How microphysical changes affect cirrus properties in P3 in SCREAM

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CFMIP-GASS
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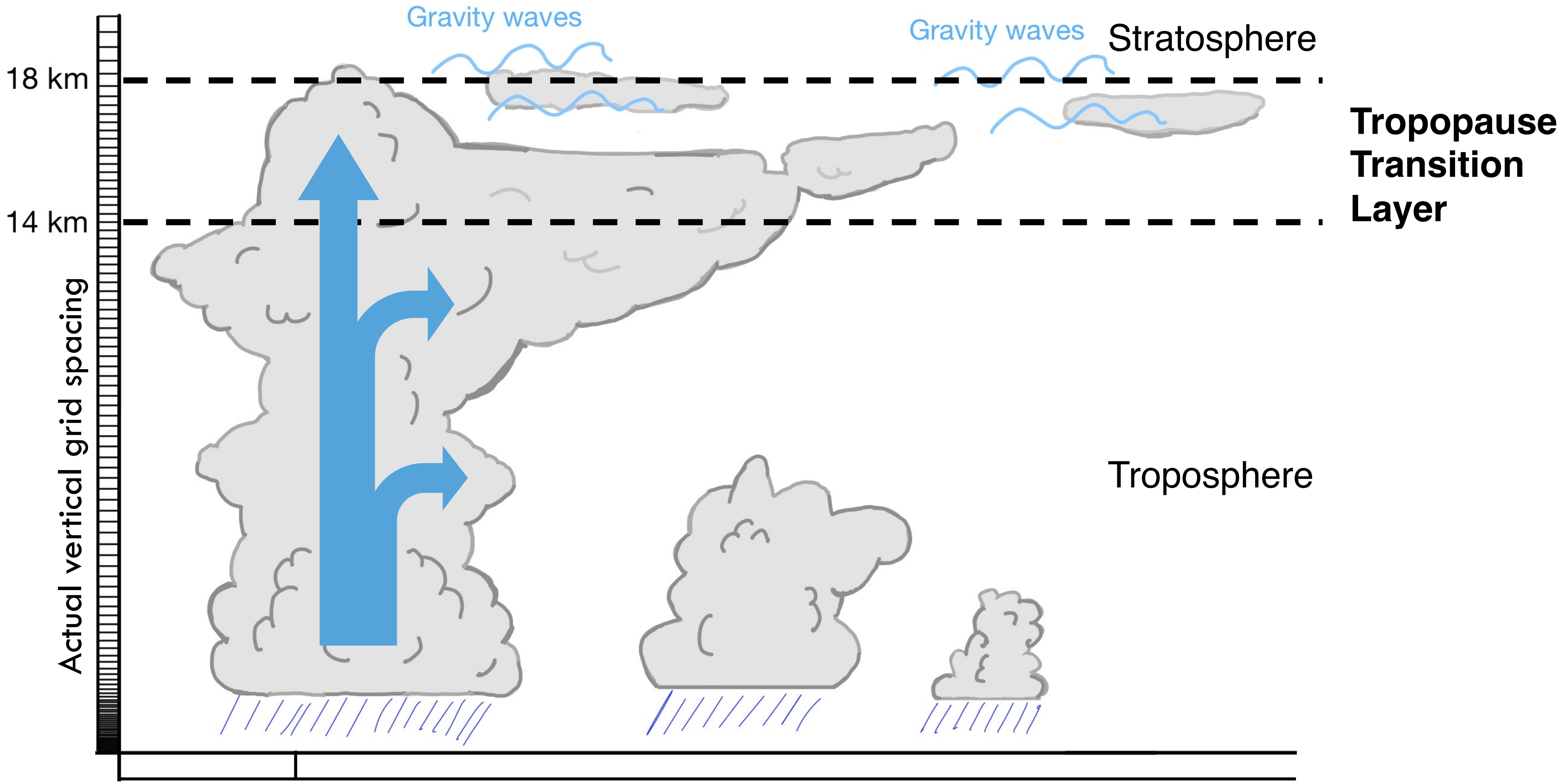
Anvil and TTL cirrus occur across a range of scales

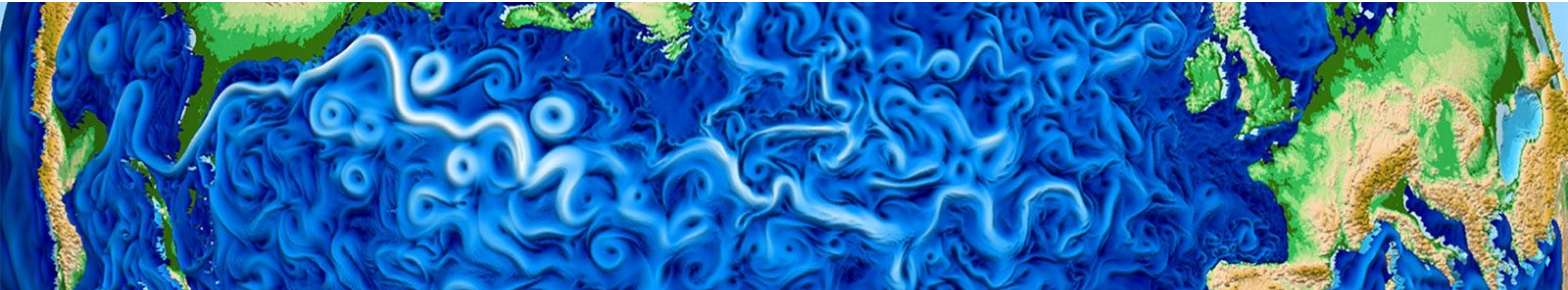


Microphysics Sensitivity Study Using SCREAM

3.3 km horizontal resolution

128 vertical levels (17 in the TTL)

