

Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 3, 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 also neutral with weak pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to first trend positive and then negative the next two weeks as pressure/geopotential height anomalies turn negative this week but then positive next week across Greenland.

- Troughing/negative geopotential height anomalies with normal to below normal temperatures are predicted for Southcentral Europe this week but in general the predicted weather pattern for Europe including the United Kingdom (UK) the next two weeks is ridging/positive geopotential height anomalies with normal to above normal temperatures.
- The predicted pattern for Asia this week is ridging/positive geopotential height anomalies with normal to above normal temperatures across much of Asia but especially Northern Asia with regional troughing/negative geopotential height anomalies with normal to below normal temperatures in Eastern Siberia and the Caspian Sea region. However, for next week ridging/positive geopotential height anomalies with above normal temperatures are predicted to consolidate in Eastern Asia, with troughing/negative geopotential height anomalies with normal to below normal temperatures in Western Asia.
- The general pattern for North America the next two weeks, is ridging/positive geopotential height anomalies with normal to above normal temperatures from the Rockies eastward and troughing/negative geopotential height anomalies accompanied by normal to below normal temperatures in western North America. One exception will be this week with predicted troughing/negative geopotential height anomalies and normal to below normal temperatures in the Central United States (US).
- In the Impacts section I discuss the very warm month of July in the Arctic and implications for the mid-latitude continents of the Northern Hemisphere (NH).

Impacts

The heat dome that originated over Siberia in June moved into the Central Arctic for July. It brought record warm temperatures to the Central Arctic during July (see **Figure i**; in the lower troposphere though I do not know if this is true at the surface) and record low sea ice extent for the month of according to Dr. Zack Labe (Twitter @ZLabe). One region of the globe that is often inversely related to Arctic weather, at least in winter, is Europe. The relationship is not as strong in summer but this summer it certainly seems to be. The Arctic and Europe have been inversely related for much of this summer. During July the Arctic was dominated by strong high pressure and warm temperatures while Europe has been dominated by low pressure and relatively cool temperatures especially compared to recent summers. The high pressure across the Arctic is weakening for August allowing for relatively cooler temperatures while high pressure strengthens across Europe with warmer temperatures. These trends across both the Arctic and Europe look to continue for much of August.

925 hPa TEMPERATURE ANOMALY : JULY 2020

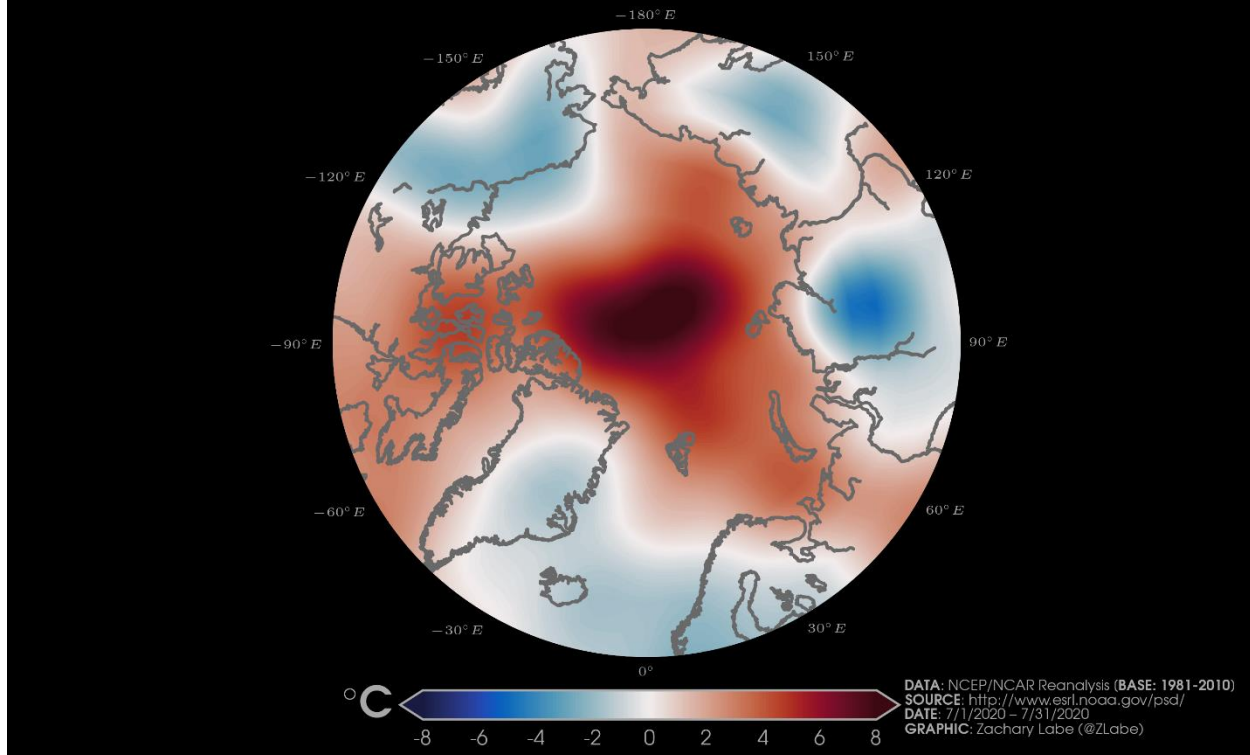


Figure i. Observed temperature anomalies at 925 hPa from 1 July - 31 July 2020 from the NCEP/NCAR reanalysis. Plot posted @ZLabe (Dr. Zack Labe).

High pressure and warm temperatures in the Arctic have accelerated Arctic sea ice melt and contributed to July Arctic sea ice achieving record low extent. However, the change in the circulation in the Arctic from high to low pressure may be just enough to prevent an all-time record low extent but it will be close. Extrapolation of current sea ice trends puts the annual sea ice minimum between the all-time low of 2012, last year and 2007 (see **Figure ii**). It will depend on the ability of general lower heights and pressure to persist in the Central Arctic and whether there are any strong cyclones that mechanically destroy sea ice. As I tweeted out this morning, the lack of sea ice and even clouds allowing for solar radiation to be absorbed into the ocean, is adding much heat content into the Arctic ocean. This heat will be pulled back into the atmosphere once the air temperatures cool lower than ocean temperatures starting in October. It remains a matter of debate, but all that extra heat added into the Arctic atmosphere may alter the Arctic circulation and even mid-latitude circulation through weakening of the polar vortex, but we are a long way off from any such impacts.

