July 22, 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.

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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 trend first negative and then positive back to neutral over the next two weeks.
- The current neutral AO is reflective of mixed pressure/geopotential height anomalies across the Arctic and mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is also neutral as mixed pressure/geopotential height anomalies are spread across Greenland and is predicted to remain near neutral over the next two weeks as geopotential height anomalies are predicted to remain weak across Greenland.
- Ridging/positive geopotential height anomalies currently dominate much of Europe and are predicted to amplify before sliding north into the Arctic allowing for troughing/negative geopotential height anomalies to dominate by the first

week of August. This pattern favors normal to above temperatures across much of Europe for this week and next week but especially Central and Northern Europe including the United Kingdom (UK).

- Ridging/positive geopotential height anomalies with relatively warm temperatures are predicted to dominate much of Central Asia and troughing/negative geopotential height anomalies with normal to below normal temperatures in part of Western Asia and Eastern Asia. However over time troughing/negative geopotential height anomalies with normal to below normal temperatures are predicted to consolidate over Western Asia with ridging/positive geopotential height anomalies with normal to above normal temperatures over East Asia.
- This week, troughing/negative geopotential height anomalies and normal to below temperatures are predicted to dominate the Eastern United States (US) and Eastern Canada with ridging/positive geopotential height anomalies and relatively warm temperatures across Alaska, and Western Canada and the Western US. However, the forecast is for above normal geopotential heights and relatively warm temperatures to become more widespread across the US and Canada over the next two weeks. One exception is a trough and accompanying cool temperatures that is predicted to enter Western Canada and the Pacific Northwest from the Gulf of Alaska next week.

Impacts

Now that summer is a little more than half over, I thought to check up on the AER summer forecast for the Northern Hemisphere (NH; posted on May 24, 2019 on the blog) shown in **Figure i**. So far it is doing quite well in my not so objective opinion. To be fair, the warming trend in summer is quite robust and a forecast of above normal temperatures has a better chance of verifying than in winter. The AER model predicted widespread above normal temperatures with the greatest departures focused on western North America, Europe and Siberia, which matches the observations so far this summer. The two regions that have the best odds of recording a below normal average temperature for the summer are Western Russia and northwestern Canada. I have mentioned previously, cool summers in Western Russia has been the theme recently for reasons I don't understand and based on the short-term forecast that is looking more and more likely. On the other hand, a cool summer in northwestern Canada would be bucking the recent summer trend. Possibly the most surprising region of cool temperatures so far this summer is the Western US, which in general have been experiencing hot summers. There is still plenty of summer left and my expectations would be for the area of below normal temperatures to shrink with time. The one region of below normal temperatures that has the best chance of persisting in my opinion is the Southern Plains.

