Sensitivity of the hydrologic cycle to surface flux enhancement by convection

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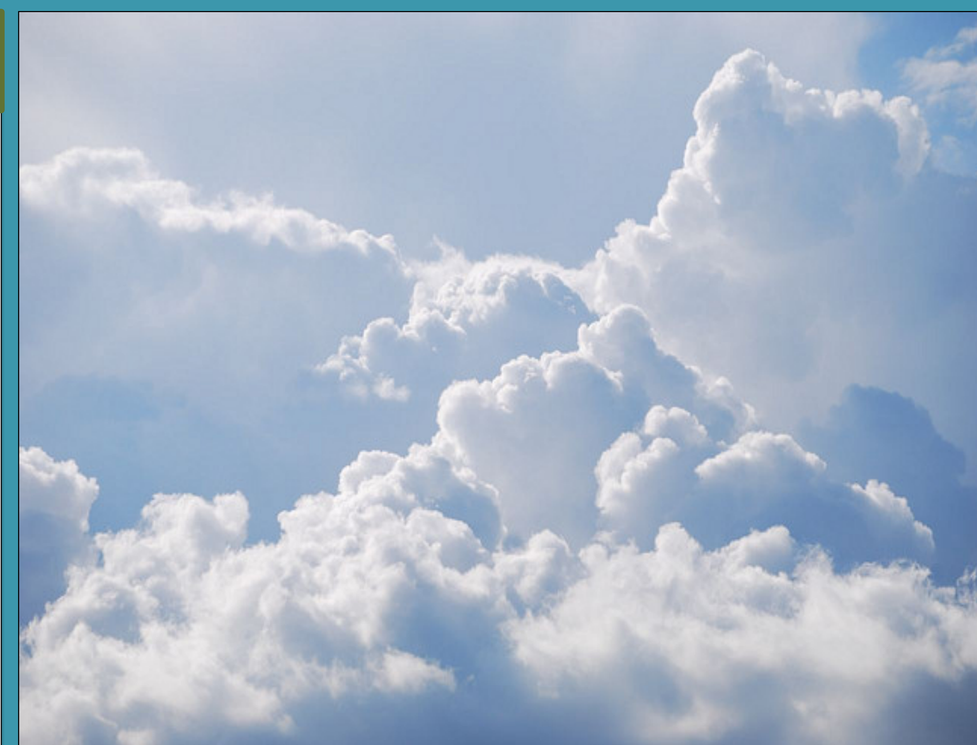
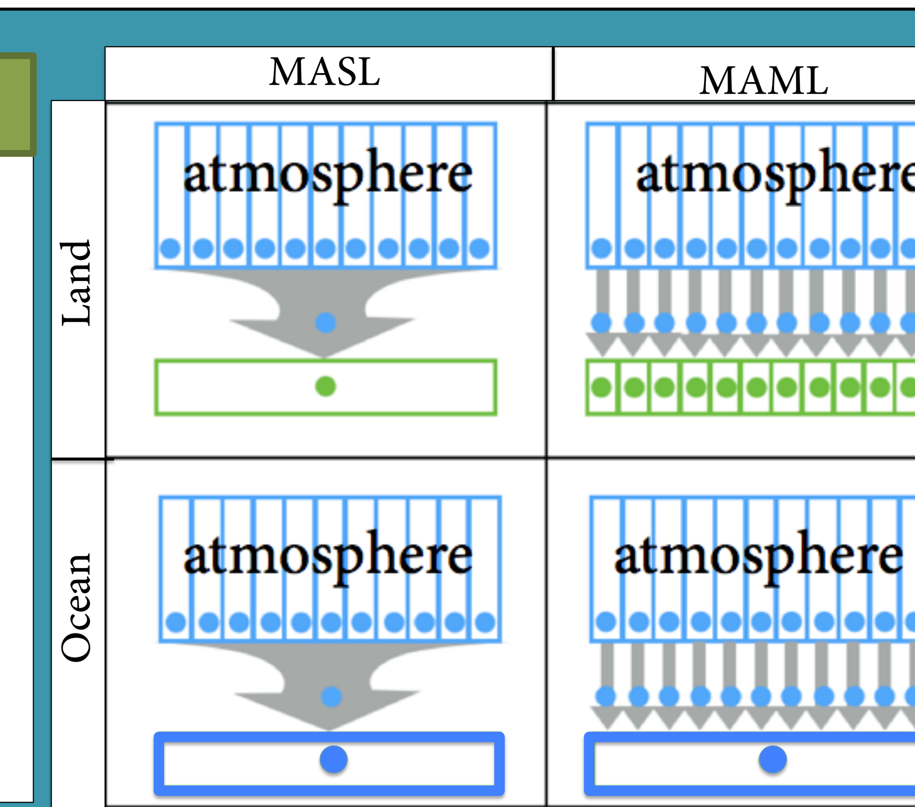
1. Introduction