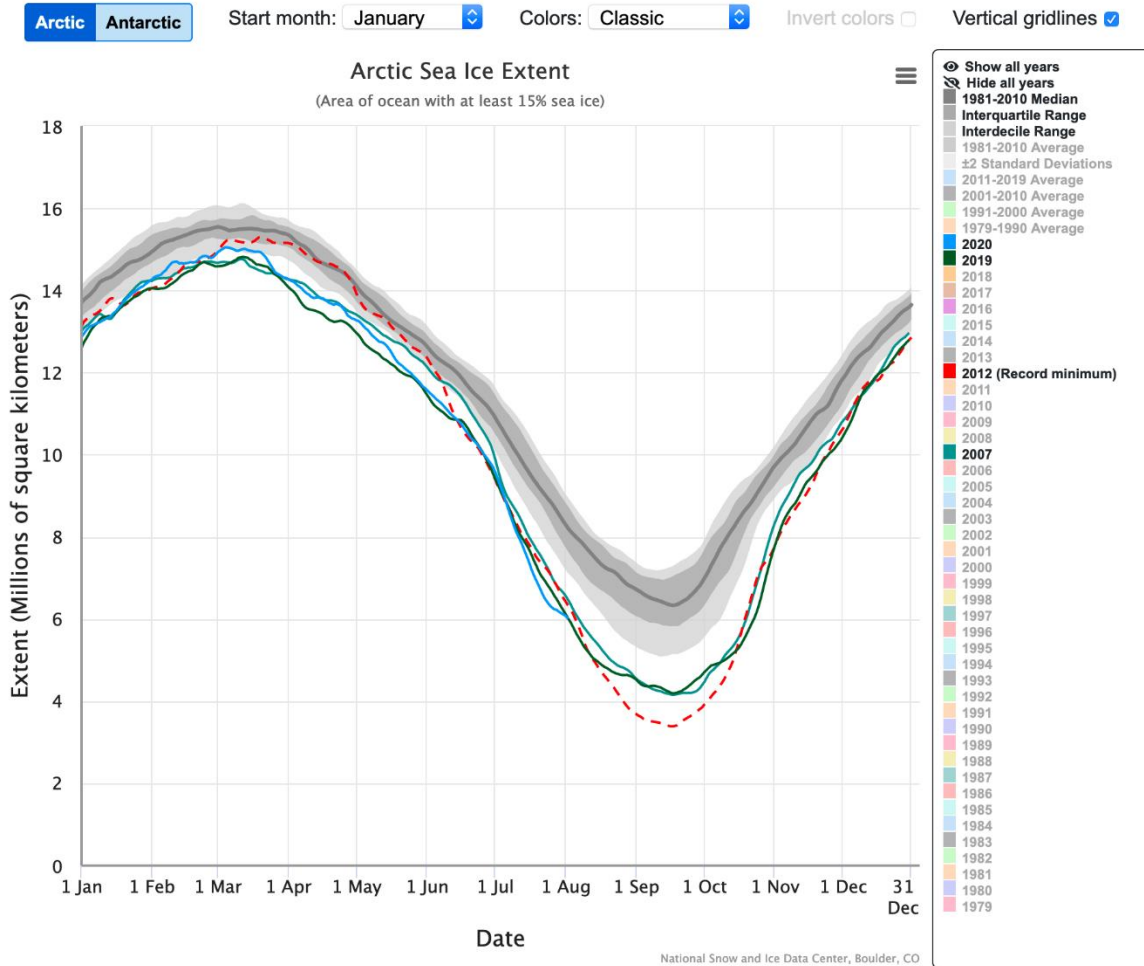


Figure ii. Daily mean Arctic sea ice extent (black line) and variability (gray shading). Also shown are the curves of sea ice extent for 2007 (light green), 2012 (red dashed), 2019 (dark green) and 2020 (blue). Plot created at <https://nsidc.org/arcticseaicenews/>.

Though there is a clear transition in the general circulation for both the Arctic and Europe, the forecasts for North America are predicting a persistence of the same pattern. Troughing along the west coast of North America will continue to anchor a heat dome of high pressure and relatively warm temperatures from the Rockies eastward. A hot July looks to be followed by a warm August as well.

1-5 day

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

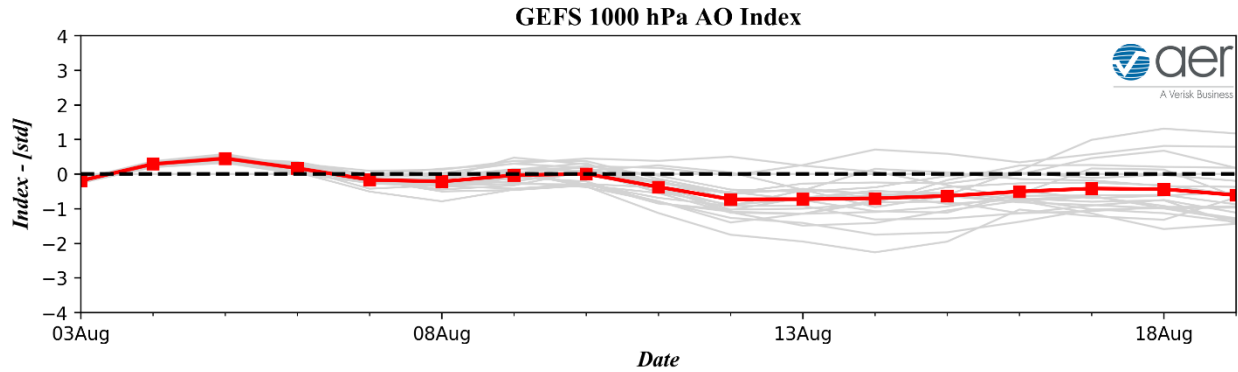


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 3 August 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, as ridging/positive geopotential height anomalies in the Central Arctic abate, troughing/negative geopotential height anomalies with normal to below normal temperatures in Europe will recede to Southcentral Europe as ridging/positive geopotential height anomalies and normal to above normal temperatures overspread Northern Europe including the UK (**Figures 2 and 3**). Across Asia, ridging/positive geopotential height anomalies will dominate much of Asia but especially cross Northern Asia with troughing/negative geopotential height anomalies mostly confined to Eastern Siberia and the Caspian Sea region (**Figure 2**). This pattern favors normal to above normal temperatures for much of Asia except for normal to below normal temperatures in Eastern Siberia and the countries that border the Caspian Sea (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/03/2020 FCST: 08/04/2020 to 08/08/2020

