Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 23, 2021

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) 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 negative and is predicted to remain negative over the next two weeks with positive pressure/geopotential height anomalies across the North Atlantic side of the Arctic and mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently negative and is predicted to remain

negative as pressure/geopotential height anomalies are predicted remain positive across Greenland the next two weeks.

- The next two weeks, ridging/positive geopotential height anomalies across Greenland will favor troughing/negative geopotential height anomalies coupled with normal to below normal temperatures across much of Europe. One exception is predicted ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across far Western Europe including the United Kingdom (UK).
- Over the next two weeks much of Asia will be dominated by ridging/positive geopotential height anomalies coupled with normal to above normal temperatures in Central Asia. A couple of exceptions are troughing/negative geopotential height anomalies coupled with normal to below temperatures in East Asia this week and then in early September and troughing/negative geopotential height anomalies coupled with cooler temperatures will swing east of the Urals into Western Siberia next week.
- This general pattern across North America over the next two weeks is ridging/positive geopotential height anomalies coupled with normal to above normal temperatures. Some exceptions are troughing/negative geopotential height anomalies coupled with normal to below temperatures across Alaska, Southwestern Canada and the Northwestern United States (US) this week into next and then in Southeastern Canada and the Northeastern US in early September.
- In the Impacts section I share an early summary of the summer pattern across the Northern Hemisphere (NH) and anticipate the upcoming Arctic sea ice minimum.

Impacts

As we enter the last full week of summer, we can begin to assess the summer season which features widespread above to well above normal temperatures across the Northern Hemisphere (NH) as shown In **Figure i**. Regions that experienced exceptional warmth include Southwestern Canada, the Western US, Eastern Europe, North Africa, Western and Central Asia and Siberia. Regional exceptions to the overall warmth that experienced a relatively cool summer are the Southeastern US, Western Europe and parts of Northeast Asia.

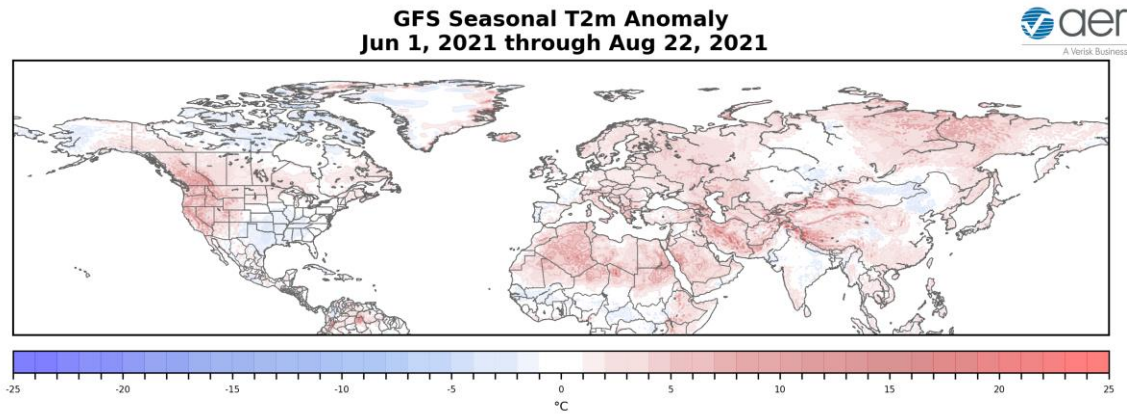

Figure i. Observed surface temperature anomalies (°C; shading) over the NH for 1 June through 5 August 2021 based on GFS analysis.

Also, as we approach the Arctic sea ice annual minimum in the coming weeks, the slowing of sea ice melt has been impressive. During much of July, sea ice extent was at a record low pace. But based on **Figure ii**, Arctic sea ice extent is higher on this date than all years since 2015 and 2014 is the most recent year with higher extent. Large parts of the ice are still vulnerable to melt before the Arctic Ocean begins to refreeze, but we should be safely above a new record low extent.

