

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

*October 21, 2024*

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. In late 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 slowly trend negative the next two weeks as pressure/geopotential height anomalies across the Arctic are currently negative and are predicted to become increasingly mixed to positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently positive with negative pressure/geopotential height anomalies across Greenland and the NAO is predicted to also slowly trend negative the next two weeks as pressure/geopotential height anomalies are predicted to remain negative to mixed across Greenland.

This week troughing/negative geopotential height anomalies across Greenland will support ridging/positive geopotential height anomalies centered on Central Europe. Then next week as weak ridging troughing overspreads Greenland, troughing will overspread Europe. This pattern will support this week normal to above normal temperatures across Europe including the United Kingdom (UK) while induced northwesterly flow will support normal to below normal temperatures across Turkey. Then next week normal to below normal temperatures will become begin to spread across Western and then Central Europe.

The general pattern predicted for Asia the next two weeks is ridging/positive geopotential height anomalies centered over the Urals forcing troughing/negative geopotential height anomalies

across Southwest and Northeast Asia. This pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to the Middle East and Eastern Siberia, however next week the colder temperatures are predicted to become even more limited to just Eastern Siberia.

This general predicted pattern across North America is troughing/negative geopotential height anomalies across Alaska, in the Gulf of Alaska, Western Canada and the Western United States (US) forcing ridging/positive geopotential height anomalies across eastern North America. This pattern favors normal to below normal temperatures across Alaska, Western Canada and the Western US with normal to above normal temperatures across Eastern Canada and the US east of the Rockies.

In the Impacts section I discuss some early signs of the upcoming winter weather in the Northern Hemisphere (NH).

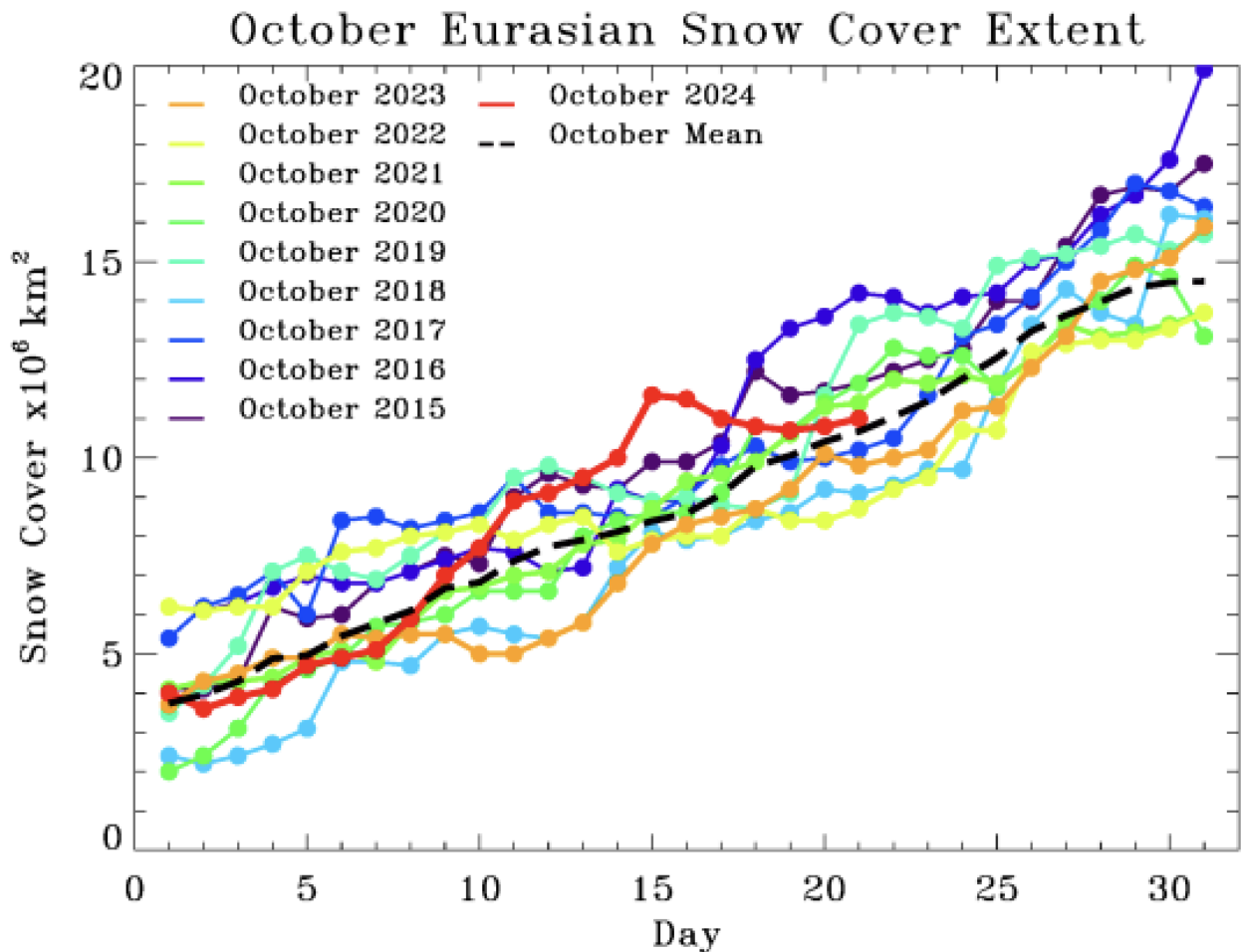
## Plain Language Summary

The Ural blocking/high pressure) that brought cold and snow to Siberia is predicted to become strung out (see **Figure 5 & 8**) and therefore the rapid advance of snow cover across Asia is likely over the remainder of October (see **Figure i**). A rapid advance in Eurasian snow cover could have been a precursor to an overall colder winter across the Northern Hemisphere but now it will likely be a weak signal at best. In the shorter term, the polar vortex is predicted to strengthen (see **Figure 12b**) and this will likely usher in some warmer weather for eastern North America and northern Eurasia (see **Figure 9**). Western Europe looks to be a notable exception and maybe it is an early sign of a changing pattern.

## Impacts

As I discussed in the blog two weeks ago, in October my focus is on the snow cover advance across Siberia and what impact it may have on the stratospheric polar vortex (PV). 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 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. Another research effort emphasizes November as an important month, something that I consider as well.

As I shared on Twitter, the snow cover extent across Eurasia got out of the gate quickly with snow cover extent (SCE) higher than any of the previous nine years through the second week of October. I include the latest update to the plot of daily Eurasian SCE so far in October in **Figure i**. The black dashed line represents the mean value using October 2009 through 2023. So far, the advance was above normal the first half of October based on recent Octobers (which are on average above the longer-term mean) but has since fallen back to average.

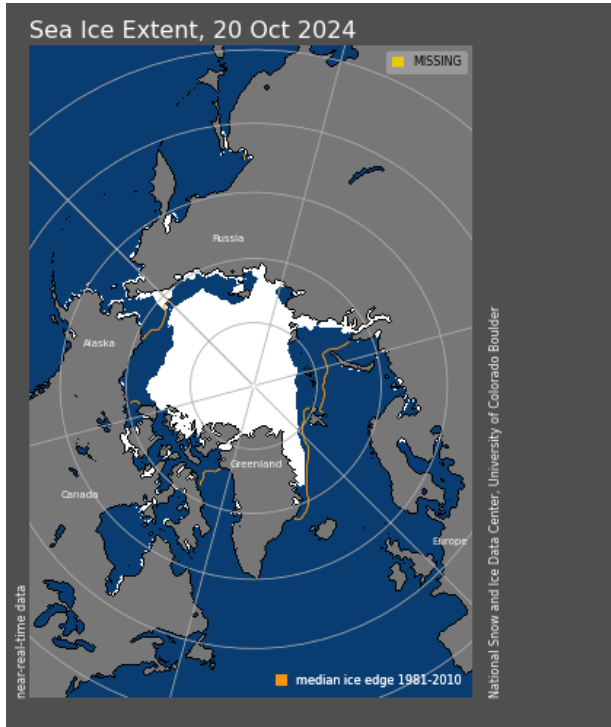


**Figure i.** Observed daily Eurasian snow cover extent through 20 October 2024. Included are the daily values from October 2015 through 2023 and the mean value the mean value from October 2009 through 2023 (black dashed line).

