Lightning, convective intensity and severe weather from 13 years of PR and TMI precipitation features and implications for the GPM era

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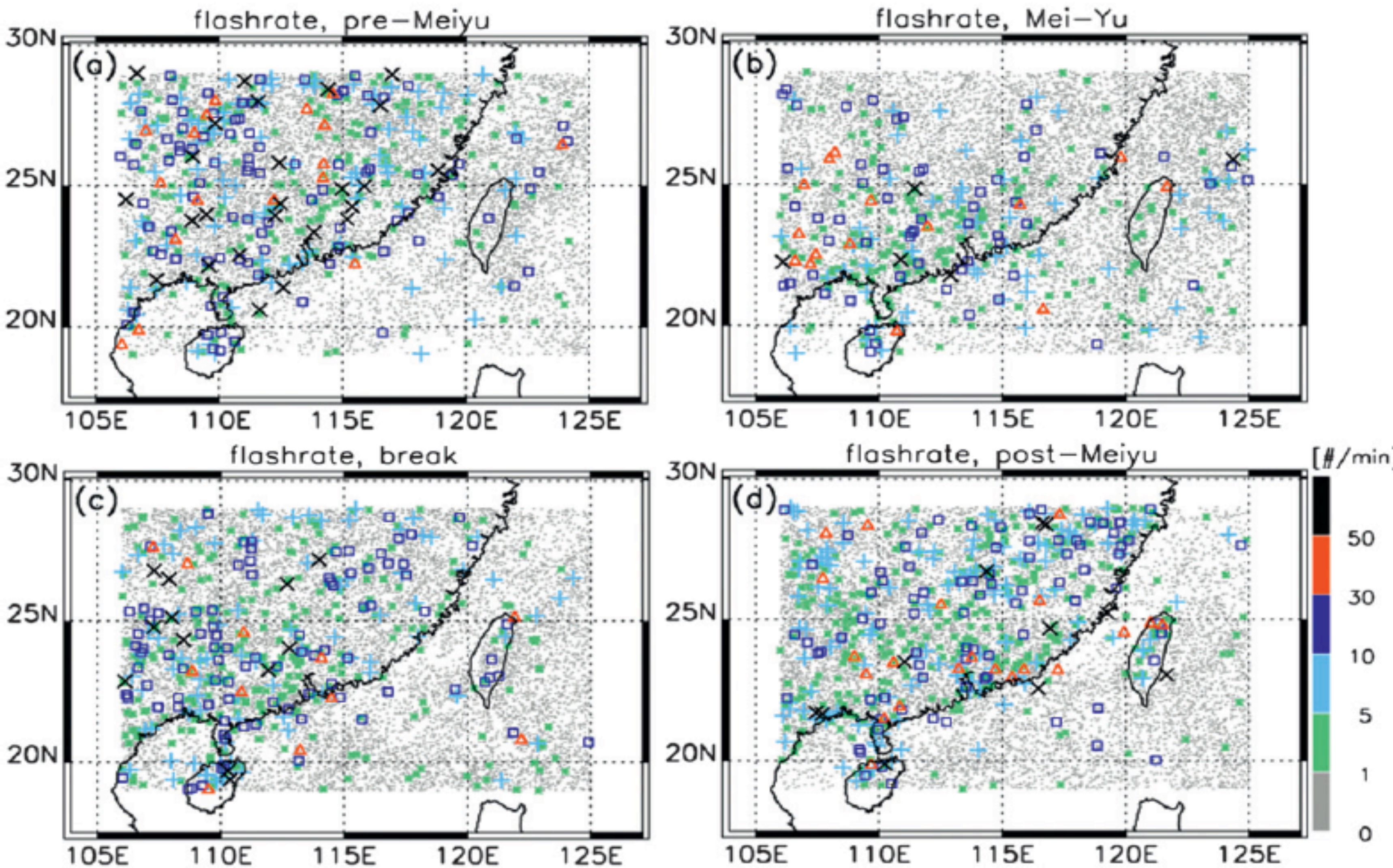
Brief Outline

- Using 13 years of TRMM data for improved "regional climatologies" of precipitation features: Southeast Asia, North American monsoons, Argentina - poster highlights
- TRMM V6 vs. V7 comparison – poster highlights
- TRMM 3B43 rainfall over tropical ocean ITCZ and comparison with 4 reanalysis datasets – poster highlights
- Contributions to MC3E field program
- What % of LIS lightning is in stratiform regions and anvils?
- Lightning vs. convective storm structure from PR and TMI

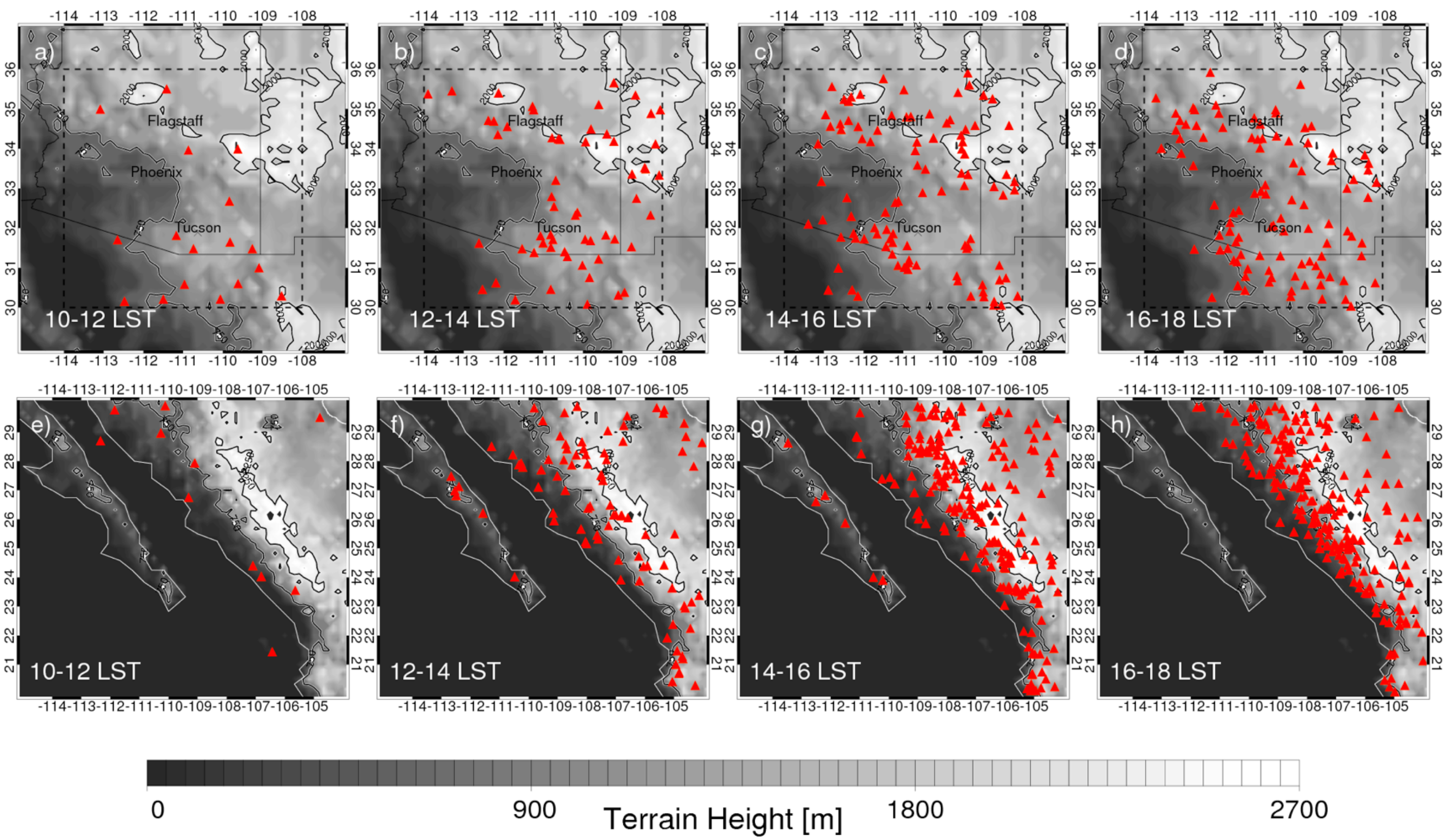
Southeast Asia: MCSs in Mei-yu fronts (Weixin Xu)



Studies of precipitation, lightning, and diurnal variations of precipitation features

Xu et al. MWR 2009, JGR 2010, J.Climate 2011, MWR 2012…

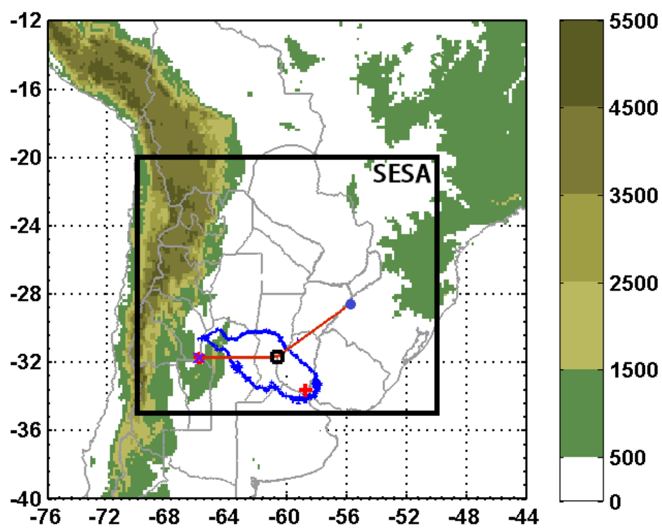
Over North America: Comparison between AZ/NM and NAME regions for July-August precipitation (Christy Wall)



