Spectrally resolved Polarimetric Observation and ~~Modelling~~ Computation of Clouds - SPO~~M~~CC

of Clouds - SPOMCC

PROM Kick-Off Meeting, Bonn, 17-18 October 2018

PI‘s: Patric Seifert (obs), Oswald Knoth (model)

PhD‘s: Junghwa Lee, Majid Hajipour

Partners:
- **Michael Frech (DWD)**
- **Herman Russchenberg (TU Delft)**
- **Alexander Myagkov**

„Toward modeling and observing the hydrometeor ratio during the onset of precipitation.“

Member of the Leibniz Association

ACCEPT

TROPOS
Leibniz Institute for Tropospheric Research

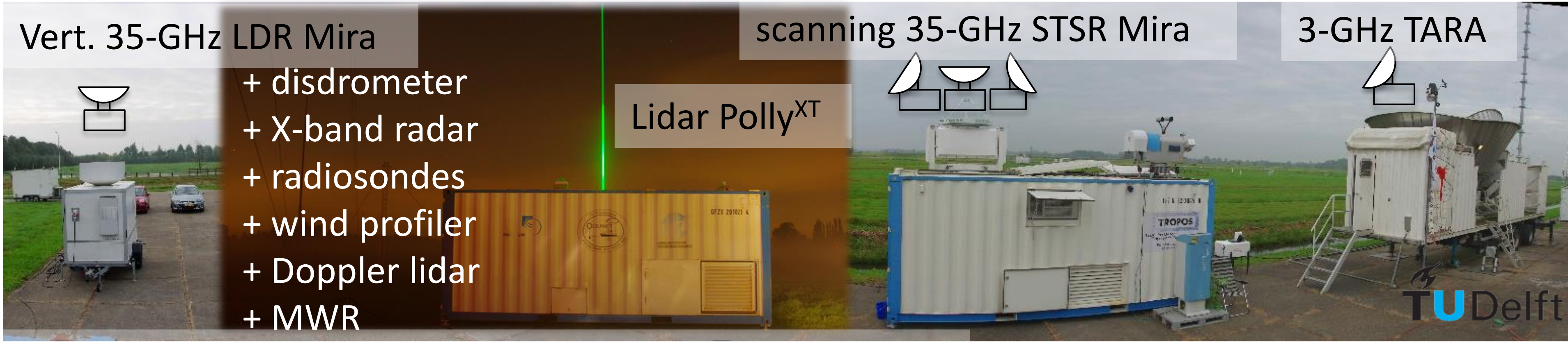
ACCEPT: The prerequisite for the SPOCC project

ACCEPT

Analysis of the Composition of Clouds with Extended Polarization Techniques

- 6-week measurement campaign at CESAR obs., Cabauw
- **Vert. pointing LDR-mode Mira-35 (TROPOS)**
- **Scanning STSR/hybrid-mode Mira-35 (TROPOS/Metek)**
- Slanted (45°) full-polarimetric S-band TARA (TU Delft)

+ Lidars, MWR, Doppler lidar, wind profiler, radiosondes, solar radiation measurements



CESAR site, Cabauw, the Netherlands, 7 Oct – 16 Nov 2014

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

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Analysis of the Composition of Clouds with Extended Polarization Techniques

Forster, L., Seefeldner, M., Wiegner, M., and Mayer, B.: **Ice crystal characterization in cirrus clouds: a sun-tracking camera system and automated detection algorithm for halo displays**, Atmos. Meas. Tech., 10, 2499-2516, https://doi.org/10.5194/amt-10-2499-2017, 2017.

Myagkov, A., Seifert, P., Bauer-Pfundstein, M., and Wandinger, U.: **Cloud radar with hybrid mode towards estimation of shape and orientation of ice crystals**, Atmos. Meas. Tech., 9, 469-489, https://doi.org/10.5194/amt-9-469-2016, 2016a.

