Evaluating cloud ice microphysics in COSMO-DE with satellite observations

Reitter[1], **S.**, C. Köhler[2], A. Seifert[2], and S. Crewell[1]
[1] Institute of Geophysics and Meteorology, University of Cologne, [2] Deutscher Wetterdienst

1. Motivation

DWD simulates MSG SEVIRI BTs from COSMO-DE output, in order to enable the assimilation of observed BTs in the future. COSMO-DE is known to distinctly underestimate the occurrence of low BTs at 10.8 µm [*Böhme et al, 2011*].

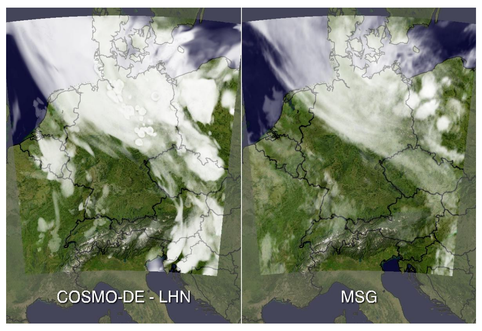

***Fig. 1**: Simulated and measured BTs at 10.8 µm on 16 June 2007 04 UTC [courtesy of Jan Keller].*

Questions

- Is this reproducible on a case study basis?
- Is a novel ice microphysical scheme able to perform better?
- If yes, which part of the new scheme is responsible for the improved performance?
- Does an increase in vertical level number have a similar effect?

2. COSMO-DE

General

- Non-hydrostatic cloud-resolving regional NWP model of DWD
- Resolution: 2.8 x 2.8 km, 50 hybrid levels (50 – 1000 m thick)

This study

- 3 main experiments: June 2010, driven by COSMO-EU analyses (only 0, 6, 12 UTC runs, but 24h):

9009	▪ currently operational ▪ 5 hydrometeor classes: cloud water, rain, cloud ice, snow, graupel ▪ 1-moment bulk scheme
8819	▪ as 9009 but without graupel
8822 *Köhler [2013]*	▪ hydrometeor classes as 8819 ▪ 2-moment 2-mode cloud ice scheme: – cloud ice is 2-moment (QI & QNI prognostic variables), all other 1-moment (QI) – 2-mode: heterogeneously and homogeneously formed cloud ice are treated separately ▪ sedimentation of cloud ice ▪ tracking variable for activated ice nuclei to avoid cloud ice overproduction ▪ relaxation approach instead of simple saturation adjustment for depositional growth of cloud ice ▪ heterogeneous ice nucleation *by Phillips [2008]* instead of *Fletcher [1962]*

- Sensitivity experiments – part I:

k50/85/150	▪ as 8819 but with increasing level number (50, 84, 150)

3. Main runs vs MSG

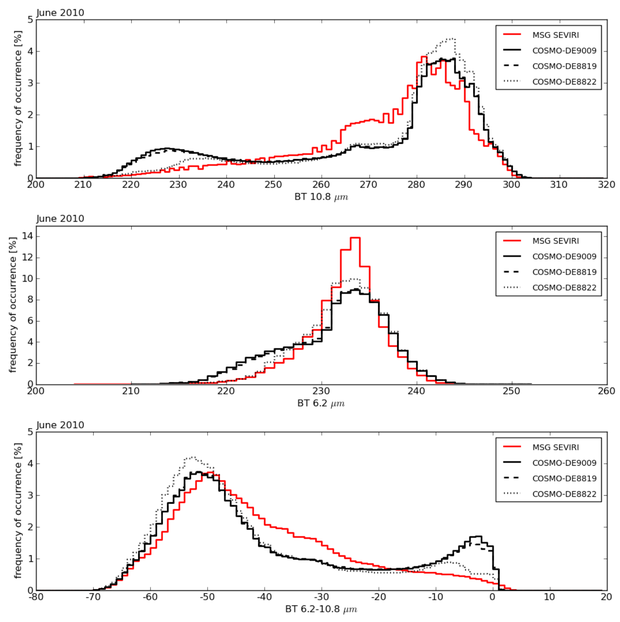

***Fig. 2**: Frequency of occurrence of brightness temperatures (BTs) for June 2010. Only 12 h old runs included.*

→ Multi-year feature is reproducable for 1 month and for single cases.