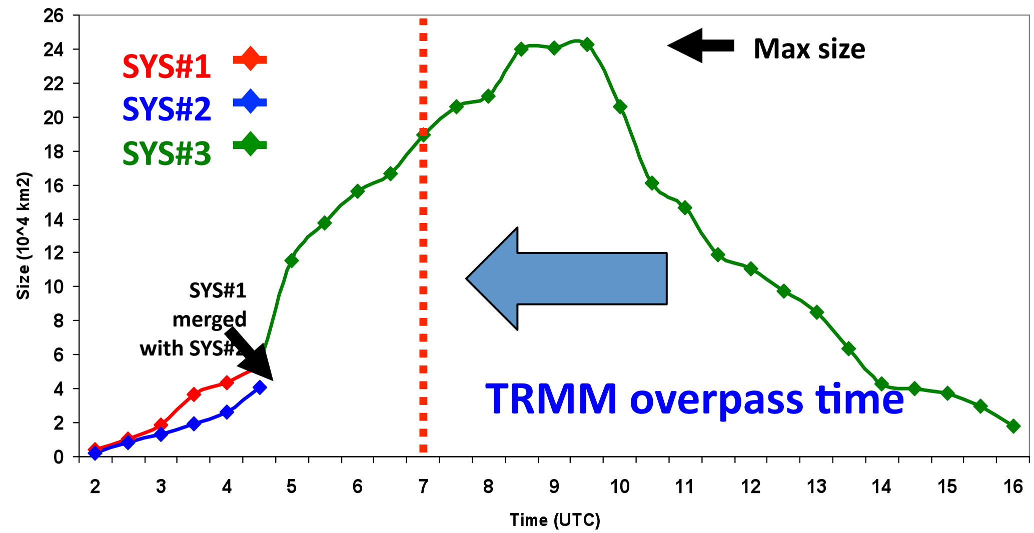
AZNM and NAME regions have similar diurnal patterns of convection, but AZNM is more likely to have deep convective features remaining over high terrain later in the day. NAME produces slightly larger features.

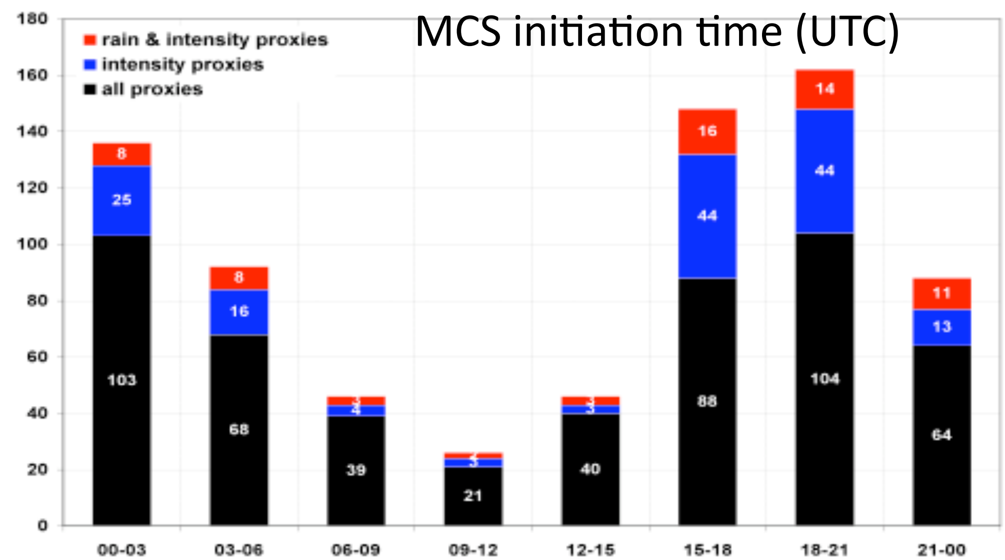
Wall et al., J. Hydrometeor. 2011

MCSs over Southeast South America (SESA)
(Luciano Vidal and Paola Salio)



Tracking MCSs using half hour infrared images



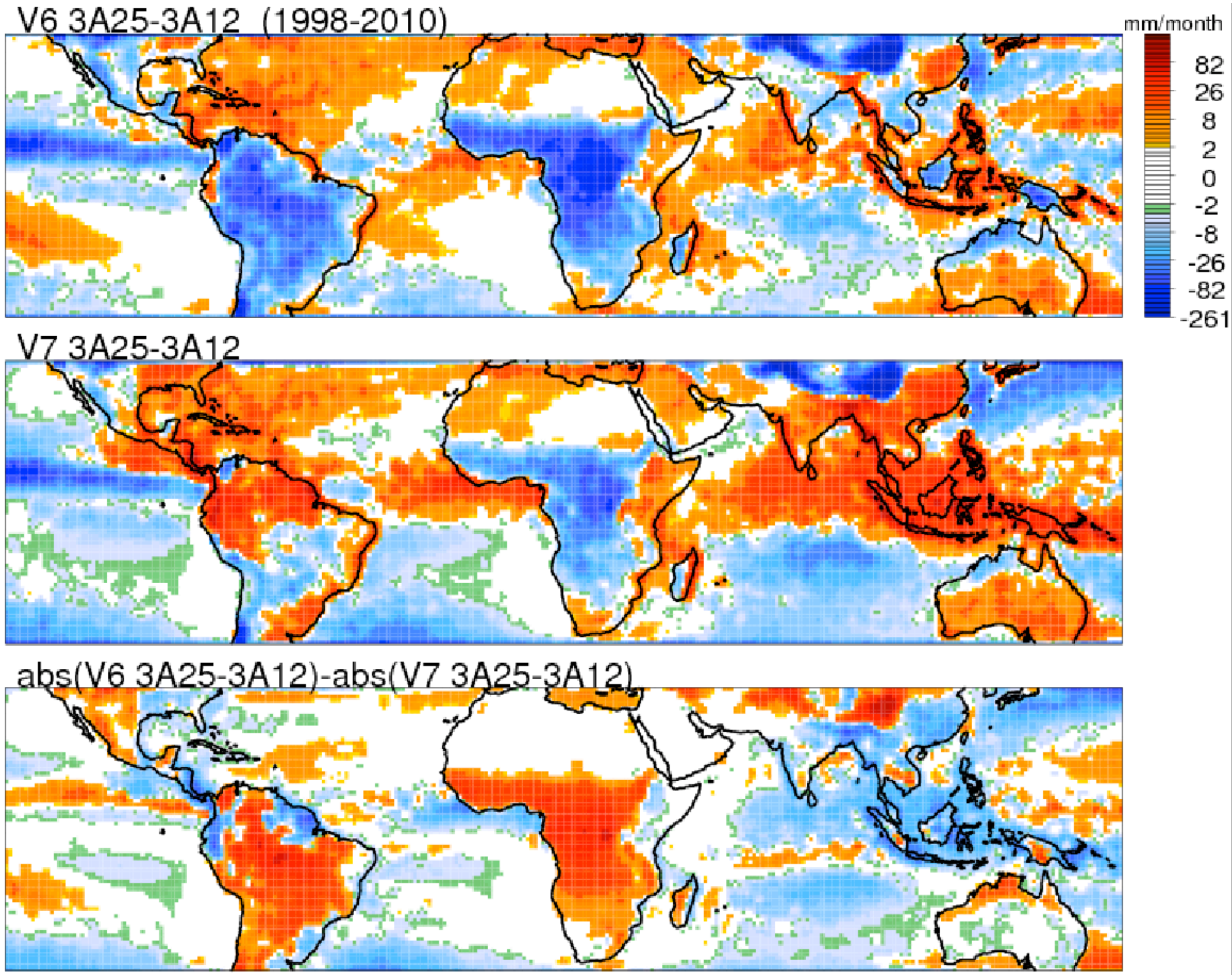


Why the secondary maximum in initiation time after sunset?

Where are these MCSs initiated?

Details- see poster this afternoon

TRMM rainfall retrieval V6 vs. V7 comparison (Chuntao Liu)

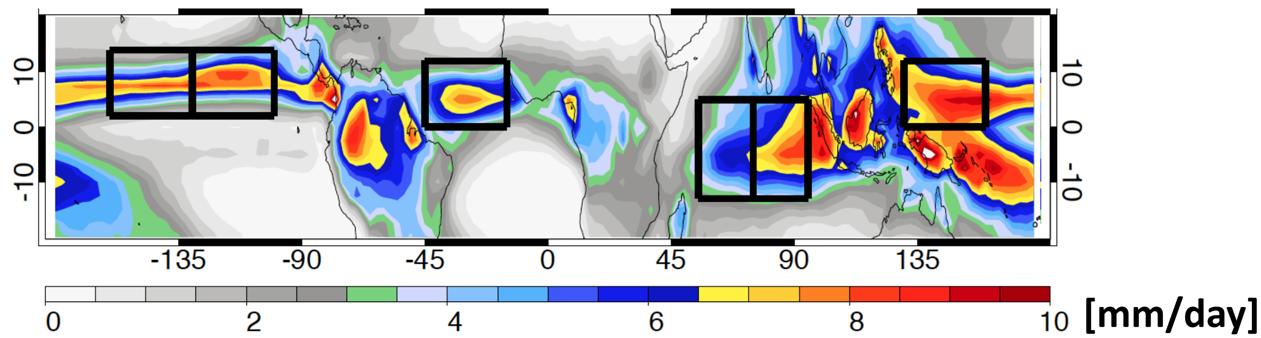


What are the differences in deep and shallow systems? *Details: see poster this afternoon.*

TRMM rain characteristics and large-scale vertical motions in 4 reanalysis datasets over tropical oceans (Chie Yokoyama)

