

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 31, 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 straddle neutral 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

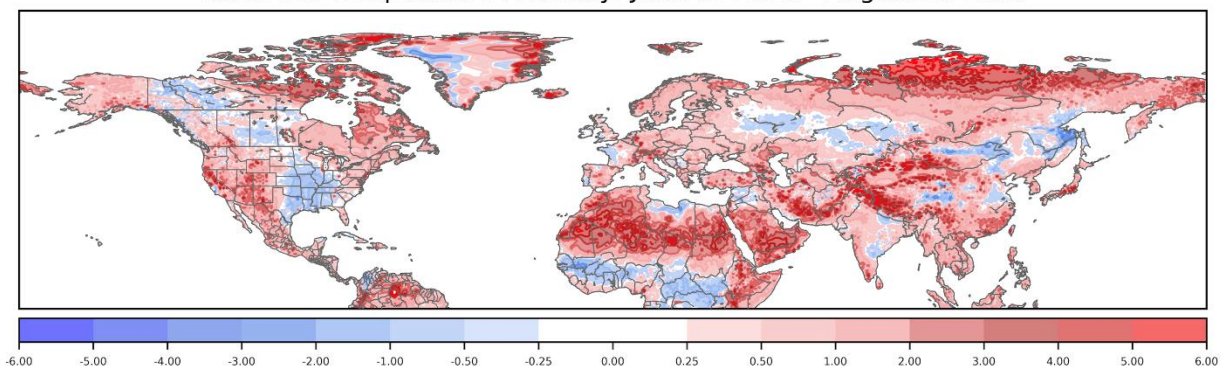
across the mid-latitudes. The North Atlantic Oscillation (NAO) is also currently neutral with weak pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to be positive to neutral the next two weeks as pressure/geopotential height anomalies remain weak to slightly negative over the next two weeks across Greenland.

- With the exception of this week when northerly flow will bring normal to below normal temperatures to Western and Central Europe including the United Kingdom (UK), Europe will be dominated by ridging/positive geopotential height anomalies with normal to above normal temperatures. One exception could be far Western Europe where predicted troughing/negative geopotential height anomalies centered in the North Atlantic could bring normal to below normal temperatures.
- The predicted general pattern for Asia the next two weeks is widespread ridging/positive geopotential height anomalies with normal to above normal temperatures. One exception is troughing/negative geopotential height anomalies with normal to below normal temperatures in Central Asia, especially next week.
- The general pattern for North America the next two weeks, is for ridging/positive geopotential height anomalies in the Gulf of Alaska and extending into western North America coupled with normal to above normal temperatures to force troughing/negative geopotential height anomalies accompanied by normal to below normal temperatures first in central North America and then eventually the Eastern United States (US).
- In the Impacts section I provide some preliminary thoughts on the Northern Hemisphere (NH) summer and the end of the Arctic sea ice melt season.

### ***Impacts***

Today is the last day of meteorological summer and I have a first look at the Northern Hemisphere surface temperature anomalies for the entire summer, once again with the help of my colleague Erik Fanny, in **Figure i**. If anyone sees a discrepancy with other similar plots, please let me know. I hope to compare the observed anomalies with the predicted anomalies presented in the blog back in May in my next blog. Though as expected much of the hemisphere experienced above normal temperatures with just some few regional exceptions and I would argue that is the top headline from this summer for the NH. Some standouts on the warm side are Northern Siberia, that received so much attention in the news, the Middle East, Northeastern Canada, the Northeastern US and the US Rockies. I am struck by the magnitude of the warm anomalies across the Sahara, I would think that would be difficult to achieve since it is so hot already. On the cool side, if correct the slightly below normal temperatures in the Central US down to the Gulf of Mexico continues the “warming hole” in the Central and Southern US. Europe was warm but not nearly as warm as recent summers.

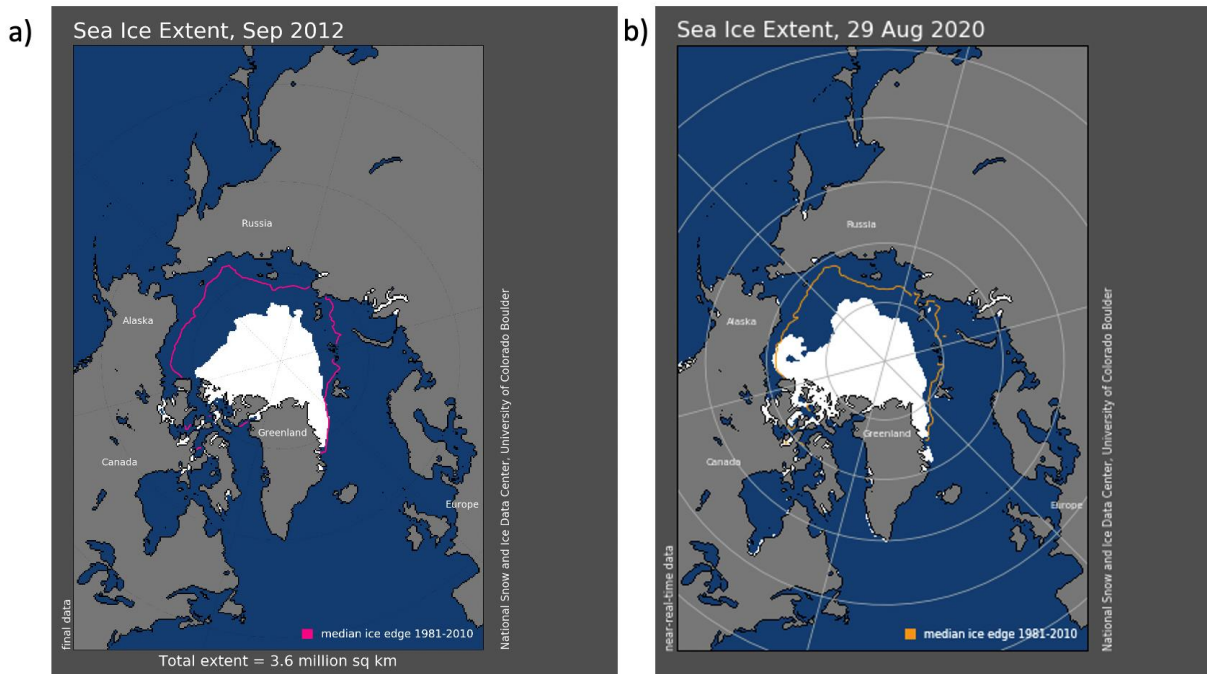
Observed Temperature Anomaly: June 01 2020 - August 31 2020



**Figure i.** Observed surface temperature anomalies for June, July and August 2020 based on the GFS daily analysis. Climatology is 1981-2010 from CFSR.

