Arctic Oscillation and Polar Vortex Analysis and Forecasts

November 29, 2021

Dear AO/PV blog readers:

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

For those who would like an early look on Mondays, we will be offering at a nominal price (US $25) a PDF version of the upcoming blog, and we will be rolling out in the coming weeks 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 trend positive this week and then remain positive the next two weeks with mostly negative pressure/geopotential height anomalies across the Arctic and mixed

pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently negative and is predicted to also trend positive as pressure/geopotential height anomalies that are currently positive become increasingly negative across Greenland the next two weeks.

- This week ridging/positive geopotential height anomalies in the central North Atlantic will favor troughing/negative geopotential height anomalies coupled with normal to below temperatures across Northern and Western Europe including the United Kingdom (UK). However next week the return of troughing/negative geopotential height anomalies across Greenland will no longer support troughing/negative geopotential height anomalies and heights are predicted to rise across Europe with normal to above normal temperatures becoming more widespread across Europe including the UK.
- The predicted general pattern across Asia this week is troughing/negative geopotential height anomalies coupled with normal to below temperatures across far Northern Asia with ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across much of Asia. However next week ridging/positive geopotential height anomalies coupled with normal to above temperatures are predicted to develop across Western Asia forcing troughing/negative geopotential height anomalies coupled with normal to below normal temperatures across Northeastern Asia.
- The predicted pattern across North America the next ten days is ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across the Western and Southern United States (US) with ridging/positive geopotential height anomalies coupled with normal to above temperatures extending from Alaska into the Northeastern US. However, next week strengthening ridging/positive geopotential height anomalies near the Aleutians will force troughing/negative geopotential height anomalies coupled with normal to below normal temperatures across western North America with strengthening ridging/positive geopotential height anomalies coupled with normal to above temperatures in the Eastern US and Southeastern Canada.
- In the *Impacts* section I present an updated winter Northern Hemisphere (NH) temperature forecast and share some bewildering observations from the current pattern.

Plain Language Summary

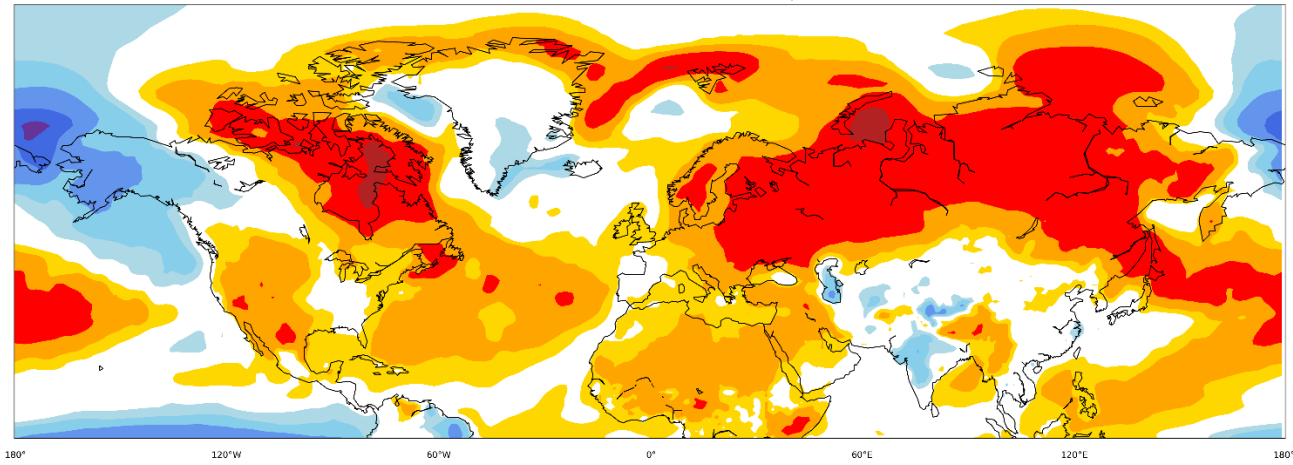
We have updated the AER winter forecast placing more emphasis on sea surface temperatures in the North Pacific. The revised forecast is warmer across the US Lower 48 compared to the initial forecast. But for the forecast to verify some big changes are needed to the atmospheric circulation because the current pattern of a strong polar vortex and cold Arctic, if persistent, strongly favors an overall mild winter across the Northern Hemisphere continents. But signs the cavalry is just over the hill, the predicted return of high pressure to the Urals and Barents-Kara Seas region. But it will need to

persevere without the help of melted sea ice, given the unexpected extensive Arctic sea in the region.

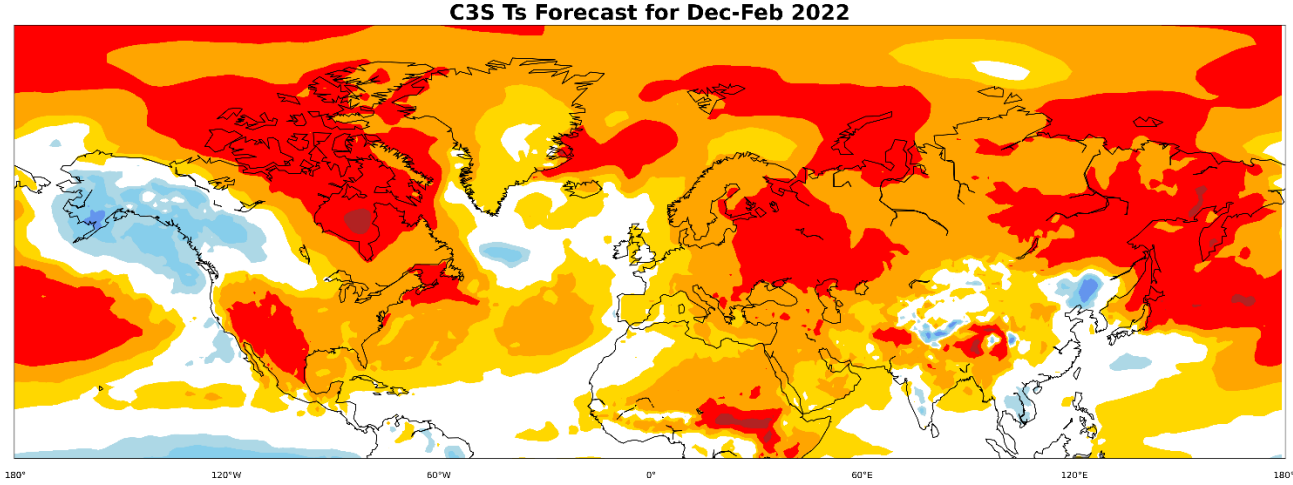
Impacts

We have updated the AER NH winter temperature anomaly forecast in **Figure i**. We used an estimate of the sea ice extent anomaly in the Barents-Kara Seas for October instead of observed September full Arctic sea ice extent anomalies and we used the observed October value of the Pacific Decadal Oscillation (PDO) instead of an estimate of the December-February PDO. In the updated forecast the negative temperature anomalies became colder in Asia, though the extent of below normal temperatures shrank in areal extent across Eurasia and temperatures overall warmed across North America. Northern Europe, Northern and Eastern Asia and western North America are predicted to be relatively cold while the eastern Mediterranean, Southern Asia, Eastern Canada and the Southern US and US East Coast are predicted to be relatively mild. I still consider it a very challenging forecast. The PDO is typically not used as a predictor, and I do wonder if it is over emphasized in the model since such an extreme negative value was observed in October. Based on how the winter is predicted to commence, I do wonder if the model is too cold in the Western US. I also wonder if the extent of cold temperatures across Northern Asia is overdone given the predicted widespread warmth for the first half of December. I also included the winter temperature anomaly forecast from the North American multi-model ensemble (NMME) and the European multi-model ensemble (C3S).

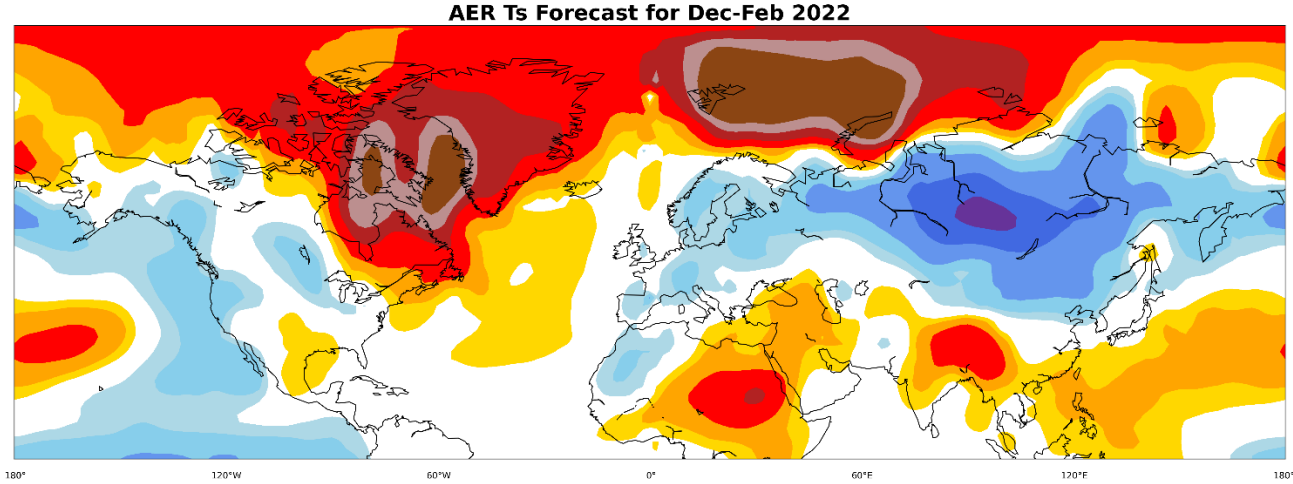
NMME Ts Forecast for Dec-Feb 2022



C3S Ts Forecast for Dec-Feb 2022



AER Ts Forecast for Dec-Feb 2022



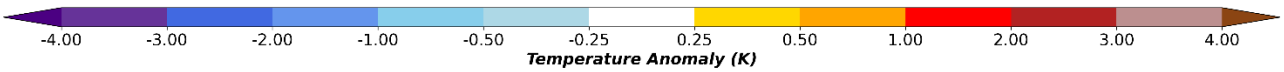


Figure i. The NMME winter temperature anomaly forecast for December, January and February 2022 from https://www.cpc.ncep.noaa.gov/products/NMME/ (top). The C3S winter temperature anomaly forecast for December, January and February 2022 from https://www.copernicus.eu/en (center). c) The AER winter temperature anomaly forecast for December, January and February 2022 (bottom).

