CLIMATE PROGRAM OFFICE
Advancing scientific understanding of climate, improving society's ability to plan and respond
Modeling, Analysis, Predictions, and Projections

JPL

# Extended-Range Prediction of Hurricane Genesis in a High-Resolution Global Coupled Climate Model System

09/08/2017 *Source: NOAA*

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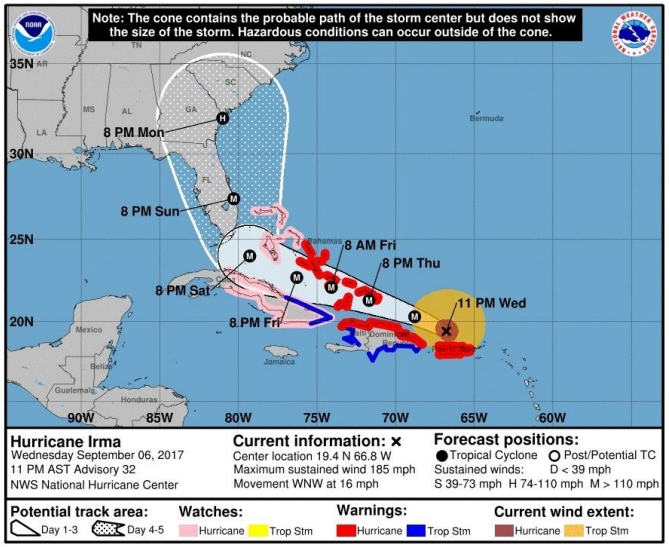
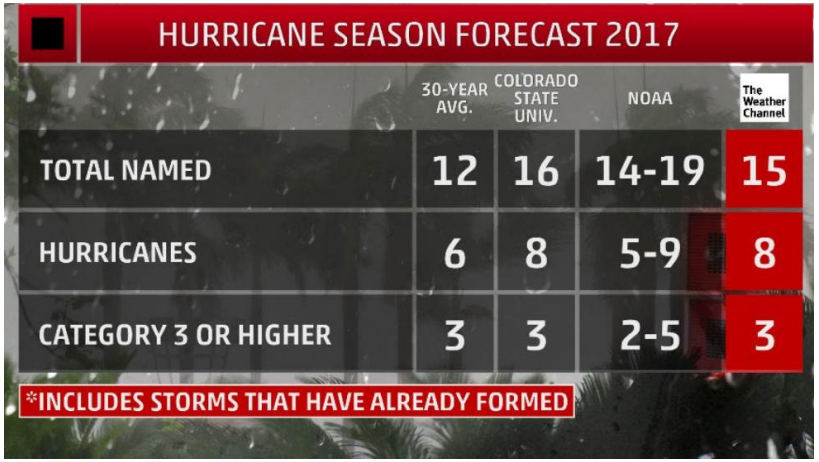
Acknowledgment: B. Xiang, M. Zhao, S.-J. Lin, J. Chen (GFDL), T. Li (UH), Z. Wang (UIUC)

# Hurricane prediction at different time-scales

**Short-term Prediction** (~ days)
(Initial condition)




**Seasonal Outlook** (~months)
(SST, QBO, PDO, AMO, etc)



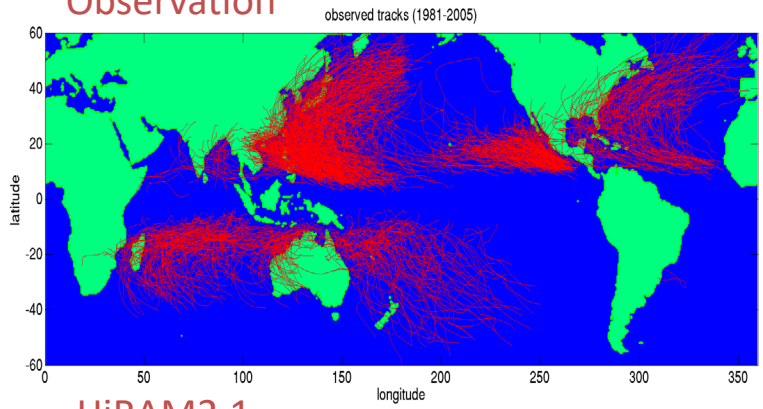

**Extended-range Prediction** (~ weeks)

(*Madden-Julian Oscillation,* CCEWs, SST, etc)

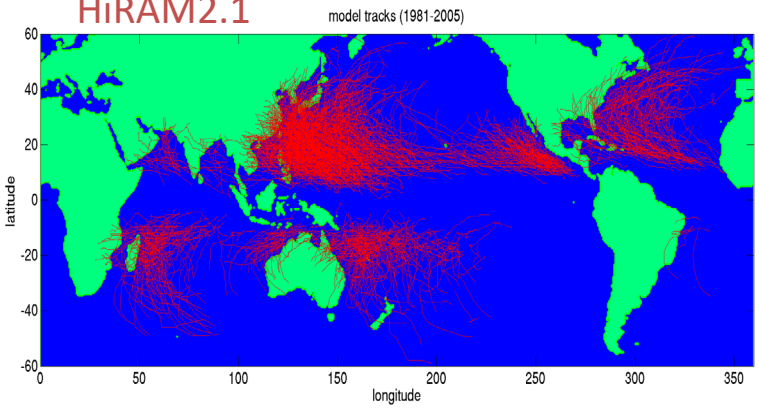
# Hurricane in GFDL High-Resolution Atmospheric Model (HiRAM)

