Calibration and Evaluation of GEFS Ensemble Forecasts at Weeks 2-4

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NGGPS PI Meeting, August 2, 2016 NCEP/NOAA/NWS

Overviews

- The 1st-kind predictability (Lorenz 1982) could be extended closer to 2 weeks in the new NGGPS. This range is still at the lower end of the targeted lead-time of 2-4 weeks.
- The predictability is diminished by growing chaotic noises but increased by lasting signals.
- One way to improve the predictability is to separate the lasting signals from the noises before calibrating the NGGPS ensemble forecasts.

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Overviews

- EOF/PCA is an ideal approach

  It has complete orthogonal basis with only a limited number of modes which are sorted in significance from most to least.
  No edge effect for real-time applications.

- Selected signals in the GEFS
  - Atmospheric Blocking (PMZ)
  - Madden-Julian Oscillation (MJO)
  - Tropical Cyclone-genesis for its evolving impact

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Overviews - Data

- The GEFS V10 Reforecasts II (*Hamill et al. 2013*)
  ESRL/NOAA website and HPSS/JET tapes
  00Z Daily, 10 members

- GEFS V11 Reforecasts (Zhu and Guan)
  00Z every 5 days, 5 members

- References
  GFS FNL, NCEP/NCAR and NCEP/DOE Reanalyses

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Results

- Blocking + persistent ridges

Ping Liu, Yuejian Zhu, Qin Zhang, Jon Gottschalck, Minghua Zhang, Christopher Melhauser, Wei Li, Hong Guan, Xiaqiong Zhou, Dingchen Hou, Malaquias Peña Mendez, Guoxiong Wu, Yimin Liu, Linjiong Zhou, Bian He, Wenting Hu, Raymond Sukhdeo

"Tracking Persistent Maxima of 500-hPa Geopotential Height (PMZ)"

submitted to *Mon. Wea. Rev.*

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Results

- Blocking + persistent ridges

- ♦ Why PMZ
- ♦ How to track
- ♦ Predictability in the GEFS
- ♦ Improvement to AC
- ♦ Real-time monitoring

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Why PMZ?

Atmospheric blocking induces droughts and heatwaves. It is a major mode of subseasonal phenomenon in middle latitudes and a major signal for weeks 2-4 predictions.

Existing indices (Tibalti and Monteni 1990 - CPC blocking web page; Pelly and Hoskins 2003; Dole and Gordon 1983) require a blocking to have

Easterly winds in place of prominent westerly; equivalent to a reversal of pressure gradient or potential temperature at 2-PVU (Potential vorticity unit; dynamical tropopause) surface

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Why PMZ?

These indices neglect persistent open ridges, miss immature blockings (early stages) and some omega-shape blockings.

But, persistent open ridges alone can induce exactly the same severe droughts and heatwaves, for example, the catastrophic heatwave in early August 2003 over Western Europe (Black et al. 2004).

And omega-shape blockings are major systems impacting North America.

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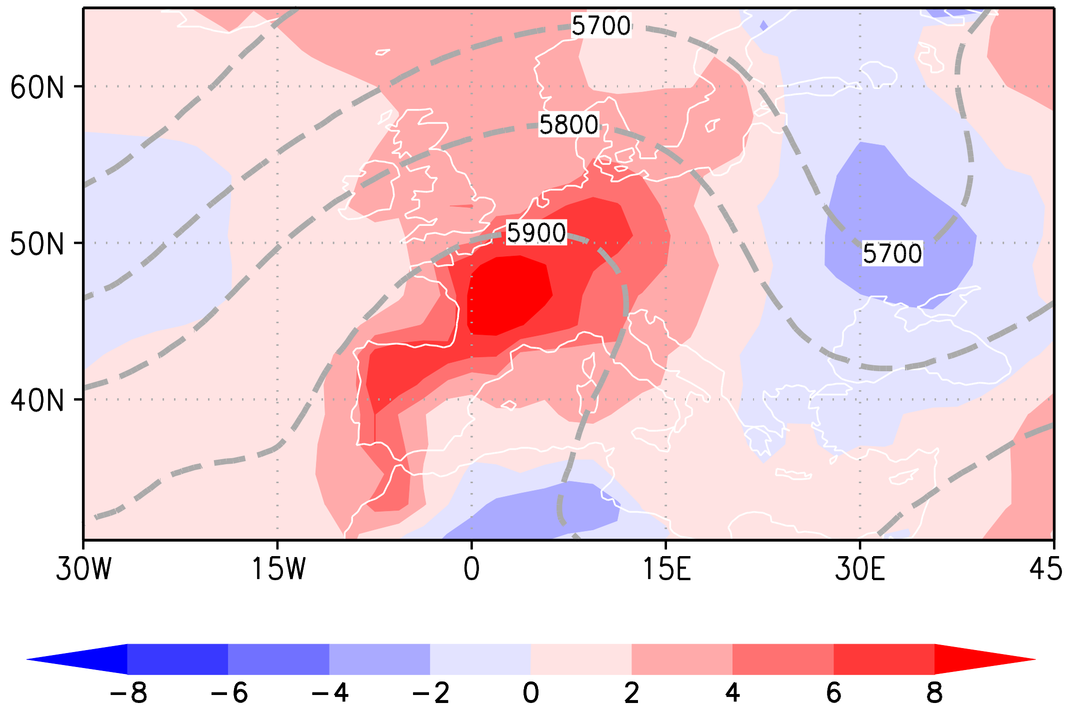
A PMZ event caused the heatwave Aug03 in Western Europe



2-13 Aug 03
T_s' and Z500

NCEP/NCAR R
2.5x2.5
1979.1.1-
2015.12.31

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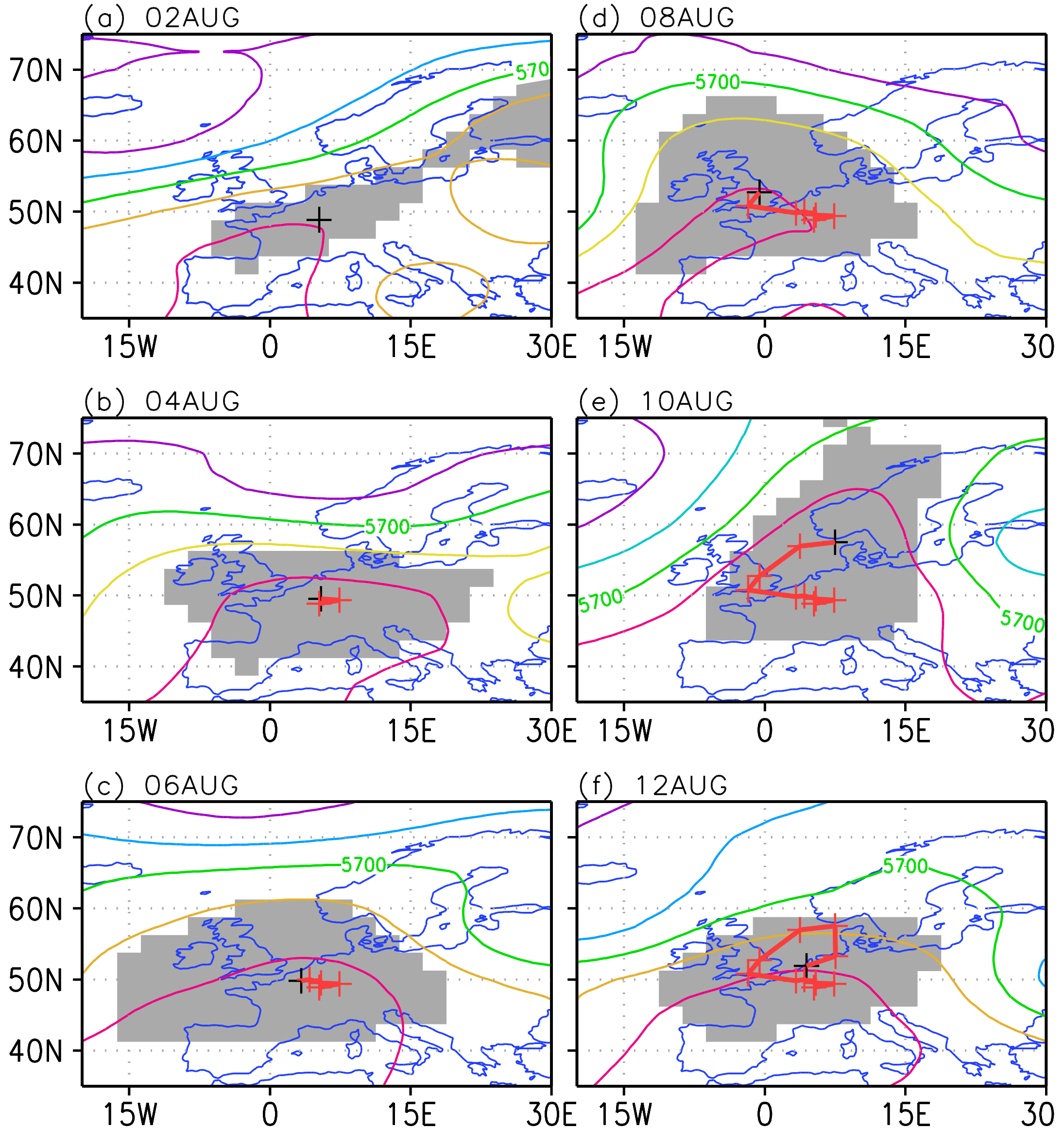
Tracking and impact areas of the PMZ

2-13 Aug03



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Why PMZ?

