Arctic Oscillation and Polar Vortex Analysis and Forecasts

November 30, 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 neutral and is predicted to remain neutral to negative the next two weeks.
- The current neutral AO is reflective of mostly negative pressure/geopotential height anomalies in the Central Arctic but positive pressure/geopotential height

anomalies on the periphery of the Arctic with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently also neutral with mixed pressure/geopotential height anomalies across Greenland and Iceland; and the NAO is predicted to trend negative the next two weeks as pressure/geopotential height anomalies are predicted to trend positive.

- The next two weeks, ridging/positive geopotential height anomalies in the central North Atlantic are predicted to force downstream troughing/negative geopotential height anomalies coupled with normal to below normal temperatures across Western and Central Europe including the United Kingdom (UK) while southwesterly flow ushers normal to above normal temperatures to Eastern Europe.
- Over the next two weeks ridging/positive geopotential height anomalies with normal to above normal temperatures becoming centered near the Urals are predicted to force troughing/negative geopotential height anomalies with normal to below normal temperatures to the south across Southwestern Asia and downstream across East Asia.
- The predicted pattern across North America the next two weeks is ridging/positive geopotential height anomalies with normal to above normal temperatures anchored across western North America will force troughing/negative geopotential height anomalies coupled with normal to below normal temperatures downstream across eastern North America and eventually to the southwest across the Southwestern United States (US).
- In the Impacts section I discuss the winter forecast for the Northern Hemisphere (NH) and the increasing likelihood of a polar vortex (PV) disruption.

Impacts

Certainly, today is one of those days that I envisioned when I embarked on the AO/PV blog where I share a forecast that not only includes tropical predictors but Arctic ones as well in formulating a winter temperature anomaly forecast for the Northern Hemisphere (NH), the stratospheric PV plays a central role in anticipating the atmospheric circulation and resultant weather anomalies in the coming weeks and even months and when I incorporate the latest research into my thinking and discussion. So, if there ever was a day to read the blog this might be it.

In **Figure i**, I present the AER winter (December, January and February) 2021 temperature anomaly forecast for the NH. The general pattern is relatively cold in the interior of the continents and relatively mild on the northern and southern edges. The largest negative departure from normal is in Central Asia with a secondary minimum in the Plains straddling the US-Canadian border. Europe is seasonable with some below normal temperatures in Central Europe. The largest positive temperature anomalies are in the Arctic with the largest departures centered in the Barents-Kara Seas with secondary maximums in Baffin Bay and the Bering Sea. This temperature anomaly forecast is broadly consistent with a moderate La Niña and below normal sea ice in the

Barents-Kara Seas, Bering Sea and Baffin Bay. This forecast is broadly consistent with the analysis presented in the blog on November 9th. Though there are additional predictors in the forecast including Eurasian October snow cover extent, La Niña and below normal sea ice in the Barents-Kara Seas are the dominant factors. The largest negative temperature anomalies are in Central Asia where both La Niña and low Barents-Kara Seas favor relatively cold temperatures. The region of below normal temperatures in North America are mostly related to La Niña.

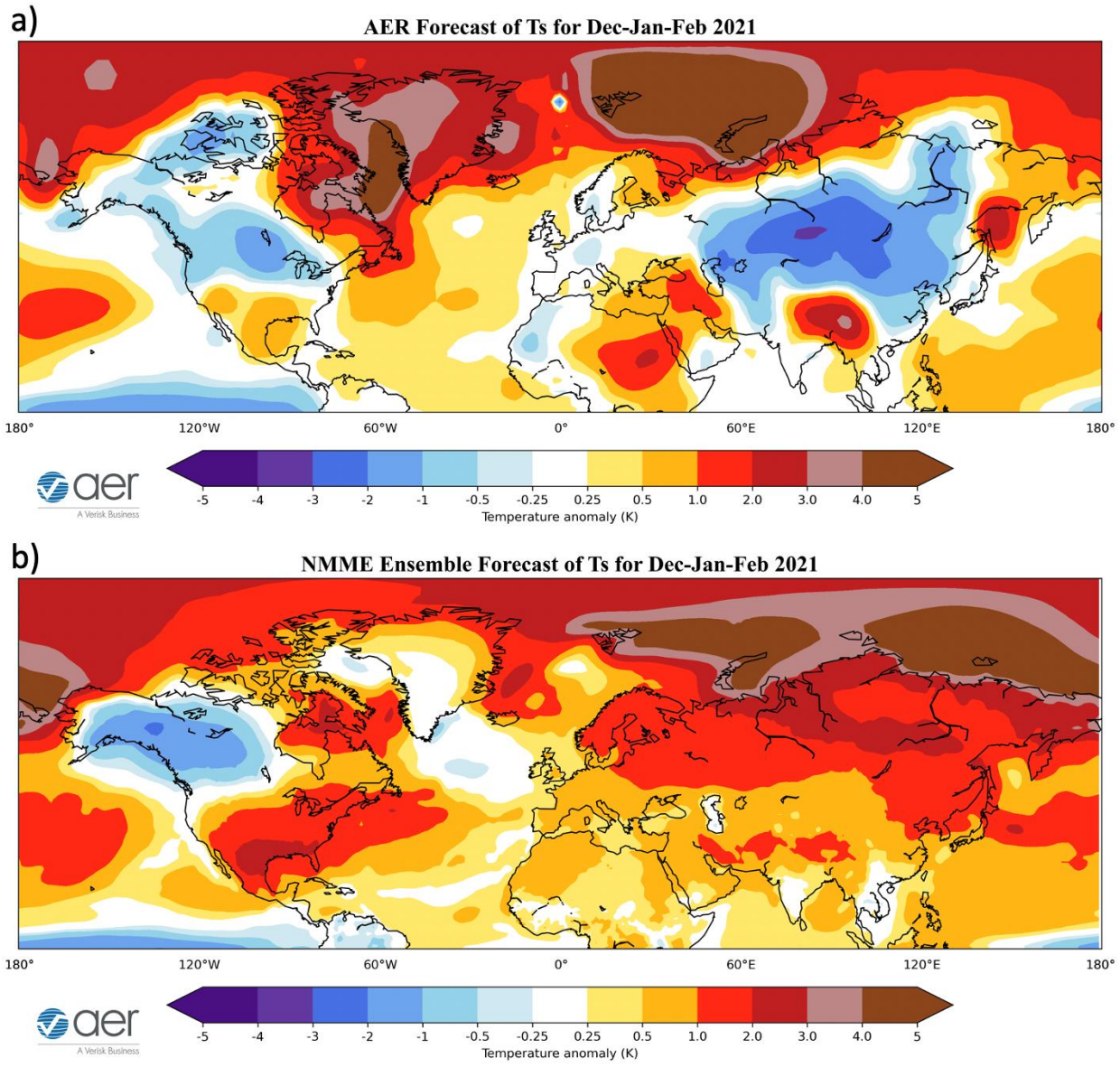

Figure i. **a**) The AER winter temperature anomaly forecast for December, January and February 2021. **b**) the NMME winter temperature anomaly forecast for December, January and February 2021 from https://www.cpc.ncep.noaa.gov/products/NMME/.

I also include the winter 2021 temperature anomaly forecast for the NH from the North American multi-Model Ensemble in **Figure i**. The dynamical model forecast is quite a bit warmer than the AER forecast with widespread warmth across all of Europe, Asia and much of the US. The only region predicted to experience below normal temperatures are Alaska and Western Canada. Any below normal temperatures seem to be related to La Niña. In **Figure ii** I show the C3S multi model ensemble, which includes the models from ECMWF, UK Met Office and Meteo France. Incredibly enough it is hard to distinguish the winter forecast between the American and European models. The C3S ensemble also predicts universal warmth for Europe, Asia, and the US lower 48 with below normal temperatures limited to Alaska and Northwestern Canada. The lack of model spread is something to take note of and if nothing else I believe a beneficial reason for the blog is that the AER forecast, while shows many consistencies with the dynamical model forecasts, does provide a different perspective on the possibilities of the upcoming winter, especially across Eurasia where no below normal temperatures are predicted.

