

Arctic Oscillation and Polar Vortex Analysis and Forecasts

October 7, 2024

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO) and Polar Vortex (PV). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather. In late Spring, we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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

Summary

The Arctic Oscillation (AO) is currently negative and is predicted to trend positive the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mostly positive and are predicted to become increasingly mixed to negative over the next two weeks.

The North Atlantic Oscillation (NAO) is currently negative with strongly positive pressure/geopotential height anomalies across Greenland and the NAO is predicted to also trend positive the next two weeks as pressure/geopotential height anomalies are predicted to remain positive to neutral across Greenland.

This week ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies centered on Western Europe. Then next week as troughing overspreads Greenland, ridging will overspread Europe. This pattern will support this week normal to below normal temperatures across Northern and Western Europe including the United Kingdom (UK) while induced southwesterly flow will support normal to above normal temperatures across Southeastern Europe. Then next week normal to above normal temperatures will become more widespread across Europe.

The general pattern predicted for Asia the next two weeks is ridging/positive geopotential height anomalies centered over the Urals forcing troughing/negative geopotential height anomalies across Central Asia with more ridging centered across East Asia. This pattern favors this week normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to Siberia and Kazakhstan, however next week the colder temperatures are predicted to spread into East Asia.

This general predicted pattern across North America is troughing/negative geopotential height anomalies in the Gulf of Alaska forcing ridging/positive geopotential height anomalies across the interior of North America. This pattern favors widespread normal to above normal across much of Canada and the United States (US) with normal to below normal temperatures limited to Southeastern Canada and the US East Coast.

In the Impacts section I discuss the polar vortex and what might be its next move and its potential influence on the weather in the Northern Hemisphere (NH).

Plain Language Summary

The Greenland blocking/high pressure) that brought cooler weather to Western and Northern Europe is abating (see **Figure 5**) and should allow for a warmup for Europe (see **Figure 9**). Meanwhile low pressure troughing in the Gulf of Alaska is persisting the mild pattern across much of Canada and the US (see **Figure 6**). But the polar vortex is predicted to stretch (see **Figure i**) and this will likely usher in some cooler weather for the US East Coast next week (see **Figure 6**). What happens next for the polar vortex is highly uncertain.

Impacts

As I have noted and others the Northern Hemisphere (NH) polar vortex (PV) has been unusually weak, near or at record weak, all of September and even into October. It does seem to me that the climax of this overall weak PV will be a stretched PV next week (see **Figure i**). The stretched PV in my opinion is related to the cooler temperatures forecast for the US East Coast but it is still very early, and this is not an impressive event. Reminds me of last winter when stretched PV events were focused pretty far east with much of the cold air simply spilling out into the North Atlantic Ocean.

GEFS 6-10 Day Forecast 10 mb GPH & T Anomaly
INIT: 00Z 10/07/2024 FCST: 10/13/2024 to 10/17/2024

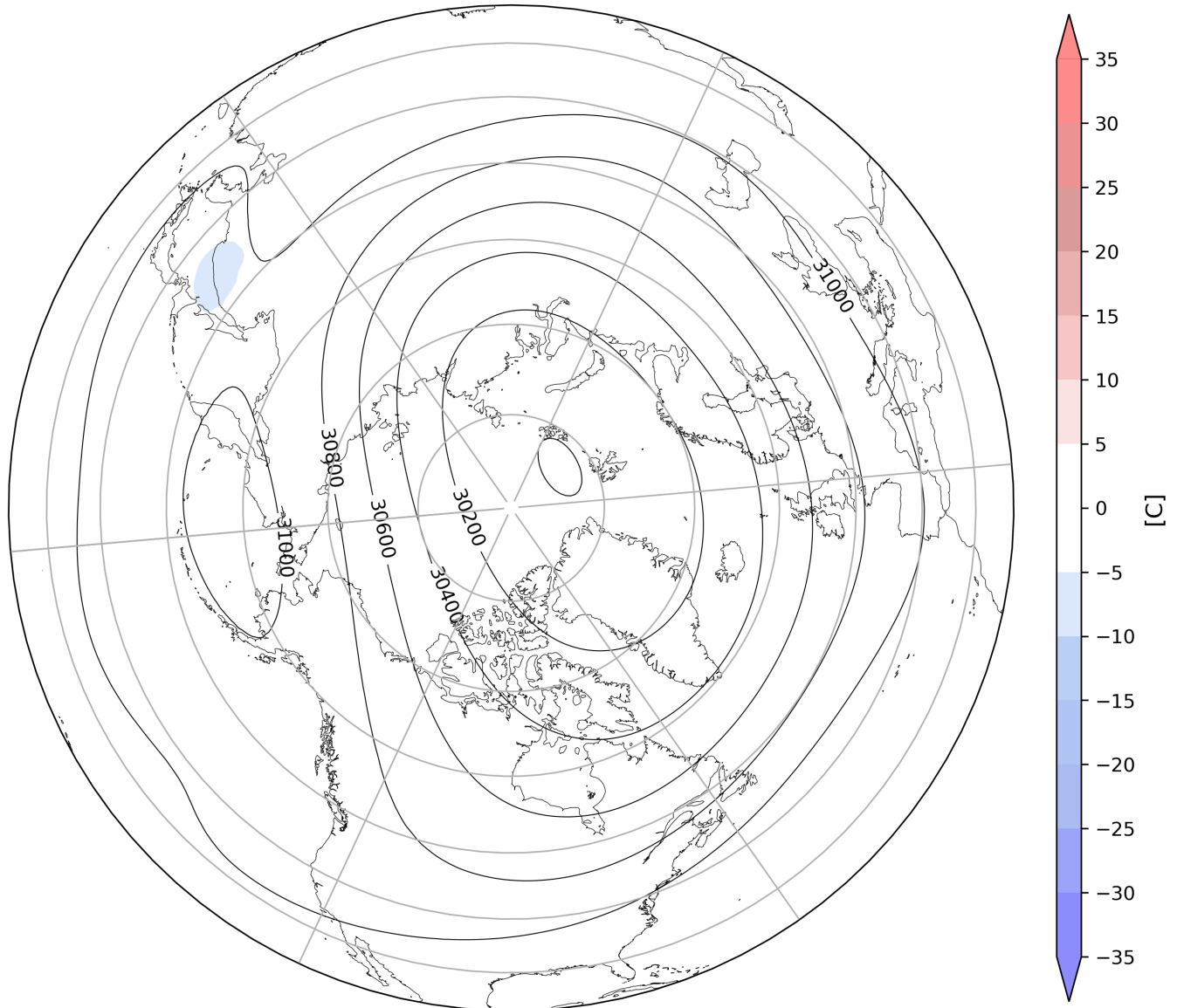


Figure i. Observed 10 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13–17 October 2024.

After that the PV will likely strengthen as is often the case with stretched PVs. The stretched PV of next week could be followed up by another stretched PV or even a Canadian warming, that is what the GFS is suggesting. A Canadian warming does favor colder temperatures in Siberia but very mild temperatures in much of North America. I think the predicted persistence of high pressure ridging near the Urals (see **Figure 8**) favors some kind of perturbed PV but for now another stretched PV, a Canadian Warming or a strong quasi circular PV are all plausible solutions.