It is necessary to track both open ridges and blockings as one event.

Another case: 9-26 January, 2013

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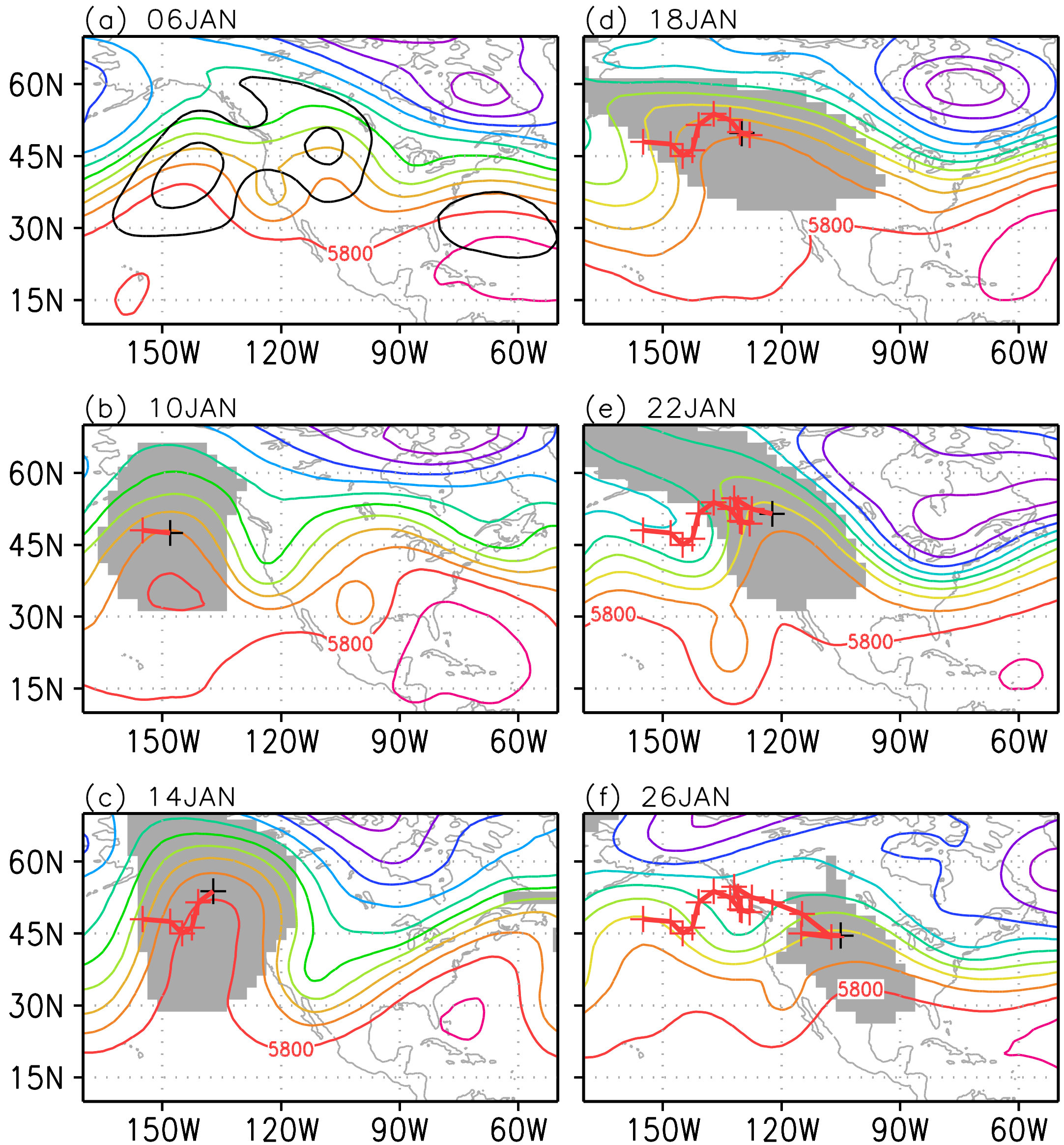
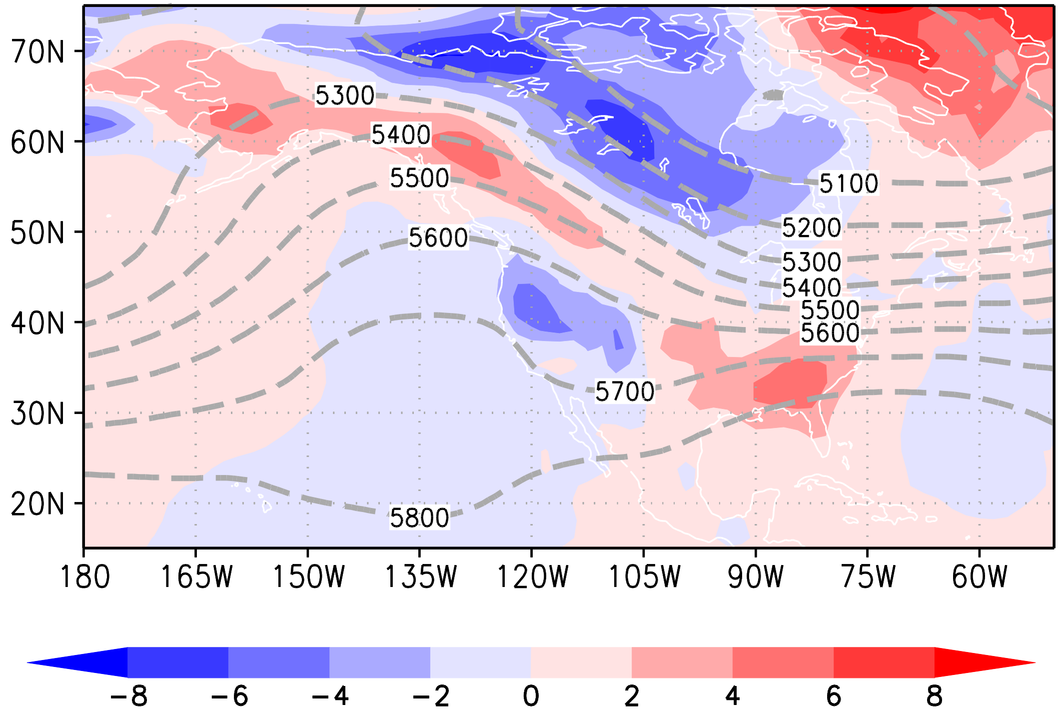
Persistent open ridges + Ω blocking over 9-26 Jan 2013



Why PMZ?

Persistent open ridges + Ω blocking and CONUS T_s' in Jan 2013



09-26 Jan 13

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How to track a PMZ?

Tracking – targeting Z* (eddy component of Z500)

- A core includes a local maximum of eddy Z^* and its neighboring grids whose values are greater than 100 GPMs and decrease radially to 20 GPMs smaller than the maximum value.
- Two cores on consecutive Z^* maps belong to a PMZ event if they share at least one grid point and move at a pace of at most 10^o longitude per day.
- The PMZ ends at the core without a successor.
- Each of the tracked cores is expanded to include more contiguous points whose Z^* values are at least 100 GPMs and decrease radially. The larger number of points better represent the actual area impacted by the PMZ.

