

Arctic Oscillation and Polar Vortex Analysis and Forecasts

December 23, 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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Summary

- The Arctic Oscillation (AO) is currently near neutral and is predicted to remain close to neutral with a negative bias the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to remain mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently positive with negative pressure/geopotential height anomalies across Greenland and the NAO is predicted to slowly trend negative the next two weeks as pressure/geopotential height anomalies are predicted to become increasingly positive across Greenland.
- This week troughing/negative geopotential height anomalies across Greenland will favor ridging/positive geopotential height anomalies across Northern Europe with troughing/negative geopotential height anomalies in the Mediterranean. However next week increasing geopotential height anomalies across Greenland will favor deepening geopotential height anomalies across Northern Europe with ridging across Central and Southern Europe. This pattern will support mostly normal to above normal temperatures across much of Europe including the United Kingdom (UK) with the exception of normal to below normal temperatures across the Mediterranean countries this week. Then next week temperatures will cool across Northern Europe including the UK with mild temperatures across Central and Southern Europe.
- The predicted pattern for Asia the next two weeks is ridging/positive geopotential height

across Europe and then Western Asia supporting troughing/negative geopotential height anomalies across Eastern Asia. This pattern favors widespread normal to above normal temperatures across much of Asia, with regional normal to below normal temperatures across Central and East Asia the next two weeks.

- A transitional pattern predicted across North America the next two weeks with troughing/negative geopotential height anomalies centered in Alaska, Western Canada and the Western United States (US) supporting ridging/positive geopotential height anomalies across Eastern Canada and the Eastern US this week but is predicted to flip to ridging/positive geopotential height anomalies across Alaska, Western Canada and near Greenland with troughing/negative geopotential height anomalies across Central Canada and the US. This pattern favors normal to above normal temperatures across Canada and the US Upper Midwest with the exception of normal to below normal temperatures across Alaska. However next week normal to below normal temperatures across Alaska are predicted to flow out of Canada into Western Canada and eventually into the Northwestern and Eastern US with normal to above normal temperatures across Eastern Canada and the Southwestern US.
- The battle continues and in the Impacts section I discuss the competing influences of a strong polar vortex (PV) and high latitude blocking on the upcoming weather in the Northern Hemisphere (NH). But the high-latitude blocking made a miraculous recovery and may be getting the upper hand. So far this winter it is all about the PV stretching and then relaxing over and over again in quick succession. That is predicted to continue after the intermission of a Canadian Warming or is the PV ready for something new in the New Year?

Plain Language Summary

Four stretched polar vortices are in the books (most recent just winding down) and a fifth is looking increasingly likely immediately after the New Year. They are bringing cold weather to the Eastern US and East Asia (see **Figures 3 & 9**) but nothing impressive. In between an interlude of a strong polar vortex and for something different and new a Canadian warming favors a very milder pattern across North America next week pattern (see **Figure 6**). Europe isn't strongly influenced by stretched PVs, instead the weather is more dependent on Greenland high or low pressure. Low pressure across Greenland this week will extend the mild weather pattern (see **Figure 3, 6 and 9**). The Canadian Warming could spell colder weather for Europe in January. Lots of uncertainty though in January, how much cold air, where will it be focused how long will it last. And for the polar vortex more of the same or is there one more new trick to unveiled.

Impacts

The polar vortex (PV) continues to transition to different phases or modes at breakneck speed. I have been describing the PV variability as "lather, rinse, repeat" and for the most part that seems to be true. As I tweeted the PV is inserting a new trick, a Canadian warming, in between the stretched and the snapping back to strong and circular that I jokingly called the

soak cycle. Regardless, we are still on this cycle of very quick changes not only in the PV but riding a temperature roller coaster for at least for the next two weeks. We have this first minor stretched PV (number four of the season) that is winding down that is bringing a short duration cold shot but is very cold in the core. This is quickly followed by a Canadian warming. This will be accompanied by a ridiculously mild end of December for North America but relative to normal, the warmth will be much more impressive in Canada than the US. Then this will transition to yet another stretched PV in early January and a return to colder weather. All the transitions can be seen in the latest PV animation in Figure i.

Initialized 00Z 10 hPa HGT/HGTa 23-Dec-2024

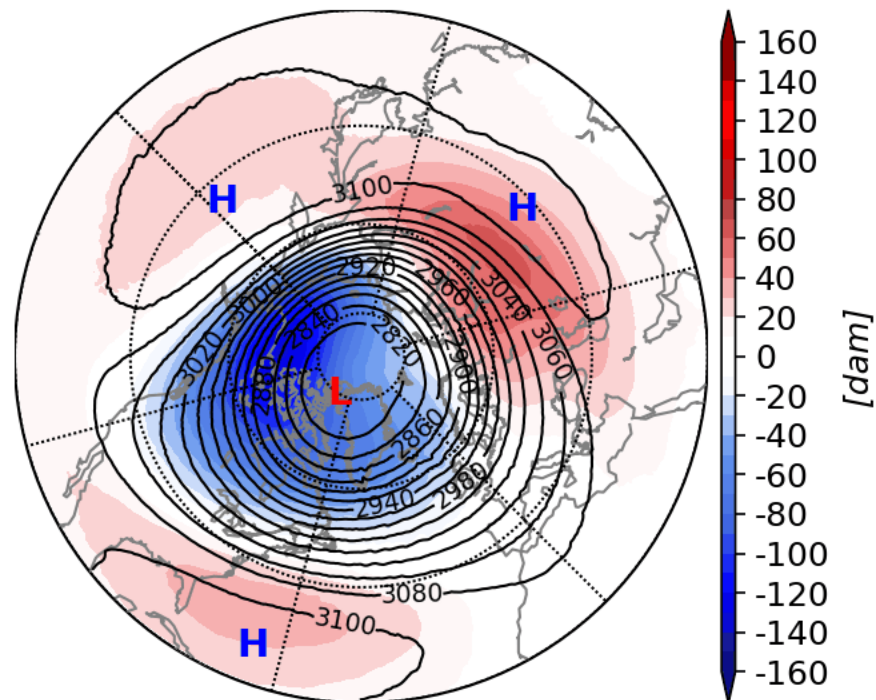


Figure i. Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for 23 December 2024 and forecasted from 24 December 2024 to 7 January 2025. The forecasts are from the 00Z 23 December 2024 GFS model ensemble.

Last week I discussed the transition to a colder pattern across North America around New Year's Day or maybe a few days later. This was in contrast to the weather models that were bringing the cold a little later. Since last week the weather models have made good progress in transitioning from the very mild pattern across North America (record warmth probable in the US and almost a guarantee widespread in Canada), though not as mild right along the US East Coast, to an overall colder pattern basically beginning on New Year's Day. The cold air will enter the Western US and then make steady progress from there into the Eastern US but the relatively coldest air is predicted to target the Southeastern US.

Last Monday I was paying attention to a possible Canadian Warming I thought that it was still unlikely as it was absent in the weather model ensembles. Ironically my original prediction of a pattern transition from mild to cold around New Year's Day was spot on in the end despite missing the Canadian warming. I did think that if we get the Canadian warming the mild weather could linger longer. I do think my thinking was overly influenced by last year's Canadian warming in December that resulted in a very warm month of December across North America that finally ended with a sudden stratospheric warming in January. It makes sense that a Canadian warming that precedes an SSW leads to an extended mild period for North America, while a Canadian warming that precedes a stretched PV does not and can more quickly transition to a colder period. I have not spent a lot of time analyzing Canadian warmings but the maybe having one in each of the two most recent Decembers has provide me with new insight into their impact.

As I wrote last week, a Canadian warming transitions almost exclusively to an SSW or a stretched PV. Without sustained Ural blocking an SSW seems unlikely to me in the near term and almost guarantees a transition to a stretched PV. The models still do not predict any severe cold in the Eastern US through the end of their model runs, however I think that the potential exists for severe cold in the first half of January in the Eastern US. But as I have been saying all winter this is a very challenging environment for the weather models, the forecasts are highly volatile and of low confidence and any forecast beyond a week to maybe ten days should be allowed a health spread in plausible outcomes. I will begin with the model temperature forecasts by temperature swings and for those interested in the gory details can read below in more detail with the different factors influencing the forecast.

Again, Europe is the easiest to predict as stretched PVs don't normally have much of an impact, though seems to shift the temperatures mild across Europe other than maybe Scandinavia. So overall over the next two weeks temperatures look to remain overall mild with the exceptions along the Mediterranean this week under an upper-level low and then next week in Scandinavia as heights start to fall across Northern Europe (see **Figures 3, 5 and 8**).

