Arctic Oscillation and Polar Vortex Analysis and Forecasts

December 23, 2019

Special blog on winter 2018/2019 retrospective can be found here - http://www.aer.com/winter2019

Special blog on winter 2017/2018 retrospective can be found here - http://www.aer.com/winter2018

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) and Polar Vortex (PV). 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.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed 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 first trend negative this week and then positive next week.
- 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 also near neutral with weak positive pressure/geopotential height anomalies spread across Greenland and Iceland; and the NAO is predicted to trend positive over the next two weeks as heights turn negative across Greenland.

- The general pattern across Europe the next two weeks is ridging/positive geopotential height anomalies over Western Europe and troughing/negative pressure/geopotential over Eastern Europe. The general above normal geopotential heights and the lack of snow cover will result in widespread normal to above normal temperatures across Europe including the United Kingdom (UK) especially in Northeastern Europe. One exception could be extreme Southeastern Europe next week where geopotential heights are predicted to be below normal.
- The predicted pattern for Asia this week is ridging/positive geopotential height anomalies with normal to above normal temperatures dominating much of Western and Southeastern Asia and troughing/negative pressure/geopotential height anomalies and normal to below normal temperatures across Central and Northeastern Asia. However, over time the ridging/positive geopotential height anomalies and warming temperatures are predicted to spread into Central Asia with troughing/negative pressure/geopotential height anomalies and normal to below normal temperatures mostly confined to Northeastern Asia.
- This week the predicted pattern across North America is troughing/negative pressure/geopotential height anomalies with widespread normal to below normal temperatures across Alaska and Western Canada and the Western United States (US) with ridging/positive geopotential height anomalies and normal to above normal temperatures widespread in central and eastern North America. However, the forecast is for a piece of the troughing/negative pressure/geopotential height anomalies and normal to below normal temperatures now in Alaska to spread into Eastern Canada and the Eastern US.
- In the Impacts section I focus on my expectations for the coming weeks and months.

Impacts

First, I want to make sure to make a point that I have meant to share for a while now. The blog is like climate and Twitter like the weather. The blog integrates and synthesizes many thoughts and over a long period of time. I try to keep the blog consistent from week to week with large changes in the forecast only if the evidence becomes overwhelming. My Tweets are immediate responses to mostly recent model data and sometimes observations with almost no prior thought and with even sometimes with little afterthought. There is no intended consistency from one Tweet to the next. Also, the Tweets are often meant to provoke and that is not the case with the blog. So in summary, the blog is the signal and Twitter the noise. I am unlikely to reverse a forecast in a tweet.

Today is one of those days that all that can go through my head is the country music song by Ed Bruce and covered by Waylon Jennings and Willie Nelson “Mammas don’t let your babies grow up to be cowboys...let’em be doctors and lawyers and such!...and their always alone” and instead of “cowboys” I substitute in my head “seasonal forecaster.” I have said many times the first thing that you learn as a seasonal forecaster is humility and these are one of those times. What is humbling me at the

moment is that I have expected a weakening of the stratospheric polar vortex (PV) based on fall Arctic predictors – extensive Siberian snow cover, more limited Arctic sea ice extent and a relatively warm Arctic. Following the PV weakening or disruption, severe winter weather would be more frequent at least regionally across the mid-latitudes of the Northern Hemisphere (NH). But to be honest it is hard to see from today's viewpoint how this verifies. And as I have shared on Twitter the new operational GFS, the FV3, has been especially bullish on a strong PV.

The biggest challenge that I see right now is the center of low mid-tropospheric heights currently just north of Alaska and is expected to expand in breadth over the next two weeks enough so to fill the entire Arctic basin. This a fairly class pattern of low heights in the Arctic and high heights in the mid-latitudes resulting in a cold Arctic/warm continents pattern, all consistent with a positive AO. It seems a bit ironic (at least to me) that with the record low sea ice in the Chukchi-Bering seas this fall, the incredibly warm year Alaska just experienced both in part due to persistent ridging in the region, this same region is predicted to now experience an extended period of low heights and below normal temperatures. As an aside, this is something that I had a hard time anticipating even just a few weeks ago. Another example where it is easy to become overconfident in outcomes based on recent trends. By itself this is not necessarily a threat to the veracity of the forecast but coupled with a strong stratospheric PV this pattern could become persistent and even dominate the winter means. I would be confident in a near term pattern reversal with a forecast of Ural/Scandinavian blocking as predicted by the GFS last week, but the GFS has backed off those forecasts.

But if I don't see much reason to feel confident about the forecast, in large part contingent on a weak/disrupted PV, I also don't see strong evidence to walk away from the forecast. Maybe in large part because it has been challenging for the weather models to correctly predict the state of the polar stratosphere and the behavior of the polar vortex with so many poor and contradicting forecasts and therefore, I have low confidence in any one scenario or outcome.

So, for now I remain steadfast in the winter forecast that based on high fall snow cover/low Arctic sea ice that they will in tandem perturb the PV. Given the westerly quasi-biennial oscillation (QBO) I expect a scenario somewhere between winter 2016/17 and winter 2017/18. Both of those winters were westerly QBO winters and the most significant disruption of the stratospheric PV took place in February. The PV disruption in February 2018 was achieved major warming status and the coupling to the surface was much stronger. Still the more minor disruption in February 2017 did result in coupling to the surface and an increase in severe winter weather, at least as far as snowfall in the Northeastern US. I include in **Figure i**, the polar cap geopotential height anomaly (PCH) plot from this winter starting on October 1, 2019 and the analogous plots from winter 2016/17 and 2017/18 for comparison.