Of course it is October, and I am focused on Siberian snow cover. Much of September and now into October the NAO has been strongly negative with impressive Greenland blocking. I thought that therefore the Siberian snow season might start out of the gate like gangbusters but so far I have been underwhelmed. The snow cover extent is quite similar to last October on this date and certainly clustered with most of the recent Octobers but looks to be on the lighter side of the past decade or so (see Figure ii). I will try to plot my own version later this week and tweet it out and include in future blog updates.

Daily snow extent and anomalies

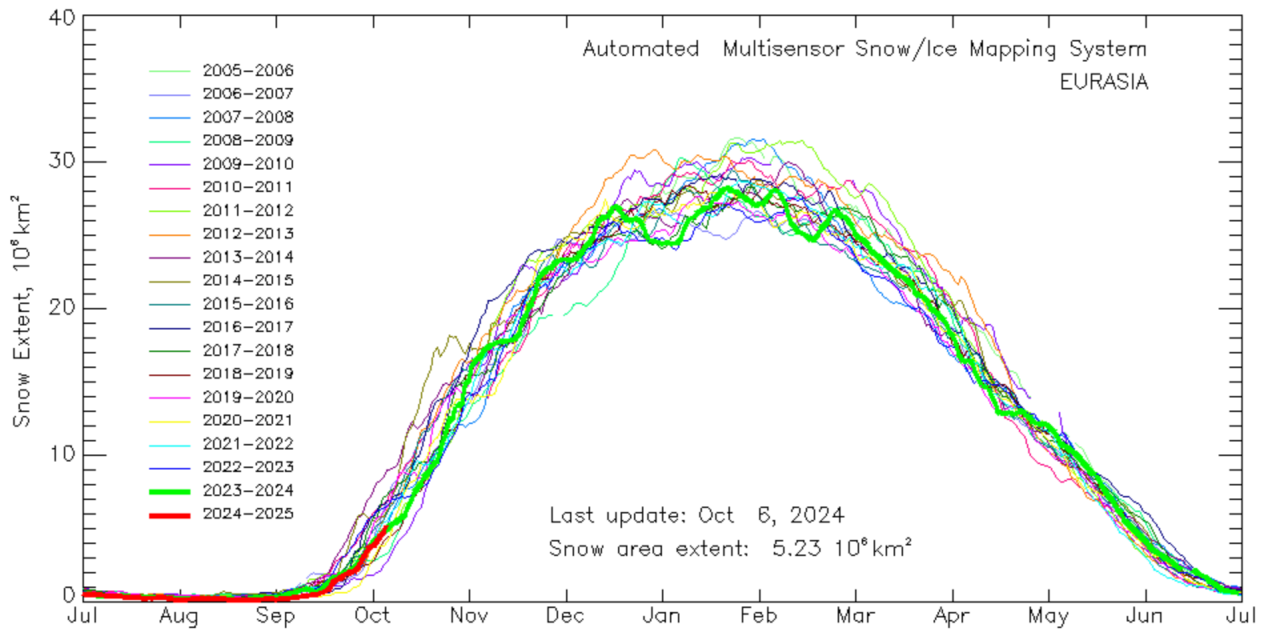


Figure iii. Figure 19. Observed Eurasian snow cover extent through 6 October 2024. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_monitor.html The negative NAO and Greenland blocking that has been around for most of the fall is predicted to wane (e.g., see Figure 5). That could slow down an already anemic month of snow cover advance. However the forecasts for later this month include Ural blocking that is also conducive to snow cover advance across Siberia and the forecast plots of predicted snowfall look fairly healthy (see for example Figure iii). I think the smart money is on that this year October Siberian snow cover extent will come close to the past four Octobers at slightly above normal that really doesn't signify a strong signal.

GEFS 6-10 Day Forecast SNOD Change
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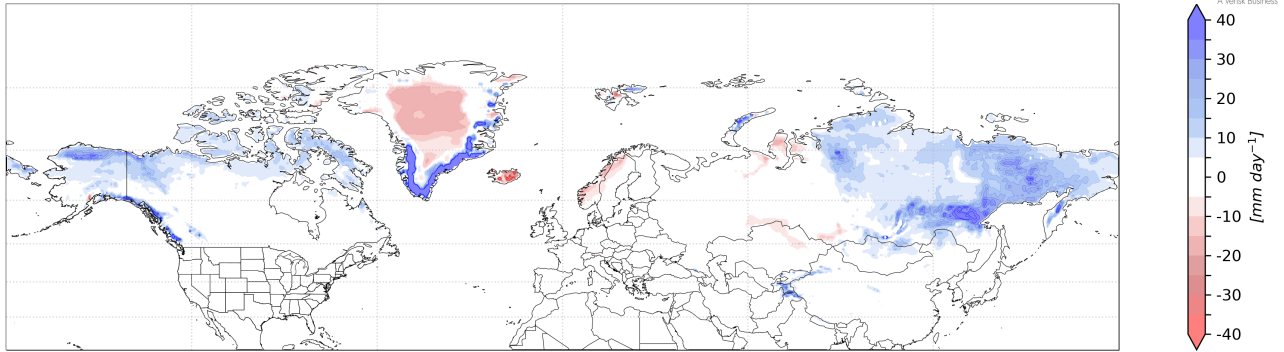


Figure iii. Forecasted snow depth changes (mm/day; shading) from 13 – 17 October 2024. The forecast is from the 00Z 31 January 2022 GFS ensemble.

Finally, Arctic sea ice extent put in a minimum for the year and is starting to grow but slowly for now. Sea ice extent is currently low all around the Arctic with no preferred regions (see **Figure iv**). It is the lack of sea ice in the Barents Kara Seas that favors a weak PV. So we will just have to wait to see which region emerges as the clear loser in sea ice extent later this fall and into early winter.

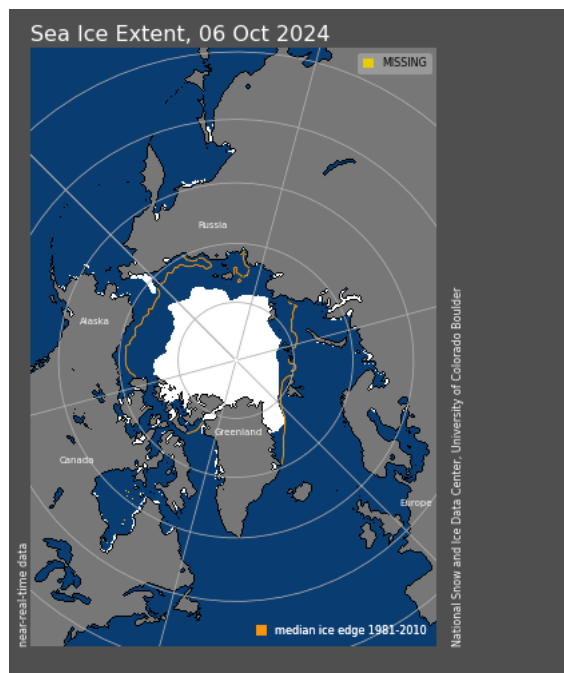


Figure iv. Observed Arctic sea ice extent on 6 October 2024 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC). URL: <https://nsidc.org/sea-ice-today>

