

Arctic Oscillation and Polar Vortex Analysis and Forecasts

October 16, 2023

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.

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. During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to remain very close to neutral the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mostly positive and are predicted to remain mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative with mostly positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to remain negative to neutral the next two weeks as pressure/geopotential height anomalies remain mostly positive to mixed across Greenland.
- Over the next two weeks, the general predicted pattern across Europe is ridging/positive geopotential height anomalies across the northern North Atlantic. Including Scandinavia, forcing troughing/negative geopotential height anomalies across Europe especially Western Europe. This pattern will support normal to below normal temperatures across Northern and Eastern Europe with normal to above normal temperatures across Southern and Western Europe including the United Kingdom (UK) this week and then normal to below normal temperatures across Northern and Western Europe including the UK with normal to above normal temperatures across Southern and Eastern Europe next week.

- This week the predicted pattern across Asia is ridging/positive geopotential height anomalies across Central Asia with troughing/negative geopotential height anomalies across Eastern and Western Asia. Then next week the pattern reverses with ridging/positive geopotential height anomalies across Western and Eastern Asia with troughing/negative geopotential height anomalies in Central Asia. This pattern favors normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures beginning in Western Russia and then spreading into Central Asia next week including Siberia.
- The general predicted pattern across North America this week is ridging/positive geopotential height anomalies dominating much of North America with troughing/negative geopotential height anomalies limited to the Eastern United States (US). However next week strengthening ridging/positive geopotential height anomalies in the Gulf of Alaska will force troughing/negative geopotential height anomalies in western North America that then slides into the interior of North America to end the month. This pattern generally favors this week normal to above normal temperatures across much of Alaska, Canada and the Western and Central US with normal to below normal temperatures in the Eastern US. Next week below normal temperatures will spread across Western Canada and the Western US and then spread eastward across both Canada and the US.
- In the Impacts section I remain focused on Eurasian snow cover as I believe October is the critical month for predicting the upcoming winter circulation and weather. And I discuss a stretched polar vortex disruption next week.
- I am beginning the transition to the winter season, which should occur over the next few weeks starting with this week's blog.

Plain Language Summary

I use October Eurasian snow cover extent as one of our main winter predictors. The advance of snow cover remains sluggish (see **Figure i**) but there is still a chance for a late innings rally.

In the meantime, a stretching of the polar vortex like a rubber band being pulled on both ends should bring colder weather first to East Asia and then eastern North America (see **Figure 9**).

Impacts

Since it is still October, I remain focused on the snow cover advance across Siberia and what impact it may have on the stratospheric polar vortex (PV). I am sure I will be discussing this pathway more in the coming months. More extensive snow cover across Eurasia in October, and this mostly confined to Siberia, the more likely the PV will be weaker than normal during the winter months that favors widespread colder temperatures across the Northern Hemisphere (NH) but in particular in East Asia and the US east of the Rockies. It also includes Northern Europe, but the relationship is weaker across Europe and in my own research rarely is it statistically significant.

I include an update to the plot of daily Eurasian snow cover extent (SCE) so far in October in **Figure i**. The black dashed line represents the mean value using October 2009 through

2022. So far, the advance is clearly below normal based on recent Octobers (which are on average above the longer-term mean). The SCE is equal to the value from October 2022 on this date and close to the value of October 2019. Both of those winters were dominated by a stronger than normal PV for much of the winter and mild temperatures in the Eastern US and Europe. If you are a winter weather enthusiast those are not comforting analogs. This isn't over but as of today the message that I am receiving from Eurasian SCE, a mild winter is favored so far in the Eastern US. But even I can be focused on the wrong signal or message.

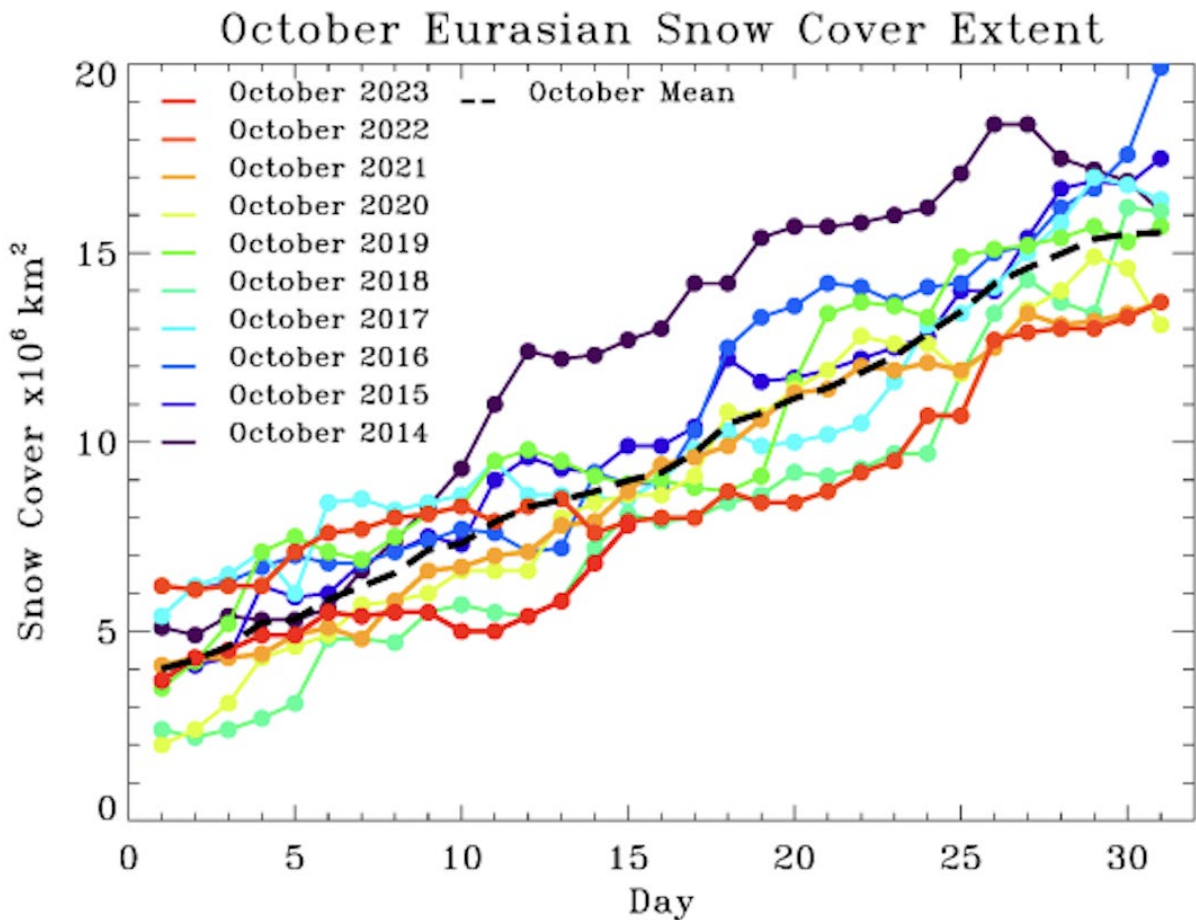


Figure i. Observed Eurasian daily snow cover extent (SCE) in millions of km squared for the month of October through 16 October 2023 (shown in red).

