

Arctic Oscillation and Polar Vortex Analysis and Forecasts

November 7, 2022

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Wednesday through the winter season.

For those who would like an early look on Mondays, we will be offering at a nominal price (US \$50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

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

the next two weeks as pressure/geopotential height anomalies are currently and are predicted to remain mixed to negative across Greenland.

- Over the next two weeks troughing/negative geopotential height anomalies in the eastern North Atlantic will favor ridging/positive geopotential height anomalies across much of Europe. This pattern will favor normal to above normal temperatures across much of Europe including the United Kingdom (UK). However, in mid November the North Atlantic troughing could extend far enough east to bring normal to below normal temperatures across far Western Europe including the western UK.
- Over the next two weeks, predicted amplifying European ridging/positive geopotential height anomalies will force downstream troughing/negative geopotential height anomalies across Northern Asia especially Western and Central Siberia with ridging/positive geopotential height anomalies in Eastern Siberia and East Asia. This pattern favors widespread normal to below normal temperatures across Northern Asia with normal to above normal temperatures across Southern and Eastern Asia including Eastern Siberia the next two weeks.
- The general pattern the next two weeks across North America is amplified ridging/positive geopotential height anomalies centered in the Gulf of Alaska and Alaska and extending into Western Canada forcing downstream troughing/negative geopotential height anomalies initially in the Western United States (US) with strong ridging/positive geopotential height anomalies in Eastern Canada and the Eastern US. However, by next week the troughing/negative geopotential height anomalies will slide into eastern North America. This pattern favors this week widespread normal to above normal temperatures across Alaska, Eastern Canada and the Eastern US with normal to below normal temperatures across Western Canada and the Western US. However, starting next week colder temperatures will spread across Eastern Canada and the Eastern US.
- In the *Impacts* section I continue to discuss October Eurasian snow cover extent and current Arctic sea ice and how they might portend the behavior of the polar vortex (PV) and the Northern Hemisphere (NH) winter.

Plain Language Summary

I discuss the current state of two fall Arctic predictors that I use for our winter forecast. The first is Eurasian snow cover extent which was above normal for October but just barely. Second is Arctic sea ice, which is below normal in two regions that mostly cancel each other's influence. So, for now no strong signals have emerged. But I do think that the overall environment supports polar vortex stretching which favors cold in East Asia and eastern North America but mild in Europe.

Impacts

In my absence the final numbers for Eurasian (but mostly across Siberia) snow cover extent (SCE) for October became available. As can be seen from **Figure i**, the SCE was relatively low the entire second half of the month. But please keep in mind of all the years shown in the plot, only 2011 was below normal so, 2022 is low relative to recent years but high compared to the long-term average. And I have been estimating over the past month, the final number will still likely come in slightly above normal due to the fast start to the month.

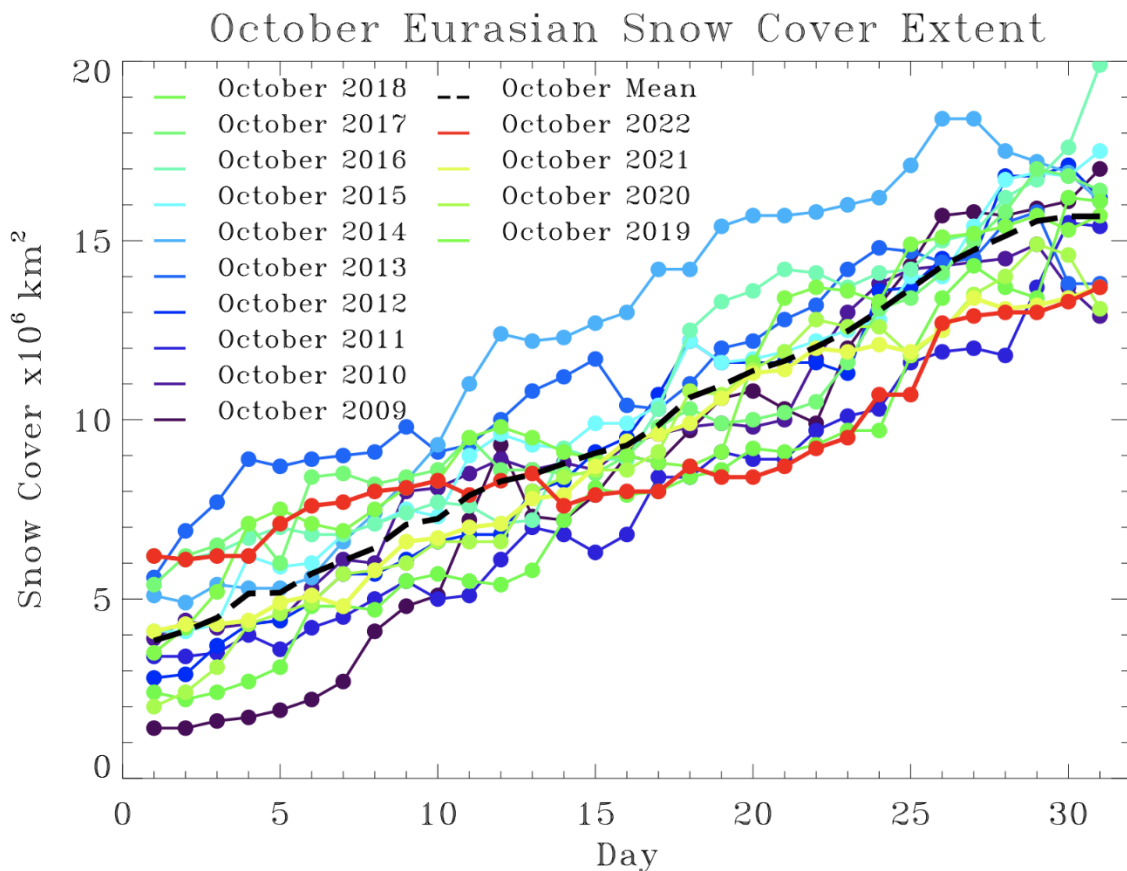


Figure i. Observed Eurasian daily snow cover extent in km² throughout the month of October from 2009 through 2021. Also shown on red is the snow cover extent 1 – 31 October 2022. The black dashed line is the mean of all Octobers from 2009 through 2021.

In **Figure ii**, I present the timeseries for Eurasian mean October SCE anomalies since 1979 and 2022 was slightly indeed above normal. In fact, it is very similar to the observed values for the past two Octobers. It is my impression that El Niño does favor a faster advance of Eurasian SCE than La Niña, and it could be the three-peat La Niña has suppressed the SCE the past three Octobers, albeit at historically high values.

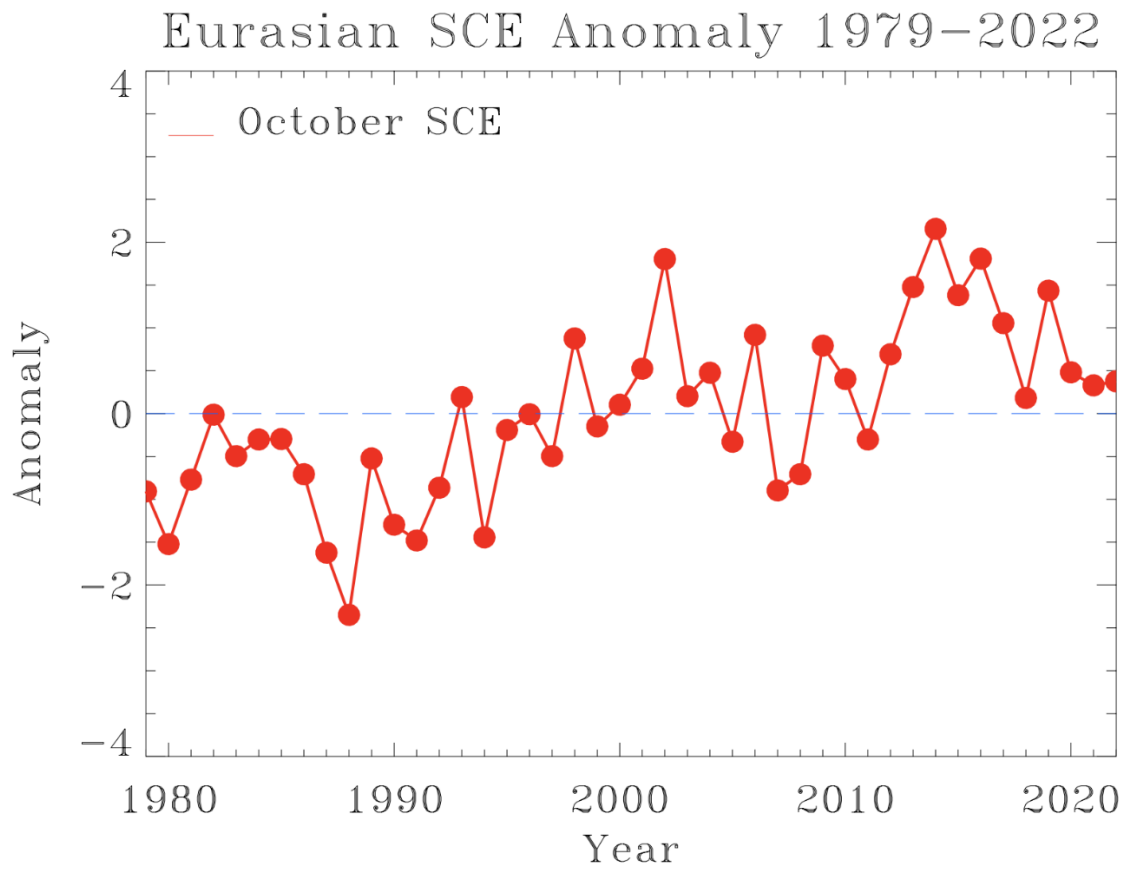


Figure ii. Observed Eurasian monthly snow cover extent anomaly in km² for the month of October from 2009 through 2022. October 2022 was slightly above normal.