Near-Term

This week

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

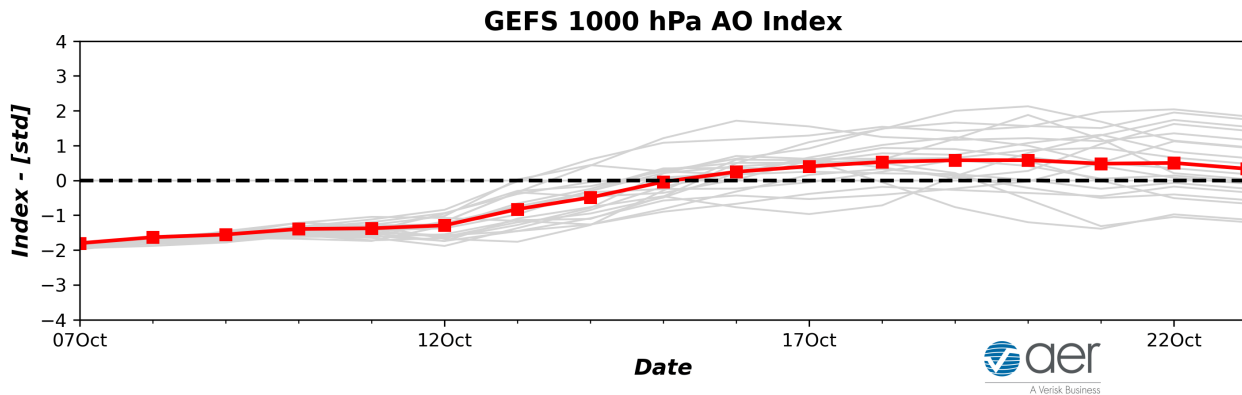


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 7 October 2024 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies centered on Western Europe this week (**Figures 2**). This pattern will favor normal to below normal temperatures across Northern and Western Europe including the UK while induced southwesterly flow favors normal to above normal temperatures across Southern and Eastern Europe (**Figure 3**). This week the predicted pattern across Asia is ridging/positive geopotential height anomalies centered over Western Asia forcing troughing/negative geopotential height anomalies across Central Asia with more ridging across East Asia (**Figure 2**). This pattern favors normal to above normal temperatures across Southern Asia with normal to below normal temperatures across Northern Asia but primarily Siberia (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/07/2024 FCST: 10/08/2024 to 10/12/2024

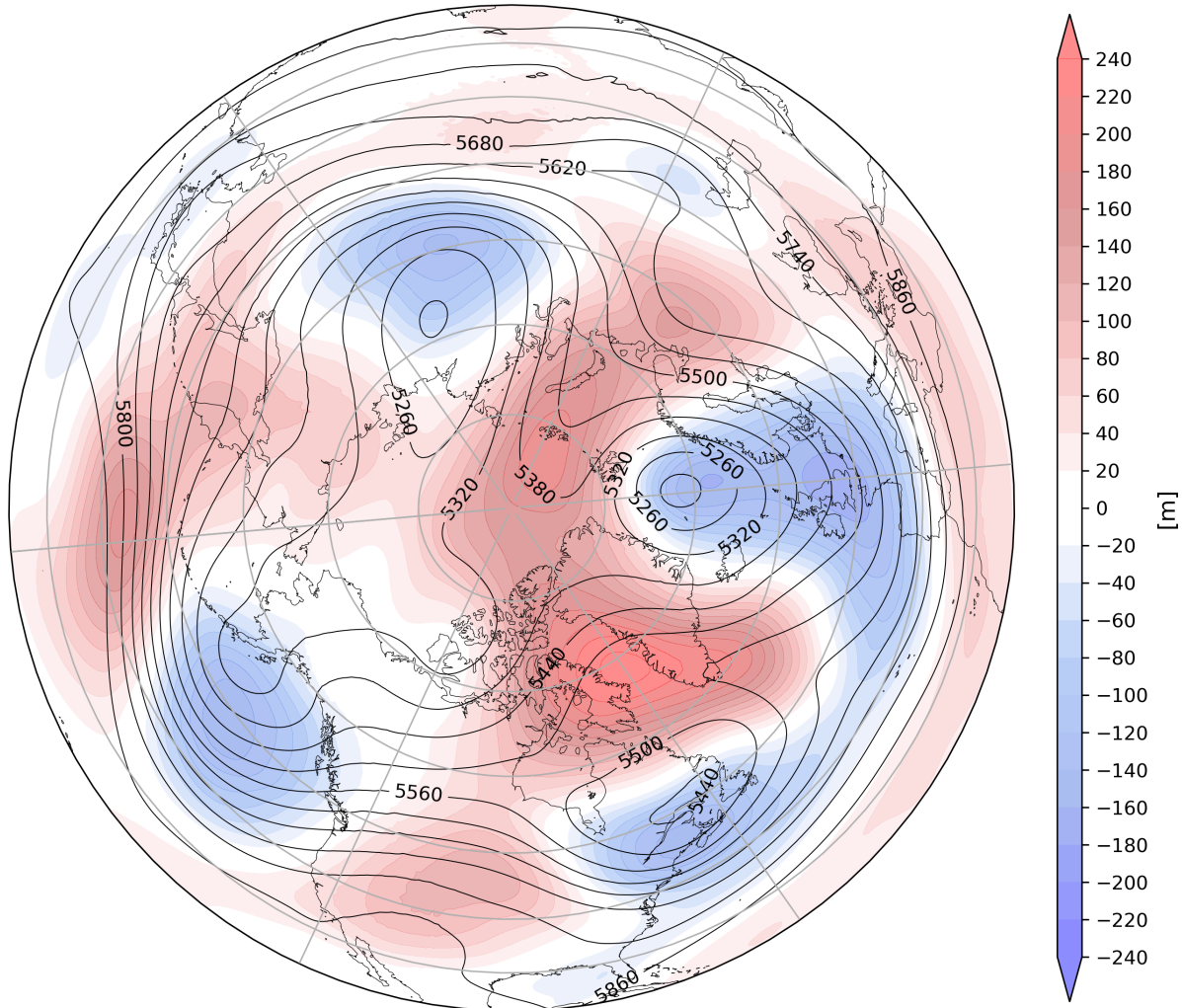


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble.

This week troughing/negative geopotential height anomalies in the Gulf of Alaska, will force ridging/positive geopotential heights across the interior of North America with the exception of troughing in Southeastern Canada and the Northeastern US (**Figure 2**). This pattern will favor normal to above normal temperatures across eastern Alaska, much of Canada and the US with normal to below normal temperatures limited to Southeastern Canada and the US East Coast (**Figure 3**).

