

Arctic Oscillation and Polar Vortex Analysis and Forecasts

June 20, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Wednesday through the winter season.

For those who would like an early look on Mondays, we will be offering at a nominal price (US \$50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

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.

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. 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.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to trend positive the next two weeks and remaining positive to neutral as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to remain mostly negative to mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently positive and is predicted to remain positive the next two weeks as pressure/geopotential height anomalies will remain mostly negative across Greenland.
- Over the next two weeks predicted persistent troughing/negative geopotential height anomalies across Greenland will anchor ridging/positive geopotential height anomalies across Europe with the exception of troughing/negative geopotential height anomalies across Southeastern Europe next week. This pattern favors the next two weeks normal to above normal temperatures across much of Europe including the United Kingdom (UK) with the exception of normal to below normal temperatures across Southeastern Europe next week.
- The next two weeks the general predicted pattern across Asia is troughing/negative geopotential height anomalies Northwestern Asia with ridging/positive geopotential height anomalies in Northeastern and Southern Asia. This pattern favors normal to above normal temperatures widespread across much of East Asia and Southern Asia with normal to below normal temperatures across Western Asia but mostly focused in Western Russia.
- The general predicted pattern predicted across North America the next two weeks is ridging/positive geopotential height anomalies across Canada with troughing/negative geopotential height anomalies across Alaska, the Southwestern and the Southeastern United States (US). This pattern generally favors normal to above normal temperatures for much of Canada and building in the Central US with normal to below normal temperatures across Alaska, the Southwestern and Southeastern US
- In the Impacts section I discuss the predicted pattern change in the atmospheric circulation across the Northern Hemisphere (NH) and the implications for the remainder of the summer.
- **Through mid-September I have extended international travel planned and I also hope to post one to two more winter summaries, which will likely result in disruptions to blog postings for the remainder of the summer.**

Plain Language Summary

The model forecasts are signaling a change in the atmospheric circulation moving from a cooler pattern for much of the US and Eastern Europe to a warmer pattern (e.g., see **Figures 1 and 9**). I think it is likely that Europe will experience another hot summer.

Impacts

In early June, I highlighted this strange atmospheric feature that suggested stratosphere-troposphere coupling where warm/positive polar cap geopotential height anomalies (PCHs) seems to be propagating down from the stratosphere to the surface

and forcing a negative AO (see tweet from [1 June 2023](#)). I don't have any good explanation for what physically was happening, but it did seem to result in some unusual weather patterns across the Northern Hemisphere (NH), especially compared to recent summers.

In **Figure i**, I post the NH surface temperature anomalies for the summer so far, and I think especially for North America, it has been unusually cool. Much of the US including Alaska have had a relatively cool summer. In contrast, it has been very warm relative to normal in Canada, which has contributed to a record early fire season so far. Also, it has been cool in Eastern Europe and in East Asia, different than most recent summers. But it has been relatively warm in Northern and Western Europe and the above normal temperatures are predicted to expand across much of Europe in the coming weeks (see **Figures 3** and **6**). Similarly, relatively warm temperatures are predicted to become more widespread across East Asia (see **Figures 3** and **9**). It has also been relatively cool in Western Russia so far. But this is close to the region where summers have been more seasonable recently and that trend is predicted to continue.

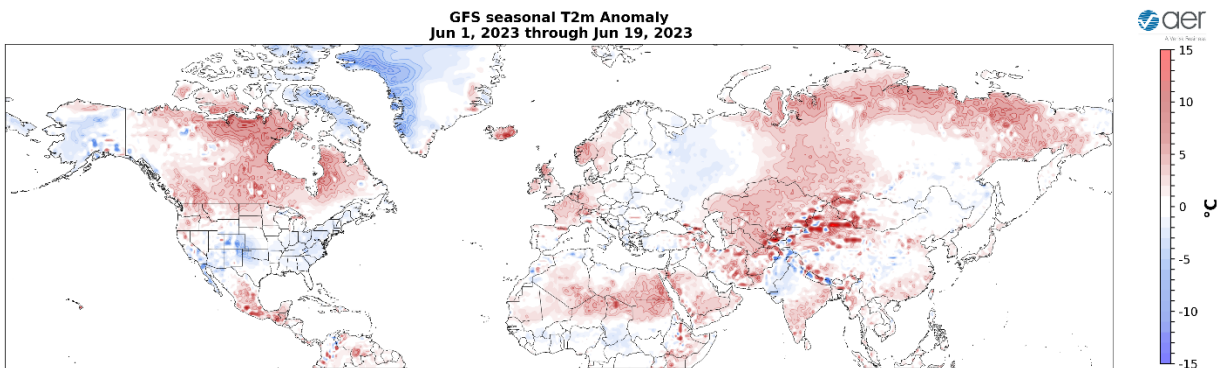


Figure i. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere from 1 – 19 June from the initialized GFS ensemble.

But from **Figures 1** and **11**, it does seem that the real or apparent stratosphere-troposphere coupling including the warm/positive lower tropospheric PCHs and negative AO is over. The biggest implication of the pattern transition seems to be a gradual return a NH surface temperature pattern more similar to previous summers with the regions of cool or more seasonable temperatures mostly limited to near the Urals and the Central US rather than the US East Coast and Eastern Europe respectively. Warmer temperatures are predicted for the Eastern US, Europe and East Asia, at least more so than what has been observed in the first three weeks of June. I know that I have sounded like a broken record about this, but the summer warming trends across Europe seem incredible to and overall, it is looking more and more likely that a good portion, maybe not all, of Europe will again experience above normal and even well above normal temperatures this summer.

For what it's worth it does seem that the CFS is predicting a circulation and temperature pattern more reminiscent of past summers. I posted the CFS forecast for July below but I include here the monthly 500 hPa geopotential heights (**Figure ii**) and surface temperatures forecasts for August (**Figure iii**) from the latest CFS. In general, both the July and August mid-tropospheric circulation patterns show a dominant low pressure centered near the North Pole surrounded by positive height anomalies or ridging along the northern edges of the continents (August less so but also a lower confidence forecast). This should favor widespread above normal temperatures across the NH continents skewed towards higher latitudes with the best chance of below normal temperatures in the US Plains and near the Urals.

