



Challenges in simulating convective clouds in cloud-permitting model and how could GoAmazon observations help

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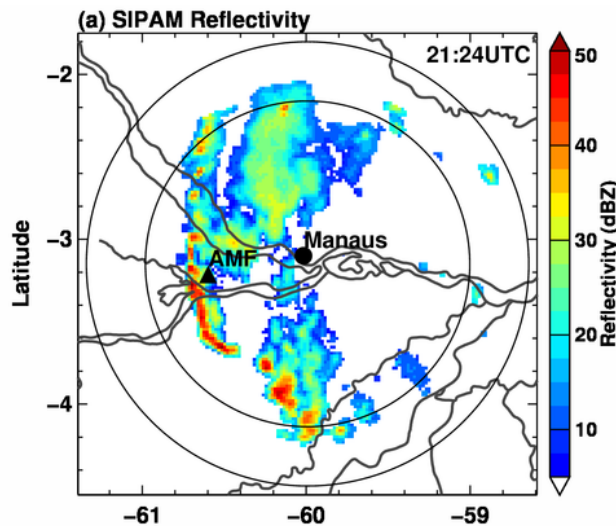
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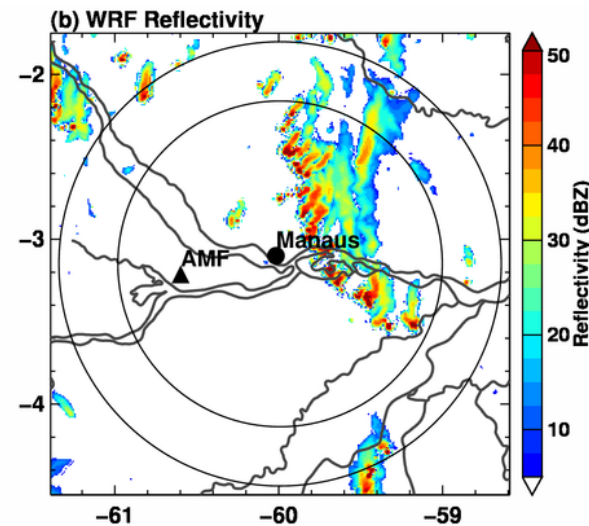
Motivation

- ▶ Challenges in simulating convection in GCMs (previous talk)
- ▶ Cloud-permitting models can explicitly resolve deep convection, hold great promises in understanding and representing the diurnal cycle of convection
- ▶ **New challenges** emerge as model resolution enters the “gray zone” for certain climatically important clouds, where they are **neither resolved nor parameterized** (e.g. Shallow Cumulus)

