# Arctic Oscillation and Polar Vortex Analysis and Forecasts

**December 7, 2020**

***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) 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. With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less 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 negative and is predicted to remain neutral to negative the next two weeks.
- The current negative AO is reflective of mostly positive pressure/geopotential height anomalies on the North Atlantic side of the Arctic with mixed

pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently neutral with weak pressure/geopotential height anomalies across Greenland and Iceland; and the NAO is predicted to remain neutral to negative the next two weeks as pressure/geopotential height anomalies are predicted to remain positive.

- This week, ridging/positive geopotential height anomalies in the central North Atlantic are predicted to force downstream troughing/negative geopotential height anomalies across much of Europe coupled with normal to below normal temperatures across parts of Western, Central and Eastern Europe including the United Kingdom (UK) while southwesterly flow ushers normal to above normal temperatures to Southeastern Europe. However next week the North Atlantic ridging/positive geopotential height anomalies are predicted to spread across Europe with widespread normal to above normal temperatures.
- Over the next two weeks persistent ridging/positive geopotential height anomalies with normal to above normal temperatures centered near the Urals/Scandinavia/Barents-Kara Seas are predicted to force troughing/negative geopotential height anomalies with normal to below normal temperatures downstream cross Central Asia and much of Siberia into East Asia.
- The predicted general pattern across North America the next two weeks is mostly zonal with ridging/positive geopotential height anomalies with normal to above normal temperatures across the United States (US) and Southern Canada with troughing/negative geopotential height anomalies coupled with normal to below normal temperatures across Alaska and Northern Canada.
- *In the Impacts section I discuss the polar vortex (PV) and the implications for the weather in the coming weeks and months.*

***Impacts***

In last week's blog I provided a decision tree of sorts where more active vertical transfer of energy from the troposphere to the stratosphere could result in three different scenarios. The first is a reflective event where the upward energy transfer from the troposphere to the stratosphere reflects or boomerangs off the stratospheric PV back into the troposphere. This event is associated with cold temperatures across North America east of the Rockies and the resultant pattern change to the tropospheric circulation is relatively short on the order of one to two weeks. I thought that this scenario was likely for much of late November. However these events are characterized by striations of positive values quickly followed by negative values in the Wave Activity Flux (WAFz) or poleward heat transport. At least according to the GFS, there are only positive values predicted for the next two weeks (see **Figure 12**). Also, I no longer believe that the stratospheric circulation is favorable for this event. The predicted circulation at 10 hPa does resemble a reflected or stretched PV event (see **Figure 13**) but not at 100 hPa, which is likely more critical for these events. So, for now I am no longer expecting a reflective or stretching PV event.

The other two scenarios involve the upward energy transfer from the troposphere to the stratosphere and is absorbed in the stratosphere. One scenario is the energy is absorbed in the polar stratosphere causing the stratospheric PV to weaken. In this last scenario, the energy is directed away from the North Pole towards the equator causing the stratospheric PV to strengthen. This is where the quasi-biennial oscillation (QBO) plays a role. During easterly QBO the energy is more likely to be directed towards the North Pole causing the PV to weaken and during westerly QBO the energy is more likely to be directed towards the equator causing the PV to strengthen. The QBO seems a mess to me this winter but is probably mostly westerly.

The upward vertical energy (or more accurately the increase since it is almost always upward) has not happened yet but will start this week. All the models are predicting some weakening of the stratospheric PV over the next two weeks. However, I have to admit that I am somewhat surprised that the weakening of the PV is not more substantial given the magnitude of the anomalies in WAFz. I interpret this as a mix of scenarios two and three where some of the upward energy is being directed towards the North Pole resulting in some PV weakening but some of that energy is also being directed towards the equator that is preventing a weakening of the PV of greater magnitude.

Though scenarios two and three have different impacts on the stratospheric PV, I do believe that the impacts on the tropospheric circulation and weather are consistent at least in the near term (two weeks or so). I don't think I have ever seen this in the scientific literature but based on my own observations the Eastern US and more often than not Europe are relatively mild when the upward energy is anomalously active from the troposphere to the stratosphere and it is not reflected. The regions that tend to be relatively cold are East Asia and often western North America when the upward energy is anomalously active. This thinking or observation is certainly consistent with the Northern Hemisphere temperature forecast for the next two weeks
(see **Figures 6** and **9**).

However, there are longer term implications for the tropospheric circulation and the weather depending on scenarios two and three. The mild pattern in the Eastern US and Europe, can but not always, end with a mature disruption of the stratospheric PV usually after a duration of two to four weeks. If the upward energy is directed towards the stratospheric PV that is more efficient at disrupting the PV and hence a reversal from a mild to a colder pattern can commence much sooner in scenario two. In scenario three where the upward energy transfer is more inefficient at disrupting the PV, the mild pattern in the Eastern US and Europe tends to persist for longer and can instead of being on the order of two to four weeks can be more like four to six weeks and also ends with a mature disruption of the stratospheric PV.

My experience in the past, anticipating a stratospheric PV disruption is that it can be like waiting for paint to dry. It typically takes four to six weeks of positive anomalous

upward energy transfer for a mature PV disruption (Polvani and Waugh 2004). The upward energy anomaly is only predicted to turn positive this week so that most likely puts us into January before a mature PV disruption at the earliest, if it were to happen at all.

I still believe though that the pattern remains favorable for disrupting the stratospheric PV. Over the next two weeks the main ridging/blocking in the NH remains in the Urals/Scandinavian/Barents Kara Seas region that is favorable for disrupting the PV. While during last week's blog the dominant wave pattern in the NH was a wave three this week it now seems more wave two but especially wave one. Only energy from the two largest tropospheric waves escape the troposphere for the stratosphere. It is also my observation that when the upward energy transfer takes place from the troposphere to the stratosphere, it favors weakening ridging/blocking in the Urals region. If the Ural blocking decays prior to causing a meaningful disruption of the PV, then we could be off to the races with a strong PV, positive AO and widespread mild temperatures across the NH and in particular the Eastern US, Europe and East Asia for much of the winter.

The most encouraging sign to me of an eventual large PV disruption is the predicted development of cold temperatures in Northern Asia. I do consider relatively cold temperatures in Siberia and East Asia favorable for disrupting the PV. Last winter with the record strong PV, temperatures were incredibly mild across Siberia (and all of northern Eurasia) all winter long. In **Figure i**, I show the temperature anomalies from last winter from the Climate Reanalyzer. Those anomalies were simply mind blowing across Siberia. In fact, it has been a few years since we have observed expansive cold across Siberia. So, the forecast of more widespread cold and possibly large negative departures (see **Figure 10**) stands in stark contrast to last winter of a record strong PV and positive AO.

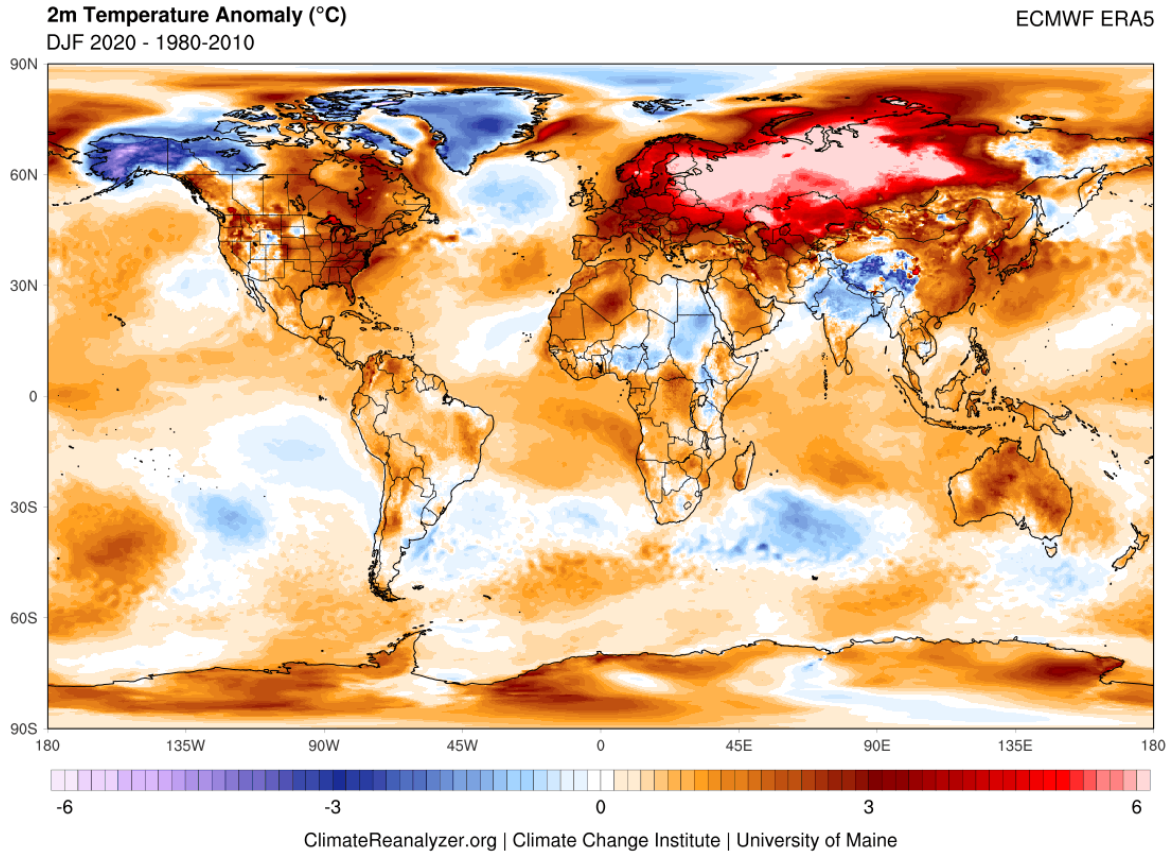


**Figure i**. **a**) Observed winter temperature anomalies for December, January and February 2020 based on ERA5 from https://climatereanalyzer.org/.

