

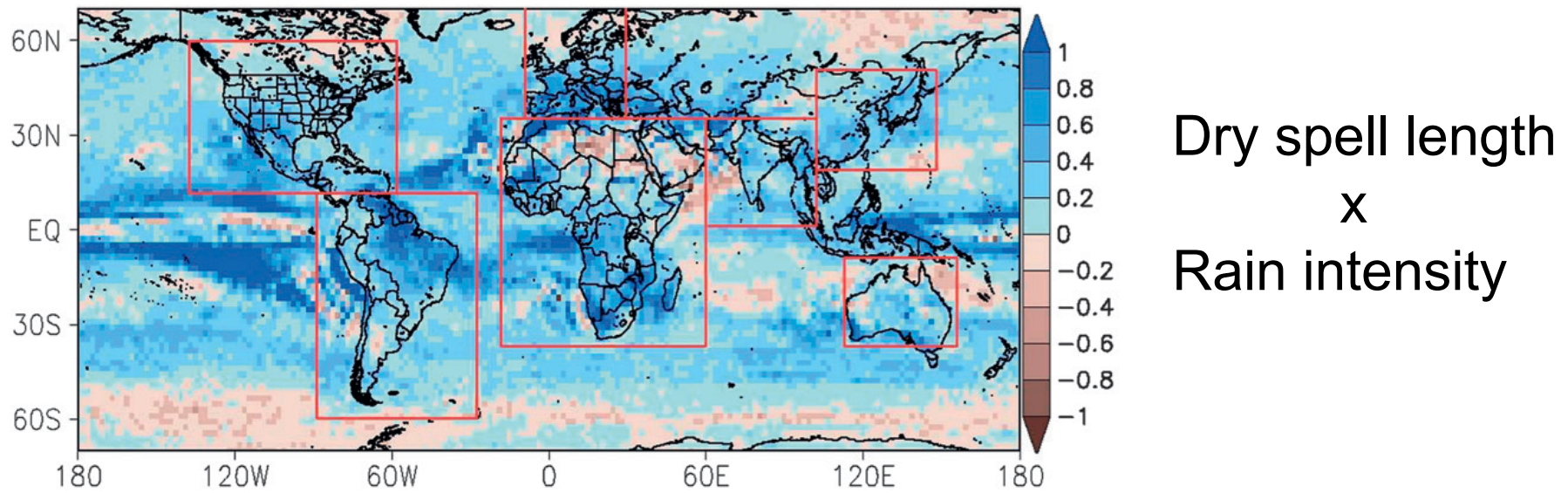
precipitation frequency & intensity in instantaneous and aggregated data

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Context: Increased dry counts and rainfall intensity are taken together as indication of an enhanced hydrologic cycle in simulation of global warming.



Is there a relationship between intensity and frequency?

Is it valid across time scales? Across places?

Outline

Intensity & frequency of rainfall from instantaneous and aggregated (daily) data.

Tropics-wide observations of frequency and intensity

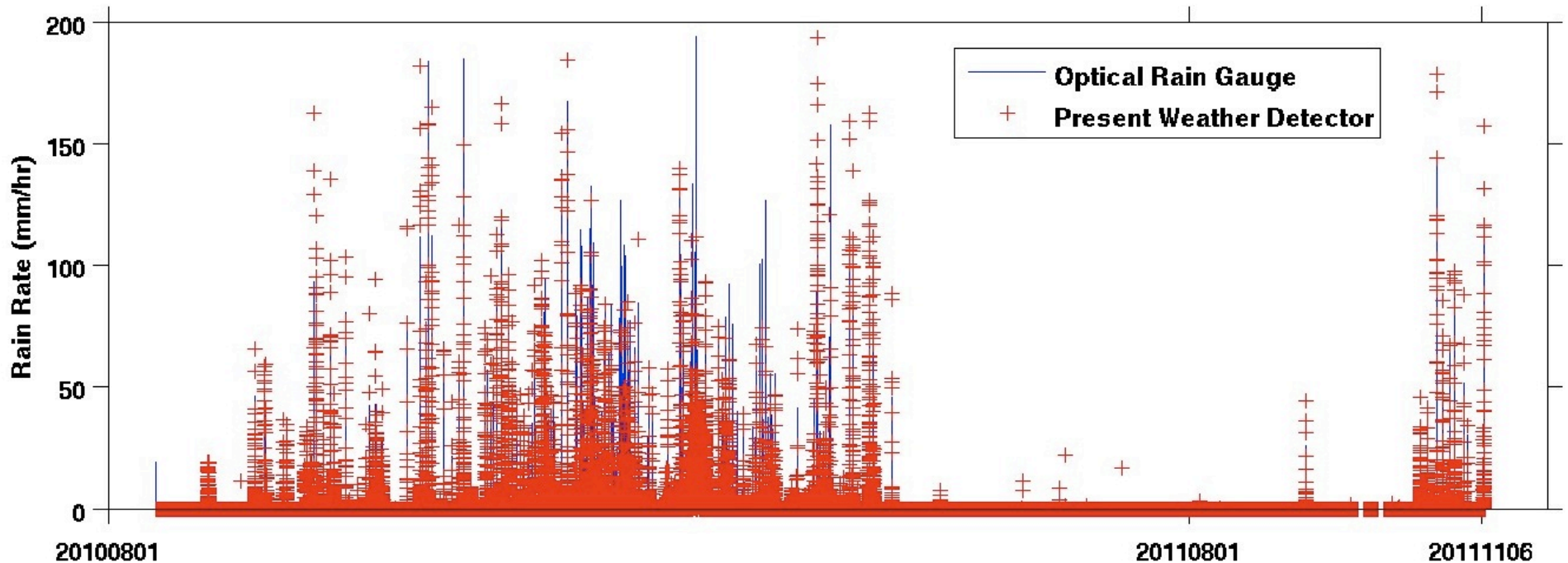
- Instantaneous (TRMM PR data)
- Daily (TRMM 3B42)

Seasonal changes in frequency and intensity:

- Monsoon regions
- Equatorial land regions
- Ocean

Implications (and a suggestion for model diagnostics)

Minute-by-minute precipitation in Darwin, Australia (ARM data)

