Karlsruhe Institute of Technology

Evaluating and Improving Convection-Permitting Simulations of the Life Cycle of Convective Storms using Polarimetric Radar Data

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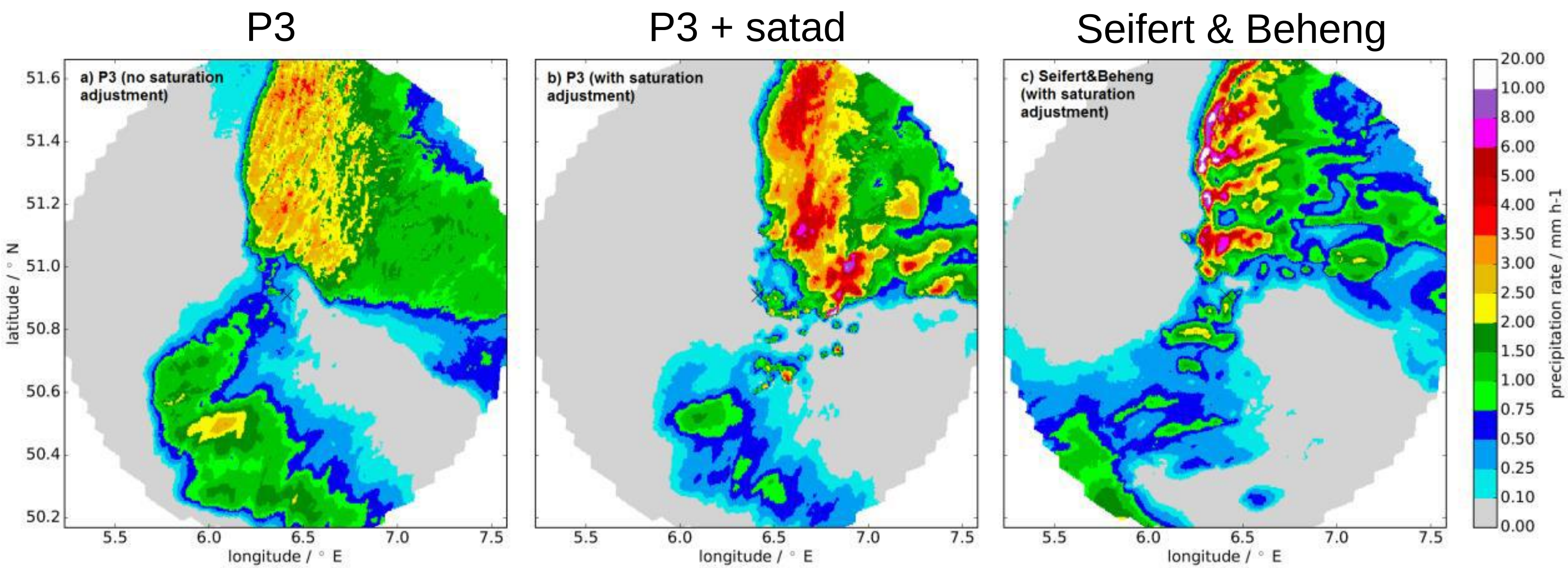
Introduction

- Convection-permitting simulations are common, and the future of global modelling

- Convective updrafts can be 2-3 times too strong (Varble et al., 2014)
- Choice of microphysics scheme can affect updraft velocity by 6-8m/s (Marinescu et al., 2016)

- Basic idea:
  - How much does microphysics control the **structure** of convection
  - Can we use this structure to reduce uncertainty in microphysics schemes?
- How:
  - Use ICON-LAM with 2(3) microphysics schemes, evaluate differences and **causes** of the differences. Evaluate storm structure against radar.
  - Build toolbox for improving models, by systematically varying microphysics
  - Use synthesis of models and radar to identify most relevant processes for producing “damaging precipitation”.

