

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

June 20, 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 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 stay tethered to neutral as pressure/geopotential height anomalies are predicted to remain weak and mixed across Greenland over the next two weeks.
- Over the next two weeks persistent ridging/positive geopotential height anomalies south of Greenland will support troughing/negative geopotential height anomalies across Western Europe with ridging/positive geopotential height anomalies across Central and Eastern Europe the next two weeks. This pattern favors seasonal temperatures across Western Europe including the United Kingdom (UK) with normal to above normal temperatures in Central and Eastern Europe the next two weeks.

- The general pattern this week across Asia is weak troughing/negative geopotential height anomalies across Western Asia with ridging/positive geopotential height anomalies dominating most of Central and Eastern Asia however next week the West Asian trough will slide east of the Urals into Western Siberia and deepen. This pattern favors widespread normal to above normal temperatures across much of Asia, with the exception of Western Asia and then next week normal to below normal temperatures will sweep across Western Siberia and then east into other parts of Siberia while normal to above normal temperatures dominate the rest of Asia.
- The general pattern this week across North America is ridging/positive geopotential height anomalies centered near the Aleutians forcing troughing/negative across western North America with more ridging/positive geopotential height anomalies in the Eastern United States (US). However, starting next week, the ridging/positive geopotential height anomalies will slide into western North America favoring increasing troughing/negative geopotential height anomalies across eastern North America. The pattern favors this week normal to below normal temperatures across much of Southwestern Canada and the Western US with normal to above normal temperatures across Alaska, Northern and Eastern Canada and the Eastern US. Then beginning next week normal to above normal temperatures will become widespread across Alaska, Western Canada, and the Western US with normal to below normal temperatures across Eastern Canada and the Central and Eastern US.
- In the *Impacts* section I discuss what dominant summer temperature patterns appear to be emerging.

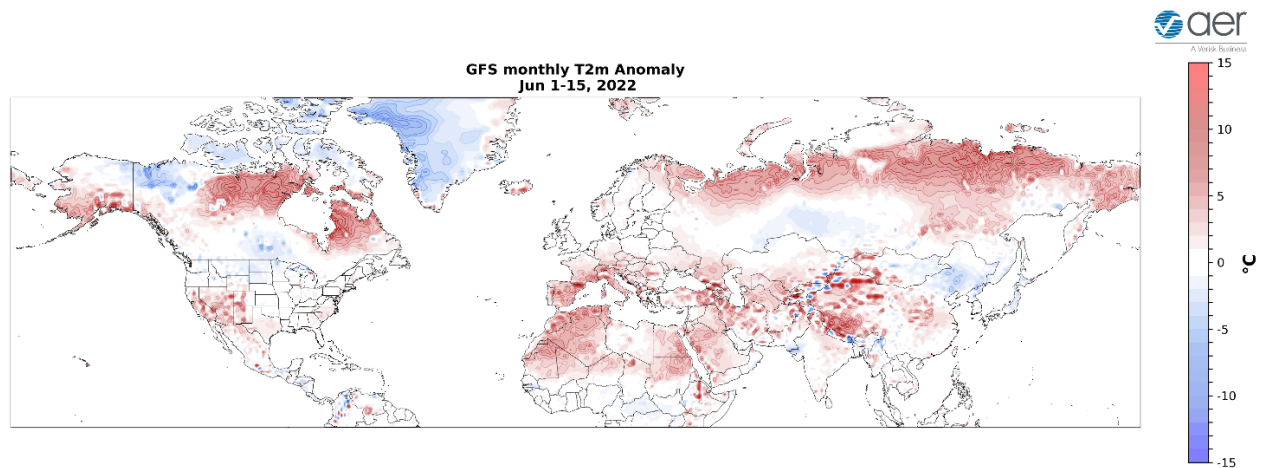
### ***Plain Language Summary***

The warm pattern in Europe is predicted to continue into July and I think an overall warm summer in Europe is looking likely. A pattern change is predicted for North America with a relatively cool pattern in western North America being replaced by a hotter pattern and a hotter pattern in the Central US being replaced by a cooler pattern. Since the new pattern is consistent with recent interannual trends, I do think that the new temperature pattern could persist.

### ***Impacts***

We are heading into the heart of summer, and we have already observed some impressive heat across the Northern Hemisphere including Europe, Asia, the Central and Southern US (see **Figure i**). It seems to me that an overall warm Europe is looking likely. It has been hot already and there are no signs in the short term that the overall warm pattern is going to relax. Also as seen in the sea surface temperature (SSTs) plot below (see **Figure 14**), SSTs in the Mediterranean are above normal basin wide. Some of the research that I have been associated with shows that warm SSTs in the Mediterranean are related to above normal summer temperatures in Europe. From

what I can tell it has been relatively warm across Asia as well, especially in Siberia. The temperature forecast plots below suggest a cooler period coming up for Siberia and it will be interesting to see how long the cooler pattern can last.

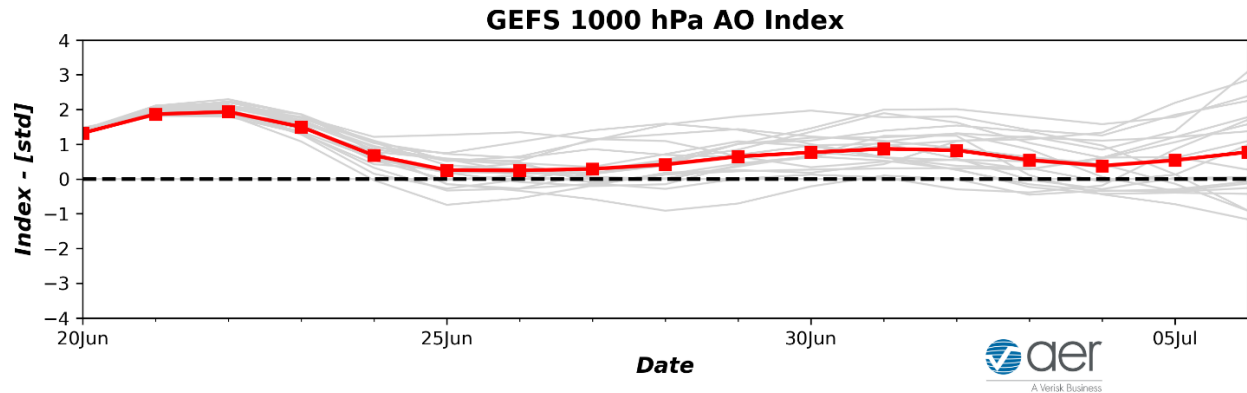


**Figure i.** Observed surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 1 – 15 June 2022 from the GFS analysis.

As far as North America the temperature anomalies have diverged somewhat from recent interannual trends. It has been relatively cool in the Northwestern US and Western Canada compared to recent summers while it has been hotter in the Central and Southeastern US compared to recent summers. 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. I do think that this pattern change could have some persistence.