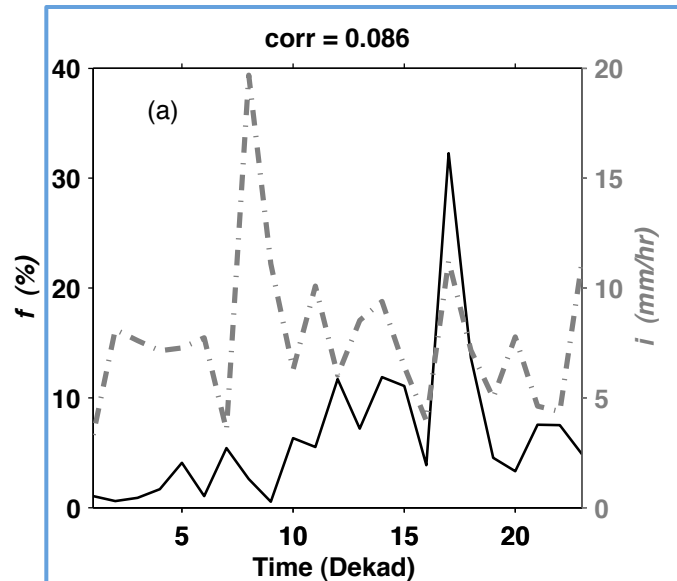


Rainy = a datapoint with rain rates larger than 0.4 mm/hr

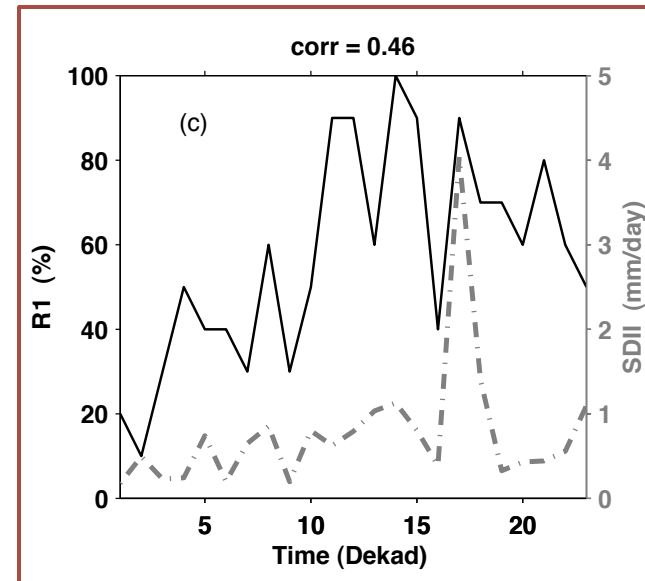
Rain Frequency = Rainy datapoints / Total datapoints

(Conditional) Rain Intensity = average rain rates during rain episodes (excluding dry datapoints)₄

Dekadal frequency and intensity in Darwin from “instantaneous” and daily-aggregated gauge data:



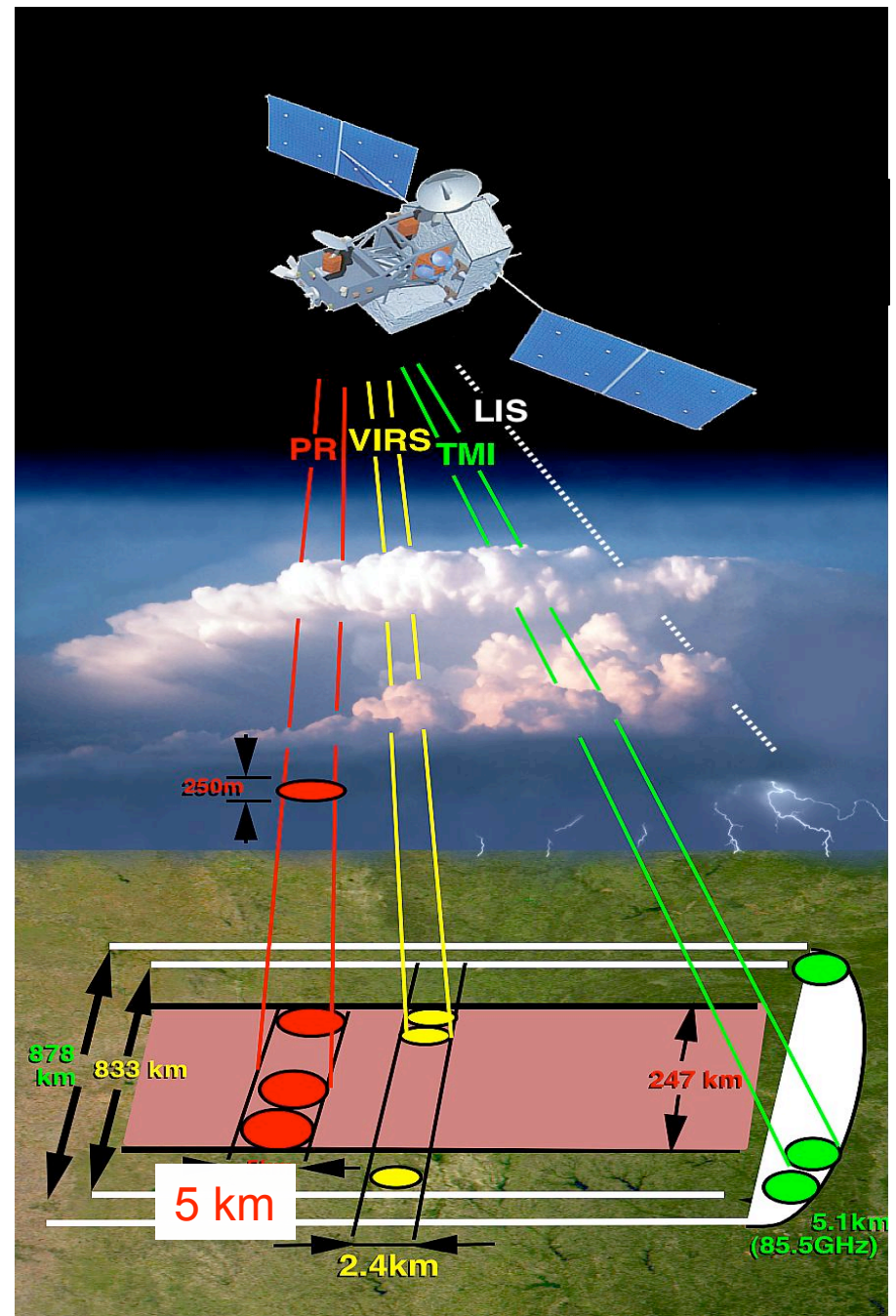
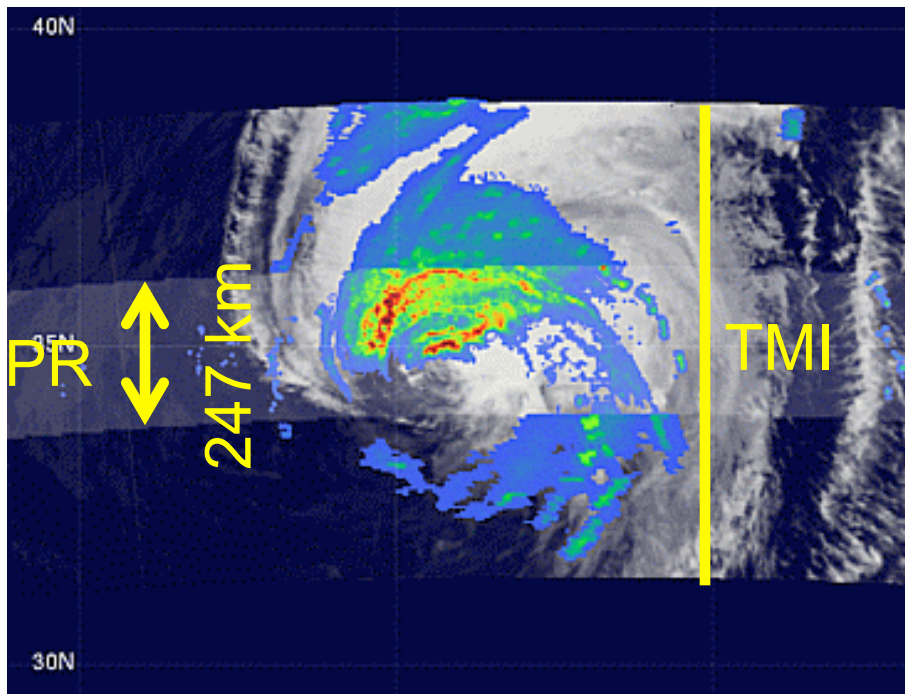
Rainy = 0.4+ mm/hr

