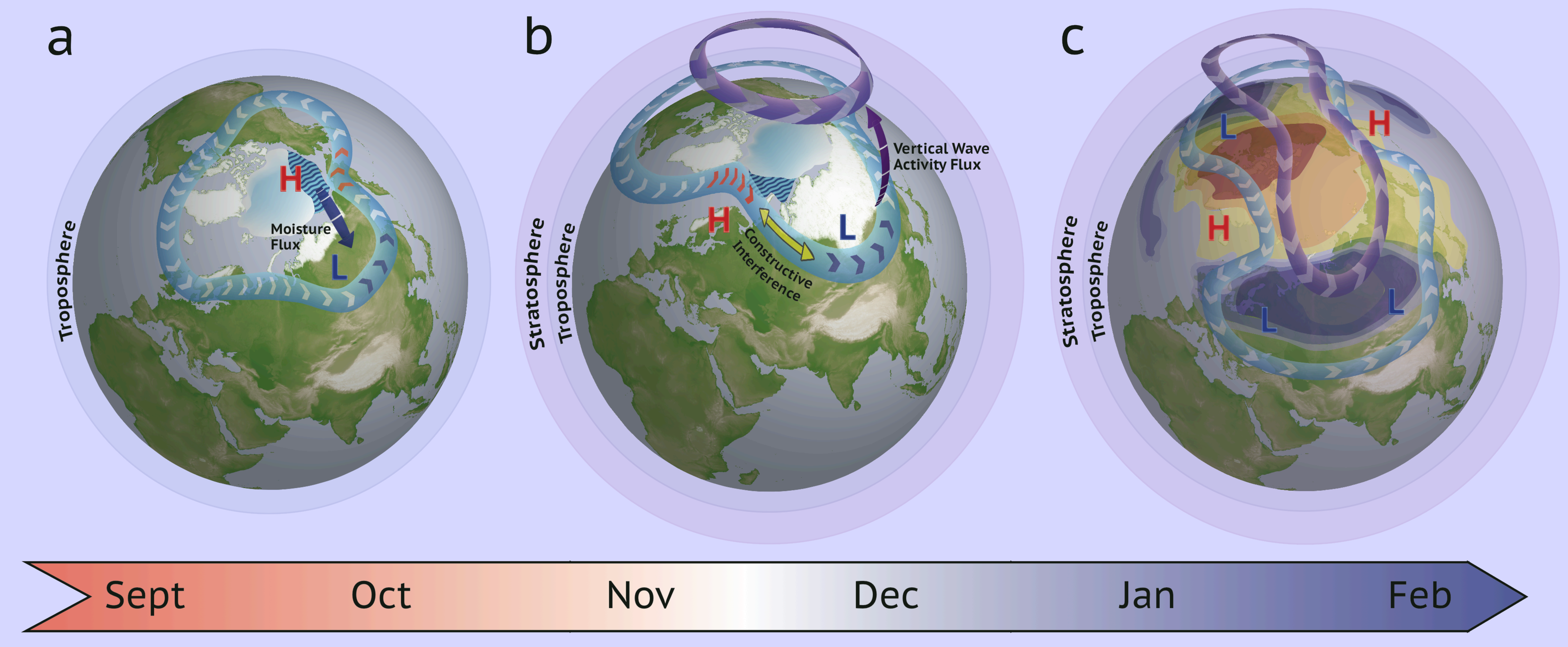
Arctic vs. Tropical Influence on Mid-Latitude Weather over the period of Arctic Amplification

Atmospheric and Environmental Research

RUTGERS

Judah Cohen[1], Karl Pfeiffer[1] and Jennifer Francis[2]

[1]*Atmospheric and Environmental Research, Lexington, MA,* USA [2]Department of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, USA



INTRODUCTION. The tropics in general and El Niño/Southern Oscillation (ENSO) in particular are almost exclusively relied upon for seasonal forecasting. Much less considered and certainly more controversial is the idea that Arctic variability is influencing mid-latitude weather. However, since the late 1980s and early 1990s the Arctic has undergone the most rapid warming observed globally, referred to as Arctic amplification (AA), which has coincided with an observed increase in severe winter weather (synthesis of theories linking the two is shown on left). Analysis of observed trends in hemispheric circulation over the period of AA more closely resembles variability associated with Arctic boundary forcings than with tropical forcing (Fig. 2). Furthermore, with a record strong El Niño in the fall and winter of 2015/16, winter seasonal predictions should have been afforded a rare opportunity to showcase forecast accuracy especially across the North American continent. However, winter 2015/16 forecasts are noted for their shortcomings, not successes (Figs. 3-4). Finally, analysis of intra-seasonal temperature variability shows that the cooling in continental mid-latitude winter temperatures has been accompanied by an increase in temperature variability and not a decrease, popularly referred to as “weather whiplash” (Fig. 1).

