Arctic Oscillation and Polar Vortex Analysis and Forecasts

January 2, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Wednesday through the winter season.

For those who would like an early look on Mondays, we will be offering at a nominal price (US $50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

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. With the start of 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 slowly trend negative over the next two weeks as pressure/geopotential height anomalies across the Arctic that are currently mixed are predicted to become increasingly positive. The North Atlantic Oscillation (NAO) is currently positive and is predicted to remain positive the next two weeks as pressure/geopotential height anomalies are predicted to be mostly negative across Greenland.
- Over the next two weeks ridging/positive geopotential height anomalies centered in the Barents-Kara Seas will favor troughing/negative geopotential height anomalies across Northern Europe but mostly ridging/positive geopotential height anomalies across Southern Europe. This pattern will generally favor normal to above normal temperatures across Southern and Central Europe including the United Kingdom (UK) with normal to below normal temperatures across Scandinavia and eventually the Baltic States.
- Over the next two weeks, predicted ridging/positive geopotential height anomalies in the Barents-Kara Seas will force troughing/negative geopotential height anomalies across Siberia with more ridging/positive geopotential height anomalies in Southern Asia. This pattern favors expanding normal to below normal temperatures first across northern Siberia but then spreading across all of Siberia with normal to above normal temperatures across much of the rest of Asia over the next two weeks.
- Over the next two weeks, troughing/negative geopotential height anomalies centered in the Gulf of Alaska will force ridging/positive geopotential height anomalies across Canada and the United States (US) east of the Rockies. This pattern favors widespread normal to above normal temperatures Central and Eastern Canada and the Central and Eastern US with normal to below normal temperatures limited to Western Canada and the Western US.
- I discuss what we can expect in the coming weeks with the polar vortex (PV), which is clearly predicted to become increasingly perturbed and hemispheric temperatures.
- I am ill once again so please excuse more than the usual typos in today's blog.

Plain Language Summary

The strong polar vortex (PV) that supported a very mild pattern east of the Rockies in North America, Europe and Asia is showing signs of change. It is speculative on my part at this point, but I do think another stretched PV or even the larger sudden stratospheric warming that supports colder temperatures across the Northern Hemisphere is probable later in January. So far, the weather models do not support my expectations.

I have revised my thinking since Monday and now think that a stretched PV will be relatively short lived and so will its impacts on our weather. A larger PV disruption akin to a sudden stratospheric warming is looking more likely to me. That should lead to a

milder pattern in the Eastern US at least at first but could lead to a longer duration cold across the NH but details of that are still unknown.

Impacts

First happy New Year!

The influence of the strong polar vortex (PV) and the cold/negative polar cap geopotential height anomalies (PCHs) throughout the atmospheric column can be seen on current surface temperature anomalies across the Northern Hemisphere (NH). Overall surface temperatures are warm to record warm across North America, Europe and Asia (see **Figure i**).

I do see signs of a pattern change in **Figure i** but they are subtle for now, it's the couplet of relatively warm temperatures in the Arctic focused in the Barents-Kara Seas and a small region of below normal temperatures east of the Urals. However, in large part due to predicted high pressure ridging centered over the Barents-Kara Seas the relatively cold temperatures are predicted to become widespread over Siberia and even Northern Europe over the next two weeks (e.g. **Figure 9**). Now is not the time for this discussion but I don't think that it is a coincidence that the re-emergence of high latitude blocking, critical for a colder pattern in the mid-latitudes, is in the region where sea ice loss is currently greatest in the Arctic, the Barents-Kara Seas (see **Figure 16**).

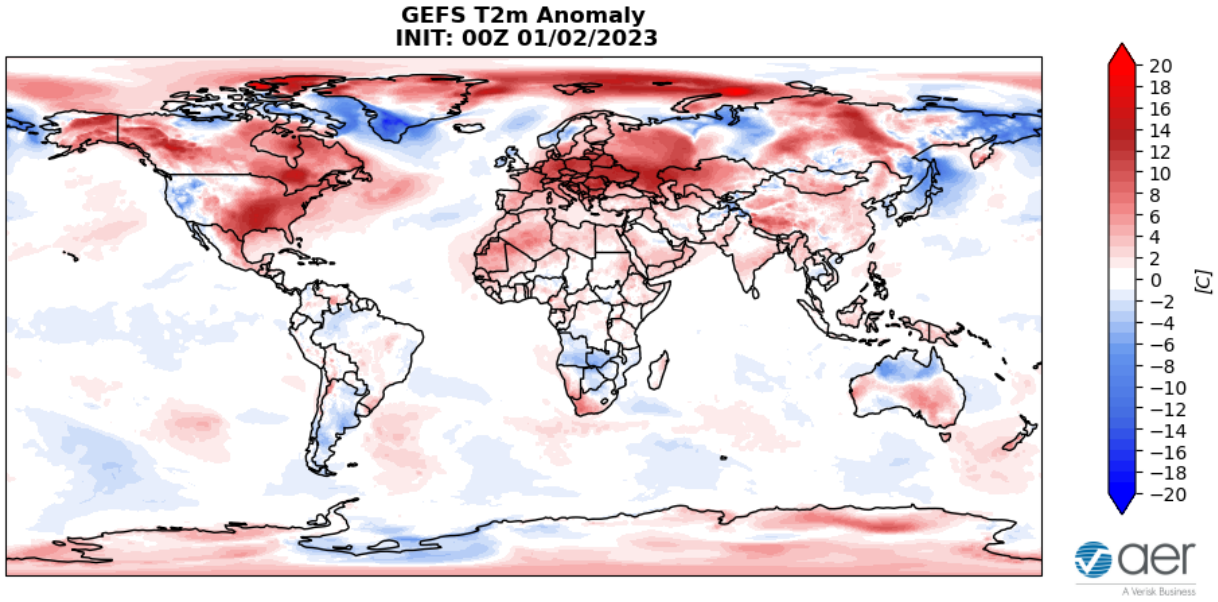

Figure i. Initialized surface temperature anomalies (°C; shading) for 2 January 2023 from the 00Z 2 January 2023 GFS ensemble.

But it does appear that the stratospheric PV will become increasingly perturbed in the coming weeks. The predicted circulation pattern in the mid-troposphere with high

pressure ridging in the vicinity of the Barents-Kara Seas and eventually across the Urals coupled with downstream low pressure troughing across Siberia and now even the Aleutians is favorable for exciting vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere as predicted the next two weeks (see **Figure 12**). This will lead to disruption of the PV, potentially the largest of the winter and even the whole PV season.

The predicted shape of the PV is consistent with a stretched PV/reflective event with warming and ridging near Alaska and an elongated PV center stretching from Siberia to the Eastern US (see **Figure 13b**). Also supportive of the idea of a stretched PV reflective event is the predicted WAF in the vertical and latitudinal direction (see **Figure ii**). The WAF is upward over Asia, reflects off the PV and then is downward over North America. Typically, this behavior of the WAF both strengthens high pressure ridging near Alaska and downstream low pressure troughing across eastern North America that delivers Arctic air in Canada and the US east of the Rockies. In my opinion it is hard to draw a better configuration of the PV for delivering cold air across eastern North America than the one predicted for mid-January. For example compare to what was shown in the blog from 19 December 2022 (see Figure 13a).

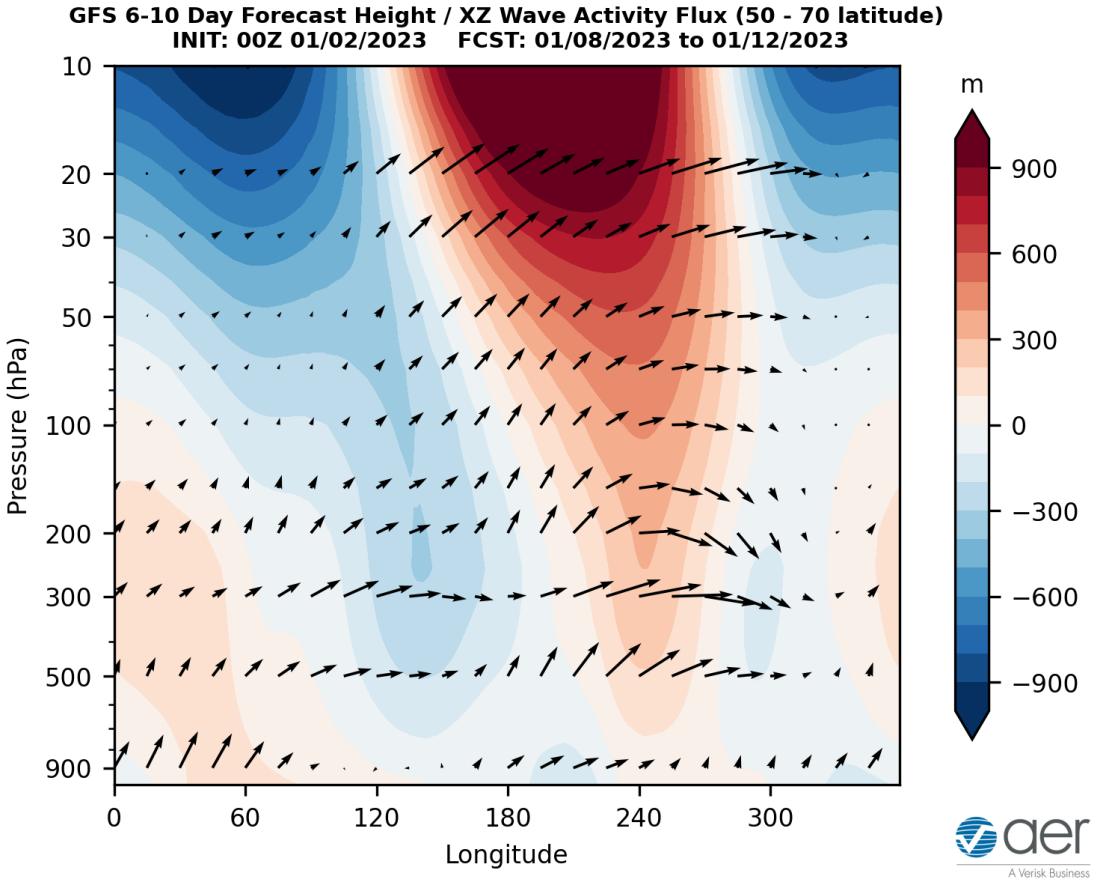

Figure ii. Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 8 – 12 January 2023. The forecast is from the 00Z 2 January 2023 GFS operational model.

The one feature that is missing so far from a classical stretched PV/reflective event is positive WAFZ quickly followed by negative WAFz. So far there is no prediction of this as was observed in mid-December, instead only positive WAFz is predicted (see Figure 12). Only positive WAFz is more of an indication of an impending SSW.

But admittedly there is not much support for the pattern change associated with a stretched PV in the today's weather models. I will note that it is my observation that the models are slow to predict the correct pattern related to stretched PVs. Also there is typically a delay from the peak in stretched PV/reflective events and the cold temperatures across eastern North America of about a week (see Figure 11 in Matthias and Kretschmer 2020). So, I don't think that it is sign a transition to a colder pattern is not happening just because the models aren't showing it just yet.

