MJO and tropical cyclone prediction in a new version of GFDL coupled model

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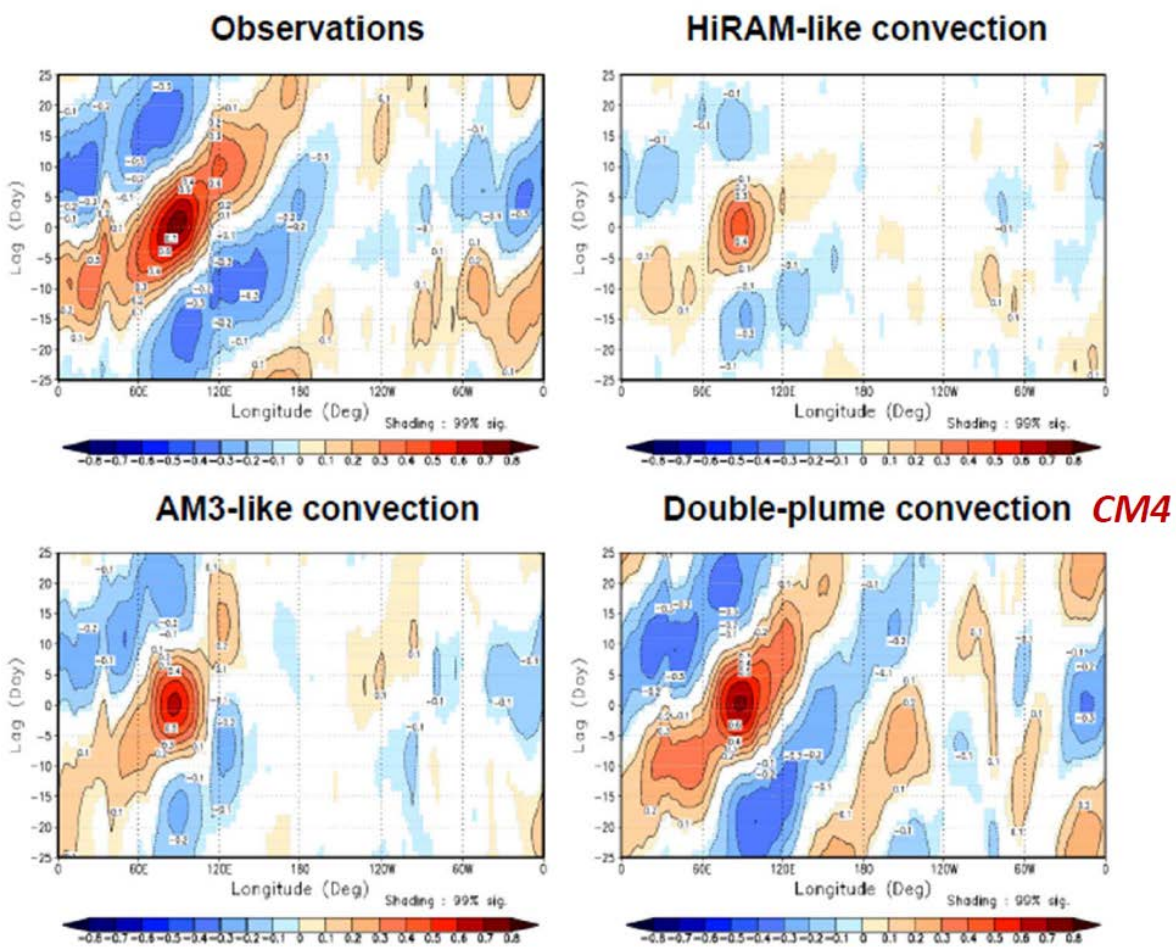
1. Modulation of Tropical Cyclone Activity over the Intra-Americas Sea by Intra-seasonal variability: implications for dynamical TC prediction on intraseasonal time scales
2. Seasonal prediction of landfall hurricanes (Sandy supplemental)

Model

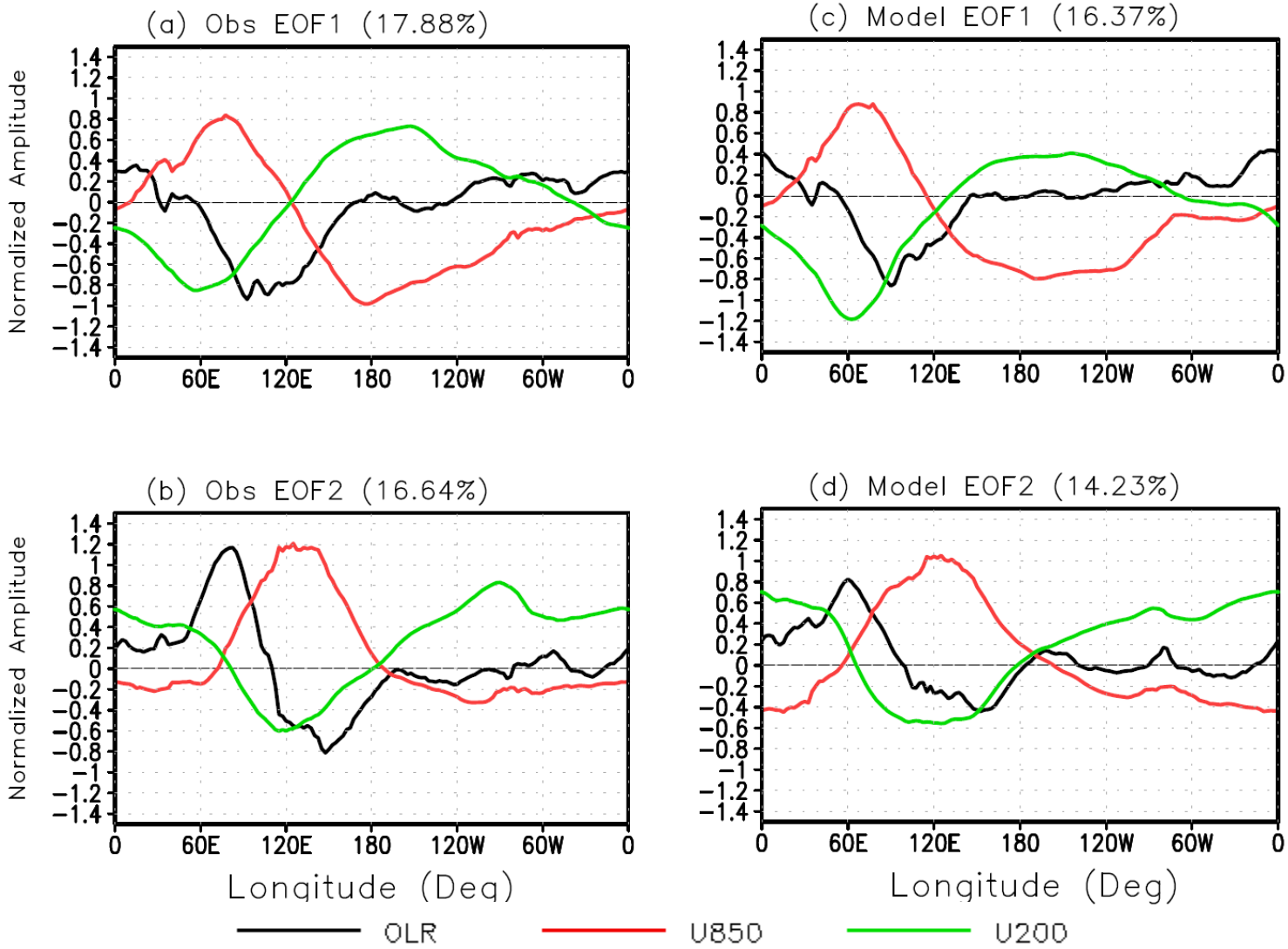
Similar to CM2.5 (Delworth et al. 2012) but with different Convection Scheme:

50km Cubed-sphere atmosphere & 1 degree ocean/sea ice



Zhao et al. in preparation

Combined EOF analysis of the tropical (15S-15N) OLR, U850, U200



Observations **Model**

Hindcast experiments
(11 years: 2003 to 2013)

Methodology:

Nudging AGCM to GFS analysis data (U, V, Surface Pressure, Temperature)

Nudging SST to NOAA daily SST

Initialized at every 1st, 6th, 11th, 16th, 21st, 26th for each month during November-April (NDJFMA)

6 ensemble members

Totally, we have 6d*6m*11y=396 events

396*6 ens=2376 forecasts

Based on this, we evaluate the MJO prediction skill by using the bivariate anomaly correlation coefficient (ACC) (Lin et al. 2008).

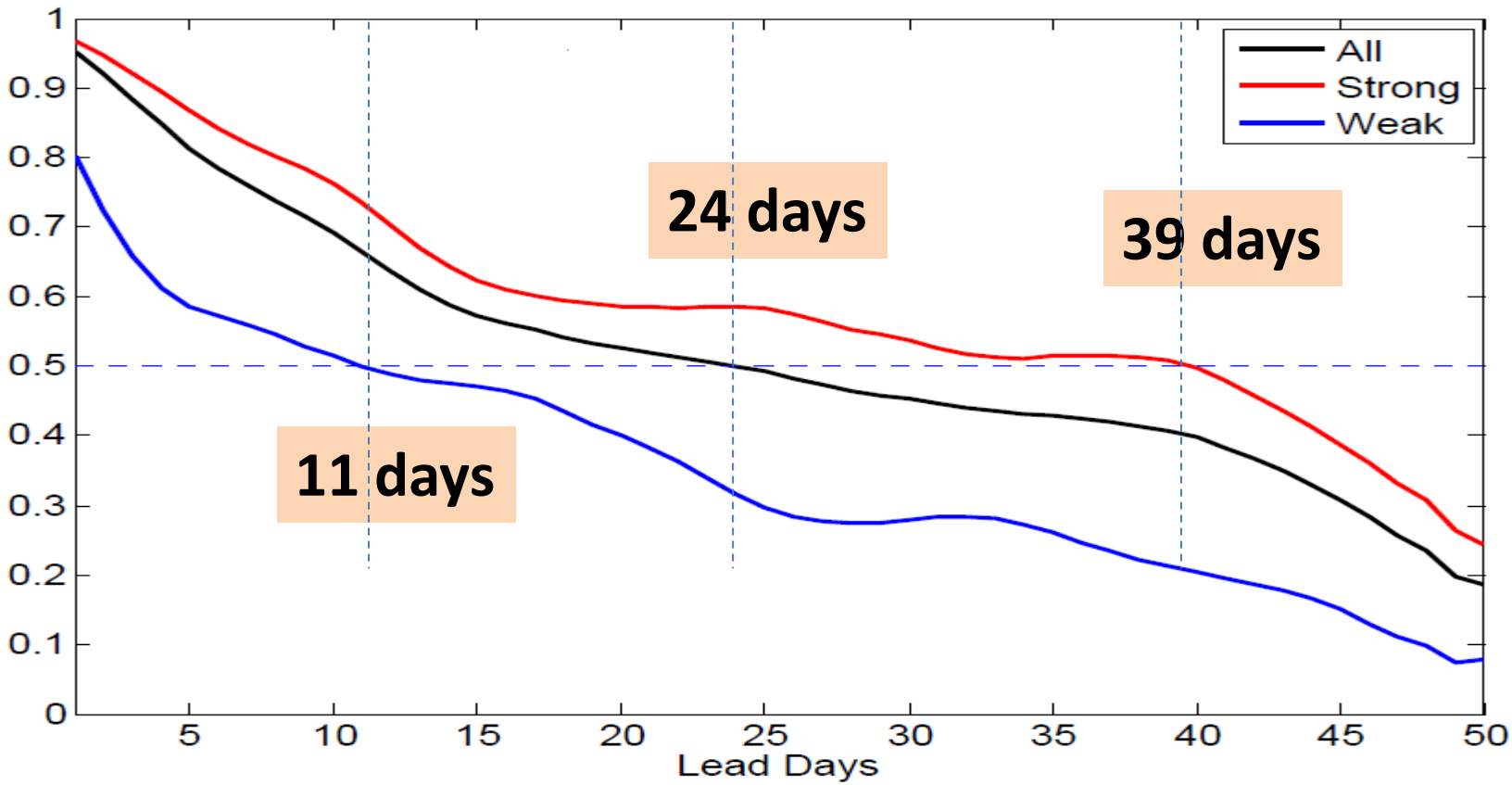
$$\mathrm{ACC}(\tau) = \frac{\sum_{t=1}^{N}[a_1(t)b_1(t,\tau) + a_2(t)b_2(t,\tau)]}{\sqrt{\sum_{t=1}^{N}[a_1^2(t) + a_2^2(t)]}\sqrt{\sum_{t=1}^{N}[b_1^2(t,\tau) + b_2^2(t,\tau)]}}$$

$$ERR_{phs}(\tau) = \frac{1}{N}\sum_{t=1}^{N} tan^{-1}\left(\frac{a_1b_2 + a_2b_1}{a_1b_1 + a_2b_2}\right)$$

Here $a_1(t)$ and $a_2(t)$ are the verification RMM1 and RMM2 at time t $b_1(t,\tau)$ and $b_2(t,\tau)$ are the corresponding forecasts for time t for a lead time of τ days.