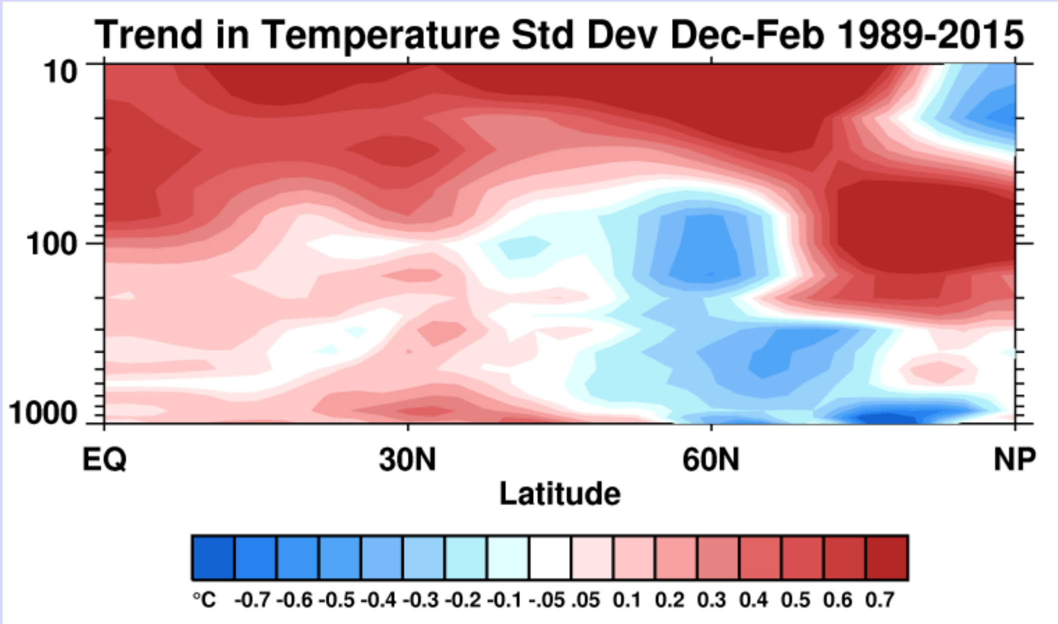


Figure 1. Zonal mean of trend of intra-annual standard deviation of air temperatures at each grid point for December, January, and February (DJF) winters 1988/1989 – 2014/2015. Note that temperature variability has decreased in the Arctic but has increased in the stratosphere and in the mid-latitudes.

