Arctic Oscillation and Polar Vortex Analysis and Forecasts

September 2, 2022

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. 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.

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

Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to trend positive this week back towards neutral and then is predicted to straddle neutral next week as pressure/geopotential height anomalies are mostly positive across the Arctic this week but then next week pressure/geopotential height anomalies are predicted to become more mixed with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently negative and is predicted to slowly trend positive this week into next week as pressure/geopotential height anomalies are positive this week and then trend weaker across Greenland next week.
- Over the next two weeks, ridging/positive geopotential height anomalies across Greenland will favor troughing/negative geopotential height anomalies across Northern and Eastern Europe with ridging/positive geopotential height anomalies across Southern and Western Europe. This pattern will favor over the next two weeks normal to above normal temperatures across Southern and Western Europe including the United Kingdom (UK) with normal to below normal temperatures across Northern and Eastern Europe.

- Over the next two weeks, ridging/positive geopotential height anomalies across Greenland will favor troughing/negative geopotential height anomalies across Northern and Western Asia with ridging/positive geopotential height anomalies across Southern and Eastern Asia. This pattern favors normal to above normal temperatures across Southern and Eastern Asia with normal to below normal temperatures across Northern and Western Asia this week.
- The general pattern this week across North America is widespread ridging/positive geopotential height anomalies across much of Canada and the United States (US) with troughing/negative geopotential height anomalies in Eastern Canada. This pattern favors widespread normal to above normal temperatures across Alaska Western Canada and much of the US with normal to below normal temperatures mostly limited to Eastern Canada.
- In the *Impacts* section I provide a quick summary of the overall summer pattern and start to look ahead to the fall and winter seasons.

Plain Language Summary

It might be September, but the models are still predicting an overall warm pattern for the US, Western Europe, and East Asia. It was a hot summer, and the model forecasts all did reasonably well with their nearly universal relatively warm forecasts. The minimum in Arctic sea ice extent is quickly approaching and the annular summer atmospheric circulation was supportive of one the slower melting seasons over the past decade.

Impacts

My apologies for the delay in publishing an update to the blog. But personal reasons and summer vacation combined for an unusual long hiatus between blogs. Things should return to normal in September, but I might use some of the weeks in September to catch up on winter summaries.

Now that September has begun, we can reflect on the Northern Hemisphere (NH) summer. Seems to me that heat, drought, and floods dominated the news headlines. Also of note were the lack of tropical systems in the North Atlantic. The heat seems to have been particularly extreme in Europe, China, and western North America (see **Figure i**). Regions of below normal temperatures were limited to southern Siberia and the Great Lakes/Upper Midwest and southern Canadian Plains.

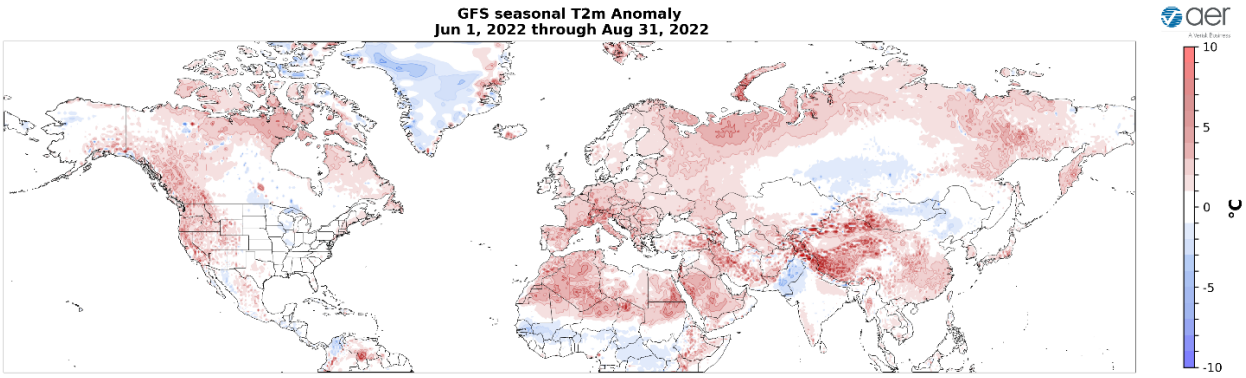

Figure i. Observed surface temperature anomalies (°C; shading) from 1 June – 31 August 2022 from the GFS analysis.

The forecasts from the North American, European and AER models were posted on the blog, but they don't seem to be in the archives, so I include it in **Figure ii**. Ironically the North American models did best in the forecast for Europe and the European models did best in the forecast for North America! All forecasts did well since they all predicted close to universal above normal temperatures as was observed but all the modes did better and worse in matching the observed pattern of anomalies. I will try to provide in a future blog a figure where the predicted and observed anomalies can be more easily compared.