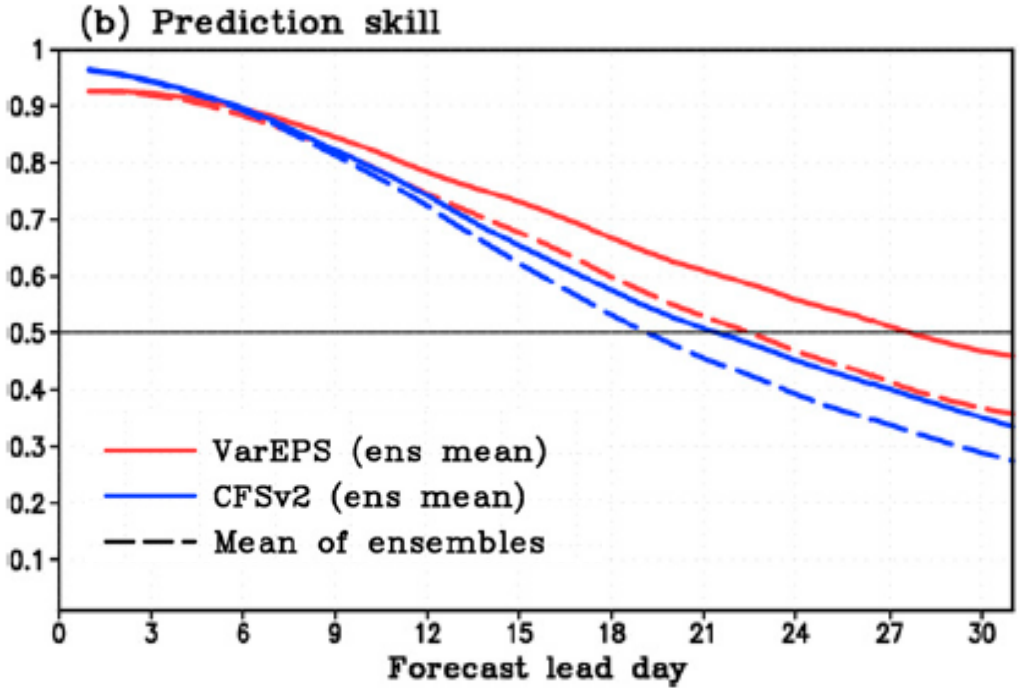
Lin et al. 2008; Rashid et al. 2011

The bivariate Anomaly Correlation Skill (2003-2013)

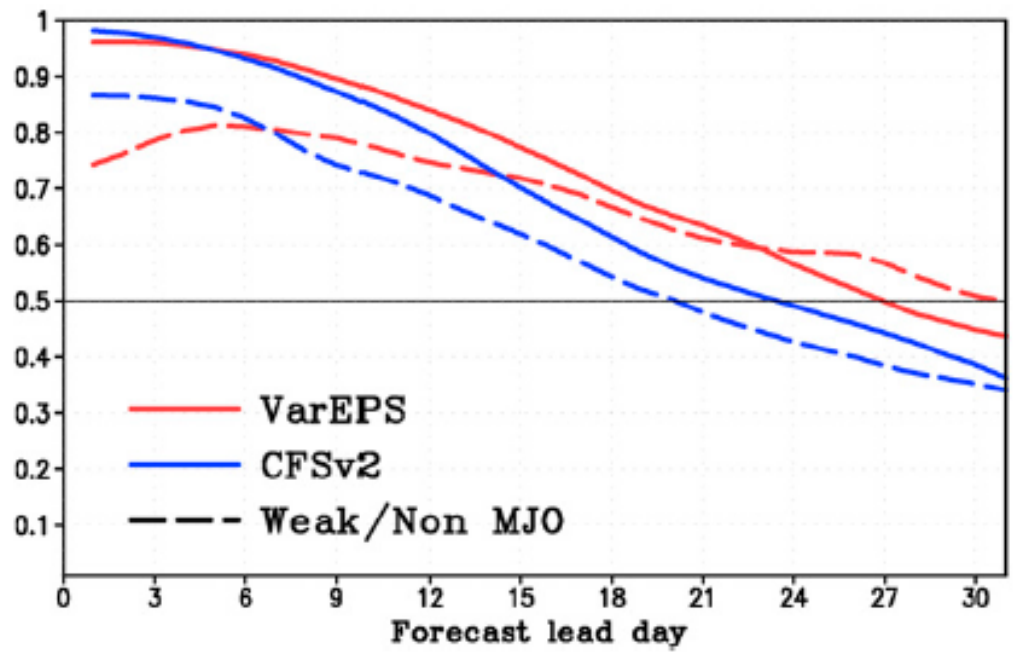


All: 396 events

Strong: 239 events (60%); Weak: 157 events (40%)



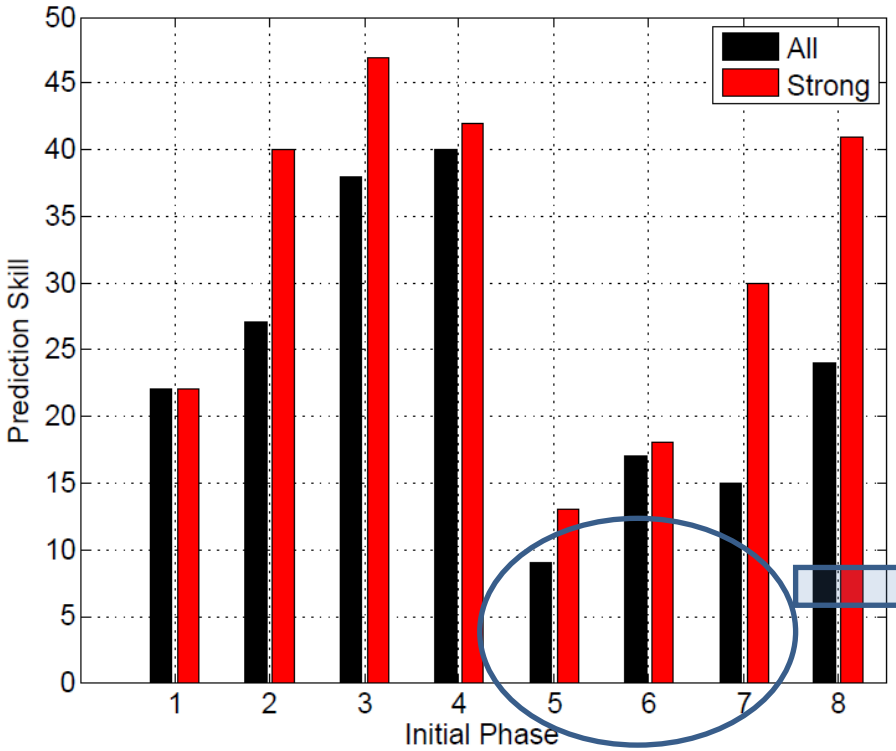
ECMWF: 27 days
NCEP CFSv2: 21 days

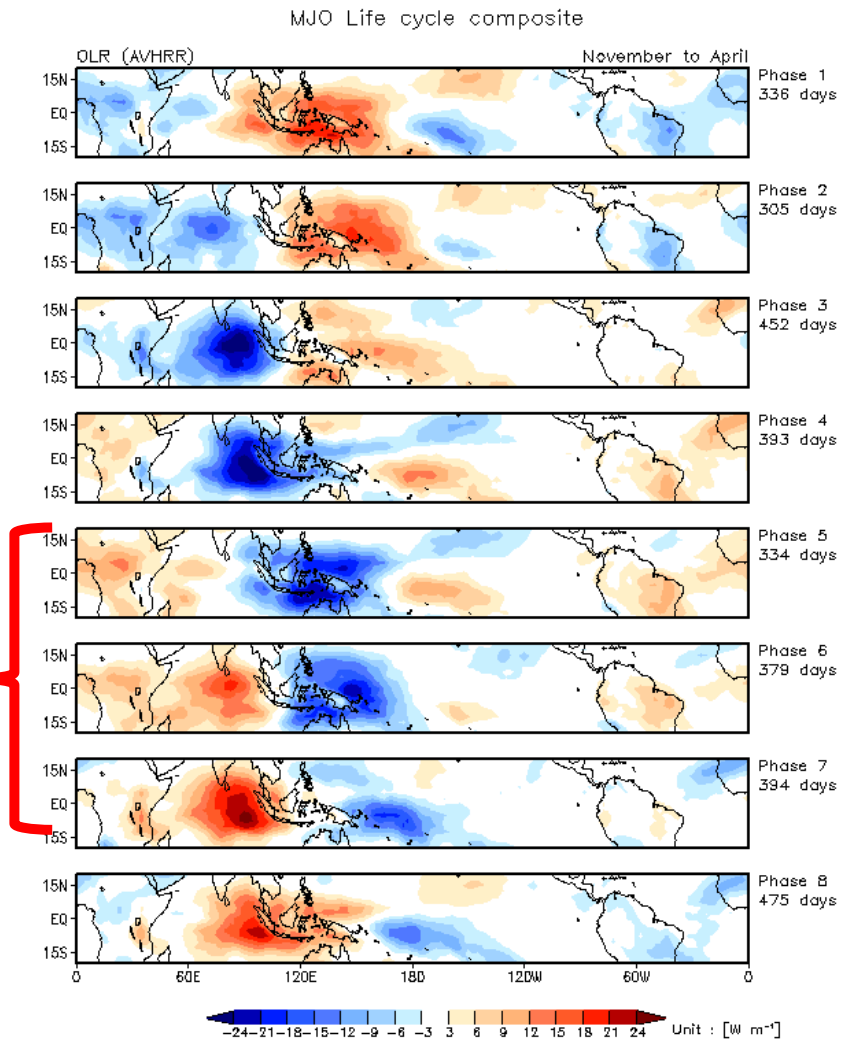


The skill does not vary much for initially strong and weak MJO events

Kim et al. 2014

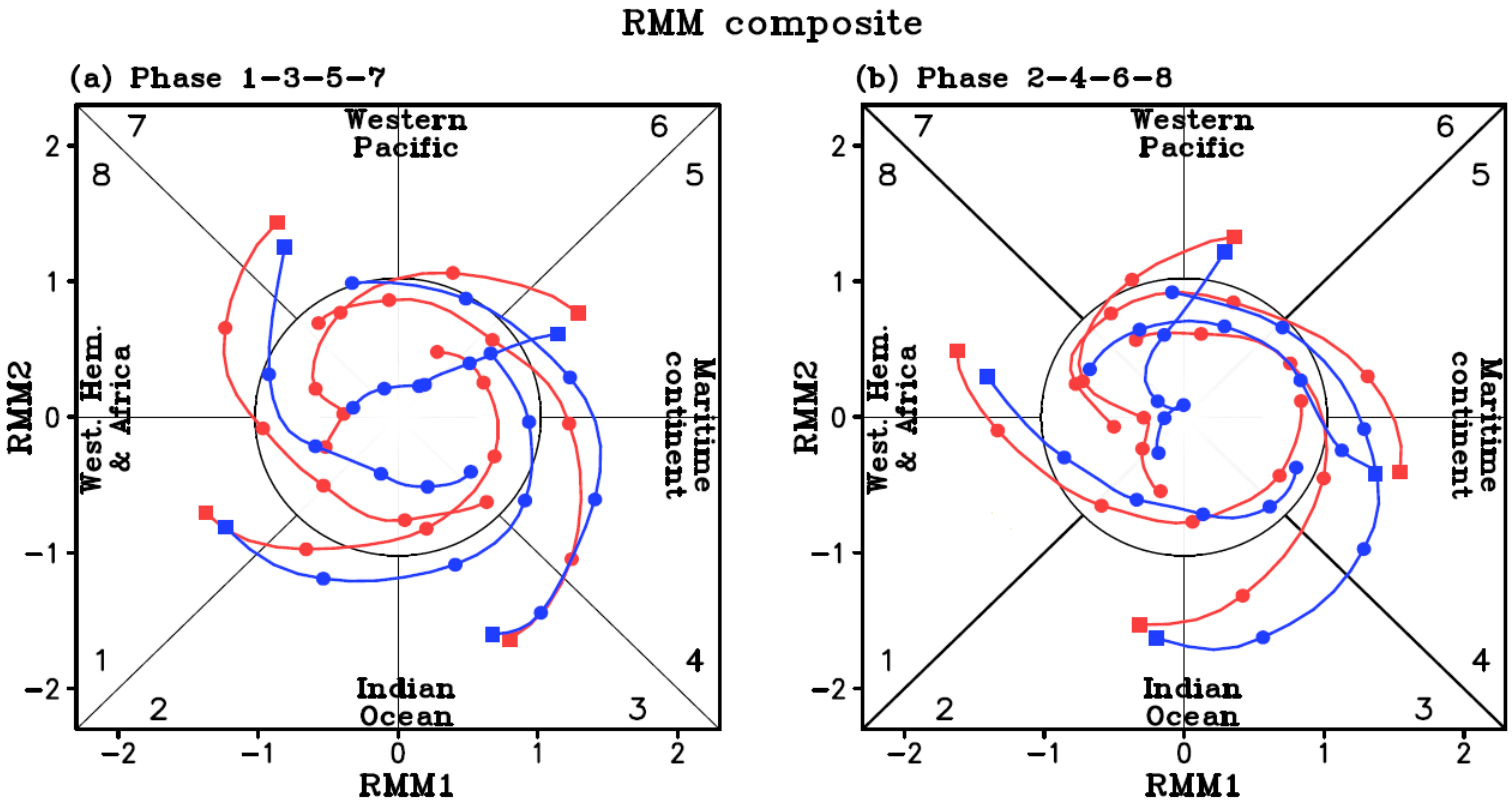
Phase dependence of MJO prediction skill





