

Arctic Oscillation and Polar Vortex Analysis and Forecasts

July 03, 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 negative this week and then remain negative to neutral as pressure/geopotential height

anomalies across the Arctic are currently mixed and are predicted to turn mostly positive to mixed over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative and is predicted to remain negative the next two weeks as pressure/geopotential height anomalies will remain mostly positive across Greenland.

- Over the next two weeks ridging/positive geopotential height anomalies across Greenland will anchor troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe next week. This pattern generally favors the next two weeks normal to below normal temperatures across Northern Europe including the United Kingdom (UK) with normal to above normal temperatures across Southern and Central Europe.
- This week, Asia is predicted to be dominated by ridging/positive geopotential height anomalies. However next week troughing/negative geopotential height anomalies are predicted to develop across Northern Asia. This pattern mostly favors normal to above normal temperatures widespread across much of Asia with the exception of normal to below normal temperatures across Northern Asia including Siberia next week that lingers longest across Southern Siberia.
- The general predicted pattern predicted across North America the next two weeks is ridging/positive geopotential height anomalies across western and eastern North America with troughing/negative geopotential height anomalies in Alaska, central North America especially in the Plains of Canada and the United States (US). This pattern generally favors normal to above normal temperatures for Western and Eastern Canada and the Western and Eastern US with normal to below normal temperatures across Alaska, the Plains of Canada and US.
- In the Impacts section I discuss the predicted the atmospheric circulation across the Northern Hemisphere (NH) and the implications for the remainder of the summer and how it is similar to past summers and how it differs.
- **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

What should be a surprise to no one, it is shaping up as another hot summer for the Northern Hemisphere. No reason to expect any large changes as warm temperatures are predicted for much of North America, Europe and Asia in the coming weeks (see Figures 3, 6 and 9). There are some notable exceptions like the Central US and the UK. As we head into the heart of the summer the overall pattern is reminiscent of past summers but with possibly more high latitude blocking. This could result in accelerated melt of Arctic sea ice and Greenland land ice in July.

Impacts

I have been highlighting 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. This coupling persists and once again is supporting a negative AO/NAO and Greenland blocking. Though from **Figure 11**, it appears to peaking early this week and then weakening, but this feature seems to pulsate, and I believe there is a good chance it will strengthen again. Greenland blocking could favor troughing and seasonable temperatures in Northern Europe and the Northeastern US.

High latitude blocking seems to be a more common summer feature of late, but it does seem to me that the high latitude blocking is so far stronger this summer than other recent summers. One consequence are the very large warm anomalies centered near Hudson Bay in Canada (see **Figure i**).

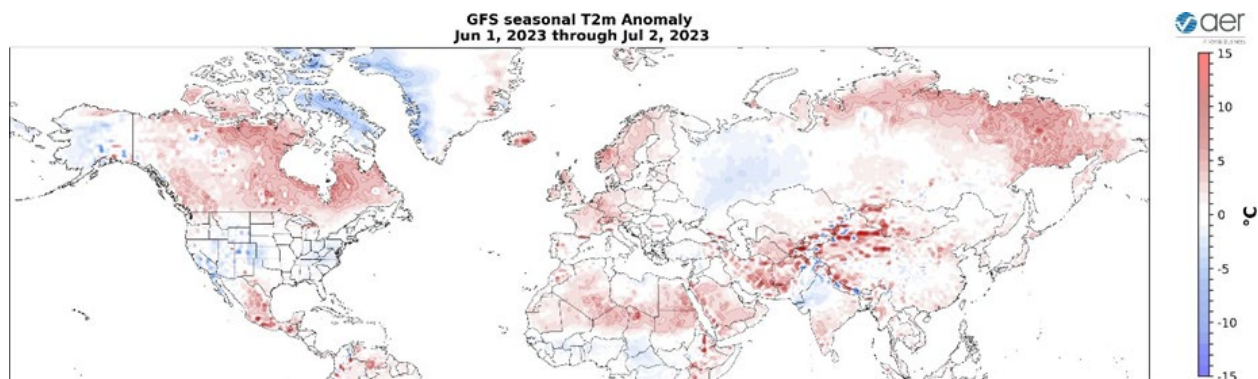


Figure i. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere from 1 June – 2 July from the initialized GFS ensemble.

I am seeing on Twitter that June 2023 was the warmest June on record for the globe (see from [@Climatologist49](#)) including for the UK (see from [UK Met Office](#)). So as predicted in the summer forecasts (dynamical and statistical), no reason not to expect another overall warm summer across the NH.

In **Figure i**, I post the NH surface temperature anomalies for the summer so far. The summer forecast was included in the [22 May 2023](#) blog post. All three forecasts show different flavors of an overall warm forecast. The NMME is most aggressive with the warm temperatures over Canada as observed so far but is shifted east relative to the observations. On the other hand, it is most different from the observed anomalies so far over Asia. But we have almost two thirds of the summer left so the pattern will continue to evolve with time. The US has been relatively cool so far but both coasts could warm up over the coming weeks.

Arctic sea ice melt during the spring of 2023 was relatively moderate. However, the recent migration of higher geopotential heights into the Central Arctic seems to have accelerated of Arctic sea ice melt (see **Figure ii**). With the possibility of continued high

latitude blocking, the accelerated sea ice melt could continue. This is something that I will continue to monitor through the summer.

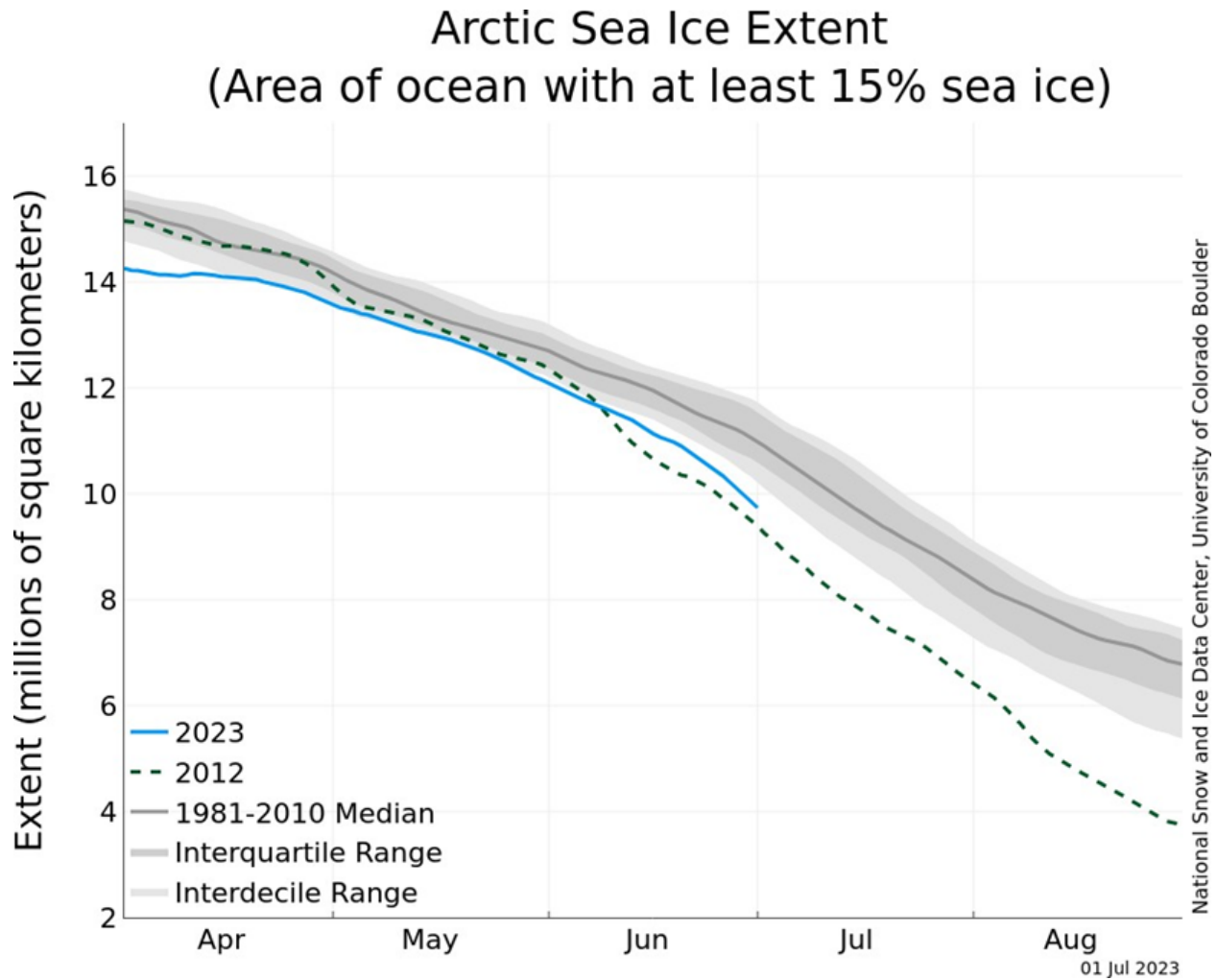


Figure ii. Arctic sea ice extent through July 1, 2023 (blue solid line). Plot taken from <https://nsidc.org/arcticseaicenews/>

