

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

June 22, 2020

*Special blog on winter 2018/2019 retrospective can be found here*  
- <http://www.aer.com/winter2019>

*Special blog on winter 2017/2018 retrospective can be found here*  
- <http://www.aer.com/winter2018>

*Special blog on winter 2016/2017 retrospective can be found here*  
- <http://www.aer.com/winter2017>

*Special blog on winter 2015/2016 retrospective can be found here*  
- <http://www.aer.com/winter2016>

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) recently 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 remain neutral to slightly negative over the next two weeks.
- The current neutral AO is reflective of mixed pressure/geopotential height anomalies across the Arctic with mixed pressure/geopotential height anomalies

across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently neutral with weak pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to become increasingly negative the next two weeks as pressure/geopotential height anomalies rise across Greenland and Iceland.

- The predicted weather pattern for Europe including the United Kingdom (UK) this week is general ridging/positive geopotential height anomalies with normal to above normal temperatures. However next week, troughing/negative geopotential height anomalies with cooling temperatures will become more widespread across Europe including the UK.
- The predicted general pattern for Asia the next two weeks is ridging/positive geopotential height anomalies with normal to above normal temperatures in Eastern Asia with troughing/negative geopotential height anomalies with normal to below normal temperatures initially in Western Eastern Asia. However, in early July the ridging and above normal temperatures are predicted to become more widespread across Asia.
- This week, troughing/negative geopotential height anomalies accompanied by normal to below normal temperatures are predicted for Alaska and the Eastern United States (US) with ridging/positive geopotential height anomalies with normal to above normal temperatures elsewhere. Next week, the troughing with normal to below normal temperatures are predicted to shift into the Western US with ridging and normal to above normal temperatures in the Eastern US. However, in early July ridging/positive geopotential height anomalies with normal to above normal temperatures are predicted to become widespread across much of North America.
- In the Impacts section I discuss my expectations of the general summer weather pattern across the Northern Hemisphere (NH).

### ***Impacts***

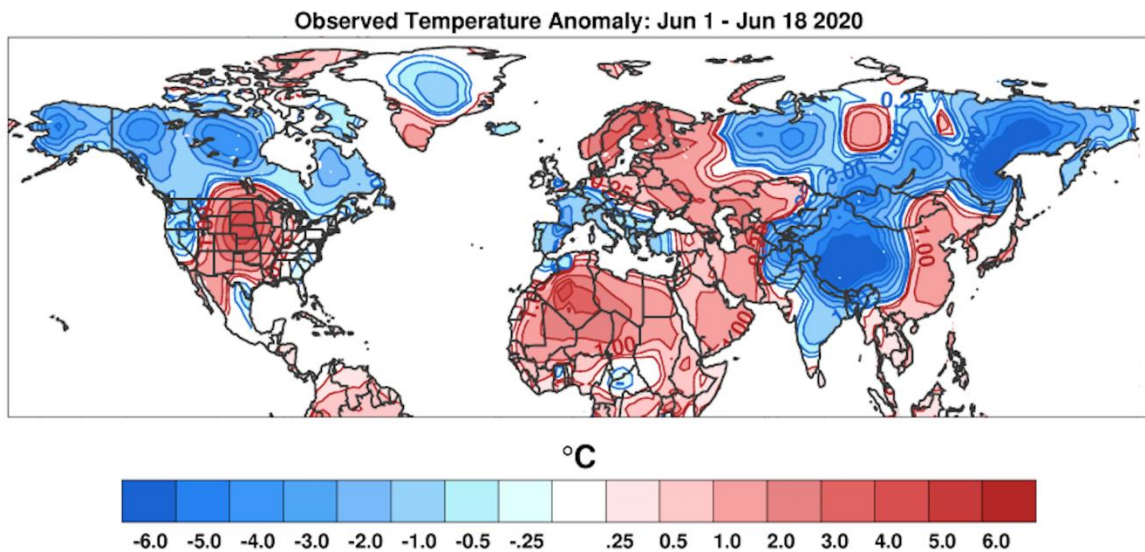
As I have discussed previously in the blog the general summer pattern across the NH has been ridging coupled with warm temperatures in Europe, East Asia, western North America and along the east coast of North America with troughing and seasonable to cool temperatures in Western Asia and possibly weak troughing in the Central US. This is roughly the pattern predicted for this week across the NH. During recent summers, the ridging in East Asia has been yielding well above normal temperatures coupled with wildfires in Siberia. Siberia has once again made news headlines with temperatures topping 100°F this weekend for the first time ever ([CBS News](#)) and smoke from wildfires easily visible from satellites.

However, the current pattern of ridging across Europe with troughing in Western Asia and more ridging in East Asia is not predicted to last beyond this week. The predicted pattern for early July is general troughing across Europe and ridging for Asia. Despite the predicted pattern change, I believe that there is a good chance that the observed

pattern of recent summers (West Asian troughing sandwiched by European and East Asian ridge) will return and dominate the summer pattern.

Across North America the predicted weather pattern this week of ridging on the coasts and troughing centered in the Great Lakes is also predicted to transition in early July with widespread ridging centered over the interior of the continent and troughing along the US West Coast. However, across North America I am less confident that the pattern observed in recent summers will repeat this summer as well. Certainly, so far, the axis of ridging has been centered over the interior of North America and not the western edge of North America. I could see this pattern persisting for much of the summer.

Looking at the surface temperature anomalies so far this summer (**Figure i**), the pattern does not resemble recent summers. The two standout relatively warm regions are Northern Europe and the Central US. However, I do expect the relatively warm temperatures to become more widespread as summer progresses.

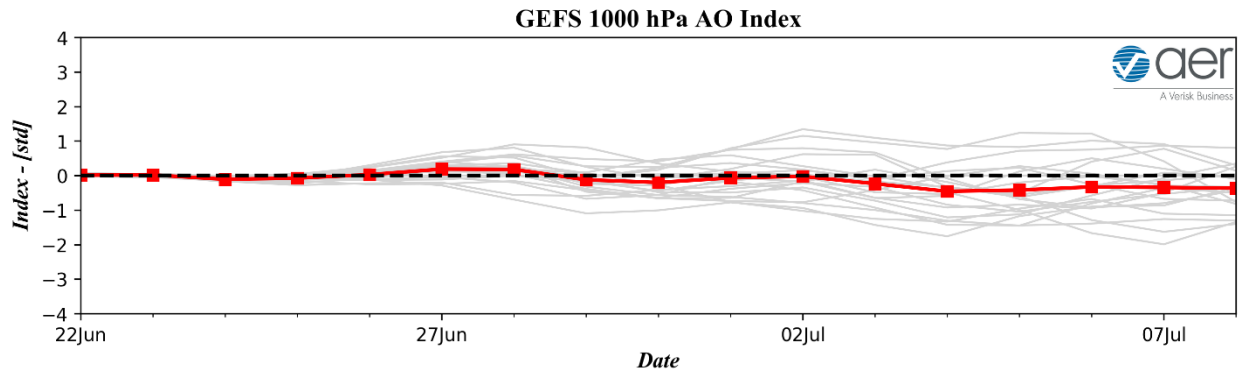


**Figure i.** Observed surface temperature anomalies (°C; shading) from 1 – 18 June 2020. The anomalies are computed from the NCEP/NCAR reanalysis.