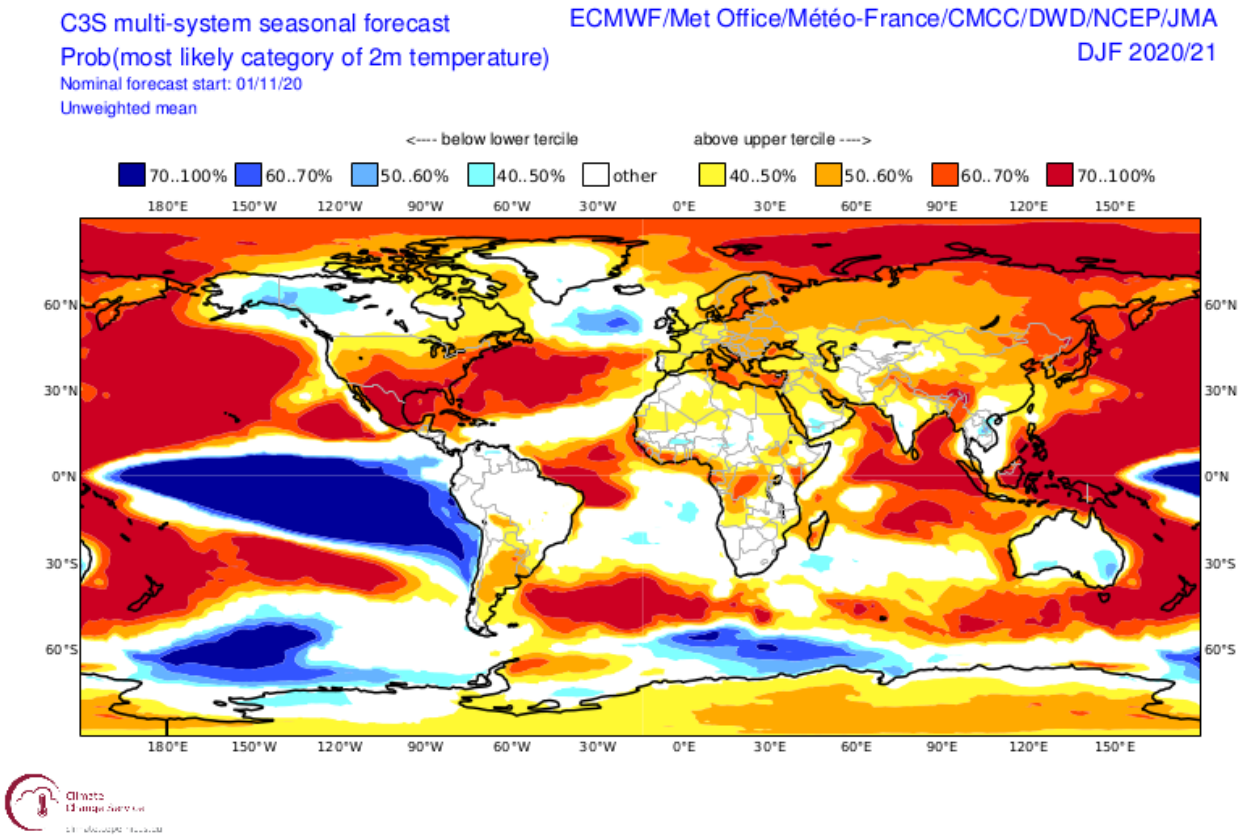

Figure i. The C3S winter temperature anomaly forecast for December, January and February 2021 from https://www.copernicus.eu/en.

Another reason for the blog is just as it states in the Bible “man shall not live by bread alone“ (Deuteronomy and Matthew) so do I believe that weather/climate is not

dependent on the El Niño/Southern Oscillation (ENSO) alone. In addition, I do believe that the behavior of the PV can have a large impact on the weather across the NH. I doubt there are many that would argue with me on this point but where my ideas might be either more forward thinking or controversial is that we can predict the behavior of the PV multiple weeks in advance or even characterizing the PV in a seasonal sense, months in advance.

I believe that low sea ice in the Barents-Kara Seas and high snow cover across Eurasia favors a weaker PV during the winter. Sea ice in the Barents-Kara Seas is running well below normal and there is little reason to expect this to change all winter. Eurasian snow was only slightly above normal in October and I don't think was a strong signal either way. However, the snow cover in November and even heading into December could be more favorable for disrupting the PV, based on studies that I discussed also in the November 9th blog. But boundary forcings alone are not going to disrupt the PV, they need to favor or nudge a certain atmospheric pattern that will excite the transfer of energy from the troposphere to the stratosphere. As I said many times the atmospheric feature that I believe is most important for exciting that energy transfer is Ural-Scandinavian blocking. Ural blocking is already established and based on the weather models will likely persist for another two weeks. I do believe that this will weaken the PV, weaker than probably any time all of last winter. We have an experimental polar vortex model that predicts a fairly weak PV the last week of December. And I do believe that a major mid-winter warming ((MMW; reversal of the zonal mean zonal wind from westerly or positive to easterly or negative at 60°N and 10 hPa) is possible either very late December or more likely early January but remains a low confidence forecast for now and admittedly all of this remains speculative. I also note that the Madden Julian Oscillation (MJO) was last in phase three (see **Figure 18**) and an MMW is most likely approximately one month after MJO phase three Garfinkel et al. (2012).

A third reason for the blog is to incorporate or apply recent research to subseasonal to seasonal forecasting. On Twitter I have been highlighting the risk of below and even well below normal temperatures east of the Rockies across Canada and the US. This is based on some recent analysis that I have done that I hope to submit soon for publication. But this is as speculative as it gets and the timing likely does at least partially coincide with the period that NOAA CPC week 3-4 currently predicts above normal for the entire country, so we shall see. I would also add that the ECMWF ensembles or EPS continue to be at odds with my own thinking. (Often differences can be explained or attributed to different MJO forecasts but a different MJO forecast is not obvious to me but this is admittedly outside of my expertise. Instead, I will offer an alternative explanation for the model differences, but it is mostly conjecturing on my part.)

Less speculative - I do anticipate based on the persistence of Ural blocking, that the energy transfer from the troposphere to the stratosphere will become more active after an extended hiatus and is showing up in the week-two GFS forecasts (see **Figure**

12). There is one wrench in the works though and that is the ridging in the mid-North Atlantic. Only vertically propagating energy from atmospheric waves one and two escape the troposphere and make it into the stratosphere. Currently we observe Ural blocking/ridging with downstream troughing in East Asia and into the northern North Pacific with more ridging across western North America with downstream troughing in the Eastern US (see for example **Figure 5**). If this troughing in the Eastern US extended across the North Atlantic into Europe this would give a wave two pattern – Ural ridging East Asia/North Pacific troughing as one wave and western North America ridging with Eastern US/North Atlantic/Europe troughing as the second wave. But with the added ridging in the central North Atlantic coupled with the European troughing gives you a third wave. So, this complicates the troposphere-stratosphere coupling but the Ural ridging and East Asia/North Pacific troughing is of very large extent (half a hemisphere) so I think this will be sufficient to catapult energy into the stratosphere but I don't know for certain. Alternatively, if the Ural-western North America ridge bridge materializes, you could convince yourself there is really just one wave – troughing in East Asia/North Pacific troughing and ridging from North America to Europe.

Assuming that vertical pulses from the troposphere to the stratosphere commence - there are two possible outcomes for the energy pulses. One, they reflect off the stratospheric PV and force a ridge/trough pattern across North America that drives cold air east of the Rockies. This typically has a striation signature in the WAFz plot (**Figure 12**) with positive values followed almost immediately by negative values. Positive values are predicted for the second week of December. If this is then followed by negative values about a week later, we would likely be observing a reflective event or a stretching of the PV and cold air would start to move south across North America with or soon after the negative WAFz values (this may be more consistent with the GEFS or Canadian ensembles).

The second possibility is that the energy is absorbed in the stratosphere. Then we would not observe negative WAFz values immediately following the energy pulse the second week of December. This would likely mean a larger disruption of the PV is taking place that favors at least initially cold temperatures across Eurasia. In fact, I would expect it to turn quite mild across the Eastern US for at least two weeks (this may be more consistent with the EPS forecast). A third possibility I have never heard discussed before, and not sure if it is possible, the energy passes right through the stratosphere and therefore I will not consider. A fourth possibility is that the upward energy is reflected towards the equator, then the PV will spin up. But so far, I don't see any signs of that possibility but certainly should be considered.

Unfortunately, I don't know how to completely distinguish between a reflective and absorptive pulse. There is literature that says you get a reflective pulse if the wind speed decreases with height in the stratosphere, which is not the case and is not predicted in the near term, but zonal plots don't tell the whole story. My gut tells me the initial pulse is likely to be reflective with absorptive pulses increasingly likely with

subsequent pulses. Bottom line – I see an increasingly influential role of the stratospheric PV on the NH weather with growing cold risks across North America, Europe and especially Asia as the PV becomes disrupted, since Asia is the one region that can turn cold both under reflective and absorptive vertical energy pulses.

