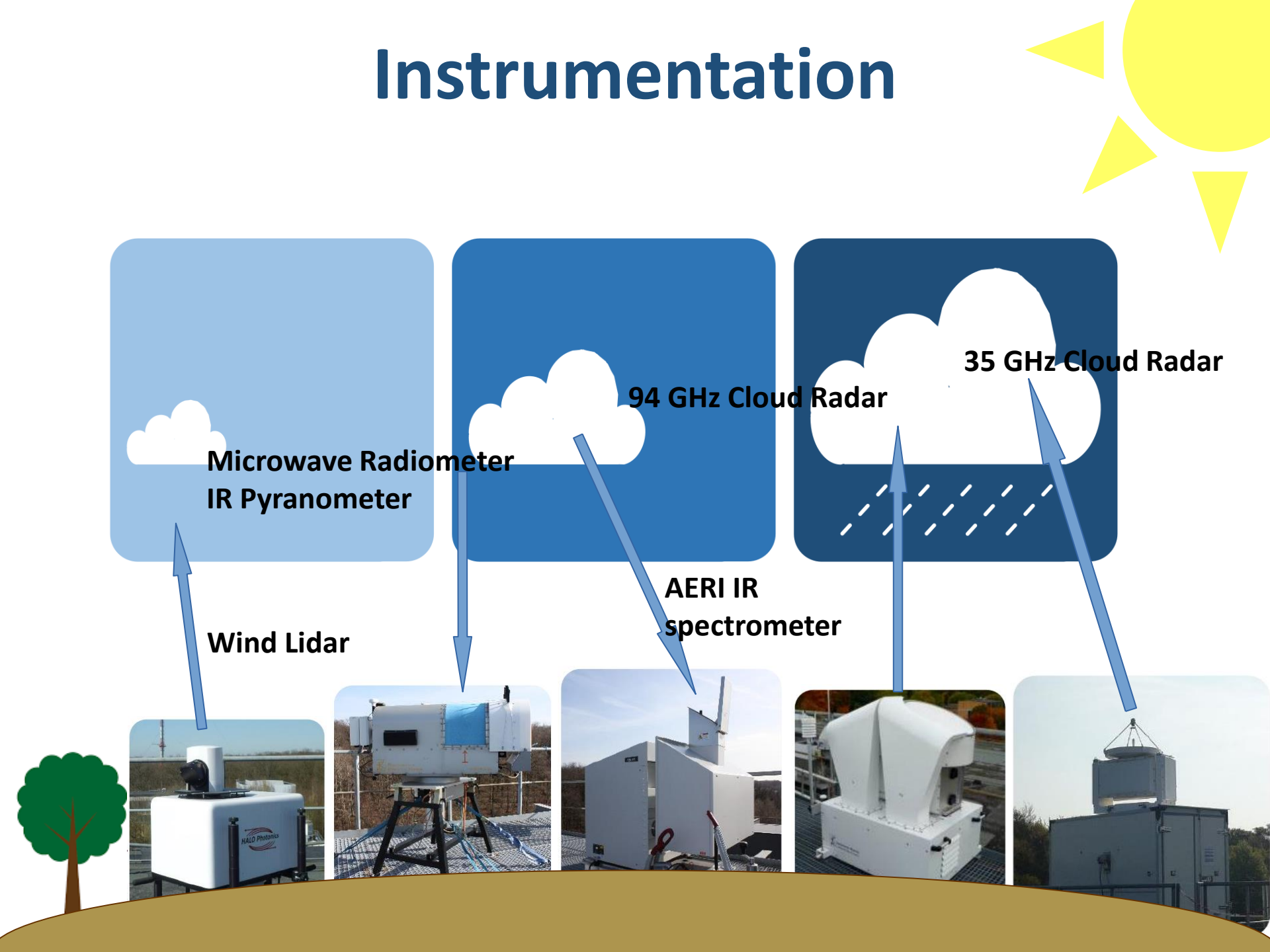
Radiation Sensors



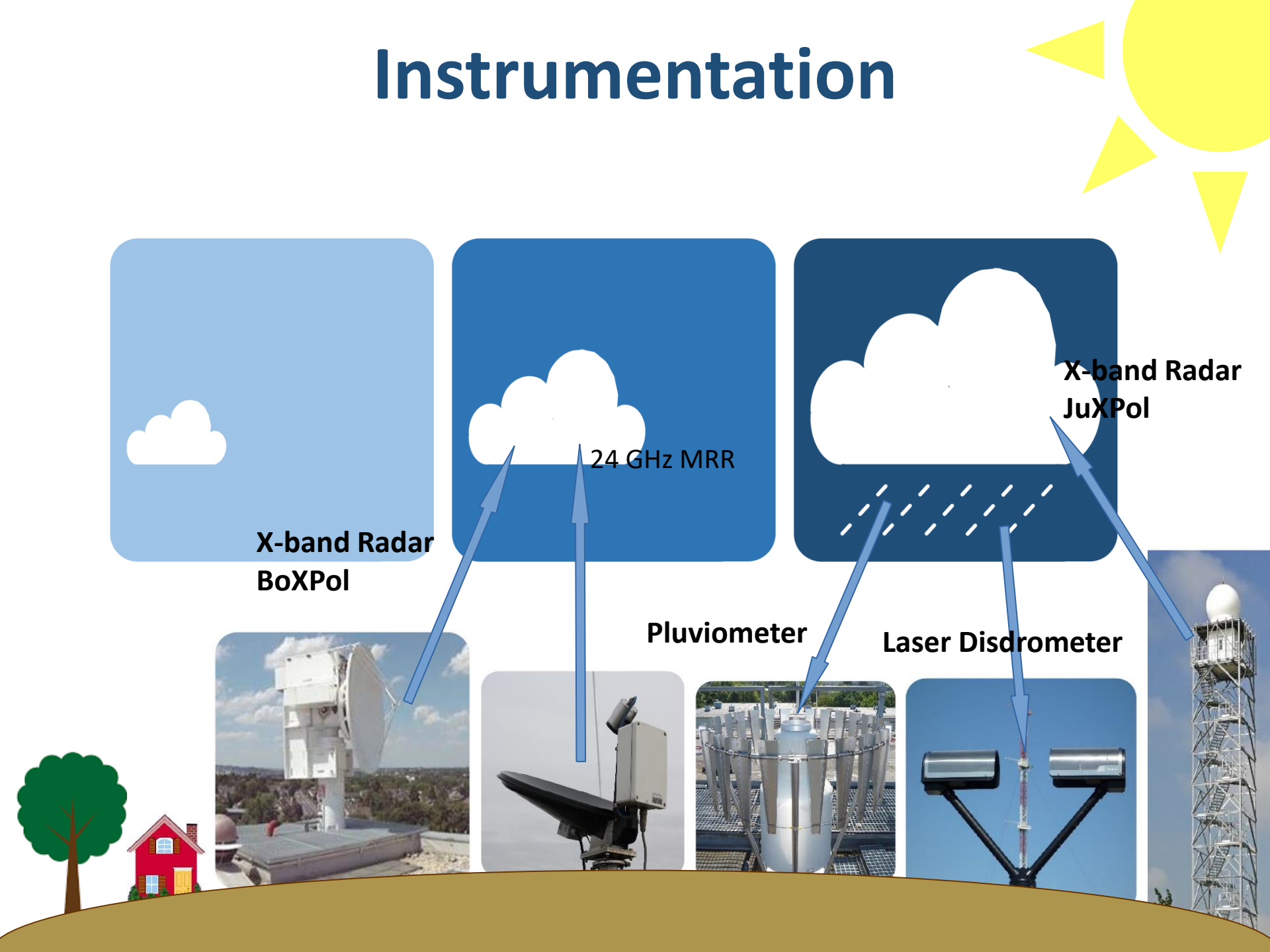




Instrumentation



Instrumentation



Core Instruments – Doppler cloud radar MIRA

Science issues

- Morphology of clouds (phase, location, thickness, overlap,…)
- Cloud microphysical properties (water content, particle size,...)

