Arctic Oscillation and Polar Vortex Analysis and Forecasts

Jun 09, 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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Summary

- The Arctic Oscillation (AO) is currently positive and is predicted to trend negative towards neutral as pressure/geopotential height anomalies across the Arctic are currently mostly negative and are predicted to turn more positive over the next two weeks. The North Atlantic Oscillation (NAO) is currently positive as negative pressure/geopotential height anomalies dominate across Greenland and the NAO is predicted to trend negative towards neutral the next two weeks as pressure/geopotential height anomalies are predicted to become increasingly positive across Greenland.
- This week, troughing/negative geopotential height anomalies across Greenland will force ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Eastern Europe and then next week strengthening ridging across Greenland will favor more widespread troughing across Europe. This pattern will support widespread normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe this week and then next week normal to below normal temperatures in Eastern Europe will slowly spread westward into Central Europe.
- This week, ridging/positive geopotential height anomalies will dominate Western Asia with weak troughing/negative geopotential height anomalies centered in East Asia. Then next week troughing will deepen across Western Asia with ridging becoming centered in Central

Asia. This pattern favors normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures limited to pockets in Central Asia. Then next week normal to below temperatures will become more widespread across Western Russia and Siberia with normal to above normal temperatures across Central and Southern Asia.

- The general pattern across North America the next two weeks is ridging/positive geopotential height anomalies across western North America with troughing/negative geopotential height anomalies across Eastern Canada and the Eastern United States (US). This patten will favor widespread normal to above normal temperatures across Alaska, Western Canada and the Western US the next two weeks with normal to below normal temperatures spreading from Central Canada and the Eastern US. However next week as the eastern North America trough weakens, above normal temperatures will become more widespread.
- I discuss the Northern Hemisphere (NH) summer temperature forecast in this week's blog.

Plain Language Summary

Widespread warmth dominated the land areas of the Northern Hemisphere (NH) this spring especially across Eurasia (see **Figure**). The biggest exception has been Canada and close to the Dateline (see **Figure**). In the Impacts section I present the Northern Hemisphere (NH) summer temperature forecast from one suite of dynamical models and the AER seasonal forecast model (**Figures ii** and **iii**). Generally, the forecast for the summer can be summarized as a continuation of the overall relatively warm pattern.

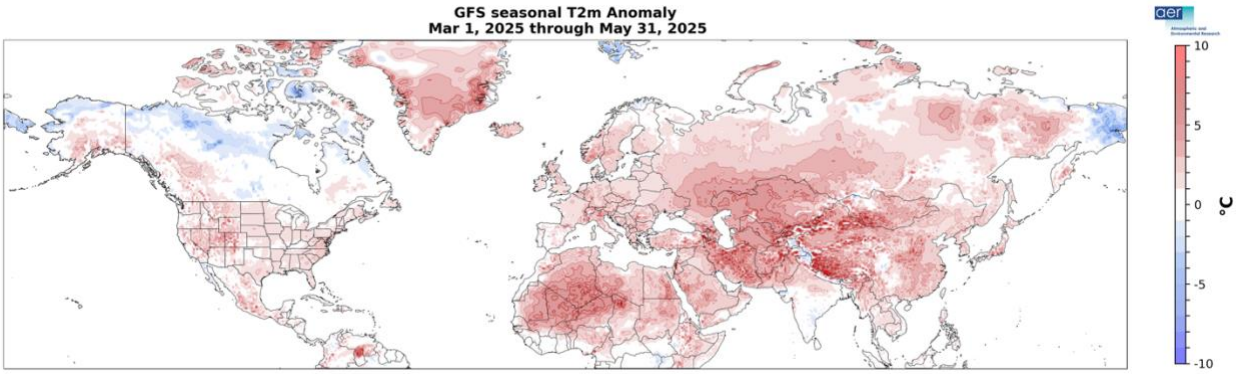

Figure. Estimate of the observed surface temperatures (°C; shading) from 01 Mar to 31 May 2025 based on GFS initializations and the GFS forecast from the 1 June 2025 run.

Impacts

My apologies but the blog was scheduled to be posted last week but I got sick, so it is delayed by one week.

With no more guidance from the polar vortex or its lingering influence my focus is solely on the troposphere. 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.

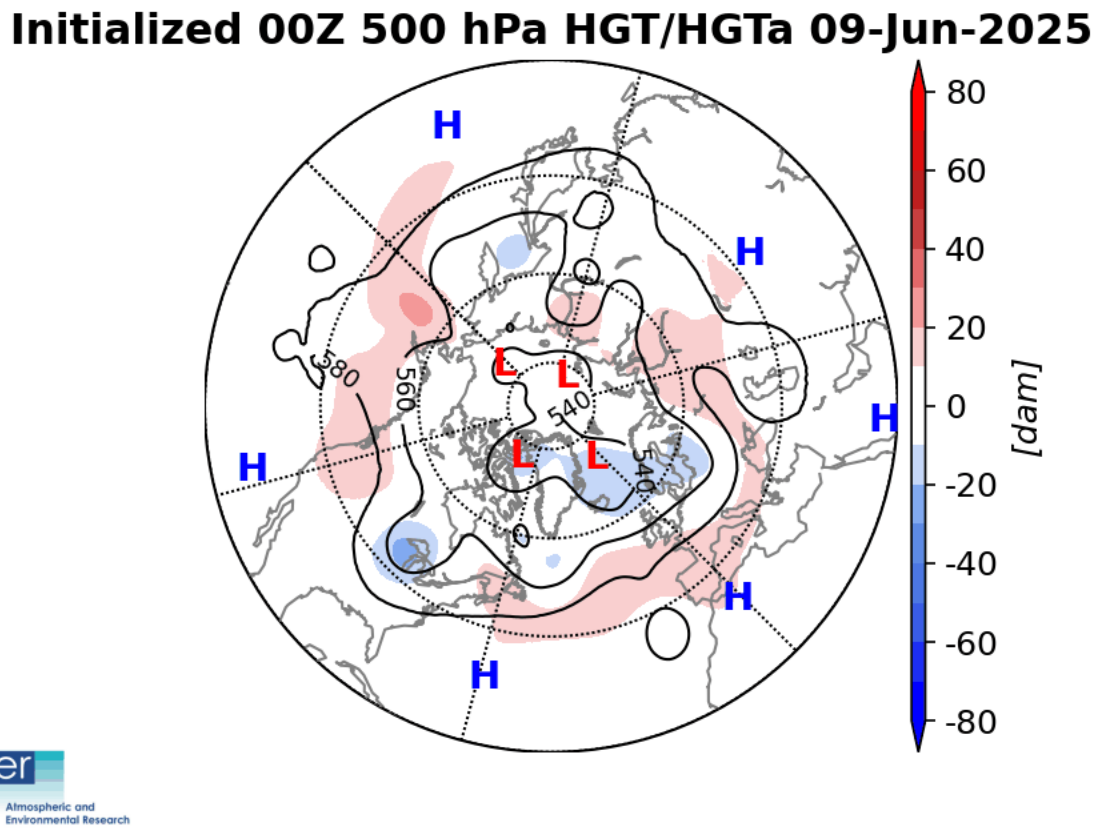

Figure i. Initialized 500 mb geopotential heights (dam; contours) and decameter anomalies (dam; shading) across the Northern Hemisphere for 09 Jun 2025 and forecasted from 10 Jun to 14 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS model ensemble.