CFS 500 hPa Forecast Anomaly Aug 2023
Valid as of 20 Jun 2023

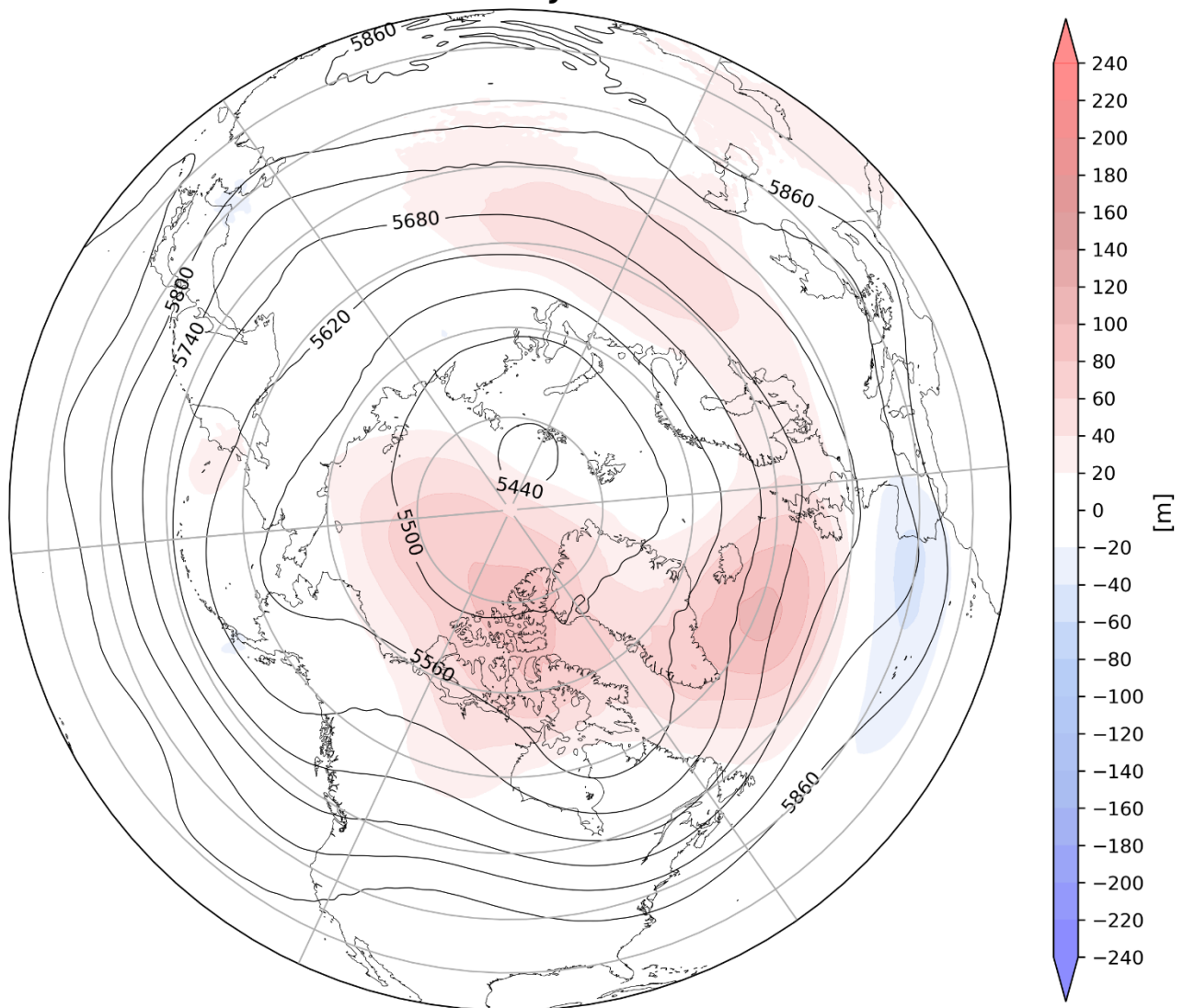


Figure ii. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2023. The forecasts are from the 00Z 20 June 2023 CFS.

Intense heat is ongoing and predicted for Texas, at least in the short term. It is also very dry in the Plains but especially the Central Plains. The forecast is for drought to improve in the Plains but there is always the potential for heat and dry soil to reinforce each other to favor a hot, dry summer in at least part of the region. This doesn't seem to be predicted by the models, but the situation could change quickly.

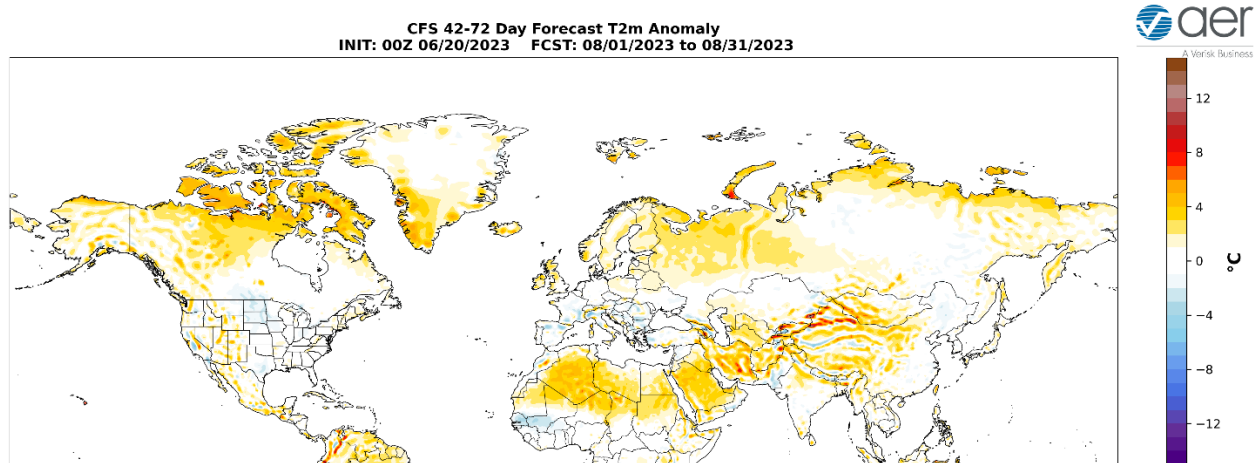


Figure iii. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for August 2023. The forecasts are from the 00Z 20 June 2023 CFS.

So far Arctic sea ice melt during the spring and early summer of 2023 has been relatively moderate. Still monitoring the possibility of the migration of higher geopotential heights into the Central Arctic that could result in an acceleration of Arctic sea ice melt. But the probability of a new Arctic sea ice extent record minimum is decreasing. Of course, regardless, sea ice thickness remains relatively thin.

Thursday Update

Mark Twain famously quipped when a reporter inquired about his death, “Just say the report of my death has been grossly exaggerated.” That is how I feel about declaring the end of the “stratosphere-troposphere” coupling that has resulted warm/positive lower tropospheric PCHs and high latitude blocking. I did intend to include in Monday’s blog, but then neglected to do so, that I expect the impacts including on surface temperatures of the warm/positive tropospheric PCHs to linger even once the warm/positive PCHs reversed to cold/negative. But today’s forecast is even more emphatic than what I was considering on Monday.

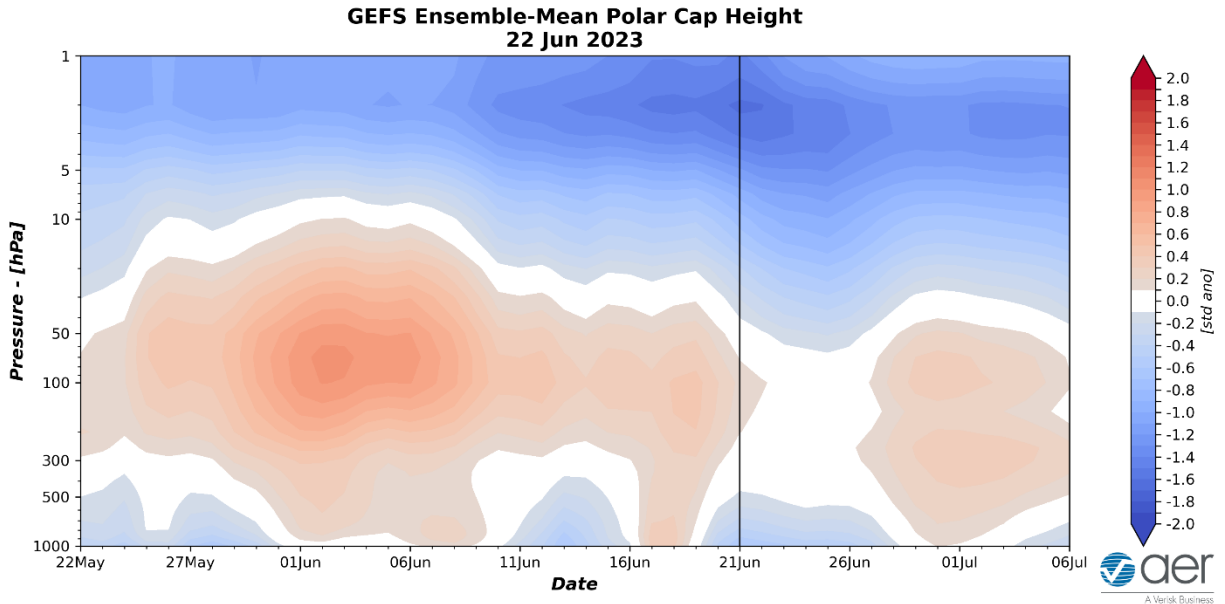


Figure iv. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 22 June 2023 GFS ensemble.