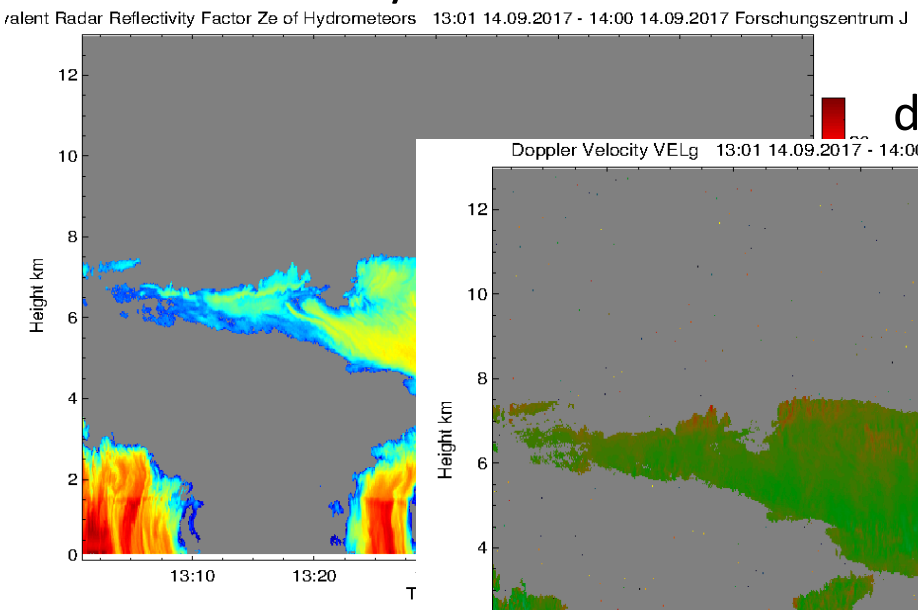
Specifications:

- frequency of 35.5 GHz (8 mm) → sensitive towards cloud droplets
- height range 150-15000 m, range resolution 30 m, temporal resolution 1-10 s
- Doppler radar with polarimetric capabilities
- scanning capability: combined azimuth and elevation scans
  → information on 3-dimensional cloud structure