1-5 day

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

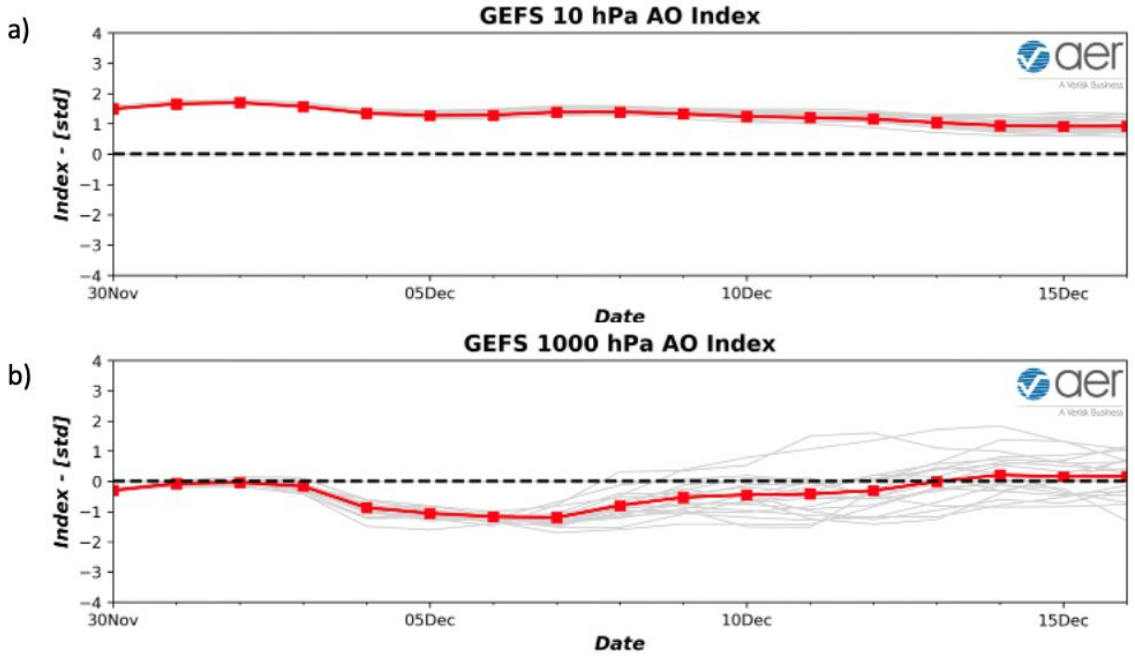

Figure 1. (**a**) The predicted daily-mean AO at 10 hPa from the 00Z 30 November 2020 GFS ensemble. (**b**)The predicted daily-mean near-surface AO from the 00Z 30 November 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given 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 Western and Central Europe including the UK while southwesterly flow transports normal to above normal temperatures to Eastern Europe (**Figure 3**). This week, ridging/positive geopotential height anomalies will be centered on the Urals are predicted to force

troughing/negative geopotential height anomalies across Kazakhstan and Eastern Siberia that extends south into East Asia (**Figure 2**). This pattern favors widespread normal to above normal temperatures **f**or Northern and far Southern Asia with normal to below normal temperatures in Kazakhstan, Eastern Siberia and East Asia **(Figure 3**).

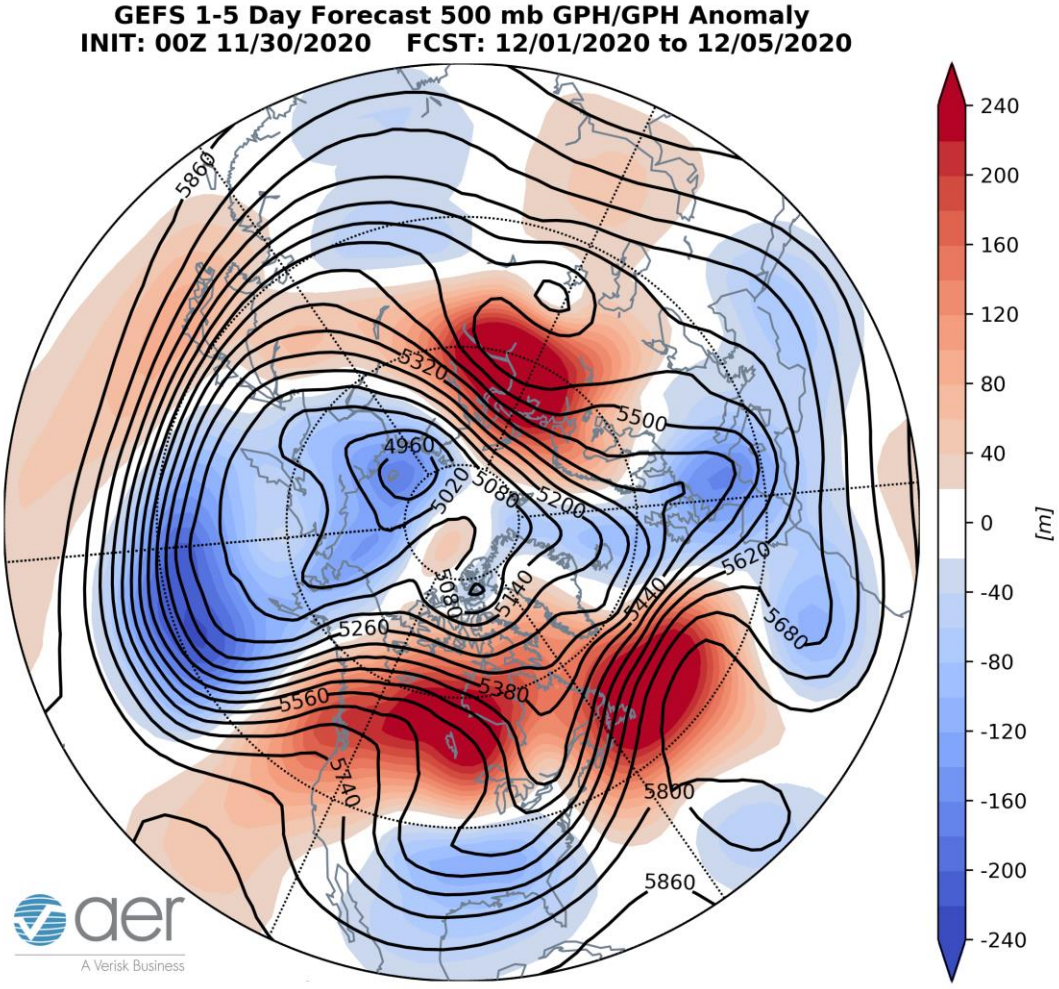

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 1 – 5 December 2020. The forecasts are from the 00z 30 November 2020 GFS ensemble.

This week ridging/positive geopotential height anomalies are predicted to stretch across much of Canada will force troughing/negative geopotential height anomalies across the southern two thirds of the US (**Figure 2).** This pattern is predicted to bring normal to above normal temperatures across much of Alaska and much of Canada with normal to below normal temperatures for Southwestern Alaska and the Southeastern US **(Figure 3).**

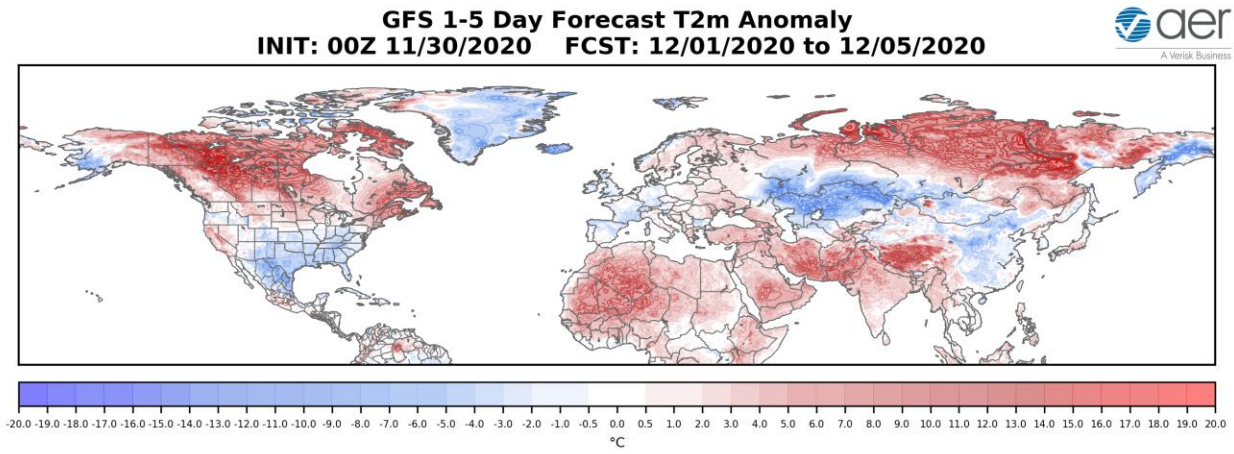

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 1 – 5 December 2020. The forecast is from the 00Z 30 November 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across Scandinavia, the Alps, the Pyrenees, Siberia and parts of East Asia and the Himalayas while warmer temperatures will cause snow melt in Central Asia (**Figure 4**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, Northern Canada, the Ohio Valley and into New England and the US Rockies while warmer temperatures will cause snow melt in parts of Southern Canada and the Pacific Northwest (**Figure 4**).

