

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

*November 18, 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 neutral and is predicted to remain neutral to negative the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to remain mixed to mostly positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative with strong positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to remain negative but slowly trend positive towards neutral the next two weeks as pressure/geopotential height anomalies are predicted to remain positive but weaken across Greenland.

The next two weeks ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies across Northern Europe ridging/positive geopotential height anomalies across Southern Europe. However next week as Greenland ridging/troughing across northern Europe will weaken. This pattern will support mostly normal to below normal temperatures across Northern Europe including the United Kingdom (UK) normal to above normal temperatures across Southern Europe. However next week above normal temperatures will begin to advance northward.

The next two weeks ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies across far Northern Asia with ridging/positive geopotential height anomalies dominating most of Asia and centered in

Central Asia. However next week as the ridging consolidates near the Urals this will support troughing digging southward across East Asia. This pattern favors widespread normal to above normal temperatures across much of Asia, however next week, normal to below normal temperatures will push southward across East Asia and eventually spread across much of East China.

The next two weeks ridging/positive geopotential height anomalies centered near the Aleutians and near Baffin Bay will support troughing/negative geopotential height anomalies western North America and increasingly the Eastern United States (US) separated by ridging in the Central US. This pattern favors normal to below normal temperatures across Alaska, Western Canada and the Western US and then the Eastern US next week with normal to above normal temperatures of the season will build across Western Canada and start filtering into the Northern Plains of the US.

In the Impacts section I discuss some impacts of polar vortex (PV) stretching and how it will impact the upcoming weather in the Northern Hemisphere (NH) but important changes are occurring in Siberia and the PV that could have long term impacts.

## Plain Language Summary

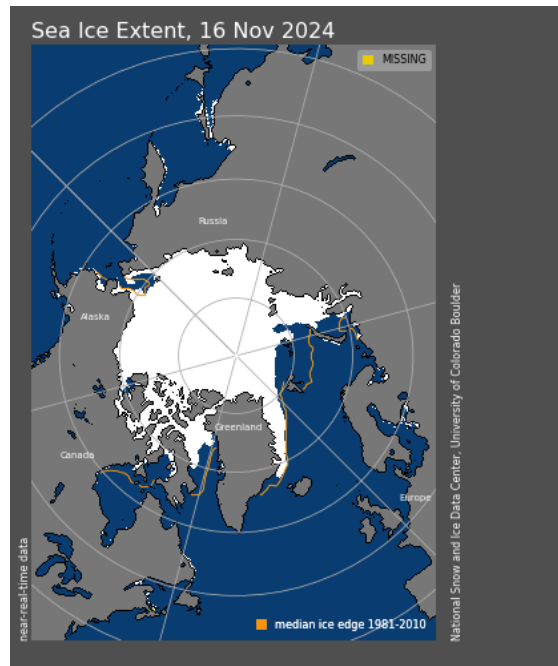
Strong Greenland blocking is bringing an early taste of winter with cold and snow to Europe (see **Figures 2 and 3**). Not one but two stretched polar vortices are predicted in the next two weeks and they will tag team to finally bring some cold air to the US, strongest in the Northern Plains but making it all the way to the East Coast (see **Figure 9**) and even some snow. But longer term the circulation and the strong polar vortex favor a milder pattern.

## Impacts

Now that October Eurasian snow cover is in the record books, I am more focused on Arctic sea ice extent (SIE) which continues to grow relatively slowly for now. And as I expected over the past several blogs, sea ice growth occurred preferentially in the North Pacific sector relative to the North Atlantic sector and the large negative anomaly in the North Atlantic sector compared to the North Pacific sector is now clearly dominant, with sea ice in the North Pacific close to normal (see **Figure ii**). This is important because it is the lack of sea ice in the Barents Kara Seas that favors a weak PV. The other region where sea ice is below normal is around Greenland and into Hudson Bay. It appears to me that sea ice anomalies are evolving that are most favorable for supporting colder weather not only across Eurasia but possibly even the US. I do wonder if the low sea ice in and around Baffin Bay contributed to more persistent ridging in the region than originally predicted by the weather models

November SCE extent could also be giving the low sea ice in the Barents-Kara Seas if an east-west dipole develops with positive anomalies in East Asia and negative anomalies in Western Asia and Europe. With the onset of Greenland blocking snow cover should advance in Western Eurasia so still a fluid situation. That is then followed by a cold air outbreak into China. So, in

summary, which region will feature the largest negative anomalies in the coming weeks remains uncertain.



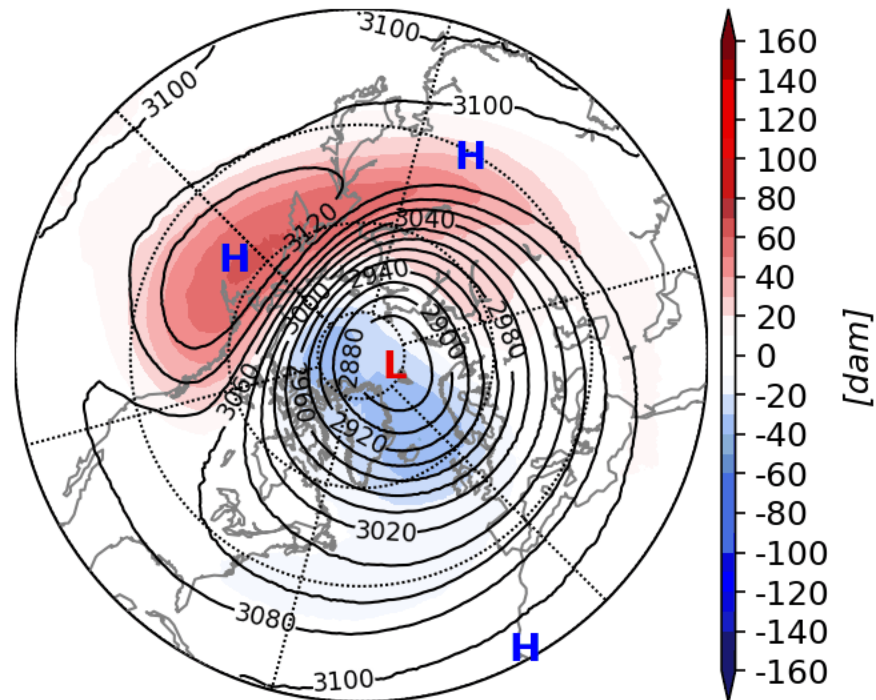
**Figure ii.** Observed Arctic sea ice extent on 16 November 2024 (white). Orange line show climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC). URL: <https://nsidc.org/sea-ice-today>.