My tweet from yesterday about “winter is healing” I think struck a chord with a few and for me if I could wish for one thing to occur this winter it would be for an extended period of expansive and deep cold temperatures across Siberia (easy for me to wish so I won’t be there to experience it). I have said for decades that “Siberia is the refrigerator of the NH.” That is no longer true if Siberia has the same climate as the US Dakotas with cold winters but nothing extreme and hot summers. The hot air generated this past summer’s Siberian heat wave literally vaporized Arctic sea ice this summer. The Arctic is already past a climate tipping point but that would be accelerated if Siberia no longer experiences exceptional cold.

I expect the mild pattern for the Eastern US and Europe to continue for at least two weeks and likely longer. In the interim the region’s most likely to experience cold air outbreaks are East Asia and likely including western North America. I expect the mild pattern in the Eastern US and/or Europe to end when the disruption of the PV peaks most likely sometime in January but could be delayed even further. Then the location of the cold and the timing will likely be dependent on the nature of the PV disruption, details I won’t pretend to even guess. Though based on some analysis that I did last year the Eastern US is favored for colder with displacements and Europe with splits. I

believe the trend is your friend can be useful in predicting the weather so as to whether a split or displacement would be favored – all large PV disruptions since 2009 have been splits. Though put all of these observation in the speculative pile. Of course, much can change in the coming weeks.

I created a table (see **Table 1**) trying to summarize the weather during and after the vertical energy transfer for the three different scenarios. It is meant to serve as a tool to help the reader understand what to expect based on the three scenarios that I described in the blog the past two weeks. This is based in my experience and not the published literature. Obviously, there is large event to event variability and the table is generalized and simplified for the blog. I don't have analysis to support the table and as such should be treated as speculative.

**Table 1**. Expected weather during and after three different vertical energy transfer scenarios described in the blog.

| **Vertical atmospheric energy transfer type** | **Weather during energy transfer** | **Duration of induced weather** | **Main impact on weather during PV disruption** | **Weather 2-4 weeks after PV disruption** |
|---|---|---|---|---|
| reflective | N/A | days | Cold eastern North America/Central Asia | N/A |
| Absorptive polar region | Mild Eastern US/Europe & cold East Asia/western North America | 2-4 weeks | Cold northern Eurasia can also cause cold in western North America | Consistent with negative AO, displacement favors cold eastern North America while split favors cold in Europe and/or US |
| Absorptive equatorial region then transitioning to absorptive polar region | Mild for entire Northern Hemisphere transitioning to Mild Eastern US/Europe & cold East Asia/western North America | 4-6 weeks (or possibly more if it does not culminate in large PV disruption) | Cold northern Eurasia can also cause cold in western North America | Consistent with negative AO, displacement favors cold eastern North America while split favors cold in Europe and/or US |

*1-5 day*

The AO is currently negative **(Figure 1**) with positive pressure/geopotential height anomalies across the North Atlantic side of the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted weak positive geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to also be neutral to weakly negative this week.

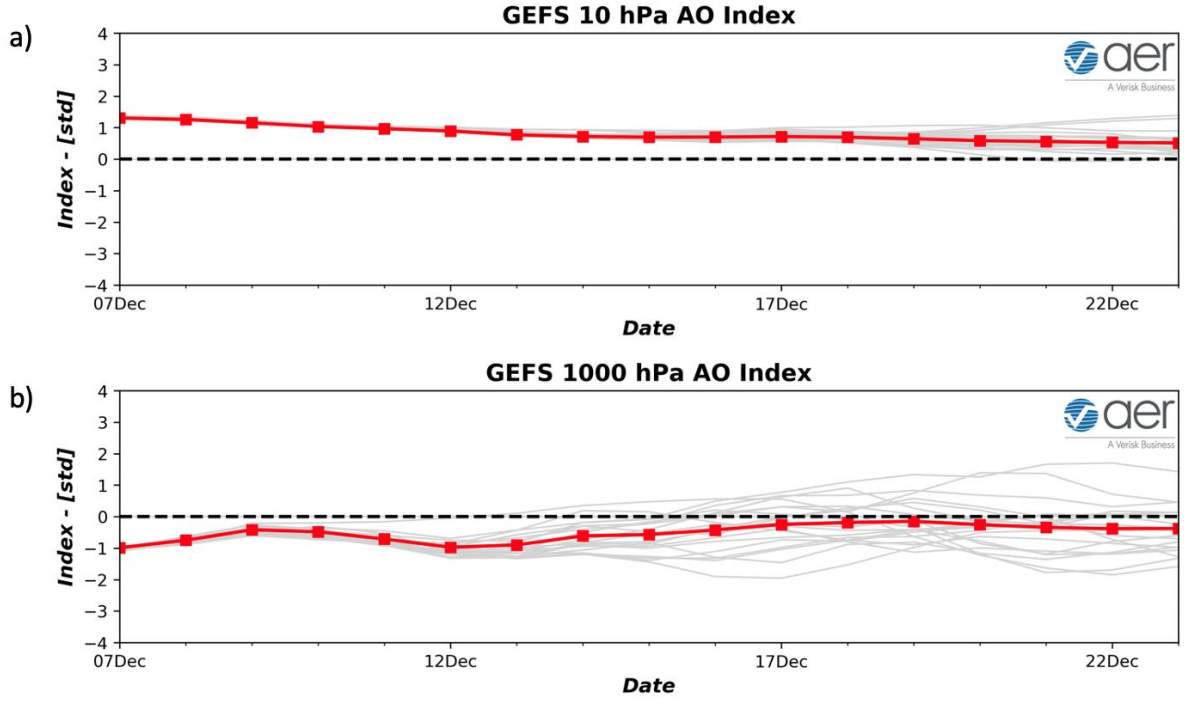


**Figure 1**. (**a**) The predicted daily-mean AO at 10 hPa from the 00Z 7 December 2020 GFS ensemble. (**b**)The predicted daily-mean near-surface AO from the 00Z 7 December 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ridging/positive geopotential height anomalies in the central North Atlantic will force downstream troughing/negative geopotential height anomalies across Europe (**Figure 2**). This pattern favors normal to below normal temperatures across parts of Western, Central and Eastern Europe including the UK while southwesterly flow transports normal to above normal temperatures to Southeastern Europe (**Figure 3**). This week, ridging/positive geopotential height anomalies centered near the Urals are predicted to force downstream troughing/negative geopotential height anomalies across much of Siberia and Central Asia with more ridging/positive geopotential height anomalies in the Far East (**Figure 2**). This pattern favors normal to above normal temperatures **f**or the Urals, the Middle East and Southern and East Asia with normal to below normal temperatures in Central Asia and much of Siberia **(Figure 3**).