December 22-25 – cold in the Eastern US but mostly along the East Coast. Cold air winding down in East Asia. Both pushes of cold air was related to the recent stretched PV (see **Figure 3**).

December 26-31 – mild for the whole US including the Eastern US due to the Canadian Warming (see **Figure 5 and 12a**). Another push of cold air into East Asia related to renewed Ural blocking (see **Figure 4 and 5**).

January 1-5 – turning colder in the Eastern US from west to east. Models are predicting seasonable cold as the core of the cold heads into the Southeastern US where temperatures are warmer climatologically. Probably more cold air heading into East Asia. The renewed push of cold air in both North America and East Asia (see **Figure 8**) are related to yet another stretched PV (number five of the season; see **Figure 12b**).

January 6-10 – this period is starting to look very uncertain. All the weather models but none consistently are suggesting the trough and the coldest air will shift into the Western US with a negative Pacific/North American teleconnection (PNA) pattern. By itself this suggests it could be mild even very mild in the Eastern US. For the past few winters this has been the

dominant weather pattern. The one exception is if it is coupled with Greenland blocking. This would create a channel to funnel cold air from the Western US into the Northeastern US, while the Southeastern US stays mild. More on this below.

I think beyond January 10 it is wide open what could happen and probably going with climatology with a wide distribution is the best forecast. It will depend on the strength and positioning of high-latitude blocking and the strength of the PV. For the PV to get cold it will be a Goldilocks situation. The PV remains overall strong any cold should be transient, if the PV weakens too much (aka an SSW) it can be mild for a longer duration but an overall weak PV with a stretch, the Eastern US could be cold for the majority of January.

Here are the factors that I see at play. This is very detailed and technical and feel free to skip it if your brain starts to hurt. I often get complaints that the blog is too technical, so if that applies to you please skip ahead, I just want to demonstrate for the readers how complicated the forecast for January is.

The easiest part of the forecast is that Canadian warmings really only transition to two other modes of PV variability a sudden stratospheric warming (SSW) or a stretched PV as I mentioned above. I don't really see the possibility of an SSW any time soon, so a stretched PV seems highly likely. Probably most models are now predicting a stretched PV in early January while others are kind of hanging on to the Canadian warming for example the European operational model (see **Figure ii**). But in the ensembles anyway it seems that the models are moving into a stretched PV and colder pattern across North America.

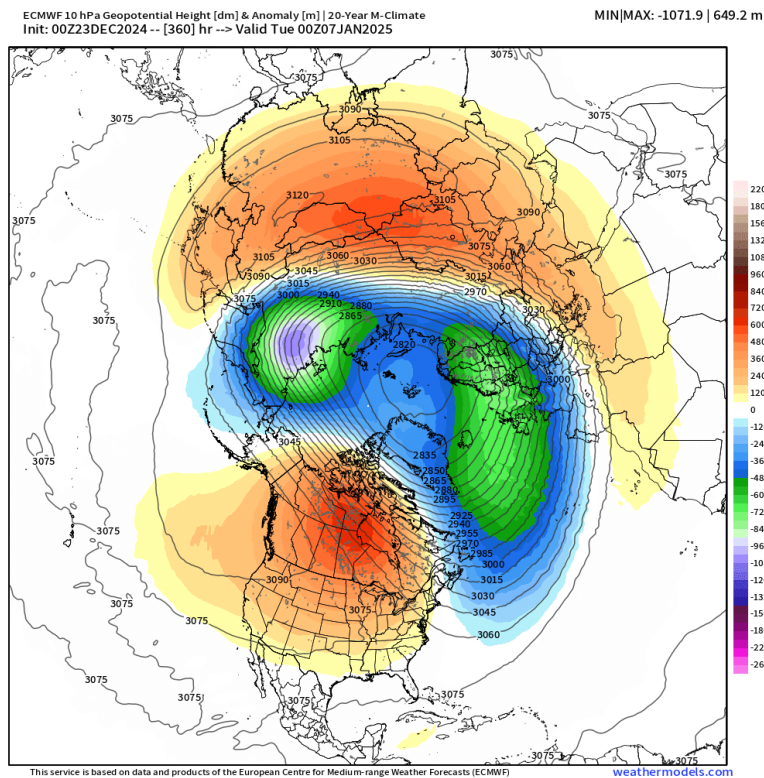


Figure ii. Forecasted 10 mb geopotential heights (dam; contours) and anomalies (meters; shading) across the Northern Hemisphere for 31 December 2024. The forecasts are from the 00Z 23 December 2024 ECMWF operational model. Plot taken from <https://weathermodels.com>.

I have a paper in review that provides deeper analysis about stretched PVs and is actually very useful for trying to understand what is going this winter. I am going to try to be a bit vague since the paper's fate is still unknown. The wave reflection (Rossby wave energy goes up over Asia, boomerangs off the PV and heads back down over North America) with this upcoming stretched PV in early December is looking very robust, almost textbook and the potentially the strongest so far this winter (see **Figure iii**). The resultant ridging with the wave reflection (arrows boomeranging off orange shading) is around 150°W and the resultant trough starting to take shape (blue shading where the arrows are pointed downward) is around 100°W. This is on the westward envelope of wave reflection and would favor the cold air being focused in the Western US more so than in the Eastern US. The energy diagnostics in **Figure iii** are very volatile and can change from day to day so caution is needed when using them to forecast. Though this could be the reason why the latest GFS ensembles are focused further west with the cold air than for example the latest Canadian ensembles (see below **Figure v**). Meanwhile the latest European is a compromise between the more westward GFS and more eastward Canadian. I am favoring the European for two reasons. I like the Solomonic approach and splitting the baby. Second, I think it best matches the AER winter forecast posted at the end of November.

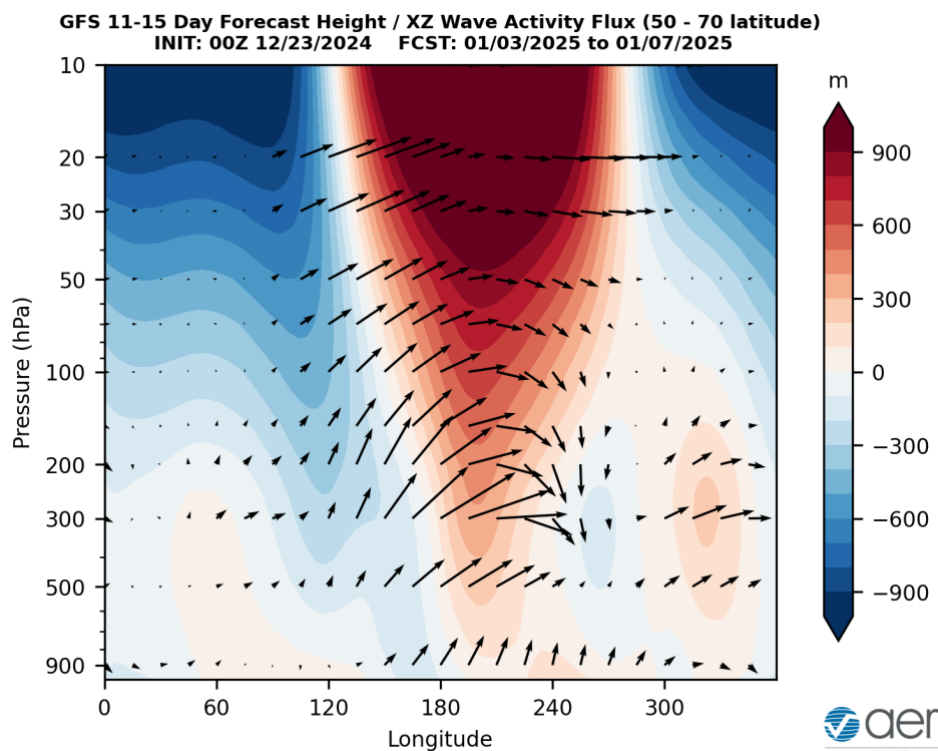


Figure iii. Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 3 through 7 January 2025. The forecasts are from the 00z 23 December 2024 GFS ensemble.

Another complication is the high latitude blocking in early January. While last week the high latitude blocking was as I called it was on “life support” it is now predicted to make a miraculously recovery and could potentially be the strongest it has been all winter (see **Figure 11**). Canadian warmings often spawn Greenland blocking and this upcoming Canadian warming for the end of the month looks no different and all the weather models have Greenland blocking to start the New Year (see **Figure 8**). But from there the models diverge with some models holding on to the Greenland blocking longer and other model forecasts losing it very quickly with it on its way to Europe. Greenland blocking is important because: one it increases the risk of cold weather in Europe. So though Europe has been mild so far this month (see Figure iv), that could change in January if the Greenland blocking can hold on.