No point crying over spilt milk, but what was looking like a strong signal from the October SCE crashed and burned this week. And given the strongly positive AO, I expect the rest of the month to be pretty forgettable limping along close the mean value ending the month with a whimper rather than a bang. And if winter 2024/25 is another bust (except for Mongolia where winters remain impressive regardless of all the background noise), I will point back to October 16 as the day winter 2024/25 died (yes, I realize that I am being overly dramatic).

What could be emerging as a stronger signal for a weak PV this winter is Arctic sea ice extent which continues to grow relatively slowly for now. Sea ice extent is currently low all around the Arctic with no preferred regions (see Figure ii). It is the lack of sea ice in the Barents Kara Seas that favors a weak PV. And looking at the weather forecasts over the next two weeks (e.g., Figures

8 & 9), that pattern should clearly favor sea ice growth in the North Pacific sector relative to the North Atlantic sector. Therefore the Ural blocking, which is looking quite ragged and strung out in the near term, could be anchored and strengthened later this fall and early winter in the Barents-Kara Seas region, putting sustained pressure on the stratospheric PV.



**Figure ii.** Observed Arctic sea ice extent on 20 October 2024 (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). URL: <https://nsidc.org/sea-ice-today>

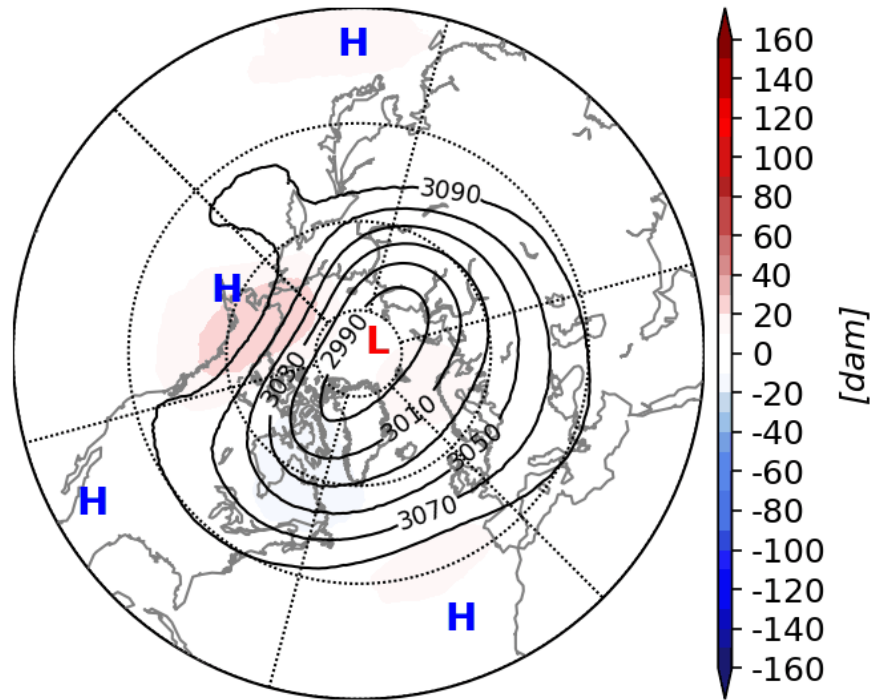
Besides sea ice, I also think sea surface temperatures could be evolving this winter such that it is more supportive of a colder winter in the Eastern US and maybe Europe as well than recent winters. Though La Niña looks likely this fall and early winter, it is looking awfully weak so far (see Figure 15). We have been ping-ponging between relatively strong states of ENSO in recent years and a weaker ENSO signal could be more supportive of more sustained winter weather.

But I am not just focused on the tropics. I don't think that it was a coincidence that the early 2010's, which featured quite a few cold winters, occurred during the period of the "warm blob" referring to warm waters along the North American west coast. That pool of warm water drifted west allowing to be replaced by relatively colder waters (see for example the [23 Oct 2023](#) blog post). At least for now the warmer waters are back (see Figure 15). This could favor more ridging rather than troughing in the Gulf of Alaska. But the evidence on this is admittedly sketchy. Finally, the North Atlantic in contrast was famous for its "cold blob" (again see for example the [23 Oct 2023](#) blog post). It too is gone for now (see Figure 15) and could favor a more negative NAO rather than a positive NAO. But again any support for this idea is flimsy at best.

But it is not snow cover alone that has soured me a bit about this upcoming winter, it is the jet stream but especially the stratospheric PV. Crazy things were happening in the polar

stratosphere all summer and it transitioned into a record weak PV in the first half of fall. Though I knew better, I thought this could continue through the late fall, especially if the Ural blocking persists. Well the Ural blocking fizzled, becoming strung out and pushing way to the east (see Figure 8) and the PV is predicted to strengthen considerably (see the latest PV animation in Figure iii).

### Initialized 00Z 10 hPa HGT/HGTa 21-Oct-2024



**Figure i.** Animation of initialized and forecasted from 21 October – 5 November 2024 10 mb geopotential heights (dam; contours) and anomalies (shading) across the Northern Hemisphere. The forecasts are from the 00Z 21 October 2020 GFS model ensemble.

Also apparent from **Figure 8**, is that wave one is going to become quite strong in early November (assuming the model forecasts are correct) and that could make the PV to start dancing but from what I can tell the biggest cold risk is to western North America. It probably wouldn't take much to bring an early start to winter in Alaska, Western Canada and the Western US, while the Eastern US basks in record warmth.

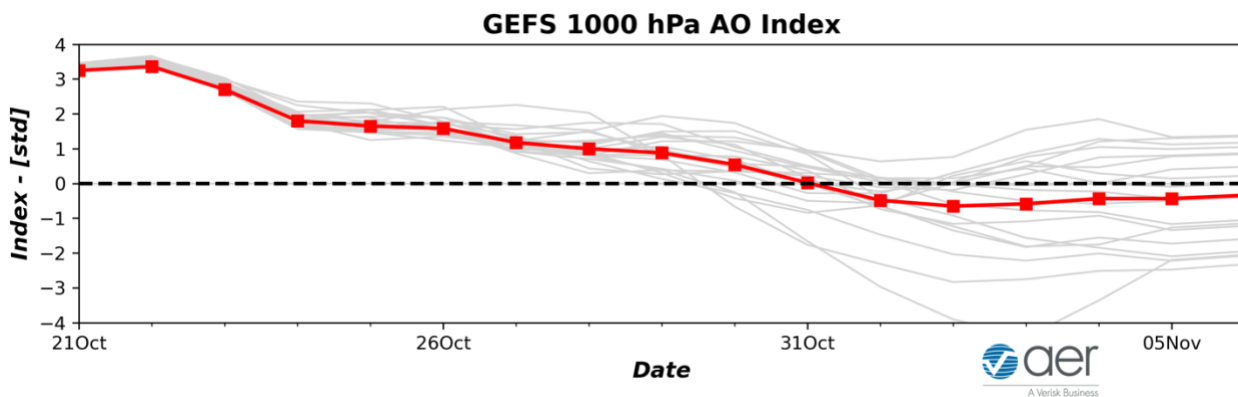
What could finally change the pattern around are the warm/positive polar cap geopotential height anomalies (PCHs) that are shown to descend from the lower stratosphere to the lower troposphere in early November. The models seem to be consolidating around increasing high latitude blocking in the North Atlantic sector of the Arctic including Greenland blocking. This

could start a more favorable pattern of a wintry pattern in the Eastern US and northern Eurasia. But the atmosphere is like an aircraft carrier than can only turn around very slowly. So something that I am currently in short supply is needed – patience.

