

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

July 18, 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 positive and is predicted to trend negative this week into negative territory and then positive towards neutral next week as pressure/geopotential height anomalies turn mostly positive across the Arctic this week but then next week pressure/geopotential height anomalies are predicted to become increasingly negative 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 to slightly negative as pressure/geopotential height anomalies are predicted to remain weak but mostly positive across Greenland over the next two weeks.
- Over the next two weeks, ridging/positive geopotential height anomalies is predicted across much of Europe with the exception of troughing/negative geopotential height anomalies across Scandinavia. 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 across Scandinavia and eventually expanding into the Baltic States.

- The general pattern across Asia this week is scattered troughing/negative geopotential height anomalies with one center in Western Siberia, another center in Northeastern Asia and yet a third in Western Russia with ridging/positive geopotential height anomalies centered in Central Asia then next week the flow across Asia will become increasingly zonal. This pattern favors normal to below normal temperatures across Western Russia and Northern and Eastern Asia, with normal to above normal temperatures focused in Central Asia. However, next week normal to above normal temperatures are predicted to become more widespread across Asia.
- The general pattern the next two weeks across North America is deep troughing/negative across Alaska with ridging/positive geopotential height anomalies across much of the United States (US). This pattern mostly favors normal to below normal temperatures across Alaska with normal to above normal temperatures across Canada and the US. However next week, normal to below normal temperatures will spread southwestwards out of Alaska, towards Southeastern Canada and the Northeastern US.
- In the *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.

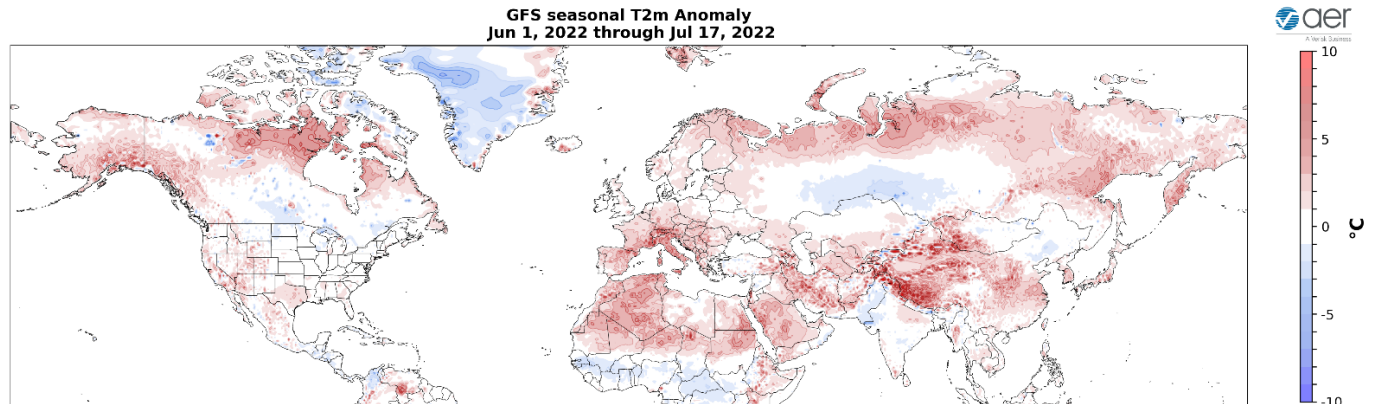
### ***Plain Language Summary***

The obsessing on an ever-warming Europe seems justified on a day like today with record breaking heat in Western Europe. And the forecast contains much of the same with more heat not only for Europe but Asia and North America. If there is silver lining to this cloud, it is that the same pattern that brings heat and wildfires to the continents is also supportive of preserving Arctic sea ice.

### ***Impacts***

On a day like today, my previous focusing on Europe seems justified with Western Europe in the grip of a deadly heat wave that is breaking all time records in Portugal, Spain, France, and the UK. Here are a few tweets I found from [@WeatherProf](#), [@ScottDuncanWX](#), [@extremetemps](#) and [@SimonLeeWx](#) for some perspective. Europe has been one the fastest warming regions in the Northern Hemisphere (NH) during summer, a fact that has puzzled me for years and I have brought up many times in the blog. And looking at the departure from normal temperatures across the NH (see **Figure i**), Europe and North Africa, Central Asia and Northern Canada are so far the three regions that have the most impressive positive departures from normal so far this summer. In the past I have thought of Europe and North Africa as two separate regions but maybe it is better to think of them as one

region surrounding the Mediterranean. Looking at the surface temperature anomaly plot maybe one simple and plausible reason for a rapidly warming Europe in summer is a stronger and more expansive heat dome over North Africa. Though I haven't read the paper yet, this seems to be consistent with the analysis and arguments of the recently published [Cresswell-Clay et al. 2022](#) that I included a link in the previous blog. But this is not my expertise and so far, I am just an interested observer.

