Arctic Oscillation and Polar Vortex Analysis and Forecasts

September 5, 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 neutral and is predicted to remain neutral to negative the next two weeks as pressure/geopotential height anomalies across

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

- Over the next two weeks, troughing/negative geopotential height anomalies across Greenland will help anchor ridging/positive geopotential height anomalies across Europe. This pattern will support normal to above to even well above normal temperatures across Europe including the United Kingdom (UK) the next two weeks. One exception could be around the Aegean Sea where normal to below normal temperatures are possibly under an upper level low this week.
- The next two weeks, the general pattern across Asia is predicted to be ridging/positive geopotential height anomalies across Western and Eastern Asia with troughing/negative geopotential height anomalies across parts of Siberia and Central Asia. This pattern mostly favors normal to above normal temperatures widespread across Western and especially Eastern Asia with normal to below normal temperatures across much of Siberia and parts of Central Asia.
- The general predicted pattern predicted across North America the next two weeks is troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska forcing ridging/positive geopotential height anomalies across western North America with troughing/negative geopotential height anomalies in the Eastern United States (US). This pattern generally favors normal to below normal temperatures for Alaska, Southeastern Canada and the Eastern US with normal to above normal temperatures across most of Canada and the Western US and even along the US East Coast this week.
- In the Impacts section I start to recap the Northern Hemisphere (NH) summer and start the pivot to next winter.
- **I have one more international travel planned for next week but overall expect a regular schedule for the blog going forward.**

Plain Language Summary

Despite the calendar reading fall, summer is hanging on tough with record heat in Europe and the US ongoing. some relief is on the way by next week especially in the Eastern US. And the string of summer extreme weather continues with record heat and flooding rainfall. The summer temperature pattern was overall consistent with forecasts posted in the blog at the end of May (see **Figure iii**). Still too early to say much about this winter other than El Niño is a certainty. It is thought to favor an overall mild winter but not always.

Impacts

As I have said before, September should no longer be considered a fall, but rather a summer month and it is looking like this September is no exception. Summer is

showing no signs of quitting or certainly leaving gracefully. We have several heat domes spread across the Northern Hemisphere (NH) including Eastern Canada, Europe and East Asia (see **Figure i**). Europe might have the most impressive blocking in the NH with a classic looking omega block with two closed lows in the mid-troposphere west of Spain and Greece. So not only is Europe experiencing record heat but also catastrophic flooding in Spain and in Greece. So, the string of extreme weather events continues.

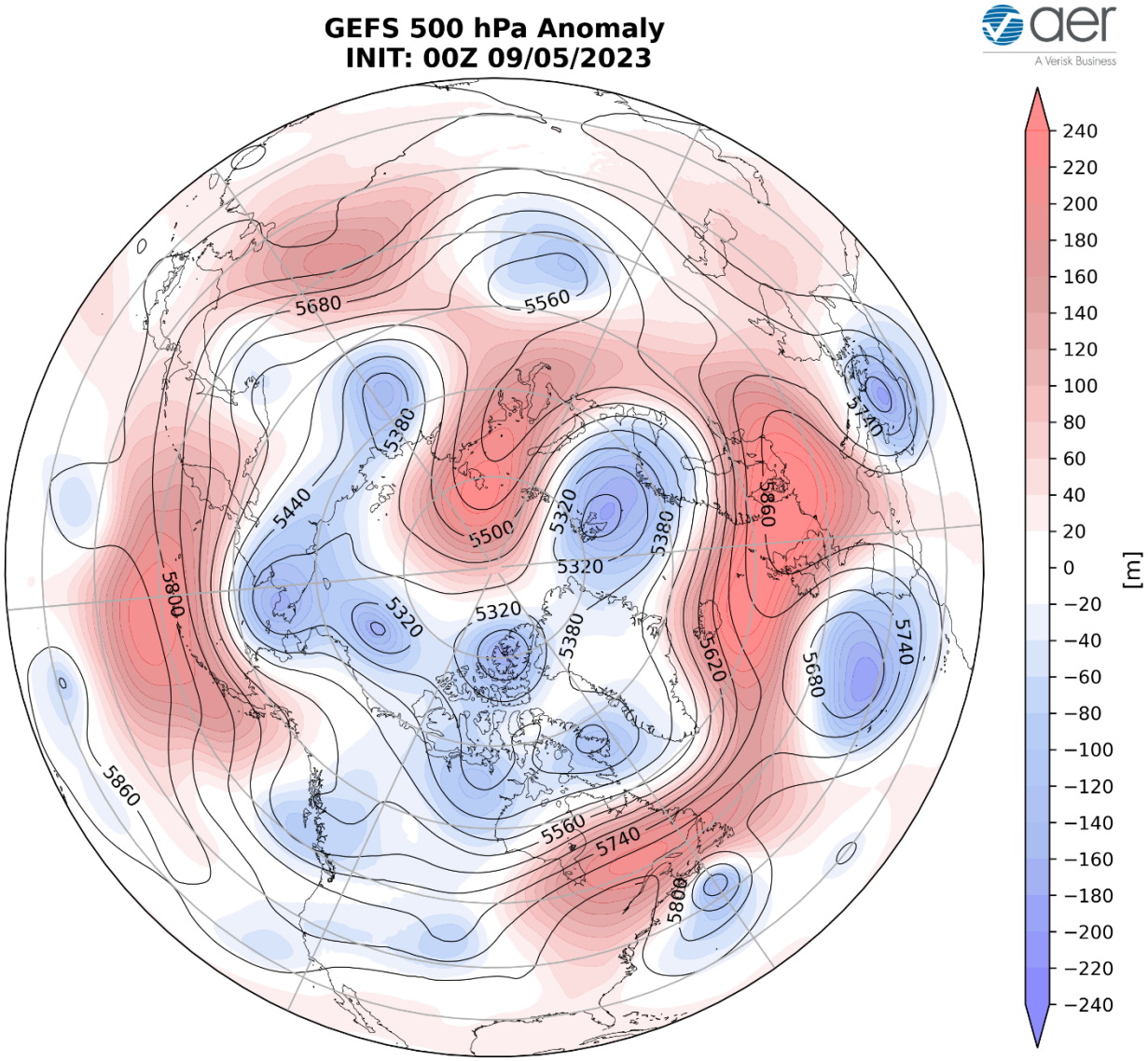

Figure i. Initialized 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for 5 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

And I don't see much evidence of a genuine fall pattern across the NH any time soon. The ridge over Europe looks to want to hang around with the weather models suggesting it might slowly slide eastward over the course of the month. Yes, the record heat in the Eastern US will moderate next week as much cooler temperatures are predicted but this only because the strong positive height anomaly is predicted to shift from Quebec to Northwest Canada and is a relapse of sorts of the dominant summer pattern across North America. Summer like heat in Northern Canada does not signal fall to me. In Europe some moderation in the record heat is predicted but above normal temperatures are predicted for the foreseeable future.

If there is one feature that is giving me hope that a turn to fall and eventually winter weather are indeed coming, it's the predicted troughing (**Figure 2**) coupled with colder temperatures (**Figure 3**) and even snow for Siberia this week. Though even this feature is predicted to weaken by next week, it could be a start of a meaningful trend, especially if the AO turns negative.

One boundary forcing that I focus on for trying to get clues about the upcoming winter is Arctic sea ice extent. Arctic sea ice is low, as it is every summer now, and is within the range of the past four summers. And given that we are approaching the end of the melt season, a new record low sea ice extent is looking highly unlikely, though it could be in the bottom five of all sea ice minima. Looking at the current Arctic sea ice extent, it is almost completely shifted onto the North Atlantic side with the North Pacific side almost devoid of ice (see **Figure ii**). Research shows that it is sea ice absence on the North Atlantic side that favors a weak polar vortex, but the extent can and will shift around so I don't want to read too much into this in early September.

