How Well Do Global Climate Models Simulate the Variability of Atlantic Tropical Cyclones Associated with ENSO?

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Outline

1. Background

2. Models & data

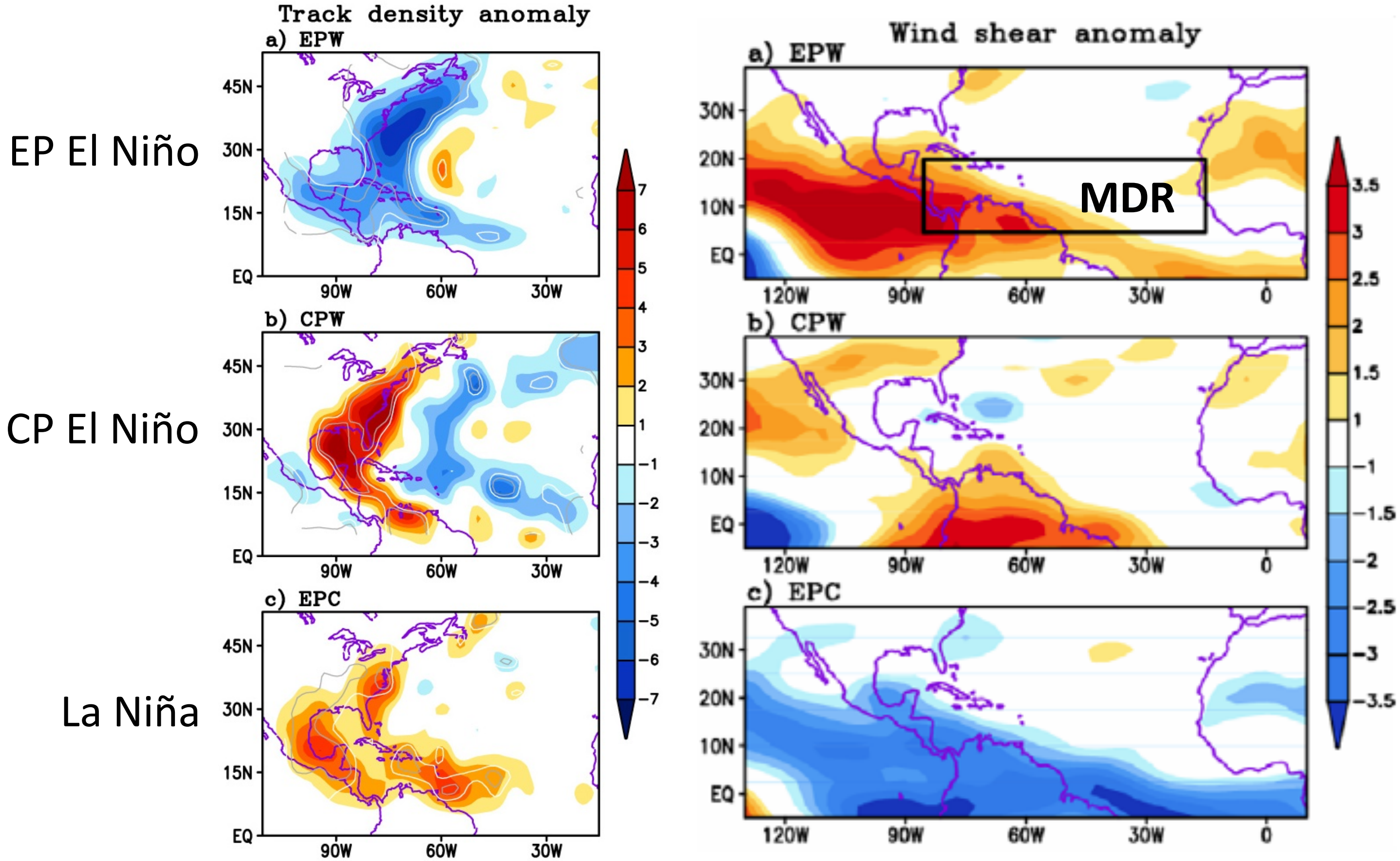
3. Results: AMIP vs. OBS

- *Model statistics*
- *Track density & origins*
- *Vertical wind shear*

4. Conclusions

Background Information

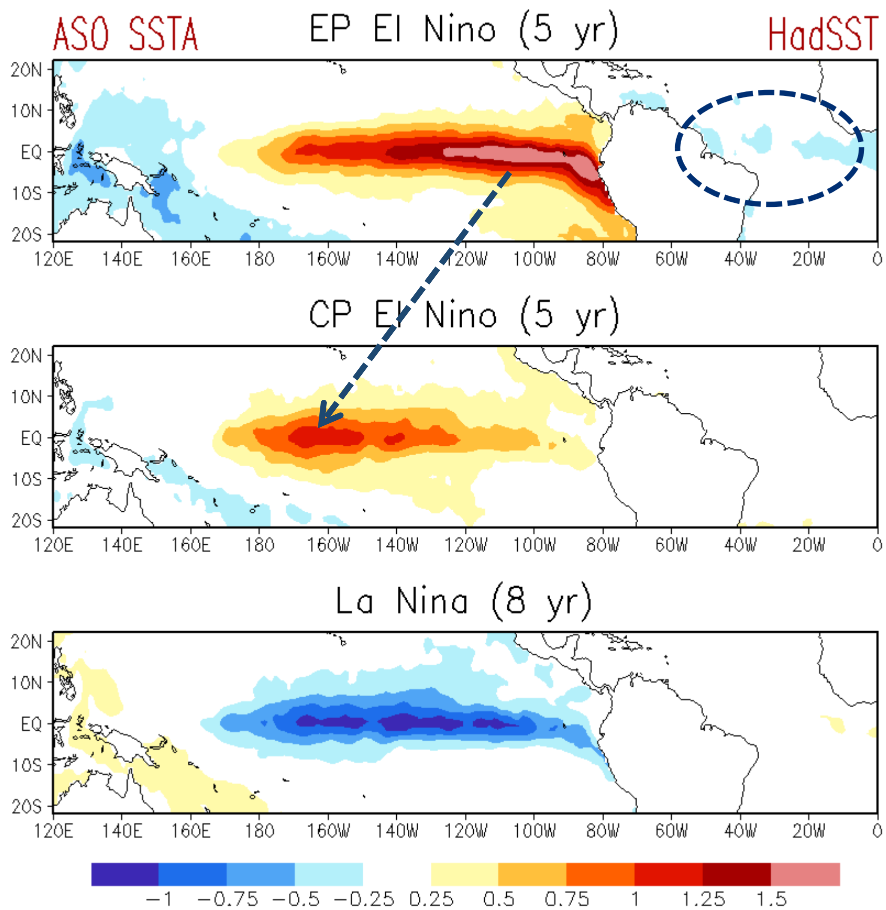
ENSO influence on the variability of Atlantic TCs



Kim, Webster, and Curry, *Science* (2009):
Impact of shifting patterns of Pacific Ocean warming on North Atlantic TCs

US CLIVAR Hurricane Working Group
Interannual Experiments

<u>AMIP runs</u>: 1982–2009 (28 years), prescribed HadSST



ENSO events during 1982–2009

Questions to be addressed

- ❑ How is the overall performance of global climate models in simulating the variability of Atlantic TCs?
- ❑ What are the characteristics of Atlantic TCs associated with ENSO in the models?
- ❑ What are the possible explanations for the differences between the models and OBS?