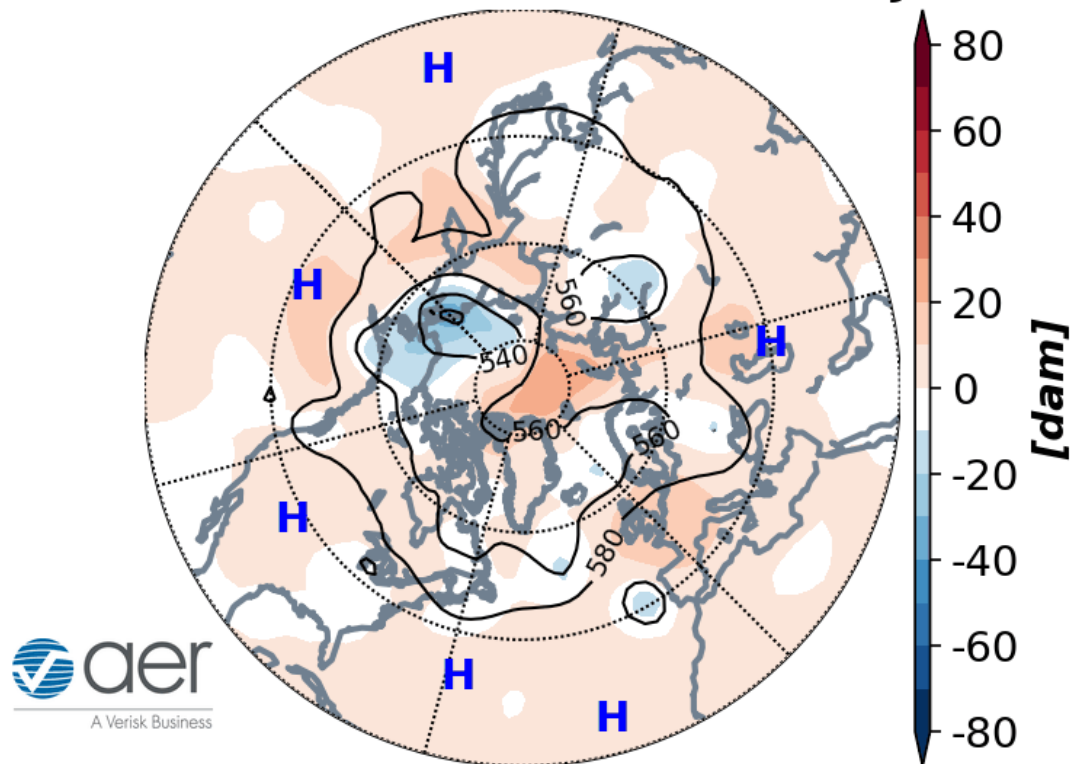


**Figure i.** Observed surface temperature anomalies (°C; shading) from 1 – 17 July 2022 from the GFS analysis.

I see no signs of big changes as we head into August. A warmer than normal Europe continues to look like a lock. Though it does appear some cooler air from the Arctic will sink south from the Arctic and could linger for a while across Scandinavia. Siberia has turned cooler but not sure how long that will last. It has been more seasonable across Southern Canada and the Northern US so far this summer but based on the forecasts the pattern looks decidedly warmer relative to normal.

The prevailing pattern of recent summers with low pressure centered near the North Pole surrounded by ridges or heat domes in Europe, Asia and North America that I like to refer to as the “ring of fire,” has temporarily weakened in today’s forecast plots but is predicted to resume next week (see **Figure ii**). This pattern can bring exceptional heat to the NH continents, but it does have the beneficial result of slowing Arctic sea ice loss. I don’t really know but it is my impression that Arctic sea ice loss has been unusually slow this July compared to recent Julys. The melting could accelerate a bit in the second half of July, but it seems to me a new record low minimum is quickly becoming out of reach barring some highly anomalous event. The Arctic sea ice might be thin but it seems to me this reoccurring “ring of fire pattern” in summer has sheltered or preserved the remaining thinner ice. But this come at the expense of the NH continents were heat domes and fires have become an increasing hazard.

## Initialized 00Z 500 hPa HGT/HGTa 18-Jul-2022

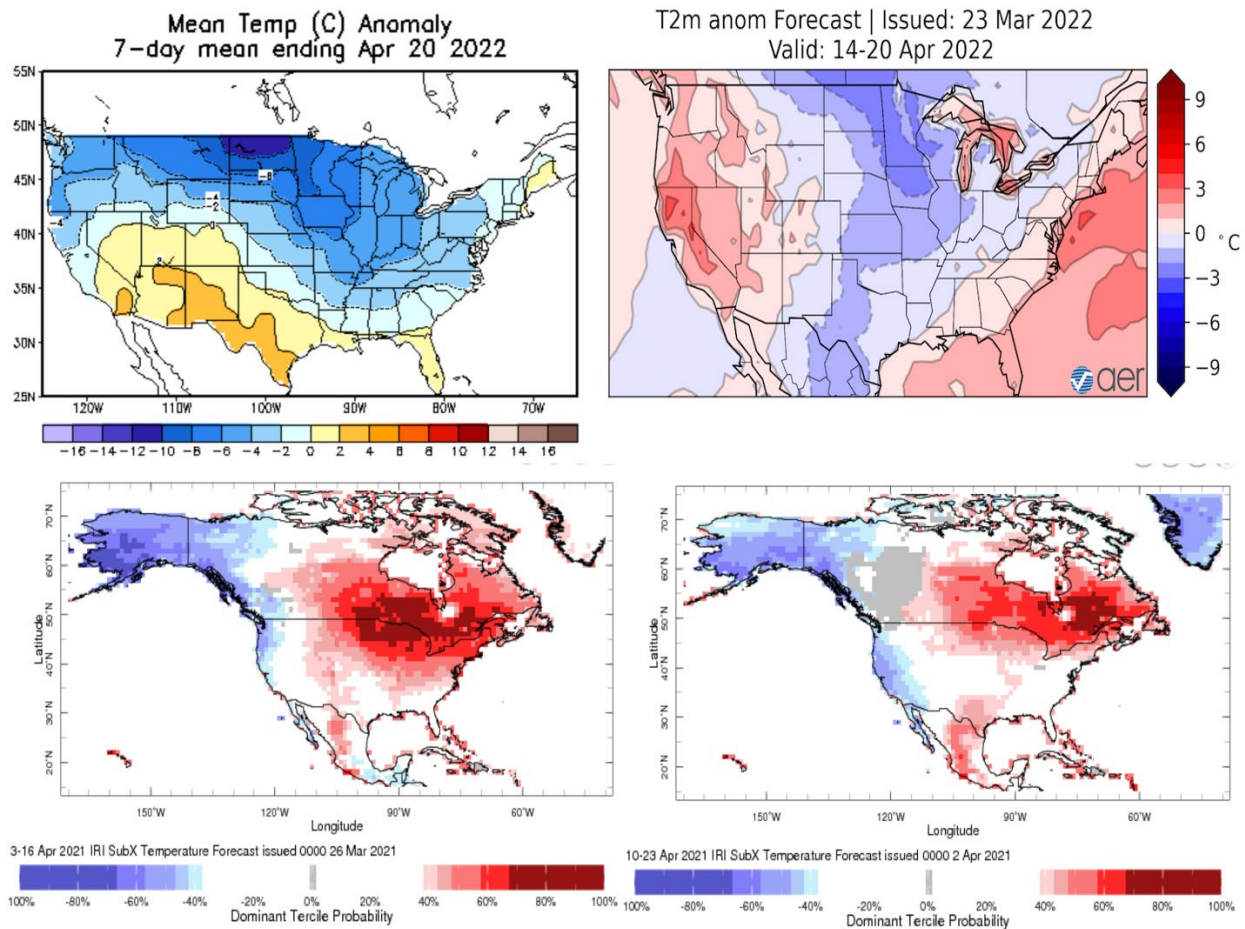


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**Figure ii.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 July – 3 August 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

Now that we are officially past the halfway point of the summer, it is time to begin thinking and preparing for winter. It occurred to me that I never did present any verification for the last machine learning (ML) model forecast from last winter/early spring that I presented in the [28 March 2022](#) blog. I didn't save any weekly forecast plots from the subseasonal forecast models and the best that I could find in archives are biweekly temperature forecasts from the SubX project. Unfortunately, it is not a direct comparison, but it does appear that once more the ML was quicker to predict a return of below normal temperatures to the Central US, whereas the dynamical models were limiting any relative cold temperatures to the West Coast (see **Figure iii**). The ML forecasts that I shared in the blog and on Twitter this past winter, all performed relatively well compared to the dynamical models, especially being early in predicting