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Results

- GEFS predictability of PMZ

(Based on GEFS V10 Reforecasts, 10 members, lead time 1-16 days. Tracking the time series of each lead day)

Two cases

- ♦ Aug2003 heatwave
- ♦ Jan2013 omega blocking

Climatological statistics

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GEFS Predictability - Onset

PMZ over 02-13 Aug 2013

Lead time (days)	Starting date (Onset)	Duration (days)	Starting Latitude	Starting Longitude	Initial Intensity (gpm)
1	02Aug2003	11	51.8°N	4.1°E	162.4
2	02Aug2003	11	51.8°N	4.0°E	160.2
3	02Aug2003	12	51.3°N	3.4°E	157.1
4	03Aug2003	11	51.7°N	3.6°E	160.2
5	03Aug2003	11	51.6°N	4.0°E	161.1
6	04Aug2003	10	52.0°N	2.3°E	168.7
7	03Aug2003	12	52.0°N	1.9°E	164.9
8	02Aug2003	13	52.4°N	2.1°E	156.8
9	03Aug2003	12	53.6°N	3.1°E	151.5
10	04Aug2003	11	53.7°N	3.7°E	145.5
11	08Aug2003	5	55.5°N	6.3°E	144.5
12	09Aug2003	7	55.1°N	7.2°E	112.6
13	11Aug2003	4	57.5°N	6.0°E	116.8
14-16	Null				

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GEFS Predictability - Onset

PMZ over 09-26 Jan 2013

Lead time (days)	Starting date (Onset)	Duration (days)	Starting Latitude	Starting Longitude	Initial Intensity (gpm)
1	09Jan2013	17	49.0°N	228.3°E	355.0
2	09Jan2013	14	49.6°N	225.0°E	377.1
3	09Jan2013	14	49.5°N	225.5°E	371.3
4	09Jan2013	16	48.3°N	228.1°E	342.7
5	09Jan2013	15	49.5°N	227.0°E	355.0
6	10Jan2013	14	49.6°N	228.8°E	359.6
7	10Jan2013	14	50.1°N	229.0°E	353.1
8	11Jan2013	13	50.3°N	228.8°E	356.3
9	09Jan2013	16	50.2°N	227.0°E	340.9
10	09Jan2013	10	49.8°N	222.0°E	325.2
11	13Jan2013	7	51.4°N	222.6°E	361.2
12	19Jan2013	6	50.9°N	227.1°E	263.7
13	10Jan2013	9	48.8°N	221.6°E	296.7
14	10Jan2013	5	46.4°N	223.4°E	236.9
15	11Jan2013	6	47.3°N	225.0°E	231.2
16	08Jan2013	4	44.3°N	212.0°E	162.0

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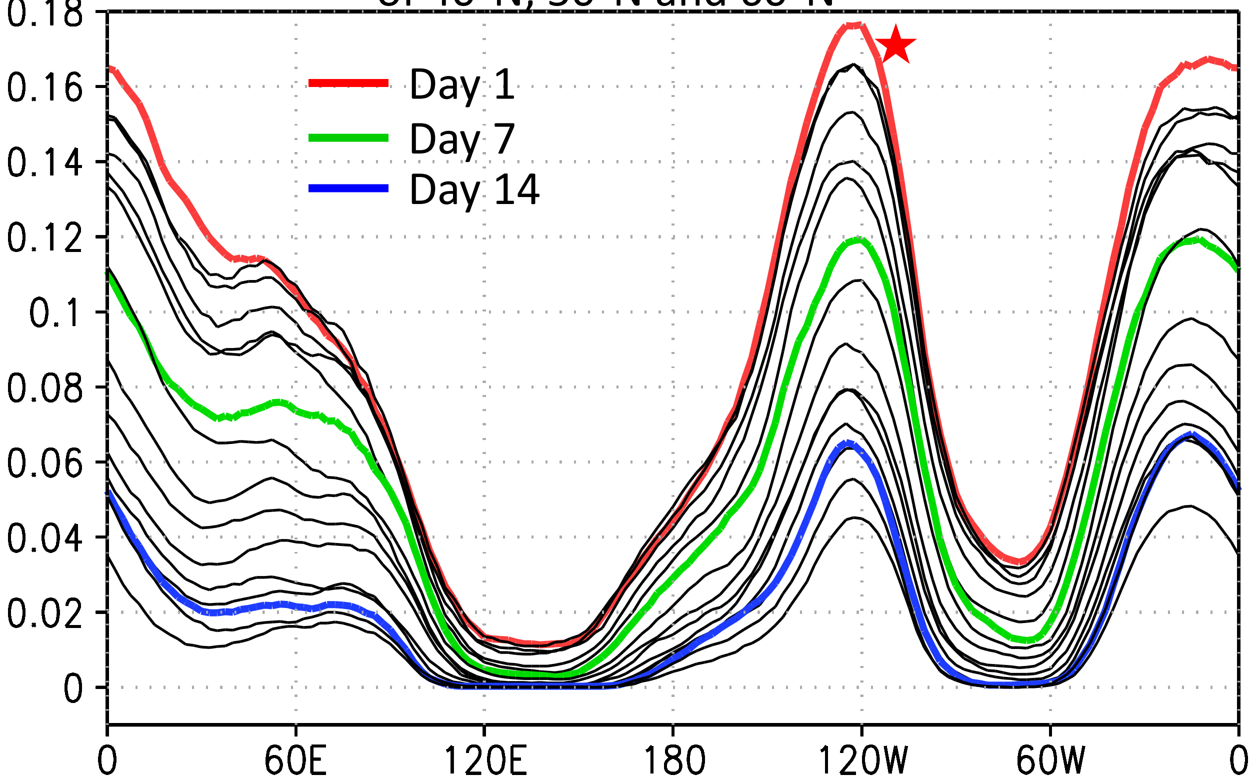
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer, ensemble mean

Annual frequency distribution of impact area with lead time, average of 40°N, 50°N and 60°N



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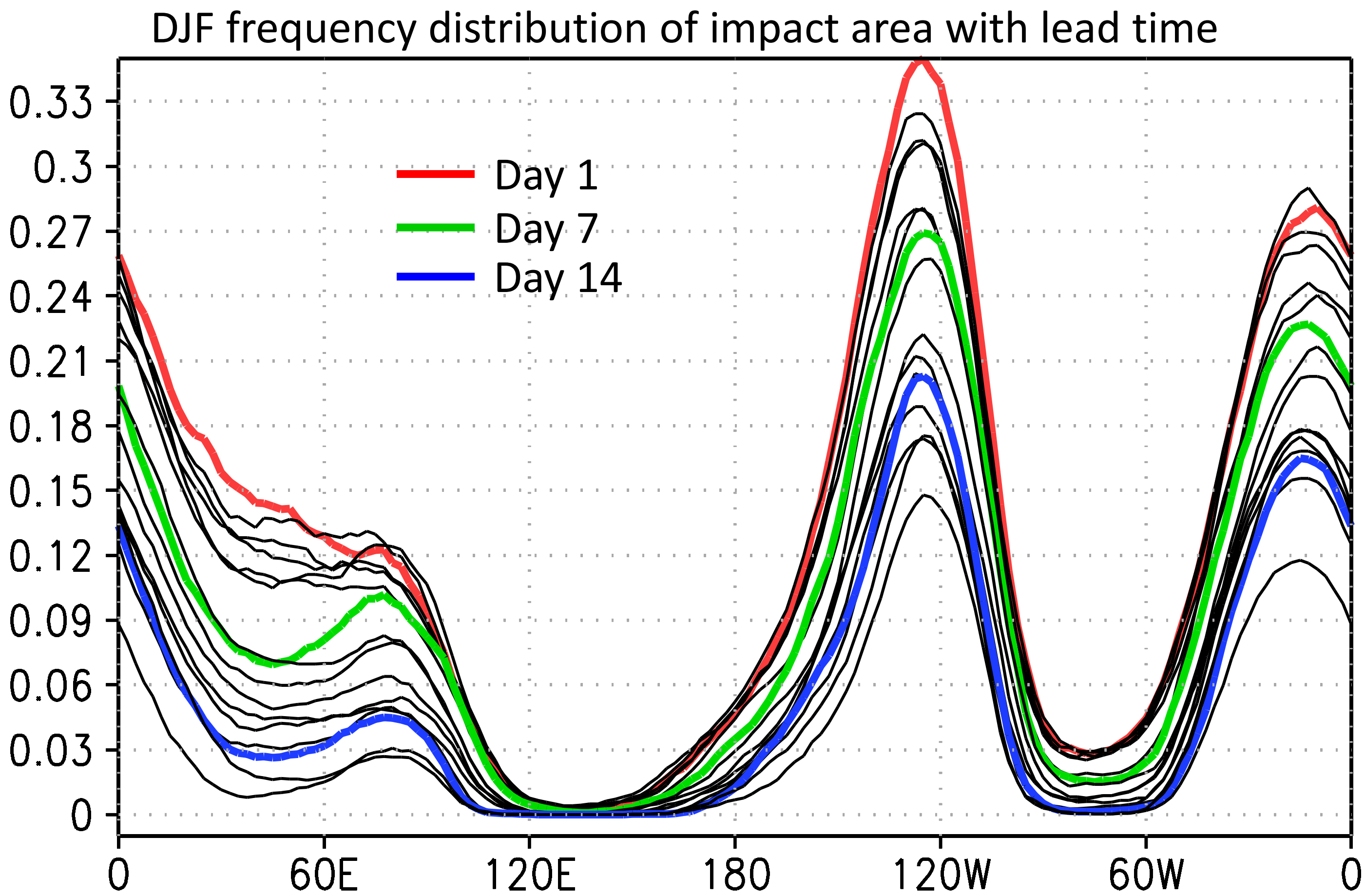
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer



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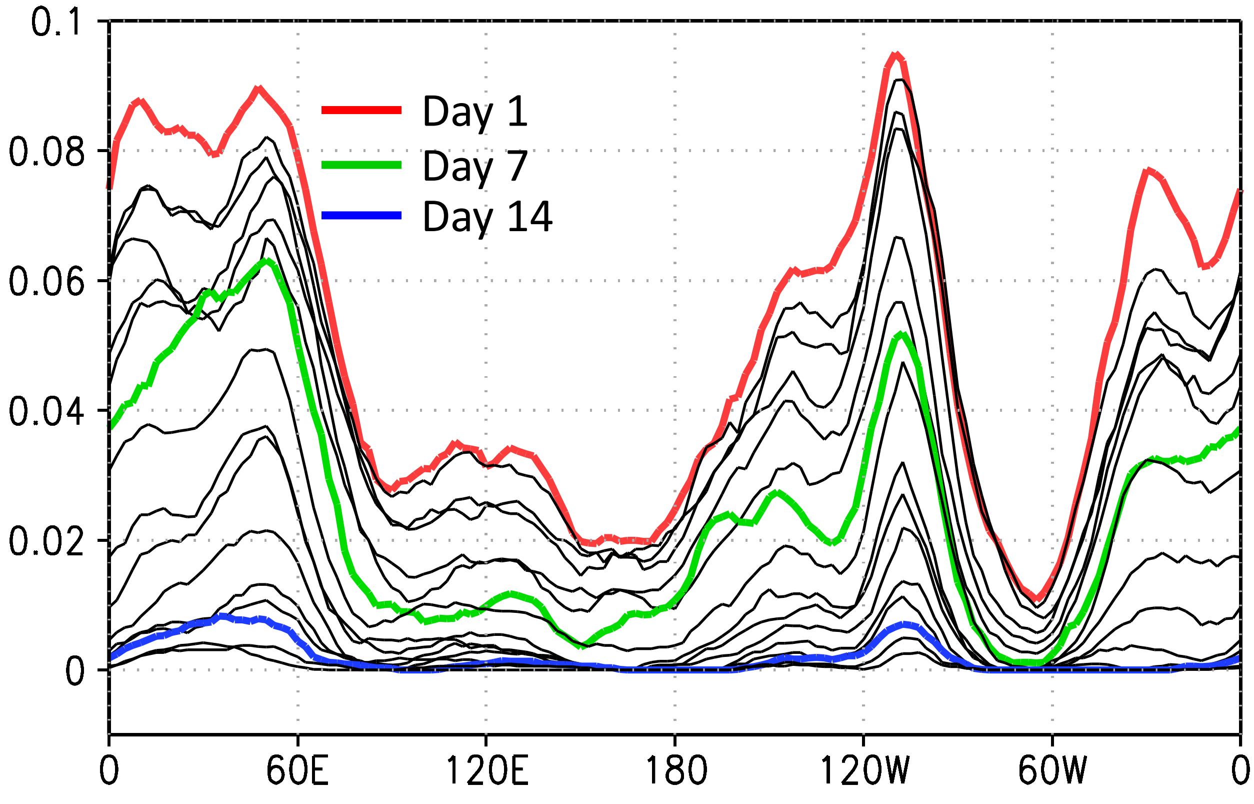
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer

JJA frequency distribution of impact area with lead time



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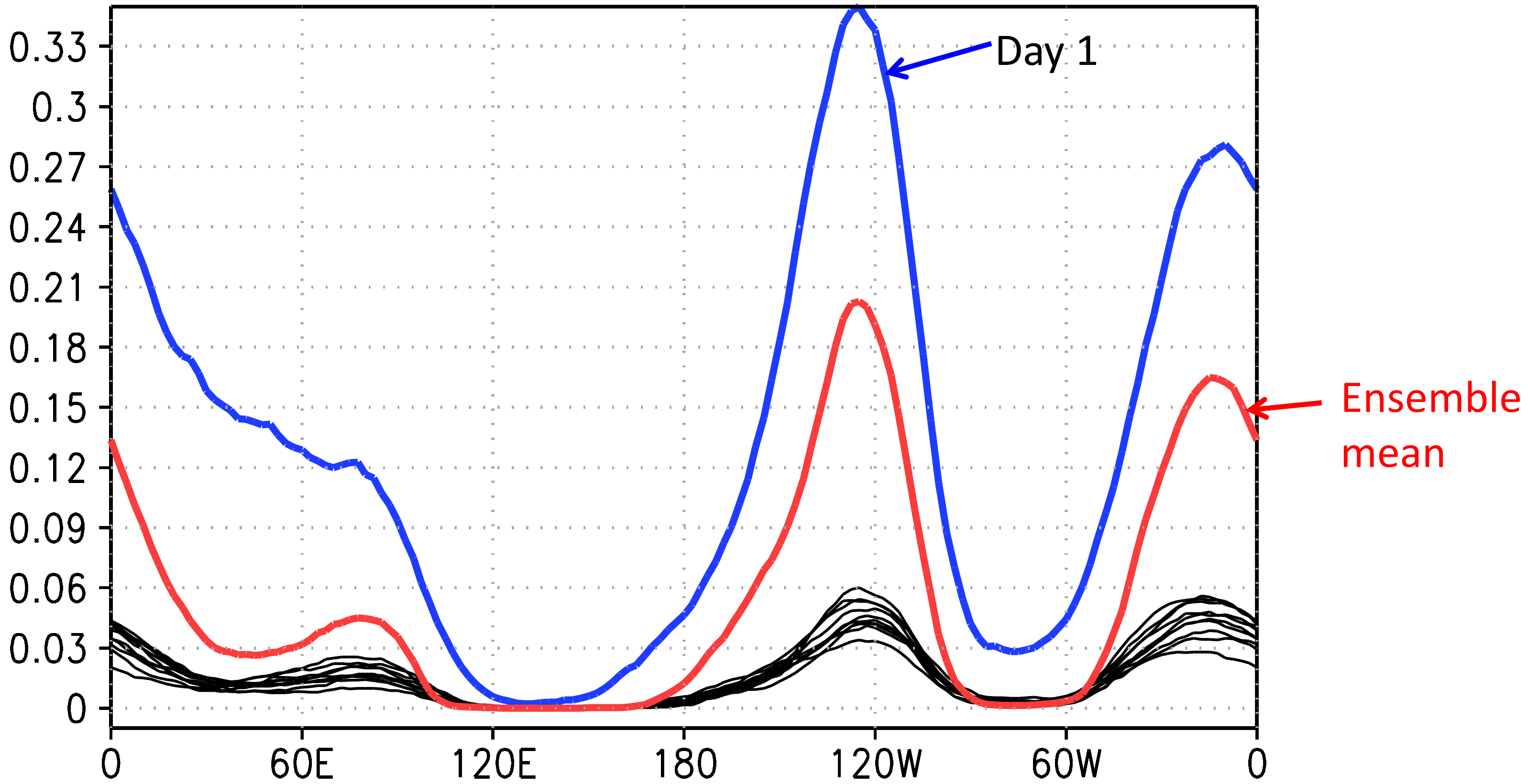
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer, ensemble members



DJF frequency of 10-member reforecasts at day 14
Red for ensemble mean; blue for mean at day 1