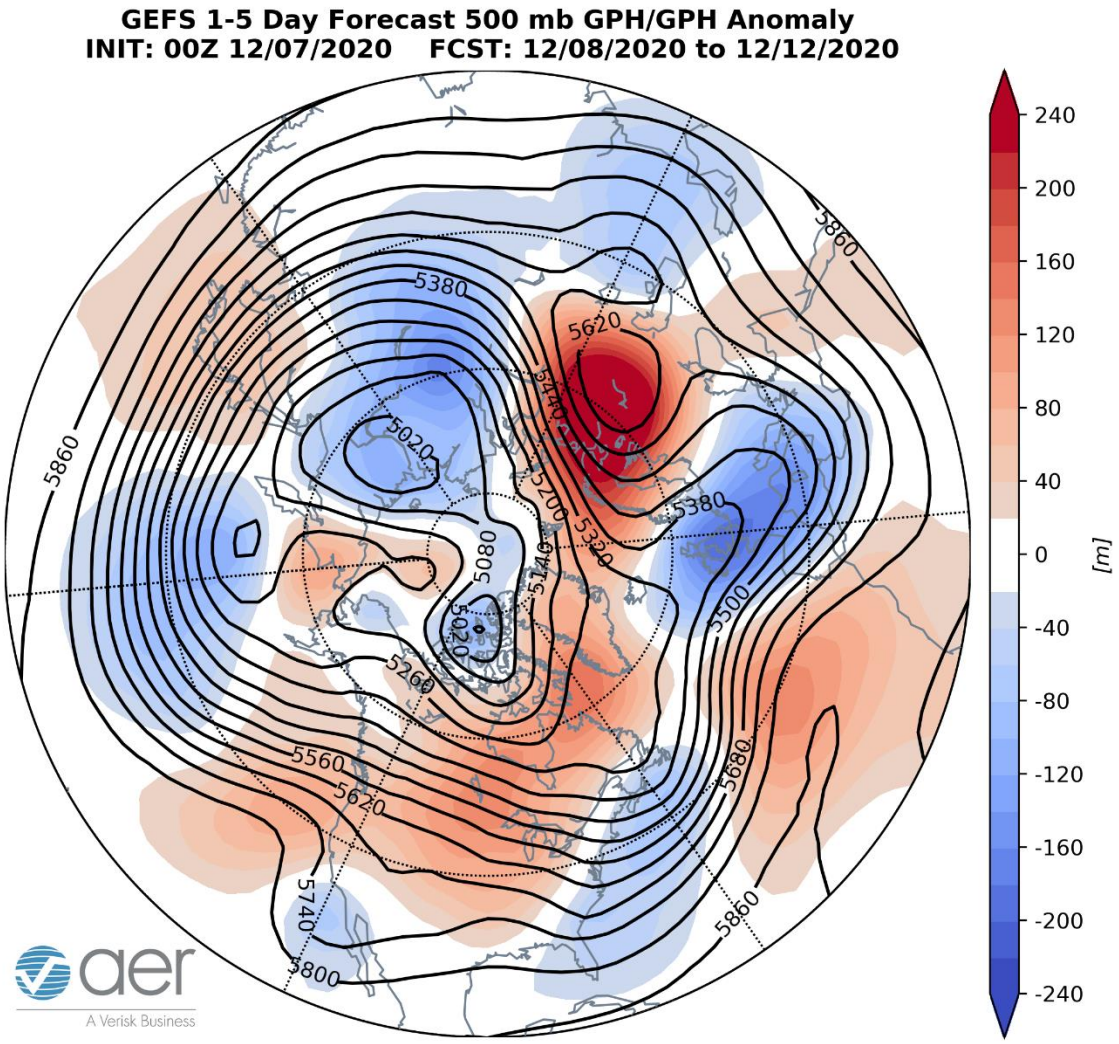


**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 December 2020. The forecasts are from the 00z 7 December 2020 GFS ensemble.

This week ridging/positive geopotential height anomalies are predicted to stretch across much of North America with the regional exceptions troughing/negative geopotential height anomalies along the US East Coast and Alaska (**Figure 2).** This pattern is predicted to bring widespread normal to above normal temperatures across much of Canada and the US with normal to below normal temperatures limited to Alaska and the US Eastern Seaboard **(Figure 3).**

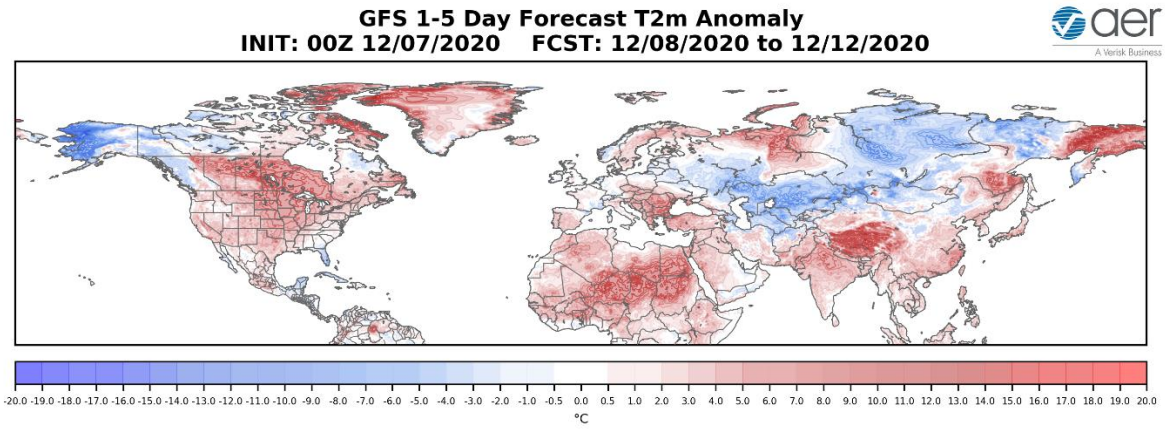


**Figure 3**. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 December 2020. The forecast is from the 00Z 7 December 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across parts of Scandinavia, the Alps, Siberia and especially Central Asia and the Himalayas while warmer temperatures will cause regional snow melt in Asia (**Figure 4**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, Northern and Western Canada, Quebec and the US Rockies into the Northern Plains while warmer temperatures will cause snow melt in parts of Southern Canada and western Hudson Bay (**Figure 4**).

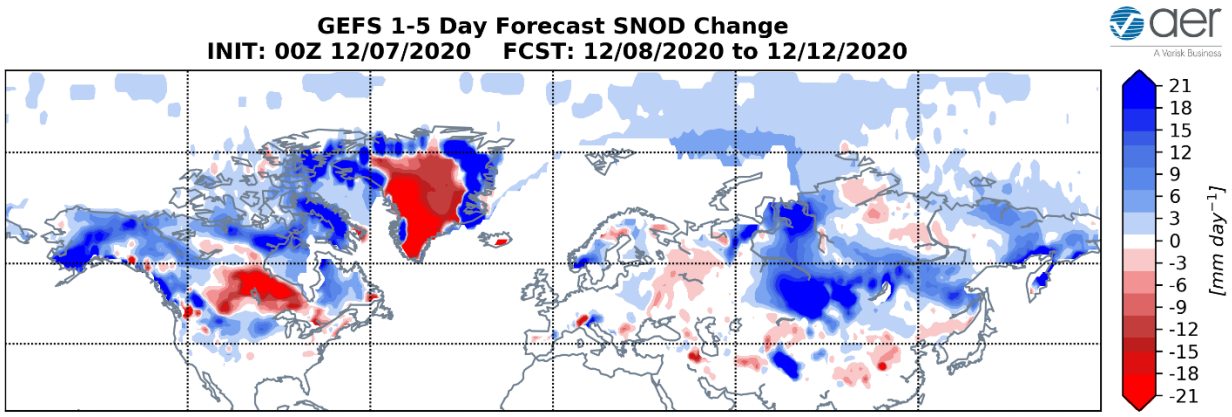


**Figure 4**. Forecasted snow depth changes (mm/day; shading) from 8 – 12 December 2020. The forecast is from the 00Z 7 December 2020 GFS ensemble.

*Mid-Term*

*6-10 day*

The AO is predicted to remain slightly negative next week **(Figure 1**) as positive geopotential height anomalies persist across the North Atlantic side of the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with positive geopotential height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to also turn negative.