A paper that I co-authored (Jonathon Preece at the University of Georgia was first author) was published last week: [Preece et al. \(2023\)](#) on the linkage between early North American snow melt (strongest in May and June) and increased summer (especially in July) Greenland blocking and ice sheet melt. The snow cover deficit over North America in May (see **Figure iii**) nicely matches the snow cover deficit pattern we show in Figure 7 in the paper. And as seen from Figures 2, 5 and 8, Greenland blocking is likely to be strong this July. No predictor is perfect and just one predictor is always an oversimplification but an intriguing and encouraging additional data point not used in our study.

Monthly SCE Departure - May 2023

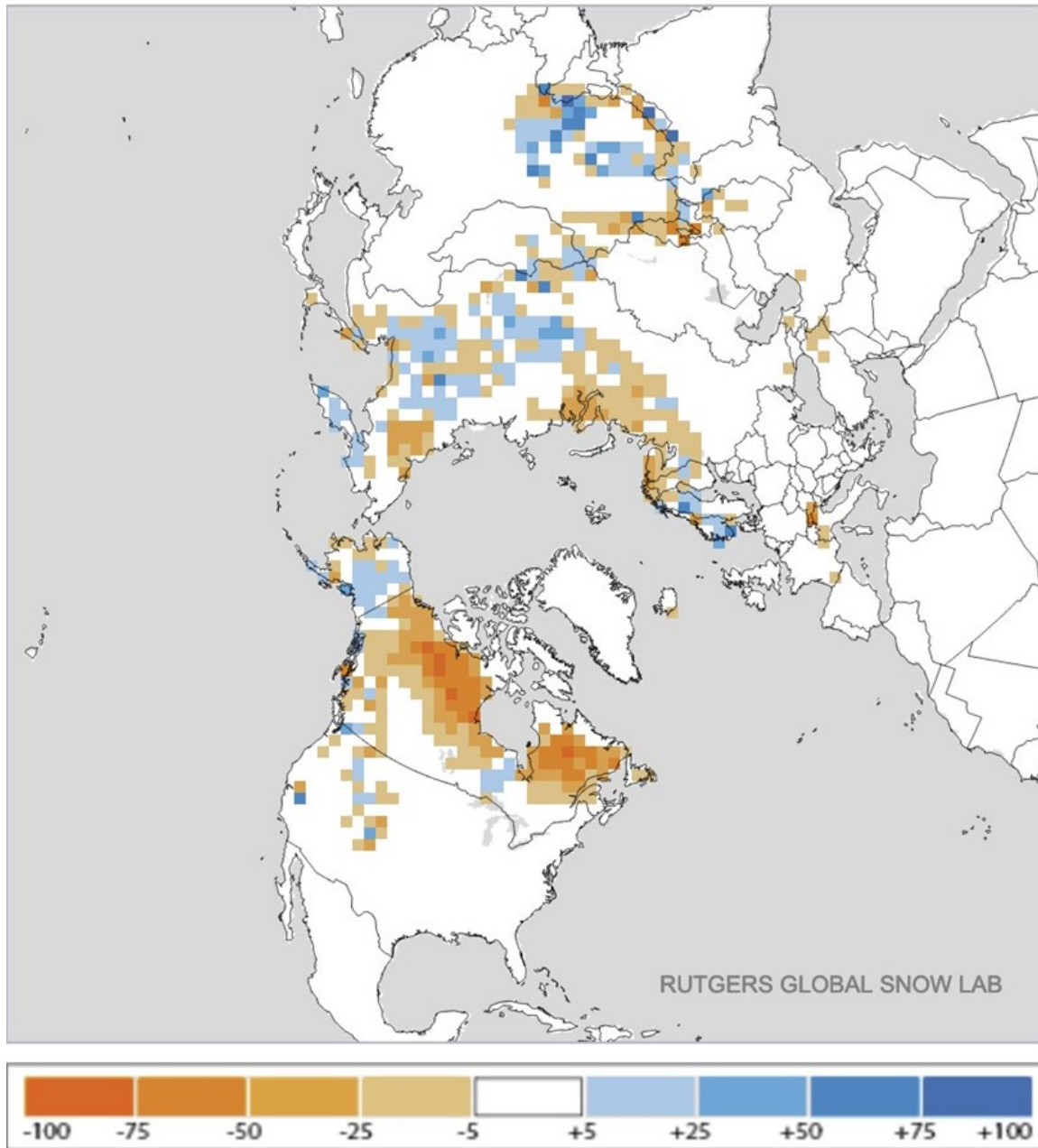


Figure iii. Observed North Hemisphere snow cover extent anomalies for May 2023. Plot taken from <http://climate.rutgers.edu/snowcover/index.php>

Wednesday Update

The possibility that I raised on Monday, in the first paragraph above, that predicted warm/positive PCHs could strengthen with subsequent forecasts seems to be playing out. Today's PCH forecast shows the warm/positive tropospheric PCHs are predicted to strengthen mid-month (see **Figure iv**).

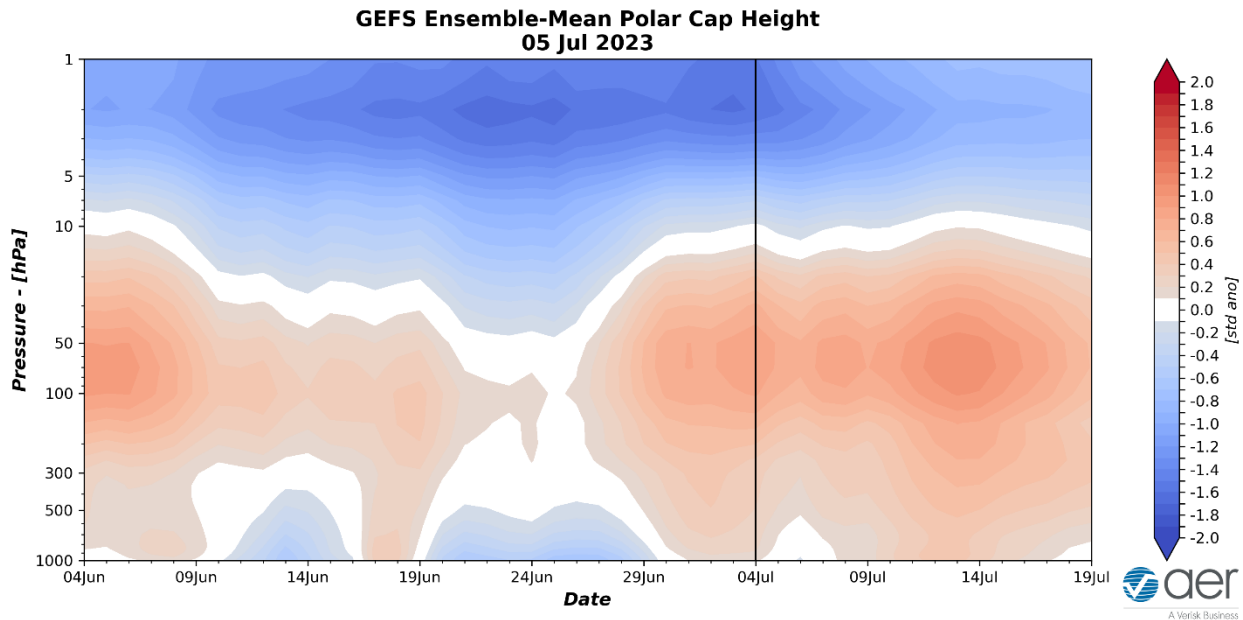


Figure iv. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 5 July 2023 GFS ensemble.

