January 7, 2019

Special blog on winter 2016/2017 retrospective can be found here - http://www.aer.com/winter2017

Special blog on winter 2015/2016 retrospective can be found here - http://www.aer.com/winter2016

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) recently embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

With transition to a fall/winter schedule, postings are once every week. Precipitation forecasts will be replaced by snow accumulation forecasts along with more emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to remain neutral to slightly negative through third week of January.
- The current neutral AO is reflective of mixed pressure/geopotential height anomalies across the Arctic and mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently slightly positive with weak positive pressure/geopotential height anomalies across Greenland and positive pressure/geopotential height anomalies across the mid-latitudes of the North Atlantic and is predicted to remain near neutral as height anomalies remain mostly weak across Greenland over the next two weeks.
- Ridging/positive geopotential height anomalies centered south of Iceland and extending into Western Europe are predicted to bring seasonable to above normal temperatures to Western Europe including the United Kingdom (UK) but force troughing/negative geopotential height anomalies and cold temperatures for Eastern but especially Northern Europe over the next two weeks.
- The main troughing/negative geopotential height anomalies will be focused across northwestern Asia over the next two weeks forcing ridging/positive geopotential height anomalies downstream centered on northwestern China with more troughing/negative geopotential height anomalies in Eastern Siberia. This

pattern is predicted to favor mostly normal to below normal temperatures across Siberia but normal to above normal temperatures elsewhere across Asia including the Middle East and East Asia. Troughing/negative geopotential height predicted for the Northern India subcontinent could bring below normal temperatures to the region especially this week.

- Troughing/negative geopotential height anomalies across Alaska, Northwest Canada and the Gulf of Alaska will bring cold temperatures to Alaska and northwest Canada while forcing mostly ridging/positive geopotential height anomalies and above normal temperatures downstream across much of the remainder of North America this week. However, the troughing is predicted to become focused further west near the Dateline with time favoring more ridging with mild temperatures across western North America with deepening troughing and cooling temperatures across eastern North America first across eastern Canada and then across the Eastern United States (US). However, the ECMWF model is not as aggressive with the western North American ridging yielding a milder solution across eastern North America.
- In the *Impacts* section, I discuss some lessons that I internalized from the polar vortex (PV) disruption of 2005/06, a stratospheric PV disruption that displayed many similarities to the current stratospheric PV disruption.

Impacts

It seems to me that my relating a story from the Talmud about Rabbi Akiva struck a chord with readers especially those that are less technically savvy or knowledgeable in climate dynamics that it made the blog more relatable. I am not sure how many stories I have in me but here is another story but not about a luminary like last week but rather me.

The first winter forecast that I went public with was the winter of 2002/03. That winter was a moderate El Niño, the first following the super El Niño of 1997/98 and another relatively mild winter was almost universally expected. But during October 2002 the second most extensive snow cover across Eurasia was observed for the month of October. And in an effort to gain credibility for my new theory linking extensive October Eurasian snow cover with cold Eastern US winters, AER and myself went public with a forecast for a cold winter in the Eastern US for the months December through February/March. This was a true David vs. Goliath story where once again the underdog Siberian snow cover slayed the giant El Niño and of course the rest is history. Well not exactly, no one seemed to care or notice.

I was confused and frustrated by the nonplussed reaction by the community and media, but I kept working to improve my prediction accuracy and awaited the next opportunity, which came three years later in winter 2005/06. Science journalist Sharon Begley from the Wall Street Journal came across my abstract submitted to Fall American Geophysical Union that December of 2005 (considering there are currently 25,000

abstracts submitted to the conference it is mind boggling that she found me) and decided to call me. This led to a front page article (second section) about the upcoming winter forecast. Once again, I was predicting a colder than the consensus overall mild winter based on extensive Siberian snow cover. And if you read the article you can see described the troposphere-stratosphere-troposphere coupling paradigm that still dominates my approach to winter prediction. In fall 2005 I was expecting a significant stratospheric PV disruption and a major mid-winter warming (MMW; where the zonal mean zonal wind reverses from westerly to easterly at 60°N and 10 hPa) most likely in January. The PV disruption would be followed by more severe winter weather across the Northern Hemisphere (NH) mid-latitudes including the Eastern US. This was based on our six-step model, which I have published many times before in the blog, but I show a slightly earlier version first published in Saito Kazuyuki's PhD thesis in 2003 in **Figure i**. Saito was truly instrumental in linking Siberian snow cover to the polar vortex and deserves a lot of credit for this discovery nearly twenty years ago now.

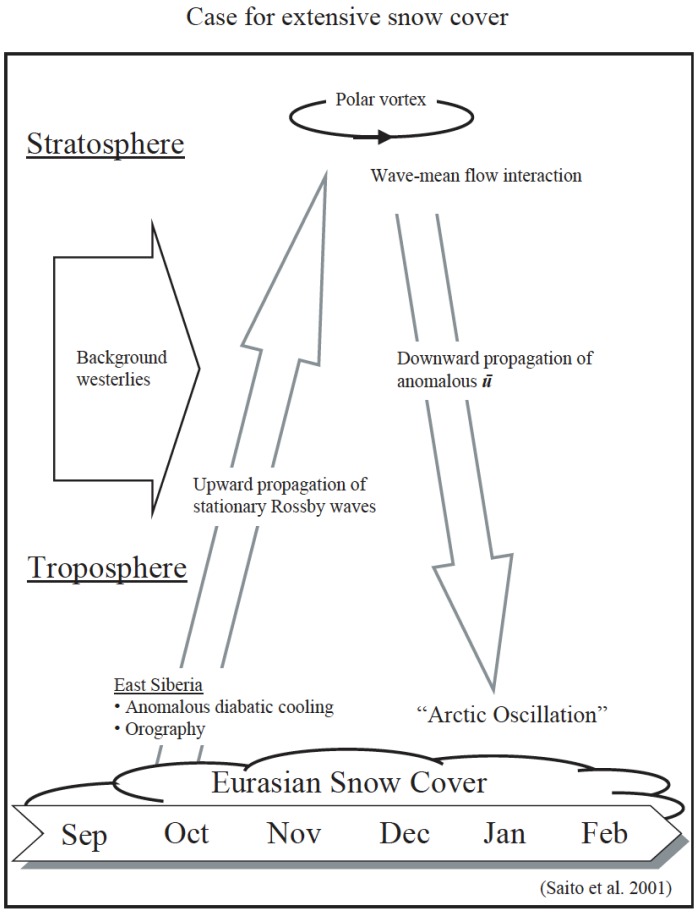

Figure i. Schematic diagram showing the atmospheric response to the early-season anomalously extensive Eurasian snow cover, and its physical/dynamical mechanisms from phD thesis of Kazuyuki Saito 2003.

Following the WSJ article I was also interviewed by CNN (I did find this transcript). At the end of the interview I had a throwaway line "I think I'm going to buy a snow blower; I'm tired of shoveling," which you can read in the transcript. That December was a cold and snowy month in the Eastern US and though I was expecting the weather to turn milder for reasons that I explained last week and two weeks before that, I was confident the cold would return following the PV disruption. All I needed was one Arctic outbreak for my high profile forecast to verify but that Arctic outbreak never came. The winter temperatures in the end averaged above normal for almost the entire US. And to add insult to injury or Mother Nature kicking me while I was down – on January 18th 2006 the strong poleward transport of heat that initiated the MMW on January 21 2006 kicked off a line of rare January severe weather in the Northeast and my car was crushed by a fallen tree. What is even scarier, I was in the car less than twenty minutes earlier from when the tree fell (see **Figure ii**). That was a real kick in the teeth on a very disappointing winter. And at least in Boston it barely snowed again that winter, which I in part blame on my snow blower line.

Figure ii. My car after a tree fell on it on January 18, 2006.