Radar



Model

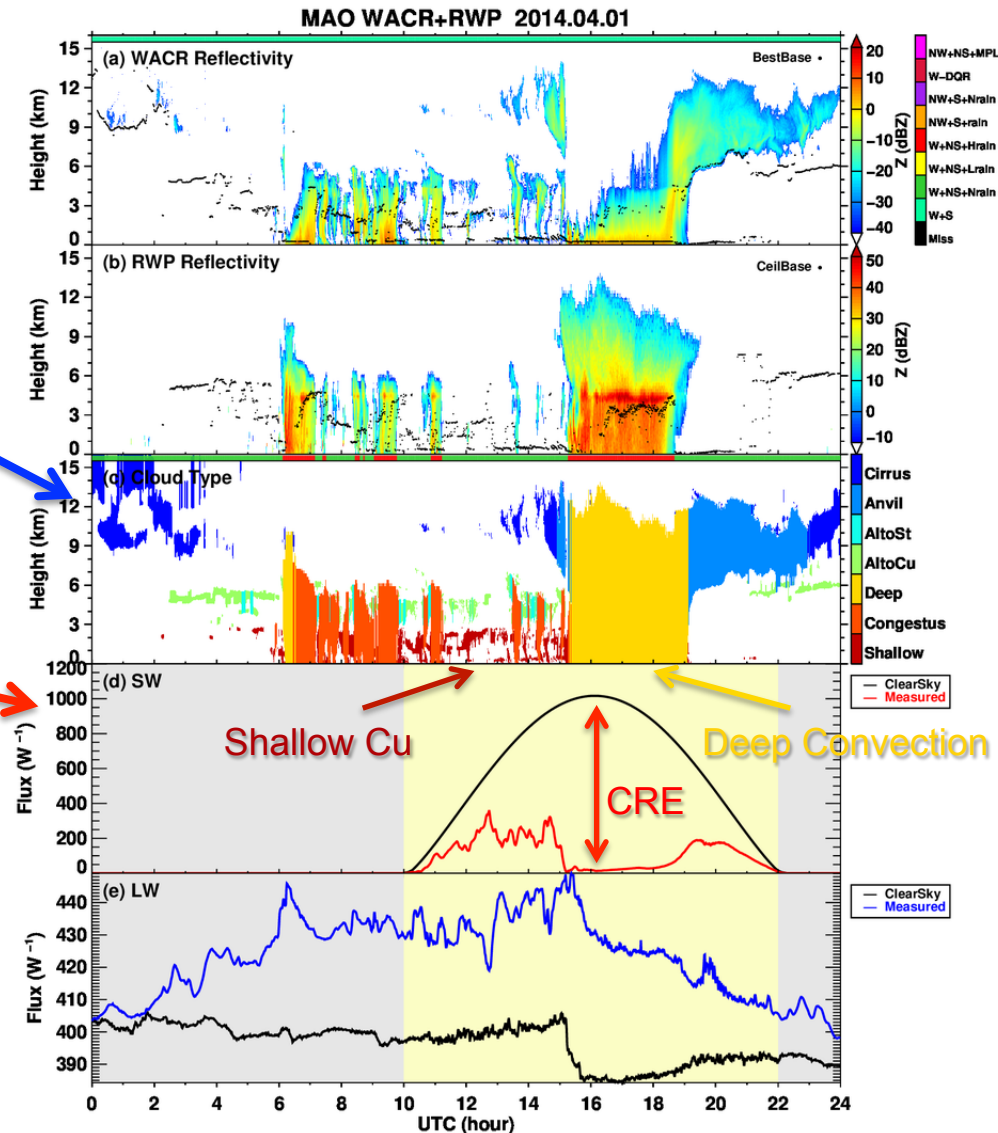


- ▶ Examine the role of shortwave radiative effect of shallow cumulus on the diurnal cycle of convection using cloud-permitting WRF simulations
- ▶ How do various pieces of GoAmazon observations help in addressing modeling challenges



Developing Merged AMF Data Products

- ▶ WACR-ARSCL+RWP merged cloud mask data product
- ▶ New dataset improves detection of all precipitating clouds
- ▶ Cloud-type classification (Burleyson et al. 2015 JAMC)
- ▶ Surface radiative flux analysis (QCed fluxes, clear-sky fluxes)
- ▶ Separate cloud radiative effects by cloud types, which is dominated by shortwave (SW) effects