## Climatology

Observation

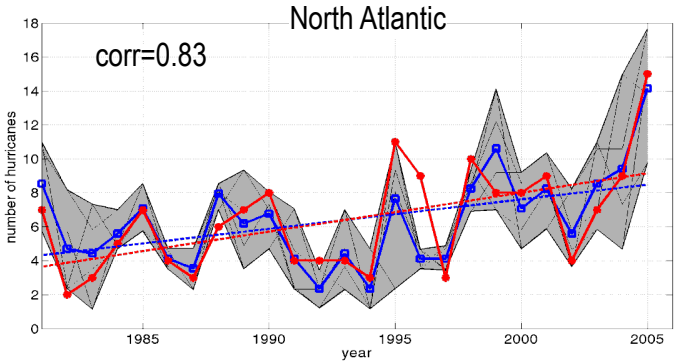


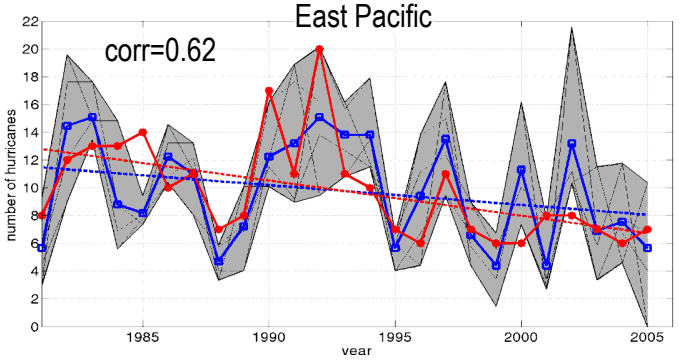

HiRAM2.1

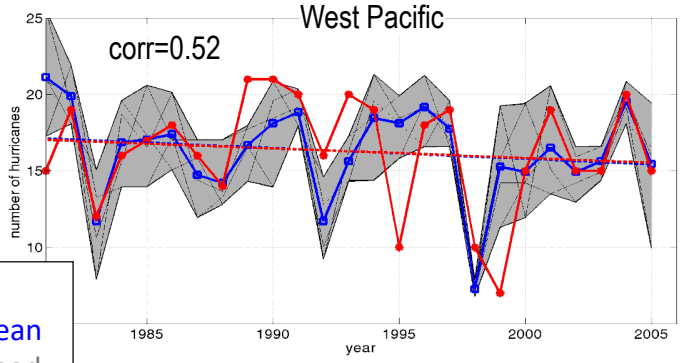



Zhao et al. (2009)

## Interannual variability



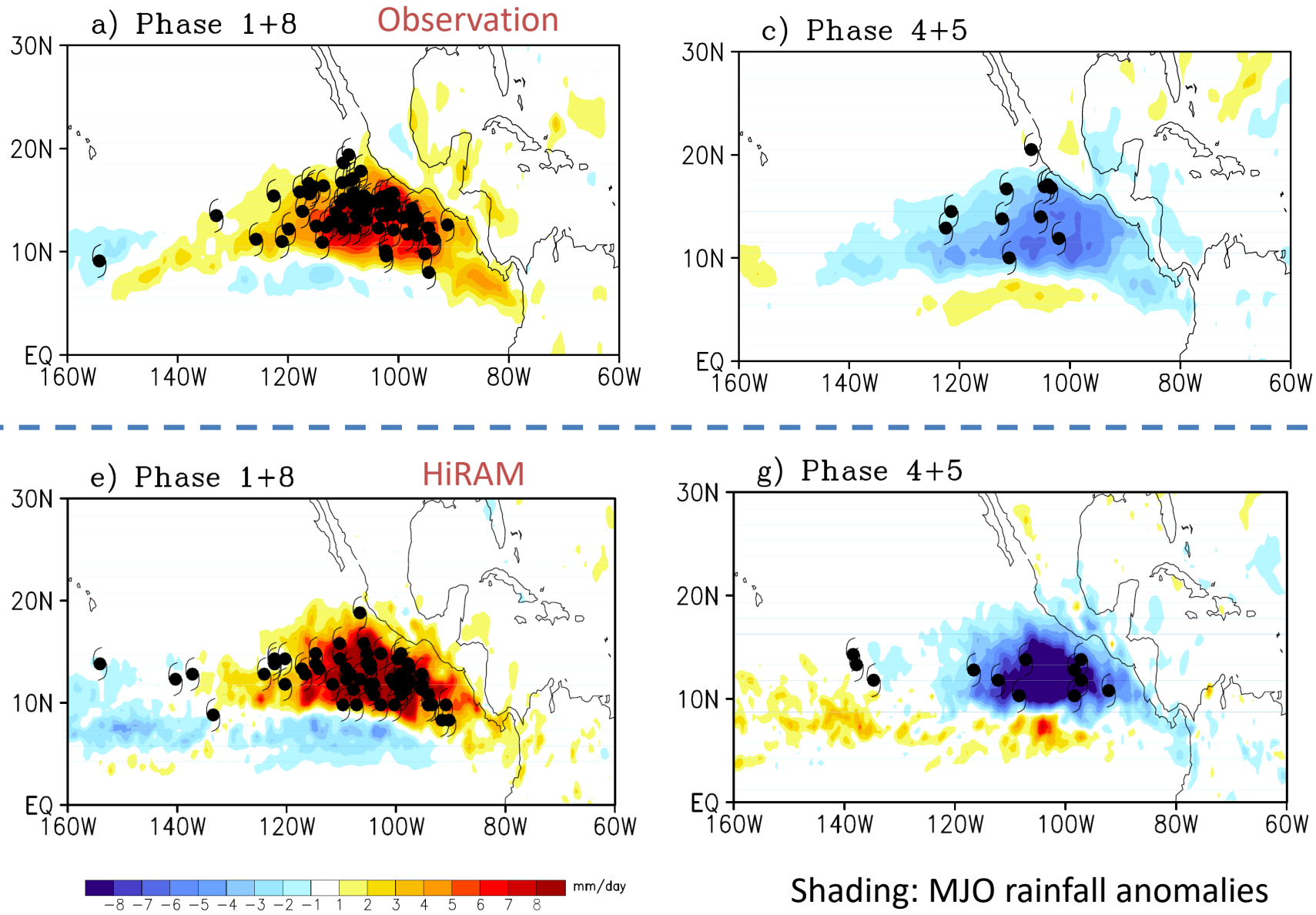




Red: Observations
Blue: HiRAM ens mean
Shading: model spread

# EPAC MJO and TC genesis in GFDL HiRAM

Jiang et al. (2012, 2013)

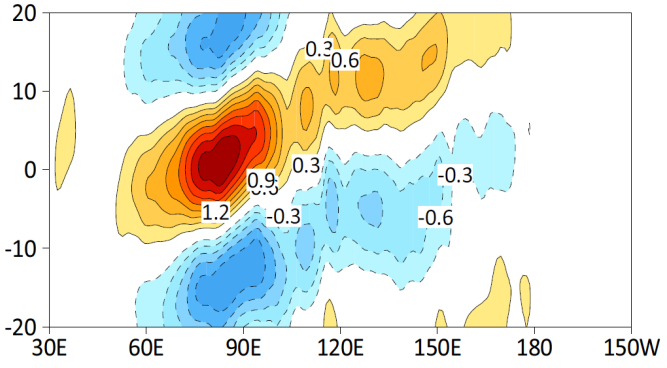



Shading: MJO rainfall anomalies

# Improvement of MJO representation in the new GFDL CM4

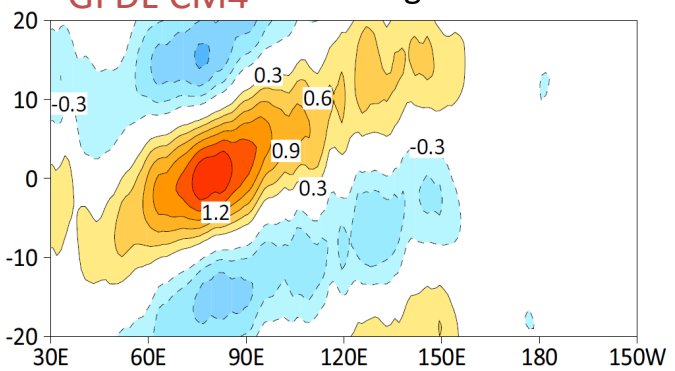
## Climate simulations: (Zhao et al. 2017)