But in addition, I do think there is a good chance that a larger PV disruption is possible more closely related to a sudden stratospheric warming (SSW) something else not supported by the weather models. Our statistical model of the PV is showing the highest probability of an SSW so far this winter for the very end of January and into early February. This model suffers from too many false positives and did so as recently for early January. But the signal for the end of the month is stronger. I do think that the risk of an SSW is greater now that below normal geopotential heights have returned to the northern North Pacific, something absent so far this fall and winter. Again, there is little support for an SSW from the weather models, but I would not expect them to be able to predict one for the end of January into early February. I showed in a previous blog that a PV displacement tends to favor cold in eastern North America but less so for Europe. I was considering showing the same graphics now, but I don't want to get ahead of myself. If one starts to look more likely there is still plenty of time to discuss the expected temperature anomalies.

In conclusion, I think a stretched PV event is likely though not all indicators are consistent with this expectation. A stretched PV should induce a pattern change that results in colder temperatures in eastern North America. However, the models are so far not supportive of my expectation of a transition to a colder pattern in eastern North America (and the 12z GFS is even less supportive than the 0z GFS). It could be that the models are slow to recognize the pattern transition or that the pattern transition is outside the models' forecast range. Of course, a third possibility is that I am wrong. I also think that it is possible that the predicted stretched PV could be the early stages of a larger PV disruption that will support colder weather but the impact on the weather is typically more delayed than from a stretched PV.

Typically, a stretched PV doesn't necessarily result in colder weather for Europe, however because the high-latitude blocking is focused in the Barents-Kara Seas and not the Urals this is more conducive for allowing colder air to flow west out of Siberia towards Northern Europe. So, after the record warmth, colder weather seems likely for at least Northern Europe.

Wednesday Update

If you have been following the blog the last few weeks, I have been struggling trying to interpret the upcoming predicted disruption to the PV; is it a reflected WAF/stretched PV event or an absorbed WAF/sudden stratospheric warming (SSW) event? It's important for the near-term weather because reflective/stretched PV events favor colder weather in the Eastern US while absorbed/SSW events favor mild temperatures in the Eastern US, at least initially. I included a table in the blog post from 7 December 2020 that is very relevant for this debate or confusion in my head, that I think is worth looking at. On the one hand the models are predicting a beautifully stretched PV but at the surface the weather model forecasts are getting warmer?

I think I may have solved the paradox and the answer is that we are seeing both. I still think that we are seeing near term a stretched PV/reflective event. I include an updated forecast for the predicted WAF in the vertical and latitudinal direction for the next five days (see **Figure iii**). It still clearly shows the WAF is upward over Asia, reflects off the PV and then is downward over North America. However, it is a relatively weak and of short duration. And it's impact on the wave pattern across North America is short enough that if you blink you will miss it. I think it shows up best in the ECMWF ensembles. Not textbook, but enough of a western ridge/eastern trough pattern for Martin Luther King weekend (see **Figure iv**; coincidence, I think not). And looks to me the first credible threat of a US East Coast snowstorm so far this winter.

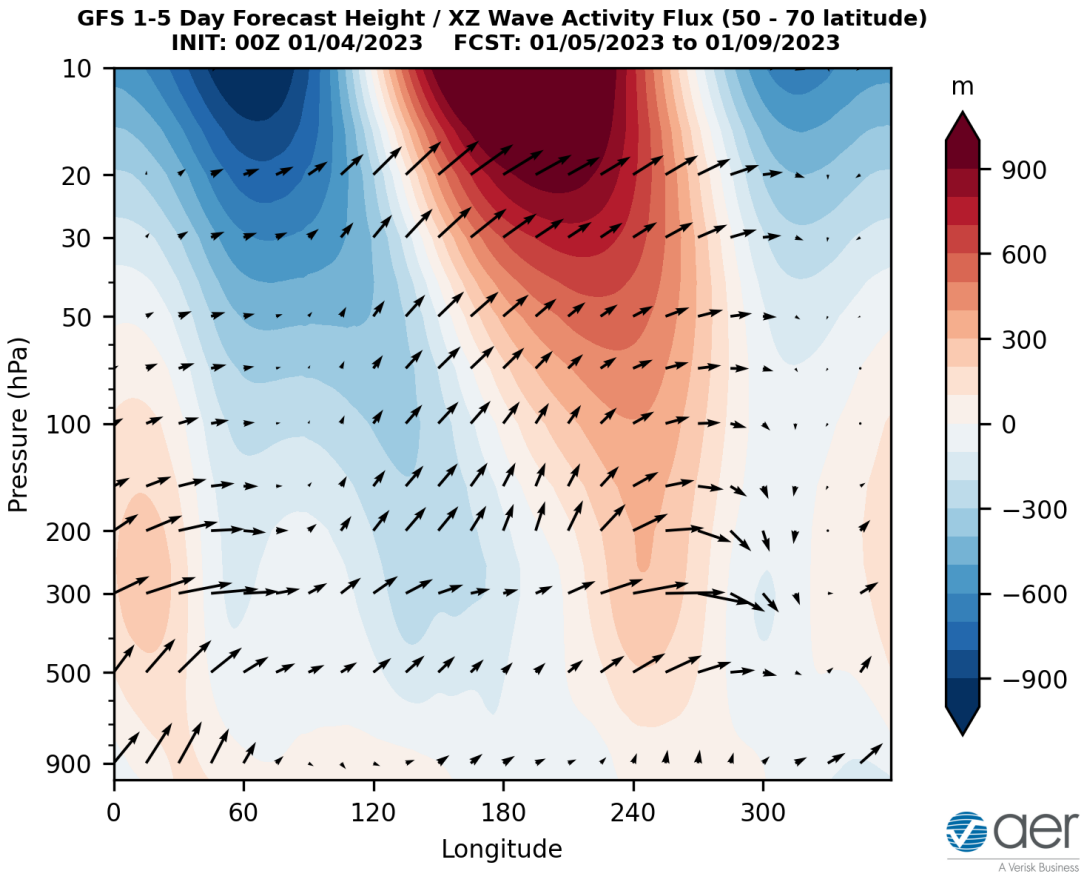

Figure iii. Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 5 – 9 January 2023. The forecast is from the 00Z 4 January 2023 GFS operational model.

But if the WAF in the next week or so has bought a return ticket from the troposphere to the stratosphere and back again to the troposphere, the WAF beginning next week is very different. But first look at the 500 hPa geopotential height forecast from the 12Z GFS today (see **Figure v**). The anomalies form some of wave-2 (2-pairs of ridge-troughs couplet across the NH) but mostly wave-1 (only 1-pair of ridge-trough across the NH). Wave-2 is needed for wave reflection as we discussed in Cohen et al. 2022. But wave-2 leads to wave absorption or SSWs almost exclusively (for now admittedly a bit speculative on my part).

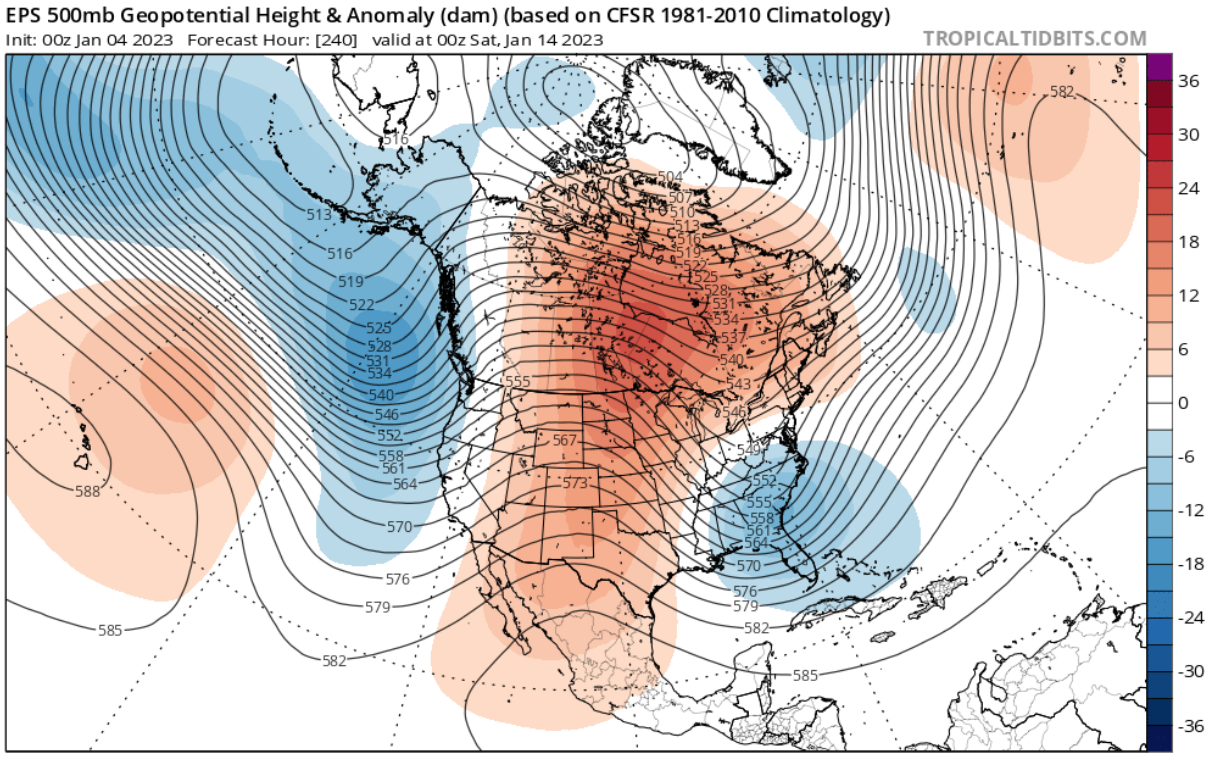

Figure iv. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across Northern America for 14 January 2023. The forecasts are from the 00z 4 January 2023 ECMWF ensemble. Graph taken from https://www.tropicaltidbits.com/analysis/models/.

And finally looking at the predicted WAF in the vertical and longitudinal direction for the 11–15-day period – the WAF is all up (see **Figure vi**). Those WAF vectors are well straight as an arrow, and they are on a one-way ticket from the troposphere to the stratosphere with no return. That WAF is clearly being absorbed in the polar stratosphere. So even though the shape or configuration of the PV looks stretched or elongated, without wave reflection there is no reason to expect the development of a western ridge/eastern trough across North America, in fact it makes sense to expect the opposite. If convergence of WAF in the troposphere over North America is needed for the western ridge/eastern trough pattern, it's absence should support just the opposite a western trough/eastern ridge pattern consistent with the model forecasts. It has always bothered me why it is almost always mild in the Eastern US leading up to an SSW. I think what I just speculated is the beginning of a reason.