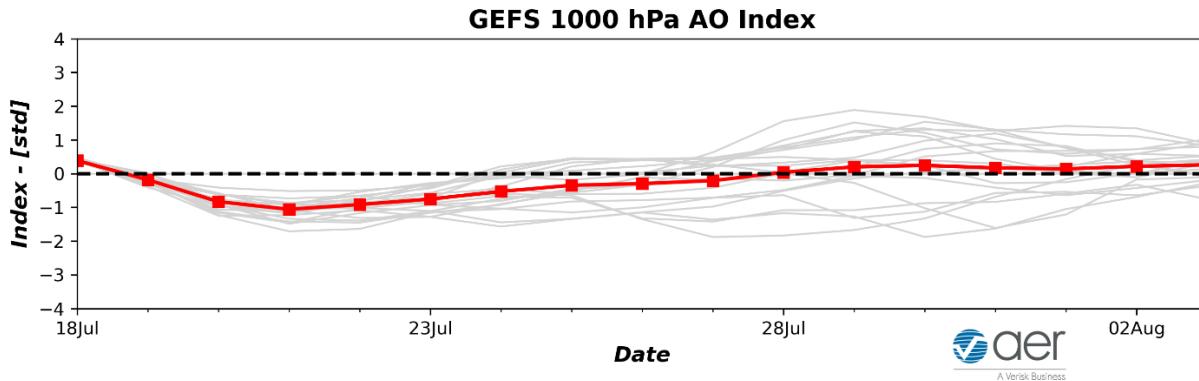
cold air outbreaks. We are working to get the ML model ready for full operational use in time for next winter.



**Figure iii.** Observed surface temperature anomalies (°C; shading) for the US averaged 14 – 20 April 2022 (top left). AER machine learning model predicted surface temperature anomalies (°C; shading) for the US averaged 14 – 20 April 2022. Forecast based on observed data through 23 March 2022 (top right). SubX ensemble mean predicted surface temperature anomalies (°C; shading) for North America averaged 3 – 16 April 2022 (bottom left) and SubX ensemble mean predicted surface temperature anomalies (°C; shading) for North America averaged 10 – 23 April 2022 (bottom right).

*1-5 day*

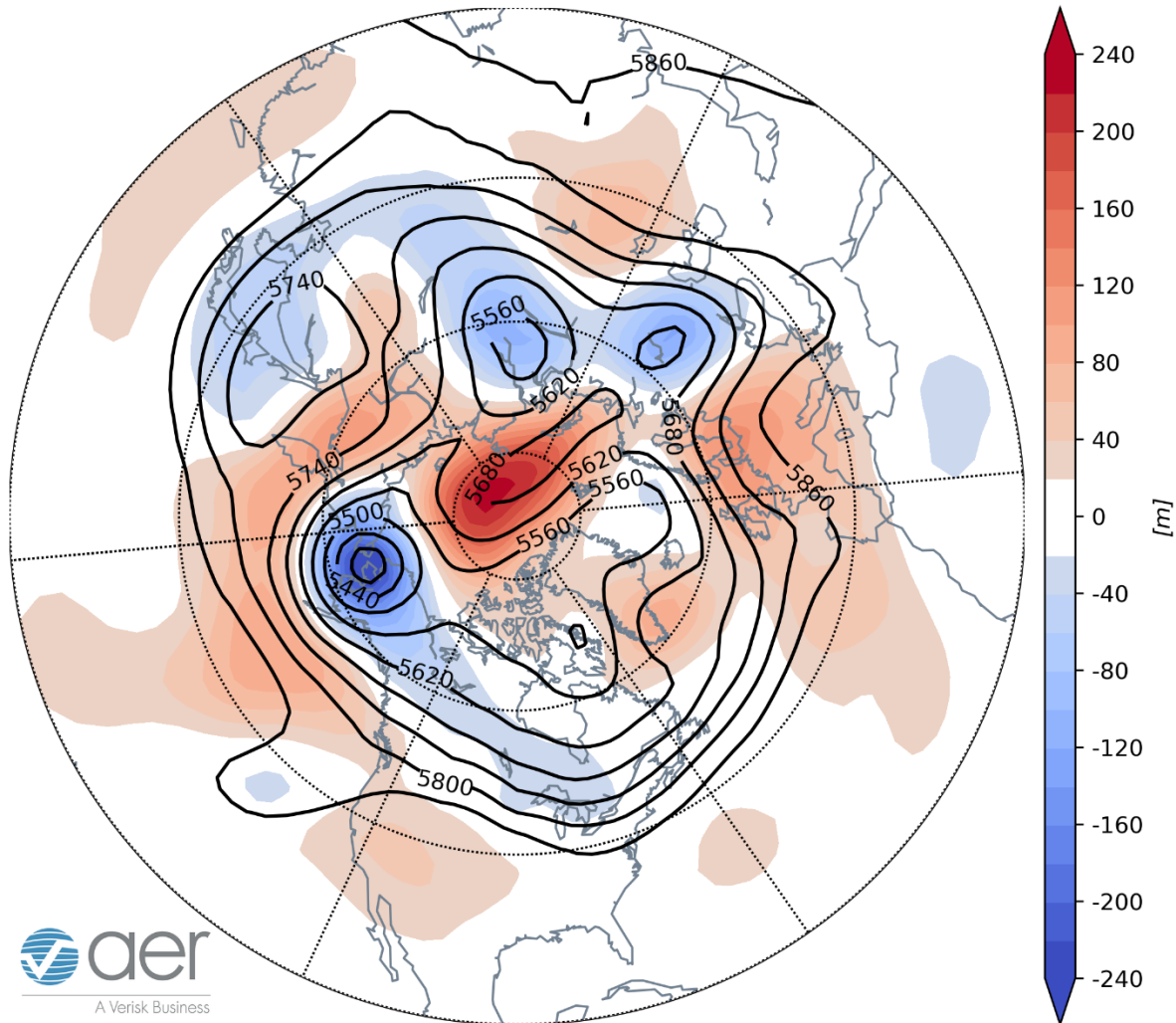
The AO is predicted to be mostly negative this week (**Figure 1**) with mostly positive geopotential height anomalies predicted across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted weak geopotential height anomalies this week 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 18 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.

Amplified ridging/positive geopotential height anomalies will dominate Europe centered over Central Europe (**Figures 2**). This will favor normal to well above normal temperatures across much Europe including the UK with normal to above normal temperatures limited to northern Scandinavia where geopotential heights will be near normal (**Figure 3**). Three separate centers of troughing/negative geopotential height anomalies are predicted across Asia with one center in Western Russia, a second in Western Siberia and a third in Northeast Asia with one main center of ridging/positive geopotential height anomalies centered in Central Asia this period (**Figure 2**). This pattern favors normal to below normal temperatures across Western Russia, much of Northeastern Asia with normal to above normal temperatures focused in Central Asia and including the Middle East (**Figure 3**).