In the short term, even brief Ural blocking is enough to trigger two stretched PV events this week and then the very end of November into early December. Both look relatively minor but the second one looks to deliver colder air and could be of longer duration. But overall, the PV looks strong, which I believe has longer term implications. The two stretched PVs amidst an overall strong PV are apparent in the latest PV animation (see **Figure iii**). The second stretched PV looks quite impressive at the very end of the run but don't let yourself be fooled; I think that is just the GFS being the GFS.

There are two predictions that keep me on alert for a warm second half of December in most locations. The first, the models are predicting a strong stratospheric PV and that always has me on alert for an overall mild pattern across the Northern Hemisphere (NH). If the strong PV couples all the way to the surface with low tropospheric heights and likely a positive AO, then the potential for an extended mild pattern is elevated.

Second many of the models have also been predicting ridging centered over Siberia with very warm surface temperatures. I like to say, "Siberia is the refrigerator for the Northern Hemisphere (NH)." If those forecasts verify, then I would say the NH refrigerator is clearly out of order.

## Initialized 00Z 10 hPa HGT/HGTa 18-Nov-2024



**Figure iii.** Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for 18 November 2024 and forecasted from 19 November to 3 December 2024. The forecasts are from the 00Z 18 November 2024 GFS model ensemble.

But unlike last week when the GFS was predicting cold/negative polar cap geopotential height anomalies (PCHs) in the stratosphere that coupled to the surface, the GFS is not predicting the same this week, or the stratosphere and troposphere remain uncoupled (see **Figure 11**). Seems to me we have a battle between the strong stratospheric PV and the surprisingly resilient high latitude blocking both in and around the Dateline and Greenland. Those two features can continue to supply cold air to North America and Eurasia. Of course, if the high latitude blocking is limited to Siberia that is a recipe for endless mild weather, so we need to watch how it all shakes out.

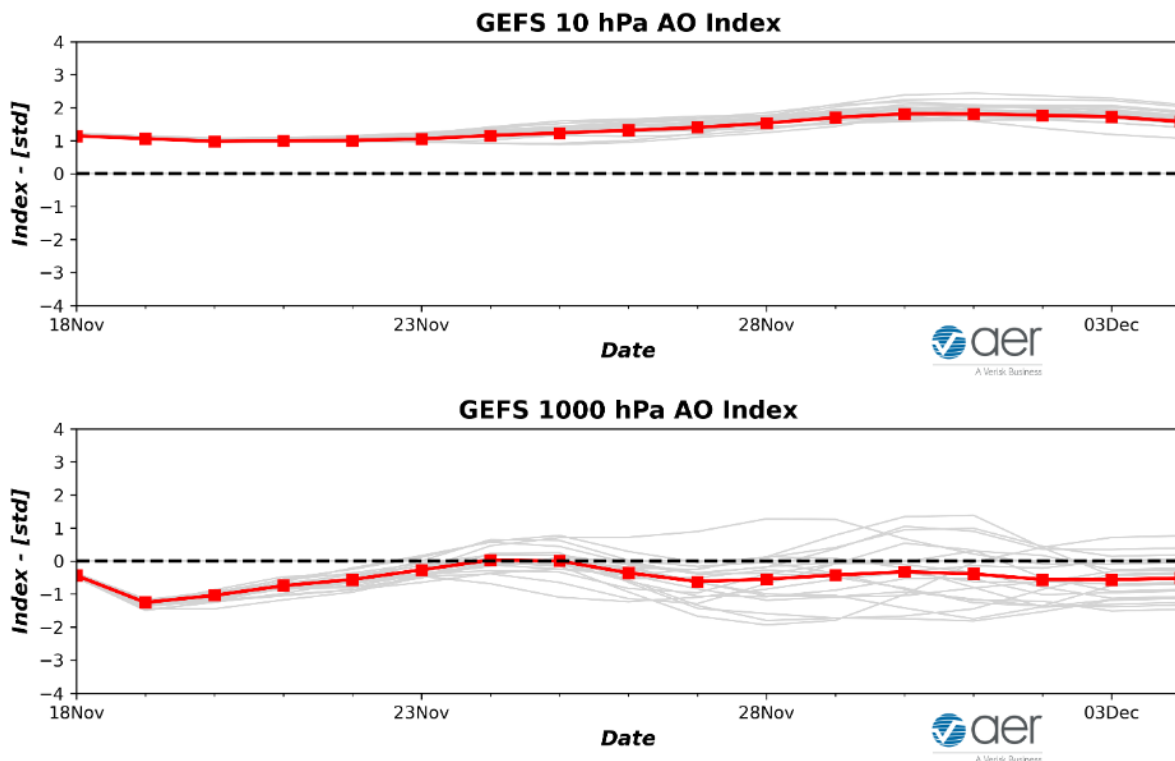
We will have to see whether the strong PV or the high latitude blocking blinks first. If the high latitude blocking fades and the strong PV can exert its will on the tropospheric circulation then a potential mild and long duration pattern is very much in play. On the other hand, if the high latitude blocking can find its way back to the Ural-Scandinavian region, a weakening of the PV is likely. And even if there is a mild pattern, it will be limited, and a colder pattern will return. Right now, a return to Ural blocking is not predicted but it looks more plausible than it did last week.

My travels end on Tuesday and next week the schedule should return to normal.

