

Arctic Oscillation and Polar Vortex Analysis and Forecasts

June 8, 2020

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.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather. With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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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 remain neutral to slightly negative over the next two weeks.
- The current neutral AO is reflective of mixed pressure/geopotential height anomalies across the Arctic with mixed pressure/geopotential height anomalies

across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently slightly positive with negative pressure/geopotential height anomalies spread across Greenland; and the NAO is predicted to become increasingly negative the next two weeks as pressure/geopotential height anomalies rise across Greenland and Iceland.

- The general weather pattern for the next two weeks is ridging/positive geopotential height anomalies with normal to above normal temperatures stretching from Greenland across to Scandinavia and into Eastern Europe favoring troughing/negative geopotential height anomalies with normal to below normal temperatures across Western and Southern Europe including the United Kingdom (UK).
- The predicted general pattern for Asia the next two weeks is ridging/positive geopotential height anomalies with normal to above normal temperatures with the exception of troughing/negative geopotential height anomalies with normal to below normal temperatures initially in Central extending into Eastern Asia that will retrograde westward into Western Russia next week.
- Over the next two weeks ridging/positive geopotential height anomalies with normal to above normal temperatures will strengthen across Canada and Alaska forcing troughing/negative geopotential height anomalies accompanied by more seasonable to possibly below normal temperatures to the south most likely along the West and East Coasts of the United States (US).
- Once again, in the Impacts section I discuss the May troposphere-stratosphere-troposphere coupling event and the implications for the Northern Hemisphere (NH) circulation pattern, with possibly the dominant Northern Hemisphere (NH) summer pattern coming into view.

Impacts

I will continue with a similar theme from many of my posts this spring – the importance of the return of positive polar cap geopotential height anomalies (PCHs) to the troposphere that started slowly in April but picked up in earnest in May associated with a troposphere-stratosphere-troposphere (T-S-T) coupling event has reversed negative/cold polar cap geopotential height anomalies (PCHs) so dominant all winter to positive/warm in the troposphere and that could potentially dominate the summer months.

As anyone who has read the blog the past several months knows, I have just been obsessed with the May T-S-T coupling event. These events are typically considered limited to the winter months and certainly when the stratospheric polar vortex (PV) exists. Yet the May T-S-T coupling event occurred after the Final Warming (where the stratospheric PV disappears until the fall). Winter blocking/high pressure in the North Atlantic sector s are also typically associated with blocking/high pressure in the North Atlantic sector centered anywhere from Greenland to the general region of Scandinavia, the Urals and the Barents-Kara Seas. This current event has so far been no

different. During the winter, blocking/high pressure in the North Atlantic sector was completely absent from Greenland to the Barents-Kara Seas. But the pattern transitioned to increasing frequency of blocking/high pressure in the North Atlantic sector beginning in April and accelerated in May following the T-S-T coupling event. This has manifested in the AO and especially the NAO that were exclusively positive all winter long to become predominately negative since April.

Based on the most recent GFS forecasts and even the CFS forecasts (**Figures 5, 8 and 12** below) blocking/high pressure in the North Atlantic sector from Greenland to Scandinavia, and the Barents-Kara Seas could persist for the next two months. In **Figure i**, I also include the 500 hPa geopotential height forecast from the latest CFS for June and August (July is provided in **Figure 12**). The latest forecast certainly suggests a tendency for blocking/high pressure in the North Atlantic sector for all three summer months. Locally high pressure brings with it warm temperatures. Centered over Greenland this could cause large melt events to parts of the Greenland ice sheet. Over towards the Barents-Kara Seas high pressure has accelerated sea ice melt in the region that is likely to continue. This pattern also has the potential to usher in an unusually hot summer to Scandinavia and possibly more forest fires. However further to the south across Western and Southern Europe it could help to keep temperatures more temperate and even bring above normal precipitation. Similarly, in the Northeastern US, Greenland blocking could keep very warm temperatures mostly confined to west of the Appalachians as the Northeastern US is frequently cooled by air from Eastern Canada and from the North Atlantic.

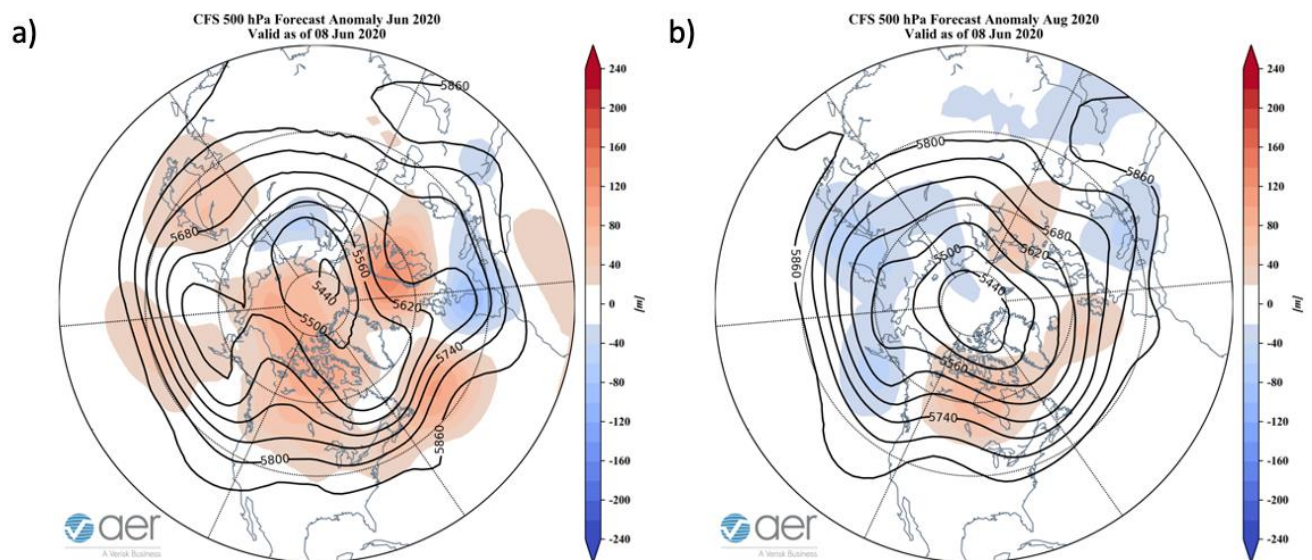


Figure i. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for **a)** June and **b)** August 2020. The forecasts are from the 00Z 8 June 2020 CFS.

For Arctic sea ice overall, it does look like the trajectory is similar to other recent summers (with the minimum extent between 4 and 5 million of squared kilometers). I think this is true as long as high pressure stays on the periphery of the Arctic such as Greenland, Scandinavia, Siberia and Alaska with a center of low pressure in the Central Arctic as predicted by the CFS. If the center of high pressure moves closer to the North Pole then the Arctic sea ice minimum could take a run at the record low of 2012.

This is the time of year when the dominant summer pattern starts to establish itself and this seems to be the early indications of such a pattern, but it is early and there could be more plot twists. But certainly, the pattern seems to be settling into one consistent with other recent summers with heat domes centered across western North America, Europe (but for now focused across Scandinavia) and East Asia with a trough and more seasonable temperatures in Western Asia. In recent summers across North America we have observed ridging on the coasts with a weakness or trough in the interior. For this summer, the GFS/CFS are suggesting a different pattern though, with ridging centered over the interior and troughing on the coasts.