P3 microphysics (Morrison & Milbrandt, 2014)



P3 Microphysics: old vs new

Standard ice_nucleation scheme

1. Default freezing mechanism (Cooper 1986)
2. Options for using predicted or prescribed CCN and number concentration

New ice_nucleation scheme

New ice nucleation scheme is more complex

Standard ice_nucleation scheme

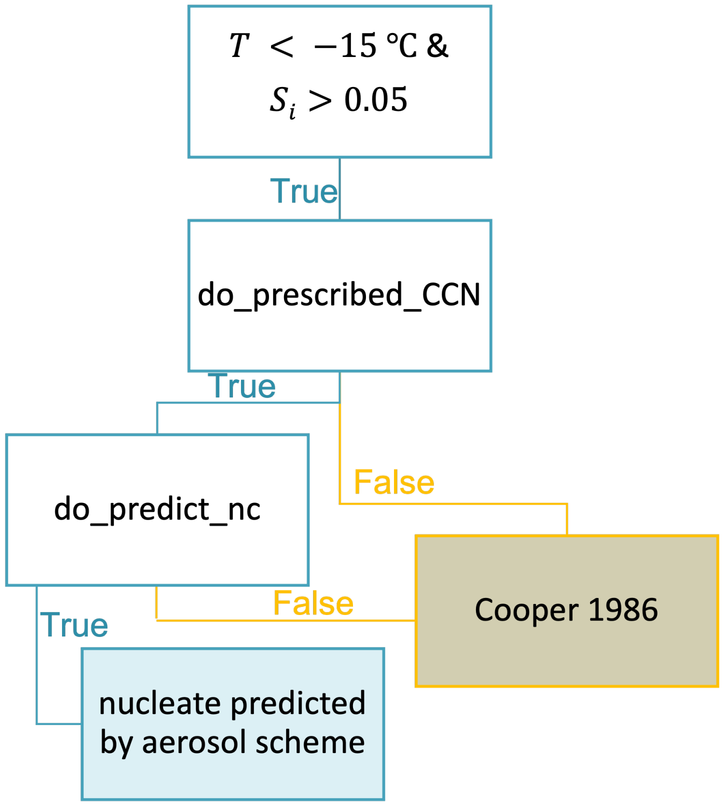
1. Default freezing mechanism (Cooper 1986)
2. Options for using predicted or prescribed CCN and number concentration

New ice_nucleation scheme

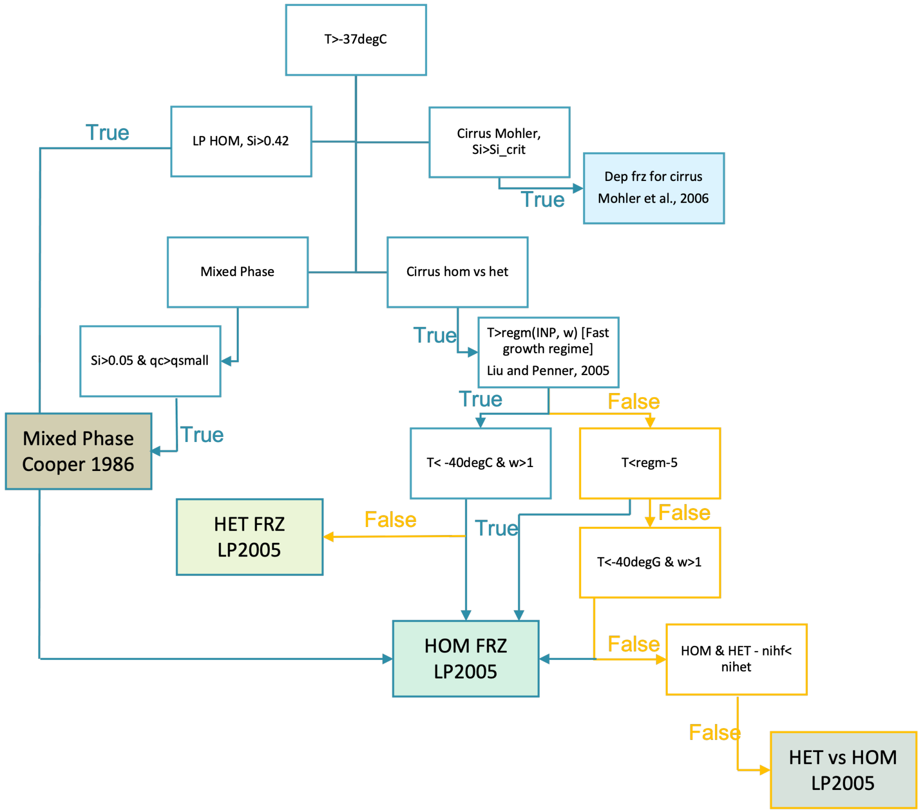
1. Freezing for mixed phase (Cooper 1986)
2. Allows for deposition freezing in cirrus (Mohler et al., 2006)
3. Allows for heterogeneous vs homogeneous competition (Liu & Penner, 2005)

New ice nucleation scheme is more complex
(and hopefully more physical)

