Arctic Oscillation and Polar Vortex Analysis and Forecasts

May 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 neutral and is predicted to trend positive and remain positive over the next two weeks with mostly negative pressure/geopotential height anomalies across the Arctic including the North Atlantic side of the Arctic the next two weeks with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently negative and is predicted to trend positive as pressure/geopotential height anomalies are predicted to become increasingly negative across Greenland over the next two weeks.
- Deepening troughing/negative geopotential height anomalies across Greenland will support strengthening ridging/positive geopotential height anomalies across Europe. This pattern favors widespread normal to above normal temperatures across much of Europe including the United Kingdom (UK) with normal to below normal temperatures limited to Eastern Europe the next ten days or so due to northerly flow.

- The general pattern across Asia the next two weeks is troughing/negative geopotential height anomalies across Northern Asia with ridging/positive geopotential height anomalies across Southern Asia. This mostly zonal pattern favors widespread normal to above normal temperatures across most of Asia with the most notable exception being East Asia where northerly flow will support normal to below normal temperatures across East Asia for much of the next two weeks.
- The general pattern this week across North America is troughing/negative in the Gulf of Alaska forcing ridging/positive geopotential height anomalies across Northern Canada with troughing/negative geopotential height anomalies across Eastern Canada and the Central United States (US). However, next week the pattern will transition to ridging/positive geopotential height anomalies in the Gulf of Alaska, western North America, the Northeastern US and the Canadian Maritimes with troughing/negative geopotential height anomalies across Central Canada and the Central US in between the ridging on both coasts. The pattern favors this week normal to above normal temperatures across Alaska, Western and Northern Canada and the Western and Southern US with normal to below normal temperatures across Eastern Canada and the Central and Northeastern US. Then next week normal to above normal temperatures will become widespread across Alaska, much of Canada and the Western and Northeastern US with normal to below normal temperatures across the Central US.
- In the *Impacts* section I discuss how it appears that the atmosphere is transitioning to its summer pattern.
- I am travelling the next two weeks and the blog after this week is likely to be in three weeks' time.

Plain Language Summary

Any influence from the large polar vortex disruption back in March is likely over. Instead, I expect the atmosphere to transition to the summer pattern. I will post the official AER summer forecast at the end of the month but in the meantime the "trend is your friend" is a good first guess. This includes low pressure with relatively seasonable to cool temperatures in the Central Arctic surrounded by a "ring of fire" across the northern continents.

Impacts

I discussed last week that based on the polar cap geopotential height anomalies (PCHs) forecast it appeared that the relationship between the large PV disruption from March and current and future weather across the Northern Hemisphere (NH) was waning. The PCH plot from this week looks very different and based on today's forecast (**Figure 11**) the influence of the PV disruption is clearly over and the troposphere has transitioned from one dominated by warm/positive PCHs to one dominated by cold/negative PCHs. This pattern favors low heights/pressures in the Central Arctic ringed by high

heights/pressures across the continents at mid- to high latitudes (e.g., **Figure 8**). This pattern could be the dominant pattern for the summer. This pattern would help to retard the melt of Arctic Ocean sea ice but could also favor heat domes over the continents supporting heat waves and wildfires. In fact, I already saw on the Twitter feed of @siberian_times many clips of current wildfires in Siberia and it is not even summer! This could portend another bad summer there.

I have included a summer surface temperature trend figure I posted in the blog from 12 July 2021 in **Figure i**. I will post the official AER summer forecast at the end of the month but in the meantime the recent decadal trend is a good first guess. Based on the latest GFS forecast, the trend seems to be in this direction, and it is hard for me to imagine what might cause the overall temperature to deviate from the recent trend.

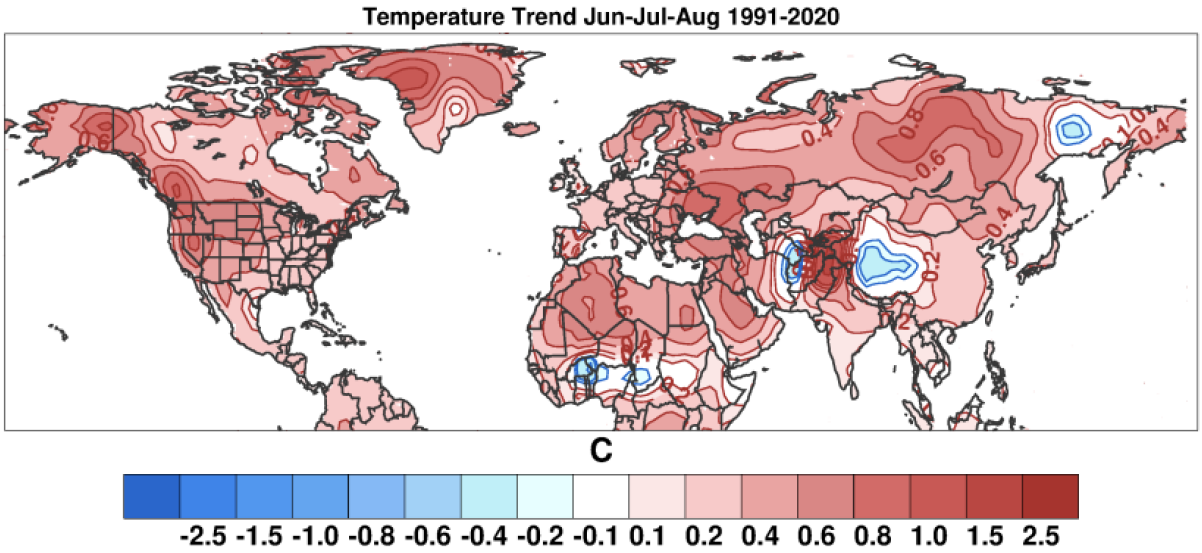

Figure i. Observed June, July, and August surface temperature trend (°C; shading) from 1990 through 2020 based on the NCEP/NCAR reanalysis.

1-5 day

The AO is predicted to be positive this week **(Figure 1**) as geopotential height anomalies are predicted to turn mostly negative across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with a predicted transition to increasingly negative geopotential height anomalies this week across Greenland (**Figure 2**), the NAO is predicted to begin negative, but trend positive this week (**Figure 1**).

