Recent ALARO microphysics developments

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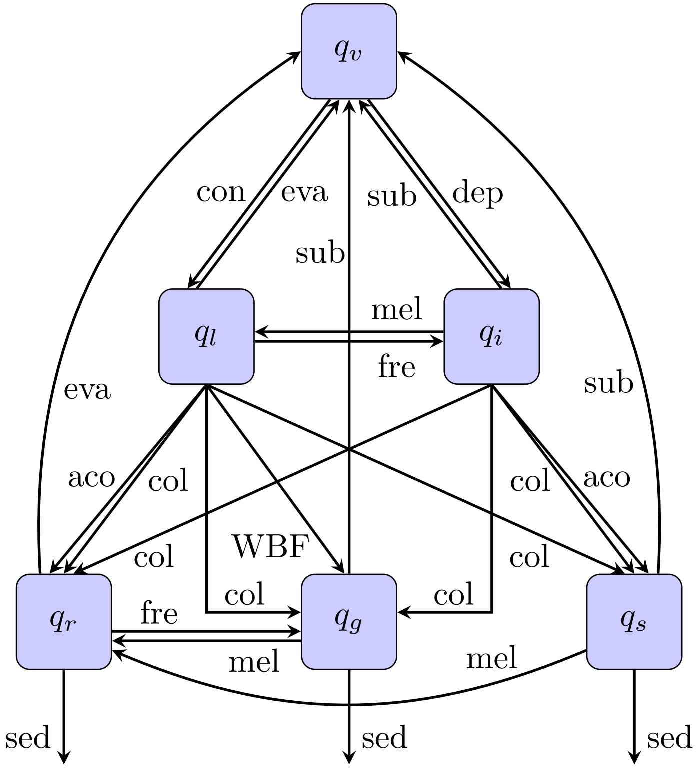
Table of contents

Current single-moment scheme

- only mass fraction of hydrometeors q is prognostical
- cloud water/ice, rain, snow, graupel
- negative-exponential size distribution
- condensates from cloud scheme and 3MT combined
- processes:
  - autoconversion + WBF process
  - collection of cloud species
  - evaporation
  - melting