Differences caused by microphysics schemes



Modified from Markus Karrer (Masters Thesis, 2018)

Objectives

- **1. How well is the lifecycle of convective storms simulated by convection-permitting models, when compared against dual-polarization radar data?**
- **2. Which processes … are most important for the production of large hail and heavy rain?**
- **3. … is it more important to correctly predict the storm structure or the microphysical processes within the storm?**

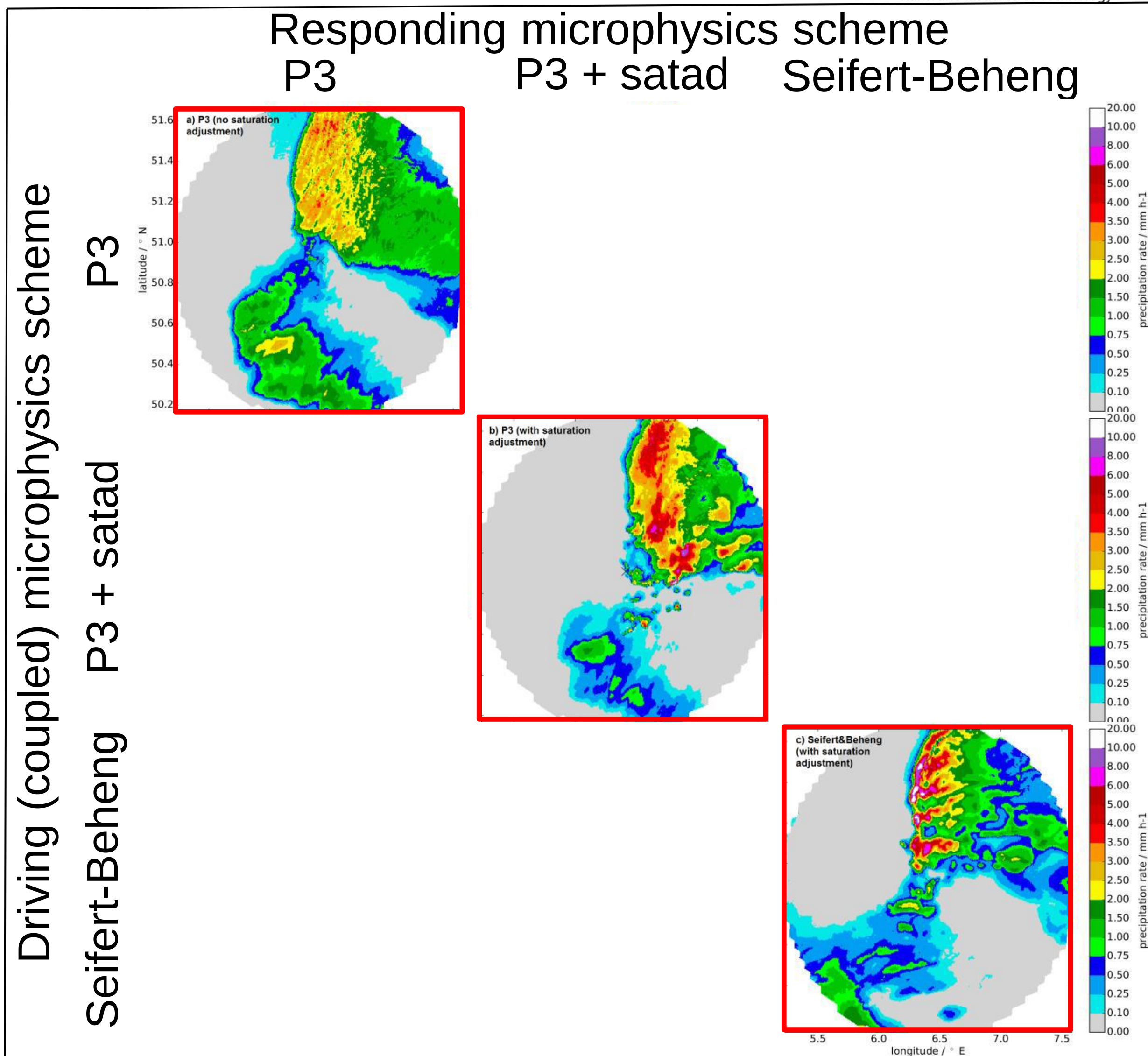
- Studied processes:
  - condensation of water vapor to liquid water, and the associated latent heating;
  - autoconversion of cloud drops to rain drops;
  - freezing of cloud/rain drops, and the associated latent heating;
  - collection of supercooled liquid water by falling ice particles (riming);
  - evaporation and melting of precipitation particles below the cloud base, and the associated latent cooling leading to the formation of cold pools.

How?

