A tale of two days in the Amazon

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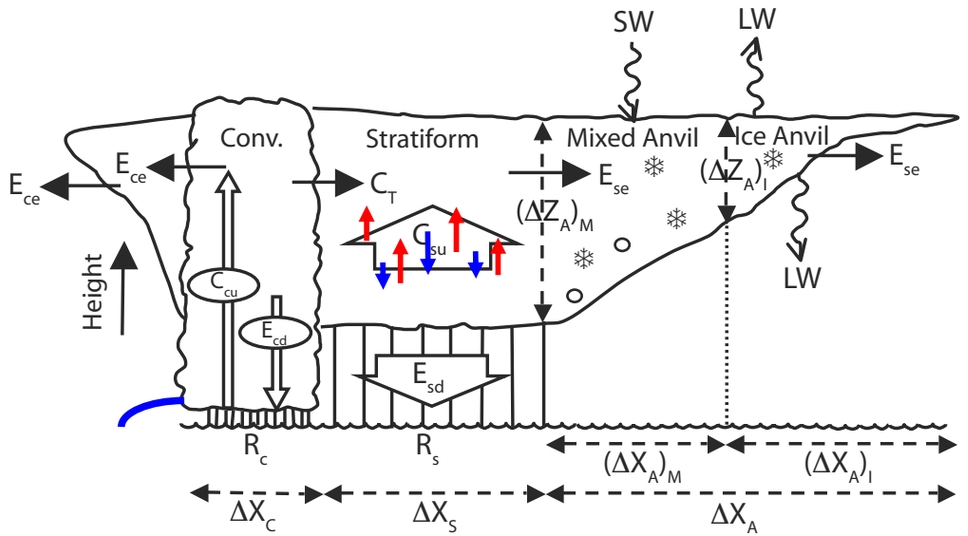
But first, an aside on some things that matter to mesoscale convective organization

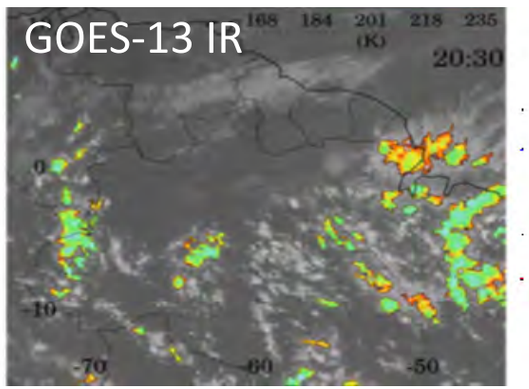
Convective initiation and maintenance	Stratiform rain and anvil production
Warm, moist boundary layer	Mid and upper level moisture
Low-level shear	Mid- and upper level shear/hydrometeor advection
Downdraft/cold pools	Gravity waves
Synoptic and mesoscale boundaries	Radiative feedbacks



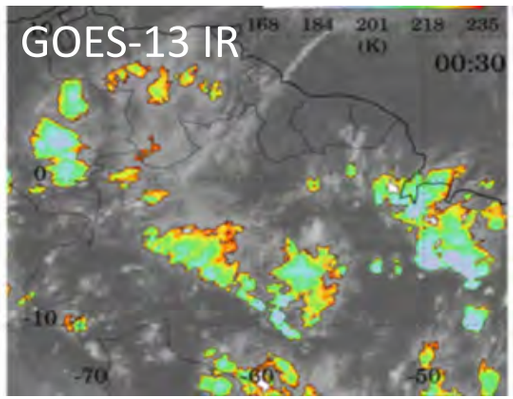
Houze et al. (1980), Frederick and Schumacher (2008)

