Arctic Oscillation and Polar Vortex Analysis and Forecasts

September 22, 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 positive and is predicted to trend negative towards neutral the next two weeks as pressure/geopotential height anomalies across the Arctic are currently mostly negative and are predicted to become mostly mixed 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 trend positive the next two weeks as pressure/geopotential height anomalies are predicted to become increasingly negative across Greenland.
- The next two weeks, strengthening Scandinavian blocking/ridging/positive geopotential height anomalies centered on Scandinavia will support troughing/negative geopotential height anomalies to the south across Central and Southern Europe. The amplified flow pattern will support widespread normal to above normal temperatures across Scandinavia with normal to below normal temperatures first across Western Europe including the United Kingdom (UK) but then spreading across Central and Southern Europe the next two weeks.
- The general pattern across Asia the next two weeks is strong Scandinavian ridging/positive geopotential height anomalies forcing troughing/negative geopotential height anomalies first across Siberia and then in Western Asia with ridging/positive geopotential height anomalies across East Asia. This pattern favors normal to below normal temperatures across Siberia this week and then including Western Asia next week with normal to above

normal temperatures across Southern and Eastern Asia the next two weeks.

- The general predicted pattern the next two weeks across North America is sprawling ridging/positive geopotential height anomalies across the continent centered on Hudson Bay with some troughing across Alaska and the Gulf of Alaska. This patten will favor widespread normal to above normal temperatures across the United States (US) and Canada the next two weeks with the biggest exceptions of normal to below normal temperatures in Alaska and US West Coast of Canada this week.
- I continue discussing my thoughts about the upcoming pattern across the Northern Hemisphere (NH) and continue with some preliminary thoughts about the upcoming winter.

Plain Language Summary

So far for September, widespread warmth dominated the land areas of the Northern Hemisphere (NH) in particular across Eastern Europe, Northwest Russia, Central Asia and especially Western Canada into the US Pacific Northwest (see **Figure**). The biggest exception has been the extensive and relatively cool temperatures in Siberia and the Central US (see **Figure**). The impressive area of cool temperatures to begin September east of the Rockies, has just as impressively has almost completely disappeared. Looking ahead over the next two weeks, overall looks like the very warm pattern across North America will continue (see **Figures 3, 6** and **9**). Cooler weather across Europe is predicted in the short term (see **Figure 6**), though likely not to last much into October. Some cool or even cold temperatures predicted for Siberia. For Siberia I think the longer-term outlook is more uncertain. And if you are a winter weather enthusiast, a flip to a milder pattern in October is not a pattern you want to see in mid-October.

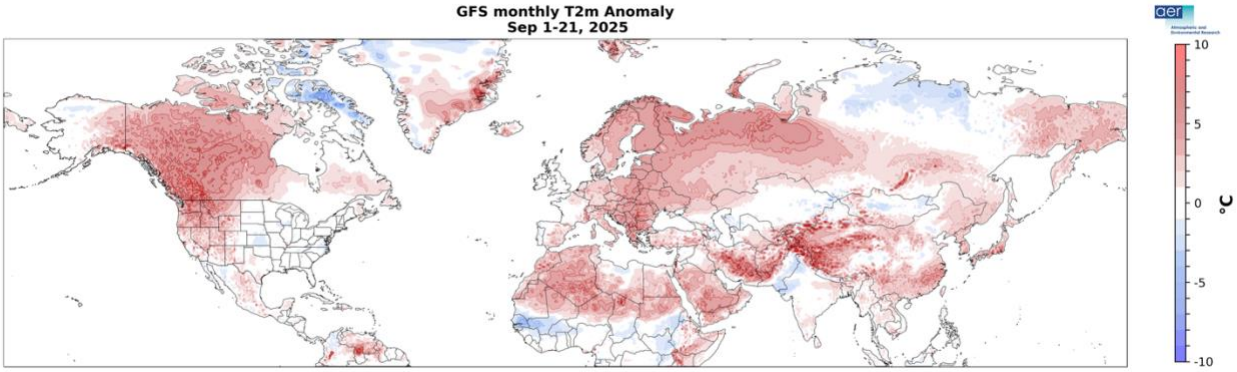

Figure. Estimate of the observed surface temperatures (°C; shading) from 01 Sep to 21 Sep 2025 based on GFS initializations and the GFS forecast from the 22 September 2025 run.

Impacts

Not to fall like in many places for the end of September, especially across North America. Once again 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**). Two dominant high-pressure centers are predicted over the next two weeks, the first over Hudson Bay and the second over Scandinavia (see **Figure ii**). The high-pressure center over Hudson Bay has even punched north towards the North Pole btu it is short lived. These high-pressure centers favor widespread warmth for Northern Europe and especially North America.

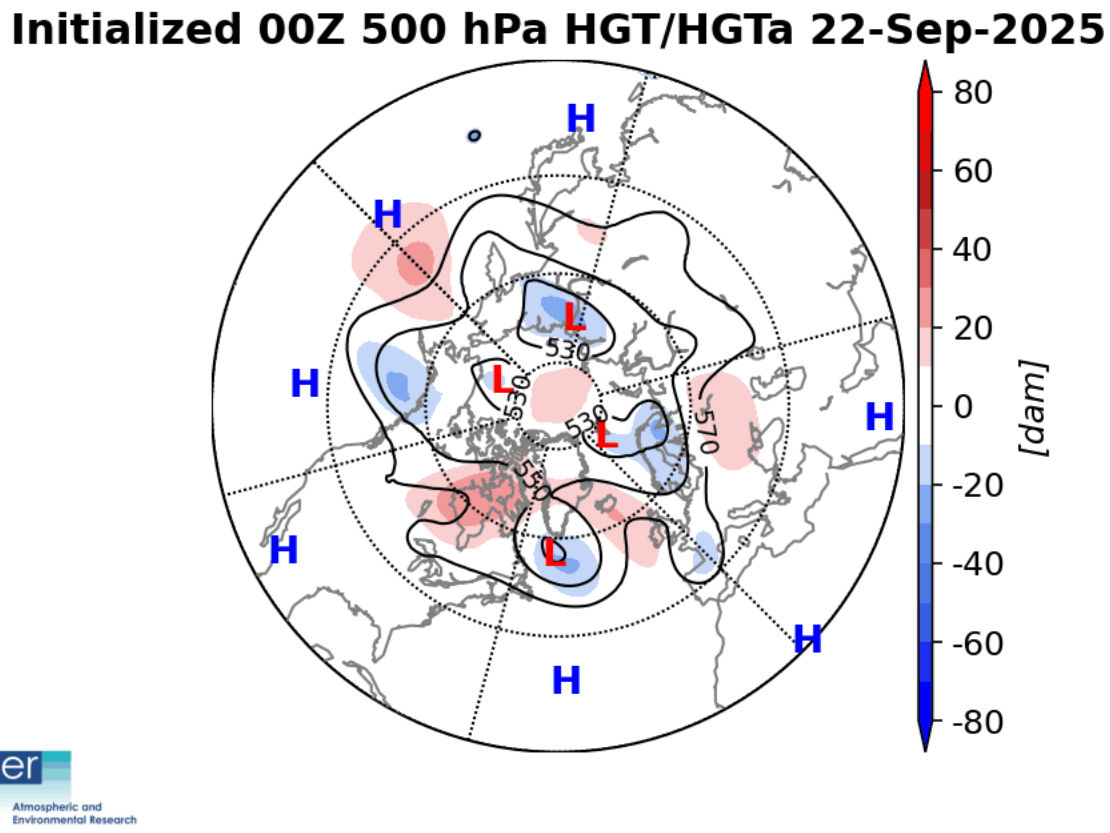

Figure i. Initialized 500 mb geopotential heights (dam; contours) and decameter anomalies (dam; shading) across the Northern Hemisphere for 22 Sep 2025 and forecasted from 23 Sep to 07 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS model ensemble.

