

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

January 8, 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

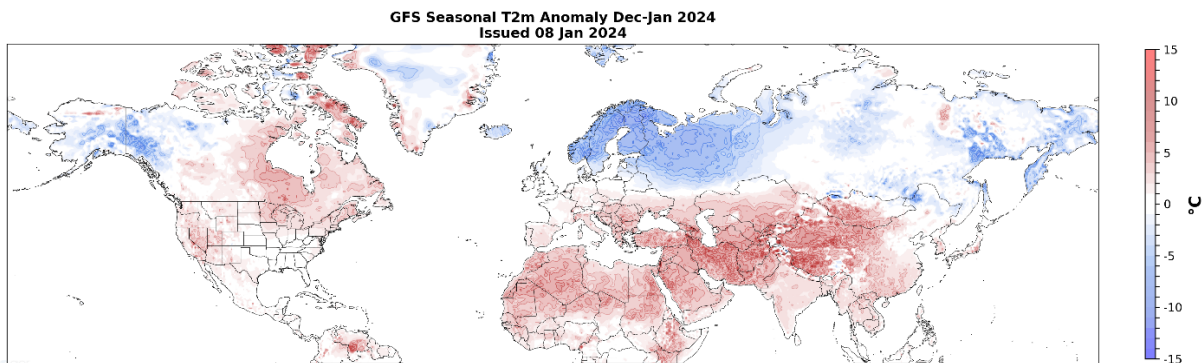
- The Arctic Oscillation (AO) is currently negative and is predicted to become increasingly negative the next week and reverse back towards neutral as pressure/geopotential height anomalies across the Arctic are currently mostly positive and are predicted to remain mostly positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently strongly negative with positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to remain negative the next two weeks as pressure/geopotential height anomalies remain positive across Greenland.
- The next two weeks, ridging/positive geopotential height anomalies across Greenland will force deepening troughing/negative geopotential height anomalies across much of Europe. This pattern will support a classic -NAO temperature pattern the next two weeks with normal to below normal temperatures across Northern and Central Europe including the United Kingdom (UK) with normal to above normal temperatures across Southern Europe.

- The next two weeks, strengthening ridging/positive geopotential height anomalies across Greenland will force troughing/negative geopotential height anomalies across Northern Asia with ridging/positive geopotential height anomalies across Central and Southern Asia. This pattern generally favors widespread normal to above normal temperatures across Southern and Central Asia with normal to below normal temperatures across Northern Asia the next two weeks.
- The general predicted pattern across North America the next two weeks is strengthening ridging/positive geopotential height anomalies across Greenland and Alaska forcing deepening troughing/negative geopotential height anomalies across the interior of North America especially Western Canada and the United States (US). This pattern favors widespread normal to above normal temperatures stretching from Alaska across Northern Canada and across Baffin Bay with normal to below normal temperatures this week across Western Canada and the Western United States (US) spreading south and east next week across the US.
- in the Impacts section I discuss the ongoing complex polar vortex (PV) disruptions in rapid succession and the impact on Northern Hemisphere (NH) weather.

## Plain Language Summary

Colder weather is on the move across the Hemisphere (NH) continents. Potentially relatively very cold temperatures can occur in both Northern Europe and the US east of the Rockies (see **Figure 6**). A relatively minor perturbation of the polar vortex (PV) where it stretches out like a rubber is bringing colder temperatures to Western Canada and the Western US that will move east with time (see **Figure 9**).

So far this winter any cold temperatures have been found in Northern Europe and Northern Asia with North America being quite mild with the exception of Alaska (see **Figure**). Cold is likely to persist across Northern Europe and Northern Asia but mild temperatures in the US and Canada could begin to reverse.



**Figure.** Estimate of the observed surface temperatures ( $^{\circ}\text{C}$ ; shading) from 1 December 2023 – 23 January 2024 based on GFS initializations and the GFS forecast from the 2 January 2024 forecast.

## Impacts

As I discussed last week, though there may yet be two distinct polar vortex (PV) centers, not once but twice over the next two weeks, this is not a classical PV split. Instead, at least for now, I think best to think of the event as a more extreme stretched PV. Something similar happened in early February 2014 and

maybe again in January 2015 and I am sure other times that I am just not aware of. In recent winters we have observed stretched PVs when the PV is relatively strong including much of winters 2021/22 and 2022/23. It is my impression that the tropospheric response can be large to any stretched PV (e.g., record cold, record snowstorms), but its duration is relatively short, on the order of days. But there are some recent examples of stretched PVs occurring when the PV is relatively weak such as in late December 2017 and a most extreme example February 2021. During this current stretched PV, the PV is relatively weak and therefore the impact on the weather can be longer, up to two weeks or so. Looking at the temperature forecasts across North America over the next two weeks, cold temperatures are predicted to dominate.

But what comes next? Certainly, the models are suggesting a generally milder pattern across the Northern Hemisphere (NH) by the last week of January. But I really think that the situation is complicated and is likely giving the models fits. First, we have impressive high-latitude blocking predicted for next week and the models have a tendency to lose the high blocking prematurely. But also, the ongoing PV disruption is complicated and the models seem to be playing catch up with the evolution. Looking at the polar cap geopotential height anomalies (PCHs) in **Figure 11**, you can see the pulsing red of the PCHs in the upper stratosphere last week that the models initially predicted could be a major warming and a full PV split with a strengthening PV thereafter. But now the models are predicting a double dip warming (by dip I mean drop in the zonal mean zonal winds at 60°N and 10hpa). This second dip is the second pulsing of the red PCHs in the mid-stratosphere over the weekend. That is now predicted to weaken the zonal mean zonal winds at 60°N and 10hpa even more than the initial warming. There is still an outside chance of a major warming still (based on the latest ECMWF forecasts it is more than an outside chance) and FWIW our PV strength model says the best chance is on January 23, but the signal is not that strong.

We have only been producing the PCHs up to 1 hpa for three winters now, so not very long, but this staircase down of SSW type disruptions seems common. There can yet be another staircase down of red pulsing PCHs in the troposphere, which would likely accompany extreme weather at least regionally in the NH. This is a possibility I discussed last week but as of yet not predicted by the GFS at least. This doesn't always happen, it happened in February 2021 but not in February 2023. So, I do think that we still need to sort out what will be the full impact on our weather of the SSW/stretched PV predicted for next week.

I did tweet out that the mid-tropospheric pattern of ridging in Siberia coupled with troughing in Scandinavia is supportive of PV strengthening. The models are still predicting that pattern and not surprisingly in general are predicting a stronger PV and cold/negative PCHs are predicted to return to the upper stratosphere the end of the third week of January. But it is what is occurring in the mid and especially lower stratosphere that has the greatest impact on our weather. No sign yet of a reversal of PCHs in those regions of the atmosphere, so we have time.

So here is my best guess. We have Arctic outbreaks to the US and Europe that probably peaks next week but maybe into the next week the further east and west you go respectively. Then I expect a relaxation of the pattern in both regions. The cold in Europe is from the Greenland blocking and the cold in the US is from the stretched PV. The time scale for a stretched PV is up to two weeks and for high latitude blocking up to three weeks, so the cold in the US may end sooner. But of course, there are many caveats.

