Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 22, 2023

Dear AO/PV blog readers:

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

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

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

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.

Subscribe to our email list or follow me on Twitter (@judah47) for notification of updates.

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

Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to remain negative to neutral the next two weeks as pressure/geopotential height

anomalies across the Arctic are currently mixed to mostly positive and are predicted remain mixed to mostly positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative with positive pressure/geopotential height anomalies across Greenland and are predicted to trend positive the next two weeks as pressure/geopotential height anomalies will slowly become increasingly negative across Greenland.

- Over the next two weeks ridging/positive geopotential height anomalies across Greenland will slowly reverse ridging/positive to troughing/negative geopotential height anomalies across Europe. This pattern will reverse normal to above normal temperatures across Europe this week to normal to below normal temperatures across Western Europe including the United Kingdom (UK) with normal to above normal temperatures lingering longer across Eastern Europe next week.
- The next two weeks, the general pattern across Asia is predicted to be ridging/positive geopotential height anomalies across Central Asia sandwiched by troughing/negative geopotential height anomalies across Western Russia and East Asia. This pattern mostly favors normal to above normal temperatures widespread across Central Asia and much of Siberia with normal to below normal temperatures across Eastern Siberia across Western Russia and Central and Eastern China.
- The general predicted pattern predicted across North America the next two weeks is ridging/positive geopotential height anomalies across western North America with troughing/negative geopotential height anomalies in eastern North America. This pattern generally favors normal to above normal temperatures for Alaska, Western Canada and the Western United States (US) with normal to below normal temperatures across Eastern Canada and the Eastern US but especially the Northeastern US.
- In the Impacts section I discuss the predicted the atmospheric circulation across the Northern Hemisphere (NH) and the possibility of relief for those regions were heat has been relentless this summer.
- **Through mid-September I have extended international travel planned and I also hope to post one to two more winter summaries, which will likely result in disruptions to blog postings for the remainder of the summer.**

Plain Language Summary

Summer is hanging on tough with record heat in Europe and the US ongoing. But I do think some relief is on the way by next week. But despite the abundance of extreme weather overall this summer the pattern is reminiscent of recent summers but with possibly more high latitude blocking. The summer temperature pattern was overall consistent with forecasts posted in the blog at the end of May (see **Figure iii**).

Impacts

Summer is certainly going out with a bang across North America and Europe (see **Figure i**). We have several heat domes spread across the Northern Hemisphere (NH). The region with the highest absolute mid-tropospheric geopotential heights is the Central US (exceeding the rare 600 decameters) with Europe being a close second. Under the Central US and Southern European heat domes, well above normal temperatures are being recorded (see **Figure ii**) and even record warm temperatures this week (see tweets from @WeatherProf and @WMO). However, the most impressive heat dome measured by anomalous positive geopotential heights and surface temperatures is currently over Greenland.

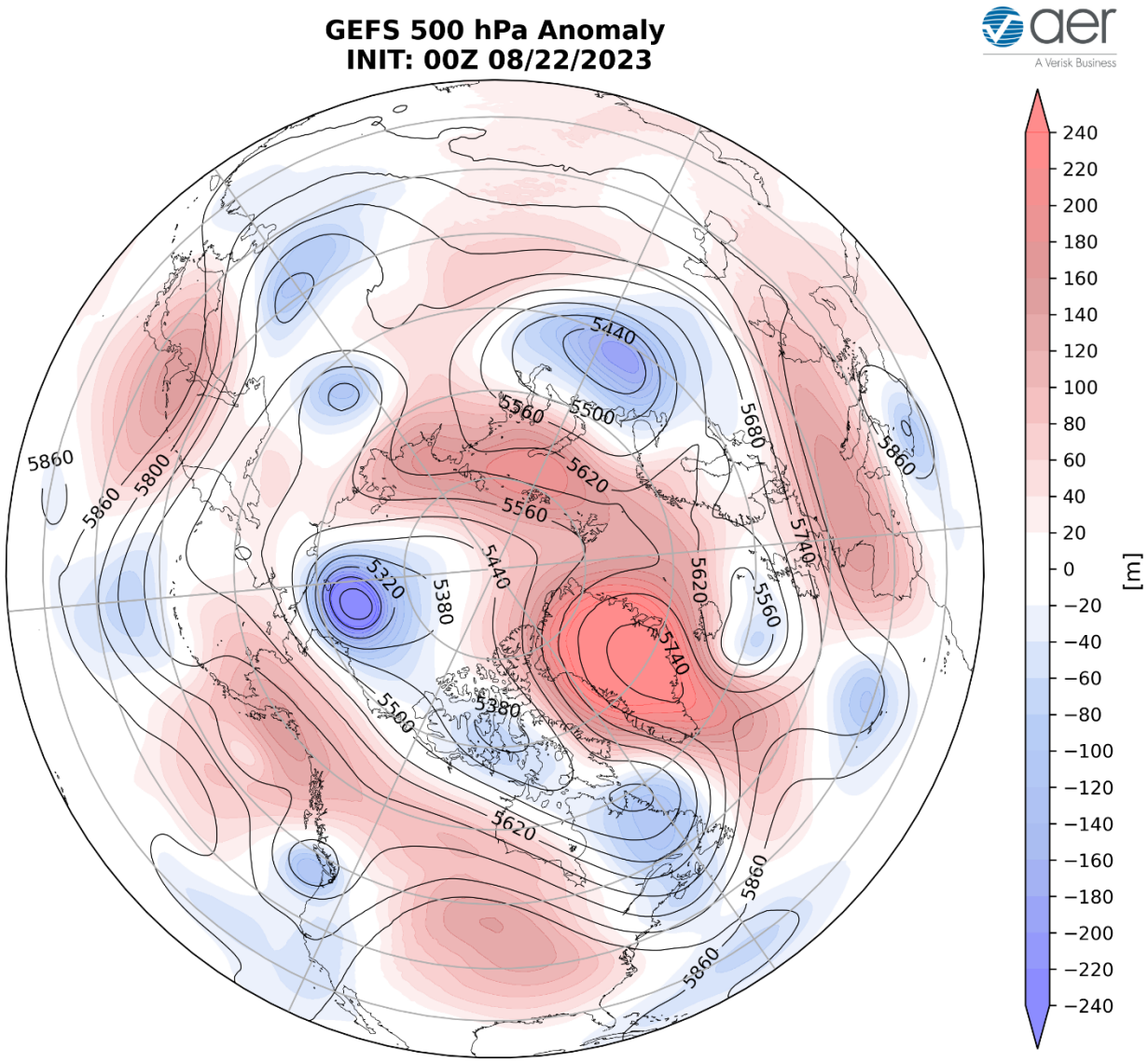

Figure i. Initialized 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for 22 August 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

It seems that the strong Greenland high pressure or blocking is related to an unusual atmospheric feature that suggests stratosphere-troposphere coupling where warm/positive polar cap geopotential height anomalies (PCHs) seems to be propagating down from the stratosphere to the surface and forcing a negative AO (see **Figure 11**). Warm/positive tropospheric PCHs in summer is not that unusual during recent summers but it does seem to me that the magnitude and the depth of the feature well into the stratosphere is unusual. And readers are welcome to looks at archived blogs in late summer to compare for themselves. But admittedly the variability in summer is damped so the absolute anomalies are not as impressive as the standardized anomalies suggest. How important all this is to our sensible weather in summer, I am not sure but if it persists into the fall, it will become a lot more relevant and interesting.