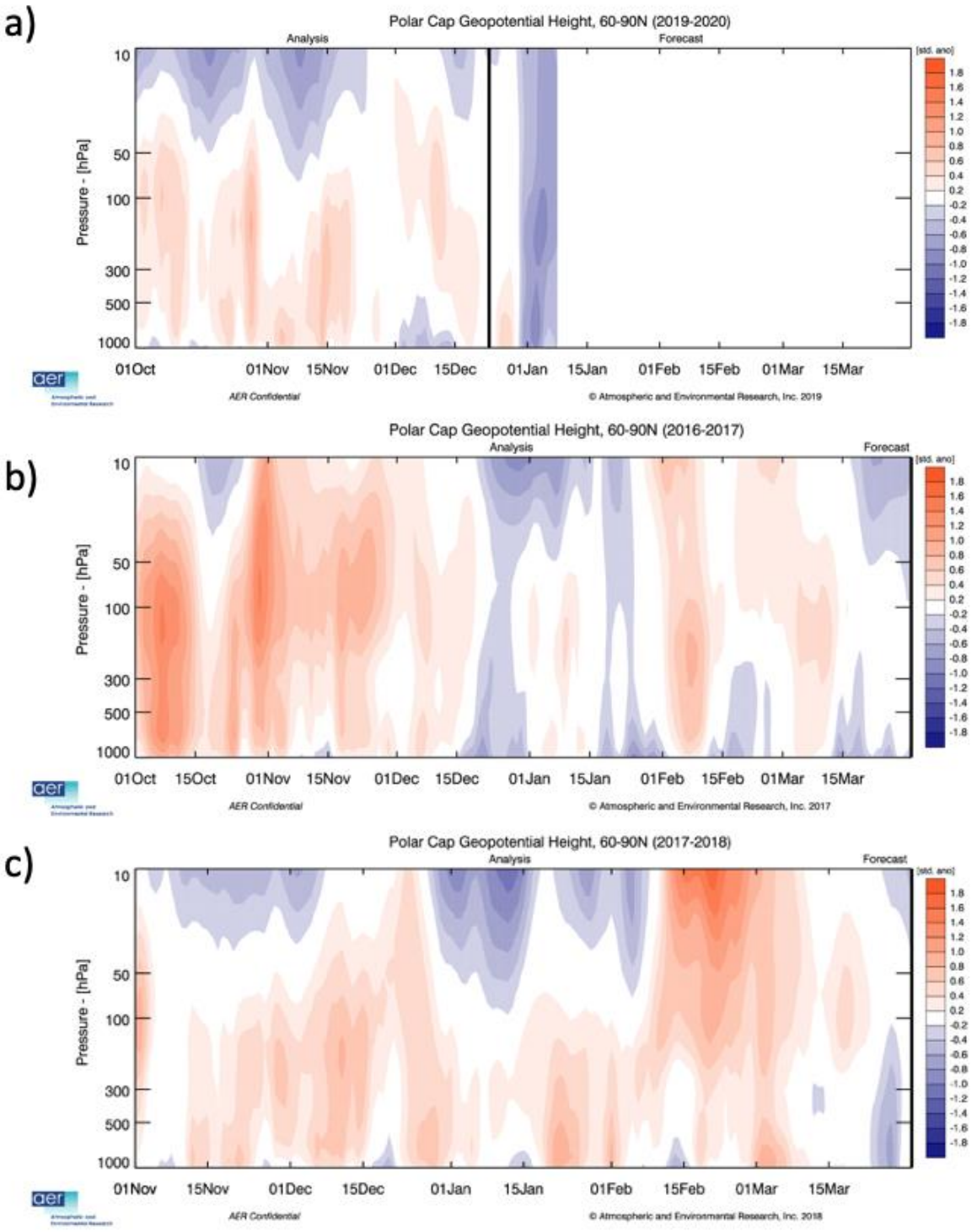

Figure i. a) Observed from Ocotber 1, 2019 and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 23 December 2019 GFS ensemble. **b)** Observed predicted daily polar cap height standardized anomaliesfrom Ocotber 1, 2016-March 31, 2017 and predicted daily polar cap height **c)** Same as **b)** but for Ocotber 1, 2017-March 31, 2018.

In **Figure ii**, I show a modified version of Figure 8 from Cohen et al. (2018) that shows the multi-annual trend in the daily PCHs (similar to last week's blog) and the AWSSI (accumulated winter season severity index) for Boston. The trend for the PCH is warming throughout the winter in the troposphere. However, in the stratosphere the early part of the winter the trend is towards colder PCH/stronger PV with warming PCHs only starting in mid-January but especially in February. The AWSSI for Boston as an example, shows a general decrease in severe winter weather in the early part of the winter especially around the holidays and right after New Year's. But this is followed by an increasing trend in severe winter weather soon after the stratospheric PV becomes disrupted in mid to late winter. In general the PCH for this winter so far have followed the general trend of warming in the troposphere and cooling in the stratosphere. But as the winter progresses the probability for the two layers to couple, with relatively warm PCHs in both the stratosphere and troposphere should increase. Past is not necessarily prologue, but my attitude is until I see differently, I am relying on recent multi-annual trends then the weather models for forecasts beyond two weeks.

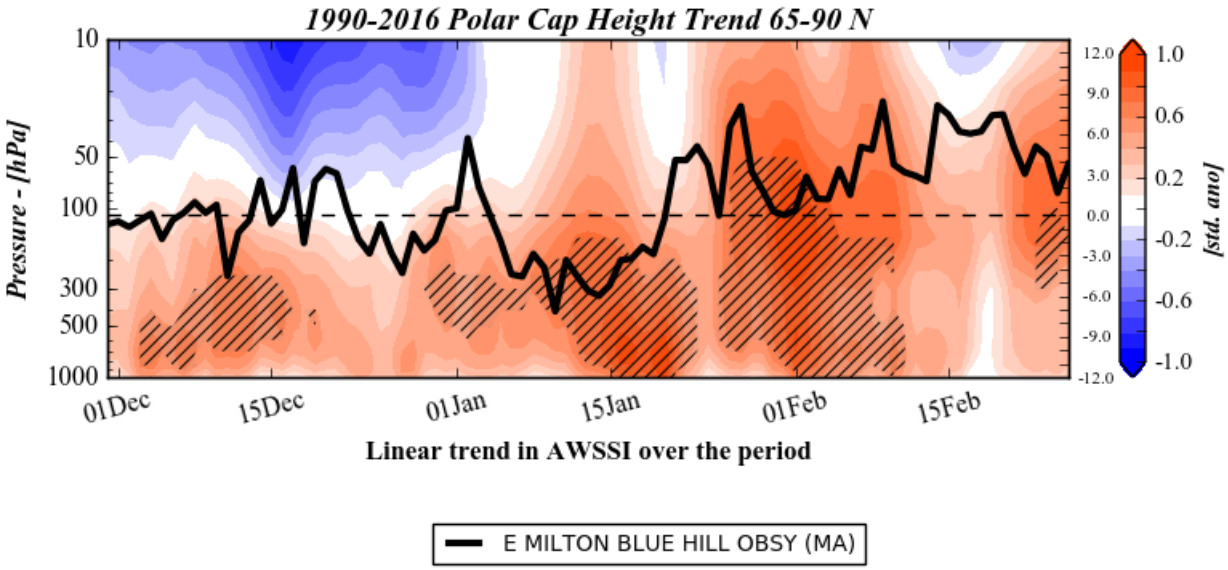

Figure ii. The annual daily trend in the polar cap geopototential height (PCH) from the surface to the mid-stratosphere (10 hPa) from 1990-2016. Statistical significance above 90% for PCH trends are hatched in dark gray. Also included as a solid black line the annual trend in the daily change in the AWSSI for Boston from 1990-2016.

If we can predict that the model forecast will be universally warm for Siberia and that the observations will be colder, then this is less consistent with randomness and more with systemic model errors i.e., the models incorrectly simulate the influence of Arctic forcing on mid-latitude temperatures, or at least Arctic influence is incorrectly overwhelmed by tropical influence and/or global warming.

It is my impression that often winter shows its true character around the transition of the calendar year. It seems to me that December is often an outlier to winter as a whole

that January-March are more in common weather-wise with December going its own way. It will be interesting to see what the weather models are predicting in about a week's time. I will be especially focused on the atmospheric vertical energy transfer. The below normal sea ice in the Barents Kara Seas and the lack of snow cover in Eastern Europe both favor heating of the atmospheric column and high pressure in that region so favorable for exciting vertical energy transfer. But as we are seeing now, favorable boundary conditions don't always translate into atmospheric anomalies.

I just want to end that a review paper that I have worked very hard on and has consumed the bulk of my time over the past two years was finally published today in Nature Climate Change: https://rdcu.be/bZAqO (you can read the full article using this link). Here is what I feel was the most important message of the paper. Currently the topic of Arctic amplification (AA) in general and sea ice loss in particular and their influence on mid-latitude weather is considered controversial and with little to no consensus. This paper argues that there is consensus, but they are split among two polarized camps. The first camp are the studies based on observational evidence that argue that AA contributes to more severe winter weather across the mid-latitudes including the US, Europe and East Asia and that pathway goes through the stratospheric PV. AA favors disrupting the PV that increases the probability of severe winter weather including cold air outbreaks and disruptive snowfalls. The second camp are the studies based on modeling experiments that mostly support that AA either has little influence on mid-latitude winter weather or contributes to milder winter weather. There are of course exceptions to both type of studies.

I have been accused of model bashing even as recently as this past AGU. Just as I started today's blog, when you make long range forecasts (of the seasonal variety not decadal or longer) you quickly realize your limitations. Using empirical evidence as well as models has its drawbacks/limitations. I am trying my best to simply squeeze the most signal I can from both. I am working hard to demonstrate that goal in the blog.

Near Term Conditions

1-5 day

The AO is currently neutral **(Figure 1**) with mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with weak positive geopotential height anomalies across Greenland and Iceland (**Figure 2**), the NAO is near neutral as well.

