Cloud and water vapor Influences on ERA5, AMPS, and ModelE3 Surface Downwelling Longwave Radiation Biases in West Antarctica

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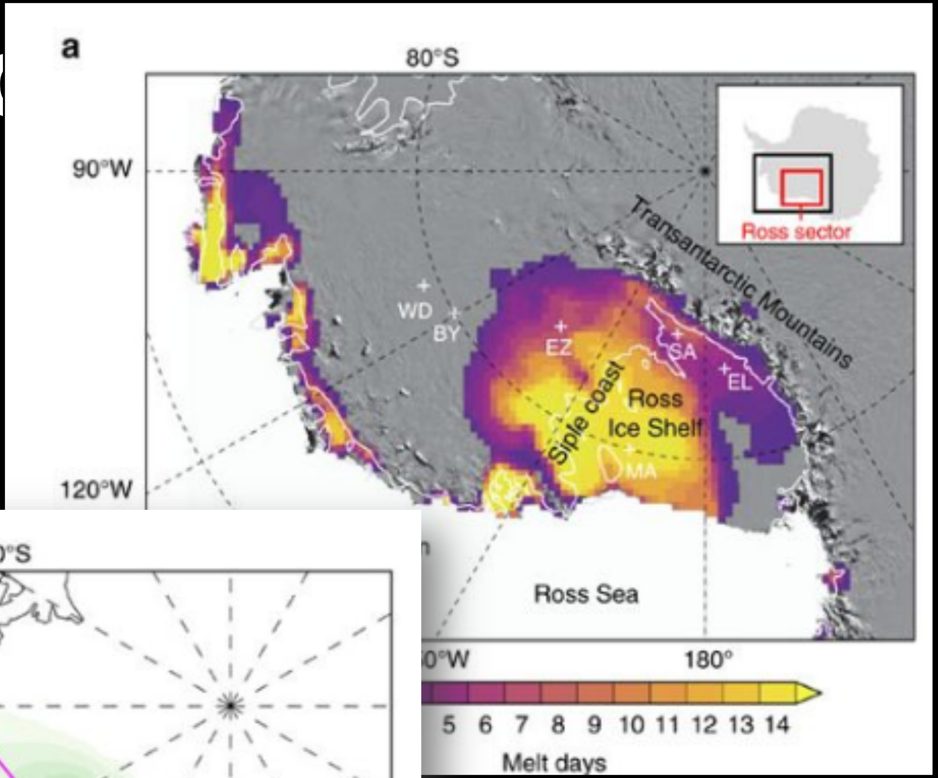
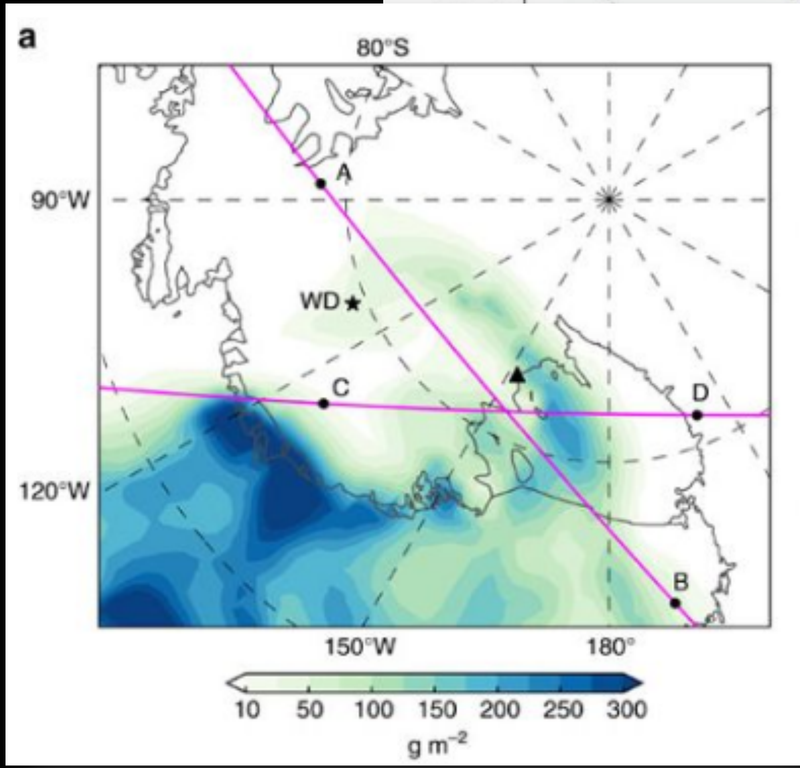
Background

- Polar clouds impact the surface energy budget, even when they optically thin.