As I tweeted out this morning, summer is hanging tough in many regions of the NH but especially the Western US. And across North Africa, Europe and Asia above normal temperatures are widespread with only pockets of below normal temperatures. And in many ways September has transitioned from a fall to summer month in recent years. One possible exception this year could be Central Canada and the Central US. Near record strong ridging in the Gulf of Alaska will support relatively chilly temperatures in central North America for the first half of September and in those areas, it will feel like fall has arrived. But central North America will be an outlier compared to the rest of the NH.

With the end of summer also comes the end of the melt season for Arctic sea ice. The annual minimum should occur in the next two or three weeks, though refreeze will likely be quite slow as much heat is absorbed throughout the summer in the open waters of the Arctic ocean. At least based on the NSIDC data, this year's annual minimum will not exceed that of 2012 as there are signs that the rapid melt of early and mid-August is abating or decelerating. I include a comparison of sea ice extent from yesterday and the monthly average from September 2012 for comparison in **Figure ii**.

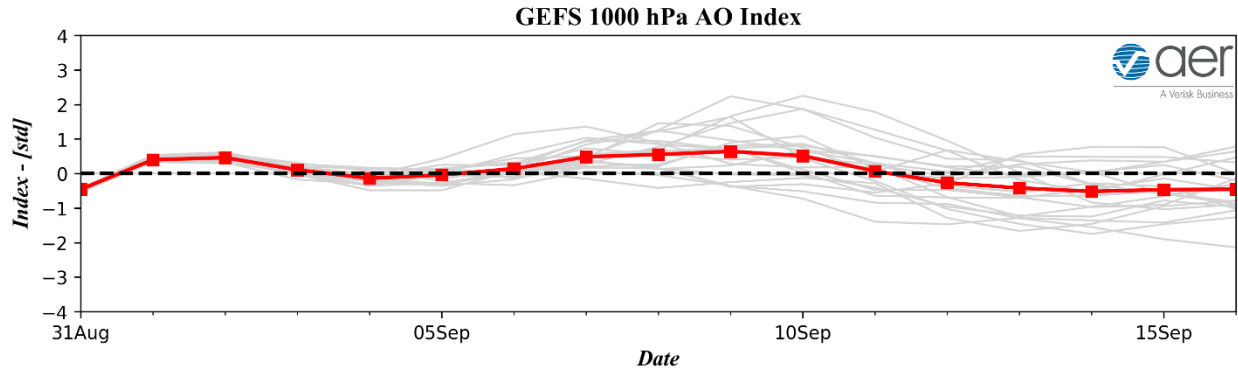


**Figure ii.** Observed Arctic sea ice extent a) September 2012 and b) on 29 August 2020 (white). Magenta/orange line shows climatological extent of sea ice based on the years 1981-2010.

The areal extents look quite similar with the biggest difference being that there is more sea ice in the region of the Canadian Archipelagos currently than eight years ago, though since the ice is still melting the two years may converge further. In fall 2012 the greatest negative sea ice anomalies persisted in the Barents-Kara Seas that I would argue contributed to ridging/blocking in the region, cold temperatures across Eurasia and even a strong breakdown of the polar vortex that winter. It is still too early to tell where the greatest negative anomalies will persist throughout the fall and early winter, whether on the North Atlantic or North Pacific side of the Arctic. This could have important implications for the weather but only if the sea ice anomalies couple with the atmospheric anomalies. For the most part it does not appear the two coupled last winter. Strong ridging is predicted over the next two weeks in the Gulf of Alaska and into the Arctic. It is still too early for that to couple with the open waters of the Arctic Ocean but starting in September that could change and something to watch as we head into the fall season.

*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 weak geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to be near neutral this week.