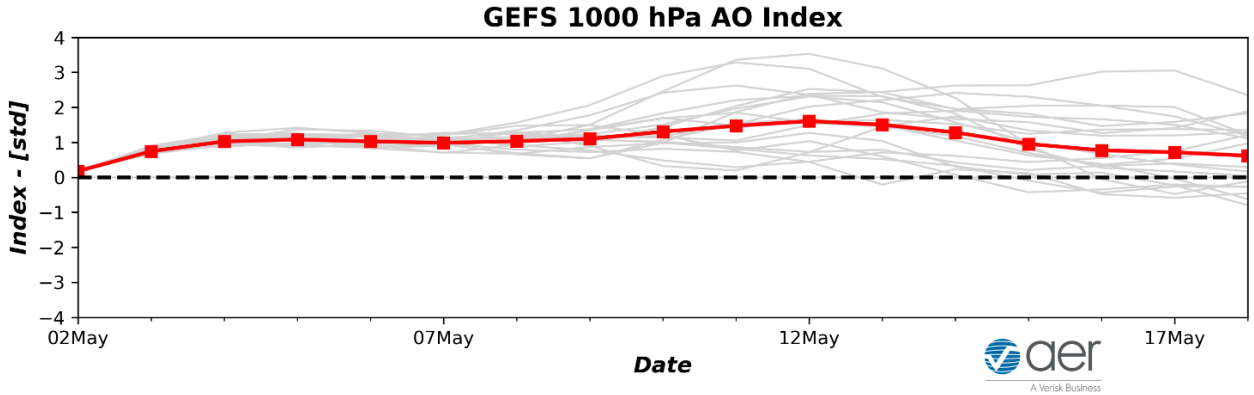

Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 2 May 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Deepening troughing/negative geopotential height anomalies across Greenland will support strengthening ridging/positive geopotential height anomalies across Western Europe with downstream troughing/negative geopotential height anomalies across Eastern Europe (**Figures 2).** This will result in normal to above normal temperatures across Western and Southern Europe including the UK with normal to below normal temperatures across Northern and Eastern Europe (**Figure 3**). Troughing/negative geopotential height anomalies is predicted across Western and Northeastern Asia with ridging/positive geopotential height anomalies across Central and Southern Asia this period (**Figure 2**). This pattern favors normal to below normal temperatures across Western and Northeastern Asia with normal to above normal temperatures across Central and Southern Asia **(Figure 3**).

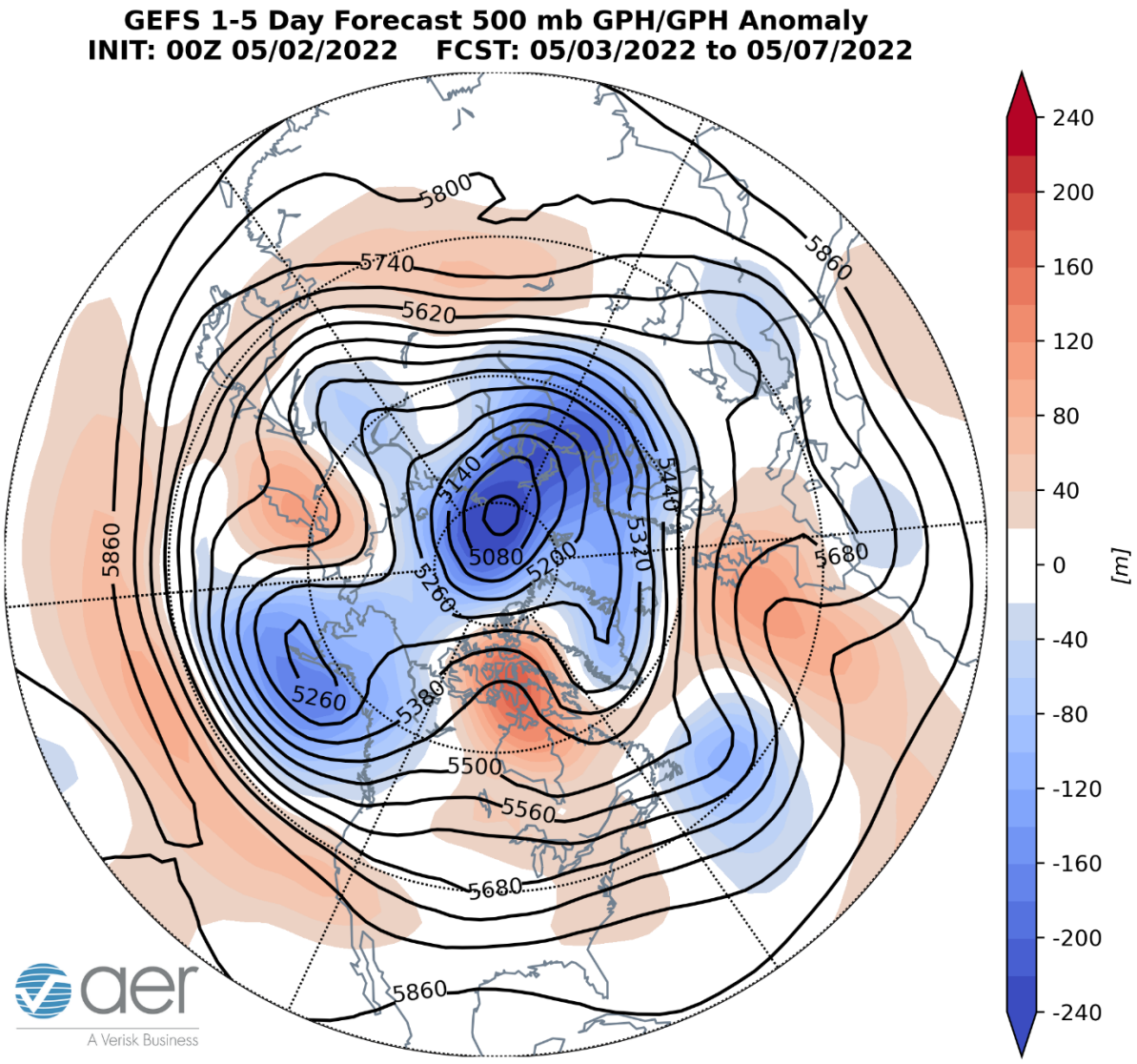

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 May 2022. The forecasts are from the 00z 2 May 2022 GFS ensemble.

