Mid-Latitude Climate Change: The impacts of Arctic Amplification on the jet stream, atmospheric blocking, and teleconnections

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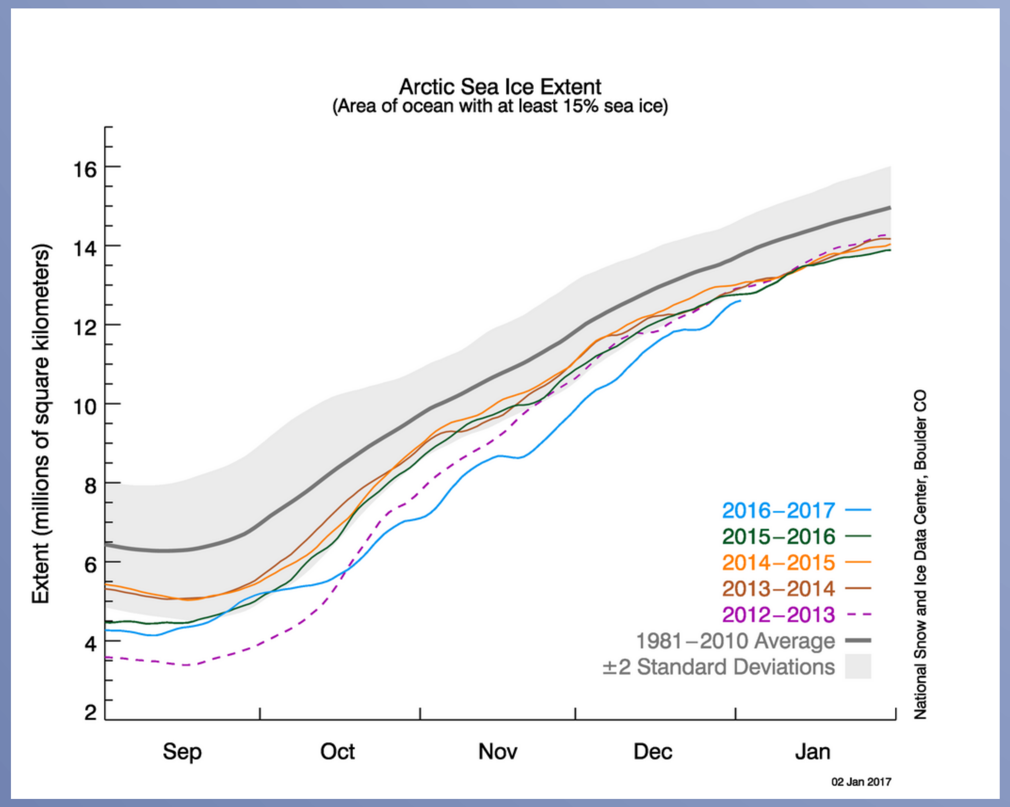
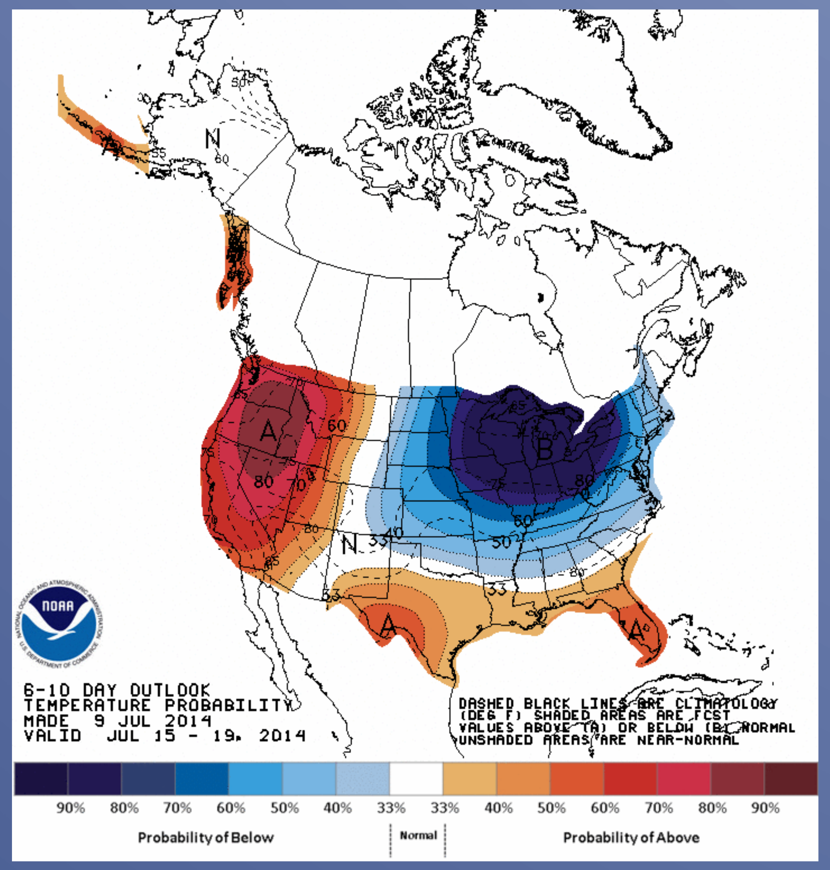
Introduction

