UA Modeling Team Update

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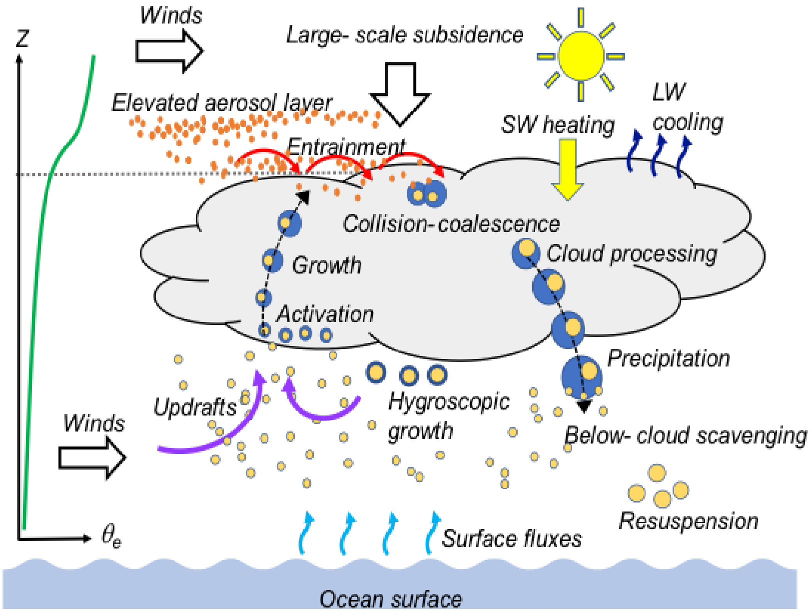
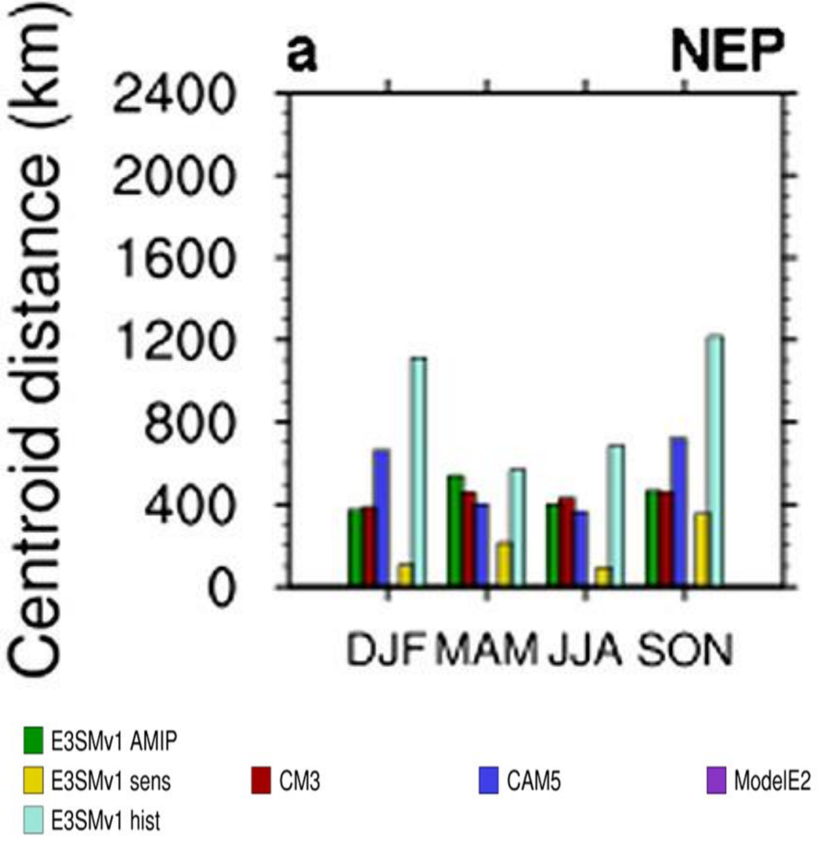


(Sorooshian et al. 2019)

- Clouds affect radiation, precipitation, and atmospheric state
- Clouds are affected by aerosols, cloud microphysics, atmospheric thermodynamics, turbulence (including PBL height), and atmospheric dynamics (wind)

Q: How do we evaluate GCMs and provide insights on model physics improvements using field campaign data?