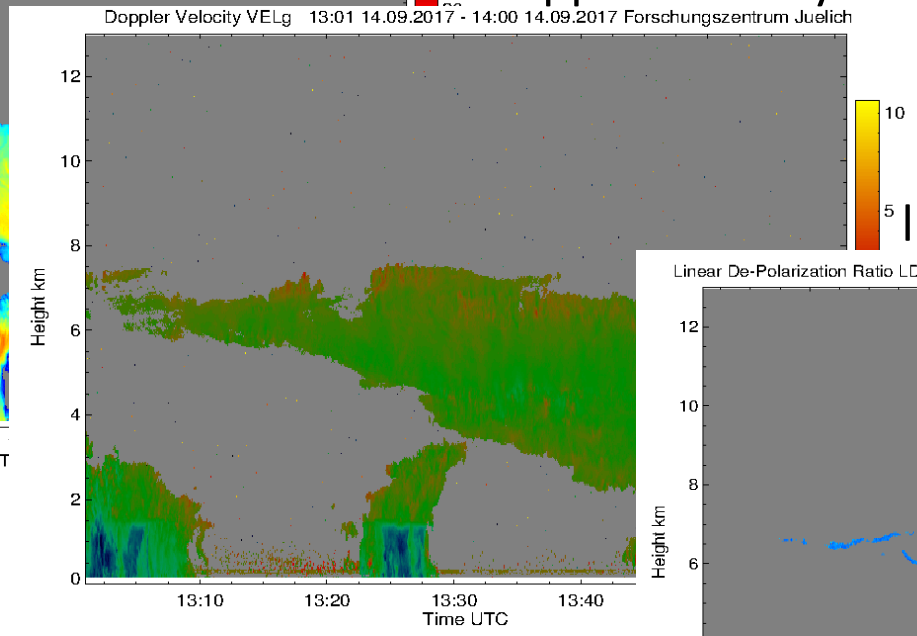
Core Instruments – Doppler cloud radar MIRA

radar reflectivity factor

14. 9. 2017 Jülich

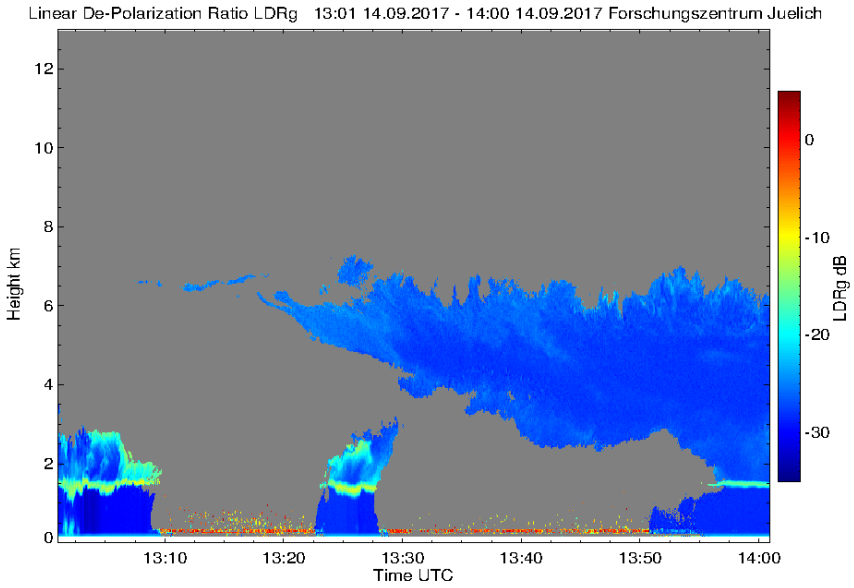


doppler velocity



35 GHz
cloud radar
MIRA

linear depolarization ratio



backscatter proportional $\mathbf{r^6}$
(disadvantage for mass determination)

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Instruments – Multi frequency radars

OPTIMIce
Emmy Noether group
Stefan Kneifel

Triple-frequency Doppler Spectra	Polarimetry and spatial structure	Radiosonde Super-cooled liquid water	Auxilliary sensors

SYNOBS

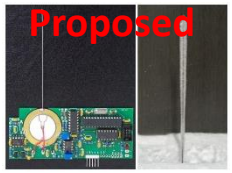
- Unique setup in Germany (soon 3 vertically pointing radars)
- Cloud and precipitation processes
- Ice microphysics

„Jülich Column“

Scanning

BoXPOL Bonn

JuXPOL Sophienhöhe



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Core instruments – Microwave radiometer

Science issues

- thermodynamic state in the clear AND cloudy atmosphere (water vapor, temperature, cloud condensate)
- observe the diurnal cycle

→ Integrated Water Vapor (IWV): 0.6 kg/m^2

→ Liquid Water Path (LWP): 20 g/m^2

→ Humidity profiles: 0.4-0.8 g/m^3 (2 degrees of freedom)

→ Temperature profiles 0.5-1.0 K (4 degrees of freedom, especially boundary layer)