Today’s forecast of PCHs resurrects warm/positive tropospheric PCHs that appears to be related to “stratosphere-troposphere” coupling that favors high latitude blocking (see **Figure iv**). It is a common deficiency of the weather models to weaken and predict the disappearance of high latitude blocking in winter and I guess the same can be said of summer. The GFS forecast shows high latitude blocking extending from Northern Canada, across northern Greenland and over to Northern Scandinavia (see **Figure v**). This helps to support troughing both over the Eastern US and Northern

Europe.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 06/22/2023 FCST: 06/28/2023 to 07/02/2023

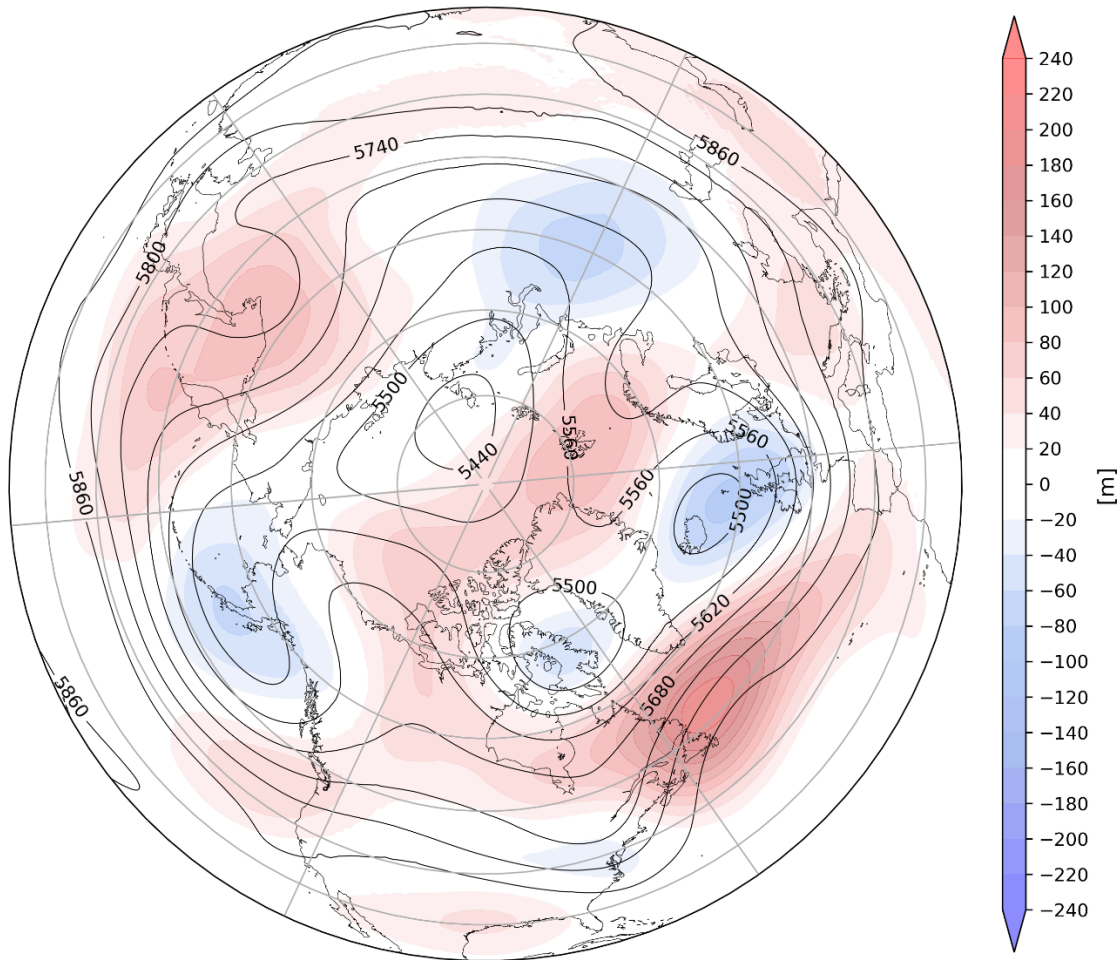


Figure v. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 June – 2 July 2023. The forecasts are from the 00z 22 June 2023 GFS ensemble.

This mid-tropospheric pattern supports cooler temperatures in the Eastern US (mostly west of the Appalachians) and even Northern Europe (see **Figure vi**). Seems to me the models are struggling with the forecast so I would consider the forecast to be of low confidence. And the trends established in June could linger into early July and possibly longer.

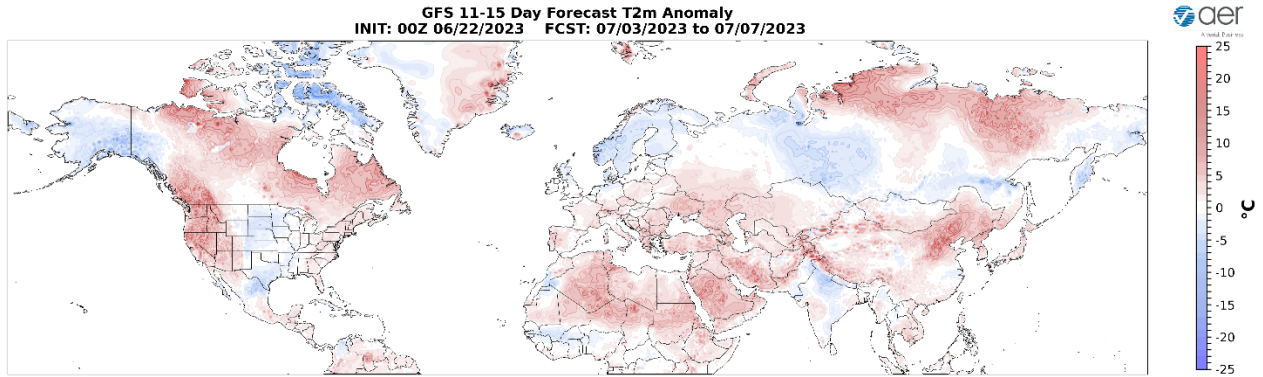


Figure vi. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 July 2023. The forecast is from the 00Z 22 June 2023 GFS ensemble.

Near-Term

0-1 week

The AO is predicted to be positive this week (**Figure 1**) with mostly negative geopotential height anomalies across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). With mostly negative geopotential height anomalies across Greenland (**Figure 2**), the NAO is predicted to be positive this period as well.

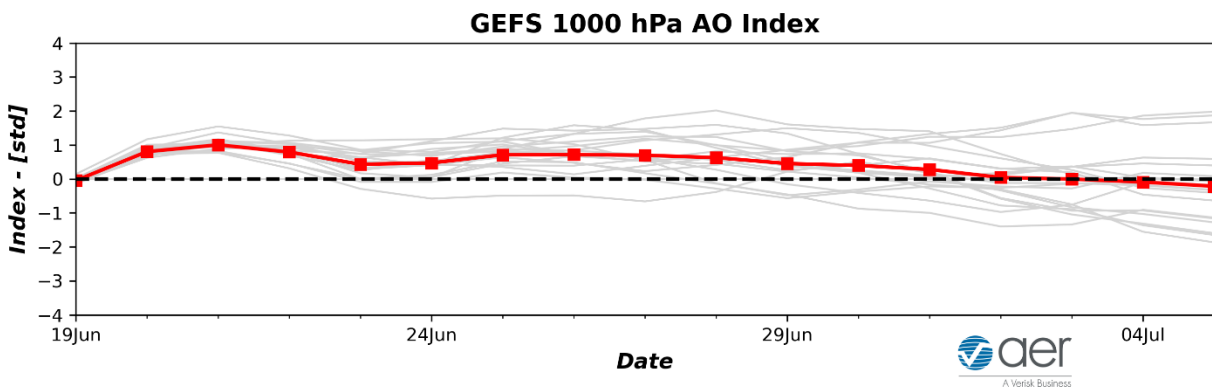


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 20 June 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies strung across Greenland will force ridging/positive geopotential height anomalies across Europe centered over the Baltic Sea (**Figures 2**). This pattern favors normal to above normal temperatures widespread across Europe including the UK (**Figure 3**). The predicted pattern this week is deep troughing/negative geopotential height anomalies in Northwest Asia and much weaker

troughing in Northeast Asia with ridging/positive geopotential height anomalies across much of Southern and Eastern Asia (**Figure 2**). This pattern favors normal to above normal temperatures across Southern and most of Eastern Asia with normal to below normal temperatures across Western Asia but especially across Western Russia and in parts of Northeast China and Southeast Siberia (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 06/20/2023 FCST: 06/21/2023 to 06/25/2023