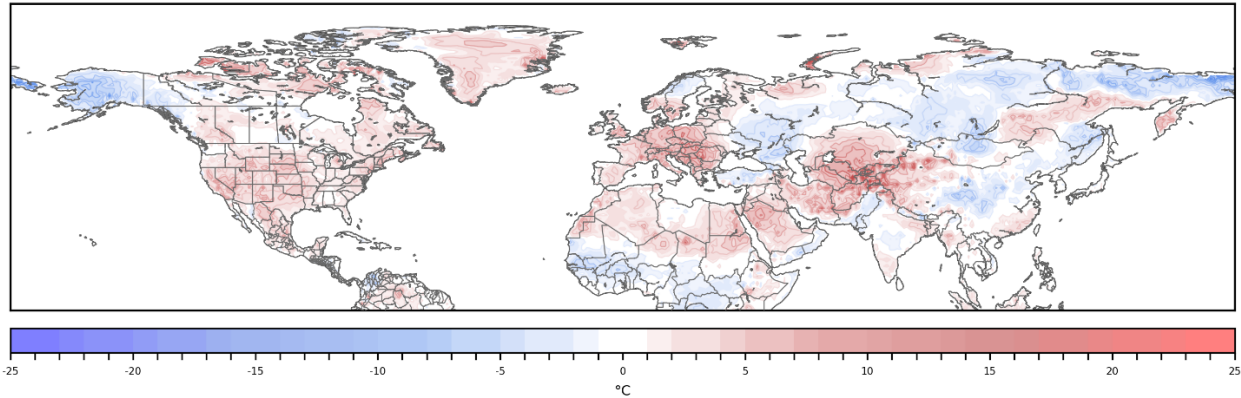
**GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly  
INIT: 00Z 07/18/2022 FCST: 07/19/2022 to 07/23/2022**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 19 – 23 July 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

The general pattern across North America this week is deep troughing/negative geopotential height anomalies across Alaska with ridging/positive geopotential height anomalies US setting up mostly zonal flow across the continent (**Figure 2**). The pattern will favor normal to below normal temperatures across Alaska and the Yukon with widespread normal to above normal temperatures across much of Canada and the US (**Figure 3**).

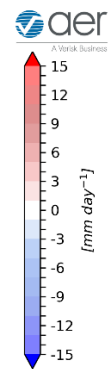
**GFS 1-5 Day Forecast T2m Anomaly**  
**INIT: 00Z 07/18/2022 FCST: 07/19/2022 to 07/23/2022**



**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 19 – 23 July 2022. The forecast is from the 00Z 18 July 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for France, Western Russia, Siberia and parts of Southern and Eastern Asia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across Alaska, the Yukon, Southeastern Canada and New England (**Figure 4**).

**GEFS 1-5 Day Forecast PRATE Anomaly**  
**INIT: 00Z 07/18/2022 FCST: 07/19/2022 to 07/23/2022**



**Figure 4.** Forecasted precipitation rate (mm/day; shading) from 19 – 23 July 2022. The forecast is from the 00Z 18 July 2022 GEFS ensemble.