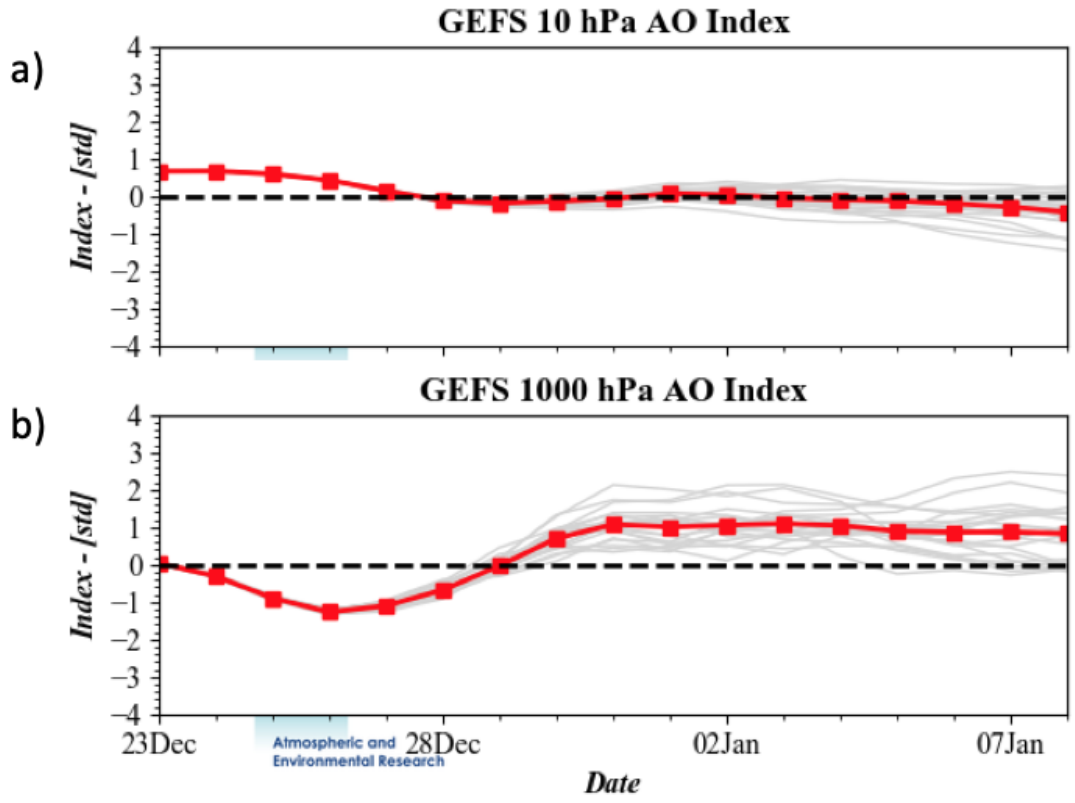

Figure 1. (**a**) The predicted daily-mean AO at 10 hPa from the 00Z 23 December 2019 GFS ensemble. (**b**)
The predicted daily-mean near-surface AO from the 00Z 23 December 2019 GFS ensemble. Gray lines
indicate the AO index from each individual ensemble member, with the ensemble-mean AO index
given by the red line with squares.

This week ridging/positive geopotential height anomalies are predicted to dominate Western and Northern Europe with troughing/negative geopotential height anomalies mostly confined to Southeastern Europe (**Figure 2**). General high heights and lack of snow cover will result in normal to above normal temperatures across much of Europe including the UK with the possible exception of normal to below normal temperatures across Norway (**Figure 3**). This week ridging/positive geopotential height anomalies are predicted to dominate much of Western and Southeastern Asia (**Figure 2**) favoring widespread normal to above normal temperatures across much of West and Southeast Asia **(Figure 3**). In contrast, Central and Northeastern Asia will be dominated by troughing/negative geopotential height anomalies (**Figure 2**), which are predicted to result in widespread normal to below normal temperatures **(Figure 3).**

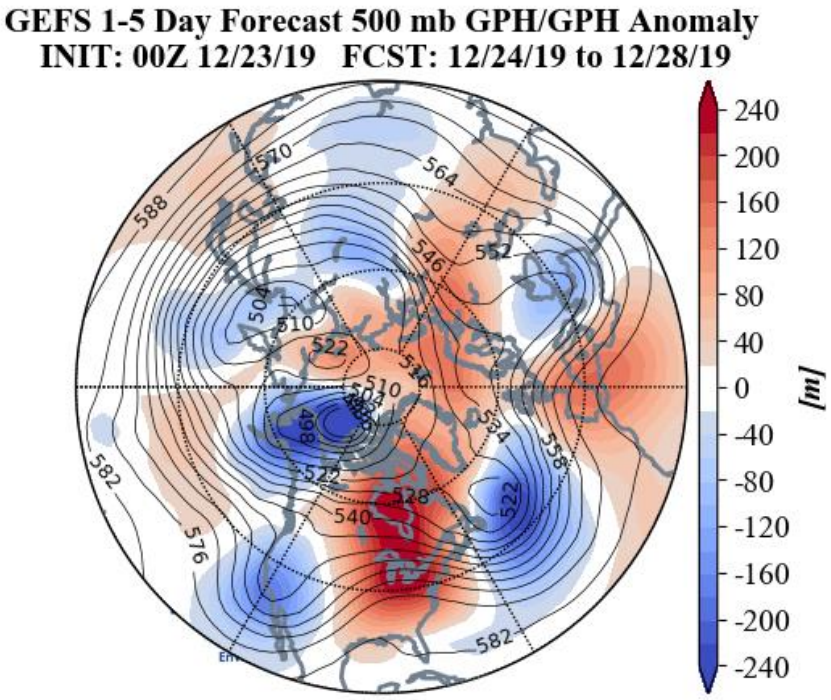

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 – 28 December 2019. The forecasts are from the 23 December 00z GFS ensemble.

This week, troughing/negative geopotential height anomalies in Alaska, the Gulf of Alaska and the Western US will force downstream ridging/positive geopotential height anomalies across central and eastern North America (**Figure 2**). This is predicted to result in normal to below normal temperatures in Alaska, Southwestern Canada and the Western US with normal to above normal temperatures across much of Canada and the Central and Eastern US **(Figure 3).**

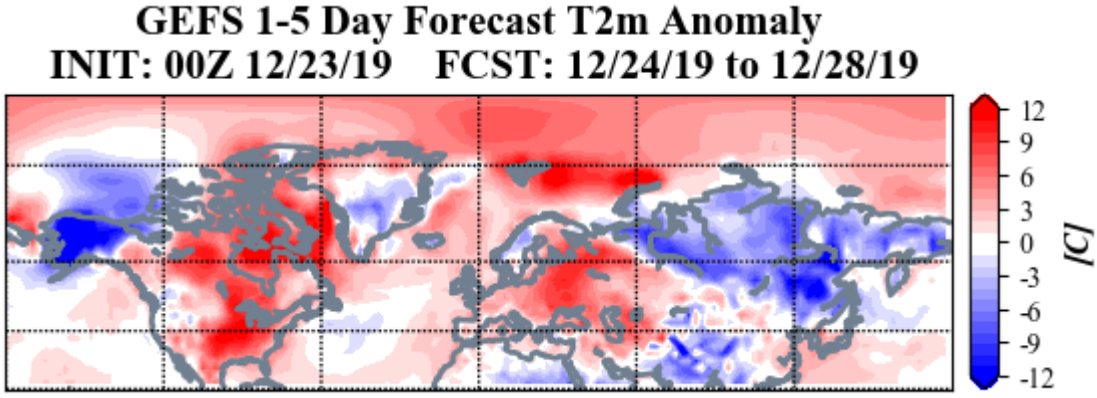

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 24 – 28 December 2019. The forecast is from the 00Z 23 December2019 GFS ensemble.

Troughing and/or cold temperatures are predicted to bring new snowfall across Siberia, the Tibetan Plateau, and possibly parts of Northern Europe (**Figure 4**). Troughing and cold temperatures are predicted to bring new snowfall to Alaska, much of Northern Canada and the Western US (**Figure 4**). Warmer temperatures are predicted to result in snowmelt for Western Asia, the Canadian Rockies, Southeastern Canada and the Northeastern US (**Figure 4**).