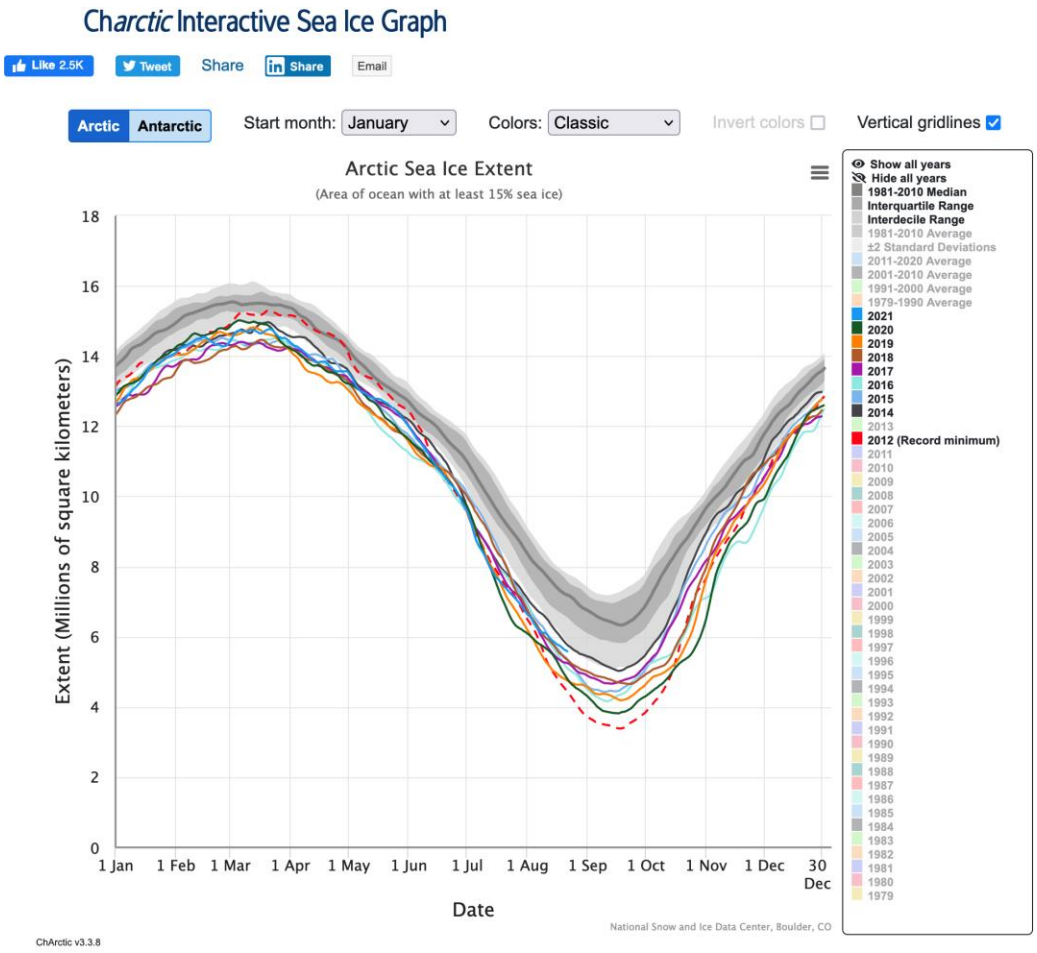

Figure ii. Observed Arctic sea ice extent on 22 August for the years 2014 through 2021. Image courtesy of National Snow and Ice Data Center (NSIDC).

I will just end with it appears from **Figure 11** that the blocking in the North Atlantic that steered tropical storm Henri towards the Northeastern US descended from the stratosphere. Not sure how real this is but I do find it interesting.

1-5 day

The AO and NAO are predicted to be negative this week **(Figure 1**) as geopotential height anomalies are predicted to be positive across the North Atlantic side of the Arctic including Greenland with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**).

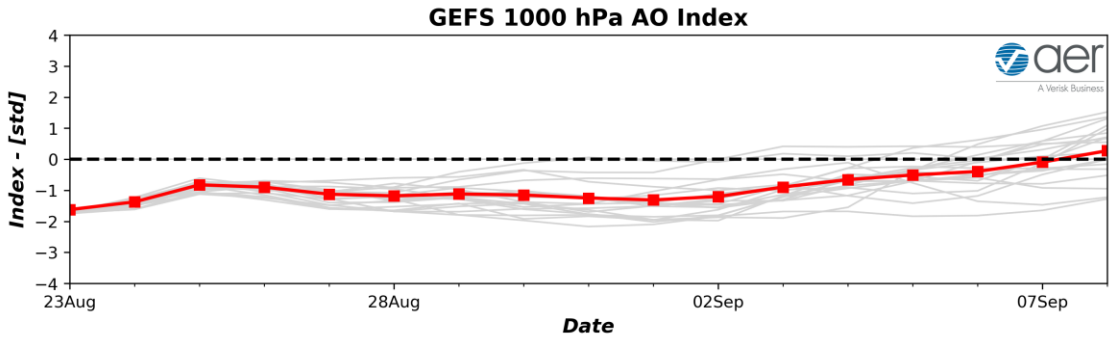

Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 23 August 2021 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies centered between Iceland and the UK this week will force troughing/negative geopotential height anomalies across Central and Eastern Europe (**Figures 2).** This will favor widespread normal to below normal temperatures across much of Europe except for normal to above normal temperatures across far Western Europe including the UK (**Figure 3**). The general pattern across Asia this period is ridging/positive geopotential height anomalies across much of Asia with regional troughing/negative geopotential height anomalies in Eastern China (**Figure 2**). This pattern favors normal to above normal temperatures across much of Asia with normal to below normal temperatures in Eastern Asia **(Figure 3**).