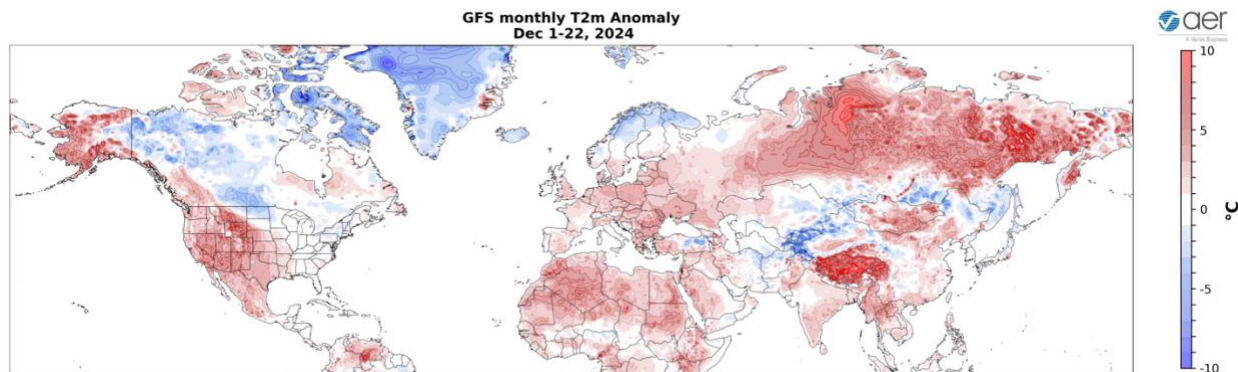


Figure iv. Observed surface temperature anomalies (°C; shading) from 1 Dec to 22 Dec 2024. The forecast is from the initialized GFS ensemble. Climatology used is 1991-2020.

The second reason why a stationary Greenland blocking is important is because if we do get a pattern that favors cold in the Western US, without Greenland blocking the cold air will be directed further north into Canada and it could potentially be very mild in the Eastern US. With Greenland blocking the cold air heading east will be shunted south so at least the Northeastern US can remain cold even if it turns milder in the Southeastern US. Looking at the most recent GFS ensembles it has stronger Greenland blocking while the Canadian has it well on its way for a European vacation.

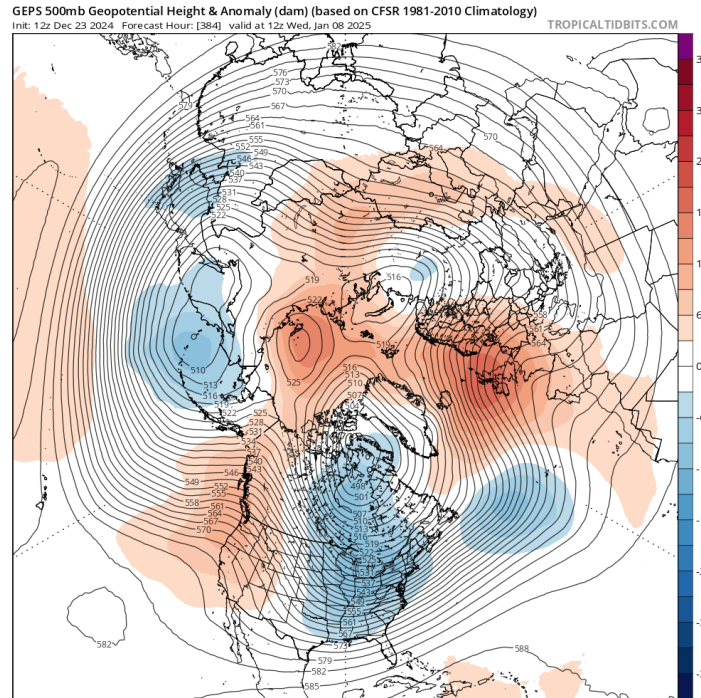


Figure v. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere 08 Jan 2025. The forecasts are from the 12Z 23 December 2024 Canadian ensemble. Plot taken from <https://www.tropicaltidbits.com/analysis/models/>

But there are two other regions where we need to watch for high latitude blocking, near Alaska and near the Urals. All models predict pretty strong Alaskan ridging by early January. The magnitude and the axis of the Alaskan blocking will determine for how long the cold will be repeatedly delivered into the US and where it is focused, the Western or Eastern US. One pretty good rule of thumb is to watch how cold it gets in Alaska. If Alaska turns cold that favors the cold being focused in the Western US, if Alaska turns mild that favors the cold being focused in the Eastern US. The duration of the Alaskan blocking and the axis of the ridging or high pressure differs among the model forecasts, complicating the temperature forecast for the entire US beyond the first five days of January.

The last region of important high-latitude blocking is the Urals but really Ural-Scandinavian blocking. Here too the models are offering a wide range of possibilities with more persistent Ural blocking and more transient Ural blocking. The stronger and the more persistent the Ural blocking, the weaker the PV will become. So, the character of Ural blocking in the first half of January will be key as to whether the PV remains relatively strong or actually drops into weaker than normal territory, which has large implications for temperatures in the US but also East Asia and Europe. Unfortunately, it is a systemic deficiency that weather models poorly predict high latitude blocking. Therefore, I expect large model errors in the model forecasts of high latitude blocking certainly beyond ten days but even beyond seven days.

Finally, one last very important complication is the strength of the PV over the coming weeks. The models underestimated the strength and breadth of the Ural (including Scandinavia) blocking this week and into next week and therefore model forecasts predicted a PV that was too strong for the next two weeks. The models are now predicting a weaker PV than they did last week though on average still stronger than normal but that could change as we head towards mid-January. Our PV strength model that I have discussed in previous winters had the PV strengthening through December 27 and then weakening through January 11. This model overall has its flaws, but it does seem to do well with PV trends and this upcoming period looks like the model could perform well again, at least on the trends. The model is now predicting further weakening of the PV post the MLK weekend. Could that be more stretching or maybe even an SSW, hard to know at this point.

But more immediately the weaker PV forecasts have important implications for the upcoming stretched PV. I think the upcoming stretched PV could be the strongest of the season. This increases the possibility of severe cold in the US. All the models are predicting a large pool of warm air building in Asia (in the stratosphere; see **Figure 12b**) at the end of their respective runs, which is strongly suggestive of further weakening of the PV. But the complication is, if it results in another or further strengthening of a stretched PV that is a cold signal for the Eastern US but if it is the beginning of an SSW, that would likely signal an extended mild period for the Eastern US.

Last thing, I have been following tropical convection. It is currently in phase six, a warm phase for the Eastern US, but it has been in a phase that favors a warm Eastern US since Thanksgiving. At the very end of December and very early January it is predicted to move into phase seven that still favors warm in the Eastern US but now also cold in the Western US. This could be a factor in the models that are predicting the cold to be focused in the Western US come the second week of January. And from there it weakens to the point there is no longer a reliable signal. So at least to my limited understanding of tropical convection, it is at best providing a weak cold signal for the Eastern US or at worst providing no signal or even possibly a warm signal for the Eastern US for early January. In contrast might be favoring cold shifted west across the US.

