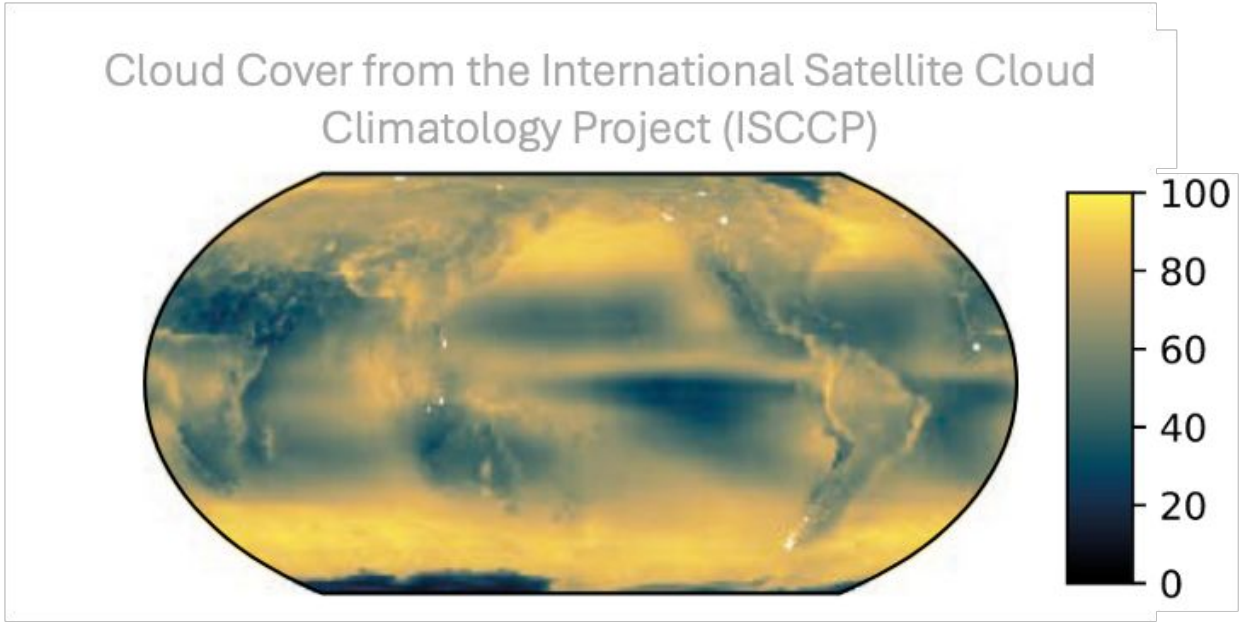
NSF | NCAR
OPERATED BY UCAR

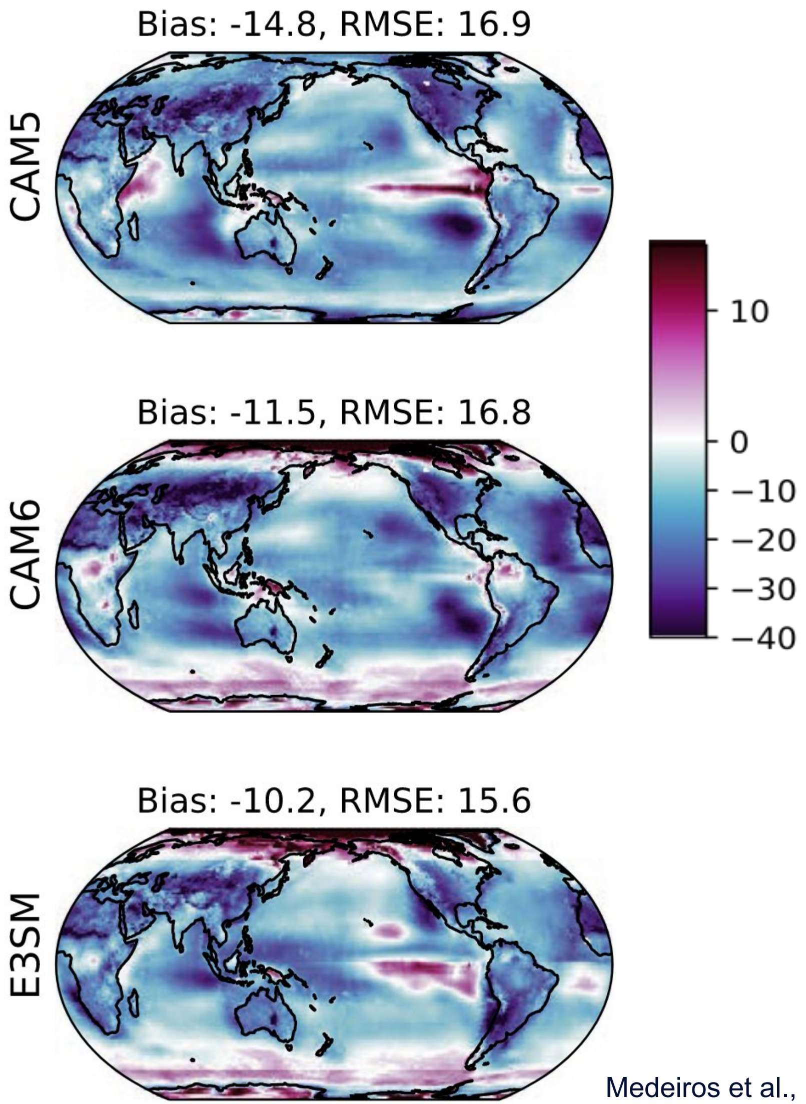
Bridging the Gap Between Field Measurements and CESM: Updates from the INFORM Project

Ryan Patnaude, Justin Richling, Isla Simpson, John Truesdale, Christina McCluskey

This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

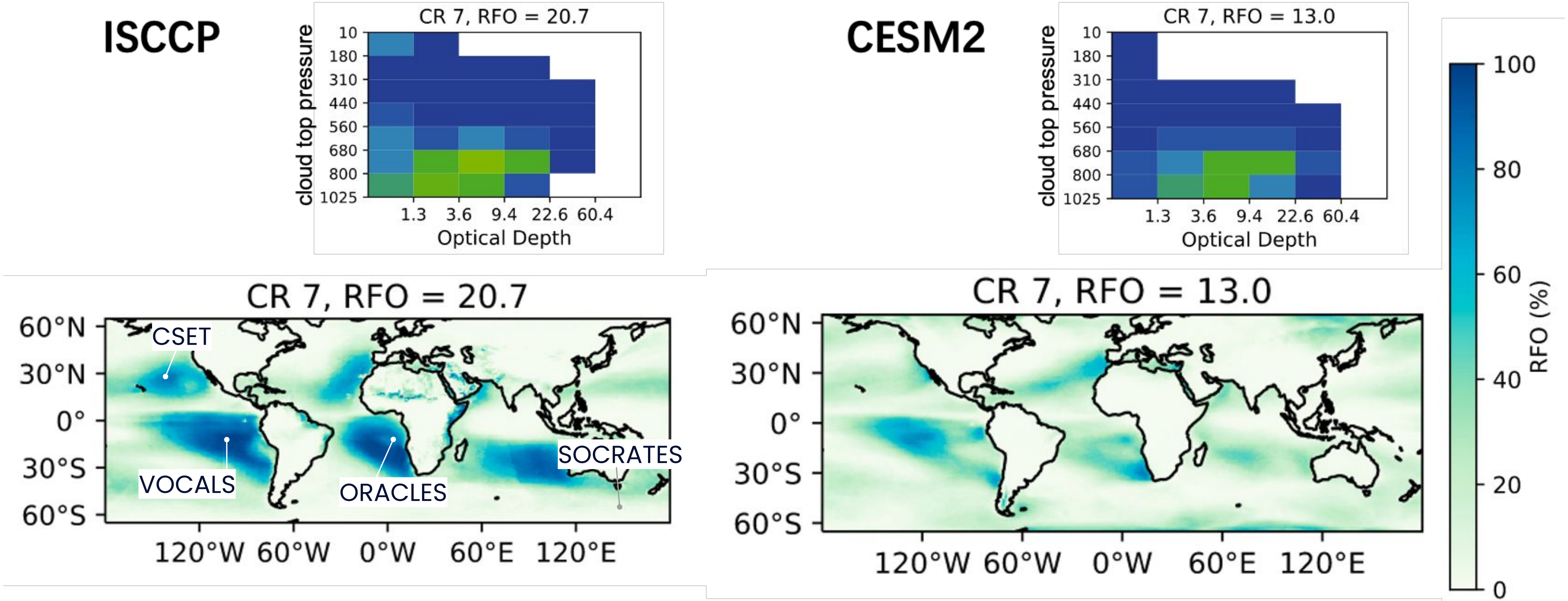
Global Climate Model Biases in Cloud Cover





Medeiros et al.,

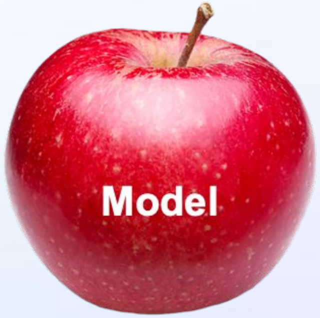
Coarse resolution models struggle with liquid phase physics and stratocumulus to cumulus transitions



Davis and Mederios, 2024

Challenges in assessing models against field observations

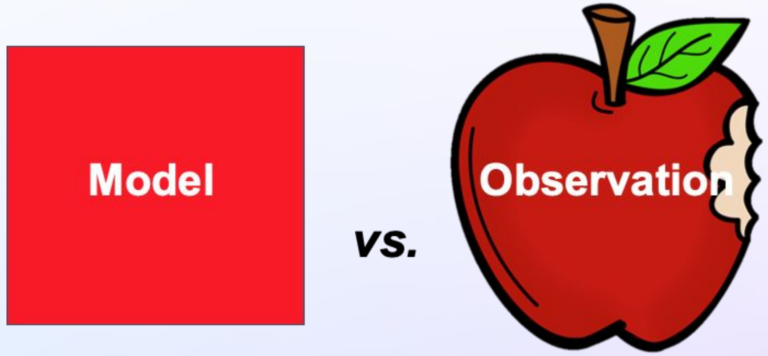
Ideal:



vs.