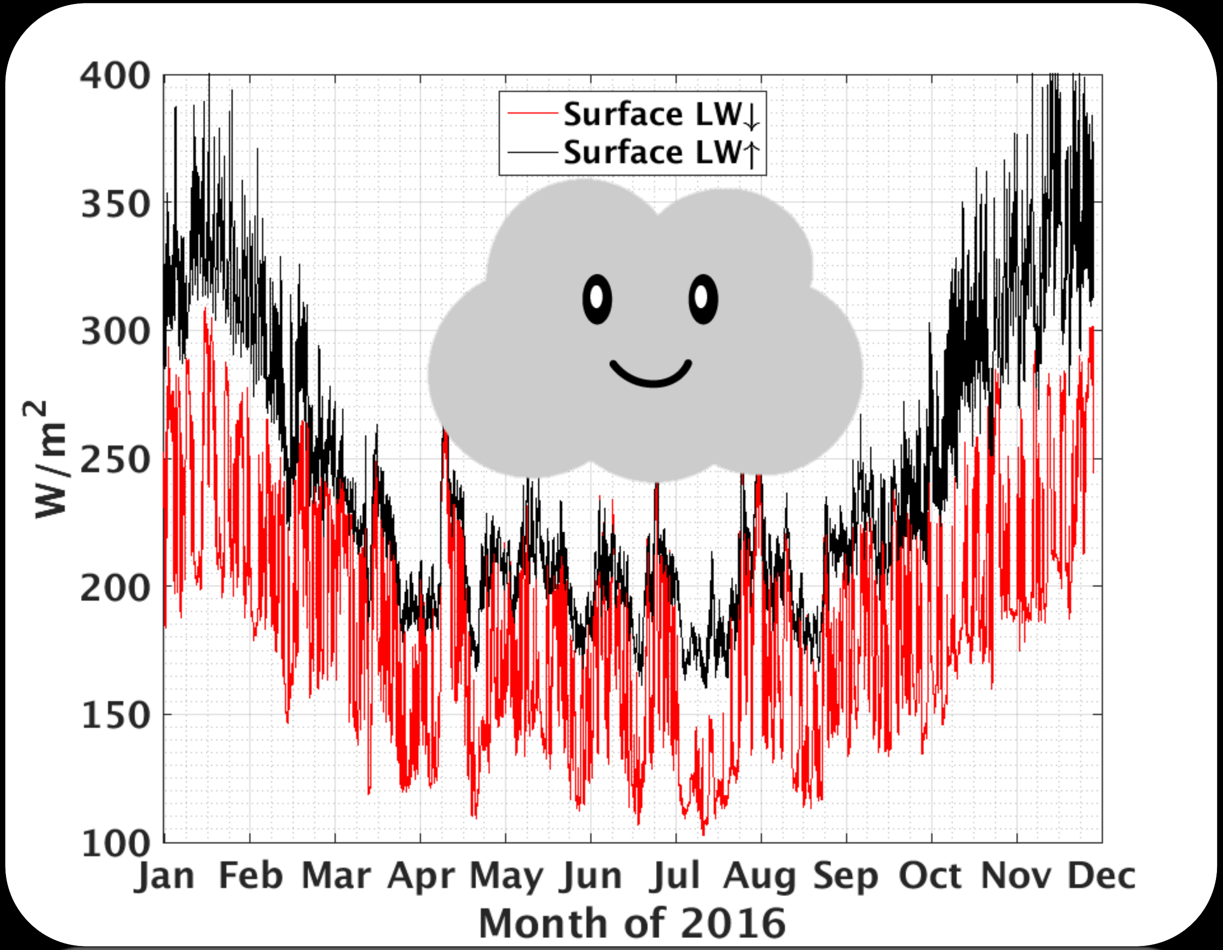




Nicolas et al., *Nat. Commun.*, 2017

Background

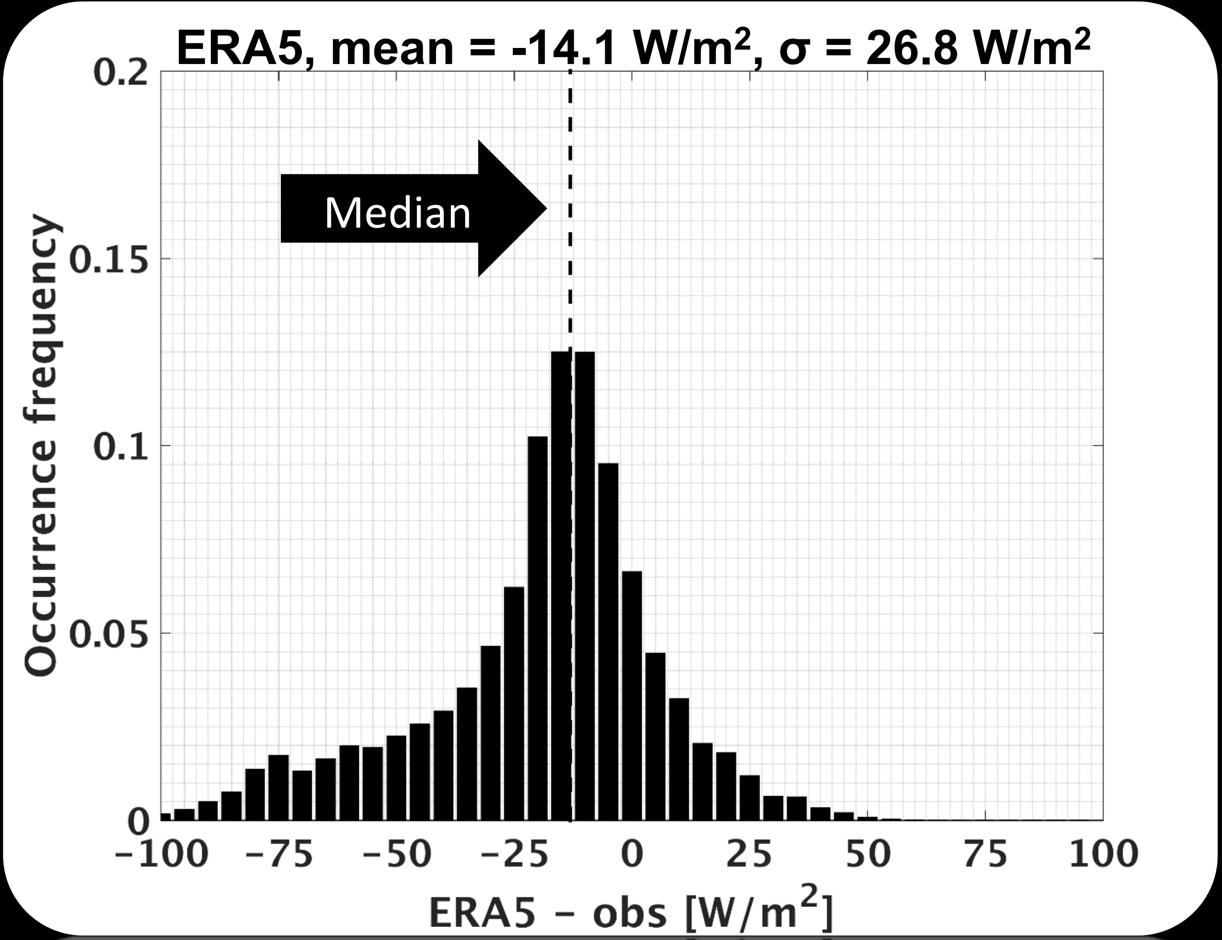
- Polar clouds impact the surface energy budget, even when they optically thin.
- How well do models represent the surface LW↓, the main component controlled by overlying clouds?
- What is the contribution of Antarctic clouds (and their phase) to the model-observation differences?
- Comparison of observations with model output from:
    1. ECMWF ERA5 (reanalysis model).
    2. AMPS (forecast model).
    3. ModelE3 (climate model) – first results.

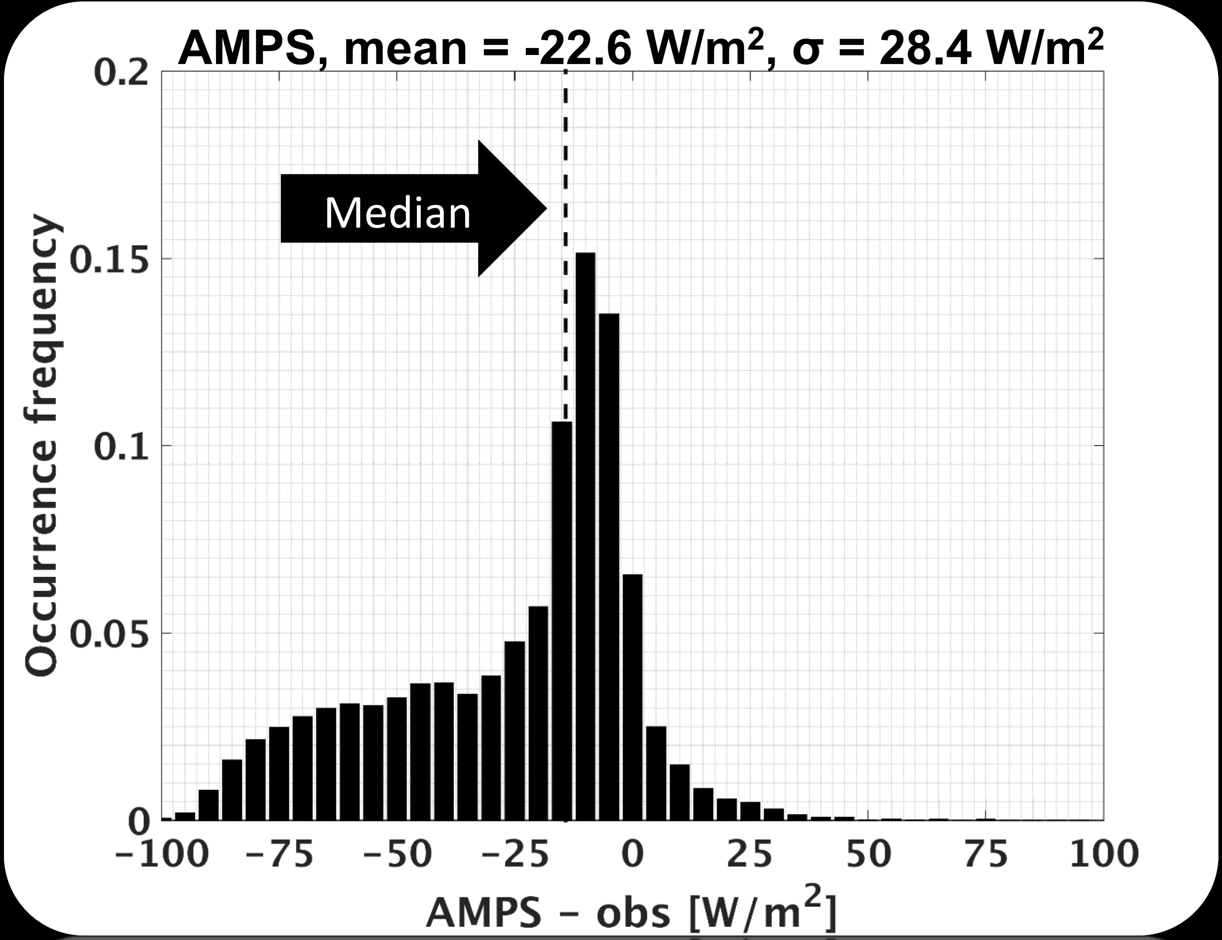


Evaluation of the models in clear-sky periods, ice-cloud occurrences, and tenuous (LWP < 25 g/m^2) and opaque (LWP ≥ 25 g/m^2) liquid-bearing cloud occurrences (see Silber et al., 2018).