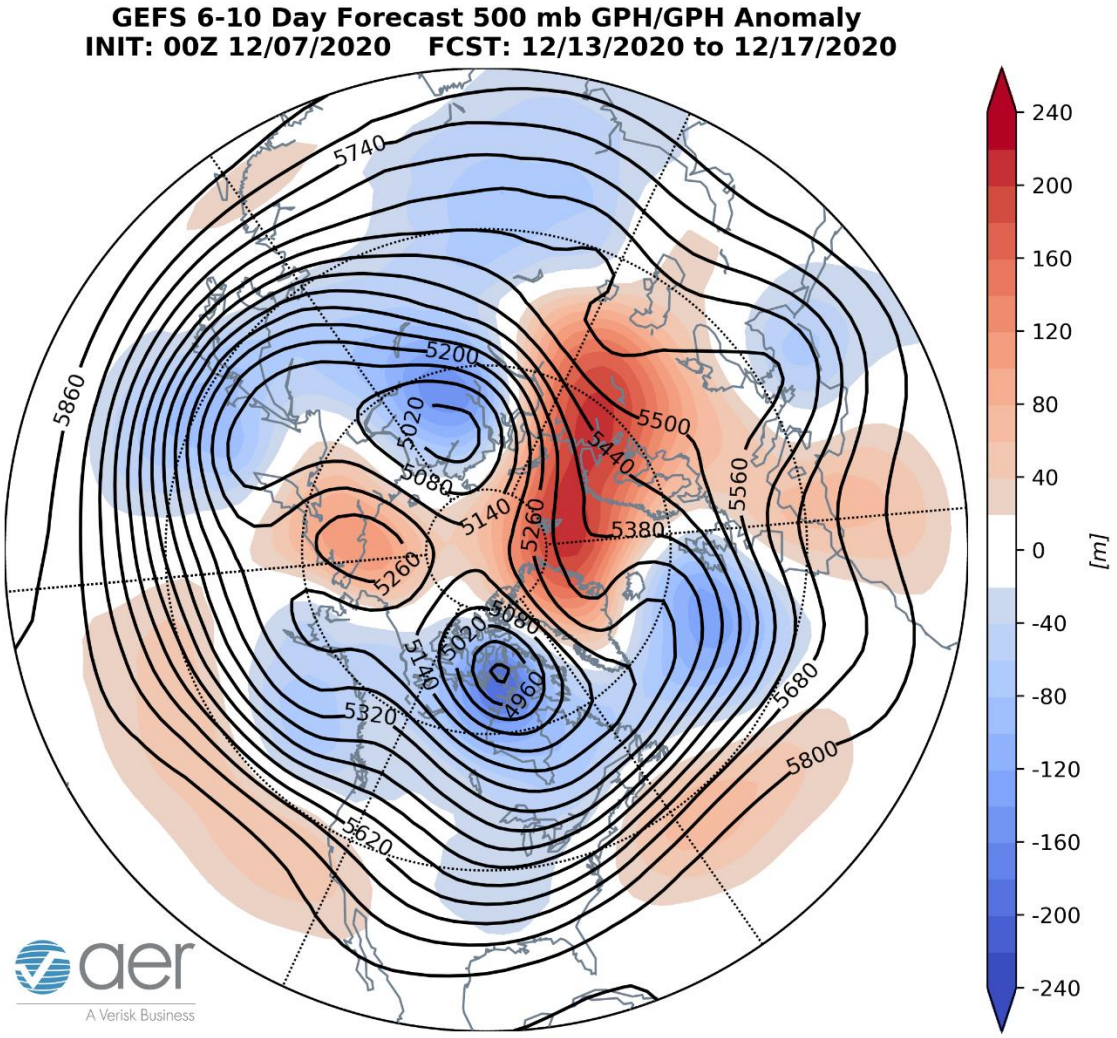


**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 December 2020. The forecasts are from the 00z 7 December 2020 GFS ensemble.

Ridging/positive geopotential height anomalies previously in the central North Atlantic are predicted to replace troughing/negative geopotential height anomalies across Europe this period (**Figures 5).** This pattern favors normal to above normal temperatures across much of Europe including the UK with the possible exception of normal to below normal temperatures in Scotland and Norway (**Figure 6**). Persistent ridging/positive geopotential height anomalies centered near the Urals are predicted to

anchor troughing/negative geopotential height anomalies downstream across Central Asia and Siberia that extends south across East Asia this period (**Figure 5**). This is predicted to favor widespread normal to below normal temperatures across much of Northern, Central and East Asia with normal to above normal temperatures in the Ural region and Southern Asia **(Figure 6**).

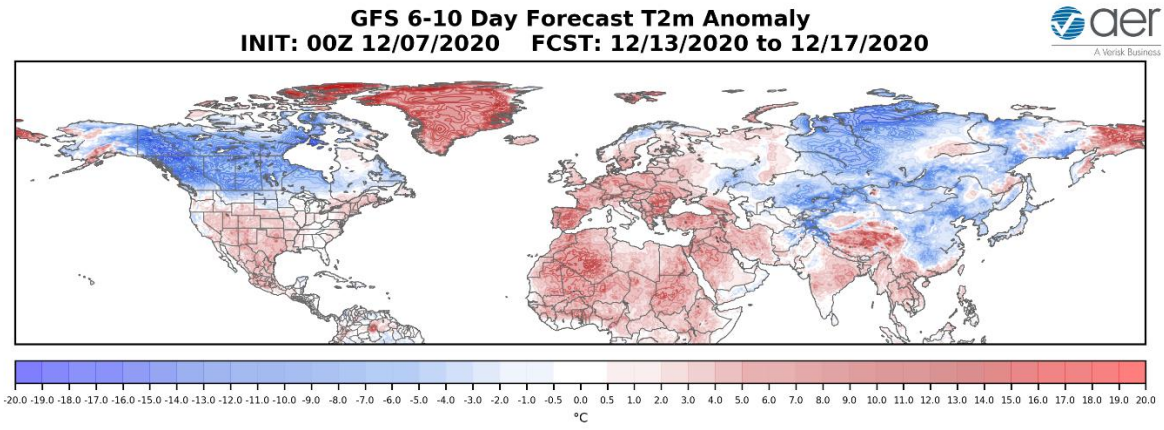


**Figure 6**. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 December 2020. The forecasts are from the 00Z 7 December 2020 GFS ensemble.

Predicted zonal flow with ridging/positive geopotential height anomalies across much of the US with troughing/negative geopotential height anomalies across Alaska and Canada is predicted to persist this period **(Figure 5). T**his pattern is predicted to bring widespread normal to above normal temperatures across the US with normal to below normal temperatures across Alaska and much of Canada **(Figure 6).**

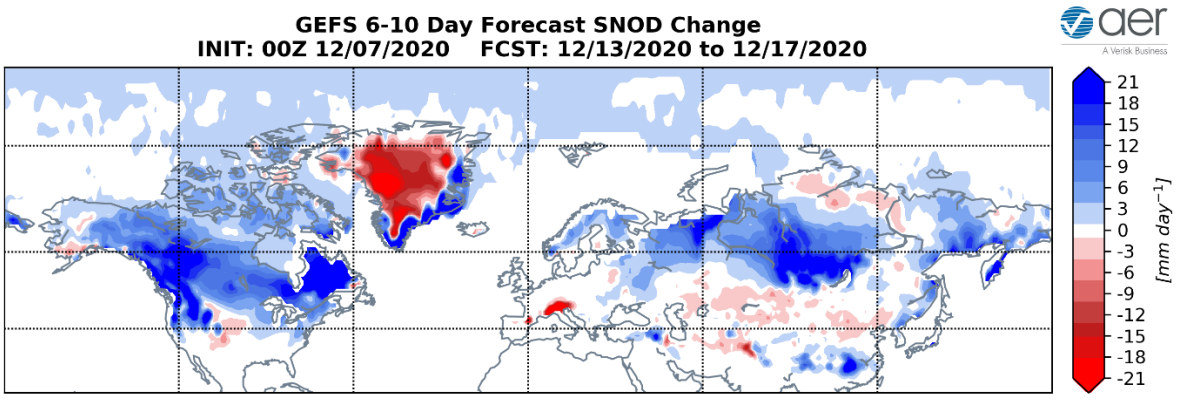


**Figure 7**. Forecasted snow depth changes (mm/day; shading) from 13 – 17 December 2020. The forecasts are from the 00Z 7 December 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across Scandinavia, Northern Asia and parts of China while warmer temperatures will cause

regionalized snow melt including the Pyrenees and the Alps (**Figure 7**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, much of Canada, the Northwestern US and possibly the Northeastern US while warmer temperatures will cause possible snow melt in the US Central Rockies (**Figure 7**).

*11-15 day*

As geopotential height anomalies are predicted to remain positive on the North Atlantic side of the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO should straddle neutral to slightly negative this period (**Figure 1**). With continued positive pressure/geopotential height anomalies spread across Greenland (**Figure 8**), the NAO is predicted to remain negative this period.

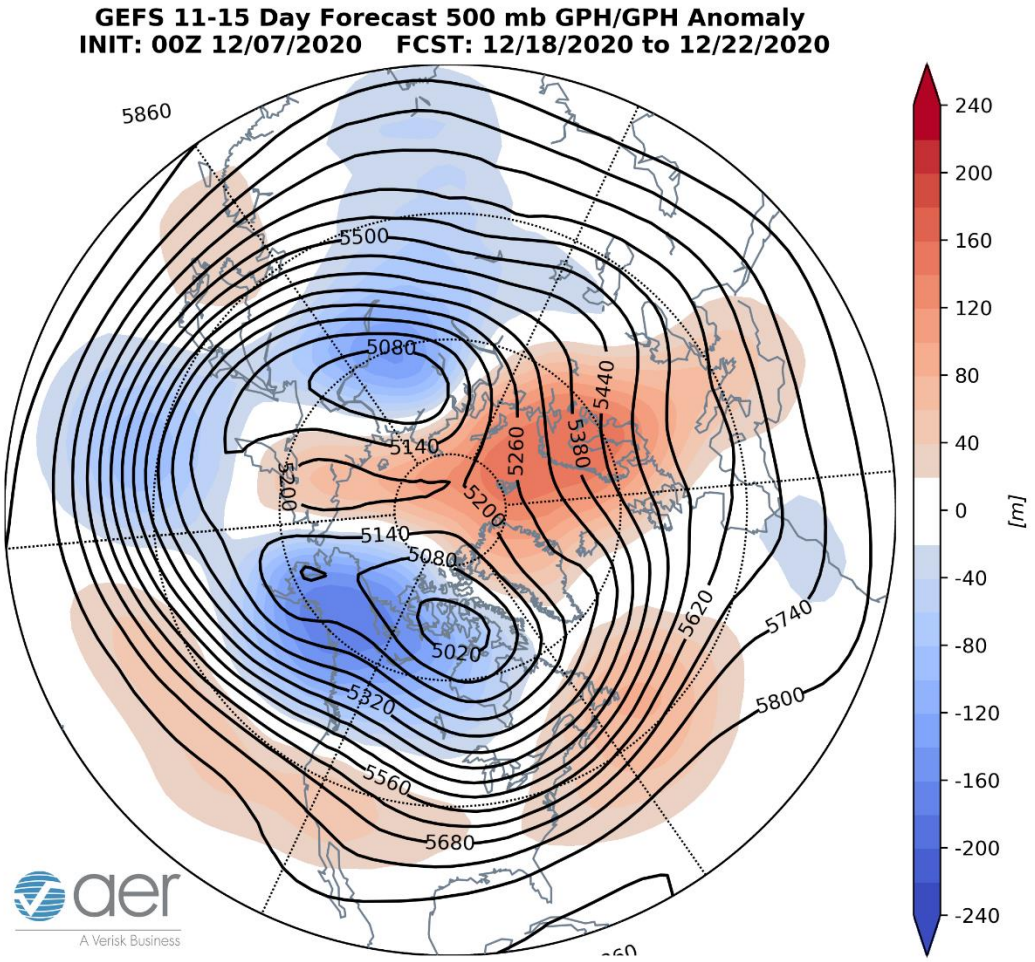


**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 December 2020. The forecasts are from the 00z 7 December 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist across Europe with troughing/negative geopotential height anomalies limited to far Western Europe this period (**Figures 8**). The forecast is for widespread normal to above normal temperatures across Europe with more seasonable temperatures across far Western Europe including the UK this period (**Figures 9**). Predicted persistent ridging/positive geopotential height anomalies focused near the Urals and now edging into the Central Arctic this period will continue to support downstream troughing/negative geopotential height anomalies across Siberia that extends south to East Asia this period (**Figure 8**). This pattern favors normal to above normal temperatures across the Central and Southern Asia with normal to below normal temperatures across much of Siberia and into East Asia (**Figure 9**).