The consequence of stronger warm/positive tropospheric PCHs is a more negative AO and increased high latitude blocking. From the GFS forecast for the third week of July (see **Figure v**) we can see positive geopotential heights covering much of the Arctic but focused in the Beaufort Sea and near Greenland, centered in Baffin Bay. I think the details of the high latitude blocking are still to be determined as a look at the ECMWF shows the centers of the blocking in different locations but on the general vicinity.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 07/05/2023 FCST: 07/16/2023 to 07/20/2023

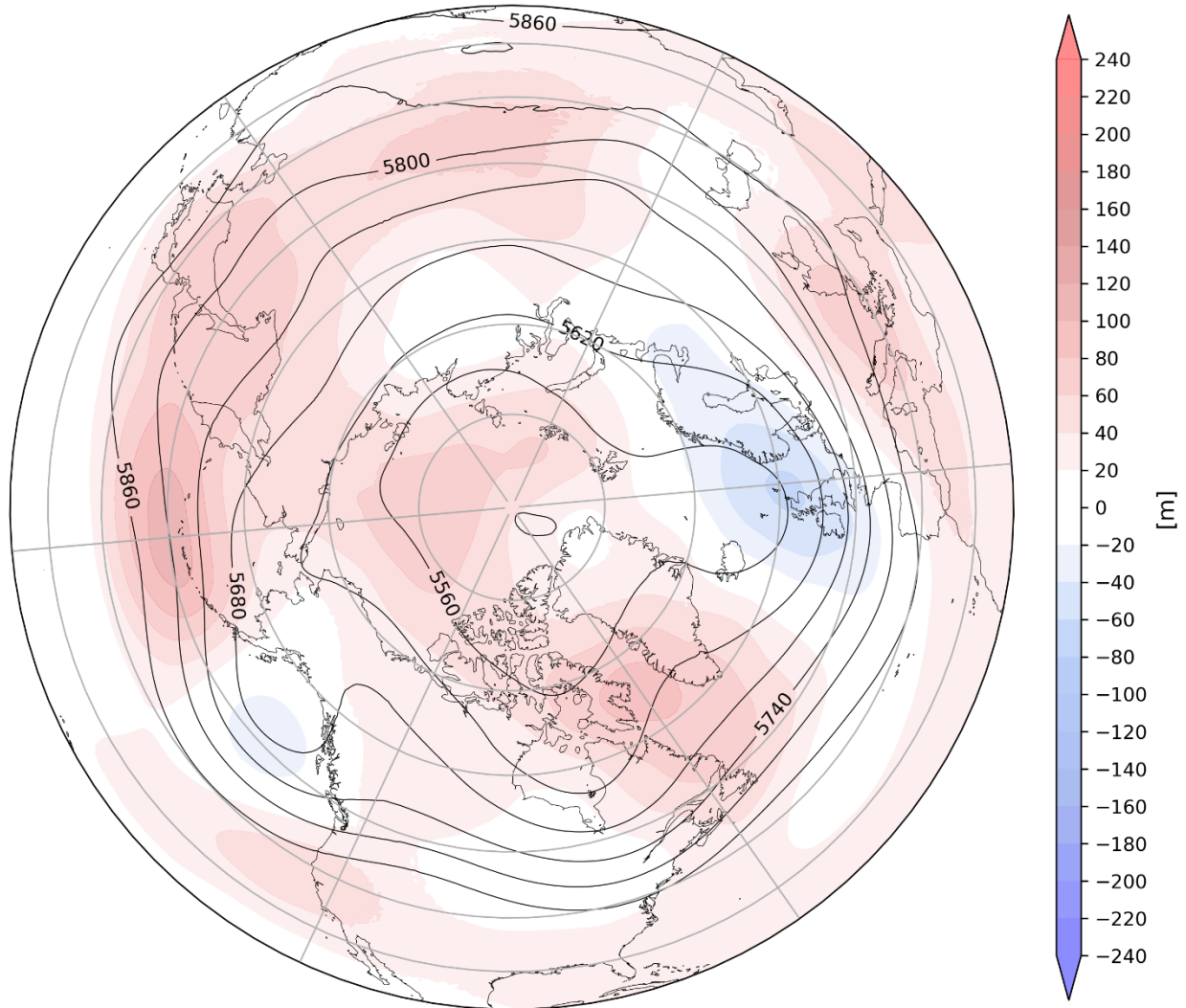


Figure v. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 16 – 20 July 2023. The forecasts are from the 00z 5 July 2023 GFS ensemble.

However, both model forecasts are showing high latitude blocking on the North Pacific side of the Arctic and in and around Greenland. Blocking in these locations should favor more seasonable temperatures to parts of North America east of the Rockies and Northern Europe mid through late July (see **Figure vi**).

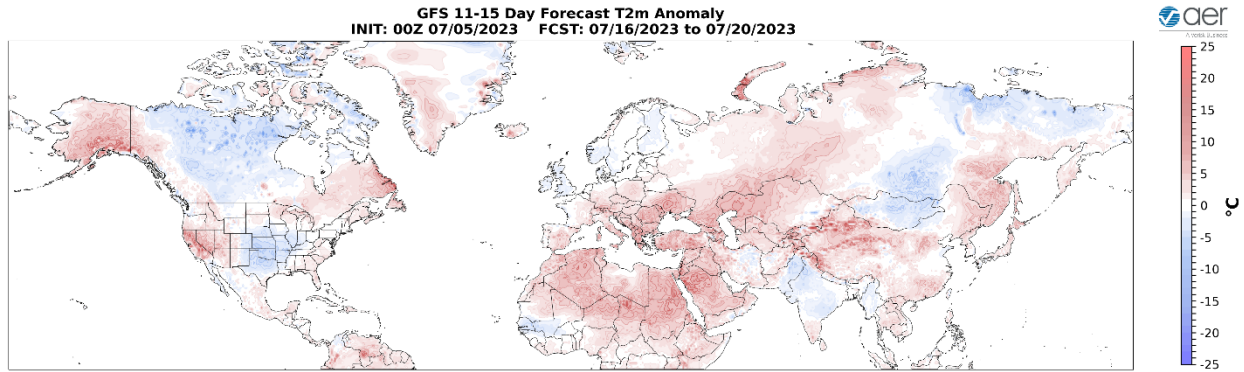


Figure vi. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 16 – 20 July 2023. The forecast is from the 00Z 5 July 2023 GFS ensemble.

