

Arctic Oscillation and Polar Vortex Analysis and Forecasts

October 3, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Thursday.

For those who would like an early look on Tuesdays, 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.

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. 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.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently positive and is predicted to remain very close to neutral the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mostly negative and are predicted to remain mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative with mostly positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to remain negative to neutral the next two weeks as pressure/geopotential height anomalies remain mostly positive to mixed across Greenland.
- Over the next two weeks, the general predicted pattern across Europe is ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Northern Europe. This pattern will support normal to above normal temperatures across Southern, Western and Central Europe including the United Kingdom (UK) with normal to below normal temperatures across Scandinavia and the Baltic States the next two weeks.
- Over the next two weeks, the general predicted pattern across Asia is ridging/positive geopotential height anomalies across Central and Eastern Asia with troughing/negative geopotential height anomalies across Western Asia. This pattern favors normal to above normal temperatures widespread across Central and Eastern Asia with normal to below normal temperatures mostly limited to Western Russia and Southern China under some localized troughing.
- The general predicted pattern across North America this week is troughing/negative geopotential height anomalies across Alaska, and the Central and Eastern United States (US) with ridging/positive geopotential height anomalies across Western and Eastern Canada. However next week deepening troughing in the Gulf of Alaska will force strengthening ridging centered in Central Canada. This pattern generally favors this week normal to below normal temperatures across Alaska and the Central and Eastern US with normal to above normal temperatures widespread across most of Canada and the Western US. Next week above normal temperatures will persist across Canada and spread eastward across the US.
- In the Impacts section I turn my attention to Eurasian snow cover as I believe October is the critical month for predicting the upcoming winter circulation and weather. And I discuss two potential polar vortex disruptions in the coming weeks.

Plain Language Summary

“The heat goes on, the heat goes on. Models keep pounding a rhythm to the brain.” My modification of the Sonny and Cher song that seems appropriate. Still no end in sight to superlative above normal temperatures (see **Figure i**). Though as many like to point out a warm day in October is not the same as a warm day in July or August. But just like in July and August in 2023, the warm temperatures are coming to you with a good helping of smoke.

I use October Eurasian snow cover extent as one of our main winter predictors. And if you like me was hoping that snow cover might come to the rescue and help put an end to the endless streak of above to well above normal temperatures, well still no sign of the cavalry.

Impacts

If you read this blog with any regularity, then you know possibly the topic that I have researched the longest is — does fall Eurasian snow cover influence Northern Hemisphere winter climate? October and Siberia are of particular importance and the pathway of influence is through the stratospheric polar vortex (PV). I am sure I will be discussing this pathway more in the coming months. But the simplest idea is that more extensive snow cover across Eurasia in October, and this mostly confined to Siberia, the more likely the PV will be weaker than normal during the winter months that favors widespread colder temperatures across the Northern Hemisphere (NH) but in particular in East Asia and the US east of the Rockies. It also includes Northern Europe, but the relationship is weaker across Europe and in my own research rarely is it statistically significant.

September is in the books, and it was a warm one globally. In fact, based on the early returns it was quite an extraordinarily month with unprecedented record warmth. And after a summer of almost endless superlative extremes this seems to be possibly the most superlative. For example, this tweet from [@mikarantane](#). Well at least across the NH mid-latitudes, the exceptional warmth is predicted to continue. In **Figure i**, I present the NH surface temperature forecast from six different models hosted on the Copernicus website. All the models are predicting incredible warmth across the NH that increases in magnitude from south to north. All the models show at least a regional maximum over Siberia with some models showing an absolute maximum over the Arctic Ocean.

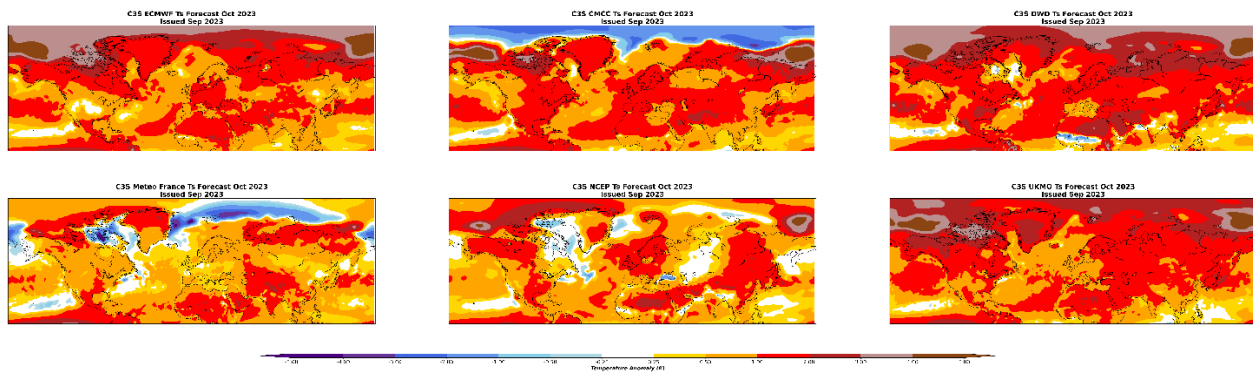


Figure i. The surface temperature anomaly forecast for October 2023 from six different dynamical models from the Copernicus website. See https://climate.copernicus.eu/charts/packages/c3s_seasonal/

These monthly forecasts are consistent with the shorter-range weather model forecasts. Looking at **Figures 5** and **6**, in particular we see the strongest anomalous ridging of high pressure in the whole NH centered on Siberia with well above normal temperatures widespread across much of Asia but with a regional maximum right over Western Siberia during the second week of October. This is a pretty hostile environment for the rapid expansion of snow cover across Siberia.

Currently snow cover extent across Siberia is close to average for this early date in the snow advance season (see **Figure ii**). But I do expect snow cover advance to either slow down or even retreat next week. And with the overall circulation across Asia settling into a western trough/eastern ridge pattern the prospects for above normal snow cover for the month of October are looking bleak. This is especially surprising to me given that snow cover extent has been perennially above normal for the past decade (last below normal month of October was in 2011) and for an overwhelming majority of the past two decades and that it is an El Niño fall, which has favored higher snow cover extent than La Niña.

Daily SCE Departure - October 2, 2023 (Day 275)