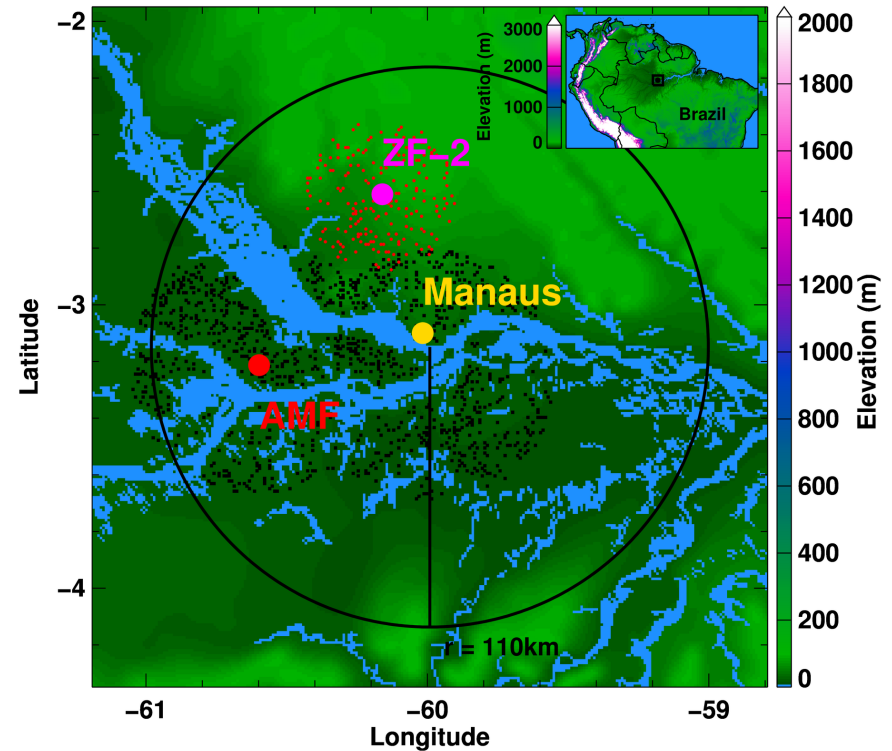
WRF Model Setup

- ▶ Domain: 500x500 km,
 $\Delta x = 1\text{km}$, 60 vertical levels
- ▶ Model evaluation is performed near AMF & Manaus

Model Setup

Period	March 1-10, 2014
Lateral forcing	NCEP FNL analysis
PBL	MYNN2.5 (TKE)
Surface	MYNN
Land surface	NOAH land surface model
Radiation	RRTMG