Reanalyses: NCEP, ERA-Interim, JRA25/JCDAS, and MERRA

Six tropical oceans: WPAC, CPAC, EPAC, ATL, WIO, and EIO



Q. How does rainfall relate to ω on a monthly time scale?

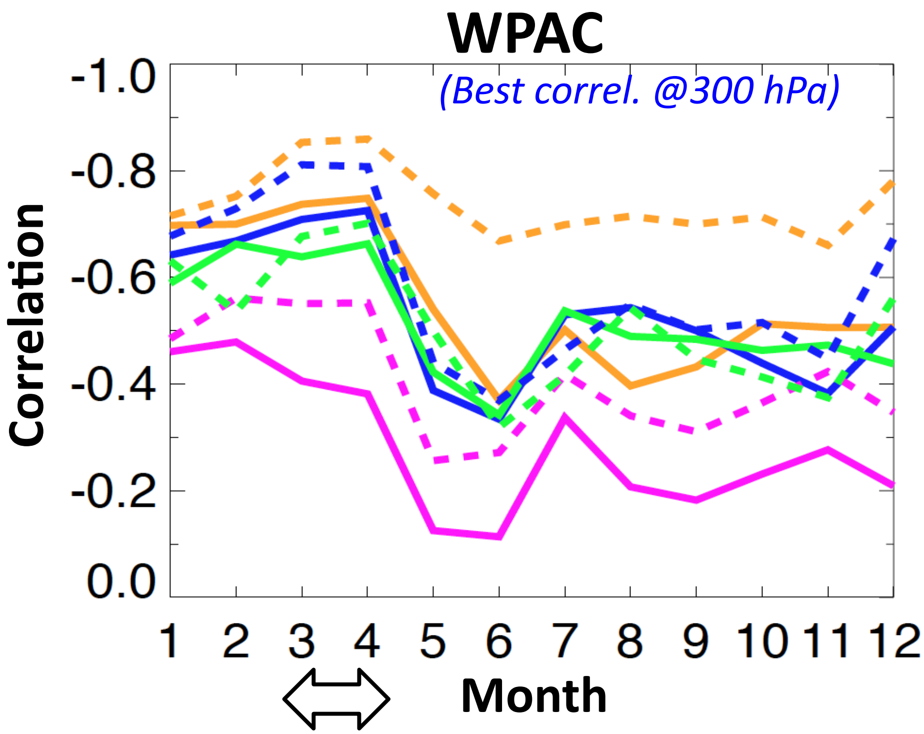
Mean spatial correlations between 3B43 rainfall and ω for 1998-2010

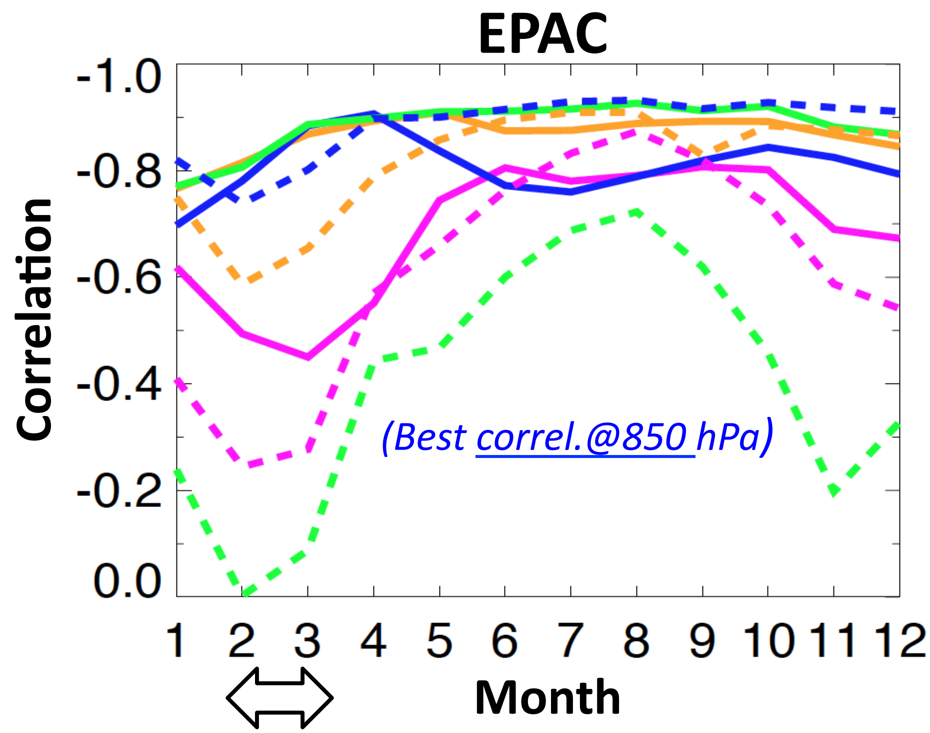
	WPAC				EPAC			
	NCEP	ERA	JRA	MERRA	NCEP	ERA	JRA	MERRA
ω300	-0.41	-0.74	-0.58	-0.51	-0.61	-0.82	-0.88	-0.40
ω850	-0.28	-0.55	-0.53	-0.52	-0.68	-0.87	-0.81	-0.88

- Higher correlations tend to be found at 850 hPa over EPAC, but at 300 hPa over WPAC.
- Correlations are lower over WPAC than over EPAC.

Seasonal changes in correlations between rainfall and ω

NCEP ERA-Interim JRA25/JCDAS MERRA
850 hPa - - - 300 hPa





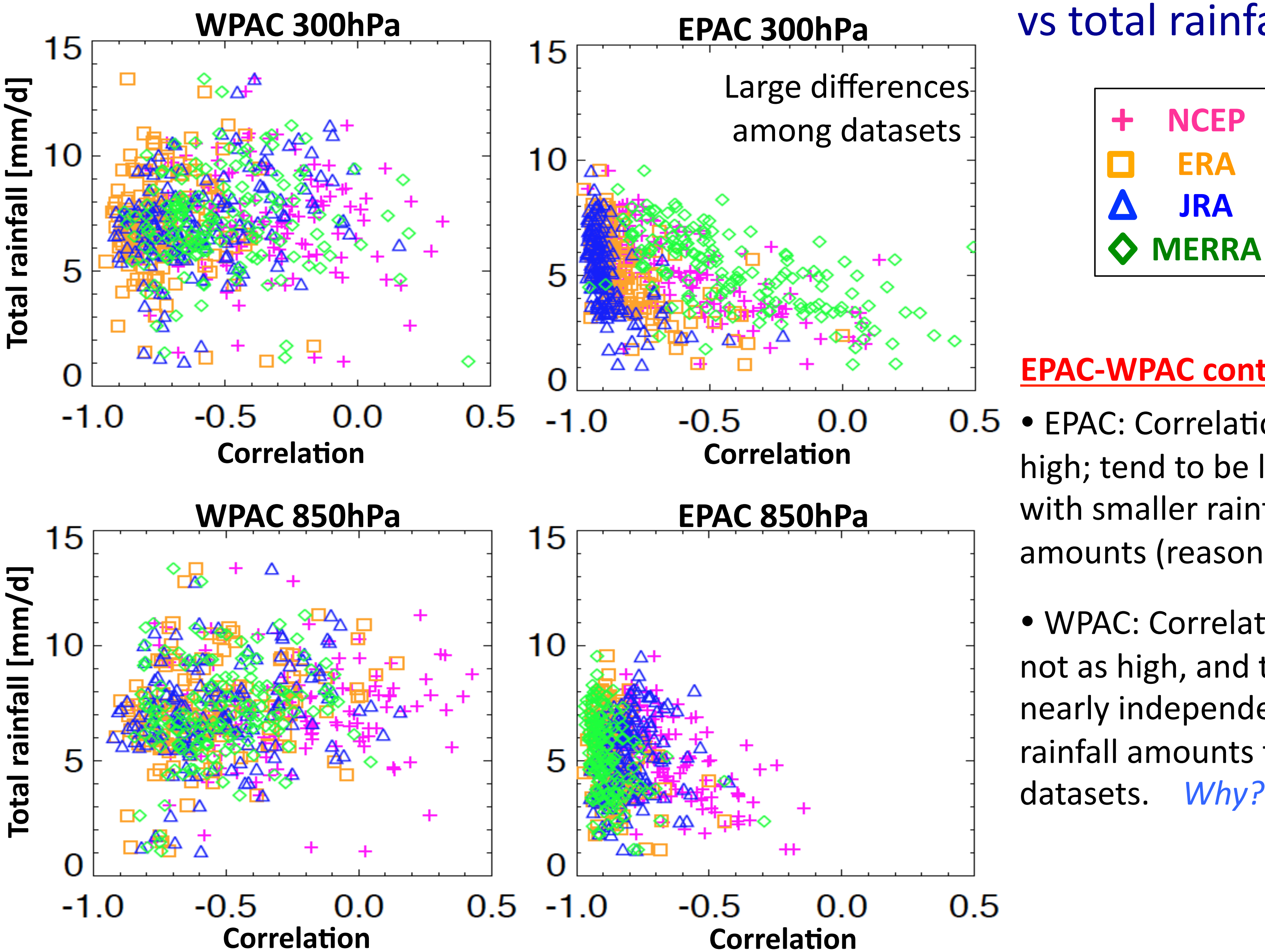
Over WPAC, higher correlations are found in Mar-Apr when weak ITCZ banding occurs.

Over EPAC, lower correlations are found in light-rain season.

We wish to understand the major differences between reanalyses: NCEP often has low correlation; ERA-interim often has highest. Why?

Q. How are correlations determined?

Scatter of correlations vs total rainfall



EPAC-WPAC contrast

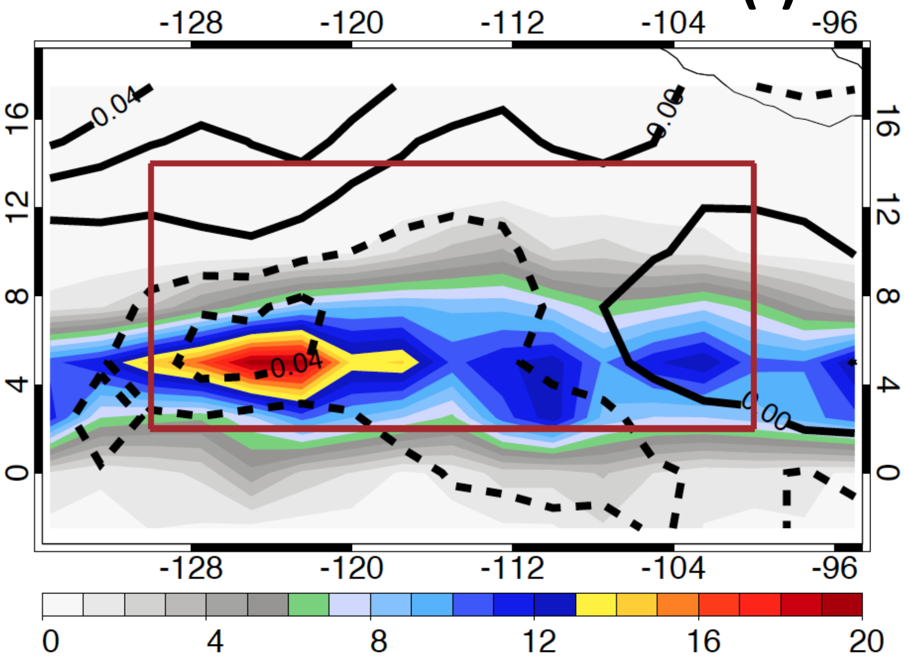
- EPAC: Correlations are high; tend to be lower with smaller rainfall amounts (reasonable).
- WPAC: Correlations are not as high, and they are nearly independent of rainfall amounts for all datasets. *Why?*