## Near-Term

### This week

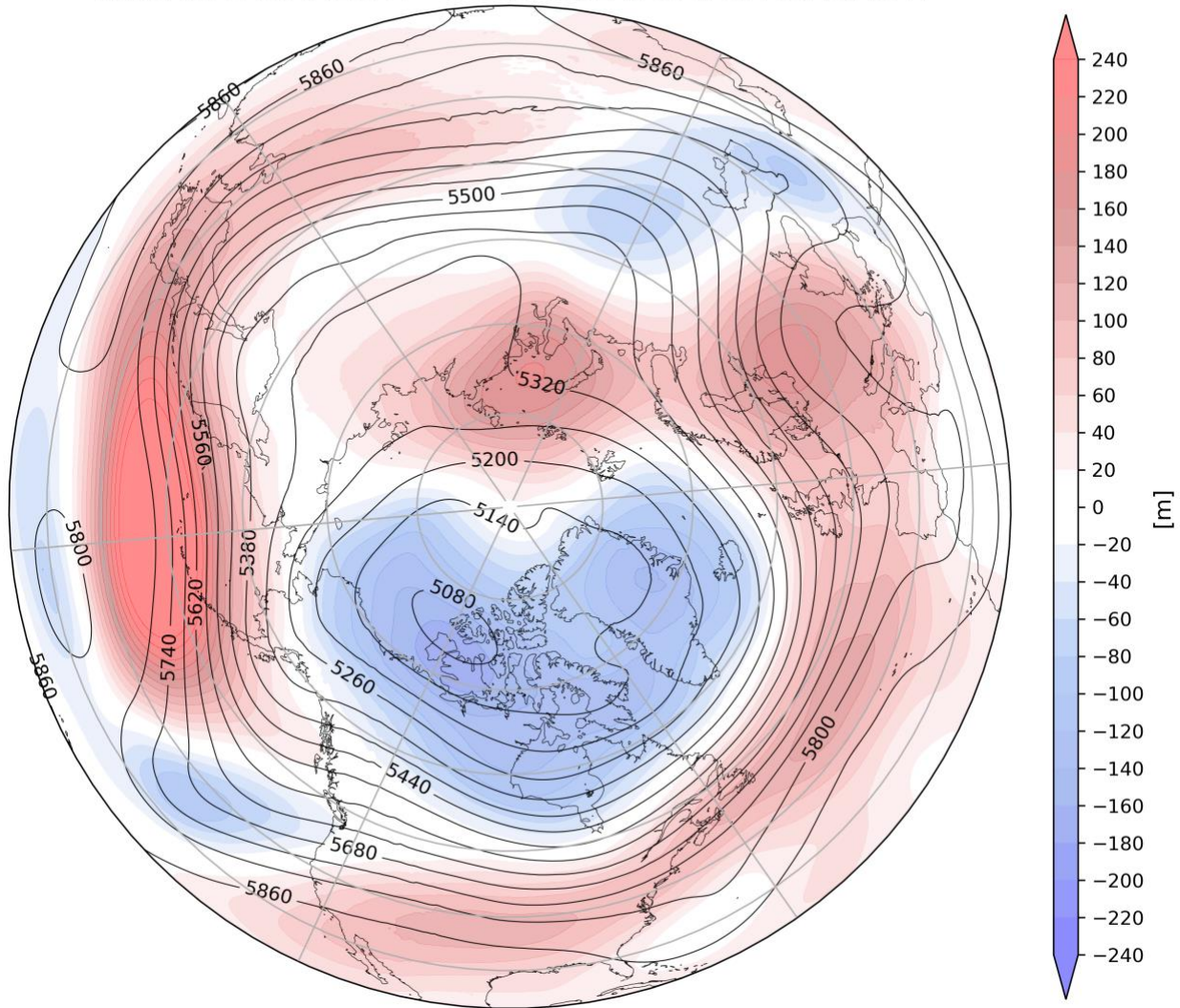
The AO is predicted to be positive this week (**Figure 1**) with mostly negative geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With predicted negative geopotential height anomalies across Greenland (**Figure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



**Figure 1.** The predicted daily-mean AO at 1000 hPa from the 00Z 21 October 2024 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.

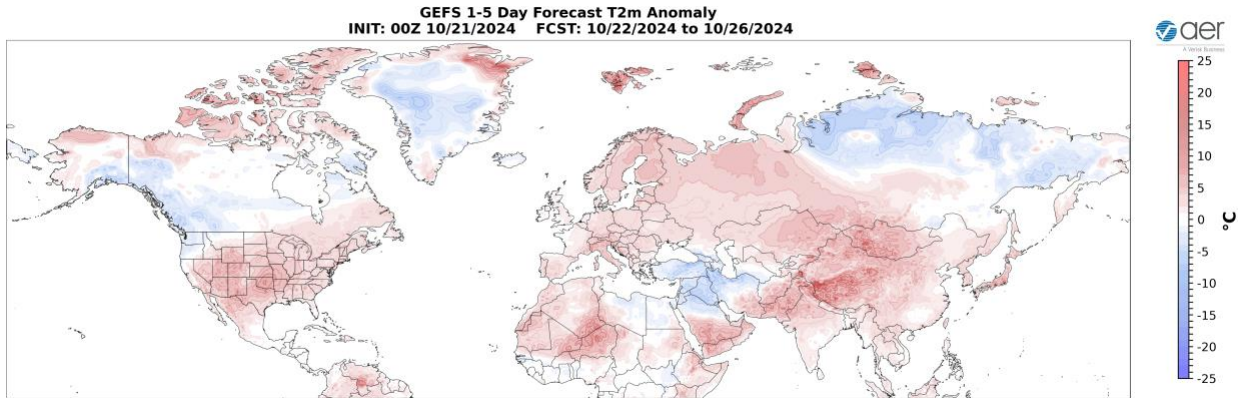
This week, troughing/negative geopotential height anomalies across Greenland will support ridging/positive geopotential height anomalies centered on Central Europe this week (Figures 2). This pattern will favor normal to above normal temperatures across Europe including the UK while induced northwesterly flow favors normal to below normal temperatures across Turkey (Figure 3). This week the predicted pattern across Asia is ridging/positive geopotential height anomalies centered over the Barents-Kara Seas forcing troughing/negative geopotential height anomalies across Southwest Asia and Siberia with more ridging across East Asia (Figure 2). This pattern favors normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to Southwest Asia and much of Siberia (Figure 3).

**GEFS 1-5 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 10/21/2024 FCST: 10/22/2024 to 10/26/2024**



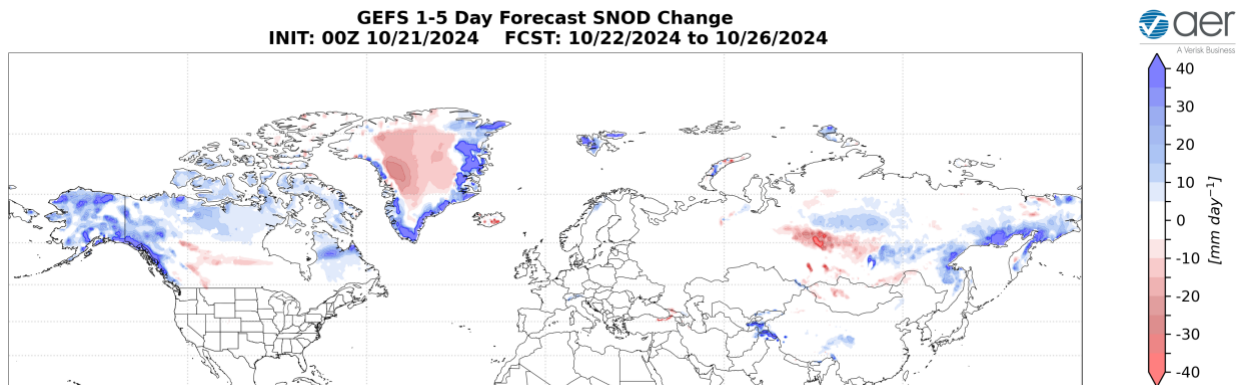
**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 22 – 26 October 2024. The forecasts are from the 00z 21 October 2024 GFS ensemble.