Near-Term

0-1 week

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

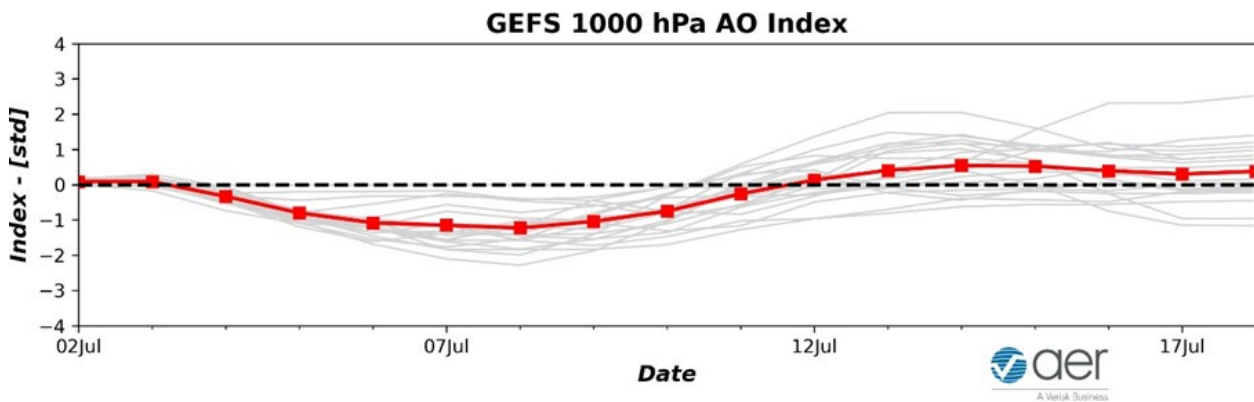


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 3 July 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies across Greenland will force troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe (**Figures 2**). This pattern favors normal to below normal temperatures across Northern Europe including the UK with normal to above normal temperatures across Southern and

Central Europe (**Figure 3**). This week Asia is predicted to be dominated by widespread ridging/positive geopotential height anomalies with the regional exceptions of troughing/negative geopotential height anomalies across Northern China and Eastern Siberia (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Asia with normal to below normal temperatures limited to Mongolia, Northeast China and Eastern Siberia (**Figure 3**).

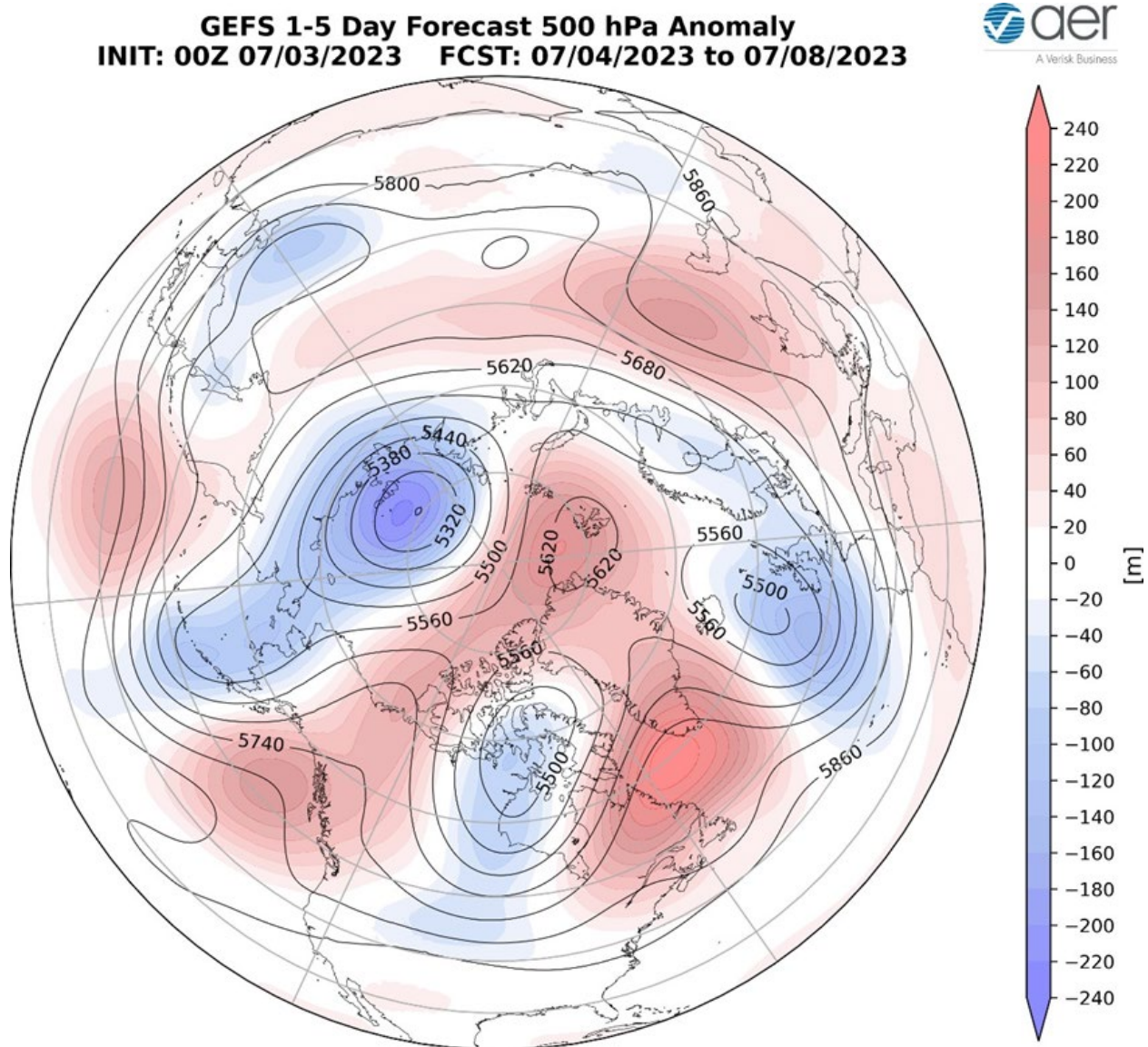


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 4 – 8 July 2023. The forecasts are from the 00z 3 July 2023 GFS ensemble.

The pattern this week across North America is ridging/positive geopotential height anomalies spread across western and eastern North America with troughing/negative geopotential height anomalies in central North America (**Figure 2**). This pattern will

favor widespread normal to above normal temperatures across Western and Eastern Canada and the Western, Eastern and Southern US with normal to below normal temperatures across Alaska, and much of the Central US (**Figure 3**).

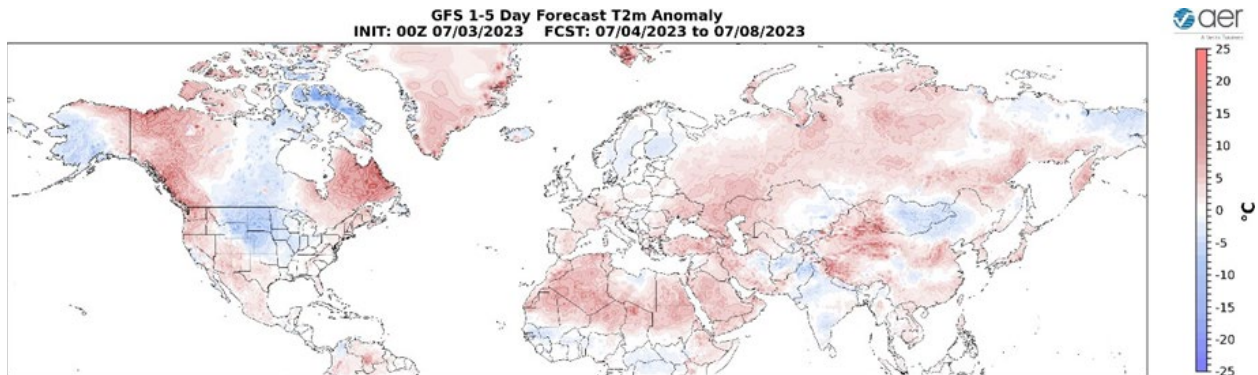


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 4 – 8 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across Northern and Southeastern Europe, Northeastern China, India and the Tibetan Plateau 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 Alaska, the US Central and Northern Plains and the Northeastern US (**Figure 4**).