Across North America the general pattern is troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska that will support ridging/positive geopotential height anomalies across Northern Canada and the Western and Southern US with more troughing/negative geopotential height anomalies across Eastern Canada **(Figure 2).** The pattern will favor normal to above normal temperatures across Alaska, Northern and Western Canada and the Western and Southern US with normal to below normal temperatures across Central and Eastern Canada and the Central and Northeastern US **(Figure 3).**

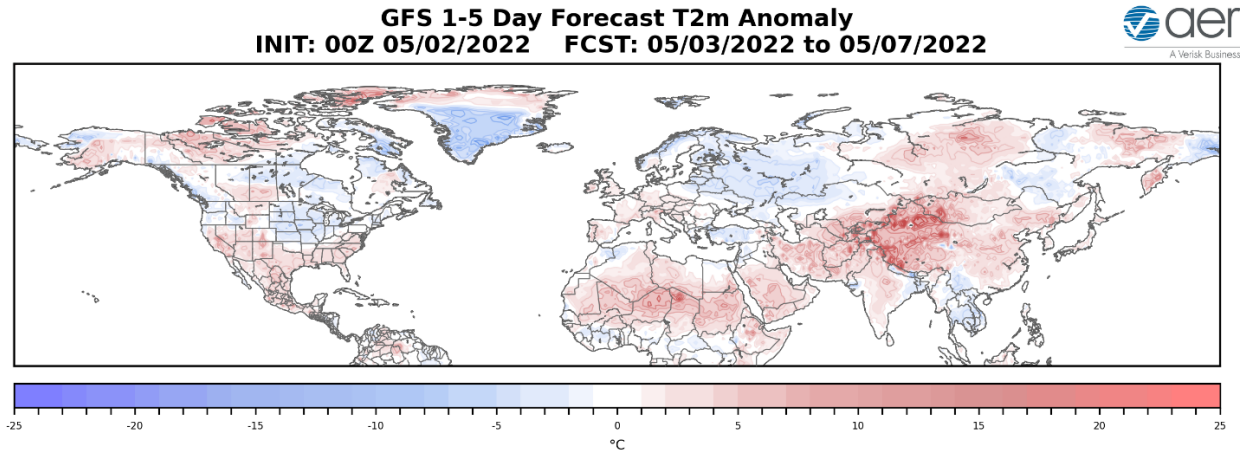

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 May 2022. The forecast is from the 00Z 2 May2022 GFS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Southeast Asia and Western Siberia (**Figure 4**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Southern Alaska, Western Canada, and the Central and Eastern US (**Figure 4**).

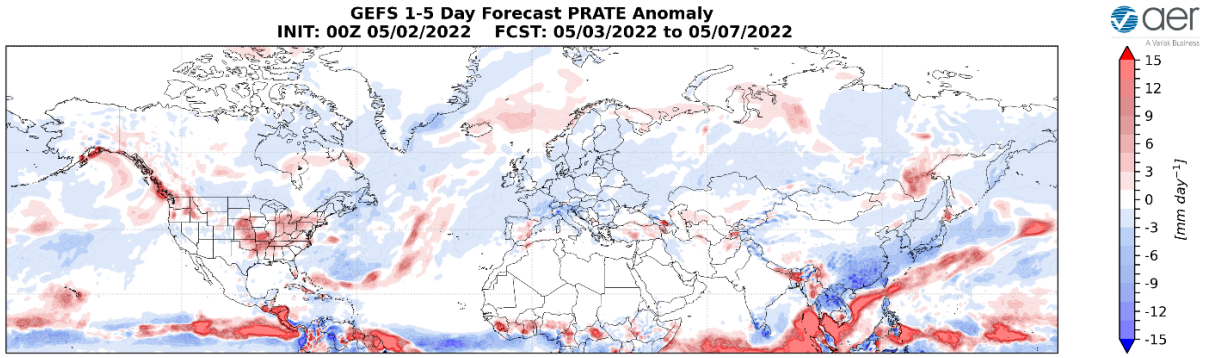

Figure 4. Forecasted precipitation rate (mm/day; shading) from 3 – 7 May 2022. The forecast is from the 00Z 2 May 2022 GEPS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain positive this period **(Figure 1**) as geopotential height anomalies remain mostly negative across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And as geopotential height

anomalies continue to trend negative across Greenland (**Figure 5**), the NAO is predicted to trend positive this period.