*Mid-Term*

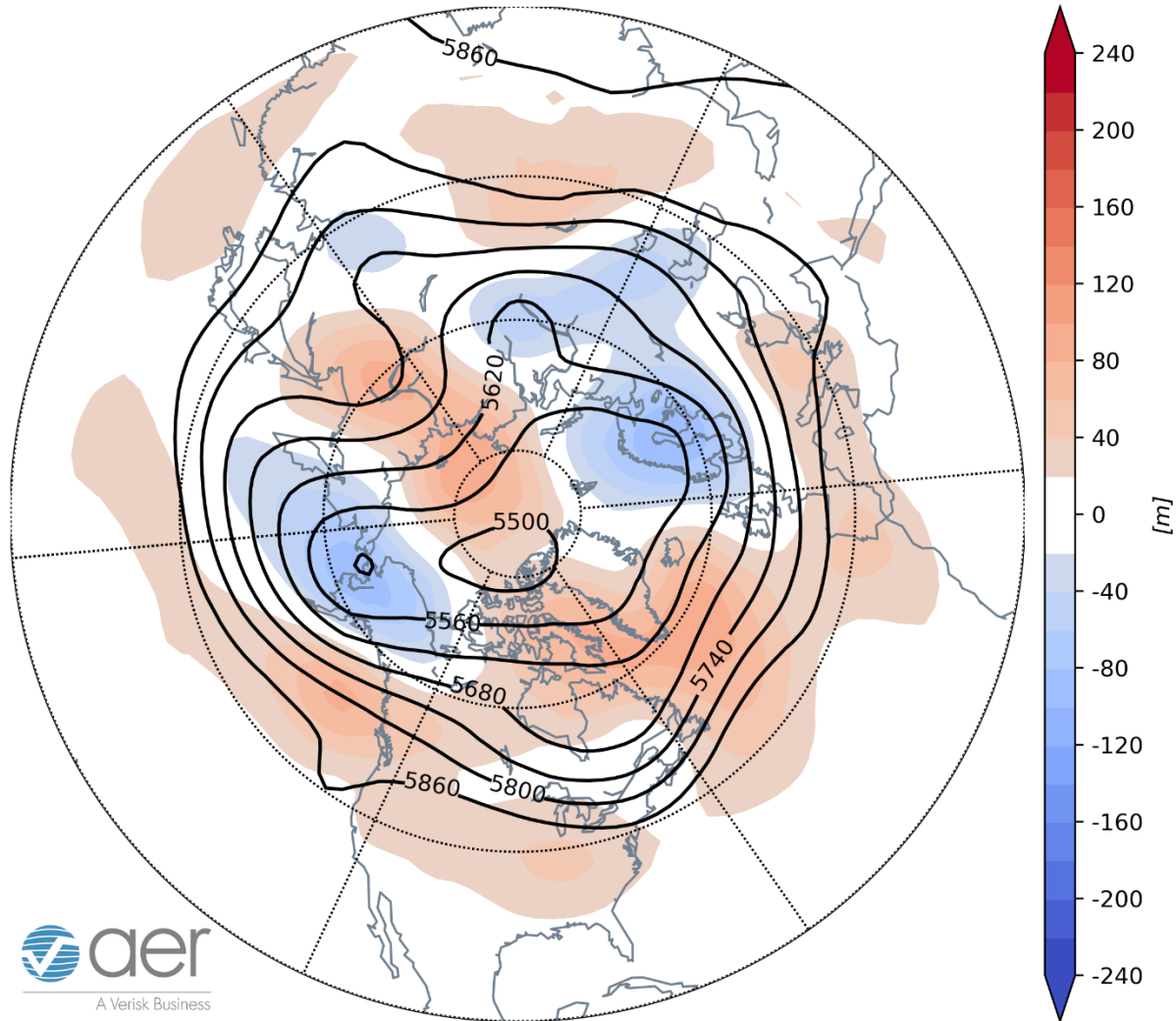
*6-10 day*

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



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

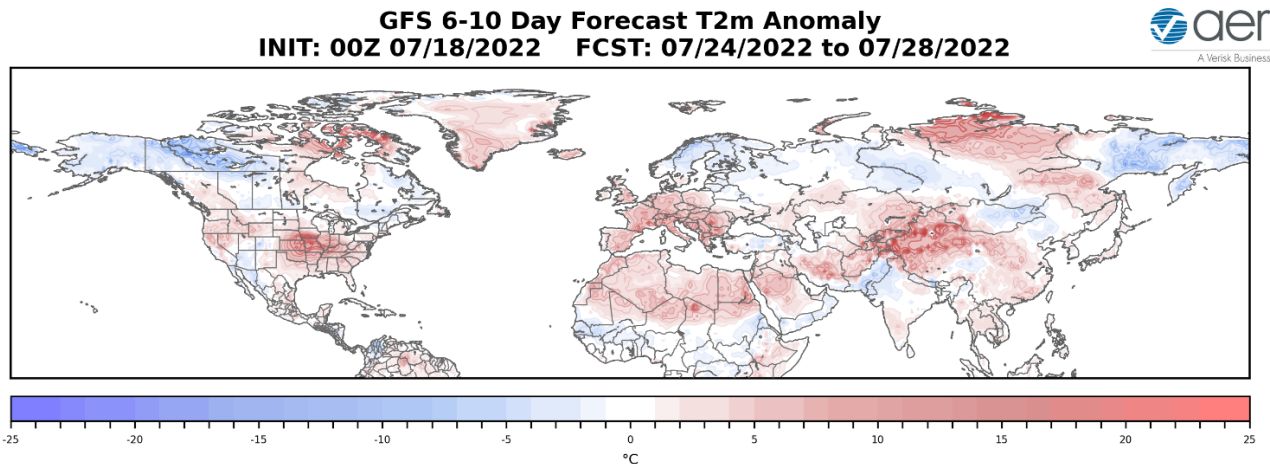
**GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 07/18/2022 FCST: 07/24/2022 to 07/28/2022**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 – 28 July 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

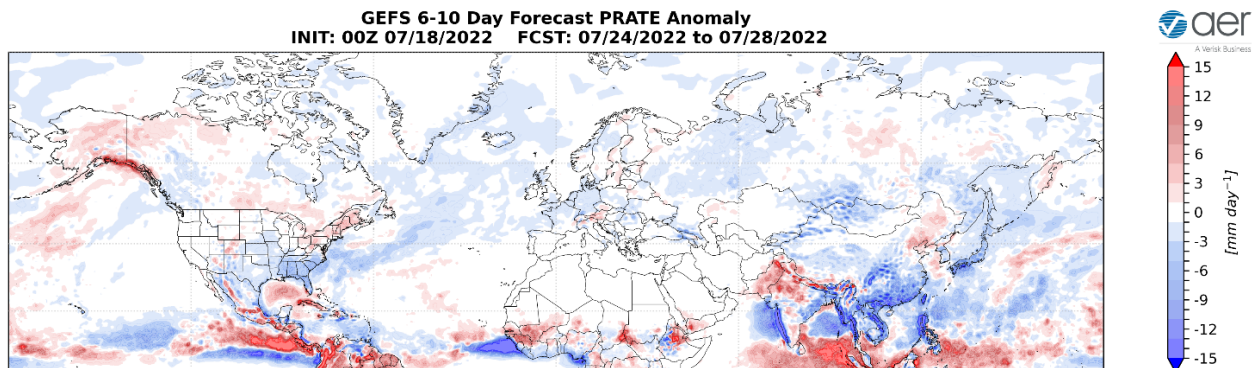
Ridging/positive geopotential height anomalies is predicted to dominate Southern Europe with troughing/negative geopotential height anomalies across Northern Europe this period (**Figures 5**). The mostly zonal flow is predicted to result in normal to above normal temperatures across Central and Southern Europe including the UK with normal to below normal temperatures across Scandinavia and the Baltic States (**Figure 6**). The overall pattern of three centers of troughing/negative geopotential height anomalies with one center in Western Russia another center in Northeastern Asia and a third in

Eastern Siberia with ridging/positive geopotential height anomalies focused in Central Asia is predicted to persist this period (**Figure 5**). This pattern favors normal to below normal temperatures across Western Russia, Mongolia, Northeastern China and Eastern Siberia with normal to above normal temperatures widespread across Western Siberia and much of Western and Southern Asia (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 24 – 28 July 2022. The forecasts are from the 00Z 18 July 2022 GFS ensemble.

Trouching/negative geopotential height anomalies are predicted to persist across Alaska, with developing troughing in Southeastern Canada with ridging/positive geopotential height anomalies across much of Canada and the US (**Figure 5**). This will favor normal to below normal temperatures across Alaska, Northwestern and Southeastern Canada with normal to above normal temperatures across Southwestern and Northeastern Canada and much of the US (**Figure 6**).



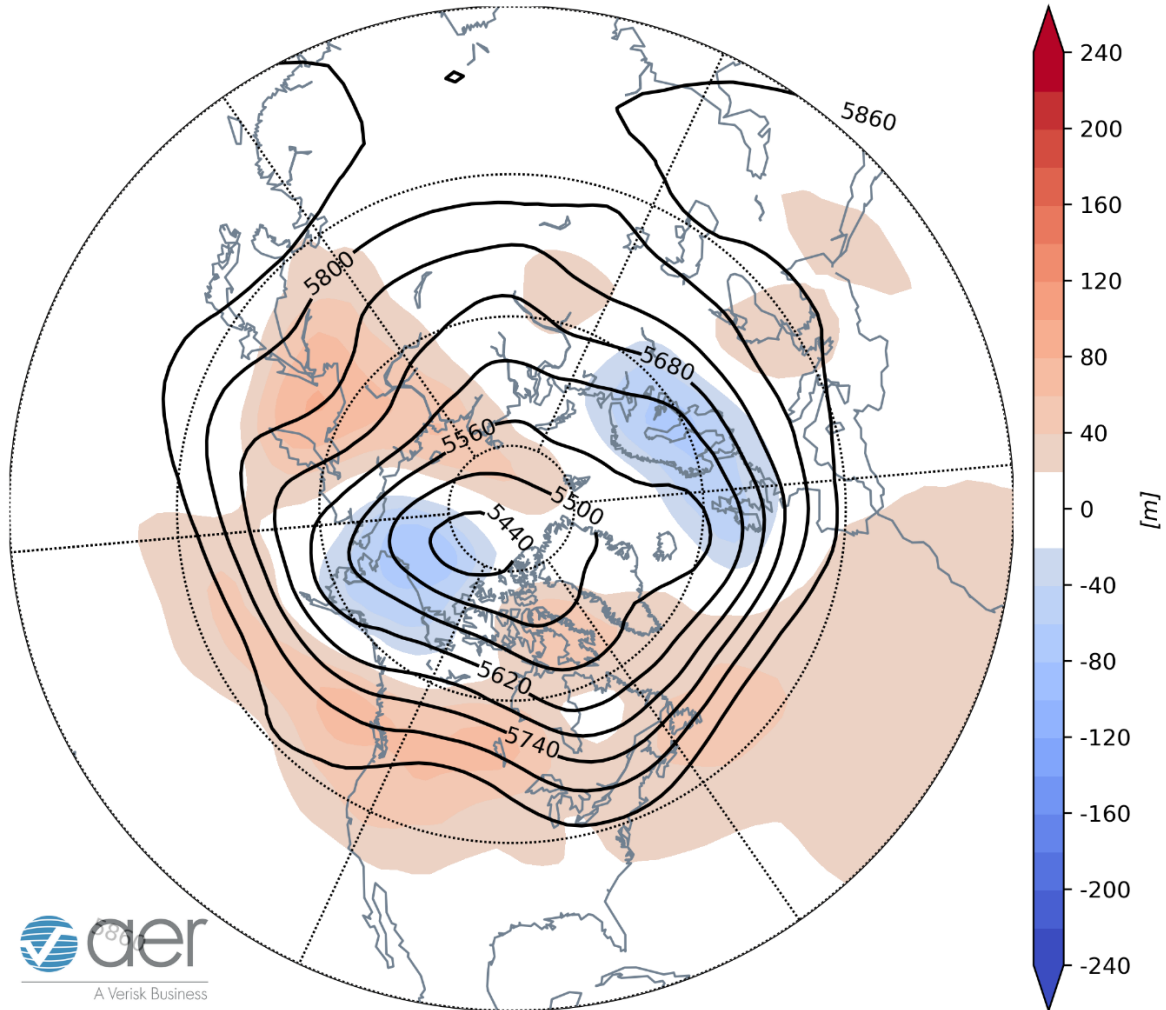
**Figure 7.** Forecasted precipitation rate ( $\text{mm}/\text{day}$ ; shading) from 24 – 28 July 2022. The forecast is from the 00Z 18 July 2022 GEFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for parts of the Tibetan Plateau (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across Alaska, the Northeastern US and Northwestern Canada (**Figure 7**).