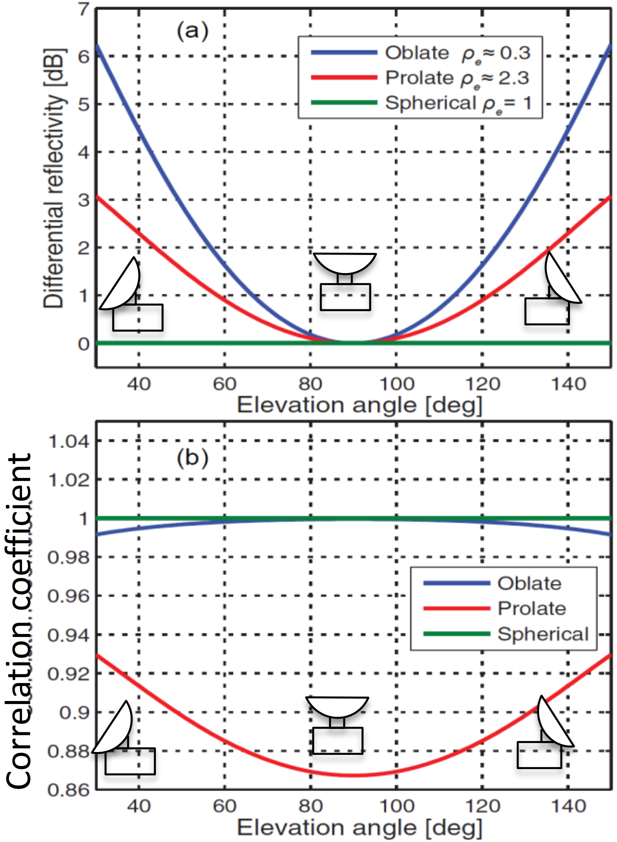
Myagkov, A., Seifert, P., Wandinger, U., Bühl, J., and Engelmann, R.: **Relationship between temperature and apparent shape of pristine ice crystals derived from polarimetric cloud radar observations during the ACCEPT campaign**, Atmos. Meas. Tech., 9, 3739-3754, https://doi.org/10.5194/amt-9-3739-2016, 2016b.

Rusli, S. P., Donovan, D. P., and Russchenberg, H. W. J.: **Simultaneous and synergistic profiling of cloud and drizzle properties using ground-based observations**, Atmos. Meas. Tech., 10, 4777-4803, https://doi.org/10.5194/amt-10-4777-2017, 2017.

Pfitzenmaier, L., Y. Dufournet, C.M. Unal, and H.W. Russchenberg, 2017: **Retrieving Fall Streaks within Cloud Systems Using Doppler Radar.** *J. Atmos. Oceanic Technol.,* **34**, 905–920, https://doi.org/10.1175/JTECH-D-16-0117.1

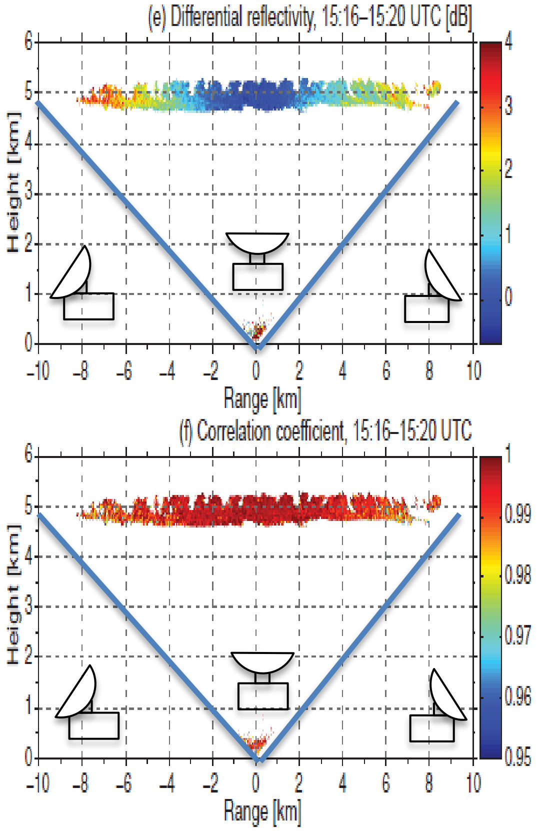
Pfitzenmaier, L., Unal, C. M. H., Dufournet, Y., and Russchenberg, H. W. J.: **Observing ice particle growth along fall streaks in mixed-phase clouds using spectral polarimetric radar data**, Atmos. Chem. Phys., 18, 7843-7862, https://doi.org/10.5194/acp-18-7843-2018 , 2018.

