

Arctic Oscillation and Polar Vortex Analysis and Forecasts

July 20, 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 slightly negative and is predicted to remain neutral to slightly negative over the next two weeks.
- The current negative AO is reflective of mostly positive 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 negative with weak positive pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to remain negative to near neutral the next two weeks as pressure/geopotential height anomalies remain weakly positive across Greenland.

- The predicted weather pattern for Northern and Central Europe including the United Kingdom (UK) this week is general troughing/negative geopotential height anomalies with normal to below normal temperatures. However, across Southern Europe, ridging/positive geopotential height anomalies will bring normal to above normal temperatures especially Spain, Portugal and the Balkan States.
- The predicted general pattern for Asia this week is ridging/positive geopotential height anomalies with normal to above normal temperatures in Northwestern and Northeastern Asia with troughing/negative geopotential height anomalies with normal to below normal temperatures in Central Asia. However, next week the pattern is predicted to transition to ridging/positive geopotential height anomalies with above normal temperatures becoming more widespread across Asia, with troughing/negative geopotential height anomalies with normal to below normal temperatures limited to far Northeastern and Northwestern Asia.
- The next two weeks, North America from the Rockies eastward will be dominated by ridging/positive geopotential height anomalies and normal to above normal temperatures with the exception this week when a short wave trough/negative geopotential height anomalies accompanied by normal to below normal temperatures will swing through from the Great Lakes into the Canadian Maritimes. For the west coast of North America including the West Coast of the United States (US) the predicted pattern is troughing/negative geopotential height anomalies with normal to below normal temperatures.
- In the Impacts section I discuss the observed temperature pattern across the Northern Hemisphere (NH) so far this summer.

Impacts

With meteorological summer just past the half point, I plotted the observed Northern Hemisphere (NH) surface temperature anomalies for the first half of the summer in **Figure i**. So far this summer widespread above normal temperatures have been observed in the Eastern US, Eastern Canada, Northern and Eastern Europe, the Middle East and East Asia. Below normal temperatures have been observed in the Alaska, Western Canada, the Western US, Western Europe, Central Asia and large parts of Siberia. The plot met my expectations except in Siberia. The anomalous heat in Siberia has been one of the biggest weather stories of the summer, so **Figure i** certainly seems incongruent with the [AER summer forecast](#) and with the [news reporting](#). But I can confidently rule out my own plotting routine which is consistent with plotting the data on the [NOAA website](#). And it is possible there are issues with the reanalysis dataset. I tried to find an online plot from another dataset online but was unsuccessful.

pressures and warmer temperatures in the Central Arctic (and extending over to Greenland) is likely related to relatively cool temperatures in Western Europe, Alaska and Western Canada. The argument that a warm Arctic is related/can contribute to cooler temperatures across the NH continents is almost exclusively applied to the winter season but it seems to me that it can also be applied in the summer season as well as ridging/warm temperatures in the Arctic are related/promote troughing/cooler temperatures downstream across the NH continents. To be clear, the mechanism where Arctic warming can contribute to continental cooling is through the polar vortex. That mechanism does not operate in the summer months.

1-5 day

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

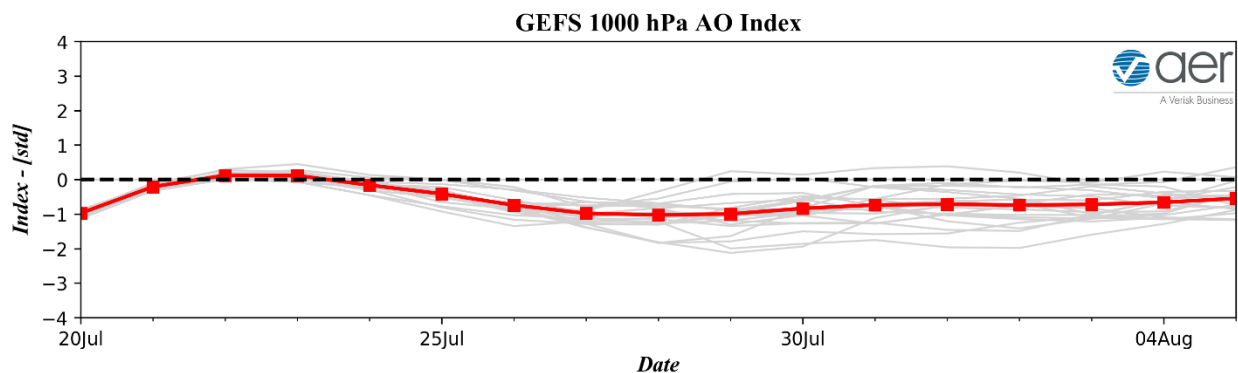


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 20 July 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ongoing ridging/positive geopotential height anomalies in the central Arctic will contribute to favor troughing/negative geopotential height anomalies with normal to below normal temperatures for much of Europe including the UK with the exceptions of ridging/positive geopotential height anomalies and normal to above normal temperatures in Spain, Portugal and in the Eastern Mediterranean (**Figures 2 and 3**). Across Asia, ridging/positive geopotential height anomalies in Northwestern and Northeastern Asia will bookend troughing/negative geopotential height anomalies in Central Asia (**Figure 2**). This pattern favors normal to above normal temperatures across Western and Eastern Siberia with normal to below normal temperatures in Central and Southern Asia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 07/20/2020 FCST: 07/21/2020 to 07/25/2020