There was a large PV disruption in late February 2023, but its impacts were felt too late to influence the winter temperature averages. At his time, I do think if there is a large PV disruption this winter, I do believe that it will be earlier than last winter for a reason I discuss below.

The ridge across Siberia is predicted to re- strengthen this week (see **Figure 2**), though not as much as last week. So even though SCE has rallied for the past four days or so, I would expect the rally to fizzle this week and for SCE to remain below the recent climatological value. I added

snowfall forecast plots in this week's blog, and in you can still see from **Figure 4** predicted snowmelt in Western and Southern Siberia.

However, starting next week there is predicted a meaningful change in the overall pattern. High pressure ridging is predicted to take hold in Northwestern Asia and eventually near the Urals and the Barents-Kara Seas (see **Figure 8**). This pattern is supportive of cold temperatures and an acceleration of snow advance across Central and Eastern Asia and in particular across Siberia. So potentially a slow start but a fast finish to snow cover advance across Eurasia for the month of October.

One reason for the more favorable pattern for cold and snow in East Asia (and also eastern North America) is a predicted stretched polar vortex (PV) event starting next week. You can see in **Figure 12** that the PV is predicted to evolve from a nearly circular shape this week to a more elongated shape the last week of October. It is early and this is far from a textbook case, but the stretched PV is just enough to shift ridging to near the Barents-Kara Seas and Alaska, which is typical for these events. It is not always the case but the tropospheric polar circulation, or PV if you like, is also predicted to take on a similar elongated shape as seen in **Figure 8**. These events typically last on the order of one to two weeks. Therefore, I would expect the colder weather to last until early November before relaxing. The colder weather typically starts in East Asia and end in eastern North America so look for milder weather first in Asia and then to follow in North America. Stretched PVs can repeat and even eventually be a harbinger of a much bigger PV disruption or become an inflection point to a strengthening PV and too early to know today, how the PV will evolve through the month of November.

Moving over to Arctic sea ice (see **Figure ii**), it does appear to me that the lopsided negative anomalies almost completely in the North Pacific sector are starting to now migrate into the North Atlantic sector. What would be interesting to monitor in the coming weeks – does the predicted high pressure ridging and mild temperatures in the Barents-Kara seas couple with increasing negative sea ice extent anomalies to reinforce each other? If they do and the high pressure ridging in the region can persist for multiple weeks, then this will pressure a weaker PV in the coming weeks and months.

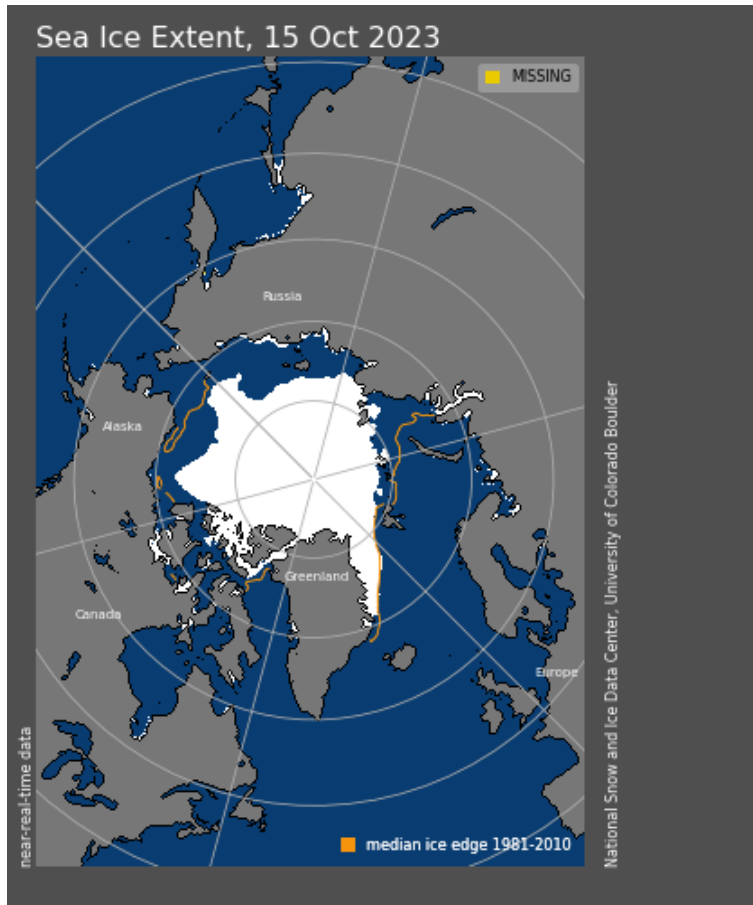


Figure ii. Observed Arctic sea ice extent on 15 October 2023 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC). Snow and Ice Data Center (NSIDC).

For what it's worth, the CFS does seem to like this idea (see **Figures 13 and 14**). The CFS is locked in on high pressure ridging in the Barents-Kara Seas with downstream cold temperatures across Siberia. The CFS only amplifies this pattern in December and I debated with myself whether to include it but I decided against gratuitous posting of the CFS forecast. But if (and a really huge if) this is correct, we can potentially observe a relatively early large PV disruption, which I do believe is supported by an easterly quasi-biennial oscillation (QBO). And if there is a large PV disruption, the probability of cold and snowy weather greatly increases across the Northern Hemisphere (NH). But it is not hard for me to contain my enthusiasm since I want to see more than a CFS forecast before I jump all in (or even a little) on this scenario.

Near-Term

This week

The AO is predicted to be neutral this week (**Figure 1**) with mixed geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes of the

NH (**Figure 2**). With positive geopotential height anomalies between Greenland and Scandinavia (**Figure 2**), the NAO is predicted to be negative this period.