Challenges in assessing models against field observations

Reality:



Challenges in assessing models against field observations

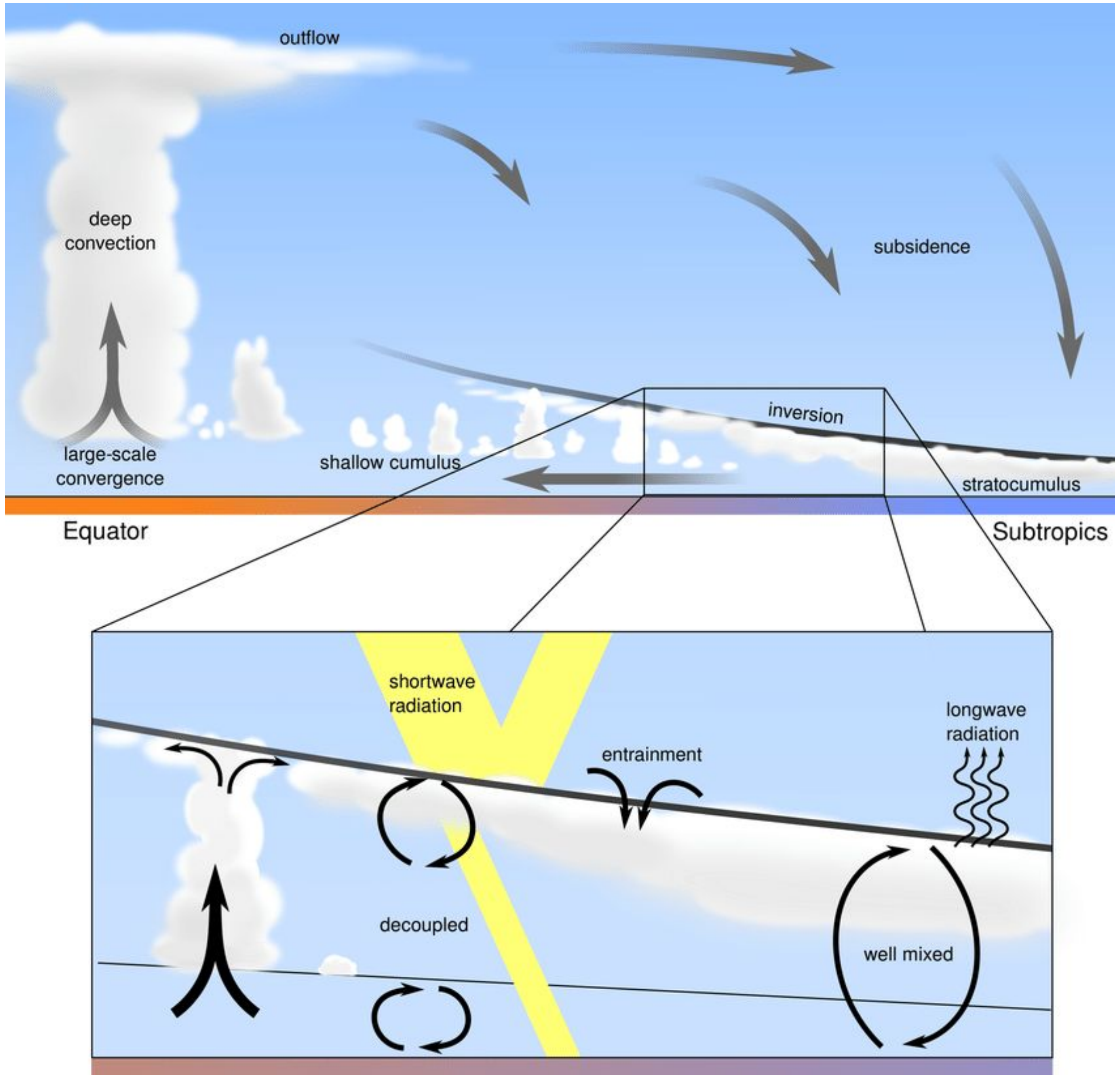
Goal:

vs.

Temporal & Spatial Representativeness *sampling bias, detection limits*	Spatial & temporal resolution mismatch *co-location mismatch vs. process bias*	Instrument "simulators" structural errors difficult to address	Usability for model development *Aim: Incorporate framework and practices into ESMValTool, ADF, etc.*

Integrating Field Observations and Research Models COmmunity Model Process-oriented Assessments for Earth System Science (INFORM – COMPASS)

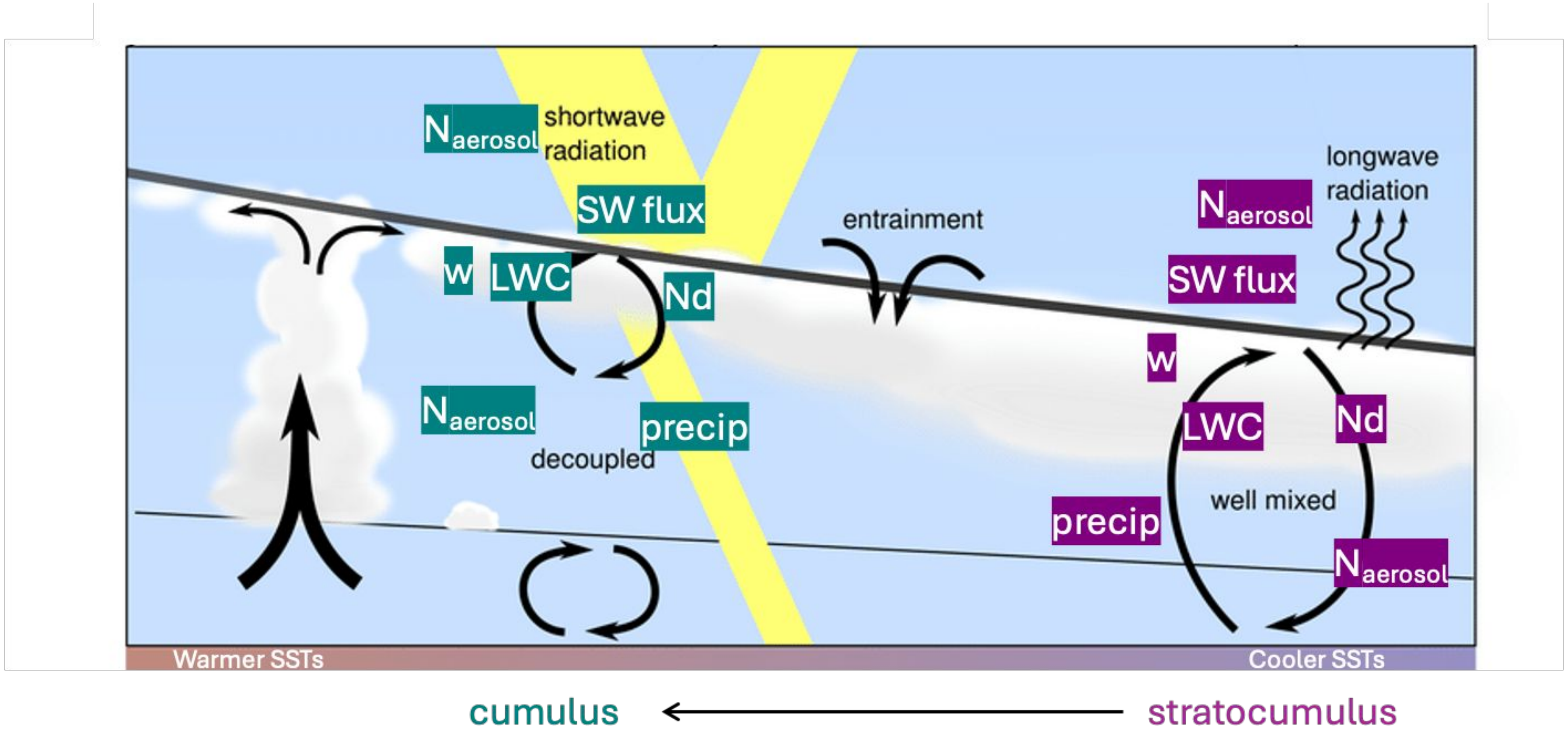
A regime-based **process-system** approach to assessing research models