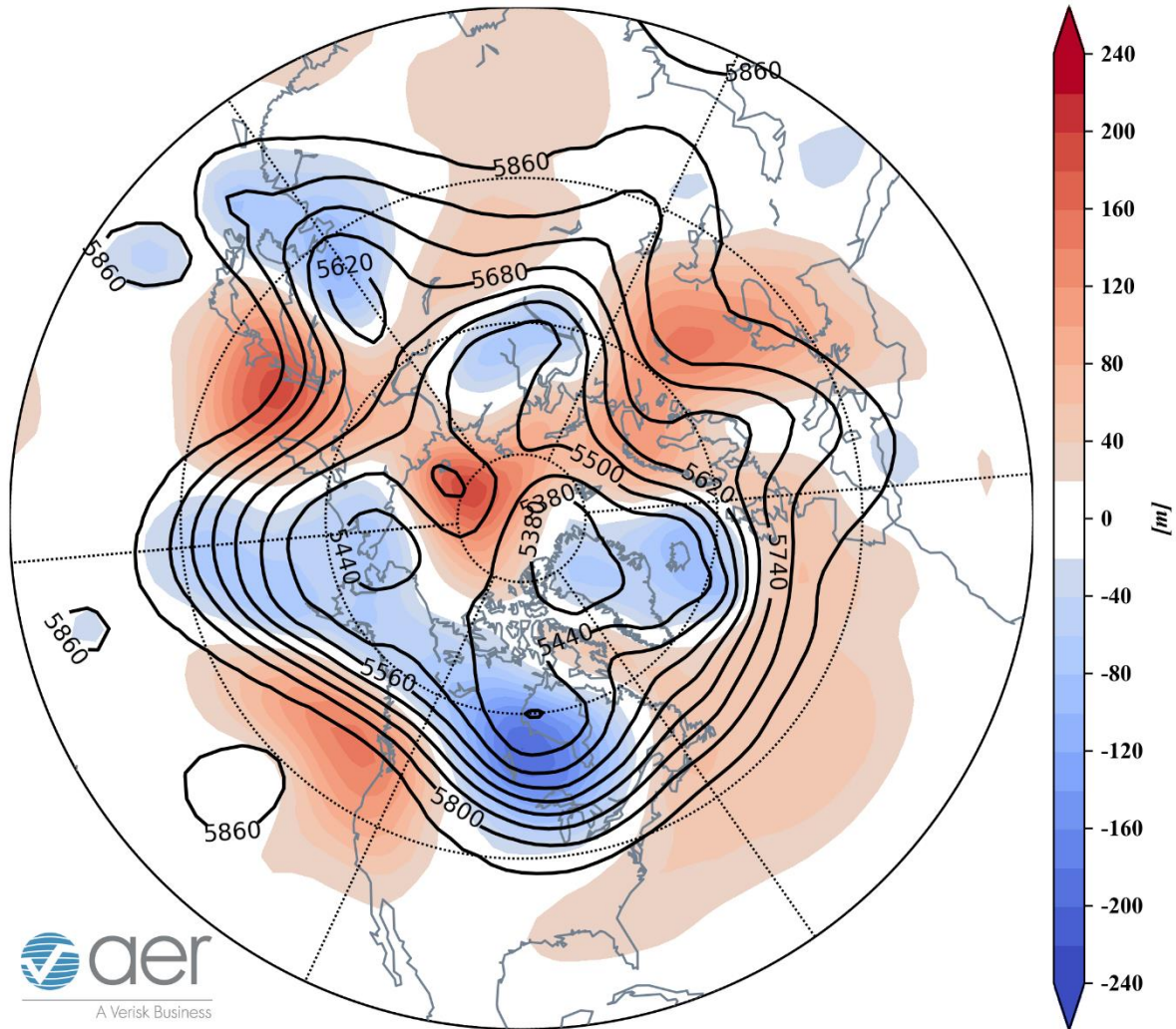


**Figure 1.** The predicted daily-mean AO at 1000 hPa from the 00Z 31 August 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, weak troughing/negative geopotential height anomalies with northerly flow will swing through Western and Central Europe while ridging/positive geopotential height anomalies hold steadfast across Eastern Europe (**Figure 2**) resulting in normal to below normal temperatures for much of Western and Central Europe including the UK with normal to above normal temperatures for Eastern Europe (**Figure 3**). Across Asia this week, ridging/positive geopotential height anomalies will dominate much of Asia with the exception of regional troughing/negative geopotential height anomalies in parts of Central and Eastern Asia, especially Eastern Siberia (**Figure 2**). This pattern favors widespread normal to above normal temperatures for much of Asia with the exceptions of normal to below normal temperatures in Western and Eastern Siberia and Northeast China (**Figure 3**).



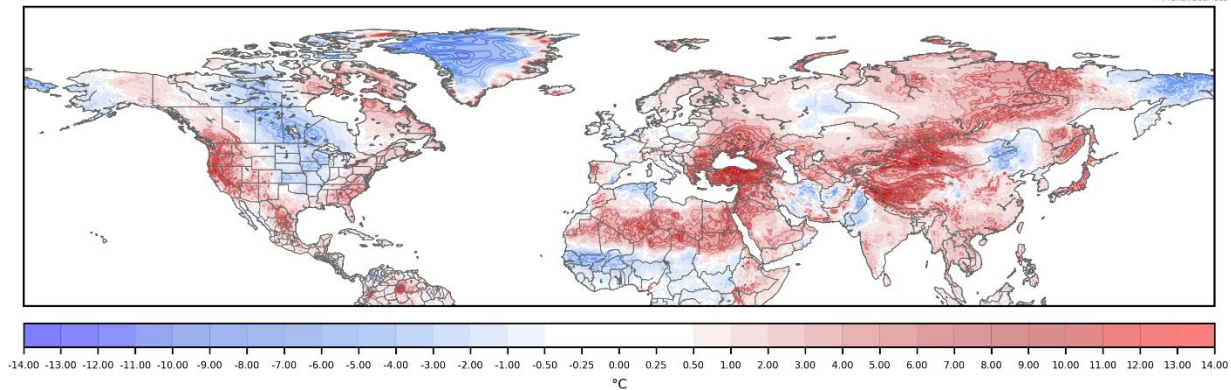
GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly  
INIT: 00Z 08/31/2020 FCST: 09/01/2020 to 09/05/2020



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 1 – 5 September 2020. The forecasts are from the 00z 31 August 2020 GFS ensemble.

This week, ridging/positive geopotential height anomalies in the Gulf of Alaska will begin to expand eastward and northward across western North America which will force deepening troughing/negative geopotential height anomalies in central North America with more ridging/positive geopotential height anomalies along the East Coasts of the US and Canada (**Figure 2**). This pattern is predicted to bring normal to above normal temperatures across eastern Alaska, Western and Eastern Canada and the West and East Coasts of the US with normal to below normal temperatures for much of Central Canada and the Central US with the exception of along the Gulf Coast (**Figure 3**).

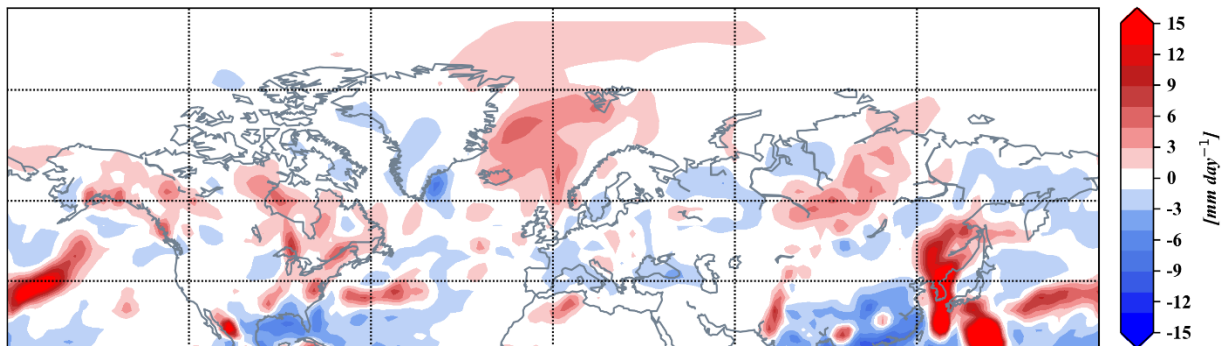
GFS 1-5 Day Forecast T2m Anomaly  
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**Figure 3.** Forecasted surface temperature anomalies (°C; shading) from 1 – 5 September 2020. The forecast is from the 00Z 31 August 2020 GFS ensemble.

Below normal precipitation is predicted for much of Europe and Asia with the exceptions of above normal precipitation in Western Siberia, along the India/Pakistan border and Japan/East Asia associated with Typhoon Maysak (**Figure 4**). Below normal precipitation is predicted for much of North America with above normal precipitation for eastern Alaska, Northwest and Eastern Canada and the Northeastern US (**Figure 4**).

