Impact of Sub-grid Shallow Cumulus on the Diurnal Cycle of Convection in Convection-Permitting Simulations

ZHE FENG

Contributions: Samson Hagos, Casey Burleyson, Larry Berg, Jerome Fast (PNNL)
Scott Giangrande, Courtney Schumacher, Mariko Oue, Die Wang, Joseph Olson

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Motivation and Objective

▶ GoAmazon 2014/5 observations show that shallow cumulus clouds dominate surface cloud radiative effects for both wet and dry seasons

▶ But shallow clouds are in the **gray zone** and under resolved for km-scale convection-permitting models

▶ **Goal:** examine representation and impact of shallow cumulus clouds on diurnal cycle of the convective cloud populations
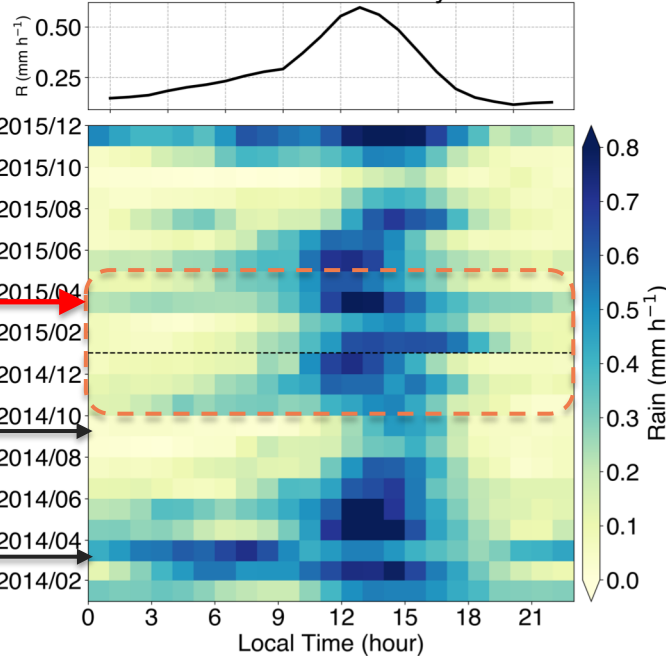
PI Product in submission
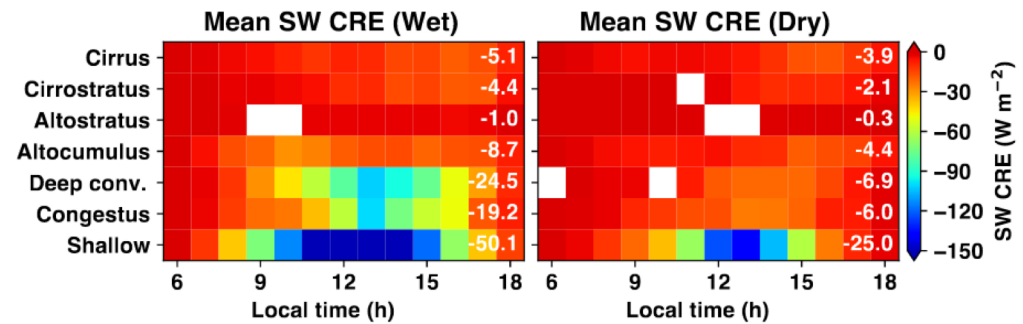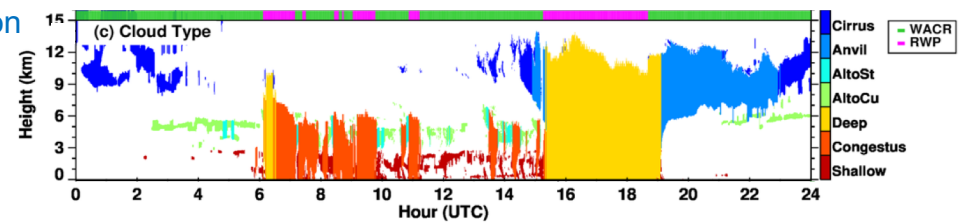
(Giangrande et al. 2017)