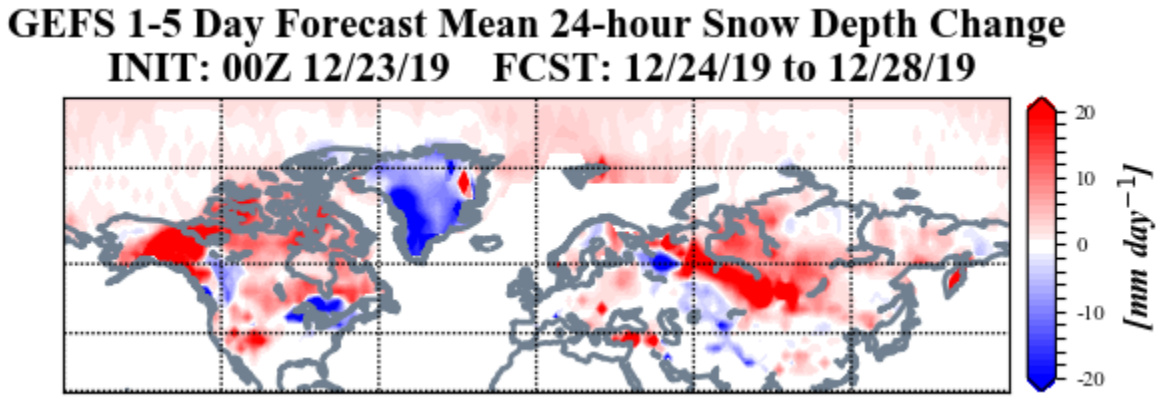

Figure 4. Forecasted snowdepth anomalies (mm/day; shading) from 24 – 28 December 2019. The forecast is from the 00Z 23 December2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to transition from negative to positive this period **(Figure 1**) as geopotential height anomalies turn more negative across the Central Arctic and North Atlantic side of the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with weak negative geopotential height anomalies predicted across Greenland (**Figure 2**), the NAO is predicted to turn more positive.

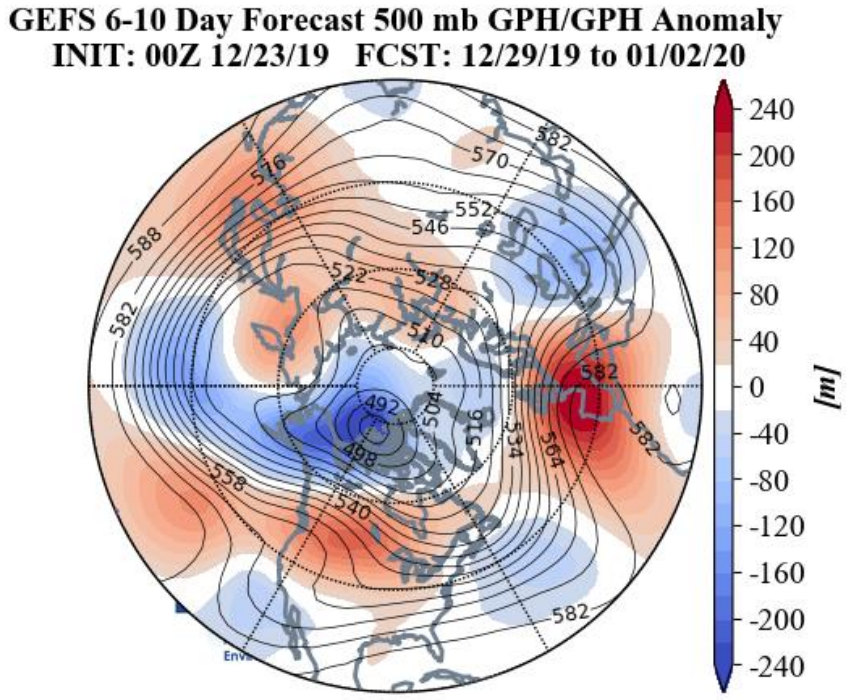

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 December 2019 – 2 January 2020. The forecasts are from the 23 December 00z GFS ensemble.

The general pattern of ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Eastern Europe is predicted to persist this period (**Figures 5).** Once again generally high geopotential heights and lack of snow cover will favor widespread normal to above normal temperatures for much of Europe Including the UK with the possible exception of far Southeastern Europe where below normal heights will support cold temperatures (**Figures 6**). Ridging/positive geopotential height anomalies will dominate Southeastern Asia and the Urals with troughing/negative geopotential height anomalies across much of Siberia (**Figure 5**). This is predicted to yield normal to above normal temperatures for much of Western and Southeastern Asia with normal to below temperatures across much of Siberia and Northeast Asia **(Figure 6**). Southwesterly flow out ahead of the trough in the Eastern Mediterranean will result in a mild southwesterly flow of air across Southwestern Asia **(Figure 6**).

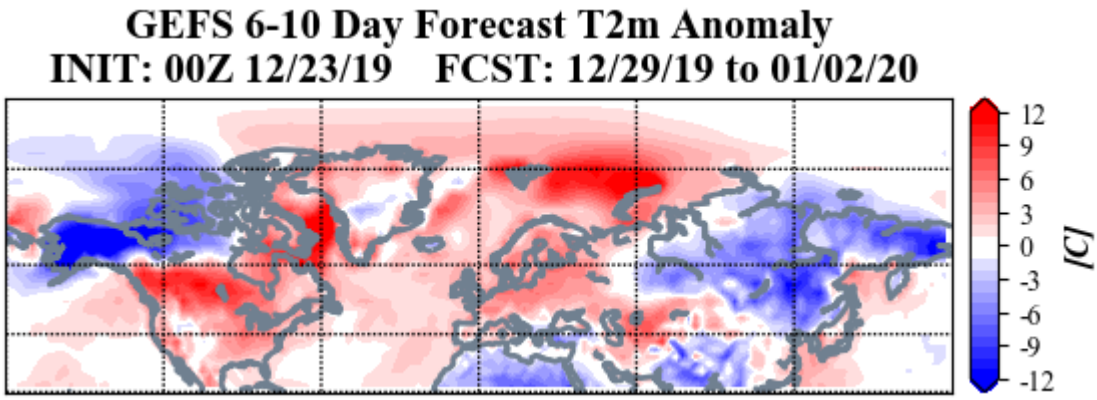

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 29 December 2019 – 2 January 2020. The forecasts are from the 00Z 23 December 2019 GFS ensemble.

Troughing/negative geopotential height anomalies will be mostly confined to Alaska and the Southwestern US with ridging/positive geopotential height anomalies across much of interior North America **(Figure 5).** This pattern is predicted to bring normal to below normal temperatures across Alaska and the Southwestern US with normal to above normal temperatures for much of Canada, except adjacent to Alaska, and much of the Central and Eastern US **(Figure 6).**

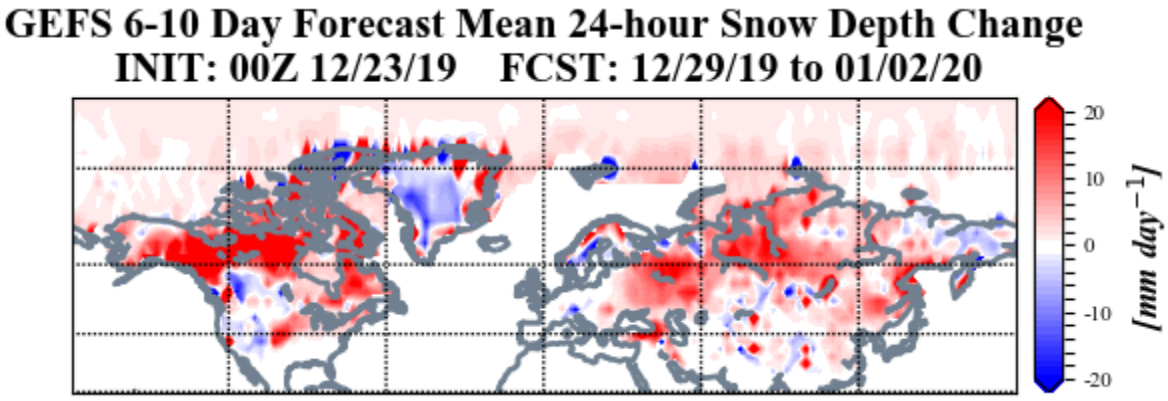

Figure 7. Forecasted snowdepth changes (mm/day; shading) from 29 December 2019 – 2 January 2020. The forecasts are from the 00Z 23 December 2019 GFS ensemble.

Troughing and/or cold temperatures will support the potential for new snowfall across much of Northern Asia, possibly Western Russia and Scandinavia, parts of the Middle East, the Tibetan Plateau, Northeast Asia, much of Northern and Eastern Canada, Alaska and possibly the Midwestern and Northeastern US (**Figure 7**). Some snowmelt is predicted in the Rockies and Finland (**Figure 7**).