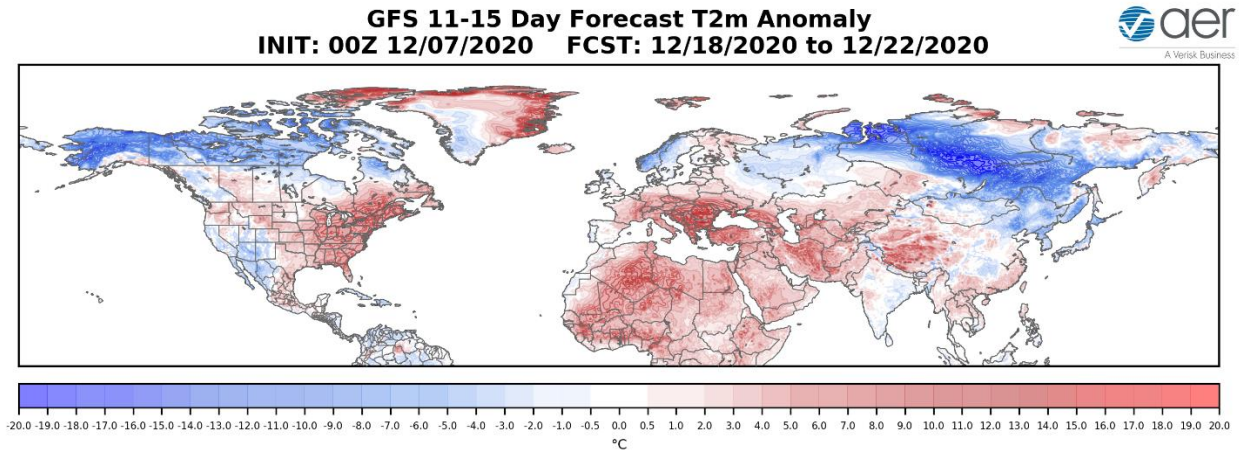


**Figure 9**. Forecasted surface temperature anomalies (°C; shading) from 18 – 22 December 2020. The forecasts are from the 00z 7 December 2020 GFS ensemble.

Persistent zonal flow with ridging/positive geopotential height anomalies across the US with troughing/negative geopotential height anomalies in Alaska and Northern Canada are predicted to persist this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures for much of the US and Southern Canada with normal to below normal temperatures for Alaska and Northern Canada (**Figure 9**). A trough swinging through the Southwestern US could bring seasonable temperatures to the region (**Figure 9**).

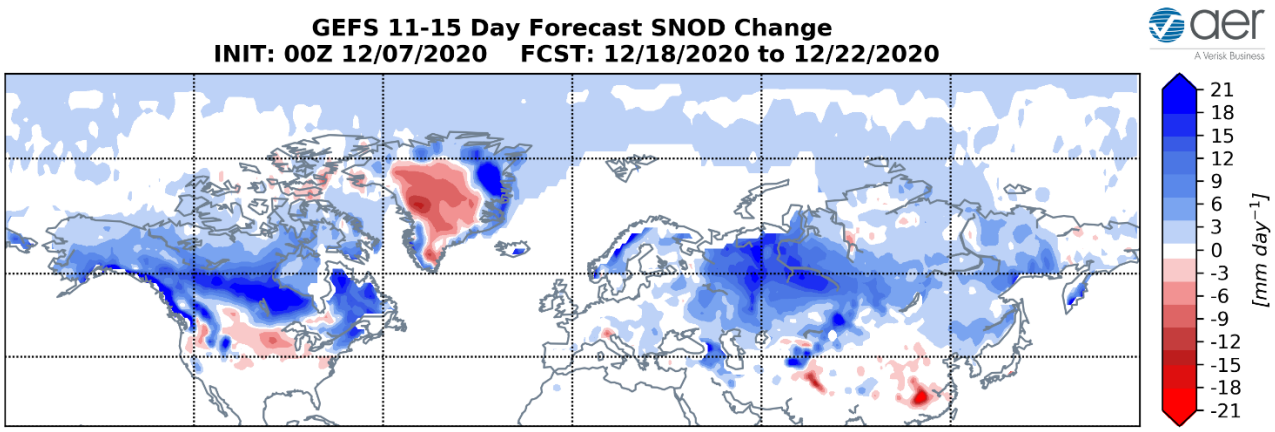


**Figure 10**. Forecasted snow depth changes (mm/day; shading) from 18 – 22 December 2020. The forecasts are from the 00z 7 December 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across Scandinavia and much of Northern and Central Eurasia and even possibly Eastern Europe while warmer temperatures will cause possible snow melt in China and Himalayas (**Figure 10**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, Canada and possibly New England while warmer temperatures will cause possible snow melt in the US Upper Midwest (**Figure 10**).

*Longer Term*

*30–day*

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive normal PCHs in the mid to lower troposphere but cold/negative PCHs in the stratosphere and upper troposphere (**Figure 11**). The cold/negative stratospheric PCHs are predicted to slowly weaken the next two weeks (**Figure 11**).

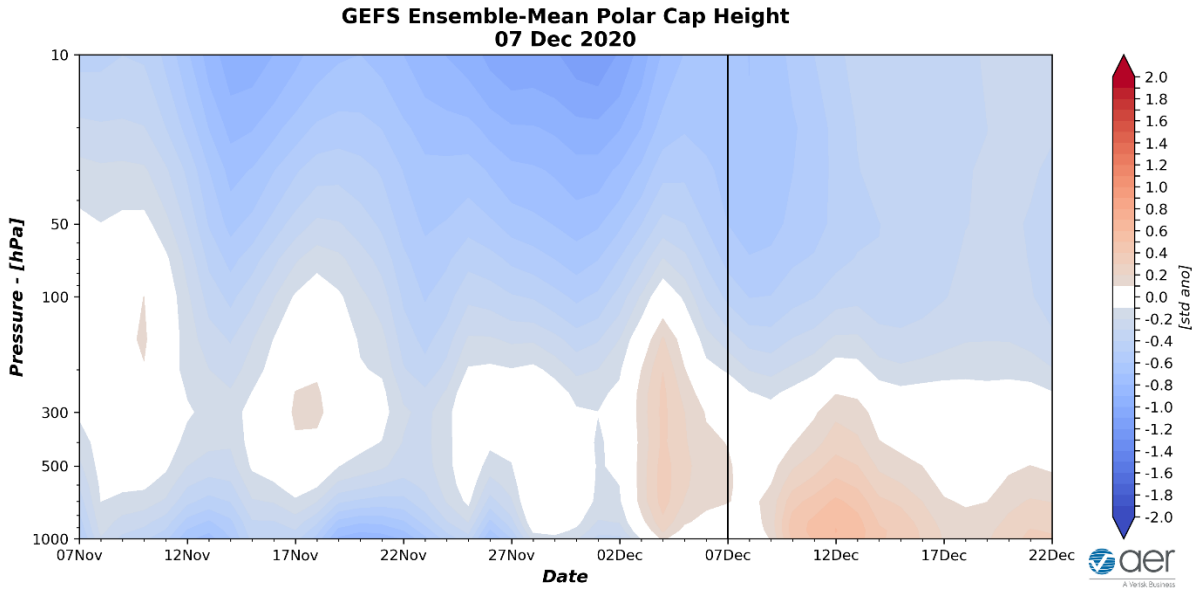


**Figure 11**. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 7 December 2020 GFS ensemble.

Normal to warm/positive PCHs in the lower troposphere are consistent with the predicted neutral to negative surface AO the next two weeks (**Figure 1**). Cold/negative PCHs in the stratosphere are consistent with the positive stratospheric AO the next two weeks (**Figure 1**). I still believe there could be volatility in the PCH forecast that have important long-term implications for troposphere-stratosphere coupling.