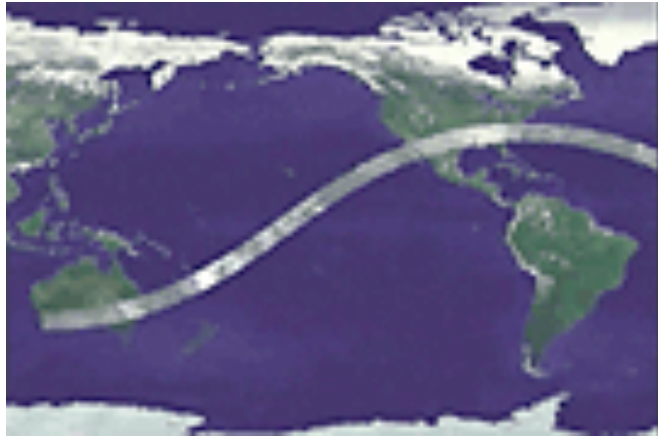


Rainy = 1+ mm

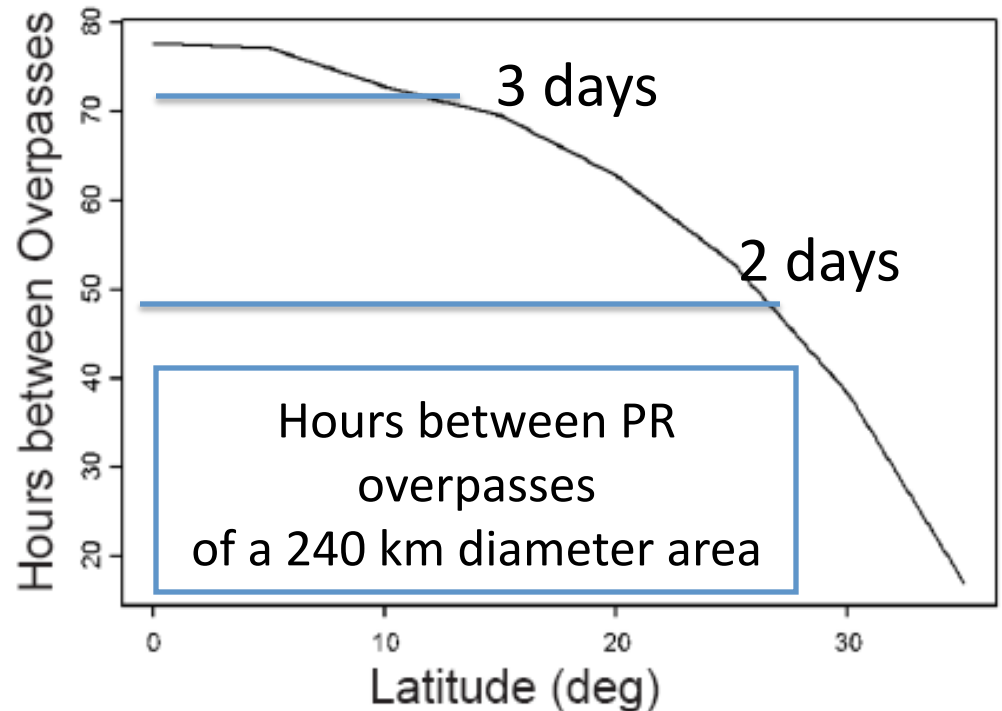
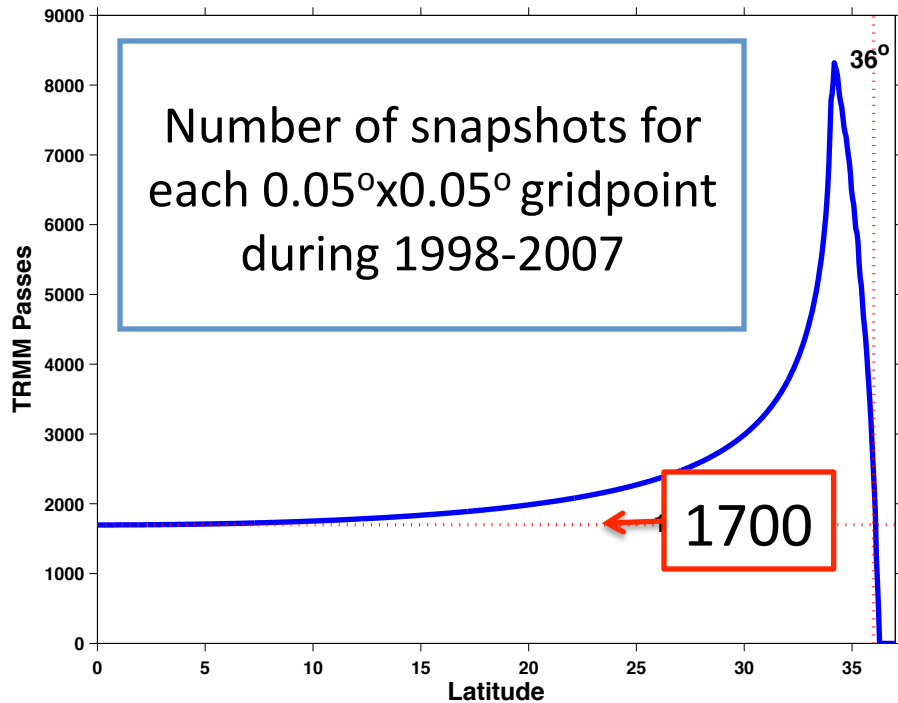
(conditional) intensity = intensity of rainy timesteps
(minutes or days)

TRMM Precipitation Radar
 narrow swath, 5km x 5km res.
 coverage gaps in time
TRMM 3B42
 microwave + IR + gauge
 large swath, 0.25° x 0.25° res.
 3-hourly coverage



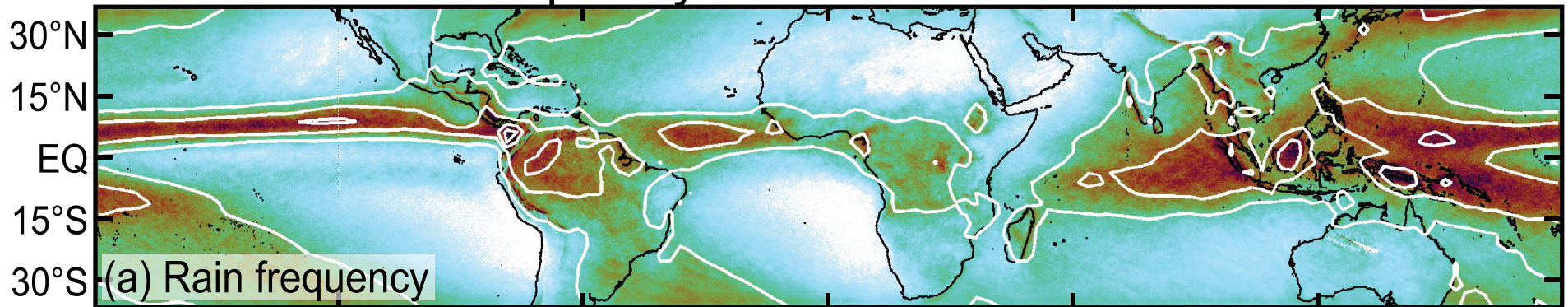


TRMM orbit has a nadir of 35° ; about 16 orbits a day, with a recurrence time of 46 days (good diurnal coverage at low-latitudes).