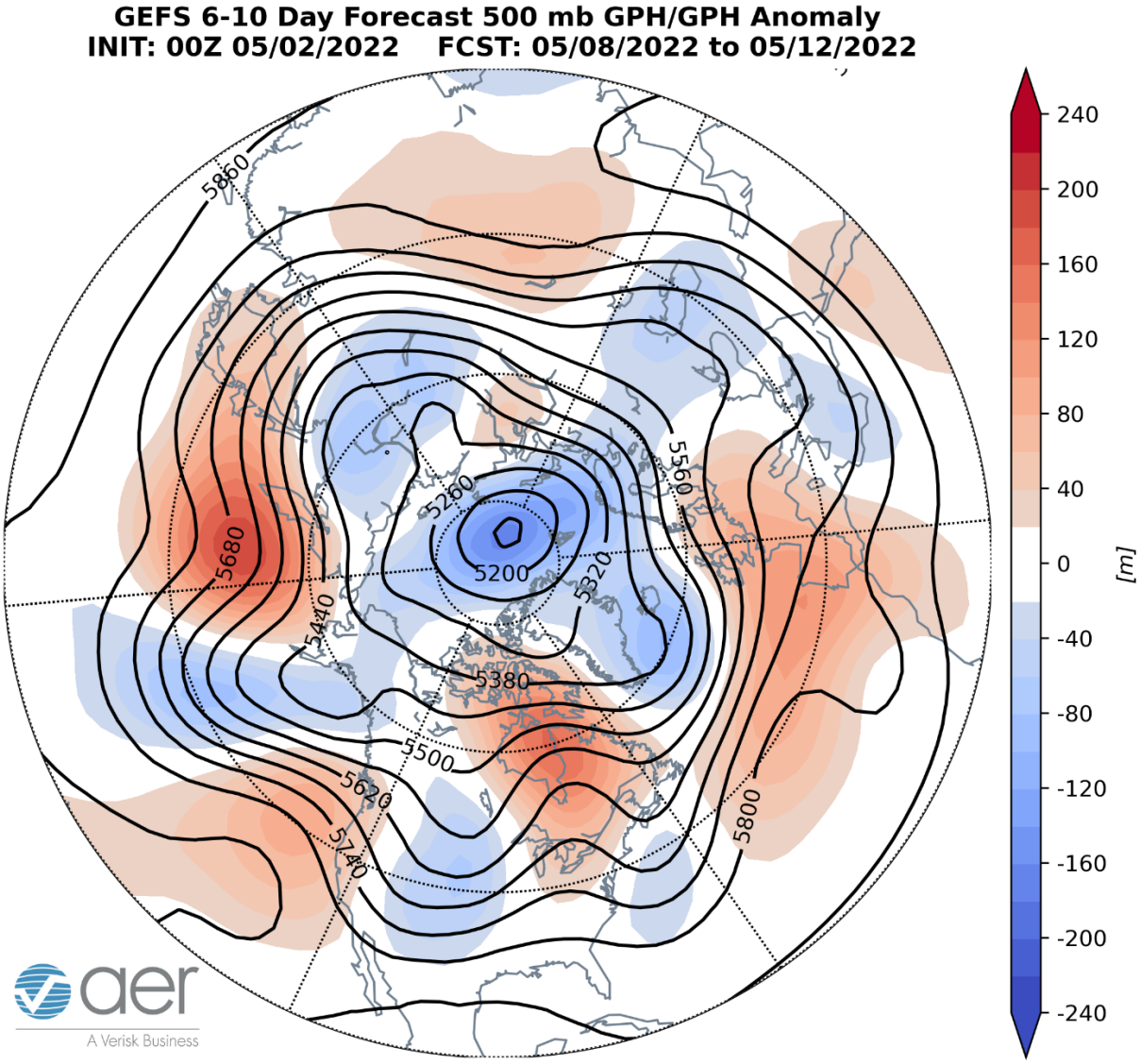

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 8 – 12 May 2022. The forecasts are from the 00z 2 May 2022 GFS ensemble.

Predicted troughing/negative geopotential height anomalies across Greenland will continue to support deepening ridging/positive geopotential height anomalies across Western and Central Europe with northerly flow on the downstream side of the ridge across Eastern Europe this period (**Figures 5).** This will result in normal to above normal temperatures across Western and Central Europe including the UK with normal to below normal temperatures limited to Eastern Europe (**Figure 6**). The pattern across

Asia is predicted to persist with troughing/negative geopotential height anomalies across Western and Northeastern Asia with ridging/positive geopotential height anomalies across Central and Southern Asia this period (**Figure 5**). This pattern favors normal to below normal temperatures across much of Western and Northeastern Asia with normal to above normal temperatures across Central and Southern Asia **(Figure 6**).

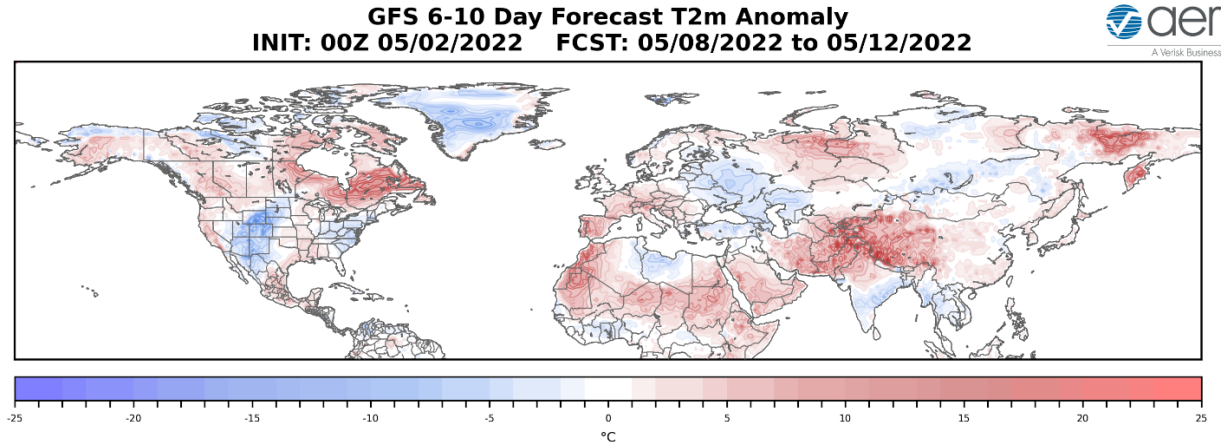

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 8 – 12 May 2022. The forecasts are from the 00Z 2 May 2022 GFS ensemble.

Troughing/negative geopotential height anomalies are predicted to transition to ridging/positive geopotential height anomalies in the Gulf of Alaska and the Western US favoring developing troughing/negative geopotential height in the Central US with more ridging/positive geopotential height anomalies across Northern and Eastern Canada **(Figure 5).** This will favor normal to above normal temperatures across Alaska, much of Canada and the Western US with normal to below normal temperatures across the Central and Eastern US **(Figure 6).**