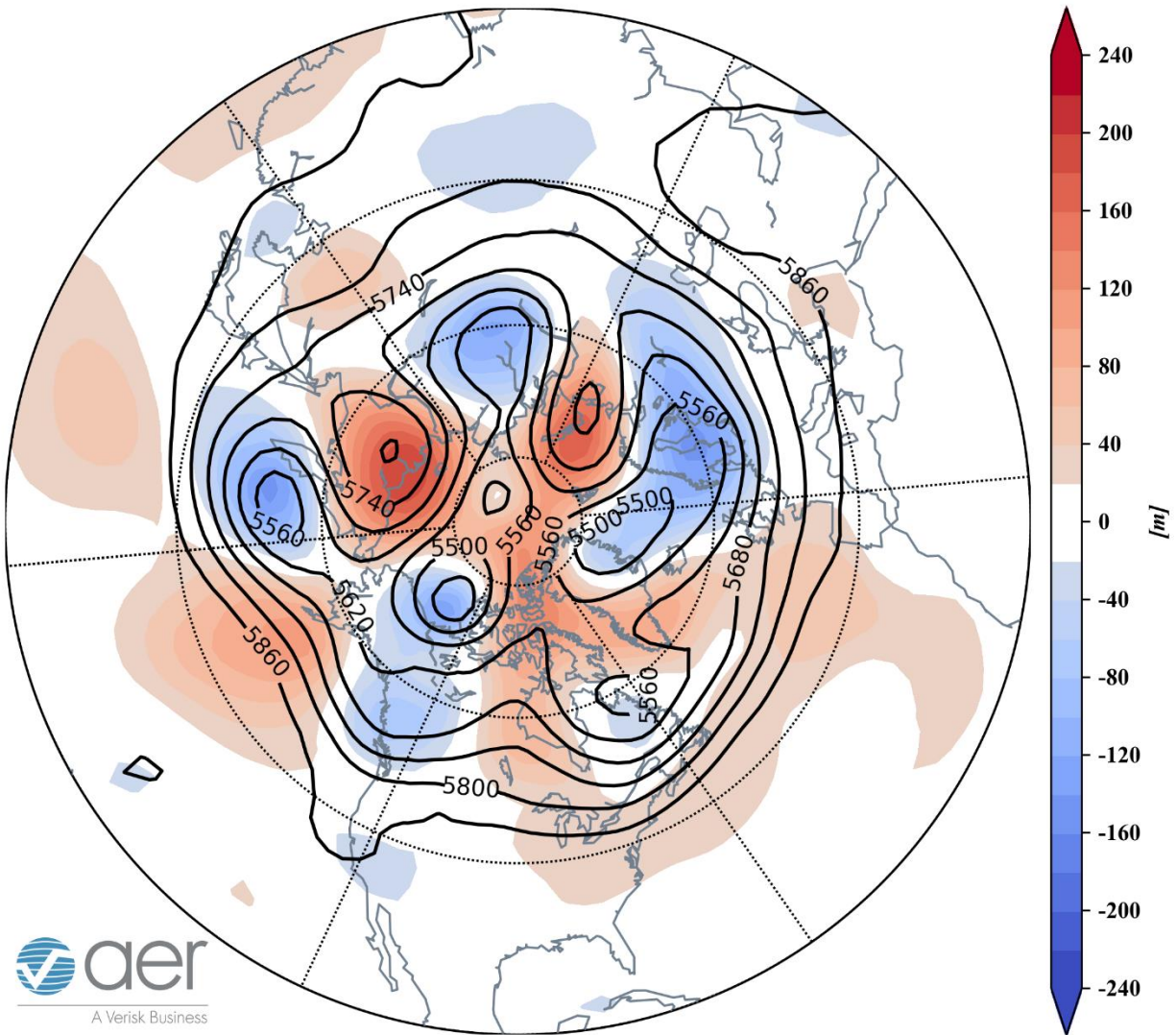


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 21 – 25 July 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

This week, troughing/negative geopotential height anomalies along the entire length of the west coast of North America and in the Canadian Maritimes will bookend ridging/positive geopotential height anomalies in the interior of North America (**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 and the Eastern US (**Figure 3**). Some weak troughing swinging through the Great Lakes could bring seasonably cool temperatures to the Great Lakes region(**Figures 2 and 3**).

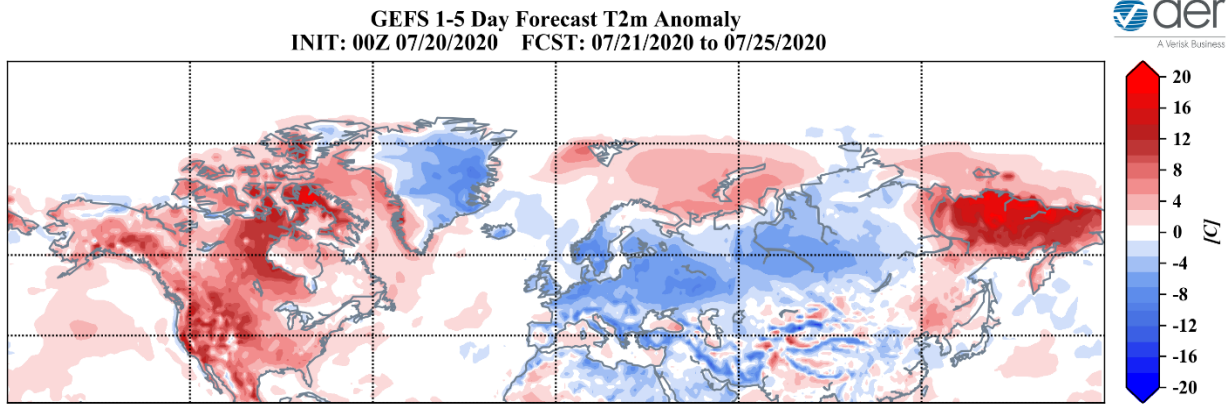


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 21 – 25 July 2020. The forecast is from the 00Z 20 July 2020 GFS ensemble.