*1-5 day*

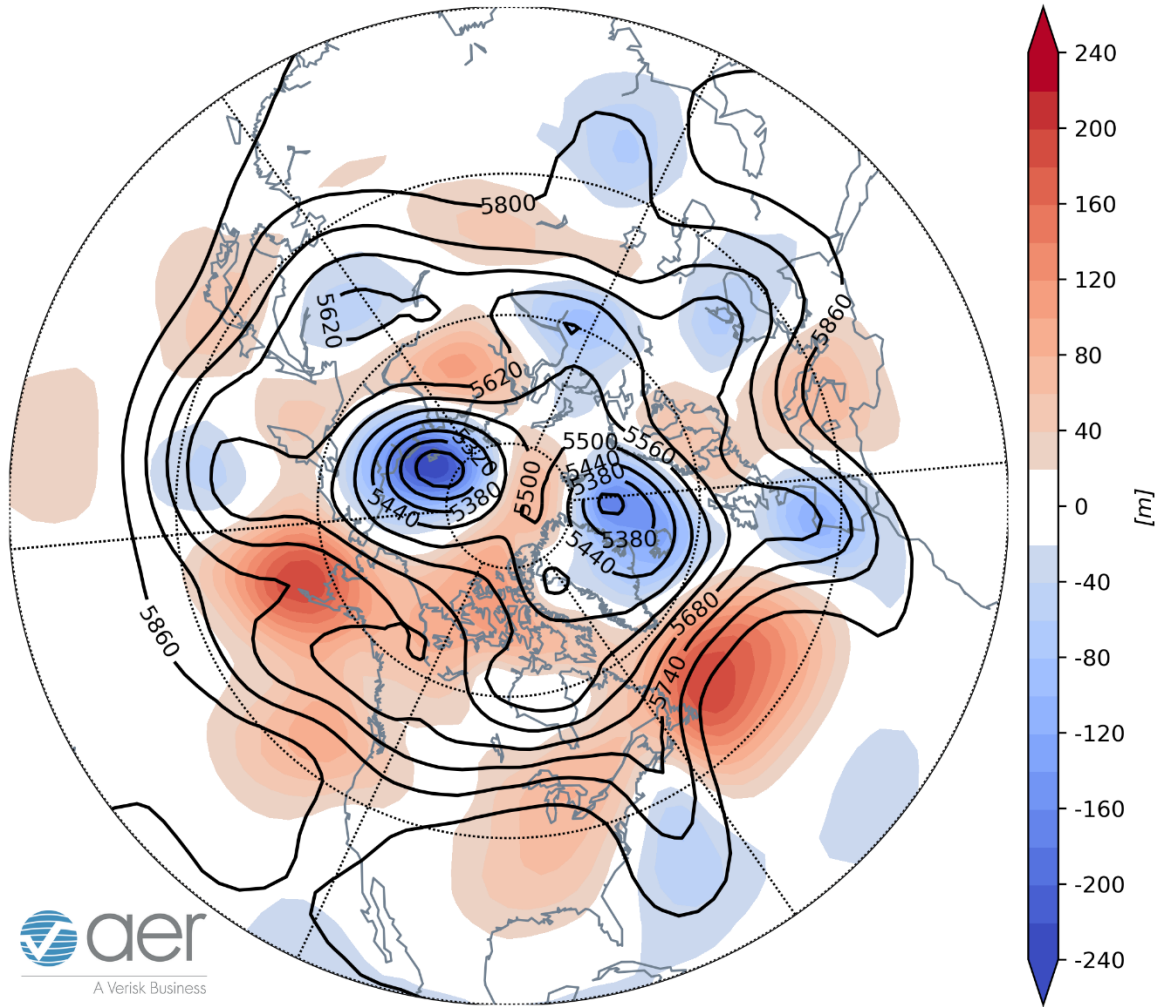
The AO is predicted to be positive to strongly positive this week (**Figure 1**) with mostly negative geopotential height anomalies predicted across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted mix and weak geopotential height 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 20 June 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.

Ridging/positive geopotential height anomalies centered south of Greenland this week will support troughing/negative geopotential height anomalies across Western Europe with ridging/positive geopotential height anomalies in Central Europe with more troughing/negative geopotential height anomalies in Southeastern Europe (**Figures 2**). This will favor normal to below normal temperatures across far Western Europe including the western UK and Southeastern Europe with normal to above normal temperatures across Central and Northern Europe (**Figure 3**). Troughing/negative geopotential height anomalies is predicted across Western Asia and Eastern Siberia with ridging/positive geopotential height anomalies across much of Central and Eastern Asia this period (**Figure 2**). This pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to Western Russia and Eastern Siberia (**Figure 3**).