The dynamically based forecasts are overall milder for North America and especially Eurasia relative to the AER model. In contrast the AER model is warmer in the Arctic relative to the dynamical models. It is typical of recent winters that the dynamical models are too warm in their winter forecast for the NH mid-latitudes and too cold for the Arctic (see Figure 4 from Cohen et al. 2020). Though the AER model is going to start the winter in a hole or disadvantaged compared to the dynamical models as the NH continents are relatively mild and the Arctic is relatively cold (see **Figure ii**). The global temperature anomaly pattern is pretty unusual relative to the recent past. The Arctic is the coldest region relative to normal for the entire globe. The overall warm NH is mostly due to the widespread above normal temperatures in the mid-latitudes. This is reminiscent of winter 2019/20 and is a plausible scenario that I am all too well aware of. Also Antarctica is relatively warmer than the Arctic and is in fact the warmest region on the globe. This doesn't happen too often so might be a plot worth framing.

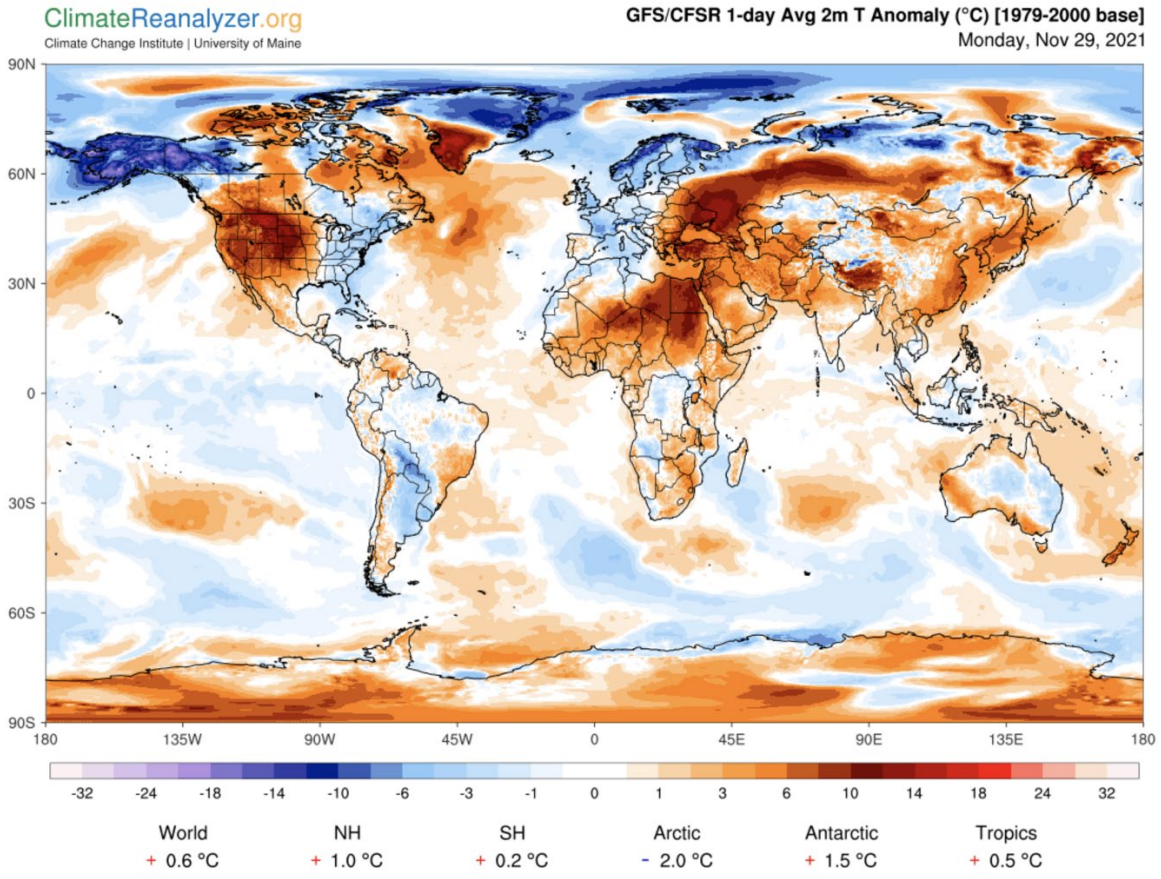


Figure ii. Observed surface temperature anomalies for the globe in °C from https://climatereanalyzer.org/wx/DailySummary/#t2anom.

It is my opinion for the AER model forecast to have any chance to verify, the polar vortex will need to be highly disrupted in mid-winter. At this point I would consider it unlikely for a large disruption of the PV to occur in December given the lack of blocking/high pressure/ridging near the Urals for all of November. But the models are consistently predicting a transition to more high pressure/ridging starting next week, that could potentially persist for multiple weeks (See Figures **5, 8** and **14**). I do consider high pressure/ridging in the region of the Urals, Barents-Kara Seas and Scandinavia with downstream troughing across East Asia and into the North Pacific the most favorable atmospheric circulation pattern to disrupt the PV. See for example Martius et al. 2009, Garfinkel et al. 2010 and Cohen and Jones 2021. I consider the predicted return of Ural blocking a significant development and its establishment, amplitude and persistence could be the single most important factor determining the character of this winter. Though one thing that I could not have anticipated as recently as two months ago, sea ice is not as favorable for persisting Ural blocking as it has been in recent falls and early winters. As seen in **Figure 16**, sea ice extent in the Barents-Kar Seas is approaching the climatological average. Near normal sea ice in the region could prevent a long enough duration of Ural blocking to ensure a significant disruption of the PV and tip the scales towards a mild winter. It is my intention to (obsessively) focus on this feature in many of the upcoming blogs.

I have been anticipating an overall mild start to the winter across the continents of the mid-latitudes based on the strong PV and the positive AO and from **Figures ii, 3, 6** and **9** that looks likely. One major exception is Europe and that is due to ridging in the North Atlantic that is contributing to downstream troughing/northerly winds across Europe. But I do believe that the predicted transition of the NAO from negative to positive likely signals relatively milder temperatures for Europe by mid-December. There seems little doubt that the winter will begin mild to potentially very mild for the US Lower 48 (just see the CPC forecast - https://www.cpc.ncep.noaa.gov/). Though I have to admit being dumbfounded by one aspect – ridging/high pressure near the Aleutians should teleconnect with troughing in the Western US with the current ridge in this Western US kicking east of the Rockies. This is your canonical negative Pacific/North American (PNA) pattern (see **Figure iii** from NOAA) and also consistent with La Niña.

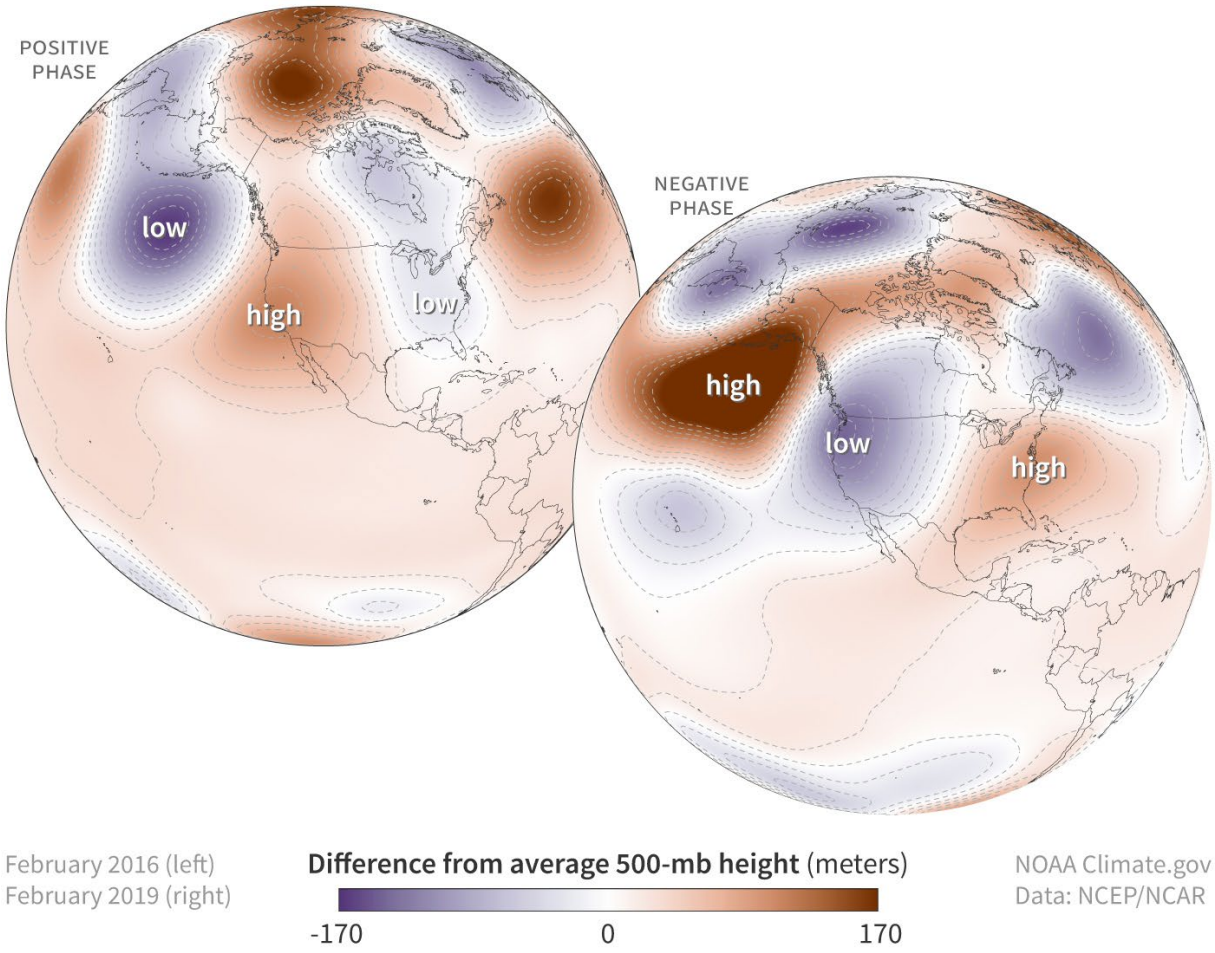


Figure iii. The atmospheric circulation associated with the positive and negative phases of the Pacific/North American patterns from https://www.climate.gov/media/13077.