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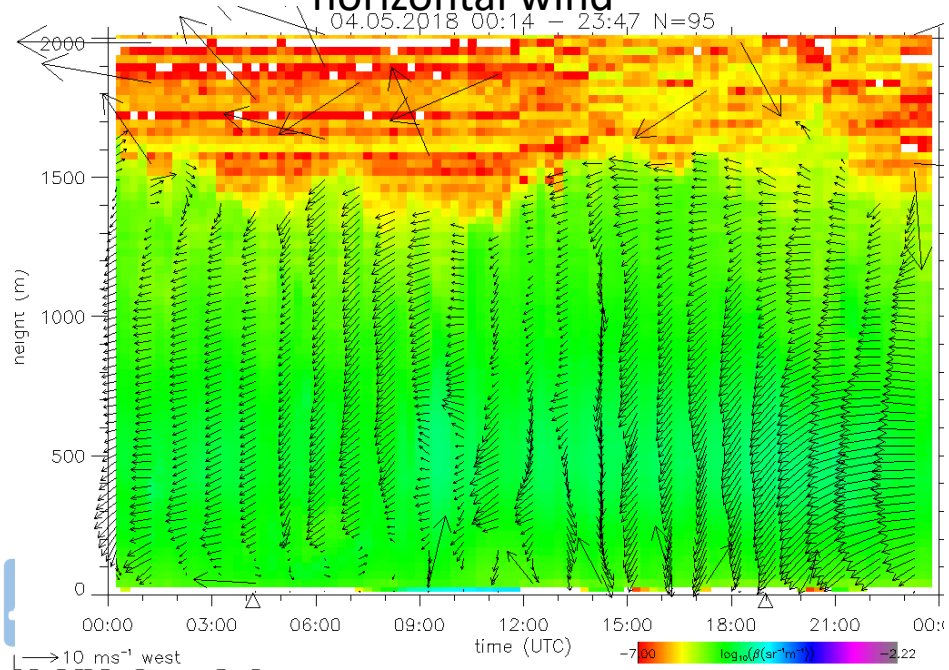
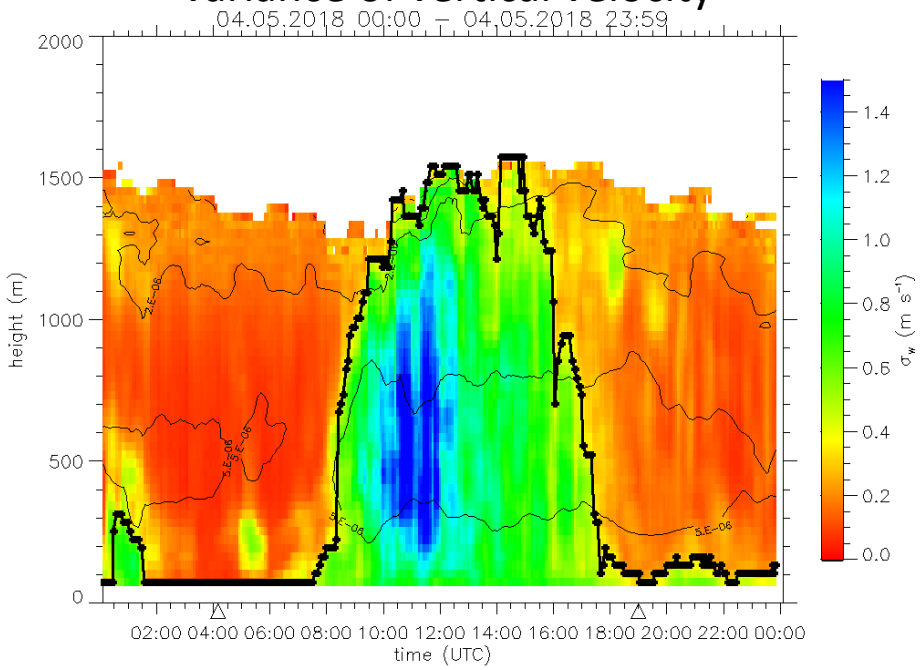
Core instruments – Doppler lidar

- Delivers profiles of backscatter coefficient
- Measures Doppler effect on small particles (e.g. aerosols)
  - → along-sight Doppler velocity
  - → scanning configurations allows to derive wind vector as a function of height