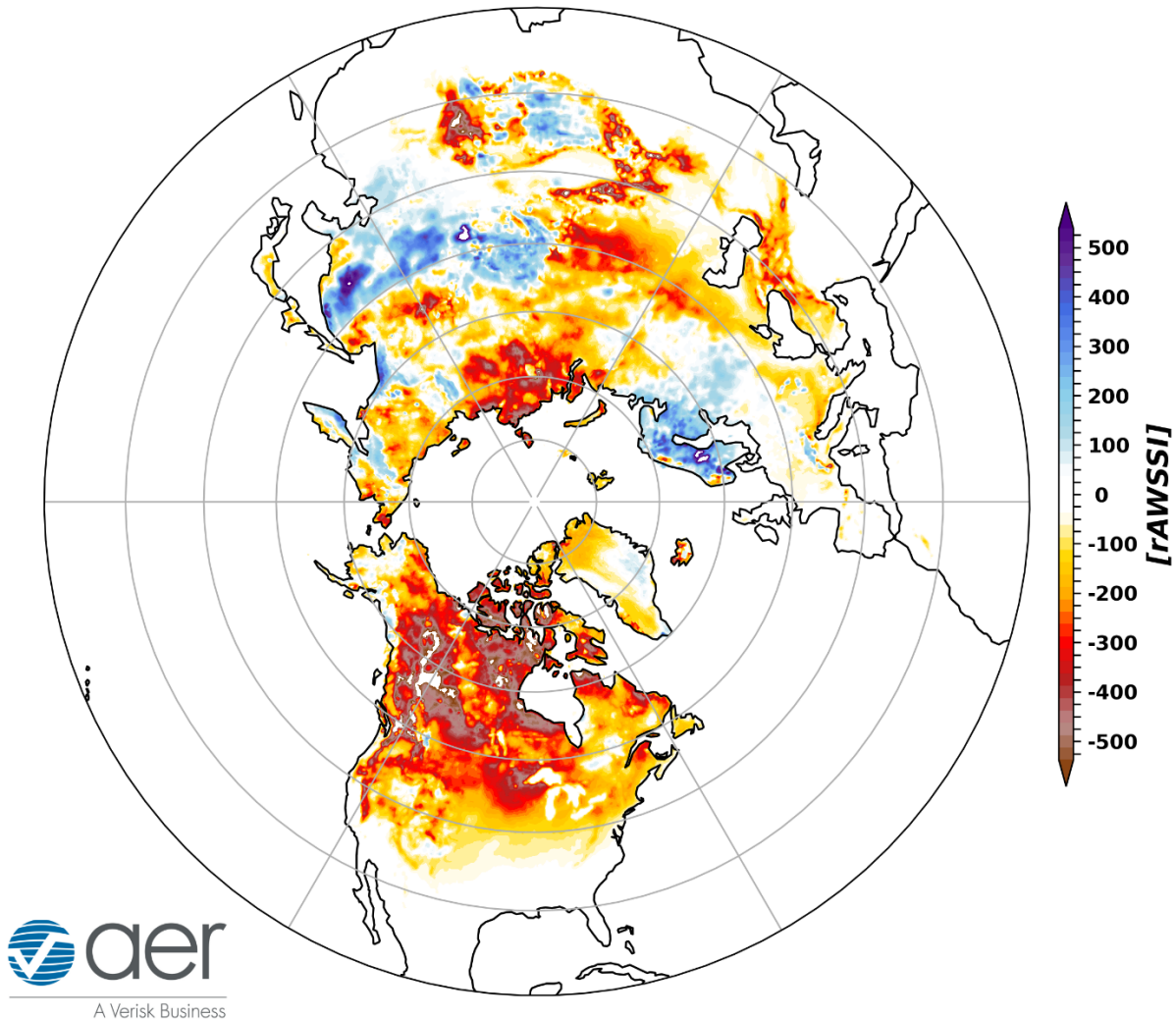
After that I really don't see signs of another SSW and assuming a strengthening PV, the more likely PV disruption is a stretched PV. For now, at least the models are not predicting that the Siberian ridge will be a long-lasting feature, so I think there is a good chance of more PV stretching either in late January or early February. So, when the pattern turns milder in the US and Europe, I think that it could be more of a complete breakdown of the cold pattern in Europe (except for Scandinavia of course) but possibly only a relaxation of the pattern in the US. But I do want to emphasize that I think visibility into the evolving pattern is poor or the confidence in any particular forecast is low.

Finally, I am excited to introduce a new dataset that we are creating, or probably more accurately a new dataset that we are expanding. In [Cohen et al. \(2018\)](#) we used the Accumulated Weather Seasonal Severity Index (AWSSI) created by [Mayes-Bousted et al. \(2015\)](#) to analyze against Arctic temperatures. The original dataset uses station data and is limited to the US. So, we have created a reanalysis version of the index, and it is global in extent. We have chosen to use the ERA5 reanalysis ([Copernicus ERA5 data library](#)), generally considered the best reanalysis dataset currently. I have a manuscript in preparation that I am hoping to submit shortly for review to be accompanied by a dataset going back to 1950.

As a teaser of the dataset I include in **Figure i** the AWSSI anomaly so far for winter 2023/24 (November and December). If you are a winter weather lover, it is not a pretty sight and also not very surprising. Negative anomalies dominate the Northern Hemisphere, and they are ubiquitous across North America (this must be a rare feat). Negative anomalies dominate Eurasia as well with Scandinavia and Northeast China the most notable exceptions. But we can also break out the index into temperature and snow contributions separately to the winter severity. I am not including it today but may show it a later date. Now that the dataset has been transferred to reanalysis, we can also use the dataset to make forecasts to get the full impact of the winter weather (snow and cold) for society, hopefully as soon as next fall for winter 2024/25.



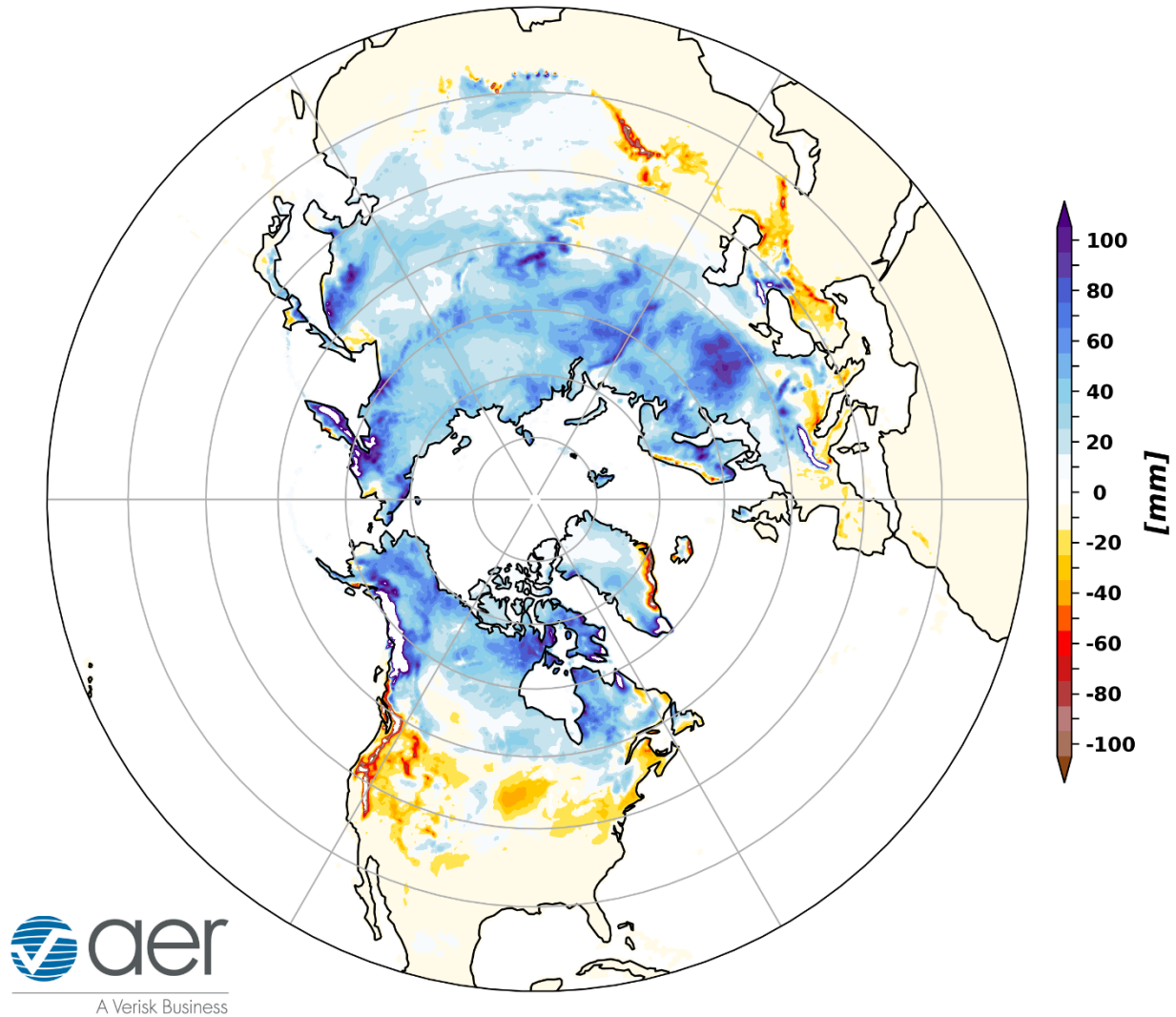
## ERA5 Cumulative rAWSSI Total Anomaly Nov-Dec 2023



**Figure i.** A new reanalysis based AWSSI index (rAWSSI) anomaly averaged over the months of November and December 2023 for the entire Northern Hemisphere. Climatology is based on 1980 through 2023.

I have been also sharing the snowfall seasonal anomaly updated in **Figure ii**. It can be generally characterized as above normal snowfall north of 50°N and below normal south of 50°N. One notable exception is Northeast China. This pattern of a transfer of snowfall from lower to higher latitudes during winter is consistent with climate change model projections. Once again it is my hope that we can produce a winter snowfall anomaly forecast for the entire Northern Hemisphere next fall.