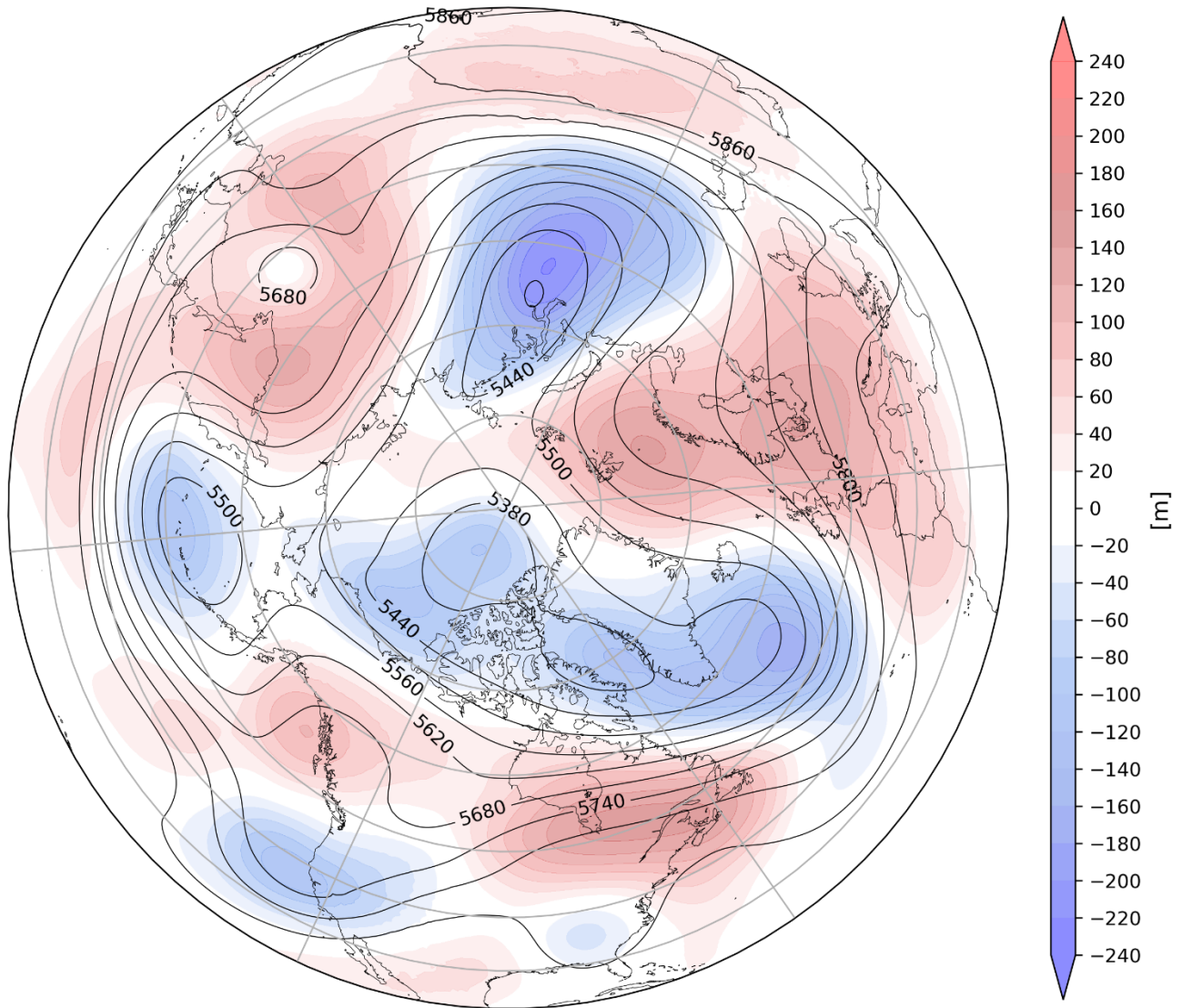


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 21 – 25 June 2023. The forecasts are from the 00z 20 June 2023 GFS ensemble.

The pattern this week across North America is ridging/positive geopotential height anomalies spread across much of Canada, Alaska and Texas with troughing/negative

geopotential height anomalies in the Southwestern and the Southeastern US this period (**Figure 2**). This pattern will favor widespread normal to above normal temperatures across southern Alaska, much of Canada and Texas with normal to below normal temperatures across northern Alaska, and much of the US (**Figure 3**).

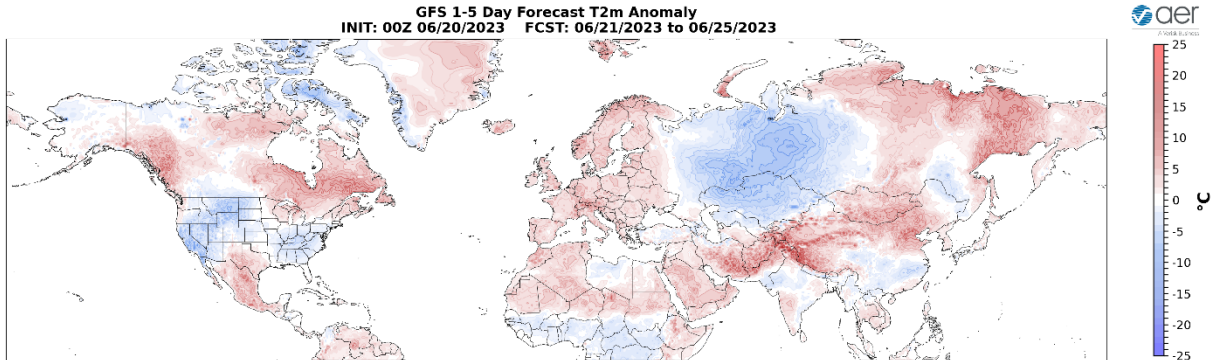


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 21 – 25 June 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across parts of Western Europe, Western Siberia, Northeastern and Southeastern Asia this week (**Figure 4**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across the mountain ranges of Alaska, the US Central and Northern Plains and the Eastern US (**Figure 4**).

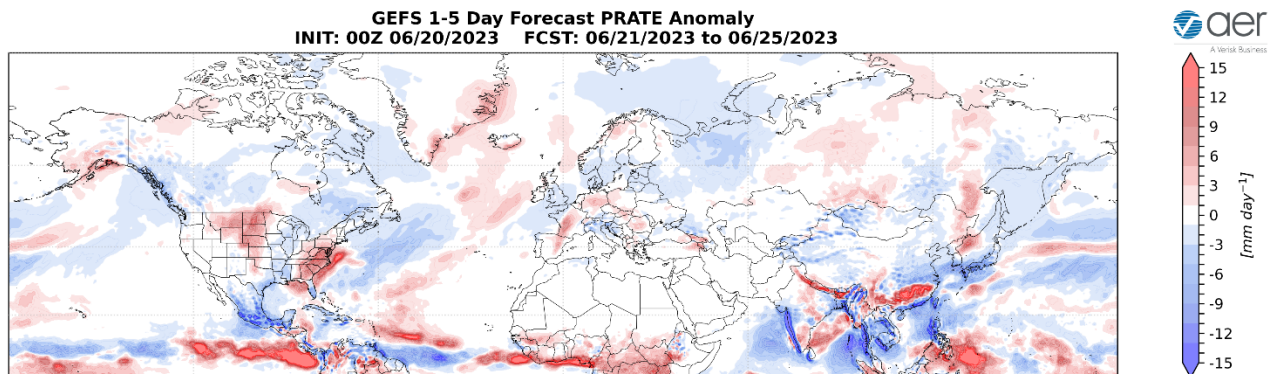


Figure 4. Forecasted precipitation rate (mm/day; shading) from 21 – 25 June 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

1-2 week

With mostly negative geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO

should remain mostly positive this period (**Figure 1**). With predicted negative pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely remain negative this period as well.