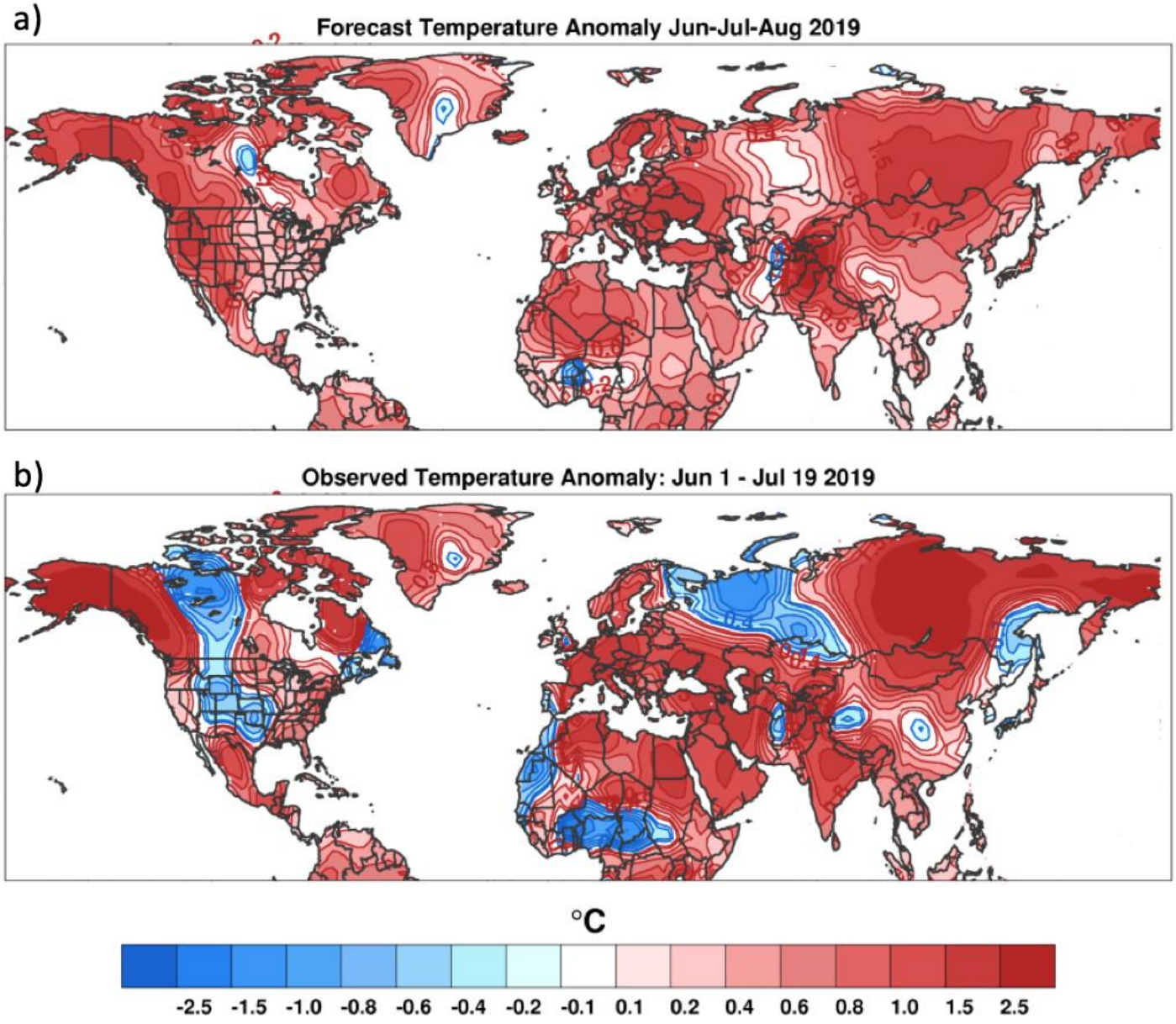

Figure i. a) Predicted surface tempearture anomalies (°C; shading) across the Northern Hemisphere from 1 June – 31 August 2019. b) Observed surface tempearture anomalies (°C; shading) across the Northern Hemisphere from 1 June – 1 July 2019.

I see little reason to deviate from the forecast of widespread above normal temperatures. This week's return of extreme heat to Europe should pretty much seal an above normal if not well above normal summer in regard to temperatures. In the US where temperatures have averaged closer to average or even below average, the summer anomaly is more in doubt. Still I expect temperatures to mostly average above normal for the remainder of the summer. However, high latitude blocking could still deliver a cool surprise to the US and is something that is worth monitoring. Parts of

Eastern Siberia have been cool but otherwise much of East Asia has experienced above normal temperatures and I expect that to continue.

Near Term Conditions

1-5 day

The AO is currently neutral **(Figure 1**) with mixed geopotential height anomalies across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with weak geopotential height anomalies across Greenland and Iceland (**Figure 2**), the NAO will be neutral this week as well.

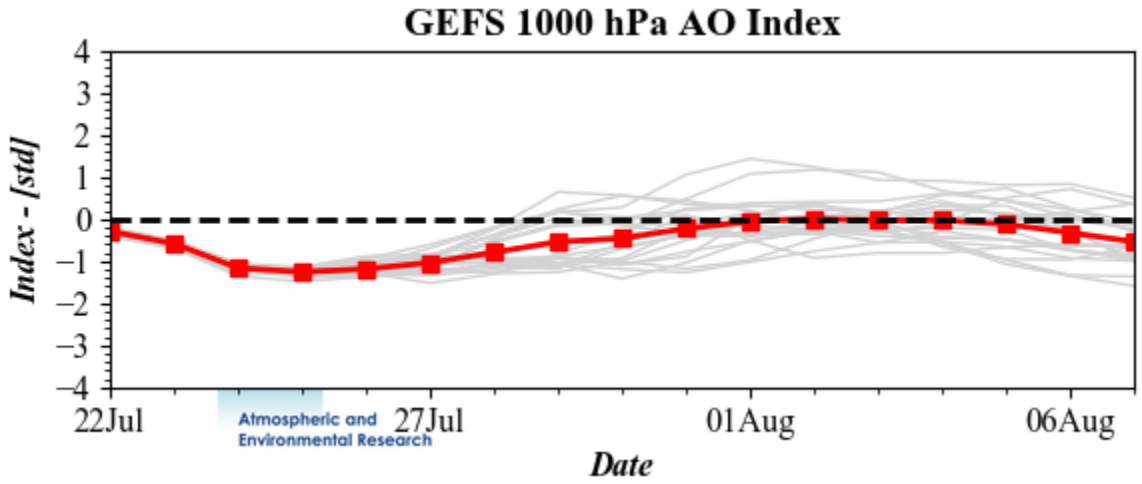

Figure 1. The predicted daily-mean AO at 10 hPa from the 00Z 22 July 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies centered over Central Europe will dominate much of Europe (**Figure 2**) resulting in normal to above temperatures across much of Europe including the UK (**Figure 3**). Geopotential height anomalies are predicted to be mixed across Asia with troughing/negative geopotential height anomalies in Western Russia, Southern and Eastern Siberia (**Figure 2**). This is predicted to yield normal to above normal temperatures for much of Asia including the Middle East, Central Asia including Central Siberia and East Asia with normal to below normal temperatures in Western Russia, Southern and Eastern Siberia **(Figure 3**).