In a follow up to last week's blog on the summer forecast I did find on the Copernicus website the summer temperature anomaly plot from the C3S system (see **Figure ii**). My plot is too cold in eastern North America and Scandinavia but otherwise looks good. Thank you to those that reached out to me!

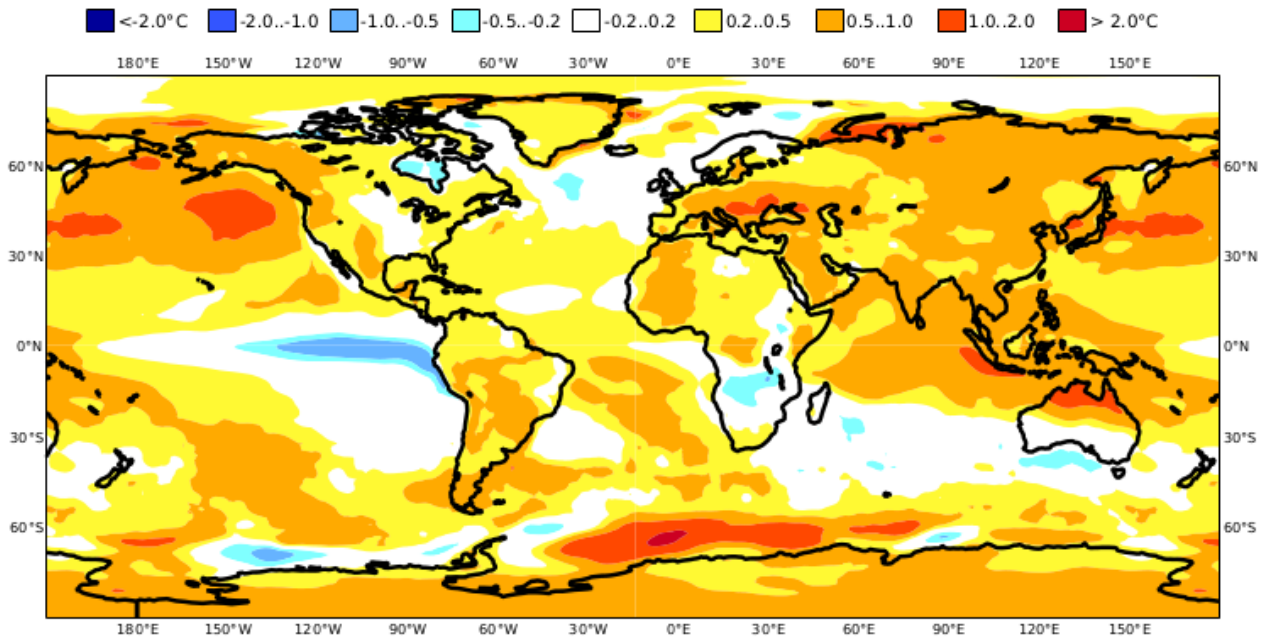


Figure ii. The temperature anomaly forecast for June, July and August 2020 from the C3S ensembles. The C3S can be found on the [Copernicus](https://climate.copernicus.eu) website.

1-5 day

The AO is currently neutral (**Figure 1**) with mixed geopotential height anomalies focused across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with predicted weak negative geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to straddle neutral this week.

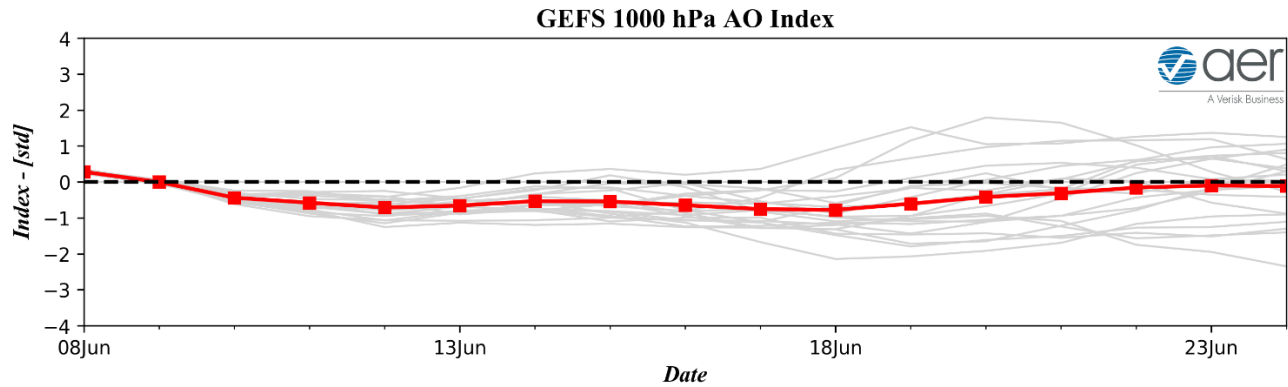


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 8 June 2020 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

This week, ridging/positive geopotential height anomalies with normal to above normal temperatures across Northern and Eastern Europe will favor troughing/negative geopotential height anomalies and normal to below normal temperatures for much of Southern and Western Europe including the UK (**Figures 2 and 3**). Ridging/positive geopotential height anomalies in Western Asia, will help to anchor troughing/negative geopotential height anomalies in Central and into Eastern Asia with more ridging/positive geopotential height anomalies in Southeastern Asia this week (**Figure 2**). This pattern favors normal to above normal temperatures across Western, Northern and Southeastern Asia with normal to below normal temperatures in Central and Northeastern Asia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 06/08/2020 FCST: 06/09/2020 to 06/13/2020