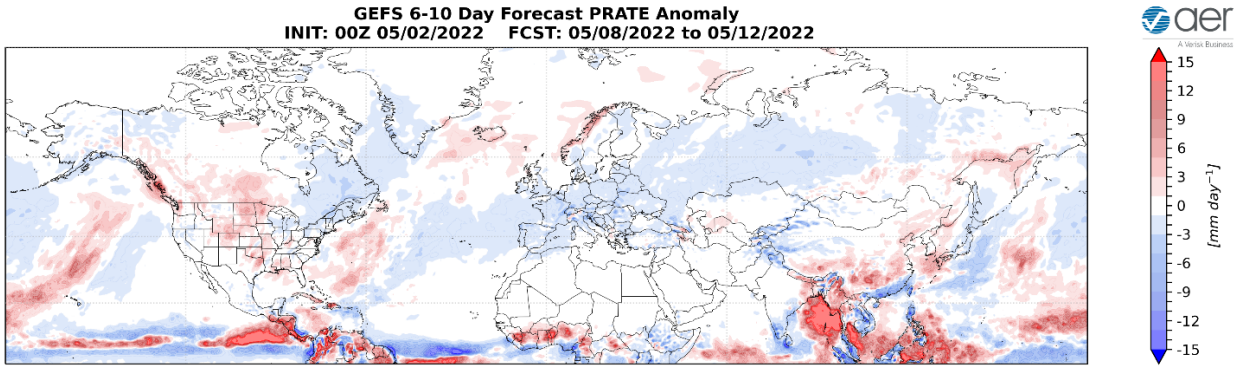

Figure 7. Forecasted precipitation rate (mm/day; shading) from 8 – 12 May 2022. The forecast is from the 00Z 2 May 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Norway and Southern and Eastern Asia (**Figure 7**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for the West Coast of Canada, the Canadian Maritimes, the Upper Midwest, and the Eastern US (**Figure 7**).

11-15 day

Geopotential height anomalies are predicted to remain mostly negative in the Central Arctic this period (**Figure 8**), therefore the AO should remain positive (**Figure 1**). With predicted weak and negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to also remain on the positive side of neutral this period.

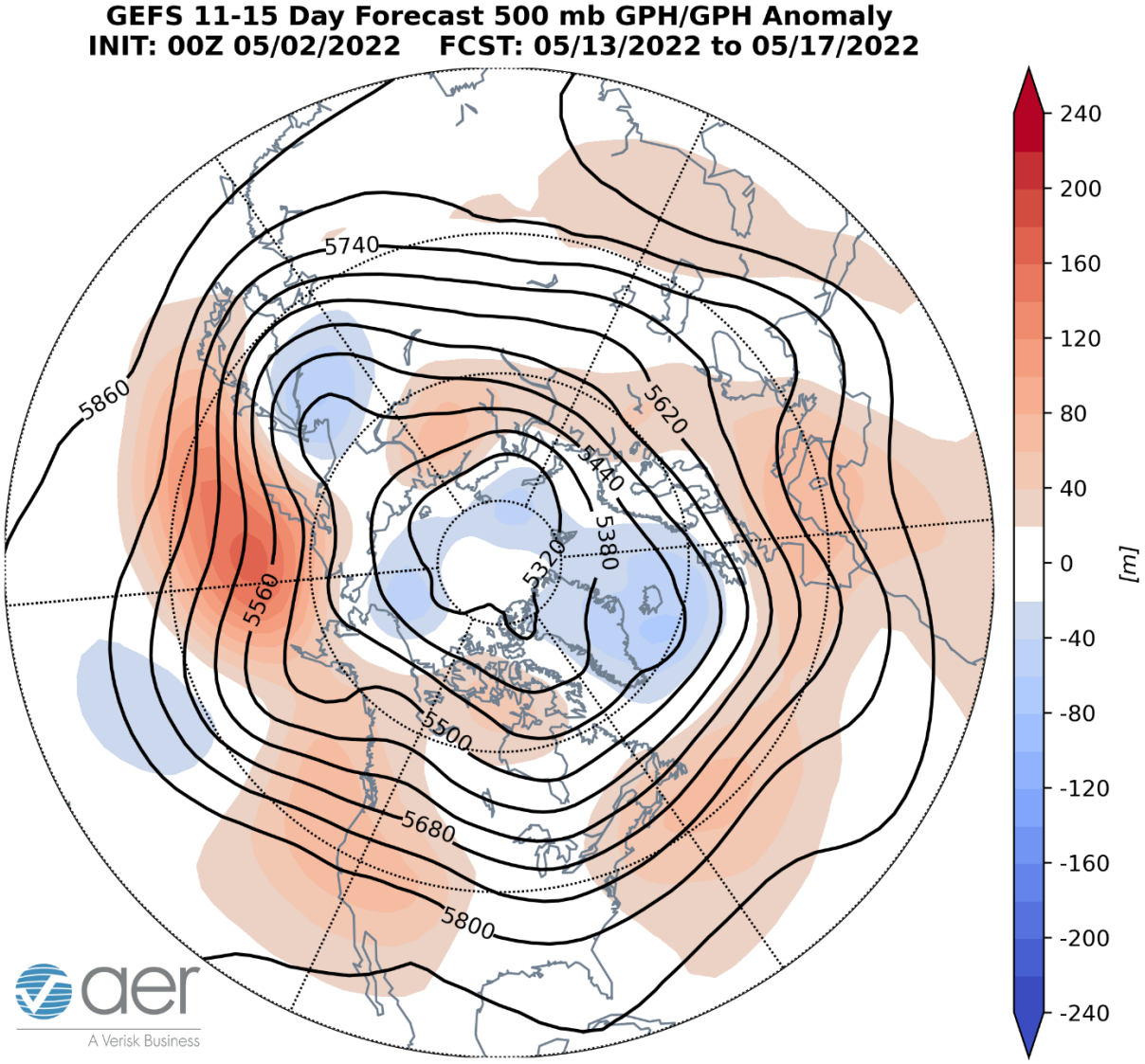

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 13 – 17 May 2022. The forecasts are from the 00z 2 May 2022 GFS ensemble.

Persistent troughing/negative geopotential height anomalies across Greenland will continue to support ridging/positive geopotential height anomalies across much of Europe this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures widespread across Europe including the UK (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to become more widespread across Asia this period with troughing/negative geopotential height anomalies limited to East 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 Eastern Asia (**Figure 9**).