Near-Term

This week

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

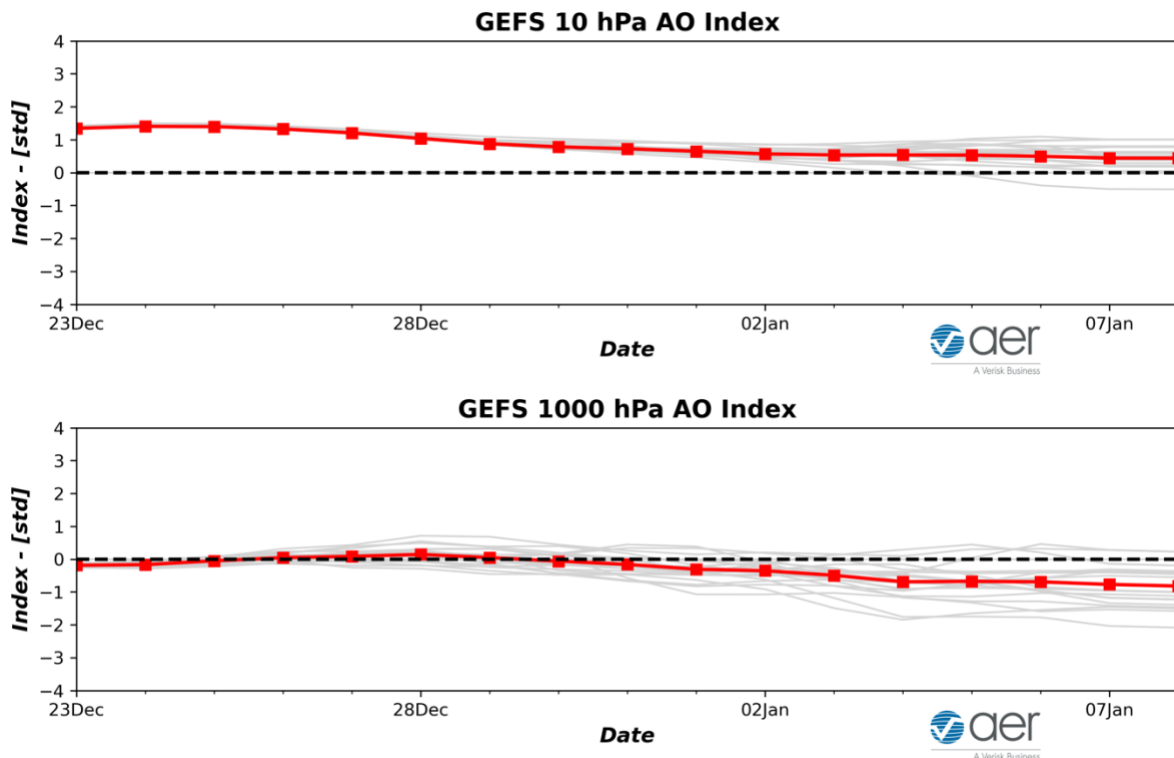


Figure 1. a) The predicted daily-mean AO at 10 hPa from the 00Z 23 December 2024 GFS ensemble. b) The predicted daily-mean AO at 1000 hPa from the 00Z 23 December 2024 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble mean AO index given by the red line with squares.

This week, toughing/negative geopotential height anomalies across Greenland will support ridging/positive geopotential height anomalies across much of Europe with toughing/negative geopotential height anomalies across the Mediterranean (**Figures 2**). This pattern will favor normal to above normal temperatures across most of Europe including the UK with normal to below normal temperatures limited to the Mediterranean countries (**Figure 3**). This week Northern European ridging/positive geopotential height anomalies will extend into Western Asia supporting troughing/negative geopotential height anomalies across Eastern Asia (**Figure 2**). This pattern favors normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures limited to parts of Central and Eastern Asia including Eastern Siberia (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 12/23/2024 FCST: 12/24/2024 to 12/28/2024

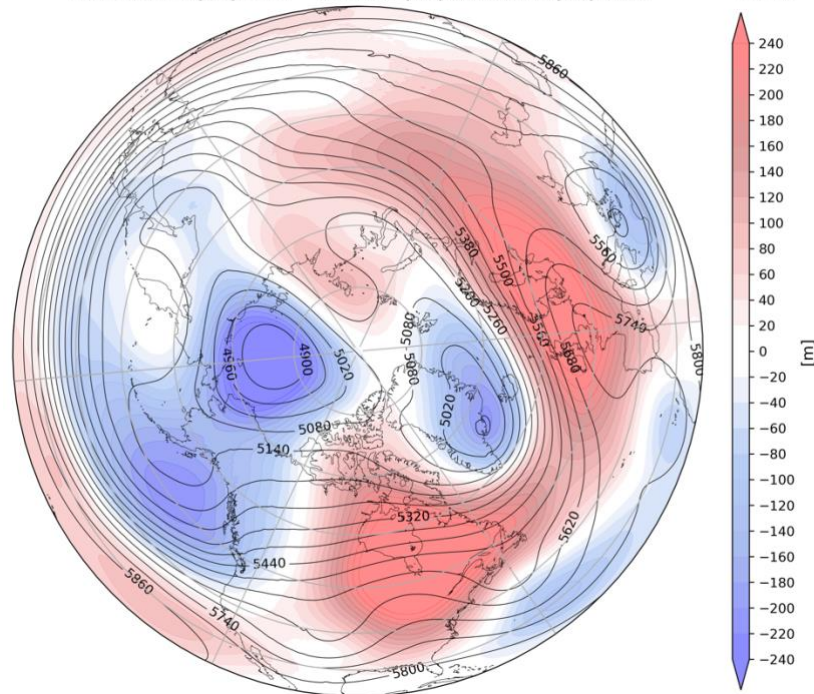


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 Dec to 28 Dec 2024. The forecasts are from the 00Z 23 December 2024 GFS ensemble.

This week troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska will support ridging/positive geopotential height anomalies across Central and Eastern Canada and the Eastern US. (**Figure 2**). This pattern will favor normal to above normal temperatures across much of Canada, and the US normal to below normal temperatures mostly limited to Alaska and possibly along the immediate US East Coast (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 12/23/2024 FCST: 12/24/2024 to 12/28/2024

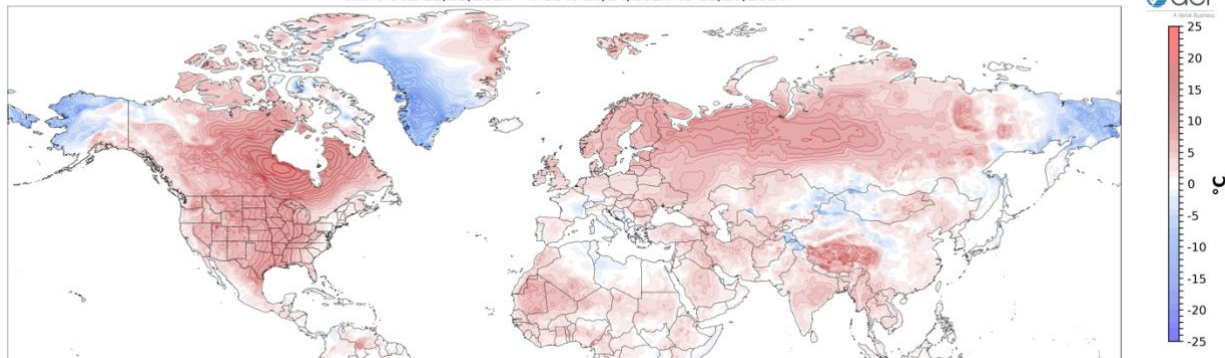


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 24 Dec to 28 Dec 2024. The forecast is from the 00Z 23 December 2024 GFS ensemble.

Trouching and/or cold temperatures will support new snowfall in Turkey, Western Siberia and Northeast Asia while warm temperatures will support snowmelt in Scandinavia, the Alps, the Balkans and Western Russia this week (**Figure 4**). Trouching and/or cold temperatures will support new snowfall across western Alaska, Northern Canada, the higher elevations of the Canadian West Coast and the Northwestern US while warm temperatures will support snowmelt in Central Canada, the Upper Midwest and the Northeastern US this week (**Figure 4**).

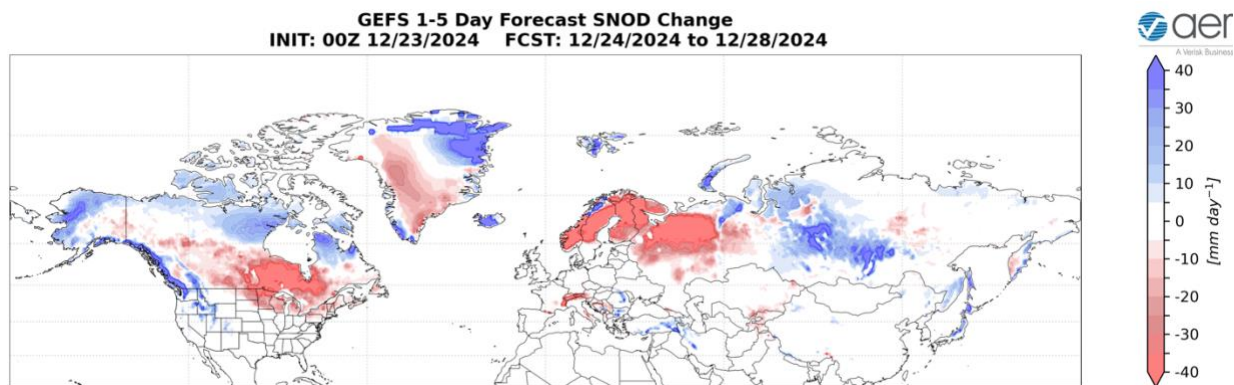


Figure 4. Forecasted snow depth changes (mm/day; shading) from 24 Dec to 28 Dec 2024. The forecast is from the 00Z 23 December 2024 GFS ensemble.

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 near neutral this period (**Figure 1**). With predicted weak but positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be near neutral this period.