I will admit that I am surprised that the plot depicts as much below normal temperatures as it does, especially in a place like Siberia that has received so much attention for unprecedented heat. The overall pattern does look correct to me but regional anomalies may be sensitive to the dataset and my plotting routine.

1-5 day

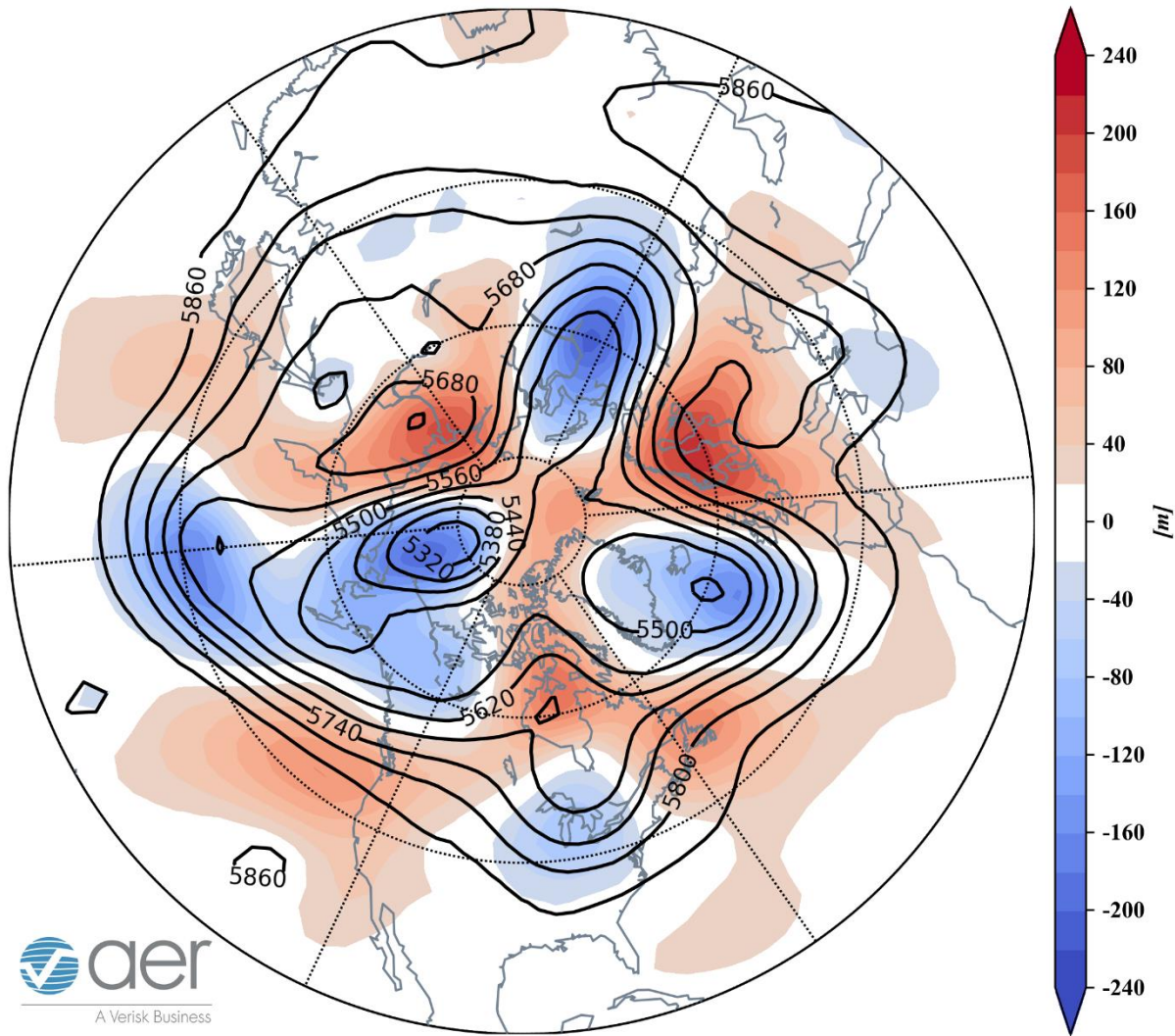
The AO is currently neutral (**Figure 1**) with mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted weak geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to straddle neutral this week as well.



**Figure 1.** The predicted daily-mean AO at 1000 hPa from the 00Z 22 June 2020 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.

This week, ridging/positive geopotential height anomalies with normal to above normal temperatures will dominate much of Europe including the UK with the possible exception of troughing/negative geopotential height anomalies and normal to below normal temperatures in far Southeastern Europe (**Figures 2 and 3**). Troughing/negative geopotential height anomalies in Western Asia, will help to anchor ridging/positive geopotential height anomalies in Eastern Asia (**Figure 2**). This pattern favors normal to below normal temperatures across Western Asia with normal to above normal temperatures in Eastern Asia but especially Siberia (**Figure 3**).

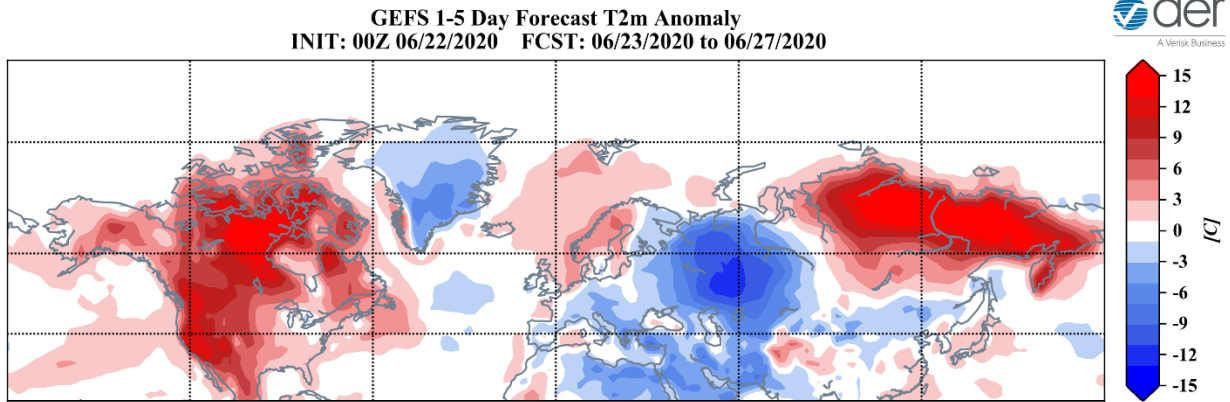
**GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly**  
INIT: 00Z 06/22/2020 FCST: 06/23/2020 to 06/27/2020



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 23 – 27 June 2020. The forecasts are from the 00z 22 June 2020 GFS ensemble.

