

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

December 11, 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.

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 be positive to neutral the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to remain mostly negative to mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently positive with mostly negative pressure/geopotential height anomalies across Greenland and the NAO is predicted to remain positive the next two weeks as pressure/geopotential height anomalies become increasingly negative across Greenland.
- This week, troughing/negative geopotential height anomalies in the North Atlantic including Greenland will force mostly ridging/positive geopotential height anomalies across Europe with the exception of some regional

troughing/negative geopotential height anomalies across Scandinavia and Western Europe. This pattern will support widespread normal to above normal temperatures across Europe including the United Kingdom (UK) with the exceptions of normal to below normal temperatures across Scandinavia this week and Western Europe next week.

- The next two weeks the predicted general across Asia is ridging/positive geopotential height anomalies across Western Asia and troughing/negative geopotential height anomalies across East Asia. This pattern favors widespread normal to below normal temperatures across Northern and East Asia with normal to above normal temperatures across Southern Asia this week. However next week the normal to above normal temperatures will become more widespread across Asia with normal to below normal temperatures becoming much more limited to Eastern Siberia and East Asia.
- The general predicted pattern across North America the next two weeks is troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska forcing ridging/positive geopotential height anomalies across most of North America. This pattern favors widespread normal to above normal temperatures across North America with the exceptions of normal to below normal temperatures across Alaska and the Southeastern United States (US) this week.
- In the Impacts section I discuss the growing likelihood of a large polar vortex (PV) disruption and the impact on Northern Hemisphere (NH) weather.

## Plain Language Summary

Weather models reversed course over the weekend and now are predicting deep low pressure in the Arctic and Greenland that has resulted in a milder forecast across the Northern Hemisphere (NH) continents (see **Figure 8**). Any anticipated cold in the Eastern US is looking less likely to me for the remainder of the month.

But while the models taketh they also giveth. A larger PV disruption is more likely in early January that has the potential to reverse the overall mild pattern for the NH to a much colder one. Hard to provide details just yet and I expect a lot of volatility in the forecasts so buckle up.

## Impacts

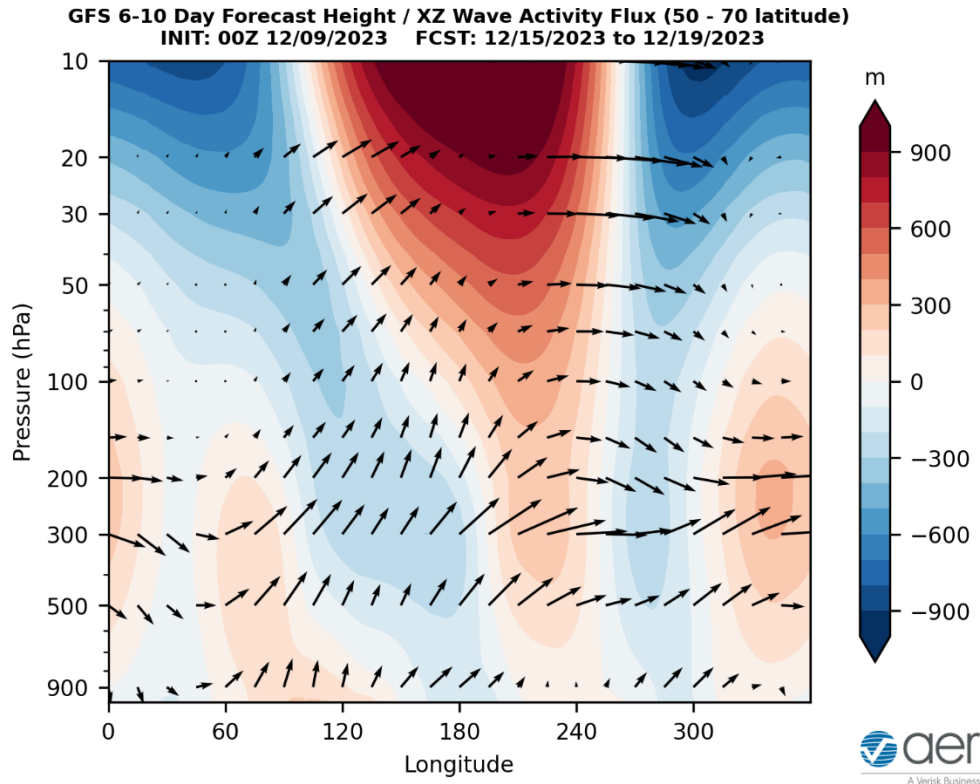
I joke now every winter that the official first day of winter should be moved from December 1<sup>st</sup> or December 21<sup>st</sup> to Martin Luther King (MLK) weekend (mid-January). For those of us who eagerly await winter weather over the traditional winter season this joke has had more than a little truth to it. And for the Eastern US if there is going to be any meaningful winter, it will probably not occur before MLK weekend. That

is because the Eastern US is almost always mild leading up to and following a sudden stratospheric warming (and I cannot recall when it wasn't), which is likely to be on the order of four weeks in length.

As I have been discussing for the past two weeks, I think this December will experience multiple Polar Vortex events in fairly quick succession. The first is a Canadian Warming that is currently winding down. I feel that this has contributed to the cold temperatures across Northern Eurasia and the mild temperatures across North America. The second is a stretched PV for early next week. And the third is more of a sudden stratospheric warming (SSW) type but whether it will achieve major warming status (winds at 60°N and 10hPa reverse from westerly to easterly) or not, is very much an open question in my mind.

I feel that I have done as good and probably a better job anticipating the behavior of the stratospheric polar vortex than I have done in any previous winter, so far. I have correctly anticipated the Canadian warming, the stretched PV (more on this below) and I have consistently been writing since October that the most likely time for a sudden stratospheric warming (SSW) is late December to early January, and as a point of reference our PV strength forecast model is predicting that the most likely time for an SSW is from 27 December 2023 through 5 January 2024. In addition, at least for now all of the weather models are in agreement with me. But let me be clear, I have been burned before on weather models predicting a robust SSW for it all to quickly disappear, so I take nothing for granted. Also, I would have liked to have seen our PV strength model to show greater weakening of the PV than it has done so far to be more confident of a major warming. So, I do think that there are red flags.

However, the devil is in the details and correctly translating the behavior of the polar vortex into sensible weather is what most care about. As I discussed last week, in our historical analysis there were stretched PV events with mild temperatures in North America but as long as I have been paying attention to them in real time, I don't recall one. Therefore, until I saw differently my expectations were for the model forecast to turn colder approaching the holiday season. Even the energy diagnostics are looking better, more clearly showing wave reflection not only in the vertical meridional direction but also in the vertical latitudinal direction (see **Figure i**). While I do think that the stretched PV in the stratosphere will have an impact on the tropospheric Jet Stream it is becoming increasingly likely that it will not result in any meaningful cold temperatures east of the Rockies.

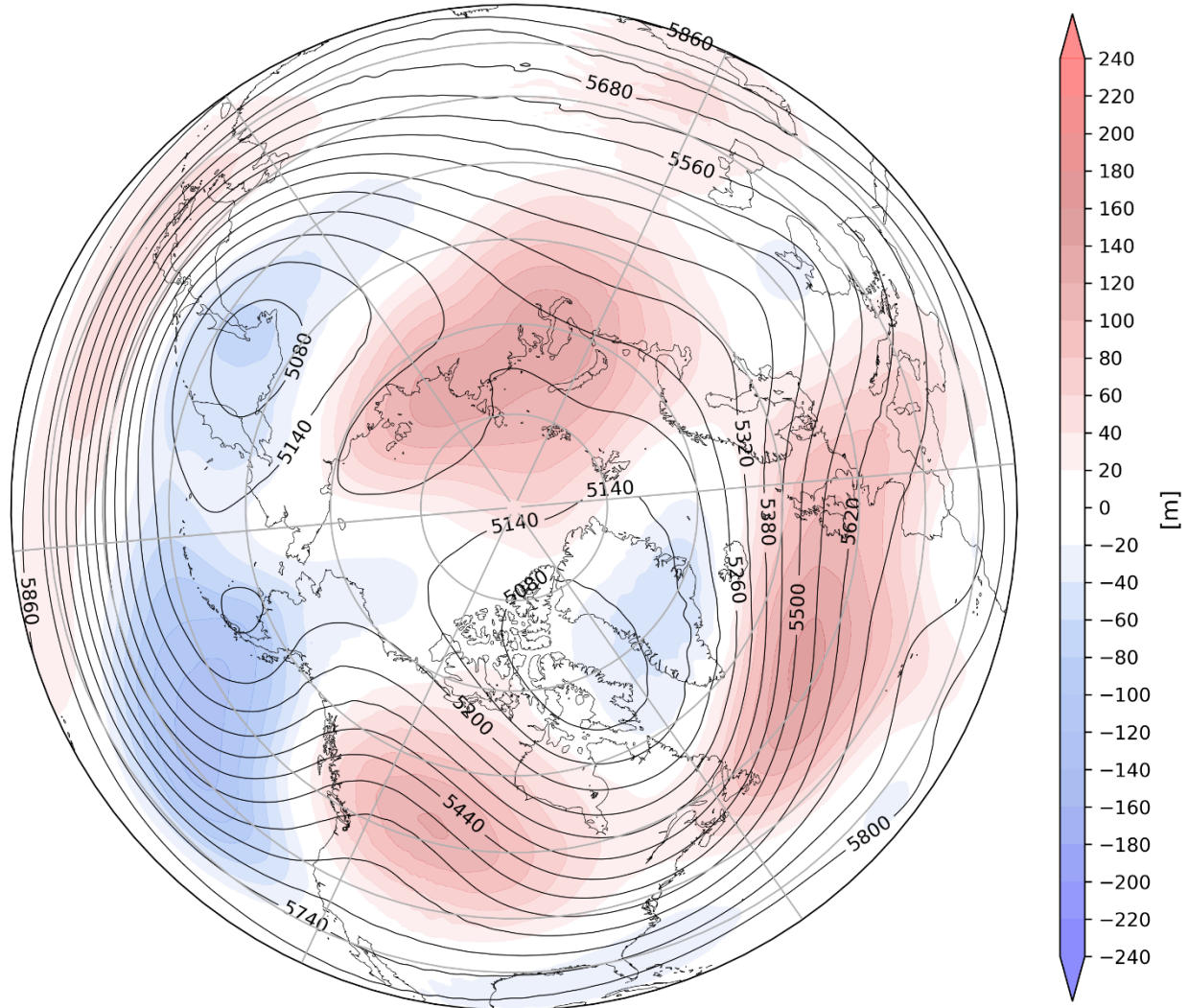


**Figure i.** Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 15 – 19 December 2022. The forecasts are from the 00z 9 December 2023 GFS ensemble.