Of course, there are exceptions especially downstream of the centers of high latitude high pressure systems. The biggest exception over the next two weeks is troughing and relatively cool temperatures predicted for Western Russia and Eastern Europe in part due being downstream from ridging in Western Europe. Western Russia has been a region that has experienced either near normal temperatures or even slightly below normal temperatures in recent summers,

including last summer (but not in summer 2023). So it will be interesting to see if this pattern of warm Europe, cool Western Russia, warm Central Asia can persist.

With that being said, here is the summer temperature anomaly forecast, first from C3S ensemble suite. The forecast is for universal above normal temperatures with the largest departures over Europe, Siberia, Central Asia, the Northern US and Southern Canada. Regions with a forecast of relatively warm temperatures but not as warm are near the Urals, East Asia and the Southern US. Unlike in winter, the summer forecast from the dynamical models is more believable in my opinion. The "valley" in above normal temperatures centered on the Urals is consistent with recent summer trends. Never ceases to amaze me, how fast Europe has been warming in recent decades and at least based on the C3S forecast, that trend is likely to continue. However, I do note that the past two summers, Northwestern Europe has been relatively cool and may hinge on the amount of Greenland blocking this summer.

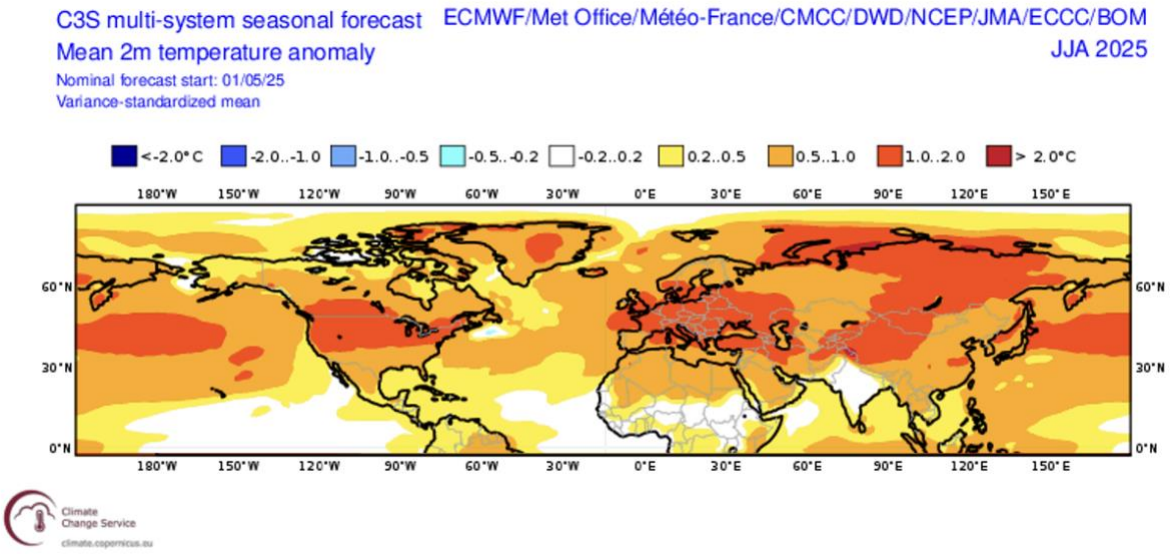

Figure ii. Predicted surface temperature anomalies (°C; shading) across the Northern Hemisphere for June, July and August 2025 from the C3S suite of models. Models used to create multi-model mean shown in title of the plot. The forecast was downloaded from: https://climate.copernicus.eu/charts/packages/c3s_seasonal/.

In the past I have also included the NMME ensemble suite of models but not that interesting to me. It also predicts universal warmth, with little regional variation and even warmer than the C3S. For those interested the NMME forecast can be found here.

Next, I include the AER summer forecast as well. The AER model uses four predictors: El Niño/Southern Oscillation (ENSO), multi-annual temperature trends and spring temperature and soil moisture anomalies. It also predicts widespread warmth with some exceptions, including Northwestern Europe, eastern Siberia, parts of Alaska and the West Coast of Canada. I don't believe the large area of below normal temperatures in Central Asia, especially western

China. I think that must be an artifact of NCEP/NCAR reanalysis. Neither forecast predicts below normal temperatures in the US but last summer it was relatively cool east of the Rockies. There is a noted "warming hole" in the Central and Southeastern US, and it wouldn't surprise me if a region of below normal temperatures does show up in the Eastern US this summer.

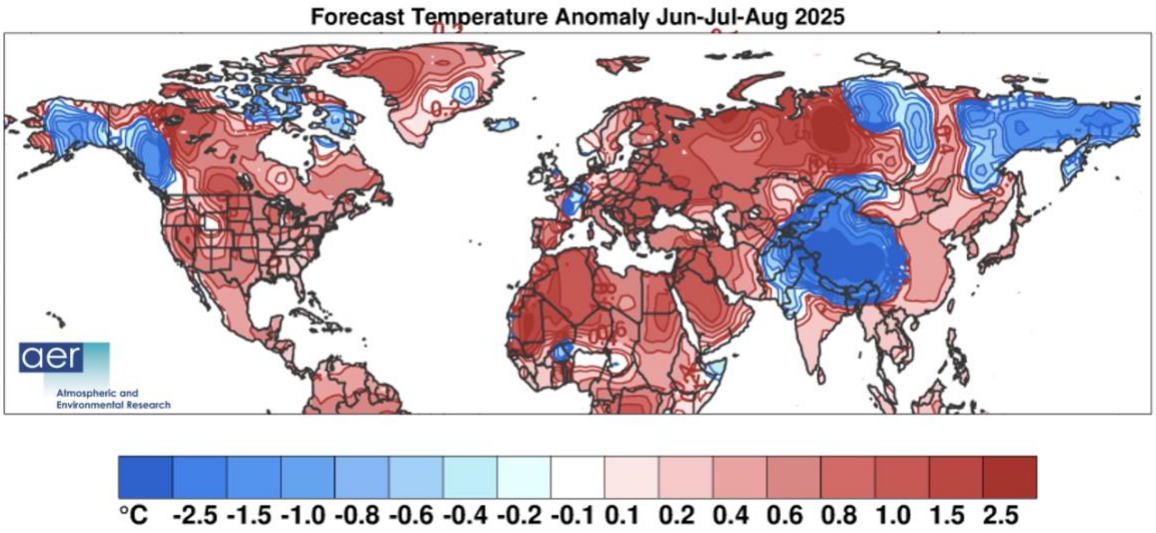

Figure iii. Predicted surface temperature anomalies (°C; shading) across the Northern Hemisphere for June, July and August 2025 from the AER seasonal forecast model. Models used to create multi-model mean shown in title of the plot.