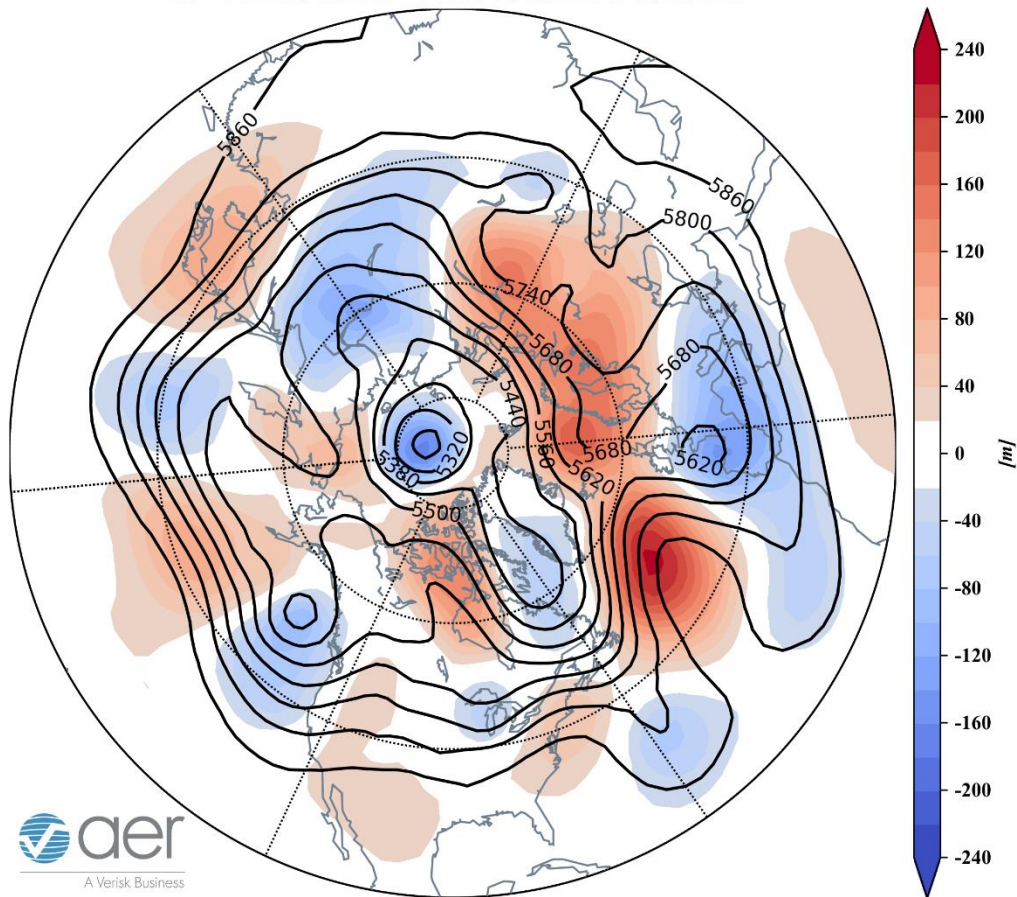


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 June 2020. The forecasts are from the 00z 8 June 2020 GFS ensemble.

This week, ridging/positive geopotential height anomalies are predicted for Alaska, Northwestern Canada, the Interior Western US and along the Eastern Seaboard with troughing/negative geopotential height anomalies in Eastern Canada, along the US West Coast and the Great Lakes (**Figure 2**). This pattern is predicted to bring normal to above normal temperatures across Alaska, Northwest Canada, the interior Western US and the US East Coast with normal to below normal temperatures in Eastern Canada, the Great Lakes and the US West Coast (**Figure 3**).

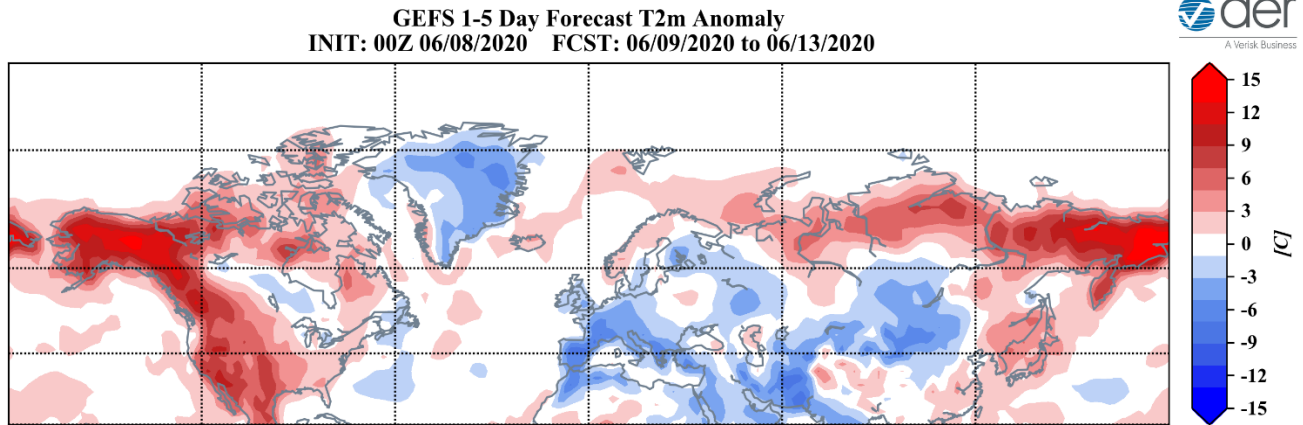


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 9 – 13 June 2020. The forecast is from the 00Z 8 June 2020 GFS ensemble.

Below normal precipitation is predicted for much of Europe and Asia with the exceptions of above normal precipitation for Western and Southern Europe, and East Asia (**Figure 4**). Below normal precipitation is predicted for much of North America with above normal precipitation across the Pacific Northwest and the Great Lakes (**Figure 4**).

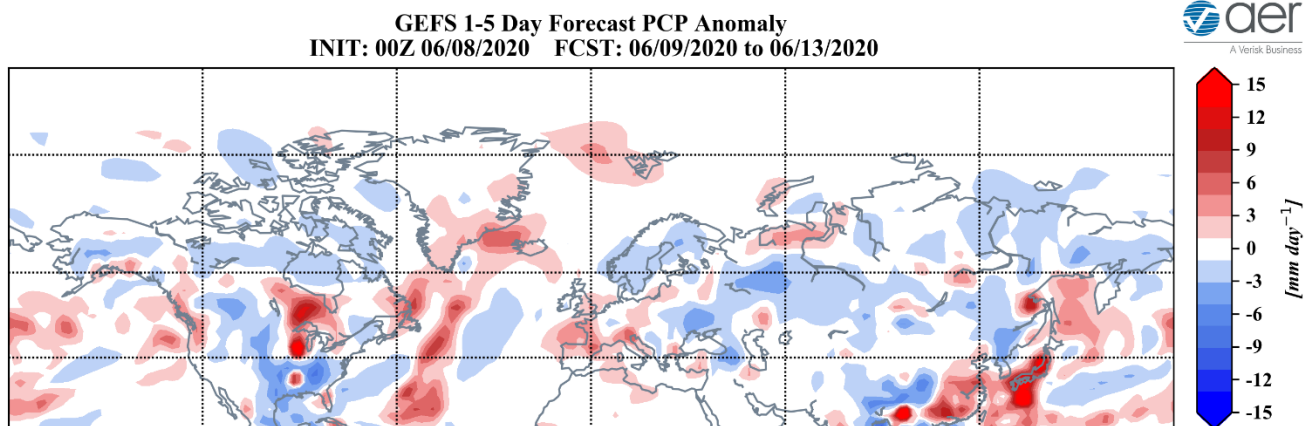


Figure 4. Forecasted precipitation anomalies (mm/day ; shading) from 9 – 13 June 2020. The forecast is from the 00Z 8 June 2020 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain steady (**Figure 1**) at weakly negative 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

weak positive geopotential height anomalies predicted across Greenland (**Figure 2**), the NAO is predicted to remain weakly negative as well.