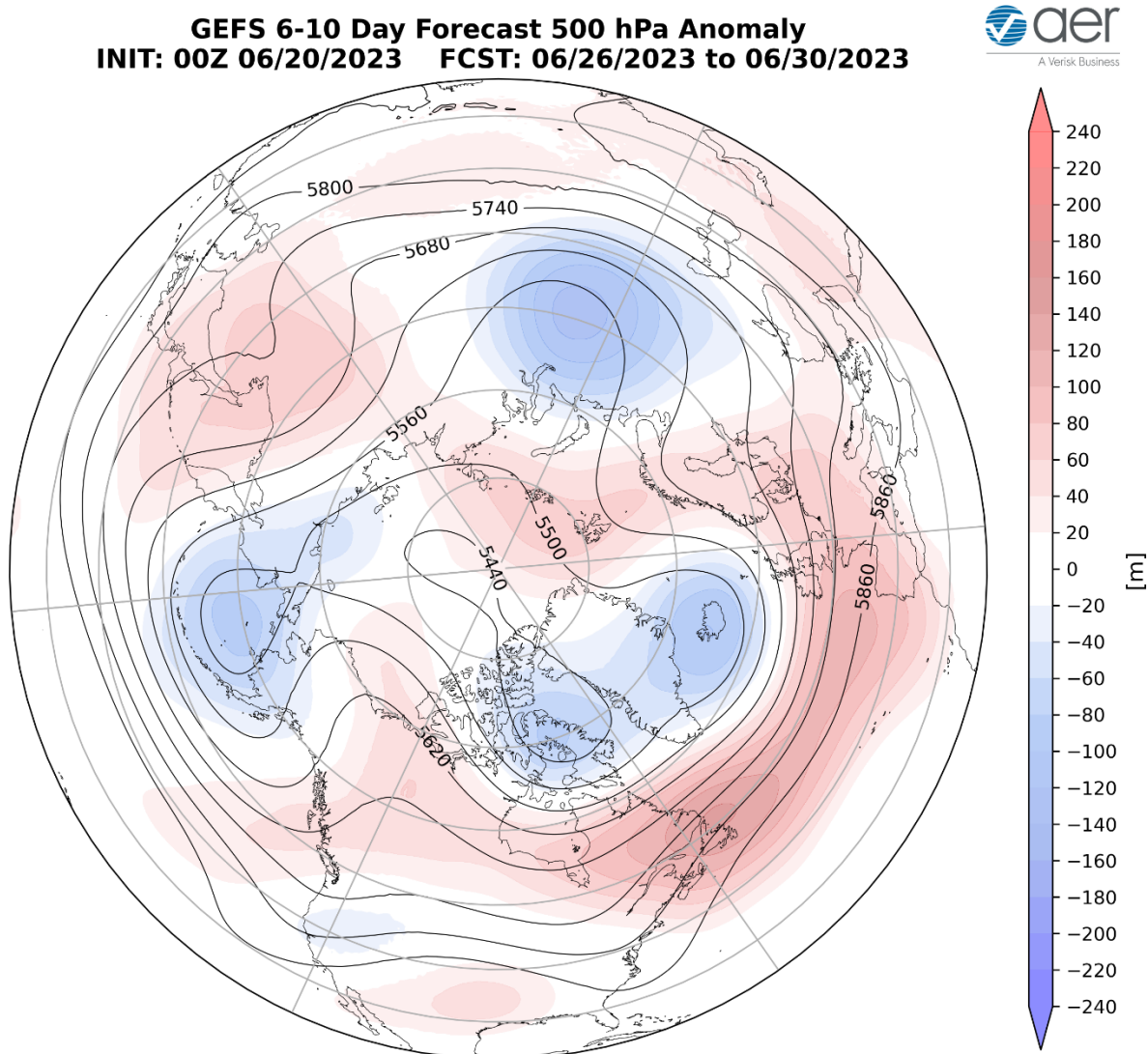


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 26 – 30 June 2023. The forecasts are from the 00z 20 June 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies across Greenland will continue to support ridging/positive geopotential height anomalies across most of Europe with the exception of troughing/negative geopotential height anomalies across Southeastern Europe that expands southwestward from Western Russia this period (**Figure 5**). This pattern should continue to favor normal to above normal temperatures across much of Europe including the UK with normal to below normal temperatures limited to Southeastern Europe (**Figures 6**). The general pattern across Asia is

ridging/positive geopotential height anomalies across Southern and Eastern Asia with troughing/negative geopotential height anomalies across Western Asia and Eastern Siberia this period (**Figure 5**). The pattern favors normal to below normal temperatures across Western Asia but especially Western and Eastern Siberia with normal to above normal temperatures across Eastern and Southern Asia this period (**Figure 6**).

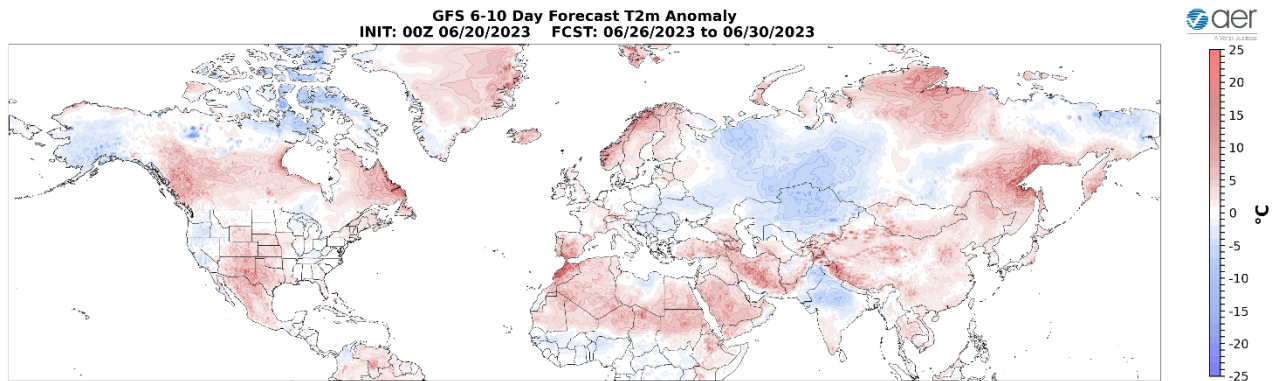


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 26 – 30 June 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

The general pattern of ridging/positive geopotential height anomalies across Canada and Texas with troughing/negative geopotential height anomalies in the Southwestern and Southeastern US is predicted to persist this period (**Figure 5**). This pattern favors normal to above normal temperatures across much of Canada and the US Plains with normal to below normal temperatures across much of Alaska, the Western and Southeastern US (**Figure 6**).

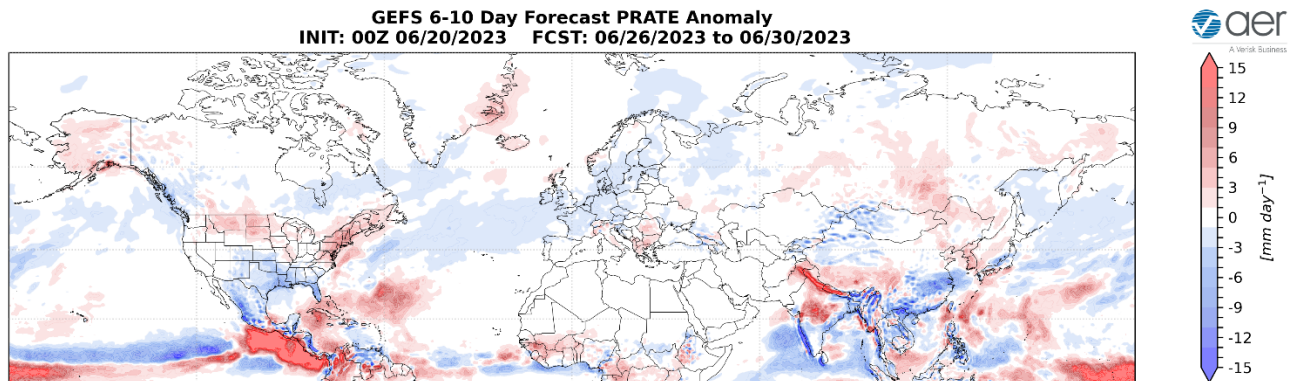


Figure 7. Forecasted precipitation rate (mm/day; shading) from 26 – 30 June 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across the Balkans, parts of Siberia, Northern India and the Tibetan Plateau this period (**Figure 7**). Mostly normal to dry conditions are

predicted across Canada and the US with the exceptions of normal to wet conditions across Alaska, the US Northern Rockies, the Northern Plains and the Northeastern US (Figure 7).

