Tropical convective systems in the CNRM global km-scale model

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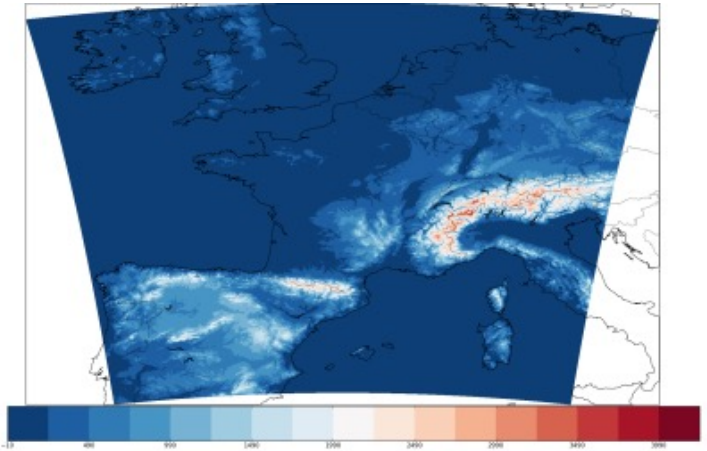
AROME-global



AROME

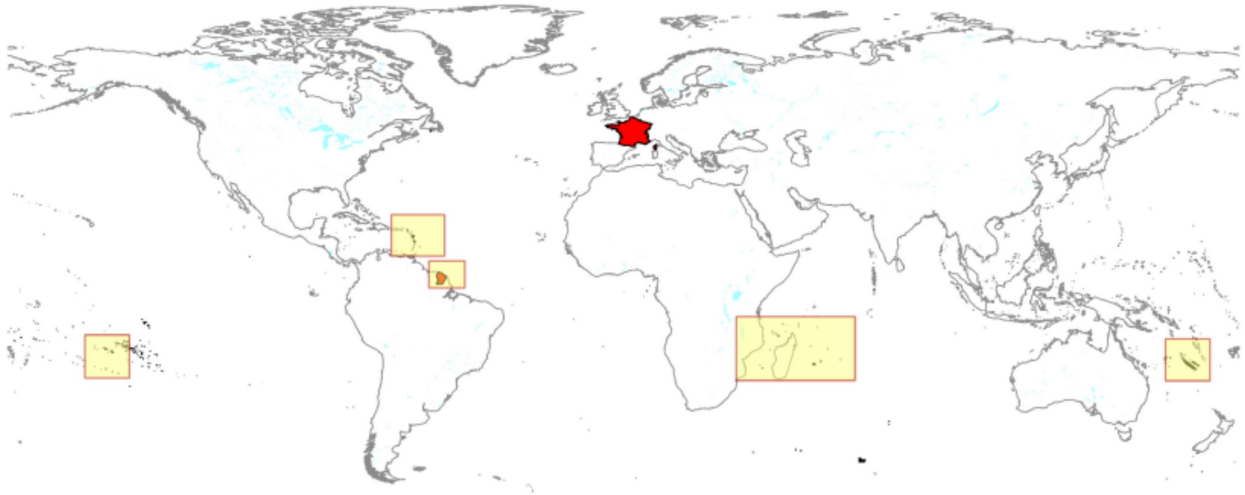
- Operational over France since 2008,
  over French overseas territories since 2015
- ➢ Developed for km-scale modelling and validated for more than 10 years

AROME-Global

- ARPEGE-IFS dynamical core, with non-hydrostatic option
- Atmospheric and surface physics from AROME
- TL8000 (2.5 km), 75 vertical levels

DYAMOND2 simulation

- 20/01/2020 – 19/05/2020 (4 months)
- Initialized from ECMWF analysis
- Prescribed SST/SIC (smoothed over 7 days)
- 15-min 2D and 3D output
- ➢ Only the first 20 days are analysed



AROME-Global performance to capture tropical mesoscale convective system (MCS) properties?

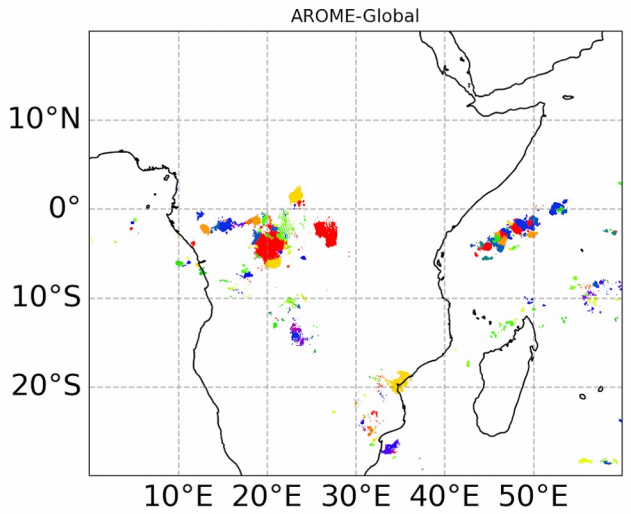
Detecting and tracking convective systems

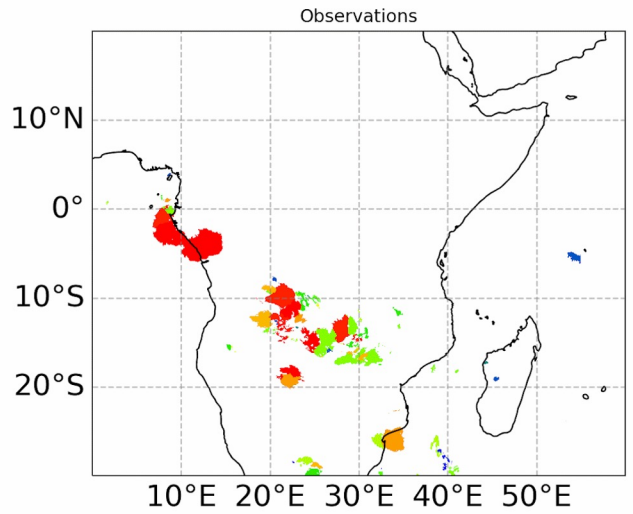
TOOCAN

- Detection and tracking of MCS
- Temporal resolution: 30 min
- Based on infrared brightness temperature
- Cold cloud shield: $T_b \leq 235$ K