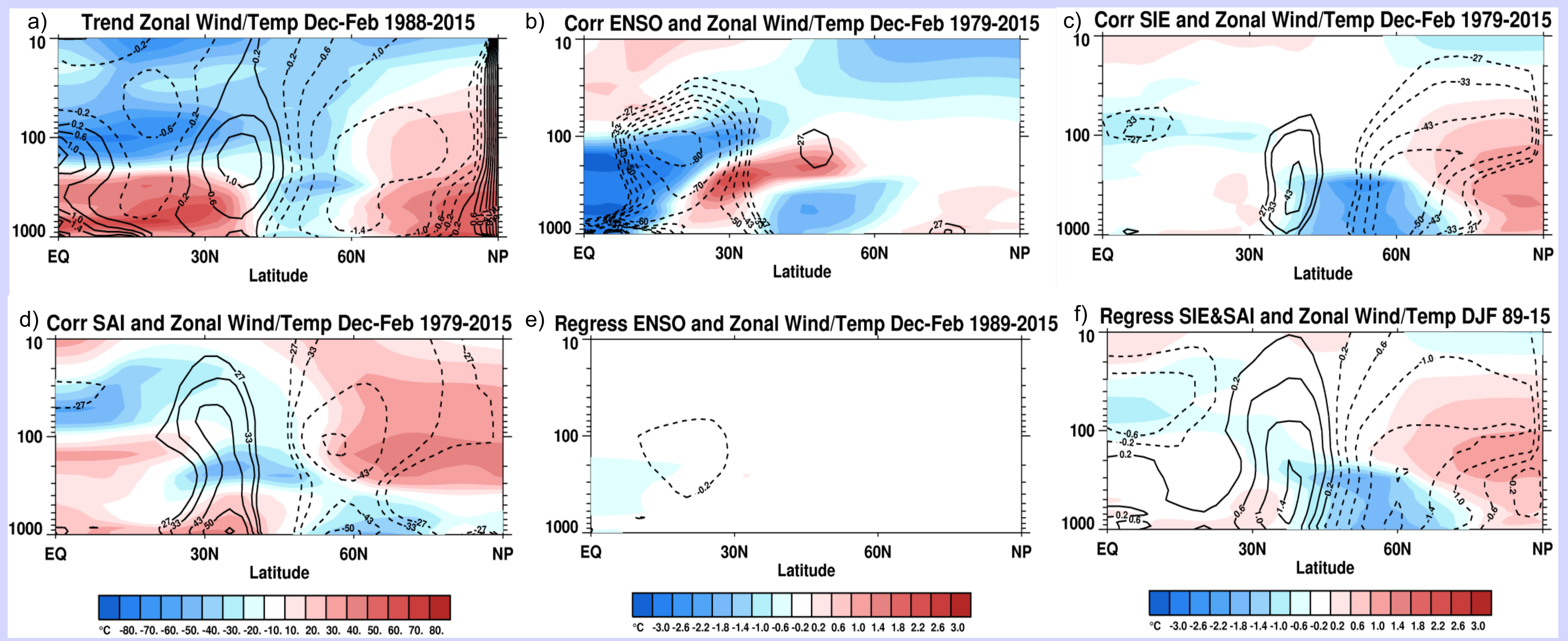


Figure 2. a) Trend in the zonal mean zonal wind (contours; ms^{-1}) and zonal mean air temperature (shading; °C) from 1000 to 10 hPa for December, January and February (DJF) winters 1988/89-2014/15. b) Correlation (×-100) of ENSO index (DJF Niño 3.4) with zonal mean zonal wind (contours) and zonal mean air temperature (shading) for winters 1979/80-2014/15. c) November sea ice concentration index (×-1) in the Barents-Kara Seas with zonal mean zonal wind (contours) and zonal mean air temperature (shading) for winters 1979/80-2014/15. (d) Correlation (×100) of October snow advance index for Eurasia with zonal mean zonal wind (contours) and zonal mean air temperature (shading) for winters 1979/80-2014/15. e) Regression of trend in ENSO index with zonal mean zonal wind (contours) and zonal mean air temperature (shading) for winters 1979/80-2014/15. f) Multiple regression of trend in November sea ice concentration index in the Barents-Kara Seas and the October snow advance index for Eurasia from 1988/1989 to 2014/2015 with zonal mean zonal wind (contours) and zonal mean air temperature (shading). Wind averaged over all longitudes but temperature averaged over longitudes 0-130°E and 75-120°W.