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

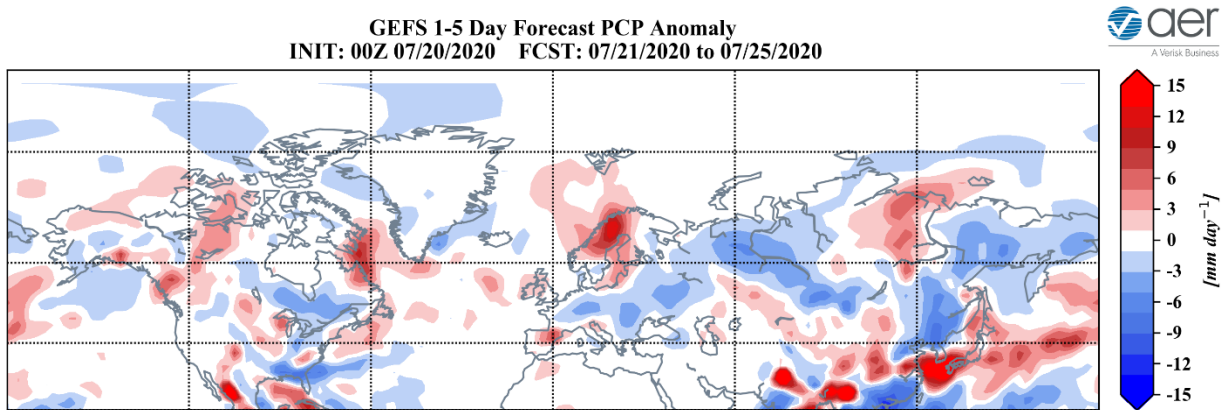


Figure 4. Forecasted precipitation anomalies (mm/day ; shading) from 21 – 25 July 2020. The forecast is from the 00Z 20 July 2020 GFS ensemble.

Mid-Term

6-10 day

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

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 07/20/2020 FCST: 07/26/2020 to 07/30/2020

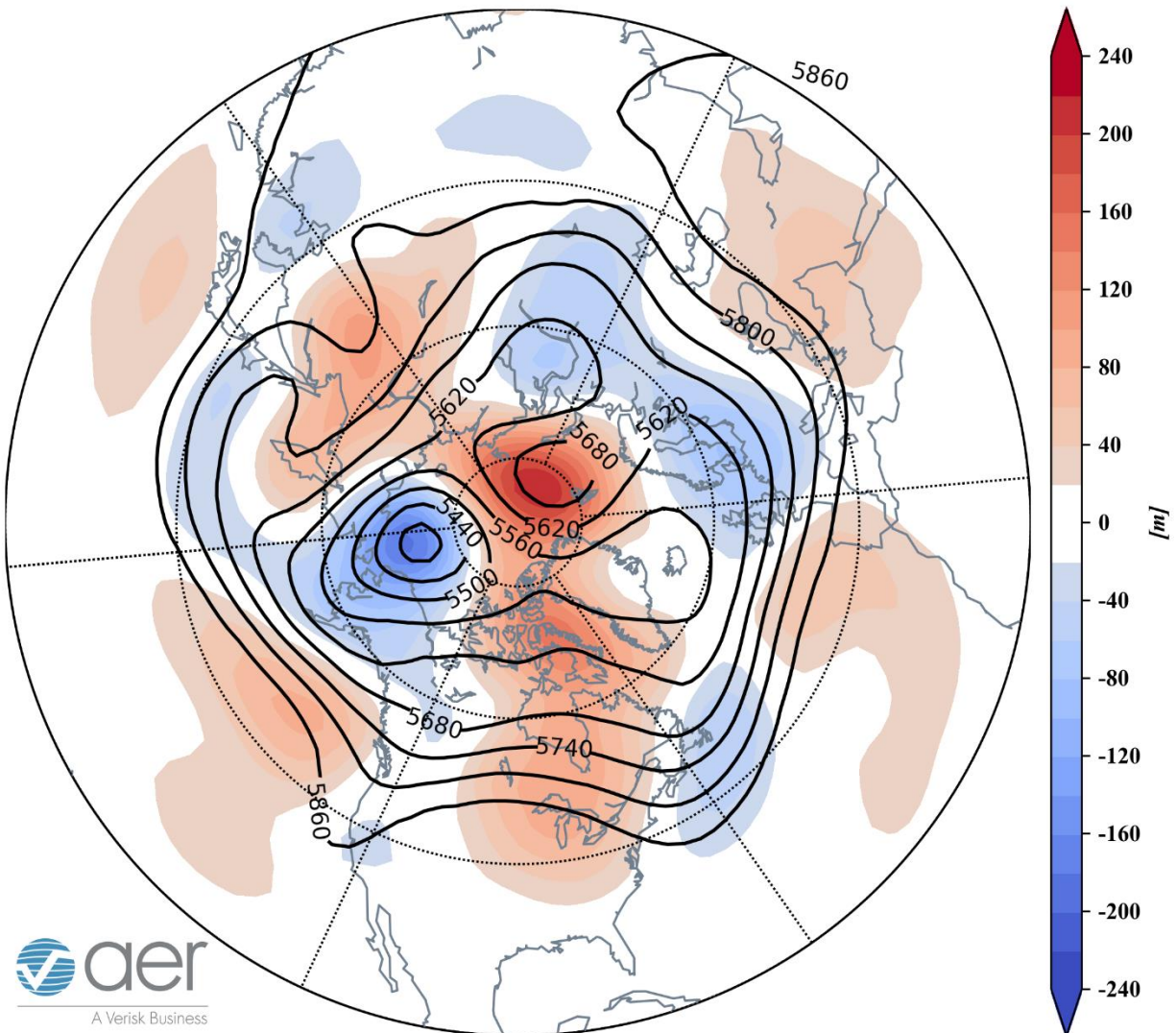


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 26 – 30 July 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

As ridging/positive geopotential height anomalies in the Central Arctic are predicted to drift into the Barents - Kara Seas, it will continue to anchor troughing/negative geopotential height anomalies across Northern and Central Europe with ridging confined to Spain, Portugal and the Eastern Mediterranean (**Figures 5**). Therefore,

temperatures are still predicted to remain normal to below normal across much of Europe including the UK with the exception of normal to above normal temperatures across Spain, Portugal and the Balkan States (**Figure 6**). Troughing/negative geopotential height anomalies previously in Northcentral Asia are predicted to drift westward into northwestern Asia and begin merging with troughing/negative geopotential height anomalies in Northern Europe allowing ridging/positive geopotential height anomalies in Northeast Asia to expand into Northcentral Asia (**Figure 5**). This is predicted to yield normal to above normal temperatures in in Northeastern Asia **with** normal to below temperatures In Northwestern 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 while ridging in the Middle East brings normal to above normal temperatures to Southwest Asia (**Figures 5 and 6**).

