Arctic Oscillation and Polar Vortex Analysis and Forecasts

October 19, 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) 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. 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 neutral and is predicted to straddle neutral to slightly positive over the next two weeks.
- The current neutral AO is reflective of mixed pressure/geopotential height anomalies across the Arctic with mixed pressure/geopotential height anomalies

across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently negative with positive pressure/geopotential height anomalies spread across Greenland and Iceland; and the NAO is predicted to trend positive this week and continue into next week as pressure/geopotential height anomalies are predicted to slowly turn negative across Greenland the next two weeks.

- This week ridging/positive geopotential height anomalies with normal to above normal temperatures will dominate much of Europe including the United Kingdom (UK) with troughing/negative geopotential height anomalies with normal to below normal temperatures limited to Scotland and Scandinavia. However next week the pattern is predicted to transition to troughing/negative geopotential height anomalies with normal to below normal temperatures in Western Europe including the UK with ridging/positive geopotential height anomalies with normal to above normal temperatures for Eastern Europe.
- The predicted general pattern for Asia this week is troughing/negative geopotential height anomalies in Western Asia with ridging/positive geopotential height anomalies in Eastern Asia. However next week, ridging/positive geopotential height anomalies are predicted to strengthen across Western Asia forcing troughing/negative geopotential height anomalies across East Asia. This pattern favors normal to below normal temperatures in Northwestern Asia with normal to below normal temperatures in Southern and Eastern Asia this week. However next week normal to below normal temperatures are predicted to spread south and east out of Northwestern Asia with normal to above normal temperatures in Southeastern Asia.
- The general pattern for North America this week is for ridging/positive geopotential height anomalies in Alaska and the Gulf of Alaska forcing troughing/negative geopotential height anomalies coupled with normal to below normal temperatures in much of Canada and the Northwestern United States (US) with more ridging/positive geopotential height anomalies and normal to above normal temperatures in the Eastern US. However next week the pattern is predicted to shift east with ridging/positive geopotential height anomalies and normal to above normal temperatures moving into western North America while troughing/negative geopotential height anomalies accompanied by normal to below normal temperatures slides into eastern North America including the Eastern US.
- In the Impacts section I discuss the Northern Hemisphere (NH) winter forecast and what to expect from the polar vortex (PV). The blog also completes its transition from summer to winter format.

Impacts

There is a lot that I actually want to write about today but unfortunately, I cannot cover it all today but hopefully over the next few weeks.

It is written in the eighth chapter of Deuteronomy "Man cannot live on bread alone." I have tried to argue a seasonal forecast corollary – seasonal forecasts cannot be accurate based on ENSO (El Niño/Southern Oscillation) alone. Last week NOAA's Climate Prediction Center issued its official winter forecast. I performed a Google search this weekend and this news article popped up in my feed: NOAA winter 2020/21 outlook.

I read it and when I was done, I thought this article doesn't present a very flattering portrait of the state of winter seasonal forecasting and this includes my own comments in the article (that I was not expecting to read)! First it highlights how little progress has been made with seasonal forecasting. The NOAA forecast is a pretty much a straight La Niña forecast that is appearing likely this winter. The relationship between La Niña and US precipitation and temperature anomalies that almost exclusively determined NOAA's forecast is basically unchanged from our analysis of this relationship performed in the 1980's and certainly the 1990's. And if you compare this upcoming winter's outlook with the most recent La Niña winter of 2017/18 you will be hard to find any differences: NOAA winter 2017/18 outlook.

A simple correlation of La Niña with NH temperatures reveals the predicted temperature pattern by NOAA with increased likelihood of below normal temperatures stretching from Alaska to the Pacific Northwest and the Northern Plains (**Figure i**). There is also a suggestion of above normal temperatures in the Southeastern US though that relationship does not seem as robust. But include some global warming in the forecast and you can reproduce the NOAA temperature forecast. In **Figure ii** I include the ECMWF winter forecast which predicts a similar pattern but is more aggressive with global warming, I would argue. Regardless the conclusion is that the La Niña theme is consistent across forecast platforms.

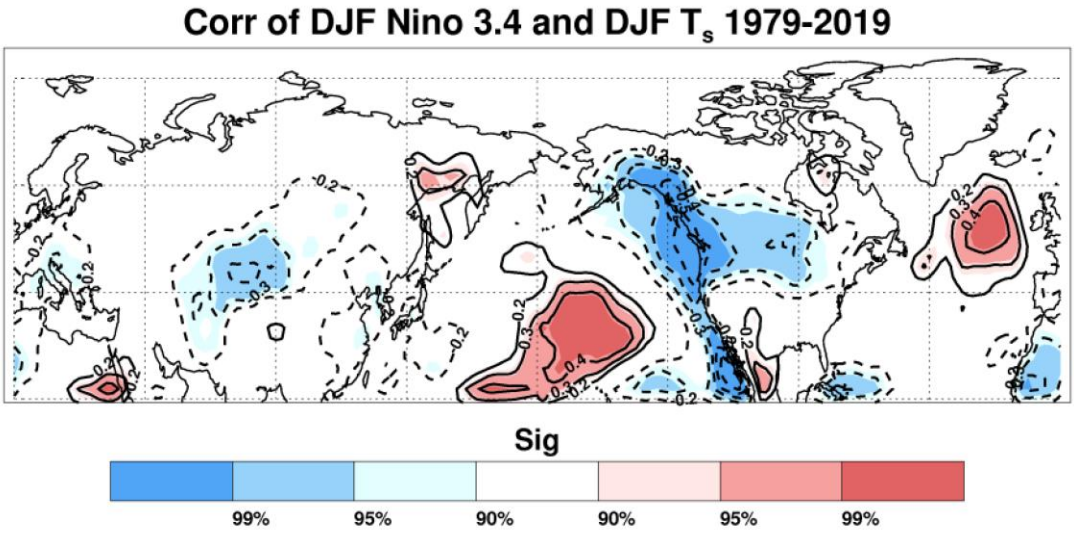

Figure i. Correlation of Niño 3.4 index with NH December, January and February surface temperatures 1979/90 through 2019/20 (contouring starting at value of 0.20). Statistically significance is shaded. Index is inverted to show temperature anomalies for La Niña.

ENSO is the largest and most important teleconnection phenomenon that we understand and when a robust ENSO event is anticipated, it would be malpractice not to weigh it heavily in a winter outlook. I just don't think ENSO should be the only predictor we use in a winter outlook, but that NOAA heavily relies on ENSO in its forecasts doesn't bother me very much or even as much as it used to. It what follows the forecast that I take issue with. NOAA doesn't expect the polar vortex to have much influence this winter. If this quote is accurate then I have a hard time understanding how this conclusion is derived. During the last La Niña winter in 2017/18 the polar vortex played a significant role in the observed weather anomalies with at least two significant PV events that winter (in late December and early January and then again in mid-February through March) and as explained by NOAA in its retrospective: [NOAA winter 2017/18 recap] played a major role in shaping the winter means. Of course on this site you can find my own retrospective of that winter.

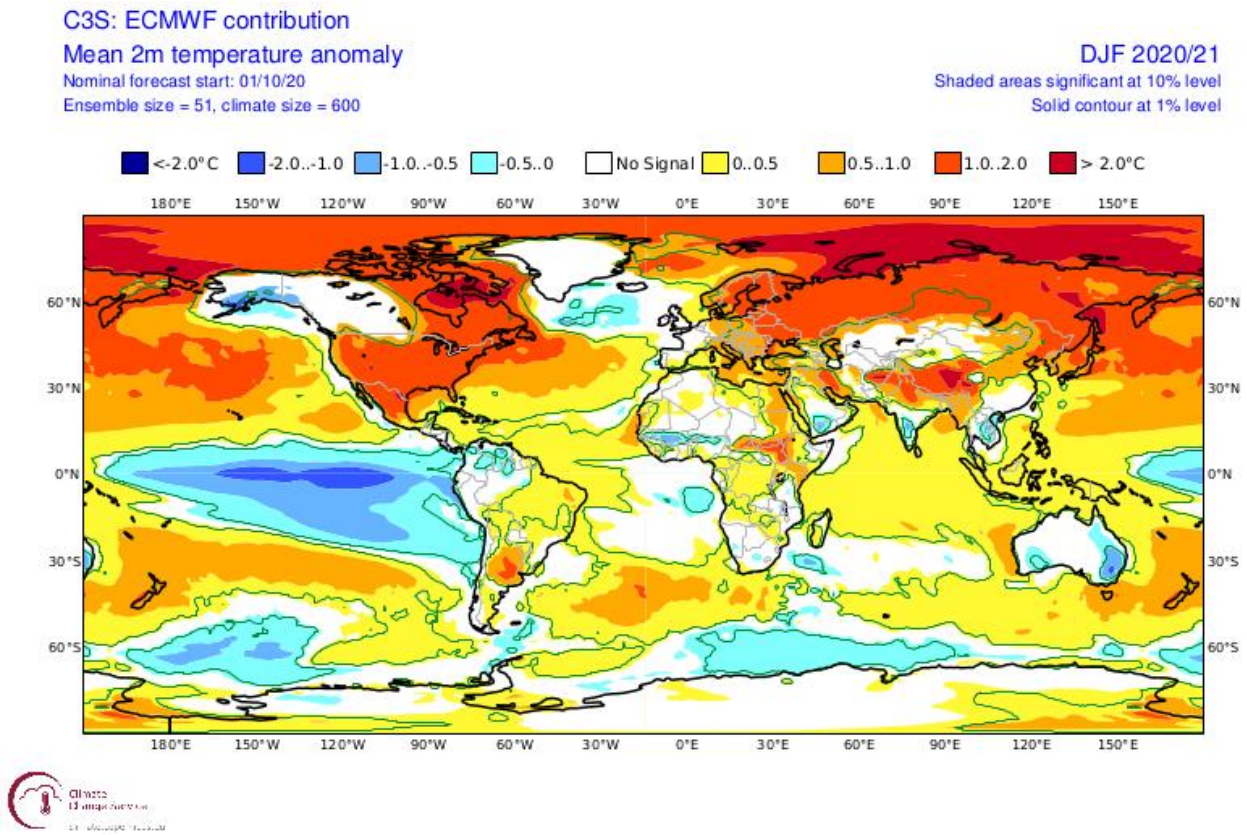

Figure ii. Predicted surface temperature anomalies for December, January and Febraury 2020/21 from the ECMWF model. Plot available from https://climate.copernicus.eu/charts/c3s_seasonal/.