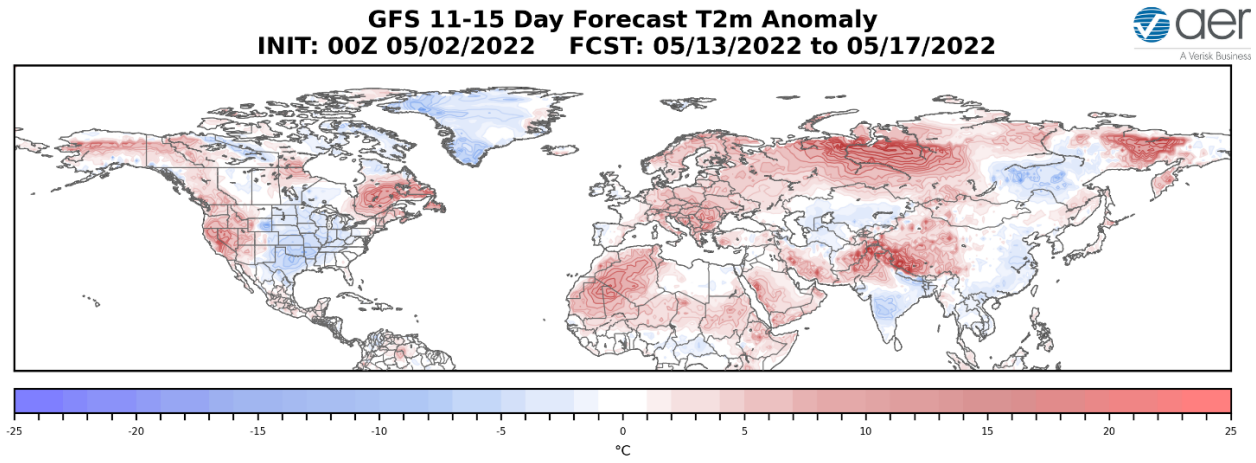

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 13 – 17 May 2022. The forecasts are from the 00z 2 May 2022 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted for both coasts of North America allowing for troughing/negative geopotential height anomalies in the interior of the continent this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across Alaska, much of Western and Eastern Canada and the Western and Northeastern US with normal to below normal temperatures limited to parts of Central Canada and the Central US (**Figure 9**).

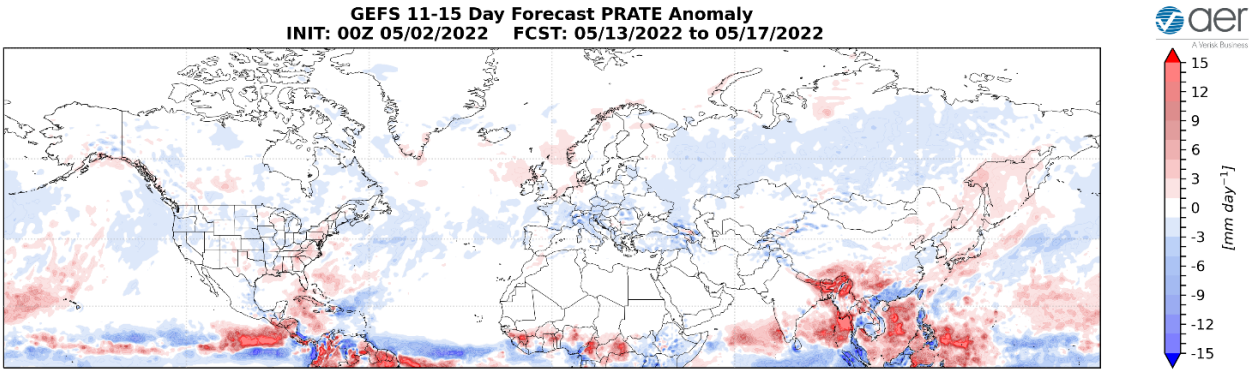

Figure 10. Forecasted precipitation rate (mm/day; shading) from 13 – 17 May 2022. The forecast is from the 00Z 2 May 2022 GEPS ensemble.

Mostly below normal precipitation is predicted across Eurasia with above normal precipitation predicted for Southern and Eastern Asia (**Figure 10**). Mostly below normal precipitation is predicted across North America with above normal precipitation predicted for Southeastern Alaska, Western Canada, the Canadian Maritimes, and the Eastern US (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive PCHs limited to the mid-stratosphere with cold/negative PCHs in the upper and lower stratosphere and throughout the troposphere. Warm/positive PCHs are predicted to persist in the middle stratosphere while cold/negative PCHs deepen in the troposphere next week (**Figure 11**).

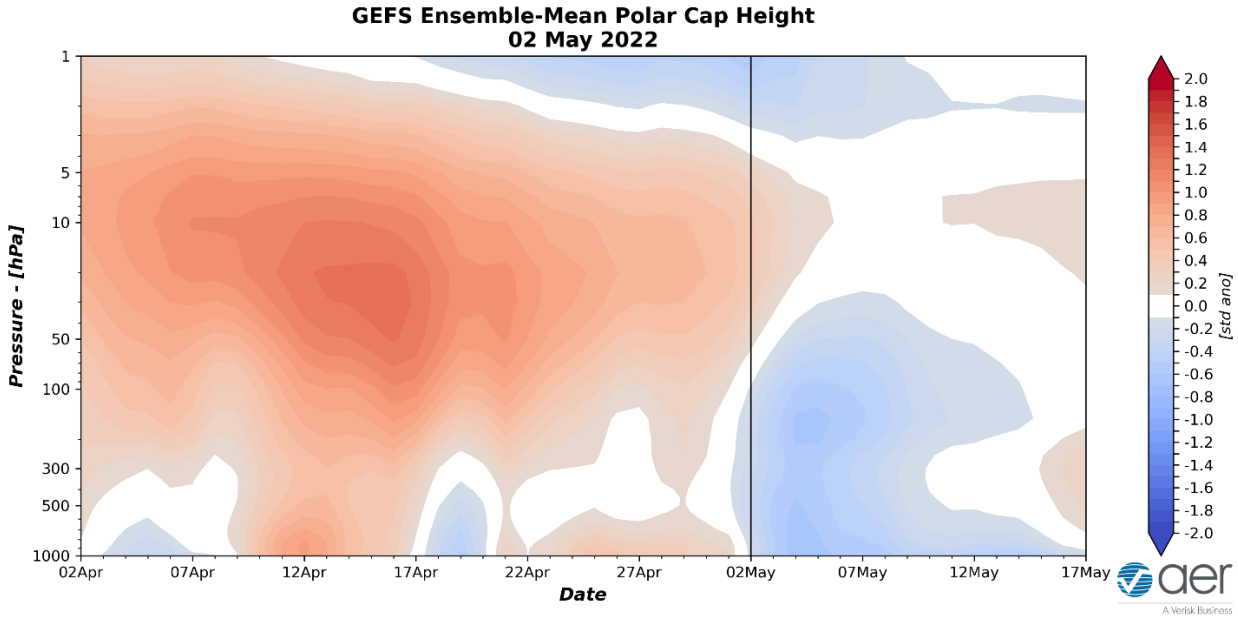

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 2 May 2022 GFS ensemble.