Near-Term

This week

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

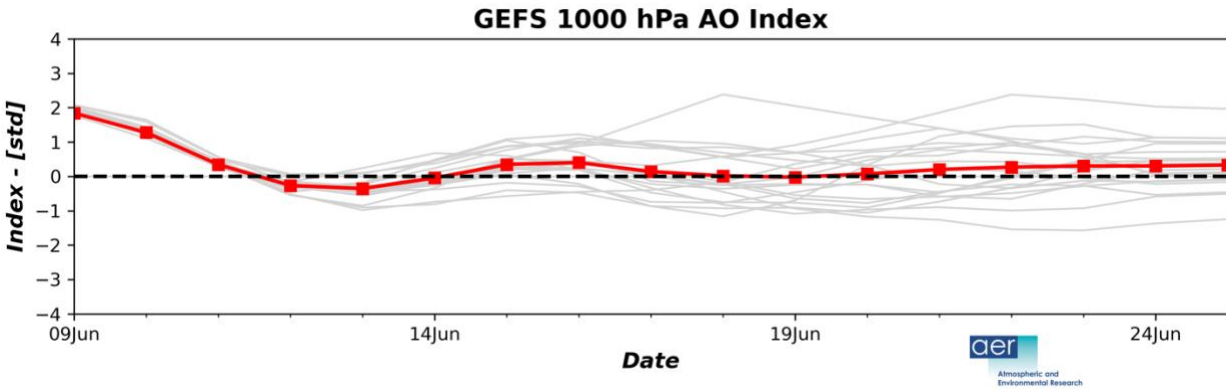

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 09 Jun 2025 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble mean AO index given by the red line with squares.

This week predicted troughing/negative geopotential height anomalies across Greenland will favor ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Eastern Europe (**Figure 2).** This pattern will favor normal to above normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe this period (**Figure 3**). This week strong ridging/positive geopotential height anomalies centered neat the Urals will support weak troughing/negative geopotential height anomalies across East Asia (**Figure 2**). This pattern favors normal to above normal temperatures widespread across much of Asia including Pakistan and Afghanistan with normal to below normal temperatures limited to pockets of Central and into East Asia **(Figure 3**).

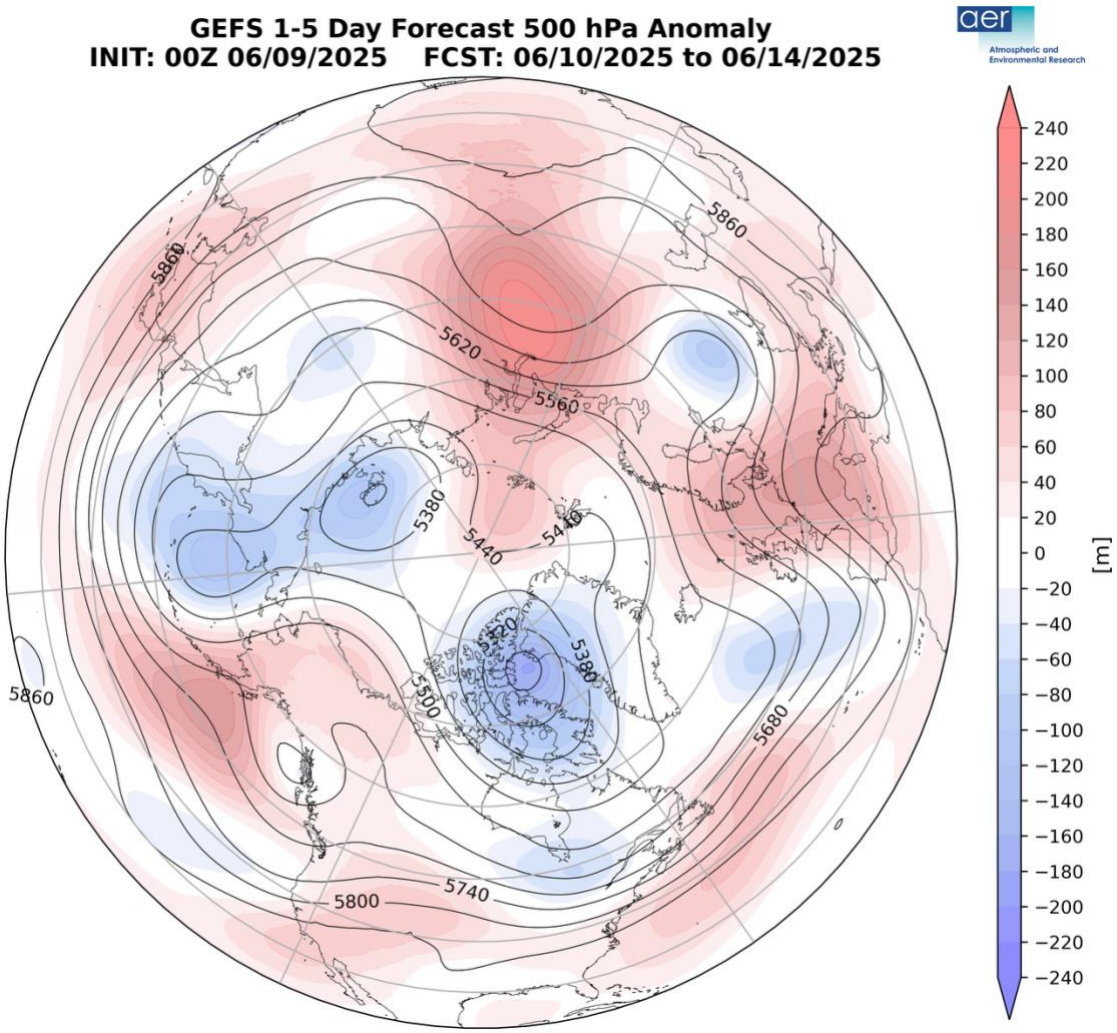

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 10 Jun to 14 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

This week ridging/positive geopotential height anomalies across Alaska, Western Canda and the Western US will support troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US (**Figure 2**). This pattern favors normal to above normal temperatures across Alaska, Western Canada and the Western US with normal to below normal temperatures spreading from Central Canada into the Eastern US. (**Figure 3**).