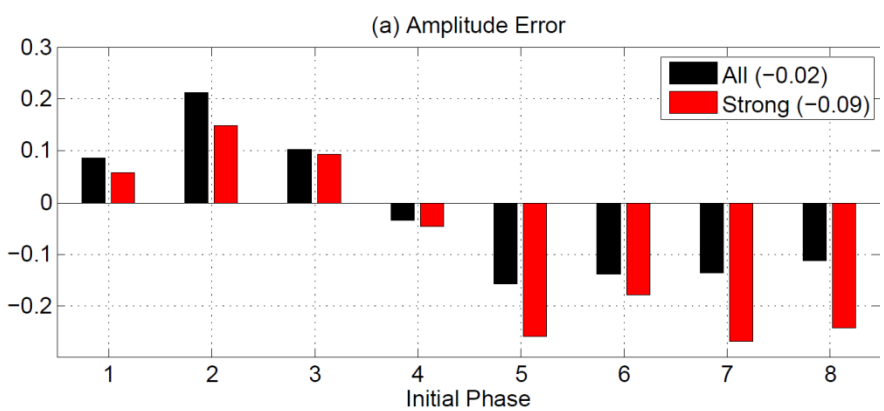
observations

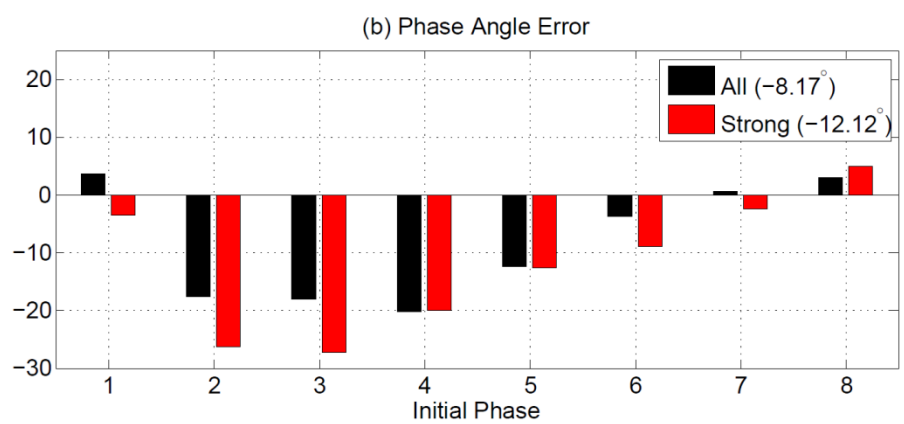
Amplitude and Phase



Obs: red

Pred: blue





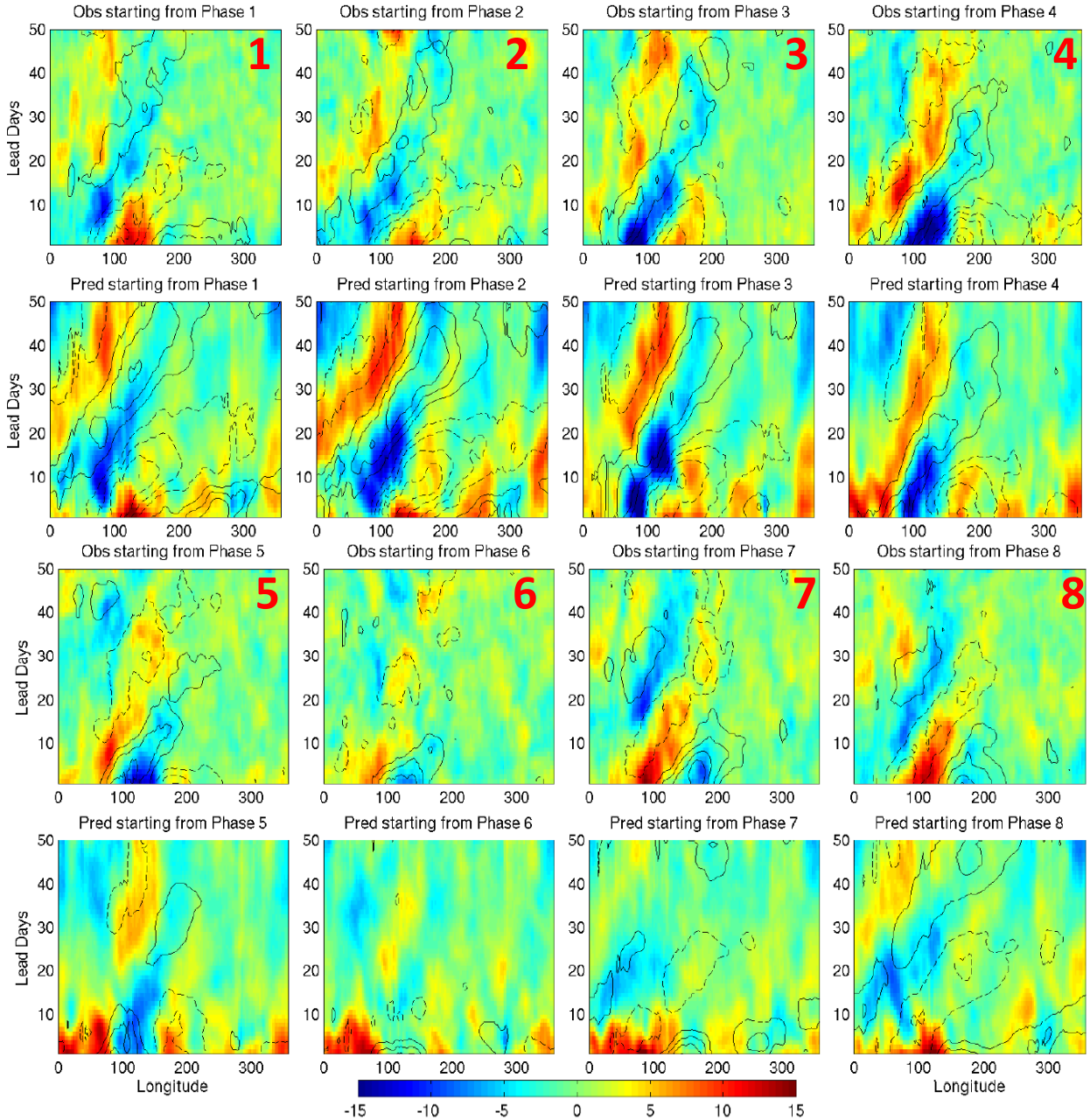
Composite results of OLR (shading) and U850 for different phases

Obs

Pred

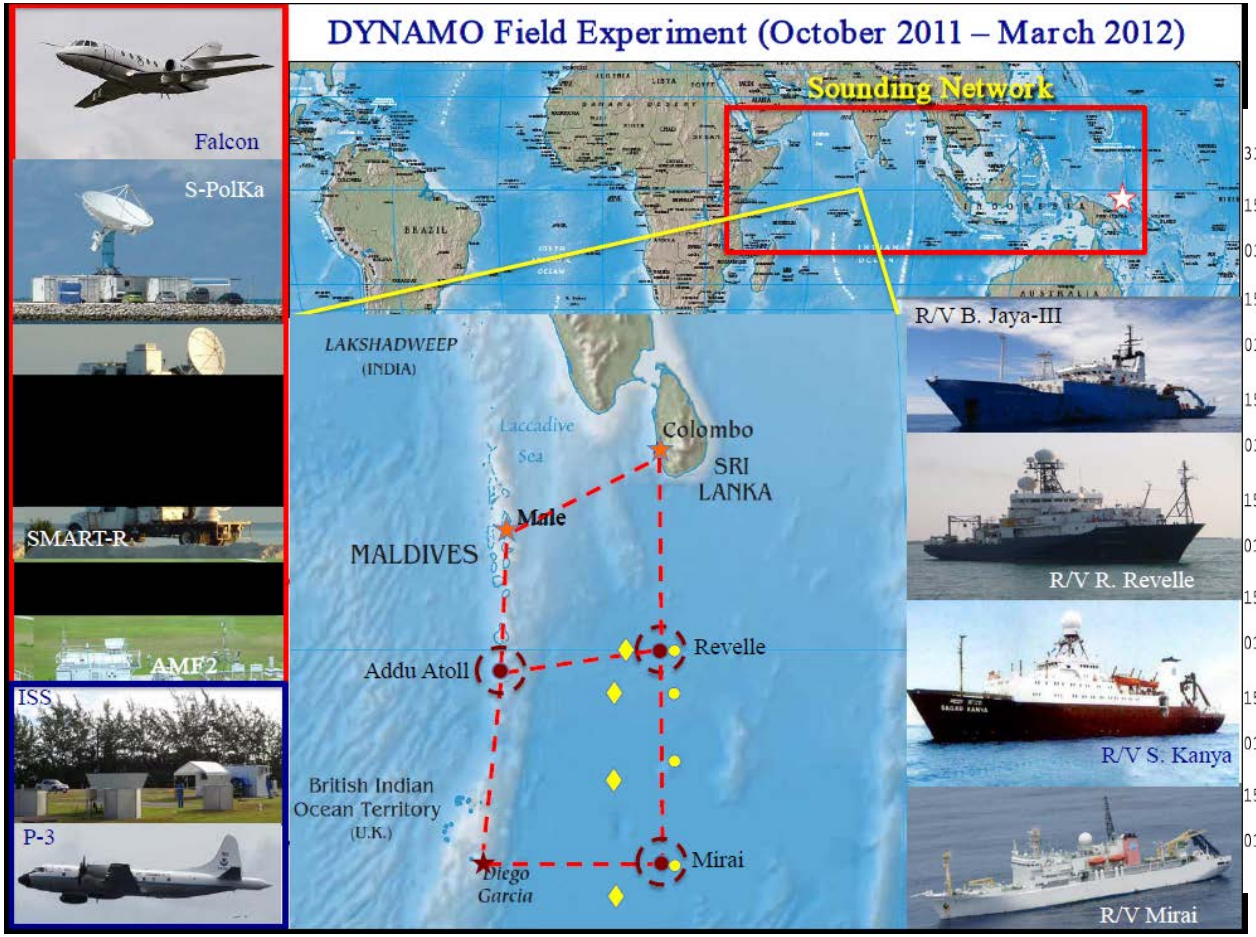
Obs

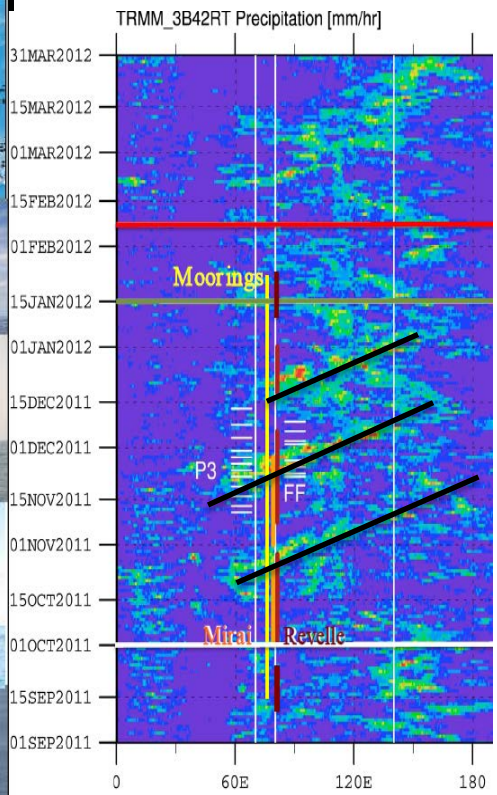
Pred

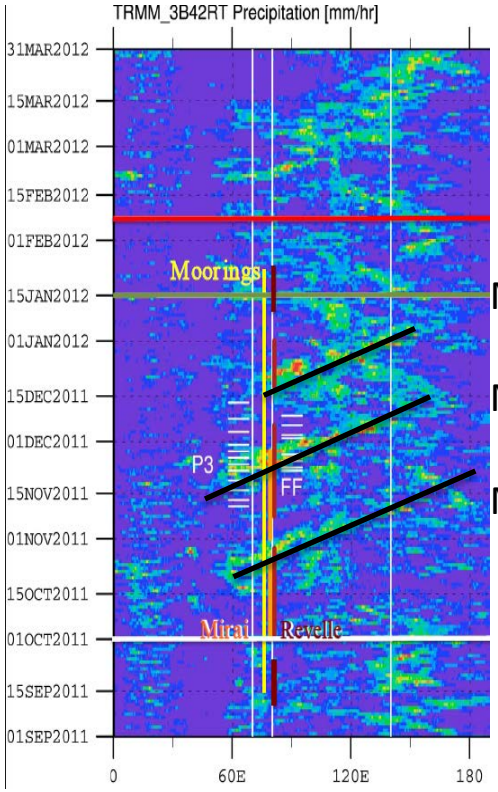


1) Higher skill when the anomalous convection is over the Indian Ocean
2) Dry phase is more difficult to predict than wet phase
3) Predicted phases 5/6 do not propagate

