

Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 1, 2022

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

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

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

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to trend positive this week into positive territory and then negative towards neutral next week as pressure/geopotential height anomalies turn mostly negative across the Arctic this week but then next week pressure/geopotential height anomalies are predicted to become increasingly positive near Greenland with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently positive and is predicted to remain near positive this week and then trend negative next week as pressure/geopotential height anomalies are predicted to remain negative this week and then trend positive across Greenland next week.
- Over the next two weeks, troughing/negative geopotential height anomalies across Greenland will favor ridging/positive geopotential height anomalies across much of Europe centered just west of the British Isles with the exception of weak troughing/negative geopotential height anomalies first near the Baltic Sea and then across Portugal and Spain. Over the next two weeks normal to well above normal temperatures across are predicted for most of Europe including

the United Kingdom (UK) with normal to below normal temperatures limited to Scandinavia and Baltic States this week and Spain and Portugal next week

- The general pattern across Asia the next two weeks is general ridging/positive geopotential height anomalies with troughing/negative geopotential height anomalies in Central Asia and Western Siberia this week which swings into Northeastern Asia next week. This pattern favors widespread normal to above normal temperatures with the exceptions of normal to below normal temperatures across Western Siberia and Central Asia this week and Northeast Asia next week.
- The general pattern this week across North America is troughing/negative geopotential height anomalies across Alaska and Canada with ridging/positive geopotential height anomalies across much of the United States (US) however next week ridging/positive geopotential height anomalies will amplify across western North America with developing troughing/negative geopotential height anomalies in eastern North America. This pattern mostly favors normal to below normal temperatures across Alaska and much of Canada with normal to above normal temperatures across much of the US this week. However next week, normal to above normal temperatures will build across Western Canada and the Western US with cooling temperatures in Southeastern Canada and the Northeastern US.
- In the *Impacts* section I discuss the overall summer pattern and that the pattern of July is likely to continue into August.
- *Impacts* section I discuss the heat in Europe and where to expect the warmest summer temperature anomalies across the Northern Hemisphere (NH) to be in the coming weeks.
- Expect irregular postings of the blog for this month.

Plain Language Summary

The donut shaped atmospheric circulation of July that has delivered hot and dry conditions to Europe and the US is likely to continue into August. But inside the donut hole, centered on the North Pole, it has been relatively cool helping to insulate Arctic sea ice and Greenland land ice.

Impacts

We have entered the last month of meteorological summer and I think that we have a pretty good sense of the major themes of summer 2022. Overall, for Europe and North America it has been a hot and dry summer. Northern Hemisphere (NH) surface temperature anomalies are shown in **Figure i** and global soil moisture anomalies are shown in **Figure ii**. Asia has been hot as well but moister than the other two continents. Besides the dry conditions there have been regional extreme rainfall and flooding.

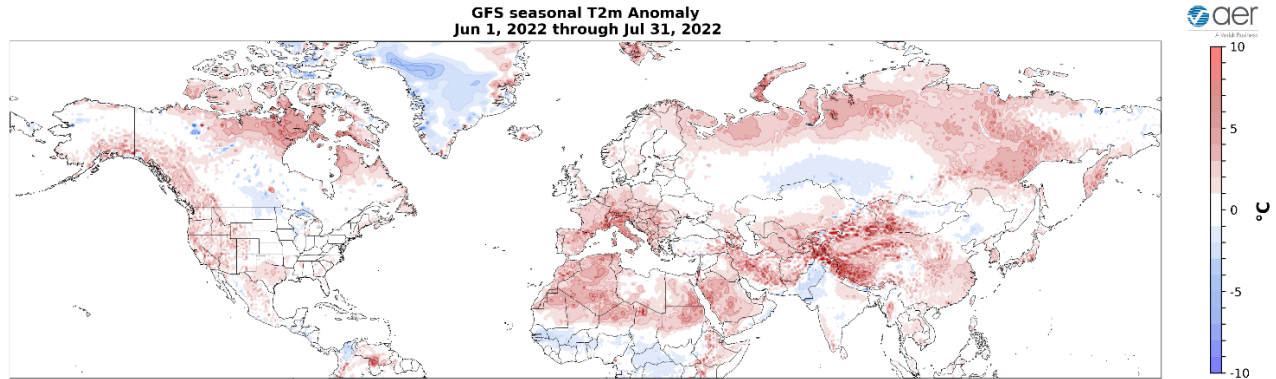


Figure i. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 June – 31 July 2022 from the GFS analysis.

It is interesting that surface temperature anomaly pattern on both continents looks like a sandwich with well above normal temperatures across northern and southern Eurasia and North America with a layer of cooler than normal temperatures in the mid-continent. This pattern reminds me more of recent winters with cooling in the interior of the continents. Though I am uncertain that this pattern will last through the end of summer across North America, as the potential exists for a very hot August in central North America.

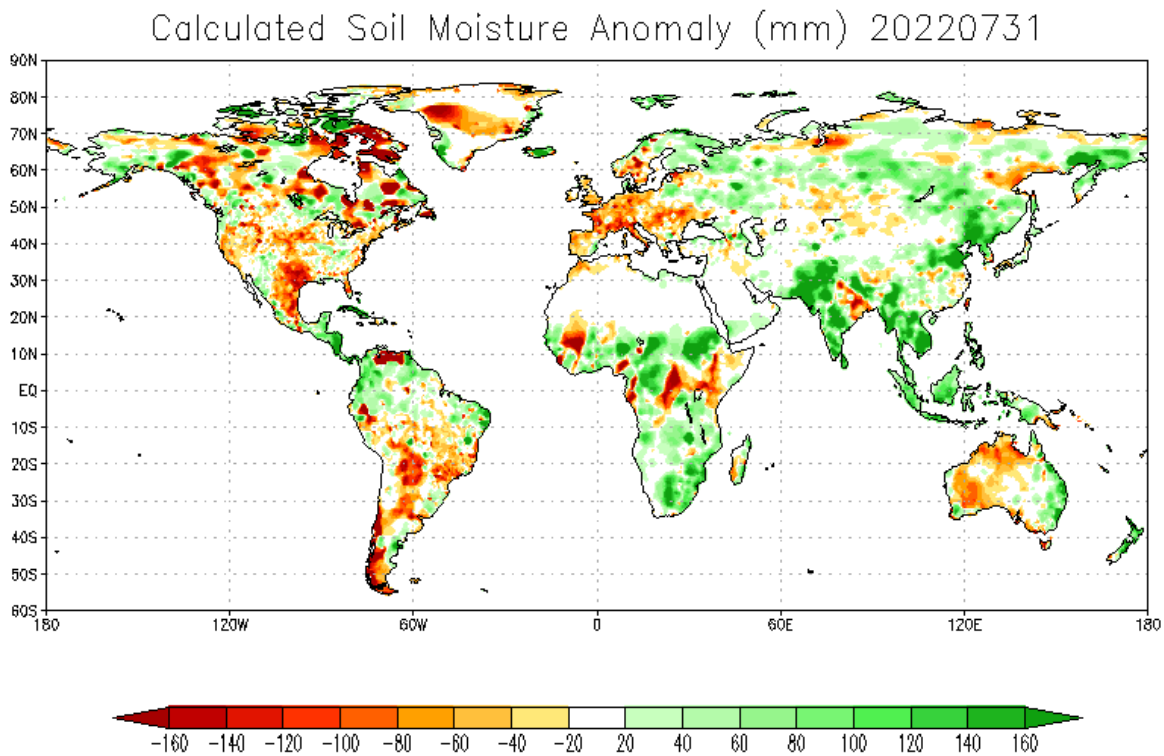


Figure ii. Global soil moisture anomalies from 31 July 2022. Plot copied from https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/GLB/glb_s.shtml

There is always the problem of what came first the chicken or the egg, but it does seem plausible that the ribbon of very warm temperatures along the northern edges of the continents and just south of the much colder Arctic Ocean, has helped to anchor and even strengthen the Jet Stream close to 60°N with the possible exception of Asia (see **Figure iii**).