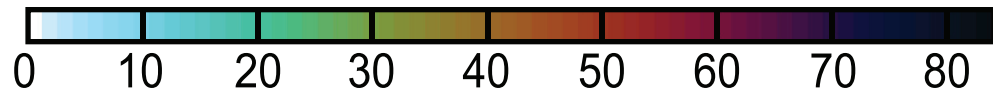
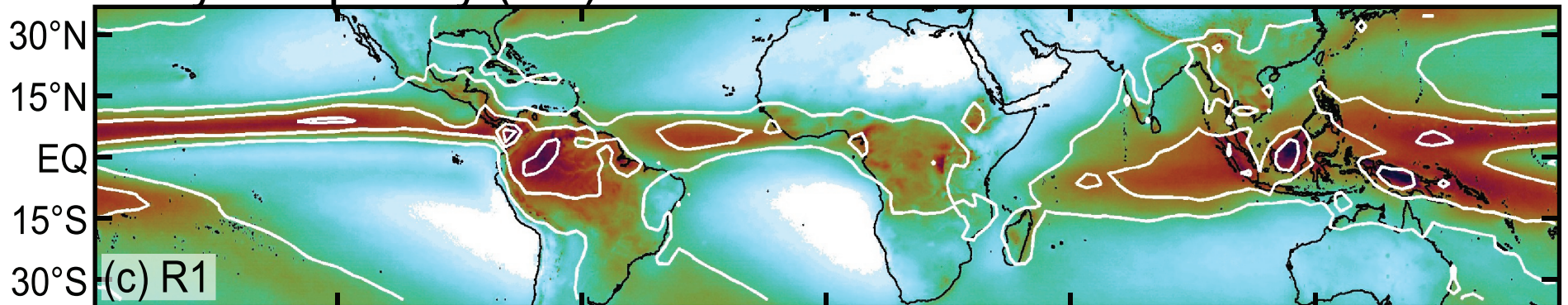


Rain rates closely resemble rain frequency for both levels of aggregation: high rain frequency over oceans.

Instantaneous Frequency

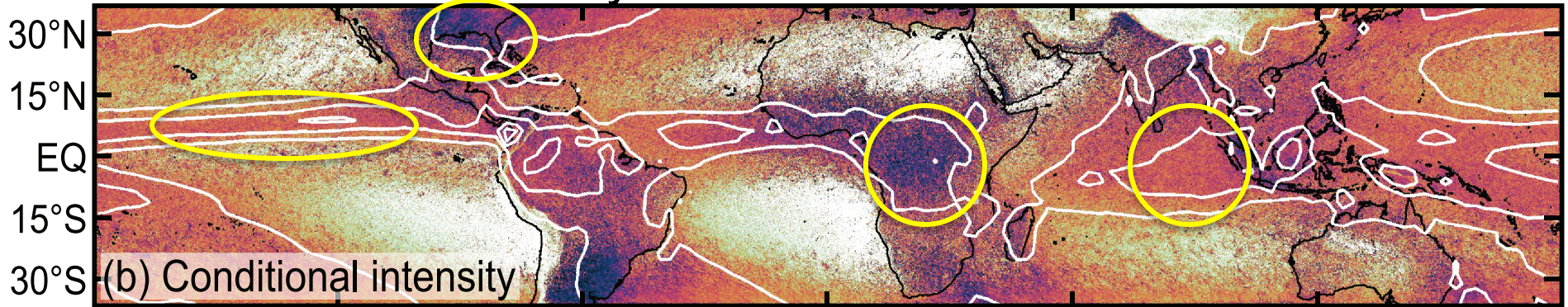


Daily Frequency (R1)

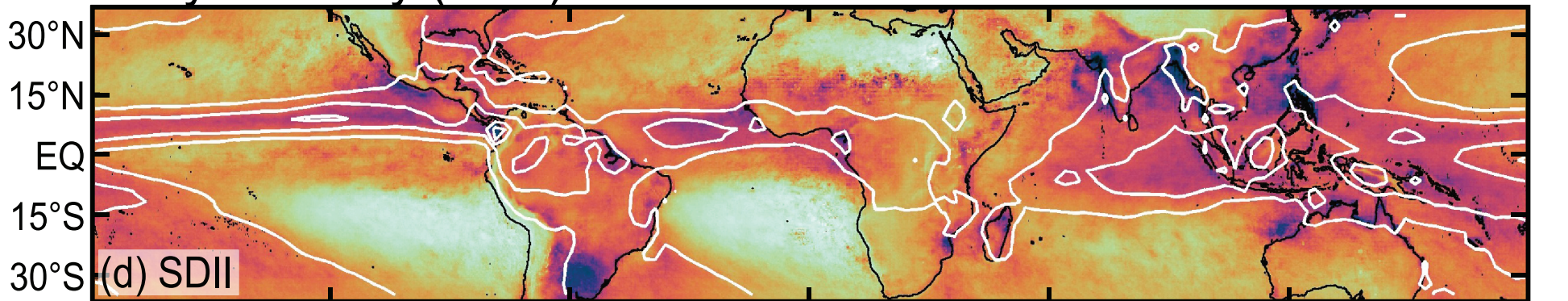


Spot the difference:

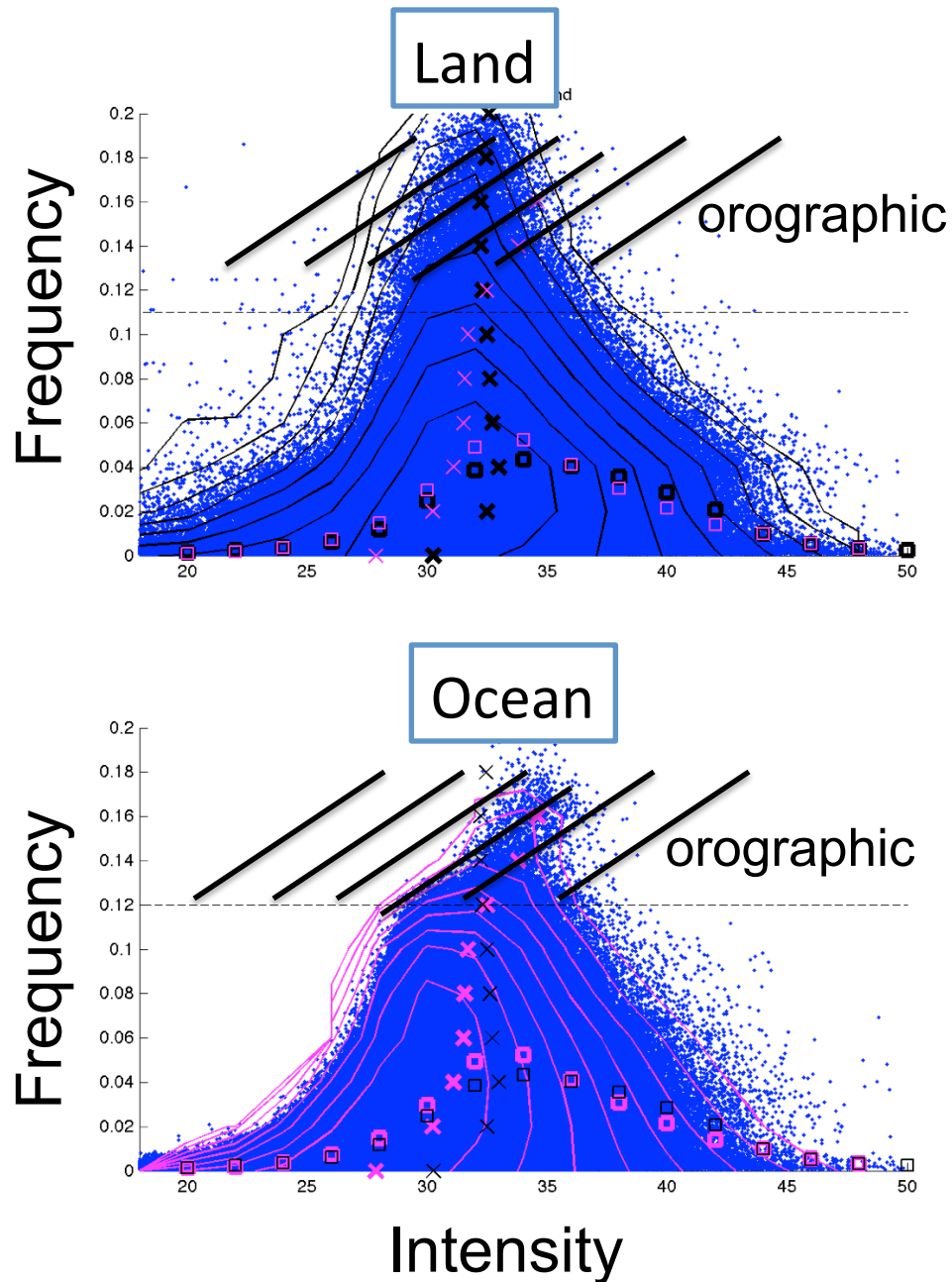
Instantaneous Intensity



Daily Intensity (SDII)



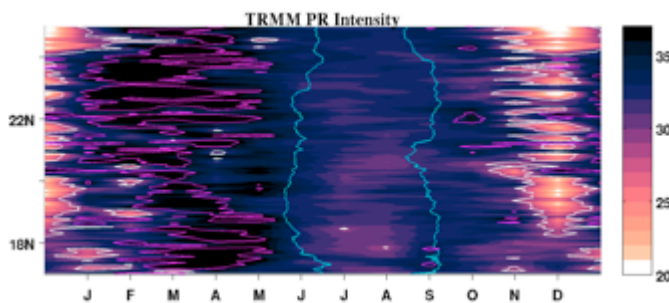
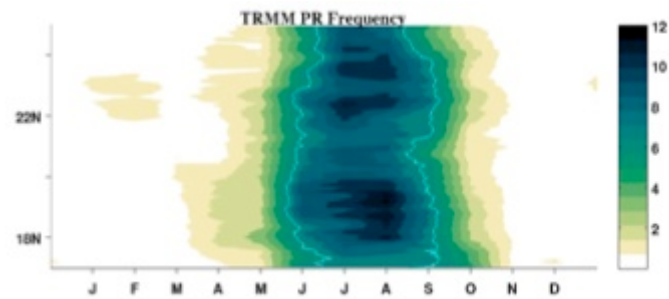
Joint PDF of mean frequency and mean intensity



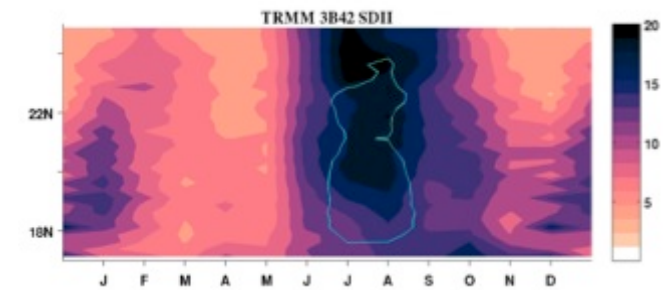
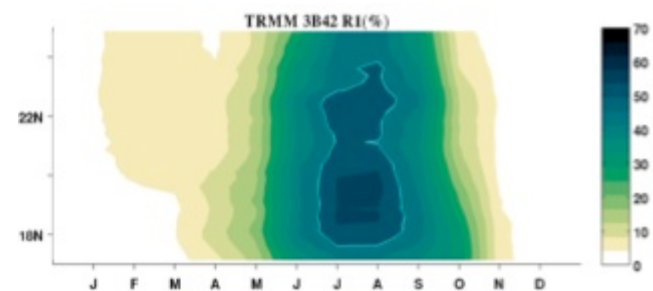
Tropical land regions on average experience more intense and less frequent rainfall than oceanic regions --- but there is no universal trade-off between intensity and frequency.

Seasonal changes in frequency and intensity over Central India (16N-26N; 78E-83E)

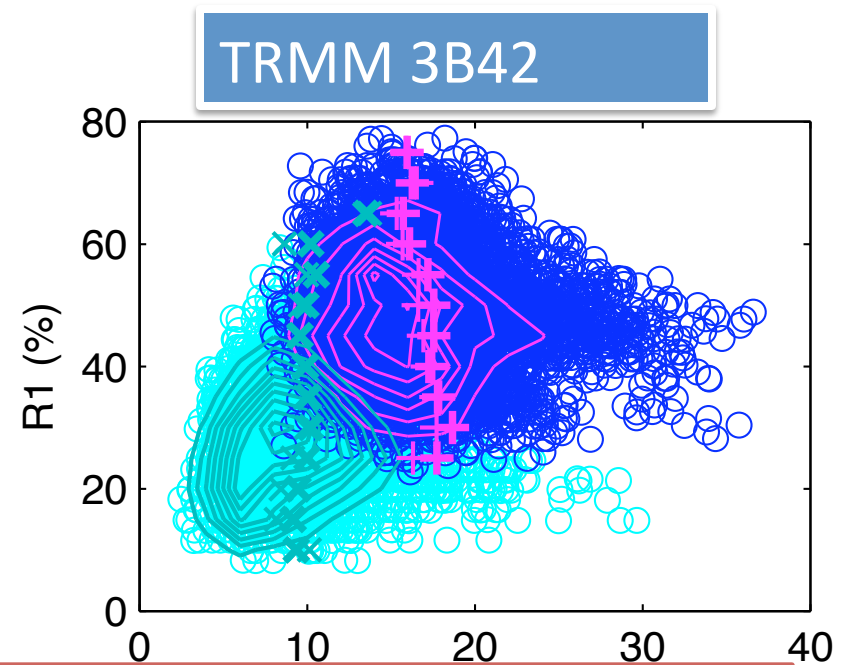
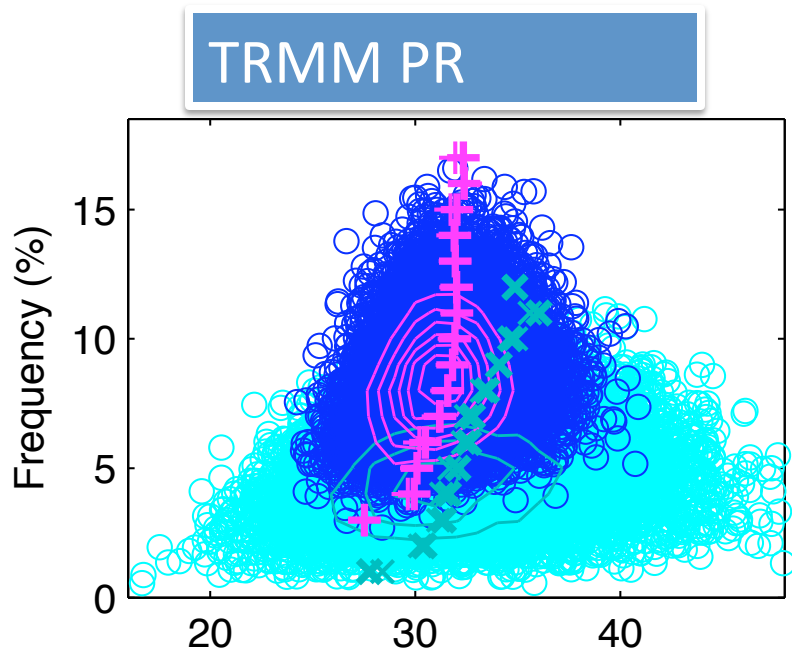
TRMM PR