- Two *superparameterized* versions of CAM, a global circulation model (GCM)
- How does the newer version affect the hydrologic cycle?
- Two parameters: precipitation and surface latent heat flux, an analog for evaporation
- How do simulated differences in thunderstorms affect surface evaporation?
- How do the model versions differ?

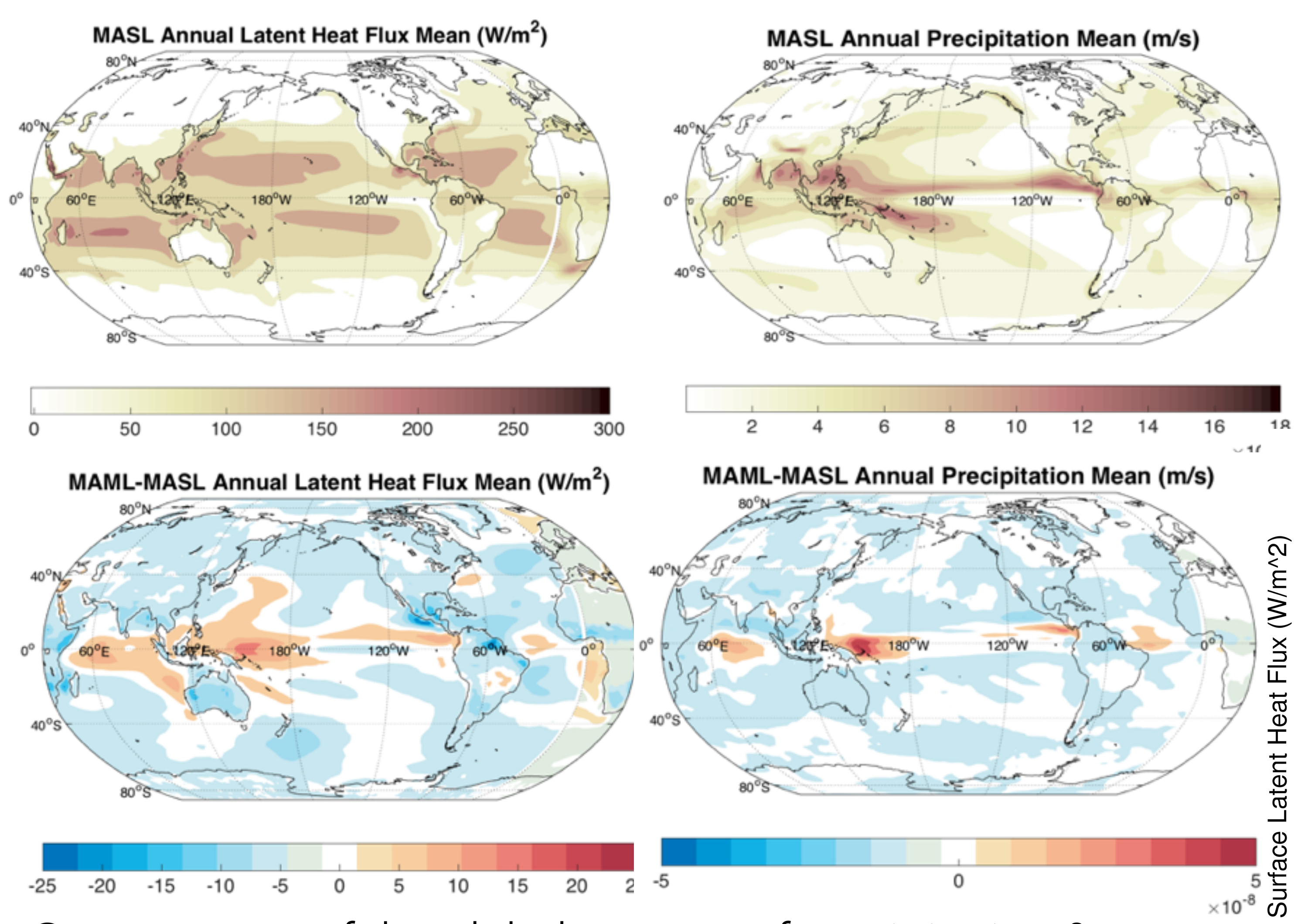


2. Models

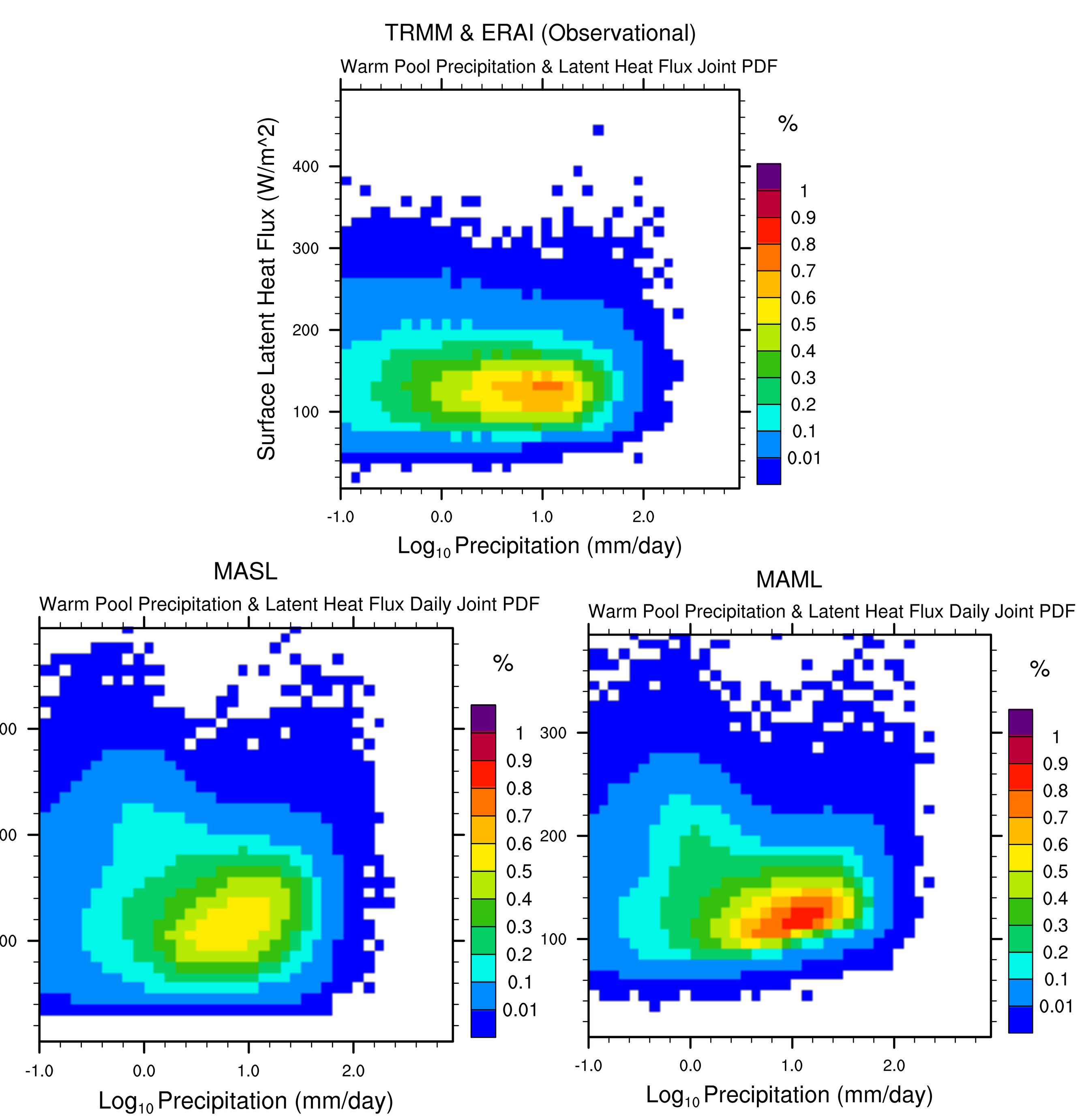
- *Superparameterization* : each grid cell has an embedded two-dimensional cloud-resolving model (CRM: 32 columns, each 4 kilometers wide).
- More accurate representation the physical effects of clouds on the hydrologic cycle.
- Model versions: Multiple Atmosphere Single Land (MASL); Multiple Atmosphere Multiple Land (MAML); *shown in figure to the right*
- MASL: surface fluxes computed on GCM scale: wind speeds averaged together to produce one latent heat flux value.
- MAML (new): fluxes calculated on CRM scale; wind speeds used to calculate unique fluxes.
- MAML: **expect more occurrences of stronger latent heat flux**: because winds not averaged first (increased evap. rate); over land, more complicated: cloud shadows (cause cooler ground, thus lower latent heat flux) and wet patches of soil from rain (cause increased latent heat flux).