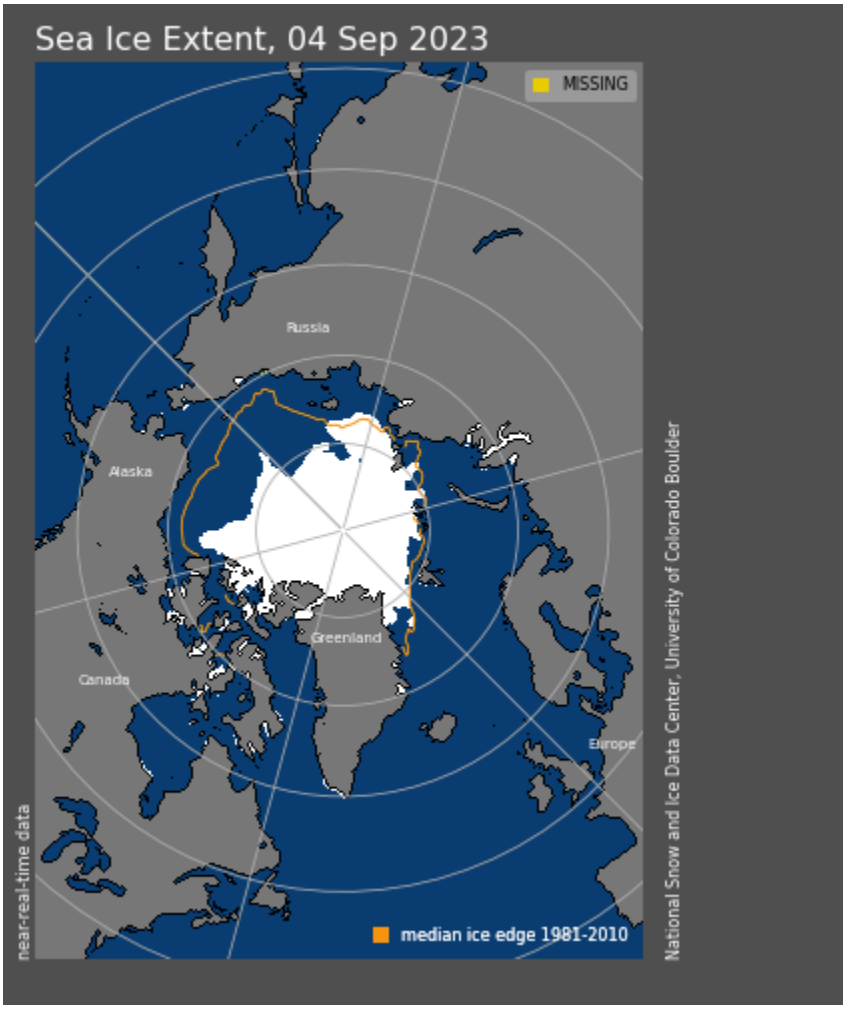

Figure ii. Observed Arctic sea ice extent on 4 September 2023 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC) https://nsidc.org/arcticseaicenews/

El Niño is all but certain for this winter and the one remaining question is how strong. A lot of the dynamical models are predicting a strong El Niño this winter. There are not that many historical data points for strong El Niño's, but all have them have featured widespread mild temperatures. Many of the statistical models are predicting a moderate El Niño this winter and though again many were associated with overall mild winters, here we have some more interesting examples, most recently the winter of 2009/10. I saw that some folks were posting on Twitter the latest ECMWF forecast which features high latitude blocking including around Greenland with troughing over Europe but especially the US East Coast. If verified, this would make for an interesting winter and possibly quite active in the Eastern US, but I for now I see it more for entertainment value than a reliable forecast. I am waiting for Siberian October snow cover extent to get excited, and El Niño does favor a more rapid extent of fall Siberian snow cover and even sudden stratospheric warmings, so who knows maybe the ECWMF is on to something?

Summer 2023 is in the record books, at least technically if not based on the facts on the ground. Above normal temperatures were almost universal most notably western North America, Europe, the Middle East, North Africa and Central Asia (see **Figure iii**). Some regional exceptions were below normal temperatures in the Eastern US, Western Russia, parts of China and along the India-Pakistan border. I hope to post a comparison between the observed and predicted summer temperature anomalies by the next blog.

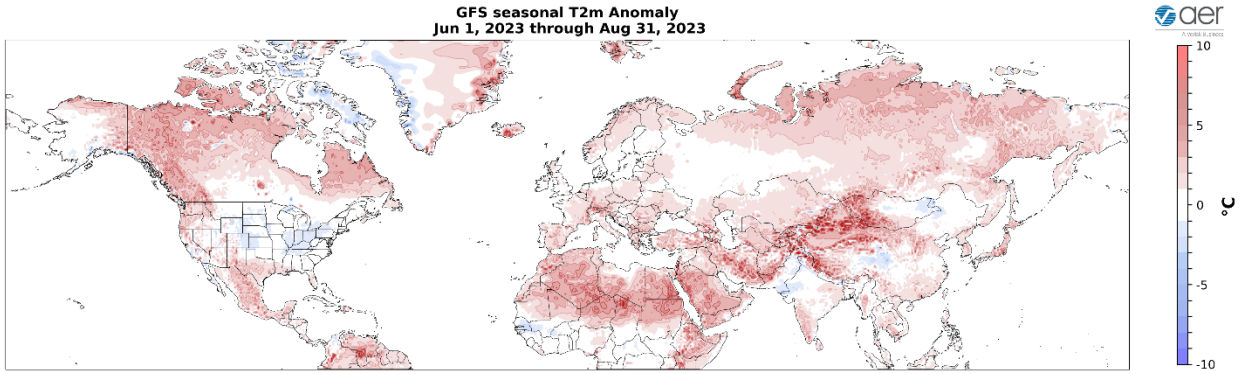

Figure iii. Observed surface temperature anomalies (°C; shading) across the Northern Hemisphere from 1 June – 31 August 2023 from the initialized GFS ensemble.

Thursday Update

Not much new to report today so I will simply welcome the NH polar vortex (PV) back from its summer hiatus. As you can see in Figure iv, a well-formed PV is evident in the CFS forecast for the remainder of the month. For me it is like a reunion with a good friend.