TRMM 3B42

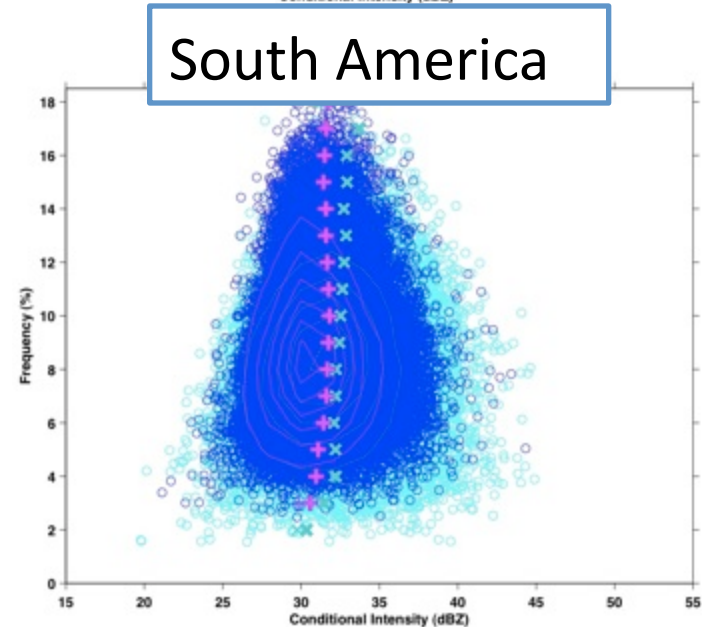
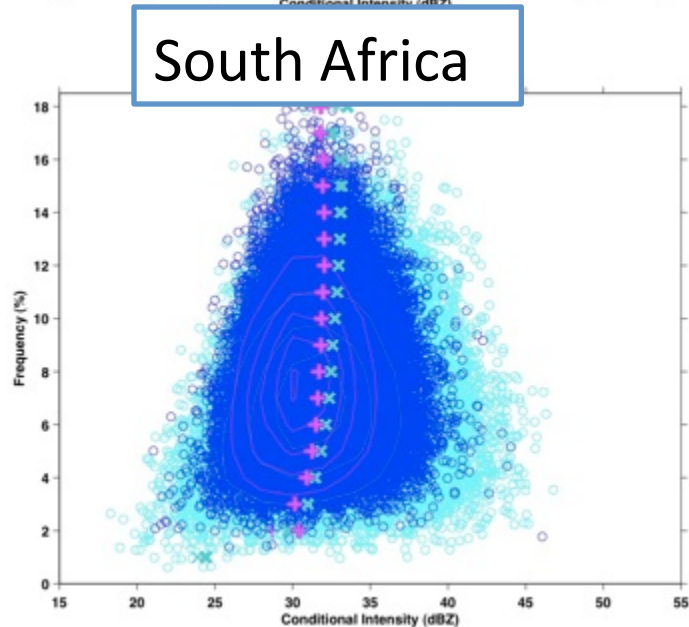
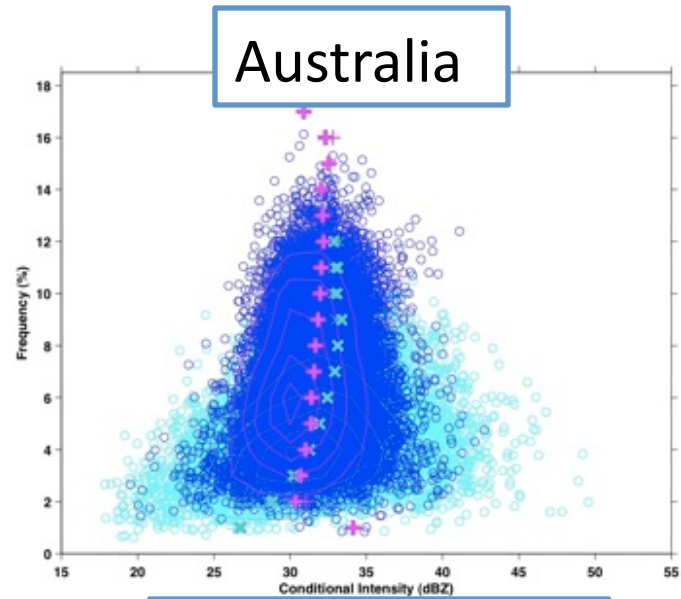
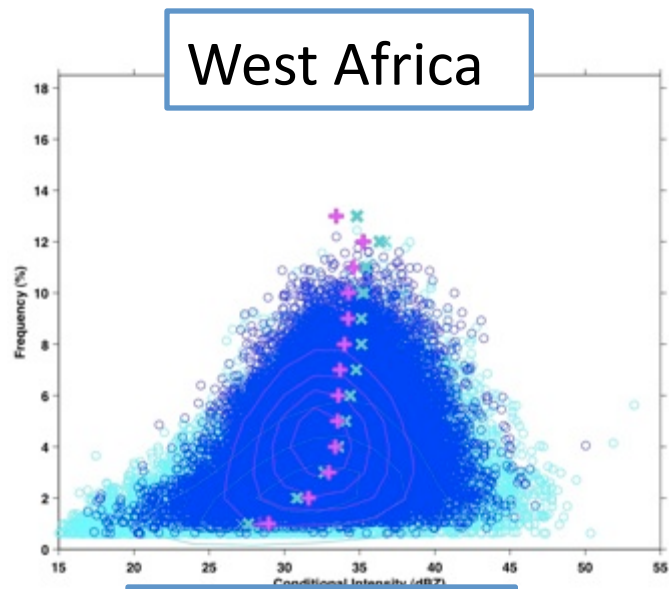


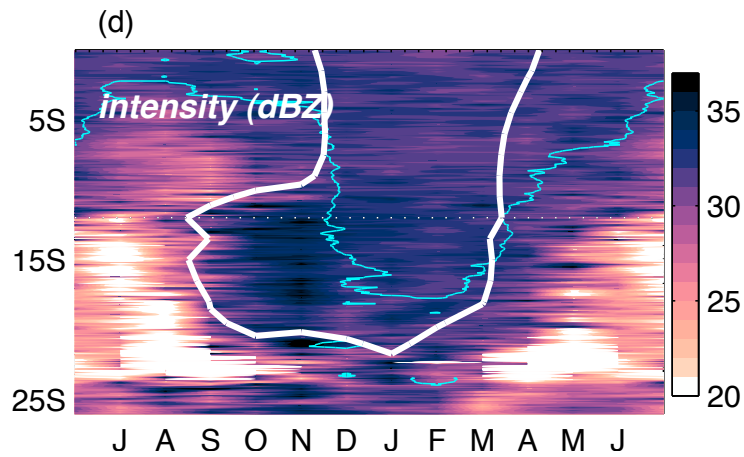
Joint distribution of frequency and intensity from instantaneous and daily data over central India: pre-onset and monsoon seasons.



