Arctic Oscillation and Polar Vortex Analysis and Forecasts

September 6, 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.

Subscribe to our email list or follow me on Twitter (@judah47) for notification of updates.

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

anomalies are predicted to remain mixed to mostly negative across Greenland the next two weeks.

- The next two weeks, ridging/positive geopotential height anomalies coupled with normal to above normal temperatures are predicted to dominate much of Europe including the United Kingdom (UK).
- Over the next two weeks much of Eastern Asia will be dominated by ridging/positive geopotential height anomalies coupled with normal to above normal temperatures with troughing/negative geopotential height anomalies coupled with normal to below temperatures in Western Asia.
- This general pattern across North America this week is ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across western North America with troughing/negative geopotential height anomalies coupled with normal to below temperatures in the Eastern United States (US). However next week the pattern is predicted to flip with troughing/negative geopotential height anomalies coupled with normal to below temperatures in western North America and ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across eastern North America.
- In the brief holiday edition of the *Impacts* section, I share a brief summary of the summer pattern across the Northern Hemisphere (NH) and anticipate the upcoming Arctic sea ice minimum.

Impacts

My apologies but there were issues with our plots today and with the holiday they were not all resolved.

With the end of summer, we can 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. I will show the observations with the predicted summer surface temperature anomalies in the next blog.

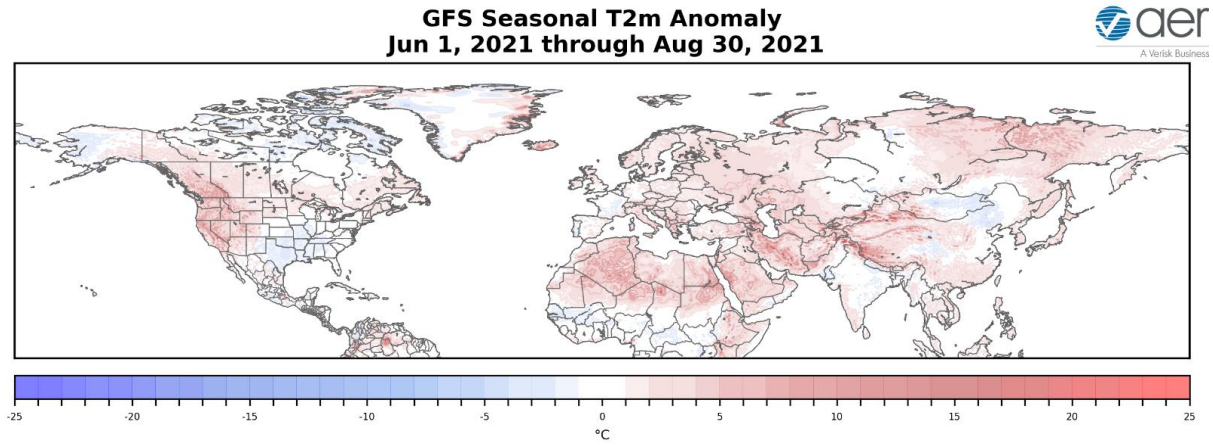

Figure i. Observed surface temperature anomalies (°C; shading) over the NH for 1 June through 30 August 2021 based on GFS analysis.

Also, as we approach the Arctic sea ice annual minimum in the coming week or so, the slow sea ice melt continues to be impressive. Sea ice extent continues to be greater than any year since 2014 and there is a good chance that will hold. Sea ice is near normal on the North Pacific side of the Arctic and well below normal on the Eurasian to North Atlantic side of the Arctic. I think this is an interesting anomaly pattern that is conducive to perturb the polar vortex but we shall see as it is very, very early.

On the left side menu, we included a video describing the importance of our new study published in the September 3, 2021 issue of *Science*.