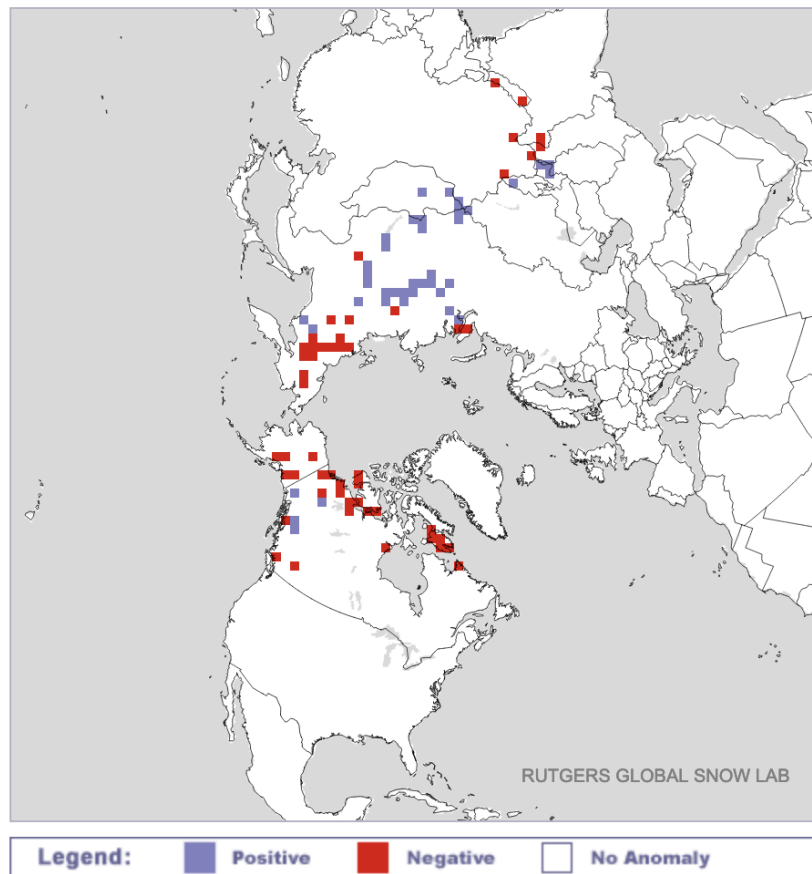


Figure ii. Observed snow cover extent (SCE) anomalies on 2 October 2023 taken from <http://climate.rutgers.edu/snowcover/>

Assuming Eurasian snow cover extent is below normal this month, this would favor an overall strong PV in the winter months and milder temperatures across the mid-latitude continents of the NH probably more so for the Eastern US and East Asia than Europe, though Europe seems to be warm these days regardless.

But the pattern looks to be mostly progressive and maybe by the end of October the pattern will be more conducive to more rapid snow cover advance across Siberia. Certainly, if you believe the CFS, November looks like a much more interesting month (see **Figure 12**). But when I start pointing to the CFS as my best sign of hope, you know that I am desperate.

Of course, if I feel that the community relies too heavily on ENSO in seasonal forecasting, so I don't want to overplay the accuracy of snow cover alone in making a winter forecast (a fact many are very happy to point out to me) and there seems to be many potentially important players in determining the character of this upcoming winter. El Niño is related to a deeper Aleutian low and that seems to be a more common feature in the weather maps of late and shows up nicely in **Figure 8**. A deeper Aleutian low this winter would favor a weaker PV and possibly colder temperatures in the Eastern US.

Besides snow cover I also look at Arctic sea ice extent but not much new from the most recent blog and I will focus on that more next month while I focus on snow cover for this month.

Just so that no one feels that I am ignoring the PV, there seems to be two predicted minor disruptions of the PV, the first and second weeks of October. The one for this week is a reflective event where a ridge forms in the stratosphere near Alaska that helps stretch the PV towards North America (see **Figure iii**). This event in my opinion is connected to the trough and colder temperatures predicted in the short term in the Eastern US.

GEFS 1-5 Day Forecast 10 mb GPH & T Anomaly
INIT: 00Z 10/03/2023 FCST: 10/04/2023 to 10/08/2023

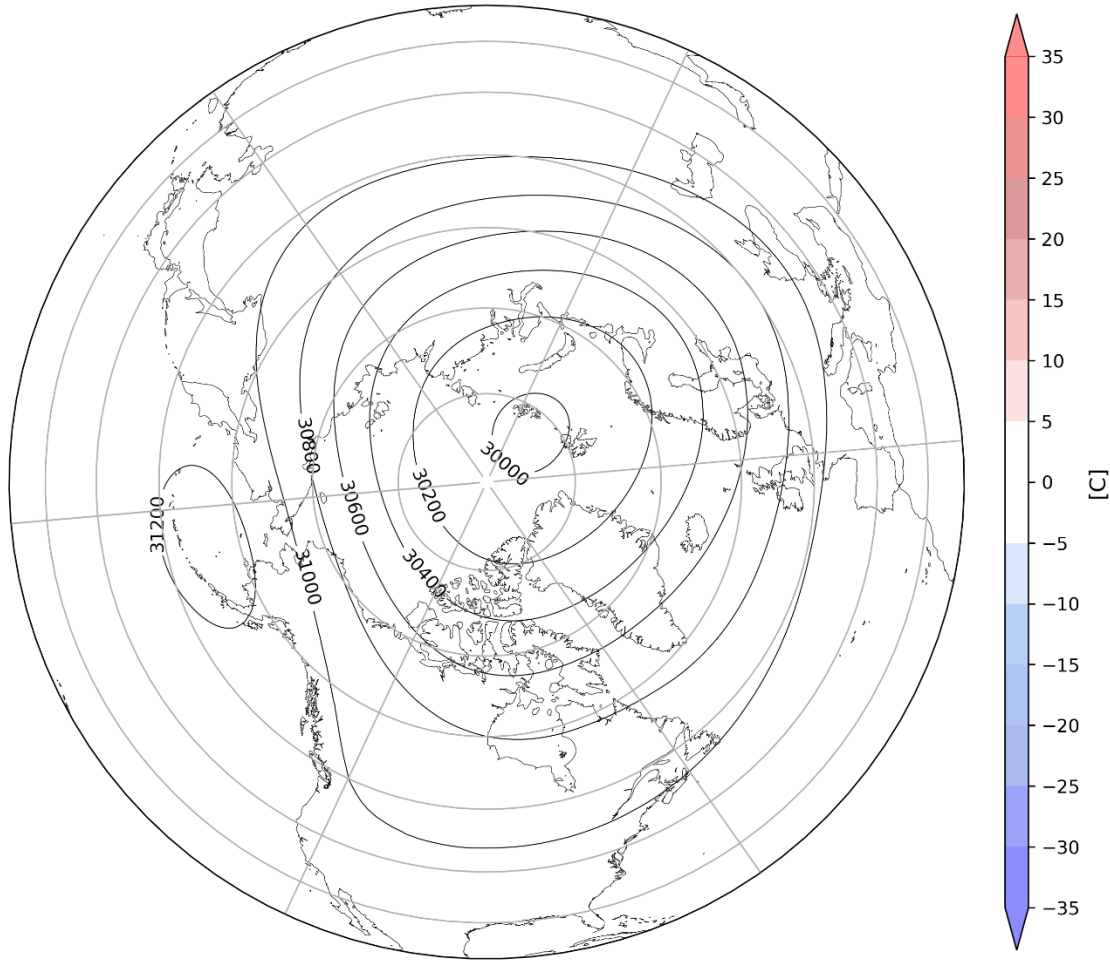


Figure iii. Forecasted average 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere from 4 – 8 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

The one for next week is a bit more robust and even shows up in the polar cap geopotential height anomaly (PCH) plot in **Figure 11** manifesting as weak but positive/warm PCHs in the stratosphere after October 12. Most PV perturbations this early in the season are reflective events but this one as far as I can tell is an absorptive event akin to a sudden stratospheric warming. Though the models are predicting a PV configuration that most closely resembles what is referred to as a “Canadian warming.” (you can see in **Figure iv** that the stratospheric ridging is over Canada and the PV center is displaced towards Eurasia). My own research shows that these events are associated with above normal temperatures in Canada and the Northern US but below normal temperatures across Northern Siberia. There is always the possibility it could evolve, couple back to the surface and influence the weather further down the road, so something to watch.