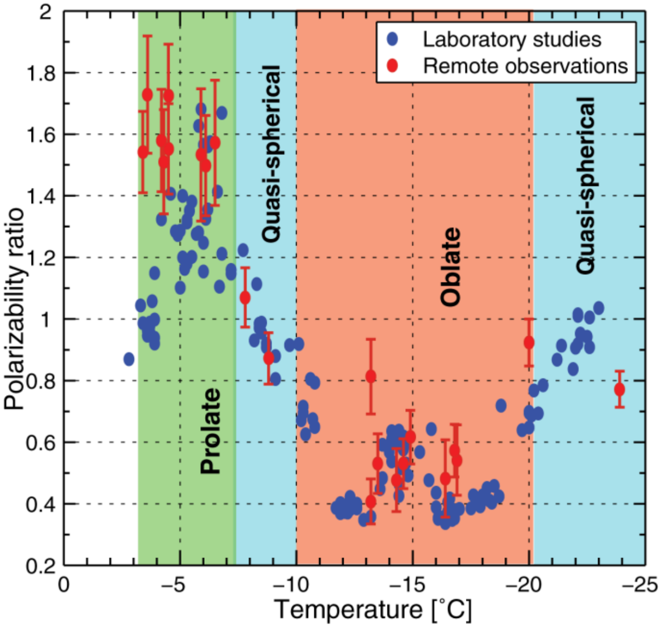
Polarimetric spheroidal model



22 case studies of thin, liquid-topped mixed-phase clouds

→ **Only from the main peak in the Doppler spectrum**





Myagkov et al., AMT, 2016a; Myagkov et al., AMT, 2016b

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Polarimetric spheroidal model

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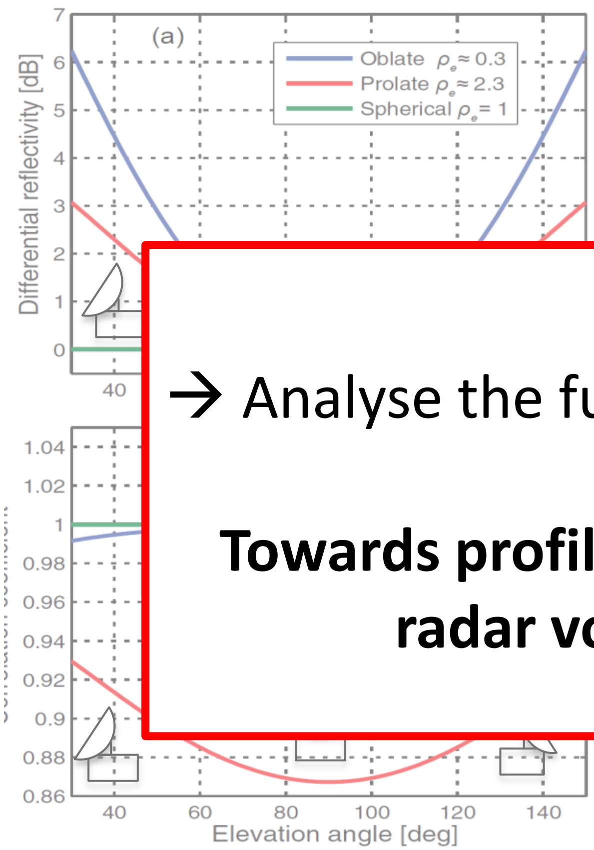