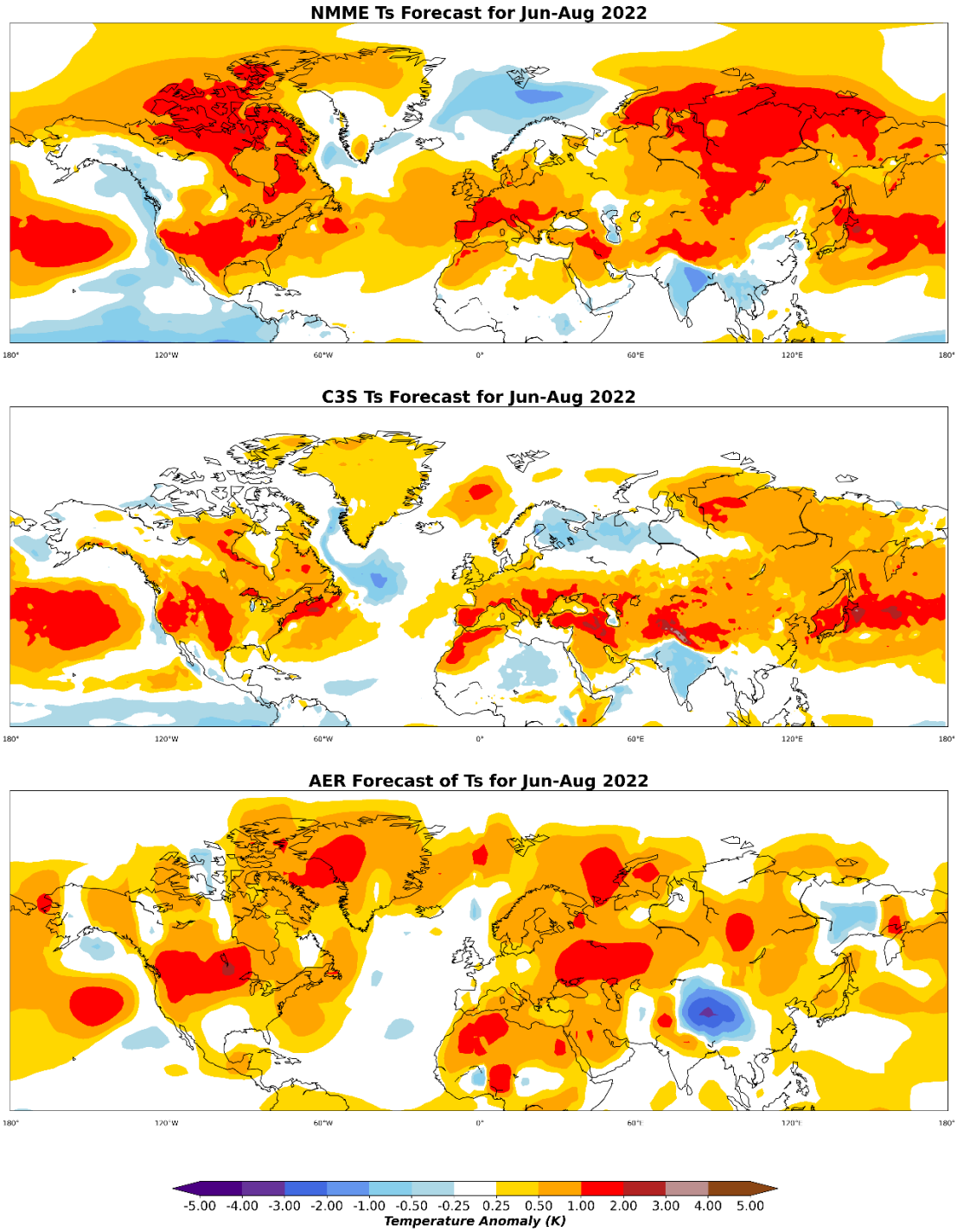

Figure ii. The NMME summer temperature anomaly forecast for June, July and August 2022 from https://www.cpc.ncep.noaa.gov/products/NMME/ (top). The C3S summer temperature anomaly forecast for June, July and August 2022 from https://www.copernicus.eu/en (center). c) The AER summer temperature anomaly forecast for June, July and August (bottom).

Meteorological summer might be over, but I see little reason not to expect the overall pattern to continue for much of the US, Europe and East Asia in September and probably into October. I am impressed with the extent of the predicted area of below normal temperatures in Northern Asia and will be interesting to see if it can one persist, and two generate an early and rapid expansion of snow cover in Siberia.

September is the month when we observe the Arctic sea ice minimum. As I have discussed in the blog during the summer, the general atmospheric circulation pattern of relatively low geopotential heights centered near the North Pole surrounded by higher heights across the mid-latitudes was conducive to preserving Arctic sea ice and even Greenland land ice. It does look like the minimum will come in between what was observed last September and those in 2013 and 2014. The following winter of 2013/14, 2014/15 and 2021/22 all featured a stretched polar vortex or reflective events during the winter but no sudden stratospheric warmings. Wondering what a stretched polar vortex or reflective event is? Then you can read our paper online just published today on the subject but focused on the winter of 2013/14: Cohen et al. 2022 and the paper is open access. It is too early to really know the character of the polar vortex this winter and is simply a gratuitous way to plug the new paper. But I will be interested to anticipate and see if the character if any of polar vortex disruptions this winter.

1-5 day

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

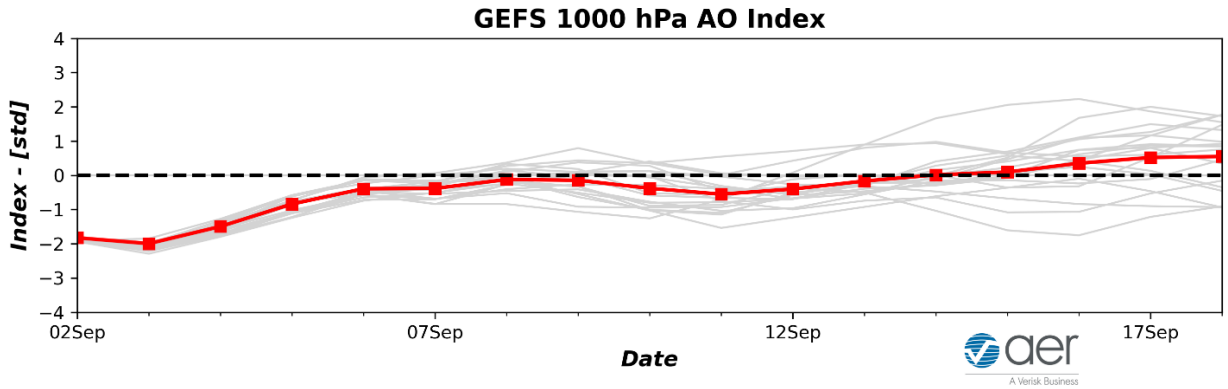

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 2 September 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Predicted ridging/positive geopotential height anomalies across Greenland will force troughing/negative geopotential height anomalies across Northeastern Europe and a closed low just west of the British Isles with ridging/positive geopotential height anomalies across Southern Europe (**Figure 2).** This will favor normal to above normal temperatures across Southern and most of Western Europe including England and Scotland with normal to below normal temperatures across Ireland, Portugal, Northern and Eastern Europe (**Figure 3**). Strong ridging/positive geopotential height anomalies across Greenland are predicted to contribute to troughing/negative geopotential height anomalies focused across Western and Northern Asia with a weaker trough in Northeastern China and ridging/positive geopotential height anomalies across Southern Asia (**Figure 2**). This pattern favors widespread normal to below normal temperatures across Northeastern China, Northern and Western Asia with normal to above normal temperatures across Southern and Central Asia **(Figure 3**).

