

# The Predictability of Northern Hemispheric Blocking Using an Ensemble Mean Forecast System

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# Introduction

- A generic definition may be that blocking is a non-linear large-scale phenomenon that occurs in the atmospheric pressure field that results in a quasi-stationary steady state in the mid-latitude flow.
- Cyclonic wave breaking, which results in the upscale cascade of enstrophy, is important in the maintenance of mid-latitude weather and climate.

# Introduction

- Previous work on blocking predictability investigated the frequency, seasonal variability and the synoptic predictability of blocking.
- Studies have found that models still have a difficult time replicating the observed occurrence of blocking and the durations. Also, models still have some difficulty predicting blocking in as little as two days.

# Motivation

- Most studies have examined the predictability of blocking onset (in time and space) as well as duration. Here we will also look at block intensity.
- To determine how well the NCEP Global Ensemble Forecast System (GEFS) ensemble mean forecast represent block onset, duration, and the intensity at onset.

# Goals

- To examine the link between the Lupo-Smith block formation mechanism and the Integrated Regional Enstrophy (IRE) and Block Intensity (BI) diagnostic at onset.
- To examine a broader range of characteristics in order to test an ensemble model's capability of forecasting block onset and maintenance.

# Data

- Datasets used for this study is provided by the NCEP Global Ensemble Forecast System (GEFS) ensemble mean forecast and the NCAR Reanalyses associated with four Northern Hemisphere blocking events from 2016-2017.
- From the ensemble forecast model this study used the Northern Hemisphere 500-hPa height fields (m) for the mean and spaghetti plots. These 500-hPa heights were analyzed for ten days (240 hrs.) focusing on their location, duration and intensity in comparison to observed atmospheric blocking

# Methods

- We used the Lupo-Smith (1995) blocking criteria to identify observed and model blocking.
- In order to evaluate the performance of the ensemble mean model, lead times beginning with seven days (168 h) prior to the observed event were examined. The results will summarise this by showing lead times of seven, four, and one day.

# Methods

- IRE is calculated and defined as:

- $$Enstrophy = \sum_{\lambda_i > 0} \lambda_i \approx \int \zeta^2$$

- Block intensity was calculated as:

- $$BI = \left( \frac{\frac{Center}{2} + \frac{lowest\ upstream + center}{2}}{2} - 1 \right) \times 100$$



# Synoptic Discussion

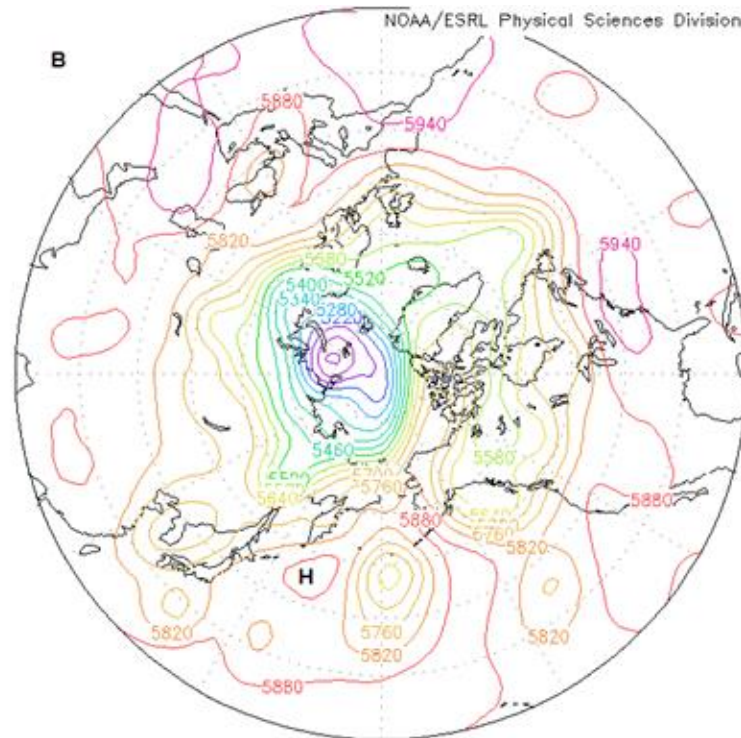
- Blocking events and their characteristics:

#	Location (at onset)	Date/longevity	Observed Intensity
1	Atlantic (50° N 20° E)	12Z 23 June – 00Z 8 July 2016	2.46
2	Pacific (50° N 160° E)	00Z 27 Aug – 00Z 4 Sept 2016	1.99
3	Atlantic (55° N 0°)	00Z 3 Oct – 00Z 27 Oct 2016	3.94
4	Pacific (50° N 160° W)	00Z 23 Feb – 00Z 16 Mar 2017	4.40

- called Weak Atlantic (1), Weak Pacific (2), Strong Atlantic (3), and Strong Pacific (4).

# Synoptic Discussion

- Example: Weak Pacific event:



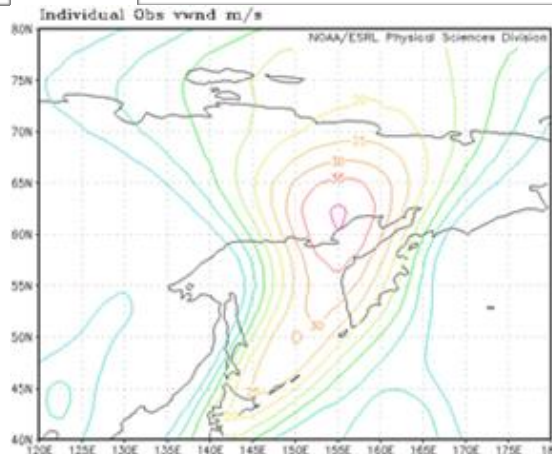
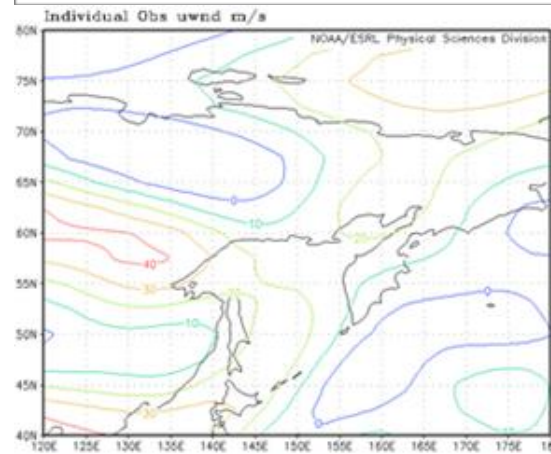
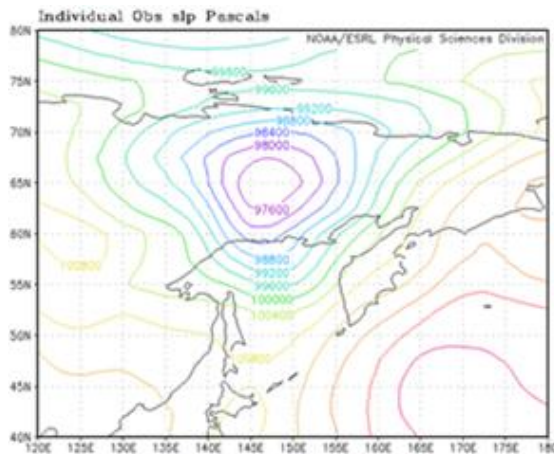
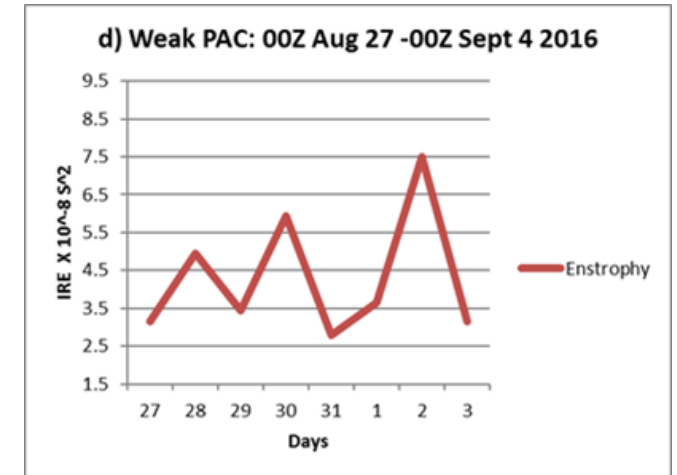
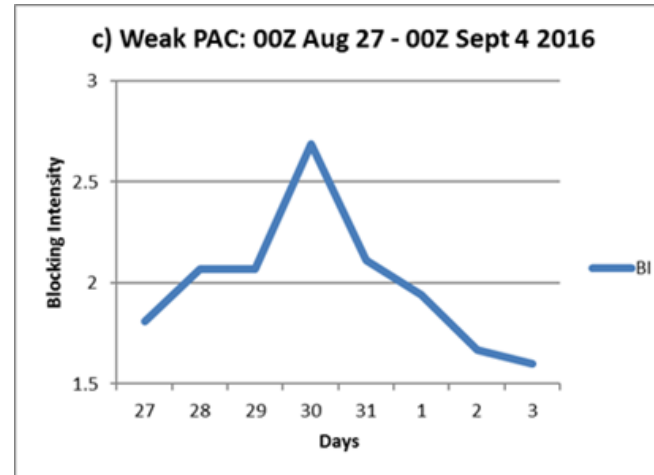
# Synoptic Discussion