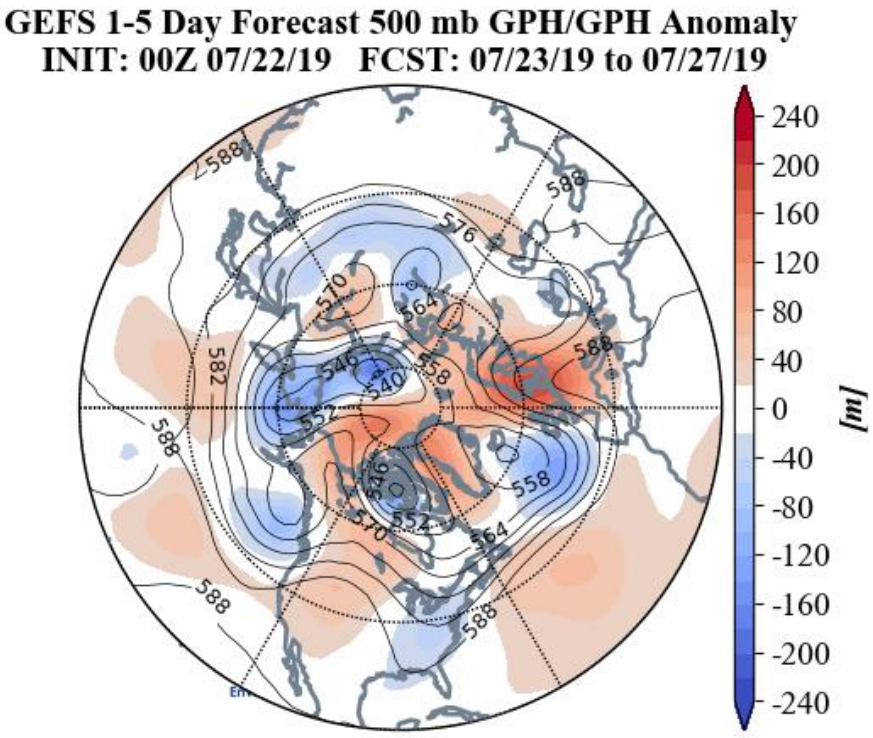

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 23 – 27 July 2019. The forecasts are from the 22 July 00z GFS ensemble.

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

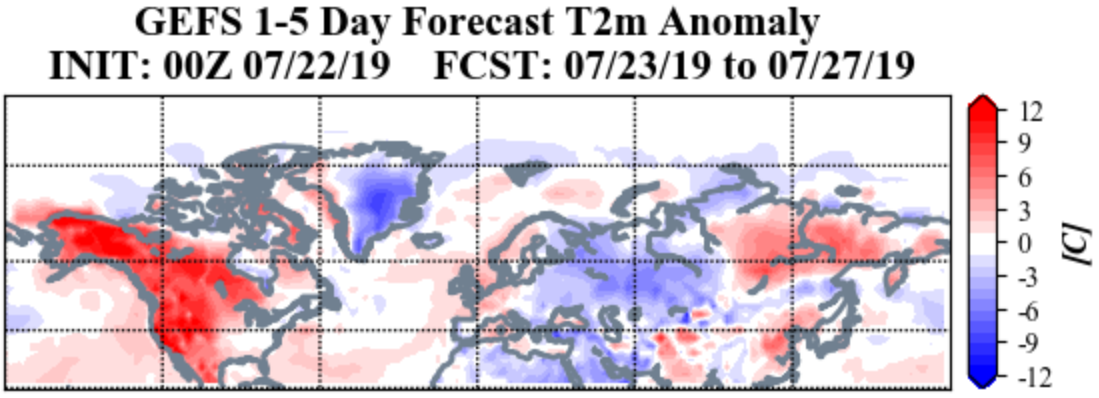

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 23 – 27 July 2019. The forecast is from the 00Z 22 July 2019 GFS ensemble.

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

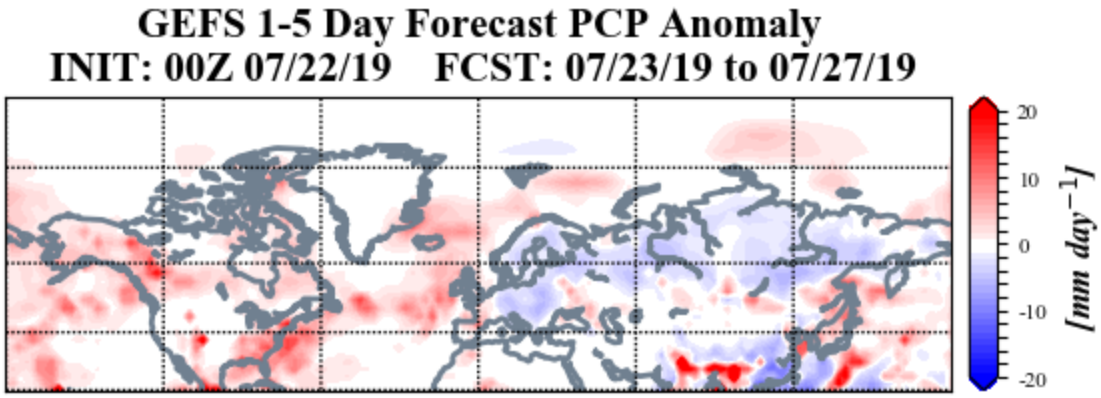

Figure 4. Forecasted rainfall anomalies (mm/day; shading) from 23 – 27 July 2019. The forecast is from the 00Z 22 July 2019 GFS ensemble.

