

Arctic Oscillation and Polar Vortex Analysis and Forecasts

June 14, 2021

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) 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 positive over the next two weeks as pressure/geopotential height anomalies in the Central Arctic are predicted to be normal to below normal with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently also neutral and is predicted to remain

neutral to positive over the next two weeks as pressure/geopotential height anomalies are predicted to alternate between normal to negative across Greenland the next two weeks.

- The predicted generally positive NAO and troughing/negative geopotential height anomalies across Greenland favors ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across much of Europe over the next two weeks. Some exceptions are troughing/negative geopotential height anomalies coupled with normal to below temperatures across Southeastern Europe this week and far Western Europe including parts of the United Kingdom (UK) much of the next two weeks.
- Amplifying European ridging/positive geopotential height anomalies will contribute to a quasi-omega block pattern across Asia with troughing/negative geopotential height anomalies coupled with normal to below temperatures in Western and Eastern Asia with ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across Central Asia, especially Western and Central Siberia.
- This general pattern across North America over the next two weeks is ridging/positive geopotential height anomalies coupled with normal to above normal temperatures across the Gulf of Alaska extending into western North America and along the east coast of North America with troughing/negative geopotential height anomalies coupled with normal to below temperatures across central North America. This pattern will favor normal to below temperatures in the Central and Eastern United States (US) with mid-summer heat in the Western US.
- In the Impacts section I discuss how the summer pattern across the Northern Hemisphere (NH) is looking like most recent summers and in contrast to last summer.

Impacts

From the latest GFS forecast of the general circulation across the NH for the remainder of June, it does appear that the circulation pattern will resemble recent summers with last summer being an exception. The general pattern across Eurasia has been characterized by ridging across Europe and East Asia with troughing in Western Russia. Across North America the general pattern has been characterized by ridging across western North America and along the east coast of North America with weak troughing in the interior of the continent. Finally, low pressure has dominated the Central Arctic. This has favored, cloudiness and temperatures close to normal that has slowed the rate of Arctic Sea ice melt. So even though near record low sea ice extent has been observed in recent winters, a new record September Arctic sea ice extent minimum last occurred ten years ago in 2012.

The atmospheric circulation forecast for the next two weeks is also characterized by ridging and warm temperatures across Europe and Siberia with troughing and cooler

temperatures in western Asia. Across North America ridging will dominate both coasts but especially the west coast with troughing across the interior. Positive geopotential heights in the Gulf of Alaska look to be the most anomalous of the NH, forcing impressively deep troughing downstream across Central Canada and the US for a summer month. Finally, relatively low geopotential heights in the Central Arctic are predicted to persist for the foreseeable future. This is favorable for clouds and cool temperatures that would slow Arctic sea ice melt. And in fact, a [Tweet from @AlaskaWx](#) (Rick Thoman) shows sea ice melt in the North Pacific sector is near normal in sharp contrast to recent years where rapid sea ice melt has been the norm. Looking at the most recent sea ice extent from NSIDC in **Figure i** shows that Arctic sea ice extent is close to normal across the Arctic basin with the notable exception of the Barents-Kara Seas (though open water has developed in the Laptev Sea that is normally ice covered). If the current circulation in the Central Arctic persists into and for much of July a new record low sea ice minimum is highly unlikely this September even though sea ice is relatively thin and is highly vulnerable to rapid melt.

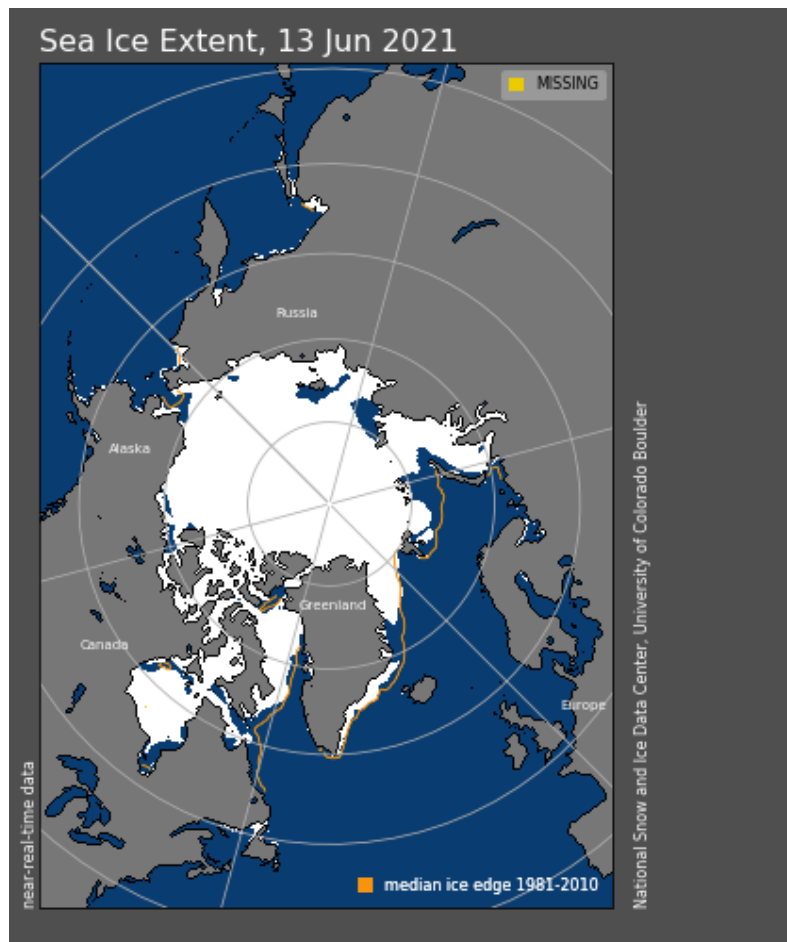


Figure i. Observed Arctic sea ice extent on 13 June 2021 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC).