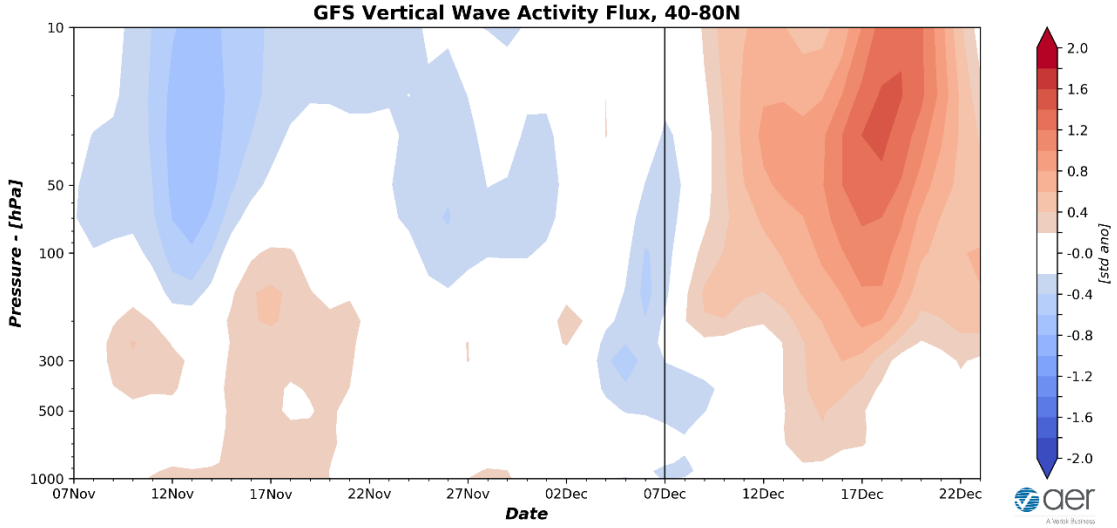

**Figure 12**. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 7 December 2020 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport forecasts are showing an active period of WAFz in the troposphere but especially the stratosphere the next two weeks (**Figure 12**). The lack of active WAFz much of the fall has allowed the stratospheric PV to become anomalously strong. But weakening of the PV is looking more likely with the upcoming active period of WAFz.

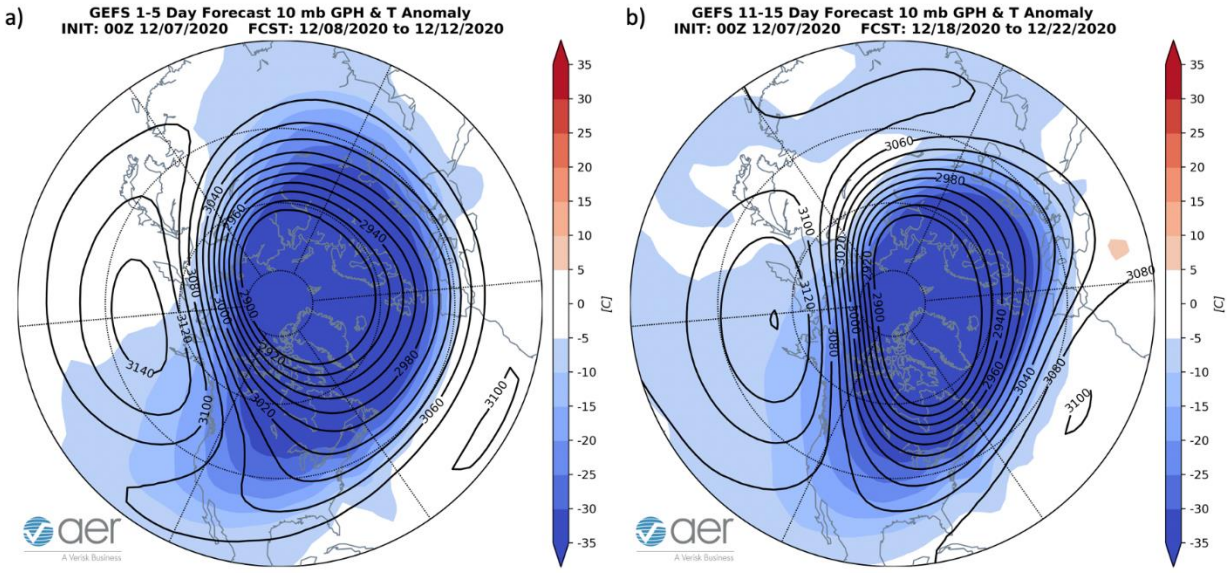


**Figure 13**. (**a**) Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 8 – 12 December 2020. (**b**) Same as (a) except forecasted averaged from 18 – 22 December 2020. The forecasts are from the 00Z 7 December 2020 GFS model ensemble.

The PV is predicted to remain strong and centered near the North Pole this week (**Figure 13**). However, the GFS for next week is predicting high pressure to build near the Dateline that would likely displace the PV center towards Svlabard and stretch it. The predicted perturbation of the PV could be suggestive of an upcoming disruption of the PV that is looking more like an absorptive event, which is most closely associated with cold temperatures in Northern Eurasia.

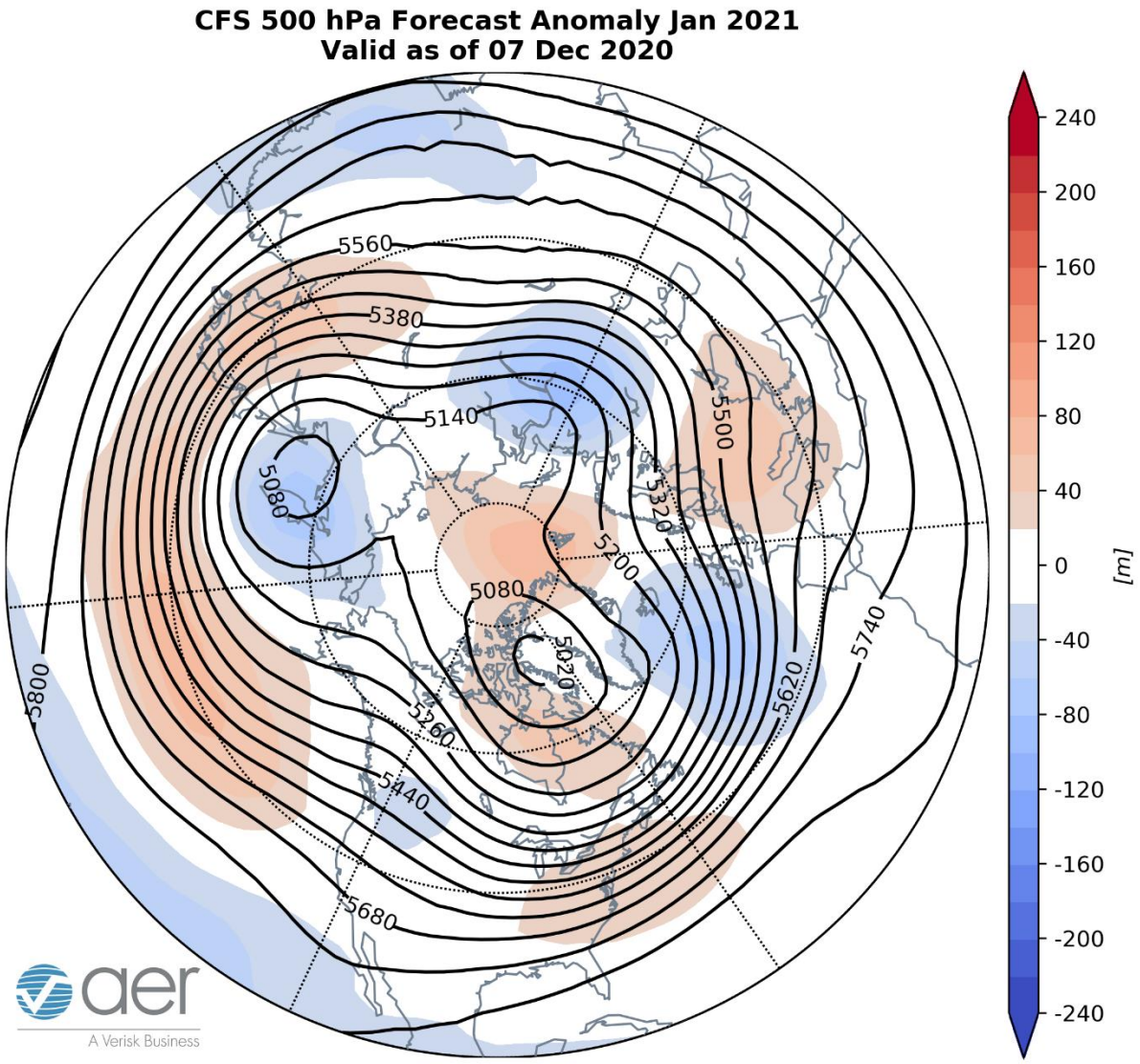


**Figure 14**. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2020. The forecasts are from the 00Z 7 December 2020 CFS.

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 in Europe and south of the Aleutians with troughing centered on the Urals, Southeast Asia, Eastern Siberia, Eastern Canada into the North Atlantic (**Figure 14).** This pattern favors relatively warm temperatures for much of Europe, Northeast Asia, Siberia, much of the US and Western Canada with seasonable to relatively cold temperatures for Southeast Asia, Eastern Siberia and Eastern Canada (**Figure 15**).