Observation

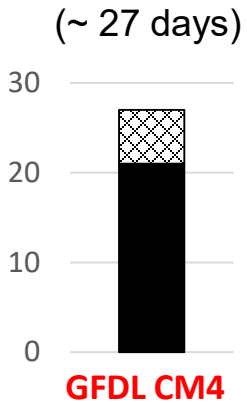


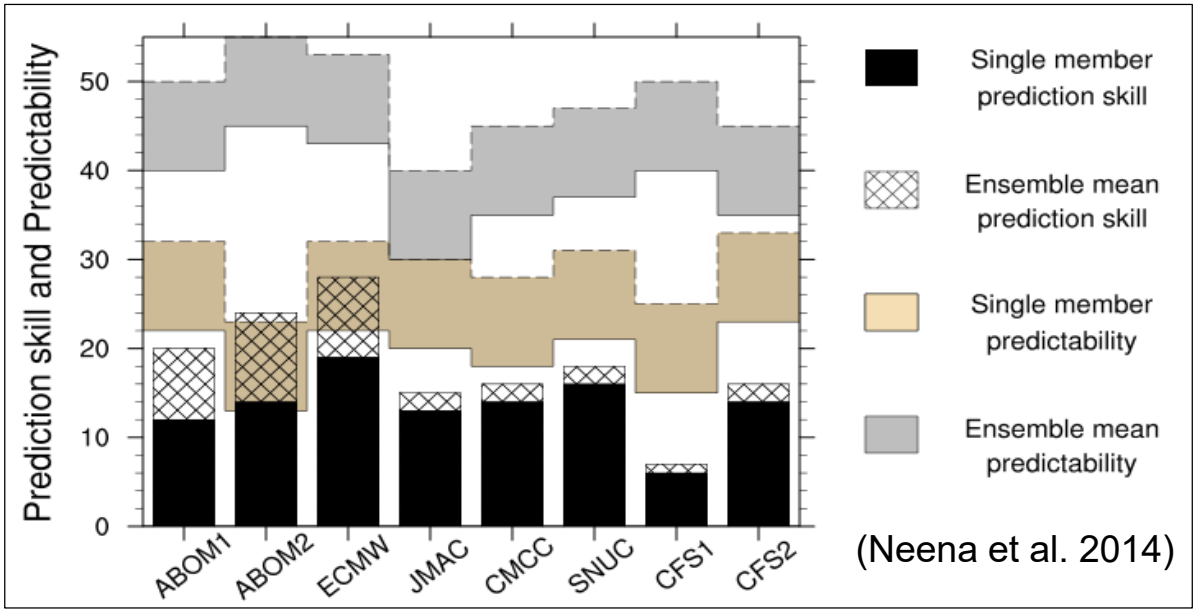

GFDL CM4

Shading: MJO rainfall anomalies




## MJO prediction skill (Xiang et al. 2015a)

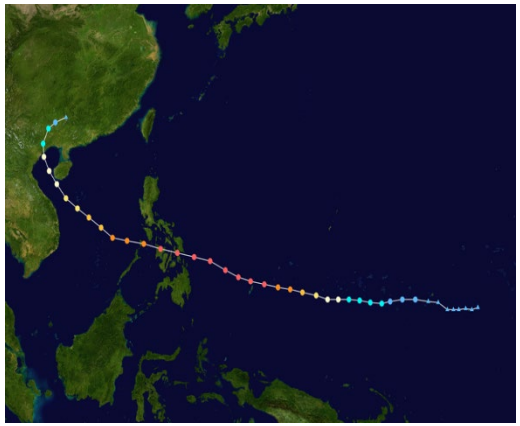


# Subseasonal Prediction of TC genesis – Case studies

Sandy (Oct 2012)

Haiyan (Nov 2013)



| | |
|---|---|
| Model | Global Coupled GFDL CM4, Atmos ~50 km; Ocean ~ 1 deg |
| Atmos I.C. | Nudging u, v, T, h, Ps to NOAA GFS analysis (6 hourly) |
| Ocean I.C. | Nudging SST to NOAA daily SST (daily) |
| Forecast | Daily |
| Ensemble | 24 (00Z-24Z at hourly interval) |
| Integration | 50 days |