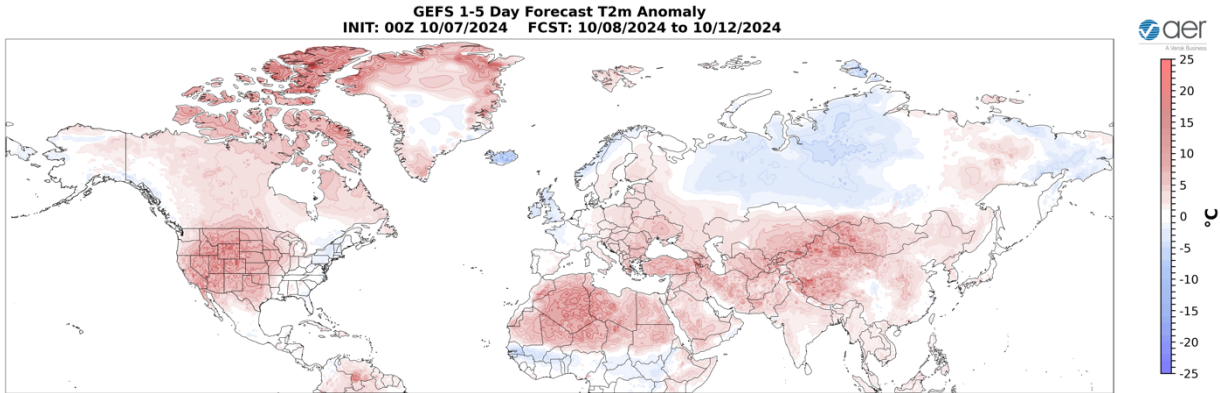


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 October 2024. The forecast is from the 00Z 7 October 2024 GFS ensemble.

Trouging will support above normal rainfall across the Northern and Western Europe, parts of Siberia, the Tibetan Plateau and parts of India with normal to below normal rainfall elsewhere across Eurasia this week (**Figure 4**). Trouging will support above normal rainfall across Southern Alaska, the Canadian Maritimes, and Florida due to Hurricane Milton with normal to below normal rainfall across the remainder of North America this week (**Figure 4**).

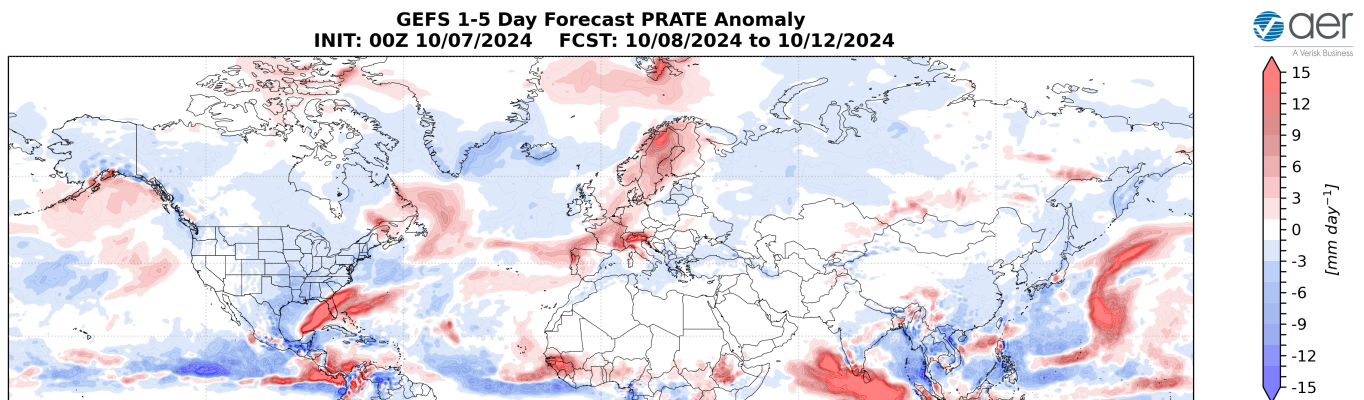


Figure 4. Forecasted precipitation rate (mm/day; shading) from 8 – 12 October 2023. The forecast is from the 00Z 7 October 2023 GFS ensemble.

Near-Mid Term

Next week

With geopotential height anomalies turning more mixed across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO will likely turn neutral this period (**Figure 1**). With predicted mixed pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be persist slightly negative to neutral this period.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 10/07/2024 FCST: 10/13/2024 to 10/17/2024

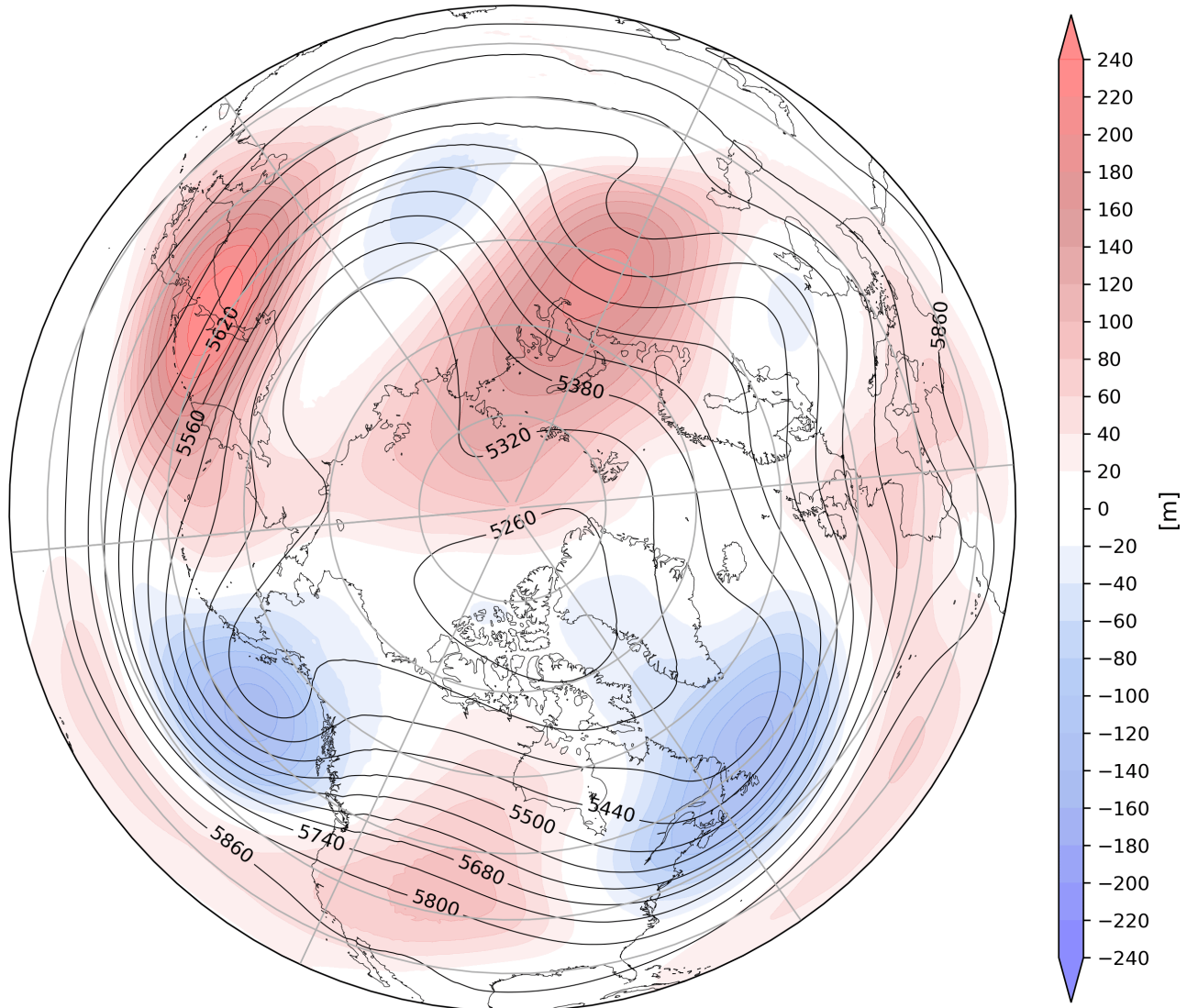


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble.

