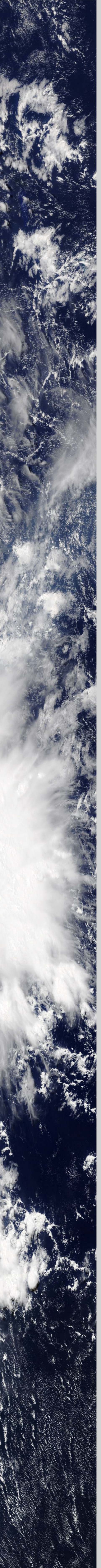

Simple microphysical changes improve cirrus representation in cloud resolving models

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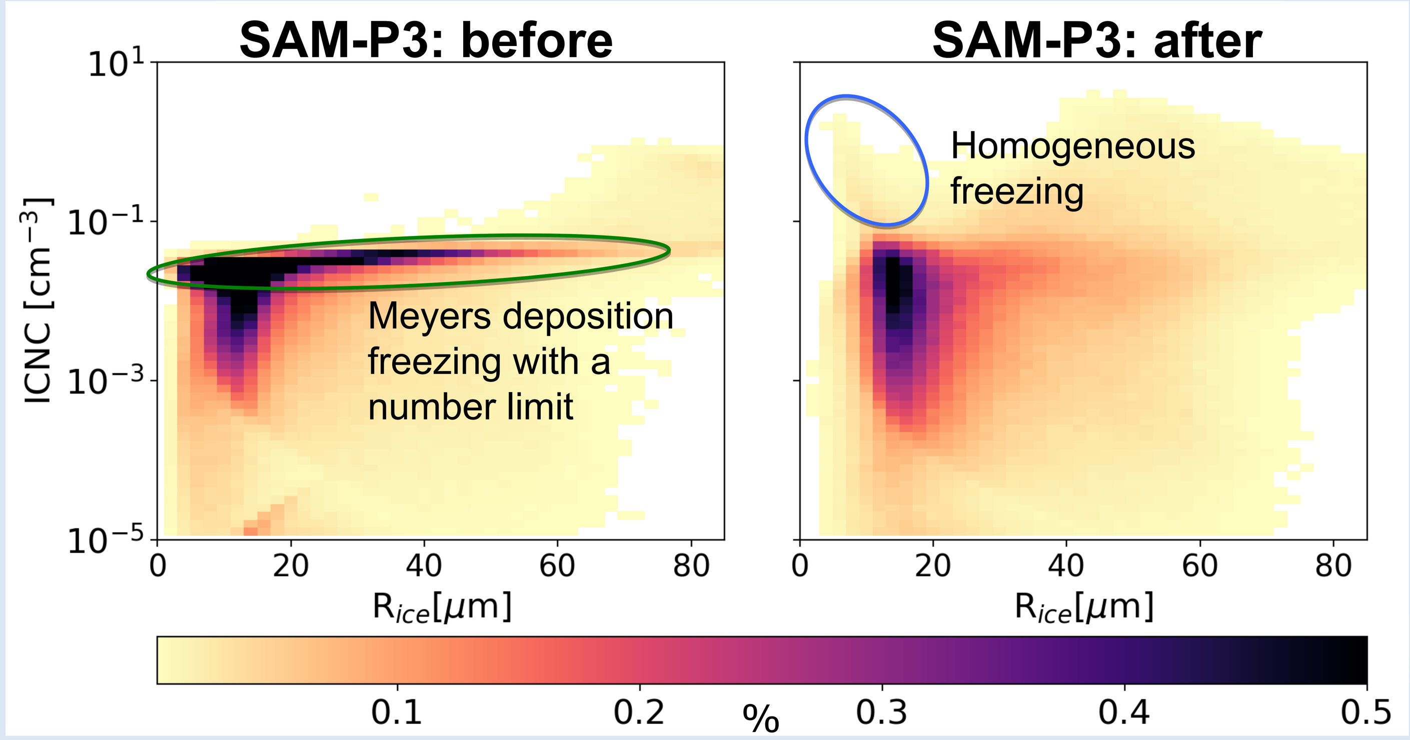
Why and What

(Global) cloud resolving models perform poorly in the representation of tropical cirrus. Most cannot reproduce the observed tropical microphysical and optical properties, leading to substantial radiative biases that decrease the confidence in their climate projections.

In this work we modified the P3 microphysical scheme in SAM cloud resolving model to correctly represent tropical high cloud microphysical properties.