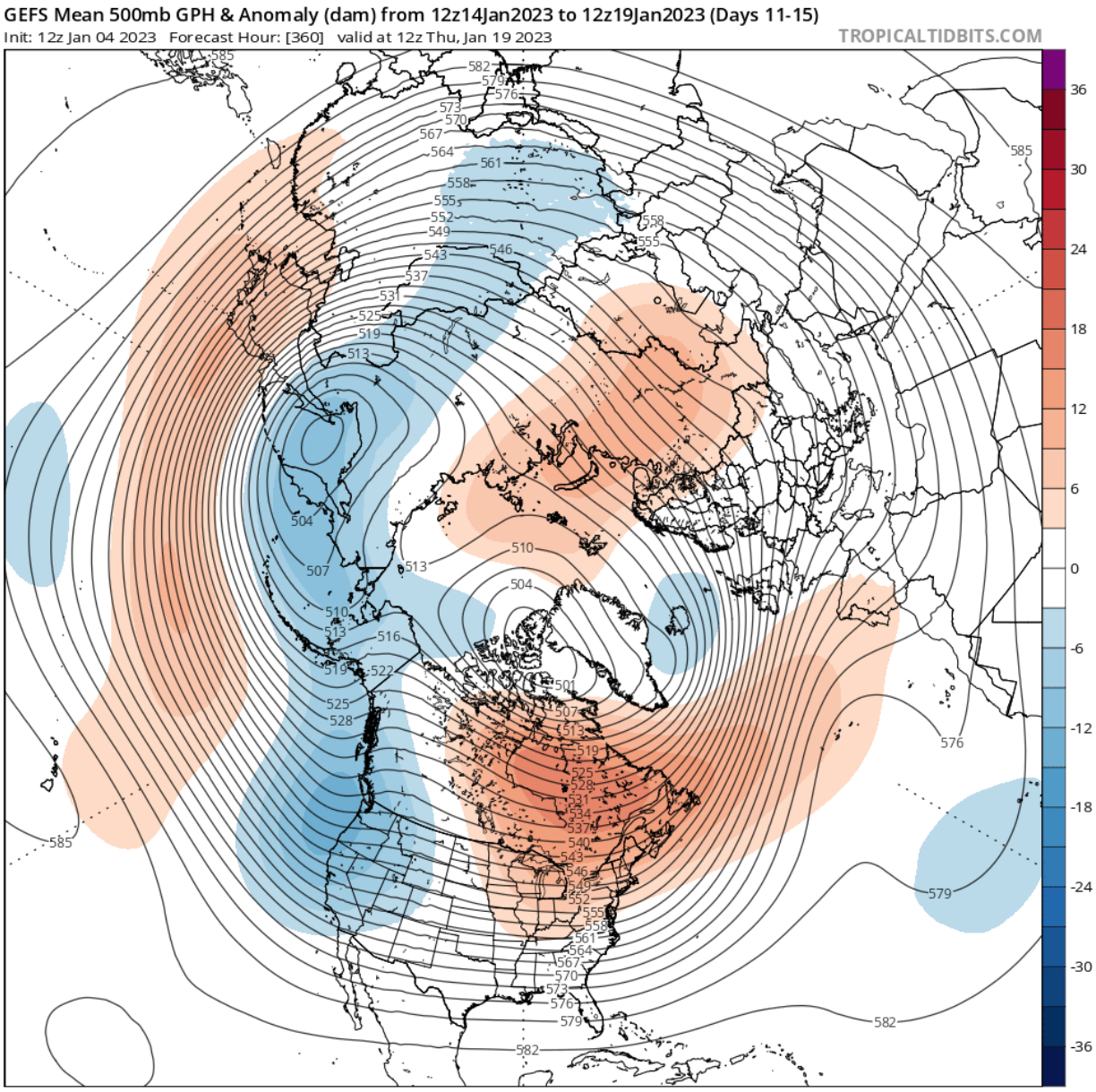

Figure v. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 19 January 2023. The forecasts are from the 12z 4 January 2023 GFS ensemble. Graph taken from https://www.tropicaltidbits.com/analysis/models/.

So if I am right (always a valid question), for the Eastern US we have a brief reflective event for MLK weekend. It coincides with a winter storm threat. I am a big believer that Mother Nature likes to foreshadow and therefore IMO if there is any meaningful winter left in the tank of 2023 for the Northeastern US, I think a snowstorm of some sort needs to materialize. But this very quickly followed by a regime consistent with the lead up to an SSW. Cold air should be focused across Northern Eurasia and probably in western

North America. If the SSW materializes, a cold pattern should dominate possibly through the remainder of winter but the details of who gets the cold and the snow are still yet to be determined depending on the evolution of the SSW and coupling with the troposphere. But as seems to be the case these days there could be dramatic differences between winner and losers, and how you define winners and losers depends on your perspective.

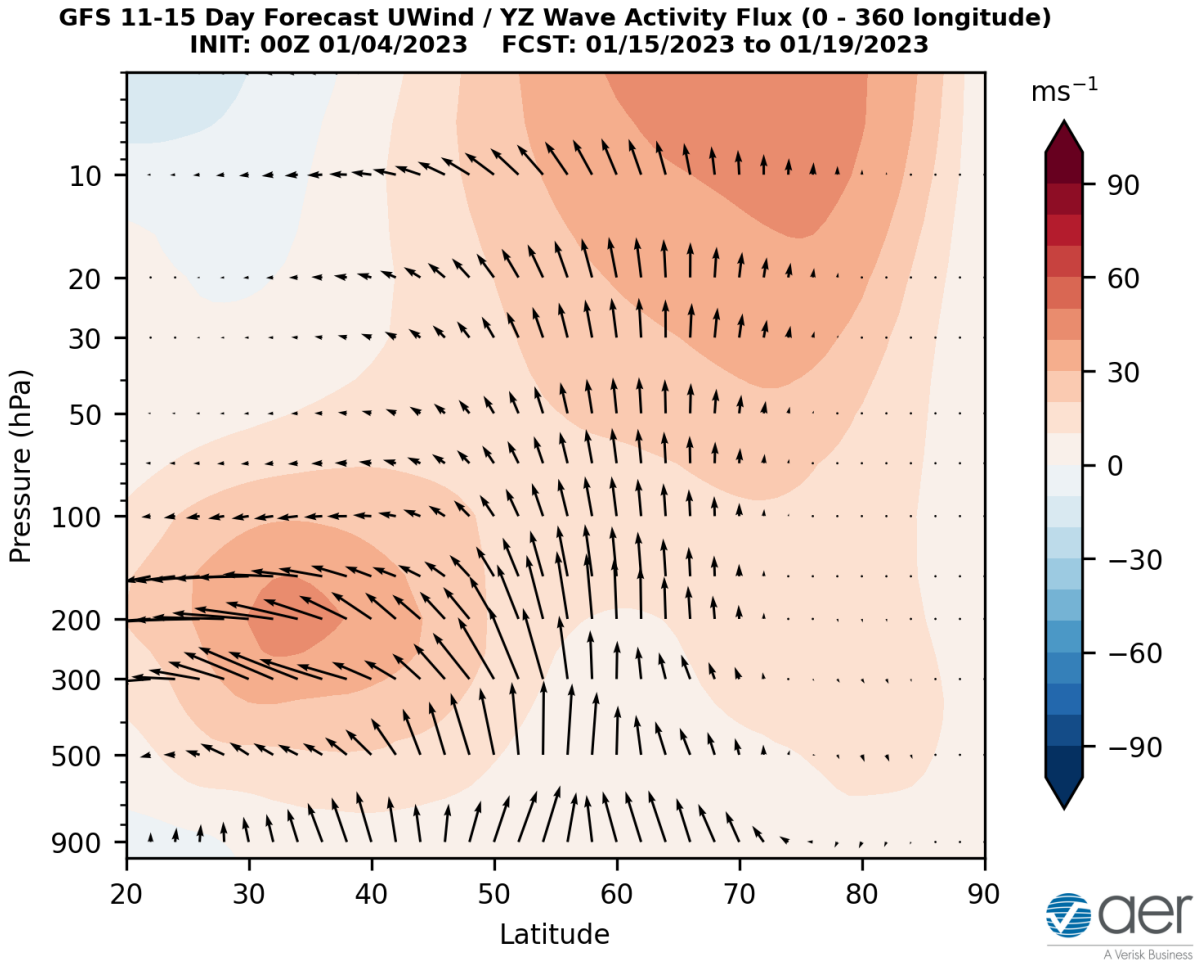

Figure vi. Latitude-height cross section of zonal mean zonal wind (shading) and wave activity flux (vectors) forecasted for 15 – 19 January 2023. The forecast is from the 00Z 4 January 2023 GFS operational model.

Lots going on with the stratospheric polar vortex, a large range of possibilities and lots of uncertainty. But this is why I write the blog and hopefully you enjoy reading it.

Recent and Very Near Term Conditions

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

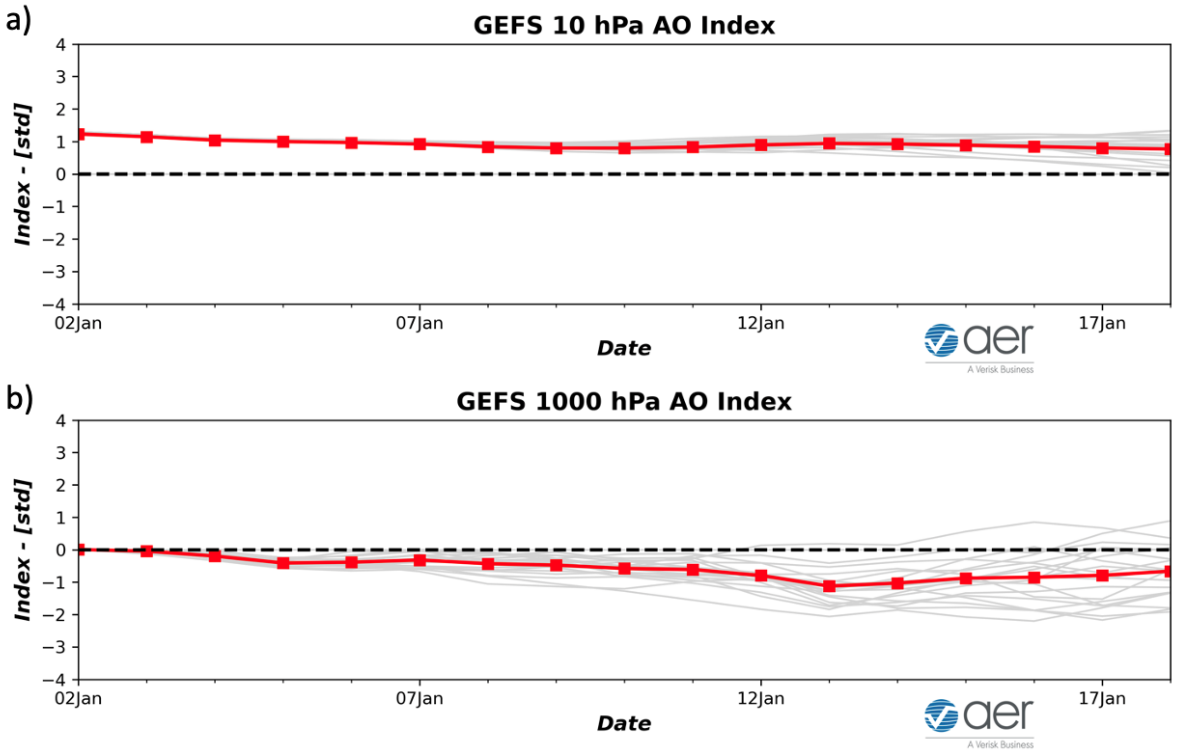

Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 2 January 2023 GFS ensemble. (b)The predicted daily-mean near-surface AO from the 00Z 2 January 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Predicted troughing/negative geopotential height anomalies across Greenland will favor ridging/positive geopotential height anomalies across much of Europe with the exception of troughing/negative geopotential height anomalies across Northwestern Europe (**Figure 2).** This will favor normal to above normal temperatures across much of Europe including the UK except for normal to below normal temperatures across Scandinavia (**Figure 3**). Ridging/positive geopotential height anomalies in the Barents-Kara Seas will favor troughing/negative geopotential height anomalies across Siberia with more ridging/positive across Southern Asia (**Figure 2**). This pattern favors normal to above normal temperatures across much of Asia with normal to below normal temperatures mostly limited to Northern Siberia **(Figure 3**).