This week troughing/negative geopotential height anomalies across Alaska and Northern Canada will force ridging/positive geopotential heights across much of the US (**Figure 2**). This pattern will favor normal to above normal temperatures across northern Alaska, Northern and Southeastern Canada and most of the US with normal to below normal temperatures limited to Southeastern Alaska, Western and Central Canada and the US Pacific Northwest (**Figure 3**).



**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 22 – 26 October 2024. The forecast is from the 00Z 21 October 2024 GFS ensemble.

Trouging and/or cold temperatures will support new snowfall across Siberia and the Tibetan Plateau while warm temperatures will support snowmelt in Southwestern Siberia this week (Figure 4). Trouging and/or cold temperatures will support new snowfall across Alaska, Northern and Western Canada while warm temperatures will support snowmelt in Southern Canada this week (Figure 4).



**Figure 4.** Forecasted snow depth changes (mm/day; shading) from 22 – 26 October 2023. The forecast is from the 00Z 21 October 2023 GFS ensemble.

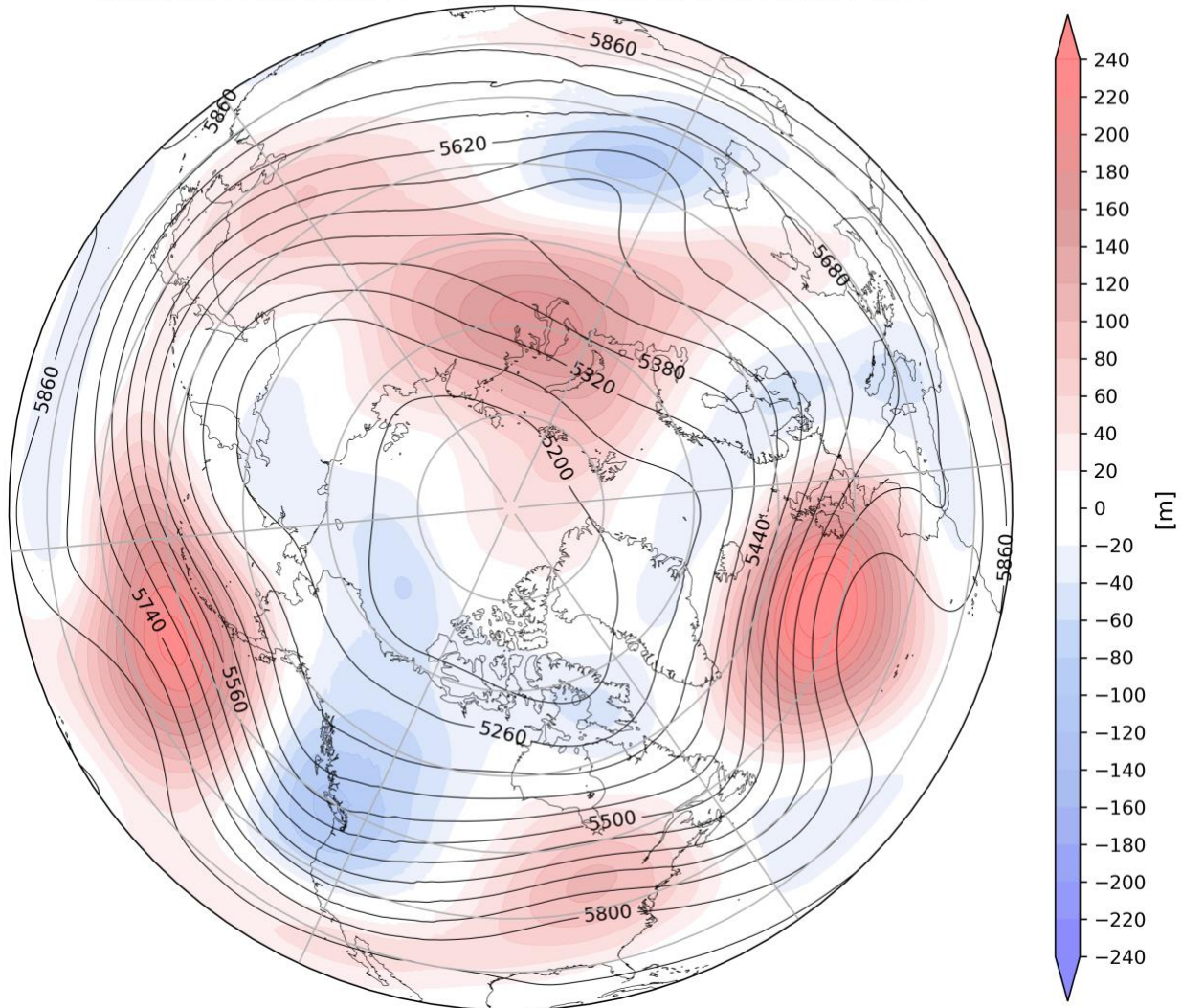
## Near-Mid Term

### Next week

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



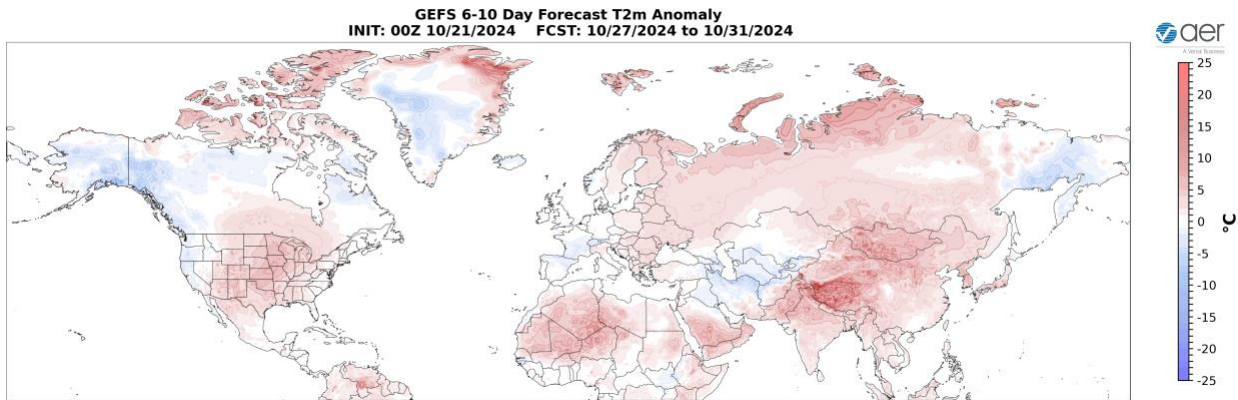
**GEFS 6-10 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 10/21/2024 FCST: 10/27/2024 to 10/31/2024**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 27 – 31 October 2024. The forecasts are from the 00z 21 October 2024 GFS ensemble.