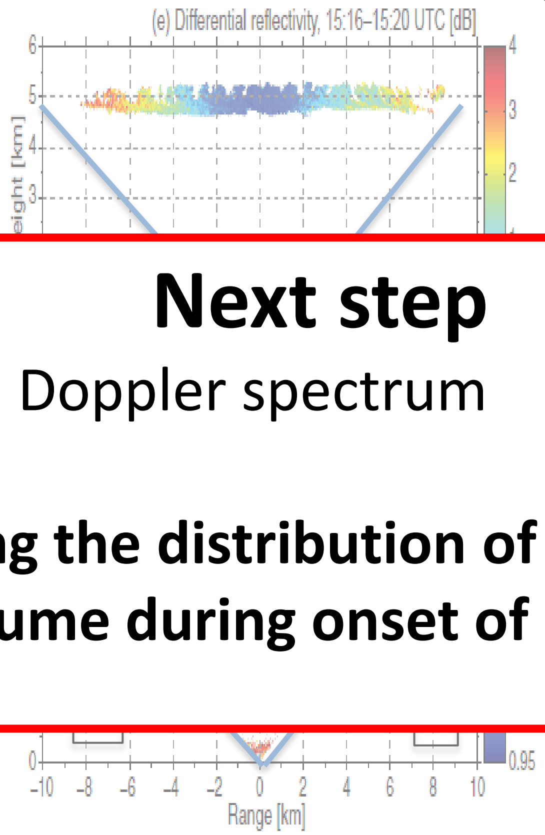

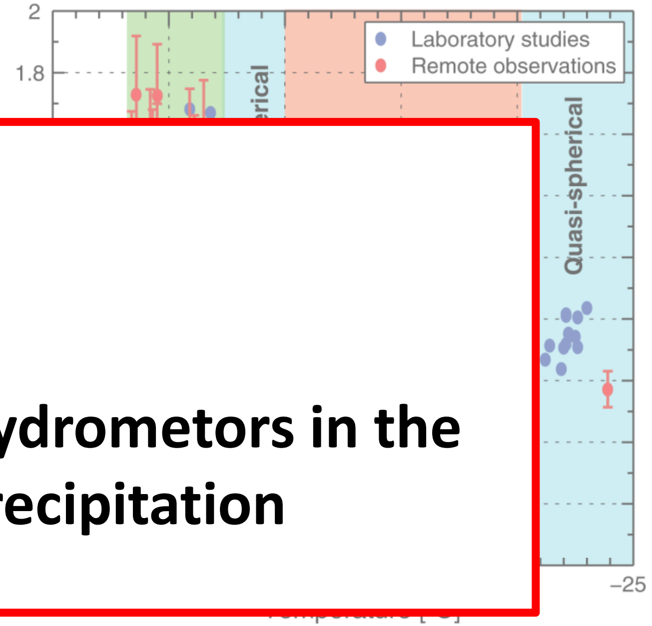

Next step

→ Analyse the full Doppler spectrum

Towards profiling the distribution of hydrometors in the radar volume during onset of precipitation

Myagkov et al., AMT, 2016a; Myagkov et al., AMT, 2016b

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Structure of SPOCC

Observations

PhD 1: Majid Hajipour

PI: Patric Seifert

Doppler-velocity-resolved hydrometeor typing from polarimetric radar RHI scans

Modelling

PhD 2: Junghwa Lee

PI: Oswald Knoth

Forward-modelling of polarimetric variables from the COSMO-SPECS simulations

PhD 1 & PhD 2

Interpretation
→ Evaluate modelled mixed-phase processes against observations and vice versa

Cooperation within PROM (e.g. PICNICC)

Spectrally resolved modelling of precipitation formation processes with COSMO-SPECS

→Concentrate on mixed-phase cloud schemes

SPOCC – Work Plan

Likely starting date: 1 March 2019

2 PhD projects: **PhD 1 → Observations** **PhD2 → Modelling** **PhD1/2 → Interpretation**

WP	Task	Year 1				Year 2				Year 3			
1	**From bulk to spectral radar polarimetry**												
1.1	ZDR and ρ_{hv} from bulk observations	■	■	■									
1.2	Adaption to German weather radar network				■	■							
1.3	Toward spectrally resolved hydrometeor ratios						■	■	■	■	■	■	■
2	**Extension of COSMO-SPECS**												
2.1	Extension of SPECS → Toward hydrometeor types	■	■	■	■	■							
2.2	Forward modelling of spectral-bin modelled data						■	■	■				
2.3	Application of COSMO-SPECS to ACCEPT cases									■	■	■	■
3	**Interpretation of ACCEPT case studies**												
3.1	Evaluation of the model setup									■			
3.2	Evaluation of microphysical processes										■	■	■