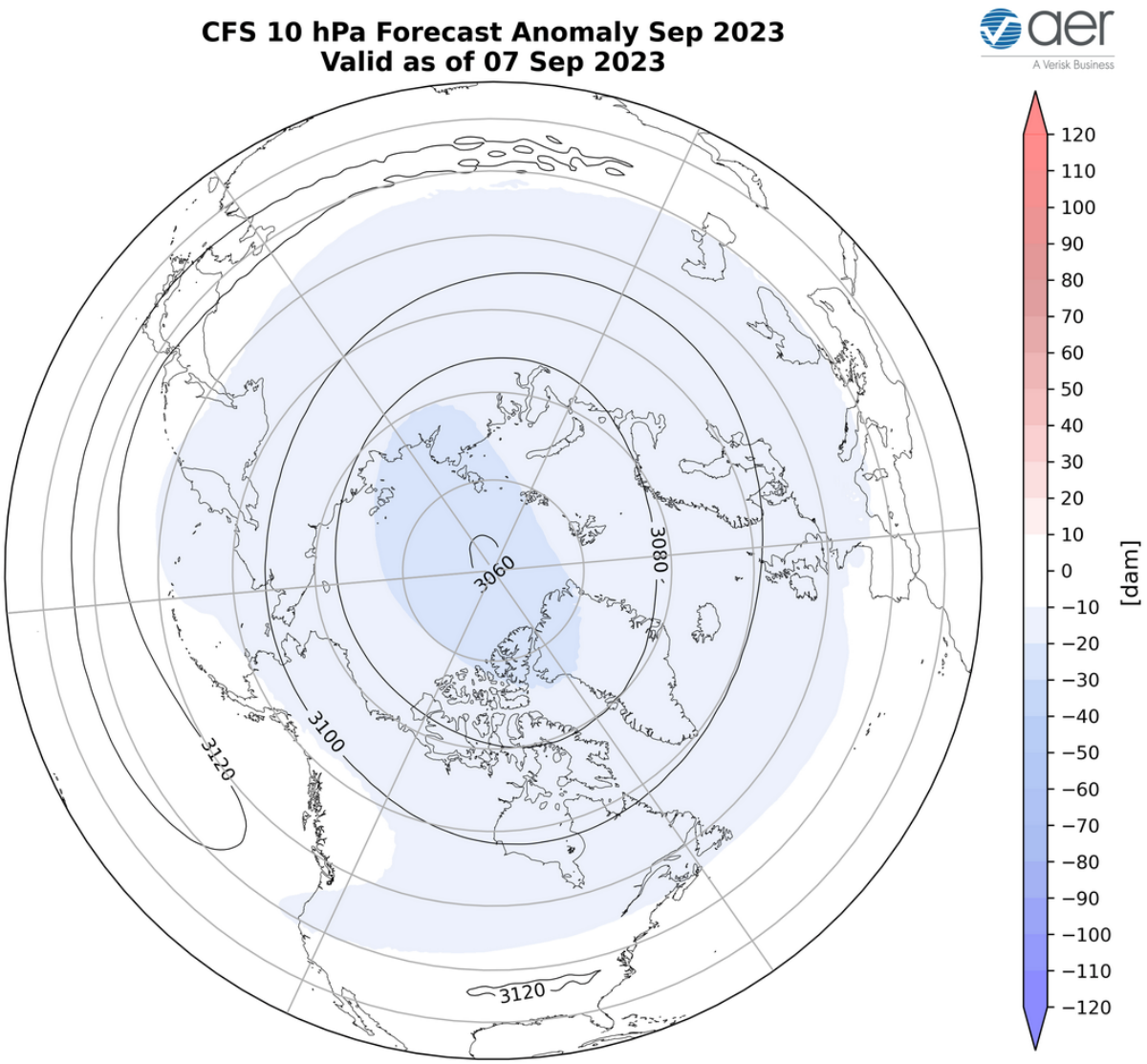

Figure iv. Forecasted average 10 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2023. The forecasts are from the 00Z 7 September 2023 CFS.

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 negative geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to be positive this period.

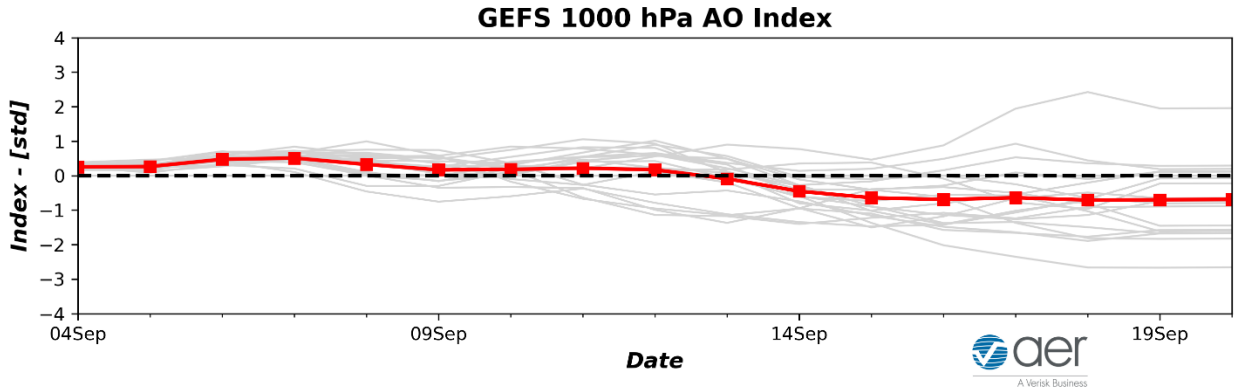

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 5 September 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Troughing/negative geopotential height anomalies across Greenland will force strong ridging/positive geopotential height anomalies across Europe with the exception of troughing/negative geopotential height anomalies centered between Sicily and Greece (**Figures 2).** This pattern favors normal to above and well above normal temperatures across much of Europe including the UK with the largest departures in Western Europe and normal to below normal temperatures limited to Southern Italy and Greece (**Figure 3**). This week Asia is predicted to be dominated by ridging/positive geopotential height anomalies centered in Northwestern and Eastern Asia with troughing/negative geopotential height anomalies in Siberia and Central Asia centered over Kazakhstan (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Northwestern and Eastern Asia with normal to below normal temperatures in most of Siberia and parts of Central Asia **(Figure 3**).