horizontal wind

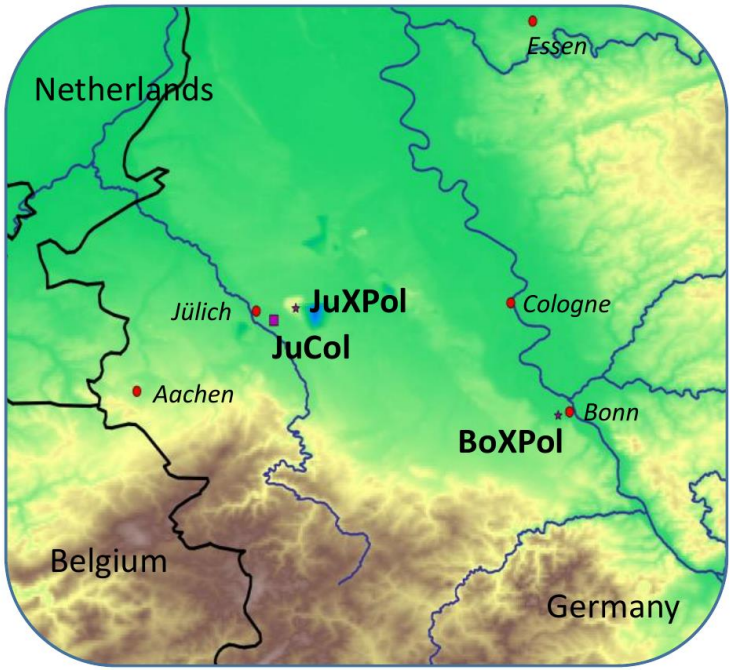


variance of vertical velocity



Core Instruments – BoXPol and JuXPol

	BoXPol	JuXPol
Location (Lat./Lon.)	50.73052° / 7.071663°	50.92750° / 6.45626°
Height (m)	99	310
Frequency (GHz)	~ 9.3	~ 9.3
Type	EEC (DWSR-2001-X-SDP	EEC (DWSR-2001-X-SDP
Elevation	0° - 90°	0° - 90°
3-dB beamwidth	~ 1.05°	~ 1.1°
Signal Processor	Enigma3 Enigma4	Enigma3 Enigma4
Max range (km)	150	150
Special	Without radom	With radom



- 48 km distance between BoXPol and JuXPol
- JuXPol on artificial hill (open-pit-mining, industry)
- BoXPol in urban area (partial and full beam-blockage)

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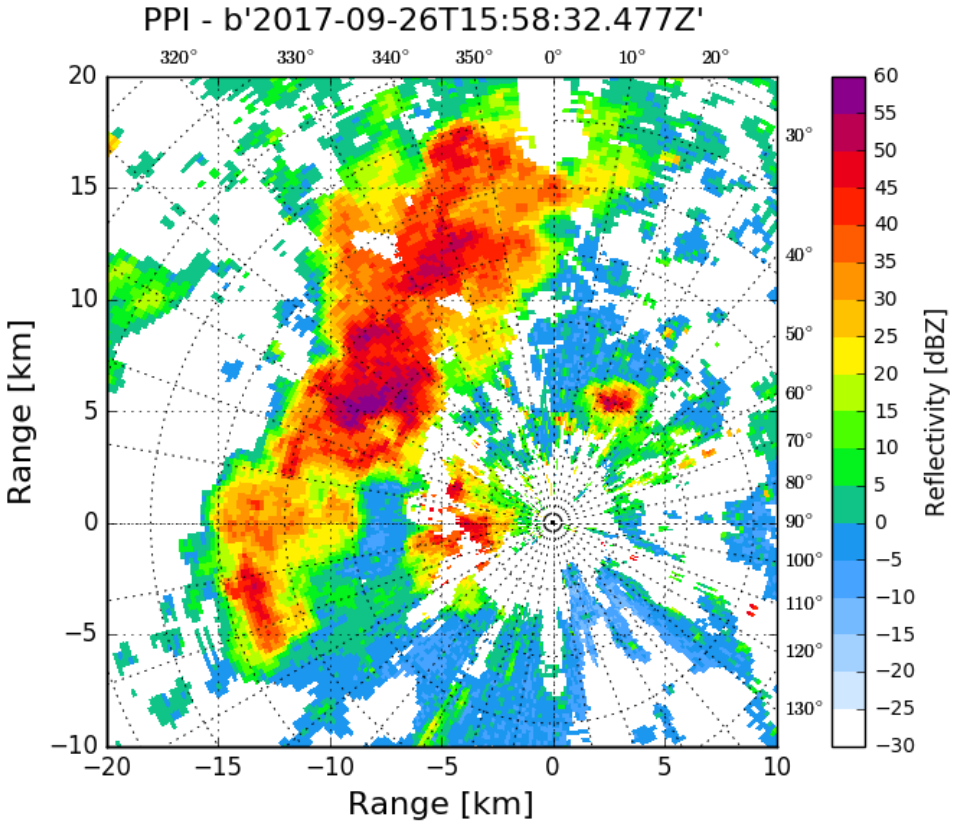
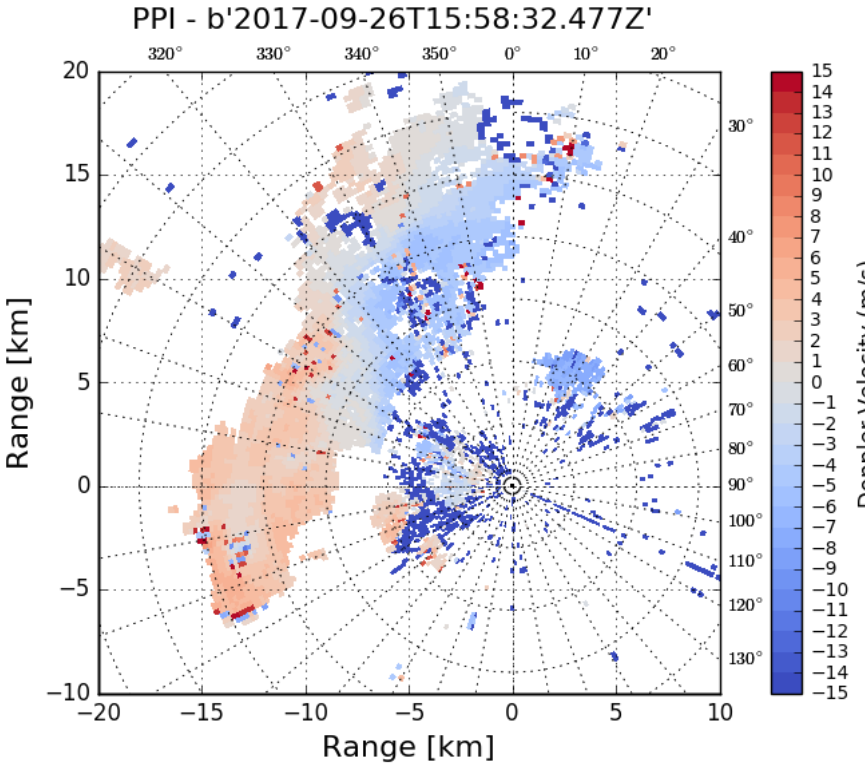
Reflectivity and Doppler velocity





