Investigation of the Initiation of Convection and the Evolution of Precipitation using Simulations and Polarimetric Radar Observations at C- and Ka-Band

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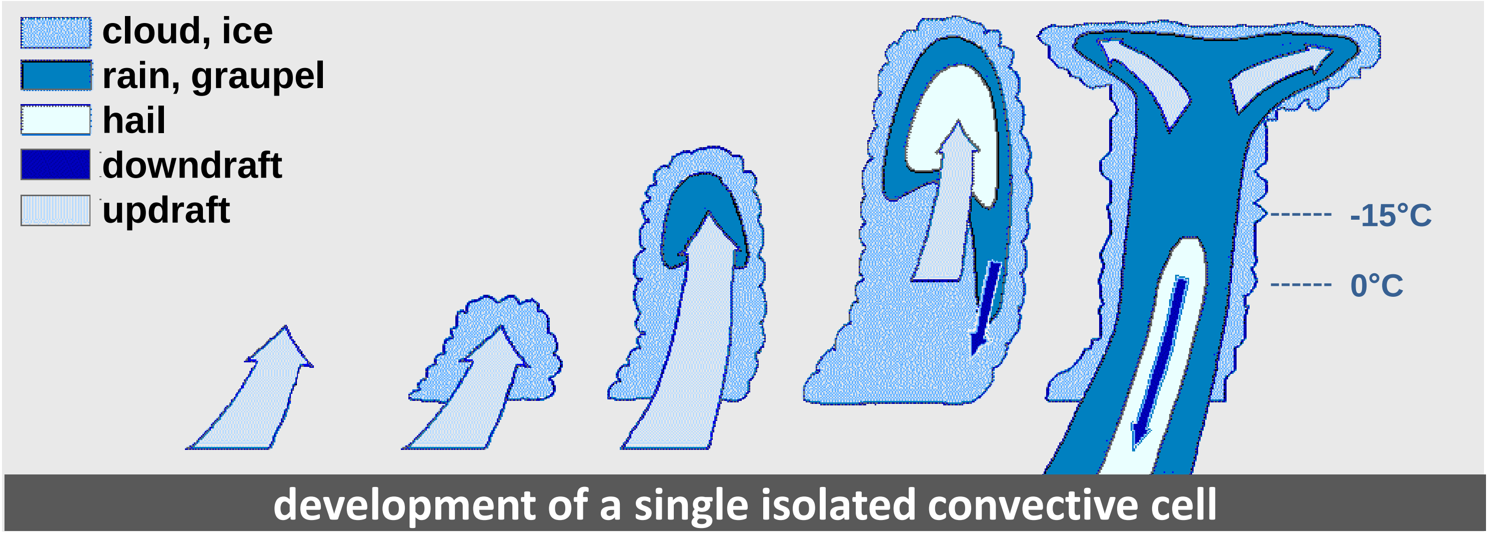
Understanding Precipitation Initiation in Mixed Phase Clouds

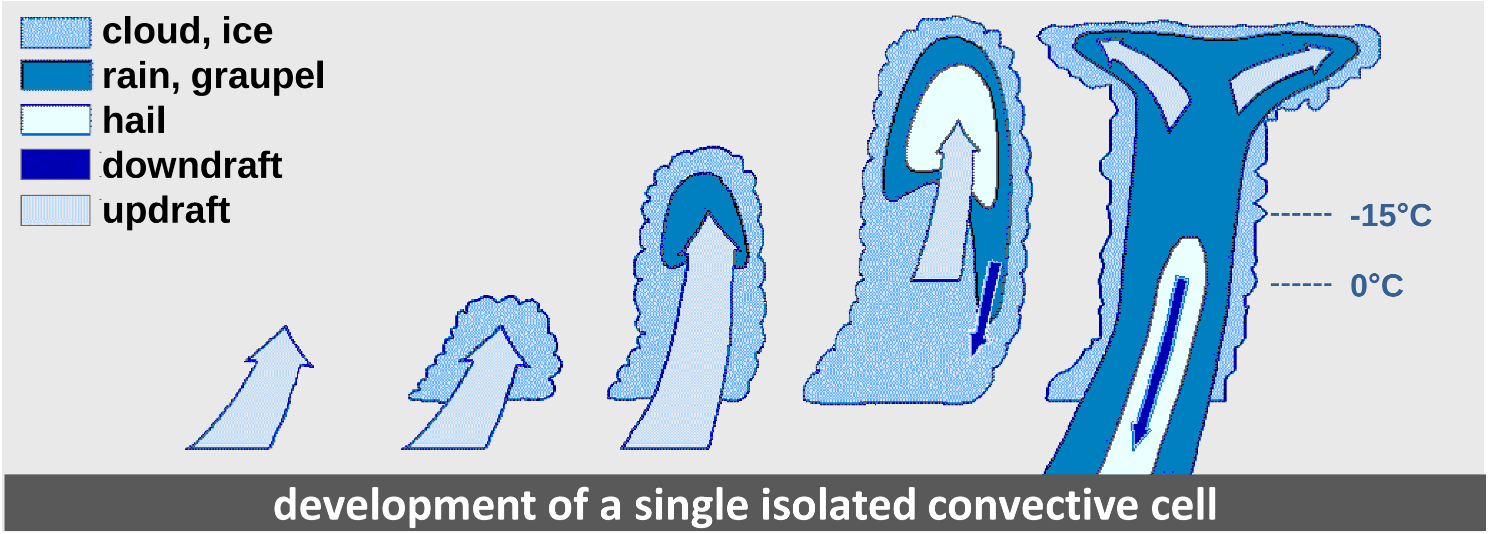


after Höller, 1994

Key Questions:

- when does precipitation initiation take place?
- when will ice be formed?
- how is precipitation initiation related to ice formation?