- Correlations of BI lagging behind IRE:

Correlation with lag of BI				
	Not Lagged	24- Hr.	48-Hr.	72-Hr.
WA	0.29	0.40*+	-0.15	0.20
WP	0.15	-0.39	0.41*	-0.26
SA	0.49*+++	0.40++	0.07	-0.20
SP	0.16	-0.31	-0.18	0.36*+

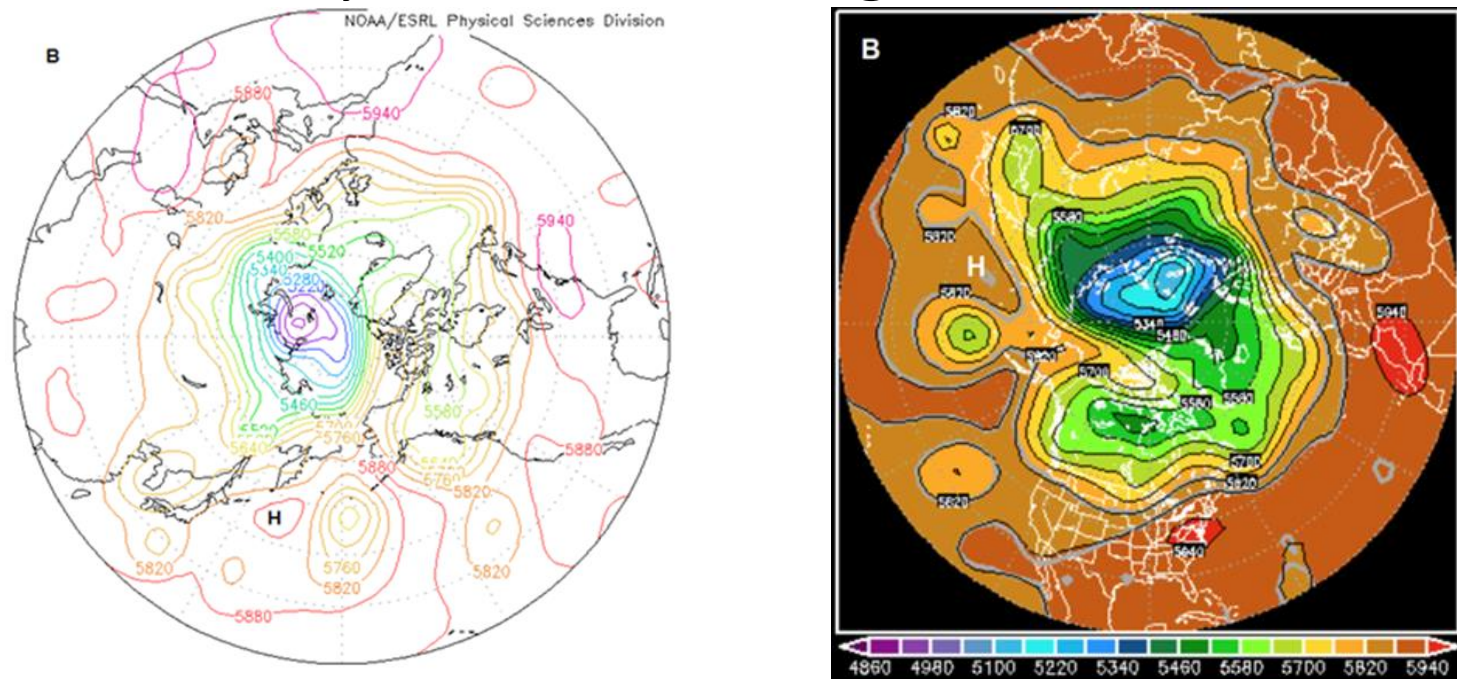
# Synoptic Discussion

- Weak Pacific Event:
- IRE vs BI →
- LS95 (block formation)



# GEFS Model Comparison

- 48 h GEFS forecast for day 2 of the blocking event. Weak Pacific shown here:



- Model does well with the onset location and time at 1 day out!

# GEFS Model Comparison

- How did the GEFS model do in representing block formation?