GEFS 1-5 Day Forecast PCP Anomaly  
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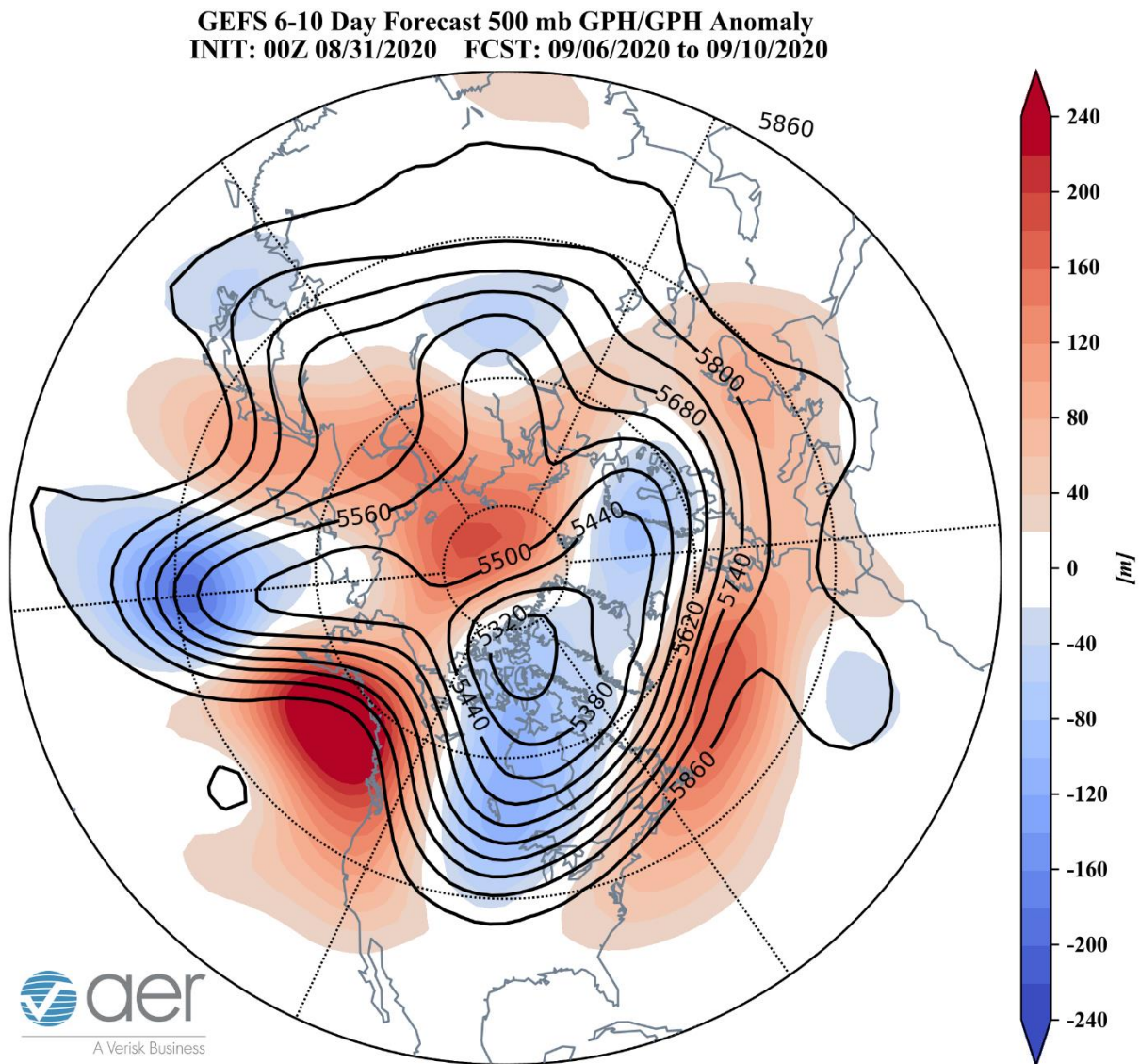
**Figure 4.** Forecasted precipitation anomalies (mm/day; shading) from 1 – 5 September 2020. The forecast is from the 00Z 31 August 2020 GFS ensemble.

*Mid-Term*

*6-10 day*

The AO is predicted to remain neutral (**Figure 1**) with positive geopotential height anomalies across the Asian and North Pacific side of the Arctic with negative

geopotential height anomalies across the Canadian, North Atlantic and European sides of the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with weak negative geopotential height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to remain near neutral to weakly positive.

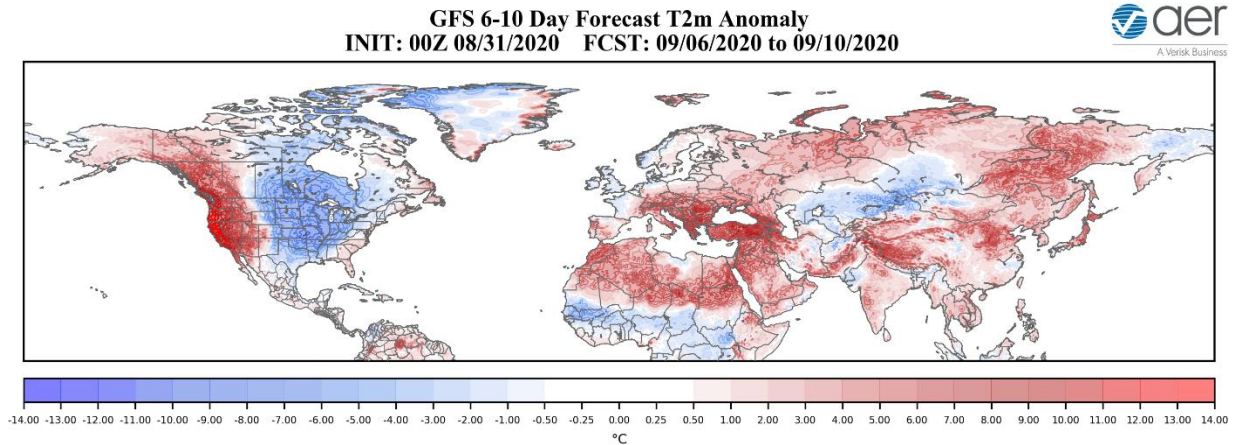


**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 September 2020. The forecasts are from the 00z 31 August 2020 GFS ensemble.

Trouching/negative geopotential height anomalies are predicted to stretch from the UK and across Scandinavia with ridging/positive geopotential height anomalies stretched across the remainder of Europe (**Figure 5**). This pattern favors normal to below normal across Northwestern Europe including the UK with normal to above normal

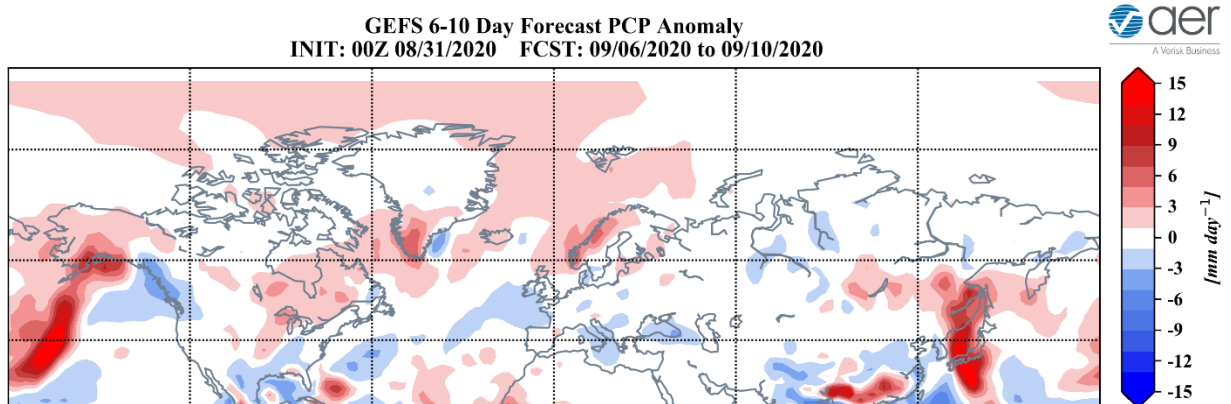


temperatures across the remainder of Europe (**Figure 6**). Ridging/positive geopotential height anomalies are predicted to dominate Western and Eastern Asia bookending troughing/negative geopotential height anomalies in Central Asia this period (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures in Western, Northern and Eastern Asia with normal to below temperatures in Central Asia and far Eastern Siberia (**Figure 6**).