Mid-Term

6-10 day

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

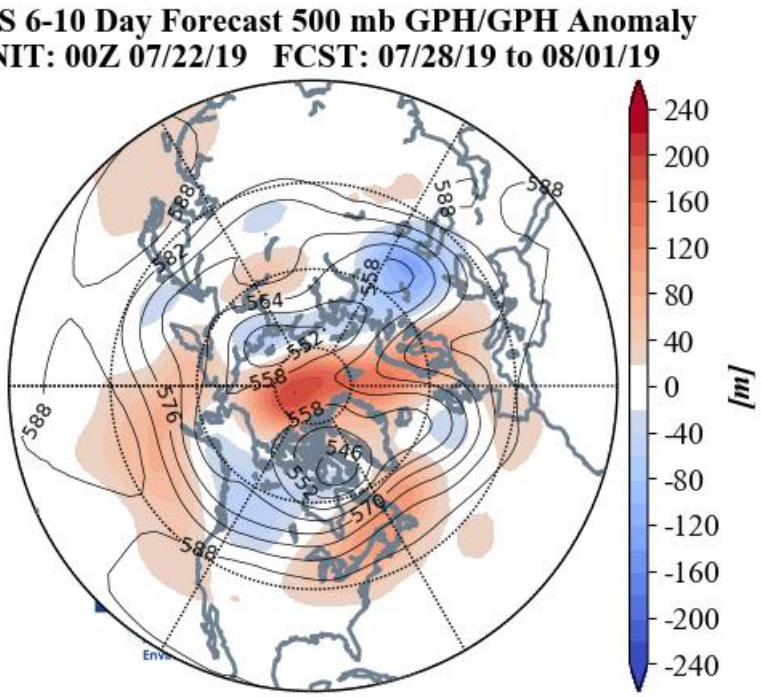

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 July – 1 August 2019. The forecasts are from the 22 July 00z GFS ensemble.

Ridging/positive geopotential height anomalies will continue to dominate Europe (**Figure 5**) persisting normal to above normal temperatures across much of Europe including the UK with the possible exception of normal to below normal temperatures in far Eastern Europe due to northerly flow (**Figure 6**). The amplified ridging/positive geopotential height anomalies in Europe will force troughing/negative geopotential height anomalies in Western Asia with weak ridging/positive geopotential height anomalies in East Asia (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures for much of Central and Eastern Asia including the Middle East and East Asia with normal to below normal temperatures across Western Russia, and eastern Turkey **(Figure 6**).

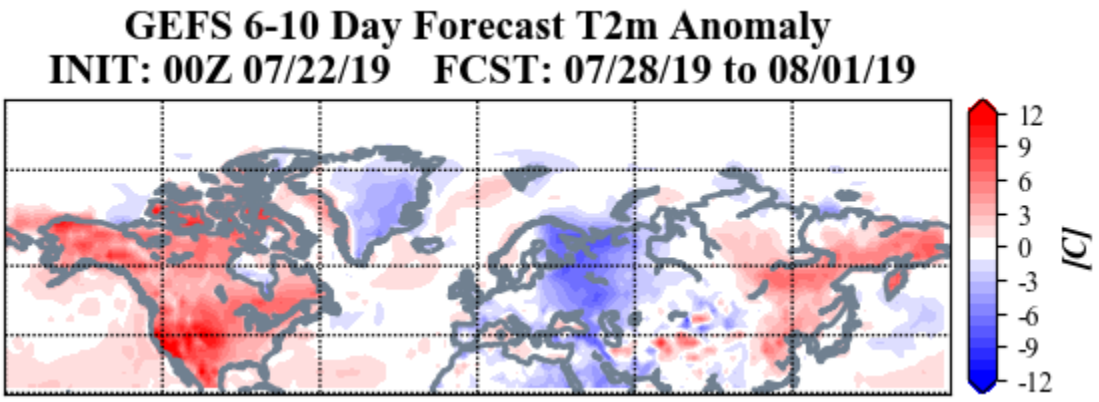

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 28 July – 1 August 2019. The forecasts are from the 00Z 22 July 2019GFS ensemble.