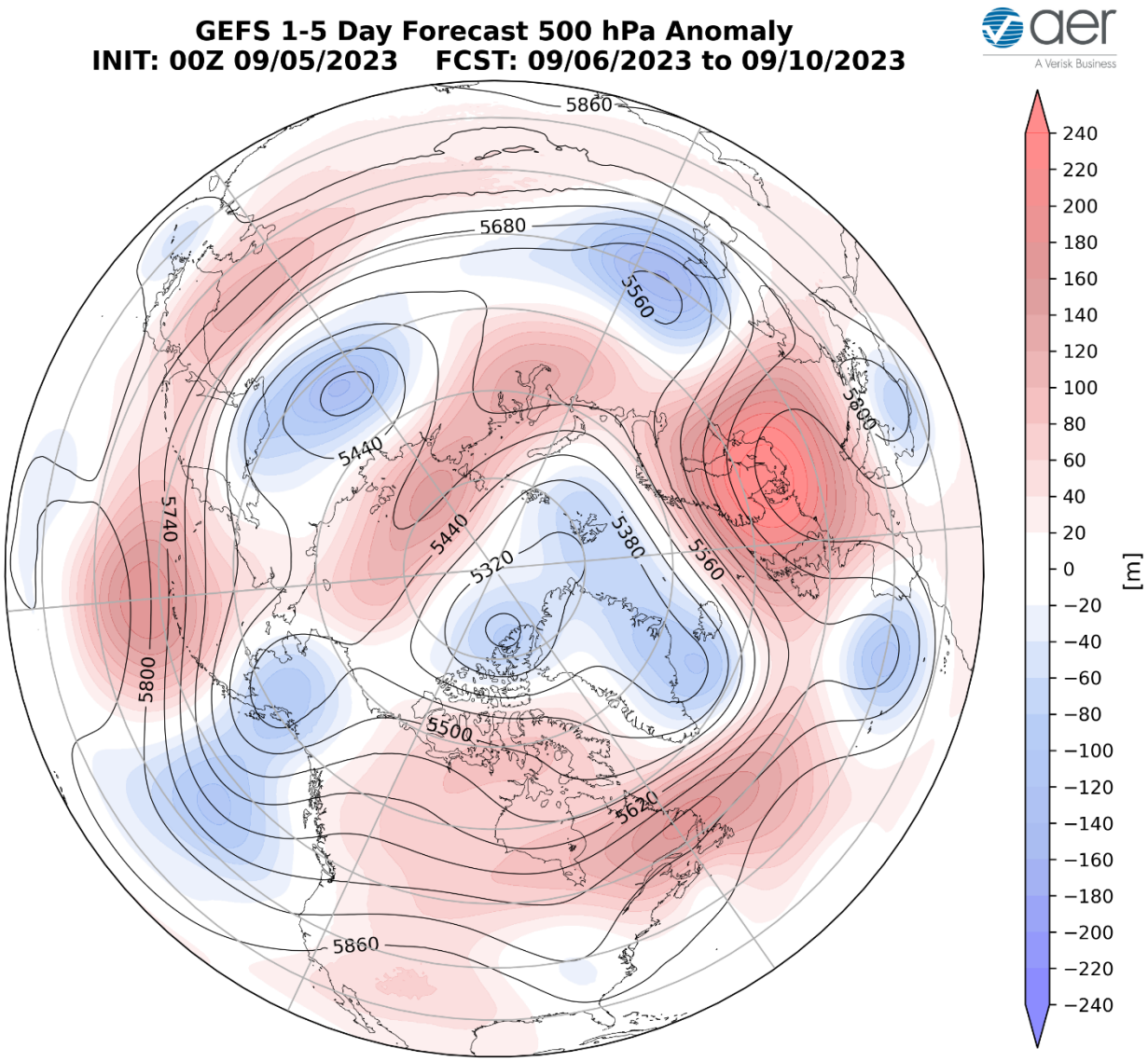

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

The pattern this week across North America is troughing/negative geopotential height anomalies across Alaska and Gulf of Alaska forcing ridging/positive geopotential height anomalies across much of Canada and the Western US with weak troughing/negative geopotential height anomalies in the Eastern US **(Figure 2).** This pattern will favor widespread normal to above normal temperatures across much of Canada, the Western US and the US East Coast with normal to below normal temperatures across Alaska, Ontario and the Great Lakes **(Figure 3).**

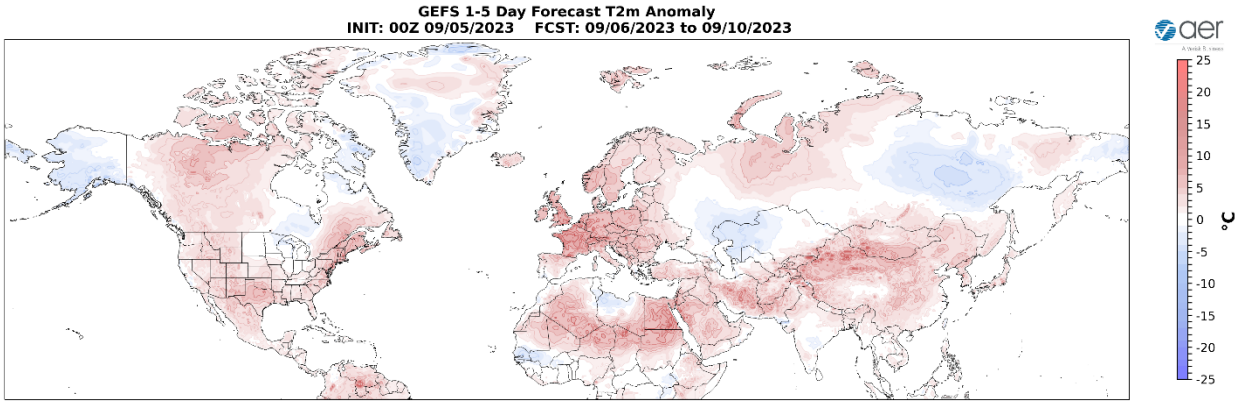

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 6 – 10 September 2023. The forecast is from the 00Z 5 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Southern Italy and (possibly catastrophic) Greece, Kazakhstan, Eastern Siberia, Central China and northern India 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, Southeastern Canada and the Northeastern US (**Figure 4**).

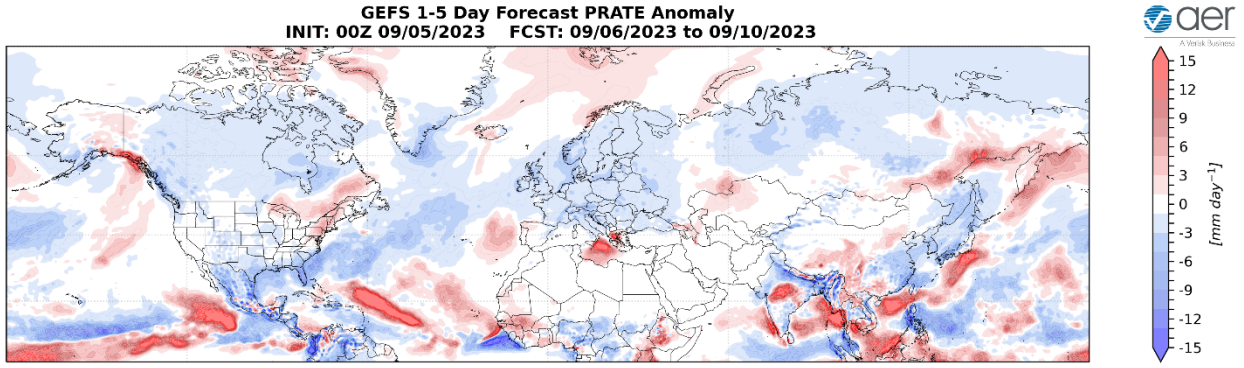

Figure 4. Forecasted precipitation rate (mm/day; shading) from 6 – 10 September 2023. The forecast is from the 00Z 5 September 2023 GFS ensemble.

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 negative pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be positive this period.