Last summer was an exception to recent summers when strong ridging and record warm temperatures in Siberia last June slid into the Central Arctic in July leading to high pressure over the Central Arctic and rapid sea ice melt.

Now that the upcoming circulation pattern matches many recent summers, I think the “trend is your friend” could be a good rule of thumb. The predicted pattern seems like a relatively stable one and could persist for a while. There is large natural variability in the system, and anything is still possible this summer, but I would consider a repeat of last summer where a large positive geopotential height anomaly center pushes bodily into the Central Arctic less likely.

1-5 day

The AO is predicted to be mostly positive this period (**Figure 1**) as geopotential height anomalies are predicted to be mostly negative in the Central Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with negative geopotential height anomalies predicted across Greenland (**Figure 2**), the NAO is predicted to also be neutral to positive this period.

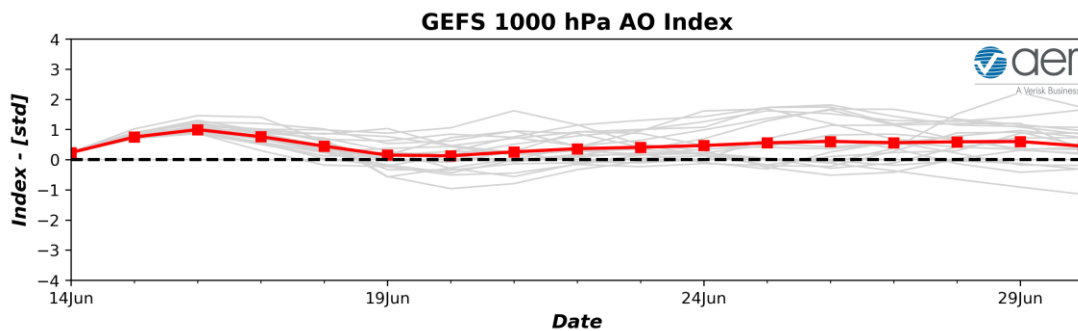
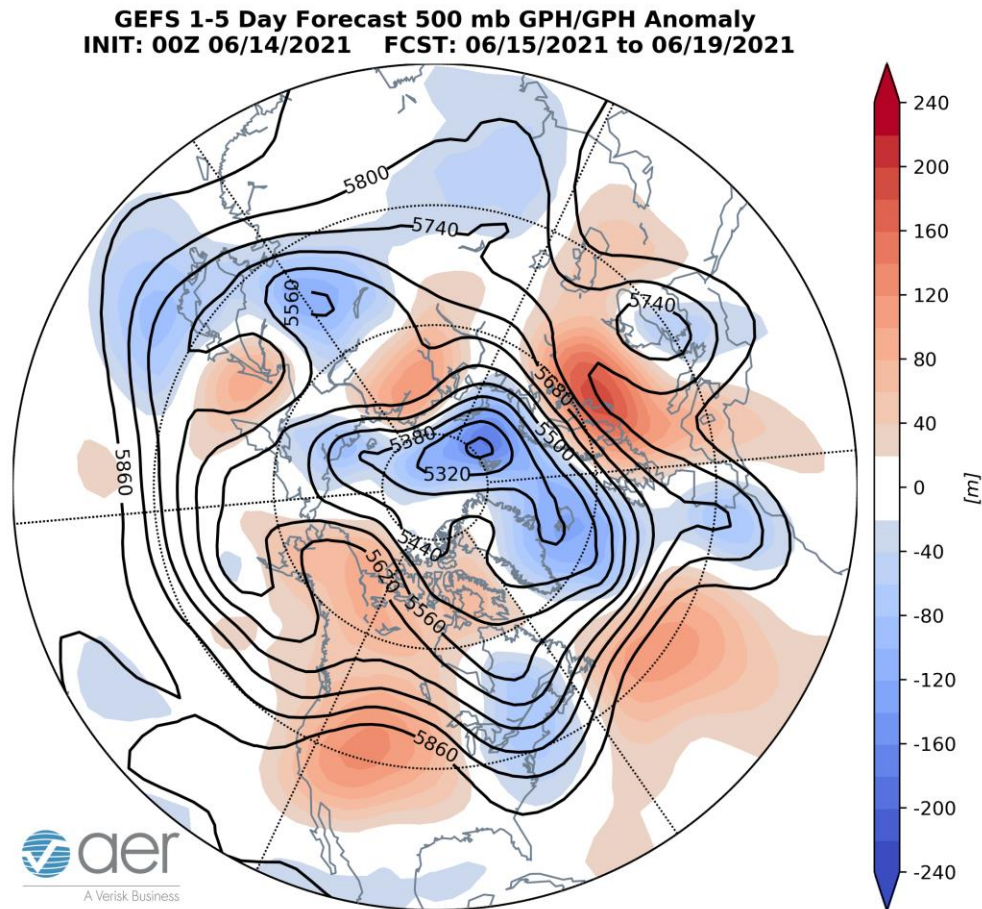


Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 14 June 2021 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies across Greenland are predicted to force ridging/positive geopotential height anomalies across much of Europe especially across Northern Europe with the exceptions of troughing/negative geopotential height anomalies across Southeastern and far Western Europe (**Figures 2**). This will favor normal to above normal temperatures across much of Europe especially Central Europe with normal to below normal temperatures across Southeastern and far Western Europe including the UK (**Figure 3**). The general pattern across Asia this period is ridging/positive geopotential height anomalies across Western Asia especially Western Siberia with troughing/negative geopotential height anomalies in East Asia (**Figure 2**). This pattern favors normal to above normal temperatures across Western

and into Central Asia but especially Western Siberia with normal to below normal temperatures in East Asia (**Figure 3**).



Widespread ridging/positive geopotential height anomalies are predicted across western North America and much of Canada with troughing/negative geopotential height anomalies mostly confined to Southeastern Canada and the Eastern US (**Figure 2**). This pattern is predicted to bring normal to above normal temperatures across much of Canada and the Western US with normal to below normal temperatures across Southeastern Canada and the Eastern US (**Figure 3**).

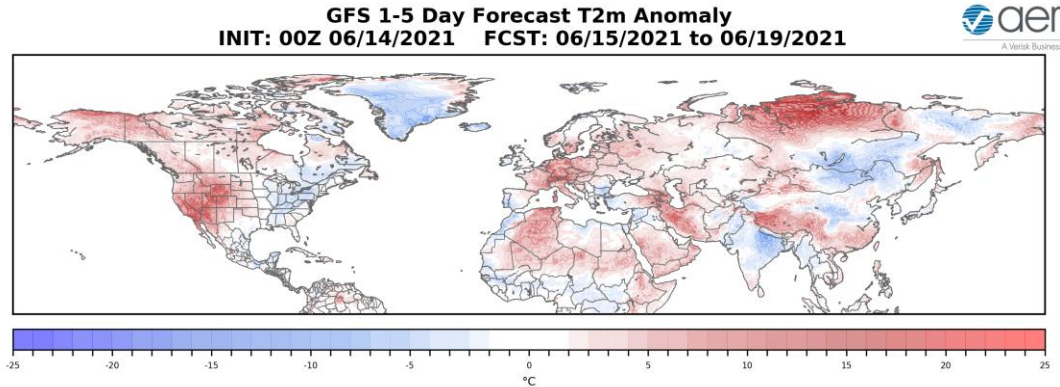


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 15 – 19 June 2021. The forecast is from the 00Z 14 June 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation across Western Europe, Scandinavia, Northwest Russia, Southern and Eastern Asia (**Figure 4**). Normal to below normal precipitation is predicted for much of North America with the exceptions of normal to above normal precipitation in Southeastern Alaska, Western Canada, the eastern Gulf of Mexico, New England and the Canadian Maritimes (**Figure 4**).

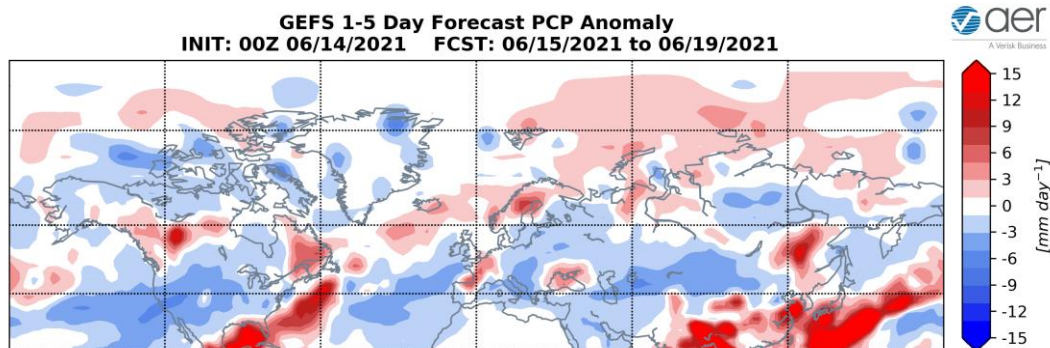


Figure 4. Forecasted precipitation anomalies (mm/day; shading) from 15 – 19 June 2021. The forecast is from the 00Z 14 June 2021 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to still remain neutral to positive this period (**Figure 1**) as geopotential height anomalies remain normal to below normal across the Central Arctic

with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with normal to below normal geopotential height anomalies predicted across Greenland (**Figure 5**), the NAO is predicted to remain neutral to positive this period.