Weakening ridging/positive geopotential height anomalies across Greenland will continue to support troughing/negative geopotential height anomalies across Europe this period albeit weakening (**Figure 5**). This pattern will favor normal to below normal temperatures across much of Europe including the UK with normal to above normal temperatures across Southern Europe (**Figures 6**). The predicted pattern across Asia is ridging/positive geopotential height anomalies centered over the Urals forcing troughing/negative geopotential height anomalies across Central Asia extending across Siberia with more ridging/positive geopotential height anomalies across Far East Asia (**Figure 5**). This pattern favors normal to above normal temperatures across all of

Western, Southern and East Asia with normal to below normal temperatures across much of Siberia and Kazakhstan (**Figure 6**).

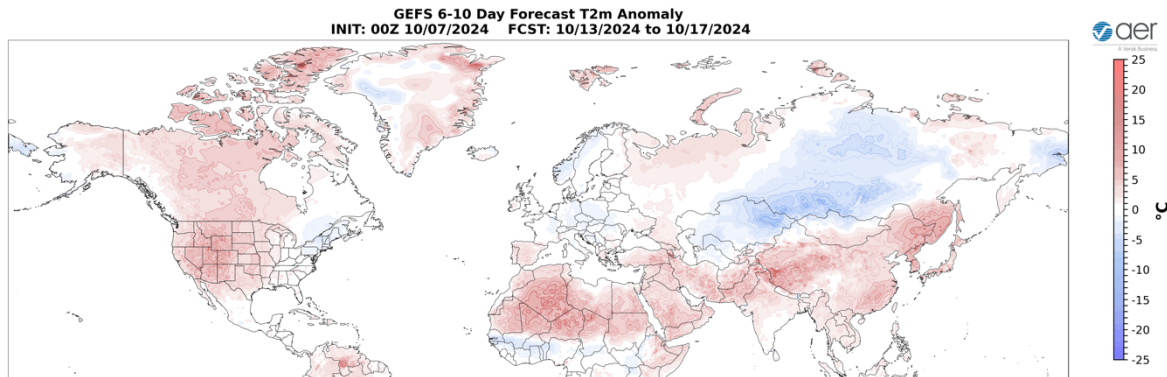


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble

Persistent troughing/negative geopotential height anomalies in the Gulf of Alaska will force ridging/positive geopotential height anomalies across most of Canada and the US with the exception of troughing in Southeastern Canada and the US East Coast this period (**Figure 5**). This pattern will favor normal to above normal temperatures across Alaska, most of Canada and the US with normal to below normal temperatures limited to Southeastern Canada and the US East Coast (**Figure 6**).

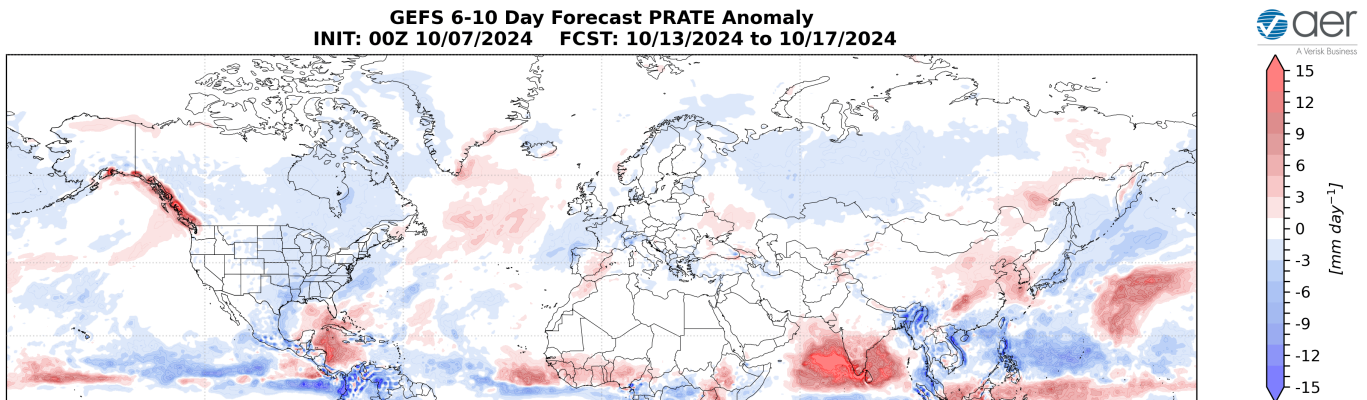


Figure 7. Forecasted precipitation rate (mm/day; shading) from 13–17 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble.

Troughing will support above normal rainfall across Spain, Eastern Siberia, and parts of East Asia with normal to below normal rainfall elsewhere across Eurasia this period (**Figure 7**). Troughing will support above normal rainfall across southeastern Alaska and the West Coast of Canada with normal to below normal rainfall across the rest of North America this period (**Figure 7**).

Mid Term

Week Two

With predicted medium to negative geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO will likely persist near neutral to positive this period (**Figure 1**). With predicted mixed to negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will likely be neutral this period.

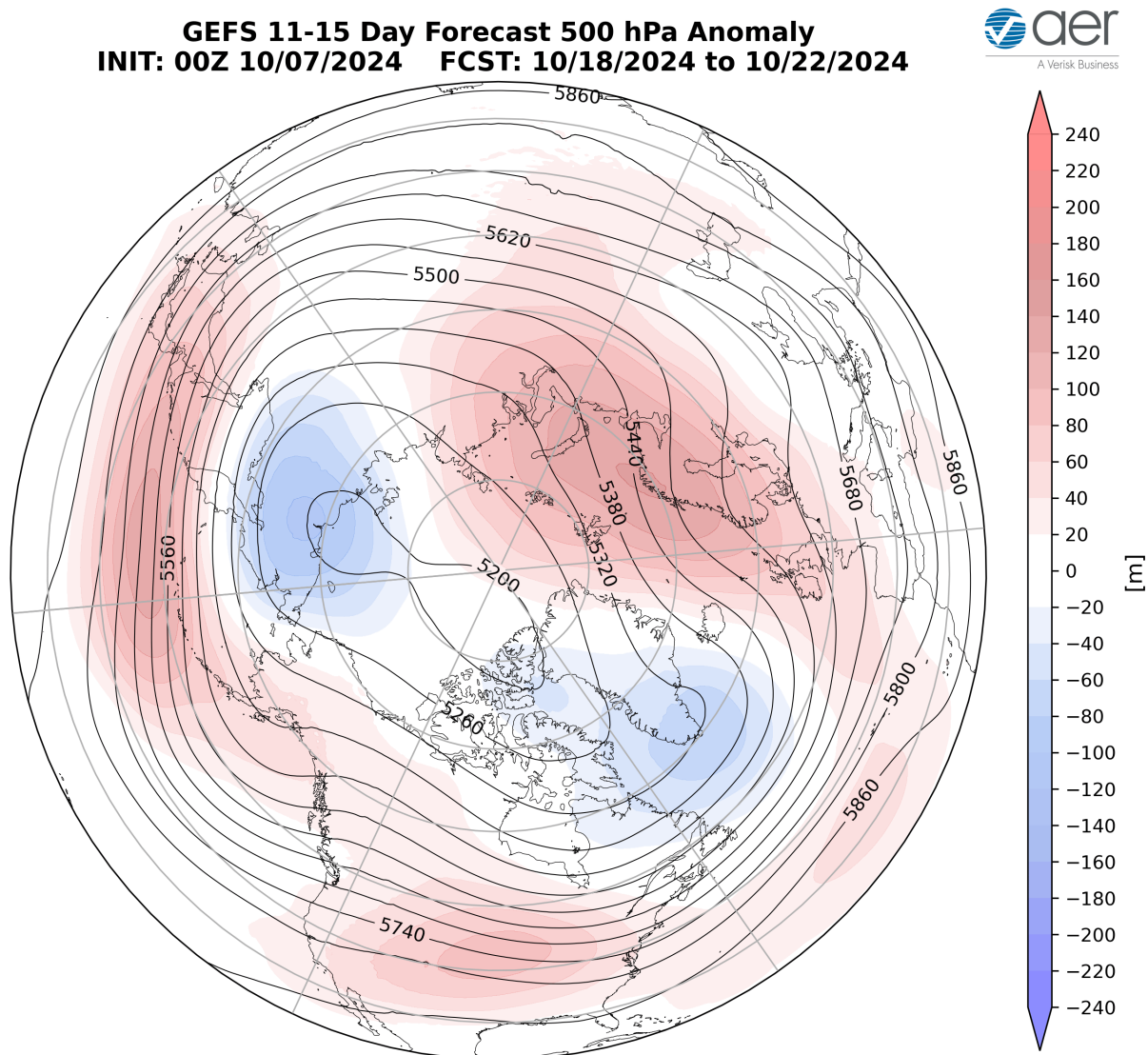


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 October 2024. The forecasts are from the 00z 7 October 2024 GFS ensemble.

Increasing troughing/negative geopotential height anomalies across Greenland will now support ridging/positive geopotential height anomalies across much of Europe this period (**Figure 8**). This pattern should favor widespread normal to above normal temperatures across Europe including the UK this period (**Figures 9**). The predicted pattern across Asia this period is ridging/positive geopotential height anomalies centered on the Urals and the Barents-Kara Seas forcing troughing/negative geopotential height anomalies across Siberia and Eastern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across Western and Southern Asia with normal to below normal temperatures widespread across Siberia and East Asia this period (**Figure 9**).

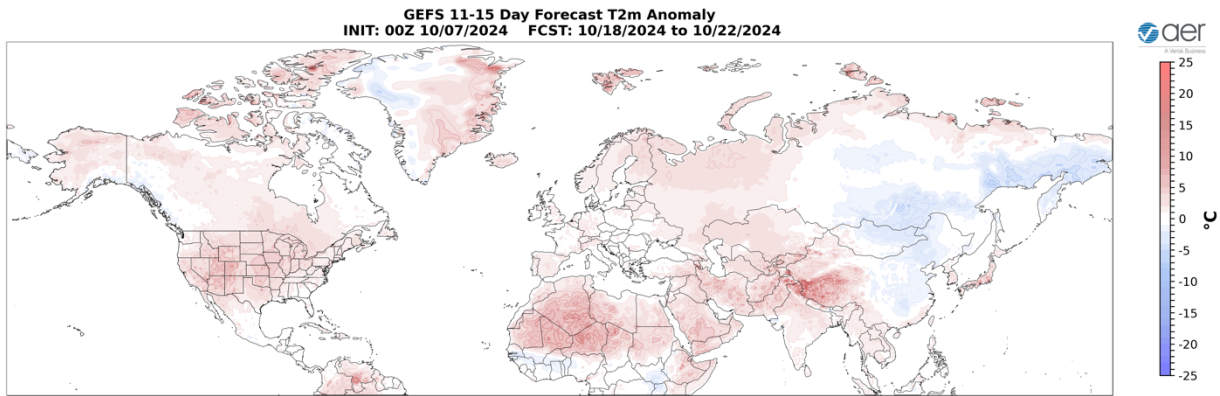


Figure 9. Forecasted surface temperature anomalies (°C; shading) from 18 – 22 October 2024. The forecast is from the 00Z 7 October 2024 GFS ensemble.

Predicted persistent troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska will force ridging/positive geopotential height anomalies across most of Canada and the US (**Figure 8**). This pattern will favor normal to below normal temperatures across southern Alaska, the West Coast of Canada, the US Pacific Northwest and parts of the Southeastern US with widespread normal to above normal temperatures across much of northern Alaska, Canada and the US (**Figure 9**).

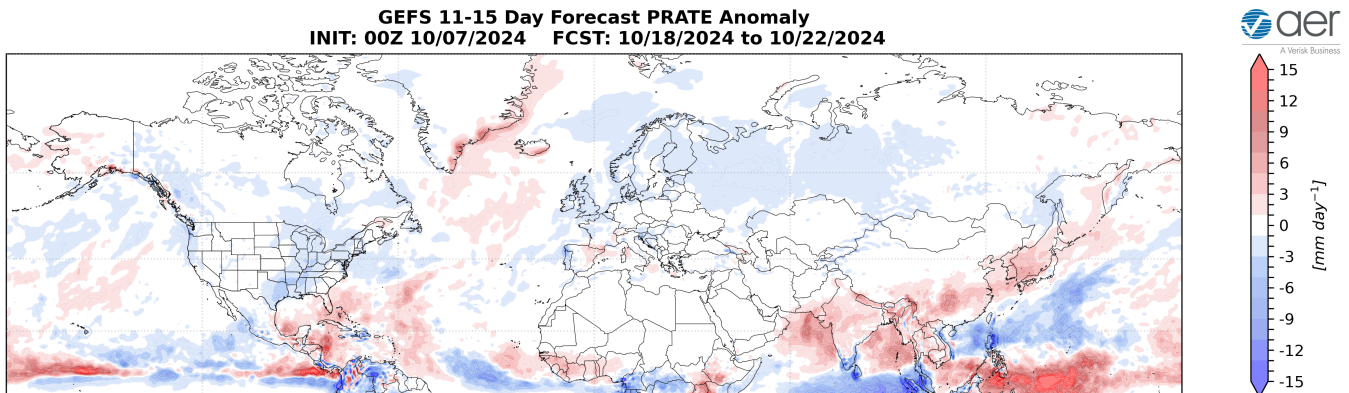


Figure 10. Forecasted precipitation rate (mm/day; shading) from 18 – 22 October 2024. The forecast is from the 00Z 7 October 2024 GFS ensemble

Trouthing will support above normal rainfall across the Mediterranean region, Tibetan Plateau, India and East Asia with normal to below normal rainfall elsewhere across Eurasia this period (**Figure 10**). Trouthing will support above normal rainfall for parts of Alaska and the West Coast of Canada with normal to below normal rainfall across the remainder of North America this period (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive PCHs through much of the stratosphere and troposphere with the exception of cold/negative PCHs in the upper stratosphere (**Figure 11**). Then next warm/positive PCHs will persist in the stratosphere and upper troposphere but weaken and reverse to cold/negative in the lower troposphere and surface (**Figure 11**).