1-5 day

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

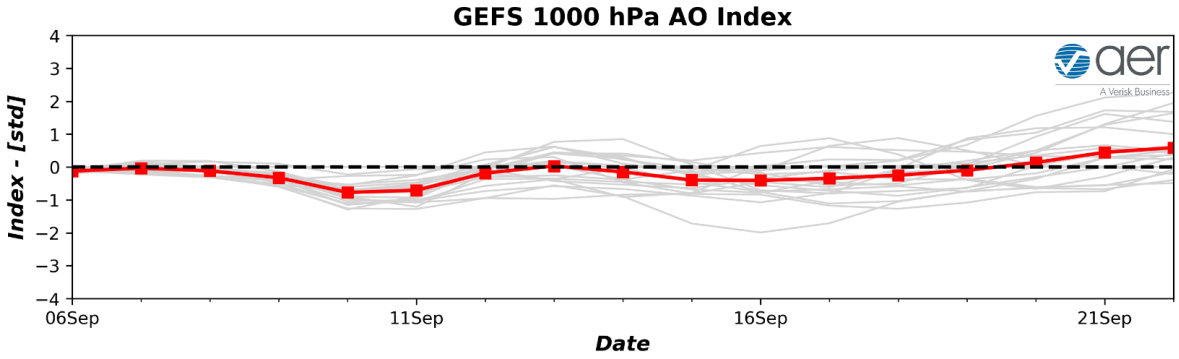

Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 6 September 2021 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies will dominate much of Europe with the exception of troughing/negative geopotential height anomalies in Eastern Europe (**Figures 2).** This will favor widespread normal to above normal temperatures across much of Europe including the UK except for normal to below normal temperatures across far Eastern Europe (**Figure 3**). The general pattern across Asia this period is ridging/positive geopotential height anomalies across much of Eastern Asia with troughing/negative geopotential height anomalies in Western Asia (**Figure 2**). This pattern favors normal to above normal temperatures across much of East Asia with normal to below normal temperatures in West Asia **(Figure 3**).

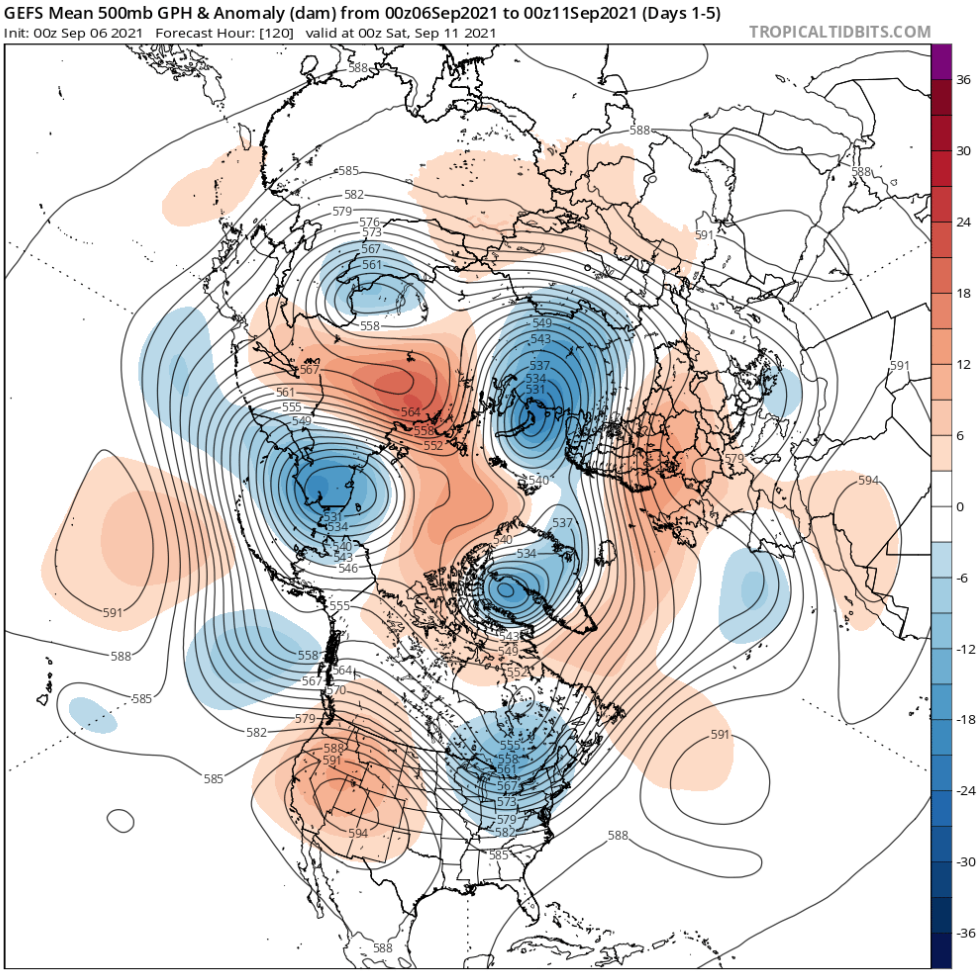

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 7 –

11 September 2021. The forecasts are from the 00z 6 September 2021 GFS ensemble and is downloaded from https://www.tropicaltidbits.com.