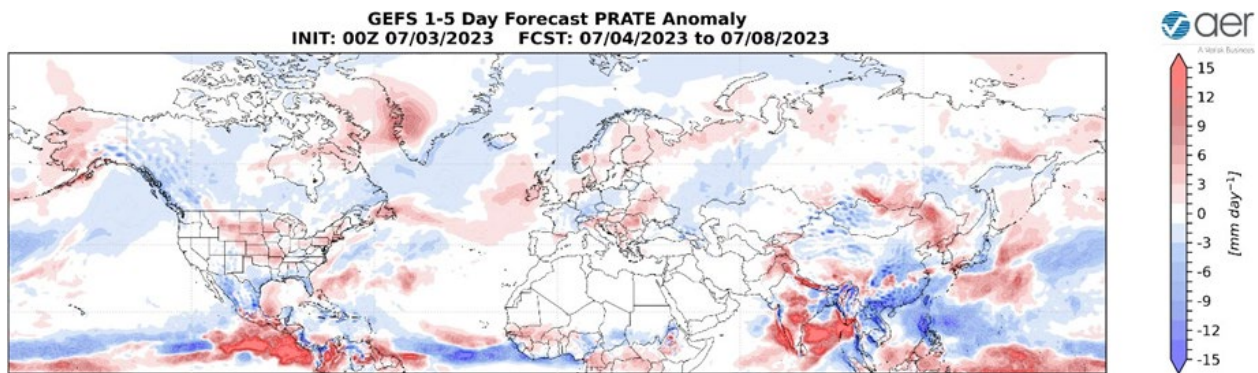


Figure 4. Forecasted precipitation rate (mm/day; shading) from 4 – 8 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

1-2 week

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

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

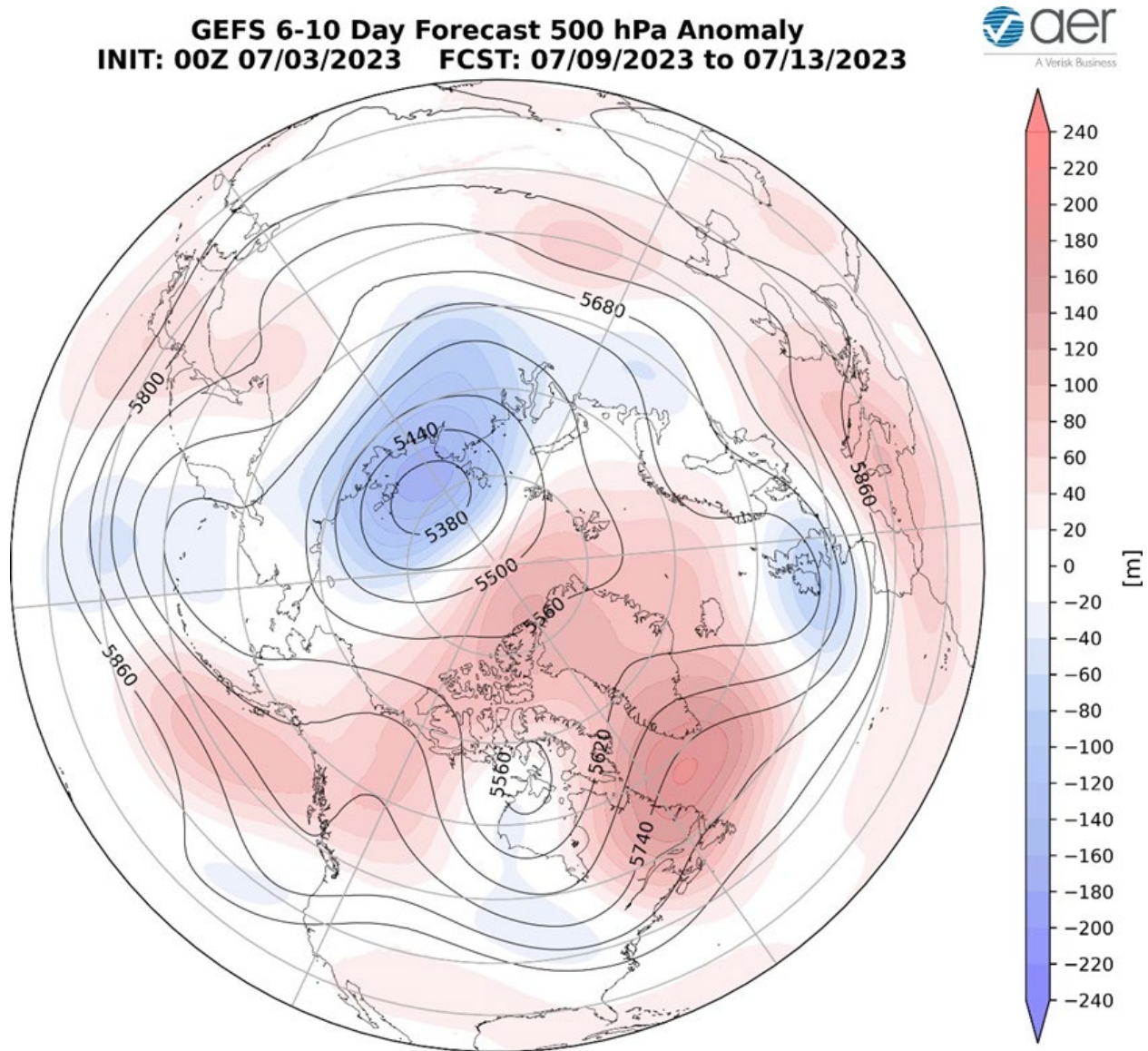


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 July 2023. The forecasts are from the 00z 3 July 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Greenland will continue to support troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe this period (**Figure 5**). This pattern should favor widespread normal to above normal temperatures across much of Europe with normal to below normal temperatures mostly limited to Northwestern Europe including the UK (**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 Northern and Western Asia this period (**Figure 5**). The pattern favors normal to below normal temperatures across Western and Central Russia with normal to above normal temperatures across Southern and Eastern Asia including Eastern Siberia this period (**Figure 6**).

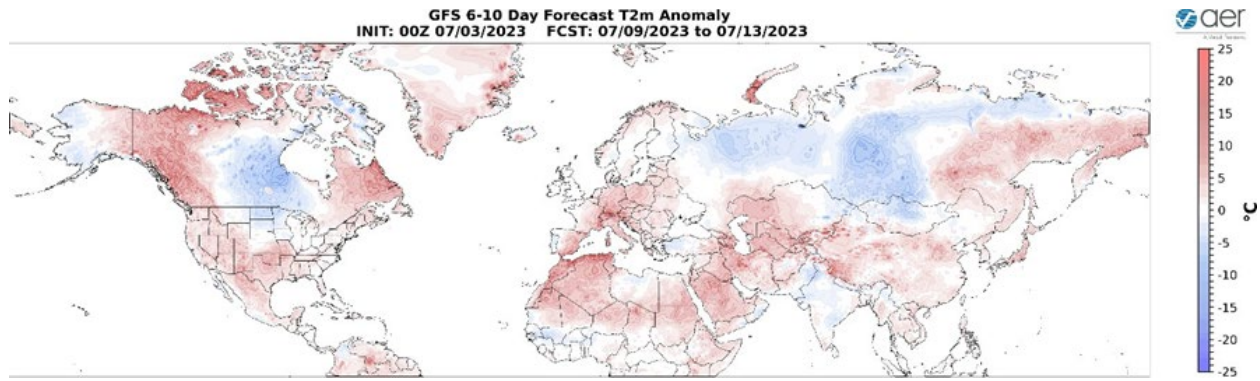


Figure 6.Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 9 – 13 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

The general pattern across North America this period is persistent ridging/positive geopotential height anomalies across western and eastern North America and the Southern US with troughing/negative geopotential height anomalies in central North America (**Figure 5**). This pattern favors normal to above normal temperatures across eastern Alaska, Western and Eastern Canada and much of the US with normal to below normal temperatures across western Alaska, Central Canada and the US Northern Plains (**Figure 6**).