There is no universal trade-off between intensity and frequency, but there is a clear difference in the seasonal evolution of the two over land regions

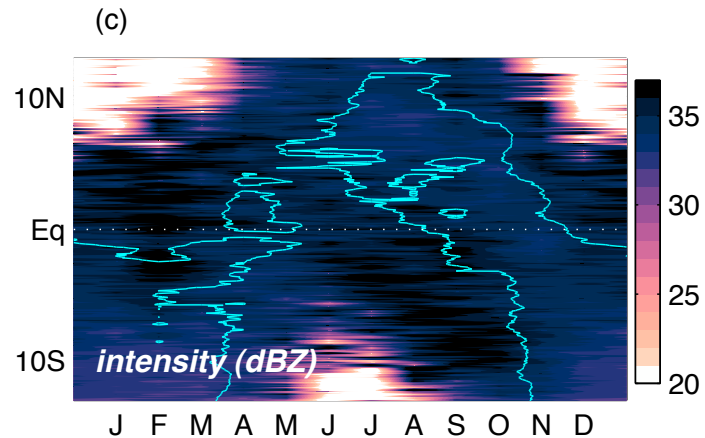
In all monsoon regions, pre-onset rain intensity is more variable and the average event is more intense.



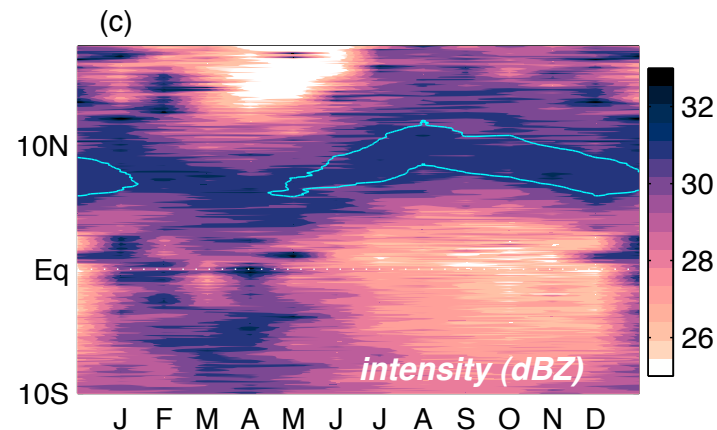


Semi-arid monsoon regions:
e.g. Australia

Intensity peaks before frequency over tropical land regions with very different climates



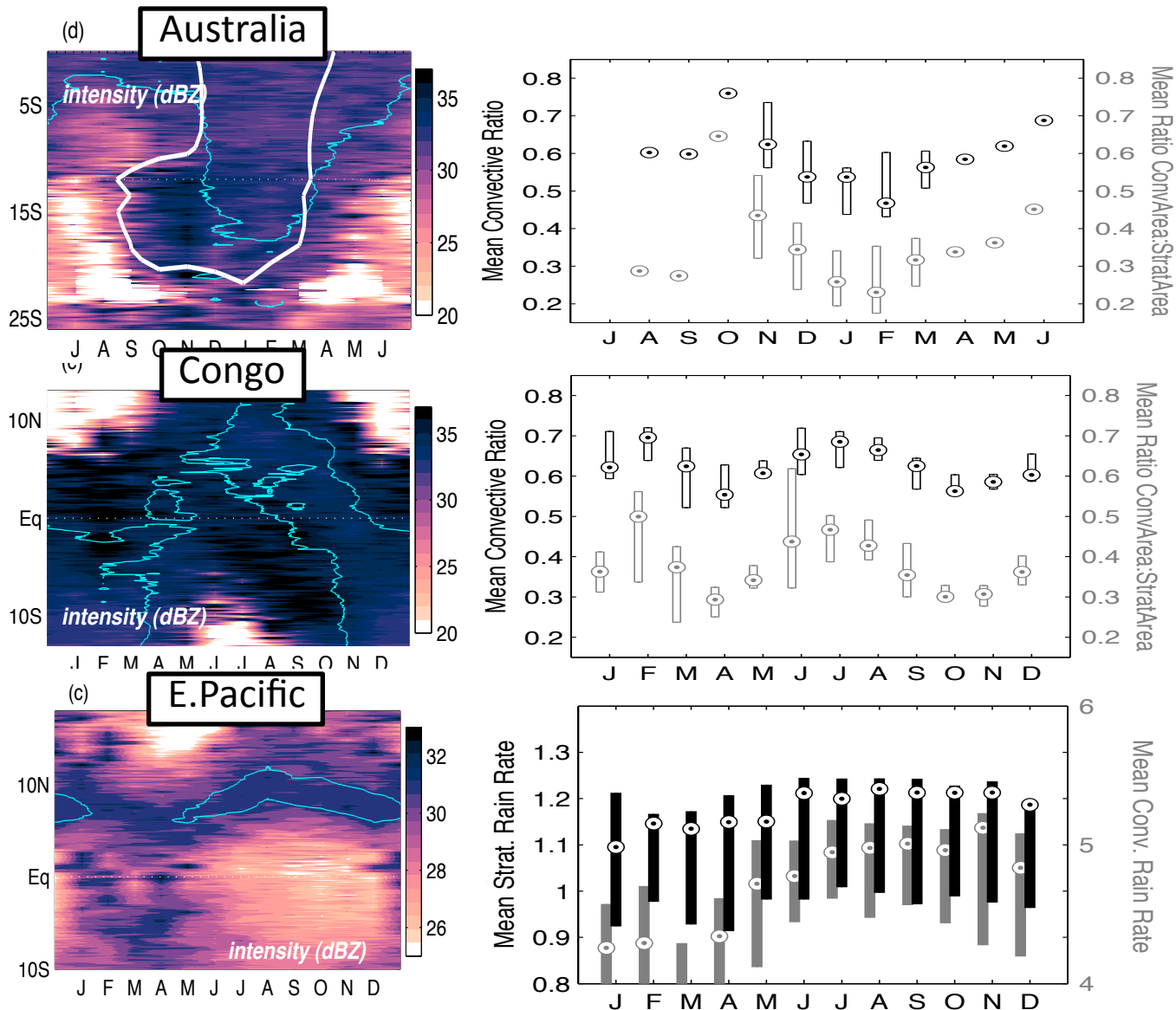
Humid equatorial regions:
e.g. Congo.



Oceanic regions
e.g. East Pacific.