And though the weather models keep predicting the Western US ridge/high pressure sliding east of the Rockies it never gets any sooner than the 11–15-day time frame. I am scarred by many of just the opposite scenarios. The models consistently advertise a large trough being carved out in the Eastern US and it is constantly being delayed and can never cross into the less than ten-day threshold. And when it finally does happen, it is weak and short-lived. Since I know that it can happen with a forecast for a Western ridge/Eastern trough it makes sense it can happen in reverse with a Western ridge/Eastern trough. The current scenario of the models predicting a Western trough that always remains 11-15 days out reminds of me of Lucy and her frustrating Charlie Brown with the football (**Figure iv**) where the models tease and frustrate with their long-range forecast and deny satisfaction.

Figure iv. Gif meme of Lucy placing the football in front of Charlie Brown for him to kick but then pull it away at the last second. Seems to me an apt metaphor for the weather models predicting Western US troughing that never gets closer in time.

But I am curious about the stubbornness of the Western US ridge/high pressure and the lack of eastward movement. I don't have an answer, certainly not based on what I see in the Arctic. In fact, a positive AO and strong polar vortex, I think argue against a Western US ridge. Some on Twitter point to tropical convection. Paul Roundy of SUNY Albany has a nice website on tropical convection that includes the predicted atmospheric circulation: http://www.atmos.albany.edu/facstaff/roundy/waves/. He was generous to share with me a plot from his site yesterday shown in **Figure v**. It does seem that the source of the stubborn Western US ridge could indeed be tropical convection but this is not my expertise and I defer to others like Paul Roundy. I did check the site today and the tropical forecast of persistent US troughing could be caving as well (at least for mid-month). But to be fair the predicted ridging in the Eastern US is transitory and troughing returns for much of the second half of December. This even has support from the latest GFS ensembles that are now suggestive of a return of troughing to the Eastern US the second half of December. Though I also looked at the latest ECWMF weekly forecast and that shows the Eastern US ridge from hell with winter "smothered in its crib" for the Eastern US. I

believe this is an unusual pattern and in transition and therefore very challenging for man and machine to predict.

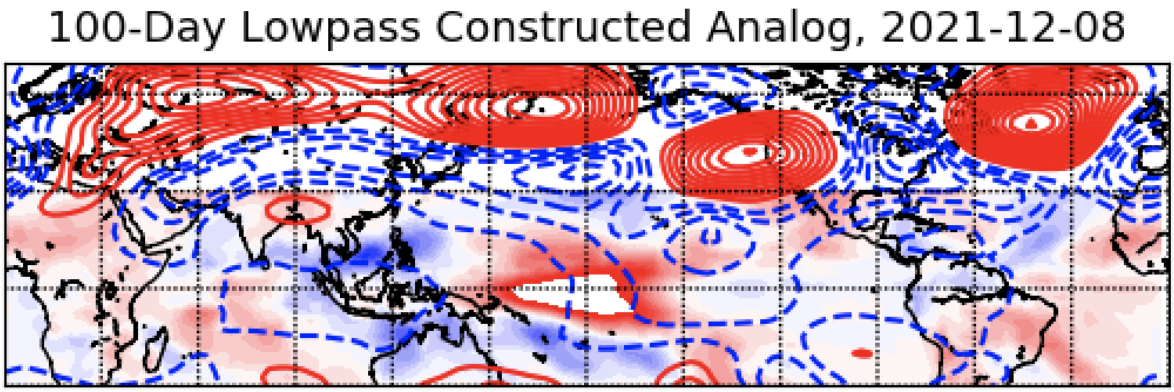


Figure v. Predicted 300 hPa geopotential height anomaly (contoured every 20 m) predicted for the five days centered on 8 December 2021 and tropical convection (shading) based on observed tropical convection. Plot taken from: http://www.atmos.albany.edu/facstaff/roundy/waves/

Anyway, ironically if you want a decent mid- to late- winter in the Eastern US you might want to be rooting for the Western US trough in early December. It is my sense from experience the pattern that is most favorable for disrupting the PV is Ural blocking coupled with troughing in the Gulf of Alaska and extending into western North America. In my opinion, long term the current pattern will not evolve into a cold winter across the mid-latitudes, that is just wishful thinking, the polar vortex is too strong exemplified by the very cold Arctic. I don't think this pattern simply transitions into a cold winter in the Eastern US and even Europe without an extended ugly period (and by ugly, I mean mild to very mild), i.e., no pain no gain. Of course, I could be wrong, I have been in the past many times and will be again in the future. To disrupt the PV northward transport of heat needs to pick up and often that heat has travel over the Eastern US and Europe en route to the Arctic. As long as the Arctic stays cold, winter weather will be absent with the possible one-off event (please read Cohen et al. 2018)

I still believe that pool of cold air in Alaska and Northwestern Canada puts the US Lower 48 at risk for an Arctic outbreak most likely focused west of the Mississippi and I would put the highest risk in the Northern Plains (this has been consistently predicted by our experimental machine learning model over the past week), whom by the way are currently experiencing an impressive snow drought. Maybe a Western US Arctic outbreak will help carve out a Western US trough and nudge the atmospheric circulation in a configuration more favorable for inflicting some damage on the polar vortex or the AER winter forecast will likely be toast, literally. Do I sound nervous?

1-5 day

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

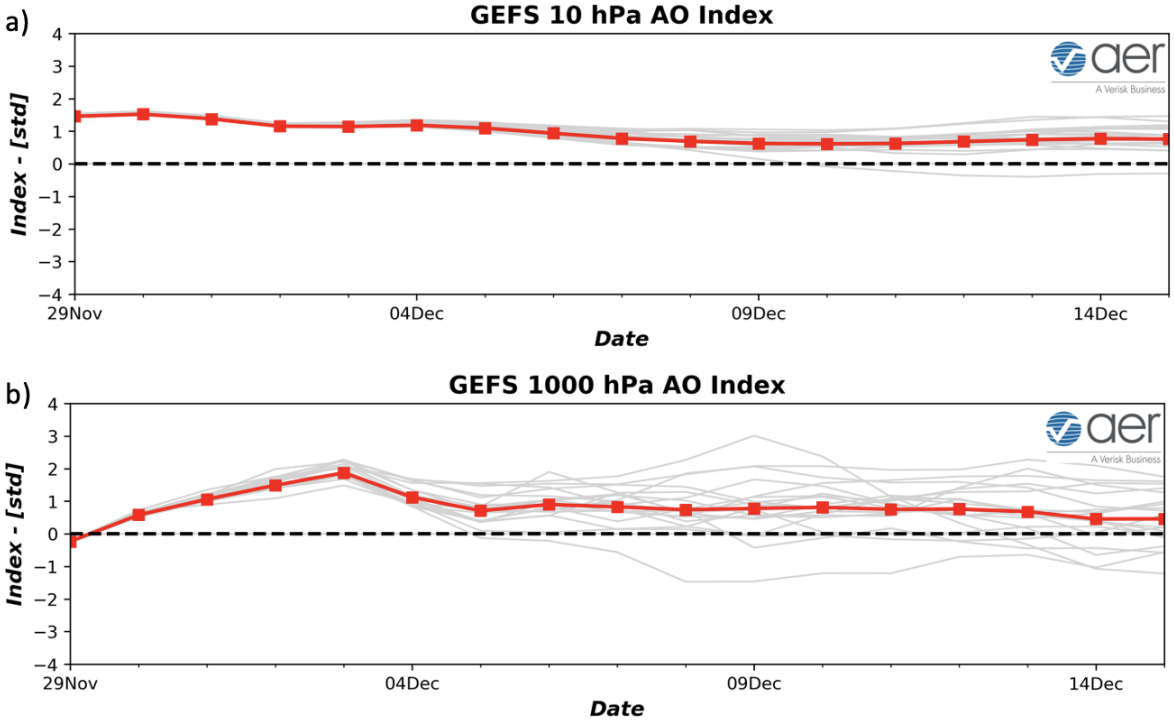


Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 29 November 2021 GFS ensemble. (b)The predicted daily-mean near-surface AO from the 00Z 29 November 2021 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ridging/negative geopotential height anomalies centered in the central North Pacific will partially force troughing/negative geopotential height anomalies across much of Europe including the UK this period (**Figures 2).** This will result in normal to below normal temperatures across Northern and Western Europe including the UK with normal to above normal temperatures across Southeastern Europe under southwesterly flow (**Figure 3**). Troughing/negative geopotential height anomalies are predicted draped across far Northern and East Asia and with ridging/negative geopotential height anomalies over much of Asia this period (**Figure 2**). This pattern favors normal to

above normal temperatures across much of Asia with normal to below normal temperatures across far Northern and Eastern Asia (**Figure 3**).