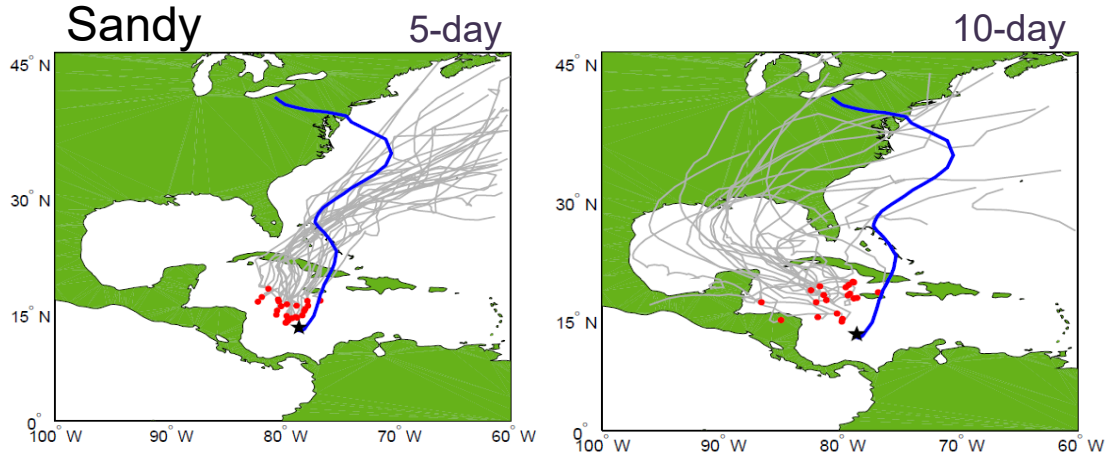
no data assimilation

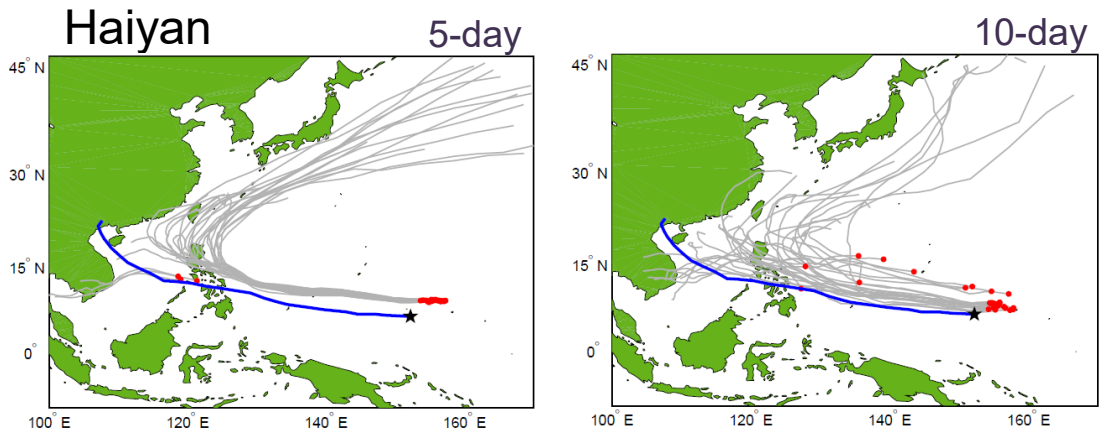
Xiang et al. 2015b

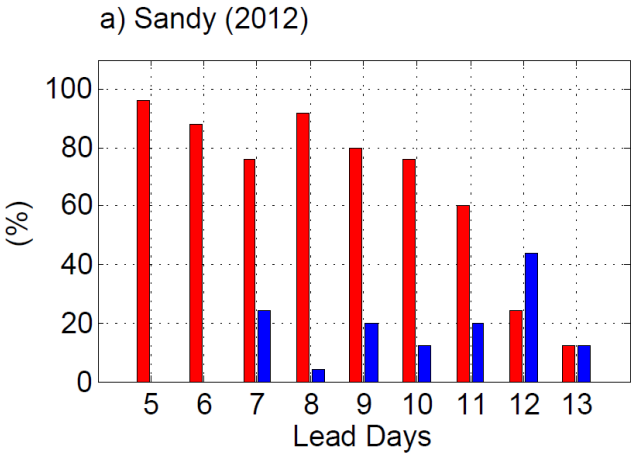
# Genesis Forecast Skill for Sandy and Haiyan in CM4

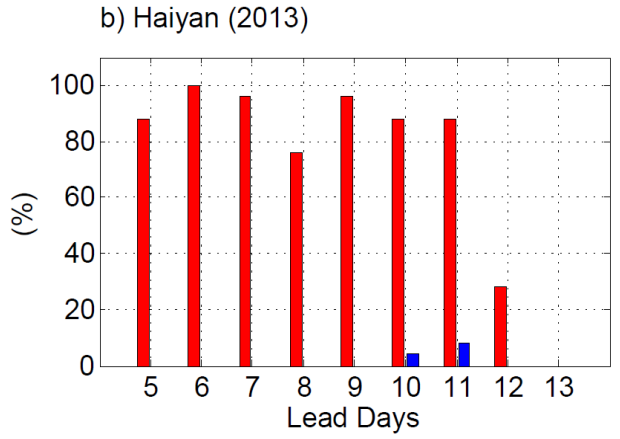
Beyond-weather prediction skill (~11 day)!

**Genesis validation**: +/- 1.5 days; within 8° from observed TS genesis



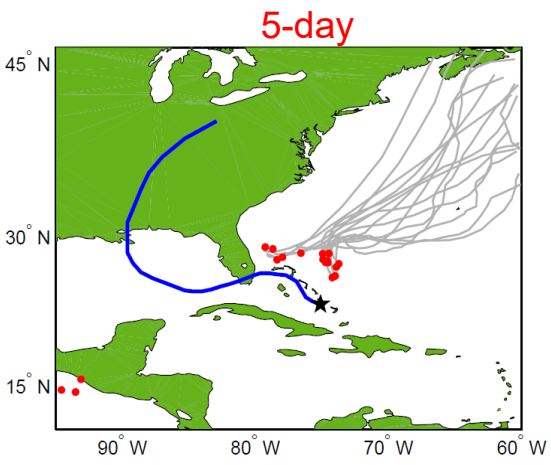

Hit rate (red, 3-day window)
Early / late genesis rate (blue, 10-day window)

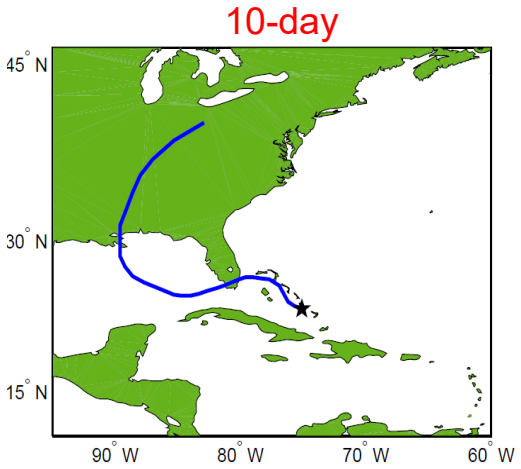
**Blue:** best track
**Grey:** ensemble forecasts

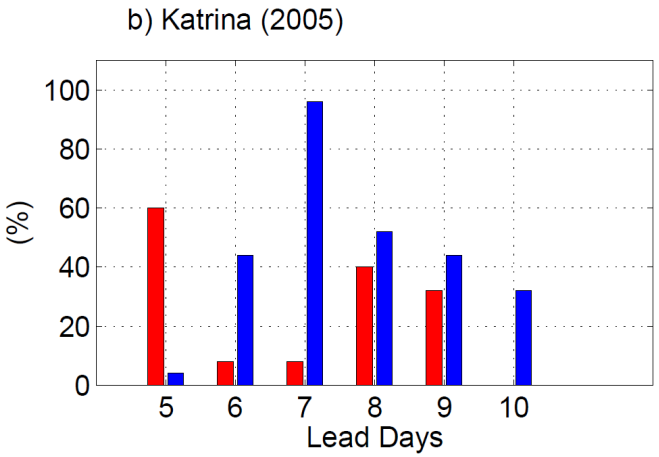
Xiang et al. 2015b

# Genesis forecast of Katrina (Aug 2005)

Much lower skill than Sandy/Haiyan.