However, on the flip side, the high-pressure center over Scandinavia will usher in northerly flow downstream over Siberia and eventually into East Asia. And some of that air will be cold enough to support snow in parts of Siberia (see **Figure ii**), and Siberian snow cover is off to a quick start. If you are rooting for a weak polar vortex this winter this is pattern you would like to see persist for the October. But the persistence of the pattern that is supportive of a rapid advance of Siberian snow cover for most of the month has become cloudy and uncertain in my opinion.

Therefore, if the predicted trough in the next couple of weeks across Siberia transitions to high-pressure ridging, that would not be supportive of a weak polar vortex and colder weather this winter. So, it is certainly crunch time in my opinion.

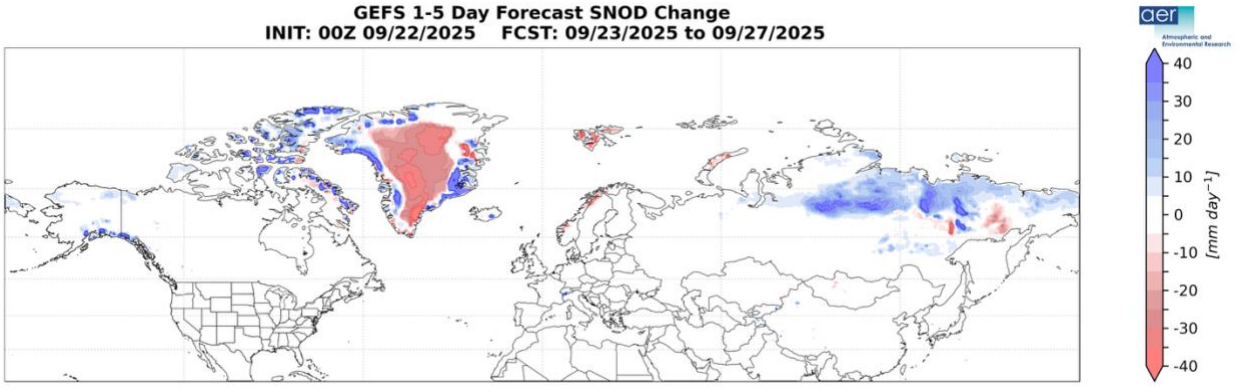

Figure ii. Forecasted snow depth change (mm/day; shading) from 23 Sep to 27 Sep 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Once again, I will end with the Arctic sea ice minimum, which according to the National Snow and Ice Data Center (NSIDC) has likely occurred on September 10 (see **Figure iv**). In the previous blog I estimated a minimum between 4.4-4.8 million squared kilometers and the NSIDC are pegging the minimum smack in the middle of my range at 4.6 million squared kilometers tied with 2008 and 2010 as shown in **Figure iii**.

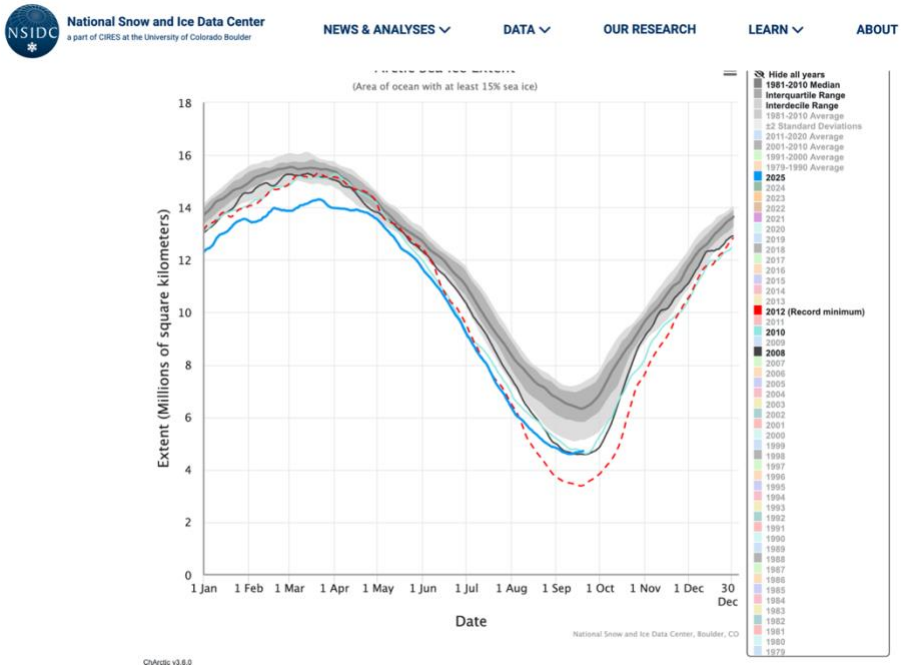

Figure iv. Forecasted snow depth change (mm/day; shading) from 14 Sep to 18 Sep 2025. The forecasts are from the 00Z 08 Sep 2025 GFS ensemble.

It has been shown that less sea ice in the North Atlantic sector of the Arctic weakens the polar vortex while less sea ice in the North Pacific sector strengthens the polar vortex. Since sea ice is currently low in both the North Atlantic and the North Pacific sectors, I think best to follow the evolution of sea ice melt and growth this fall before trying to infer what could be the possible impact on the fall and winter PV. And that is something that I will be following closely in the coming months.

Last week I tweeted about a possible stretched polar vortex (PV) in early October. This was based on what I saw in the GFS and not the ECMWF. Since then, even the GFS has backed off, and I think ridging ping-ponging between the UK and Scandinavia is not the best pattern to force a stretched PV rather ridging between Scandinavia and the Urals would be more supportive. Still the latest wave energy diagnostics shows some robust wave reflection (see **Figure iv**) that is supportive of a stretched PV that would flip the mild pattern across North America to a colder one. So, something to watch but highly uncertain.

