Subcolumns in CAM
Sampled From a Higher Order Closure Moist Turbulence Parameterization

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Background

“The parameterization of liquid microphysical processes has a strong physical basis at the process level. Instead, **the major uncertainties concern the cloud “macrophysical” assumptions— cloud fraction, fractional condensation closure, and subgrid cloud water distribution.** ...These uncertainties represent a major challenge to future parameterization development in both GCMs and higher-resolution models.” (Morrison and Gettelman, 2008)

- Parameterizations break apart processes that interact at many scales, and lead to overlapping and inconsistent assumptions.

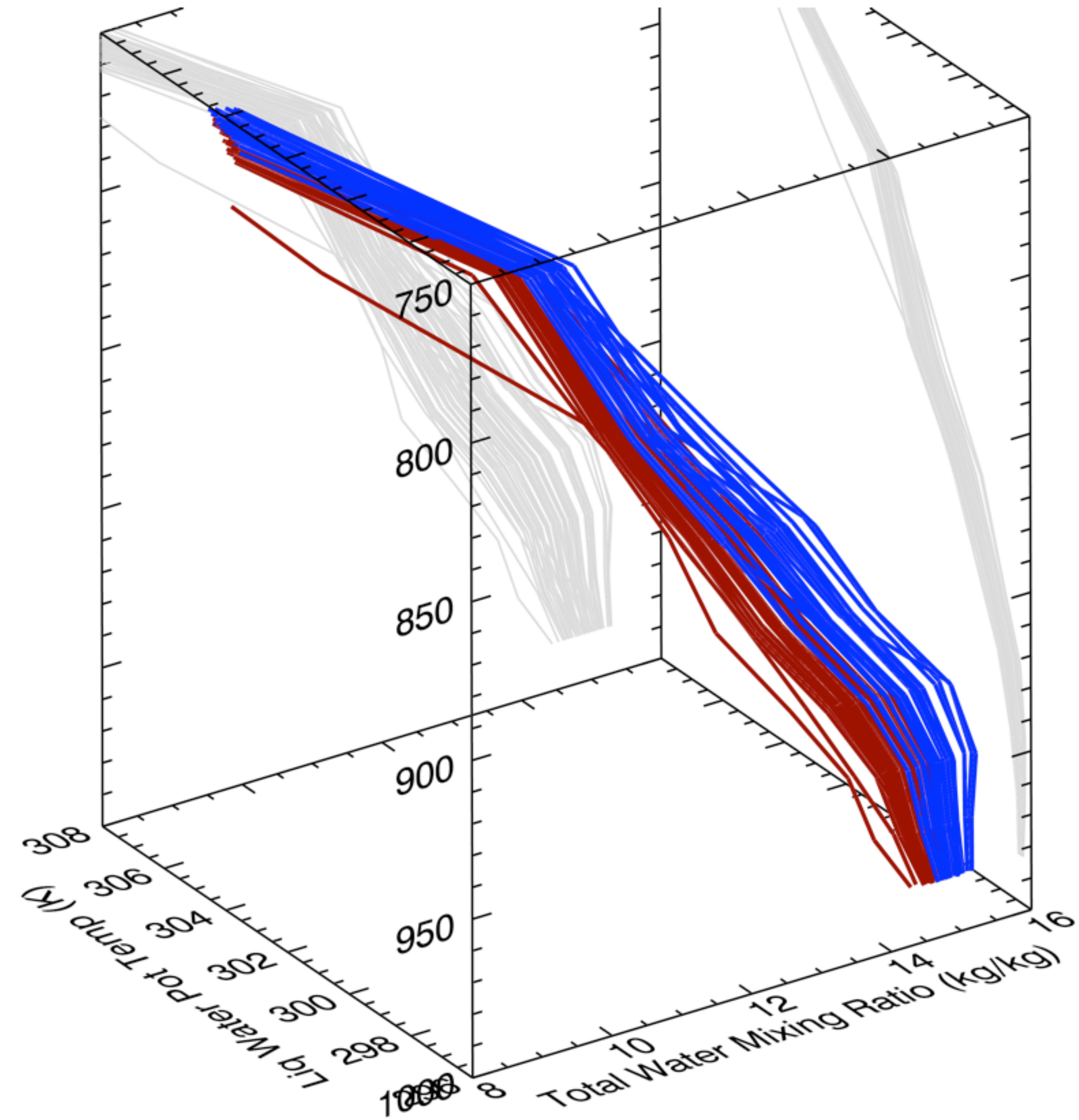
- **Our goal is to increase consistency across the parameterizations for shallow clouds and microphysics in CAM using the new subcolumn framework.**

Overview

- What is a subcolumn?
- What is the subcolumn framework in CAM?
- How do we generate subcolumns? (What are SILHS and CLUBB?)
- Early SCM Testing