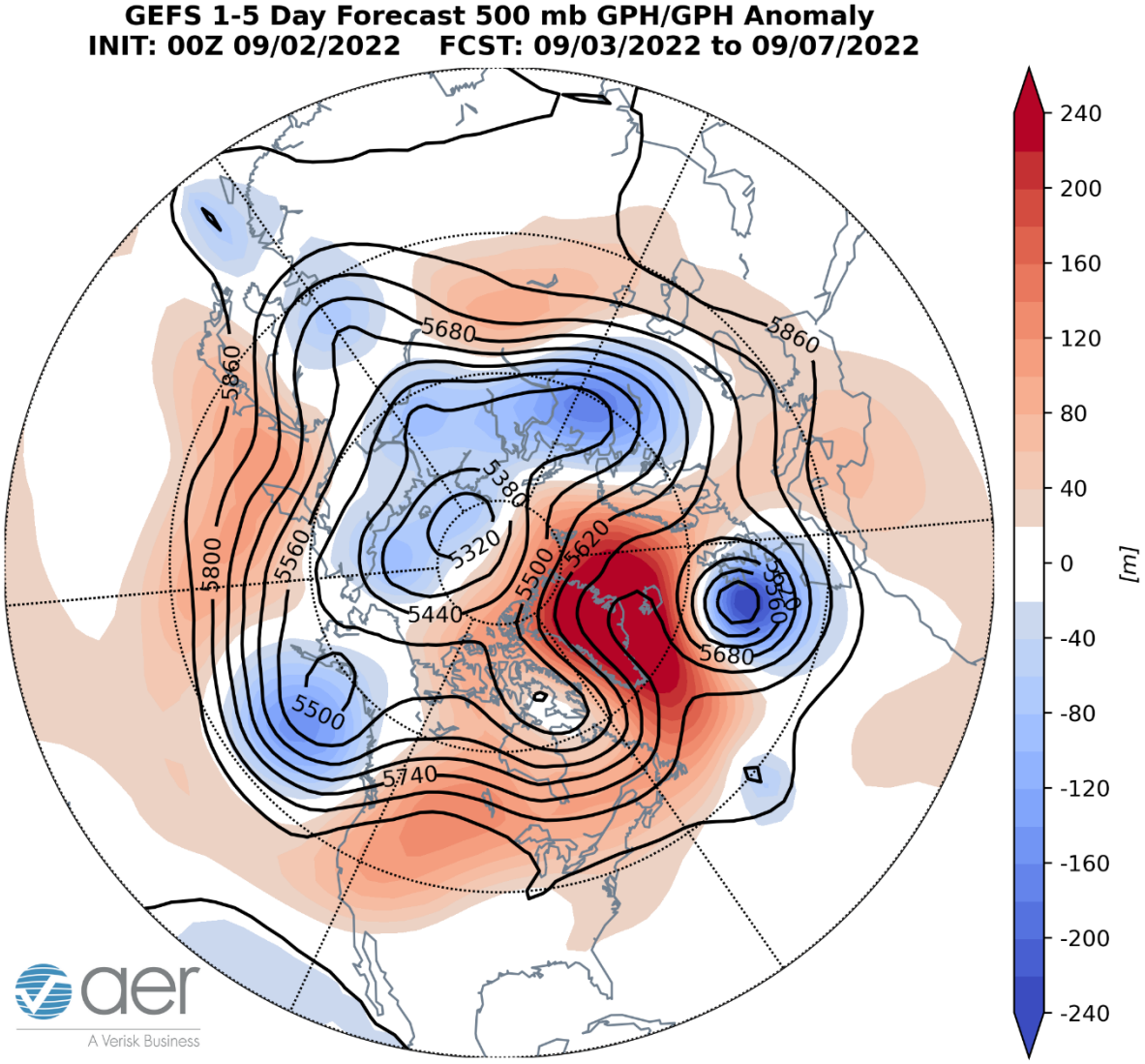

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 September 2022. The forecasts are from the 00z 2 September 2022 GFS ensemble.

Troughing/negative geopotential height anomalies in the Gulf of Alaska will contribute to widespread ridging/positive geopotential height anomalies across much of North America with weak troughing limited to the US Southern Plains **(Figure 2).** The pattern will favor widespread normal to above normal temperatures across Alaska most of Canada and the US with normal to below normal temperatures limited to the Southern Plains of the US **(Figure 3).**

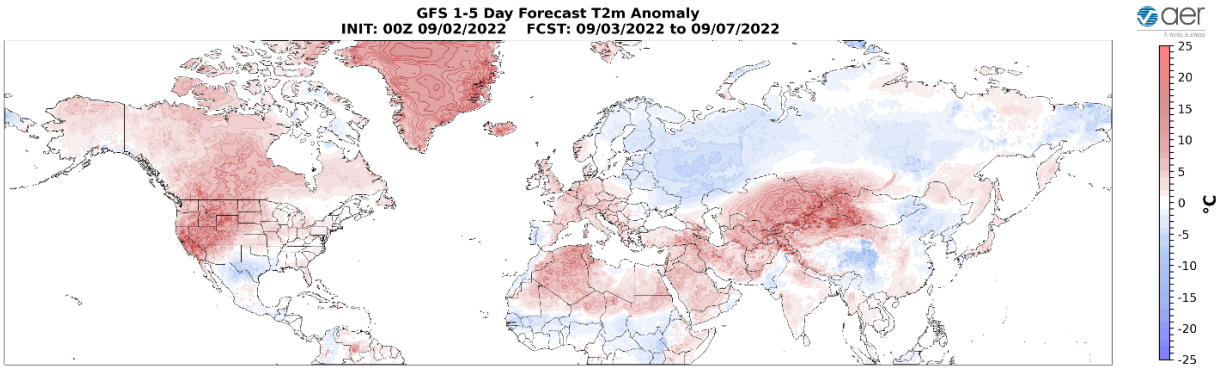

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 September 2022. The forecast is from the 00Z 2 September 2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Western Europe and parts of Southern and Eastern Asia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across Southeastern Alaska, and parts of the Southern and Eastern US (**Figure 4**).

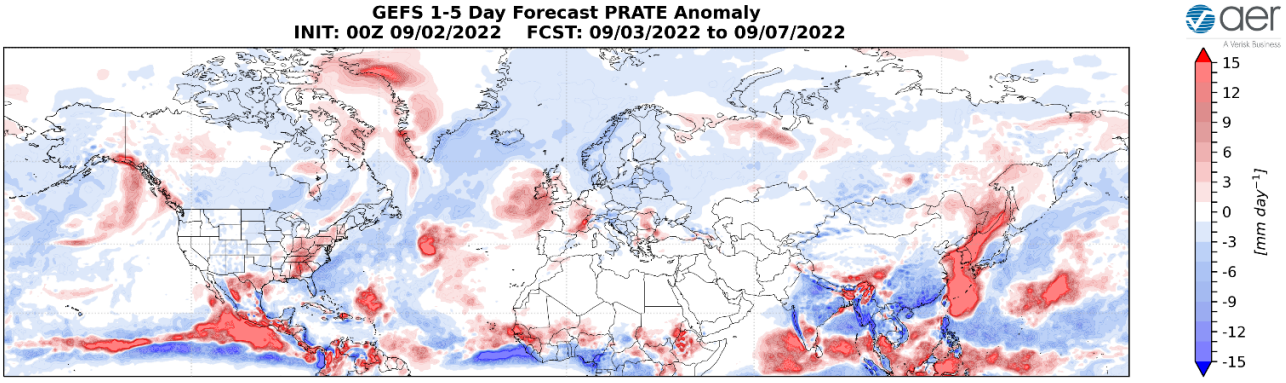

Figure 4. Forecasted precipitation rate (mm/day; shading) from 3 – 7 September 2022. The forecast is from the 00Z 2 September 2022 GEPS ensemble.