Of course, the question becomes how to interpret the advance of Eurasian SCE in 2022 relative to the character of the upcoming Northern Hemisphere (NH) winter given mixed signals at best. The advance itself was very sluggish but the average for the month is still above normal so therefore I am hesitant to interpret the SCE as favoring a strong stratospheric polar vortex (PV) to dominate the upcoming winter. SCE in 2022 is similar to 2020, which was followed by a relatively weak PV during winter 2020/21 culminating with an historically impactful stretched PV event in February 2021. In contrast the PV was relatively strong during winter 2021/22 but repetitive stretched PV events did deliver a cold winter to North America. So unfortunately based on SCE in 2022, I do think that a wide range of scenarios are still possible.

Since my own research on October SCE and the winter PV and NH temperature anomalies, subsequent research has found a relationship between a dipole in SCE anomalies across Eurasia in November and the winter PV and temperature anomalies where below normal SCE in western Eurasia with above normal SCE in eastern Eurasia favor a weaker PV and colder NH temperatures (for example [Park et al. 2020](#) and [Wegmann et al. 2020](#)). From the predicted circulation pattern, it does seem to

me the dipole that favors a weaker PV and colder temperatures is likely in November 2022.

I usually also discuss the snow advance index (SAI) (see [Cohen and Jones 2011](#)). Given how flat the snow advance is in **Figure i**, clearly the SAI is quite negative. Based on the paper this would favor a positive AO this winter. I would interpret the negative SAI as favoring a large disruption of the PV later in the winter rather than earlier in the winter.

The other surface condition that I follow closely is Arctic sea ice extent. In my absence I was not following this closely but based on what I see from today's sea ice extent, sea ice expanded rapidly over the past two weeks. The regions of the largest sea ice deficits are the Barents-Kara Seas and the Chukchi Sea (see **Figure iii**). Based on ridging and warm temperatures predicted over the next two weeks for both regions, negative anomalies could expand in both regions. For now, I don't see a strong signal from Arctic sea ice extent in regard to the strength of the PV as negative anomalies in both the North Atlantic and North Pacific sectors could cancel each other out.

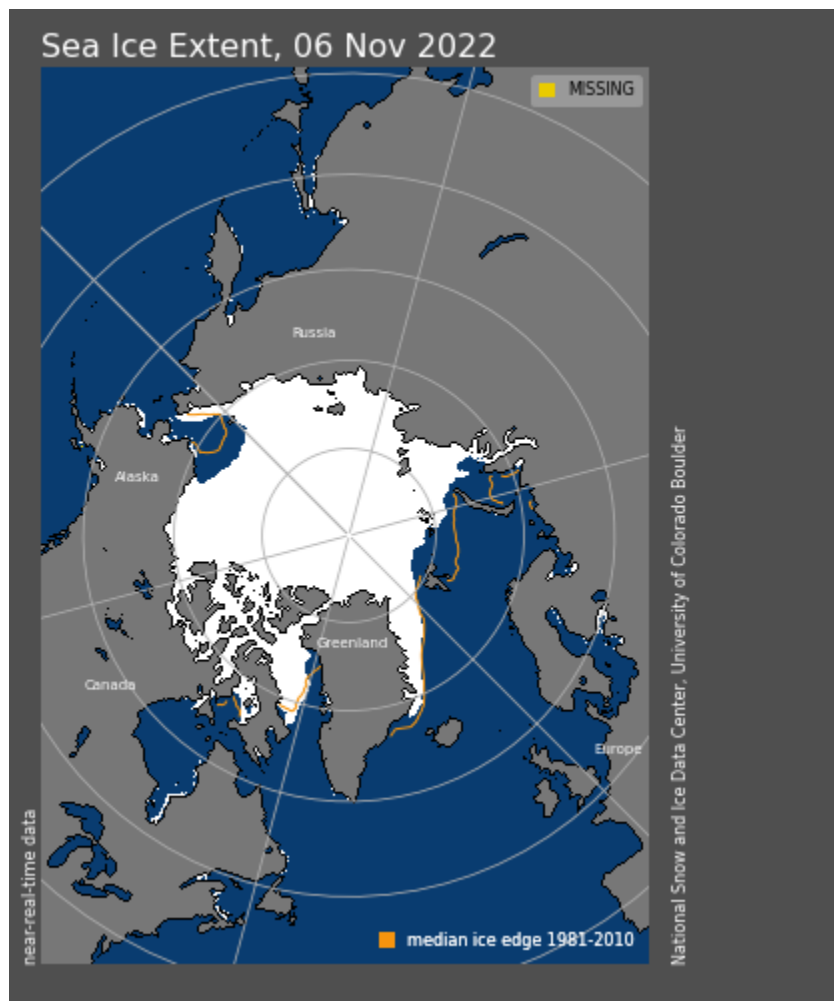


Figure ii. Observed Arctic sea ice extent on 6 November 2022 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC).

Prior to my absence I was anticipating that a stretched PV would deliver colder weather east of the Rockies across Canada and the US. The dynamical models showed no sign of this but now clearly do starting the end of this week. Now that the stretch PV and the surface impacts have all but verified, what comes next. I see two plausible scenarios. The first is a much milder pattern. The environment that supports stretched PVs or reflective events tends to protect the PV from upwelling energy from the troposphere allowing the PV to strengthen. If a relatively strong and circular PV couples to the surface resulting in a positive AO surface pattern, that would likely result in a mild pattern for much of the NH continents. A great example is winter 2019/20. For now, this is not what I consider the most likely scenario, but it is one that I am looking out for.

The second more likely scenario are subsequent stretched PVs. Stretched PVs favor cold temperatures in East Asia and North America east of the Rockies but a mild Europe. But even in the US, I would expect highly variable weather colloquially known as "weather whiplash." I think the snow cover and sea ice extent anomalies favor stretched PVs as does the mid-tropospheric ridging near Scandinavia and Alaska. In fact, the models hint at a Scandinavia-Alaska ridge-bridge (see **Figure 5**) that could result in some extreme cold relative for the time of year in eastern North America the second half of November and something to watch.

Eventually repetitive stretched PVs can give way to a larger PV disruption known as sudden stratospheric warming. This is the best chance I believe to bring cold air into Europe. This is certainly a possibility, but it takes lots of time and for now I don't see it any time soon. It does seem to me the favored weather pattern for the Eastern US in recent years is cold in November, mild in December with cold returning sometime in January and most likely in February. It will be interesting to see if this scenario repeats itself this winter or not.

I try not to inject my personal life into the blog, but I will make an exception this time. My erratic posting and eventual absence from the blog and Twitter was due to my mother's failing health and eventual passing. I mention this because my path to meteorology or climatology was not an obvious one with many obstacles, but my mother was always a strong supporter of my decision to pursue this unconventional career path (at least for me) that was my passion. And I will always be grateful to my mother for her support. I feel fortunate to do every day what I truly love. Also, people asked me during my bereavement period, was there a weather event that influenced me the most to pursue a career in meteorology. As long as I can remember I loved snow but the one event that I remember most fondly was the Blizzard of 1978. I grew up in Brooklyn not Boston but it was a major snowstorm there as well. I found some pictures from the event that I had forgotten about from the blizzard. I posted photos of those

pictures that unfortunately are not the greatest quality but hopefully for those interested in having a look (I am talking to all snow lovers), you can see how the snowstorm transformed my neighborhood into a winter wonderland (link is here [Blizzard of 1978](#)), and I would estimate snow totals in the 24-30 inch range given how the cars are almost completely buried.

Next week I will be making a pilgrimage to a holy site for all snow lovers - the Upper Peninsula of Michigan to give a seminar on the relationship between snow cover and winter weather. I plan to publish a new blog next week but there could be a delay. With any luck I will see my first snow of the winter season.