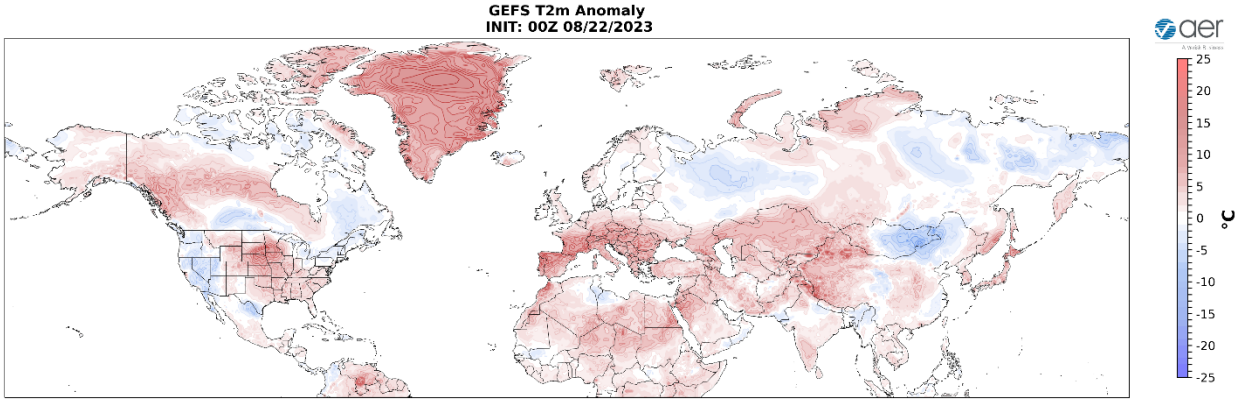

Figure ii. Initialized surface temperature anomalies (°C; shading) for 22 August 2023. The forecast is from the 00Z 22 August 2023 GFS ensemble.

It has been an incredibly hot summer in the Southern US and Southern Europe. The overall warm pattern looks to continue but I do think the intensity will abate. The Greenland blocking is predicted to force new troughing into Europe bringing with it cooler temperatures especially to Western Europe but should make its way across the Mediterranean. Meanwhile a bowling ball of a low-pressure system in the Beaufort Sea will start heading east into Baffin Bay and help reinforce and expand troughing in eastern North America displacing the Central US heat dome into western North America. This will induce northerly flow in the Southcentral and Southeastern US. Below normal temperatures are not yet predicted but should result in at least some relief that could grow with time.

As I discussed in the previous blog, despite the seemingly exceptional weather this summer across the NH, I think the overall pattern of surface temperature anomalies is consistent with recent summers and with summer forecasts from this past spring (the summer forecast was included in the 22 May 2023 blog post). In **Figure iii**, I post an update of the NH surface temperature anomalies for the summer so far and given there is only a little over a week left the pattern will not change much. Above normal temperatures are widespread across the NH with two notable exceptions Western Russia and the US east of the Rockies. These two regions have often been the

exceptions to universal warmth in recent summers. The one posted forecast that showed seasonable to cool temperatures in these two regions was the AER forecast and overall, the AER is performing well relative to the other two dynamical forecasts. But I will provide a more complete analysis next month.

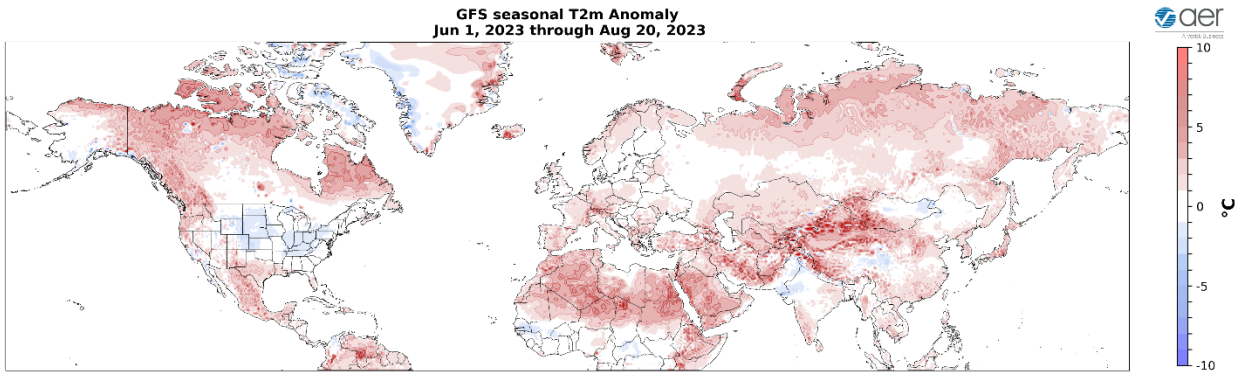

Figure iii. Observed surface temperature anomalies (°C; shading) across the Northern Hemisphere from 1 June – 20 August 2023 from the initialized GFS ensemble.

Arctic sea ice is low, as it is every summer now, and is within the range of many recent summers. And given that we are approaching the end of the melt season, a new record low sea ice extent is looking highly unlikely. Ironic how the fortunes of boreal and austral sea ice have reversed to a degree. With negative sea ice anomalies much more extreme in the Southern Ocean relative to the Arctic Ocean.

Thursday Update

Really not much changed in the forecasts from Monday. More for entertainment value than anything else, the pattern forecast for early September would be a very interesting winter pattern with blocking/high pressure in the Barents-Kara Seas and in the Gulf of Alaska (see **Figure iv**). This pattern would favor colder than normal temperatures in both Asia and North America east of the Rockies.