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

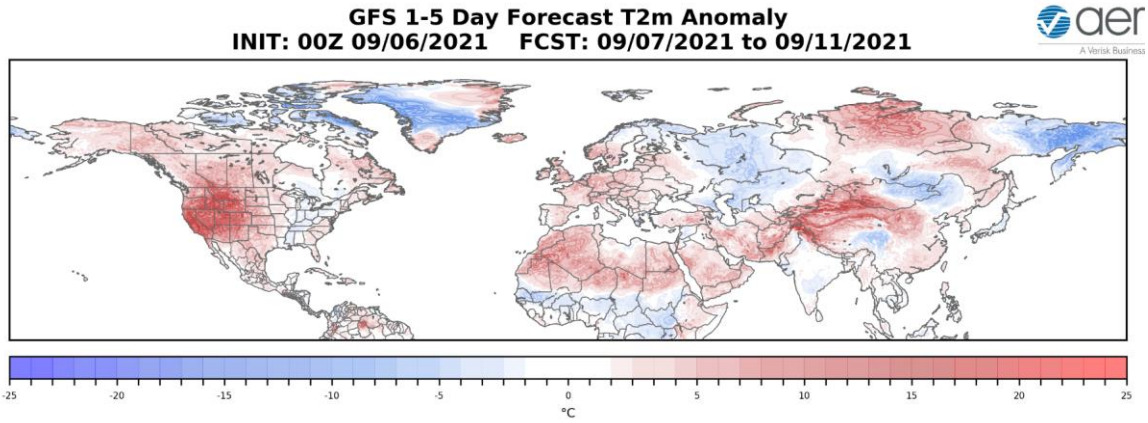

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 7 – 11 September 2021. The forecast is from the 00Z 6 September 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation across Norway, 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 western Alaska, Western Canada, along the Gulf of Mexico, the Southeastern US and into the Canadian Maritimes (**Figure 4**).

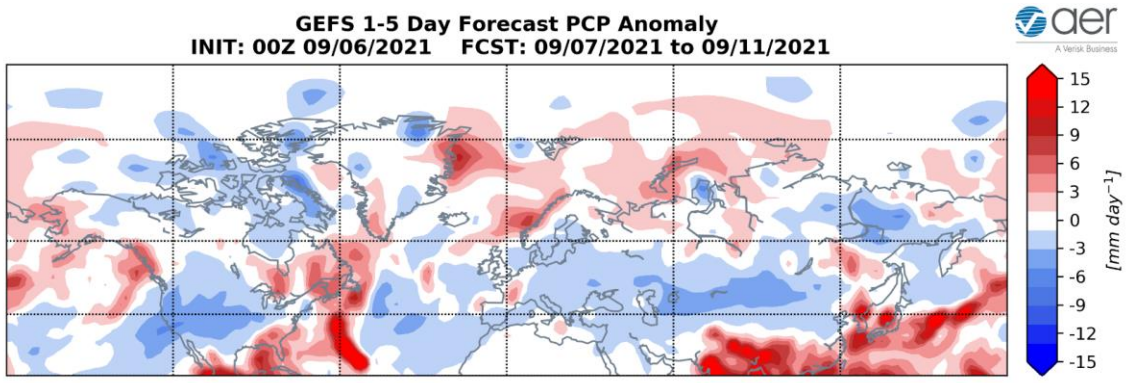

Figure 4. Forecasted precipitation anomalies (mm/day; shading) from 7 – 11 September 2021. The forecast is from the 00Z 6 September2021 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to continue to remain neutral to negative this period **(Figure 1**) 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 mostly negative geopotential height anomalies continuing across Greenland (**Figure 5**), the NAO is predicted to be neutral to positive this period.