Models

4 models, **12** ensemble members

Model	Number of runs	Data grid
FSU	3	384×192
GFDL	3	576×360
NASA GSFC	1	576×361
NCEP GFS	5	360×181

Resolution: $0.5^{o} \sim 1^{o}$

MME: (1) ensemble means for each model
(2) average of the individual ensemble means

Data

Observations

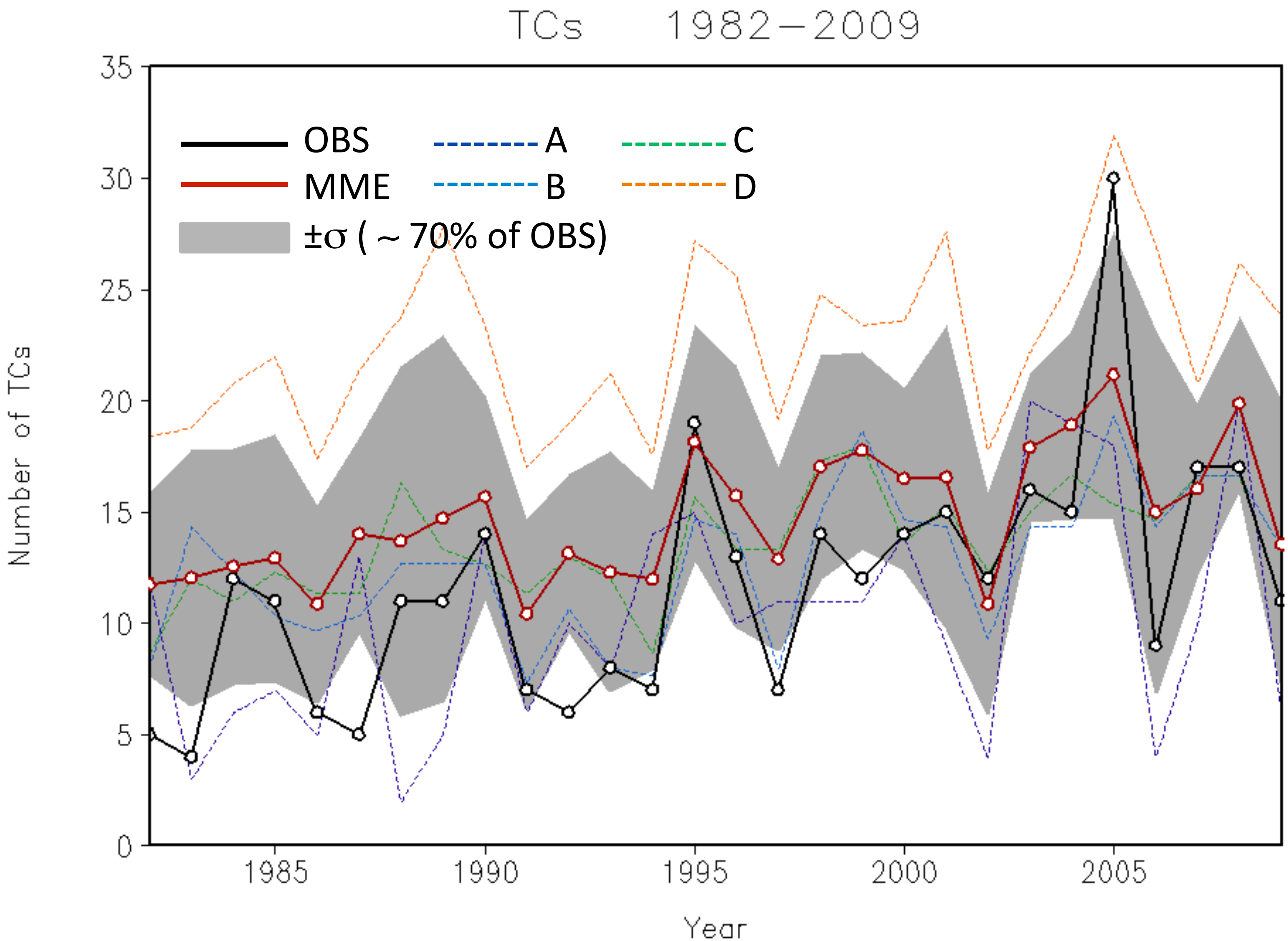
- Best Track Data (HURDAT2)
- HadSST
- CMAP Precipitation
- NCEP–DOE Reanalysis (R2)

Model data

- Track density
- TC origin
- Precipitation
- U200–U850

ASO seasonal mean

TC Time Series



A, B, C, D – ensemble mean of individual models
MME – average of the ensemble means of individual models

TC Statistics

	Mean	Trend	AC	RMSE	Rank
OBS	11.7	3.9			
MME	14.8 4	2.1 4	0.82 1	4.6 3	2
Model **A**	10.3 2	2.5 1	0.53 5	5.3 4	3
Model **B**	12.7 1	2.2 2	0.73 3	3.8 1	1
Model **C**	13.5 3	1.7 5	0.60 4	4.7 2	4
Model **D**	22.7 5	2.2 3	0.75 2	11.5 5	5

Rank

AC – anomaly correlation
Trend – increase of TCs per decade
MME – average of ensemble means of all individual models

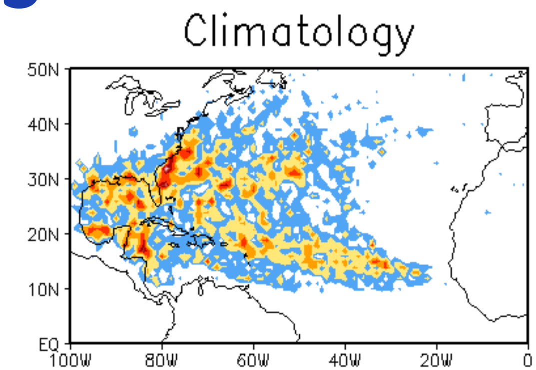
TC Statistics

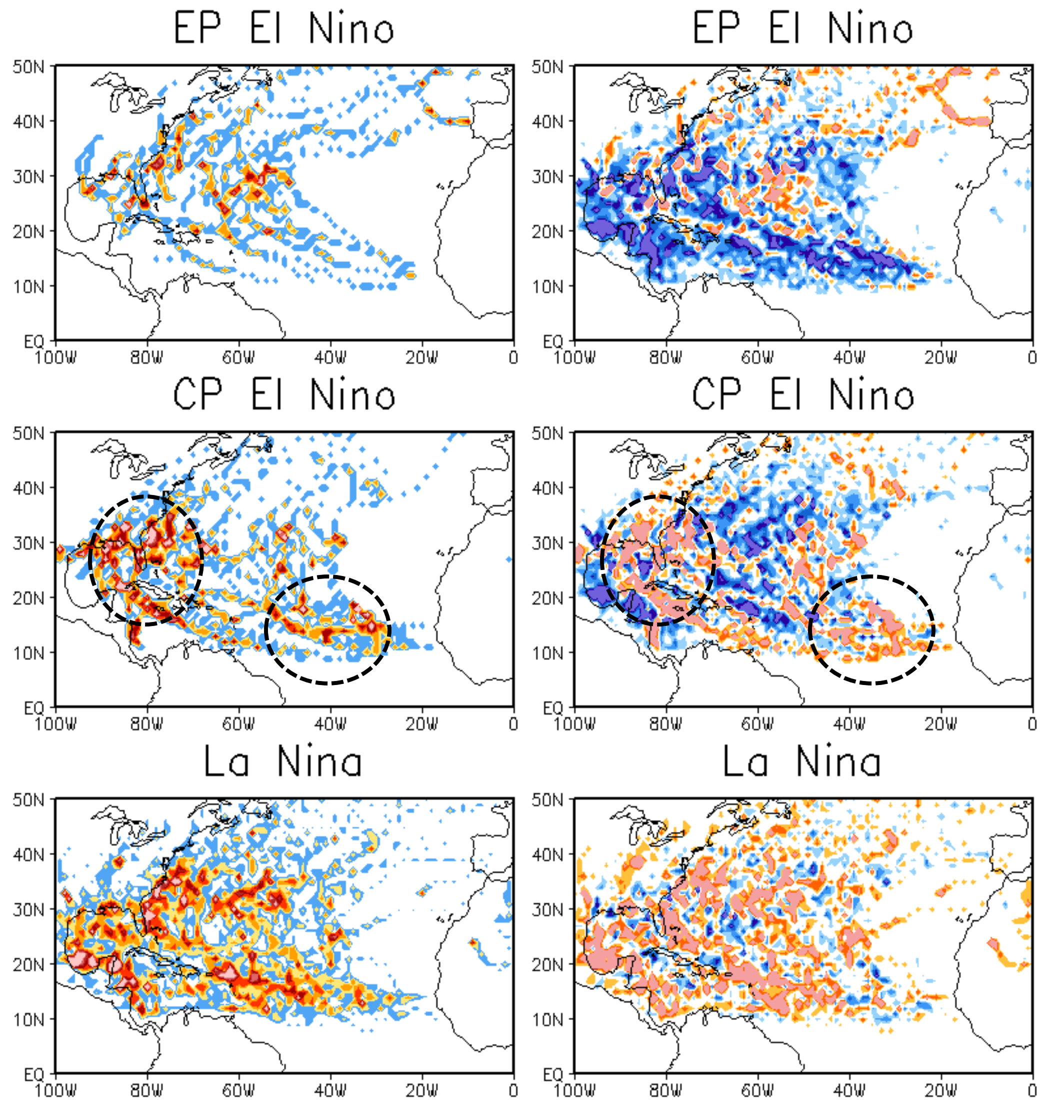
Number of TCs (per season)

