

August 5, 2019

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.

With the start of spring we transitioned 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 negative and is predicted to remain negative over the next two weeks.
- The current negative AO is reflective of mostly positive pressure/geopotential height anomalies across the Arctic and mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is strongly negative as strong positive pressure/geopotential height anomalies are spread across Greenland and is predicted to remain negative over the next two weeks as geopotential height anomalies are predicted to remain positive across Greenland.
- Troughing/negative geopotential height anomalies currently dominate much of Europe and are predicted to remain anchored across Northern Europe while

ridging/positive geopotential height anomalies remain strung across Southern Europe over the next two weeks. This pattern favors seasonable to below normal temperatures across Northern Europe including the United Kingdom (UK) and seasonable to above normal temperatures across Southern Europe over the next two weeks.

- An omega type pattern is predicted across Asia with ridging/positive geopotential height anomalies across Central Asia bookended by troughing/negative geopotential height anomalies across Western Asia and Far East Asia. This is predicted to result in relatively warm temperatures widespread across Asia with normal to below normal temperatures in parts of Eastern and Western Asia but especially Western Russia.
- Ridging/positive geopotential height anomalies are predicted to remain moored near Greenland with ridging widespread across western North America over the next two weeks. This favors troughing/negative geopotential height anomalies downstream across Western and Central Canada with seasonable to below normal temperatures that is predicted to filter into Southeastern Canada and the Eastern United States (US) over the next two weeks.
- In the *Impacts* section I discuss some thoughts on summer 2019 and climate change.

Impacts

Last week I compared the observed surface temperatures through July 19th with the AER summer forecast and this week I am presenting an update of the observed surface temperatures through August 1, 2019 in **Figure i**. With a little less than a month left to summer, I expect only relatively small changes to the large-scale pattern of surface temperature anomalies. The headline of the summer is widespread above normal temperatures with the greatest departures focused on western North America, Europe and Siberia. There are some regional exceptions but the three regions that have the best odds of recording a below normal average temperature for the summer are Western Russia, northwestern Canada and the US Southern Plains. These are regions downstream of the most amplified ridging in the Northern Hemisphere (NH). There is also some regional cooling in Eastern Siberia downstream of the strong ridging in Siberia. The strong ridging and record-breaking heat have contributed to a destructive fire season in both Alaska and Siberia.

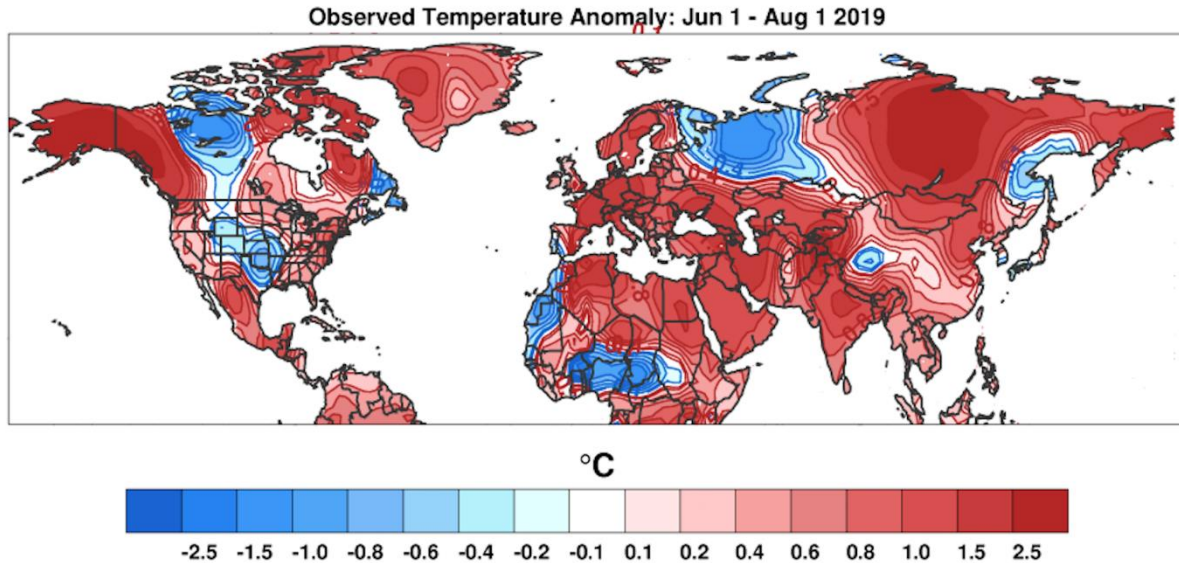


Figure i. Observed surface temperature anomalies (°C; shading) across the Northern Hemisphere from 1 June – 1 August 2019.

The pattern of strong warming in Europe, cooling or lack of a trend in Western Russia with more amplified warming in Siberia is not unique to this summer but has been a multi-annual trend. Why the long-term trend should manifest in this pattern is curious to me. I did see a recent paper that does provide a possible physical explanation. According to [Sato and Nakamura \(2019\)](#) it could be related to increased snowfall in Western Asia in winter that leads to increased soil moisture in the spring and early summer that then favors troughing in the region with ridging on either end across Europe and Siberia. It is an interesting idea and provides another impact of Arctic amplification or accelerated Arctic warming not only in the winter season but in summer as well and links the two together. My own research has focused on the possibility that accelerated Arctic warming and low sea ice are contributing to increased snowfall across Eurasia primarily in the fall and together the low sea ice and more extensive snow cover in the fall contribute to colder temperatures and heavier snowfall in winter across the continents of the NH. According to this study that impact of heavier snowfall is not confined to winter but extends into the summer with a strong influence on European summer temperatures.