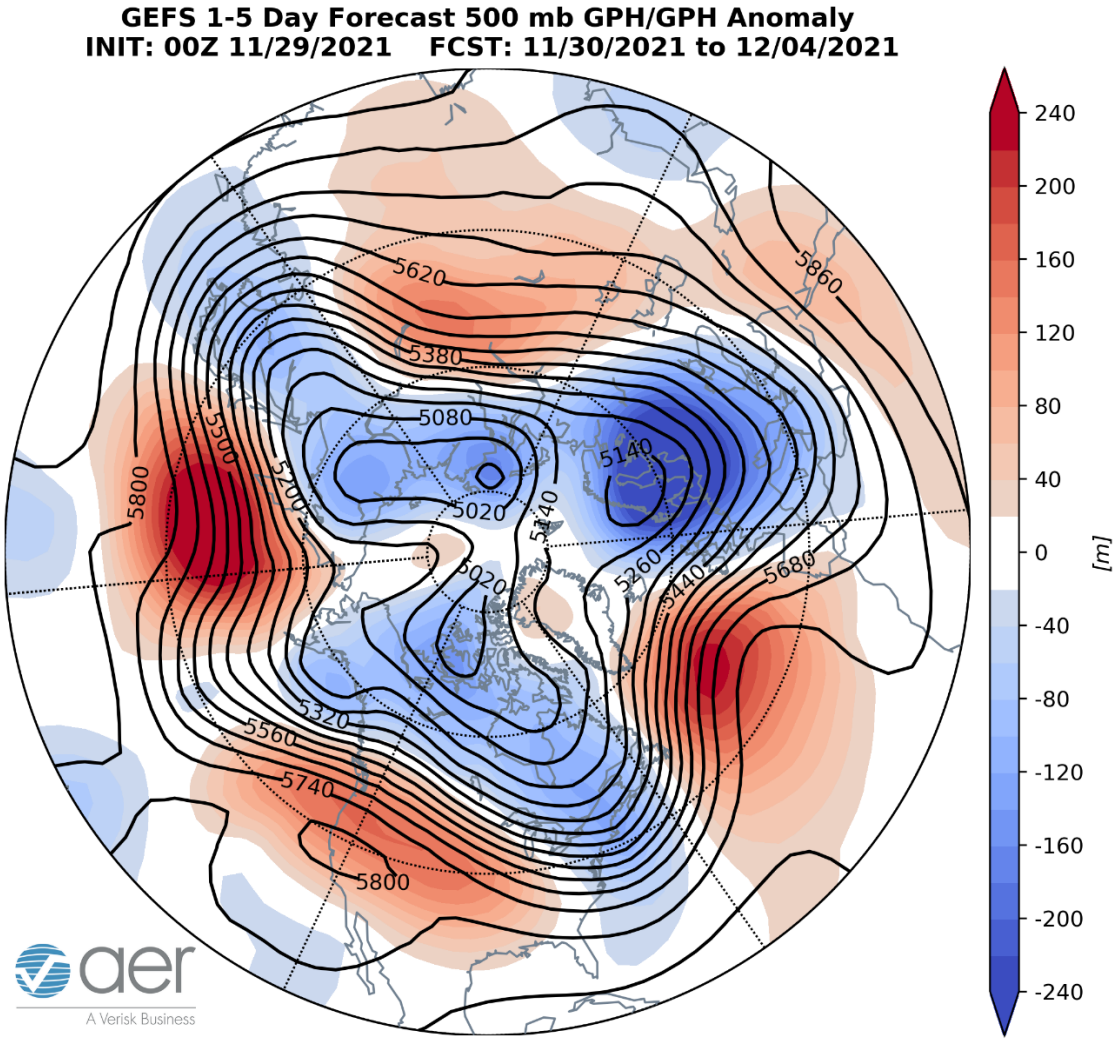


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 30 November – 4 December 2021. The forecasts are from the 00z 29 November 2021 GFS ensemble.

The general pattern this week across North America is troughing/negative geopotential height anomalies across Alaska that extends southwestward into eastern Canada and the Northeastern US with ridging/positive geopotential height anomalies across the Western US **(Figure 2).** This pattern is predicted to bring normal to below normal temperatures across Alaska, Northwestern, Central and Southeastern Canada and the Northeastern US with normal to above normal temperatures across Southwestern and Northeastern Canada and the Western and Southern US **(Figure 3).**

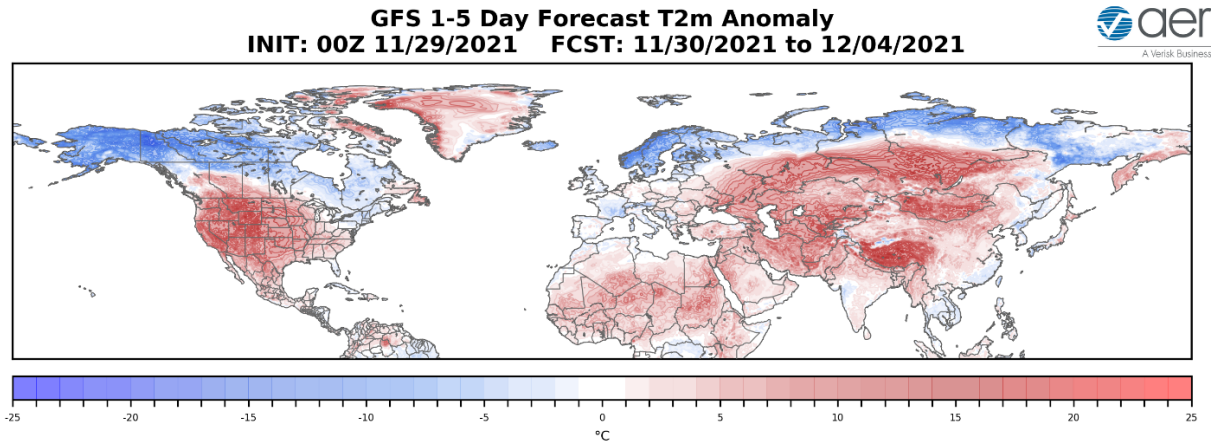


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 30 November – 4 December 2021. The forecast is from the 00Z 29 November 2021 GFS ensemble.

Troughing and/or cold temperatures are predicted to support new snowfall across Northern Scandinavia, higher elevations of Europe and Northern and Eastern Asia while mild temperatures promote snowmelt in Central Russia (**Figure 4**). Troughing and/or cold temperatures are predicted to support new snowfall across Southern Alaska and Western, Northcentral and Eastern Canada while mild temperatures promote snowmelt in the southern Canadian Plains, the Great Lakes and the Northeastern US (**Figure 4**).

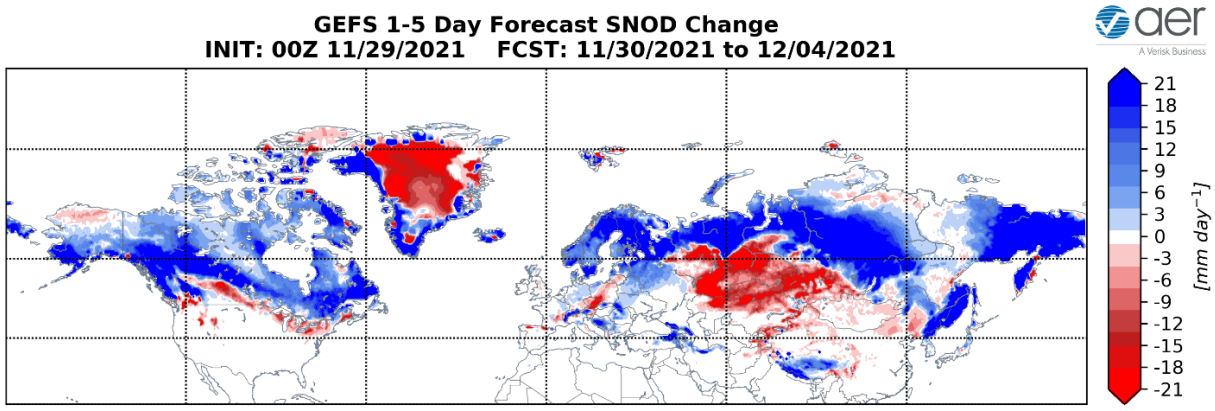


Figure 4. Forecasted snow depth changes (mm/day; shading) from 30 November – 4 December 2021. The forecast is from the 00Z 29 November 2021 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain positive this period **(Figure 1**) as geopotential height anomalies remain mostly negative across the Arctic with mixed geopotential height

anomalies across the mid-latitudes of the NH (**Figure 5**). And with geopotential height anomalies transitioning from positive to negative across Greenland (**Figure 5**), the NAO is predicted to trend positive this period.

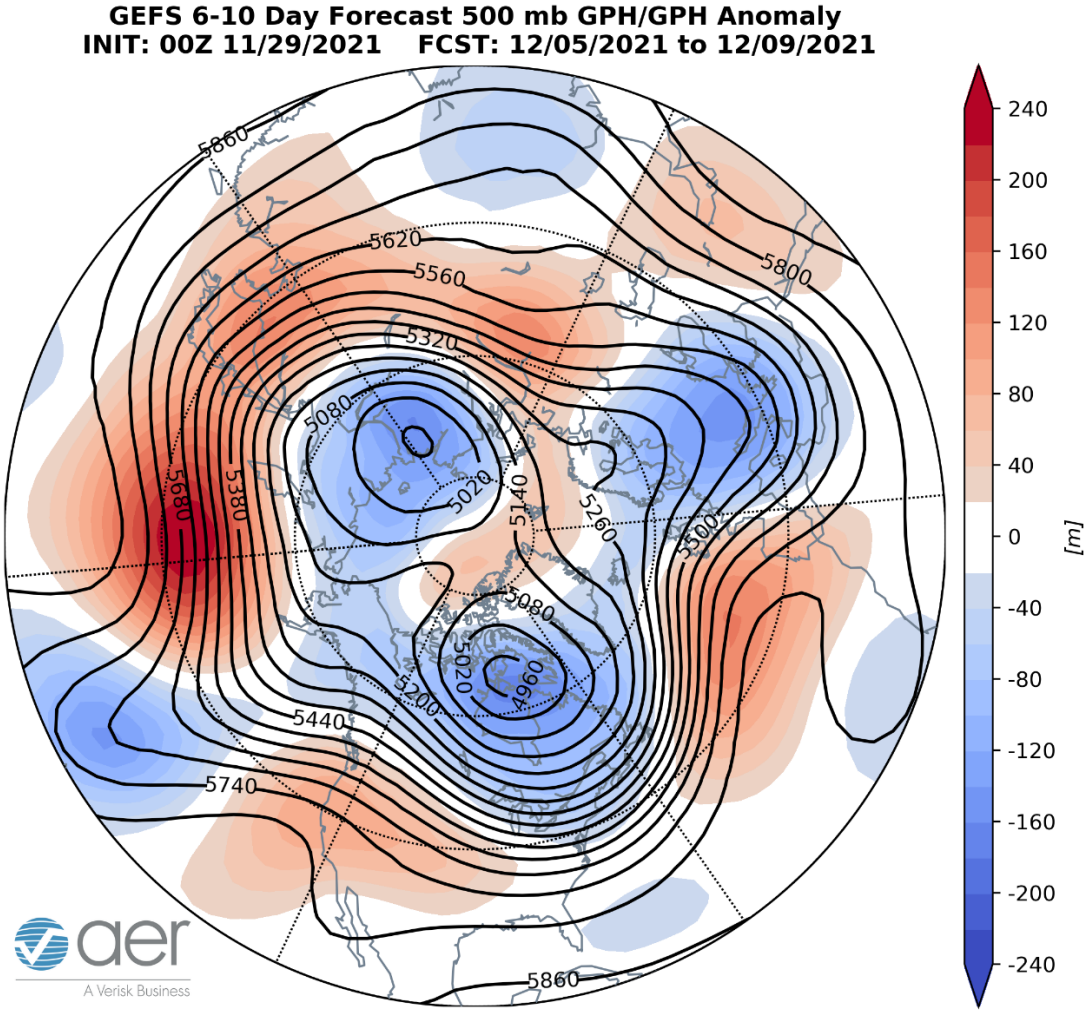


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 5 – 9 December 2021. The forecasts are from the 00z 29 November 2021 GFS ensemble.

