A framework for incorporating MJO and ENSO information into CPC probabilistic extended range forecasts

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Accomplishments over the past year:

- Diagnosed the influence of the MJO and ENSO on the dominant wintertime circulation patterns over the extended Pacific/North America region

- Assessed the ability of the CFSv2 to capture these relationships (Emily Riddle's talk)

Objectives for the coming year:

- Develop other indices that capture relationships among tropical convection, storm track variability and midlatitude weather predictability

- Test a framework for incorporating MJO and ENSO information into extended range forecasts

K-means cluster analysis of 500 hPa geopotential height

Dataset: **500 hPa heights from NCEP/NCAR Reanalysis**
Time Range: **November – March (Winter months) 1979-2011**
Averaging: **7-Day running mean**
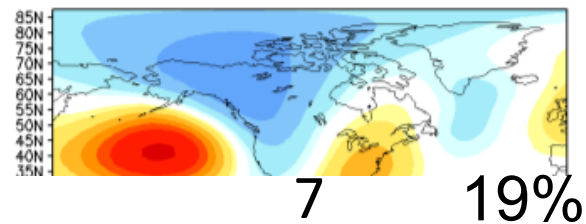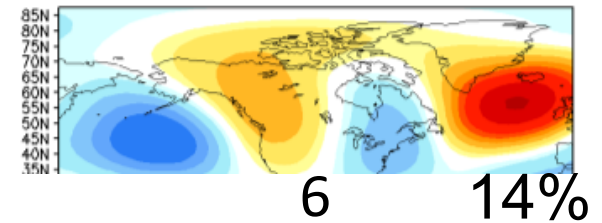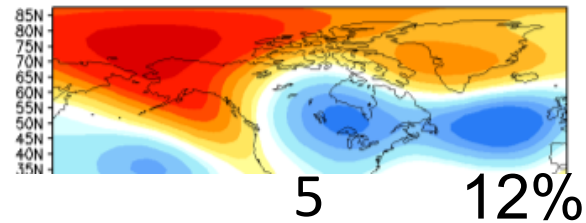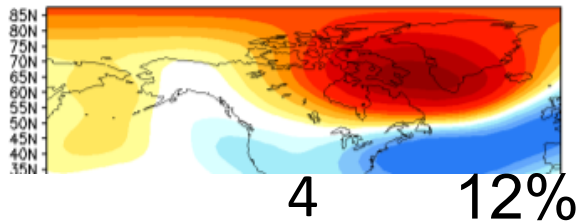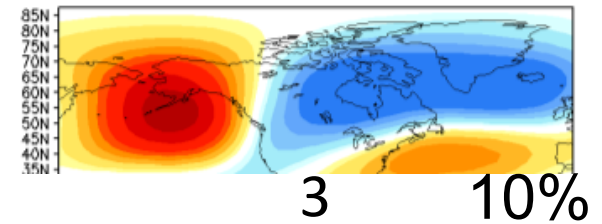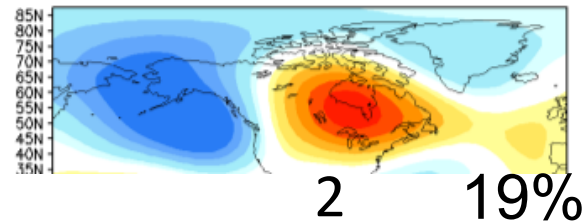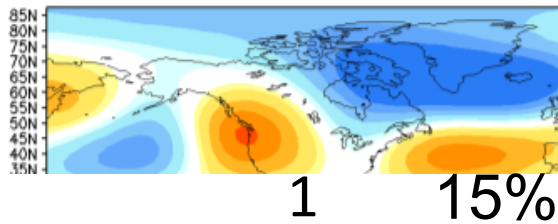
Mean 500 hPa Geopotential height anomalies (m)

The MJO strongly impacts three cluster patterns.