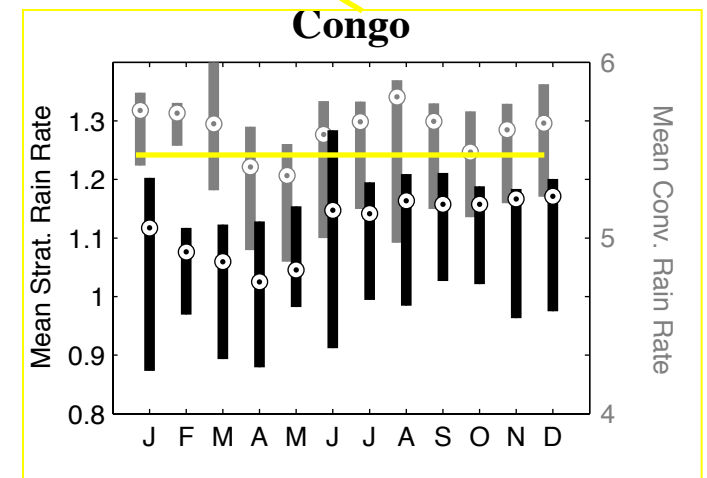
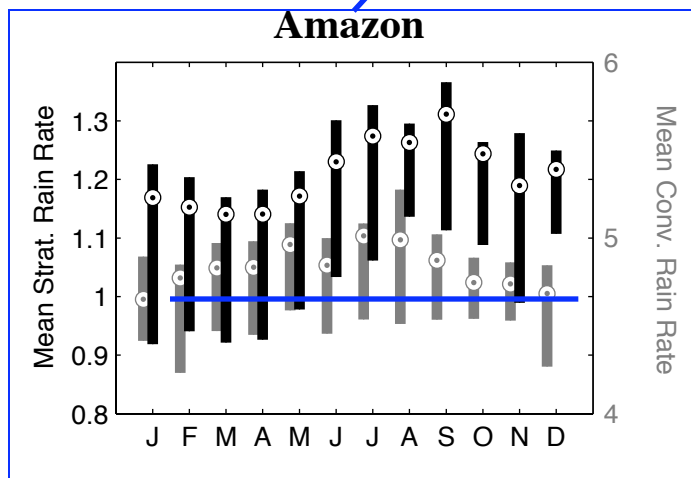
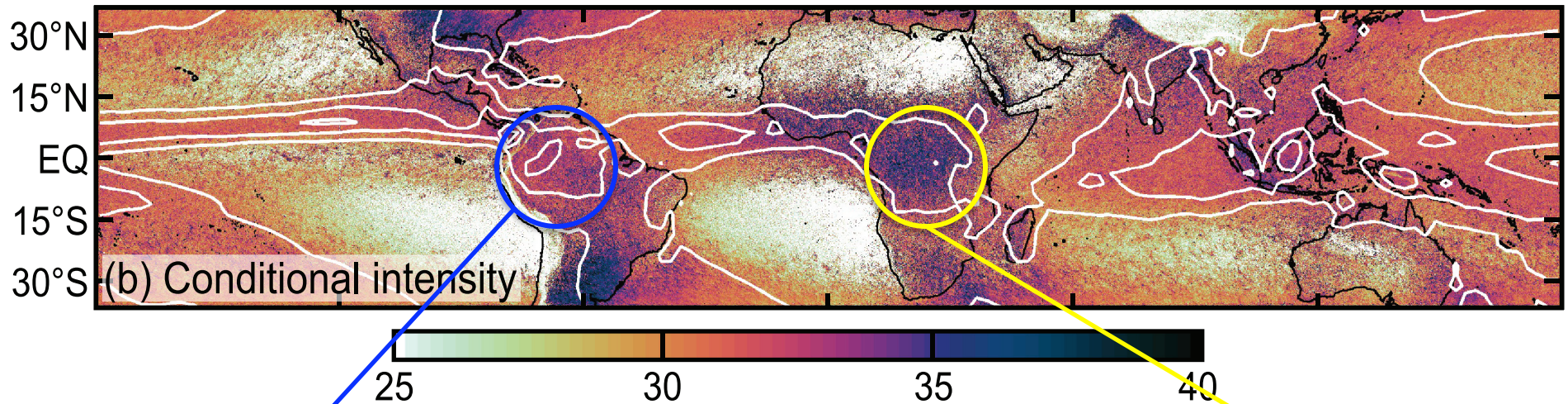
Frequency and intensity vary in synch over oceanic regions

The seasonal changes in intensity over land are mostly due to more convective rainfall (less stratiform rainfall)

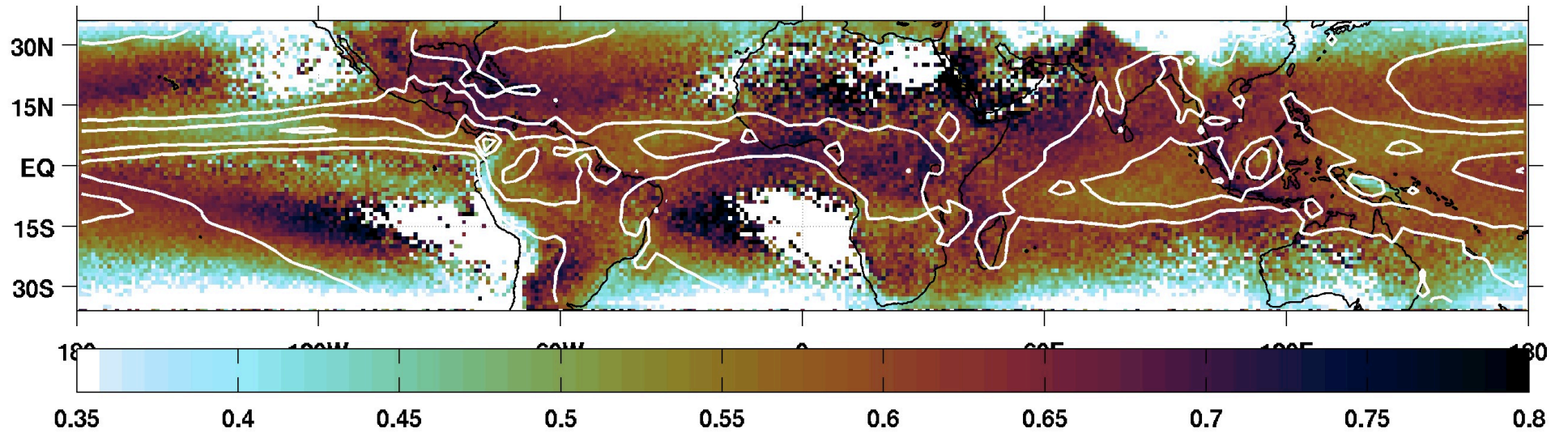


Over ocean, the seasonality of convective intensity itself is more important

Not all features of the intensity pattern can be explained by the convective ratio: knowledge of the instantaneous rain rates is needed.



Convective ratio in TRMM PR data (from monthly data)



Conclusions

The rainy season is the time of most frequent rainfall, at both instantaneous and daily timescales and in all environments.

Rainfall intensity is sensitive to the timescale used to define it, as is the relationship between frequency and intensity.

Over land, storm intensity peaks before the start of the rainy season, mostly due to the prevalence of convective over stratiform rainfall. Over ocean, frequency and intensity rise and fall together. [Another reminder that intense events over land might behave quite differently than those over ocean!]

We need a new metric for climate simulation: instantaneous conditional rainfall intensity.

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