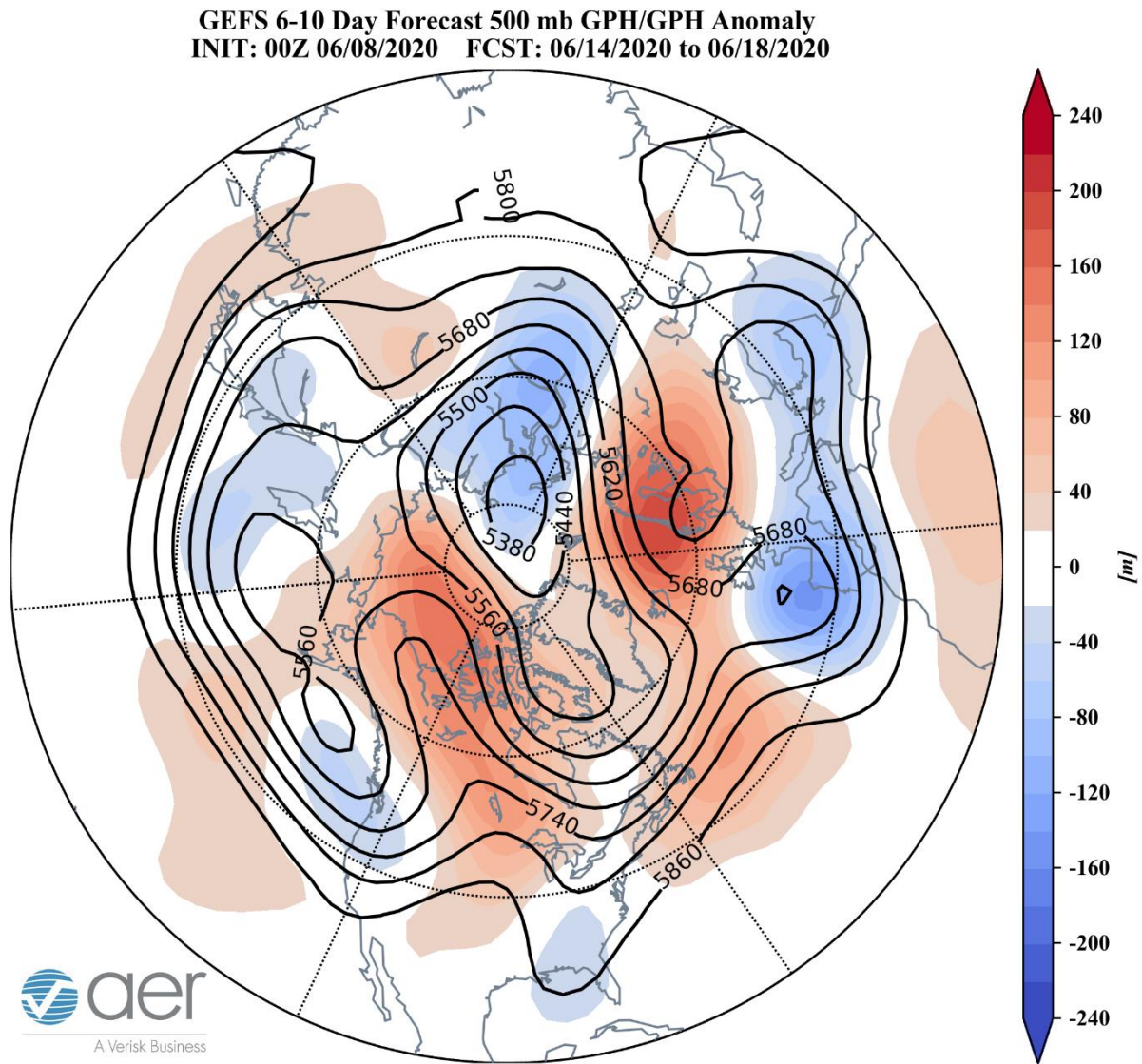


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 June 2020. The forecasts are from the 00z 8 June 2020 GFS ensemble.

Ridging/positive geopotential height anomalies anchored across Scandinavia and Eastern Europe will continue to favor troughing/negative geopotential height anomalies across Southern and Western Europe (**Figures 5**). This pattern will favor normal to below normal temperatures across Western and Southern Europe with normal to above normal temperatures across Northern and Eastern Europe including the UK (**Figure 6**). Retrograding troughing/negative geopotential height anomalies from Central Asia

will spread across Western Asia this period with ridging/positive geopotential height anomalies becoming more widespread across East Asia (**Figure 5**). This is predicted to yield normal to above normal temperatures in Eastern Asia **with** normal to below temperatures in Western Asia (**Figure 6**). Some weak troughing/negative geopotential height anomalies across the Northern Indian subcontinent will favor normal to below normal temperatures across that region (**Figures 5 and 6**).

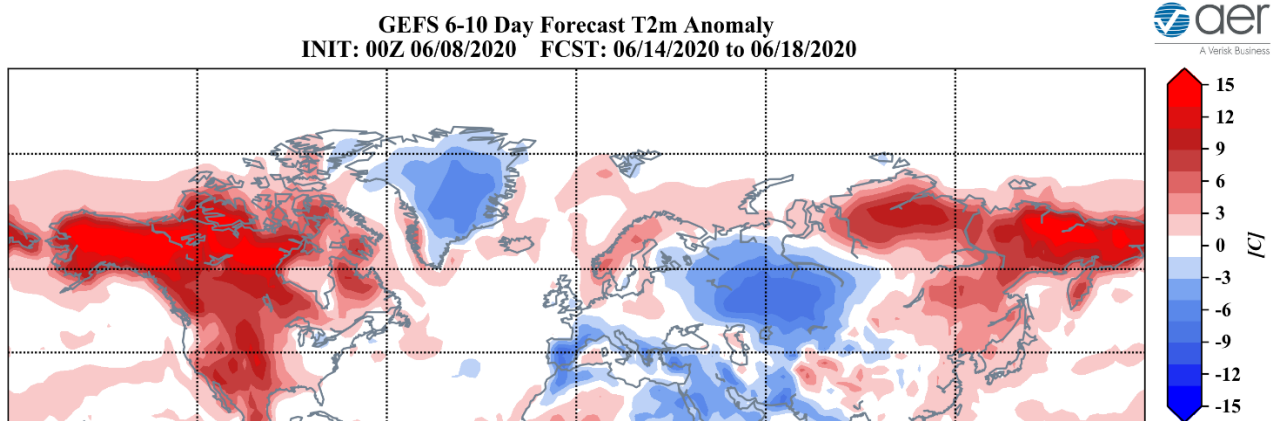


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 14 – 18 June 2020. The forecasts are from the 00Z 8 June 2020 GFS ensemble.

Ridging/positive geopotential height anomalies will strengthen and become more widespread across Alaska and Canada and into the Central US with troughing/negative geopotential height anomalies along the West and East Coasts of the US this period (**Figure 5**). This pattern is predicted to bring widespread normal to above normal temperatures across Alaska, Canada and the Central US with normal to below normal temperatures for US West Coast and the Eastern US (**Figure 6**).

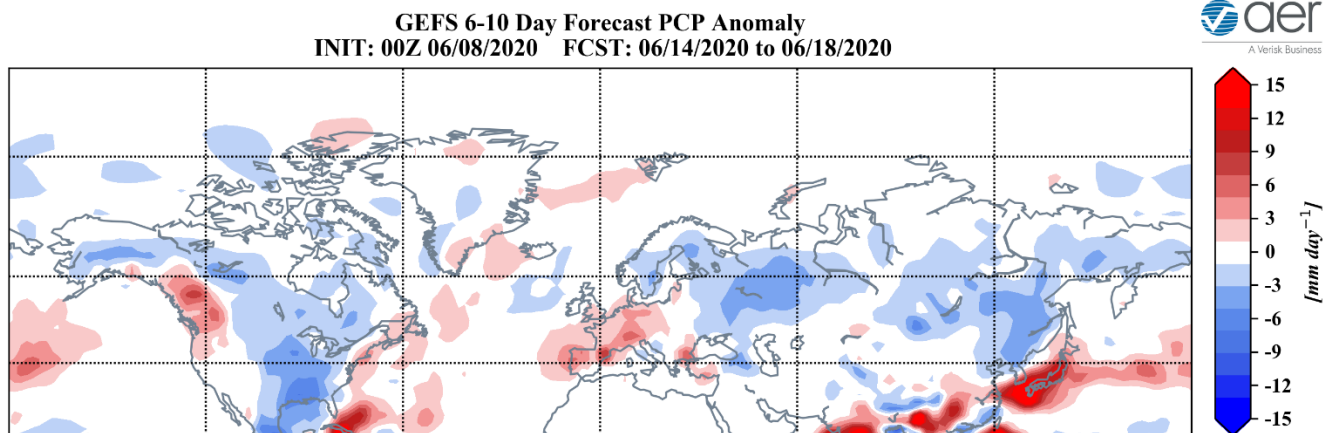


Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 14 – 18 June 2020. The forecasts are from the 00Z 8 June 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia with the exceptions of above normal precipitation in Western and Central Europe and Southeastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America with above normal precipitation predicted for the West Coast of Canada and the Northeastern US into the Canadian Maritimes (**Figure 7**).

11-15 day

With predicted mostly positive geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO is predicted to remain weakly negative this period (**Figure 1**). With weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to be neutral to slightly negative as well.

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
 INIT: 00Z 06/08/2020 FCST: 06/19/2020 to 06/23/2020

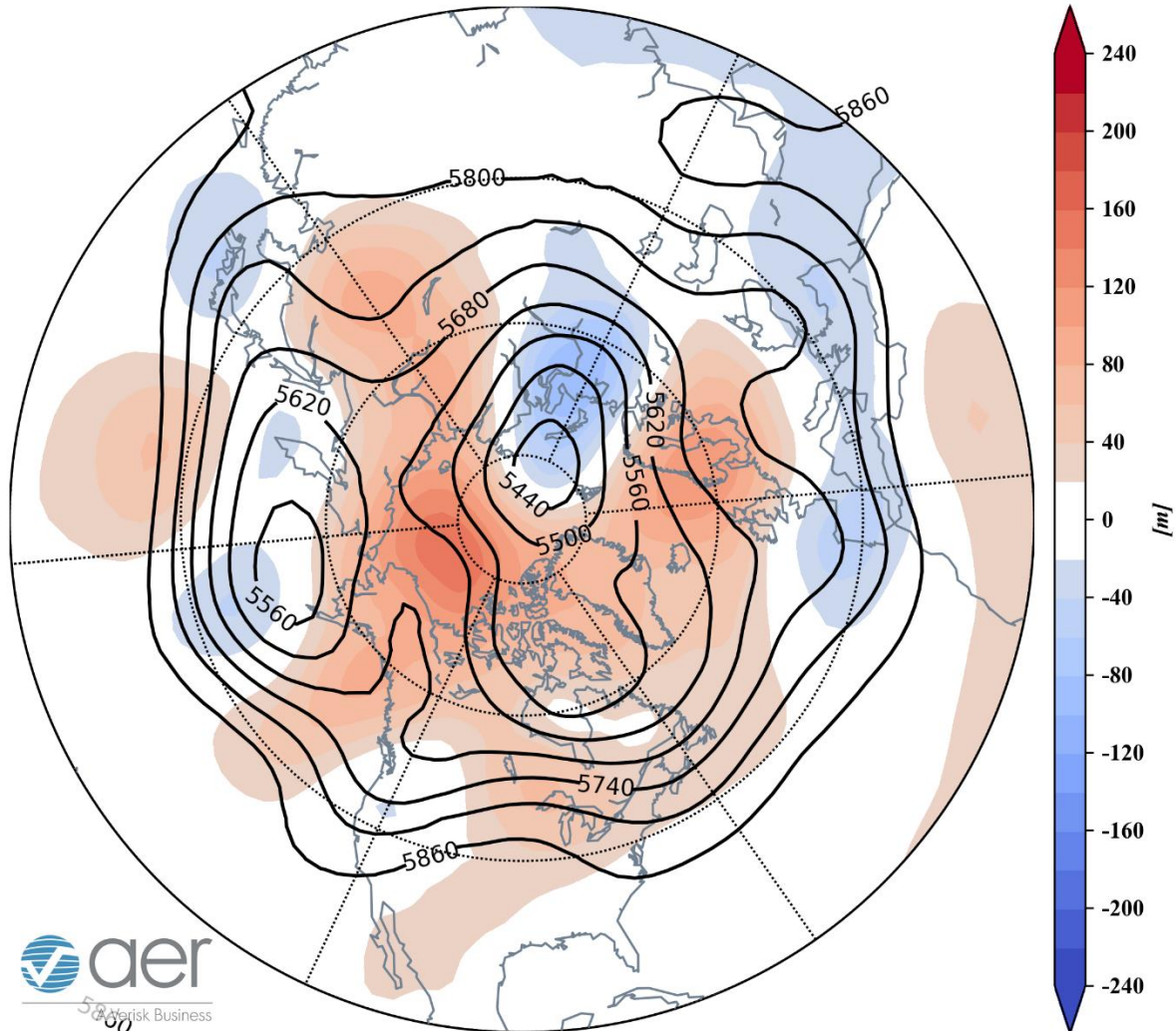


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 19 – 23 June 2020. The forecasts are from the 00z 8 June 2020 GFS ensemble.

Persistent ridging/positive geopotential height anomalies stretching from Greenland across to Northern and Eastern Europe are predicted once again to favor troughing/negative geopotential height anomalies across Western Europe and Southern Europe (**Figures 8**). The forecast is for normal to below normal temperatures across Western and Southern Europe with normal to above normal temperatures across Northern and Eastern Europe including the UK this period (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to become more widespread across East Asia with troughing/negative pressure/geopotential height anomalies in Western Asia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Northern and Eastern Asia with normal to below normal

temperatures in Western Asia (**Figure 9**). Some weak troughing/negative geopotential height anomalies across the Northern India subcontinent will favor normal to below normal temperatures in the region (**Figures 8 and 9**).

