

Arctic Oscillation and Polar Vortex Analysis and Forecasts

July 5, 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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Summary

- The Arctic Oscillation (AO) is currently positive and is predicted to remain neutral to positive the next two weeks as mostly negative pressure/geopotential height anomalies dominate across the Arctic with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently neutral and is predicted to remain near neutral as pressure/geopotential height anomalies are predicted to remain weak but mostly negative across Greenland over the next two weeks.
- Over the next two weeks, a propensity towards troughing/negative geopotential height anomalies across Greenland will promote increasing ridging/positive geopotential height anomalies and less troughing/negative geopotential height anomalies across Europe the next two weeks. This week normal to above normal temperatures across are predicted for Western Europe including the United Kingdom (UK) and Eastern Europe with normal to below normal temperatures in Central Europe. Next week the temperature pattern will transition to widespread normal to above normal temperatures across most of Europe including the UK.

- The general pattern the next two weeks across Asia is troughing/negative geopotential height anomalies anchored in Central Asia bookended by ridging/positive geopotential height anomalies in Western and Eastern Asia. This pattern favors normal to above normal temperatures across Western and Eastern Asia, with normal to below normal temperatures in Central Asia. However, by mid-month normal to above normal temperatures are predicted to become more widespread.
- The general pattern this week across North America is ridging/positive geopotential height anomalies across western North America centered near the Canadian Archipelagos with troughing/negative across Eastern Canada and the Eastern United States (US). However, next week the center of ridging/positive geopotential height anomalies will slide east into Hudson Bay with troughing/negative geopotential height anomalies spreading across Alaska. The pattern mostly favors normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures across Eastern Canada and the Eastern US this week. Then beginning next week, normal to below normal temperatures will become widespread across Alaska, with normal to above normal temperatures becoming more widespread across Canada.
- In the *Impacts* section I discuss where to expect the warmest summer temperature anomalies across the Northern Hemisphere (NH).
- *Impacts* section I discuss what dominant summer temperature patterns appear to emerge.

Plain Language Summary

The warm pattern in Europe is predicted to take a respite but should emerge by mid-July and I think an overall warm summer in Europe is close to certain. A pattern change is predicted for North America with a relatively cool pattern in western North America being replaced by a hotter pattern while a hot pattern in the Central US will transition to a cooler pattern. Since the new pattern is consistent with recent interannual trends, I do think that the new temperature pattern could persist. One region I am less confident about is Siberia where a hot June is looking to be replaced by a cooler July but really unsure of its staying power.

Impacts

One common theme in the blog during the summer months has been what I consider one of the more puzzling features of summer weather - a rapidly warming Europe. Europe, East Asia and western North America have been the fastest warming regions in the Northern Hemisphere (NH) during summer. Another rapidly warming region is North Africa but has received less attention from me. And looking at the departure from normal temperatures across the NH (see **Figure i**), Europe is a standout especially in and around the Alps. The hot month likely contributed to the deadly glacial

avalanche in Northern Italy (see [marmolada-glacier-avalanche](#)). It seems that I have not been the only one noticing the accelerated warming in Europe and two new papers have been published on the subject just this week (see [Cresswell-Clay et al. 2022](#) and [Rousi et al. 2022](#)). The second paper was brought to my attention by Jennifer Francis. I have not had a chance to read them yet, but I do think that this is a very interesting topic. And I think I have made this comment before “this is not your father’s Europe” (see [not your father’s Oldsmobile](#) for the reference).

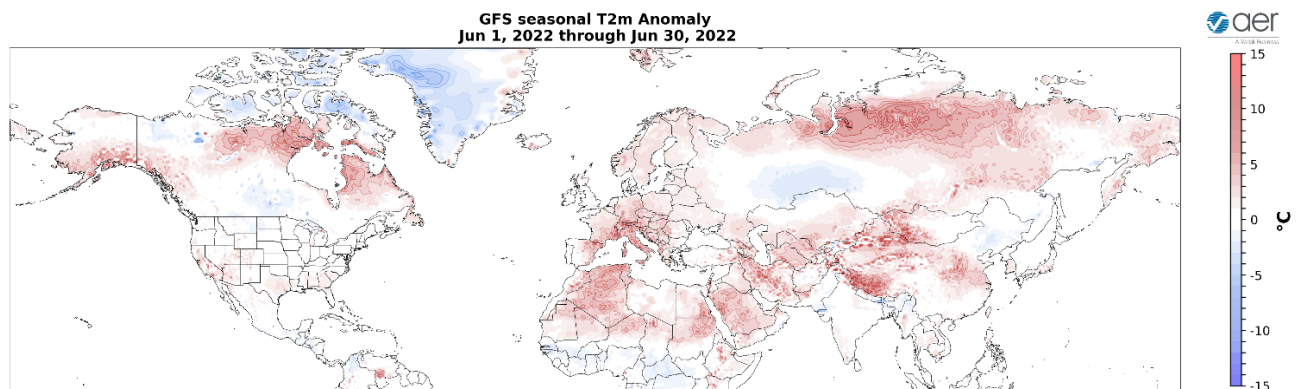


Figure i. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 – 30 June 2022 from the GFS analysis.

From the forecast plots below a respite from the heat is predicted for Central Europe but it does seem that another heat wave is building and should overspread Western Europe first and then spread east from there. So, I reiterate what I predicted in the last blog, Europe seems destined for another hot summer. From **Figure i**, other regions that are experiencing an unusually hot summer so far are Siberia, the Tibetan Plateau, North Africa, the Middle East, western North America and Northeastern Canada. Many of these same regions have been experiencing a strong interannual warming trend. A break from the heat is also predicted for Siberia (see **Figure ii**). In contrast the relatively warm temperatures in western North America have been somewhat muted compared to the trends but the forecast suggests it should heat up more across western North America in the coming weeks.

The Central and Southeastern US have been much warmer than recent summers, but the pattern is looking cooler at least for July (see **Figure ii**). Therefore, the pattern is predicted to transition to one more consistent with recent summers with hotter temperatures in western North America and relatively cooler temperatures returning to the Central US. And from **Figure 13**, the pattern across North America could be fairly stable. Though of course confidence in a forecast beyond a week let alone for next month is one of low confidence.