→ Ctrl runs COSMO-DE9009 and 8819 do not differ much.

→ The new COSMO-DE8822 performs distinctly better than 9009 and 8819.

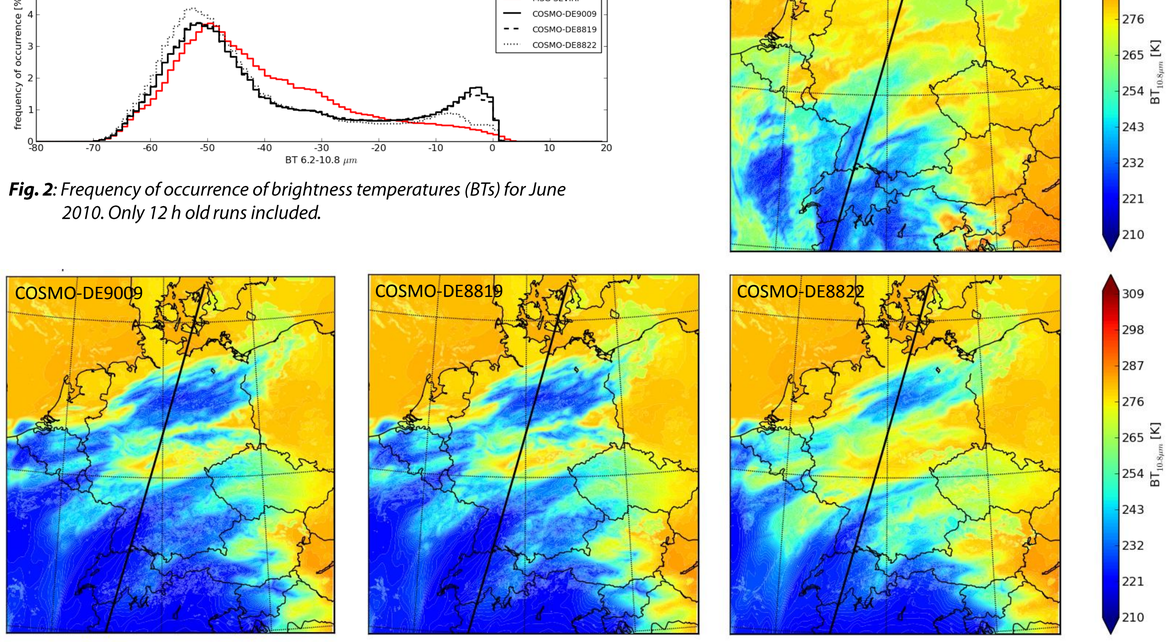

***Fig. 3**: Brightness temperatures (BTs) at 10.8 µm for 15 June 2010 14 UTC as measured from MSG SEVIRI (top) and simulated from COSMO-DE 9009 (left), 8819 (centre), and 8822 (right). Black line denotes CloudSat overpass.*

