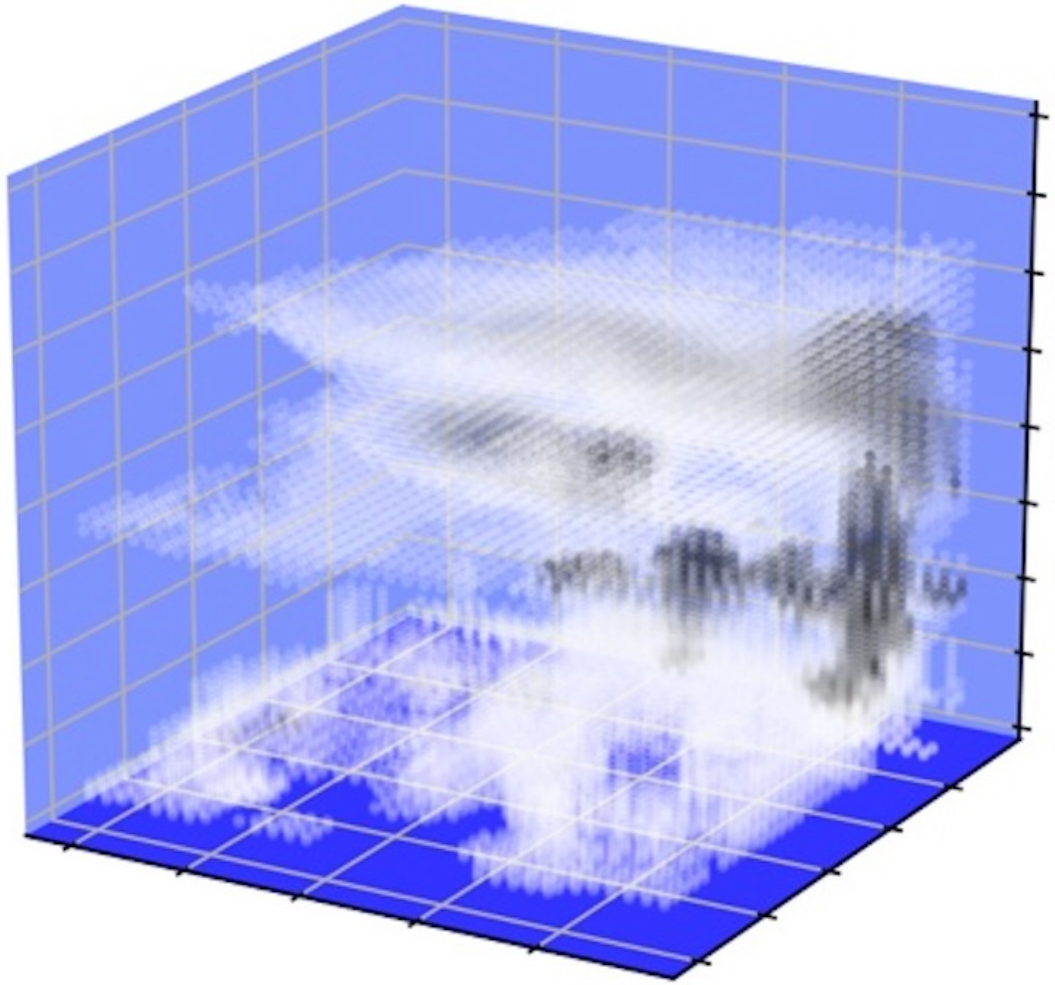
An intercomparison of tropical cirrus in global storm-resolving models



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University of Washington

AMS CMM
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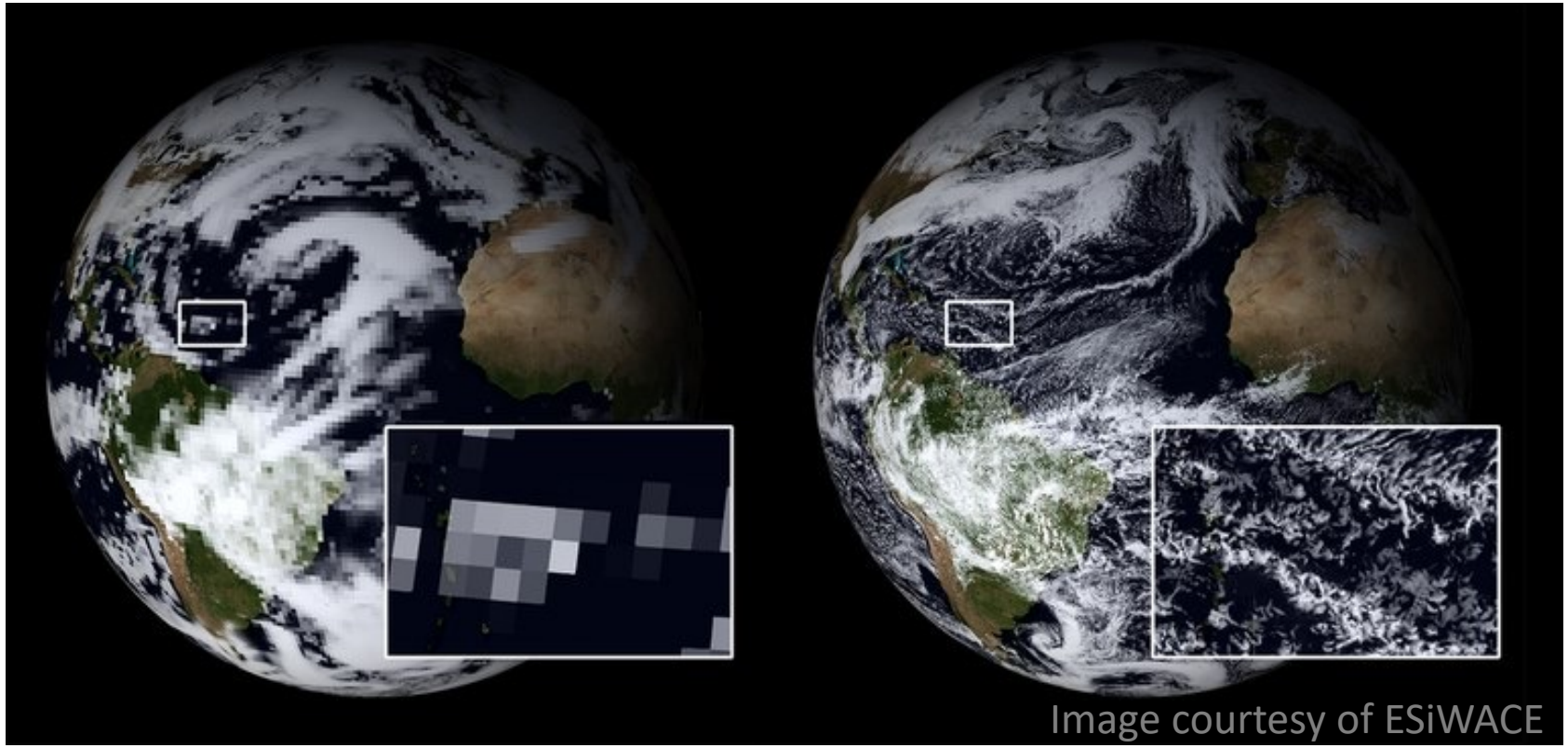
Madison, WI