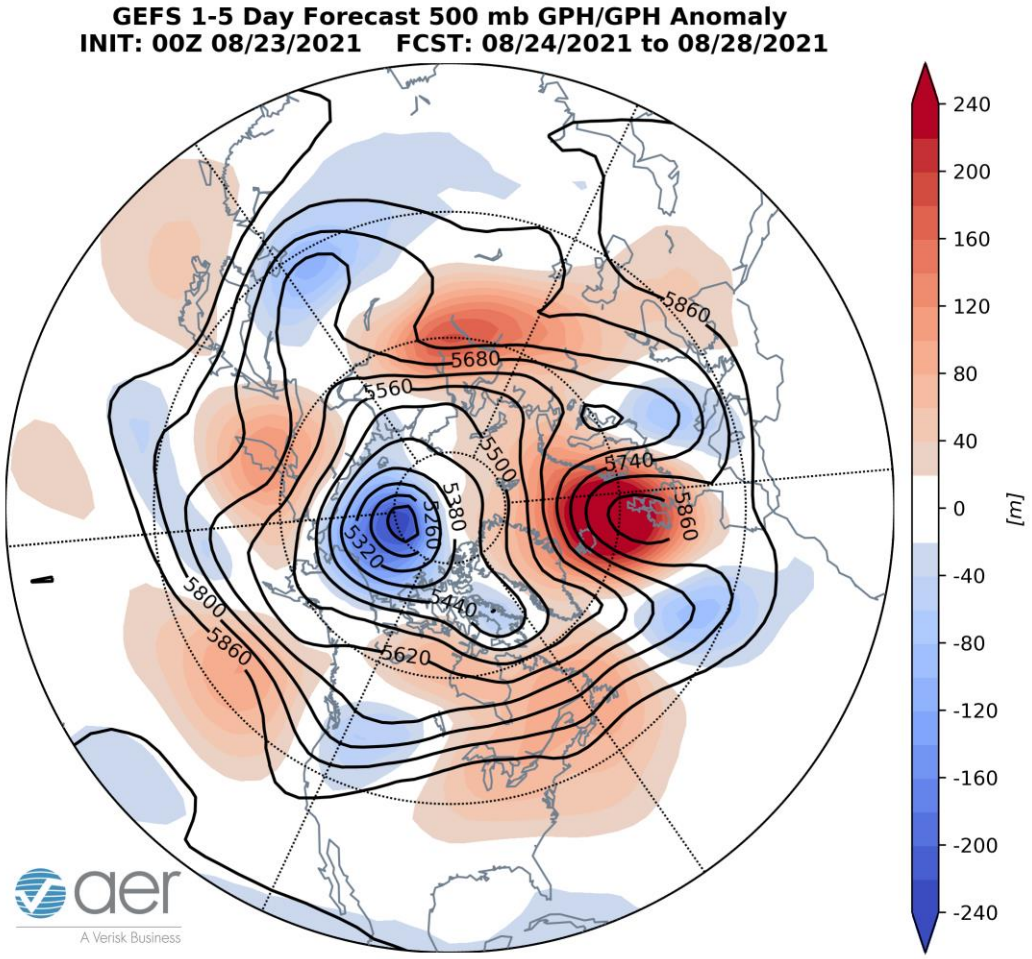

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 – 28 August 2021. The forecasts are from the 00z 23 August 2021 GFS ensemble.

The general pattern this week is ridging/positive geopotential height anomalies across much of the Eastern US, Northern and Eastern Canada with troughing/negative geopotential height anomalies across Alaska, Southwestern Canada and the Northwestern US **(Figure 2).** This pattern is predicted to bring normal to above normal temperatures across much of the Eastern US, Northern and Eastern Canada, with normal to below normal temperatures across Alaska, Southwestern Canada and the Northwestern US **(Figure 3).**

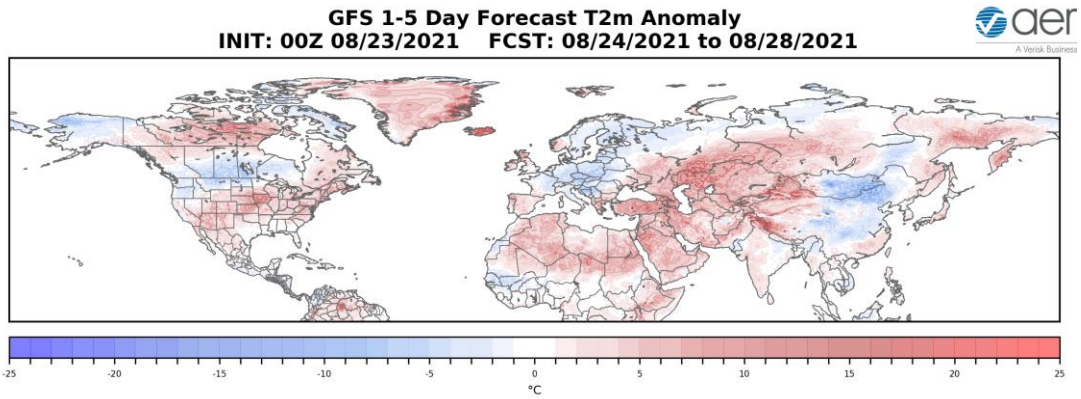

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 24 – 28 August 2021. The forecast is from the 00Z 23 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation across Scandinavia, Northern Siberia, Southern and Eastern Asia (**Figure 4**). Normal to below normal precipitation is predicted for much of North America with the exceptions of normal to above normal precipitation in Southeastern Alaska, along the Gulf of Mexico, the Great Lakes and into the Canadian Maritimes (**Figure 4**).

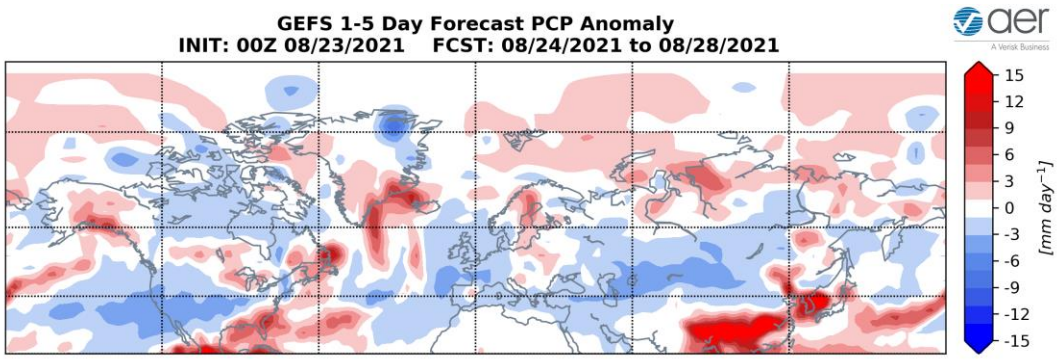

Figure 4. Forecasted precipitation anomalies (mm/day; shading) from 24 – 28 August 2021. The forecast is from the 00Z 23 August 2021 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to continue to remain negative this period **(Figure 1**) as geopotential height anomalies remain positive across the North Atlantic side of the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH

(**Figure 5**). And with positive geopotential height anomalies continuing across Greenland (**Figure 5**), the NAO is predicted to also persist negative this period.