PhD 1 Candidate:
Majid Hajipour
MSc. Elec. Engineering

PhD 2 Candidate:
Junghwa Lee
MSc. Atmos. Sciences

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SPOCC – Work Plan – PhD 1 – Task 1.1

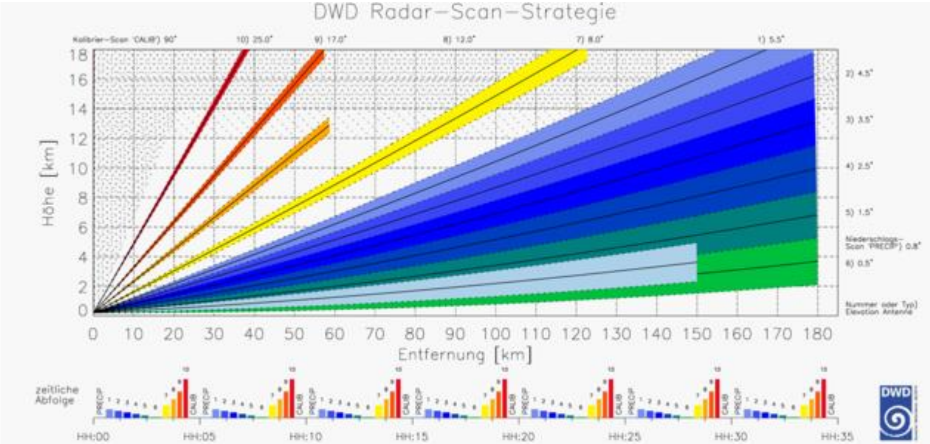
→ *ZDR and ρ_{hv} from bulk observations*

- Training and re-implementation of the technique of Myagkov et al. (2016a)
- Considering new aspects of radar-polarimetric techniques (e.g., the recent works of Sergej Matrosov (apparent density issue), Mariko Oue, and Lukas Pfitzenmaier)

SPOCC – Work Plan – PhD 1 – Task 1.2

→ *Adaption to German weather radar network*

- Test the applicability of the particle shape retrieval to combination of bird-bath scans and 25° elevation.
- Cooperation with Michael Frech (see his project in PROM)



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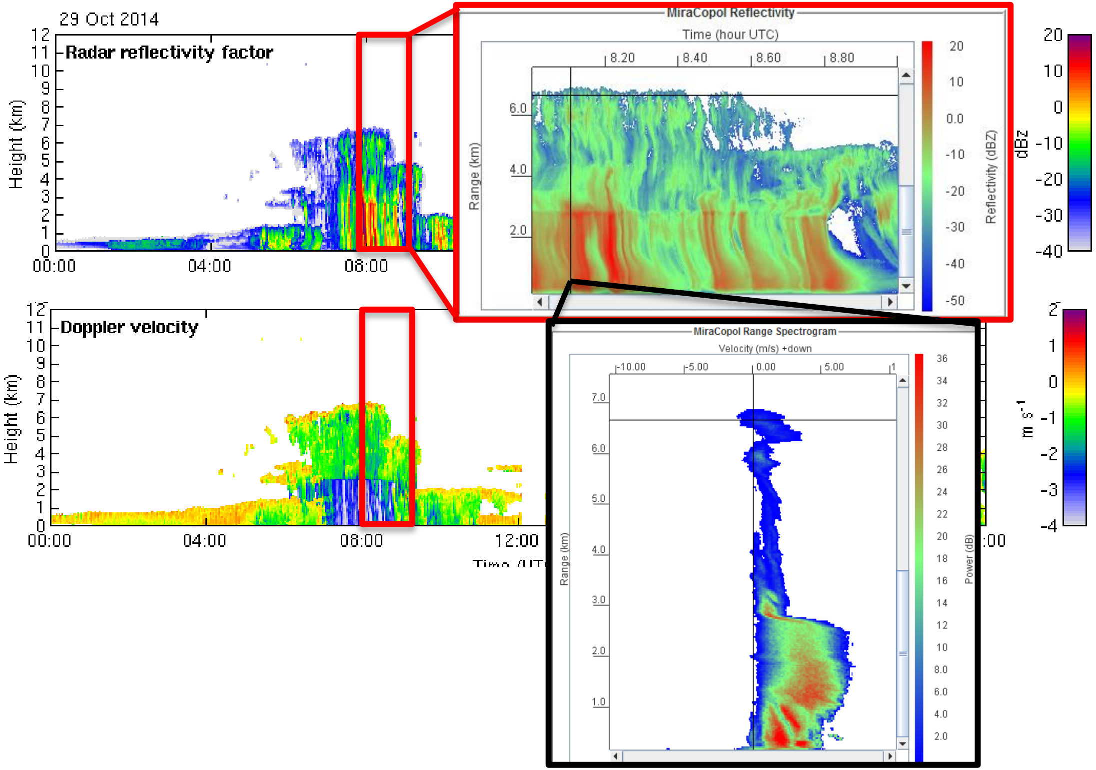
SPOCC – Work Plan – PhD 1 – Task 1.3