11-15 day

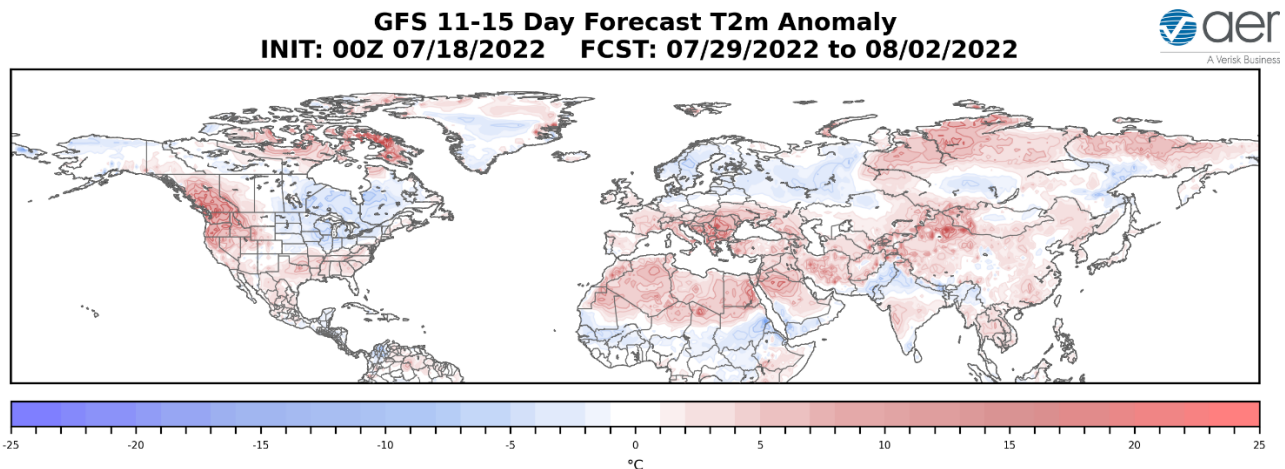
Geopotential height anomalies are predicted to remain mostly mixed across the Arctic this period (**Figure 8**), therefore the AO should straddle neutral (**Figure 1**). With predicted weak pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to also remain tethered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

**GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 07/18/2022 FCST: 07/29/2022 to 08/02/2022**



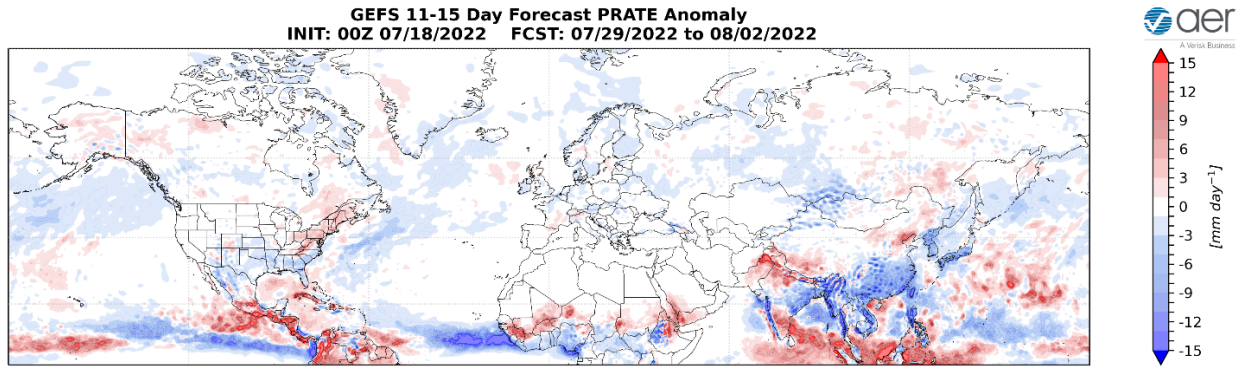
**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 July – 2 August 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

The overall zonal flow with troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe is predicted to persist this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Central and Southern Europe including the UK with normal to below normal temperatures across Scandinavia and around the Baltic Sea (**Figures 9**). A quasi-zonal flow pattern is also predicted for Asia with troughing/negative geopotential height anomalies focused in Northwestern Russia with ridging/positive geopotential height anomalies persisting in Central Eastern and also strengthening in Eastern Siberia (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia except for normal to below normal temperatures across Northwestern Russia (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 29 July – 2 August 2022. The forecasts are from the 00z 18 July 2022 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to persist across Alaska and Southeastern Canada with ridging/positive geopotential height anomalies centered across Southwestern Canada and the Northwestern US this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Northern and Western Canada and the Western and Southern US with normal to below normal temperatures across Southern and Eastern Canada and the Northern and Eastern US (**Figure 9**).