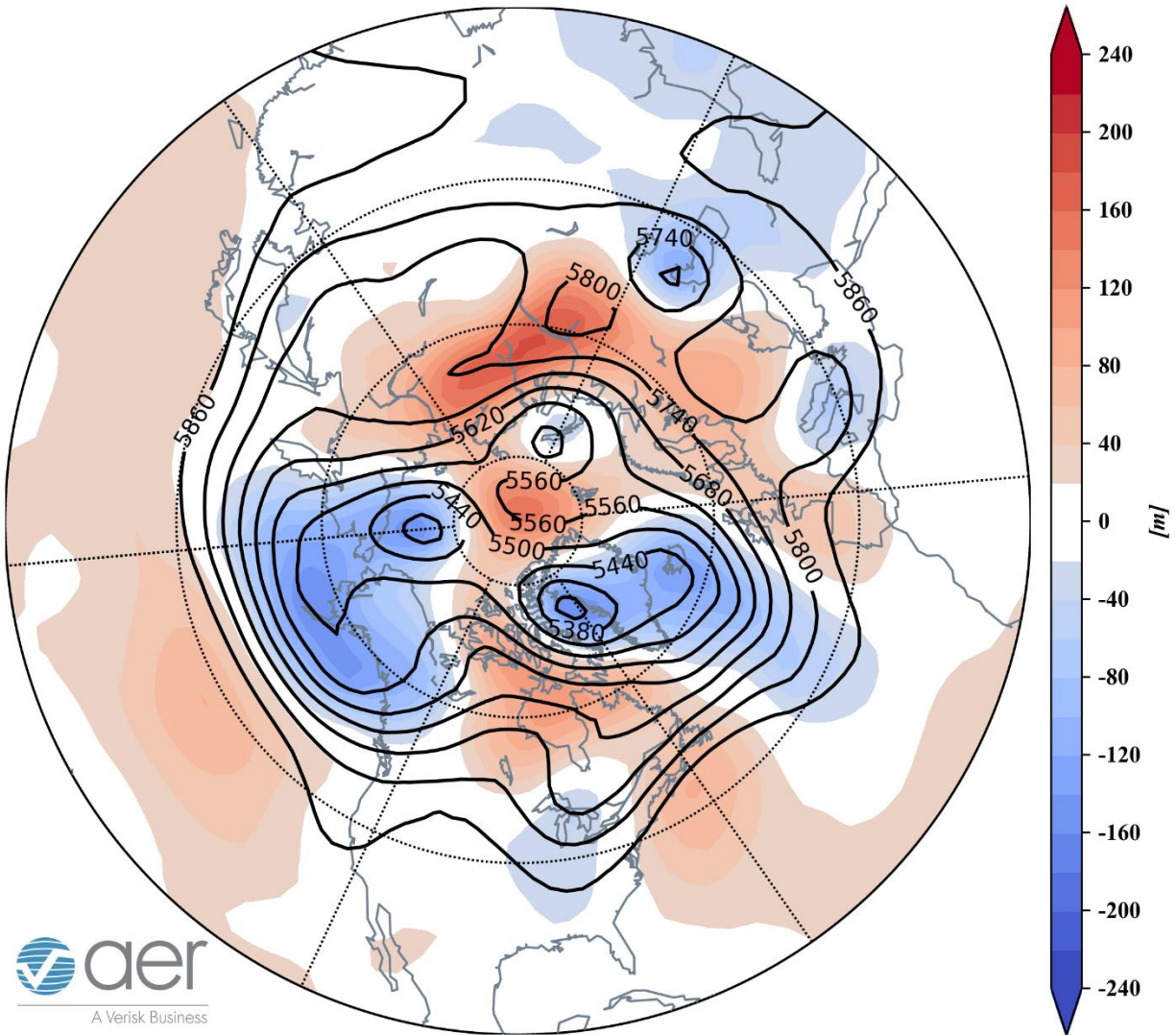


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 4 – 8 August 2020. The forecasts are from the 00z 3 August 2020 GFS ensemble.

This week, troughing/negative geopotential height anomalies along the entire length of the west coast of North America will favor ridging/positive geopotential height anomalies in Eastern Canada and the US East Coast with more regional troughing in the Great Lakes (**Figure 2**). This pattern is predicted to bring normal to below normal temperatures across Alaska, Western Canada and the US West Coast with normal to above normal temperatures for much of Eastern Canada, the US Rockies and the US East Coast (**Figure 3**). The weak troughing swinging through the Great Lakes is predicted to bring seasonable to cool temperatures from the Rockies to the Appalachians (**Figures 3**).

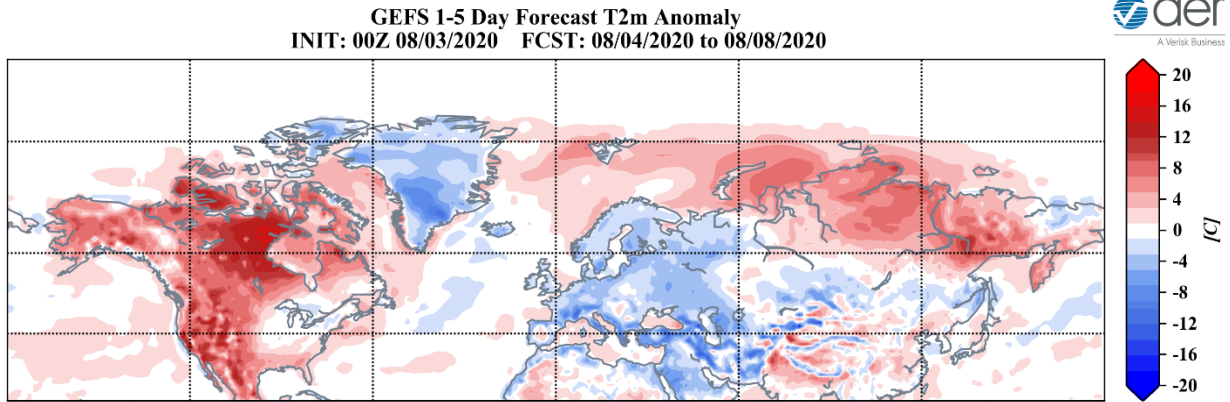


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 4 – 8 August 2020. The forecast is from the 00Z 3 August 2020 GFS ensemble.

Below normal precipitation is predicted for much of Europe and Asia with the exceptions of above normal precipitation in the Adriatic and Caspian Seas region, and East Asia including Japan (**Figure 4**). Below normal precipitation is predicted for much of North America with above normal precipitation for the South Coast of Alaska, the West Coast of Canada, the Pacific Northwest and the US East Coast related to tropical storm Isaias (**Figure 4**).

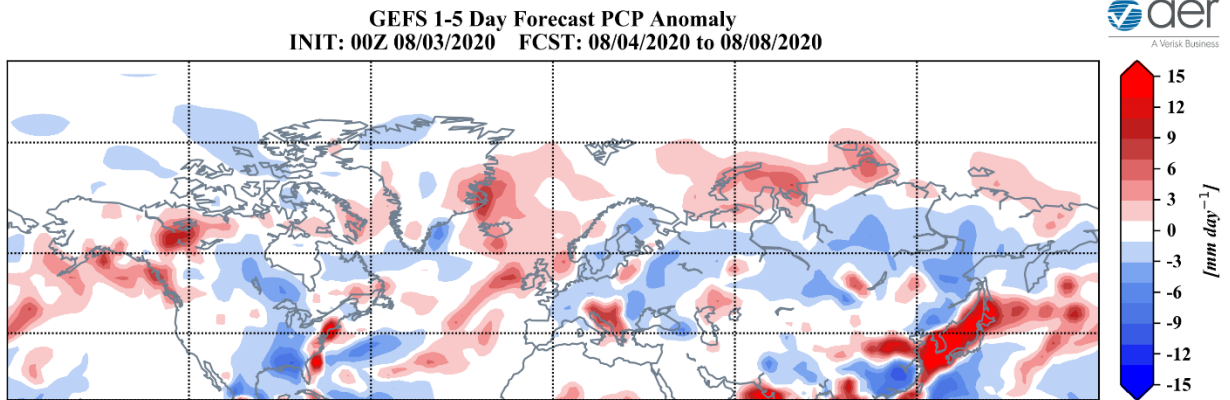


Figure 4. Forecasted precipitation anomalies (mm/day ; shading) from 4 – 8 August 2020. The forecast is from the 00Z 20 July 2020 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain neutral to weakly negative (**Figure 1**) as positive geopotential height anomalies dominate the Central Arctic with negative geopotential

height anomalies in the western Arctic and 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 near neutral to weakly negative as well.