Looking back on the forecast I would argue that it was an incredible meteorological achievement. At the time scientists started proposing using the stratosphere and the PV to predict our weather (as far as I know no one was using the stratosphere to make operational forecasts at the time) but no one was using the troposphere to predict the stratosphere to then predict the weather. My forecast of a polar vortex disruption made in the WSJ and on CNN was spot on. There was also widespread cold and snow that followed the PV disruption, but the devil is in the details and the cold was focused across Eurasia with Europe receiving the most attention. New York City even recorded their single greatest snowfall from a single storm on February 11th 2006 with

southwestern CT receiving more than 30 inches (see snowfall map from Tomer Burg). My forecast was considered a failure and I was banished to the meteorological wilderness and mostly ignored for at least the next five years.

What did I internalize from my unexpected moment in the spotlight and just as unexpected flameout? One lesson I took away was live by the composite, die by the composite. Sure, when you average all the winters following extensive October snow cover and/or winters with an MMW it is cold in the Eastern US. In retrospect that worked great in winter 2002/03 but failed in winter 2005/06. If you want to issue a forecast, it is not sufficient to predict the average you also need to acknowledge the range of possibilities. Someone reading this may think I am endorsing only issuing a forecast in the form of a probability distribution. But as a tangent, I have to admit that I am not a fan of probabilistic forecast. If I issue a cold forecast and the winter is observed to be warm well the forecast is not wrong because my range of possible outcomes included both a warm and cold winter. As I mentioned last week I don't believe in randomness in the seasonal average. If I forecast a cold winter and it is warm instead, the forecast is wrong.

But this is not the point of the blog post today but rather the ghost of winter 2005/06 still haunting me. I have once again received some attention for a forecast of a PV disruption to be followed by widespread severe winter weather. After the winter of 2005/06, I know that I cannot guarantee an outcome no matter how tantalizing close it seems to the finish line. That winter, all six steps in our model verified and yet the forecast busted, at least for the Eastern US. And I think the lessons from that winter are applicable to this winter. There has been a lot of discussion, at least on Twitter, will the stratospheric PV split couple to the surface. I don't think the question is whether the stratosphere and troposphere will couple, there is already strong evidence that they are coupling. The stratospheric and troposphere PVs are vertically stacked as I showed in a tweet earlier today and can be seen from plots below. Furthermore, the most anomalous cold and snowfall across the NH are currently co-located with those PVs.

Looking forward it looks like the coupling will strengthen over time. The GFS is predicting the first "drip" of warm polar cap geopotential height anomalies from the stratosphere to the troposphere at the end of the week and this weekend which is reflected in a short term drop in the AO. The GFS is predicting more "dripping" for the following weekend though more uncertainty exists with any event beyond a week. But regardless how robust the stratosphere-troposphere coupling currently looks, the magnitude and duration on the NH weather is still highly uncertain. And in an attempt to troll me, Mother Nature has delivered a PV split that is very much reminiscent of the PV split in winter 2006 (see **Figure iii**).

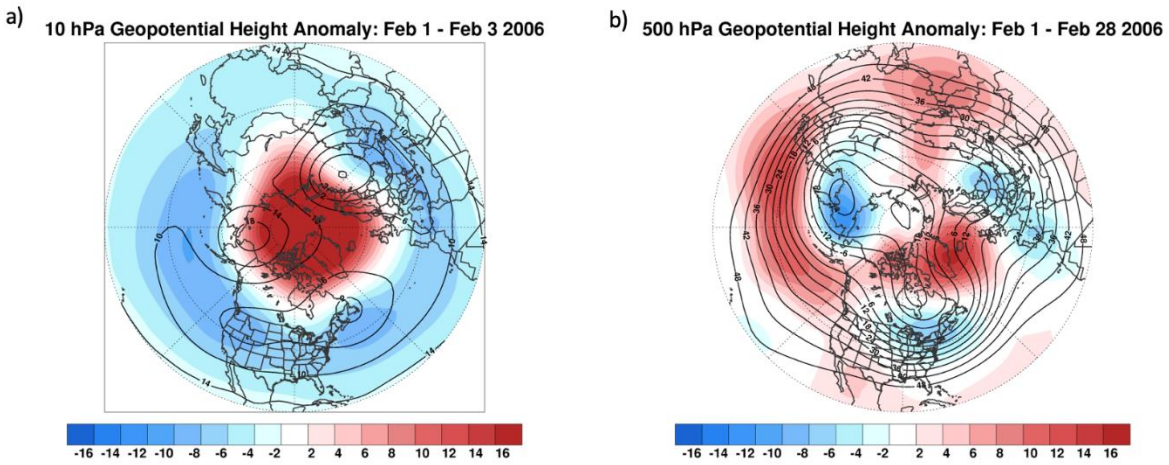

Figure iii. a) Observed 10 mb geopotential heights (contours) and geopotential height anomalies (m; shading) for 1 - 3 February 2006 and b) Observed 500 mb geopotential heights (contours) and geopotential height anomalies (shading) for 1 - 28 February 2006.

I believe that for a robust tropospheric and weather response to the stratospheric PV split a warm Arctic in the lower to mid-troposphere is critical. If I were to make a winter forecast for winter 2005/06, I would still make the same forecast and I still don't understand what went wrong with the forecast that winter. In **Figure iii** I also include the 500 mb geopotential height pattern from that winter and in contrast to the stratosphere the mid-troposphere remained cold in the Central Arctic with low pressure right over the North Pole. Surprisingly, to me at least, the Arctic in the low to mid-troposphere has been relatively cold this winter and for the most part, the forecasts are for that to continue. I think the warmer the Arctic relative to normal over the coming weeks the more likely severe winter weather including cold and snow to be widespread across the NH. In **Figure iv**, I present a bar plot of an index of the severity of winter weather in Boston compared to Arctic temperatures based on the analysis in Cohen et al. 2018. It is striking how strong the relationship is between Arctic temperatures and severe winter weather in Boston and similarly with other Northeastern US cities.

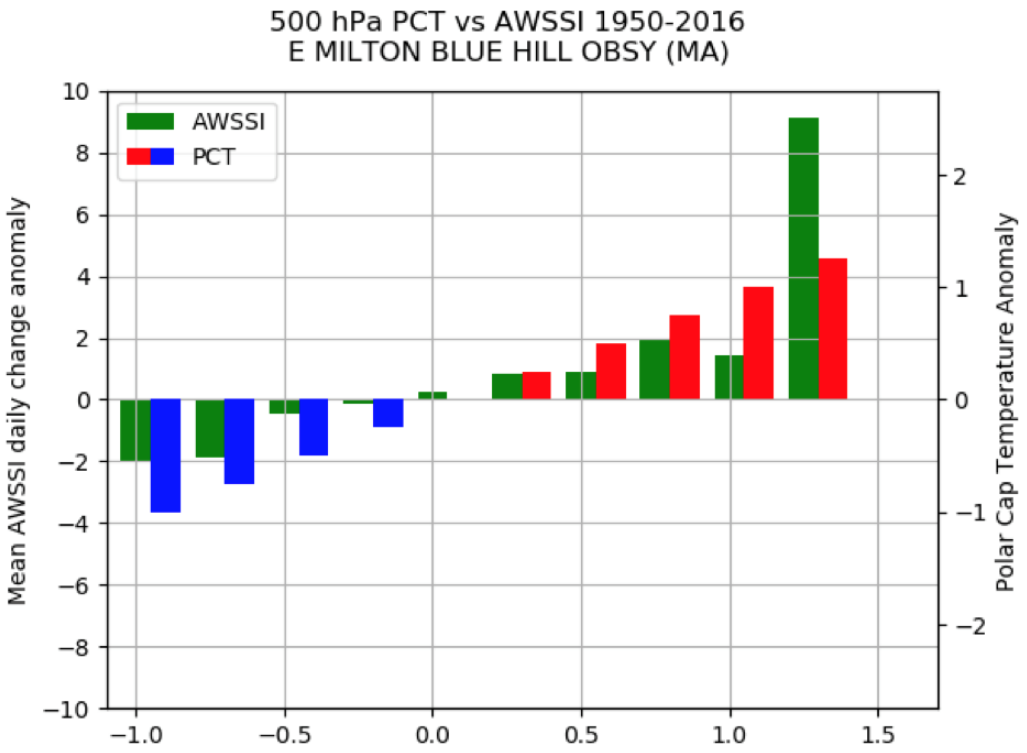

Figure iv. The departure from the winter average in daily change in the AWSSI (Accumulated Winter Season Severity Index see https://mrcc.illinois.edu/gismaps/awssi.htm) for Blue Hills (near Boston) with corresponding polar cap temperature at 500 hPa during December-February.