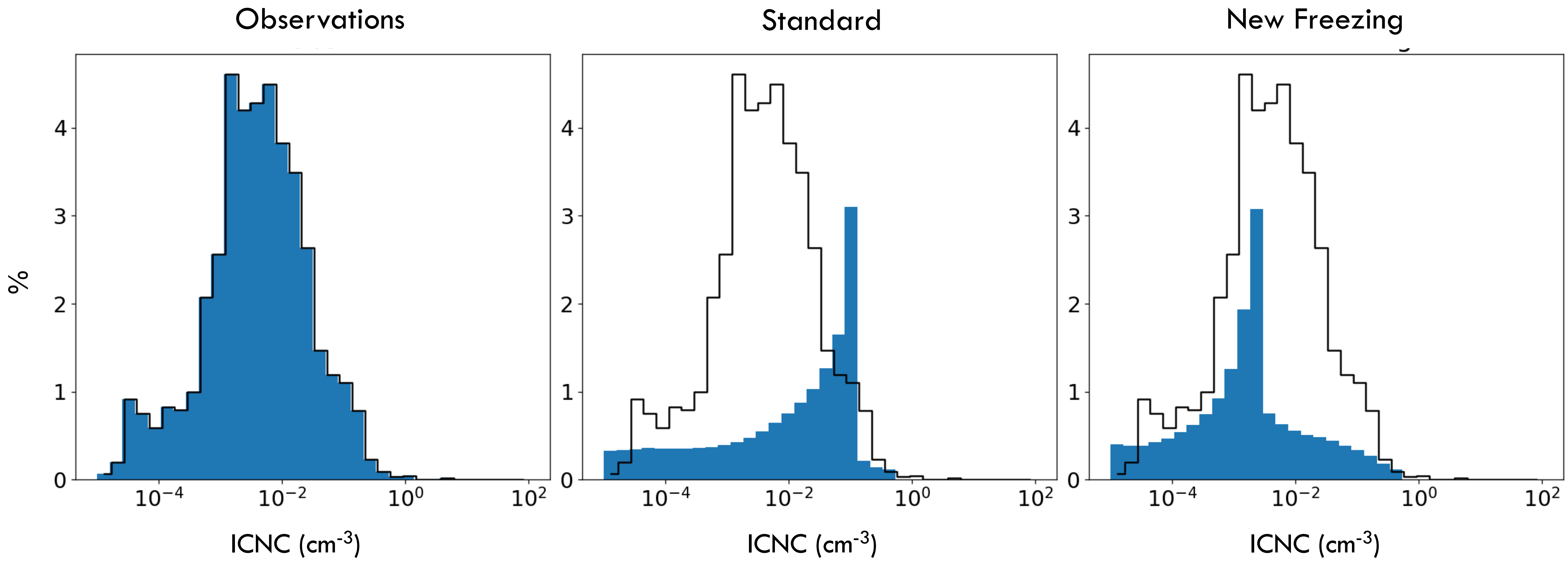
Standard ice_nucleation scheme



New ice_nucleation scheme



Microphysical changes in new freezing scheme

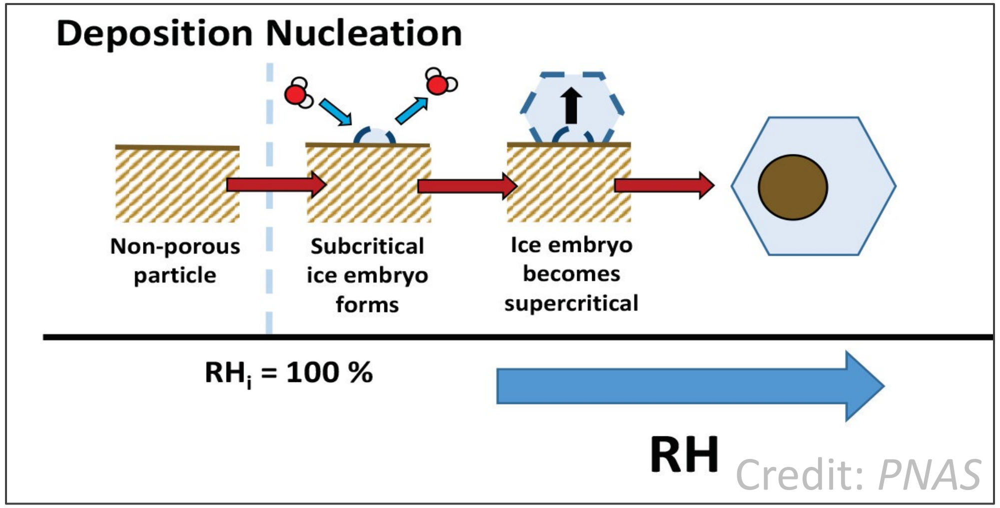


ICNC = Ice crystal number concentration

Sensitivity Study

Vapor deposition ice_deposition_sublimation

Scaling by ½ - 2 x for average grid box ice mass with $R_{eff} < 25$ µm



Credit: *PNAS*

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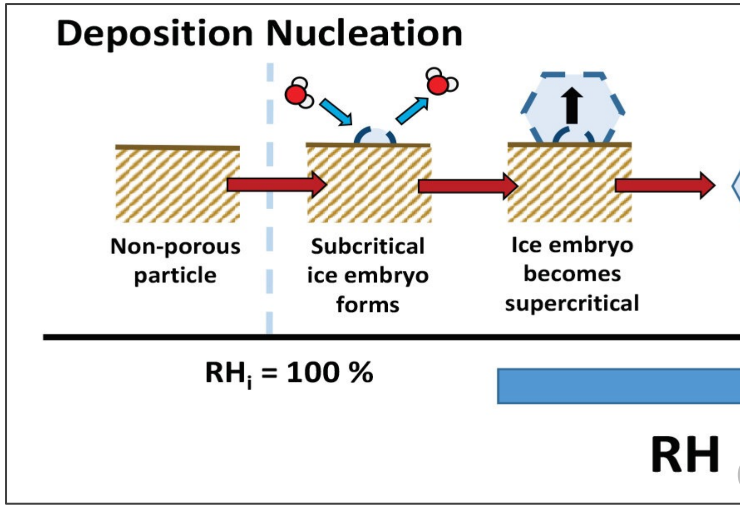
Ice sedimentation ice_sedimentation