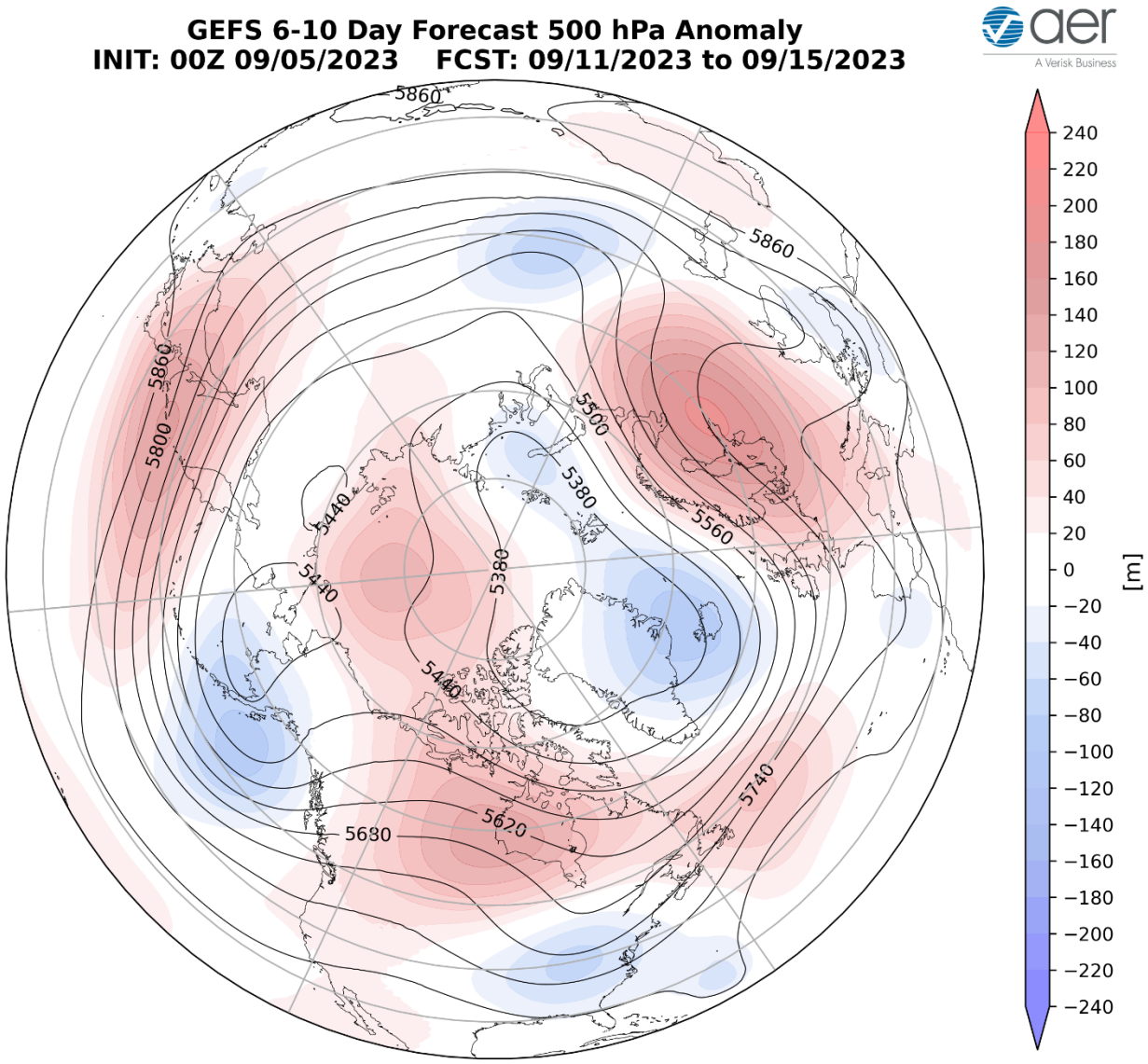

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 11 – 15 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies across Greenland will continue to support ridging/positive geopotential height anomalies across Europe this period (**Figure 5**). This pattern should favor normal to above and even well above normal temperatures across Europe including the UK (**Figures 6**). The general pattern across Asia is predicted to continue with ridging/positive geopotential height anomalies across Western and Eastern Asia with troughing/negative geopotential height anomalies persisting in Central Asia and Siberia this period (**Figure 5**). The pattern favors normal to above normal temperatures across Western and Eastern Asia with normal to below normal temperatures across Central Asia, Central and Eastern Siberia this period (**Figure 6**).

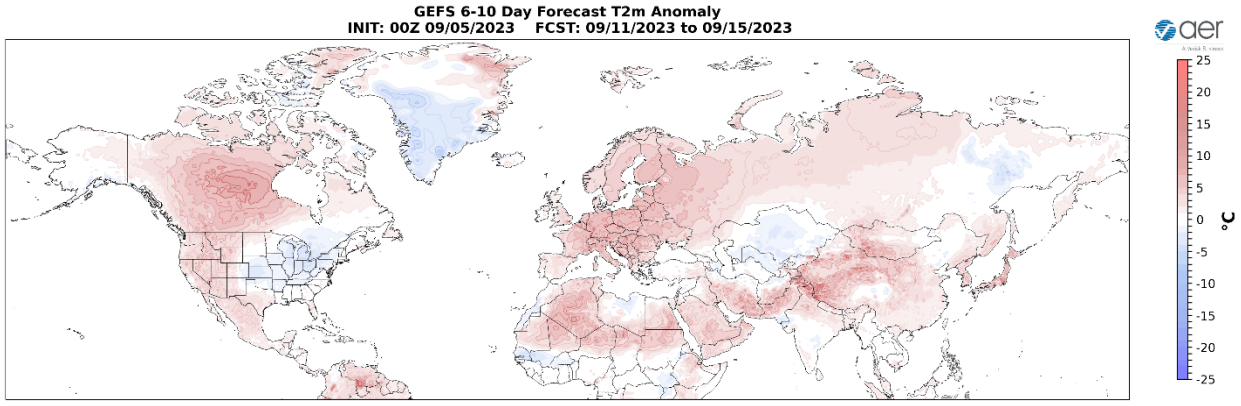

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 11 – 15 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

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

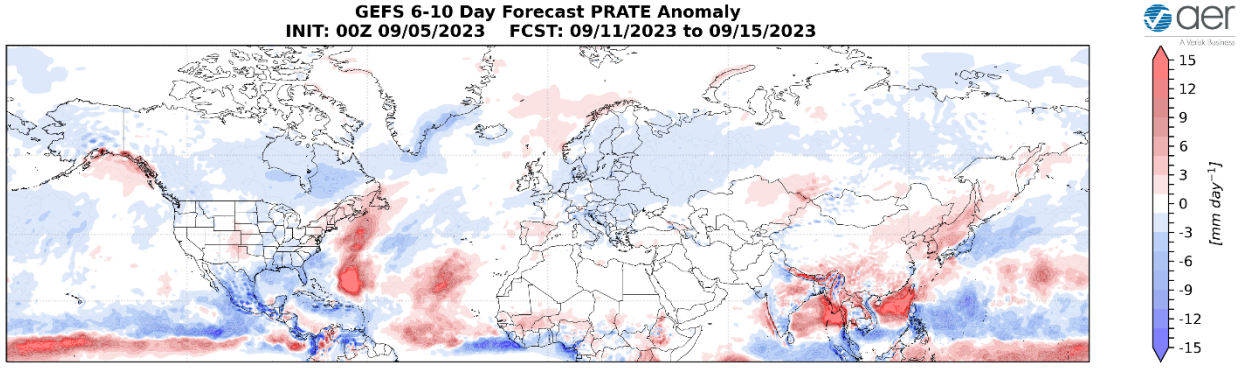

Figure 7. Forecasted precipitation rate (mm/day; shading) from 11 – 15 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Spain, 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 Southeastern Alaska, New England 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 turn negative this period (**Figure 1**). With predicted mixed and weak pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will likely approach neutral this period.