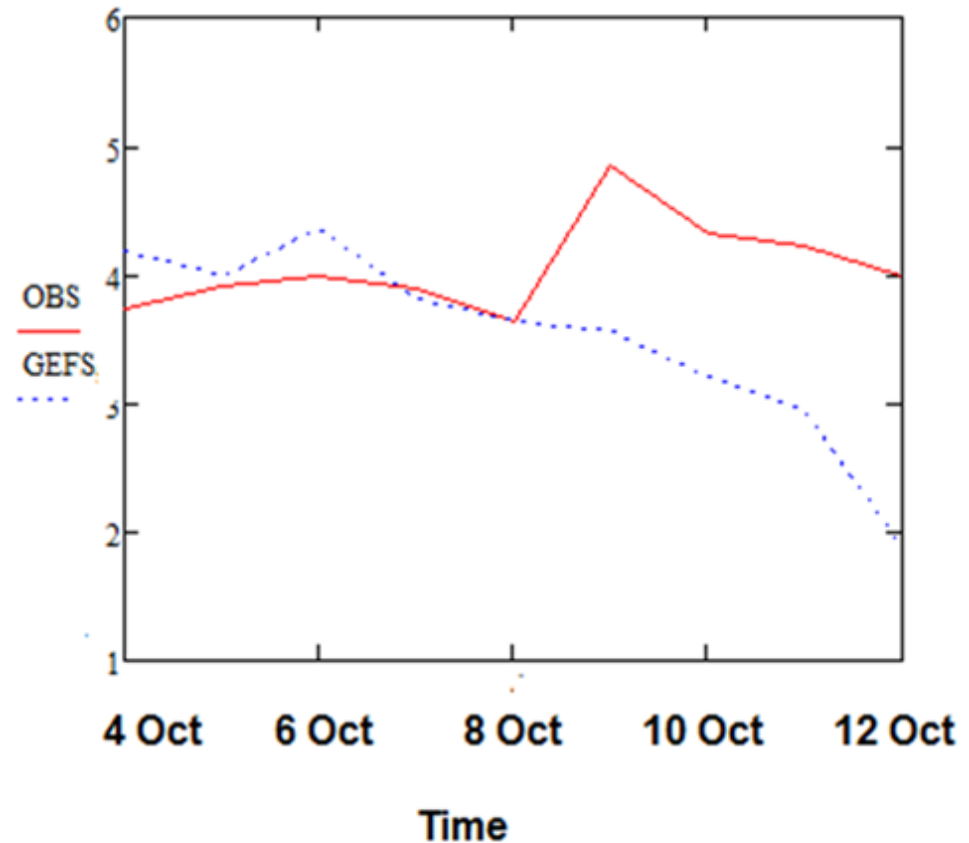
BI Comparison			
Forecast /Blocks	Model BI	Observed BI	Difference
7 day			
Block 1: WA 00Z 16 Jun 2016	1.13 (00/23-00/26)	2.32 (12/23-12/26)	1.19
Block 2: WP 00Z 20 Aug 2016	1.74 (00/30)	2.69 (12/30)	0.95
Block 3: SA 00Z 26 Sep 2016	N/A	N/A	N/A
Block 4: SP 00Z 16 Feb 2017	N/A	N/A	N/A
4 day			
Block 1: WA 00Z 19 Jun 2016	1.38 (00/23-00/27)	2.43 (12/23-12/27)	1.05
Block 2: WP 00Z 23 Aug 2016	1.82 (00/28-00/1)	2.18 (12/28-12/1)	0.36
Block 3: SA 00Z 29 Sep 2016	2.38 (00/5-00/9)	3.87 (12/5-12/9)	1.49
Block 4: SP 00Z 19 Feb 2017	3.12 (00/23-0/28)	4.93 (12/23-12/28)	1.71
1 day			
Block 1: WA 00Z 22 Jun 2016	1.49 (00/23-00/2)	2.45 (12/23-12/2)	0.96
Block 2: WP 00Z 28 Aug 2016	1.73 (00/27-00/2)	2.05 (00/27-00/2)	0.32

# GEFS Model Comparison

- GEFS model reasonably represented location of onset, even seven days out where applicable.
- Model did not capture blocking event well seven days out. At four days all events forecast, but terminated early. At one day out, GEFS still missed the onset of the Strong Atlantic Event, and the termination of the Weak Pacific event by two days.
- Intensity was the worst characteristic represented. The magnitudes improved as the forecast period shortened.

# GEFS model Comparison

- Why did the models fail to capture intensity?
- Example: Strong Atlantic:  
(red – observed,  
blue – GEFS model)