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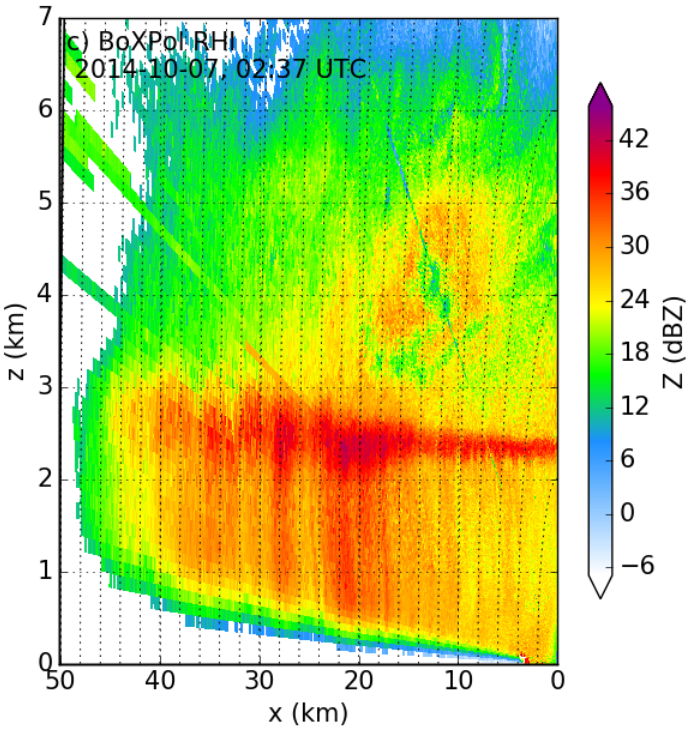
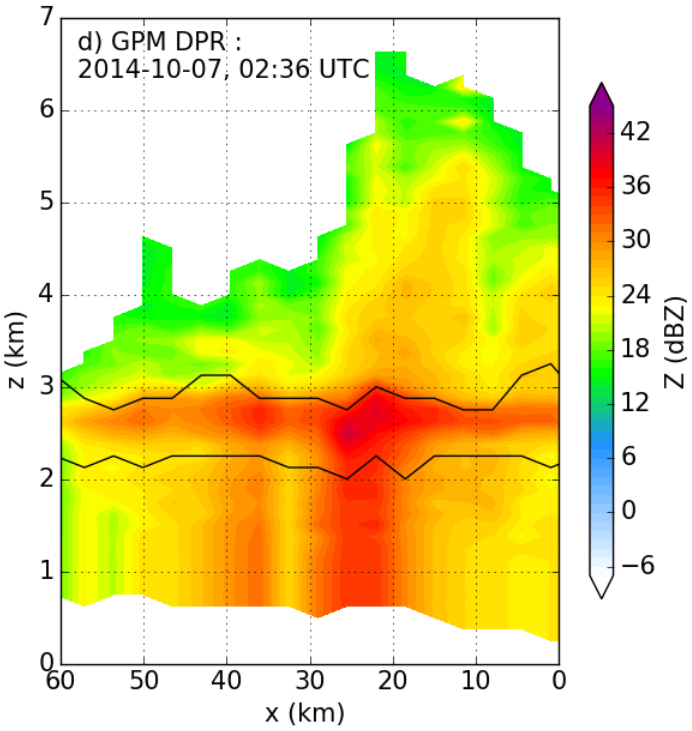
State of the art studies

- Polarimetric synergy (Trömel et al. (2017))
- 3D Komposit
- River catchments
- GPM satellite validation





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BoXPol and JuXPol

- Testbase for theories and impacts on shorter wavelengths
- Continous scans but ‘free’ access and handling make it optimal for research including radar combinations
- More free than operational DWD radars with one research radar
- Home made additional instruments allow synergies