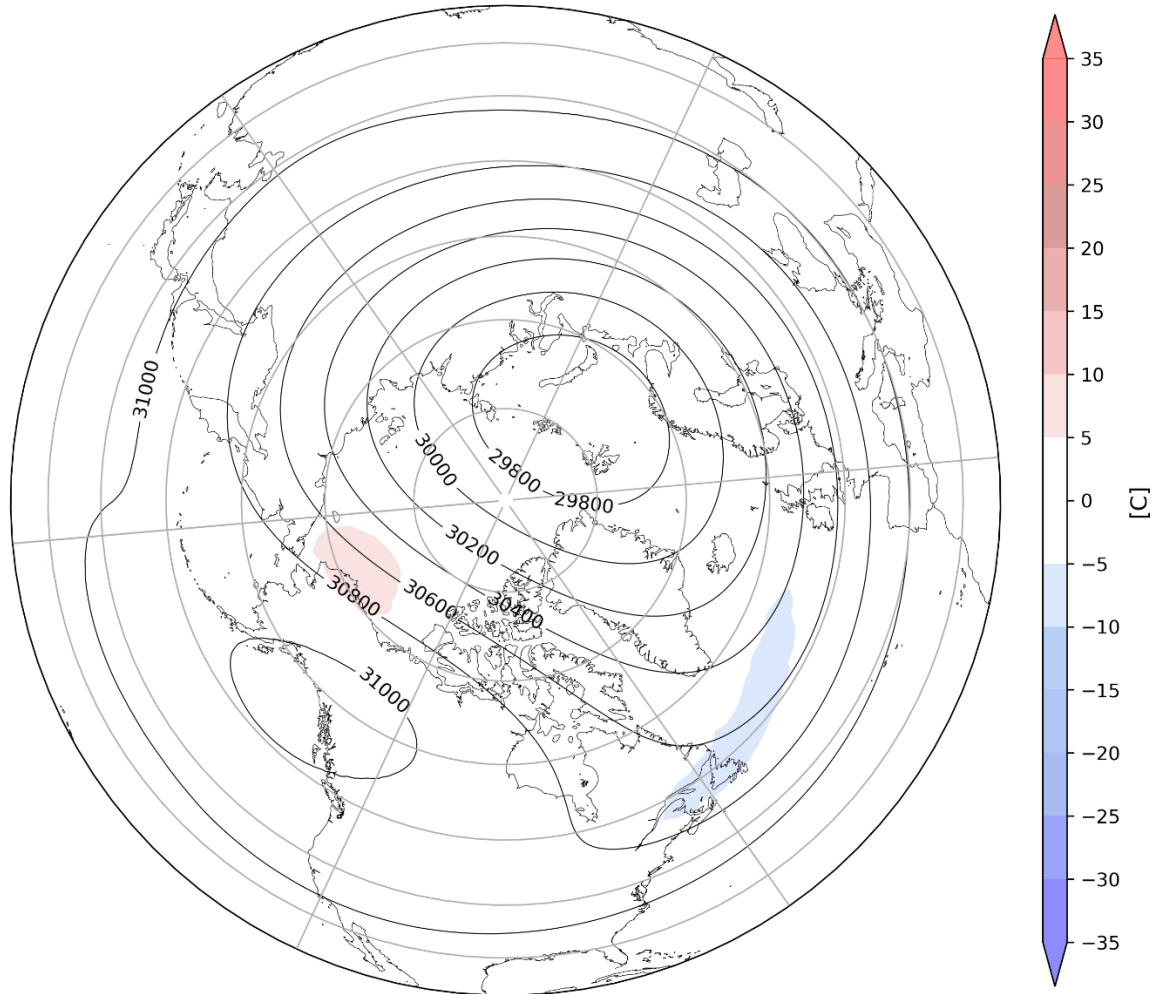


Figure iv. Forecasted average 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere from 14 – 18 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Near-Term

This week

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

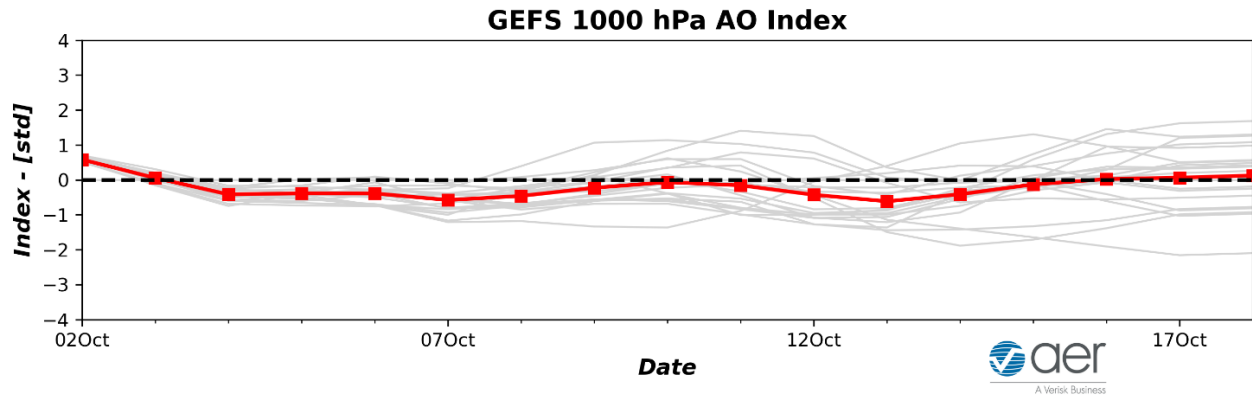


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 3 October 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies in the central North Atlantic will pump up ridging/positive geopotential height anomalies centered across Western Europe with troughing/negative geopotential height anomalies across Scandinavia and the Baltic States (**Figure 2**). This pattern favors normal to above and well above normal temperatures across Western and Central Europe including the UK with normal to below normal temperatures across Scandinavia and the Baltic States (**Figure 3**). This week Asia is predicted to be dominated by ridging/positive geopotential height anomalies centered in Central Asia with troughing/negative geopotential height anomalies in Western Asia and far East Asia (**Figure 2**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially Central Asia with normal to below normal temperatures limited to Northwestern Russia and regionally in parts of China and Japan (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/03/2023 FCST: 10/04/2023 to 10/08/2023