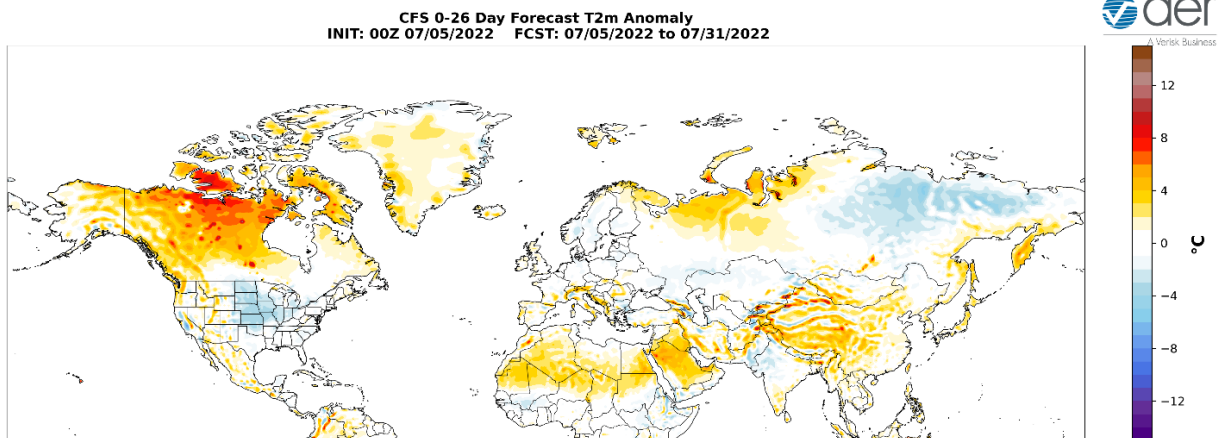


Figure ii. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for July 2022. The forecasts are from the 00Z 5 July 2022 CFS.

1-5 day

The AO is predicted to be 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 weak geopotential height anomalies this week across Greenland (**Figure 2**), the NAO is predicted to be near neutral this week (**Figure 1**).

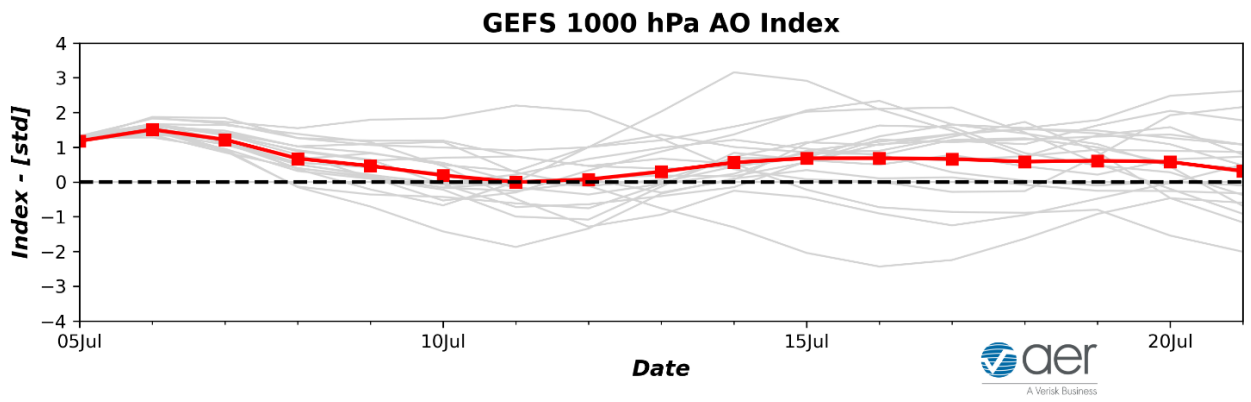


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 5 July 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouging/negative geopotential height anomalies centered south of Greenland this week will support ridging/positive geopotential height anomalies across Western Europe with trouging/negative geopotential height anomalies in Central Europe (**Figures 2**). This will favor normal to below normal temperatures across Western

Europe including the UK with normal to above normal temperatures across Central and Eastern Europe (**Figure 3**). Troughing/negative geopotential height anomalies is predicted across Central Asia sandwiched by ridging/positive geopotential height anomalies across Western and Eastern Asia this period (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Western and Eastern Asia with normal to below normal temperatures in Central Asia including much of Siberia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 07/05/2022 FCST: 07/06/2022 to 07/10/2022