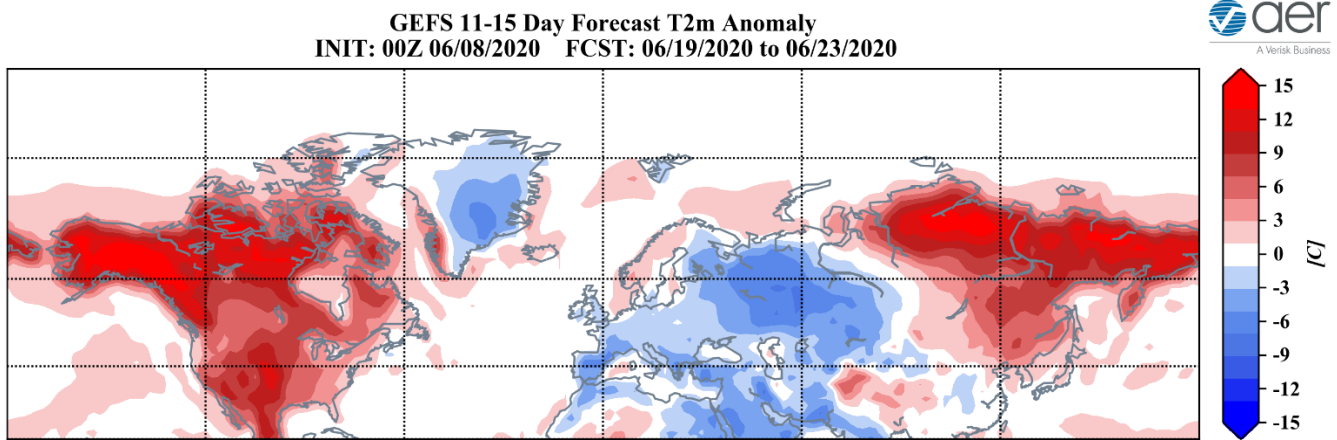


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 19 – 23 June 2020. The forecasts are from the 00z 8 June 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate North America with regional troughing/negative geopotential height anomalies along the US West and East Coasts (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, Canada and the Interior US with normal to below normal temperatures for the US West Coast and the Southeastern US (**Figure 9**).

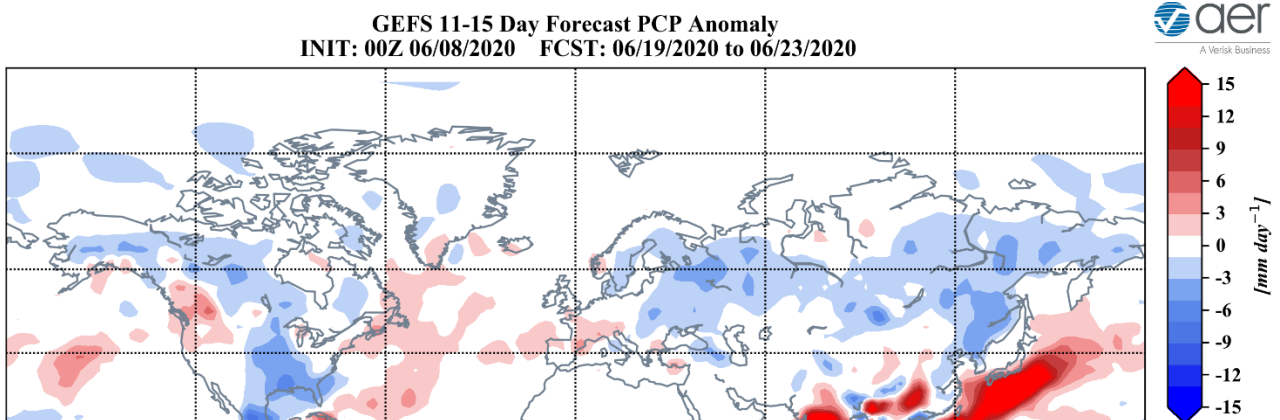


Figure 10. Forecasted precipitation anomalies (mm/day ; shading) from 19 – 23 June 2020. The forecasts are from the 00z 8 June 2020 GFS ensemble.

Normal to below normal precipitation is predicted for much of Eurasia except for normal to above normal precipitation for Southwestern Europe and Southeast Asia

(Figure 10). Normal to below normal precipitation is predicted for much North America except for above normal precipitation in the Pacific Northwest and possibly the Northeastern US into the Canadian Maritimes (Figure 10).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to above normal PCHs in both the troposphere and the stratosphere (Figure 11). However, PCHs in the stratosphere are predicted to reverse to normal to below normal next week while PCHs in the troposphere are predicted to remain mostly positive (Figure 11).

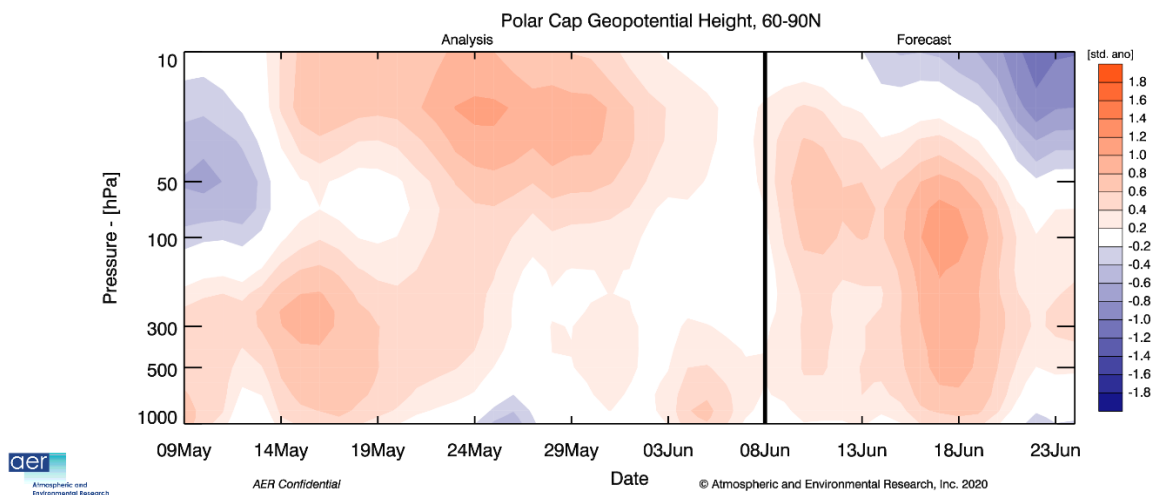


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 8 June 2020 GFS operational run.

The normal to above normal PCHs in the lower troposphere are consistent with the predicted weakly negative AO over the next two weeks (Figure 1). I do believe that the overall below normal sea ice and Arctic warming favor mostly normal to above normal PCHs in the troposphere throughout the summer months, with typical synoptic timescale variability.