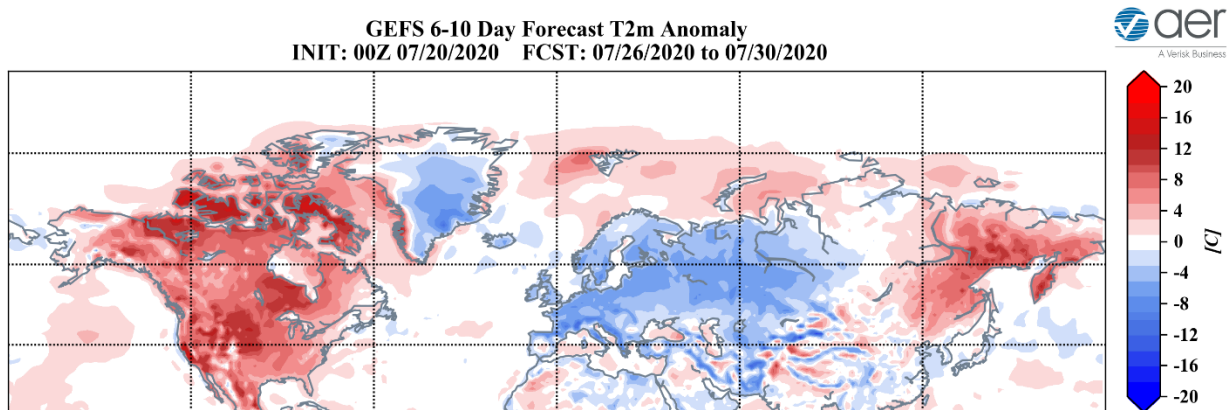


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 26 – 30 July 2020. The forecasts are from the 00Z 20 July 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate North America from the Rockies eastward with troughing/negative geopotential height anomalies along the West Coasts of the US and Canada 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**).

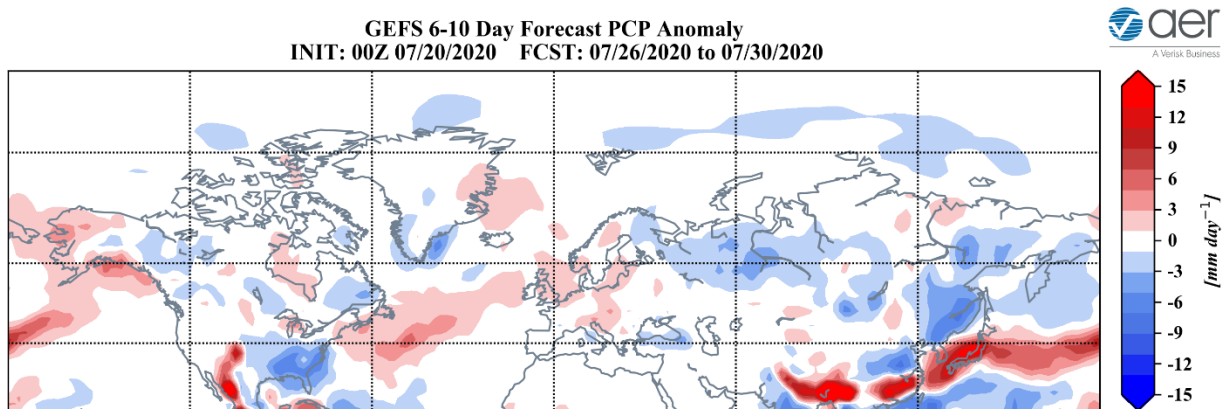


Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 26 – 30 July 2020. The forecasts are from the 00Z 20 July 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation across Northern and Central Europe and especially Southeastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for Alaska, Northwest Mexico and the Southern Rockies (**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 07/20/2020 FCST: 07/31/2020 to 08/04/2020

