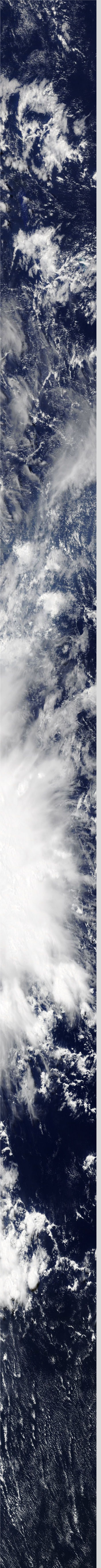


What is the fate of detrained ice in the Tropical Western Pacific?

Blaž Gasparini[1], Phil Rasch[2], Dennis Hartmann[1], Casey Wall[3], Marina Dütsch[1]

Contact: *blazg@uw.edu*

1 University of Washington, 2 Pacific Northwest National Laboratory, 3 Scripps Institution of Oceanography, UCSD

University of Washington Atmospheric Sciences

What did we do?

1. Tracked **Mesoscale convective systems (MCS)** in the Exascale Earth System Model (**E3SM**) at the horizontal resolution of 0.25° and evaluated it against **Himawari geostationary satellite data** for the Tropical Western Pacific
2. Computed **Lagrangian forward trajectories** starting at peaks of convective activity to better understand **the transition of a thick detrained anvil cloud into a thin cirrus cloud**

Why?

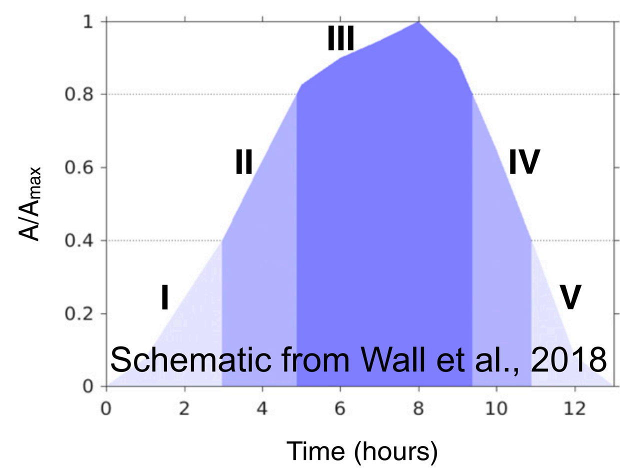
1. **Anvil clouds** are the **dominant cloud type in the Tropical Western Pacific** by both frequency and cloud radiative effects
2. It is unclear what controls the thinning of detrained anvil clouds and whether GCMs can simulate it in a satisfactory way

MCS tracking

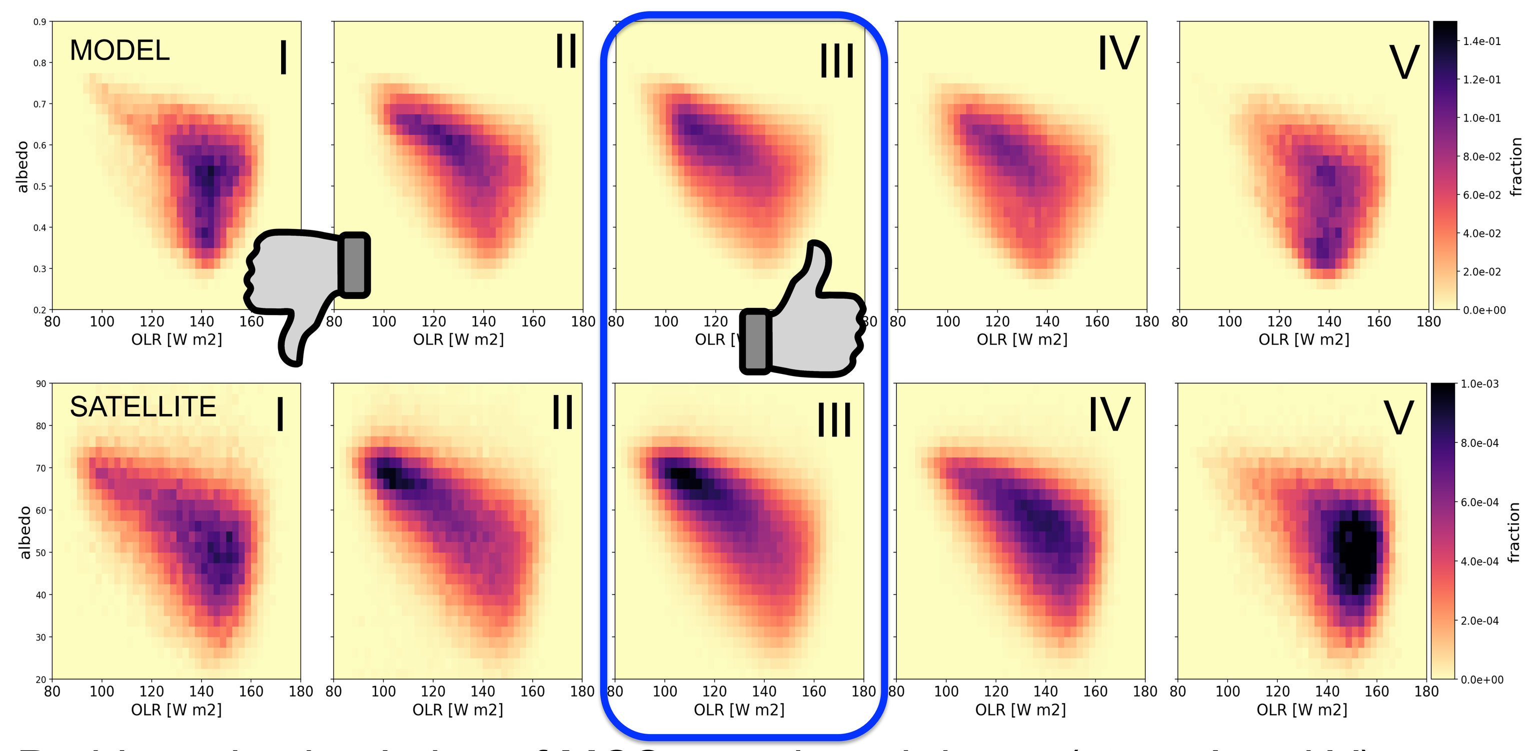
Brightness-temperature based MCS tracking algorithm with 240 K "warm" threshold
(Fiolleau and Roca, 2013 , Wall et al., 2018)