In addition, the models are predicting a western ridge/eastern trough pattern across North America. For example, the CFS for the remainder of December (see **Figure ii**). But the trough is relatively shallow, and the trough is further east than typical allowing the cold air to be shunted into the North Atlantic rather than down the center of the North America. And if you look at an animation of the surface temperature anomalies (not shown), you can see the cold air repeatedly flowing off the east coast of Canada into the North Atlantic.

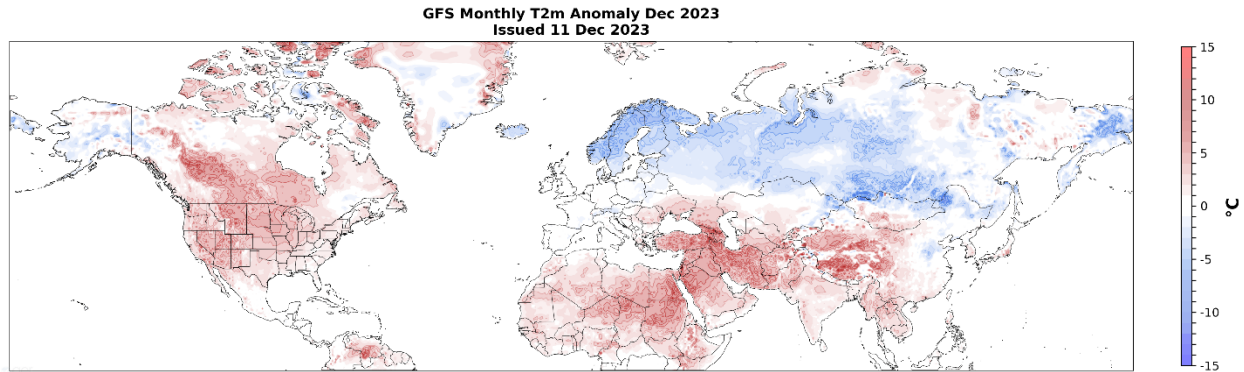


**CFS 500 hPa Forecast Anomaly Dec 2023**  
**Valid as of 10 Dec 2023**



**Figure ii.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2023. The forecasts are from the 00Z 9 December 2023 CFS.

Not sure how to explain the cold not materializing whether it is an unfavorable Madden Julian Oscillation (MJO; see below) or El Niño (though hard to find any influence of El Niño until now). But this fall does remind me of fall 2016 when a very cold Eurasia supercharged the North Pacific Jet Stream that lasted all winter and flooded North America east of the Rockies all winter long (see [recap\\_winter2017](#)). And if anything, the cold in Northern Eurasia looks even more impressive now in December 2023 than November 2016 (see **Figure iii**).

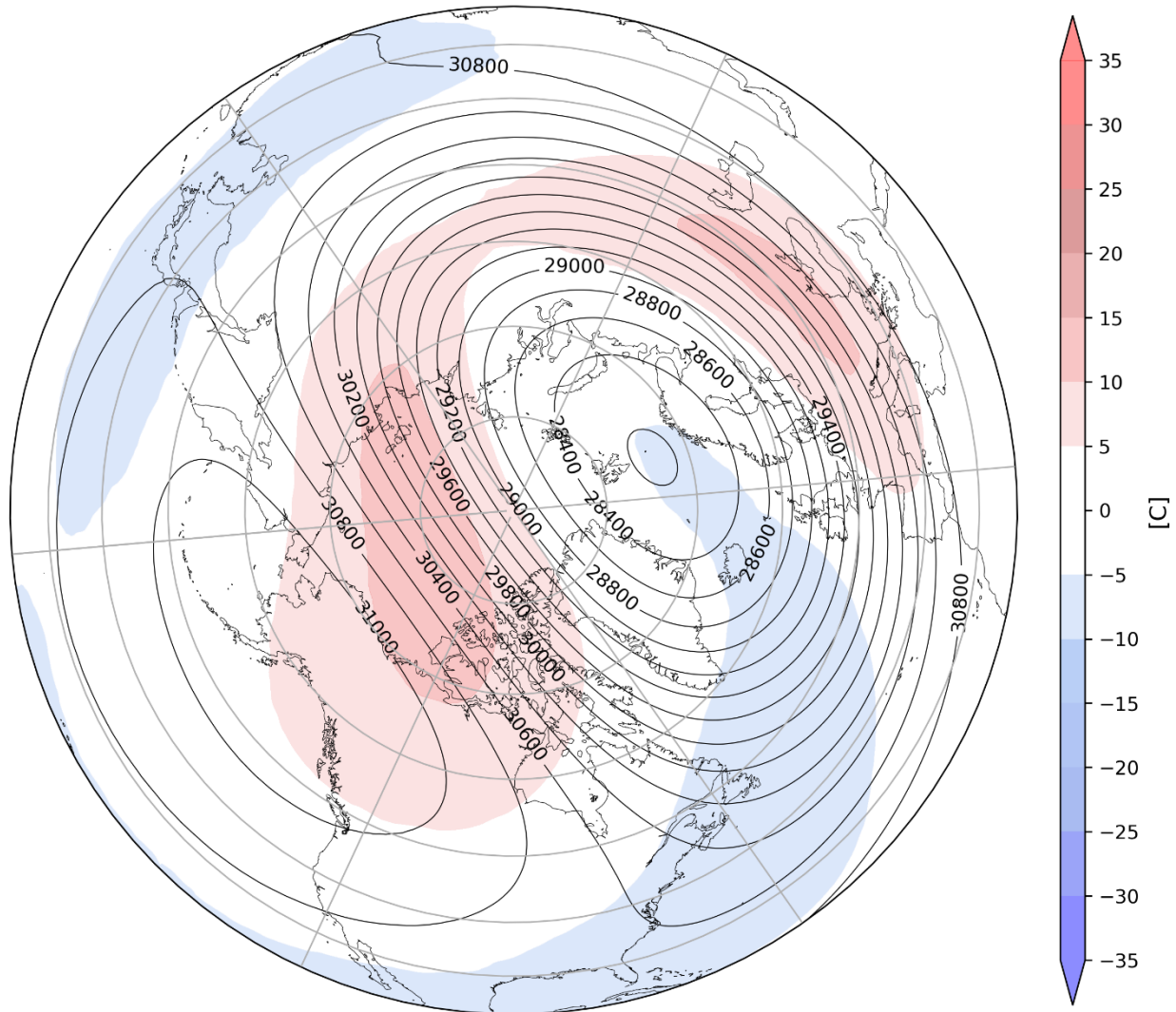


**Figure iii.** Estimate of the observed surface temperatures ( $^{\circ}\text{C}$ ; shading) from 1 – 26 December 2023 based on GFS initializations and forecasts. The forecasts are from the 00Z 11 December 2023 GFS.

But regardless of the near-term wave reflection, it does look like it will be dominated or replaced by wave absorption in the stratosphere. This will lead to a larger PV disruption than a stretched PV. It is my experience when wave absorption occurs in the polar stratosphere the Eastern US, it is almost always mild. So regardless of what else might be occurring, El Niño, MJO, I see little support for any meaningful and/or persistent cold in the Eastern US for the foreseeable future. As an aside, I don't believe that the PV controls 100% of the winter weather and I do try to take a holistic approach, but it is my expertise and I find that it provides me the biggest bang for the buck sort of speak. But I realize the limitations of any predictor including the PV, and I do try to contextualize what can go right and what can go wrong with any forecast beyond a week and certainly beyond two weeks.

All the models are all consistently predicting yet another Canadian warming (see **Figure iv**). And like the first one this month this should lead to an overall mild pattern across North America. And as I discussed two weeks ago (see [27Nov blog](#)), a Canadian warming almost always transitions to either a stretched PV or an SSW. This time I am anticipating an SSW to follow. If nothing else looking at the Vertical Wave Activity Flux (WAFz) forecast in **Figure 11**, it is looking very active.

**GEFS 11-15 Day Forecast 10 mb GPH & T Anomaly**  
**INIT: 00Z 12/11/2023 FCST: 12/22/2023 to 12/26/2023**



**Figure iv.** Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere from 22 – 26 December 2023. The forecasts are from the 00Z 11 December 2023 GFS model ensemble.