10-100 m

Precipitation Diurnal Cycle by Month over Manaus during GoAmazon 2014/5

SIPAM Radar

GPM IMERG
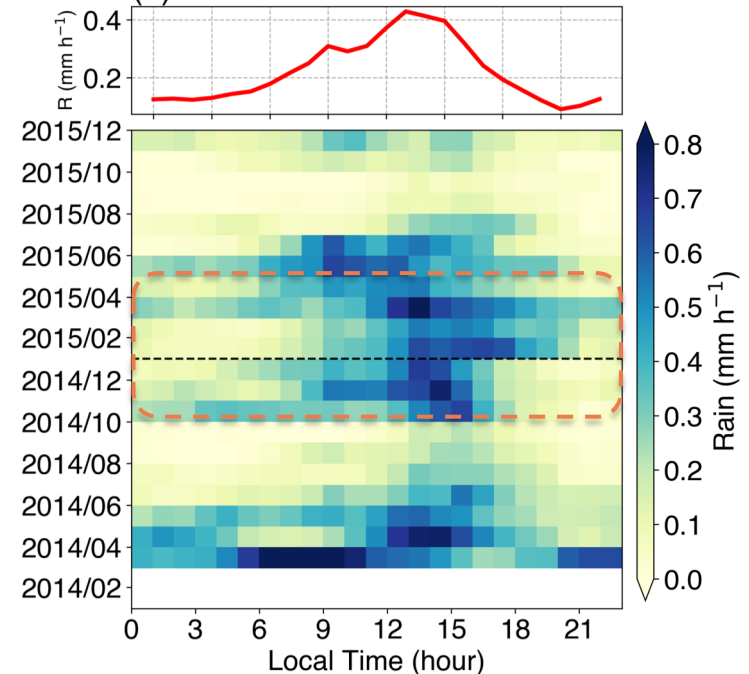
- ▶ Both SIPAM radar and GPM show 2015 wet season have more typical diurnal cycle of precipitation at Manaus than IOP1
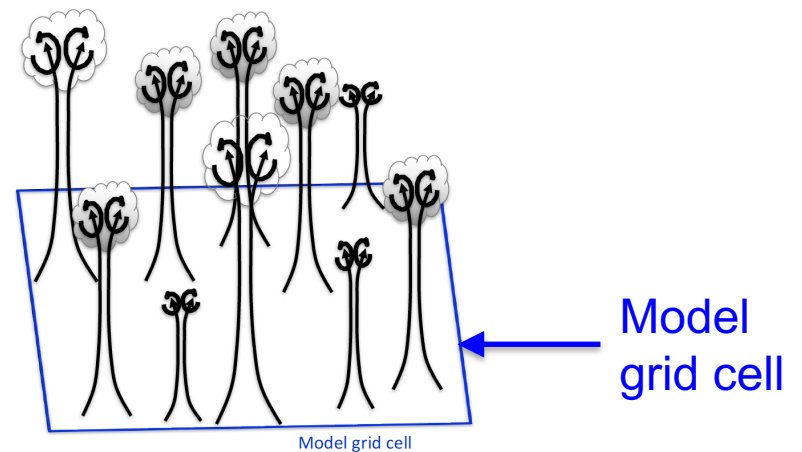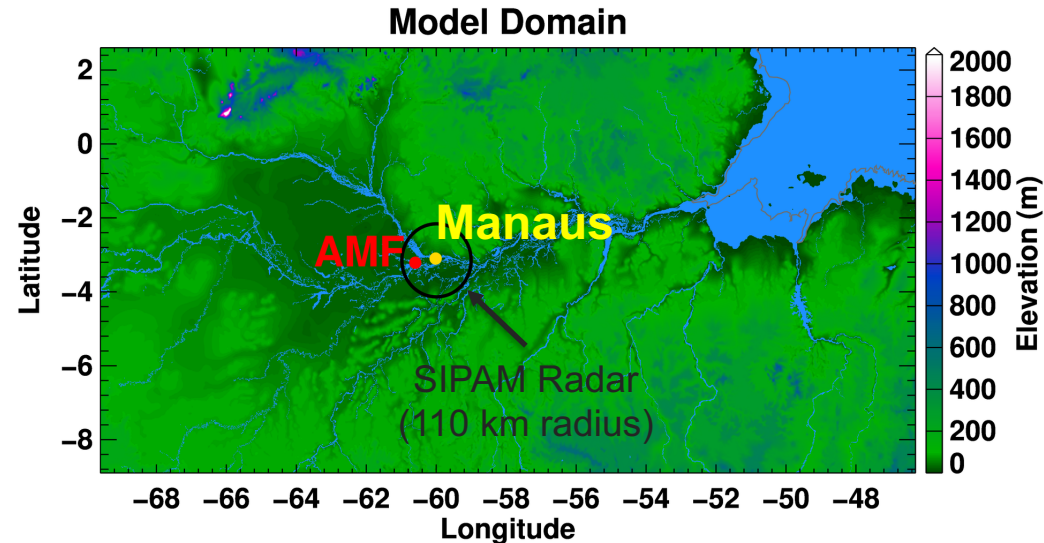- ▶ March 2015 was chosen for the simulation period