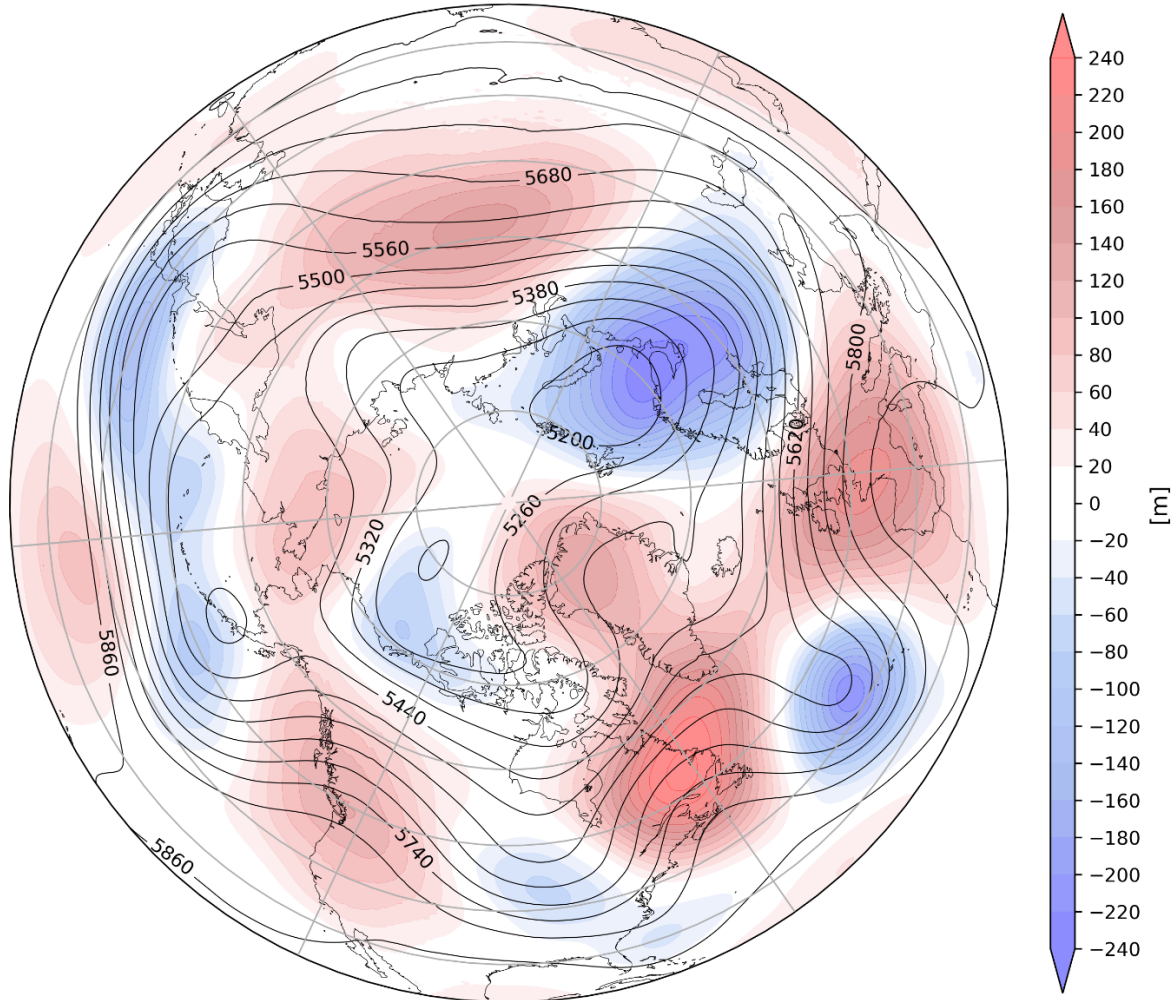


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 4 – 8 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

The pattern this week across North America is troughing/negative geopotential height anomalies across Alaska and the Central US with ridging/positive geopotential height anomalies across western North America and Eastern Canada (**Figure 2**). This pattern will favor widespread normal to above normal temperatures across much of Canada, the Northeastern and Western US with normal to below normal temperatures across Alaska and the Central US (**Figure 3**).

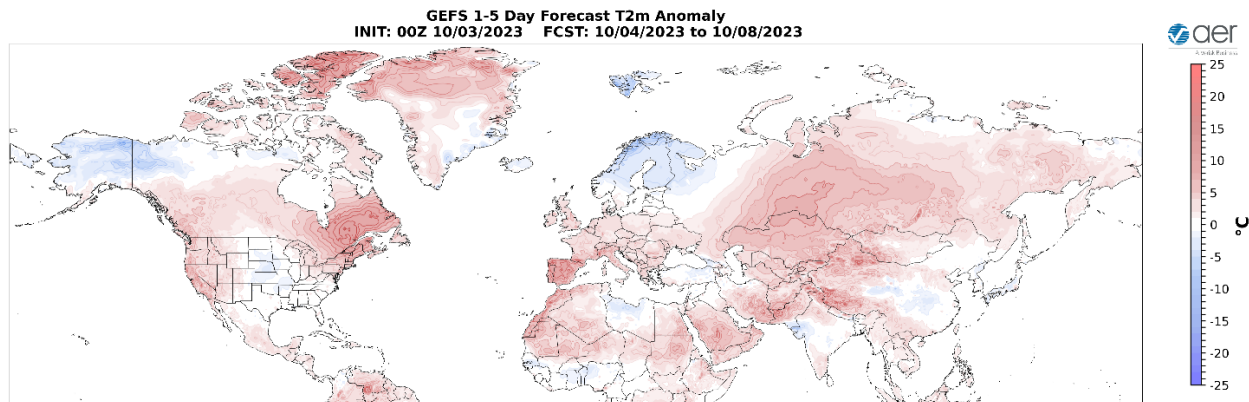


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 4 – 8 October 2023. The forecast is from the 00Z 3 October 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Norway, the Baltic States, Northwest Russia, the Tibetan Plateau and Central China this week (**Figure 4**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across Southeastern Alaska, the Central US New England and southern Quebec (**Figure 4**).

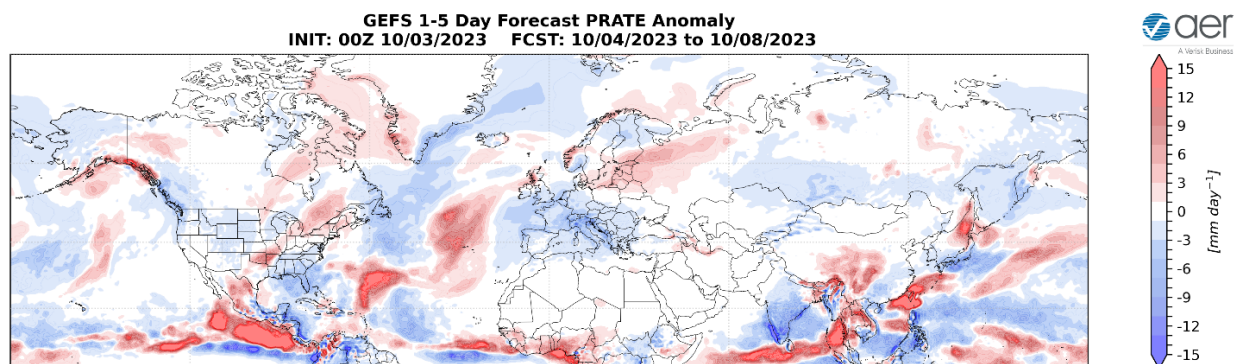


Figure 4. Forecasted precipitation rate (mm/day; shading) from 4 – 8 October 2023. The forecast is from the 00Z 3 October 2023 GFS ensemble.