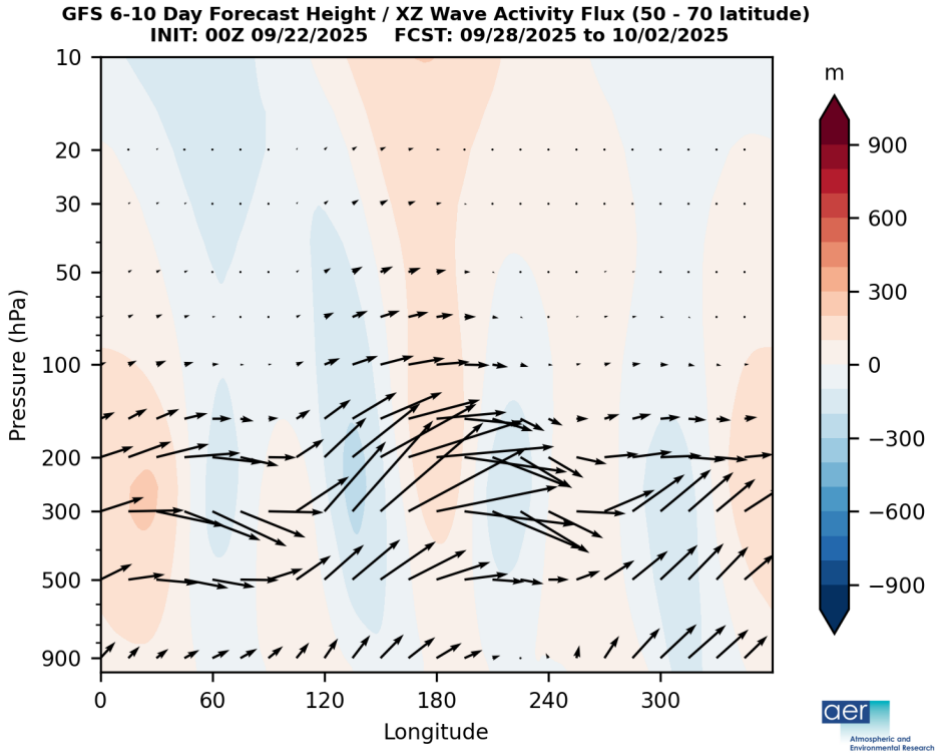

Figure ii. Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 28 September through 2 October 2025. The forecasts are from the 00Z 22 September 2025 GFS ensemble.

Too soon to discuss wave reflection and stretched PVs? We have had some interesting events in October. October 2020 comes to mind as a harbinger of February 2021.

Near-Term

This week

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

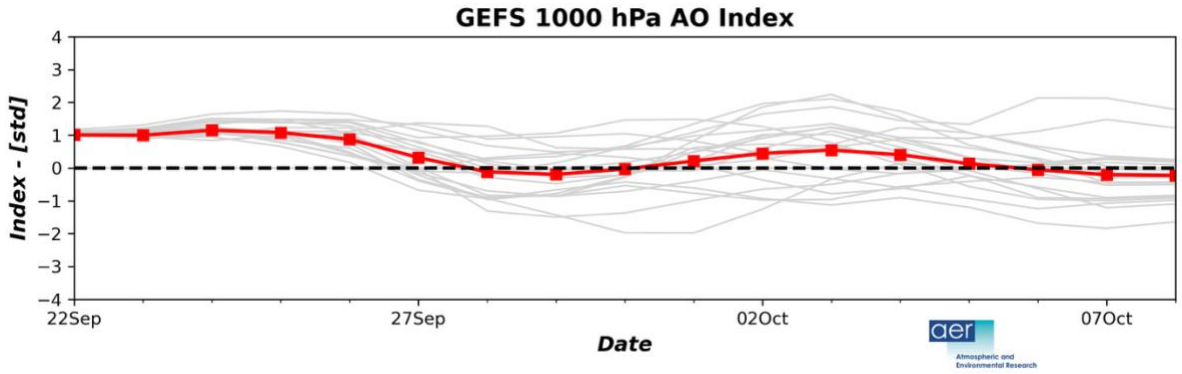

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 22 September 2025 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble mean AO index given by the red line with squares.

This week strengthening ridging/positive geopotential height anomalies centered between the UK and Scandinavia will support a troughing/negative geopotential height anomalies to the south across Western Europe with more ridging to the east across Central and Eastern Europe (**Figure 2).** This pattern will support widespread normal to above normal temperatures across Southeastern Europe with normal to below normal temperatures across Western and Central Europe including the UK this period (**Figure 3**). This week the predicted pattern across Asia is developing ridging/positive geopotential height anomalies centered near Scandinavia forcing troughing/negative geopotential height anomalies across Siberia with more ridging to the south of Siberia across East Asia and weak troughing swinging through the Caspian Sea (**Figure 2**). This pattern favors widespread normal to above normal temperatures across much of Asia with the exceptions of normal to below normal temperatures across Siberia and parts of south-west Asia and India this period **(Figure 3**).

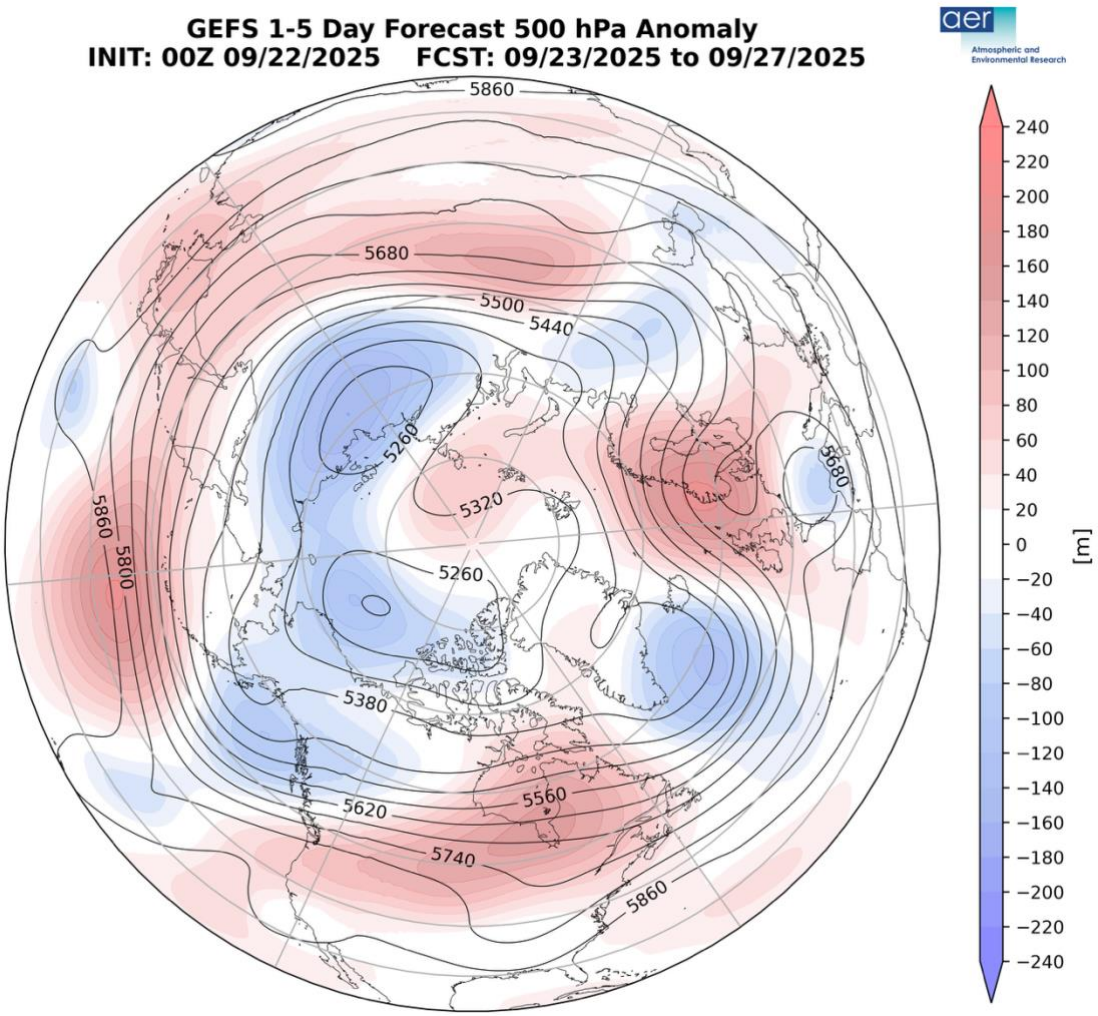

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 23 Sep to 27 Sep 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