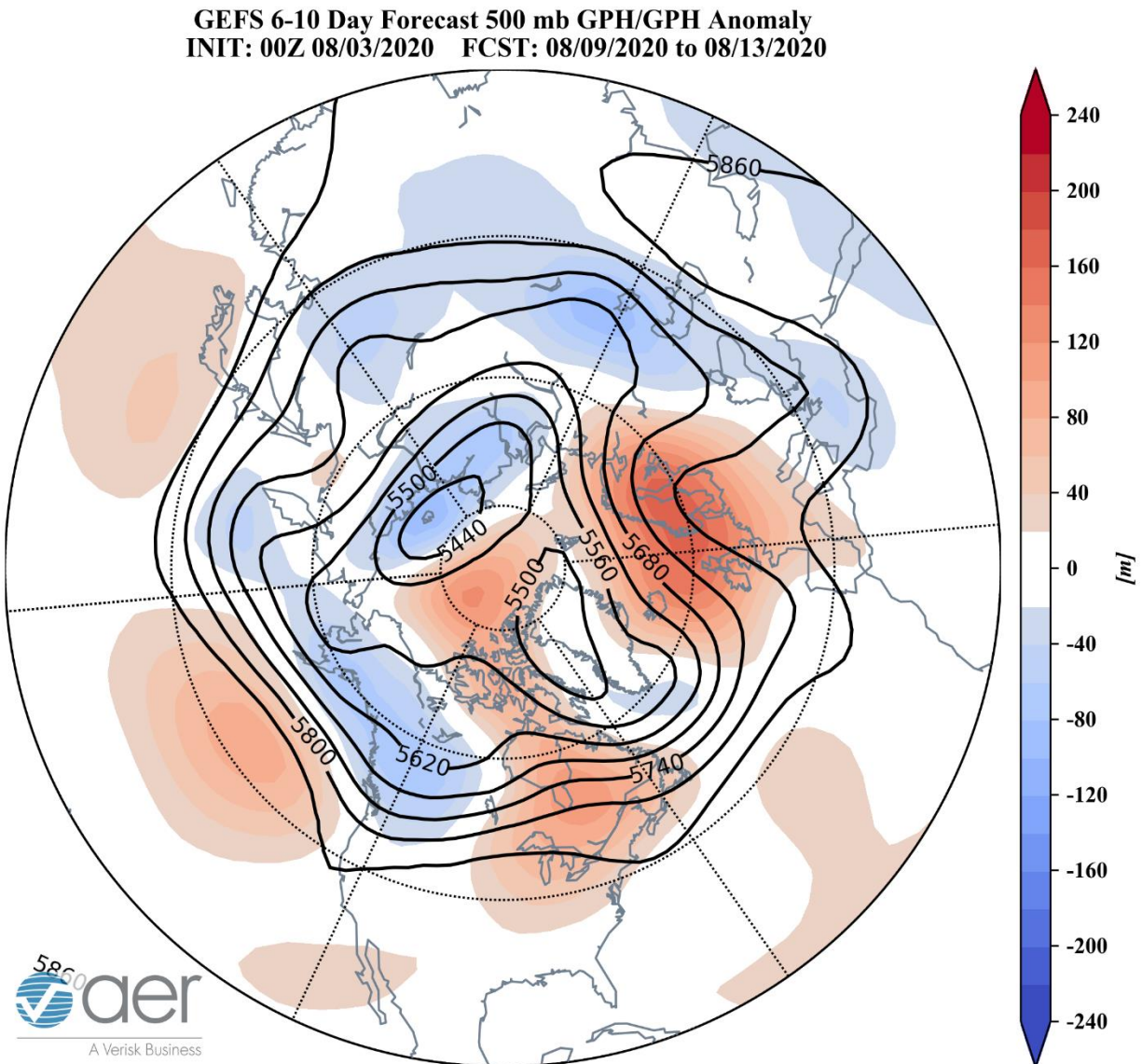


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 August 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

As ridging/positive geopotential height anomalies in the Central Arctic continue to fade, they will strengthen across Europe instead, though troughing/negative geopotential height anomalies from the Caspian Sea will spread into the Eastern Mediterranean (**Figures 5**). This pattern favors normal to above normal across much of Europe

including the UK with the exception of normal to below normal temperatures in the Balkan States (**Figure 6**). Troughing/negative geopotential height anomalies previously in Eastern Siberia and the Caspian Sea will try to merge in Western Asia this period (**Figure 5**). This is predicted to yield normal to below normal temperatures in Western Asia **with** normal to above temperatures In East Asia under broad southwesterly flow (**Figure 6**).

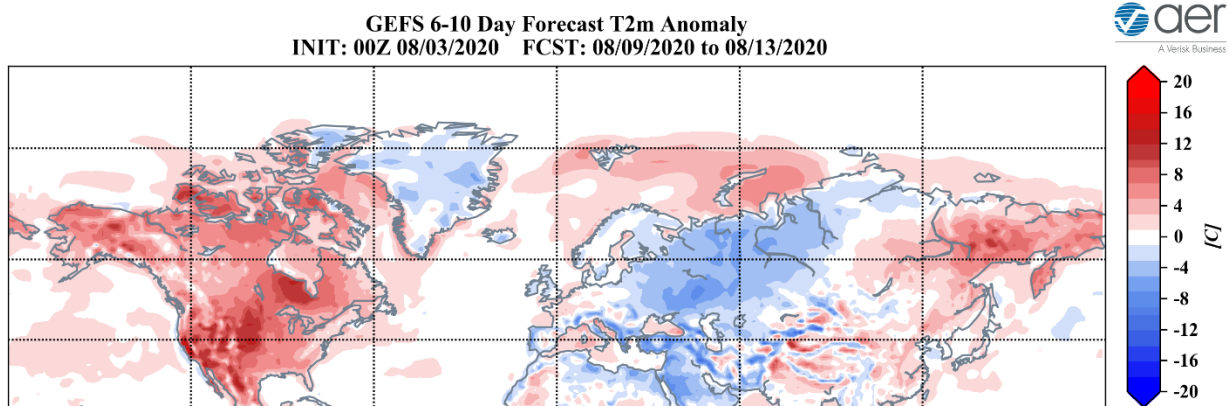


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 9 – 13 August 2020. The forecasts are from the 00Z 3 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate North America from the Rockies eastward anchored by troughing/negative geopotential height anomalies stretching from Alaska and 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**).