DYAMOND

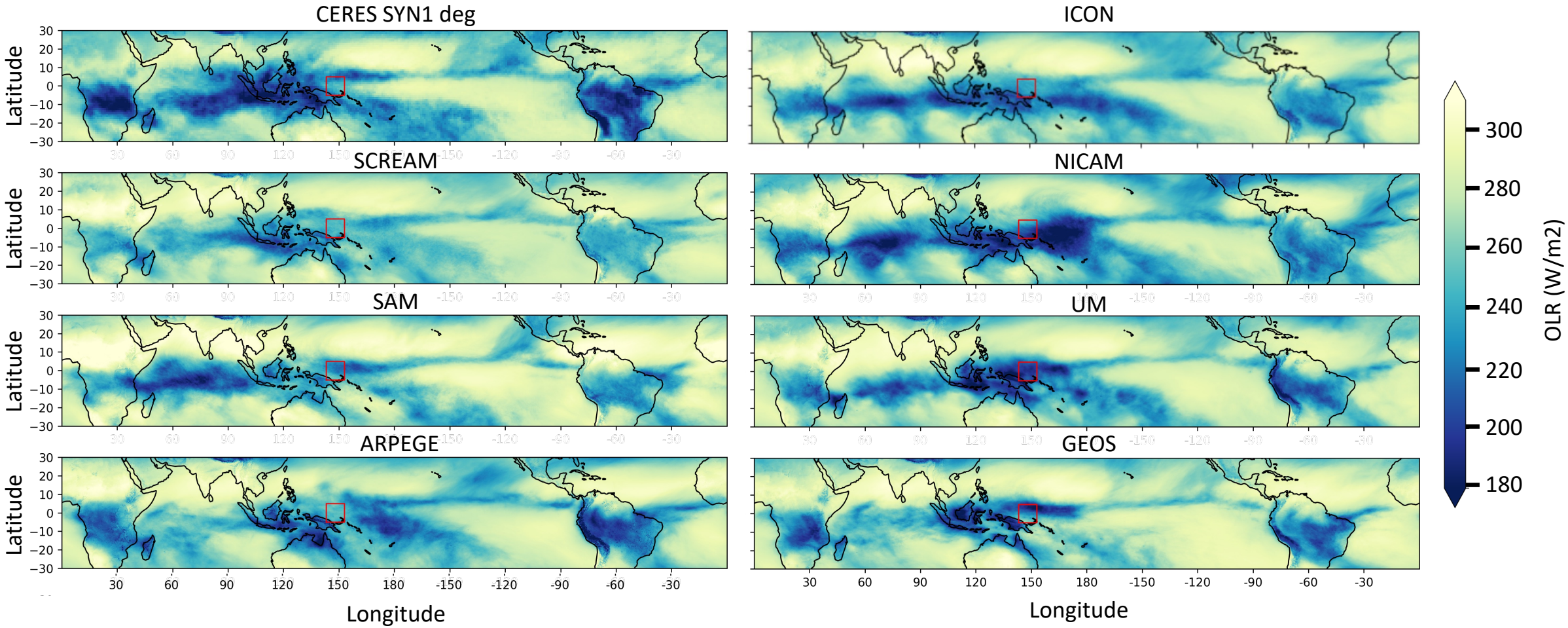
DYnamics of the Atmospheric general circulation Modeled on Non-hydrostatic Domains



- 10 Global Storm-Resolving Models (GSRMs)
  - Phase 1 – boreal summer
  - **Phase 2** – boreal winter
- High spatiotemporal resolution
  - 2.5-5km horizontal resolution
  - 51-131 vertical levels
  - 15 min 2D & 3hrly 3D output
- 40-day simulation
- Explicit convection
- Free running (not nudged)

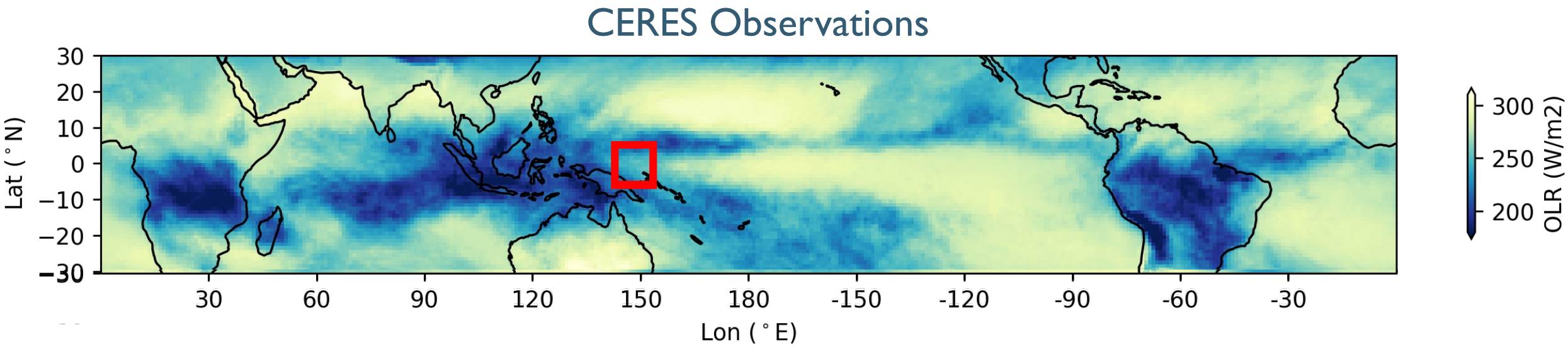
(Stevens et al., 2019 PEPS)

Models simulate the spatial pattern of OLR reasonably well compared to observations