Q. What are differences among reanalysis datasets, and why?

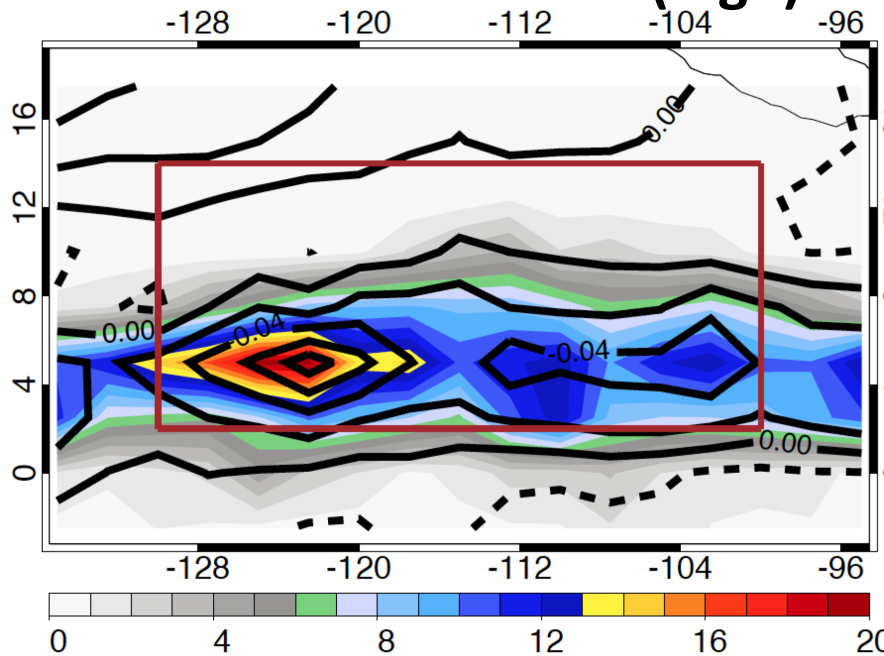
EPAC case in March 2010

Rainfall: 6mm/d
Large tall system rain: 68%

MERRA corr300= +0.49 (!)



ERA corr300= -0.93 (high)



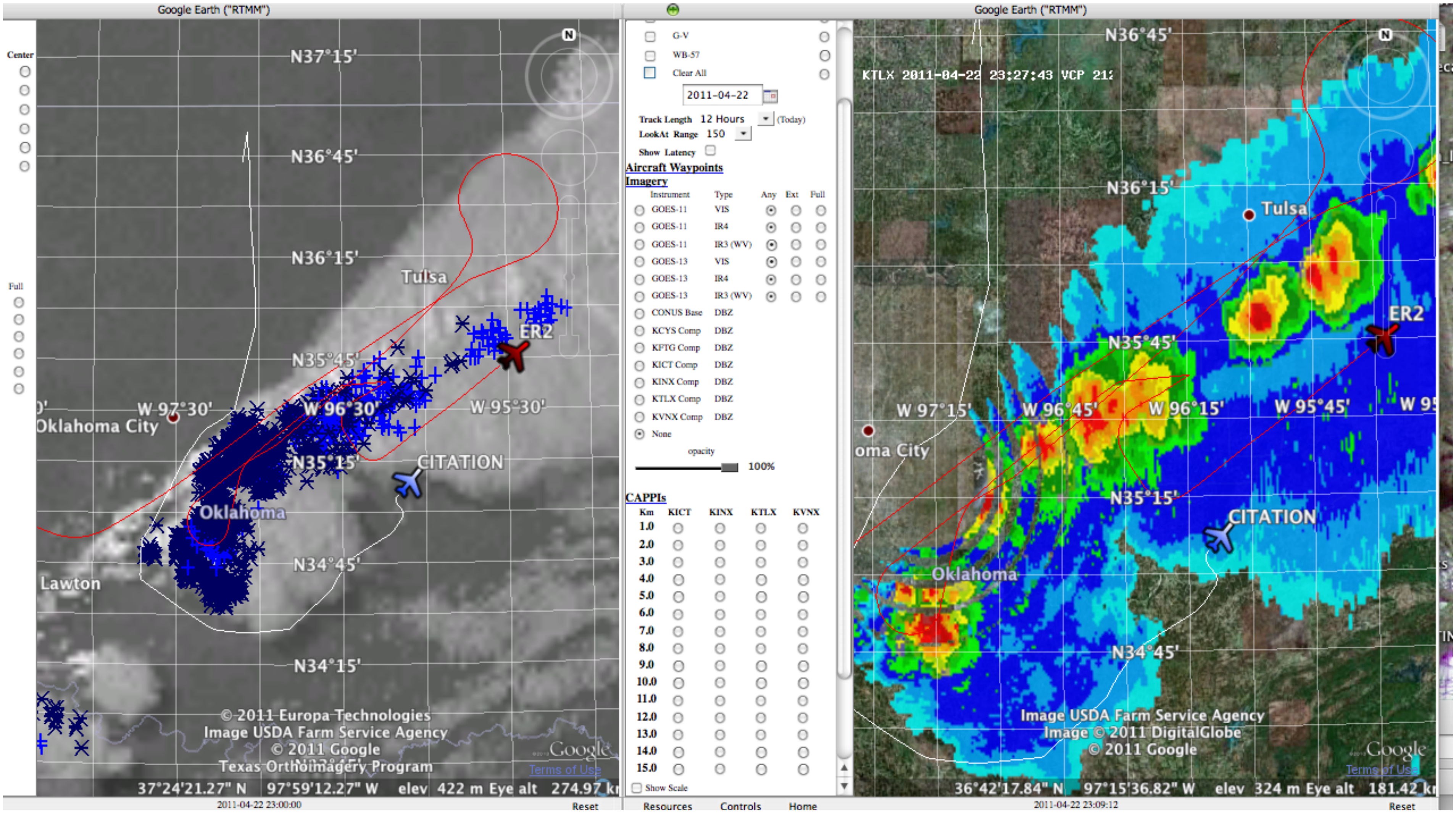
Contour: ω at 300hPa, Shade: 3B43 rainfall

- MERRA often has subsidence at 300 hPa over the ITCZ, while all others have ascent… so big question is *"is it possible that MERRA ω's at 300 hPa are correct?"*
- MERRA always has high correlations at 850 hPa regardless of correlations at 300 hPa.
- We need to know relationships between rainfall and ω on rainy days.

Details: See Chie Yokoyama at the poster this afternoon

MC3E – Assisting with Mission Science and Student Forecasters

(Arrival of ER-2 just as Line of Intense Storms Forms)



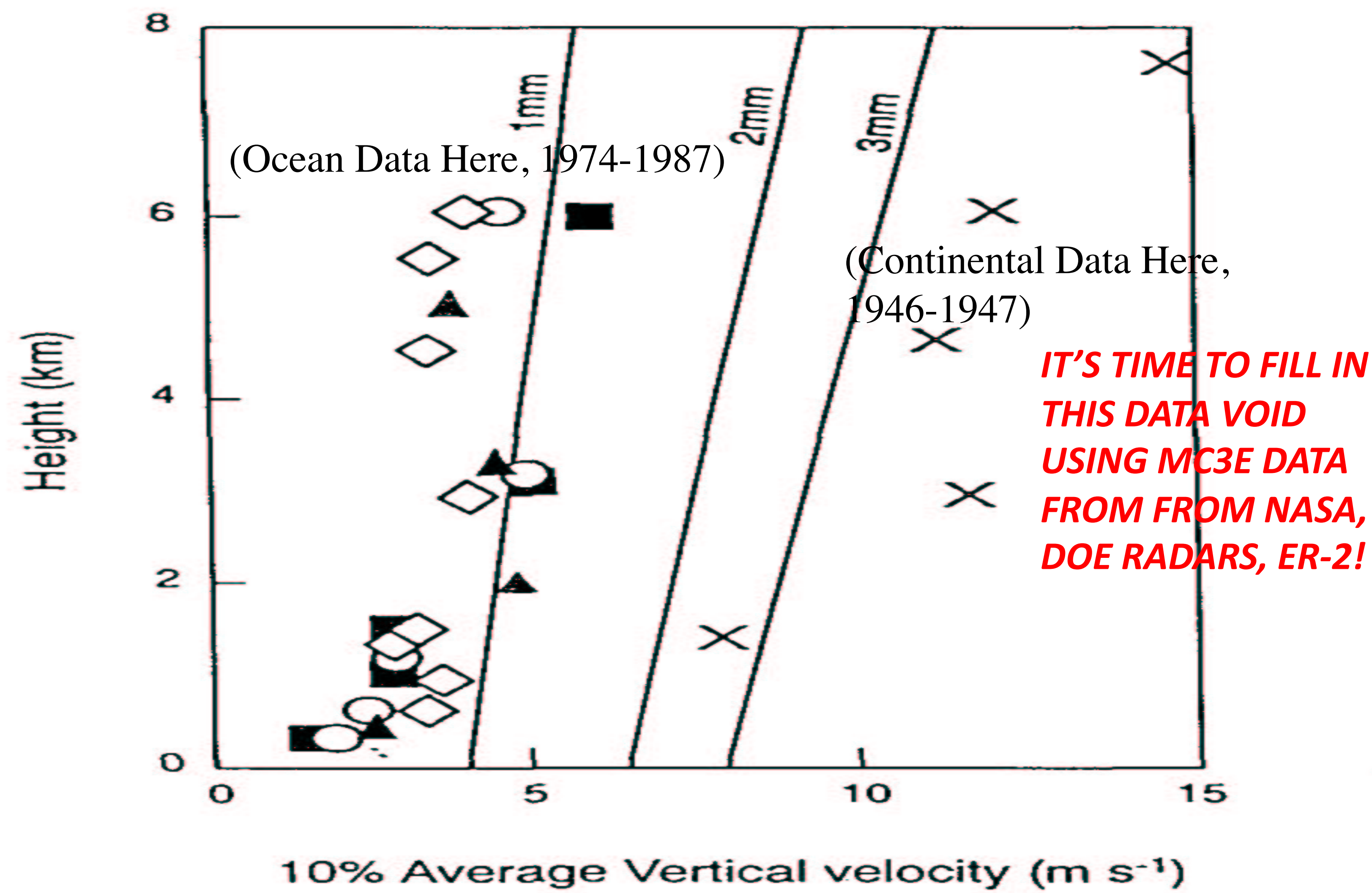


FIG. 7. Average vertical velocity in the strongest 10% of updraft cores over tropical oceans [triangles, EMEX, Lucas and Zipser (1994); circles, GATE, Zipser and LeMone (1980); diamonds, hurricanes, Jorgensen et al. (1985); squares, TAMEX, Jorgensen and LeMone (1989)] and over land [crosses, Thunderstorm Project, adapted from Zipser and LeMone (1980)]. The lines show terminal fall speeds of raindrops as a function of height, adapted from Gunn and Kinzer (1949) and Foote and DuToit (1969), after Lucas and Zipser (1994).