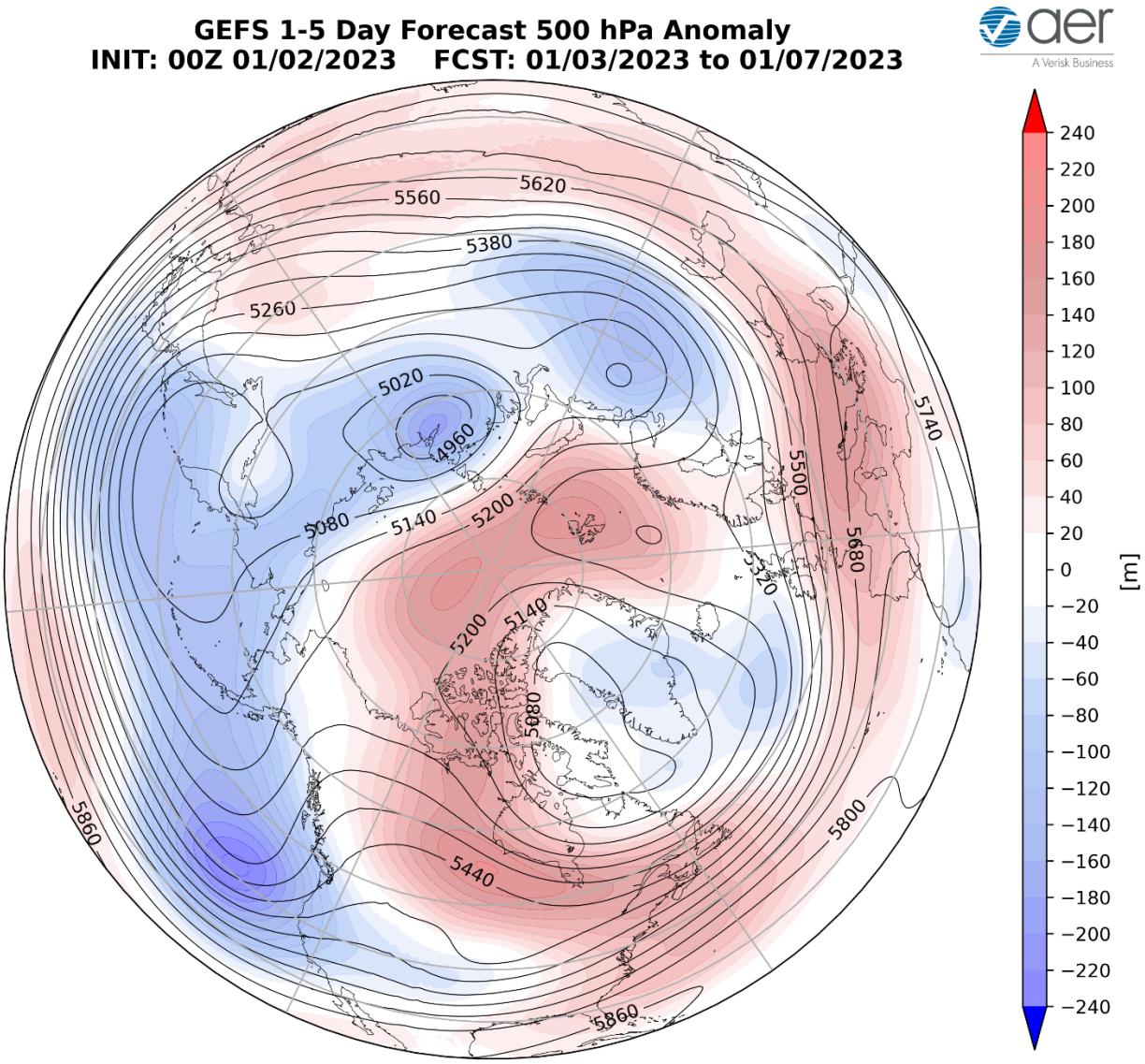

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 January 2023. The forecasts are from the 00z 2 January 2023 GFS ensemble.

Troughing/negative geopotential height anomalies predicted to be centered in the Gulf of Alaska will force ridging/positive geopotential height anomalies across eastern North America **(Figure 2).** The pattern will favor normal to above normal temperatures across much of North America except for normal to below normal temperatures across the

West Coast of Canada and the Western US **(Figure 3).**

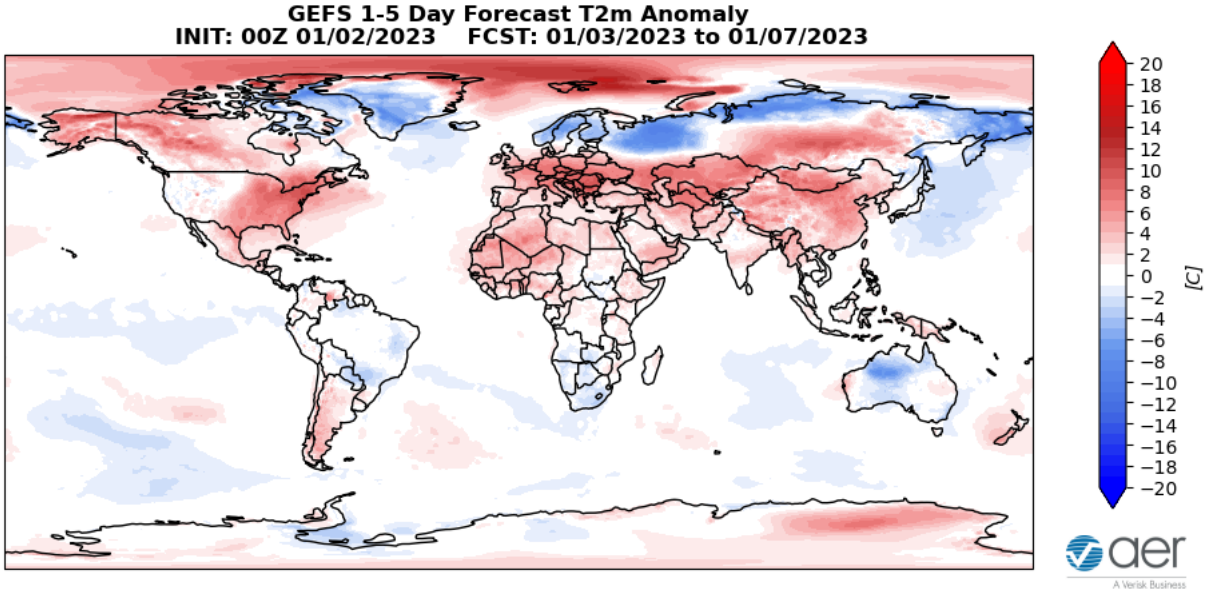

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across parts of Scandinavia, Western and Central Asia while mild temperatures will support snowmelt in across parts of Scandinavia, Western and Central Asia (**Figure 4**). Troughing and/or cold temperatures will support new snowfall across southern Alaska, Western and Central Canada the US Plains and Maine while mild temperatures will support snowmelt across Central Alaska, Southern and Western Canada, the Western US and the Great Lakes (**Figure 4**).

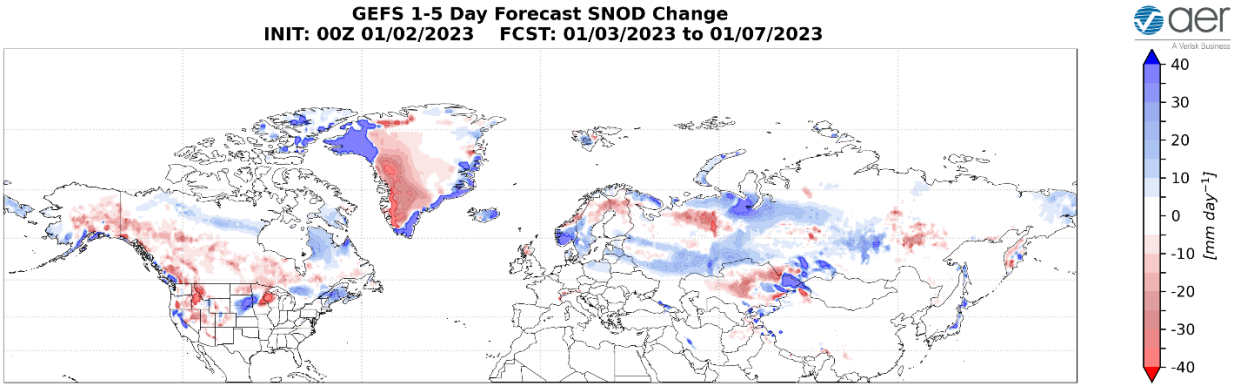

Figure 4. Forecasted snow depth changes (mm/day; shading) from 3 – 7 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Near-Term

1-2 week

The AO is predicted to slowly trend negative this period **(Figure 1**) as geopotential height anomalies become increasingly positive across the Arctic and mixed across the mid-latitudes (**Figure 5**). With mostly troughing albeit positive geopotential height anomalies across Greenland (**Figure 5**), the NAO is predicted to remain positive this period as well.