My research is on climate variability on subseasonal to seasonal time scales and I try my best not to comment on climate discussions and debates on longer timescales as this is beyond my core expertise. However, I do want to express that I have been spooked by what I have seen this summer. There is an article in today's Washington Post on [July's record heat](#). There is one line that really resonates with me "This is not your grandfather's summer" by UN Secretary General Antonio Guterres. I was fortunate enough to visit Paris for a number of summers in the 1980's and early 1990's. On none of those trips did I anticipate or pack for hot temperatures. Over that decade the

warmest weather that I encountered was in April during a fluke one off day with temperatures in the 90's. I am having a hard time juxtapositioning the summers in Paris from my memories of cool, cloudy and damp weather and the Paris of 2019 with a high temperature of 109°F; to me it is mind boggling. I never would have guessed that in my lifetime Paris would fall short of 110°F by just one degree. And it is not just one or two hot days in Paris, as there are always flukes. There have been many all-time records set this summer across Europe and in many cases by unusually wide margins. Here in Boston we did not see any all-time record highs but we did just experience our warmest month ever.

And the heat is not simply confined to the mid-latitudes but includes the Arctic as well. There have been many headlines about the melting of the Greenland ice sheet, and it is looking like 2019 will give 2012 a run for the lowest Arctic sea ice minimum in the satellite era. In August 2012 sea ice loss was unprecedented that may be hard to match in 2019, but 2019 at least second place looks like a lock. I often look at satellite pictures of Siberia for snow cover, but it is odd to see satellite pictures of Siberia with the region not covered in snow but smoke (see **Figure ii**).

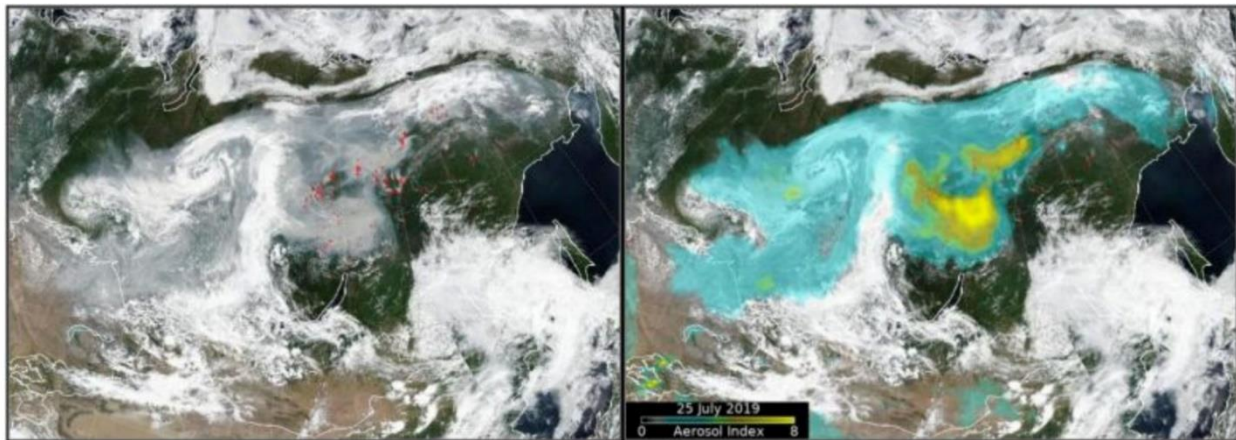


Figure ii. A satellite photo obtained on July 25, 2019, shows aerosol index overlaid (right) and the fire peaks (left) over Siberia. PHOTO: REUTERS (<https://www.straitstimes.com/world/europe/siberia-forest-fires-spark-potential-disaster-for-arctic>)

With so many all-time record high temperatures from daily to monthly and from local to global scale, melting glacial and sea ice and widespread Arctic fires it does seem we have numerous highly anomalous weather and climate events all occurring simultaneously. More than ever I feel that we have entered a “new normal.” Attribution of an event, a series of events in space and time and collectively across the globe is difficult but the best explanation that I can come up with is increasing greenhouse gases. And if the theory is correct, or maybe more likely without unforeseen negative

feedbacks, the extreme weather of 2019 will only become exacerbated in the years to come. For me this is very sobering.