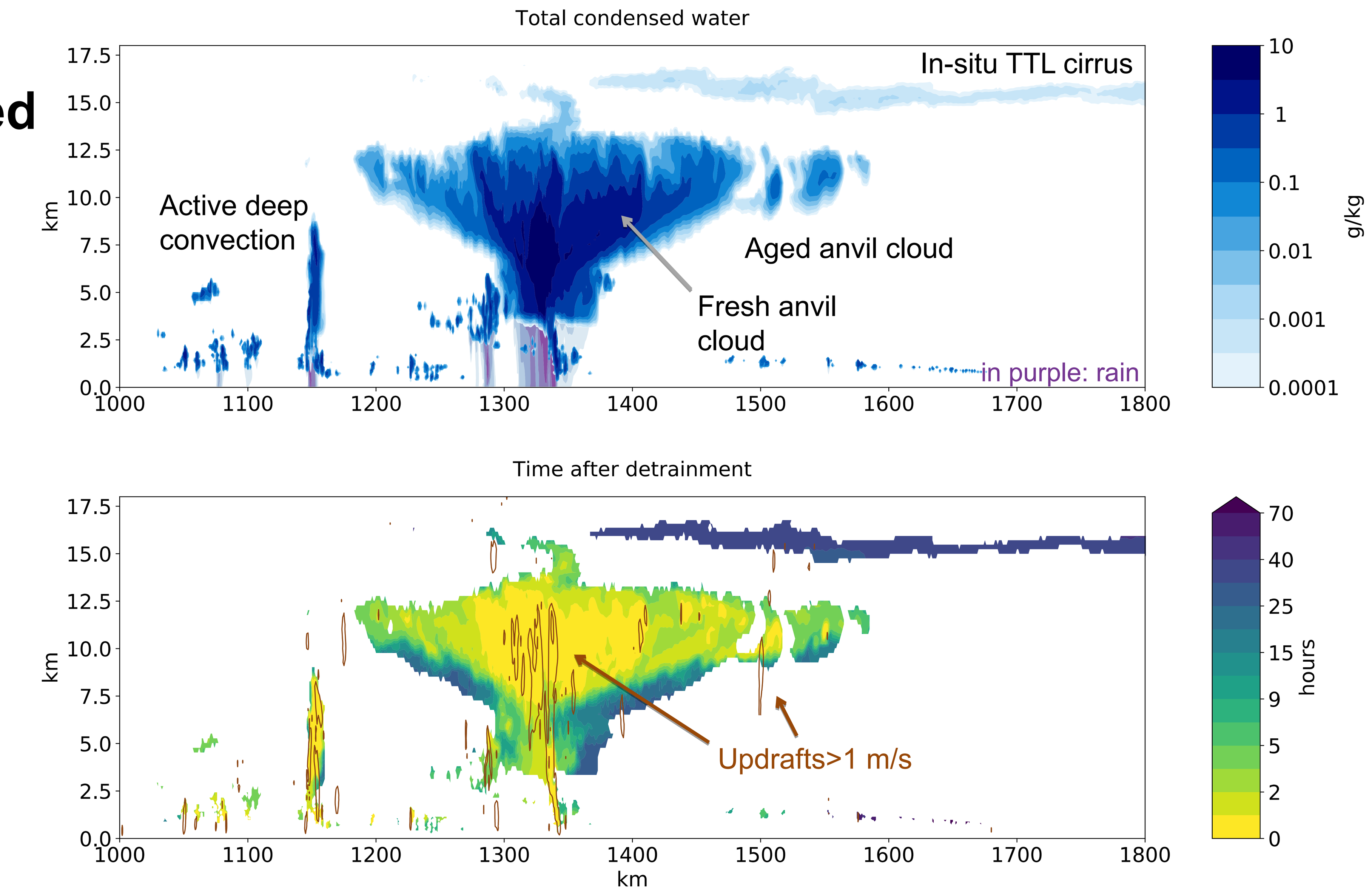
Quick recipe for modeling of tropical cirrus