AROME-Global(+RTTOV) (2.5 km)

Homogenized geostationary infrared T_b (0.04°)



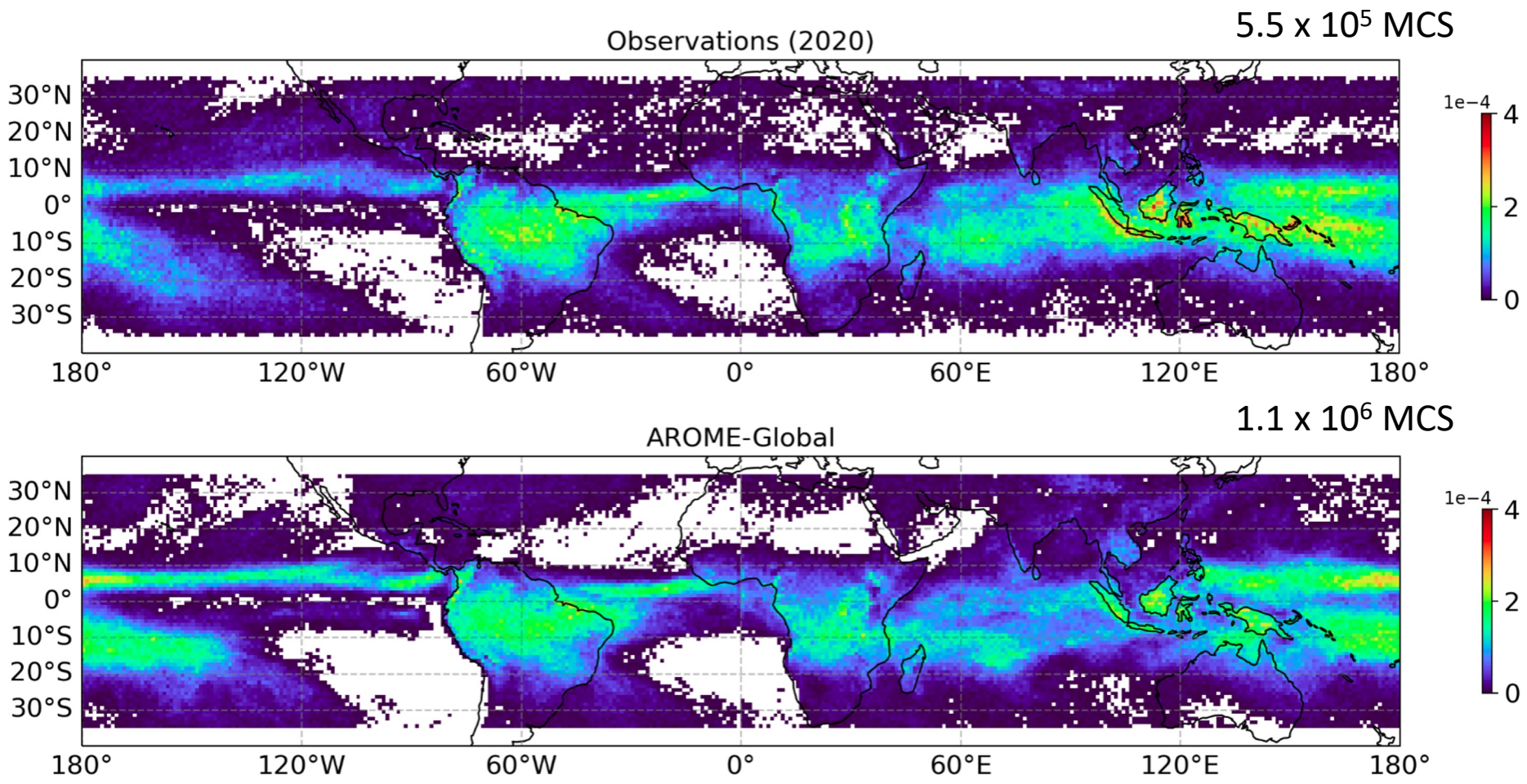


- Lifetime
- Propagation speed
- Position
- Size
- …

Fiolleau and Roca (2013), Fiolleau et al. (2019)