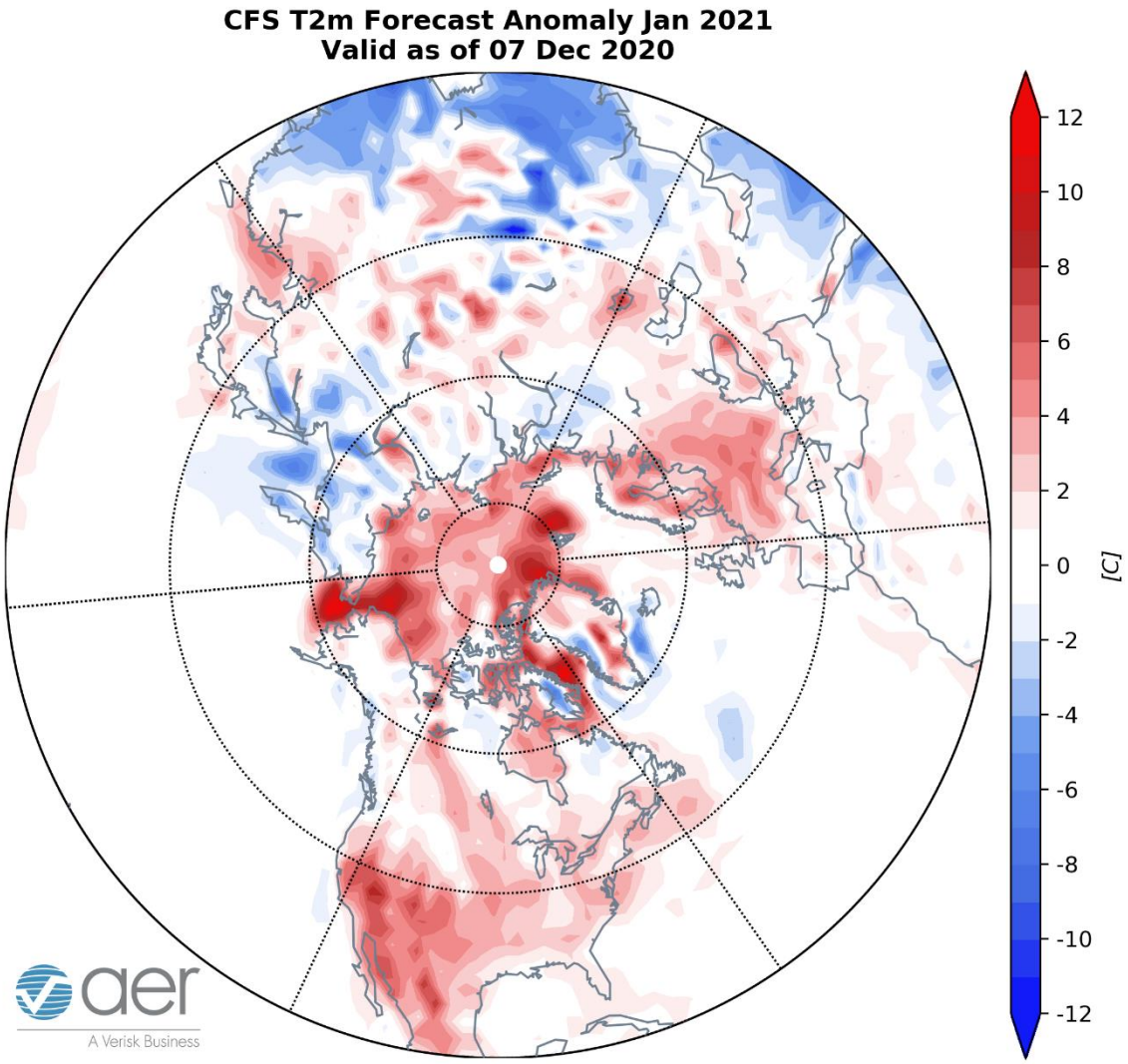


**Figure 15**. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for December 2020. The forecasts are from the 00Z 7 December 2020 CFS.

*Surface Boundary Conditions*

*Arctic sea ice extent*

Arctic sea ice continues to grow but currently remains well below normal. Negative sea ice anomalies exist continuously in the Bering and Chukchi Seas (**Figure 16**). However the largest negative sea anomalies remain focused in the Barents-Kara Seas. Below normal sea ice in the Barents-Kara seas favor Ural blocking and cold temperatures in Central and East Asia, however this topic remains controversial. Recent research has shown that the 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.  Low sea ice in the Chukchi and Bering seas may favor colder temperatures across North America but have not been shown to weaken the PV.  Though sea ice may grow quickly in this region based on the forecast.

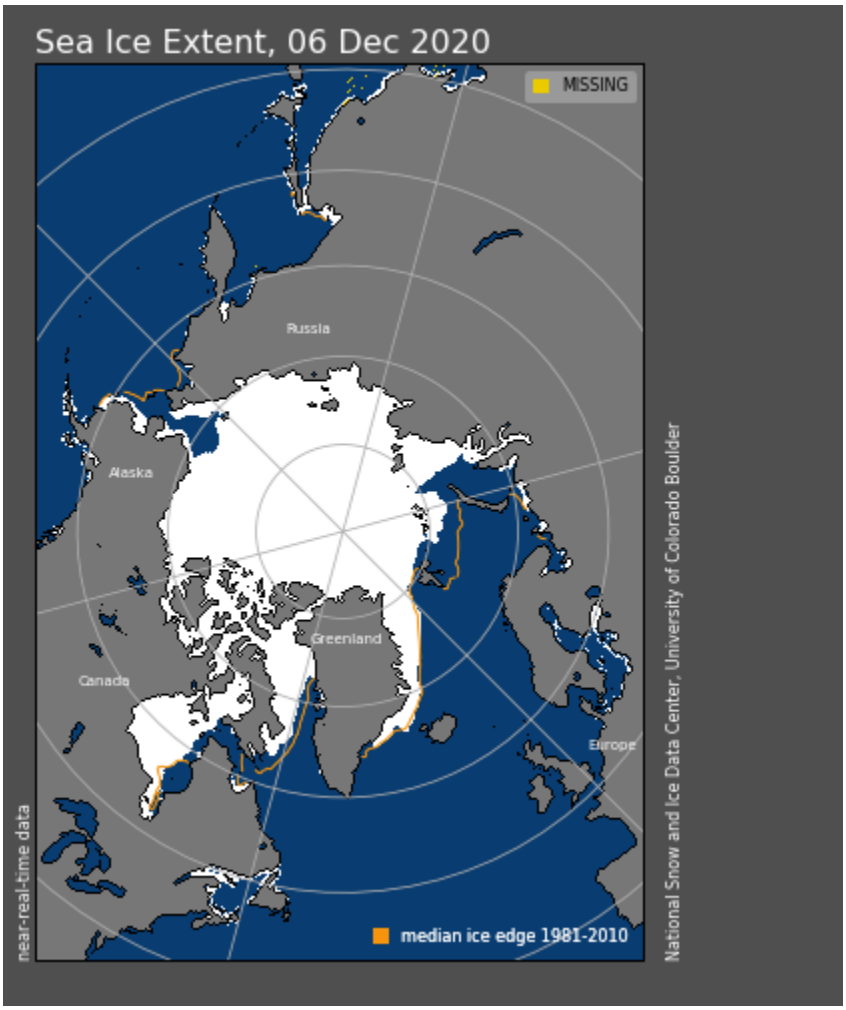


**Figure 16**. Observed Arctic sea ice extent on 6 December 2020 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC). Snow and Ice Data Center (NSIDC).

*SSTs/El Niño/Southern Oscillation*

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain negative and we continue to observe moderate La Niña conditions (**Figure 14**) and La Niña is expected to persist through the winter and remain moderate.  Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska, the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the Southern Hemisphere and south of Iceland.  Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