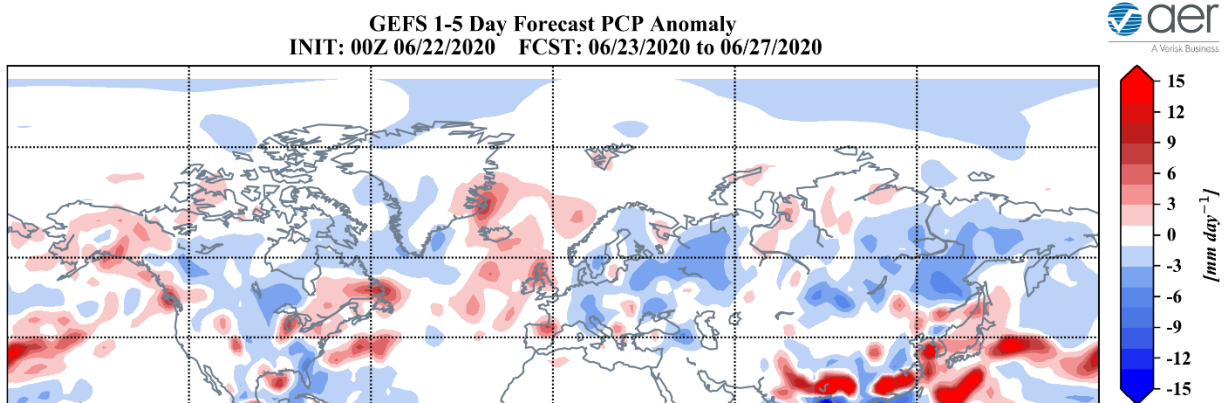
This week, troughing/negative geopotential height anomalies are predicted for Alaska, Northwestern Canada and the Eastern US with ridging/positive geopotential height anomalies in Eastern Canada, along the US West Coast (**Figure 2**). This pattern is predicted to bring normal to below normal temperatures across Alaska, Northwest Canada and the Central US with normal to above normal temperatures for much of Canada, New England and the US West Coast (**Figure 3**).





**Figure 3.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 23 – 27 June 2020. The forecast is from the 00Z 22 June 2020 GFS ensemble.

Below normal precipitation is predicted for much of Europe and Asia with the exceptions of above normal precipitation for Spain and Southeast Asia (**Figure 4**). Below normal precipitation is predicted for much of North America with above normal precipitation across the West Coast of Canada, the Pacific Northwest and the Great Lakes (**Figure 4**).



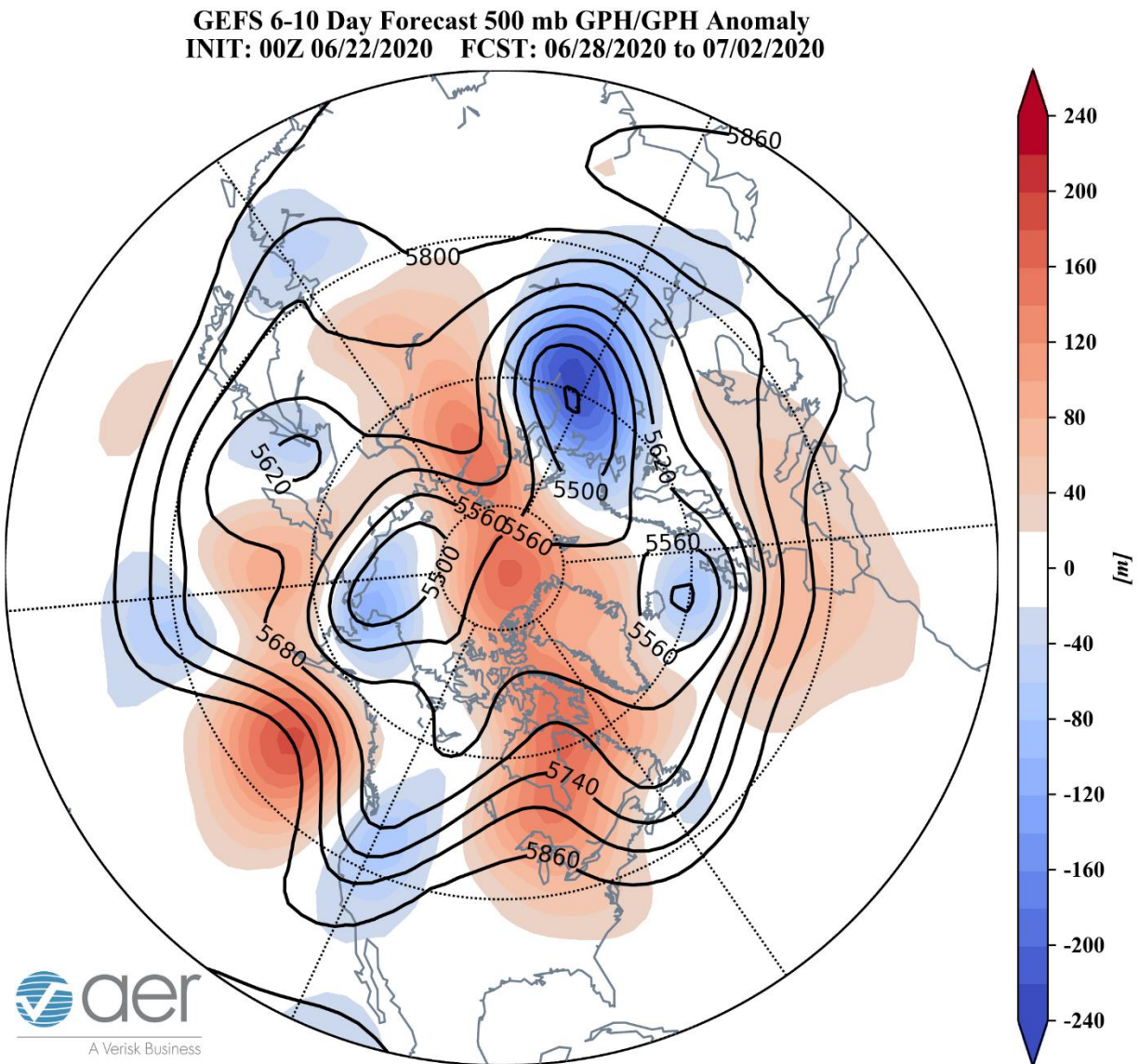
**Figure 4.** Forecasted precipitation anomalies ( $\text{mm}/\text{day}$ ; shading) from 23 – 27 June 2020. The forecast is from the 00Z 22 June 2020 GFS ensemble.