Ridging/positive troughing/negative geopotential height anomalies persisting for much of the period in the central North Atlantic will contribute to persistent troughing/negative geopotential height anomalies and northerly flow across Northern and Central Europe with ridging/positive geopotential height anomalies encroaching on Western Europe this period (**Figures 5).** This will result in normal to below normal temperatures across much of Northern and Central Europe with normal to above normal temperatures across Western Europe including the UK (**Figure 6**). Strengthening ridging/positive geopotential height anomalies in Western Asia will contribute to

deepening troughing/negative geopotential height anomalies centered in Central and Eastern Siberia with more troughing/negative geopotential height anomalies in Southeast Asia (**Figure 5**). This pattern favors normal to above normal temperatures across Western and Southern Asia with normal to below normal temperatures limited to much of Siberia **(Figure 6**).

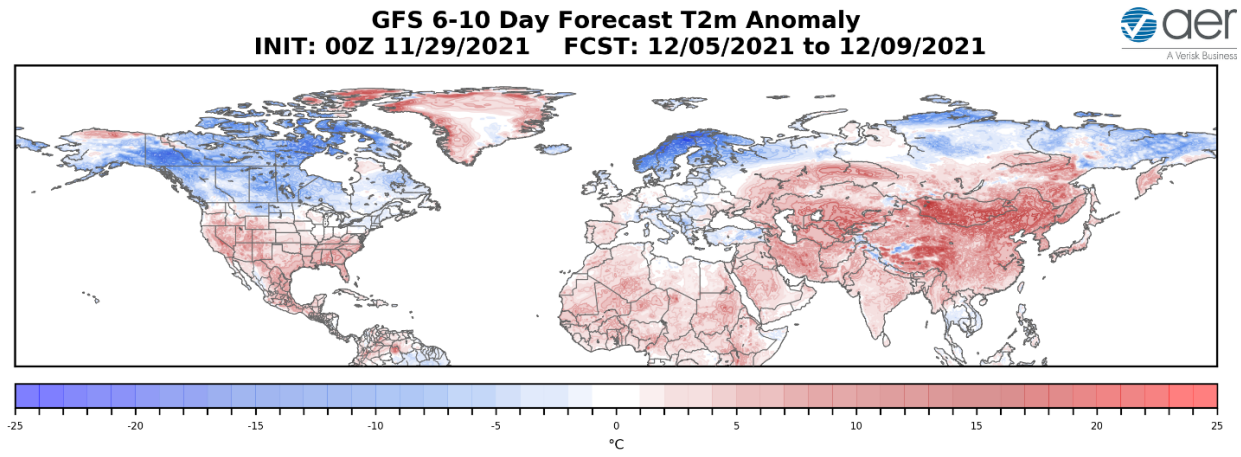


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 5 – 9 December 2021. The forecasts are from the 00Z 29 November 2021 GFS ensemble.

Persistent troughing/negative geopotential height anomalies will extend from Alaska southeastward into Eastern Canada and the Northeastern US with ridging/positive geopotential height anomalies across the Western US and Southwestern Canada this period **(Figure 5).** This will favor normal to below normal temperatures across Alaska much of Canada and the Northeastern US with normal to above normal temperatures in Southwestern Canada and the Western and Southern US **(Figure 6).**

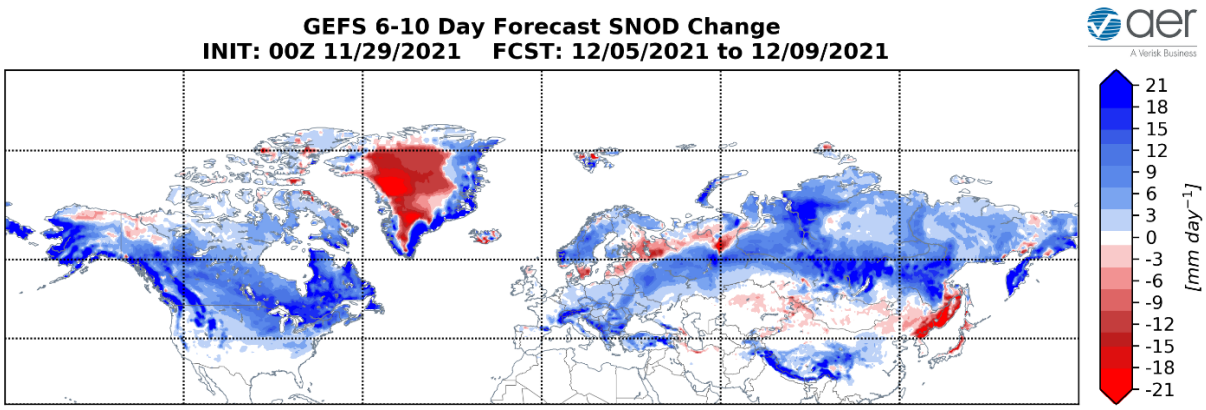


Figure 7. Forecasted snow depth changes (mm/day; shading) from 5 – 9 December 2021. The forecast is from the 00Z 29 November 2021 GFS ensemble.

Troughing and/or cold temperatures are predicted to support new snowfall across Scandinavia, the Alps, Central and Eastern Europe, Northern Asia and the Tibetan Plateau while milder temperatures promote snowmelt across East Asia (**Figure 7**). Troughing and/or cold temperatures are predicted to support new snowfall across Alaska, much of Canada and the Northern US (**Figure 7**).

11-15 day

With mostly negative geopotential height anomalies predicted across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO should remain positive this period (**Figure 1**). With predicted negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is forecasted to remain positive this period as well.

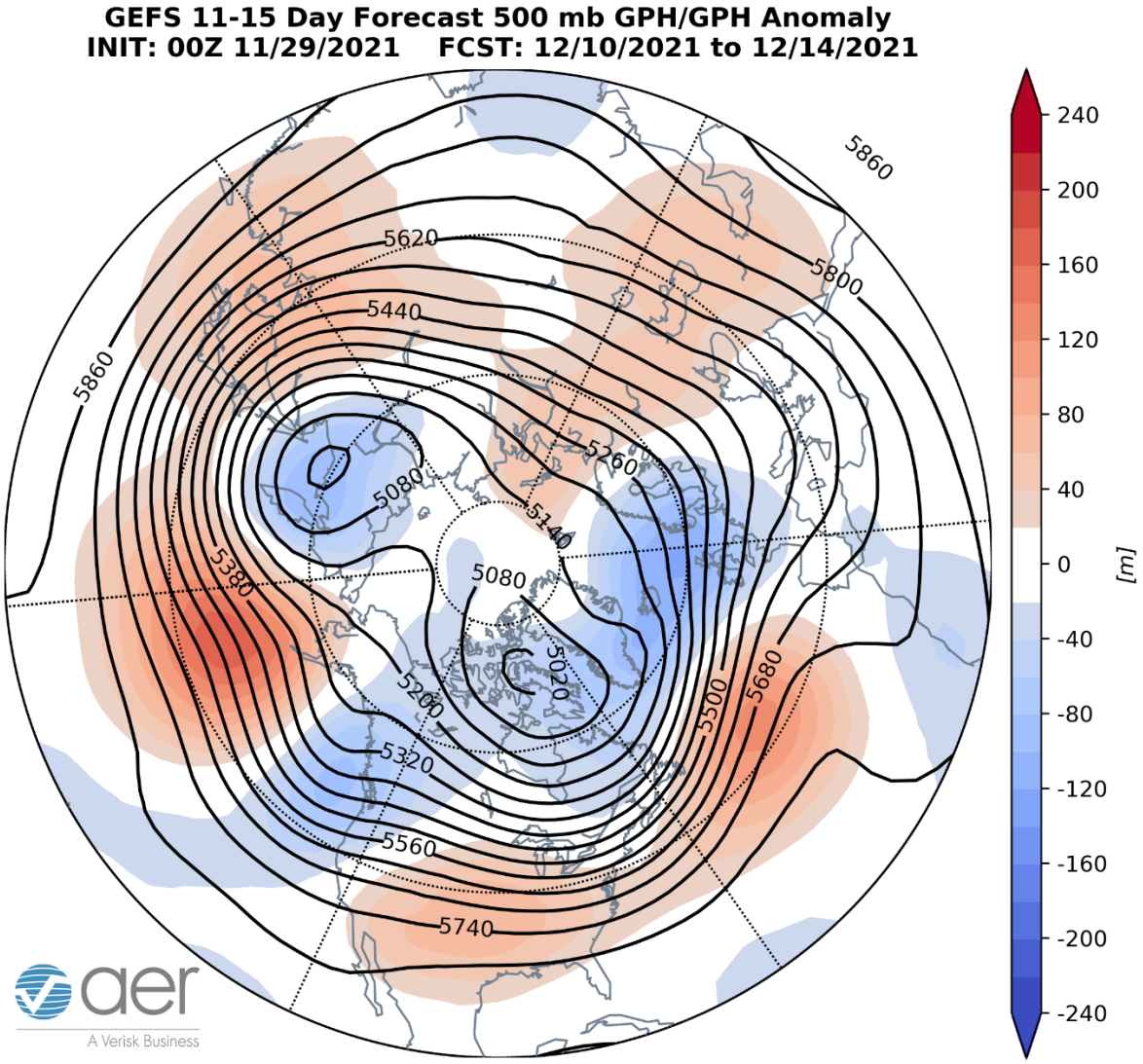


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 10 – 14 December 2021. The forecasts are from the 00z 29 November 2021 GFS ensemble.

