Far Fields Causes of Eastern North American Cold Winters

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Introduction

Cohen et al. 2014 showed that the eastern North America show cooling trends in recent decades. Thirty three extreme cold eastern North American events are identified based on NCEP/NCAR Reanalysis products. They are further divided into Greenland Blocking (GB), Alaskan Ridge (AR) and Zonal (Z) patterns according to the surface temperature anomaly (925hPa) and 700 hPa geopotential height pattern.

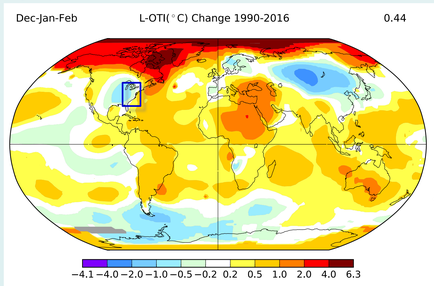


Figure 1: Linear trend of winter surface air temperature based on NASA GISS surface temperature analysis for 1990-2016 period. The box outlines the boundary where the eastern North America is defined.

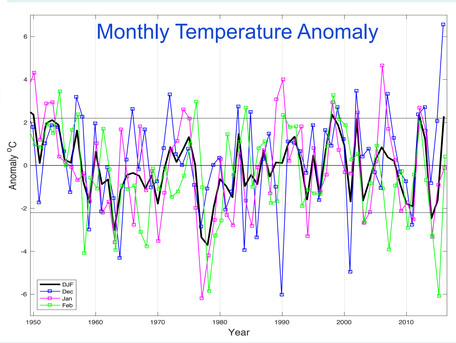


Figure 2: Monthly (thin colored lines) and seasonal mean (thick black line) surface air temperature anomalies based on NCEP/NCAR reanalysis. The December series was shifted by 1-year to go with the following winters (January and February). The thin horizontal black line indicates the mean standard deviation (one sigma).

Identified Cases

Months of cold eastern North America during1950-2016.
GB, AR, and Z represent associated temperature patterns:
Greenland Blocking(green), Alaskan Ridge (orange), and Zonal (black)

December	January	February
1958 GB	1963 Z	1958 GB
1963 Z	1966 GB	1963 GB
1976 GB	1970 Z	1967 AR
1983 AR	1977 Z	1968 Z
1985 Z	1978 AR	1978 Z
1989 AR	1979 Z	1979 GB
2000 Z	1981 Z	1980 Z
2010 GB	1982 GB	2003 Z
	1985 Z	2007 GB
	1994 AR	2010 GB
	2003 Z	2014 Z
	2011 Z	2015 AR
	2014 Z	

Summary

We identified 33 cases since 1950 with a rather uneven decadal distribution. In some but not all years there was month-to-month persistence of cold events during the winter. At this time there is no reason to reject a hypothesis that there were random climate events. All events have a west-east US temperature dipole pattern, and a west coast US ridge in the geopotential height field. The west coast ridge cases can occur with or without associated Greenland Blocking. For AR cases without GB the east coast US low height anomalies can extend northward into the Arctic. In GB cases the anomaly can be considered as a cut off vortex over eastern NA. the Z pattern can have less support for the ridge over the northeast Pacific Ocean than AR or GB cases.

Possible Remote Forcing Factors

Figure 3: Hypothesis of the possible remote forcing factors, from ocean to atmosphere to Arctic sea ice.

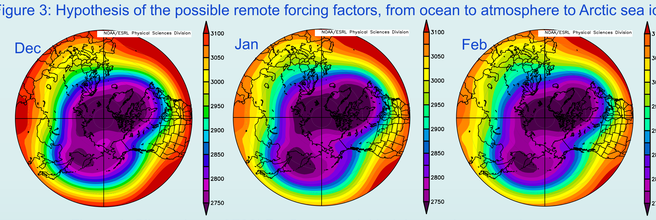


Figure 4: Climatology of 700hPa Geopotential height for winter month.