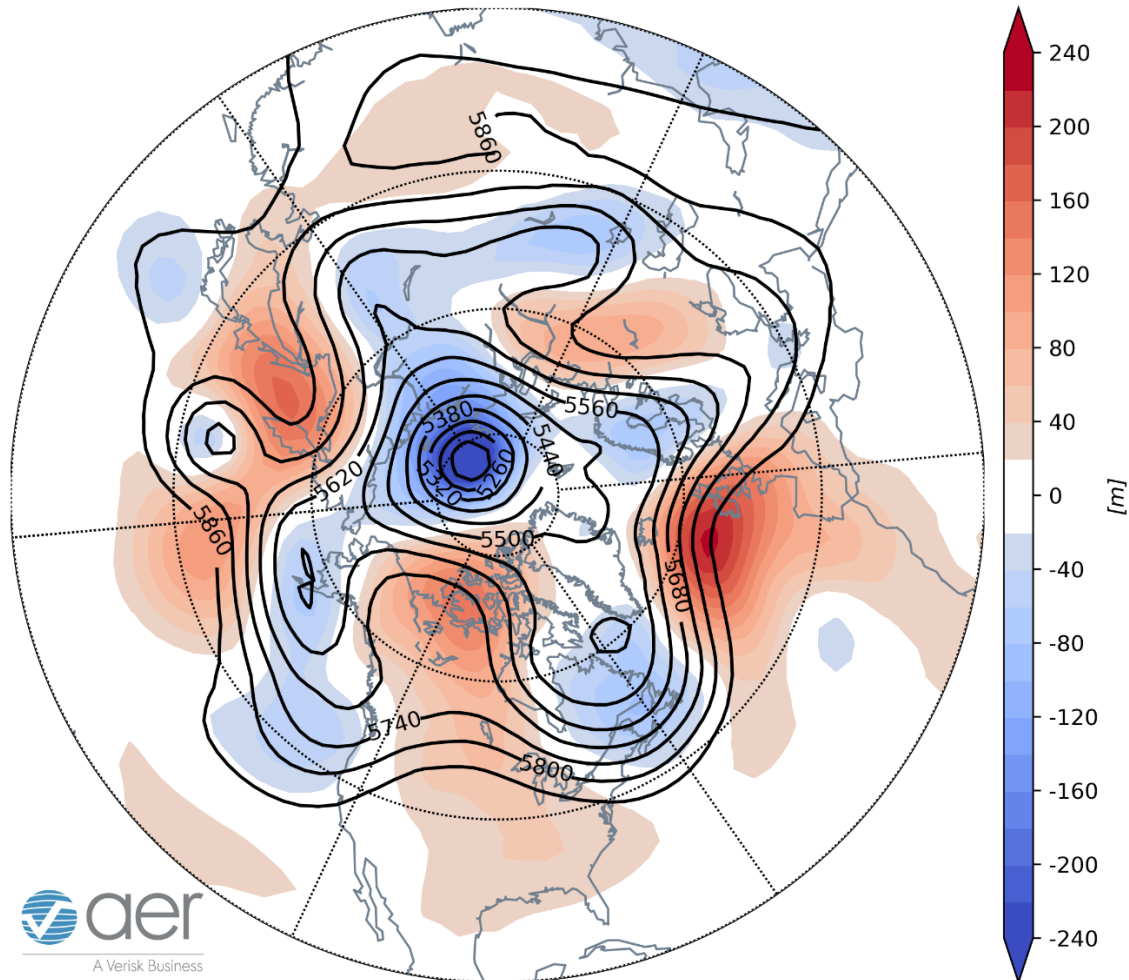


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 July 2022. The forecasts are from the 00z 5 July 2022 GFS ensemble.

Ridging/positive geopotential height anomalies centered across Northwest Canada will dominate western North America and the Southern US with troughing/negative geopotential height anomalies across Eastern Canada and the Northeastern

US (**Figure 2**). The pattern will favor normal to above normal temperatures across Alaska, Western Canada and the Southern US with normal to below normal temperatures across Eastern Canada and the Northeastern US (**Figure 3**).

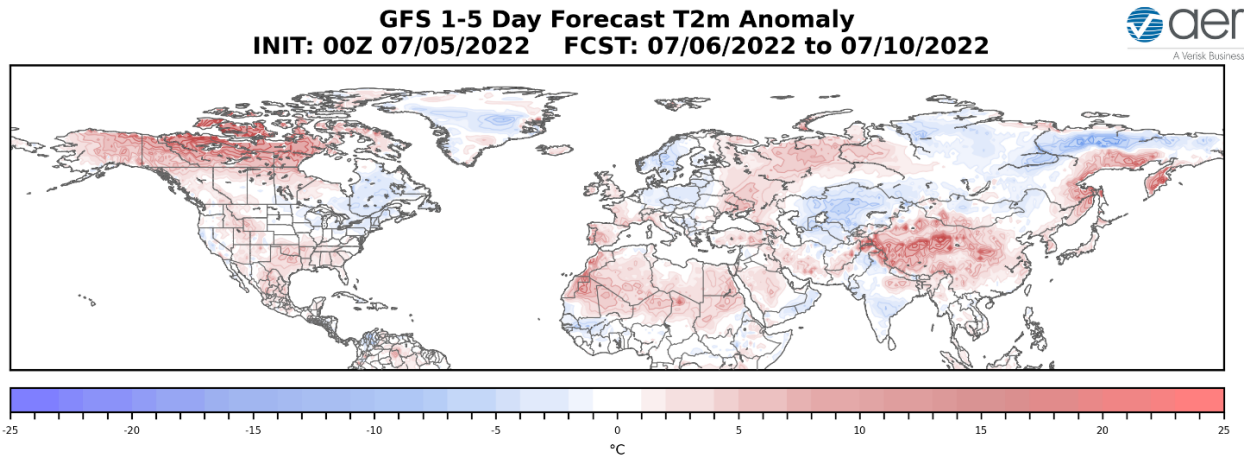


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 6 – 10 July 2022. The forecast is from the 00Z 5 July 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Norway, the Balkans and parts of Southern and Eastern Asia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted along an axis from Southwestern Canada through the US Northern Plains, the Southern Great Lakes and the Mid-Atlantic states (**Figure 4**).

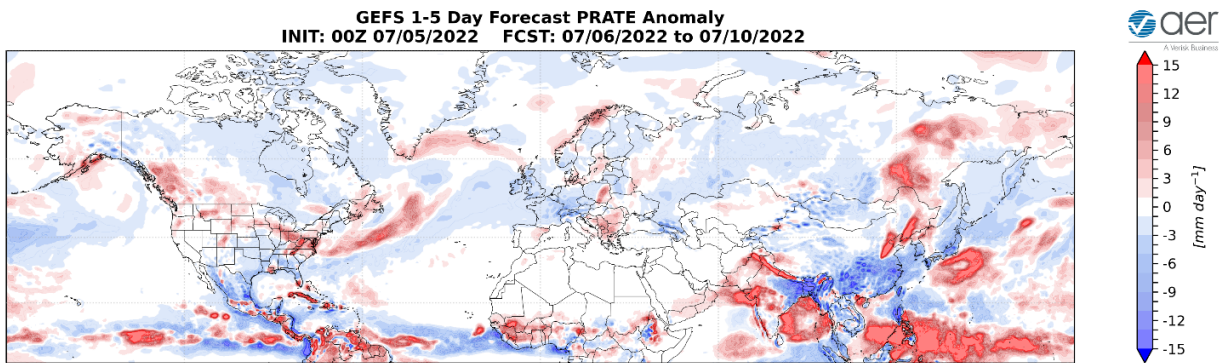


Figure 4. Forecasted precipitation rate (mm/day; shading) from 6 – 10 July 2022. The forecast is from the 00Z 5 July 2022 GEFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain neutral to positive this period (**Figure 1**) as geopotential height anomalies remain mostly negative across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). With weak negative geopotential height anomalies across Greenland and Iceland (**Figure 5**), the NAO is predicted to straddle neutral this period.