Understanding Precipitation Initiation in Mixed Phase Clouds



after Höller, 1994

Answer from Radar:

- dual-polarization hydrometeor classification
- reflectivity gives water / ice content
- ZDR, KDP, … tells about particle habit

Limitation:

- C-band radar is not sensitive enough for small cloud particles
- cloud radar (Ka- or W-band) is limited in range and suffers from attenuation
- both can derive only partly microphysical quantities or particle habits

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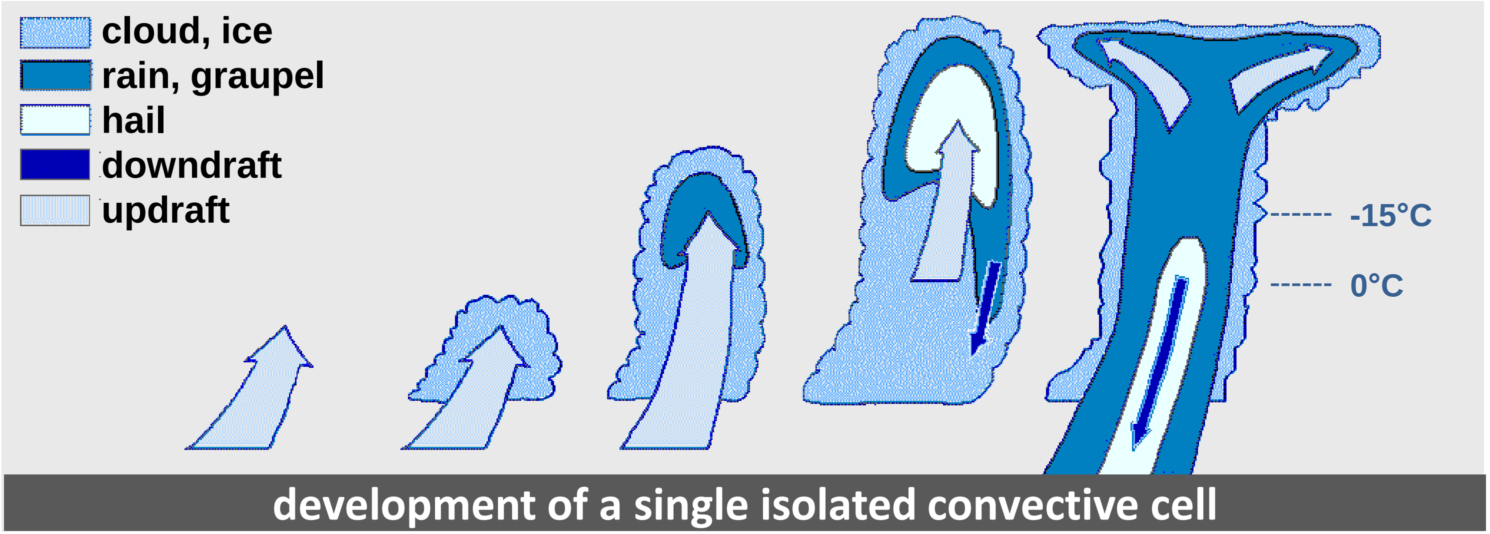

after Höller, 1994

Answer from Numerical Models:

- 3D particle phase and properties available
- 3D flow available
- particle trajectories (= history) available

Limitation:

- choice of microphysical scheme crucial (bulk > 1/2-moment > spectral bin)
- spatial resolution dependent (high resolution O(100m) required for convection)
- …