Van der Dussen et al., 2015

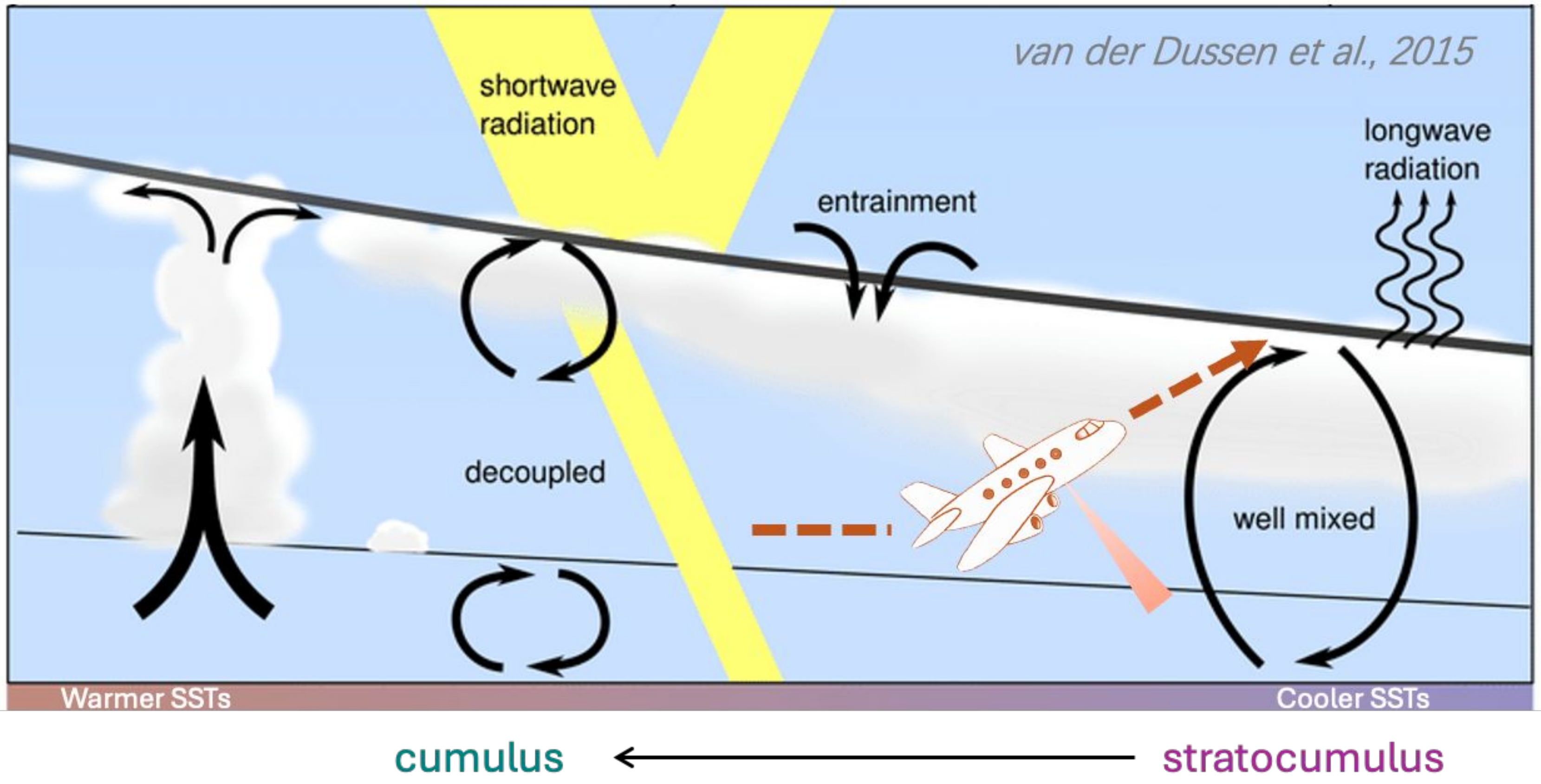
Developing a Process System Database from Aircraft Observations

Candidate Campaigns: CSET, VOCALS, SOCRATES, ORACLES, EUREC4A,... and many many more!



Developing a Process System Database from Aircraft Observations

Sampling Maneuver ID field campaign data "wrapper"



In-cloud level-leg
LWC, N_d, T, RH, w

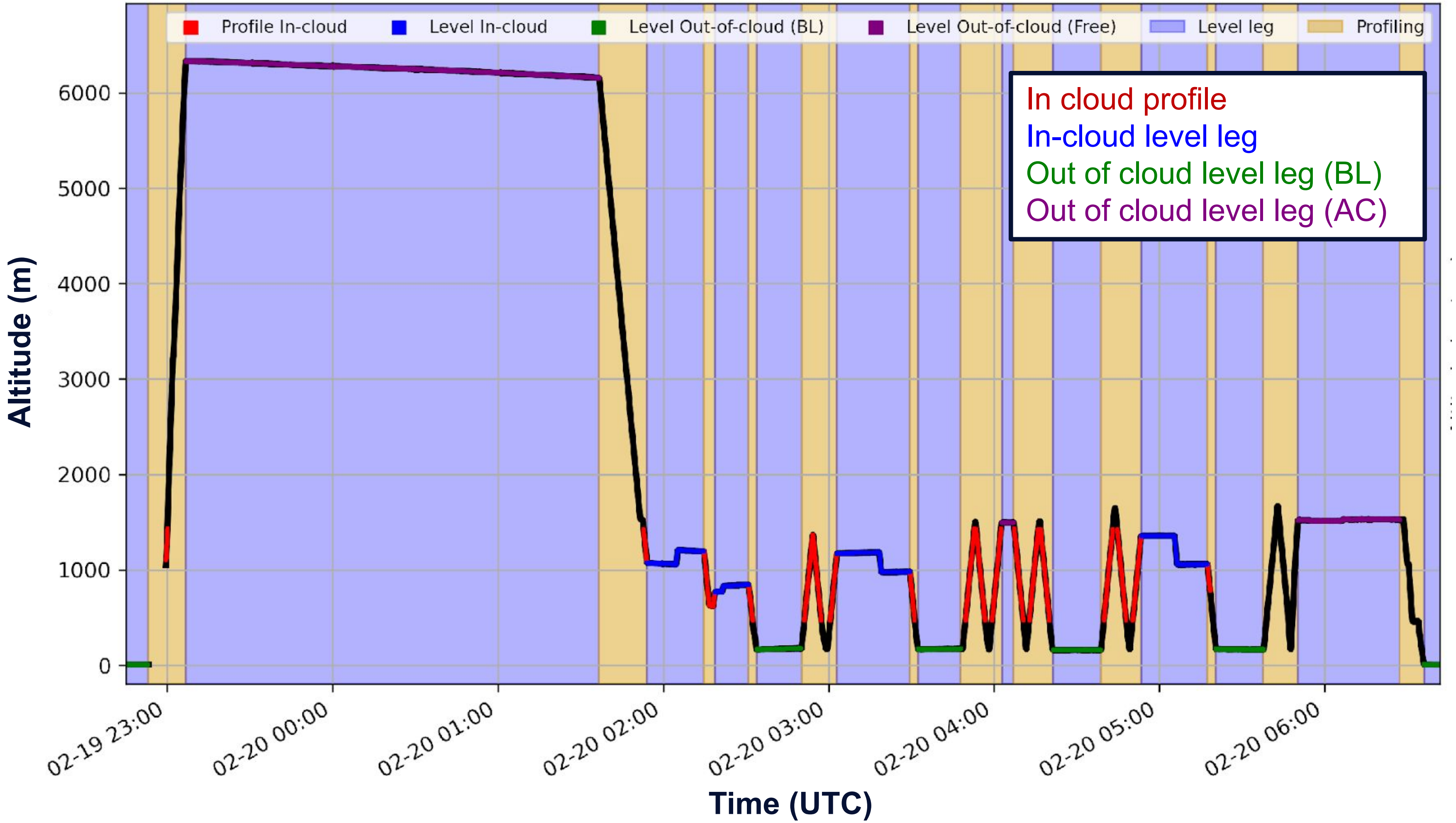
In-cloud profiling
LWP, vertical distribution of LWC, N_d, T, RH, w_{sd}

Below cloud
$N_{aerosol, MBL}$, Precipitation, HCR cloud classification and particle ID,

Above cloud
Cloud top SW flux, HCR cloud classification and particle ID, $N_{aerosol,UT}$

Developing a Process System Database from Aircraft Observations

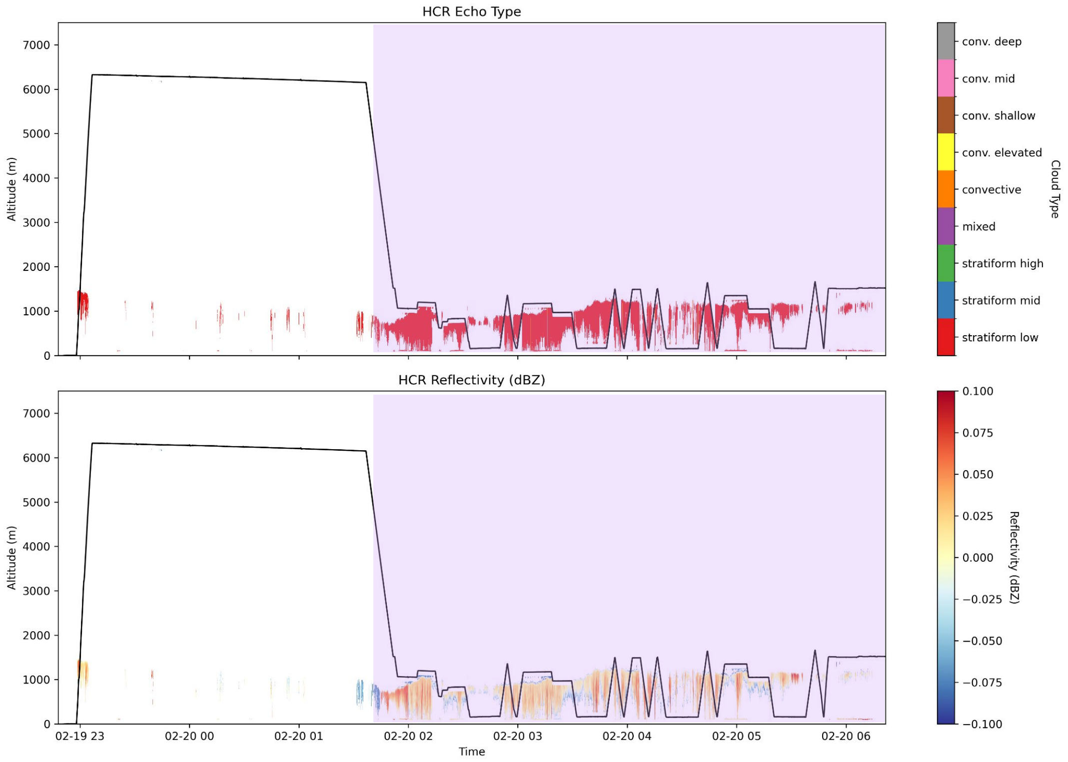
Sampling Maneuver ID field campaign data "wrapper"