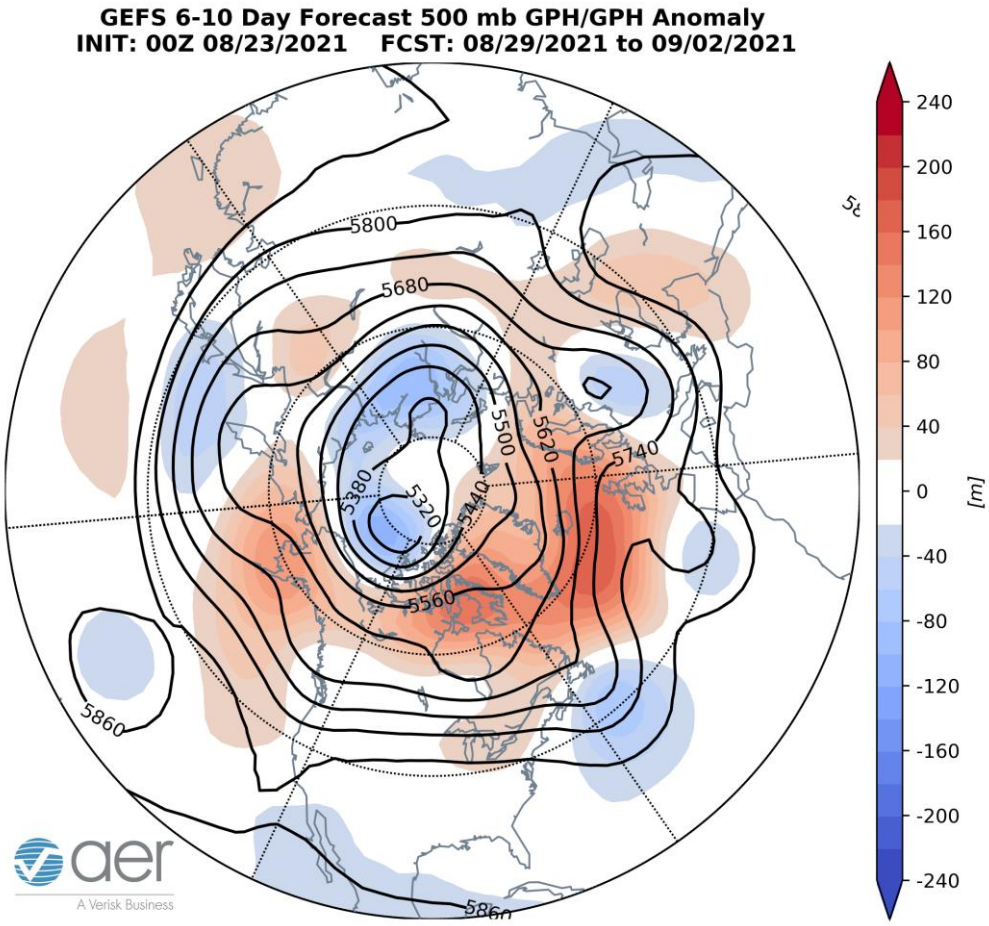

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 August – 2 September 2021. The forecasts are from the 00z 23 August 2021 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Greenland favor troughing/negative geopotential height anomalies across much of Europe except across Scandinavia and Spain this period (**Figures 5).** This will result in widespread normal to below normal temperatures across Central and Eastern Europe with normal to above normal temperatures across Scandinavia and far Western Europe including the UK (**Figure 6**). Ridging/positive geopotential height anomalies are predicted across much of Asia with only regional troughing/negative geopotential height anomalies from the Urals to Central Siberia (**Figure 5**). This pattern favors normal to above normal temperatures widespread across Asia with normal to below normal temperatures from the Urals eastward into Central Siberia **(Figure 6**).

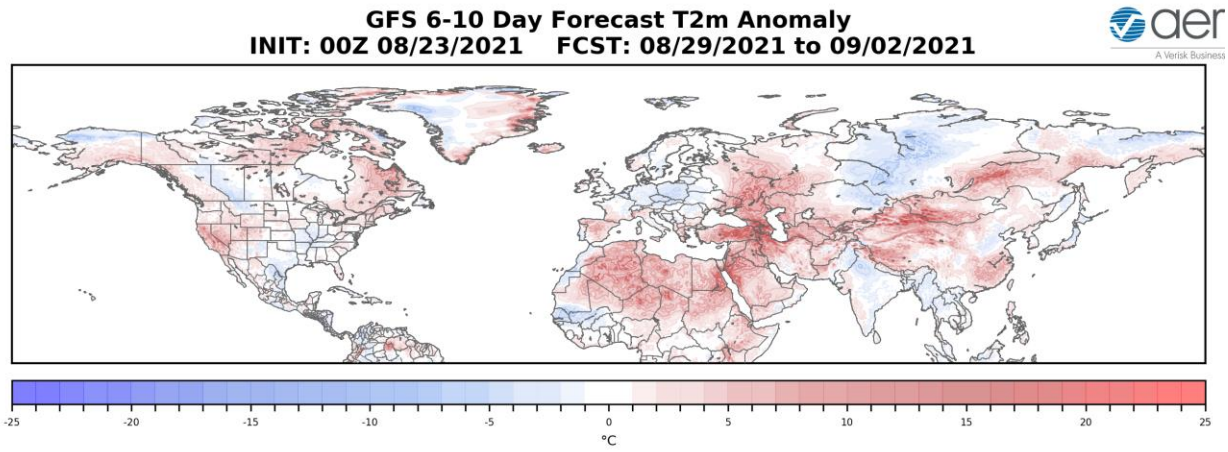

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 29 August – 2 September 2021. The forecasts are from the 00Z 23 August 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate much of North America with troughing/negative geopotential height anomalies confined to the Western US **(Figure 5).** This pattern is predicted to bring normal to above normal temperatures across much of Canada and the US with pockets of normal to below normal temperatures across Alaska, Western Canada and the Southeastern US **(Figure 6).**