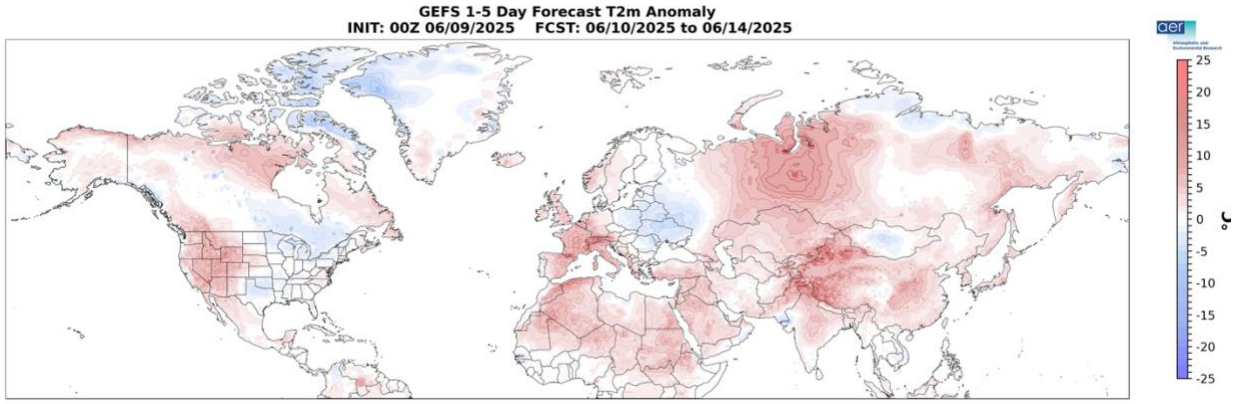

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 10 Jun to 14 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Troughing will support new rainfall across Siberia, parts of Southeast Asia and Southern India with otherwise mostly dry conditions widespread across Europe and Asia, in particular across Central Europe and Southern China this week with near normal precipitation across Afghanistan and Pakistan (**Figure 4**). Troughing will support new rainfall across the Central US and parts of Western Canada with otherwise mostly dry conditions widespread across Canada and the US this week (**Figure 4**).

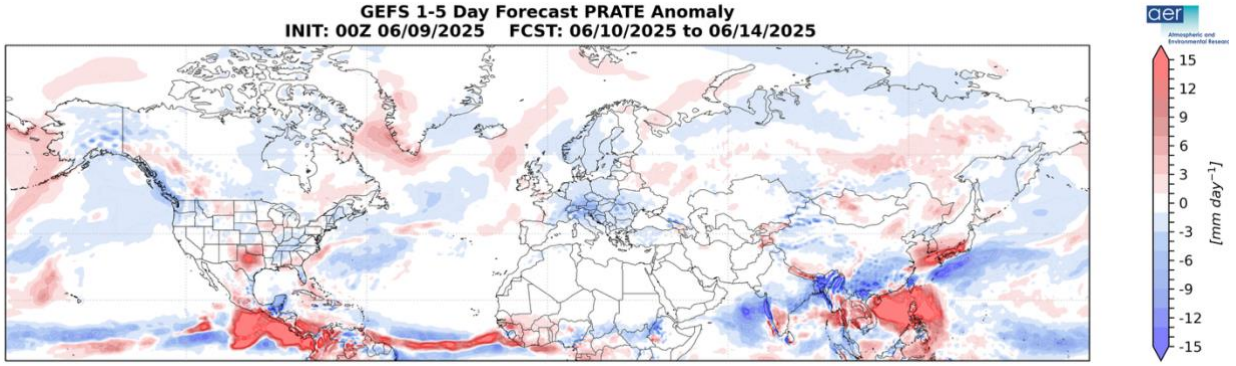

Figure 4. Forecasted rainfall (mm/day; shading) from 10 Jun to 14 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Near-Mid Term

Next week

With geopotential height anomalies becoming increasingly positive across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO will likely remain near neutral this period (**Figure 1**). With predicted weak but positive pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely also be close to neutral this period.

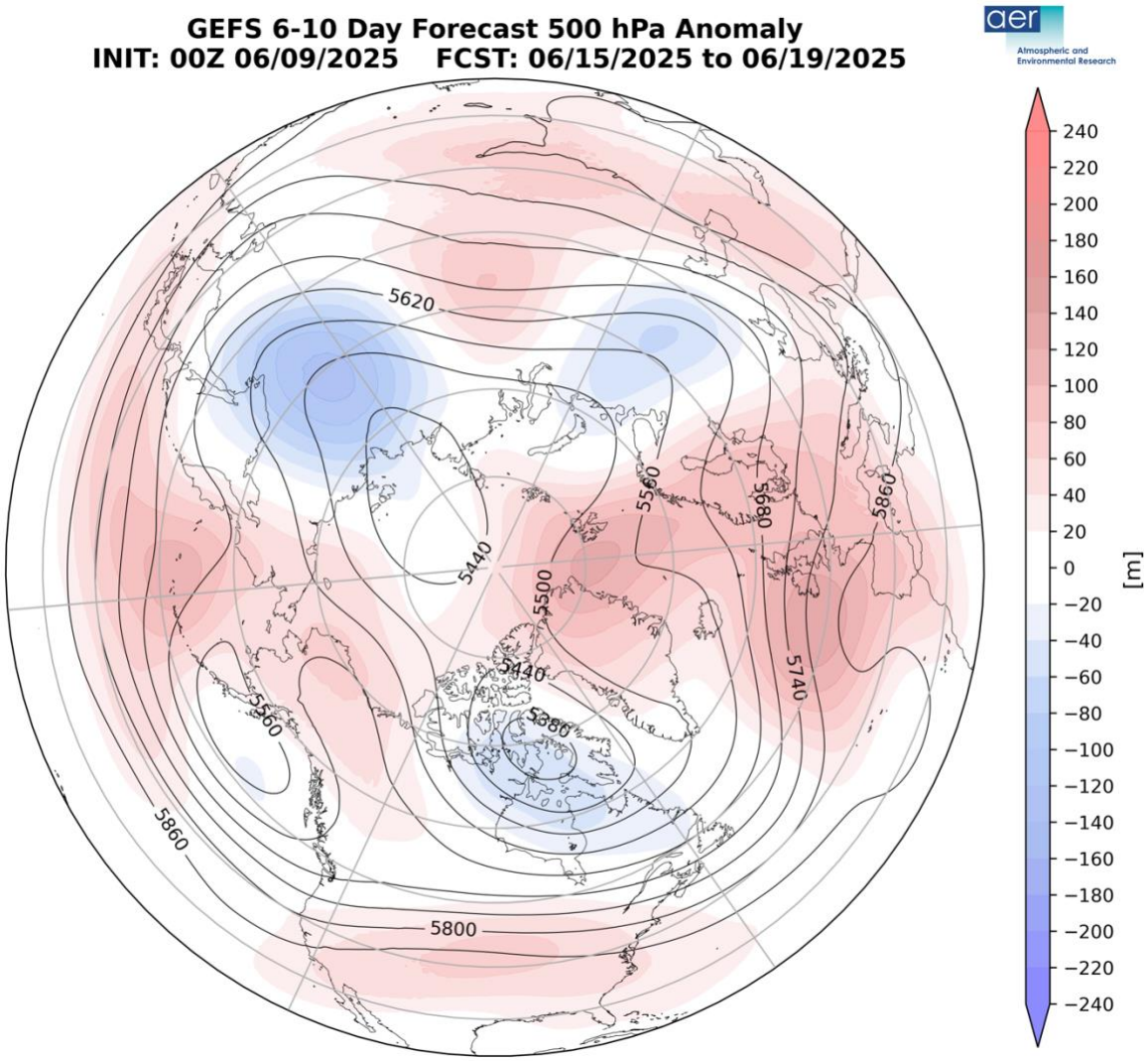

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 15 Jun to 19 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Strengthening ridging/positive geopotential height anomalies are predicted to extend from Greenland to Western Europe with troughing/negative geopotential height anomalies across

Eastern Europe (**Figure 5**). This pattern will favor normal to above normal temperatures across Western and Central Europe including the UK with normal to below normal temperatures across Eastern Europe this period (**Figure 6**). Ridging/positive geopotential height anomalies centered near Svalbard will support troughing/negative geopotential height anomalies in Western Asia while ridging in the Beaufort Sea will support troughing/negative geopotential height anomalies in Siberia with more ridging/positive geopotential height anomalies Central Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Central and Southern Asia including Afghanistan and Pakistan with normal to below normal temperatures Western Russia and Central Siberia this period (**Figure 6**).