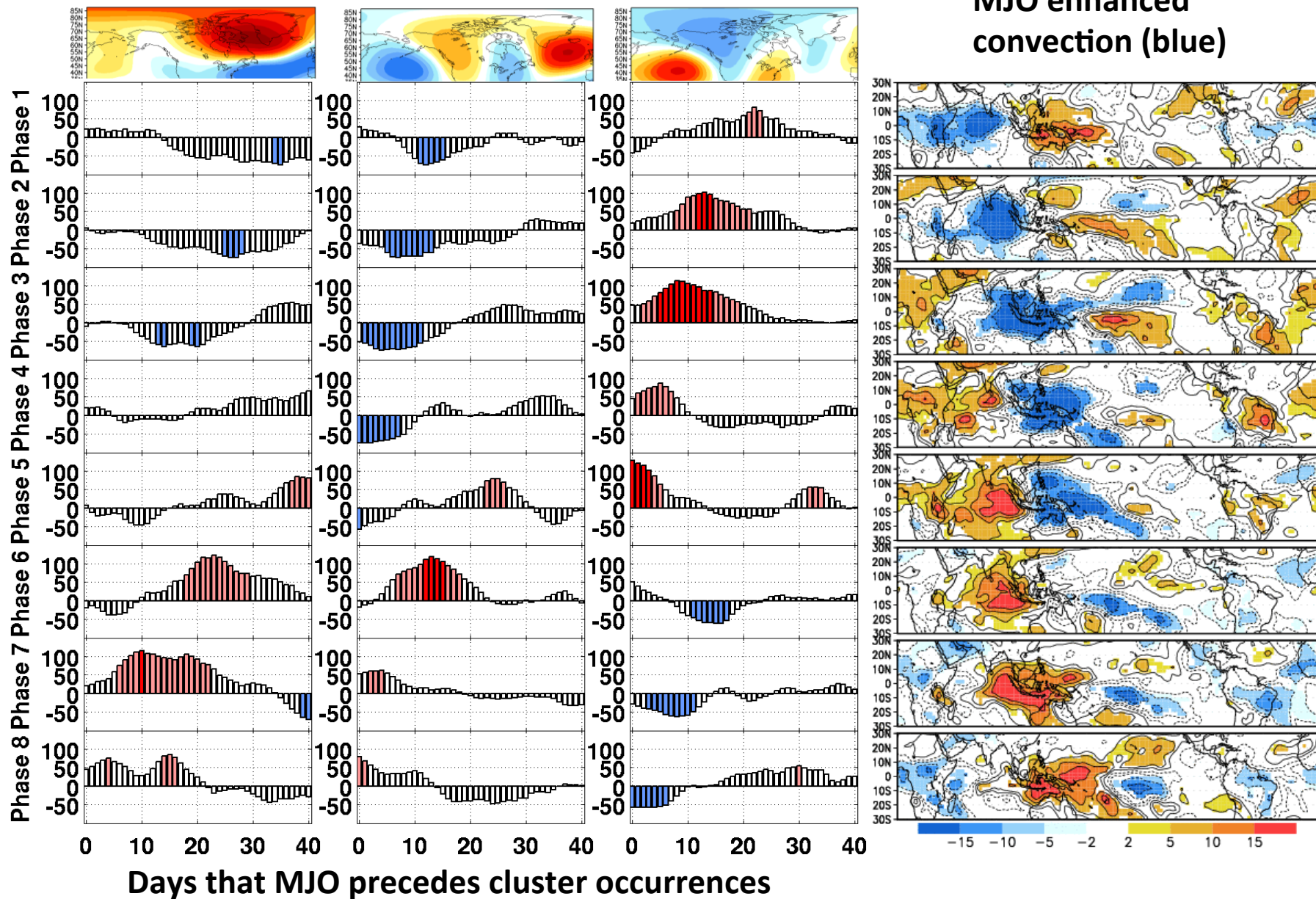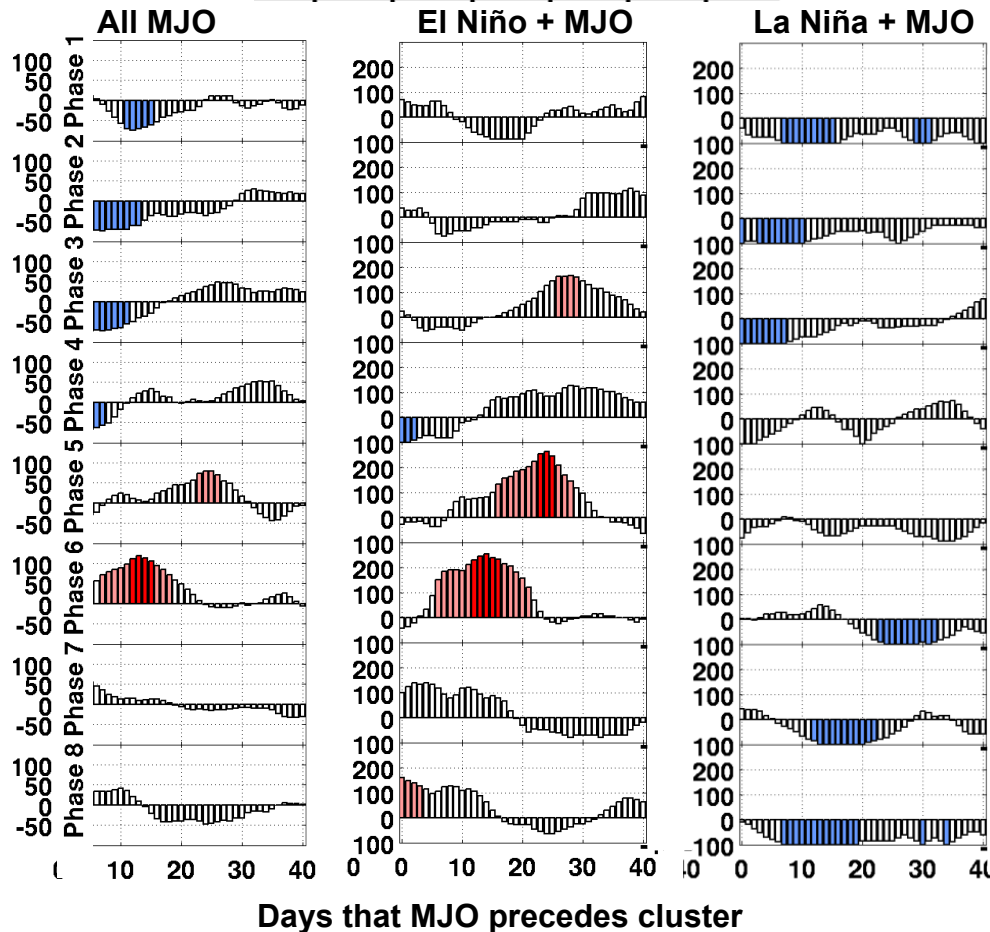**Cluster 4**