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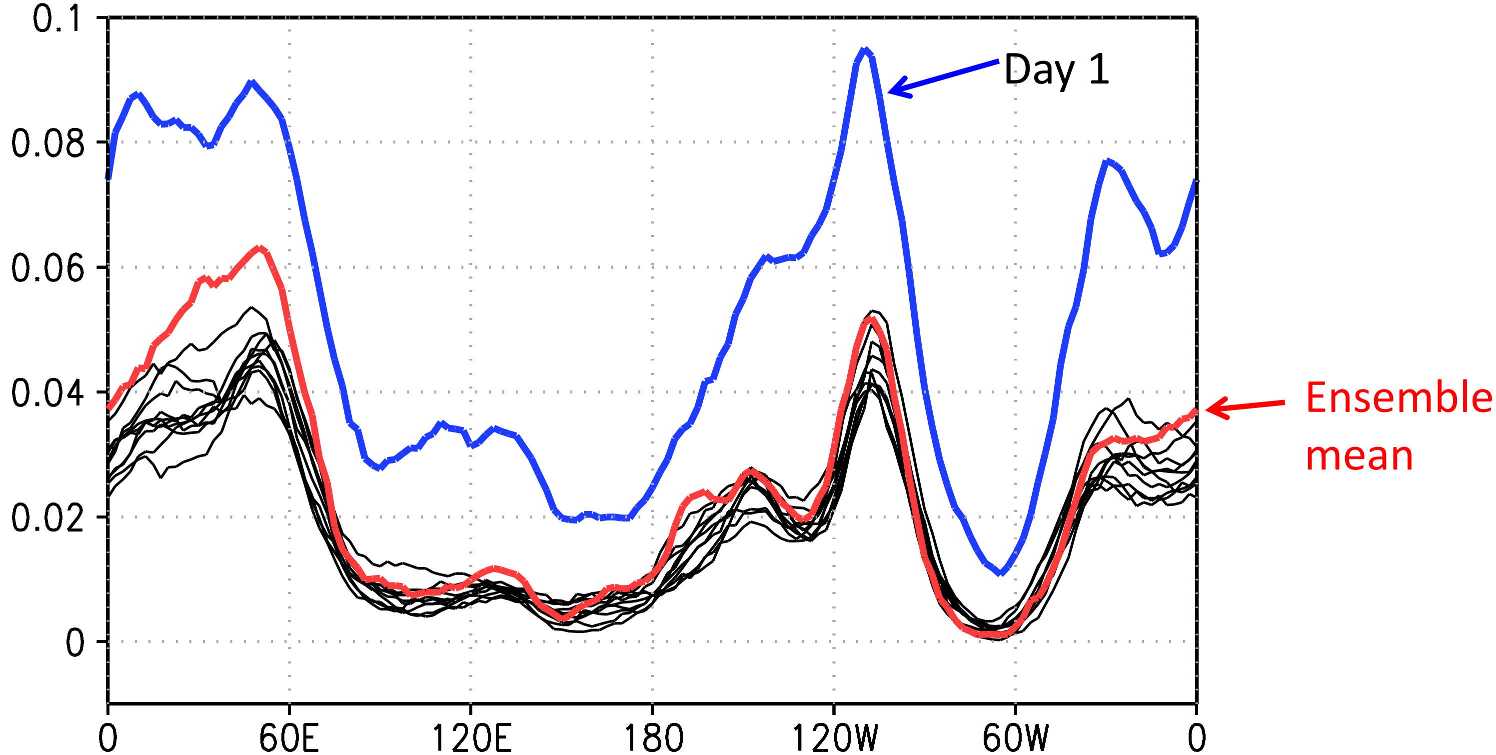
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer



JJA frequency of 10-member reforecasts at day 7
Red for ensemble mean; blue for mean at day 1

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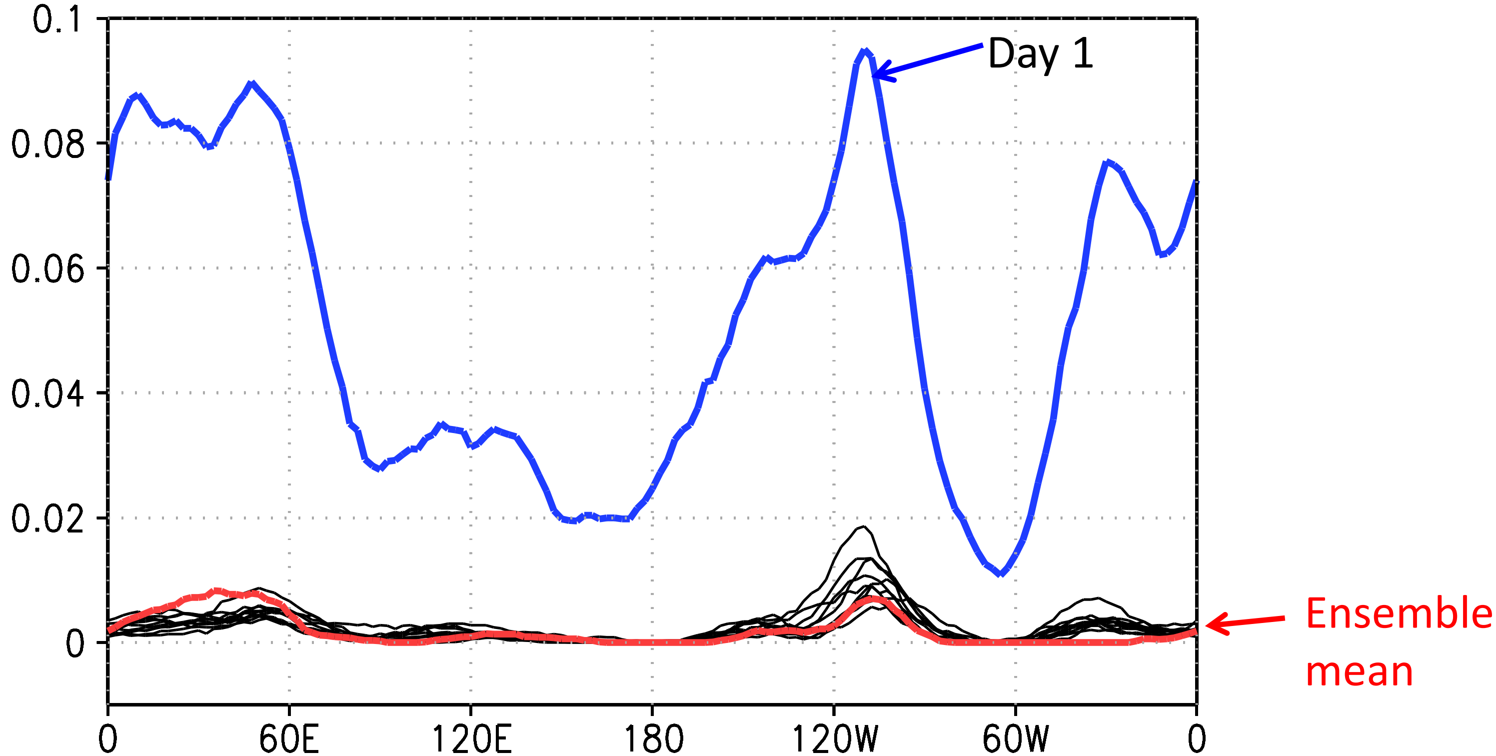
Predictability in the GEFS v10 (or Reforecast II)
PMZ of 4 days and longer



JJA frequency of 10-member reforecasts at day 14
Red for ensemble mean; blue for mean at day 1