## Near-Term

### This week

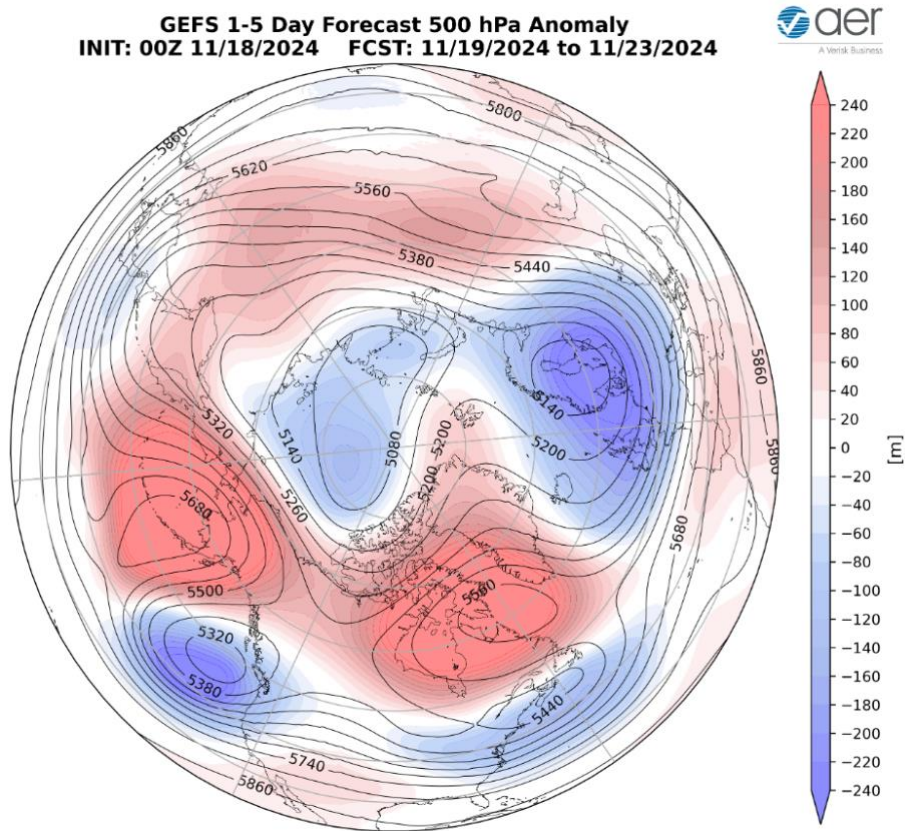
The AO is predicted to be mostly negative this week (**Figure 1**) with mixed to positive geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With predicted positive geopotential height anomalies across Greenland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



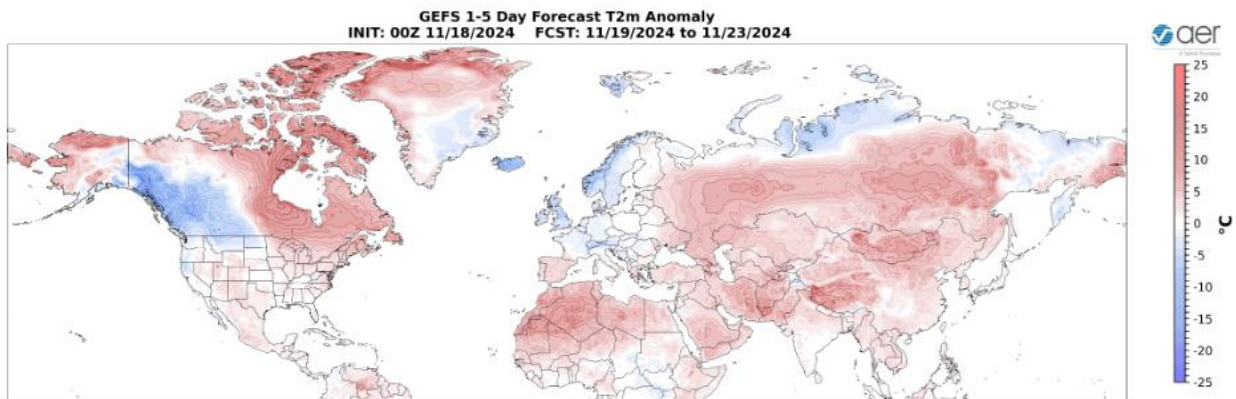
**Figure 1.** a) The predicted daily-mean AO at 10 hPa from the 00Z 18 November 2024 GFS ensemble. b) The predicted daily-mean AO at 1000 hPa from the 00Z 18 November 2024 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble mean AO index given by the red line with squares.

This week, ridging/positive geopotential height anomalies across Greenland will support toughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe (**Figures 2**). This pattern will favor normal to below normal temperatures across Northern Europe including the UK with normal to above normal temperatures across Southern Europe mostly bordering along the Mediterranean (**Figure 3**). This week the predicted pattern across Asia is ridging/positive geopotential height anomalies centered over the Central Arctic but sprawling across most of Asia with the limited exception of toughing/negative geopotential height anomalies across far Northern Asia (**Figure**

2). This pattern favors normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures limited to Northern Siberia (**Figure 3**).



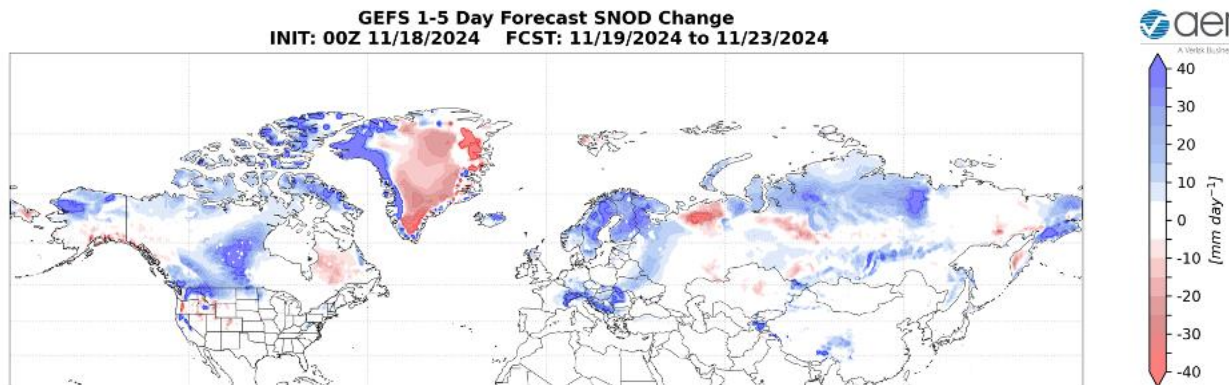
**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 19 Nov to 23 Nov 2024. The forecasts are from the 00Z 18 November 2024 GFS ensemble.



**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 19 Nov to 23 Nov 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

This week ridging/positive geopotential height anomalies south of the Aleutians will force troughing/negative geopotential height anomalies across Alaska, Western Canada and the Western US with more ridging/positive geopotential height anomalies across Eastern Canada and zonal flow across the Eastern US. (**Figure 2**). 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 Eastern US (**Figure 3**).

Troughing and/or cold temperatures will support new snowfall across Northern and Central Europe including the Alps and parts of the UK, Siberia and the Tibetan Plateau while warm temperatures will support snowmelt in Western Russia this week (**Figure 4**). Troughing and/or cold temperatures will support new snowfall across northern Alaska, British Columbia, Central Canada and the higher elevations of the Western US while warm temperatures will support snowmelt in Quebec this week (**Figure 4**).