The normal to below normal PCHs predicted the next two weeks in the lower troposphere are consistent with the predicted positive surface AO the next two weeks (**Figure 1**).

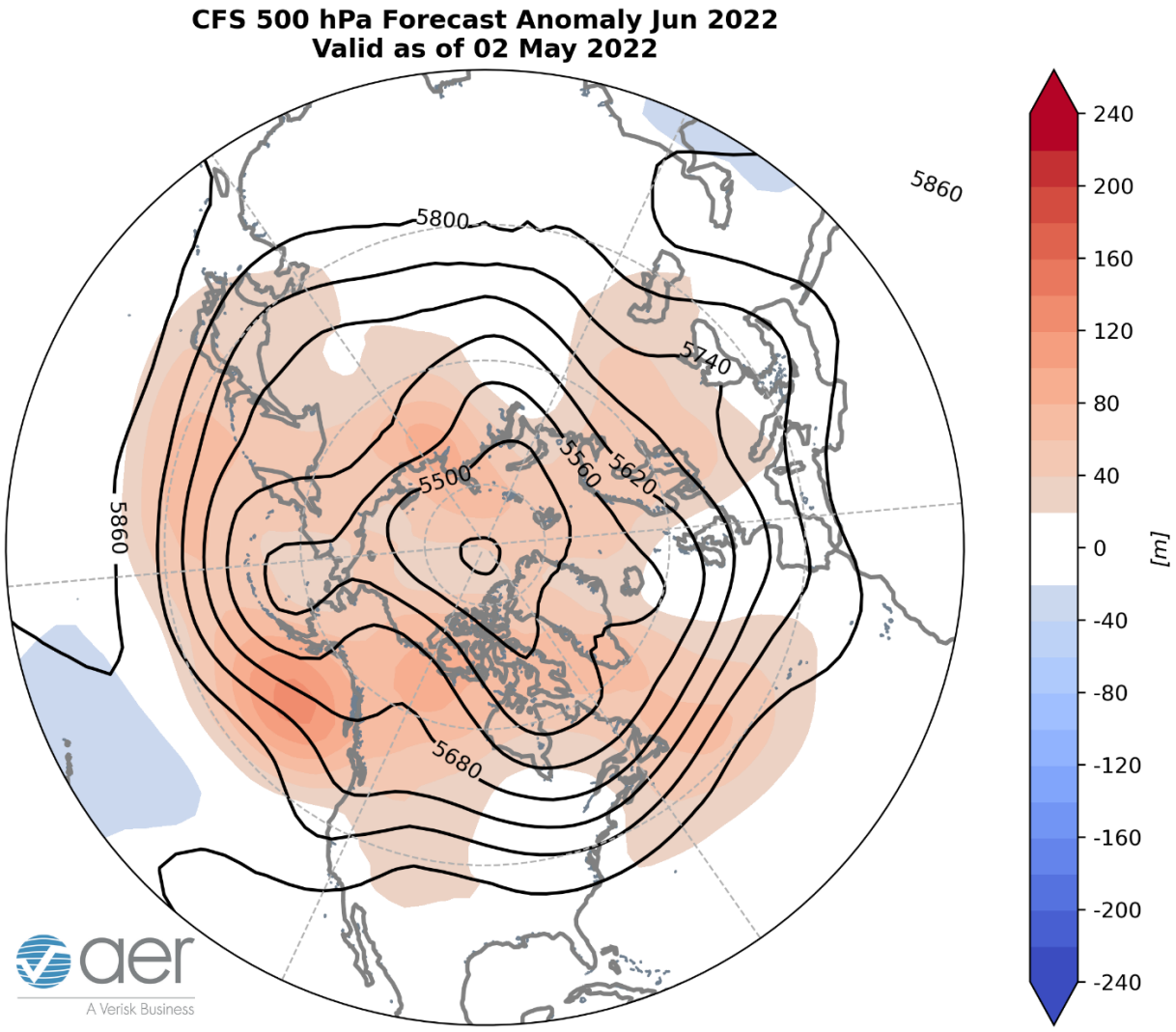

Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for June 2022. The forecasts are from the 00Z 2 May 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for June (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered in Eastern Europe and Western Asia, Siberia, the Gulf of Alaska, Western and Northern Canada with troughing across Southern Europe, Central and East Asia, the Dateline, Eastern Canada, the US West Coast and the Northeastern US (**Figure 12).** This pattern favors seasonable to relatively warm temperatures across Eastern Europe, much Asia but especially Siberia, Alaska, much of Canada and the Western and Northeastern US with seasonable to relatively cool temperatures across Western Europe and the Central and Southeastern US (**Figure 13**).

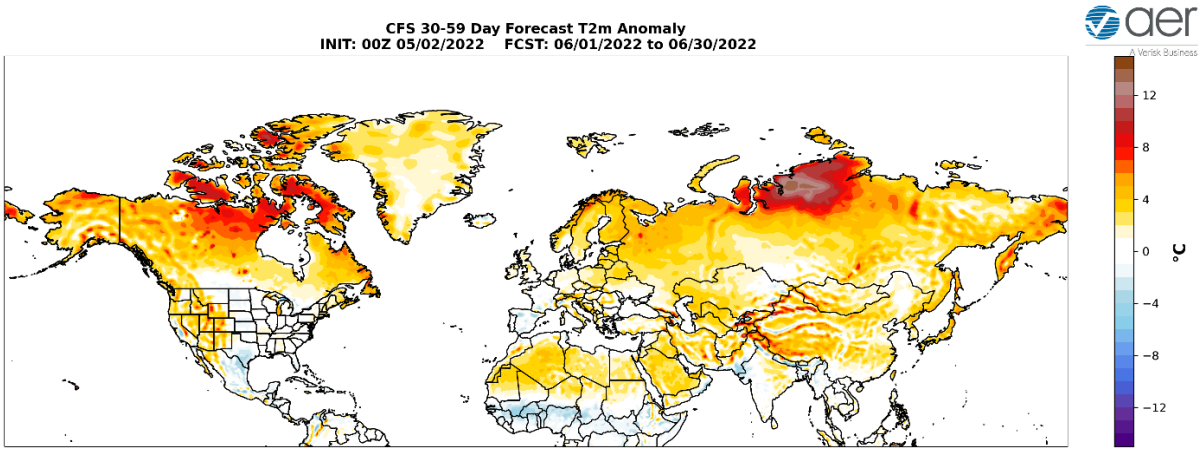

Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for June 2022. The forecasts are from the 00Z 2 May 2022 CFS.