WRF Model Setup

▶ Model domain: 2600x1300 km

Resolution	2 km
Period	March, 2015
Surface	MYNN
Land Model	Noah
Microphysics	Thompson
Radiation	RRTMG
Control Run	**MYNN**
ShCu Run	**MYNN-EDMF**

- New scale aware sub-grid mass-flux scheme for km-scale models
- Multi-plume, stochastic entrainment in clouds, momentum transport
- Parameterized ShCu coupled to radiation
- New in WRF V3.9

Model Domain

AMF · Manaus

SIPAM Radar
(110 km radius)
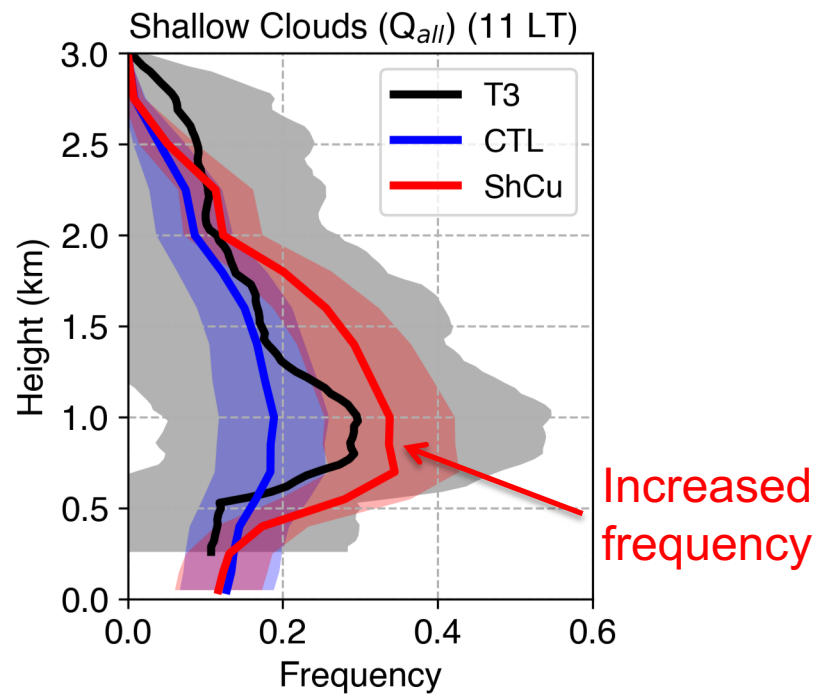

Model grid cell

Eddy-Diffusivity Mass Flux (EDMF)

