# IcePolCKa

## *Investigation of Convective Evolution towards stratiform Precipitation using simulatiOns and poLarimetric radar observations at C- and Ka-band*

*Contribution to Priority Programme SPP 2115: Polarimetric Radar Observations meet Atmospheric Modelling (PROM)*

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# IcePolCKa:
## Motivation

**What are current problems in weather forecasting?**

### Convection

- Time horizon for accurate predictions: Few hours
- White et al (2017): Strong variation between convective cases

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- Statements about uncertainties only possible based on **statistics** over a large set of data

### Microphysics

- Microphysics hard to observe on high level of detail
- Type of particle, particle shape, particle size, ...

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- Novel observations needed: Dual-frequency and polarimetric radar **observations**

# Model vs Observation:
## How to compare

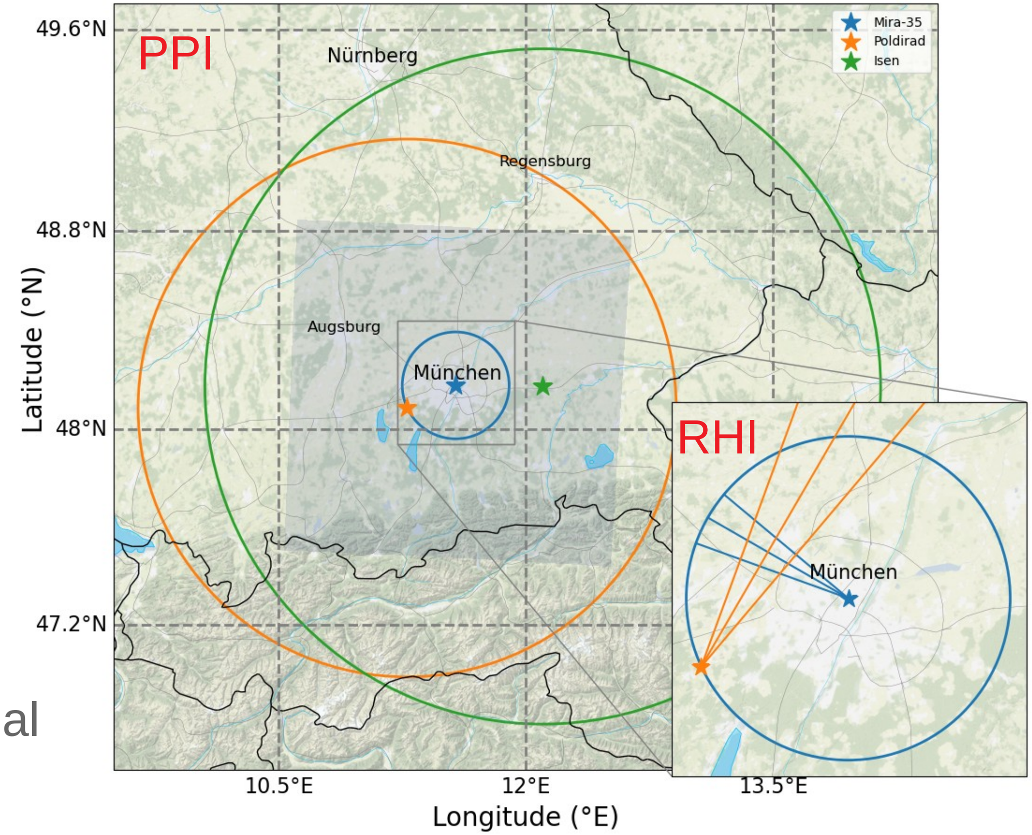
- Comparison in observation space (using CR-SIM)
- Comparison over Mira35 domain

**PPI Strategy**

- Comparison over **30** days
- Low vertical resolution but good spatial coverage