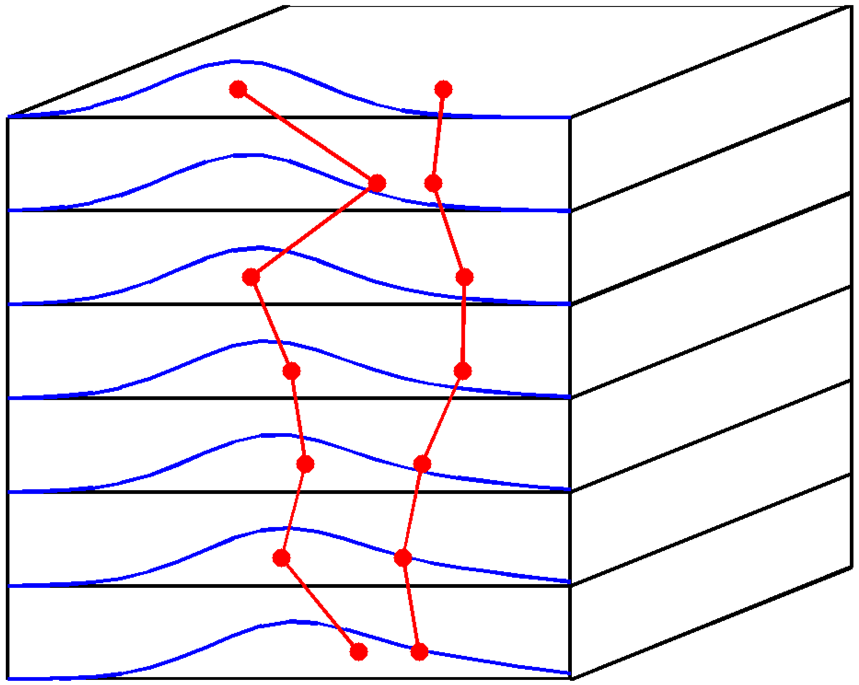
What is a Subcolumn?

- A second dimension for grid columns in CAM
- A data structure that represents the model state within a GCM grid column
- Subcolumns have the same vertical resolution as the larger grid
- Some parameterizations in CAM already use internal subcolumns



Subgrid Importance Latin-Hypercube Sampler (SILHS)

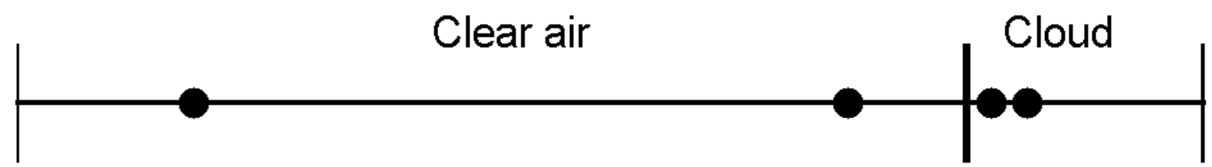
- Created at UWM and implemented in their local single-column model.
- Subcolumns are generated by sampling the PDF produced by the Cloud Layers Unified by Binormals (CLUBB) shallow cloud and macrophysics parameterization.



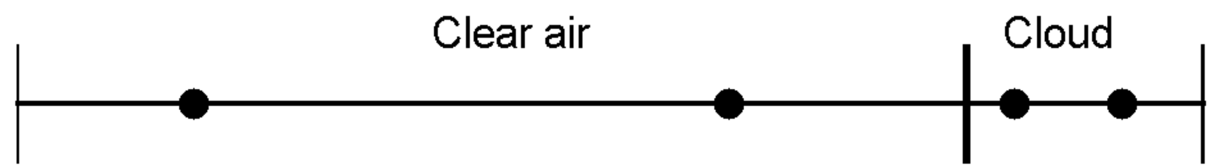
See http://clubb.larson-group.com
and Larson and Schanen, 2013 (Geoscientific Model Development)

Sampling With SILHS

- Importance Sampling: We preferentially choose values from “important” (cloudy) regions.