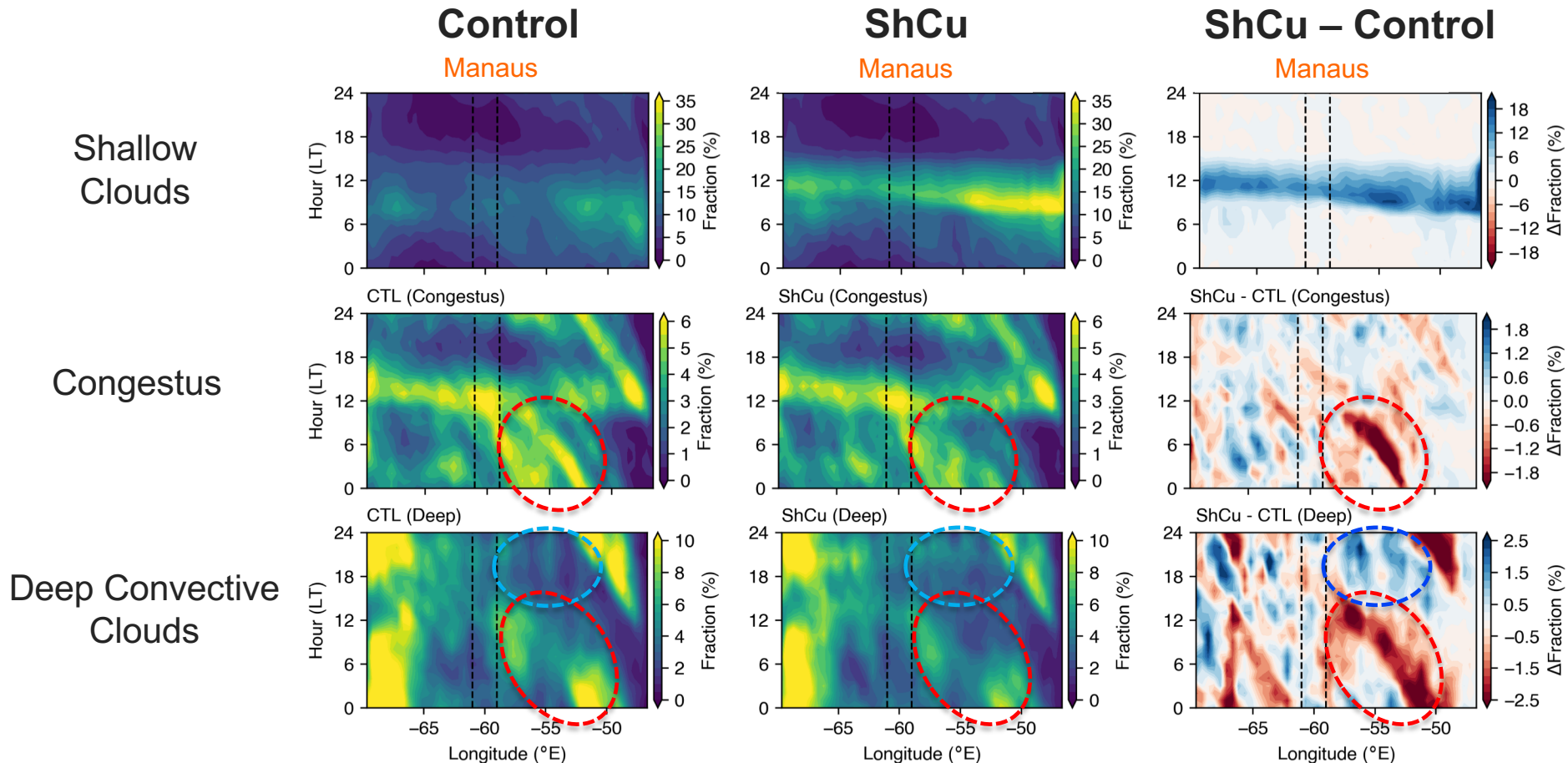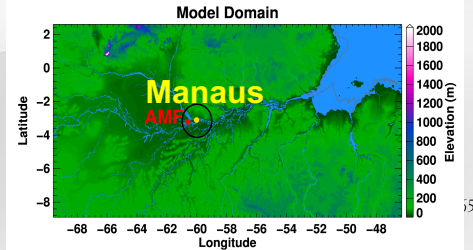# Sub-grid Mass-Flux Increases Shallow Clouds