GFS 1-day Avg

250hPa Wind Speed (kt), MSLP (hPa)
Monday, Aug 01, 2022

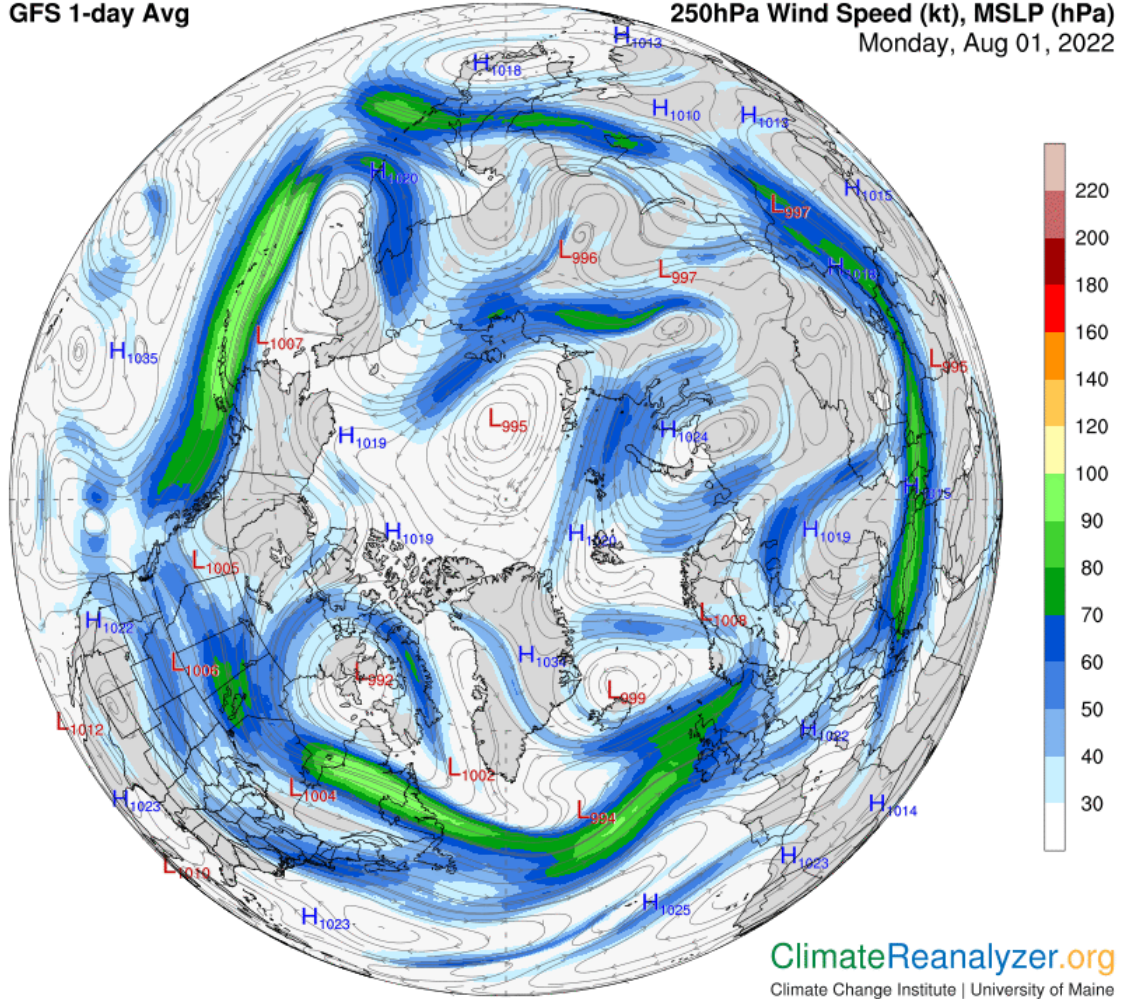


Figure iii. Observed wind speed and sea level pressure for 1 August 2022 based on the 1 August 2022 GFS analysis. Plot copied from <https://climatoreanalyzer.org/>.

It appears to me that the circulation of the NH mid-troposphere has resembled an annulus with low pressure in the Central Arctic ringed by relatively higher pressure across the mid-latitudes with centers of high pressure or heat domes. It does seem to me there have been four distinct centers of high pressure/heat domes across the NH one in the Euro-Atlantic sector, Asia, the North Pacific and North America. Under the three continental heat domes we have seen the most impressive heat and often dry conditions.

Based on the forecasts (one example from the CFS in **Figure iv**) there is little reason to expect any major changes in this overall pattern. In August there might be an expectation of a moderation in the extreme heat of July but based on the forecasts the potential exists for extreme heat in parts of Europe, China, and the US. The polar vortex (PV) returns at the end of the month, and it might take the return of the PV to finally initiate a breakdown of this overall stubborn pattern.