Convective systems in AROME-Global

MCS density (deg^{-2}) normalized by MCS total number

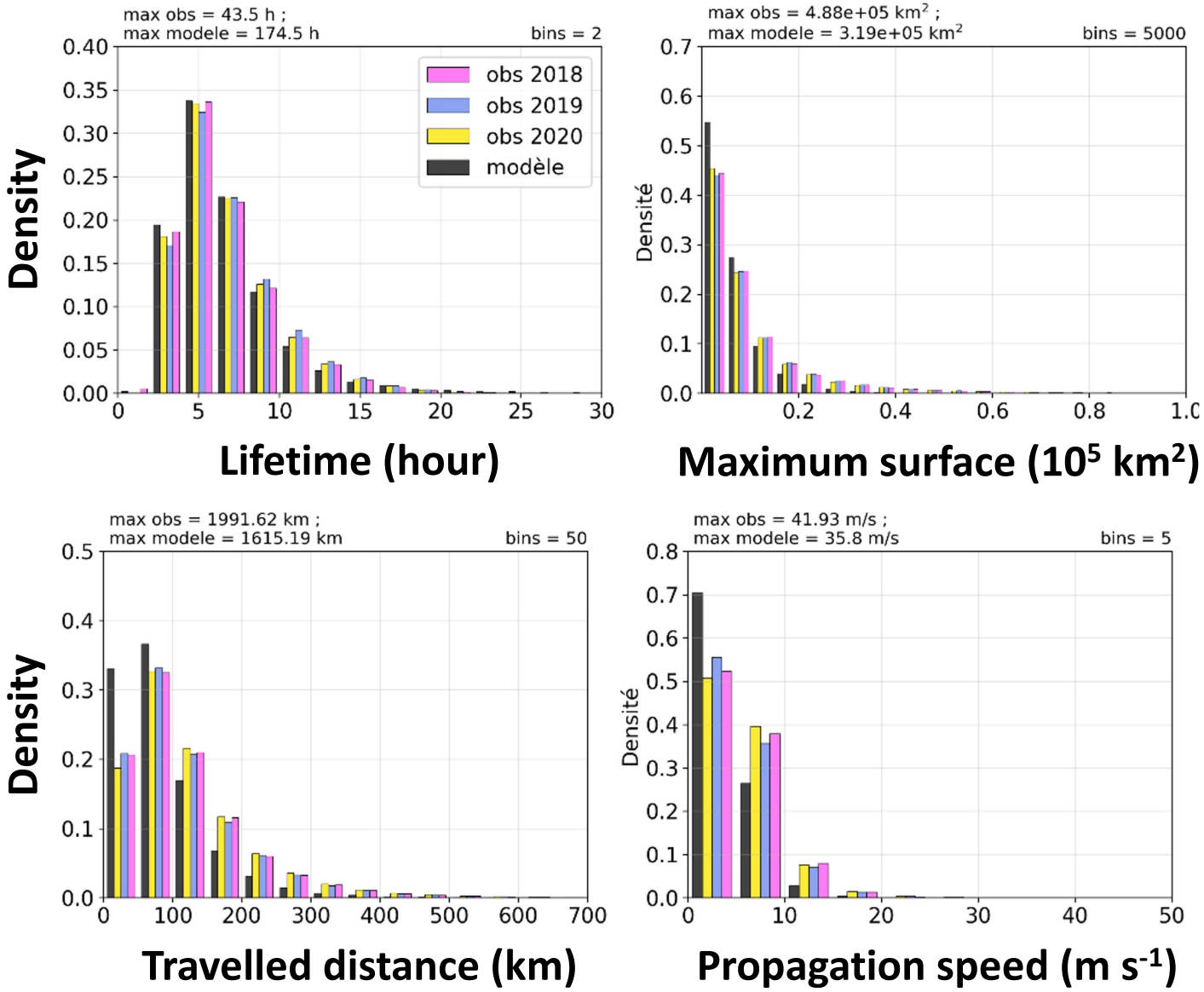


- Overestimated frequency of occurrence (~x2)
- Realistic spatial distribution

Convective systems in AROME-Global

MCS Morphology

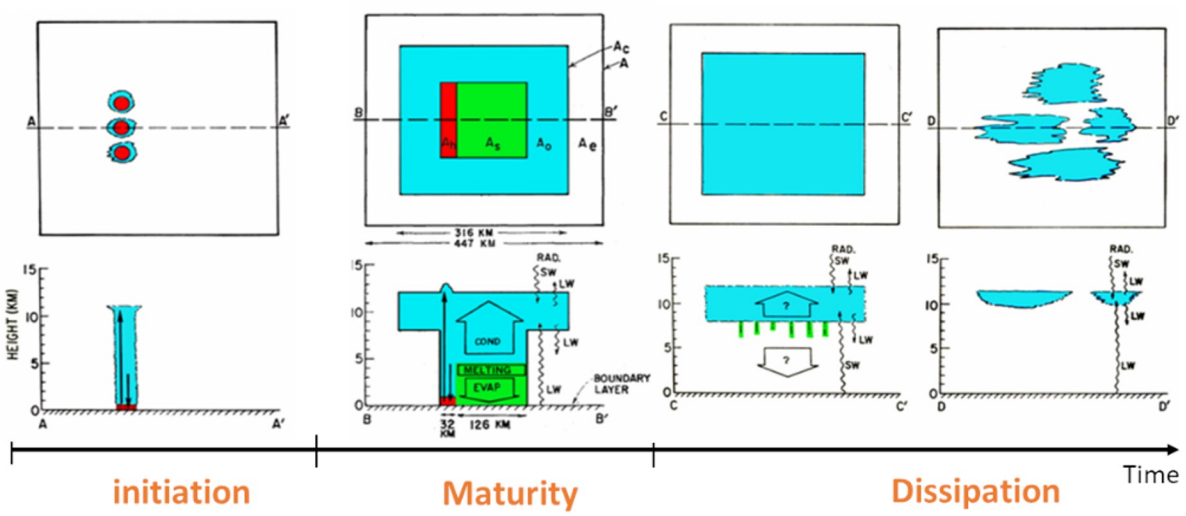
- Rather realistic
- Though AROME-global MCSs are
  - slightly smaller,
  - propagate slightly slowly, and
  - travel over smaller distances