Near-Mid Term

Next week

With mixed geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should remain close to neutral this period (**Figure 1**). With predicted weak but slightly positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be neutral to negative this period.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/03/2023 FCST: 10/09/2023 to 10/13/2023

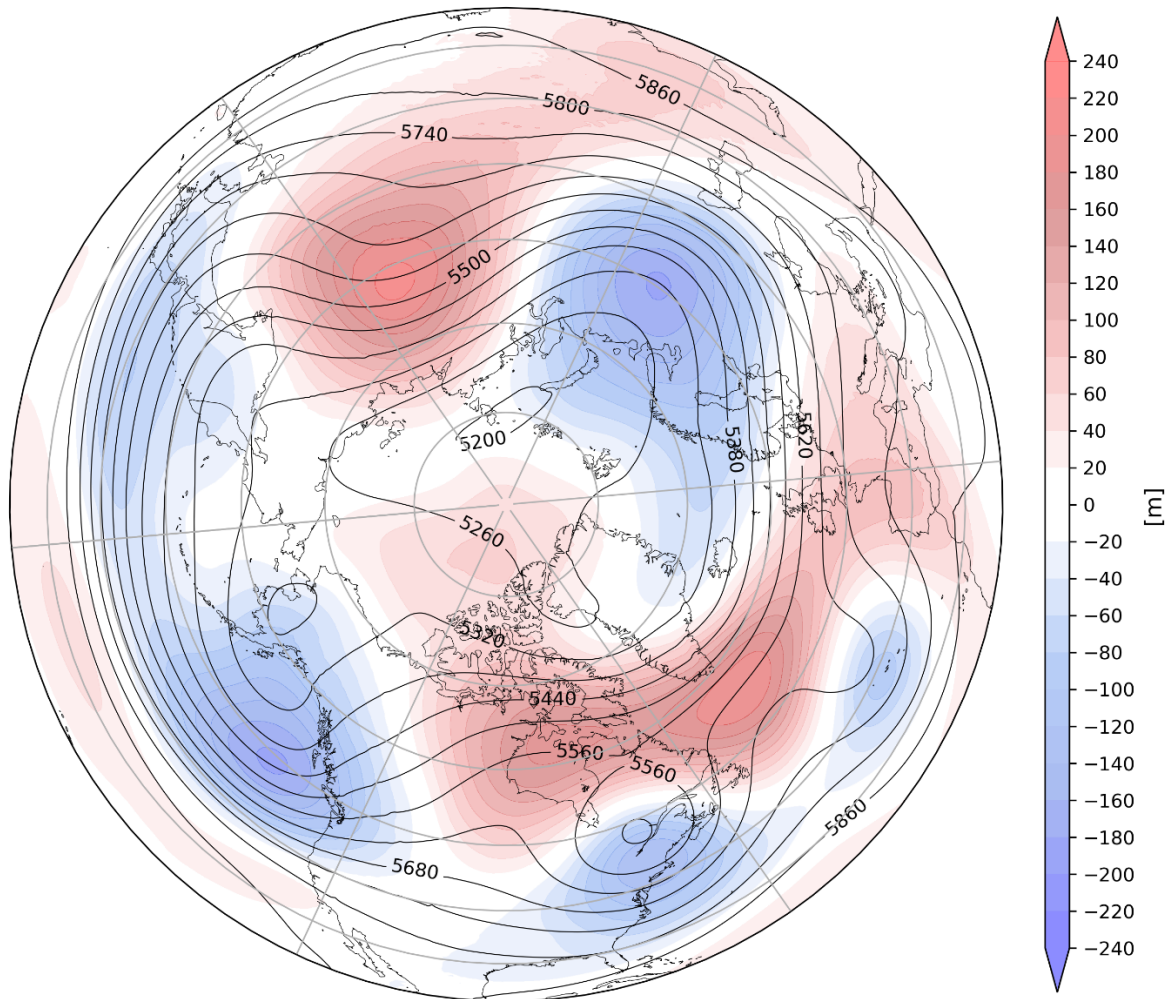


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies in the central North Atlantic will continue to support ridging/positive geopotential height anomalies across Western and Central Europe with troughing/negative geopotential height anomalies across Scandinavia and the Baltic States this period (**Figure 5**). This pattern should favor normal to above normal temperatures across Western and Central Europe including the UK **with** normal to below normal temperatures across Scandinavia and the Baltic States (**Figures 6**). The general pattern across Asia is predicted ridging/positive geopotential height anomalies centered in Central Asia with troughing/negative geopotential height anomalies in Western Asia and far East Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially

Central Asia with normal to below normal temperatures limited to Western Russia and regionally in parts of South China this period (**Figure 6**).

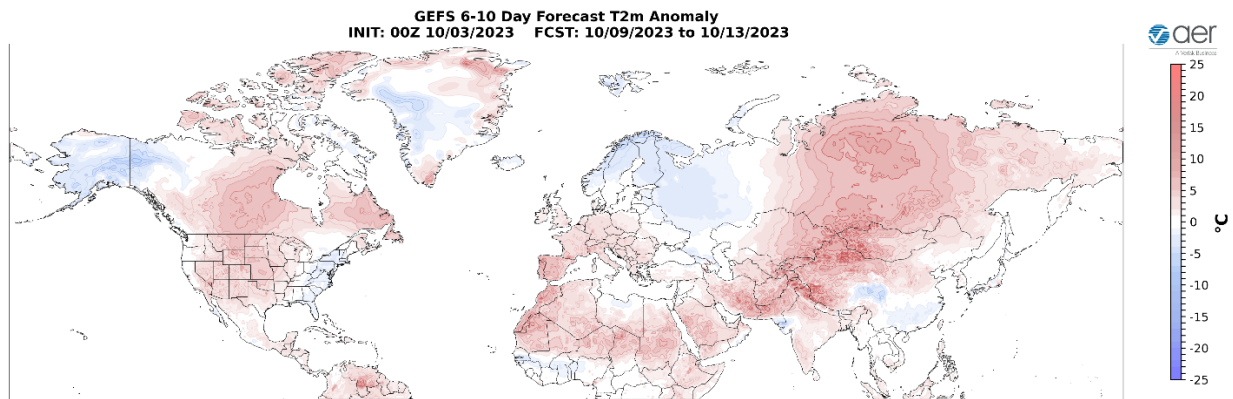


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 9 – 13 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

The predicted general pattern across North America this period is persistent troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska, the west coast of North America and the Eastern US forcing ridging/positive geopotential height anomalies across Central and Eastern Canada (**Figure 5**). This pattern favors normal to above normal temperatures across much of Canada and the Western and Central US with normal to below normal temperatures limited to Alaska and the Eastern US (**Figure 6**).

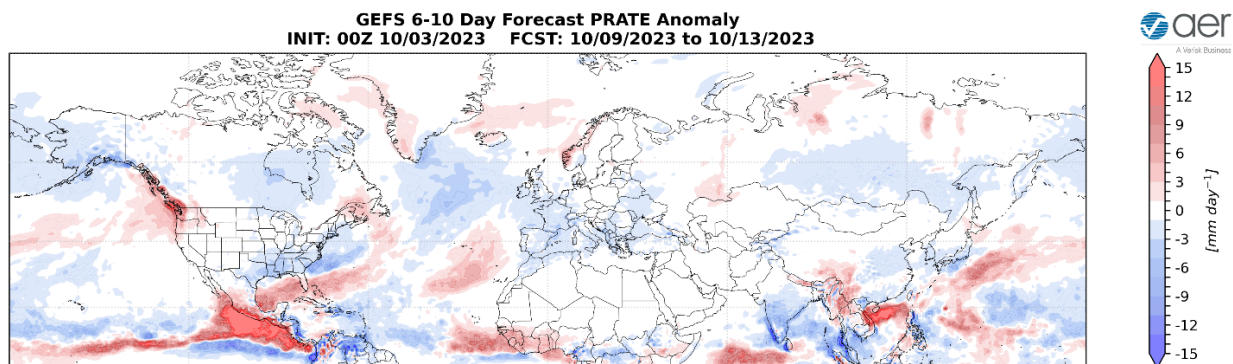


Figure 7. Forecasted precipitation rate (mm/day; shading) from 9 – 13 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Norway, Northern Siberia, the Tibetan Plateau and Central China this period (**Figure 7**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across

Southeastern Alaska, the Canadian West Coast, the US Pacific Northwest and Florida (Figure 7).