**CFS 500 hPa Forecast Anomaly Aug 2022
Valid as of 01 Aug 2022**

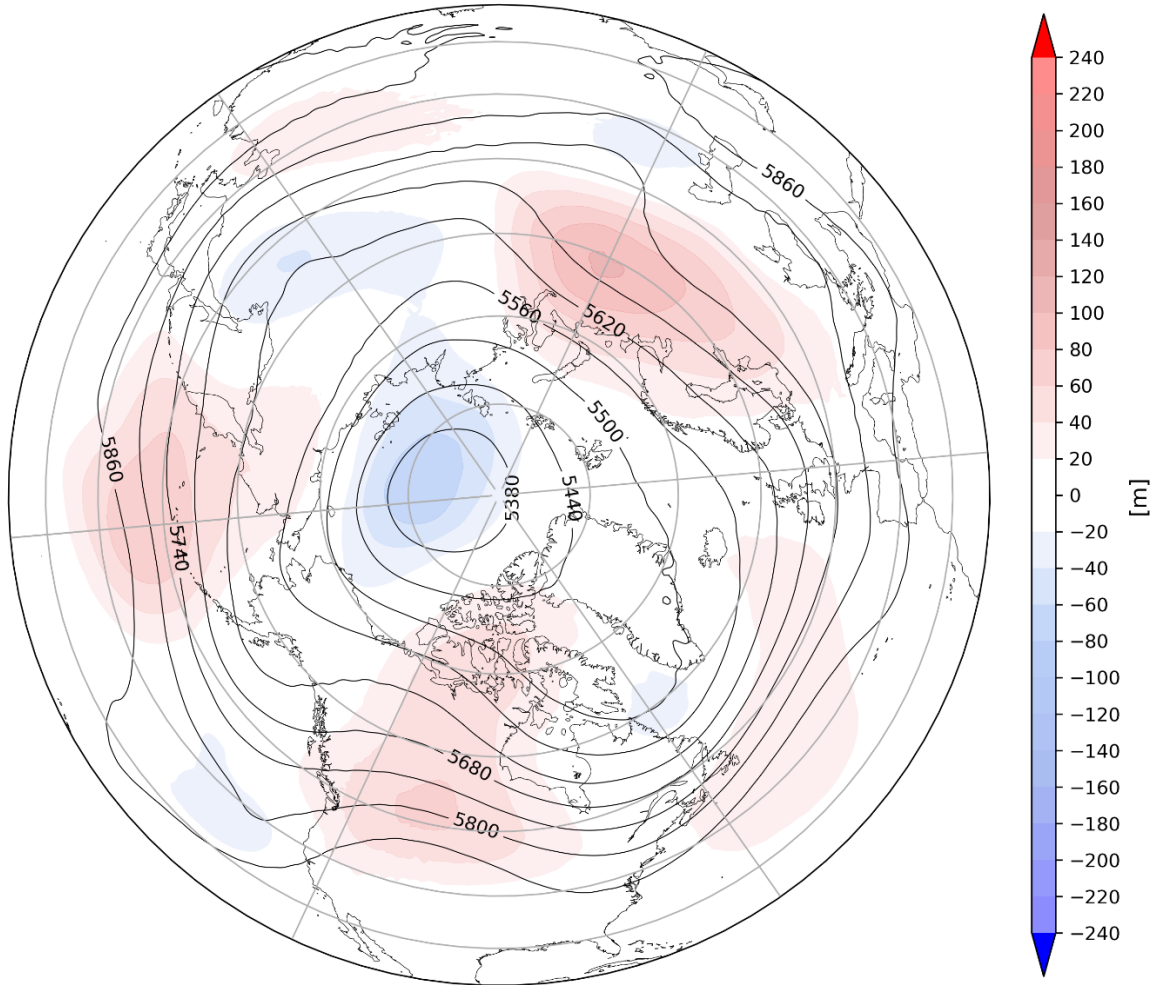


Figure iv. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2022. The forecasts are from the 00Z 1 August 2022 CFS.

But if this pattern has favored hot and dry conditions in the mid-latitudes it has been a favorable pattern for preserving land and sea ice in the Arctic Ocean and on Greenland. Both Arctic Sea ice and the Greenland glacier have melted slowly relative to recent summers. And it appears to me this overall supportive pattern of relatively slow melting is likely to continue into August. I included in **Figure v** the latest Arctic Sea ice extent. It is the most extensive extent since at least 2015. It also looks as we enter fall the region along the Eurasian coast will be the region with the greatest negative anomalies.

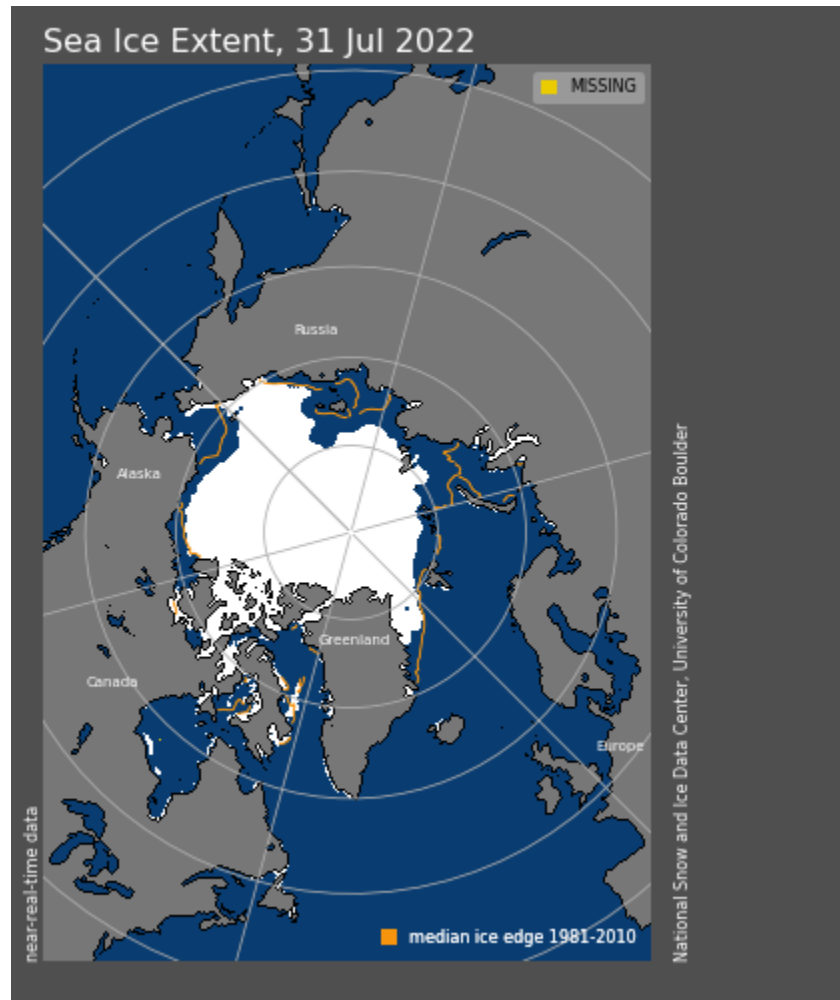


Figure v. Observed Arctic Sea ice extent on 31 July 2022 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC).

1-5 day

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

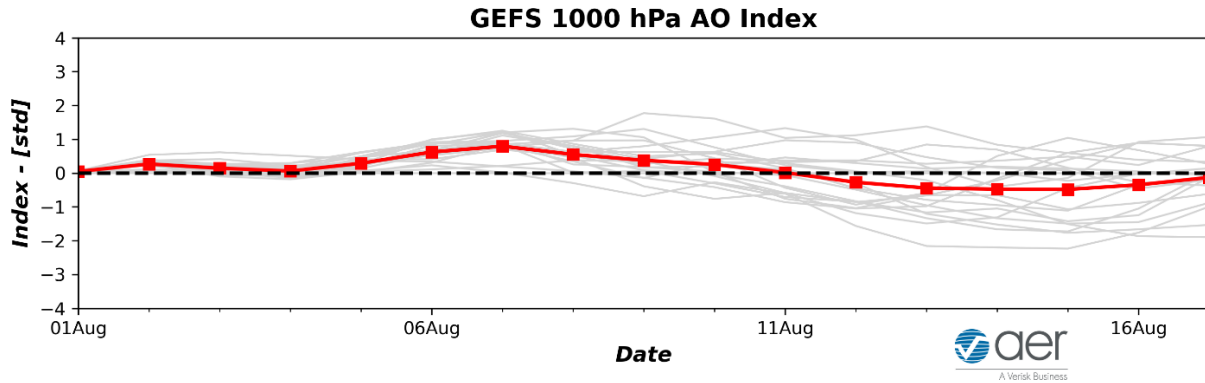


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 1 August 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

A mostly zonal flow is predicted for Europe with ridging/positive geopotential height anomalies to the south centered over Central Europe and troughing/negative geopotential height anomalies from Scotland to Scandinavia (**Figures 2**). This will favor normal to well above normal temperatures across much Europe including the Southern UK with normal to below normal temperatures limited to Scotland and Scandinavia where geopotential heights will be below normal (**Figure 3**). Ridging/positive geopotential height anomalies are predicted to dominate Asia with the exception of troughing/negative geopotential height anomalies across Western Siberia that extends into Central Asia (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Asia with normal to above normal temperatures limited to Western Siberia and Kazakhstan (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/01/2022 FCST: 08/02/2022 to 08/06/2022