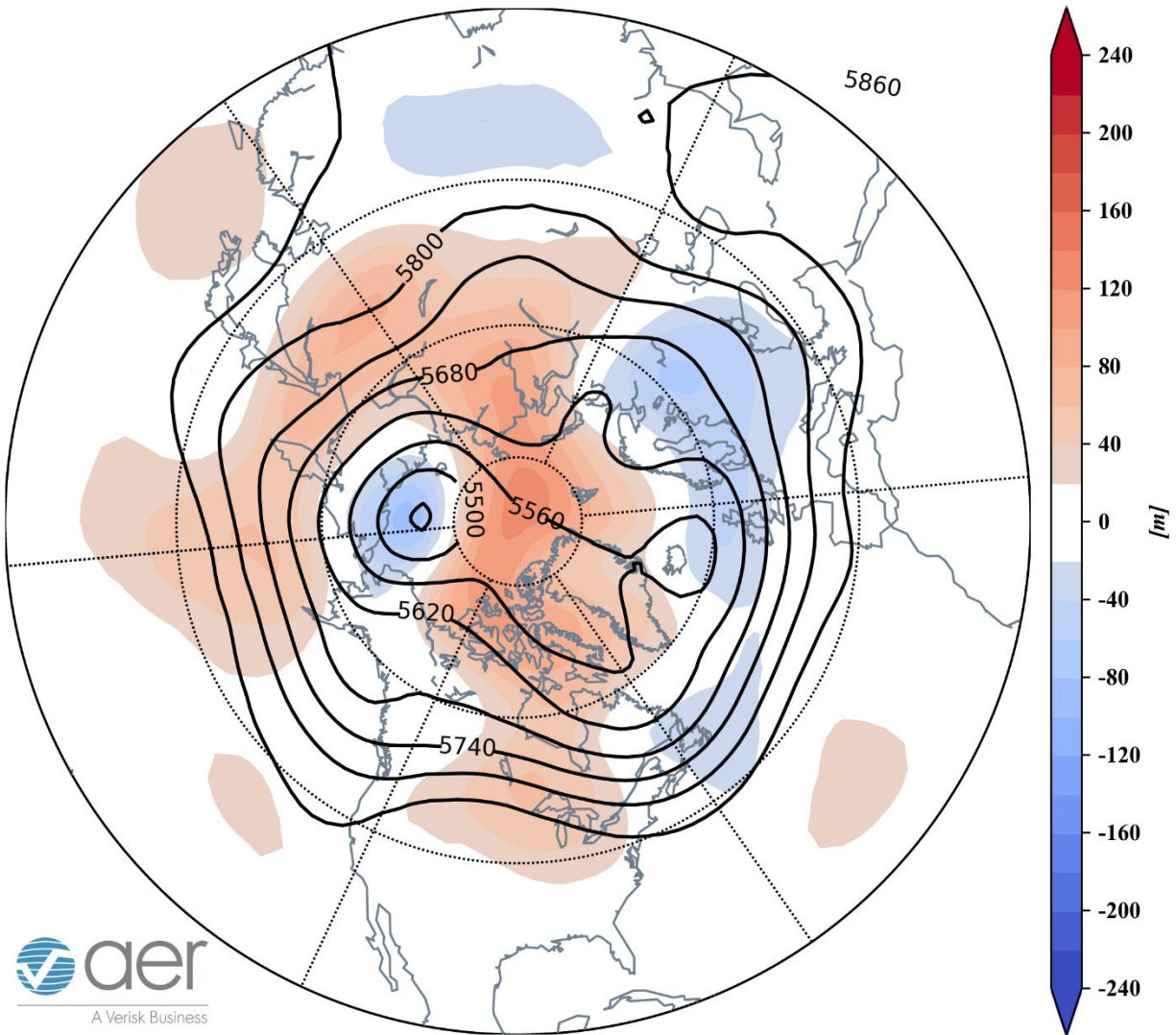


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 31 July – 4 August 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

Weak ridging/positive geopotential height anomalies from the Arctic are predicted to spread across Scandinavia with troughing/negative geopotential height anomalies elsewhere across Europe with the exception of Spain and Portugal this period (**Figures 8**). The forecast is for normal to above normal temperatures across Scandinavia, Spain and Portugal with normal to below normal temperatures elsewhere across Europe including the UK this period (**Figures 9**). For Asia, the general predicted pattern is for widespread ridging/positive geopotential height anomalies with troughing/negative geopotential height anomalies confined to far 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 in far Western and Southcentral Asia (**Figure 9**).

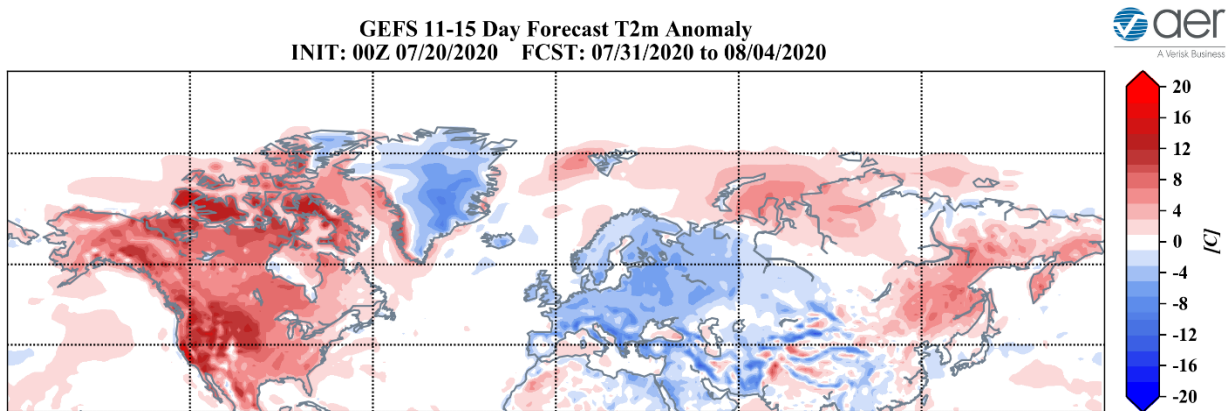


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 31 July – 4 August 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate North America with the exception of 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 with the possible exception of normal to below normal temperatures for the Canadian and US West Coasts (**Figure 9**).

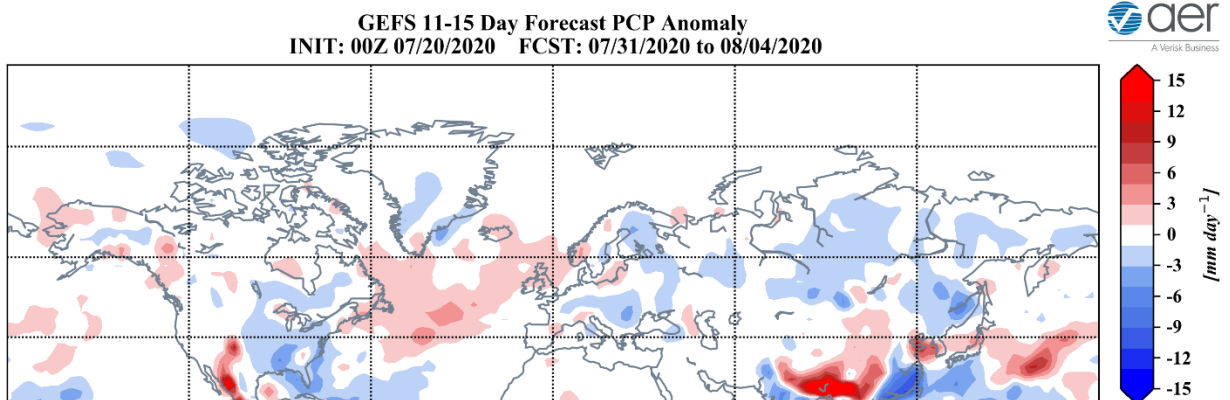


Figure 10. Forecasted precipitation anomalies (mm/day ; shading) from 31 July – 4 August 2020. The forecasts are from the 00z 20 July 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Northwestern Europe and parts of Southeast and Far East Asia (**Figure 10**). Normal to below normal precipitation is predicted for