The Arctic has warmed drastically in comparison to the rest of the Northern Hemisphere, a phenomenon known as Arctic Amplification (AA). It has been hypothesized that increasing Arctic temperatures weaken the meridional (north-south) temperature gradient across the middle latitudes, slowing the polar jet stream and increasing its amplitude (range of latitudes crossed), potentially accompanying more frequent and/or longer-lasting blocking episodes.



Artic Sea Ice Extent Source: National Snow and Ice Data Center

However, there is significant controversy in the science community regarding AA possibly affecting mid-latitude weather and climate via the jet stream, primarily because the results of numerical modeling studies differ among themselves, and also from the few observational studies that have been conducted. A potential Arctic-mid-latitudes linkage is also an area of research interest when seeking to assess the roles of anthropogenic forcing of climate versus random or natural variations.

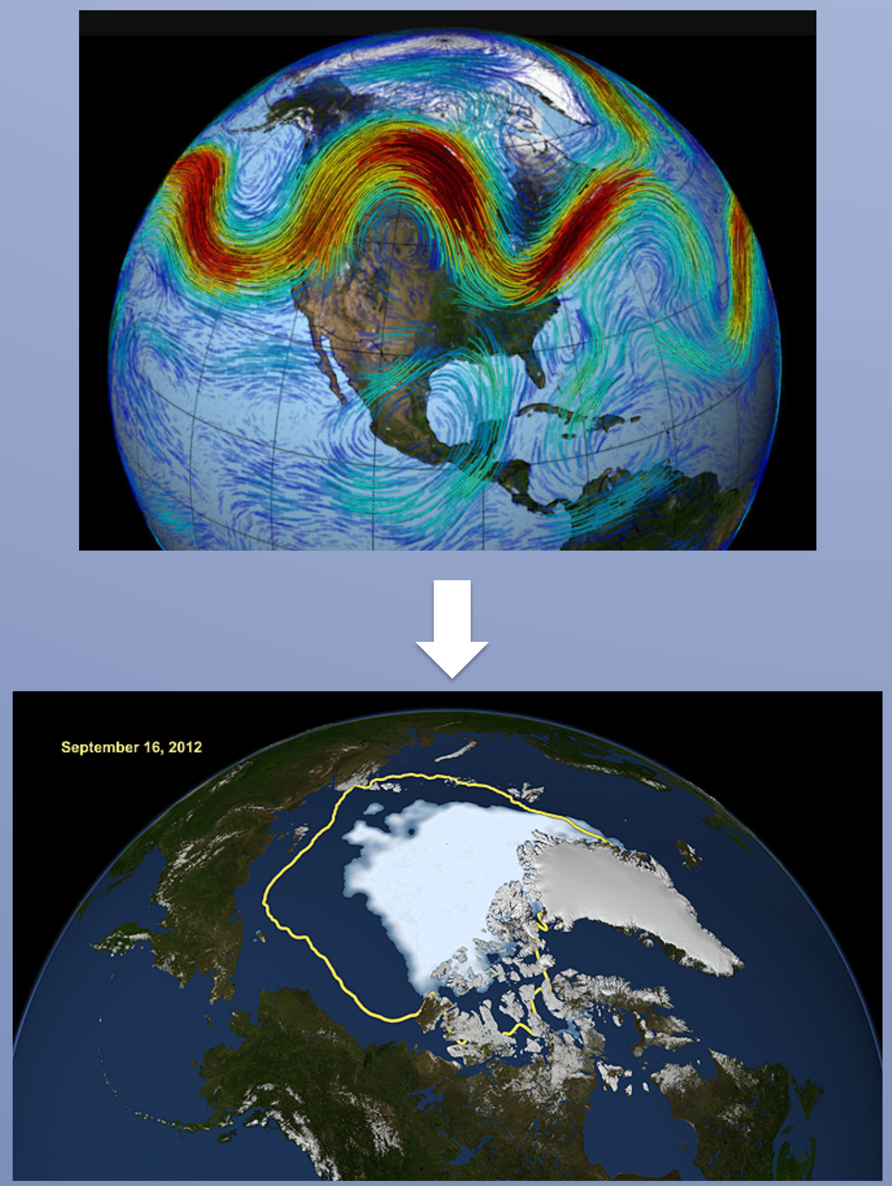


6-10 day temperature outlook Source: National Weather Service Climate Prediction Center

Research Questions

(1) Is there an increased tendency for the polar jet stream to meander possibly accompanying more frequent and/or longer-lasting blocking events, as the latitude temperature gradient decreases in response to low sea ice years/AA, during the seasons of summer and fall?