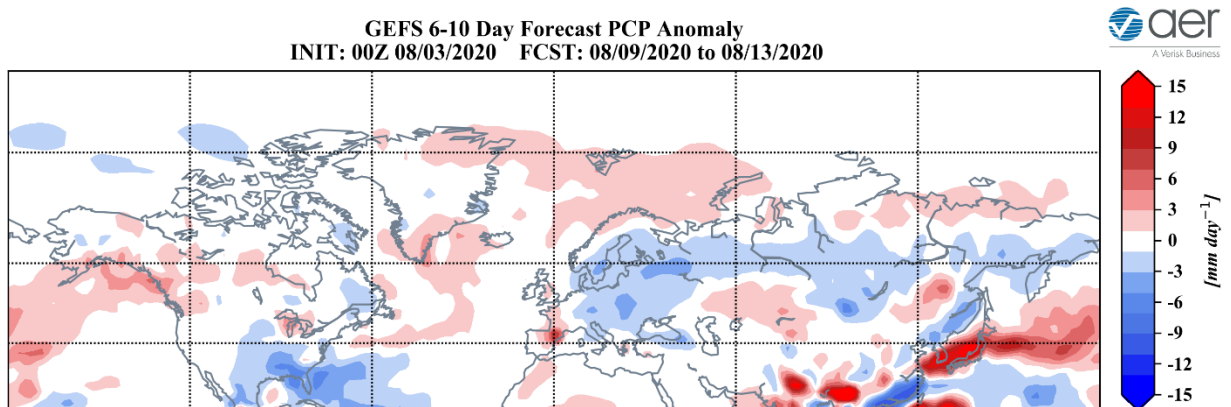


Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 9 – 13 August 2020. The forecasts are from the 00Z 3 August 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation across Spain and especially Southern Asia and Japan (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for Southern Alaska and Western Canada (**Figure 7**).

11-15 day

With mostly positive but weak 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 remain 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 08/03/2020 FCST: 08/14/2020 to 08/18/2020

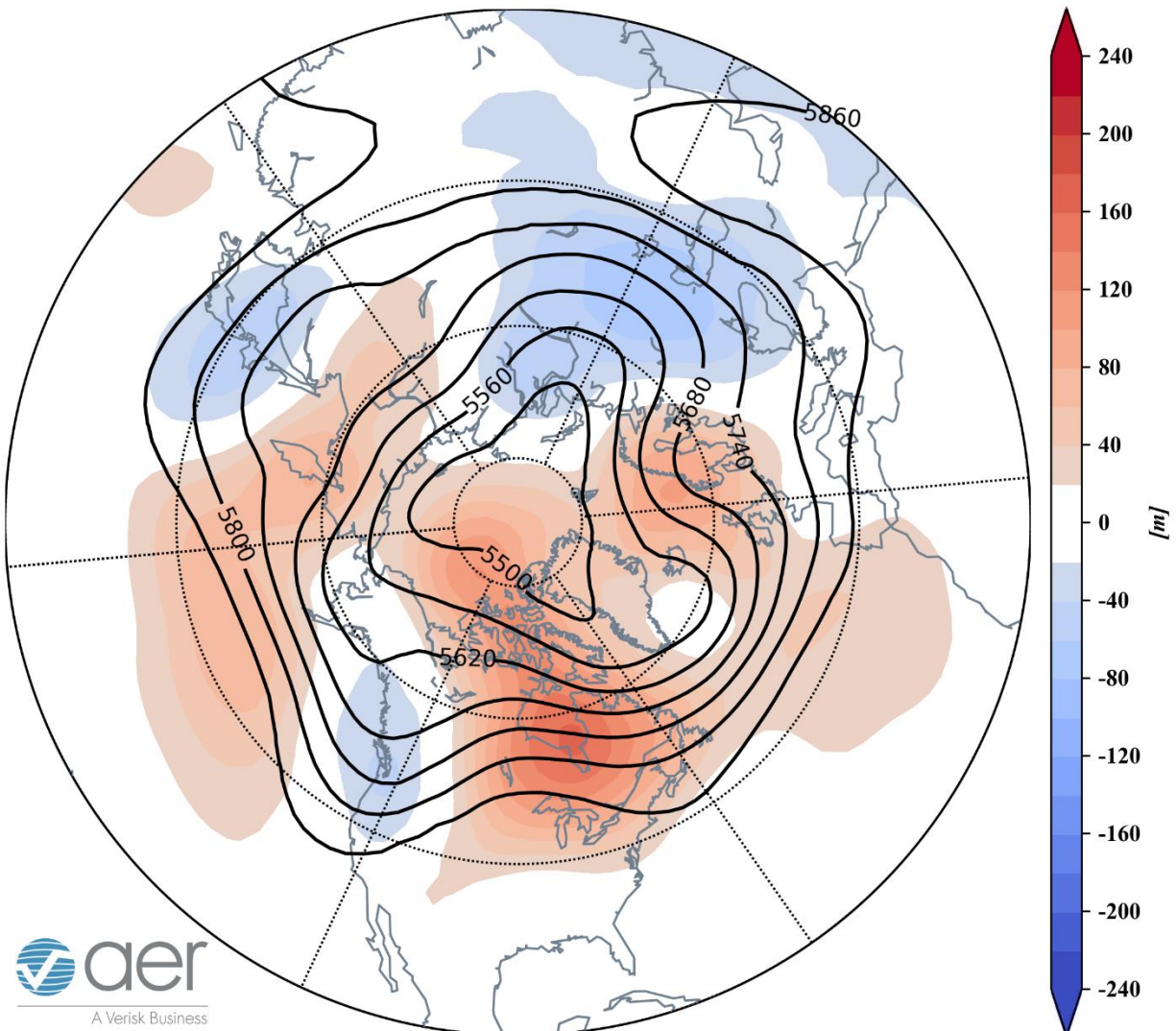


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 August 2020. The forecasts are from the 00z 3 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate Europe but focused near Scandinavia, however troughing/negative geopotential height anomalies retrograding westward from Western Asia are predicted to encroach on Eastern Europe this period (**Figures 8**). The forecast is for normal to above normal temperatures across Western and Central Europe including the UK with normal to below normal temperatures across Eastern Europe this period (**Figures 9**). For Asia, the general predicted pattern is for widespread ridging/positive geopotential height anomalies in Eastern Asia with troughing/negative geopotential height anomalies in Western Asia and much of Southern Asia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Northern and Eastern Asia with normal to below normal temperatures across Western and Southern Asia (**Figure 9**).

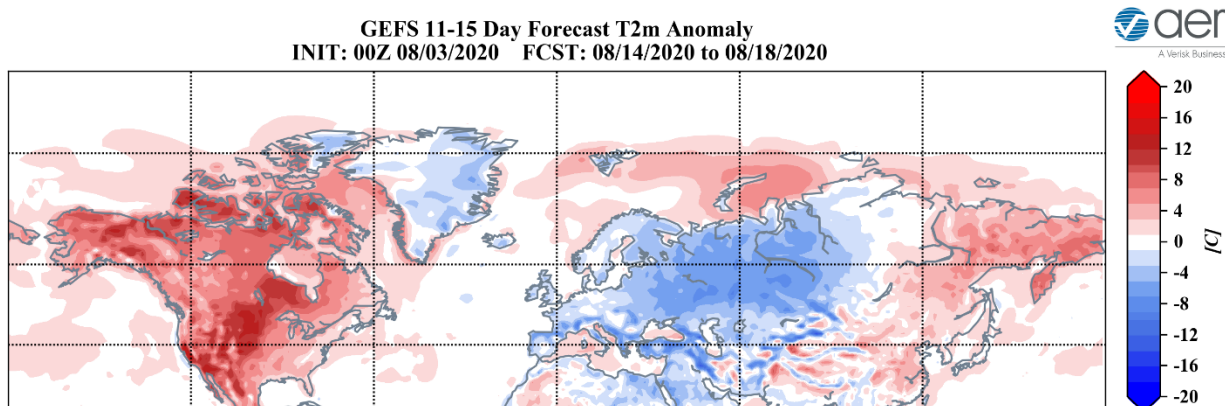


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 14 – 18 August 2020. The forecasts are from the 00z 3 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to strengthen across eastern North America with persistent troughing/negative geopotential height anomalies along the west coast of North America (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, Canada and much of the US from the Rockies eastward with normal to below normal temperatures for the Canadian and US West Coasts (**Figure 9**).