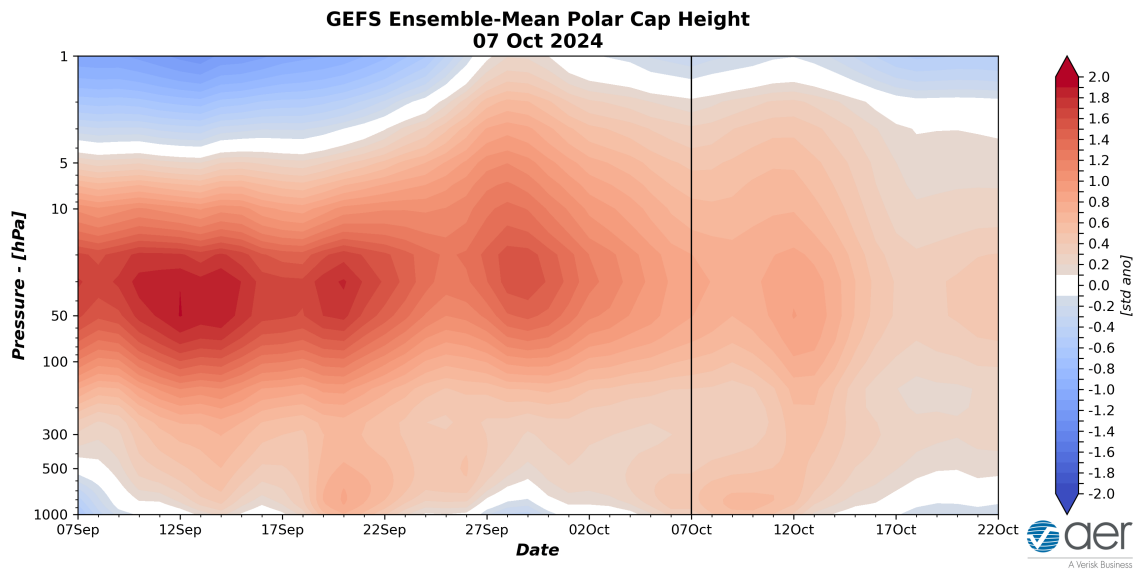


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 7 October 2024 GFS ensemble.

The predicted warm/positive PCHs near the surface this week (**Figure 11**) are consistent with the predicted negative surface AO this week (**Figure 1**). However, next week when the PCHs in the lower troposphere are predicted to trend cold/negative, this will force a period of a more neutral to positive AO next week.

**CFS 500 hPa Forecast Anomaly Nov 2024
Valid as of 07 Oct 2024**

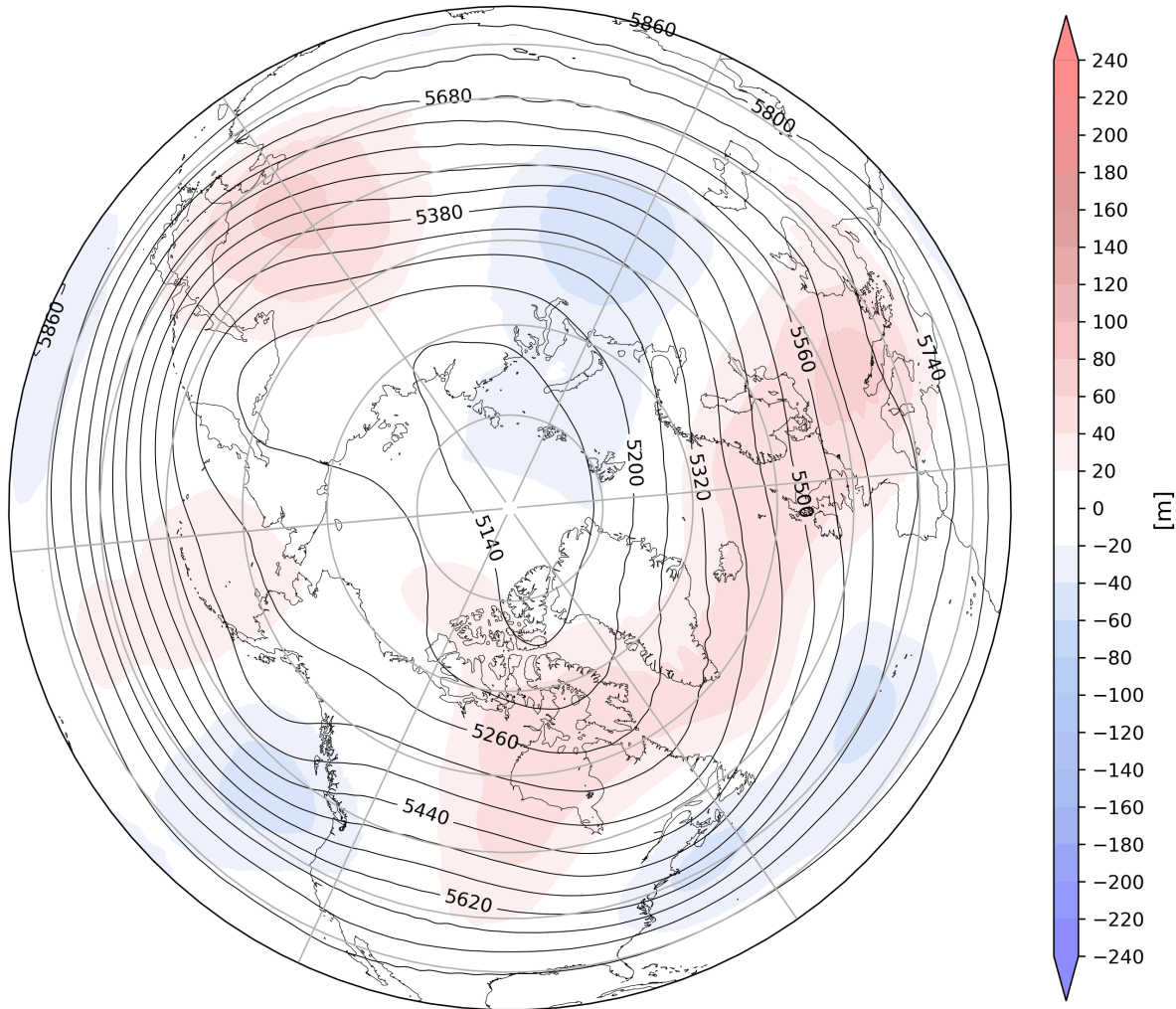


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2024. The forecasts are from the 00Z 7 October 2024 CFS.

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 across Baffin Bay and Greenland, Eastern Asia, the Aleutians and much of Canada and the US with troughing across Western Asia, Siberia, Alaska, the Gulf of Alaska and the Eastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Europe, Southern and Eastern Asia, northern Alaska much of Canada and the US with seasonable to relatively cool temperatures for parts of Central Asia, parts of Siberia, Northeast Asia, southern Alaska, the West Coast of Canada and parts of the US East Coast (**Figure 13**).