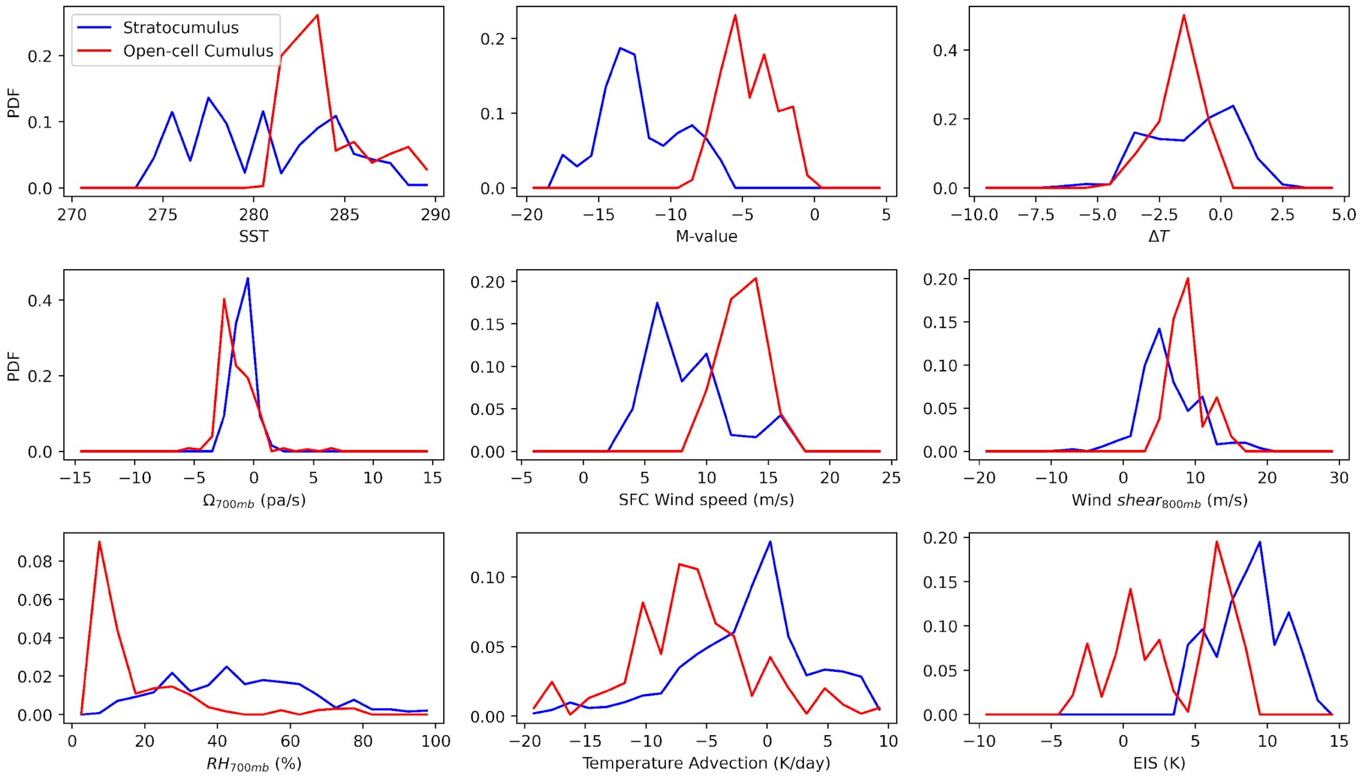
Developing a Process System Database from Aircraft Observations

Cloud Regime Compositing Method Development

HCR cloud echo type categorization from Romatschke (2023) and Romatschke and Dixon (2022)



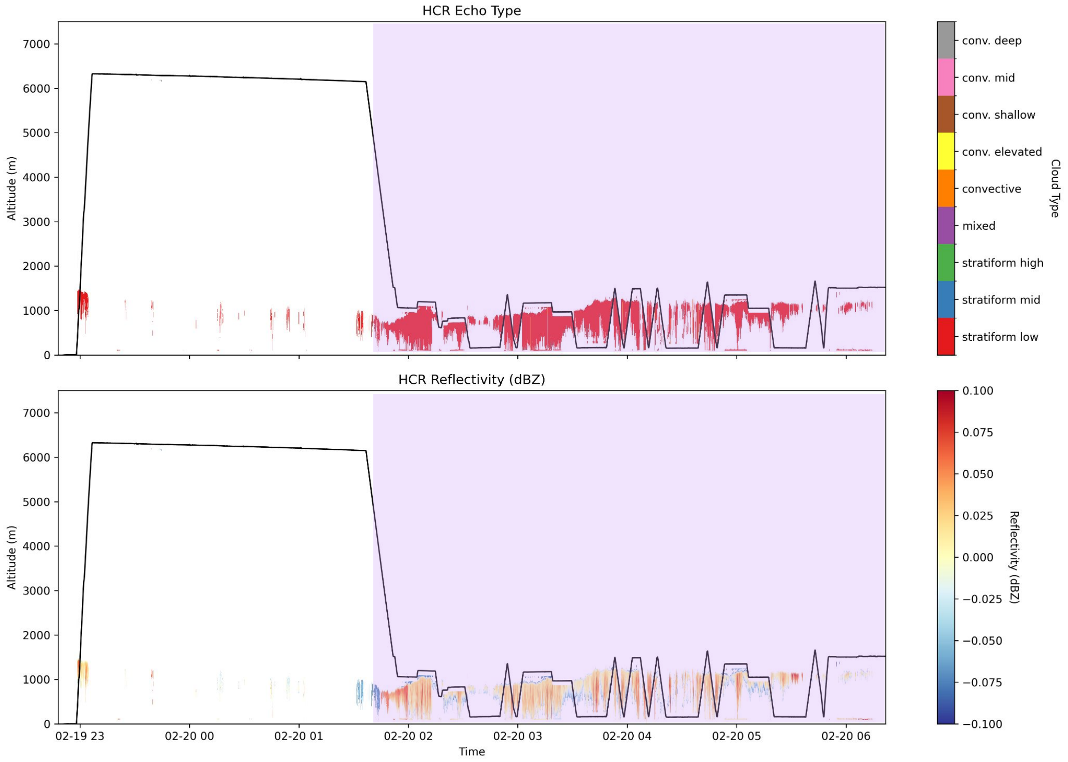
Co-located ERA5 Cloud Controlling Factors based on decades of literature



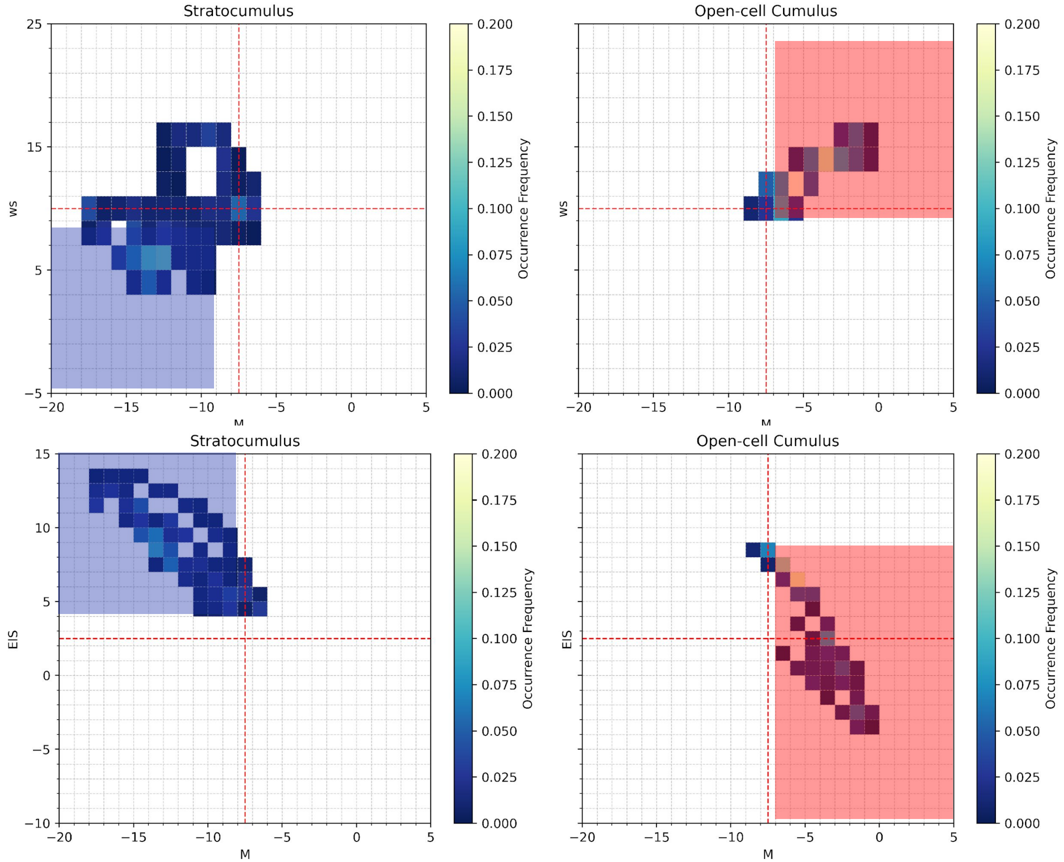
Developing a Process System Database from Aircraft Observations

Cloud Regime Compositing Method Development

HCR cloud echo type categorization from Romatschke (2023) and Romatschke and Dixon (2022)