11-15 day

With mostly negative geopotential height anomalies predicted for the Arctic (**Figure 8**), the AO is predicted to remain positive this period (**Figure 1**). With predicted negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to remain positive this period as well.

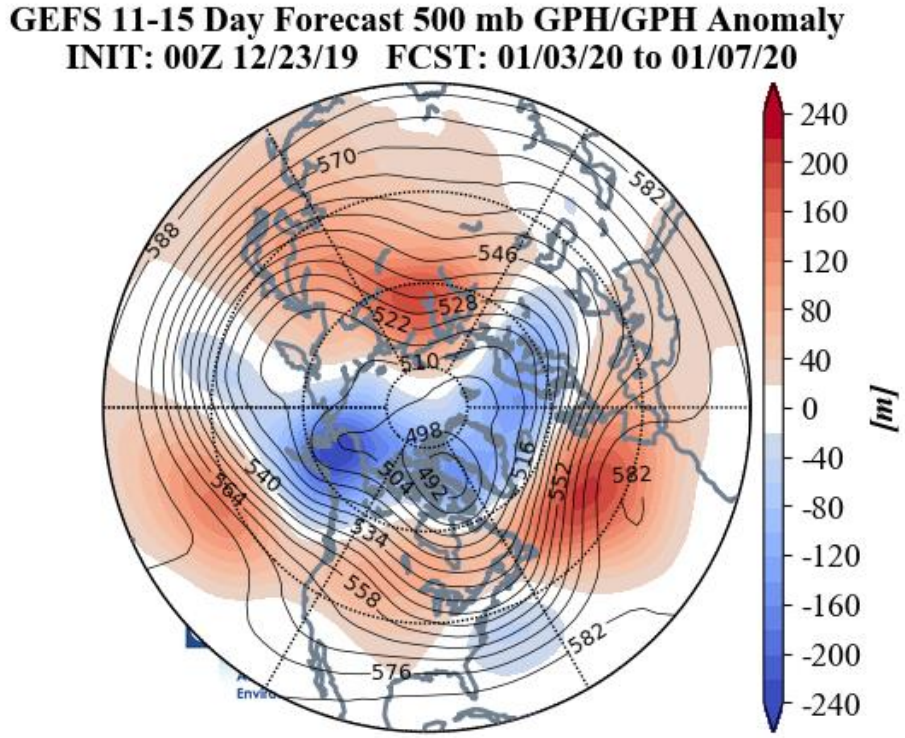

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 January 2020. The forecasts are from the 23 December 00z GFS ensemble.

Ridging/positive geopotential height anomalies will continue to dominate Western and Southern Europe with troughing/negative geopotential height anomalies across Northern and Eastern Europe (**Figures 8**). Above normal heights dominating the region will continue to favor widespread normal to above normal temperatures across much of Europe including the UK this period, however low geopotential heights could support relatively cold temperatures across Northern Scandinavia (**Figures 9**). Ridging/positive geopotential height anomalies previously over Western Russia will slide east, now centered over Western Siberia, helping to persist troughing/negative geopotential height anomalies over Eastern Siberia and Northeast Asia (**Figure 8**). This pattern favors normal to above normal temperatures across much of Asia including the Middle East and Southeast Asia with normal to below normal temperatures mostly confined to Eastern Siberia and Northeast Asia (**Figure 9**).

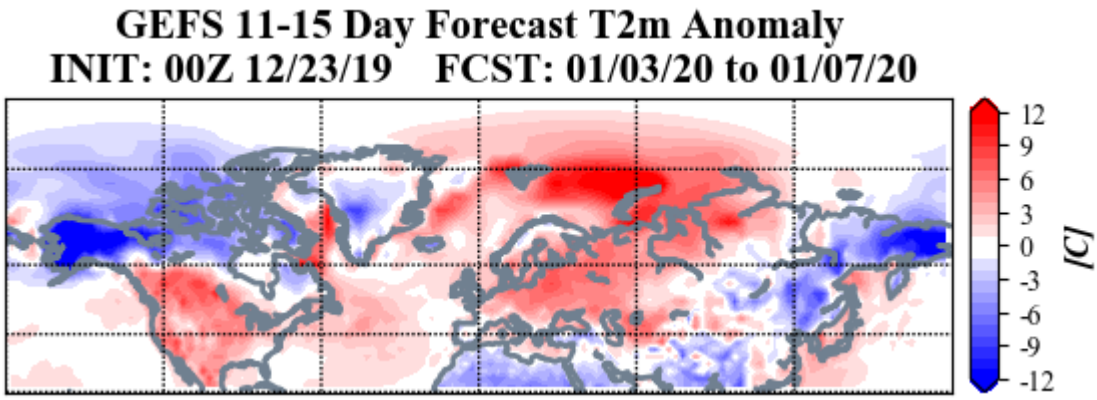

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 January 2020. The forecasts are from the 23 December 00z GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to persist across Alaska, however a small piece is predicted to peel off to the southeast towards the Northeastern US while ridging/positive geopotential height anomalies continue to dominate much of interior North America (**Figure 8**). This pattern is predicted to favor normal to below normal temperatures across Alaska, most of Northern Canada and the Southwestern US with normal to above normal temperatures for much of Southern Canada and the US (**Figure 9**). Some residual troughing will bring more normal to below normal temperatures to the Southwestern US (**Figures 8 and 9**).

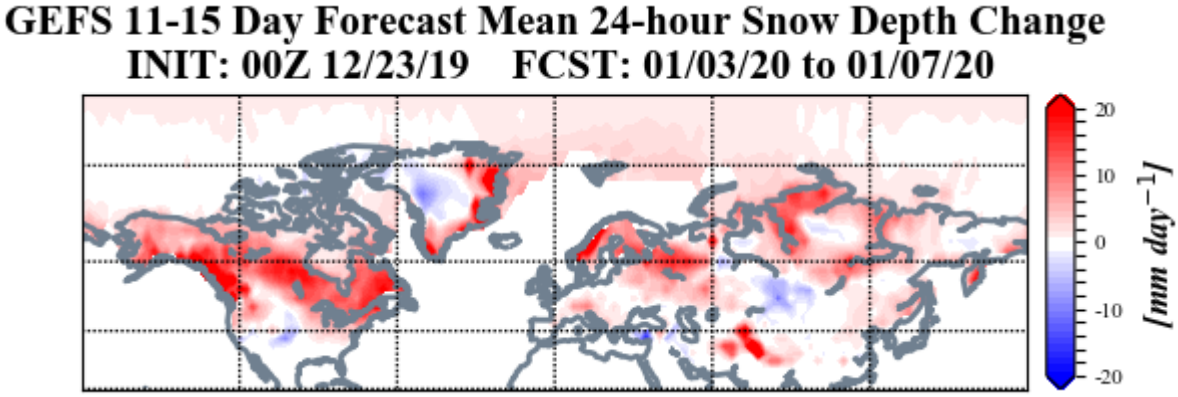

Figure 10. Forecasted snow depth changes (mm/day; shading) from 3 – 7 January 2020. The forecasts are from the 00z 23 December GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across much of northern Asia, the Tibetan Plateau and Northern Europe but with the best chances across Northwestern Russia, Eastern Siberia and Scandinavia (**Figure 10**). New snowfall is possible across Alaska, much of Canada, the Northeastern US and the Northwestern US (**Figure 10**). Some snowmelt is possible in Central Asia the US Plains (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows only weak anomalies with above normal PCHs in the mid- to lower- troposphere with normal to below normal PCHs in the middle stratosphere (**Figure 11**). The weak warm PCHs in the lower troposphere are consistent with a predicted neutral to negative AO this week (**Figure 1**). The predicted warm PCHs in the lower troposphere this week appear to have descended from a small stratospheric disruption earlier this month. However, the PCHs are predicted to turn colder next week and also seem to be a response to downward propagation of cold PCHs in the middle stratosphere due to a strengthening PV (**Figure 11**).