I created a table of all the observed La Niña winters over the past twenty years. The table includes the winter, the strength of La Niña, the phase of the quasi-biennial oscillation (QBO and I looked at 50-70 hPa), how many major mid-winter warmings were observed that winter and whether it was generally relatively cold or warm that winter across the Eastern US.

La Niña winters past twenty years

Year	La Niña	QBO	Major Mid-winter warming	Eastern US temperatures
2017/18	weak	westerly	1	cold
2011/12	weak	weak westerly	0	warm
2010/11	moderate	westerly	0	cold
2008/09	weak	westerly	1	cold
2007/08	moderate	easterly	1	cold late
2005/06	weak	easterly	1	warm
2001/02	weak	easterly	1	warm
2000/01	weak	westerly	2	cold
1999/2000	moderate	westerly	1	warm

I found it remarkable that over the past nine La Niñas of the past twenty years, eight major mid-winter warmings (MMWs; these are the strongest PV disruptions where the winds reverse at 10hPa and 60°N) were observed and these MMWs are equally distributed between westerly and easterly QBOs. They say past performance is not indicative of future results, but I would be resistant to argue against the influence of the PV this upcoming winter.

To end the discussion of La Niña, I think it will be interesting to watch sea surface temperatures (SSTs) in the North Pacific. From **Figures i** and **ii**, the expectation during La Niña is for the center or core of the warm SST anomalies to be in the central North Pacific south of the Aleutians with closer to normal SSTs along the North American west coast. This is related to the expectation of mid-tropospheric ridging in the same region as seen in **Figure iii**. With a ridge centered south of the Aleutians would favor troughing in western North America and more ridging along the US East Coast, consistent with the NOAA winter outlook. But from **Figure 14** the current SST pattern is inverted with the maximum positive SST anomalies near the West Coast and cooler SST anomalies in the central North Pacific. If this persists for the entire winter, I am willing to bet that the North Pacific ridging will be to the east of the forecast with downstream troughing east of the Rockies and colder temperatures. However, SSTs are very sensitive to the atmospheric circulation and the surface winds especially and a lot can change in just a few weeks as happened in fall 2016. So. for now it is something to watch but too premature to utilize to make a long-term prediction. And I am certainly not going to predict the winter SSTs in October.

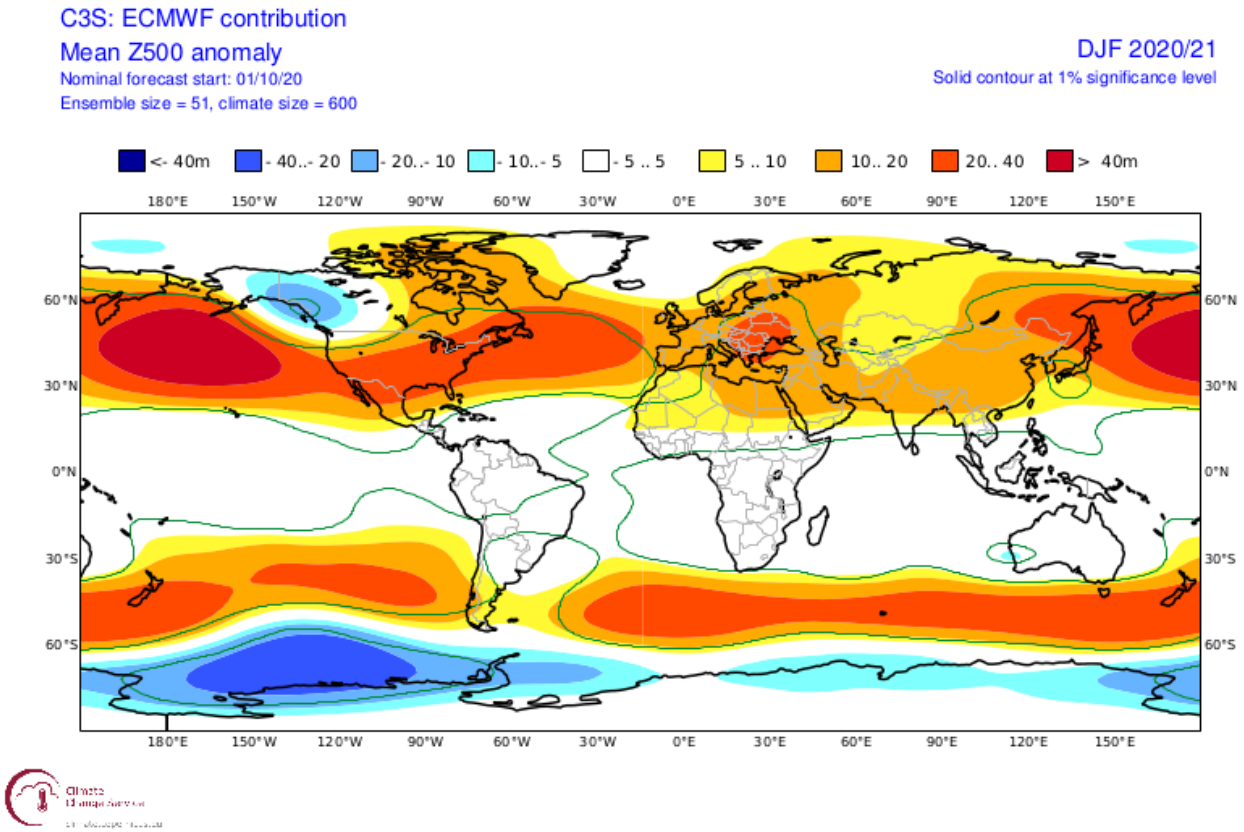

Figure iii. Predicted 500 hPa geopotential height anomalies for December, January and February 2020/21 from the ECMWF model. Plot available from https://climate.copernicus.eu/charts/c3s_seasonal/.

Getting back to the article, to be fair I am also critical of my own quote predicting a harsher winter based on the PV. Not sure if I said the quiet part out loud where I provided my wishcast and not a forecast or I was just flat out drunk, but I don't know that either. Using the past eight La Niñas to forecast a harsh winter courtesy of the PV is a poor use of statistics.

In the article there are only two predictors mentioned ENSO and Eurasian snow cover extent (SCE). It is amazing to me that as far as I know there are really only two predictors mentioned in the media used for winter forecasts. This demonstrates how hard it is to find a dependable signal to make seasonal forecasts. Of course, ENSO is universally used and Eurasian or Siberian snow cover is much more controversial and may even be more correctly described as a niche predictor. And though they are not mentioned in the article, Arctic sea ice and extratropical sea surface temperatures could be thrown into the mix as well.

From the article, you may walk away with the impression that we don't know much about the PV and what influences its behavior, but I believe much progress has been made over the past decade or so in this regard.

We know the atmospheric circulation pattern that is most favorable for weakening the PV. It consists of blocking/high pressure near the Urals and Scandinavia region with low pressure in the respective ocean basins. The weather forecast models are predicting such a pattern heading into November (see **Figure 8**). I think that it is hard to know now, but if this pattern dominates that monthly averages of November (something that is not really predicted in the CFS forecast below) this will have an impact on the PV and will make it vulnerable to further weakening. And as shown in Cohen et al. 2014 this pattern in November is strongly related to increased vertical energy transfer between the troposphere and the stratosphere in December and weakening of the PV in late December and into January.

In the article the harsher winter forecast is not based on La Niña but rather Eurasian SCE. More extensive Eurasian SCE favors/predicts a weaker winter PV. For much of the month, Eurasian SCE has been near normal to possibly slightly below normal but the expectation is for a strong finish to the month but that is hard to know for sure at this time. I do want to discuss Eurasian SCE in more detail but that will have to wait for another week. We did find that October SCE in East Asia has a stronger relationship with the PV/AO than SCE in Western Asia. We never published the result but it has been shown by other groups (e.g., Han and Sun 2018 and Wegmann et al. 2020) but for November. If the favorable pattern for weakening the PV is ridging in Western Asia and troughing in Eastern Asia, then an extensive snow cover especially in East Asia makes sense where snow induced cooling forces troughing. Based on the GFS snowfall forecast (**Figure 10**), there should be a strong push of snow cover in East Asia at month's end and into early next month. Heavy snowfall in East Asia is an indicator of weaker PV.

It is early in the process but the prospects for a PV weakening look intriguing based on the weather forecasts. I will likely discuss this in much more detail in the coming weeks, but persistence is critical. I would think conditions in the Arctic increase this likelihood and there is much to discuss just on the current conditions in the Arctic that can only be described as going off of the rails. But like other subjects raised earlier, it will have to wait for another day.