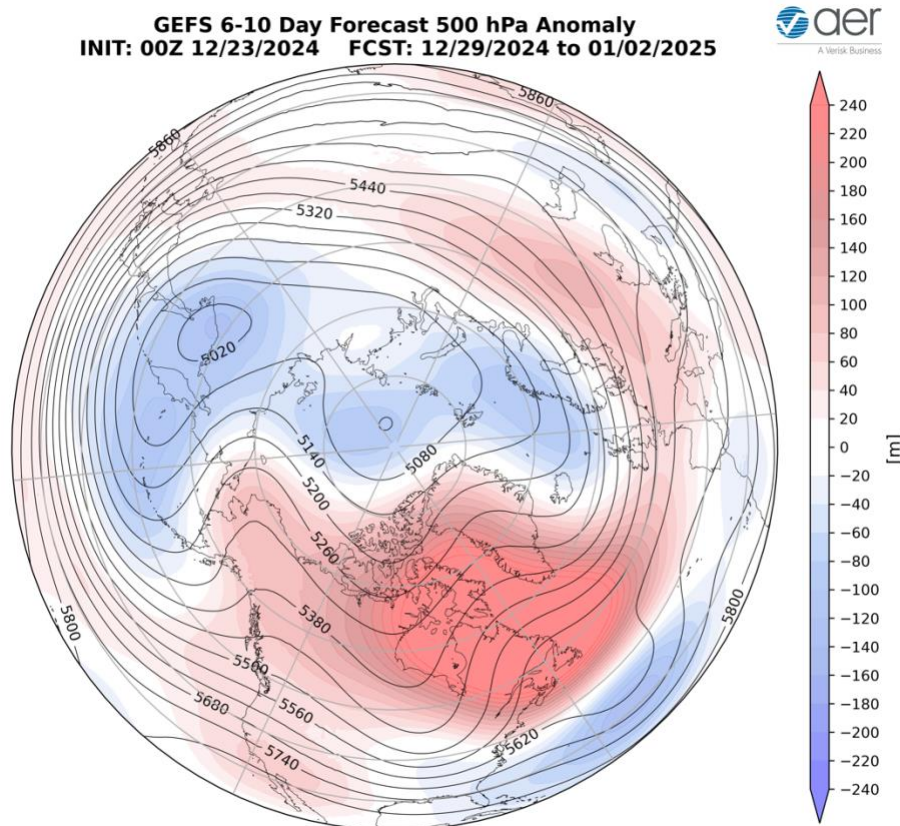


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 Dec to 02 Jan 2025. The forecasts are from the 00Z 23 December 2024 GFS ensemble.

Predicted strengthening ridging/positive geopotential height anomalies across Greenland will support deepening troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Central and Southern Europe this period (**Figure 5**). Normal to above normal temperatures across much of Europe including the UK with normal to below normal temperatures limited to Southeastern Europe are predicted to persist this period (**Figure 6**). The predicted pattern across Asia is ridging/positive geopotential height anomalies across Western Asia anchoring troughing/negative geopotential height anomalies across Eastern Asia (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Asia with normal to below normal temperatures limited to parts of Central and Northeastern Asia (**Figure 6**).

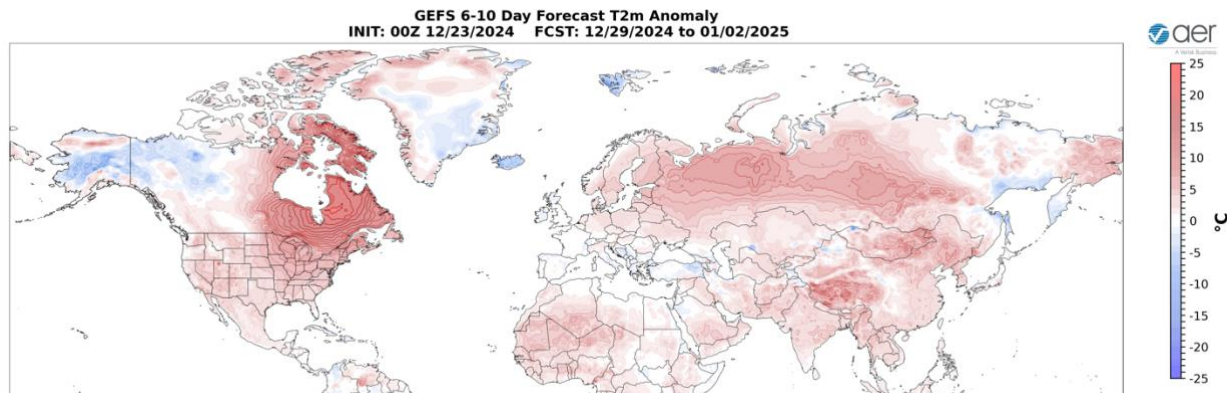


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 29 Dec to 02 Jan 2025. The forecast is from the 00Z 23 December 2024 GFS ensemble.

The transient pattern continues across North America with another pattern flip with ridging/positive geopotential height anomalies predicted across Alaska, Western and Eastern Canada and the Western US with troughing/negative geopotential height anomalies across Central Canada and the Eastern US this period (**Figure 5**). This pattern will favor widespread normal to above normal temperatures across much of North America with normal to below normal temperatures on the move out of Alaska and Northwestern Canada (**Figure 6**).

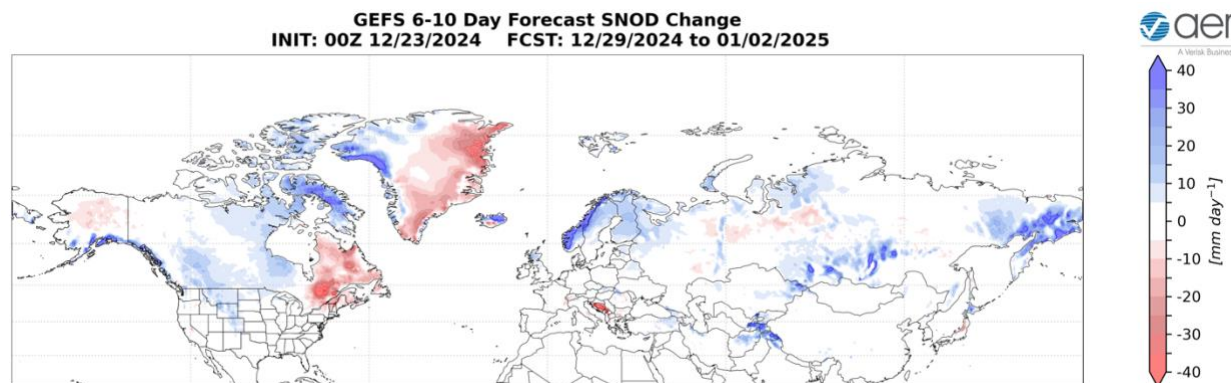


Figure 7. Forecasted snow depth changes (mm/day ; shading) from 29 Dec to 02 Jan 2025. The forecast is from the 00Z 23 December 2024 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Scandinavia, Tibetan Plateau, Western and Eastern Siberia while warm temperatures will support snowmelt in the Balkan region and Western Russia this period (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across southern Alaska, the West Coast mountains of Canada, Northern and Central Canada and the US Northern and Central Plains while warm temperatures will support snowmelt in Eastern Canada and new England this period (**Figure 7**).

Mid Term

Week Two

With predicted increasingly positive geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO will likely remain dip into negative this period (**Figure 1**). With predicted weak and positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will likely remain positive close to neutral or slightly negative this period.