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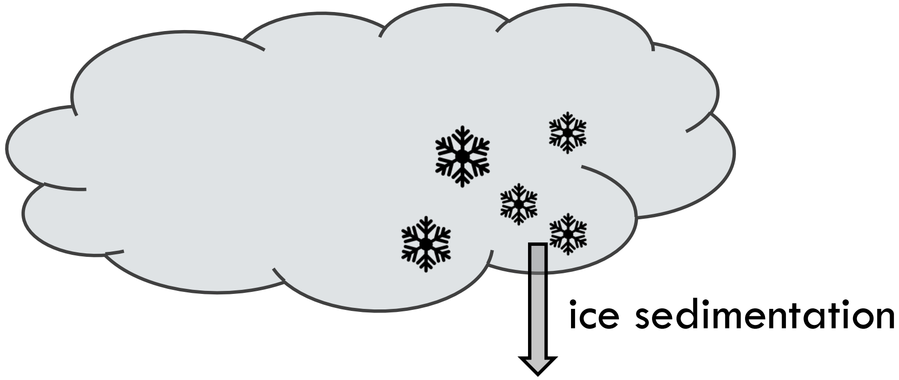

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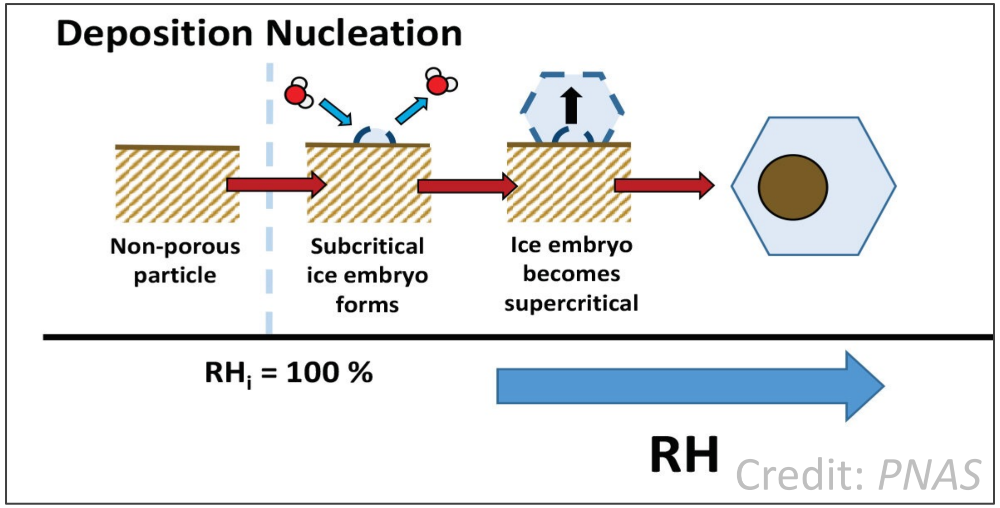
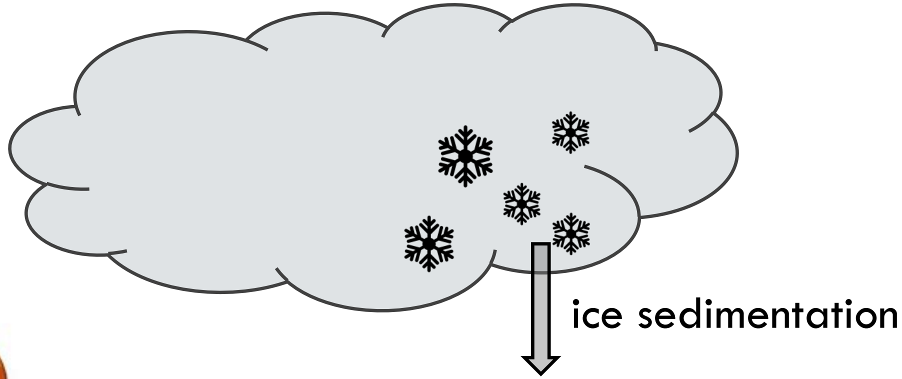
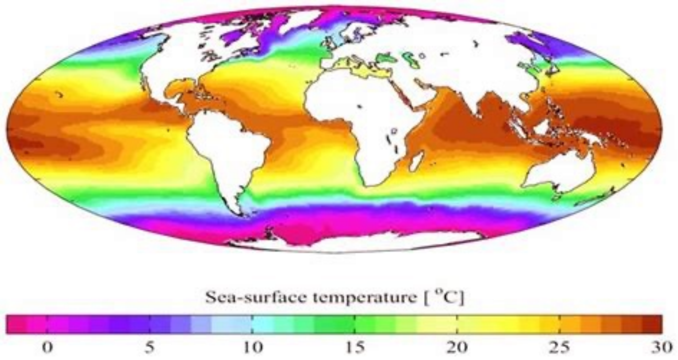
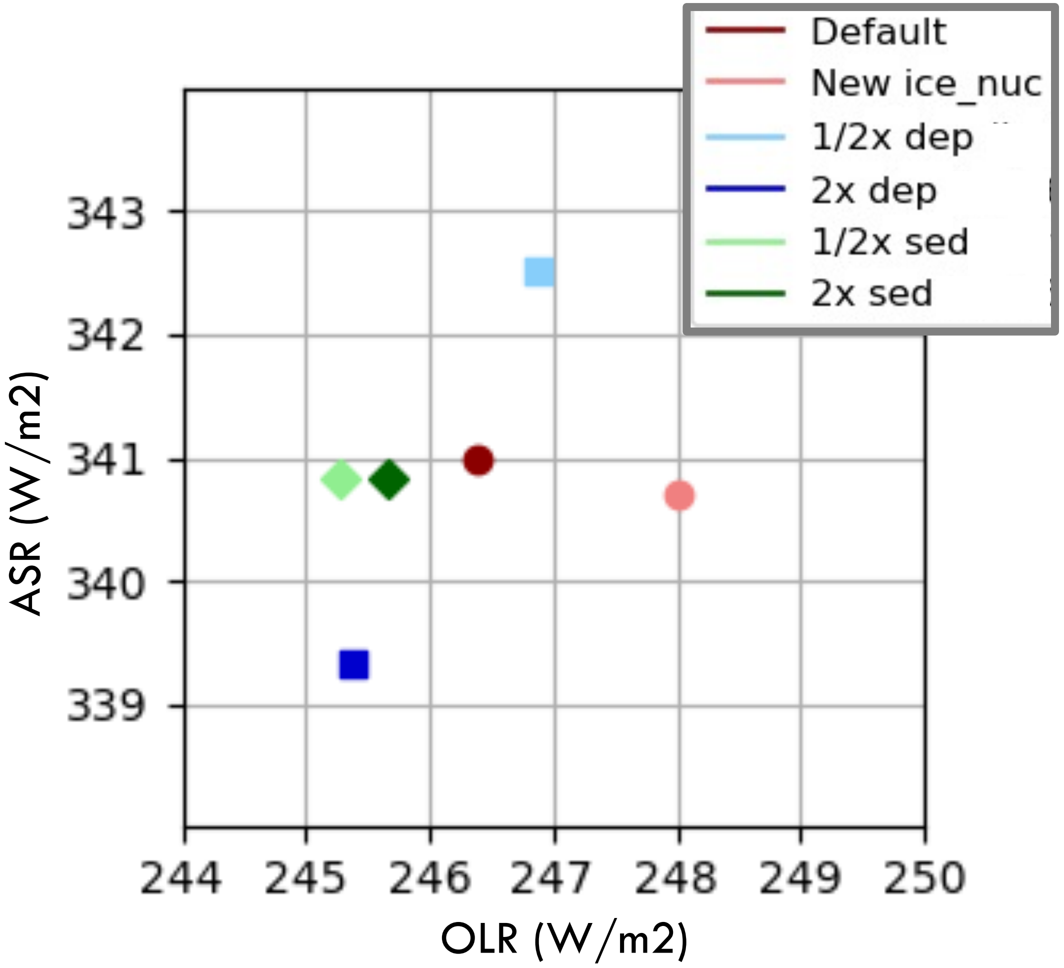