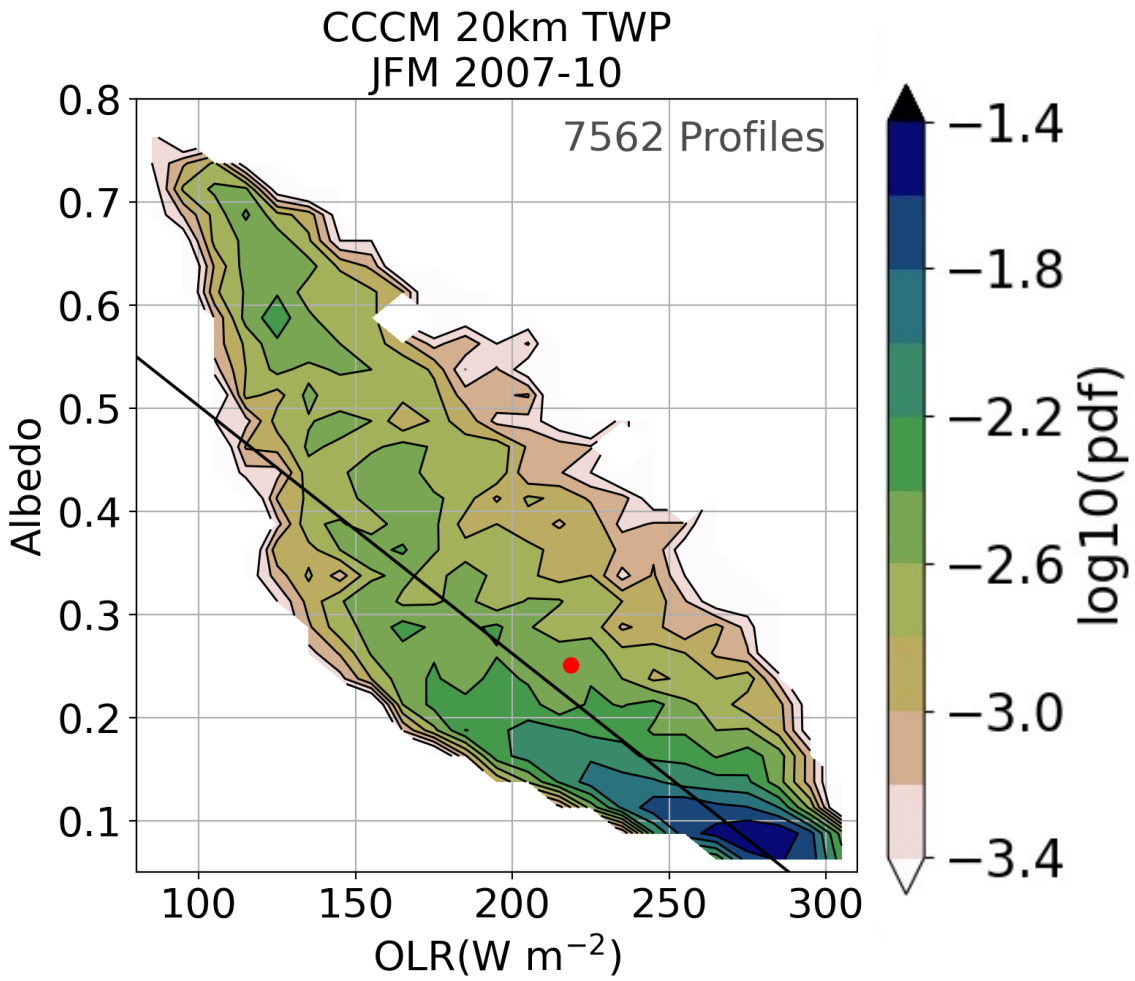


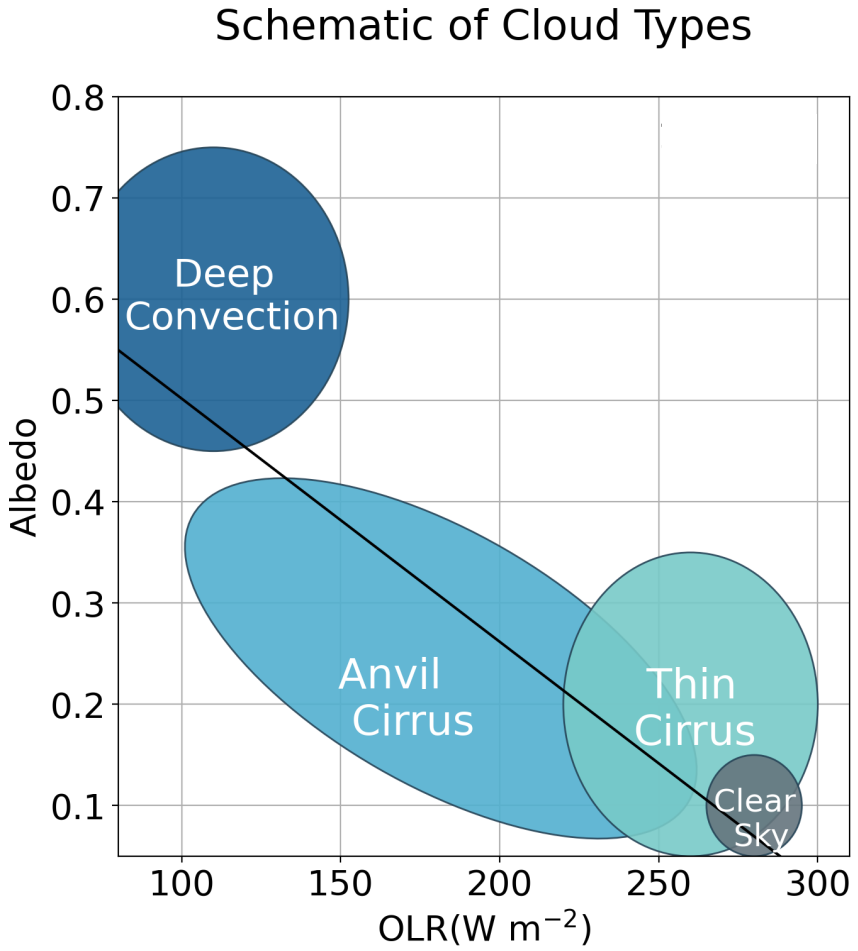
Main differences are land-ocean contrasts

How well do DYAMOND models simulate clouds in the Tropical Western Pacific (TWP) region?



Observations have a banana-shaped distribution of clouds from deep convection to thin cirrus





Clear sky values are included, Black line is where CRE = 0

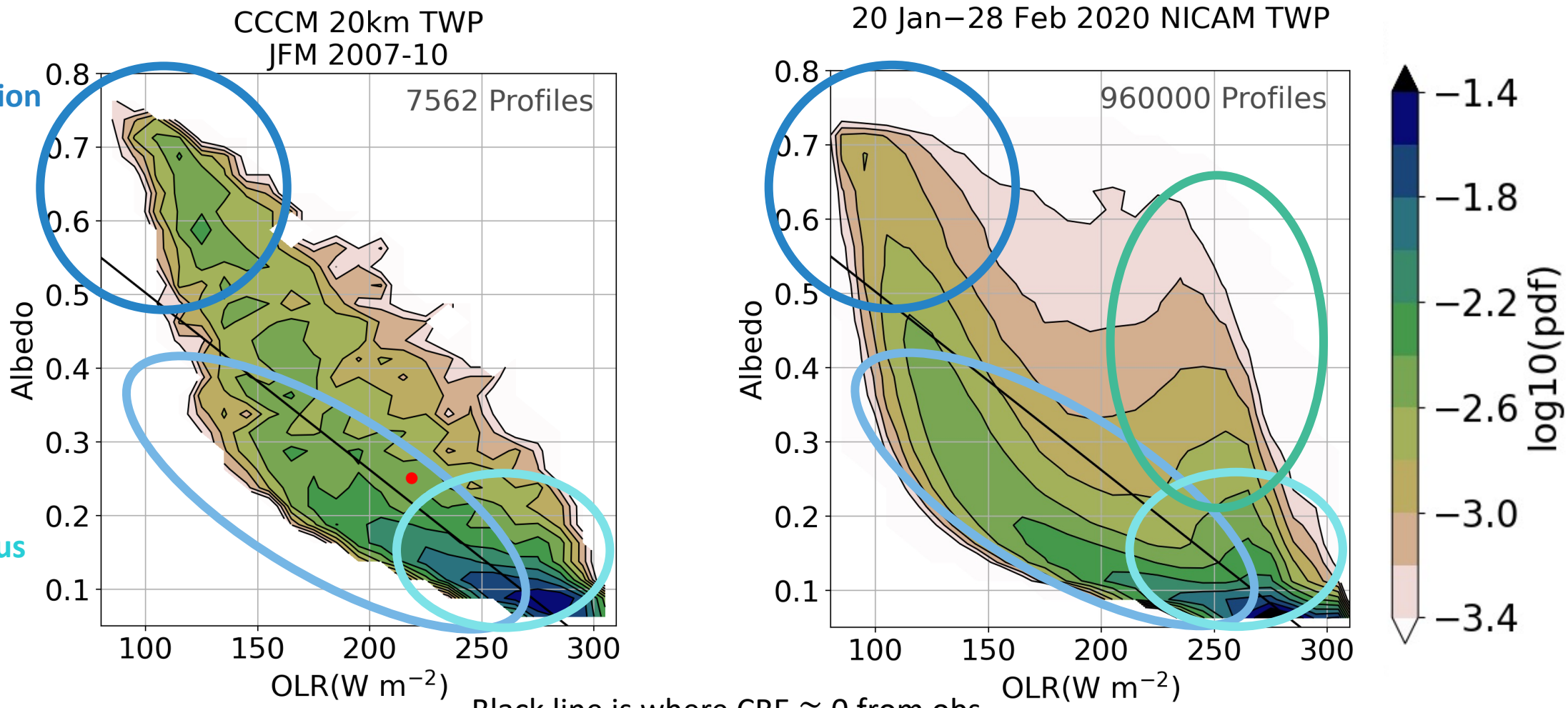
NICAM qualitatively captures the key aspects of the observations