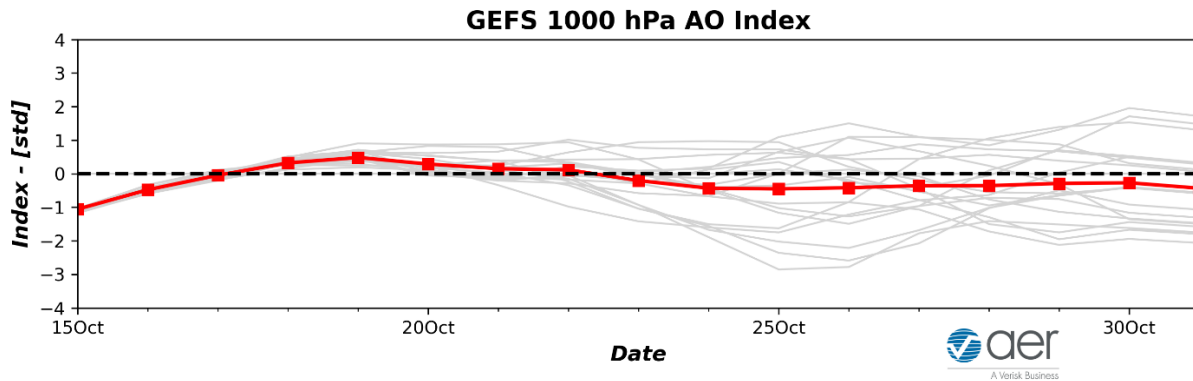


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 3 October 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies in the northern North Atlantic that will extend into Scandinavia will support troughing/negative geopotential height anomalies across much of Europe to the south (**Figures 2**). This pattern favors normal to above and well above normal temperatures across Western and Southern Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (**Figure 3**). This week Asia is predicted to be dominated by ridging/positive geopotential height anomalies centered in Central Asia bookended with troughing/negative geopotential height anomalies in Western Asia and Eastern Asia (**Figure 2**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially Central Asia with normal to below normal temperatures limited to Western Russia and regionally in parts of China and Eastern Siberia (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/16/2023 FCST: 10/17/2023 to 10/21/2023

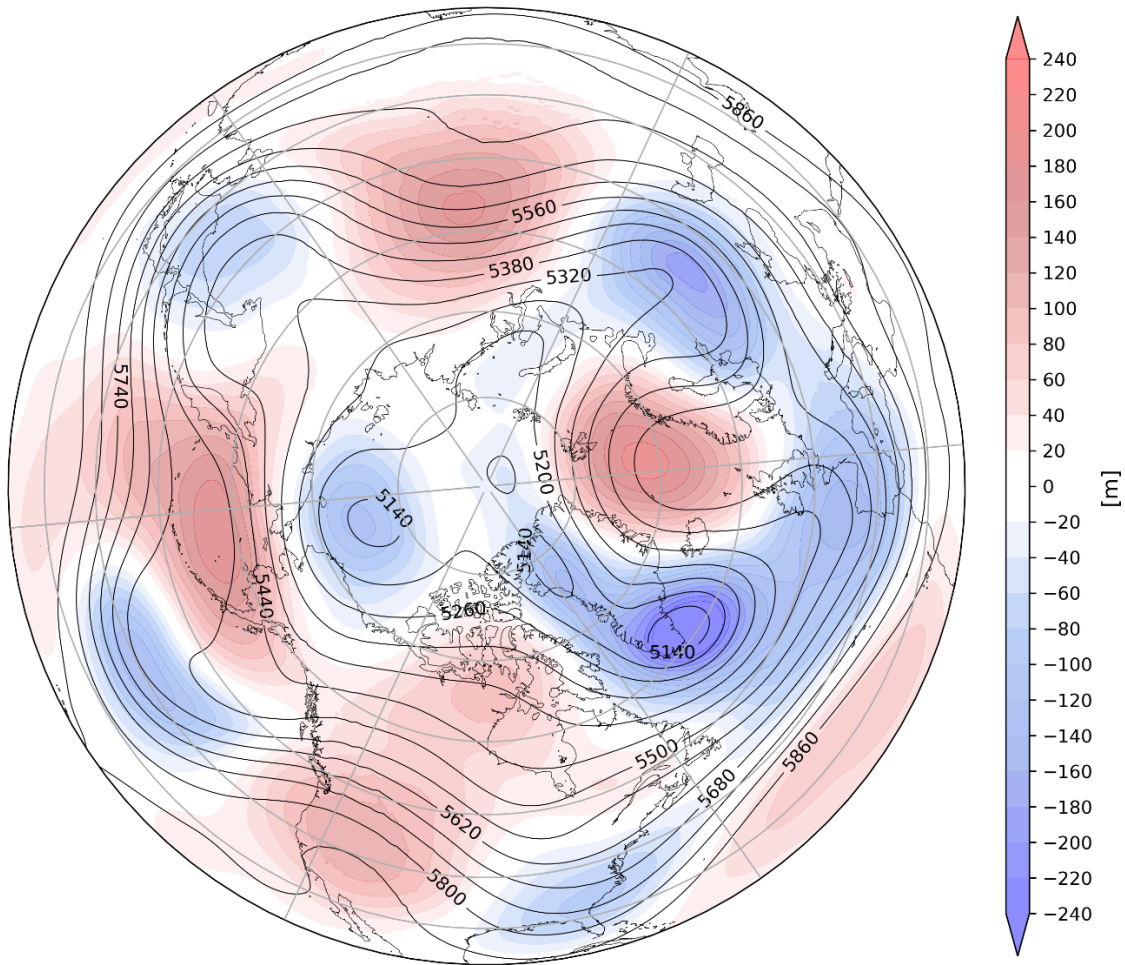


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 October 2023. The forecasts are from the 00z 16 October 2023 GFS ensemble.

The pattern this week across North America is ridging/positive across much of Canada and the US with troughing/negative geopotential height anomalies mostly limited to the Eastern US (**Figure 2**). This pattern will favor widespread normal to above normal temperatures across much of Alaska, Canada, the Western and Central US with normal to below normal temperatures mostly limited to the Eastern US (**Figure 3**).

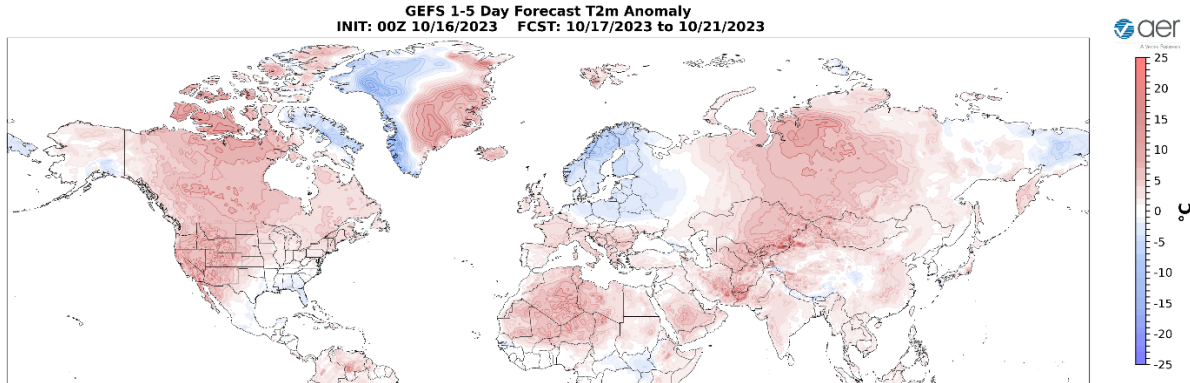


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 17 – 21 October 2023. The forecast is from the 00Z 16 October 2023 GFS ensemble.

Trouging and/or cold temperatures will support new snowfall across Central and Eastern Siberia while mild temperatures will support snowmelt in Western Siberia this week (**Figure 4**). Trouging and/or cold temperatures will support new snowfall across Northern Alaska, Northern and Western Canada this week (**Figure 4**).