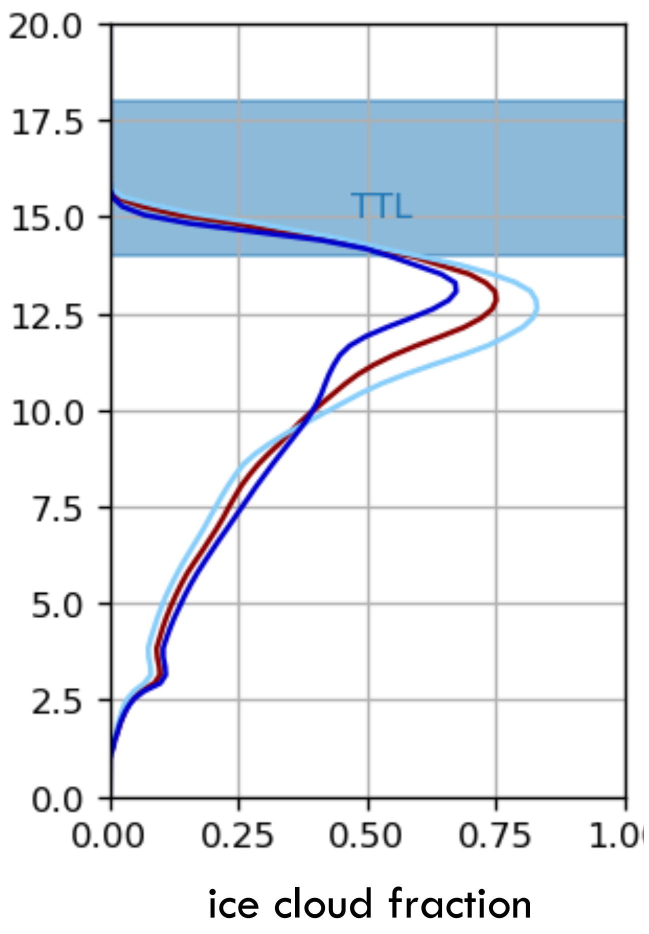
Microphysical changes affect top-of-atmosphere radiation