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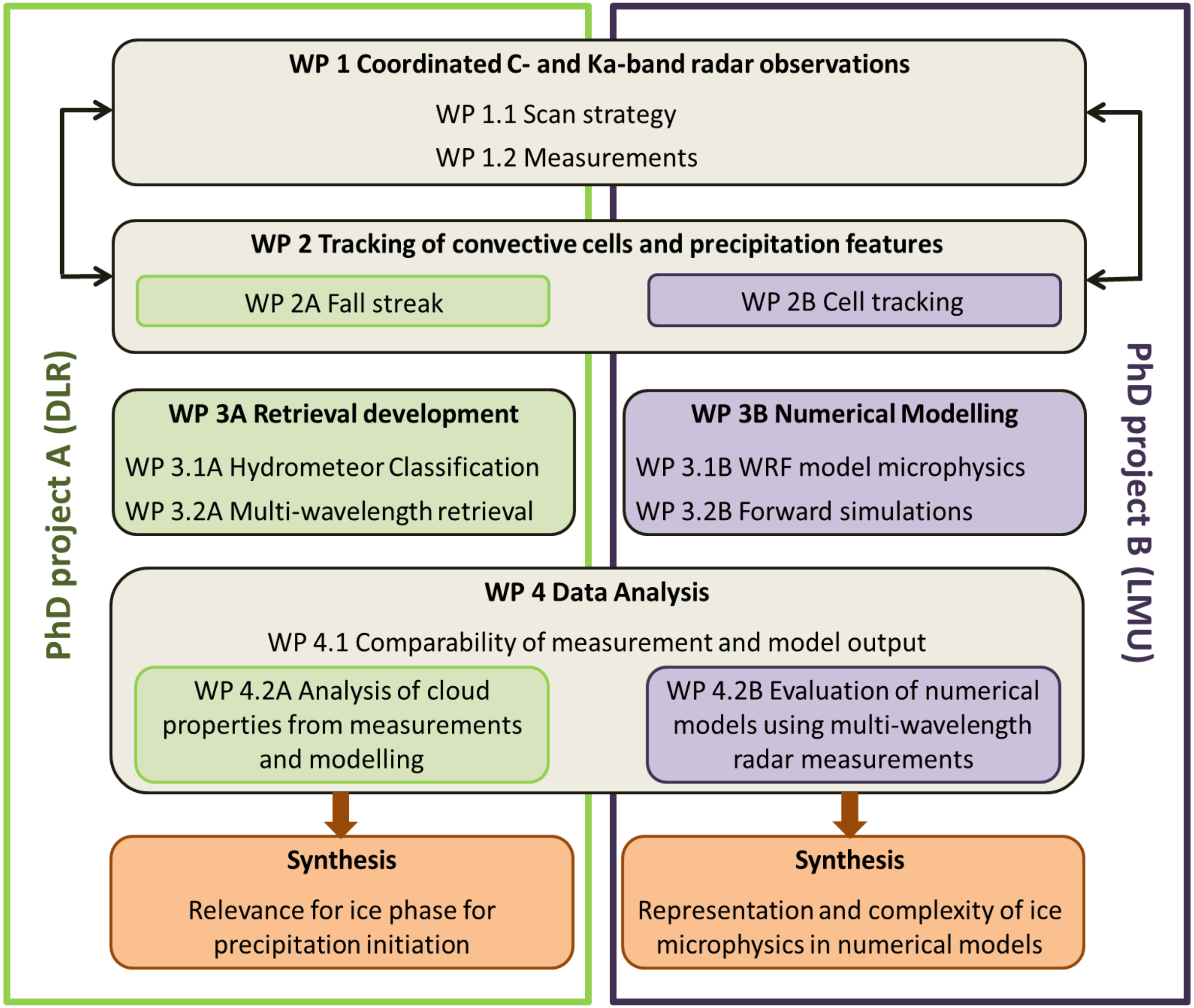
