Arctic Oscillation and Polar Vortex Analysis and Forecasts

July 16, 2025

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. In late 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 near neutral and is predicted to remain neutral to positive the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mixed and are predicted to remain mostly mixed to positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently negative as positive pressure/geopotential height anomalies dominate across Greenland and the NAO is predicted to slowly trend positive towards neutral the next two weeks as positive pressure/geopotential height anomalies are predicted to slowly weaken across Greenland.
- The next two weeks, ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies extending across the North Atlantic into Central Europe with ridging/positive geopotential height anomalies across Southern and Northern Europe. This pattern will support widespread normal to above normal temperatures across Southern and Northern Europe including the UK with normal to below normal temperatures in Central Europe the next two weeks. However, by the last week of July, troughing and cooler temperatures from Northwest Russia will spread across Northern Europe.
- The general pattern across Asia the next two weeks is troughing/negative geopotential height anomalies across Western Russia and Western Siberia with ridging/positive geopotential height anomalies across much of the rest of Asia. This pattern favors normal to below normal

temperatures across Western Russia and extending into Western Siberia with normal to above normal temperatures across much of the remainder of Asia.

- Ridging/positive geopotential height anomalies are predicted to be centered over the Gulf of Alaska and the Eastern United States (US) with troughing/negative geopotential height anomalies across Central Canada and the Northcentral US the next two weeks. This patten will favor widespread normal to above normal temperatures across Western Canada and the Western and Eastern US with normal to below normal temperatures across Central and Eastern Canada and the US Plains the next two weeks. However July could end on a hot note for much of the US.
- I discuss the Northern Hemisphere (NH) summer circulation and temperature forecast in this week's blog.

Plain Language Summary

Widespread warmth dominated the land areas of the Northern Hemisphere (NH) for the first half of summer especially across Western and Southern Europe and Central Asia (see **Figure**). Warmth has also dominated western and eastern North America. The biggest exceptions have been relatively cool temperatures in Central Canada, the Central US, Central and Eastern Siberia and India and with close to seasonable temperatures in Scandinavia and Northeastern Europe and Western Russia (see **Figure**). Seems like for the most part the trend is your friend. For the upcoming week the warm temperatures will continue across most of Europe with the exception of Central Europe (see **Figure 3**). Warm temperatures will also continue across the Western and Eastern US (see **Figure 3**). For the end of the month warm temperatures will dominate Southern Europe and the US with some cooler temperatures across Northern Europe and Canada (see **Figure 9**).

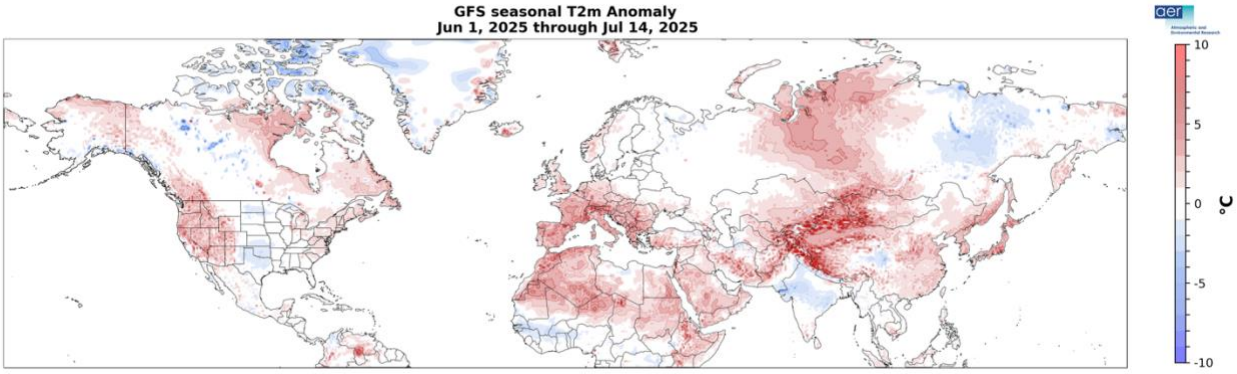

Figure. Estimate of the observed surface temperatures (°C; shading) from 01 Jun to 14 Jul 2025 based on GFS initializations and the GFS forecast from the 23 June 2025 run.

Impacts

Still in Germany so more disruptions to the publication of the blog in the coming weeks. Though lucky for me, Germany is sandwiched between warmer weather to the north and south with relatively pleasant temperatures.

Once again nothing profound in today's blog. As I have been describing in general, the two-week forecast for the mid-tropospheric circulation is characterized by low pressure centered near the North Pole and high latitude ridging along the periphery of the Arctic (see **Figure i**). This pattern generally favors widespread warmth across both the Eurasian and North American continents (see **Figures 3, 6** and **9**). A pattern that I am fond as referring to as the "ring of fire" summer pattern. As can be seen in the animation of **Figure i**, the biggest heat dome this week will be focused across Scandinavia. But lucky for me in Germany, low pressure from the North Atlantic will undercut the heat dome to bring more comfortable temperatures but also unsettled weather. However, with time the domain high pressure will develop over the Beaufort Sea and may even slide to near the North Pole, at least placing a pause on this ring of fire summer pattern.