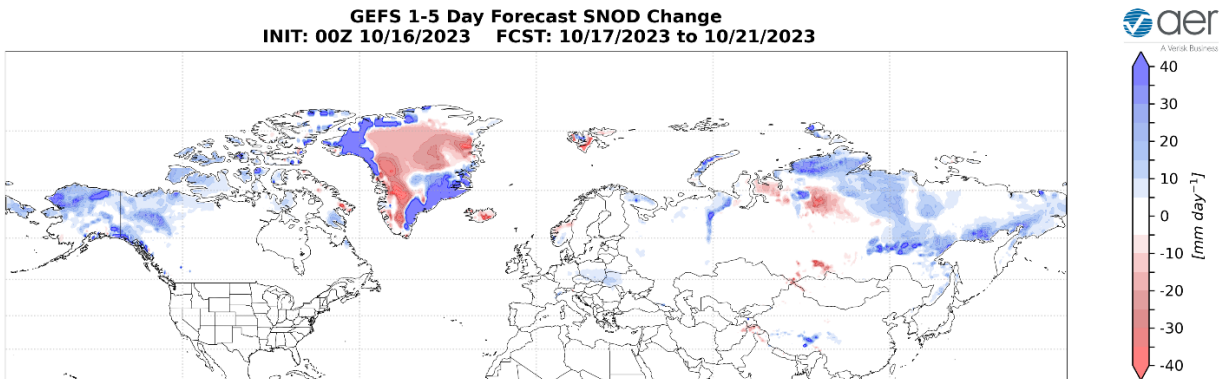


Figure 4. Forecasted snow depth changes (mm/day; shading) from 17 – 21 October 2023. The forecast is from the 00Z 16 October 2023 GFS ensemble.

Near-Mid Term

Next week

With mixed geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should remain close to neutral this period (**Figure 1**). With predicted weak but slightly positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be negative to neutral this period.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/16/2023 FCST: 10/22/2023 to 10/26/2023

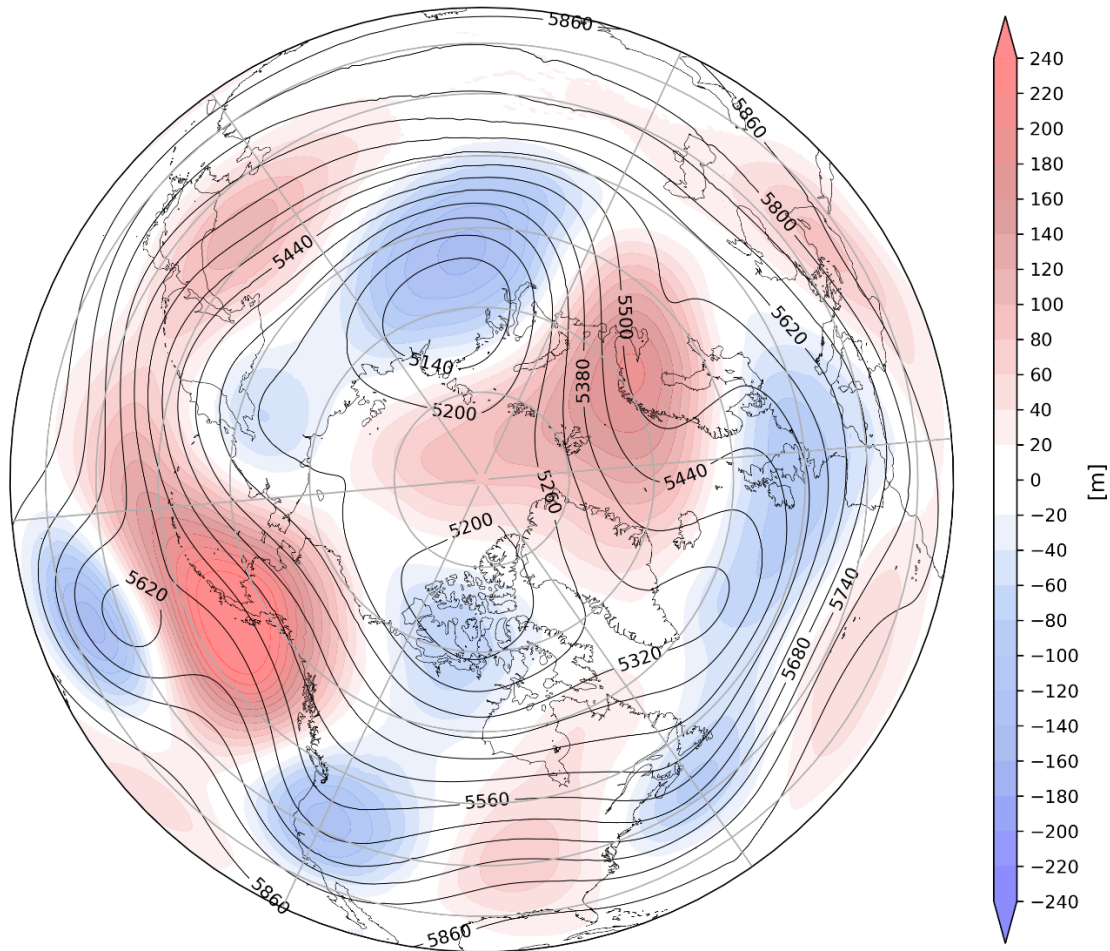


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 22 – 26 October 2023. The forecasts are from the 00z 16 October 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies in the northern North Atlantic that extends into Scandinavia will continue to support troughing/negative geopotential height anomalies to the south across Europe but centered in Western Europe this period (**Figure 5**). This pattern should favor normal to above normal temperatures across Southern and Eastern Europe **with** normal to below normal temperatures across Northern and Western Europe including the UK (**Figures 6**). The general pattern across Asia is predicted ridging/positive geopotential height anomalies centered in Northwest and Northeast Asia with troughing/negative geopotential height anomalies in Central Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially Central and Southern Asia with normal to below normal temperatures limited to Western Russia this period (**Figure 6**).

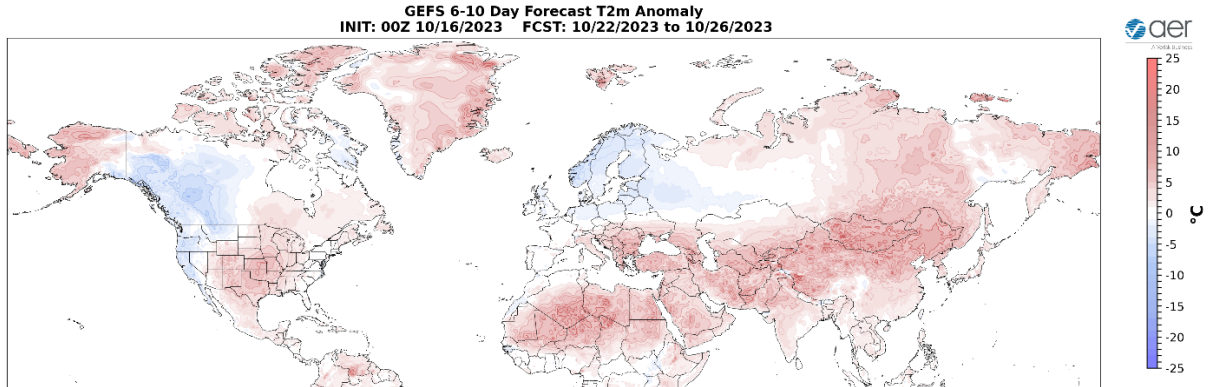


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 22 – 26 October 2023. The forecasts are from the 00z 16 October 2023 GFS ensemble.