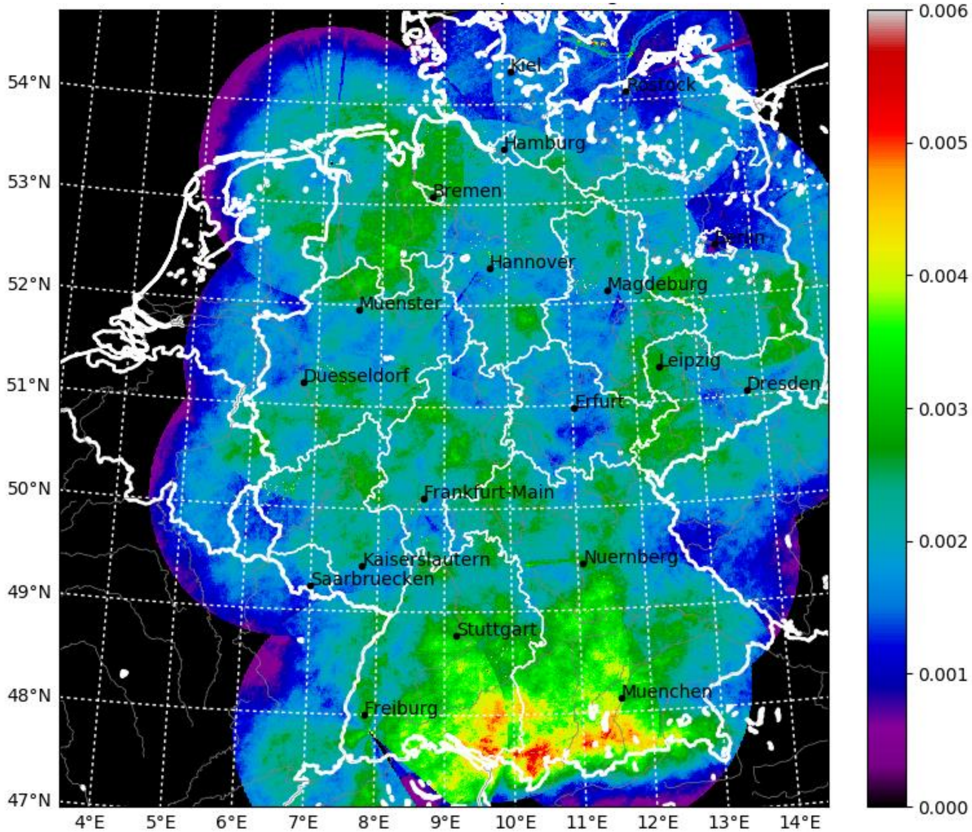
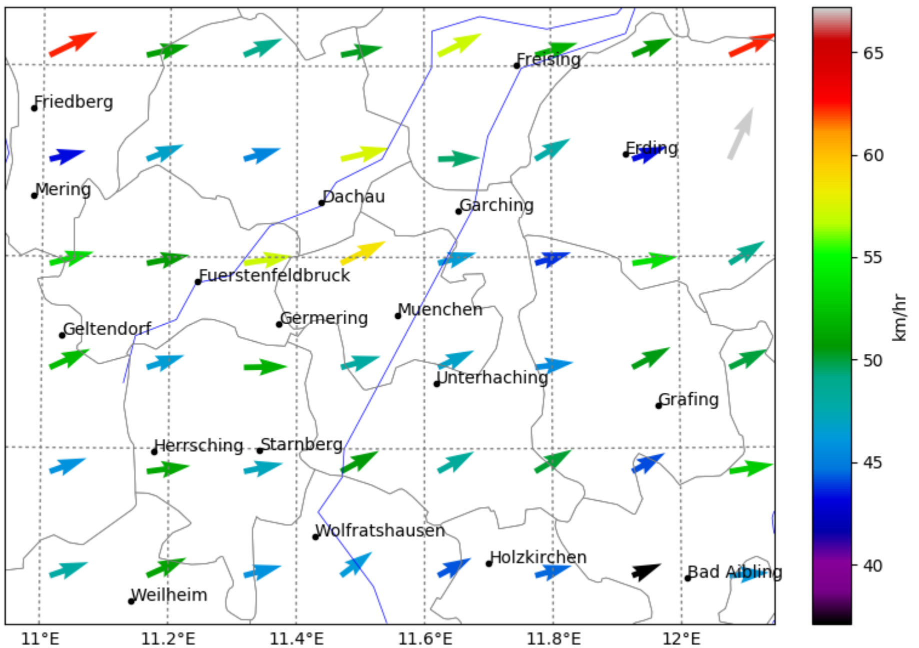
Work Package Structure