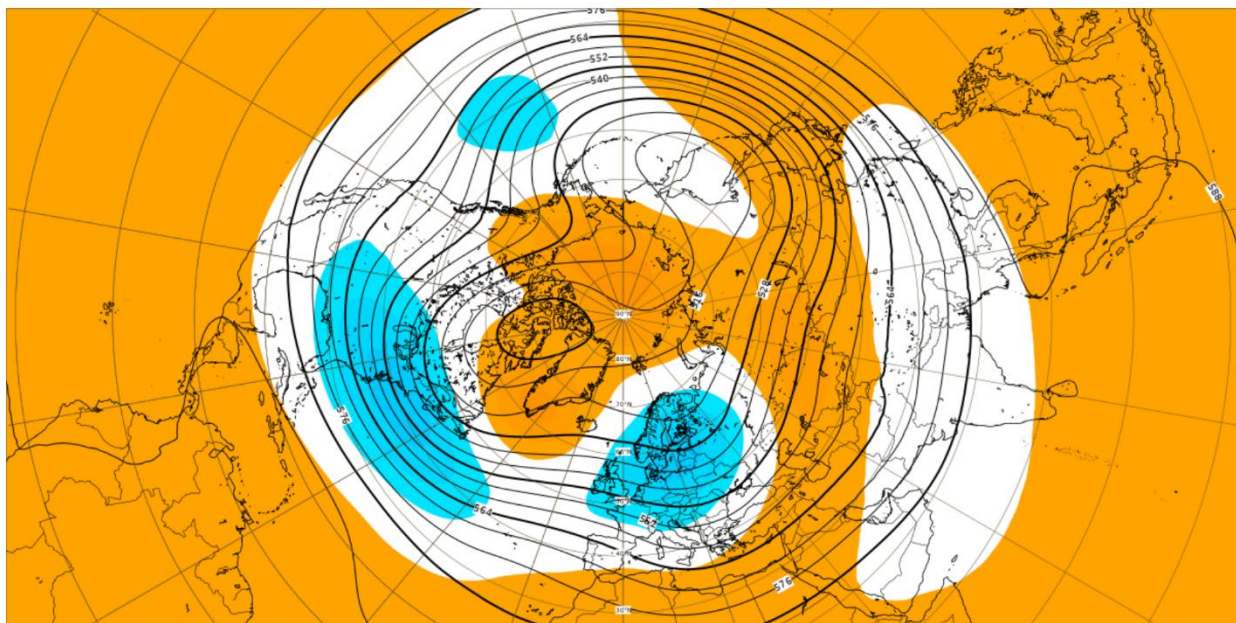
It is of my opinion, much of the winter will likely hinge on the nature of this SSW that is predicted to begin the last week of December. I think the models were slow to appreciate the magnitude of the energy transfer from the troposphere to the stratosphere. Where the energy leaves or diverges it creates cold, low pressure and the westerly winds increase or in this case in the troposphere. Where the energy enters or converges it creates warm, high pressure and the westerly winds decrease or in this case in the stratosphere. That is why I believe that the weather models both showed a more robust weakening of the PV simultaneously predicting more low pressure and less high latitude blocking in the troposphere and milder temperatures across the continents.



As I wrote in last week's blog, if the baton can be successfully handed off from the PV to the Jet Stream and our weather, the overall mild pattern should start reversing and a colder pattern can start emerging across the NH ala the CFS forecast below (though as far as I can tell the CFS pulled a rabbit out of a hat) and even the latest ECMWF weeklies shown in in **Figure v**). Though the holy grail of high pressure focused in the Arctic with low pressure and relatively cold temperatures in Northern Europe, East Asia and the Eastern US simultaneously, as predicted but both the CFS and ECMWF, almost never happens and I am skeptical.

### 500 hPa height: Weekly mean anomalies

Base time: Sun 10 Dec 2023 Valid time: Mon 08 Jan 2024 - Mon 15 Jan 2024 (+864h) Area : North Pole



Extended range: 500 hPa geopotential (dm)

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Source: [www.ecmwf.int](https://www.ecmwf.int)  
Licence: CC BY 4.0 and ECMWF Terms of Use (<https://apps.ecmwf.int/datasets/licences/general/>)  
Created at 2023-12-11T19:04:24.657Z



**Figure v.** Chart shows 7-day mean anomalies of 500 hPa height from 8 – 15 January 2024 from the initialized 10 December 2023 ECMWF extended range ensemble. Plot taken from <https://charts.ecmwf.int/>

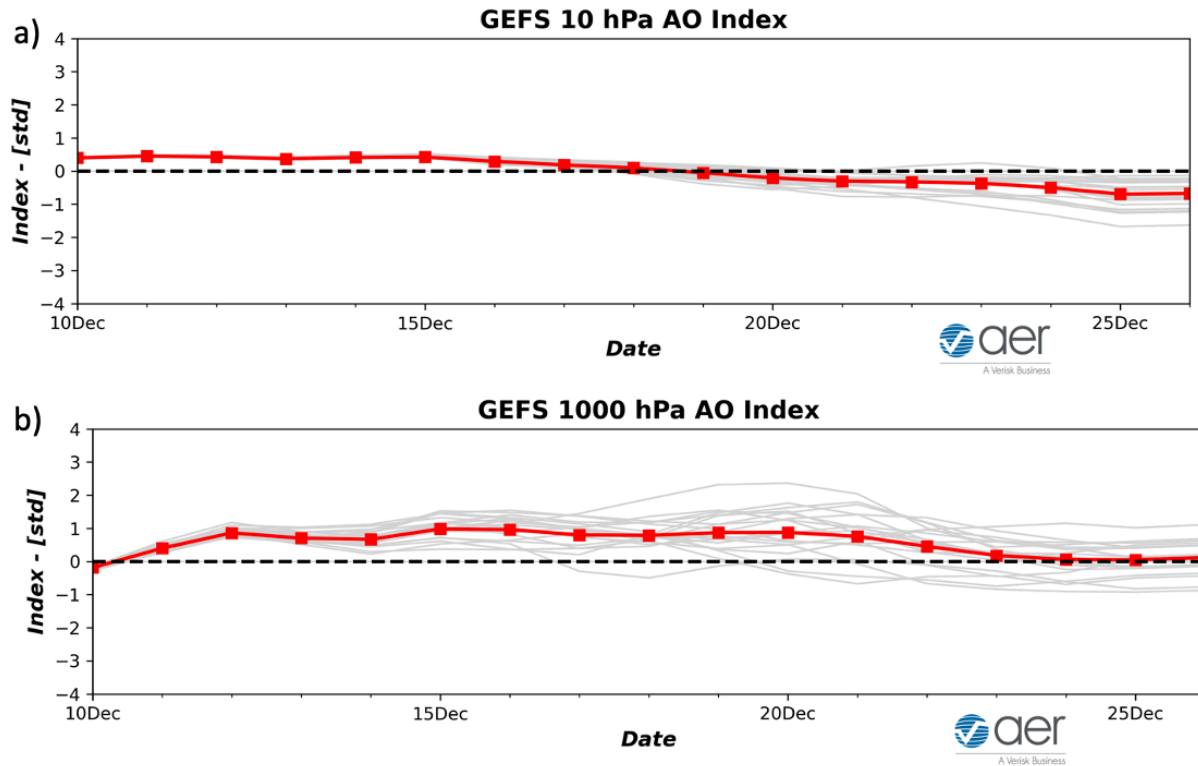
But if the SSW starts to go sideways and has little or limited (in both time and/or space) impact, I see little reason anticipate anything but an overall mild period for a more extended period. Once an SSW rolls over prematurely it is my experience that it takes many weeks for a chance at another one.

Given so much uncertainty I will refrain to say much more today other than to expect greater than usual model volatility in the lead up to the SSW and even beyond. But I will leave you with two teasers. First the quasi-biennial oscillation (QBO) has a long history as an in and out fad and recently it is back in. This winter it is easterly and according to the most recent research that favors a more robust tropospheric response to an SSW and overall colder temperatures across the NH post the SSW. Second all the weather models are for now predicting a PV displacement, but this is still an evolving situation. The weather models are converging on a dominant wave-2 in the troposphere for late December (for example see **Figure 8**) with ridging centered near the Urals and western North America and troughing in the North Pacific and North Atlantic. My personal favorite PV disruption, the PV split, is thought to be favored when wave-2 dominates the tropospheric pattern. You gotta love the Canadian model, it is practically there already for the last week of December. I just won't post it because I don't want to be thought of as endorsing the Canadian forecast, at least not yet. But maybe I will with time.

## Near-Term

### *This week*

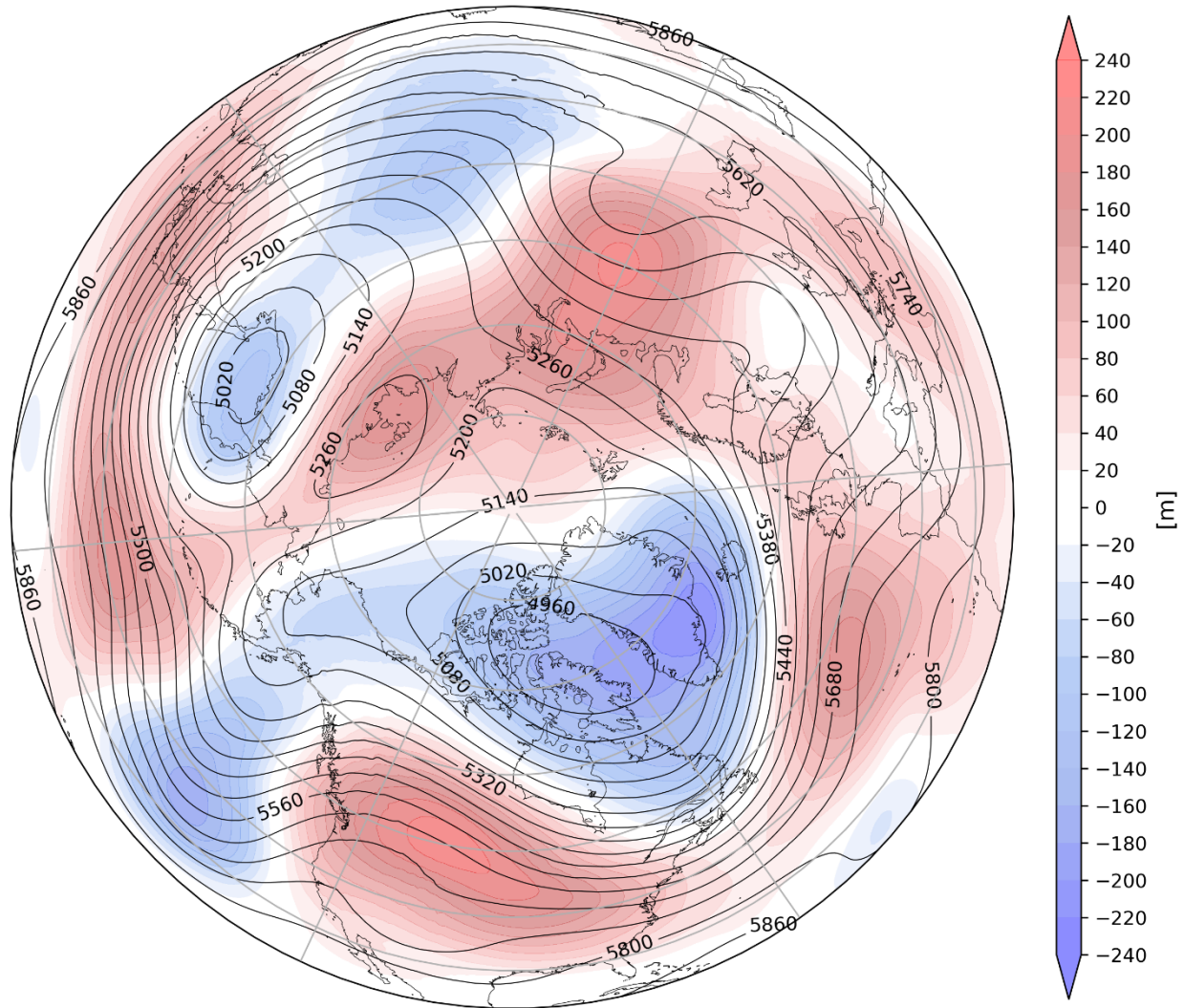
The AO is predicted to be positive this week (**Figure 1**) with mostly negative geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With predicted negative geopotential height anomalies across Greenland (**Figure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



**Figure 1.** (a) The predicted daily-mean AO at 1000 hPa from the 00Z 11 December 2023 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 11 December 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.