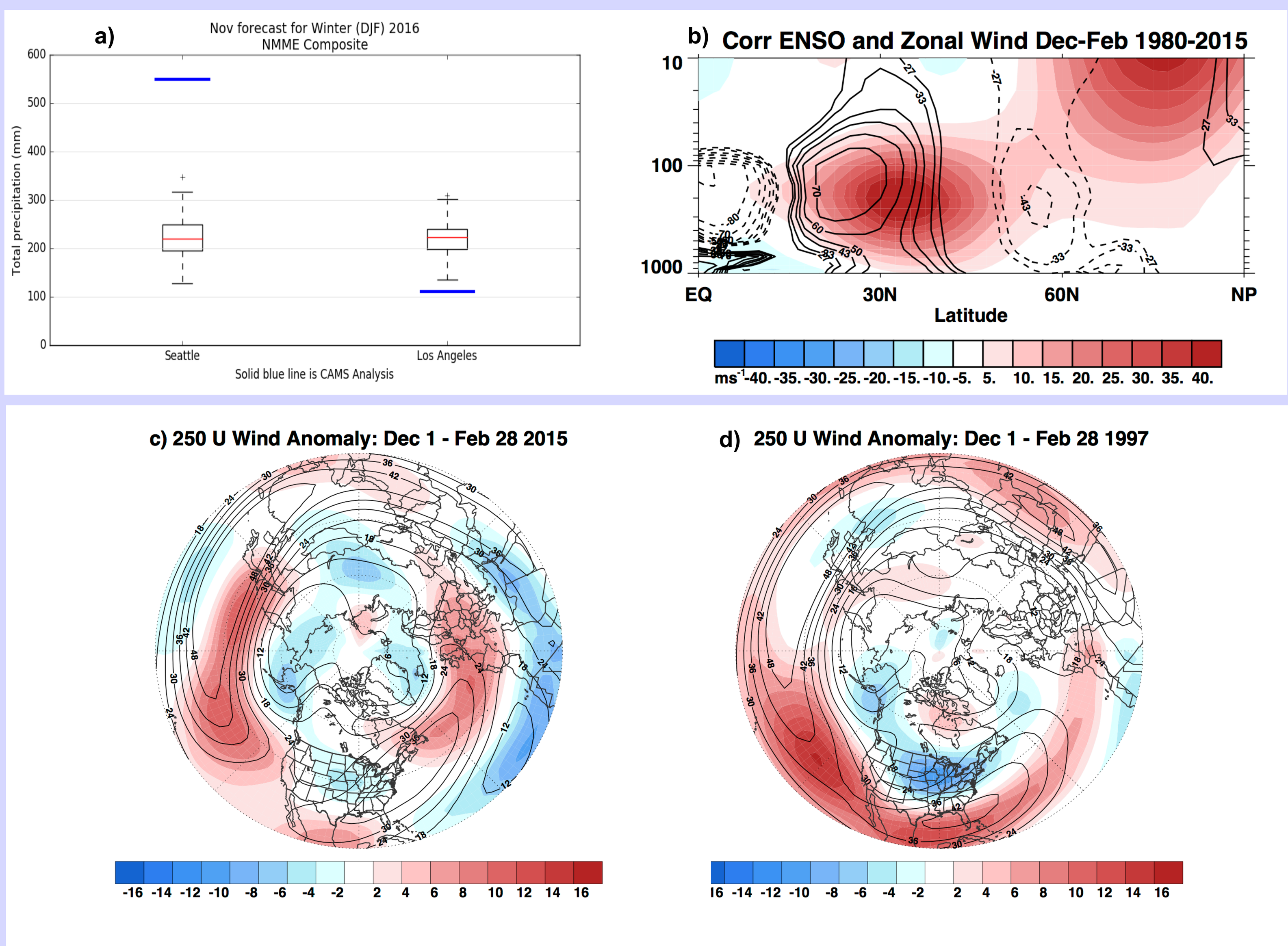