**RHI Strategy**

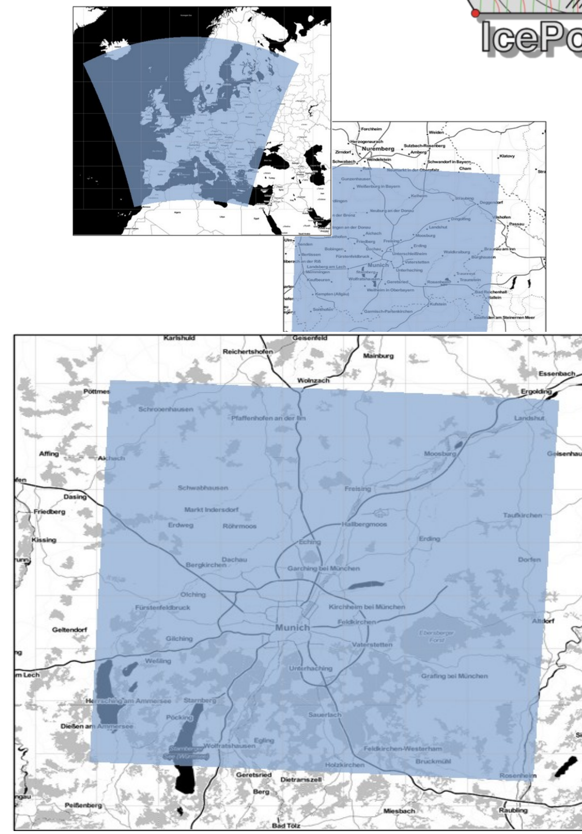
- Comparison over **5** days
- High resolution profiles but low spatial coverage




Köcher et al (2022), AMT

# WRF simulations:
## Model setup

- **WRF**: Weather Research and Forecasting Model (Skamarock et al, 2019)
  - ➢ Regional numerical weather prediction model (NWP)
- Different **MP**-schemes:
  - ➢ **Bulk** (Thompson 2-mom, Morrison 2-mom, Thompson 2-mom aerosol aware)
  - ➢ **Spectral Bin** (Shpund 2019)
  - ➢ **P3** (Morrison and Milbrandt 2015)
- Comparison to operational NWPs:
  - ➢ Grid spacing at ~2km (e.g., ICON, 2.1 km)
  - ➢ Typically bulk MP-schemes