4. Main runs vs level runs

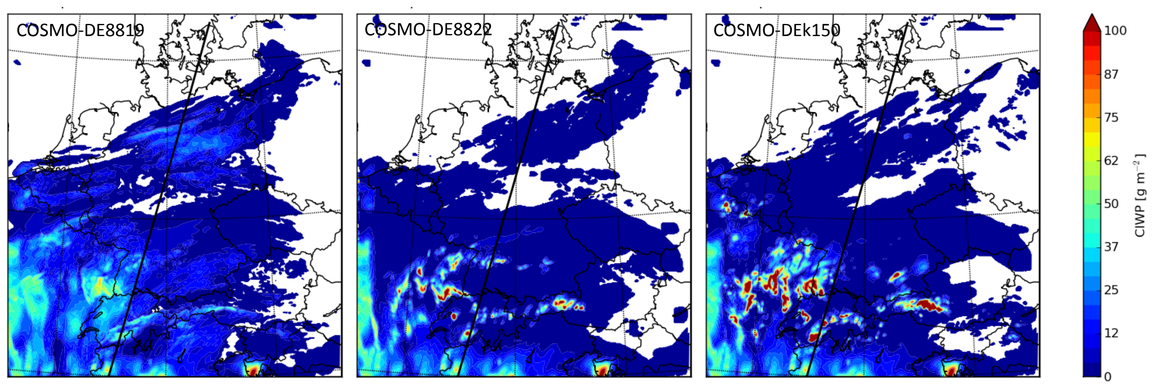

***Fig. 4**: Cloud ice water paths (CIWPs) for COSMO-DE8819 (left), COSMO-DE8822 (centre), and COSMO-DEk150 (right) for 15 June 2010 14 UTC. Black line denotes CloudSat overpass.*

→ Both the new COSMO-DE8822 and the increased level number COSMO-DEk150 produce more distinct features in comparison to the ctrl run COSMO-DE8819.

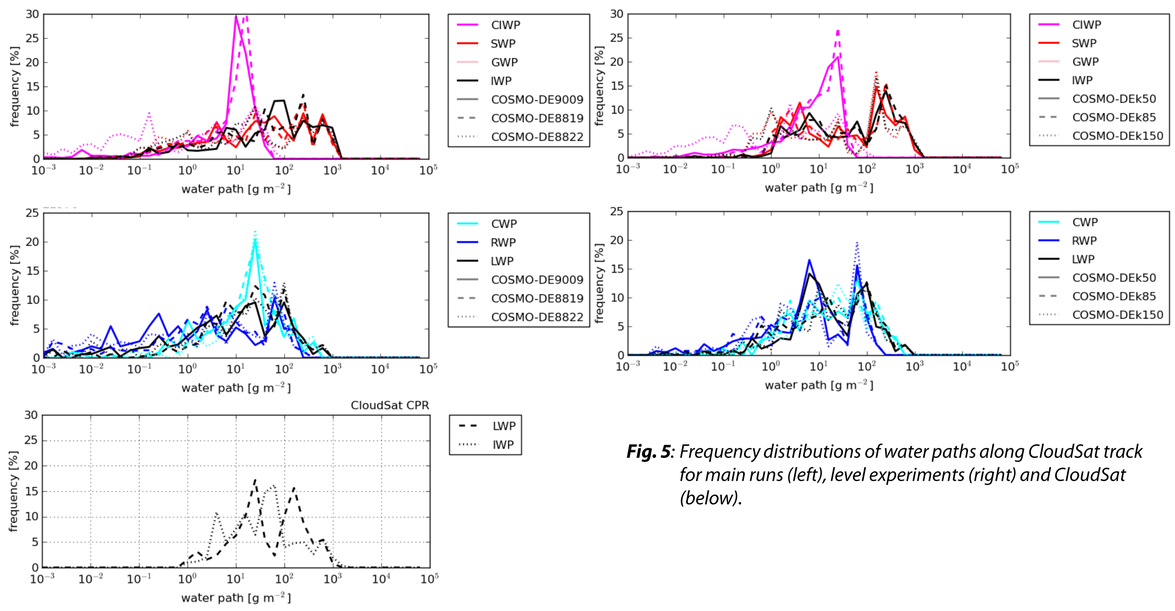

***Fig. 5**: Frequency distributions of water paths along CloudSat track for main runs (left), level experiments (right) and CloudSat (below).*

→ Both the new COSMO-DE8822 and COSMO-DEk150 reduce CIWP distinctly.