Microphysics	Morrison 2-Moment

Model Evaluation Domain



Model underestimated ShCu frequency dominates bias in SW CRE



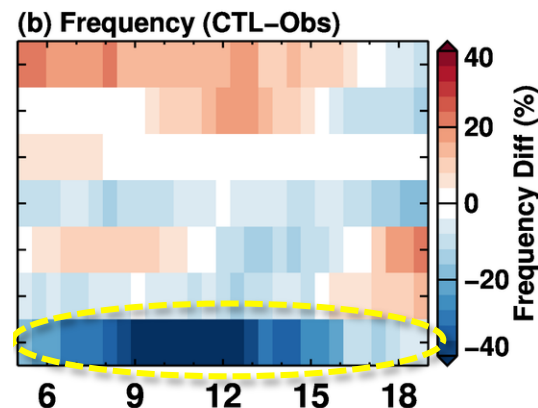
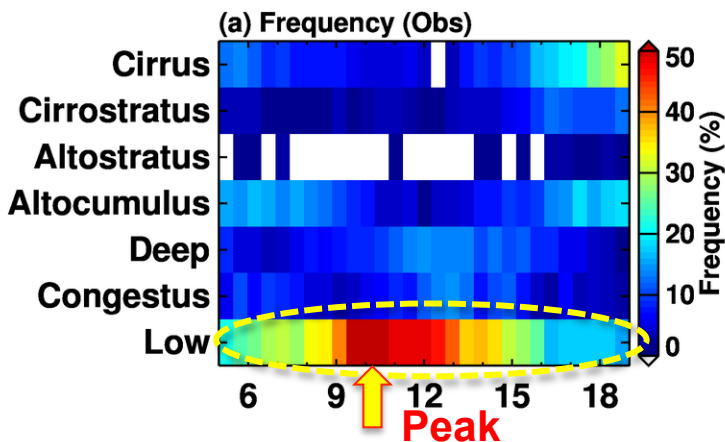
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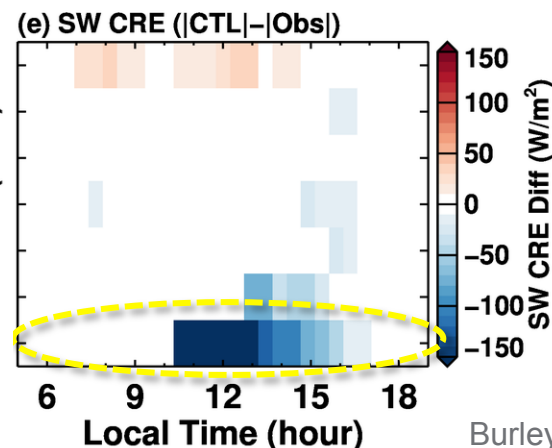
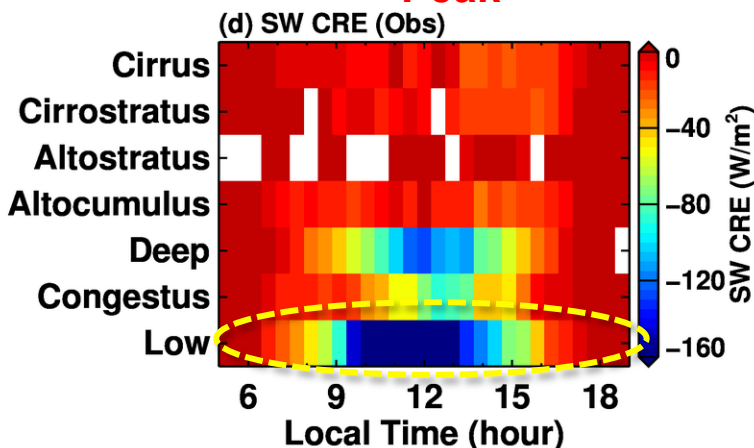
Observation

