

June 7, 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 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 negative as positive pressure/geopotential height anomalies are spread across most of Greenland and is predicted to remain negative over the next two weeks.
- Ridging/positive geopotential height anomalies are predicted to dominate Europe much of next week. However, troughing/negative geopotential height anomalies initially from the east centered over the Western Siberia and then eventually from the west initially over the Northeastern US and Southeastern Canada are

predicted to weaken the ridging over Europe. This pattern favors seasonable to relatively warm temperatures across much of Europe for next week but with temperatures returning to more seasonable levels as heights fall across the continent. One exception is far Western Europe including the United Kingdom (UK) where temperatures are predicted to be seasonable to cool where troughing is persistent over the next two weeks.

- Ridging/positive geopotential height anomalies with relatively warm temperatures are predicted to dominate much of Asia over the next two weeks. Predicted exceptions troughing/negative geopotential height anomalies with normal to below normal temperatures in Kazakhstan and Northeast Asia next week and then across northwest Russia for the following week.
- Currently ridging/positive geopotential height anomalies centered near the Aleutians is supporting troughing/negative geopotential height anomalies with relatively cool temperatures in Northwestern Canada. This pool of cool air is predicted to sink south into the Central and Eastern United States (US) beginning next week and continuing into the following week. In general, above normal geopotential heights are predicted across Greenland, the North American Arctic and the Western US bringing with it above normal temperatures while supporting below normal geopotential heights and relatively cool temperatures in the Eastern US over the next two weeks.
- *In the Impacts section I discuss my thoughts about the possible duration of the long streak of high latitude blocking.*

Impacts

When I started writing the blog it was intended to be focused on the AO and using predictions of the AO to focus on hemispheric weather anomalies on the time scale of days, weeks and even months in advance. However, in winter I have gravitated to writing more about the stratospheric polar vortex (PV) and for now I do believe that the PV framework provides better predictive information than the AO framework; and of course, the two are related and not independent. Still in summer I have remained focused on discussing the AO as the PV does not seem relevant for our summer weather.

With that introduction it is quite surprising for me to be still thinking and discussing the PV. Since April I have been discussing this unusually late season troposphere-stratosphere-troposphere coupling event that has resulted in persistent positive polar cap geopotential height anomalies (PCHs) since early May that has resulted in high latitude blocking, a strongly negative N/AO and a suppressed and active Jet Stream. The temperature response has been well above normal temperatures across much of the Arctic and I would say surprisingly large stretches of relatively cool temperature in Europe, Asia but especially the Western and Northeastern US and Southeastern Canada.

A similar late season troposphere-stratosphere-troposphere coupling event seemed to happen in May 1997 with the warm/positive tropospheric PCHs finally dissipating in early June. We are currently in early June and there are no signs of the tropospheric PCHs waning and disappearing. Now that the warm/positive tropospheric PCHs have shown such strong persistence, it is not obvious to me what other than synoptic or internal variability can reverse the warm/positive PCHs to cold/negative PCHs. The loss of high latitude snow cover and Arctic sea ice will certainly act as a positive feedback maintaining the warm/positive PCHs. This might be true in winter as well, but in winter troposphere-stratosphere-troposphere coupling and radiatively cooling during the continuous Arctic night could force PCHs from warm to cold but this does not apply in summer. 2008 was the last time when the AO was so strongly negative in May and in that summer the PCHs remained predominantly positive and the AO stayed negative for all three months (see **Figure i**).