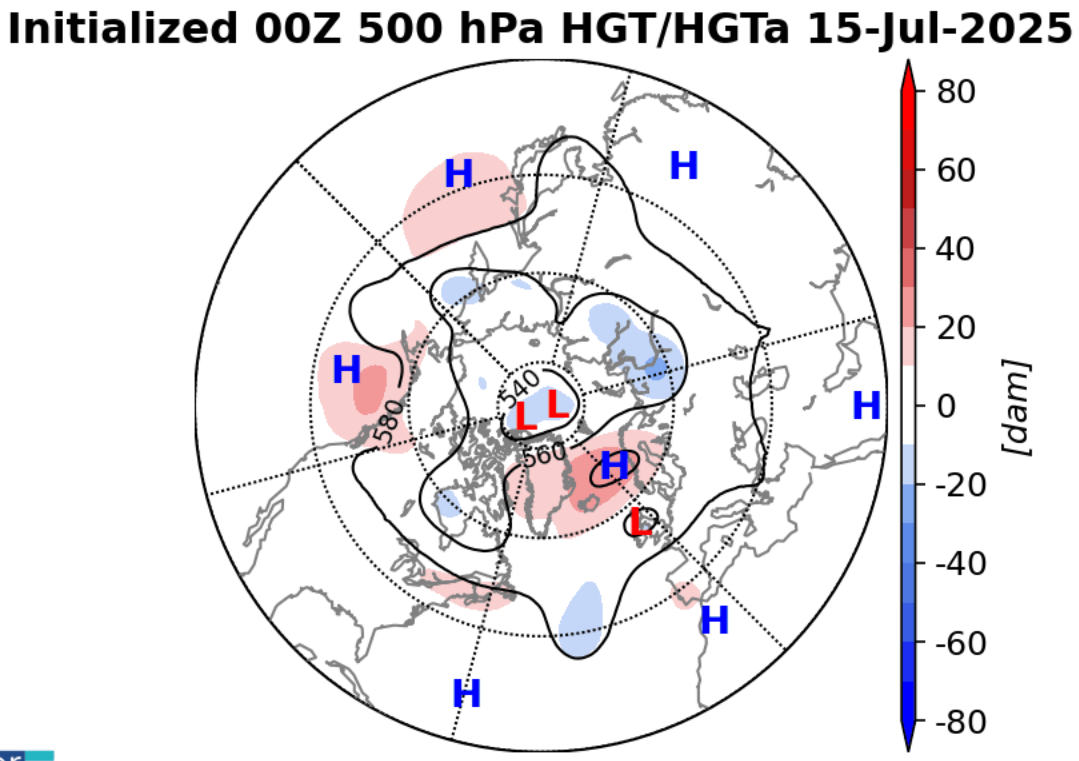

Figure i. Initialized 500 mb geopotential heights (dam; contours) and decameter anomalies (dam; shading) across the Northern Hemisphere for 23 Jun 2025 and forecasted from 15 Jul to 30 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS model ensemble.

Otherwise seems like the overall pattern is close to “what you see is what you get.” It has been very warm in Western and Southern Europe. The overall warm pattern in Europe will continue with the exception fo Central Europe. Eventually the heat wave across Scandinavia will abate as cooler air now in Western Russia spreads westward into Northern Europe.

Warm temperstures are also predicted to continue in the Eastern and Western US but eventually a sizeable heat dome is predicted over the interior of the US and the end of July looks hot for much of the US.

This summer looks to resemble the decadal trends in the previous blog. Western Canada and the Western US are on track for a hot summer. A secondary maximum in warming trends along the US East Coast is also consistent with recent trends. In contrast, it has been relatively cool in the Plains of the US and Canada and into parts of the Southeastern US. This region is referred to as the “warming hole” and this summer will likely once again justify the label.

Europe is one of the fastest warming regions on the globe and this summer will not be any different. However, decadal warming has been focused in Eastern Europe and Western Russia. So far that is not the case with warming focused more in Western and Southern Europe. The NAO did turn negative with some Greenland blocking that is bringing some cooler weather. But it won’t be enough to alter another hot summer for Europe though the warmest anomalies will be in Western not Eastern Europe this summer.

A relatively warm East Asia and a relatively cool Siberia or at least Eastern Siberia also looks on track. So, across the Northern Hemisphere “what’s past is prologue” for summer temperatures once again.

If anyone needs a break, or at least a distraction, from the dog days of summer, we have a new paper just published on winter temperature trends across the US and why cooling trends have shifted west over the past decade or so. Unlike in summer where I am not sure of the summer temperature trend pattern (though it is mostly just different degrees of warming), we attribute the winter temperature trends to variations in polar vortex behavior where the polar vortex becomes elongated in shape or stretches: Agel et al. 2025.

Near-Term

This week

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

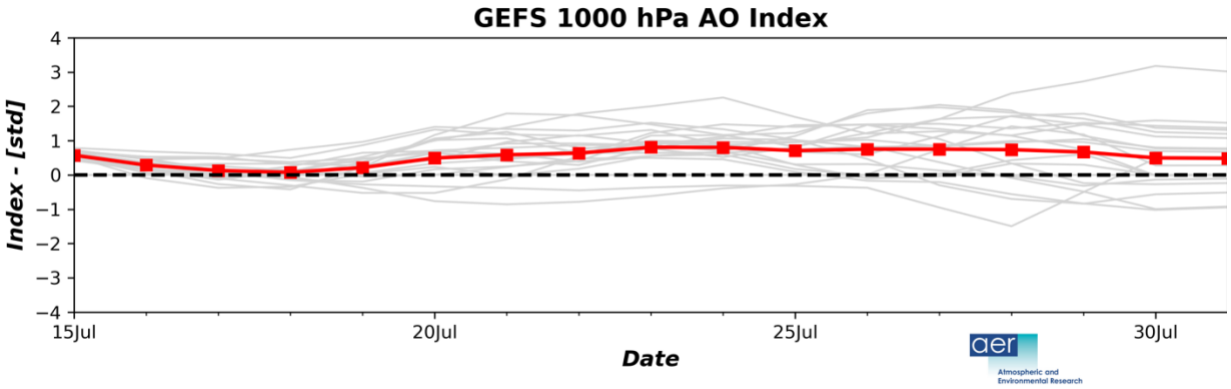

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 15 July 2025 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble mean AO index given by the red line with squares.

This week predicted ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies to the south that will extend into Central Europe with ridging/positive geopotential height anomalies across Northern and Southern Europe (**Figure 2).** This pattern will favor normal to above normal temperatures across Northern and Southern Europe including the UK with normal to below normal temperatures across Central Europe this period (**Figure 3**). This week the predicted pattern across Asia is troughing/negative geopotential height anomalies across Western Russia with ridging/positive geopotential height anomalies across much of the rest of Asia except for some weak troughing in East Asia (**Figure 2**). This pattern favors normal to above normal temperatures widespread across Southern, Central and Eastern Asia including Afghanistan with normal to below normal temperatures across Western Russia, Northeast China. Pakistan and northern India **(Figure 3**).