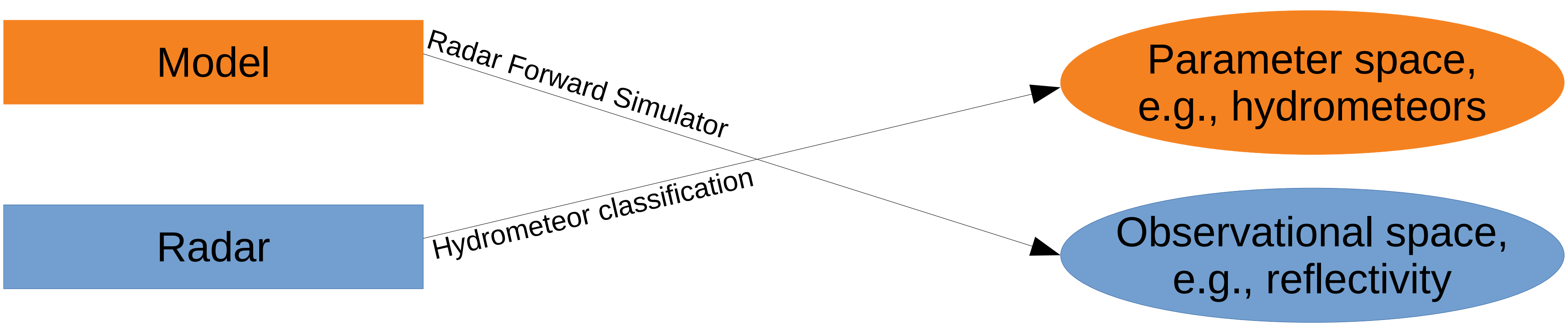


Munich domain with grid spacing of 400 m

# Towards modelling:
## Strategies to compare model and observation

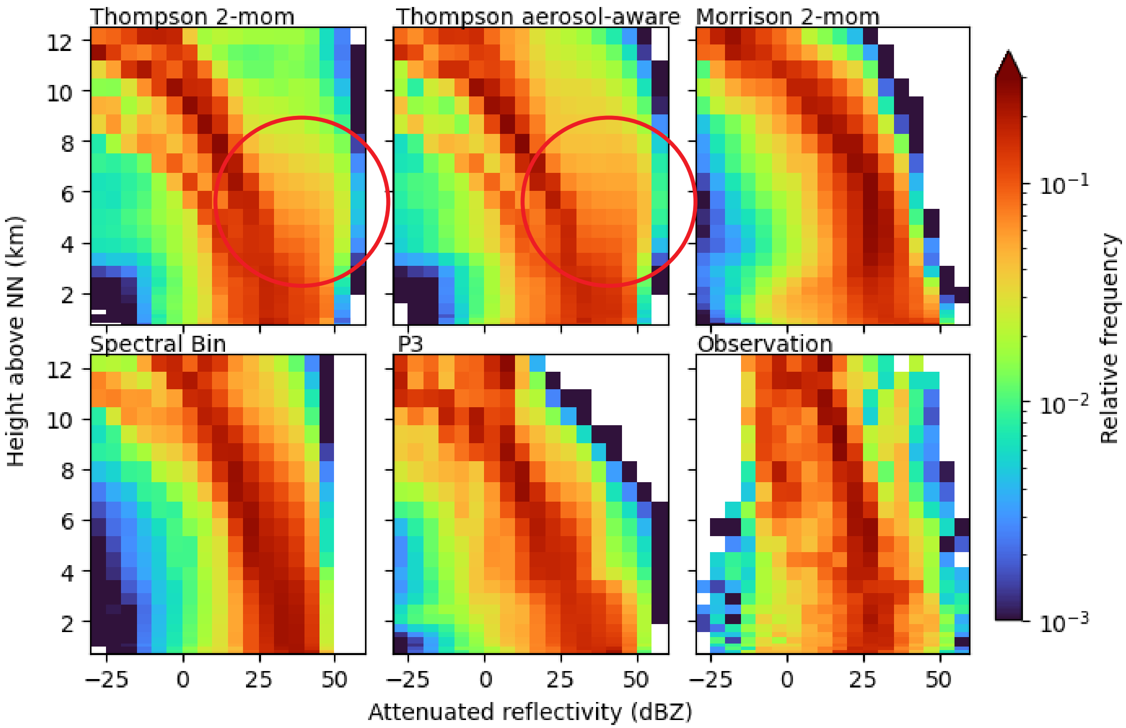
**Goal: Improvement of microphysics schemes**

- Use polarimetric and dual-wavelength measurements to analyze model performance
- Comparison in parameter space or observational space
- Use as many measurements as possible to get sound statistics