2-3 week

With mostly mixed geopotential height anomalies across the Arctic and mixed geopotential height anomalies across the mid-latitudes this period (Figure 8), the AO should remain positive to neutral this period (Figure 1). With mostly weak negative pressure/geopotential height anomalies across Greenland (Figure 8), the NAO will likely be positive to neutral this period.

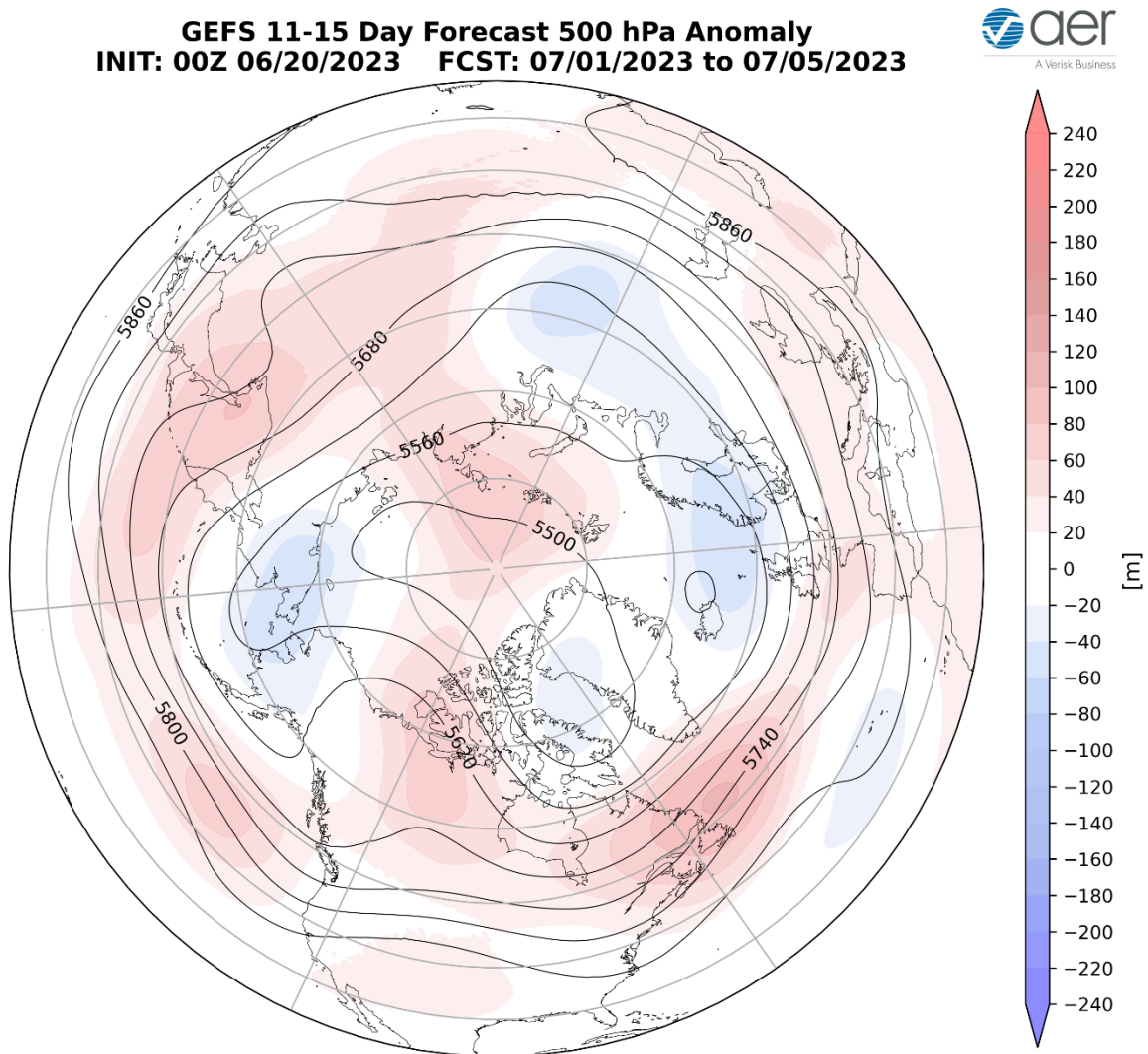


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 1 – 5 July 2023. The forecasts are from the 00z 20 June 2023 GFS ensemble.

Ongoing albeit weakening troughing/negative geopotential height anomalies centered across Greenland will continue to favor ridging/positive geopotential height anomalies across Southern Europe with troughing/negative geopotential height anomalies across Northern Europe this period (**Figure 8**). The zonal pattern should favor normal to above normal temperatures widespread across Europe including the UK with the possible exception of normal to below normal temperatures along the border of Southwestern Russia this period (**Figures 9**). The general pattern of ridging/positive geopotential height anomalies across Southern and Eastern Asia with troughing/negative geopotential height anomalies across Western and parts of Eastern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures across Western Russia, Eastern and even parts of Southern Siberia this period (**Figure 9**).

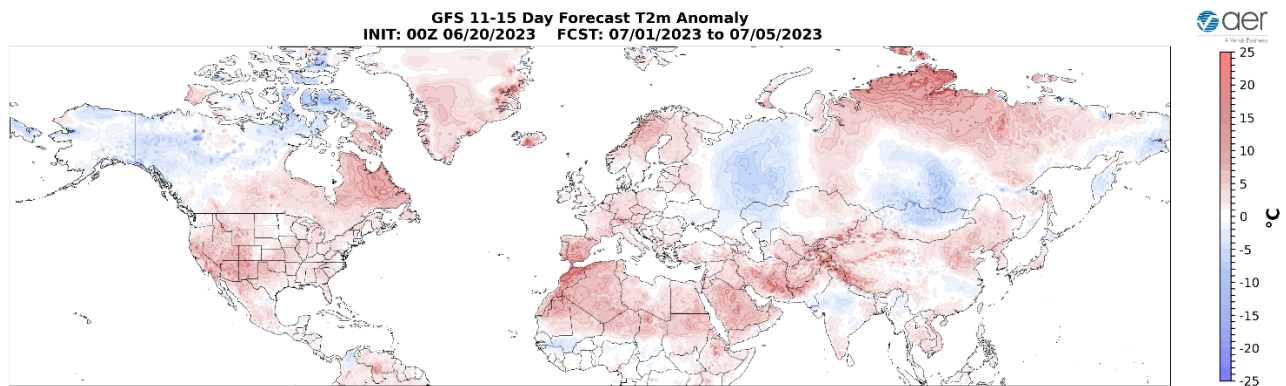


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 – 5 July 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

Ridging/positive geopotential height anomalies is predicted to dominate much of North America with troughing/negative geopotential height anomalies across Alaska, Western Canada and the Southeastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Eastern Canada and the much of the US with normal to below normal temperatures across Alaska, Western Canada and possibly the US Rockies and/or the Southeastern US (**Figure 9**).