To end I will circle back to the snow blower. It has taken thirteen years, but I finally have a snow blower. I fully acknowledge that this may have erected a magical force field around Boston keeping the snow away. If it doesn't snow again this winter, I fully take the credit or the blame, depending on your perspective.

Near Term Conditions

1-5 day

The AO is currently neutral **(Figure 1**), with mostly negative geopotential height anomalies across the North Pacific side of the Arctic but mostly positive geopotential height anomalies across the North Atlantic side of the Arctic **(Figure 2)**. Geopotential height anomalies are weakly positive across Iceland and Greenland with positive geopotential height anomalies across the mid-latitudes of the North Atlantic **(Figure 2)** and therefore the NAO is slightly positive. The AO is predicted to turn briefly negative at the end of the week as the first "drip" of warm polar cap geopotential height anomalies reach the troposphere from the stratosphere.

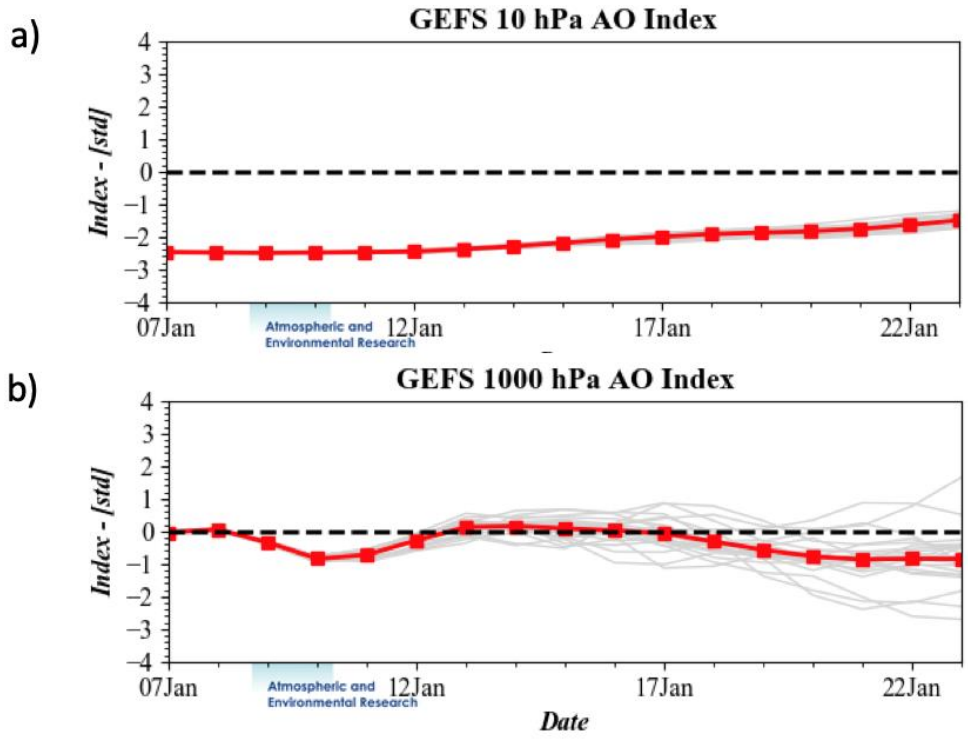

Figure 1. (**a**) The predicted daily-mean AO at 10 hPa from the 00Z 7 January 2019 GFS ensemble. (**b**) The predicted daily-mean near-surface AO from the 00Z 7 January 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Currently ridging/positive geopotential height anomalies centered South of Iceland and extending across Northern Europe (**Figure 2**) are forcing troughing/negative geopotential height anomalies downstream across Eastern Europe that extend southwestward across Southern Europe (**Figure 3**). With high heights dominating, normal to above normal temperatures are widespread across Northern Europe including the UK while low heights and northerly winds are bringing normal to below normal temperatures for Eastern and Southern Europe (**Figure 3).** Troughing/negative geopotential height anomalies dominate much of the North Slope of Asia with ridging/positive geopotential height anomalies widespread across the remainder of Asia (**Figure 2**) yielding widespread normal to above normal temperatures across much of Asia including the Middle East and East Asia with the exception of normal to below normal temperatures for Northern Siberia (**Figure 3).** However, troughing/negative geopotential height anomalies across the northern India subcontinent (**Figure 2**), are predicted to result in normal to below normal temperatures across Southern Northern India and Pakistan **(Figure 3).**

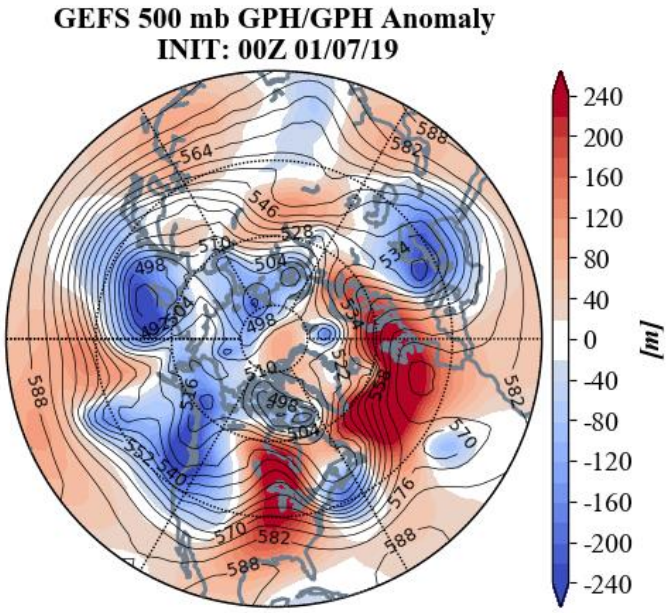

Figure 2. Observed 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) for 00Z 7 January 2019.

Troughing/negative geopotential height anomalies spread across Alaska, Western Canada, the Northwestern US and the Gulf of Alaska are helping to force downstream ridging/positive geopotential height anomalies across much of the remainder of North America with the exception of troughing/negative geopotential height anomalies in New England and Nova Scotia (**Figure 2**). This is predicted to result in normal to below normal temperatures in Alaska and Western Canada with normal to above normal temperatures for Eastern Canada and much of the US **(Figure 3).**

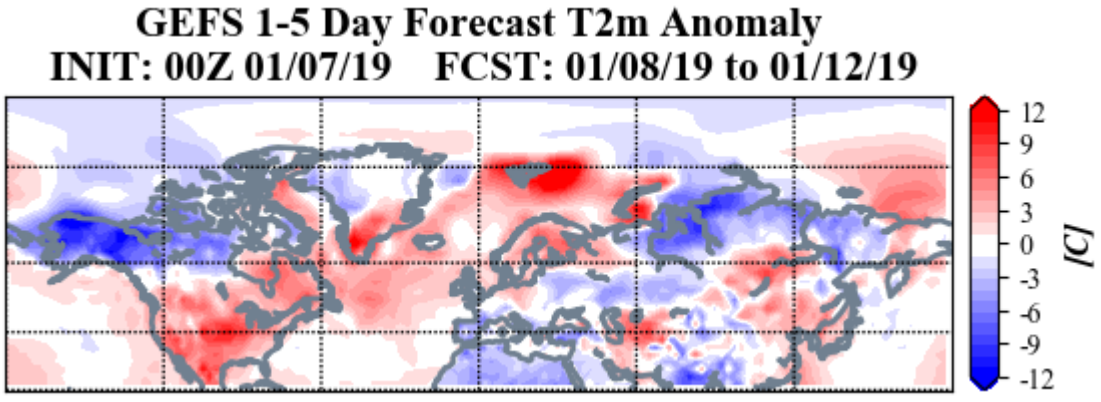

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 January 2019. The forecast is from the 00Z 7 January 2019 GFS ensemble.