(2) Are the contrasts in weak versus stronger meridional temperature gradient conditions evident in the phase and intensity characteristics of the dominant teleconnection patterns over extratropical northern latitudes, the AO, the NAO, the NPO, and the PNA pattern, and what are the lead/lag associations?



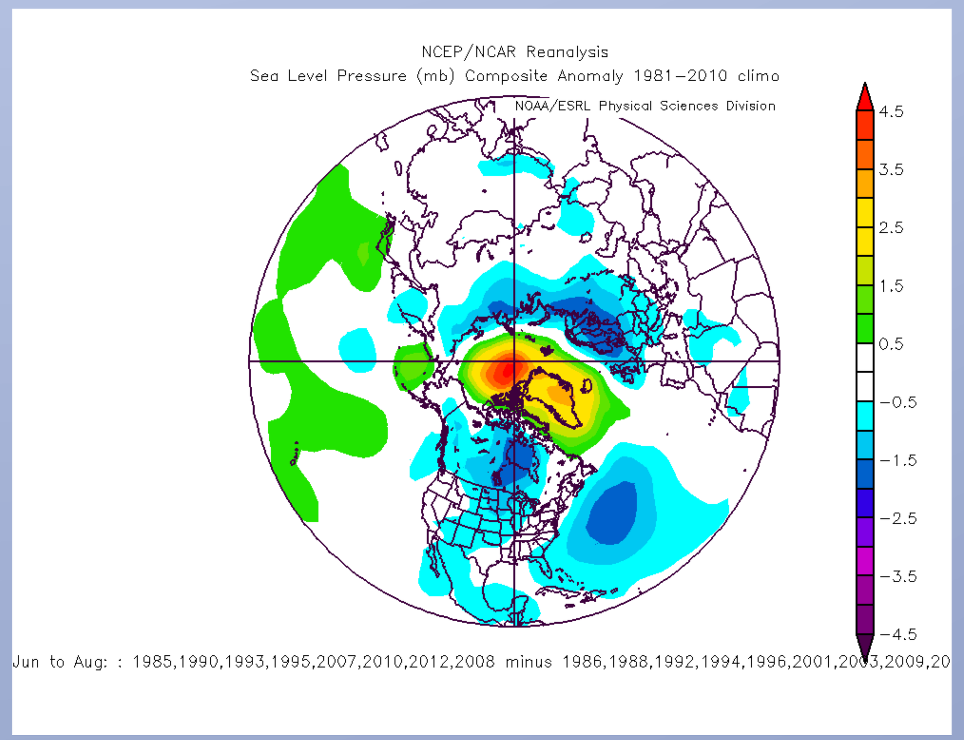
Meandering jet stream and Artic Sea Ice Extent Source: NASA