1-5 day

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

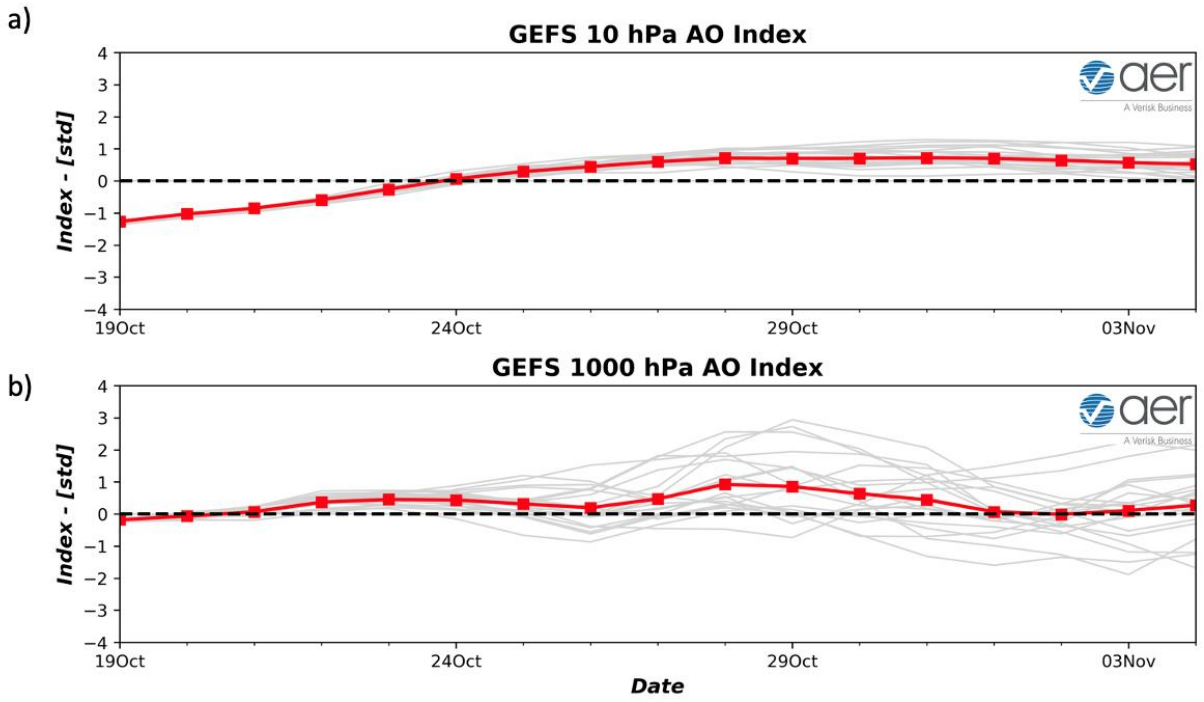

Figure 1. (**a**) The predicted daily-mean AO at 10 hPa from the 00Z 19 October 2020 GFS ensemble. (**b**)The predicted daily-mean near-surface AO from the 00Z 19 October 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ridging/positive geopotential height anomalies are predicted to dominate much of Europe with troughing/negative geopotential height anomalies limited to Scotland and Scandinavia (**Figure 2**). This pattern favors normal to above normal temperatures for much of Europe including much of the UK with normal to below

normal temperatures in Scotland and Scandinavia (**Figure 3**). Across Asia this week, predicted ridging/positive geopotential height anomalies in Europe will force downstream troughing/negative geopotential height anomalies across Western Asia with more ridging/positive geopotential height anomalies in Eastern Asia (**Figure 2**). This pattern favors widespread normal to above normal temperatures for much of Southern and Eastern Asia with normal to below normal temperatures mostly limited to Northwestern Asia **(Figure 3**).

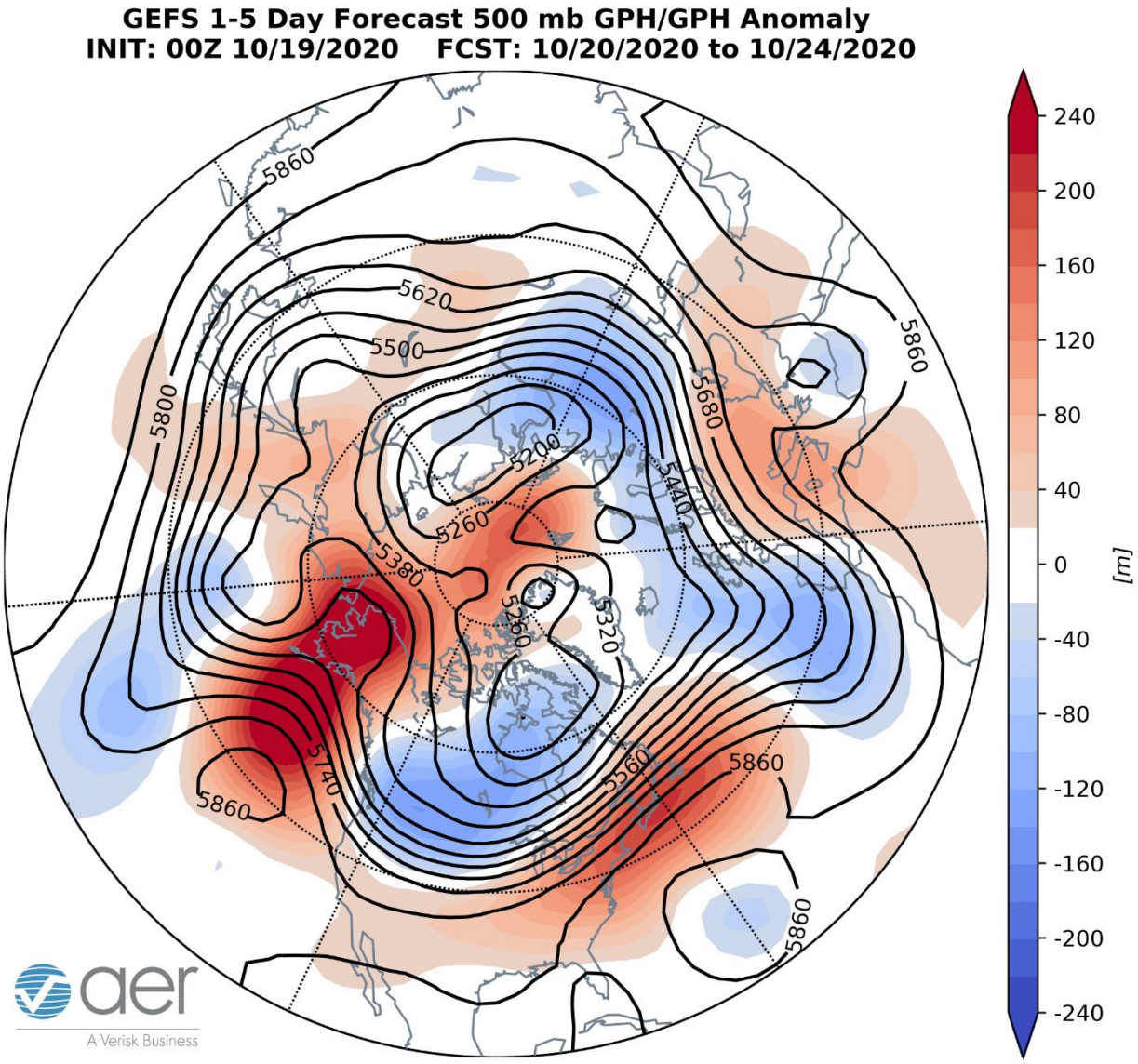

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 20 – 24 October 2020. The forecasts are from the 00z 19 October 2020 GFS ensemble.

This week predicted strong ridging/positive geopotential height anomalies centered on Alaska and in the Gulf of Alaska will force deepening troughing/negative geopotential height anomalies downstream across much of Canada and the Northwestern US with more ridging/positive geopotential height anomalies along the North American east coast **(Figure 2). T**his pattern is predicted to bring normal to above normal temperatures across Alaska, the Southwestern US, the Canadian Maritimes and the Eastern US with normal to below normal temperatures for Western, Central and Northeastern Canada and the Northwestern US **(Figure 3).**

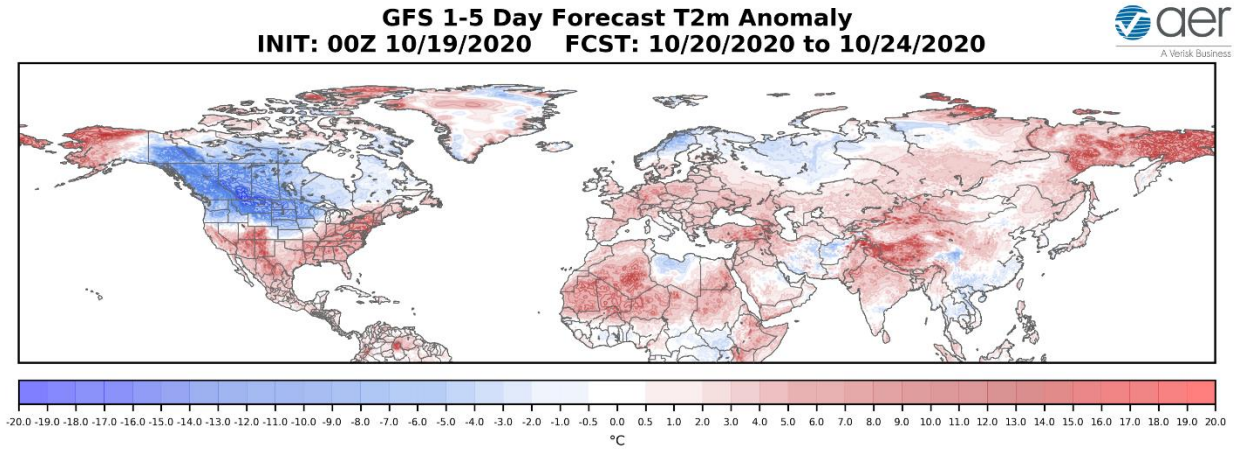

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 20 – 24 October 2020. The forecast is from the 00Z 19 October 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across Northern Eurasia including Scandinavia while warmer temperatures will cause snow melt in Central Asia (**Figure 4**). Troughing and/or colder temperatures are predicted to support new snowfall across Southern Alaska, Western and Central Canada and along the US-Canadian border with little predicted snow melt (**Figure 4**).