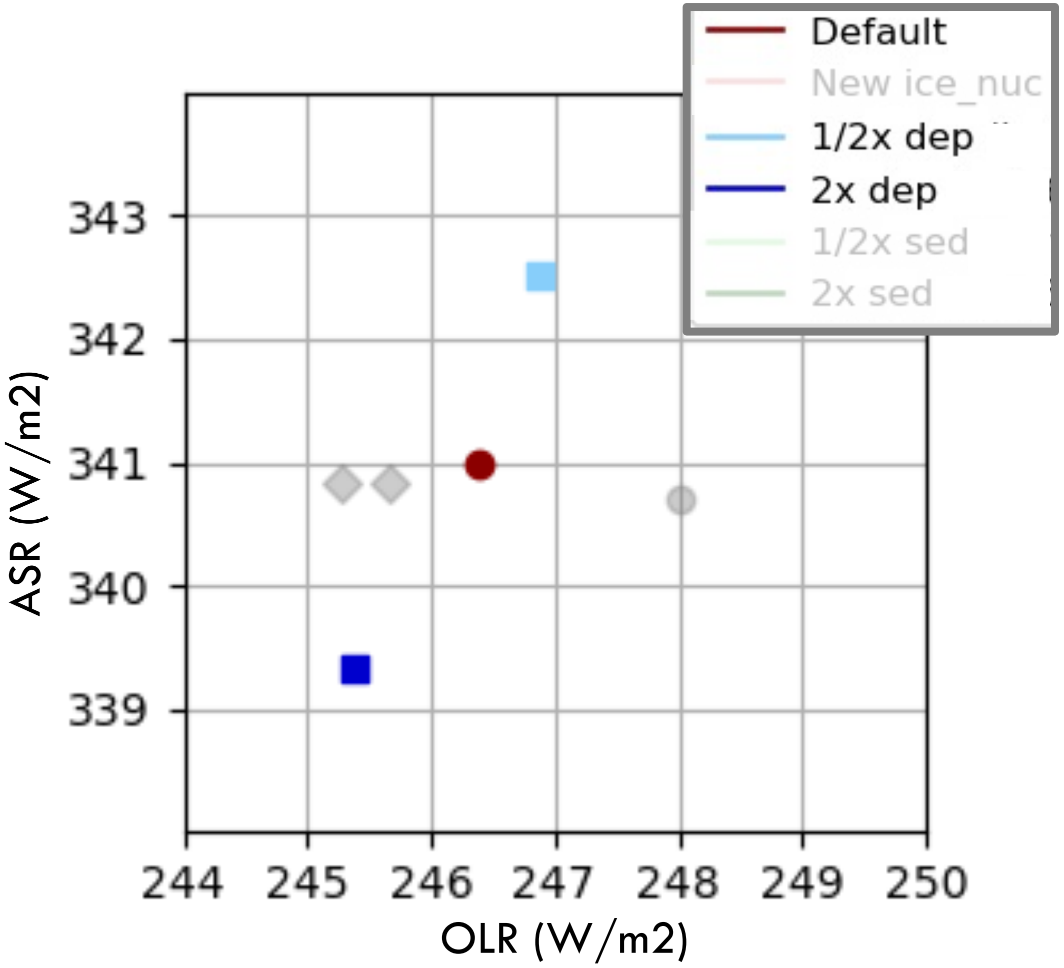
DYAMOND models had a standard deviation of 10 W/m2 in OLR