Q: can we use field campaign data to evaluate GCM clouds over the same grid box?



Q: how do we quantify spatial errors in subtropical stratocumulus cloud decks? centroid distance (offset, shown left), area ratios (size), and overlap ratios (location, size, and shape).

Q: What OBS data? In situ and satellite data and satellite simulator (GOCCP)

- GCMs have large spatial location errors

Q: How to separate dynamics from physics? Sensitivity run "SENS" with wind fields nudged to MERRA2 reanalysis.

- Model physics (widely recognized) and physics-dynamics interaction (less recognized) errors are primarily responsible

Implication: challenging to use field campaign data to evaluate GCM results over the same grid box.

Brunke et al. (2019, Geophys. Res. Lett.)

Q: How does model turbulence compare to observations?

Our idea: use ACTIVATE aircraft measurements for atmospheric model process evaluation.

We find that:

- Boundary layer turbulence simulated by global models is weaker than observed (left).
- Maximum turbulence kinetic energy is most often within clouds in observations but mostly below cloud in the model.
- Observations are similar to bivariate Gaussian probability distribution functions assumed in the model for turbulence closure.

Implication: These results provide guidance for further model improvement and development of model parameterization of boundary layer turbulence and shallow clouds.

Brunke et al. (2022, JGR-Atmospheres)

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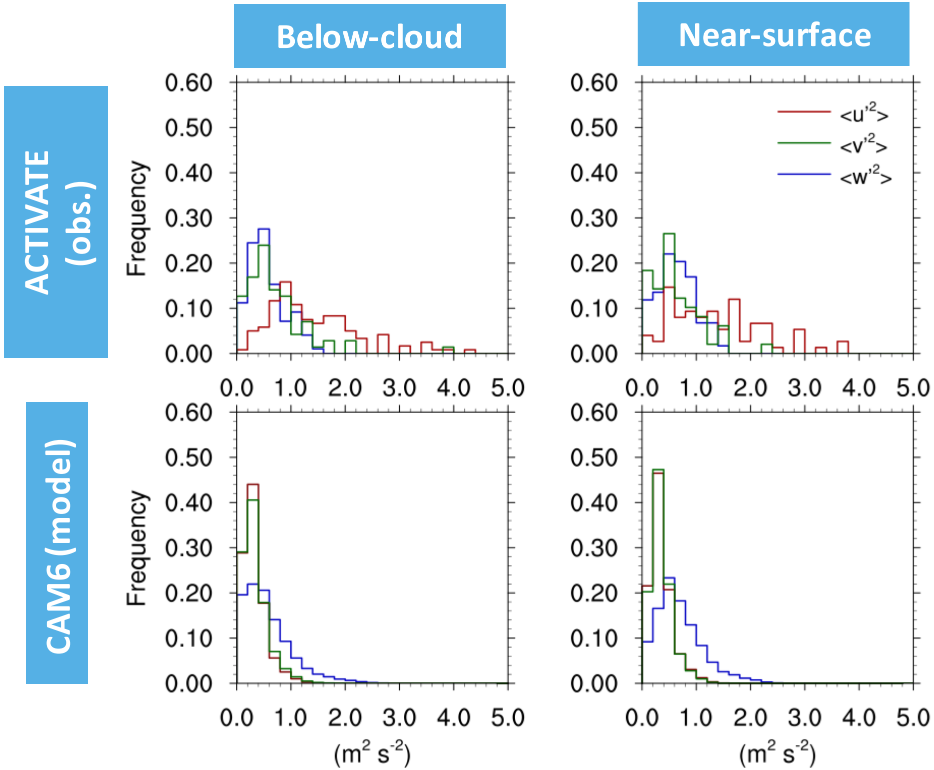


Frequency of wind variances at two level legs in cloudy ensembles from ACTIVATE (top) and from cloudy grid cells in model simulations (bottom).

Q: Are the conclusions of the following studies robust?