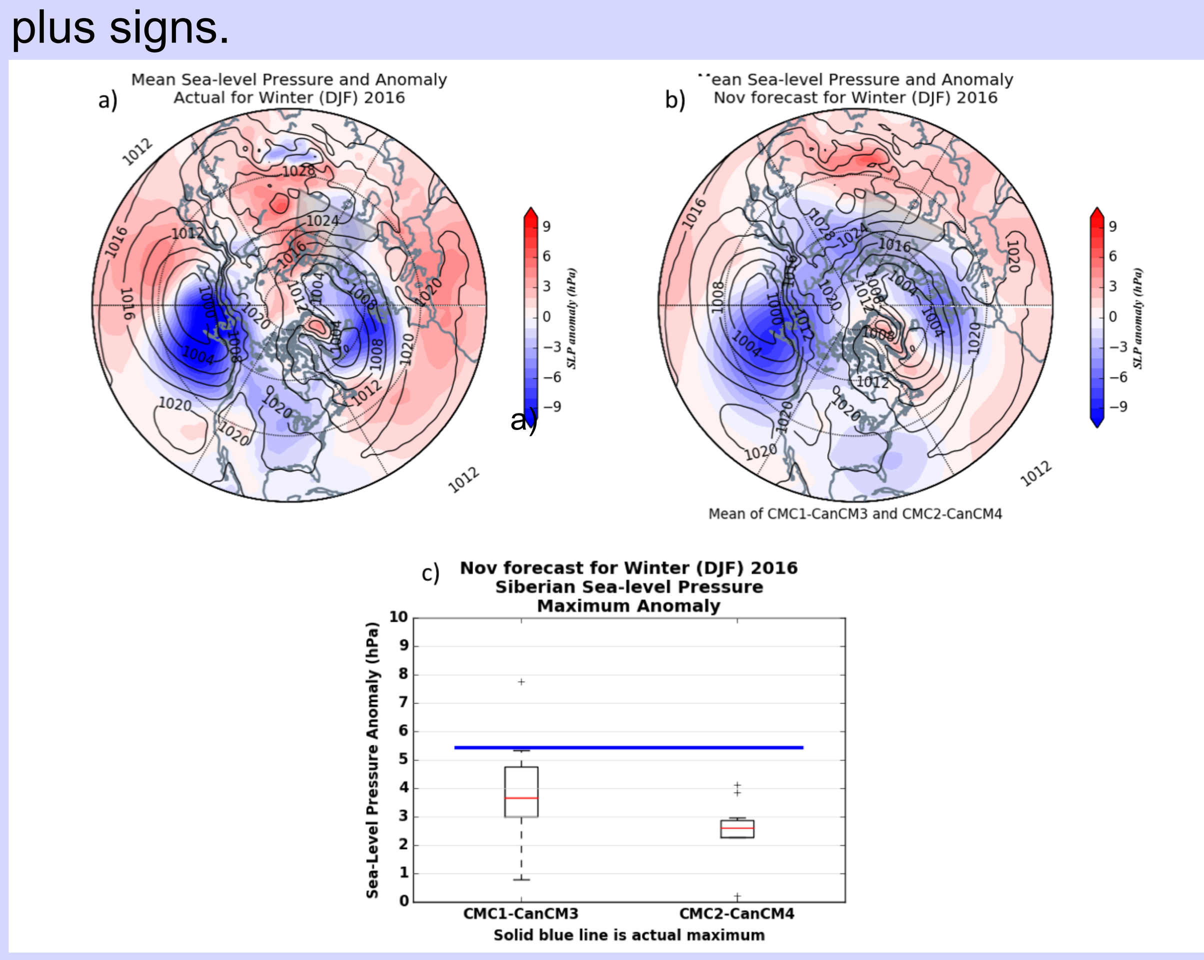