Deep convection

Anvil cirrus

Thin cirrus

Congestus

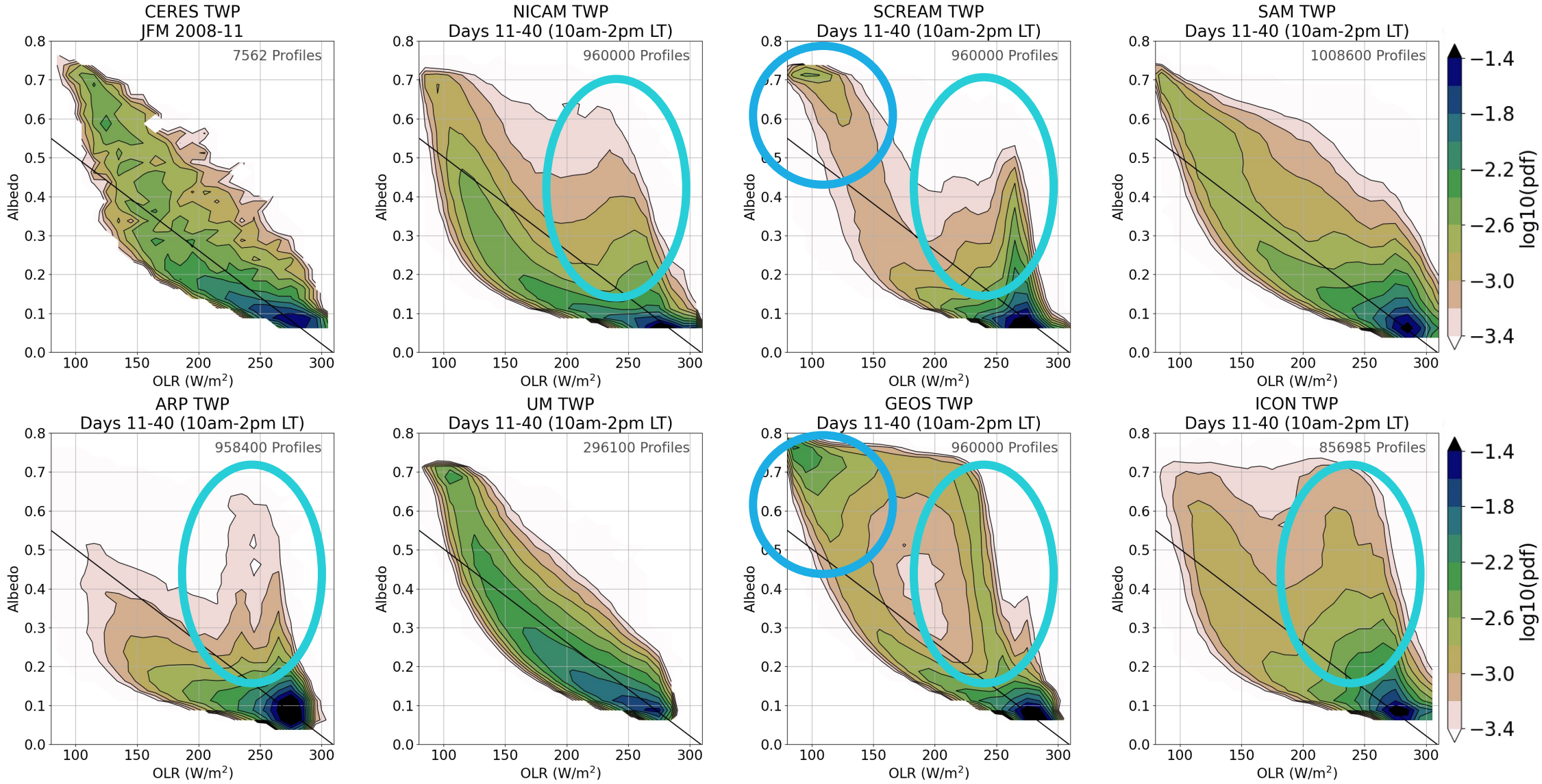


Black line is where CRE ≅ 0 from obs, models coarsened to match obs

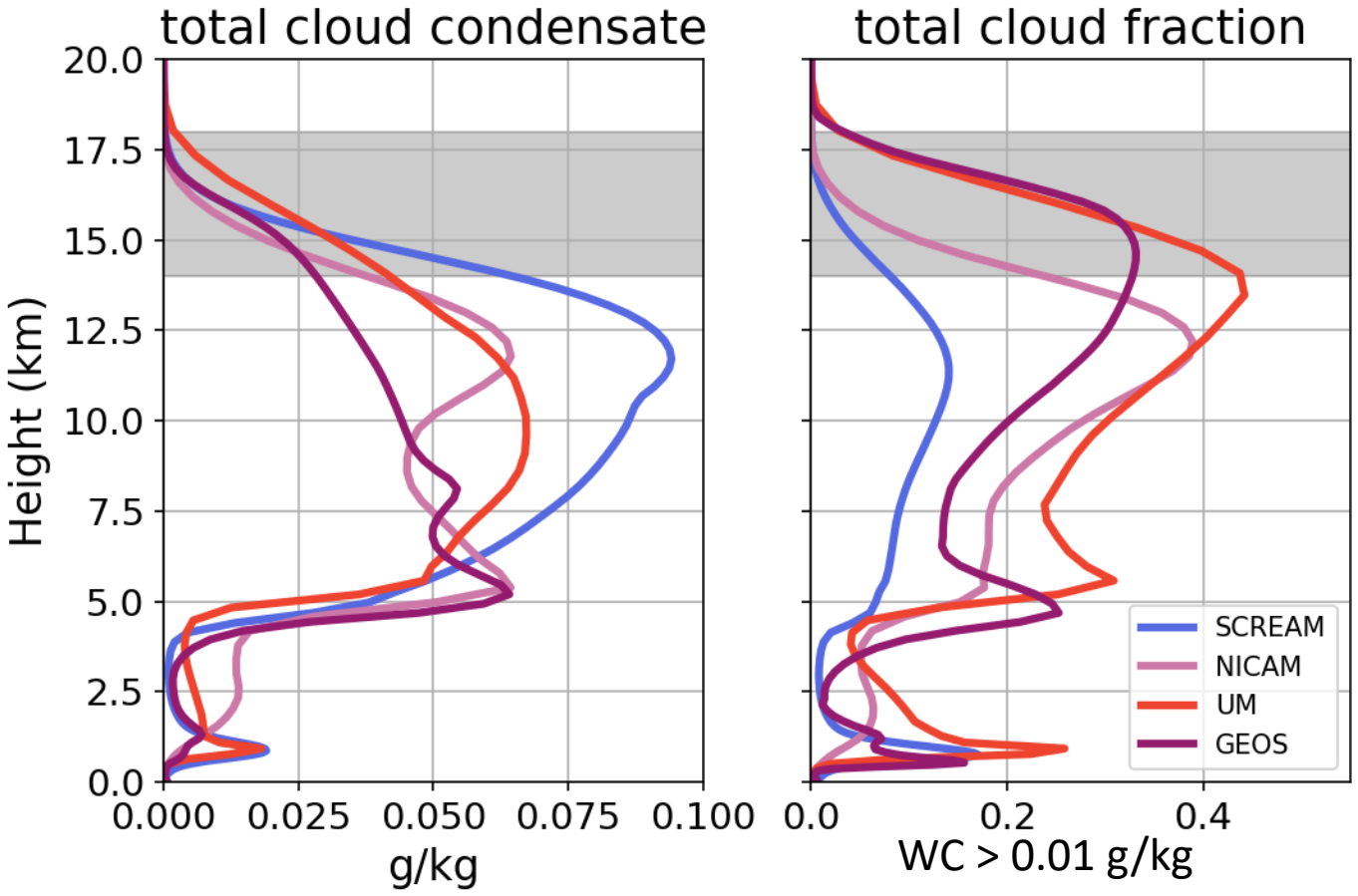
There is large model spread in the shape of distributions and frequency of cloud types