- Can detect only thick and intermediatly thick high ice cloud "shields"

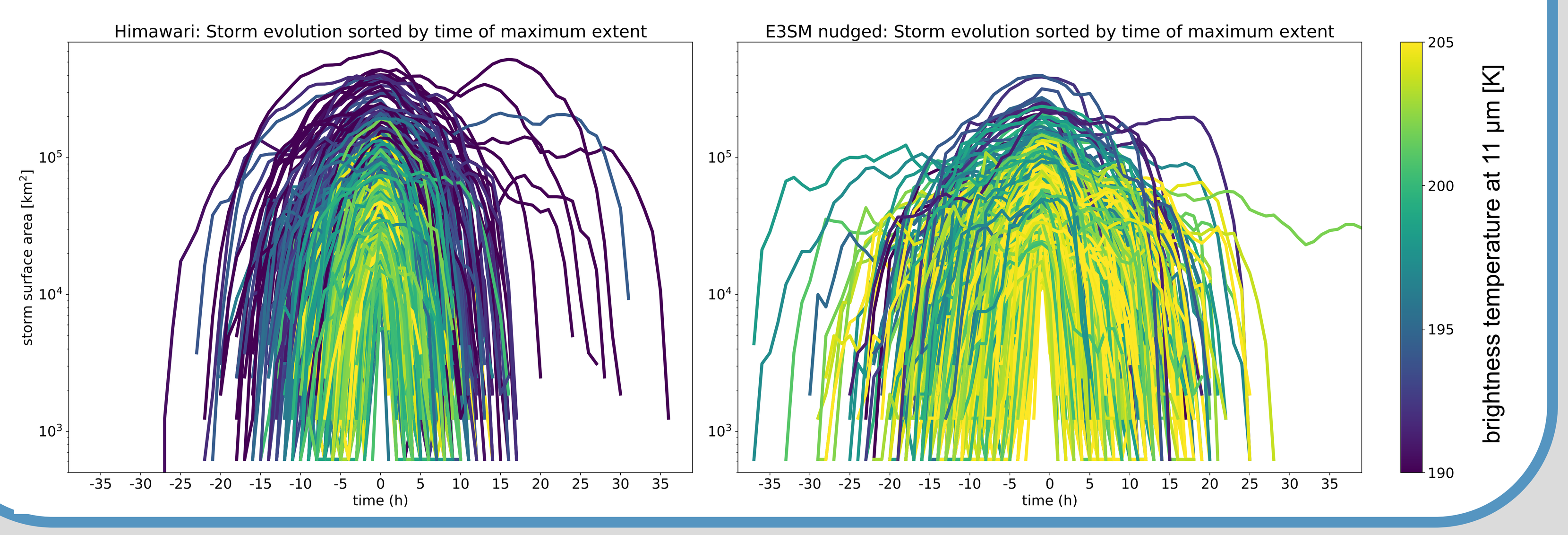
Storms divided into 5 lifecycle stages based on their normalized surface area