Mid-Term

6-10 day

The AO is predicted to straddle neutral this period (**Figure 1**) as geopotential height anomalies turn mostly negative across the Eurasian side of the Arctic with mostly positive geopotential height anomalies across the North American side of the Arctic (**Figure 5**). With mostly positive geopotential height anomalies across Greenland and Iceland (**Figure 5**), the NAO is predicted to remain negative this period.

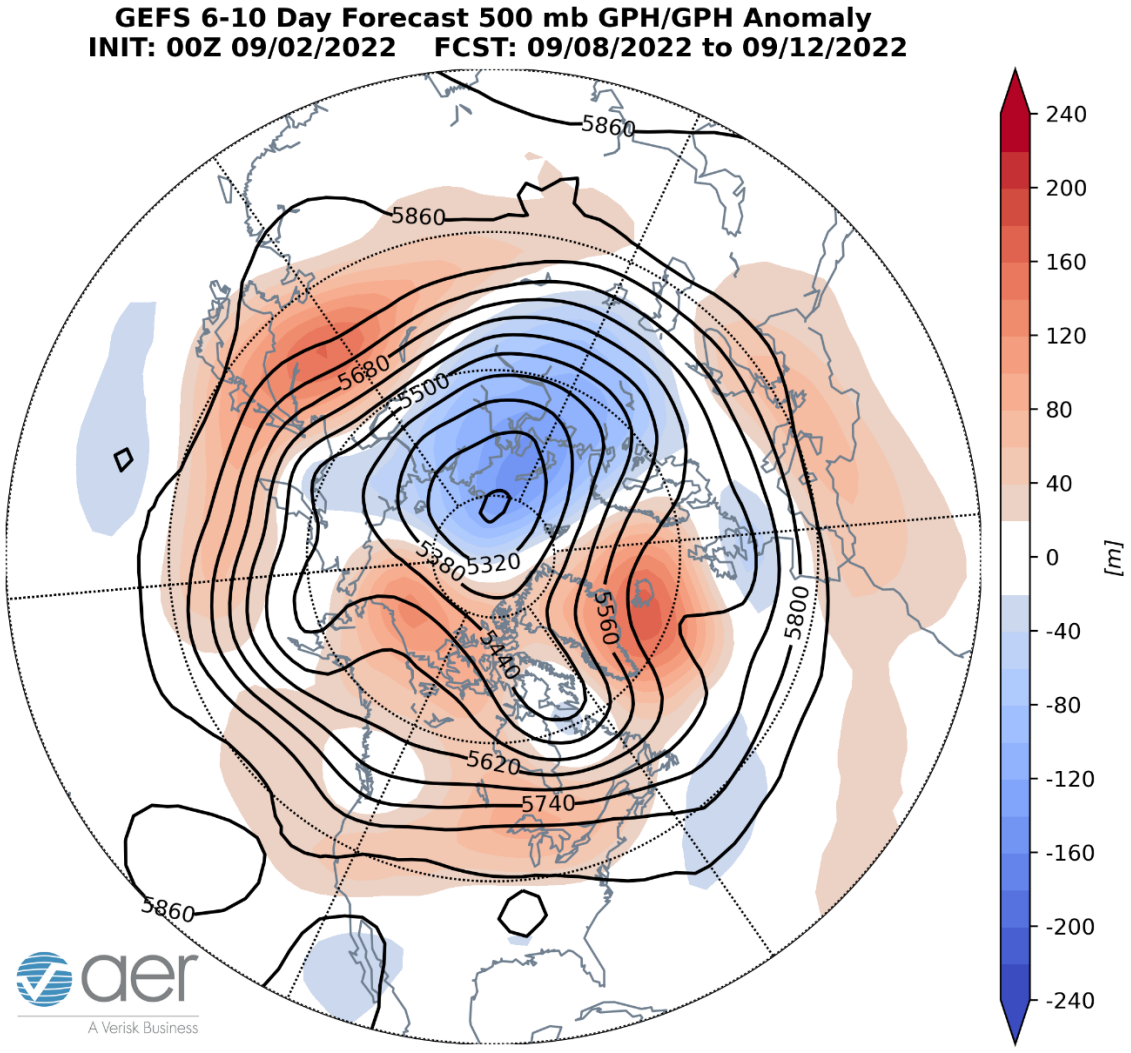

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 September 2022. The forecasts are from the 00z 2 September 2022 GFS ensemble.

Ridging/positive geopotential height anomalies across Greenland will favor troughing/negative geopotential height across Northern and Eastern Europe with a weaker trough cross the British Isles and ridging/positive geopotential height anomalies across Southern Europe this period (**Figures 5).** The pattern is predicted to result in normal to above normal temperatures across Southern and Western Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (**Figure 6**). Ridging/positive geopotential height anomalies across Greenland will continue to favor troughing/negative geopotential height anomalies in Northern and Western Asia with ridging/positive geopotential height anomalies across Southern and Eastern Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures across Southern and Eastern Asia with normal to below normal temperatures across Northern and Western Asia **(Figure 6**).