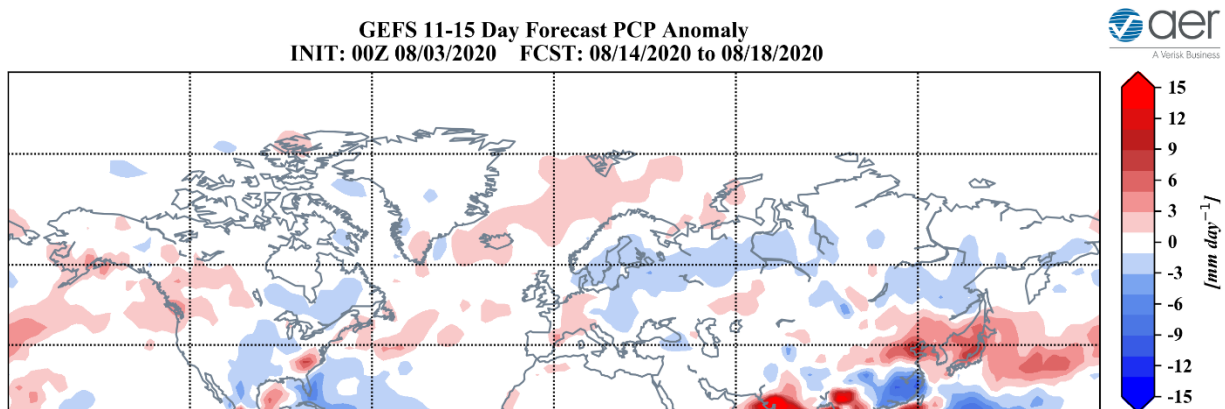


Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 14 – 18 August 2020. The forecasts are from the 00z 3 August 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Western Europe and parts of Southern and East Asia (**Figure 10**). Normal to below normal precipitation is predicted for much of North America except for above normal precipitation for Southern Alaska, Western Canada and the Carolinas (**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 lower stratosphere with normal to below normal PCHs in the mid-stratosphere (**Figure 11**). However, PCHs in the lower stratosphere are predicted to reverse to normal to below normal while PCHs in the troposphere are predicted to remain mostly normal to above normal with the exception right near the surface at the end of this week (**Figure 11**). The GFS forecasts of a reversal to cold stratospheric PCHs have been overdone much of the spring and summer and I wouldn't consider the forecast reliable.

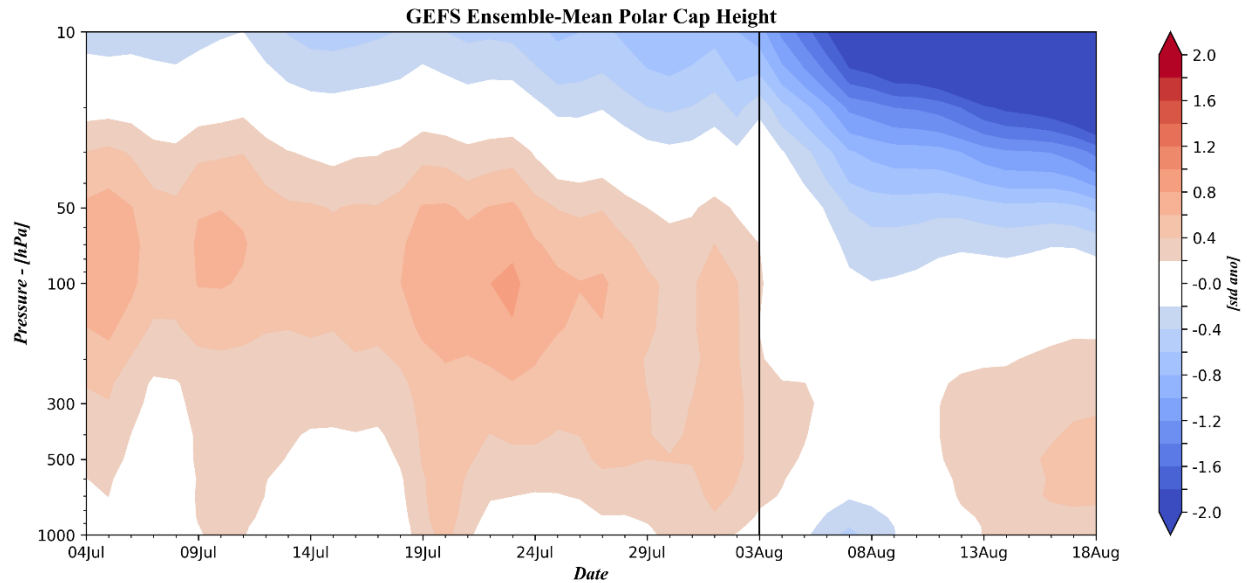


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 3 August 2020 GFS ensemble.

The normal to above normal PCHs in the troposphere are consistent with the predicted neutral to weakly negative AO over the next two weeks with the exception of this week when PCHs are predicted to be negative right near the surface (**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.