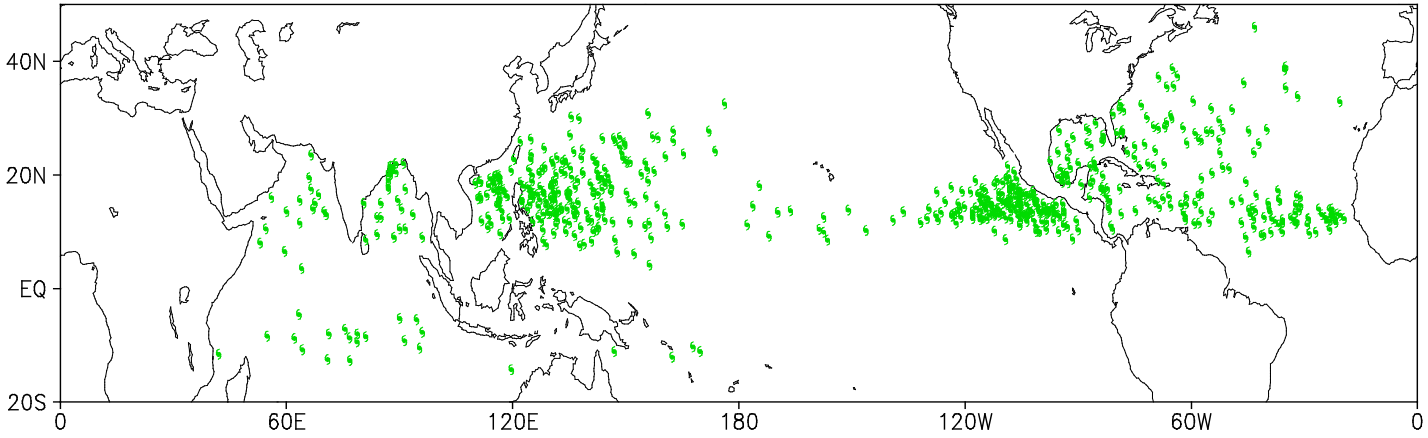




- How predictable of TC genesis in general on extended-range time scales?
- What factors affect TC genesis prediction skill?

# Subseasonal Prediction of TC genesis – Multi-year hindcasts

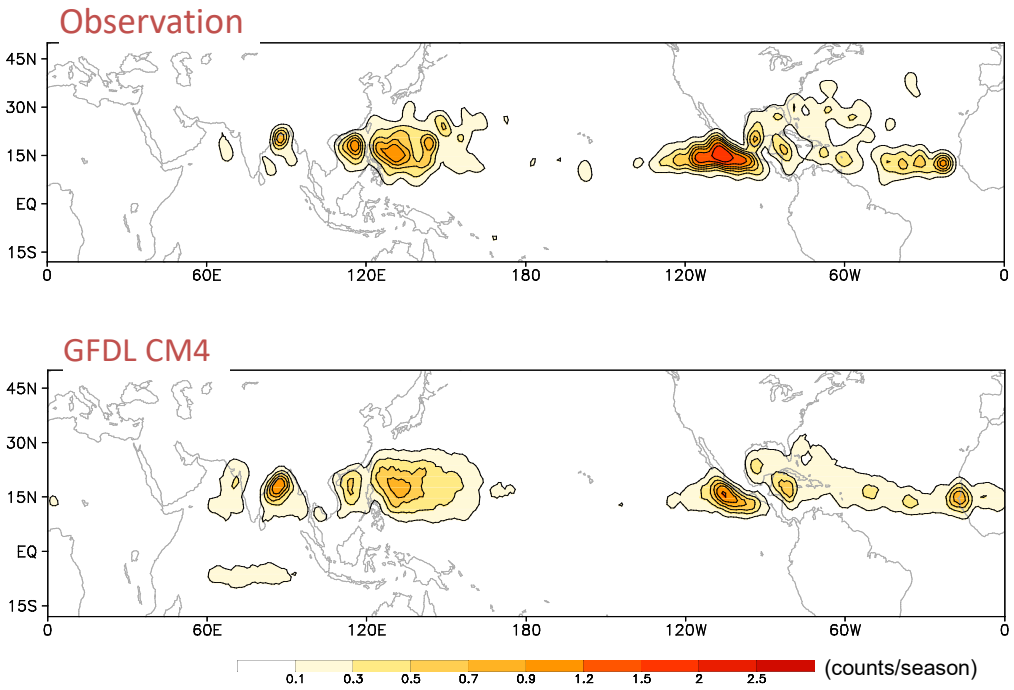
- Jun-Nov, 2003-2013
- 6 times each month (1st, 6th , 11st, 16th, 21st , 26th)
- 12 ensemble members (00Z, 02Z, …., 22Z)
- 50-day forecast

**Observations: 657 Tropical Storms** (Jun-Nov, 2003-2013)

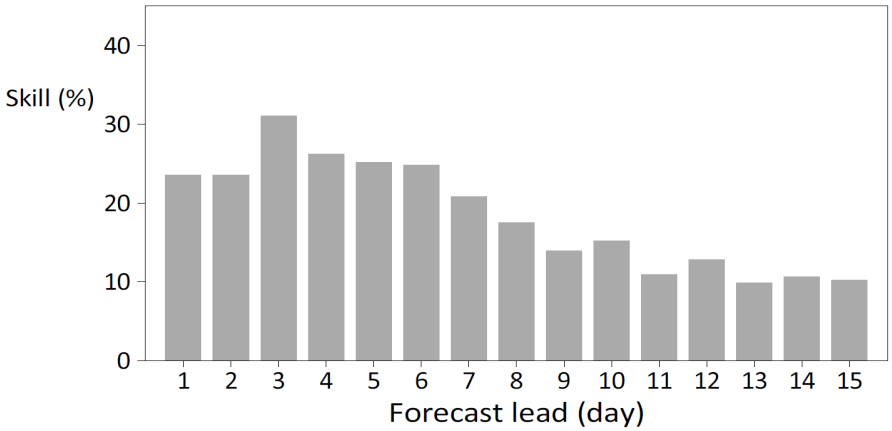



Jiang et al. 2017

# Climatological TS Genesis Occurrence Frequency in Hindcasts




# Globally (WP, EP, NA) averaged TS genesis skill (#594)




Global TS genesis skill is limited.