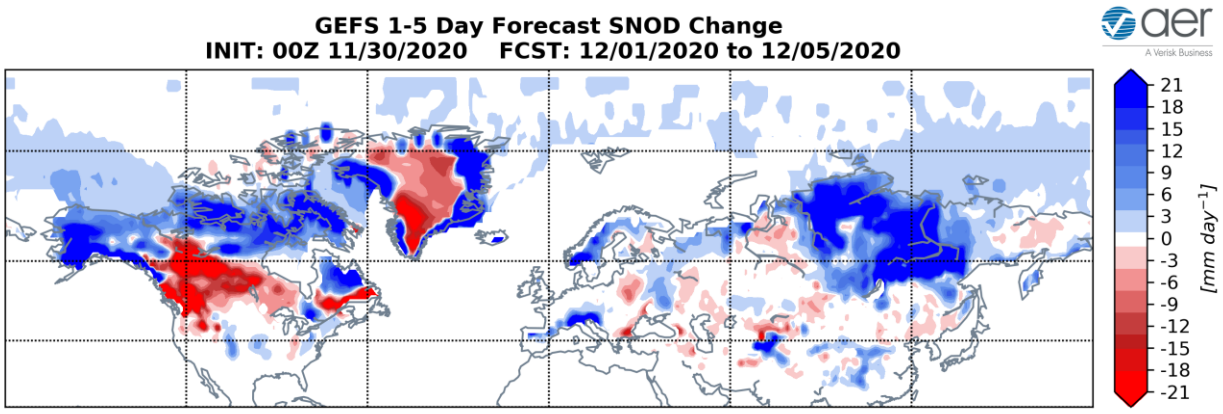

Figure 4. Forecasted snow depth changes (mm/day; shading) from 1 – 5 December 2020. The forecast is from the 00Z 30 November 2020 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to trend slightly negative next week **(Figure 1**) as geopotential height anomalies begin to rise 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.

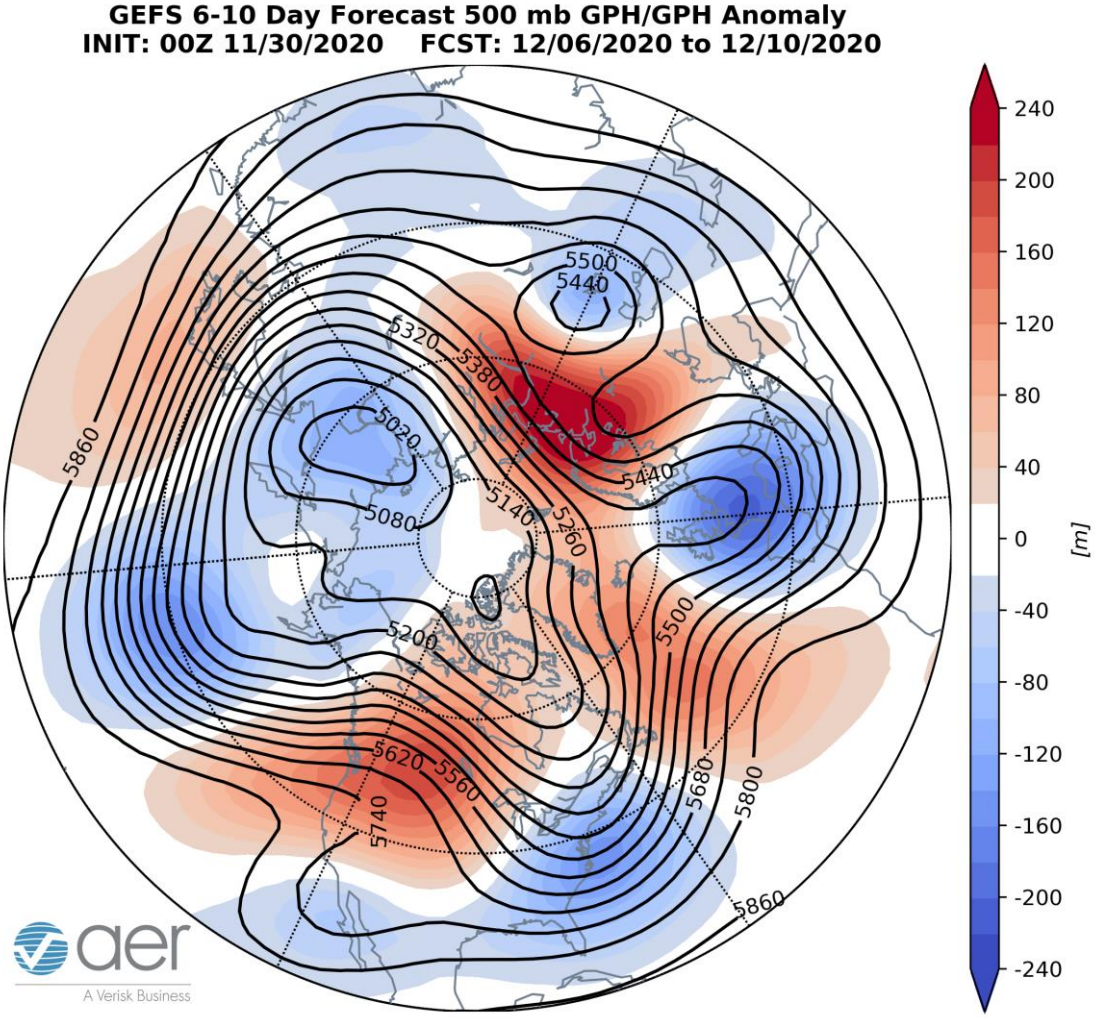

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 December 2020. The forecasts are from the 00z 30 November 2020 GFS ensemble.

Persistent ridging/positive geopotential height anomalies in the central North Atlantic are predicted to force troughing/negative geopotential height anomalies across Europe (**Figures 5). T**his pattern favors normal to below normal temperatures across much of Western and Central Europe including the UK with normal to above normal temperatures across Eastern Europe under southwesterly flow (**Figure 6**). Persistent ridging/positive geopotential height anomalies centered near the Urals are predicted to anchor

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

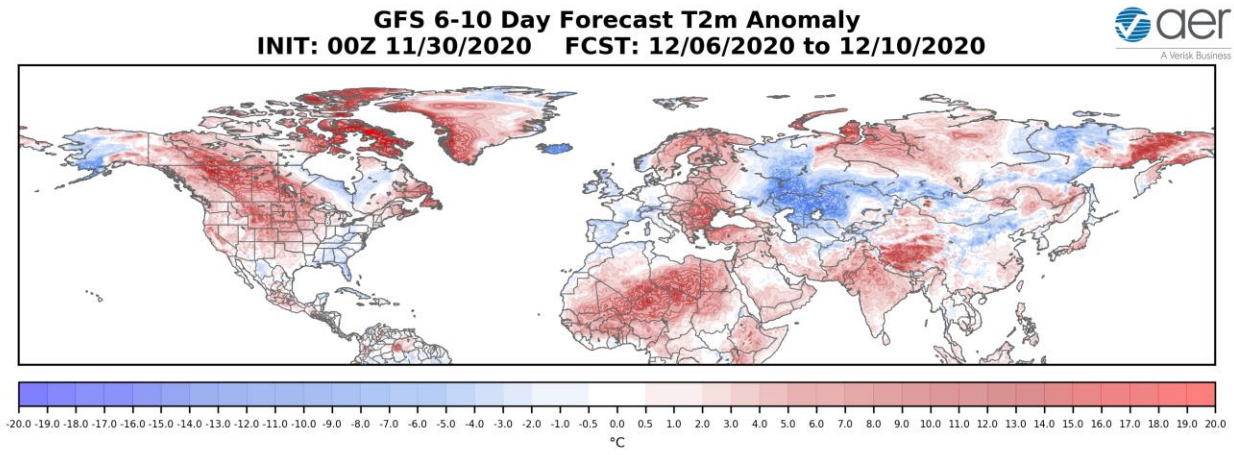

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 6 – 10 December 2020. The forecasts are from the 00Z 30 November 2020 GFS ensemble.

Predicted ridging/positive geopotential height anomalies across western North America will again force troughing/negative geopotential height anomalies in the Eastern US this period **(Figure 5).** This pattern is predicted to bring widespread normal to above normal temperatures across eastern Alaska, Canada and the Western US with normal to below normal temperatures across western Alaska and the Eastern US **(Figure 6).**

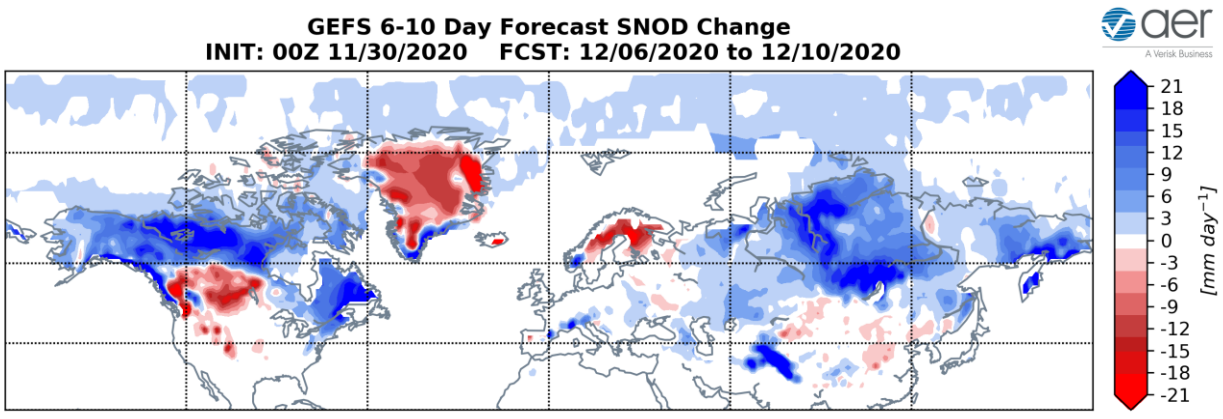

Figure 7. Forecasted snow depth changes (mm/day; shading) from 6 – 10 December 2020. The forecasts are from the 00Z 30 November 2020 GFS ensemble.