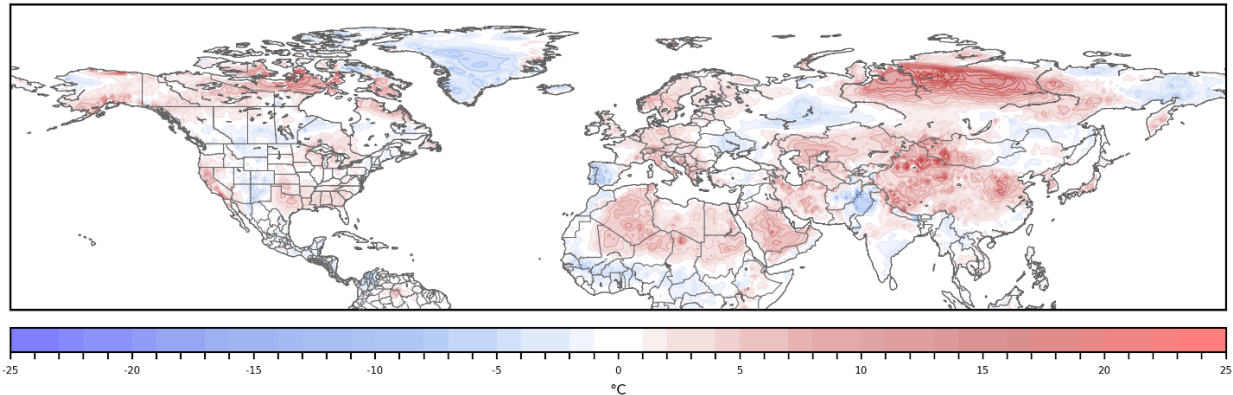
**GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 06/20/2022 FCST: 06/21/2022 to 06/25/2022**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 21 – 25 June 2022. The forecasts are from the 00z 20 June 2022 GFS ensemble.

Ridging/positive geopotential height anomalies centered near the Aleutians will force troughing/negative geopotential height anomalies across western North America with ridging/positive geopotential height anomalies centered in the Great Lakes (**Figure 2**). The pattern will favor normal to above normal temperatures across Alaska, Northern and Eastern Canada and the Eastern US with normal to below normal temperatures across Southwestern Canada and the Western US (**Figure 3**).

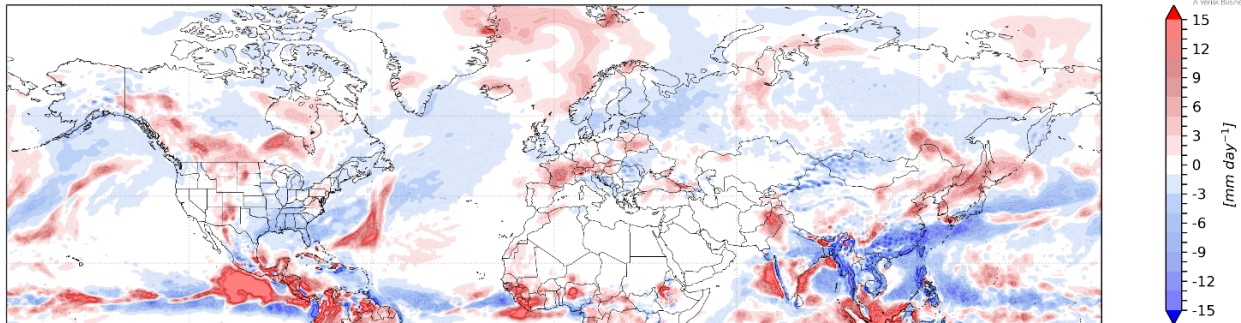
**GFS 1-5 Day Forecast T2m Anomaly**  
**INIT: 00Z 06/20/2022 FCST: 06/21/2022 to 06/25/2022**



**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 21 – 25 June 2022. The forecast is from the 00Z 20 June 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for the Pyrenees, Alps, and parts of Southeast Asia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Western Canada and the US Rockies (**Figure 4**).

**GEFS 1-5 Day Forecast PRATE Anomaly**  
**INIT: 00Z 06/20/2022 FCST: 06/21/2022 to 06/25/2022**



**Figure 4.** Forecasted precipitation rate (mm/day; shading) from 21 – 25 June 2022. The forecast is from the 00Z 20 June 2022 GEFS ensemble.