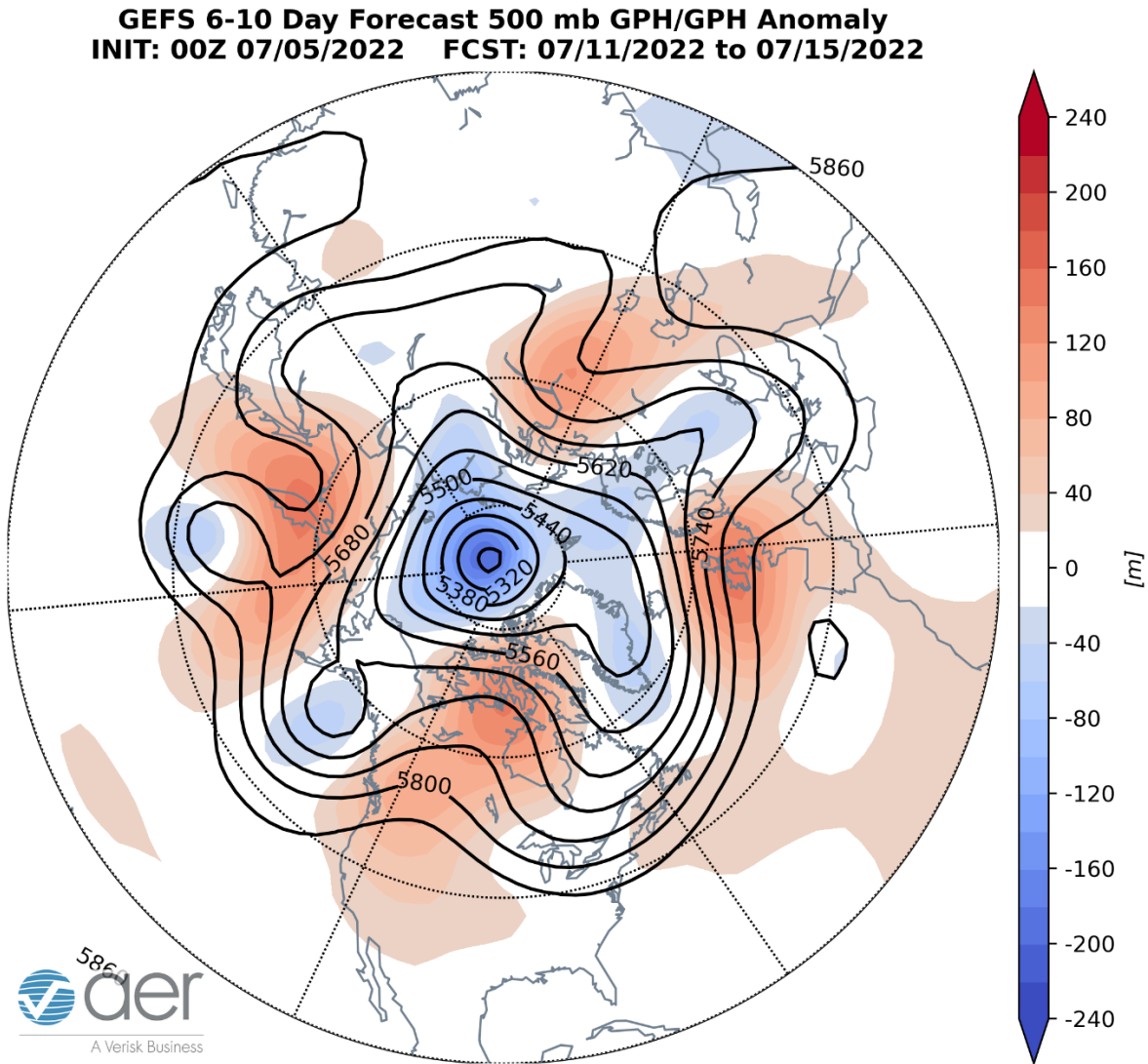


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 11 – 15 July 2022. The forecasts are from the 00z 5 July 2022 GFS ensemble.

Trounging/negative geopotential height anomalies across Greenland will help push ridging/positive geopotential height anomalies deeper into Western Europe with trounging/negative geopotential height anomalies across Eastern Europe this period (**Figures 5**). This will result in normal to above normal temperatures across Western

Europe including the UK with normal to below normal temperatures across Eastern Europe (**Figure 6**). The overall pattern of troughing/negative geopotential height anomalies previously in Central Asia bookended by ridging/positive geopotential height anomalies across Western and Eastern Asia is predicted to persist this period (**Figure 5**). This pattern favors normal to below normal temperatures across Central Asia including Western and Central Siberia with normal to above normal temperatures widespread across much of Western and Eastern Asia (**Figure 6**).

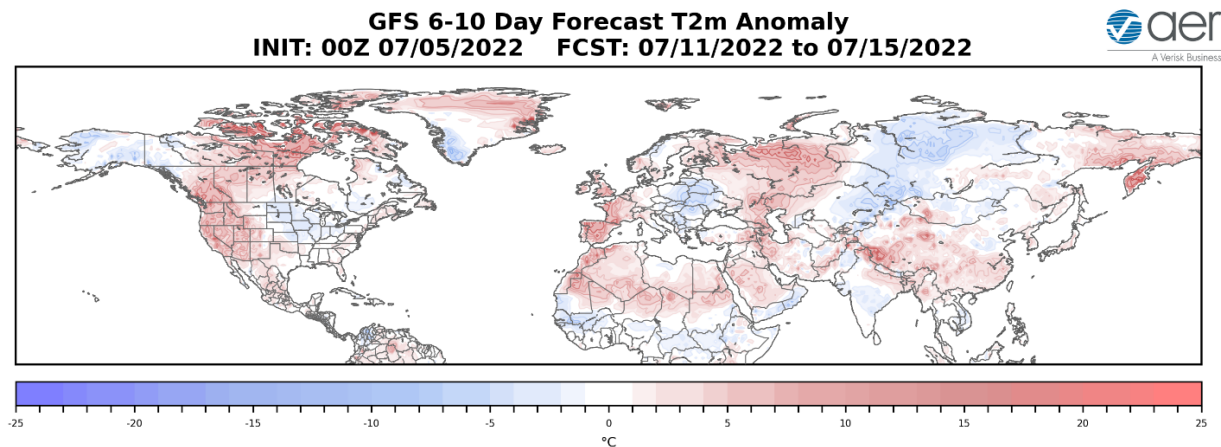


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 11 – 15 July 2022. The forecasts are from the 00Z 5 July 2022 GFS ensemble.