Zipser and Lutz, MWR 1994

MC3E – Assisting with Mission Science and Student Forecasters

N-POL radar

2D Disdrometer

UND Citation

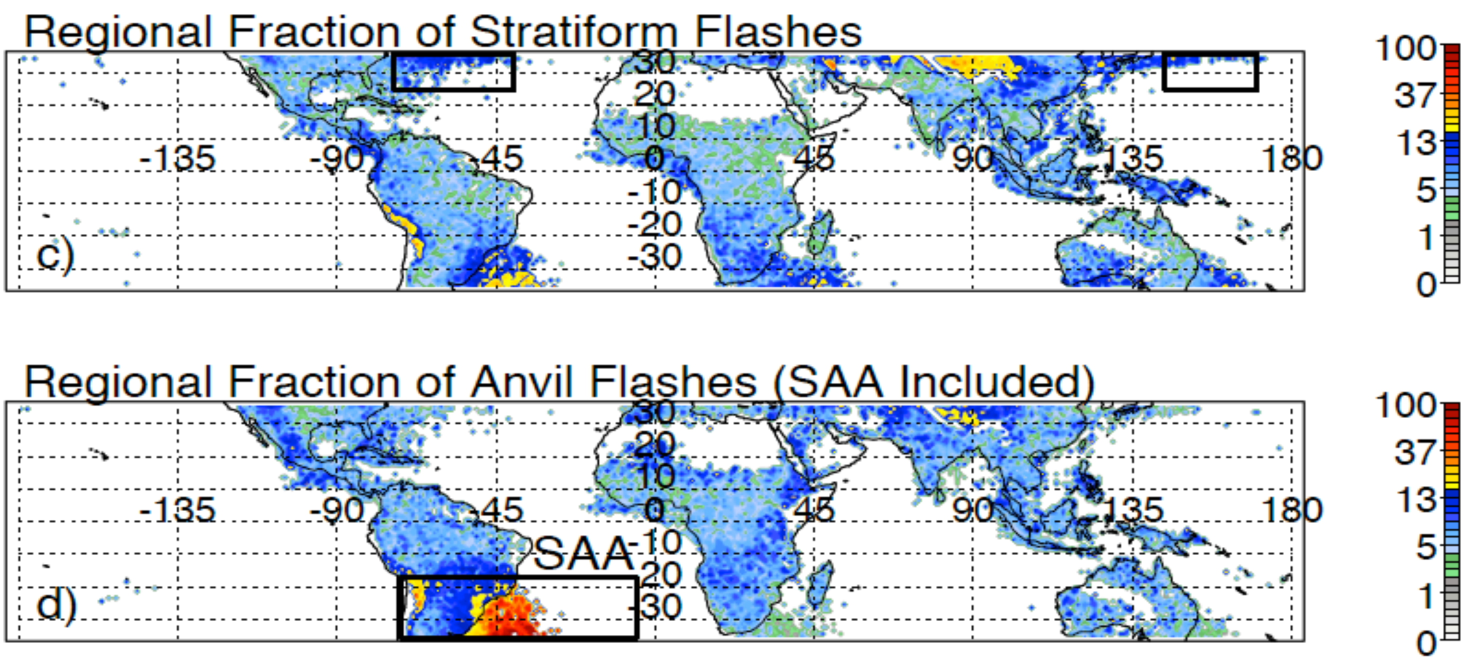
...after an all-nighter...

Ops Center

(ask me about this later)

Statistics of lightning flashes over anvil and stratiform regions (Michael Peterson)

	Global		Land Only		Ocean Only	
	Count	%	Count	%	Count	%
All	5934492		4840322		1094205	
Anvil	324052	5.46	266894	5.51	57160	5.22
Stratiform	334660	5.64	251818	5.20	82844	7.57



Peterson and Liu, *JGR, 2011*

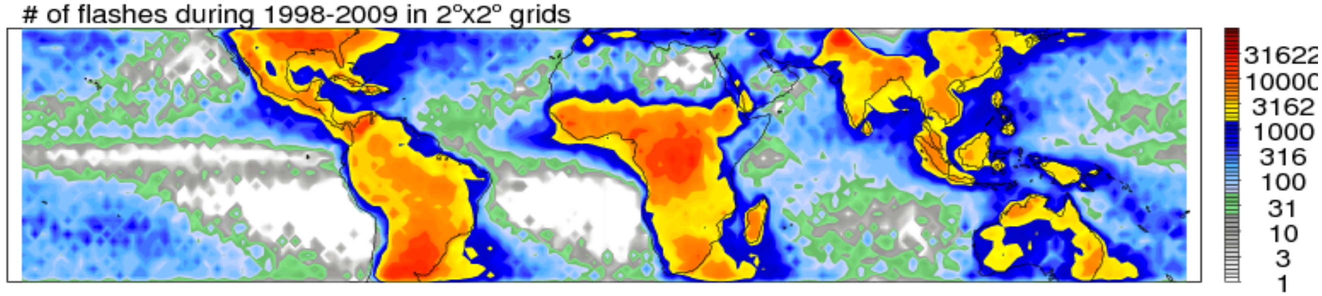
Relationship between flash rate and the 37 and 85 GHz PCT
(Chuntao Liu, Dan Cecil and Ed Zipser – *JGR 2011*)

The best correlations:

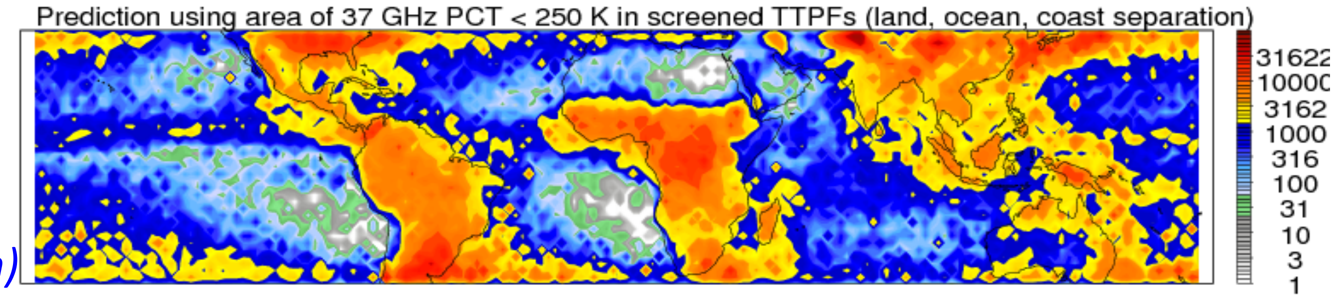
Flashrate ∞ Area $_{85\ GHz\ PCT\ <\ 150\ K}$ Flashrate ∞ Area $_{85\ GHz\ PCT\ <\ 250K}$

Thunderstorm screening: Land: $PCT_{85GHz} < 217$ K $PCT_{37GHz} < 280$ K Ocean: $PCT_{85GHz} < 212$K $PCT_{37GHz} < 258$ K

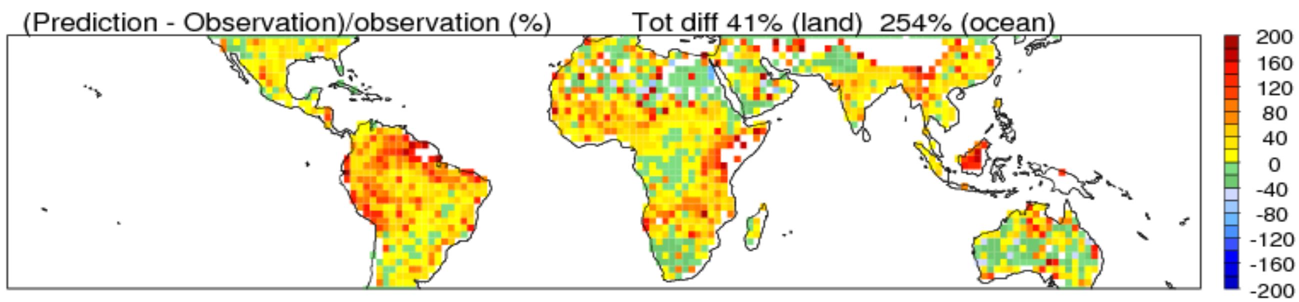
Observation of flashes



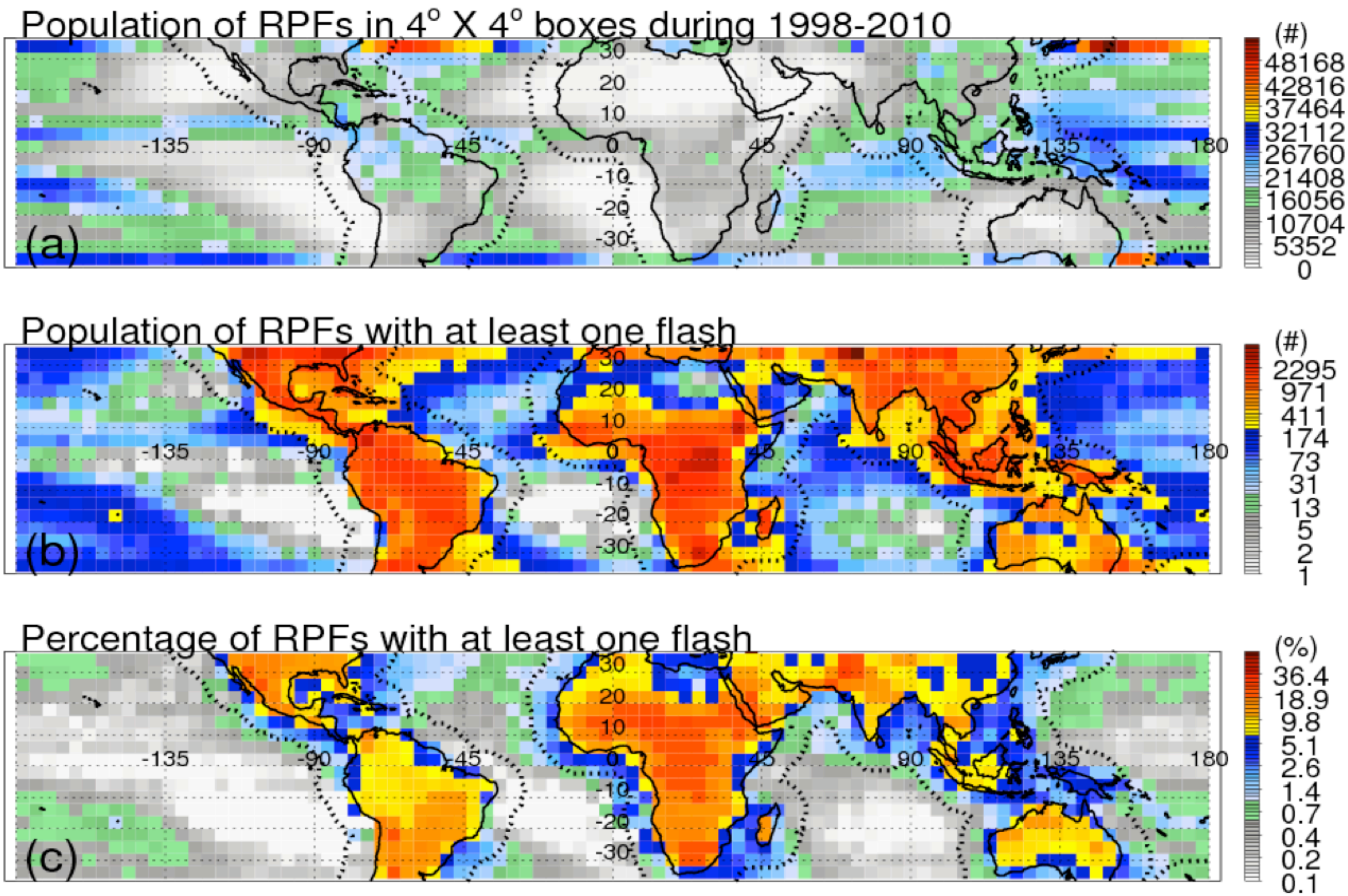
"Prediction" using
Area of 37 PCT < 250 K
(Not bad over land, but overestimates over ocean)



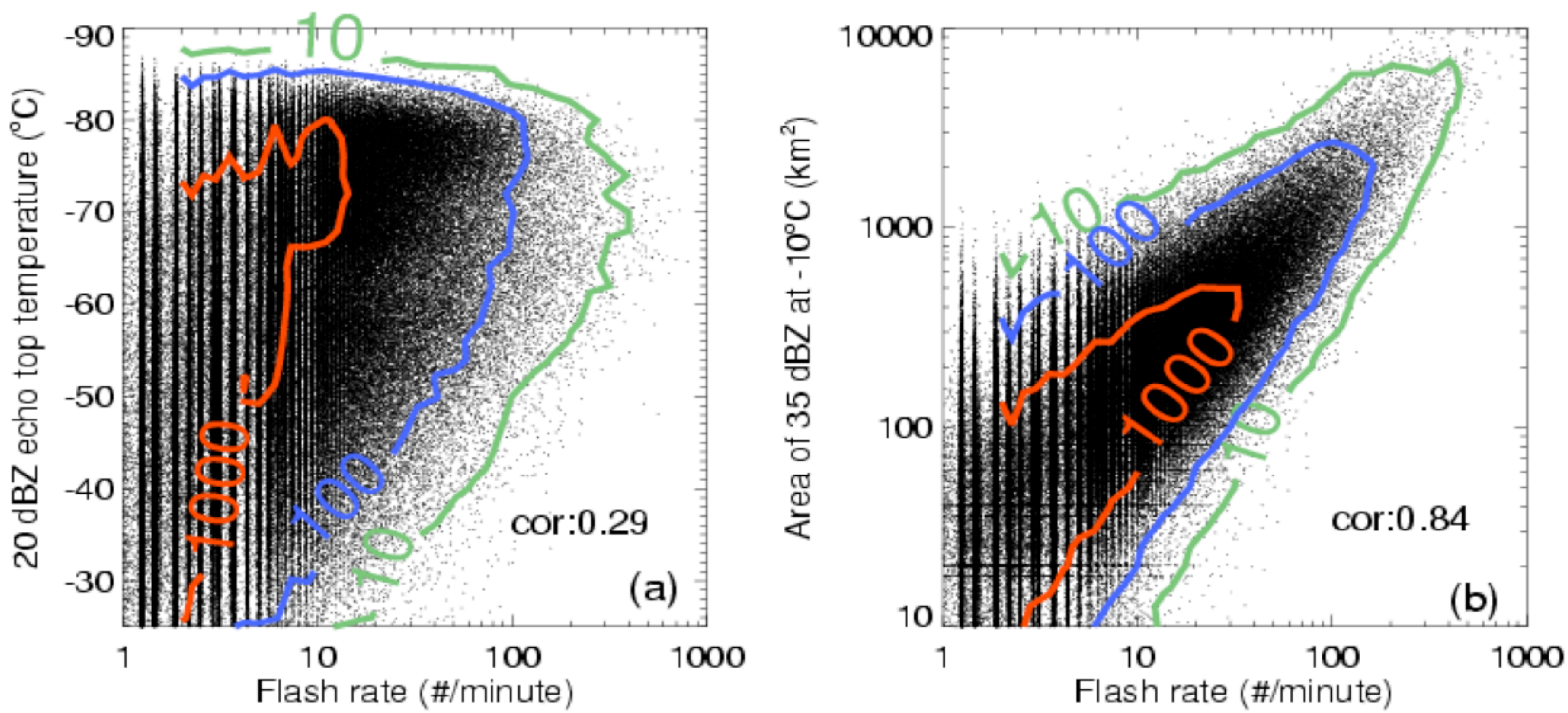
Difference over land



Relationships between flash rate and radar reflectivity profile
(Chuntao Liu, Dan Cecil and Ed Zipser; *submitted to JGR*)



Correlation between radar reflectivity vs. flash rate in precipitation features

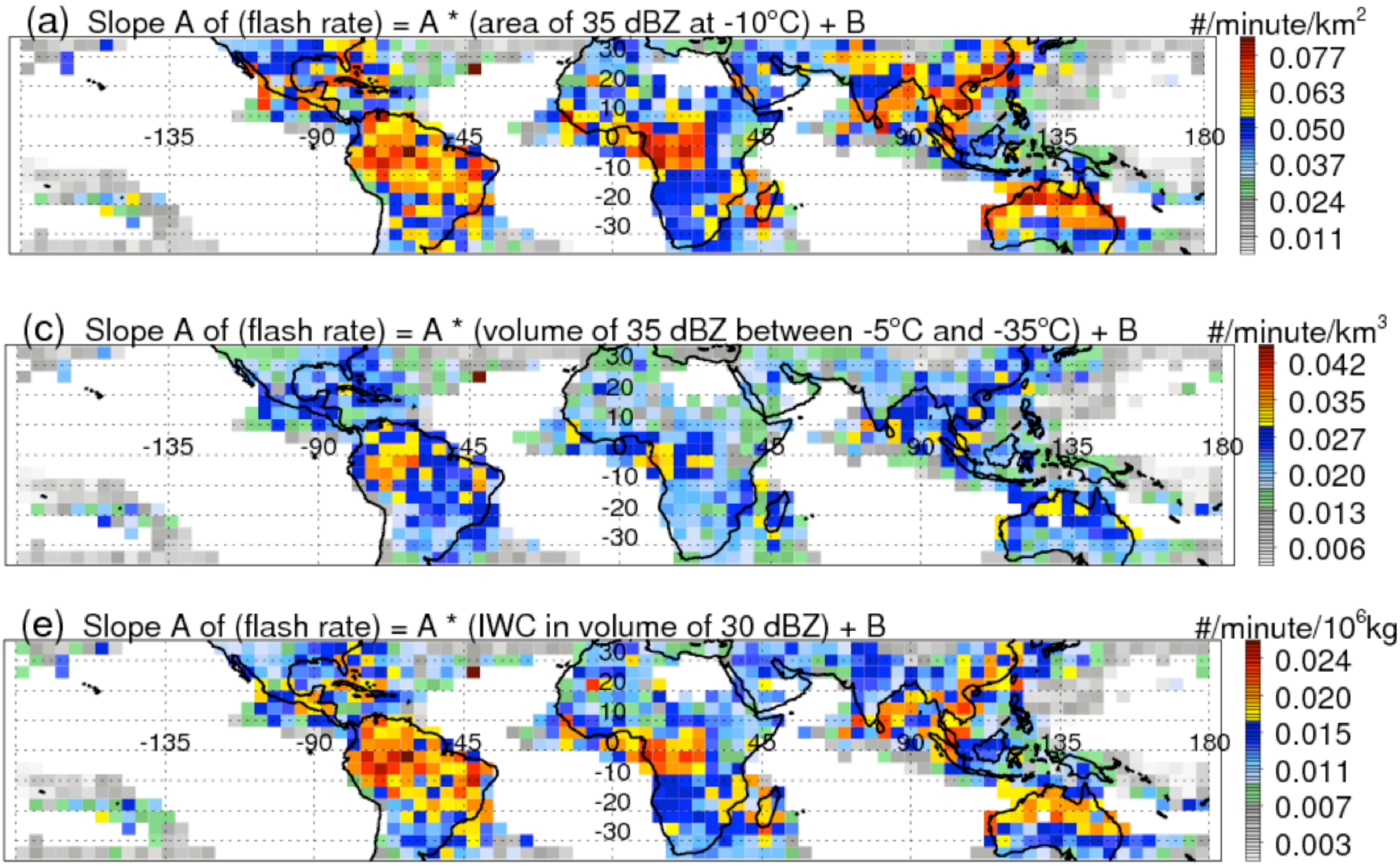


The best correlations are found from flash rate to the area or volume of 30-40 dBZ echo in the mixed phase region.