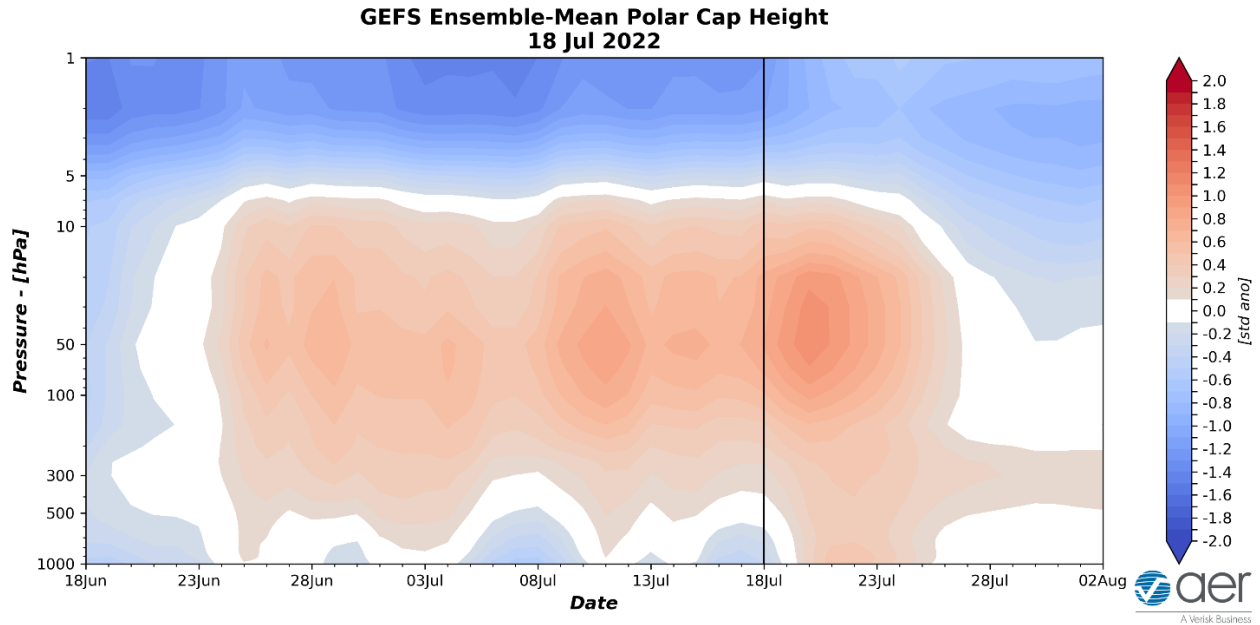
**Figure 10.** Forecasted precipitation rate (mm/day; shading) from 29 July – 2 August June 2022. The forecast is from the 00Z 18 July 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for in parts of Southern and Eastern Asia (**Figure 10**). Weak and mixed precipitation anomalies are predicted across North America except for Alaska, Northwestern Canada and the Northeastern US (**Figure 10**).

#### *Longer Term*

#### *30-day*

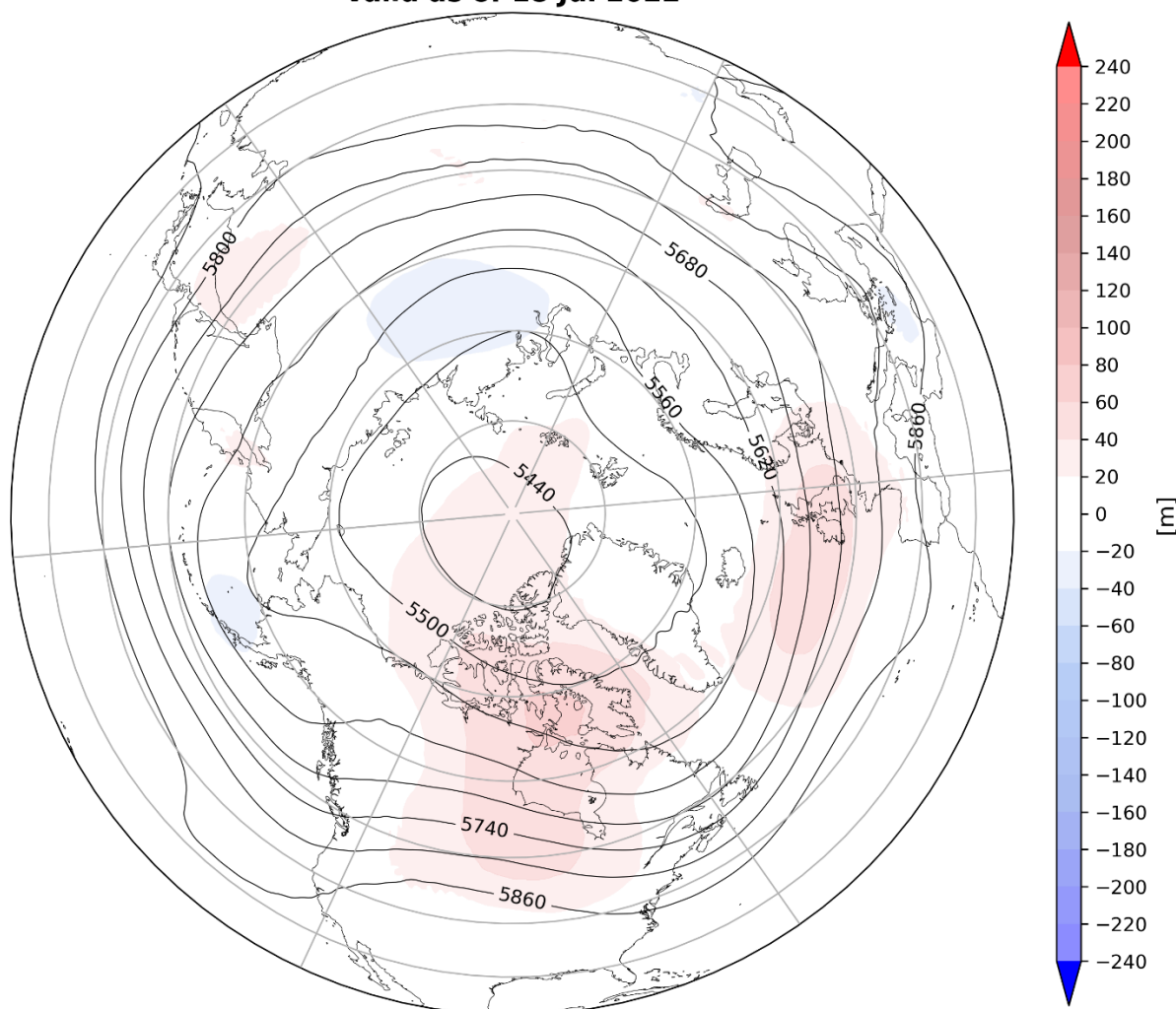
The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs in the upper stratosphere and the lower troposphere with warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). The warm/positive PCHs in the upper stratosphere are predicted to descend into the mid and lower troposphere this week (**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 18 July 2022 GFS ensemble.

The normal to cold/negative PCHs in the lower troposphere (**Figure 11**) are consistent with the initial positive surface AO (**Figure 1**). The predicted warm/positive PCHs reaching the surface this week (**Figure 11**) is also consistent with the predicted negative trend in the surface AO this week (**Figure 1**).