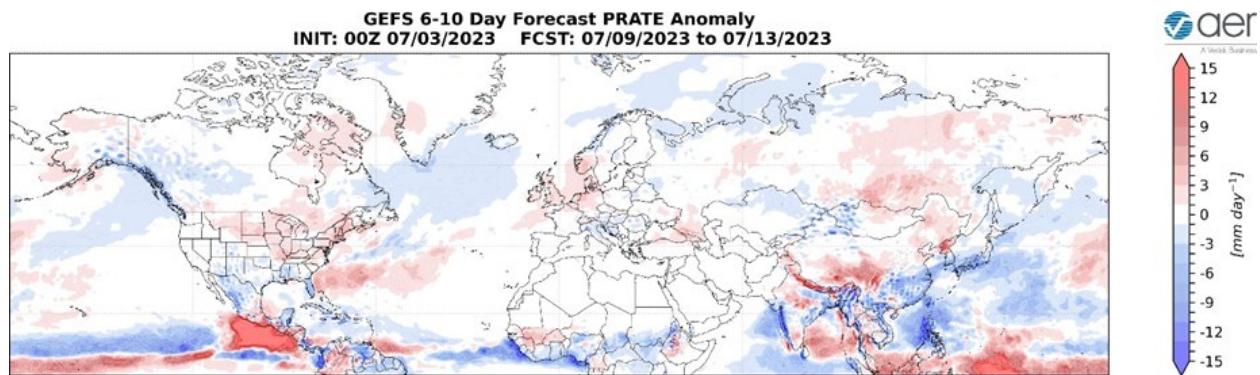


Figure 7.Forecasted precipitation rate (mm/day; shading) from 9 – 13 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across Northwestern Europe, 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 northern and western Alaska, Ontario, 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 negative to neutral this period.

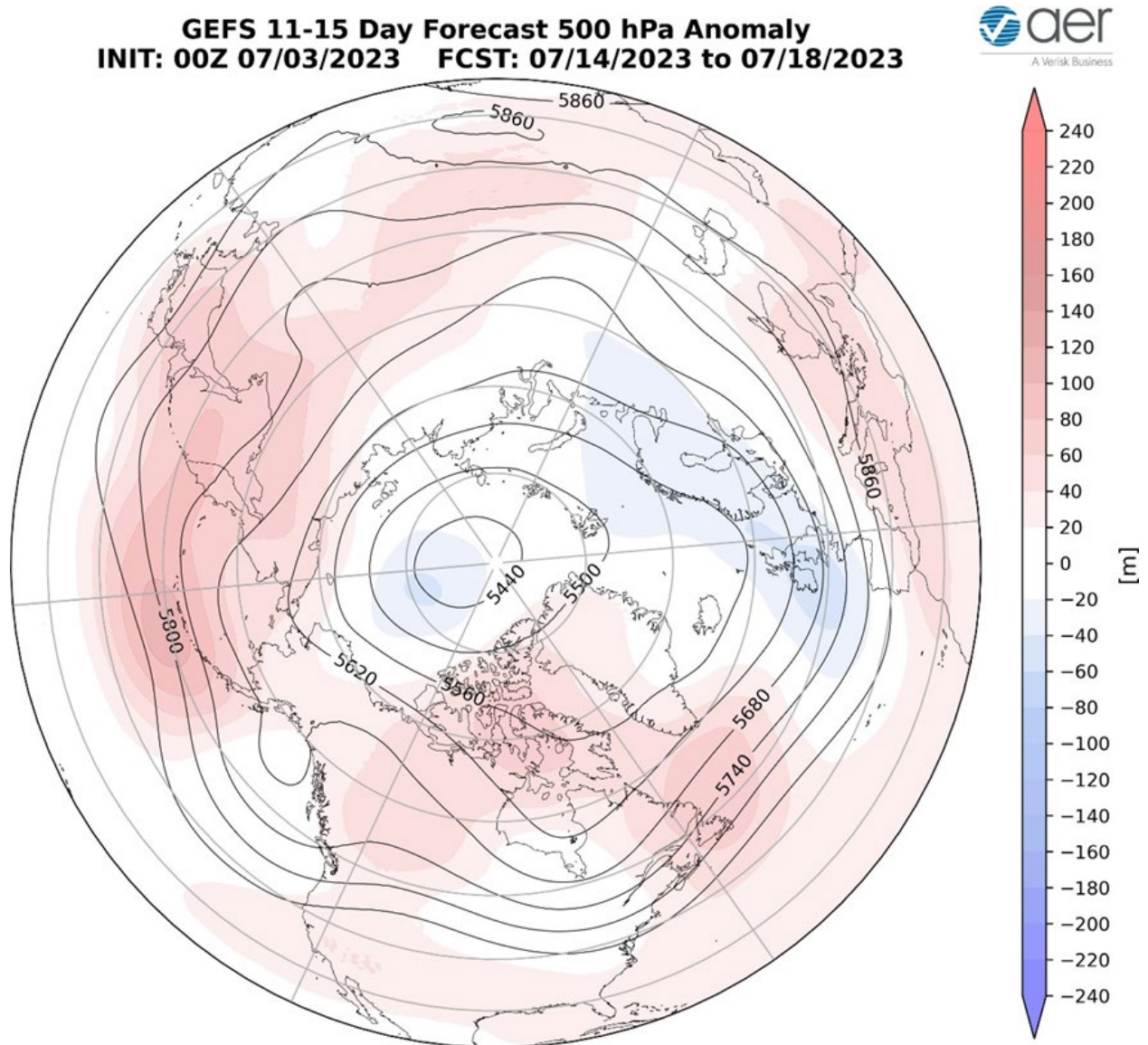


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 July 2023. The forecasts are from the 00z 3 July 2023 GFS ensemble.

Ongoing albeit weakening ridging/positive geopotential height anomalies centered across Greenland will continue to favor troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe this period (**Figure 8**). The mostly zonal pattern should favor normal to below normal temperatures across Northern and Western Europe including the UK with normal to above normal temperatures across Southern and Eastern Europe this period (**Figures 9**). Again ridging/positive geopotential height anomalies is predicted to dominate Asia with the exception of weak troughing/negative geopotential height anomalies across Northwestern Russia and parts of Northeast 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 limited to Northwestern Russia, and Southern Siberia this period (**Figure 9**).

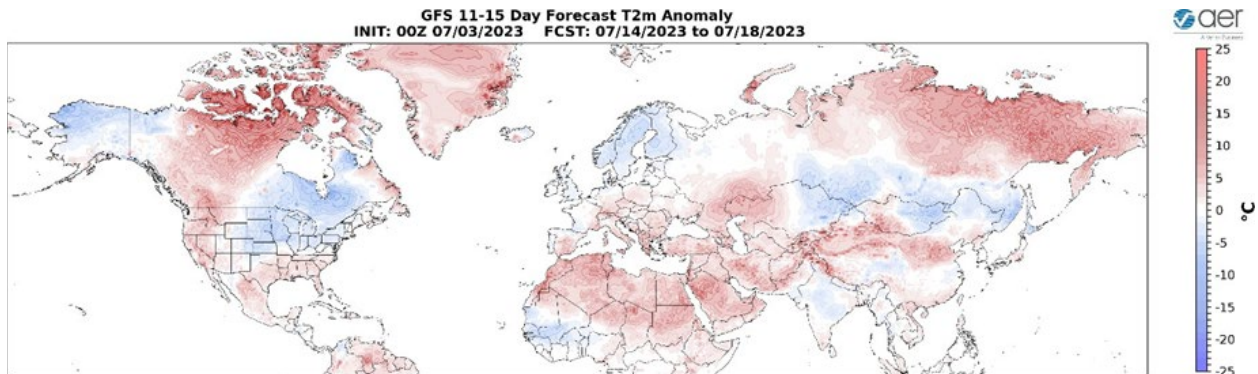


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 14 – 18 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist across western and eastern North America and the Southern US with troughing/negative geopotential height anomalies across Alaska, Central Canada and the Northeastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Western Canada, the Canadian Maritimes and the Western and Southern US with normal to below normal temperatures across Alaska, Central to Eastern Canada and the Northeastern US (**Figure 9**).