OLR = Outgoing longwave radiation
ASR = Absorbed shortwave radiation

Corresponding impacts on vertical distribution of clouds





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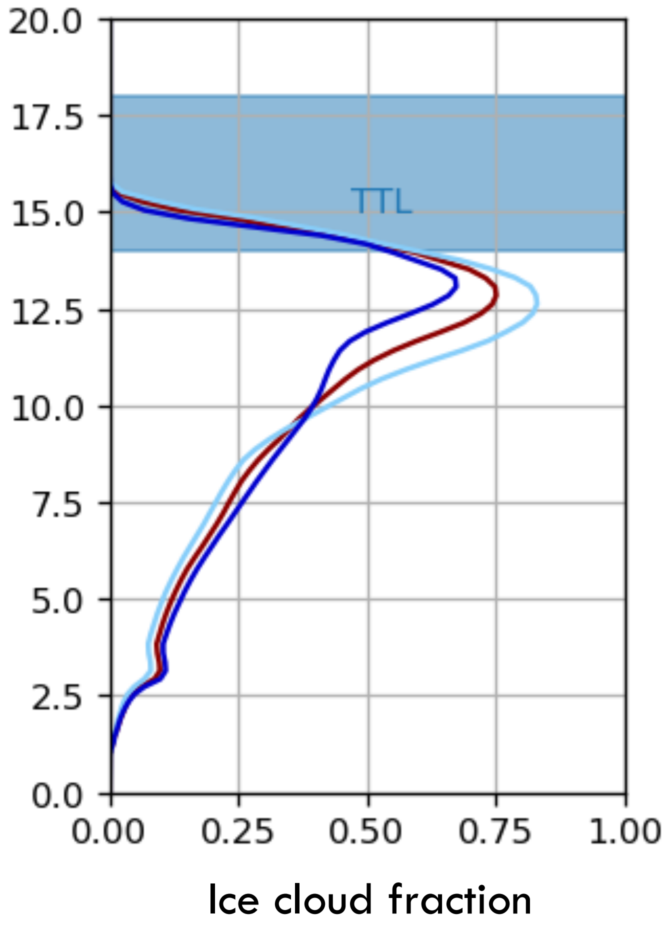
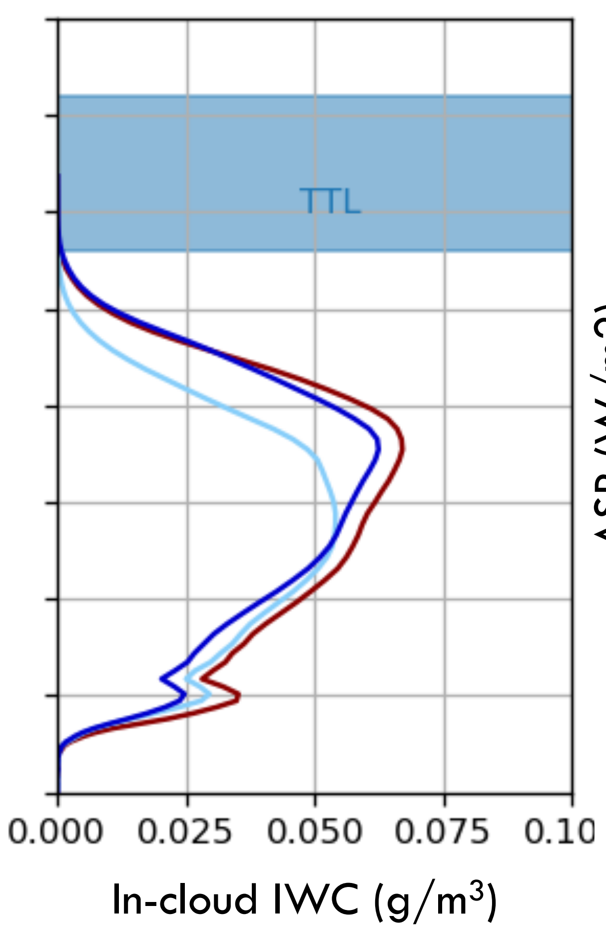
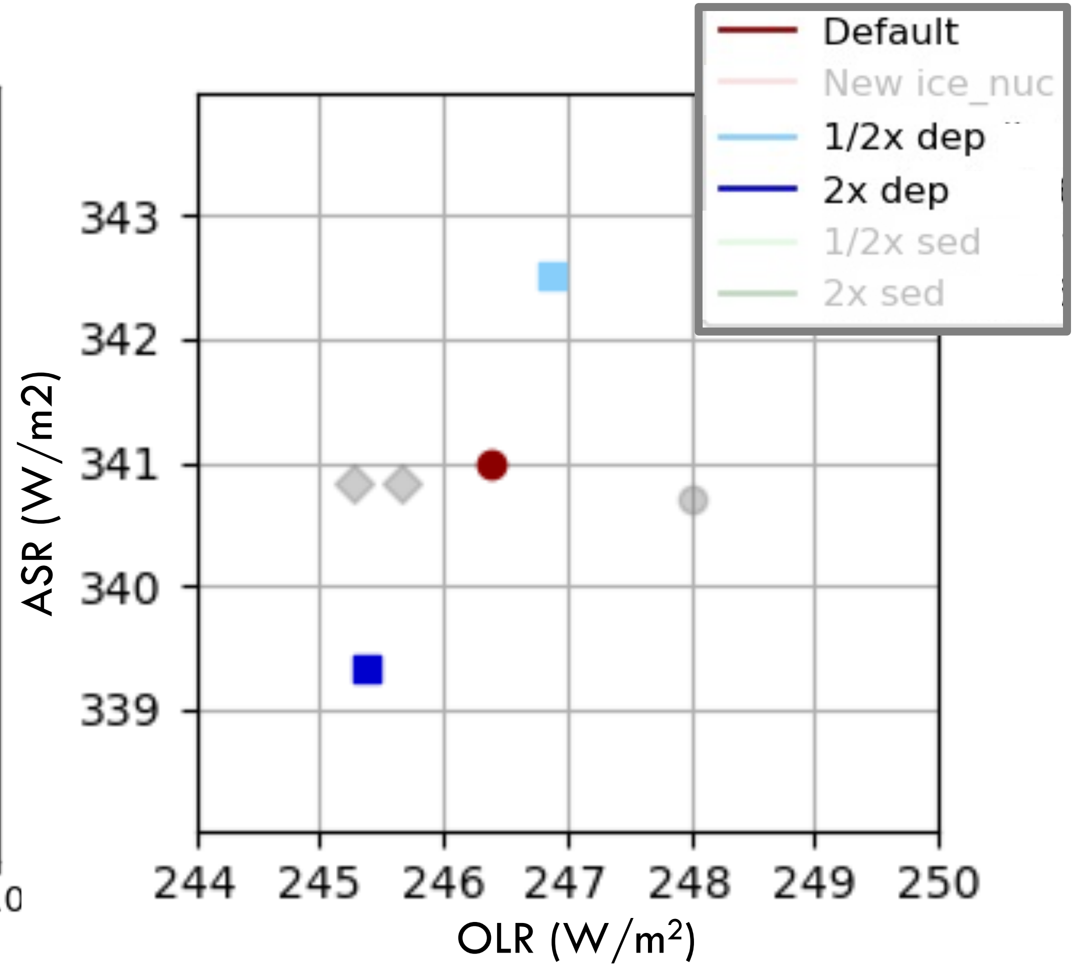
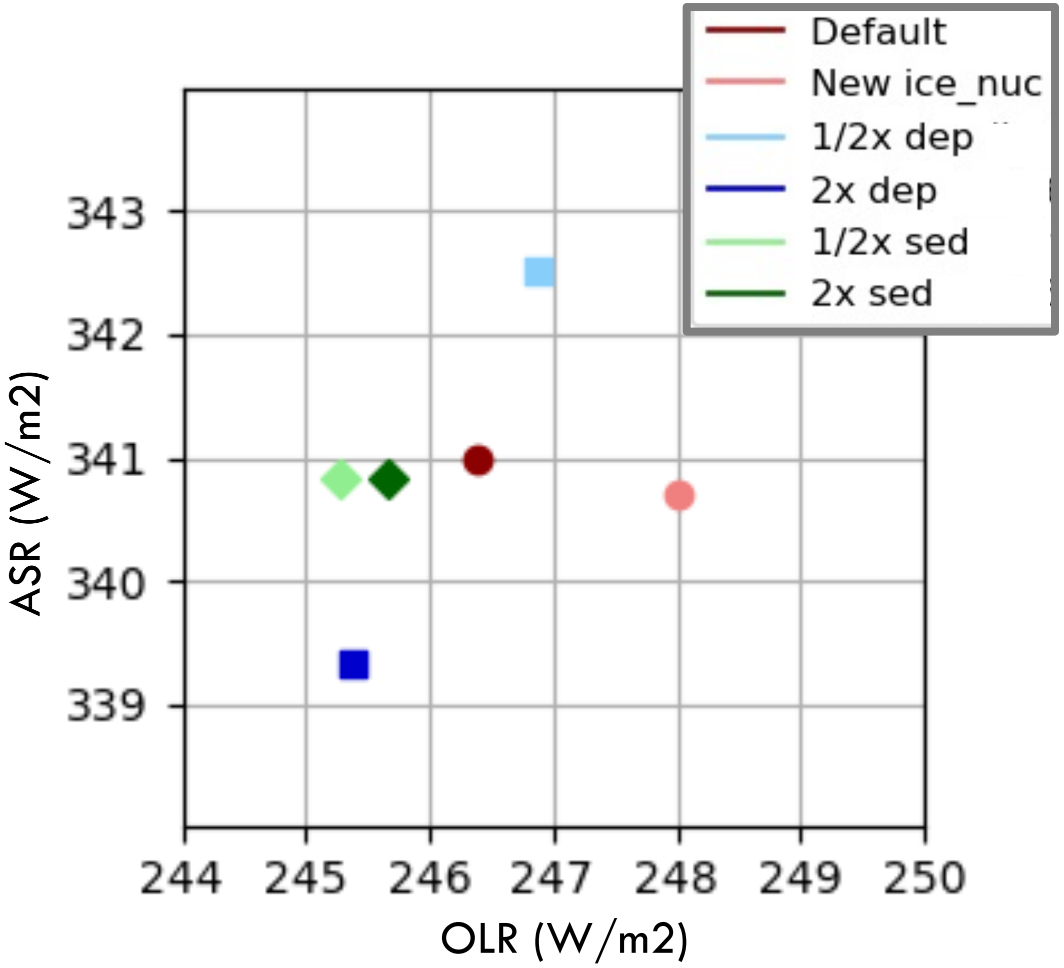