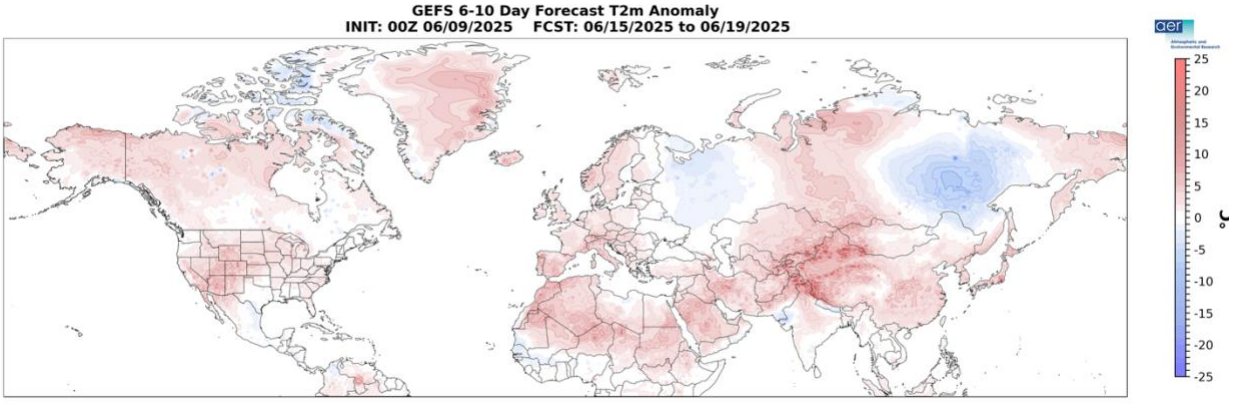

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 15 Jun to 19 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

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

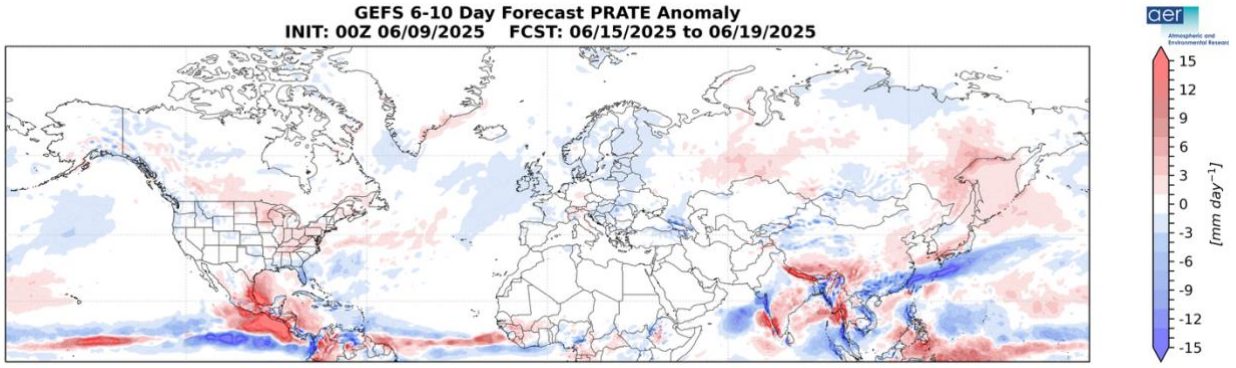

Figure 7. Forecasted precipitation rate (mm/day; shading) from 15 Jun to 19 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Troughing will support new rainfall near the Urals, Eastern Siberia, Southern India, parts of Southeast Asia and the Tibetan Plateau 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 parts of Southern Canada and the Eastern US with otherwise mostly dry conditions widespread across Alaska, Canada and the US this week (**Figure 7**).

Mid Term

Week Two

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

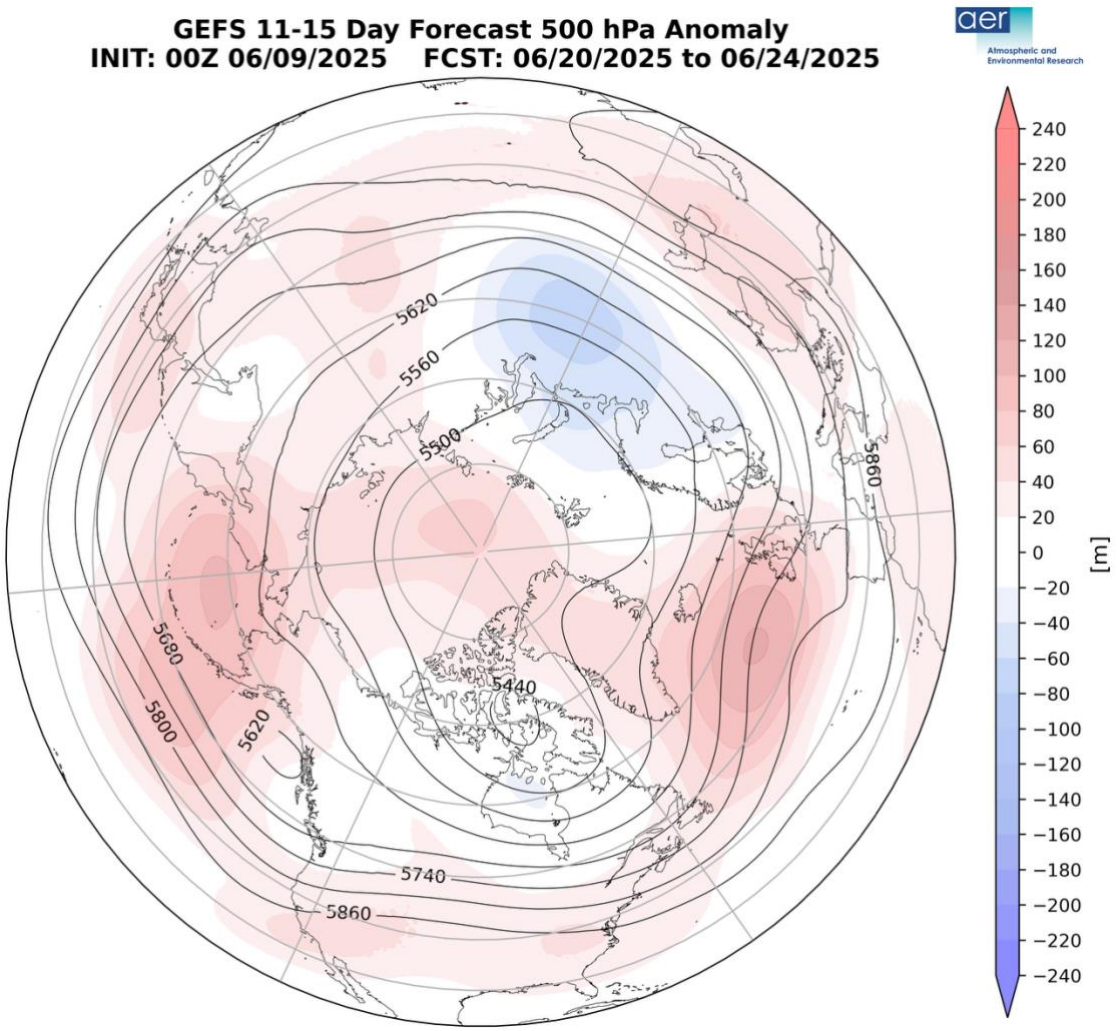

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 20 Jun to 24 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Ridging/positive geopotential height anomalies centered south of Iceland and extending into Western Europe will support troughing/negative geopotential height anomalies in Eastern Europe and now spreading into Central Europe this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Western Europe including the UK with normal to below normal temperatures across Central and Eastern Europe this period (**Figures 9**). Ridging/positive geopotential height anomalies in Western Europe and near the North Pole will support deepening troughing/negative geopotential height anomalies across Western Asia with ridging/positive geopotential height anomalies across Central and Southern Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across most of Asia including Pakistan and Afghanistan with normal to below normal temperatures across Western Russia and northern Kazakhstan and India this period (**Figure 9**).

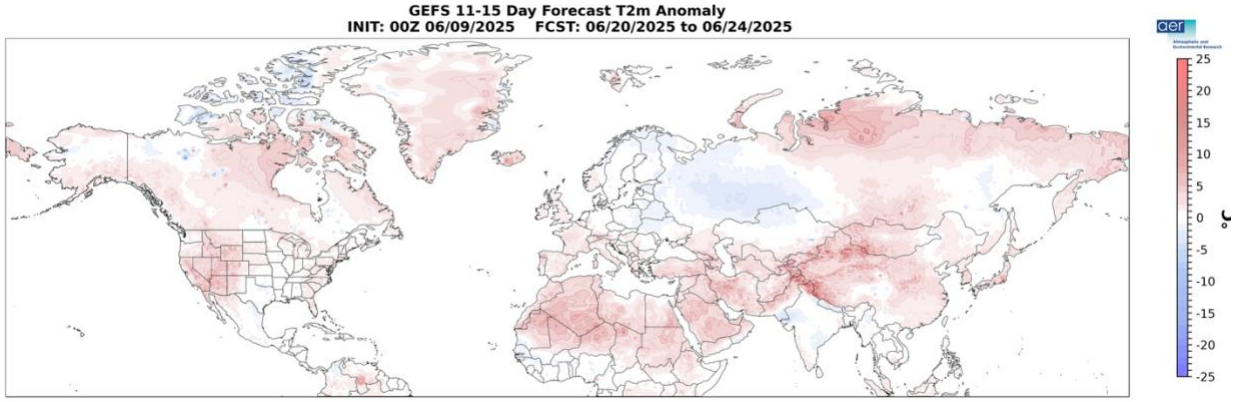

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 20 Jun to 24 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate Alaska, Western Canada and the US with weak troughing/negative geopotential height anomalies persisting across Eastern Canada this period (**Figure 8**). This pattern supports widespread normal to above normal temperatures across Alaska, much of Canada and the US with normal to below normal temperatures limited to the Quebec and the US Upper Midwest this period (**Figure 9**).

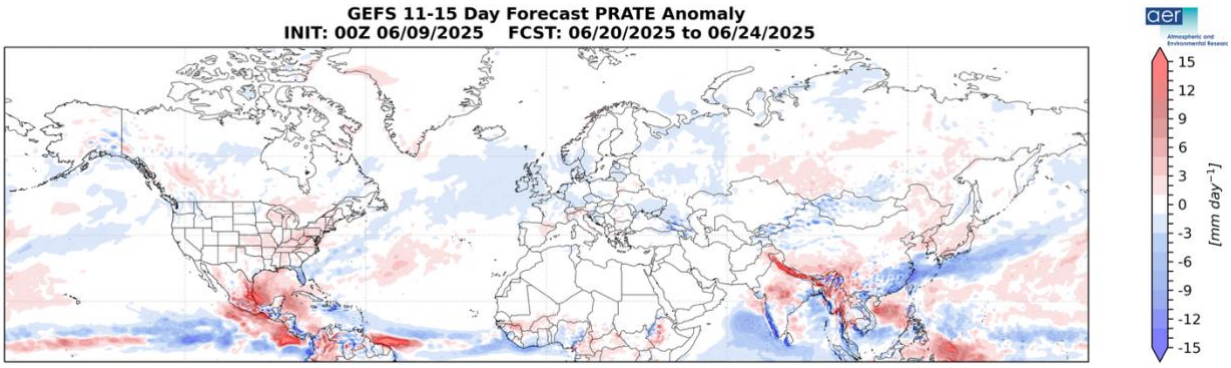

Figure 10. Forecasted precipitation rate (mm/day; shading) from 20 Jun to 24 Jun 2025. The forecasts are from the 00Z 09 Jun 2025 GFS ensemble.

Troughing will support new rainfall across Southern Siberia, parts of Northeast and Southeast 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 Western Canada and 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 very weak warm/positive PCHs throughout the mid to low stratosphere with cold/negative PCHs in the upper stratosphere and the troposphere (**Figure 11**). The warm/positive PCHs in the lower stratosphere are predicted to strengthen somewhat and descend all the way to the surface at the end of this week.