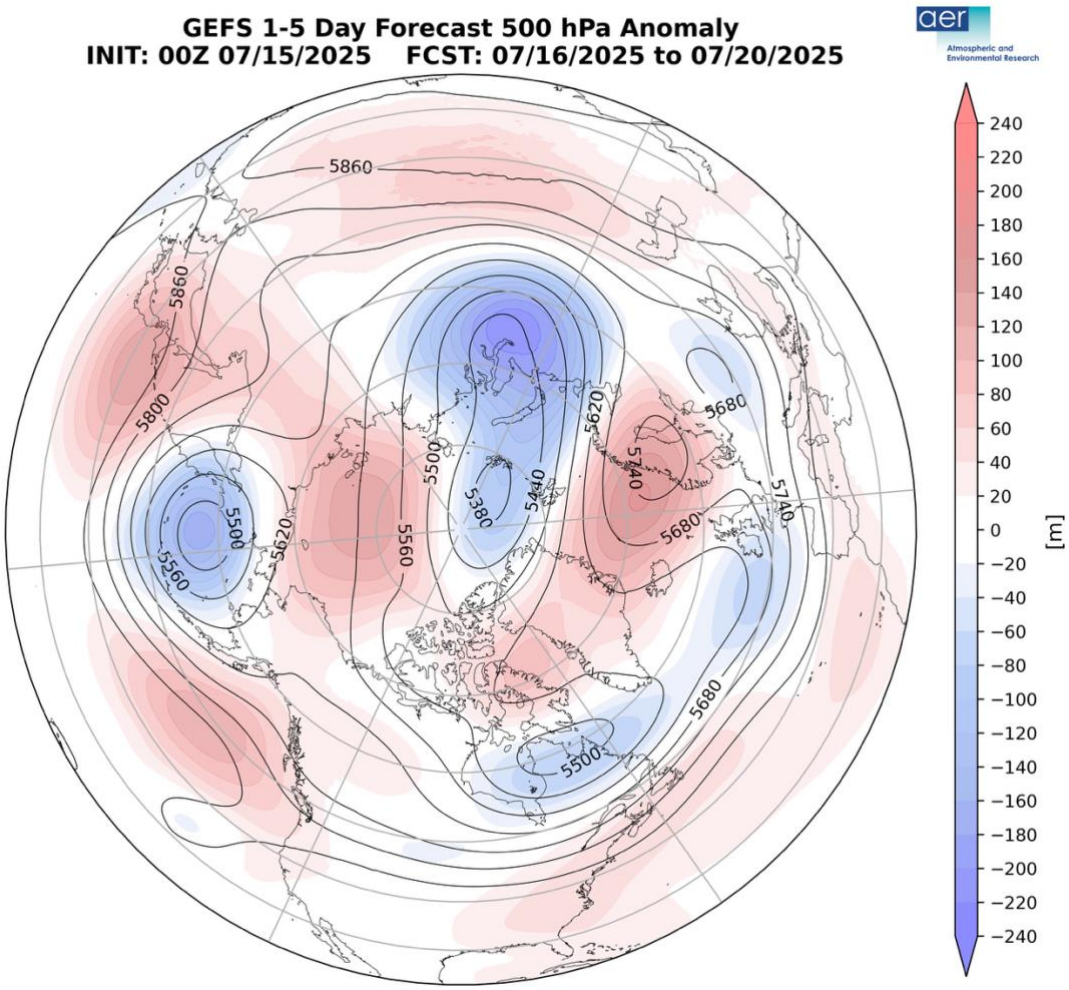

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 16 Jul to 20 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

This week ridging/positive geopotential height anomalies are predicted to be centered in the Beaufort Sea and the Eastern US with troughing/negative geopotential height anomalies across Alaska and the Western US (**Figure 2**). This pattern favors normal to above normal temperatures across much of Canada and the Eastern US with normal to below normal temperatures limited to Alaska into the Western US. (**Figure 3**).

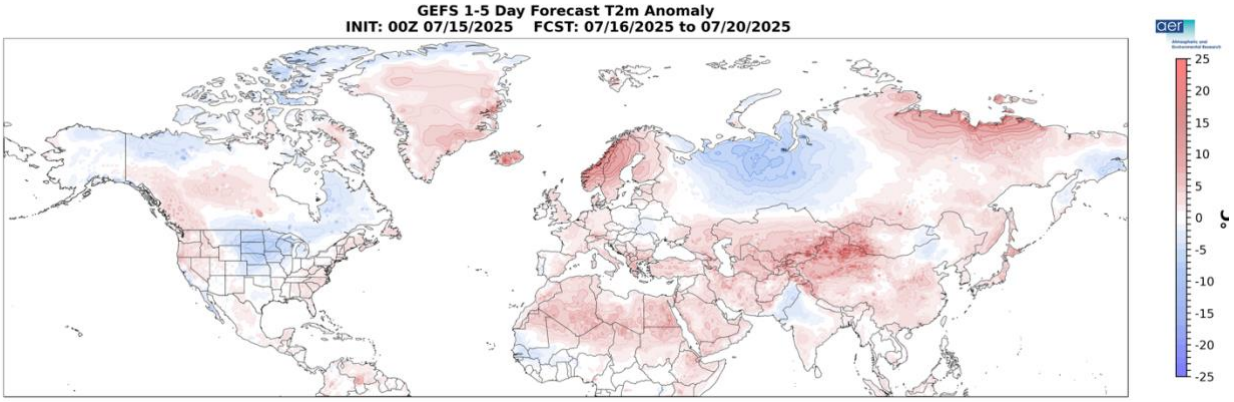

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 16 Jul to 20 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Troughing will support new rainfall across the UK, Eastern Europe into Western Russia, Siberia, parts of Southeast Asia and the Tibetan Plateau with otherwise mostly dry conditions widespread across Europe and Asia, with near normal precipitation across Afghanistan and Pakistan this week (**Figure 4**). Troughing will support new rainfall across parts of Western Canada and the Central and Eastern US with otherwise mostly dry conditions widespread across Canada and the US this week (**Figure 4**).

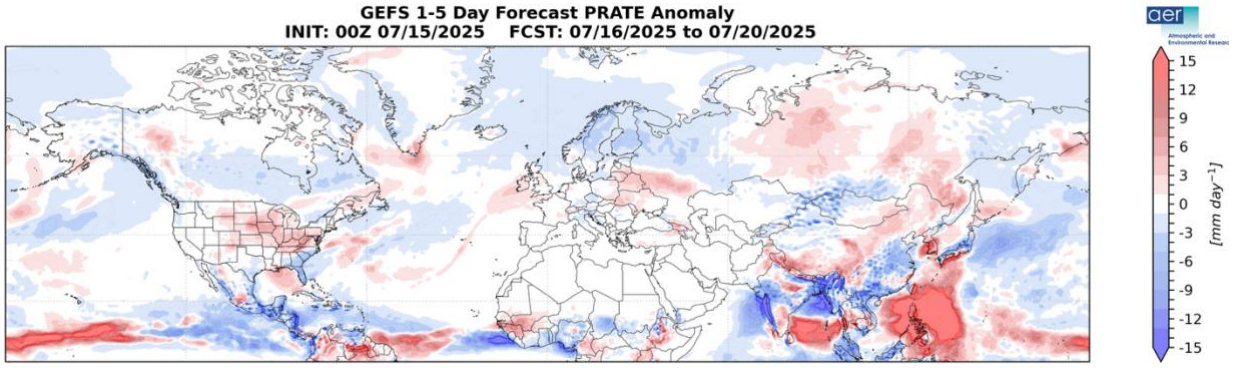

Figure 4. Forecasted rainfall (mm/day; shading) from 16 Jul to 20 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Near-Mid Term

Next week

With geopotential height anomalies becoming mostly negative across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO will likely turn positive this period (**Figure 1**). With predicted positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely be negative this period.