Recent and Very Near Term Conditions

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

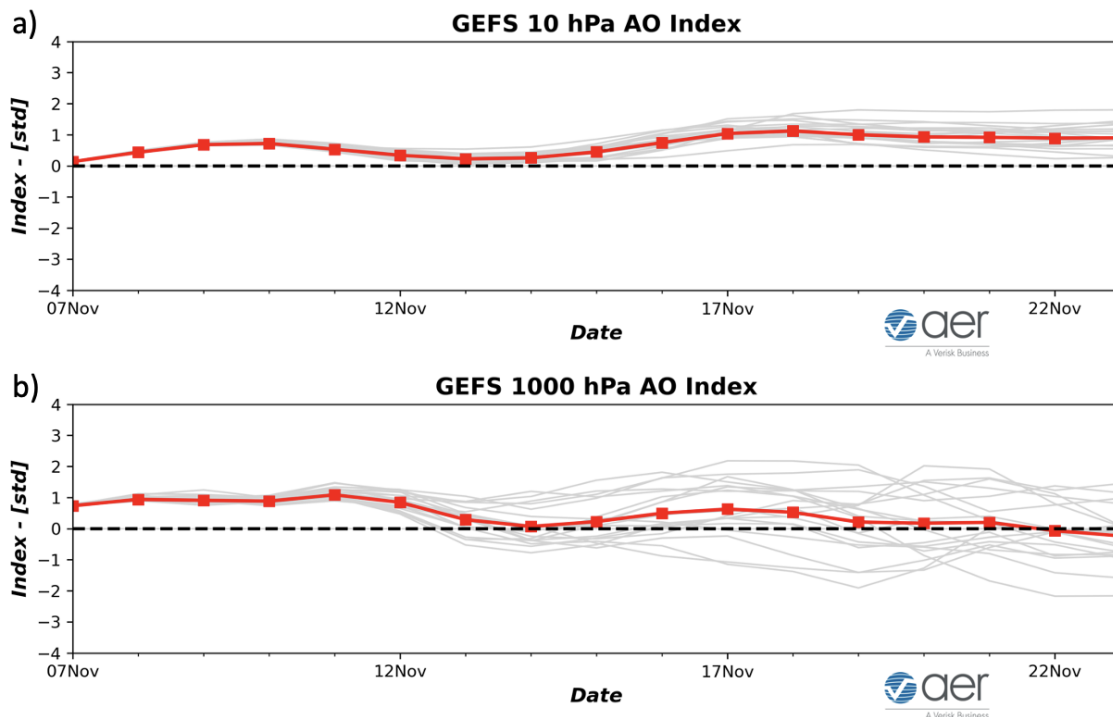


Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 7 November 2022 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 7 November 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Predicted troughing/negative geopotential height anomalies in the eastern North Atlantic will force ridging/positive geopotential height anomalies across much of Europe (**Figure 2**). This will favor normal to above normal temperatures across much of Europe including the UK but especially across Scandinavia (**Figure 3**). Ridging/positive geopotential height anomalies in Europe are predicted to force downstream troughing/negative geopotential height anomalies across Siberia that extend southwestward into Central Asia with ridging/positive geopotential height anomalies in East Asia (**Figure 2**). This pattern favors normal to below normal temperatures across Siberia and Central Asia with normal to above normal temperatures across Eastern and Western Asia (**Figure 3**).

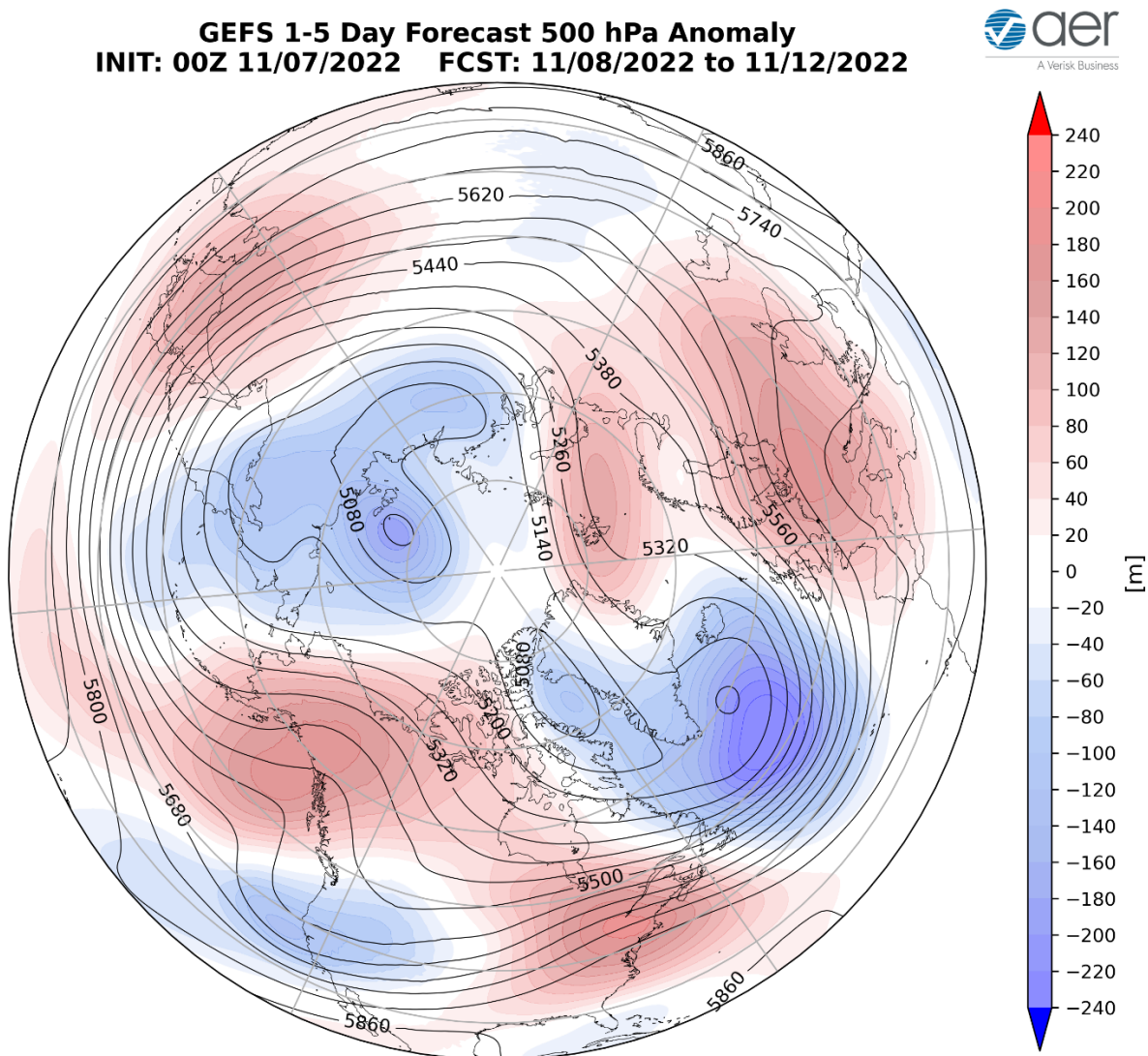


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 November 2022. The forecasts are from the 00z 7 November 2022 GFS ensemble.

Amplified ridging/positive geopotential height anomalies are predicted for Alaska, Western and Southeastern Canada and the Eastern US with troughing/negative geopotential height anomalies in the Western US and Northeastern Canada (**Figure 2**). The pattern will favor normal to above normal temperatures across Alaska, Western and Southeastern Canada and the Eastern US with normal to below normal temperatures across Northeastern Canada and the Western US (**Figure 3**).