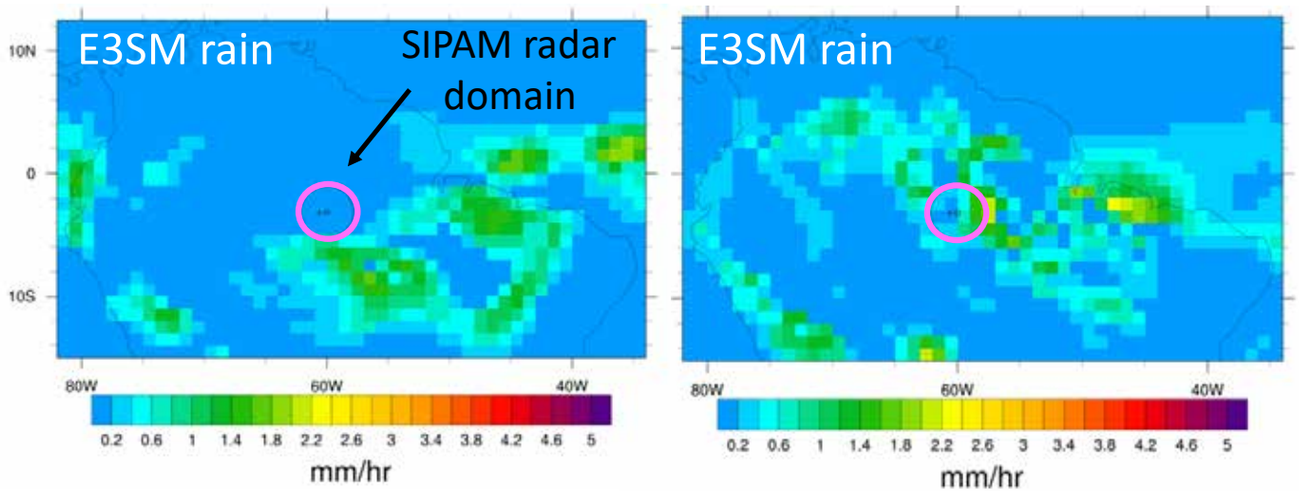
Introducing the two days

11 April 2014 (20 Z)



2 April 2014 (0 Z)





- GoAmazon2014/5 took place over the central Amazon from 2014-2015
- April 2nd was much more convectively active than April 11th
- A 1° E3SM simulation was run with horizontal winds nudged toward MERRA2
- Note: a 1° grid box may contain all convective, all stratiform, or a mix of both rain types
- Models output single grid values of:

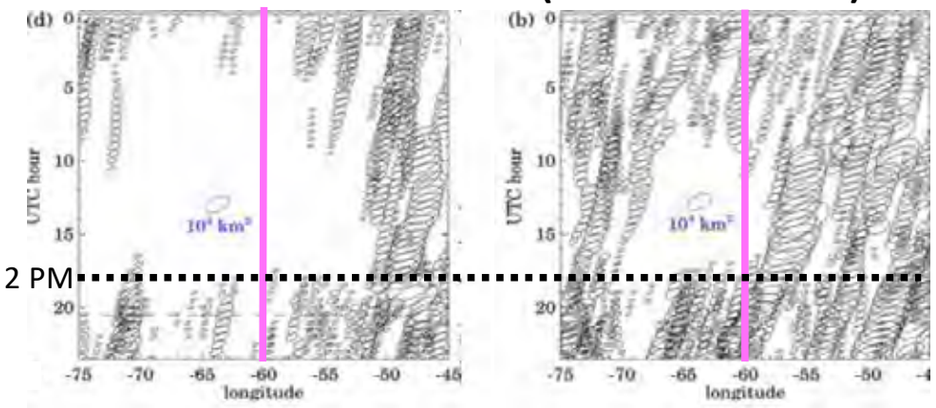
-Convective rain rate (from convective param)
-Convective cloud cover (from convective param)
-Large-scale rain rate (from microphysics)
-Total cloud cover (from microphysics)
-T tendency

Are GCM model physics and these variables sufficient to describe MCSs and their interactions with the large-scale circulation (including diurnally forced flow, convectively coupled waves, and the MJO)?

Diurnal cycle

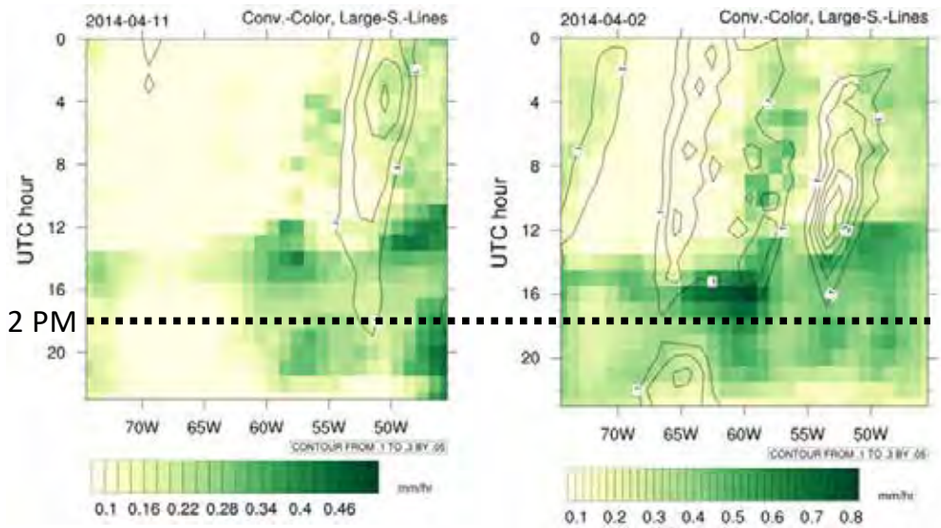
11 April 2 April

GOES-13 IR clusters (from E. Anselmo)