The predicted general pattern across North America this period is strengthening ridging/positive geopotential height anomalies the Gulf of Alaska forcing troughing/negative geopotential height anomalies across Western Canada and the Western US with more ridging/positive geopotential height anomalies across the Eastern US (**Figure 5**). This pattern favors normal to above normal temperatures across much of Alaska, Eastern Canada and the Central and Eastern US with normal to below normal temperatures limited to Western Canada and the Western US (**Figure 6**).

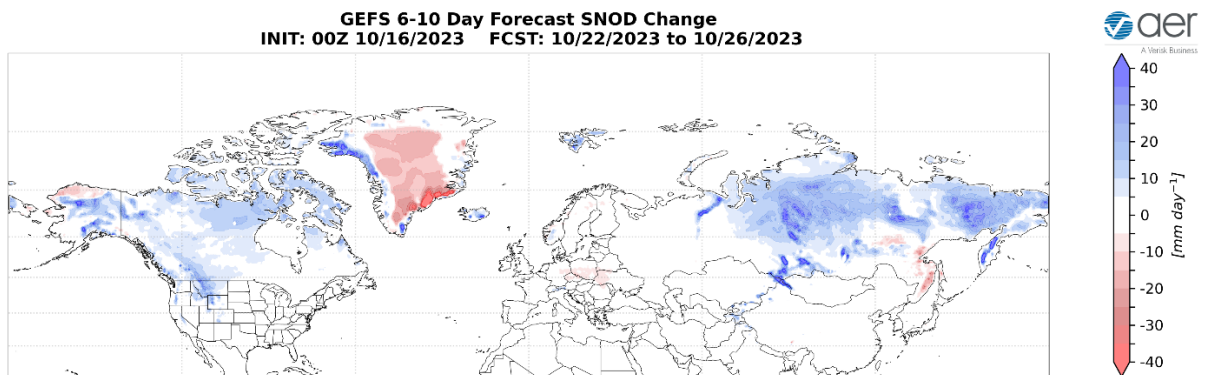


Figure 7. Forecasted snow depth changes (mm/day; shading) from 22 – 26 October 2023. The forecast is from the 00Z 16 October 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across much of Siberia while mild temperatures will support snowmelt in Southeastern Siberia this period (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across the higher elevations of Alaska, Northern, Western and even Central Canada and the US Northern Rockies this period (**Figure 7**).

Mid Term

Week Two

With predicted mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO should remain close to neutral but maybe more of a negative bias this period (**Figure 1**). With predicted mixed and weak pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will likely also remain close to neutral or slightly negative this period as well.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/16/2023 FCST: 10/27/2023 to 10/31/2023

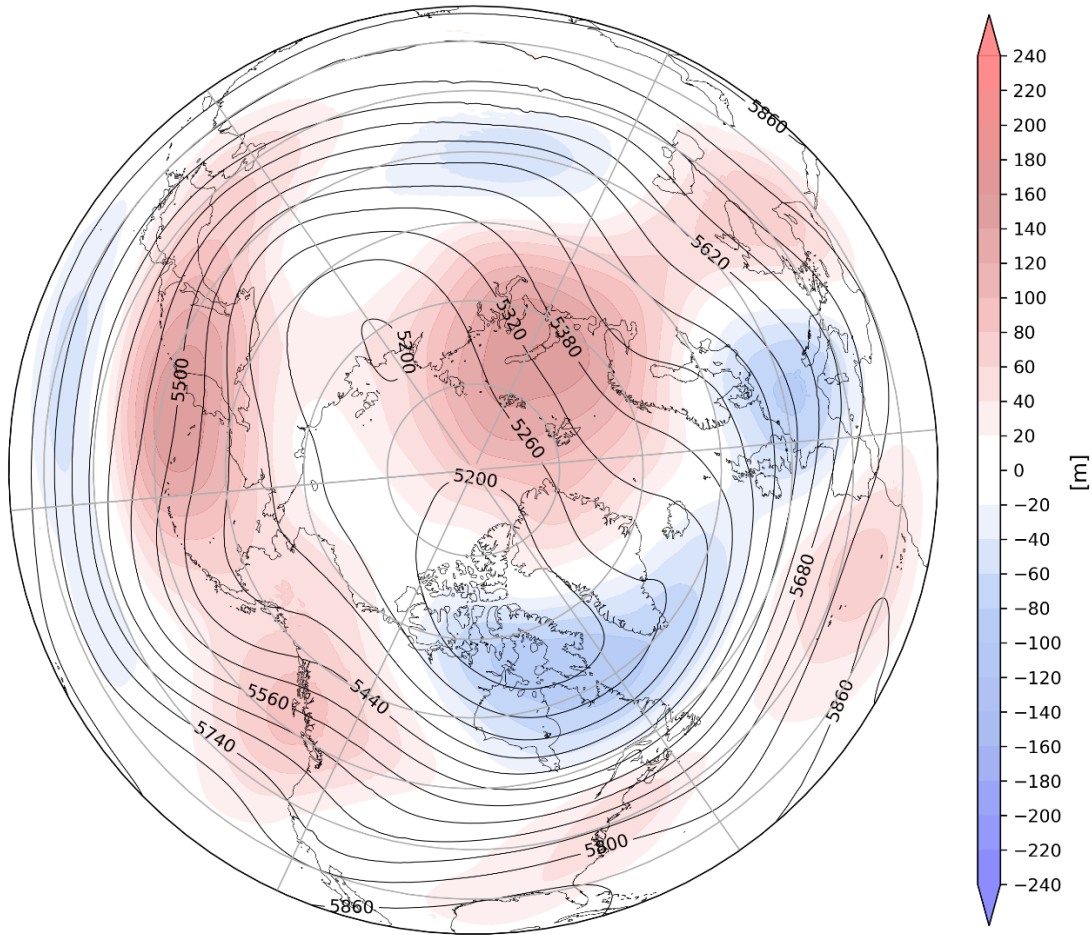


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 27 – 31 October 2023. The forecasts are from the 00z 16 October 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Scandinavia and now into the Barents-Kara Seas will continue to support troughing/negative geopotential height anomalies to the south across Europe and centered in Western Europe this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Southern and Eastern Europe with normal to below normal temperatures across Northern and Western Europe including the UK this period (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to consolidate in the Barents-Kara Seas and Northwestern Asia and East Asia with troughing/negative geopotential height anomalies across Central Asia and Siberia this period (**Figure 8**). The

predicted pattern favors widespread normal to above normal temperatures across much of Asia especially along the edges with normal to below normal temperatures mostly limited to the interior of Asia, including Siberia this period (**Figure 9**).