Troughing/negative geopotential height anomalies previously in the Gulf of Alaska is predicted to come ashore into Western Canada and the US Pacific Northwest forcing ridging/positive geopotential height anomalies previously over western North America into the Eastern US and Eastern Canada (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across Alaska, Eastern Canada and the Northeastern and Southwestern US with normal to below normal temperatures for Western Canada, the Pacific Northwest and around the Gulf of Mexico **(Figure 6).**

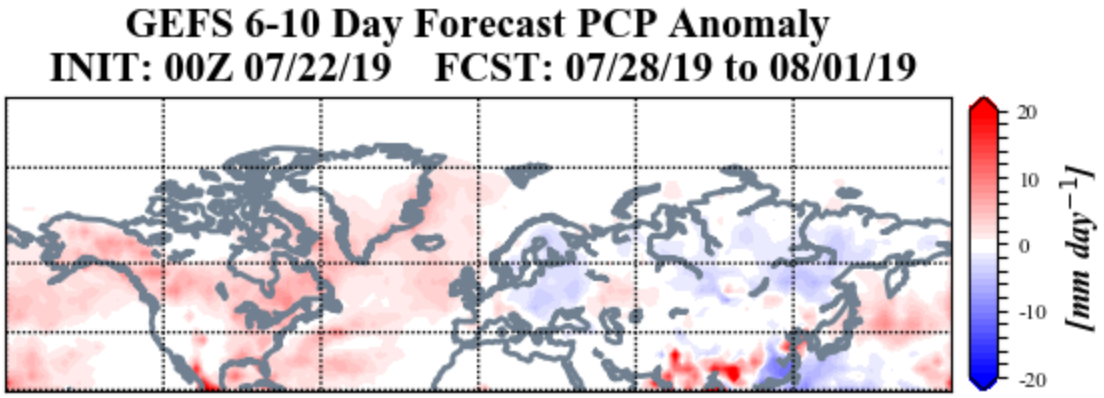

Figure 7. Forecasted rainfall anomalies (mm/day; shading) from 28 July – 1 August 2019. The forecasts are from the 00Z 22 July 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation (**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 weak 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.

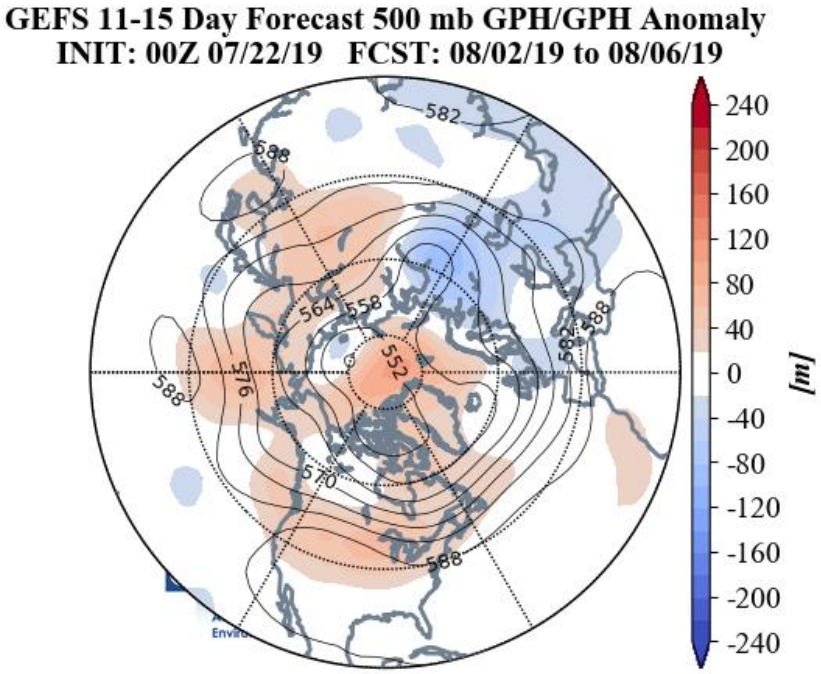

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 2 – 6 August 2019. The forecasts are from the 22 July 00z GFS ensemble.

Troughing/negative geopotential height anomalies previously south of Iceland are predicted to slide east this period into Europe and replacing previous ridging/positive geopotential height anomalies over much of Europe (**Figure 8**). This pattern is predicted to result in more seasonable to possibly above normal temperatures for most of Europe including the UK (**Figure 9**). The circulation pattern from the previous period is predicted to amplify across Asia this period with ridging/positive geopotential height anomalies in East Asia and troughing/negative geopotential height anomalies in Western Asia (**Figure 8**). This pattern favors normal to above normal temperatures for most of Central and East Asia with normal to below normal temperatures in Western Asia including the Middle East (**Figure 9**).

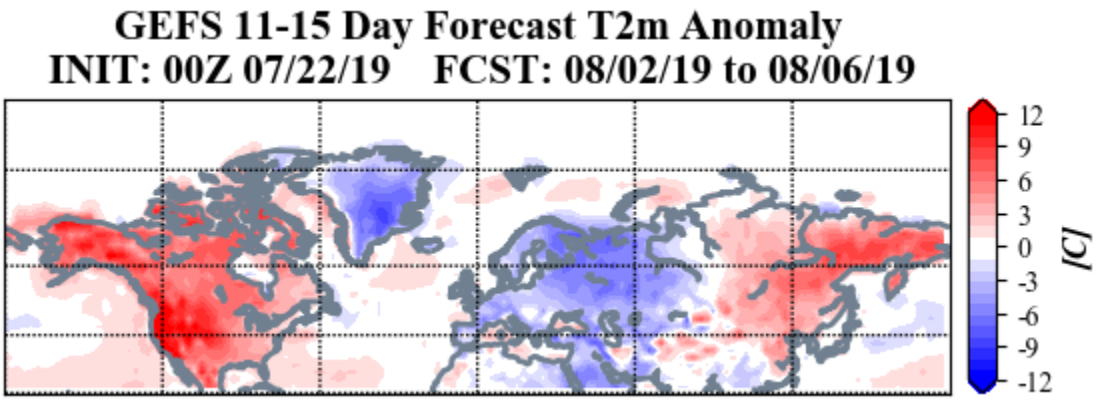

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 2 – 6 August 2019. The forecasts are from the 00Z 22 July 2019 GFS ensemble.