- Very little convection overnight on 4/11 (Amazon LT is UTC-4)
- Clusters are larger, last longer on 4/2

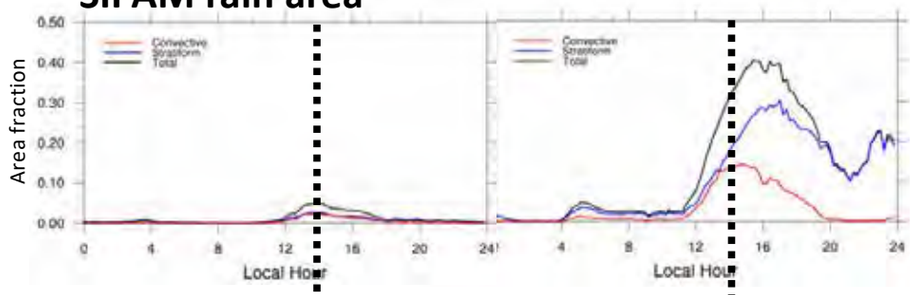
E3SM rain



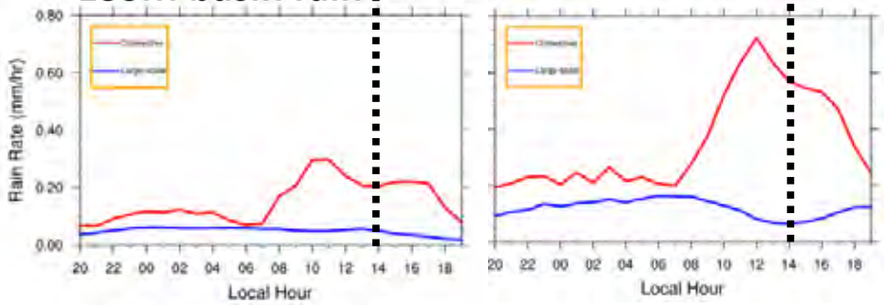
- E3SM convective rain (shading) shows westward propagation at similar longitudes in morning and enhanced rain at midday, although it arrives early and is overly strong
- E3SM large-scale rain (contours) disconnected from convective rain

11 April 2 April

SIPAM rain area



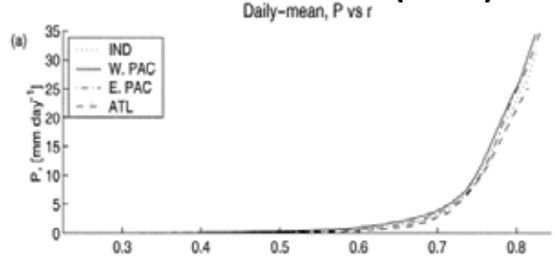
E3SM basin rain



- E3SM convective rain peaks early on both days and large-scale rain shows no notable diurnal cycle, unlike stratiform rain from radar
- Both days have same mean large-scale rain fraction (23%) across the basin despite very different convective activity