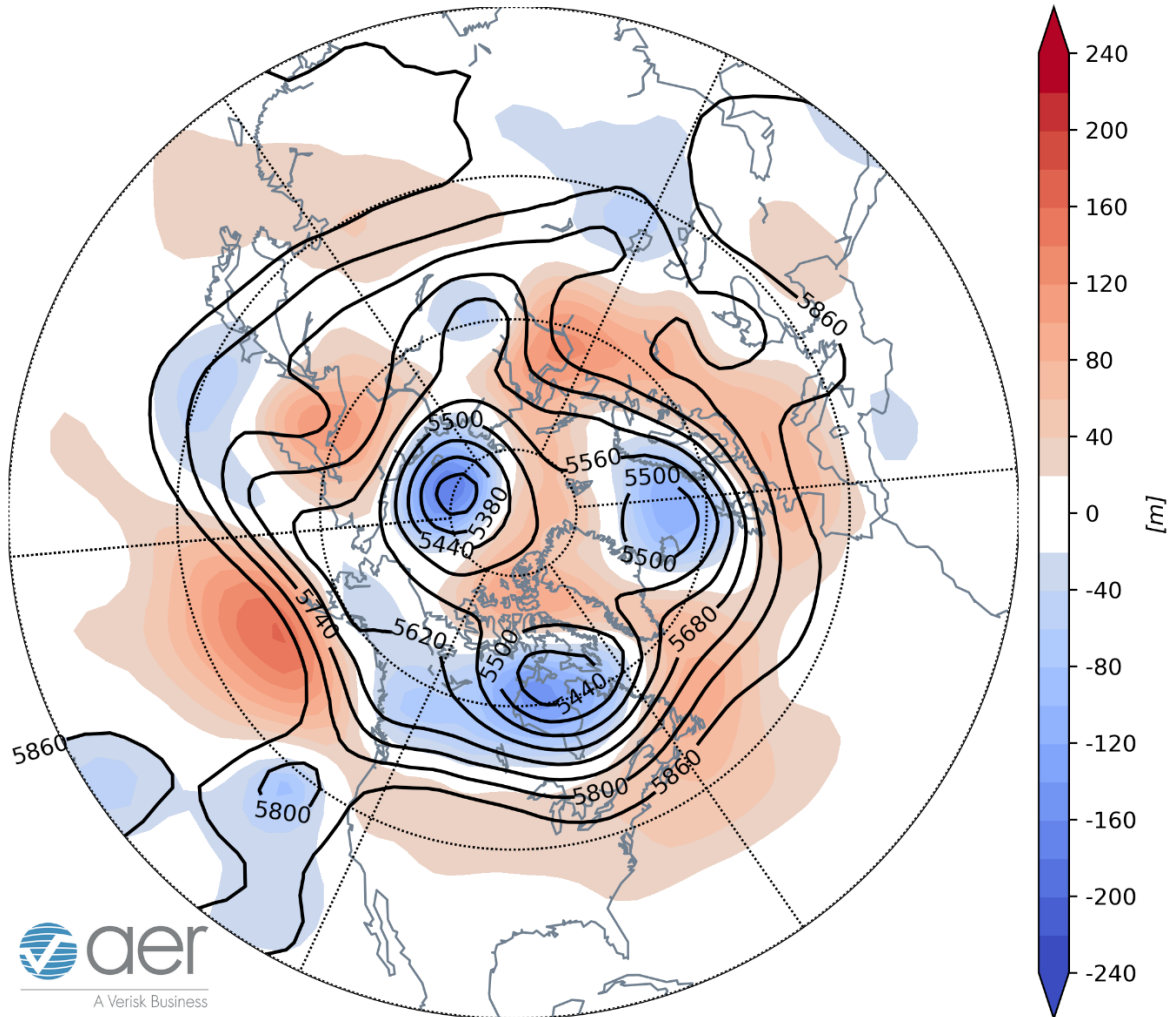


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 2 – 6 August 2022. The forecasts are from the 00z 1 August 2022 GFS ensemble.

A general zonal flow pattern across North America is predicted this week with troughing/negative geopotential height anomalies across Alaska and most of Canada with ridging/positive geopotential height anomalies draped across the US (**Figure 2**). The pattern will favor normal to below normal temperatures across Southern Alaska and most of Canada with widespread normal to above normal temperatures across much of the US and northern Alaska (**Figure 3**).

GFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 08/01/2022 FCST: 08/02/2022 to 08/06/2022

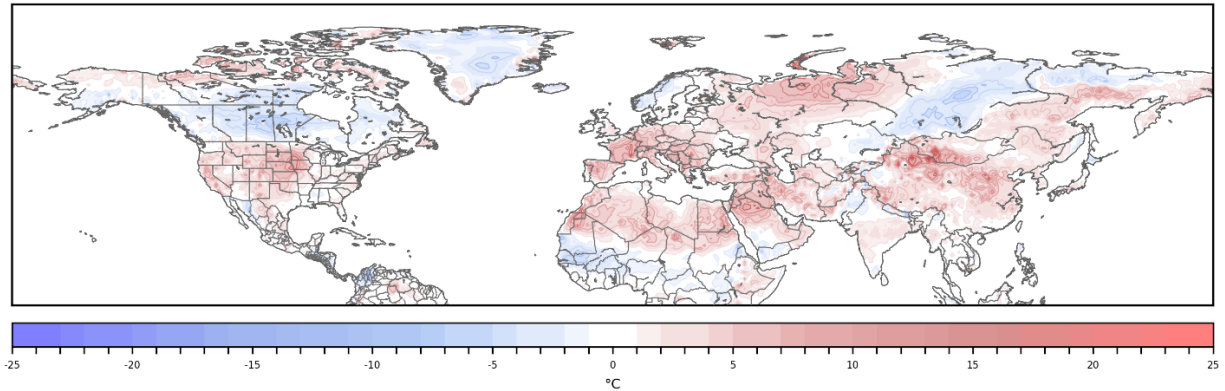


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 2 – 6 August 2022. The forecast is from the 00Z 1 August 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Scotland, Norway, Eastern Ukraine and parts of Southern and Eastern Asia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across Southern Alaska, Western and Eastern Canada and Ohio Valley and Northeastern US (**Figure 4**).

GEFS 1-5 Day Forecast PRATE Anomaly
INIT: 00Z 08/01/2022 FCST: 08/02/2022 to 08/06/2022

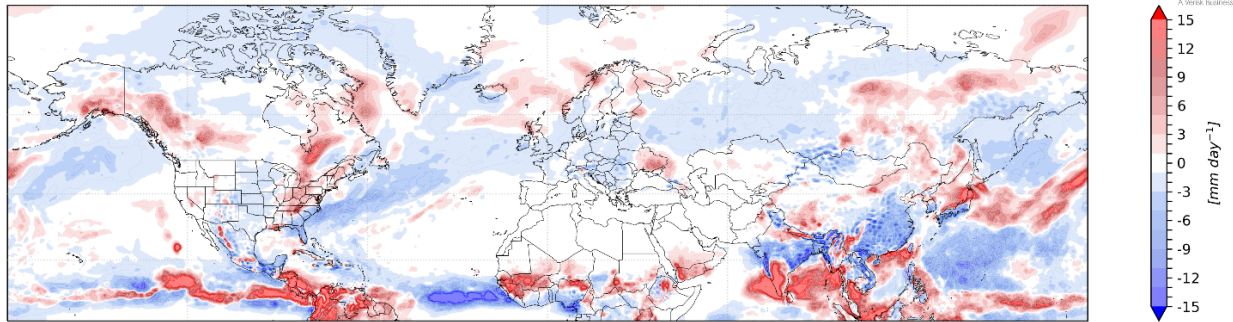


Figure 4. Forecasted precipitation rate (mm/day; shading) from 2 – 6 August 2022. The forecast is from the 00Z 1 August 2022 GEPS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain mostly positive this period (**Figure 1**) as geopotential height anomalies turn mostly negative across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). With mostly negative

geopotential height anomalies across Greenland and Iceland (**Figure 5**), the NAO is predicted to remain positive this period.