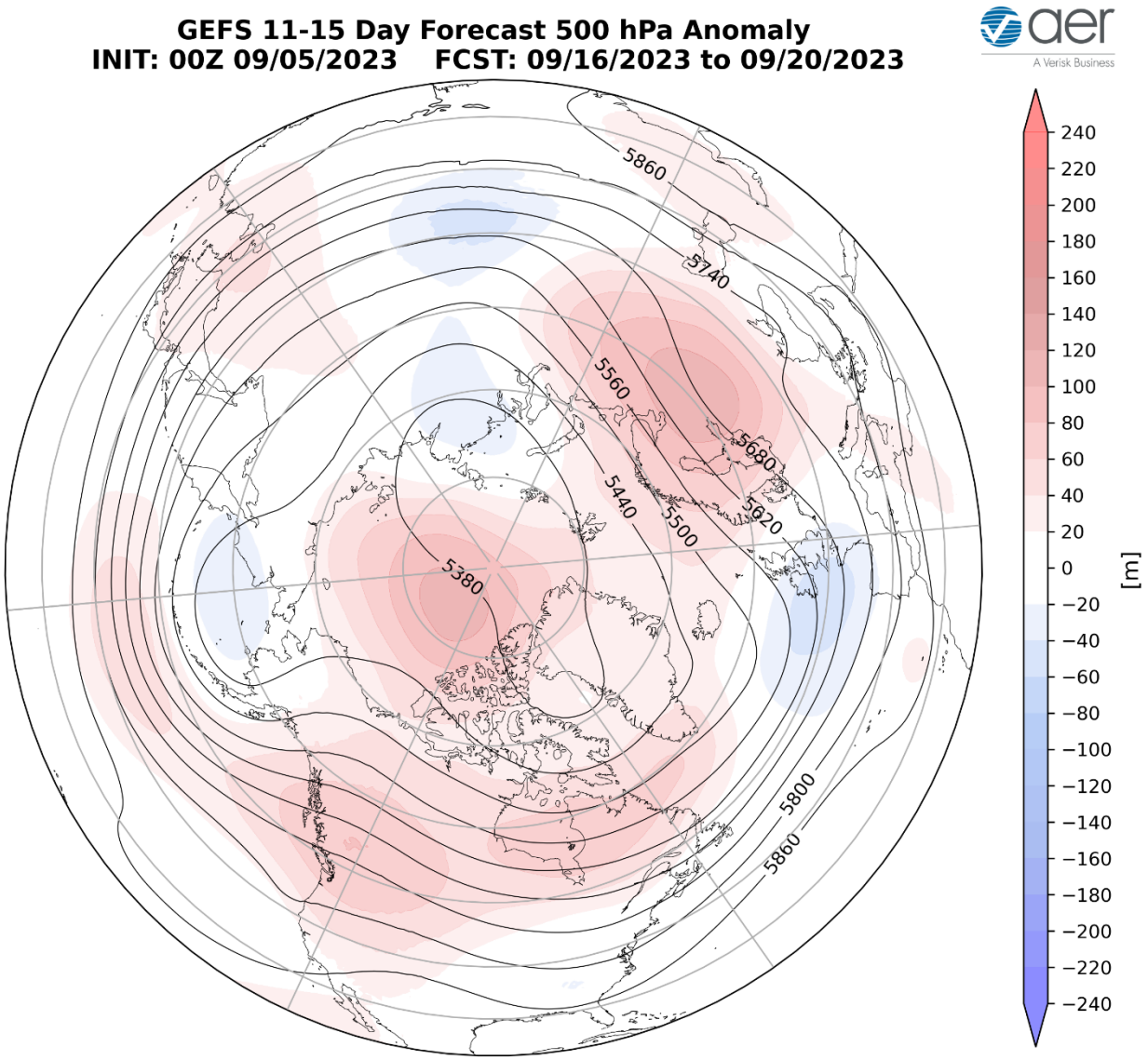

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 16 – 20 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

Troughing/negative geopotential height anomalies previously across Greenland will start sliding towards Western Europe but overall, ridging/positive geopotential height anomalies will continue to dominate Europe this period (**Figure 8**). This pattern should

favor normal to above normal temperatures across Europe including the UK with the largest departures in Eastern Europe this period (**Figures 9**). The overall pattern of ridging/positive geopotential height anomalies in Western and Eastern Asia bookending troughing/negative geopotential height anomalies across Central Asia is predicted to persist this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across Western and Eastern Asia with normal to below normal temperatures limited to Central Asia this period (**Figure 9**).

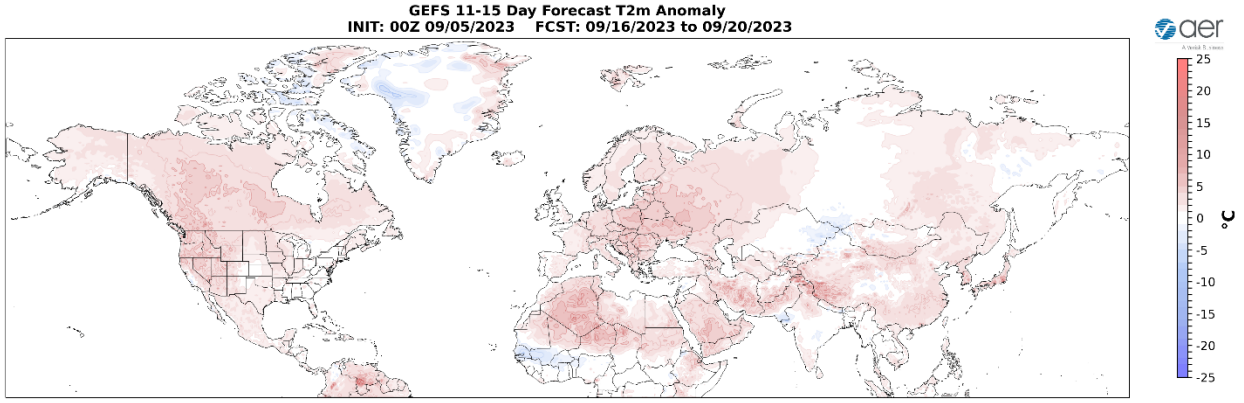

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 16 – 20 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

Troughing/negative geopotential height anomalies previously over Alaska are predicted to slide west towards the Dateline forcing ridging/positive geopotential height anomalies across much of North America with weakening troughing/negative geopotential mostly limited to the Eastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, most of Canada and much of the US with normal to below normal temperatures mostly limited to the US East Coast (**Figure 9**).

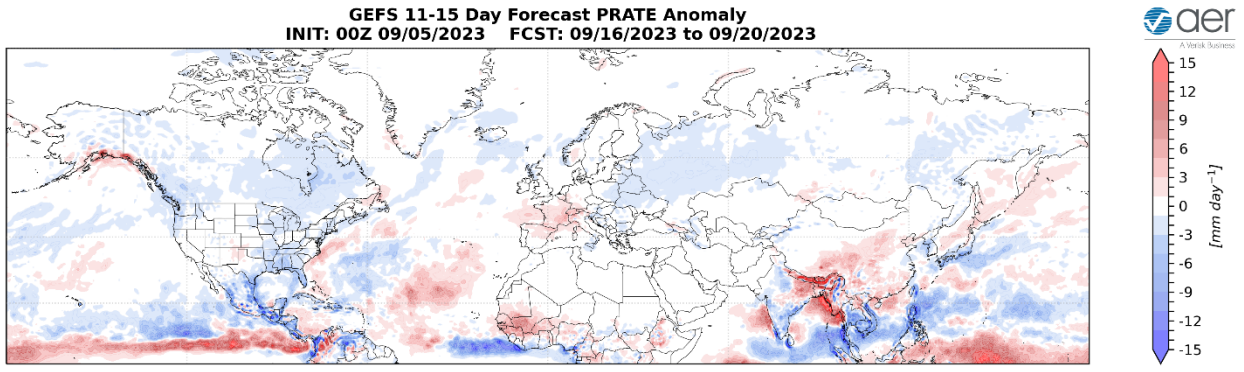

Figure 10. Forecasted precipitation rate (mm/day; shading) from 16 – 20 September 2023. The forecasts are from the 00z 5 September 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Eurasia with the exceptions of normal to wet conditions across Western Europe, the Tibetan Plateau and Central and Eastern China 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 (**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 warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). Next week warm/positive PCHs in the upper troposphere are predicted to descend into the lower troposphere (**Figure 11**).