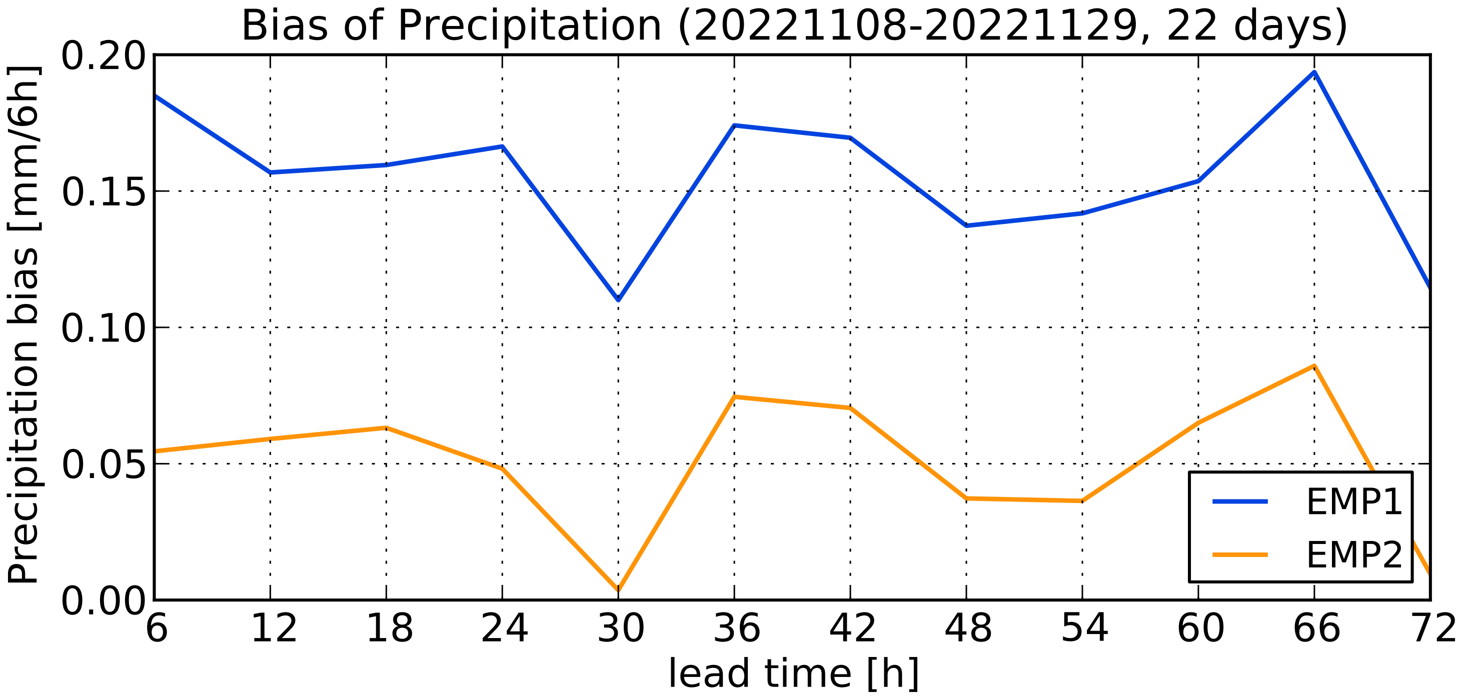
Recent change of the evaporation scheme

- original Kessler scheme based on tabulated data from Smithsonian Meteorological Tables (1953)
- known to underestimate evaporation rates (Ghosh and Jonas, 1998)
- current Lopez scheme based on the "standard" evaporation equation (for one drop):