DYNAMO/CINDY field Campaign







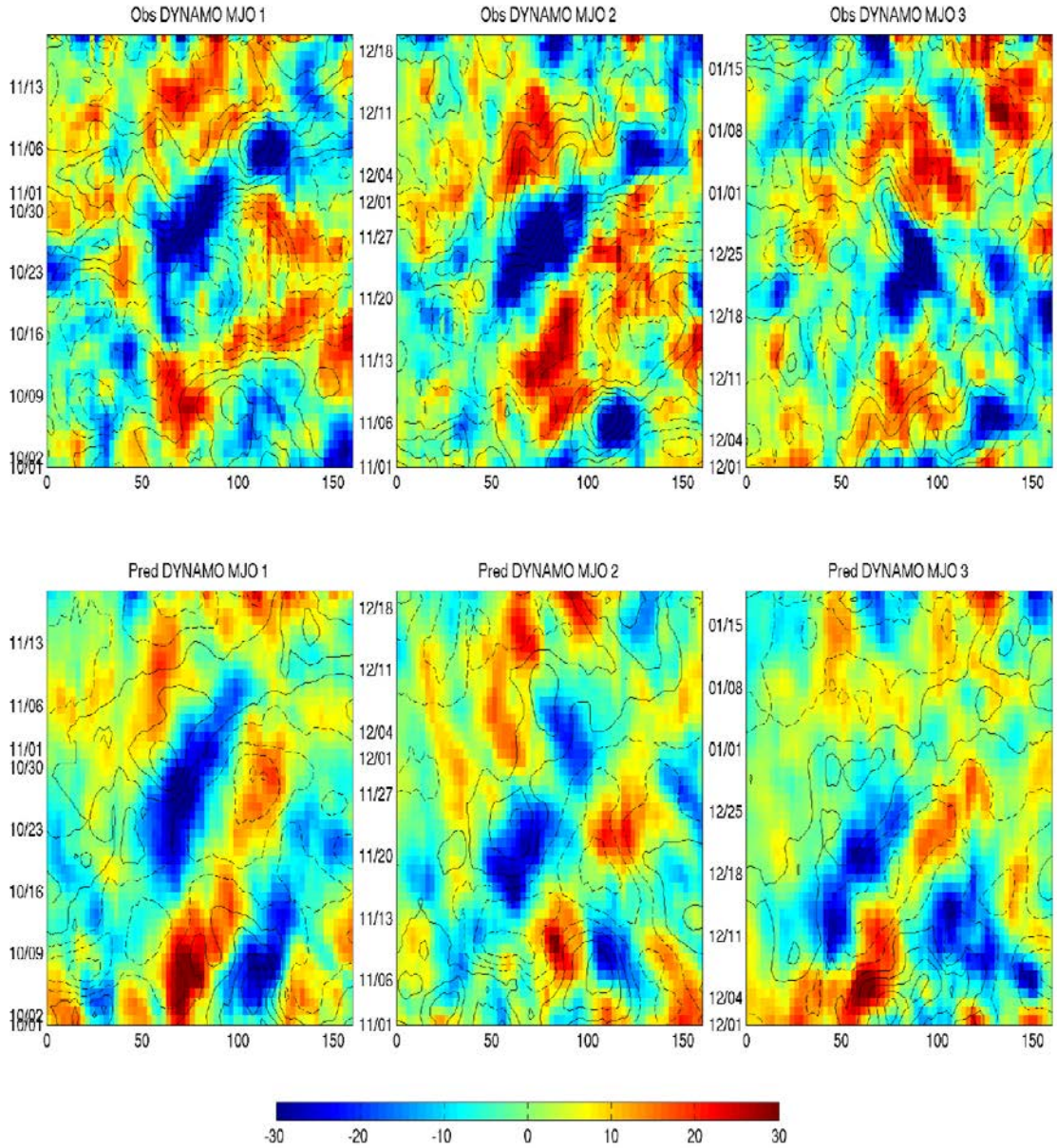
Obs

MJO3

MJO2

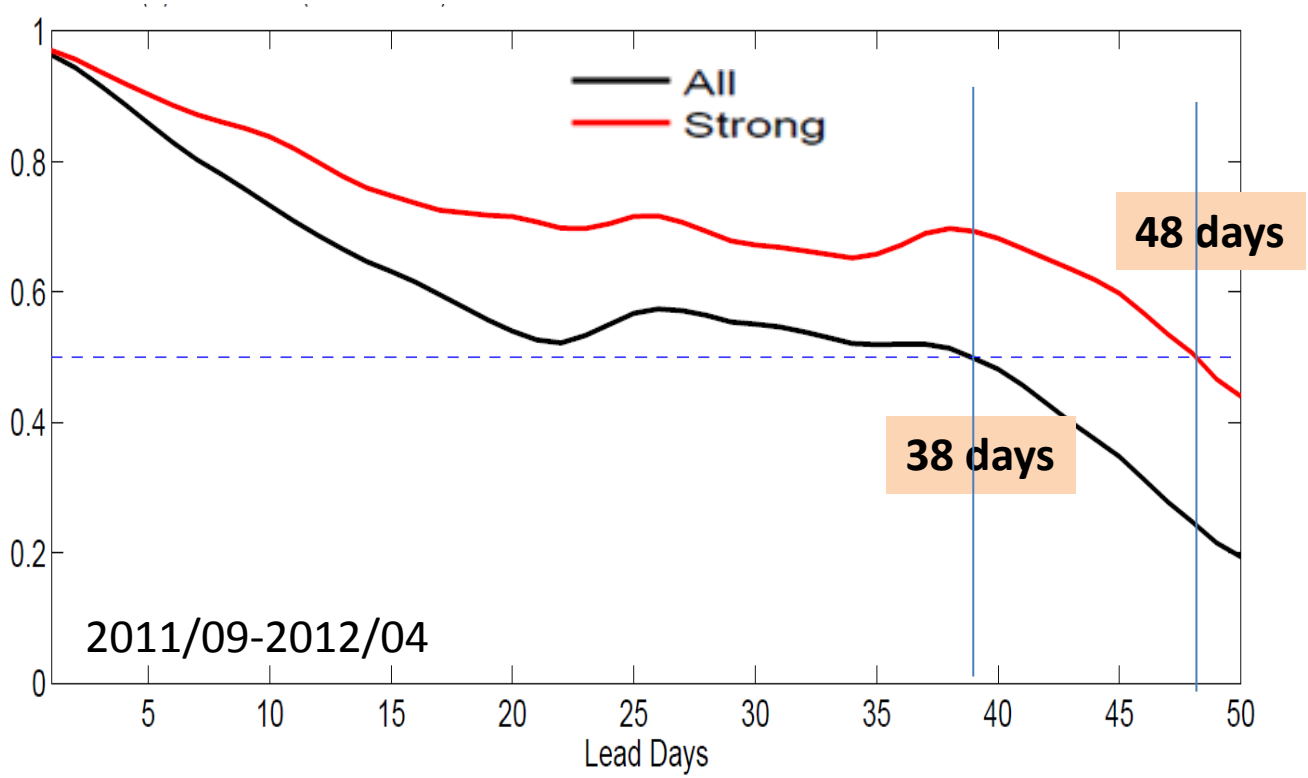
MJO1

Pred



OLR (shading), U850 (contours)

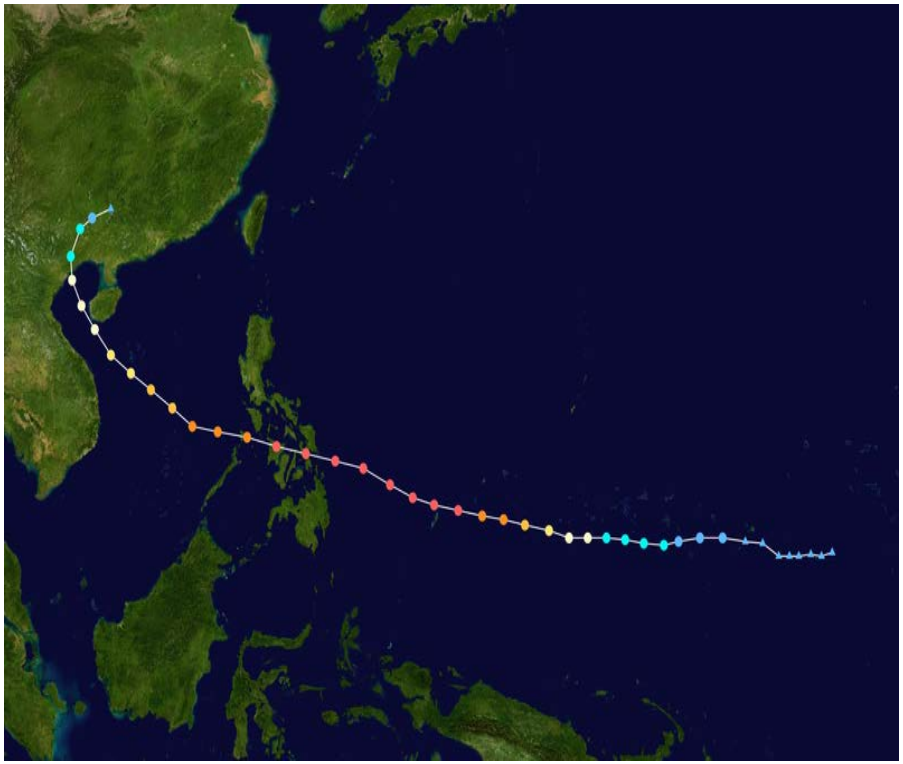
The bivariate Anomaly Correlation Skill (2011/09-2012/04)



Skillful MJO prediction also benefits TC prediction …

Sandy (Oct 2012)

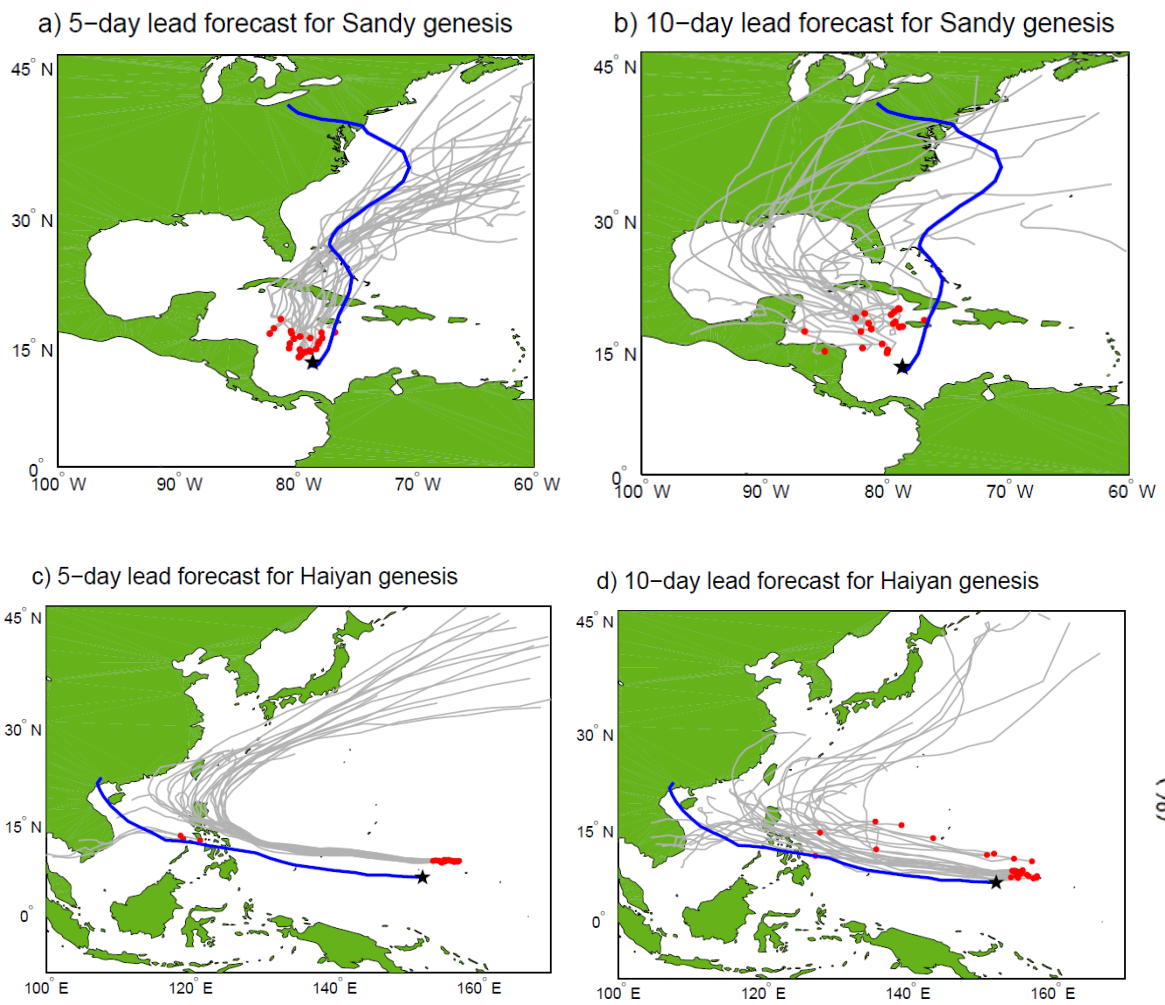
Haiyan (Nov 2013)

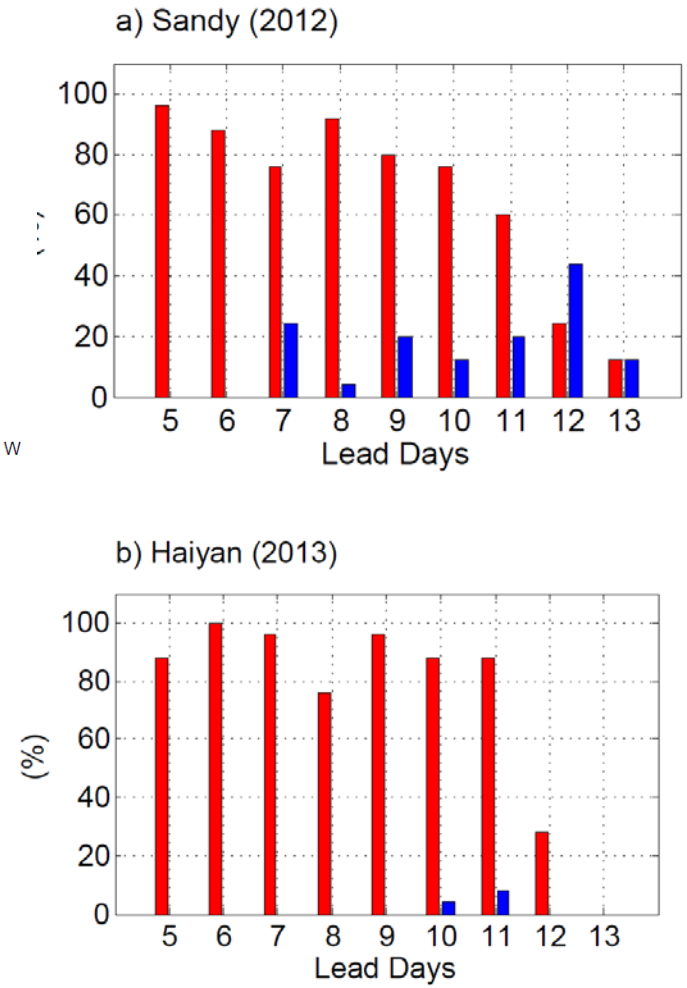


Genesis on **Oct 22** as a TS
Landfall on **Oct 29**

Genesis on **Nov 4** as a TS
land fall on **Nov 7** in Guiuan, Eastern Samar

Genesis forecast of Sandy & Haiyan

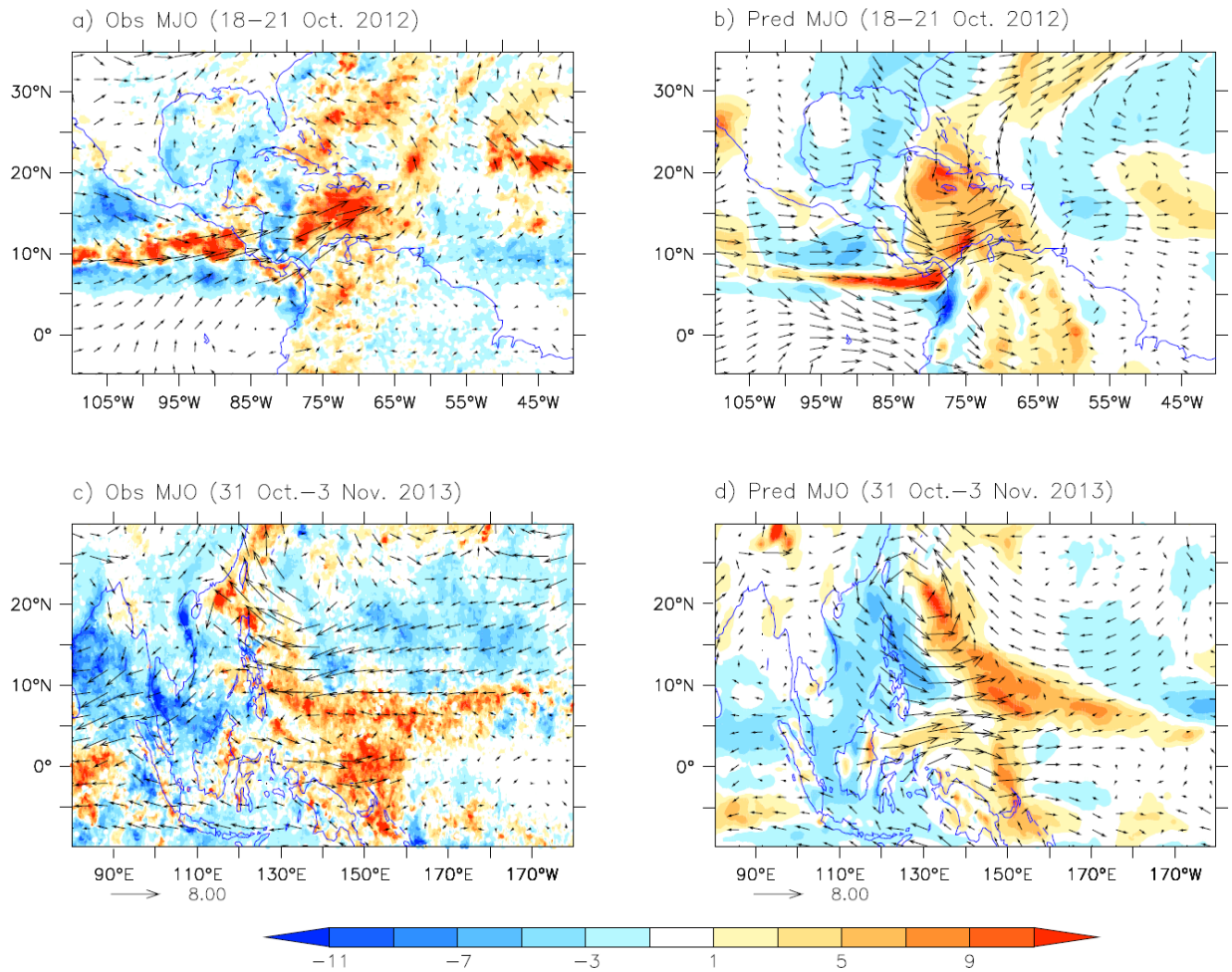




TC tracker: Lucas Harris's simply tracker.
Each day has 24 ensemble forecast members

What is the predictability Source?