### Mid-Term

#### 6-10 day

The AO is predicted to remain steady (**Figure 1**) near neutral as geopotential height anomalies remain mixed across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with weak positive geopotential

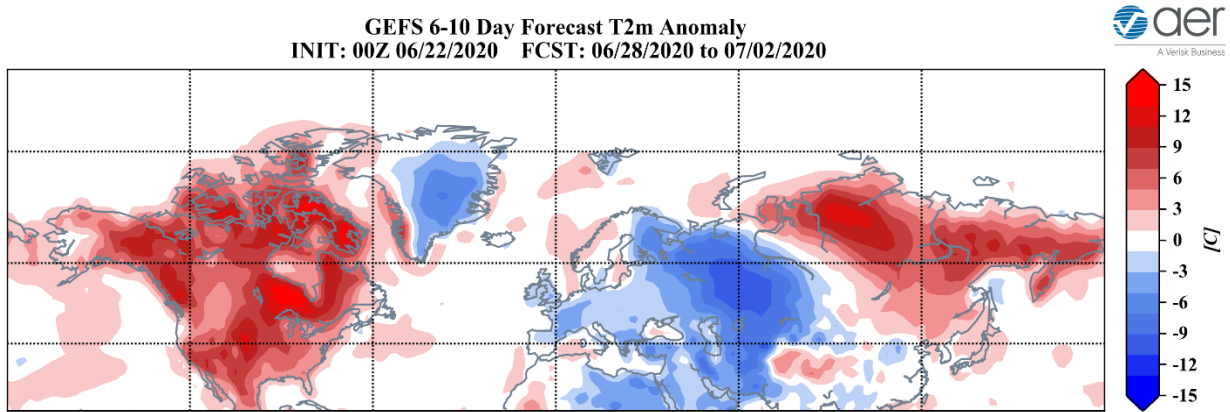
height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to remain weakly negative.



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 June – 2 July 2020. The forecasts are from the 00z 22 June 2020 GFS ensemble.

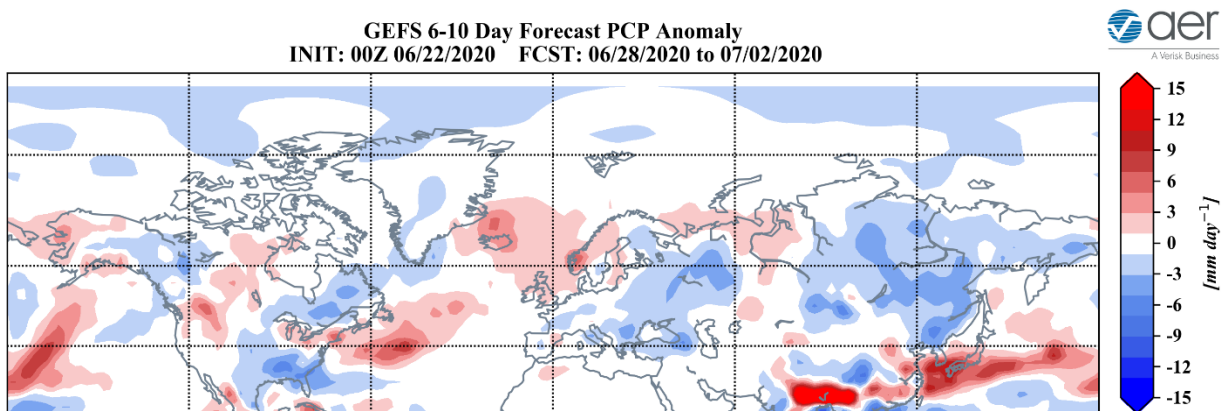
Ridging/positive geopotential height anomalies previously widespread across Europe will be suppressed to the south across Southern Europe as troughing/negative geopotential height anomalies come in from the North Atlantic and spread across Northern Europe (**Figures 5**). Despite lowering of heights across Northern Europe temperatures are still predicted to remain normal to above normal across much of Europe with the exception of normal to below normal across the UK (**Figure 6**). The

general pattern across Asia will remain steady with troughing/negative geopotential height anomalies in Western Asia anchoring ridging/positive geopotential height anomalies across East Asia (**Figure 5**). This is predicted to yield normal to above normal temperatures in Eastern Asia **with** normal to below temperatures In Western Asia (**Figure 6**). Some weak troughing/negative geopotential height anomalies across the Northern Indian subcontinent will favor normal to below normal temperatures across that region (**Figures 5 and 6**).



**Figure 6.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 28 June – 2 July 2020. The forecasts are from the 00Z 22 June 2020 GFS ensemble.

Ridging/positive geopotential height anomalies will become more widespread across Eastern Canada and into the Eastern US with troughing/negative geopotential height anomalies stretching from Alaska south along the West Coasts of Canada and the US this period (**Figure 5**). This pattern is predicted to bring widespread normal to above normal temperatures across Eastern Canada and the Eastern US with normal to below normal temperatures for Alaska and the West Coasts of Canada and the US (**Figure 6**).



**Figure 7.** Forecasted precipitation anomalies ( $\text{mm}/\text{day}$ ; shading) from 28 June – 2 July 2020. The forecasts are from the 00Z 22 June 2020 GFS ensemble.