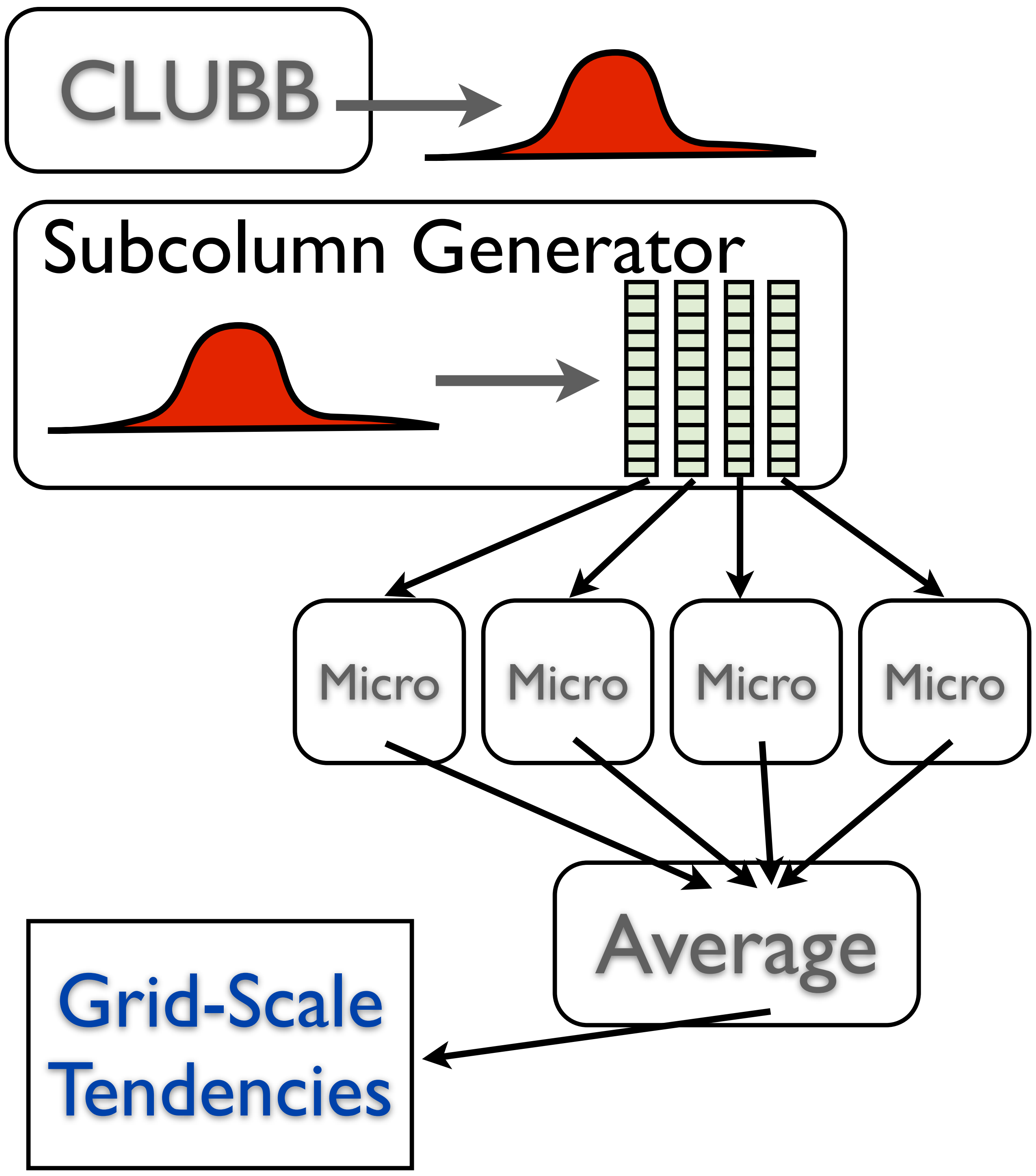


- Latin-Hypercube Sampling: We spread out sample values within each region to avoid clumping.



CAM-CLUBB-SILHS

- Cloud Scheme (CLUBB) generates PDF
- Subcolumn Generator runs SILHS and populates each subcolumn using a single multivariate sample
- Temperature
- Vertical Velocity
- Water Vapor
- Cloud Liquid and Ice
- Cloud Liquid and Ice Number Concentrations
- Microphysics runs on each Subcolumn
- Microphysics tendencies are averaged with SILHS-generated weighting

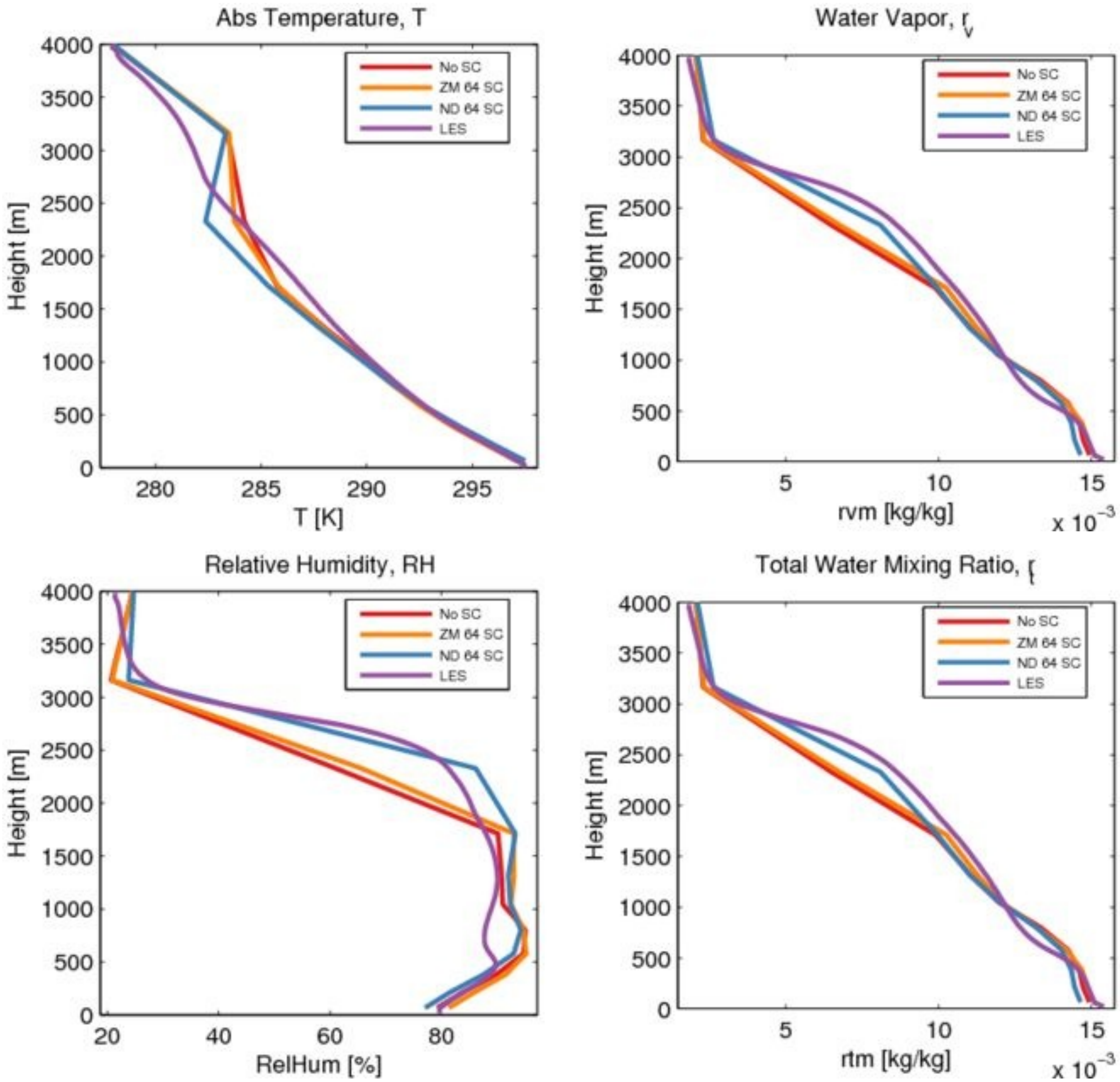


Single Column Model Tests

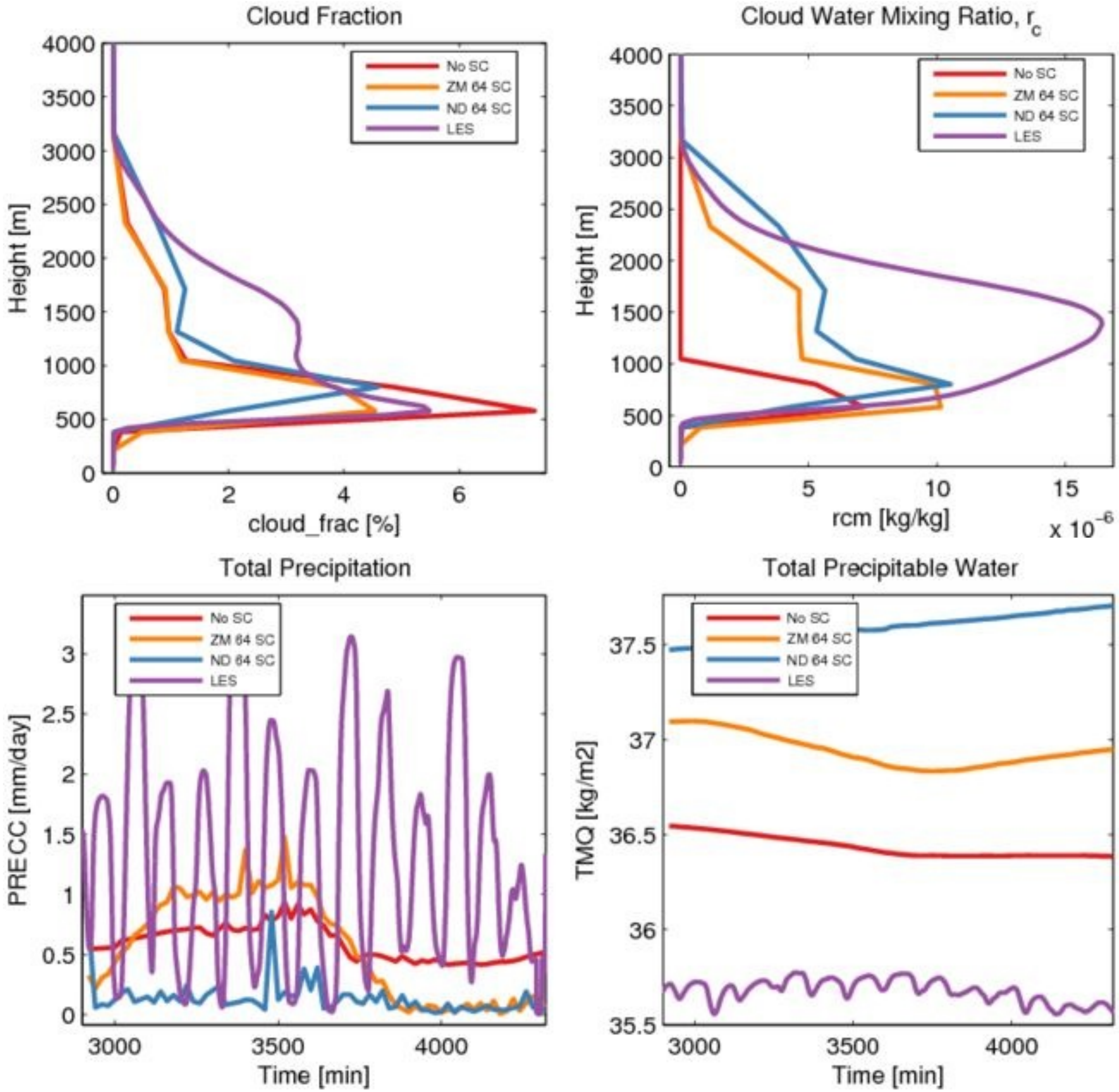
- Single Column version (SCAM) of CAM 5.3
- Eulerian Dycore, 10 minute timestep between SILHS sampling, 30 vertical levels, 64 subcolumns, forcing from RICO and ARM IOPs
- Using CLUBB as the shallow cumulus and stratiform (macrophysics) parameterization, and MG 1.5 for microphysics.

➡ ZM deep convection ON or OFF (No Deep)

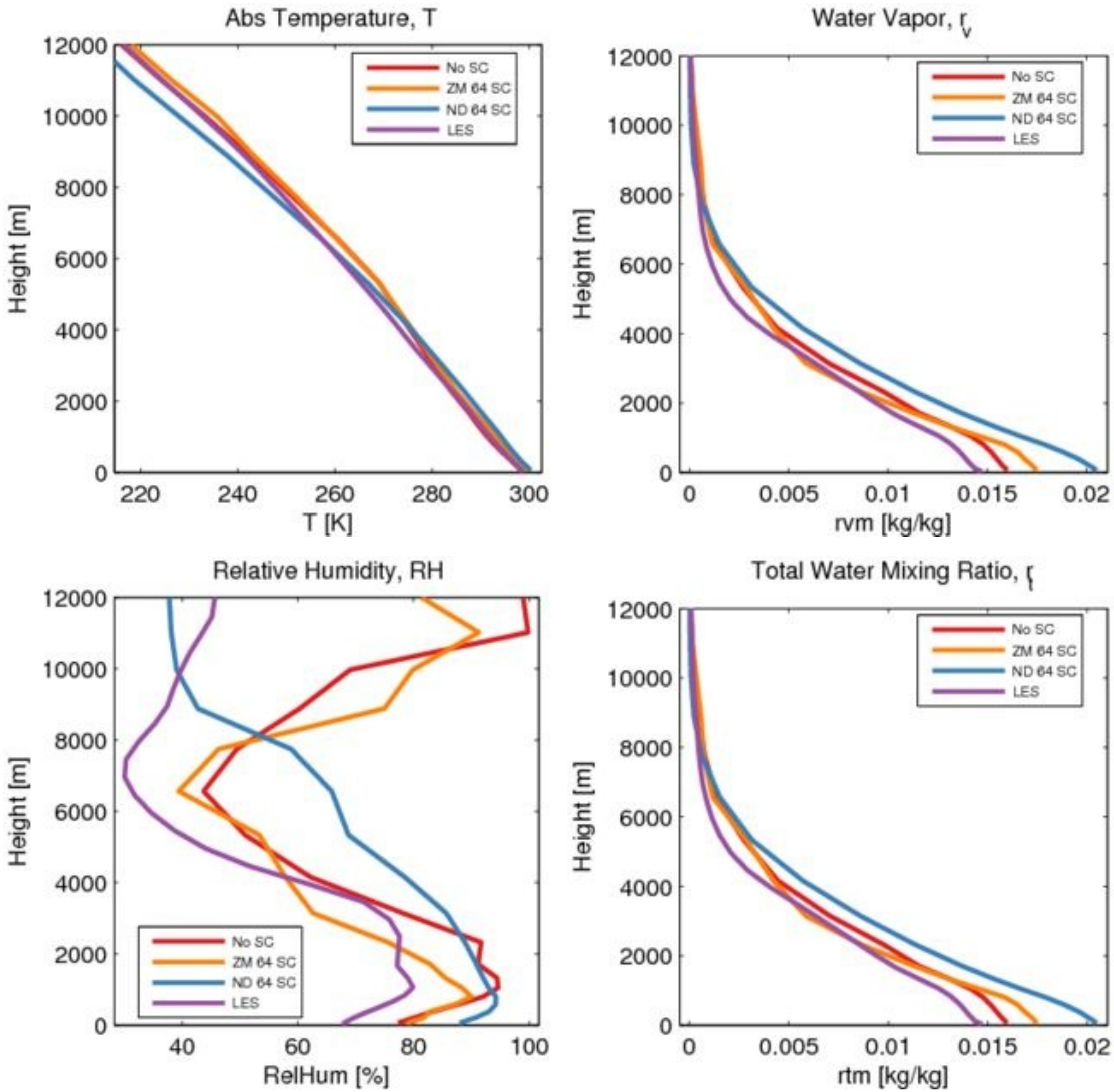
Rico SCAM Testing - 64 SCOL



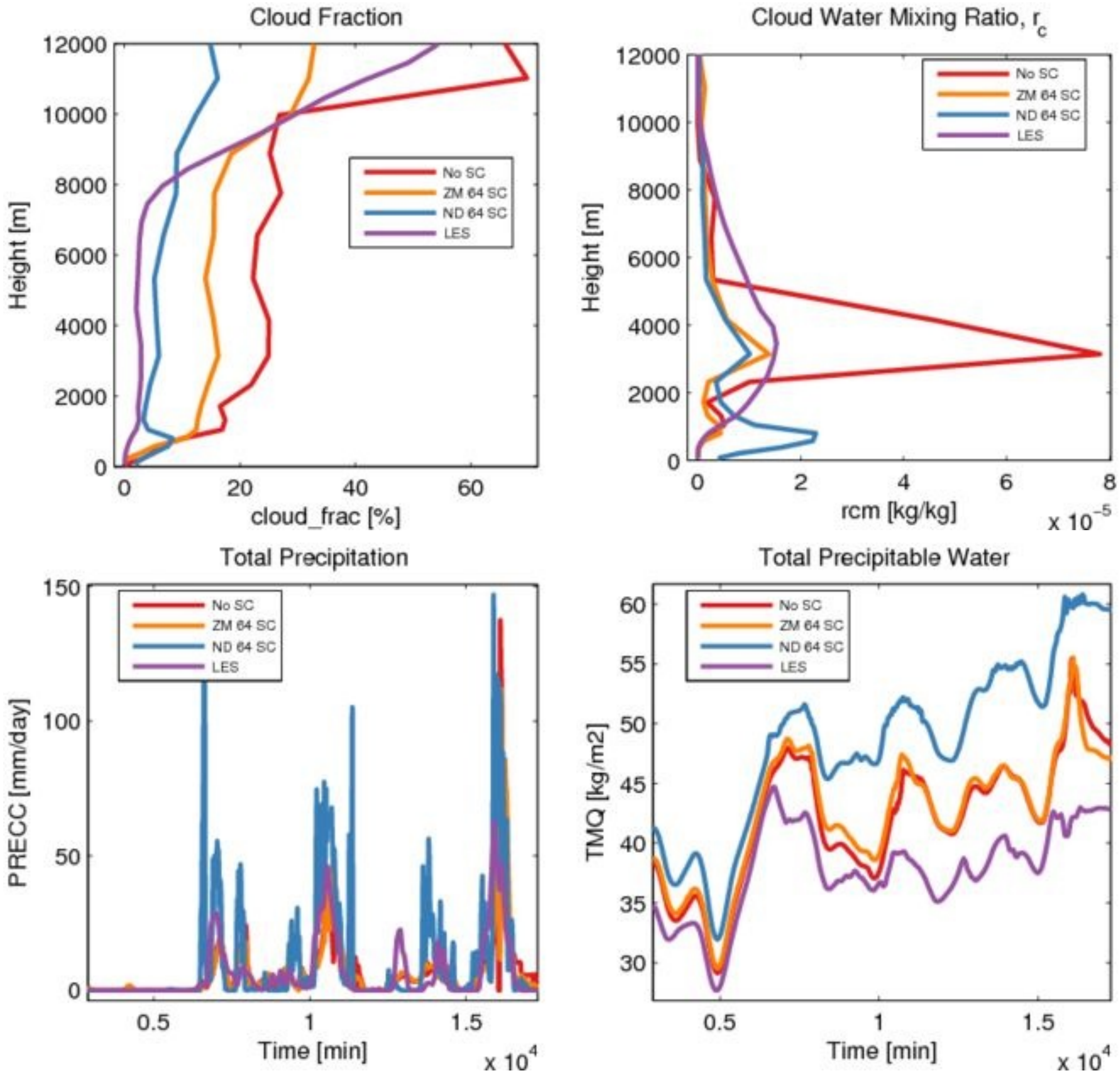
Rico SCAM Testing - 64 SCOL



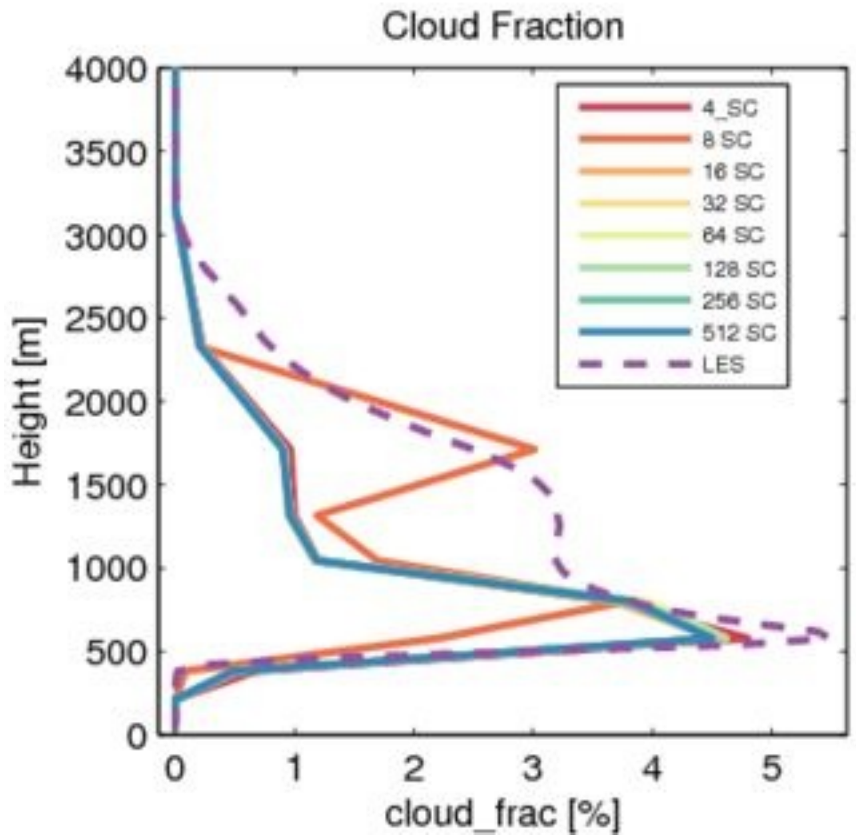
ARM SCAM Testing - 64 SCOL

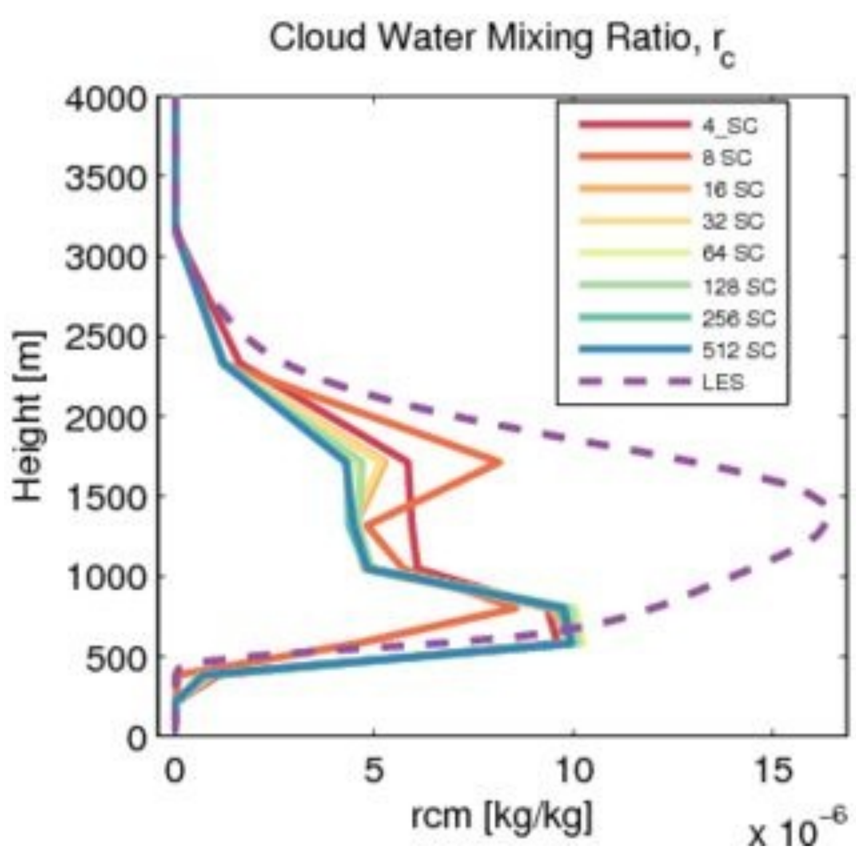


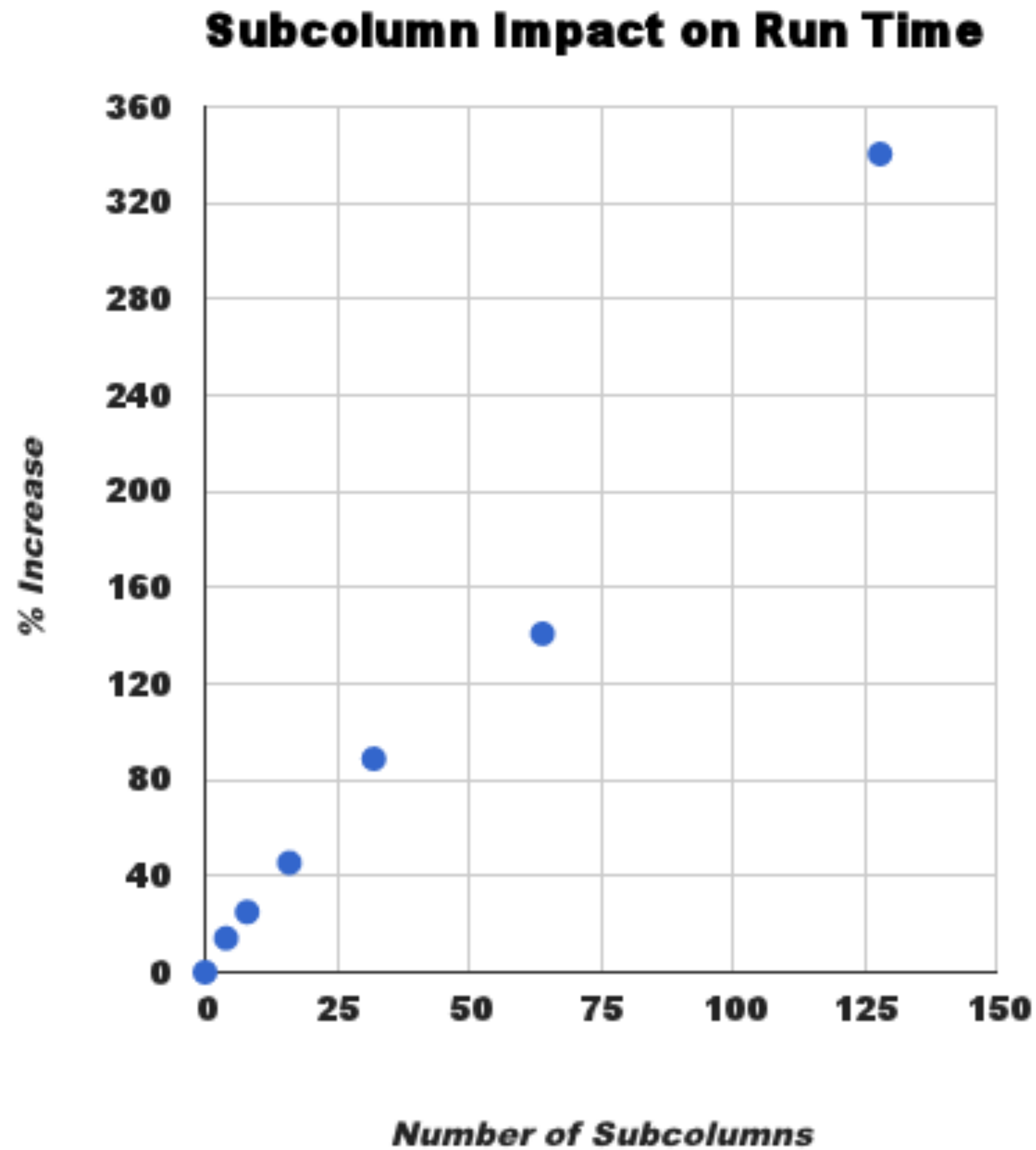
ARM SCAM Testing - 64 SCOL



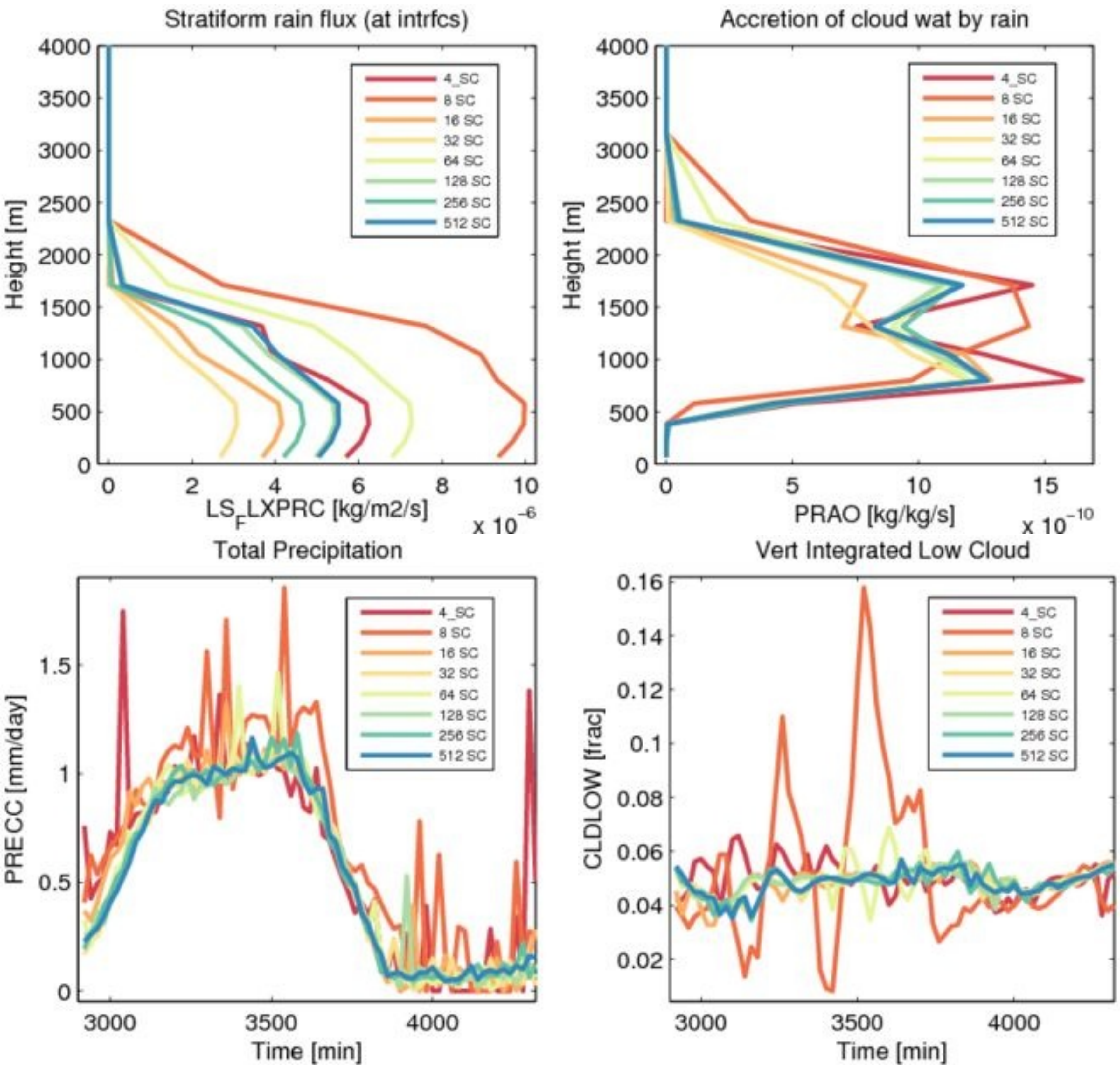
Subcolumn Computational Cost







Subcolumn Computational Cost



Wrap-up

- Currently developing support for subcolumns in CAM that can be accessed across parameterizations
- A flexible framework with many possible uses
- UWM implemented a subcolumn generator that produces profiles using the SILHS software and the CLUBB PDF
- Microphysics is now using the subgrid distribution of clouds and water as predicted by the cloud parameterization
- Future work includes testing different configurations (MG2, sub-stepping, improved CLUBB No-Deep, etc), exploring sensitivities, and global simulations.

Thank you for your time!

- References

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