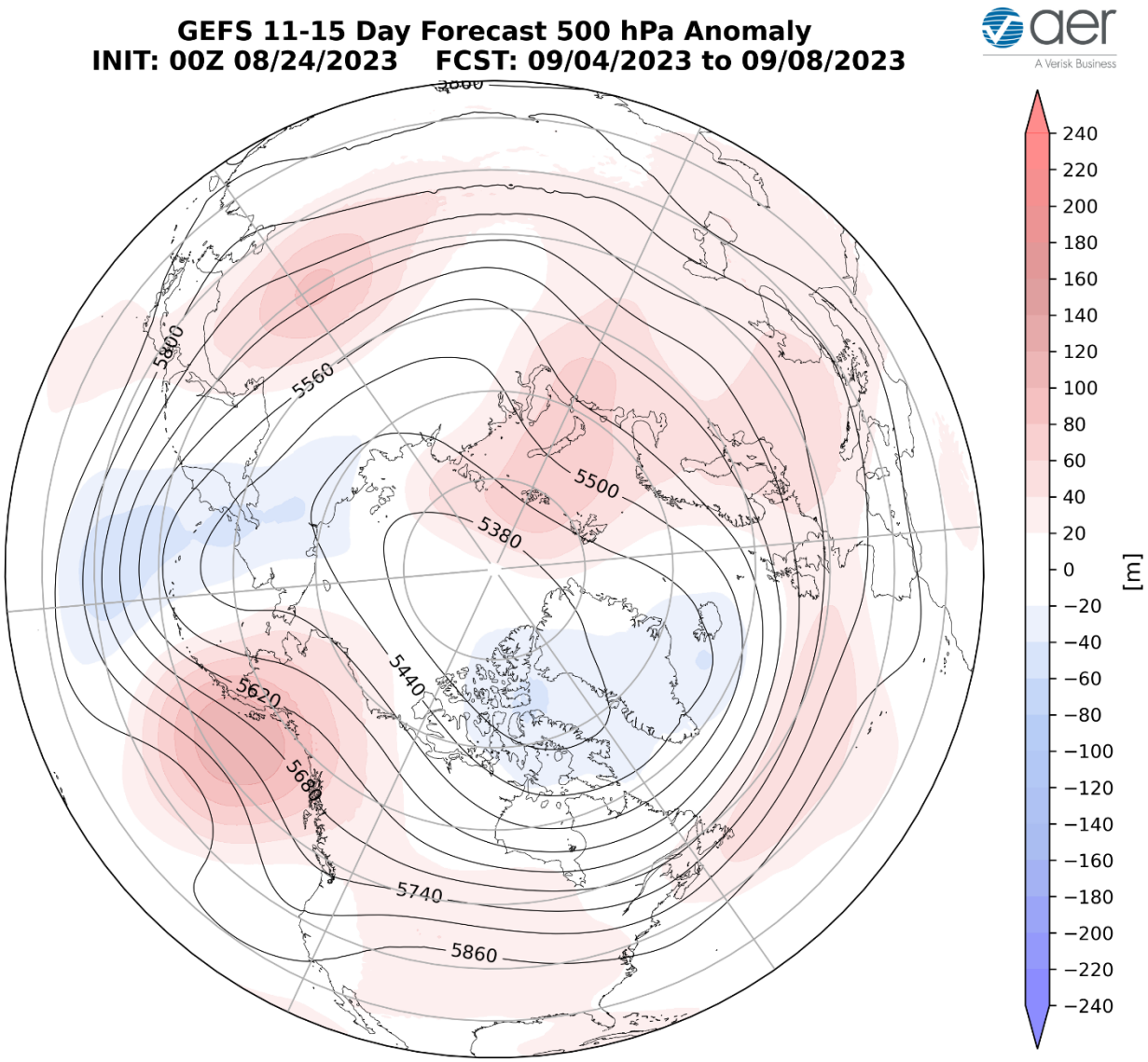

Figure iv. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 4 – 8 September 2023. The forecasts are from the 00z 24 August 2023 GFS ensemble.

The temperature forecast for the same time period looks somewhat muted (see **Figure v**), but the cold anomalies may strengthen and expand with time. Also, the snow season across the high latitudes will begin and this pattern would favor an early expansion of snow cover across Siberia. This pattern is favorable for weakening the polar vortex (PV) but in September still not that relevant.

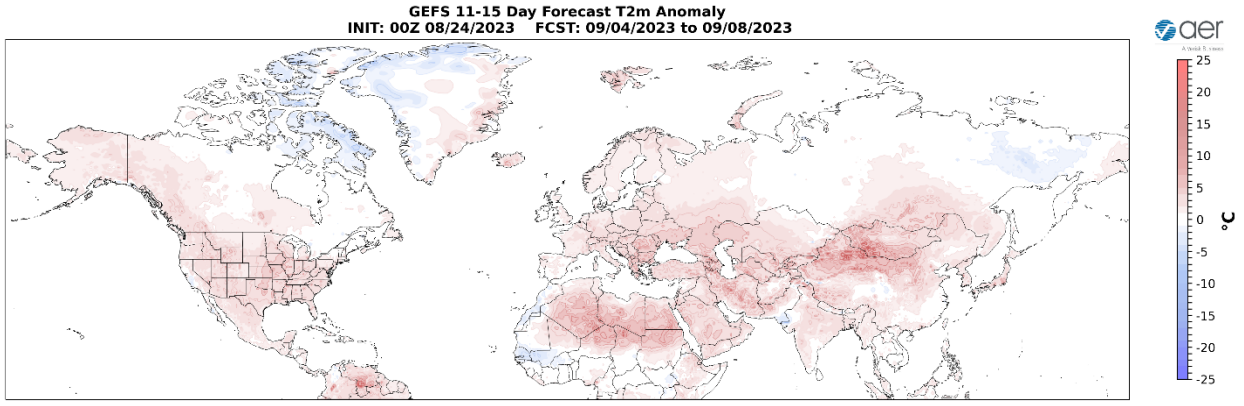

Figure v. Forecasted surface temperature anomalies (°C; shading) from 4 – 8 September 2023. The forecasts are from the 00z 24 August 2023 GFS ensemble.

Near-Term

This week

The AO is predicted to be neutral to negative this week **(Figure 1**) with mostly positive 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 as well.

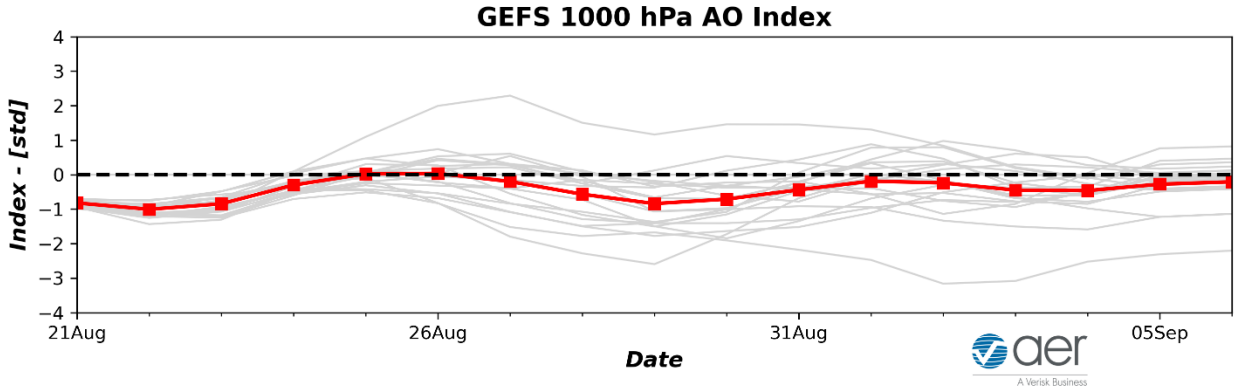

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 22 August 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies across Greenland will force deepening troughing/negative geopotential height anomalies across Europe with ridging/positive geopotential height anomalies persisting across Eastern Europe (**Figures 2). T**his pattern favors normal to above normal temperatures across much of Europe including

the UK (Figure 3). This week Central Asia is predicted to be dominated by ridging/positive geopotential height anomalies centered in Western Siberia bookended by troughing/negative geopotential height anomalies in Western Russia and East Asia centered in China (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Central Asia and Siberia with normal to below normal temperatures in Western Russia, Eastern Mongolia, Eastern China and Southeastern Siberia **(Figure 3**).