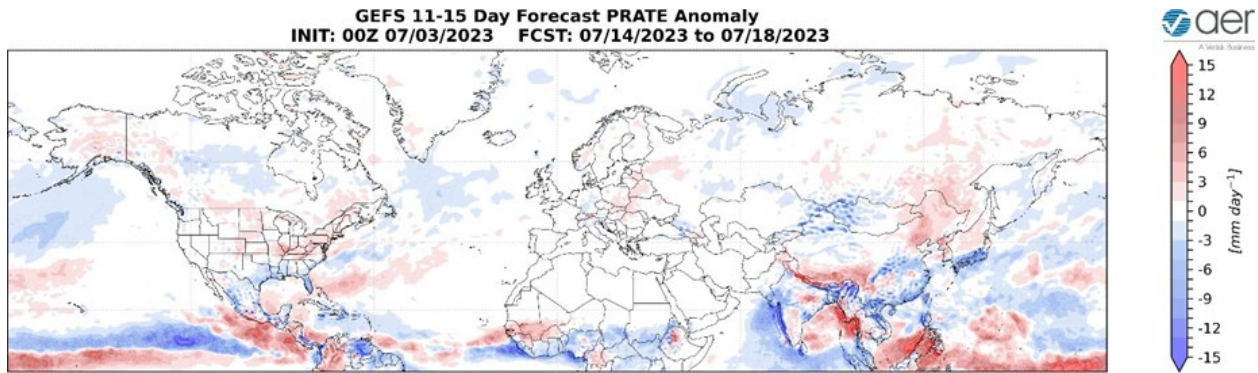


Figure 10. Forecasted precipitation rate (mm/day; shading) from 14 – 18 July 2023. The forecast is from the 00Z 3 July 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across parts of Northeast Asia, 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 with warm/positive PCHs in the lower stratosphere and troposphere (**Figure 11**). However, next week the warm/positive PCHs in the lower troposphere are predicted to contract, weaken, and possibly flip to cold/negative (**Figure 11**).

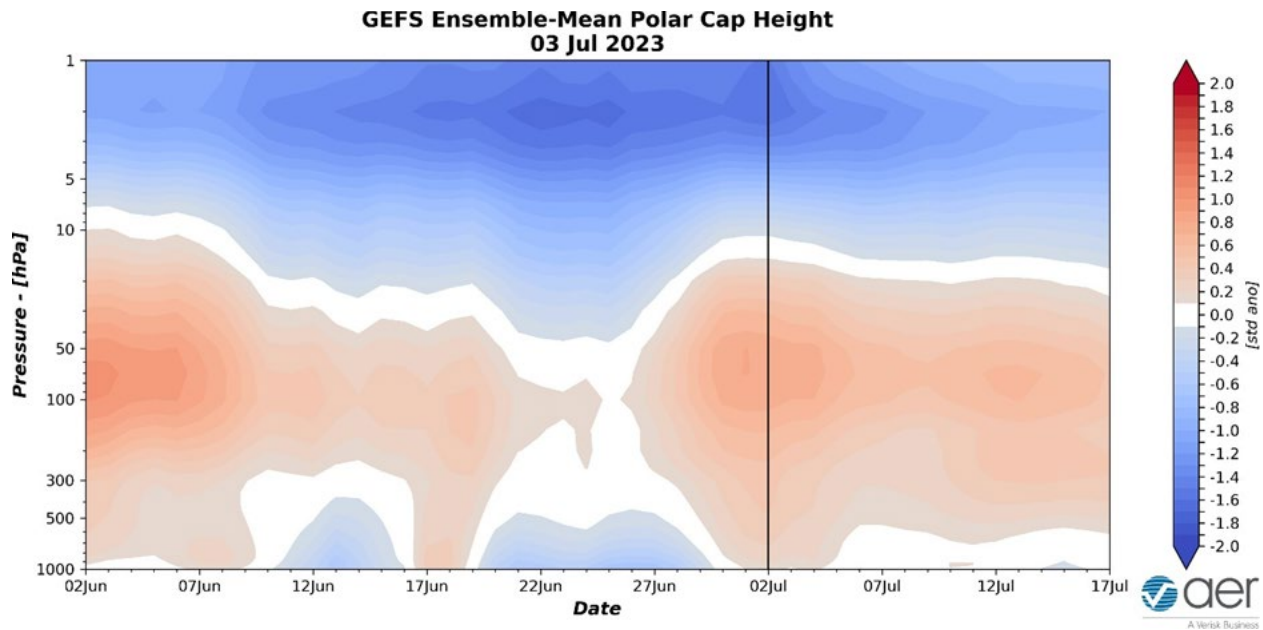


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 3 July 2023 GFS ensemble.

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

**CFS 500 hPa Forecast Anomaly Aug 2023
Valid as of 03 Jul 2023**

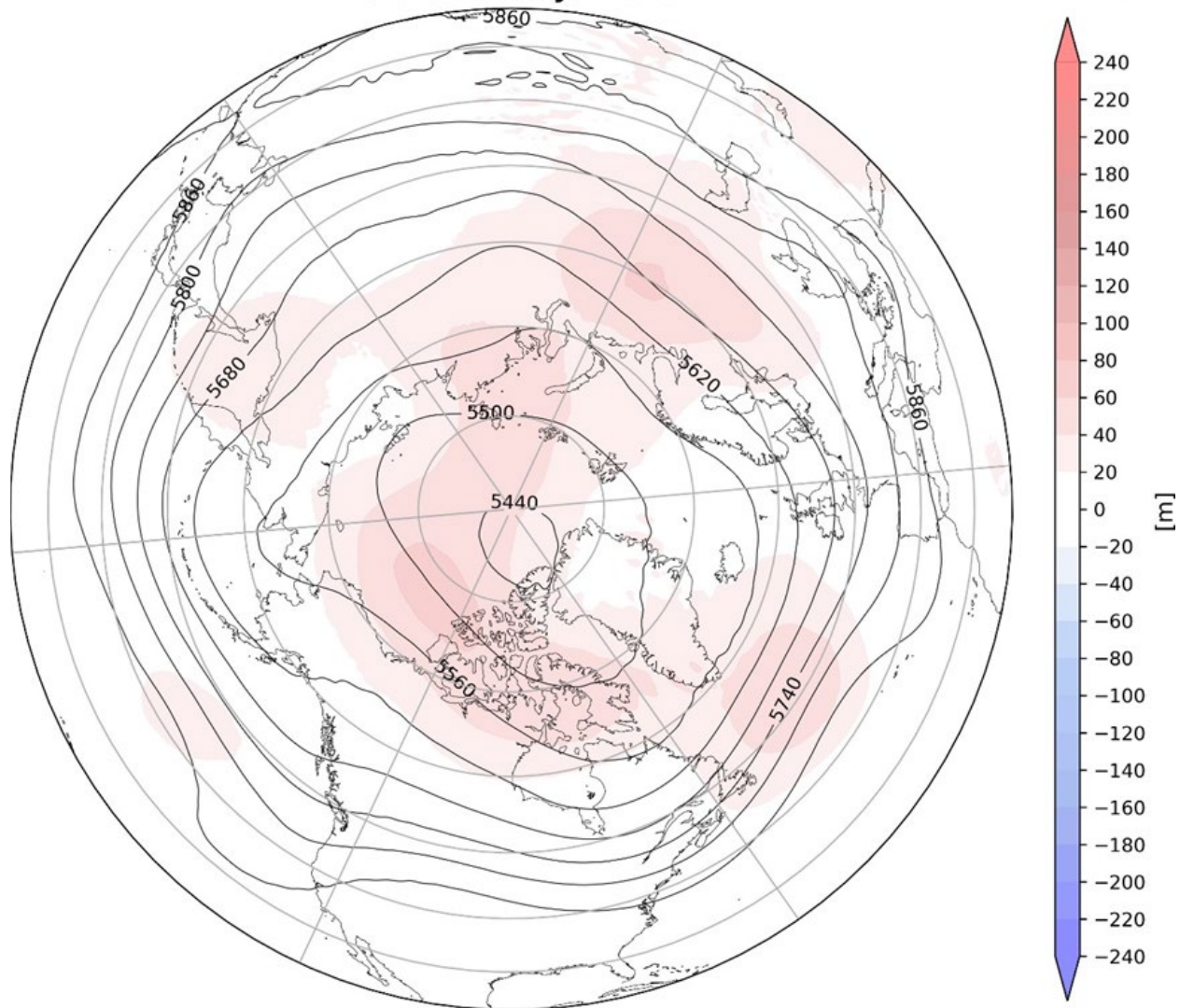


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2023. The forecasts are from the 00Z 3 July 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for August (**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 Urals, the Barents-Kara-Laptev Seas, the Beaufort Sea, Eastern Asia and south of Greenland with troughing across Western Europe, Central Asia, Eastern Siberia, Alaska, Eastern Canada and the Eastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Southern and Eastern Europe, much of Asia, Northern and Western Canada, the Western and Southern US with seasonable to relatively cool temperatures across the Western Europe, Kazakhstan, Southeastern Canada and the Northcentral US (**Figure 13**).