Cluster 6

Cluster 7

MJO enhanced convection (blue)

Phase 1 · Phase 2 · Phase 3 · Phase 4 · Phase 5 · Phase 6 · Phase 7 · Phase 8

Days that MJO precedes cluster occurrences

ENSO strongly modulates the MJO impact on the cluster frequencies.

Cluster 6

All MJO   El Niño + MJO   La Niña + MJO

Phase 1 Phase 2 Phase 3 Phase 4 Phase 5 Phase 6 Phase 7 Phase 8

Days that MJO precedes cluster
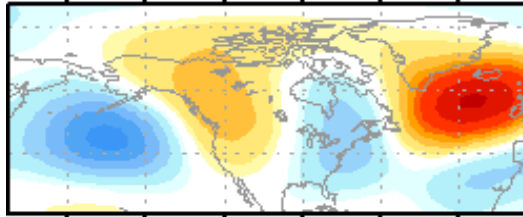
- Cluster 6 strongly enhanced after phases 5 and 6 of the MJO during El Niño but suppressed for most MJO phases during La Niña.

- Statistically significant anomalous frequencies for lags of 10-30 days

But how can CPC incorporate this sort of information into their extended range forecast products?

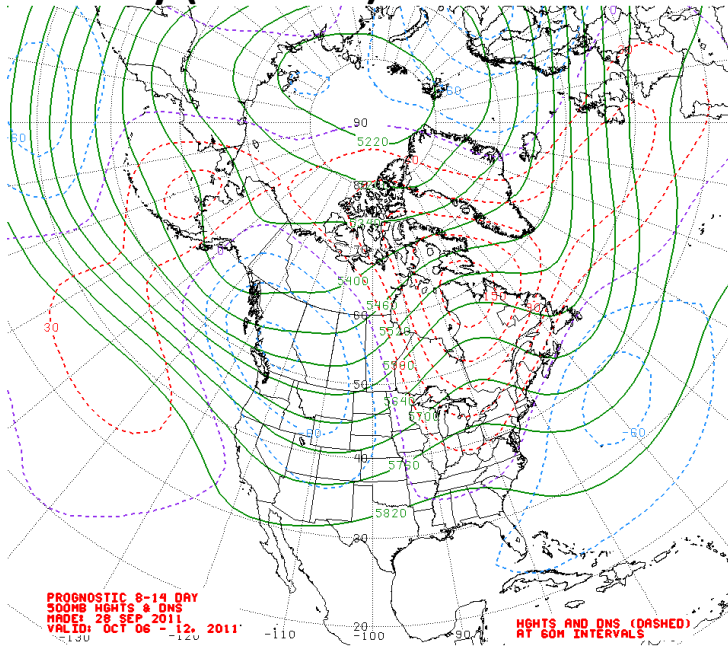**CPC 8-14 day (Oct 6-12) Outlook: 500 hPa heights**