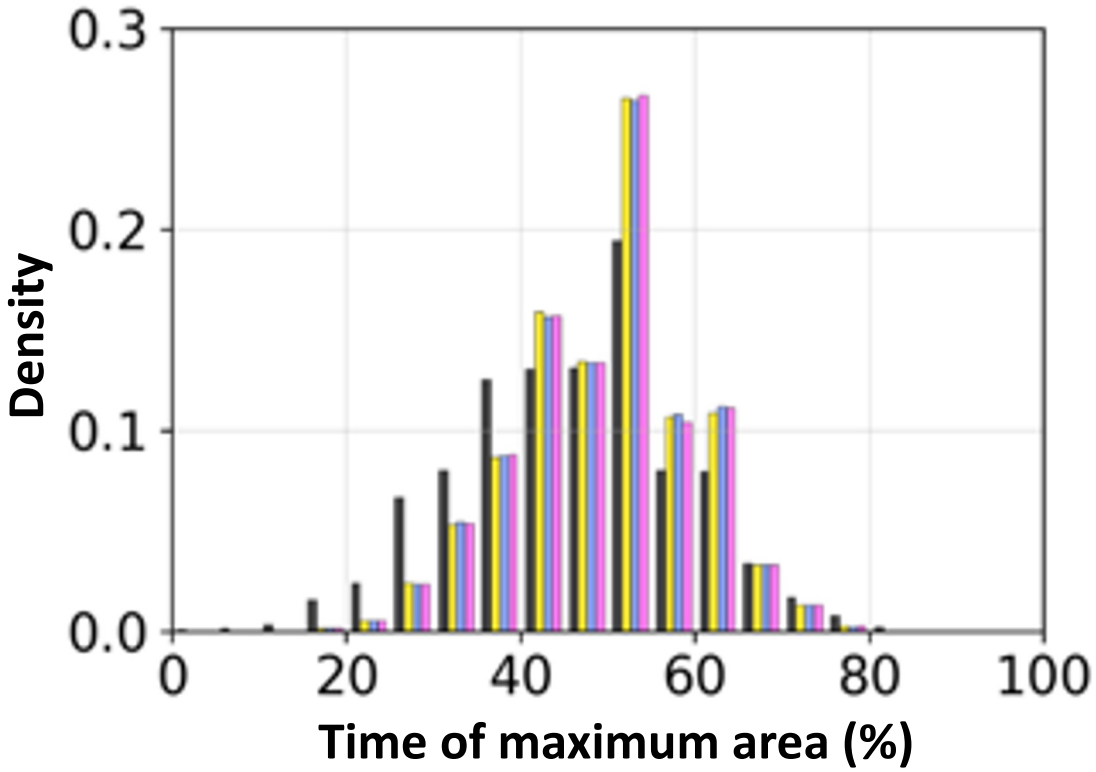


The life cycle of convective systems

MCS life cycle

- The MCS cold cloud shield grows about half of the MCS life cycle and decays the other half





Houze (1982)

The life cycle of convective systems

MCS life cycle

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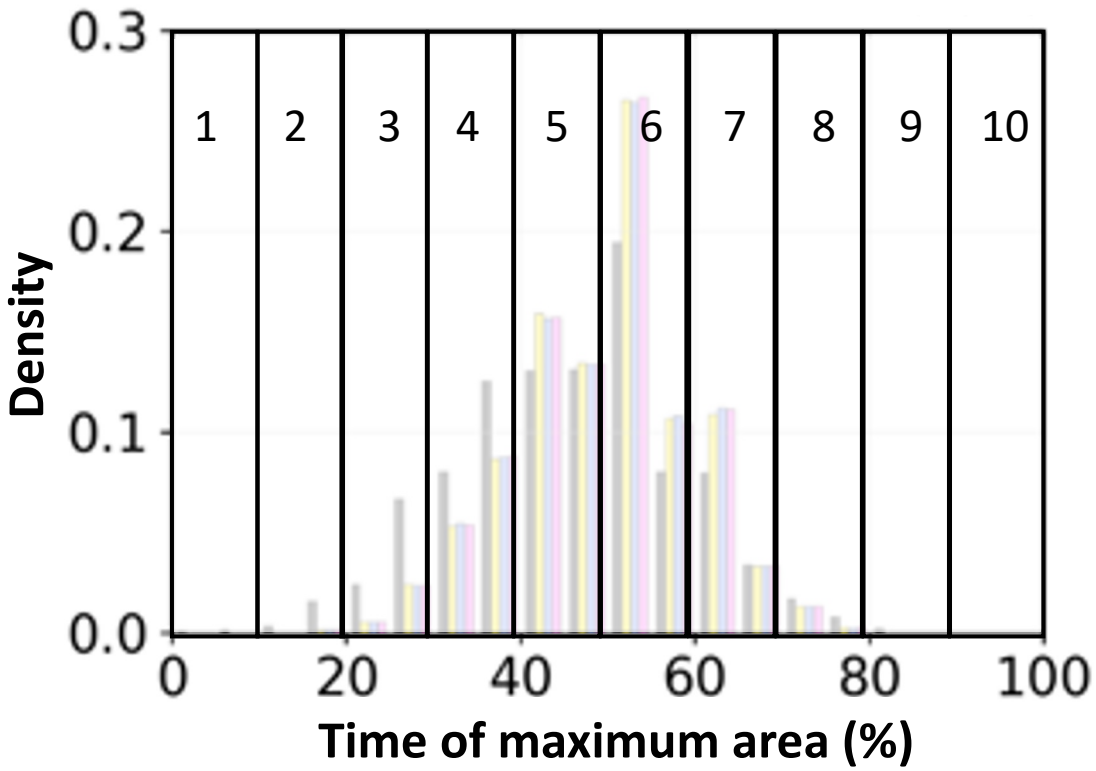
- **The life cyle is divided into 10 steps for composite analysis**