→ *Toward spectrally resolved hydrometeor ratios*

- Adaption of the shape retrieval of Myagkov et al. (2016a) to the full Doppler spectrum
- Challenges:
  - Tracking the spectral signatures over a range of elevation angles
  - Signal-to-noise limitations
  - Incorporate estimates of apparent density
    → derive actual shapes of different hydrometeor populations
- Includes secondment to TU Delft (Hermann Russchenberg / Christine Unal)



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SPOCC – Work Plan – PhD 2 – Task 2.1

- SPECS (SPEctral Cloud microphysicS), Grützun et al 2008, Simmel et al 2005
- Two spetra (liquid and ice-liquid), additional property aerosol content
- Follow the Spectral Ice Habit Prediction System (SHIPS), Hashino/Tripoli (2007)
- Diagnosing particle growth history for each ice particle bin, „Continuous-property approach" by allowing solid hydrometeors evolve the properties continuously
- Piecewise linear presentation, after Chen and Lamb 1994
- Improved water vapor deposition
- Suitable mixing rules from last bulk parameterizations

SPOCC – Work Plan – PhD 2 – Task 2.1

- COSMO-SPECS Simulation by Diehl/Grützun
- Study of different ice nucleation modes at high altitudes
- Covered by an area of 80 km x 80 km
- 48 vertical layers
- Vertical profiles after Weissman/Klemp