**Figure 6.** Forecasted surface temperature anomalies (°C; shading) from 6 – 10 September 2020. The forecasts are from the 00Z 31 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to strengthen in the Gulf of Alaska and western North America contributing to deepening troughing/negative geopotential height anomalies in Central Canada and the Central US with more ridging/positive geopotential height anomalies along the East Coast of the US and the Canadian Maritimes this period (**Figure 5**). This pattern is predicted to bring widespread normal to above normal temperatures across Alaska, Western Canada, the Western US, the US East Coast and the Canadian Maritimes with normal to below normal temperatures for much of Central and Eastern Canada and the Central and Eastern US (**Figure 6**).



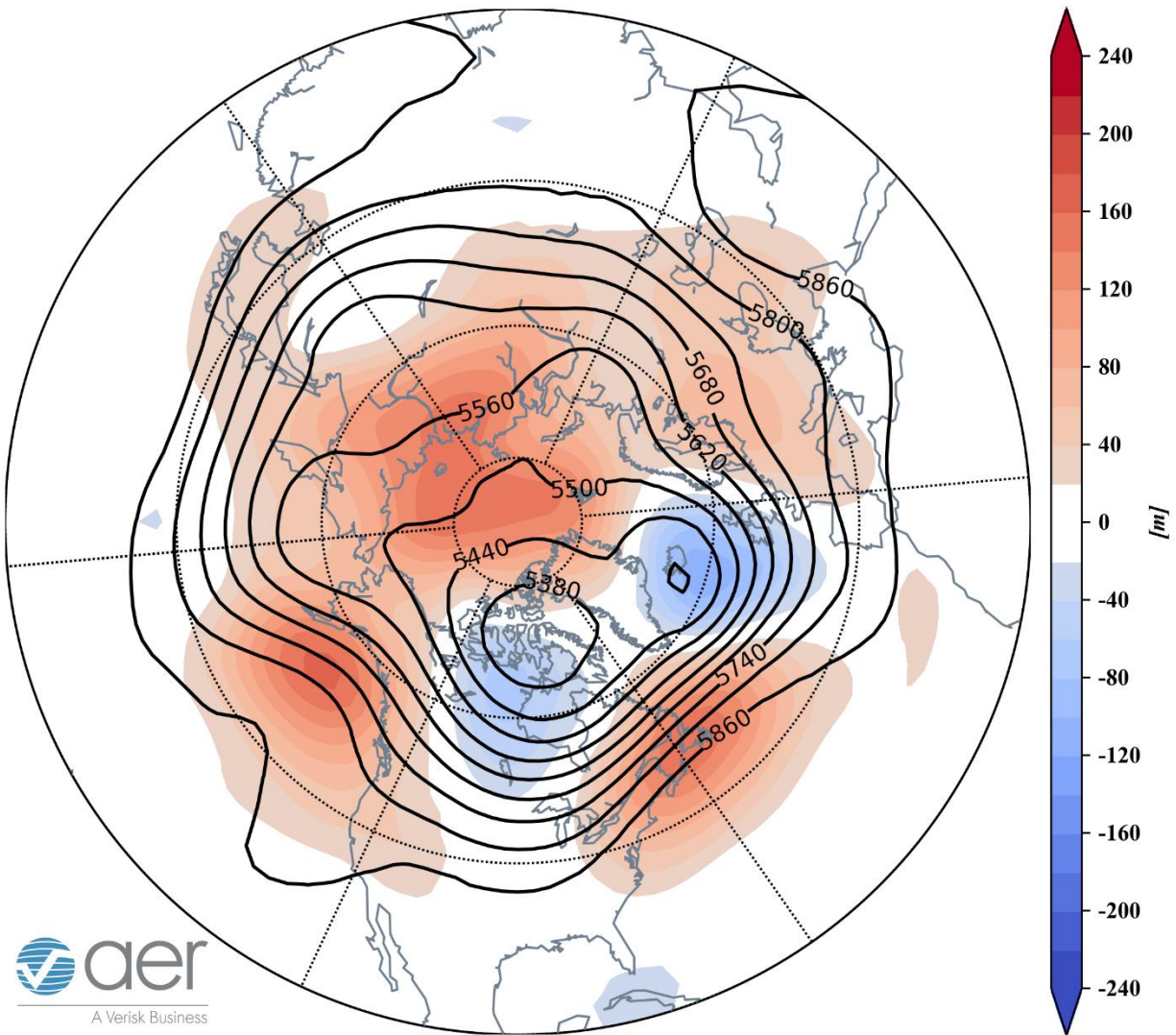
**Figure 7.** Forecasted precipitation anomalies (mm/day; shading) from 6 – 10 September 2020. The forecasts are from the 00Z 31 August 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation across Scandinavia and East Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for Alaska, the Great Lakes and Eastern Canada (**Figure 7**).

*11-15 day*

With mostly positive but weak 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 remain neutral to possibly weakly negative this period (**Figure 1**). With weak and mixed pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to be neutral as well.

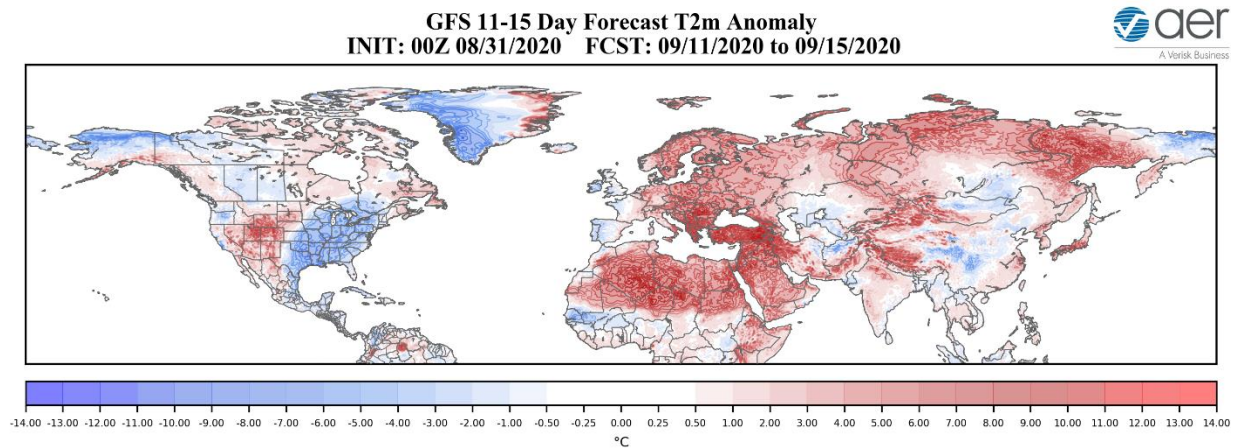
**GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly**  
INIT: 00Z 08/31/2020 FCST: 09/11/2020 to 09/15/2020



**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 11 – 15 September 2020. The forecasts are from the 00z 31 August 2020 GFS ensemble.