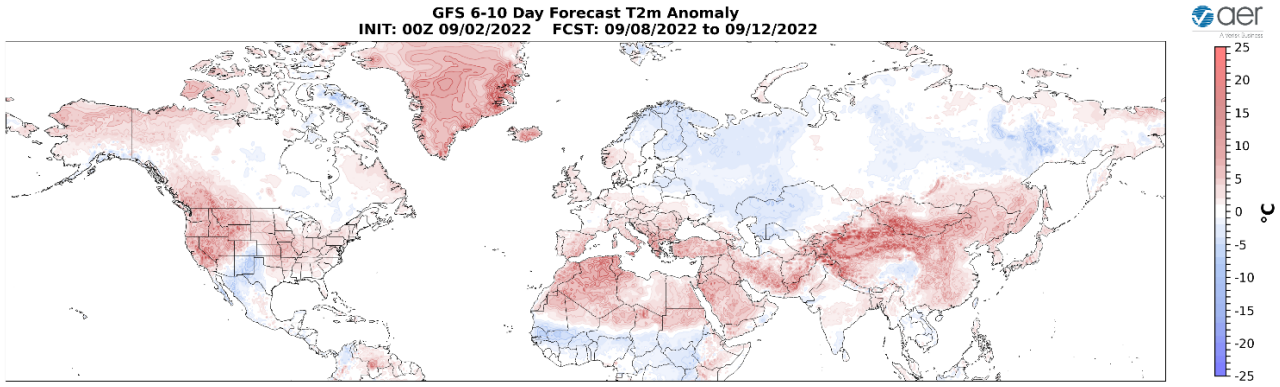

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 September 2022. The forecasts are from the 00Z 2 September 2022 GFS ensemble.

Rdging/positive geopotential height anomalies are predicted to continue to dominate much of North America with weak troughing/negative geopotential height anomalies limited to Eastern Canada and the US Southern Plains **(Figure 5).** This pattern will favor normal to above normal temperatures widespread across Alaska, much of Canada and the US with normal to below normal temperatures limited to parts of Eastern Canada and the US Southern Plains **(Figure 6).**

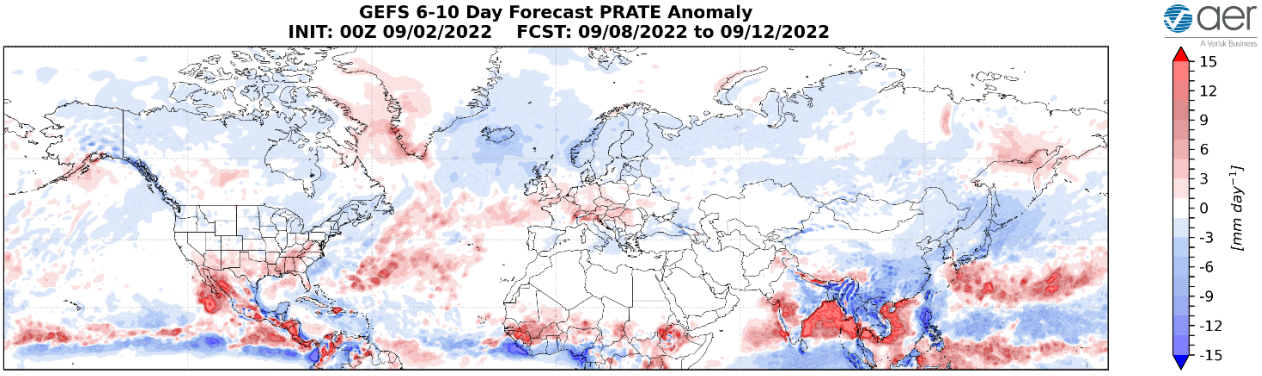

Figure 7. Forecasted precipitation rate (mm/day; shading) from 8 – 12 September 2022. The forecast is from the 00Z 2 September 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Central Europe and parts of Southern and Eastern Asia (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted across southwestern Alaska and the Southern US (**Figure 7**).

11-15 day

Geopotential height anomalies are predicted to turn mixed and weak across the Arctic this period (**Figure 8**), therefore the AO should straddle neutral (**Figure 1**). With predicted weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to remain weakly negative this period.