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

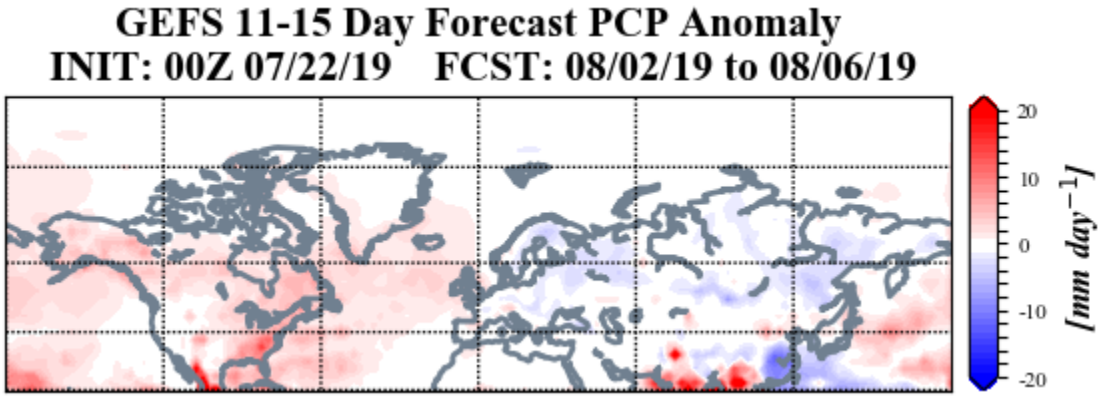

Figure 10. Forecasted rainfall anomalies (mm/day; shading) from 2 – 6 August 2019. The forecasts are from the 00Z 22 July 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation (**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) shows currently 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 near normal, consistent with the close to neutral AO (**Figure 1**).

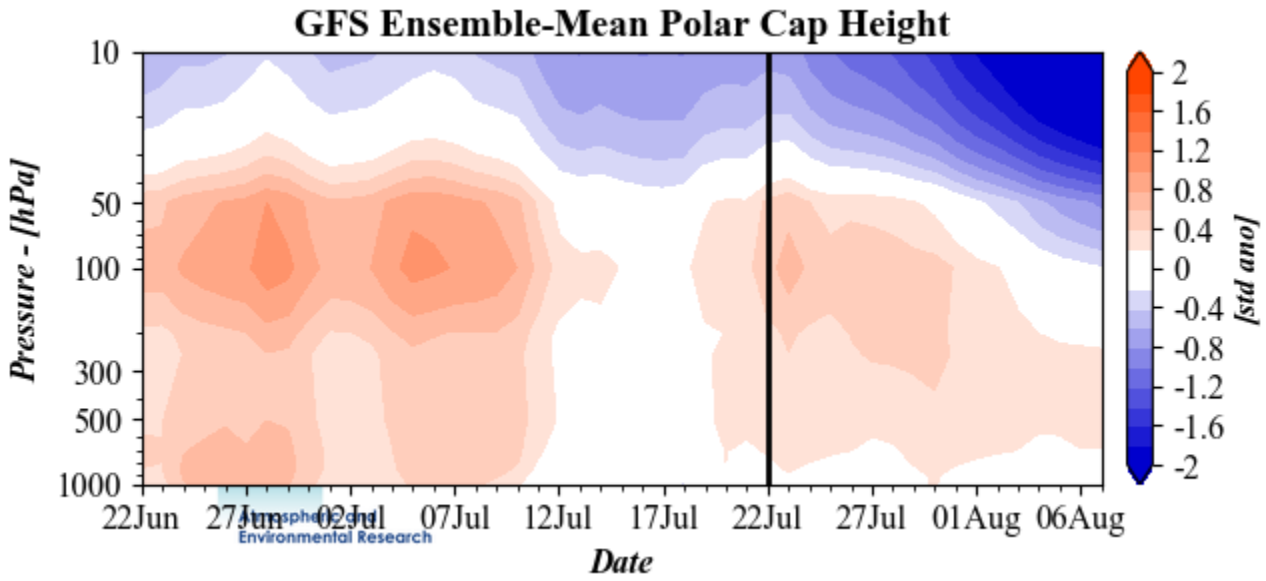

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 22 July 2019 GFS ensemble.