Ridging/positive geopotential height anomalies across western North America, centered near the Canadian Archipelagos with troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US are predicted to persist (**Figure 5**). This will favor normal to above normal temperatures across Northern and Western Canada and the Western US with normal to below normal temperatures across Alaska, Southern and Eastern Canada and the Eastern US (**Figure 6**).

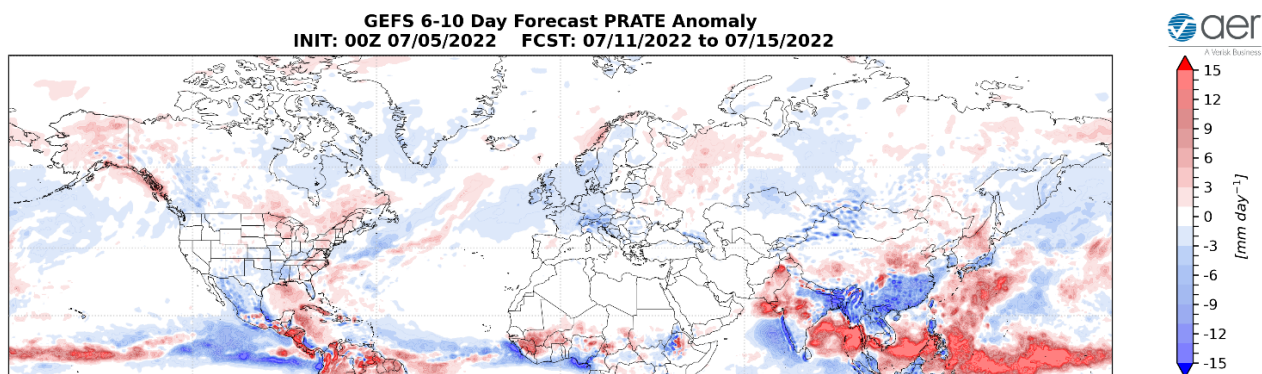


Figure 7. Forecasted precipitation rate (mm/day; shading) from 11 – 15 July 2022. The forecast is from the 00Z 5 July 2022 GEFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Western Russia and parts of Southeastern Asia (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across Alaska, the US Great Lakes, Northeastern US and Southeastern Canada (**Figure 7**).

11-15 day

Geopotential height anomalies are predicted to remain mostly negative across the Arctic this period (**Figure 8**), therefore the AO should remain positive to neutral (**Figure 1**). With predicted weak pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to also remain tethered to neutral this period.

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 07/05/2022 FCST: 07/16/2022 to 07/20/2022

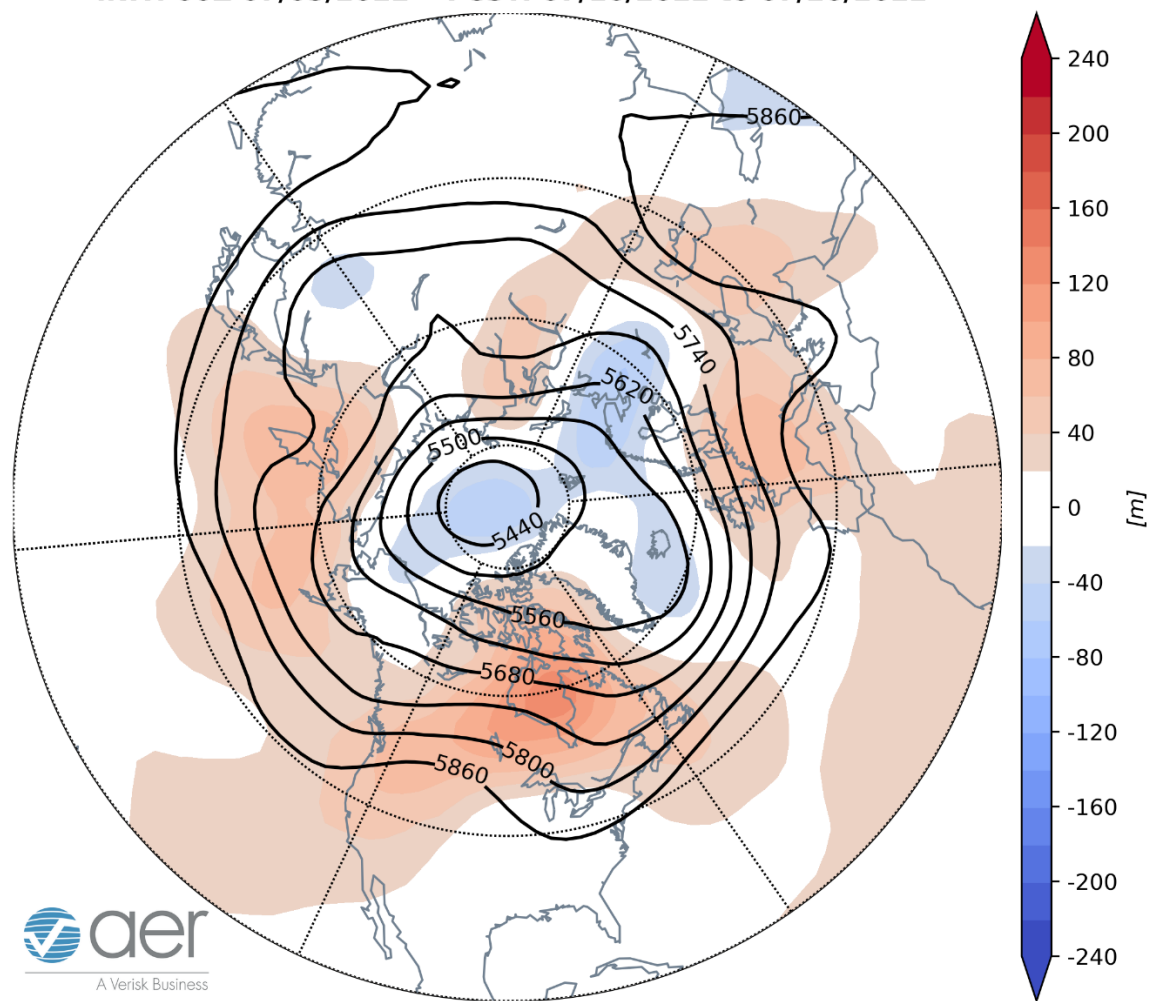


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 16 – 20 July 2022. The forecasts are from the 00z 5 July 2022 GFS ensemble.