Temperature

Precipitation

THE OFFICIAL 8-14 DAY HEIGHT PROG CONSISTS OF: 5 PERCENT OF TODAY'S OPERATIONAL 0Z GFS CENTERED ON DAY 11...5 PERCENT OF TODAY'S OPERATIONAL 6Z GFS CENTERED ON DAY 11...20 PERCENT OF TODAY'S 0Z GFS ENSEMBLE MEAN CENTERED ON DAY 11...20 PERCENT OF TODAY'S 6Z GFS ENSEMBLE MEAN CENTERED ON DAY 11...AND 50 PERCENT OF TODAY'S 0Z EUROPEAN ENSEMBLE MEAN CENTERED ON DAY 11.

FORECAST CONFIDENCE FOR THE 6-10 DAY PERIOD: NEAR AVERAGE, 3 ON A SCALE OF 1 TO 5
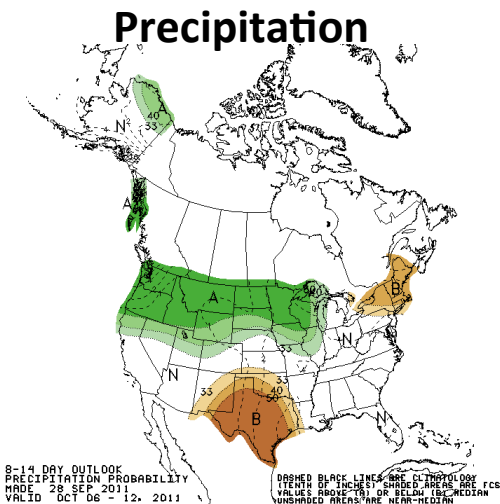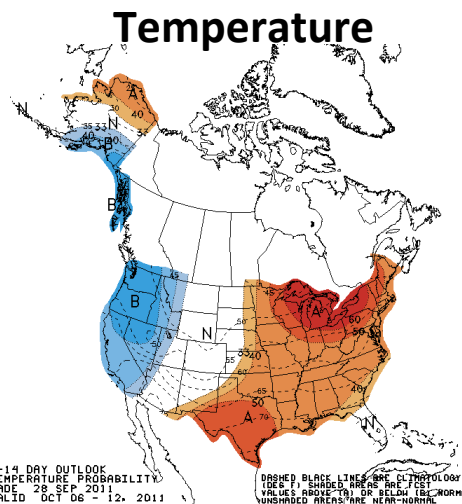
Merging forecast guidance through Bayes' theorem

$$P(\boldsymbol{\theta} \,|\, C_j) \propto P(\boldsymbol{\theta})P(C_j \,|\, \boldsymbol{\theta})$$

$[\theta_1, \theta_2, ..., \theta_K]'$

Occurrence probability for cluster patterns 1-K

Model forecast of cluster pattern j

Prior probability of **θ**
-Incorporates historical MJO and ENSO information
- May incorporate model consistency from previous forecasts

Conditional probability of C_j, given **θ**
- Based on archived model forecasts or reforecasts