▶ Sub-grid mass-flux increases PBL vertical velocity variability between morning and early afternoon

▶ Deepens PBL top, increases late morning shallow cloud frequency
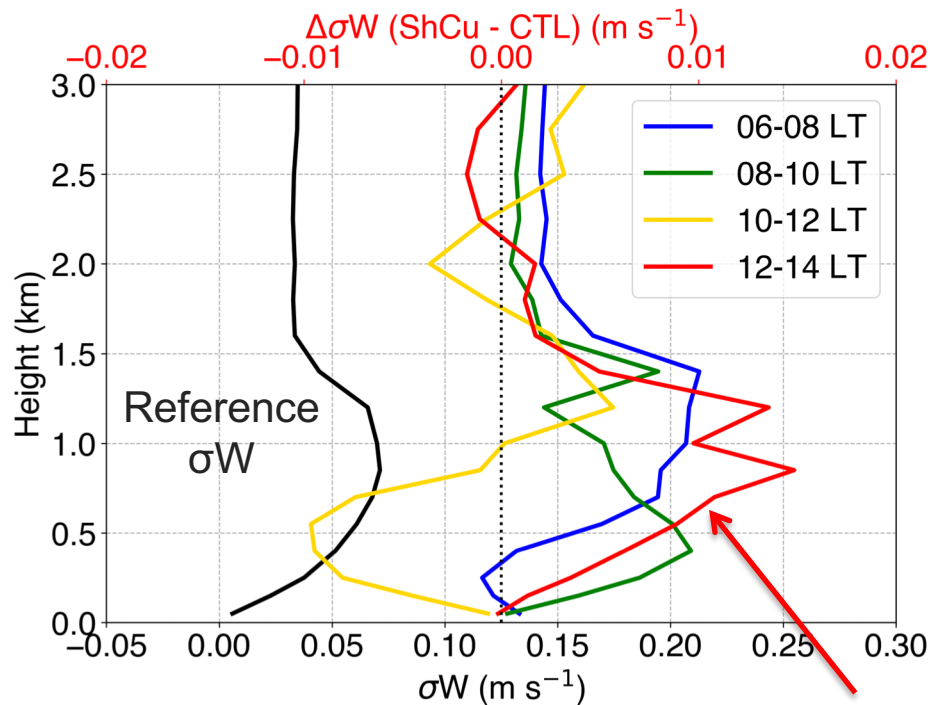
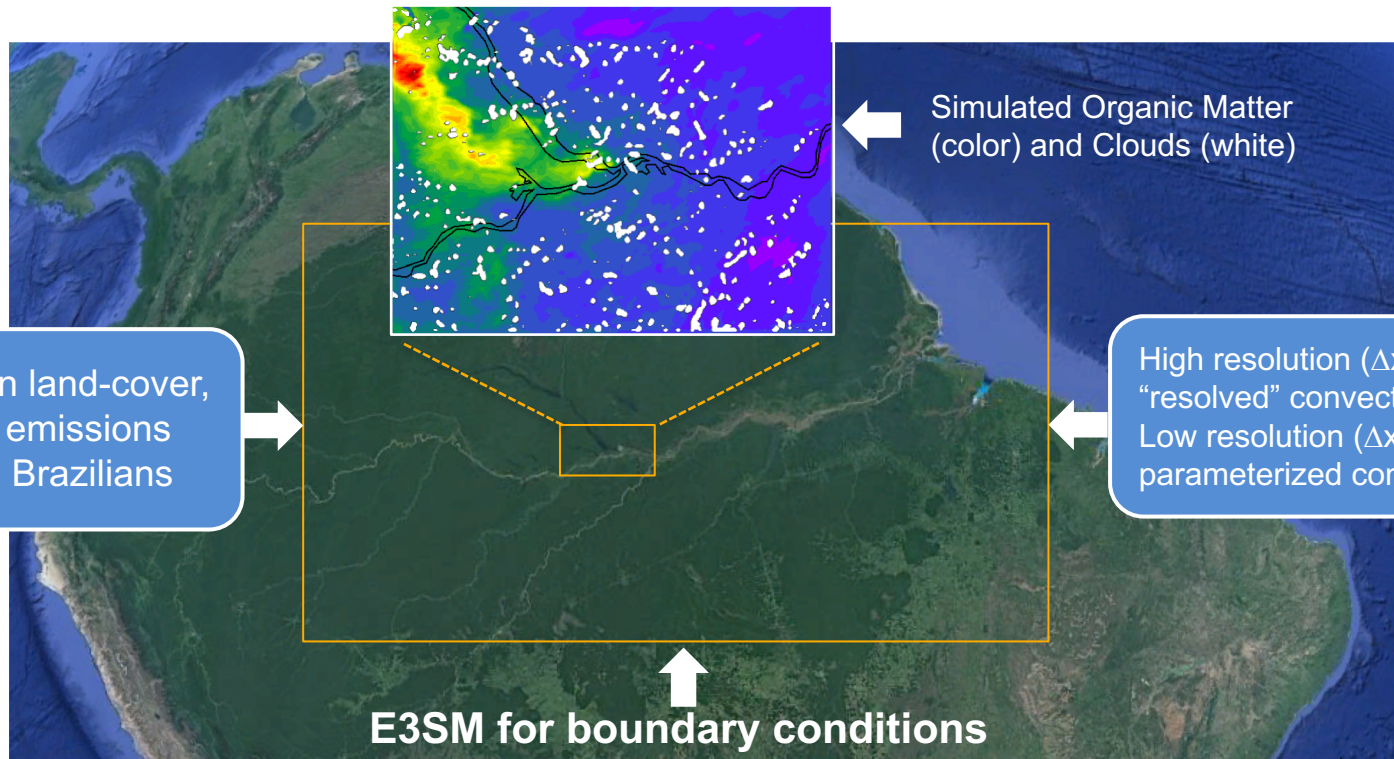# Changes to the Diurnal Cycle of Convective Cloud Populations