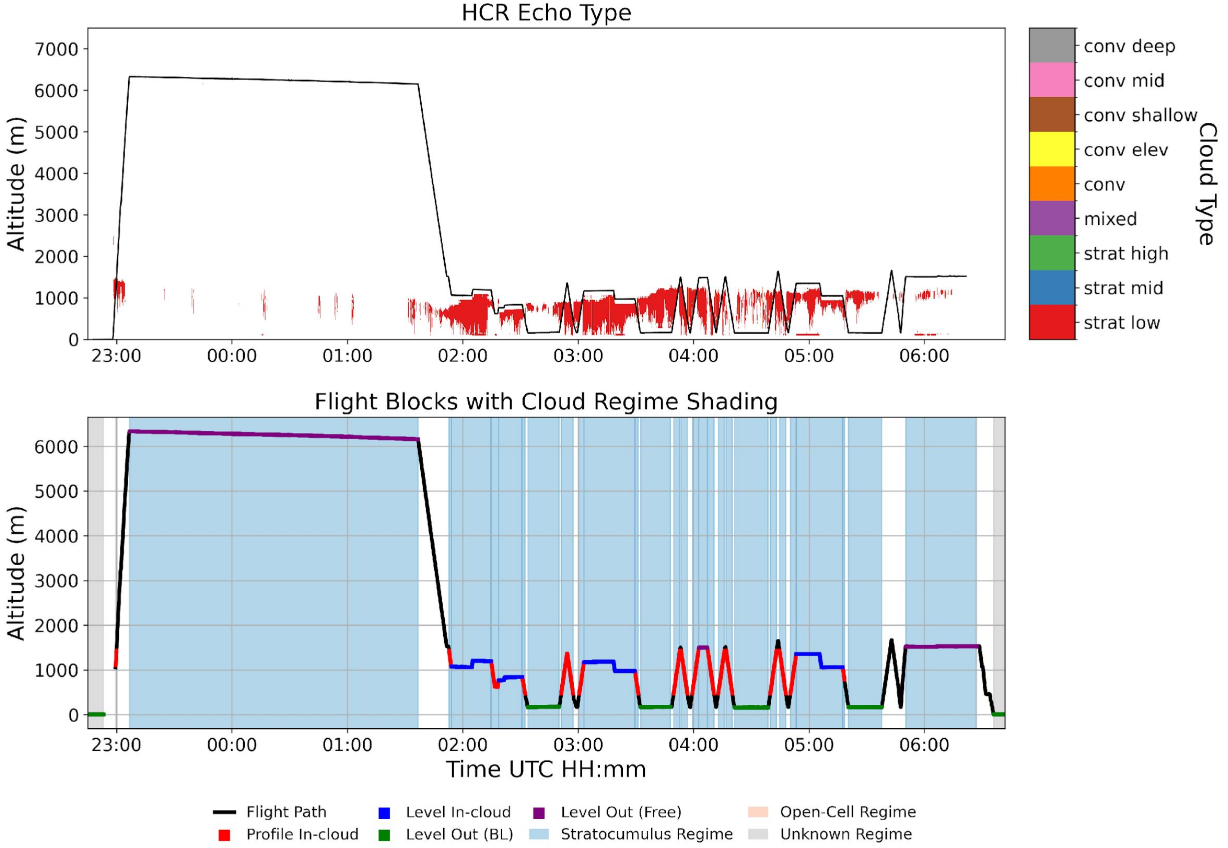
Co-located ERA5 Cloud Controlling Factors based on decades of literature



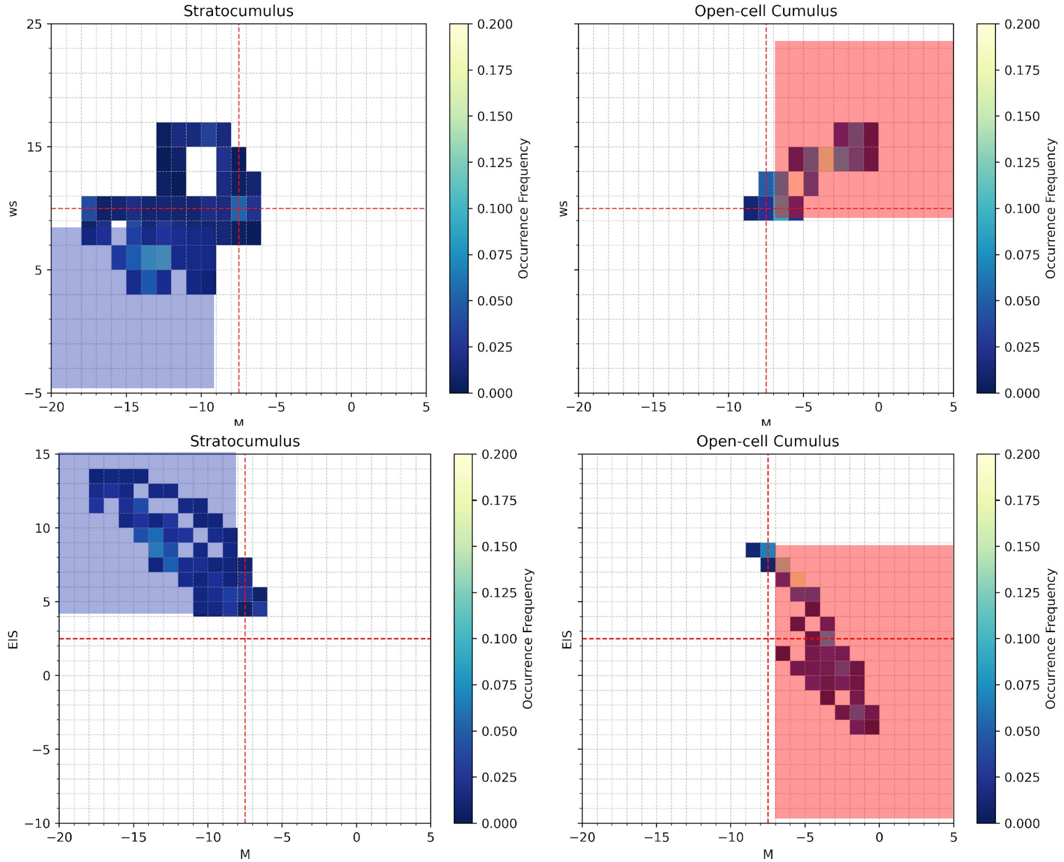
Developing a Process System Database from Aircraft Observations

Cloud Regime Compositing Method Development

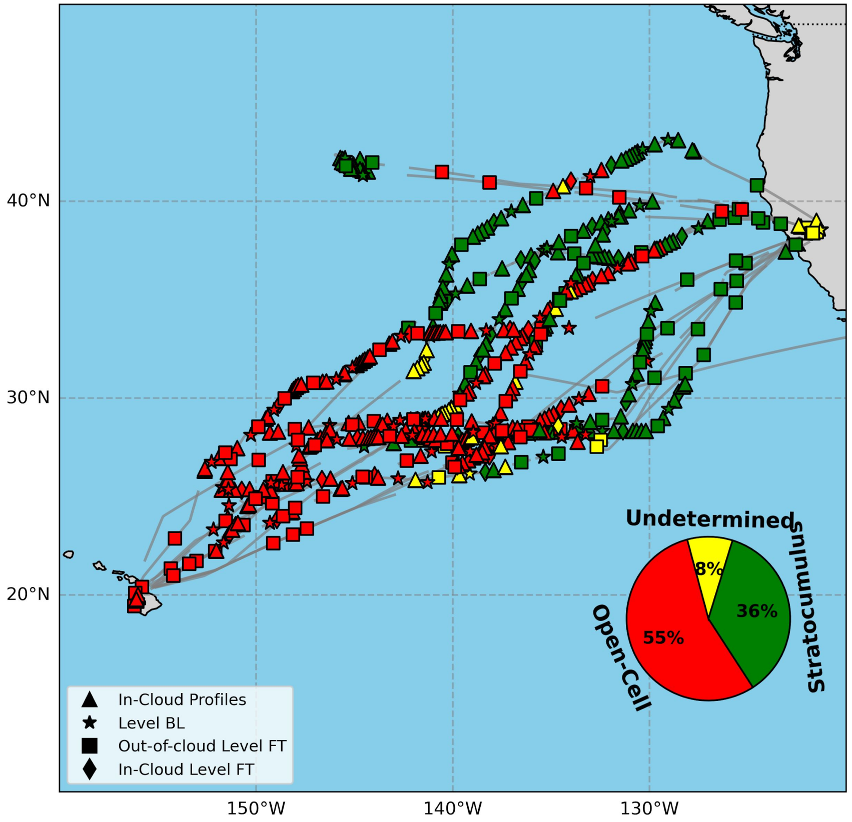
HCR cloud echo type categorization from Romatschke (2023) and Romatschke and Dixon (2022)



Co-located ERA5 Cloud Controlling Factors based on decades of literature



Developing a Process System Database from Aircraft Observations



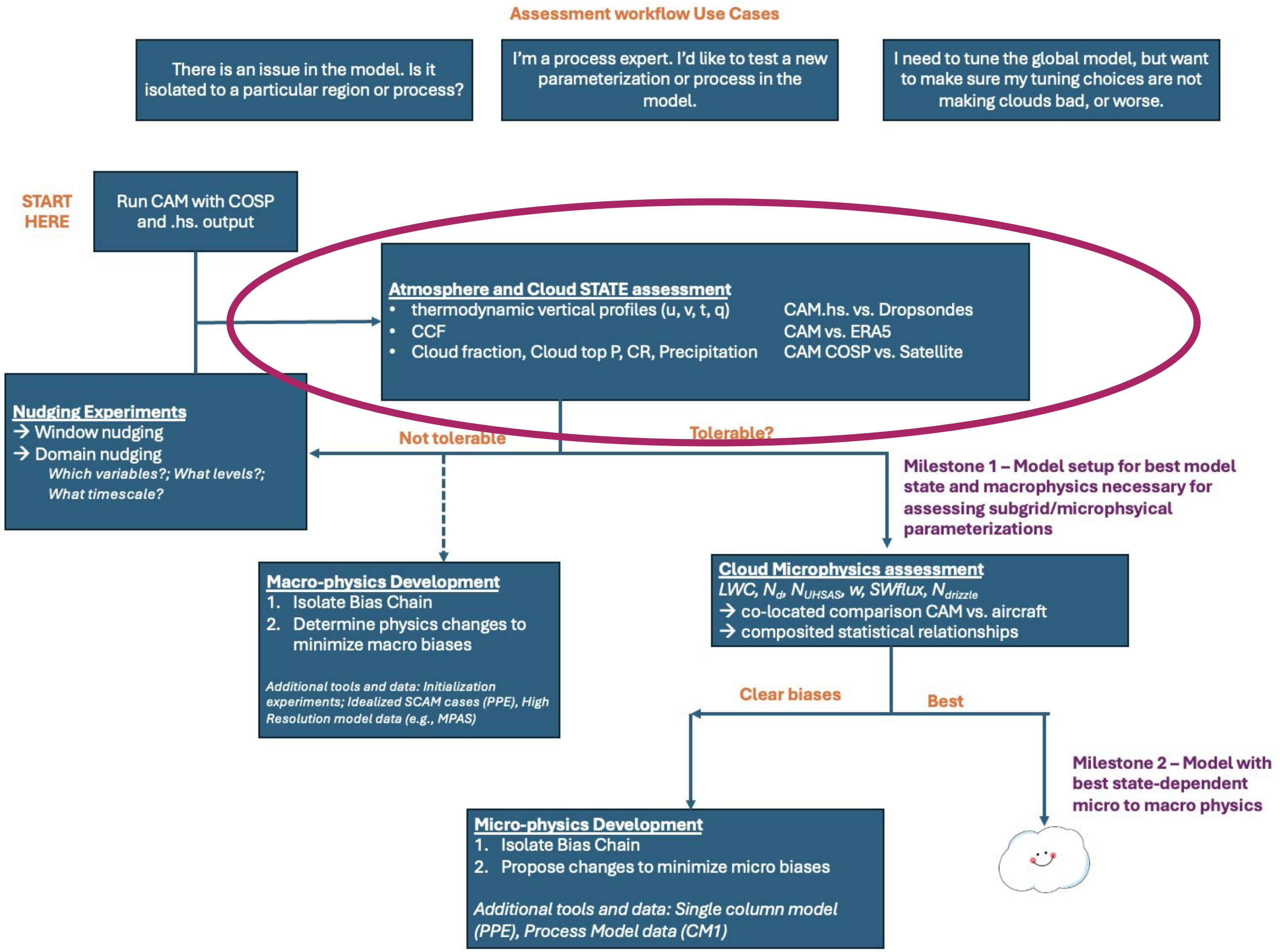
Stratocumulus:
1) M < -9K & ws < 9m/s
2) M < -10K & EIS > 7K
3) M < -10L & wshear < 9m/s

Open-cell cumulus
1) M >= -7K & ws >= 9 m/s
2) M >= -8K & EIS < 9 K
3) M >= -8K & wshear > 6m/s

Stratocumulus:
1) M < -10K & SST < 295K
2) M < -11K & T_{adv} < 0K/day

Open-cell cumulus
1) M >= -10 & SST >= 296 K
2) M >= -10 & t_{adv} >= -3 K/day

How to Assess CESM using Aircraft Observations?