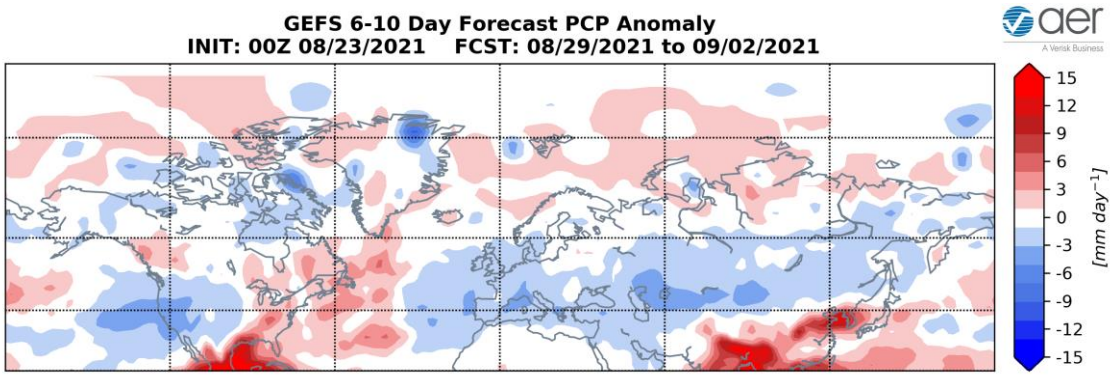

Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 29 August – 2 September 2021. The forecasts are from the 00Z 23 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation across Southern and Eastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America except for normal to above normal precipitation in Western Canada, the Eastern US and the Canadian Maritimes (**Figure 7**).

11-15 day

With persistent positive geopotential height anomalies predicted across Greenland and Iceland with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO should remain negative this period (**Figure 1**). With predicted positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is forecasted to remain negative this period as well.

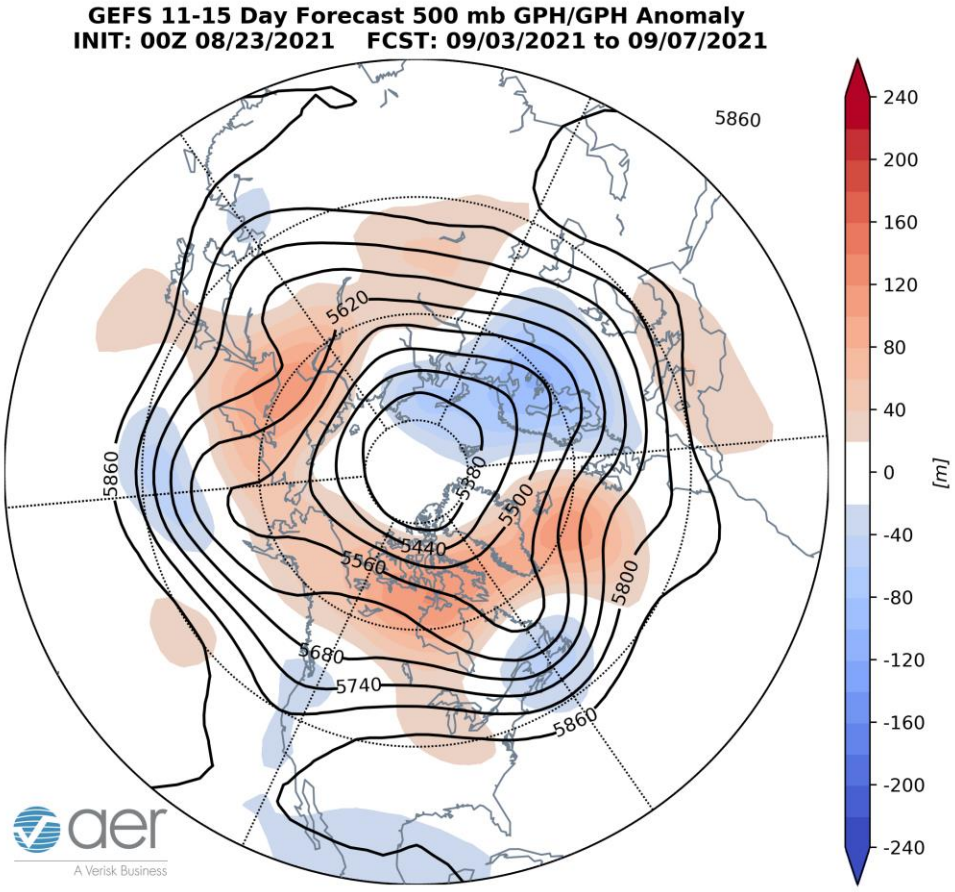

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 September 2021. The forecasts are from the 00z 23 August 2021 GFS ensemble.