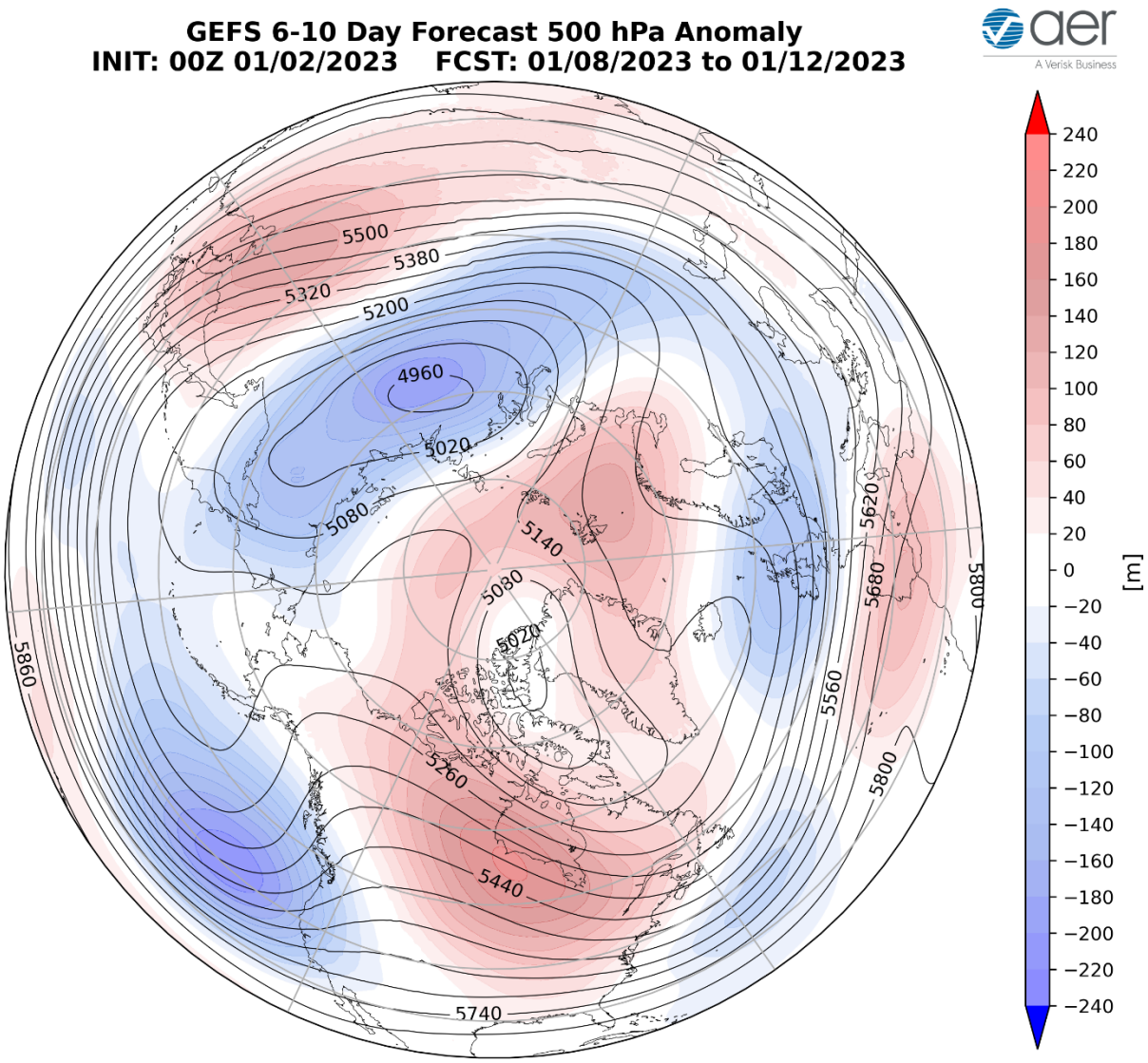

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 January 2023. The forecasts are from the 00z 2 January 2023 GFS ensemble.

Ridging/positive geopotential height anomalies across the Barents-Kar Seas favor troughing/negative geopotential height anomalies across North Europe with ridging/positive geopotential height anomalies across Southern Europe (**Figures 5).** This pattern favors normal to below normal temperatures are predicted to persist across Scandinavia this period including the Baltics States with normal to above normal temperatures across Southern and Central Europe including the UK (**Figure 6**). Persistent ridging/positive geopotential height anomalies in the Barents-Kara Seas are predicted to anchor troughing/negative geopotential height anomalies across Siberia with more ridging/positive geopotential height anomalies across Southern Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Southern Asia with normal to below normal temperatures predicted across Northern Asia **(Figure 6**).

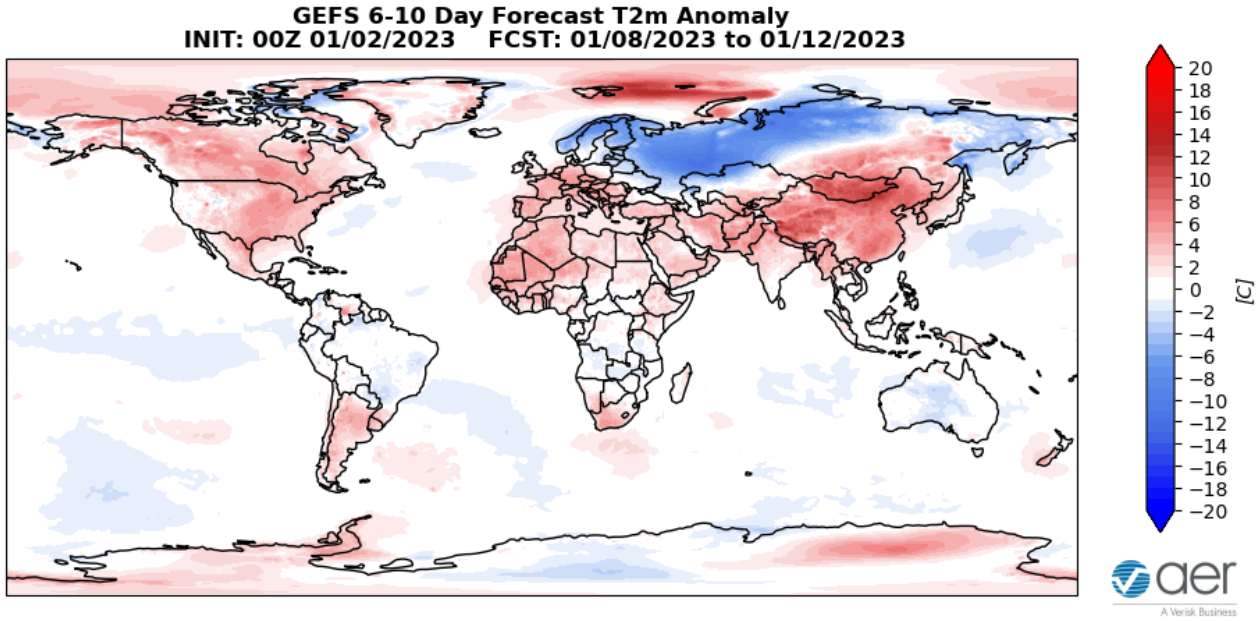

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies centered in the Gulf of Alaska will anchor ridging/positive geopotential height anomalies across eastern North America this period **(Figure 5).** This pattern will favor widespread normal to above normal temperatures North America with normal to below normal temperatures limited to parts of Alaska, the West Coast Canada and the Western US **(Figure 6).**

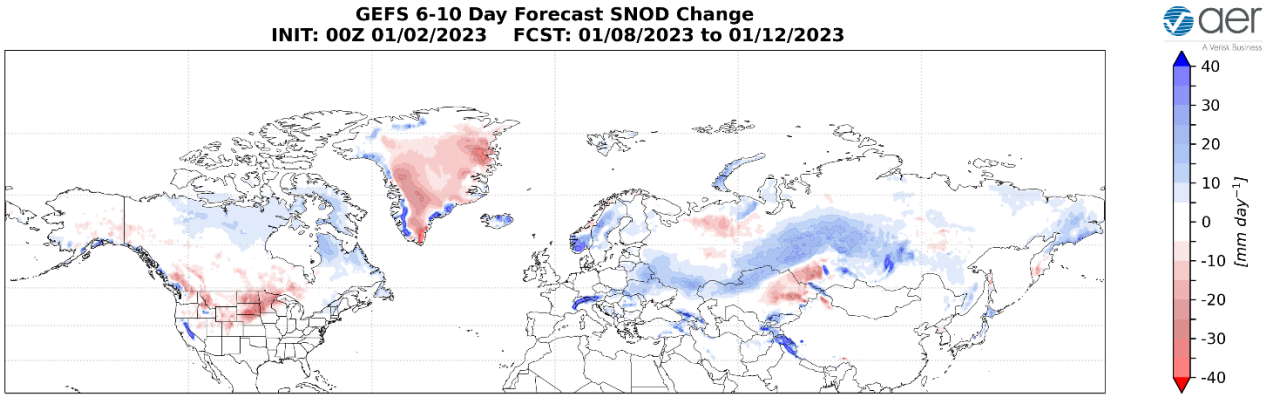

Figure 7. Forecasted snow depth changes (mm/day; shading) from 8 – 12 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Scandinavia, Eastern Europe, the Alps, Western, Central and Eastern Siberia while mild temperatures will support snowmelt in the Urals and parts of Central Asia (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across Northern and Eastern Canada and the Sierras while mild temperatures will support snowmelt in Southwestern Canada and the US Rockies and Plains (**Figure 7**).

3-4 week

As positive geopotential height anomalies are predicted to increase across the Arctic with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO should continue to trend negative this period (**Figure 1**). With weak but positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will trend to neutral this period.