Mid Term

Week Two

With predicted mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (Figure 8), the AO should remain tethered to neutral this period (Figure 1). With predicted mixed and weak pressure/geopotential height anomalies across Greenland (Figure 8), the NAO will likely also remain close to neutral this period.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/03/2023 FCST: 10/14/2023 to 10/18/2023

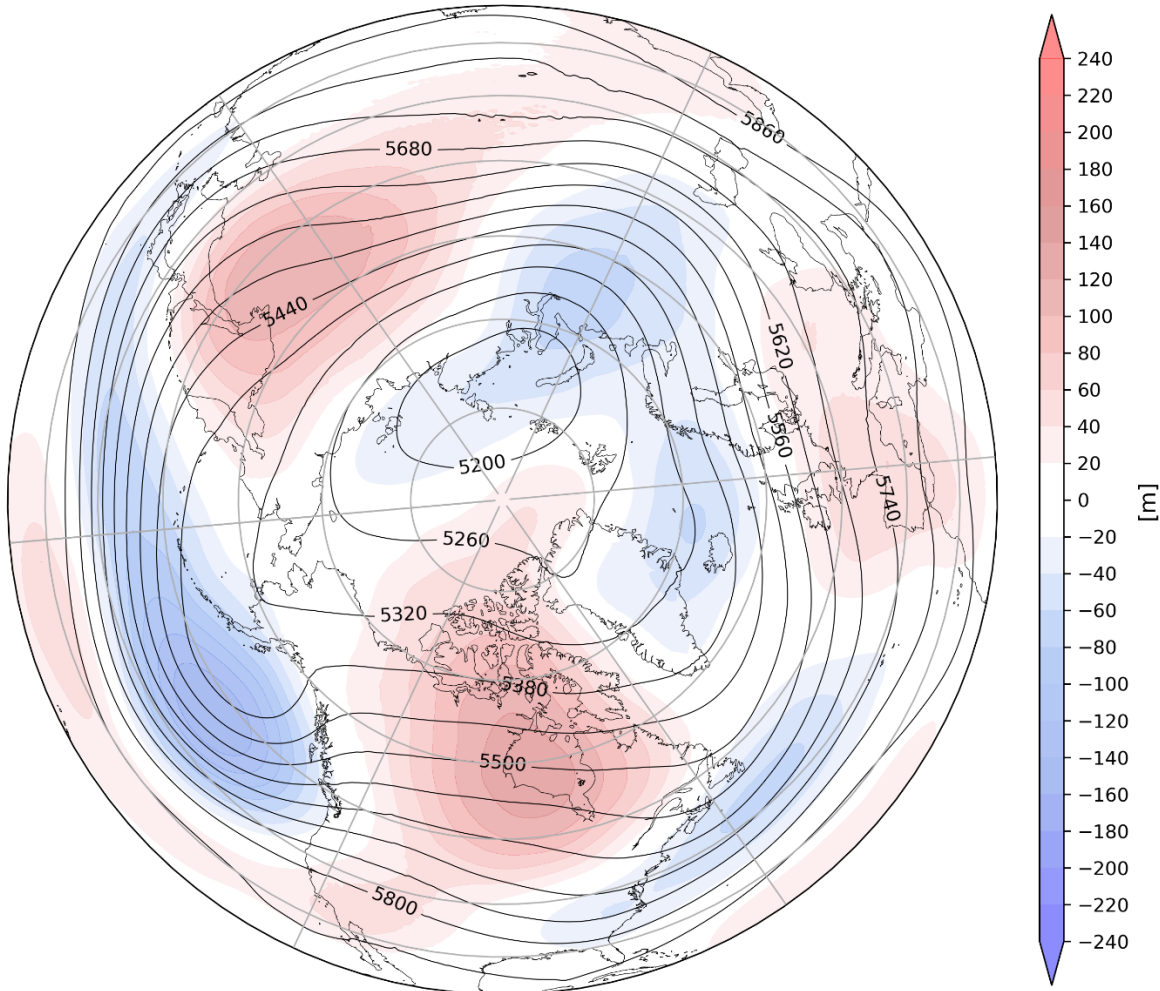


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Scandinavia are predicted this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Western and Central Europe including the UK with normal to below normal temperatures limited to northern Scandinavia this period (**Figures 9**). Widespread ridging/positive geopotential height anomalies are predicted across Central and Eastern Asia but now centered in East Asia with troughing/negative geopotential height anomalies across the Urals and Western Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures mostly limited to Western Russia this period (**Figure 9**).

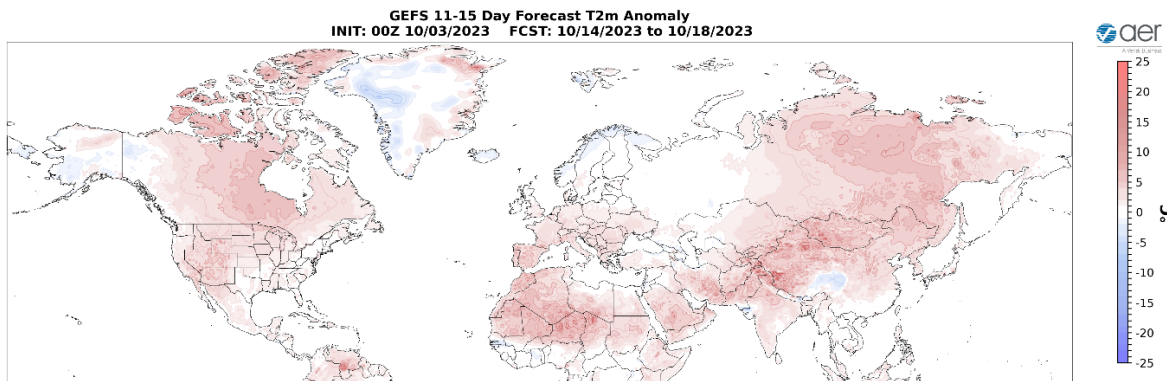


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 14 – 18 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to persist in the Gulf of Alaska forcing ridging/positive geopotential height anomalies across much of North America this period (**Figure 8**). This pattern favors normal to above normal temperatures across most of Canada and much of the US with normal to below normal temperatures mostly limited to pockets in Alaska and the West Coasts of Canada and the US (**Figure 9**).