Trounging/negative geopotential height anomalies across the North Atlantic Arctic including Greenland will support ridging/positive geopotential height anomalies across Europe this week (**Figures 2**). **The pattern favors widespread normal to above normal temperatures across Europe including the UK with the exception of normal to below normal temperatures across Scandinavia mostly due to persistence (Figure 3).** The Asian Arctic is predicted to be dominated by ridging/positive geopotential height anomalies centered near the Laptev Sea forcing trounging/negative geopotential height anomalies across Northern and Eastern Asia with more ridging centered near the Urals (**Figure 2**). This pattern favors widespread normal to below normal temperatures across much of Northern and Eastern Asia with normal to above normal temperatures across Southern Asia (**Figure 3**).

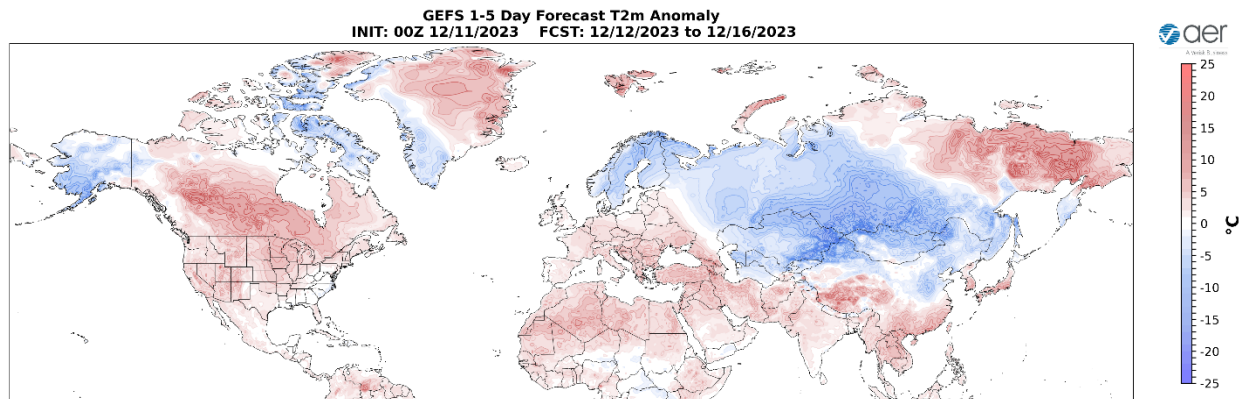
**GEFS 1-5 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 12/11/2023 FCST: 12/12/2023 to 12/16/2023**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 12 December – 16 December 2023. The forecasts are from the 00z 11 December 2023 GFS ensemble.

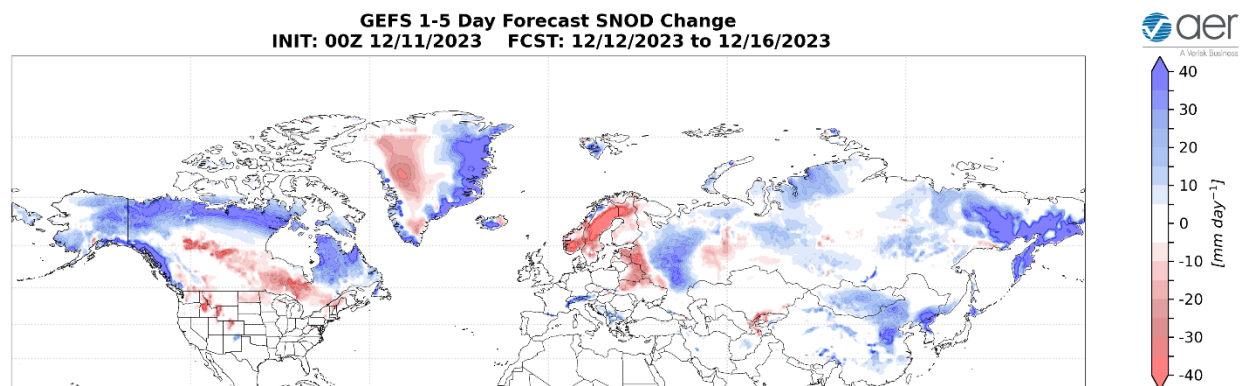
The pattern this week across North America is troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska forcing across ridging/positive geopotential height anomalies across Canada and the US with the exception of more troughing in Baffin Bay (Figure 2). **This pattern will favor normal to above normal temperatures across much of Canada and the US with normal to below normal temperatures limited to Alaska and far northeastern Canada (Figure 3).**





**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 12 December – 16 December 2023. The forecast is from the 00Z 11 December 2023 GFS ensemble.

Trouging and/or cold temperatures will support new snowfall across the Alps, Siberia and Northeastern Asia while mild temperatures will support snowmelt across Scandinavia and Eastern Europe this week (**Figure 4**). Trouging and/or cold temperatures will support new snowfall across Alaska, the West Coast of, Northern and Eastern Canada while mild temperatures will support snowmelt across Central and Southern Canada, the US Rockies and New England this week (**Figure 4**).



**Figure 4.** Forecasted snow depth changes (mm/day; shading) from 12 December – 16 December 2023. The forecast is from the 00Z 11 December 2023 GFS ensemble.

## Near-Mid Term

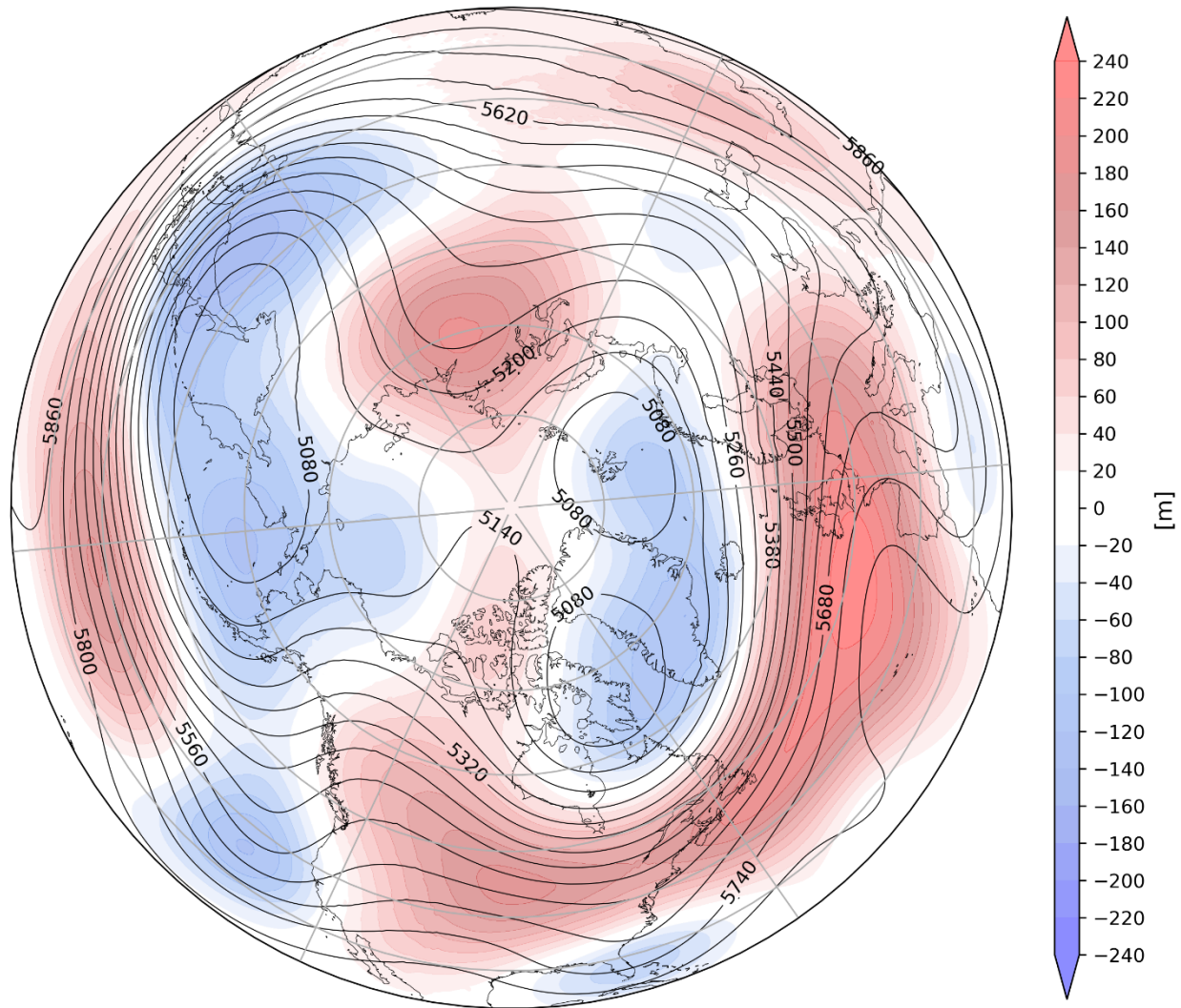
### *Next week*

With mostly negative geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should be positive this period (**Figure 1**). With predicted negative pressure/geopotential



height anomalies across Greenland (**Figure 5**), the NAO will also be positive this period as well.