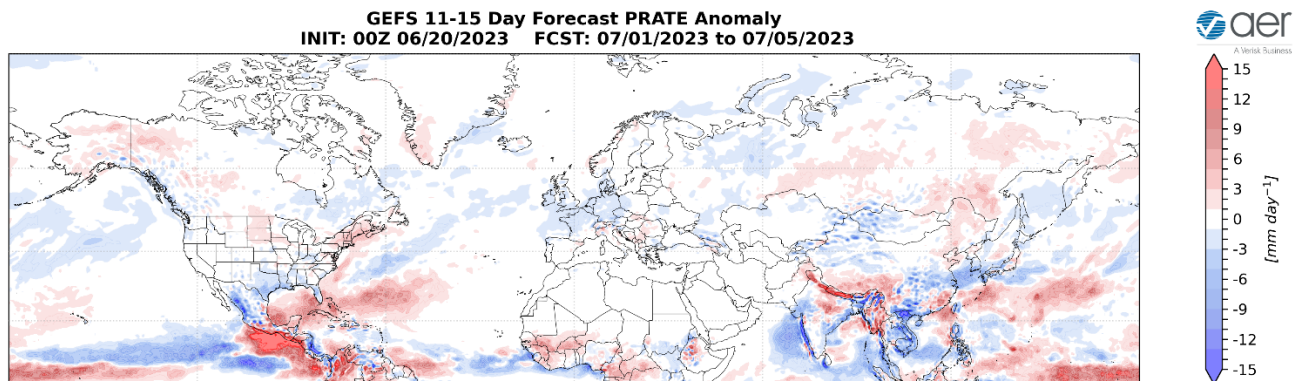


Figure 10. Forecasted precipitation rate (mm/day; shading) from 1 – 5 July 2023. The forecast is from the 00Z 20 June 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across the Balkans, parts of Siberia, Northern India and the Tibetan Plateau this period (**Figure 10**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across Alaska, Northwestern Canada, the US Northern Plains and the Northeastern US (**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 mid to upper stratosphere and lower troposphere with warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). However, next week the cold/negative PCHs in the lower troposphere are predicted to contract and weaken (**Figure 11**).

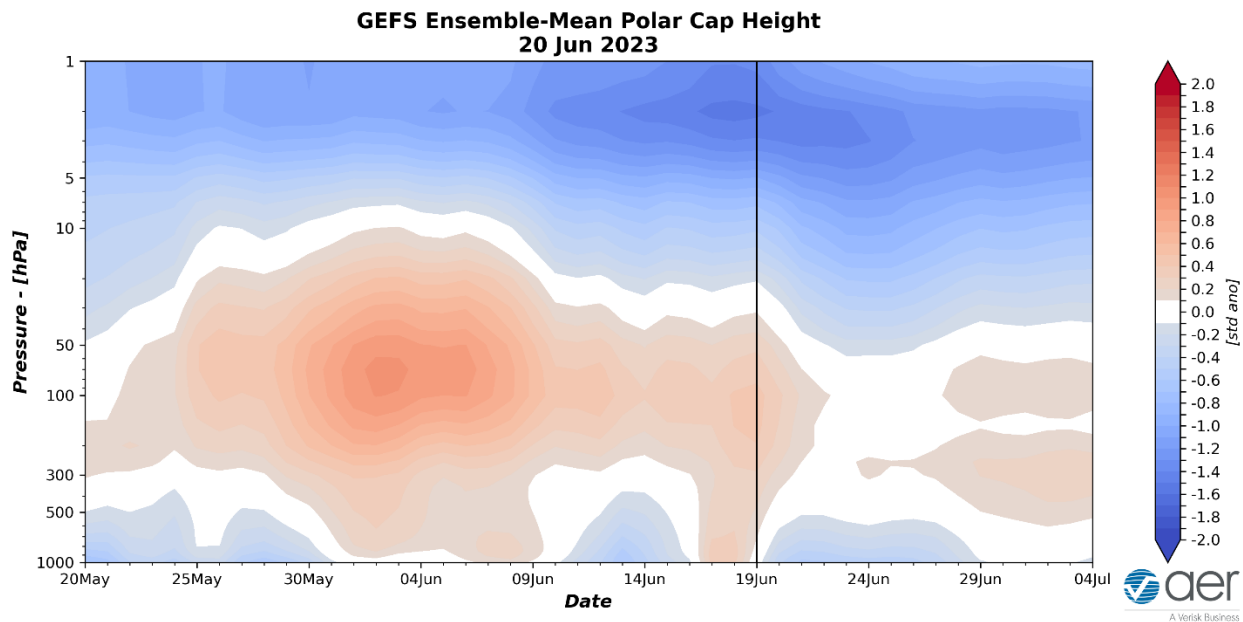


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 20 June 2023 GFS ensemble.

The predicted cold/negative PCHs in the lower troposphere this week and into next week (**Figure 11**) are consistent with the predicted positive surface AO over the next ten days (**Figure 1**). However, the AO is predicted to return to neutral later next week

(Figure 1) coinciding with the predicted contraction of cold/negative PCHs in the lower troposphere (Figure 11).

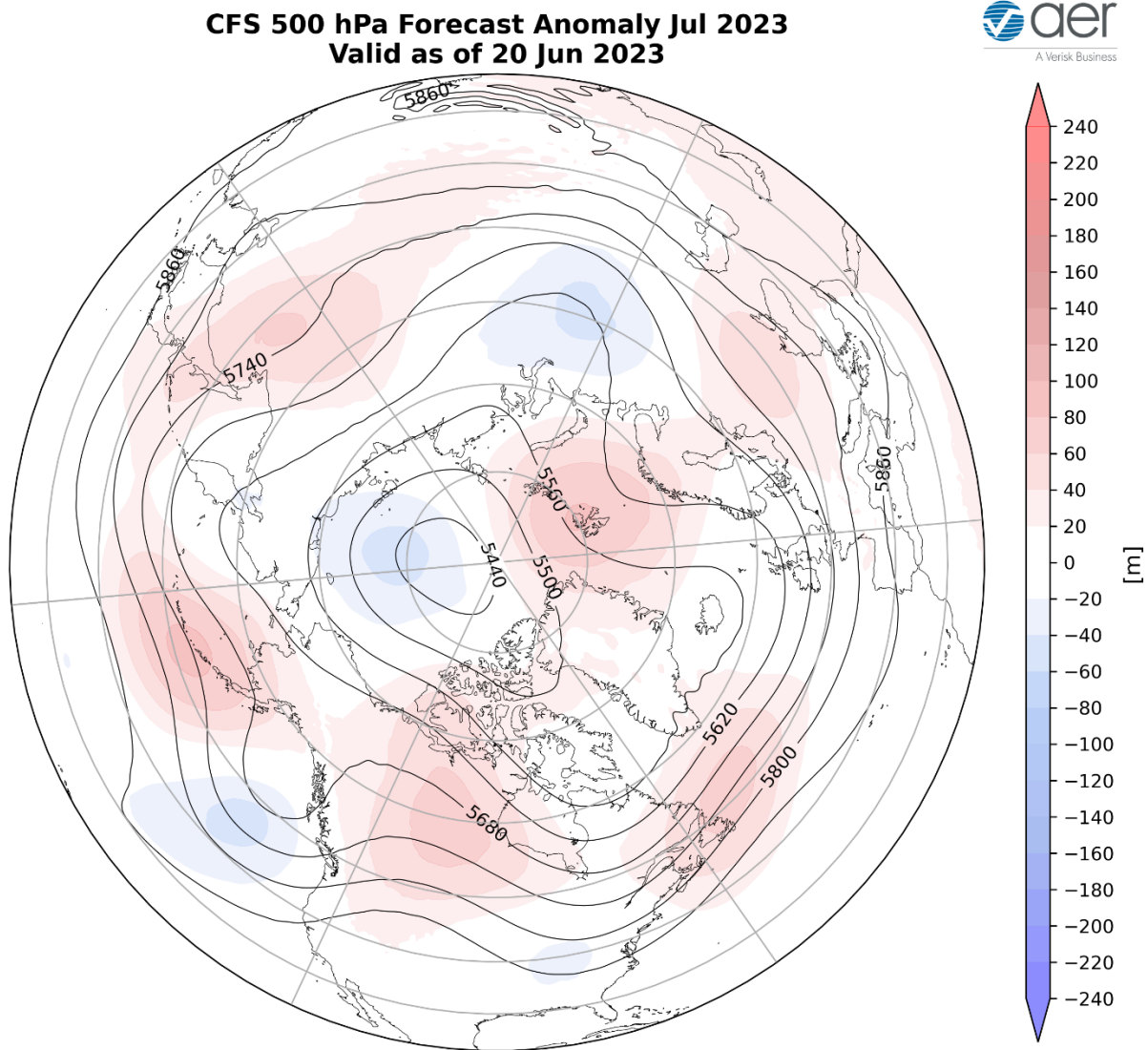


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2023. The forecasts are from the 00Z 20 June 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for July (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging in the Barents-Kara Seas, Iceland, Eastern Europe, Eastern Asia, the Aleutians, Western Canada and with the Canadian Maritimes with troughing across the Chukchi Sea, Iceland, Western Europe, the Urals, Eastern Siberia, the Gulf of Alaska and the Eastern US (**Figure 12**). This pattern favors seasonable to relatively warm

temperatures across Southern and Eastern Europe, far Northern Siberia, Central, Southern and Eastern Asia, parts of Alaska, much of Canada, the US Rockies and the Western US with seasonable to relatively cool temperatures across the Western Europe, Western Russia, Kazakhstan, interior Alaska and the Central US (**Figure 13**).