Modeled LW↓ Bias

$$\text{Error} = LW{\downarrow}_{model} - LW{\downarrow}_{obs}$$

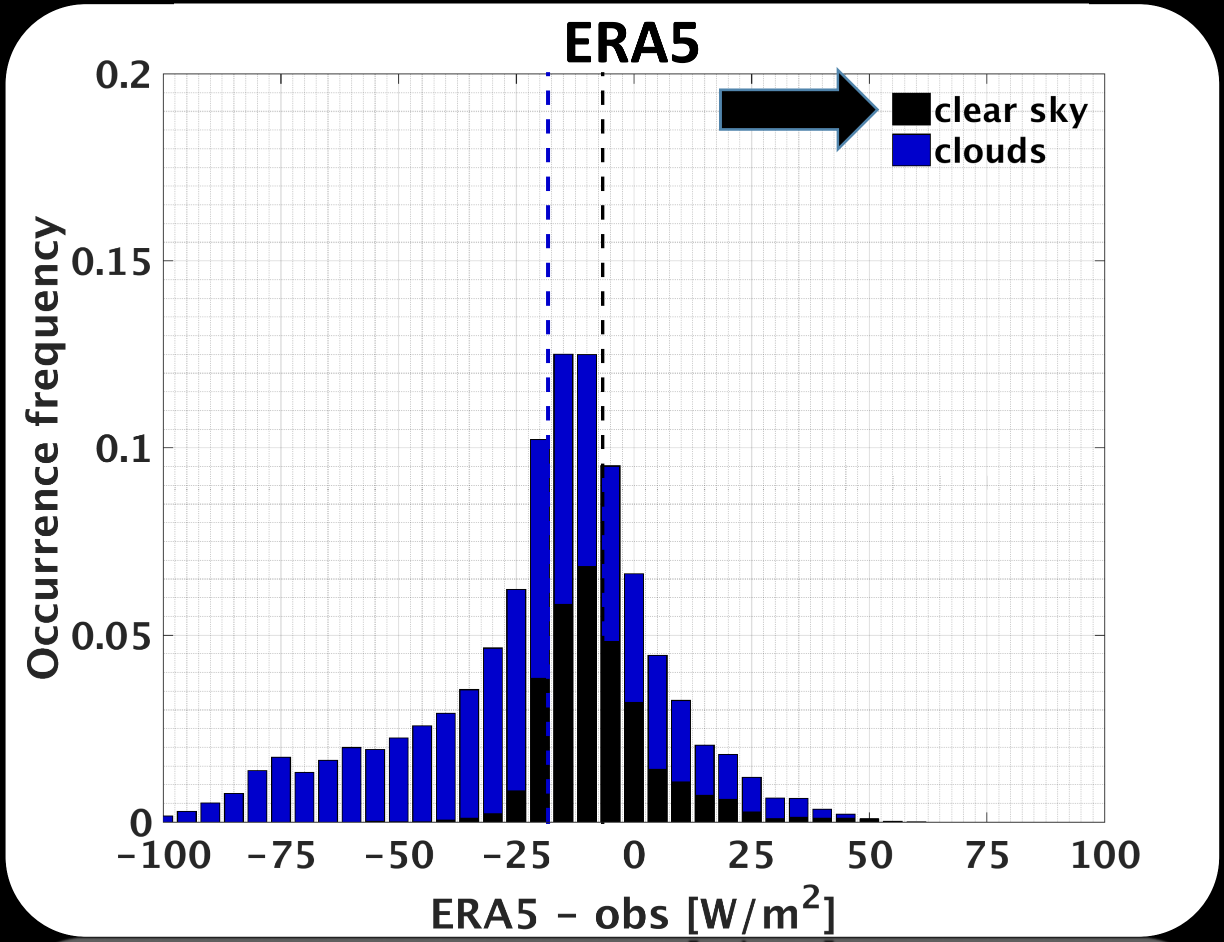


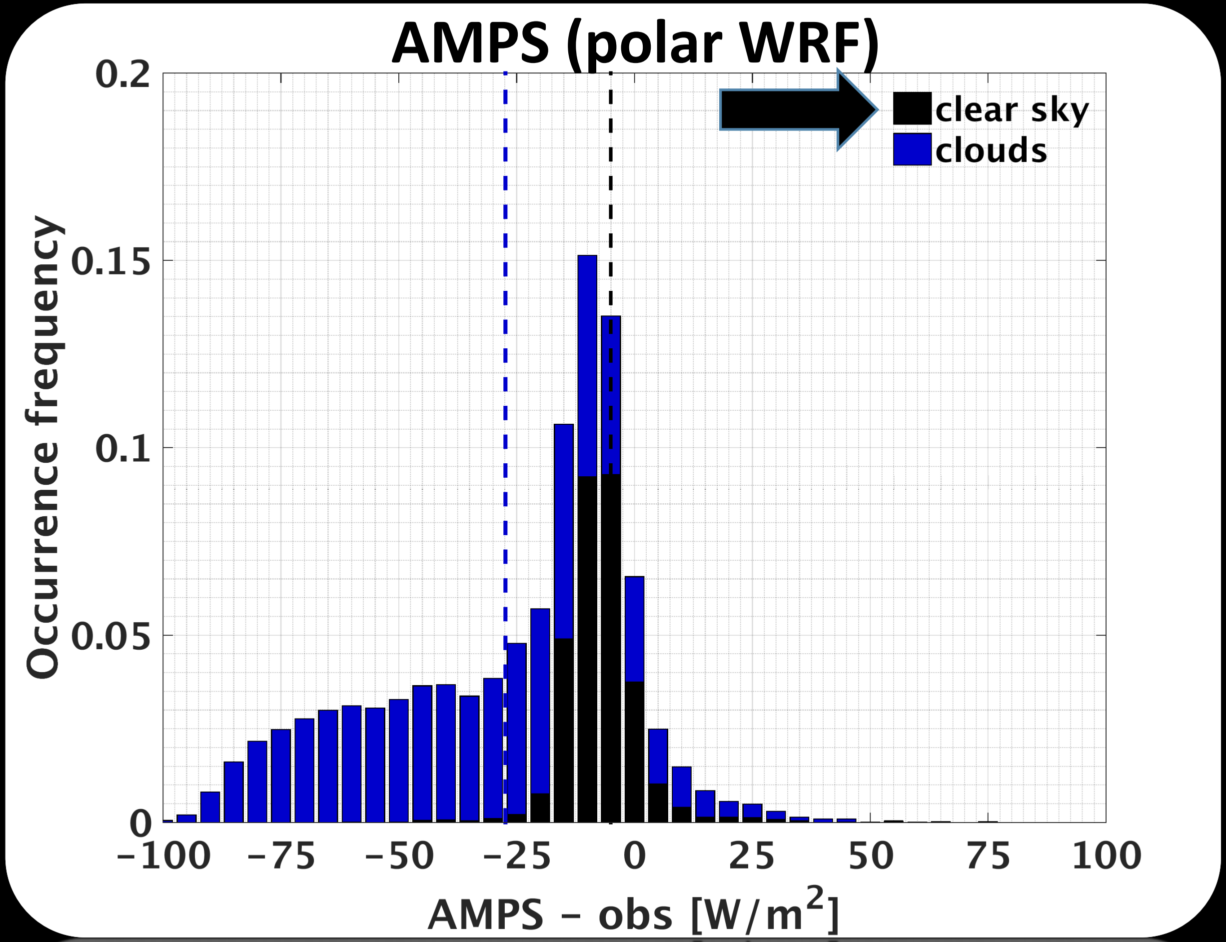


Modeled LW↓ Bias

Underestimation of the total water vapor and/or deviations in the temperature-vapor profiles (especially in the lower kilometer).