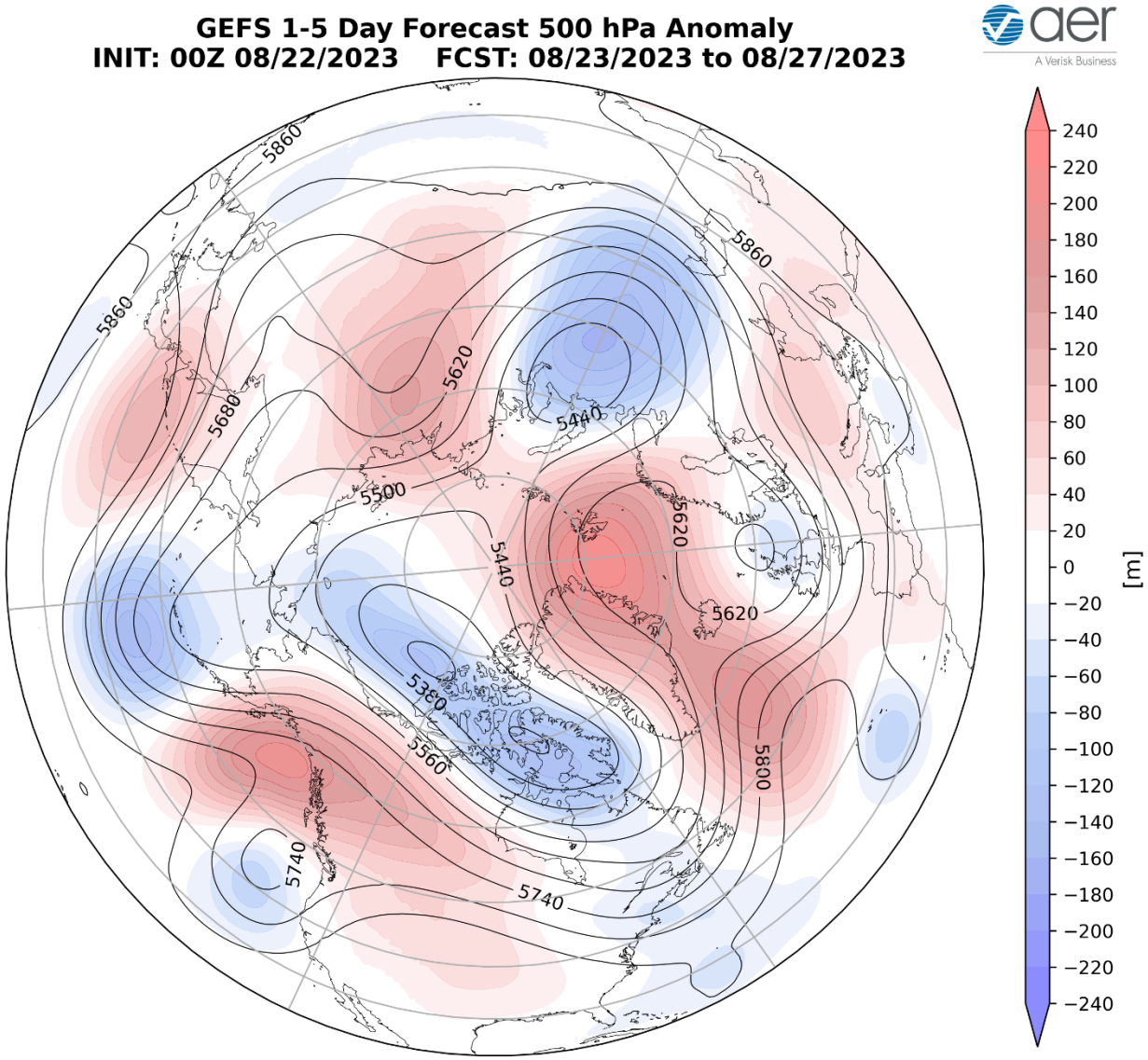

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 23 – 27 August 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

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

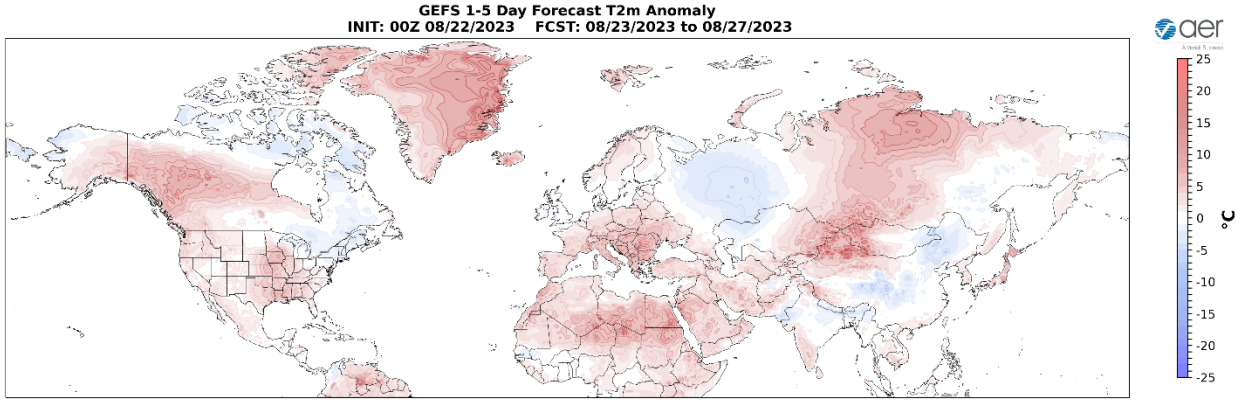

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 23 – 27 August 2023. The forecast is from the 00Z 22 August 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Southern Scandinavia, Central Europe, coastal Siberia, Southern China, northern India and the Tibetan Plateau 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 Alaska and the Northeastern US (**Figure 4**).

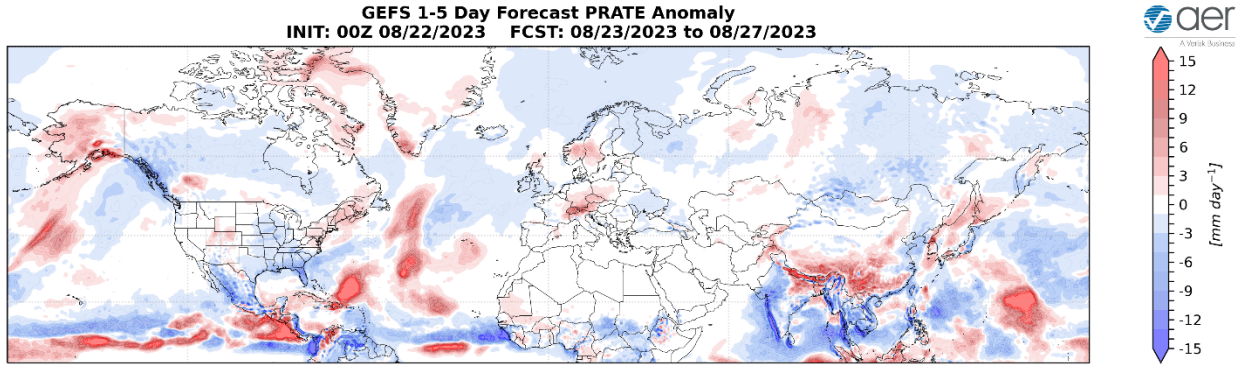

Figure 4. Forecasted precipitation rate (mm/day; shading) from 23 – 27 August 2023. The forecast is from the 00Z 22 August 2023 GFS ensemble.