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 16**) and La Niña conditions are expected through the spring. La Niña could favor a North America heat dome during the summer months and a more active North Atlantic hurricane season. 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.

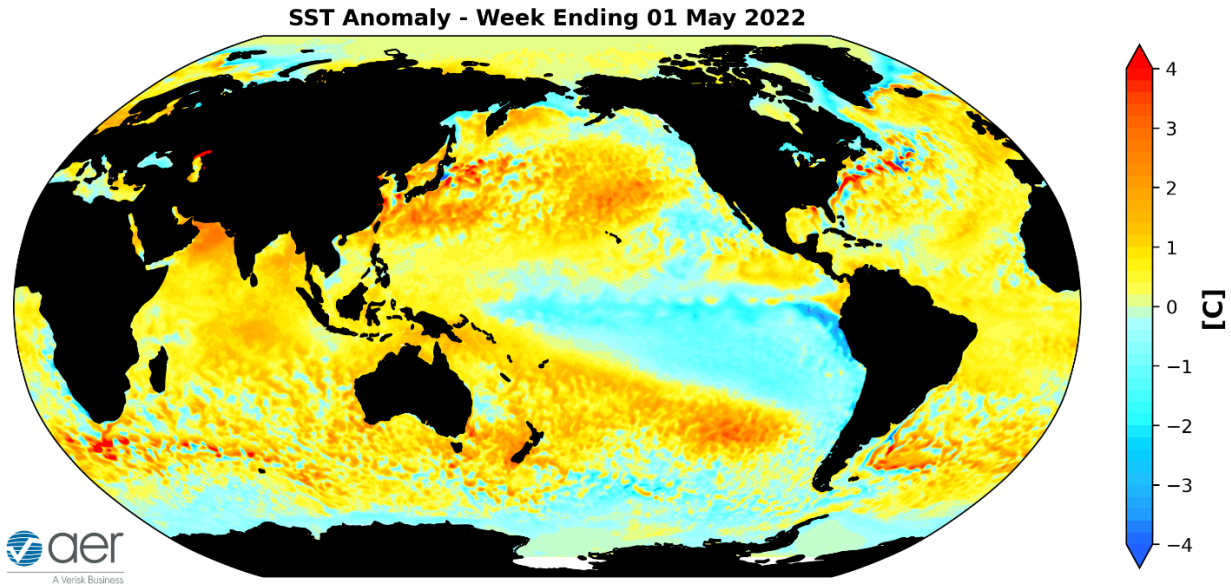

Figure 16. The latest weekly-mean global SST anomalies (ending 1 May 2022). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 17**). The forecasts are for the MJO to remain weak where no phase is favored and then in mid-May emerge in phase 6. Therefore it is hard to for me to see that the MJO is likely influencing the weather across North America but the MJO could constructively interfere with the existing pattern of ridging across Northern Canada in mid-May. But admittedly this is outside of my expertise.

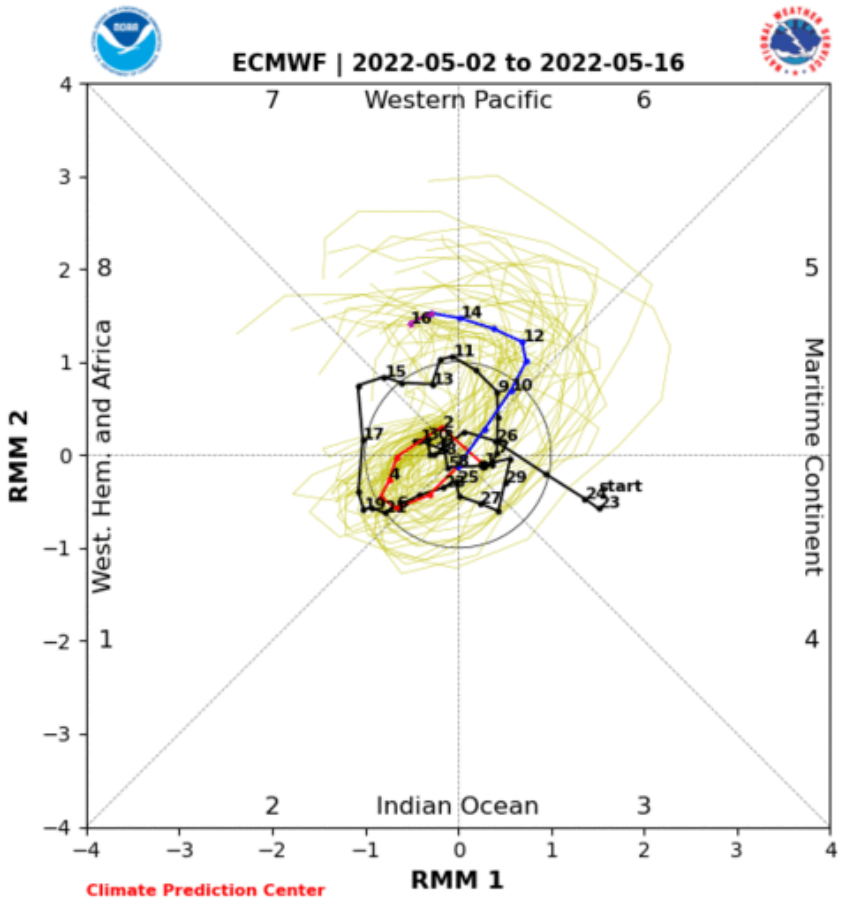

Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 2 May 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate 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!