Near Term Conditions

1-5 day

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

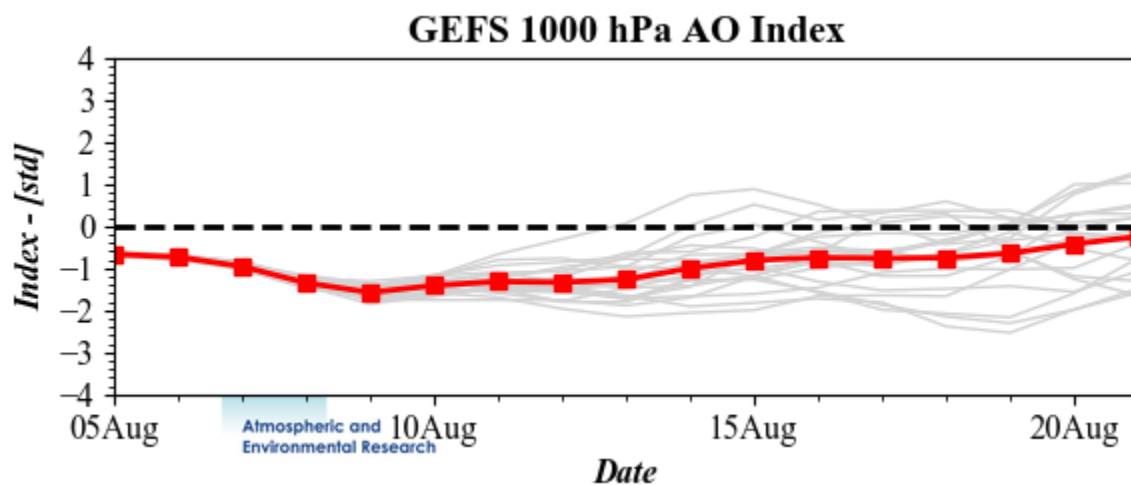


Figure 1. The predicted daily-mean AO at 10 hPa from the 00Z 5 August 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Strong ridging/positive geopotential height anomalies centered over Greenland favor troughing/negative geopotential height anomalies across Northern Europe with more ridging/positive geopotential height anomalies across Southern Europe (**Figure 2**) resulting in normal to below normal temperatures across much of Northern Europe including the UK and normal to above normal temperatures in Southern Europe (**Figure 3**). An omega type pattern is predicted across Asia with troughing/negative geopotential height anomalies in Western Asia and Eastern Siberia and ridging/positive geopotential height anomalies across Central Asia (**Figure 2**). This is predicted to yield normal to above normal temperatures for much of Asia including Central Asia but especially Central Siberia and East Asia with normal to below normal temperatures in much of Western Asia but especially Western Russia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/05/19 FCST: 08/06/19 to 08/10/19

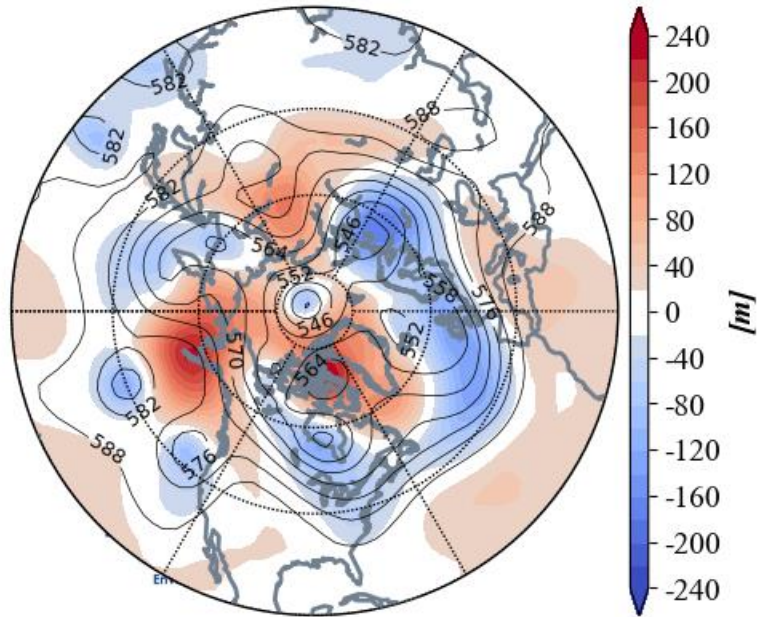


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 6 – 10 August 2019. The forecasts are from the 5 August 00z GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to stretch from Alaska down along the west coast of North America with troughing/negative geopotential height anomalies downstream across and Central Canada and the Eastern US (**Figure 2**). This pattern is predicted to deliver normal to above normal temperatures in Alaska, the West Coast of Canada and the Western US with normal to below normal temperatures for much of Central and Southeastern Canada and the Eastern US (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 08/05/19 FCST: 08/06/19 to 08/10/19

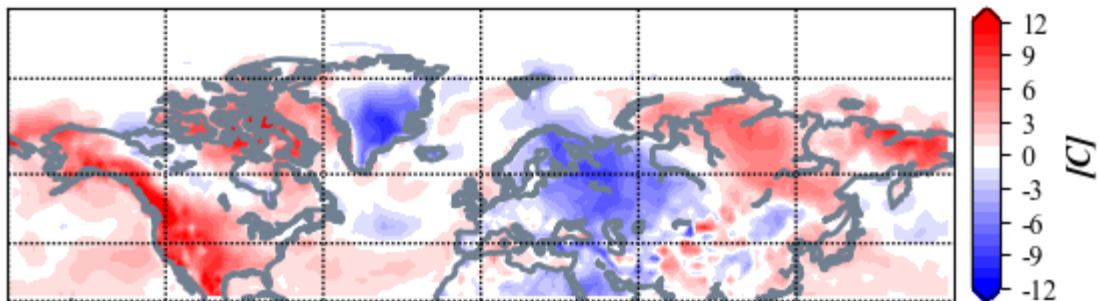


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 6 – 10 August 2019. The forecast is from the 00Z 5 August 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation (**Figure 4**). Troughing is predicted to bring above normal rainfall to the monsoon regions of India, East Asia, Mexico and the Southwestern US and the Eastern US (**Figure 4**).