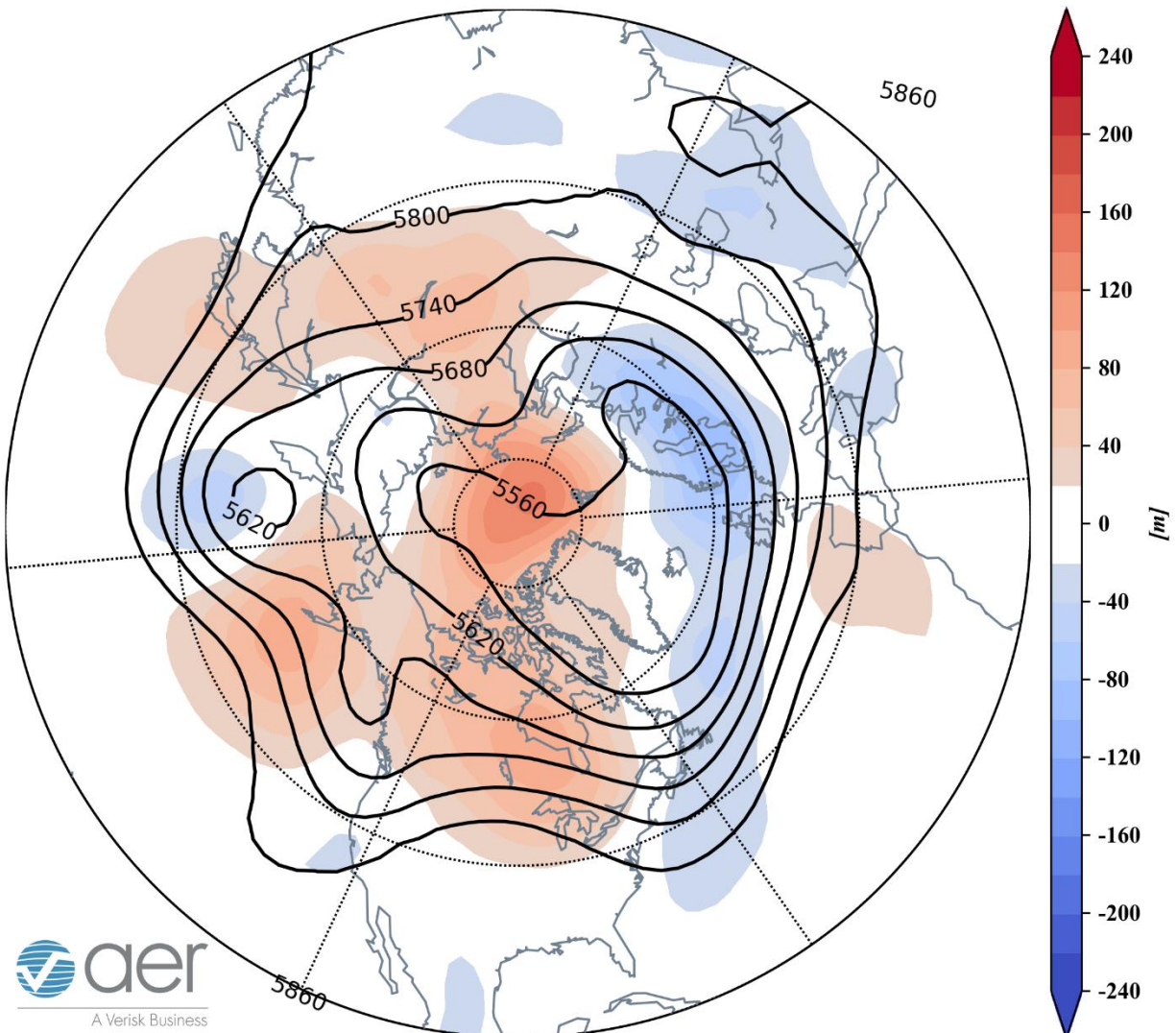


Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation across Northern Europe and Southeastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for the Northern Rockies and the Northeastern US into Nova Scotia (**Figure 7**).

11-15 day

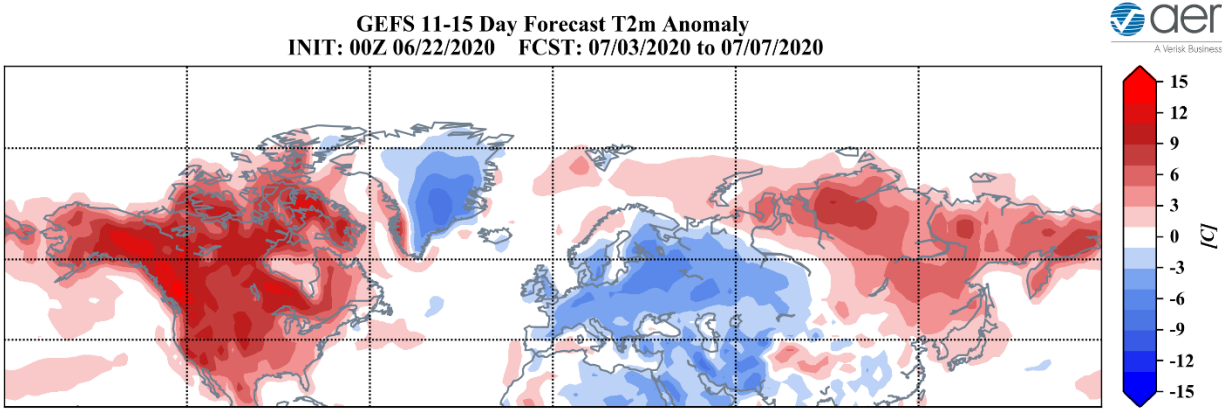
With predicted mostly positive geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO is predicted to be weakly negative this period (**Figure 1**). With weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to be weakly negative as well.

**GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly**  
INIT: 00Z 06/22/2020 FCST: 07/03/2020 to 07/07/2020



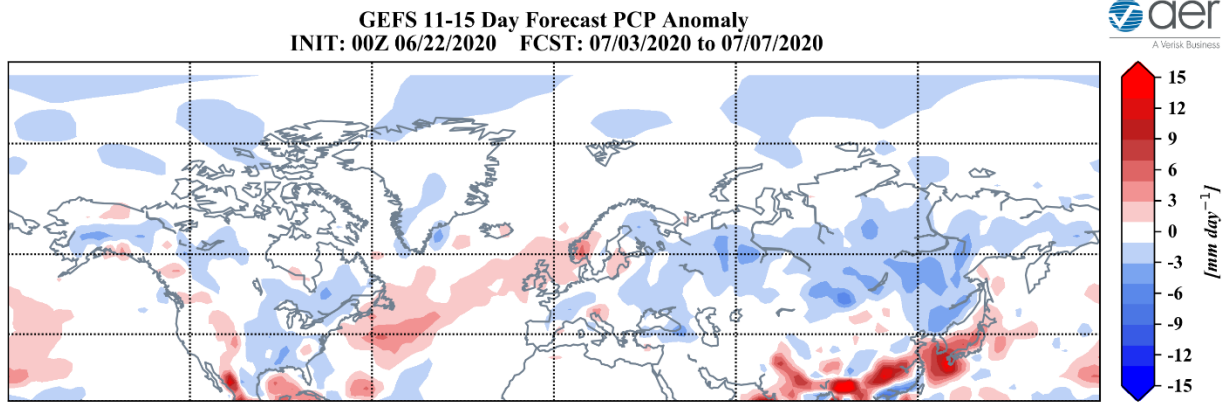
**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 July 2020. The forecasts are from the 00z 22 June 2020 GFS ensemble.