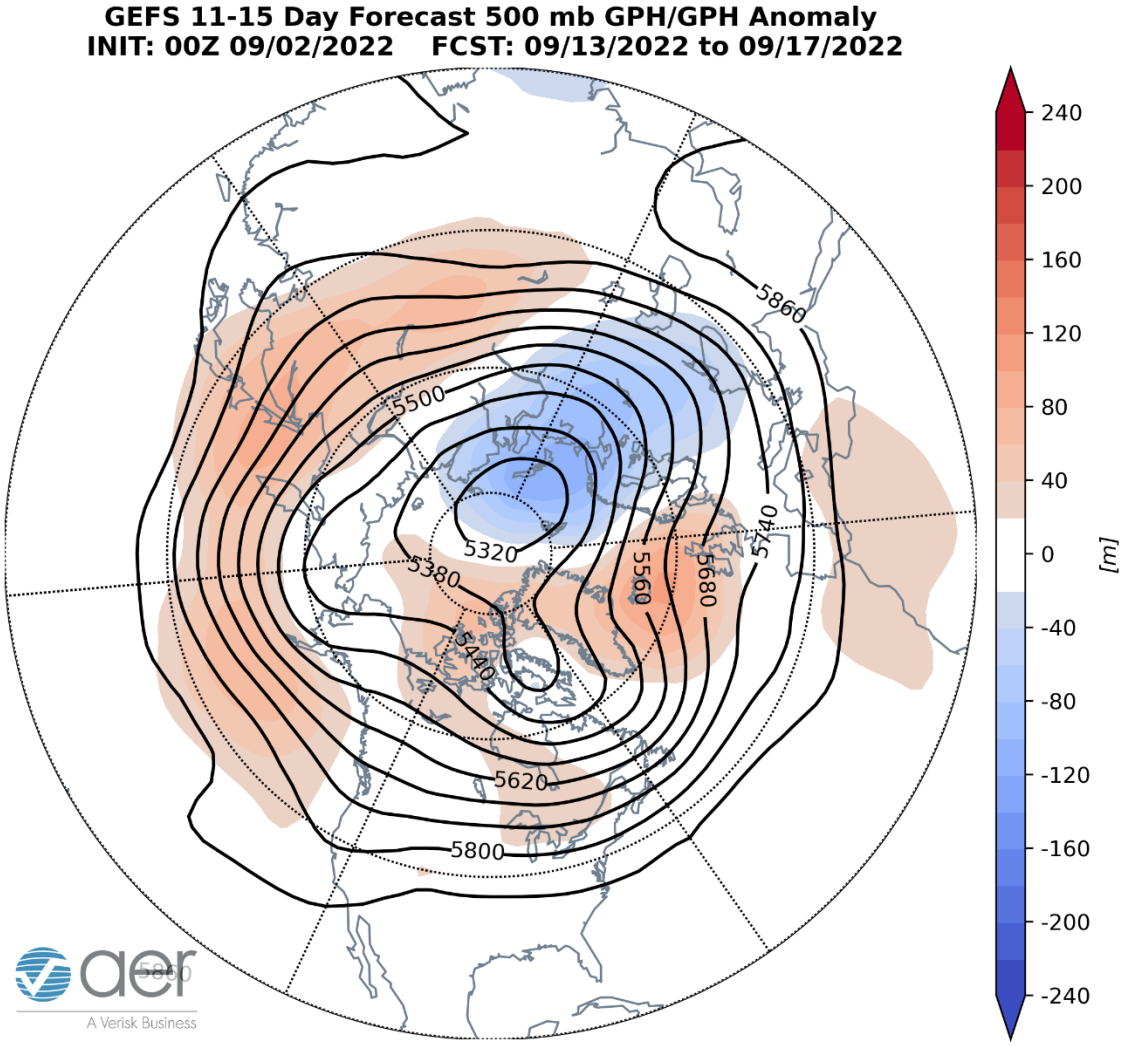

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 September 2022. The forecasts are from the 00z 2 September 2022 GFS ensemble.

Weakening but persistent ridging/positive geopotential height anomalies between Iceland and Greenland will continue to support troughing/negative geopotential height anomalies across Northern and Eastern Europe with ridging/positive geopotential height anomalies across Western and Southern Europe this period (**Figure 8**). This pattern favors normal to above normal temperatures across Western and Southern Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (**Figures 9**). Persistent albeit weakening ridging/positive geopotential height anomalies centered near Greenland will continue to support troughing/negative geopotential height anomalies in Northern and especially Western Asia with ridging/positive geopotential height anomalies across Southern and Eastern Asia (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures mostly limited to Western Asia (**Figure 9**).

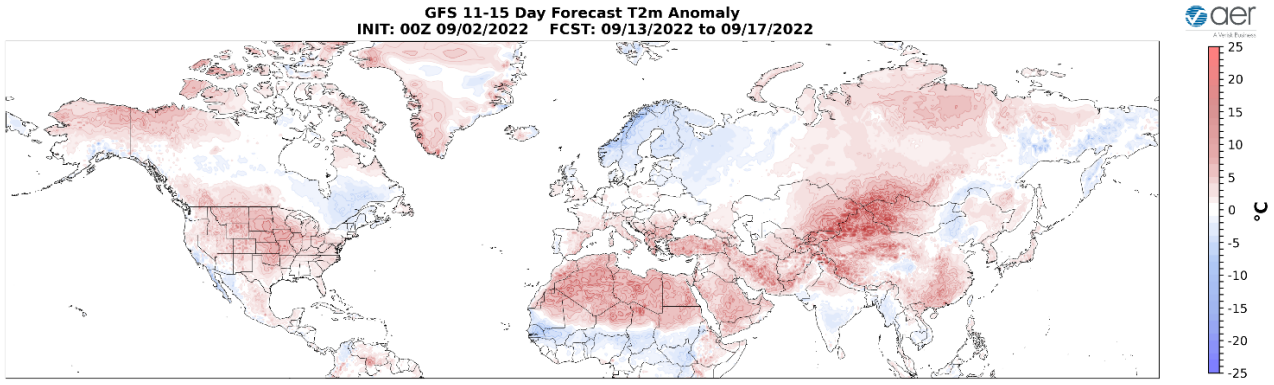

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 September 2022. The forecasts are from the 00z 2 September 2022 GFS ensemble.

The predicted pattern across North America this period is weak ridging/positive geopotential height anomalies across much of North America with weak troughing/negative geopotential height anomalies across Eastern Canada this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, Northern and Western Canada and much of the US with normal to below normal temperatures limited to Eastern Canada (**Figure 9**).

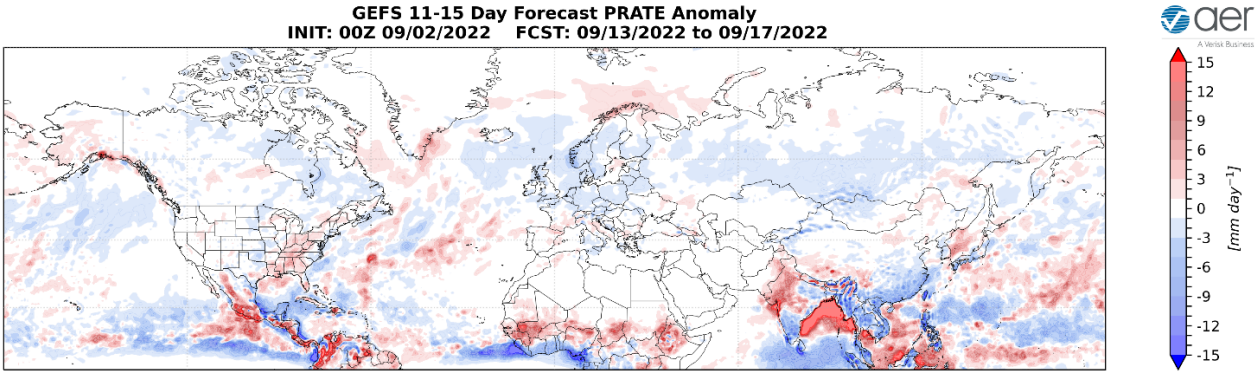

Figure 10. Forecasted precipitation rate (mm/day; shading) from 13 – 17 September 2022. The forecast is from the 00Z 2 September 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for parts of Southern and Eastern Asia (**Figure 10**). Mostly below normal precipitation is predicted across North America except for Alaska, and the Eastern US (**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 with warm/positive PCHs in the lower stratosphere and troposphere (**Figure 11**). However next week, cold/negative PCHs are predicted to develop in the lower troposphere (**Figure 11**).