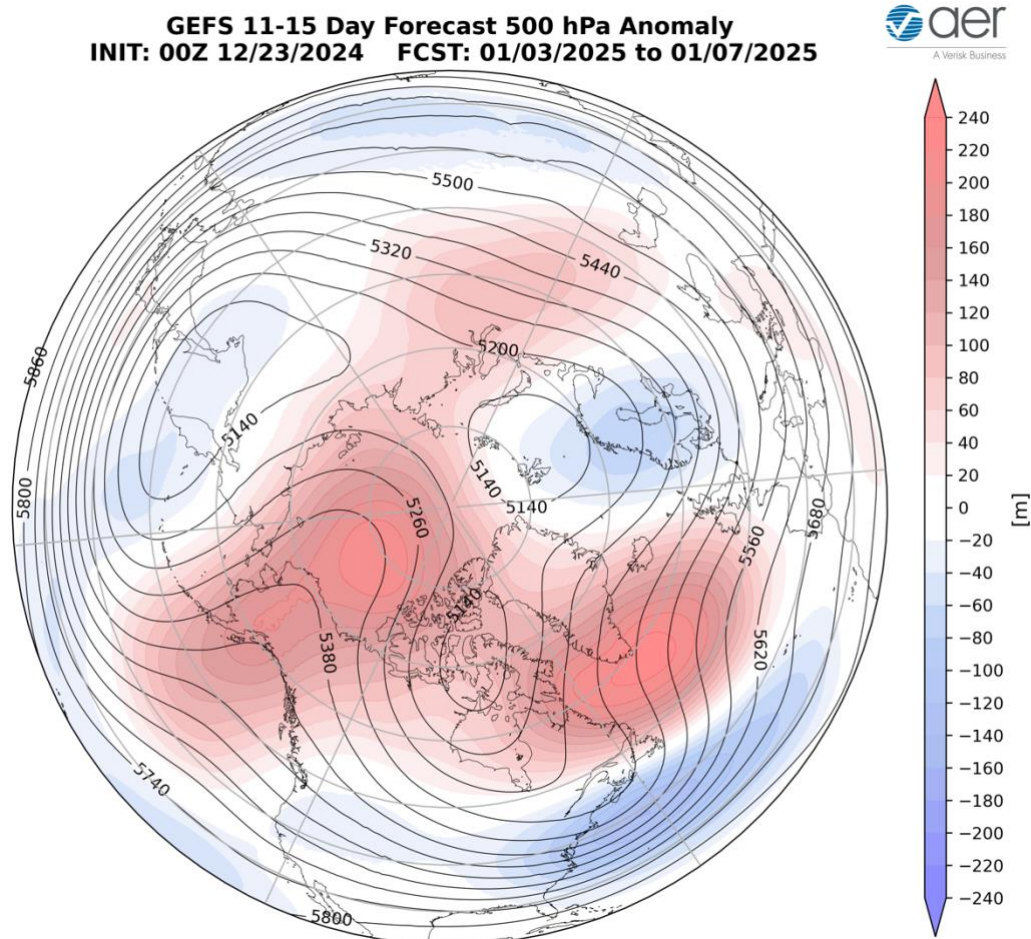


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 03 Jan to 07 Jan 2025. The forecasts are from the 00Z 23 December 2024 GFS ensemble.

Mostly ridging/positive geopotential height anomalies across Greenland is predicted to continue to support deepening troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies persisting across Southern Europe (**Figure 8**). This pattern should favor widespread normal to above normal temperatures across much of Europe with normal to below normal temperatures across Northern Europe including the UK this period (**Figures 9**). The pattern across Asia is predicted to mostly persist this period with ridging/positive geopotential height anomalies centered near the Urals forcing

troughing/negative geopotential height anomalies across East Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures limited to parts of Siberia, Central and East Asia this period (**Figure 9**).

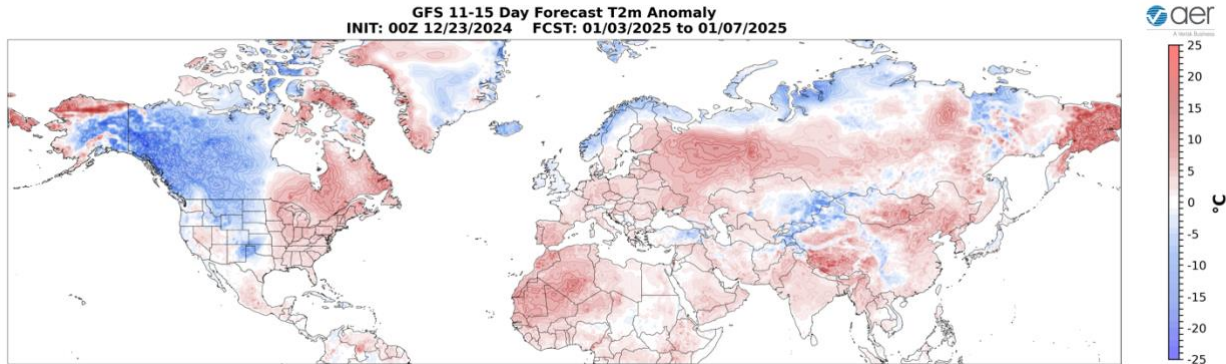


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 03 Jan to 07 Jan 2025. The forecast is from the 00Z 23 December 2024 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist across Alaska and the Gulf of Alaska, Western and Northeastern Canada supporting troughing/negative geopotential height anomalies across Central Canada and the US this period (**Figure 8**). With a less transient pattern, below normal temperatures will continue to spread out of Alaska into Western Canada and the Western US with normal to above normal temperatures across Eastern Canada and the Eastern US this period (**Figure 9**).

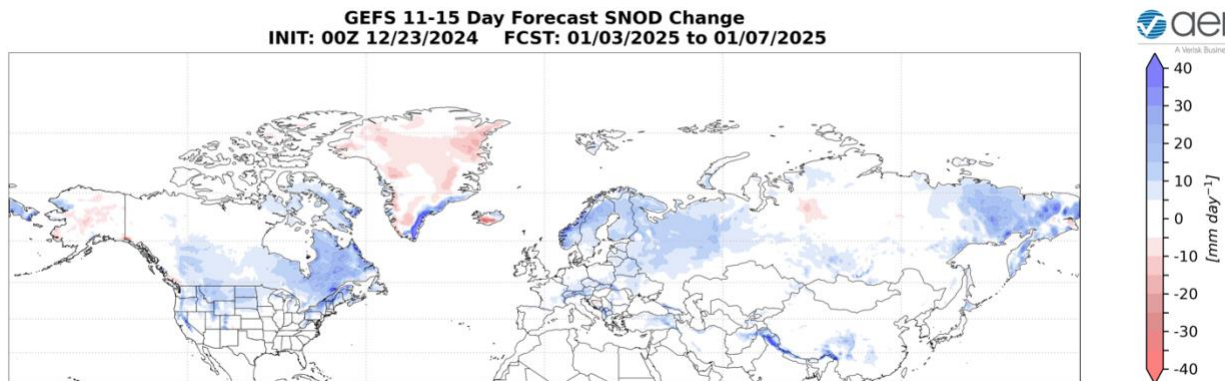


Figure 10. Forecasted snow depth changes (mm/day; shading) from 03 Jan to 07 Jan 2025. The forecast is from the 00Z 23 December 2024 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Scandinavia, the Alps, the Baltic region, Western Russia Eastern Siberia and the Tibetan Plateau while warm temperatures will support snowmelt in near the Urals this period (**Figure 10**). Troughing and/or cold temperatures will support new snowfall across Southern and Eastern Canada and the Northern US while warm temperatures will support snowmelt in western Alaska this period (**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 mid troposphere, albeit very weak with cold/negative PCHs in the stratosphere and lower troposphere (**Figure 11**). The cold/negative PCHs from the stratosphere are predicted to the next two weeks but still persist while the warm/positive PCHs in the mid troposphere are predicted to strengthen and expand. The contrast between cold/negative PCHs in the stratosphere and warm/positive PCHs in the troposphere continues for yet another two weeks (**Figure 11**). For now, this suggests that the stratosphere and troposphere are mostly uncoupled but does look like the high latitude blocking has made a remarkable recovery leading to an increasingly weak PV.

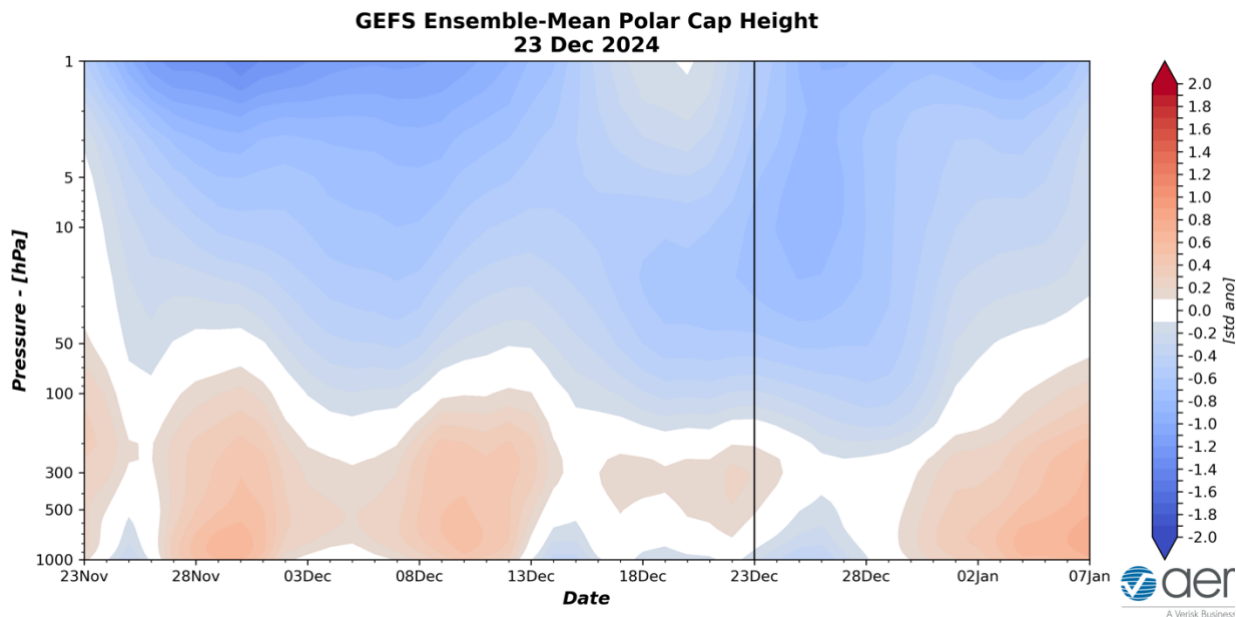


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 23 December 2024 GFS ensemble.