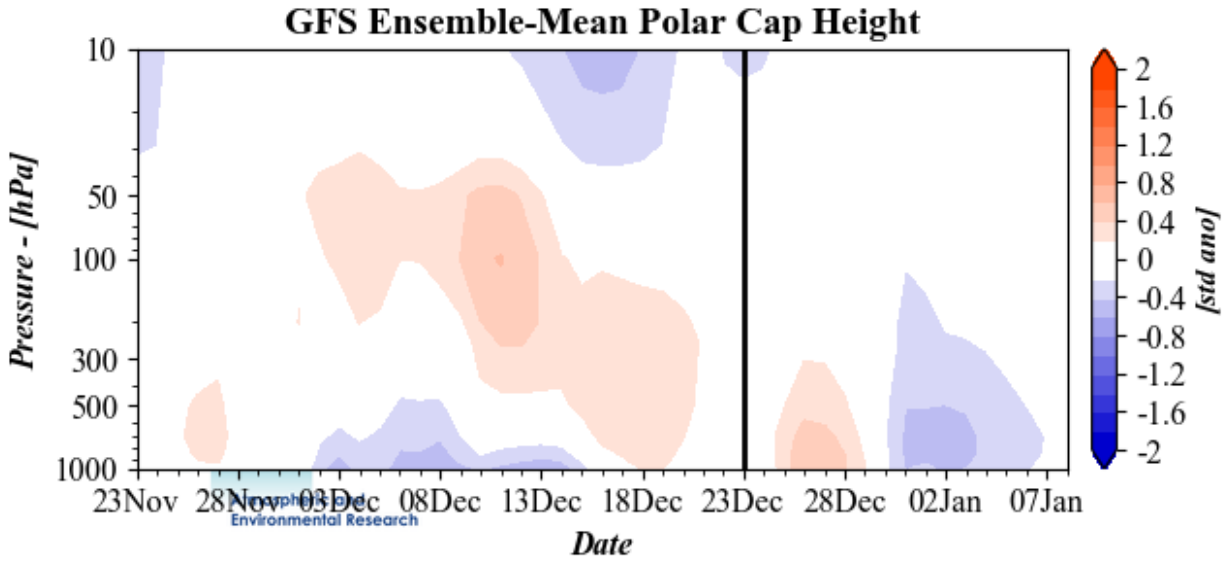

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 23 December 2019 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport shows relatively active week with strong positive anomalies predicted (**Figure 12**). The predicted positive WAFz for the upcoming week are not predicted to result in significant weakening of the stratospheric PV but mostly prevent the stratospheric PV from strengthening further. As I have been tweeting, the GFS operational which is an updated version of the GFS known as the FV3, does predict that the stratospheric PV strengthens further.

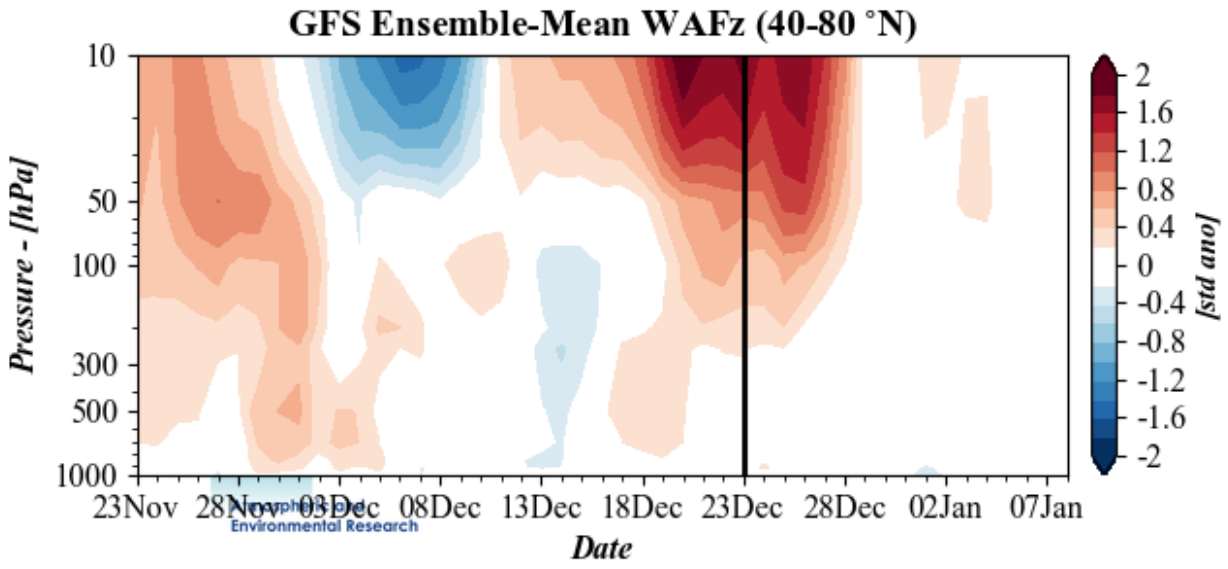

Figure 12. Observed and predicted daily vertical component of the wave activity Wux (WAFz)
standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 23 December 2019
GFS ensemble.

The stratospheric AO is currently slightly positive (**Figure 1**) reflective of a relatively normal PV. However, despite the positive WAFz predicted this week, the stratospheric AO is predicted to remain near neutral (**Figure 1**). The ridging near Alaska with an elongated PV center in the mid-stratosphere are consistent with a reflective disruption of the stratospheric PV that result in short-lived, cold air outbreaks in central and eastern North America. However there seems to be uncertainty among the model forecasts whether this will continue.

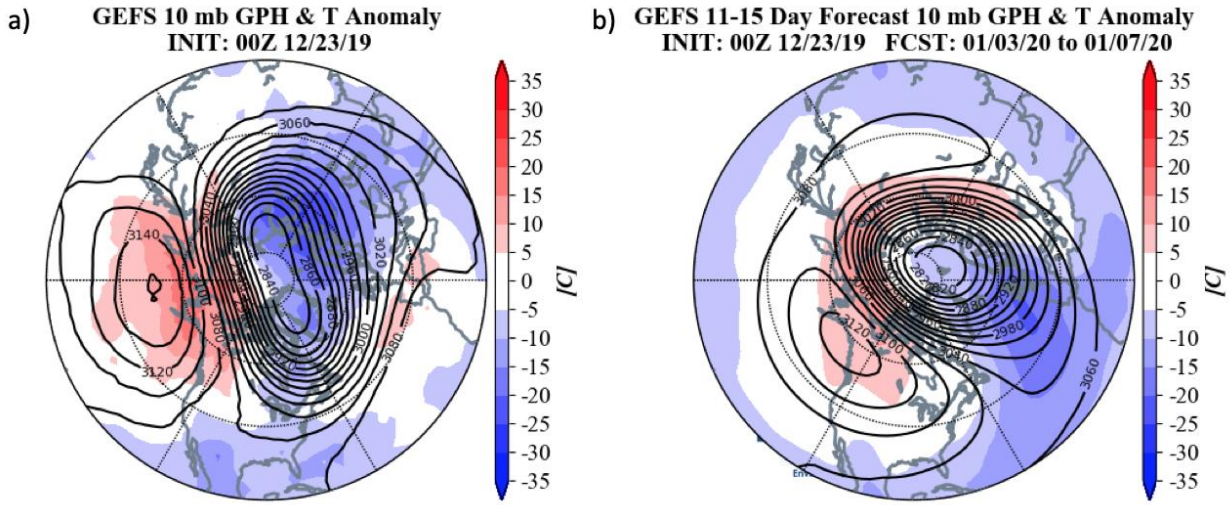

Figure 13. (**a**) Analyzed 10 mb geopotential heights (dam; contours) and temperature anomalies (°C;
shading) across the Northern Hemisphere for 23 December 2019. (**b**) Same as (a) except forecasted
averaged from 3 – 7 January 2020. The forecasts are from the 00Z 23 December 2019 GFS operational
model.

Currently the stratospheric PV remains elongated but centered near the North Pole (**Figure 13**). The largest negative temperature departures in the polar stratosphere are over Northwest Eurasia, likely supporting the predicted low tropospheric heights in that region predicted starting next week.