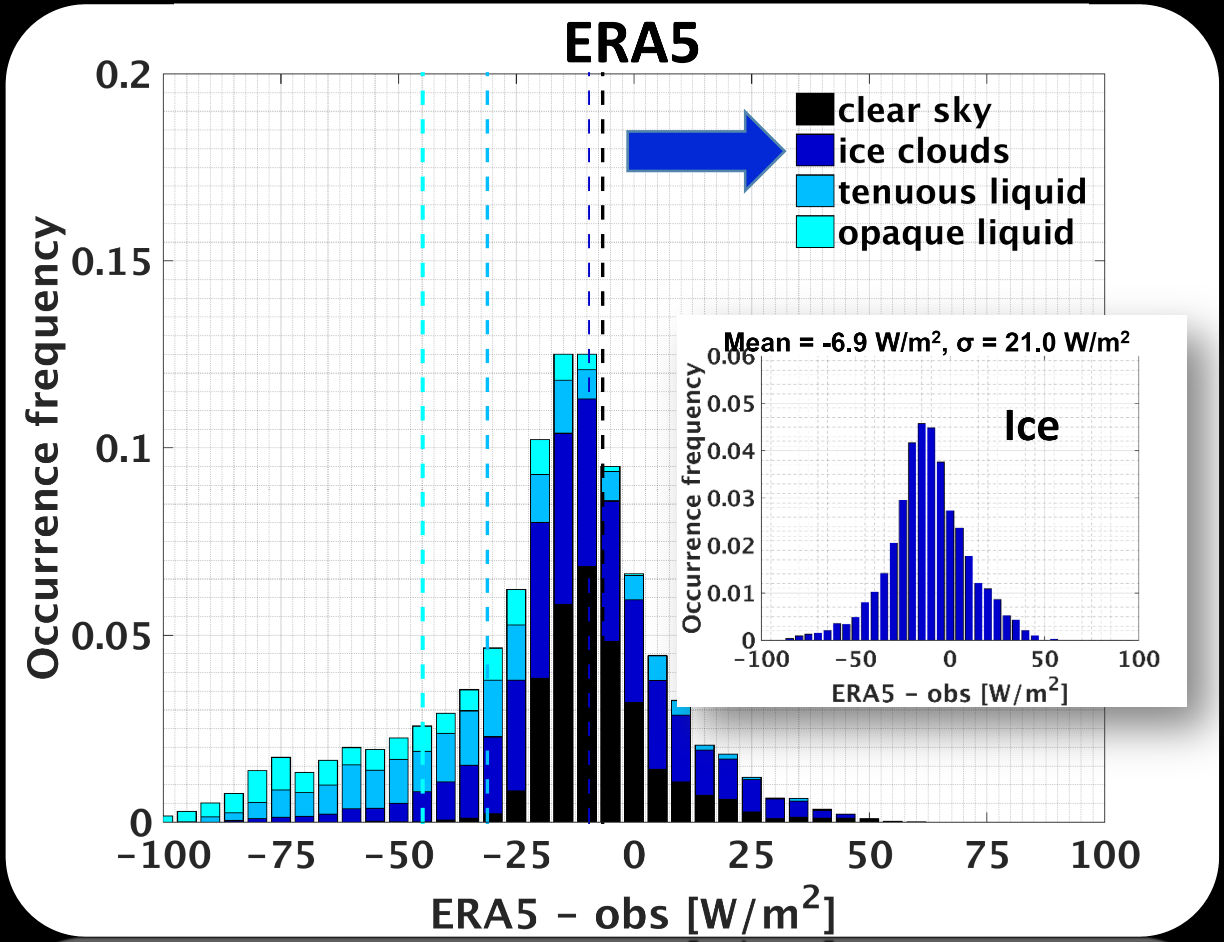
Predominantly underestimation of LW↓ during clear-sky periods by ~5 W/m²