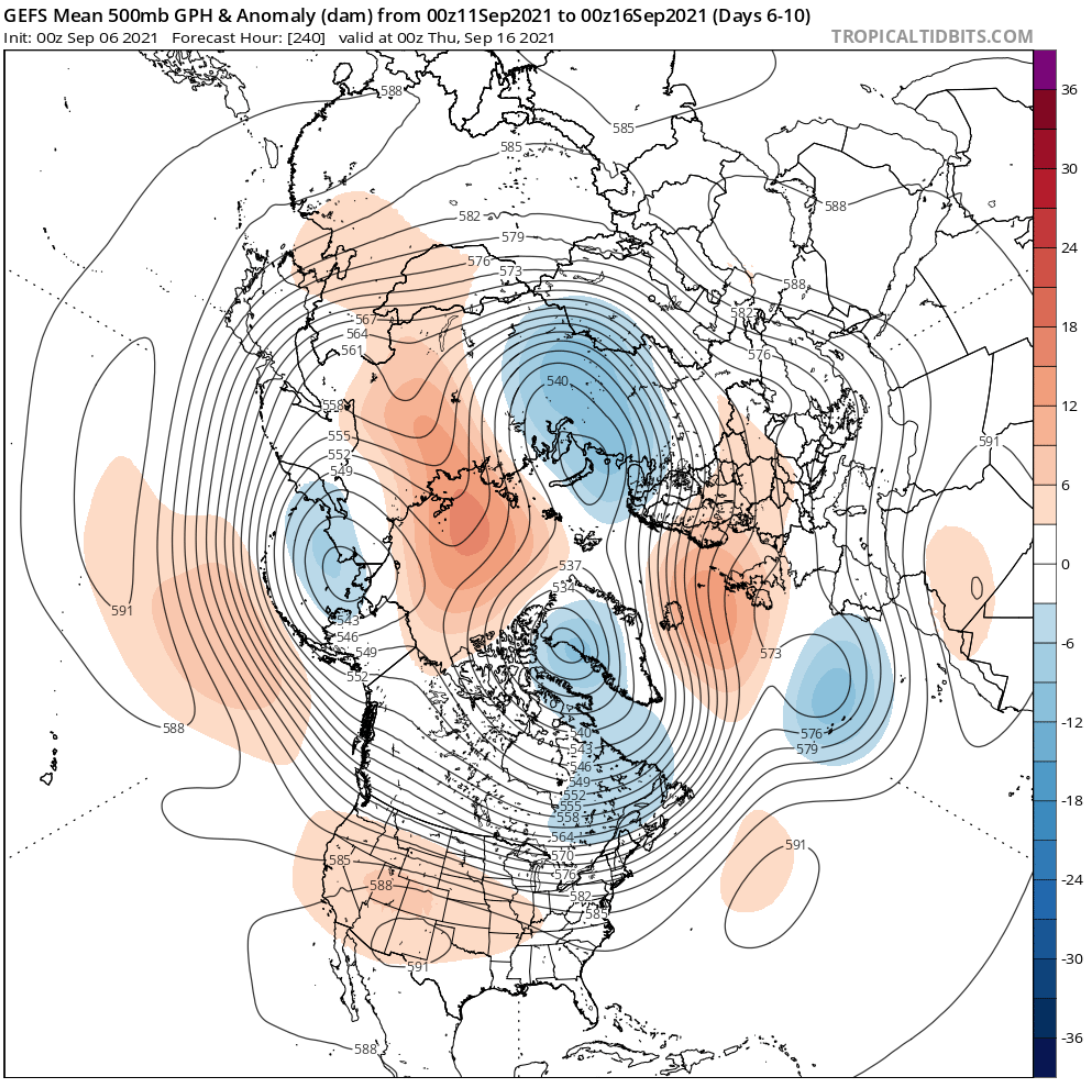

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 12–16 September 2021. The forecasts are from the 00z 6 September 2021 GFS ensemble and is downloaded from https://www.tropicaltidbits.com.

Persistent ridging/positive geopotential height anomalies are predicted across much of Europe including the UK except across northern Scandinavia this period (**Figures 5).** This will result in widespread normal to above normal temperatures across Europe with normal to below normal temperatures across Scandinavia (**Figure 6**). Ridging/positive geopotential height anomalies are predicted across Western Asia with troughing/negative geopotential height anomalies across Eastern Siberia and Western Asia once again this period (**Figure 5**). This pattern favors normal to above normal temperatures widespread across East Asia with normal to below normal temperatures in West Asia and Eastern Siberia **(Figure 6**).

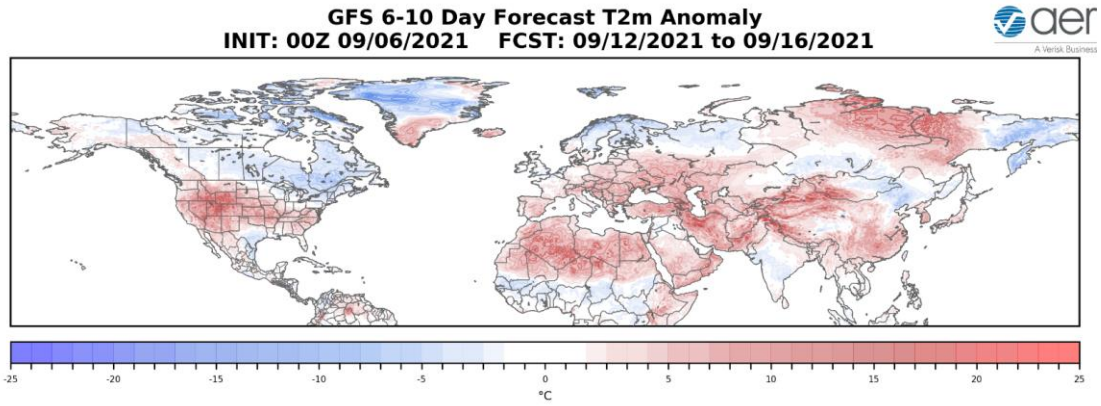

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 12– 16 September 2021. The forecasts are from the 00Z 6 September 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate the US with troughing/negative geopotential height anomalies across Canada **(Figure 5).** The mostly zonal flow pattern is predicted to bring normal to above normal temperatures across much of Alaska, Western Canada and the US with normal to below normal temperatures across Eastern Canada **(Figure 6).**