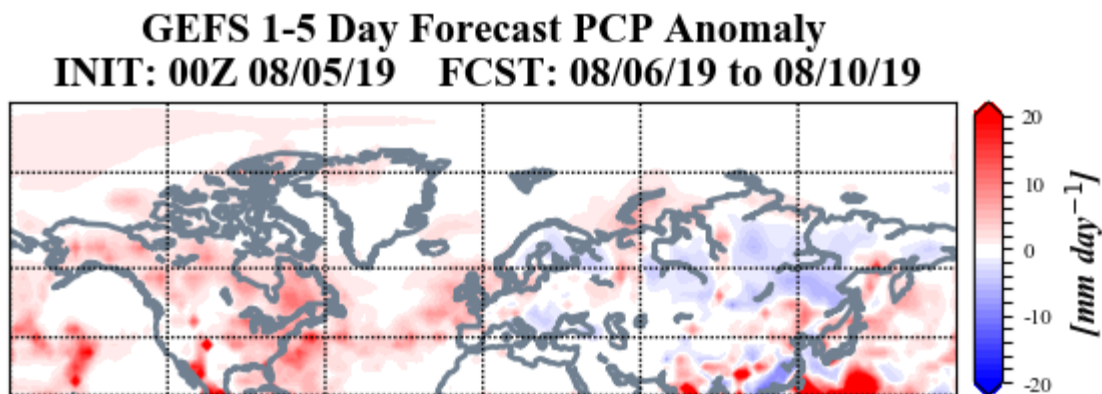


Figure 4. Forecasted rainfall anomalies (mm/day; shading) from 6 – 10 August 2019. The forecast is from the 00Z 5 August 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain negative this period (**Figure 1**) as positive geopotential height anomalies persist across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with positive geopotential height anomalies across Greenland (**Figure 5**), the NAO will also remain negative.

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/05/19 FCST: 08/11/19 to 08/15/19

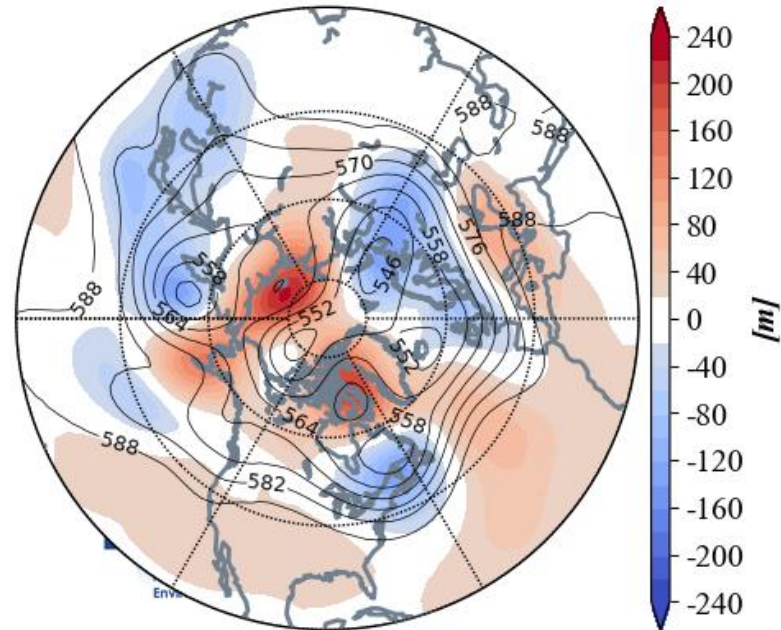


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 11 – 15 August 2019. The forecasts are from the 5 August 00z GFS ensemble.

Trouching/negative geopotential height anomalies will remain stretched across Northern Europe with ridging/positive geopotential height anomalies stretched across Southern Europe (**Figure 5**) persisting normal to below normal temperatures across much of Northern Europe including the UK with normal to above normal temperatures in Southern Europe (**Figure 6**). The omega type pattern across Asia with ridging/positive geopotential height anomalies in Central Asia but focused in Central Siberia with troughing/negative geopotential height anomalies in Far East Asia but especially Western Asia (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures for much of Central and Southern Asia and the Middle East with normal to below normal temperatures across Western Russia and Western Kazakhstan (**Figure 6**).