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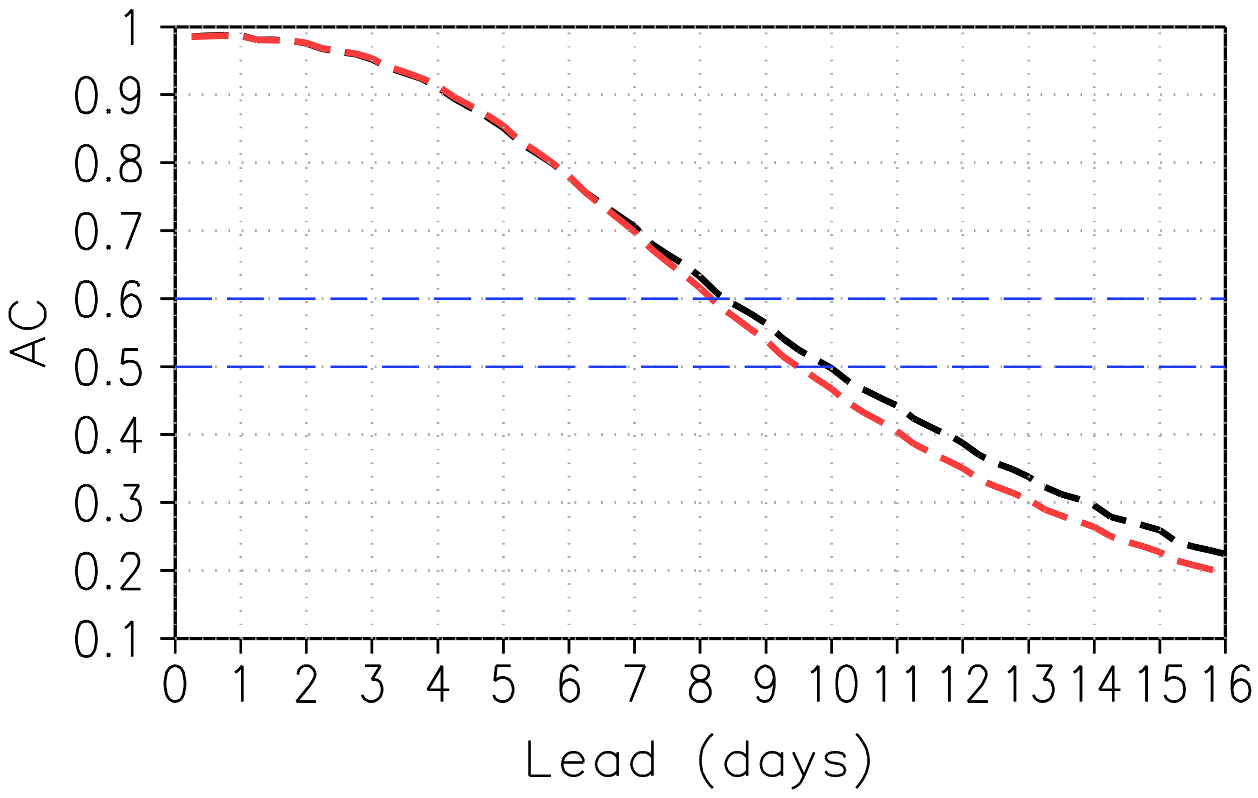
Results – PMZ improves AC

- Computed the anomalies at each lead time
- EOF/PCA decomposing and reconstructing retaining the first 30-90% variance
- 60% appears best to separate PMZ signals

Improved AC of Z500



AC during 1985-2012. Dashed: all cases; solid: first 60% of EOF; red: all cases; black : 131 PMZ events lasting for longer than 12 days; starting from onset.

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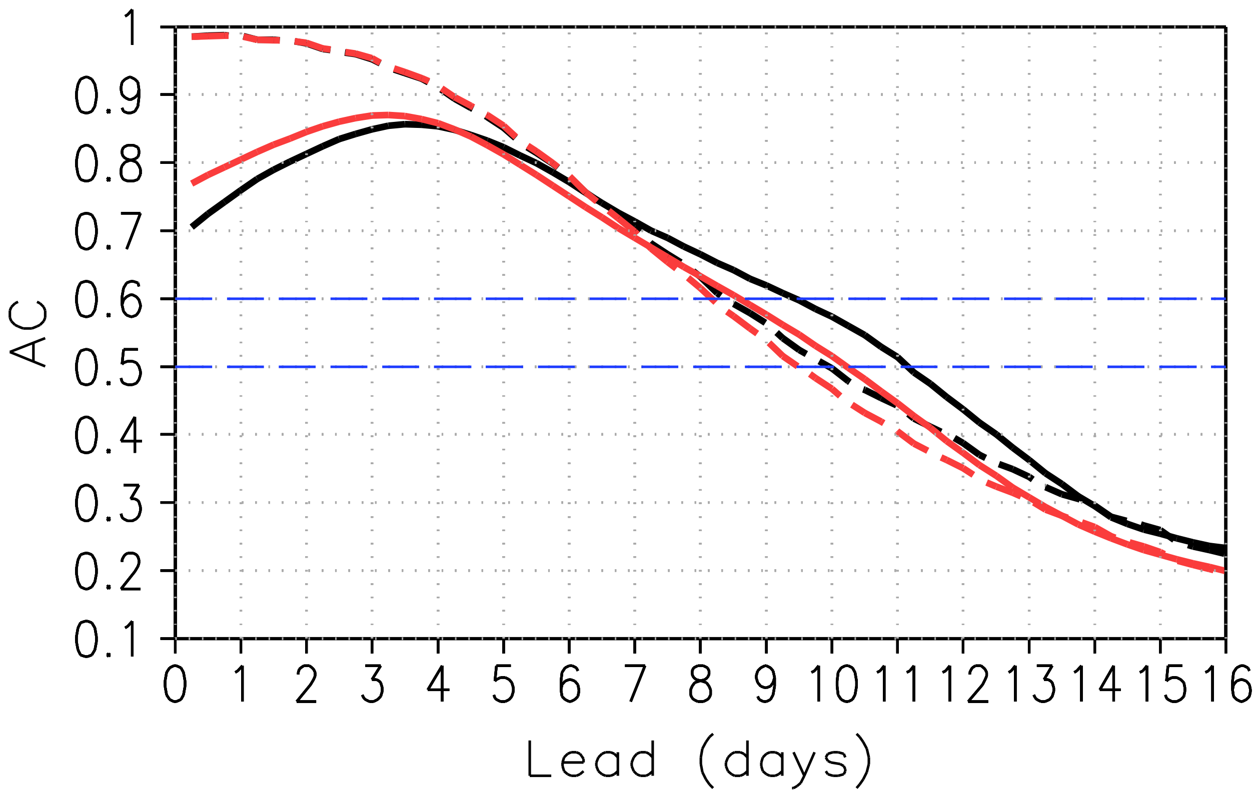
Improved AC of Z500



AC during 1985-2012. Dashed: all cases; solid: first 60% of EOF; red: all cases; black : 131 PMZ events lasting for longer than 12 days; starting from onset.

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Real-time Monitoring PMZ

In collaboration with
Jon Gottschalk, Qin Zhang, and Yuejian Zhu
(The opportunity for transition to EMC
and the operational potential)

http://mjo.somas.stonybrook.edu/PMZ

A snapshot on 28 June, 2016

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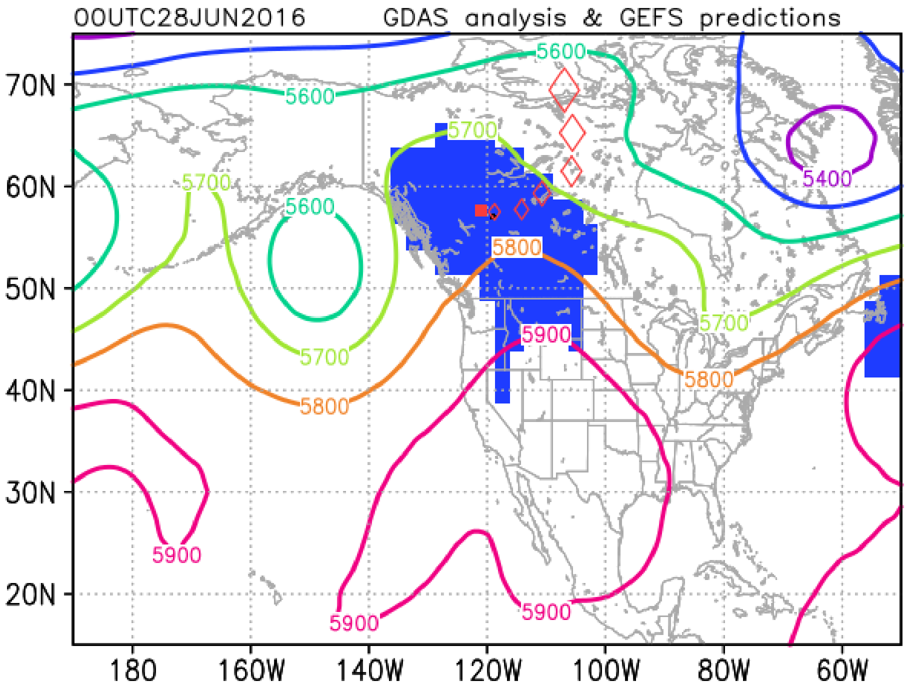