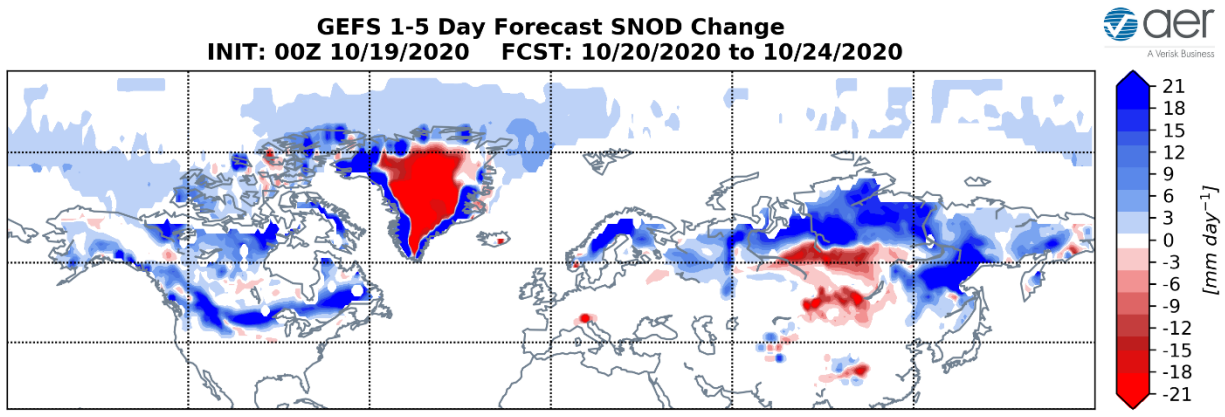

Figure 4. Forecasted snow depth changes (mm/day; shading) from 20 – 24 October 2020. The forecast is from the 00Z 19 October 2020 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain neutral to positive next week **(Figure 1**) as negative geopotential height anomalies return to the Central Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with the return of negative geopotential height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to flip positive as well.

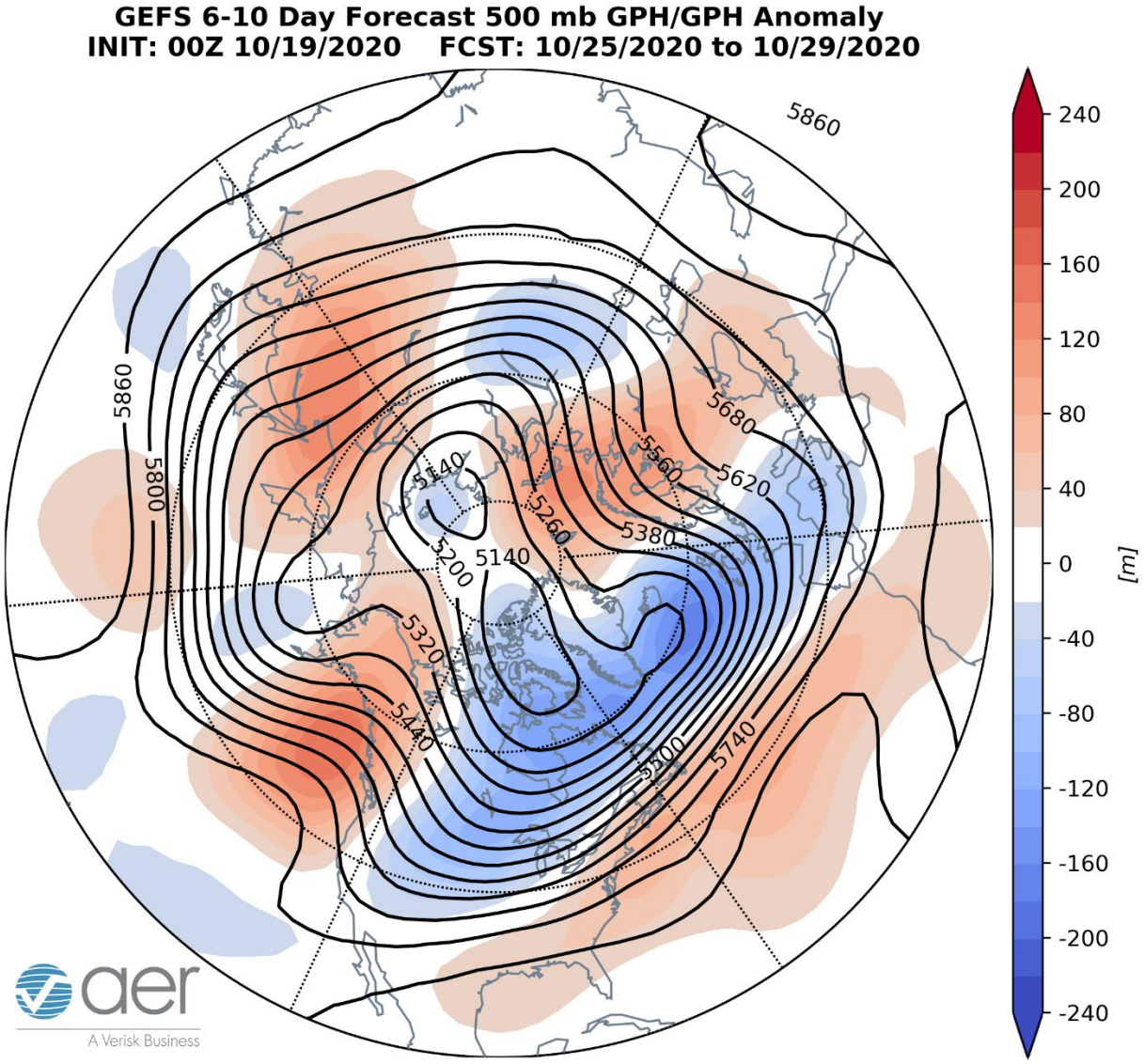

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 25 – 29 October 2020. The forecasts are from the 00z 19 October 2020 GFS ensemble.

Troughing/negative geopotential height anomalies previously in the eastern North Atlantic are predicted to come ashore across Western Europe forcing previous ridging/positive geopotential height anomalies into Eastern Europe (**Figures 5).** This pattern favors normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe (**Figure 6**). Eastern European ridging/positive geopotential height anomalies are predicted to expand into Western Asia with previous troughing/negative geopotential height anomalies sliding into central Asia with more ridging/positive geopotential height anomalies in Eastern Asia this period (**Figure 5**). This is predicted to expand normal to below normal temperatures in Northwestern Asia into Western Siberia **with** normal to above temperatures In Southwestern, Central and Eastern Asia **(Figure 6**).

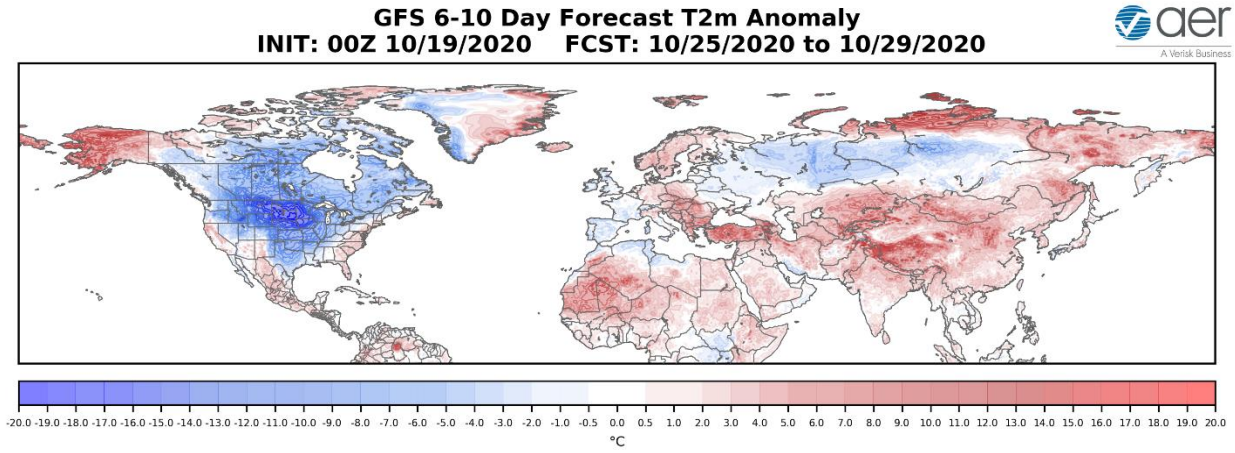

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 25 – 29 October 2020. The forecasts are from the 00Z 19 October 2020 GFS ensemble.

Persistent ridging/positive geopotential height anomalies in Alaska and the Gulf of Alaska will force troughing/negative geopotential height anomalies in central North America with more ridging/positive geopotential height anomalies along the US East Coast this period (**Figure 5**). This pattern is predicted to bring widespread normal to below normal temperatures across much of Canada and the US but especially the Plains with normal to above normal temperatures confined to the edges including Alaska, the Desert Southwest, the US East Coast and the Canadian Maritimes **(Figure 6).**

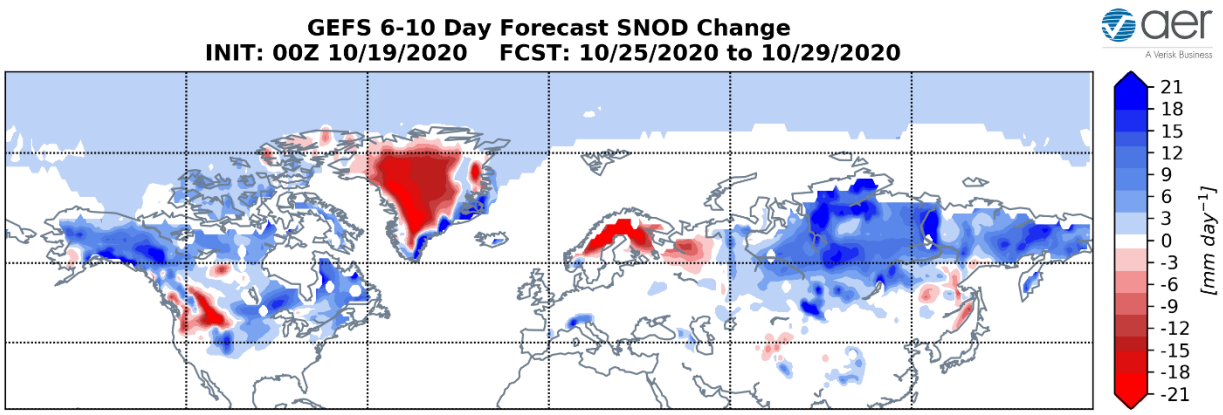

Figure 7. Forecasted snow depth changes (mm/day; shading) from 25 – 29 October 2020. The forecasts are from the 00Z 19 October 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across much of Northern Asia, the Alps and the Himalayas while warmer temperatures will cause snow melt in Scandinavia (**Figure 7**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, Central and Eastern Canada, the Central US and even possibly New England while warmer temperatures will cause snow melt in Western Canada and the Pacific Northwest (**Figure 7**).