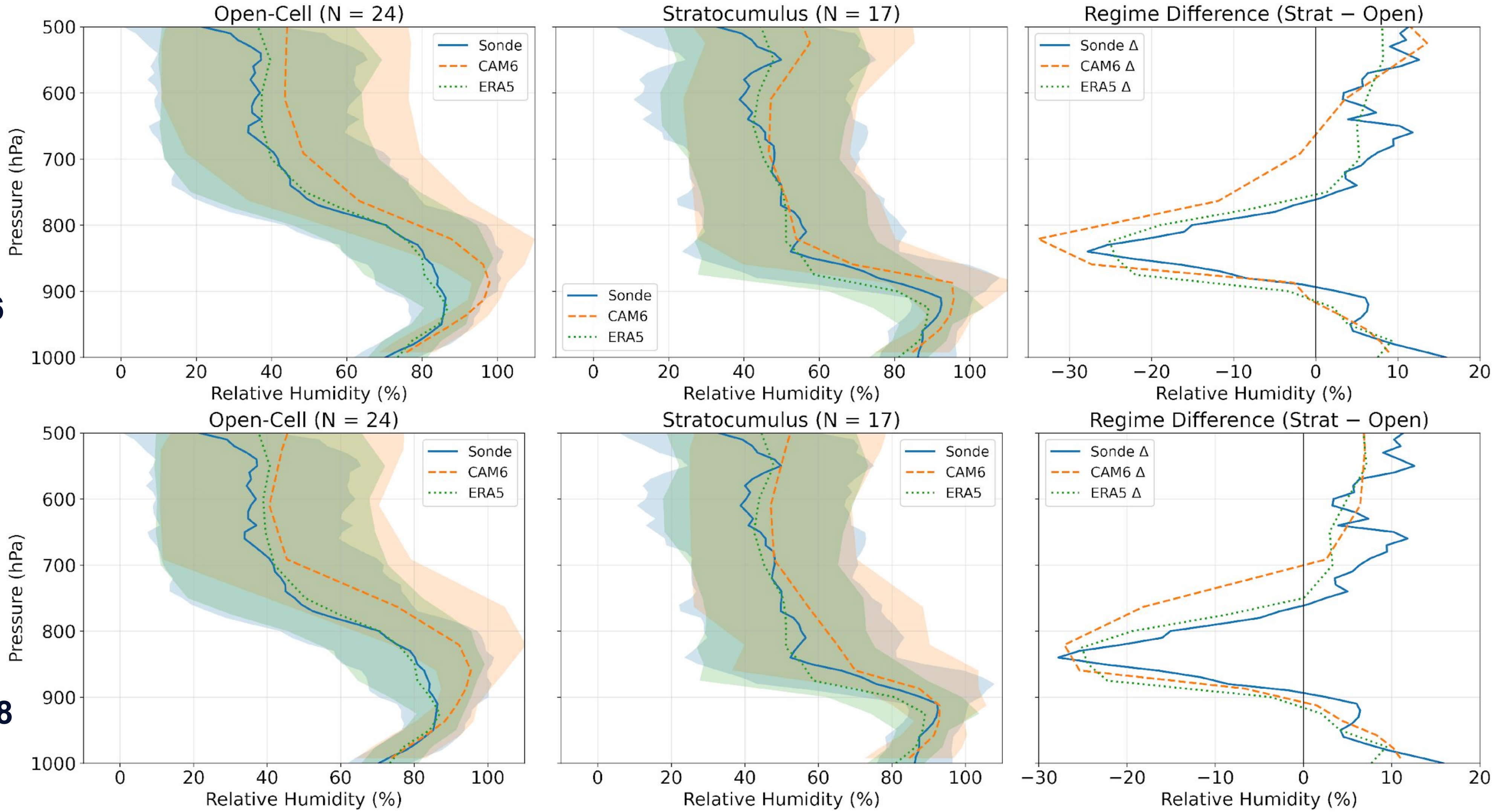


Assess Model Base State – Composited Observation and Model Thermodynamic Profiles

CAM6

τ = 6

τ = 48

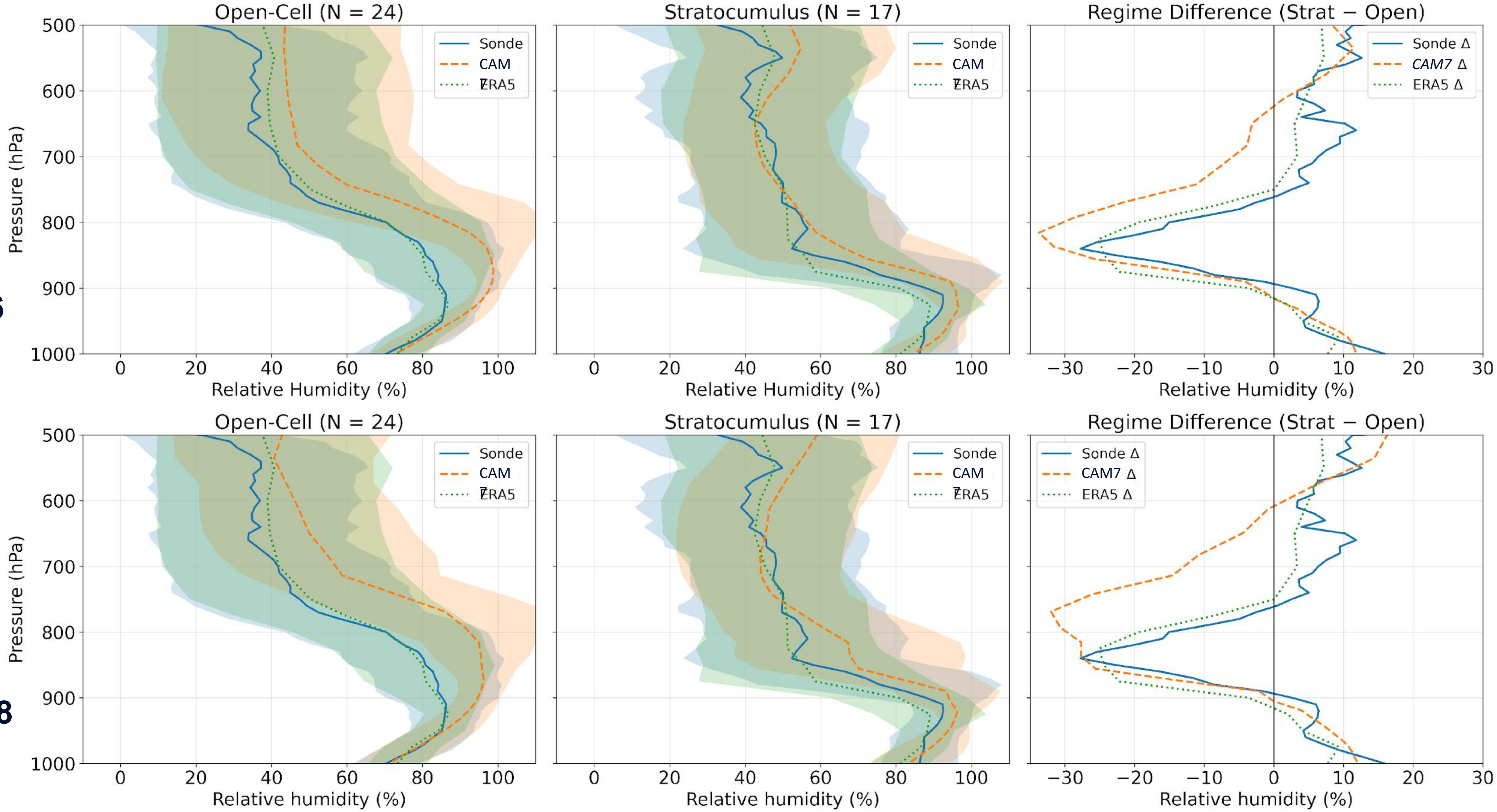


Assess Model Base State – Composited Observation and Model Thermodynamic Profiles