$$\frac{dm}{dt} = \frac{2\pi D(R_H - 1)}{\mathcal{K} + \mathcal{D}} F$$

- then integrated over the whole size spectrum

Reduction of precipitation bias in autumn



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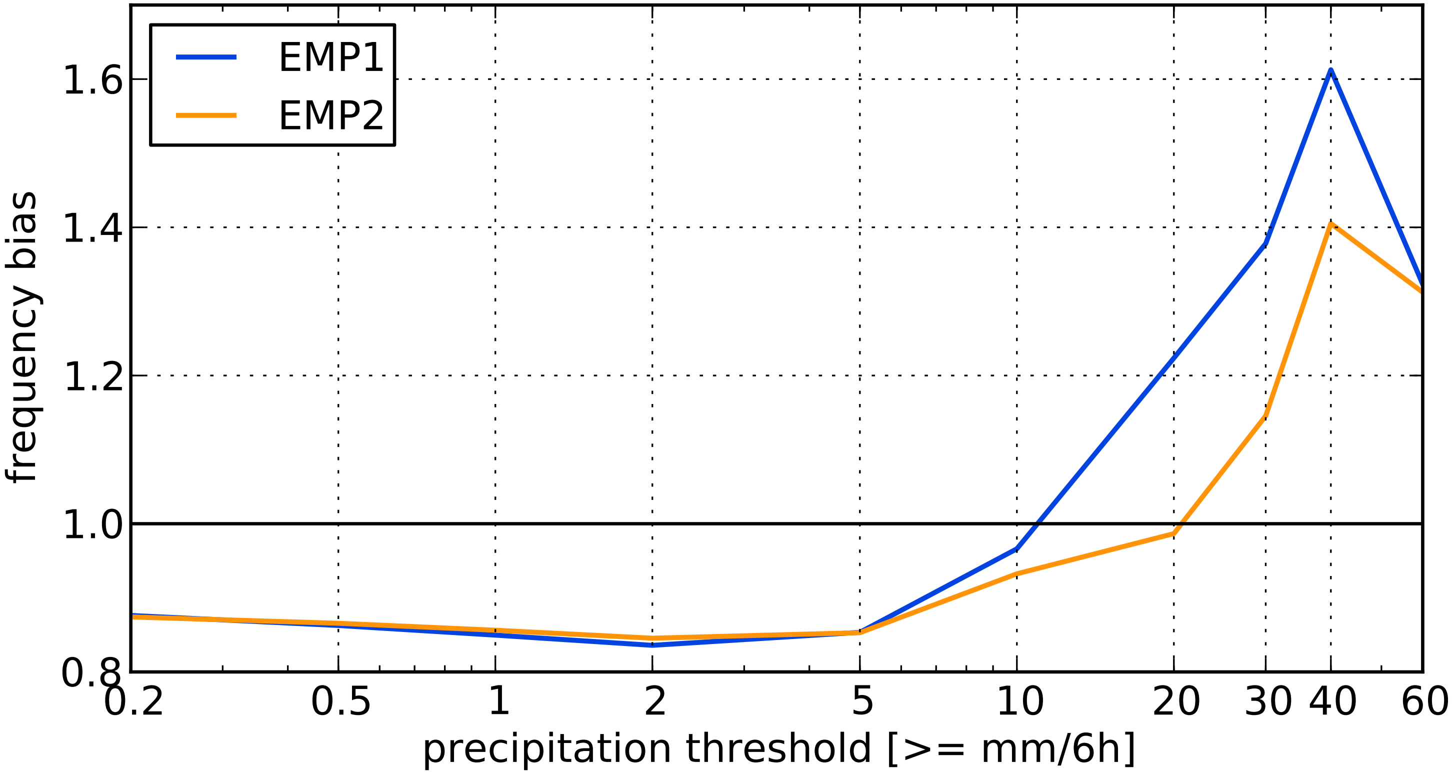
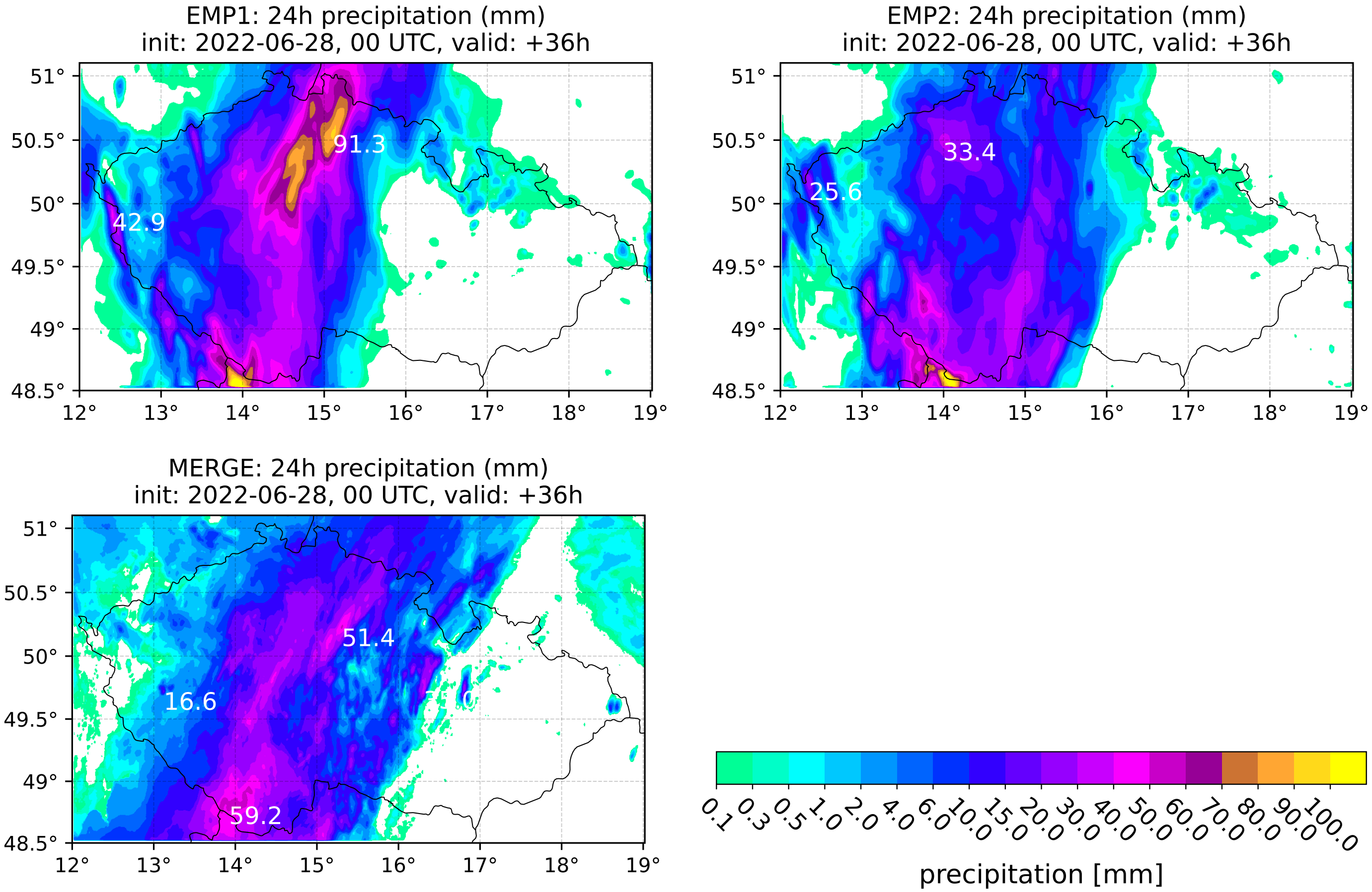
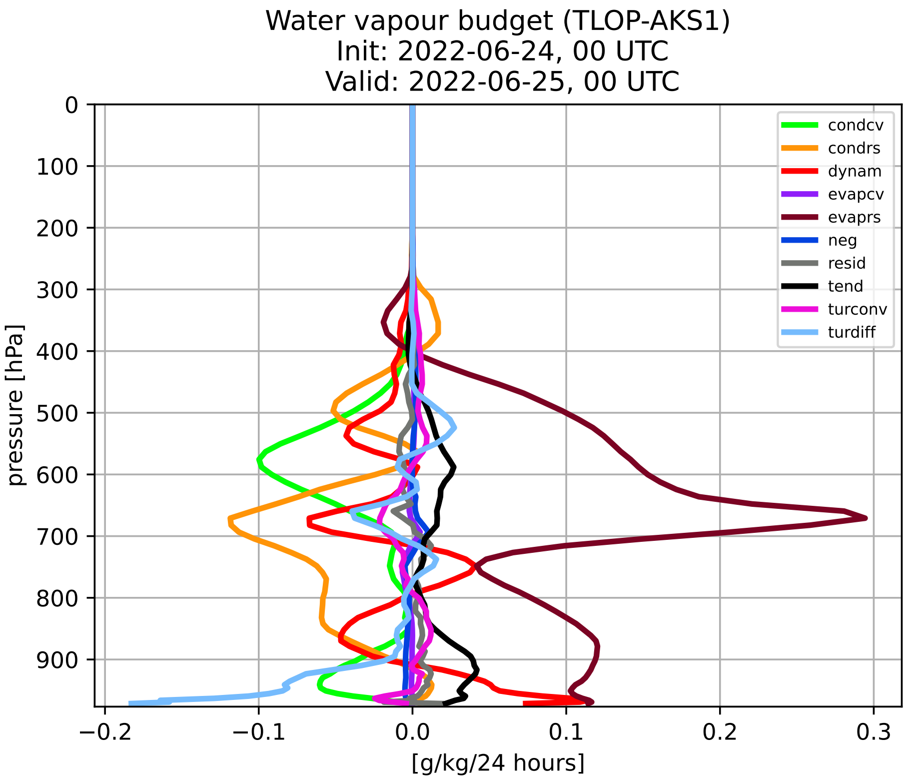
Reduction of frequency bias in summer