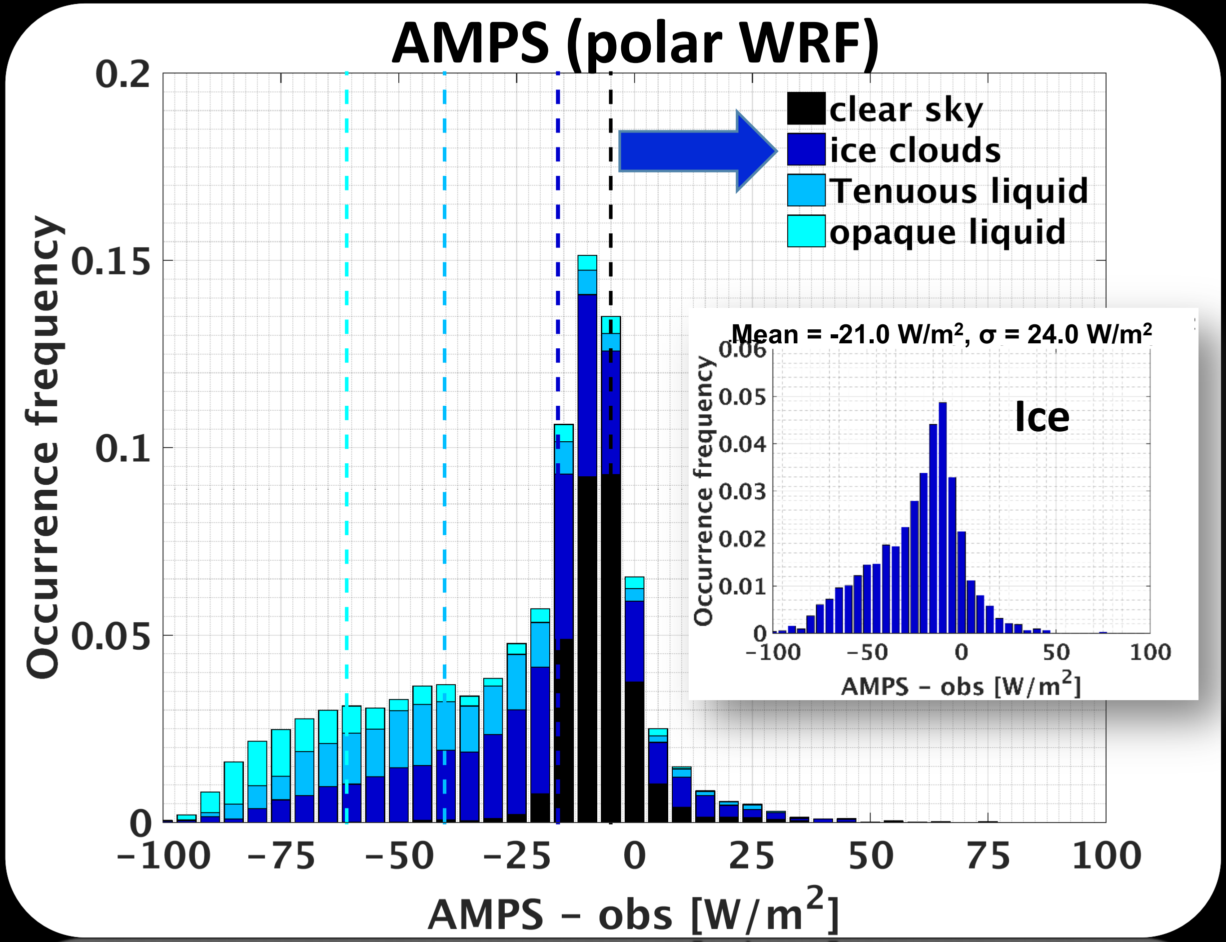




Modeled LW↓ Bias

Very large ice cloud spread, tendency for underestimation



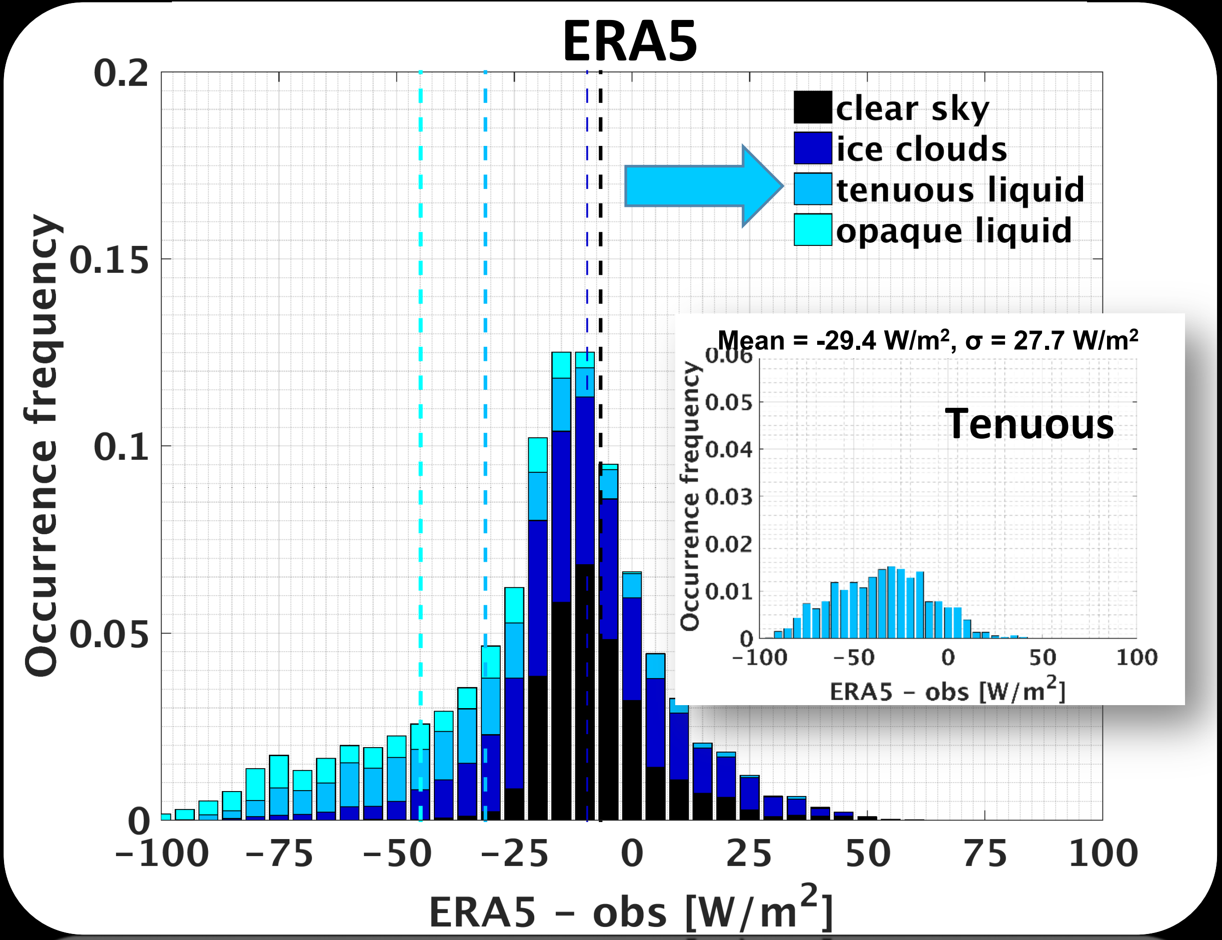


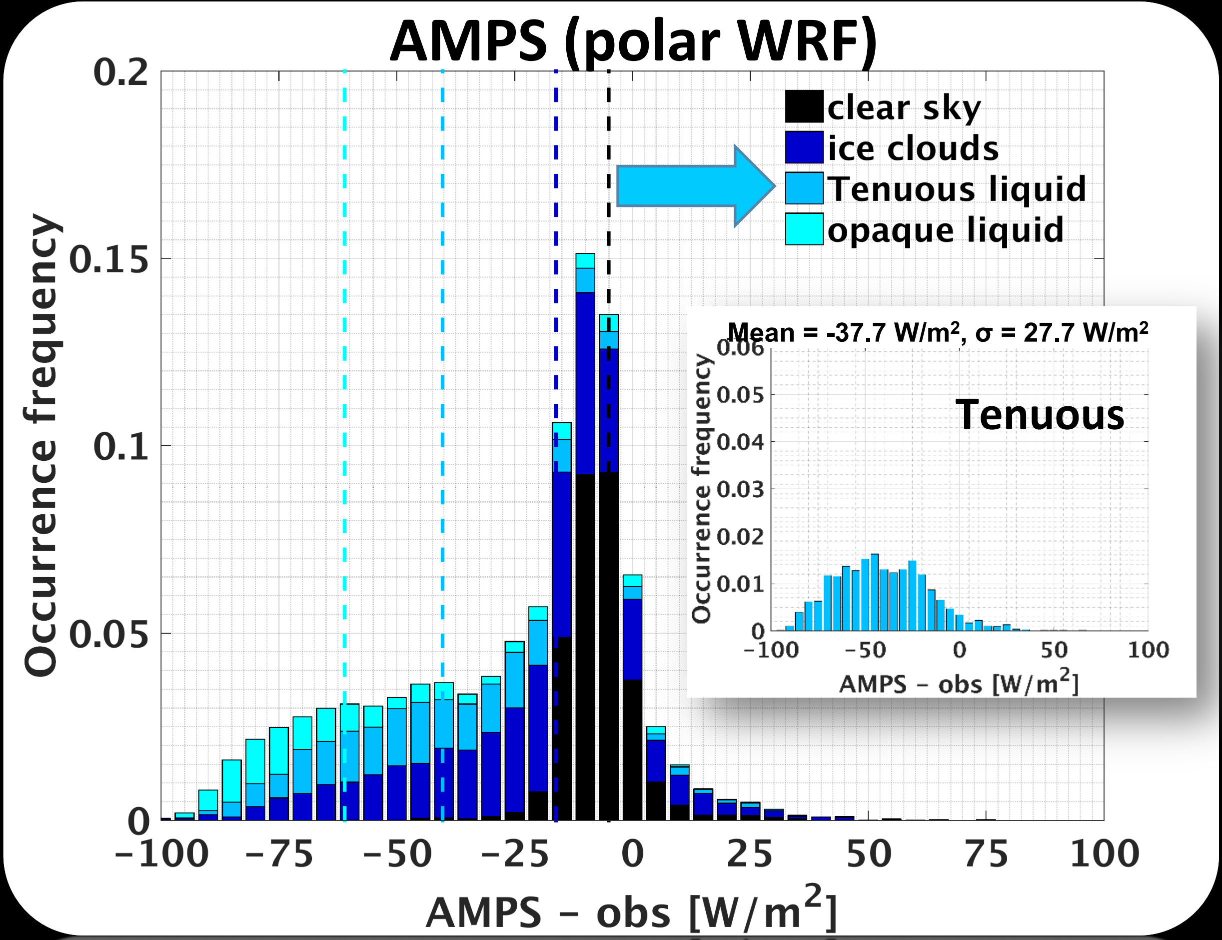
Silber et al., *J. Clim.*, in revision

Modeled LW↓ Bias

LW↓ is consistently underestimated during Liquid-bearing cloud occurrence