# Statistical comparison:
## CFADs of reflectivity

Above the melting layer height

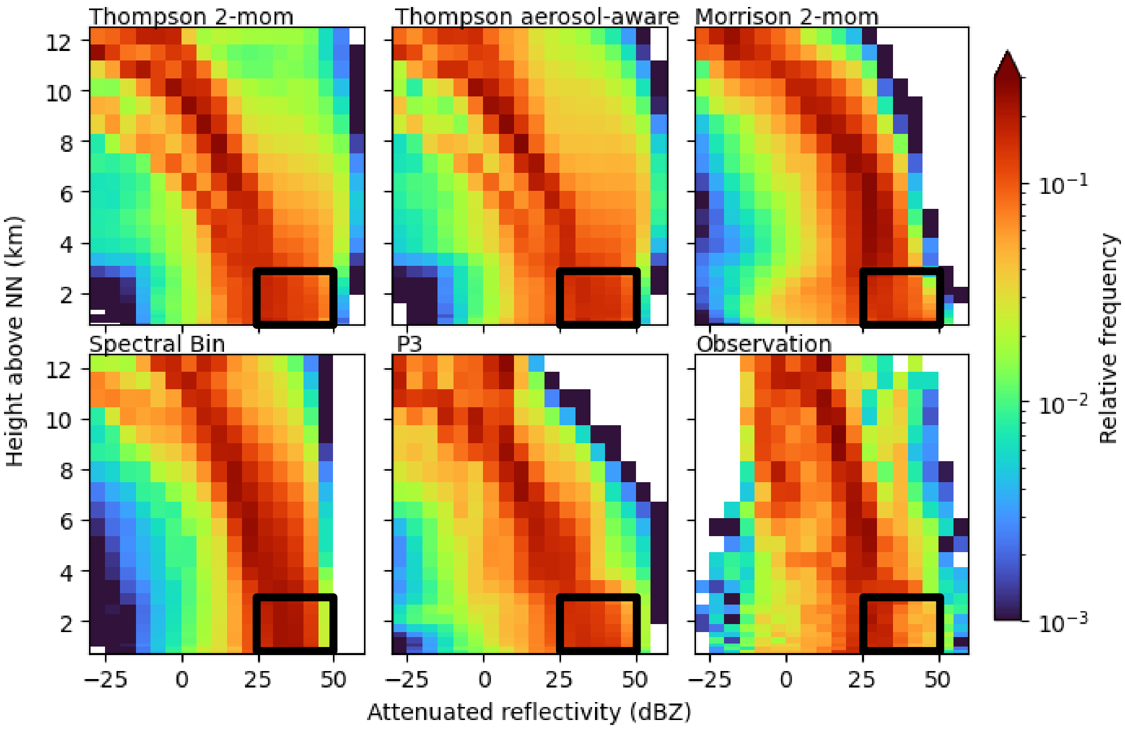



- Thompson often show extreme reflectivities of more than 45 dBZ
- Produced mostly by graupel (and some lifted rain)
  - Simulated graupel could be:
    1) Too **frequent**
    2) Too **large**
    3) Too **dense**