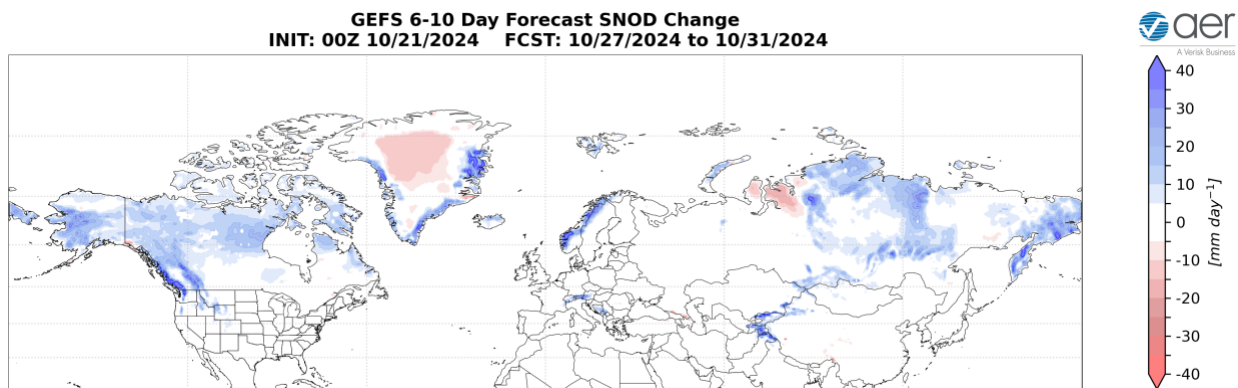
Weakening troughing/negative geopotential height anomalies across Greenland will continue to support ridging/positive geopotential height anomalies across Western Europe with weak troughing in Central Europe this period (Figure 5). This pattern will favor normal to above normal temperatures across much of Europe while induced northerly flow will usher in normal to below normal temperatures across Western Europe including the UK (Figures 6). The predicted pattern across Asia is ridging/positive geopotential height anomalies centered over the Urals forcing

trouching/negative geopotential height anomalies across Southwestern Asia and Eastern Siberia with more ridging/positive geopotential height anomalies across East Asia (Figure 5). This pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to Southwestern Asia and Eastern Siberia (Figure 6).



**Figure 6.** Forecasted surface temperature anomalies (°C; shading) from 27 – 31 October 2024. The forecasts are from the 00z 21 October 2024 GFS ensemble

Persistent troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska, Western Canada and the Western US will force ridging/positive geopotential height anomalies across Eastern Canada and the Eastern US this period (Figure 5). This pattern will favor normal to below normal temperatures across Alaska, Western Canada and the Western US with normal to above normal temperatures across Eastern Canada and the US east of the Rockies (Figure 6).



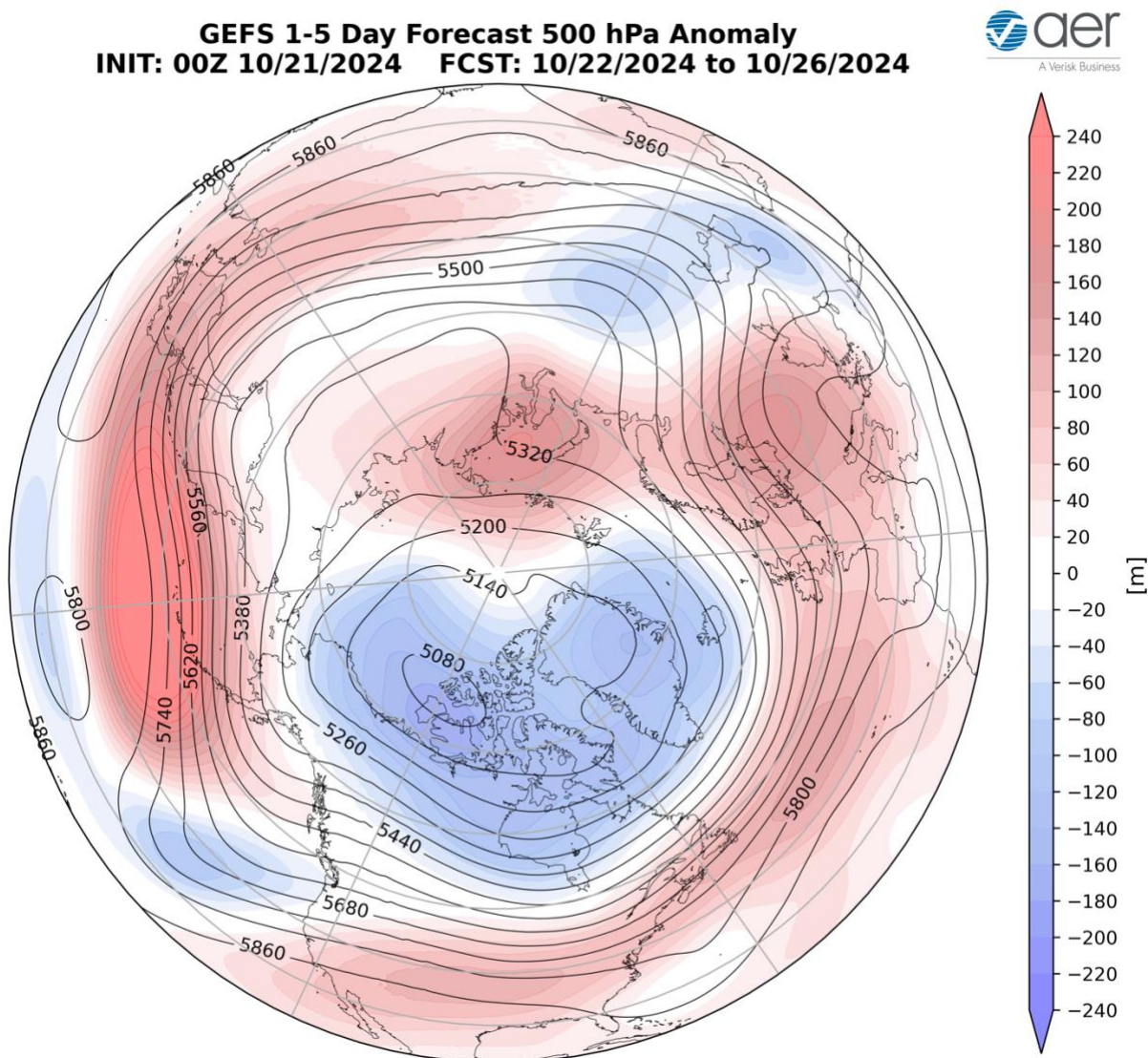
**Figure 7.** Forecasted snow depth changes (mm/day; shading) from 27 – 31 October 2024. The forecasts are from the 00z 21 October 2024 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Siberia and the Tibetan Plateau while warm temperatures will support snowmelt in the northern Urals this week (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across Alaska, Northern and Western Canada and the higher elevations of the Northwestern US this week (**Figure 7**).