much of North America except for above normal precipitation for Western Canada, the Canadian Maritimes, Northwest Mexico and the Southern Rockies (**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 (**Figure 11**). The GFS forecasts of a reversal to cold stratospheric PCHs have been overdone much of the spring and the early summer I wouldn't consider the forecast reliable.

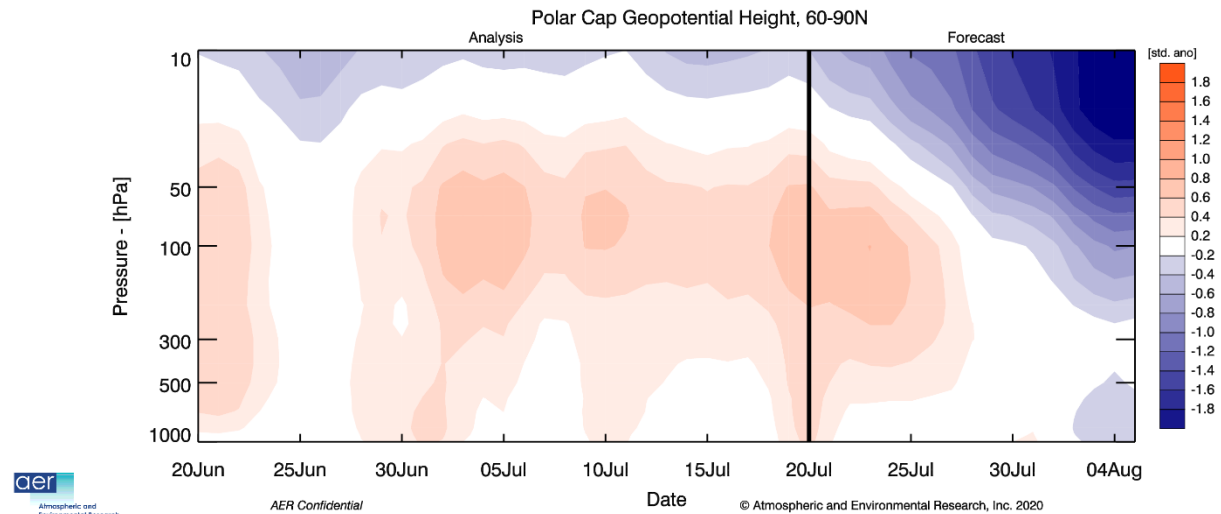


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 20 July 2020 GFS operational run.

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. Therefore, I am skeptical of a GFS run that predicts a change to negative/cold PCHs in the troposphere in early August.