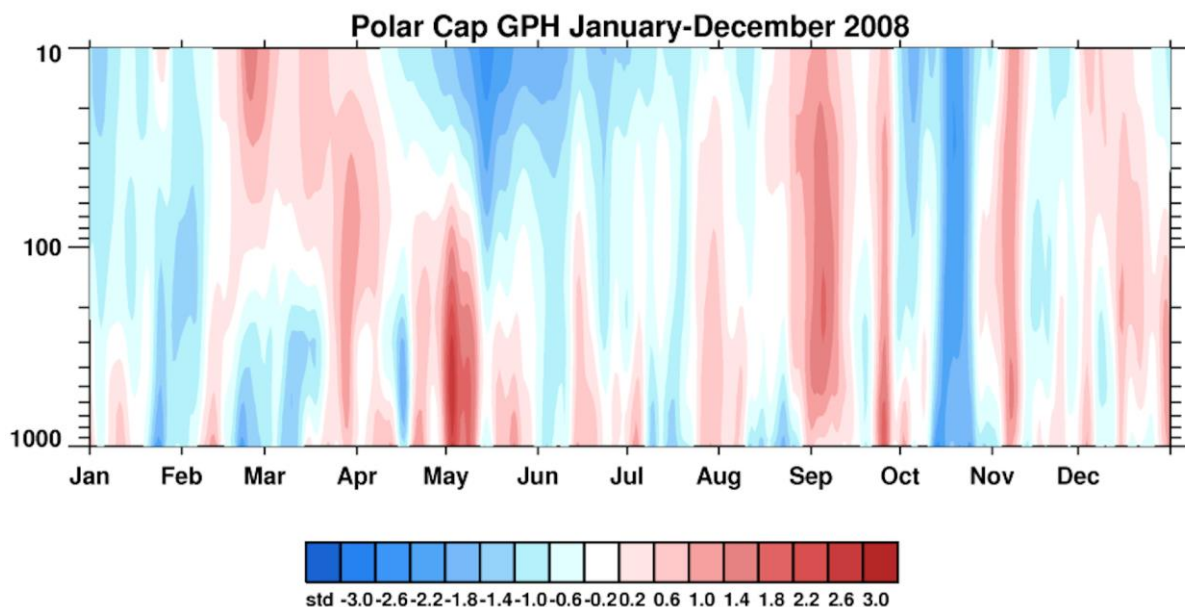


Figure i. Observed daily polar cap height (i.e., area-averaged geopotential height anomalies poleward of 60°N) standardized anomalies from 1 January -31 December 2008.

I feel that the probability of a summer characterized by a negative AO and warm tropospheric PCHs has increased given the short-term forecasts but is far from guaranteed. So, summer 2008 may be another good analog for summer 2019 (see **Figure ii**). It doesn't show widespread below normal temperatures across the Northern Hemisphere (NH) mid-latitudes but rather regionally including the Central US, Western Europe and Northwestern Russia. I still believe that it will be difficult for below normal temperatures to be widespread across the NH continents. However the longer high latitude blocking, a negative AO and a suppressed and active Jet Stream persist

the better the possibility of larger scale below normal temperature anomalies in particular the regions that saw relatively cool temperatures in summer 2008.

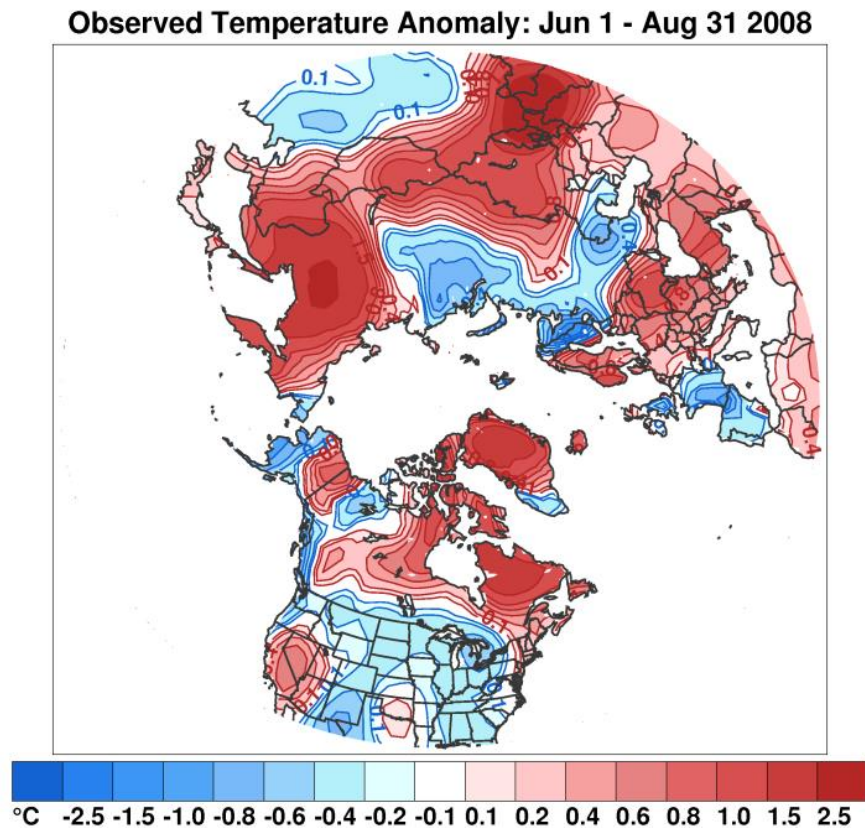


Figure ii. Observed surface temperature anomalies (°C; shading) from 1 June – 31 August 2008.

Near Term Conditions

1-5 day

The AO is currently negative and is predicted to remain negative over the next several days (**Figure 1**) with mostly positive geopotential height anomalies across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with positive geopotential height anomalies across Greenland and Iceland (**Figure 2**), the NAO will likely be negative this week as well.