# Mid Term

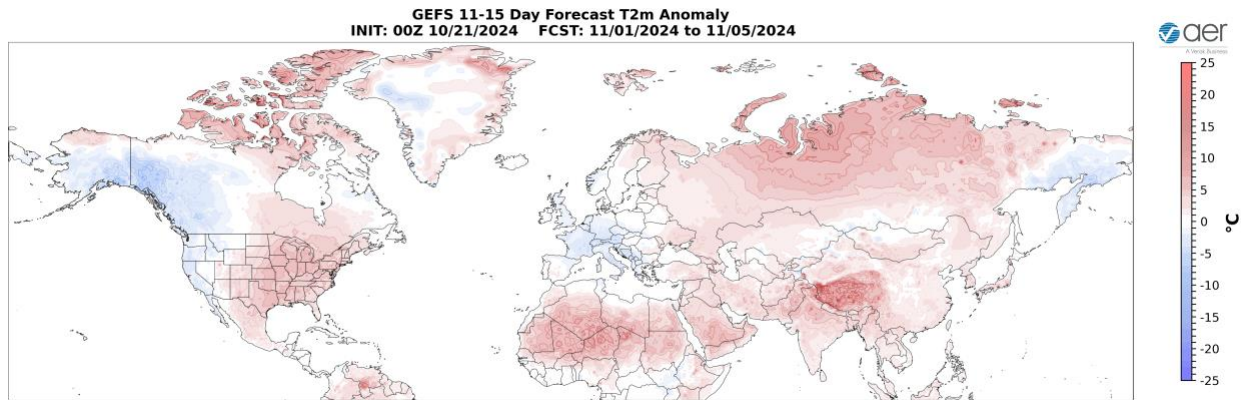
## Week Two

With predicted medium to negative geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (Figure 8), the AO will likely persist near neutral to positive this period (Figure 1). With predicted mixed to negative pressure/geopotential height anomalies across Greenland (Figure 8), the NAO will likely be neutral this period.



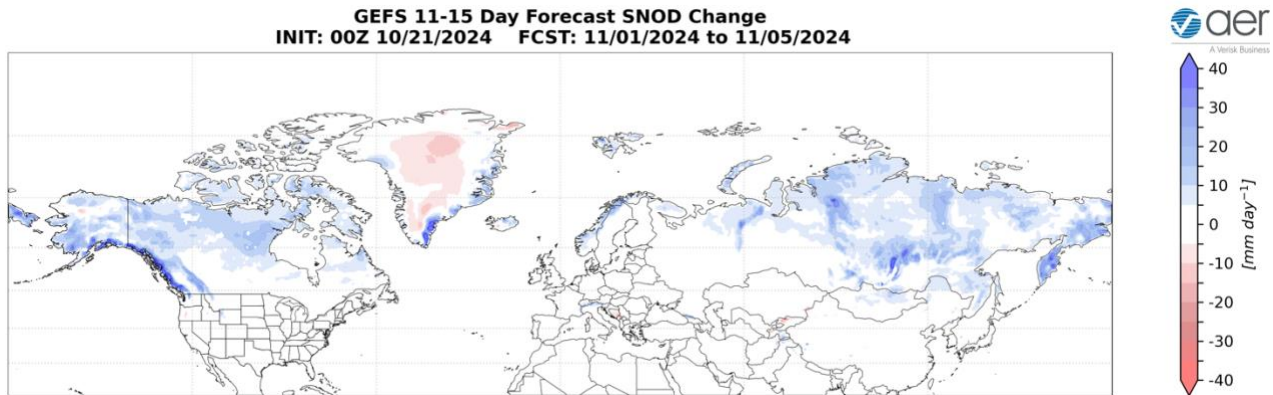
**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble.

Increasing troughing/negative geopotential height anomalies across Greenland will now support ridging/positive geopotential height anomalies across much of Europe this period (**Figure 8**). This pattern should favor widespread normal to above normal temperatures across Europe including the UK this period (**Figures 9**). The predicted pattern across Asia this period is ridging/positive geopotential height anomalies centered on the Urals and the Barents-Kara Seas forcing troughing/negative geopotential height anomalies across Siberia and Eastern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across Western and Southern Asia with normal to below normal temperatures widespread across Siberia and East Asia this period (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 18 – 22 October 2024. The forecast is from the 00Z 7 October 2024 GFS ensemble.

Predicted persistent troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska will force ridging/positive geopotential height anomalies across most of Canada and the US (**Figure 8**). This pattern will favor normal to below normal temperatures across southern Alaska, the West Coast of Canada, the US Pacific Northwest and parts of the Southeastern US with widespread normal to above normal temperatures across much of northern Alaska, Canada and the US (**Figure 9**).



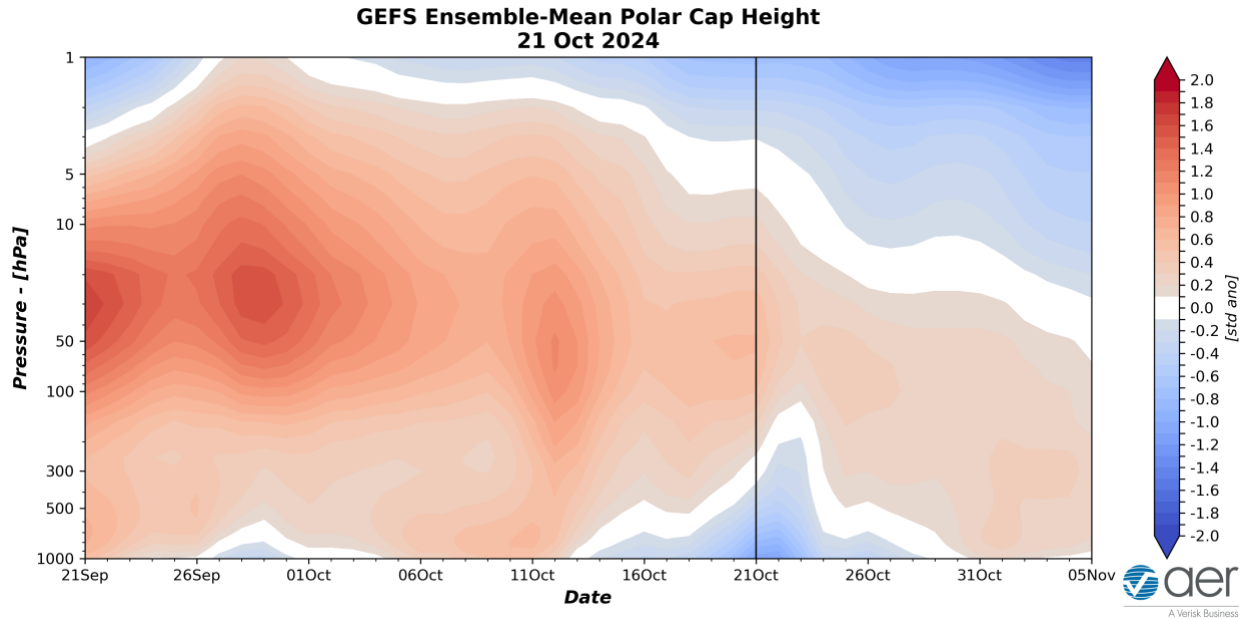
**Figure 10.** Forecasted precipitation rate (mm/day; shading) from 18 – 22 October 2024. The forecast is from the 00Z 7 October 2024 GFS ensemble

Trouging will support above normal rainfall across the Mediterranean region, Tibetan Plateau, India and East Asia with normal to below normal rainfall elsewhere across Eurasia this period (**Figure 10**). Trouging supports above normal rainfall for parts of Alaska and the West Coast of Canada with normal to below normal rainfall across the remainder of North America (**Figure 10**).

## Longer Term

### 30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to warm/positive PCHs in the lower stratosphere and the upper troposphere with cold/negative PCHs in the upper stratosphere and the lower to mid-troposphere (**Figure 11**). This week and into next week warm/positive mid tropospheric PCHs are predicted to descend to the surface while cold/negative PCHs are predicted to expand into the mid-stratosphere (**Figure 11**).