CFS 500 hPa Forecast Anomaly Aug 2020
Valid as of 20 Jul 2020

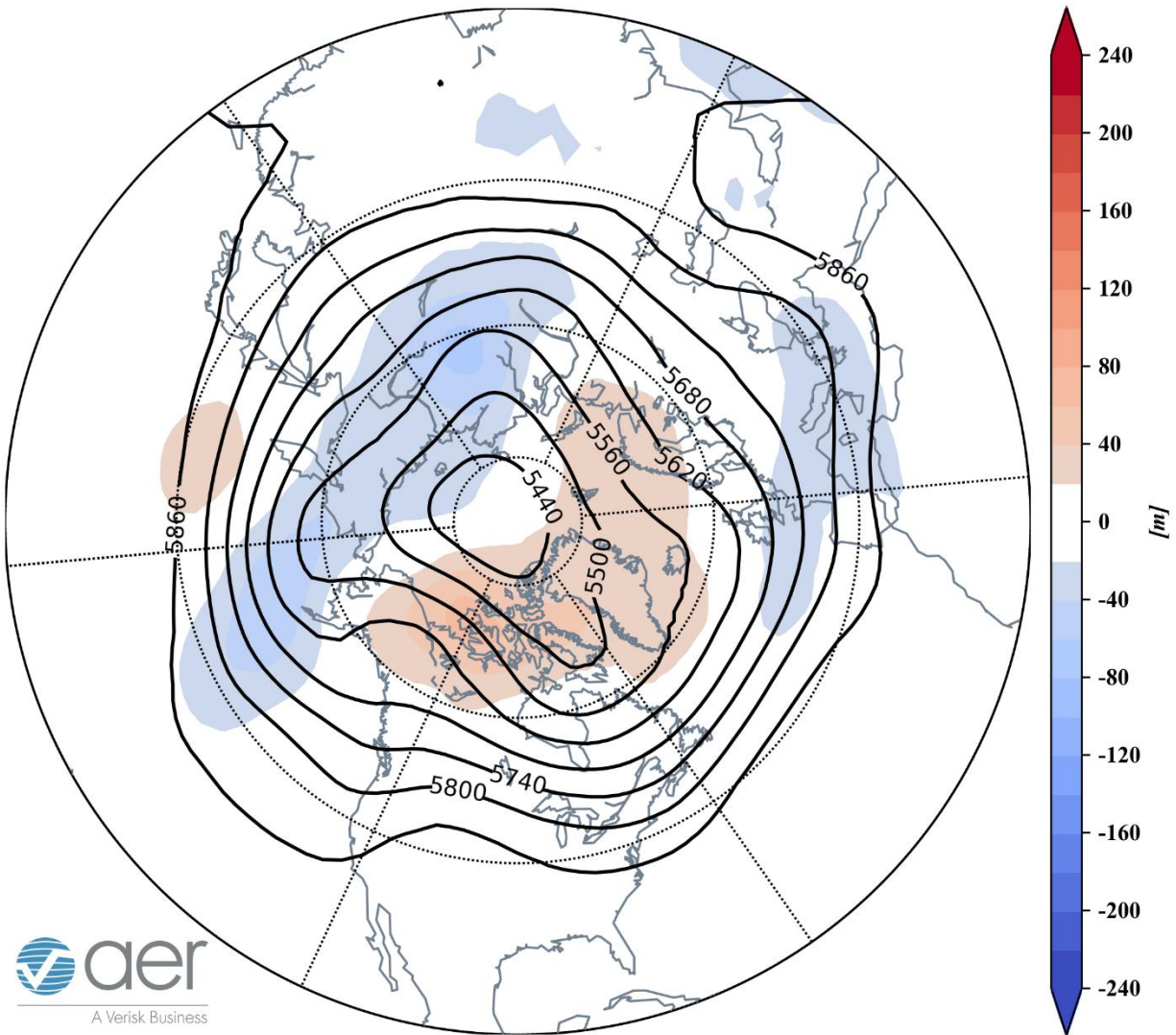


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2020. The forecasts are from the 00Z 20 July 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for August from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging in Northern Europe, Eastern Siberia, Western Canada and the US Rockies with troughing in the Central and Southern Europe, Central Asia, the Dateline, and eastern North America (**Figure 12**). This pattern favors relatively warm temperatures for Northern Europe, much of Southern and Eastern Asia and western North America with seasonable to relatively cool temperatures for Central and Southern Europe, Siberia, Eastern Canada and the Central and Northeastern US (**Figure 13**). We

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

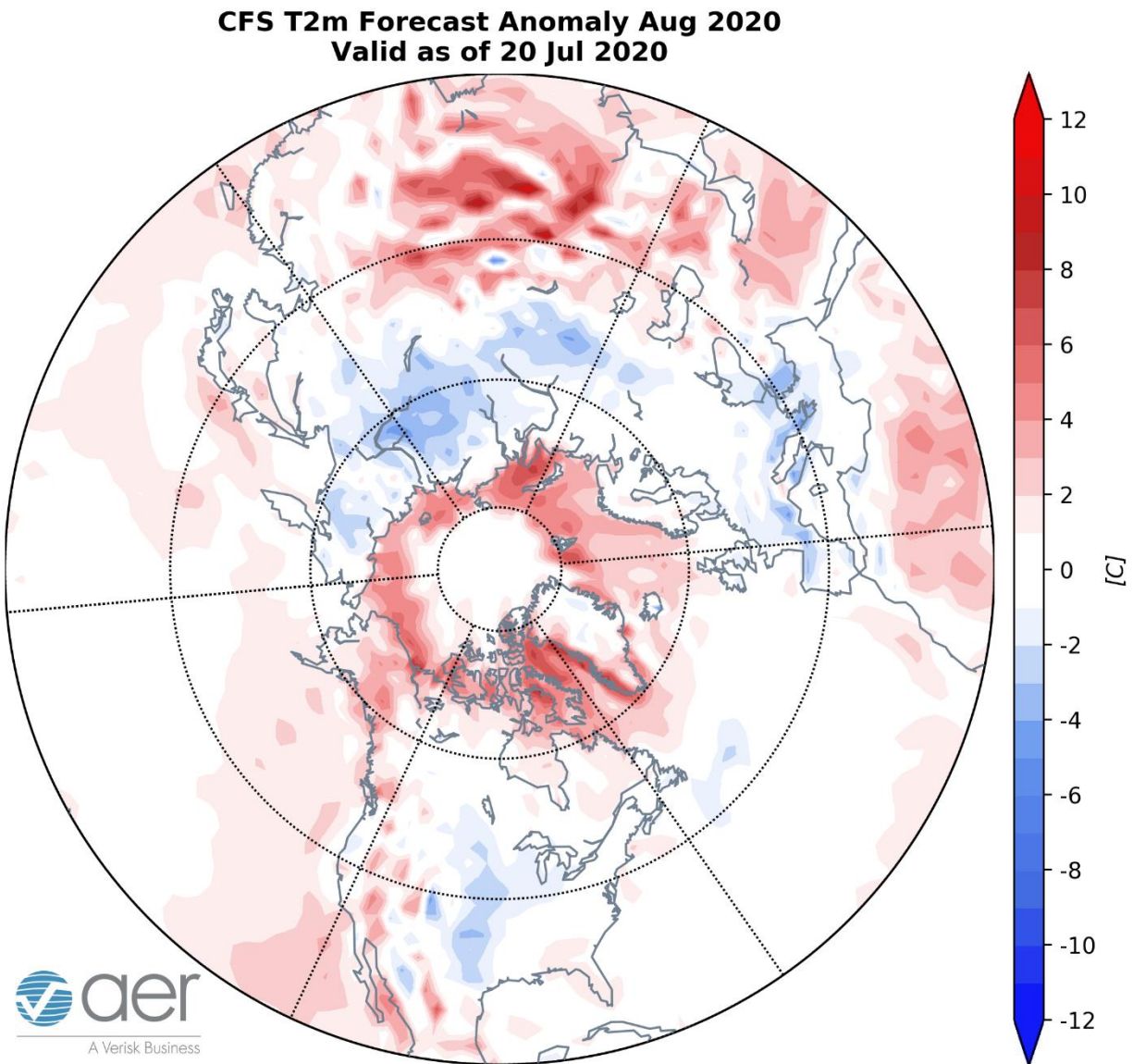


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for August 2020. The forecasts are from the 00Z 20 July 2020 CFS.

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.