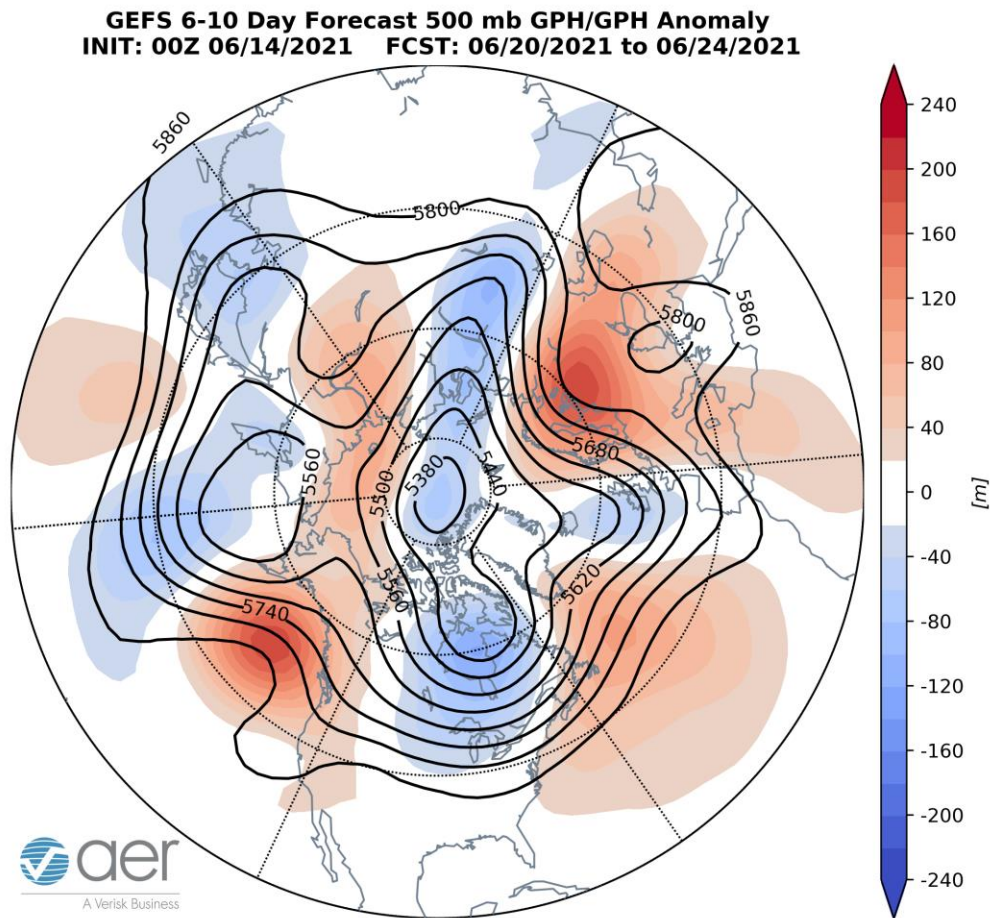


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 20 – 24 June 2021. The forecasts are from the 00z 14 June 2021 GFS ensemble.

General troughing/negative geopotential height anomalies across Greenland into the northern North Atlantic will contribute to strengthening ridging/positive geopotential height anomalies across Europe especially Northern Europe with the exceptions of residual troughing/negative geopotential height anomalies across Southeastern Europe and across far Western Europe (**Figures 5**). This will favor normal to above normal temperatures across much of Europe with normal to below normal temperatures confined across far Western Europe including the UK (**Figure 6**). Strengthening ridging/positive geopotential height anomalies will contribute to deepening troughing/negative geopotential height anomalies in Western Russia with ridging/positive geopotential height anomalies in Central Asia with residual troughing/negative geopotential height anomalies in East Asia (**Figure 5**). This pattern

favors normal to above normal temperatures across much of Central Asia especially Central Siberia with normal to below normal temperatures in Western Asia and Northeast Asia (**Figure 6**).

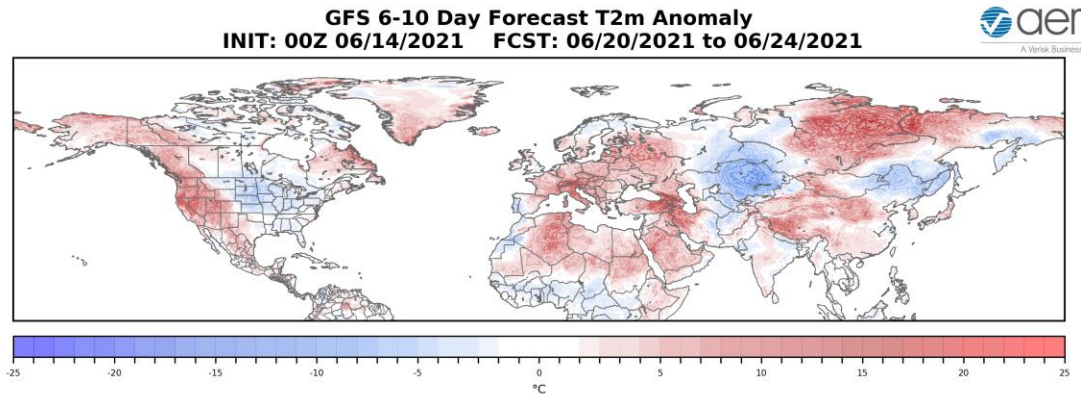


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 20 – 24 June 2021. The forecasts are from the 00Z 14 June 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to become more focused in the Gulf of Alaska and extending into western North America helping to deepen troughing/negative geopotential height anomalies in central North America (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across much of Western Canada, the Canadian Maritimes and the Western US with normal to below normal temperatures across Central Canada, the Central and much of the Eastern US (**Figure 6**).