Troughing and/or colder temperatures are predicted to support new snowfall across the Alps, Northern, Central and East Asia while warmer temperatures will cause regionalized snow melt including Scandinavia, Eastern Europe and China (**Figure 7**). Troughing and/or colder temperatures are predicted to support new snowfall across Alaska, much of Northern and Eastern Canada and possibly the Northeastern US while warmer temperatures will cause possible snow melt in Southwestern Canada and the US 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 spreading across Greenland (**Figure 8**), the NAO is predicted to remain negative this period.

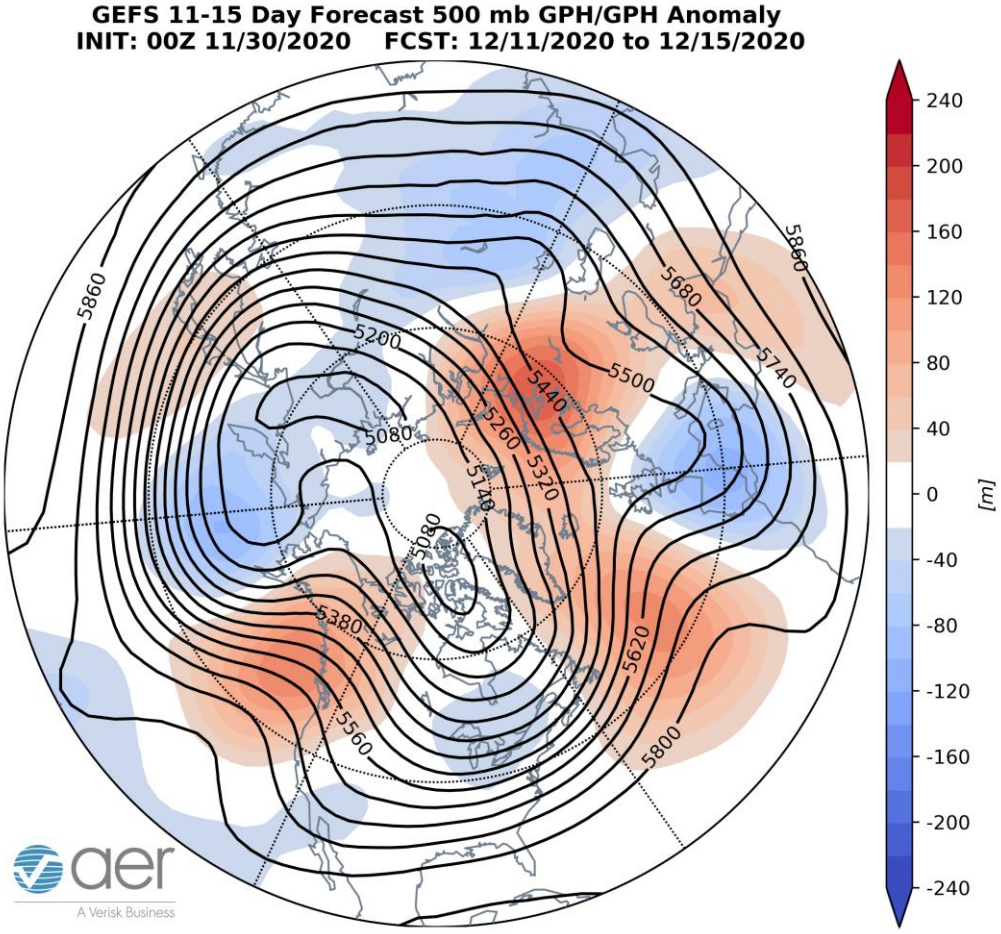

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 11 – 15 December 2020. The forecasts are from the 00z 30 November 2020 GFS ensemble.

Persistent ridging/positive geopotential height anomalies are predicted across the central North Atlantic and into Greenland will help tether troughing/negative geopotential height anomalies across Europe this period (**Figures 8**). The forecast is for normal to below normal temperatures across Western and Central Europe including the UK with normal to above normal temperatures across Eastern Europe as southwesterly winds maintain a milder flow of air this period (**Figures 9**). Predicted persistent ridging/positive geopotential height anomalies focused near the Urals and now edging closer to Scandinavia this period will continue to support troughing/negative geopotential height anomalies across Southwestern Asia and Eastern Siberia that extends south to East Asia this period (**Figure 8**). This pattern favors normal to above normal temperatures across the North Slope of Asia and Southern Asia with expanding normal to below normal temperatures in Western, Central and East Asia and Siberia (**Figure 9**).

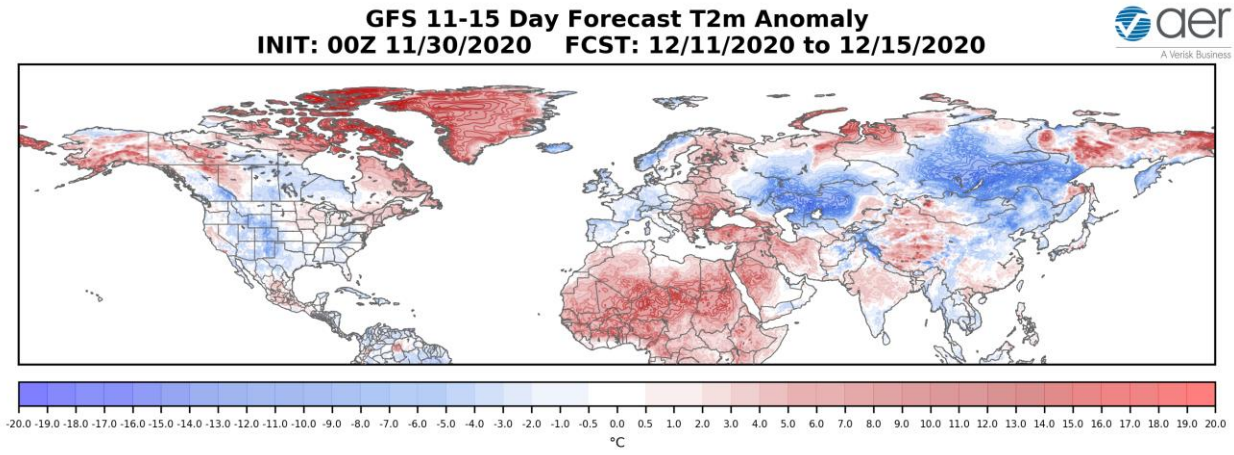

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 11 – 15 December 2020. The forecasts are from the 00z 30 November 2020 GFS ensemble.

Predicted persistent ridging/positive geopotential height anomalies across western North America with more troughing/negative geopotential height anomalies in Eastern Canada, the Eastern US that trails back into the Southwestern US this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures for Alaska, Western and Eastern Canada and New England with normal to below normal temperatures for Central Canada and much of the US (**Figure 9**).

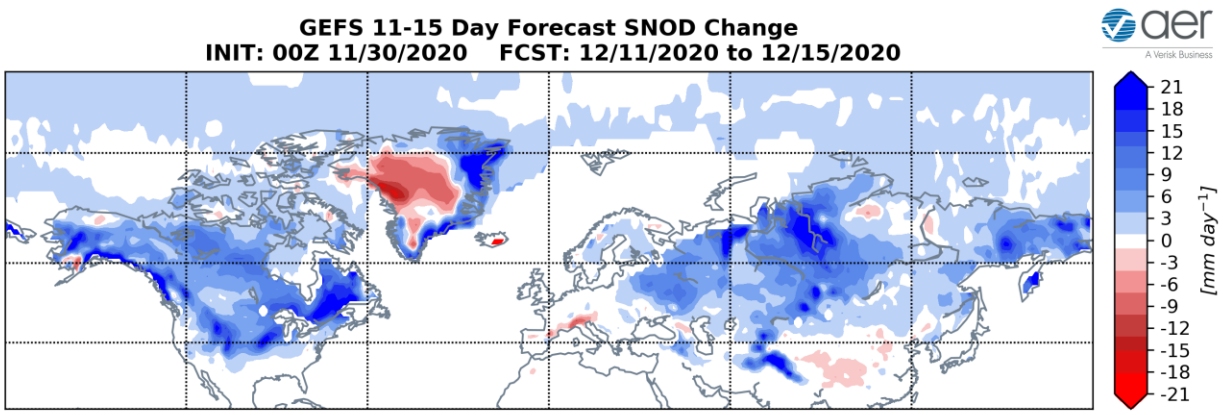

Figure 10. Forecasted snow depth changes (mm/day; shading) from 11 – 15 December 2020. The forecasts are from the 00z 30 November 2020 GFS ensemble.

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

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal PCHs in the mid to upper troposphere but cold/negative PCHs in the stratosphere and lower troposphere (**Figure 11**). The cold/negative stratospheric PCHs are predicted to persist in the stratosphere through mid-December but weaken especially the second week of December (**Figure 11**).