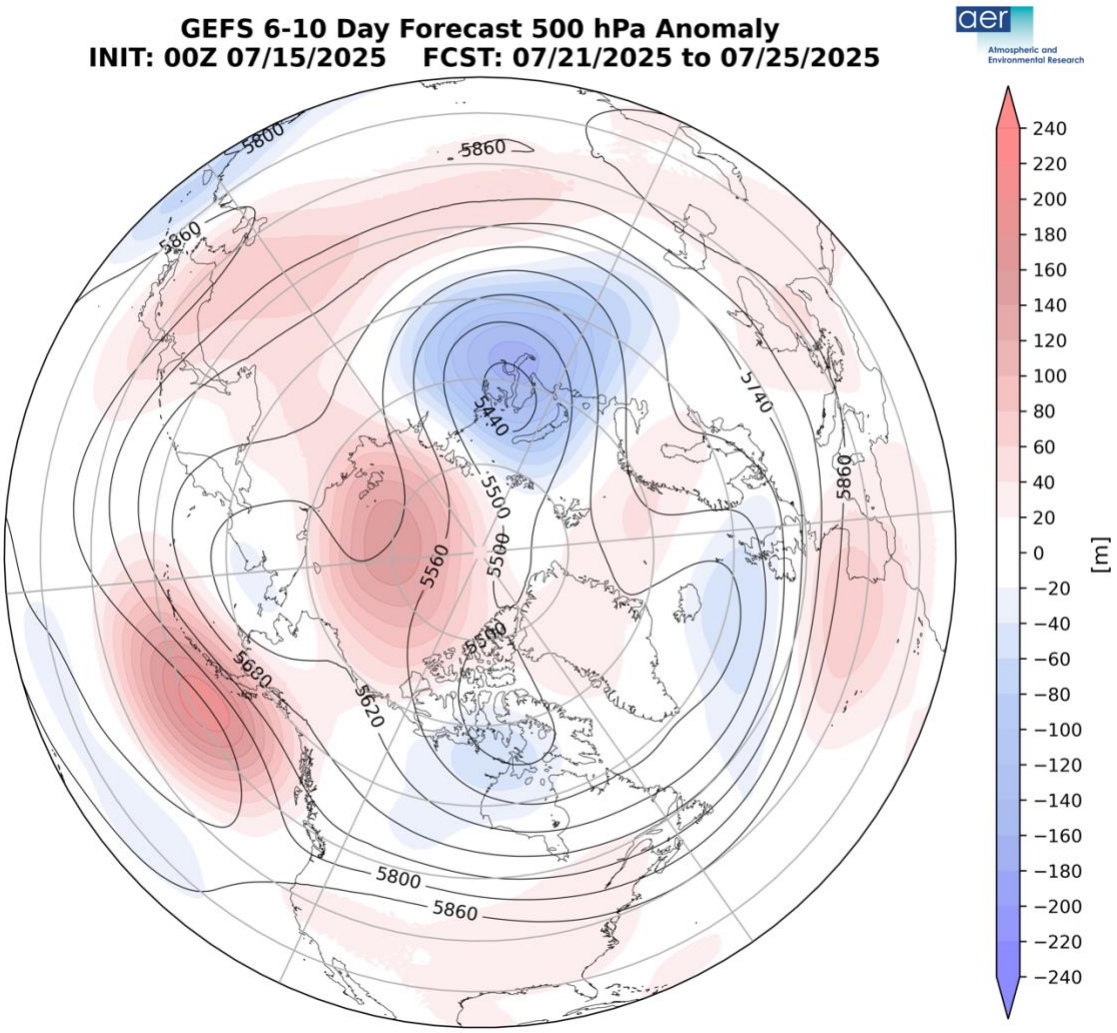

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 21 Jul to 25 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Persistent ridging/positive geopotential height anomalies across Greenland will continue to support troughing/negative geopotential height anomalies across the North Atlantic that extend into Central Europe with ridging/positive geopotential height anomalies across Southern and Northern Europe this period (**Figure 5**). This pattern will favor normal to above

normal temperatures across Northern and Southern Europe including the UK with normal to below normal temperatures across Central Europe this period (**Figure 6**). Ridging/positive geopotential height anomalies across Greenland will support troughing/negative geopotential height anomalies in Western Russia extending into Western Siberia with ridging/positive geopotential height anomalies Southern Central and East Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Central, Eastern and Southern Asia including Afghanistan and Pakistan with normal to below normal temperatures Western Russia and Western Siberia this period (**Figure 6**).

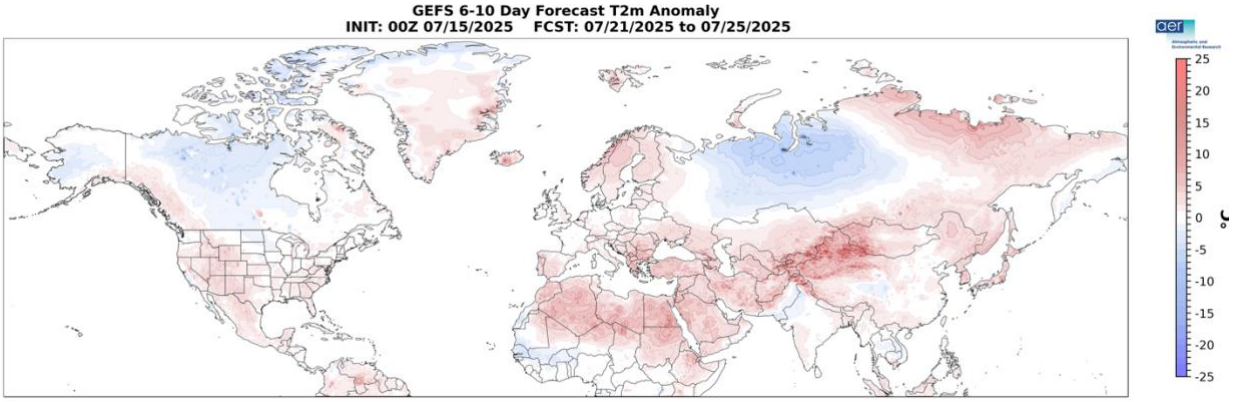

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 21 Jul to 25 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

The predicted pattern across North America is ridging/positive geopotential height anomalies centered over the Gulf of Alaska and much of the US with troughing/negative geopotential height anomalies limited to Central Canada this period (**Figure 5**). This pattern will favor normal to above normal temperatures across Western Canada and much of the US with normal to below normal temperatures limited to Alaska, Central and Eastern Canada and the US Northern Plains (**Figure 6**).