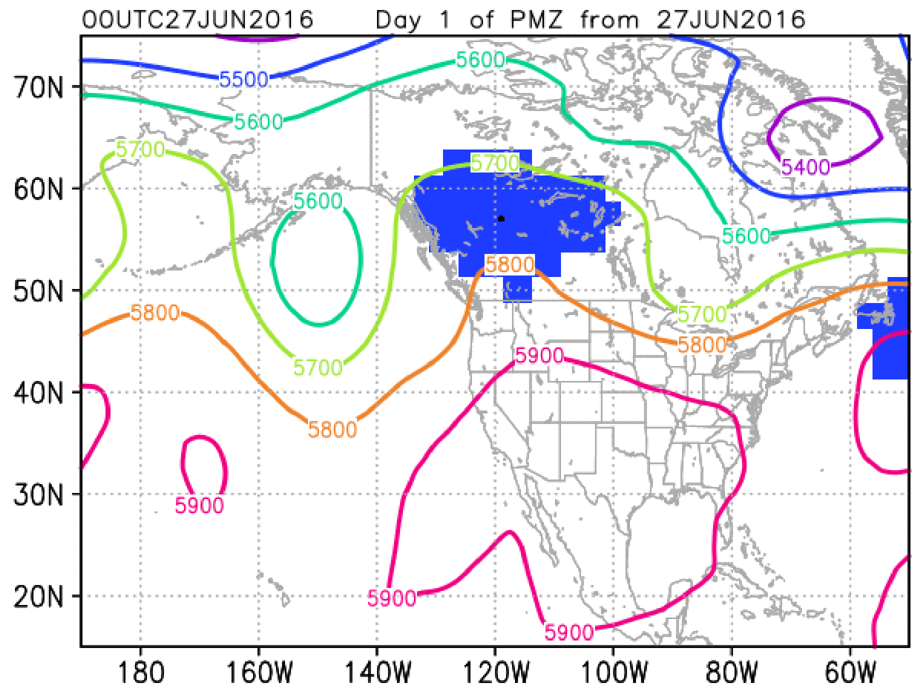

A PMZ event starting on 27 June 2016

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Results -- MJO

"A revised Real-time Multivariate MJO index" (Liu et al., 2016, Mon. Wea. Rev.)

Normalizing only the OLR anomalies with 2 W m^{-2} before the CEOF step will substantially increase the MJO power spectra in OLR at zonal wavenumbers 2-5 while slightly reduce those in U850 and U200.

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Results -- MJO

♦ A comparison between RMM-r and RMM

In representing a recent MJO event

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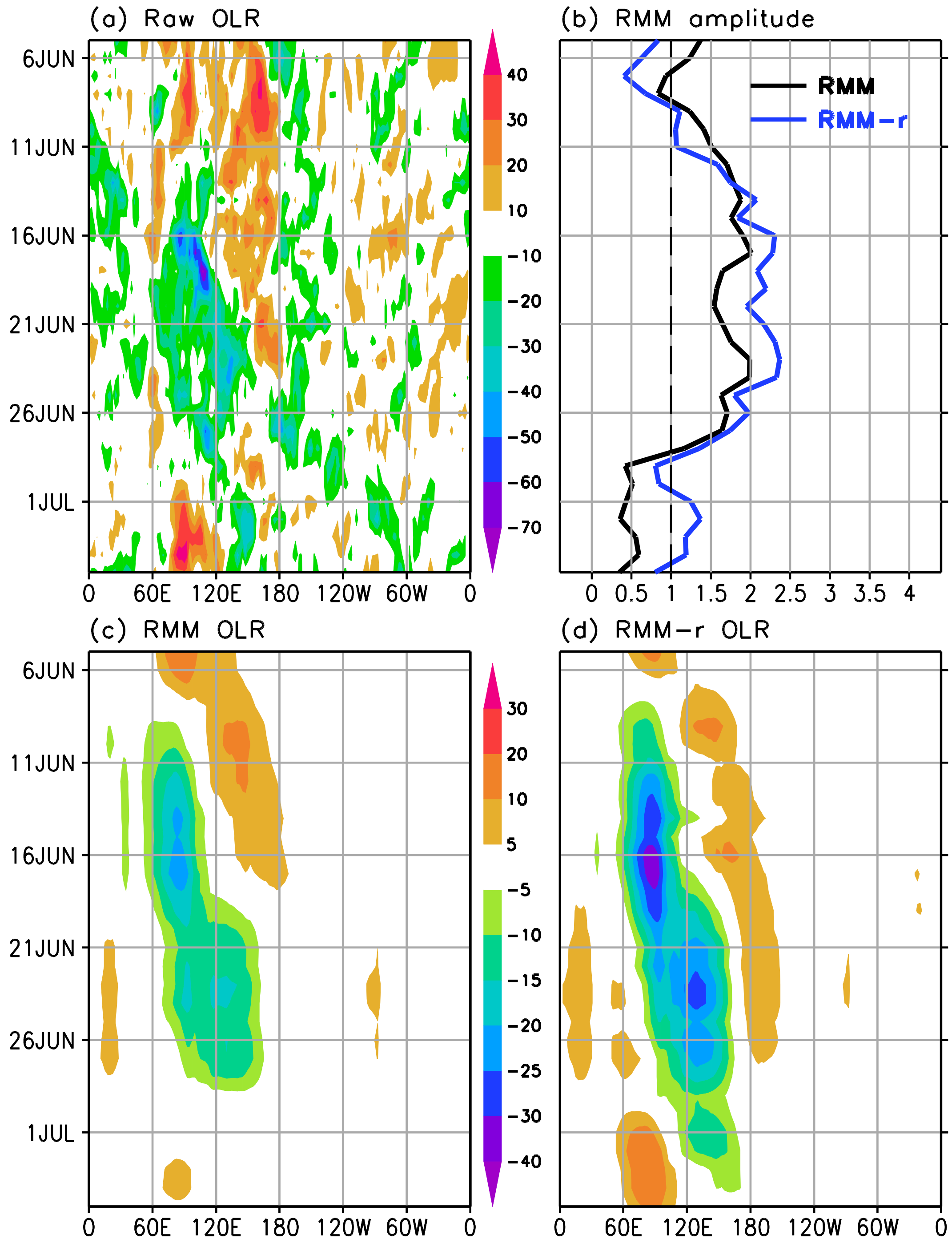
MJO in June-July 2016



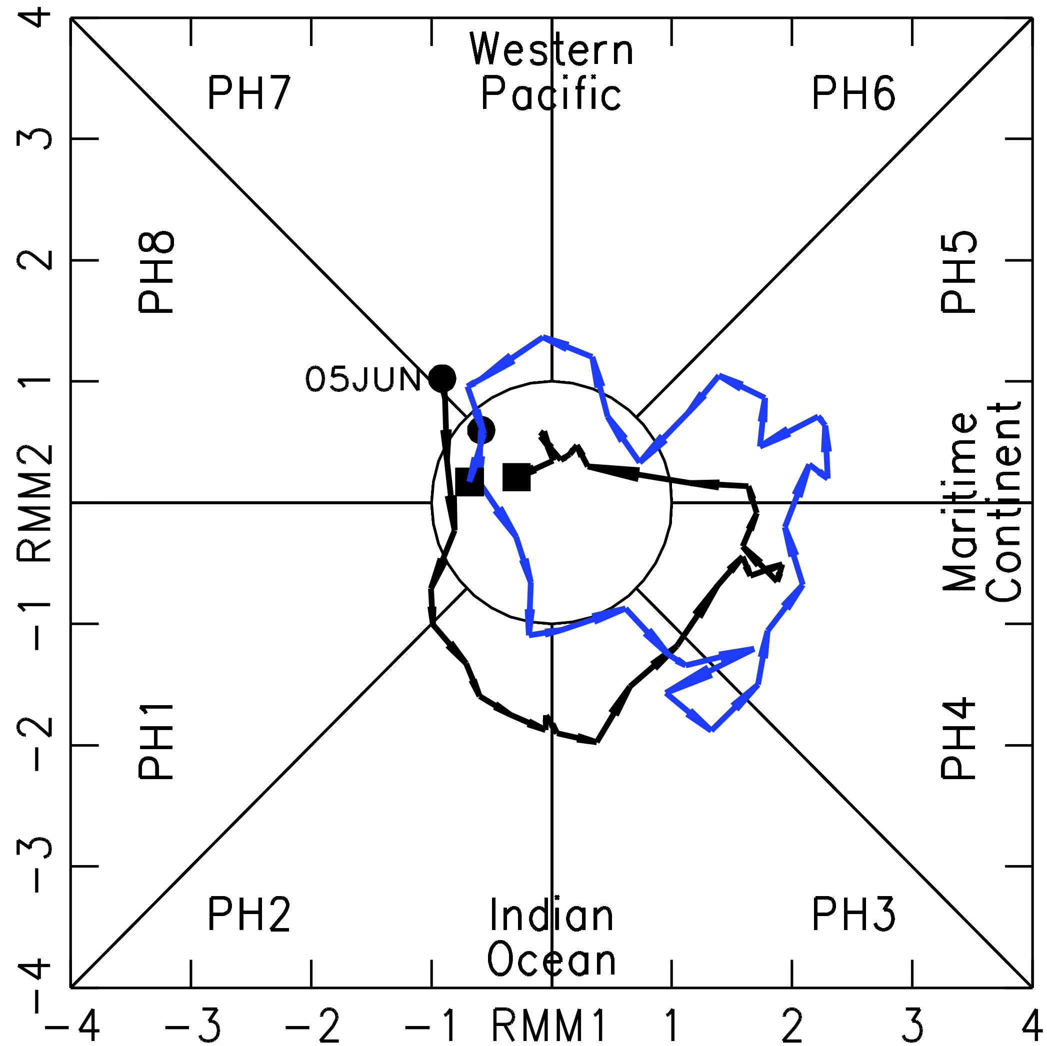
MJO case in 05 June- 05 July 2016

Black – RMM
Blue – RMM-r

. Larger amplitude in maritime continent

. Phases in Western Pacific

. Difference in western Indian Ocean ~ wind?