"Popcorn" convection

Too many congestus



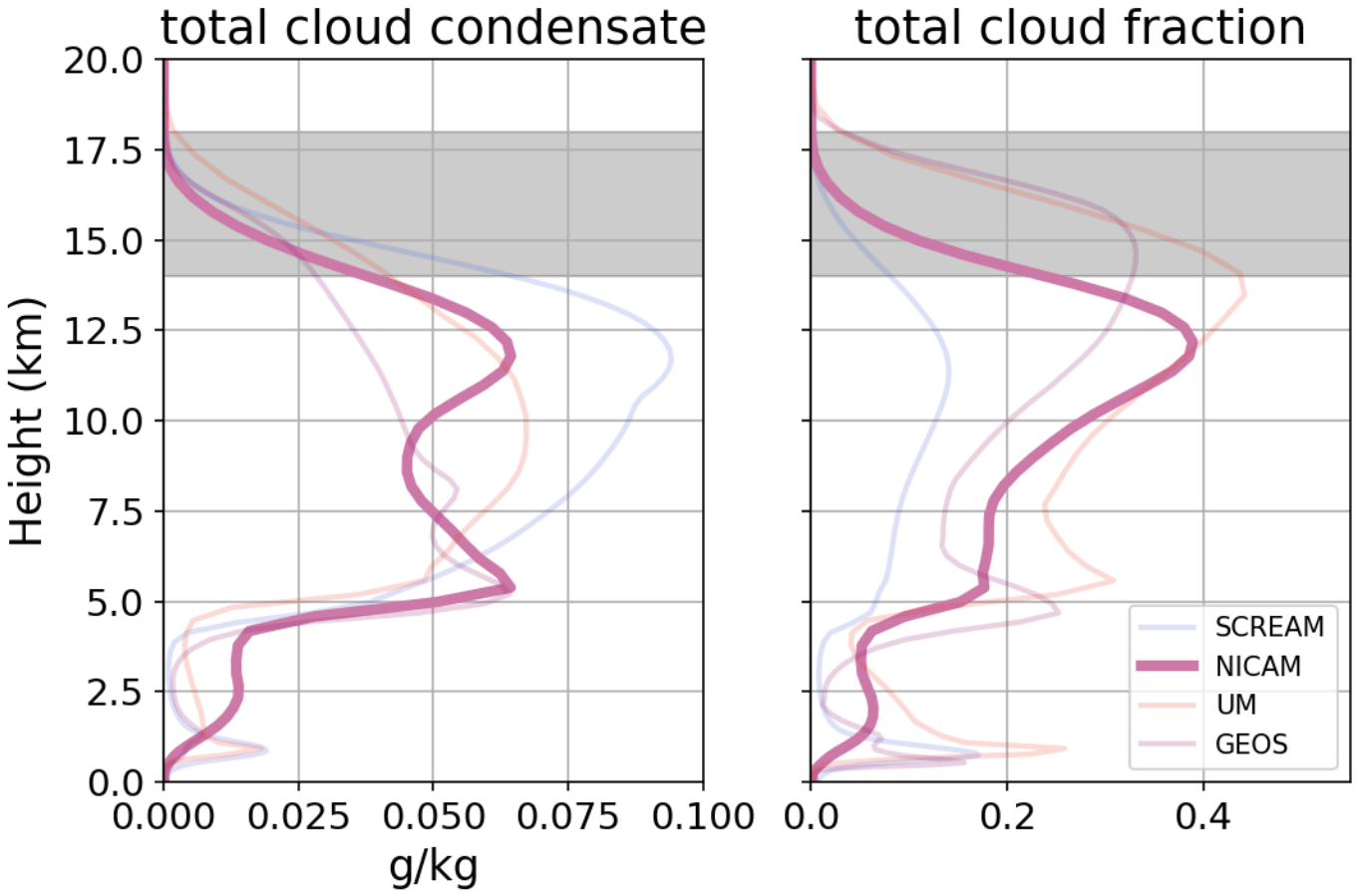
The vertical structure of clouds differ most in the TTL and near the freezing level

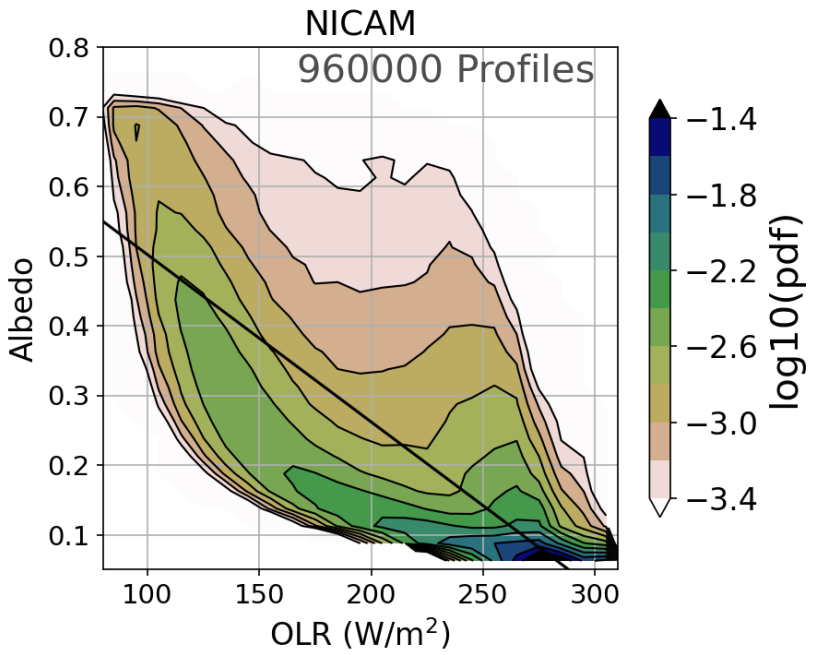


Differences are driven by unresolved sub-grid processes such as microphysics

Models with total frozen condensate are shown

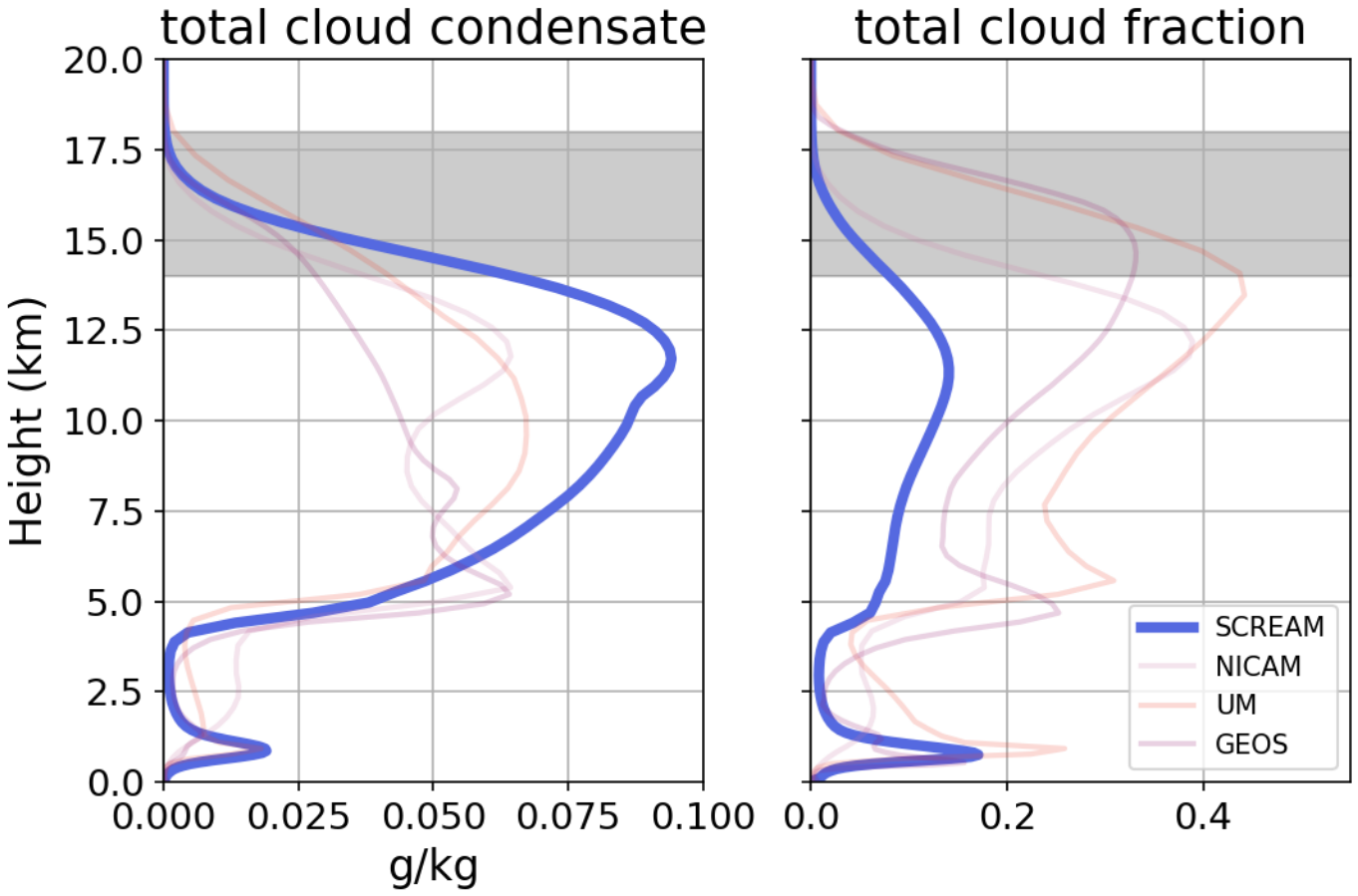
NICAM has a lot of upper-level cirrus and thick "congestus" clouds