## ERA5 Cumulative Snowfall Anomaly Nov-Dec 2023

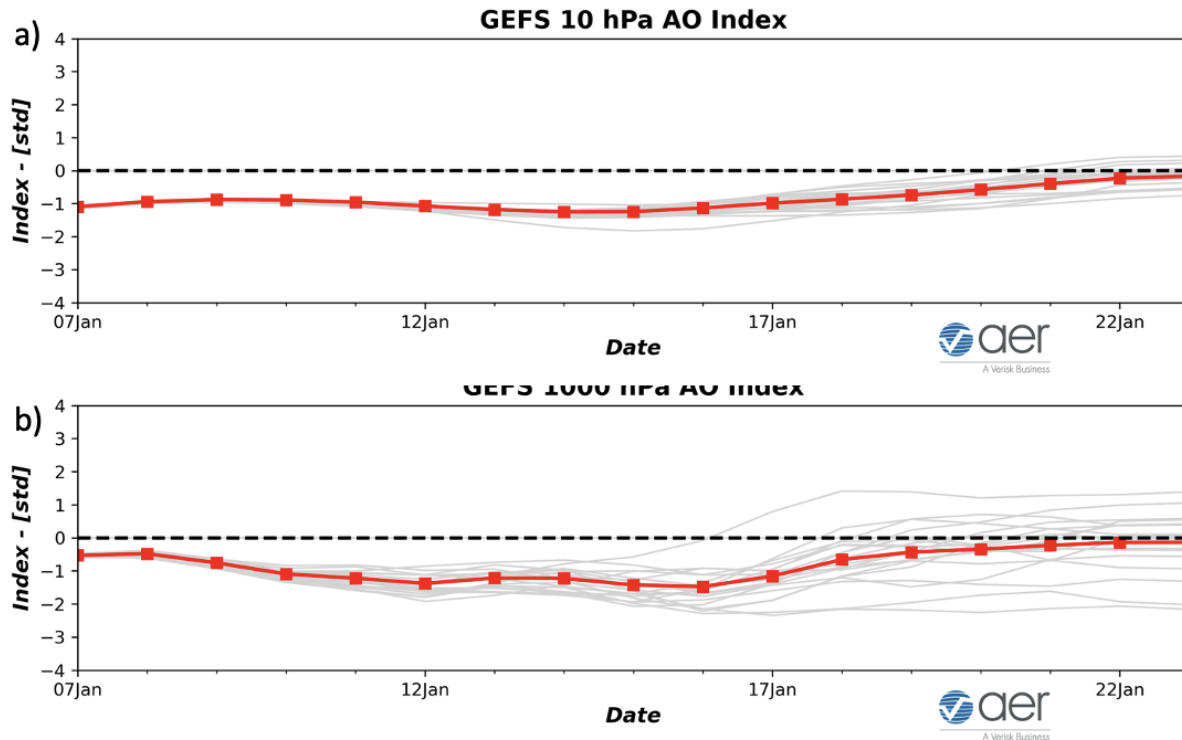


**Figure ii.** Chart shows snowfall anomaly for the months of November and December 2023.

### Near-Term

#### *This week*

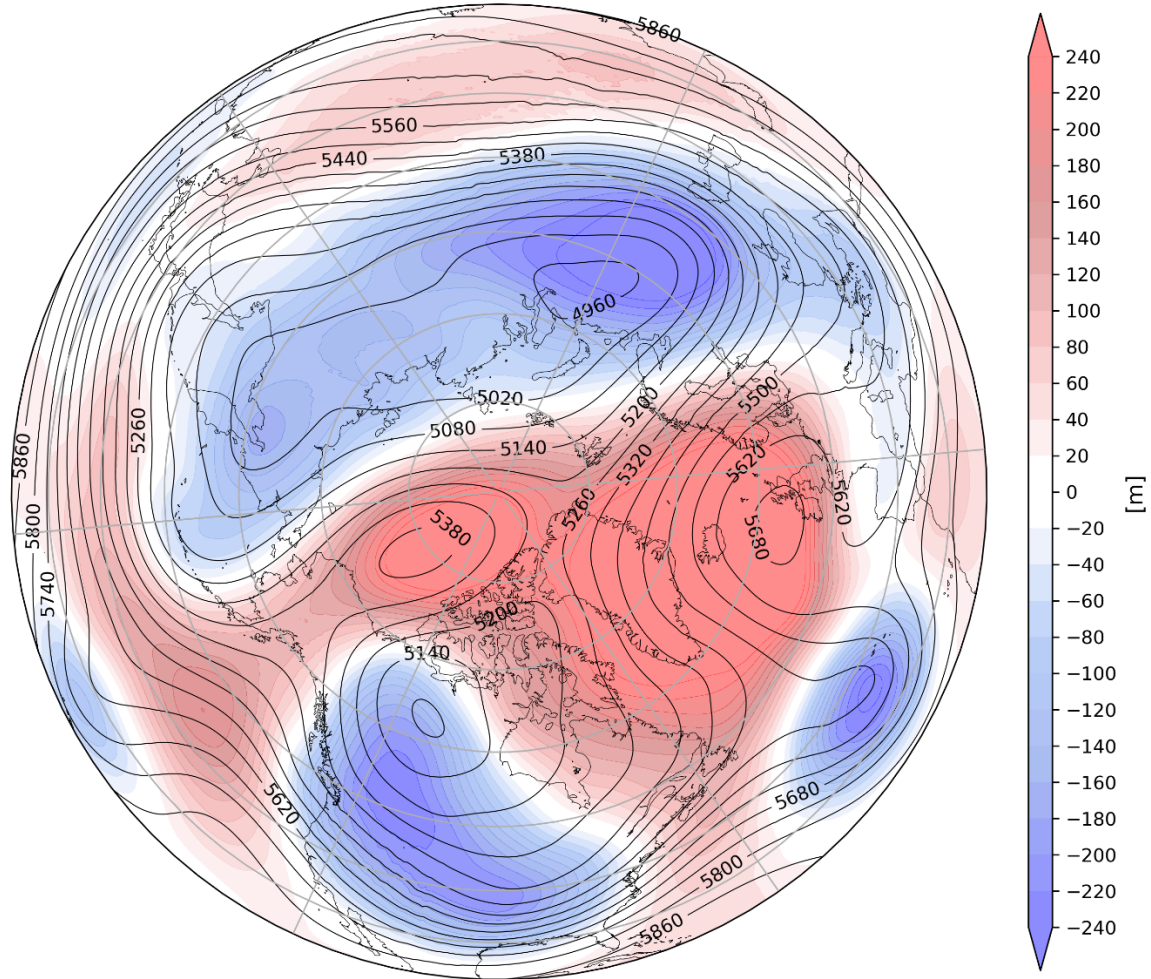
The AO is predicted to be negative this week (**Figure 1**) with mostly positive geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With predicted strongly positive geopotential height anomalies across Greenland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



**Figure 1.** (a) The predicted daily-mean AO at 1000 hPa from the 00Z 8 January 2024 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 8 January 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.

Strengthening ridging/positive geopotential height anomalies centered near Iceland will force deepening troughing/negative geopotential height anomalies across Northern and Eastern Europe with some residual ridging/positive geopotential height anomalies across Southern and Western Europe this week (**Figure 2**). The pattern favors widespread normal to below normal temperatures across much of Europe including the UK with normal to above normal temperatures limited to parts of Scandinavia (**Figure 3**). Predicted strengthening ridging/positive geopotential height anomalies centered near Iceland will force deepening troughing/negative geopotential height anomalies across Northern Asia with more ridging/positive geopotential height anomalies across Southern Asia this period (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Southern and Central Asia with normal to below normal temperatures across Northern Asia (**Figure 3**).

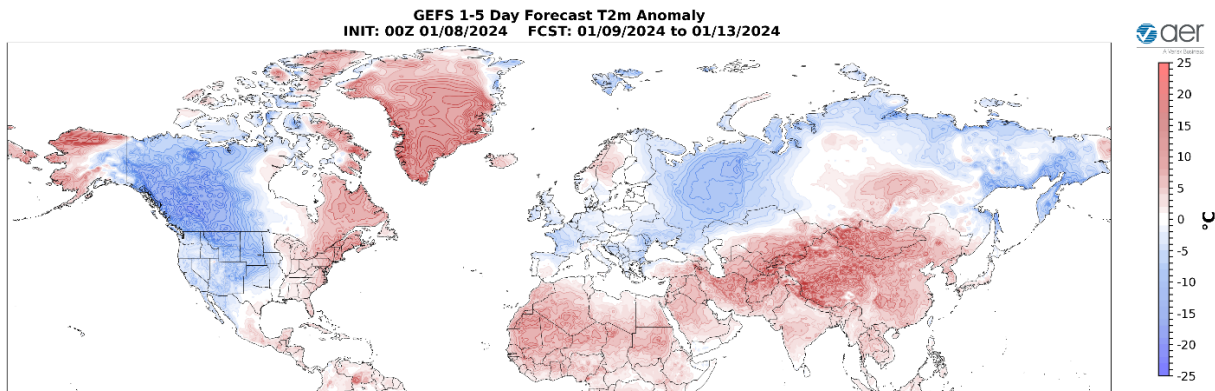
**GEFS 1-5 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 01/08/2024 FCST: 01/09/2024 to 01/13/2024**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 January 2024. The forecasts are from the 00z 8 January 2024 GFS ensemble.