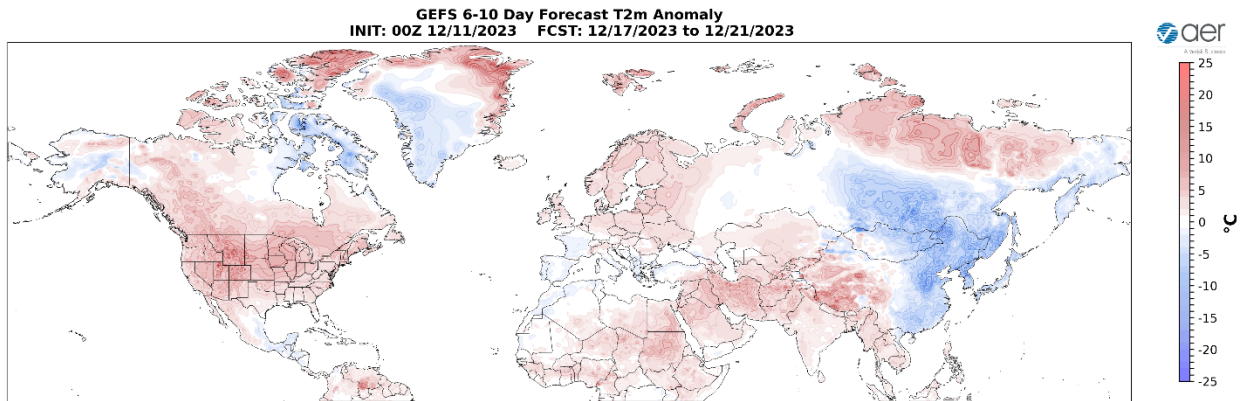
**GEFS 6-10 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 12/11/2023 FCST: 12/17/2023 to 12/21/2023**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 December 2023. The forecasts are from the 00z 11 December 2023 GFS ensemble.

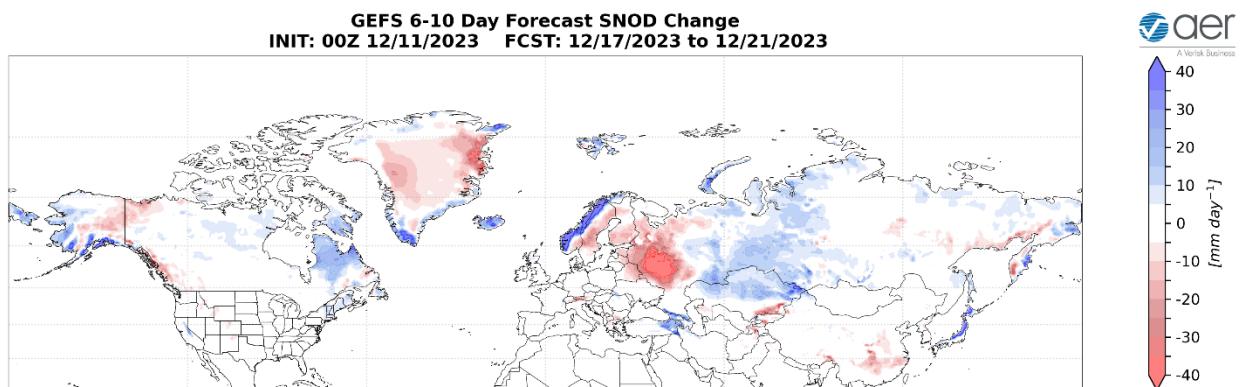
Persistent troughing/negative geopotential height anomalies across the North Atlantic and Greenland will support widespread ridging/positive geopotential height anomalies across much of Europe with the exception of troughing/negative geopotential height anomalies across Southwestern Europe this period (**Figure 5**). The pattern will favor widespread normal to above normal temperatures across Northern and Eastern Europe

including the UK **with** normal to above normal temperatures across Southern and Western Europe (**Figures 6**). Ridging/positive geopotential height anomalies will persist across Western and Southern Asia with troughing/negative geopotential height anomalies across the Northern and Eastern Asia this period (**Figure 5**). This pattern favors widespread normal to below normal temperatures across much of Northern and Eastern Asia including Eastern Siberia with normal to above normal temperatures across Western and Southern Asia and Northern Siberia this period (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies (°C; shading) from 17 – 21 December 2023. The forecasts are from the 00z 11 December GFS ensemble.

The predicted general pattern across North America this period is troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska forcing ridging/positive geopotential height anomalies across much of North America with the exception of more troughing in Baffin Bay (**Figure 5**). This pattern favors widespread normal to above normal temperatures across much of Canada and the US with normal to below normal temperatures limited to parts of Alaska and Northeastern Canada (**Figure 6**).



**Figure 7.** Forecasted snow depth changes (mm/day; shading) from 17 – 21 December 2023. The forecast is from the 00Z 11 December 2023 GFS ensemble.

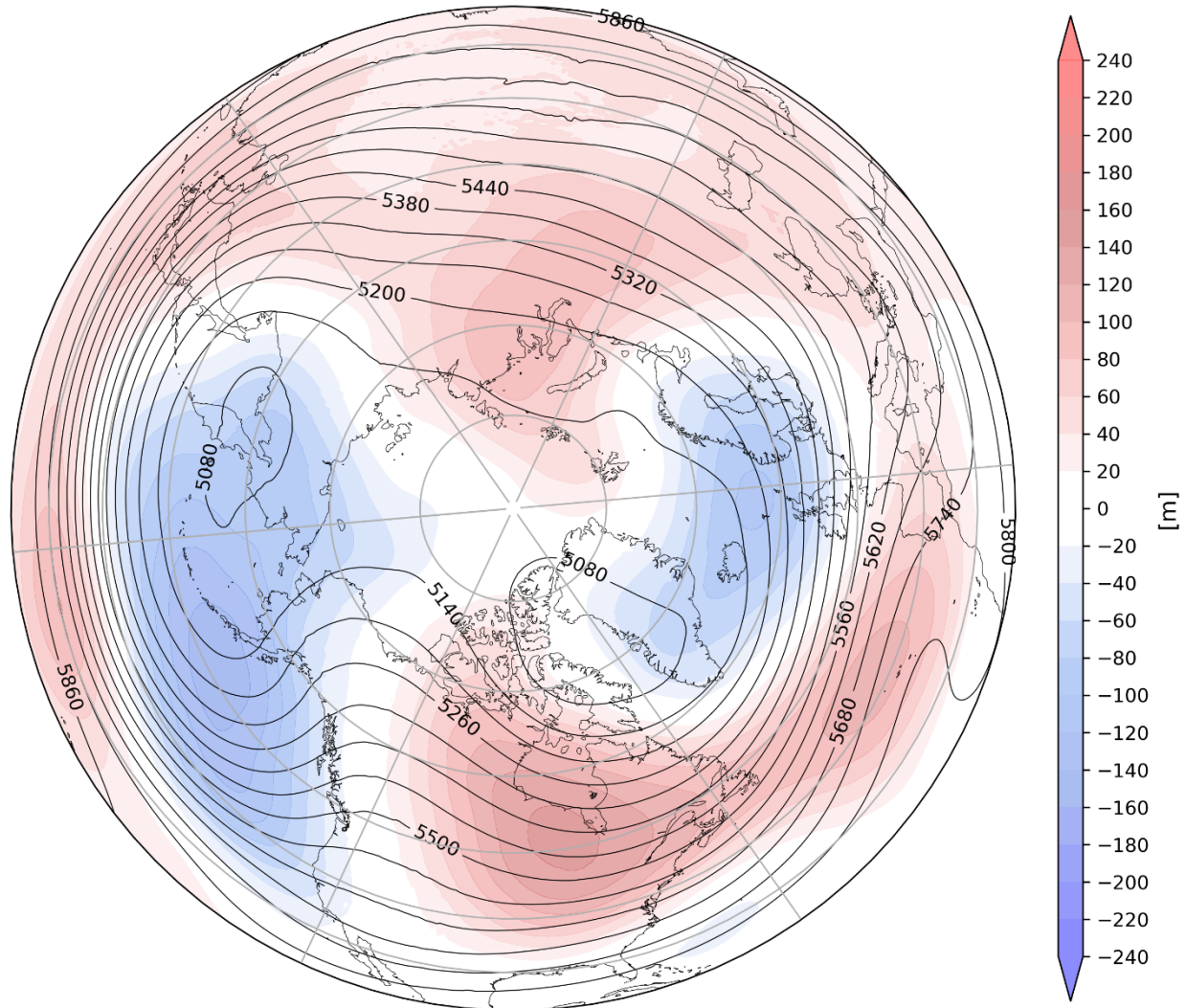
Trouching and/or cold temperatures will support new snowfall across Norway, and centered around the Urals while mild temperatures will support snowmelt in Scandinavia, Eastern Europe and Western Russia this period (**Figure 7**). Trouching and/or cold temperatures will support new snowfall across western Alaska, Northeastern Canada and possibly New England while mild temperatures will support snowmelt in eastern Alaska and the higher elevations of the West Coast of Canada this period (**Figure 7**).