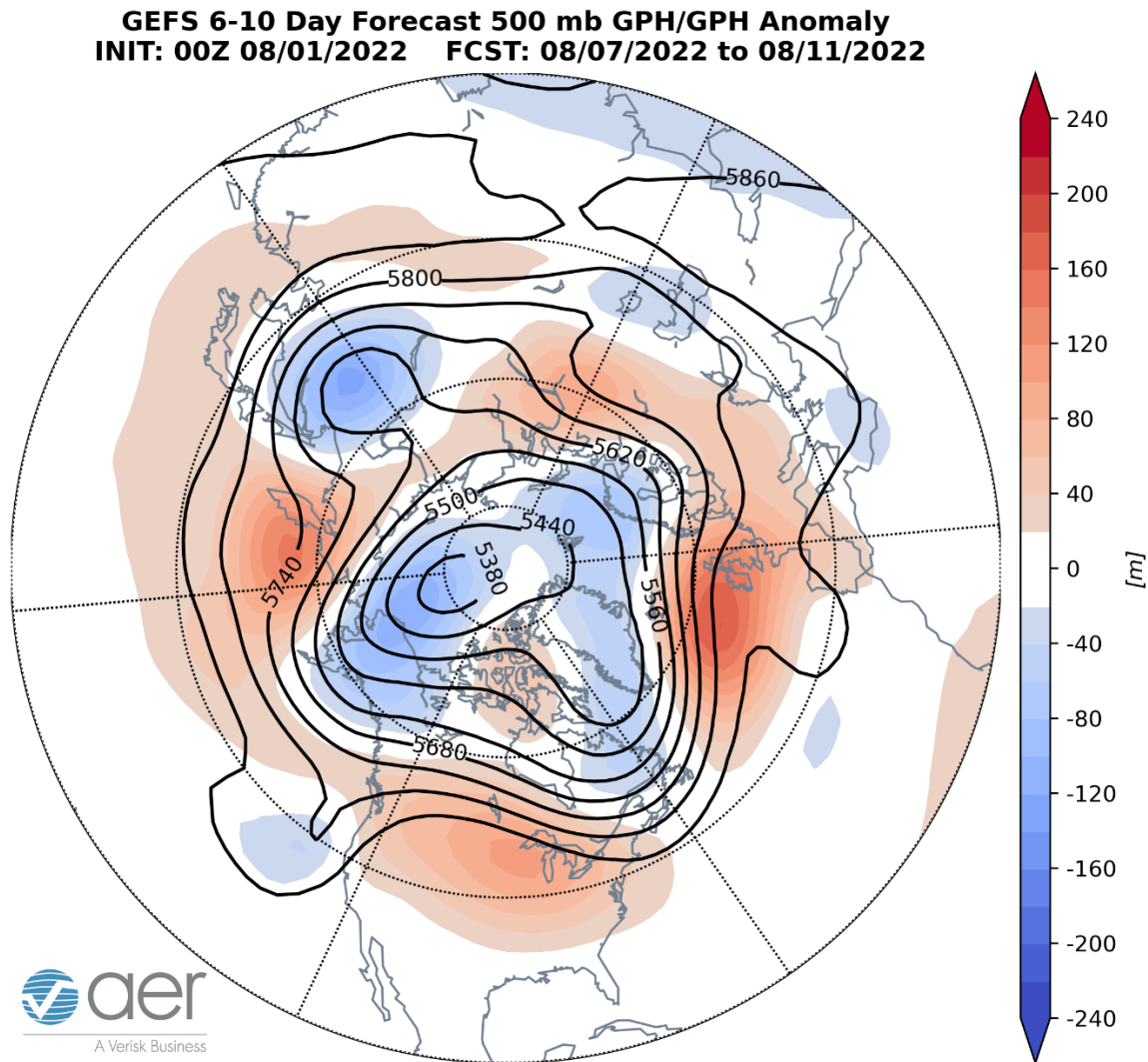


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 7 – 11 August 2022. The forecasts are from the 00z 1 August 2022 GFS ensemble.

Trounging/negative geopotential height anomalies across Greenland will favor ridging/positive geopotential height anomalies just west of the British Isles that extend across much of Europe with the exception weak trounging/negative geopotential height anomalies centered in the Baltic Sea this period (**Figures 5**). The pattern is predicted to result in normal to above normal temperatures across most of Europe including the UK with normal to below normal temperatures limited to the Baltic States (**Figure 6**). The trough/negative geopotential height anomalies previously in Western Siberia is predicted to slide into Northeastern Asia this period with ridging/positive geopotential

height anomalies dominating the rest of Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Asia with normal to below normal temperatures limited to Northeastern Asia and Pakistan and Northern India due to weak troughing in the region (**Figure 6**).

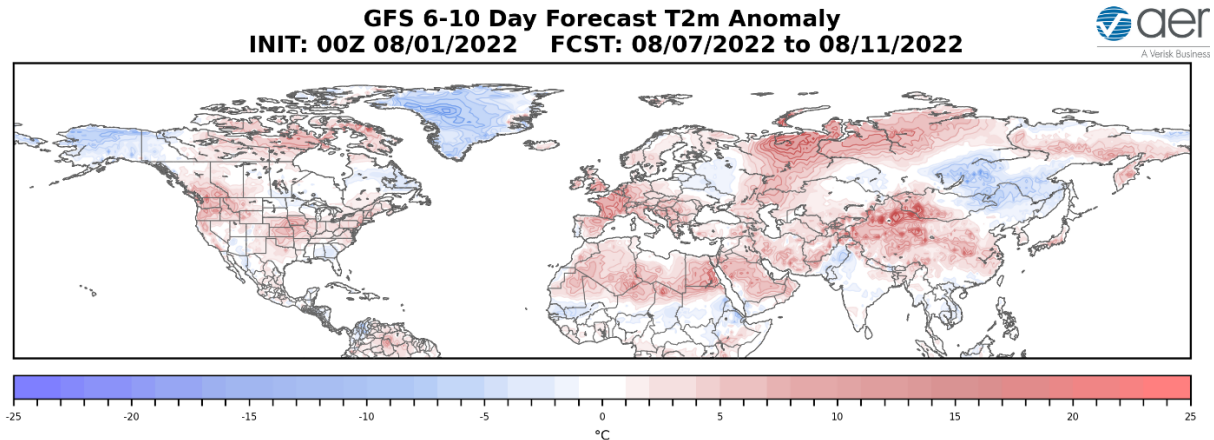


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 7 – 11 August 2022. The forecasts are from the 00Z 1 August 2022 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to consolidate in the interior of North America with troughing/negative geopotential height anomalies along the edges across much Alaska and Quebec (Figure 5). This pattern will favor normal to above normal temperatures across much of Canada and the US with normal to below normal temperatures limited to Alaska and Quebec (**Figure 6**).

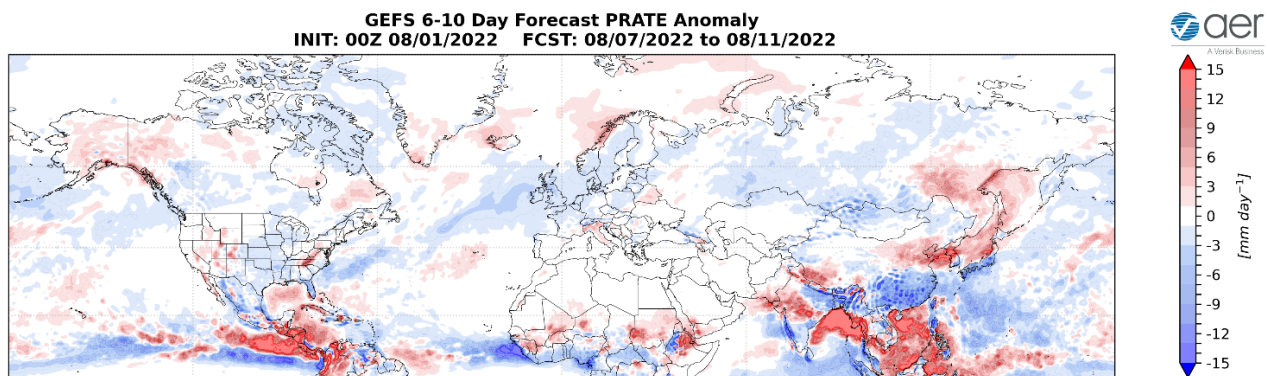


Figure 7. Forecasted precipitation rate (mm/day; shading) from 7 – 11 August 2022. The forecast is from the 00Z 1 August 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Norway and parts of Southern and Eastern Asia (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal

precipitation predicted across Alaska, the Yukon, the Southwestern US and the Southern Appalachians (Figure 7).