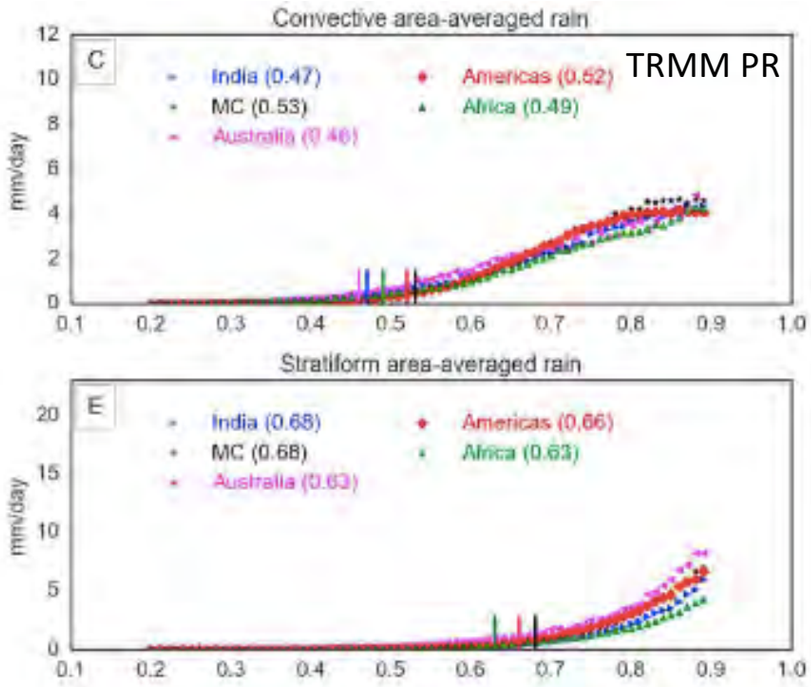
Precipitation-moisture relationships

Bretherton et al. (2004)

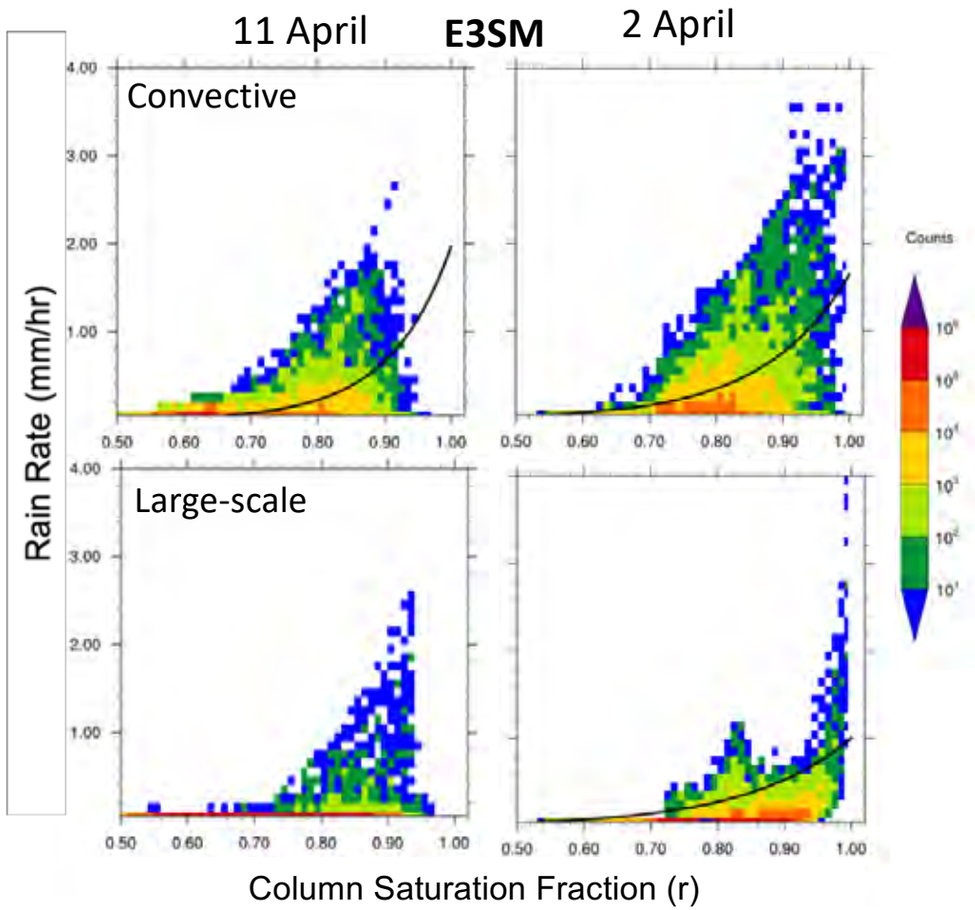


- Daily <u>total</u> rainfall over ocean picks up rapidly after column saturation fraction (r) > 0.7

Ahmed and Schumacher (2017)



- <u>Convective</u> rain over land picks up in a more linear fashion after r > 0.5 (up to 5 mm/day)
- <u>Stratiform</u> rain over land picks up more quickly after r > 0.65 (up to 5-8 mm/day)