Microphysical changes affect top-of-atmosphere radiation

Vapor deposition seems to be the strongest influence on thin cirrus clouds and TOA radiation



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Summary

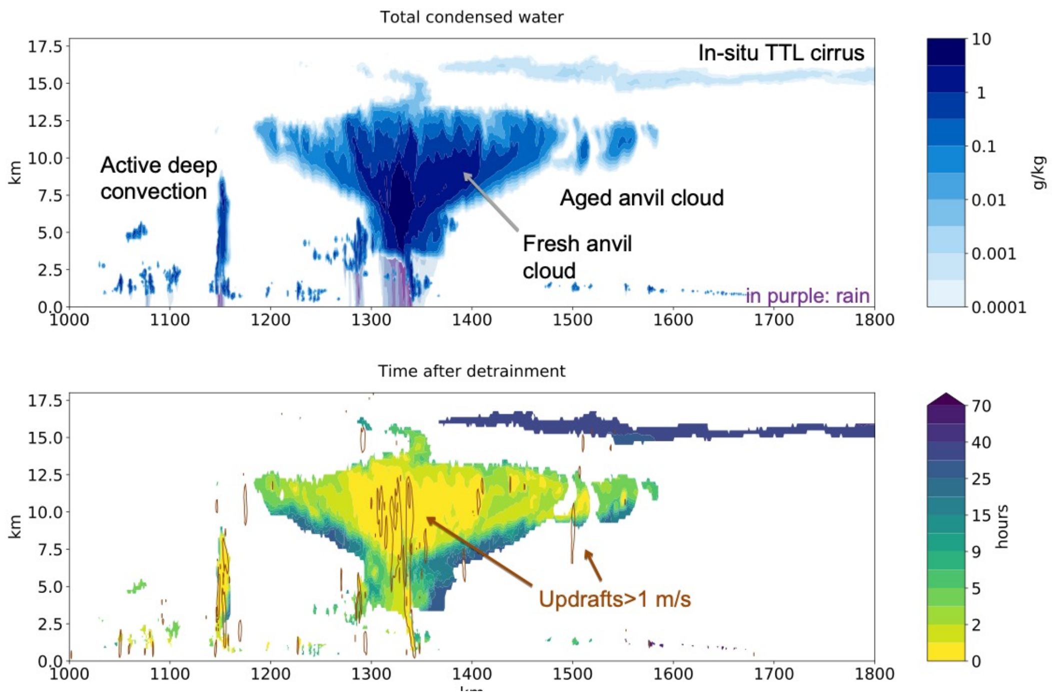
- New freezing scheme allows for more natural nucleation of ice
    - Better ICNC compared to observations

- Deposition > sedimentation sensitivity for cirrus clouds

- Microphysics is important for TOA radiation and macrophysics

Future plans

- Add tracers for time since convection & nucleation
- Include L.S. ascent for more realistic TTL
- Run in large domain (bowling alley/variable resolution global configuration) to allow for self-aggregation
- Horizontal grid spacing (1 km)
- Update microphysics to include…
  1. New results from Kärcher, 2022 (JGR)
  2. Pre-existing ice option



Gasparini

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Model:

The SCREAM Project

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DKRZ Deutsches Klimarechenzentrum

UCAR University Corporation for Atmospheric Research