This week sprawling ridging/positive geopotential height anomalies centered near Hudson Bay will dominate Canda and the US with the exceptions of troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska this week (**Figure 2**). This patten will favor widespread normal to above normal temperatures across the US and Canada with the exceptions of normal to below normal temperatures in Alaska and the West Coast of Canada (**Figure 3**).

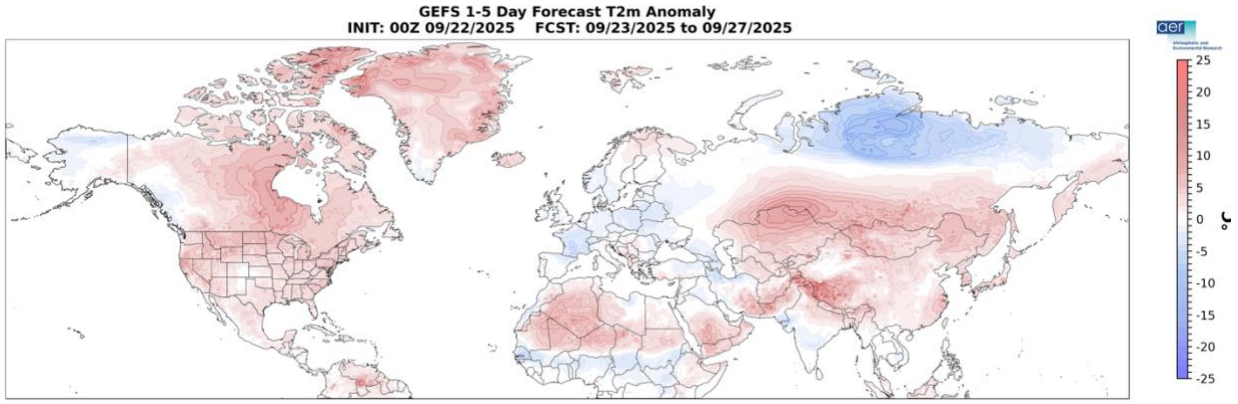

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 23 Sep to 27 Sep 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Troughing will support new rainfall across northern Scandinavia and Central Europe including the Alps, Siberia, parts of East Asia and India 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 the West Coast of Canada and the Central and Eastern US with otherwise mostly dry conditions widespread across Canada and the US this week (**Figure 4**).

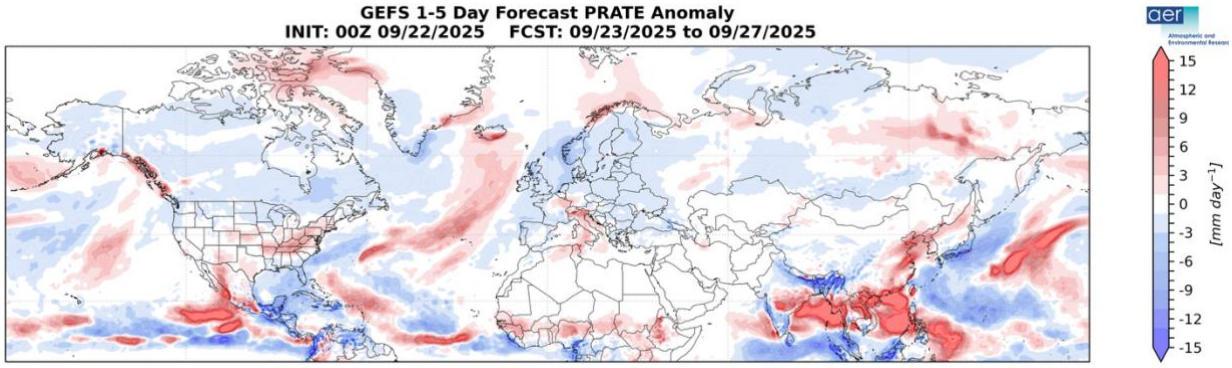

Figure 4. Forecasted rainfall (mm/day; shading) from 23 Sep to 28 Sep 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Near-Mid Term

Next week

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

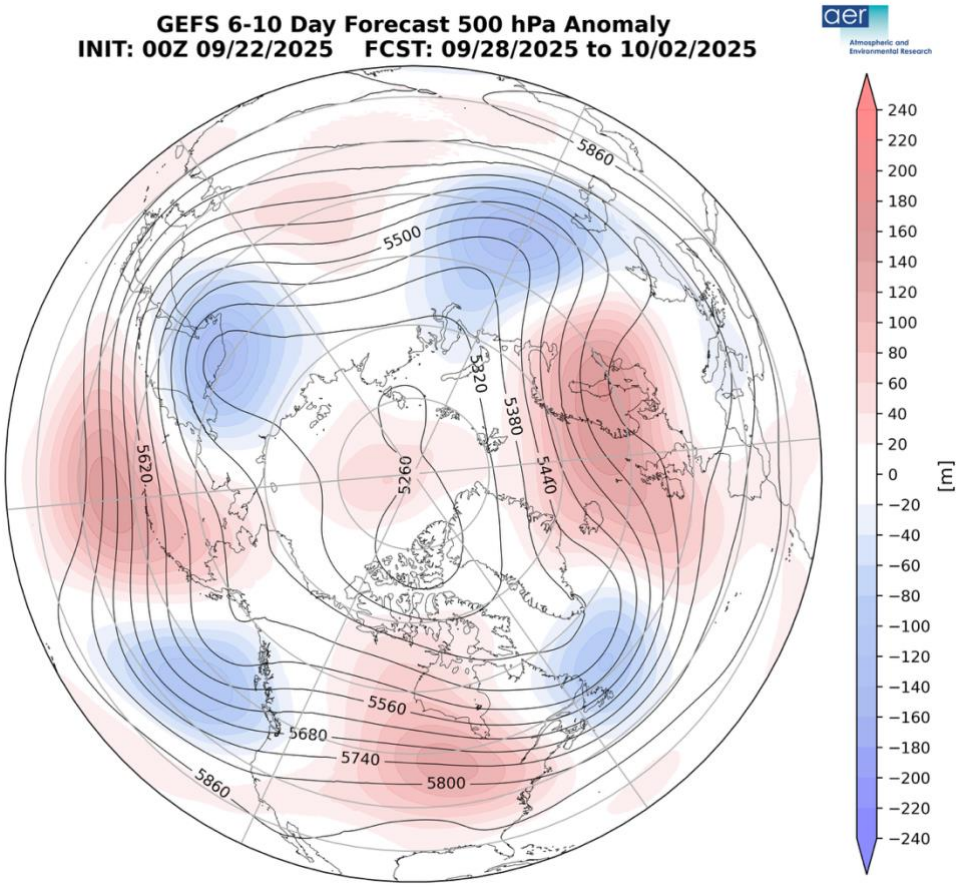

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 28 Sep to 02 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Strengthening ridging/positive geopotential height anomalies across Northern Europe will become centered over Scandinavia supporting troughing/negative geopotential height anomalies to the south across Central and Southern Europe (**Figure 5**). The blocked pattern will support normal to above normal temperatures across Northern Europe including the UK with normal to below normal temperatures across Central and Southern Europe this period (**Figure 6**). Persistent Scandinavian ridging/positive geopotential height anomalies will support troughing/negative geopotential height anomalies both across Siberia and Western