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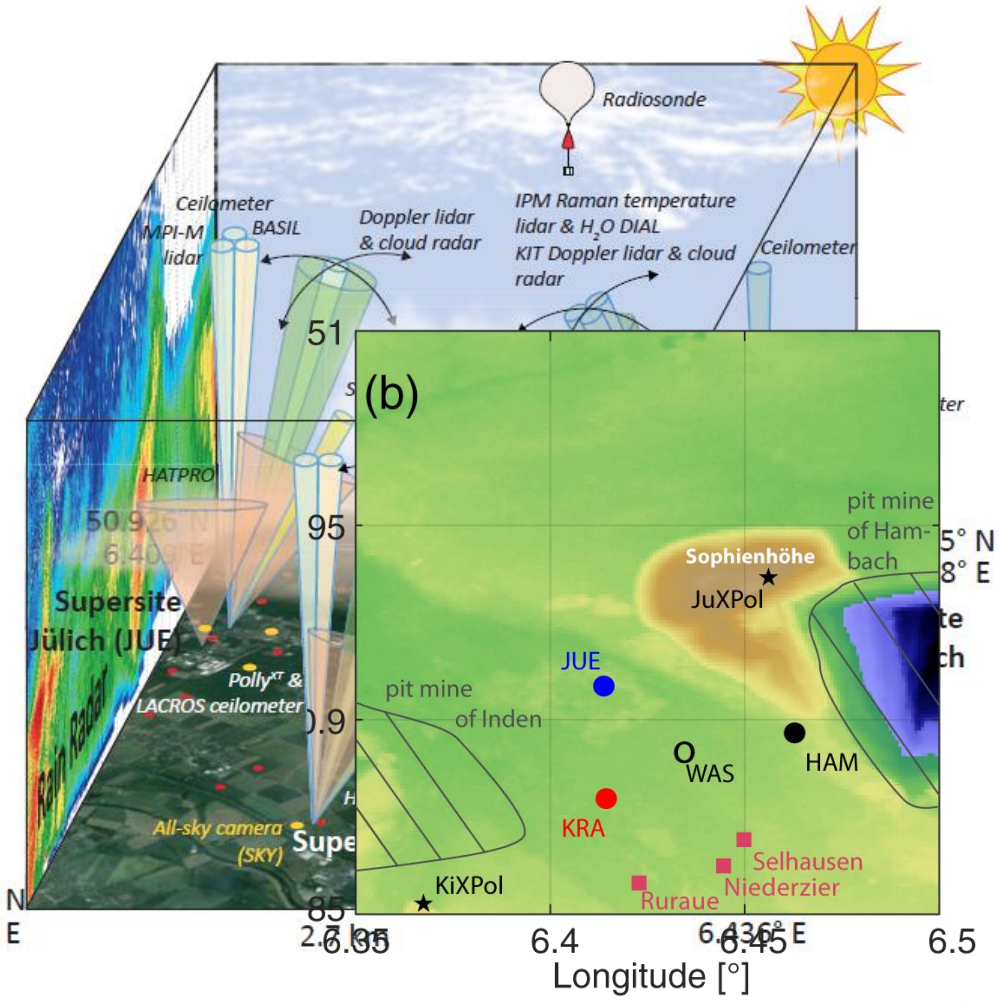
Projects and Campaigns at JOYCE-CF

- **HOPE – HD(CP)² Observation Prototype Experiment** *(Macke et al., 2017)* – 2 months intensive observations
- Observation of small-scale variability in the area around Jülich for model evaluation
- Deployment of instruments from other institutions (in total 3 supersites including TROPOS, KIT)
- Variability of solar radiation with pyranometer network
- Frequent radiosoundings



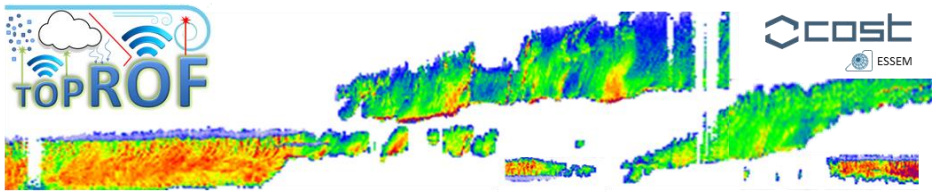
Projects at JOYCE-CF

- HD(CP)² Phase 2 – Supersite coordination
- TR32 (Soil-Atmosphere-Vegetation interaction)
- ET-CC (Energy Transition and Climate Change) -> cloud variability
- ACTRIS2 (Cloudnet), ACTRIS-PPP
- COST TOPROF
- Hans Ertel Zentrum (HErZ)

HD(CP)²
High definition clouds and precipitation for advancing climate prediction

ETCC
ENERGY TRANSITION& CLIMATE CHANGE

ACTRiS



Hans-Ertel-Zentrum
für Wetterforschung

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Instrument Synergy

- Steady increase of co-located instruments since 2008 for cloud and precipitation studies, especially focusing on boundary layer
- Instrument synergy vital for optimal observations
- Cloud studies also need information on
  - temperature
  - water vapor
  - 3D wind vector
  - turbulence
  - aerosols
  - radiation
- JOYCE-CF provides datasets for various applications over many years

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Examples for instrument synergy