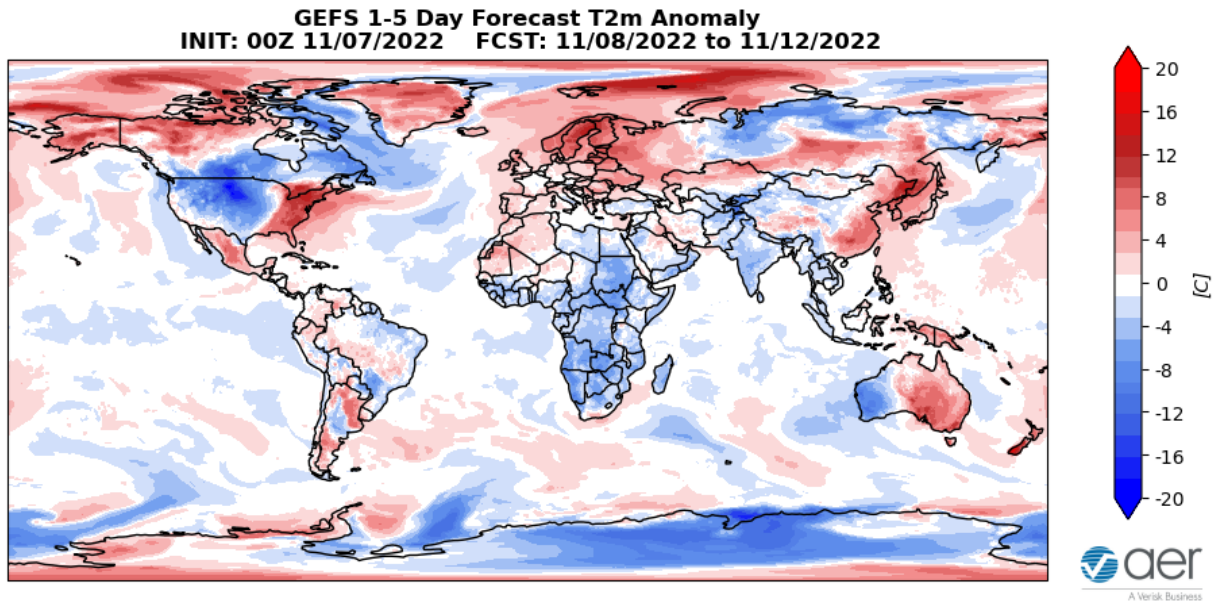


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 8 – 12 November 2022. The forecast is from the 00Z 7 November 2022 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Siberia and the Tibetan Plateau while mild temperatures will support snowmelt in Norway and the Urals region (**Figure 4**). Troughing and/or cold temperatures will support new snowfall across Alaska and along a track from the US Rockies through the US Northern and Canadian Plains and into Quebec (**Figure 4**).

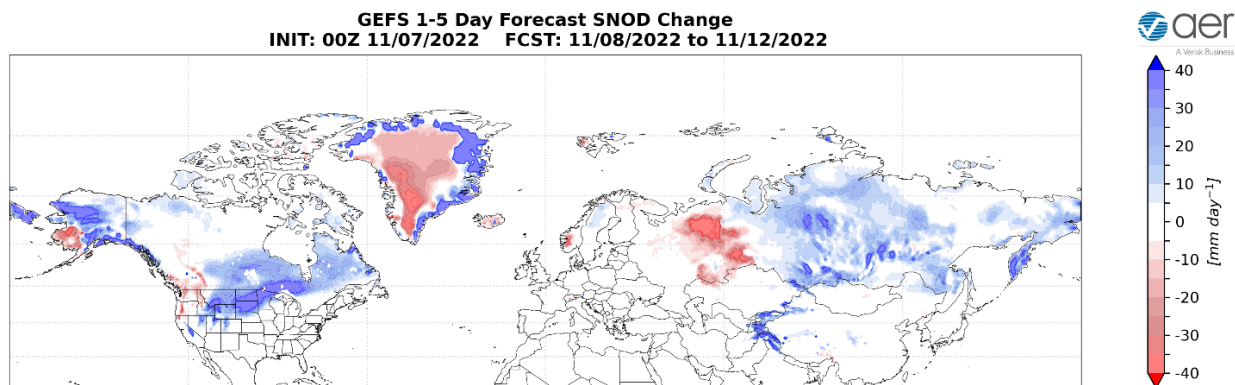


Figure 4. Forecasted snow depth changes (mm/day; shading) from 8 – 12 November 2021. The forecast is from the 00Z 7 November 2021 GFS ensemble.

Near-Term

1-2 week

The AO is predicted to remain positive this period (**Figure 1**) as geopotential height anomalies remain mostly negative across the Arctic and mixed across the mid-latitudes (**Figure 5**). With mixed but mostly negative geopotential height anomalies across Greenland (**Figure 5**), the NAO is predicted to remain positive this period as well.

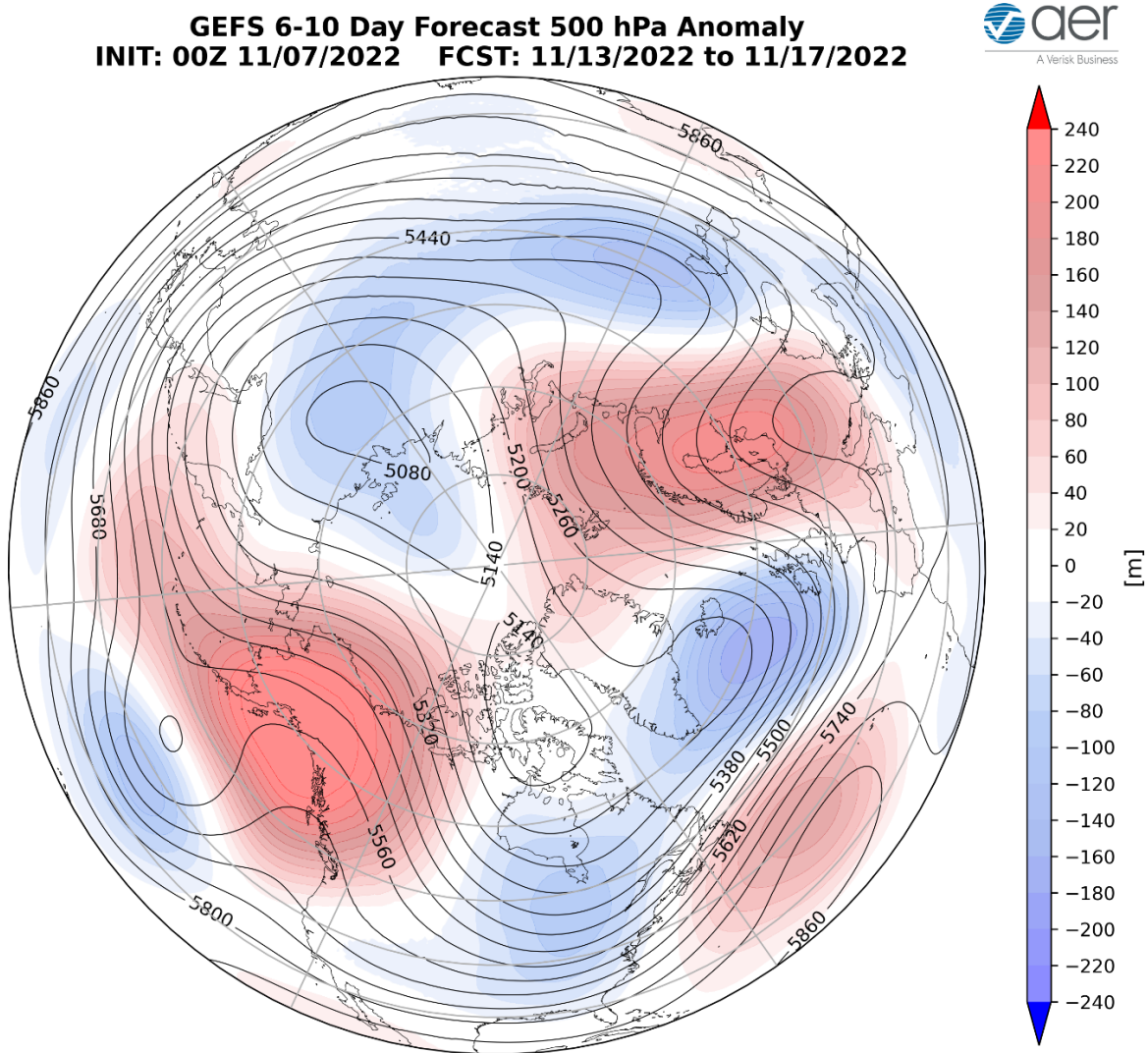


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 November 2022. The forecasts are from the 00z 7 November 2022 GFS ensemble.

Predicted persistent troughing/negative geopotential height anomalies in the eastern North Atlantic will continue to support amplified ridging/positive geopotential height anomalies persisting across Europe and centered on Scandinavia with the exception of troughing/negative geopotential height anomalies in the northern UK (**Figure 5**). The pattern is predicted to result in widespread normal to above normal temperatures across Europe including England with normal to below normal temperatures limited to Ireland and Scotland (**Figure 6**). Persistent European ridging/positive geopotential height anomalies are predicted to force downstream troughing/negative geopotential height anomalies across Siberia that extends southwestward towards the Middle East with ridging/positive geopotential height anomalies in eastern Siberia this period (**Figure 5**). This pattern favors widespread normal to below normal temperatures across Northern and Western Asia with normal to above normal temperatures across Eastern Siberia and Central Asia (**Figure 6**).