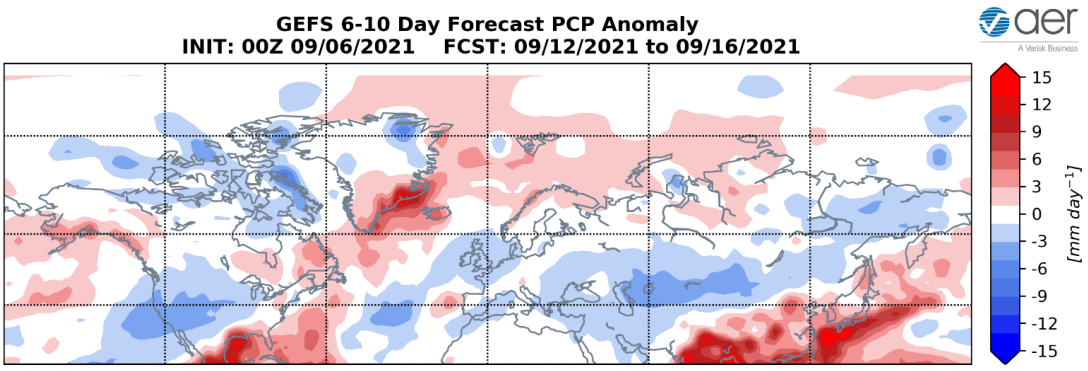

Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 12– 16 September 2021. The forecasts are from the 00Z 6 September 2021 GFS ensemble.

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 Southern Alaska, Western Canada, along the Gulf of Alaska and the Canadian Maritimes (**Figure 7**).

11-15 day

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

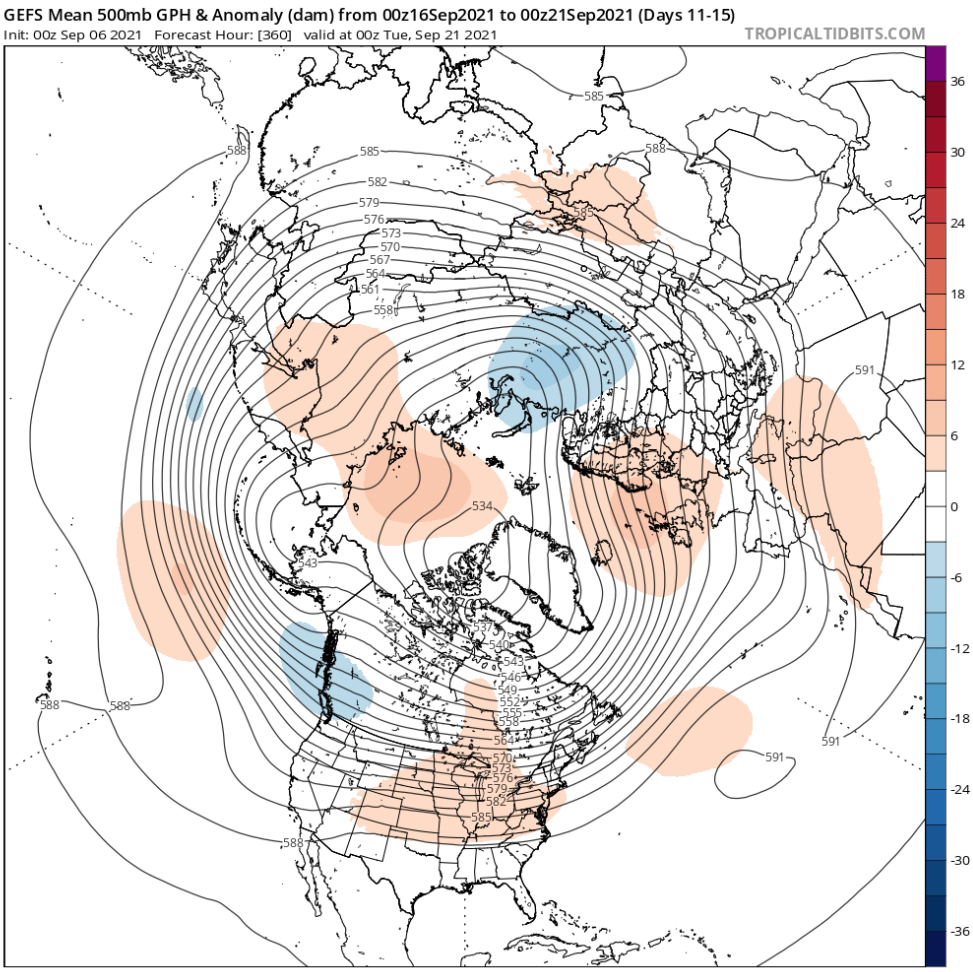

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 September 2021. The forecasts are from the 00z 6 September 2021 GFS ensemble and is downloaded from https://www.tropicaltidbits.com.