Köcher et al (2022), AMT

# Statistical comparison:
## CFADs of reflectivity

Below the melting layer height

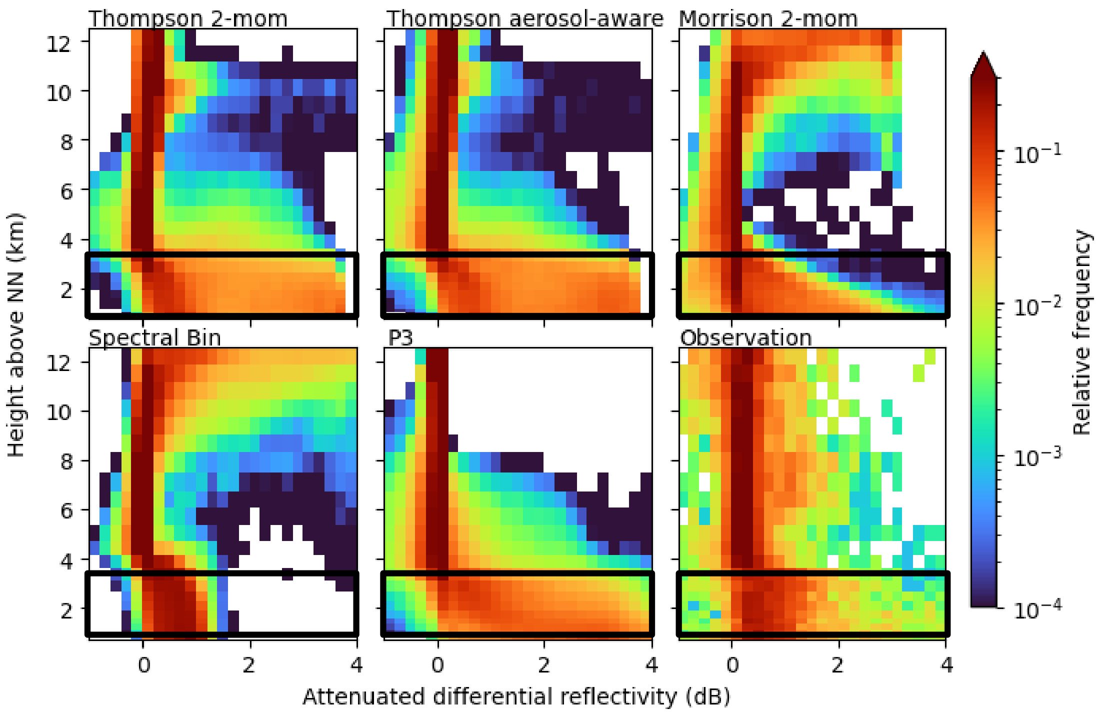



- Simulations agree on average reflectivity with each other
- Compared to observations, simulated reflectivities are too high
  - ➢ Reflectivity comes mostly from rain
  - ➢ Suggesting that particle size distributions (PSDs) contain too many large drops

Köcher et al (2022), AMT

# Statistical comparison:
## CFADs of differential reflectivity

Below the melting layer height

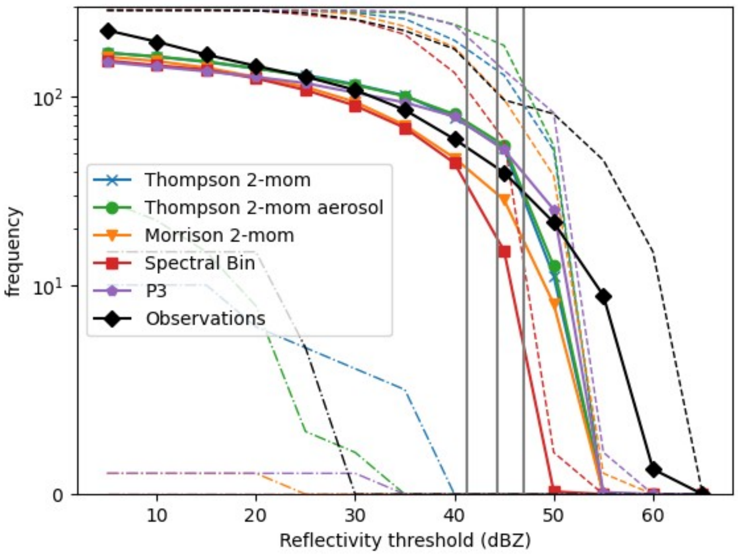



- All schemes except spectral bin show spread to high ZDR
  - Signal mainly from rain
  - Suggesting that spectral bin better captures the rain PSD
  - All other schemes produce too many (isolated) large drops

Köcher et al (2022), AMT

# What does this all mean for forecast at the ground?
# Statistics of high impact weather events

1) NWP simulations and radar observations of **30** convective days
2) Simulate **polarimetric radar signals** from NWP output
3) Apply **hydrometeor classification** on simulated and observed radar signals
4) How **frequently** did precipitation with reflectivities higher than **'x'** occur?
5) Shown is the minimum (dashed dotted), **mean** (solid) and maximum (dashed)