Sometimes the change can be noticeable



Melting tooth



Why a double-moment scheme?

- prognostics: mass fraction q and number concentration N_l [kg^{-1}]
- distinction between drops of different origins: big from melting, small in drizzle
- can account for cloud-aerosol interaction
- but also more computationally expensive
- new processes necessaary:
  - activation scheme
  - self-collection + break-up

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Principles we keep

- ascending compatibility
- NWP oriented
- in 3MT cascade
- CAMS aerosols

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CAMS aerosols

- climatological: 11 species
- near-real time: 14 species (+ 2 nitrates and amonium)
- each of them has size distribution, taken from Bozzo (2020)
- microphysics needs 2 categories: soluble and insoluble
- climatological for first tests

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Current status of developments (1/2)

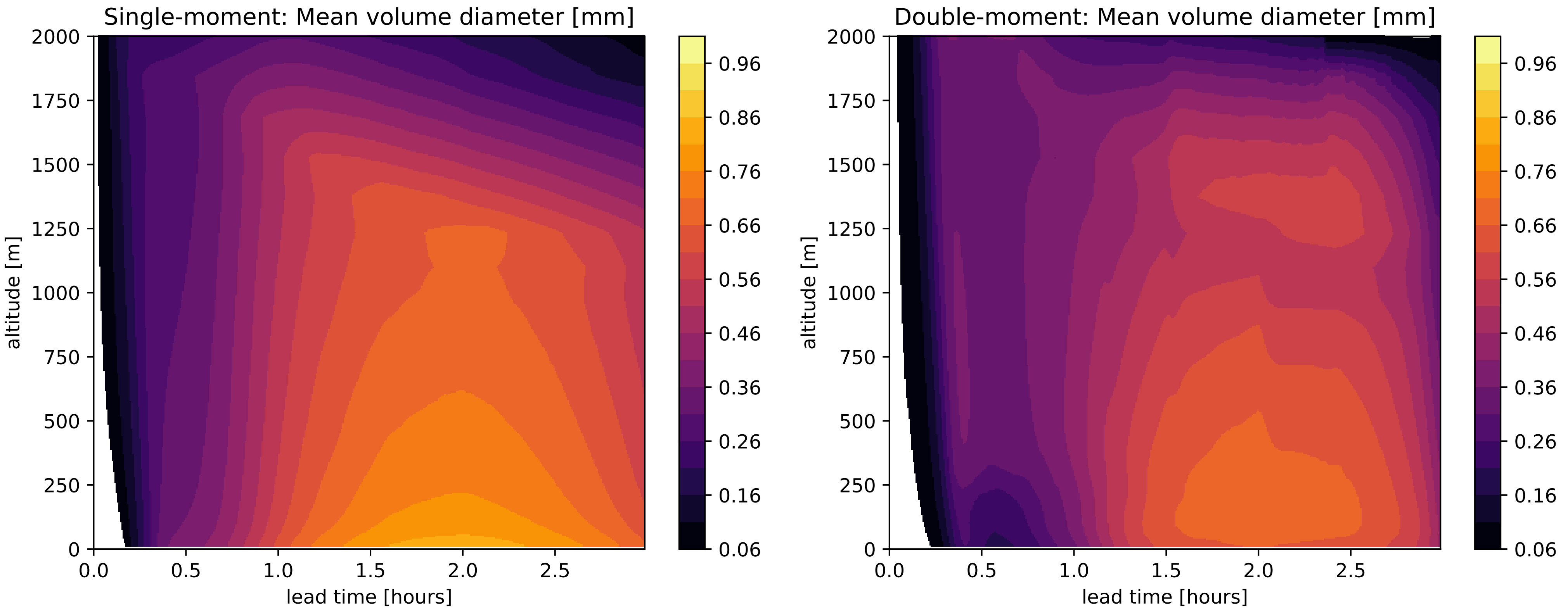
- two moments for cloud water and rain
- or cheap diagnostic of N_l every time-step
- gamma distributions:

$$N(D) = N_T \frac{\lambda^{\mu+1}}{\Gamma(\mu+1)} D^{\mu} e^{-\lambda D}, \quad \lambda = \left[\frac{\rho_w \pi N_T \Gamma(\mu+4)}{6 \rho_a \Gamma(\mu+1) q} \right]^{\frac{1}{3}} \tag{1}$$

Current status of developments (2/2)

- activation based on T, w, and aerosol concentration
- loss of N_l: self-collection
- autoconversion dependent on q_l, N_l, μ_l
- continuous collection model
- Lopez evaporation

Maximum of $\overline{D_r^V}$ near melting



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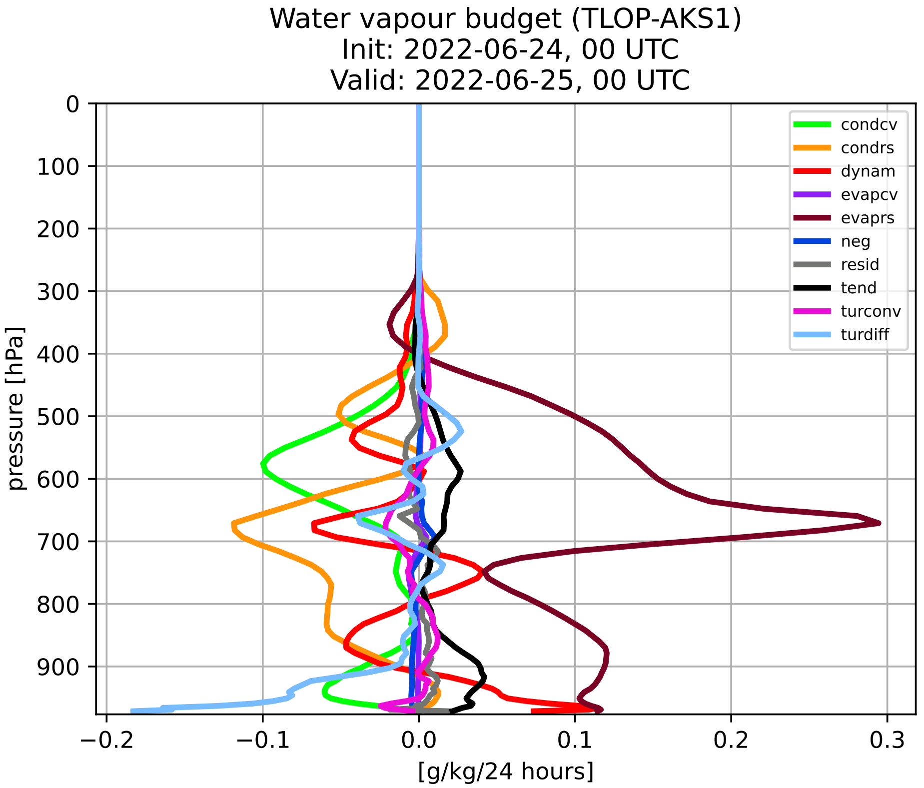
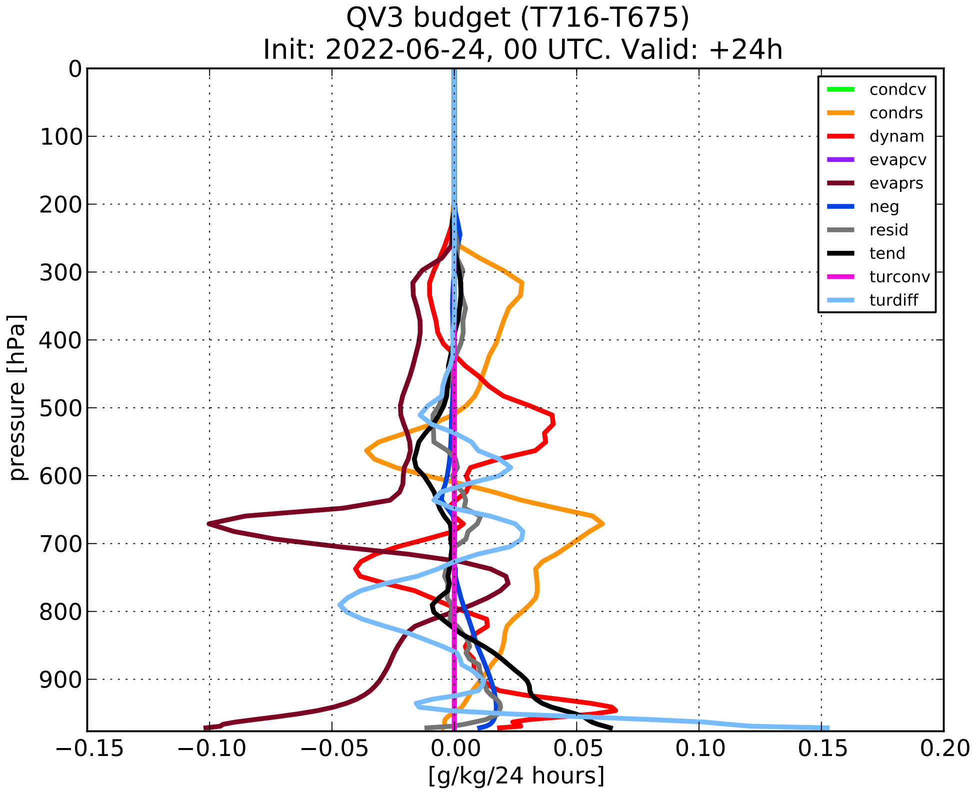
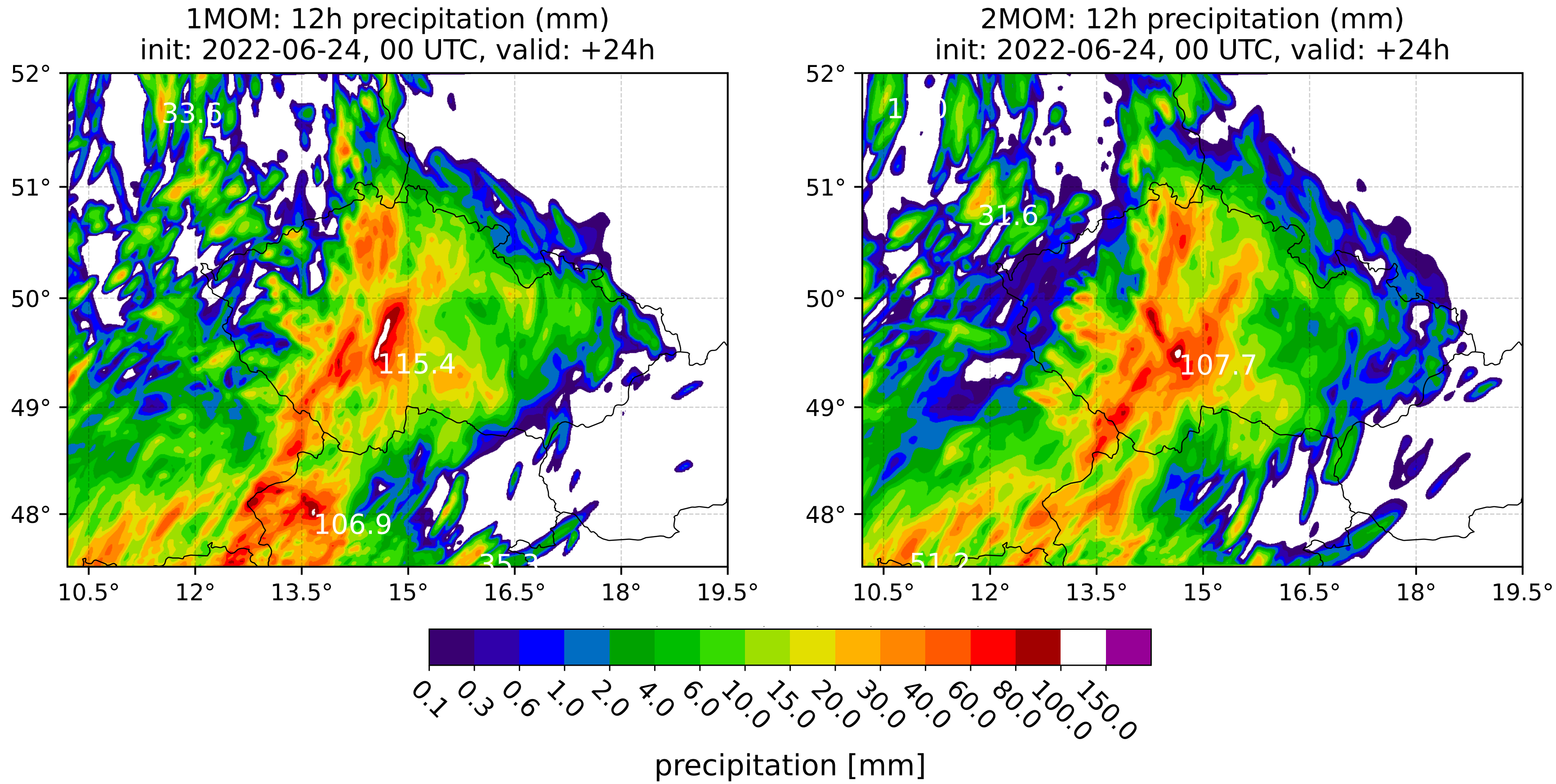
Reduced evaporation near melting