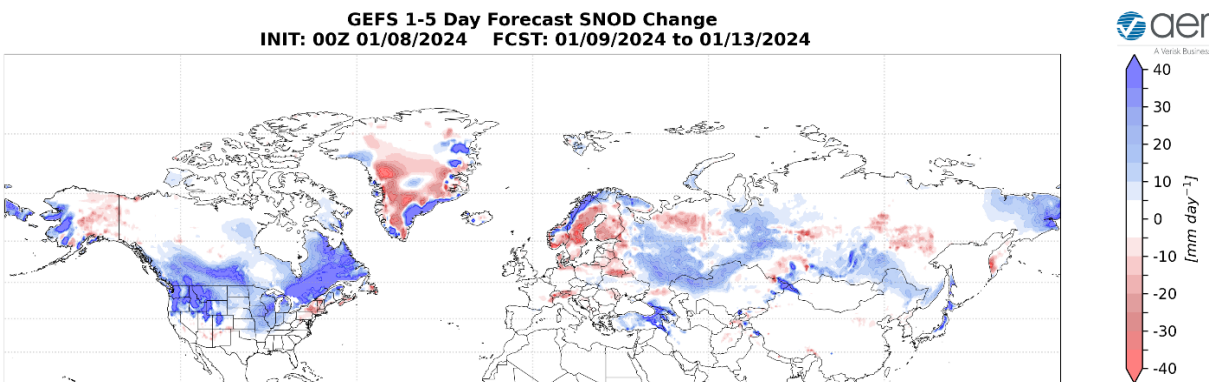
The pattern this week across North America is ridging/positive geopotential height anomalies across the Greenland, Beaufort Sea and the Gulf of Alaska forcing troughing/negative geopotential height anomalies across Western Canada and the Western US with more ridging/positive geopotential height anomalies along the US East Coast (**Figure 2**). This pattern will favor normal to above normal temperatures across Alaska, Eastern Canada and the Eastern US with normal to below normal temperatures across Western Canada and the Western US (**Figure 3**).





**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 9 – 13 January 2024. The forecast is from the 00Z 8 January 2024 GFS ensemble.

Trouging and/or cold temperatures will support new snowfall across Norway, Turkey and Northern Asia while mild temperatures will support snowmelt across Sweden, Finland, the Baltic States, Northwestern Russia and Southeastern Siberia this week (**Figure 4**). Trouging and/or cold temperatures will support new snowfall across western Alaska, Southwestern and Eastern Canada, the high elevations of the Western US and the US and Great Lakes while mild temperatures will support snowmelt across eastern Alaska and the Northeastern US this week (**Figure 4**).



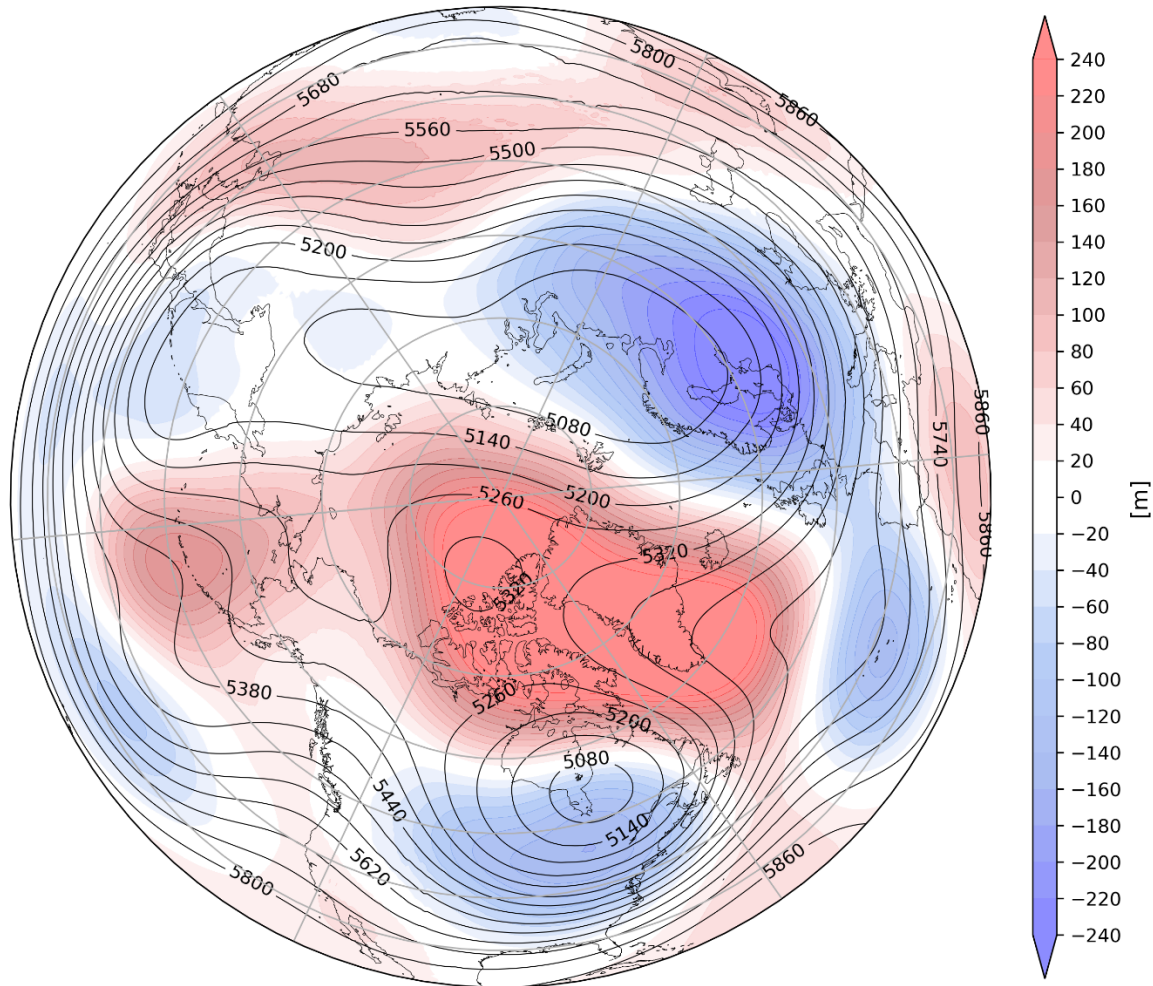
**Figure 4.** Forecasted snow depth changes (mm/day; shading) from 9 – 13 January 2024. The forecast is from the 00Z 8 January 2024 GFS ensemble.

## Near-Mid Term

### Next week

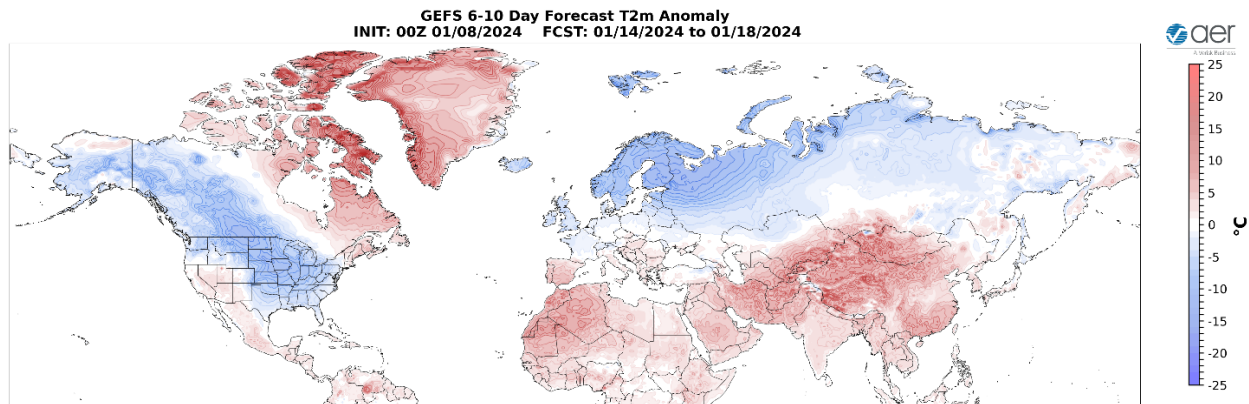
With mostly positive geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should remain negative this period (**Figure 1**). With predicted persistent positive pressure/geopotential height anomalies across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