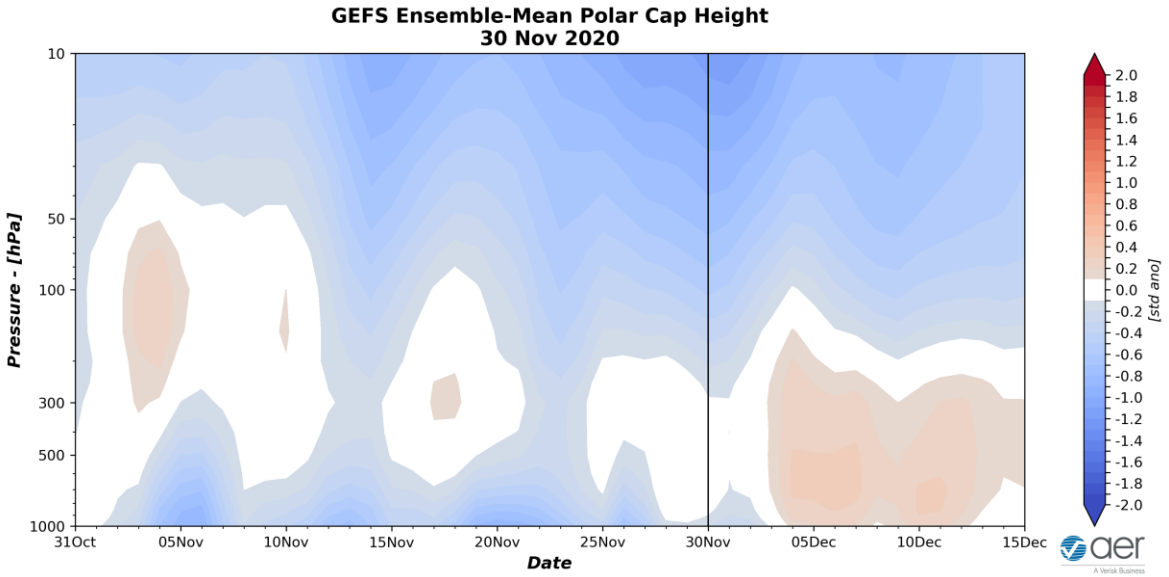

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 30 November 2020 GFS ensemble.

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

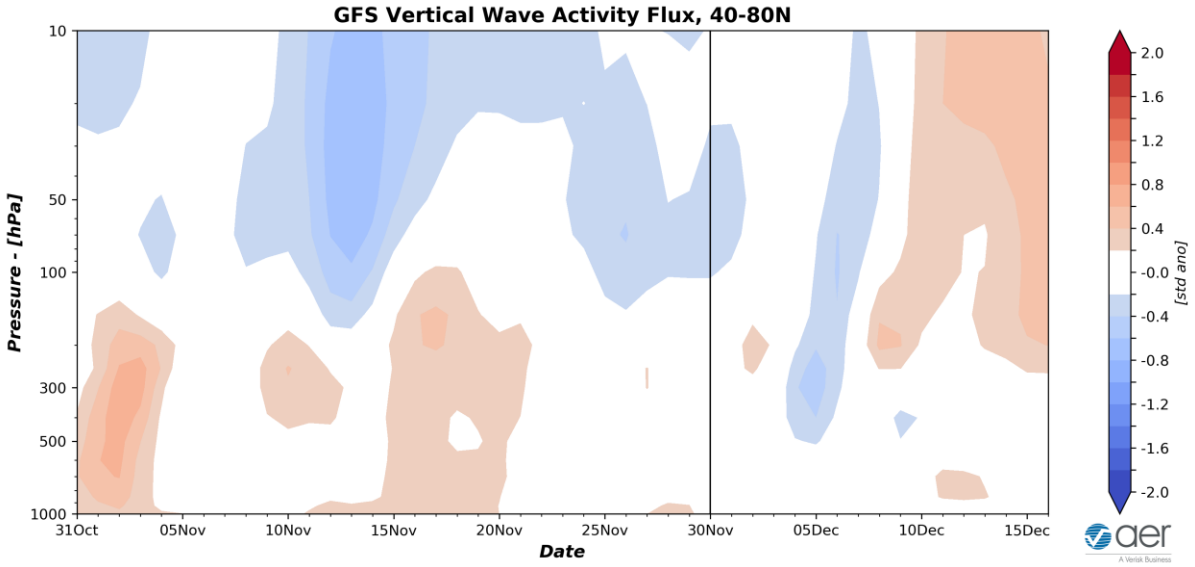

Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 30 November 2020 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport forecasts are finally showing the end of the extended quiet period of WAFz in the troposphere but especially the stratosphere the second week of December (**Figure 12**). The lack of active WAFz has allowed the stratospheric PV to remain anomalously strong. But weakening of the PV is looking more likely.

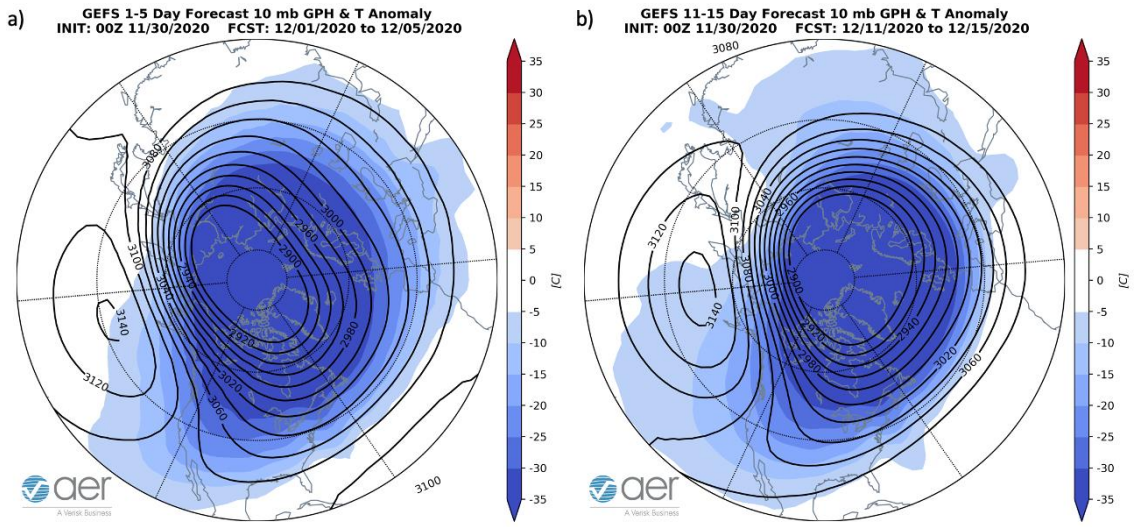

Figure 13. (**a**) Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 1 – 5 December 2020. (**b**) Same as (a) except forecasted averaged from 11 – 15 December 2020. The forecasts are from the 00Z 30 November 2020 GFS model ensemble.

The PV is predicted to remain centered near the North Pole over the next two weeks (**Figure 13**). However, the GFS for next week is predicting high pressure to build near the Dateline that would likely stretch the PV and could be suggestive of an upcoming minor disruption of the PV that drives cold air south across North America.