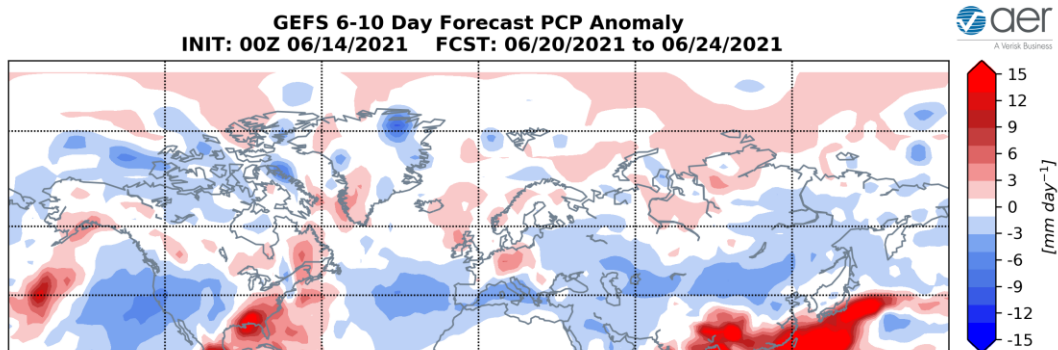


Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 20 – 24 June 2021. The forecasts are from the 00Z 14 June 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation in Central Europe and Southeast Asia (**Figure 7**). Normal to

below normal precipitation is predicted for much of North America except for normal to above normal precipitation in Southern Alaska and the Eastern US (**Figure 7**).

11-15 day

With persistent normal to below normal geopotential height anomalies across the Central Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO should remain neutral to possibly positive this period (**Figure 1**). With possibly weak negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to remain neutral to positive this period as well.

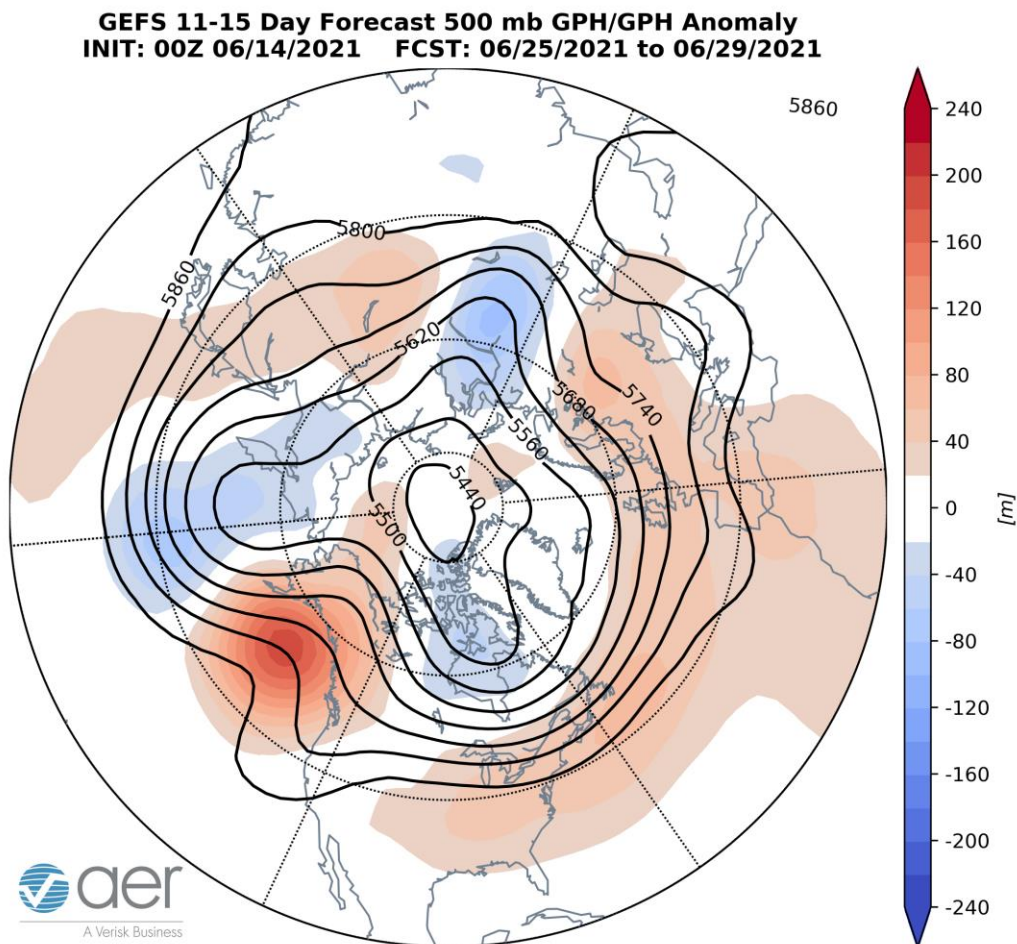


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 25 – 29 June 2021. The forecasts are from the 00z 14 June 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate Europe with the exception of residual weak troughing/negative geopotential height anomalies in Southeastern Europe (**Figure 8**). This pattern favors normal to above

normal temperatures across much of Europe Including the UK with the possible exception of normal to below normal temperatures confined to northern Scandinavia where geopotential heights are predicted to be closer to normal (**Figures 9**). Predicted European ridging/positive geopotential height anomalies will help anchor troughing/negative geopotential height anomalies in Western Asia, with ridging/positive geopotential height anomalies in much of Central and Eastern Asia with more troughing/negative geopotential height anomalies in Eastern Siberia this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia but with regional normal to below normal temperatures across parts of Western Asia, Eastern Siberia and East Asia (**Figure 9**).