Very large ice cloud spread, tendency for underestimation





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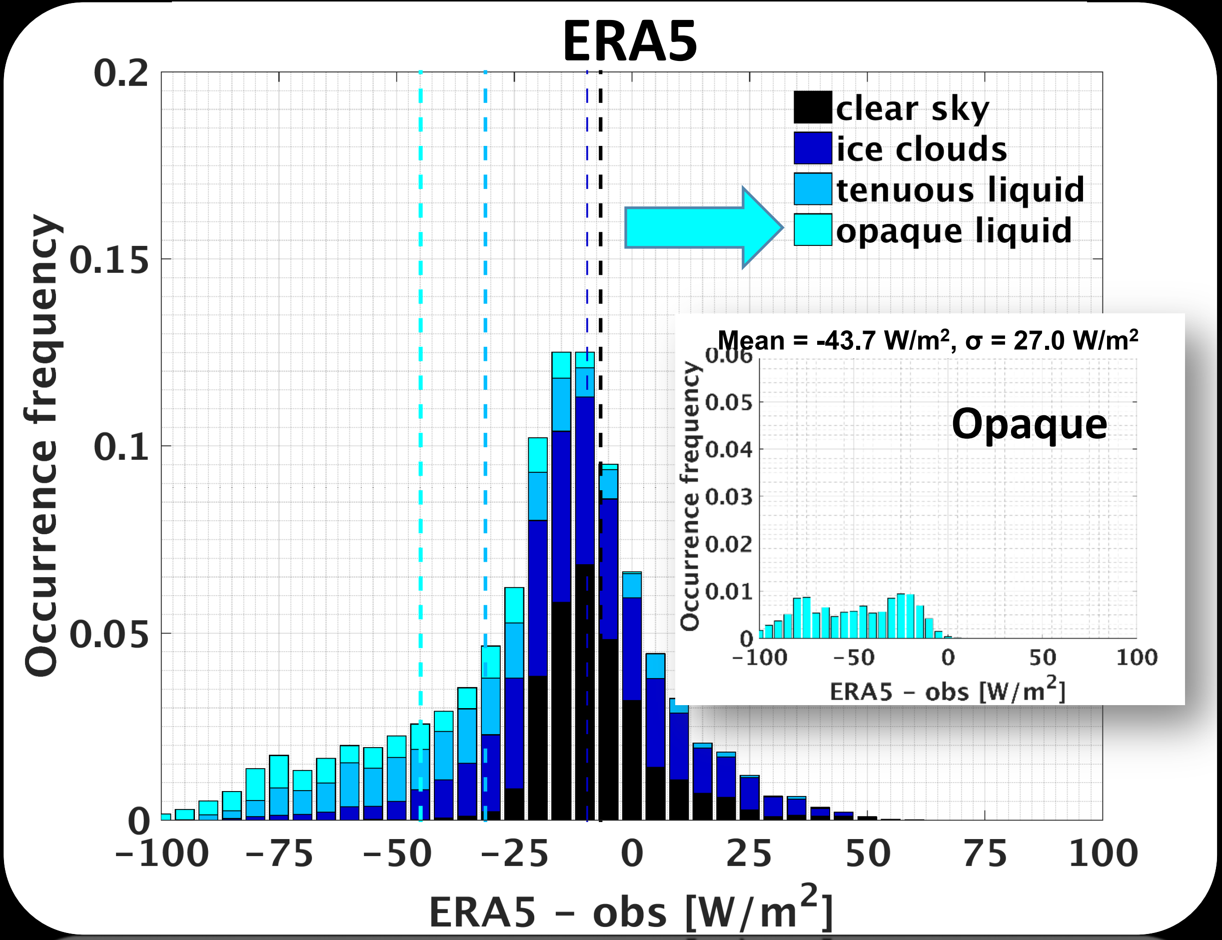
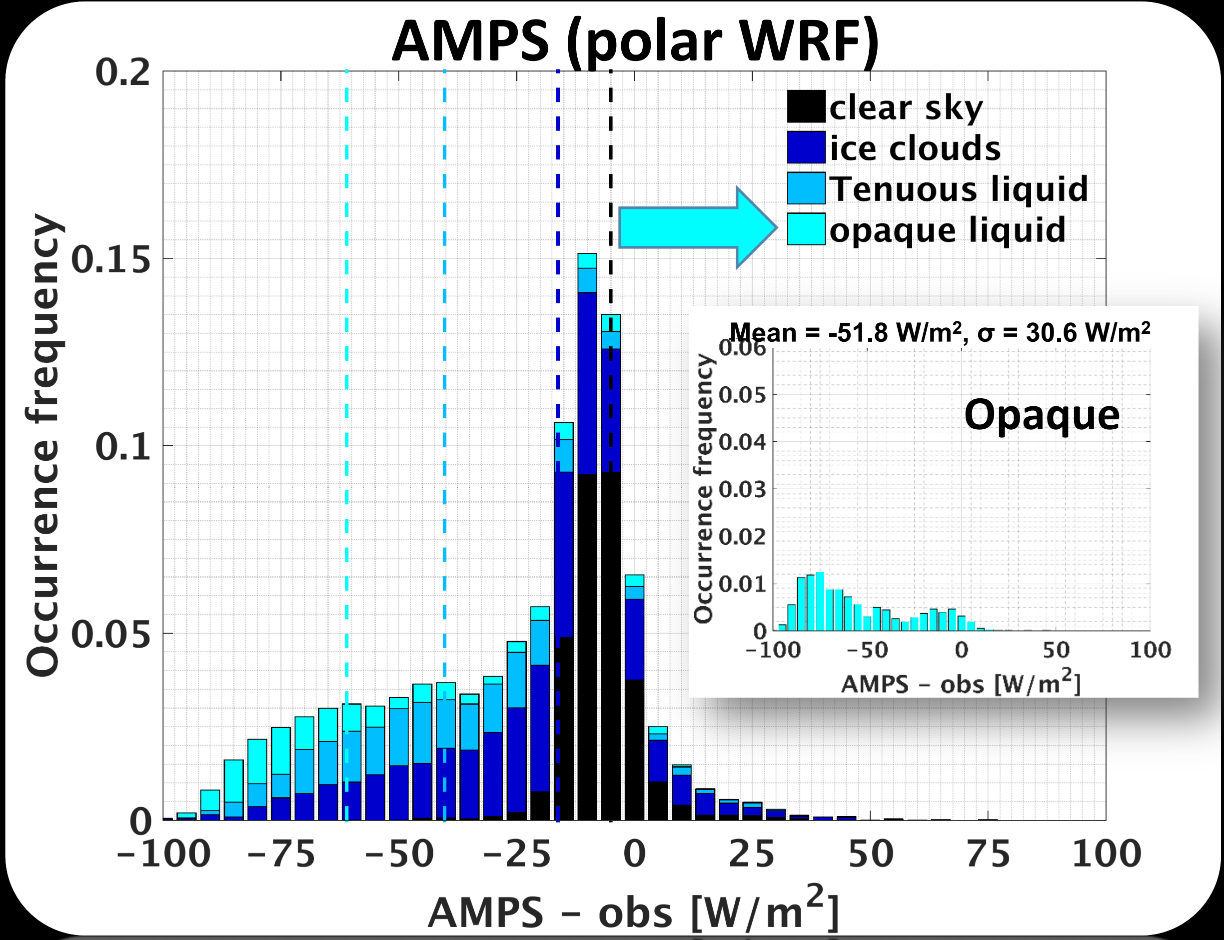
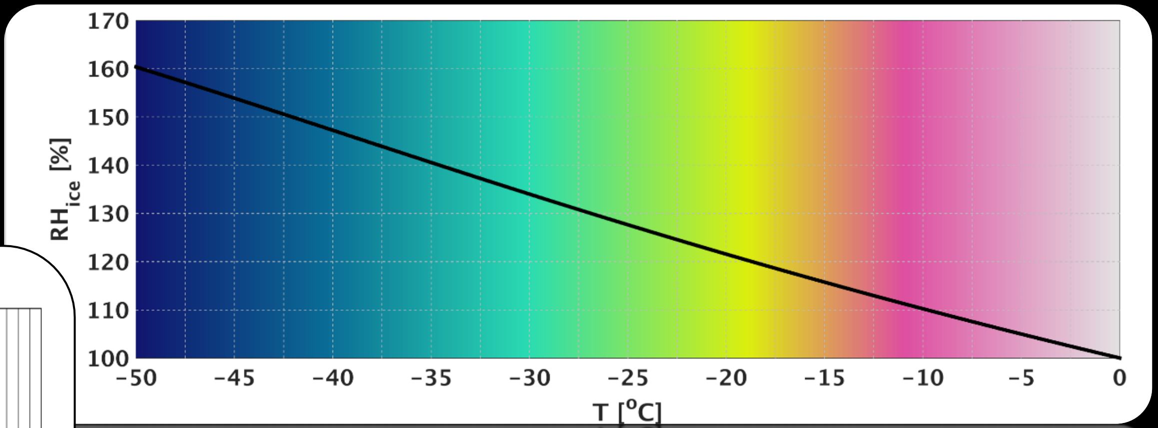




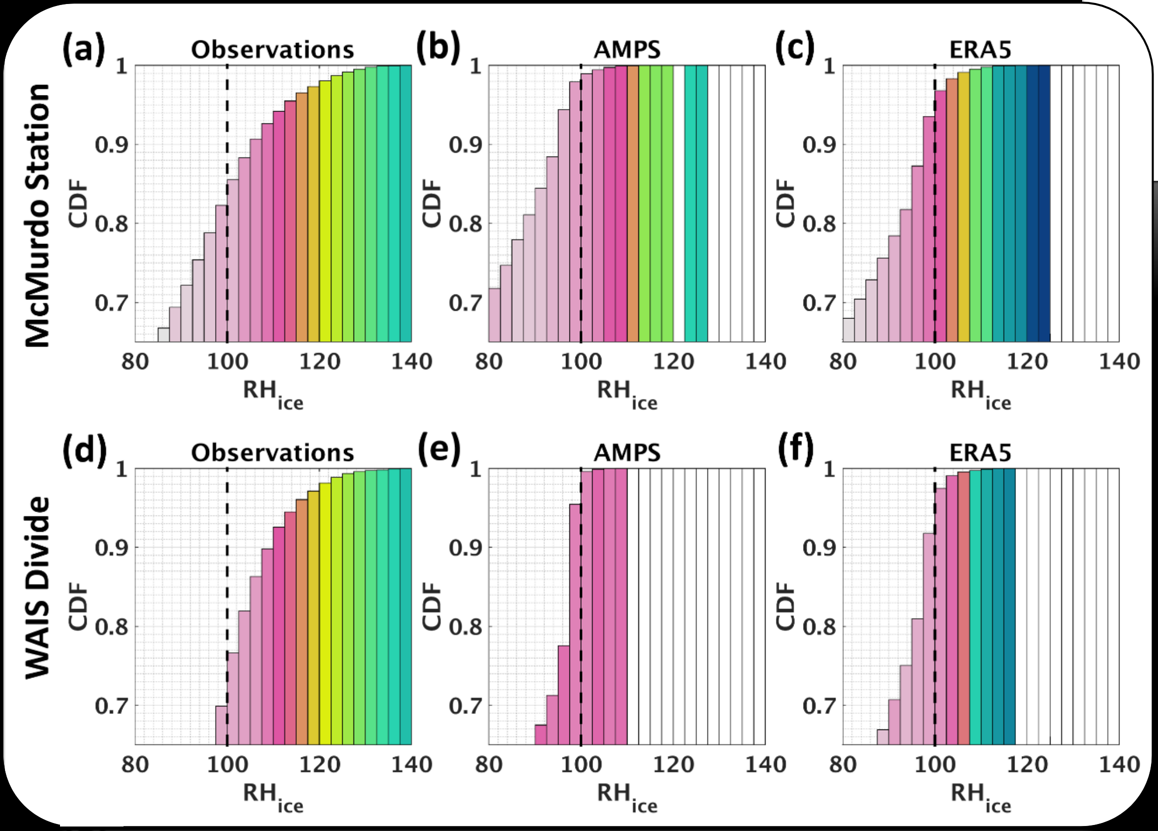
Silber et al., *J. Clim.*, in revision

RH_{ice} Comparison (0-6 km)