Asia with more ridging across Central and East Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Central and Eastern Asia including Pakistan and Afghanistan with normal to below normal temperatures across Siberia and Western Asia this period (**Figure 6**).

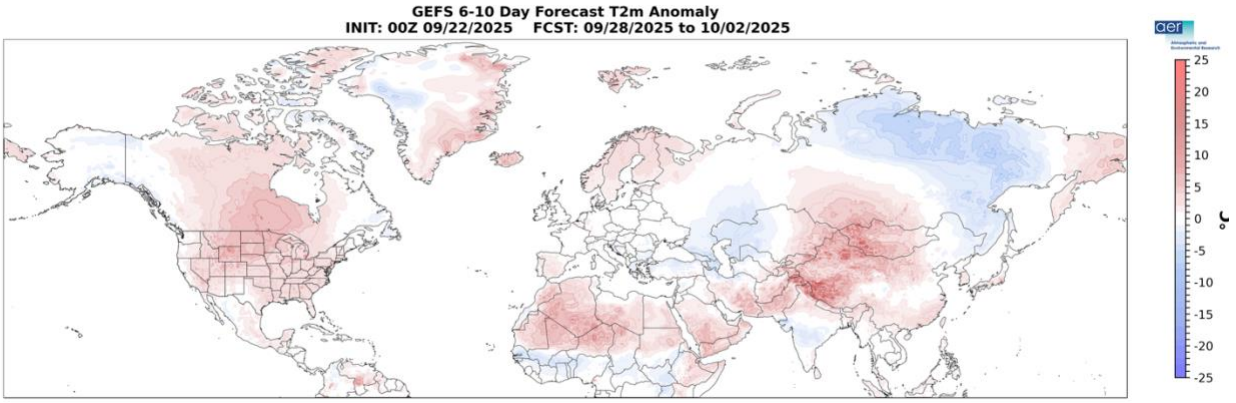

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 28 Sep to 02 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

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

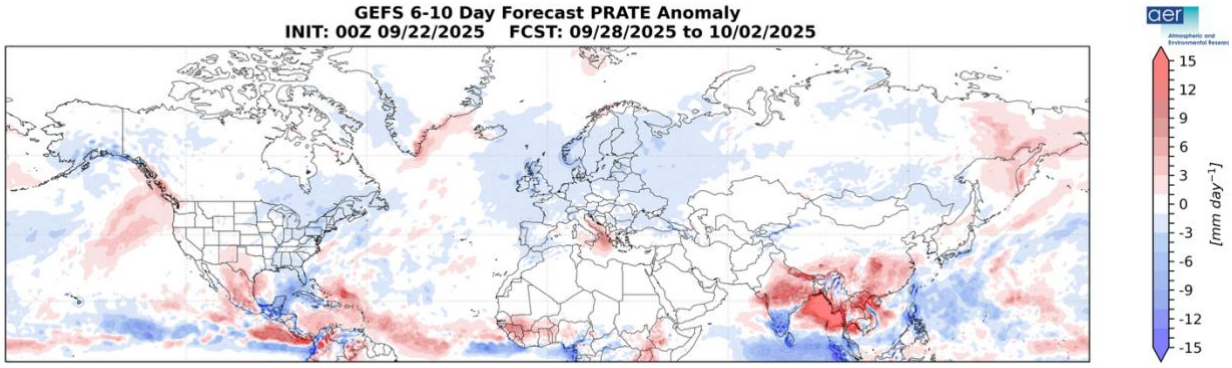

Figure 7. Forecasted precipitation rate (mm/day; shading) from 28 Sep to 02 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Troughing will support new rainfall around the Aegean Sea, Eastern China, parts of Southeast Asia, India and the Tibetan Plateau with otherwise mostly dry conditions widespread across Europe and Asia and near normal across Afghanistan and Pakistan this period (**Figure 7**). Troughing will support new rainfall across the West Coast of Canada, New Mexico and Texas this period (**Figure 7**).

Mid Term

Week Two

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

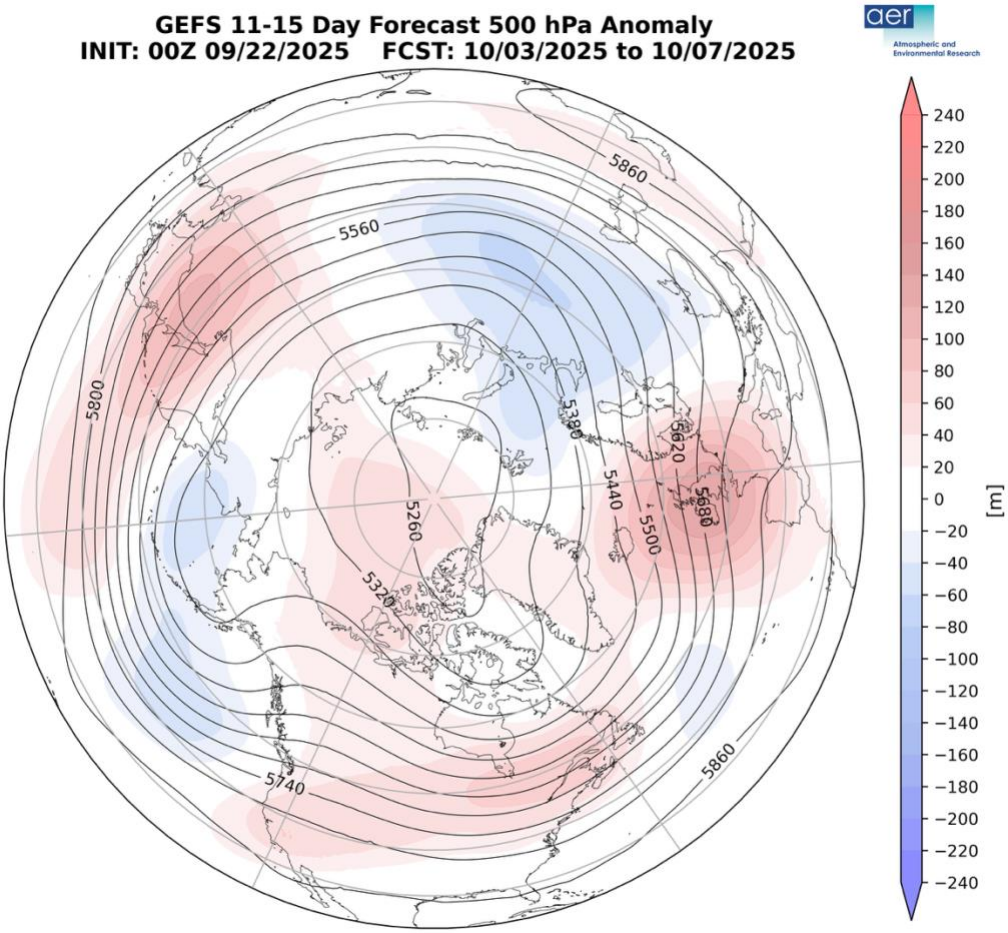

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 03 Oct to 07 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