Near-Mid Term

Next week

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

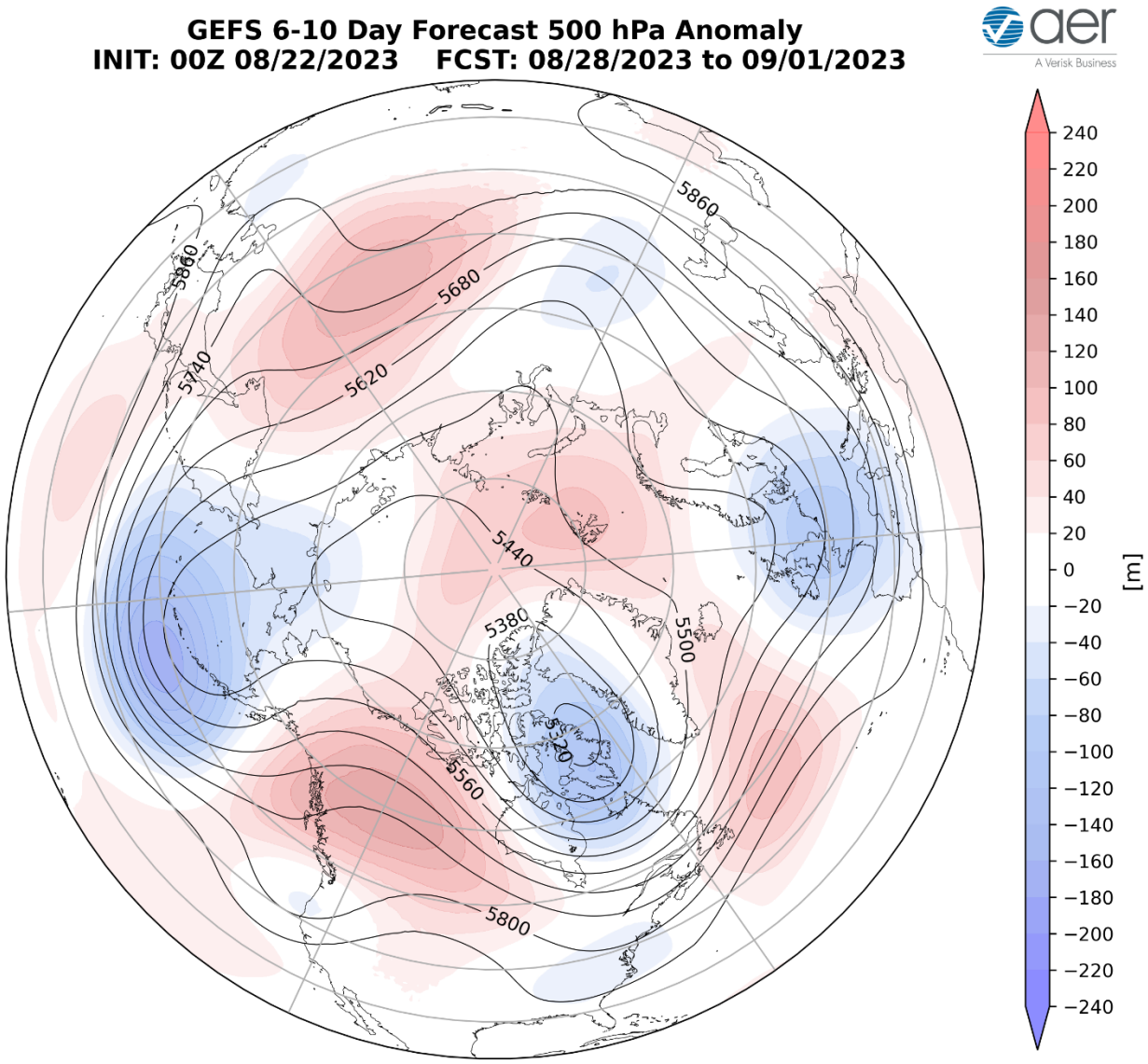

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 August – 1 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Greenland will continue to support troughing/negative geopotential height anomalies across Europe this period

(**Figure 5**). This pattern should favor normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe under southwesterly flow (**Figures 6**). The general pattern across Asia is ridging/positive geopotential height anomalies across Central Asia with troughing/negative geopotential height anomalies persisting in Western Russia and China this period (**Figure 5**). The pattern favors normal to above normal temperatures across Central and Southern Asia with normal to below normal temperatures across Western Russia, Central and Eastern China this period (**Figure 6**).

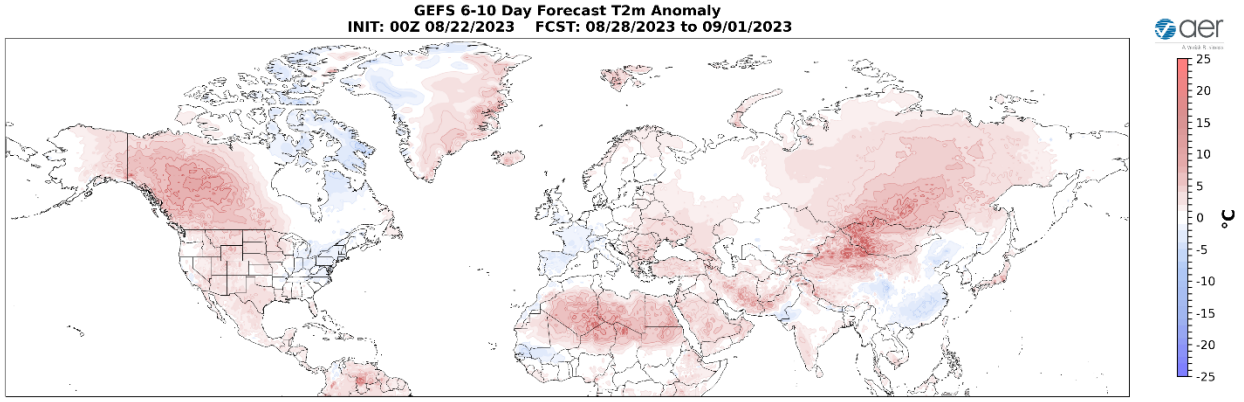

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 28 August – 1 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

The general pattern across North America this period is persistent ridging/positive geopotential height anomalies across western North America with troughing/negative geopotential height anomalies in eastern North America (**Figure 5**). This pattern favors normal to above normal temperatures across Alaska, Western Canada and the Western and Southern US with normal to below normal temperatures across Eastern Canada and the Northeastern US (**Figure 6**).

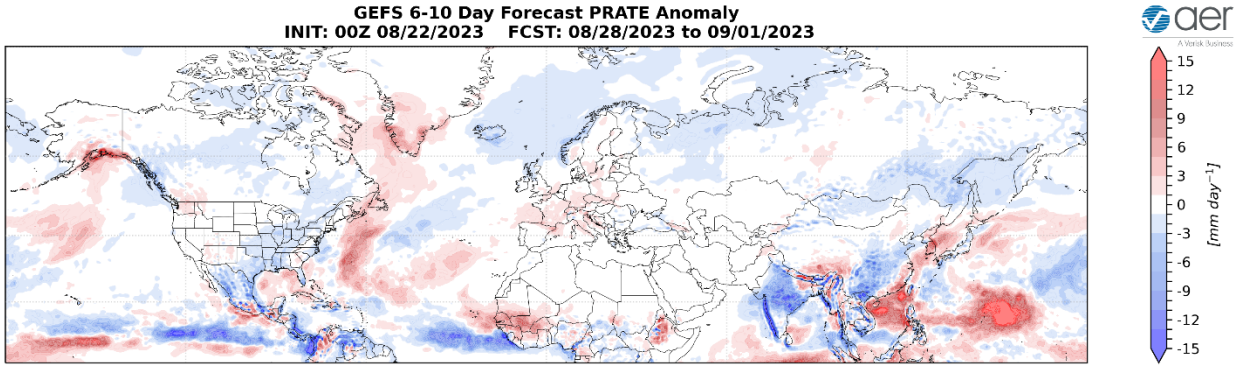

Figure 7. Forecasted precipitation rate (mm/day; shading) from 28 August – 1 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Western Europe, coastal East Asia and the Tibetan Plateau 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 Southern Alaska and the Canadian Maritimes (**Figure 7**).