► ShCu simulation enhances congestus/deep convective clouds in afternoon east of Manaus, but decreases them in the morning

Summary and Discussions

▶ Understanding the interactions between **large-scale winds** and local **boundary layer processes** are likely key to understanding the diurnal cycle of convection in the Amazon

▶ GoAmazon local observations should be supplemented with **additional measurements up/down wind** to help constrain regional model simulations

▶ Future work will examine sub-grid mass-flux impact on evolution of **convective cloud population transitions**

  ■ Does deeper PBL and more dense shallow clouds lead to delay of transitioning to congestus/deep convections and precipitation?

  ■ What are the mechanisms for reduction of nocturnal convection?

  ■ Impact of Kelvin waves to diurnal cycle (collaboration with Yolande Serra and Angela Rowe)

PNNL Activities: *Common Modeling Framework for LACI, Convective Clouds, and Aerosols*

Simulated Organic Matter (color) and Clouds (white)

high resolution land-cover, soil moisture, emissions datasets from Brazilians

High resolution (Δx = ~2 km) for "resolved" convection
Low resolution (Δx = 10 km) for parameterized convection

E3SM for boundary conditions

Land-Surface
Compare CLM with other treatments and explore how different versions of MEGAN affect BVOCs

Secondary Organic Aerosol
Evaluate VBS approach with updates to biogenic and aqueous chemistry

Cloud-Aerosol Interactions
Examine effect of UAP for all stages of convection and for more cases

Convection
Evaluate how well STOMP and KF-CuP represents the observed cloud populations

Microphysics
Explore sensitivity to new schemes such as P3 and aerosol-aware Thompson

Laboratory Studies