Troughing and/or cold temperatures will bring widespread new snowfall to Northern and Western Asia, Eastern, Central and Northern Europe (**Figure 4**). Across North America, troughing and cold temperatures will bring widespread new snowfall across Canada, and even New England while milder temperatures will result in snowmelt across parts of Southwestern Canada and the intermountain Western US (**Figure 4**).

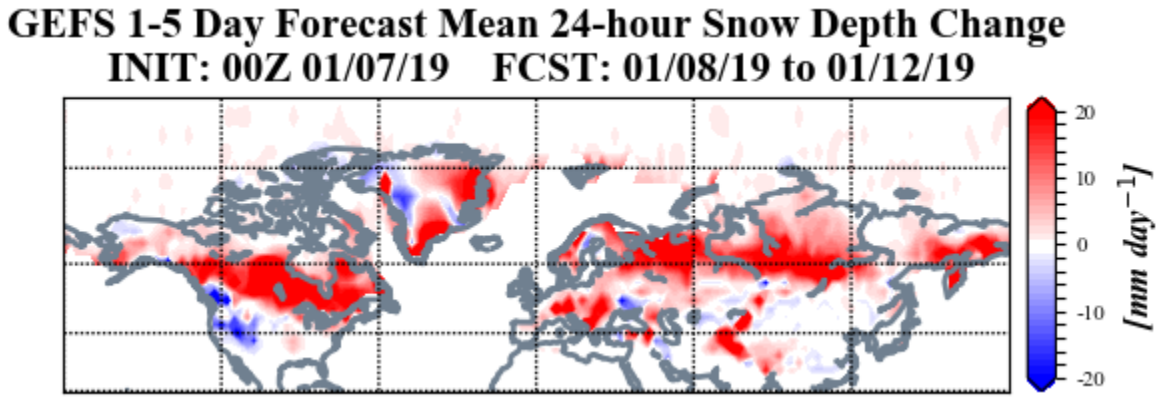

Figure 4. Forecasted snowfall anomalies (mm/day; shading) from 8 – 12 January 2019. The forecast is from the 00Z 7 January 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain near neutral next week **(Figure 1**) with mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes (**Figure 5a**). And with weak geopotential height anomalies across Greenland, the NAO will likely be near neutral as well next week.

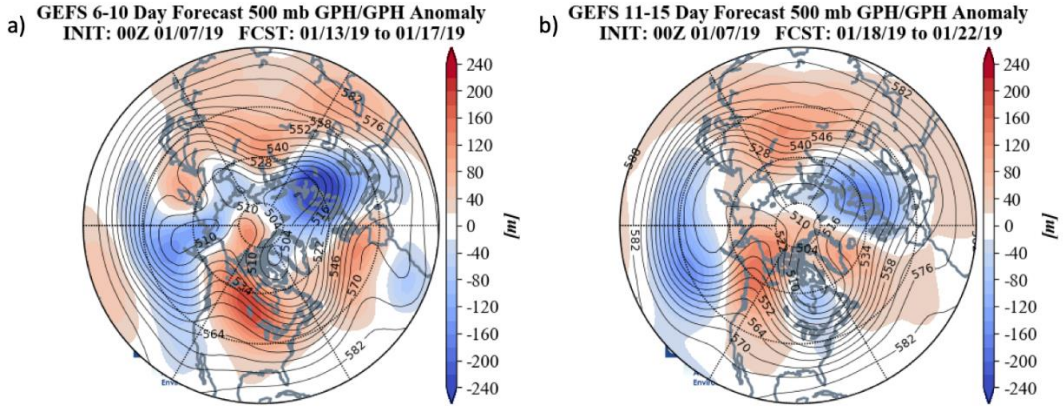

Figure 5. (a) Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 January 2019. (b) Same as (a) except averaged from 18 –22 January 2019. The forecasts are from the 7 January 2019 00z GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to remain centered between Iceland and Western Europe helping to anchor deepening troughing/negative geopotential height anomalies across Northern and Eastern Europe this period (**Figure 5a**). This is likely to result in a normal to above normal temperatures for much of Western and Central Europe including the UK with normal to below normal temperatures for Eastern Europe and especially Scandinavia (**Figure 6**). Troughing/negative geopotential height anomalies will remain centered in Western Siberia and extending across the North slope of Asia with ridging/positive geopotential height anomalies spread across the remainder of Asia (**Figure 5a**). This is predicted to yield normal to below normal temperatures for far Western Asia and Siberia with normal to above normal temperatures for the rest of Asia including the Middle East, East Asia and likely the northern Indian subcontinent (**Figure 6**).

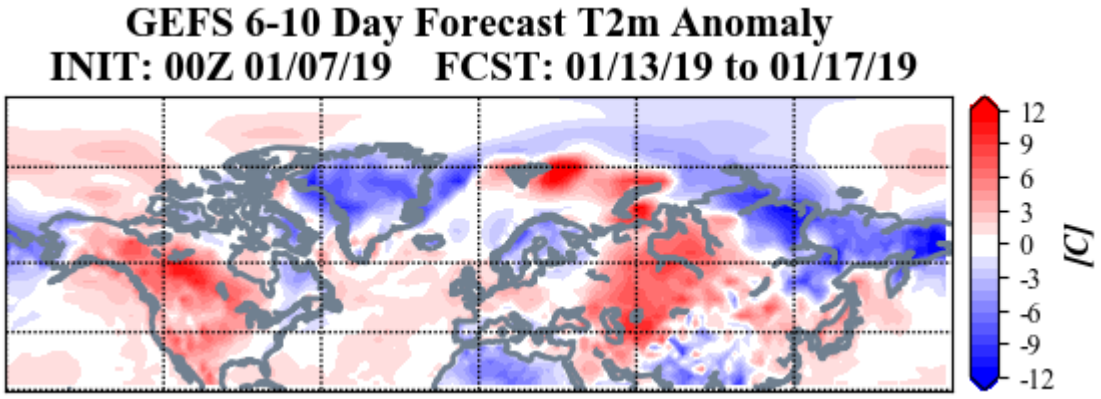

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 13– 17 January 2019. The forecasts are from the 00Z 7 January 2019GFS ensemble.