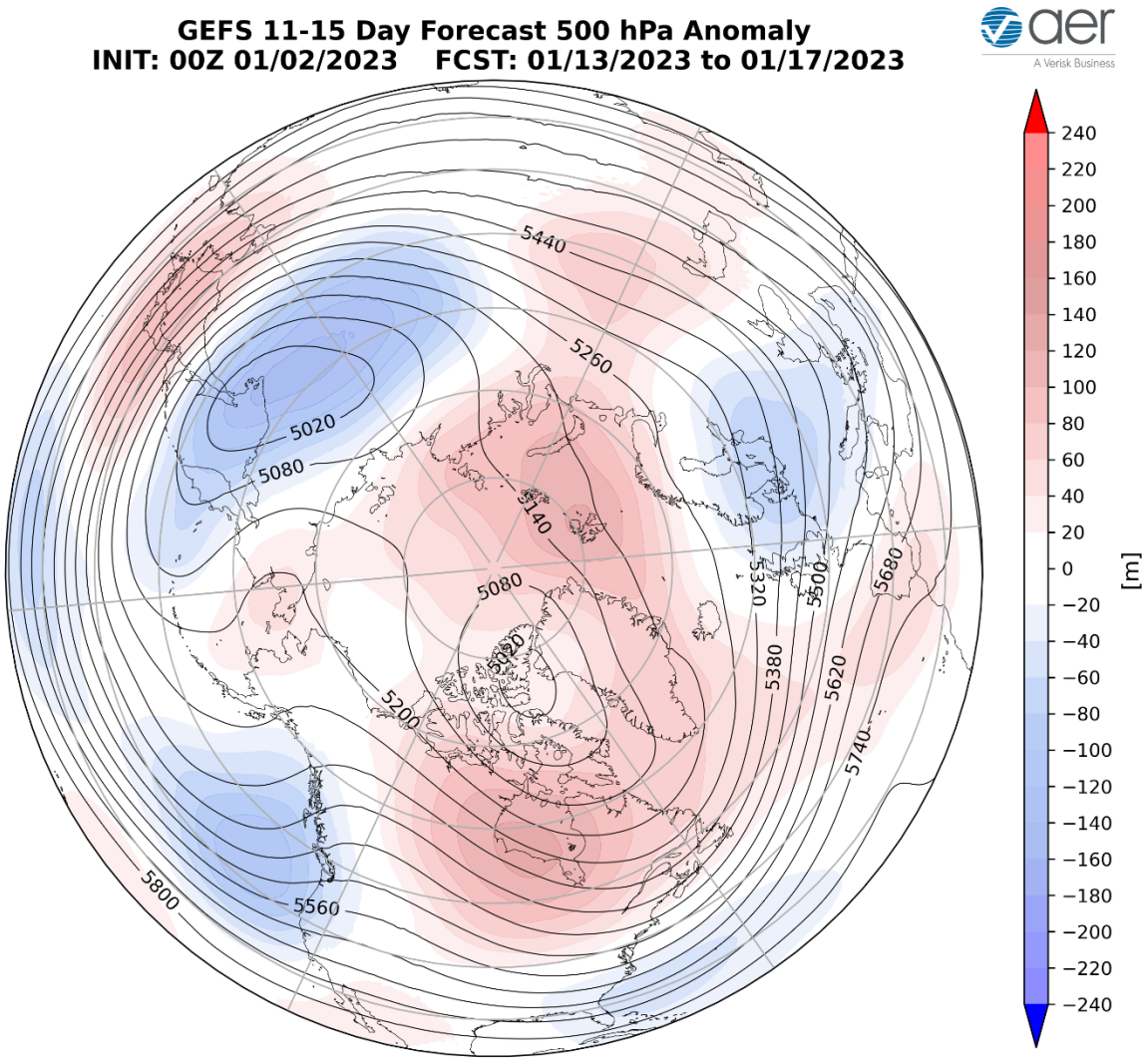

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 January 2023. The forecasts are from the 00z 2 January 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies predicted across the Barents-Kara Seas that now extends southward across the Urals will support troughing/negative geopotential height anomalies centered on the Baltic Sea with more ridging/positive geopotential height anomalies across Southwestern Europe this period (**Figure 8**). This pattern favors normal to above normal temperatures across Southern and Central Europe with normal to below normal temperatures across Northern and Eastern Europe including Scotland (**Figures 9**). Predicted persistent ridging/positive geopotential height anomalies the Barents-Kara Seas will help to anchor troughing/negative geopotential height anomalies across Siberia with more ridging/positive geopotential height anomalies across Southeastern Asia (**Figure 8**). This pattern favors widespread

normal to below normal temperatures across Northern Asia with normal to above normal temperatures across Southern Asia (**Figure 9**).

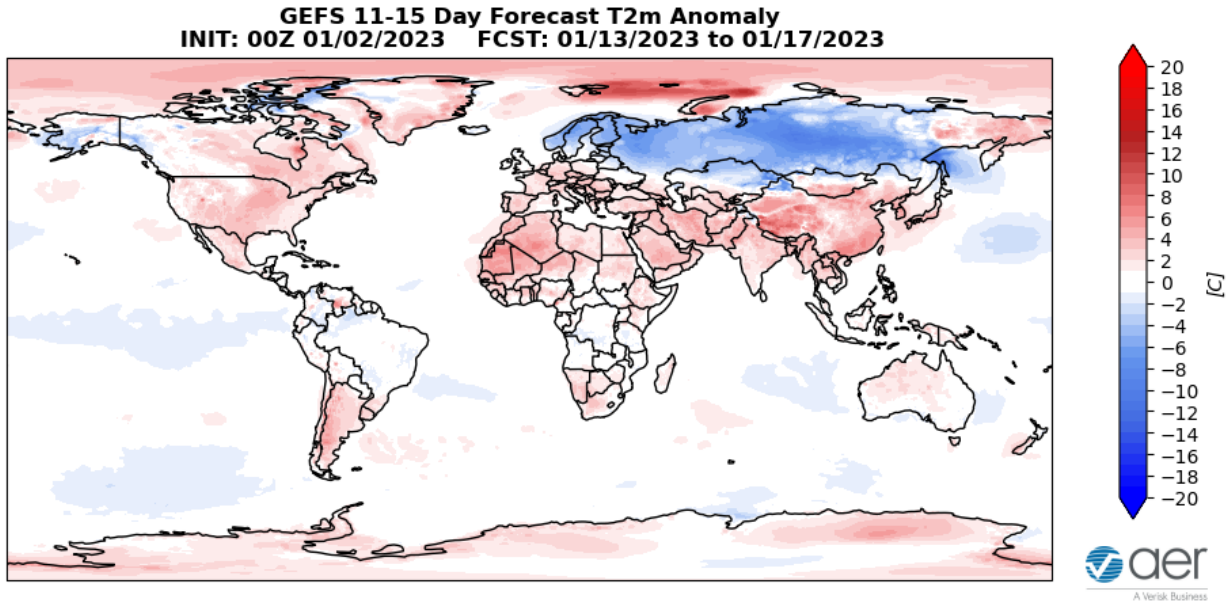

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Predicted persistent troughing/negative geopotential height anomalies in the Gulf of Alaska will continue to favor ridging/positive geopotential height anomalies across eastern North America with the exception troughing/negative geopotential height anomalies in the Southeastern US this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Canada and the US with the exception of normal to below normal temperatures across parts of Alaska, the West Coasts Canada and the US (**Figure 9**).

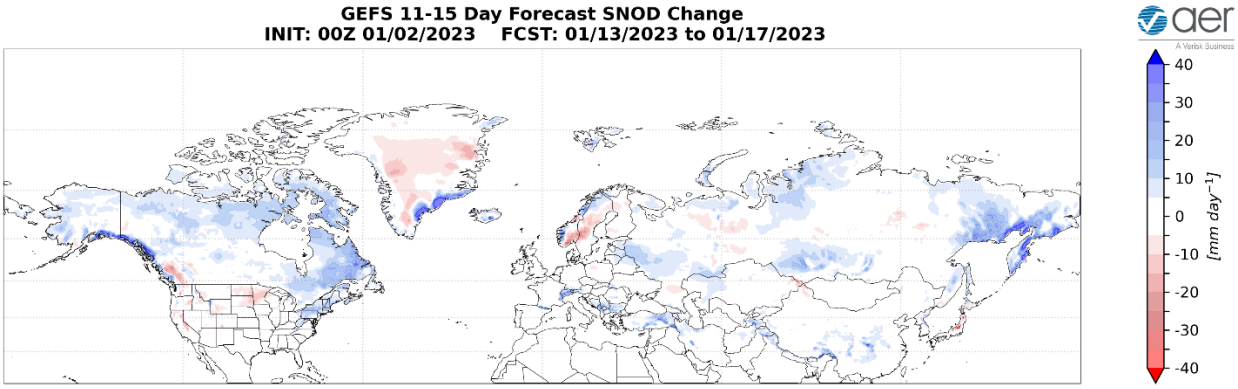

Figure 10. Forecasted snow depth changes (mm/day; shading) from 13 – 17 January 2023. The forecast is from the 00Z 2 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Norway, Northeastern and Southeastern Europe including Turkey, Western, Central and Eastern Asia while mild temperatures will support snowmelt in Sweden (**Figure 10**). Troughing and/or cold temperatures will support new snowfall across western Alaska, Canada and the Northeastern US while mild temperatures will support snowmelt in Southwestern Canada, the Rockies and the US Upper Midwest (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs throughout the stratosphere and the troposphere (**Figure 11**). However, the cold/negative PCHs in the stratosphere are predicted to weaken and warm/positive PCHs are predicted to appear and strengthen in the low and mid-troposphere starting this week (**Figure 11**).

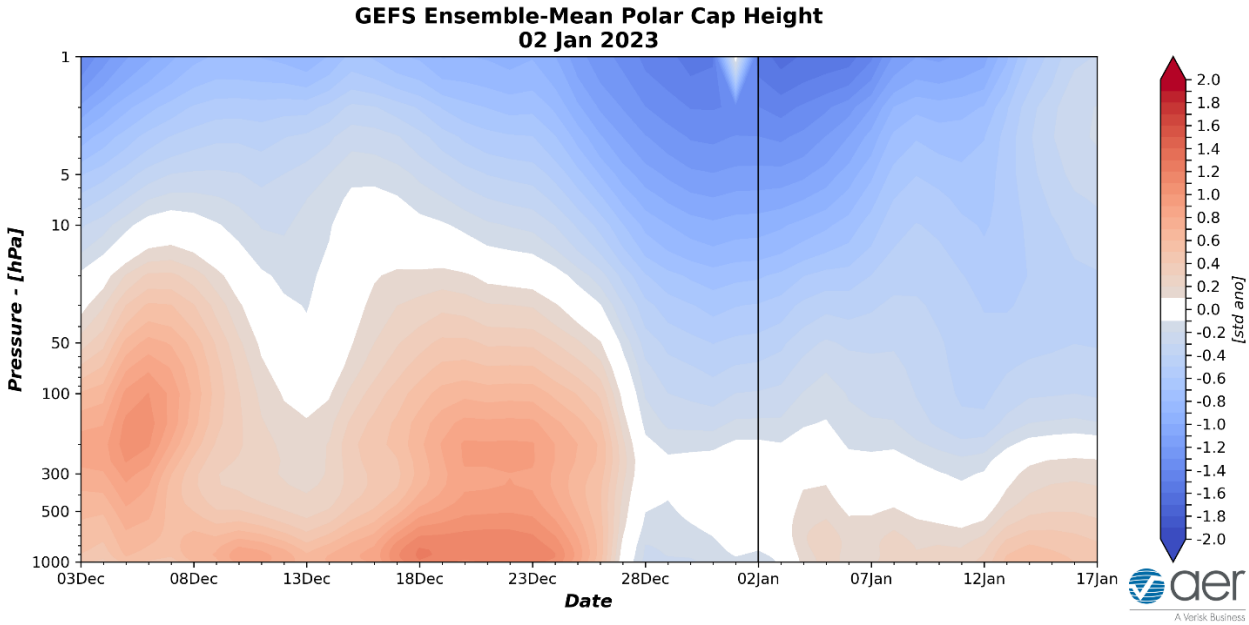

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 2 January 2023 GFS ensemble.

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

1). However next week when the warm/positive PCHs in the lower troposphere are predicted to strengthen (**Figure 11**), the AO could become more negative (**Figure 1**).