Weak but persistent troughing/negative geopotential height anomalies near Greenland and Iceland will continue to favor ridging/positive geopotential height anomalies across Western Europe with ridging/positive geopotential height anomalies expanding eastward this period except for troughing/negative geopotential height anomalies in Northeastern Europe (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Europe including the UK with the exception of normal to below normal temperatures across far Northeastern Europe (**Figures 9**). A progressive pattern is predicted for Asia as troughing/negative geopotential height anomalies previously in Europe are predicted to push into Northwestern Asia with ridging/positive geopotential height anomalies in Central Eastern and troughing/negative geopotential height anomalies previously in Central Asia move into Northern China (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia except for normal to below normal temperatures across Northwestern Asia, Mongolia and Northern China (**Figure 9**).

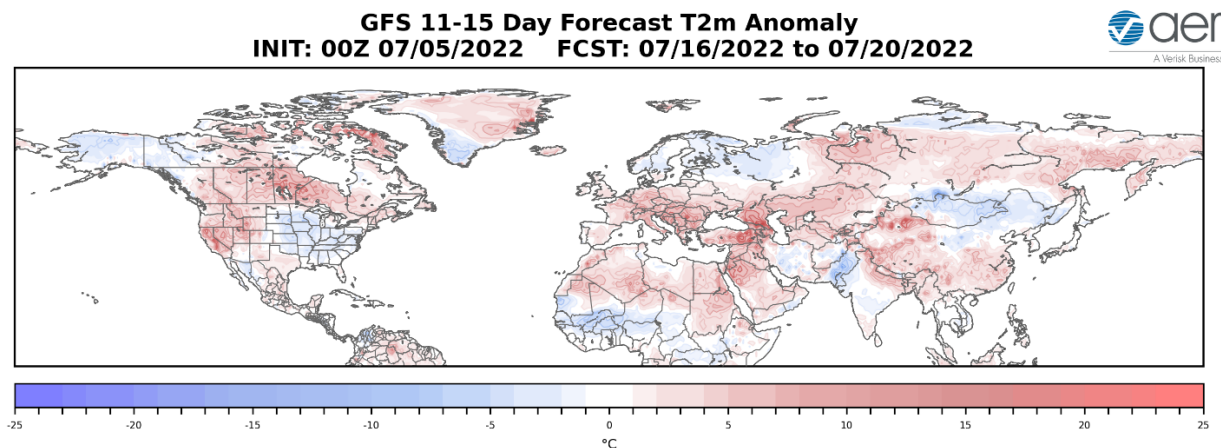


Figure 9. Forecasted surface temperature anomalies (°C; shading) from 16 – 20 July 2022. The forecasts are from the 00z 5 July 2022 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to consolidate across Hudson Bay with weak troughing/negative geopotential height anomalies across Alaska and the Northeastern US this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Canada but especially Central Canada and the Western US with normal to below normal temperatures across Alaska and Eastern US (**Figure 9**).

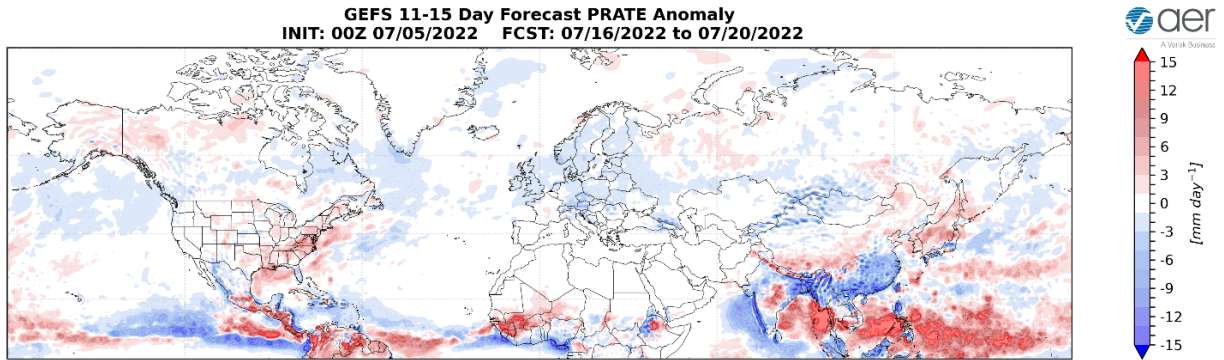


Figure 10. Forecasted precipitation rate (mm/day; shading) from 16 – 20 July 2022. The forecast is from the 00Z 5 July 2022 GEFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for in parts of Western Russia and Eastern Asia (**Figure 10**). Weak and mixed precipitation anomalies are predicted across North America except for Alaska, Northwestern Canada and the Eastern US (**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 and the mid to lower troposphere with warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). The overall pattern of warm/positive PCHs in the lower stratosphere and upper troposphere sandwiched by cold/negative PCHs in the upper stratosphere and the mid to lower troposphere is predicted to persist for the foreseeable future (**Figure 11**).