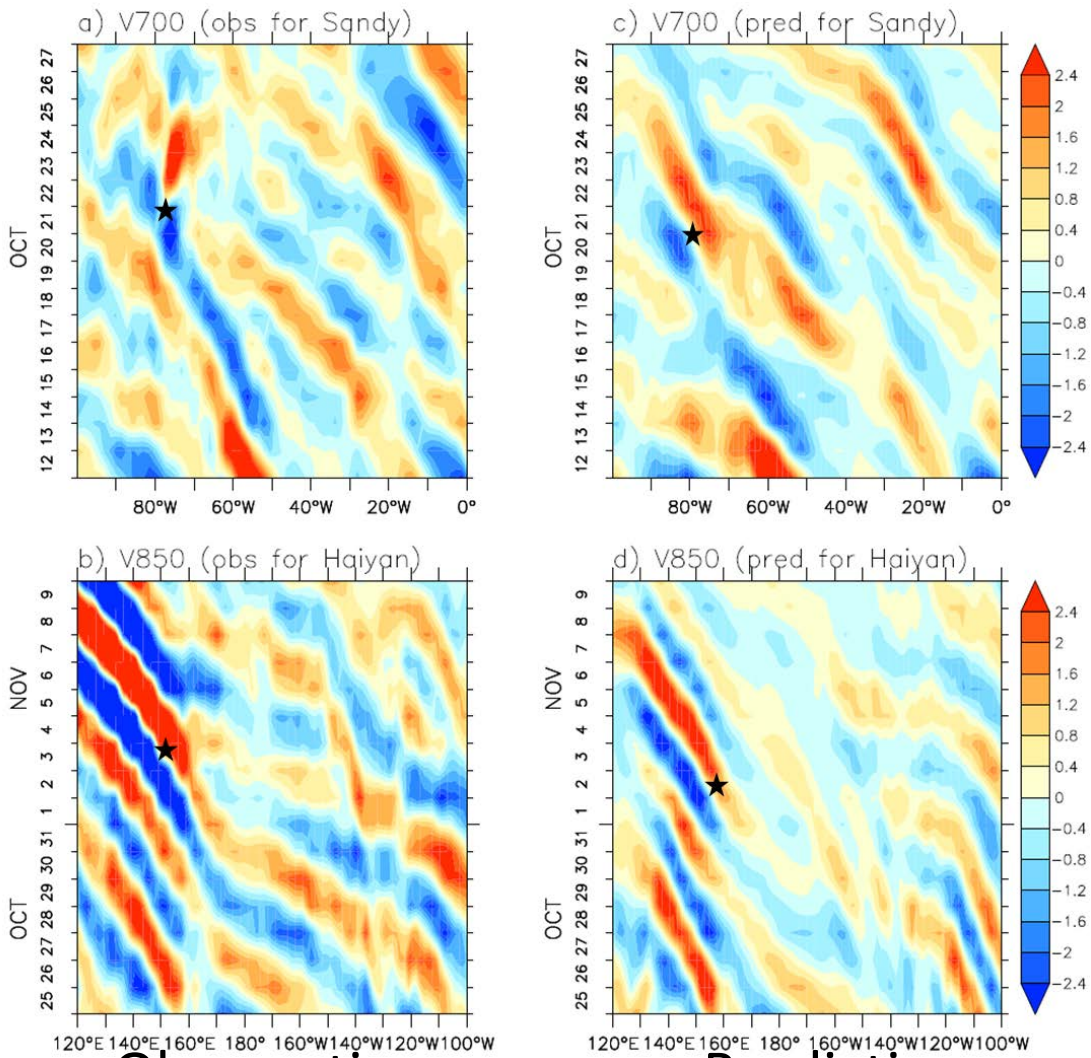
1) MJO



Observation Prediction

What is the predictability Source?

2) Easterly Wave



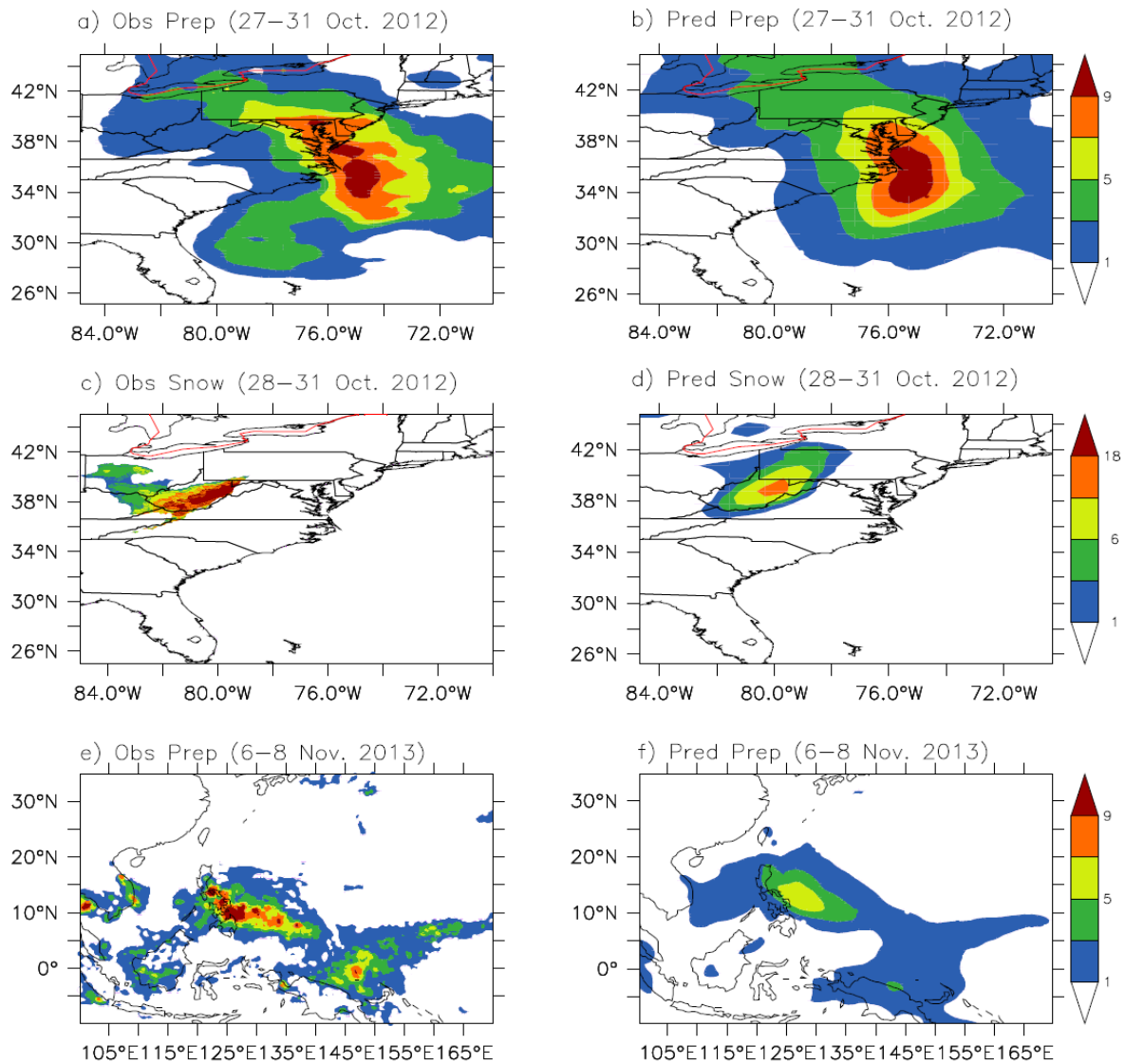
Observation Prediction

Rainfall and snowfall (in inches) associated with Sandy and Haiyan

Precipitation (Sandy)

Snowfall (Sandy)

Precipitation (Haiyan)



Observations **Prediction**

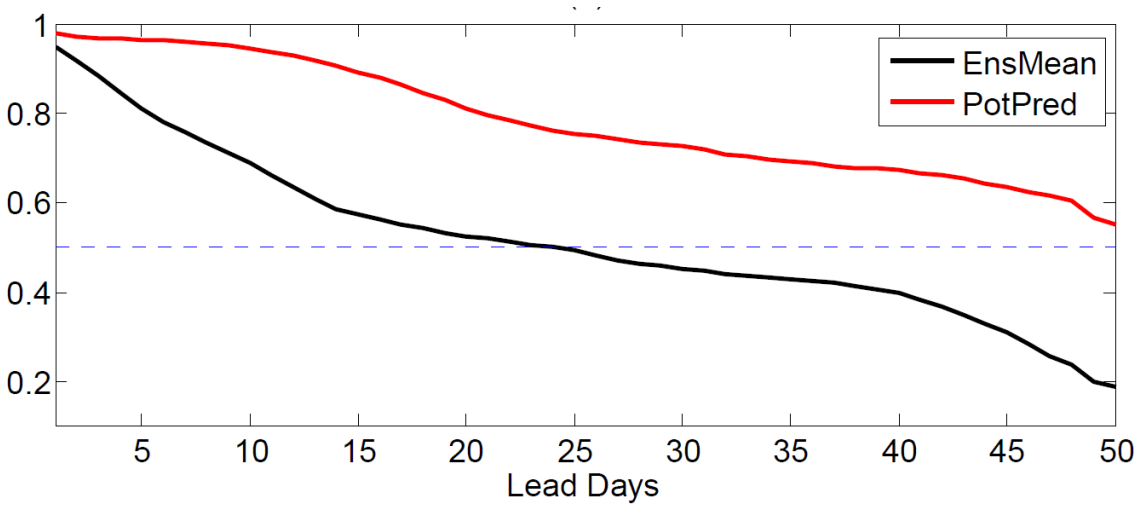
Xiang et al., Monthly Weather Review, 2014

Summary

- GFDL's model has a MJO prediction skill of 24 days
- Initially strong cases are more predictable (39 days)
- High prediction skill in DYNAMO period (38 days)
- Skillful MJO prediction benefits TC prediction, such as Hurricane Sandy and Super Typhoon Haiyan