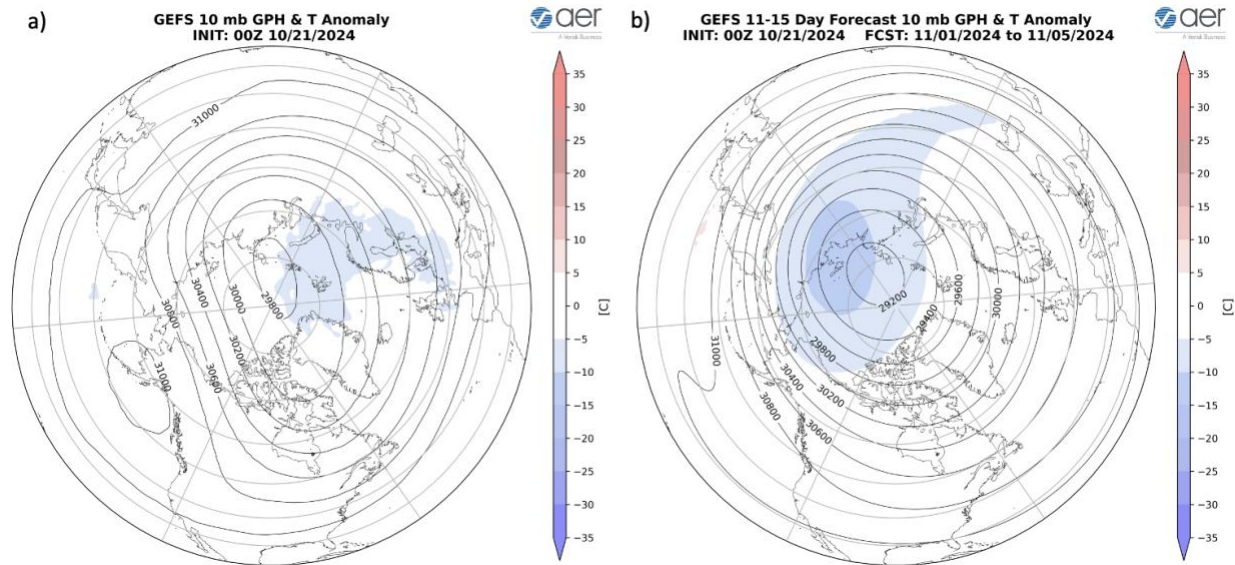


**Figure 11.** Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 21 October 2024 GFS ensemble.

The predicted negative PCHs in the lower troposphere this week (**Figure 11**) are consistent with the predicted positive surface AO this week (**Figure 1**). However, the AO is predicted to become neutral and even more biased negative starting next week (**Figure 1**) coinciding with the predicted descending of warm/positive PCHs into the lower troposphere (**Figure 11**).

This week the polar vortex (PV) is predicted to be contorted in shape where it is elongated along an axis from Western Siberia to Central Canada with the PV center shifted away from the North Pole centered near the Barents-Kara Seas (**Figure 12a**). The displaced PV center and elongation is a result of a stretched PV disruption that is winding down. However, for early November the PV center is predicted to shift to the Laptev Sea and becoming more circular in shape (**Figure 12b**). This is a classical strong PV configuration that favors mild temperatures across Northern Europe, Northern Asia and North America east of the Rockies.

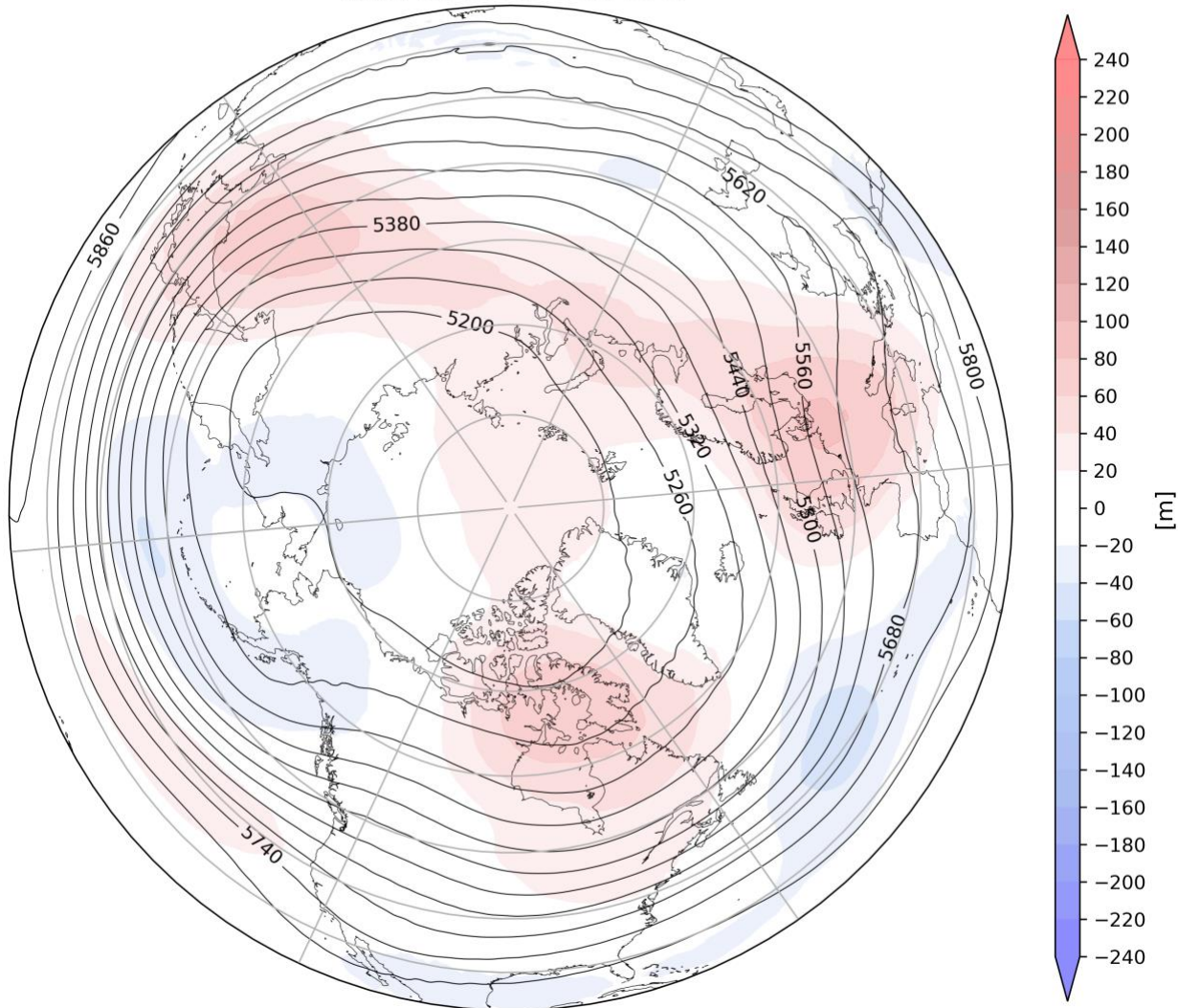
I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and surface temperatures for November (**Figure 14**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered on Baffin Bay,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



**Figure 12.** (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for 21 October 2024. (b) Same as (a) except forecasted averaged from 1 – 5 November 2024. The forecasts are from the 00Z 21 October 2024 GFS model ensemble.

This week the polar vortex (PV) is predicted to be contorted in shape where it is elongated along an axis from Western Siberia to Central Canada with the PV center shifted away from the North Pole centered near the Barents-Kara Seas (Figure 12a). The displaced PV center and elongation is a result of a stretched PV disruption that is winding down. However, for early November the PV center is predicted to shift to the Laptev Sea and becoming more circular in shape (Figure 12b). This is a classical strong PV configuration that favors mild temperatures across Northern Europe, Northern Asia and North America east of the Rockies.