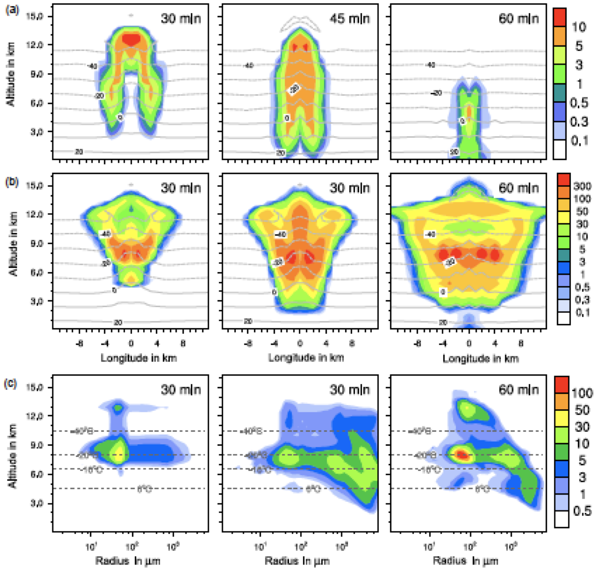
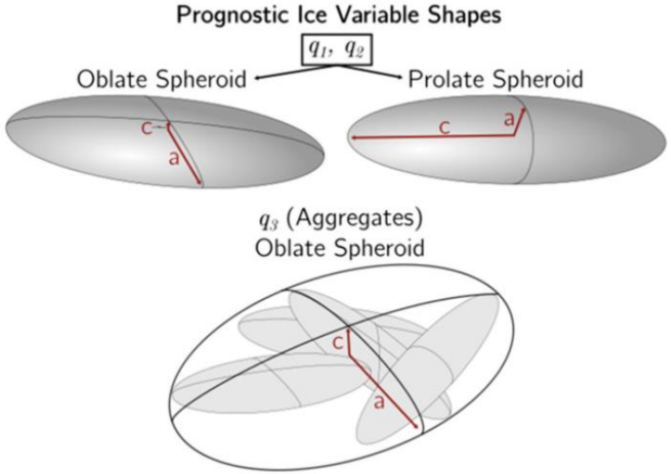
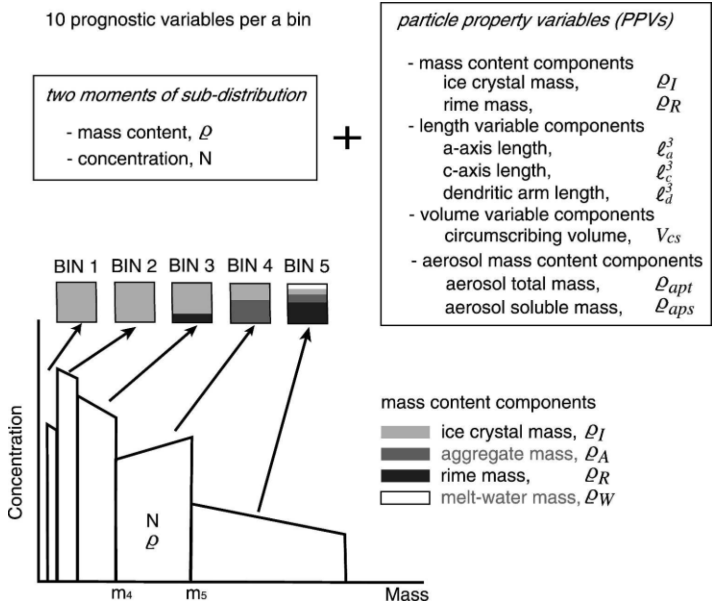


Figure 6. Ice formation from contact freezing with 10 % feldspar. **(a, b)** Temporal development of two parameters shown in a vertical cut through the cloud center. Horizontal dashed lines: temperature in °C. **(a)** Ice water contents in g kg^{-1} and **(b)** ice particle numbers per m^3. **(c)** Ice particle size spectra in the center cell of the cloud at different times. Number concentrations per m^3. Left pictures in **(b)** and **(c)** show primary contact freezing only.

SPOCC – Work Plan – PhD 2 – Task 2.1



Form parameters for ice shapes, from Jensen et al 2017



Bin representation in SHIPS, from Hishiano/Tripoli 2007

SPOCC – Work Plan – PhD 2 – Task 2.2

Preparing simulated microphysical data for cloud radar simulator

- CR-SIM (**C**loud Resolving Model **R**adar **Sim**ulator), www.radarscience.weebly.com
- PAMTRA
- Starting with data from two moment scheme and one-way refined COSMO runs for the ACCEPT campaign (2.1 km, 700 m, 200 m)

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SPOCC – Work Plan – PhD 2 – Task 2.3

Modelling of the onset of precipitation for mixed-phase clouds

- Starting with data from two moment scheme and one-way refined COSMO runs for the ACCEPT campaign (2.1 km, 700 m, 200 m)
- Improved initial first guesses from additional data obtained during accept
- Simulate special cases with spectral microphysiscs on the finer nests
    - Boundary values from two moment scheme
    - Starting times (cloud free)
- Prepare data for Task 3
- Construction of a cloud test case

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SPOCC – Work Plan – PhD 1 & PhD 2 – Task 3.1

→ *Evaluation of the model setup*

- evaluate the representation of macrophysical and thermodynamic properties of clouds in the model against the available observations

→ Usage of all instrumentation available during ACCEPT

→ Part of secondment to TU Delft

SPOCC – Work Plan – PhD 1 & PhD 2 – Task 3.2

→ *Evaluation of microphysical processes*

- evaluate the results of different model configurations against the profiles of the hydrometeor ratios obtained from the polarimetric observations
  - → Test the applicability of ice-process parameterizations
- Estimate from the different model runs, how sensitive the observations need to be for detection of changes in cloud microphysics

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