The persistent pattern of ridging/positive geopotential height anomalies across Northern Europe with troughing/negative geopotential height anomalies across Southern and Eastern Europe is predicted to continue this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Western and Northern Europe including the UK with normal to below temperatures across Southeastern Europe this period (**Figures 9**). Persistent ridging/positive

geopotential height anomalies across Northern Europe will continue to support troughing/negative geopotential height anomalies across Siberia and Western Asia with more ridging across Southern and Eastern Asia this period (**Figure 8**). The predicted pattern favors normal to above normal temperatures across Southern and Eastern Asia including Pakistan and Afghanistan with normal to below normal temperatures across Siberia and Western Asia this period (**Figure 9**).

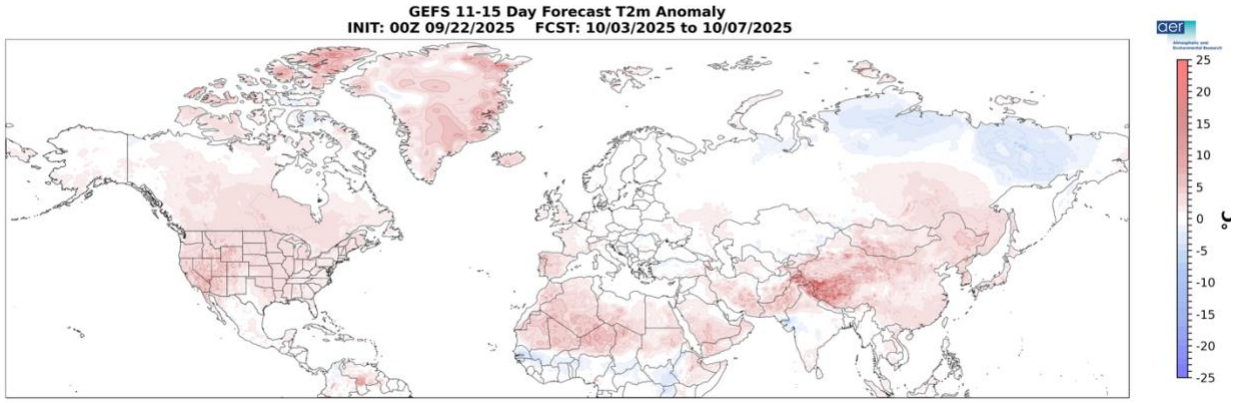

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 03 Oct to 07 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to dominate North America with troughing/negative geopotential height anomalies mostly remaining in the Gulf of Alaska this period (**Figure 8**). This pattern supports widespread normal to above normal temperatures across most of Canada and the US with normal to below normal temperatures mostly limited to Alaska this period (**Figure 9**).

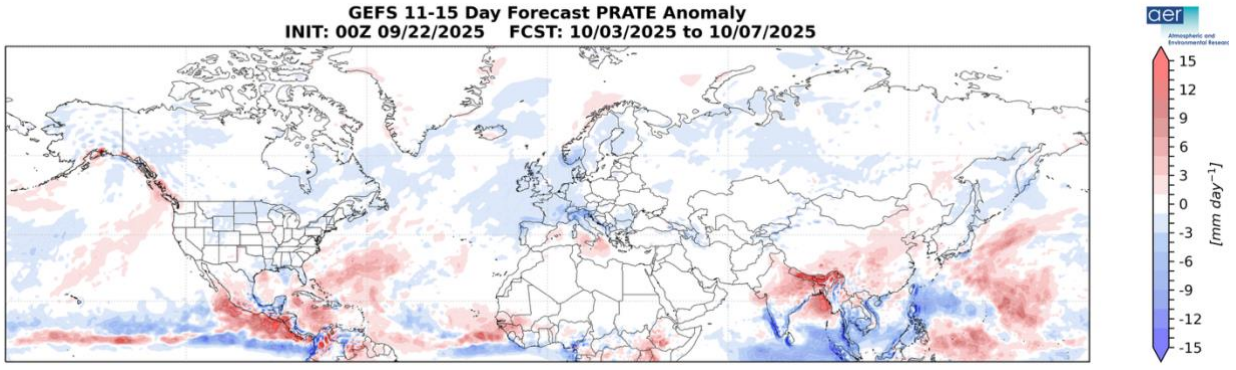

Figure 10. Forecasted precipitation rate (mm/day; shading) from 03 Oct to 07 Oct 2025. The forecasts are from the 00Z 22 Sep 2025 GFS ensemble.

Troughing will support new rainfall across Central and Eastern China, Northern India and the Tibetan Plateau with otherwise mostly dry conditions widespread across Europe and Asia and near normal precipitation in Afghanistan and Pakistan this period (**Figure 10**). Troughing will

support new rainfall along the coastal mountains of Western Canada 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 lower troposphere with warm/positive PCHs in the lower stratosphere and upper troposphere (**Figure 11**). The cold/negative PCHs are predicted to persist in the stratosphere and lower troposphere over the next two weeks with warm/positive PCHs weakening and briefly disappearing before reappearing again in the lower stratosphere and upper troposphere.

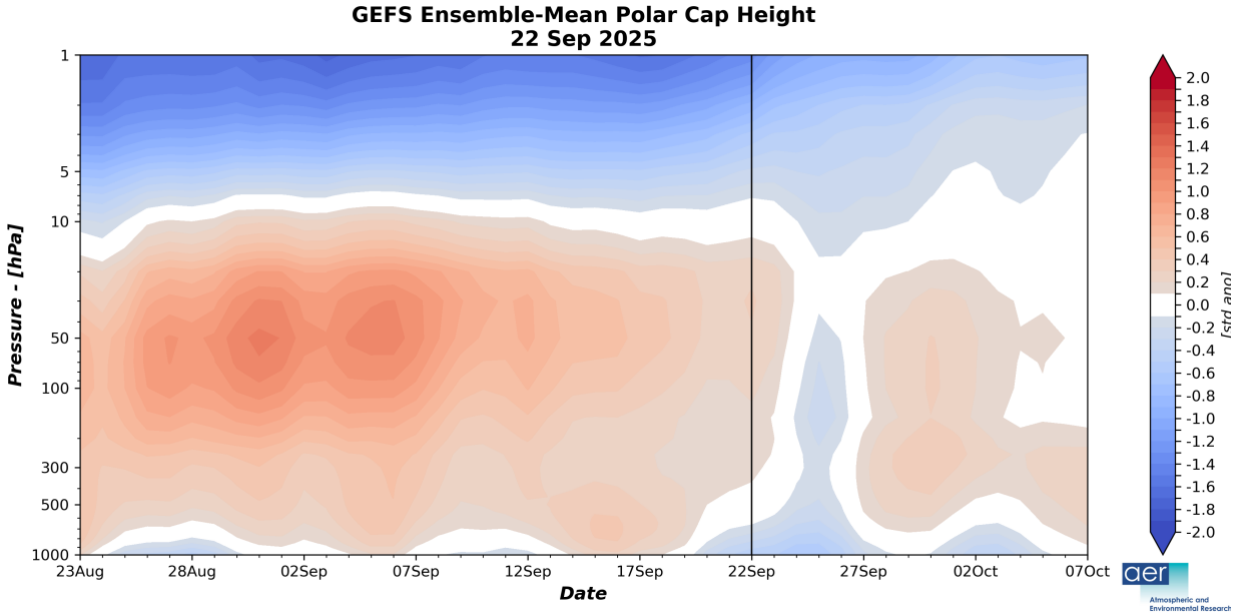

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 22 Sep 2025 GFS ensemble.

The predicted cold/negative PCHs in the lower troposphere the next two weeks (**Figure 11**) are consistent with the predicted positive to near neutral surface AO the next two weeks (**Figure 1**). Then heading towards early, the forecast of the PCHs in the troposphere (**Figure 11**) and the surface AO positive become more uncertain (**Figure 1**).

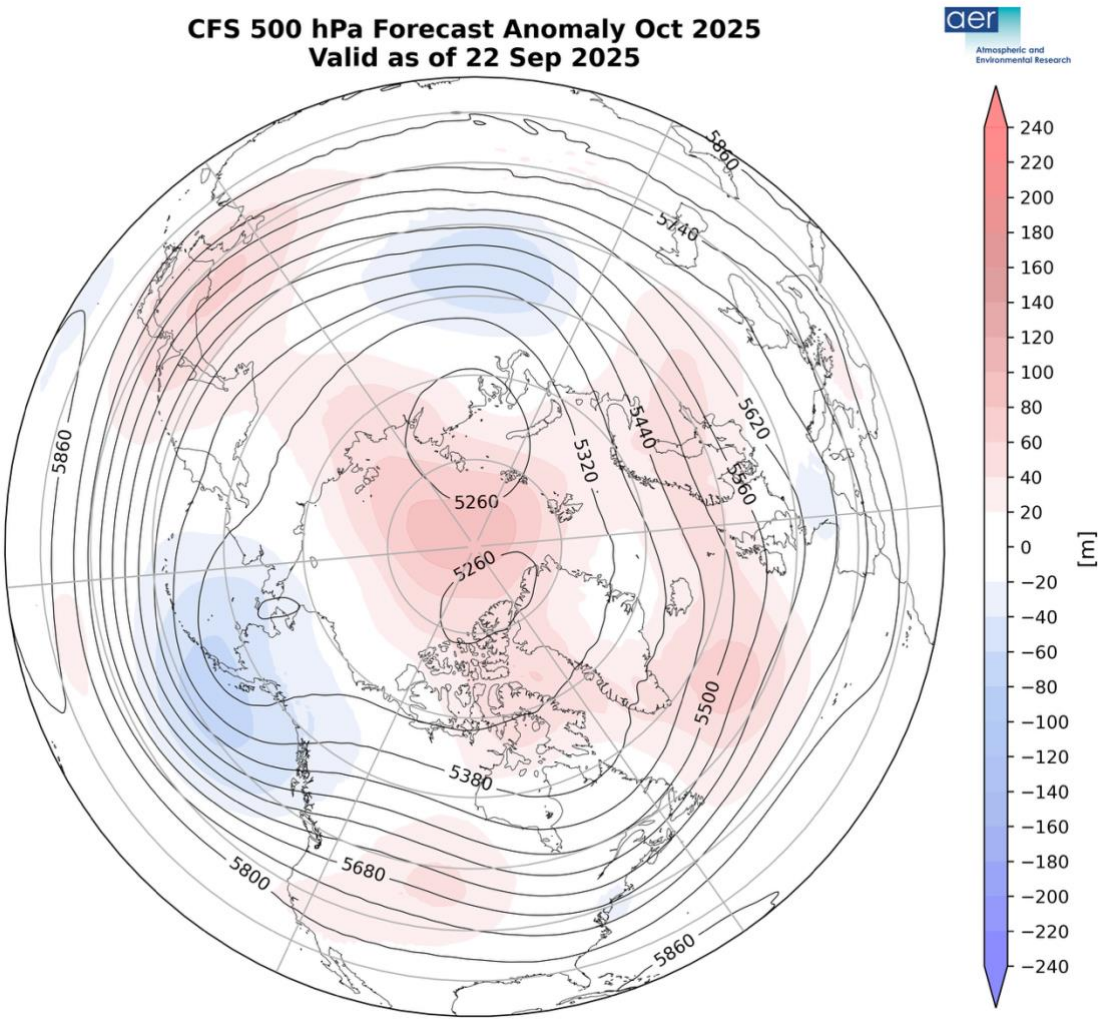

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2025. The forecasts are from the 00Z 22 Sep 2025 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for October (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered the North Pole, over Baffin Bay, Greenland and into Western Europe, East Asia, the Western US and into Central Canada with troughing across Western Europe, Central Asia, Siberia, the Gulf of Alaska and the Eastern US (**Figure 12**). This pattern favors seasonable to relatively warm temperatures across Southern and Eastern Europe, Southern and Central Asia, the Tibetan Plateau, Pakistan, Afghanistan, much of Canada and the Western US with seasonable to relatively cool temperatures across Western and Central Europe, Northern Asia including Siberia, southern Alaska, the West Coast of Canada and the Eastern US (**Figure 13**).