Predicted troughing/negative geopotential height anomalies previously centered across Alaska and the Gulf of Alaska will drift closer to the Dateline forcing ridging/positive geopotential height anomalies further west across much of North America centered in the interior of the continent with renewed troughing/negative geopotential height anomalies in Eastern Canada and the Northeastern US **(Figure 5a).** The resultant temperature anomalies across North America are predicted to be widespread normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures for Eastern Canada and the US East Coast **(Figure 6).**

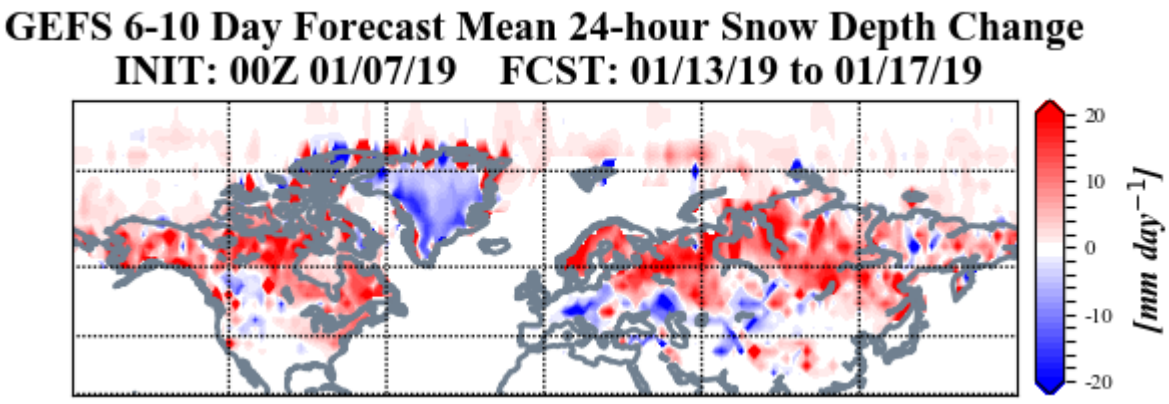

Figure 7. Forecasted snowfall anomalies (mm/day; shading) from 13 – 17 January 2019. The forecasts are from the 00Z 7 January 2019 GFS ensemble.

Troughing and cold air will bring the potential for new snowfall across much of Northern and Western Asia, Scandinavia and Eastern Europe (**Figure 7**). Across North America, new snowfall is possible in Alaska, much of Canada and the Northeastern US (**Figure 7**). Increasingly milder temperatures could result in snowmelt in parts of Central Europe and the Caucasus Mountains and even possibly the Western US (**Figure 7**).

11-15 day

With mostly positive but weak geopotential height anomalies predicted for the Arctic (**Figure 5b**), the AO is likely to trend slightly negative this period (**Figure 1**). With weak positive pressure/geopotential height anomalies across Greenland, the NAO is predicted to remain neutral to slightly negative this period as well (**Figure 1**). The predicted negative AO is related to a second “drip” of warm/positive polar cap geopotential height anomalies from the stratosphere to the troposphere.

Ridging/positive geopotential height anomalies in the North Atlantic are predicted to drift west into the central North Atlantic allowing for troughing/negative geopotential height anomalies to become more widespread across Europe (**Figure 5b**). Low heights and northerly flow are likely to result in normal to below normal temperatures for much of Northern Europe including the UK and Eastern Europe (**Figure 8**). However, a more westerly flow of air across Western and Central Europe could bring closer to seasonable temperatures (**Figure 8**). With the exception of Western Asia, above normal heights are predicted across much of Asia with the ridging/positive geopotential height anomalies centered in Northwestern China (**Figure 5b**). This pattern favors normal to below normal temperatures for Northwestern Asia, Central and Eastern Siberia and Northeast Asia due to northerly flow with normal to above normal temperatures for Western Siberia and Southern and Central Asia including the Middle East, Northern India, Pakistan and Southeast Asia (**Figure 8**).

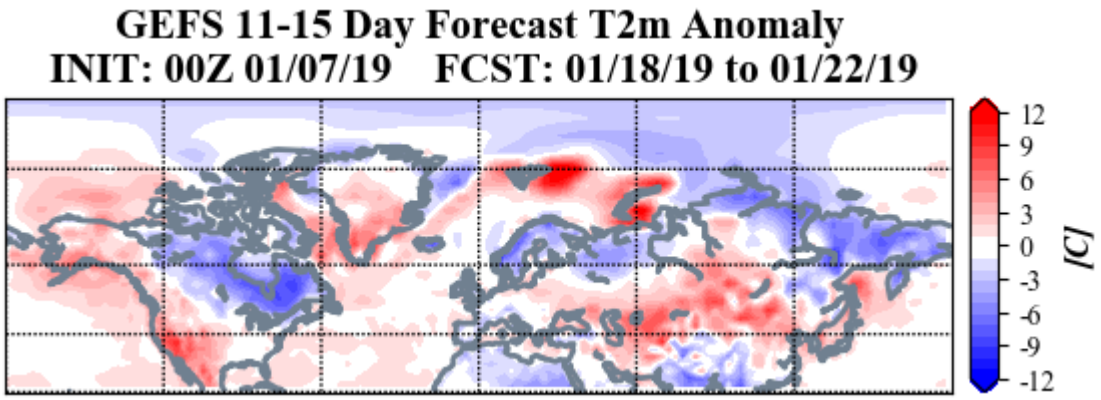

Figure 8. Forecasted surface temperature anomalies (°C; shading) from 18 – 22 January 2019. The forecasts are from the 00Z 7 January 2019 GFS ensemble.

Troughing/negative geopotential height anomalies previously centered near Alaska and the Gulf of Alaska are predicted to continue to drift towards the Dateline supporting ridging/positive geopotential height anomalies downstream over western North America centered over Western Canada with more troughing/negative geopotential height anomalies across eastern North America (**Figure 5b**). This will favor normal to above normal temperatures across Western Canada and the Western US with normal to below normal temperatures for the Eastern US and especially Eastern Canada (**Figure 8**). The ECMWF model is predicting less amplified ridging in western North America with milder temperatures in the Eastern US.

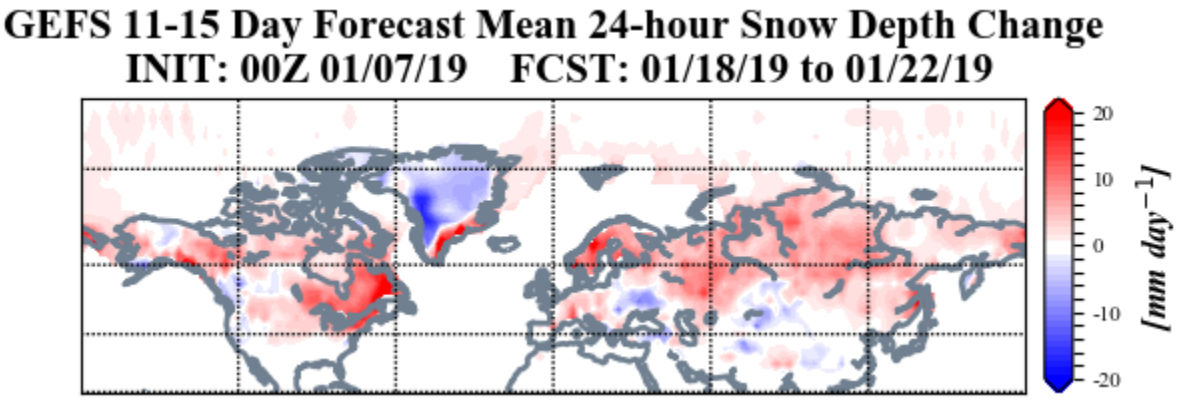

Figure 9. Forecasted snowfall anomalies (mm/day; shading) from 18 – 2 January 2019. The forecasts are from the 00Z 7 January 2019 GFS ensemble.

Once again additional snowfall is possible across much of northern Eurasia including Siberia, Western Asia, Scandinavia, Central and even possibly Western Europe (**Figure 9**). Seasonable to cold temperatures across Eastern Canada and even the Northeastern

US will also support potentially new snowfall (**Figure 9**). Mild temperatures could result in snowmelt across Southeastern Europe, Turkey, Alaska, Western Canada and the Western US (**Figure 9**).