CFS 500 hPa Forecast Anomaly Sep 2020
Valid as of 03 Aug 2020

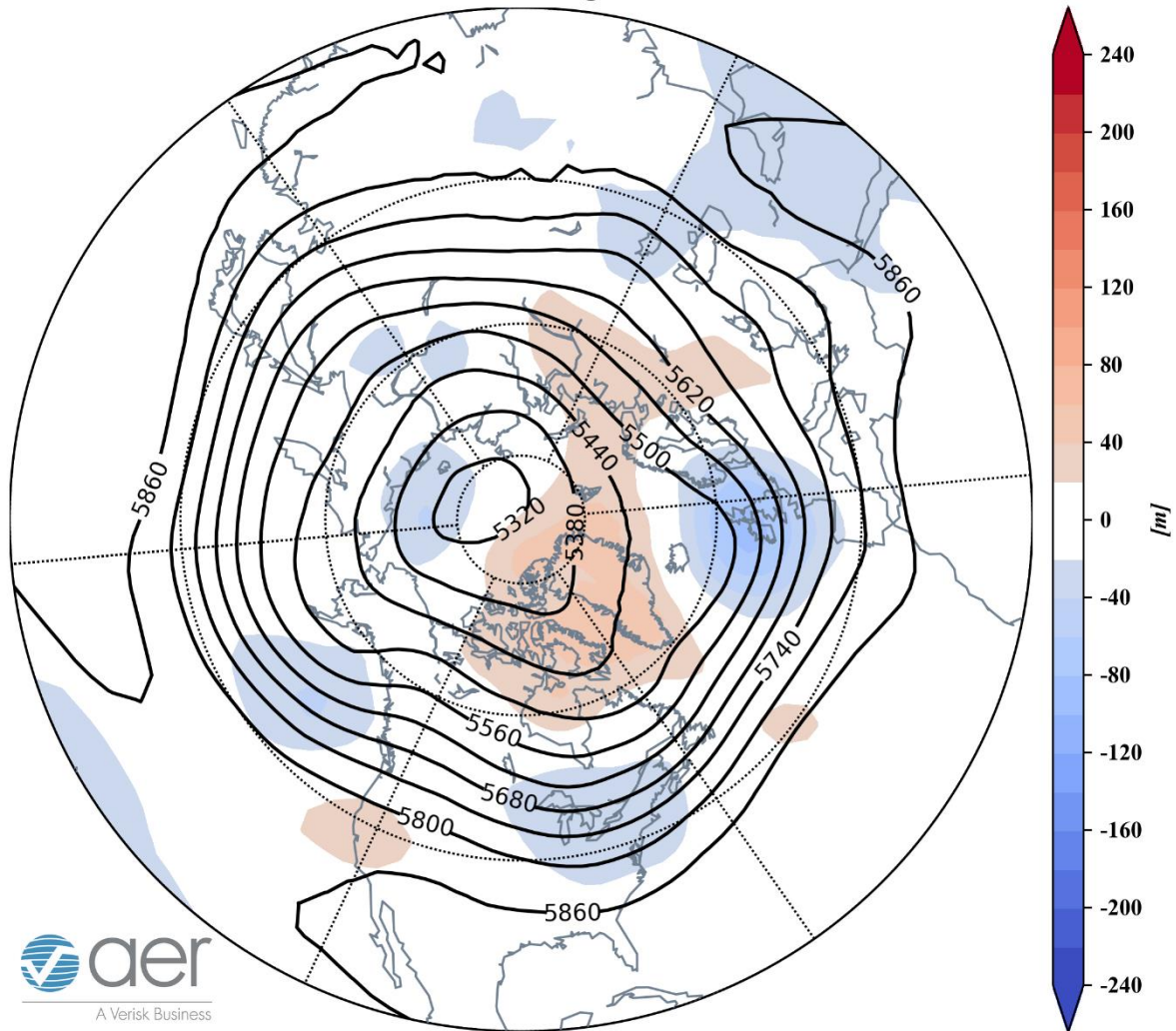


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2020. The forecasts are from the 00Z 3 August 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for September from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging in Northwestern Asia, Eastern Siberia, western North America (albeit very weak) and Greenland with troughing in Western Europe, the Arabian Peninsula, Siberia, the Gulf of Alaska and eastern North America (**Figure 12**). This pattern favors relatively warm temperatures for Eastern Europe, much of Central Asia and western North America with seasonable to relatively cool temperatures for Western Europe, the Middle East, Siberia, Southeastern Canada and the Northeastern US (**Figure**

13). We have made adjustments to the CFS forecasts that hopefully resolve many of the previous biases in the plots.

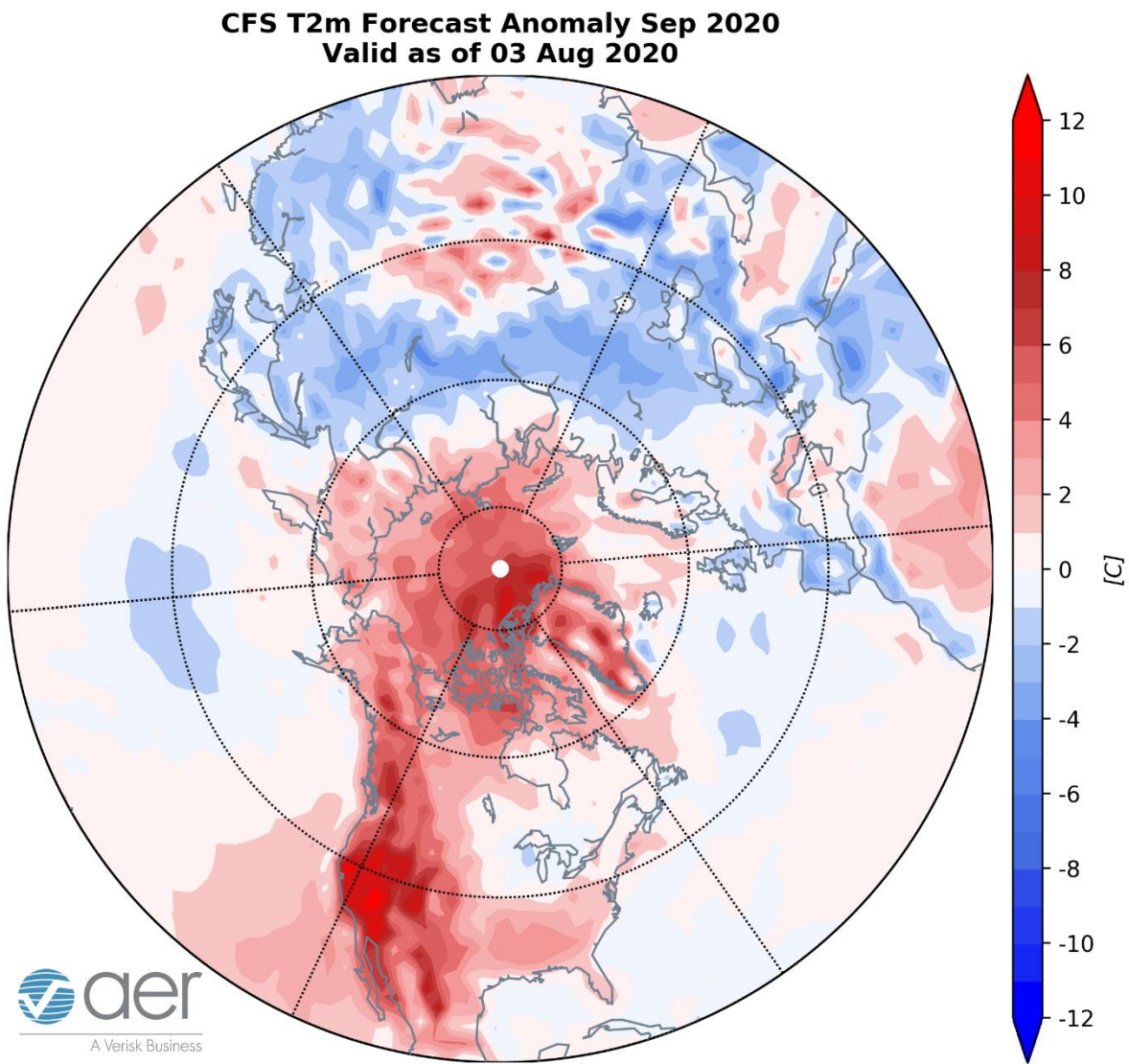


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for August 2020. The forecasts are from the 00Z 20 July 2020 CFS.