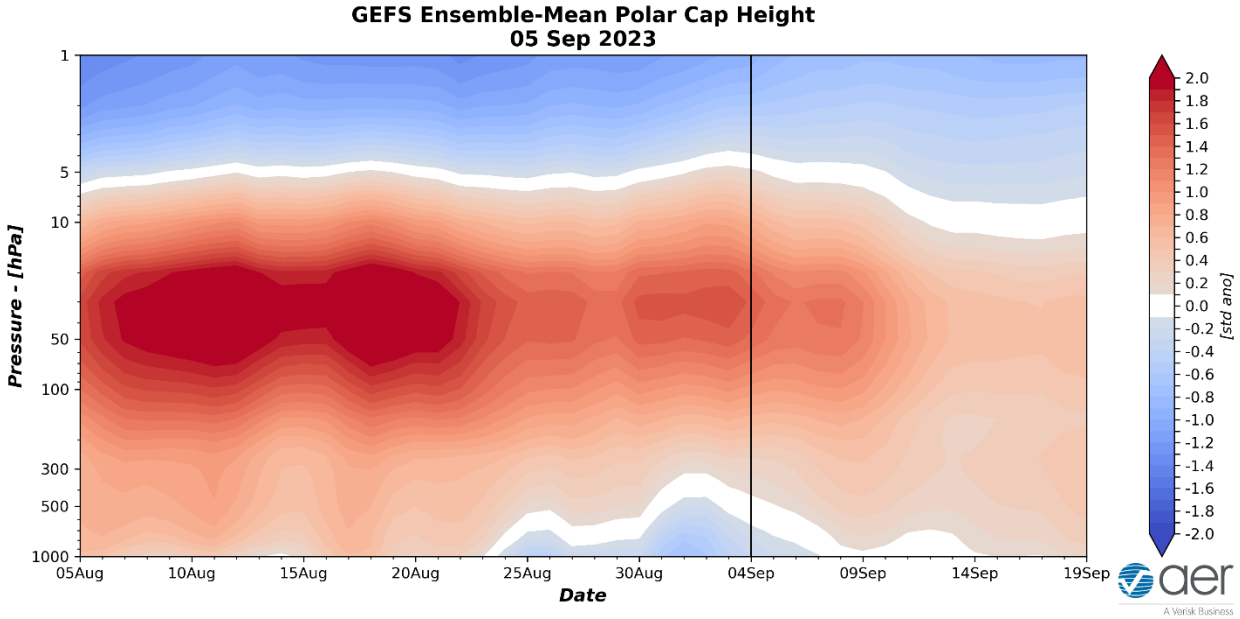

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 5 September 2023 GFS ensemble.

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

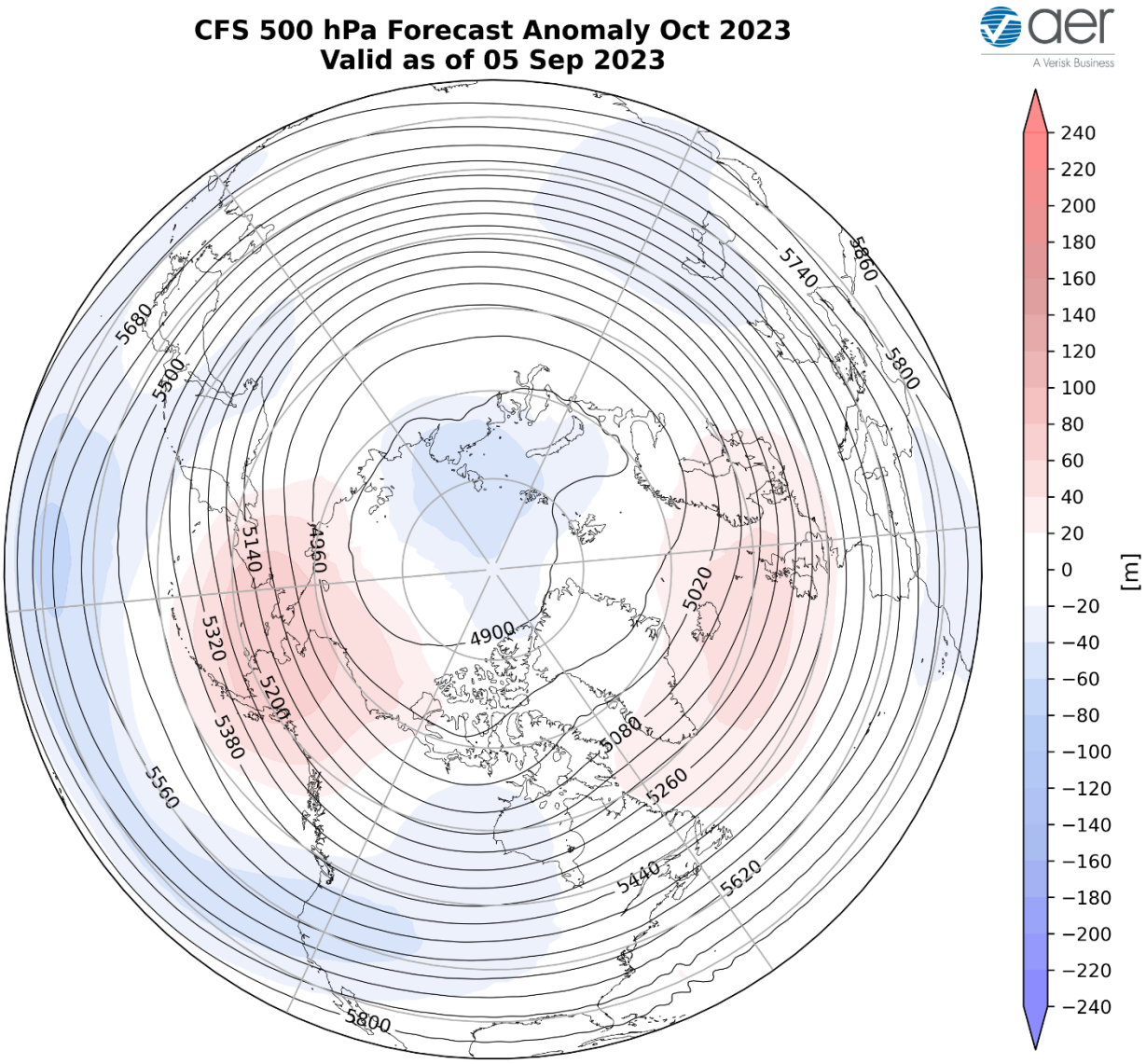

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2023. The forecasts are from the 00Z 5 September 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for October (**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 Iceland and Western Europe and the Dateline with troughing across Northern and Eastern Asia, the Gulf of Alaska and central North America (**Figure 12).** This pattern favors seasonable to relatively warm temperatures across eastern Europe, Western, Southern and East Asia, Alaska, Canada and the Western US with seasonable to relatively cool temperatures across Western Europe, Siberia, and the Eastern US (**Figure**

13).

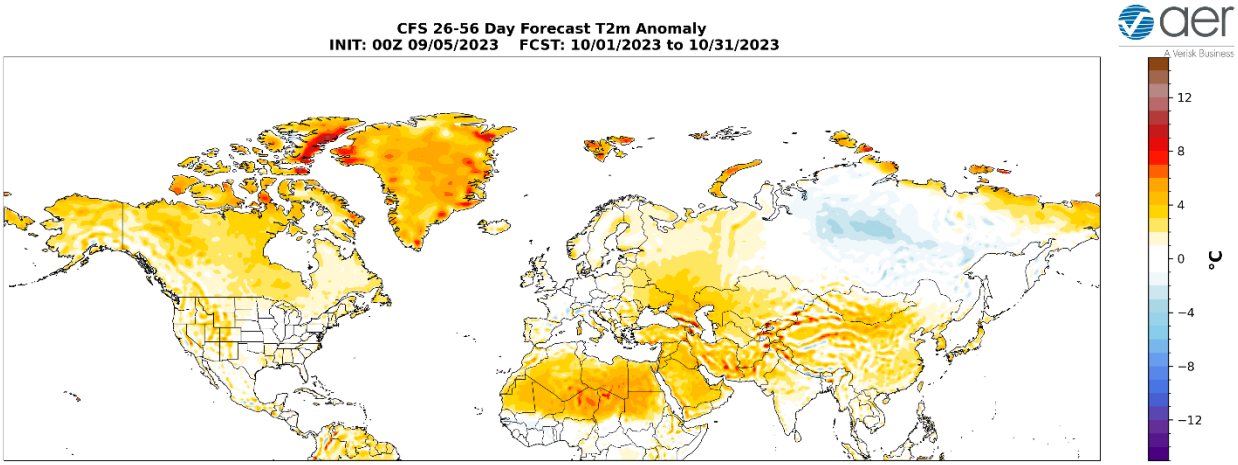

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2023. The forecasts are from the 00Z 5 September 2023 CFS.