*Mid-Term*

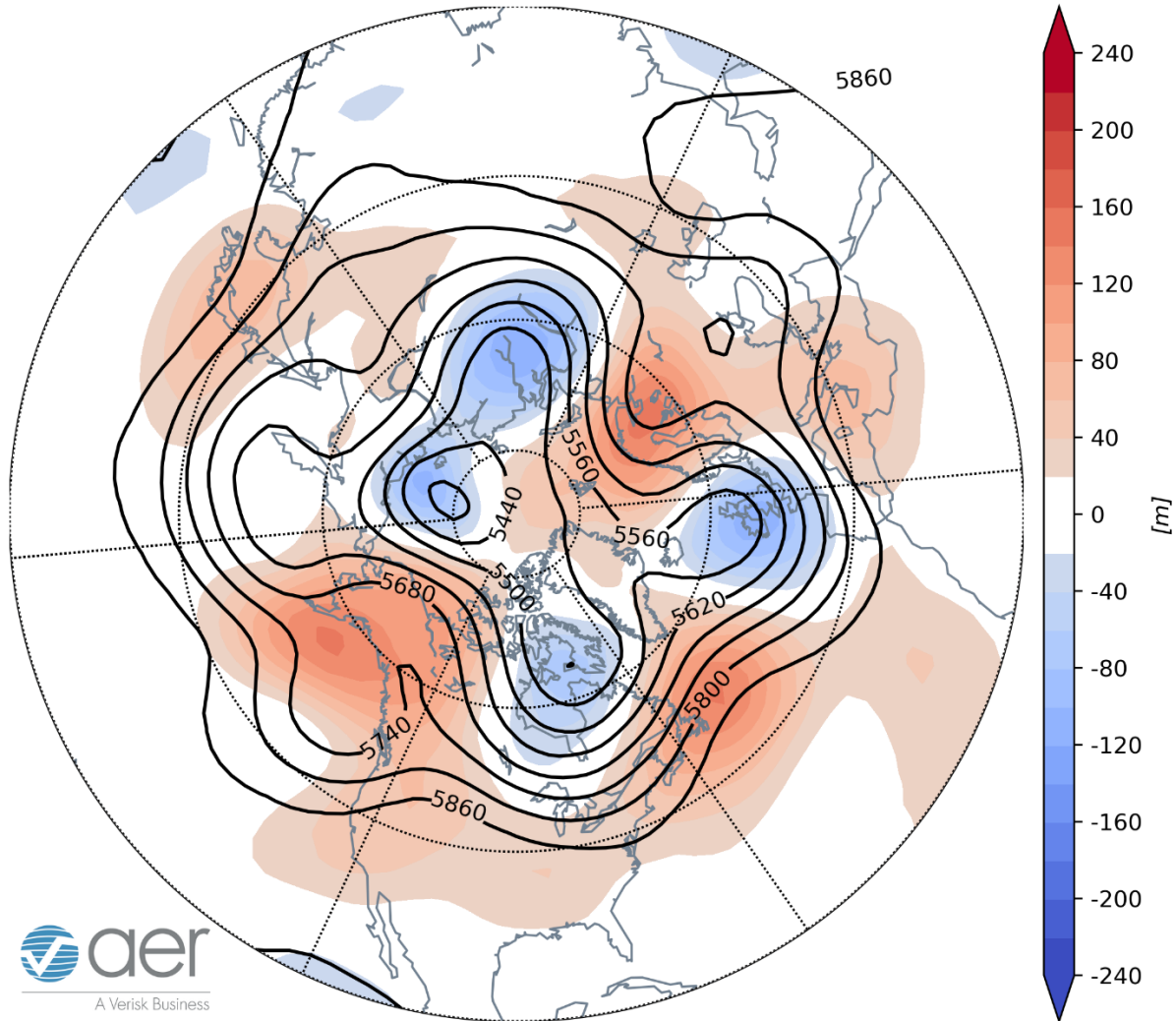
*6-10 day*

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 and mixed



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

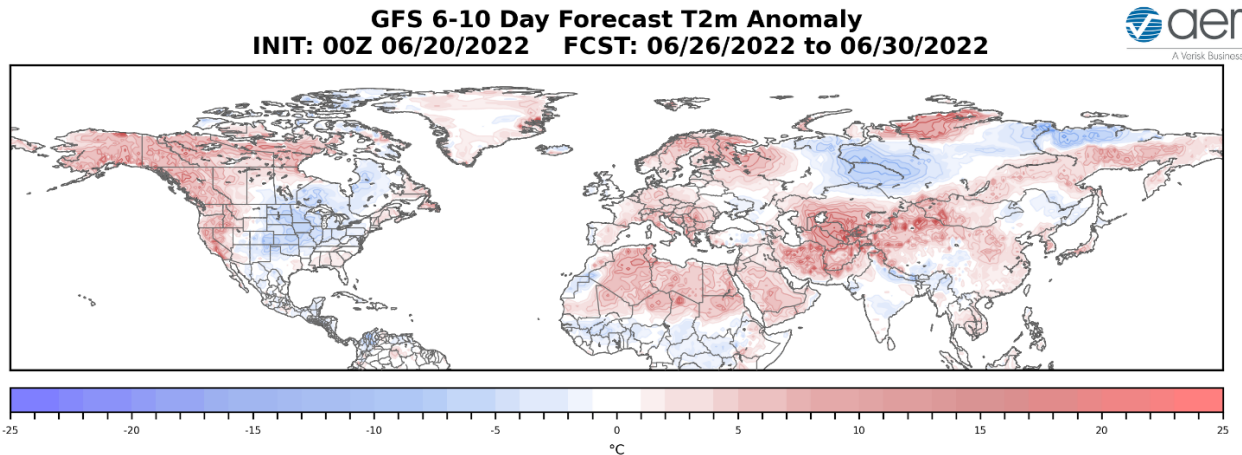
**GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 06/20/2022 FCST: 06/26/2022 to 06/30/2022**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 26 - 30 June 2022. The forecasts are from the 00z 20 June 2022 GFS ensemble.

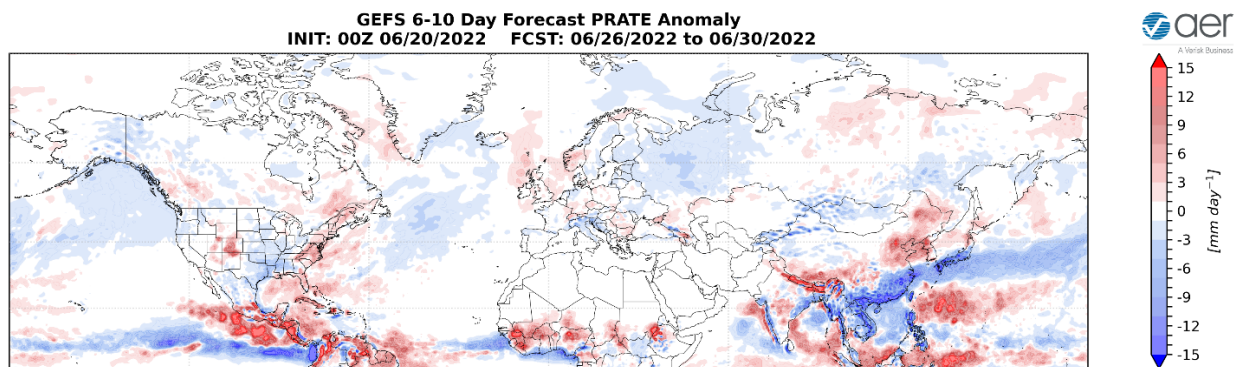
Persistent ridging/positive geopotential height anomalies centered south of Greenland will anchor troughing/negative geopotential height anomalies across Western with ridging/positive geopotential height anomalies across Central and Eastern Europe this period (**Figures 5**). This will result in normal to above normal temperatures across much of Europe with normal to below normal temperatures limited to Northwestern Europe including the UK (**Figure 6**). The troughing/negative geopotential height anomalies previously in Western Asia is predicted to slide east of the Urals and into

Western Siberia and deepen with ridging/positive geopotential height anomalies across Western and Eastern Asia this period (**Figure 5**). This pattern favors normal to below normal temperatures across Western and Northern Siberia with normal to above normal temperatures widespread across much of Asia (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 26 – 30 June 2022. The forecasts are from the 00Z 20 June 2022 GFS ensemble.

Ridging/positive geopotential height anomalies previously near the Aleutians are predicted to enter the Gulf of Alaska and western North America forcing deepening troughing/negative geopotential height anomalies across Eastern Canada and the Central US (**Figure 5**). This will favor normal to above normal temperatures across Alaska, Northern and Western Canada and the Western US with normal to below normal temperatures across Southern and Eastern Canada and the Central US (**Figure 6**).