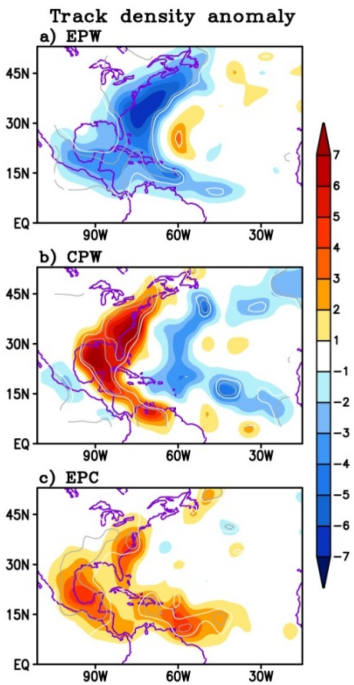
	Mean	EP El Nino		CP El Nino		La Nina	
OBS	11.7	6.8	58%	10.0	85%	14.9	127%
MME	14.8	12.2	82%	13.9	94%	16.0	109%
Model **A**	10.3	7.6	74%	11.2	109%	9.5	93%
Model **B**	12.7	9.5	75%	11.0	87%	15.5	122%
Model **C**	13.5	11.8	88%	12.0	89%	15.3	113%
Model **D**	22.7	19.8	87%	21.2	94%	23.9	105%

Mean – 1982–2009 climatology
ENSO – mean value for each ENSO category
% – percent of climatological mean value

OBS





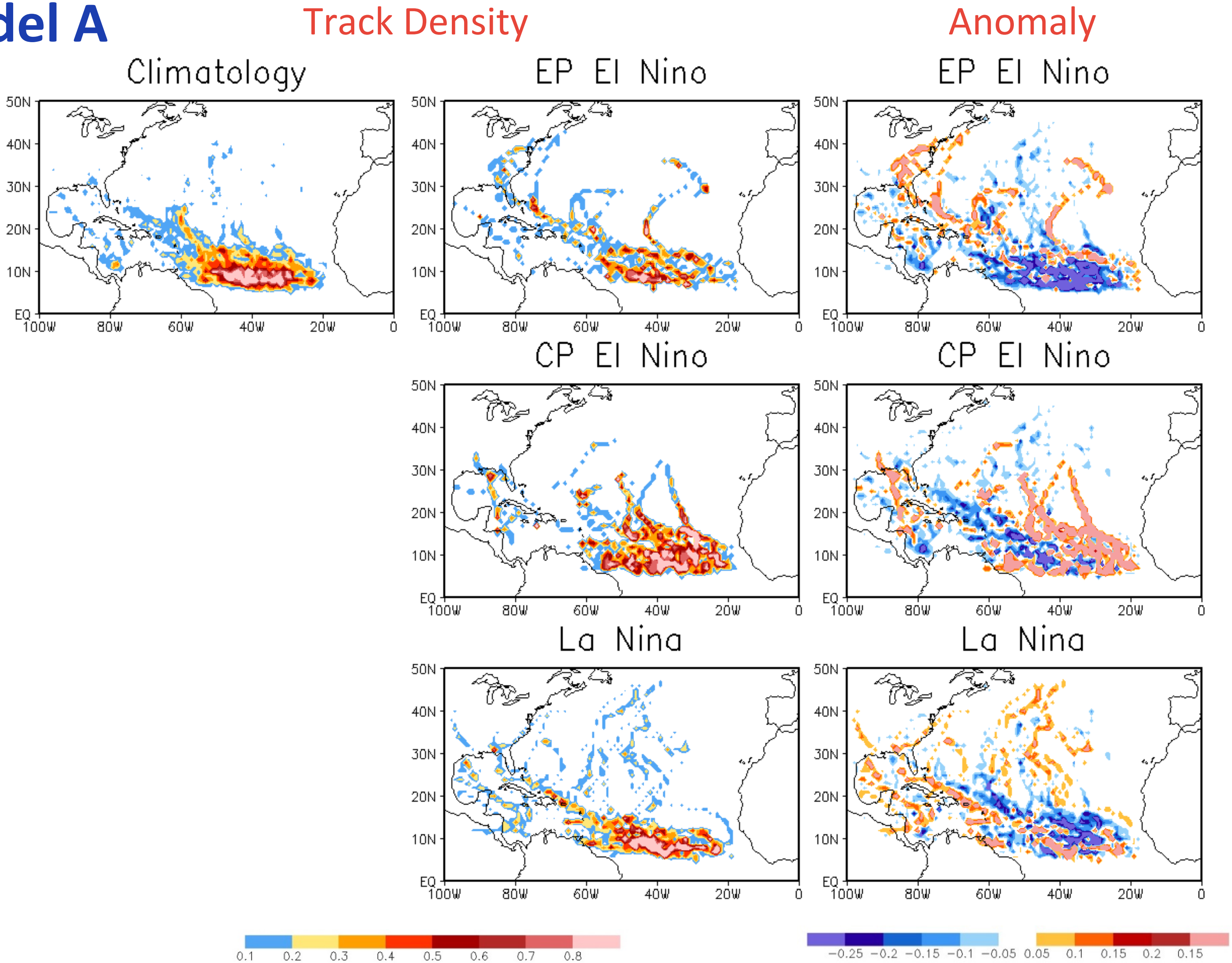


Kim et al. (2009)

Sampling issue

Grid for track density (1° × 1°)