Convective Precipitation in Munich Region

- Munich best suited for studies of convective precipitation





frequency of radar reflectivity > 36 dBZ (fraction of time during AMJJA 2012-2016)

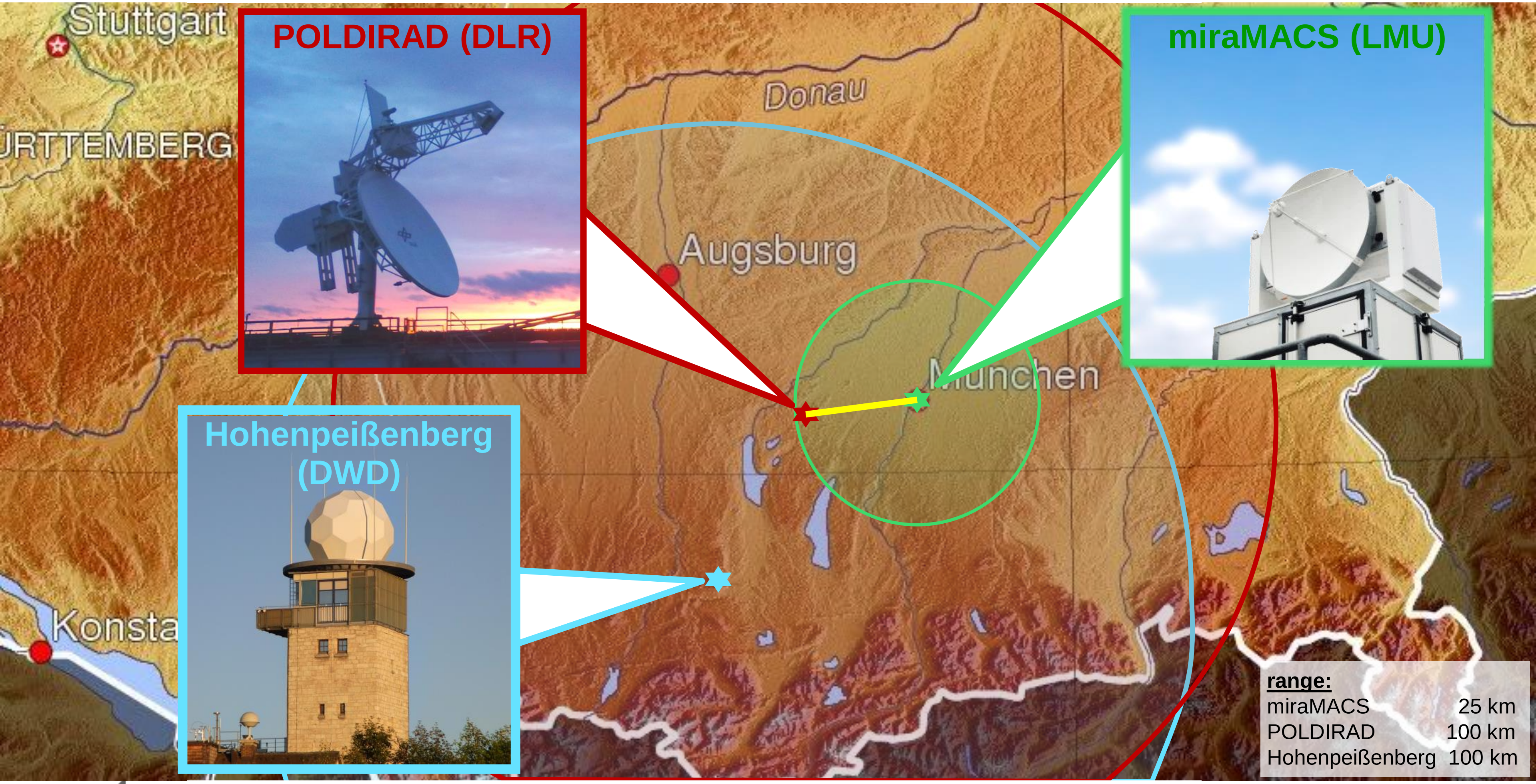
average moving direction for convective storm cells (for AMJJA 2012-2016)