WRF – Obs

Cloud
Frequency



Cloud
Radiative
Effects (CRE)

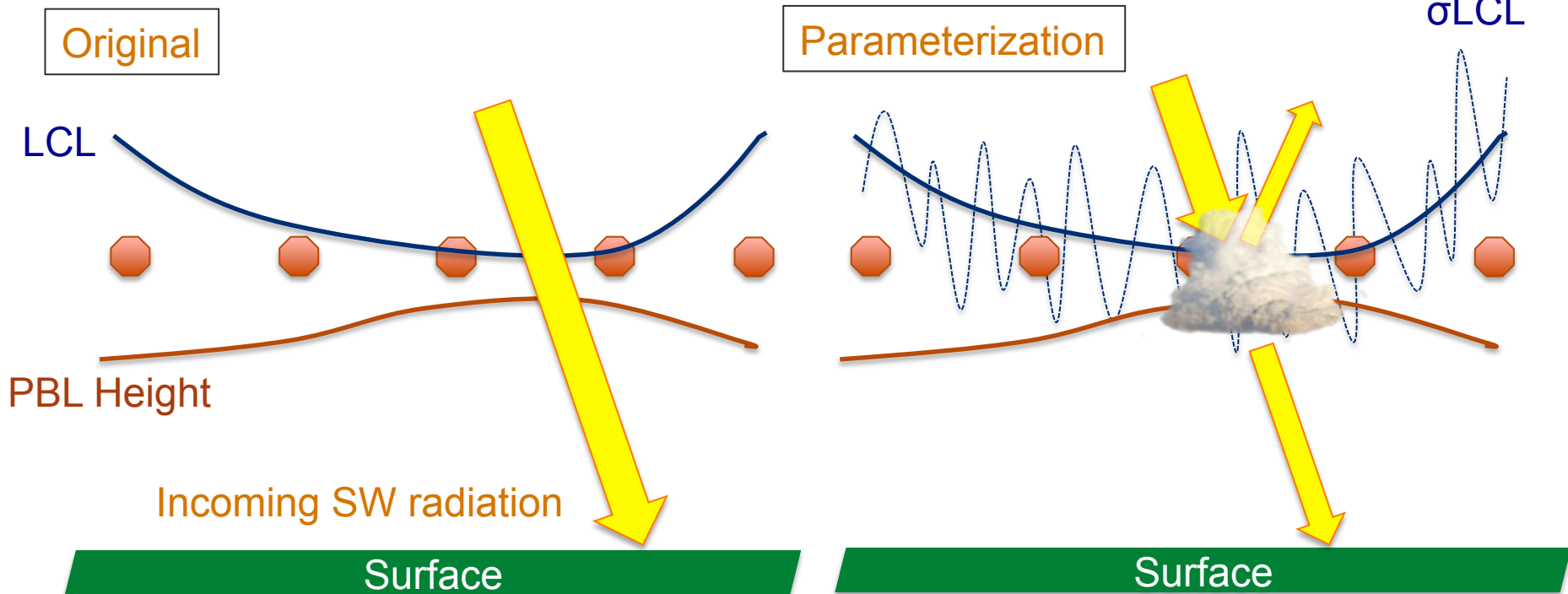


Method follows
Burleyson et al. (2015)
JAMC

- ▶ Shallow Cumulus (ShCu) dominates surface CRE, because of its high frequency of occurrence, consistent with long term TWP results
- ▶ Model lack of ShCu dominates cloud frequency and SW CRE bias

Parameterizing the shortwave radiative effect of unresolved shallow cumulus

Conceptual framework



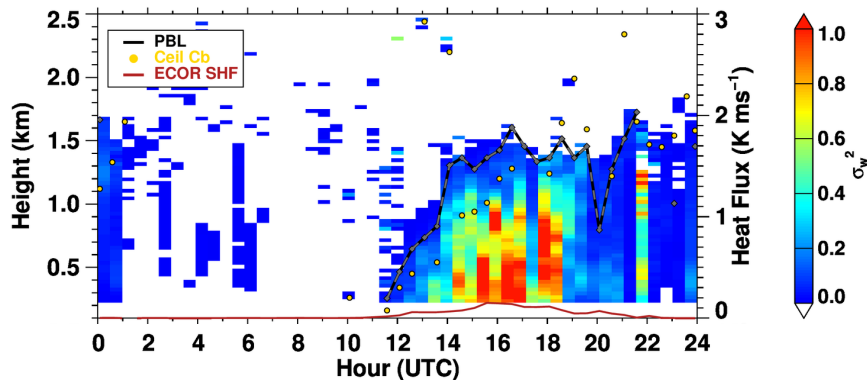
In the parameterization the albedo from shallow clouds is defined as

$$A_{sc} = 0.40 \quad \text{if} \quad LCL - \sigma(LCL) - PBLH < L$$

- ▶ Introduce a spatial variance of LCL: σLCL is calculated using the 25 grid points surrounding the grid point of interest.
- ▶ L is obtained through **iteration** by requiring that the frequency of parameterized shallow clouds match the observation.