11-15 day

With mostly negative geopotential height anomalies across the Arctic centered over the Canadian Archipelagos and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO is predicted to remain neutral to positive this period (**Figure 1**). With mostly negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is also predicted to remain neutral to positive.

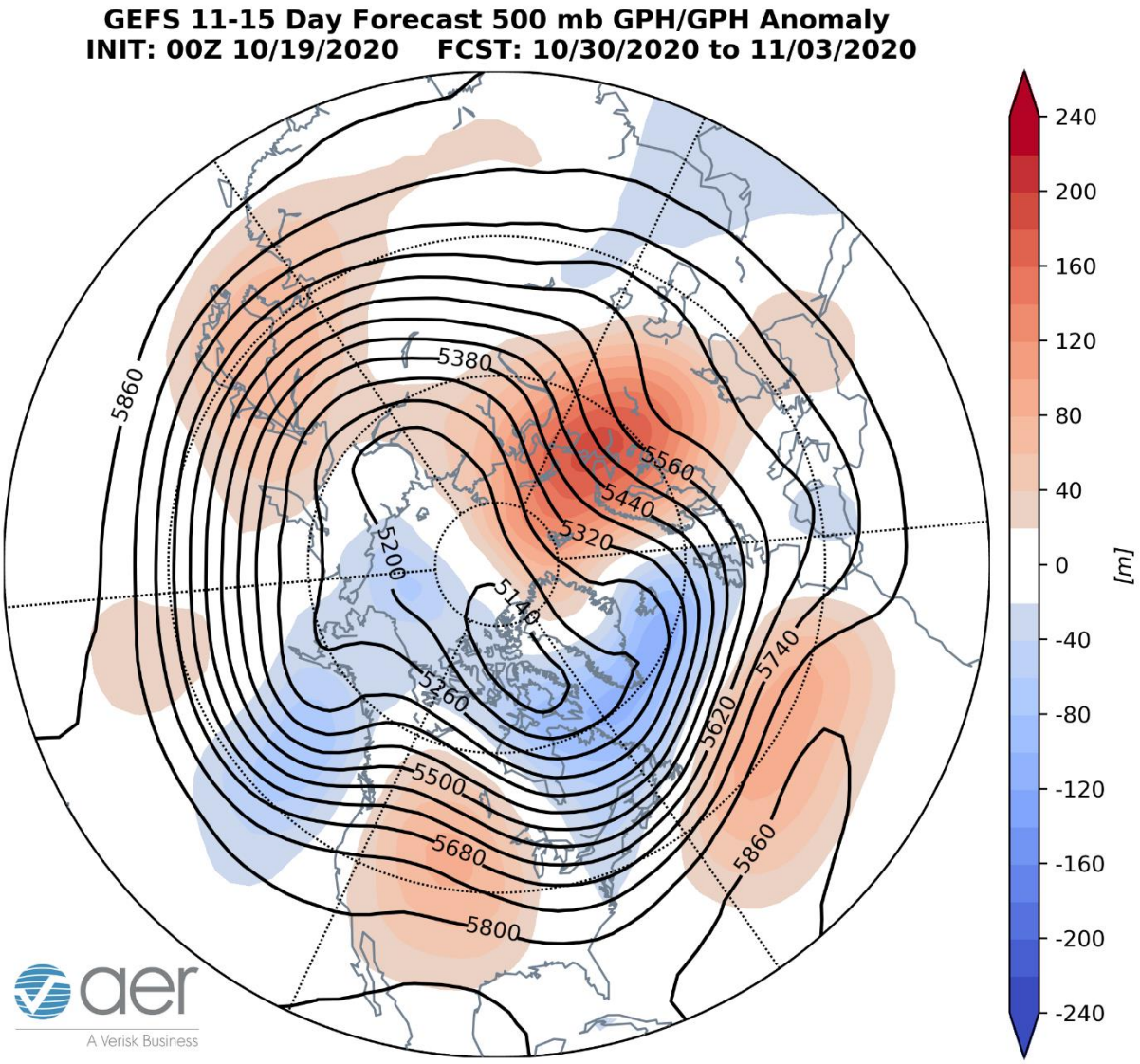

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 30 October – 3 November 2020. The forecasts are from the 00z 19 October 2020 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to persist across Western Europe as ridging/positive geopotential height anomalies are predicted to strengthen across Eastern Europe this period (**Figures 8**). The forecast is for normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe this period (**Figures 9**). Predicted strengthening ridging/positive geopotential height anomalies over Western Russia will support expanding troughing/negative geopotential height anomalies across Central and East Asia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Western Russia, northern Siberia and Southern and Eastern

Asia with normal to below normal temperatures in Central Asia and Southern Siberia (**Figure 9**).

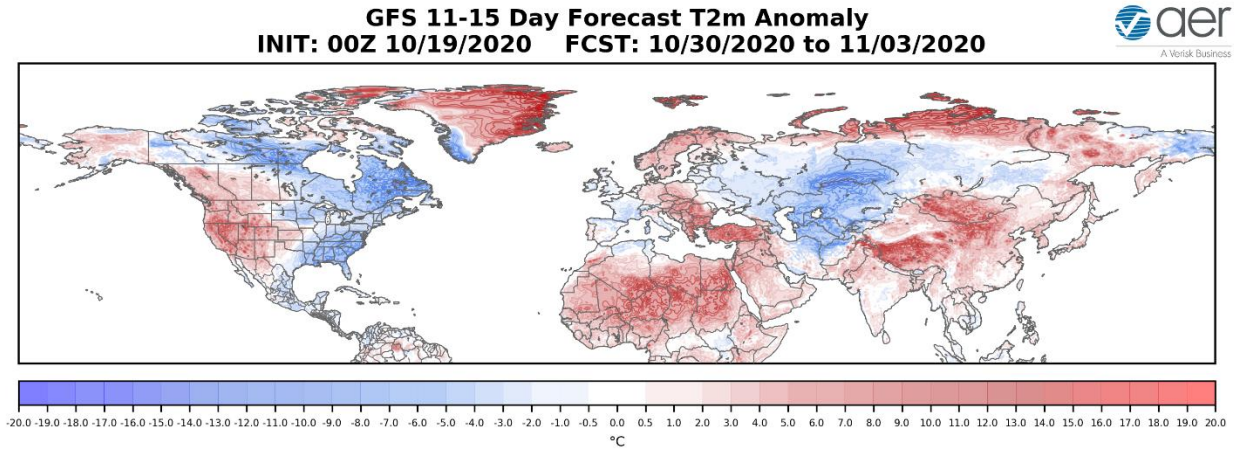

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 30 October – 3 November 2020. The forecasts are from the 00z 19 October 2020 GFS ensemble.

Ridging/positive geopotential height anomalies previously in the Gulf of Alaska are predicted to come ashore across western North America forcing troughing/negative geopotential height anomalies into eastern North America (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures for the Eastern US and Eastern Canada (**Figure 9**).

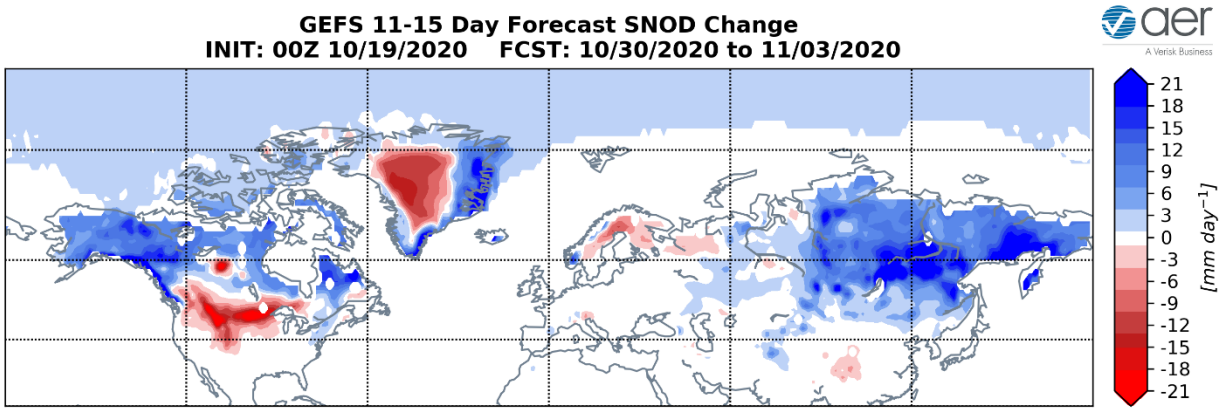

Figure 10. Forecasted snow depth changes (mm/day; shading) from 30 October – 3 November 2020. The forecasts are from the 00z 19 October 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across much of Northeastern Asia while warmer temperatures will cause snow melt in

Scandinavia (**Figure 10**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, Northern and Eastern Canada and even possibly New England while warmer temperatures will cause snow melt in Southwestern Canada, the US Northern Rockies and possibly the Northern Plains (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows above normal PCHs in both the troposphere and the stratosphere (**Figure 11**). The warm/positive PCHs are currently peaking in the lower stratosphere with gradual weakening into next week with cold/negative PCHs possible by the end of the month in the troposphere and especially the stratosphere (**Figure 11**).