Methods

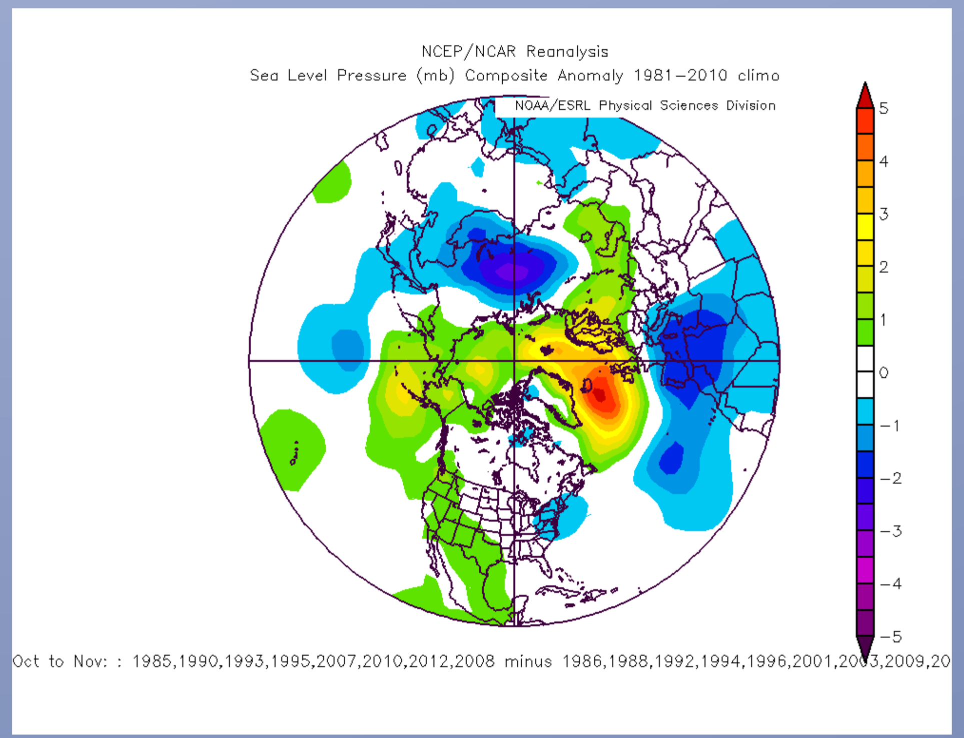
- The Northern Hemisphere poleward of about 25° N will be studied primarily for the period 1979 to present
- I will investigate low sea ice years versus high sea ice years in the Arctic separately for the summer (July August, September) and fall (October, November) seasons
- I will also examine the more recent period (2001-2016) - characterized by generally rapid and marked ice decrease - separately from the previous period (1979-2000) in terms of relatively low and high ice years
- I will use the NCAR/NCEP Reanalysis atmospheric data for both the seasonal (summer, fall) and the late versus early sub-periods of sea ice extent

Preliminary Results

- The composites suggested strongly that the variations in the sea ice are dominated by the AO
- Pictured below shows persistence of the AO from the summer into the Fall (Sea level pressure)



JJA Below the trend line minus Above the trend line sea ice in September



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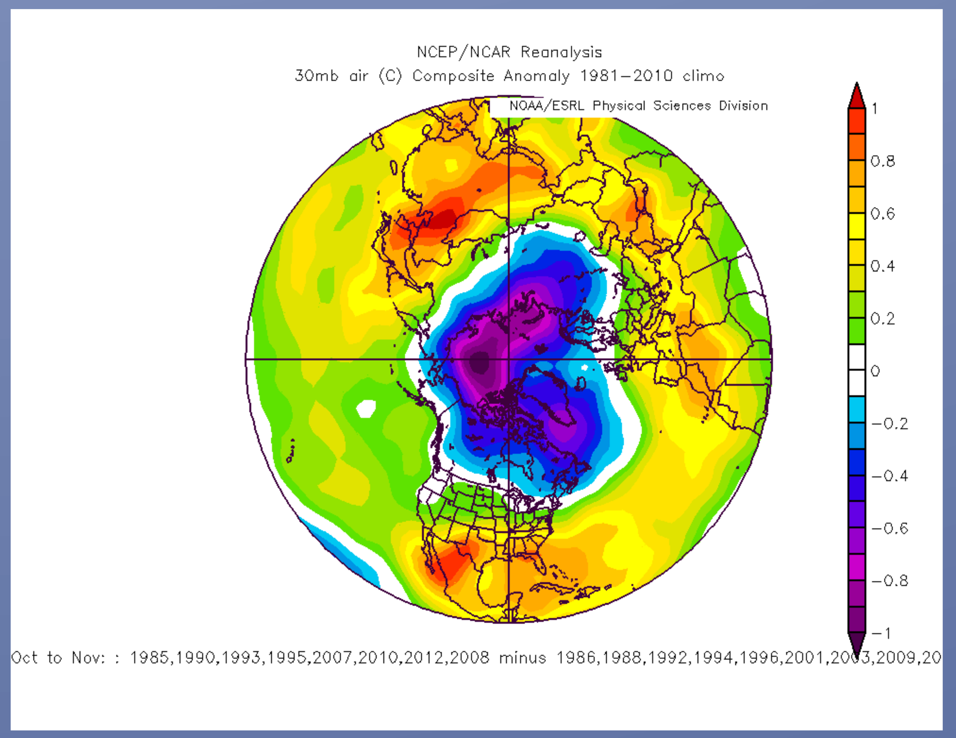
- The composites suggested anomalously cold temperatures in the Arctic for the Fall (pictured below 30 mb air temperature)