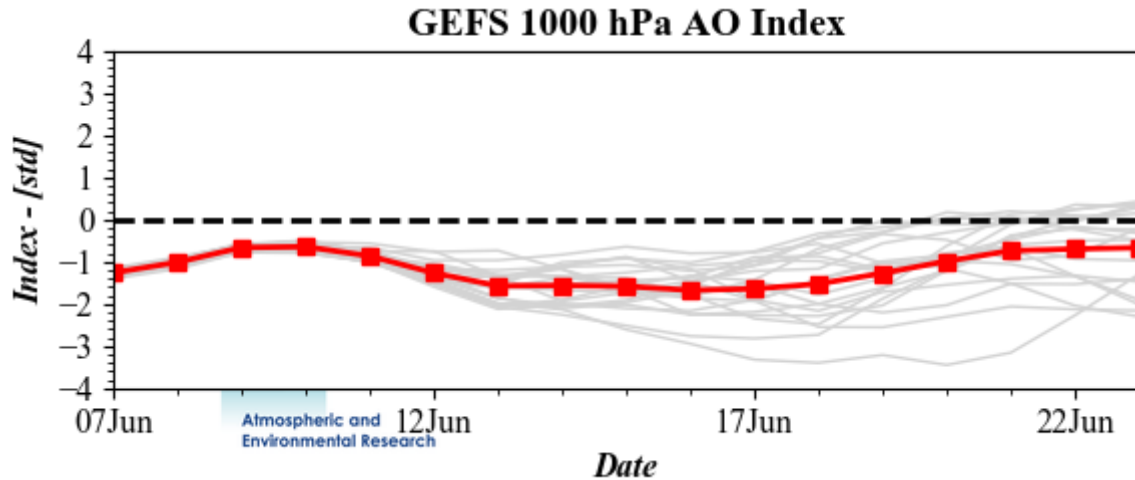


Figure 1. The predicted daily-mean AO at 10 hPa from the 00Z 7 June 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies centered near the Baltic States will dominate much of Europe with troughing/negative geopotential height anomalies limited to Western Europe (**Figure 2**). This pattern is predicted to result in normal to above normal temperatures across much of Europe except for normal to below temperatures across the UK, Portugal, Spain and France underneath mid-tropospheric troughing (**Figure 3**). Much of Asia will be dominated by ridging/positive geopotential height anomalies with the exception of troughing/negative geopotential height anomalies for Kazakhstan and Northeast Asia (**Figure 2**). This is predicted to yield normal to above normal temperatures for much of Asia including the Middle East and Southeast Asia and normal to below normal temperatures for Kazakhstan and Northeast Asia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 06/07/19 FCST: 06/08/19 to 06/12/19

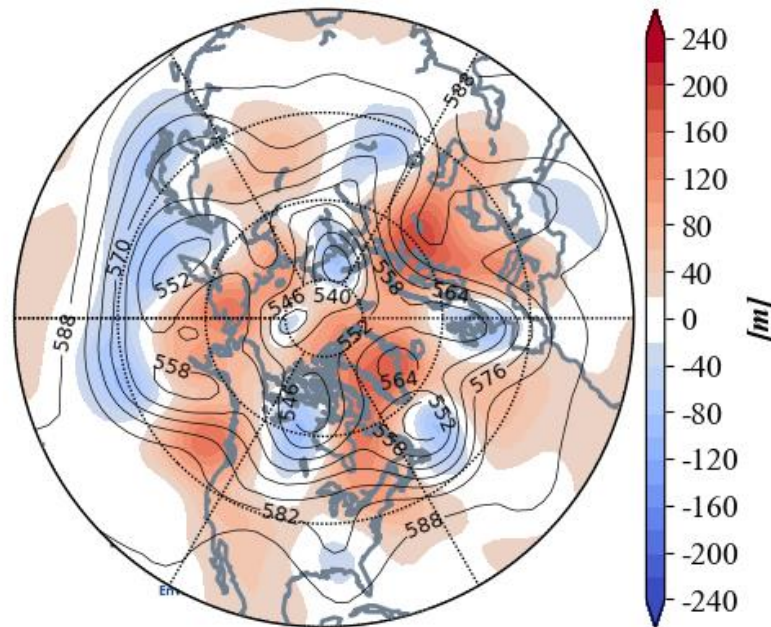


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 June 2019. The forecasts are from the 7 June 00z GFS ensemble.

Ridging/positive geopotential height anomalies across Alaska and the Gulf of Alaska are predicted to force troughing/negative geopotential height anomalies downstream across Northcentral Canada while ridging/positive geopotential height anomalies across Greenland favor troughing/negative geopotential height anomalies in the Eastern US (**Figure 2**). This pattern is predicted to bring normal to below normal temperatures in Central Canada and the Eastern US with normal to above normal temperatures for Alaska, the Western US and Eastern Canada (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 06/07/19 FCST: 06/08/19 to 06/12/19

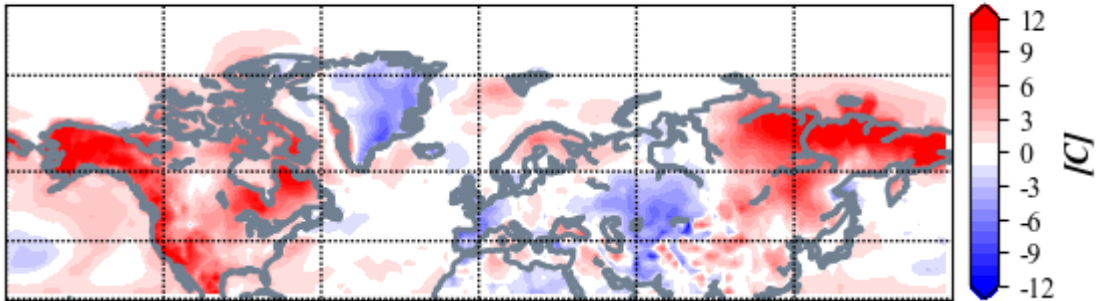


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 8 – 12 June 2019. The forecast is from the 00Z 7 June 2019 GFS ensemble.