## **Mid Term**

### *Week Two*

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

**GEFS 11-15 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 12/11/2023 FCST: 12/22/2023 to 12/26/2023**

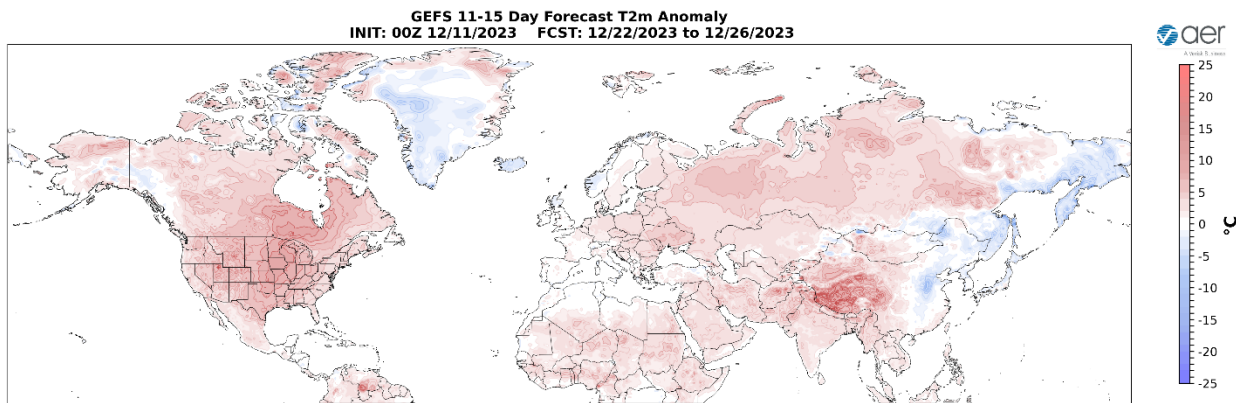


**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 22 – 26 December 2023. The forecasts are from the 00z 11 December 2023 GFS ensemble.

The predicted pattern for Europe this period is a zonal flow pattern with troughing/negative geopotential height anomalies across Northern Europe and ridging/positive geopotential height anomalies across Southern Europe this period (**Figure 8**). This pattern should favor normal to above normal temperatures across most of Europe including the UK with normal to below normal temperatures limited to the Iberian Peninsula this period (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to continue to persist across Western and Southern Asia with troughing/negative geopotential height anomalies limited to Northeastern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal

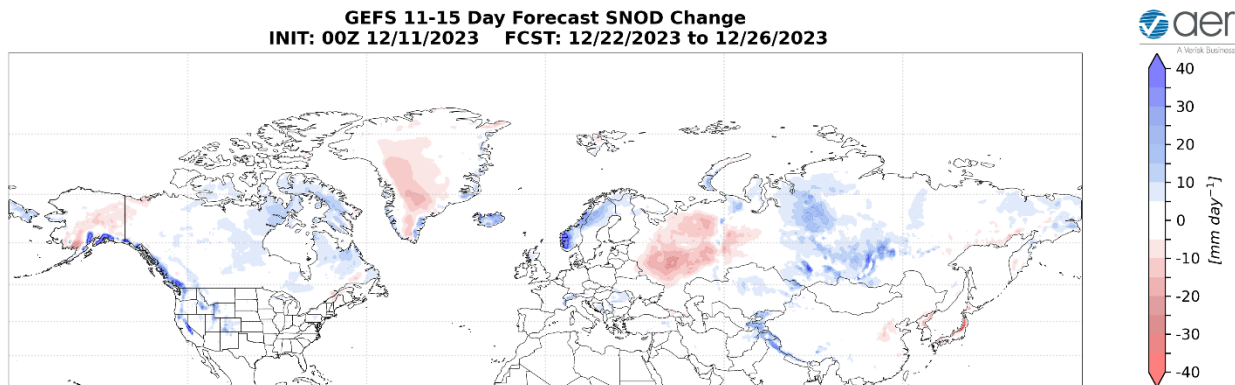


temperatures across Asia with the exception of normal to below normal temperatures across far East Asia and Eastern Siberia this period (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 22 – 26 December 2023. The forecasts are from the 00z 11 December 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies in the Gulf of Alaska will continue to force ridging/positive geopotential height anomalies across much of North America with more troughing in Baffin Bay this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Canada and the US with normal to below normal temperatures limited to western Alaska and Ellesmere Island (**Figure 9**).



**Figure 10.** Forecasted snow depth changes (mm/day; shading) from 22 – 26 December 2023. The forecast is from the 00Z 11 December 2023 GFS ensemble.

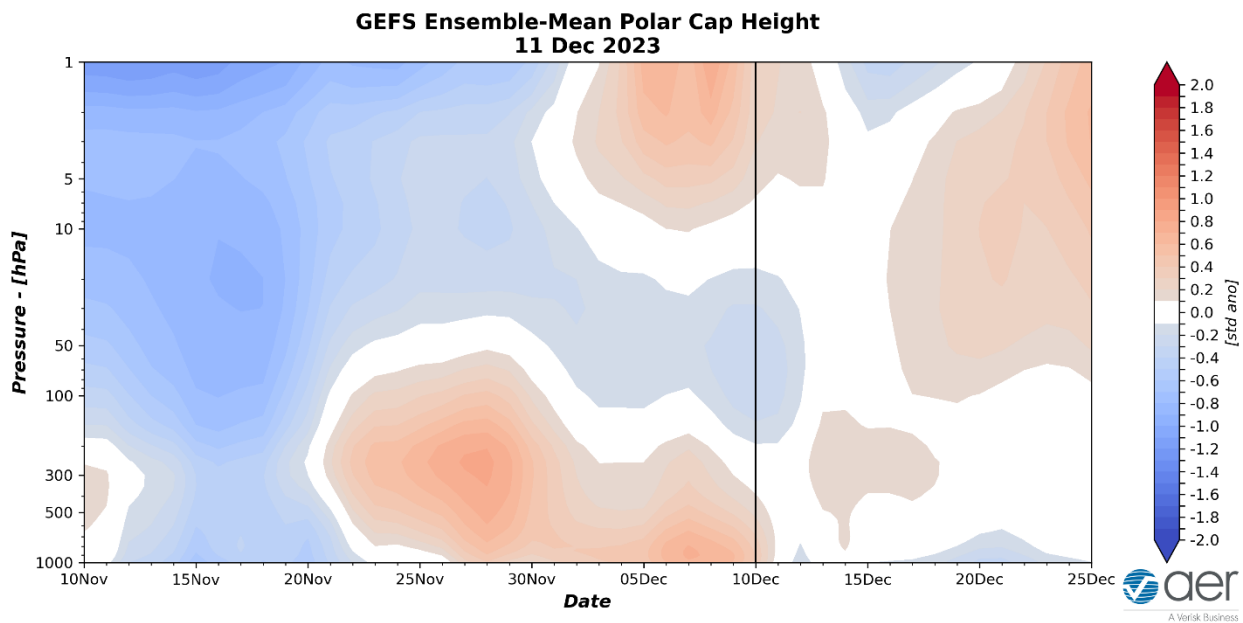
Troughing and/or cold temperatures will support new snowfall across Scandinavia, Siberia and Central Asia while mild temperatures will support snowmelt in Western Russia this period (**Figure 10**). Troughing and/or cold temperatures will support new snowfall across southern Alaska, Western and Northeastern Canada and the higher

elevations of the Western US. Mild temperatures will support snowmelt in Alaska this period (**Figure 10**).

## Longer Term

*30-day*

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs in the mid to lower stratosphere with warm/positive PCHs in the upper stratosphere (related to a Canadian warming) and the troposphere (**Figure 11**). However, next week PCHs are predicted to become increasingly warm/positive in the stratosphere and cold/negative in the lower troposphere (**Figure 11**). Overall, the PCHs forecast looks like a mess to me and I feel that it is a sign of high uncertainty in the model forecast.

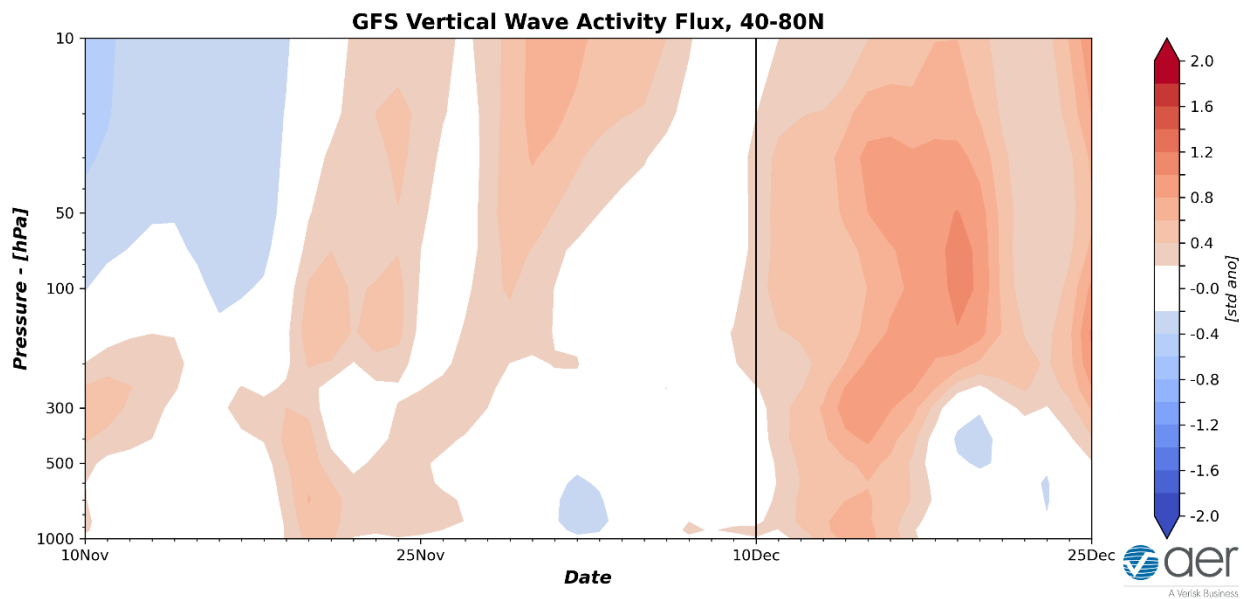


**Figure 11.** Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 11 December 2023 GFS ensemble.

The predicted neutral to cold/negative PCHs in the lower troposphere for the next two weeks (**Figure 11**) are consistent with the predicted positive to neutral surface AO the next two weeks (**Figure 1**).