Model A

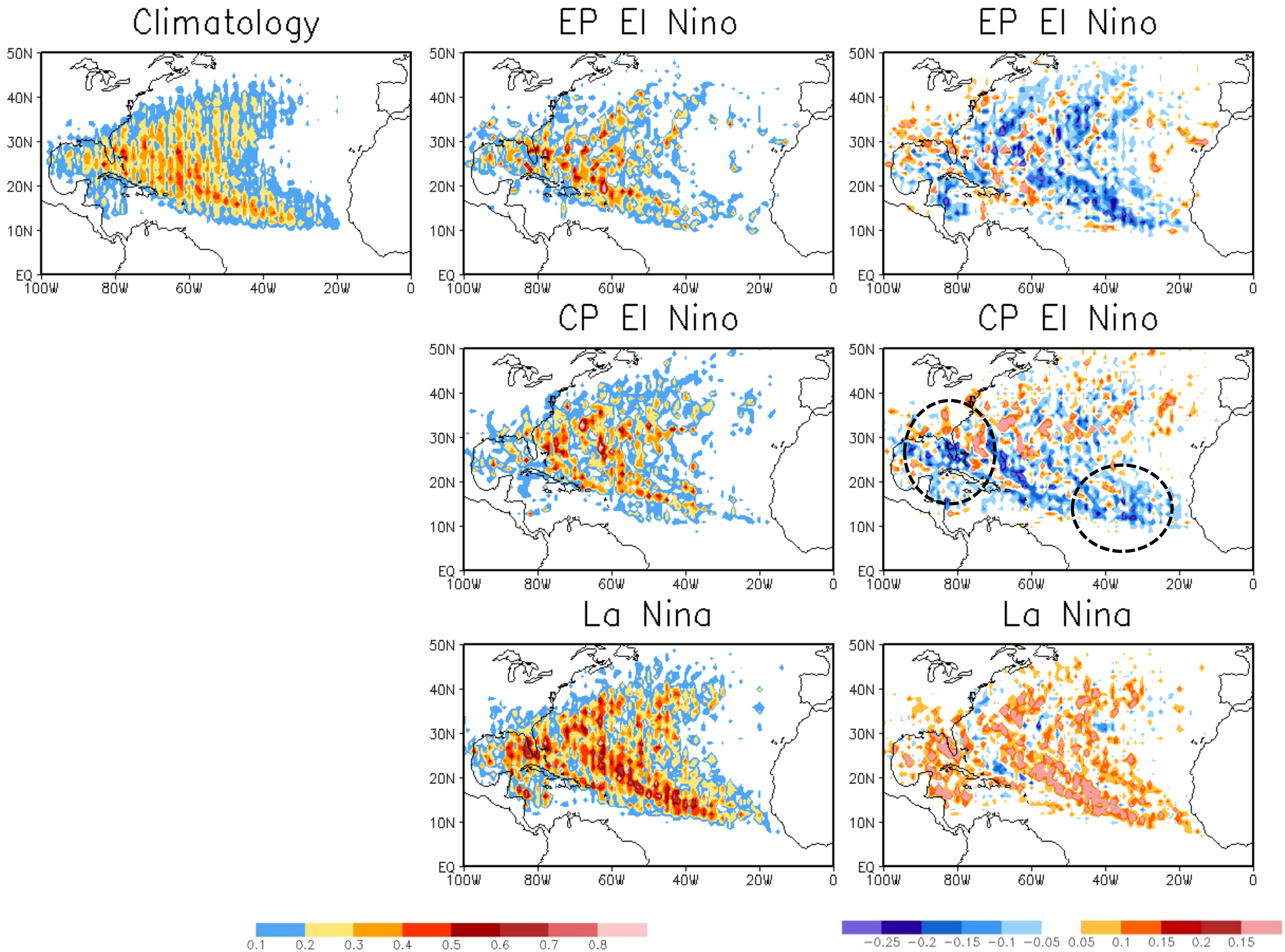


Ensemble mean for each model

Model B

Track Density

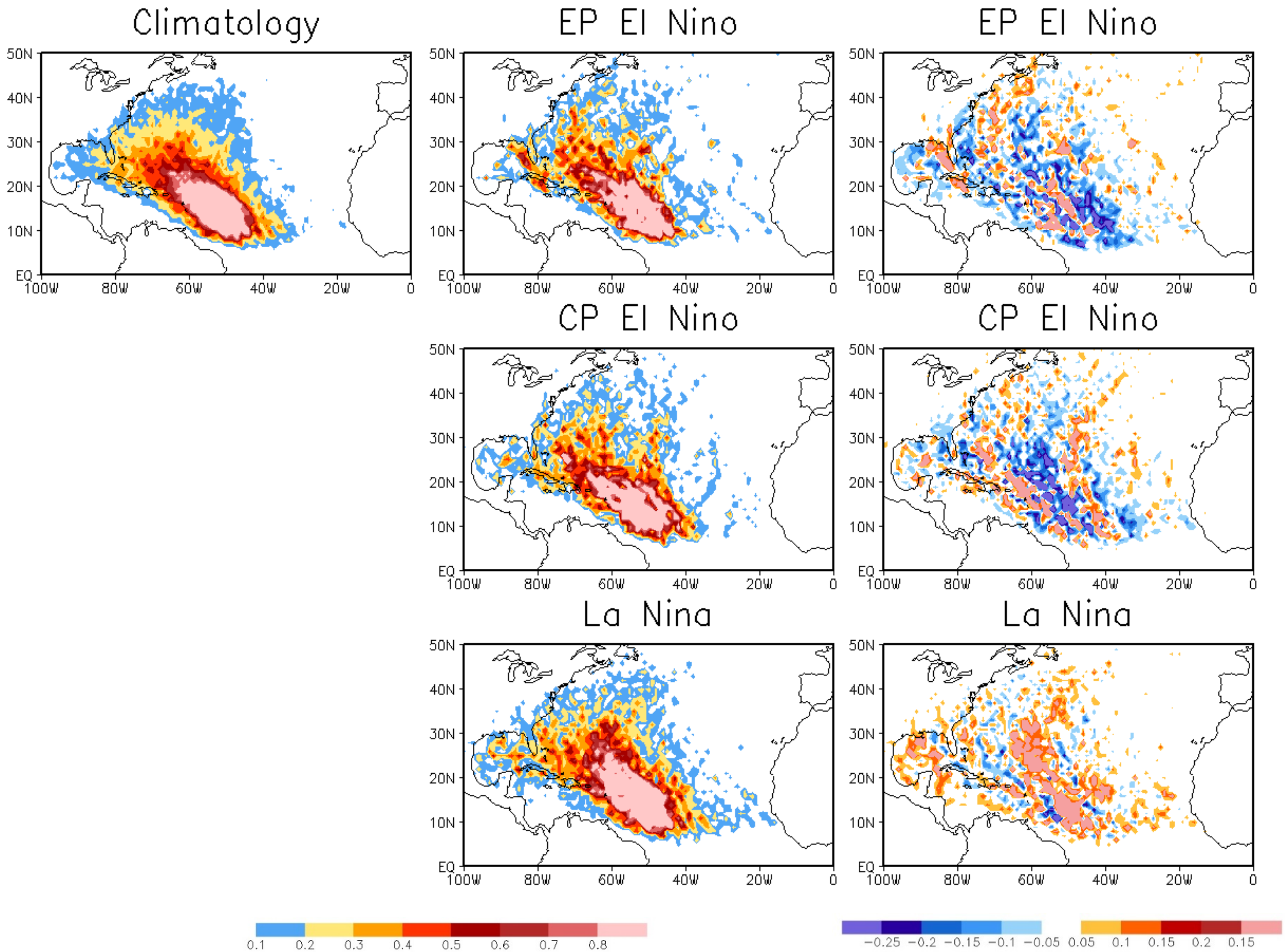
Anomaly



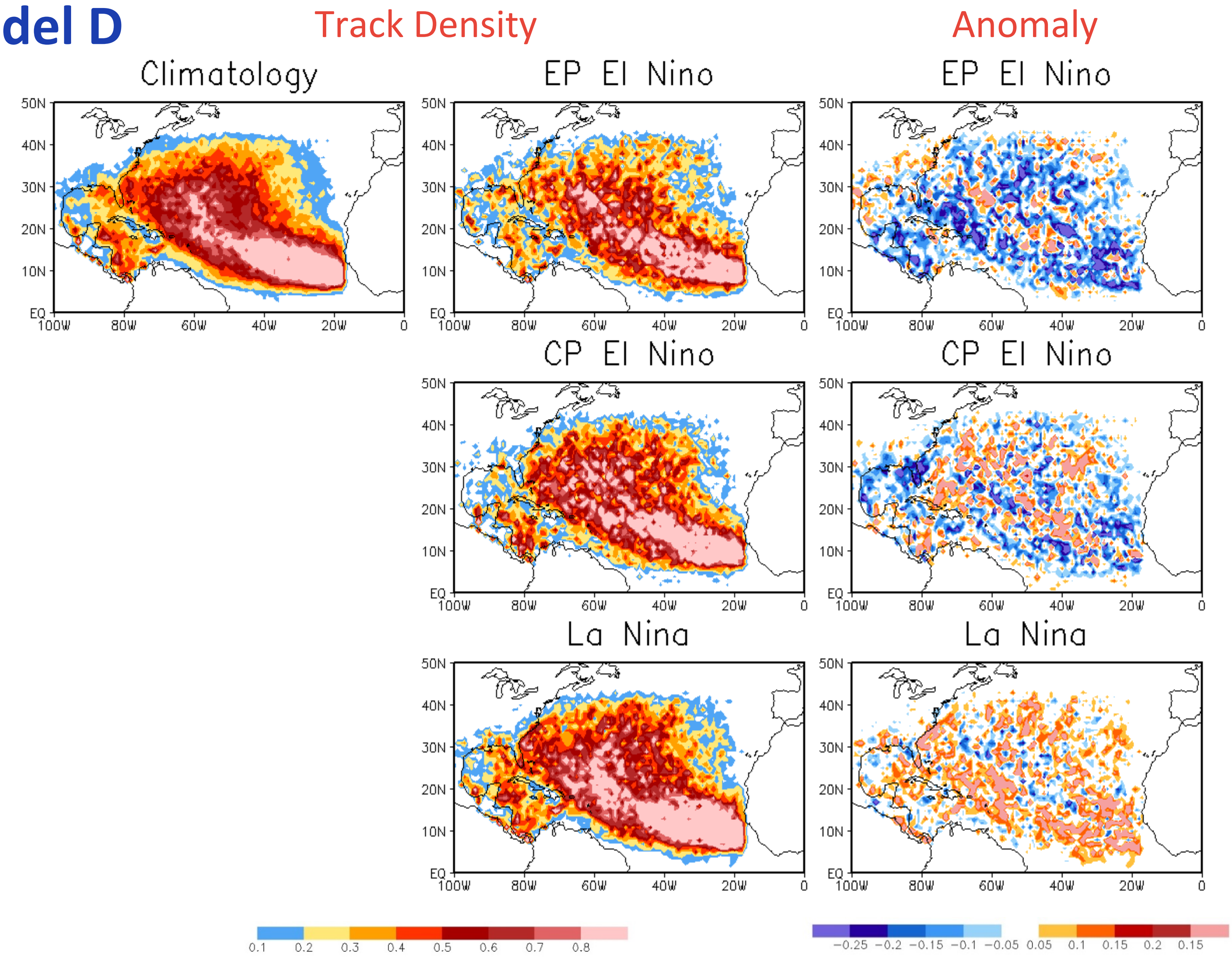
Model C

Track Density

Anomaly



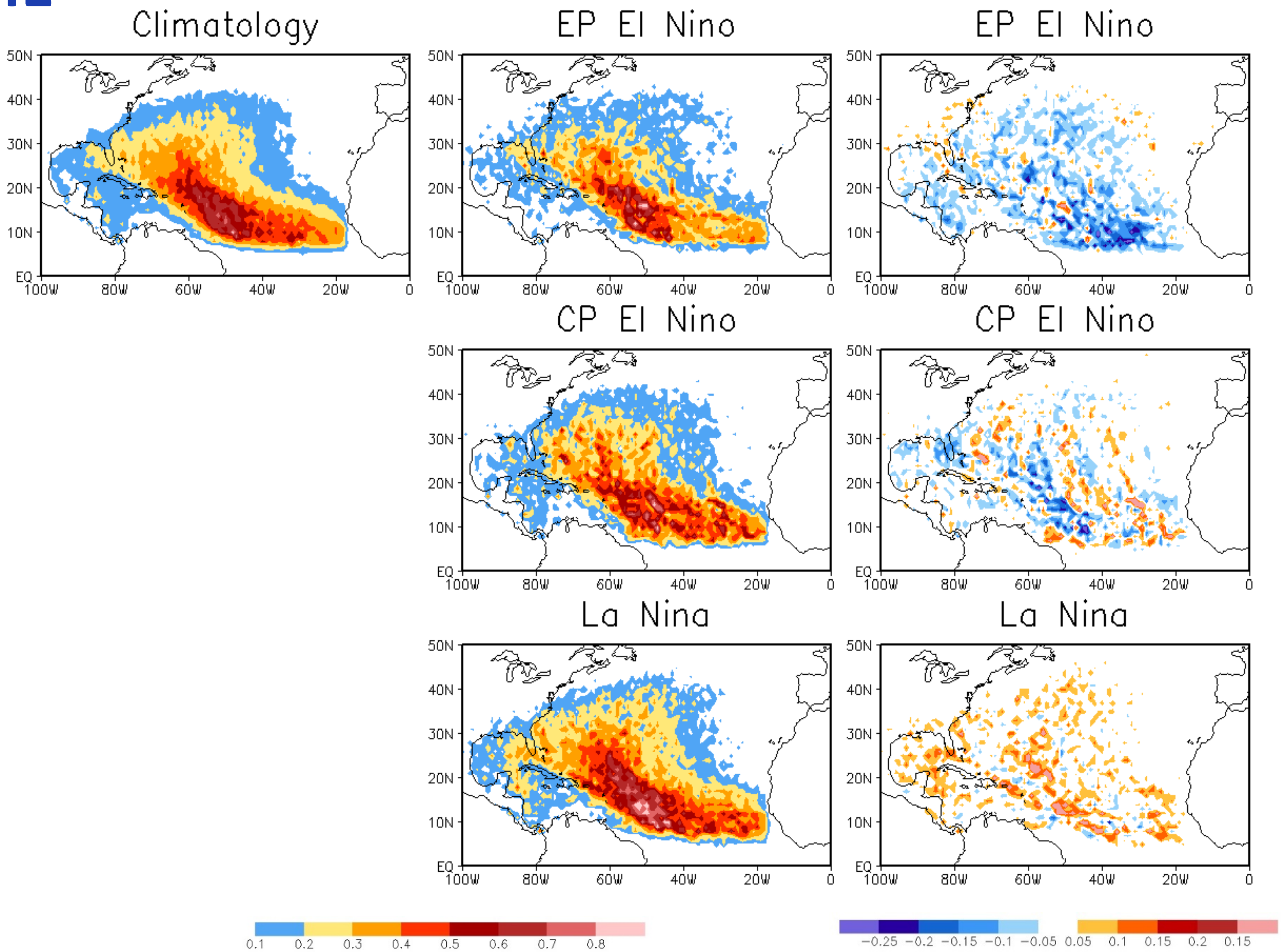
Model D