Longer Term

30–day

The latest plot of the polar cap geopotential heights (PCHs) shows in general predicted normal to above normal PCHs in the stratosphere with normal PCHs in the troposphere (**Figure 10**). The near normal PCHs in the lower troposphere are consistent with a predicted neutral AO this week (**Figure 1**). The above normal PCHs in the stratosphere are also consistent with the negative stratospheric AO for the next two weeks (**Figure 1**). The strongly positive PCHs and negative stratospheric AO are related to a sudden stratospheric warming (SSW) and a major mid-winter warming (MMW; where the zonal mean zonal wind reverses from westerly to easterly at 60°N and 10 hPa). The stratospheric positive PCHs are predicted to peak currently with the strongest anomalies propagating from the mid-stratosphere to the lower stratosphere over the next two weeks, consistent with downward propagation expected with these events. Over the past several days the GFS has been consistently predicting that the warm PCHs will begin to "drip" through the troposphere to the surface. The first drip will take place later this week and over the weekend and could coincide with a possible US East Coast snowstorm and a turn to colder and snowier weather across Northern Europe.

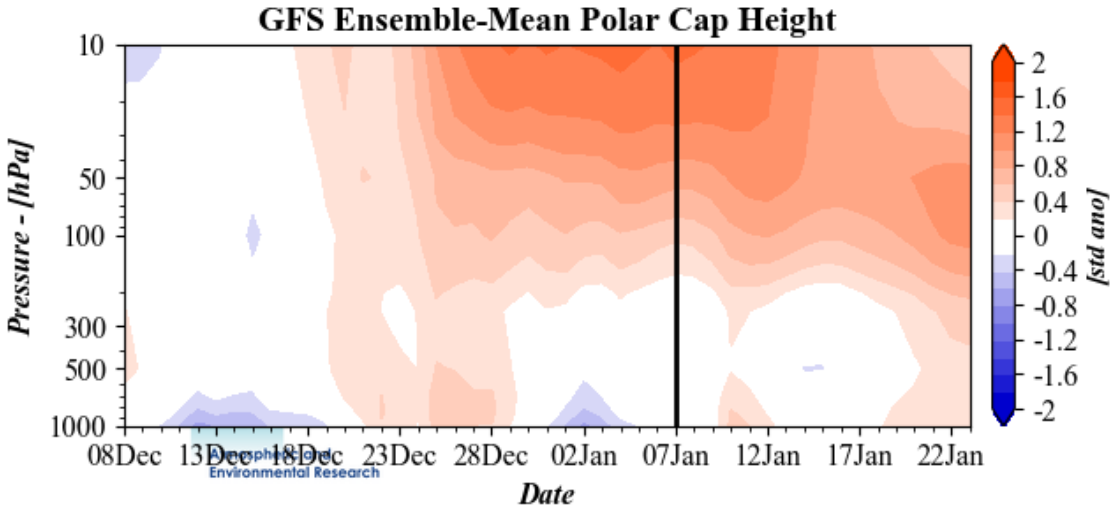

Figure 10. Observed and predicted daily polar cap height (i.e, area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 7 January 2019 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport indicates mostly negative WAFz **(Figure 11**). Below normal WAFs is consistent with a reversal in the winds in the stratosphere. The below normal WAFz is related to the downward propagation of warm PCHs through the stratosphere and troposphere.

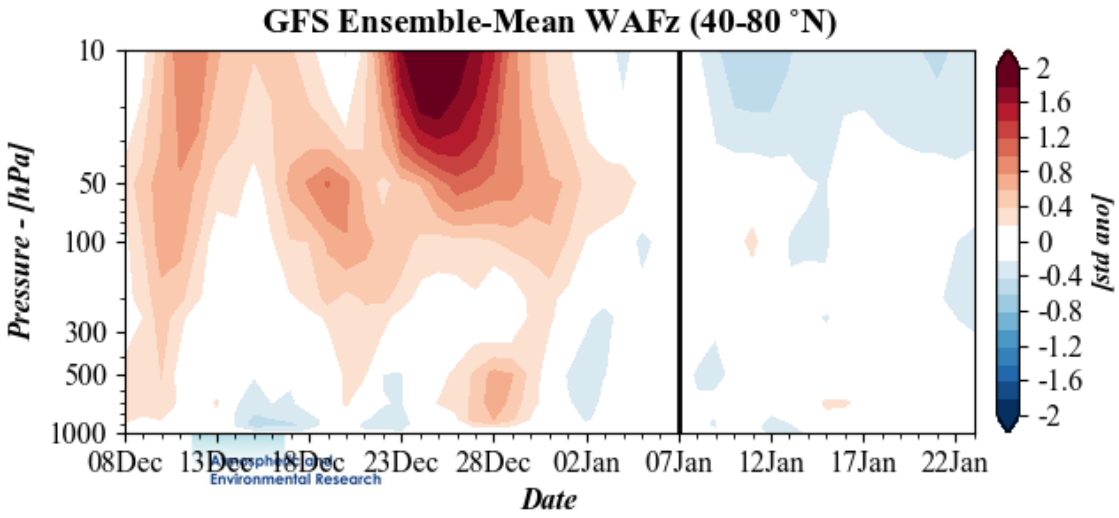

Figure 11. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 7 January 2019 GFS ensemble.

Currently the stratospheric PV has broken into several pieces or daughter vortices. The major daughter vortex is centered near Scandinavia and a minor daughter vortex is centered over Quebec and New England with a possible third daughter vortex over the North Pacific with ridging and accompanying warming centered in the Beaufort Sea (**Figure 12)**. The daughter vortex over Scandinavia is predicted to drift west and further split into two with one vortex over Northwest Russia and another over Western Europe with the other vortex over Quebec and New England drifting west into Central Canada.

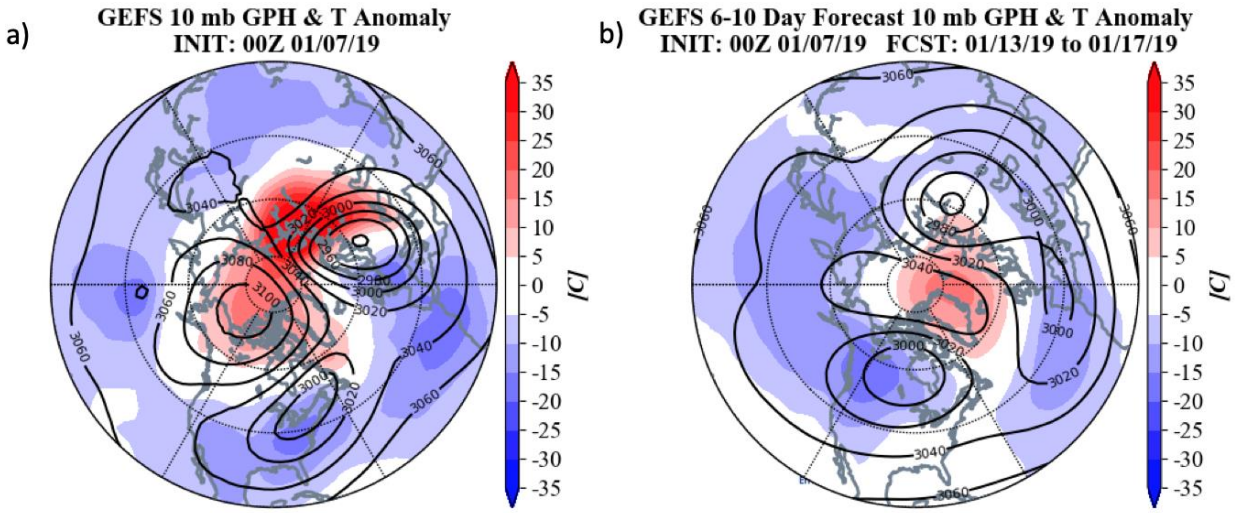

Figure 12. (a) Analyzed 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 7 January 2019. (**b**) Same as (**a**) except forecasted averaged from 13 – 17 January 2019. The forecasts are from the 00Z 7 January 2019 GFS operational model.