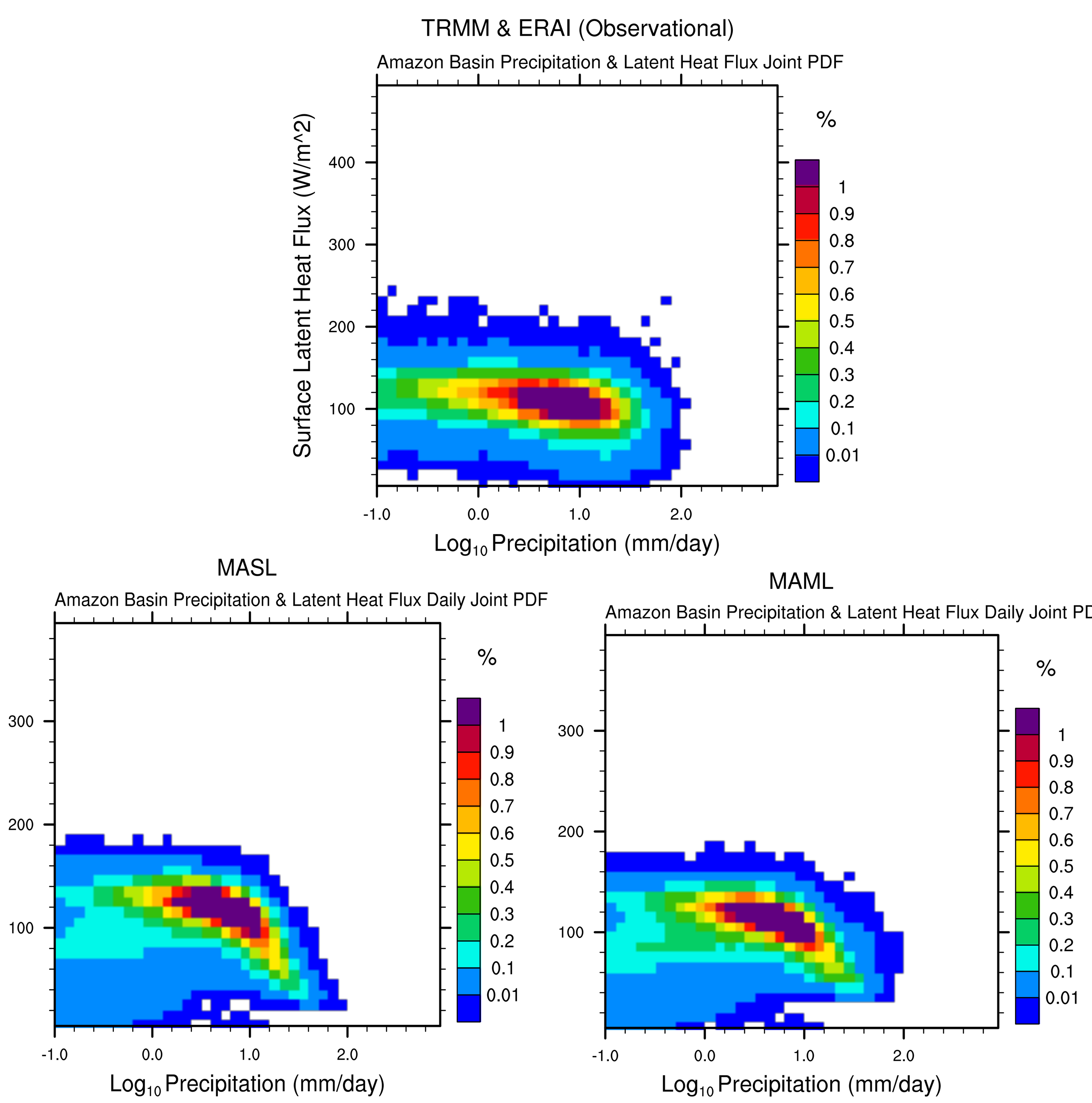
3. Results



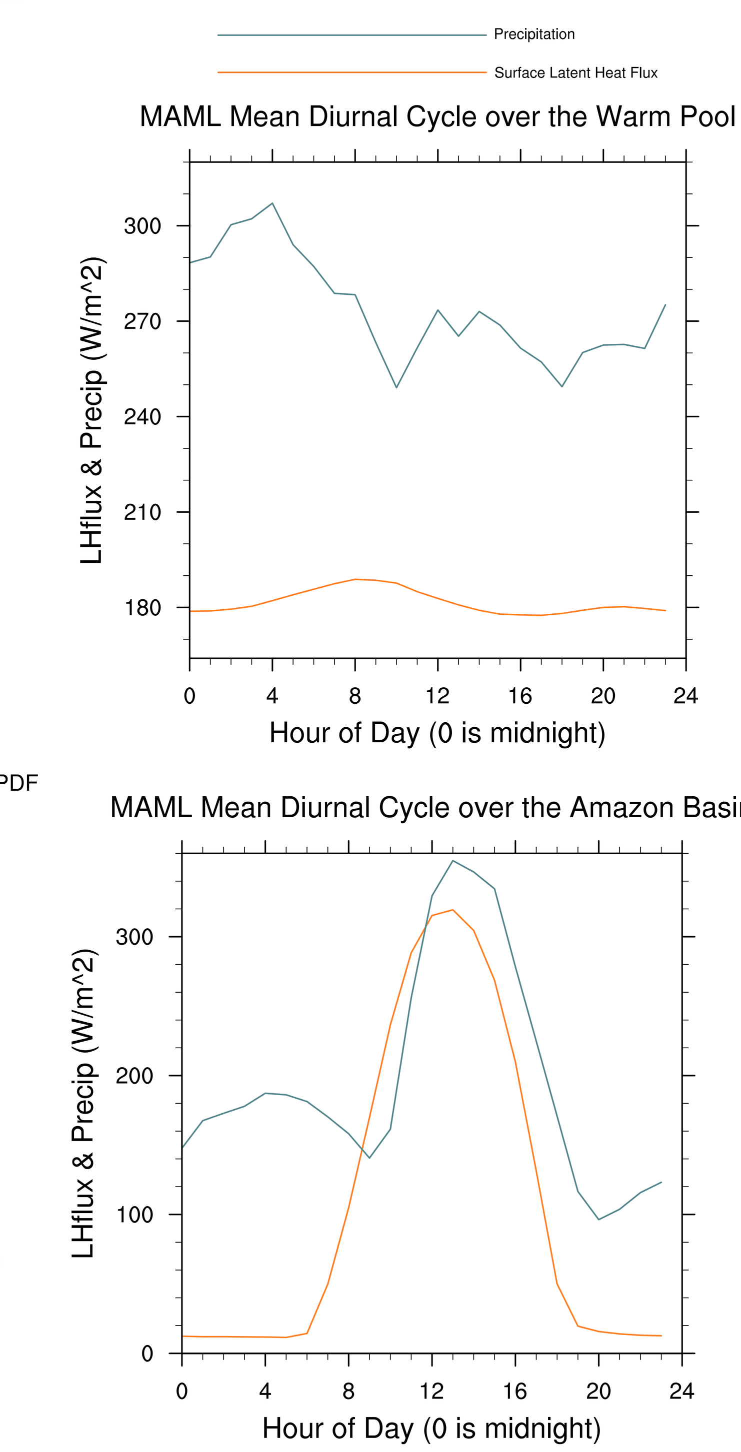
On top, maps of the global average of precipitation & evaporation (surface latent heat flux) from MASL. Below, difference maps of these global averages MAML-MASL. Heavy rain in the tropics is evident, especially over the Warm Pool in MAML, compared to MASL.