GEFS 6-10 Day Forecast T2m Anomaly
INIT: 00Z 08/05/19 FCST: 08/11/19 to 08/15/19

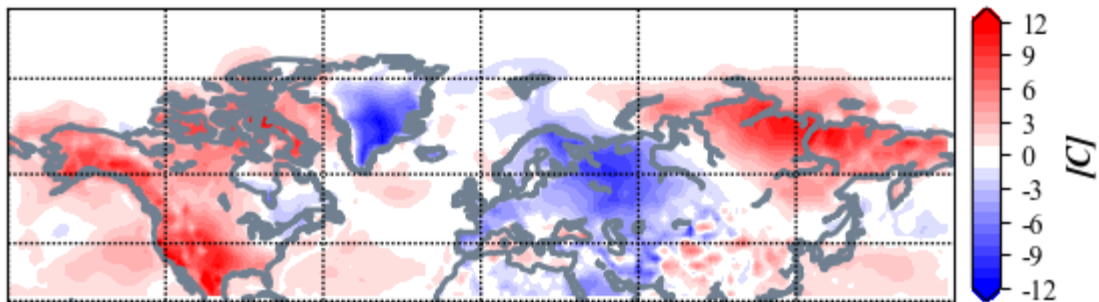


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 11 – 15 August 2019. The forecasts are from the 00Z 5 August 2019 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist in the Gulf of Alaska, Alaska and into Western Canada favoring troughing/negative geopotential height anomalies downstream Southeastern Canada and in the Northeastern US (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across Alaska, Western Canada and the Southern US with normal to below normal temperatures for Eastern Canada and the Northeastern US (**Figure 6**).

GEFS 6-10 Day Forecast PCP Anomaly
INIT: 00Z 08/05/19 FCST: 08/11/19 to 08/15/19

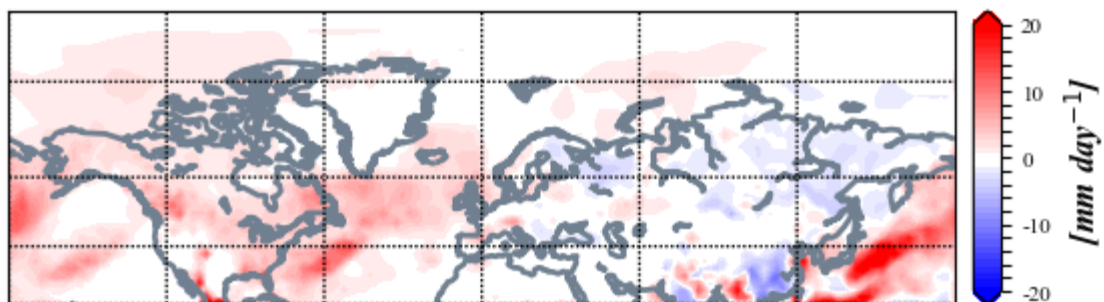


Figure 7. Forecasted rainfall anomalies (mm/day; shading) from 11 – 15 August 2019. The forecasts are from the 00Z 5 August 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation however above normal precipitation is predicted along the line of cooler temperatures to the north and warmer temperatures to the south and along the higher elevations of Europe (**Figure 7**). Troughing is predicted to bring above normal rainfall to the monsoon regions of India, Southeast Asia, and Mexico, Western Canada and the Eastern US (**Figure 7**).

11-15 day

With continued mostly positive height anomalies predicted for the Arctic (**Figure 8**), the AO is likely to remain negative to neutral this period (**Figure 1**). With predicted weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to be slightly negative this period.

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/05/19 FCST: 08/16/19 to 08/20/19

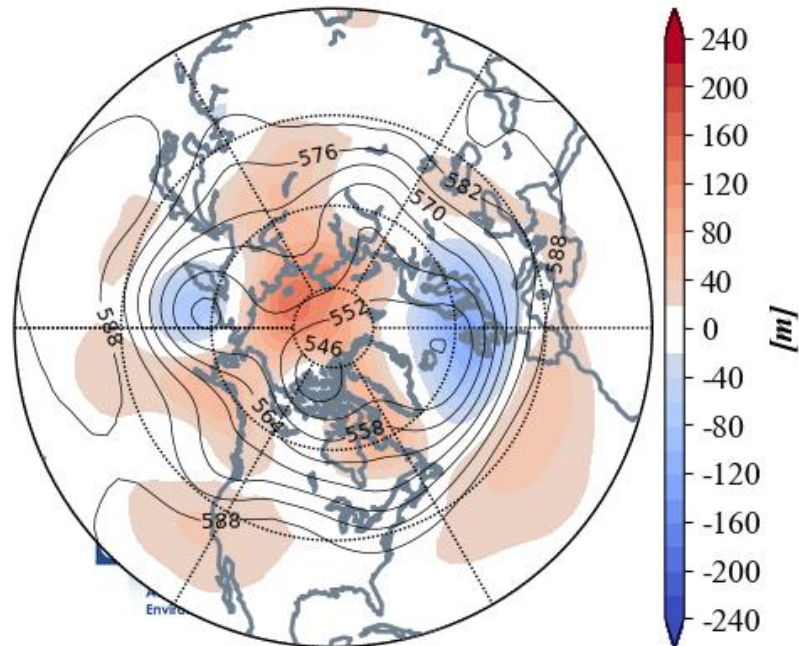


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 2 – 6 August 2019. The forecasts are from the 5 August 00z GFS ensemble.