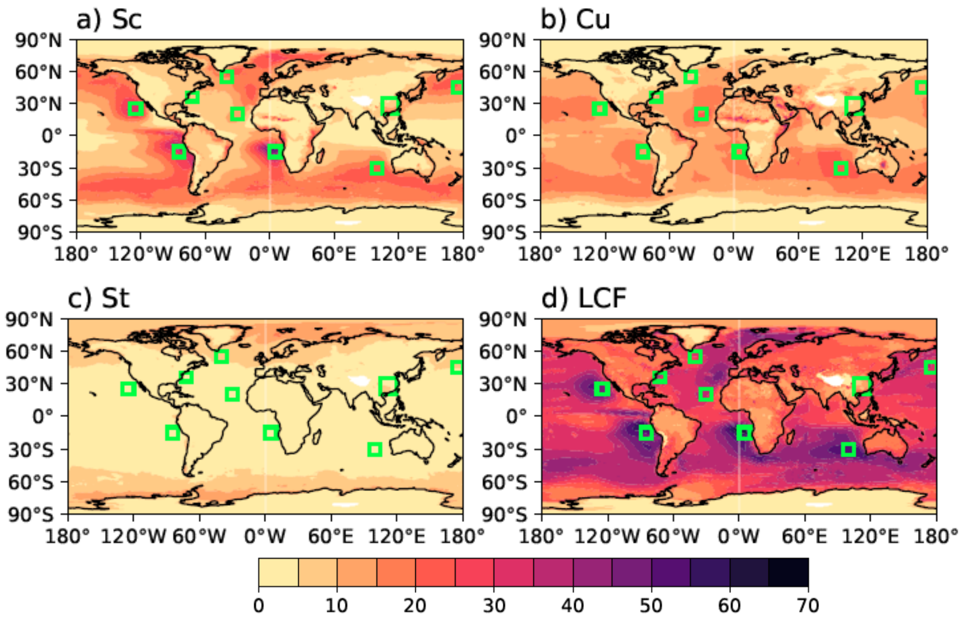
Klein and Hartmann (1993) established a strong relationship between low cloud fraction (LCF) and lower-tropospheric stability (LTS)

$$LTS = \theta_{700} - \theta_{sfc}$$

Wood and Bretherton (2006) established a stronger relationship between LCF and estimated inversion strength (EIS)

$$EIS = LTS - \Gamma_m^{850}(z_{700} - LCL)$$

Cutler et al. (2022, Geophys. Res. Lett.)