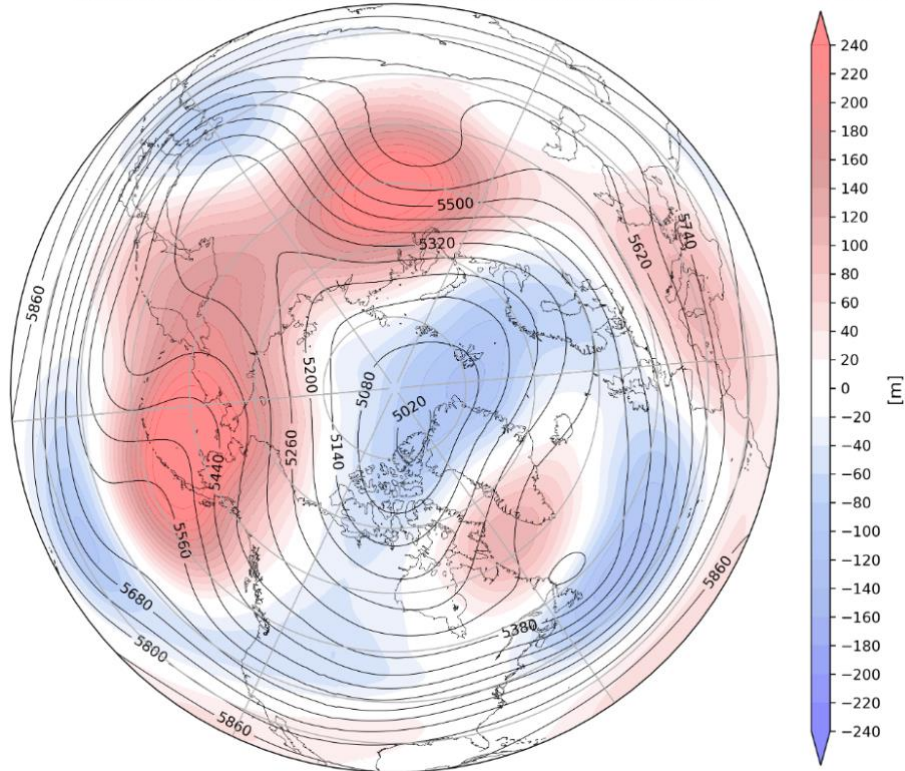
**Figure 4.** Forecasted snow depth changes (mm/day; shading) from 19 Nov to 23 Nov 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

## Near-Mid Term

### Next week

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

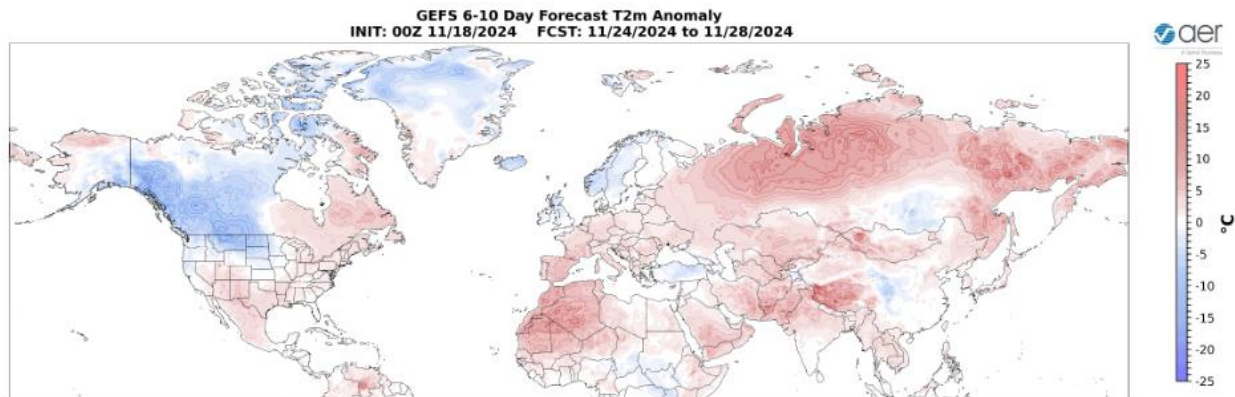
**GEFS 6-10 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 11/18/2024 FCST: 11/24/2024 to 11/28/2024**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 Nov to 28 Nov 2024. The forecasts are from the 00Z 18 November 2024 GFS ensemble.

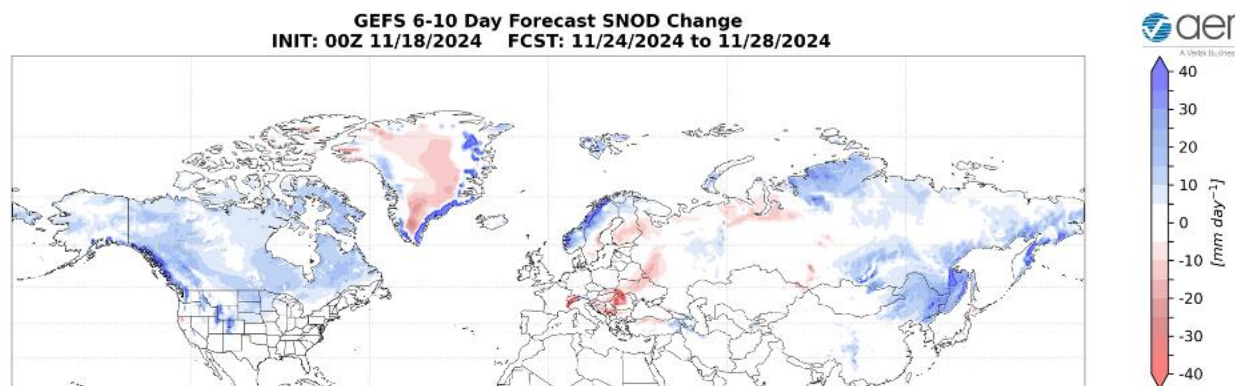
Weakening ridging/positive geopotential height anomalies across Greenland will continue to support troughing/negative geopotential height anomalies across Northern Europe but ridging/positive geopotential height anomalies previously confined to Southern Europe will push north into Central Europe this period (**Figure 5**). This pattern will favor normal to below normal temperatures across Northern Europe including the UK with normal to above normal temperatures across Southern and Central Europe (**Figure 6**). The predicted pattern across Asia is sprawling ridging/positive geopotential centered over the Urals forcing troughing/negative geopotential height anomalies to deepen 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 Kazakhstan, Mongolia and northwest China (**Figure 6**).