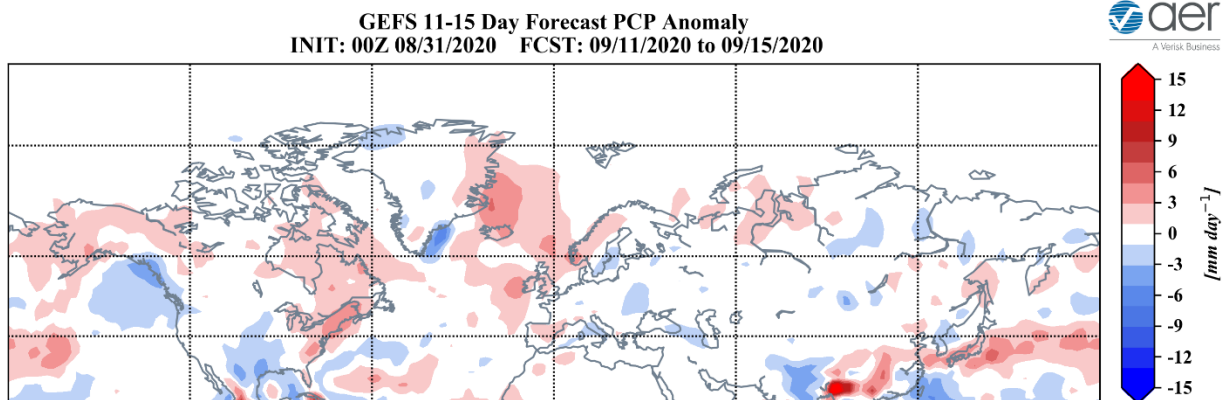
Trouging/negative geopotential height anomalies in the eastern North Atlantic are predicted to anchor ridging/positive geopotential height anomalies across much of Europe this period with the exception of far Western Europe (**Figures 8**). The forecast is for normal to above normal temperatures across most of Europe with the exception of normal to below normal temperatures across far Western Europe including the UK this period (**Figures 9**). For Asia, the general predicted pattern is for ridging/positive geopotential height anomalies especially Northern Asia with only weak trouging/negative geopotential height anomalies in Mongolia and Northern China this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures

across Asia with only regional normal to below normal temperatures across Mongolia and Northern China (**Figure 9**).



**Figure 9.** Forecasted surface temperature anomalies (°C; shading) from 11 – 15 September 2020. The forecasts are from the 00z 31 August 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist in the Gulf of Alaska forcing troughing/negative geopotential height anomalies across central North America with more ridging/positive geopotential height anomalies along the East Coast of the US and the Canadian Maritimes this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska and much of Western and Eastern Canada and the Western US with normal to below normal temperatures for Central Canada and Eastern US (**Figure 9**).



**Figure 10.** Forecasted precipitation anomalies (mm/day; shading) from 11 – 15 September 2020. The forecasts are from the 00z 31 August 2020 GFS ensemble.

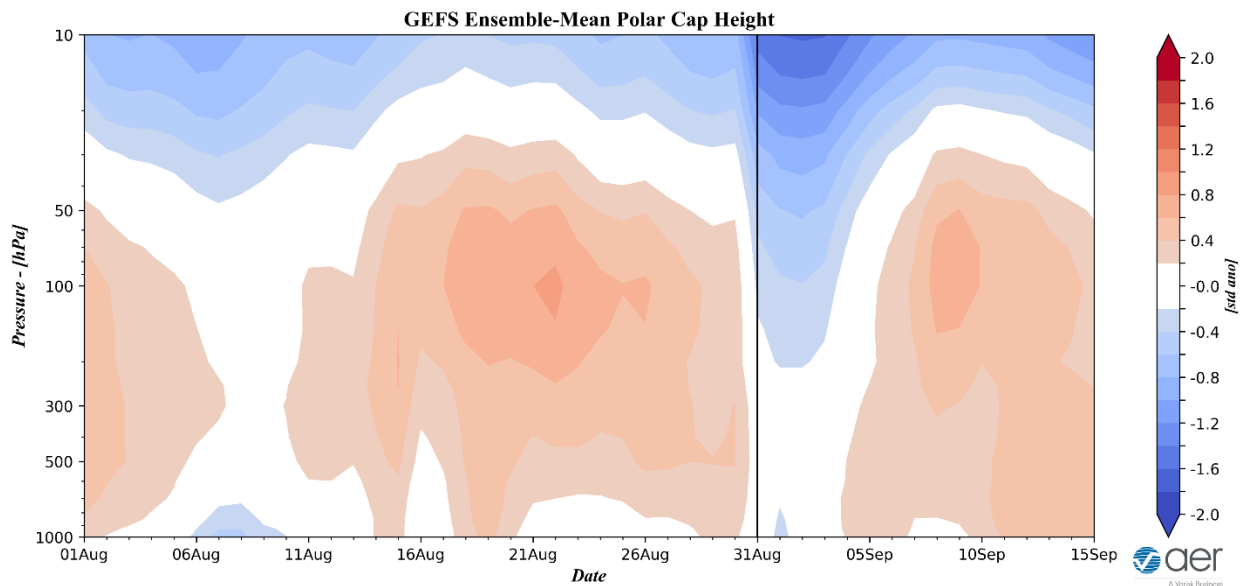


Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Northern Europe and parts of Southern and Far East Asia (**Figure 10**). Normal to below normal precipitation is predicted for much of North America except for above normal precipitation for Alaska, Eastern Canada and the Northeastern US (**Figure 10**).