CAM7

τ = 6

τ = 48

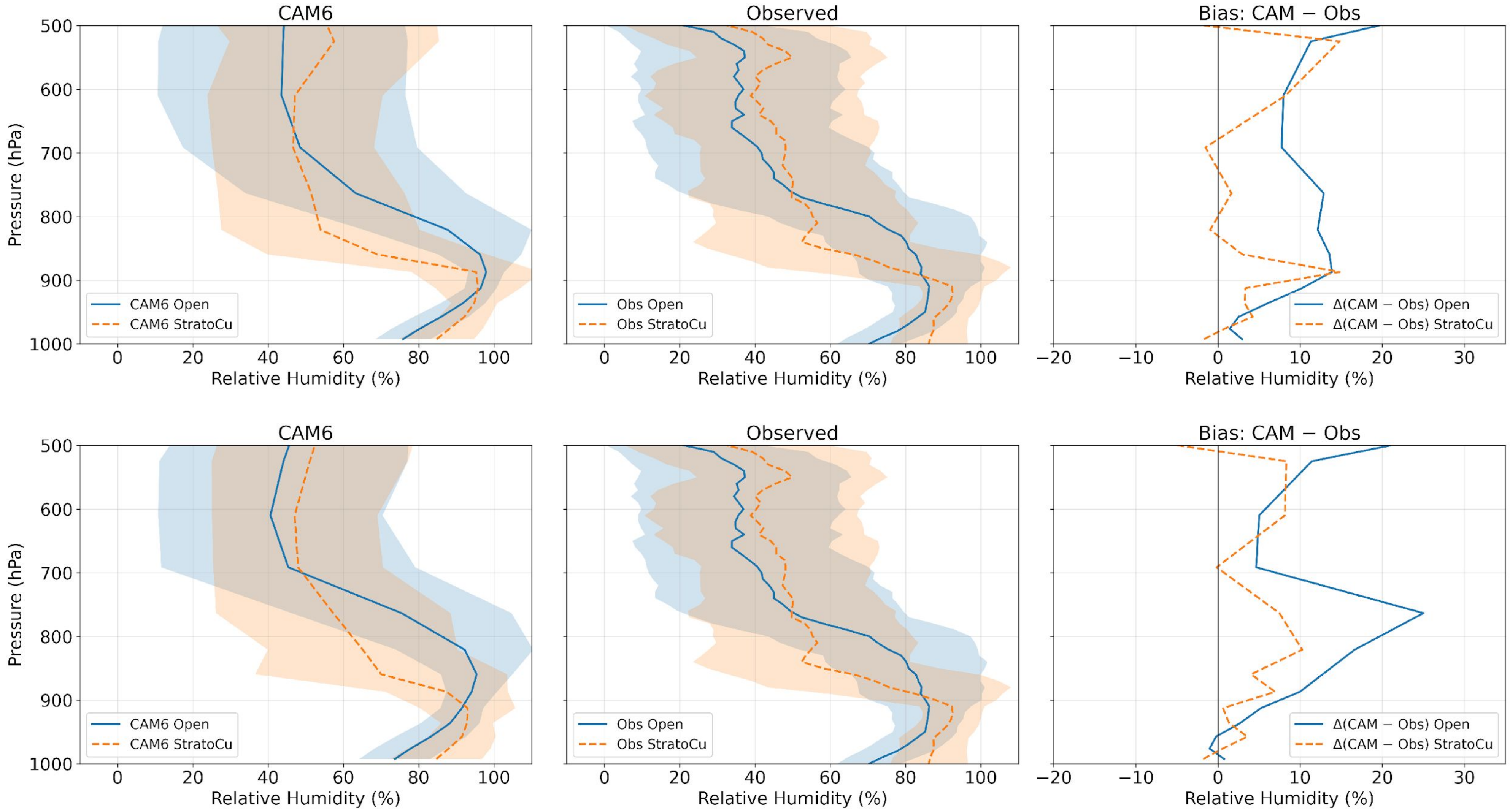


Assess Model Base State – Composited Observation and Model Thermodynamic Profiles

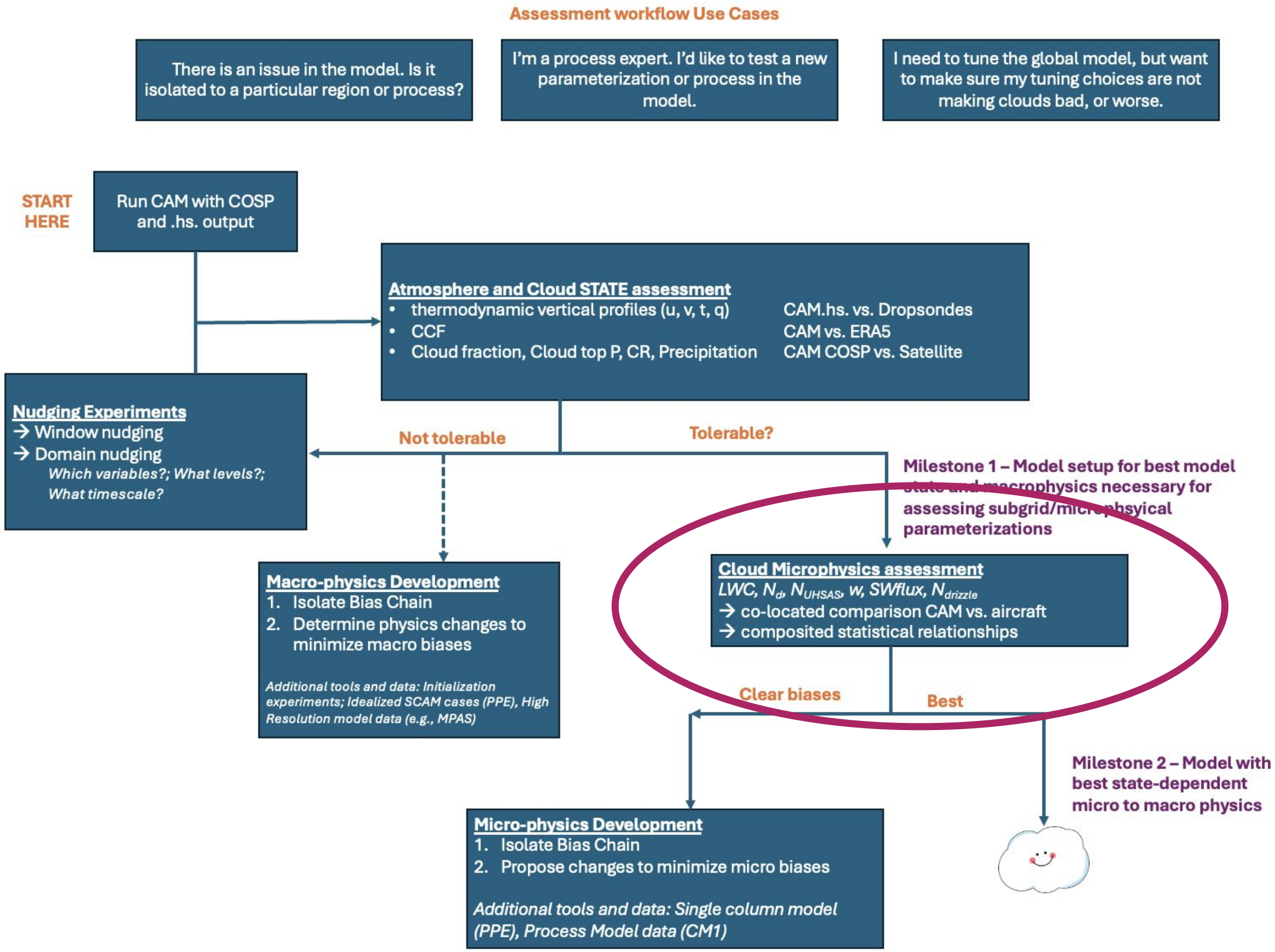
CAM6

τ = 6

τ = 48

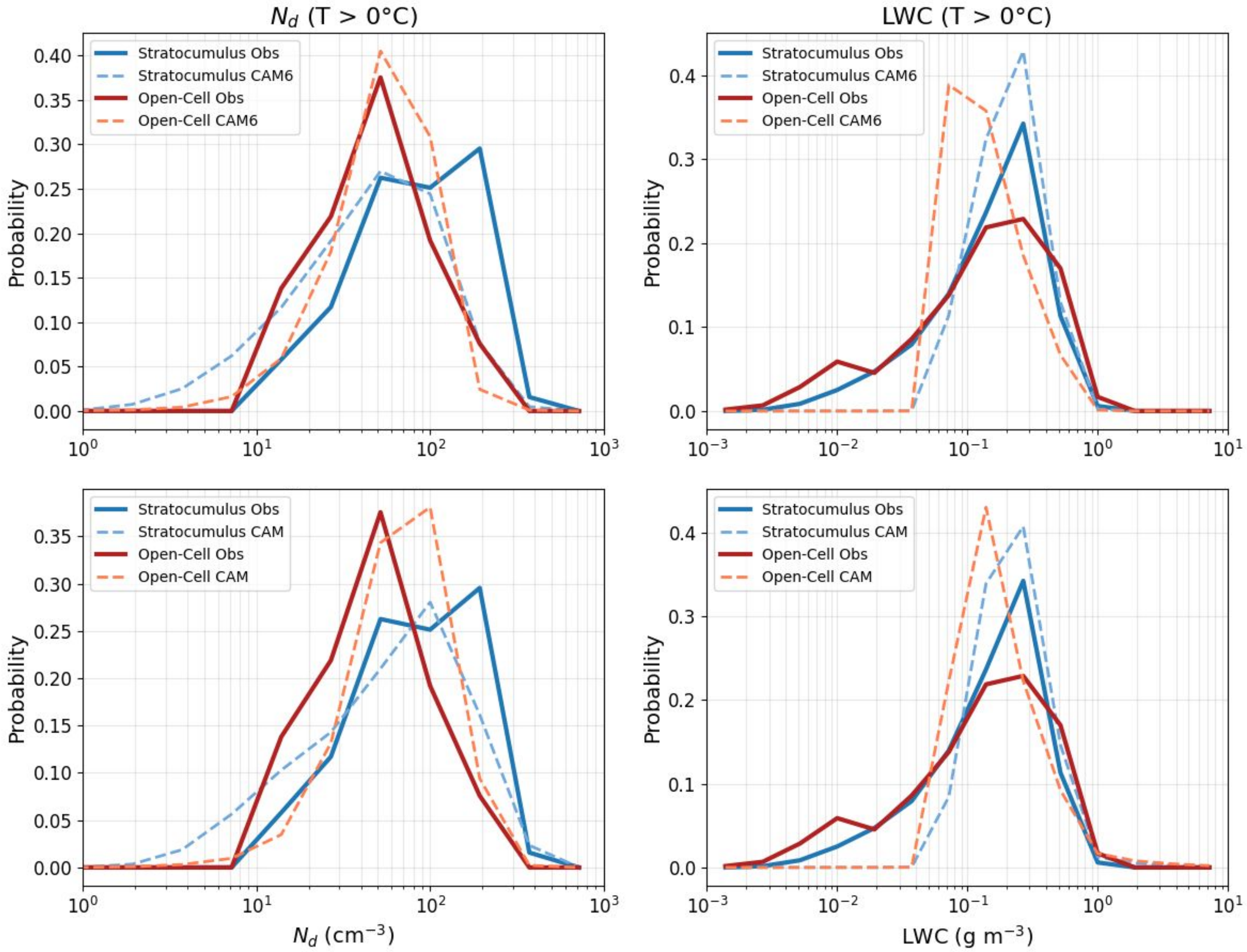


How to Assess CESM using Aircraft Observations?