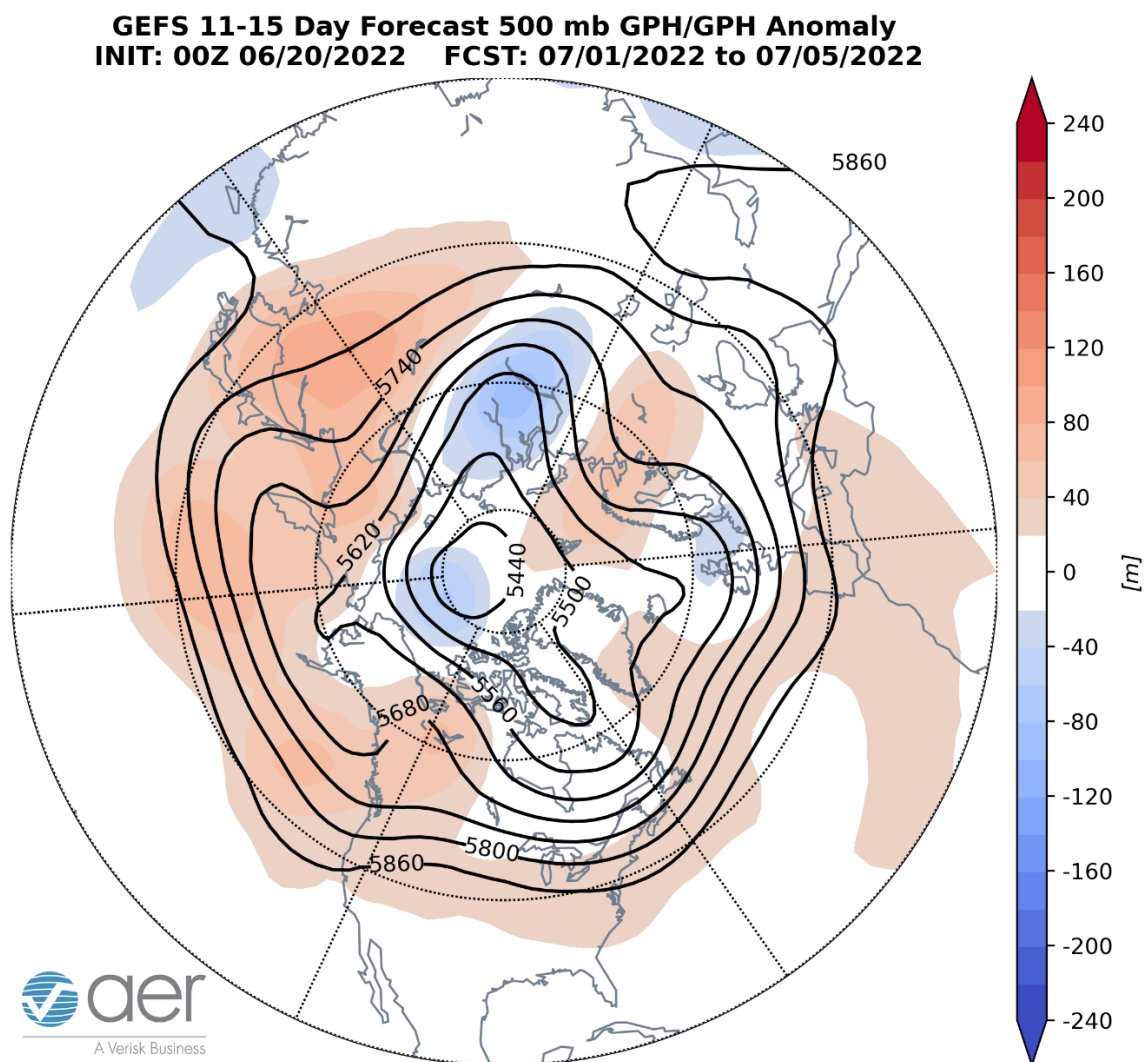
**Figure 7.** Forecasted precipitation rate (mm/day; shading) from 26 – 30 June 2022. The forecast is from the 00Z 20 June 2022 GEFS ensemble.



Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Northwestern Europe and Southeastern Asia (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted along the Central Rockies and the US East Coast (**Figure 7**).

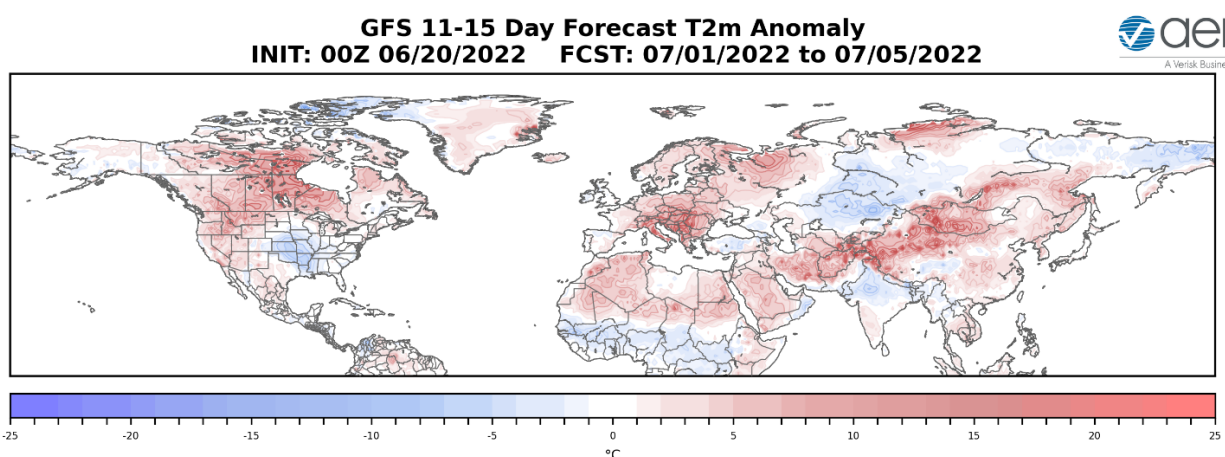
11-15 day

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 and mixed pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to remain tethered to neutral this period.