With ridging/positive geopotential height anomalies in the central North Pacific predicted to weaken, troughing/negative geopotential height anomalies in Europe are also predicted to weaken this period (**Figure 8**). This pattern favors more widespread normal to above normal temperatures across much of Europe including the UK with normal to below normal temperatures limited to Northern Scandinavia and Southeastern Europe this period (**Figures 9**). Persistent ridging/positive geopotential height anomalies in Western Asia will continue to support troughing/negative geopotential height anomalies across most of Siberia and Northeast Asia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Western and Southern Asia with normal to below normal temperatures across Siberia and Northeast Asia this period (**Figure 9**).

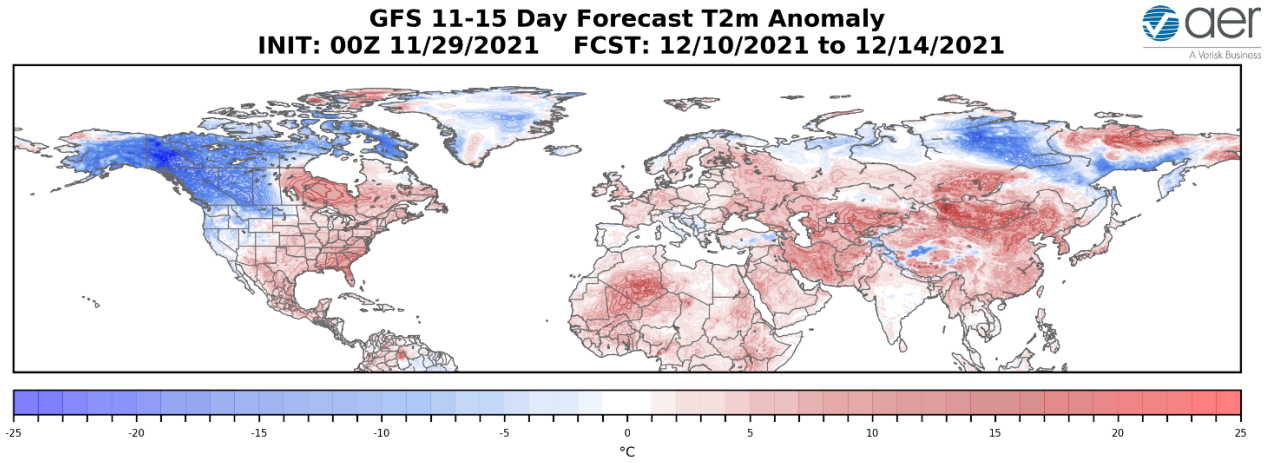


Figure 9. Forecasted surface temperature anomalies (°C; shading) from 10 – 14 December 2021. The forecasts are from the 00z 29 November 2021 GFS ensemble.

Strengthening ridging/positive geopotential height anomalies south of the Aleutians will contribute to deepening troughing/negative geopotential height anomalies in western North America with strengthening ridging/positive geopotential height anomalies across the US east of the Rockies this period (**Figure 8**). This pattern favors normal to below normal temperatures widespread across Alaska, Western Canada and the Western US with normal to above normal temperatures in Eastern Canada and the US east of the Rockies (**Figure 9**).

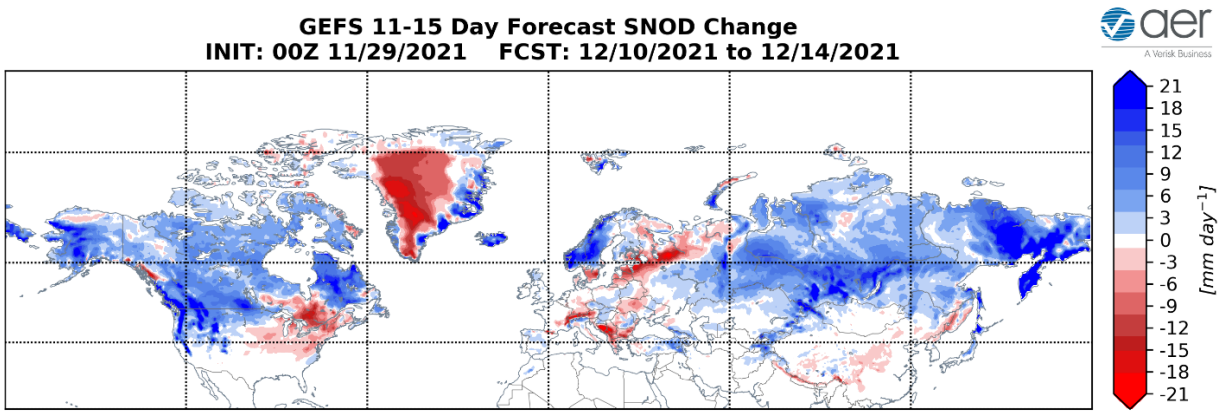


Figure 10. Forecasted snow depth changes (mm/day; shading) from 10 – 14 December 2021. The forecast is from the 00Z 29 November 2021 GFS ensemble.

Troughing and/or cold temperatures are predicted to support possible new snowfall across Northern Scandinavia and Northern Asia while milder temperatures promote snowmelt across the Alps, Central and Eastern Europe (**Figure 10**). Troughing and/or cold temperatures are predicted to support possible new snowfall across Alaska, much of Northern and Western Canada and the Western US while milder temperatures promote snowmelt across Southeastern Canada and the Northeastern US (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs throughout the stratosphere and troposphere (**Figure 11**). However, a region of deeper cold/negative PCHs in the lower stratosphere are predicted to descend to the surface this week (**Figure 11**). This is potentially the first stratosphere-troposphere coupling event in a while and certainly the first of winter 2021/22 but likely not the last.

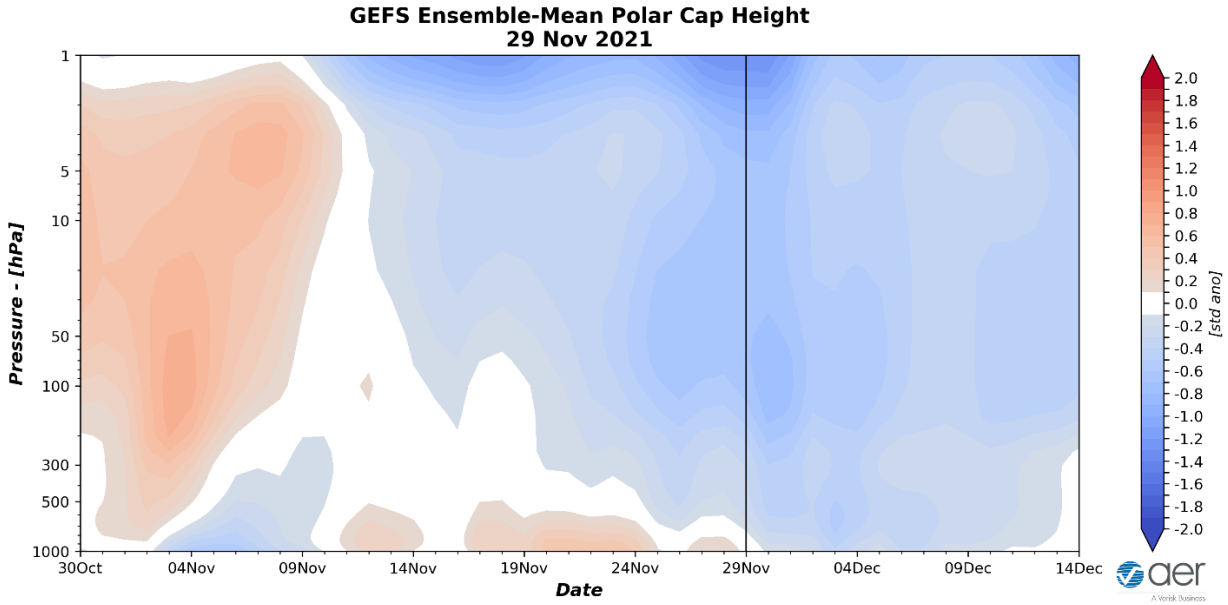


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 29 November 2021 GFS ensemble.

The below normal PCHs in the lower tropospheric are consistent with the predicted positive surface AO the next two weeks (**Figure 1**). A fully coupled strong stratospheric polar vortex and positive surface AO is a favorable environment for widespread mild temperatures in the Eastern US, Northern Europe and Northern Asia. There are some exceptions but overall, the winter should start off mild in many regions.

The vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere has been below normal for the entire second half of November (**Figure 12**). Relatively weak WAFz anomalies allowed the polar vortex to strengthen. However, WAFz is predicted to become more active in early December with the onset of Ural ridging (**Figure 12**).

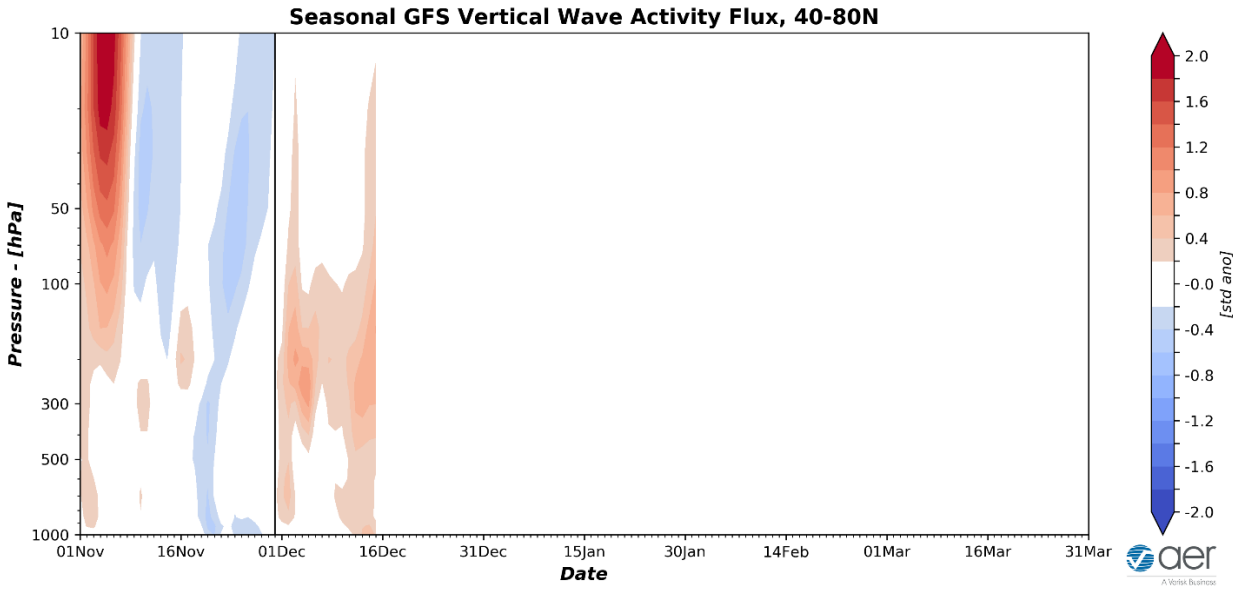


Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 29 November 2021 GFS ensemble.