MJO - predictability

11 - ensemble member, *N* - number of forecasts
a - analysis, *f* – forecast, τ - lead time

$$\mathrm{COR}(\tau) = \frac{\sum_{j=1}^{11}\sum_{i=1}^{N}[\mathrm{RMM1}_i^a \mathrm{RMM1}_{ij}^f + \mathrm{RMM2}_i^a \mathrm{RMM2}_{ij}^f]}{\sqrt{\sum_{j=1}^{11}\sum_{i=1}^{N}[\mathrm{RMM1}_i^{a2} + \mathrm{RMM2}_i^{a2}]}\sqrt{\sum_{j=1}^{11}\sum_{i=1}^{N}[\mathrm{RMM1}_{ij}^{f2} + \mathrm{RMM2}_{ij}^{f2}]}} \quad (1)$$

$$\mathrm{RMSE}(\tau) = \sqrt{\frac{1}{N \times 11}\sum_{j=1}^{11}\sum_{i=1}^{N}\{[\mathrm{RMM1}_i^a - \mathrm{RMM1}_{ij}^f]^2 + [\mathrm{RMM2}_i^a - \mathrm{RMM2}_{ij}^f]^2\}}, \quad (2)$$

(Hamill and Kiladis 2014)

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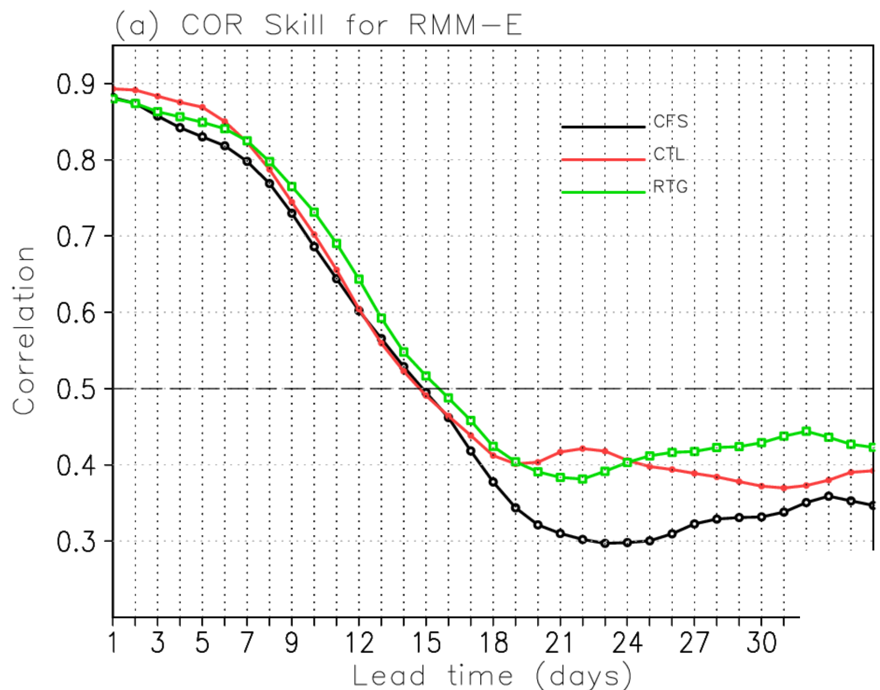
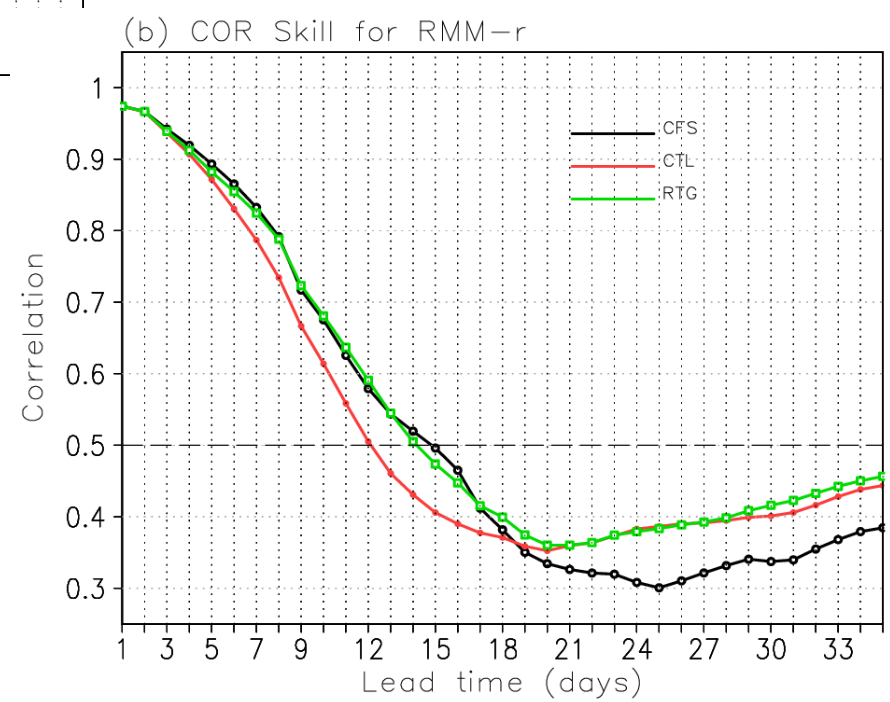


2013-14 half year, 35-day experiment
GEFS V10, ensemble mean

Using different SST – real SST is important



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Real-time Monitoring MJO

In collaboration with
Qin Zhang, Yuejian Zhu, and Jon Gottschalk

http://mjo.somas.stonybrook.edu

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Tropical cyclone genesis

(ongoing)

Ping Liu, Jiayi Peng, Yuejian Zhu, Raymond Sukhdeo

- To reduce false alarm rate in the GEFS, we are testing Relaxed screening thresholds (*Halperin et al. 2013*) for the GEFS
  - $MSLP_{min}$ with at least one closed isobar
  - 850-hPa ζ_{max} within $2.5^{\circ} \times 2.5^{\circ}$ of $MSLP_{min}$
  - maximum $Z_{250-850}$ within 2° of the $MSLP_{min}$
  - $|V|_{925} \geq |V|_{c}$ within 5° of the $MSLP_{min}$
  - The above criteria hold for at least 24 hours
- Object tracking (similar to the package for tracking blocking)

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Algorithms for TC genesis probabilistic forecast

How to define global model TC genesis?

The prediction vortices in Global Ensemble Forecast Systems are very weak. (25kts ?)

Step No.1: (for GEFS, ECMWF, CMC, FNMOC ensembles)

We track every vortex by checking:

1)850/700hPa/surface relative vorticity (max)

2)850/700hPa geopotential height (min)

3)Sea level pressure (min)

4)850/700hPa/surface wind speed (min)

5)SLP gradient (0.0015mb/km), Wind speed at 850hPa (≥ 1.5m/s)

6)Closed SLP contour checked

Step No.2: (for GEFS and ECMWF ensemble)

We filter those vortices based on the following criteria:

1)Surface maximum wind speed ≥ 10kts

2)850hPa maximum vorticity ≥ 10**(-4) 1/s

3)300-500hPa temperature anomaly ≥ 0.5c

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Courtesy of 2013 GEFS/EMC Verification Team ppt

Directions in Coming Years

- Event-by-event predictability of the PMZs and MJOs
- How will the RMM-r and the PMZ algorithm help the predictions of precipitation and T_{2m} over the CONUS?
- How will the EOF approach further improve the predictions in precipitation and T_{2m} associated with PMZ and MJO? And perhaps improve the TC genesis?
- Will such predictabilities be improved in the new NGGPS runs?

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