11-15 day

Geopotential height anomalies are predicted to turn mixed and weak across the Arctic this period (Figure 8), therefore the AO should straddle neutral (Figure 1). With predicted positive pressure/geopotential height anomalies building just east of Greenland (Figure 8), the NAO is predicted to also remain tethered to neutral this period.

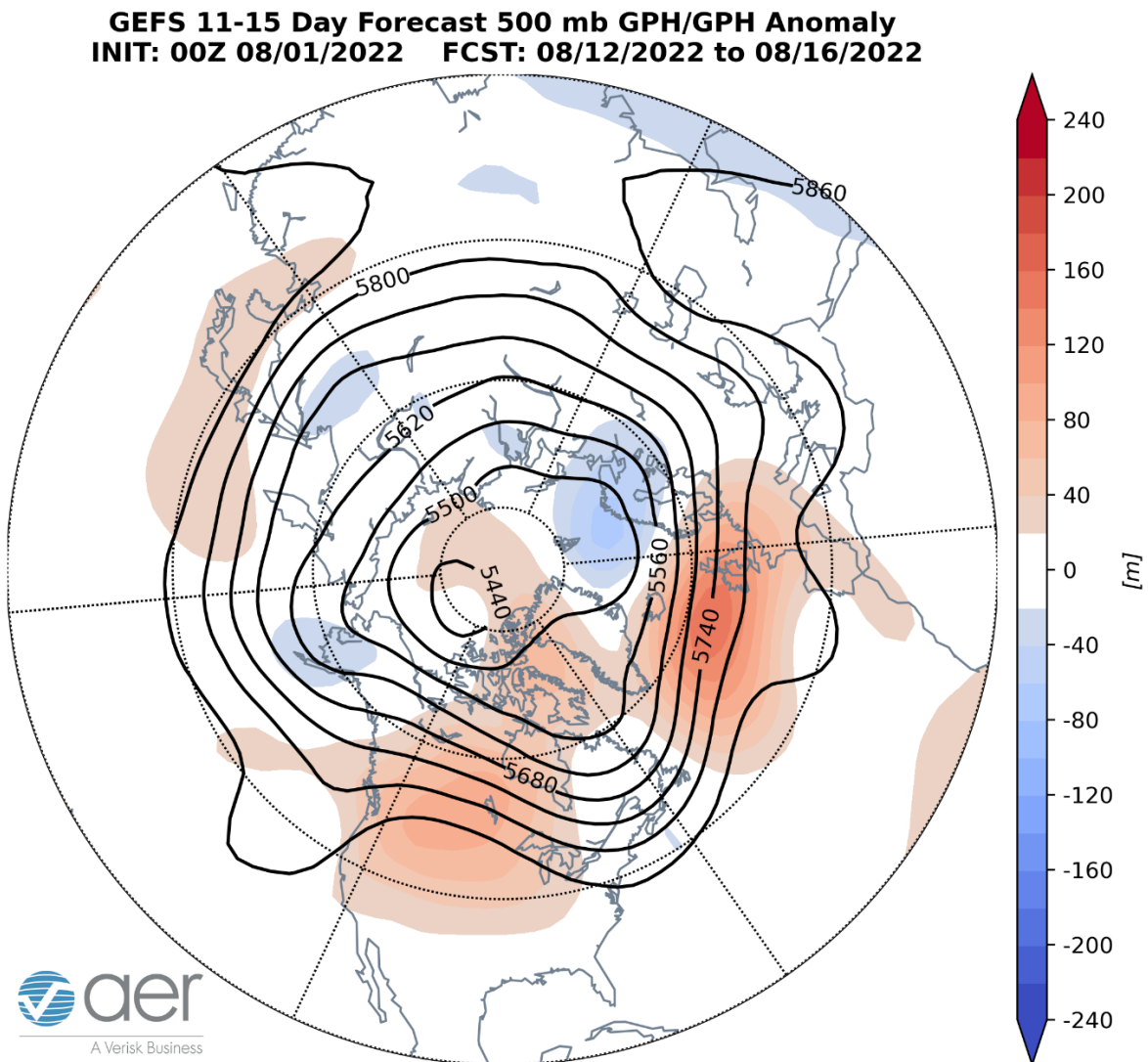


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 12 – 16 August 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

Amplifying ridging/positive geopotential height anomalies between Iceland and the UK that extends across Europe are predicted to continue with weak troughing/negative geopotential height anomalies across Portugal and Spain this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Europe including the UK with normal to below normal temperatures limited to Portugal and Spain (**Figures 9**). A dipole pattern is predicted for Asia with ridging/positive geopotential height anomalies centered near the Urals and troughing/negative geopotential height anomalies in Eastern Asia (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Western and Southern Asia with normal to below normal temperatures across much of Siberia and Northeastern Asia (**Figure 9**).

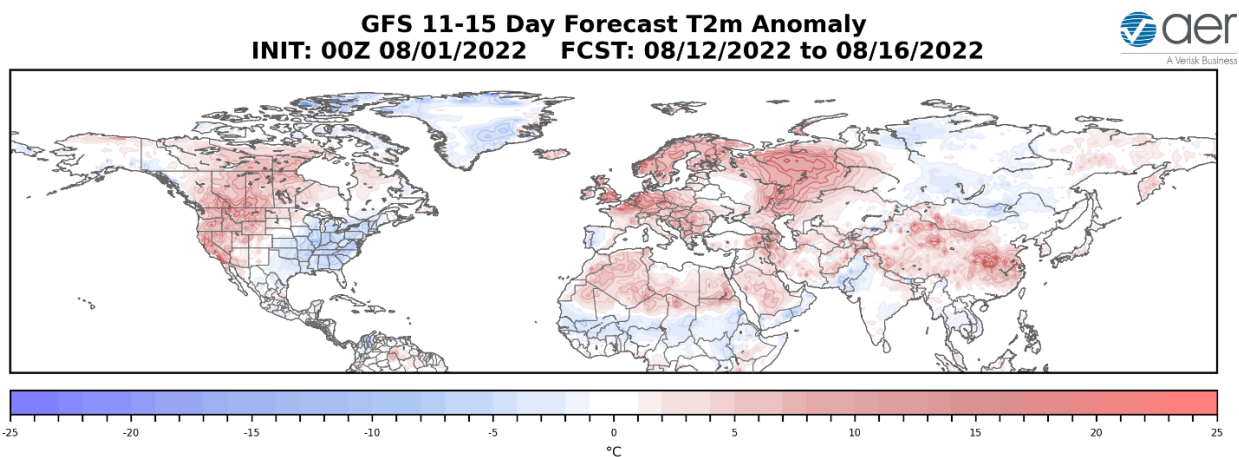


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 12 – 16 August 2022. The forecasts are from the 00z 1 August 2022 GFS ensemble.

The predicted pattern across North America this period is ridging/positive geopotential height anomalies centered across Western Canada and the Western US with troughing/negative geopotential height anomalies across Alaska and Southeastern Canada this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across northern Alaska, Northern and Western Canada and the Western US with normal to below normal temperatures across Southern and Eastern Canada and the Eastern US (**Figure 9**).