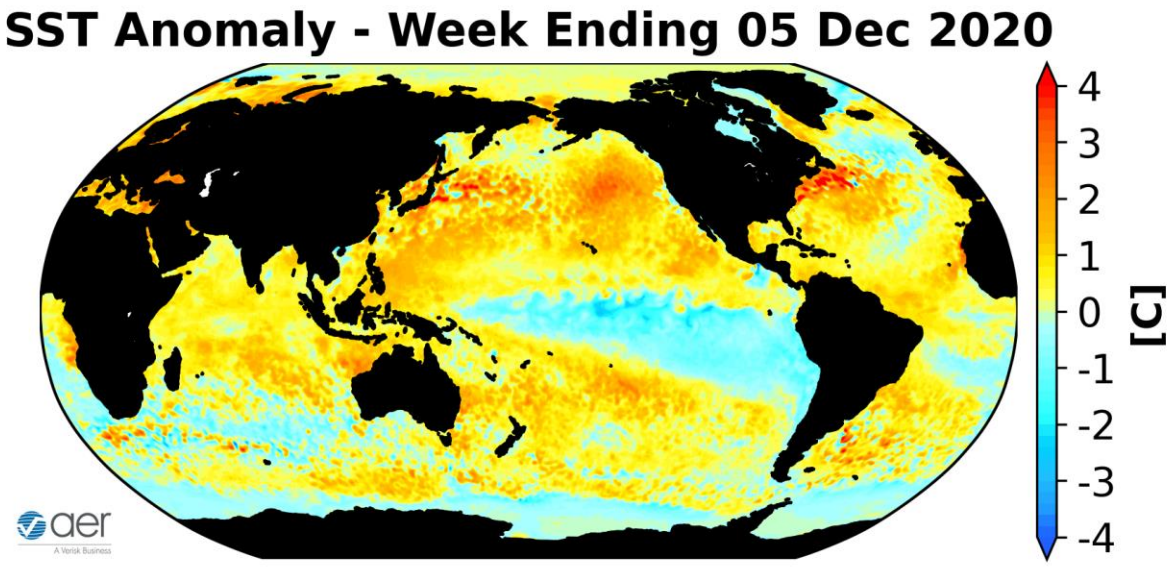


**Figure 17**. The latest weekly-mean global SST anomalies (ending 5 December 2020). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored though may emerge in phase five in two weeks' time. It doesn't appear to me that the MJO is contributing to the short-term pattern across North America but admittedly this is outside of my expertise. I will add the MJO was last in phase three and a sudden stratospheric warming occurs most often one month after MJO phase three.

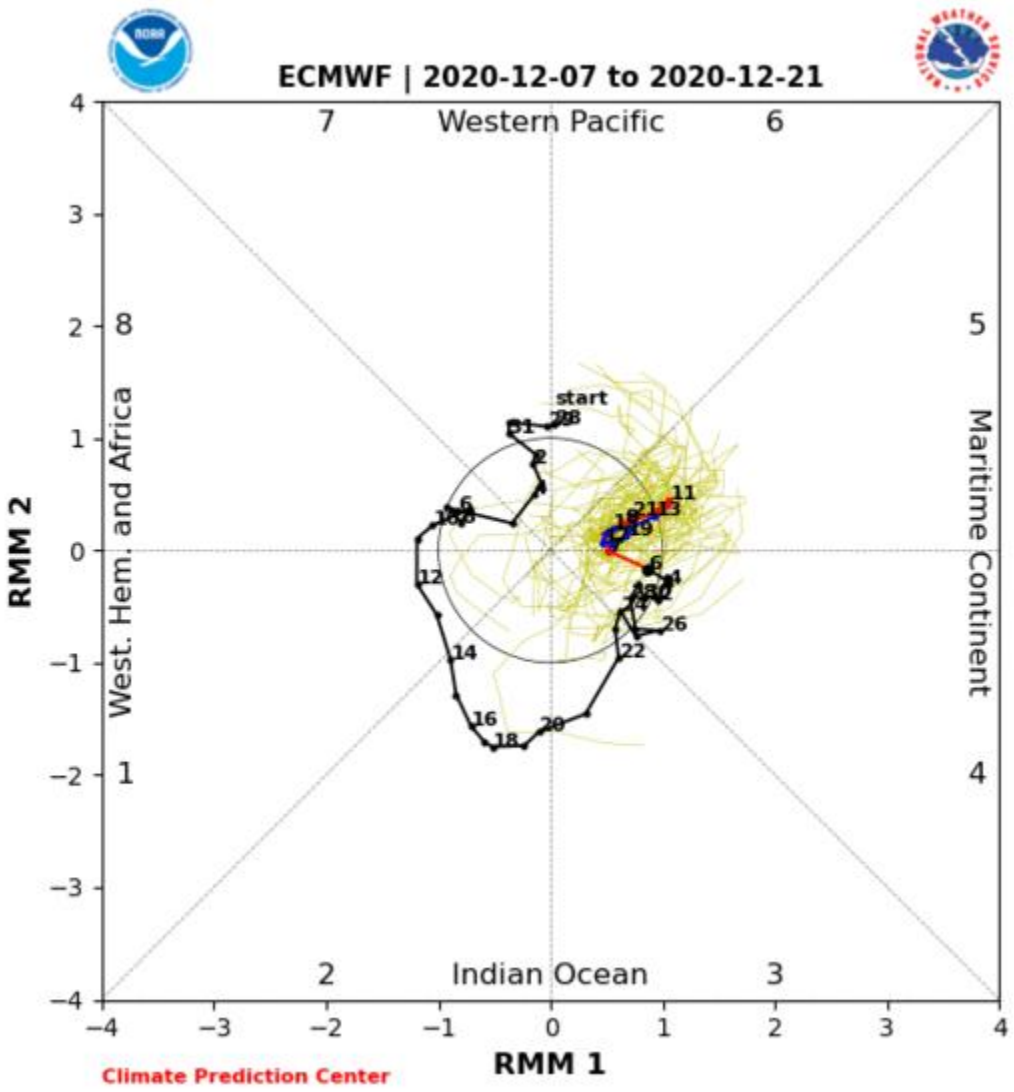


**Figure 18**. Past and forecast values of the MJO index. Forecast values from the 00Z 7 December 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers 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 advanced more slowly over the past week across Eurasia but currently still remains near decadal highs. Snow cover advance will likely continue to increase especially across East Asia and possibly into Europe the next two weeks. 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.

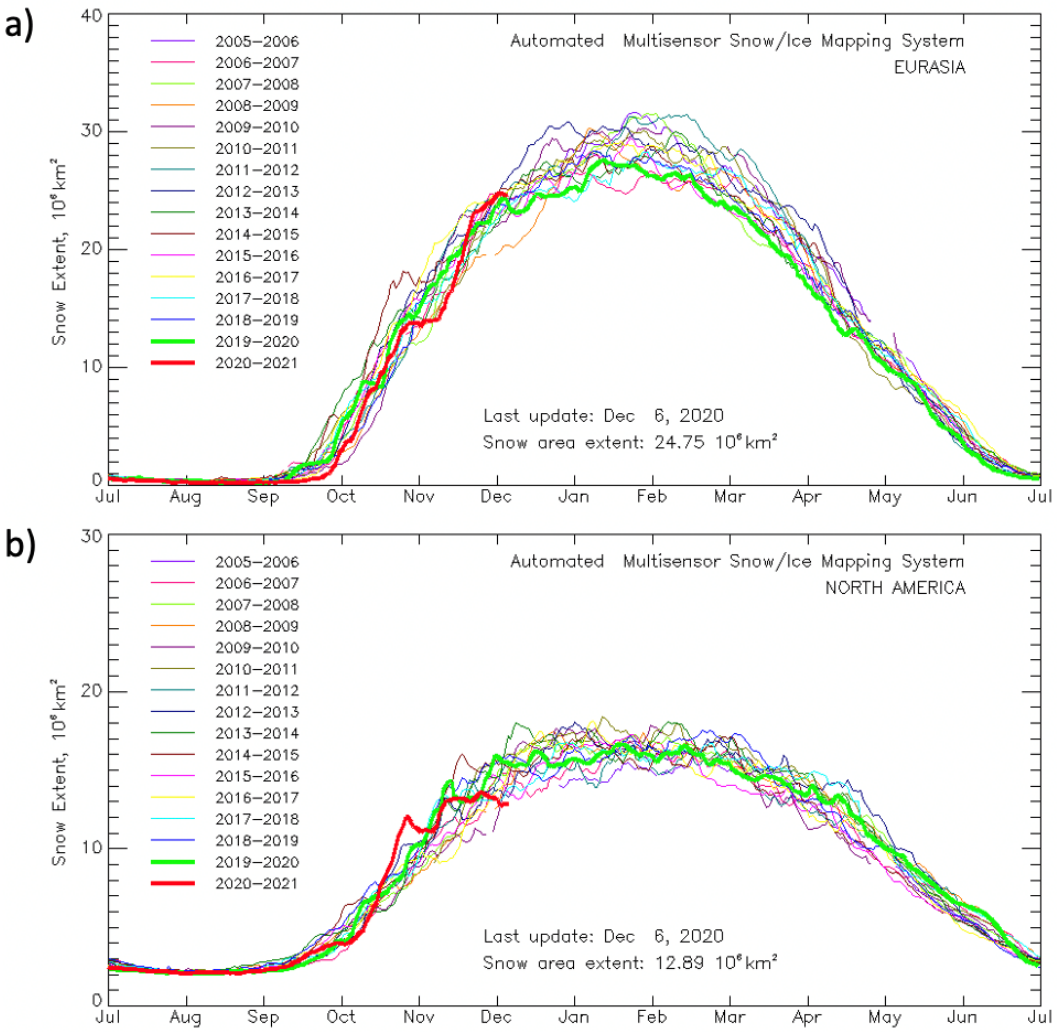


**Figure 19**. Observed Eurasian (top) and North American (bottom) snow cover extent through 29 November 2020. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html

North American snow cover advance continues its wild ride. Snow cover advance has stalled for three weeks and is now at decadal lows. The early advance of snow cover across Canada this fall, has likely contributed to an early start of cold temperatures across the Central and Eastern US but the lack of snow cover is now likely contributing to milder temperatures.