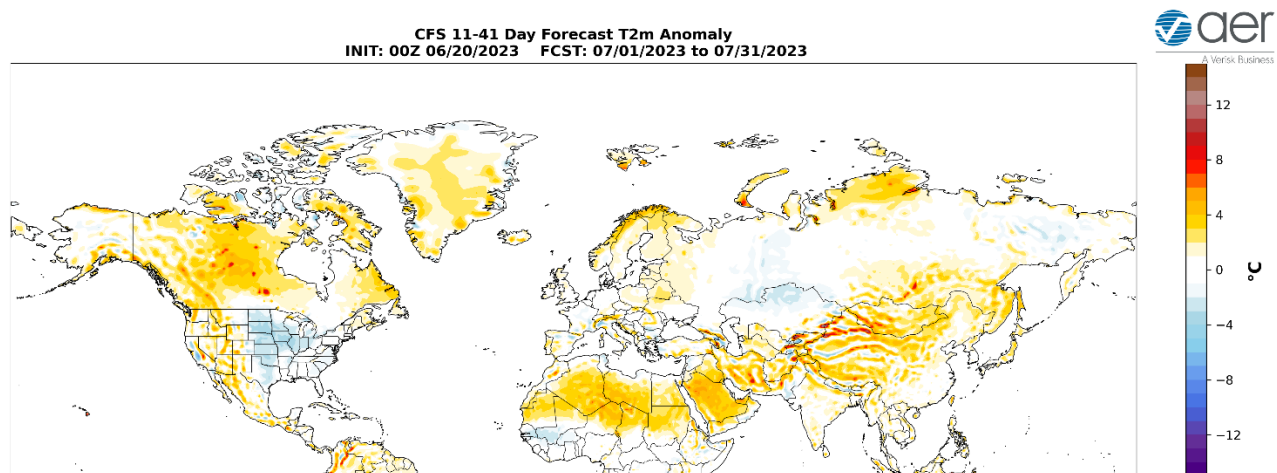


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for July 2023. The forecasts are from the 00Z 20 June 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are above normal, especially along the South America coast, indicating that the transition from La Niña to El Niño is complete (**Figure 14**) and El Niño conditions are expected through the fall. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific, the eastern North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

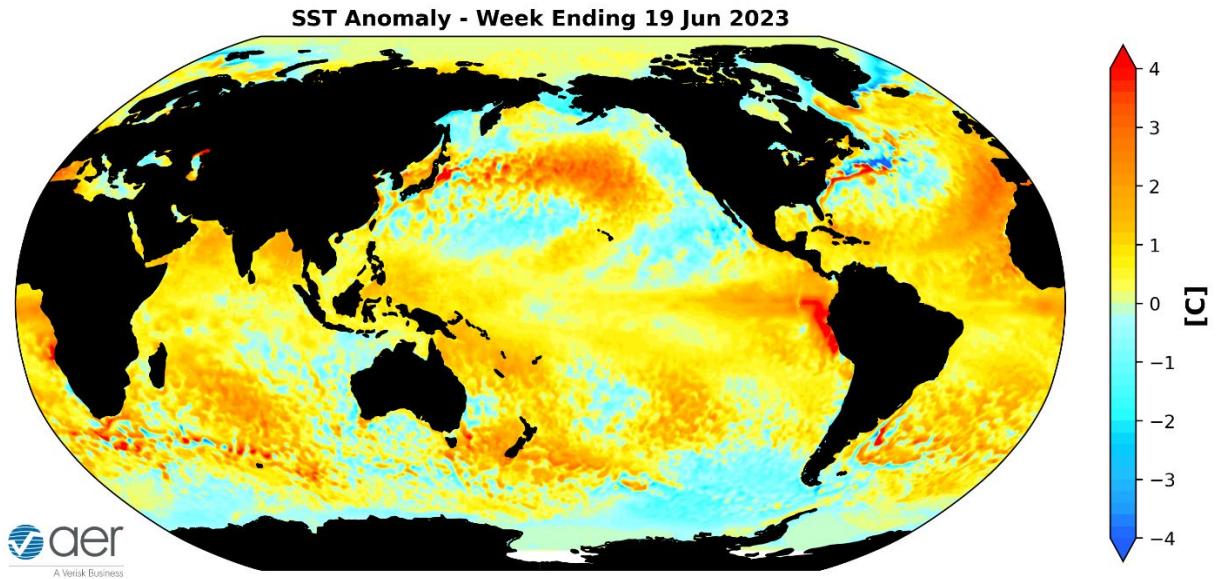


Figure 14. The latest weekly-mean global SST anomalies (ending 19 June 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently phase one of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored over the next two weeks. Seems that the MJO is having little influence on the weather across Canada in the short term. But admittedly this is outside of my expertise.

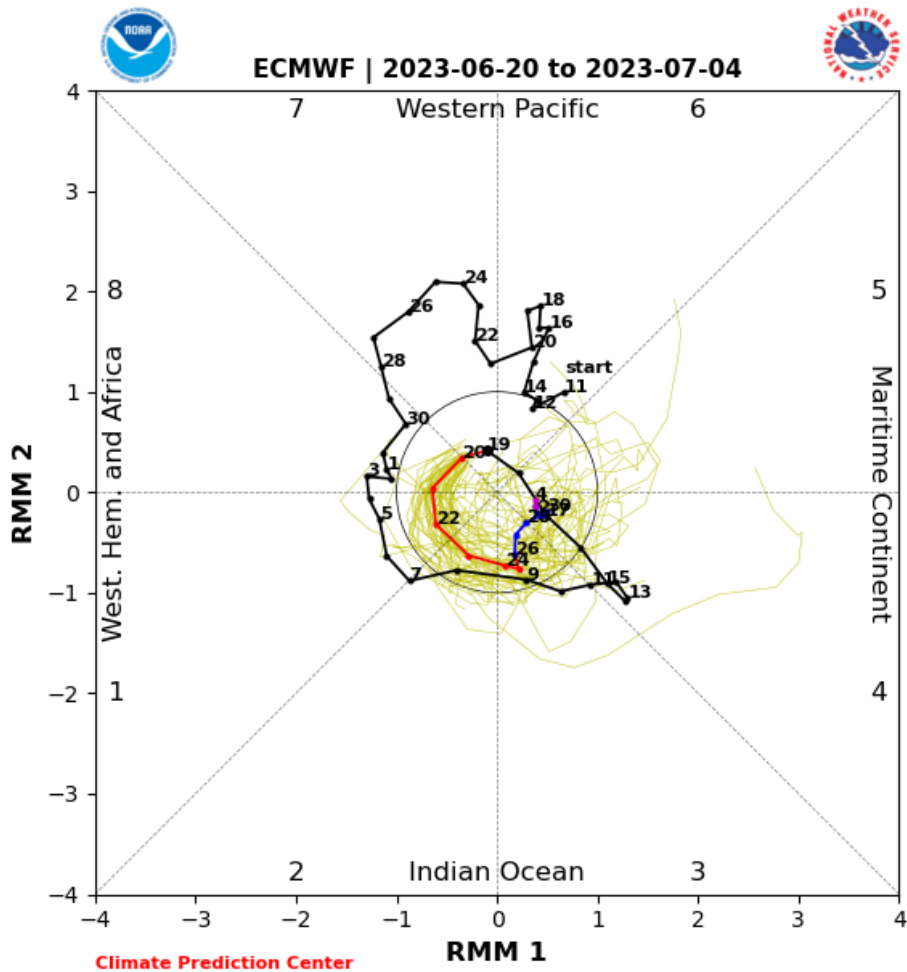


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 20 June 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase.

Image source:

https://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml