

May 24, 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 neutral and is predicted to remain neutral to negative 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 negative as positive pressure/geopotential height anomalies are spread across Greenland and Iceland and is predicted to remain mostly negative over the next two weeks.
- Ridging/positive geopotential height anomalies across Greenland and the eastern North Atlantic are predicted to force troughing/negative geopotential height anomalies to the east centered on Central Europe. This pattern favors seasonable to cool temperatures across Europe including the United Kingdom

(UK) with the exception of Southeast Europe where southwesterly flow will transport relatively warmer air into the region. However, in June the trough is predicted to weaken allowing for a warming trend across Europe.

- Currently ridging/positive geopotential height anomalies across the Arctic and building across western Asia are forcing troughing/negative geopotential height anomalies with normal to below normal temperatures first across Central Asia and then over East Asia. However, in early June a warming general warming trend is predicted with above normal temperatures widespread across much of Asia.
- I do consider the forecast of general warming to be a low confidence forecast and regions of below normal heights/temperatures could exist in June more than predicted for both Asia and especially Europe.
- Currently ridging/positive geopotential height anomalies with relatively mild temperatures dominate the Eastern United States (US) and troughing/negative geopotential height anomalies with relatively cool temperatures dominate the Western US. However, starting next week the pattern is predicted to become less amplified with more zonal like flow and general above normal geopotential heights. This should allow above normal temperatures to become widespread across North America.
- As with Europe, I do consider the forecast of general warming to be a low confidence forecast and regions of below normal heights/temperatures could exist in June more than predicted.
- In the Impacts section I present the summer temperature forecast for the Northern Hemisphere (NH).

Impacts

Since this is my last blog post of May I am including the AER summer temperature forecast. Shown in **Figure i**, are the predicted surface temperature anomalies for June, July and August 2019 for the North American multi-model Experiment (NNME), the C3S model ensemble (ECMWF, UK Met Office and Meteo France models) and from the AER model. Forecasts from all three models show widespread above normal temperatures with some regional exceptions. Both the AER model and the C3S show closer to seasonable temperatures in western Asia and in the US and Southern Canada between the Appalachians and the Plains. The C3S is even colder than the AER model in the US with below normal temperatures predicted in the Western Great Lakes and the Mississippi River Valley. The NMME models also show below normal temperatures in the US but shifted west over the Plains.

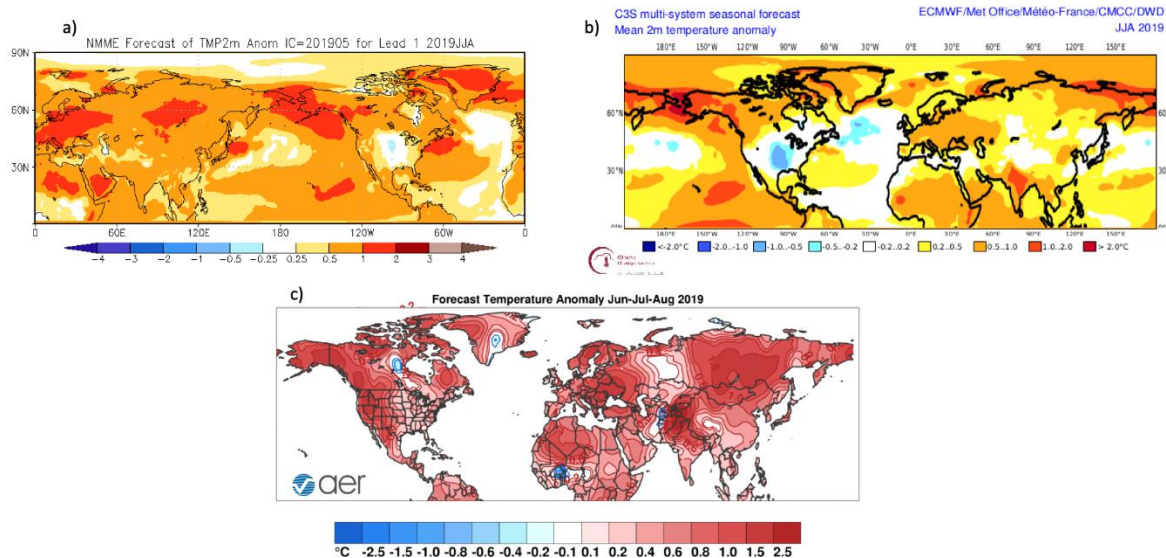


Figure i. Predicted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 June – 31 August 2019 from (a) the North American multi-model Experiment (NMME), (b) the C3S model ensemble (ECMWF, UK Met Office and Meteo France models) and (c) the AER model.

I include in **Figure ii**, the forecast of surface temperature anomalies from June, July and August 2019 from NOAA’s Climate Prediction Center (CPC). Their forecast is most consistent with the NMME forecast with above normal temperatures on both coasts and even greater below normal temperatures than predicted in the NMME in the Plains. I also include in **Figure ii** my own temperature anomaly plot for June, July and August 2019 for the US. I chose the summers of 1997, 2003 and 2015 based on El Niño summers and late season stratosphere-troposphere coupling. The temperature anomalies are consistent with the dynamical model forecasts with above normal temperatures in the Western US and parts of the Northeast with below normal temperatures in the Great Lakes and the Ohio and Tennessee Valleys. The region of cool temperatures in the analog plot is shifted east relative to the dynamical model forecasts.

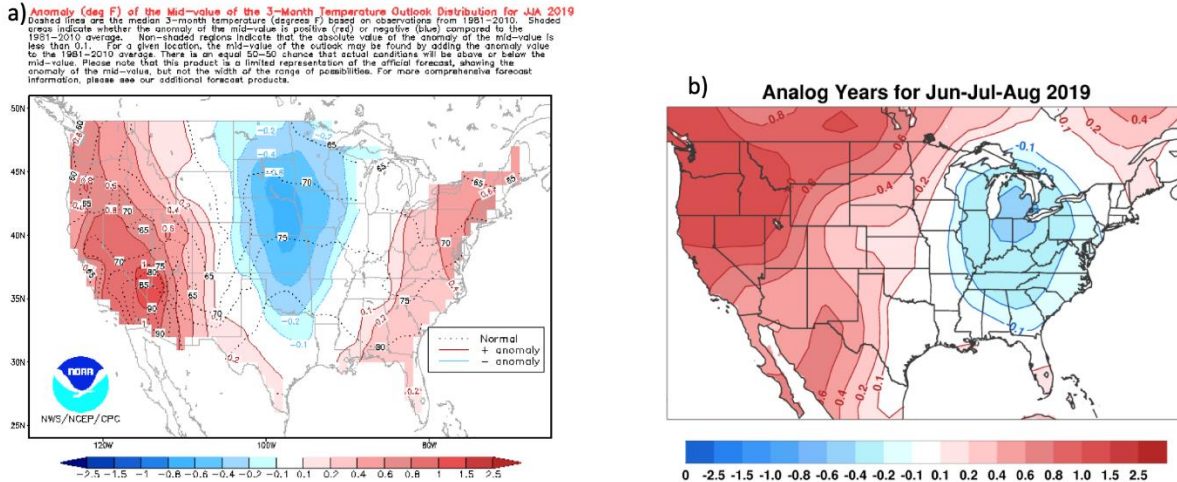


Figure ii. Predicted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 June – 31 August 2019 (a) from NOAA's Climate Prediction Center and (b) and based on analog years 1997, 2003 and 2015.

For the US I believe that temperatures are likely to average above normal along both the West and East Coasts and could even possibly stretch coast-to-coast despite the trough and accompanying cool temperatures in the middle of the country so far this spring. However, the relatively cool, wet spring does increase the possibility of below normal temperatures this summer in the interior US between the Plains and the Great Lakes.

As far as Europe the AER model as well as the dynamical models are all predicting above normal temperatures for the entire continent. There is a very robust multi-annual summer warming trend across Europe and as they say on Wall Street, "the trend is your friend." Further supporting a relatively warm summer for Europe is that the soil is relatively dry across much of Europe. However, there are a couple of circulation differences from last summer that give me pause. First, by this time last year, ridging/blocking was already well established across Northern Europe that persisted for much of the summer. Currently Europe is not dominated by ridging but instead troughing dominates much of Europe so the preconditioning favorable for summer heat is not present this year in contrast to last year. Second, is the circulation in the Arctic. Last year at this time, the Arctic was dominated by below normal geopotential height anomalies and this year the Arctic is dominated by above normal geopotential height anomalies. High heights/blocking in the Arctic favors troughing and cooler temperatures in the mid-latitudes and in that regard the high heights in the Arctic, especially on the North Atlantic side, favor troughing and relatively cool temperatures in Europe. If high heights/blocking in the Arctic especially near Greenland, can persist for much of the summer then parts of Europe could experience below normal temperatures this summer.

All forecasts predict a relatively warm summer for East Asia. Again, I think the trend is your friend in East Asia as well and the warm forecast is likely to verify. However as in Europe, persistent high heights/blocking to the north could flip the summer from hot to cool at least regionally.

Finally, if polar cap geopotential height anomalies remain on the warm/positive side for much of the summer, this could result in accelerated sea ice loss relative to recent summers.

Near Term Conditions

1-5 day

The AO is currently neutral and is predicted to remain neutral to slightly positive over the next several days (**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 positive geopotential height anomalies across Greenland and Iceland (**Figure 2**), the NAO will likely be negative this week as well.

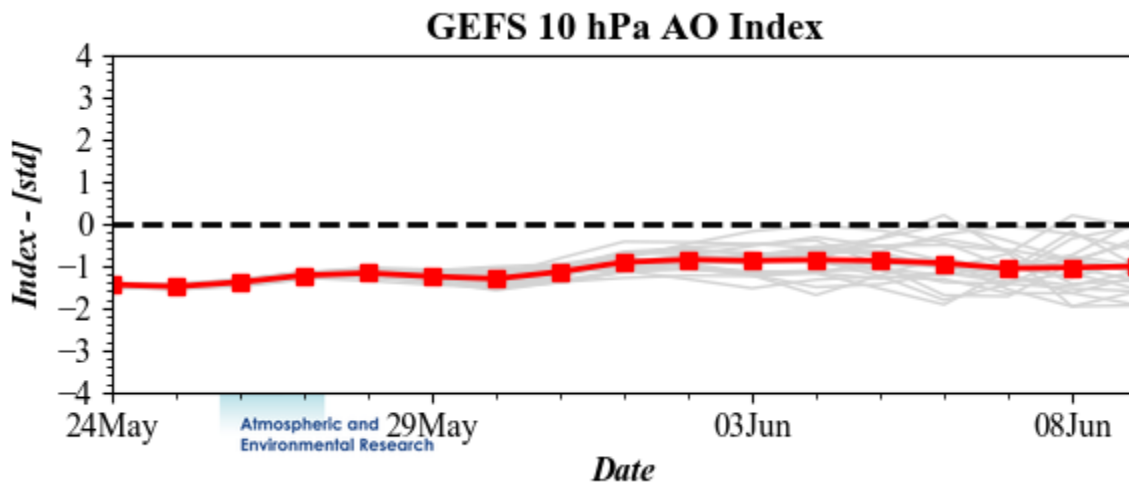


Figure 1. The predicted daily-mean AO at 10 hPa from the 00Z 24 May 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies stretching from Greenland to the Azores and covering far Western Europe as well are predicted to force troughing/negative geopotential height anomalies across Central Europe over the weekend and into next week (**Figure 2**). This pattern is predicted to result in normal to below normal temperatures across much of Europe including the UK except for normal to above temperatures across Ireland, Portugal, Spain and Southeastern Europe underneath mid-

tropospheric ridging (**Figure 3**). More ridging/positive geopotential height anomalies centered on the Laptev Sea will force troughing/negative geopotential height anomalies from Northwest Russia to Mongolia and Northeast China with ridging/positive geopotential height anomalies for much of the rest of Asia including Southeast Asia and the Middle East (**Figure 2**). This is predicted to yield normal to below normal temperatures from Northwestern Asia to Mongolia with normal to above normal temperatures across the Middle East and East Asia (**Figure 3**). Weak troughing in northwest India and Pakistan (Figure 2) will likely support relatively cool temperatures (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 05/24/19 FCST: 05/25/19 to 05/29/19

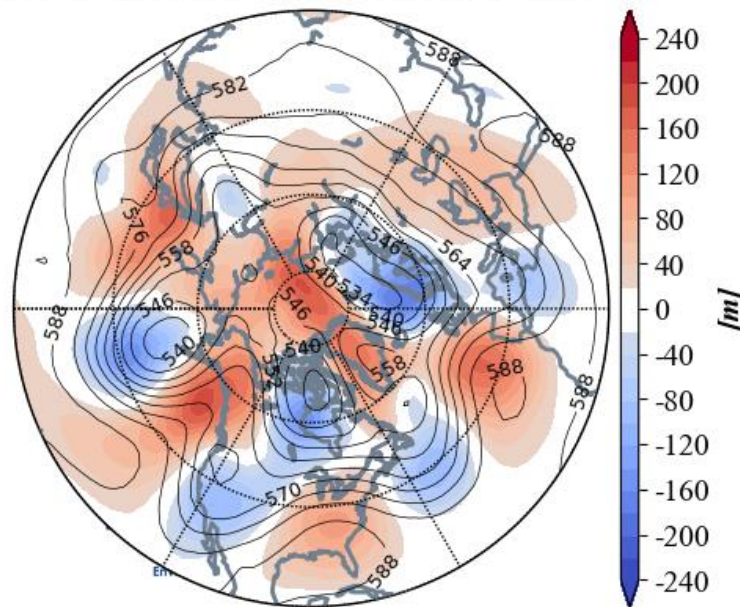


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 25 – 29 May 2019. The forecasts are from the 24 May 00z GFS ensemble.

Ridging/positive geopotential height anomalies across Alaska and the Gulf of Alaska are predicted to force troughing/negative geopotential height anomalies downstream across Central Canada while troughing/negative geopotential height anomalies in the Western US are predicted to support ridging/positive 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 Western US with normal to above normal temperatures for Alaska, the Central and Eastern US and Western and Eastern Canada (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 05/24/19 FCST: 05/25/19 to 05/29/19

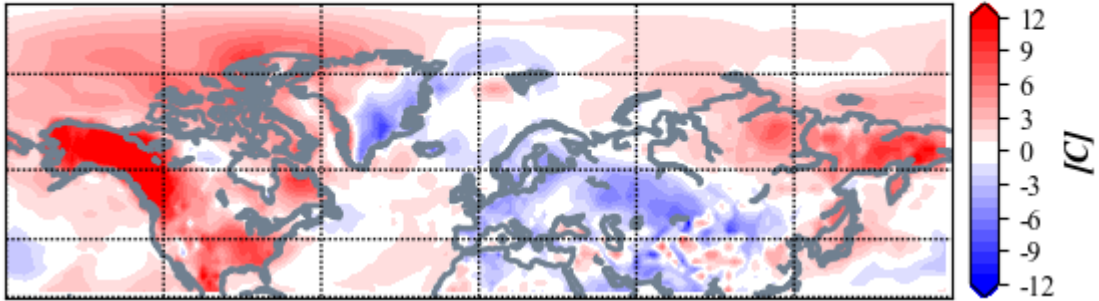


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 25 – 29 May 2019. The forecast is from the 00Z 24 May 2019 GFS ensemble.

Trouching is predicted to bring above normal rainfall to Scandinavia, the Alps, East Asia, the Northern US and Southern Canada (**Figure 4**).

GEFS 1-5 Day Forecast PCP Anomaly
INIT: 00Z 05/24/19 FCST: 05/25/19 to 05/29/19

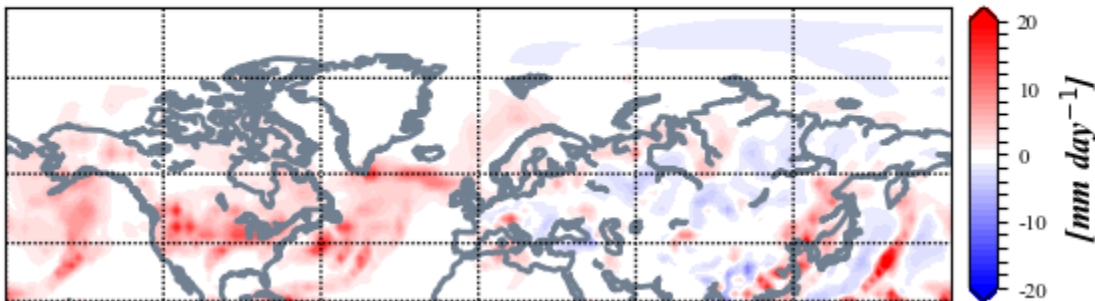


Figure 4. Forecasted rainfall anomalies (mm/day ; shading) from 25 – 29 May 2019. The forecast is from the 00Z 24 May 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to turn neutral to negative next week (**Figure 1**) as positive geopotential height anomalies become more 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 next week.

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 05/24/19 FCST: 05/30/19 to 06/03/19

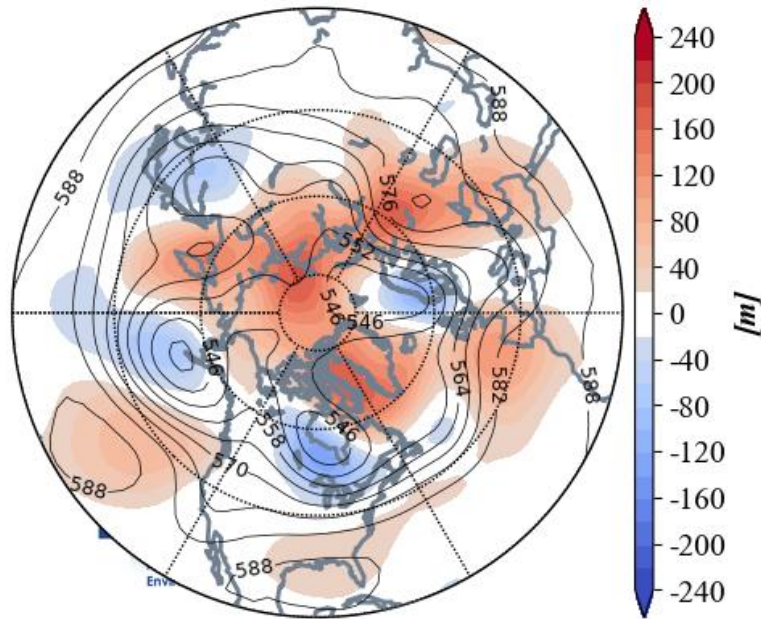


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 30 May – 3 June 2019. The forecasts are from the 24 May 00z GFS ensemble.

Continued ridging/positive geopotential height anomalies stretching from Greenland to the Azores are predicted to favor troughing/negative geopotential height anomalies downstream across Central Europe next week with more ridging to the east across Eastern Europe (**Figure 5**). This pattern is predicted to result in normal to below normal temperatures across Europe including the UK except for normal to above temperatures across Western Spain, Portugal and Southeastern Europe underneath mid-tropospheric ridging (**Figure 6**). Ridging/positive geopotential height anomalies are predicted to dominate Northern Asia with troughing/negative geopotential height anomalies in Northeastern China, Iran and Afghanistan (**Figure 5**). This is predicted to yield widespread normal to above normal temperatures for much of Northern Asia, the Middle East and East Asia with normal to below normal temperatures across Mongolia, Northeastern China, Iran, Afghanistan and possibly parts of Pakistan (**Figure 6**).

GEFS 6-10 Day Forecast T2m Anomaly
INIT: 00Z 05/24/19 FCST: 05/30/19 to 06/03/19

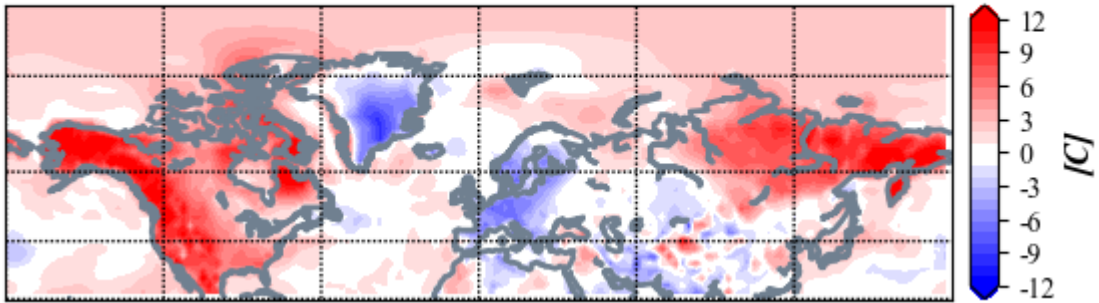


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 30 May – 3 June 2019. The forecasts are from the 00Z 24 May 2019 GFS ensemble.

Trouching/negative geopotential height anomalies previously over the Canadian Archipelagos are predicted to drop south to southern Hudson Bay helping to suppress the ridging/positive geopotential height anomalies over the Eastern US (**Figure 5**). Meanwhile troughing/negative geopotential height anomalies over the Western US will fill and weaken (**Figure 5**). This pattern is predicted to bring normal to below normal temperatures across Southeastern Canada and the Western US with normal to above normal temperatures for Alaska, Western and Northern Canada and the Eastern US (**Figure 6**).

GEFS 6-10 Day Forecast PCP Anomaly
INIT: 00Z 05/24/19 FCST: 05/30/19 to 06/03/19

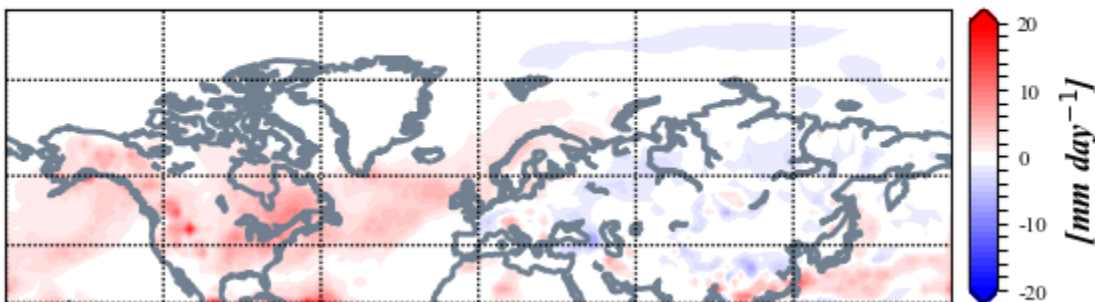


Figure 7. Forecasted rainfall anomalies (mm/day ; shading) from 30 May – 3 June 2019. The forecasts are from the 00Z 24 May 2019 GFS ensemble.

Much of Eurasia is predicted to receive below normal precipitation (**Figure 7**). Troughing is predicted to bring above normal rainfall to the Alps, Southeast Asia, the Northwestern and Northeastern 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 neutral to negative this period as well.

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 05/24/19 FCST: 06/04/19 to 06/08/19

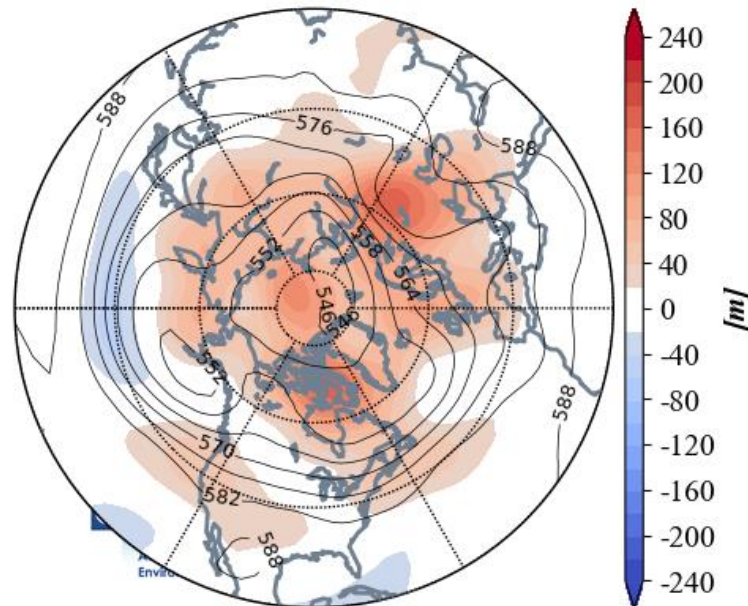


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 4 – 8 June 2019. The forecasts are from the 24 May 00z GFS ensemble.

Previous troughing/negative geopotential height anomalies across Central Europe is predicted to slide east and weaken leaving mostly ridging/positive geopotential height anomalies across Europe (**Figure 8**). This pattern is predicted to result in normal to above normal temperatures for most of Europe including the UK except for normal to below normal temperatures near the Adriatic Sea where northerly flow could usher in some cooler temperatures (**Figure 9**). Ridging/positive geopotential height anomalies are predicted to be widespread across Asia this period with some troughing/negative geopotential height anomalies mostly confined to the Tibetan Plateau and Northern India (**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 Northern India and surrounding countries (**Figure 9**).

GEFS 11-15 Day Forecast T2m Anomaly
INIT: 00Z 05/24/19 FCST: 06/04/19 to 06/08/19

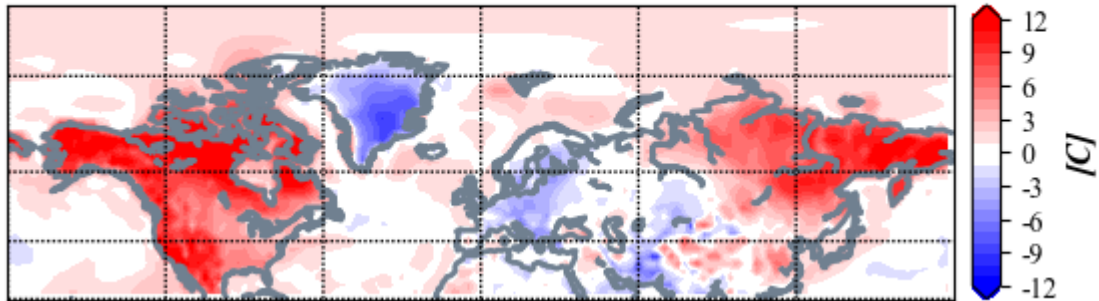


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 4 – 8 June 2019. The forecasts are from the 00Z 24 May 2019 GFS ensemble.

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 Canada (**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 British Columbia (**Figure 9**).

GEFS 11-15 Day Forecast PCP Anomaly
INIT: 00Z 05/24/19 FCST: 06/04/19 to 06/08/19

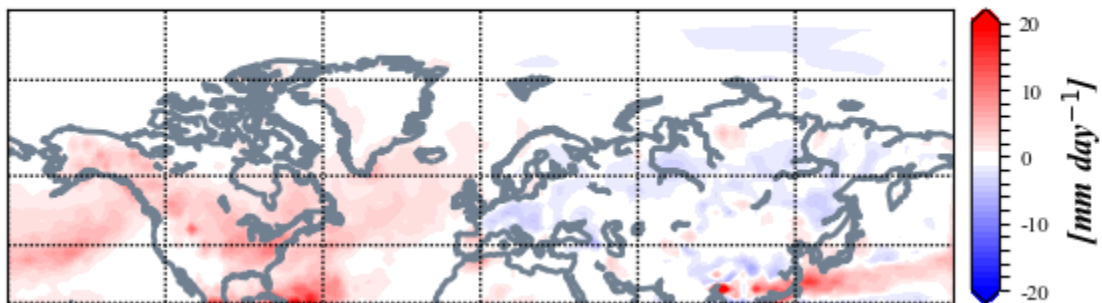


Figure 10. Forecasted rainfall anomalies (mm/day ; shading) from 4 – 8 June 2019. The forecasts are from the 00Z 24 May 2019 GFS ensemble.

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 Northeastern US (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential heights (PCHs) shows predicted normal to above normal PCHs throughout the stratosphere and the troposphere (**Figure 11**). In the lowest troposphere PCHs are near normal, consistent with a neutral AO (**Figure 1**). PCHs in the stratosphere are predicted to turn colder as the positive PCHS related to an unusually dynamic stratospheric Final Warming (where the stratospheric polar vortex disappears for the summer and winds are persistently easterly at 60°N and 10 hPa) start to dissipate.

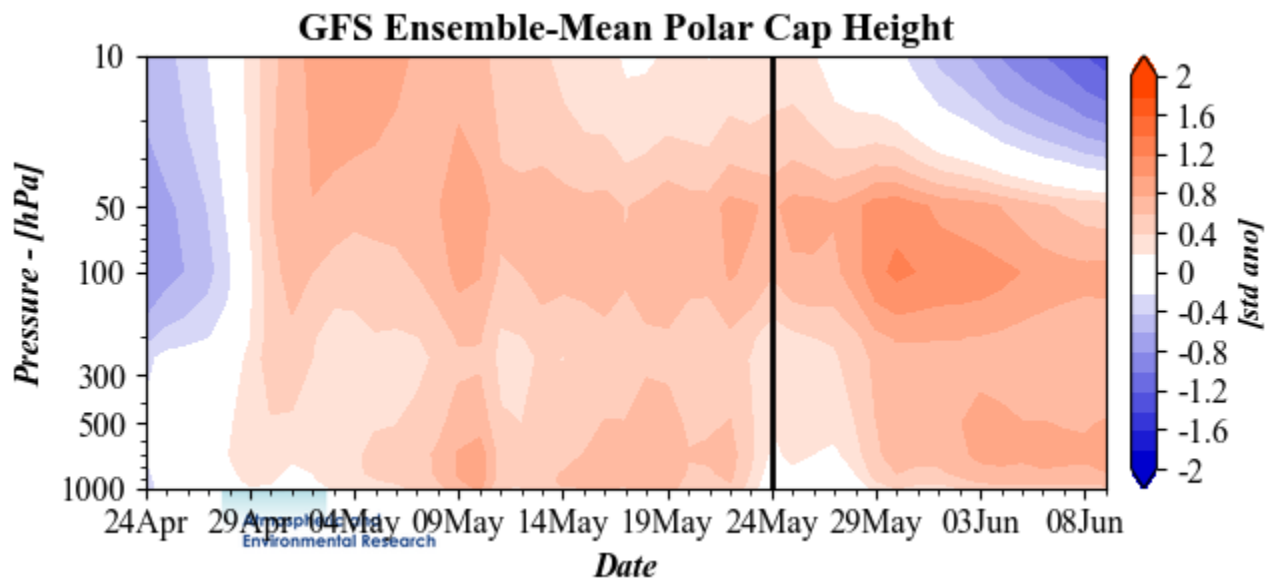


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 24 May 2019 GFS ensemble.

Positive PCHs in the mid to upper troposphere are predicted to descend into the lower troposphere in late May supporting a negative trend in the AO in early June (**Figure 11**). The descent 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 early June.