Continued ridging/positive geopotential height anomalies across Greenland are predicted to anchor troughing/negative geopotential height anomalies across much of Europe this period (**Figure 8**). This pattern favors widespread normal to below normal temperatures across much of Europe including the UK except for normal to above normal temperatures across Spain and Portugal (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to remain widespread across Asia except for weak troughing/negative geopotential height anomalies in Northeastern China this

period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia but especially Central and Southwestern Asia except for normal to below normal temperatures across Mongolia and Northeastern China (**Figure 9**).

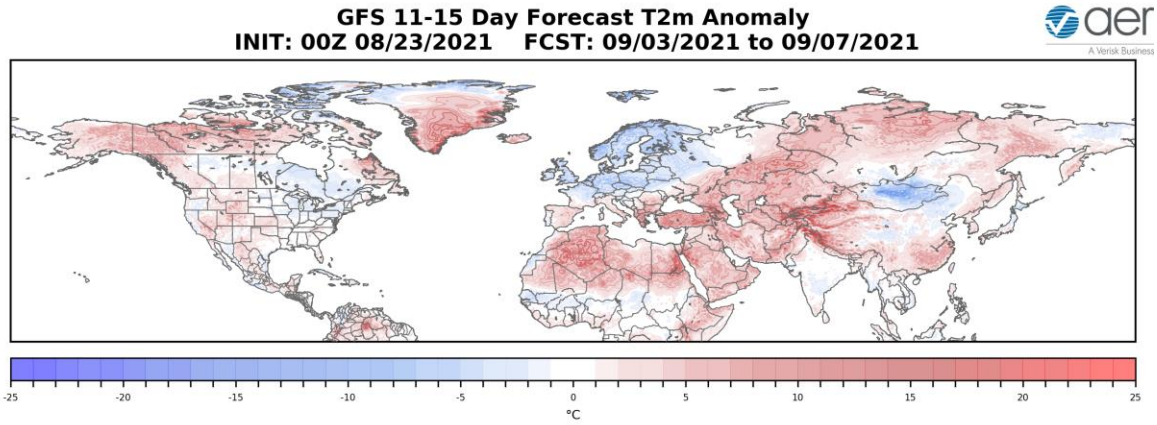

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 September 2021. The forecasts are from the 00z 23 August 2021 GFS ensemble.

The general pattern of ridging/positive geopotential height anomalies across North America with weak troughing/negative geopotential height anomalies across the US West Coast, the Northeastern US and the Canadian Maritimes this period (**Figure 8**). This pattern favors normal to above normal temperatures for much of the US and Canada except for normal to below normal temperatures across Southeastern Canada and the Eastern US (**Figure 9**).

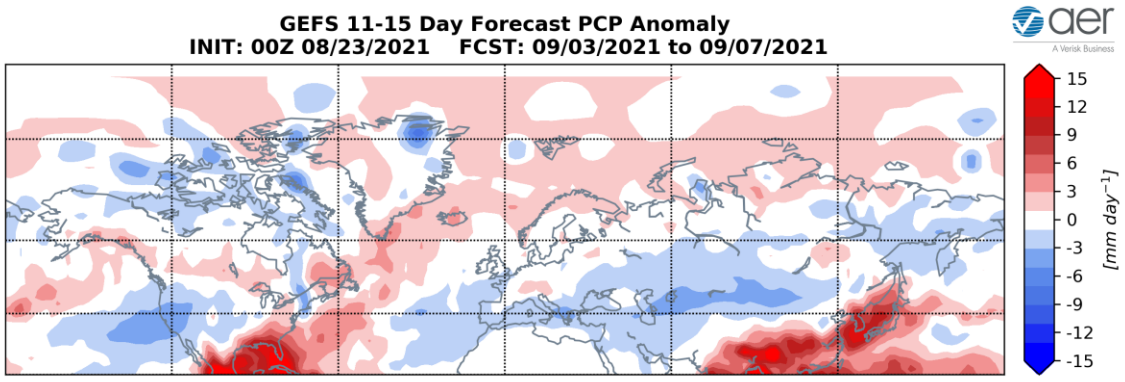

Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 3 – 7 September 2021. The forecasts are from the 00z 23 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia except for above normal precipitation across Southeast Asia (**Figure 10**). Normal to above normal precipitation is predicted for much of North America with normal to above normal precipitation in the

Alaska Panhandle, along the Gulf of Mexico, the Eastern US 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 cold/negative PCHs in the upper stratosphere with warm/positive PCHs in the mid to low stratosphere and all of the troposphere (**Figure 11**).