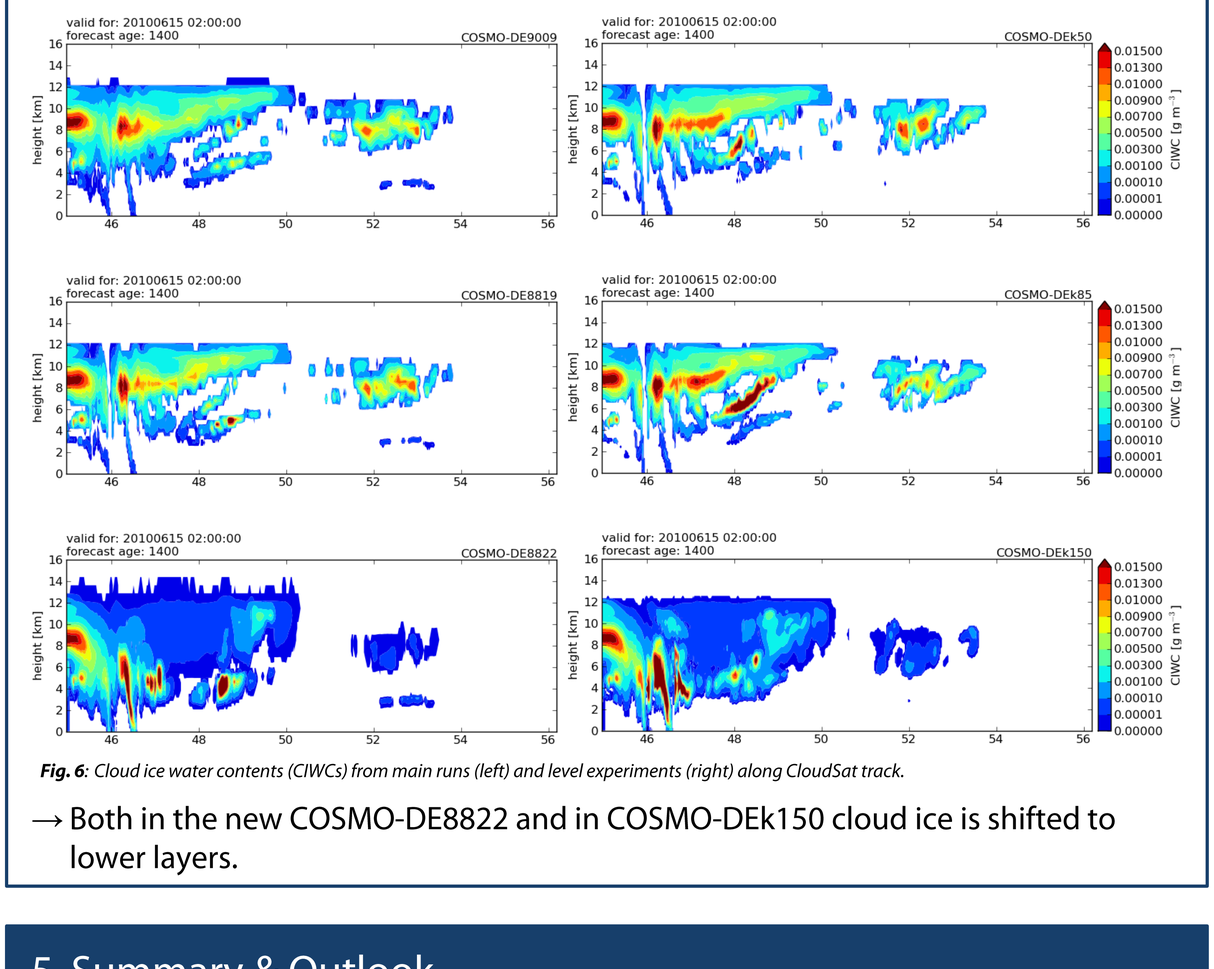

***Fig. 6**: Cloud ice water contents (CIWCs) from main runs (left) and level experiments (right) along CloudSat track.*

→ Both in the new COSMO-DE8822 and in COSMO-DEk150 cloud ice is shifted to lower layers.

5. Summary & Outlook

Novel ice microphysical scheme in COSMO-DE8822 has similar effect on cloud ice water content and vertical distribution of cloud ice as an increase in level number.

To-Do: Perform sensitivity experiments - part II: Which of the changes in the new scheme of COSMO-DE8822 is responsible for the improved performance? One specific different process treatment or rather the combination of all four?

References:

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