# Summary and Conclusions

- Four observed blocking events were studied here, two in the Atlantic and two in the Pacific Region and distributed among warm and cold season events as well as blocking events of different intensities.
- Using the NCEP/NCAR reanalysis data set as well as the NCEP GEFS model ensemble mean forecasts for a 240 h period, the ability of the model to forecast blocking intensity (BI), longevity, onset, decay, and location.
- Here we used the 500-hPa heights and the LS95, WLMT02 blocking criterion to identify blocking and calculate intensity

# Summary and Conclusions

- Overall in all cases location, the GEFS model best captured decay and longevity while blocking intensity and onset were underestimated, BI showing the worst performance;
- IRE was introduced to determine if there could be a relationship between this quantity and BI. Here it was found that there was a lag relationship between IRE and BI by up to 72 h as indicated by statistically significant correlations between the two time series.
- In the future, in order to expand on this work it is possible to introduce the Watson and Colucci (2002) probabilistic forecast to increase accuracy in blocking intensity and onset;

# Summary and Conclusions

- the GEFS mean ensemble model performed the worst in capturing BI, although this was not the case uniformly across all time-periods. The model had difficulty maintaining BI in all events and forecast time periods;
- the persistence of blocking was forecast better for the Atlantic Region events than for the Pacific Region events.