The predicted cold/negative transitioning to warm/positive followed PCHs in the lower troposphere the next two weeks (**Figure 11**) are consistent with the predicted near neutral surface AO this week but the increasingly negative bias next week (**Figure 1**). Still waiting to see if the warm/positive PCHs in the troposphere could force a larger polar vortex disruption. This week this scenario is looking more likely.

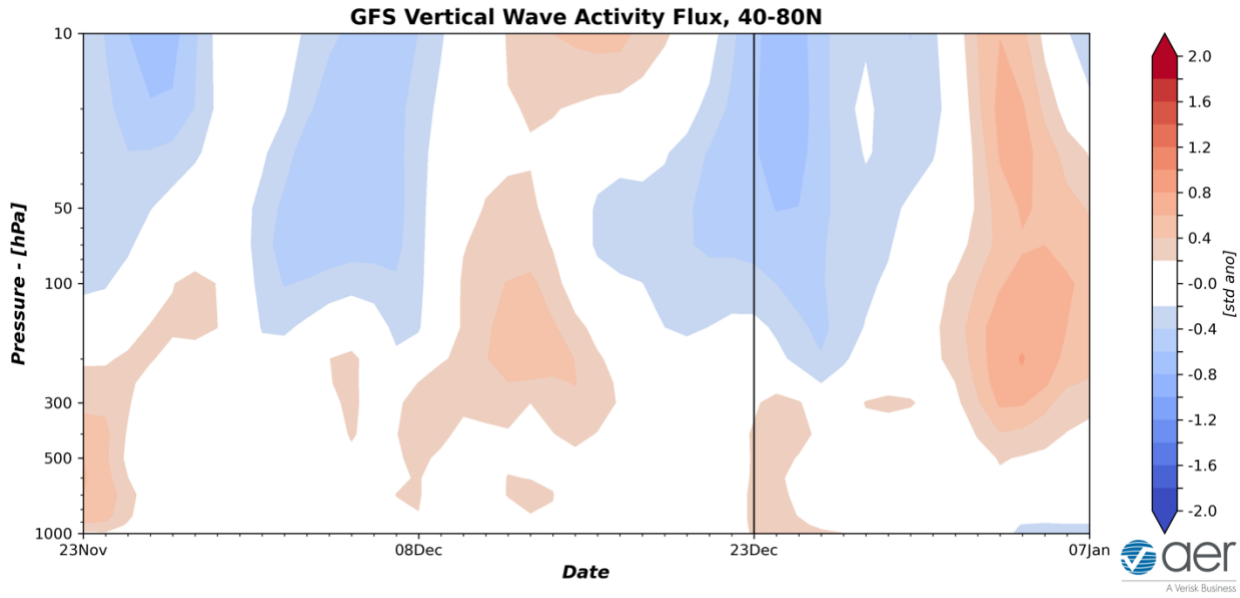


Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 23 December 2024 GFS ensemble.

Vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere has been relatively quiet this season (**Figure 12**). However, the alternating positive (red) and negative (blue) WAFz anomalies is characteristic of wave reflection associated with stretched PVs (**Figure 12**). What is unusual is the rapidity of the changes. There are suggestions that the WAFz could become more active in early January.

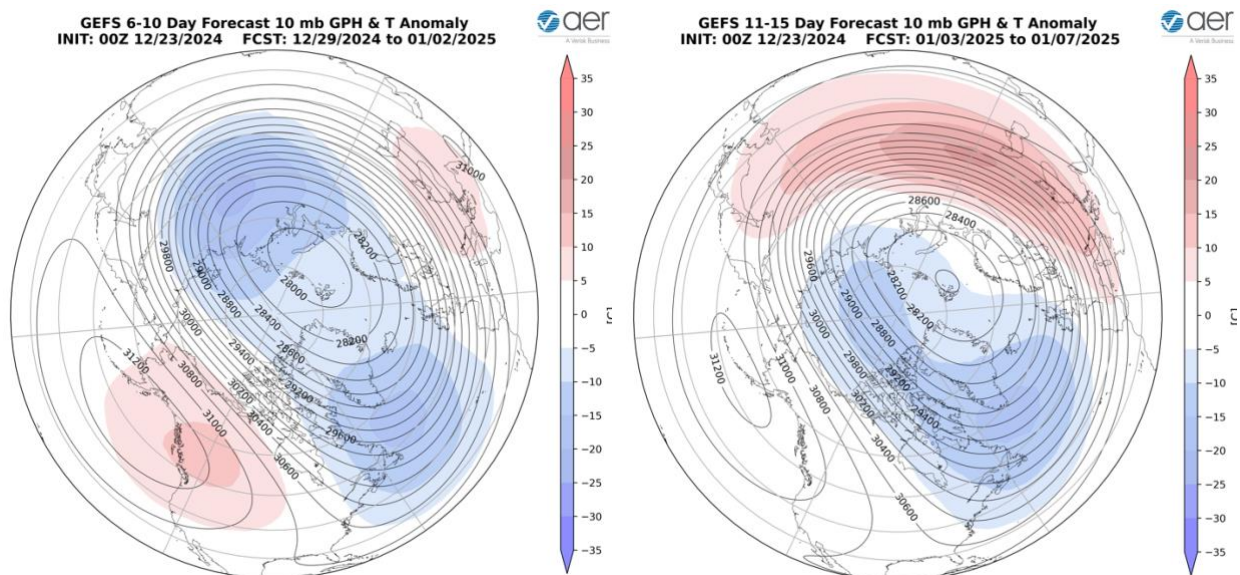


Figure 13. (a) Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 29 December 2024 to 02 January 2025. (b) Same as (a) except forecasted averaged from 03 Jan to 07 Jan 2025. The forecasts are from the 00Z 23 December 2024 GFS model ensemble.

This week the polar vortex (PV) is predicted to become more circular in shape as the PV comes out of the latest stretched PV and strengthens one more time. However next week, enough upwelling wave energy will trigger a Canadian warming with the greatest polar stratospheric warming over Canada pushing the PV center over the Barents Kara Seas (**Figure 13a**). This is related to the record warm temperatures predicted for Eastern Canada and even the US later this week and into next week. Then, in early January the PV center is predicted to move closer to Svalbard and once again become more elongated in shape with relatively cold temperatures extending from Asia towards Canada in the polar stratosphere (**Figure 13b**). This is consistent with yet another stretched PV (for those keeping score at home, the fifth of the season). The stratospheric AO in **Figure 1** this week continues to show that despite the repeated stretched PVs and even the Canadian warming, overall the PV remains strong, and any cold air outbreaks should remain brief with each individual stretched PV event. However, it does look like the PV is showing signs of weakening in early January.