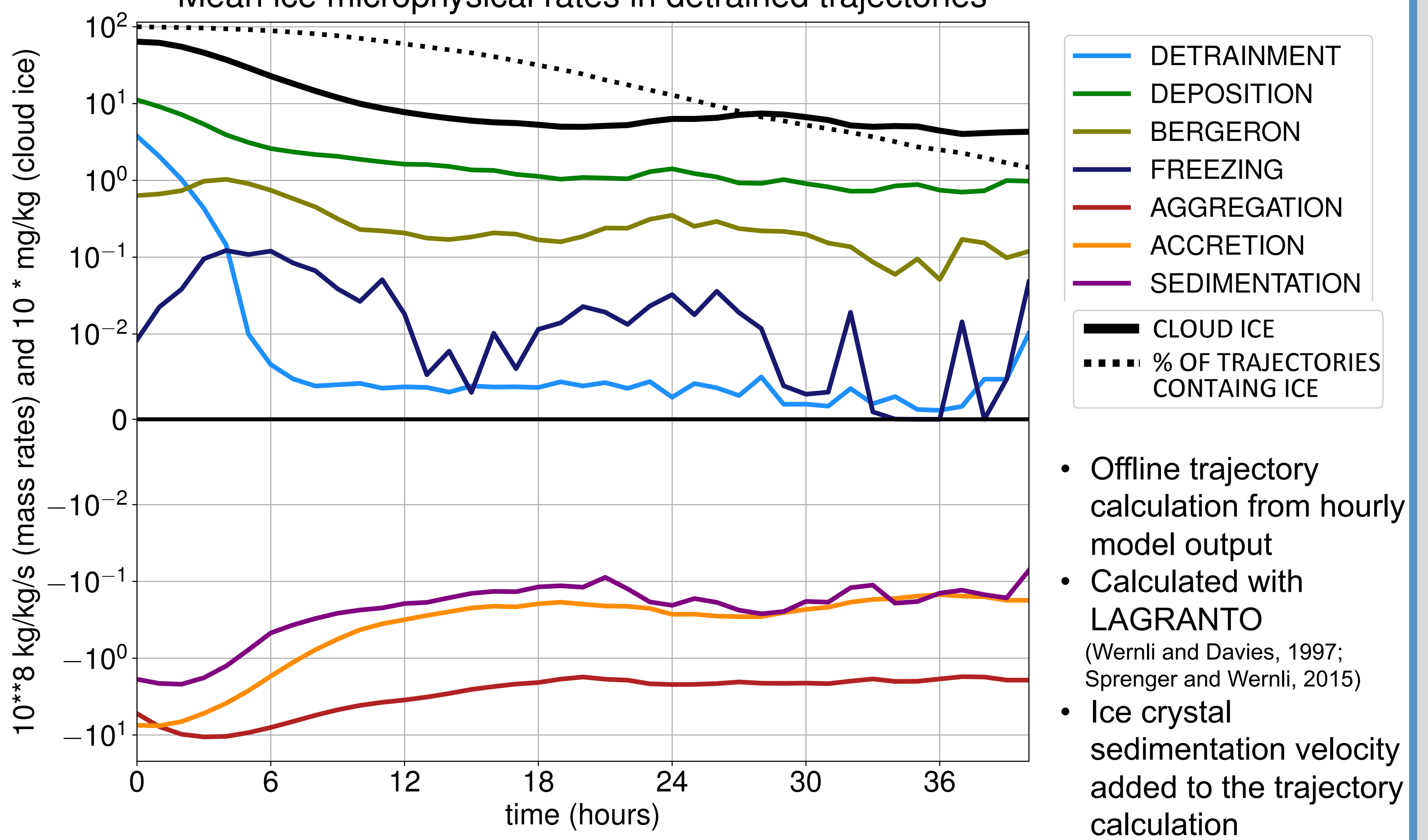
Albedo – OLR histogram for each MCS stage