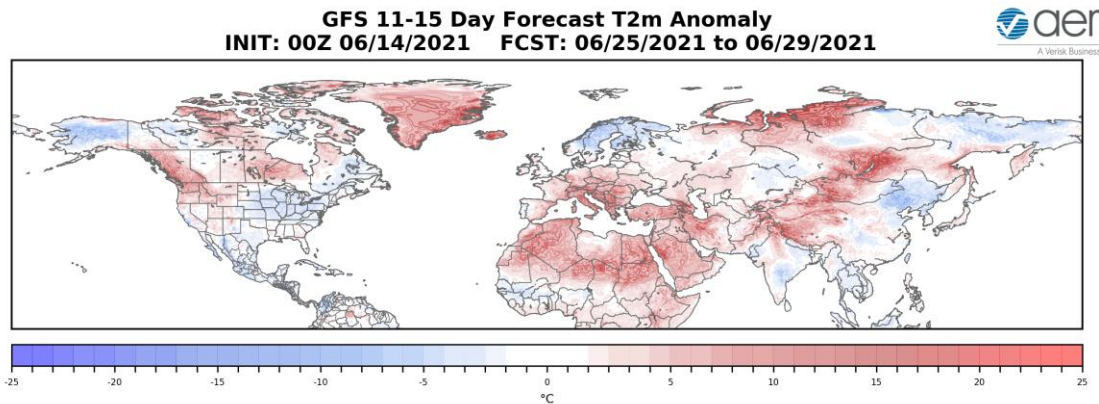


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 25 – 29 June 2021. The forecasts are from the 00z 14 June 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist in the Gulf of Alaska extending into western North America with troughing/negative geopotential height in Central Canada with more ridging/positive geopotential height anomalies in the Eastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures for Western and Eastern Canada and the Western US with normal to below normal temperatures across Western Alaska, Central Canada and the Central US, possibly into parts of the Eastern US (**Figure 9**).

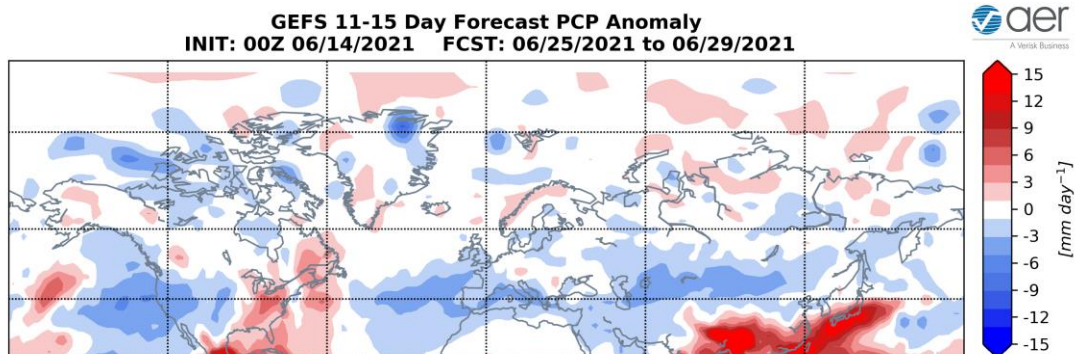


Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 25 – 29 June 2021. The forecasts are from the 00z 14 June 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia except for above normal precipitation in Norway and Southeast Asia (**Figure 10**). Normal to below normal precipitation is predicted for much of North America except for normal to above normal precipitation in the Great Lakes, the Eastern US and the Canadian Maritimes (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs in the upper stratosphere and near the surface with warm/positive PCHs in the mid to low stratosphere (**Figure 11**). However, starting later this week the warm/positive PCHs in the stratosphere are predicted to descend into the upper troposphere (**Figure 11**).

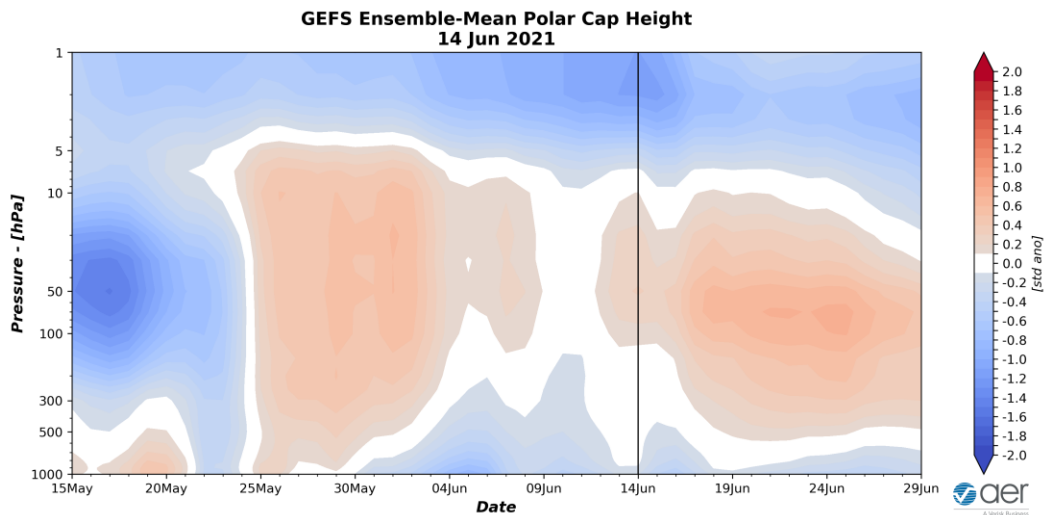


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 14 June 2021 GFS ensemble.