**GEFS 6-10 Day Forecast 500 hPa Anomaly**  
**INIT: 00Z 01/08/2024 FCST: 01/14/2024 to 01/18/2024**



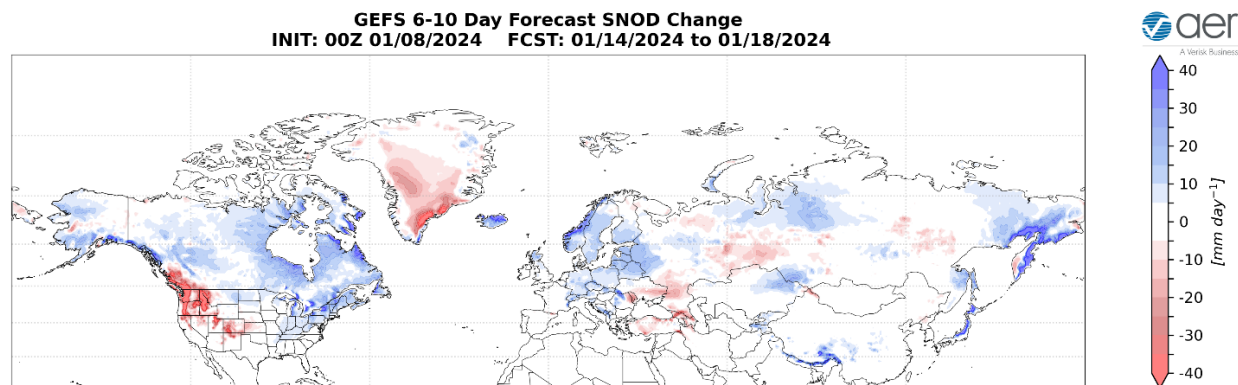
**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 January 2024. The forecasts are from the 00z 8 January 2024 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered near Greenland will continue to support troughing/negative geopotential height anomalies across much of Europe this period (**Figure 5**). This pattern will favor widespread normal to below normal temperatures across most of Europe including the UK with normal to above normal temperatures limited to Southern Europe along the Mediterranean (**Figures 6**). Ridging/positive geopotential height anomalies will persist across Greenland will anchor troughing/negative geopotential height anomalies across Northern Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Southern and Central Asia with normal to below normal temperatures across Northern Asia including much of Siberia this period (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 14 – 18 January 2024. The forecasts are from the 00z 8 January 2024 GFS ensemble.

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



**Figure 7.** Forecasted snow depth changes ( $\text{mm}/\text{day}$ ; shading) from 14 – 18 January 2024. The forecast is from the 00Z 8 January 2024 GFS ensemble.

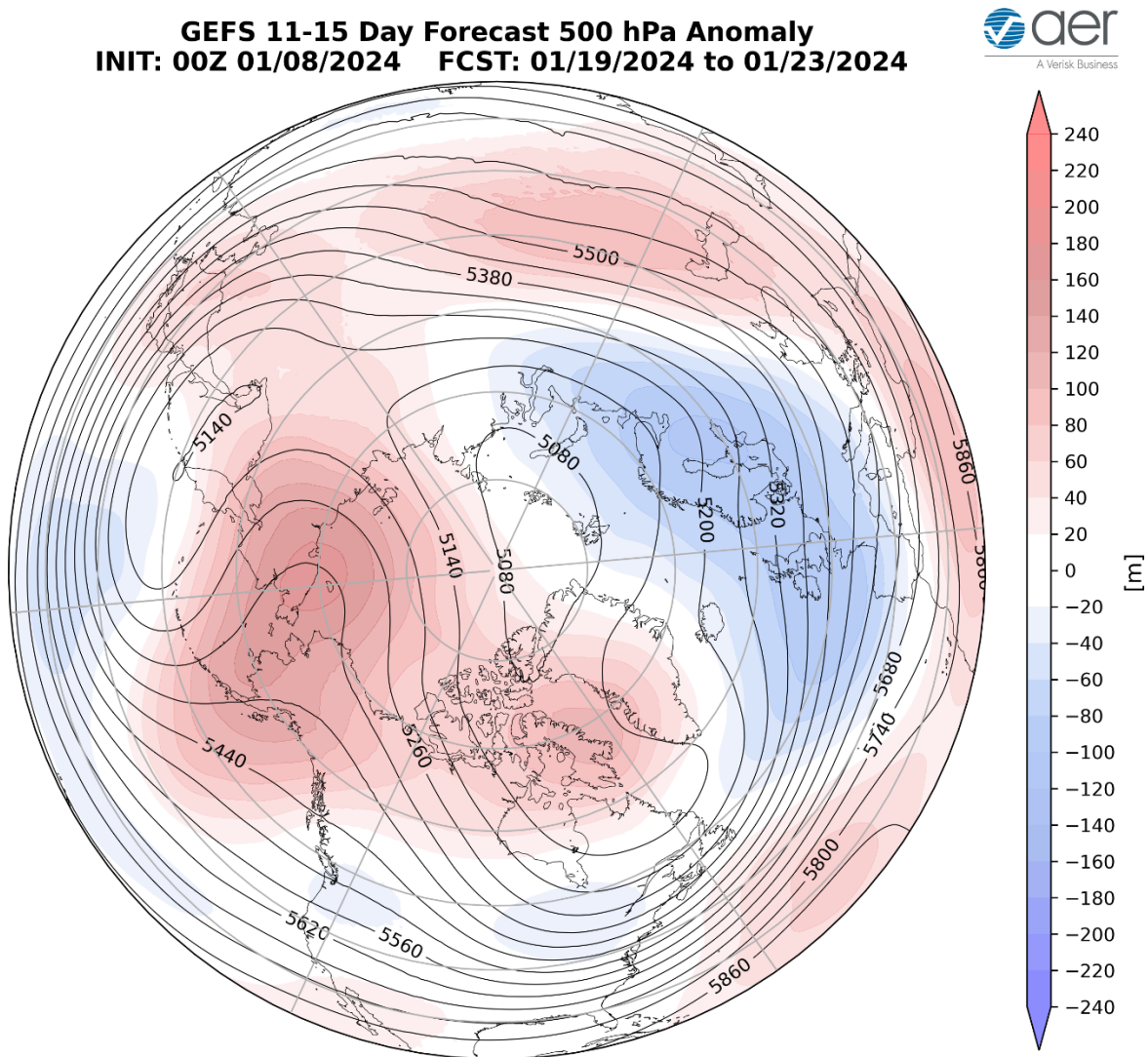
Troughing and/or cold temperatures will support new snowfall across the Scotland, Norway, Northern and Eastern Europe, the Tibetan Plateau, Siberia and Northeast Asia while mild temperatures will support snowmelt in Southeastern Europe and Southern Siberia this period (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across parts of Alaska, much of Canada, from the Ohio valley into New England while mild temperatures will support snowmelt in the higher elevations of the Western US this period (**Figure 7**).



# Mid Term

## Week Two

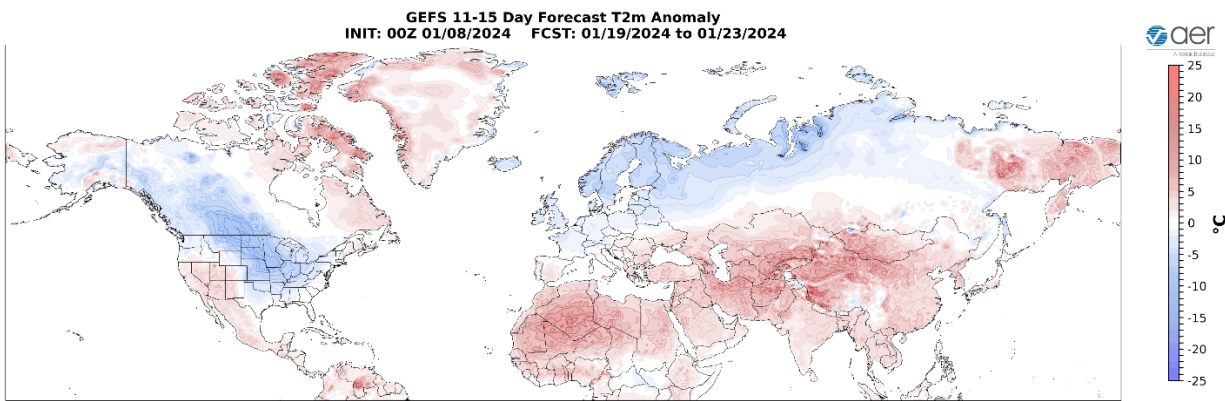
With persistent but weakening positive geopotential height anomalies across the Arctic especially Greenland and mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO remain will likely remain negative to neutral this period (**Figure 1**). With predicted persistent but weakening positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO should remain negative to possibly neutral this period.