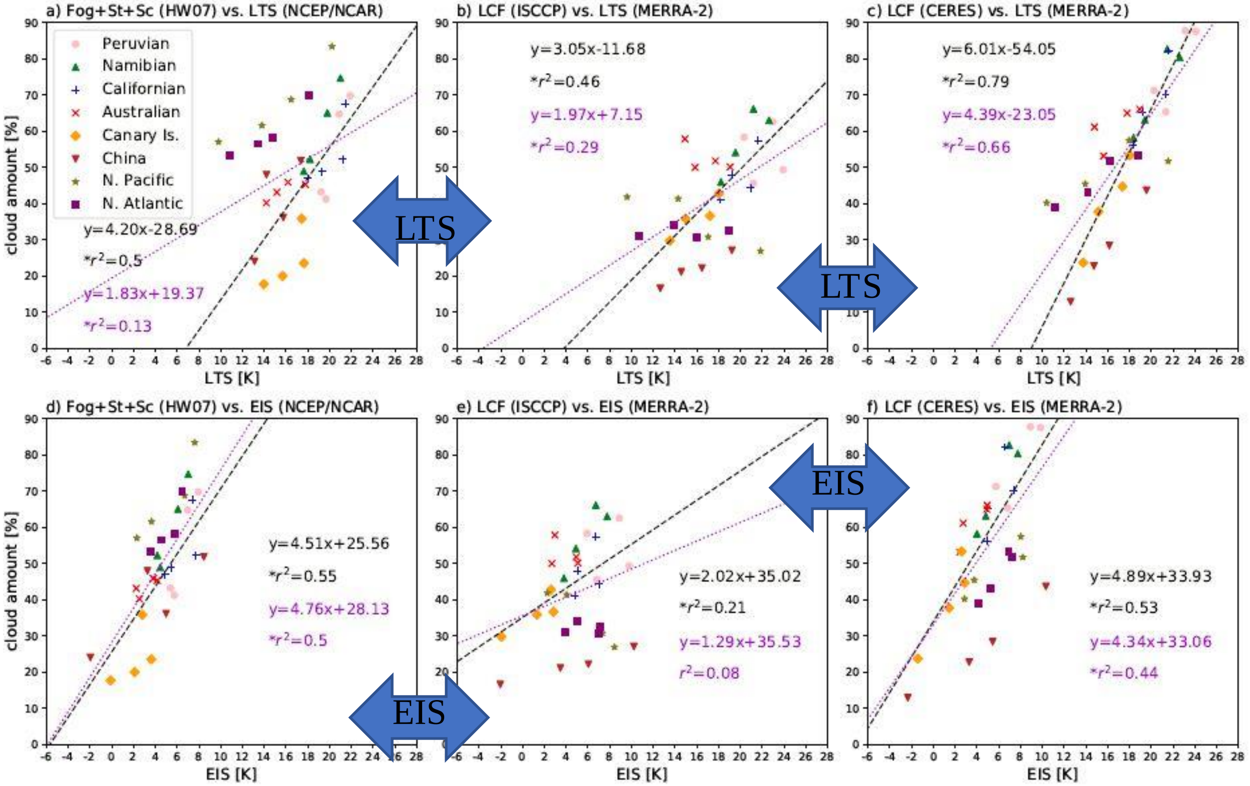


ISCCP annual cloud amount. LCF: low cloud fraction. The green boxes indicate Sc regions and a portion of the ACTIVATE region (32°-40°N, 67°-77°W).

Black=N. Atlantic& N. Pacific NOT included in linear regression

Purple=N. Atlantic & N. Pacific included in linear regression

Hahn & Warren (2007) ISCCP CERES



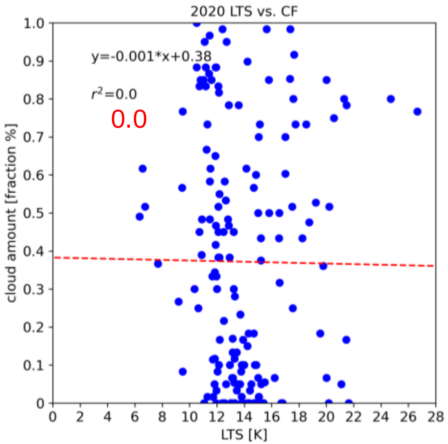
Q: What are the relations of LCF with LTS and EIS using different datasets?

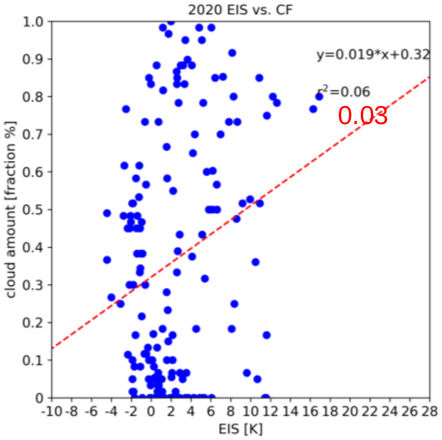
The LTS – LCF and EIS – LCF relations are not consistent across different cloud datasets.

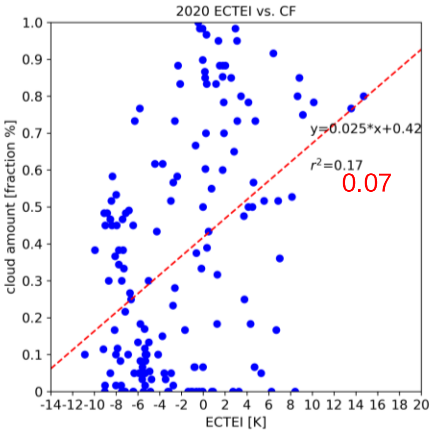
The LTS-LCF relation is not as strong as claimed in Klein & Hartmann (1993).

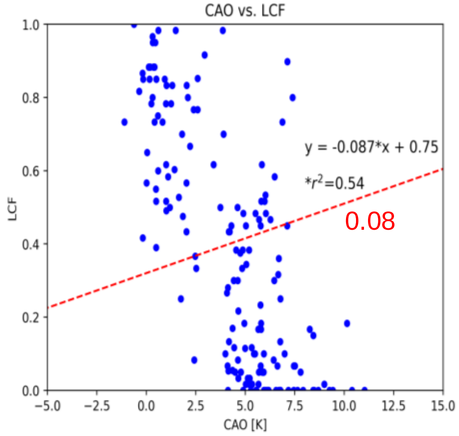
The EIS –LCF relation is not stronger than the LTS-LCF relation, as claimed in Wood & Bretherton (2006).