The predicted details of the stratospheric PV disruption are showing better consistency among the weather models. An MMW has occurred as well as a PV split. Instead there still remains much uncertainty with the impacts of the stratospheric warming on the weather. Following the peak of the stratospheric warming, I would expect the warm/positive PCHS to “drip” down into the troposphere, which is now predicted by at least the GFS. A sudden stratospheric warming not only leads to a warm Arctic in the stratosphere but also at the surface as well. And a warmer Arctic favors more severe winter weather in the NH midlatitudes including the Eastern US. I do think there is uncertainty how warm much the Arctic warms in the lower troposphere and surface and could play a major role in the duration and magnitude of the weather impacts of the PV split.

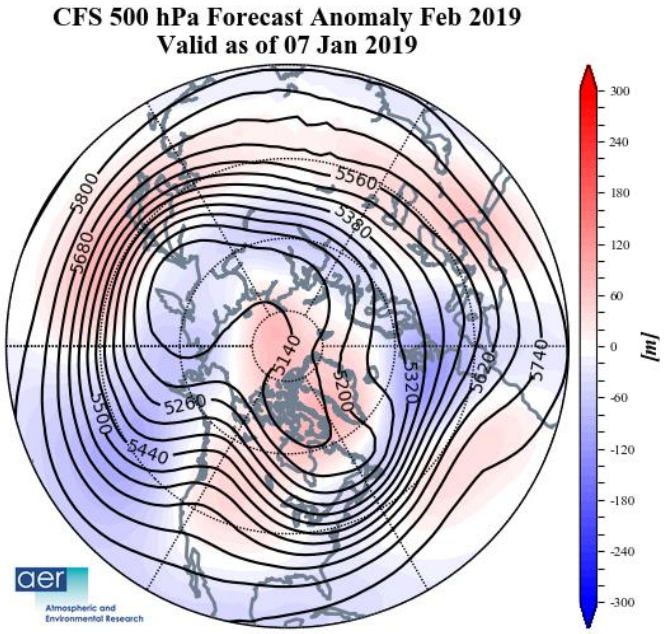

Figure 13. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for February 2019. The forecasts are from the 7 January 2019 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and the surface temperatures (**Figure 14**) forecast for February from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered on western North America extending towards Greenland and into the Central Arctic, with more ridging in the Middle East and East Asia with troughs across Western Europe, Siberia, the Aleutians and eastern North America (**Figure 13).** This pattern favors cold temperatures for Northern Europe, Northern Asia and eastern North America with relatively mild temperatures for Southern Europe, the Middle East, Southeast Asia and much of western North America. This temperature pattern is consistent with our expectations following an SSW.

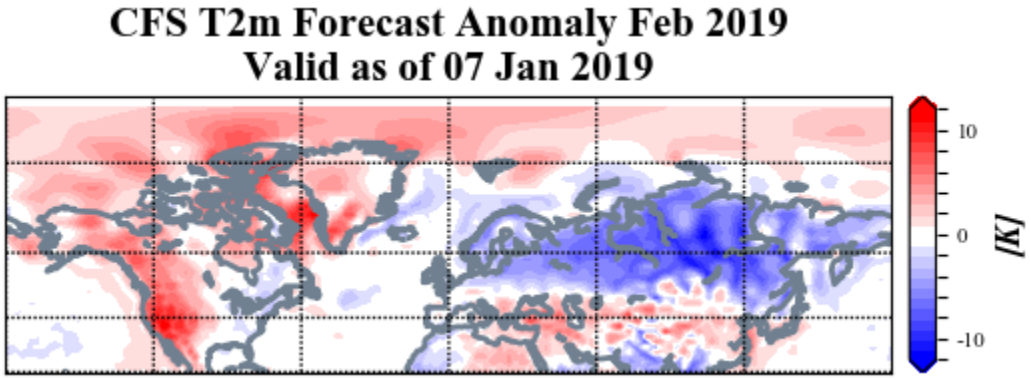

Figure 14. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for February 2019. The forecasts are from the 7 January 2019 CFS.

Surface Boundary Conditions

Arctic Sea Ice

Arctic sea ice growth rate continues at a slow rate and remains well below normal but higher than recent years. However the negative sea ice anomalies are now mostly confined to one region - the Barents-Kara Seas (**Figure 13**). Normal to above normal sea ice in and around Greenland and the Canadian Archipelagos may favor a positive winter NAO. Based on recent research low sea ice anomalies in the Chukchi and Bering seas favors cold temperatures in central and eastern North America while low sea ice in the Barents-Kara seas favor cold temperatures in Central and East Asia, however this topic remains controversial. Recent research has shown that regional anomalies that are most highly correlated with the strength of the stratospheric PV are across the Barents-Kara seas region where *low* Arctic sea ice favors a *weaker* winter PV. However it is looking more and more like the greatest negative anomalies are going to persist in the Barents-Kara Seas this winter and this may be the region most favored for ridging/blocking during the winter months. I expect that the forecasts of lower heights and colder temperatures near Alaska will continue to help sea ice grow in the Chukchi and Bering seas in the near term.

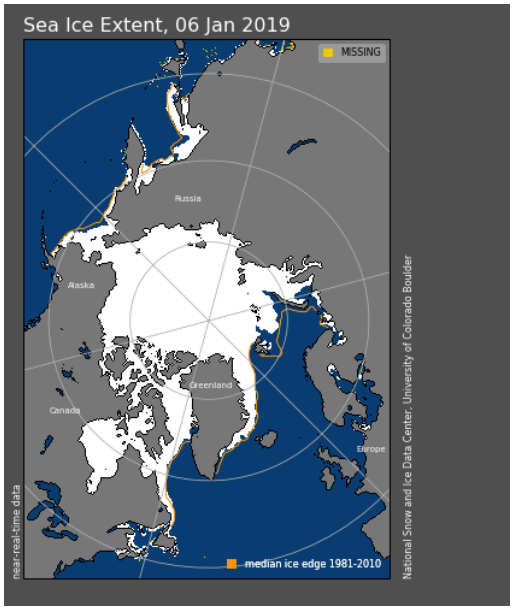

Figure 15. Observed Arctic sea ice extent on 6 January 2019 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC). Snow and Ice Data Center (NSIDC).

SSTs/El Niño/Southern Oscillation (no update fro SST mapdue to government shutdown)

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain warm and support El Niño conditions (**Figure 13**), and the forecast is for likely weak to possibly moderate El Niño conditions for this winter. The expectations have been for a Central Pacific El Niño however, the warmest SST anomalies are now near the South American coast more similar to a canonical El Niño, though uncertainty continues. Observed SSTs across the NH remain well above normal especially in the North Pacific though below normal SSTs exist regionally. Well above normal SSTs in the northern North Pacific near Alaska are reminiscent of the "blob" winters of 2013/14 and 2014/15 and could support mid-tropospheric ridging in the coming months. However warm SSTs near Alaska are not as positive as they were in the fall. However SSTs have cooled in the North Pacific and could support a stronger North Pacific jet. Cold SSTs south of Iceland and in the subtropcs of the North Atlantic with above normal SSTs in the mid-latitudes are thought to favor a positive winter NAO.