CFS 500 hPa Forecast Anomaly Jul 2020
Valid as of 08 Jun 2020

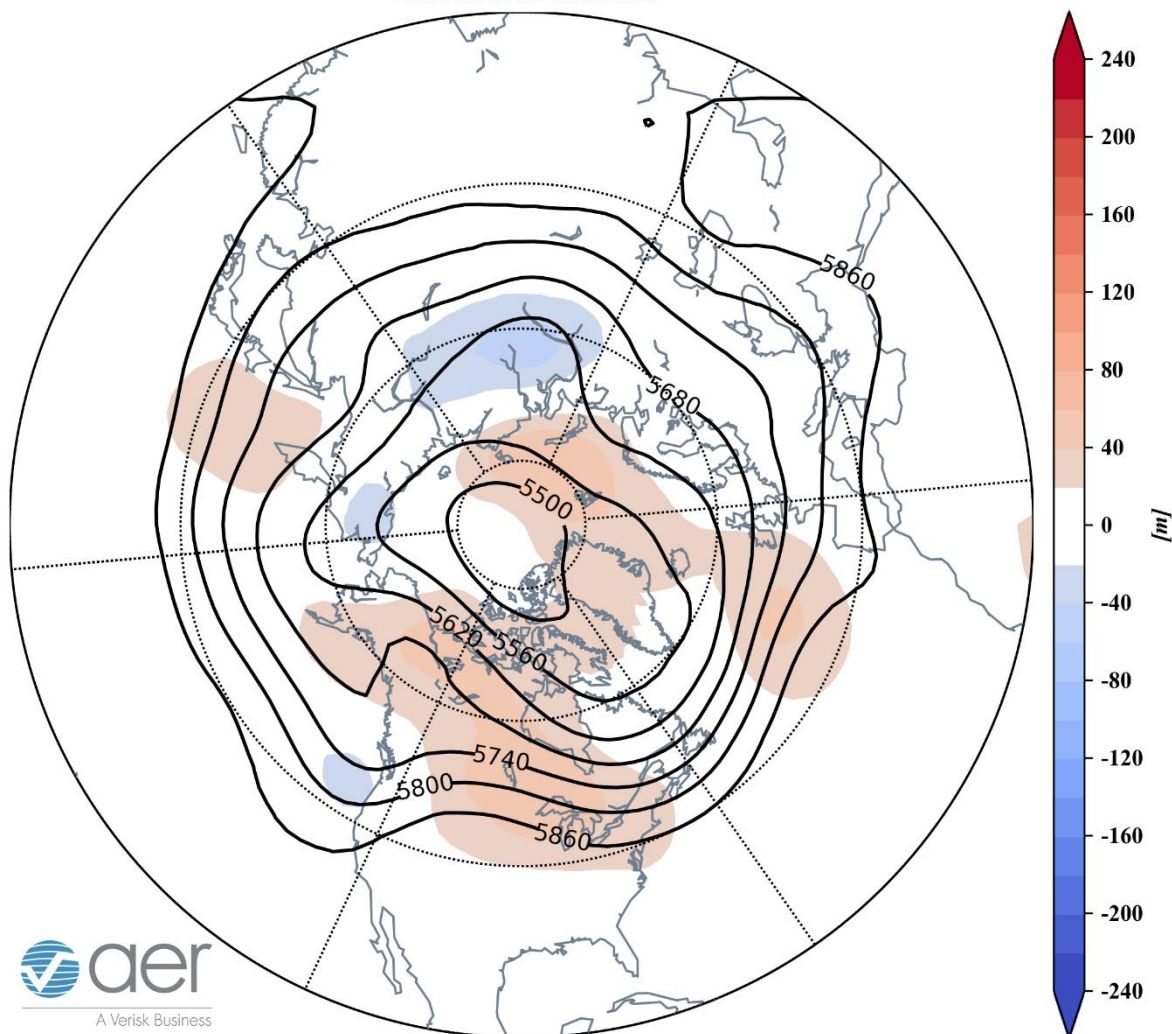


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2020. The forecasts are from the 00Z 8 June 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for July from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Greenland and into the Barents-Kara Seas, East Asia, Alaska and much of Canada with weak troughing in Western and Southern Europe, the Middle East, Western Asia, the Dateline, the US West Coast and Eastern Canada and into the Northeastern US (**Figure 12**). This pattern favors relatively mild temperatures for Northern Europe, much of Northern and Eastern Asia, Alaska Western Canada and much of the US with seasonable to relatively cool temperatures for Southern and Western Europe, Western and Southern Asia, the US West Coast, far Eastern Canada

and possibly New England (**Figure 13**). There is a clear cold bias in the temperature plot across Eurasia and probably a warm bias across North America.

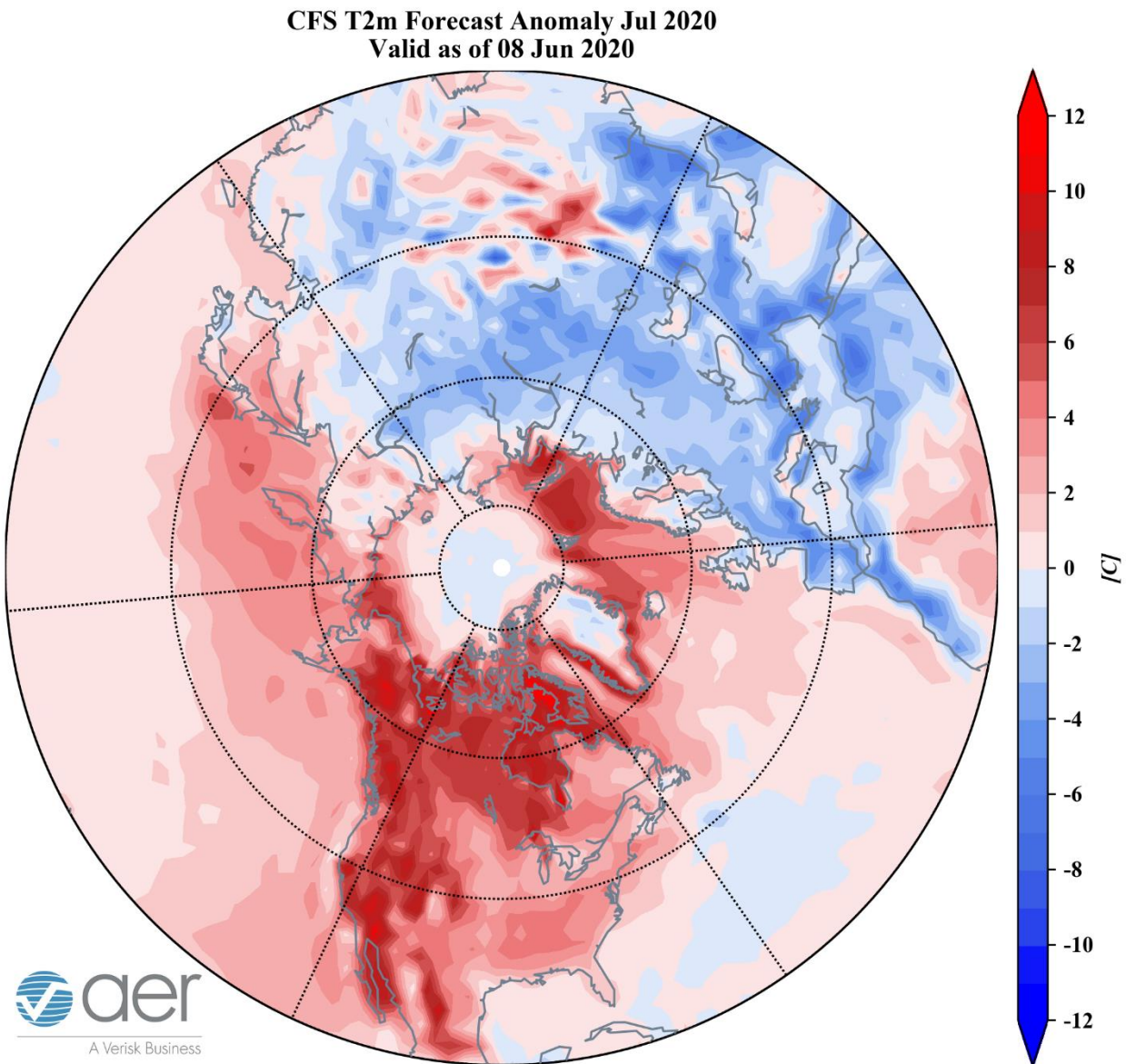


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for July 2020. The forecasts are from the 00Z 8 June 2020 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies continue to cool slowly but neutral El Niño/Southern Oscillation (ENSO) conditions seem most likely this

summer (**Figure 14**) though a La Niña is expected by this winter. Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska and the western North Pacific though below normal SSTs exist regionally especially west of South America and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