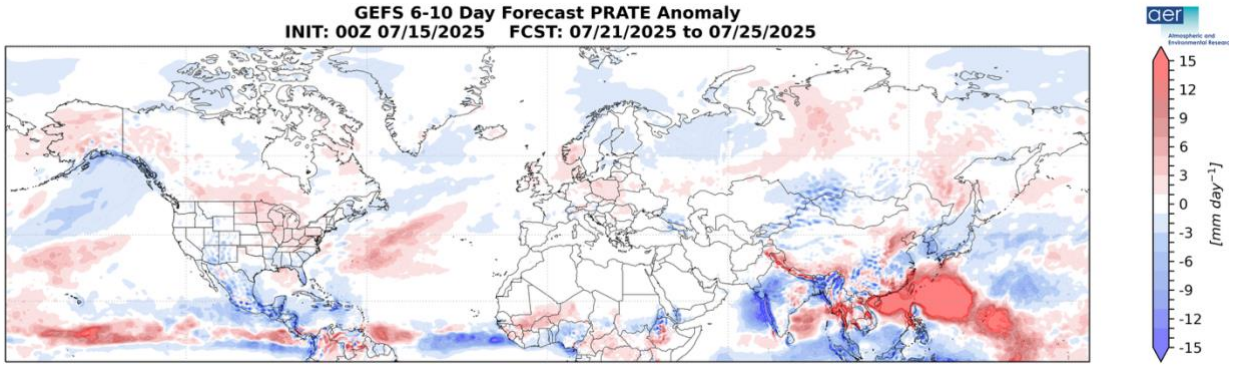

Figure 7. Forecasted precipitation rate (mm/day; shading) from 21 Jul to 25 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Troughing will support new rainfall near the Baltics, Siberia, Northeastern Asia, parts of Southeast Asia and the Tibetan Plateau including northern Pakistan with otherwise mostly dry

conditions widespread across Europe and Asia and near normal across Afghanistan and Pakistan this week (**Figure 7**). Troughing will support new rainfall across Alaska, Western Canada and the Eastern US with otherwise mostly dry conditions widespread across Canada and the Western US this week (**Figure 7**).

Mid Term

Week Two

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

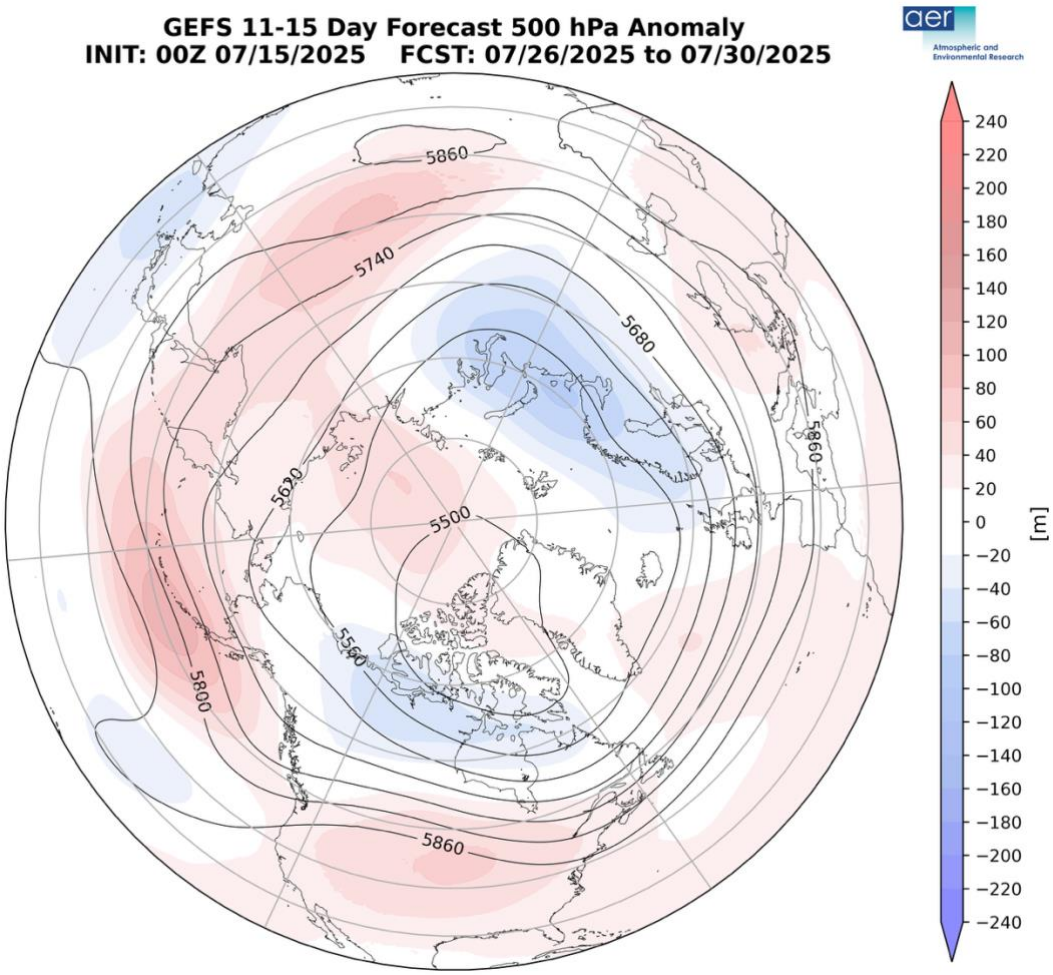

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 26 Jul to 30 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Persistent troughing/negative geopotential height anomalies across Western Russia will spread into Northern Europe with ridging/positive geopotential height anomalies across Southern Europe this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Southern Europe with normal to below normal temperatures across Northern Europe including the UK this period (**Figures 9**). Troughing/negative geopotential height anomalies are predicted to persist across Western Russia and extending into Western Siberia with ridging/positive geopotential height anomalies across Central, Eastern and Southern Asia this period (**Figure 8**). The predicted pattern favors normal to below normal temperatures across Western Russia, western Kazakhstan, Western Siberia and northern India with normal to above normal temperatures across Central, Southern and Eastern Asia including Pakistan and Afghanistan with this period (**Figure 9**).