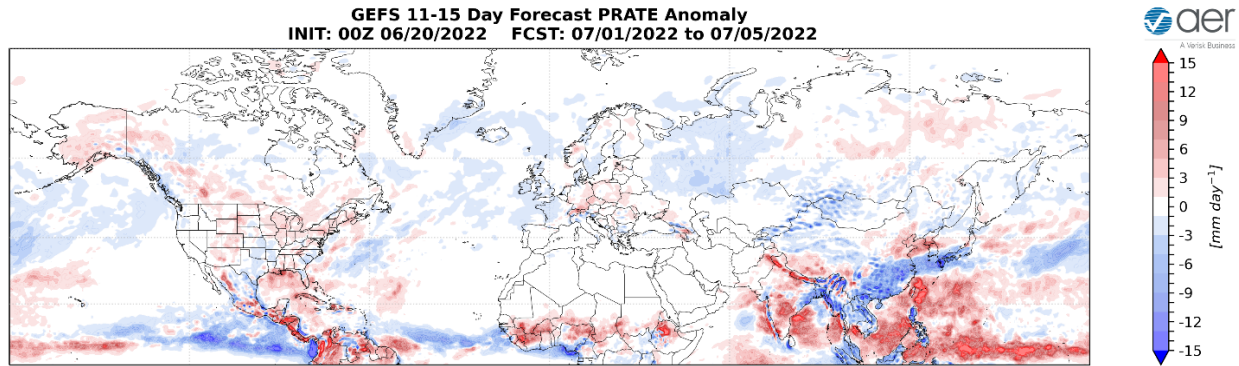
**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 1 – 5 July 2022. The forecasts are from the 00z 20 June 2022 GFS ensemble.

Persistent ridging/positive geopotential height anomalies south of Greenland will continue to favor troughing/negative geopotential height anomalies across Western Europe with ridging/positive geopotential height anomalies centered across Southern Europe this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Europe with the exception of normal to below normal temperatures across far Western Europe including the UK (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to remain across Western and especially Eastern Asia with troughing/negative geopotential height anomalies east of the Urals including Western Siberia (**Figure 8**). This pattern favors normal to above normal temperatures across much of Western and Eastern Asia with normal to below normal across Central Asia and much of Siberia (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 1 – 5 July 2022. The forecasts are from the 00z 20 June 2022 GFS ensemble.

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



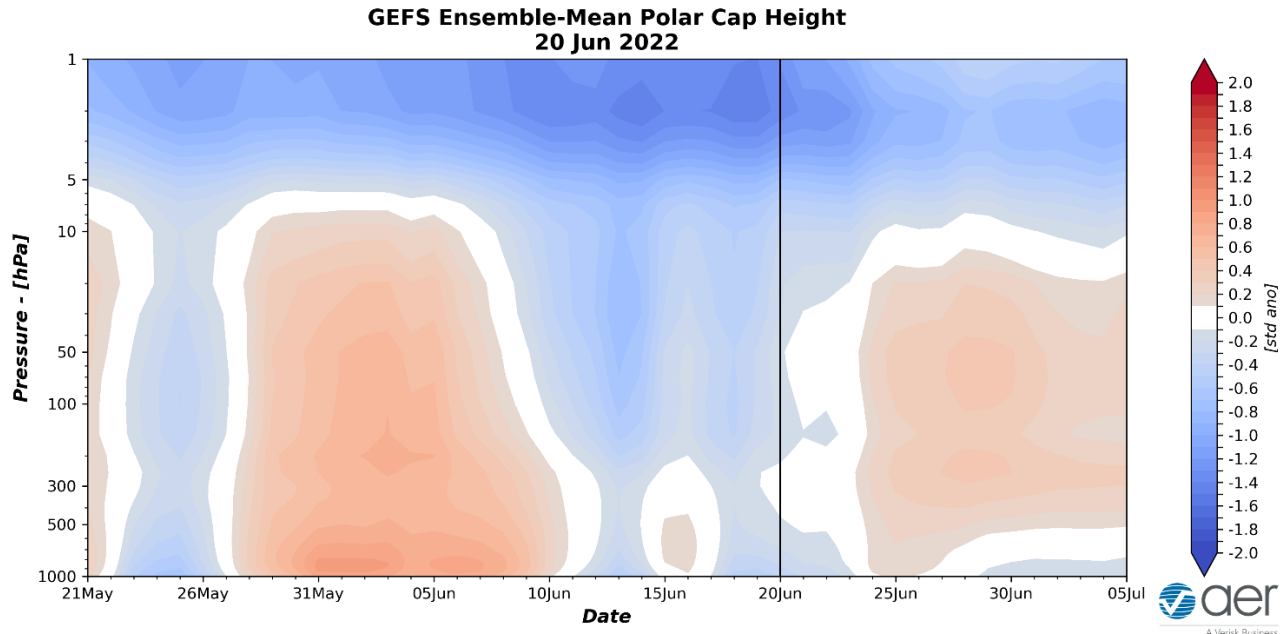
**Figure 10.** Forecasted precipitation rate (mm/day; shading) from 1 – 5 July June 2022. The forecast is from the 00Z 20 June 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for in parts of Western Siberia, Southern and Eastern Asia (**Figure 10**). Weak and mixed precipitation anomalies are predicted across North America (**Figure 10**).