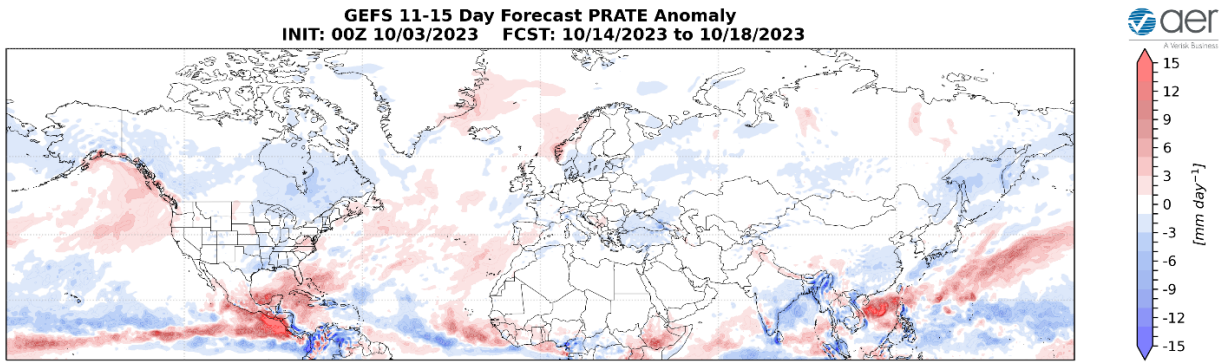


Figure 10. Forecasted precipitation rate (mm/day; shading) from 14 – 18 October 2023. The forecasts are from the 00z 3 October 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Norway, Spain and the Tibetan Plateau this period (**Figure 10**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across Southeastern Alaska and the West Coast of Canada (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs in the mid to upper stratosphere and lower troposphere with neutral PCHs in the upper and mid troposphere (**Figure 11**). This week and into next week warm/positive PCHs are predicted to develop in the mid to lower troposphere and the upper stratosphere next week (**Figure 11**).

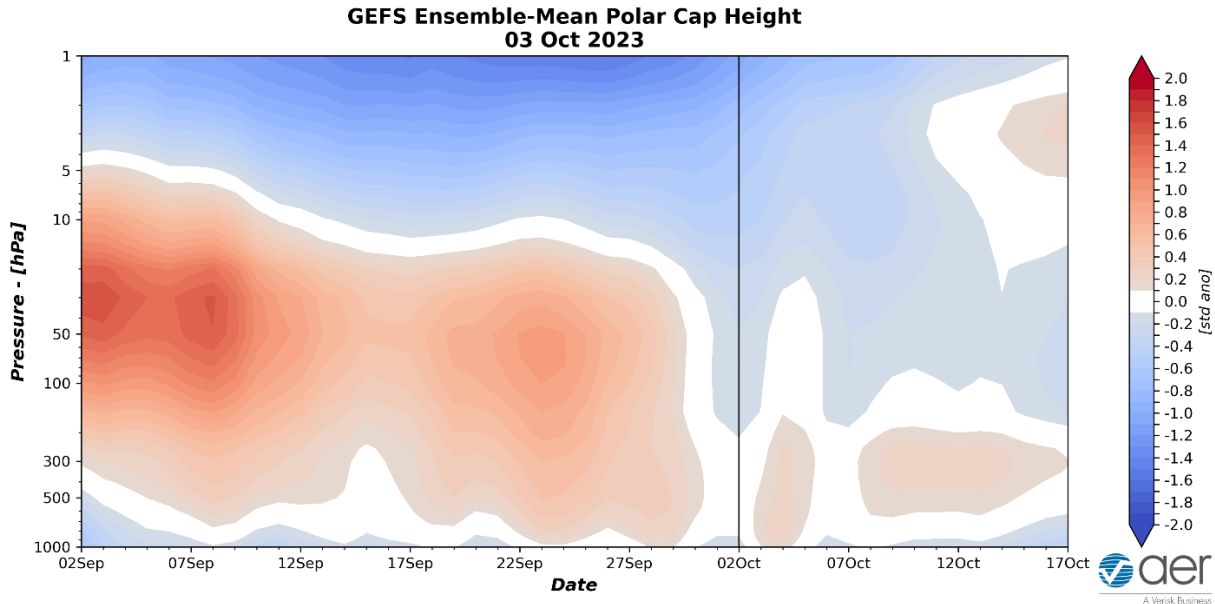


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 3 October 2023 GFS ensemble.

The predicted mixed and weak PCHs in the lower troposphere the next two weeks (**Figure 11**) are consistent with the predicted neutral surface AO the next two weeks (**Figure 1**). However, the AO is predicted to become more biased negative later this week (**Figure 1**) coinciding with the predicted developing warm/positive PCHs in the lower troposphere (**Figure 11**).

CFS 500 hPa Forecast Anomaly Nov 2023
Valid as of 03 Oct 2023

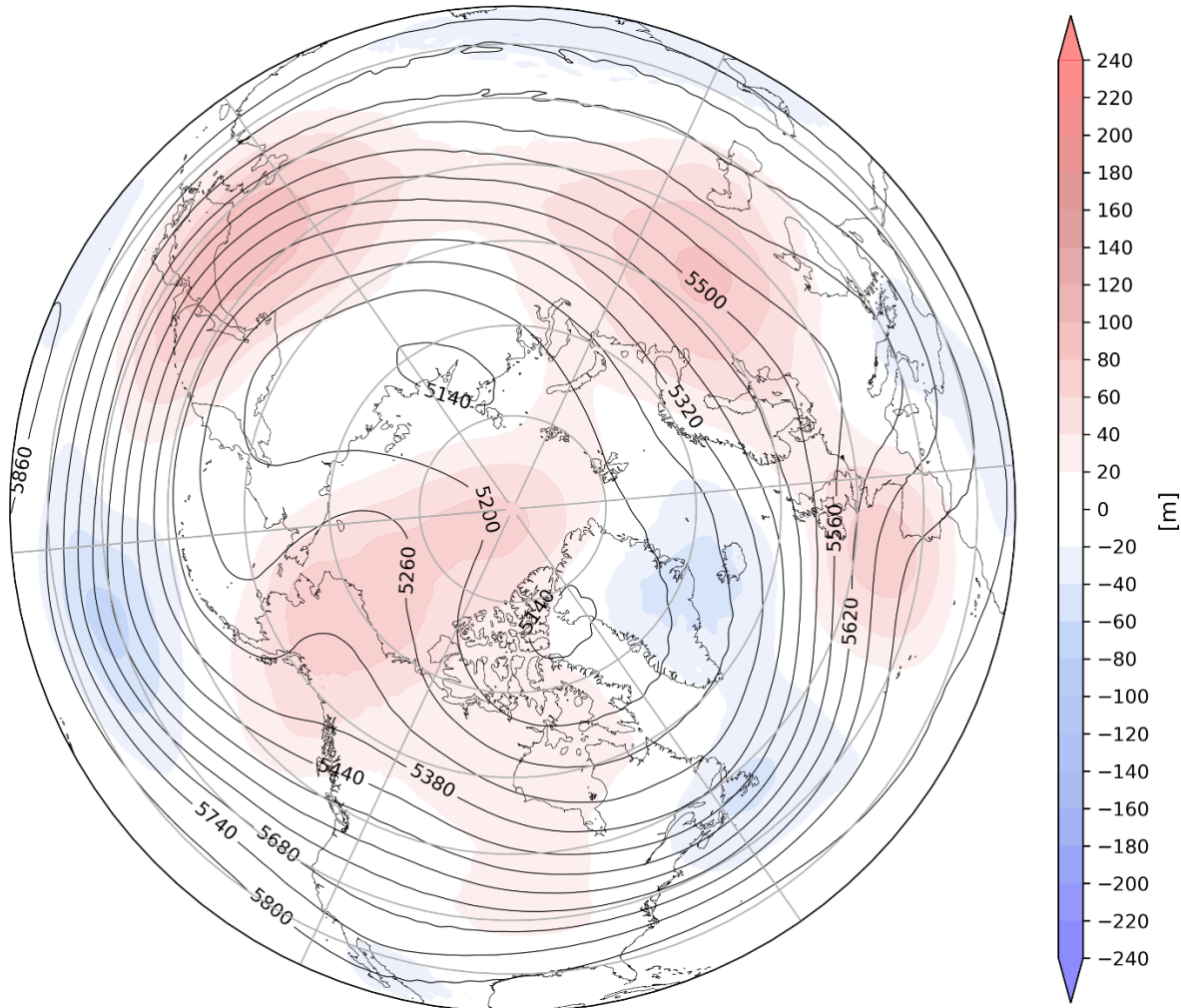


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for November 2023. The forecasts are from the 00Z 3 October 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for November (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered near Western Europe, Western Asia, Alaska and the Central Arctic with troughing across Southeastern Europe, Siberia, and eastern North America (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across much of Europe, Western and Southern Asia, Alaska, Northern Canada and the much of the US with seasonable to relatively cool temperatures across parts of Siberia, eastern Canada and the US (**Figure 13**).