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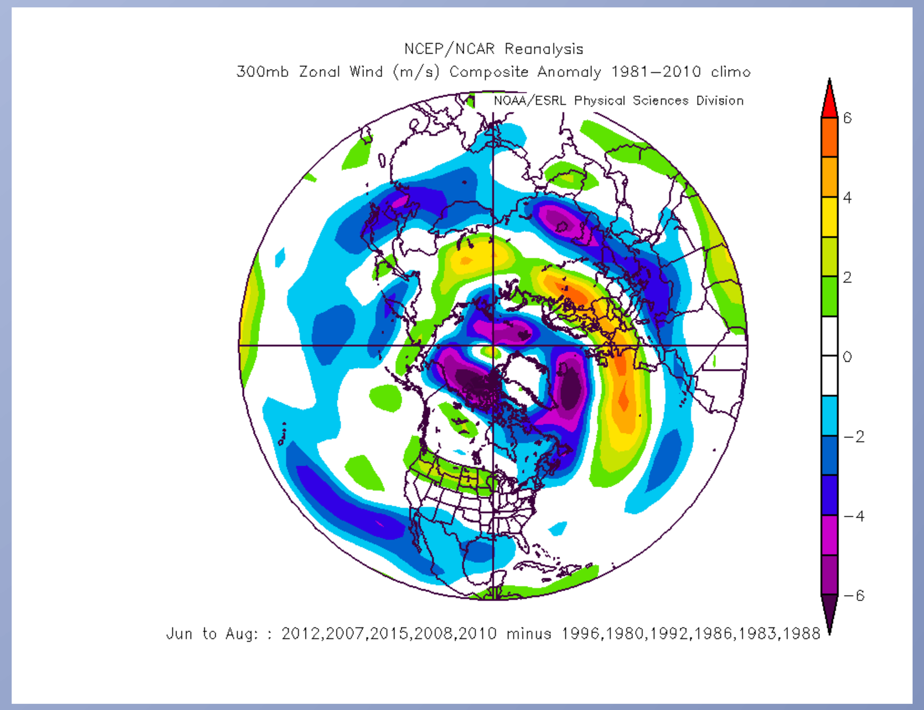
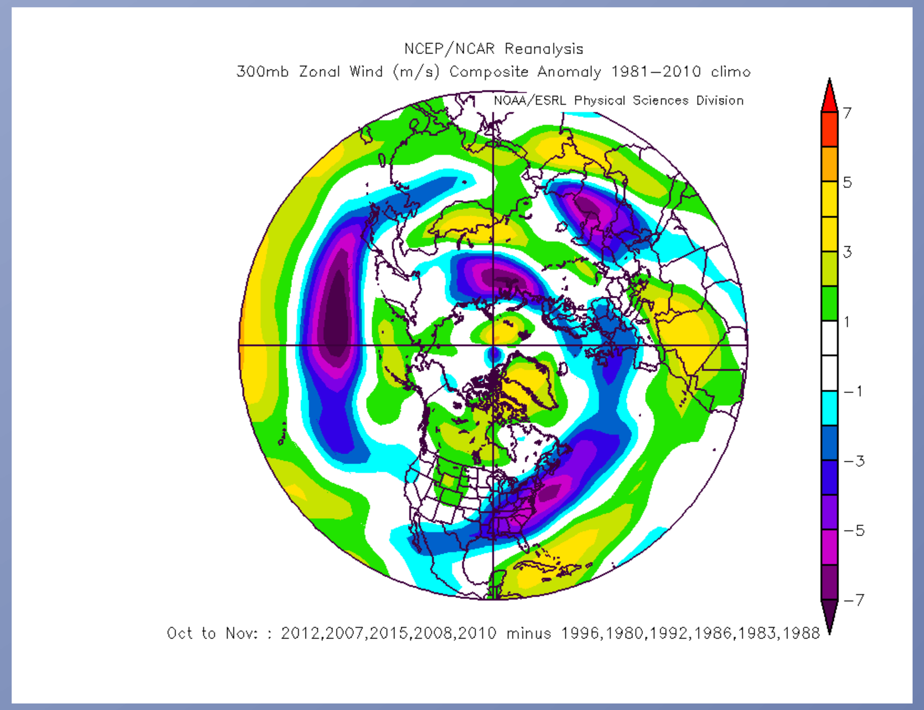
- The more recent period (2001-2016) has weaker jet streams in the subtropics and high latitudes, and a stronger middle-latitude jet (pictured below summer and fall)



JJA Low minus high sea ice in September



ON Low minus high sea ice in September

Future Analysis

I will compare the teleconnection patterns revealed by the composites of reanalysis data with the Greenland blocking index and the outputs of the CMIP 5. I will also develop a transect of station (i.e., surface) temperature data along both the west and east coasts of North America, from the subtropics to the Arctic, as an independent check of the meridional temperature gradients generated using the reanalysis data.

Literature Cited

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