SST Anomaly - Week Ending 07 Jun 2020

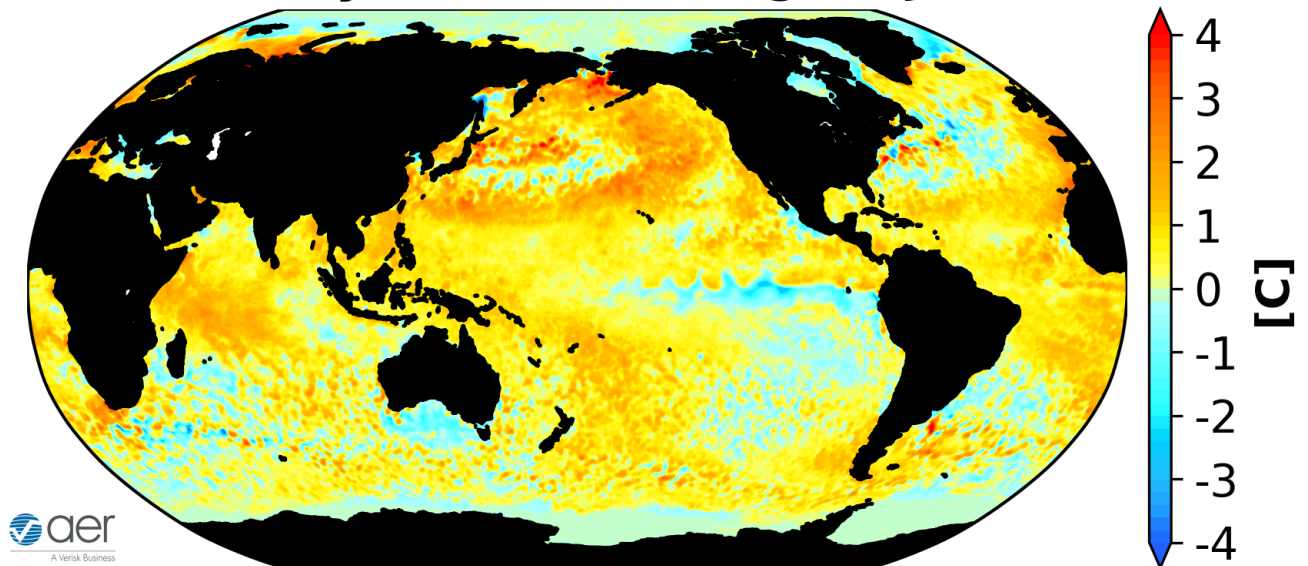


Figure 14. The latest weekly-mean global SST anomalies (ending 7 June 2020 not updated). Data from NOAA OI High-Resolution dataset (not updated).

Currently the Madden Julian Oscillation (MJO) is in phase two (**Figure 15**). The forecasts are for the MJO to stall in phase two. MJO phase two favors ridging across eastern North America and troughing in western North America especially Canada. There is little evidence that the MJO is contributing to the weather patterns across North America in the next two weeks.

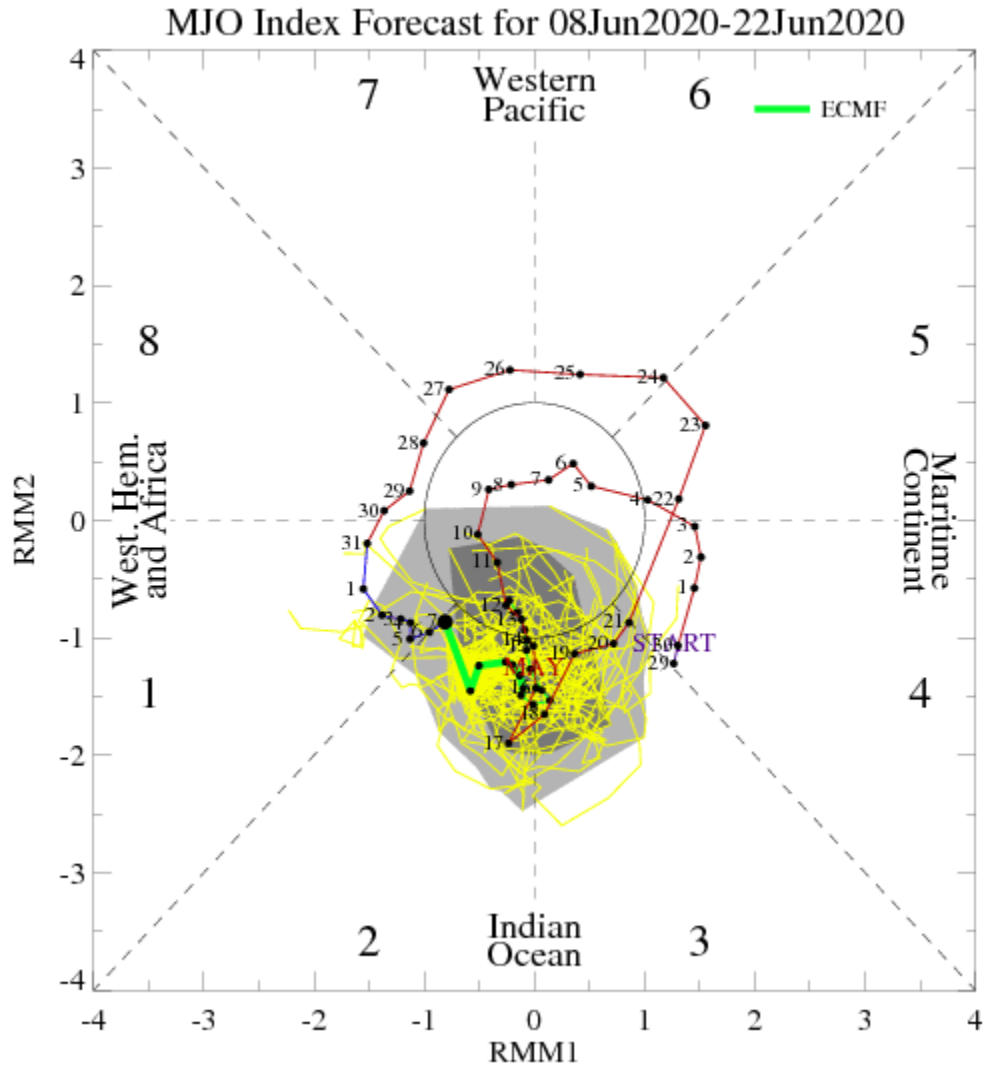


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 25 May 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>