Mid Term

Week Two

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

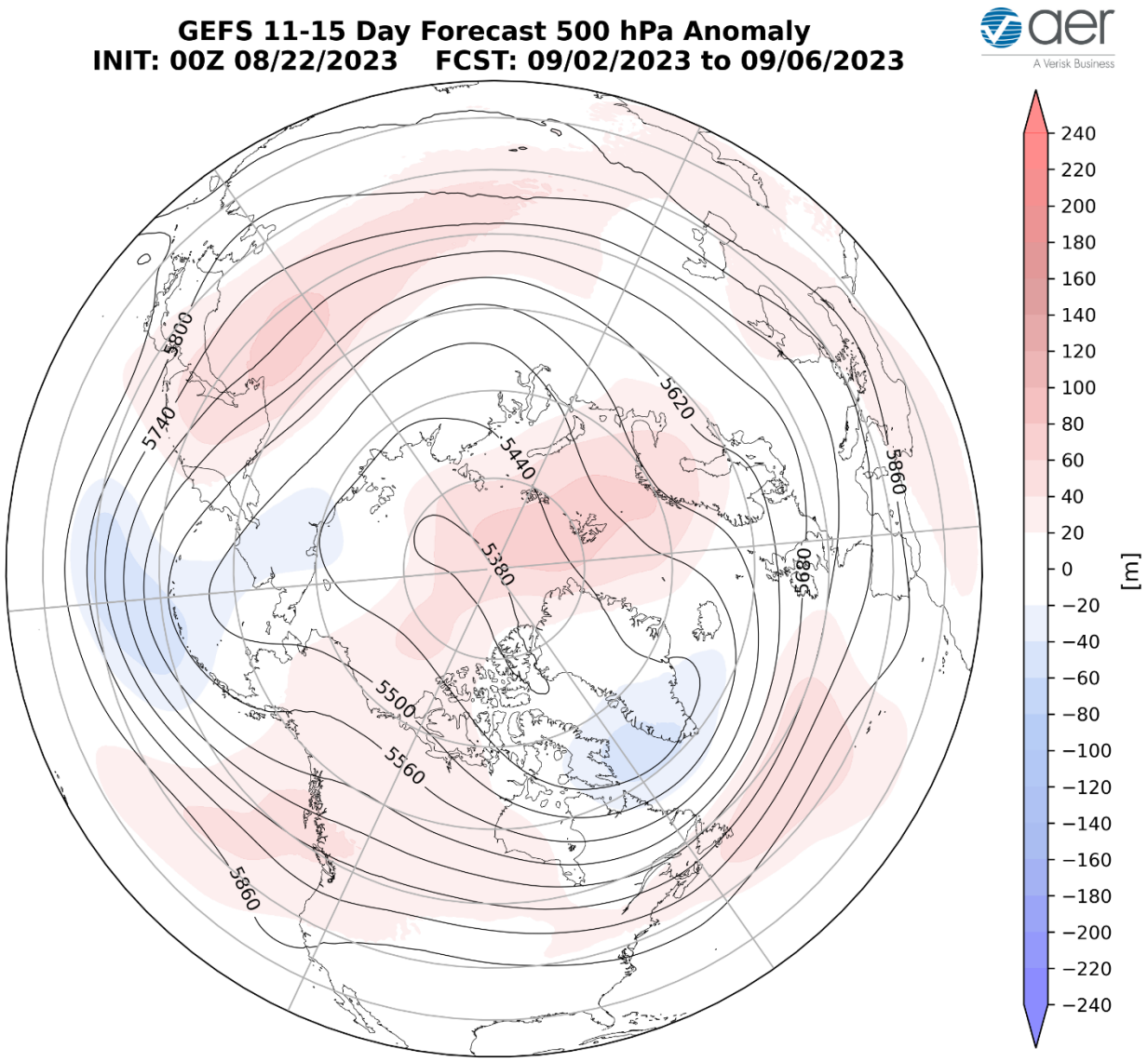

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 2 – 6 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

Ongoing but weakening ridging/positive geopotential height anomalies across Greenland and favor weakening troughing/negative geopotential height anomalies across Europe with a return to mostly zonal flow this period (**Figure 8**). This pattern should favor normal to above normal temperatures increasingly widespread across Europe with some lingering normal to above normal temperatures across Western Europe including the UK this period (**Figures 9**). Ridging/positive geopotential height anomalies previously in Central Asia are predicted to slide east into East Asia with persistent troughing/negative geopotential height anomalies across Western Russia and expanding into Siberia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal

temperatures limited to Western Russia and Northern Siberia this period (**Figure 9**).

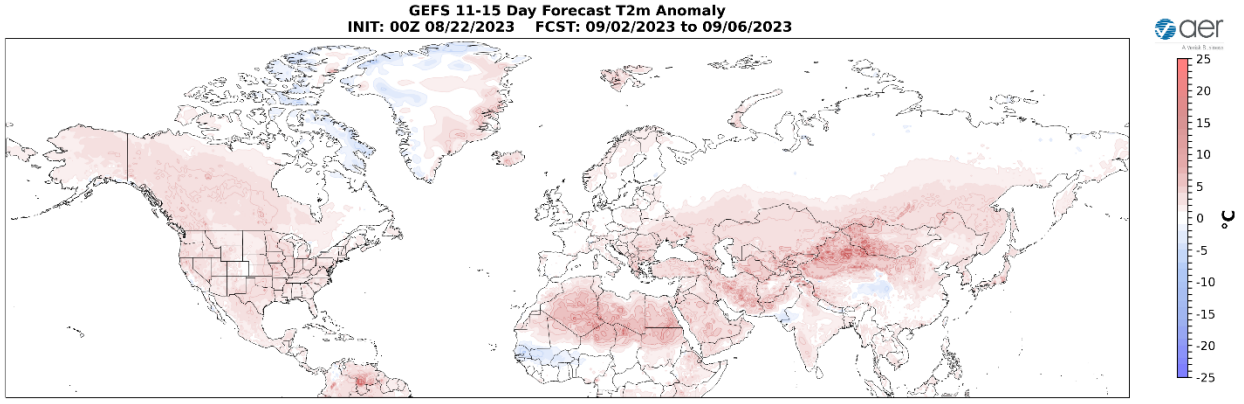

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 2 – 6 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist across western North America with weakening troughing/negative geopotential mostly limited to Eastern Canada and the Central US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, Western and Central Canada and much of the US with normal to below normal temperatures mostly limited to the Canadian Maritimes (**Figure 9**).

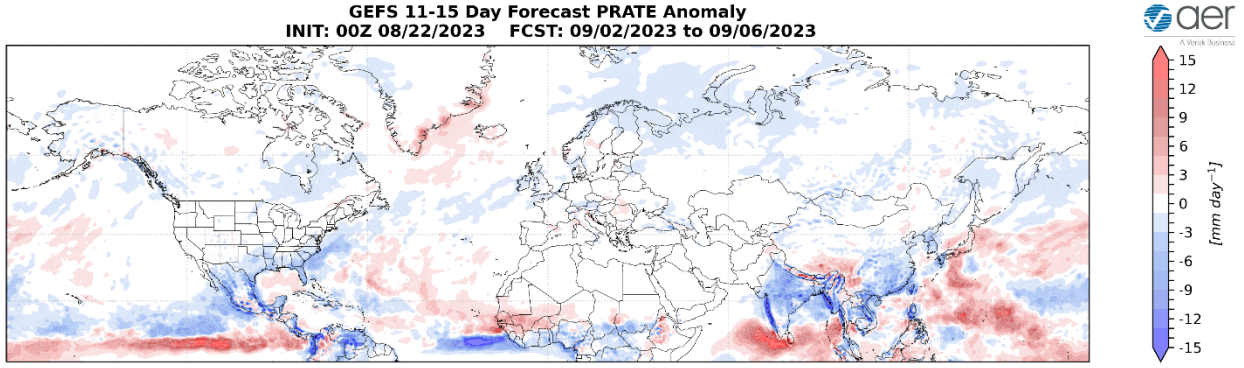

Figure 10. Forecasted precipitation rate (mm/day; shading) from 2 – 6 September 2023. The forecasts are from the 00z 22 August 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Japan 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 Northwestern 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 with warm/positive PCHs in the lower stratosphere and troposphere (**Figure 11**). Next week PCHs in the lower troposphere are predicted to flip from warm/positive to cold/negative (**Figure 11**).