The recent quiet WAFz has allowed the stratospheric PV to strengthen with the PV currently centered near the North Pole (**Figure 13**). The relatively strong PV is resulting in a current positive stratospheric AO (**Figure 11**). The relatively strong PV centered near the North Pole should persist over the next two weeks (**Figure 13**) coupled with a persistent positive stratospheric AO this week into next week (**Figure 11**).

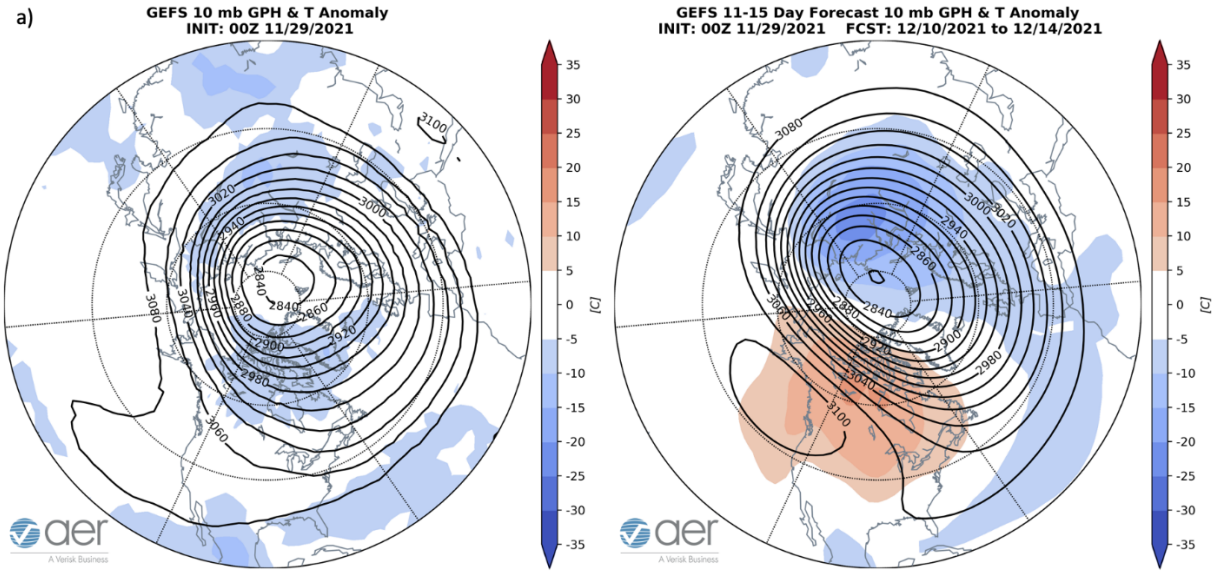


Figure 13. (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 29 November 2021. (b) Same as (a) except forecasted averaged from 10 – 14 December 2021. The forecasts are from the 00Z 29 November 2021 GFS model ensemble.

However the more active WAFz could begin to disrupt the stratospheric PV. Ridging centered in the Gulf of Alaska with warming across all of Canada is predicted in the polar stratosphere for the second week of December (**Figure 13**). With the predicted return of Ural blocking further disruption of the PV is possible.

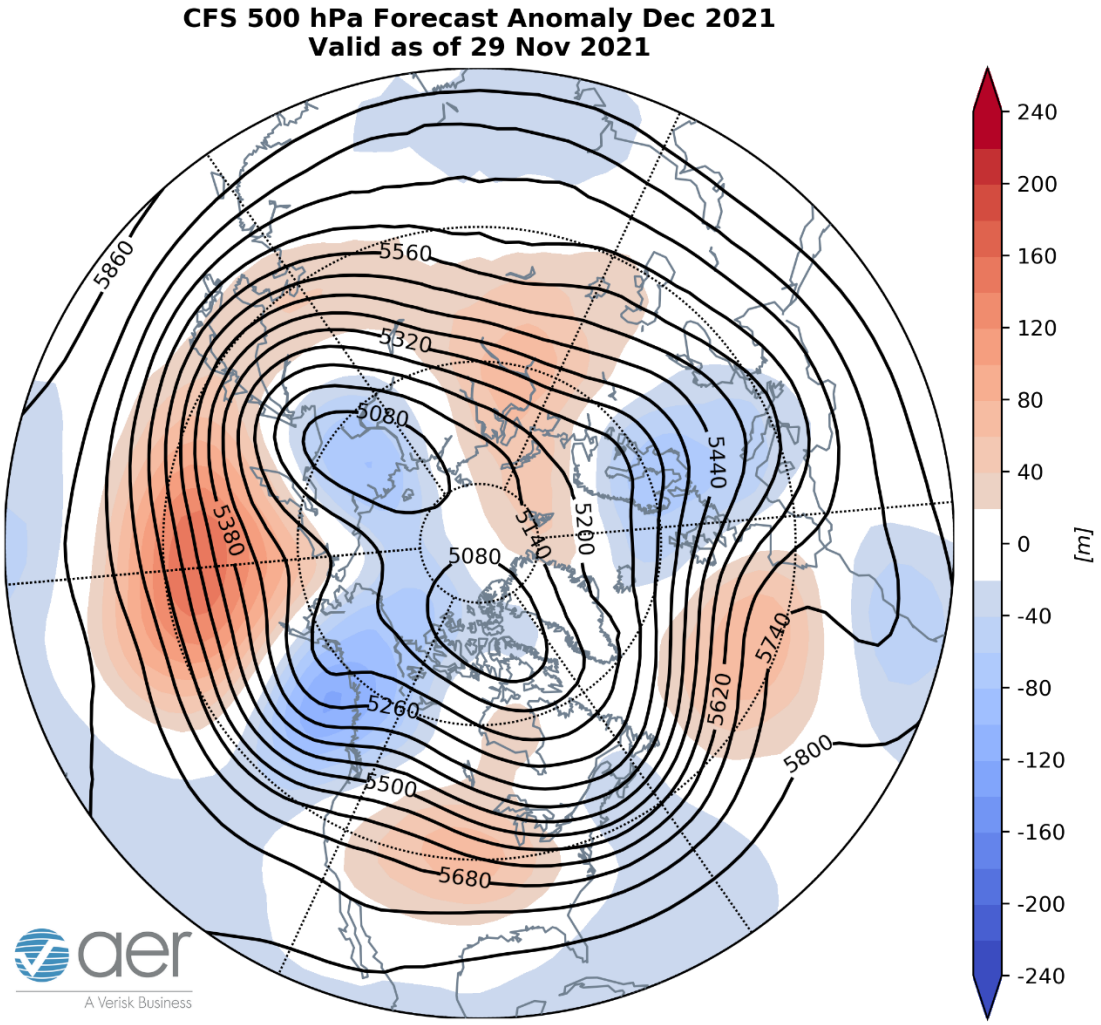


Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for December 2021. The forecasts are from the 00Z 29 November 2021 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for December (**Figure 15**) from the Climate Forecast System

(CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered in the central North Pacific, the Urals, the Dateline and the Central US with troughing in Eastern Europe, Eastern Asia, Gulf of Alaska, western North America, Eastern Canada and New England (**Figure 14).** This pattern favors seasonable to relatively warm temperatures widespread across Western Europe, Western and Southern Asia, Eastern Canada and the Western and Central US with seasonable to relatively cold temperatures across Eastern Europe, East Asia, Alaska and Western Canada and New England (**Figure 15**)**.**

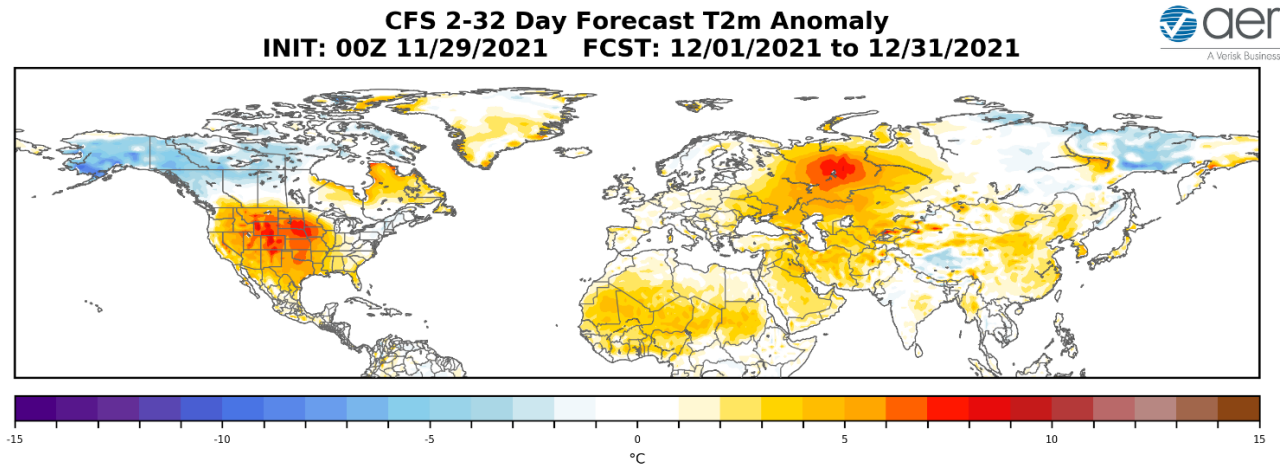


Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for December 2021. The forecasts are from the 00Z 29 November 2021 CFS.