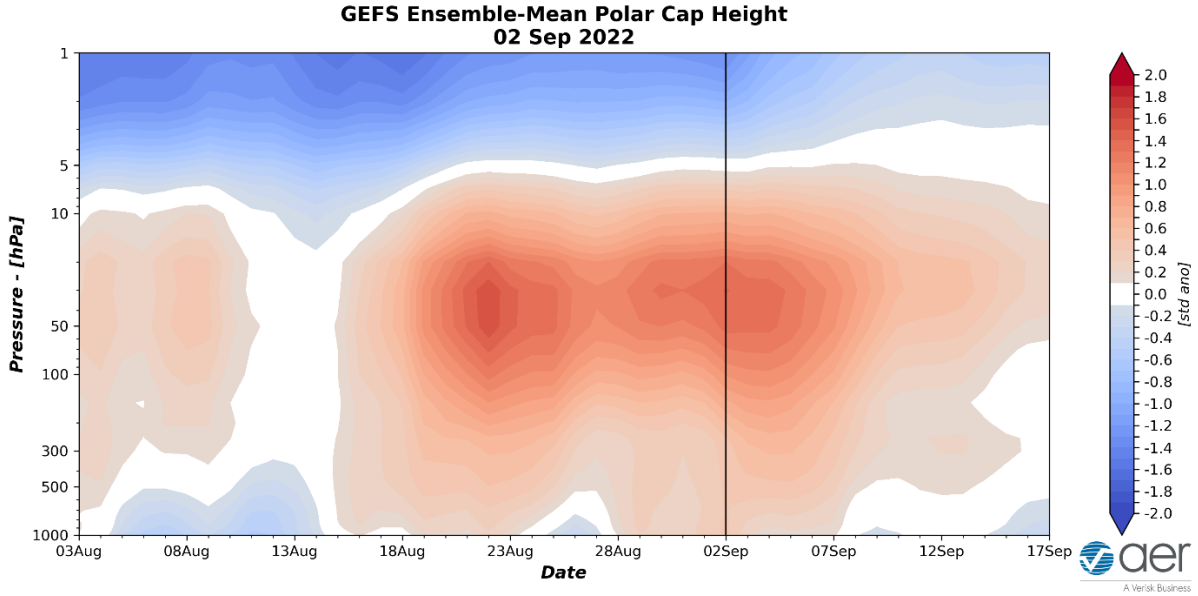

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 2 September 2022 GFS ensemble.

The warm/positive PCHs in the lower troposphere (**Figure 11**) are consistent with the predicted negative surface AO predicted for this week (**Figure 1**). However as lower tropospheric PCHs turn normal to cold next week (**Figure 11**), the surface AO is predicted to become more tethered to neutral (**Figure 1**).

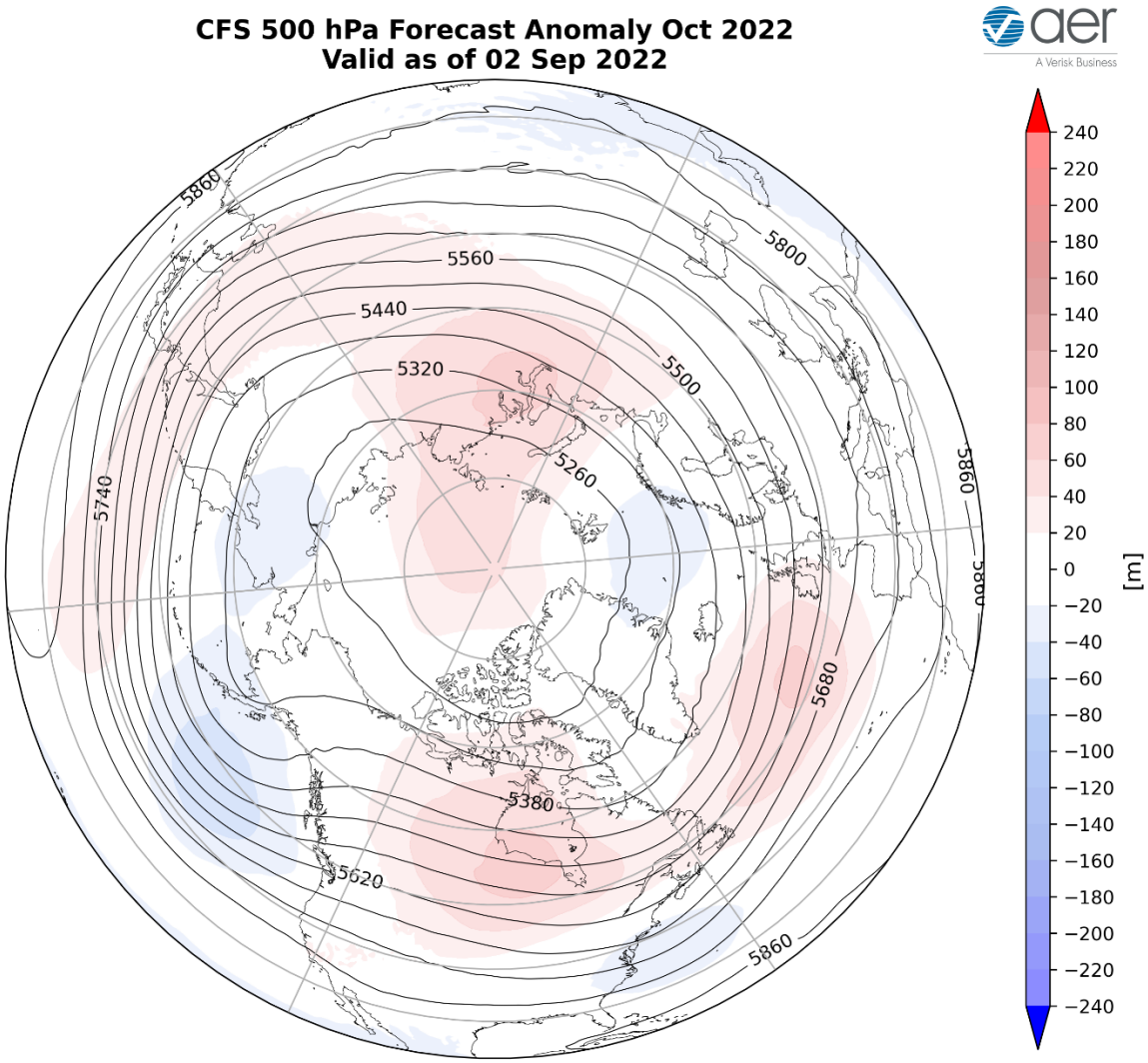

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for October 2022. The forecasts are from the 00Z 2 September 2022 CFS.

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 west of the UK, near the Urals and Laptev Sea and Hudson Bay with troughing near Greenland, Europe, Eastern Siberia, the Gulf of Alaska and the Eastern US (**Figure 12).** This pattern favors seasonable to relatively warm temperatures across Northern Europe, on either side of the Urals, Alaska, much of Canada and the Western US with seasonable to relatively cool temperatures across Central and Southern Europe, Central and Southern Asia and the Eastern US (**Figure 13**).