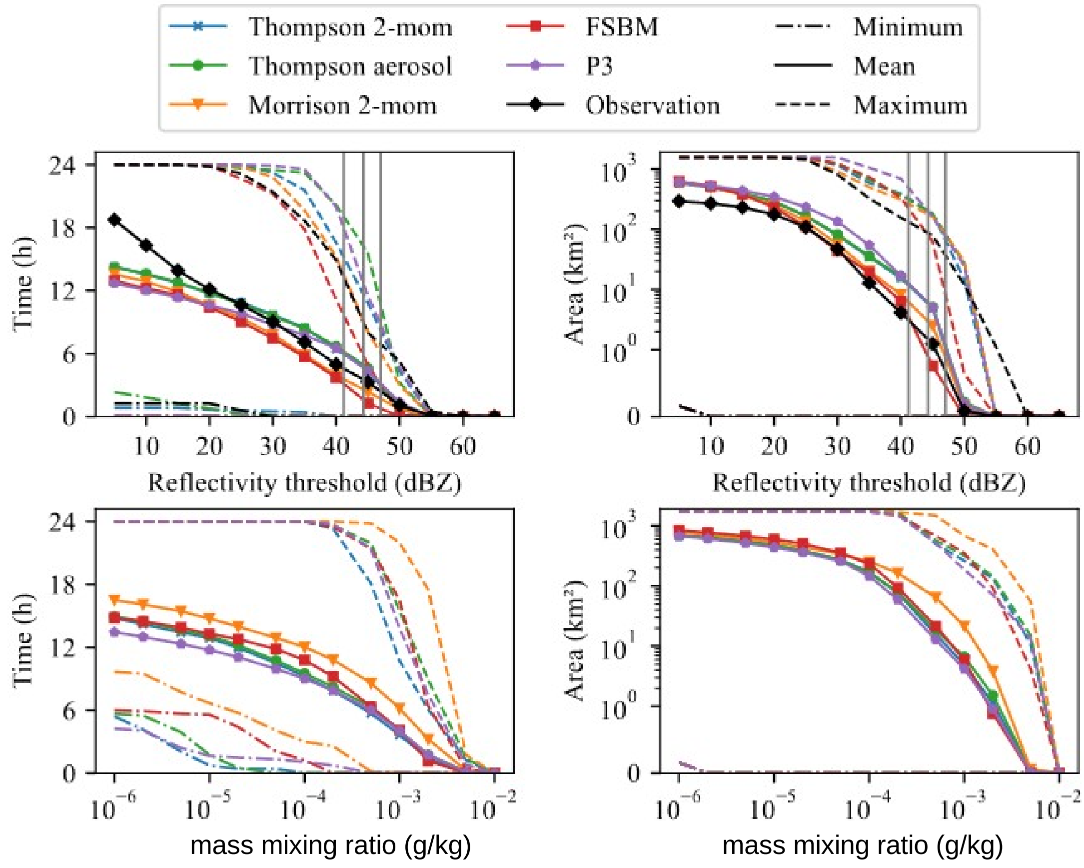

Köcher et al (2023), ACP

# Statistics of high-impact weather events:
## Heavy rain

Morrison and SBM heavy rain:

- ➢ Least frequent based on reflectivity
- ➢ Most frequent based on simulated mass mixing ratio

Role of PSD?