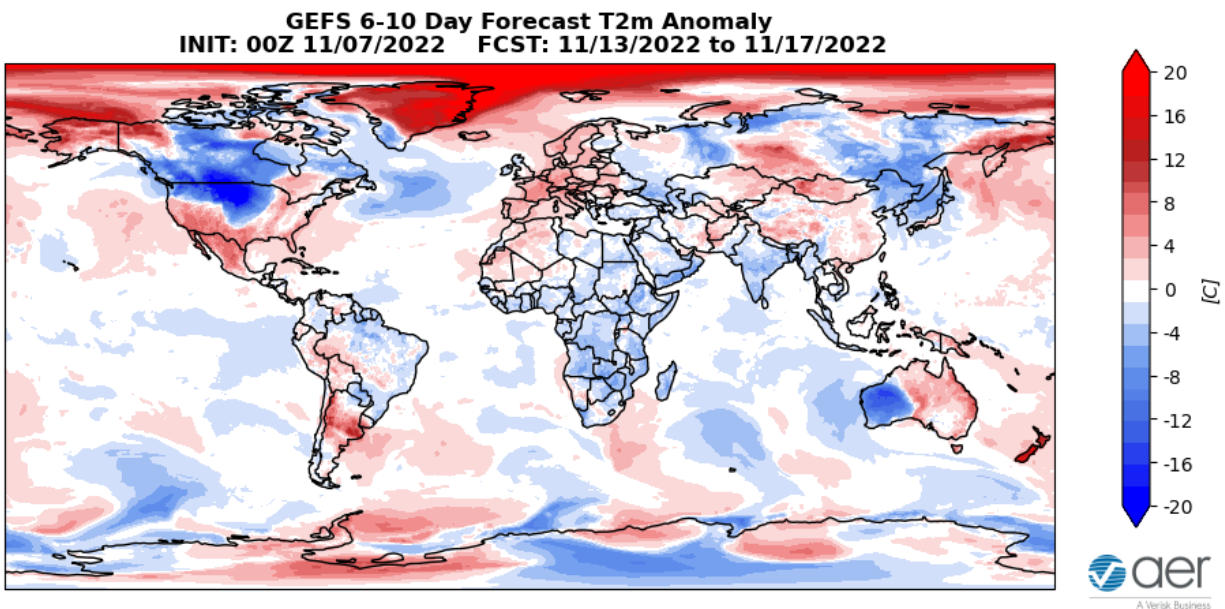


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 November 2022. The forecast is from the 00Z 7 November 2022 GFS ensemble.

Predicted amplified ridging/positive geopotential height anomalies across Alaska and Western Canada will force troughing/negative geopotential height anomalies across eastern North America centered in the Great Lakes this period (**Figure 5**). This pattern will favor normal to above normal temperatures across Alaska, the Canadian Maritimes and New England with normal to below normal temperatures across Southwestern and Eastern Canada, the Northwestern and Central US (**Figure 6**).

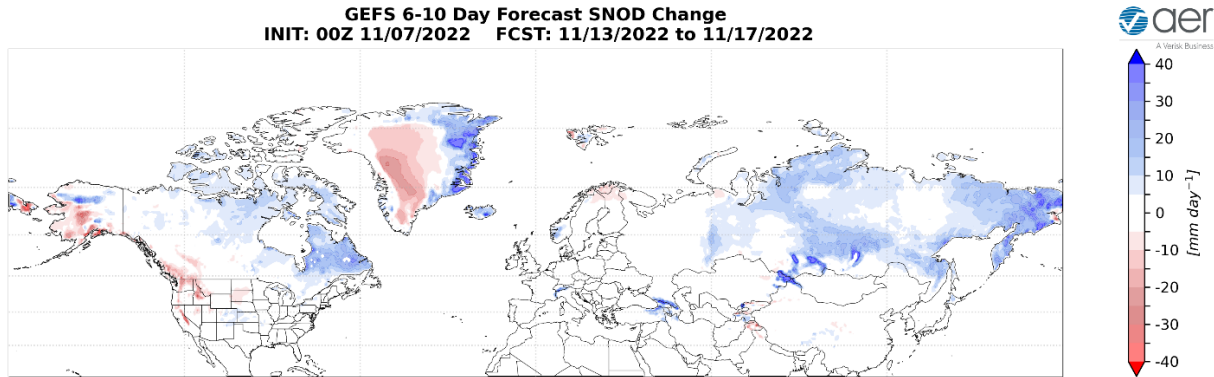


Figure 7. Forecasted snow depth changes (mm/day; shading) from 13 – 17 November 2021. The forecast is from the 00Z 7 November 2021 GFS ensemble.

Trouching and/or cold temperatures will support new snowfall across parts of Northern Asia while mild temperatures will support snowmelt in Scandinavia (**Figure 7**). Trouching and/or cold temperatures will support new snowfall across northern Alaska, Northern and Eastern Canada while mild temperatures will support snowmelt in southern Alaska and the Western US (**Figure 7**).

3-4 week

Geopotential height anomalies are predicted to remain mostly negative across the Central Arctic and mixed across the mid-latitudes this period (**Figure 8**), therefore the AO should remain positive to neutral this period (**Figure 1**). With weak but negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to remain positive to neutral this period.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 11/07/2022 FCST: 11/18/2022 to 11/22/2022

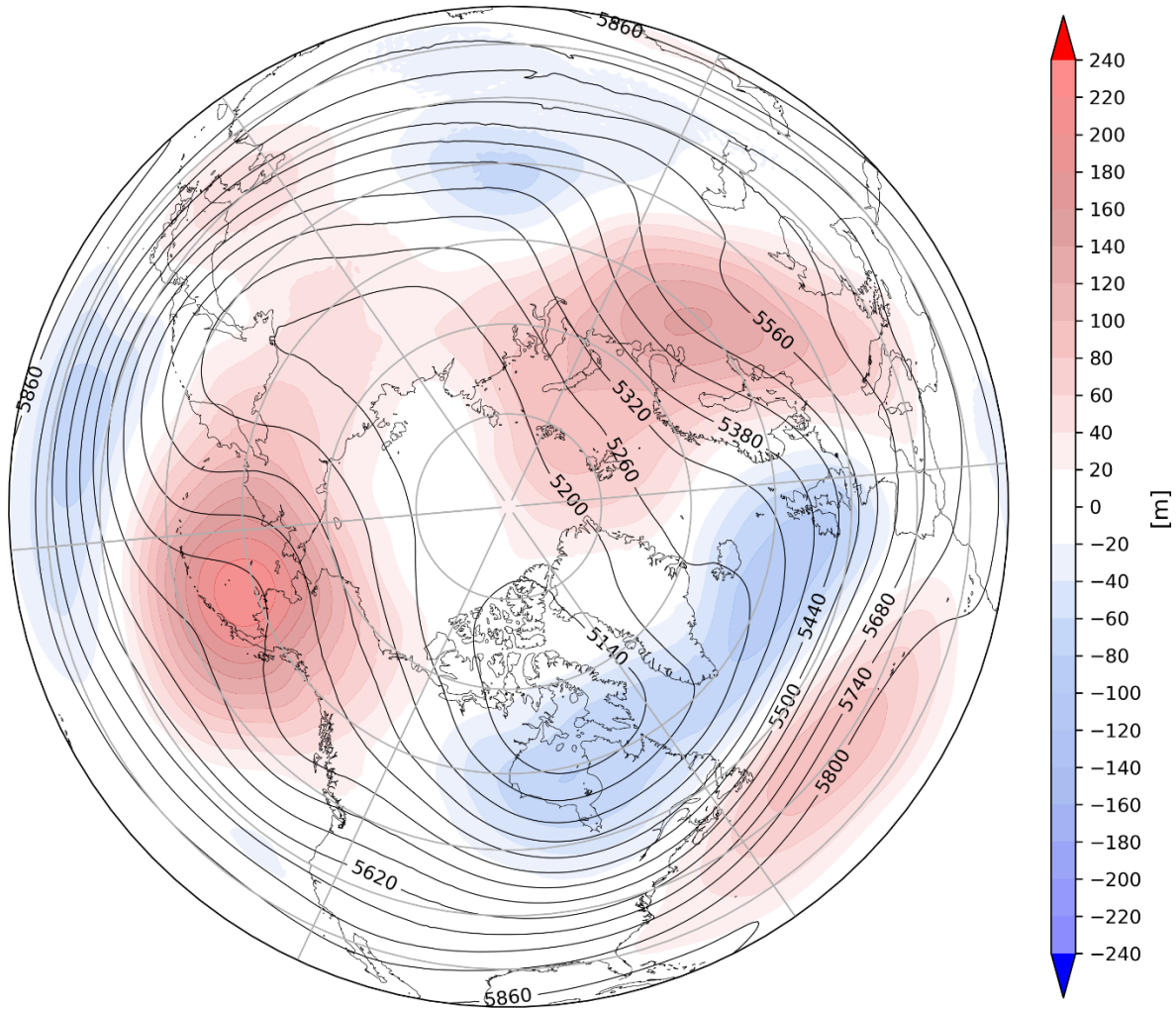


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 November 2022. The forecasts are from the 00z 7 November 2022 GFS ensemble.