Trouching is predicted to bring above normal rainfall to Western Europe, East Asia and the Eastern US (**Figure 4**).

GEFS 1-5 Day Forecast PCP Anomaly
INIT: 00Z 06/07/19 FCST: 06/08/19 to 06/12/19

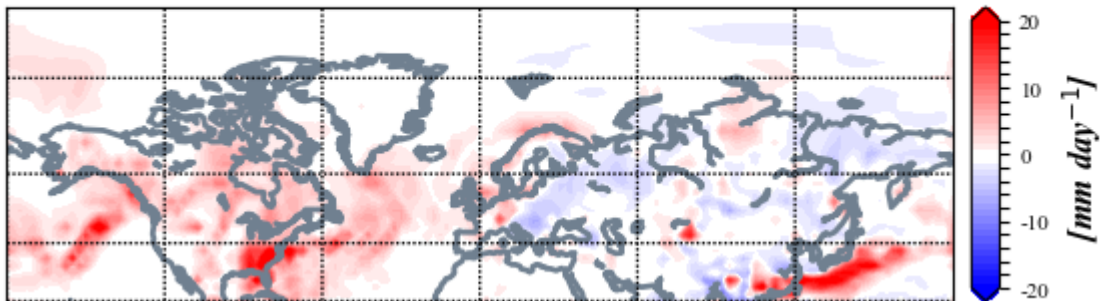


Figure 4. Forecasted rainfall anomalies (mm/day ; shading) from 8 – 12 June 2019. The forecast is from the 00Z 7 June 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain negative through the end of next week and into early of the following week (**Figure 1**) as positive geopotential height anomalies remain widespread across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with persistent positive geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely remain negative as well.

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 06/07/19 FCST: 06/13/19 to 06/17/19

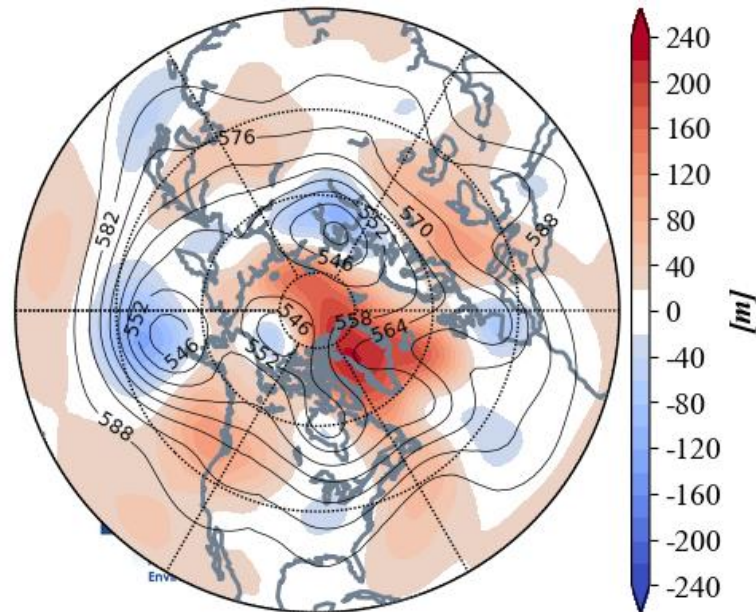


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 June 2019. The forecasts are from the 7 June 00z GFS ensemble.

Continued ridging/positive geopotential height anomalies stretching from Greenland to Iceland are predicted to favor continued troughing/negative geopotential height anomalies downstream across Western Europe next week with more ridging to the east across Central and Eastern Europe (**Figure 5**). This pattern is predicted to result in normal to above normal temperatures across much of Europe except for normal to below normal temperatures across the UK, Spain, Portugal and France underneath mid-tropospheric troughing (**Figure 6**). An expanding pool of cool temperatures in Western Siberia is predicted to start bleeding west towards northern Europe this period as well (**Figure 6**). Ridging/positive geopotential height anomalies are predicted to dominate Asia with the exception of relatively deep troughing/negative geopotential height anomalies in Western Siberia (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures for much of Asia including the Middle East and East Asia with normal to below normal temperatures across Western Siberia and parts of Central Asia (**Figure 6**).

GEFS 6-10 Day Forecast T2m Anomaly
INIT: 00Z 06/07/19 FCST: 06/13/19 to 06/17/19

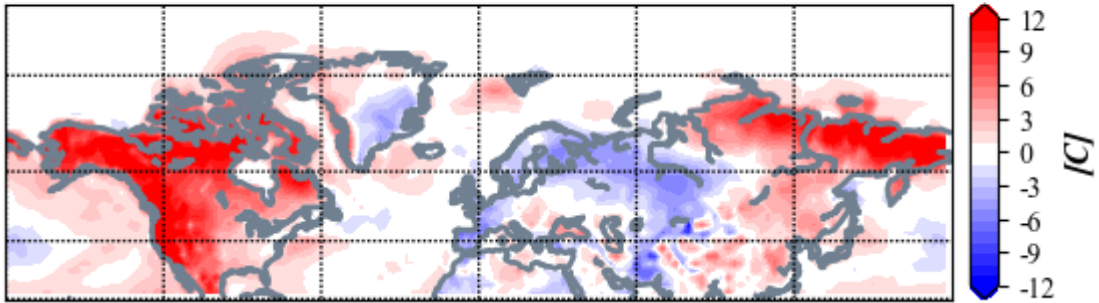


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 13 – 17 June 2019. The forecasts are from the 00Z 7 June 2019 GFS ensemble.