The overall predicted cold/negative PCHs in the lower troposphere are consistent with the predicted positive bias in the surface AO predicted for next two weeks (**Figure 1**). From now through the end of June, the warm/positive PCHs in the upper to mid troposphere are not predicted to extend to the surface (**Figure 1**).

**CFS 500 hPa Forecast Anomaly Jul 2021
Valid as of 14 Jun 2021**

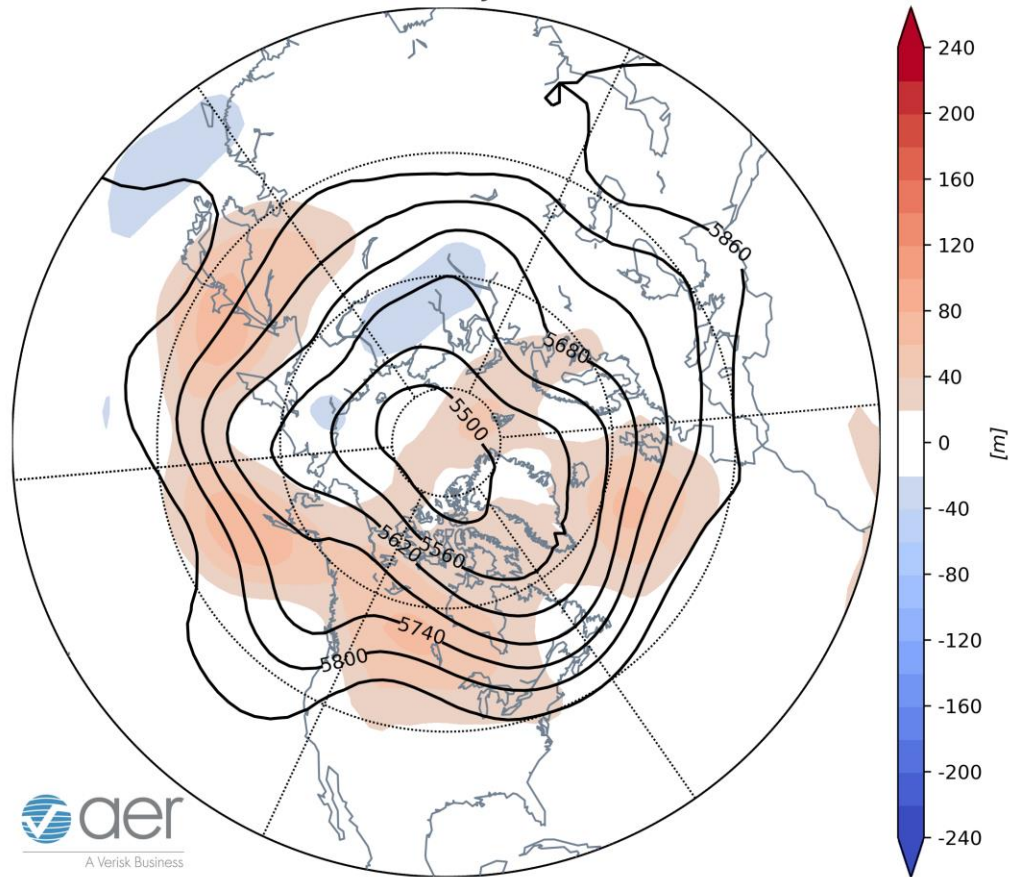


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2021. The forecasts are from the 00Z 14 June 2021 CFS.

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 in the northern North Atlantic, Western Asia, Eastern Asia, near the Aleutians and the interior of North America with troughing in Europe, Western Siberia, near the Dateline and just off the US West Coast (**Figure 12**). This pattern favors seasonable to relatively cool temperatures for Europe, Central and Eastern Siberia, Central Canada and the Central US with seasonable to relatively warm temperatures for much of Asia, Alaska, Western and Eastern Canada and the Central US (**Figure 13**). I am skeptical of the most recent CFS forecast.

CFS 17-47 Day Forecast T2m Anomaly
INIT: 00Z 06/14/2021 FCST: 07/01/2021 to 07/31/2021

