Assessment of Precipitating Marine Stratocumulus in E3SMv1: A Case Study during the MAGIC Campaign

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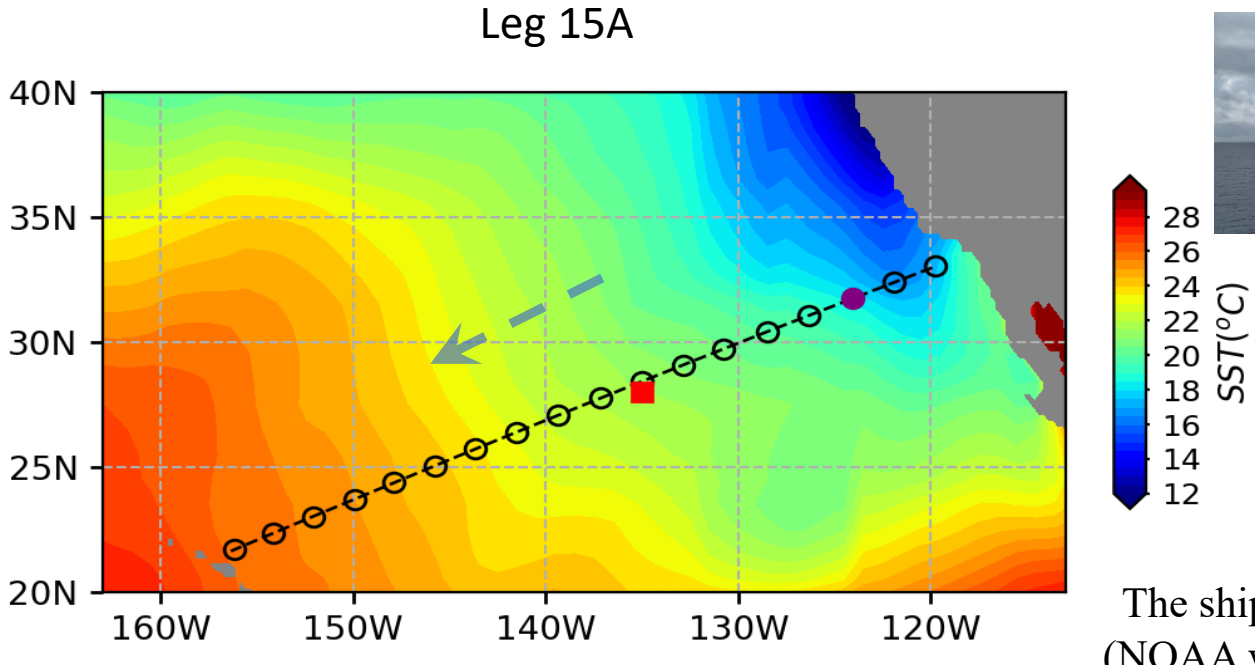
MAGIC Field Campaign

October 2012 to September 2013

Hawaii



LA

The ship track for MAGIC Leg 15A (NOAA weekly SST and the sounding locations)

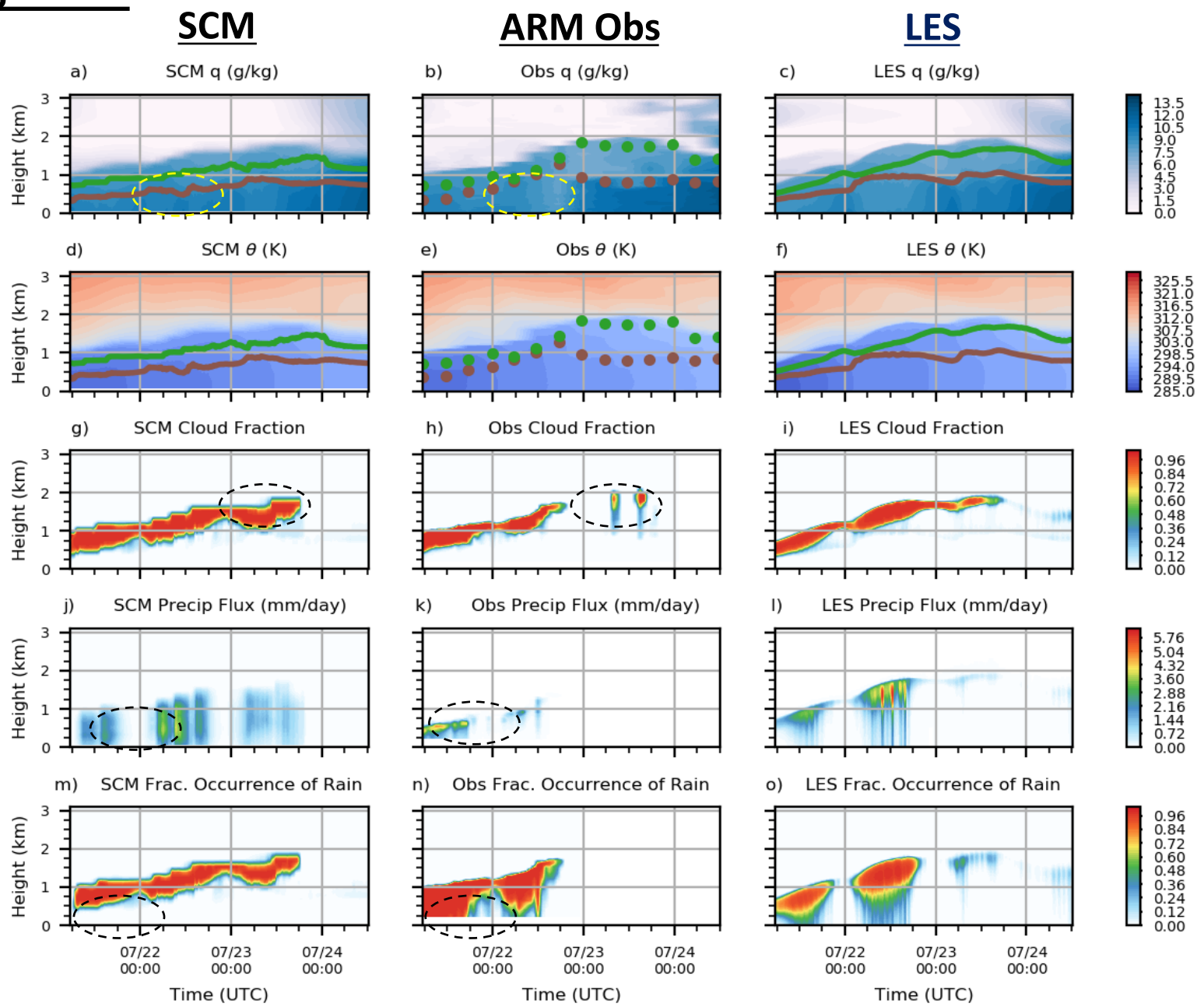
- *Persistent Sc and Cu cloud biases in GCMs*
- *Use ARM data to evaluate and improve the representation of precipitating Sc clouds in E3SM*

Data and Method

- ARM observations
  - Cloud radar reflectivity, **drizzle retrievals**, radiosonde, surface fluxes, surface radiation, surface precip rate, LWP, total precipitable water
- LES simulation (McGibbon and Bretherton, 2017)
  - Leg 15A: July 20 17:30UTC to July 25 00:00UTC, 2013
  - Large-scale forcing: large-scale ECMWF-derived forcing, 10-minute SST from ISAR measurements
  - Prescribed time-varying Nc based on surface CCN Obs
- E3SM Single-Column Mode(SCM) simulations
  - Leg 15A: July 21 05:30 UTC to July 25 00:00UTC
  - The same large-scale forcing as LES
  - Constant Nc = 50 cm^{-3}

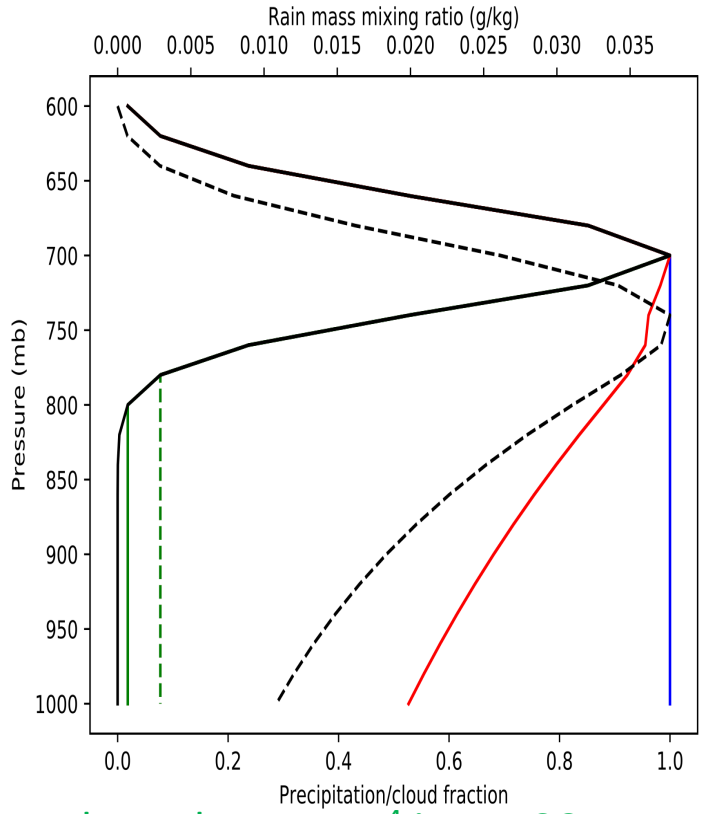
General Evaluation of Leg 15A

1. SCM generally captures the time evolution of the cloud layer and BL.
2. Too late Sc to Cu transition and too moist low-level BL on 07/22.
3. The sub-cloud precipitation flux does not clearly decrease as it does in the Obs and LES.
4. An unrealistic fractional occurrence of rain below the cloud base in SCM.



Proposed model changes

1. Precipitation fraction method = mass gradient method
2. Reduce model microphysics timestep: 300s → 30s
3. *Reduce the precipitation formation rate → prco , prao = 0.6**



mass_gradient

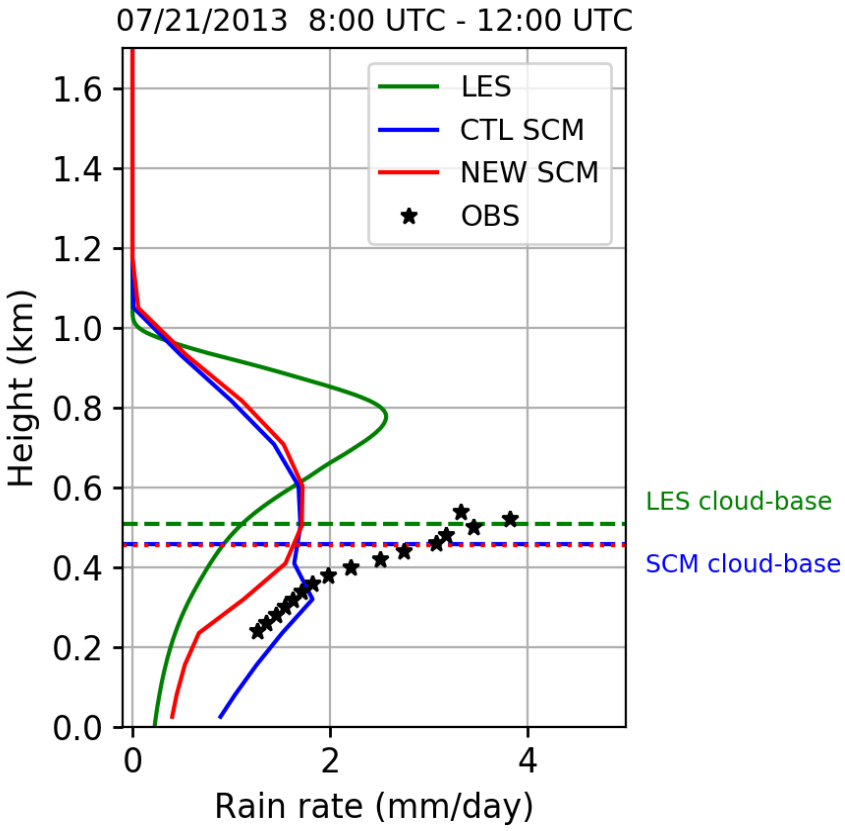
max_overlap

Default, it can be as low as $1e^{-4}$ in my SCM case

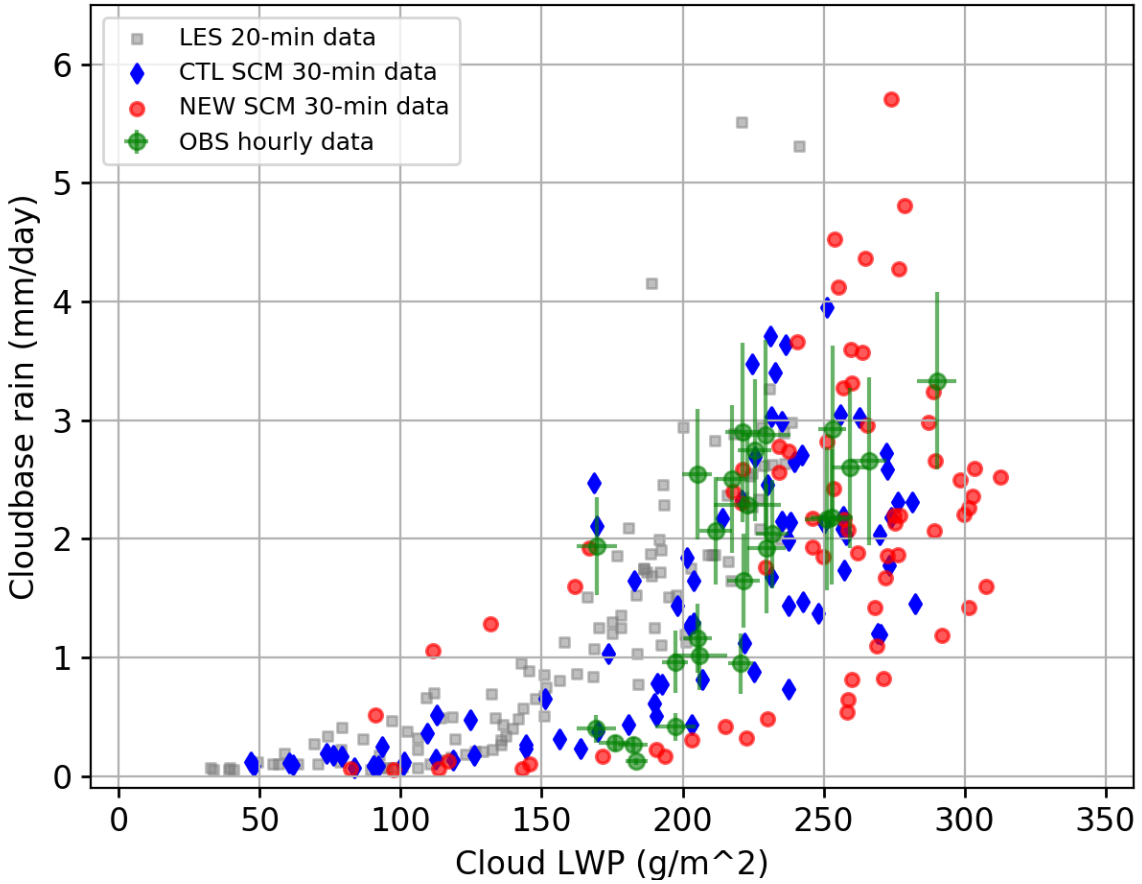
- It is used to calculate the in-area rain water, and in-area rain droplet concentration → the rain size distribution→ rain evaporation, rain fall-speed