SST Anomaly - Week Ending 18 Jul 2020

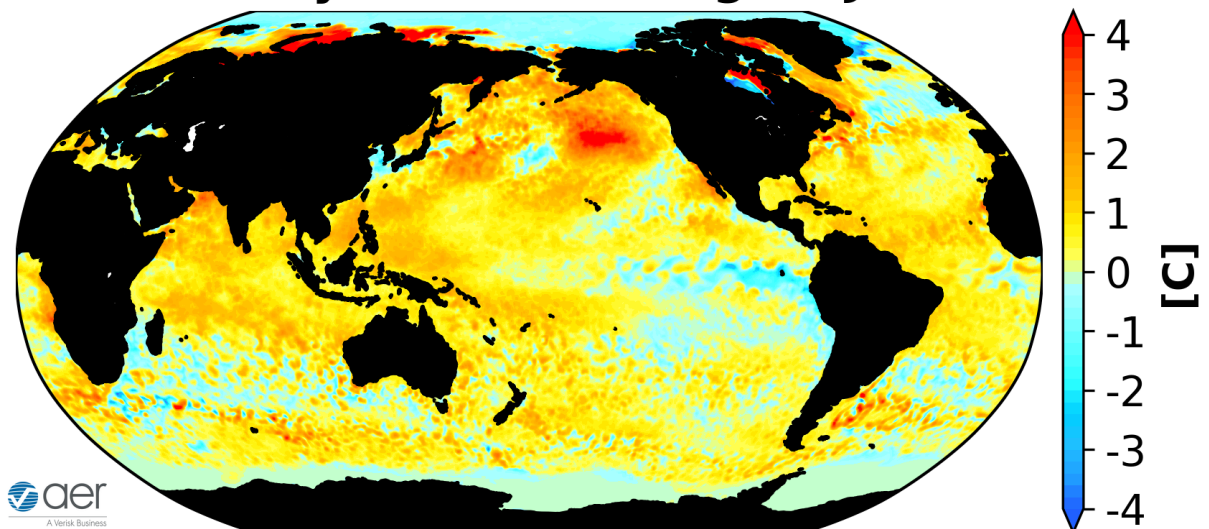


Figure 14. The latest weekly-mean global SST anomalies (ending 18 July 2020). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). The forecasts are for the MJO to move into phase two and then stall. MJO phase two initially favors ridging in Eastern Canada and troughing in Western Canada and then transitioning to troughing near the Aleutians and ridging in the Western US. The MJO could be contributing to the current pattern but the forecasts suggest that the MJO is not contributing to the upcoming weather patterns across North America over the next two weeks.

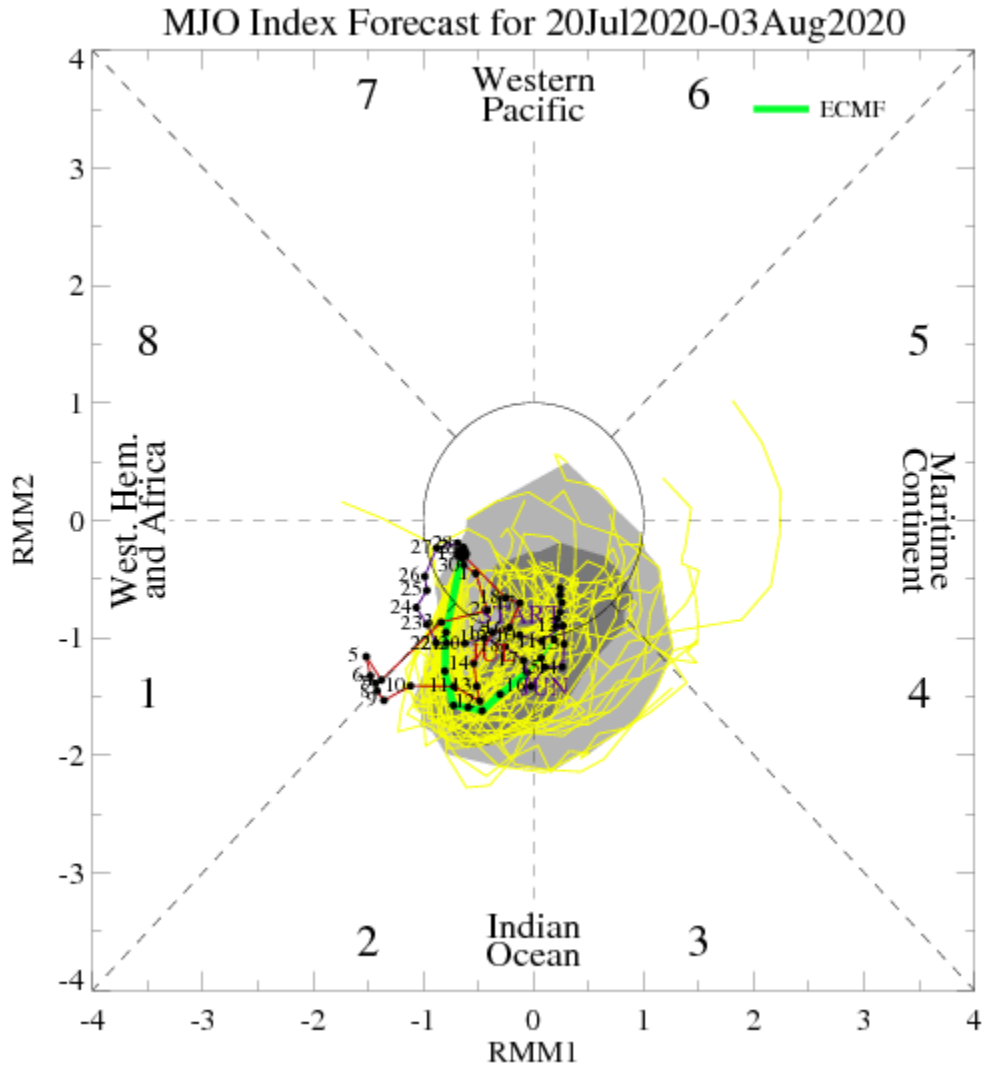


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 20 July 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>