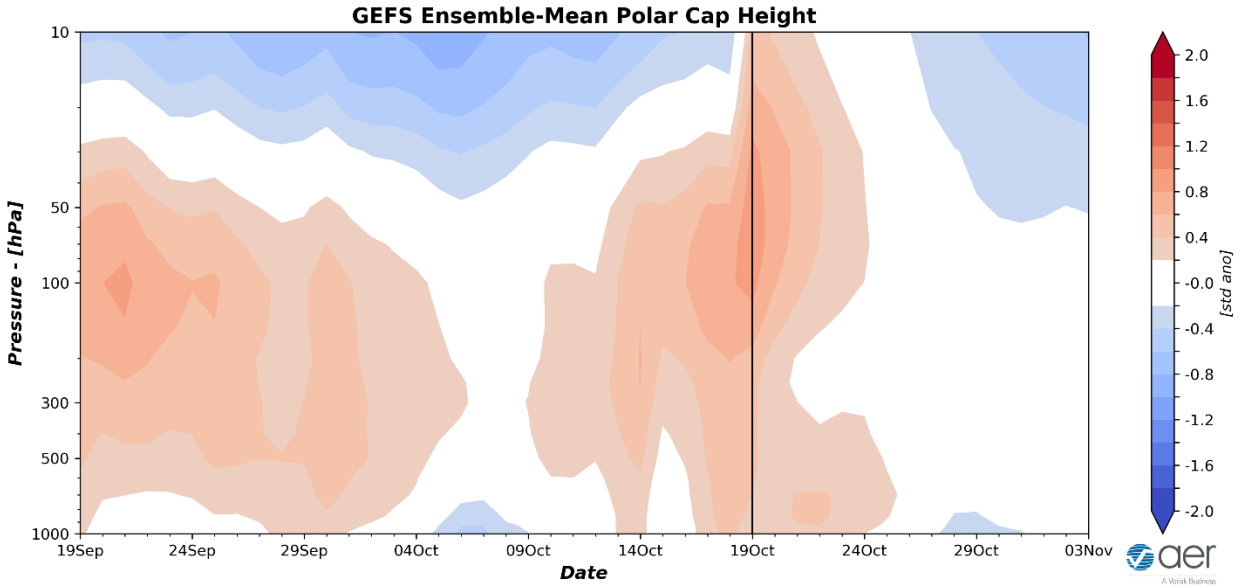

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 19 October 2020 GFS ensemble.

The current weak PCHs in the lower troposphere are consistent with the predicted near neutral AO this week (**Figure 1**). The forecast is for the warm PCHs in the troposphere to dampen over time and possibly flip negative favoring a positive AO. However, the strength of the PCH typically vacillates and I have low confidence in this forecast.

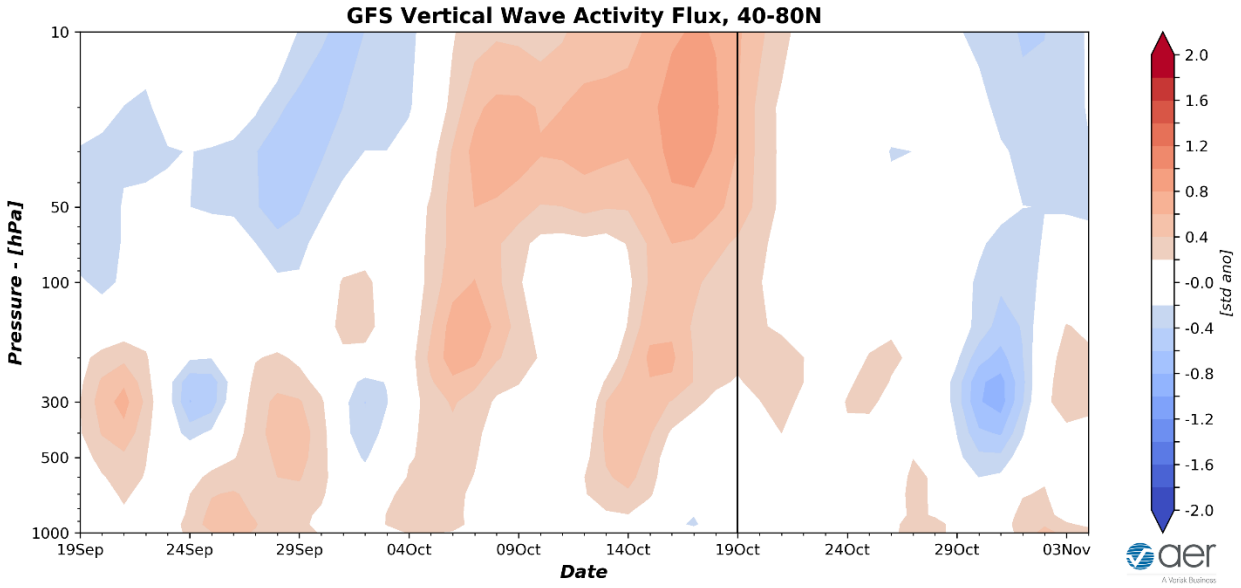

Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 19 October 2020 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport shows the active WAFz of last week winding down with a quieter two weeks predicted (**Figure 12**). I still believe that the pulse of WAFz last week resulted in a minor disruption of the PV in the form of stretching that is related to the cold weather across central and eastern North America predicted for the next two weeks (**Figure 1**).

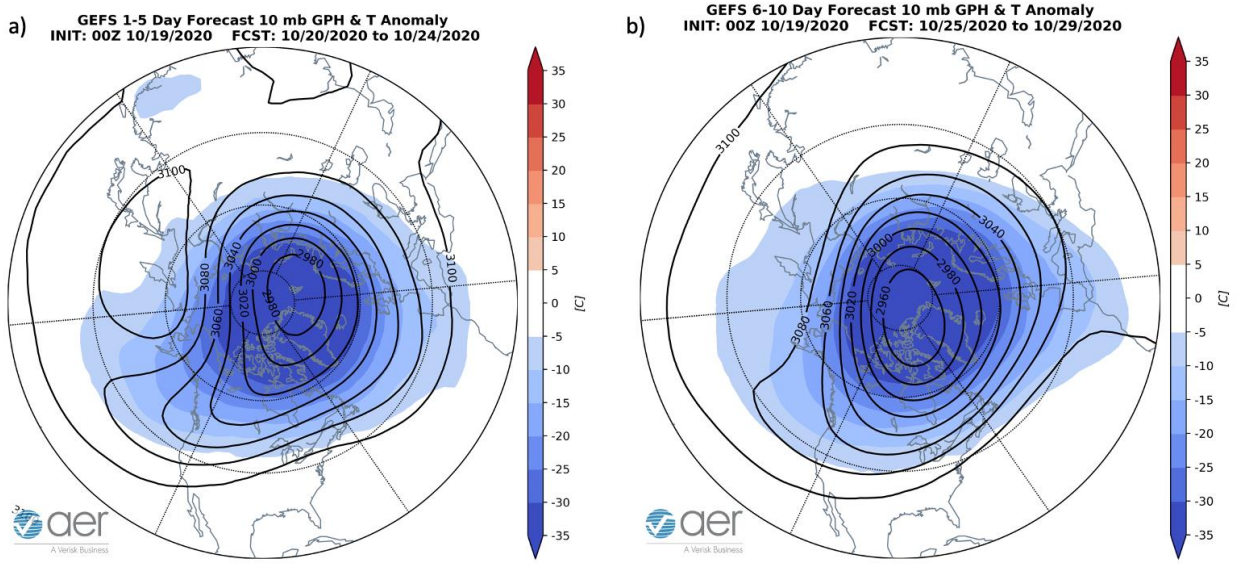

Figure 13. (**a**) Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 20 –24 October 2020. (**b**) Same as (a) except forecasted averaged from 25 – 29 October 2020. The forecasts are from the 00Z 19 October 2020 GFS model ensemble.

The minor perturbation of the PV or reflective event is characterized by ridging in the northern North Pacific sector and an elongation of the PV mostly into North America (**Figure 13**). At first the PV is displaced towards the Barents-Kara Seas/Greenland and then closer to North Pole (**Figure 13**). The forecast of a PV position centered over Svalbard coupled with an elongation of the PV (**Figure 13**) is supportive of relatively cold temperatures in eastern North America.