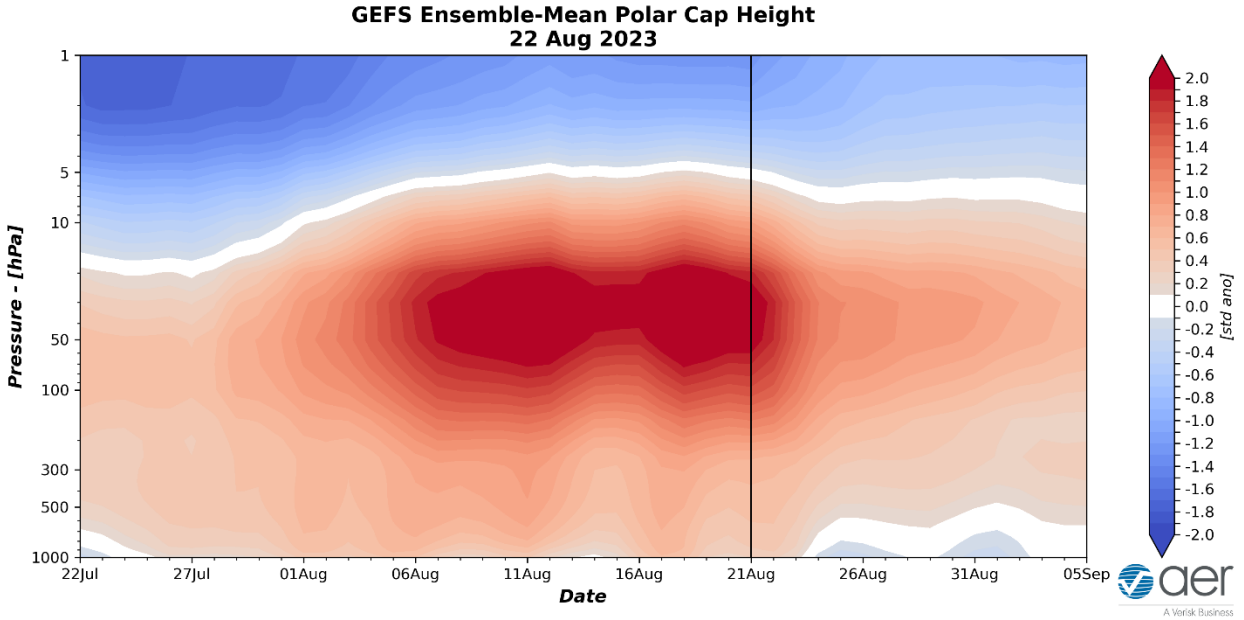

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 22 August 2023 GFS ensemble.

The predicted warm/positive PCHs in the lower troposphere this week (**Figure 11**) are consistent with the predicted negative to neutral surface AO this week (**Figure 1**). However, the AO is predicted to become more closely tethered to neutral next week (**Figure 1**) coinciding with the predicted cooling PCHs in the lower troposphere (**Figure 11)**.

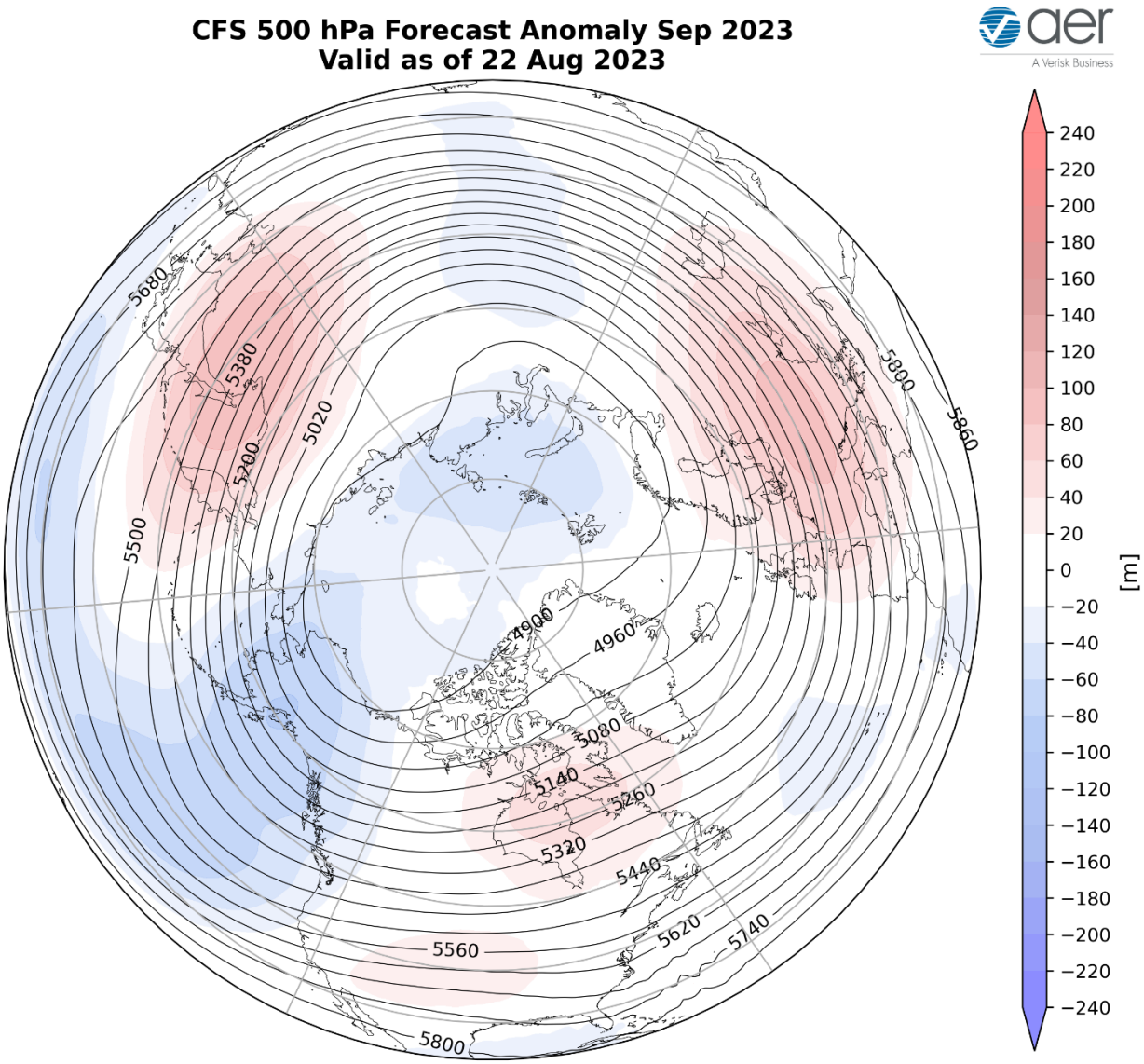

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2023. The forecasts are from the 00Z 22 August 2023 CFS.

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

13).