Our plots of the CFS did not generate and therefore a monthly forecast discussion of the CFS is not included in this week's post.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain warm and El Niño conditions are expected for this summer (**Figure 12**). 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 22 May 2019

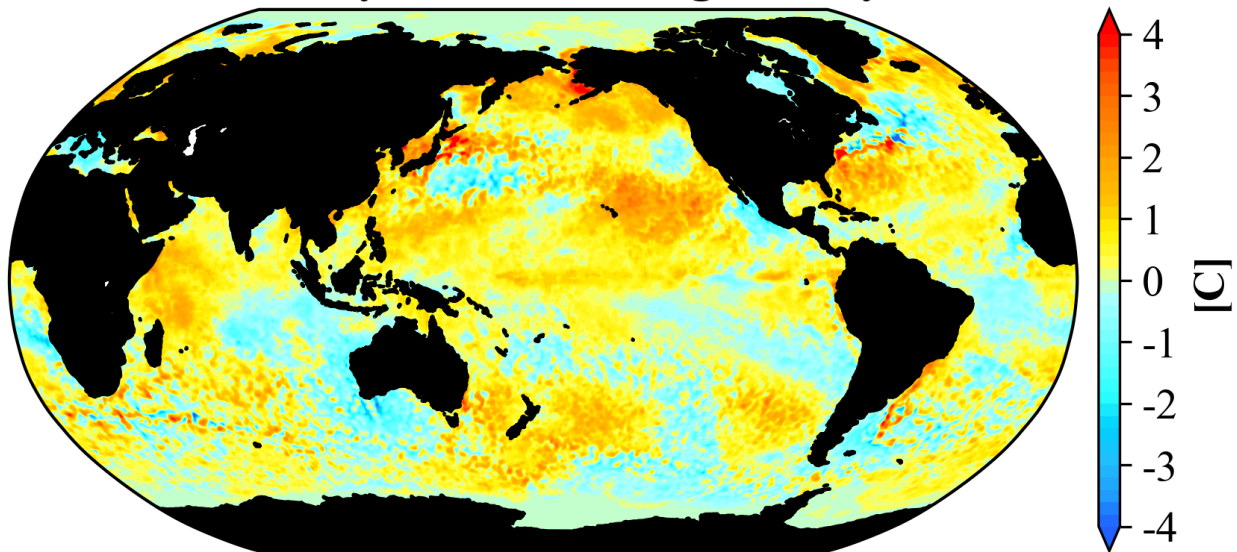


Figure 12. The latest weekly-mean global SST anomalies (ending 22 May 2019). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase eight (**Figure 13**). And the forecasts are for the MJO to then enter phases 1, 2, and where no phase is favored. MJO phases 8-1 favor ridging in Northern Canada and troughing in the Eastern US and while phase 2 favors a transition to troughing in Northern Canada and ridging in the Eastern US. MJO forcing seems to be opposite of the current pattern and the forecast across the US.

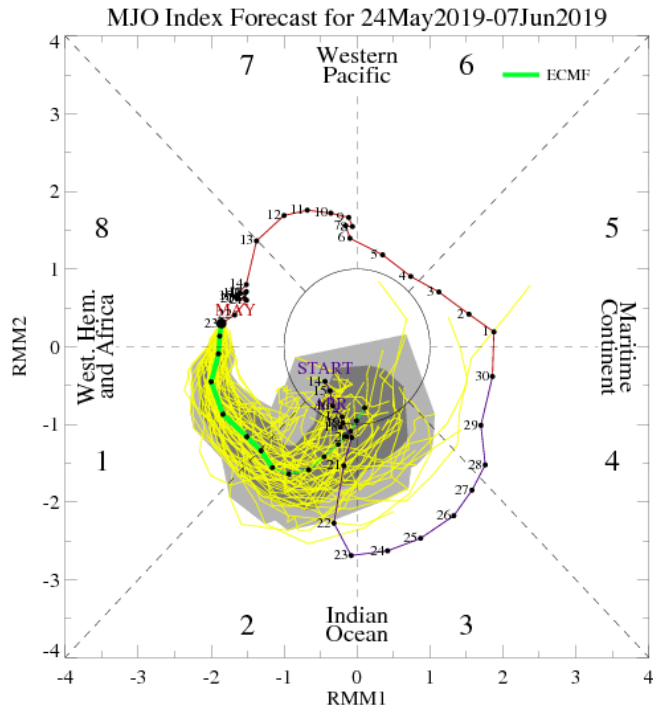


Figure 13. Past and forecast values of the MJO index. Forecast values from the 00Z 24 May 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>