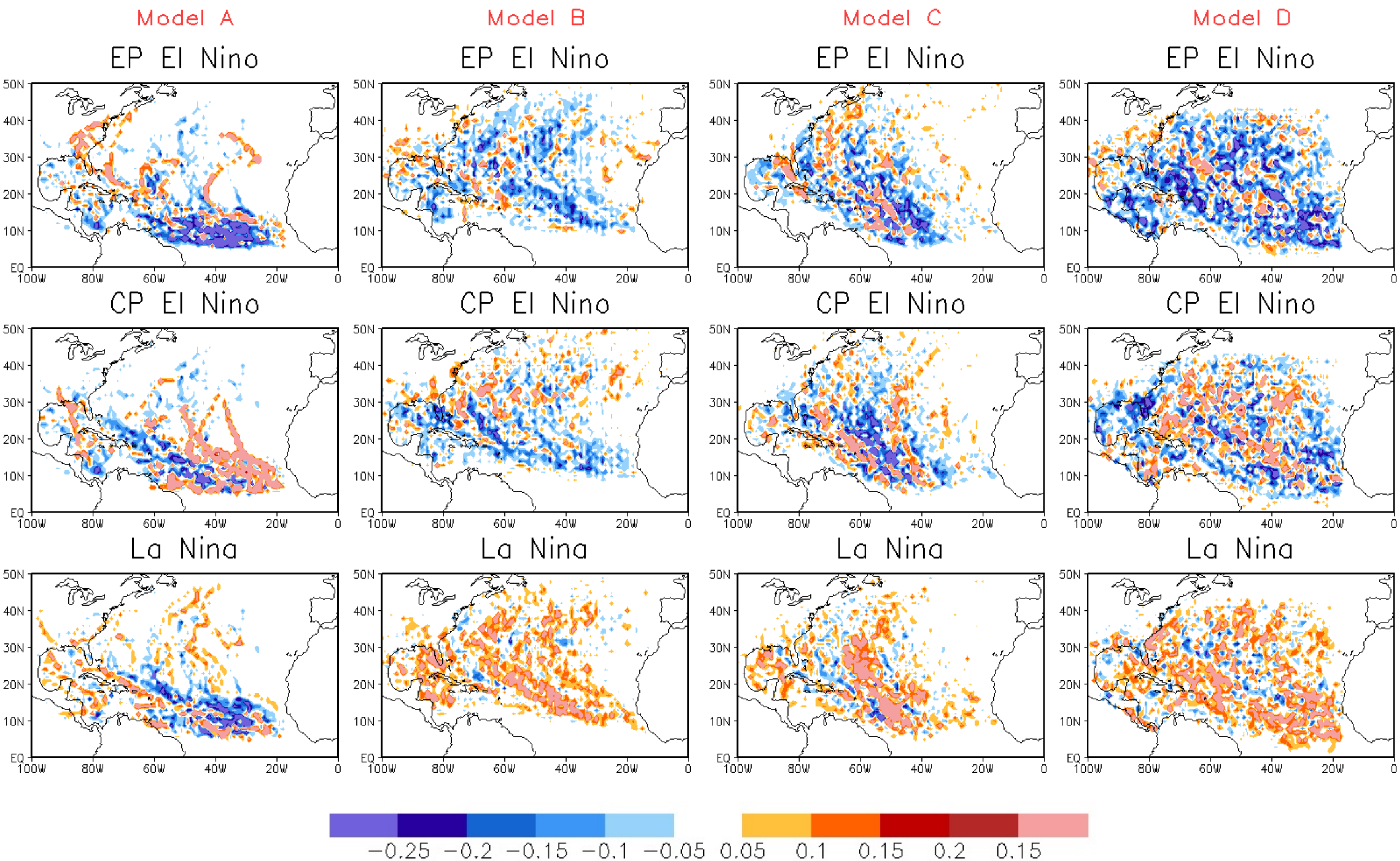
Track Density
Anomaly
Climatology
EP El Nino
EP El Nino
CP El Nino
CP El Nino
La Nina
La Nina
50N
40N
30N
20N
10N
EQ
100W
80W
60W
40W
20W
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
−0.25
−0.2
−0.15
−0.1
−0.05
0.05
0.1
0.15
0.2
0.15