There is also warming and ridging centered near the Dateline in the stratosphere with more minor warming over Western Europe (**Figure 13).** Over time the new WAFz pulse is predicted to amplify the warming near Europe as it advects into the North Pacific sector of the Arctic and eventually reinforces the ridging centered over Alaska while the PV center is predicted to remain displaced towards the North Atlantic side of the Arctic (**Figure 13)**. Ridging near Alaska with PV center towards displaced towards Greenland and elongated resembles a “reflection” PV disruption that favors cold temperatures in central and eastern North America. However, the lack of an elongated PV center will likely for now, are only suggestive of seasonable temperatures in eastern North America and not cold to unseasonably cold temperatures.

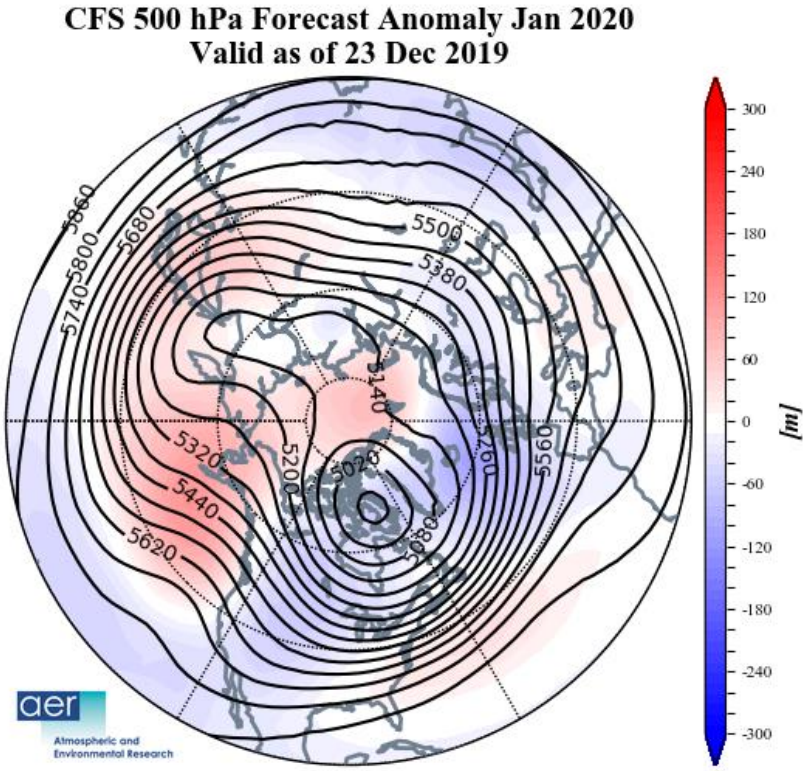

Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for January 2020. The forecasts are from the 23 December 2019 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and the surface temperatures (**Figure 15**) forecast for January from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Southwestern Europe, the Central Arctic, Southeast Asia, Alaska and the Gulf of Alaska with troughs over the eastern Mediterranean, Central Asia, Eastern Siberia/the western North Pacific and central North America (**Figure 14).** This pattern favors relatively mild temperatures for Eastern Europe, Western Asia and the Western US with seasonable to relatively cold temperatures for Siberia, Northeast Asia, Alaska, much of Canada and the Northeastern US (**Figure 15**). The CFS forecast for January has returned to predicting a circulation pattern prediction that projects on to the pattern of variability associated with a negative AO.

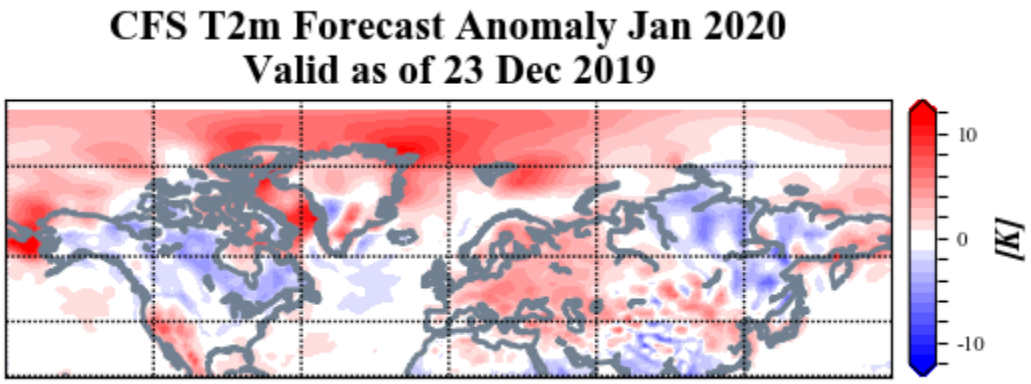

Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for January 2020. The forecasts are from the 23 December 2019 CFS.

Surface Boundary Conditions

Arctic sea ice extent

Arctic sea ice growth rate continues to grow slowly and remains well below normal. Large negative sea ice anomalies exist in three regions: the Bering Sea, around Greenland-Candian Archipleagos and Barents-Kara Seas. The anomalies in the North Pacific sector have shrank (**Figure 16**), and based on model forecasts neagtive sea ice anomalies in the Bering Sea shrink further in the next two weeks. Below normal sea ice in and around Greenland and the Canadian Archipelagos may favor a negative 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.

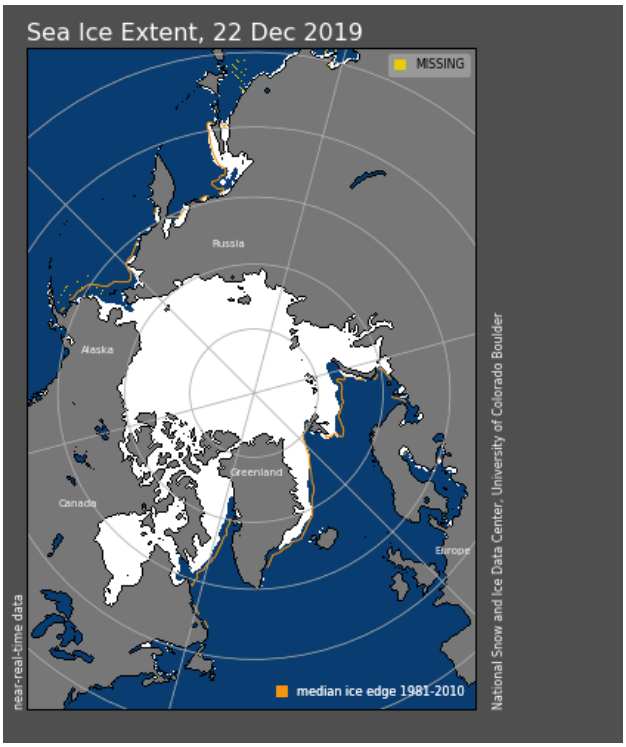

Figure 16. a) Observed Arctic sea ice extent on 22 December 2019 (white). Orange line shows
climatological extent of sea ice based on the years 1981-2010.

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies have cooled and Neutral El Niño/Southern Oscillation (ENSO) conditions seem most likely (**Figure 17**). Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska though below normal SSTs exist regionally especially west of South America. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region this winter.