Future Work

1) Further Improving MJO prediction



2) Exploring MJO Prediction skill in boreal summer

3) Exploring more cases of TC prediction

Thanks

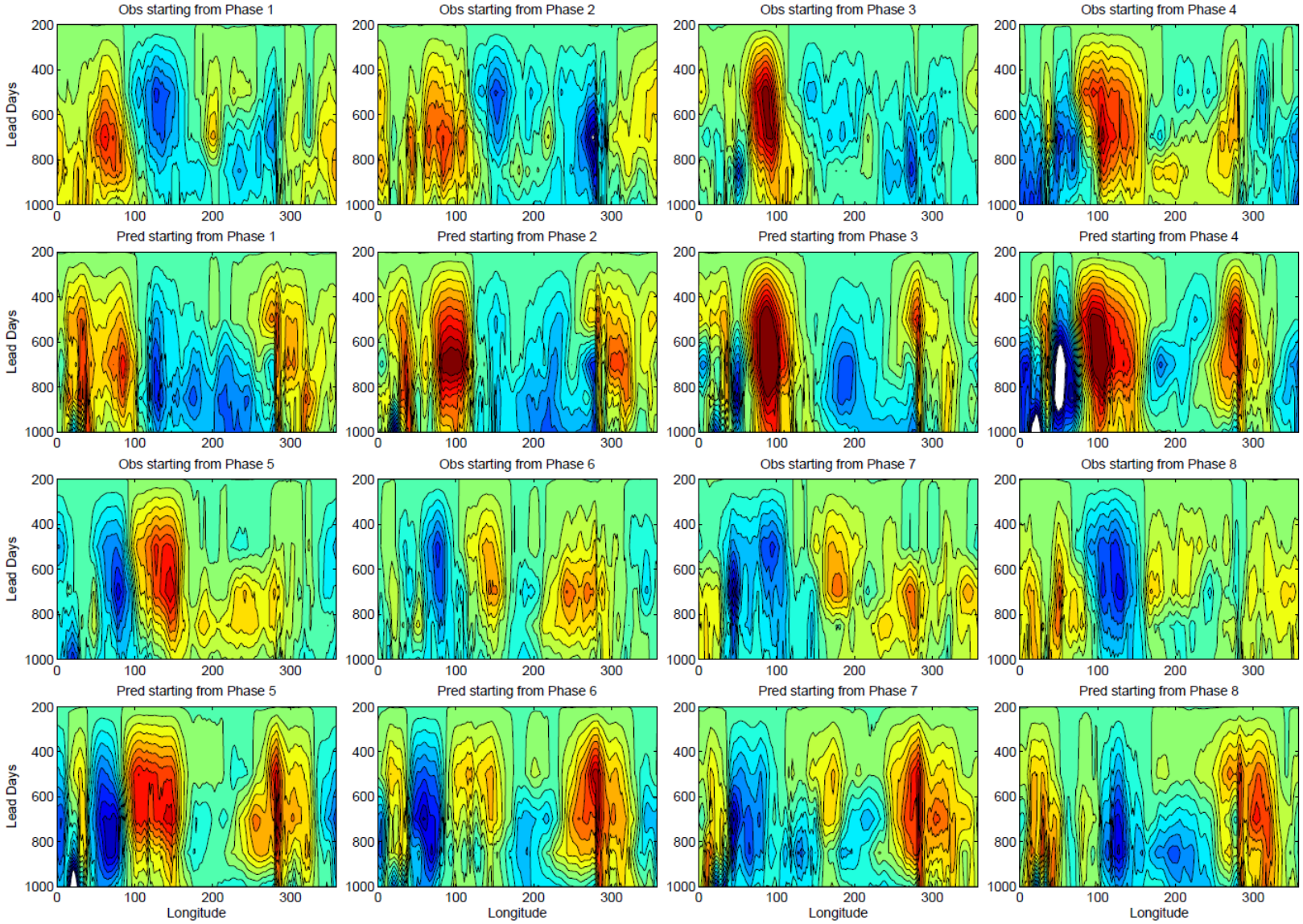
Day 1

Obs

Pred

Obs

pred



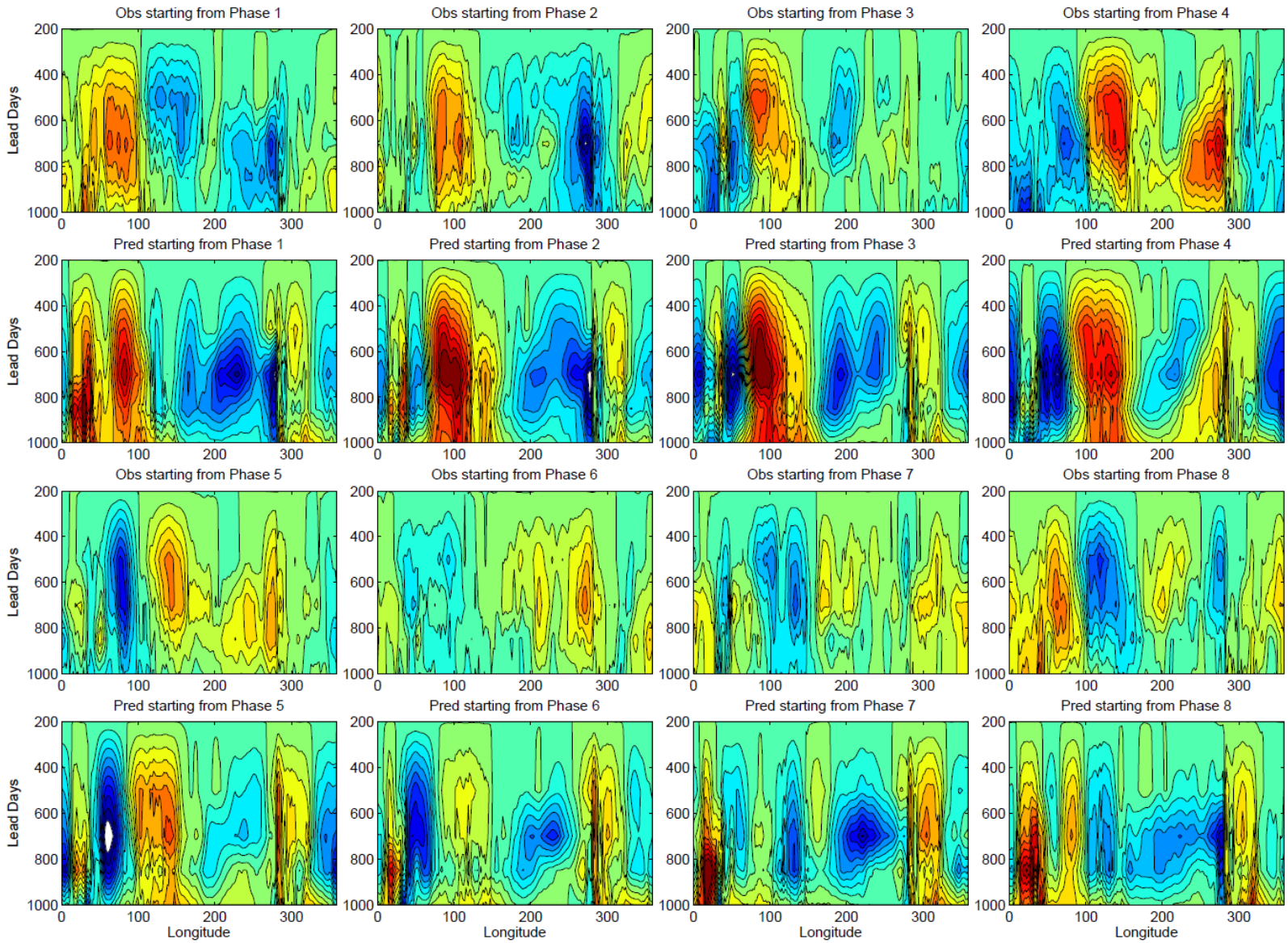
Day 6

Obs

Pred

Obs

pred



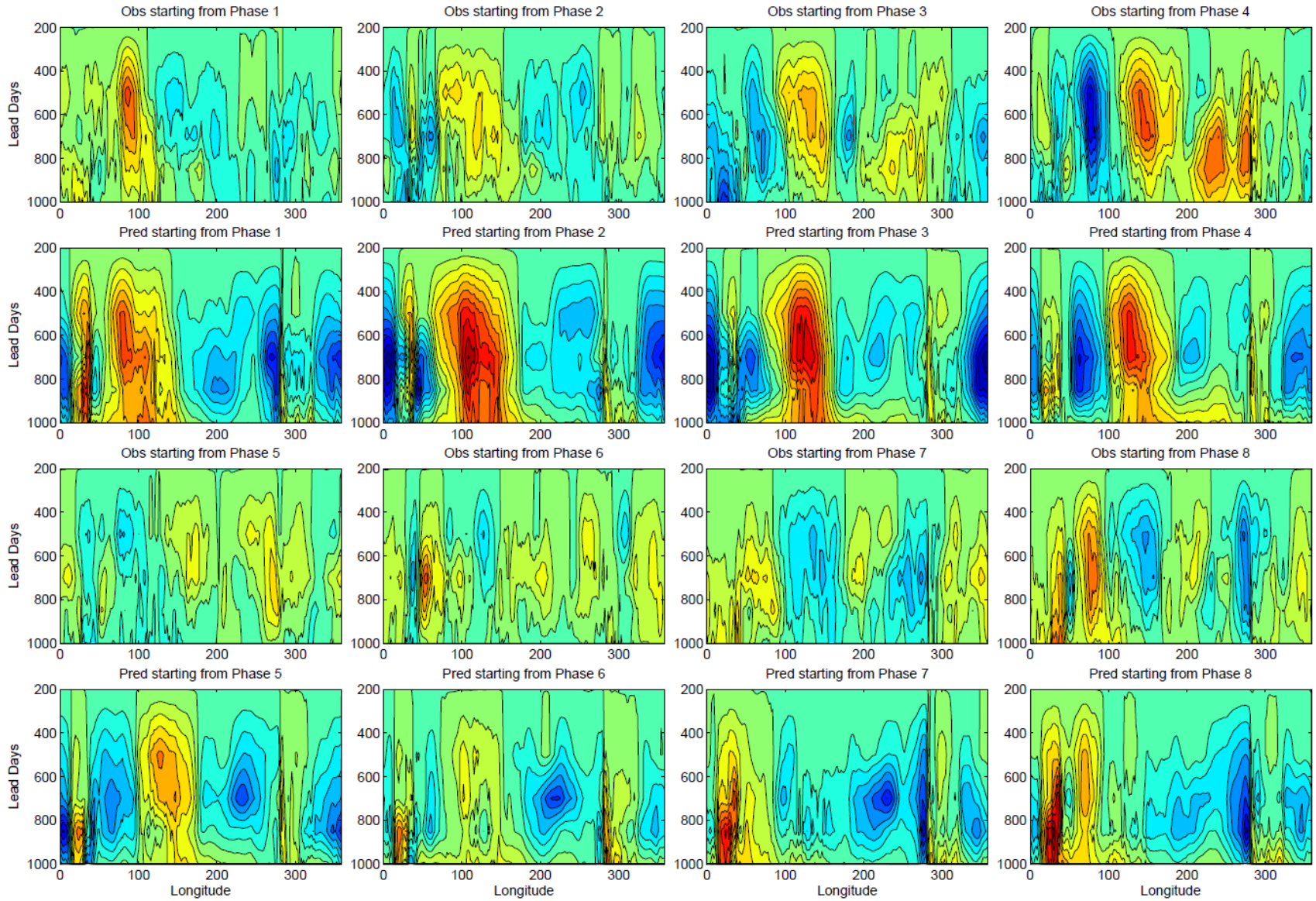
Day 11

Obs

Pred

Obs

pred



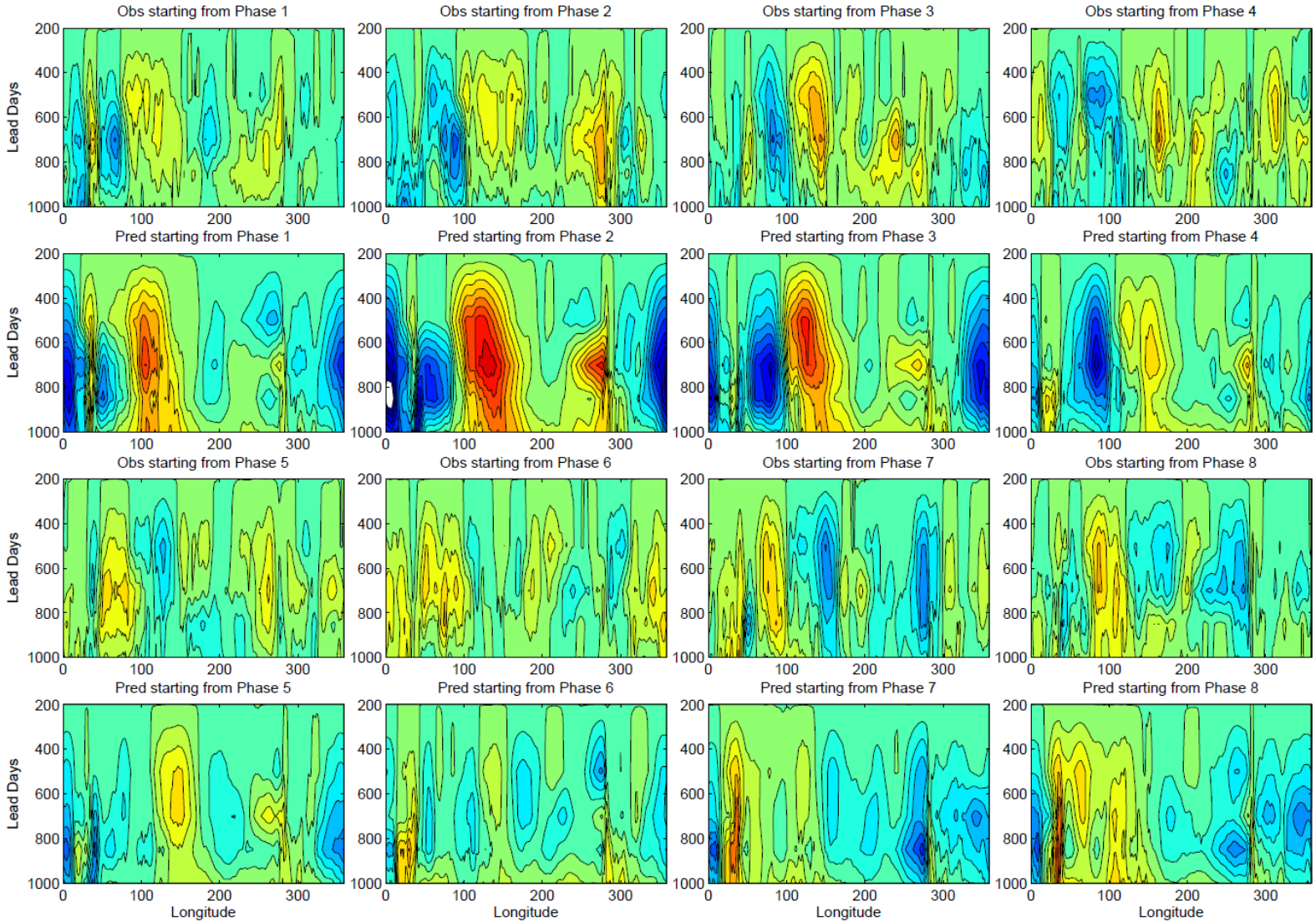
Day 16

Obs

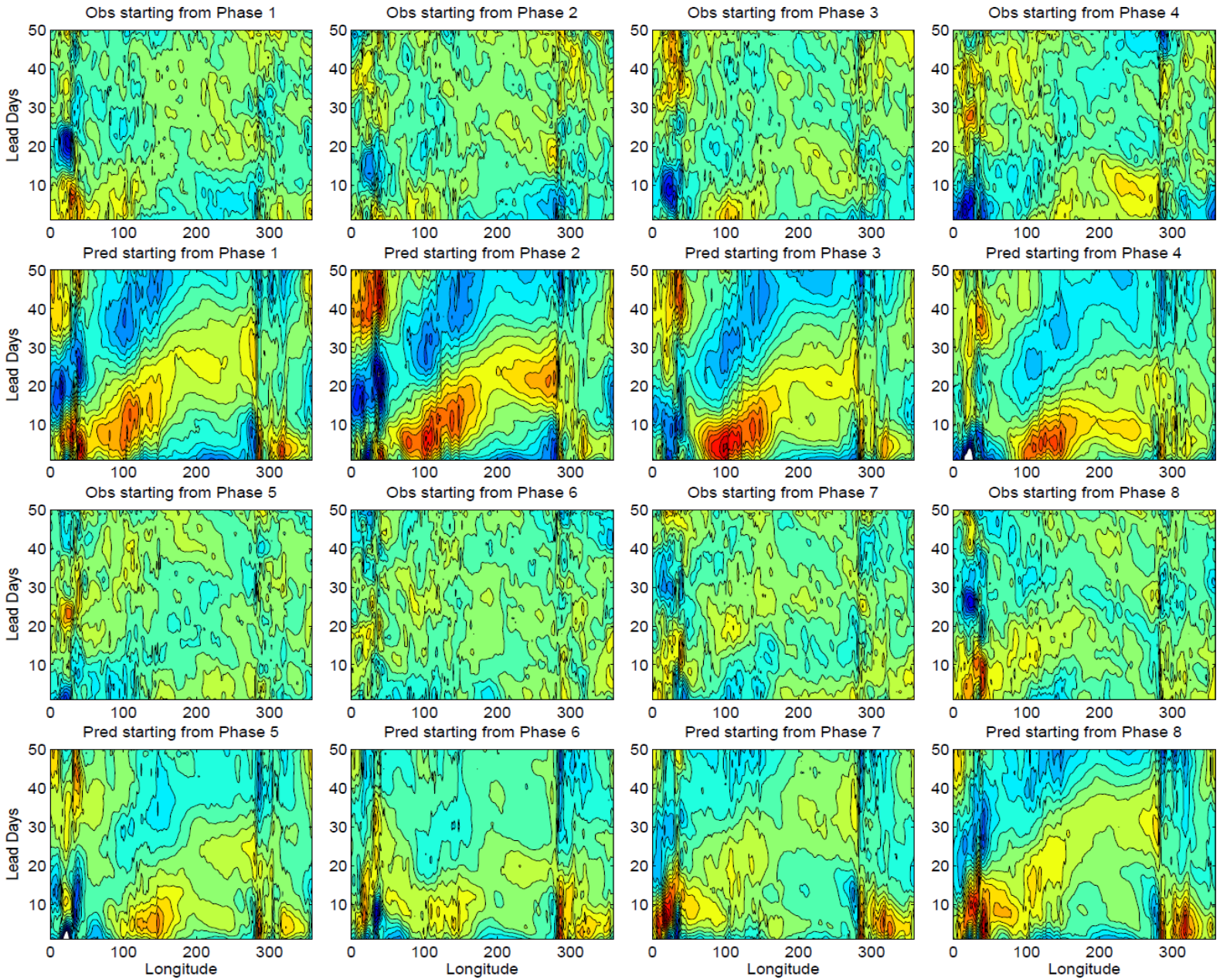
Pred

Obs

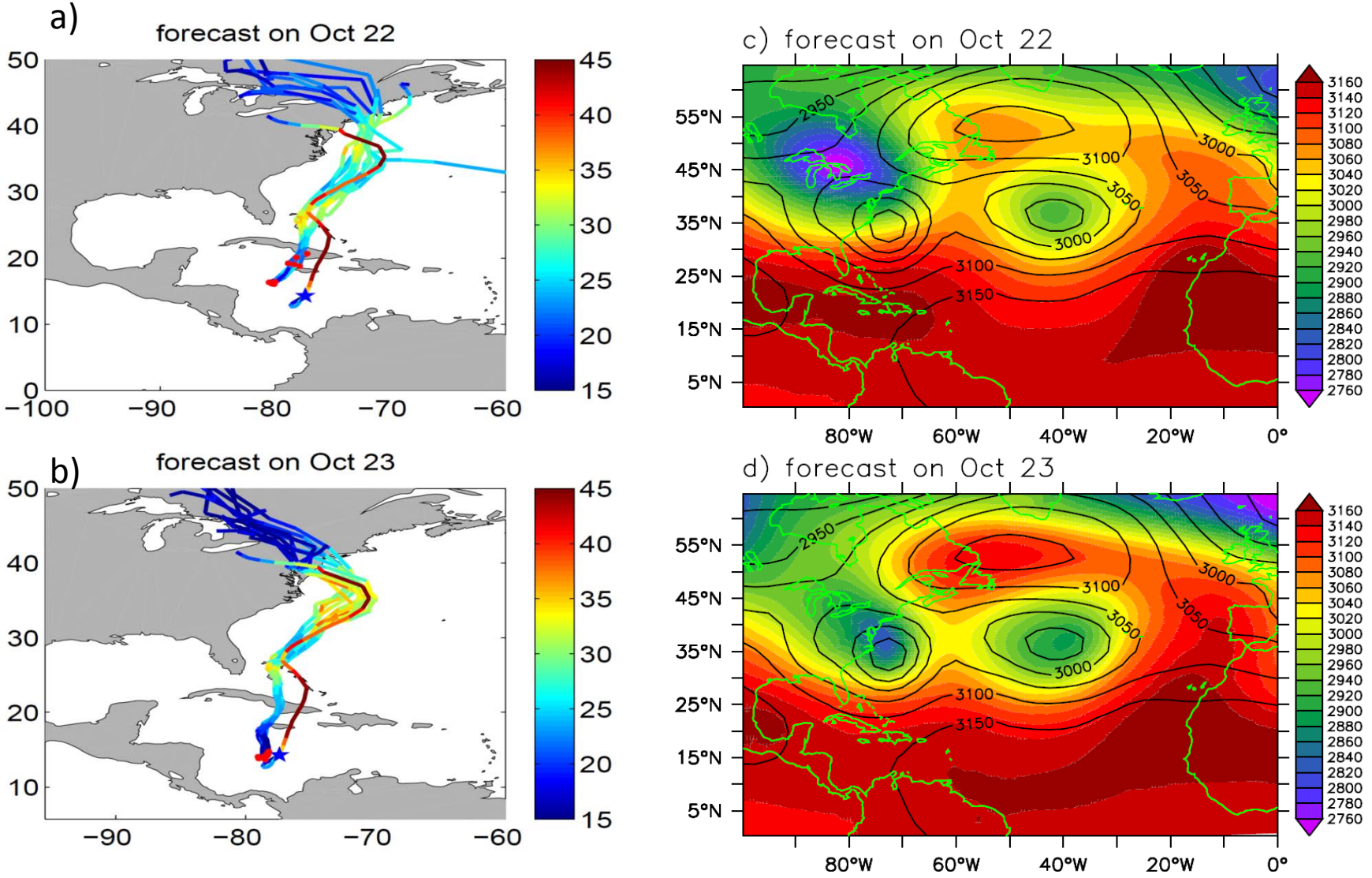
pred