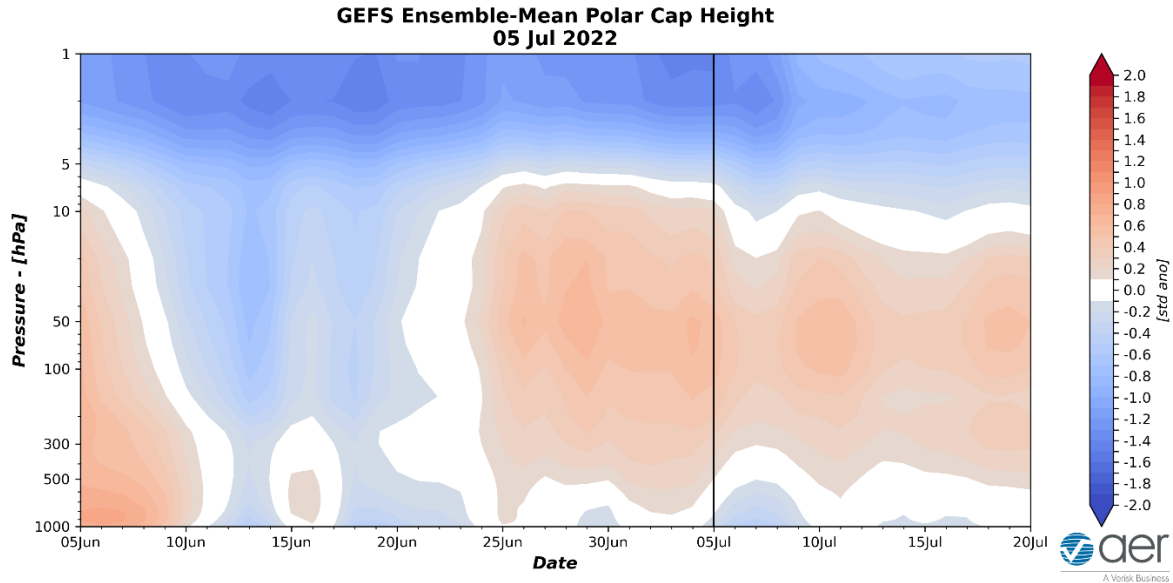


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 5 July 2022 GFS ensemble.

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

**CFS 500 hPa Forecast Anomaly Aug 2022
Valid as of 05 Jul 2022**

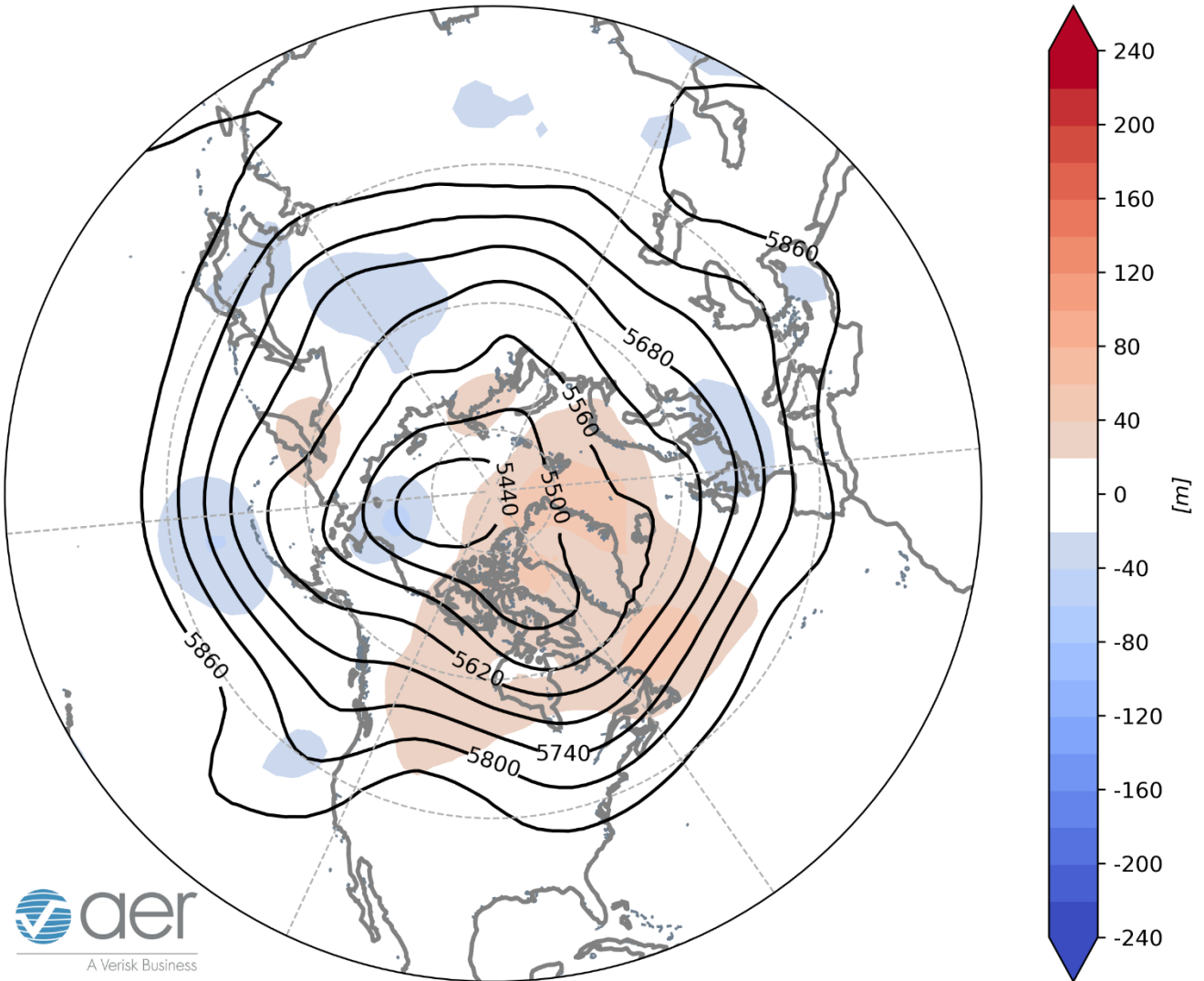


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2022. The forecasts are from the 00Z 5 July 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for August (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging mostly consolidated in the northern North Atlantic stretching from east of the Canadian Rockies to the Barents Sea with a smaller ridge in Eastern Siberia with troughing across Europe, East Asia, near the Aleutians, the Gulf of Alaska, Eastern Canada and the Northeastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Southeastern Europe, Northern Eurasia, much of Southern Asia, Alaska, much of Canada and the Western and Northeastern US with

seasonable to relatively cool temperatures across Western and Central Europe, Kazakhstan, East Asia, Southern Manitoba and the Central and Southeastern US (**Figure 13**).