### Longer Term

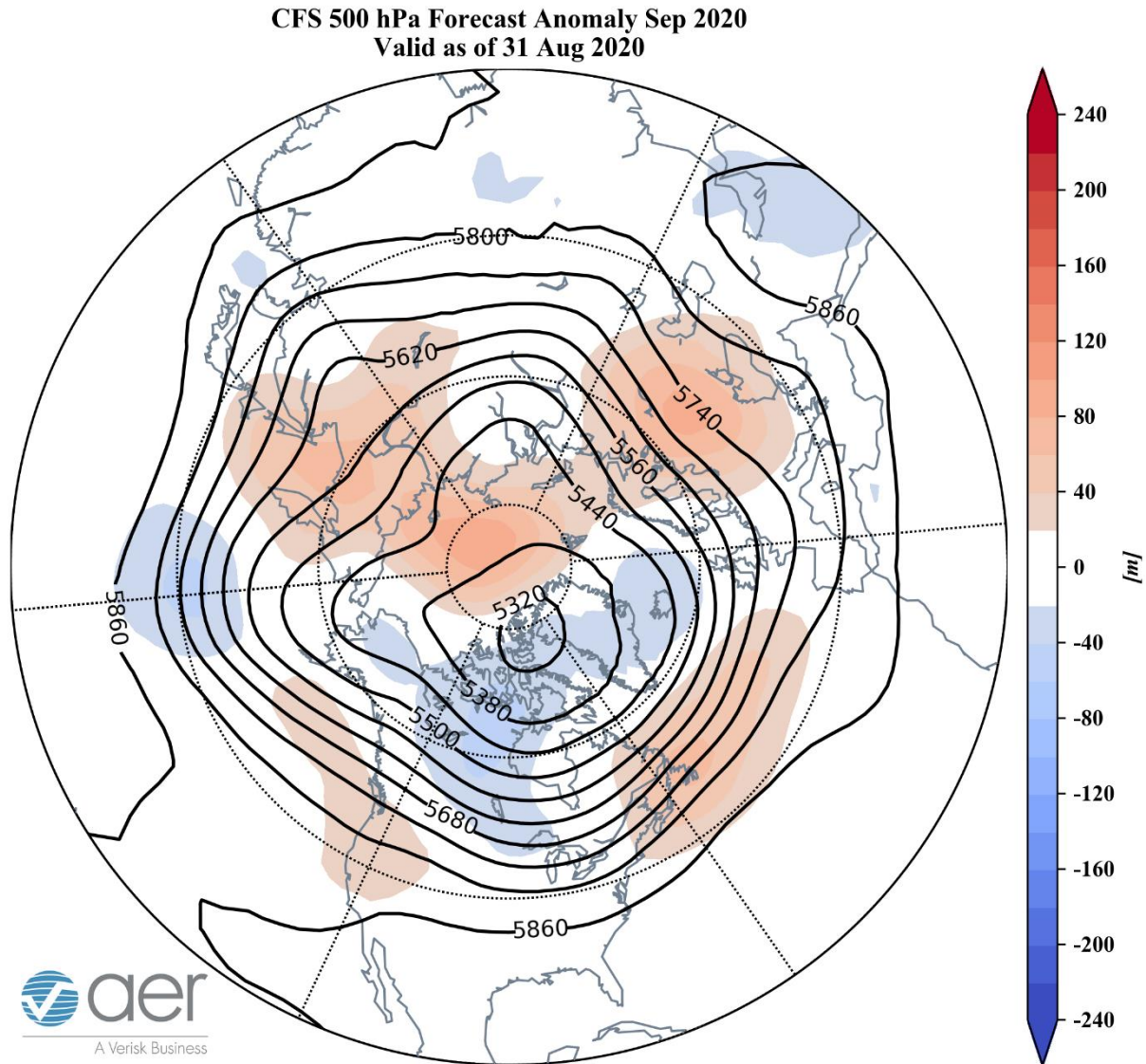
#### 30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows near normal PCHs in the troposphere but normal to below normal PCHs in the stratosphere (**Figure 11**). However, PCHs from the lower stratosphere through the troposphere are predicted to warm to normal to above normal while PCHs remain below normal in the mid-stratosphere (**Figure 11**).



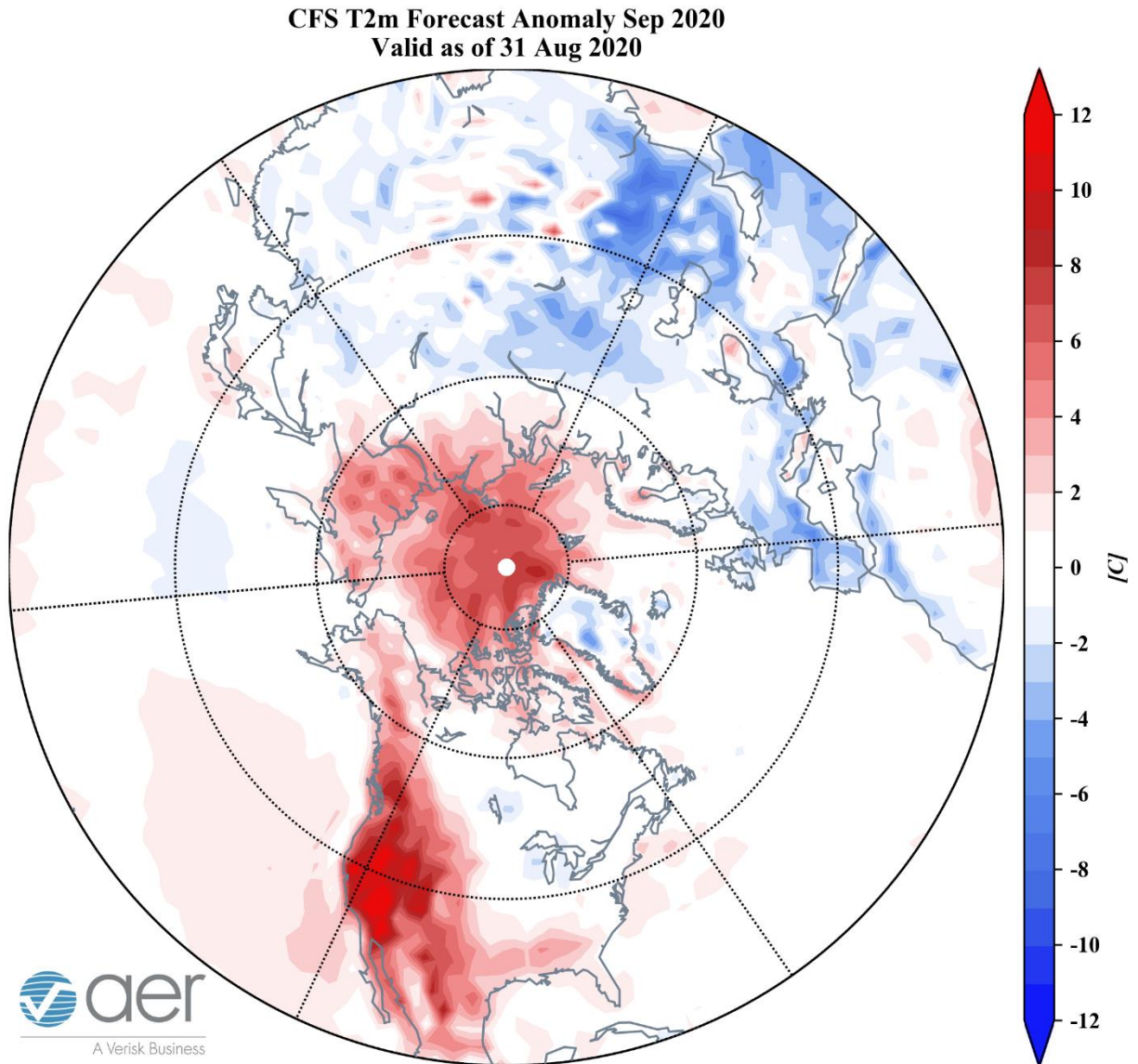
**Figure 11.** Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 31 August 2020 GFS ensemble.