BSc M. Laufmann, 2017

WP 1: Coordinated Radar Observations

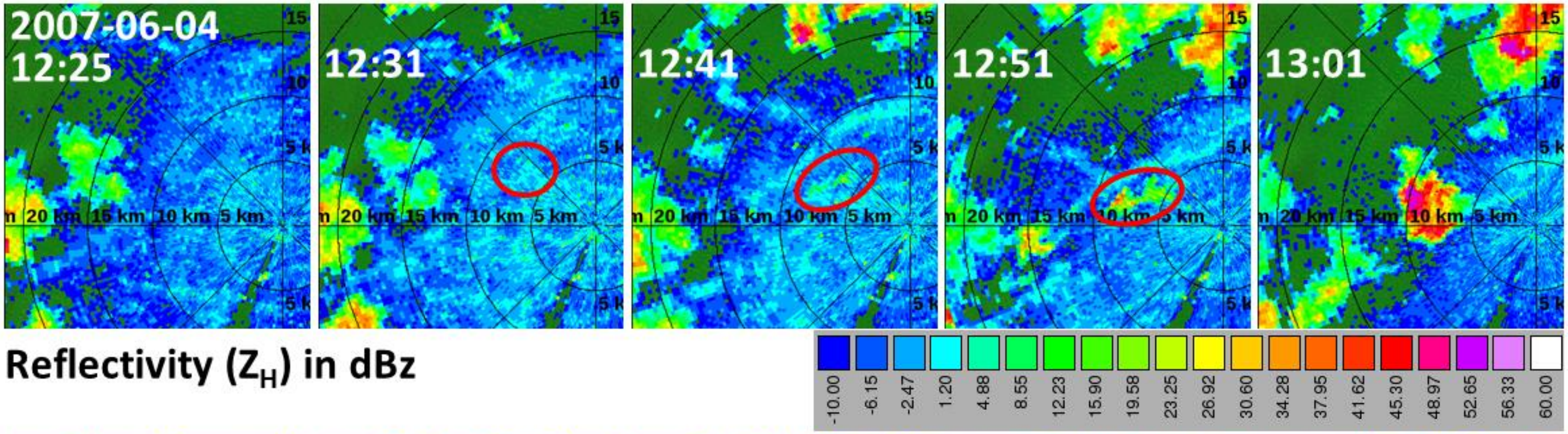
WP 1.1: Scan strategy

WP 1.2: Measurements

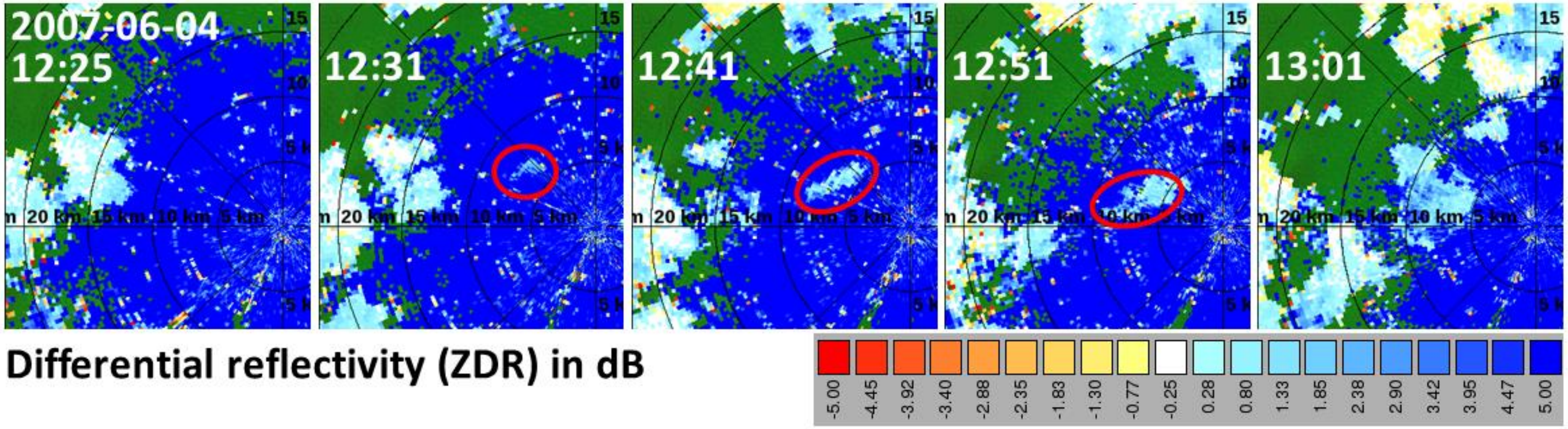


WP 3.1A: Hydrometeor Classification

- Fuzzy logic hydrometeor classification
- Initiation of convection
  → transition form clear-air echoes to cloud/precipitation