**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 19 – 23 January 2024. The forecasts are from the 00z 8 January 2024 GFS ensemble.

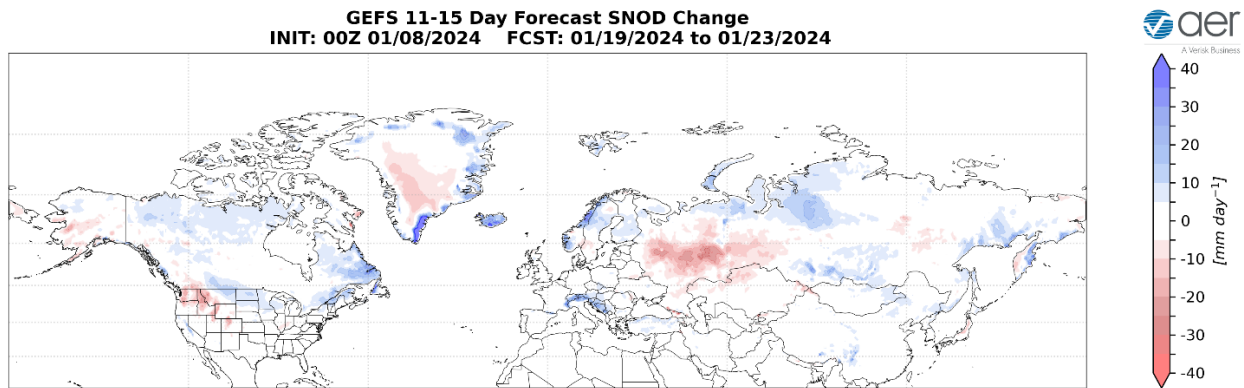


Predicted persistent ridging/positive geopotential height anomalies across Greenland should continue to support troughing/negative geopotential height anomalies across Europe this period (**Figure 8**). This pattern should favor normal to below normal temperatures widespread across most of Europe including the UK with the exception of normal to above normal temperatures across the Iberian Peninsula, Southeastern Europe and along the Mediterranean this period (**Figures 9**). With ridging/positive geopotential height anomalies persisting across the North American Arctic, and now drifting into Eastern Siberia, will help to anchor troughing/negative geopotential height anomalies across Northern Asia with more ridging/positive geopotential height anomalies across Southern and Central Asia and Eastern Siberia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures widespread across Southern and Central and Eastern Siberia Asia with normal to below normal temperatures across Northern and Western Asia this period (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 19 – 23 January 2024. The forecasts are from the 00z 8 January 2024 GFS ensemble.

Persistent ridging/positive geopotential height anomalies Alaska, near the Aleutians and in Baffin Bay will anchor troughing/negative geopotential height anomalies in eastern North America with more ridging/positive geopotential height anomalies across the Southwestern US this period (**Figure 8**). This pattern favors normal to below normal temperatures across Southern Alaska, Western and Southern Canada and the Northern and Eastern US with normal to above normal temperatures across Northern Alaska, Northeastern Canada and the Southwestern US (**Figure 9**).



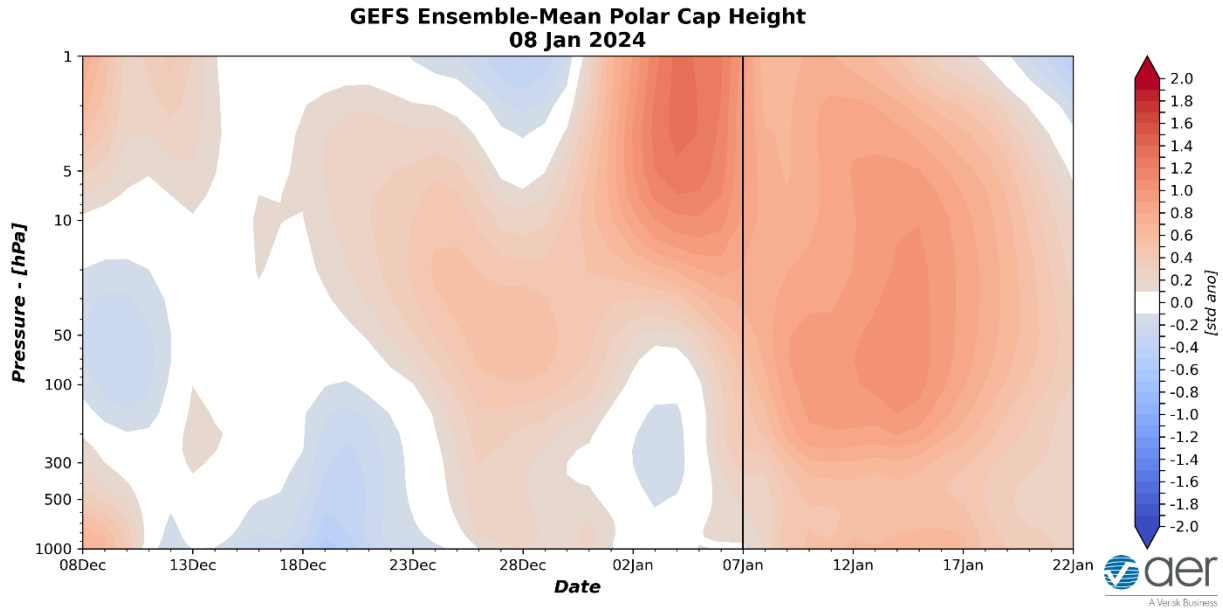
**Figure 10.** Forecasted snow depth changes (mm/day; shading) from 19 – 23 January 2024. The forecast is from the 00Z 8 January 2024 GFS ensemble.

Trouthing and/or cold temperatures will support new snowfall across Norway, the Alps, and Northern Asia while mild temperatures will support snowmelt in Western Russia this period (**Figure 10**). Trouthing and/or cold temperatures will support new snowfall across Northern and Eastern Canada and the Northern US. Mild temperatures will support snowmelt in and the higher elevations of the Western US this period (**Figure 10**).

## Longer Term

### *30-day*

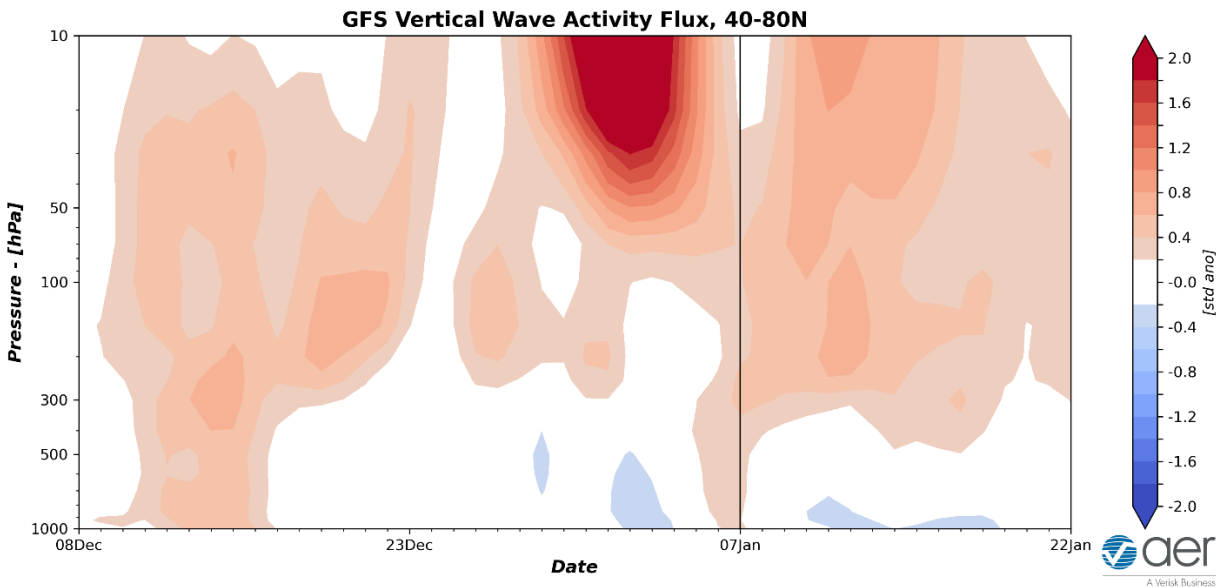
The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive PCHs throughout the stratosphere and the troposphere (**Figure 11**). However, next week PCHs in the mid-stratosphere are predicted to become increasingly warm/positive as the downward influence associated with a sudden stratospheric warming that began in the upper stratosphere migrates into the mid-stratosphere and eventually into the troposphere (**Figure 11**).