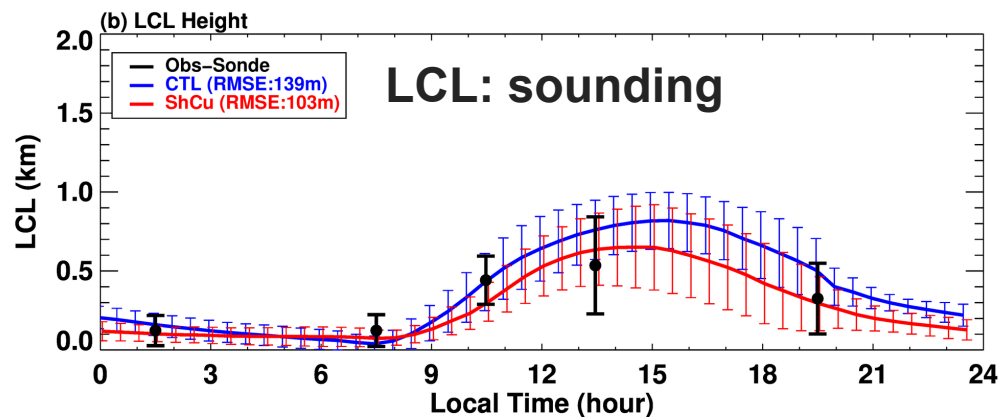
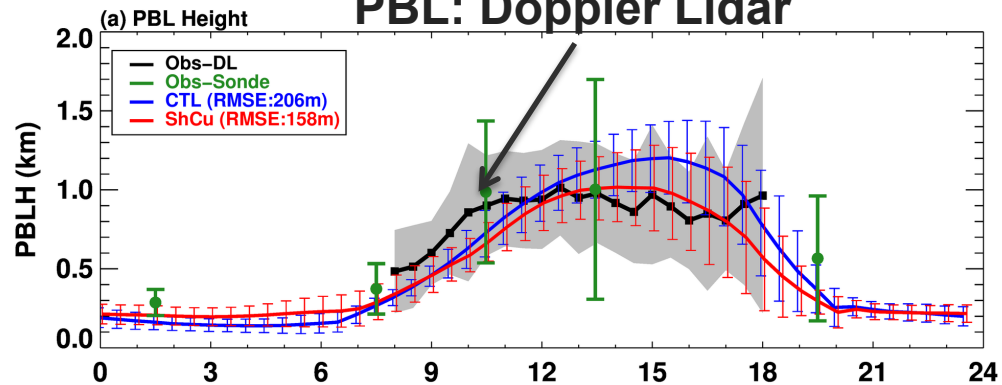
PBL and LCL biases are reduced by ShCu parameterization

Example of DL σ_w derived PBL



- ▶ Doppler Lidar (DL) vertical velocity (w) variance VAP is used to derive PBL, physically consistent with WRF PBL scheme
- ▶ Sounding at 100-200m is used to calculate LCL

PBL: Doppler Lidar



- ▶ ShCu reduces warm and dry bias near surface
- ▶ Lowers PBL and LCL, compares better with observations

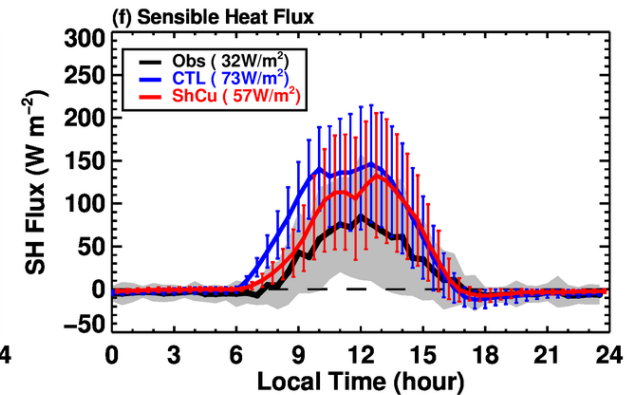
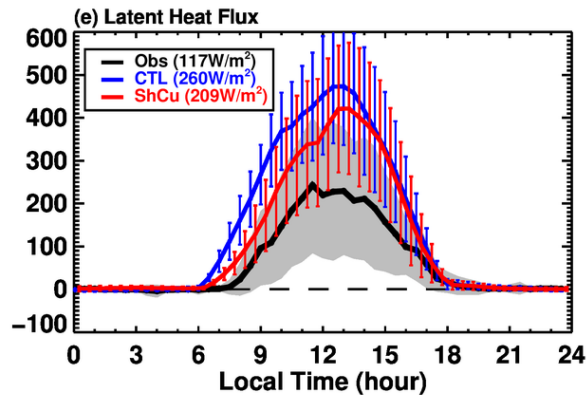
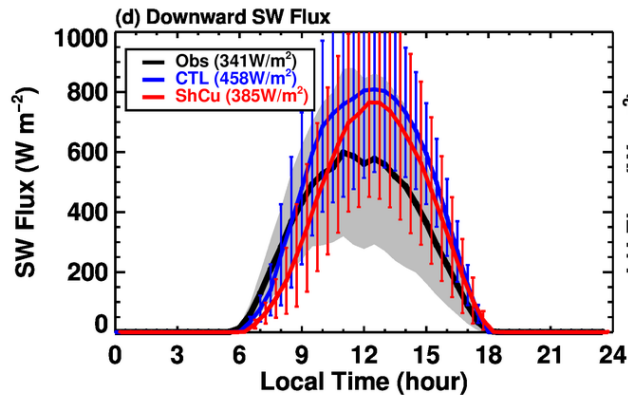