Supports previous findings by Petersen, Rutledge, Carey, Deierling.

Height, temperature of 20 dBZ top is nearly irrelevant!

There are large regional variations in the relationship between flash rate and the volume of 30-40 dBZ in the mixed phase region



Can we “predict” flash rate using radar reflectivity

- Using a simple thunderstorm screening:

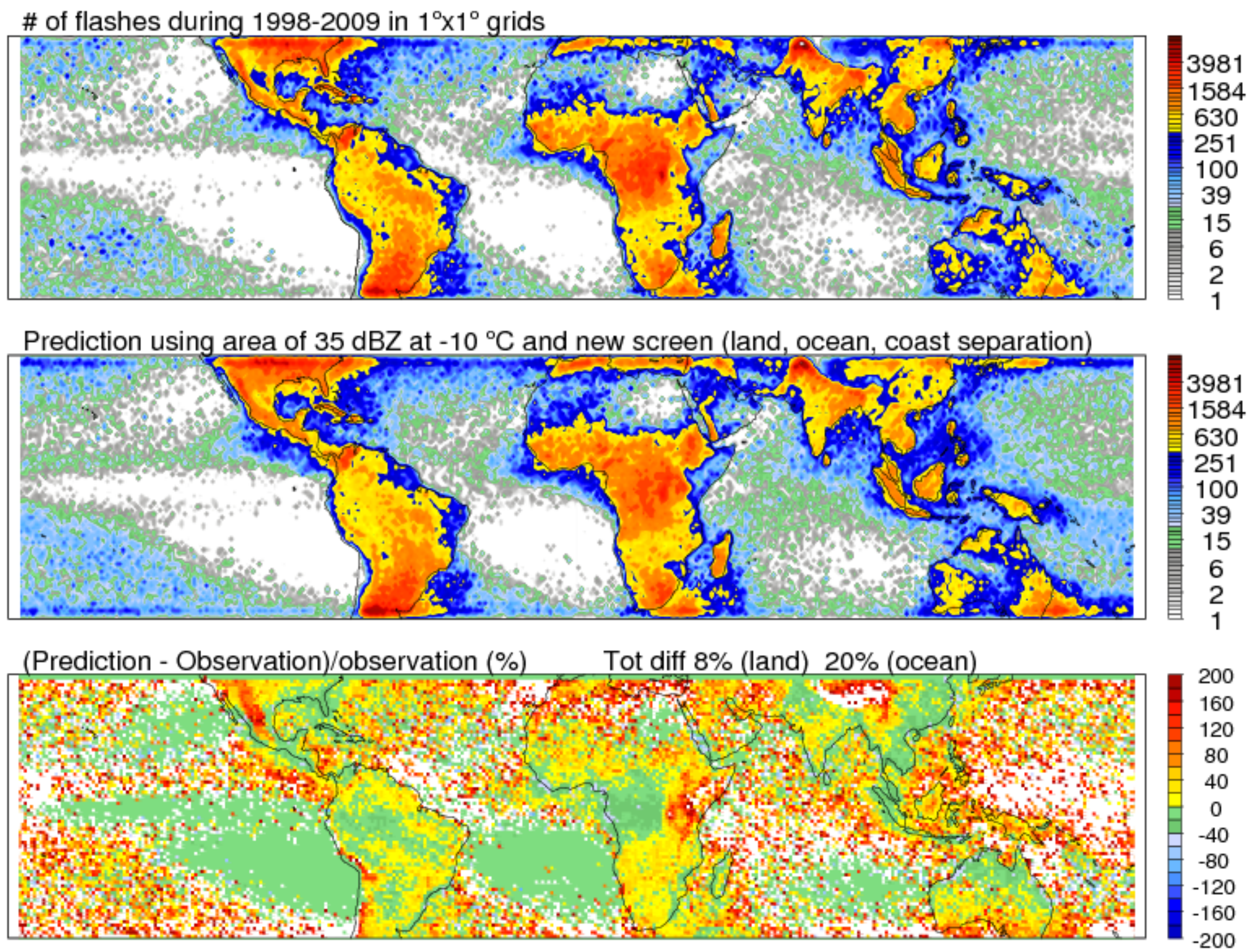
Land: $T_{30dBZtop} < -14^{o}C$ & $T_{40dBZtop} < 8^{o}C$ Ocean: $T_{30dBZtop} < -20^{o}C$ & $T_{40dBZtop} < -4^{o}C$

And simple land, ocean and coastal relationships between flash rate and the area of 35 dBZ at $-10^{o}C$.

Observed

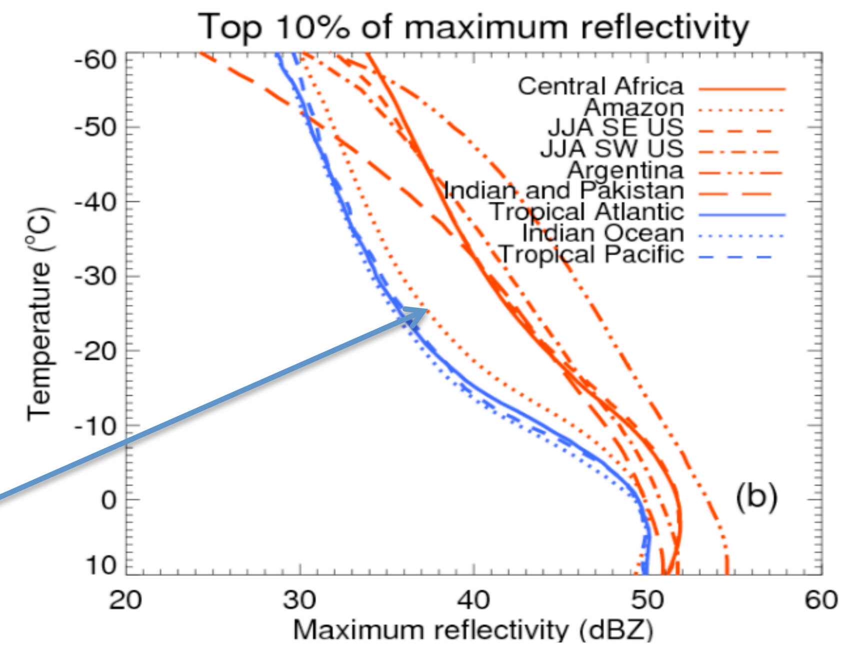
“Predicted”

Differences

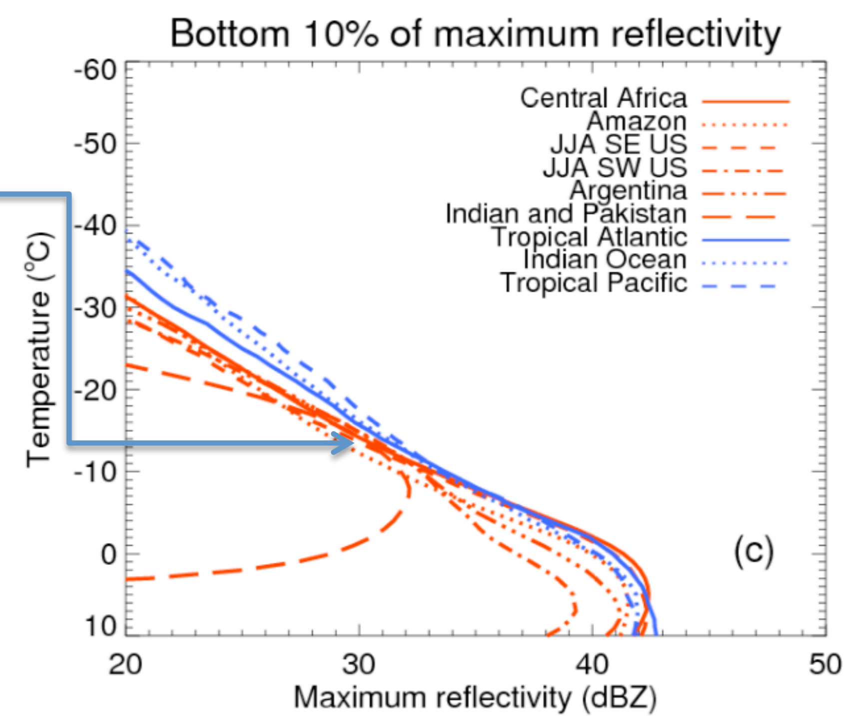


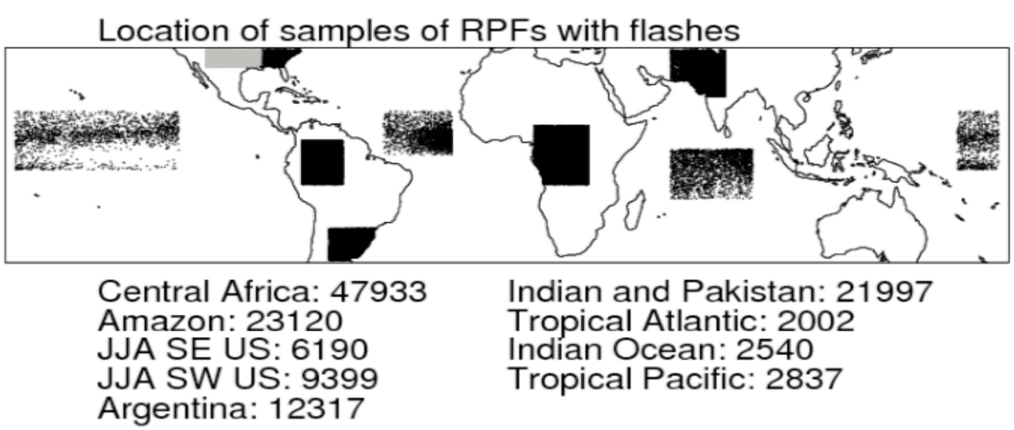
Understanding regional differences in thunderstorms by comparing the strongest 10% and weakest 10% over selected ocean and land regions

For strong storms, land radar profiles are stronger than ocean profiles, EXCEPT in the Amazon, which is close to the ocean profiles (Green Ocean?)