Positive PCHs in the mid to lower troposphere are predicted to strengthen as warm temperatures and positive geopotential heights are injected into the Arctic from Greenland and from Europe (**Figure 11**). This should cause the AO to turn negative for at least a short period. Overall temperatures are predicted to be relatively warm across the US and Europe. In winter, an intrusion of warm temperatures often precedes a turn to more severe winter weather including cold air outbreaks across the mid-latitudes. The relationship is not as strong in summer as in winter, but a possible upcoming cool period is something to watch for in the coming weeks.

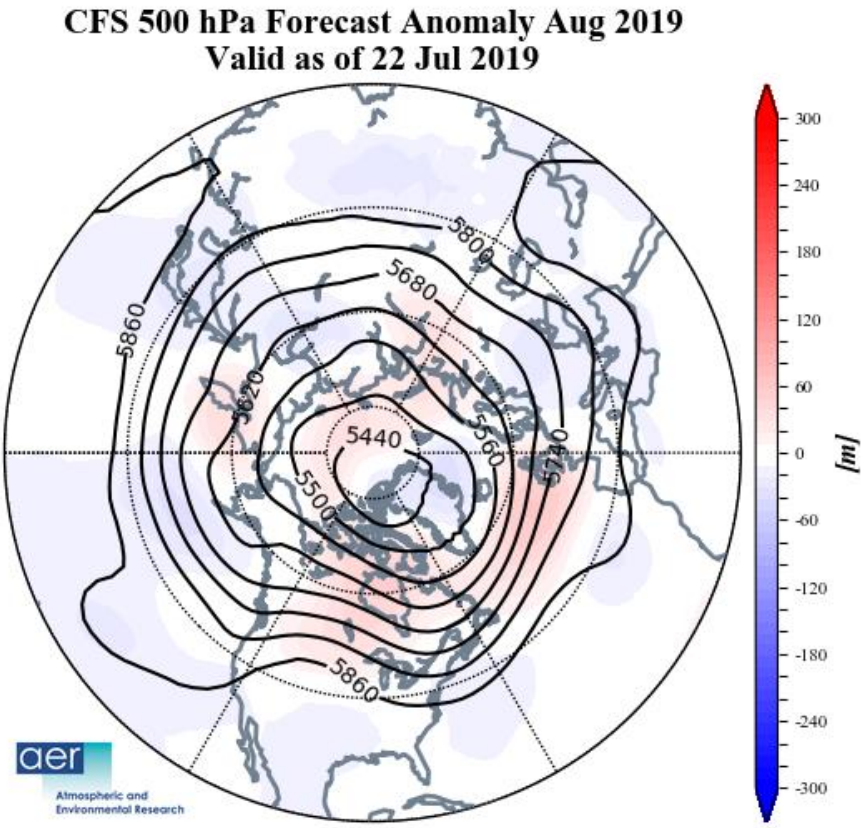

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2019. The forecasts are from the 22 July 2019 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for August from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered across Western Europe, the Urals, Eastern Siberia and Central Canada with troughs in Eastern Europe, Central Siberia, East Asia, Alaska, the Gulf of Alaska and the Eastern US (**Figure 12).** This pattern favors relatively warm temperatures for Western Europe, Western Asia, Eastern Siberia, the Western US and much of Canada with seasonable to relatively cool temperatures for Eastern Europe, Central Asia and the Eastern US (**Figure 13**). The predicted pattern does not seem likely to me.

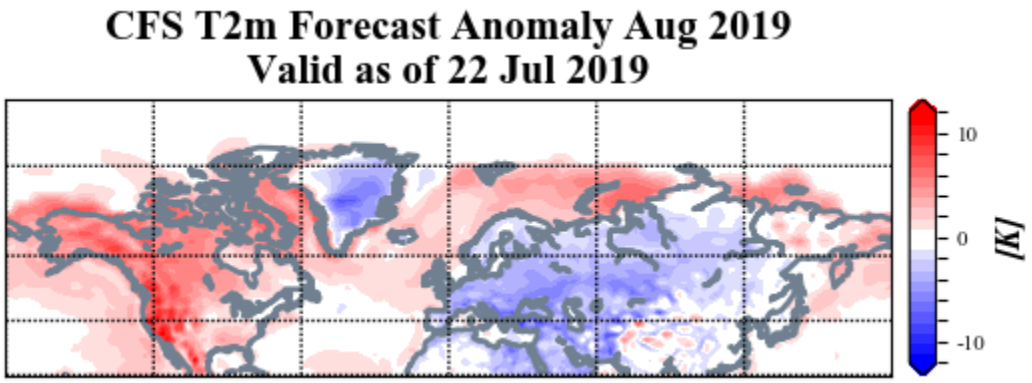

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for August 2019. The forecasts are from the 22 July 2019 CFS.

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.