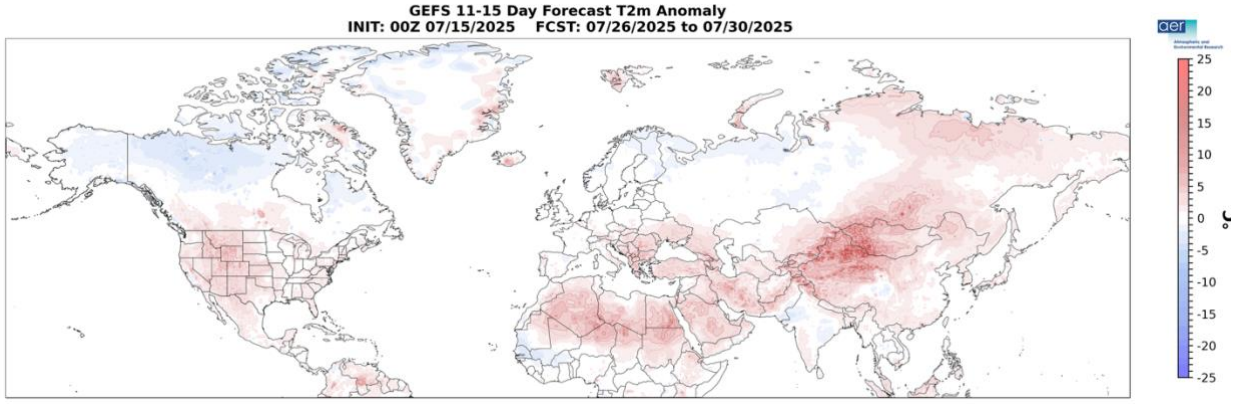

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 26 Jul to 30 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to become centered in the Central US with weak troughing/negative geopotential height anomalies spreading across Alaska and Northern Canada this period (**Figure 8**). This pattern supports widespread normal to above normal temperatures across much of Southern Canada and the US with normal to below normal temperatures across Alaska and Northern Canada this period (**Figure 9**).

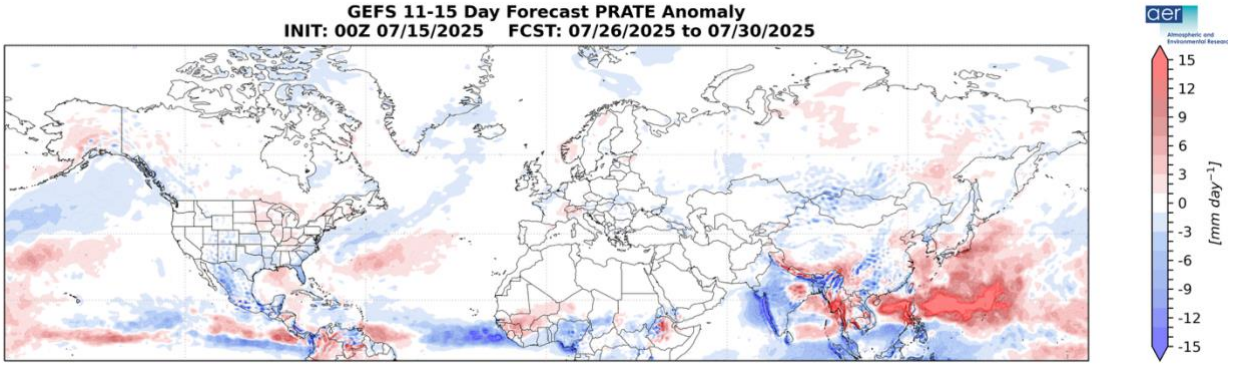

Figure 10. Forecasted precipitation rate (mm/day; shading) from 26 Jul to 30 Jul 2025. The forecasts are from the 00Z 15 Jul 2025 GFS ensemble.

Troughing will support new rainfall across Scandinavia, Siberia, parts of Northeast Asia, Northern India and the Tibetan Plateau with otherwise mostly dry conditions widespread across Europe and Asia and near normal precipitations in Pakistan and Afghanistan this period (**Figure 10**). Troughing will support new rainfall across Alaska, Western Canada and parts of the Central and Eastern US with otherwise mostly dry conditions widespread across Canada and the US this period (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs in the upper stratosphere and the lower troposphere and warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). The cold/negative PCHs are predicted to persist in the stratosphere and the lower troposphere over the next two weeks with warm/positive PCHs weakening in the lower stratosphere in late July.

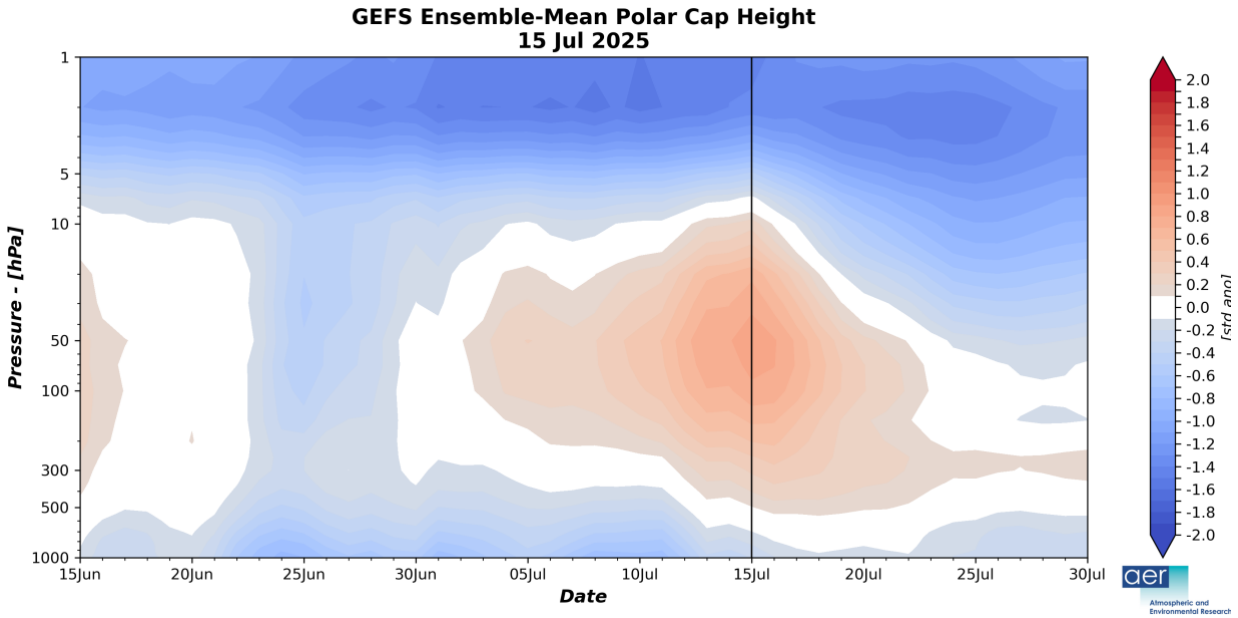

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 15 Jul 2025 GFS ensemble.