Ridging/positive geopotential height anomalies over Greenland and western North America are predicted to force troughing/negative geopotential height anomalies over the Eastern US this period (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across Alaska, much of Canada and the Western US with normal to below normal temperatures for the Eastern US (**Figure 6**).

GEFS 6-10 Day Forecast PCP Anomaly
INIT: 00Z 06/07/19 FCST: 06/13/19 to 06/17/19

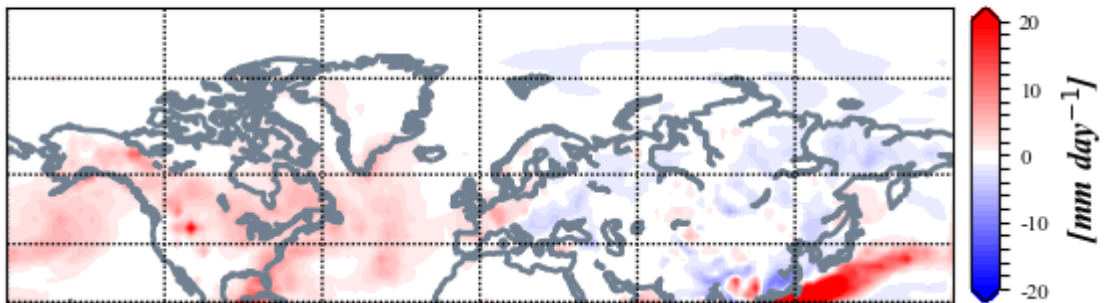


Figure 7. Forecasted rainfall anomalies (mm/day; shading) from 13 – 17 June 2019. The forecasts are from the 00Z 7 June 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation (**Figure 7**). Troughing is predicted to bring above normal rainfall to the Western Europe, Southeast Asia and the Eastern US (**Figure 7**).

11-15 day

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

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 06/07/19 FCST: 06/18/19 to 06/22/19

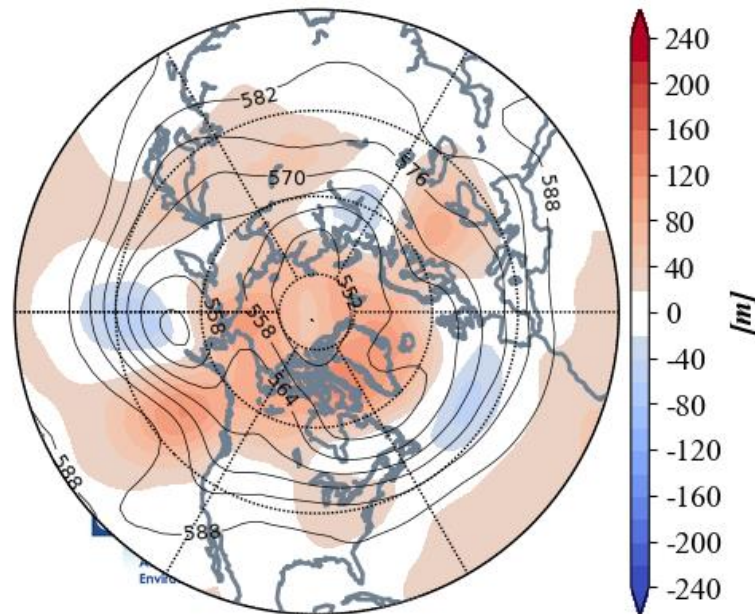


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 18 – 22 June 2019. The forecasts are from the 7 June 00z GFS ensemble.

Previous troughing/negative geopotential height anomalies across Western Europe is predicted to persist and expand to the east across Central Europe but weaken with ridging/positive geopotential height anomalies confined to Eastern Europe (**Figure 8**). This pattern is predicted to result in seasonable to above normal temperatures for most of Europe except for normal to below normal temperatures over Western Europe including the UK (**Figure 9**). Ridging/positive geopotential height anomalies are predicted to be widespread across Asia this period with residual troughing/negative geopotential height anomalies mostly confined to Western Siberia (**Figure 8**). This pattern favors normal to above normal temperatures for most of Asia including East Asia and the Middle East with normal to below normal temperatures confined to Northwest Russia (**Figure 9**).