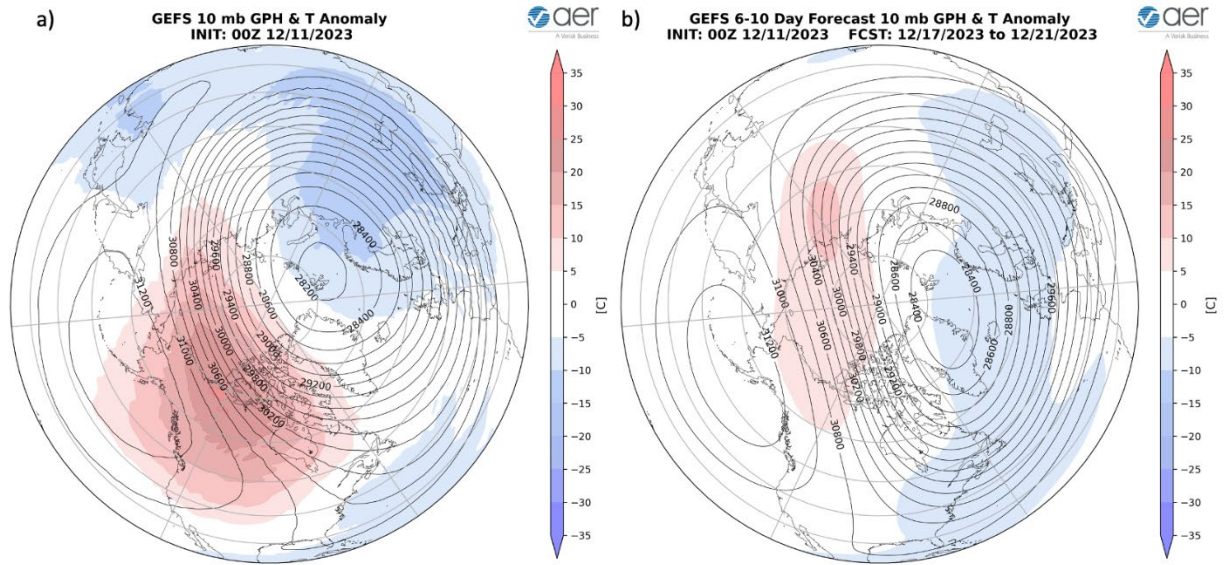
Also shown in **Figure 1** is the stratospheric AO. The stratospheric AO is currently near neutral and is predicted to dip negative the next two weeks. This is consistent with increasingly warm/positive stratospheric PCHs. The forecast of warming PCHs likely

signals an increasing likelihood of at least the beginnings of a sudden stratospheric warming in late December.



**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 11 December 2023 GFS ensemble.

Vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere has become more active since mid-November (**Figure 12**). This has resulted in the current Canadian warming (**Figure 12**) and the return of the stratospheric AO to neutral (**Figure 1**). Over the next two weeks the WAFz is predicted to become even more active (**Figure 12**), which should result in the short term a stretched PV in mid-December but then the commencement of a sudden stratospheric warming.

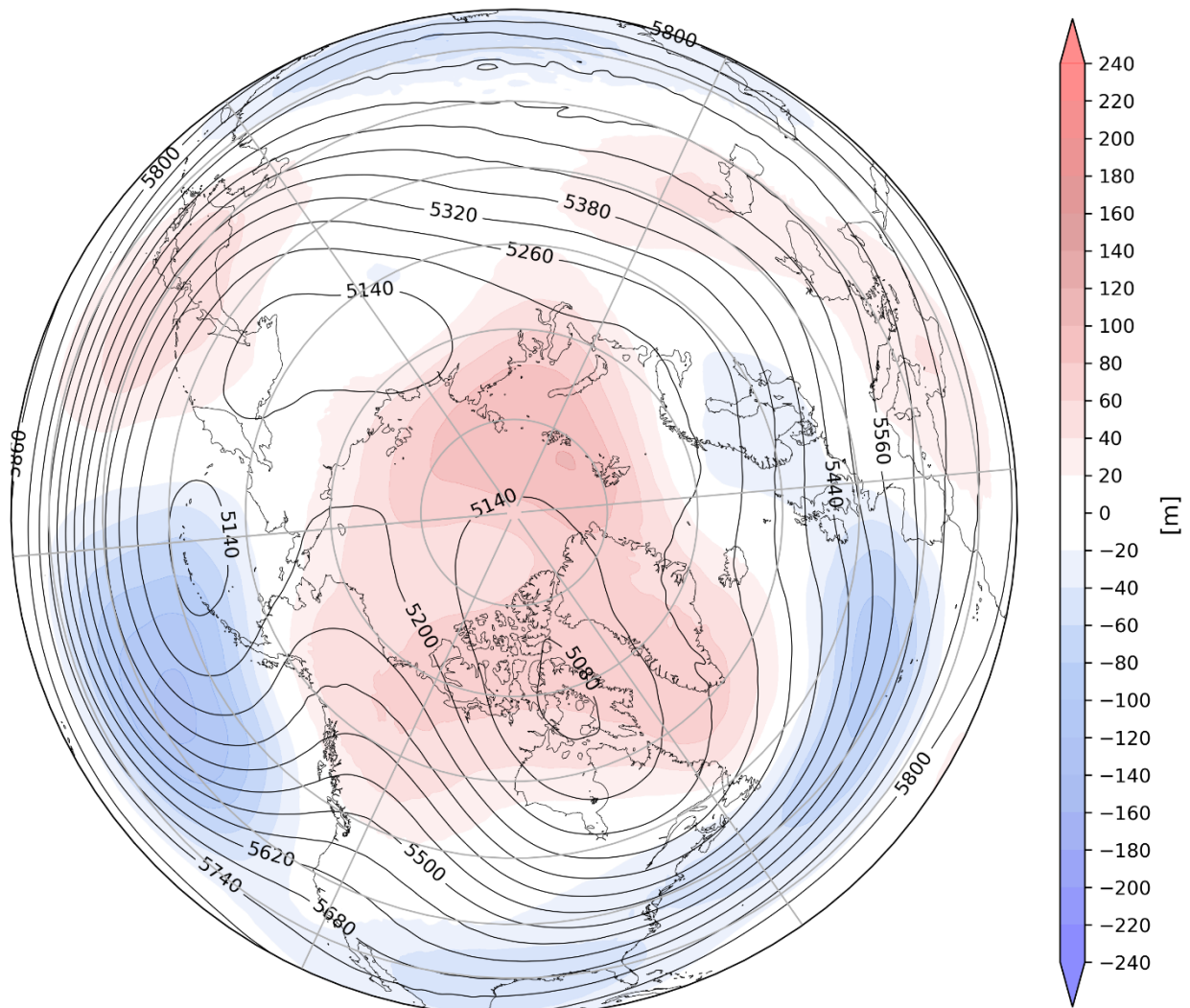


**Figure 13.** (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for 11 December 2023 . (b) Same as (a) except forecasted averaged from 17 – 21 December 2023. The forecasts are from the 00Z 11 December 2023 GFS model ensemble.

Currently the polar vortex (PV) is elongated in shape with the PV center shifted south of the North Pole in the direction of the Barents-Kara Seas (**Figure 13a**). This elongated PV configuration is predicted oriented along an axis from Siberia to Baffin Bay. Across North America a ridge is centered near Alaska with the strongest warming aimed at Northern Canada. This is characteristic of a Canadian warming that favors warm temperatures across North America but cold temperatures across northern Eurasia. Next week the PV center slides between Svalbard and Greenland with an elongated shape but now oriented from Siberia towards Hudson Bay characteristic of a stretched PV (**Figure 13b**). Induced northerly flow towards Baffin Bay and Greenland should result in colder temperatures spreading southeastward towards far eastern North America but miss much of Canada and the US.



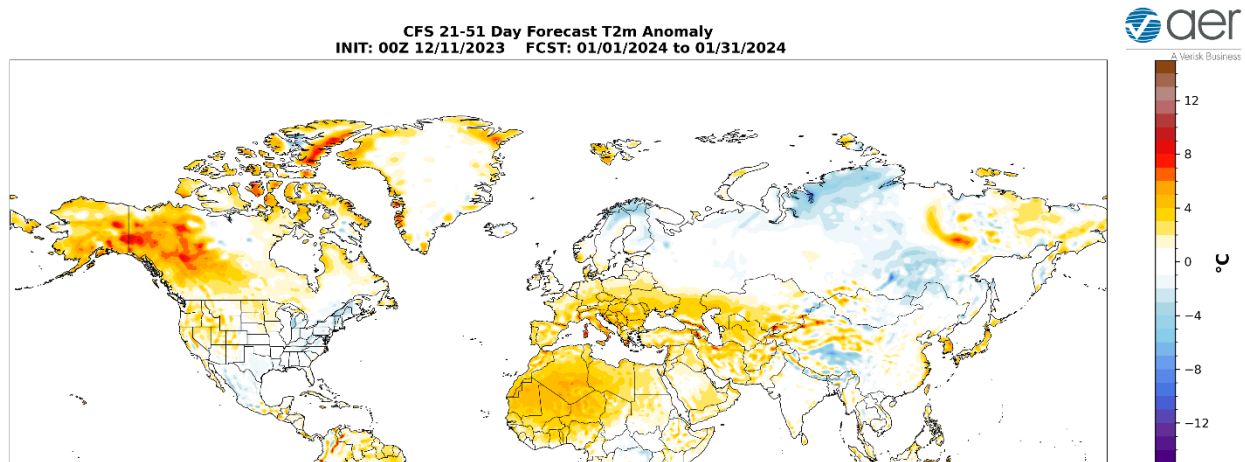
**CFS 500 hPa Forecast Anomaly Jan 2024  
Valid as of 11 Dec 2023**



**Figure 14.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for January 2024. The forecasts are from the 00Z 11 December 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for January (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging from Greenland into the Central Arctic, Eastern Siberia, Alaska, Western Canada and the Western US with troughing in Europe, Siberia, Northeast Asia, the Aleutians and eastern North America (**Figure 14**). This pattern is consistent with a negative AO following an SSW, even though the CFS is not actually predicting an SSW in January. Regardless this pattern favors seasonable to relatively warm temperatures across Southern Europe, Southern Asia, Eastern Siberia, Alaska,