The current near normal PCHs in the troposphere are consistent with the predicted neutral AO this week (**Figure 1**). However, the forecast is for the PCHs to turn positive/warm which is consistent with my belief 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, a more negative AO is possible in early to mid-September.



**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 31 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 south of Greenland and Iceland, Eastern Europe, Northeast Asia and the Western US (albeit very weak) with troughing in Western Europe, Central Asia, Alaska and central North America (**Figure 12**). This pattern favors relatively warm temperatures for Scandinavia, Eastern Europe, Northern Asia and western North America with seasonable to relatively cool temperatures for Western Europe, Central Asia, Central Canada and the Northeastern US (**Figure 13**).



**Figure 13.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for September 2020. The forecasts are from the 00Z 31 August 2020 CFS.

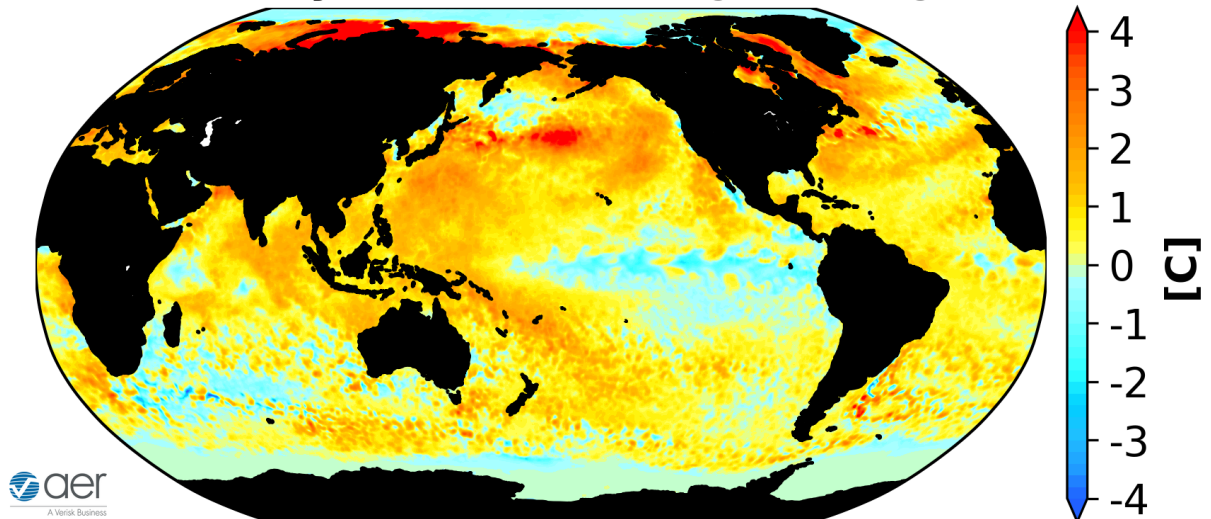
### *Surface Boundary Conditions*

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

Equatorial Pacific sea surface temperatures (SSTs) anomalies continue to cool slowly and we have now entered weak La Niña conditions (**Figure 14**) and La Niña is expected to persist through the fall. Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska, the western North Pacific and offshore

of eastern North America 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.

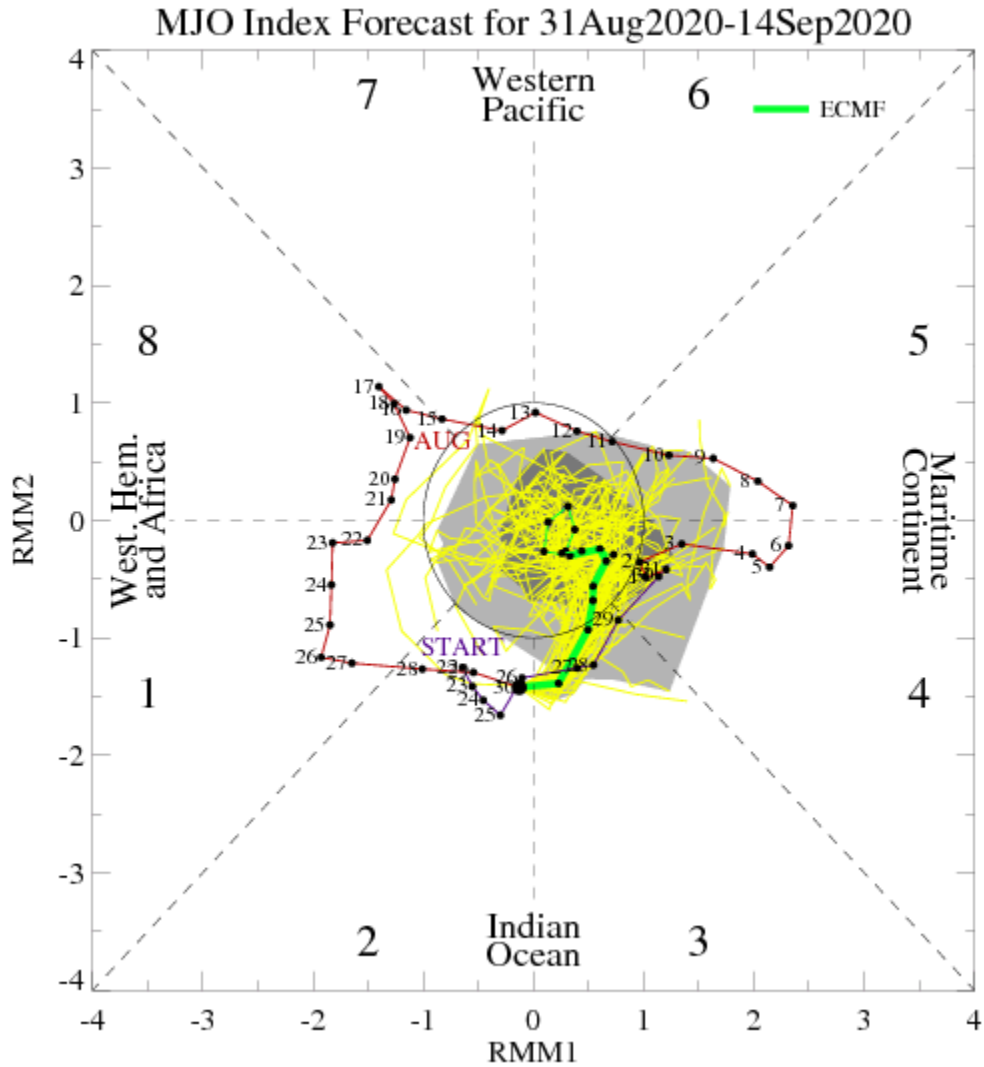
## SST Anomaly - Week Ending 29 Aug 2020



**Figure 14.** The latest weekly-mean global SST anomalies (ending 29 August 2020). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase two (**Figure 15**). The forecasts are for the MJO to quickly weaken where no phase is favored. MJO phase two does over time favor ridging in the Gulf of Alaska and troughing across the Eastern 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 31 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>