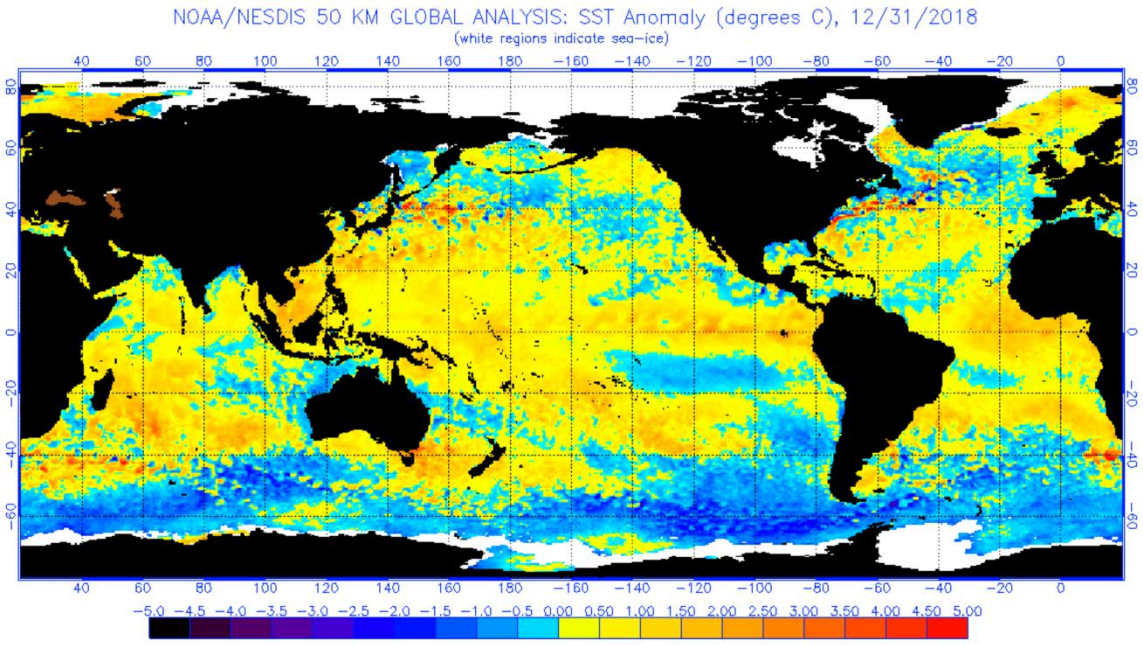

Figure 16. The latest weekly-mean global SST anomalies (ending 31 December 2018). Data from NOAA OI High-Resolution dataset. *(Updated from https://www.ospo.noaa.gov/Products/ocean/sst/anomaly/anim_full.html due to US Govenrment shutdown)*.

Currently the Madden Julian Oscillation (MJO) is in phase 8 (**Figure 14**). However the MJO is expected to weaken to where no phase of the MJO is favored over the next two weeks. MJO phases 8 favors high latitude blcoking and troughing over eastern North

America with cold temperatures and it is not obvious to me that the MJO is influencing North American weather.

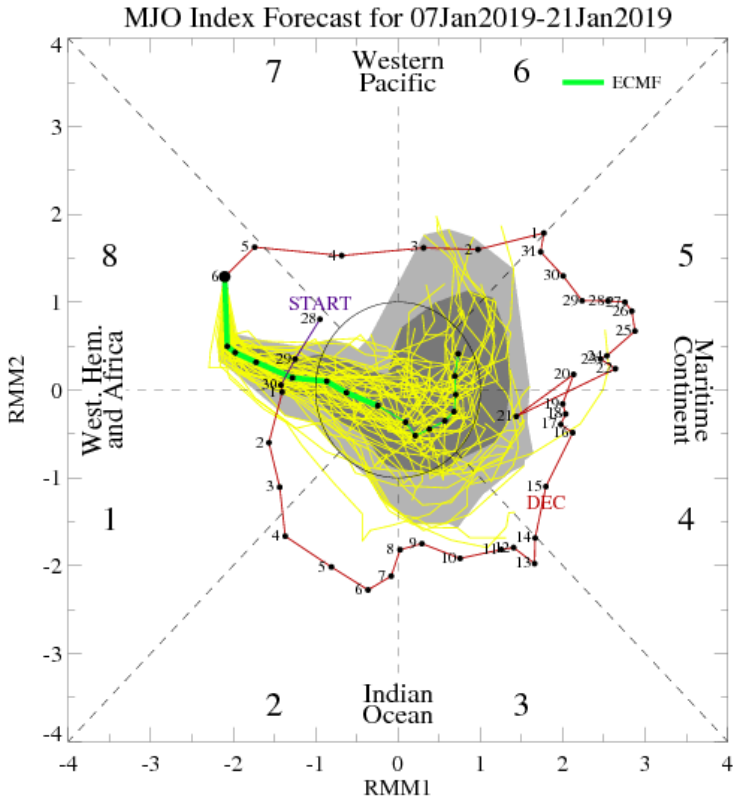

Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 7 January 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html

Northern Hemisphere Snow Cover

Snow cover advance continues its climb across Eurasia and is now near decadal means. Snow cover advance could advance further as cold temperatures start spreading west into Northern and Eastern Europe next week. Above normal snow cover extent this past October, favors a strengthened Siberian high, cold temperatures across northern Eurasia and a weakened polar vortex/negative AO this upcoming winter followed by cold temperatures across the continents of the NH.

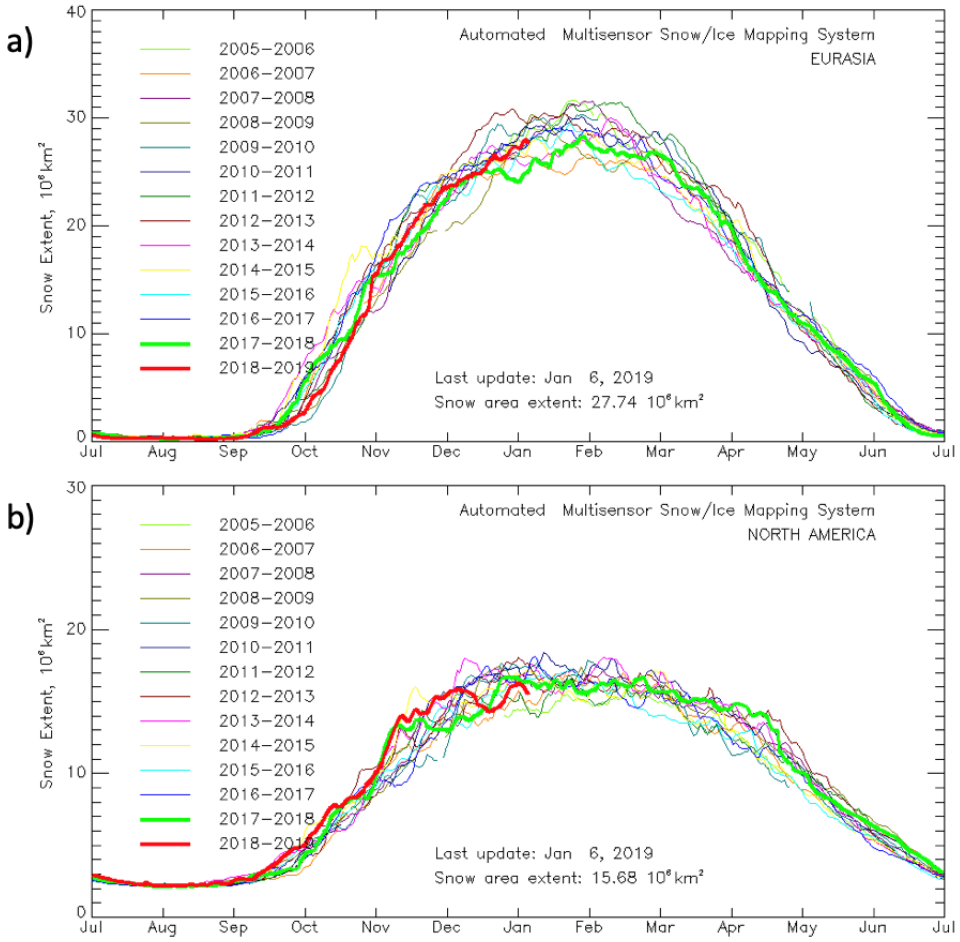

Figure 18. Observed Eurasian (top) and North American (bottom) snow cover extent through 6 January 2019. Image source:

https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html

North American snow cover has declined once again back to near decadal lows. The early advance of snow cover across Canada this fall, has likely contributed to an early start to winter across the Northern US.