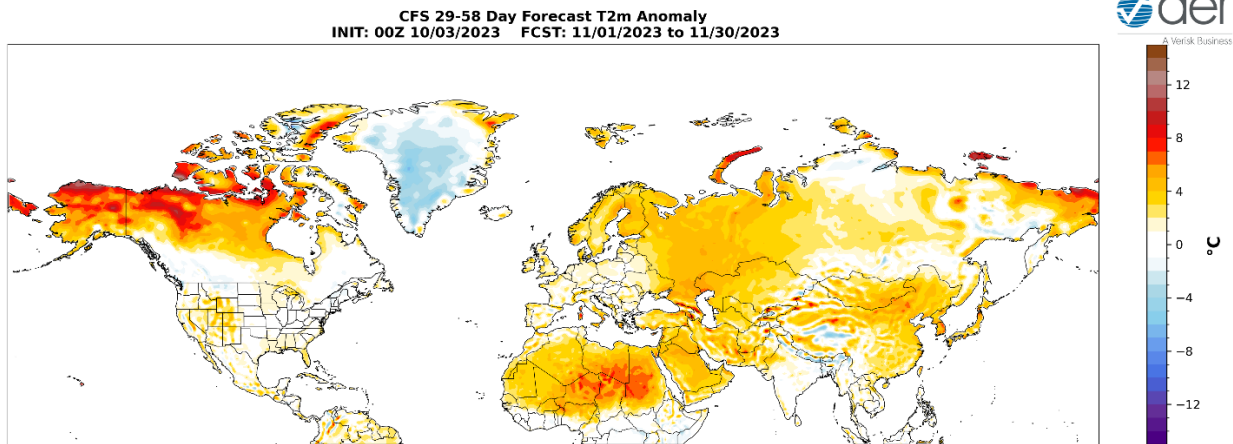


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for November 2023. The forecasts are from the 00Z 3 October 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are above normal, especially along the South America coast, indicating that the transition from La Niña to El Niño is complete (**Figure 14**) and El Niño 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, the eastern North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

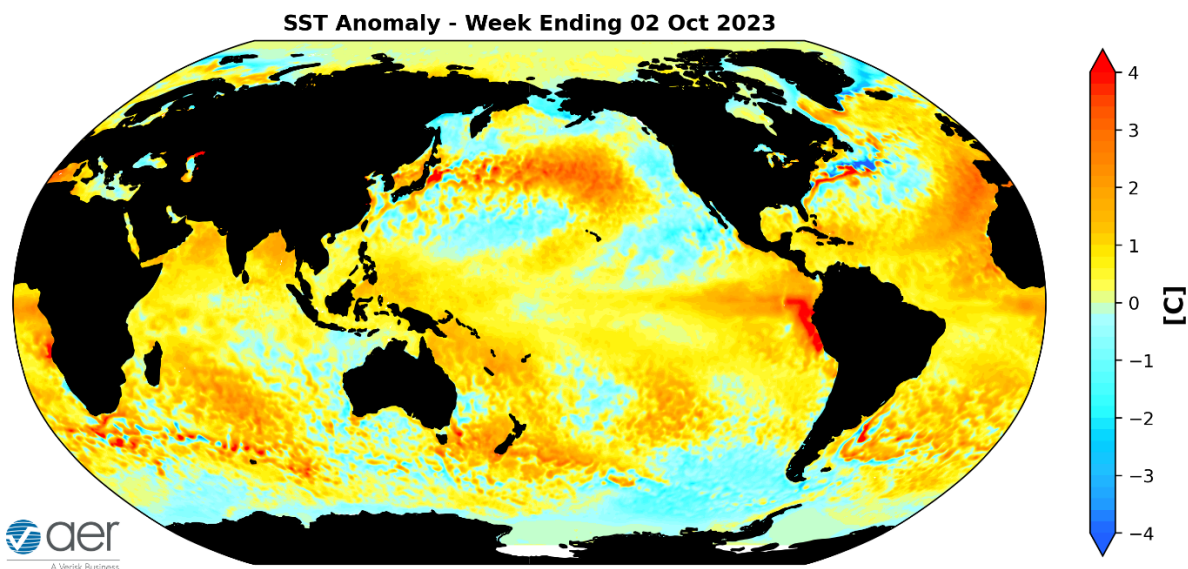


Figure 14. The latest weekly-mean global SST anomalies (ending 2 October 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is weak where no phase is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored and then emerge into phase one next week. Seems that the MJO is having little influence on the weather across North America this week. Phase one favors troughing along the west coast of North America and ridging in eastern North America. So the MJO could be influencing North American weather next week. But admittedly this is outside of my expertise.

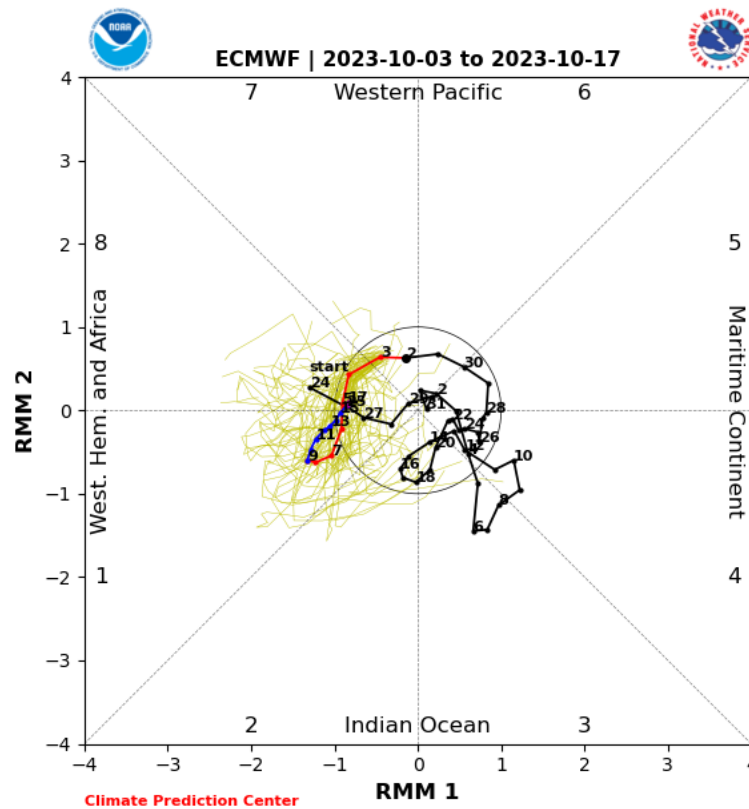


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 3 October 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source:

https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml

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!