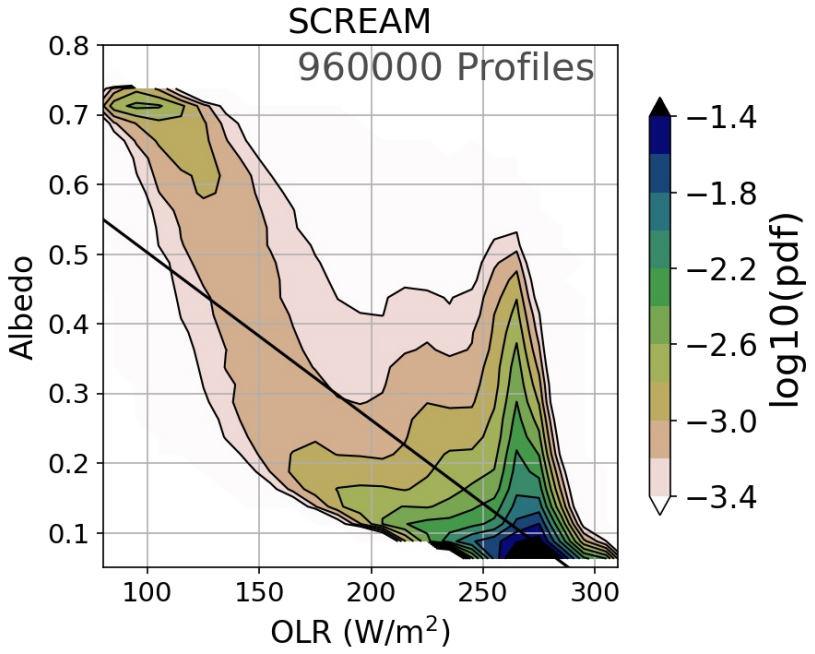




Models with total frozen condensate are shown

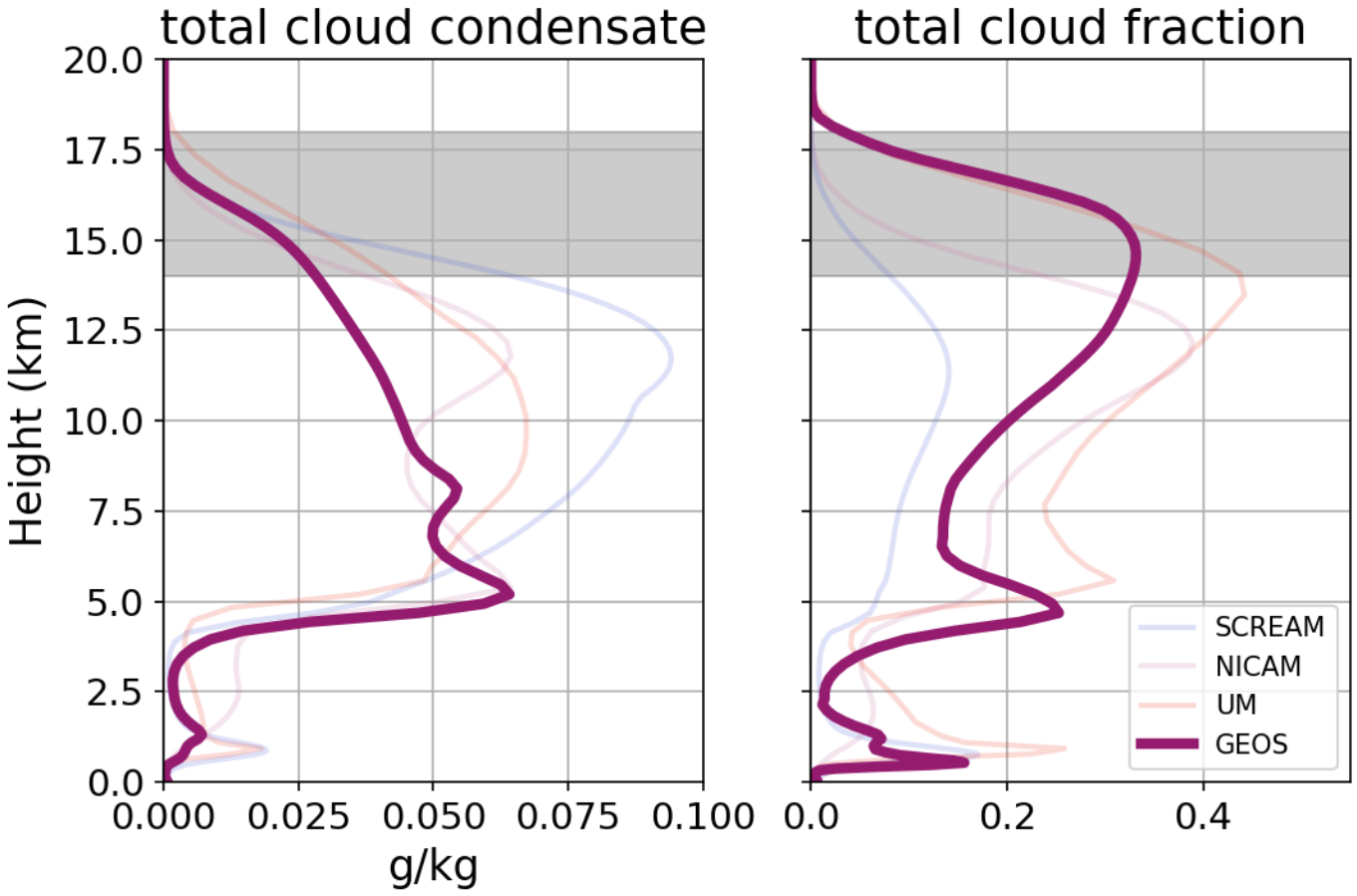
SCREAM has high ice mass “popcorn” convection