GEFS 11-15 Day Forecast T2m Anomaly
INIT: 00Z 06/07/19 FCST: 06/18/19 to 06/22/19

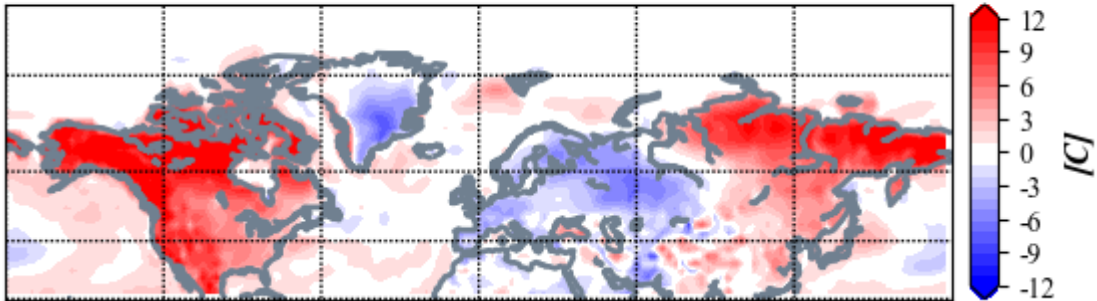


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 18 – 22 June 2019. The forecasts are from the 00Z 7 June 2019 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate much of North America with troughing/negative geopotential height anomalies confined to the West Coast of the US (**Figure 8**). This will favor normal to above normal temperatures across Alaska, much of Canada and the US with the possible exception of normal to below normal temperatures for the West Coast of the US (**Figure 9**). The European Centre for Medium-range Weather Forecasting (ECMWF) model predicts cooler temperatures for the Eastern US which seems more reasonable given the forecast of continued Greenland blocking.

GEFS 11-15 Day Forecast PCP Anomaly
INIT: 00Z 06/07/19 FCST: 06/18/19 to 06/22/19

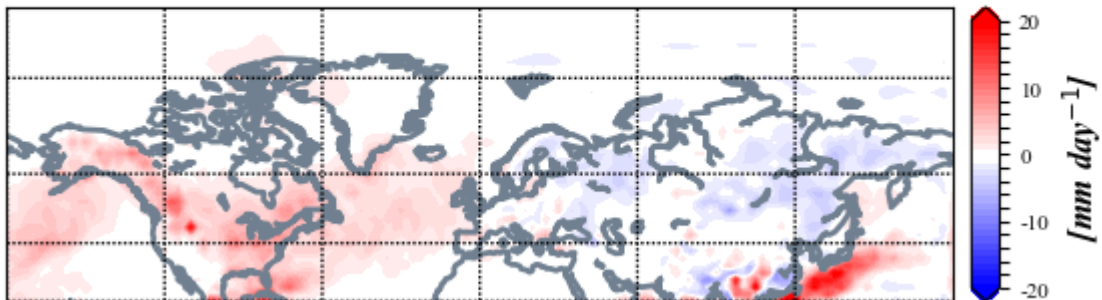


Figure 10. Forecasted rainfall anomalies (mm/day; shading) from 18 – 22 June 2019. The forecasts are from the 00Z 7 June 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation as ridging dominates the continent (**Figure 10**). Troughing is predicted to bring above normal rainfall to Spain, Southeast Asia and the Northwestern US (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential heights (PCHs) shows currently normal to above normal PCHs throughout the stratosphere and the troposphere (**Figure 11**). In the lowest troposphere PCHs are above normal, consistent with a negative AO (**Figure 1**). PCHs in the stratosphere are predicted to turn colder which is consistent with radiative cooling in the stratosphere due to increasing greenhouse gases.

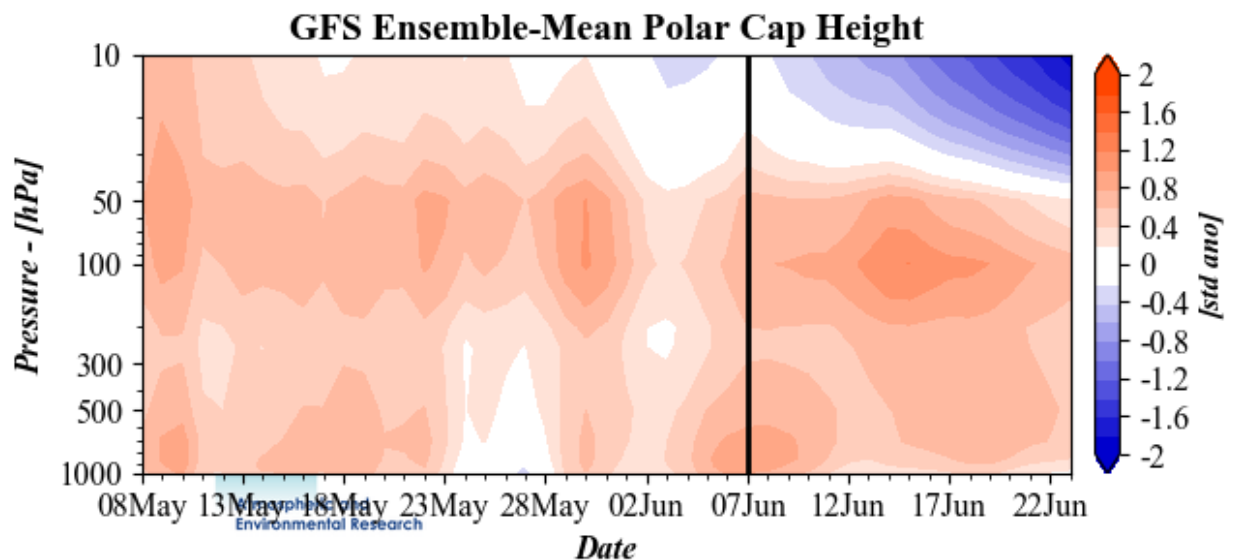


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 7 June 2019 GFS ensemble.