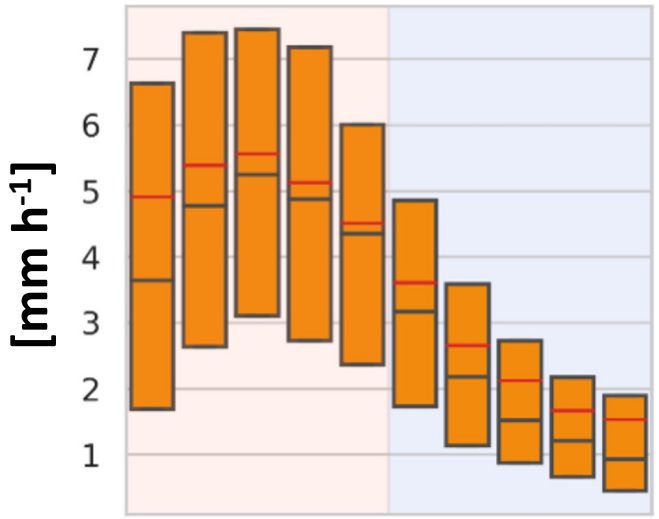


Precipitation along the life cycle of convective systems

Mean conditional rainfall (pr > 1 mm h^{-1}), ocean only

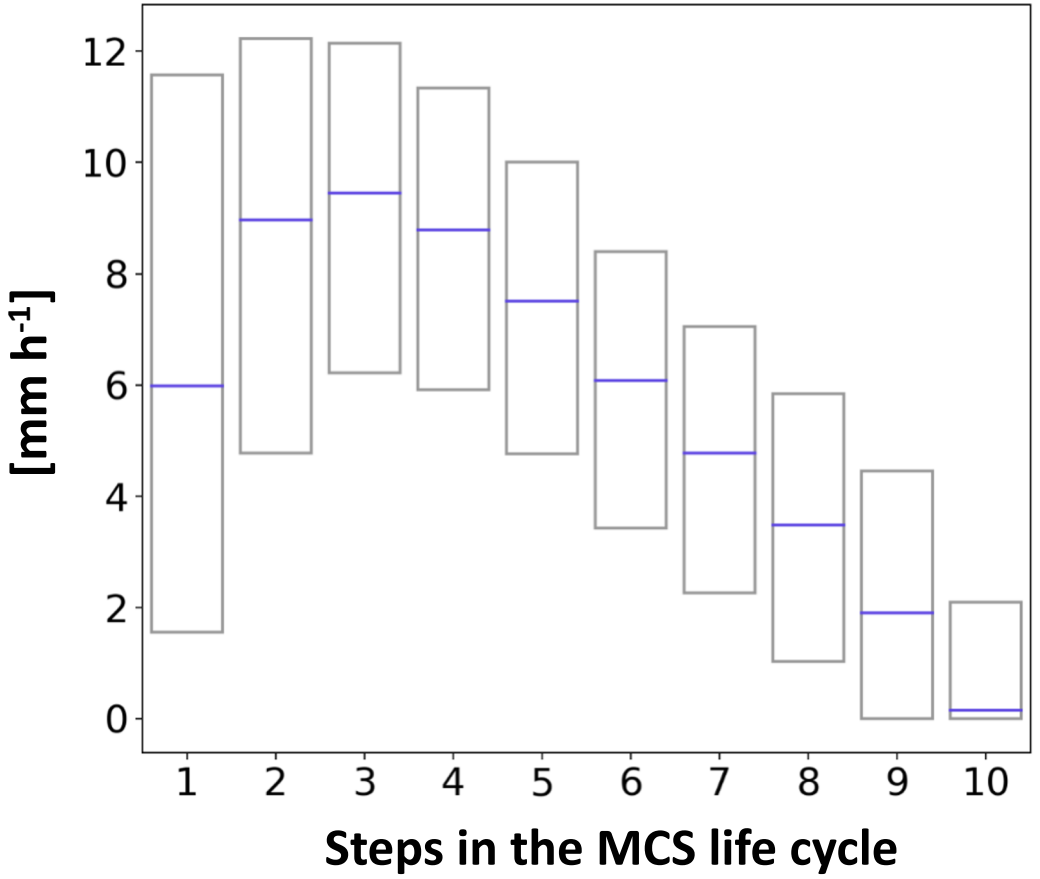
- The dynamics of precipitation along the life cycle is well captured.
- MCS rainfall overestimated, but observation analysis is preliminary and subject to uncertainties