**Figure 6.** Forecasted surface temperature anomalies (°C; shading) from 24 Nov to 28 Nov 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

Persistent ridging/positive geopotential height anomalies near the Aleutians will continue to support troughing/negative geopotential height anomalies across Alaska, Western Canada and the Northwestern US with more ridging/positive geopotential height anomalies across Eastern Canada and the Central US this period (**Figure 5**). Greenland blocking will also support weak troughing in the Eastern US (**Figure 5**). This pattern will favor normal to below normal temperatures across Alaska, Western Canada, the Northwestern US and the Southeastern US with normal to above normal temperatures across Eastern Canada and from the Southwestern to the Northeastern US (**Figure 6**).



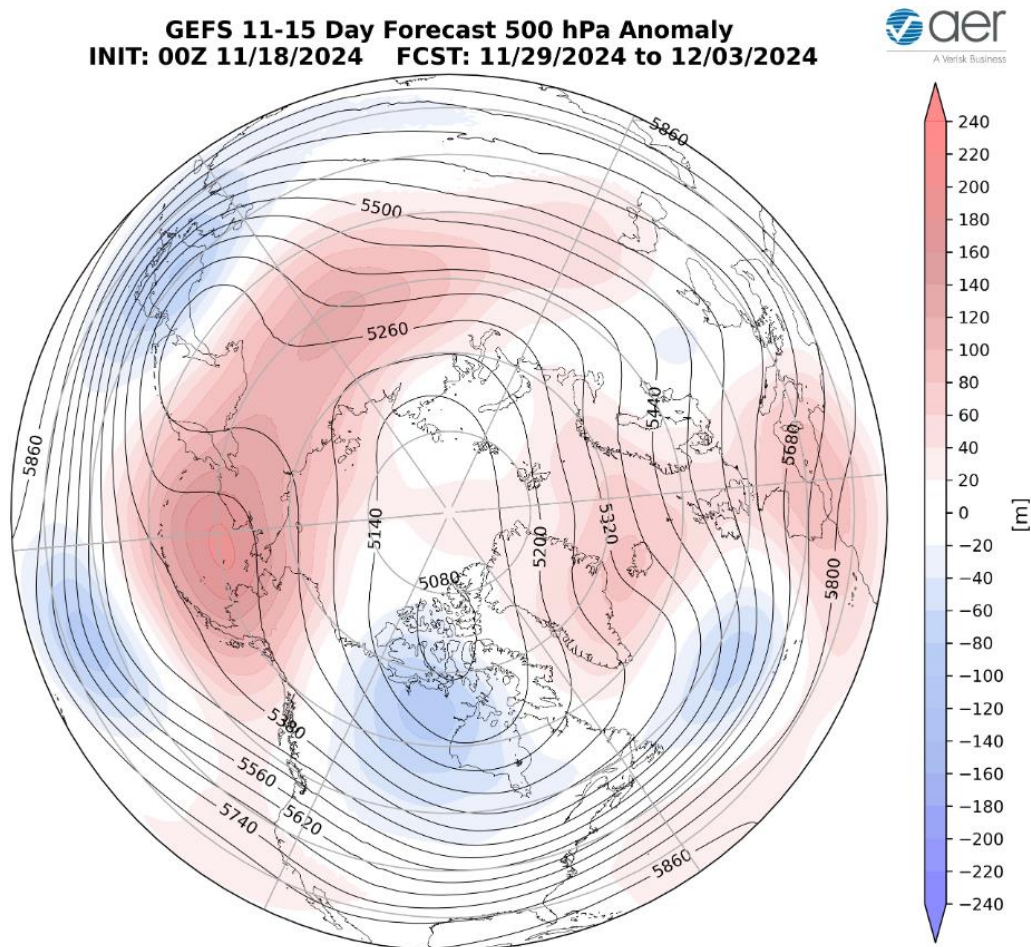
**Figure 7.** Forecasted snow depth changes (mm/day; shading) from 24 Nov to 28 Nov 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Norway, the Caucasus, the Siberia and parts of Central and Northeastern China while warm temperatures will support snowmelt in Northern and Central Europe this period (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across Alaska, much of Canada, the Cascades, Sierra and the Rockies this period (**Figure 7**).

## Mid Term

### Week Two

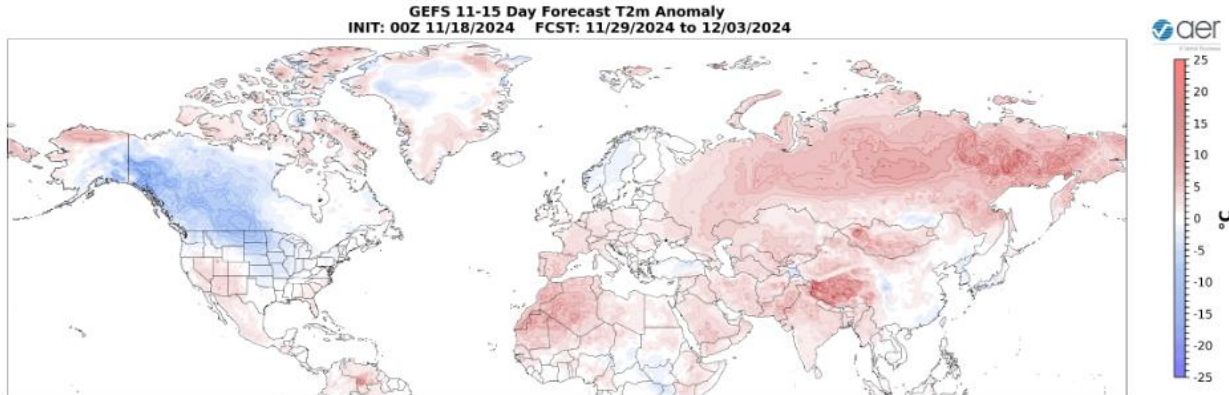
With predicted mostly mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO will likely persist near neutral (**Figure 1**). With predicted weak but positive to mixed pressure/geopotential height anomalies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



**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 Nov to 03 Dec 2024. The forecasts are from the 00Z 18 November 2024 GFS ensemble.