Trouching/negative geopotential height anomalies are predicted to dominate Europe this period but focused across Northern Europe (**Figures 8**). The forecast is for normal to below normal temperatures across Northern Europe including the UK with normal to above normal temperatures across Southern Europe this period (**Figures 9**). The general pattern is predicted to remain ridging/positive geopotential height anomalies across Eastern Asia with troughing/negative pressure/geopotential height anomalies in Western Asia this period, though the ridging is predicted to become more widespread (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Northern and Eastern Asia with normal to below normal temperatures in Western Asia (**Figure 9**). Some weak troughing/negative geopotential height anomalies across the Northern India subcontinent will favor normal to below normal temperatures in the region (**Figures 8 and 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 3 – 7 July 2020. The forecasts are from the 00z 22 June 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate North America with regional troughing/negative geopotential height anomalies along the US West and the Canadian Maritimes (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, Canada and the Interior US with normal to below normal temperatures for the US West Coast and parts of the Southeastern US (**Figure 9**).



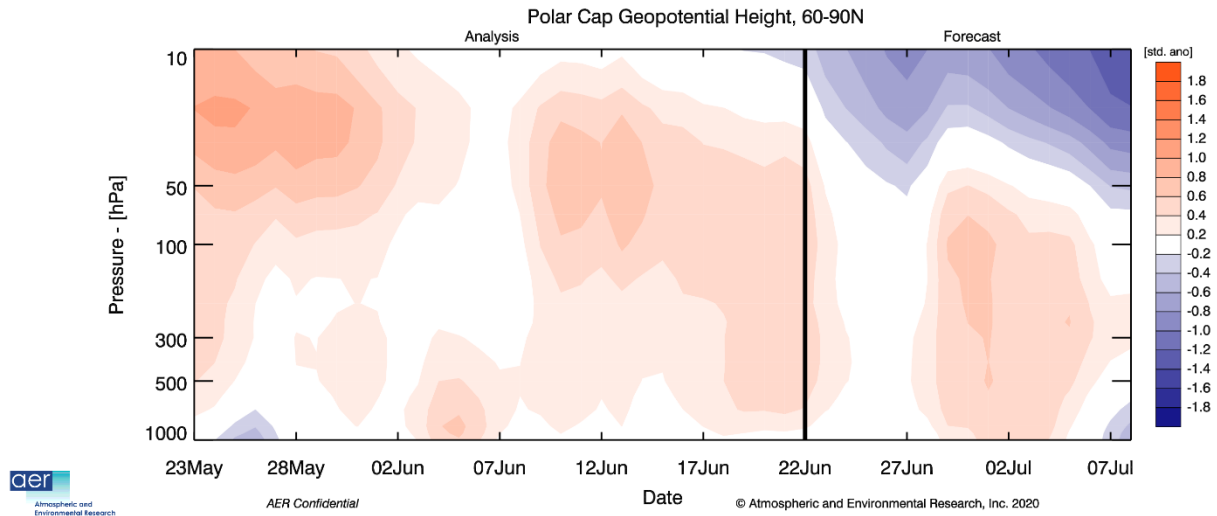
**Figure 10.** Forecasted precipitation anomalies (mm/day; shading) from 3 – 7 July 2020. The forecasts are from the 00z 22 June 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Northern Europe and Southeast Asia (**Figure 10**). Normal to below normal precipitation is predicted for much North America except for above normal precipitation lee of the Rockies and the Canadian Maritimes (**Figure 10**).

### *Longer Term*

#### *30-day*

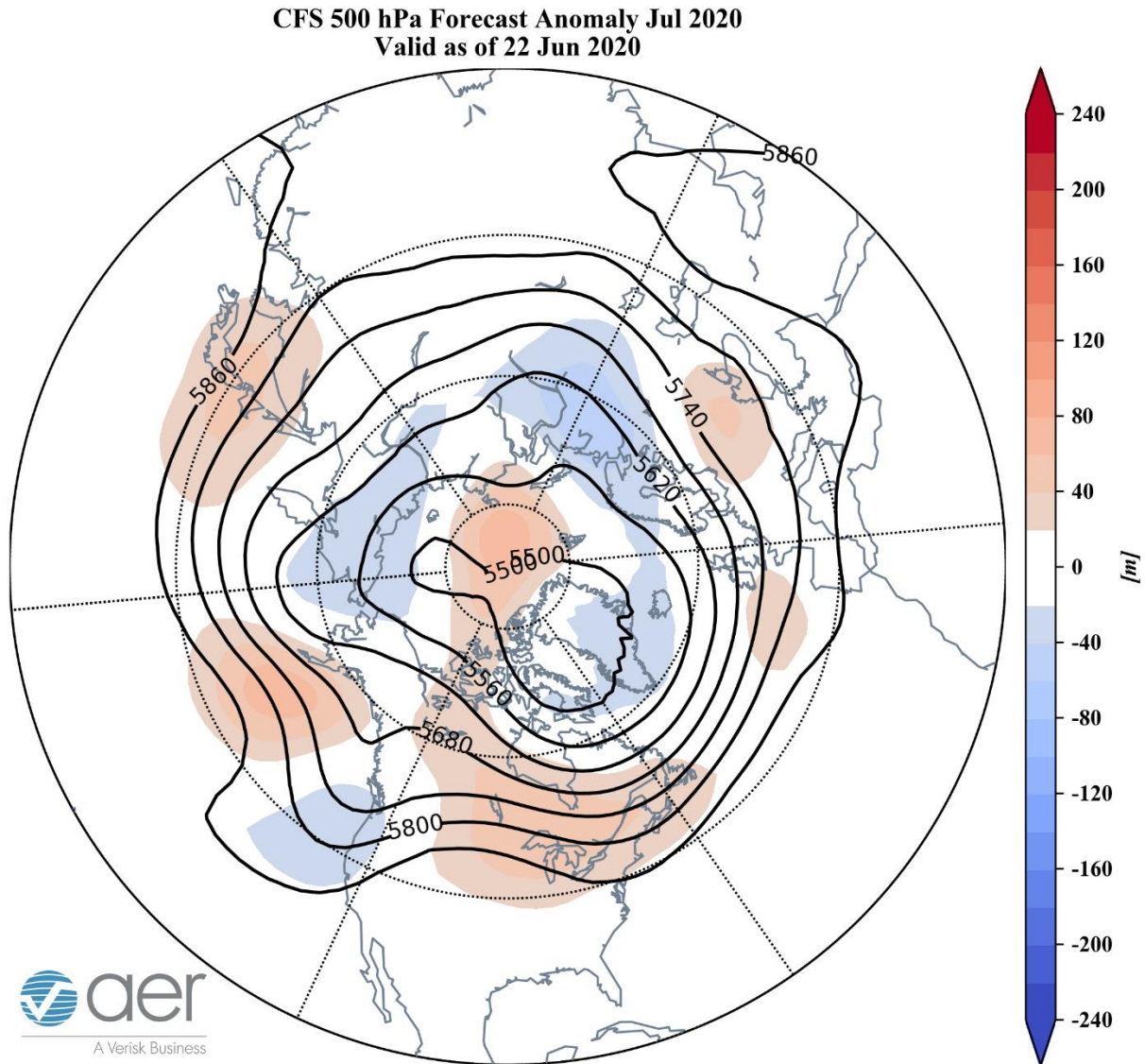
The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to above normal PCHs in both the troposphere and the stratosphere (**Figure 11**). However, PCHs in the stratosphere are predicted to reverse to normal to below normal starting this week while PCHs in the troposphere are predicted to remain mostly positive (**Figure 11**). The GFS forecasts of a reversal to cold stratospheric PCHs have been overdone much of the spring but cold PCHs are already being observed in the mid-stratosphere and are likely to deepen.