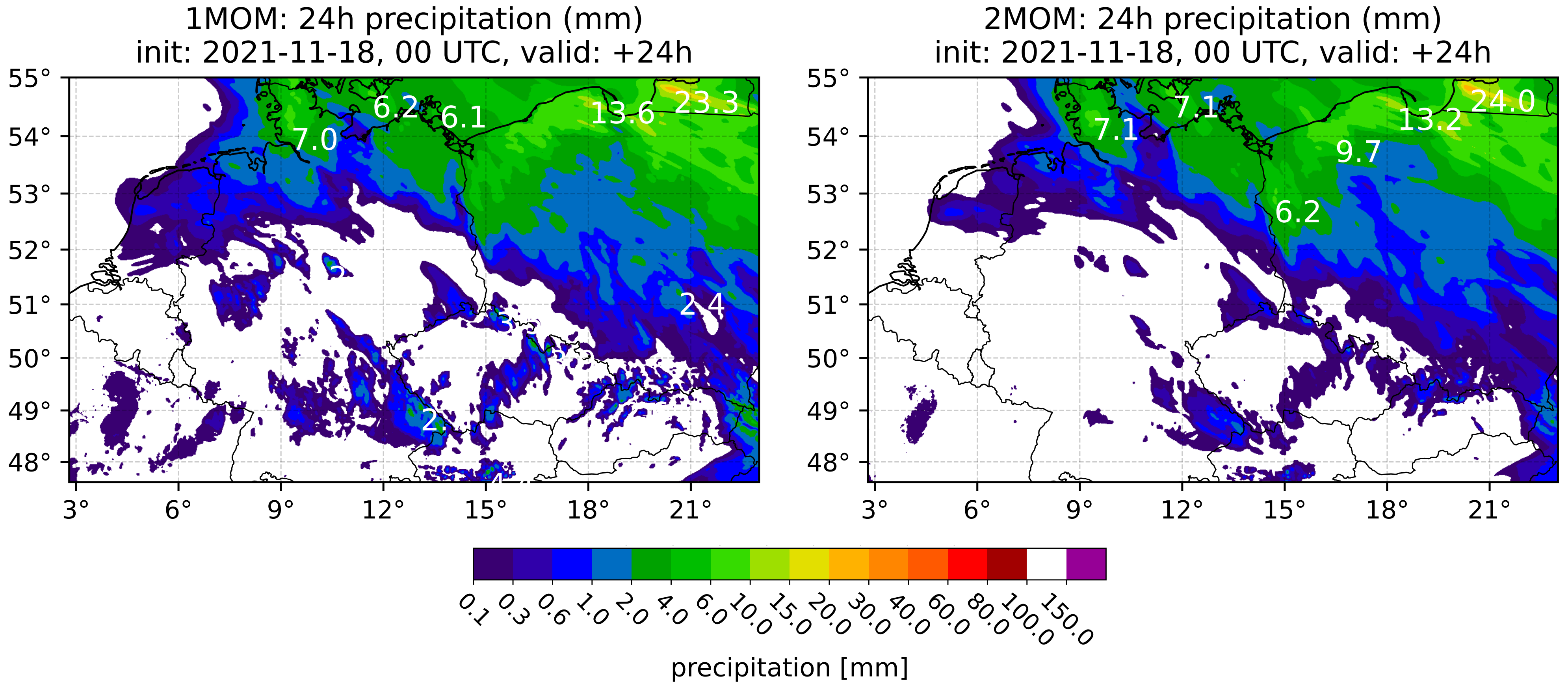




More light rain around storms (right)



Less light rain in autumn (right)



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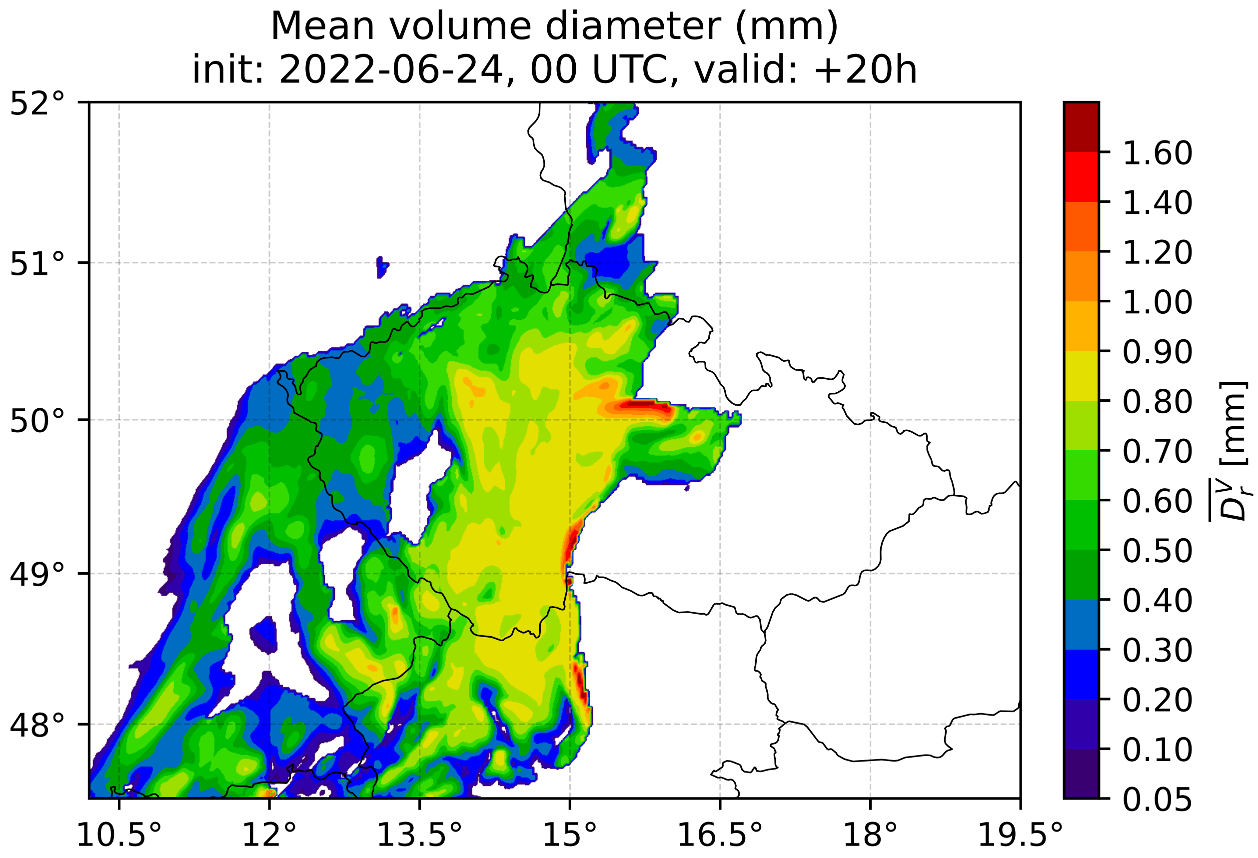
Mean volume diamater in a MCS: lowest level



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Conclusion

- updated evaporation scheme for the single-moment scheme
- first steps towards the double-moment rain and cloud water are done
- still issues to be solved
- future plans: tests with double-moment cloud ice, maybe snow and graupel + some other improvements along the way

Thank you for your attention

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