On top, the joint probability distribution of observational precipitation & latent heat flux data of the Western Pacific Warm Pool. On bottom, the joint prob. dist. for MAML & MASL.



On top, the joint probability distribution of observational precipitation & latent heat flux data in the Amazon. On bottom, the joint prob. dist. for MAML & MASL for comparison to each other and to the observational plot.



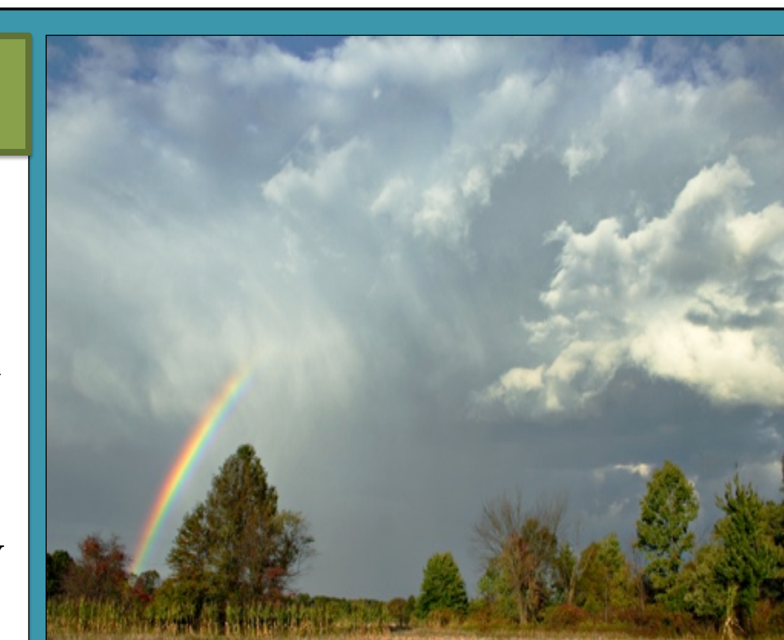
On top, the mean diurnal cycle produced by MAML over the Warm Pool. Below, the MAML mean diurnal cycle over the Amazon.

4. Discussion

- Global average maps: hydrologic cycle differs between MAML & MASL.
- Warm Pool (representative for all ocean regions considered): fluxes higher in MAML for any given precipitation value. Supports our hypothesis that MAML generally yields higher latent heat flux values than MASL.
- Amazon (representative of all land regions considered): fluxes higher in MASL and precipitation higher in MAML. Contradicts what we had anticipated, but makes sense based on diurnal cycle plots (with heaviest rainfall coming in the afternoon, after the peak in surface latent heat flux every day, the same effect of high latent heat flux is not going to arise)
- Comparing models to observations, clear bias for high latent heat flux values in both the models

5. Conclusions

- MAML does show some of the effects we expected—in particular, the stronger latent heat flux as a result of stronger winds in rainy regions over the ocean.
- MAML has a more realistic framework but does not necessarily better reflect the observations.
- Better physics can improve a model. However, in the short term, local changes can have global consequences and each new improvement uncovers previously hidden biased to explore.



Acknowledgments

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