The predicted cold/negative PCHs in the lower troposphere for the next two weeks (**Figure 11**) are consistent with the predicted neutral to positive surface AO the next two weeks (**Figure 1**). For now, no signs of a change in this pattern.

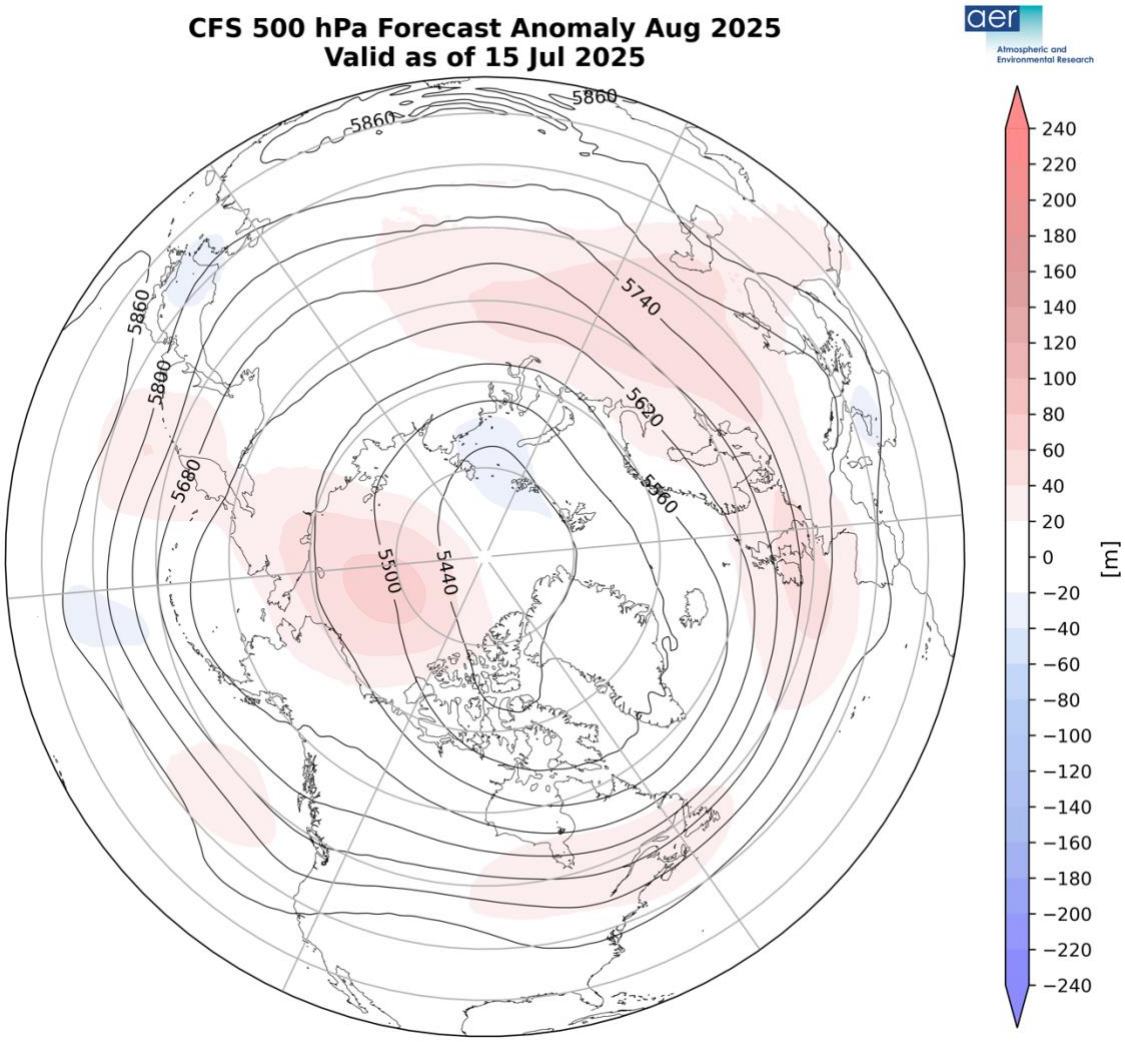

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for August 2025. The forecasts are from the 00Z 15 Jul 2025 CFS.

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 centered over Northern Europe, Western Asia, Eastern Siberia, the Beaufort Sea and along the US-Canadian border, with troughing across Southern Europe, East Asia, along the West Coasts of Canada and the US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Europe, much of Asia, including Central Asia and the Tibetan Plateau, Pakistan, Afghanistan and Eastern Siberia, Alaska, much of Canada, the Western and Northeastern US with seasonable to relatively cool temperatures across Southern Europe, Kazakhstan, Central Siberia, Eastern China, the US Plains and into the Southeastern US (**Figure 13**).

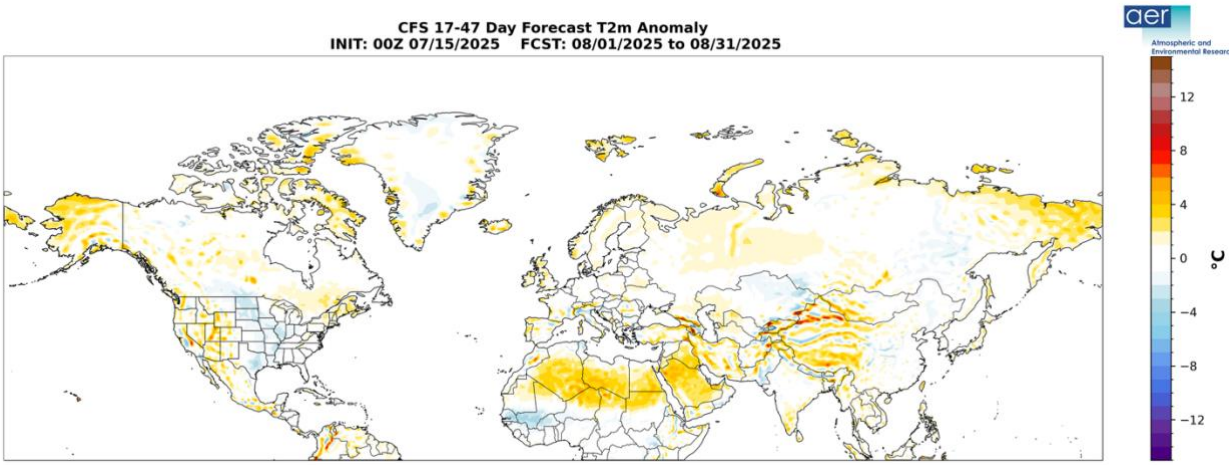

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for August 2025. The forecasts are from the CFS 00Z 15 Jul 2025.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are now slightly above normal, on either side of the Dateline, indicating that the winter La Niña event is gone (**Figure 14**) and neutral conditions are expected throughout the summer. Warming of SSTs along the equator near South America are suggestive of an emerging El Niño but for now is not predicted. Instead, current forecasts show large spread and plenty of uncertainty and mostly favor a continuation of neutral conditions. Observed SSTs across the NH remain well above normal especially in the central North Pacific centered on the Dateline and the western North Pacific and much of the North Atlantic with the exception near the Canadian Maritimes and the Northeastern US and extending south of Iceland, though below normal SSTs exist regionally especially in the South Pacific.