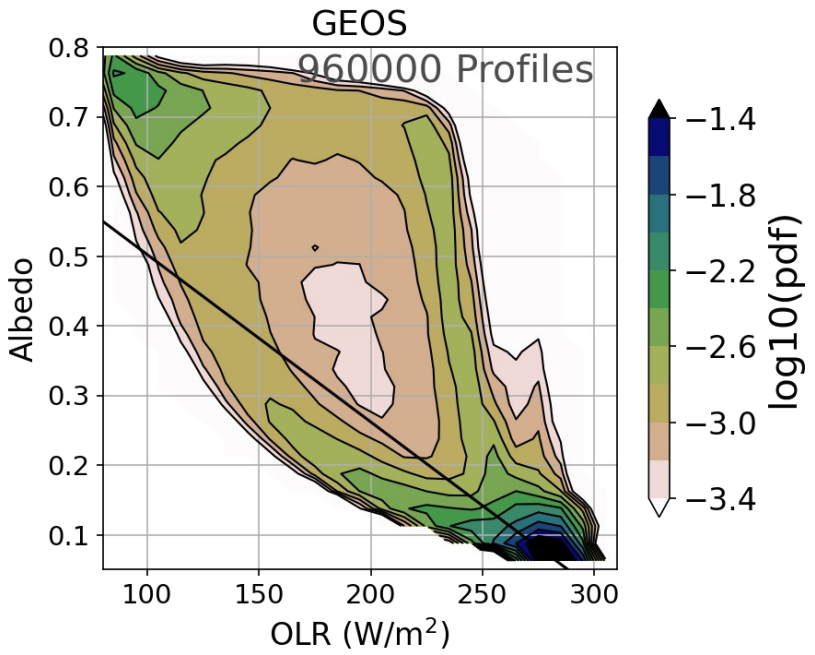




Models with total frozen condensate are shown

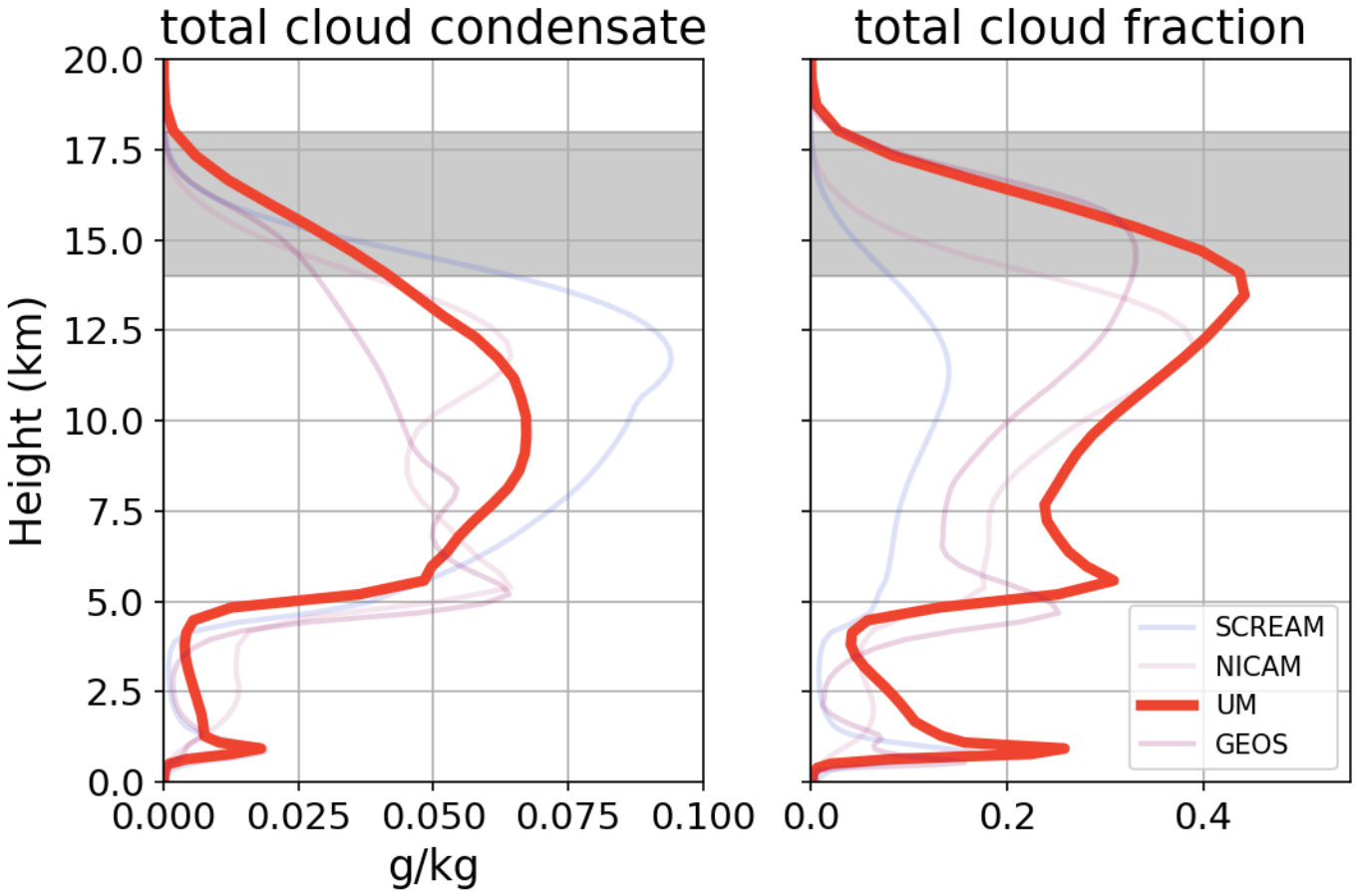
GEOS also has “popcorn” convection and thicker “congestus” clouds

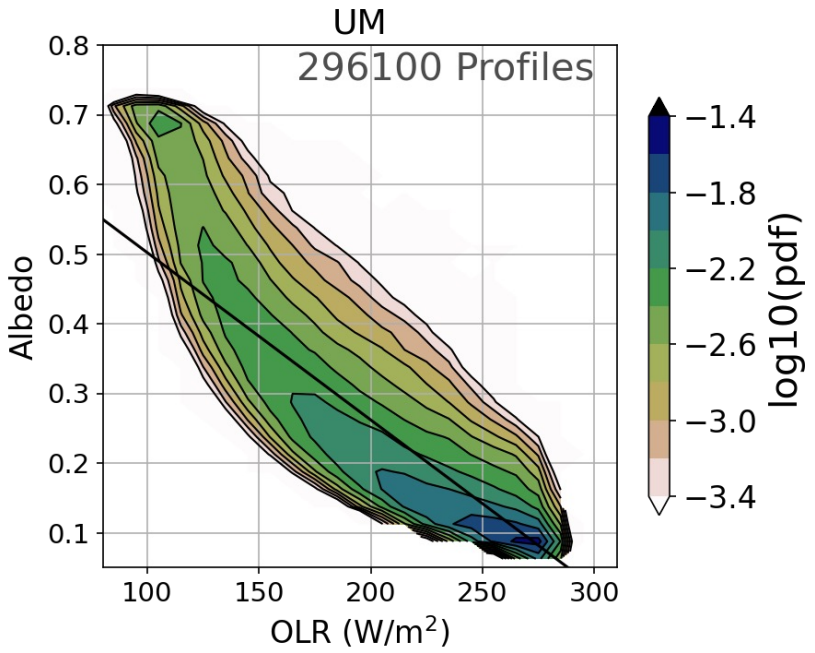




Models with total frozen condensate are shown

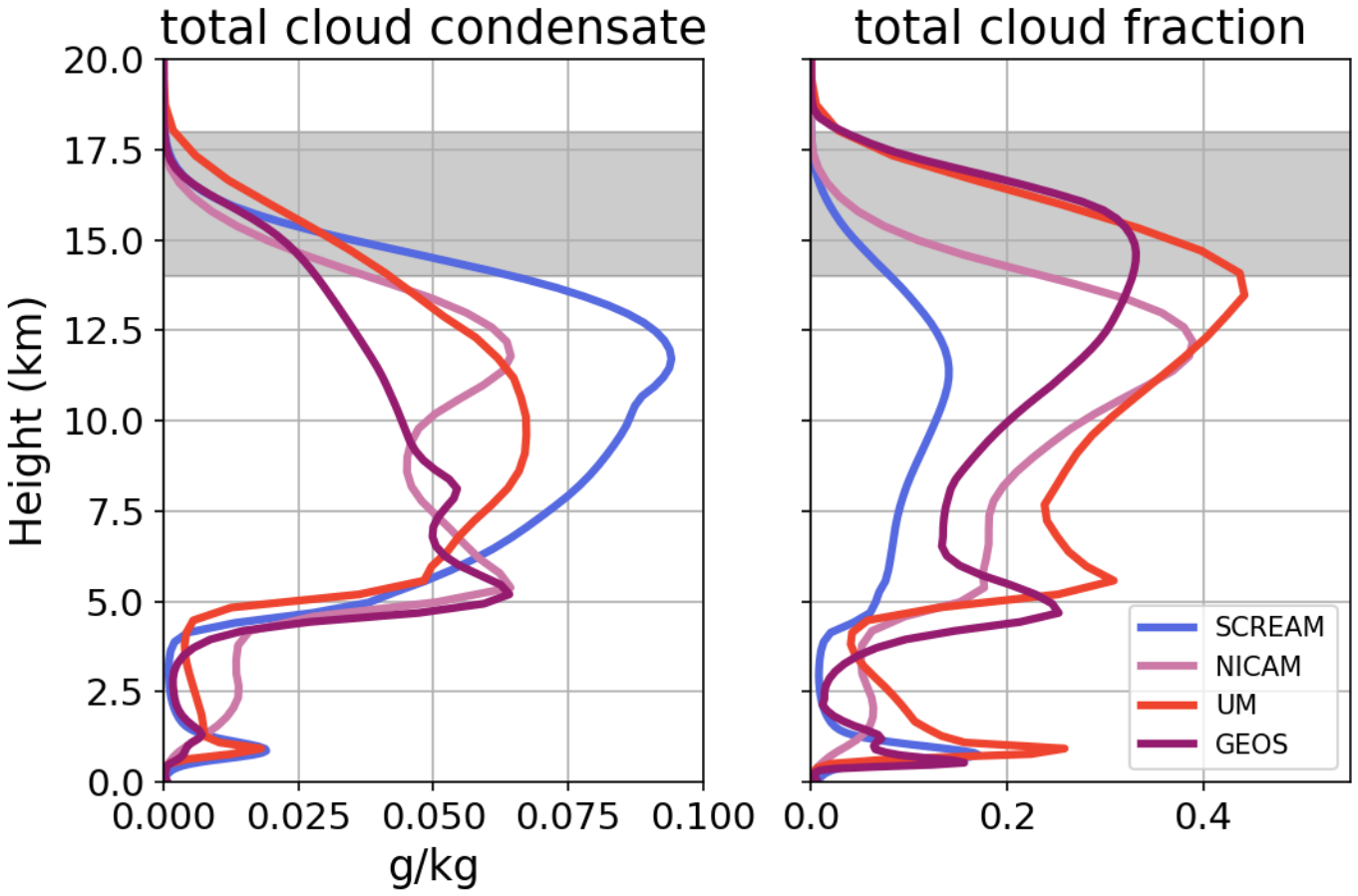
UM has a higher frequency of convection and anvil cirrus in the TTL