Persistent eastern North Atlantic troughing/negative geopotential height anomalies are continued to persist and extend into Western Europe while continuing to force ridging/positive geopotential height anomalies across Central and Eastern Europe this period (**Figure 8**). This pattern favors normal to above normal temperatures across much of Europe with the exception of normal to below normal temperatures across far Western Europe including the western UK (**Figures 9**). Persistent European ridging/positive geopotential height anomalies will contribute to troughing/negative geopotential height anomalies across Siberia and Central Asia with ridging/positive geopotential height anomalies persisting in Eastern Siberia (**Figure 8**). This pattern favors widespread normal to below normal temperatures across much of Northern and

Central Asia with normal to above normal temperatures across Western Asia and Eastern Siberia (**Figure 9**).

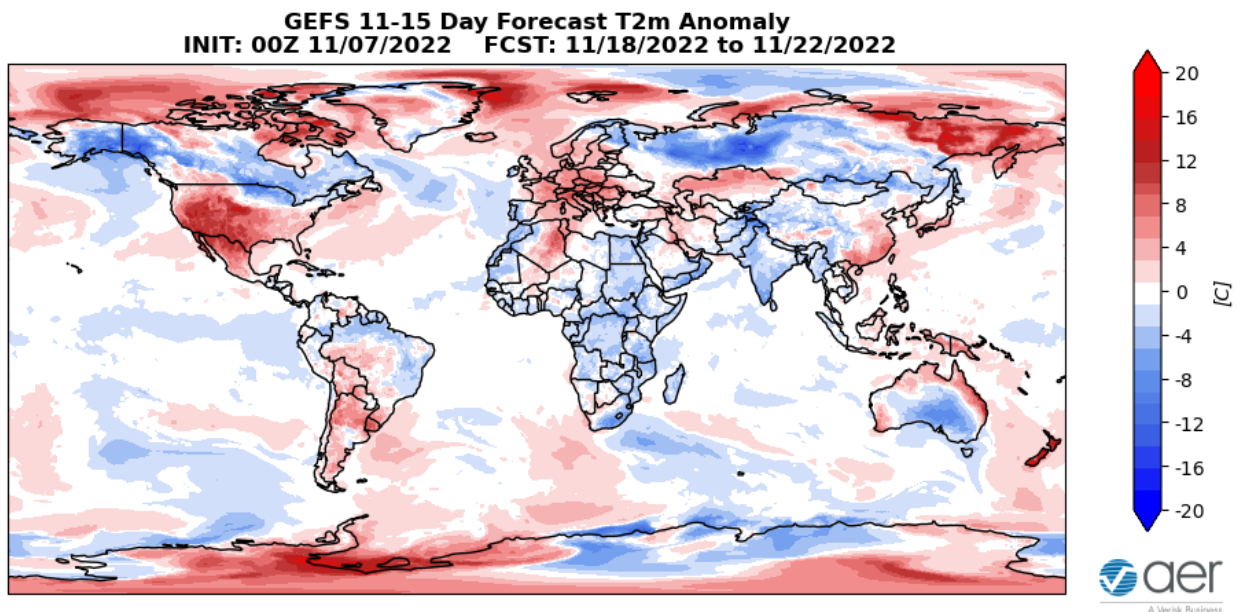


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 18 – 22 November 2022. The forecast is from the 00Z 7 November 2022 GFS ensemble.

Ridging/positive geopotential height anomalies centered on Alaska are predicted to drift westward allowing downstream troughing/negative geopotential height anomalies to slide west into Central Canada and the Central US with more ridging/positive geopotential height anomalies the North Atlantic coast this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, the Western US and the US East Coast with normal to below normal temperatures across much of Canada and the Central US (**Figure 9**).

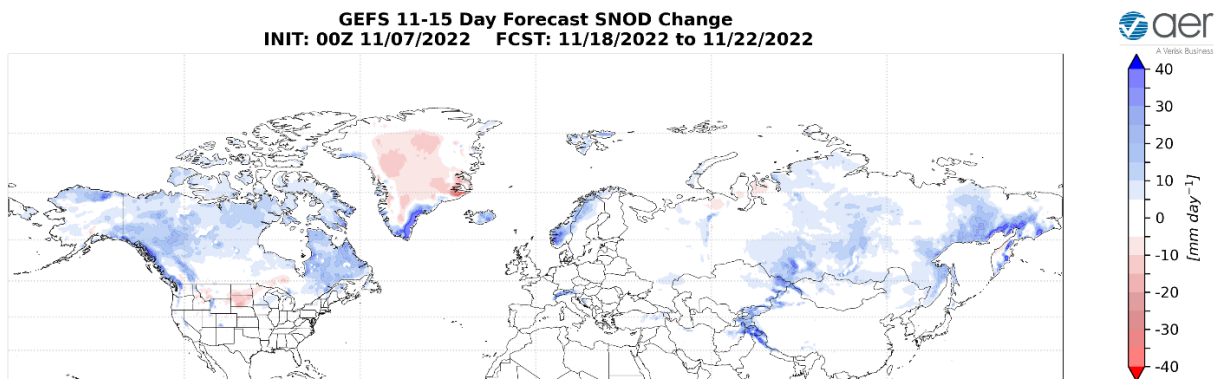


Figure 10. Forecasted snow depth changes (mm/day; shading) from 18 – 22 November 2022. The forecast is from the 00Z 7 November 2021 GFS ensemble.

Trouging and/or cold temperatures will support new snowfall across Norway, Northern Asia and the Tibetan Plateau while mild temperatures will support snowmelt near the Urals (**Figure 10**). Trouging and/or cold temperatures will support new snowfall across Alaska, Canada and the higher elevations of the Northwestern US while mild temperatures will support snowmelt in the US Plains (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs in the upper stratosphere and the lower troposphere with warm/positive PCHs in the mid to mid to lower stratosphere and the mid to upper troposphere (**Figure 11**). However, the cold/negative PCHs currently observed in the lower troposphere are predicted to become mixed as warm/positive PCHs descend from the lower stratosphere and upper troposphere (**Figure 11**).

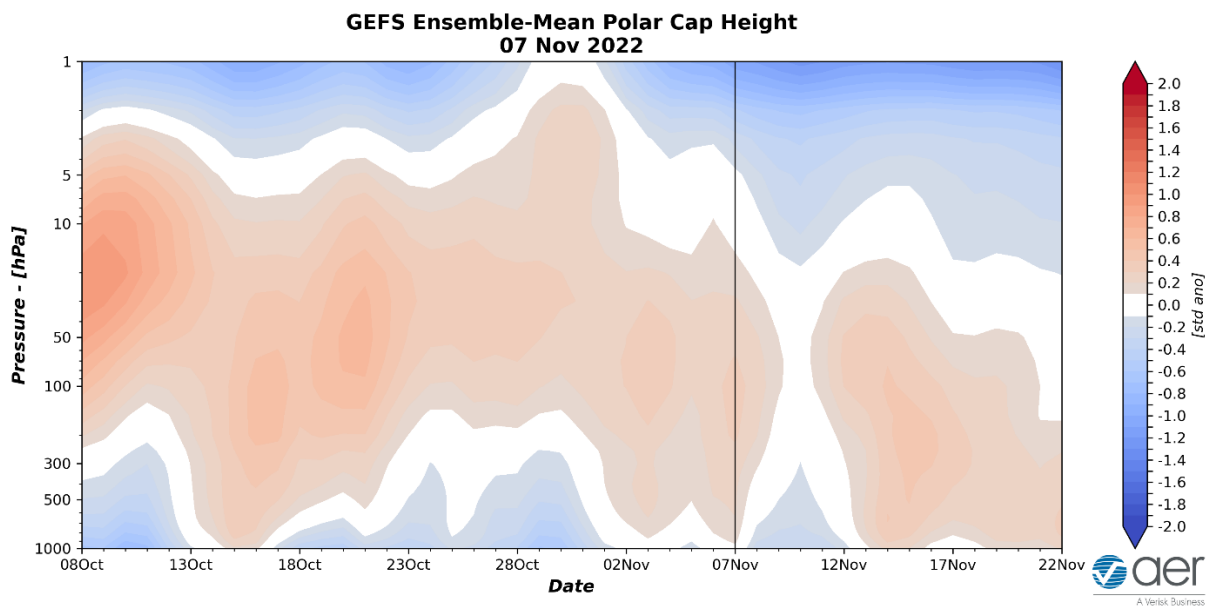


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 7 November 2022 GFS ensemble.

The cold/negative PCHs in the lower troposphere (**Figure 11**) are consistent with the predicted positive surface AO for this week (**Figure 1**). However as lower stratospheric and upper tropospheric warm/positive PCHs descend into the lower troposphere next

week (**Figure 11**), the surface AO is predicted to become more tethered to neutral in mid-November (**Figure 1**).