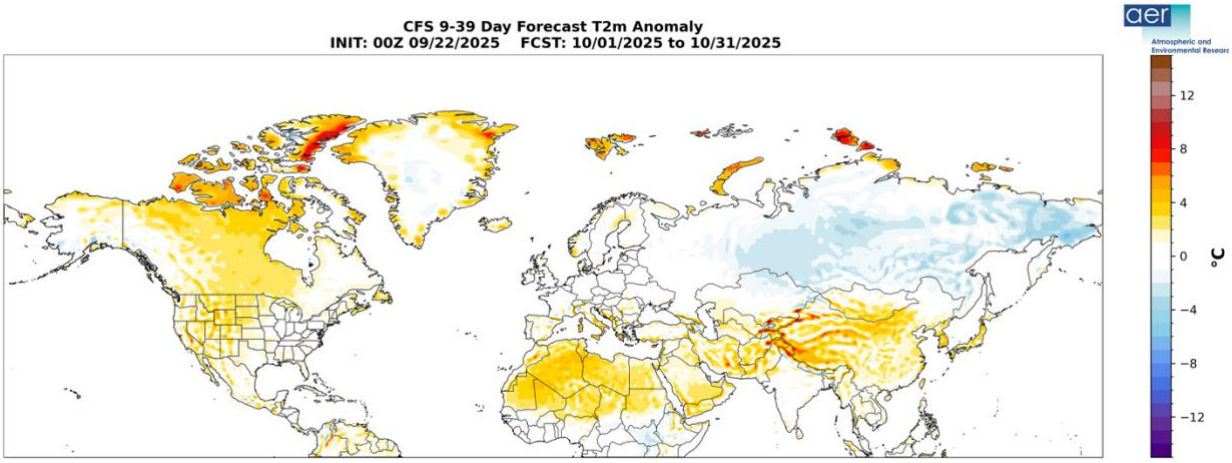

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2025. The forecasts are from the CFS 00Z 22 Sep 2025.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are slightly below normal, along the equatorial Pacific (**Figure 14**) consistent with neutral conditions but suggestive that La Niña could return once again this winter and current forecasts show large spread and plenty of uncertainty and mostly favor a continuation of neutral conditions or weak La Niña. Observed SSTs across the NH remain well above normal especially in the North Pacific (this plot is eye popping!) 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.

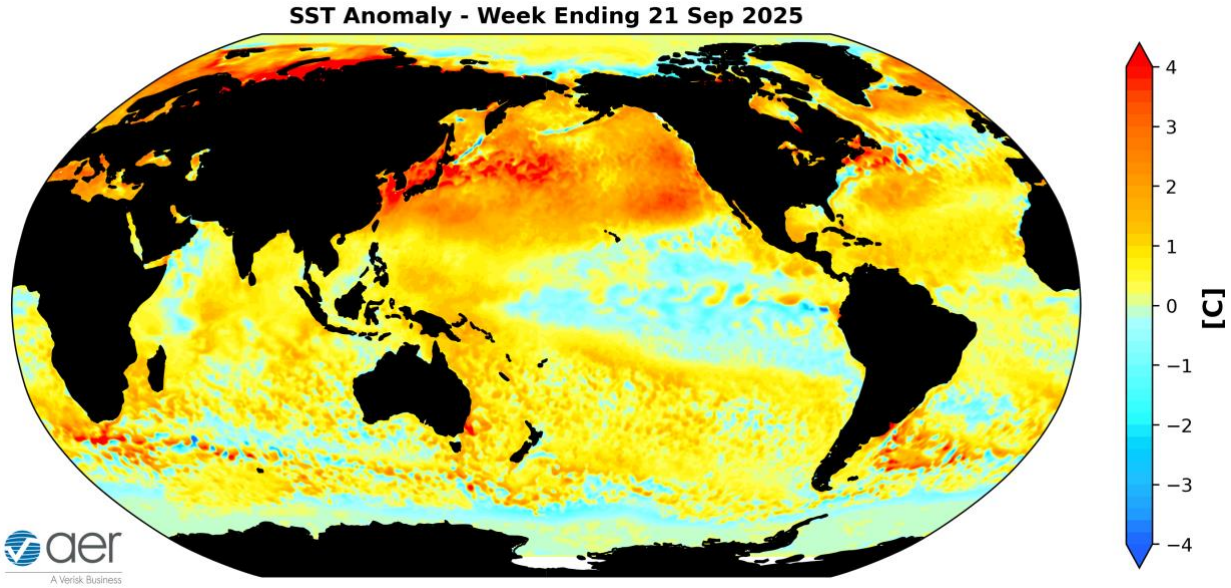

Figure 14. The latest daily-mean global SST anomalies (ending 21 Sep 2025). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently the Madden Julian Oscillation (MJO) is weak where no phase is favored (**Figure 15**) and the forecast are for the MJO to remain weak where no phase is favored for the next two weeks (**Figure 15**). Therefore, it seems to me that the MJO is likely to have little influence on North American weather the next two weeks. But admittedly this is outside of my expertise.

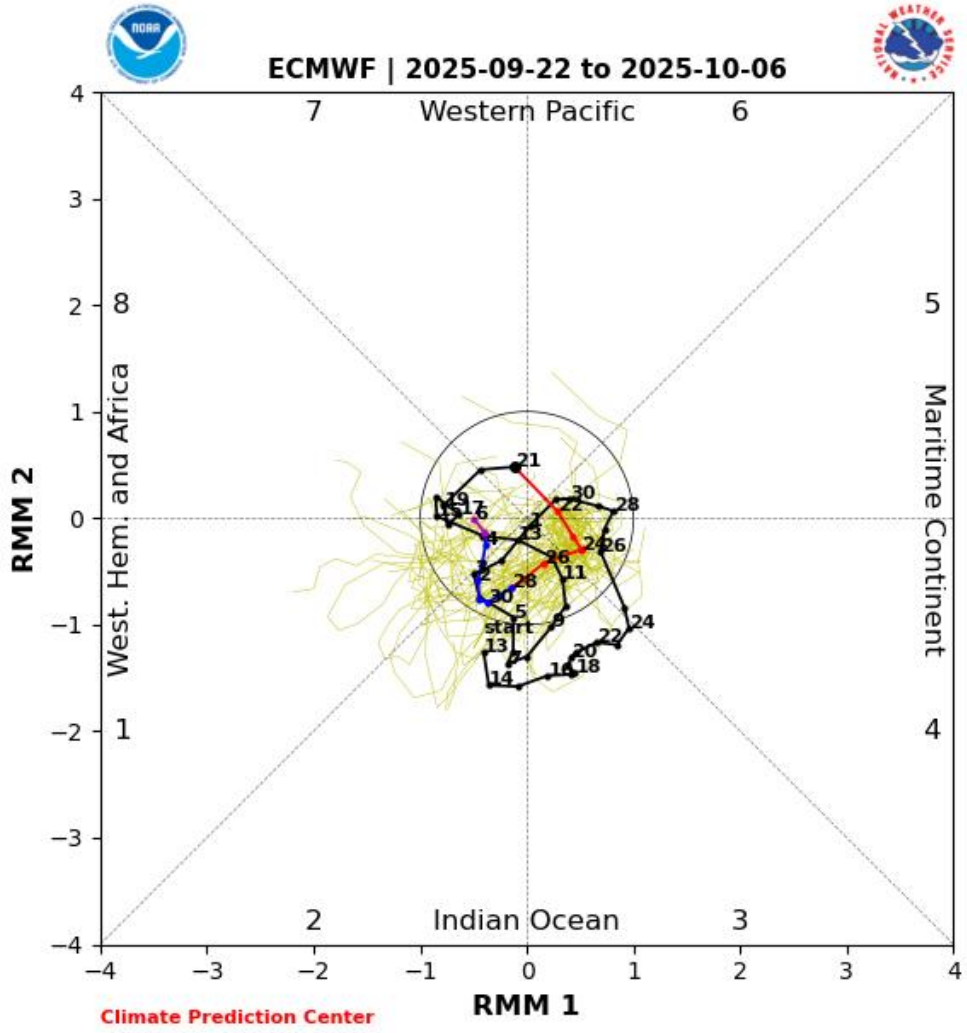

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 22 Sep 2025 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model 'spread' is denoted by the gray shading. Sector numbers indicate 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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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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