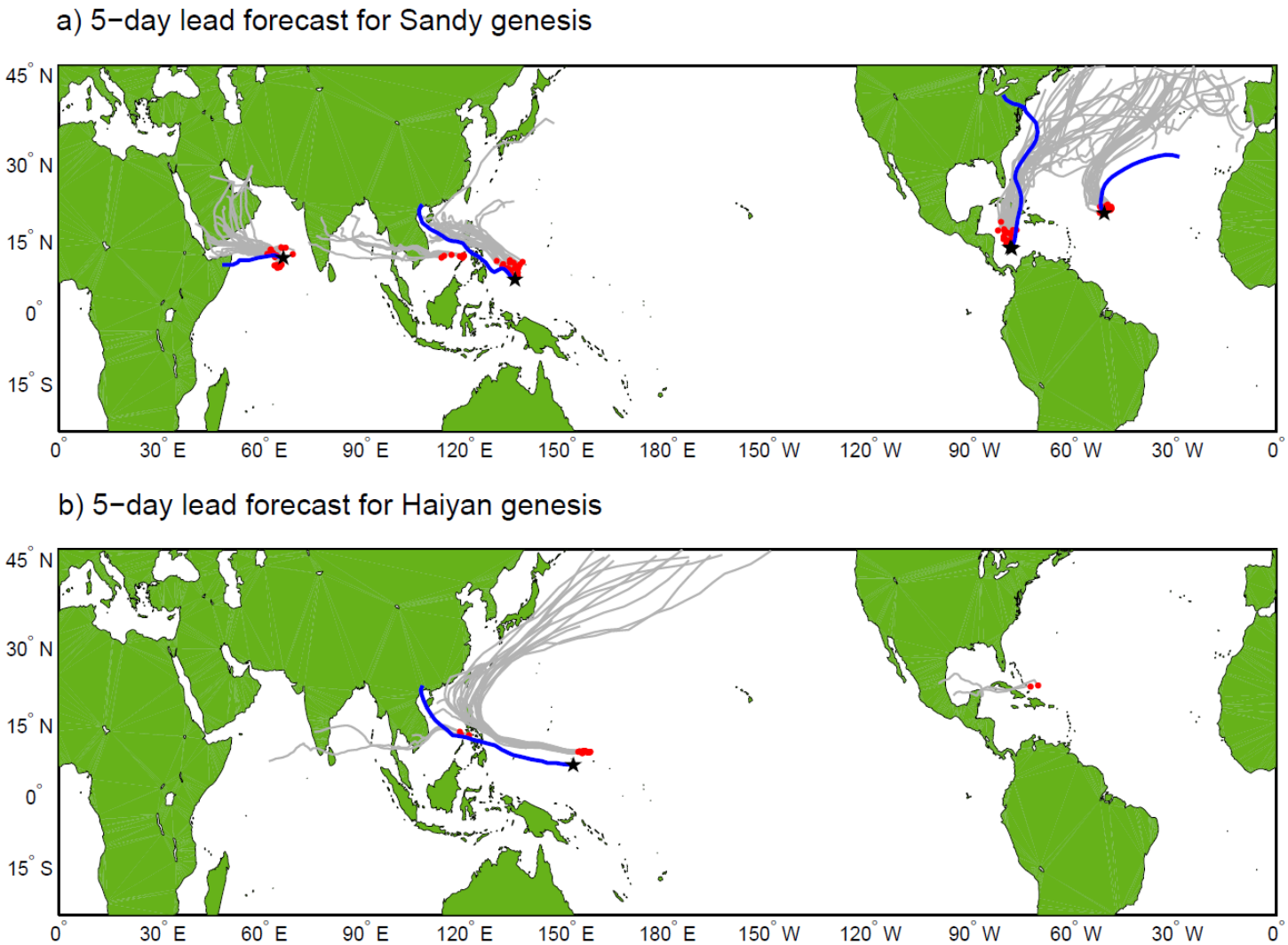
1000 hPa


Obs starting from Phase 1
Obs starting from Phase 2
Obs starting from Phase 3
Obs starting from Phase 4
Pred starting from Phase 1
Pred starting from Phase 2
Pred starting from Phase 3
Pred starting from Phase 4
Obs starting from Phase 5
Obs starting from Phase 6
Obs starting from Phase 7
Obs starting from Phase 8
Pred starting from Phase 5
Pred starting from Phase 6
Pred starting from Phase 7
Pred starting from Phase 8
Lead Days
Longitude
0
100
200
300
10
20
30
40
50