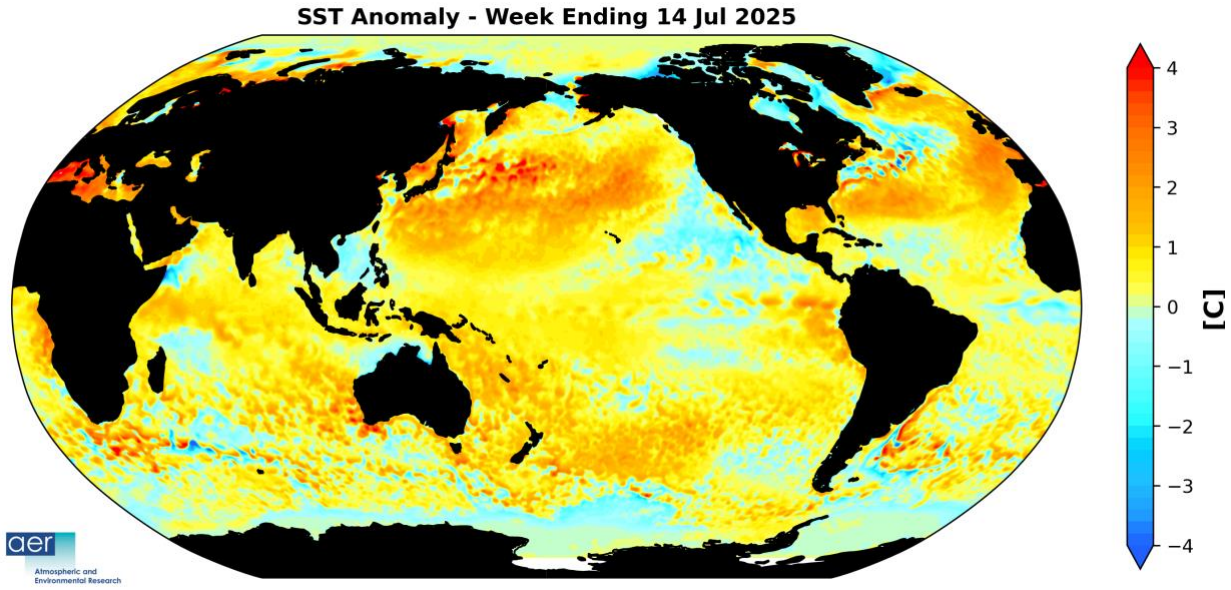

Figure 14. The latest daily-mean global SST anomalies (ending 14 Jul 2025). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is in phase five and is predicted to move into phases six and seven before weakening to where no phase is favored (**Figure 15**). Phases five through seven favor ridging in the Gulf of Alaska and western Canada with troughing in eastern North America therefore, it seems to me that the MJO is having some influence on North American weather for the next two weeks. But admittedly this is outside of my expertise.

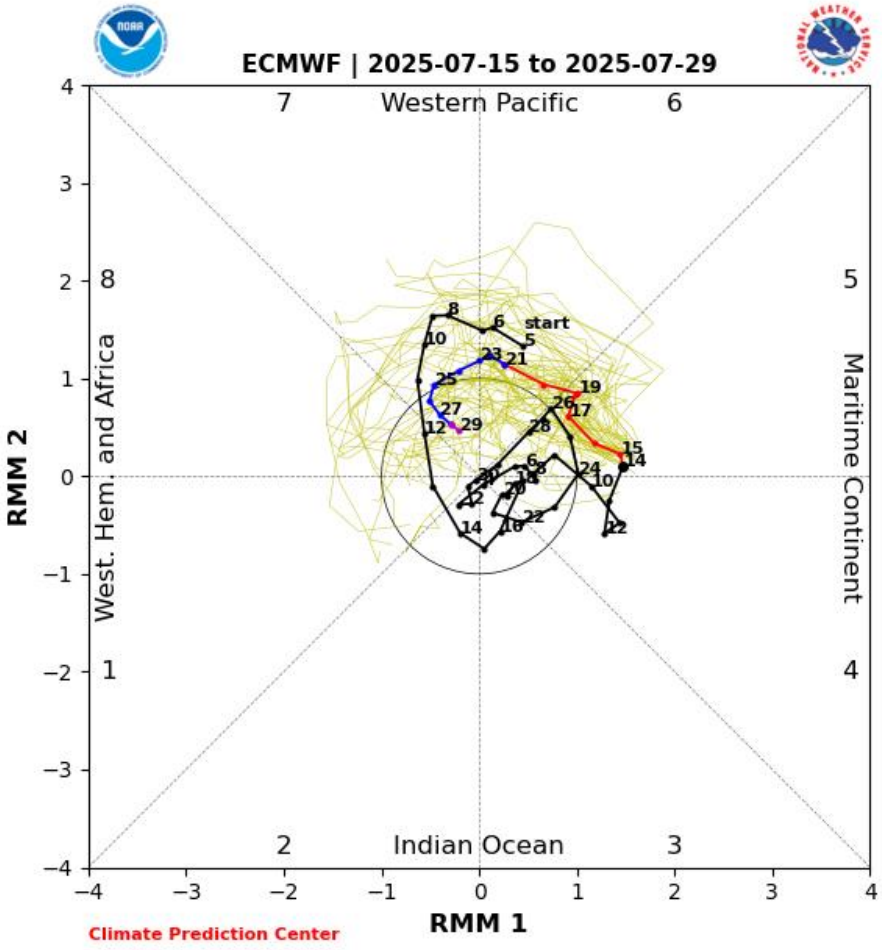

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 15 Jul 2025 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model 'spread' is denoted by the gray shading. Sector numbers indicate 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/ecmf.shtml

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We appreciate your taking the time to read the public Arctic Oscillation blog from Dr. Judah Cohen and the AER Seasonal Forecasting team.

Dr. Cohen's detailed monthly seasonal forecast, sCast, is also available. sCast provides a monthly 30-60-90-180-day outlook into temperature and precipitation, solar flux and wind anomalies across the globe, and regional population weighted cooling and heating degree forecasts for the US.

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