Trouching/negative geopotential height anomalies are predicted to dominate Northern Europe but now extending further south across the continent with ridging/positive geopotential height anomalies confined to far Southern Europe (**Figure 8**). This pattern is predicted to result in more seasonable to below normal temperatures for most of Europe including the UK except for normal to above normal temperatures along the Mediterranean coast (**Figure 9**). The general circulation pattern is predicted to persist across Asia this period with ridging/positive geopotential height anomalies in Central Asia but focused in Central Siberia with troughing/negative geopotential height anomalies in Western Asia and East Asia but especially Kamchatka (**Figure 8**). This pattern favors normal to above normal temperatures for the Middle East and most of Central, Southern and East Asia with normal to below normal temperatures in Western Russia and Western Kazakhstan (**Figure 9**).

GEFS 11-15 Day Forecast T2m Anomaly
INIT: 00Z 08/05/19 FCST: 08/16/19 to 08/20/19

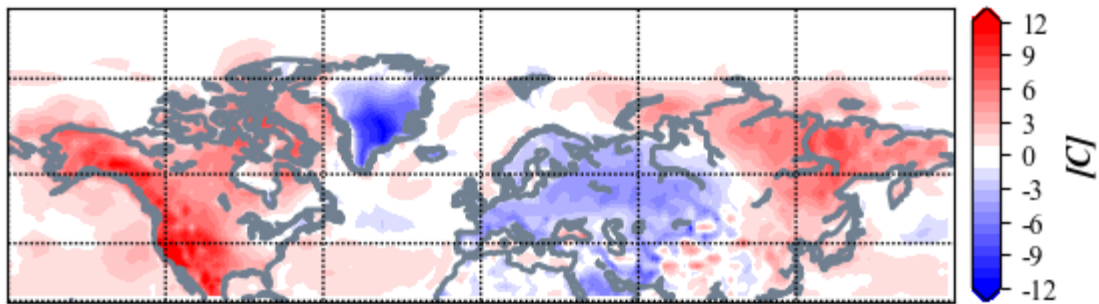


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 16 – 20 August 2019. The forecasts are from the 00Z 5 August 2019 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate much of North America with some persistent weak troughing/negative geopotential height anomalies in the Northeastern US (**Figure 8**). This will favor normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures for Southeastern Canada and the Northeastern US (**Figure 9**).

GEFS 11-15 Day Forecast PCP Anomaly
INIT: 00Z 08/05/19 FCST: 08/16/19 to 08/20/19

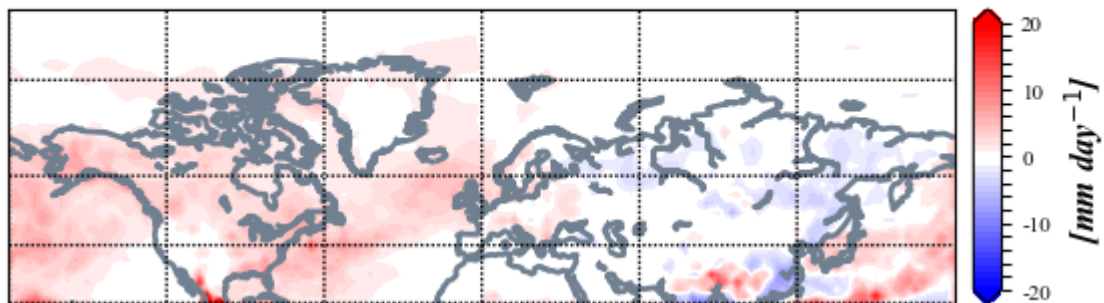


Figure 10. Forecasted rainfall anomalies (mm/day ; shading) from 16 – 20 August 2019. The forecasts are from the 00Z 5 August 2019 GFS ensemble.

Much of Asia is predicted to receive below normal precipitation but above normal precipitation is predicted for Europe as troughing dominates the region (**Figure 10**). Troughing is predicted to bring above normal rainfall to the monsoon regions of Southeast Asia, India and Mexico and the Eastern US (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to below normal PCHs in the stratosphere and normal to above normal PCHs in the mid to upper troposphere (**Figure 11**). In the lowest troposphere PCHs are above normal, consistent with the negative AO (**Figure 1**).