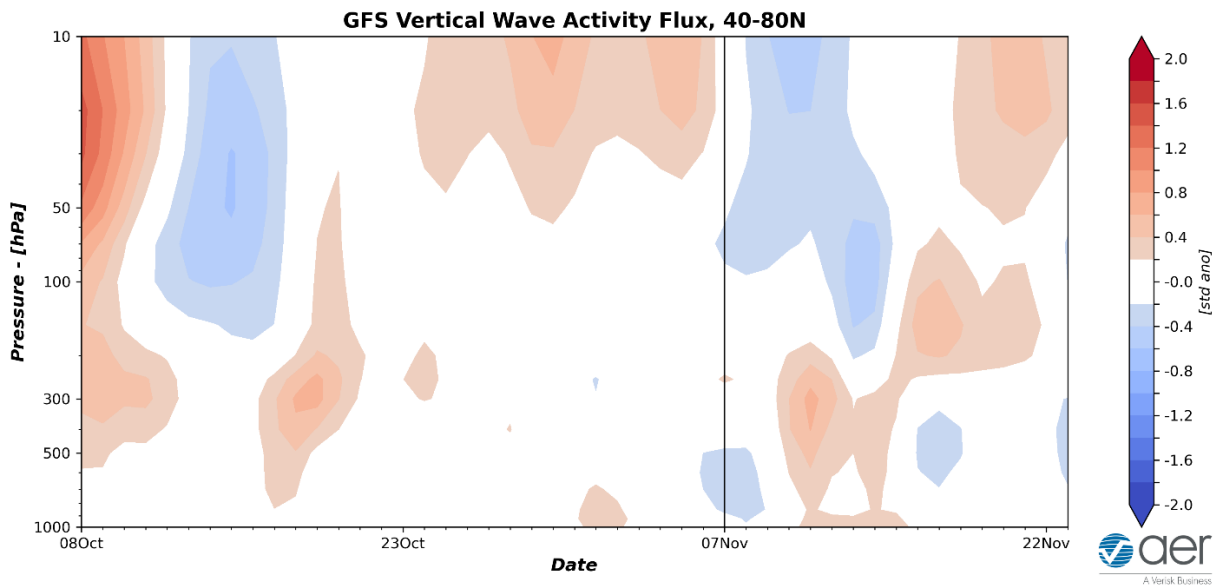


Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 7 November 2022 GFS ensemble.

The near normal vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere the past two weeks has allowed the mid to upper stratospheric PCHs to cool (**Figure 12**). The GFS is suggesting that the WAF could become somewhat more active towards the middle of the month, resulting in warming tropospheric PCHs (**Figure 12**).

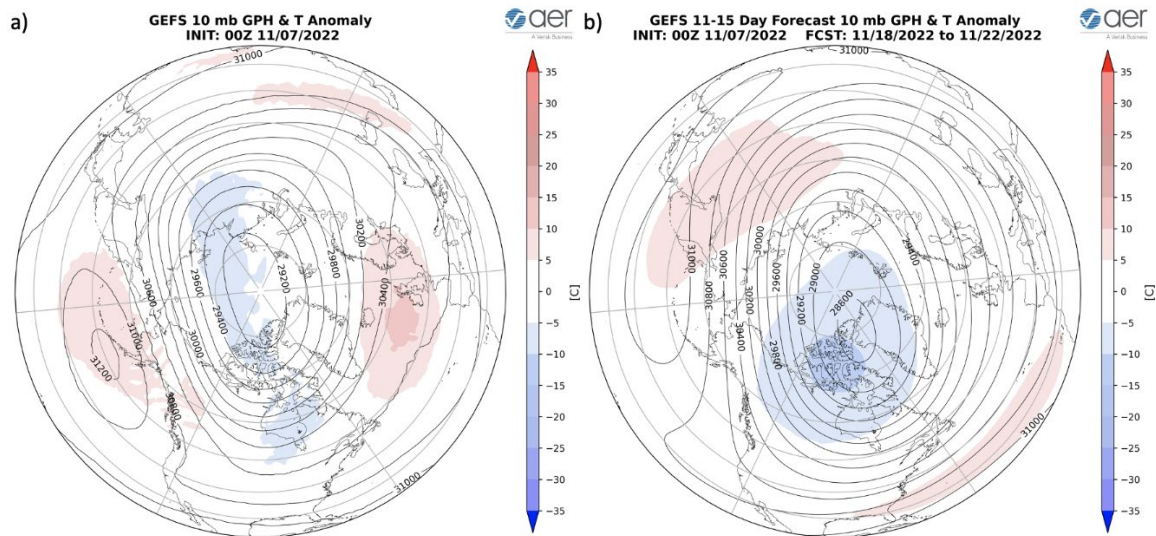


Figure 13. (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for 7 November 2022. (b) Same as (a) except forecasted averaged from 18 – 22 November 2020. The forecasts are from the 00Z 7 November 2020 GFS model ensemble.

The near normal WAFz has allowed the stratospheric PV to strengthen and centered over the North Pole (**Figure 13**). However, the uptick in WAFz in early November did lead to a minor disruption of the PV (**Figure 13**) that I believe is consistent with a stretched PV extending from Siberia to Hudson Bay and is related to the developing troughing in eastern North America this week. However, the PV is predicted to be normal to stronger than normal over the next two weeks despite remaining in a mostly elongated configuration the next two weeks (**Figure 13**). Therefore, the stratospheric AO is predicted to remain neutral to positive over the next two weeks (**Figure 1**).

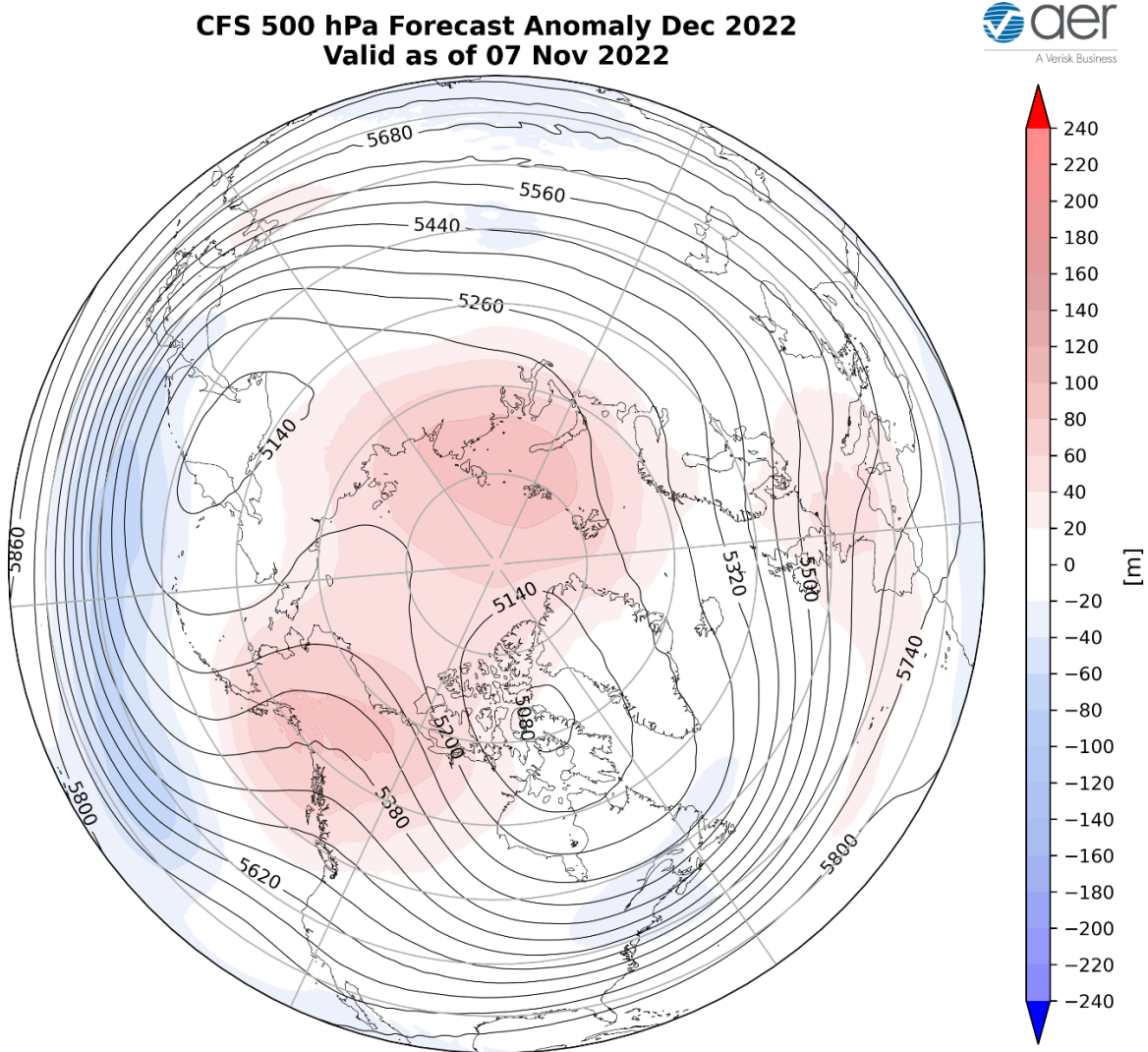


Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2022. The forecasts are from the 00Z 7 November 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for December (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered across Europe, the Barents-Kara Seas, the Gulf of Alaska, Alaska and in the Central Arctic with troughing across the eastern Mediterranean, Siberia, East Asia, Eastern Canada and the Northeastern US (**Figure 14**). This pattern favors seasonable to relatively warm temperatures across Europe, Eastern Siberia, Alaska, Northern and Western Canada and the Western US with seasonable to relatively cold temperatures across the Middle East, Northern and Eastern Asia, Southeastern Canada and the Eastern US (**Figure 15**).