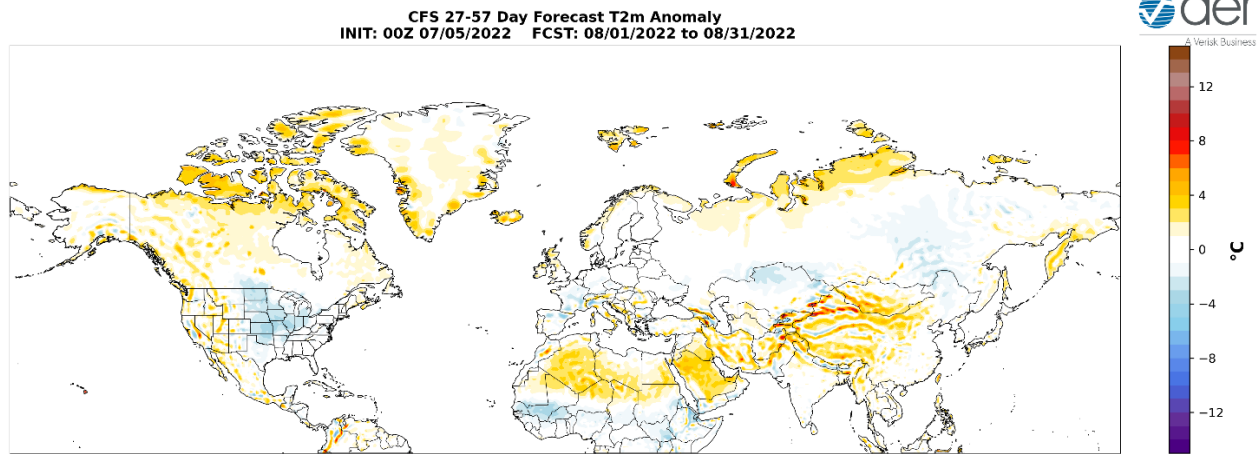


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for August 2022. The forecasts are from the 00Z 5 July 2022 CFS.

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.

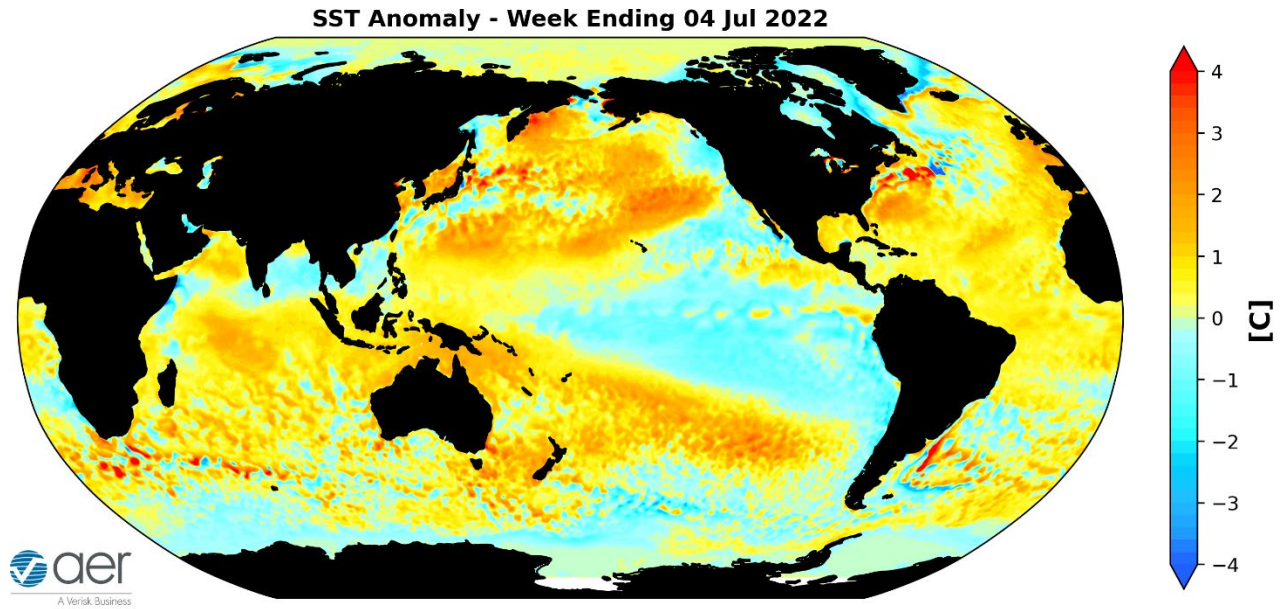


Figure 14. The latest weekly-mean global SST anomalies (ending 4 July 2022). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase 4 (**Figure 15**). The forecasts are for the MJO to remain weakly in phase 4 and then weaken to where no phase is favored. Phase 4 favors ridging and relatively warm temperatures in the Southern US with troughing and relatively cool temperatures in Canada and the Northern US. 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.

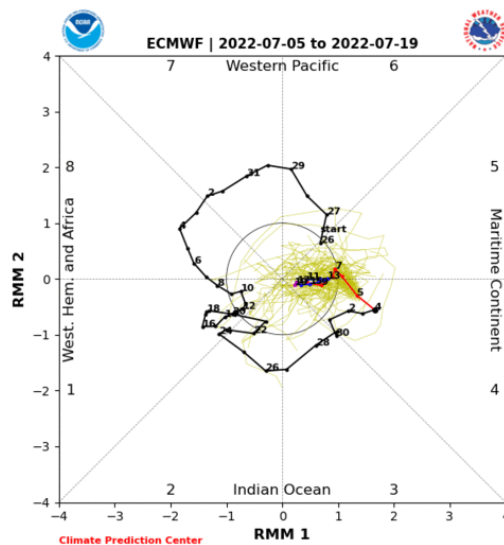


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 20 June 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>

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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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