What are the properties of the weakest storms that can have lightning? For all land and ocean regions, answer seems to be: 30 dBZ area at -15°C





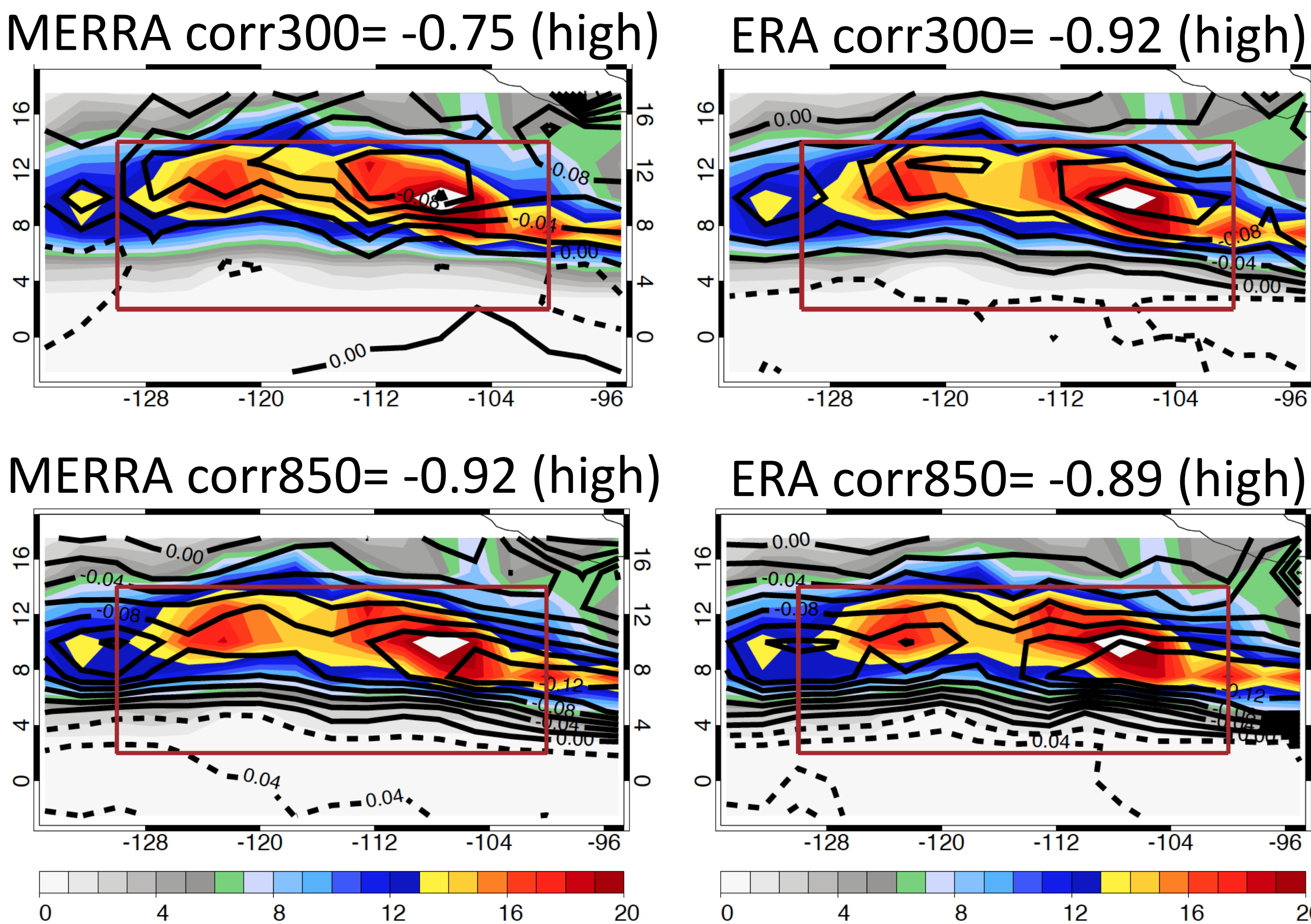
TAKE-HOME MESSAGES

- With each additional year, the TRMM database becomes ever-more valuable for studies of rainfall climatologies, diurnal cycles, convective properties…
- MC3E field phase was highly successful and the data set deserves to be exploited (NASA+DOE collaboration)
- It is important to understand the differences between global reanalyses and their relation with rainfall
- Relationships between radar, passive microwave, and lightning data are converging thanks to TRMM/LIS; should help in diagnosing severe weather in GPM era

A good heavy rainfall case: High correlation at both 850 & 300 hPa

EPAC case in August 2009

Rainfall: 9.6mm/d
Large tall system rain: 73%

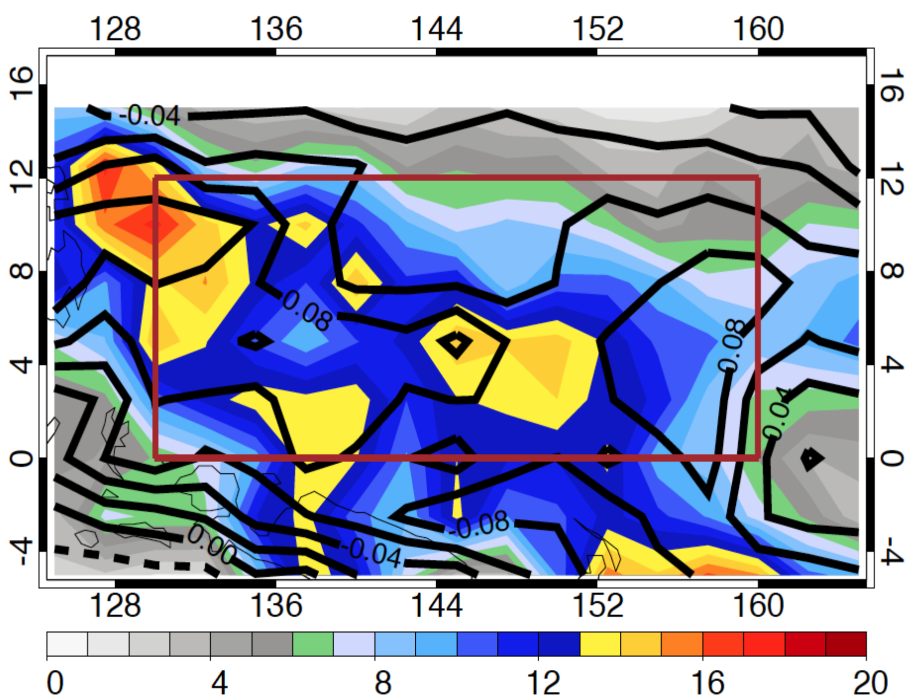


Contour: ω300 (top) and ω850 (bottom), Shade: 3B43 rainfall

WPAC cases with heavy rainfall

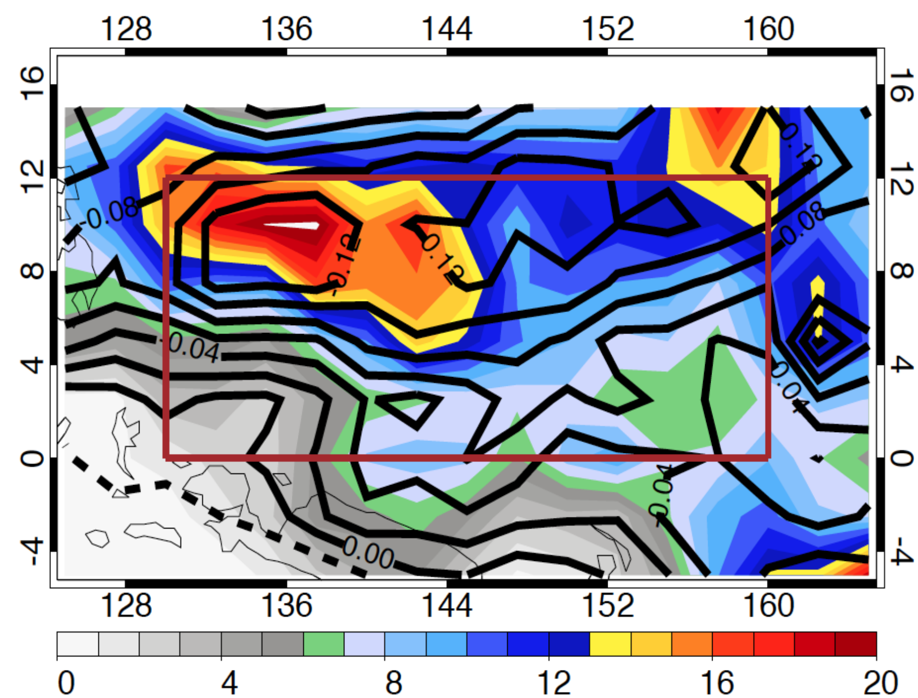
July 2003

ERA corr300=-0.43 (low)



August 2002

ERA corr300=-0.86 (high)



Contour: ω at 300hPa, Shade: 3B43 rainfall

- WPAC warm pool doesn't have forcing from geographically-fixed SST gradients as in EPAC, with almost daily shallow convergence giving high correlations between 850 hPa ω and 3B43.
- Over warm pool, heavy rainfall may occur over a wider area different on any given day, which may result in low correlations between monthly rain and monthly ω.
- Even over WPAC, correlations tend to be higher when rainfall is concentrated along a band.