- *posterior probability* of **θ** can be used to construct model forecast field weights in extended range forecast
- Extended range forecast explicitly combines MJO and ENSO information with model consistency and skill information
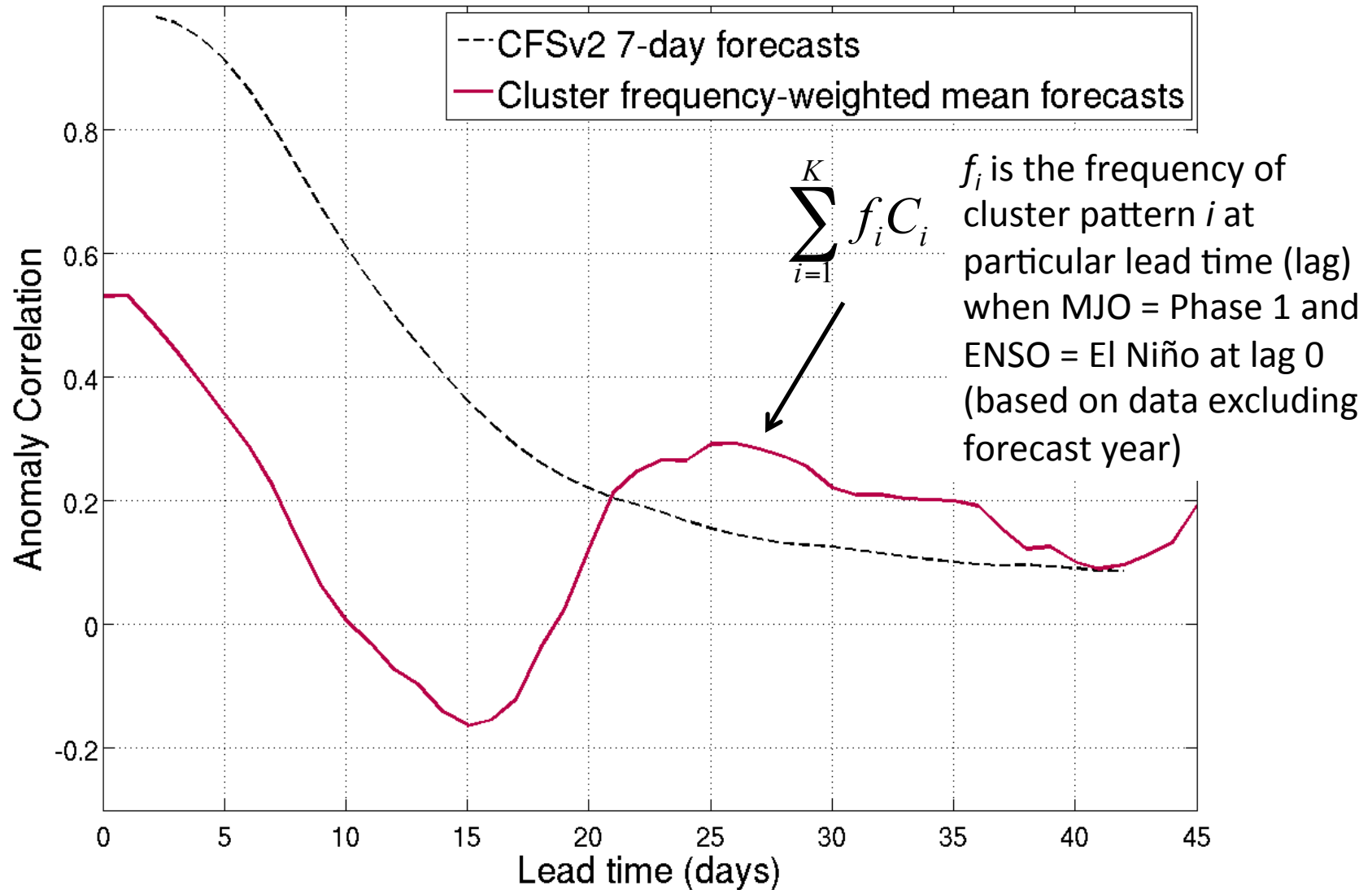
Intended benefits of a Bayesian approach

- Less subjective model weighting that combines several different sources of forecast information (better forecasts in the 6-14 day period?)

- Potential to quantify forecast uncertainty more rigorously

- Identification of "forecasts of opportunity" beyond 14-day period

- Flexible framework that can be modified easily

Wintertime 500 hPa Geopotential Height Forecast Skill over the Extended Pacific/North America region

Wintertime El Nino and MJO Phase 1

$$\sum_{i=1}^{K} f_i C_i$$

f_i is the frequency of cluster pattern i at particular lead time (lag) when MJO = Phase 1 and ENSO = El Niño at lag 0 (based on data excluding forecast year)

Summary

- The combined influence of the MJO and ENSO significantly impacts the frequency of the dominant wintertime circulation patterns over the extended Pacific/North America region.

- Statistically significant anomalous frequencies of geopotential height cluster patterns extend to lags of up to 40 days, which suggests promise of useful predictability information in the one- to four-week time period.

- Over the next year we plan to combine these results with model forecast performance information (starting with CFSv2) to test a Bayesian framework for extended range forecasts.