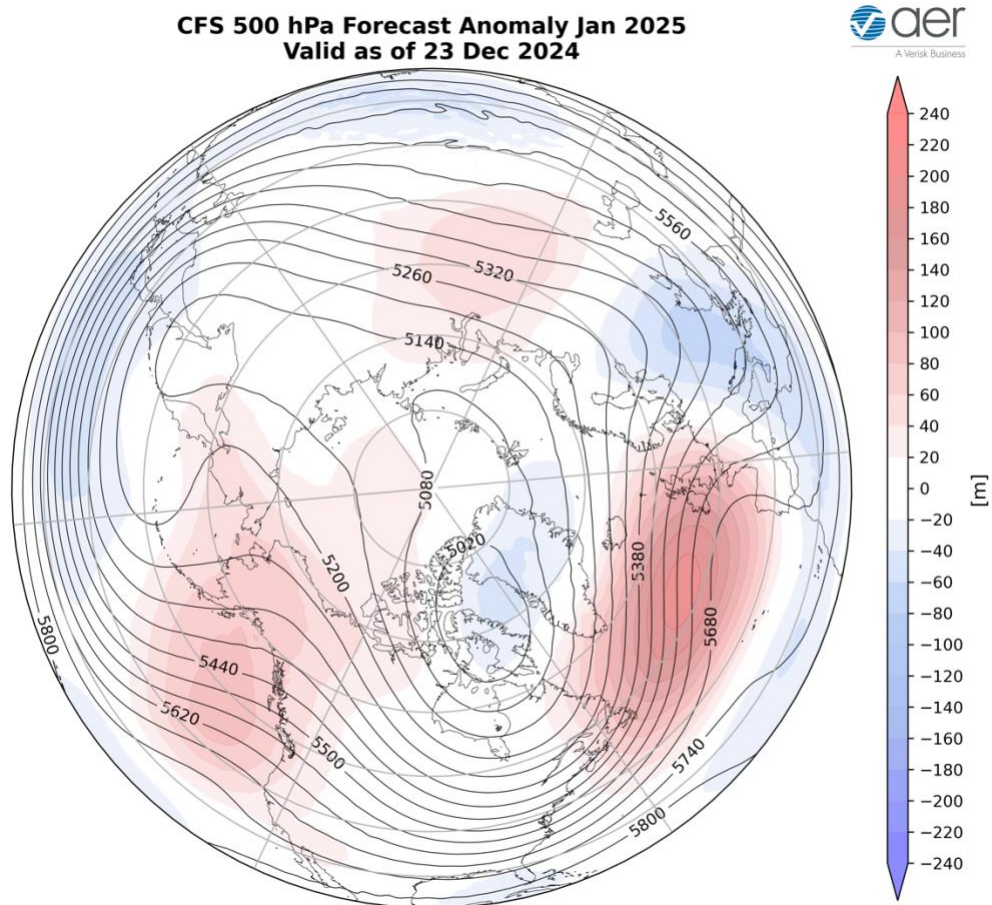


Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for January 2025. The forecasts are from the 00Z 23 December 2024 CFS.

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 across the North Atlantic south of Iceland, near the Urals, from the Gulf of Alaska extending into Alaska and Eastern Siberia with troughing across Europe and the Mediterranean, East Asia extending to the Dateline, much of Canada and the US (**Figure 14**). This pattern favors seasonable to relatively warm temperatures across Northern Europe, Western and Northern Asia, much of Siberia, Alaska, Western and Eastern Canada and the Western US with seasonable to relatively cold temperatures across the Central and Southern Europe, Central and East Asia, Central Canada and the Eastern US (**Figure 15**).

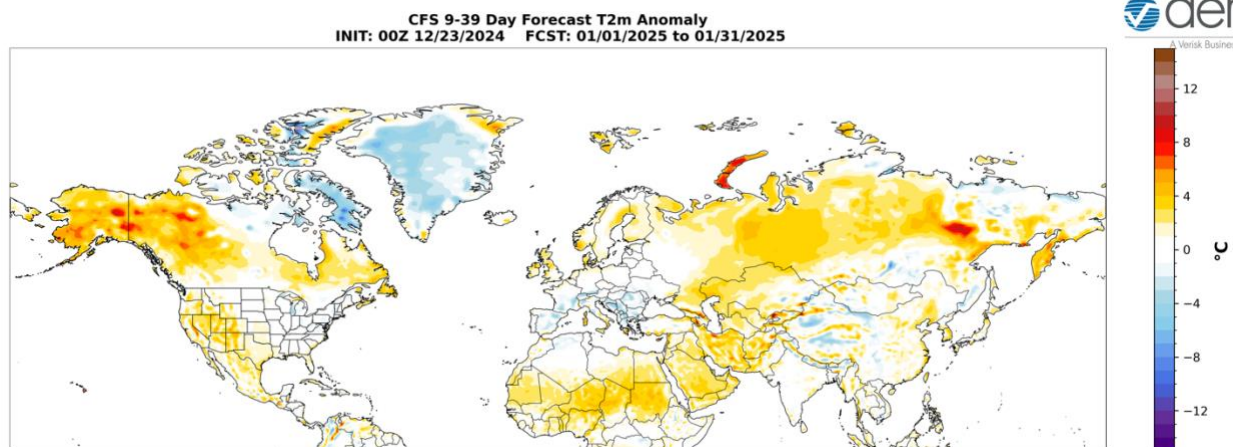


Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for January 2025. The forecasts are from the 00Z 23 December 2024.

Boundary Forcings

Arctic Sea Ice

Sea ice growth continues relatively slowly with a larger negative anomaly in the North Atlantic sector compared to the North Pacific sector though reduced from during the fall (see **Figure 15**). This is important because it is the lack of sea ice in the Barents-Kara Seas that favors a weak PV and colder temperatures across the interior of the NH continents. The other region where sea ice is below normal is Hudson Bay. I do wonder if low sea ice extent in Hudson Bay is contributing to the predicted atmospheric ridging and warming over eastern North America.

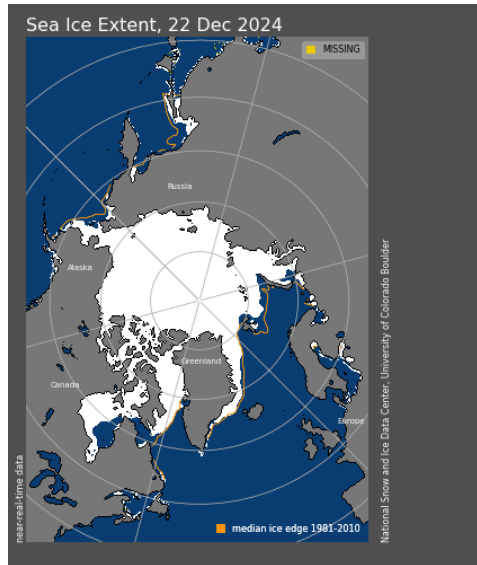
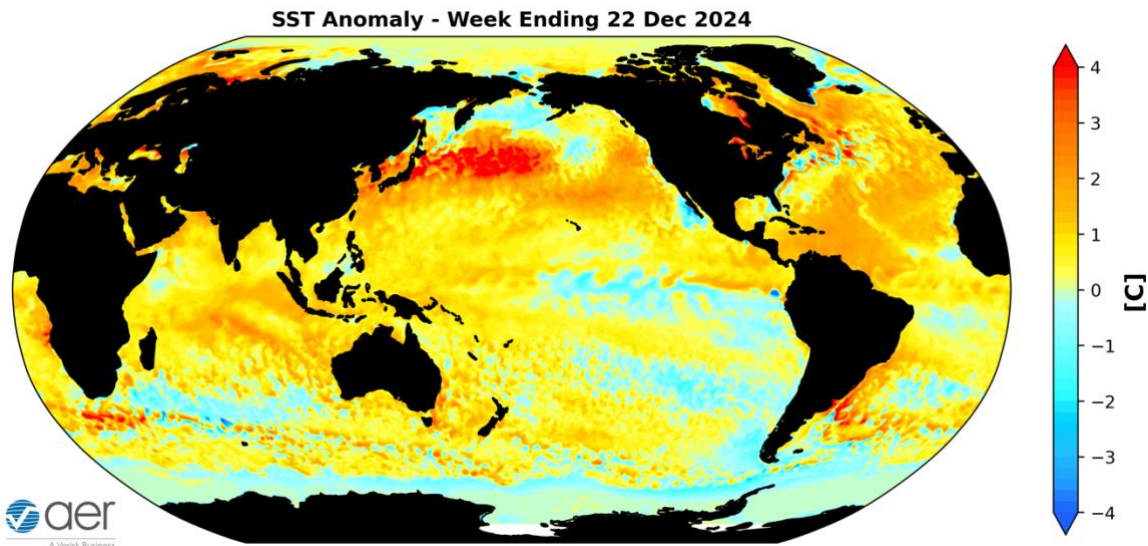


Figure 15. Observed Arctic sea ice extent on 22 December 2024 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC). URL <https://nsidc.org/sea-ice-today>.

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 17**) 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 the Canadian Maritimes though below normal SSTs exist regionally especially in the South Pacific. I do wonder if the warmer SSTs this year relative to recent years along the west coast of North America is favoring the cold air further to the east this winter compared to the past decade.



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We appreciate your taking the time to read the public Arctic Oscillation blog from Dr. Judah Cohen and the AER Seasonal Forecasting team.

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