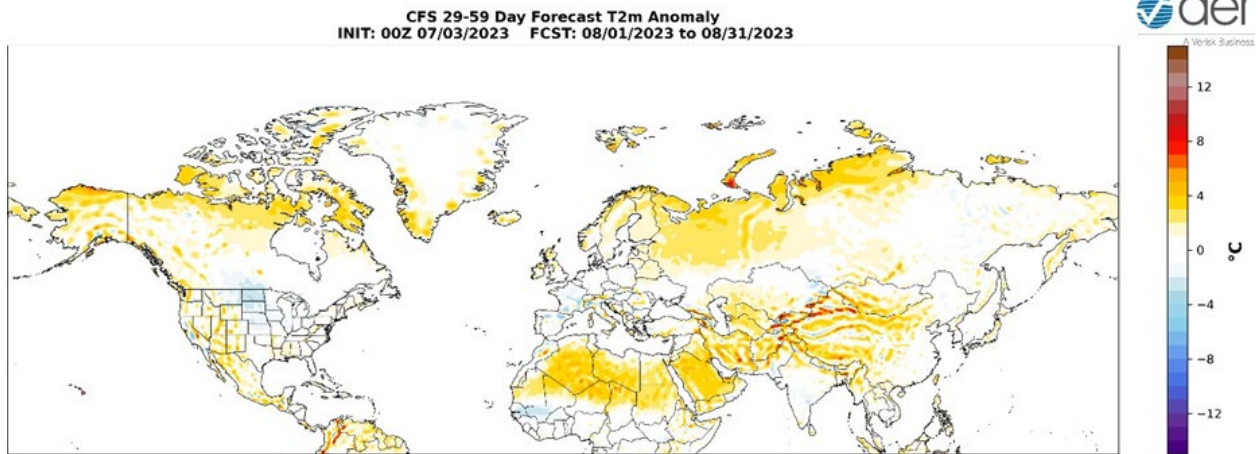


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for August 2023. The forecasts are from the 00Z 3 July 2023 CFS.

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.

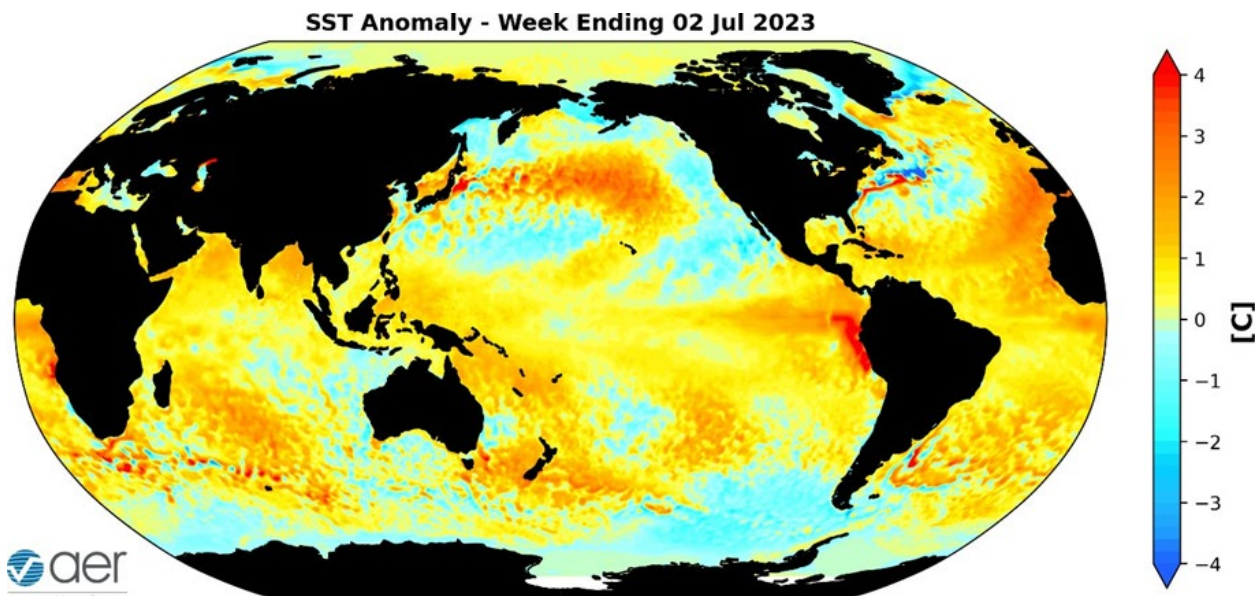


Figure 14. The latest weekly-mean global SST anomalies (ending 2 July 2023). Data from NOAA OI High-Resolution dataset.

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.

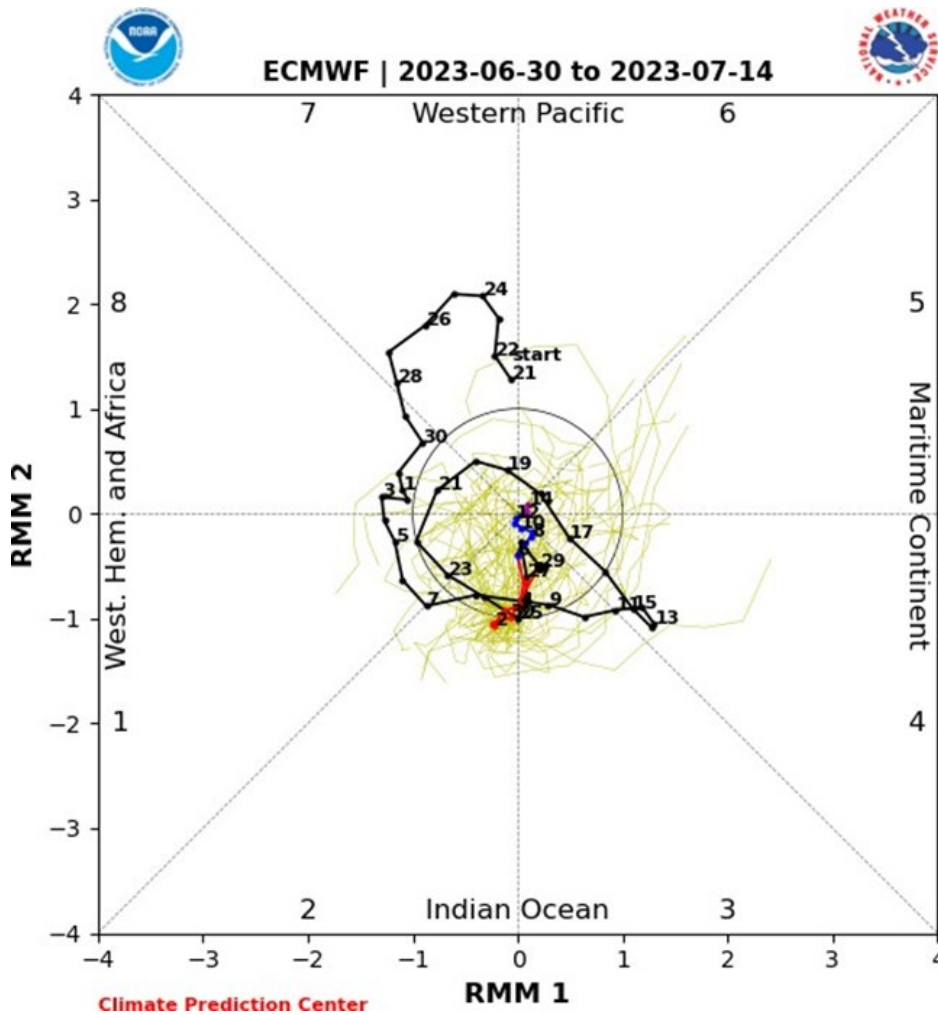


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 30 June 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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