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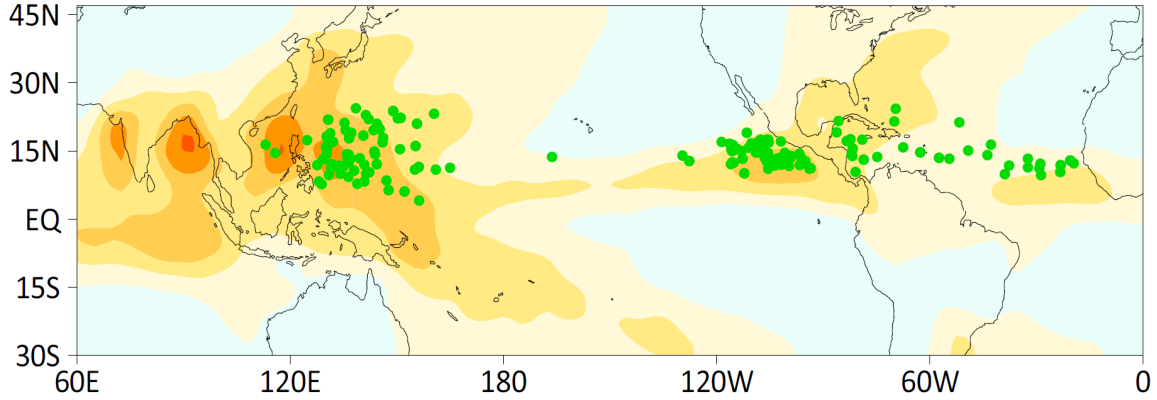
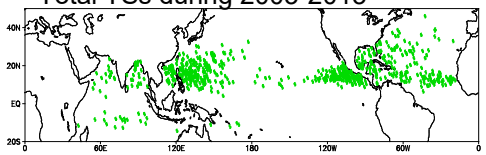
# Identification of more predictable tropical storms

More predictable TS genesis: week-1 forecast skill > 65% ; or week-2 forecast skill > 50%

Genesis location of more predictable TSs (#172 ~ 29%)

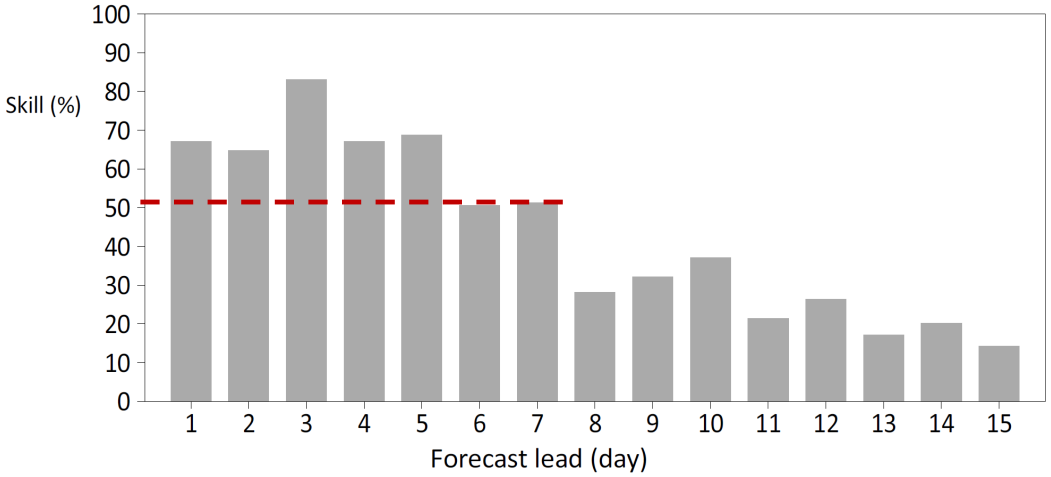



Total TSs during 2003-2013



Shading: 20-70day rainfall STD

Genesis prediction skill for selected more predictable TSs (#172)

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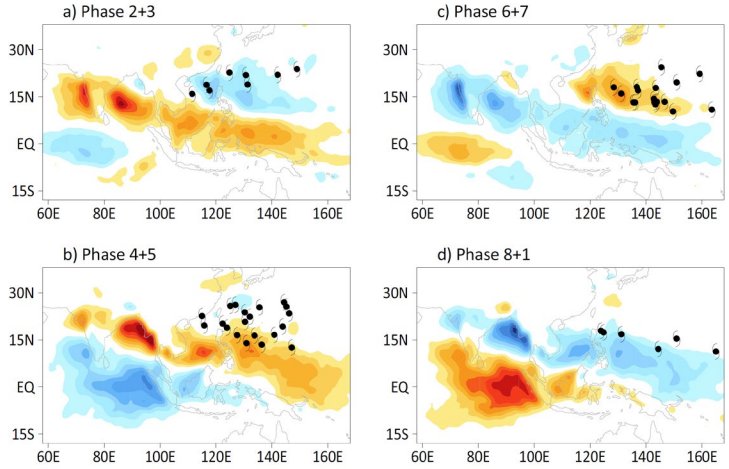
# More predictable TS genesis and large-scale forcing over the W. Pac

## More predictable TS genesis and the MJO




Shading: MJO rainfall anomalies

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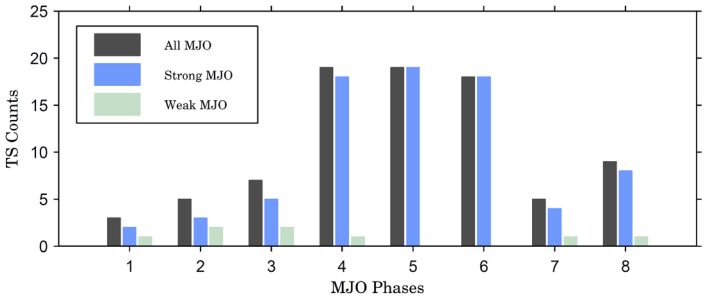
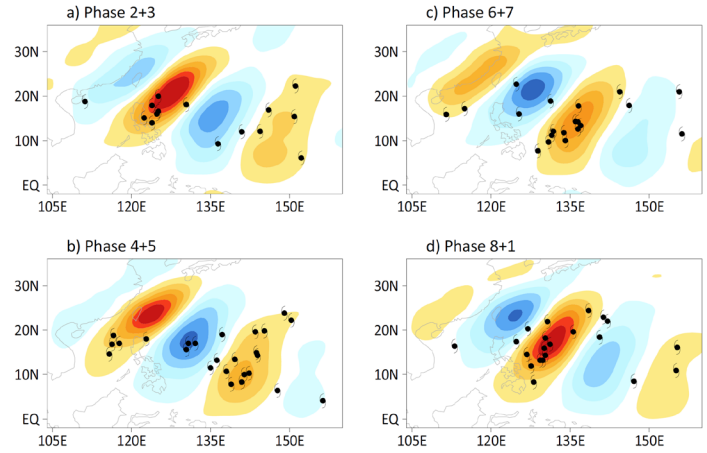
TS counts with MJO phases