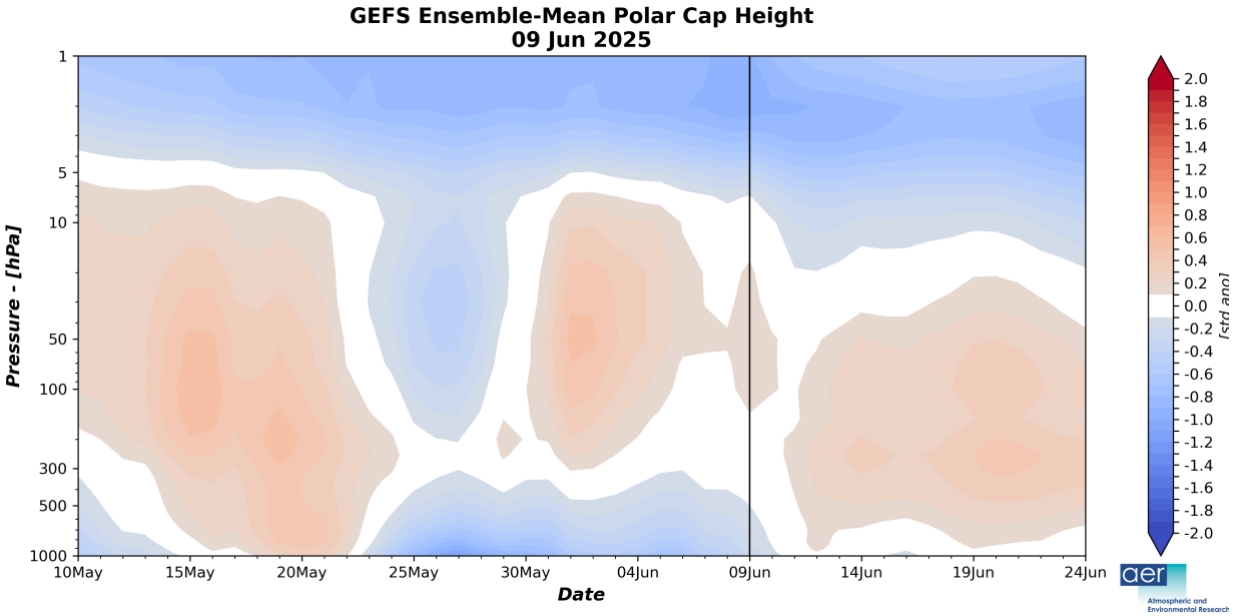

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 09 Jun 2025 GFS ensemble.

The predicted cold/negative PCHs in the lower troposphere for early this week (Figure 11) are consistent with the predicted positive surface AO early in the week (**Figure 1**). Then later this week and into next week, the predicted descent of warm/positive PCHs into the lower troposphere (**Figure 11**) are consistent with the predicted turn to a more neutral surface AO starting later this week and into next week (**Figure 1**).

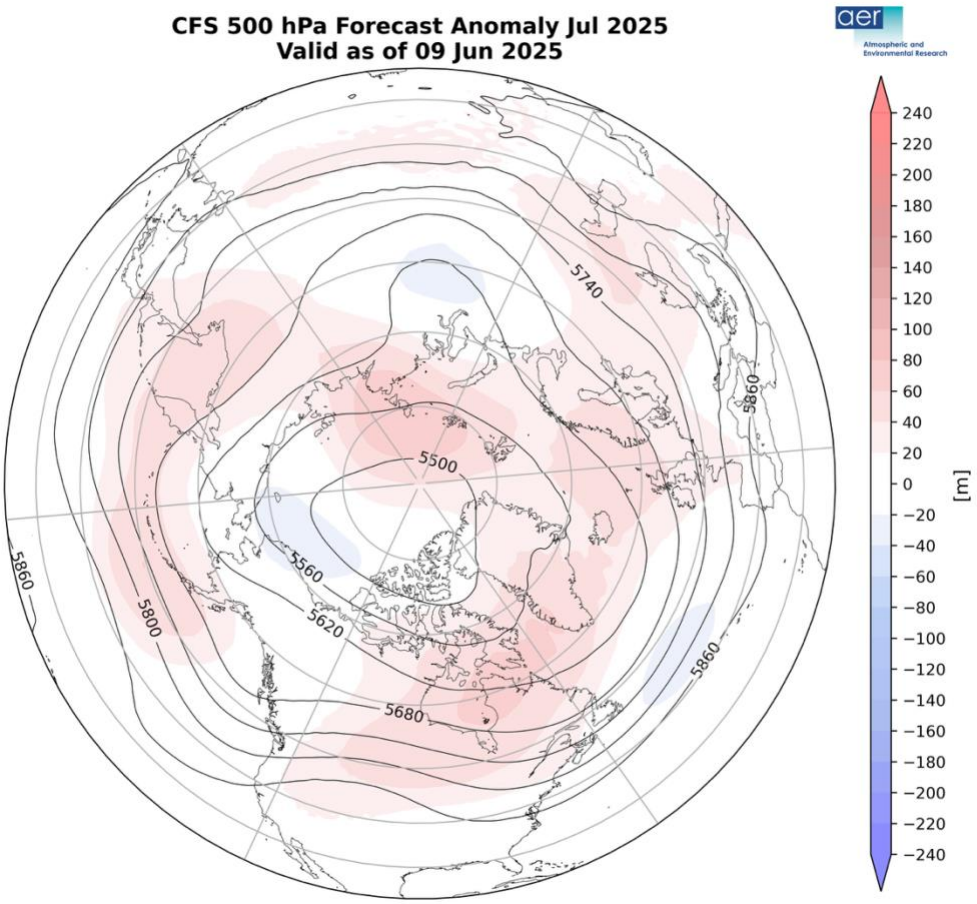

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for July 2025. The forecasts are from the 00Z 09 Jun 2025 CFS.

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 extending from Central Canada to Greenland and over to Scandinavia, Eastern Europe, Northeast Asia and south of the Aleutians, with troughing across Western Europe, Central Asia, centered around the Dateline, the US West Coast and Western Canada (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across much of Europe, much of Asia, especially Northern Siberia and the Tibetan Plateau, Pakistan and Afghanistan**.** Alaska, much of Canada, especially Northern and Eastern Canada and the Western and Eastern US with seasonable to relatively cool temperatures across Southwestern Europe, Central Asia centered on Kazakhstan, the Plains of parts of Western Canada and the Central US (**Figure 13**).

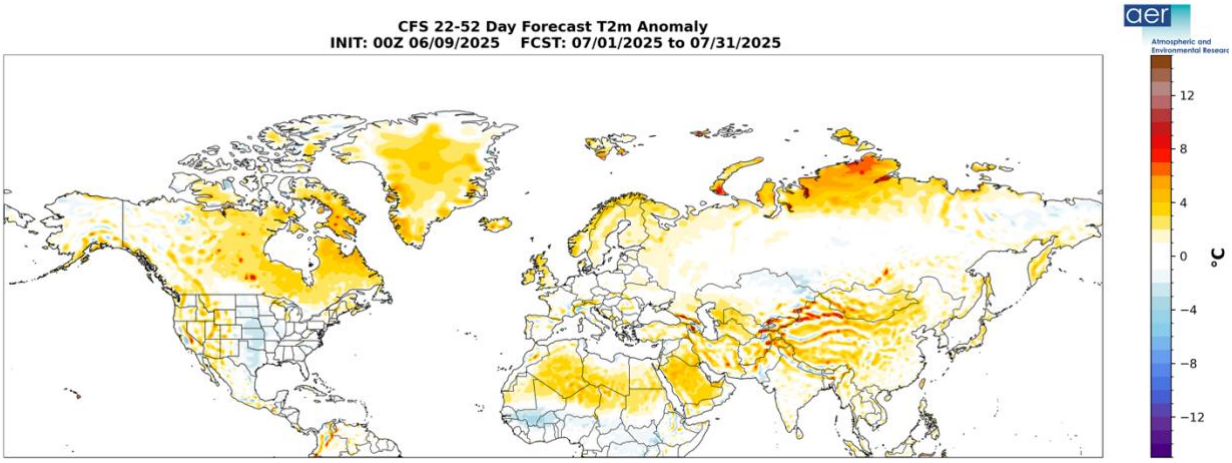

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for July 2025. The forecasts are from the CFS 00Z 09 Jun 2025.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are slightly below normal, on either side of the Dateline, indicating that the winter La Niña event is waning (**Figure 14**) and neutral conditions are expected through the summer. Warming of SSTs along the equator near South America are suggestive of an emerging El Niño. However 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 though below normal SSTs exist regionally especially in the South Pacific.