**Figure 11.** Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 8 January 2024 GFS ensemble.

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

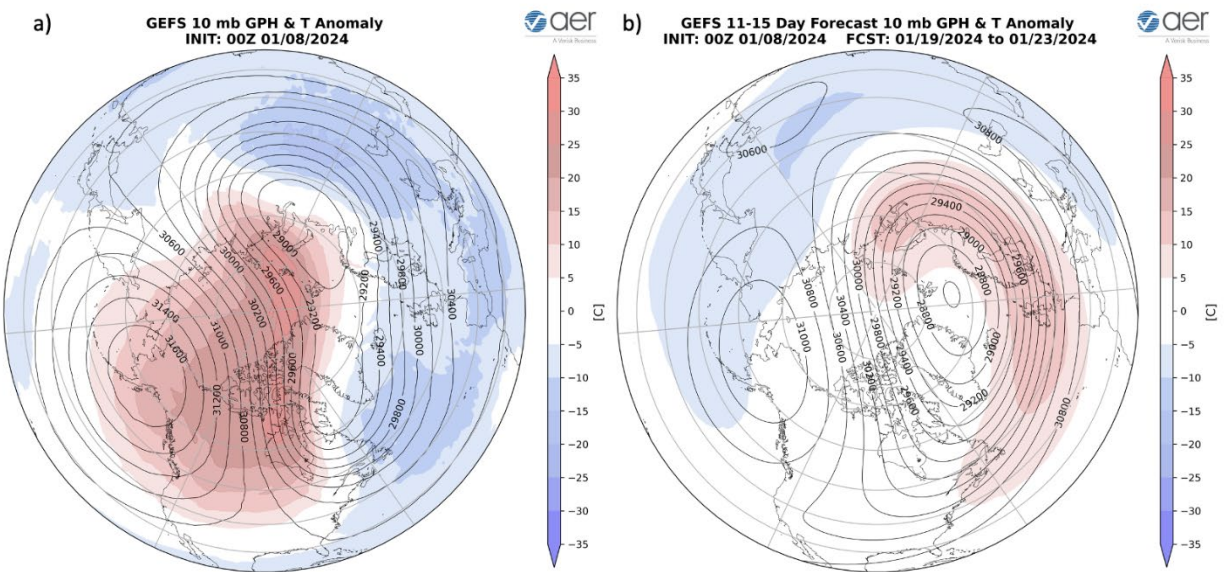
The predicted warm/positive PCHs in the lower troposphere for the next two weeks (**Figure 11**) are consistent with the predicted mostly negative surface AO the next two weeks (**Figure 1**).



**Figure 12.** Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 8 January 2024 GFS ensemble.

Also shown in **Figure 1** is the stratospheric AO. The stratospheric AO is currently negative and is predicted to dip further negative next week before trending towards neutral. This is consistent with increasingly warm/positive stratospheric PCHs. The forecast of warming PCHs likely signals an increasing likelihood of a sudden stratospheric warming albeit minor in mid-January.

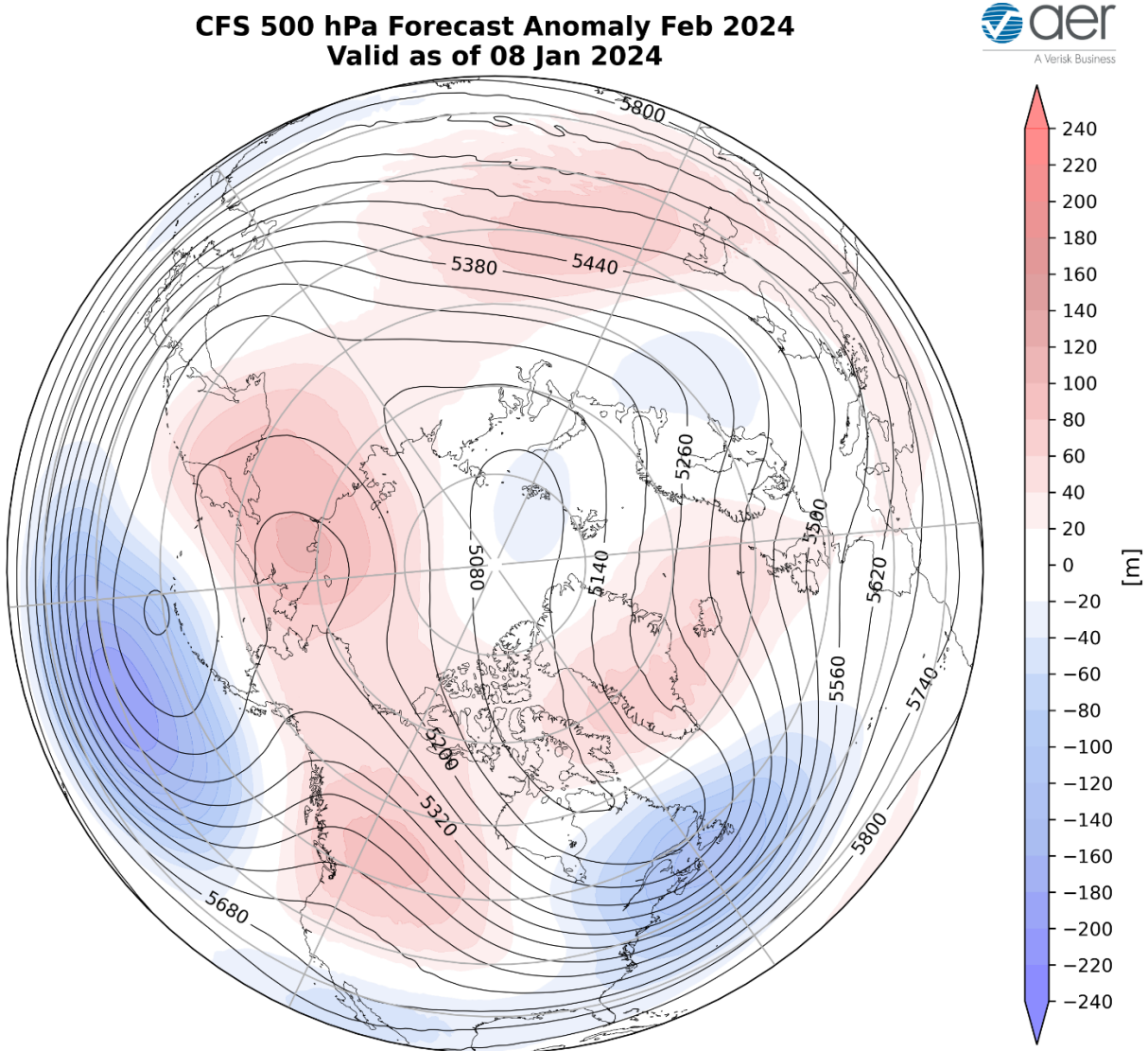
Vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere has been active since mid-November and likely peaked last week (**Figure 12**). This has resulted in multiple but brief minor PV disruptions (**Figure 12**) and a persistent negative stratospheric AO (**Figure 1**). The additional WAFz activity next week (**Figure 12**), should result in a peak in minor sudden stratospheric warming but not a major warming in the mid-troposphere. Though the models keep teasing a major warming.



**Figure 13.** (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 8 January 2024 . (b) Same as (a) except forecasted averaged from 19 – 23 January 2024. The forecasts are from the 00Z 8 January 2024 GFS model ensemble.

This week the polar vortex (PV) is elongated in shape with the PV center shifted south of the North Pole over the Barents Kara Seas and another lobe of low heights over Baffin Bay (**Figure 13a**). This elongated PV configuration is predicted oriented along an axis from Western Siberia to Eastern Canada. Ridging in the polar stratosphere is predicted to be centered over Alaska with the strongest warming centered in the Central Arctic. This PV configuration is consistent with a stretched PV that favors colder temperatures across Siberia and eastern North America. However, the warming in the Arctic is also a sign of a minor

warming in tandem of the stretched PV. This configuration of the PV is predicted to persist much of the next two weeks with the PV center sliding closer to Greenland with an elongated shape still oriented from Western Siberia towards Canada coupled with a ridge near the Dateline and warming more emanating from Northwest Eurasia (**Figure 13b**).