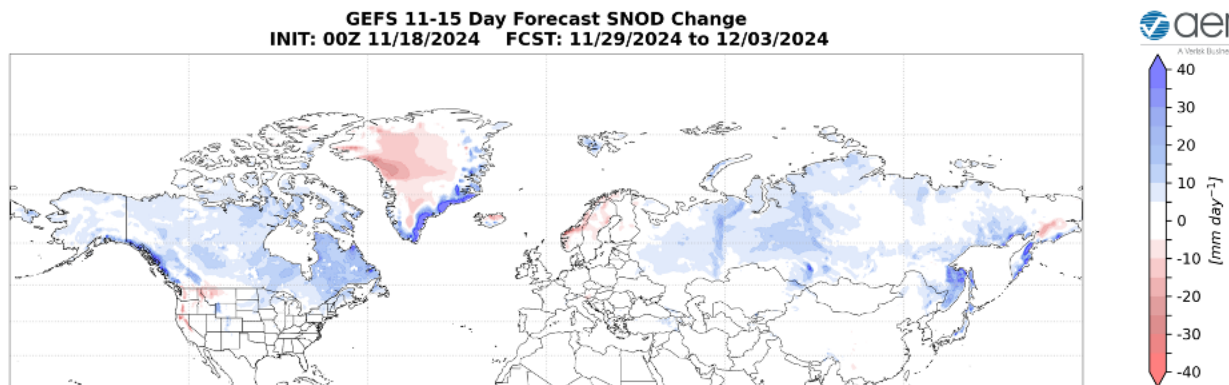
Weakening ridging/positive geopotential height anomalies across Greenland is predicted to continue to allow ridging/positive geopotential height anomalies to push north across Europe this period with weak troughing/negative geopotential height anomalies across Northwestern Europe (**Figure 8**). This pattern should favor normal to above normal temperatures across much of Europe with normal to below normal temperatures limited to Northwestern Europe including

the UK this period (**Figures 9**). The predicted pattern across Asia this period is ridging/positive geopotential height anomalies widespread across much Asia and centered on Western Siberia forcing troughing/negative geopotential height anomalies to push further east across East Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to parts of Southeastern Siberia and East Asia this period (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 29 Nov to 03 Dec 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

Predicted ridging/positive geopotential height anomalies near the Dateline will extend into the Gulf of Alaska will support troughing/negative geopotential height anomalies across much of Canada and the Eastern US this period (**Figure 8**). This pattern will favor widespread normal to below normal temperatures across much of Alaska, much of Canada and the Eastern US with normal to above normal temperatures across Northeastern Canada and the Western US this period (**Figure 9**).



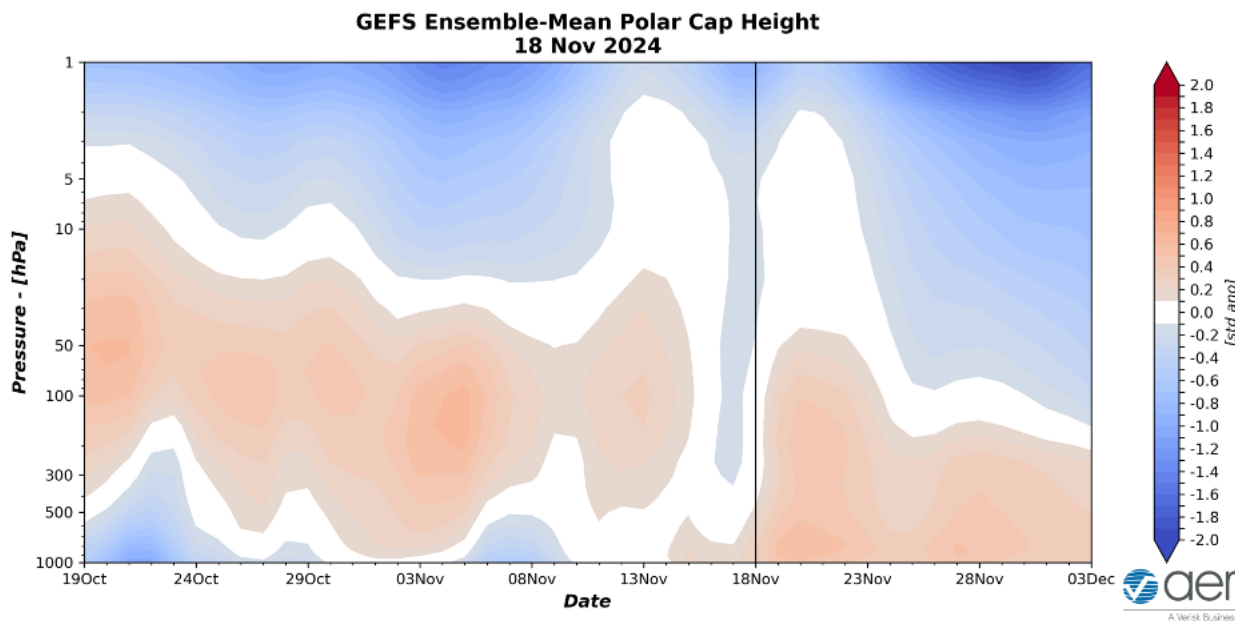
**Figure 10.** Forecasted snow depth changes ( $\text{mm/day}$ ; shading) from 29 Nov to 03 Dec 2024. The forecast is from the 00Z 18 November 2024 GFS ensemble.

Trouthing and/or cold temperatures will support new snowfall across Siberia, Northeast China and Japan this week (**Figure 10**). Trouthing and/or cold temperatures will support new snowfall across Alaska, Northern, Western and Eastern Canada and possibly the Northern Plains and new England in the US this week (**Figure 10**).