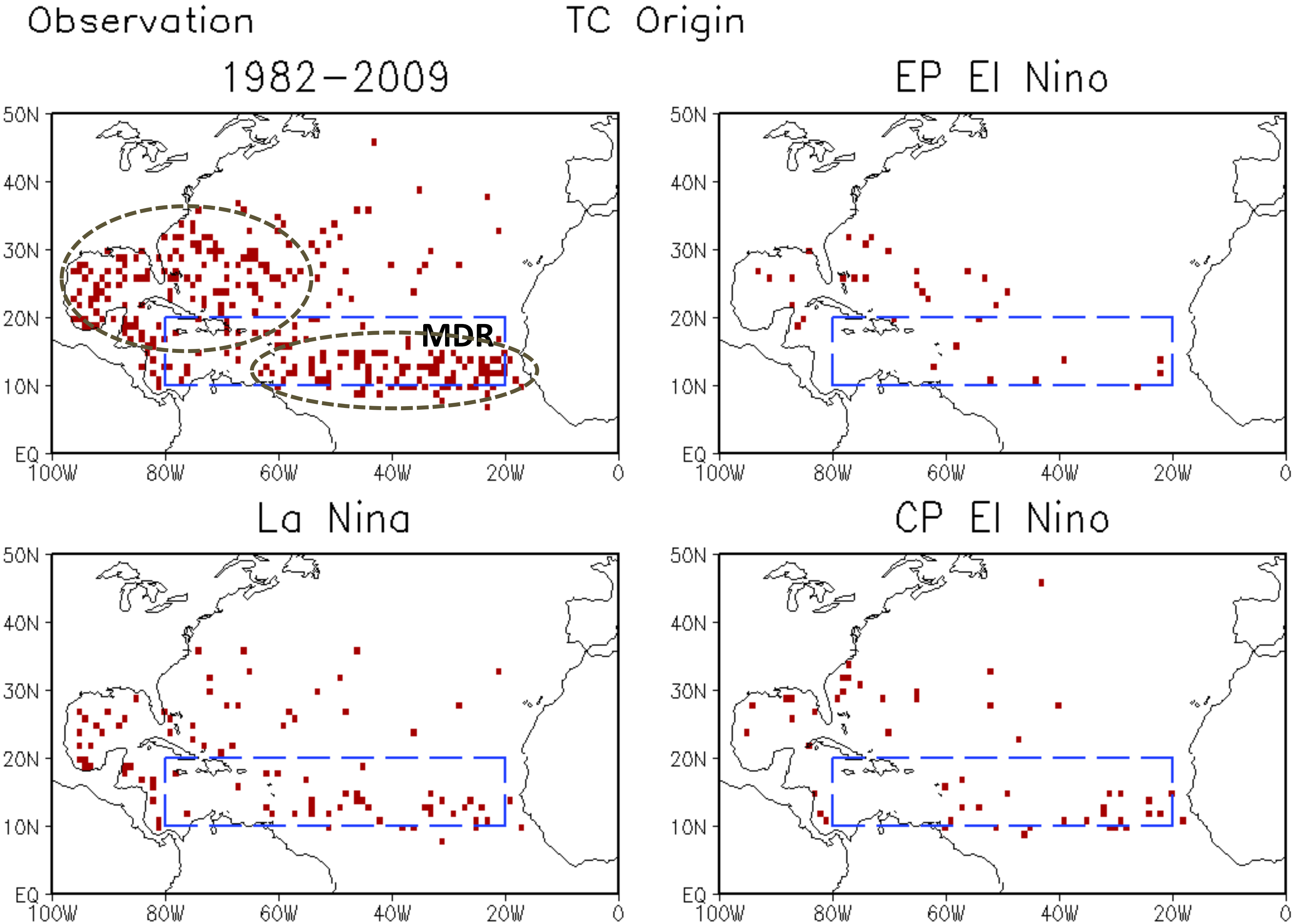
MME

Track Density | Anomaly



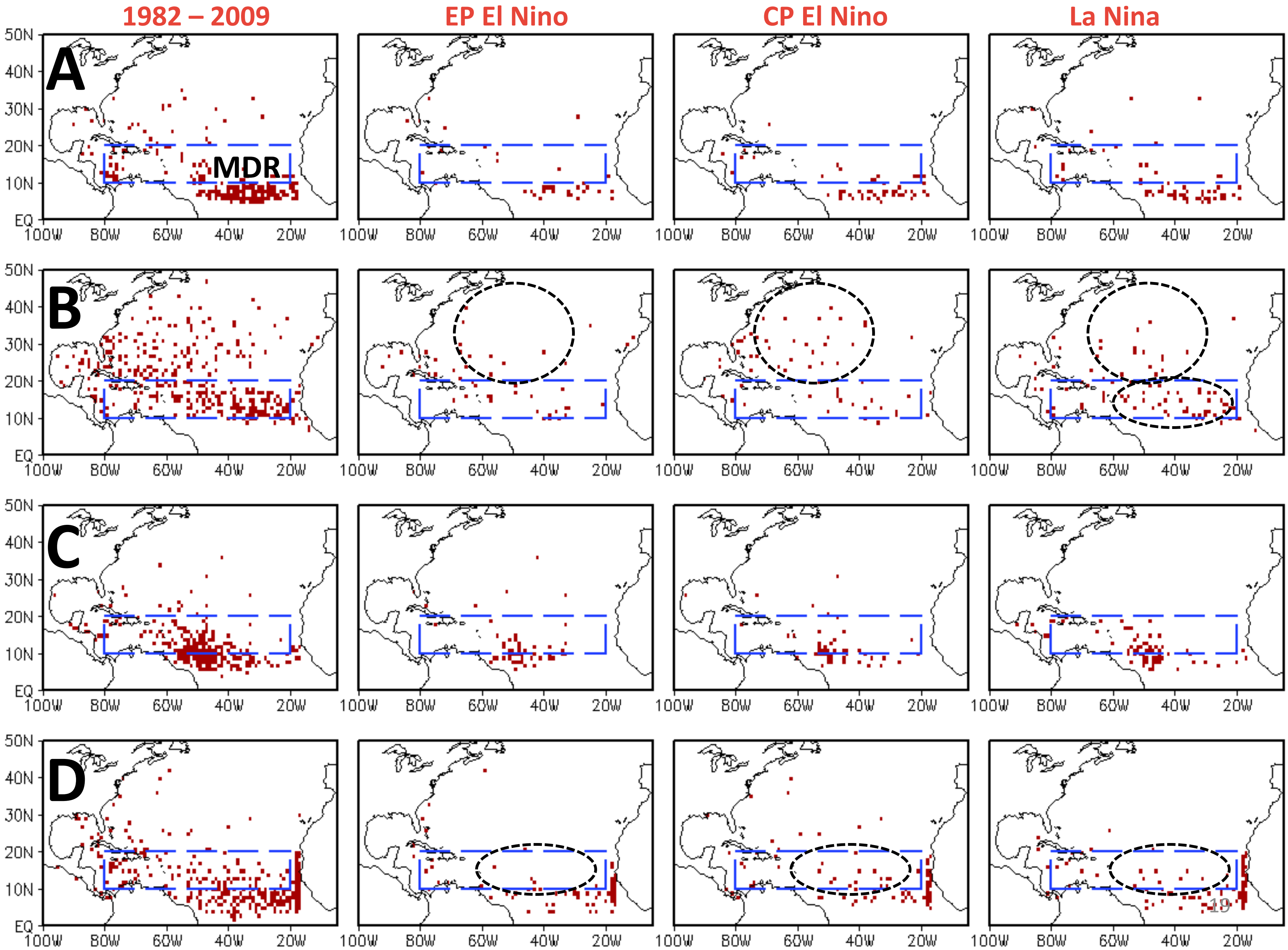
Track Density Anomaly





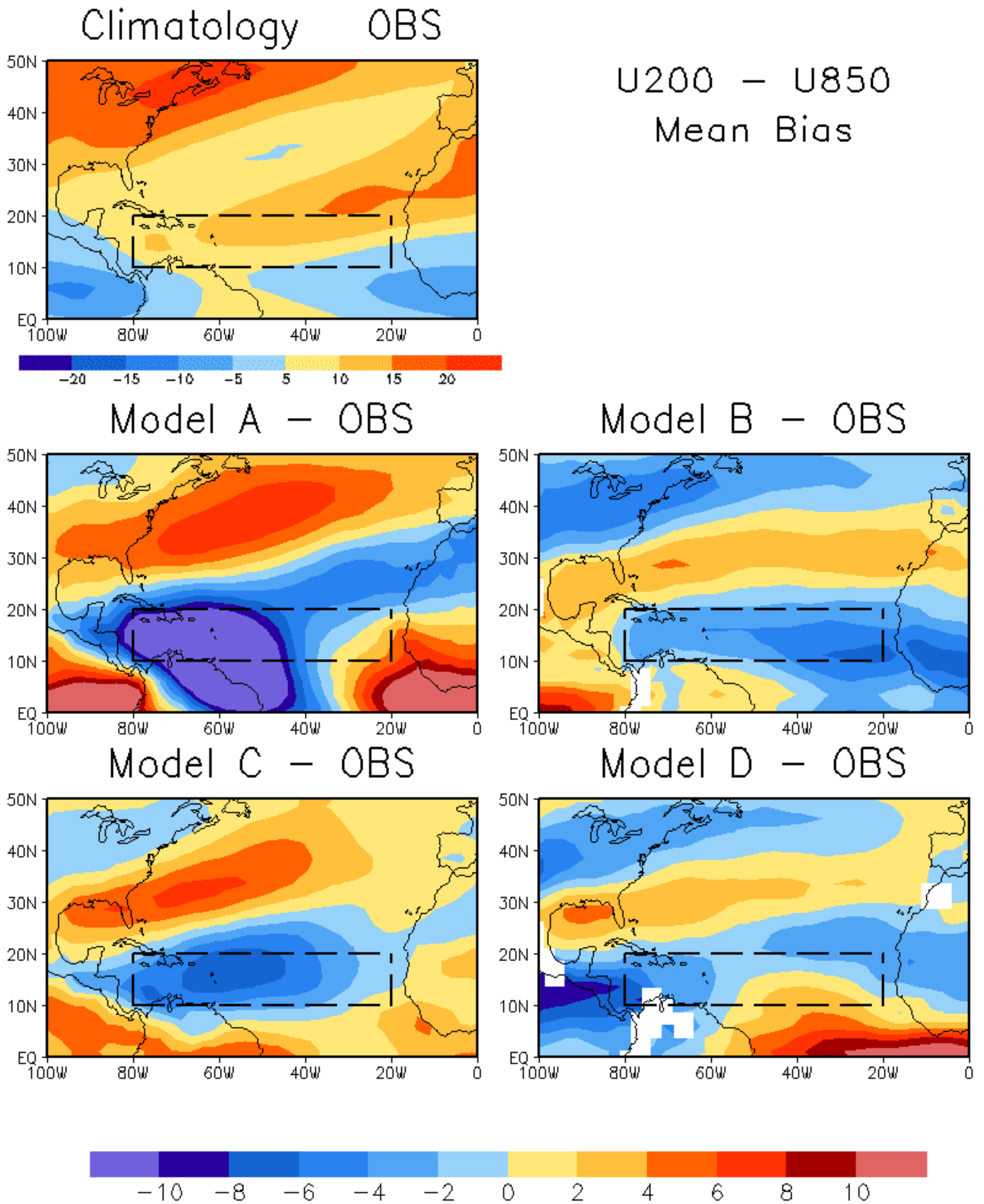
5-yr total for each ENSO category

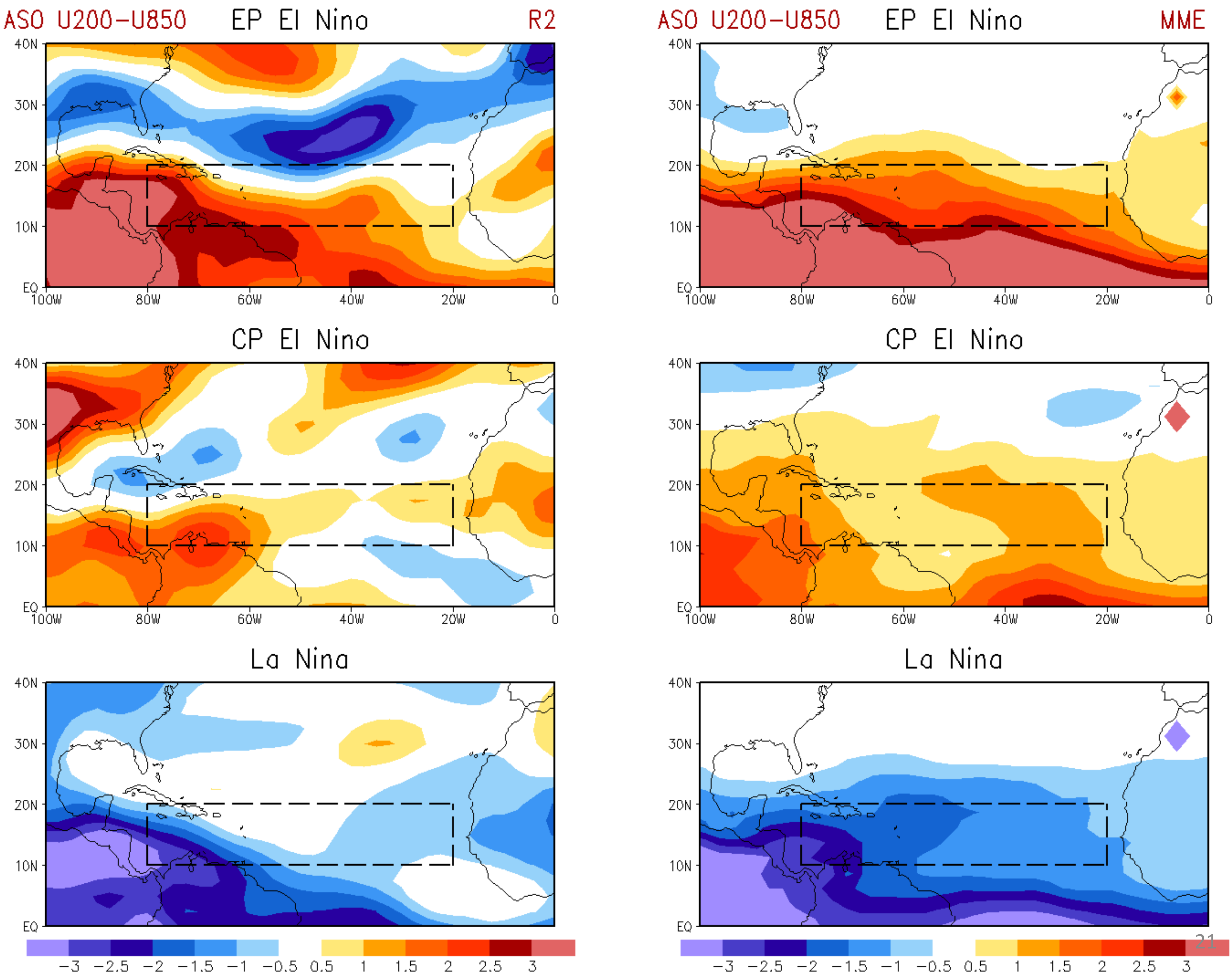
TC Origin



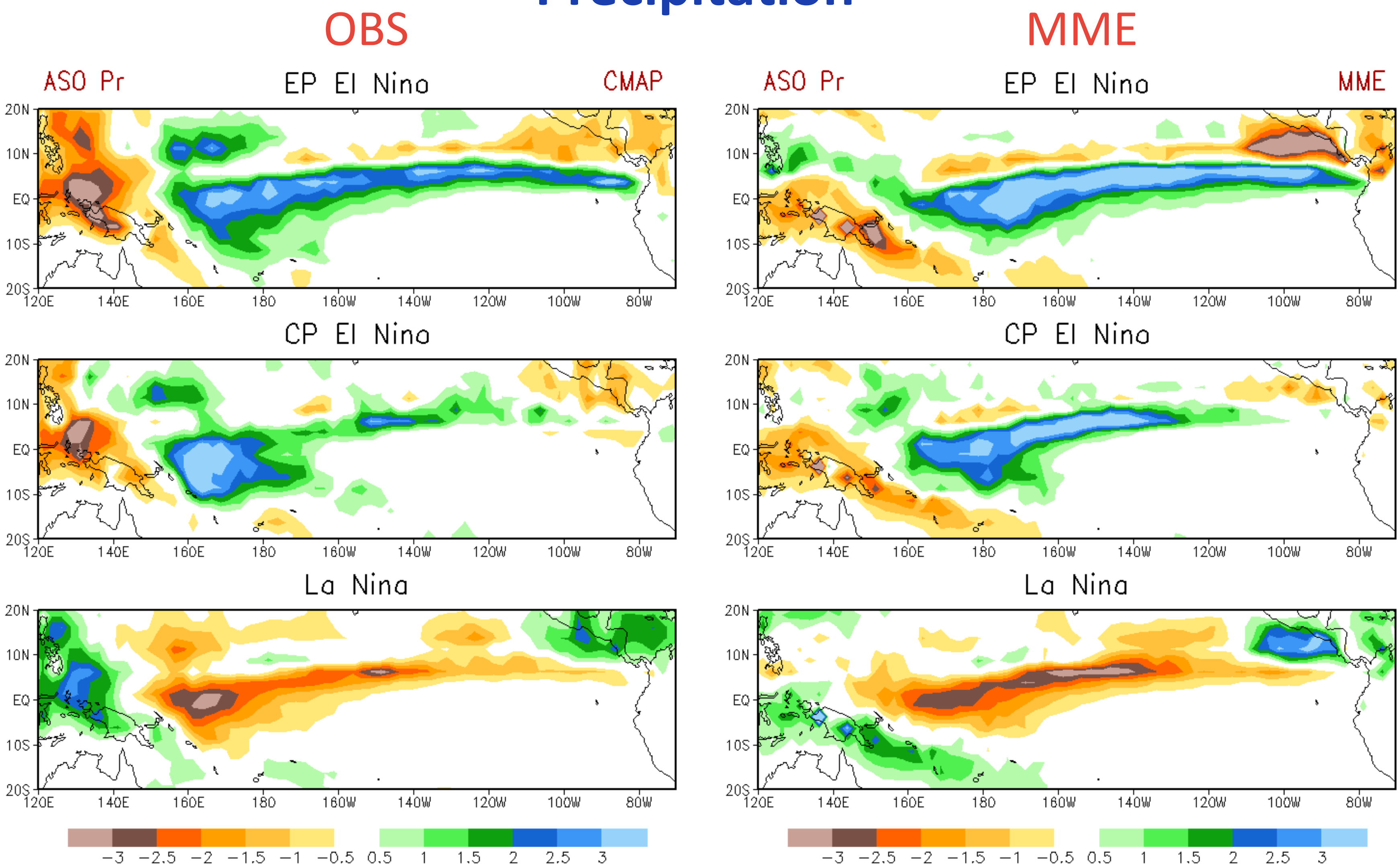
1982 – 2009
EP El Nino
CP El Nino
La Nina
A
B
C
D
MDR
50N
40N
30N
20N
10N
EQ
100W
80W
60W
40W
20W

ASO U200–U850

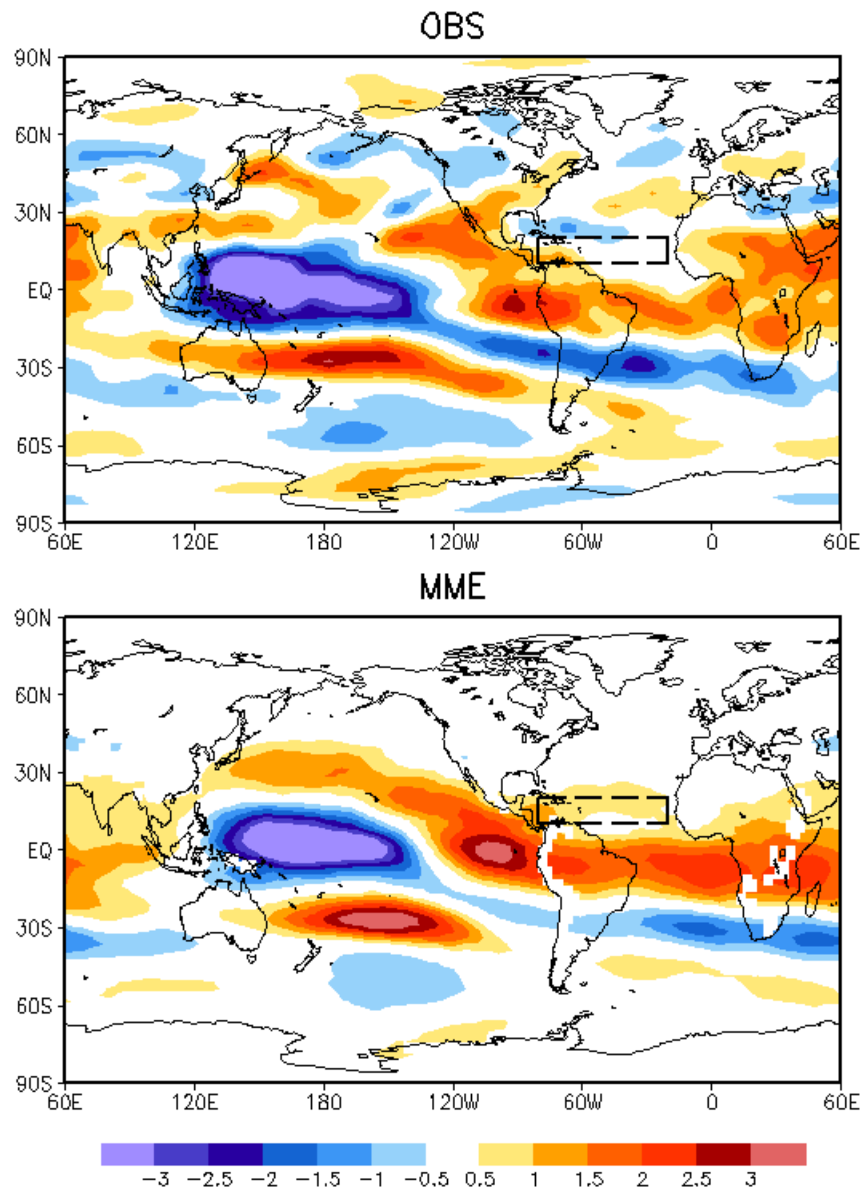



ASO U200-U850
EP El Nino
R2
MME
CP El Nino
La Nina
40N
30N
20N
10N
EQ
100W
80W
60W
40W
20W
0
-3 -2.5 -2 -1.5 -1 -0.5 0.5 1 1.5 2 2.5 3

Precipitation



ASO U200 – U850



Changes in vertical wind shear associated with the shift of El Nino SSTA from Nino3 region to Nino4

Conclusions

1. Each model has different mean biases in terms of track density and TC origin. Model B is the best model.
2. The MME has the highest anomaly correlation (AC) for TCs.
3. Overall the models simulate the variability of Atlantic TCs well with weaker activities during EP El Niño and stronger activities during La Niña.
4. For CP El Niño, there is an increase in TCs as compared with EP El Niño . The spatial distribution is less consistent among the models.
5. The differences between the models and OBS may be due to the mean bias, as well as the bias of circulation response to the shift of tropical heating associated with CP El Niño.