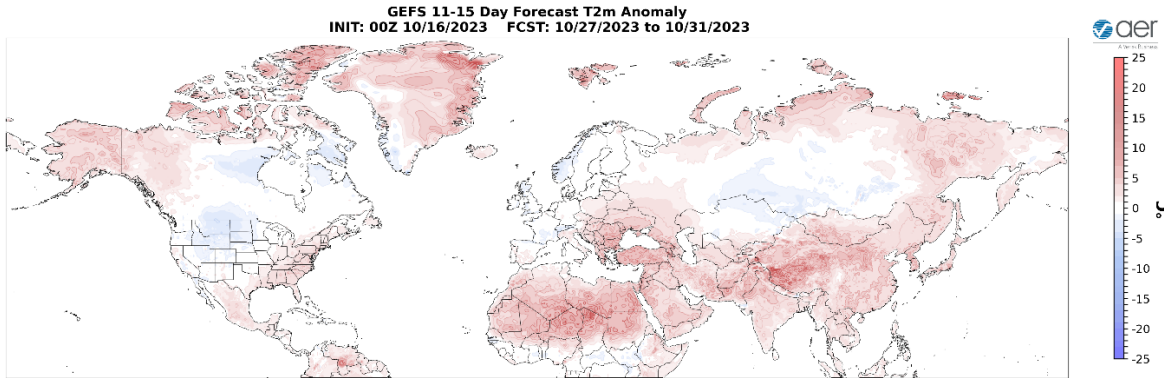


Figure 9. Forecasted surface temperature anomalies (°C; shading) from 27 – 31 October 2023. The forecasts are from the 00z 16 October 2023 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist in the Gulf of Alaska and extending into Alaska and Western Canada forcing downstream troughing/negative geopotential height anomalies across the interior of North America with more ridging/positive geopotential height anomalies in the Eastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, Western Canada and the Eastern US with normal to below normal temperatures across Central and Eastern Canada and the Western and Central US (**Figure 9**).

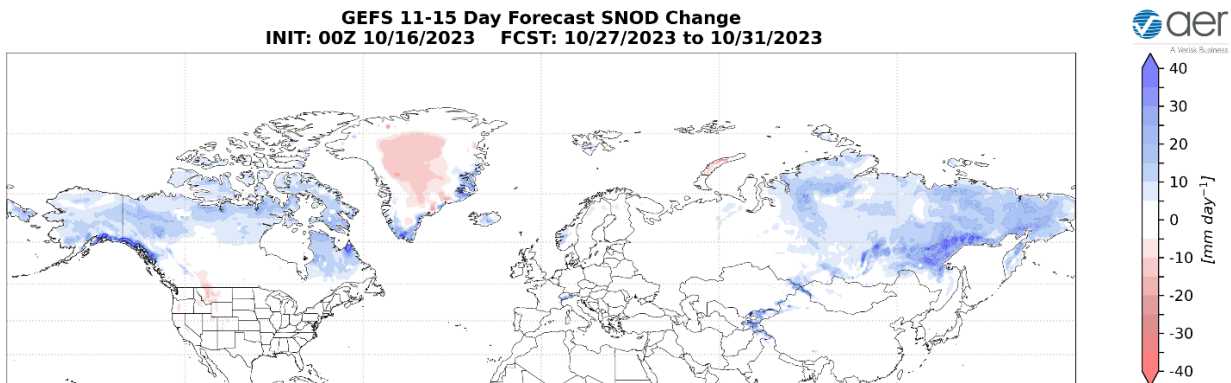


Figure 10. Forecasted snow depth changes (mm/day; shading) from 27 – 31 October 2023. The forecast is from the 00Z 16 October 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across much of Siberia and the Tibetan Plateau this period (**Figure 10**). Troughing and/or cold temperatures will support new snowfall across Alaska, the Northern half of Canada while milder temperatures will support snowmelt across the US Northern Rockies this period (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to slightly warm/positive PCHs in the stratosphere and troposphere (**Figure 11**). This week and into next week cold/negative PCHs are predicted to develop in the stratosphere while warm/positive PCHs are predicted to develop in the troposphere (**Figure 11**).

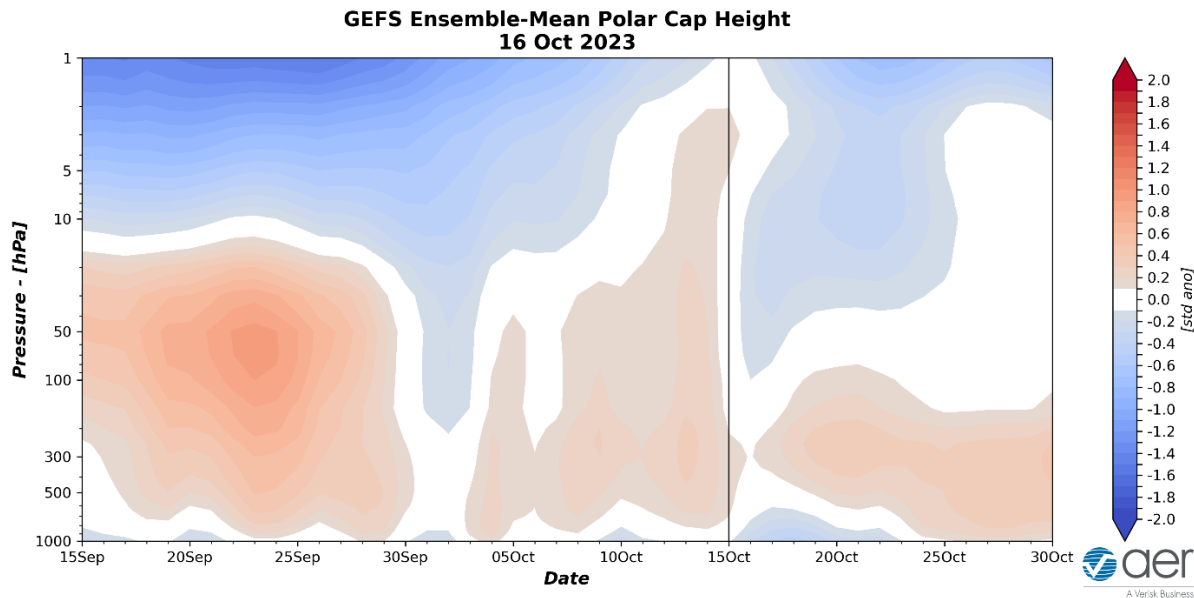


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 3 October 2023 GFS ensemble.

The predicted mixed and weak PCHs in the lower troposphere the next two weeks (**Figure 11**) are consistent with the predicted neutral surface AO the next two weeks (**Figure 1**). However, the AO is predicted to become more biased negative next week (**Figure 1**) coinciding with the predicted developing warm/positive PCHs in the lower troposphere (**Figure 11**).