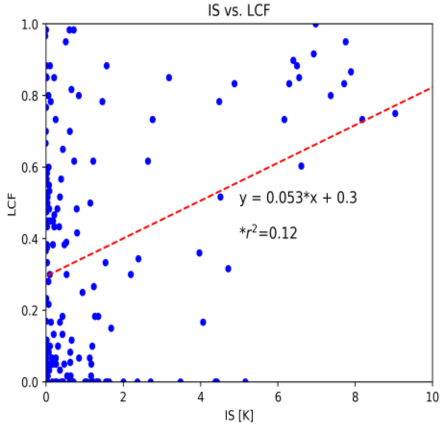
Implementation: for all prior satellite data analyses, are numerous findings using early versions of satellite data still valid?











Q: what is the instantaneous relation between cloud fraction (from HSRL2) and atmospheric stability (from dropsondes)?

- LTS, EIS, ECTEI (from prior publications) have weak relations with cloud fractions
- CAO Index is not robust.
- PBL top inversion strength?
- How about model results?

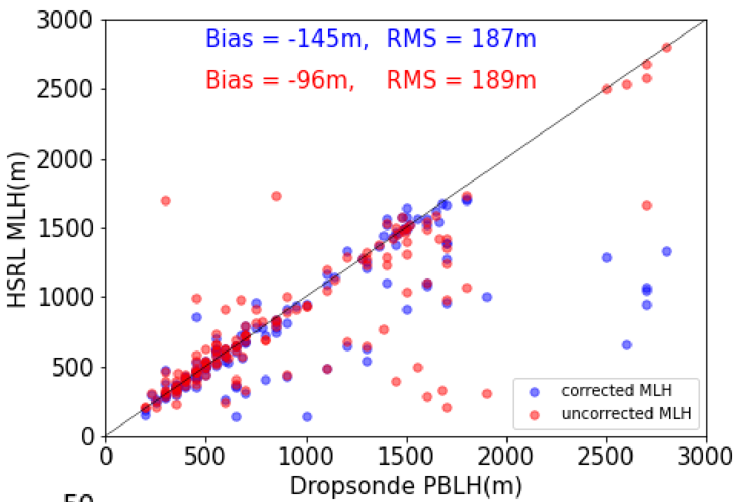
Q: how well does airborne HSRL2 measure mixed-layer height (MLH)?

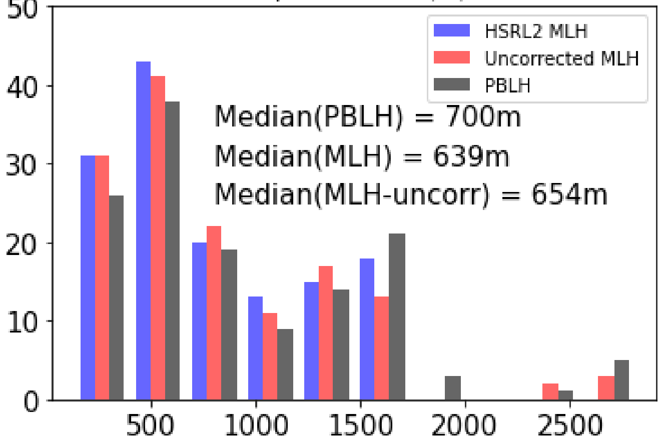
Evaluated the MLH data (retrieved by HSRL2, then corrected by scientists) using PBLH from 136 dropsondes during the ACTIVATE Campaign in 2020.

- Corrected MLH (blue) shows excellent agreement with the PBLH from the dropsondes (e.g., difference <100m for 71% of dropsondes)

To potentially improve the HSRL2 retrieval, we have also evaluated the (uncorrected) MLH (retrieved by HSRL2, without correction by scientists)

- Uncorrected MLH (red) has a similar performance to that of corrected MLH (smaller bias in magnitude, comparable RMS error, difference < 100 m for 64% of dropsondes)





Q: How to evaluate satellite precipitation over ocean?