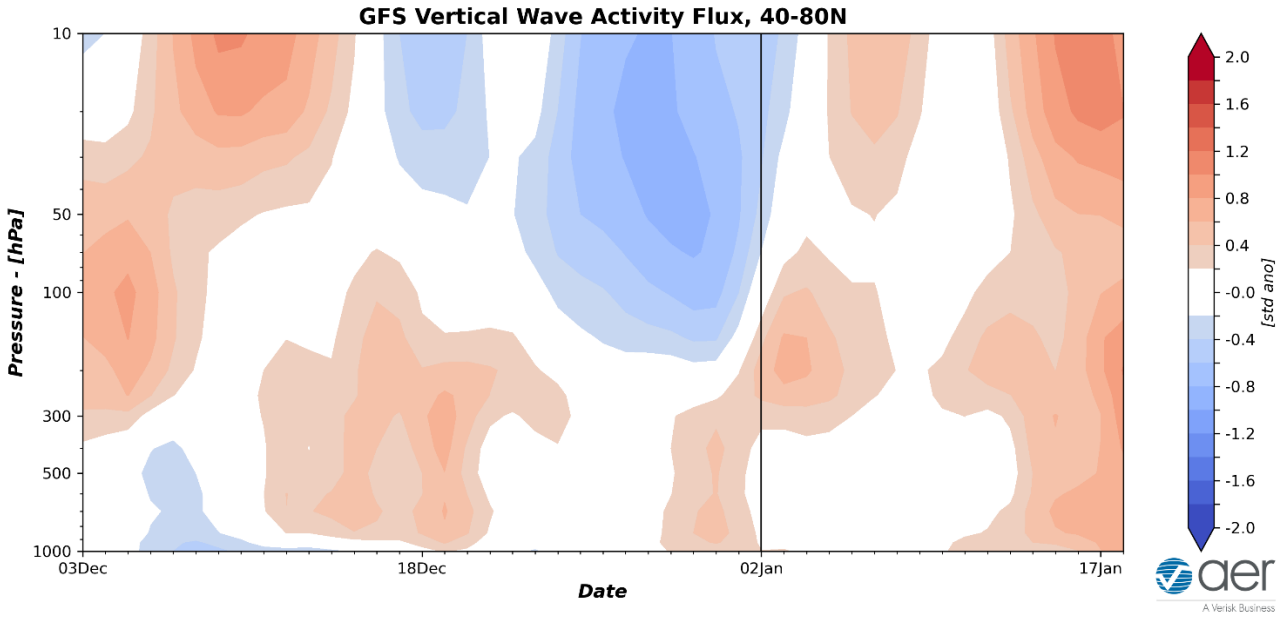

Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 2 January 2023 GFS ensemble.

The below normal vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere the past two weeks (**Figure 12**) has resulted in very cold/negative stratospheric PCHs (**Figure 11**). The GFS is predicting the WAFz will become more active in the next two weeks (**Figure 12**), resulting in overall warming of the stratospheric PCHs through mid-January (**Figure 11**).

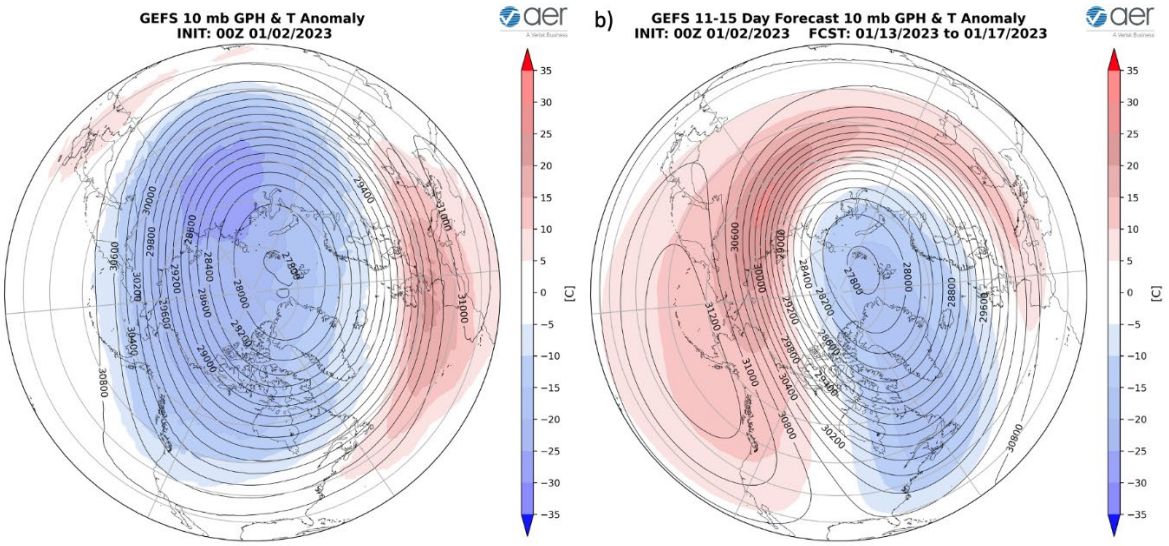

Figure 13. (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 2 January 2023. (b) Same as (a) except forecasted averaged from 13 – 17 January 2023. The forecasts are from the 00Z 2 January 2023 GFS model ensemble.

Still the lack of active WAFz has allowed for a strong stratospheric PV with the PV center shifted over towards Svalbard **(Figure 13**). The concentration of cold geopotential heights in the polar stratosphere are consistent with a strong PV (**Figure 13**). The above normal WAFz predicted for the next two weeks will perturb the PV, with the PV shape become oblong in shape and for warming/ridging to form centered near Alaska (**Figure 13**). These are all signs of a stretched PV. Despite any disruptions of the PV, the AO is predicted to remain positive over the next two weeks **(Figure 1**).

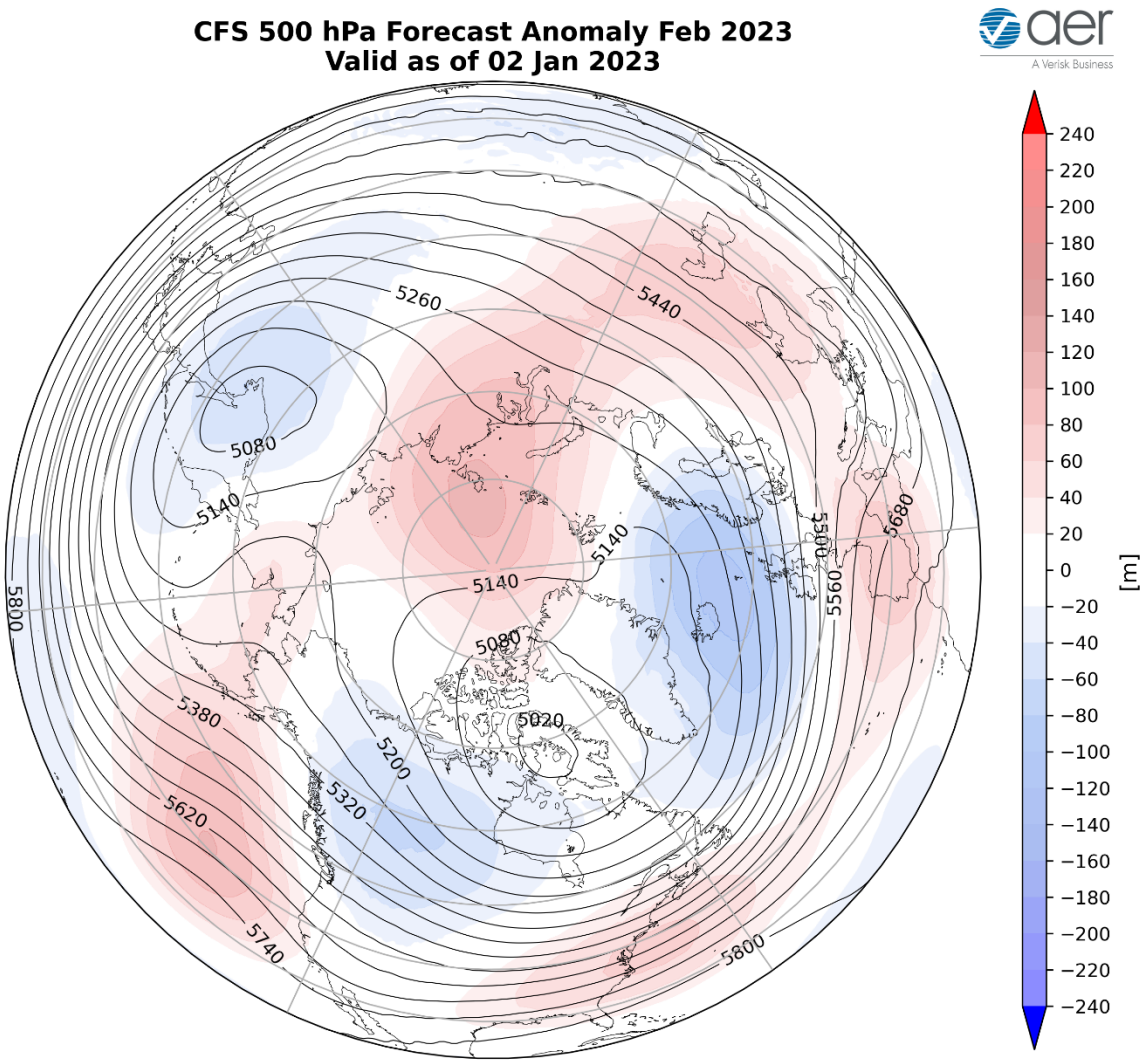

Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for February 2023. The forecasts are from the 00Z 2 January 2023 CFS.

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 across Southwestern Europe, stretching from the Laptev Sea southwestward towards the Caspian Sea, the Gulf of Alaska and the Eastern US with troughing stretching from Greenland to Scandinavia, Siberia and western North America (**Figure 14).** This pattern favors seasonable to relatively warm temperatures across Europe, Western Asia, Eastern Siberia and the Eastern US with seasonable to relatively cold temperatures across Siberia, East Asia, Alaska, Eastern Canada and the Northwestern US (**Figure**

15).

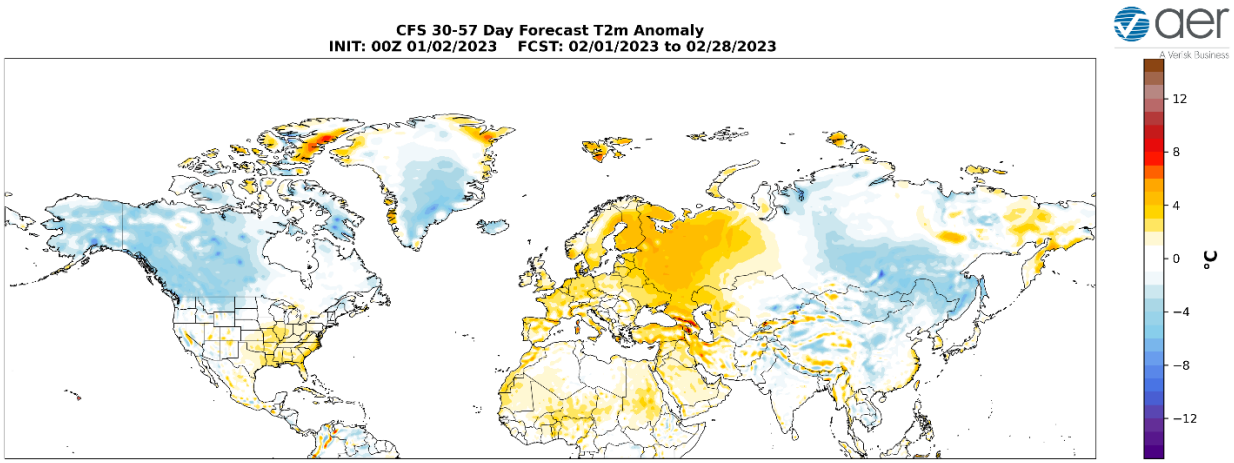

Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for February 2023. The forecasts are from the 00Z 2 January 2023 CFS.