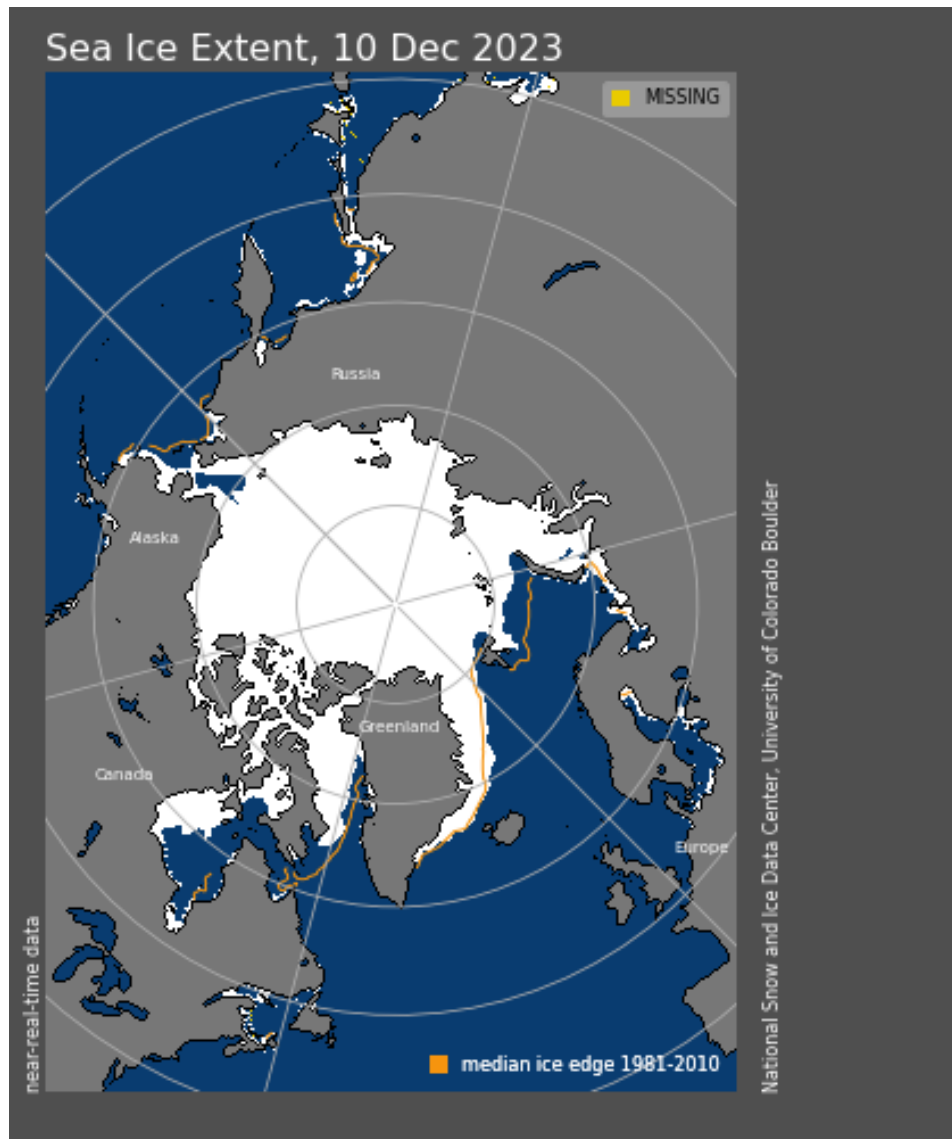
Western Canada and the Western US with seasonable to relatively cold temperatures across Northern Europe, Northern Asia including Siberia, Northeast Asia, Eastern Canada and the Eastern US (**Figure 15**).



**Figure 15.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for January 2024. The forecasts are from the 00Z 11 December 2023 CFS.

#### *Arctic sea ice extent*

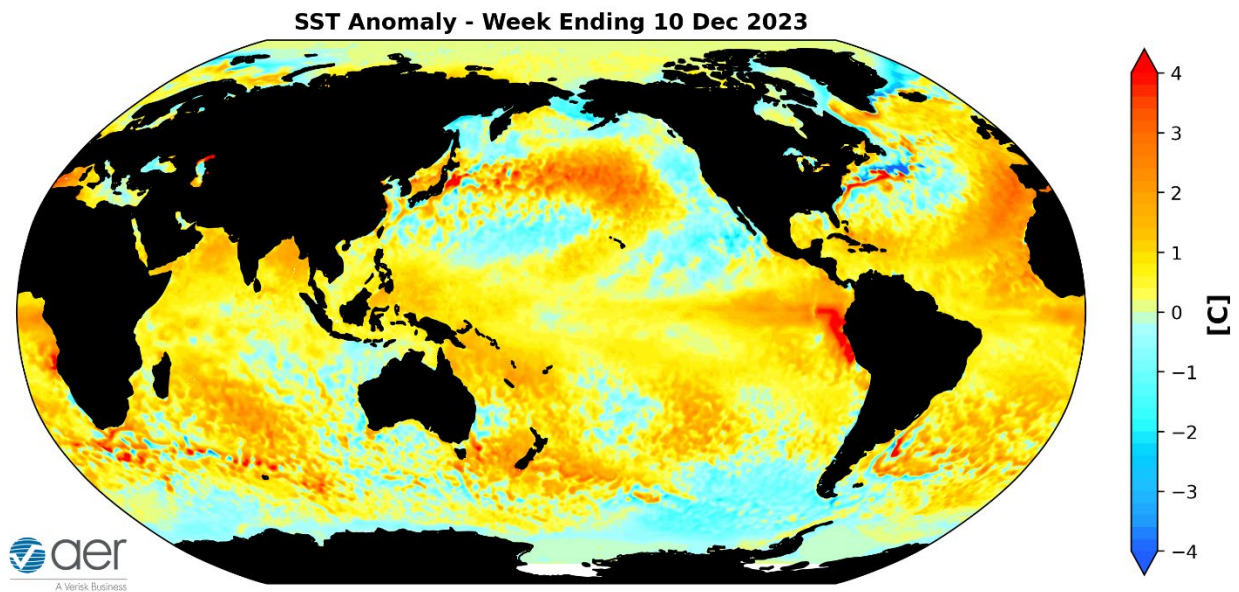
Arctic sea ice extent returned to growing but only slowly this week. I continue to expect that the negative sea ice anomalies will become more focused in the North Atlantic sector, and that is looking more likely. Blocking in the Barents-Kara sea region is critical from keeping a runaway PV that will squash any widespread and meaningful cold in Northern Eurasia and eastern North America for weeks and possibly even months to come. Outside the Arctic the sea ice is well below normal in Hudson bay and could be contributing to above normal temperatures in Eastern Canada.



**Figure 16.** Observed Arctic sea ice extent on 04 December 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).

### *SSTs/El Niño/Southern Oscillation*

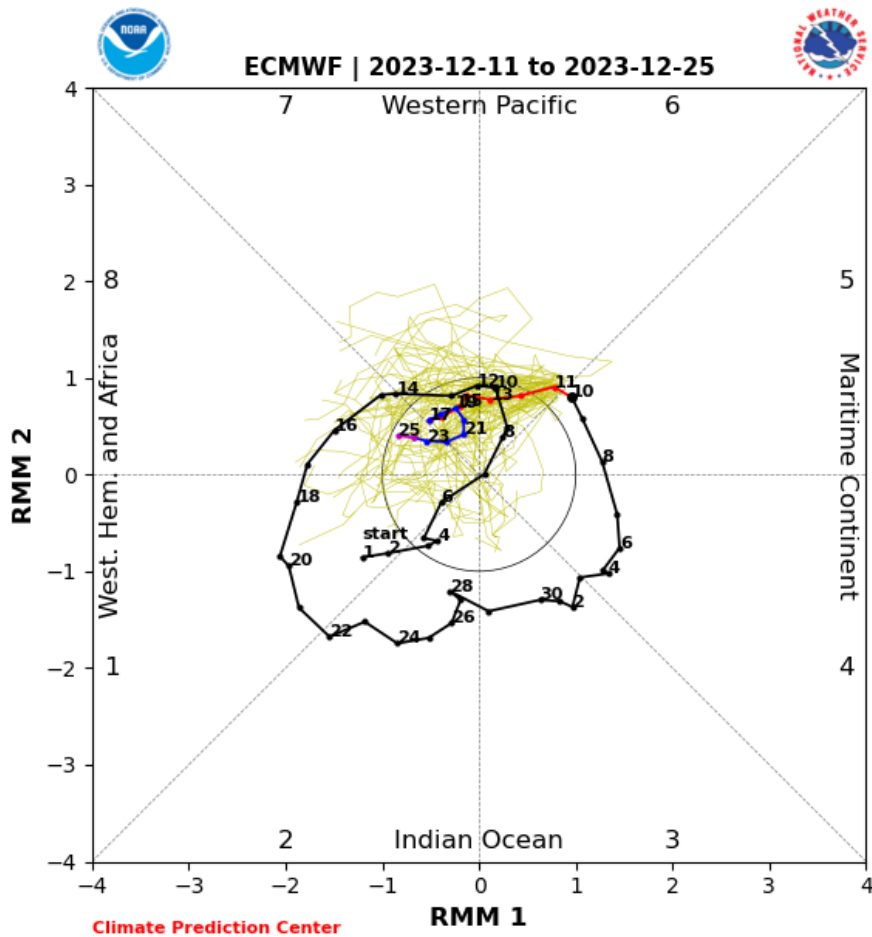
Equatorial Pacific sea surface temperatures (SSTs) anomalies are well above normal, especially along the South America coast, indicating that an El Niño is pretty much a sure thing (**Figure 17**) and El Niño conditions are expected through the winter. Observed SSTs across the NH remain well above normal 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 17.** The latest weekly-mean global SST anomalies (ending 10 December 2023).  
Data from NOAA OI High-Resolution dataset.

### *Madden Julian Oscillation*

Currently the Madden Julian Oscillation (MJO) is in phase six (**Figure 1**). The forecasts are for the MJO to weaken where no phase is favored. Phase six favors troughing near the Aleutians and ridging in the Eastern US. Therefore it seems that the MJO could be having some limited influence on North American weather next week. But admittedly this is outside of my expertise.



**Figure 18.** Past and forecast values of the MJO index. Forecast values from the 00Z 11 December 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](https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml)

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solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

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