Figure 3. a) Total observed precipitation (mm) for Los Angeles and Seattle from December 2015 through February 2016 (blue solid line), and range of operational global climate model forecasts for the ensemble mean (red solid line) b) Correlation (×100) of ENSO index (DJF Niño 3.4) with zonal mean zonal wind (contours) and zonal mean air temperature (shading) c) Mean zonal wind at 250 hPa (m s^{-1}; contours) and zonal wind anomalies (m s^{-1}; shading) over the Northern Hemisphere for DJF 1997/98. d) DJF 2015/16.

Figure 4. a) Observed climatological mean SLP (1981-2010; contours) and SLP anomalies (shading) in hPa for the from December 2015 through February 2016; b) same as (a) but from NMME forecasts; c) observed maximum SLP anomaly (hPa) in the region bounded by 45-70°N and 40-85°E (gray box in panels a and b) for December 2015 through February 2016 (solid blue line). Also shown are the ranges of NMME forecasts for the ensemble mean (red solid line), 50% of the distribution of the ensembles (box), and 100% of the distribution (whiskers). Outliers beyond ±2.67 sigma are shown as plus signs.



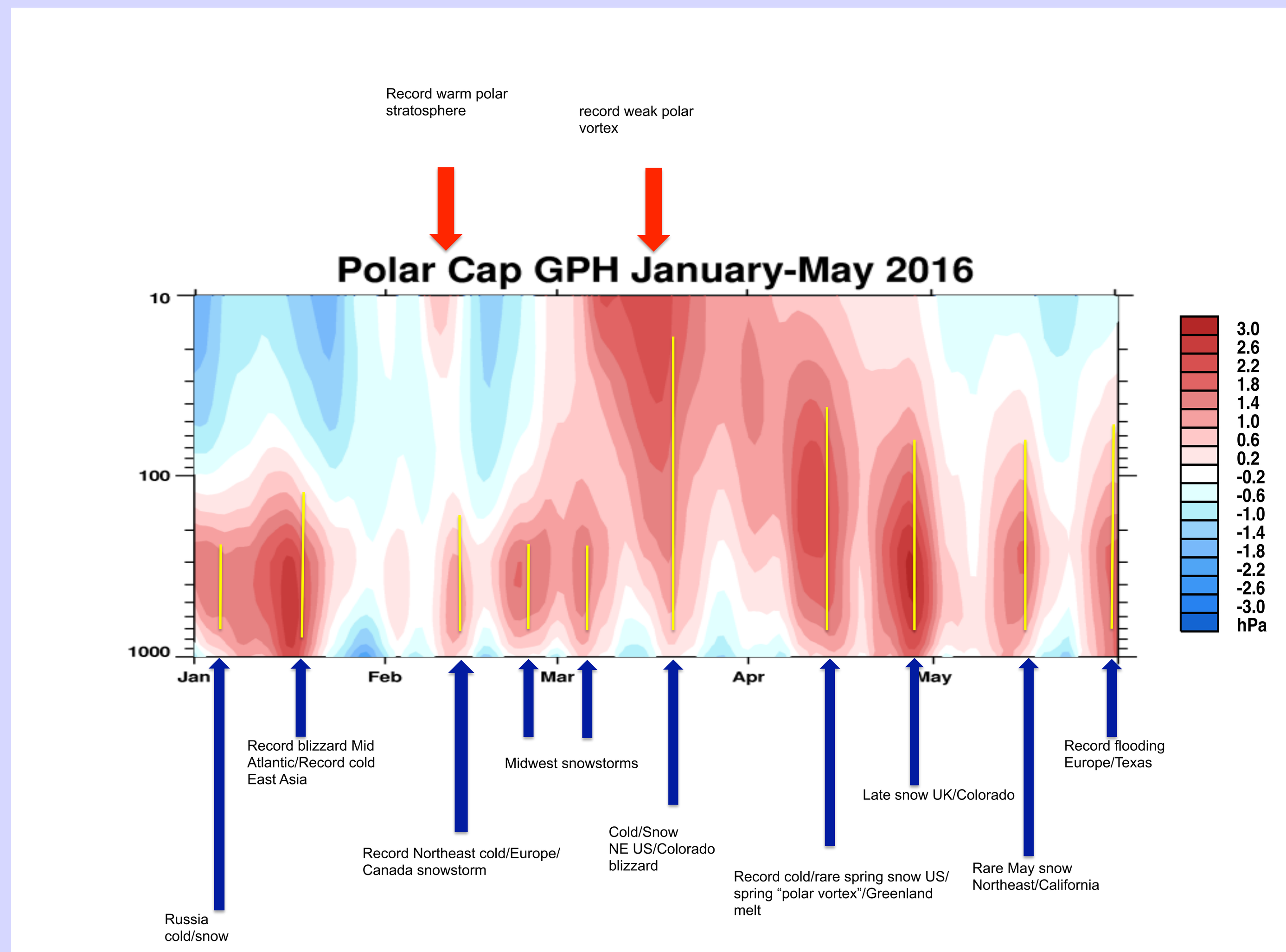


Figure 5. Extreme weather events coincide with enhanced Arctic warming. Anomalies of daily standardized polar cap (60-90ºN) geopotential height from 1 January 2016 through 31 May 2016. Anomalously high heights (corresponding with warm temperatures) shaded in red. Blue arrows denote extreme weather events across the Northern Hemisphere, while the red arrow shows the date of the two sudden stratospheric warmings. Yellow bars highlight the alignment of pulses in the PCH with an extreme event.

SUMMARY. We analyzed a simple diagnostic to compare ENSO influences on mid-latitudes with that of Arctic influences, including Barents-Kara sea ice concentration and Eurasian snow cover extent in the era of Arctic amplification. Decadal trends better match variability in the Arctic associated with reduced sea ice and extensive snow cover relative to variability associated with ENSO. In addition, the observational analysis compellingly suggests that not only is the Arctic’s influence on the large-scale mid-latitude circulation comparable to that of the tropics, but also that AA has made a greater contribution to mid-high latitude circulation trends than ENSO (and possibly the tropics as a whole) during the era of AA. Furthermore, when a record El Niño occurred this past winter, it should have been an opportunity to showcase decades of research and resources dedicated to the study of the ENSO phenomenon and its global impacts. However the dynamical forecasts performed poorly this past winter. Instead many of the significant circulation anomalies of this past winter are related to high-latitude processes, including a strengthened Siberian high and variability associated with the polar vortex. We submit that the poor forecasts of this past winter demonstrate that the science of long-range forecasting requires a paradigm shift in order to improve skill. Less reliance on the tropics and exploration of new regions of predictability, including the Arctic, are required.

Cohen, J. 2016a: An Observational Analysis: Tropical Relative to Arctic influence on Mid-latitude Weather in the Era of Arctic Amplification, *Geophys. Res. Lett.*, 43, 5287–5294, doi:10.1002/2016GL069102.
Cohen, J. 2016b: El Niño Dons Winter Disguise as La Niña. *Nature*, 533, 179.
Cohen, J., K. Pfeiffer, and J. Francis. 2017: Winter 2015/16: A Turning Point in ENSO-Based Forecasts. *Oceanography*, https://doi.org/10.5670/oceanog.2017.115.

jcohen@aer.com