Surface Boundary Conditions

Arctic Sea ice

Arctic sea ice is growing but remains below normal east of Greenland but especially in Baffin Bay and Hudson Bay. In the Barents-Kara Seas extent is getting closer to normal. Sea ice is above normal in the Bering Sea. Below normal sea ice in the Barents-Kara seas favors cold temperatures in Central and East Asia, while below normal sea ice in Baffin Bay favors cold temperatures in the Eastern Europe and Northern Europe however this topic remains controversial. Recent research has shown that the regional anomalies that are most highly correlated with the strength of the stratospheric PV are across the Barents-Kara seas region where low Arctic sea ice favors a weaker winter PV. Low sea ice in the Chukchi, Beaufort and Bering seas may favor colder temperatures across North America but has not been shown to weaken the PV.

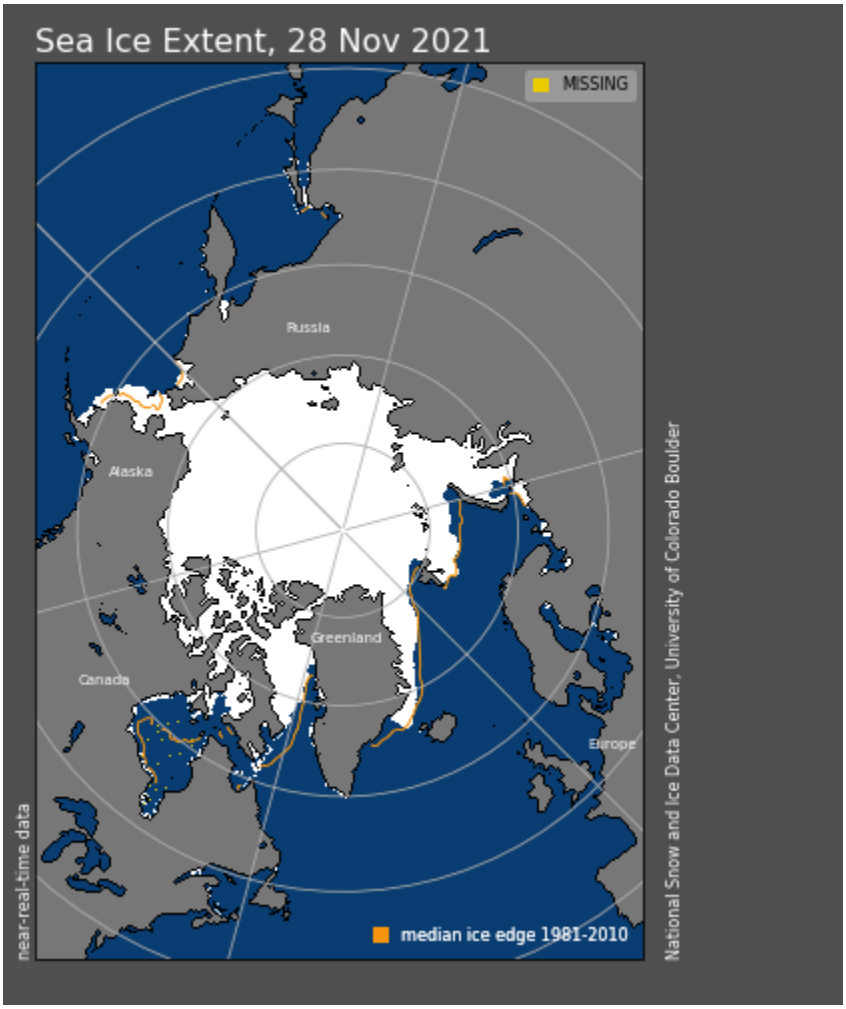


Figure 16. Observed Arctic sea ice extent on 28 November 2021 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC).

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 winter. 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 North Pacific. Not my expertise but the SST pattern in the North Pacific are strongly resembling a negative Pacific Decadal Oscillation (PDO) pattern that favors colder temperatures across northwestern North America and milder temperatures across southeastern North America.

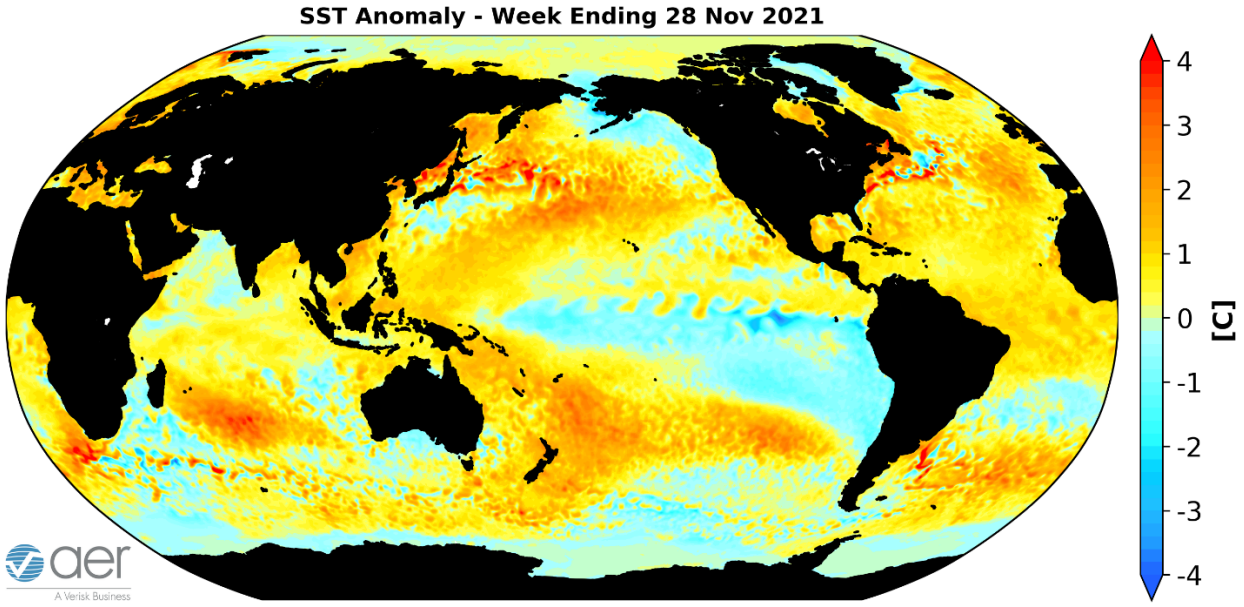


Figure 17. The latest weekly-mean global SST anomalies (ending 28 November 2021). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 18**). The forecasts are for the MJO to emerge into phases six and then seven in early December. MJO phases six and seven favor high latitude blocking including Alaska with transitioning ridges and troughs in the US. It seems to me that it is unlikely that the MJO is contributing significantly to the predicted weather pattern across North America based on model forecasts over the next two weeks but admittedly this is outside of my expertise. However tropical convection may be responsible to the resiliency of the Western US ridge.

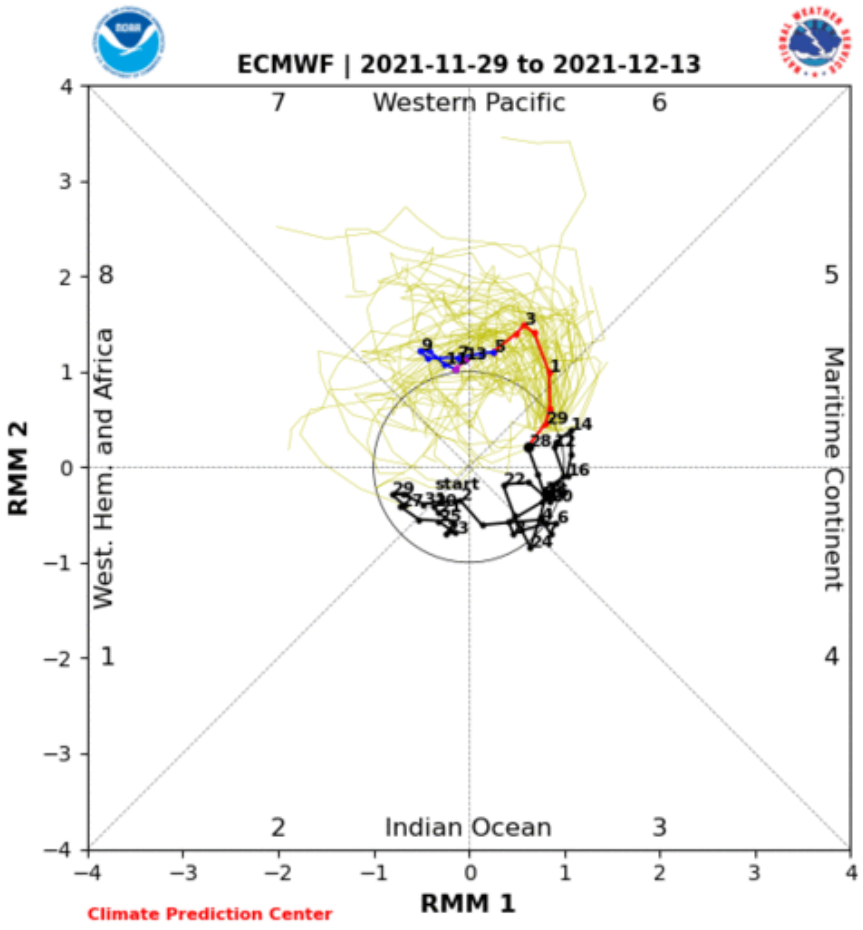


Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 29 November 2021 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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

Get Detailed Seasonal Weather Intelligence with sCast

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

Dr. Cohen's detailed monthly seasonal forecast, sCast, is also available for purchase. sCast provides a monthly 30-60-90-180-day outlook into temperature and

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

Our sCast principal engineer, Karl Pfeiffer, can help you use sCast and other AER seasonal forecast products to deliver important, long-lead time weather intelligence to your business. Please reach out to Karl today!