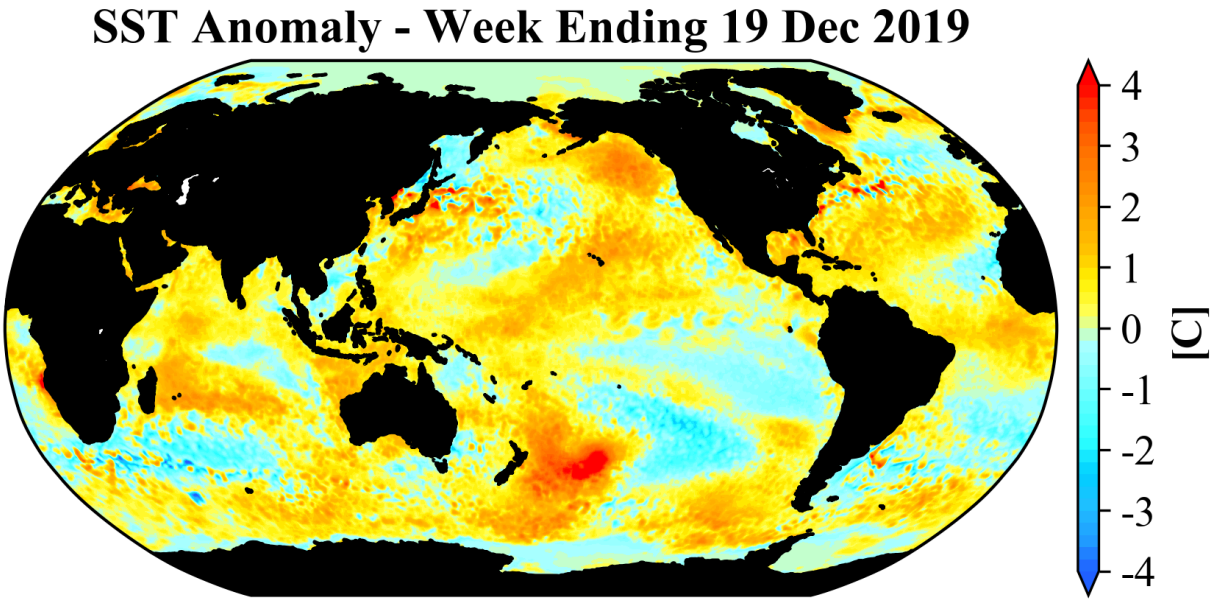

Figure 17. The latest weekly-mean global SST anomalies (ending 19 December 2019). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 18**). The forecasts are for the MJO to remain relatively weak so that no no phase is favored over the next two weeks. The MJO could briefly emrge into phases 6 or 7 but little MJO influence is expected for the weather across North American in the forecast period.

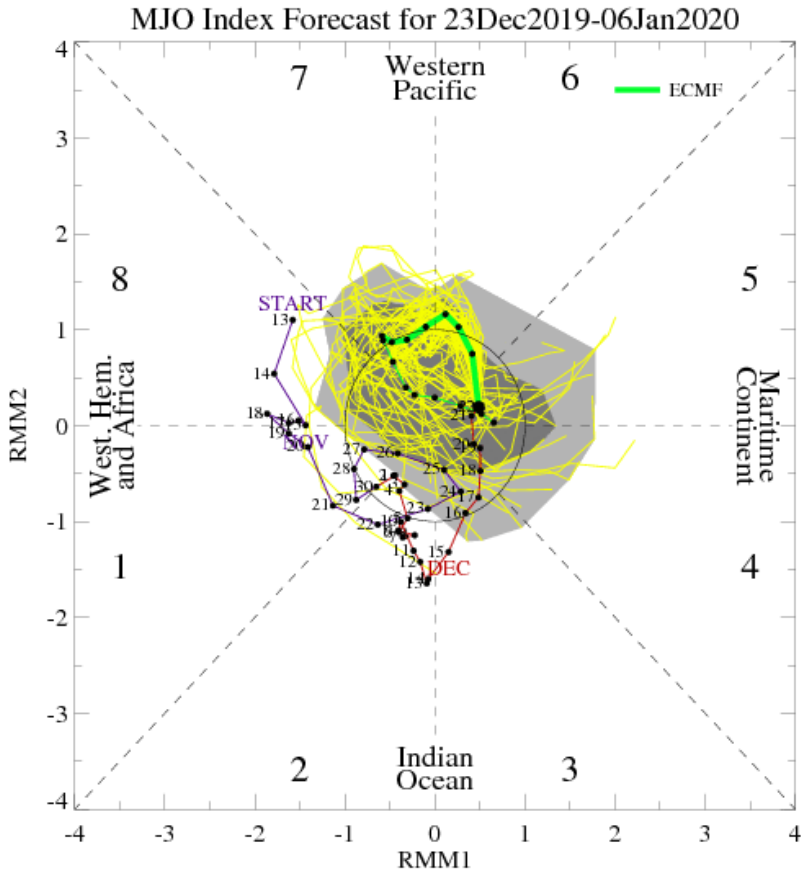

Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 23 December 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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 has remianed steady across Eurasia but rmains near near decadal lows. Snow cover predicted to advance especially across Western Asia next week though for now I don't see any major advance. Above normal snow cover extent in 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.

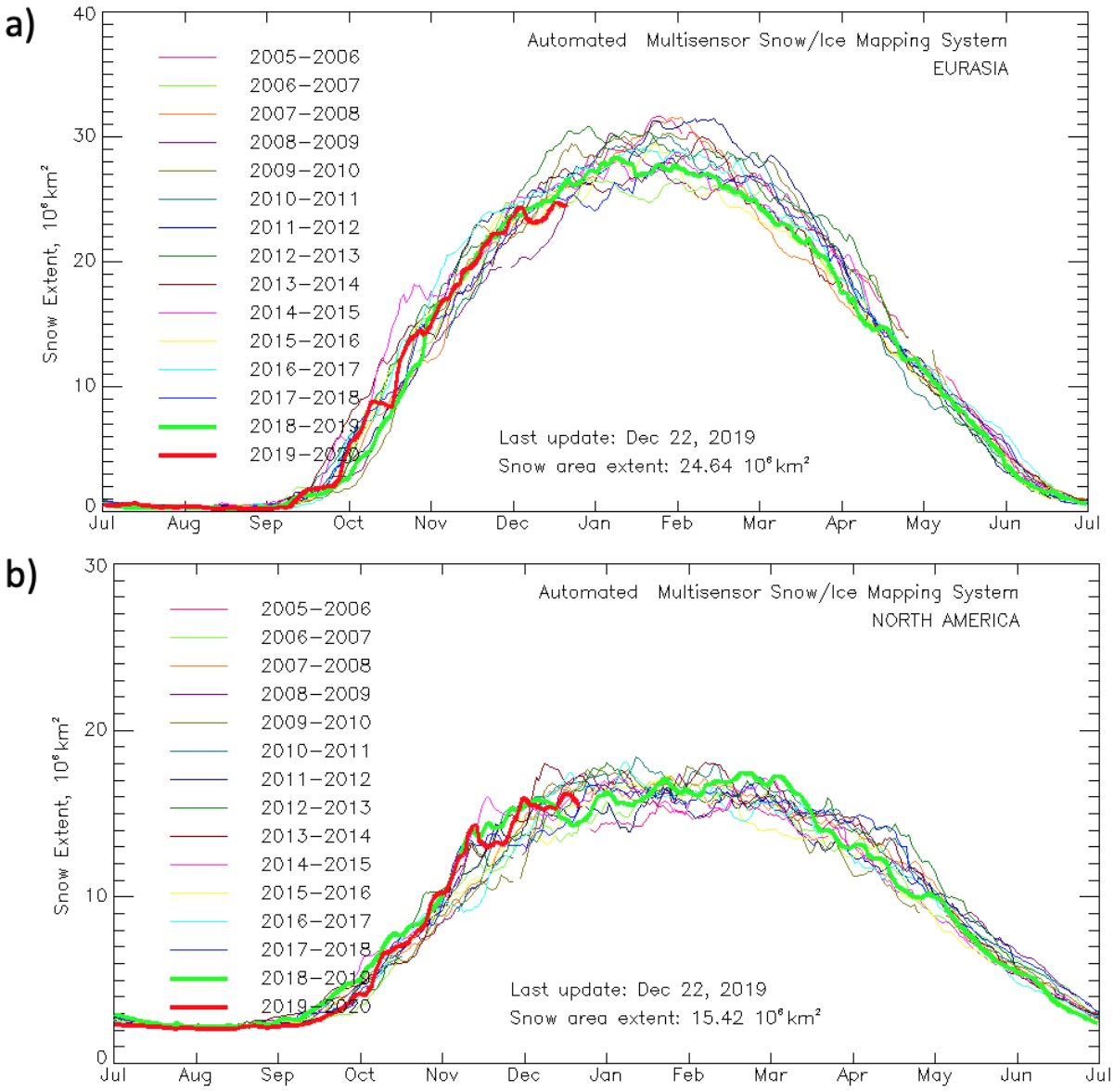

Figure 19. Observed Eurasian (top) and North American (bottom) snow cover extent through 22 December 2019. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html

North American snow cover has melted back this past week with warmer temperatures and is now near decadal means. The early advance of snow cover across Canada this fall, has likely contributed to an early start of cold temperatures across the Western US and now the Eastern US.