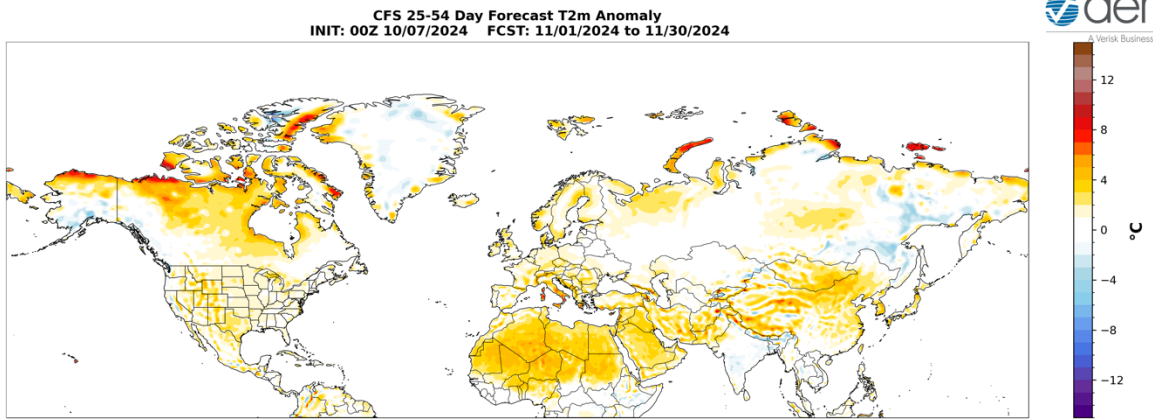


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2024. The forecasts are from the 00Z 7 October 2024 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific Sea surface temperatures (SSTs) anomalies are below normal, between the Dateline and the South America coast, indicating that an La Niña is emerging (**Figure 14**) and weak La Niña conditions are expected through the winter. Observed SSTs across the NH remain well above normal especially in the central North Pacific centered on the Dateline and the western North Pacific, much of the North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

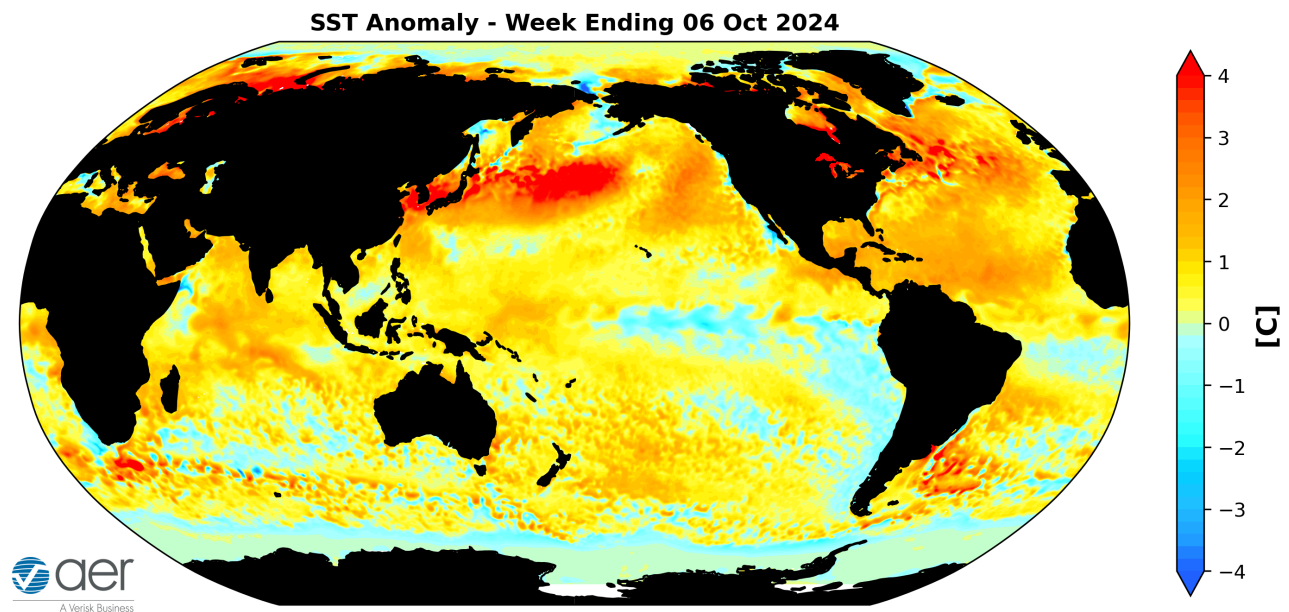


Figure 14. The latest daily-mean global SST anomalies (ending 6 October 2024). Data from NOAA OI High-Resolution dataset. Source: <https://psl.noaa.gov/map/clim/sst.shtml>

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is weak where no phase is favored (**Figure 1**). The forecasts are for the MJO to remain weak where no phase is favored and then possibly emerge in phase six in two weeks. Therefore it seems that the MJO is having limited influence on North American weather next week. But admittedly this is outside of my expertise.

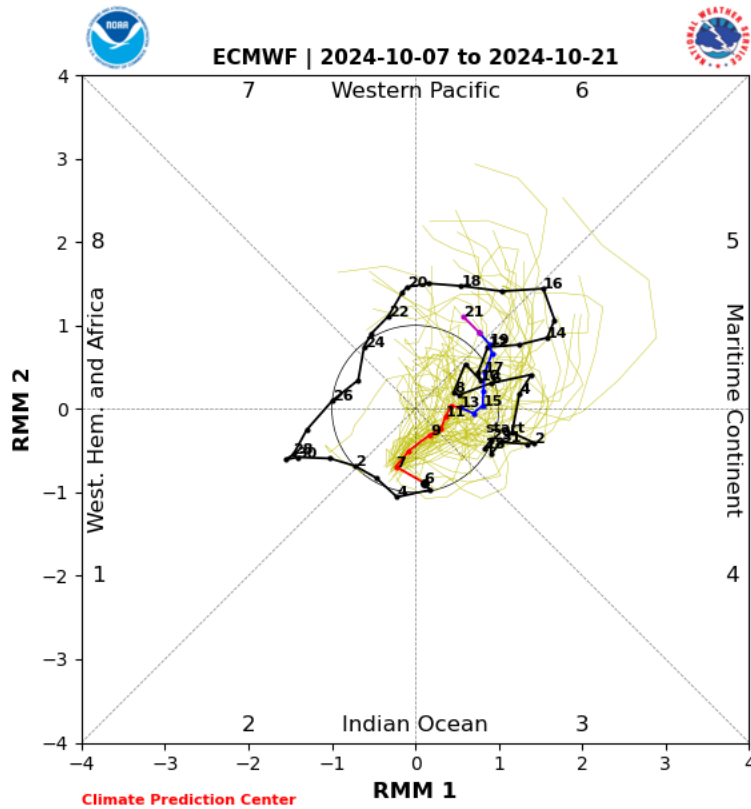


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 7 October 2024 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source:

<https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/ecmf.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!

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