## Longer Term

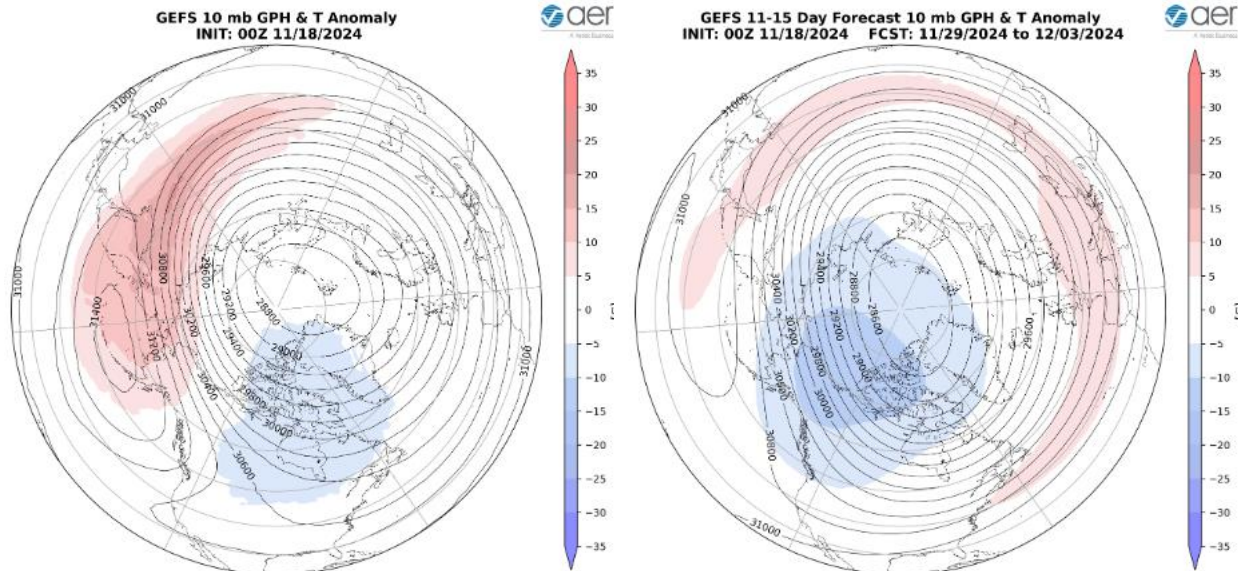
### 30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to warm/positive PCHs in the lower troposphere with cold/negative PCHs in the stratosphere and the upper troposphere (**Figure 11**). However much of this week and into next week warm/positive mid tropospheric PCHs are predicted throughout much of the troposphere while cold/negative PCHs in the upper stratosphere are predicted to deepen and descend throughout the depth of the stratosphere (**Figure 11**). For now this suggests that the stratosphere and troposphere are uncoupled but that could change with time.



**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 18 November 2024 GFS ensemble.

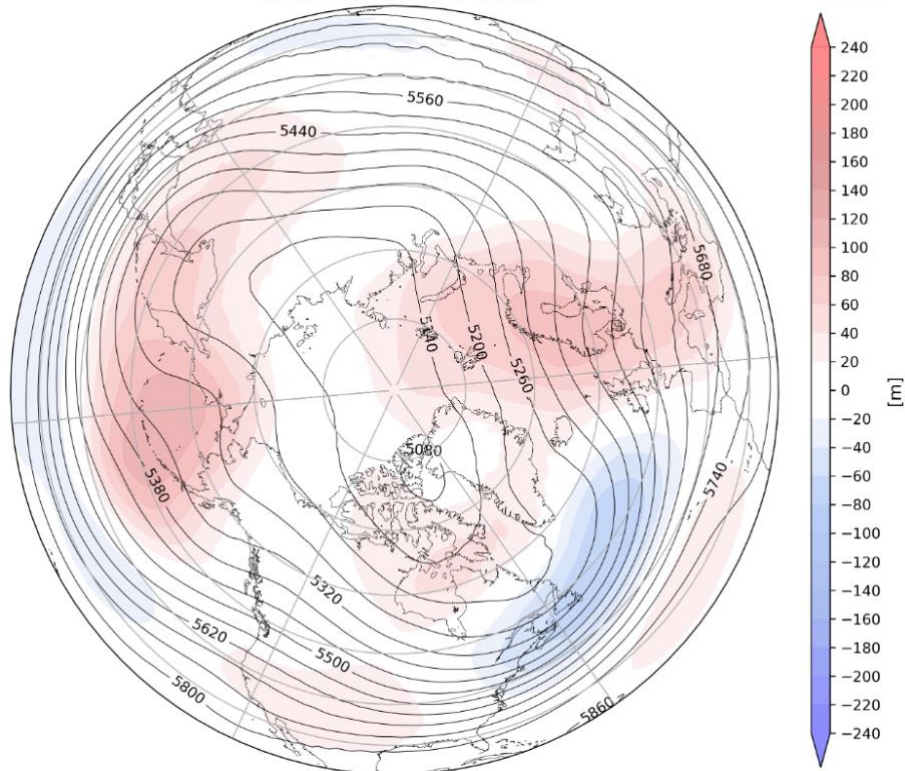
The predicted warm/positive PCHs in the lower troposphere the next two weeks (**Figure 11**) are consistent with the predicted neutral to negative surface AO the next two weeks (**Figure 1**). However, as we head into December, I believe there is much uncertainty and certainly coupling with the cold/negative stratospheric PCHs with the troposphere could force a more positive AO.



**Figure 12.** (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 18 November 2024. (b) Same as (a) except forecasted averaged from 29 Nov to 03 Dec 2024. The forecasts are from the 00Z 18 November 2024 GFS model ensemble.

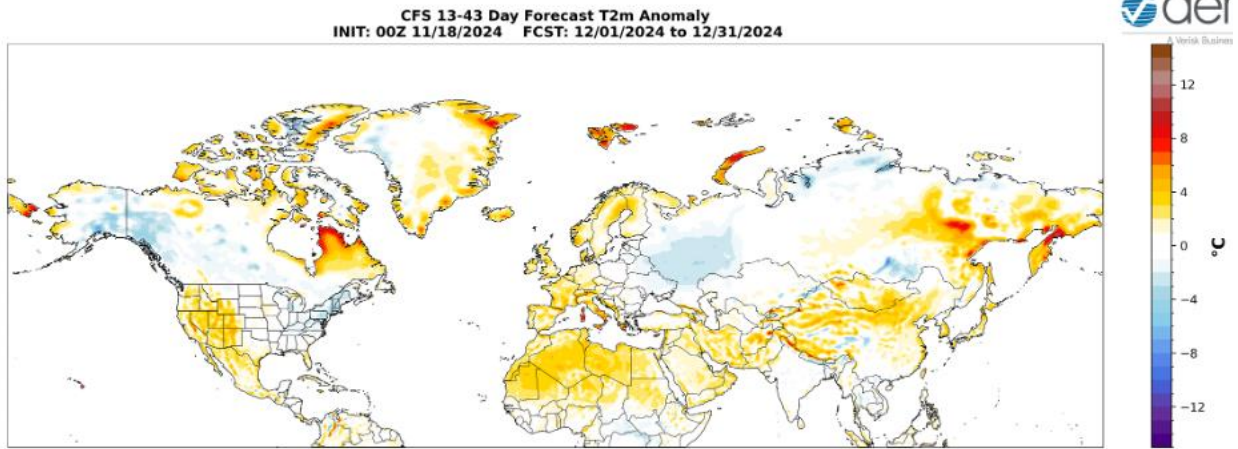
This week the polar vortex (PV) is predicted to be nearly circular in shape with the PV center between the North Pole and the Kara Sea with relatively cold temperatures focused in the Arctic (**Figure 12a**). This is consistent with a relatively strong PV. However warm air emanating from Asia towards Alaska is a precursor of a stretched PV event for this week that will bring some colder air to the US. Then, for the very end of November and early December the PV center is predicted to remain between the North Pole and the Kara Sea but become more elongated in shape with warming wrapping around Eurasia directed towards Alaska in the polar stratosphere (**Figure 12b**). This is still a stretched PV configuration. This is related to the cold air outbreak in China and should resume the flow of cold air out of Canada to the US in early December. I included the stratospheric AO in **Figure 1** this week to show despite the two stretched PVs in rapid succession overall the PV remains strong, and any cold air outbreaks should remain brief.