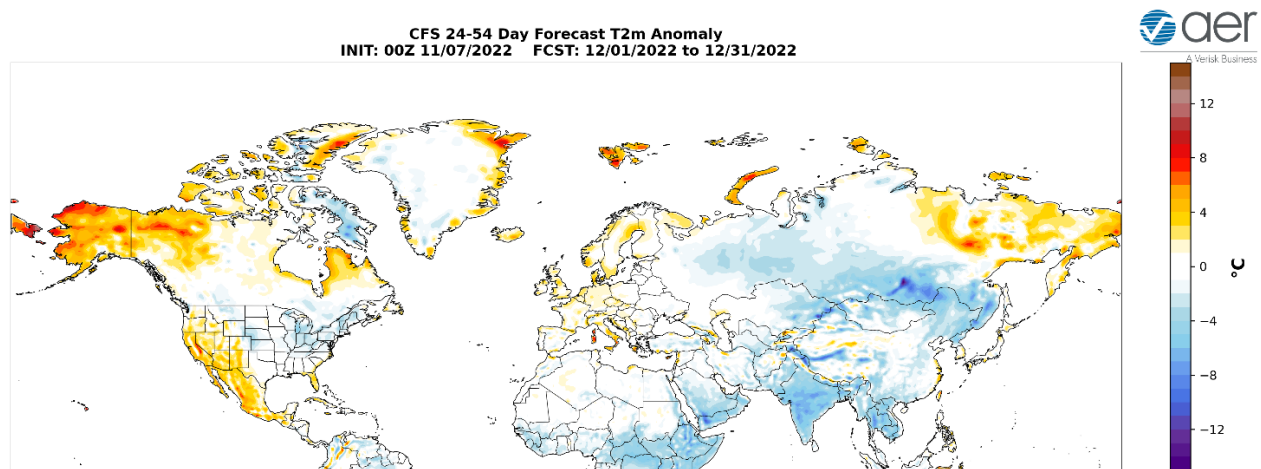


Figure 15. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for December 2022. The forecasts are from the 00Z 7 November 2022 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 16**) and La Niña conditions are expected through the fall. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

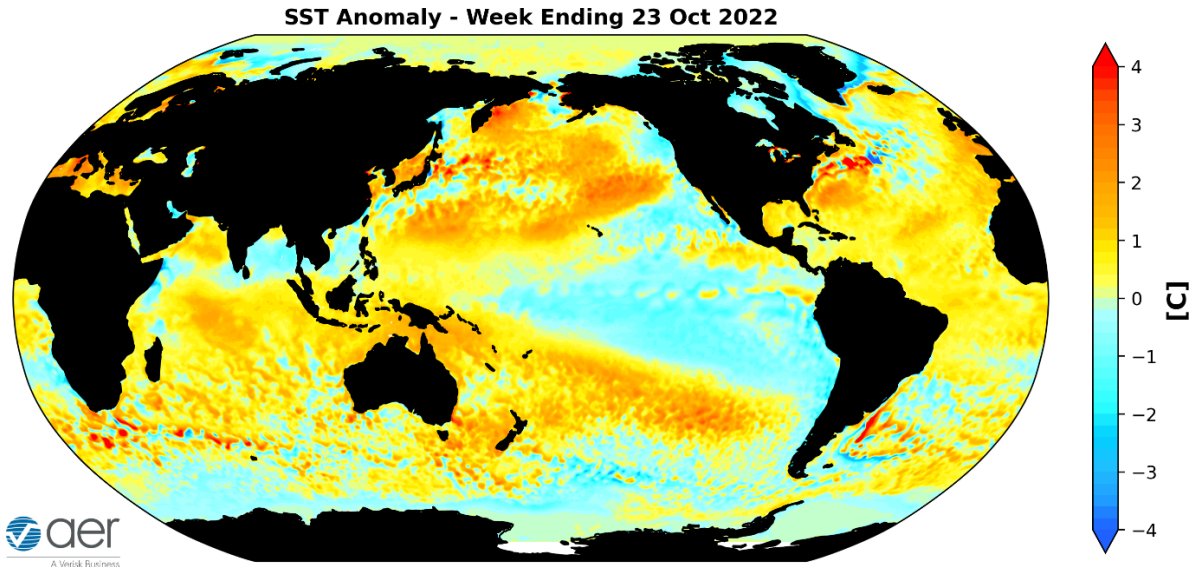


Figure 16. The latest weekly-mean global SST anomalies (ending 6 November 2022). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is in phase seven (**Figure 17**). The forecasts are for the MJO to quickly move to phase eight and then weaken to where no phase of the MJO is favored. MJO phase eight longer term favors ridging in eastern North America with troughing in western North America especially Alaska. I don't see this as consistent with the midterm weather across North America. But admittedly this is outside of my expertise.

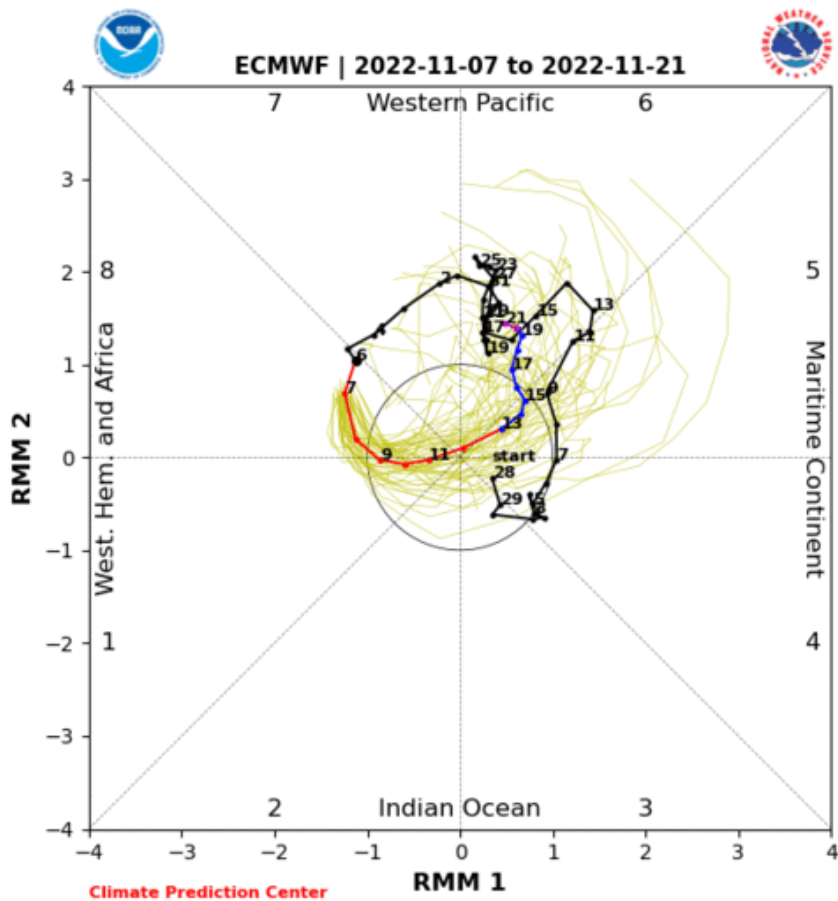


Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 7 November 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>

Get Detailed Seasonal Weather Intelligence with sCast

We appreciate your taking the time to read the public Arctic Oscillation blog from Dr. Judah Cohen and the AER Seasonal Forecasting team.

Dr. Cohen’s detailed monthly seasonal forecast, sCast, is also available for purchase. sCast provides a monthly 30-60-90-180-day outlook into temperature and precipitation, solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

Our sCast principal engineer, [Karl Pfeiffer](#), can help you use sCast and other AER seasonal forecast.