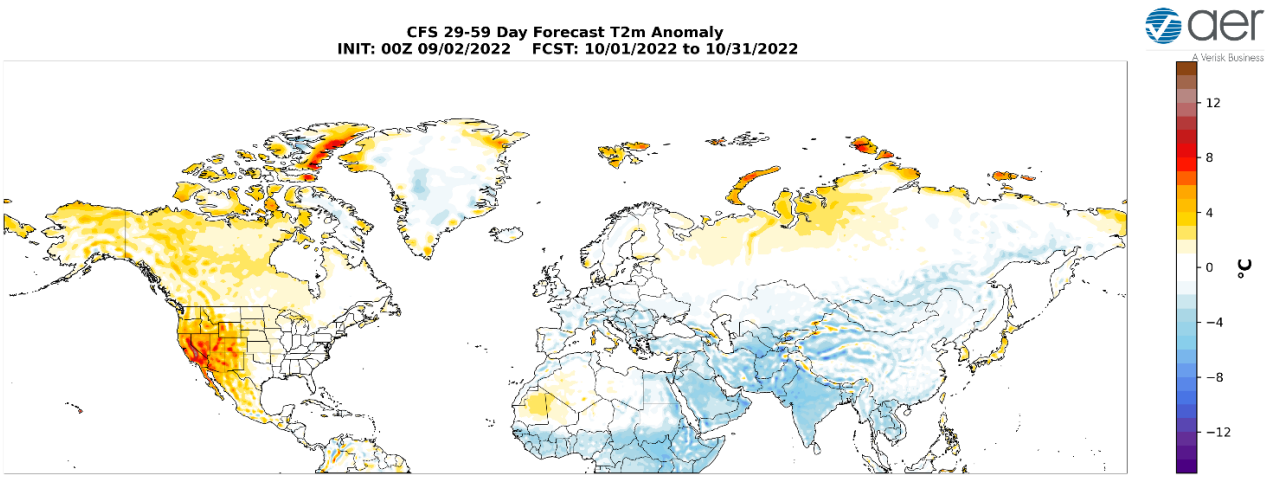

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for October 2022. The forecasts are from the 00Z 2 September 2022 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 14**) and La Niña 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 and offshore of eastern North America though below normal SSTs exist regionally especially in the North Pacific.

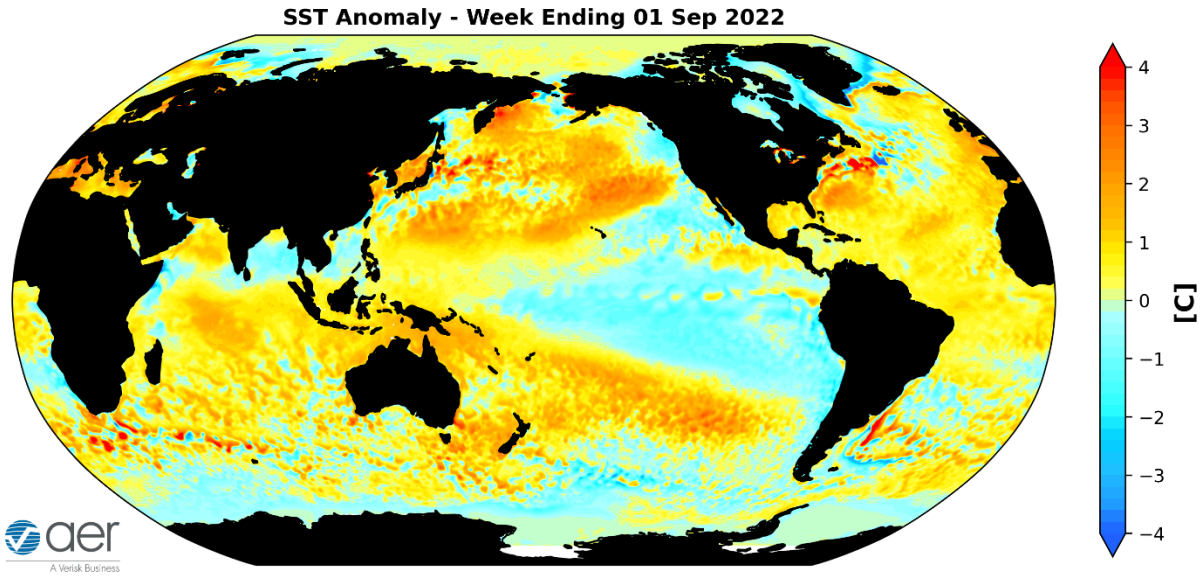

Figure 14. The latest weekly-mean global SST anomalies (ending 1 September 2022). Data from NOAA OI High-Resolution dataset.

Currently the Madden Julian Oscillation (MJO) is weak where no phase is favored (**Figure 15**). The forecasts are for the MJO to remain weak where no phase is favored. Therefore there seems to be little MJO influence in the near and long term weather across North America. But admittedly this is outside of my expertise.

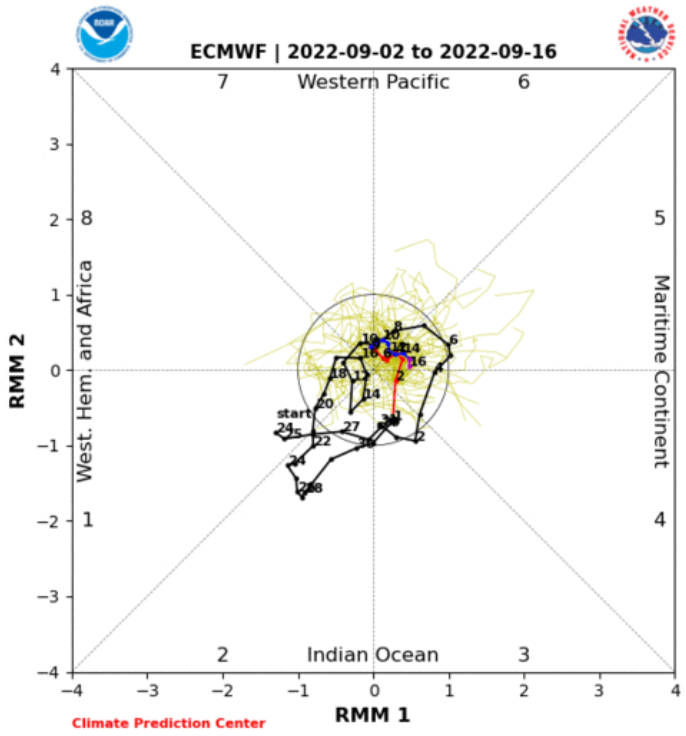

Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 2 September 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html

Get Detailed Seasonal Weather Intelligence with sCast

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 for purchase. 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!