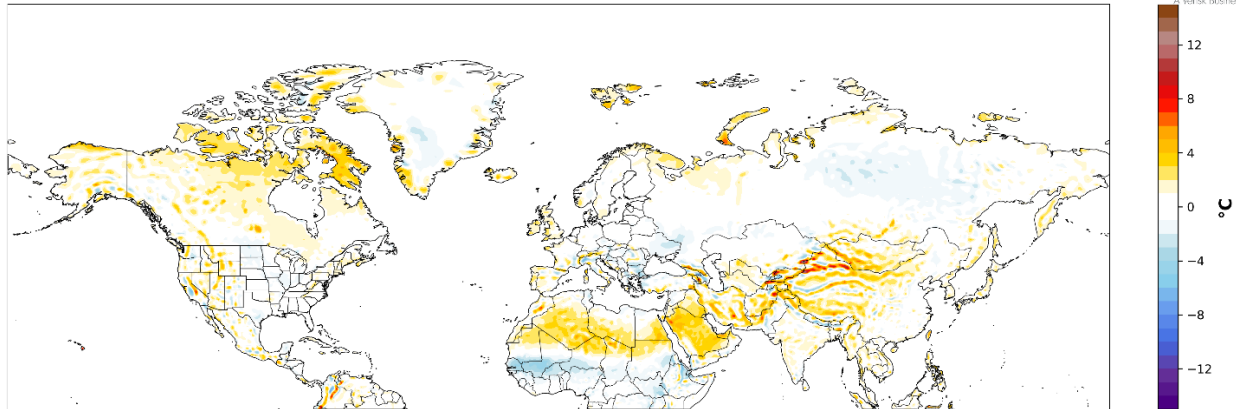
**CFS 500 hPa Forecast Anomaly Aug 2022  
Valid as of 18 Jul 2022**



**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 18 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 in the northeastern North Atlantic, East Asia and central North America with troughing across Eastern Europe, Western Siberia, near the Aleutians, the Gulf of Alaska, Eastern Canada and the Northeastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Western Europe, Southern and especially Central Asia, Alaska, much of Canada and the Western US with seasonable to relatively cool temperatures across Eastern Europe, much of Siberia, Southeastern Canada and the Northeastern US (**Figure 13**).

CFS 14-44 Day Forecast T2m Anomaly  
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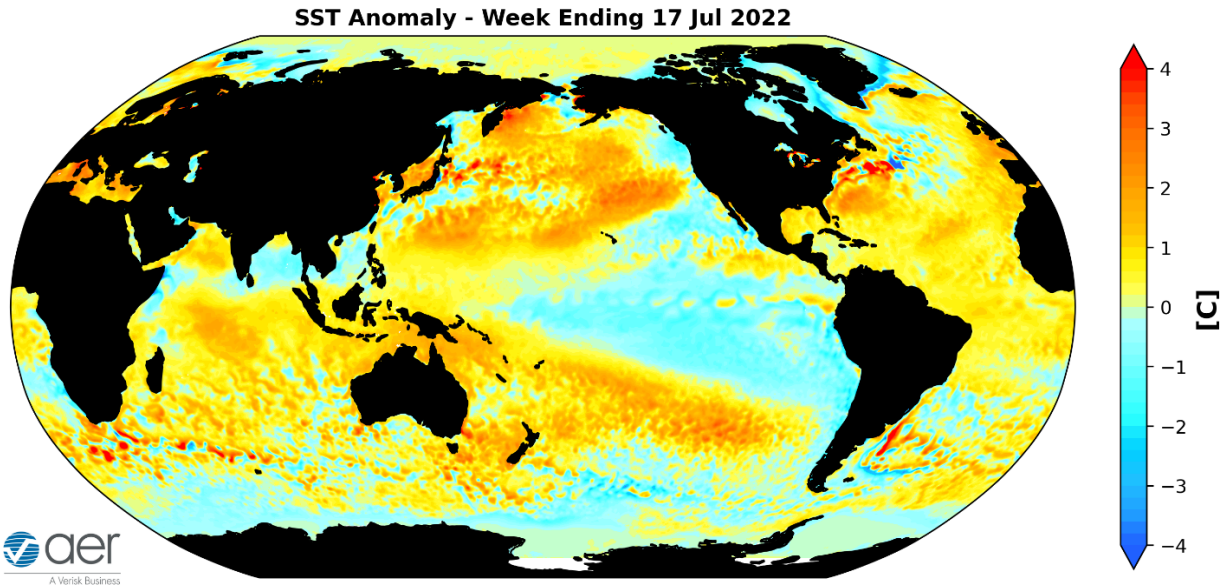
**Figure 13.** Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for August 2022. The forecasts are from the 00Z 18 July 2022 CFS.

#### *Surface Boundary Conditions*

#### *SSTs/El Niño/Southern Oscillation*

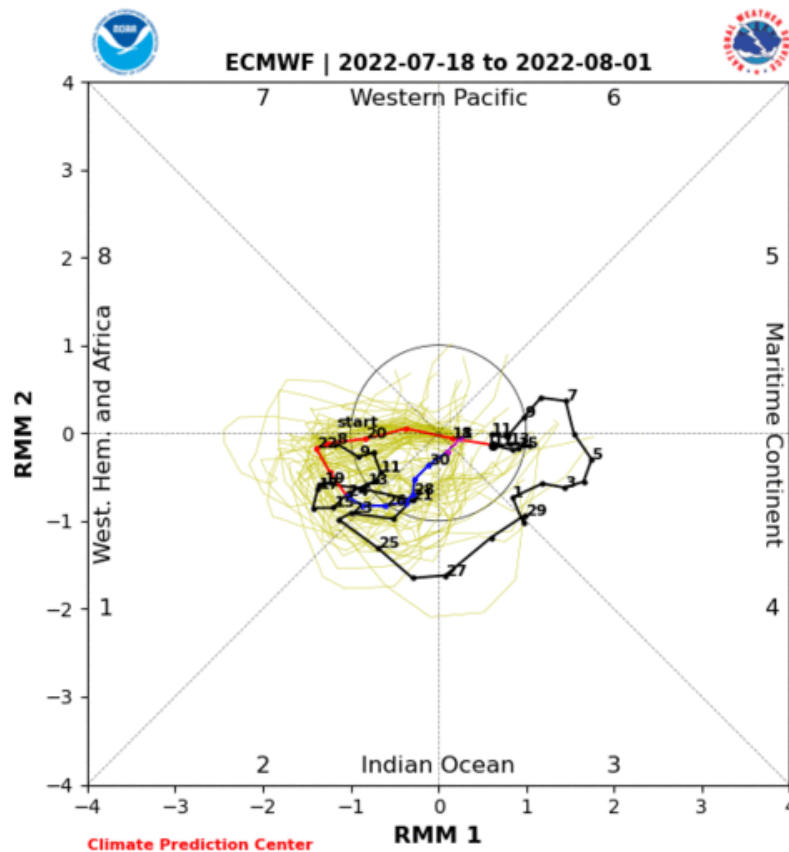
Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 14**) and La Niña conditions are expected through the summer. La Niña could favor a North America heat dome during the summer months and a more active North Atlantic 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 17 July 2022). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is weak to where no phase is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored and then later this week briefly pop into Phase one and then weaken again next week where no phase is favored. Phase one favors ridging and relatively warm temperatures in Alaska, the US West Coast, and eastern North America with troughing and relatively cool temperatures in Western Canada and the Southeastern 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 18 July 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.

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!