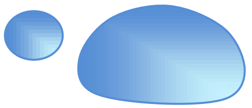


Reflectivity (Z_H) in dBz

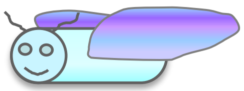


Differential reflectivity (ZDR) in dB

ZDR 0-5 dB



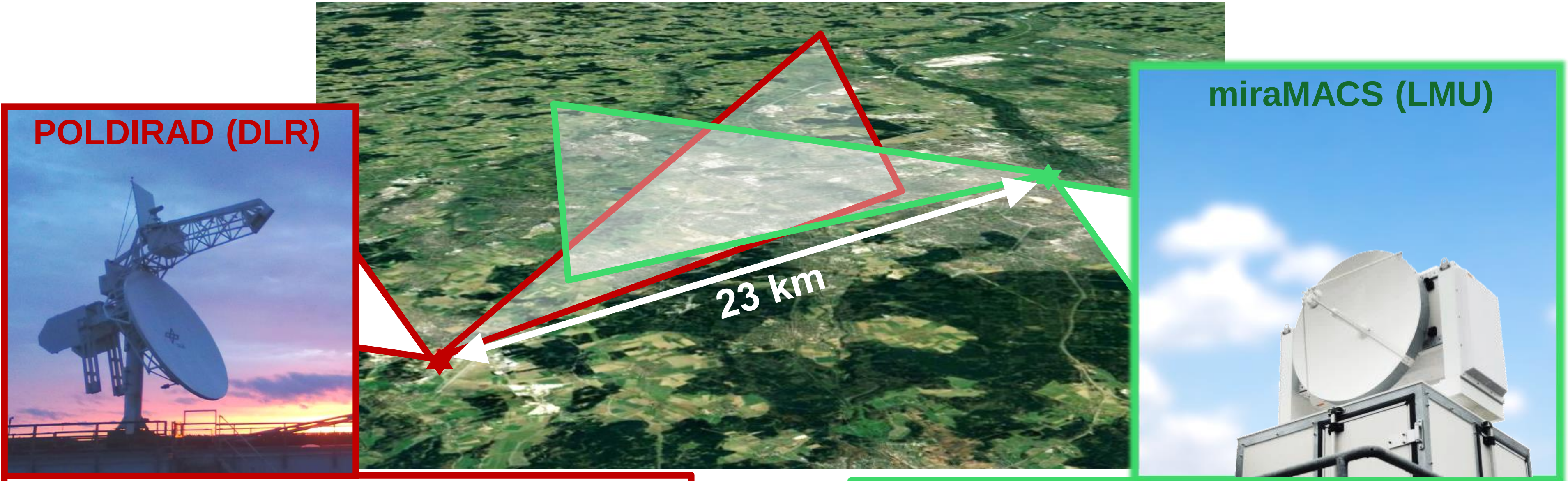
ZDR 5-9 dB



DLR Poldirad during COPS 2007

WP 3.2A: Multi-Wavelength Retrieval

- Coordinated measurements Poldirad – MIRA35



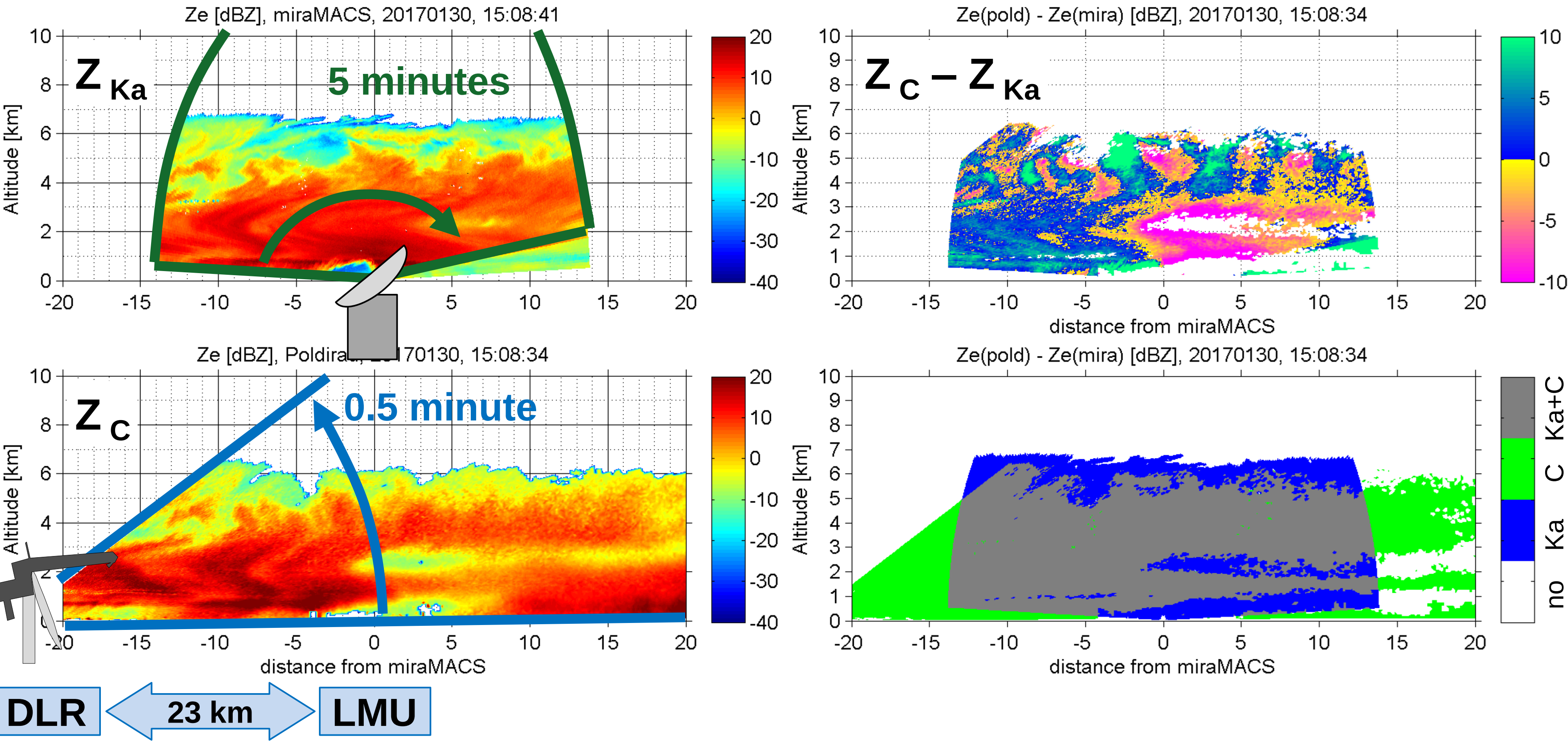
- C-band weather radar (5.5 GHz, 250 kW)
- operated at DLR Oberpfaffenhofen
- 4.5 m antenna 1° beam-width
- range res. 150 m, max 120 km
- full polarimetric (STAR and AltHV) (ZDR, LDR, KDP, rho_{HV})

- Ka-band cloud radar (scanning) (36 GHz, 30 kW)
- operated at LMU Munich city
- 1 m antenna 0.6° beam-width
- range res. 30(60) m, max 15(30) km
- linear depolarization ratio LDR

STAR: simultaneous transmit and receive
AltHV: alternate transmit and receive horizontal and vertical

WP 3.2A: Multi-Wavelength Retrieval

- Coordinated measurements Poldirad – MIRA35
- Example Measurement 2017-01-30 15:08