- Integrated Profiling Technique (IPT) Ebell et al., 2017
- Cloudnet
  - cloud radar, microwave radiometer, ceilometer
- Boundary-layer studies
  - Doppler lidar, ceilometer, microwave radiometer (e.g. Saeed et al. 2016)
- Cloud/Ice microphysics
  - multi-frequency radar (e.g. Kneifel et al., 2016)
- Thermodynamic profiles
  - microwave radiometer, AERI infrared spectrometer, lidar (e.g. Barrera Verdejo et al., 2016, Turner and Löhnert, 2014)
- Water vapour distribution
  - GPS, microwave radiometer, sun photometer (e.g. Steinke et al, 2016)

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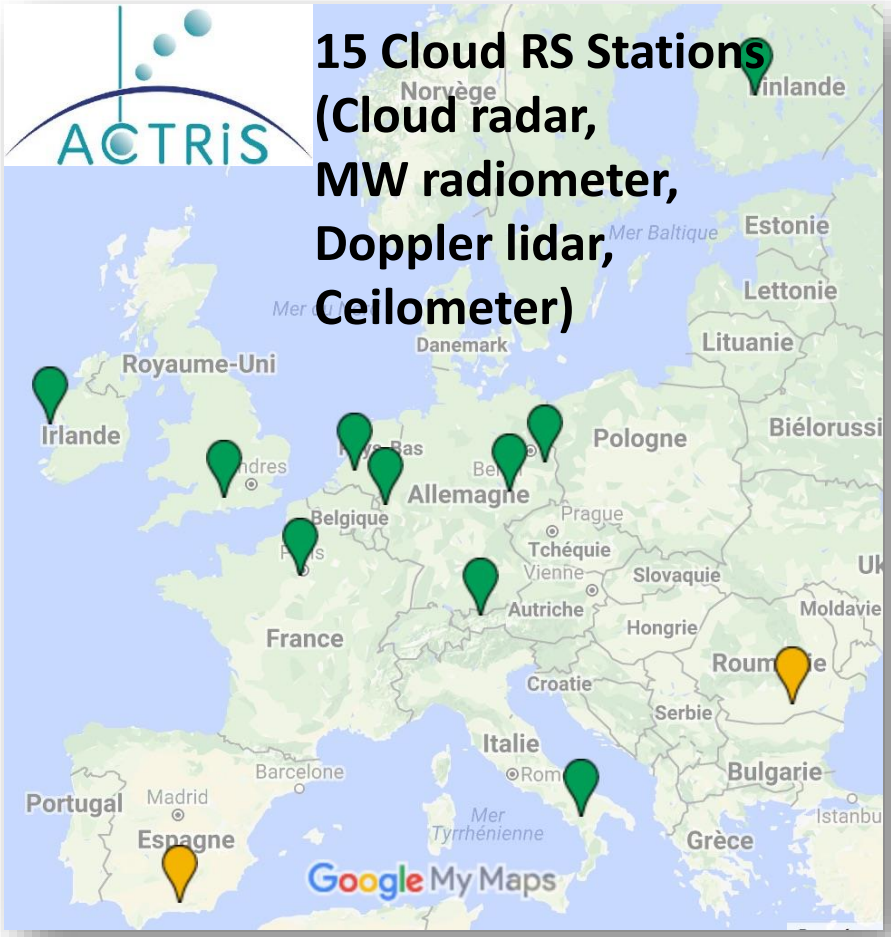
Networks (Cloudnet/ACTRIS)



- Network of operational MWR in Europe getting denser
- Within ACTRIS, every Cloudnet station needs to have a MWR
- For network activities, common calibration procedures and data quality important
- Calibration was not considered being the crucial issue until now > JOYCE-CF part of ACTRIS as topical center for MWR

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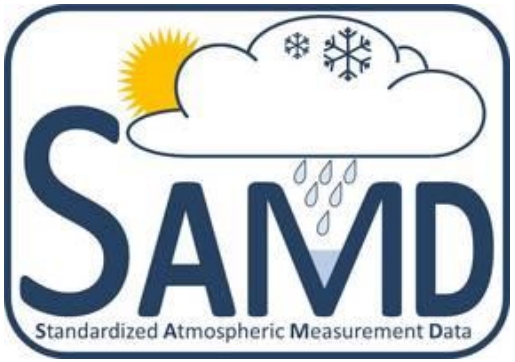
Access to data

- Data access is currently partly done via the SAMD portal (Standardized Atmospheric Measurement Data) https://icdc.cen.uni-hamburg.de/index.php?id=samd
- In future all standardized products will be available via this data base
- Website http://joyce.cloud will list all data products and their access options
- Raw data (e.g. Radar spectra) will be available on request, also linked from higher level products on SAMD



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Summary

- JOYCE-CF is a so-called “supersite” for ground-based atmospheric remote sensing
- Since 2007 continuous growth of JOYCE-CF
- Long-term observations of cloud and rain properties, special focus on boundary layer **(talk by Marke et al. yesterday)**
- Studies on surface-atmosphere interaction, cloud evolution
- Combination with atmospheric modelling **(see talks by Schemann, Acquistapace later today)**
- Participation in international networks, Access for external users

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HALO Photonics
CHM 15k