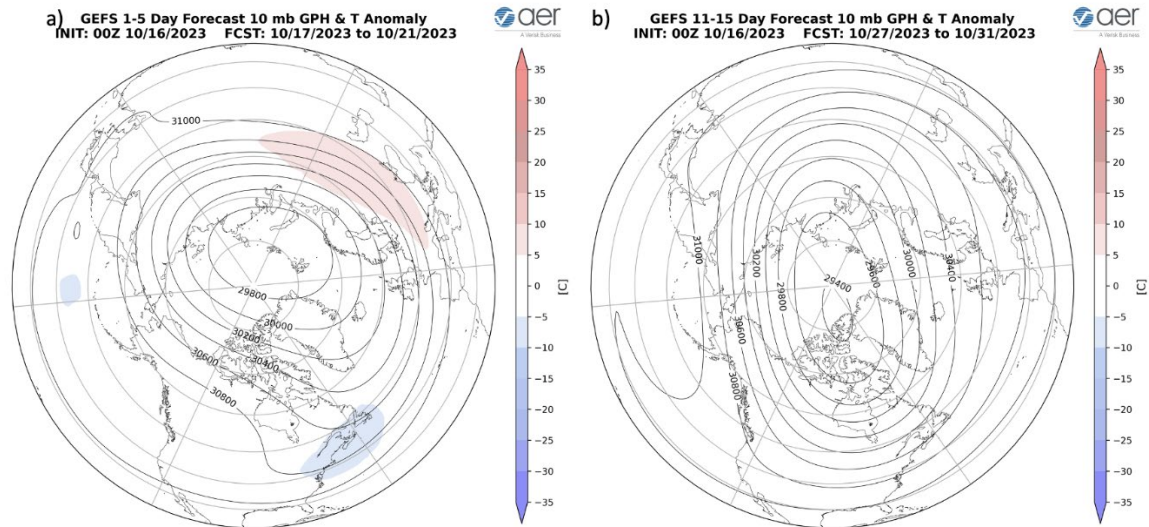


Figure 12. (a) Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for 17 – 21 October 2023. (b) Same as (a) except forecasted averaged from 27 – 31 October 2021. The forecasts are from the 00Z 16 October 2023 GFS model ensemble.

This week the polar vortex (PV) is predicted to be mostly circular in shape though shifted away from the North Pole centered near the Barents-Kara Seas (**Figure 12a**). The displaced PV center is a result of a minor PV disruption. However, for the last week of October, the PV center is predicted to return to the North Pole though the configuration becomes more elongated or stretched (**Figure 12b**). This stretched PV configuration is a new but again minor PV disruption that favors colder temperatures in both East Asia and eastern North America.

CFS 500 hPa Forecast Anomaly Nov 2023
Valid as of 16 Oct 2023

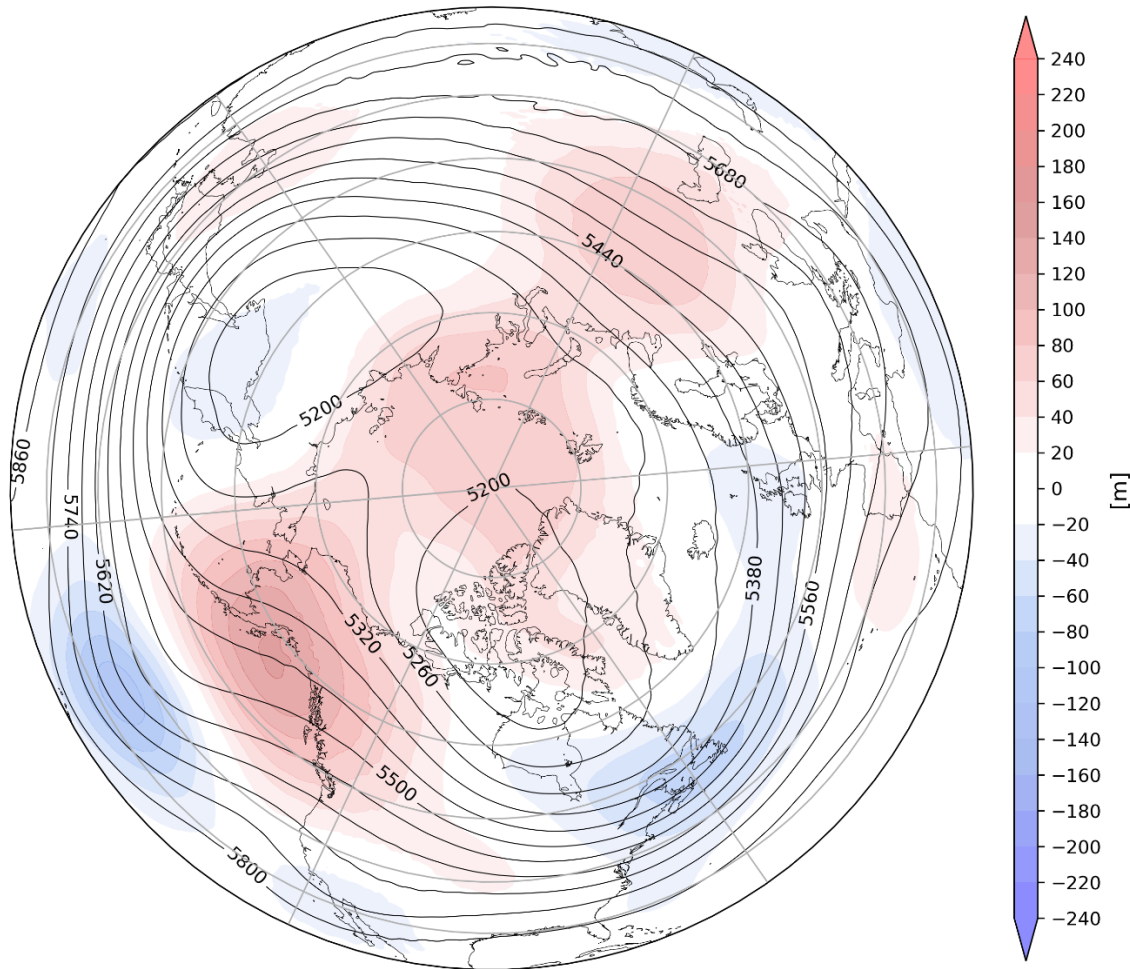


Figure 13. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for November 2023. The forecasts are from the 00Z 16 October 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and surface temperatures for November (**Figure 14**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered in the Barents-Kara Seas, Western Asia, Alaska, the Gulf of Alaska and the Central Arctic with troughing across Western and Southern Europe, Siberia, Northeast Asia and eastern North America (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across much of Europe, Western and Southern Asia, Alaska, Northern and Western Canada and the Western US with seasonable to relatively cold temperatures across parts of Siberia, eastern Canada and the Central and Eastern US (**Figure 13**).