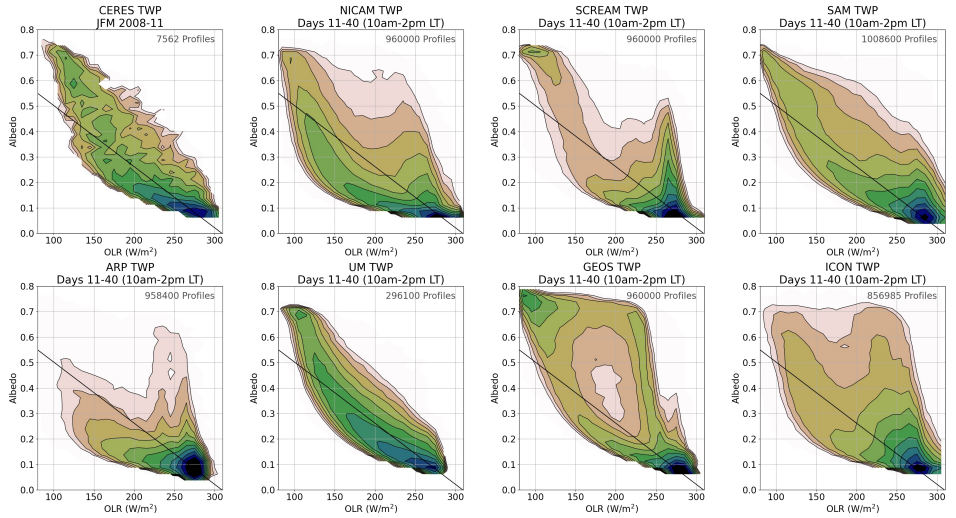




Models with total frozen condensate are shown

Differences in vertical structure are reflected in the joint histograms

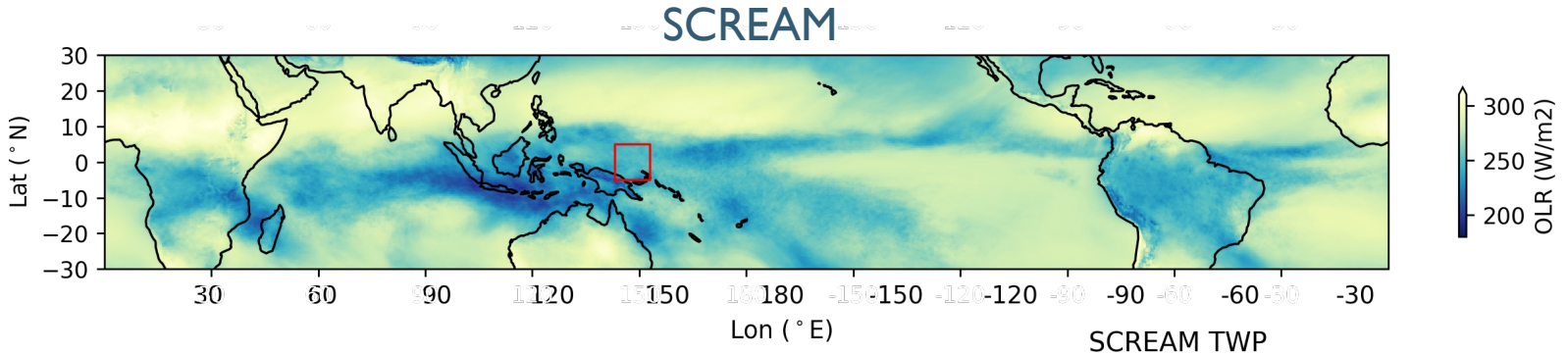


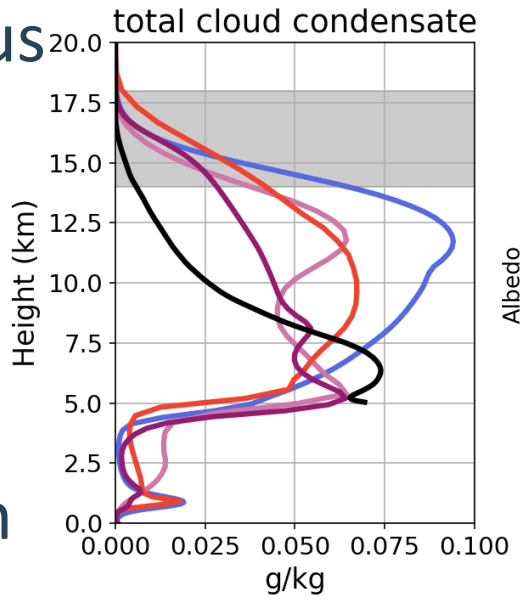


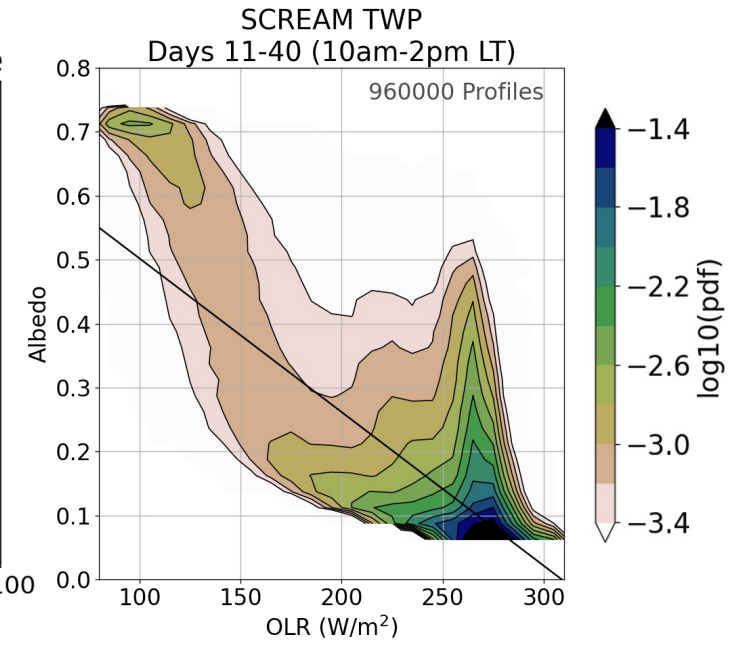
Models with total frozen condensate are shown

Future work

- Effect of microphysics on tropical cirrus using a variable resolution version of SCREAM







Summary

- The DYAMOND models reasonably reproduce tropical convection as seen through the joint histogram
- Large differences in cloud populations are driven by model microphysics and dynamics

Turbeville et al., 2022, ESS

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Thank you!