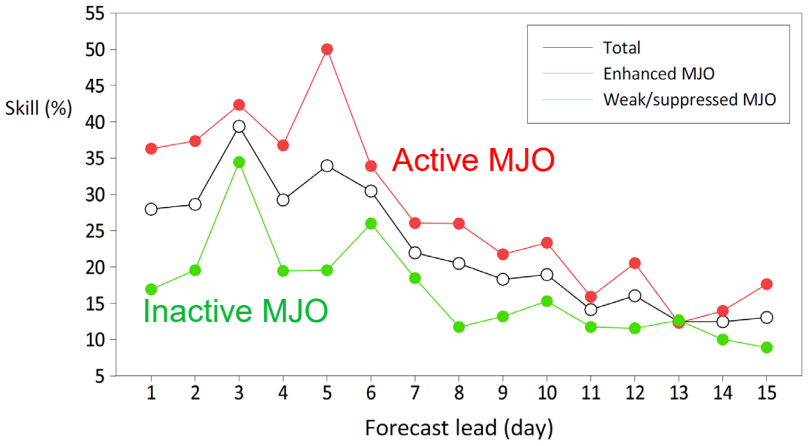



## More predictable TS genesis and Synoptic Waves

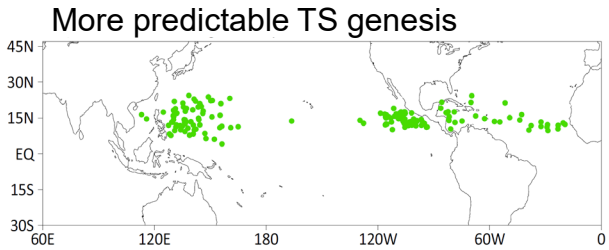



Shading: 850hPa vorticity

## MJO influences on WP/EP TS genesis prediction skill



# Predictability of large-scale fields at week-2 (day 8-14)




What's the S2S predictability sources over the tropical Atlantic?

How predictable of CCEWs on S2S time scale?

Unexploited predictability sources?

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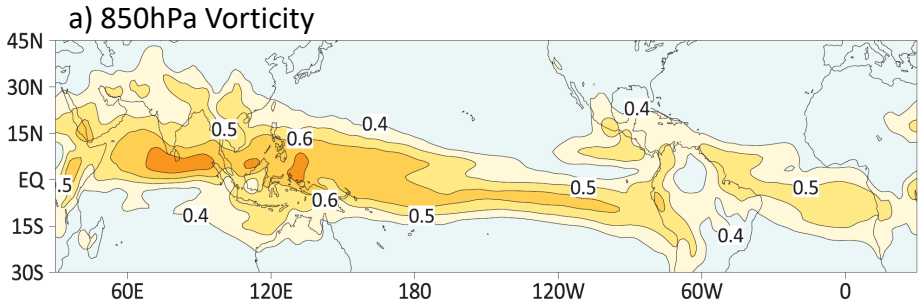
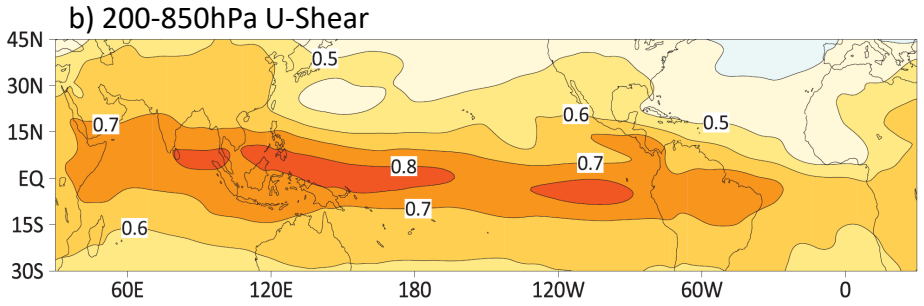
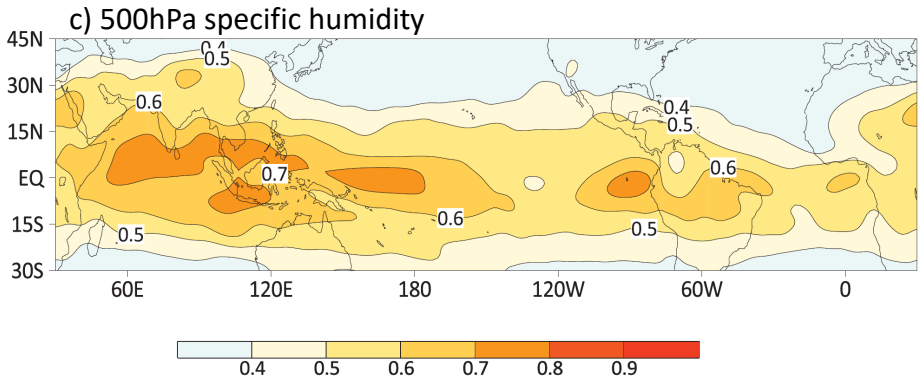