**CFS 500 hPa Forecast Anomaly Nov 2024**  
**Valid as of 21 Oct 2024**

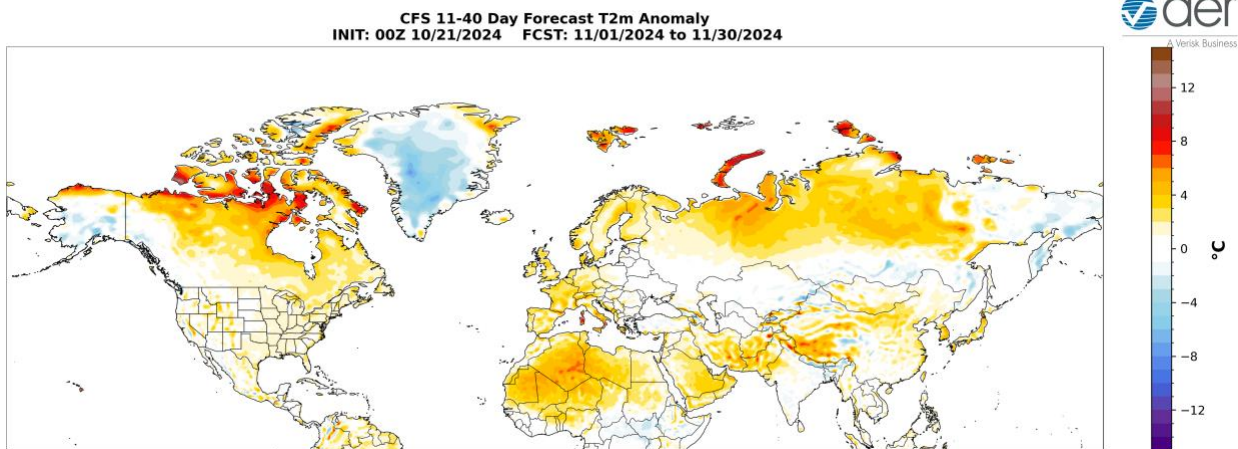


**Figure 13.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for November 2024. The forecasts are from the 00Z 21 October 2024 CFS.

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 on Baffin Bay, Northern Europe and the Barents-Kara Seas with troughing spread across Eastern Siberia, Northeast Asia and into the North Pacific, the Aleutians and Alaska (**Figure 13**). This pattern favors seasonable to relatively warm temperatures across Europe, much of Asia including Western and Central Siberia, Northern and Eastern Canada and the



US with seasonable to relatively cold temperatures across Eastern Siberia, Northeast Asia, Alaska and Western Canada (**Figure 14**).

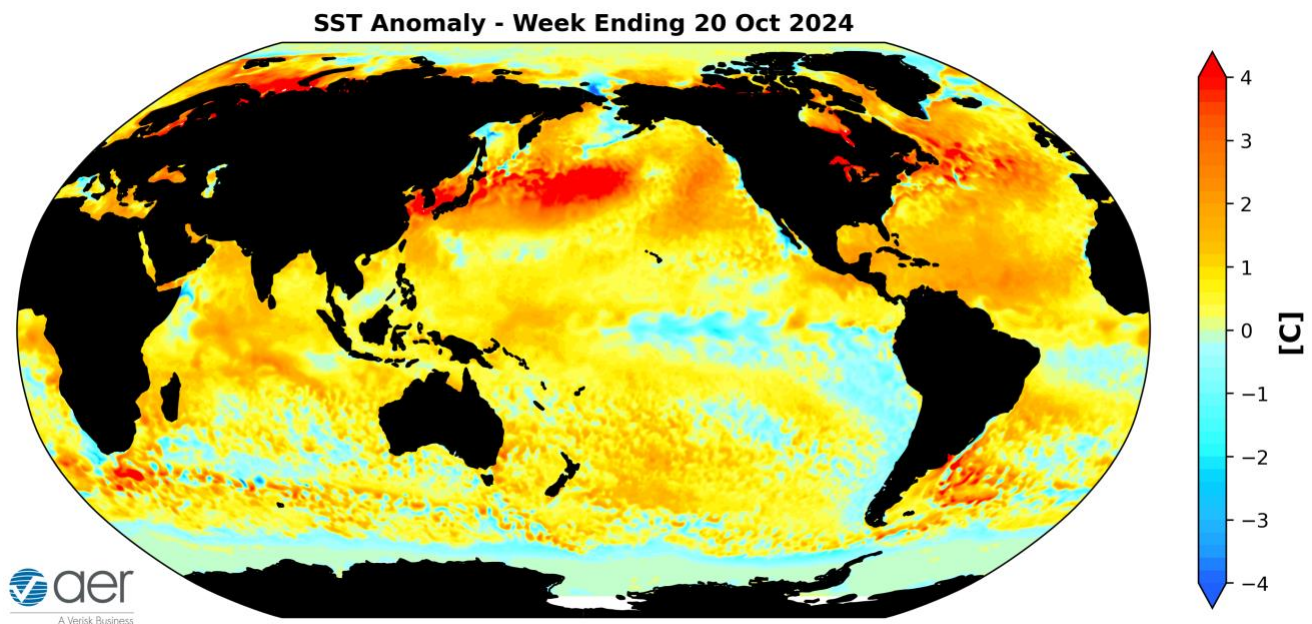


**Figure 14.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for Nov 024. The forecasts are from the 00Z 21 Oct 2024 CFS.

## Boundary Forcings

### SSTs/El Niño/Southern Oscillation

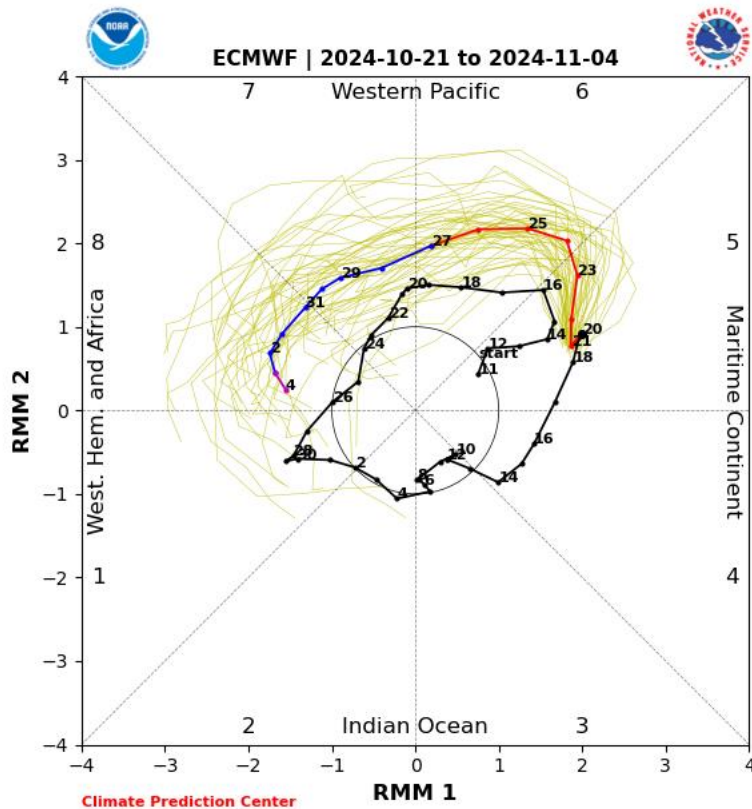
Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal, between the Dateline and the South America coast, indicating that an La Niña is emerging (Figure 15) and weak La Niña conditions are expected through the winter. Observed SSTs across the NH remain well above normal especially in the central North Pacific centered on the Dateline and the western North Pacific, much of the North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.



**Figure 15.** The latest daily-mean global SST anomalies (ending 20 October 2024). Data from NOAA OI High-Resolution dataset. Source: <https://psl.noaa.gov/map/clim/sst.shtml>

### Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is currently in phase five (**Figure 16**). The forecasts are for the MJO to rifle quickly through phases five, six, seven and eight over the next two weeks. Phase six favors troughing in western North America and ridging in eastern North America. Therefore it seems that the MJO could be having some influence on 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 21 October 2024 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/ecmf.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.

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