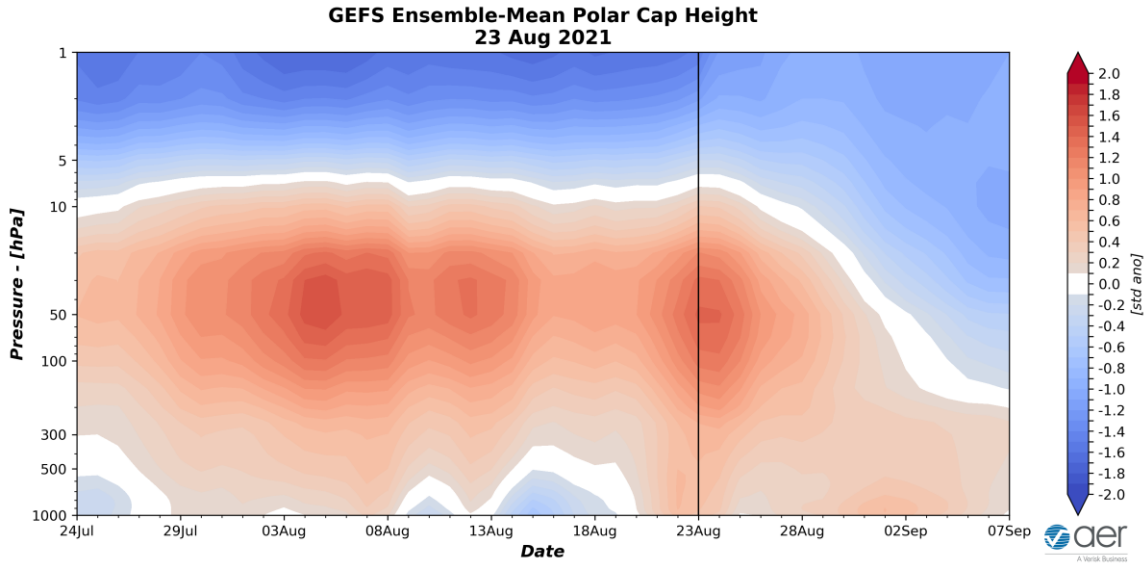

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 23 August 2021 GFS ensemble.

The overall predicted cold/negative PCHs in the upper stratosphere are predicted to descend through the stratosphere and upper troposphere next week (**Figure 11**). However persistent warm/positive PCHs in the lower troposphere are consistent with the predicted negative AO this week and into next week (**Figure 1**).

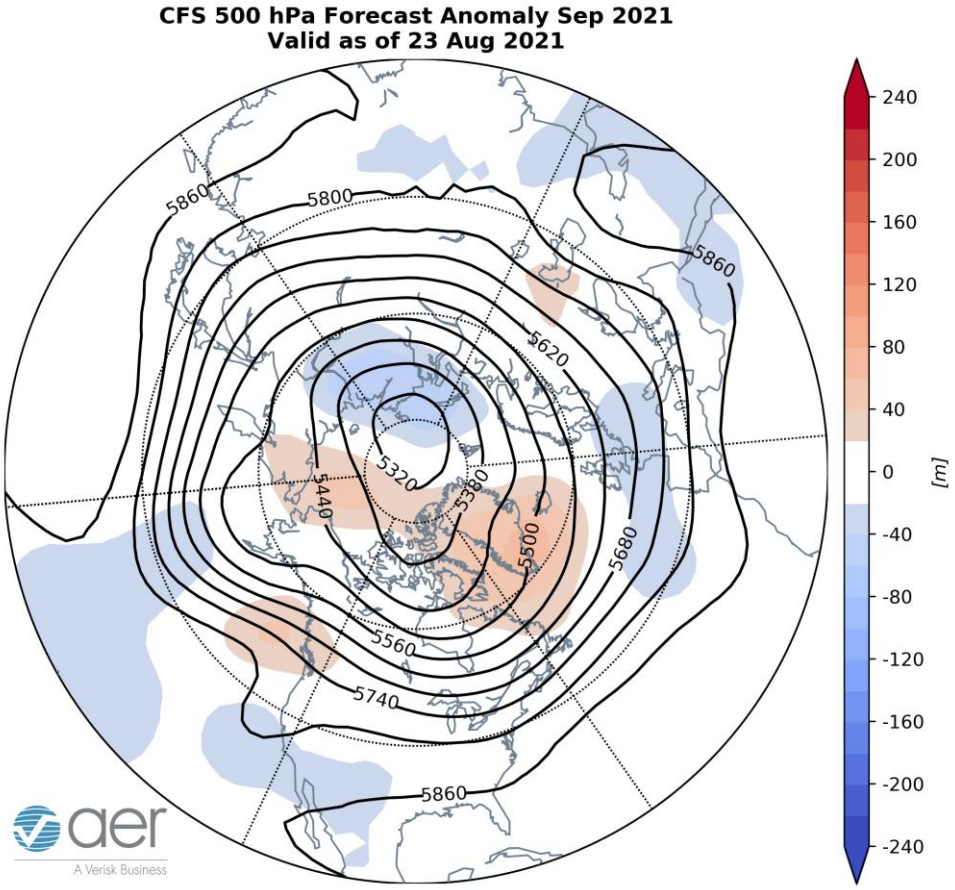

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2021. The forecasts are from the 00Z 23 August 2021 CFS.

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 across Greenland, the Beaufort Sea and the west coast of North America with troughing in Northern Europe, Siberia, east of the Dateline and eastern Canada (**Figure 12).** This pattern favors seasonable to relatively cool temperatures for Northern Europe, Northern Asia including Siberia and Northern Canada with seasonable to relatively warm temperatures for Southern Europe, Southern and Eastern Asia, Alaska, Western Canada and much of the US (**Figure 13**).