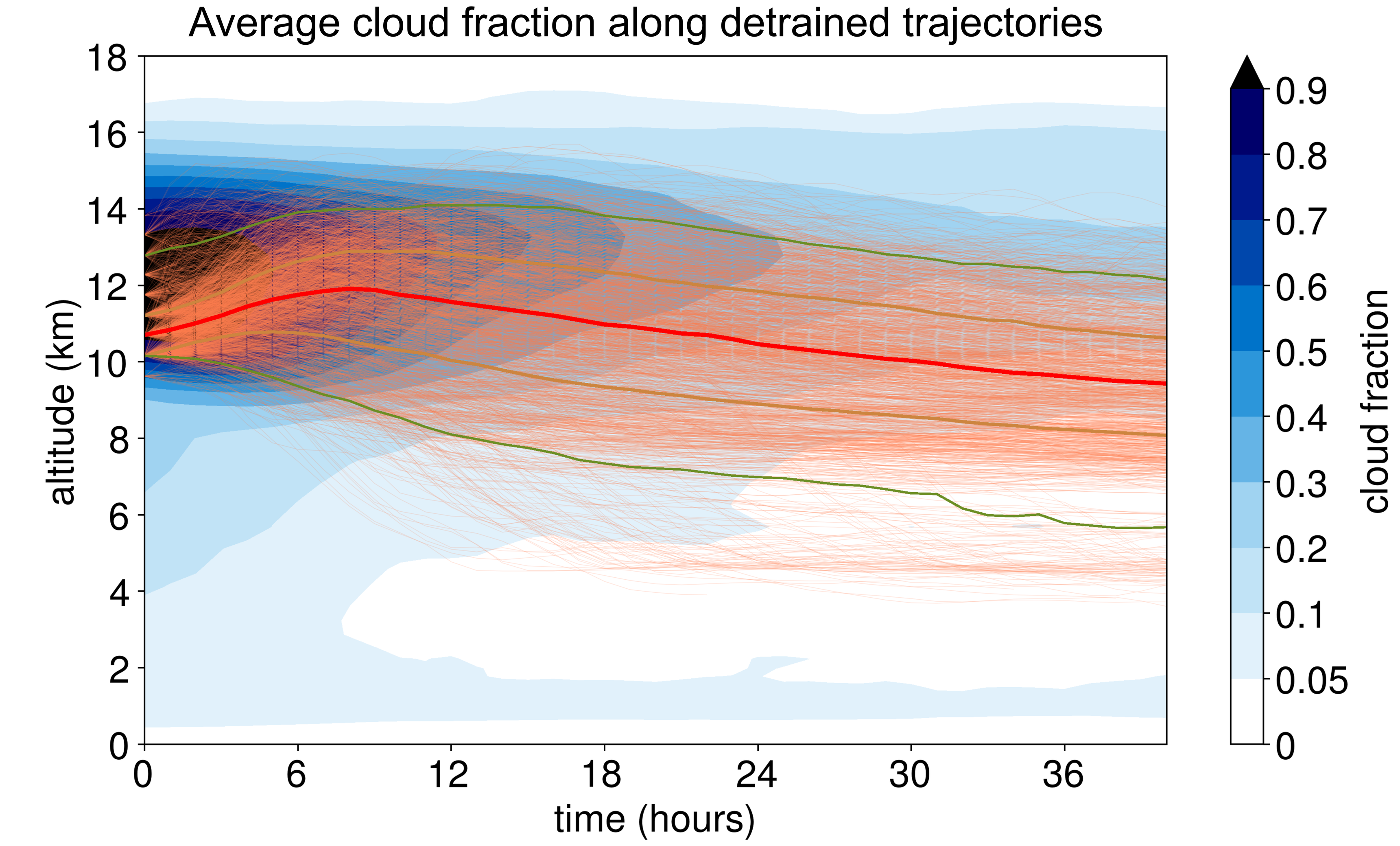
- Problems in simulation of MCS growth and decay (stage I and V)
- Peak of storm (stage III) simulated well, but with smaller albedo and OLR



Cloud properties along detrained trajectories



- Offline trajectory calculation from hourly model output
- Calculated with LAGRANTO (Wernli and Davies, 1997; Sprenger and Wernli, 2015)
- Ice crystal sedimentation velocity added to the trajectory calculation



Outlook

Can Lagrangian methods provide new insights into high cloud responses to global warming?