**CFS 500 hPa Forecast Anomaly Dec 2024  
Valid as of 18 Nov 2024**



**Figure 13.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2024. The forecasts are from the 00Z 18 November 2024 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and surface temperatures for December (**Figure 14**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Northwest Europe, centered near the UK, in Western Siberia, the Gulf of Alaska extending into Alaska and Western Canada with troughing spreading across Eastern Europe and Western Russia, Northeast Asia extending to the Dateline, Eastern Canada and the Eastern US (**Figure 13**). This pattern favors seasonable to relatively warm temperatures across Central and Western Europe, Much of Western and Northern Asia including Siberia, Alaska, Canada and the Western US with seasonable to relatively cold temperatures across Eastern Europe, Southeastern Siberia Northeast Asia, Southeastern Canada and the Eastern US (**Figure 14**).

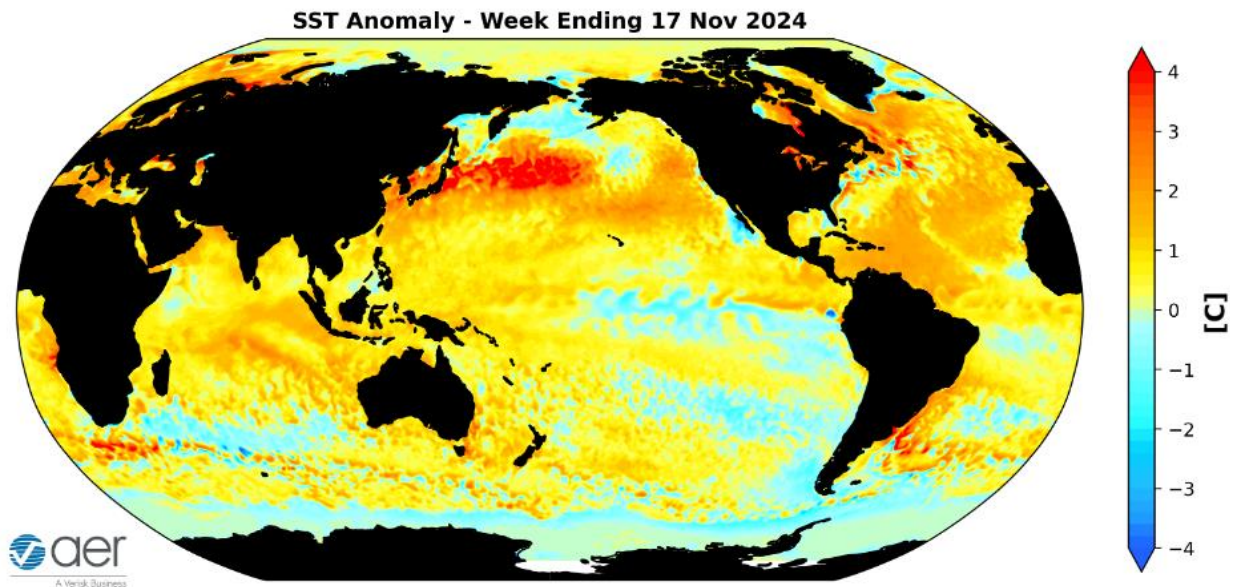


**Figure 14.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for December 2024. The forecasts are from the 00Z 18 November 2024.

## 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 a La Niña event 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.

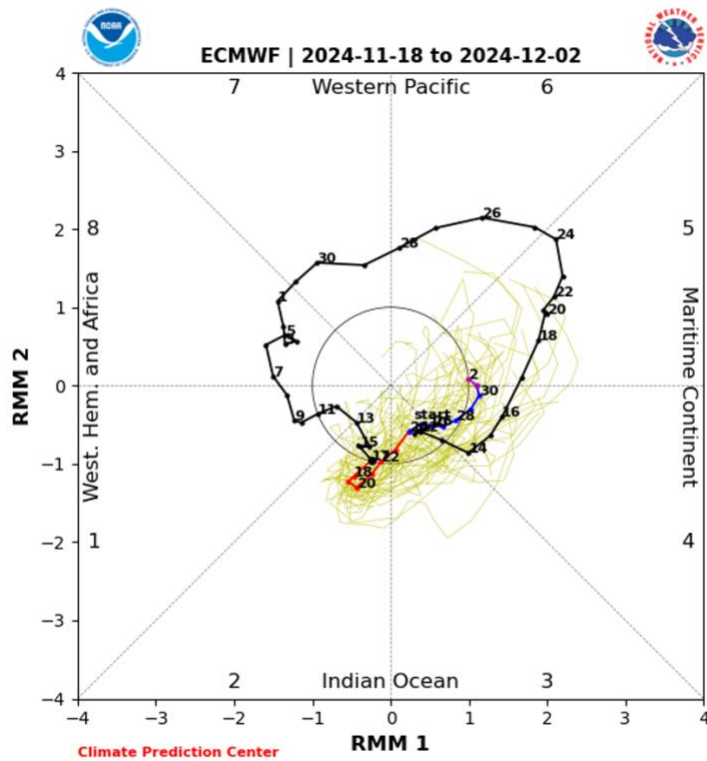


**Figure 15.** The latest daily-mean global SST anomalies (ending 17 November 2024). Data from NOAA OI High-Resolution dataset. Source <https://psl.noaa.gov/map/clim/sst.shtml>

### Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is currently weak where no phase is favored (**Figure 16**). The forecasts are for the MJO to remain mostly weak where no overall phase is favored. Therefore it seems that the MJO is having little 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 18 November 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>

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