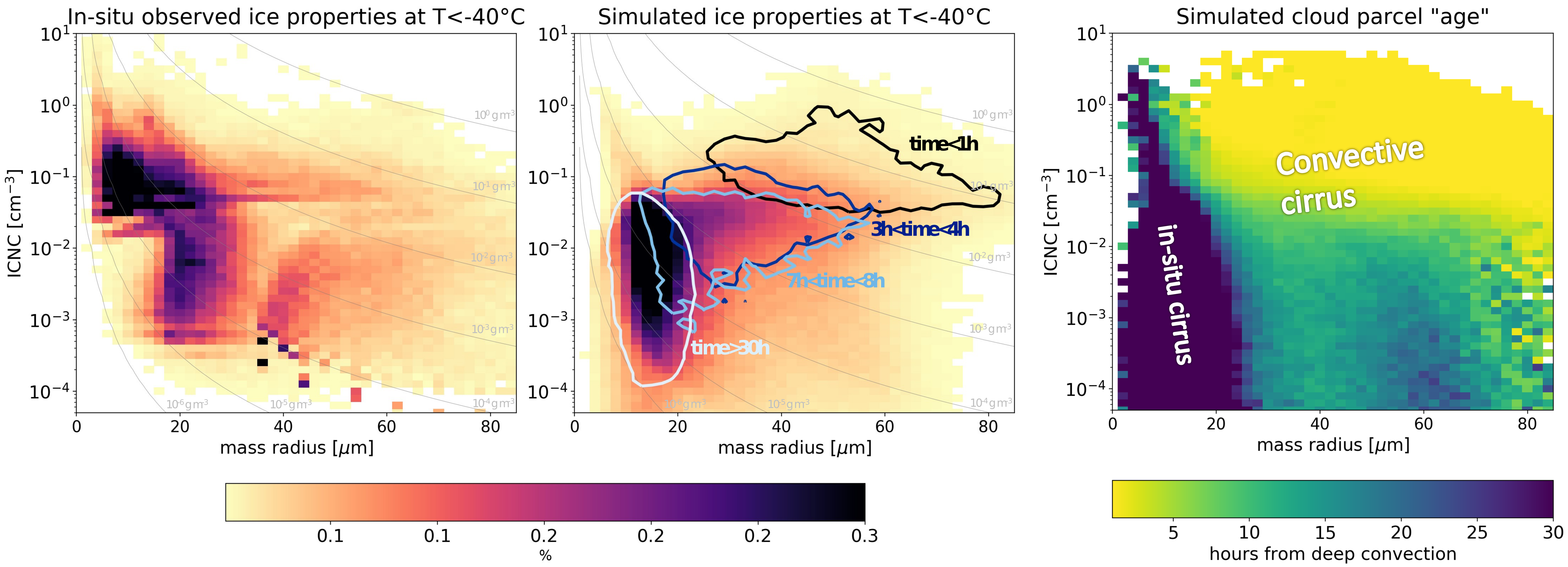
1. Remove all unphysical microphysical limits in the code
2. Make sure freezing schemes don't operate out of their range
3. Add homogeneous freezing at cirrus conditions
4. Bonus: implement competition between homogeneous and heterogeneous freezing



Distinguishing cloud types based on the time after deep convective detrainment

An additional passive tracer of buoyant cloudy updraft parcels provides a robust metric allowing to distinguish between in-situ and convective-origin cirrus clouds.





PDF of in-situ cloud properties from a unified dataset containing CONTRAST, ATTREX, and POSIDON data (Krämer et al., 2020) sorted by ice crystal number concentration (ICNC) and mean mass radius.

Model simulation data overlaid with contour lines representing PDF maxima of freshly detrained ice crystals (time<1h), gradually aging anvil clouds and in-situ cirrus (time>30).

Average time after convective detrainment as a function of ice crystal number and mass radius.

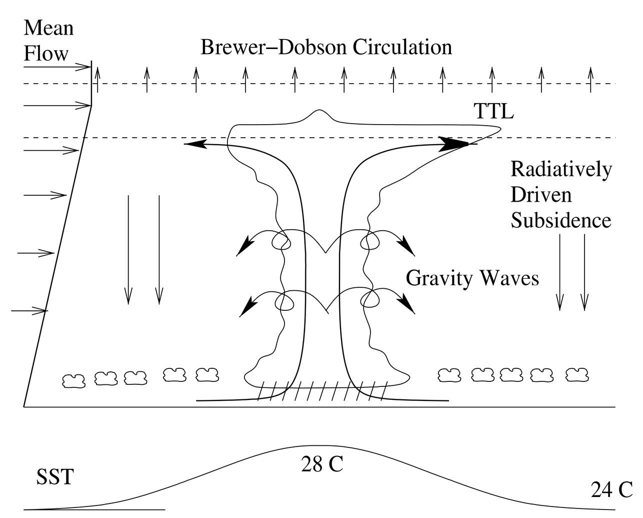
Conclusions

1. Simple changes to the ice microphysics substantially improve cloud resolving simulations of tropical cirrus
2. Convective age tracer helps in the interpretation of model biases and in the analysis of the anvil cloud lifecycle
3. The ice crystal number – ice crystal mass radius phase space can intuitively distinguish between different cirrus types

SAM model and simulation details

- Horizontal resolution of 2 km
- Upper tropospheric vertical resolution of 200 m
- P3 microphysical scheme with homogeneous freezing and pre-existing ice as per Shi et al., 2015
- Increased default upper ICNC limit

Tropical channel setup as per Blossey et al., 2010



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