Surface flux biases are reduced

Downward SW Flux (AMF)

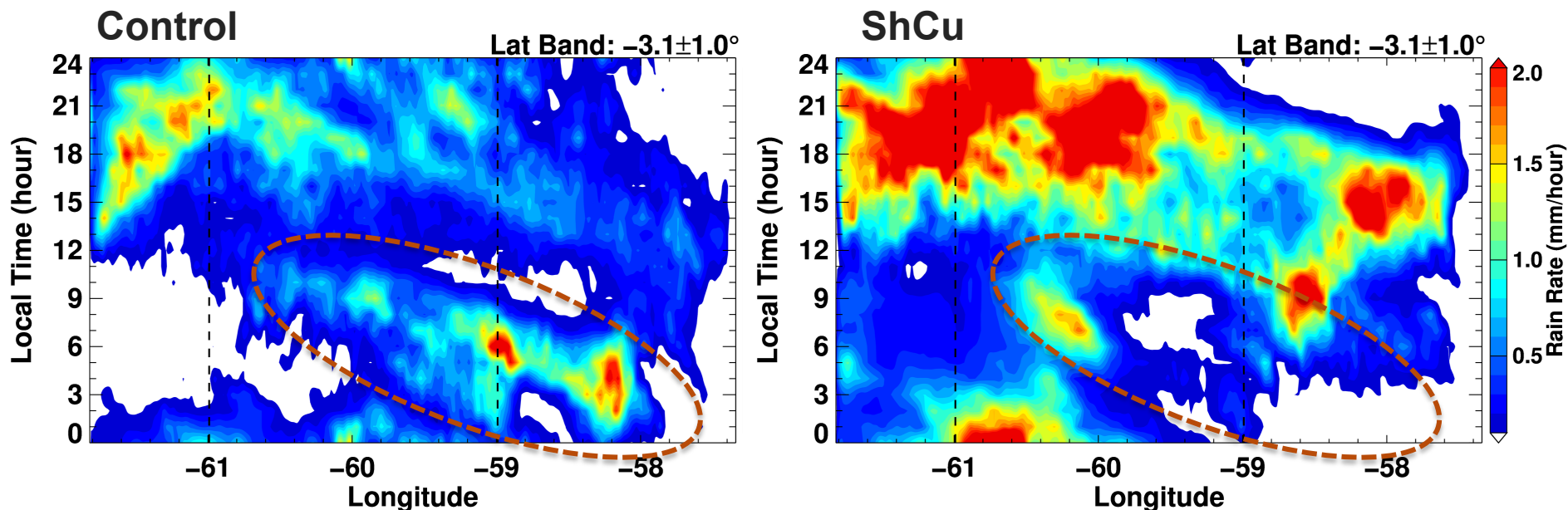
LH Flux (ZF-2)

SH Flux (ZF-2)



- ▶ Surface SW flux is reduced by 16%, although too much reduction in morning, not enough in afternoon
- ▶ LH and SH flux are reduced by 20% and 22%, respectively

Deep convection responses strongly to modified surface energy budget by ShCu



- ▶ Early morning propagating precipitation is suppressed, local afternoon precipitation is enhanced
- ▶ Model domain is too small to fully examine response of propagating deep convection

Summary and Future Work

- ▶ GoAmazon observations are used to develop a shallow cumulus (ShCu) parameterization to address the shortwave radiation bias in cloud-permitting ($\Delta x=1\text{km}$) WRF simulations
- ▶ ShCu radiative effects have large impact on the diurnal timing and intensity of deep convection
- ▶ In the future we will quantify the ShCu impact on organized convection using a larger domain simulation