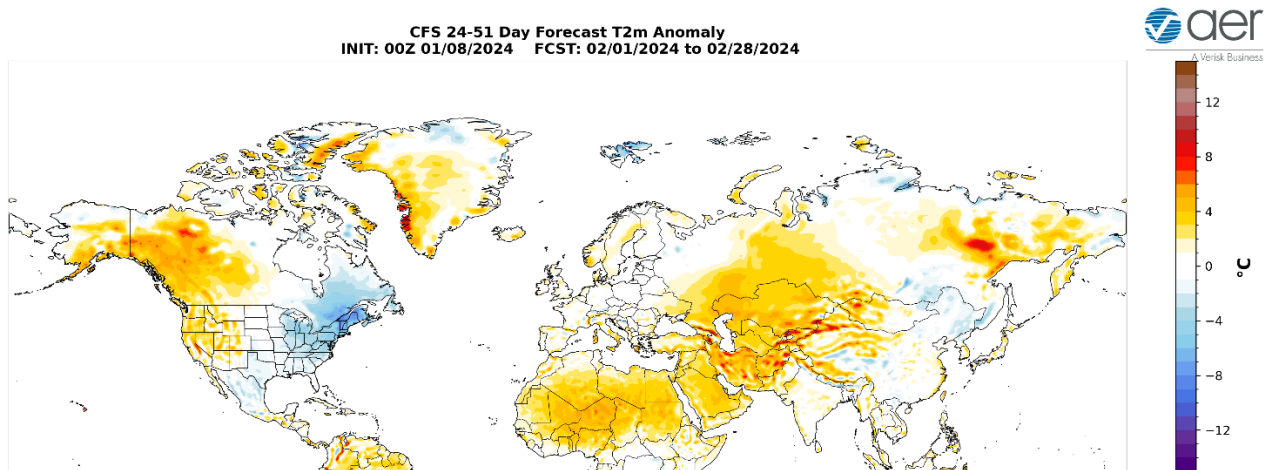


**Figure 14.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for February 2024. The forecasts are from the 00Z 8 January 2024 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for February (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging stretching centered near Greenland, Eastern Siberia, Alaska and Western Canada with troughing in Eastern Europe, Western Asia,



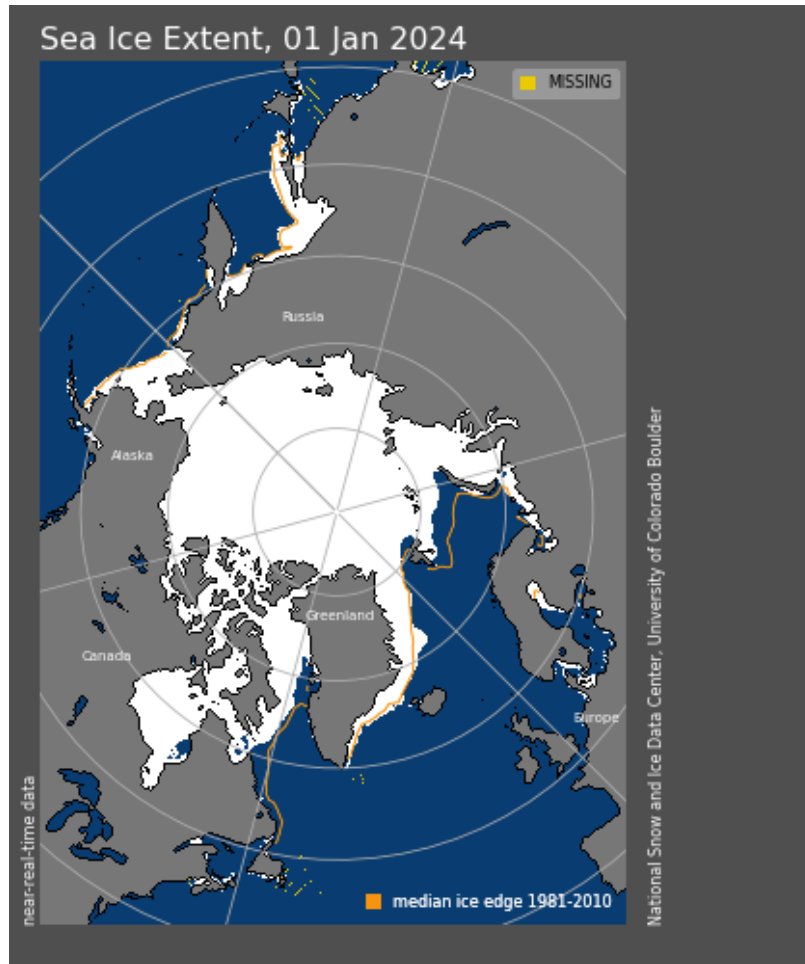
Northeast Asia, the Aleutians and eastern North America (**Figure 14**). This pattern favors seasonable to relatively warm temperatures across Southern Europe, Southern Asia, Eastern Siberia, Alaska, Western Canada and the Western US with seasonable to relatively cold temperatures across Eastern Europe, Northeast Asia, Eastern Canada and the Eastern US (**Figure 15**). Though I am always skeptical of a CFS forecast, this one is interesting to me.



**Figure 15.** Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for February 2024. The forecasts are from the 00Z 8 January 2024 CFS.

### *Arctic sea ice extent*

Arctic sea ice extent continued growing normally this week. I continue to expect that the negative sea ice anomalies will become more focused in the North Atlantic sector, which is currently the case. Blocking in the Barents-Kara sea region is critical for weakening the PV that favorable for widespread and meaningful cold in Northern Eurasia and eastern North America, which can persist for weeks. Arctic sea ice extent is higher than many recent years and is comparable to 2021 on this date.



**Figure 16.** Observed Arctic sea ice extent on 1 January 2024 (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*

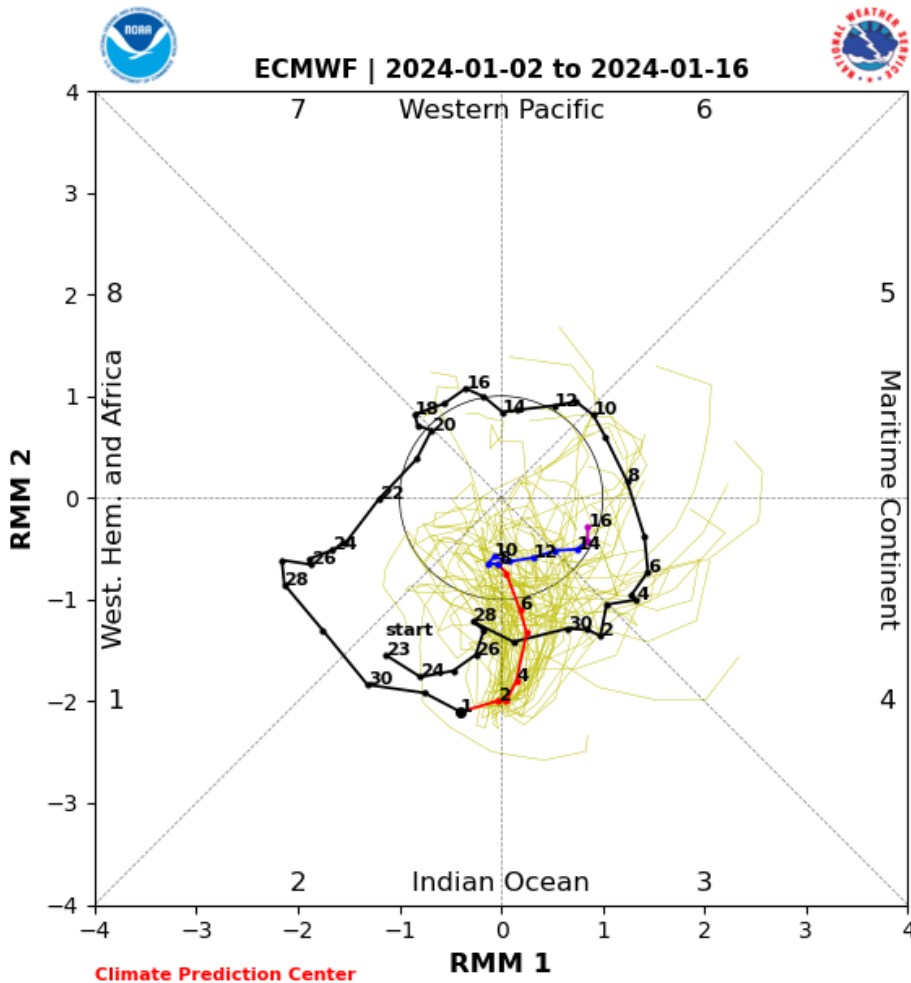
Equatorial Pacific sea surface temperatures (SSTs) anomalies are well above normal, especially along the South America coast, indicating that and El Niño is pretty much a sure thing (**Figure 17**) and El Niño conditions are expected through the winter. Observed SSTs across the NH remain well above normal 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.

**\*image missing at publication\***

**Figure 17.** The latest weekly-mean global SST anomalies (ending 30 December 2023). Data from NOAA OI High-Resolution dataset.

*Madden Julian Oscillation*

Currently the Madden Julian Oscillation (MJO) is in phase two (**Figure 1**). The forecasts are for the MJO to move into phase three and then weaken where no phase is favored. Phases two and three favor ridging near the Aleutians and ridging in western North America. Therefore it seems that the MJO could be having some influence on North American weather the next two weeks. But admittedly this is outside of my expertise.



**Figure 18.** Past and forecast values of the MJO index. Forecast values from the 00Z 2 January 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/clivar\\_wh.shtml](https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml)

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