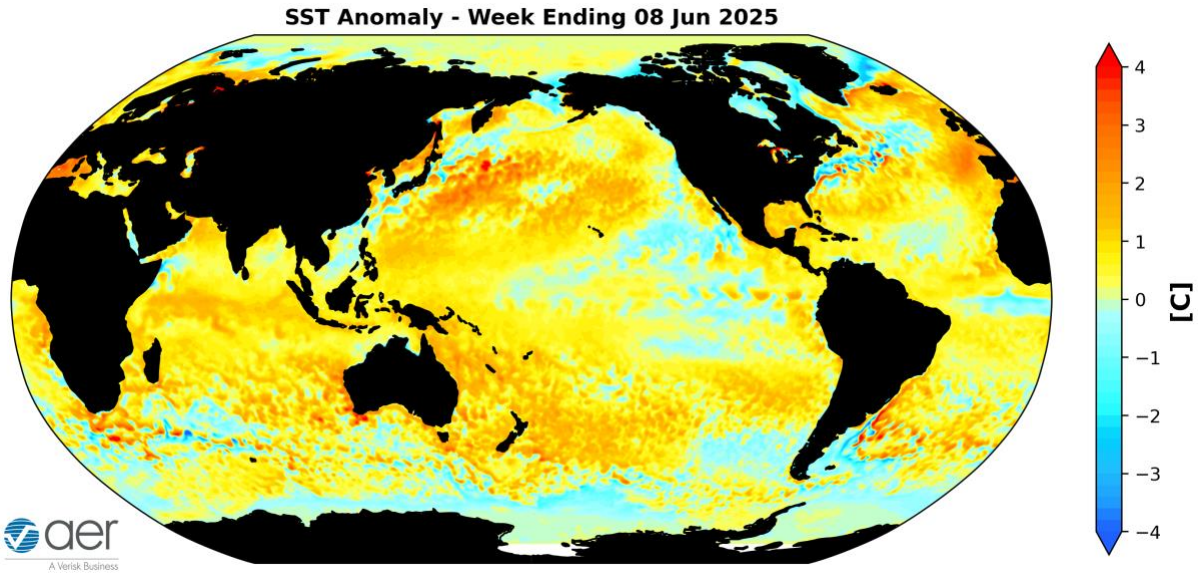

Figure 14. The latest daily-mean global SST anomalies (ending 8 Jun 2025). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is currently in phase seven but is predicted to quickly weaken weak where no phase is favored (**Figure 15**). The forecasts are for the MJO to remain overall weak where no phase is favored for the next two weeks. Therefore, it seems to me that the MJO is having little to no obvious influence on North American weather for the next two weeks. But admittedly this is outside of my expertise.

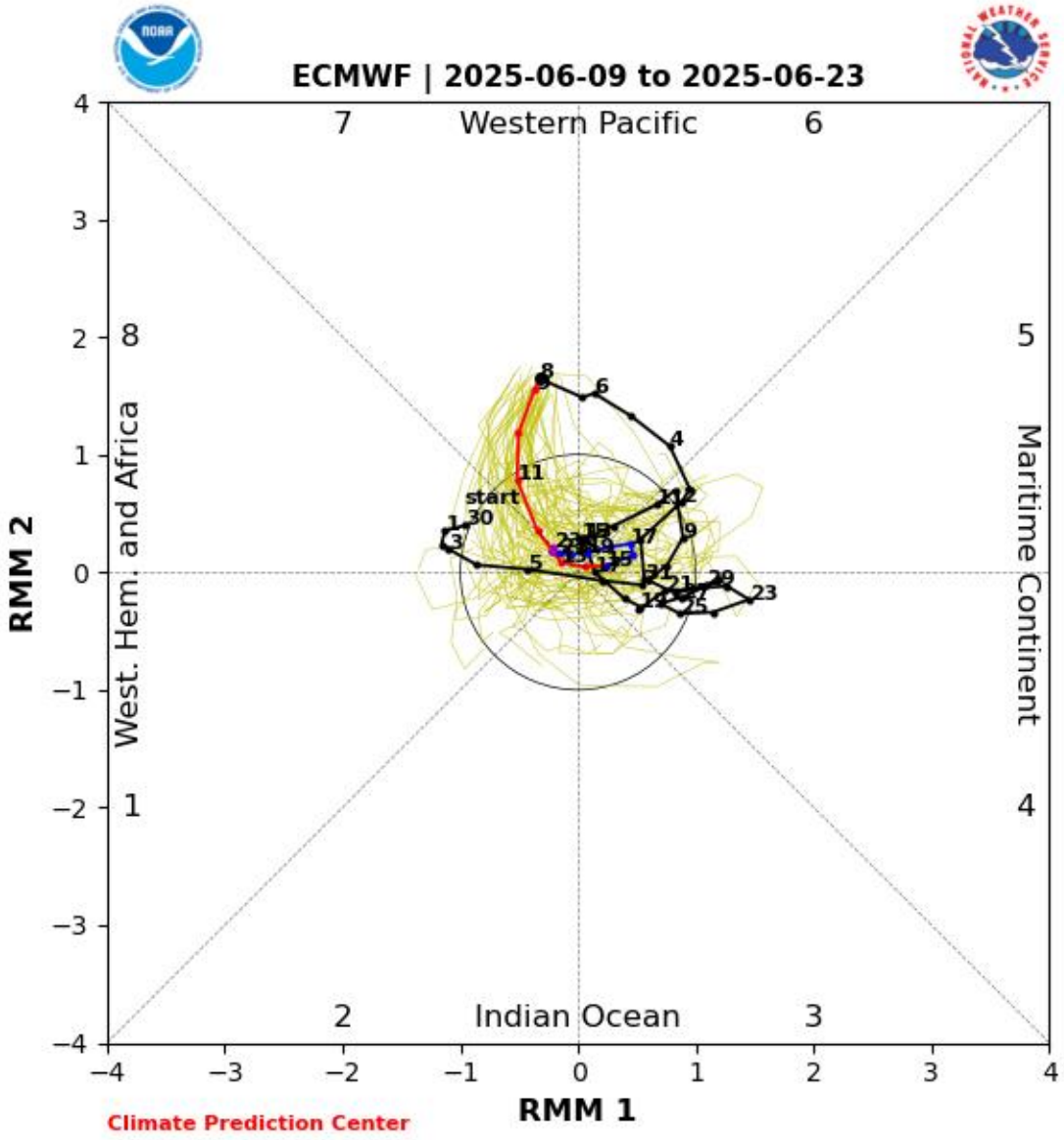

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 09 Jun 2025 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model 'spread' is denoted by the gray shading. Sector numbers indicate 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.

Our sCast principal engineer, Karl Pfeiffer, can help you use sCast and other AER seasonal forecast products to deliver important, long-lead time weather intelligence to your business. Please reach out to Karl today!