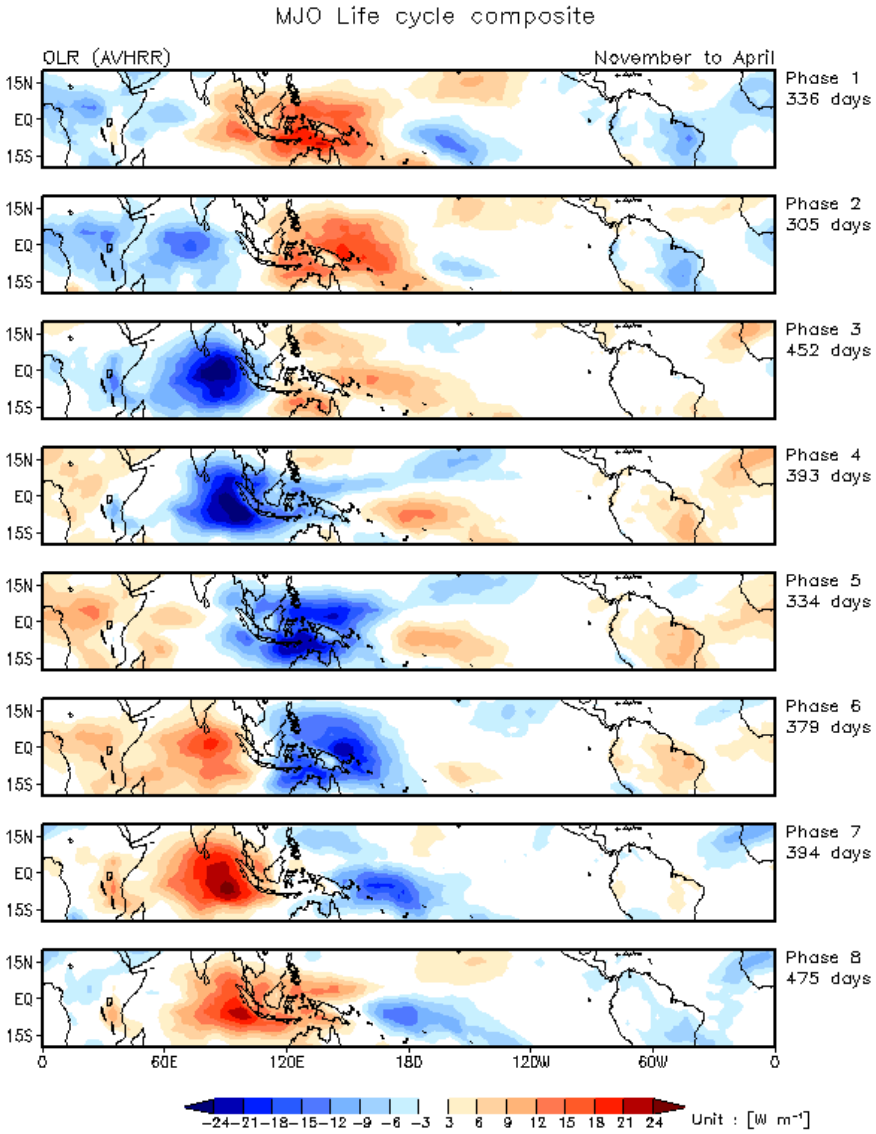
Track forecast of Sandy



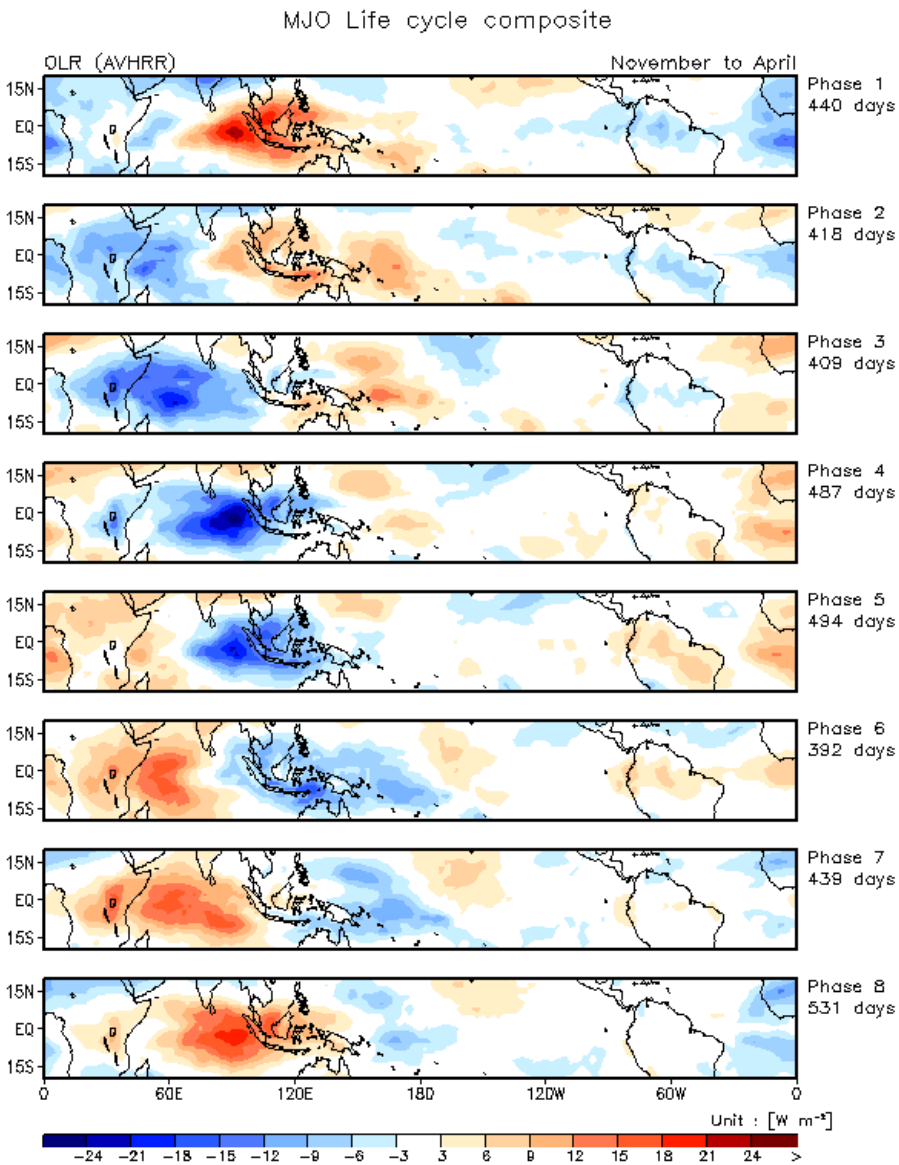
Low Spatial False Alarm



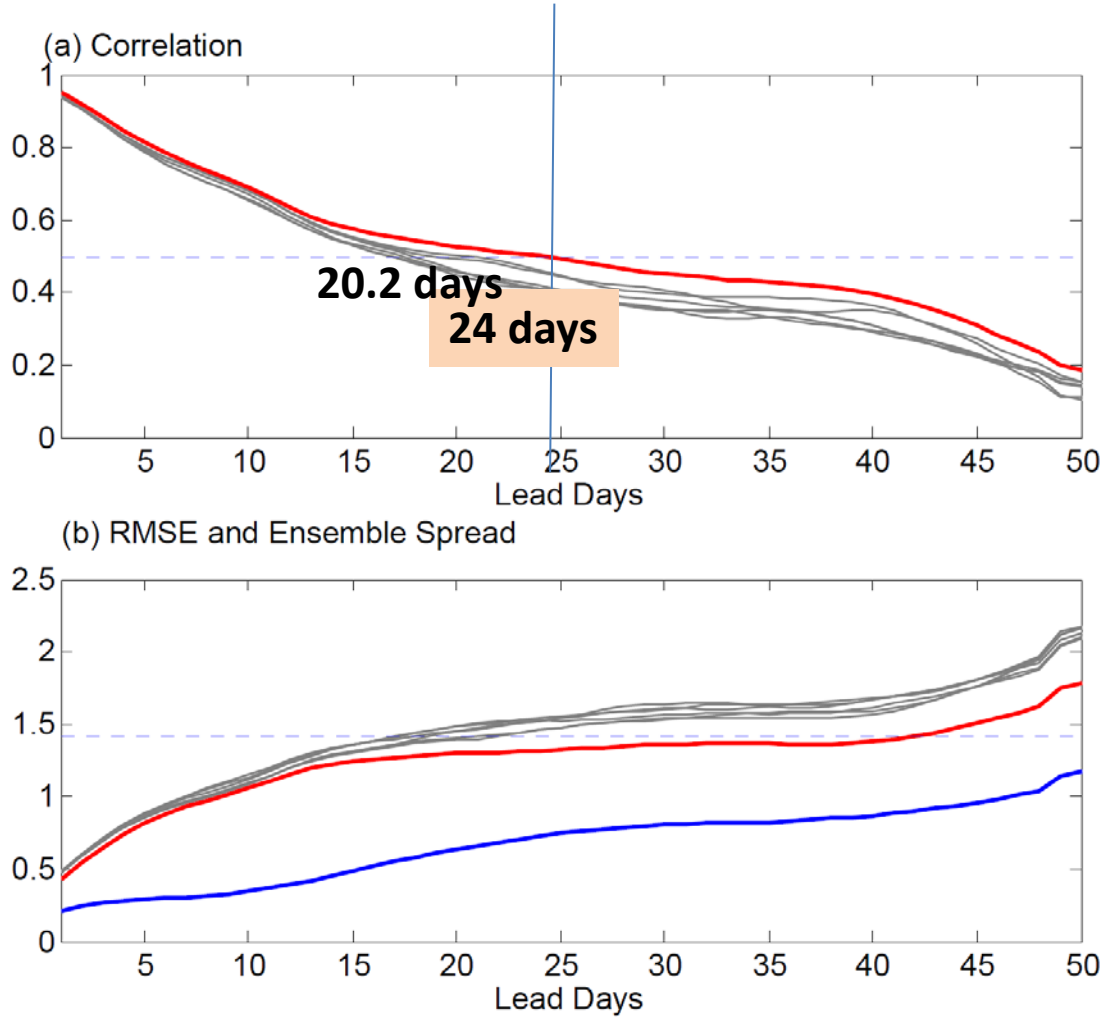
5-day lead prediction for the geneses of a) Sandy and b) Haiyan. Blue and grey lines show the track for observation and prediction. Black stars (red dots) represent the observed (predicted) tropical cyclogenesis locations.



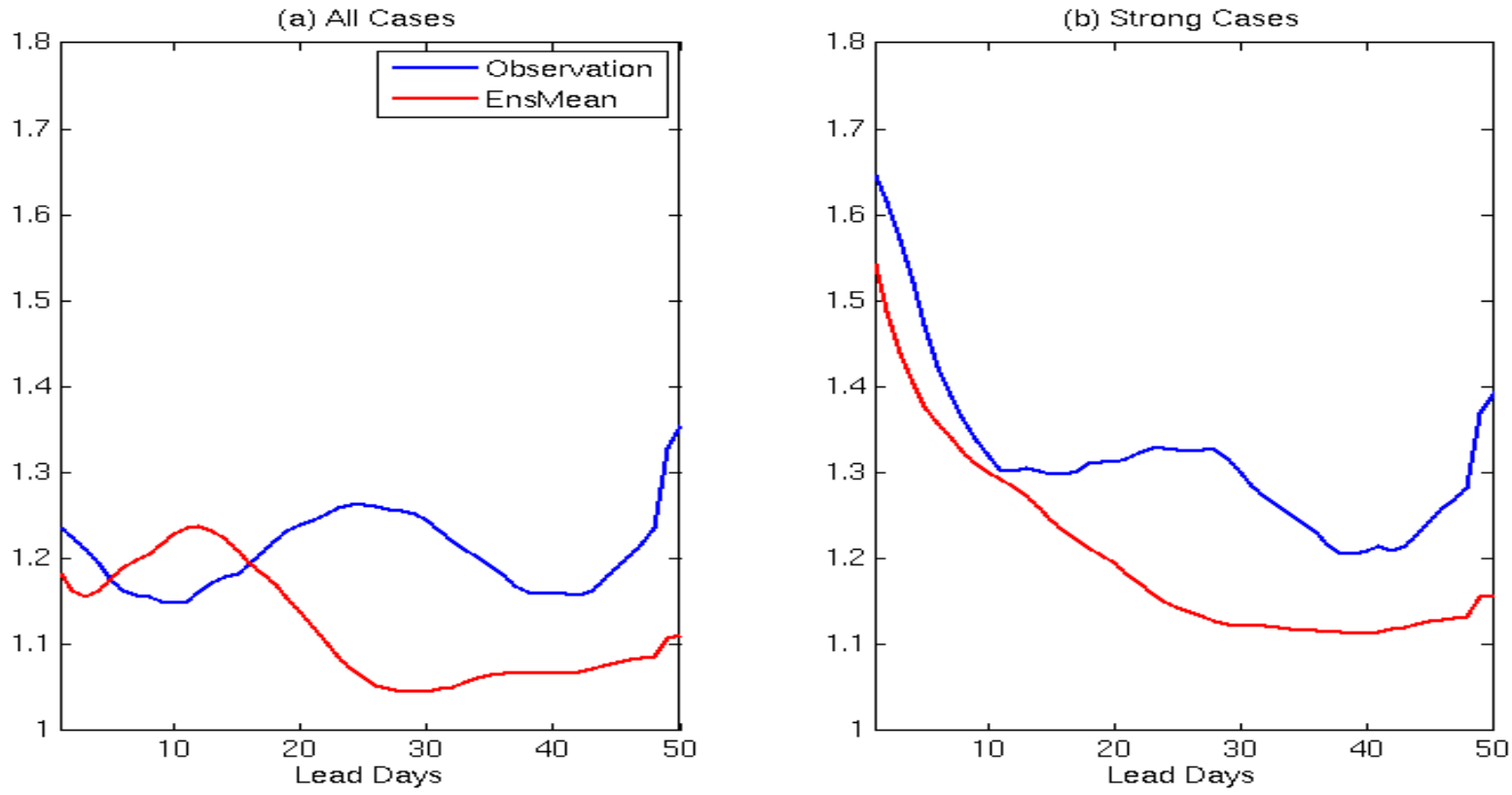
Observation



model

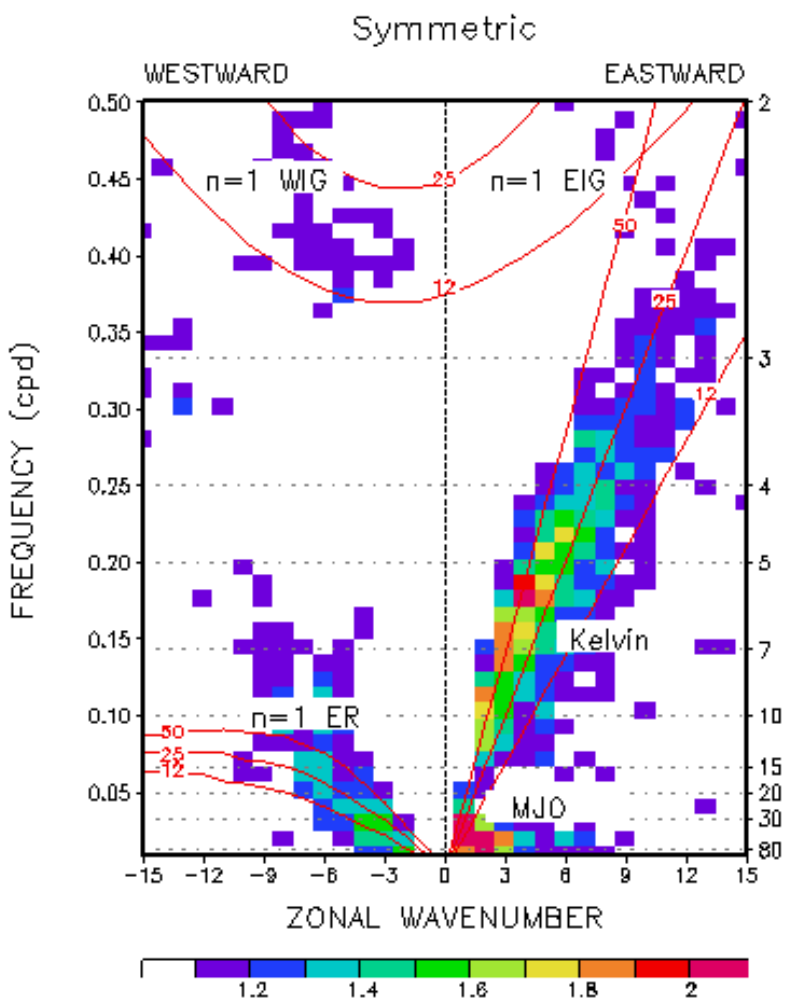
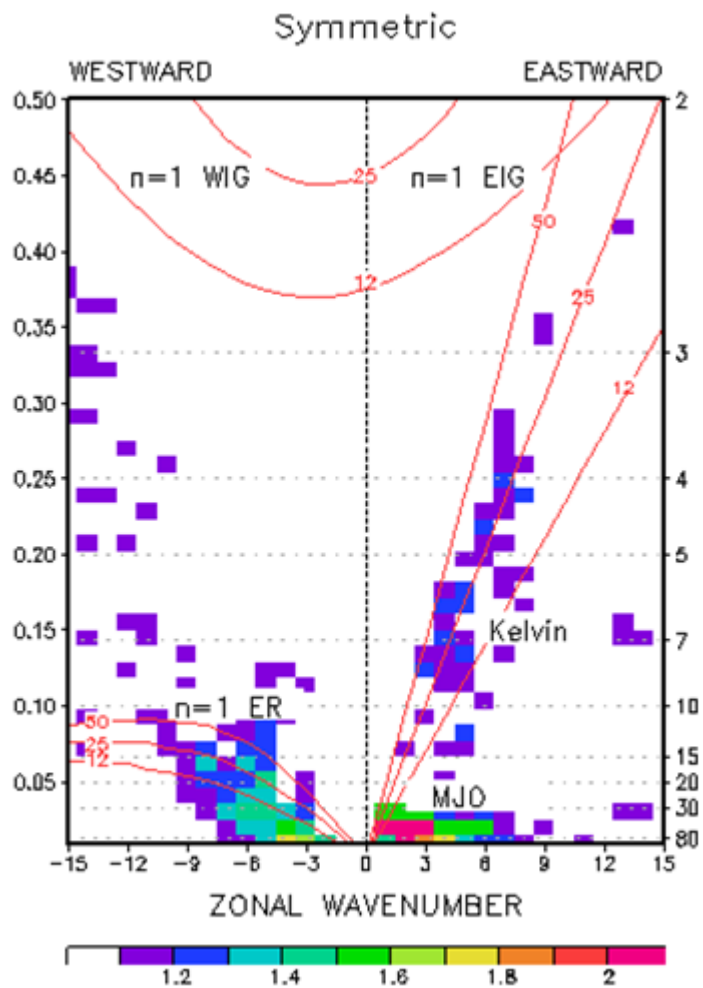

(a) Correlation
1
0.8
0.6
0.4
0.2
0
20.2 days
24 days
5
10
15
20
25
30
35
40
45
50
Lead Days
(b) RMSE and Ensemble Spread
2.5
2
1.5
1
0.5
0
5
10
15
20
25
30
35
40
45
50
Lead Days

Amplitude


(a) All Cases
Observation
EnsMean
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
10
20
30
40
50
Lead Days
(b) Strong Cases
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
10
20
30
40
50
Lead Days

Wheeler-Kiladis diagram

Observations



Model