RH_{ice} at water saturation



Obs: the atmosphere is "starving" for ice nuclei → High ice supersaturation

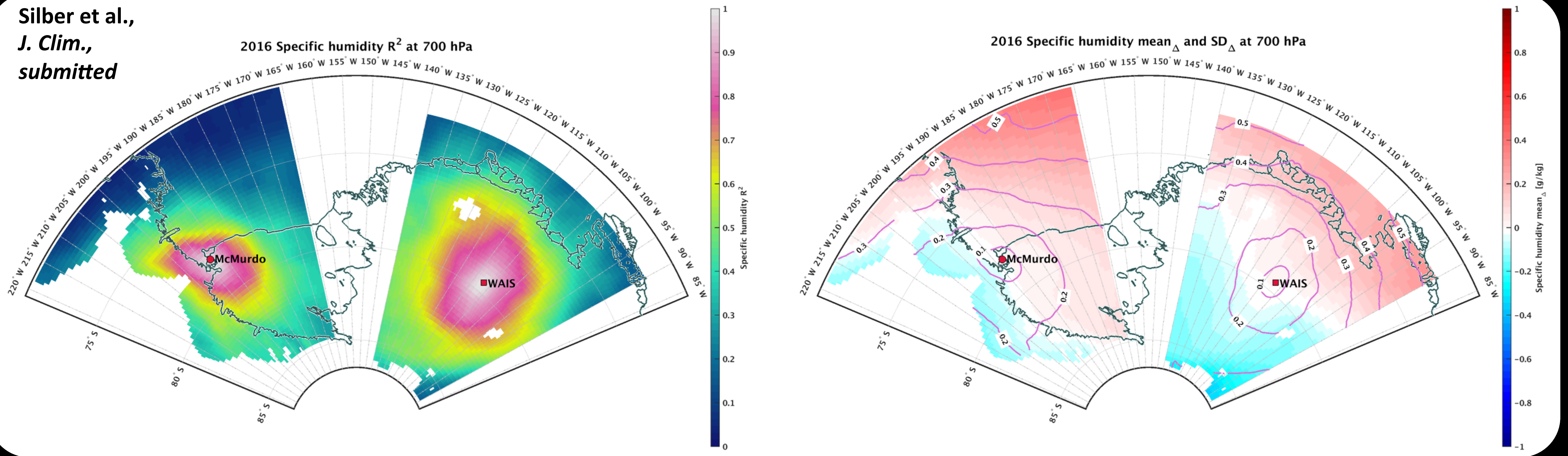


Models: Highly efficient nucleation → RH_{ice} rarely exceeds 100% → Quick desiccation of the atmosphere

Silber et al., *J. Clim.*, in revision

ModelE3 Climate Model

Silber et al.,
J. Clim.,
submitted



ModelE3 Climate Model

Silber et al.,
J. Clim.,
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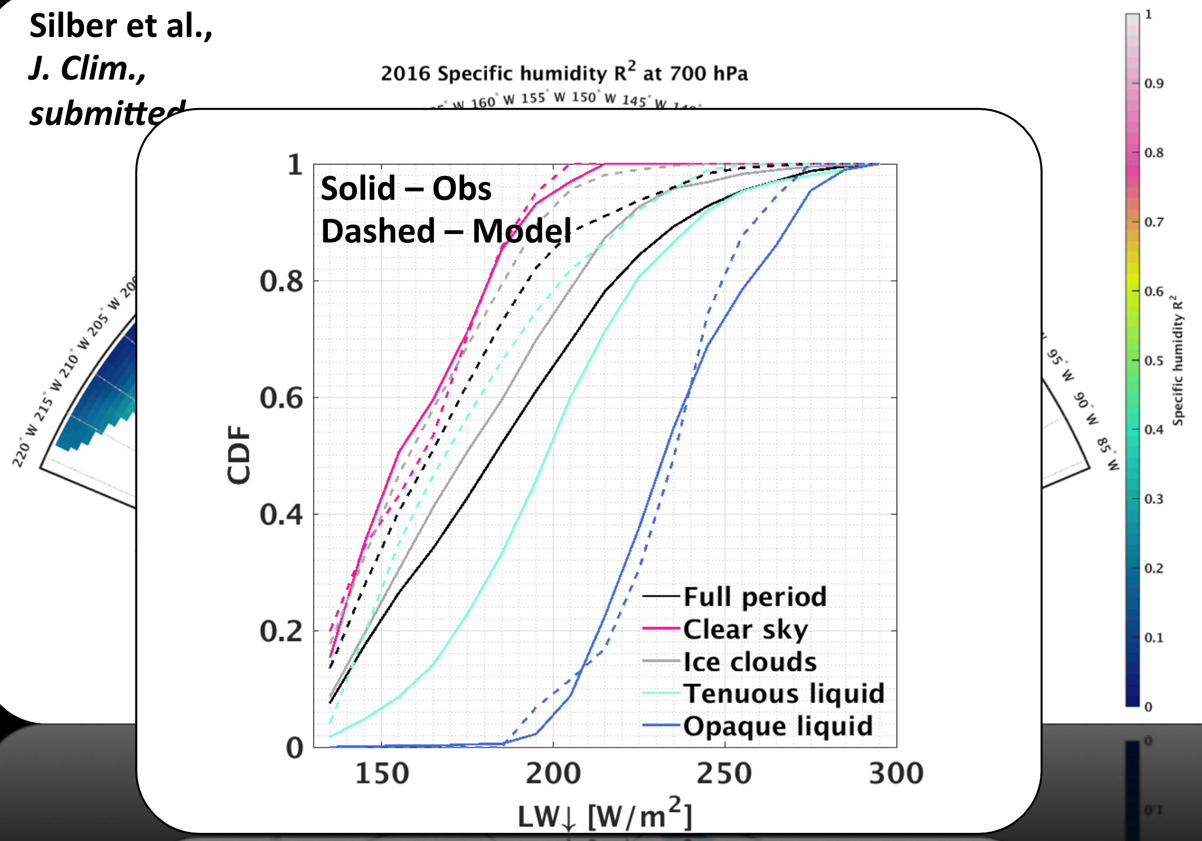