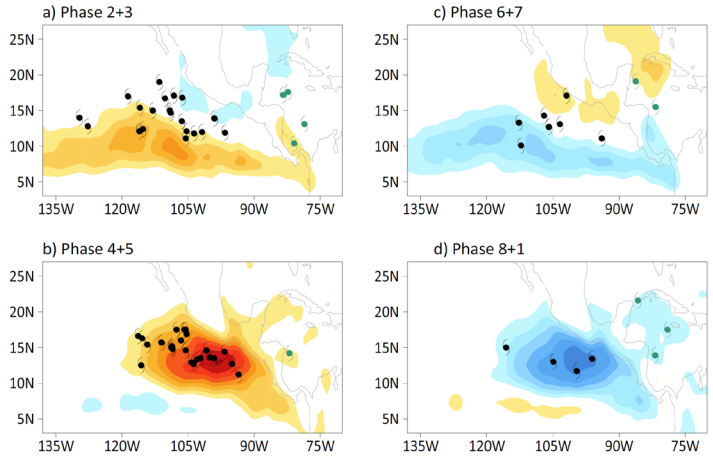



# Summary

- Recent model development with explicit TC-resolving capability and improved representation of large-scale climate variability modes, makes it possible to make extended-range prediction of TC activity;
- Beyond-weather predictability of TC genesis with about 11-day lead time is noted for Sandy and Haiyan based on the GFDL CM4;
- While prediction skill of TC genesis over global oceans is limited, more predictable TC genesis is largely located over tropical regions where the MJO and tropical waves are active;
- Predictability of TC genesis is closely linked to predictability of large-scale fields, including low-level vorticity, mid-level moisture, and vertical wind shear.

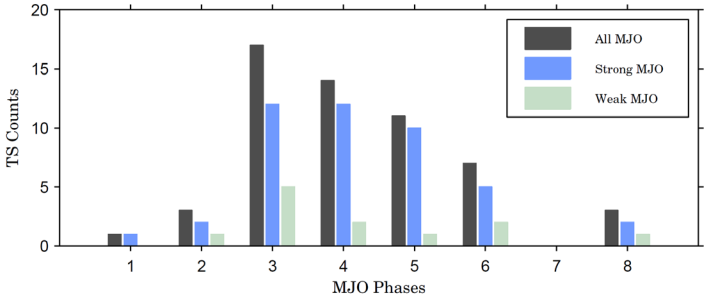
# More predictable TS genesis and large-scale forcing over the E. Pacific

## TS genesis and the MJO

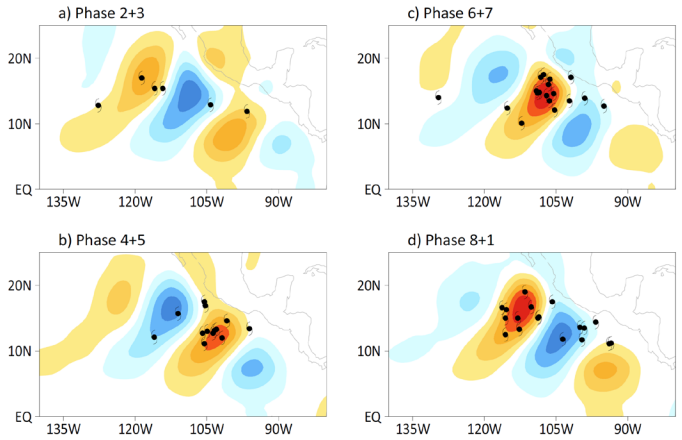



Shading: MJO rainfall anomalies

more predictable TS counts with MJO phases




## TS genesis and Easterly-waves




Shading: 850hPa vorticity

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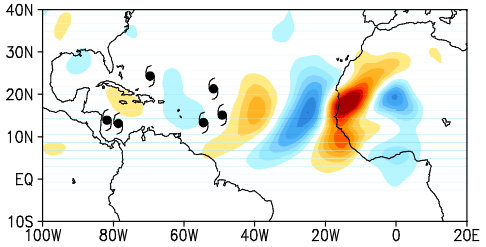
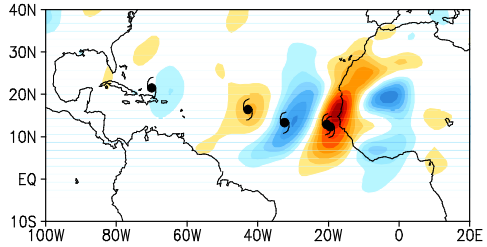
# More predictable NA TSs with Easterly Waves

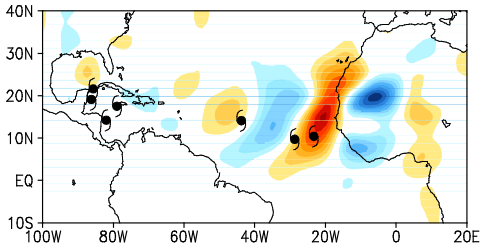
Phase 1

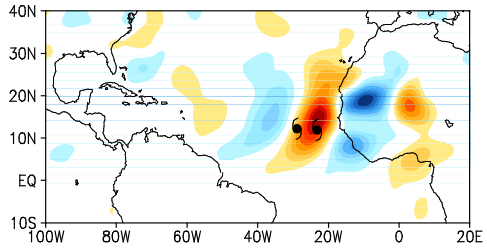



Phase 2

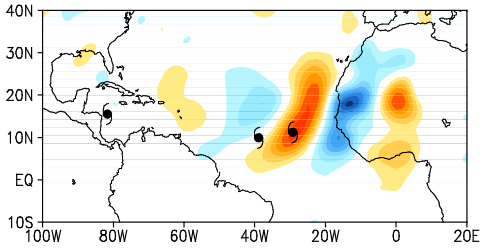
Phase 3

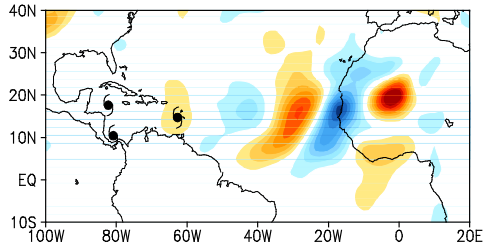



Phase 4

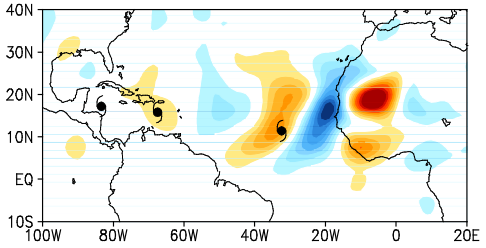
Phase 5

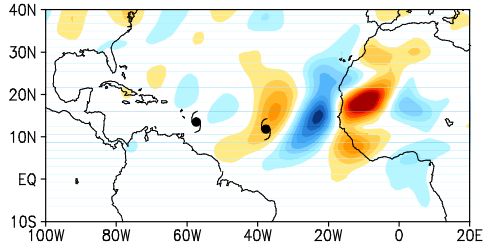



Phase 6

Phase 7




Phase 8

# False Alarm Rate (FAR)