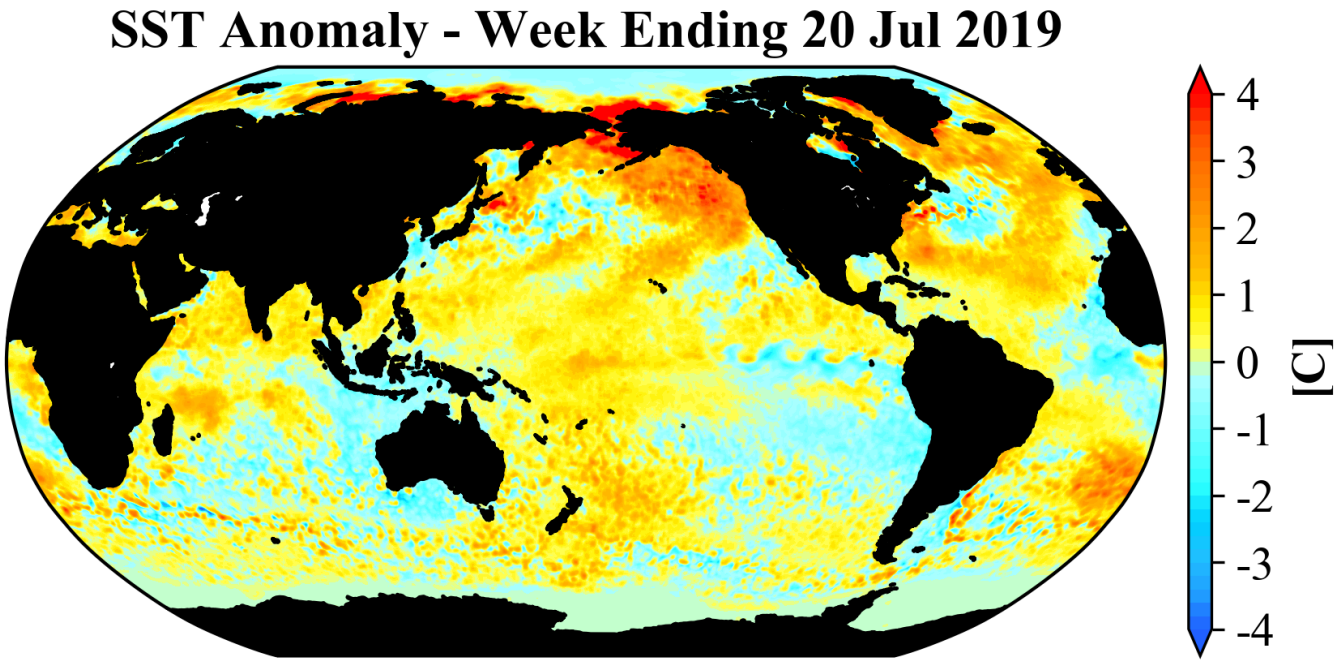

Figure 14. The latest weekly-mean global SST anomalies (ending 20 July 2019). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase two (**Figure 13**). And the forecasts are for the MJO to weaken where no phase of the MJO is favored. Phase two favor formations of ridging in the Northeastern US and troughing in Western Canada which is not consistent with the model forecasts for the upcoming week.

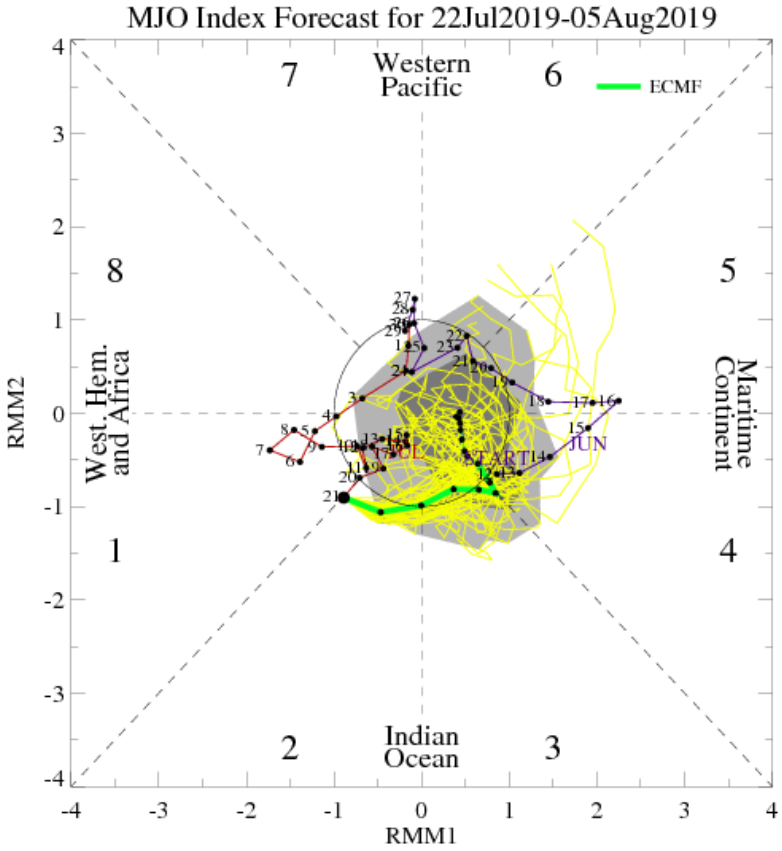

Figure 13. Past and forecast values of the MJO index. Forecast values from the 00Z 22 July 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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