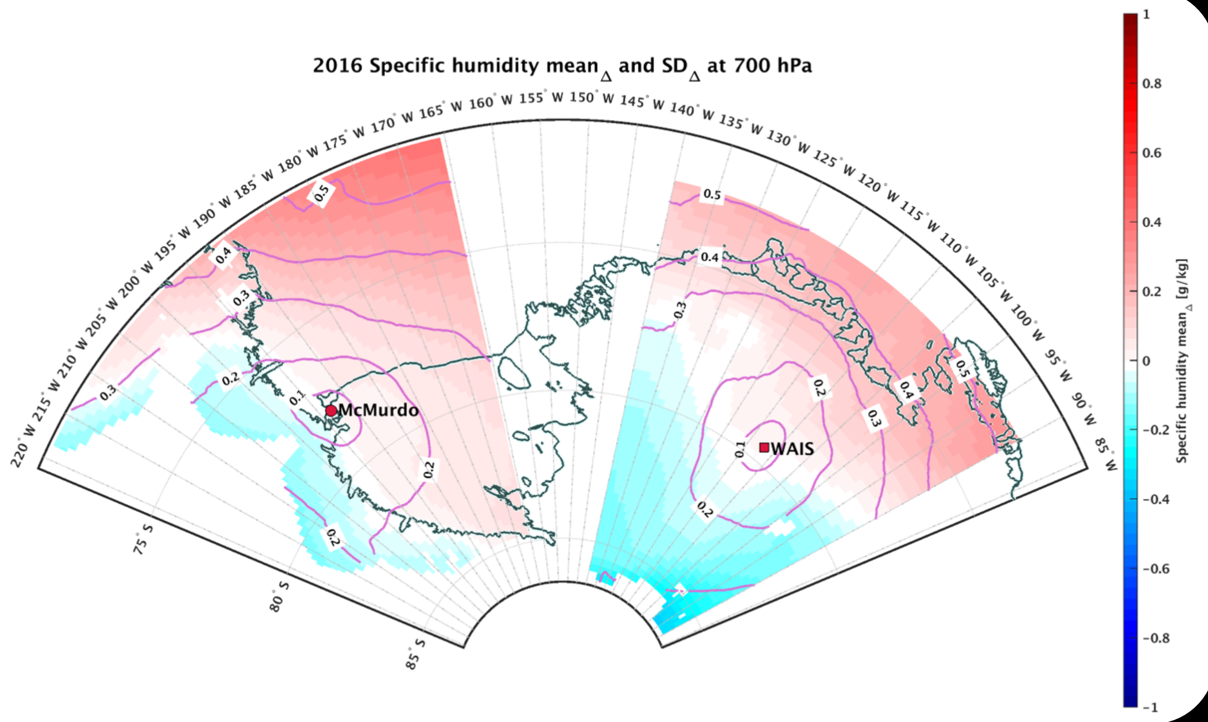

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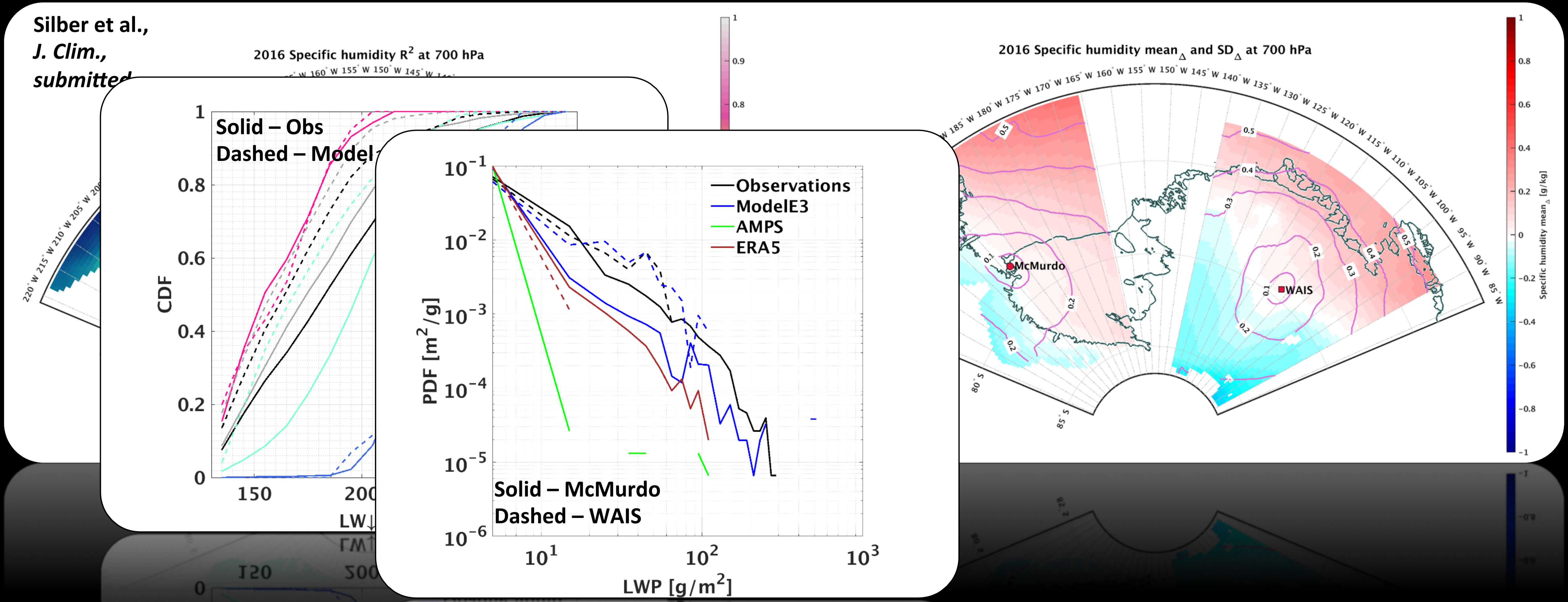

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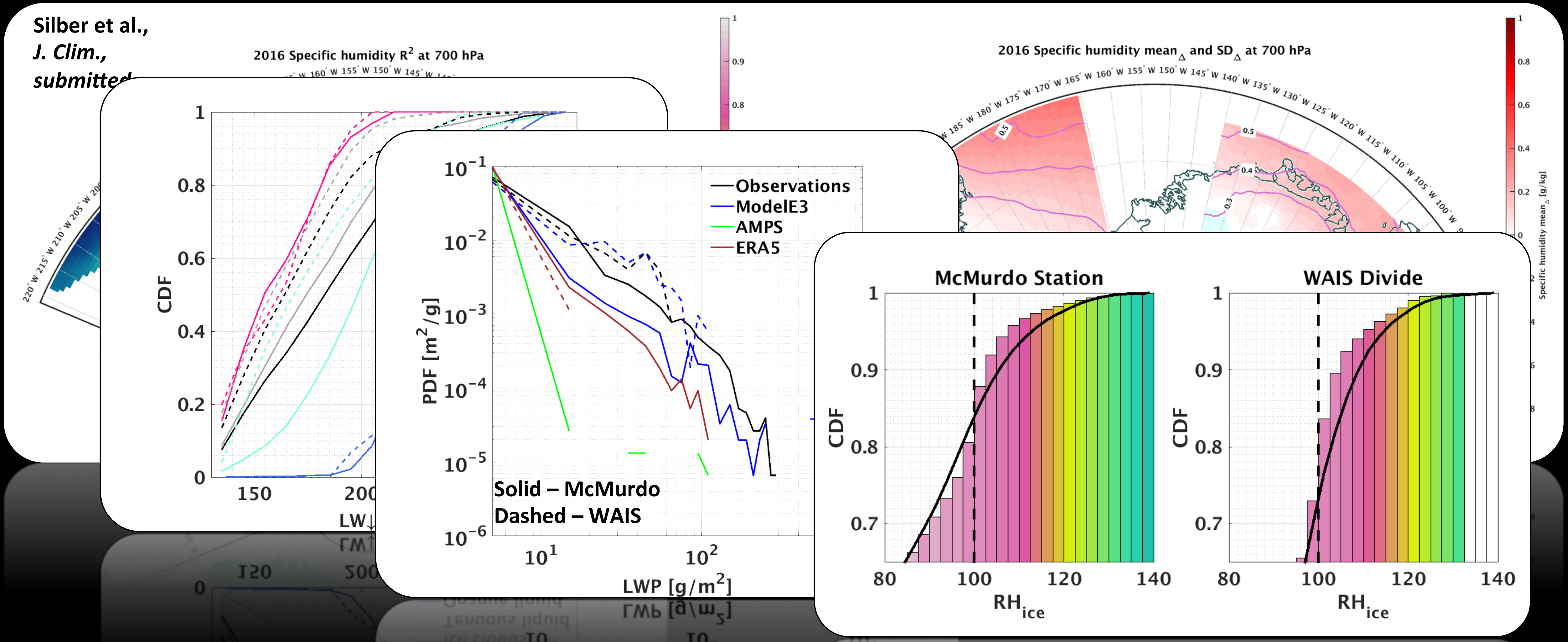

Conclusions and Summary

- Antarctic mixed-phase as well as ice clouds have a significant impact on the surface energy budget.
- Both ERA5 and AMPS, tend to underestimate the surface LW↓ relative to the observations.
- These deviations are significantly larger in the presence of liquid-bearing clouds.
- Excess production of ice is likely the culprit of the model LW↓ underestimation. The sources for this excess production of ice will be further investigated in future studies.
- Preliminary analysis of ModelE3 with nudged horizontal winds shows good results.

Poster #97 (feel free to visit #95 as well)

Silber, I., J. Verlinde, S.-H. Wang, D. Bromwich, A. M. Fridlind, M. Cadeddu, E. W. Eloranta, and C. J. Flynn (2019), Cloud influence on ERA5 and AMPS surface downwelling longwave radiation biases in West Antarctica, *J. Clim.*, in revision.