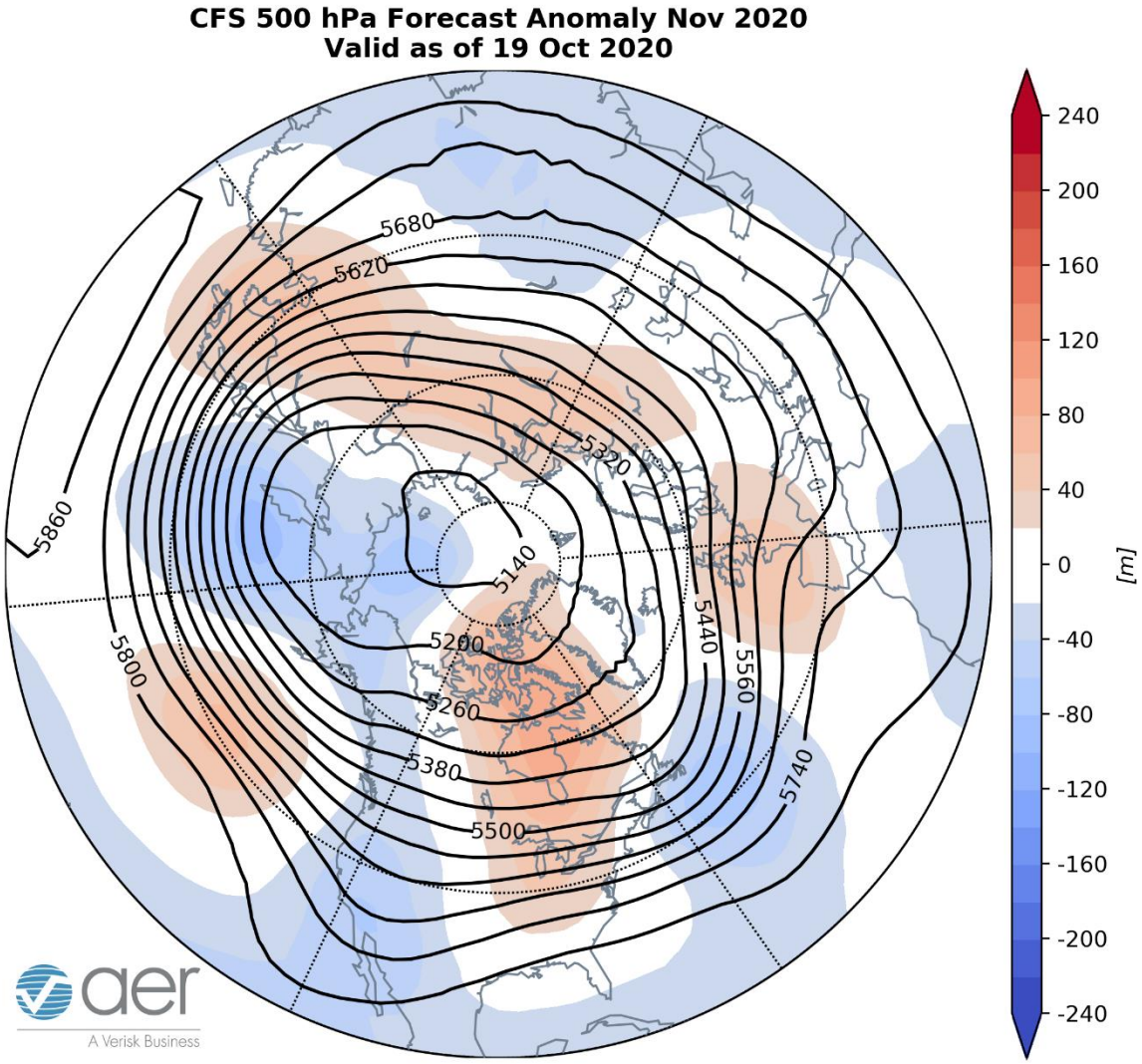

Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for November 2020. The forecasts are from the 00Z 19 October 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and the surface temperatures (**Figure 15**) forecast for November from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Western Europe, from the Urals to East Asia, South of the Aleutians and Eastern Canada with troughing in Eastern Europe, Southcentral Asia, Eastern Siberia, western North America and the Canadian Maritimes (**Figure 14).** This pattern favors relatively warm temperatures for much of Europe, Northern and Eastern Asia and much of North America with seasonable to relatively cold temperatures for Southern Europe, Southern Asia and the Canadian Maritimes (**Figure 15**)**.** I don't necessarily consider these forecasts dependable and I believe today's are worse than average.

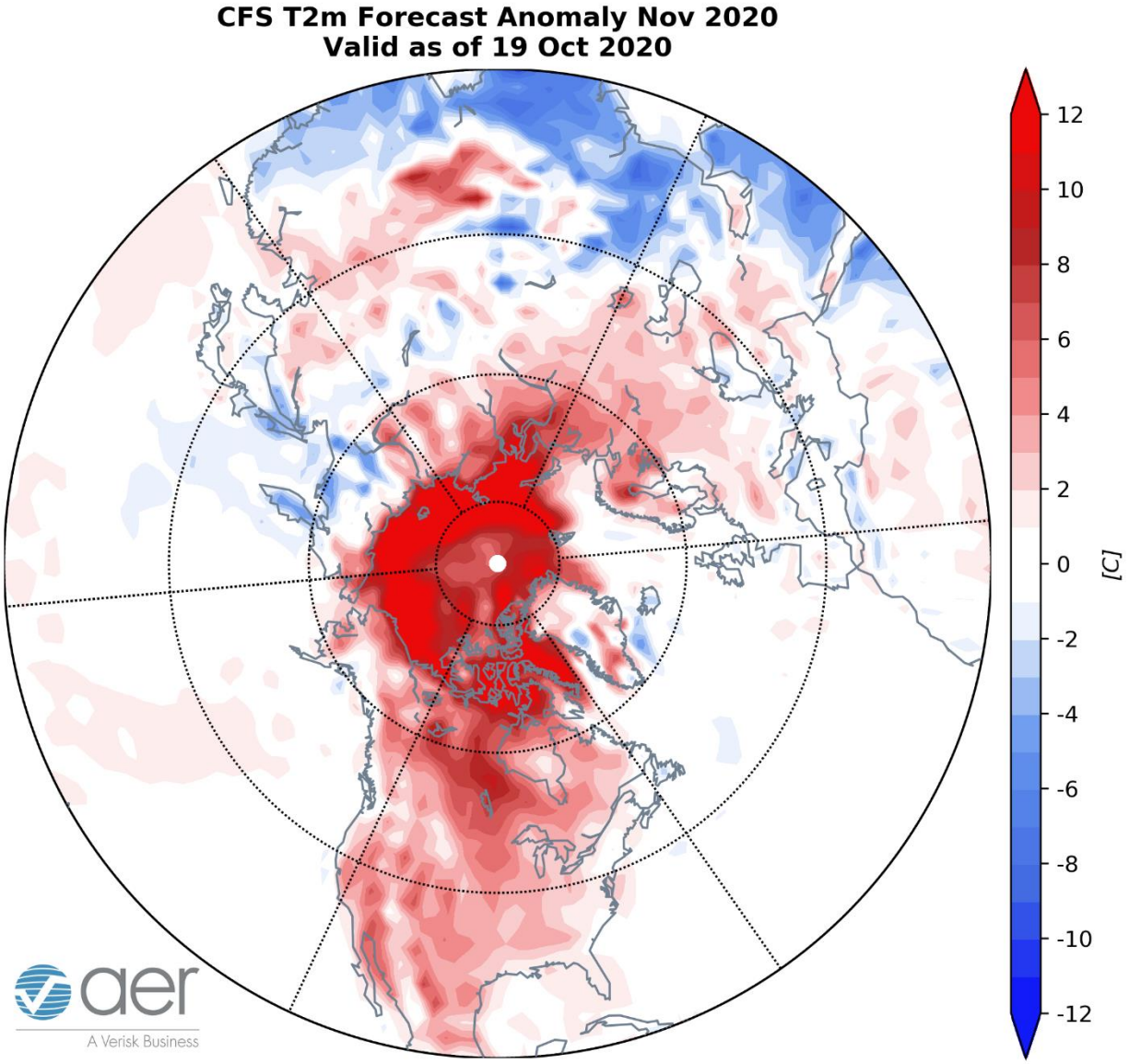

Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for November 2020. The forecasts are from the 00Z 19 October 2020 CFS.

Surface Boundary Conditions

Arctic sea ice extent

Arctic sea ice continues to grow at a slow rate and is now at record low levels below 2012 levels. Large negative sea ice anomalies exist continuously from Alaska to the Barents-Kara Seas (**Figure 16**). Below normal 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 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, Beaufort and Bering seas may favor colder temperatures across North America but has not been shown to weaken the PV.

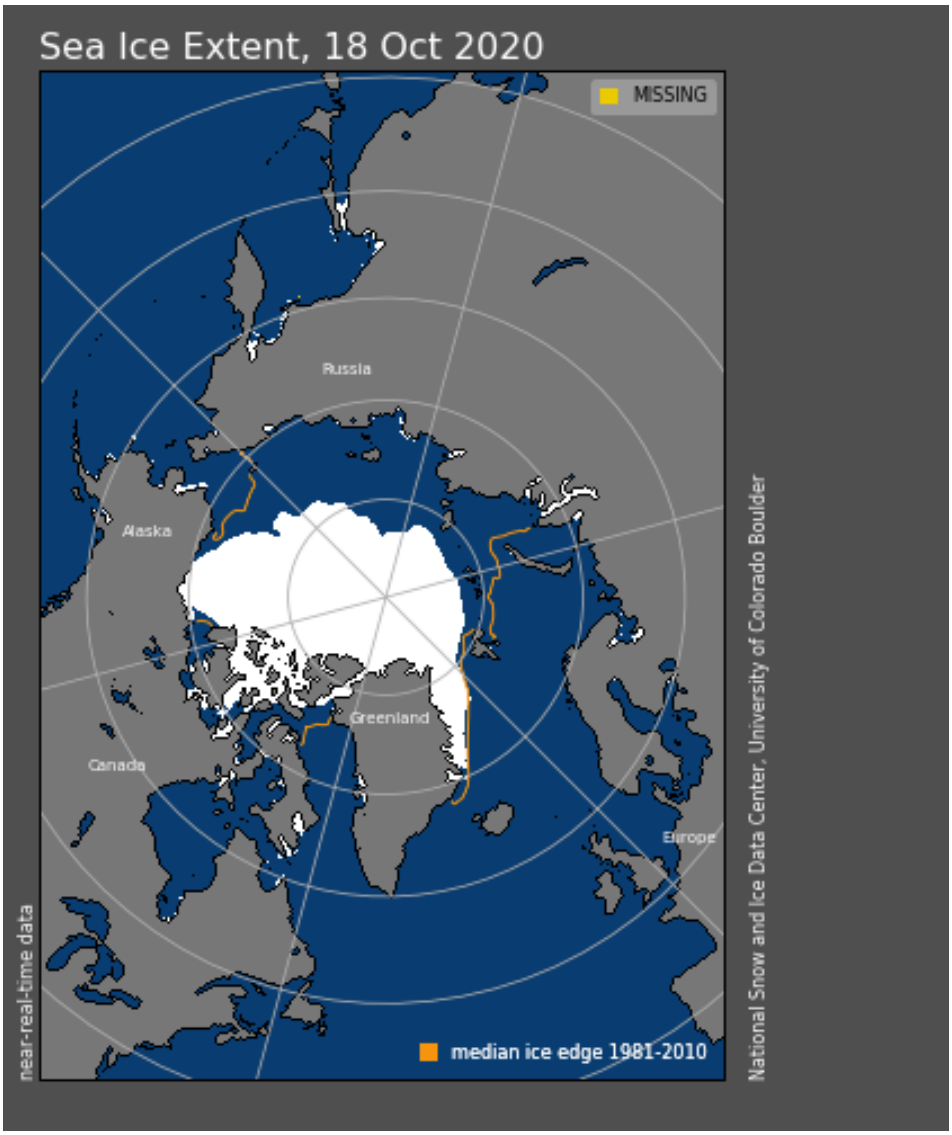

Figure 16. Observed Arctic sea ice extent on 18 October 2020 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC). Snow and Ice Data Center (NSIDC).

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies continue to cool slowly and we have now entered weak La Niña conditions (**Figure 14**) and La Niña is expected to persist through the fall. 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.