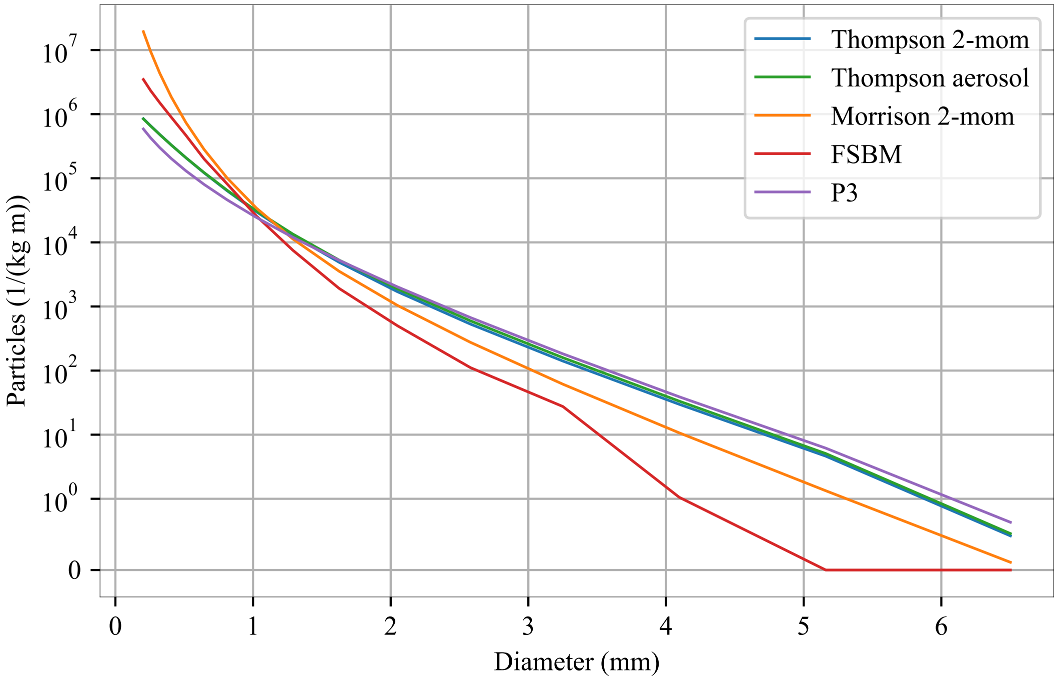

Köcher et al (2023), ACP

# Heavy rain statistics:
## Role of the PSD

Morrison and SBM heavy rain:

- High number of small drops
- Low number of large drops

→ Too few large drops!




Köcher et al (2023), ACP

# Summary and conclusions:

**What aspects of the microphysics can be improved?**

- Graupel too large in some schemes
- Rain DSD not correctly simulated
  - ➢ SBM/Morrison miss large drops
  - ➢ Thompson/P3 simulate large drops too frequently
- Inability to reproduce extreme hail reflectivities (density assumption?)

**Next steps**

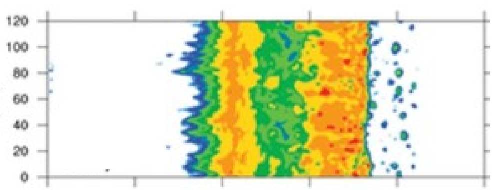
- Extend to exchange of mass between strong cores and stratiform precip regions
- Include this into cell detection and monitorig over time
- Lagrangian analyses including time development

# IcePolCKa in a nutshell

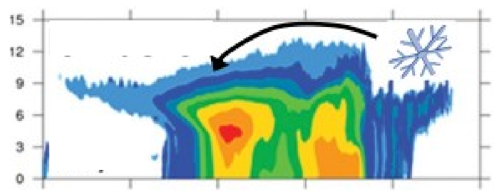
## Research Gap

*What role do ice particle properties play in the partitioning in convective and stratiform regions?*

### Horizontal advection



### Vertical transport



## Preliminary Work (Phase 1)

*Development of tools to identify microphysical fingerprints in polarimetric, multi-λ data*

▶ **Cell tracking statistics (LMU)**

- Domain / cell-based studies
- C-band network + Ka-band
- Different microphysic schemes
- Statistics of DWR and ZDR

▶ **Microphysics retrieval (DLR)**

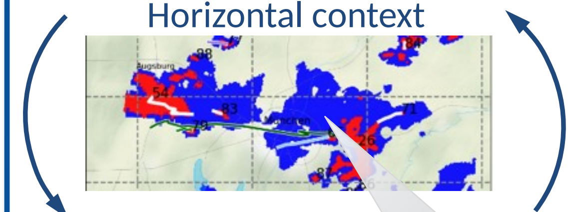
- Synchronized C/Ka-band scans
- T-matrix scattering simulations
- Retrieval of shape, size, IWC
- Combination of ZDR + DWR

## Work program (Phase 2)

*Identification of notable differences between model/obs in a combined horizontal/vertical framework*

▶ **Conv./strat. evolution (LMU)**

Horizontal context

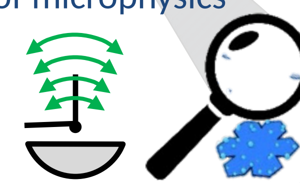


▶ **Constraint on profiles (DLR)**

Validation of microphysics

ZDR + LDR

DWR + VEL





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