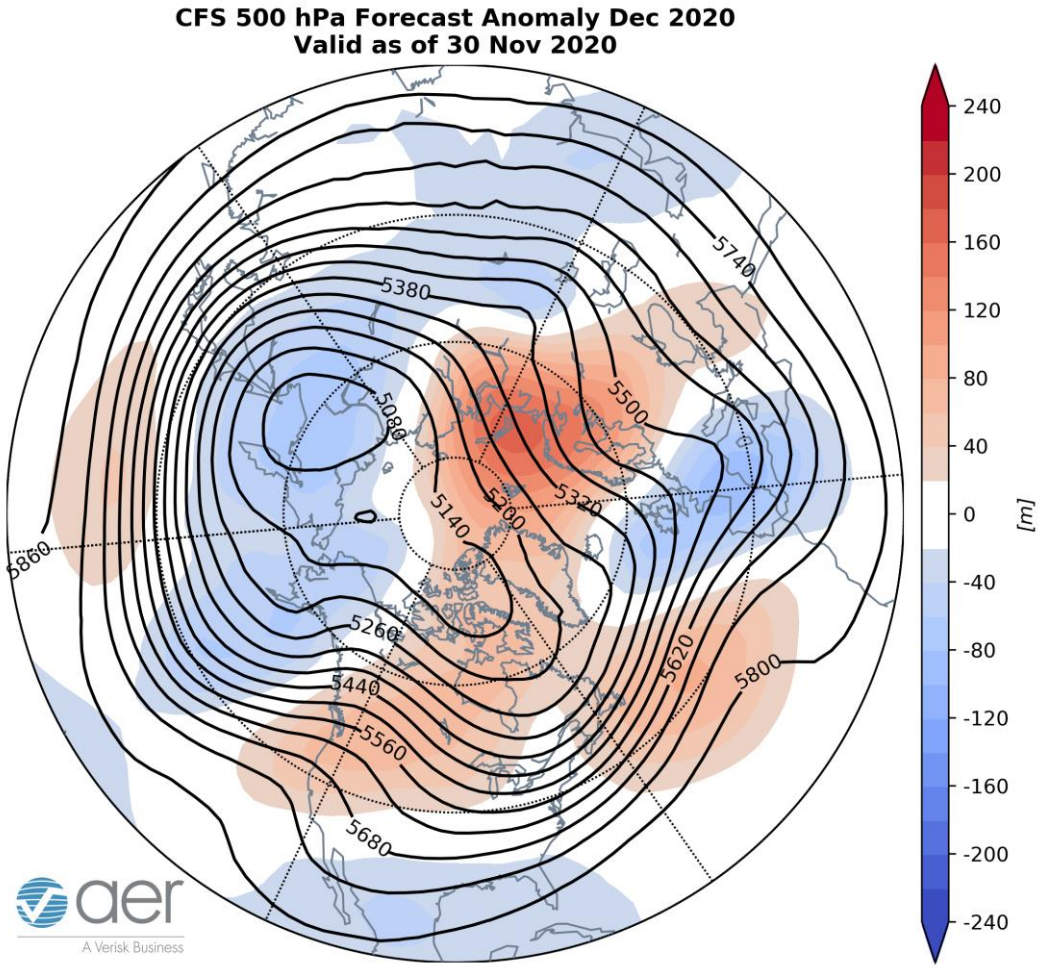

Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2020. The forecasts are from the 00Z 30 November 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and the surface temperatures (**Figure 15**) forecast for December from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging in the central North Atlantic, the Urals and western North America and much of Canada with troughing in Western Europe, Southwestern and East Asia, the Aleutians, Alaska and the Eastern US (**Figure 14).** This pattern favors relatively warm temperatures for Northern and Eastern Europe, Northern Siberia and much of North America with seasonable to relatively cold temperatures for Western Europe, Eastern Siberia, Central and Eastern Asia and the Southeastern US (**Figure 15**).

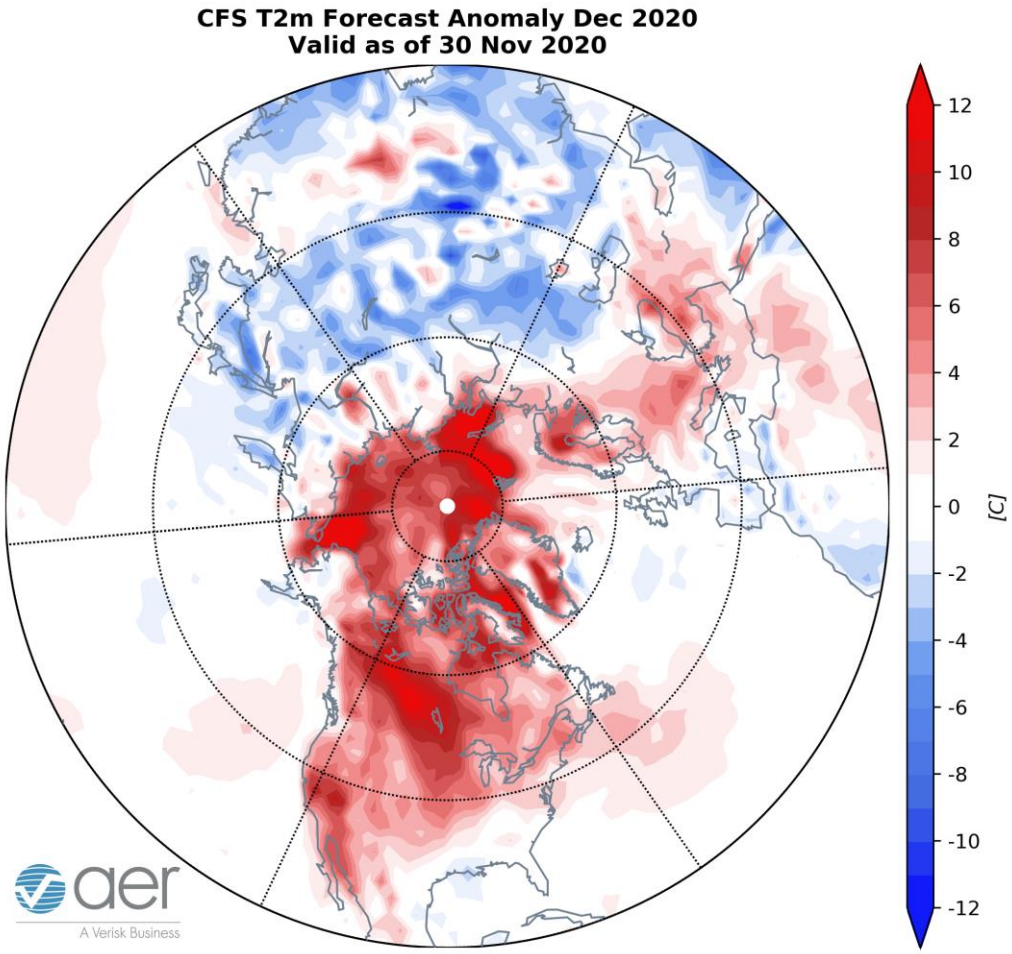

Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for December 2020. The forecasts are from the 00Z 30 November 2020 CFS.

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 from Alaska to East Siberia (**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 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.

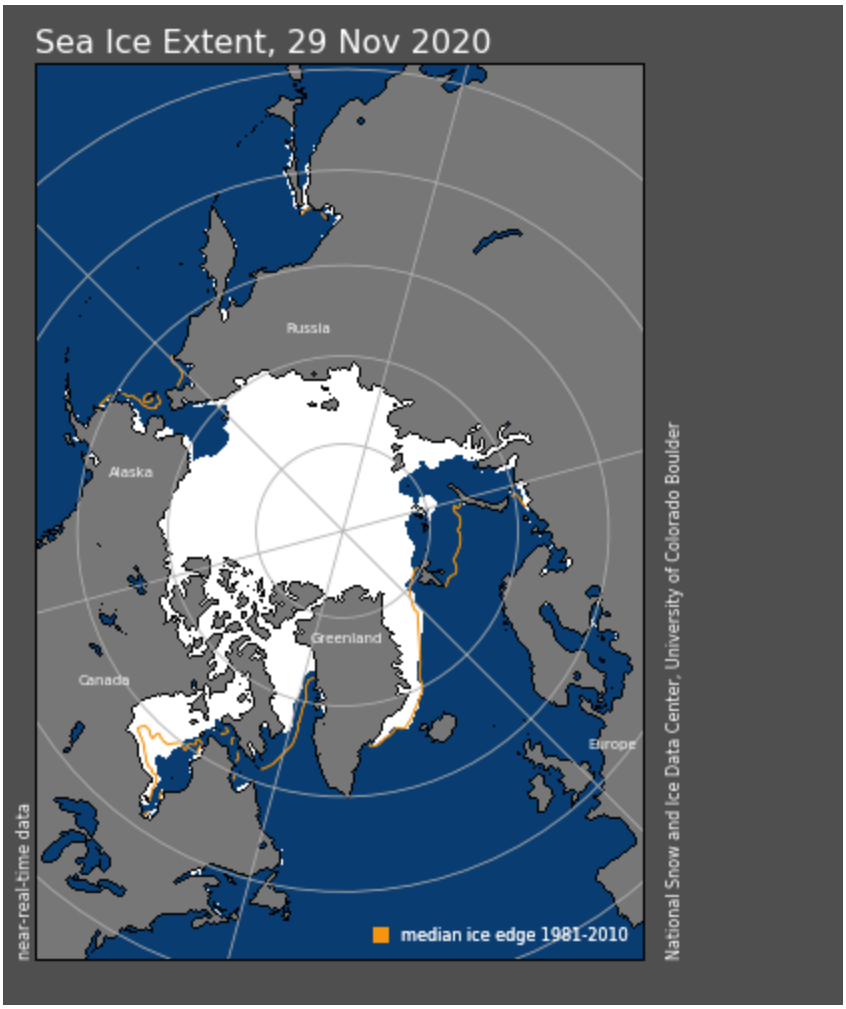

Figure 16. Observed Arctic sea ice extent on 29 November 2020 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC). Snow and Ice Data Center (NSIDC).

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.