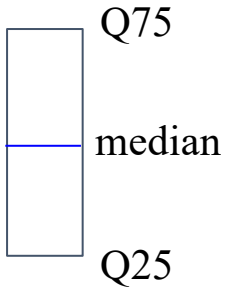
GPM DPR



Courtesy Louis Netz

AROME-Global



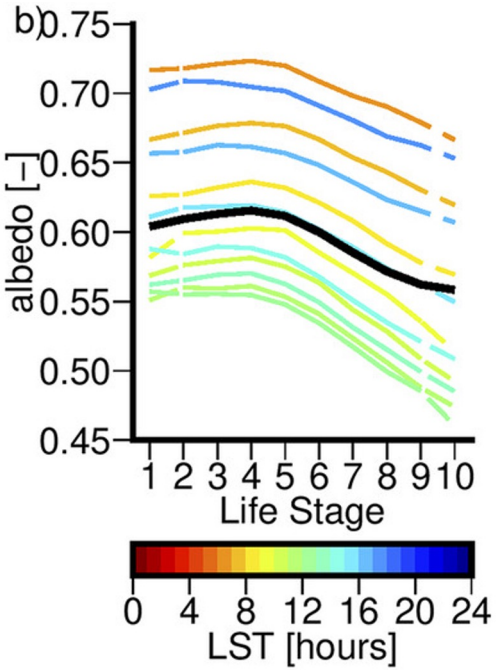


Radiative effects of convective systems

Albedo, ocean only

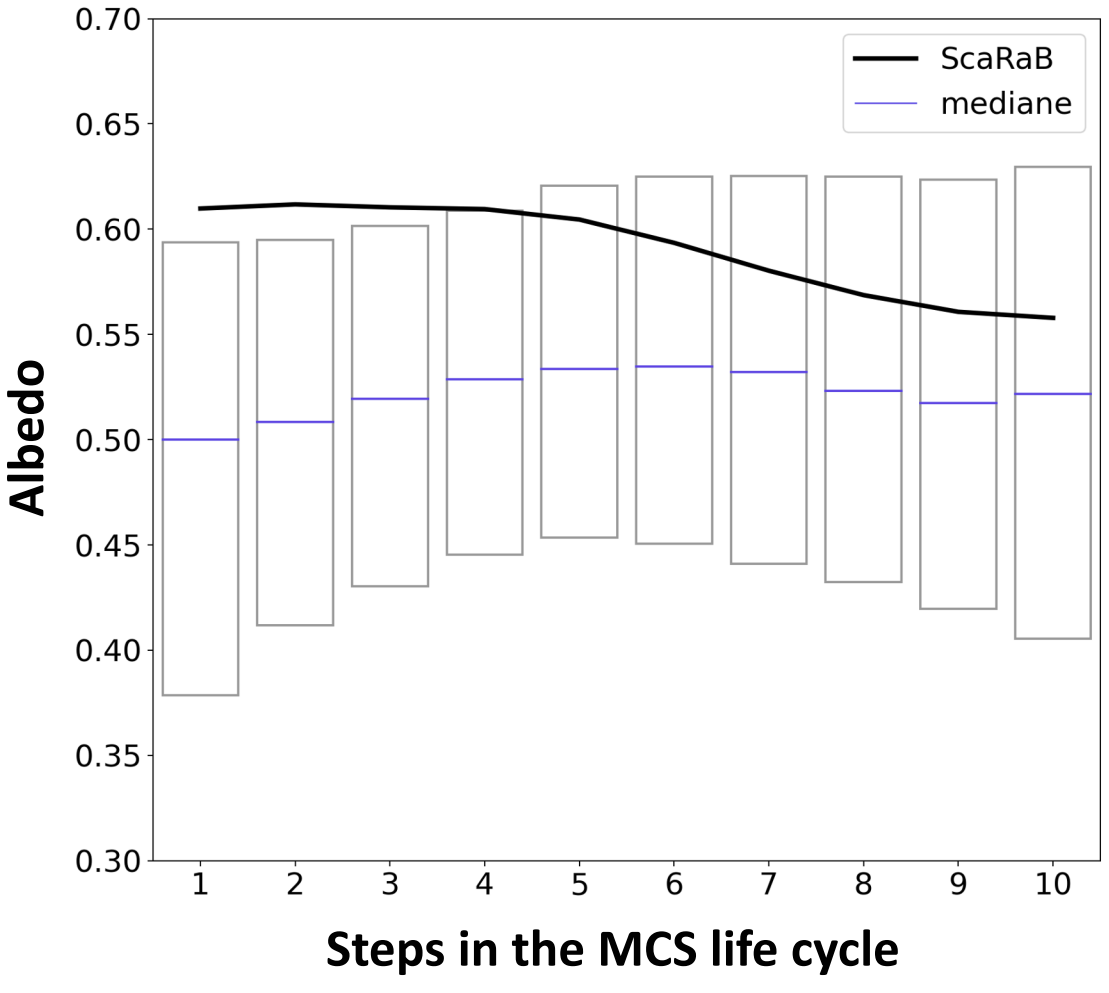
- MCS clouds not reflective enough
- Life cycle dynamics not well captured

ScaRaB



Bouniol et al. (2021)

AROME-Global



Radiative effects of convective systems

Albedo, ocean only

- MCS clouds not reflective enough
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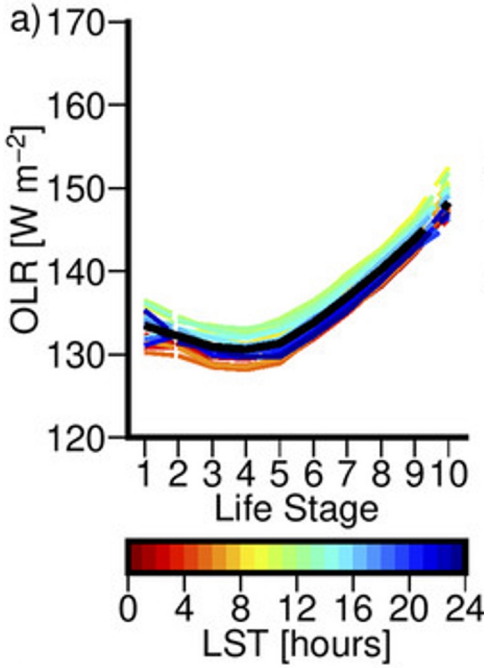
OLR, ocean only

- MCS clouds not opaque enough?
- Beginning of the life cycle dynamics not well captured

ScaRaB



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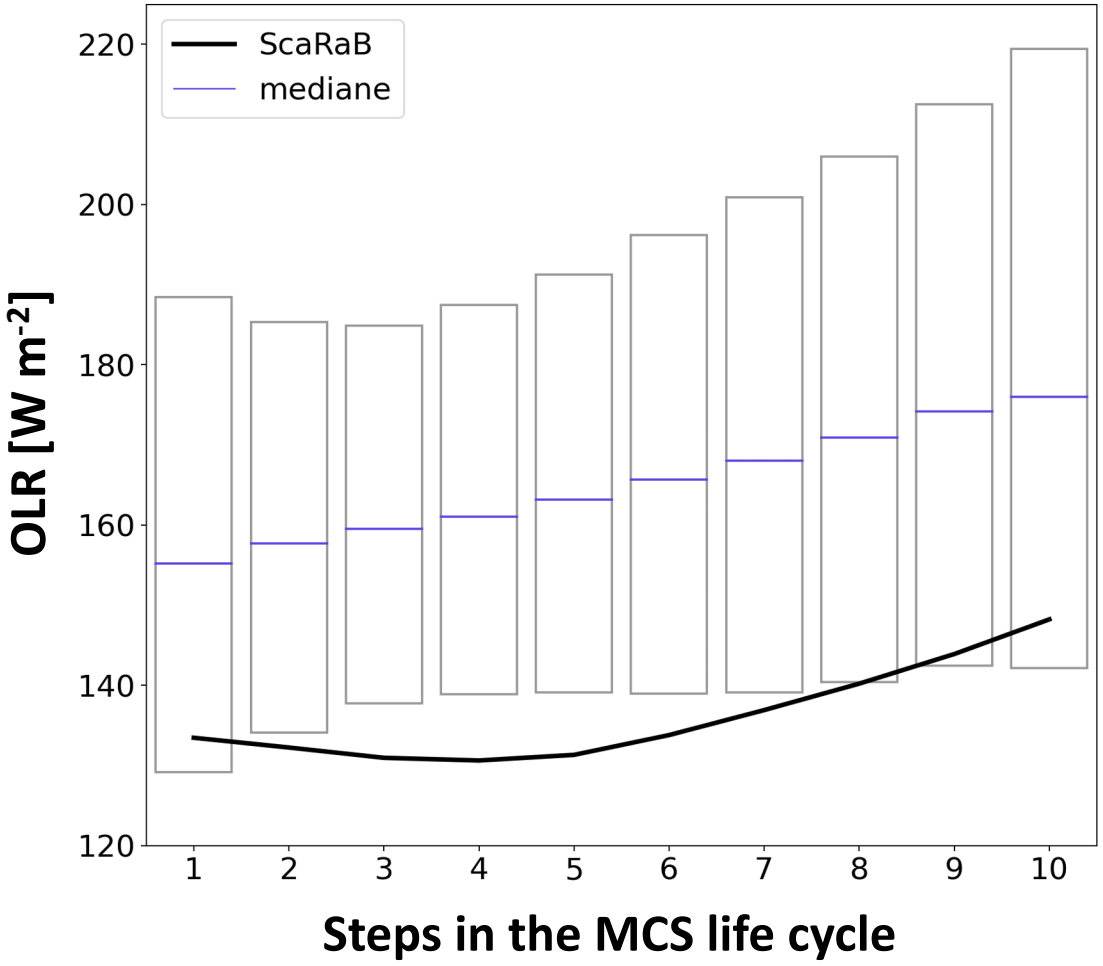
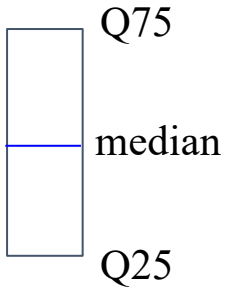
AROME-Global





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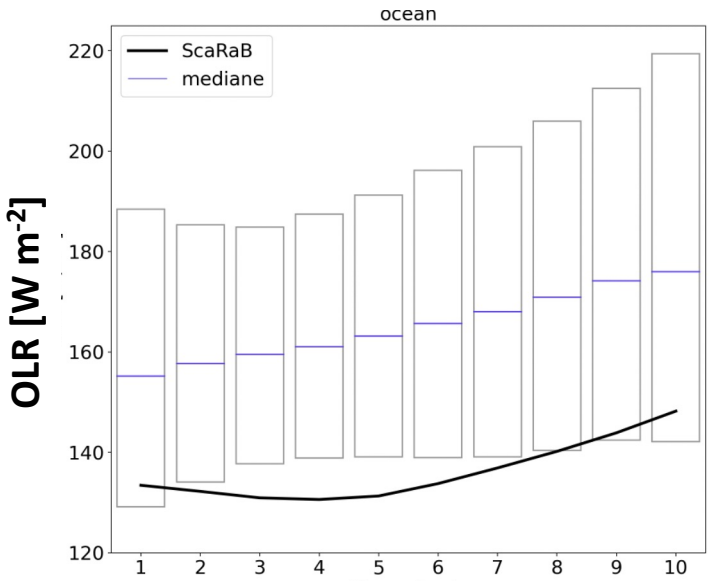
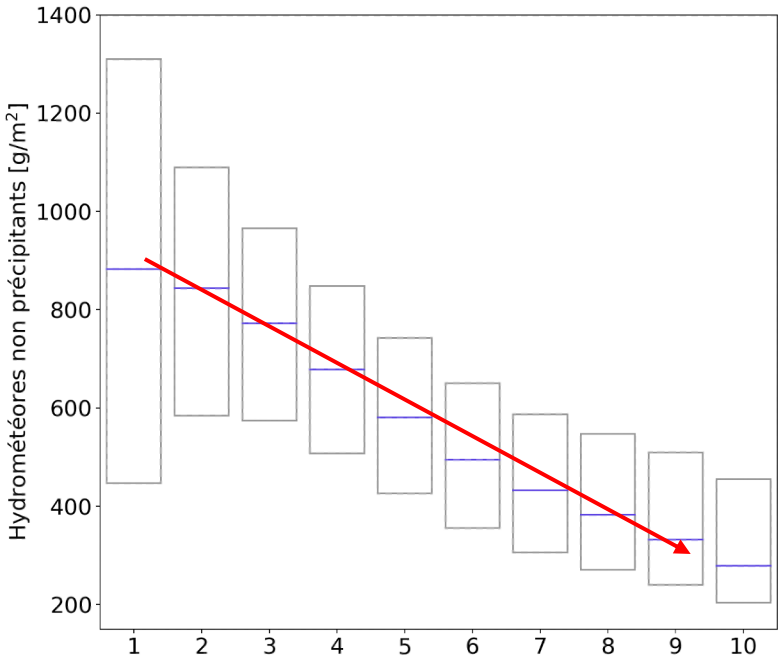


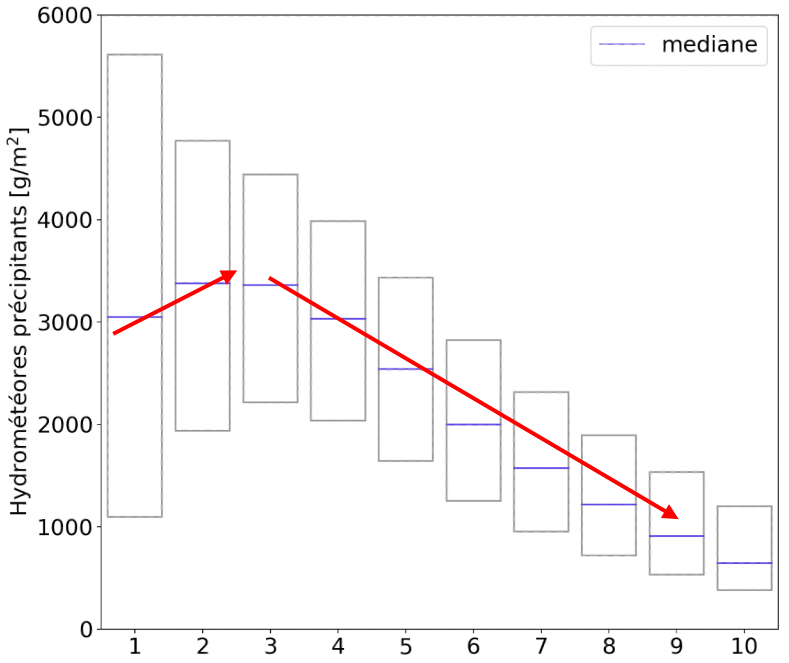
Steps in the MCS life cycle

Non-precipitating hydrometeors



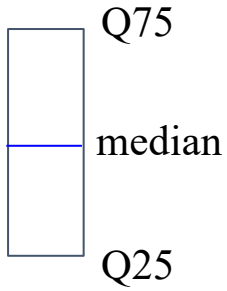
Steps in the MCS life cycle

Precipitating hydrometeors



Steps in the MCS life cycle

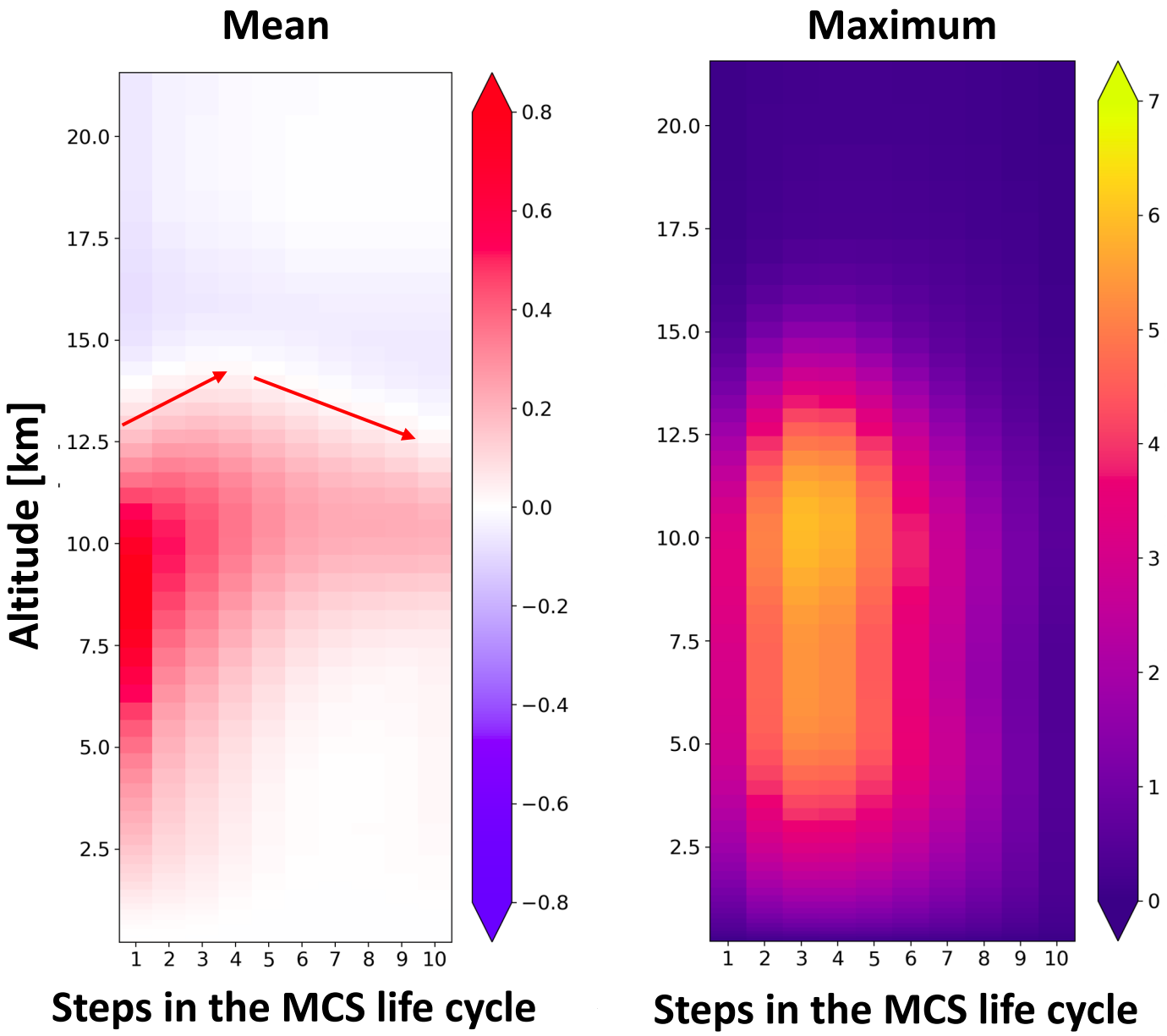
Missing radiative effects of precipitating hydrometeors?



Going beyond observations with the convective system dynamics

Composite vertical velocity

- More intense vertical velocity during the first steps of the life cycle
- Deepening then shallowing and thinning of MCSs



Conclusion

AROME-Global

- Performs rather well in terms of convective systems representation and their relationship with precipitation
- Though
  - MCS are too numerous
  - MCS radiative effects are significantly underestimated (radiative role of precipitating hydrometeors?)

➢ ***The added value of global km-scale models for representing convection is clear but needs to be further quantified and will require further work on parameterizations and model calibration.***

Upcoming satellite missions (CIEL, AOS with C^{2}OMODO and INCUS, WIVERN), which target the measurement of the convective system dynamics, will clearly help make a step forward.

Following steps

- Further understand AROME-global model radiative deficiencies

➢ ***What is the upscaling effects of MCS representation deficiencies on the large-scale features of the simulated climate?***

- Further characterize the MCS properties and dynamics within the AROME-global simulation to
  - Gain further understanding of MCSs at the scale of the tropics
  - Provide some basis to assess to the potential of C^{2}OMODO upcoming measurements
  - Inform the development and evaluation of convection parameterizations for coarser-resolution models