Ridging/positive geopotential height anomalies are predicted to persist across much of Europe this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Southern Europe normal to below normal temperatures across Northern Europe with including the UK (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to remain anchored across Eastern Asia with troughing/negative geopotential height anomalies in Western Asia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of East Asia with normal to below normal temperatures across West Asia (**Figure 9**).

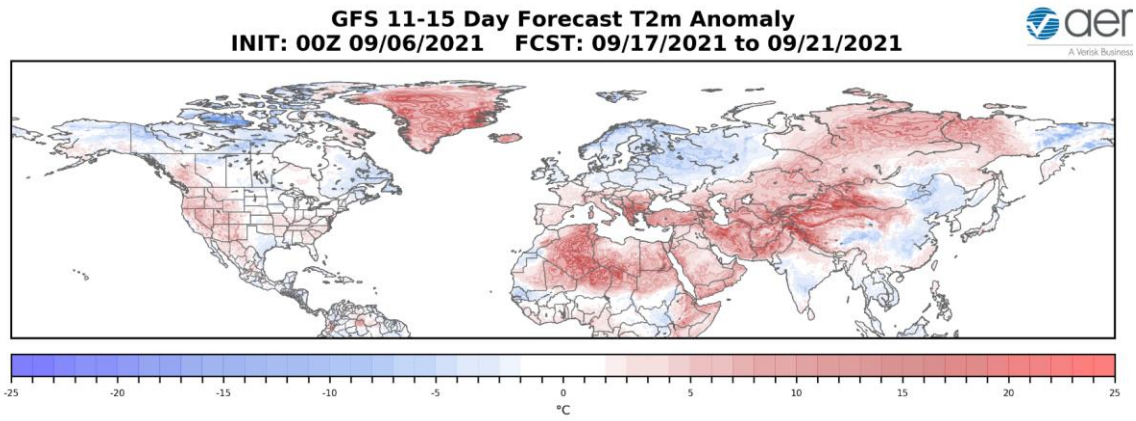

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 17 – 21 September 2021. The forecasts are from the 00z 6 September 2021 GFS ensemble.

The general pattern of ridging/positive geopotential height anomalies across the US with weak troughing/negative geopotential height anomalies across Canada is predicted to persist this period (**Figure 8**). This pattern favors normal to above normal temperatures for much of the US and Eastern Canada with normal to below normal temperatures across Western Canada and Alaska (**Figure 9**).

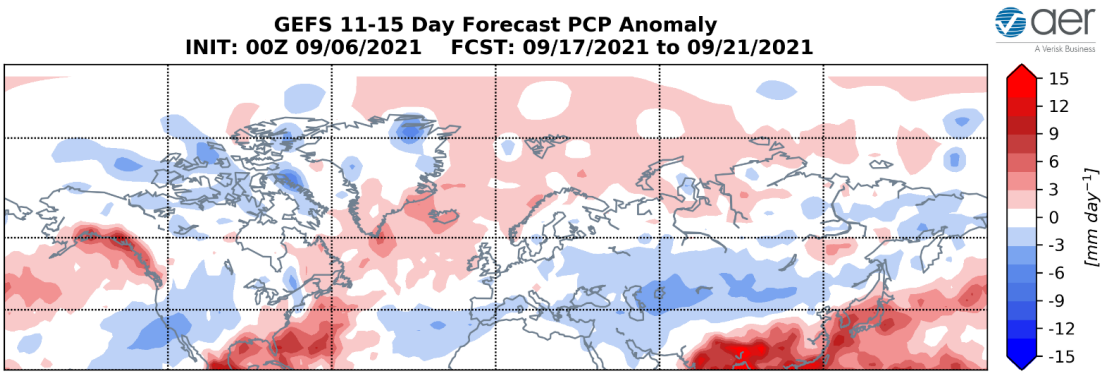

Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 17 – 21 September 2021. The forecasts are from the 00z 6 September 2021 GFS ensemble.

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, the West Coast of Canada, 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 to mid-stratosphere with warm/positive PCHs in the low stratosphere and all of the troposphere but the anomalies are very weak (**Figure 11**).