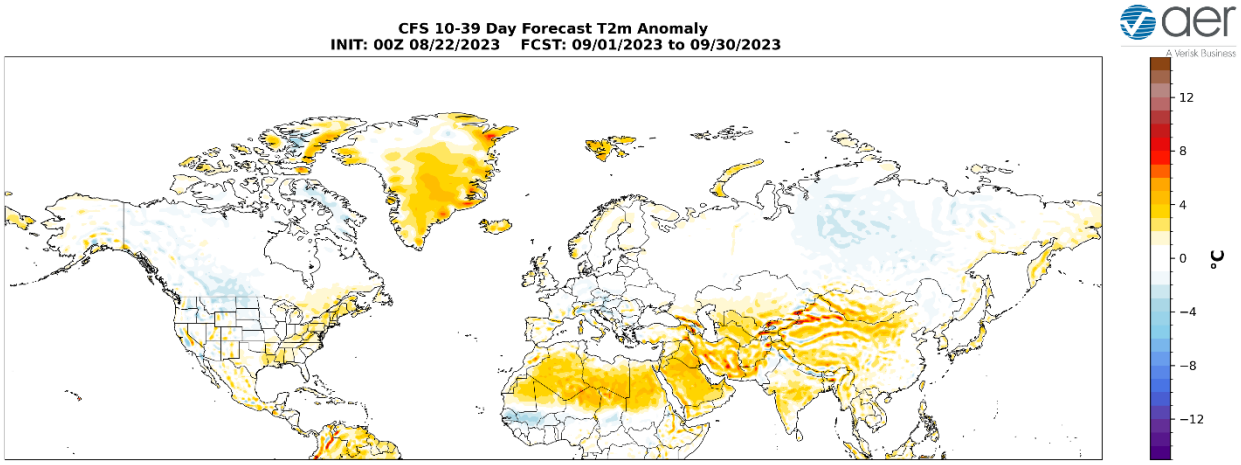

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for September 2023. The forecasts are from the 00Z 22 August 2023 CFS.

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.

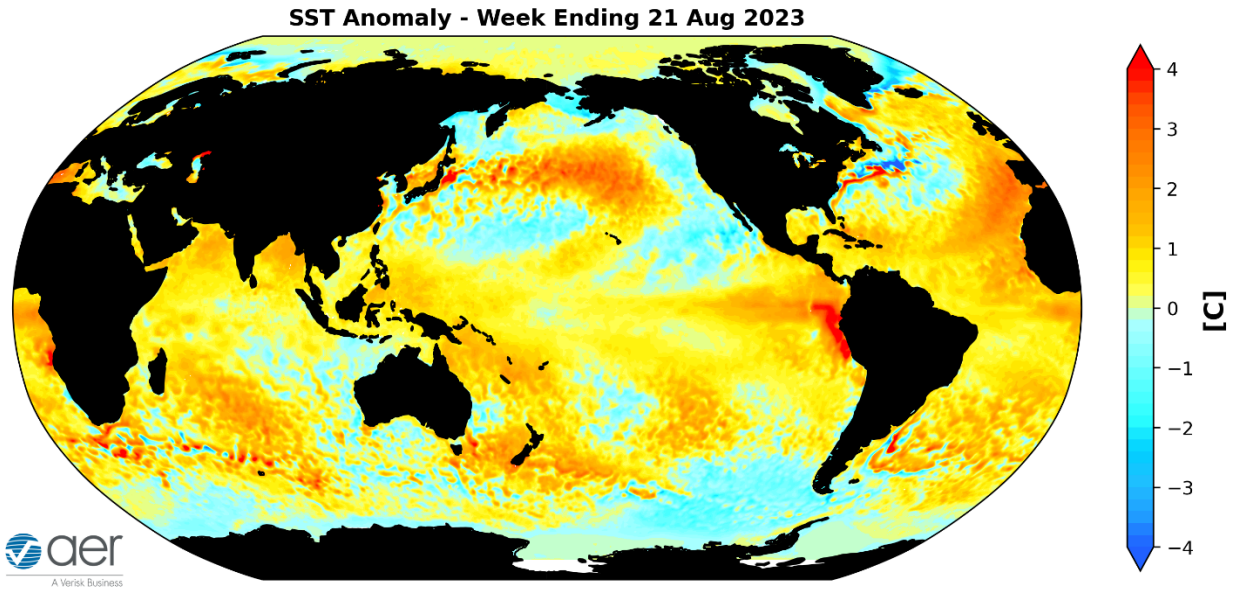

Figure 14. The latest weekly-mean global SST anomalies (ending 21 August 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently phase one of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). The forecasts are for the MJO to quickly weaken to where no phase is favored over the next two weeks. Seems that the MJO is having little influence on the weather across Canada in the short term. But admittedly this is outside of my expertise.

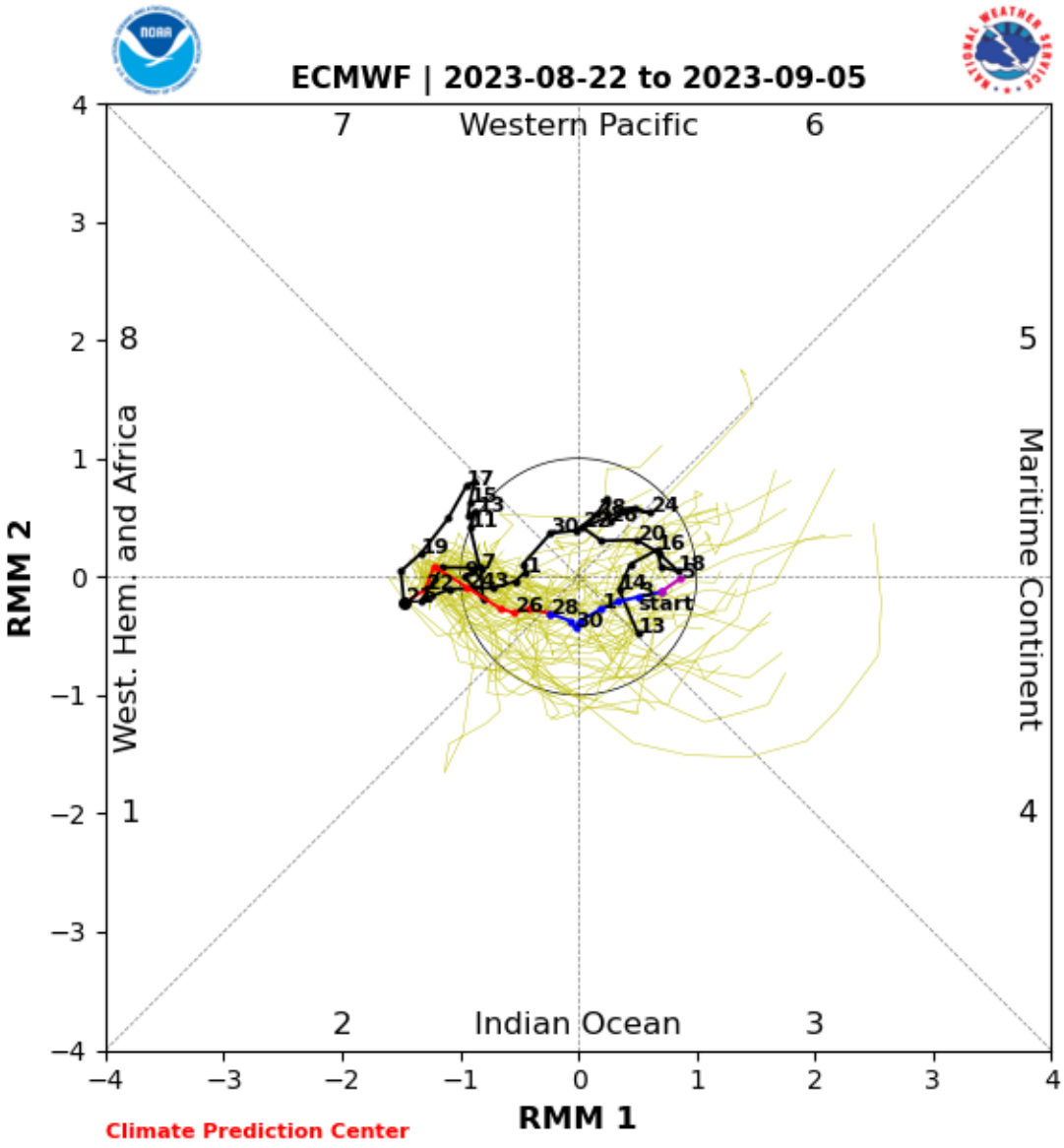

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 22 August 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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!