Boundary Forcings

Arctic Sea Ice

Arctic sea ice, which as expected is below normal (see **Figure 16**) but the regional anomalies have been more extensive in recent years. The greatest concentration of below normal is in the Barents-Kara Seas, which I believe favors high latitude blocking. So, it could be Arctic sea ice is increasingly favoring high latitude blocking in the Barents-Kara Seas region and PV disruptions.

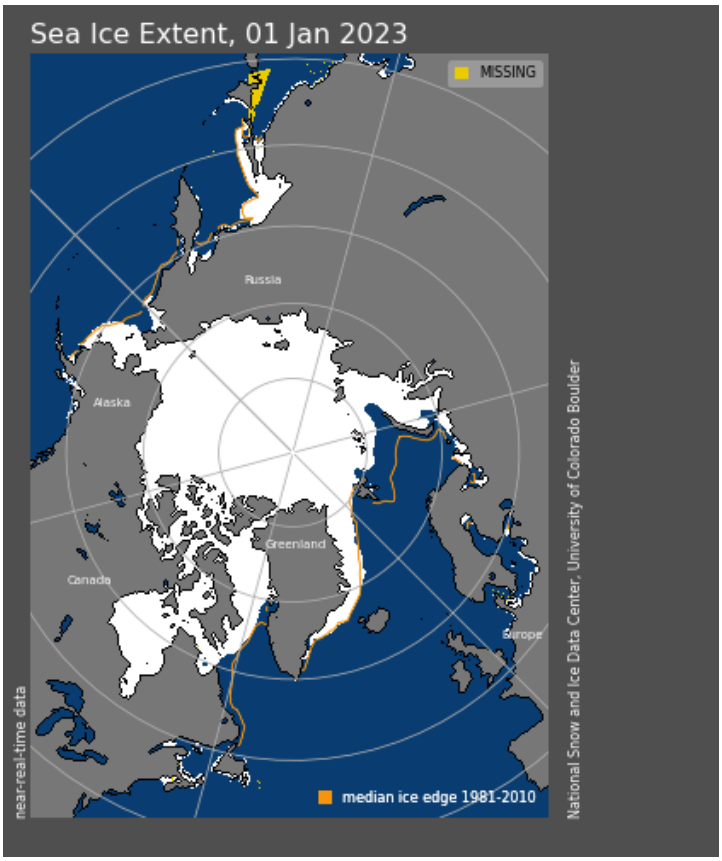

Figure 16. Observed Arctic sea ice extent on 1 January 2023 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC).

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 17)** and La Niña conditions are expected through the fall. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

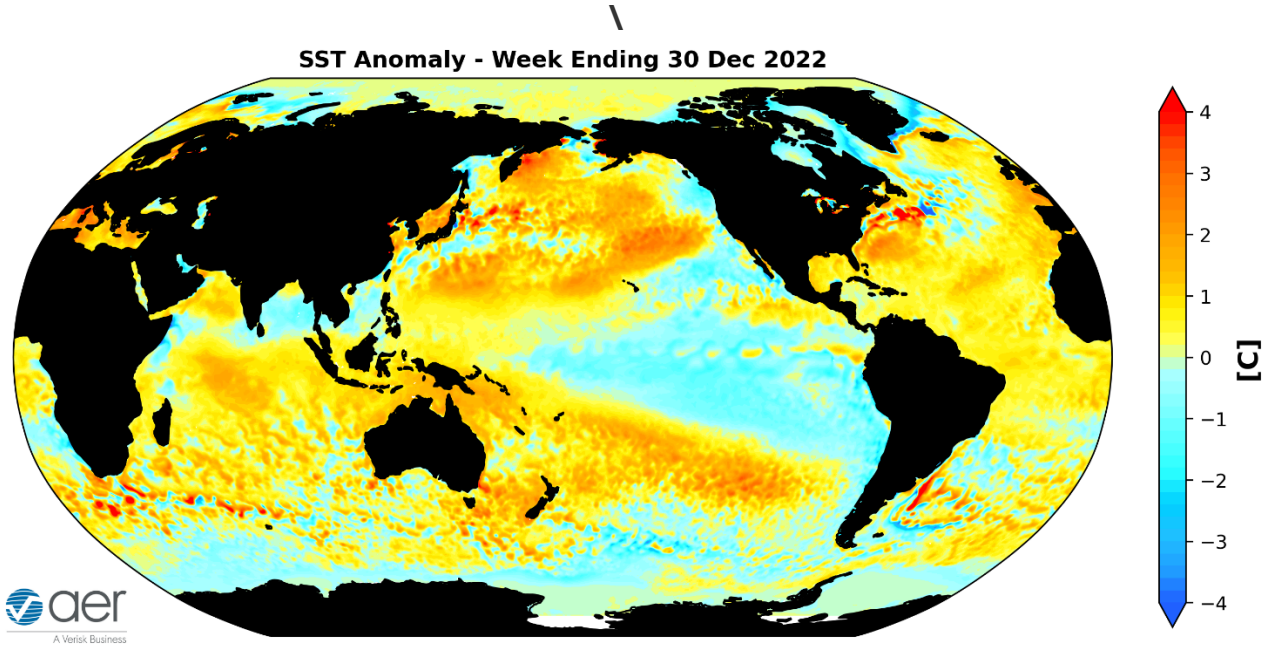

Figure 17. The latest weekly-mean global SST anomalies (ending 30 December 2022). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is in phase seven (**Figure 18**). The forecasts are for the MJO to transitions to phase eight next week. Phase seven favors first troughing over the Western US with ridging across eastern North America and then phase eight favors ridging over the Western US with increasing troughing in the Eastern US. Seems that the MJO could be having an influence on the weather across North America in the short term. But admittedly this is outside of my expertise.

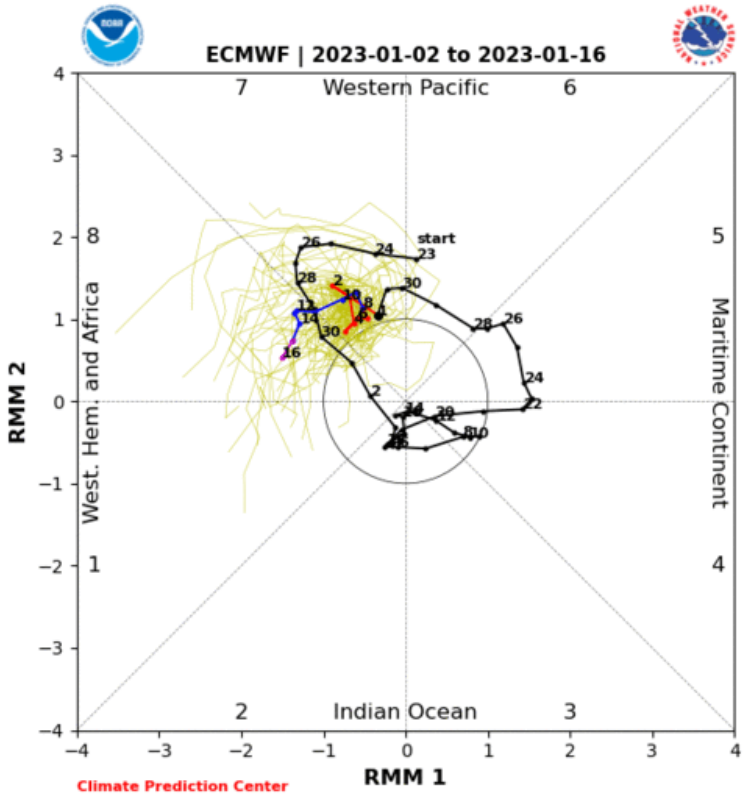

Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 2 January 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html

Snow Cover

Snow cover extent (SCE) across the NH has declined this past week due to mild temperatures in both North America and Eurasia (see **Figure 19**). Snow cover has declined both across North American sand Eurasia this week and therefore SCE is at decadal lows. With the predicted widespread cold across Eurasia, I expect snow cover to advance more rapidly across Eurasia than North America next week.

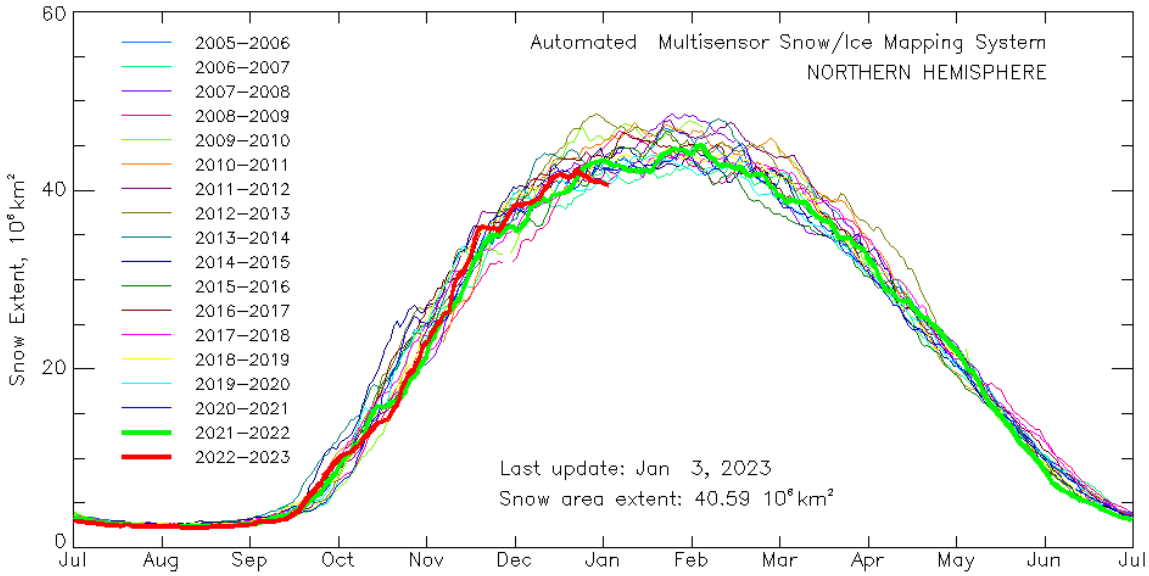

Figure 19. Observed North American snow cover extent through 3 January 2023. Plot from https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_monitor.html