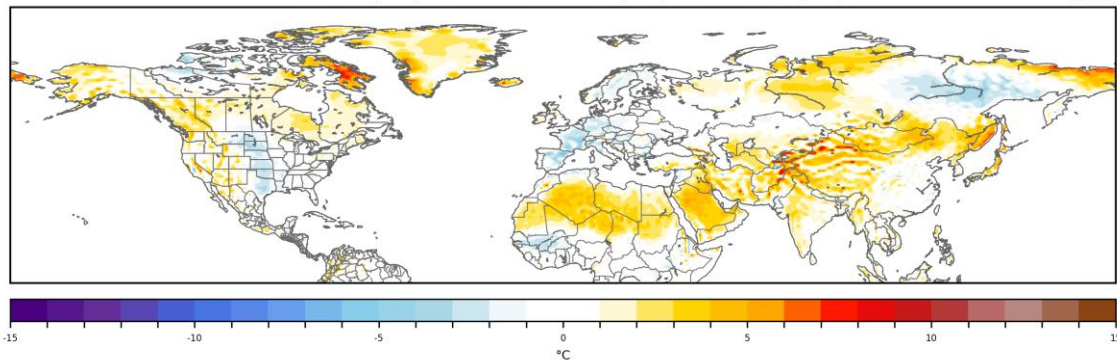


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for July 2021. The forecasts are from the 00Z 14 June 2021 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain negative and we continue to observe neutral conditions (**Figure 14**) and neutral conditions are expected through the summer. Observed SSTs across the NH remain well above normal especially in the Gulf of Alaska, the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the Southern Hemisphere and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

SST Anomaly - Week Ending 13 Jun 2021

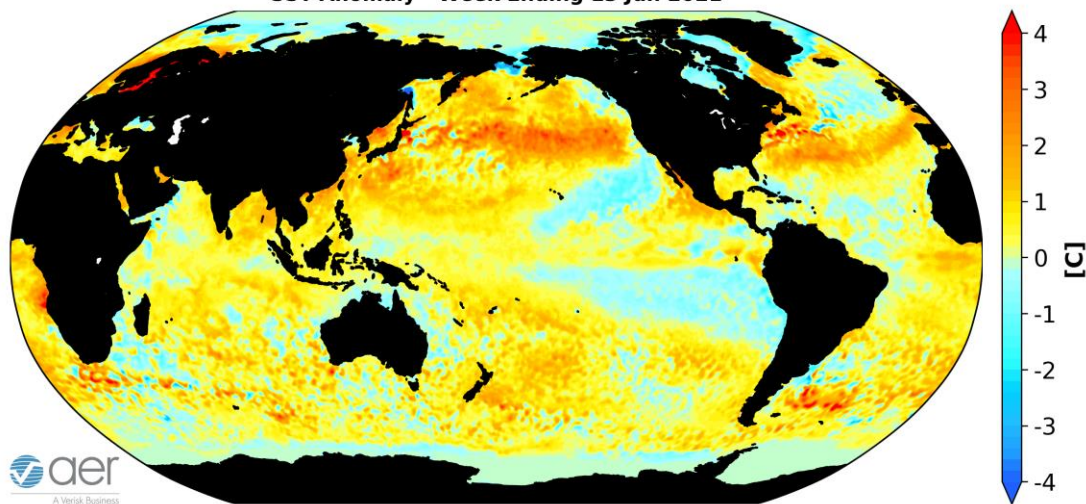


Figure 14. The latest weekly-mean global SST anomalies (ending 13 June 2021). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is in phase one (**Figure 15**). The forecasts are for the MJO to quickly transition to phase two and then weaken to where no phase is favored before once again emerging in phase one. However overall the MJO is predicted to remain weak. MJO phase one initially favors ridging across Eastern Canada and the Eastern US but then eventually favors ridging in western North America and troughing in central North America. Therefore it is possible that the MJO is contributing weakly to the predicted weather pattern across North America but admittedly this is outside of my expertise.

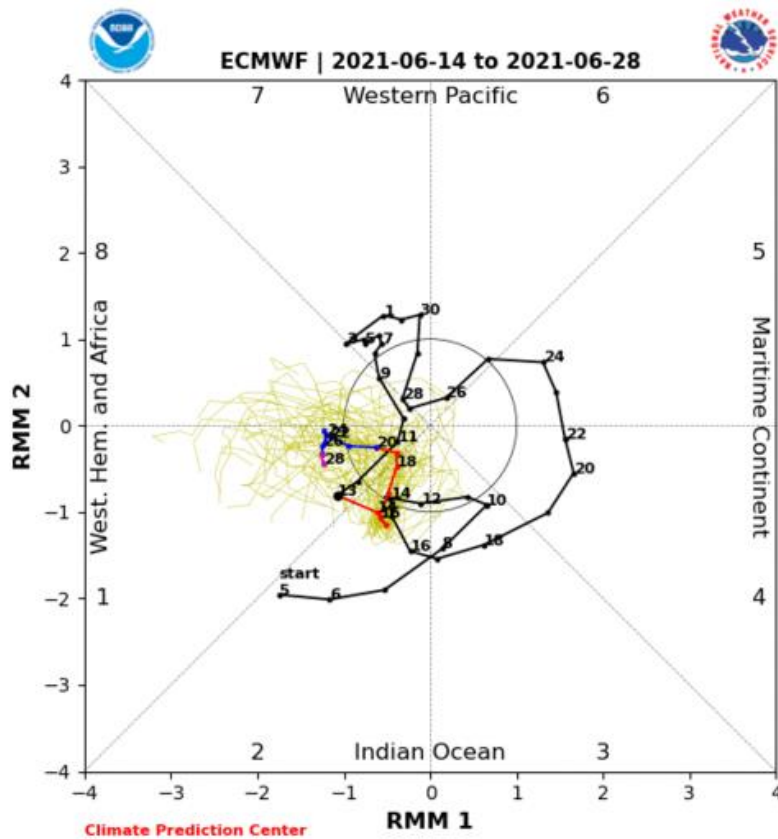


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 14 June 2021 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>