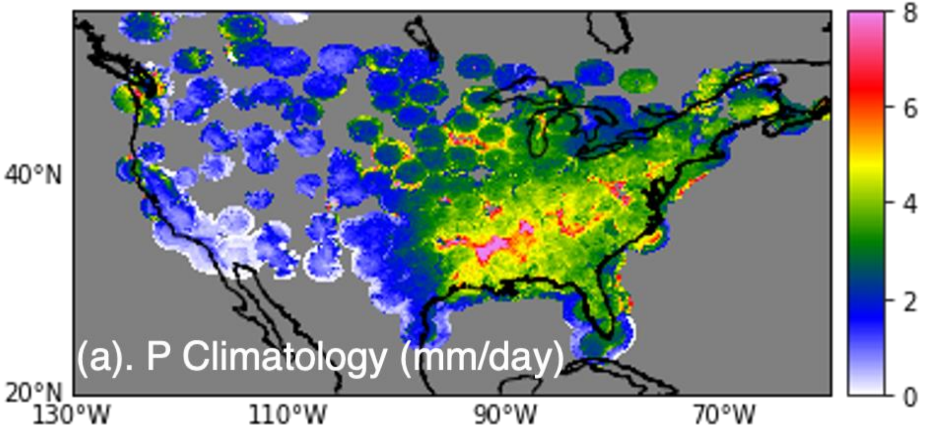
- Use three years (2018-2020) of Gauge-corrected MRMS Radar-Estimates data.

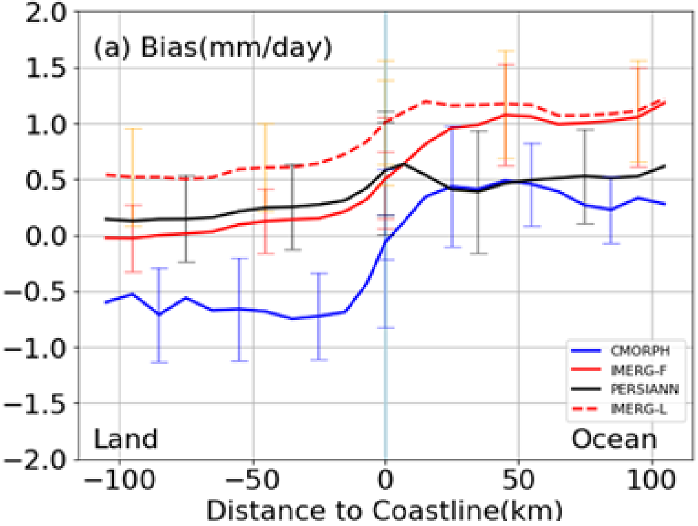
Q: How do three satellite products perform?

- IMERG-F (satellite + gauge) (——) performs much better than IMERG-L (satellite only) (- - -) due to gauge correction

- IMERG-F is the best over land; but it needs to improve over ocean

Xu et al. (2022, Remote Sensing)



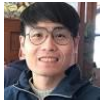


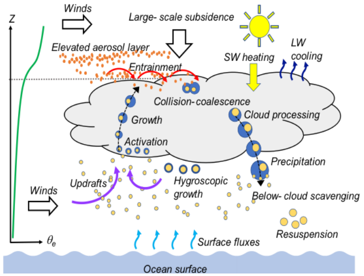
Conclusions

1. Low clouds: global models have large spatial location errors and we provide insights on the relevant processes.
2. Precipitation: IMERG product performs well over the U.S. coastal land but needs improvement over ocean
3. Atmospheric stability: its control on the low cloud climatology is not as strong as widely accepted. The instantaneous relation is under investigation.
4. Turbulence: provide new insights on model turbulent processes
5. PBL height: evaluating and possibly improving the PBL height retrieval from HSRL2 (ongoing).

Not covered:

- derived the 3D wind from satellite water vapor observations over the tropics and midlatitudes (Ouyed et al., 2022, revised)
- Gridded ACTIVATE data development (to be finished)
- Use triple colocation method to evaluate ACTIVATE HSRL2 and RSP AOD data and satellite MODIS data (Siu et al., ongoing)





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