*Longer Term*

*30-day*

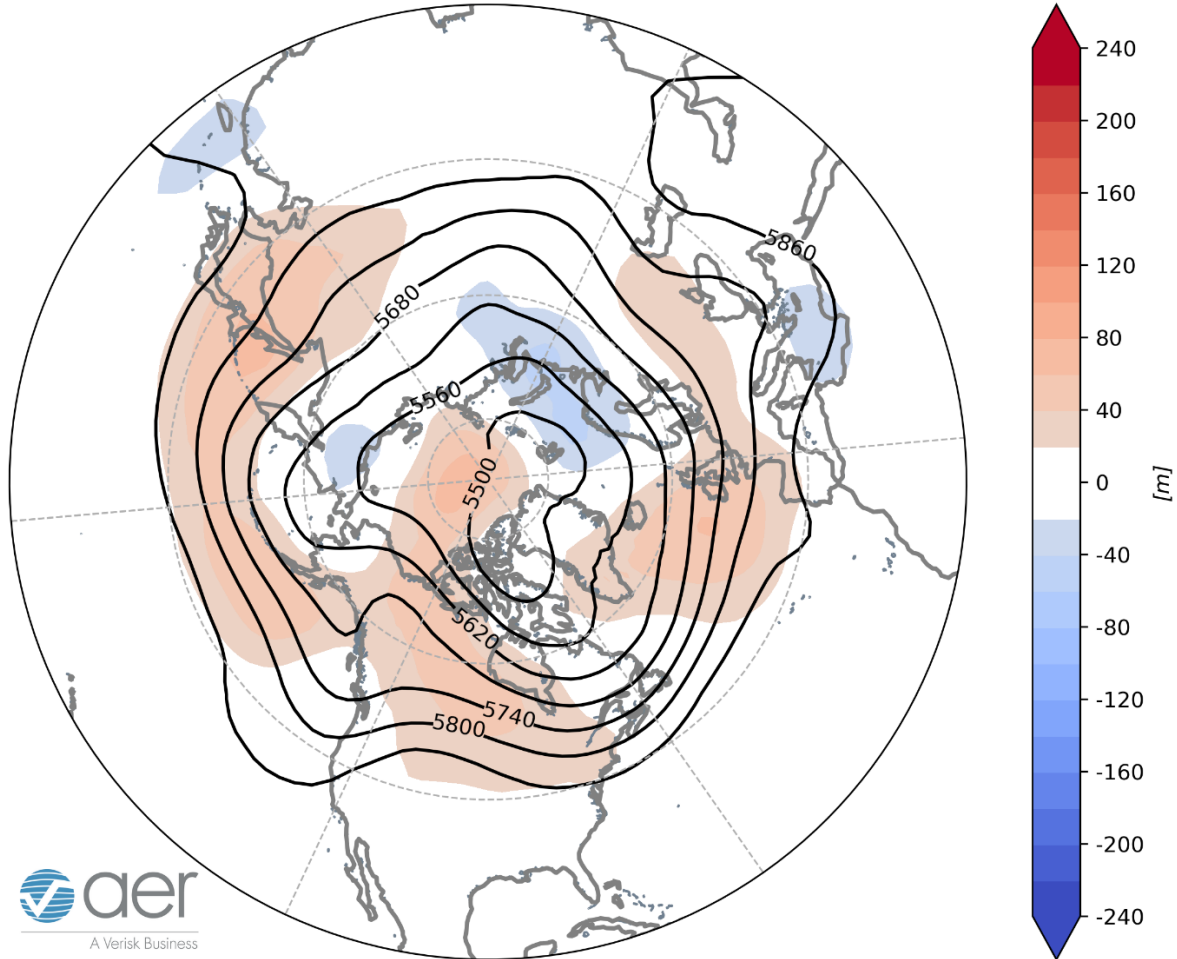
The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs throughout stratosphere and the troposphere (**Figure 11**). Cold/negative PCHs in the upper stratosphere are predicted to remain cold/negative for the foreseeable future (**Figure 11**).



**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 20 June 2022 GFS ensemble.

The cold/negative PCHs in the troposphere and lower stratosphere are predicted to reverse to warm/positive PCHs in the lower stratosphere and troposphere this and next week except in the lower troposphere where they will turn only briefly warm/positive PCHs later this week and then revert cold/negative next week (**Figure 11**). The mostly cold/negative PCHs over the next two weeks are consistent with the surface AO remaining mostly positive the next two weeks (**Figure 1**).

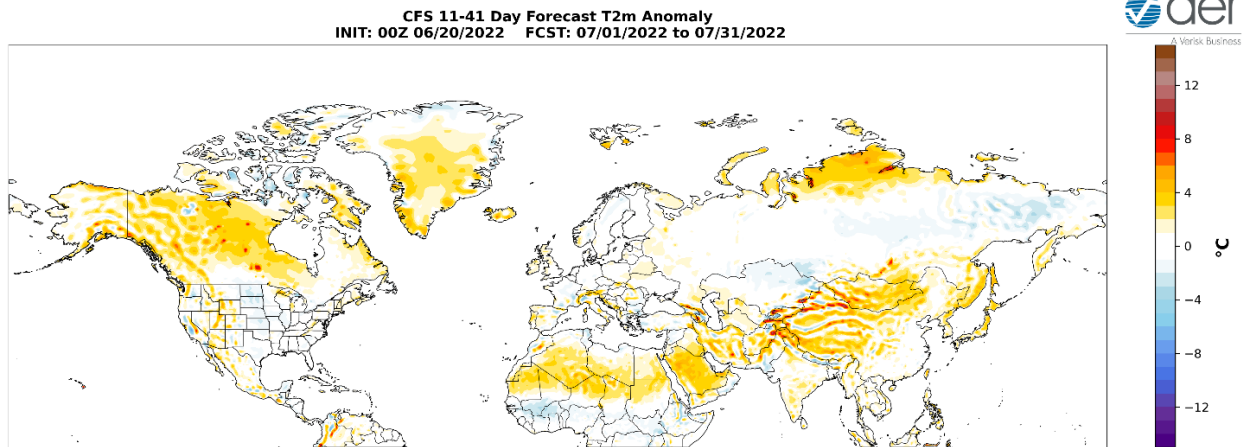
**CFS 500 hPa Forecast Anomaly Jul 2022  
Valid as of 20 Jun 2022**



**Figure 12.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2022. The forecasts are from the 00Z 20 June 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for July (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered just west of Western Europe, much of Asia but especially Central and East Asia, near the Aleutians and much of Canada with troughing across Eastern Europe, centered across the Urals, the Western US, Eastern Canada and the Northeastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across much of Europe, much of Asia but especially Central and East Asia, Alaska, much of Canada and the Western and Northeastern US with seasonable to relatively cool temperatures across parts of Western Europe, Kazakhstan, much of Central and Southern Siberia, Southeastern Canada and the Central and Southeastern US (**Figure 13**).