Positive PCHs in the mid to upper troposphere are predicted to descend into the lower troposphere in late May supporting a negative AO into mid-June and possibly beyond (**Figure 11**). The persistence of positive PCHs to the lower troposphere suggest an increased probability of high latitude blocking, which could force more troughing in the mid-latitudes. Therefore, I believe that caution is warranted for the GFS forecast of nearly universal ridging and above normal temperatures across the mid-latitudes in mid-June.

**CFS 500 hPa Forecast Anomaly Jul 2019
Valid as of 07 Jun 2019**

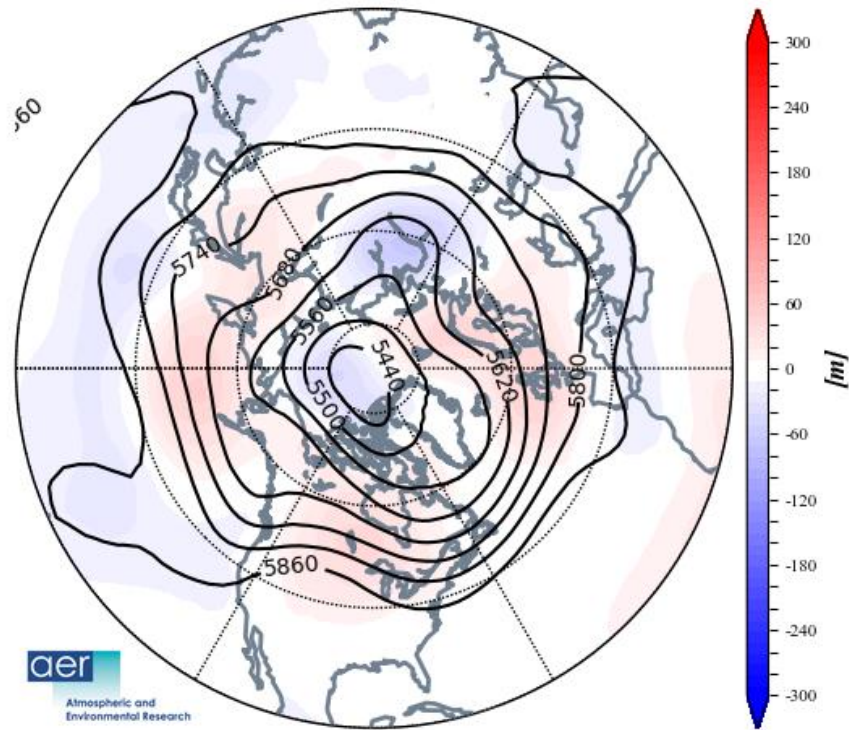


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2019. The forecasts are from the 7 June 2019 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 11**) and the surface temperatures (**Figure 12**) forecast for July from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered across Northern Europe, Northeast Asia, the Aleutians, Central Canada and the Central US with troughs in Spain, Western Russia, Southeast Asia, the US West Coast and the Northeastern US (**Figure 12**). This pattern favors relatively cool temperatures for parts of Southern Europe, Western and Southeast Asia and possibly the Northeastern US with relatively warm temperatures for Northern Europe, Northeast Asia and much of North America (**Figure 13**).

CFS T2m Forecast Anomaly Jul 2019 Valid as of 07 Jun 2019

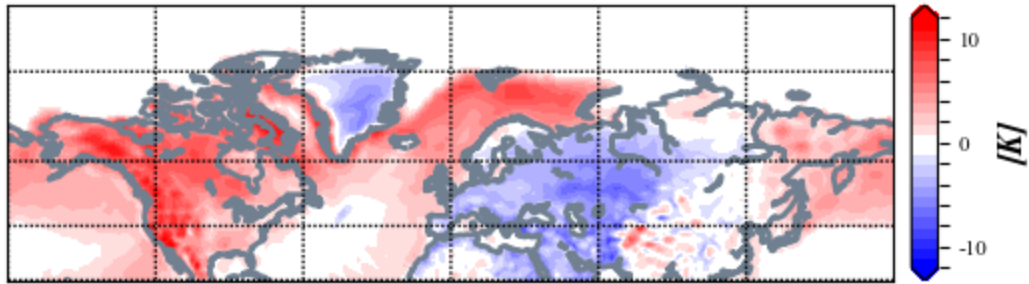


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for July 2019. The forecasts are from the 7 June 2019 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain warm and weak El Niño conditions are expected for this summer (**Figure 14**). Observed SSTs across the NH remain well above normal though below normal SSTs exist regionally. Cold SSTs south of Iceland and in the subtropics of the North Atlantic with above normal SSTs in the mid-latitudes are thought to favor a positive NAO.