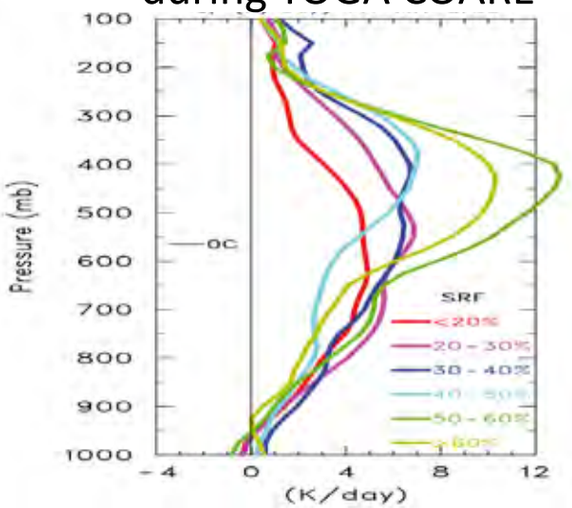


- Convective rain from E3SM shows stronger rain pick-up at r > 0.65 over Amazon (similar to stratiform rain observations)
- Large-scale rain less sensitive to column moisture and produces less intense rain rates

Heating profiles

Being redone with GoAmazon VARANAL and SIPAM radar data

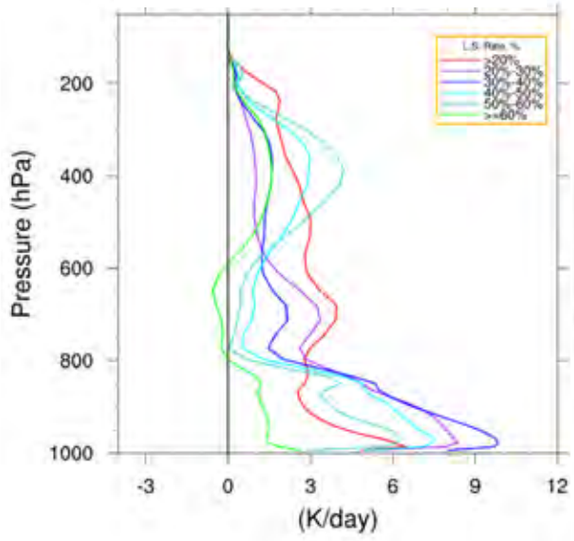
Sounding Q_1 and MIT radar stratiform rain fraction during TOGA COARE



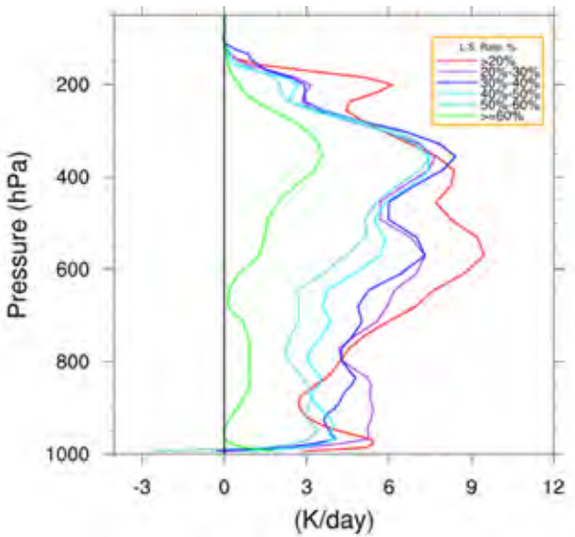
Johnson et al. (2016)

E3SM T tendency and large-scale rain fraction

11 April 2014



2 April 2014



- Johnson et al. (2016) showed that heating increases in magnitude and becomes more top heavy as stratiform rain fraction increases, consistent with many other observational studies
- E3SM shows the opposite trend in heating profiles composited by large-scale rain fraction over the Amazon, esp. on the more convectively active day

Conclusions

- In E3SM, large-scale rain accounts for almost a quarter of the total rain BUT is disconnected from convective rain production, shows very little diurnal cycle over the Amazon, does not strongly contribute to large rain events, and isn't very sensitive to column humidity (opposite of radar-observed stratiform rain)
- Impacts associated with mesoscale organized convection and stratiform rain production (e.g., evening/early morning peak in rain, rapid rainfall onset at high column humidity, and elevated heating profile) mostly come from the E3SM convective parameterization
- Thus, stratiform rain from radar and large-scale rain from GCMs are not the same thing! However, it is important to still separate observations and models by these classifications for assessment because their physical processes and model formulations are different.
- More generally, what physical processes associated with mesoscale organized convection are most important in producing their impacts and which part of the model should they apply to?
- ARM efforts related to convection (CACTI, LASSO-DC, TRACER, AMF3, ARM-DIAGS) should maintain formal paths for MCS analysis (case studies, regime identification, convective-stratiform metrics, etc.)