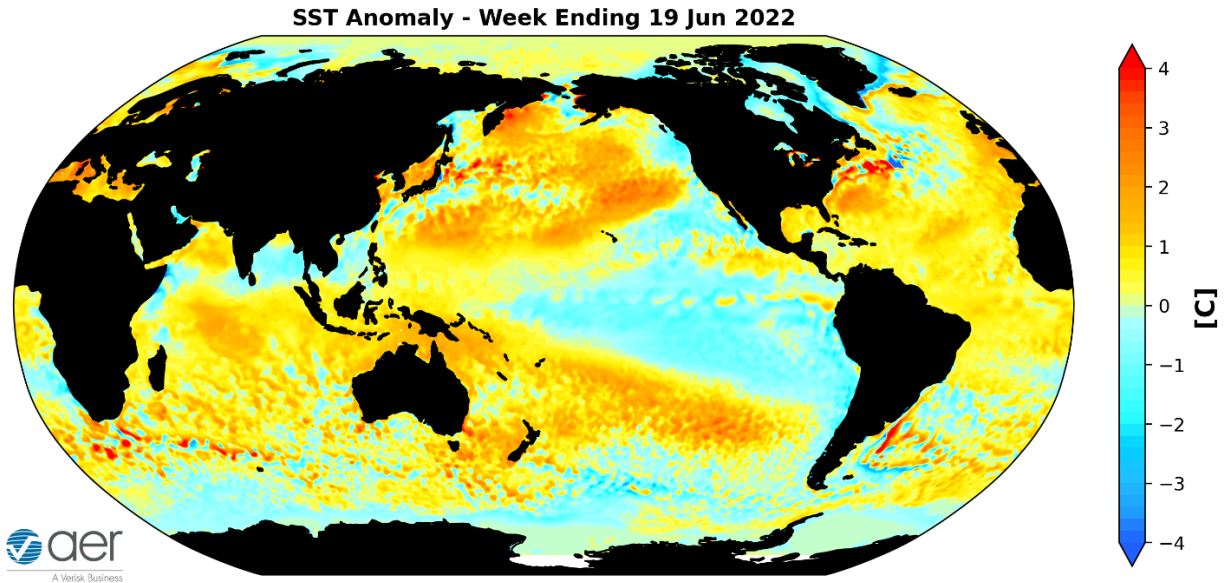


**Figure 13.** Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for July 2022. The forecasts are from the 00Z 20 June 2022 CFS.

#### *Surface Boundary Conditions*

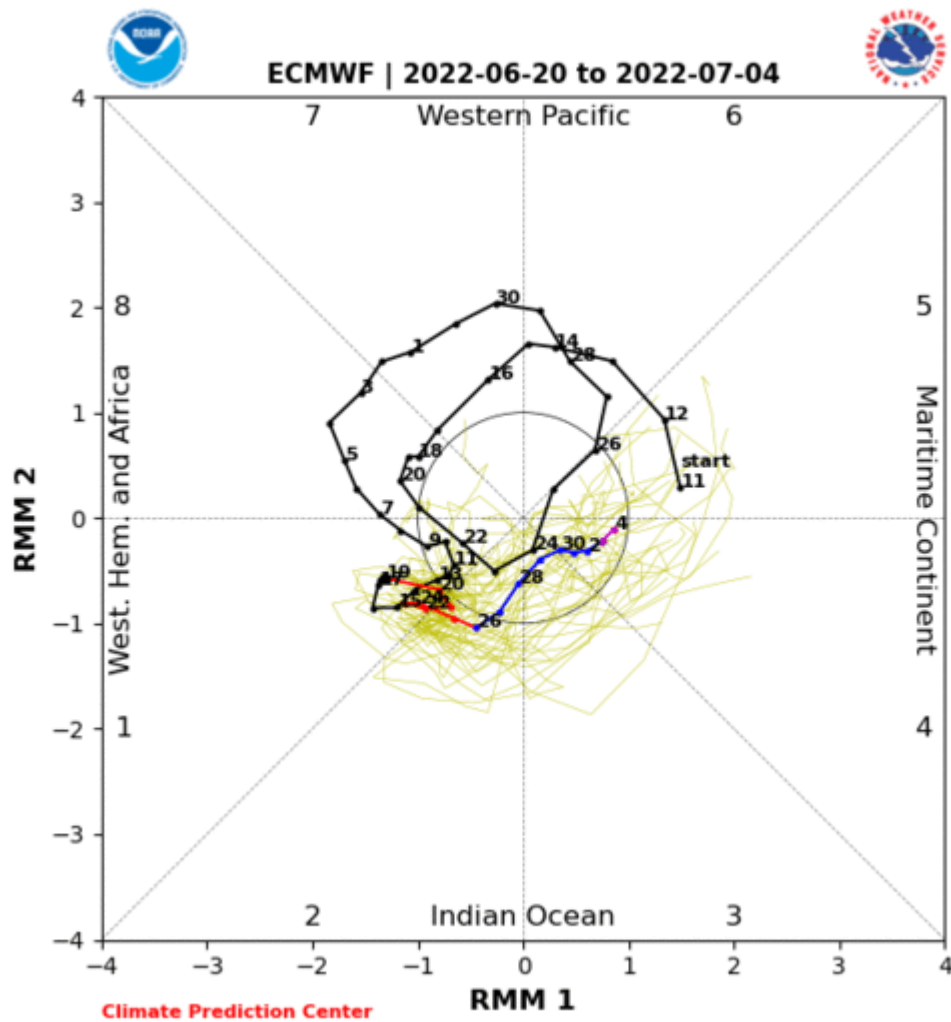
#### *SSTs/El Niño/Southern Oscillation*

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 19 June 2022). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase 1 (**Figure 15**). The forecasts are for the MJO to remain weakly in phase 1 and then weaken to where no phase is favored. Phase 1 favors ridging and relatively warm temperatures in the Western US with troughing and relatively cool temperatures in the Eastern US and then transitioning to ridging and warm temperatures in the Eastern US. Therefore there could be some MJO influence on the near term the 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>