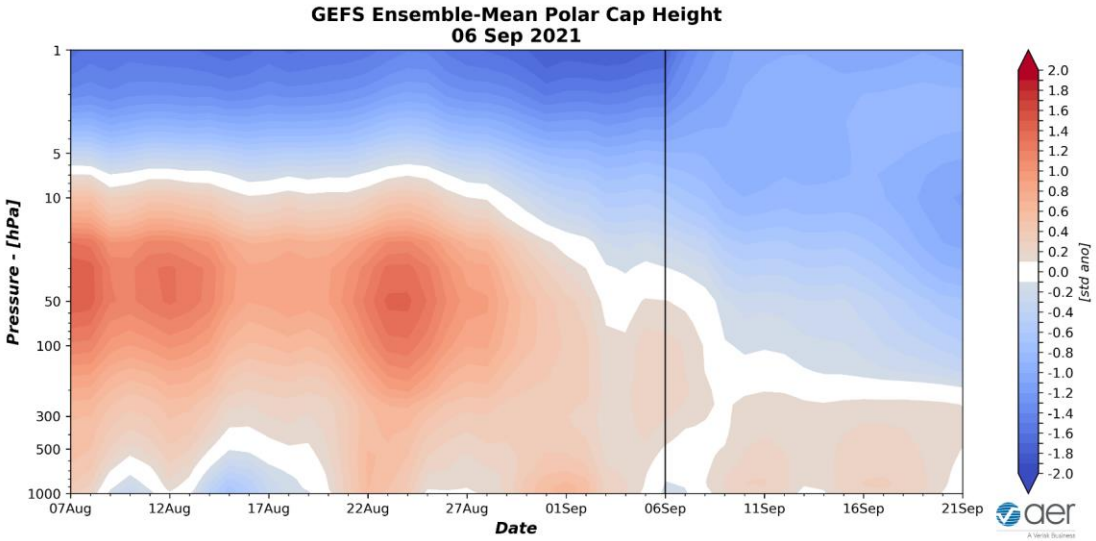

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 6 September 2021 GFS ensemble.

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 neutral to negative AO this week and into next week (**Figure 1**).

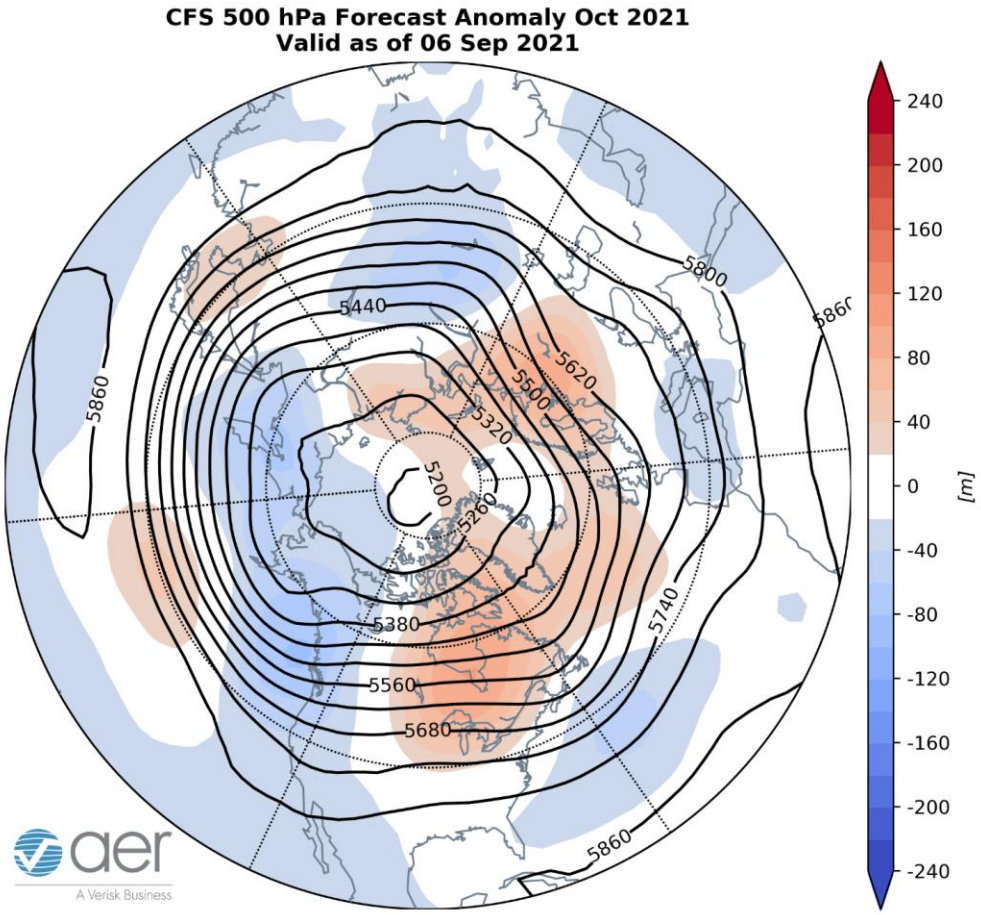

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2021. The forecasts are from the 00Z 6 September 2021 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) for October from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The surface temperatures did not generate. The forecast for the troposphere is ridging across Northern Europe, East Asia and eastern North America with troughing in Southern Europe, Central Asia, Eastern Siberia and the west coast of North America (**Figure 12).** This pattern favors seasonable to relatively cool temperatures for Southern Europe, Central Asia, Eastern Siberia and western North America with seasonable to relatively warm temperatures for Northern Europe, Eastern Asia, Eastern Canada and much of the Eastern US.