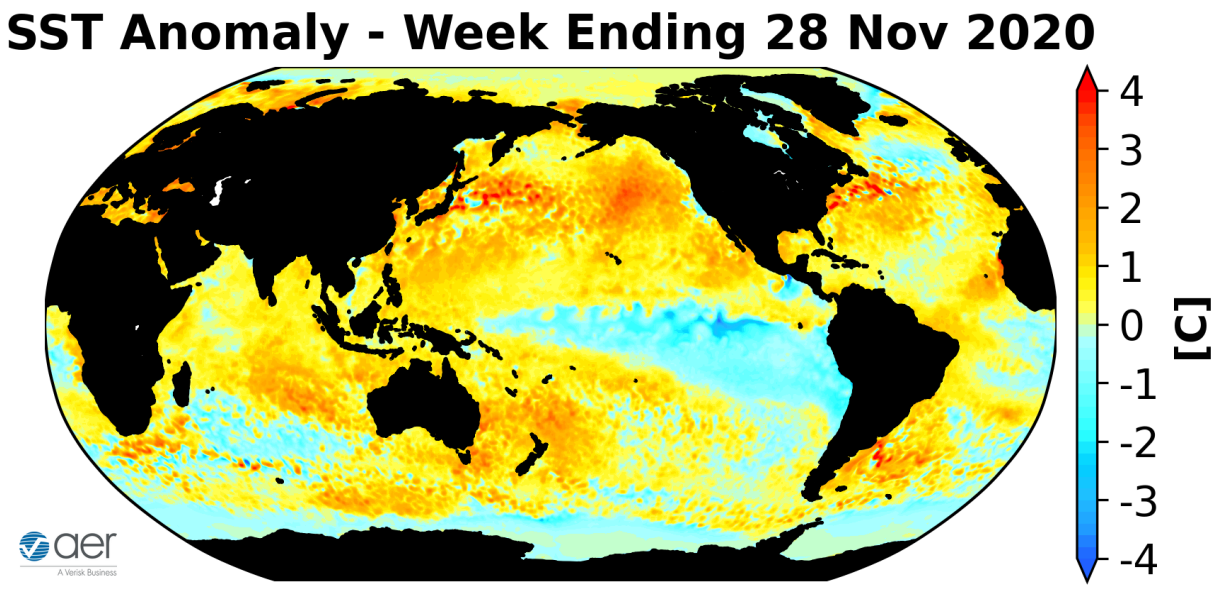

Figure 17. The latest weekly-mean global SST anomalies (ending 28 November 2020). Data from NOAA OI High-Resolution dataset.

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. 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.

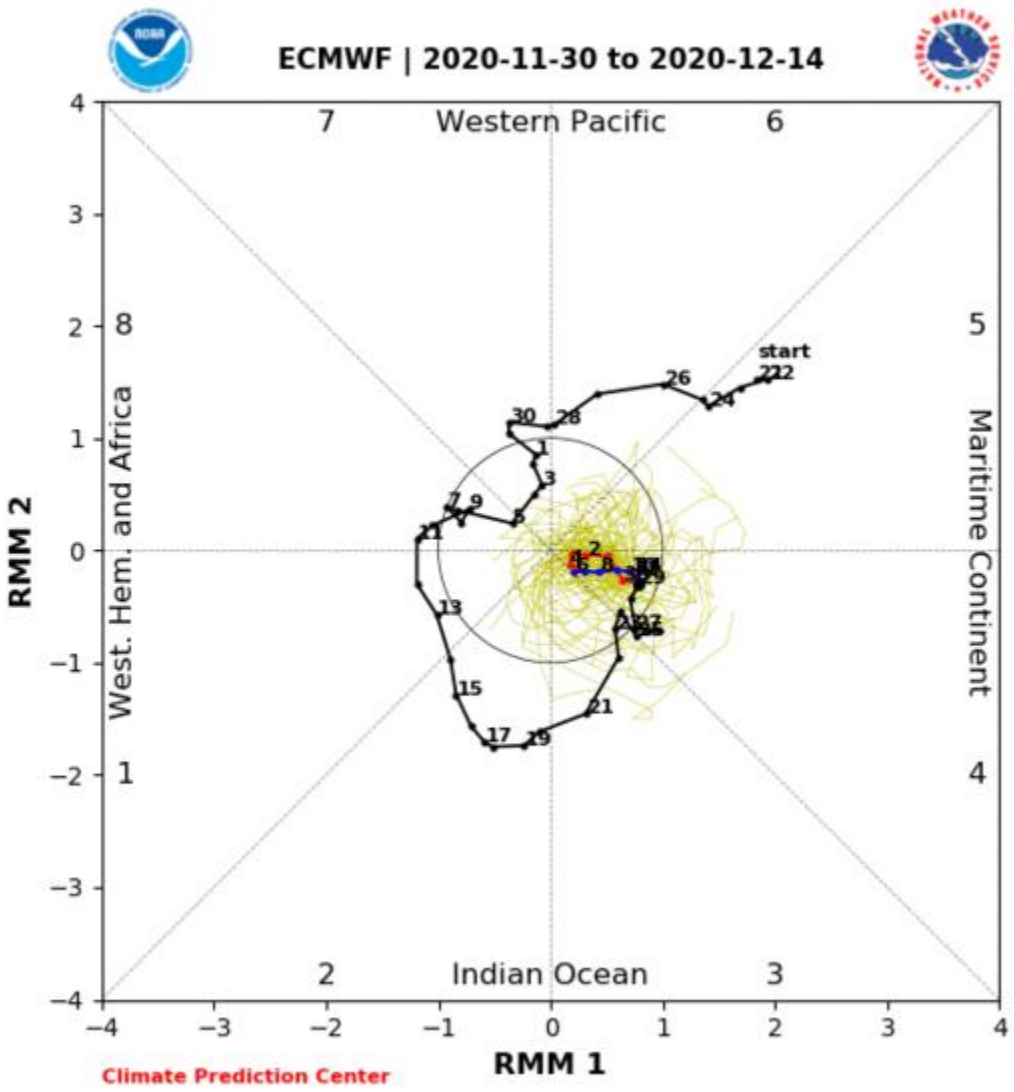

Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 30 November 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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.

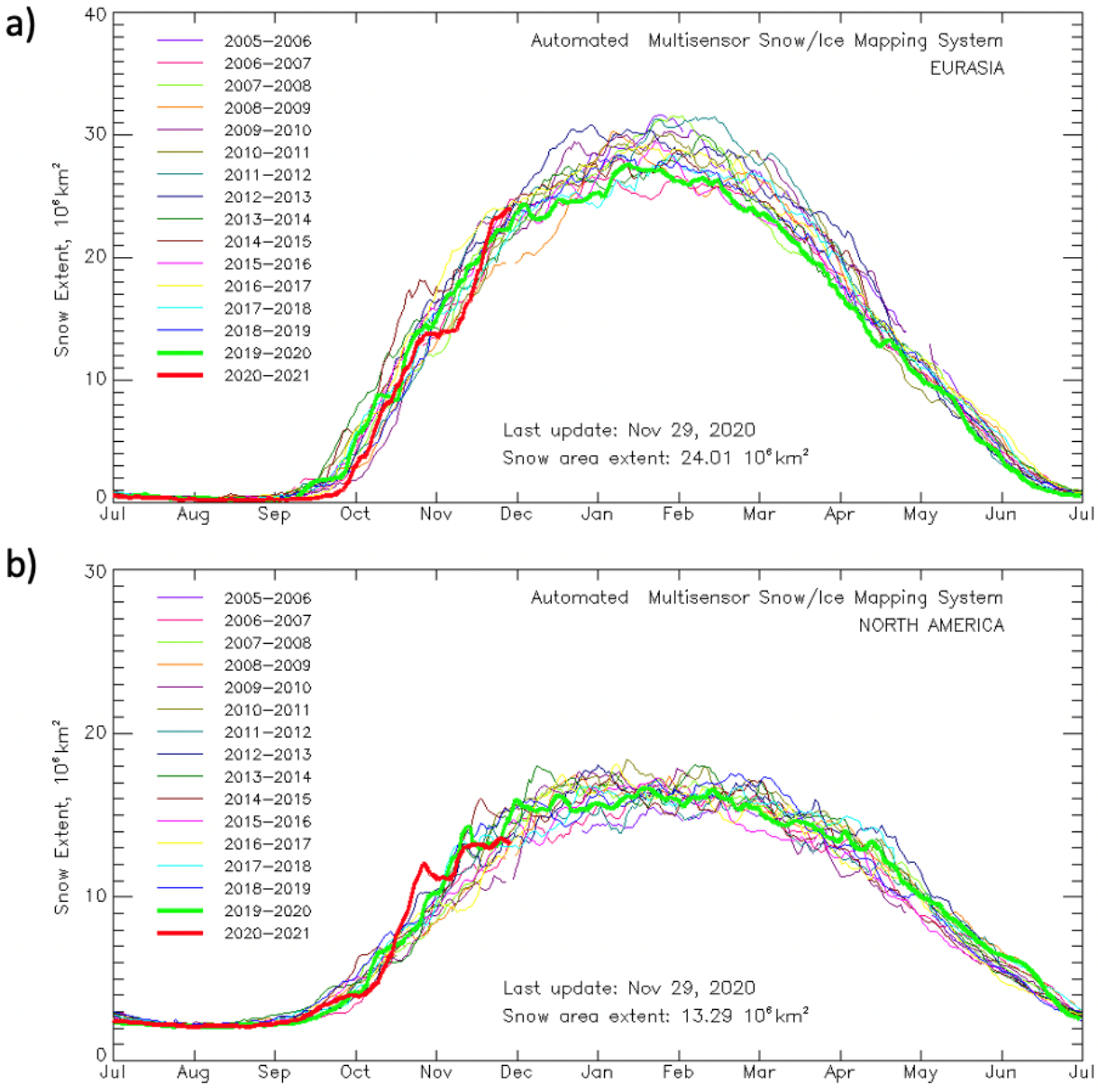

Figure 19. Observed Eurasian (top) and North American (bottom) snow cover extent through 29 November 2020. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html

North American snow cover has stalled for two weeks and is now near 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.