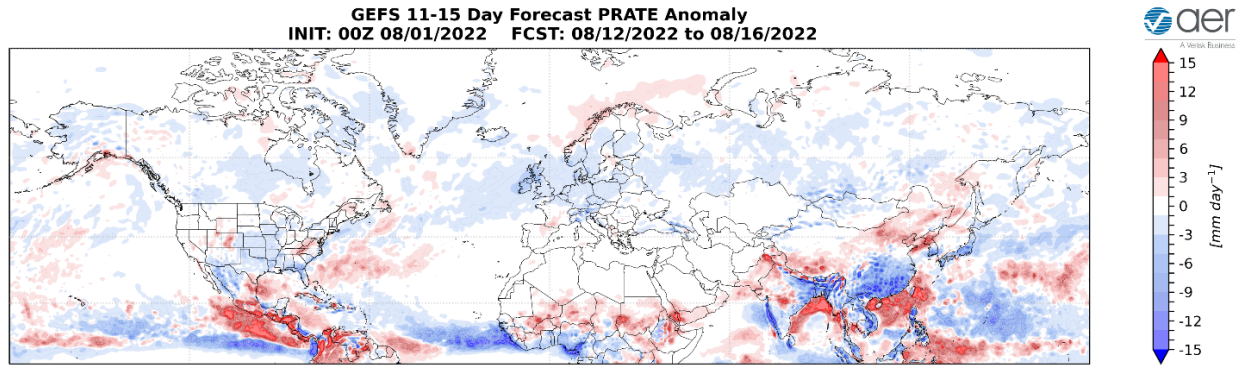


Figure 10. Forecasted precipitation rate (mm/day; shading) from 12 – 16 August June 2022. The forecast is from the 00Z 1 August 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for in parts of Norway, the Pyrenees, Southern and Eastern Asia (**Figure 10**). Mostly below normal precipitation is predicted across North America except for southern Alaska, the Central Rockies and the Southern Appalachians (**Figure 10**).

Longer Term

30-day

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

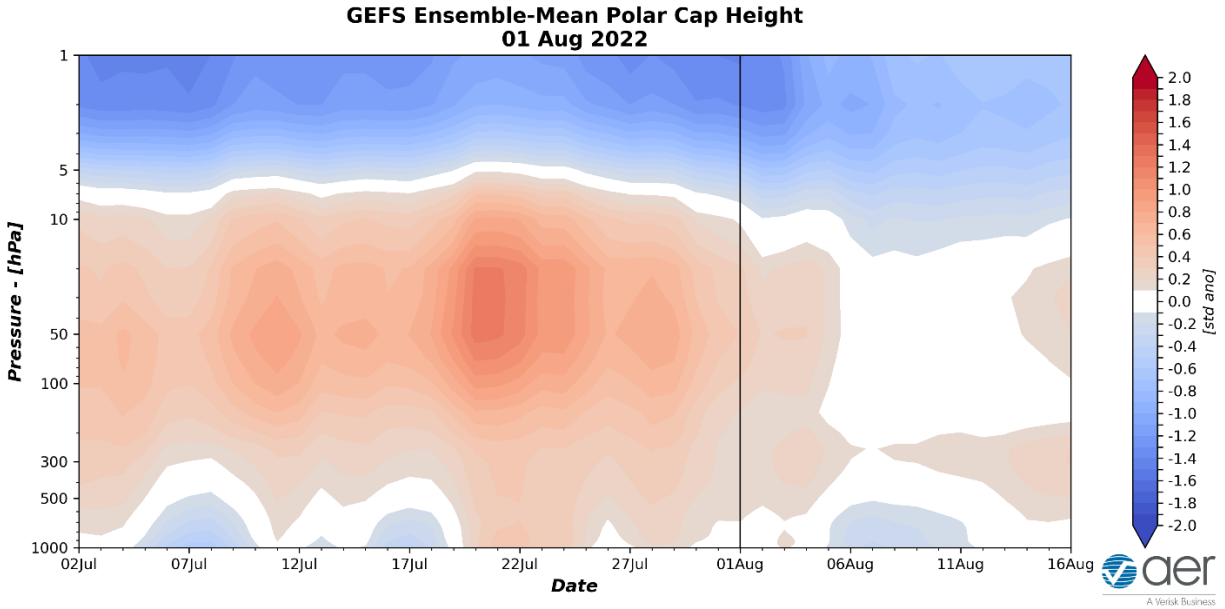


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 1 August 2022 GFS ensemble.

The normal to cold/negative PCHs in the lower troposphere (**Figure 11**) are consistent with the predicted neutral to positive surface AO predicted the next two weeks (**Figure 1**).

**CFS 500 hPa Forecast Anomaly Sep 2022
Valid as of 01 Aug 2022**

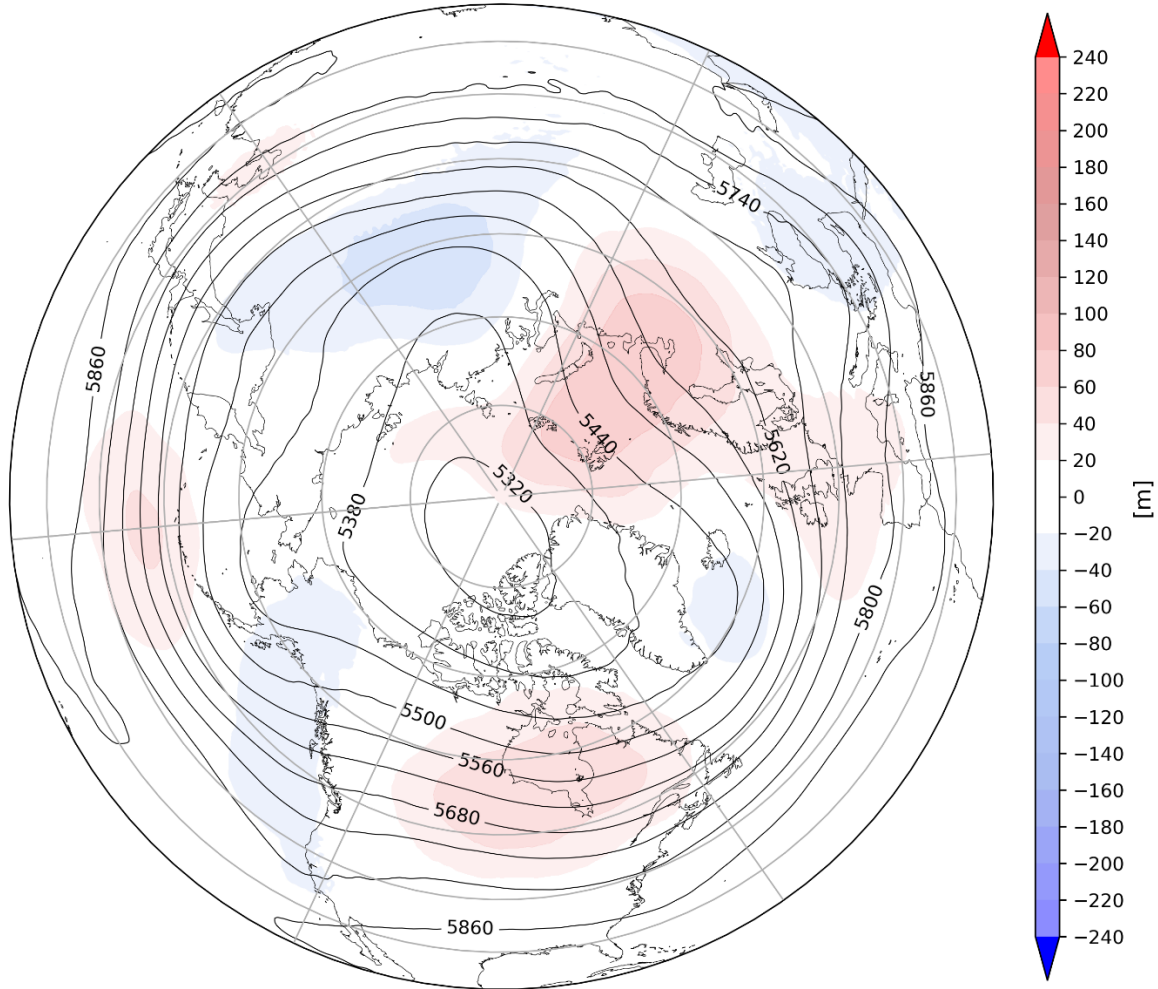


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2022. The forecasts are from the 00Z 1 August 2022 CFS.