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2021. The forecasts are from the 00Z 6 September 2021 CFS (**missing**).

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.

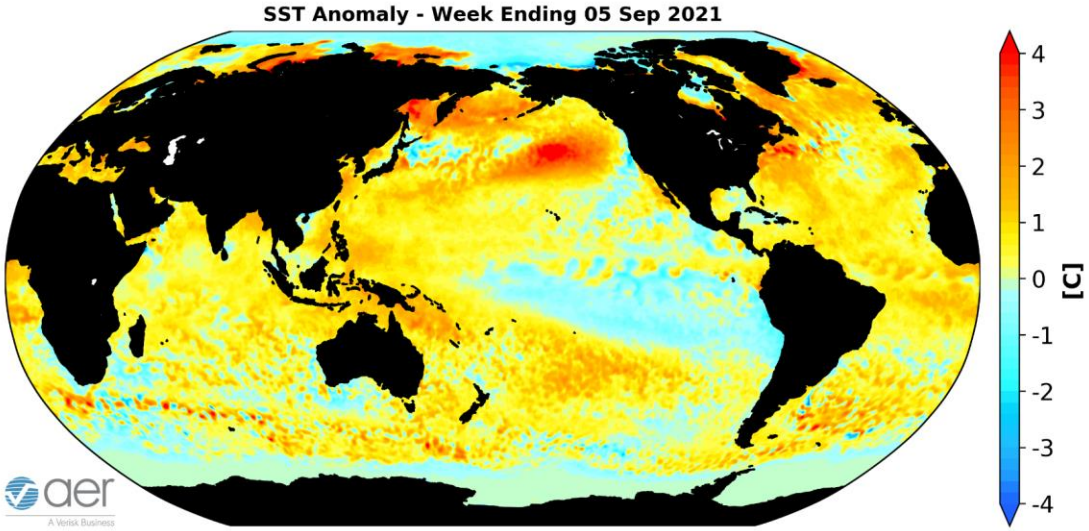

Figure 14. The latest weekly-mean global SST anomalies (ending 5 September 2021). Data from NOAA OI High-Resolution dataset.

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

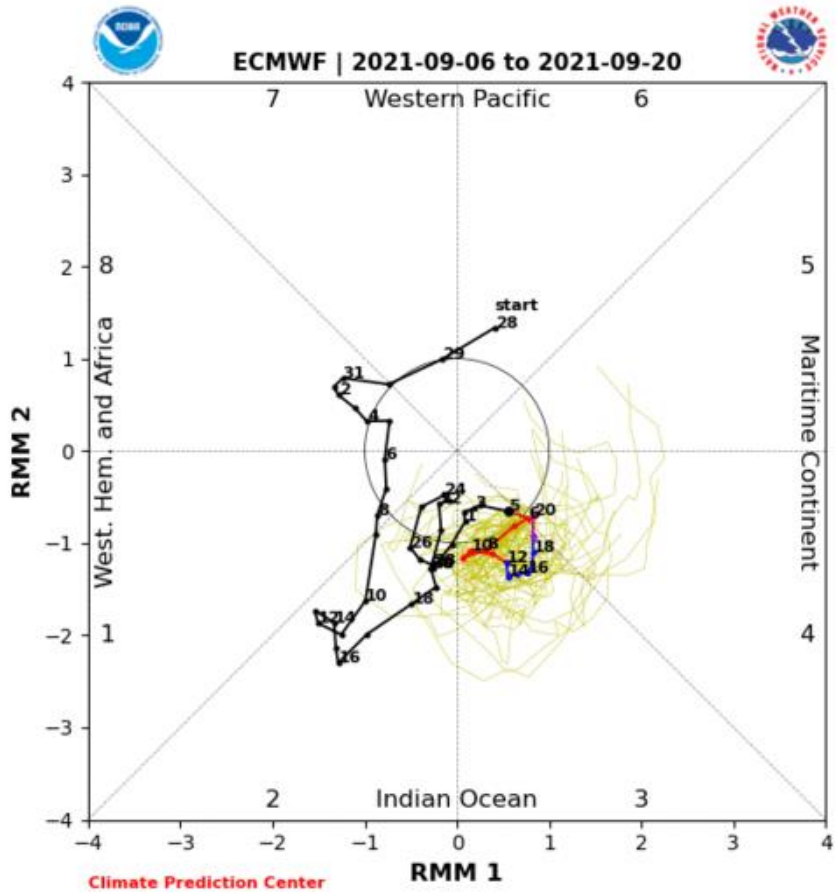

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 6 September 2021 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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