Composite of 925hPa Temperature Anomalies

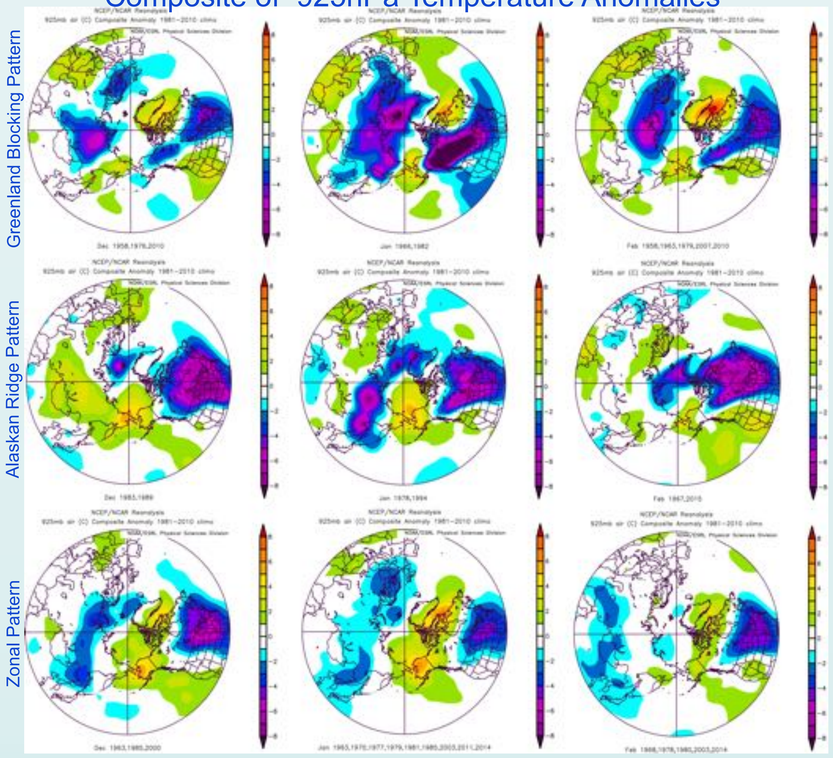
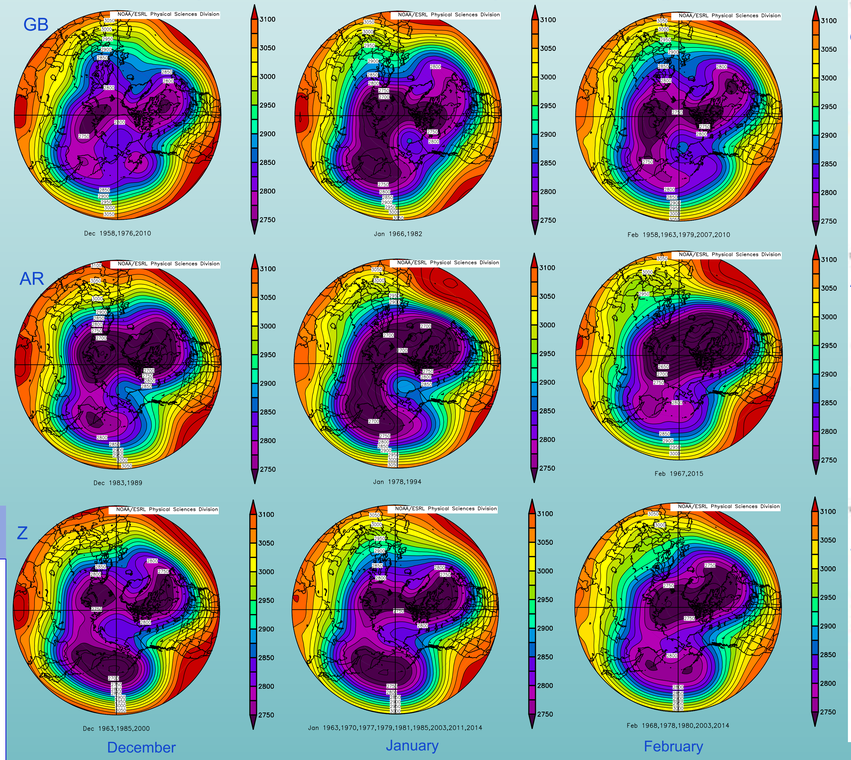


Figure 5: Composites of near surface (925hPa) air temperature anomalies for each month (December, January. and February) for each pattern. The cases that went into the composites are listed in the table left.

Composite of 700hPa Geopotential Height



Composite of 700hPa Geopotential Height Anomalies

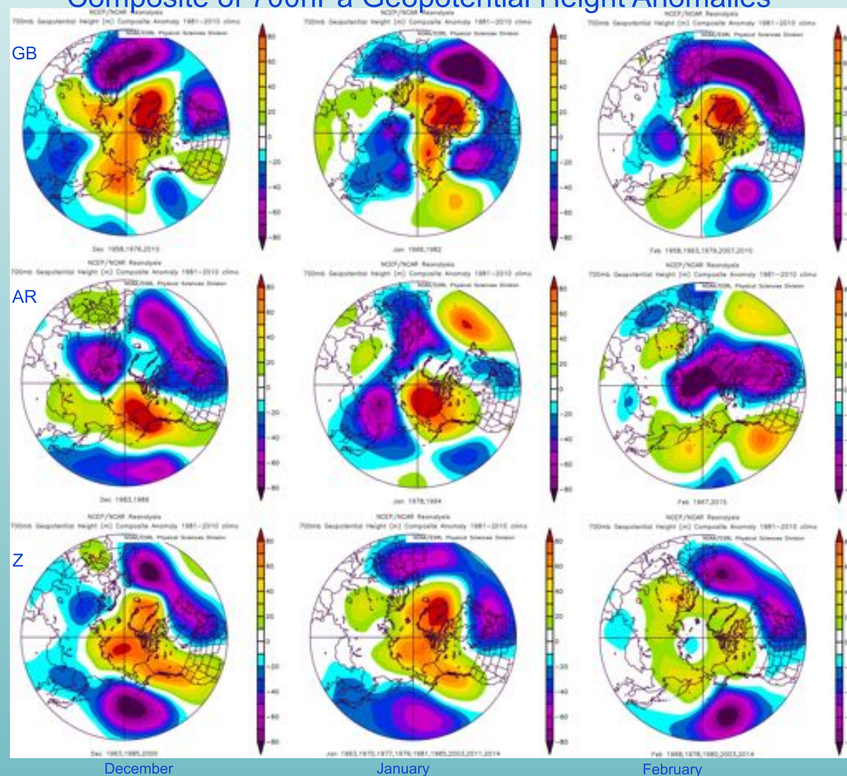


Figure 6: Composites of 700 hPa geopotential height (left) and anomalies (right) for each month (December, January. and February) for each pattern. The cases that went into the composites are listed in the table left.