SST Anomaly - Week Ending 05 Jun 2019

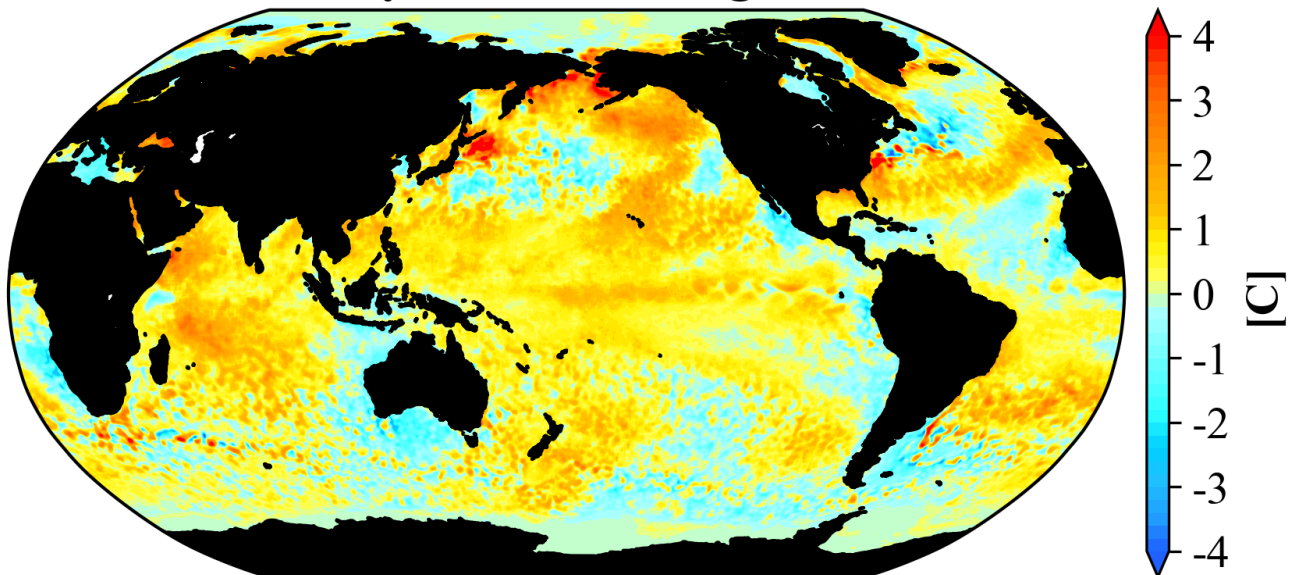


Figure 14. The latest weekly-mean global SST anomalies (ending 5 June 2019). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase three (**Figure 13**). And the forecasts are for the MJO to then enter possibly phase 4 and eventually where no phase is favored. MJO phase 3 favors ridging in the Eastern US with troughing in Greenland. MJO forcing seems to favor the opposite of the current pattern and the forecast across the US.

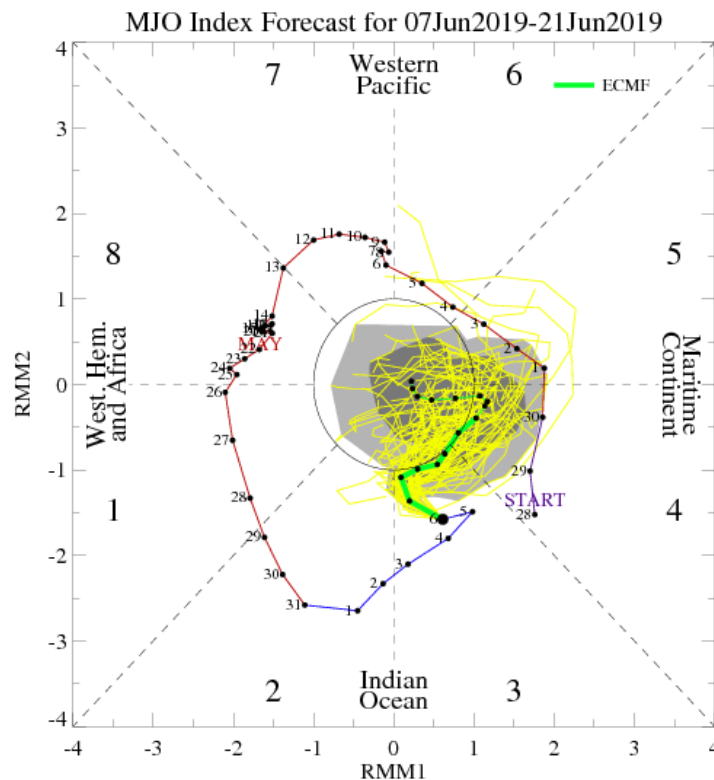


Figure 13. Past and forecast values of the MJO index. Forecast values from the 00Z 7 June 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>