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 fall. 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 in the Southern Hemisphere and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

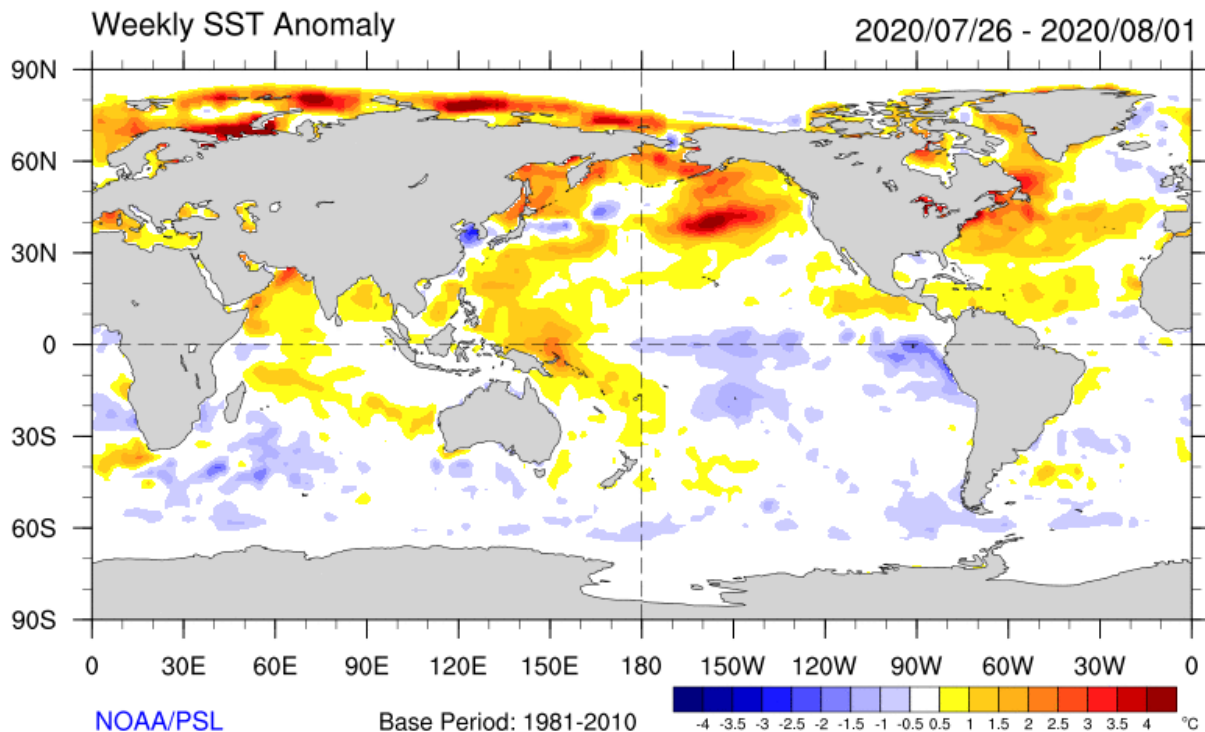


Figure 14. The latest weekly-mean global SST anomalies (ending 1 August 2020). Data from NOAA OI High-Resolution dataset copied from <https://psl.noaa.gov/map/clim/sst.shtml>.

Currently the Madden Julian Oscillation (MJO) is in phase four (**Figure 15**). The forecasts are for the MJO to weaken where no MJO phase is favored. MJO phase four initially favors ridging in the Eastern US and troughing in the Western US. The MJO could be contributing to the short term pattern across North America.

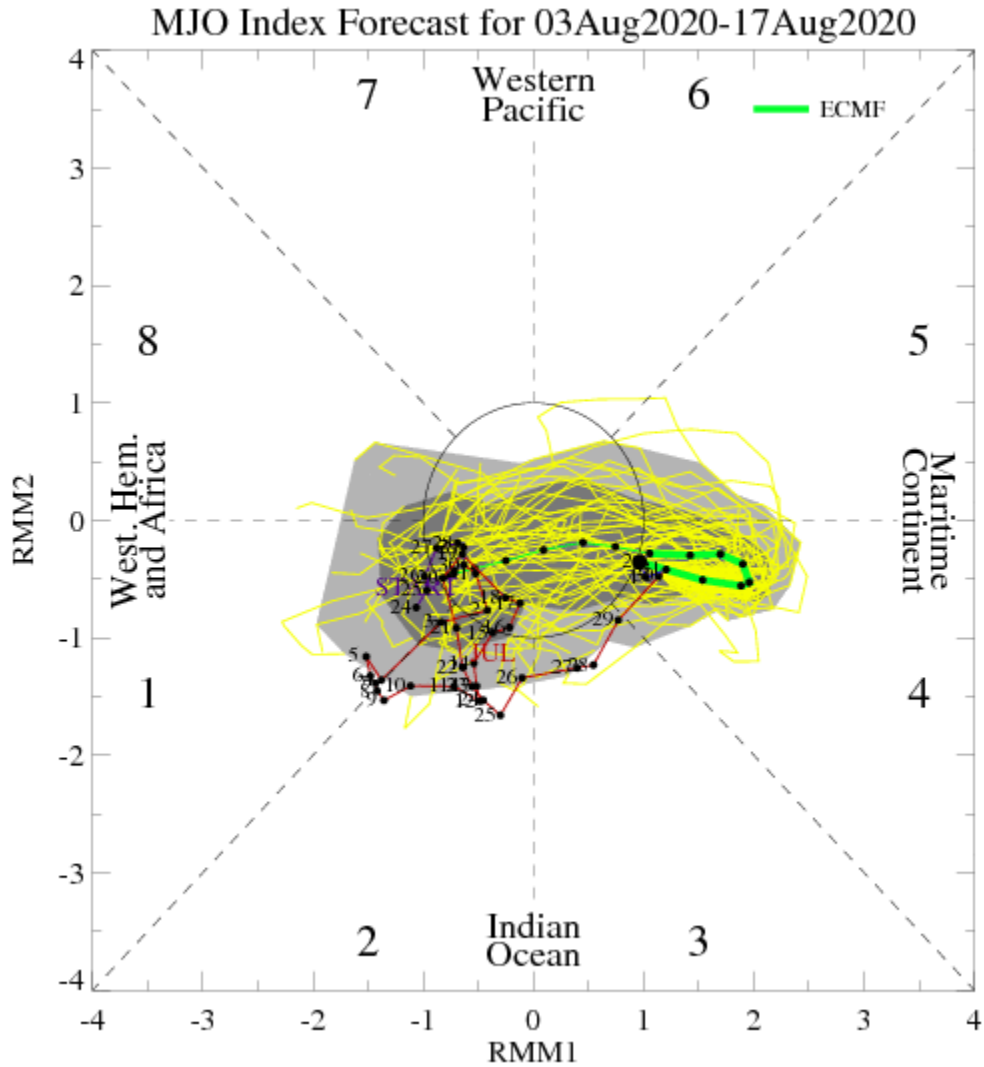


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 3 August 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>