**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 22 June 2020 GFS operational run.

The normal to above normal PCHs in the lower troposphere are consistent with the predicted neutral to weakly negative AO over the next two weeks (**Figure 1**). I do believe that the overall below normal sea ice and Arctic warming favor mostly normal to above normal PCHs in the troposphere throughout the summer months, with typical synoptic timescale variability.

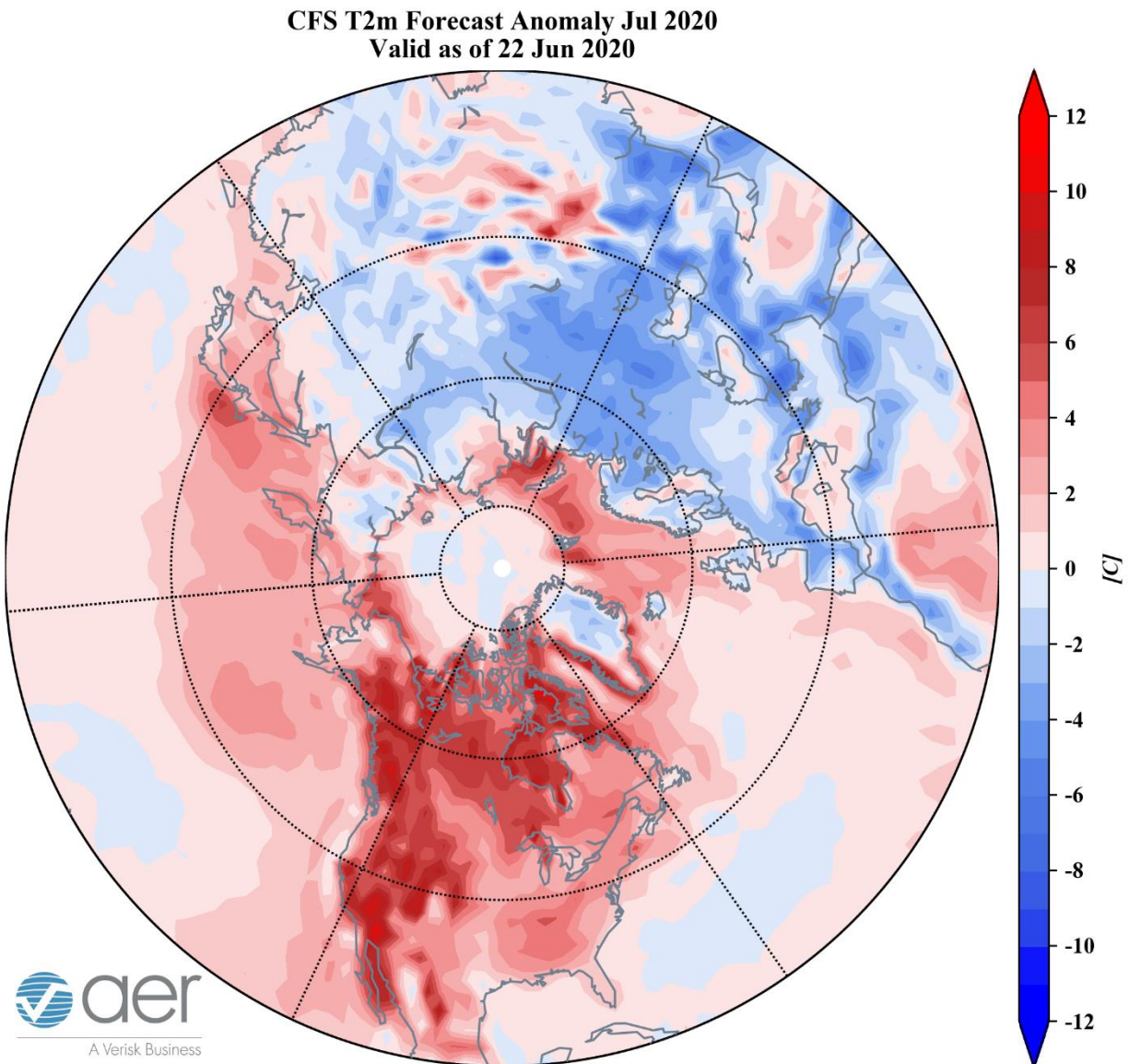




**Figure 12.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2020. The forecasts are from the 00Z 22 June 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for July from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging in the Central Arctic, Eastern Europe, East Asia, the Gulf of Alaska and much of Canada and the Central US with weak troughing in the Eastern Mediterranean, Western Asia, Eastern Siberia, the US West Coast and Greenland (**Figure 12**). This pattern favors relatively warm temperatures for Europe, much of Northern and Eastern Asia, Alaska, much of Canada and the US with seasonable to relatively cool temperatures for Western Asia, Eastern Siberia and the US West Coast (**Figure**

13). There is a clear cold bias in the temperature plot across Eurasia and probably a warm bias across North America.