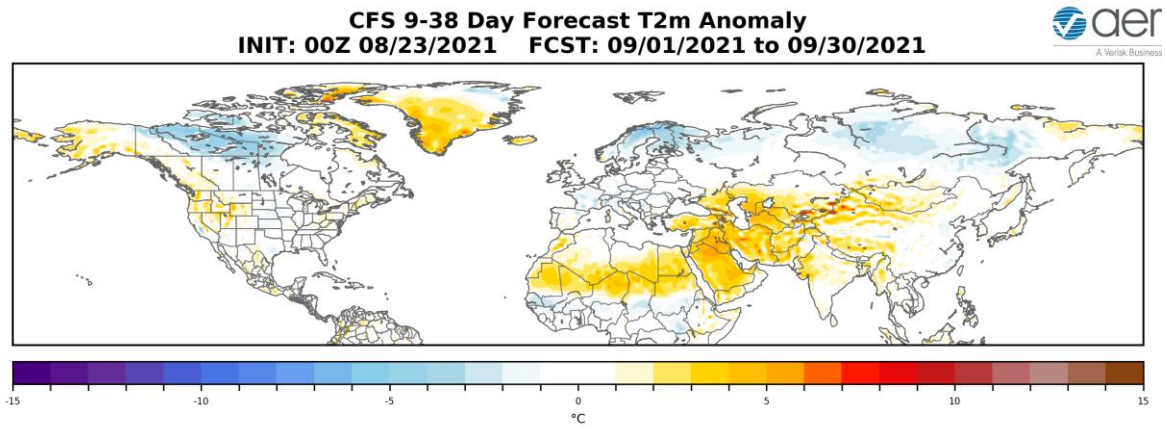

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for September 2021. The forecasts are from the 00Z 23 August 2021 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are close to normal and we continue to observe neutral conditions (**Figure 14**) and neutral conditions are expected through the summer. Observed SSTs across the NH remain well above normal especially in the Baltic Sea, Gulf of Alaska, the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the Southern Hemisphere. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

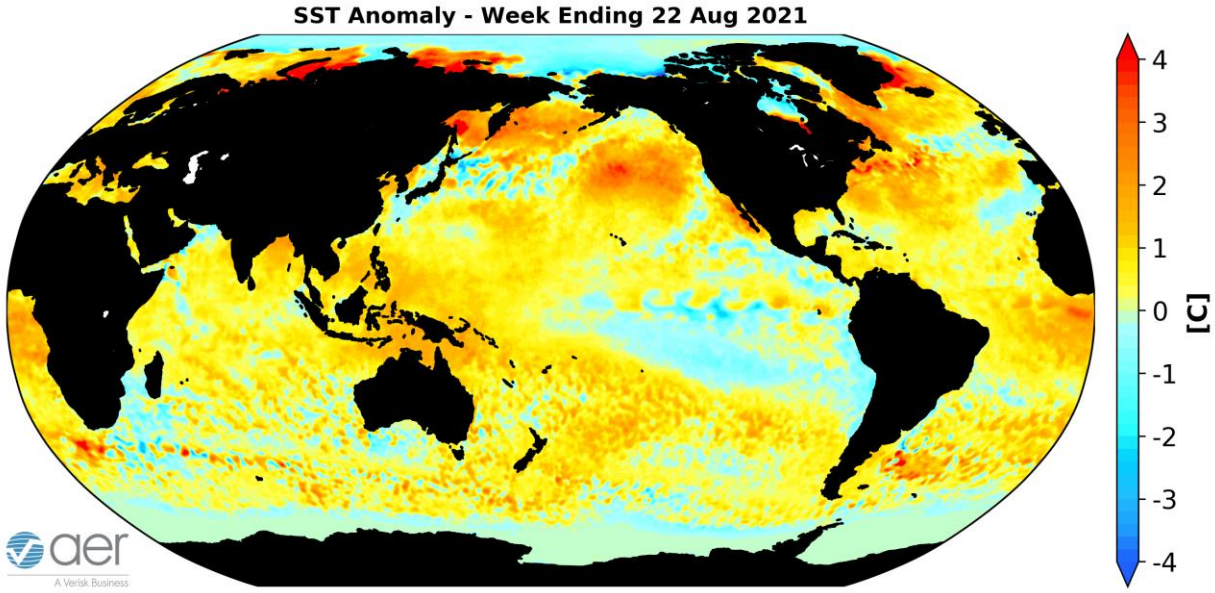

Figure 14. The latest weekly-mean global SST anomalies (ending 22 August 2021). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored over the next two weeks. Therefore it seems unlikely that the MJO is contributing to the predicted weather pattern across North America over the next two weeks but admittedly this is outside of my expertise.

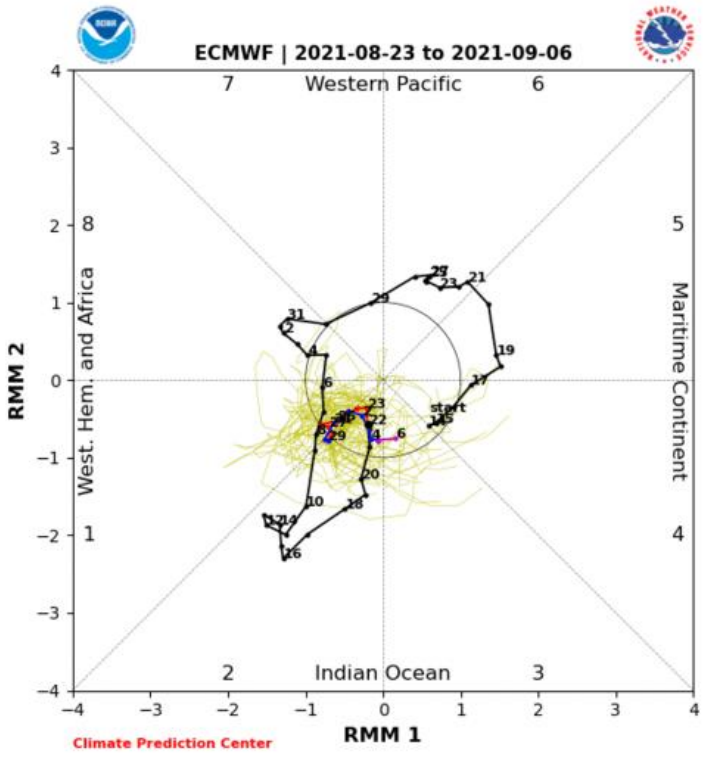

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 9 August 2021 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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