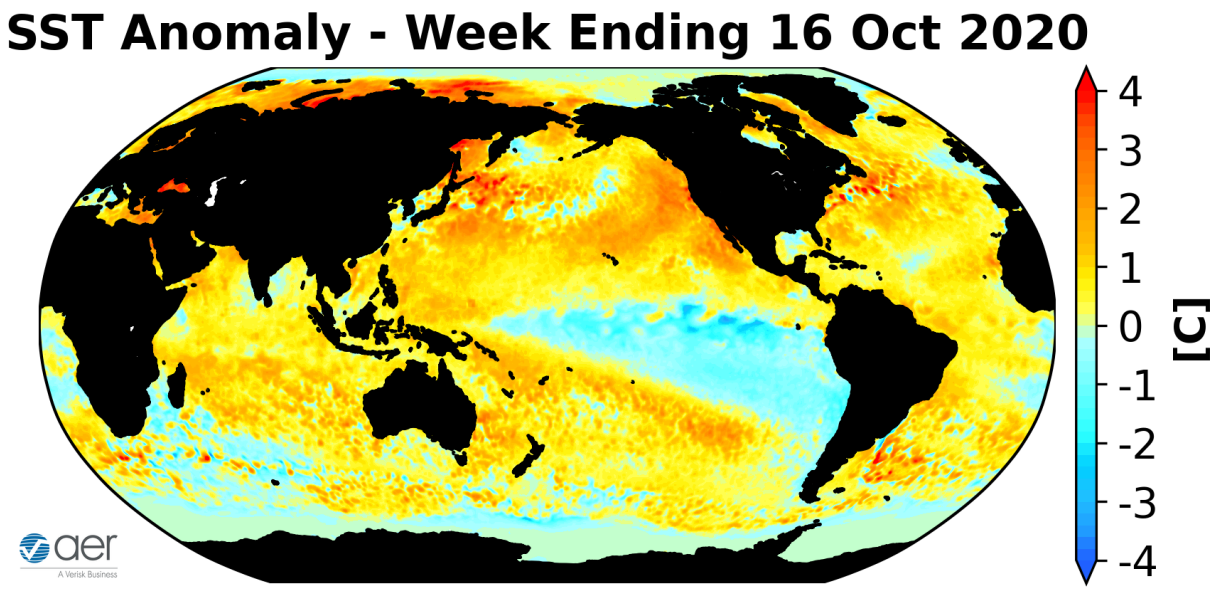

Figure 17. The latest weekly-mean global SST anomalies (ending 16 October 2020). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase five (**Figure 15**). The forecasts are for the MJO to weaken where no phase is favored. MJO phase five in the short term favors troughing across the US with ridging in Canada and then transitioning to troughing in western North America with ridging in eastern North America. The MJO does not seem to be contributing to the short term pattern across North America.

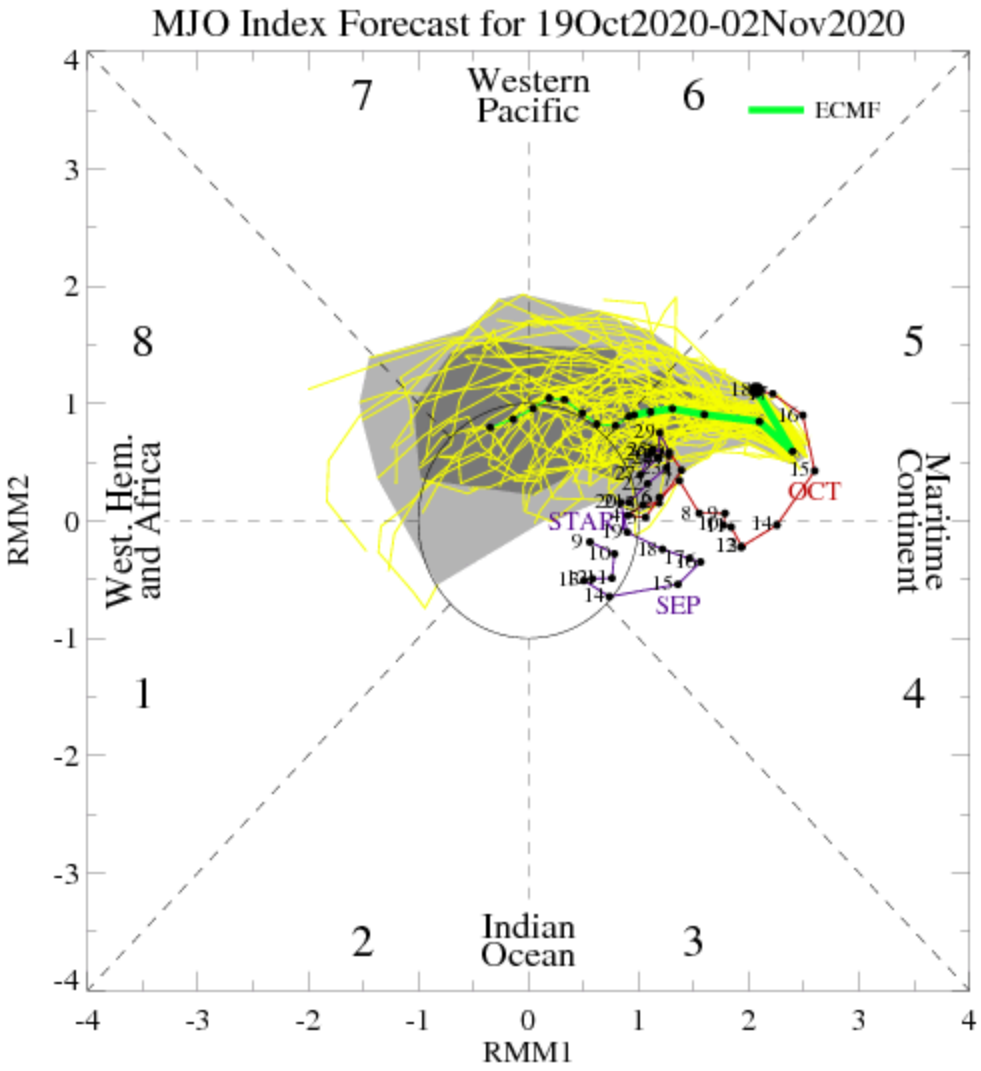

Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 19 October 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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 advance continues its climb across Eurasia and is currently near decadal means. Snow cover advance will likely continue to advance especially across East Asia the next two weeks as troughing and cold temperatures spread across the region. Above normal snow cover extent in October, favors a strenghtened 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.

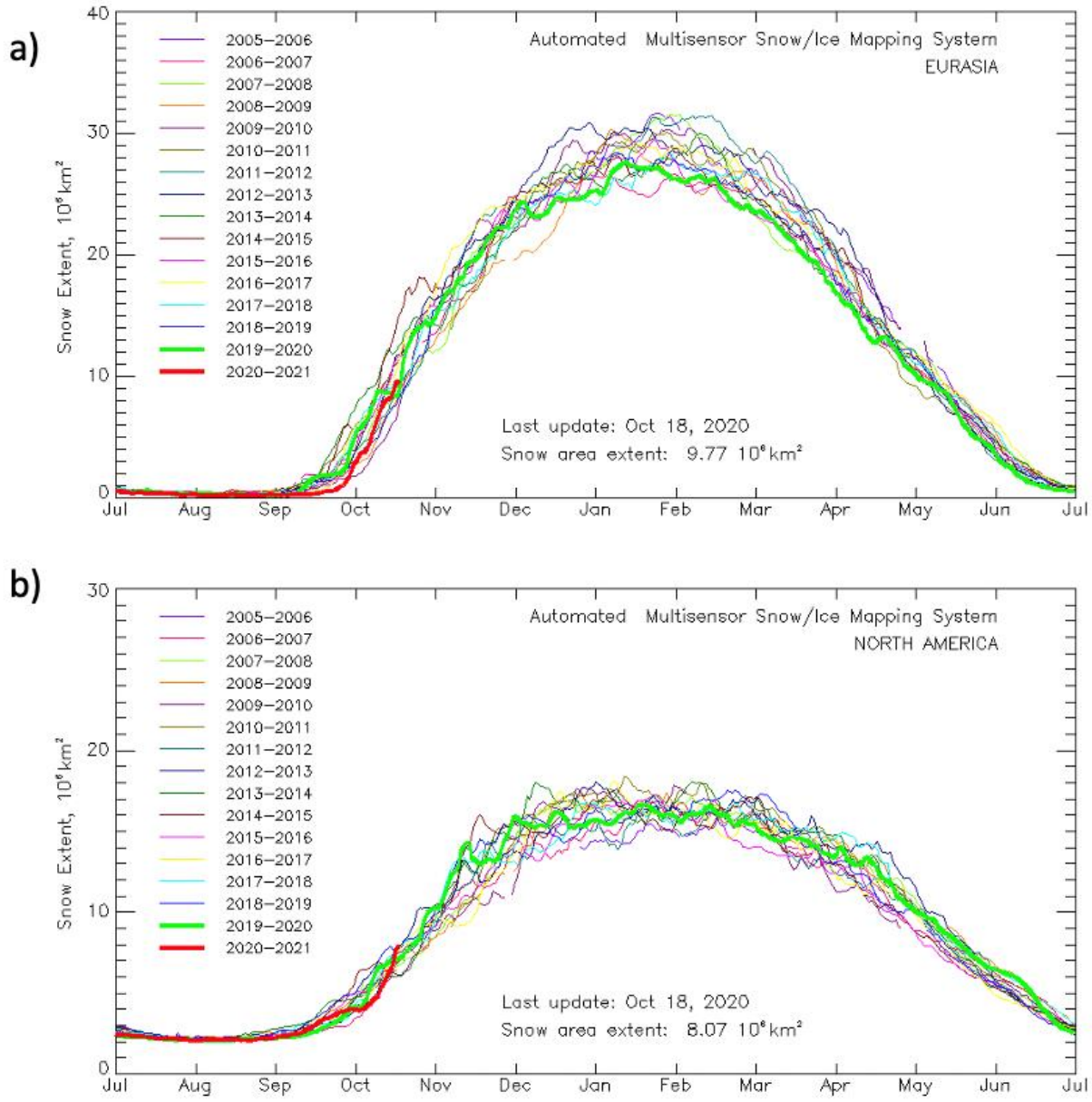

Figure 19. Observed Eurasian (top) and North American (bottom) snow cover extent through 18 October 2020. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html

North American snow cover is also steadily advancing to near decadal highs and is comparable to last year at this time. The early advance of snow cover across Canada this fall, has likely contributed to an early start of cold temperatures across the Central US.