**Figure 13.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for July 2020. The forecasts are from the 00Z 22 June 2020 CFS.

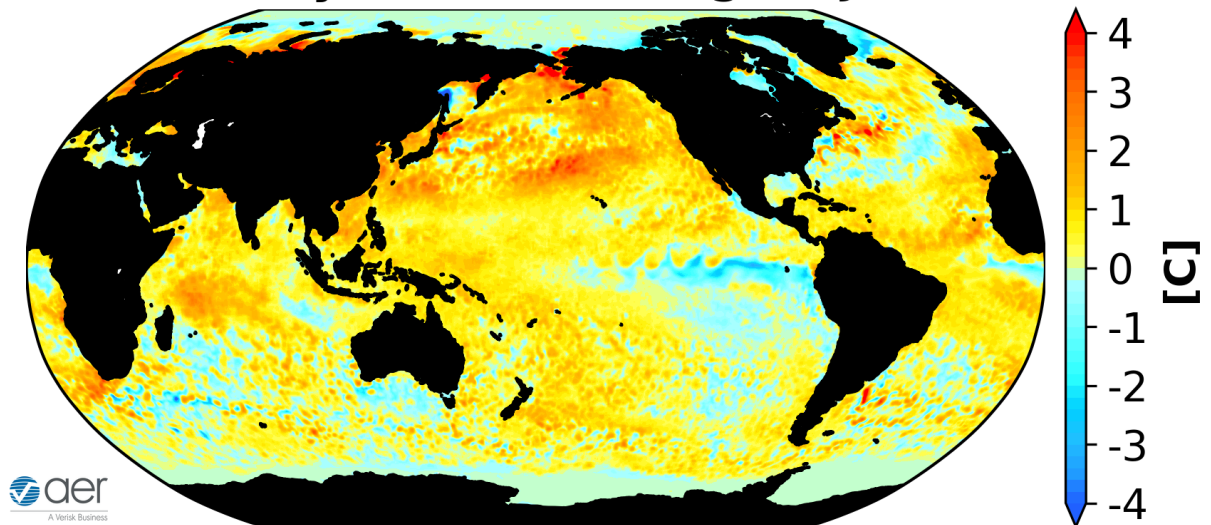
*Surface Boundary Conditions*

*SSTs/El Niño/Southern Oscillation*

Equatorial Pacific sea surface temperatures (SSTs) anomalies continue to cool slowly but neutral El Niño/Southern Oscillation (ENSO) conditions seem most likely this

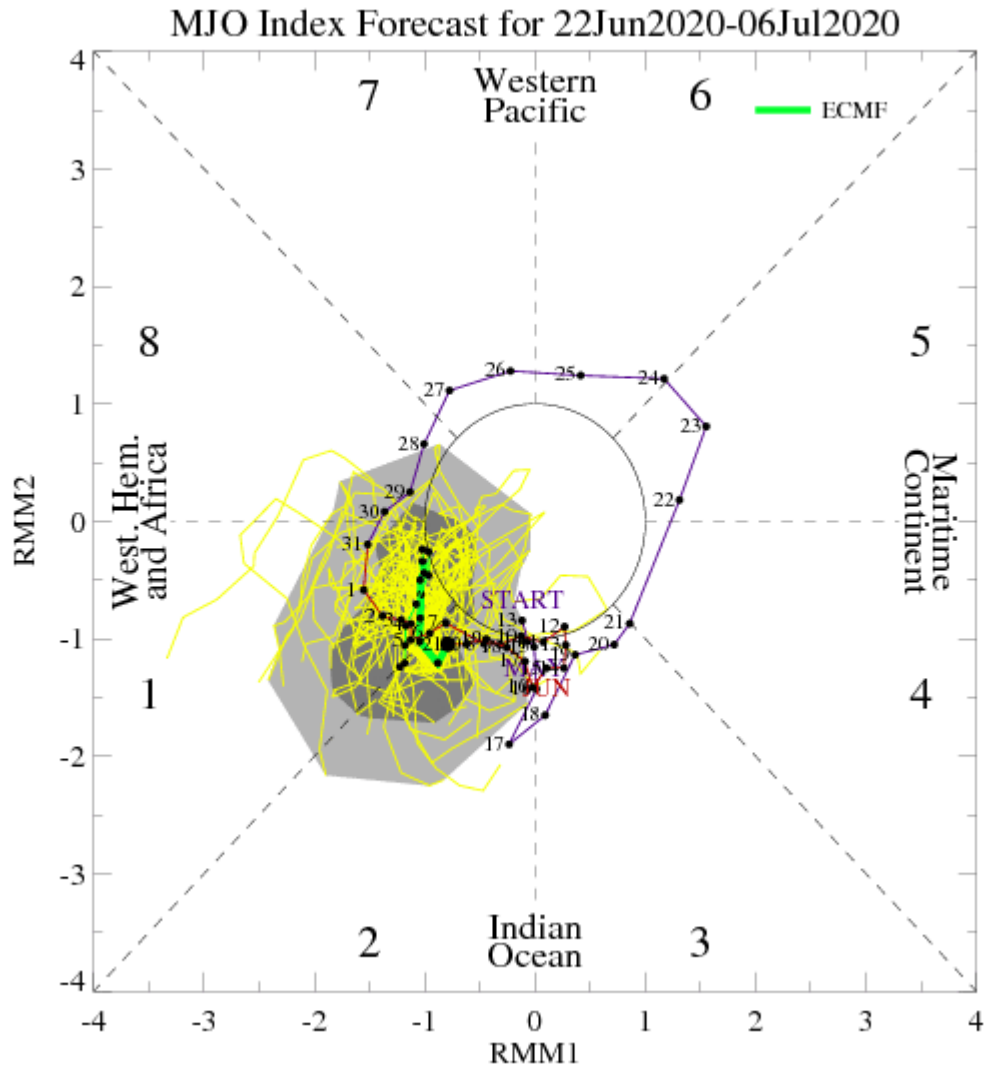
summer (**Figure 14**) though a La Niña is expected by this winter. Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska and the western North Pacific though below normal SSTs exist regionally especially west of South America and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

## SST Anomaly - Week Ending 19 Jun 2020



**Figure 14.** The latest weekly-mean global SST anomalies (ending 19 June 2020). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase one (**Figure 15**). The forecasts are for the MJO to stall in phase one. MJO phase one favors initially favors ridging across the interior of Canada and then transitioning to troughing in Central and Western Canada. There is not much evidence that the MJO is contributing to the weather patterns across North America in the next two weeks.



**Figure 15.** Past and forecast values of the MJO index. Forecast values from the 00Z 22 June 2020 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>