Compare hydrometeor tracking vs. air parcel tracking

Sensitivity to deep convective parameterization

Acknowledgements

Computation resources from EMSL *a* DOE Office of Science User Facility sponsored by the Office of Biological and Environmental Research (BER) and located at Pacific Northwest National Laboratory

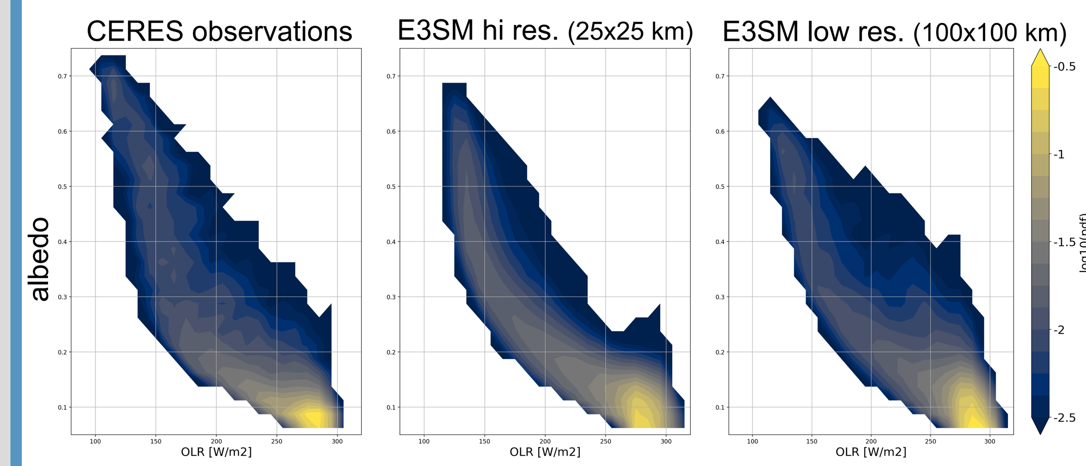
Support for BG by the Swiss Science Foundation, and (for BG and PJR), from the DOE under the BER Earth and Environmental System Modeling program.

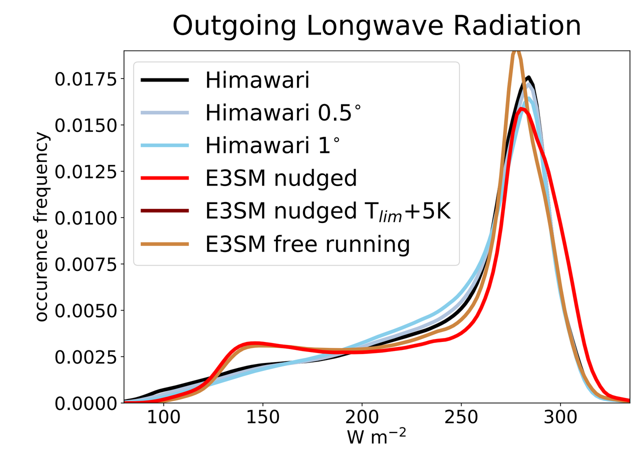
Conclusions

1. Deposition of vapor is the dominant source of ice in simulated ice clouds
2. Snow formation is the dominant sink of ice
3. E3SM represents well the climate in the Tropical Western Pacific

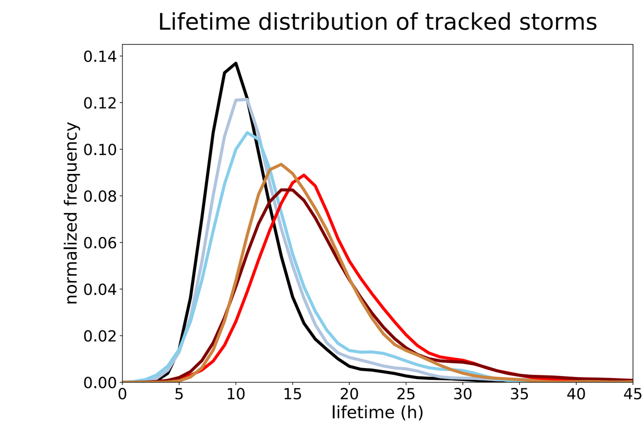
More E3SM model evaluation

The albedo-OLR distribution in E3SM matches well with CERES observations (ocean only, 12°S to 12°N, 150°E-170°E)





E3SM fails to simulate the strongest storms (with lowest OLR, highest precipitat. rates)



Simulated MCS evolution is comparable to observations, but MCS are too long-lived

MCS stage	Himawari (JJA 2016, 2500 tracked storms)	E3SM nudged (JJA 2016, 1400 tracked storms)	E3SM /Himawari fractional coverage [%]
I	2.5 h	3.7 h	6.5 / 6.0
II	1.8 h	3.1 h	21.0 / 16.7
III	3.2 h	5.3 h	49.5 / 51.4
IV	1.7 h	2.9 h	17.1 / 19.7
V	2.1 h	3.0 h	5.9 / 6.1
total	**11.3 h**	**18.2 h**	100 / 100
Mean maximum area [km^2]	4.6×10^4	5.5×10^4	/