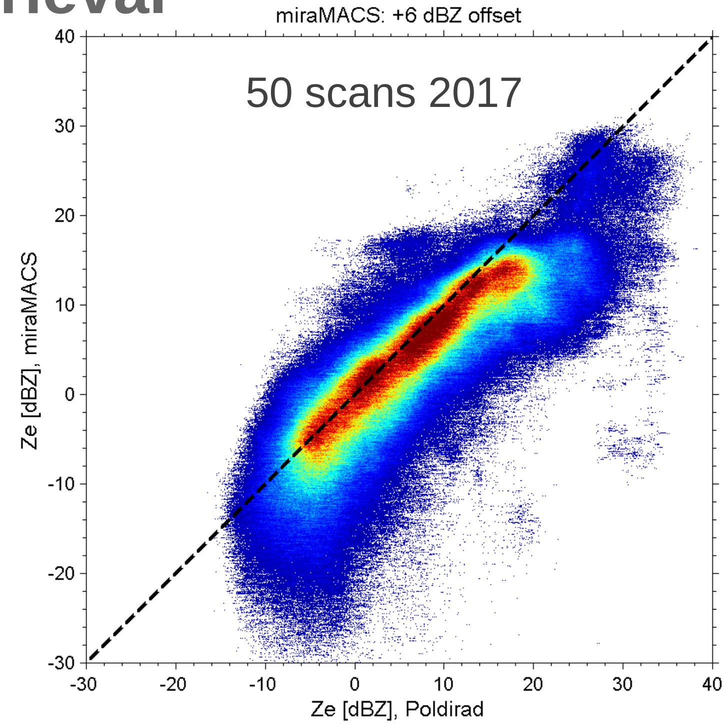
WP 3.2A: Multi-Wavelength Retrieval

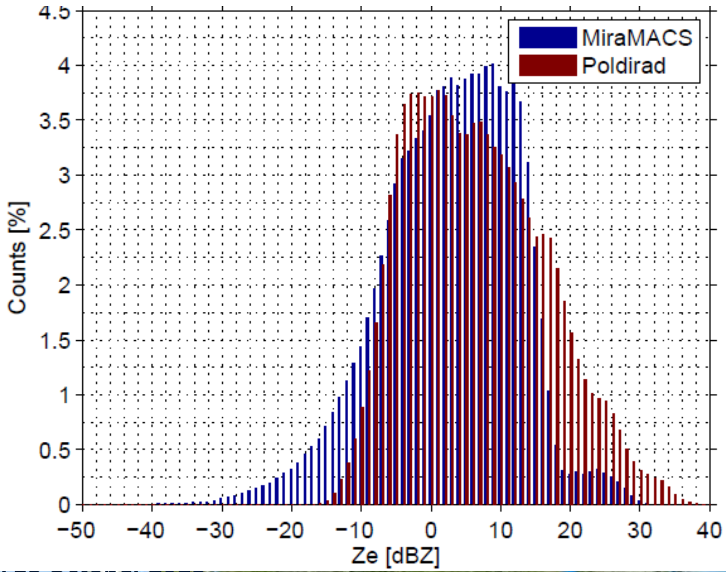
Minimum detectable/discernable signal (MDS):

- C-band POLDIRAD:
  (1 µs pulse, 64 samples)
  ~ -26 dB at 5 km
  ~ -17 dB at 15 km

- Ka-band miraMACS:
  (0.2 µs pulse, 256 samples)
  ~ -40 dB at 5 km
  ~ -31 dB at 15 km

- MIRA35 is 14 dB more sensitive than POLDIRAD

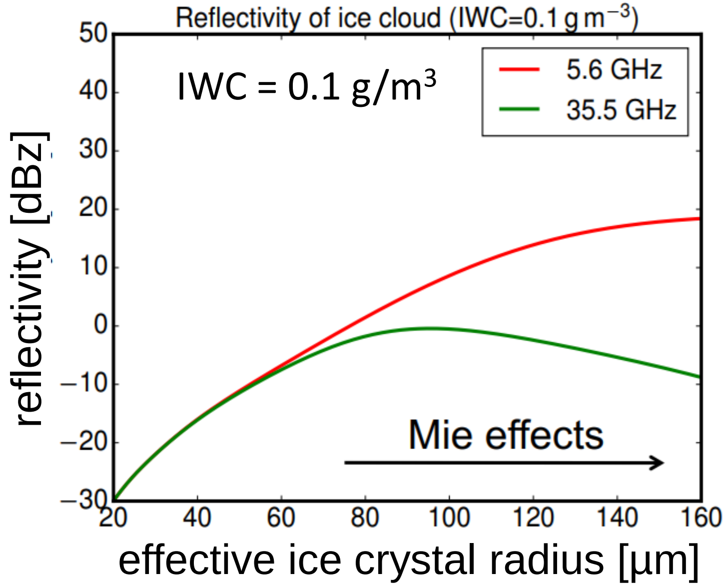


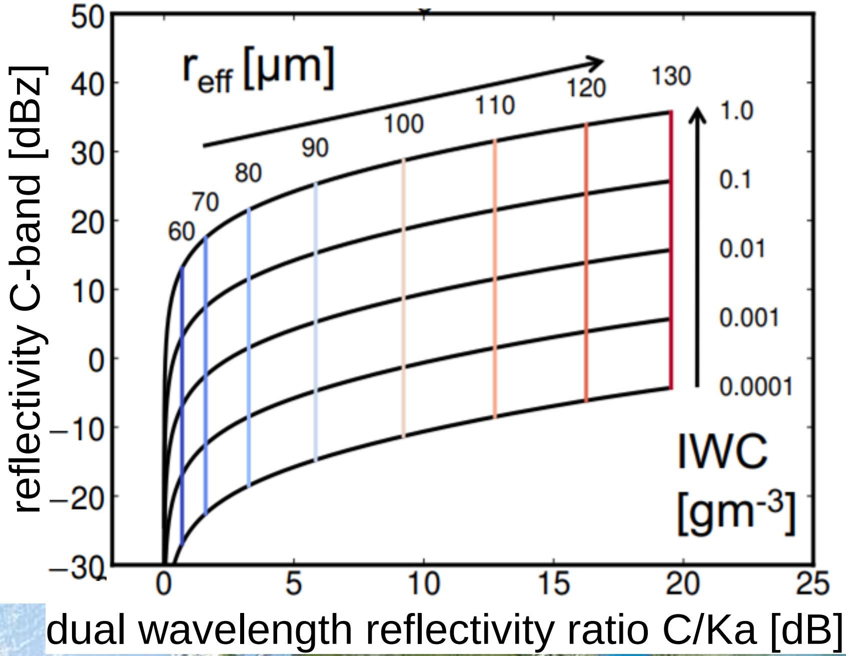


WP 3.2A: Multi-Wavelength Retrieval

Towards Ice Particle Effective Radius

- Particle size sensitivity of the Dual Wavelength Ratio
- Mie effects cause lower reflectivities for larger r_{eff}
- attenuation is negligible for ice





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Multi-Wavelength Microphysics Retrieval

Dual-polarization C- and Ka-band Retrieval:

- dual-wavelength reflectivity ratio → effective radius of ice particles
- reflectivity (long wavelength) → ice water content IWC
- dual-polarization → hydrometeor classification
  → particle habit

Lessons learned:

- calibration of both radars essential
- optimizing of C-band sensitivity necessary
- scan timing / advection to be considered
- additional W-band radar could improve retrieval

WP 4.1: Comparability of Measurement and Model Output

- Development of comparison strategy
  - observation space
  - model space