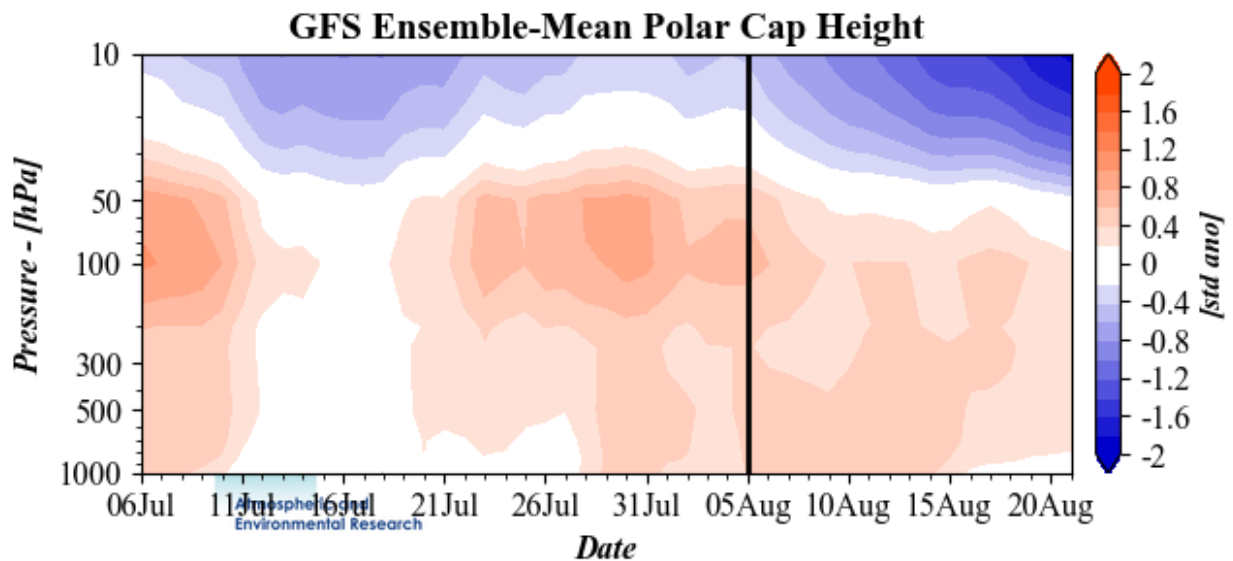


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 5 August 2019 GFS ensemble.

Positive PCHs in the mid to lower troposphere are predicted to weaken as warm temperatures and strong positive geopotential heights over Greenland become less amplified (**Figure 11**). This should cause the AO to trend positive towards neutral for at least a short period. However, as we have seen all summer even when high latitude blocking weakens it eventually re-amplifies. And as we have seen all summer, when high latitude blocking strengthens but especially over Greenland cooler air is forced south across the Eastern US and/or Europe.

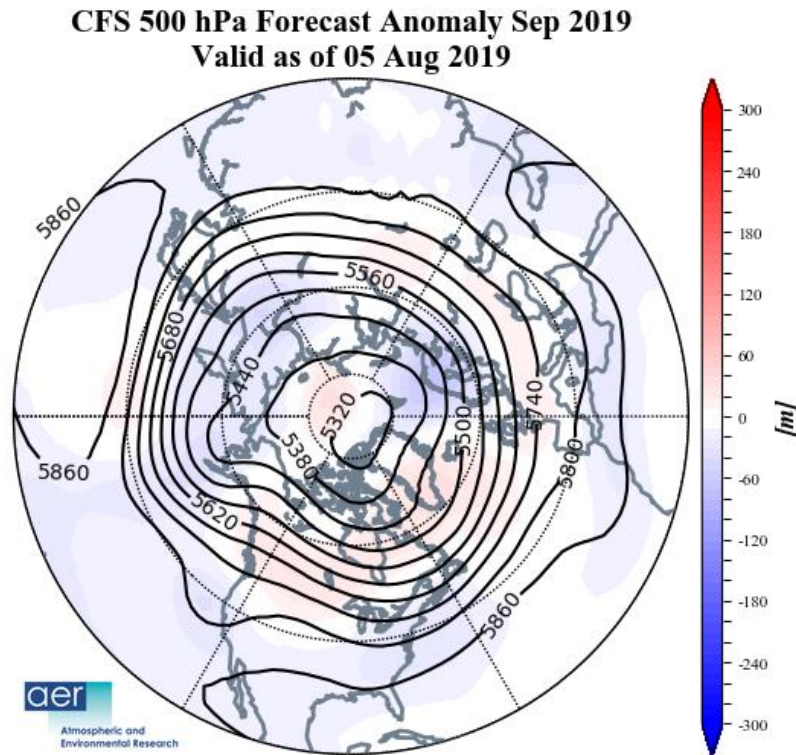


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2019. The forecasts are from the 5 August 2019 CFS.

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 centered across Southern and Europe, the Urals and Western Canada with troughs in Northern Europe, Central and Eastern Siberia, East Asia, Alaska, California and the Eastern US (**Figure 12**). However, overall the pattern is unusually zonal across the NH. This pattern favors relatively warm temperatures for Southern Europe, Northern Siberia, the Western US and much of Canada with seasonable to relatively cool temperatures for Northern Europe, Southern Siberia, Southeast Canada and the Eastern US (**Figure 13**).

CFS T2m Forecast Anomaly Sep 2019 Valid as of 05 Aug 2019

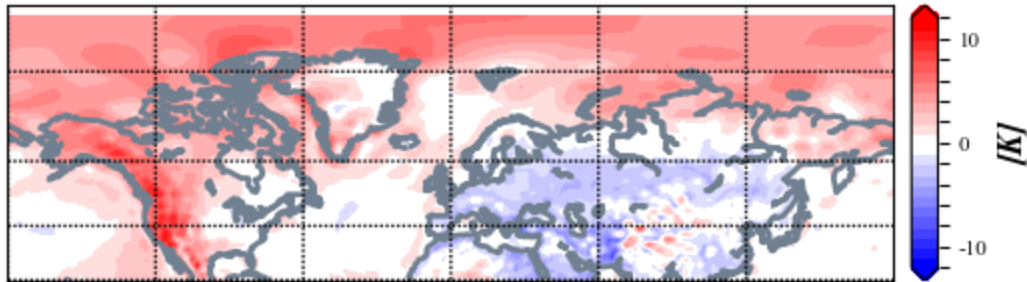


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for September 2019. The forecasts are from the 5 August 2019 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies have cooled and whether El Niño conditions will continue has become questionable (**Figure 14**). Observed SSTs across the NH remain well above normal especially near Alaska though below normal SSTs exist regionally especially west of South America.