CAM Microphysical Assessment Using Composited Approach

SOCRATES

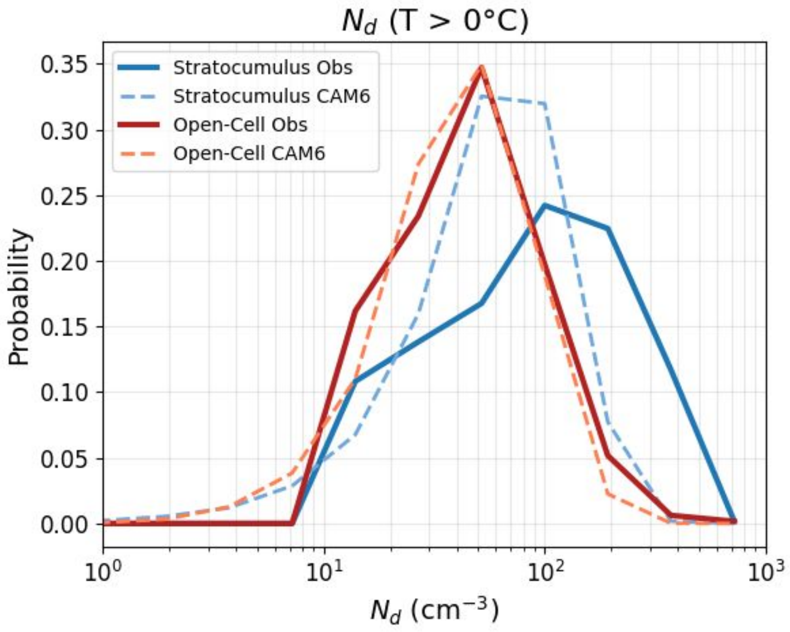


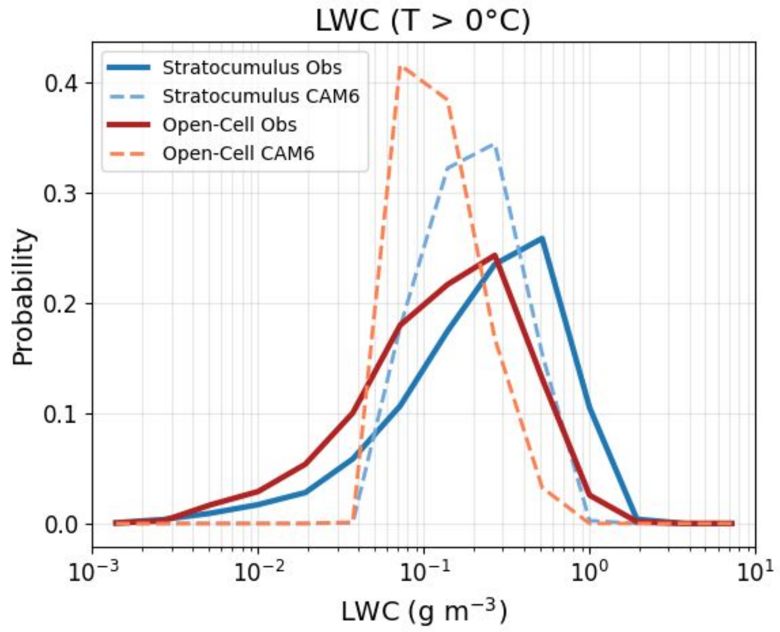
CAM6

CAM7

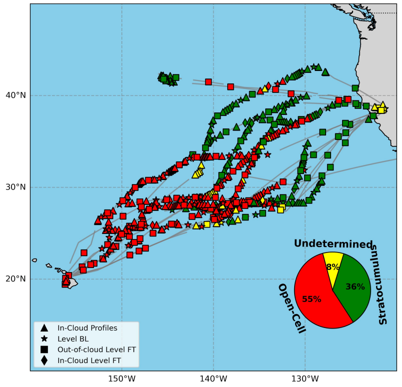
CAM Microphysical Assessment Using Composited Approach

CSET

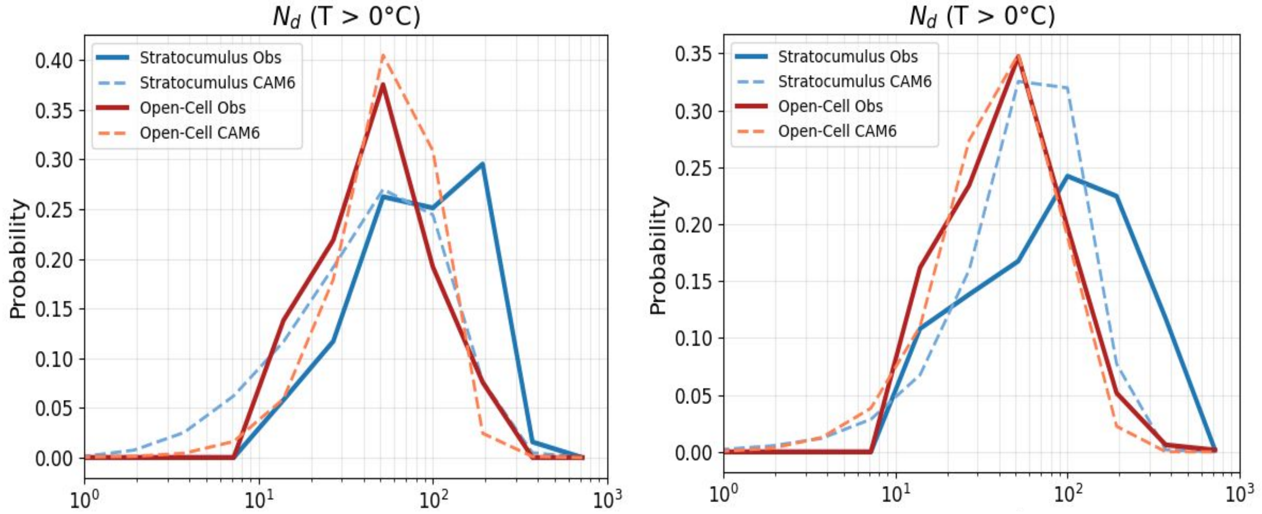




CAM6

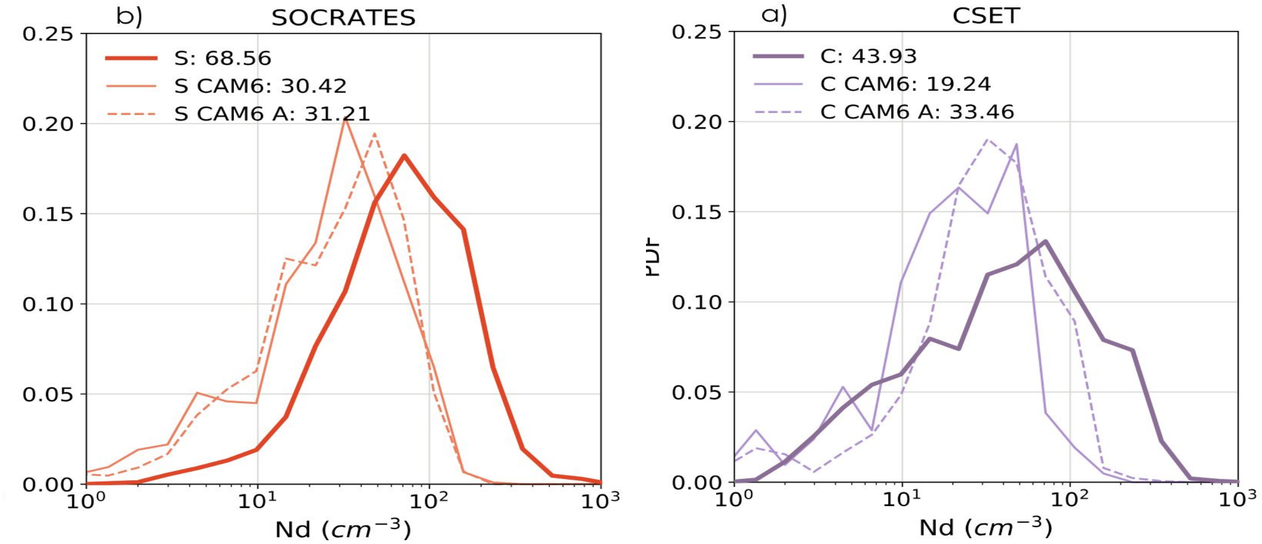


CAM Microphysical Assessment Using Composited Approach



CAM6

Co-located aircraft observations (< 4km) with CAM6



McCoy et al. (2021)

Discussion and Future work

Preliminary findings and new developments

- Created process-system database of aircraft observations
  - Composited dataset for stratocumulus and open-cell cumulus cloud regimes
  - Assessed model base state and microphysics
- Model representation of base state pretty good, can represent distinct cloud regimes
- CAM6 low bias for Nd for stratocumulus □ improved representation of Nd and LWC in CAM7
- Preliminary results suggest compositing may be better method for aircraft v CAM evaluation

Future work

- Further investigation of cloud microphysical processes in CAM
  - Impacts of aerosol and CCN loading, turbulence
- Assess CAM cloud macrophysics
  - COSP and satellite data
- Expand this process-system database to difference regions and cloud regimes
  - Marine cold-air outbreaks (CAESAR)
  - Arctic mixed-phase clouds


Thank you!
patnaude@ucar.edu

The latest INFORM Schematic (v5)