Precipitation Properties

Precipitation flux

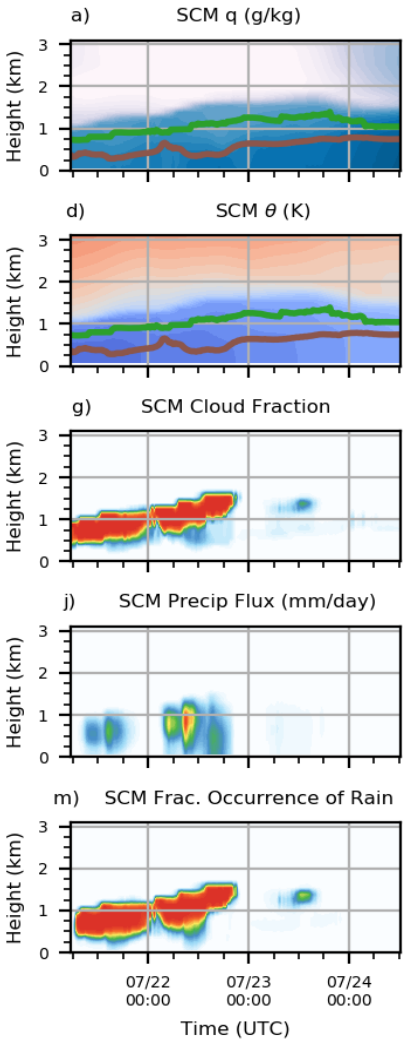


Cloud-base rain rate vs. LWP

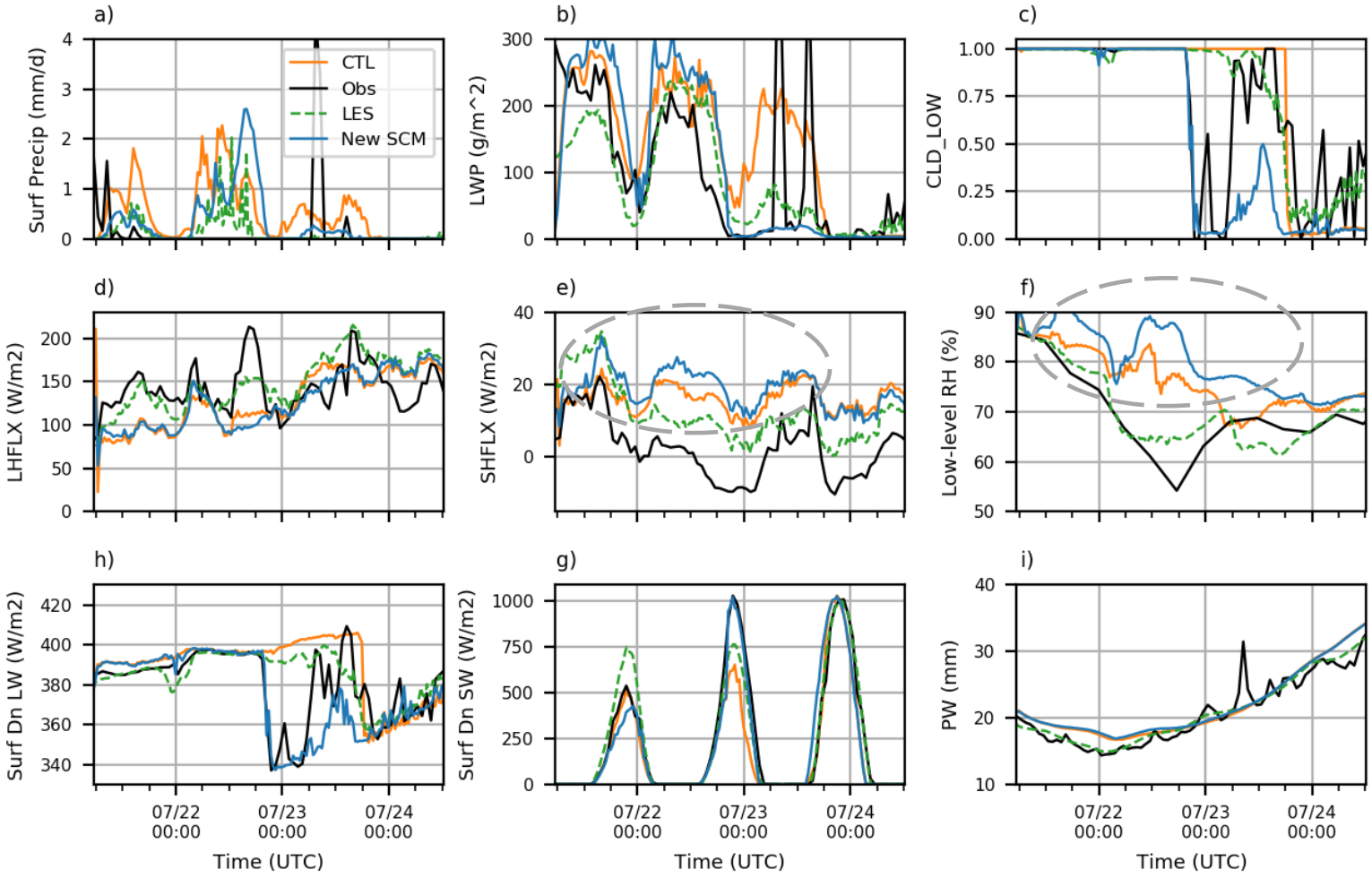


The impact of the proposed changes

New SCM



Obs-LES-SCM Inter-comparison



Enhance the growth of the BL via tuning CLUBB -> K10, C7

Summary and future work

- Sc is generally well-simulated in E3SMv1 SCM
- The SCM produces a reasonable cloud-base rain rate for a given LWP but there are problems with precipitation vertical structure
- The unrealistic precipitation vertical structure can be significantly improved with altered parameterizations (i.e. new precipitation fraction method) and shorter time-steps
- Keep using ARM Obs, particularly the drizzle-related retrievals, and the available LES simulations as the reference to evaluate the representation of the MBL precipitation processes in GCMs

Thanks!