- Microphysical Piggybacking
- Using 5 cases from High Impact Weather period in June 2016
- Simulate storms using ICON-LAM (~1km)
  - First with two different microphysics schemes
  - Then by systematically varying individual processes
- Within the simulated storms, statistically evaluate:
  - 3D distribution of hydrometeors
  - Which microphysical pathways are active
  - Dual-polarization signatures

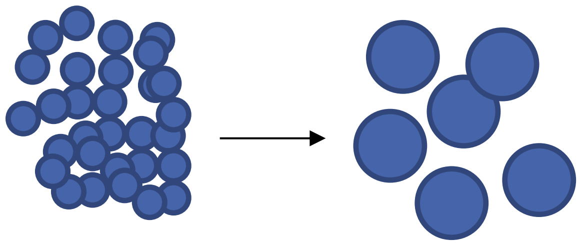
Piggybacking

- Based on Grabowski et al. (2014, 2016)
- Break the link between microphysics and dynamics
- One microphysics scheme is interacting with the dynamics (e.g. through latent heat release)
- Other scheme(s) only react to changes in wind and temperature
  - **Does not** feed back to dynamics through latent heating, water loading...

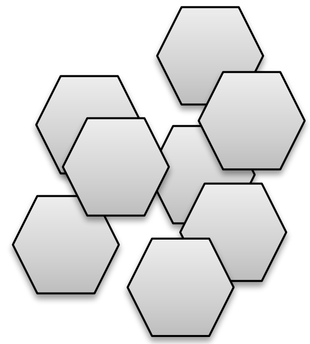


Systematic process modification

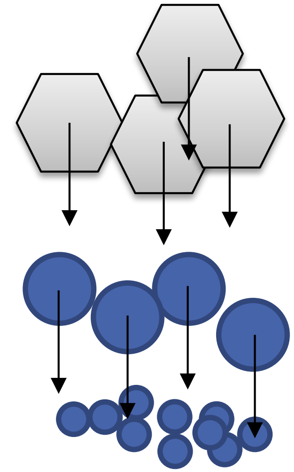
- Processes:



autoconversion



Ice nucleation / freezing

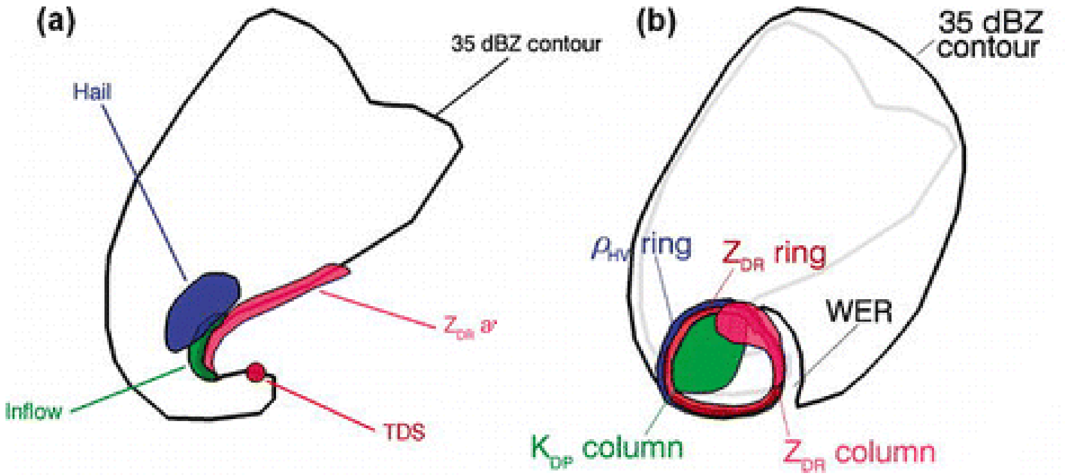


Melting and evaporation

- Systematically vary these: very low, low, medium, high, very high
- How do cloud statistics change?
- Again use piggybacking

Tracking processes of hail formation

- Current model simulations predict not enough hail, and size is too small
- With dual-pol data it is possible to identify both hail **<u>and the processes</u>** which create hail (riming, and the presence of liquid water)
- Use observations and dual-pol forward operator to evaluate model simulations
- Output relevant process from model microphysics (e.g. riming rate)



Modified from Kumjian and Ryzhkov (2008)

What will we learn?

- What causes differences in precipitation structures between Seifert & Beheng scheme and P3 scheme?
  - Is it caused by microphysical or dynamical differences?
  - Which microphysical pathways are responsible for the differences?

- How does the storm structure change when the microphysics is **systematically** varied?
  - Which processes are most important?
  - Are some processes unimportant?
  - Is the storm internal structure consistent or inconsistent with saturation adjustment?

- Which (model) processes are responsible for the heaviest precipitation/hail? How are the processes evident in the dual-pol signatures? How realistic are the dual-pol signatures?