SST Anomaly - Week Ending 30 Jul 2019

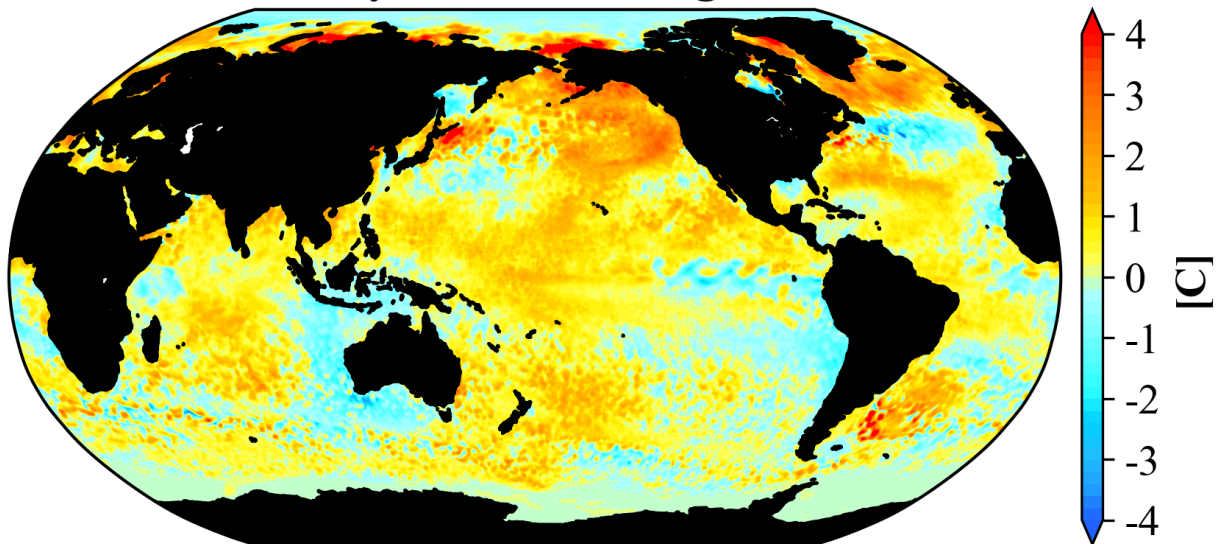


Figure 14. The latest weekly-mean global SST anomalies (ending 30 July 2019). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 13**). The forecasts are for the MJO to briefly emerge in Phase four and then again weaken where no phase of the MJO is favored. Phase four favors formations of ridging in the Eastern US and troughing in Alaska which is not consistent with the model forecasts for the upcoming two weeks.

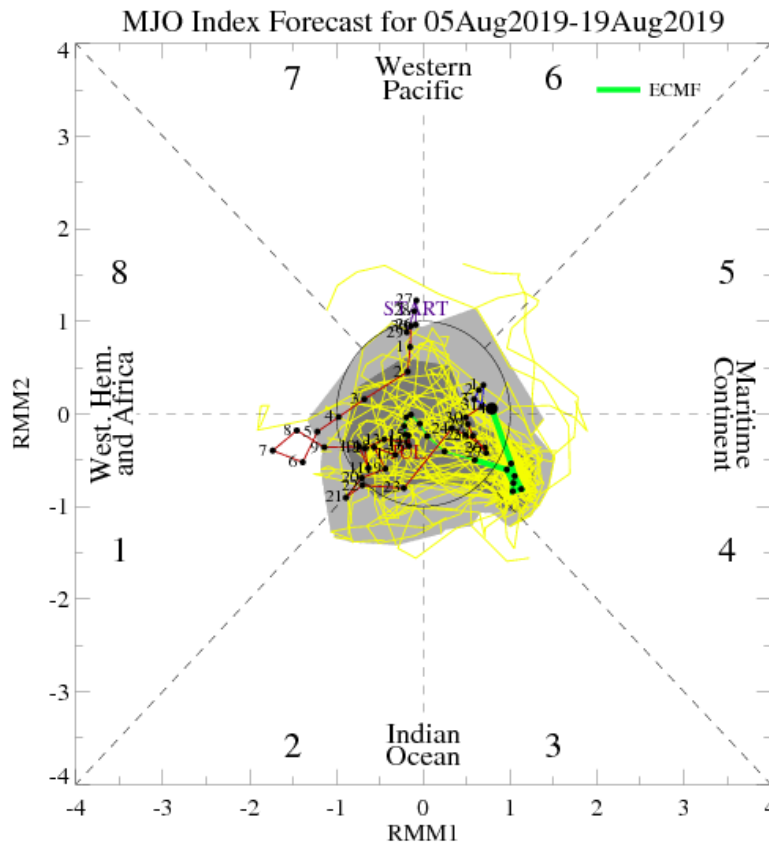


Figure 13. Past and forecast values of the MJO index. Forecast values from the 00Z 5 August 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>