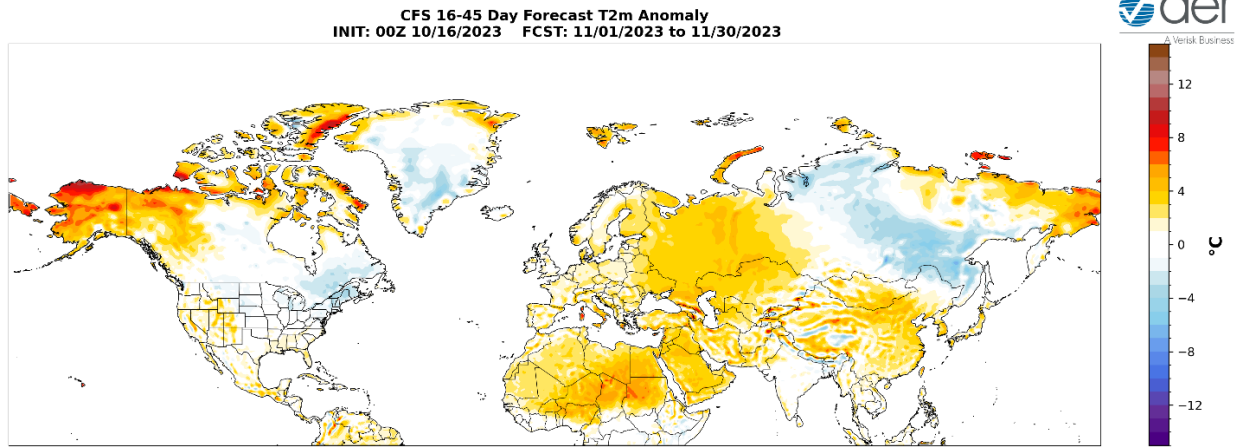


Figure 14. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for November 2023. The forecasts are from the 00Z 16 October 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific Sea surface temperatures (SSTs) anomalies are above normal, especially along the South America coast, indicating that an El Niño is pretty much a sure thing (**Figure 15**) and El Niño conditions are expected through the winter. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific, the eastern North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South and North Pacific and the North Atlantic.

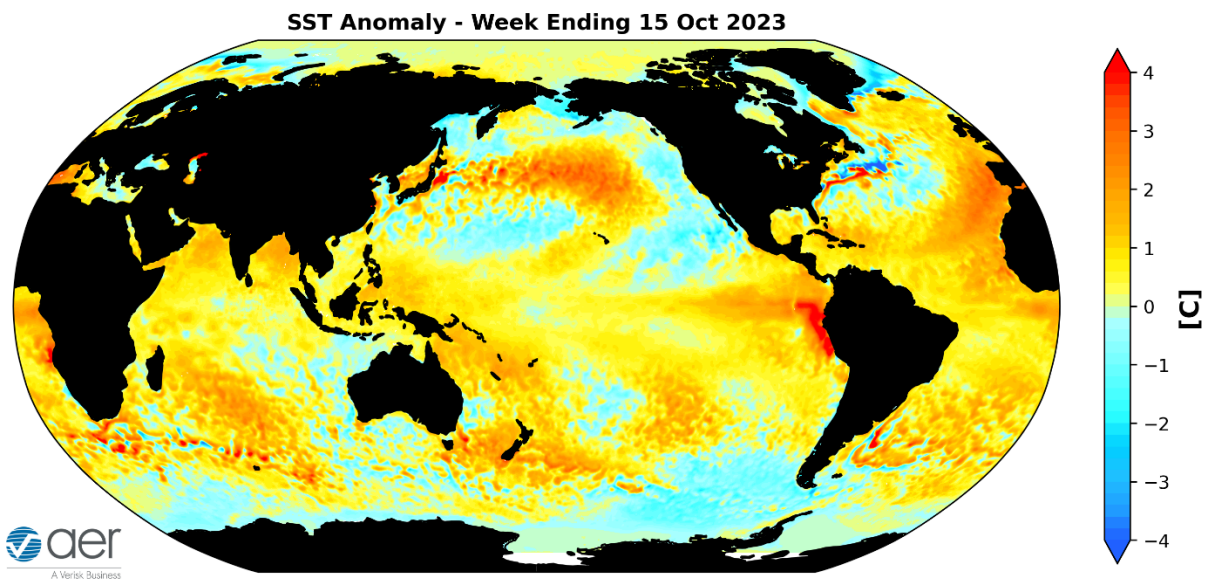


Figure 15. The latest weekly-mean global SST anomalies (ending 15 October 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is in weak phase one (**Figure 16**). The forecasts are for the MJO to remain weak into phase two and then to weaken further where no phase is favored and then emerge once again into phase seven or one the very end of the month. Seems that the MJO is having little influence on the weather across North America this week. Phases one and two favor troughing along the west coast of North America and ridging in eastern North America. So the MJO could be influencing North American weather next week. But admittedly this is outside of my expertise.

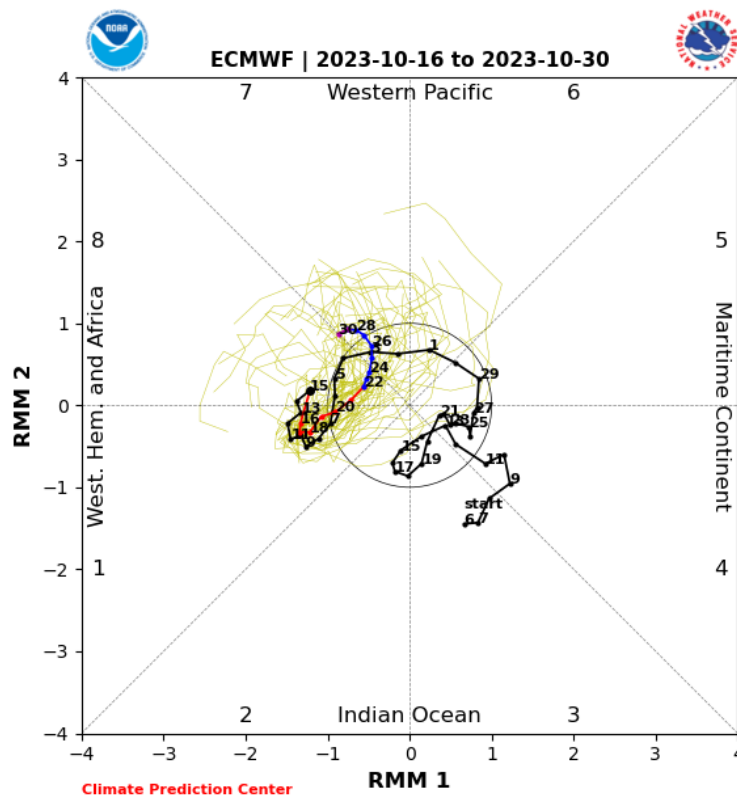


Figure 16. Past and forecast values of the MJO index. Forecast values from the 00Z 16 October 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source:

https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml

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 products to deliver important, long-lead time weather intelligence to your business. Please reach out to Karl today!