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 across Europe, centered in the Barents-Kara Seas, the Dateline, and central North America with troughing across the Middle East, Western Siberia, the Gulf of Alaska and near Greenland and Iceland (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across much of Europe, Western and Southern Asia, Alaska, much of Canada and the US with seasonable to relatively cool temperatures across the Eastern Mediterranean, much of Siberia, Northeastern Asia, Alaska and Northwestern Canada (**Figure 13**).

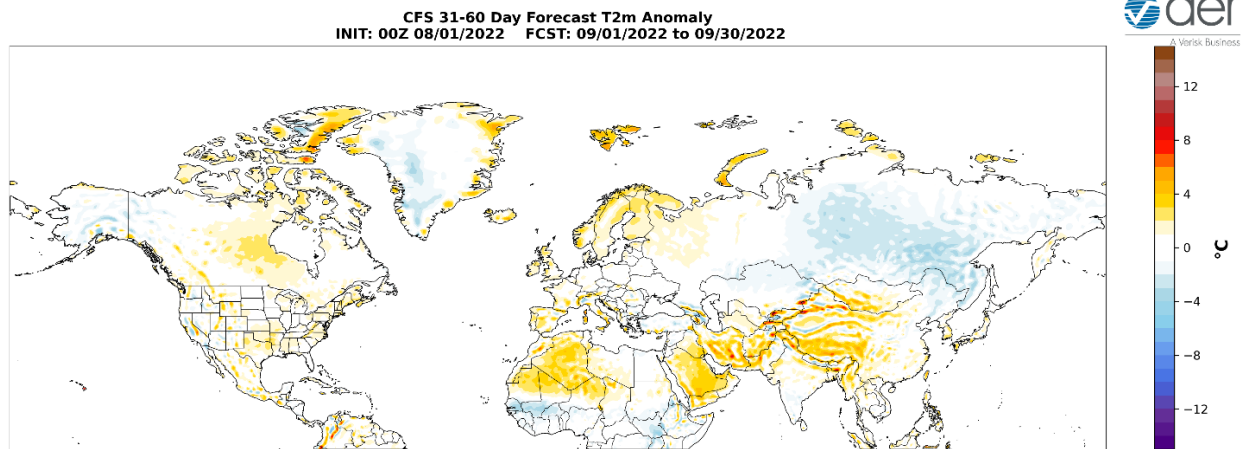


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for September 2022. The forecasts are from the 00Z 1 August 2022 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific Sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 14**) and La Niña conditions are expected through the summer. La Niña could favor a North America heat dome during the summer months and a more active North Atlantic hurricane season. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the North Pacific.

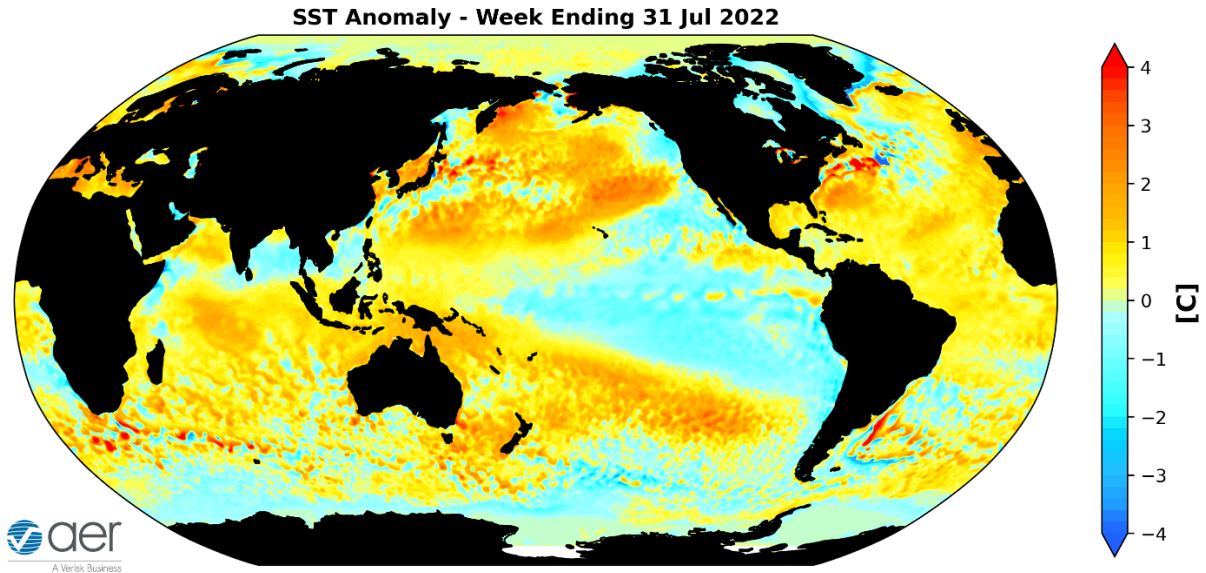


Figure 14. The latest weekly-mean global SST anomalies (ending 31 July 2022). Data from NOAA OI High-Resolution dataset.

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. Therefore there seems to be little MJO influence in the near and long term weather across North America. But admittedly this is outside of my expertise.

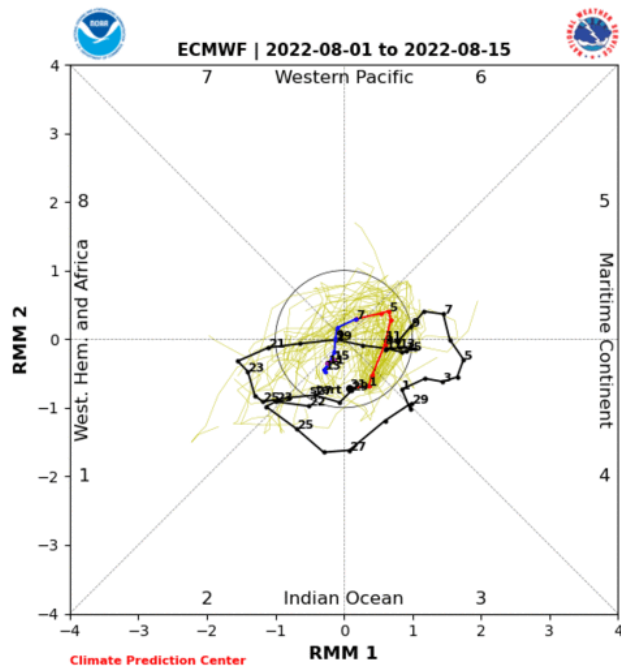


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 1 August 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image

source: <http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html>

Get Detailed Seasonal Weather Intelligence with **sCast**

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

Dr. Cohen’s detailed monthly seasonal forecast, sCast, is also available for purchase. **sCast** provides a monthly 30-60-90-180-day outlook into temperature and precipitation, solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

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