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.

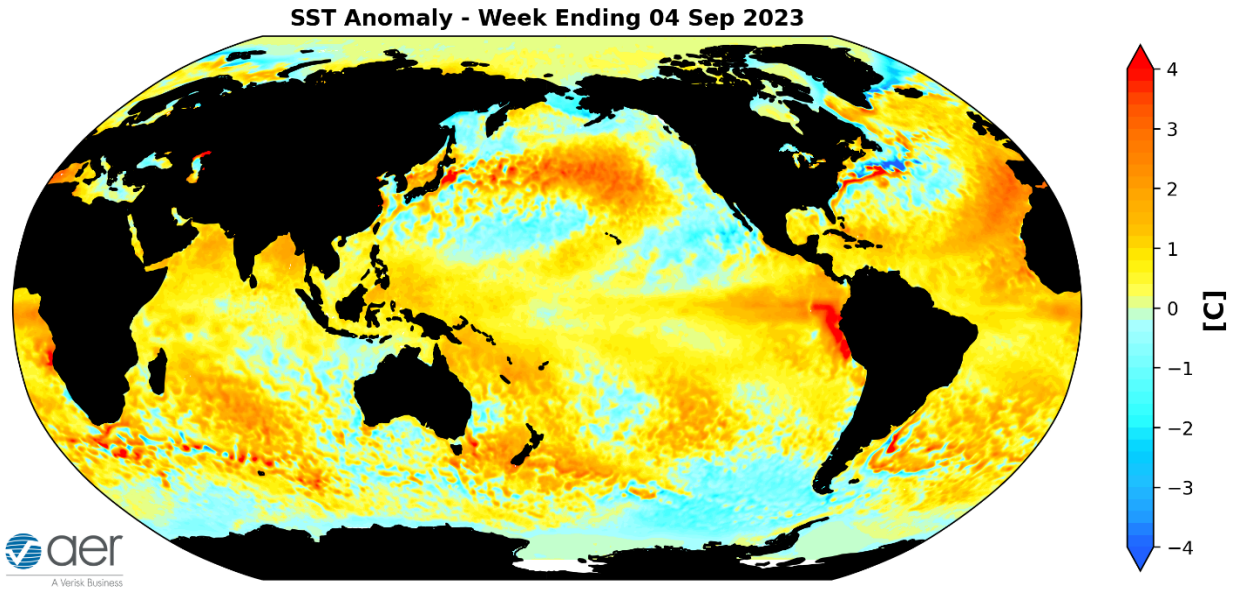

Figure 14. The latest weekly-mean global SST anomalies (ending 5 September 2023). Data from NOAA OI High-Resolution dataset.

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 briefly pop into phase three and then weaken again to where no phase is favored over the next two weeks. Seems that the MJO is having little influence on the weather across North America in the short term. But admittedly this is outside of my expertise.

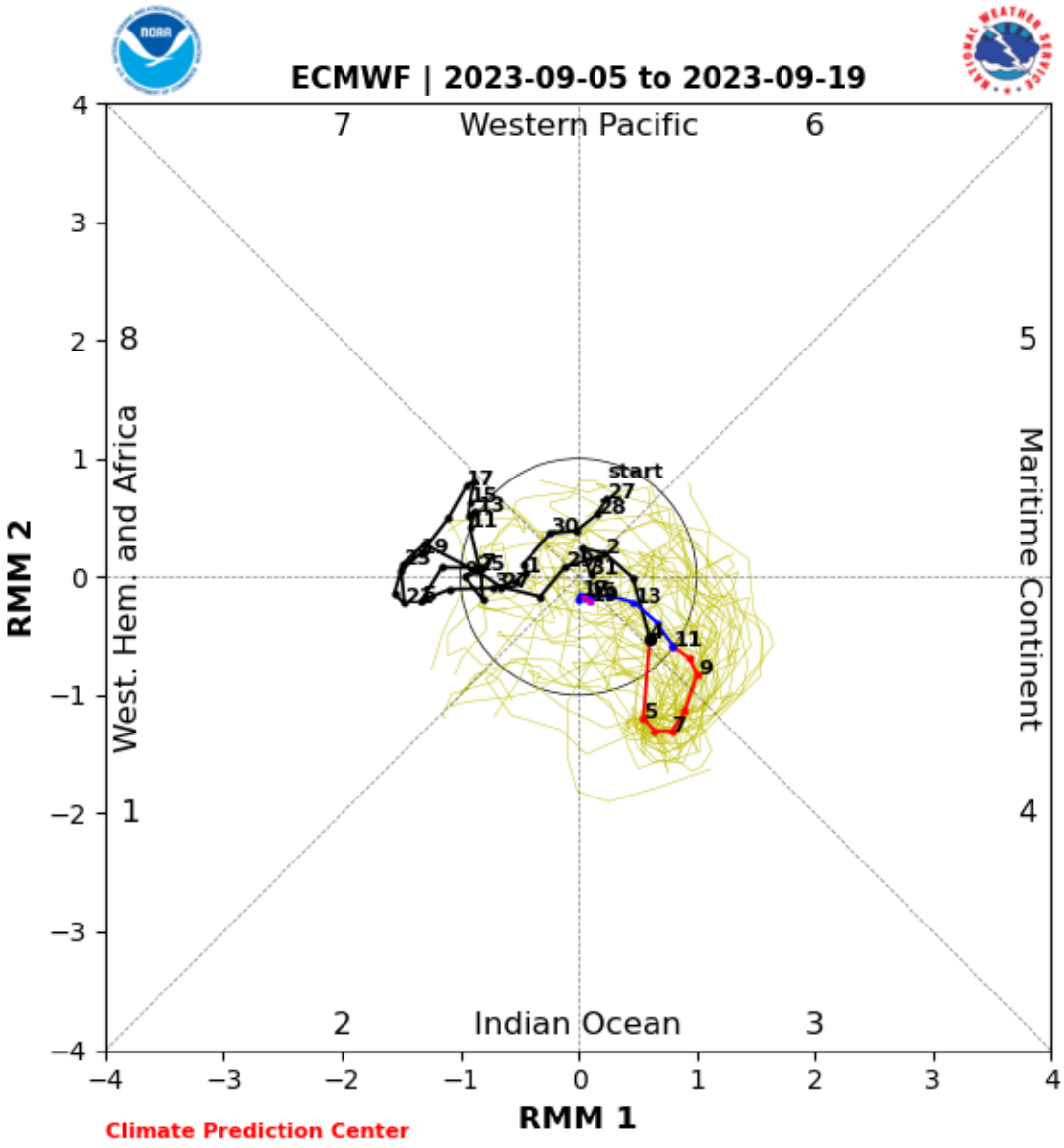

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 5 September 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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!