

Arctic Oscillation and Polar Vortex Analysis and Forecasts

April 24, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Wednesday.

For those who would like an early look on Mondays, we will be offering at a nominal price (US \$50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

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.

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. 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

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Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to remain negative to neutral the next two weeks as pressure/geopotential height

anomalies across the Arctic are currently mostly positive and are predicted to remain mostly positive except near the North Pole the next two weeks. The North Atlantic Oscillation (NAO) is currently negative and is predicted to remain negative to neutral the next two weeks as pressure/geopotential height anomalies are currently positive and are predicted to remain positive across Greenland the next two weeks.

- Over the next two weeks predicted ridging/positive geopotential height anomalies centered across Greenland will generally support troughing/negative geopotential height anomalies across much of Central and Eastern Europe with ridging/positive geopotential height anomalies across Western Europe. This pattern favors the next two weeks normal to above normal temperatures across Western Europe including the United Kingdom (UK) with normal to below normal temperatures across Central and Eastern Europe.
- The next two weeks predicted ridging/positive geopotential height anomalies in Western and Northern Asia will anchor troughing/negative geopotential height anomalies across Eastern Asia. This pattern favors normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures across East Asia and Mongolia the next two weeks.
- The general pattern predicted across North America the next two weeks is ridging/positive geopotential height anomalies across Western North America and centered in Baffin Bay anchoring troughing/negative geopotential height anomalies across the Eastern United States (US). This pattern generally favors normal to below normal temperatures across Alaska and the Eastern US with normal to above normal temperatures across much of Canada and the Western US this week. However, next week some normal to below normal temperatures will be mostly limited to east of the Rockies in the US with widespread normal to above normal temperatures across much of North America.
- Looks like that the large polar vortex disruption from February will stall summer heat from advancing across much of Europe and the Eastern US at least in the short term.

Plain Language Summary

The models are finally predicting the classical pattern that often follows a large polar vortex disruption in winter but this time in late April and early May with Greenland blocking with troughing in the Eastern US, Europe and East Asia predicted (e.g., see **Figures 2 and 8**). This pattern favors widespread below normal temperatures across, Central and Eastern. Europe, East Asia and the Eastern US (e.g., see **Figures 3 and 9**).

Impacts

If you lived in the Eastern US and Europe, you knew there was going to be pay back for an unusually mild winter and now we have an extended cool period in the middle of spring. It is frustrating to me as a winter weather enthusiast to see the weather pattern

expected with a large polar vortex disruption only materialize more than two months later. The rule of thumb is two weeks but this winter two weeks turned into two months. Not sure of the reason for the long delay but those are the vagaries of the weather.

Attribution is tricky but it seems to me that it has at least some origins to the sudden stratospheric warming (SSW) in mid-February with episodic “dripping’ of warm/positive polar cap geopotential height anomalies (PCHs) from the large polar vortex (PV) disruption ever since. In **Figure i**, I show the North Atlantic regional PCHs plot that shows warm/positive PCHs in the lower stratosphere that episodically drips into the troposphere. This has resulted in a strengthening of the warm/positive tropospheric PCHs at the end of last week that has contributed to an impressively negative AO/NAO especially for this time of year. This is accompanied by Greenland blocking, troughing in the Eastern US, Europe and East Asia and relatively cool temperatures. Here in Boston, it seems like we have experienced six and maybe will be seven months of November. Something similar happened in 2019/2020. You could say here in Boston we have two seasons - summer and November. Of course, it is with tongue and cheek that I say this, but I do wonder if this could become a more common occurrence. But no one should misinterpret this as a prediction from me, just musing out loud or venting some frustration.

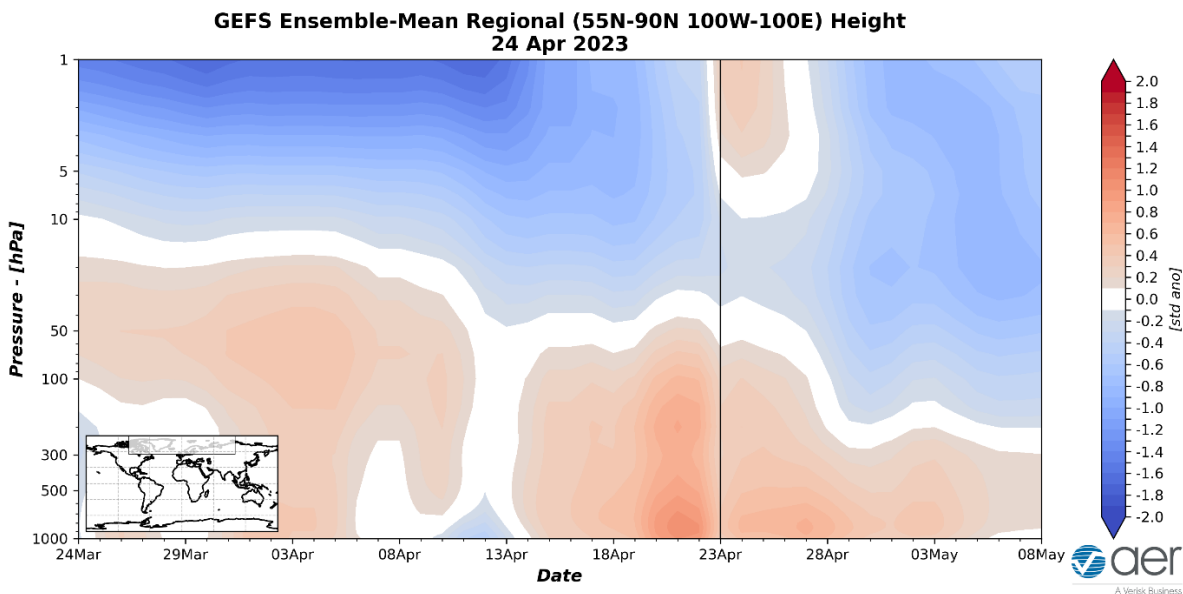


Figure i. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies for the North Atlantic sector onl (see insert). The forecast is from the 00Z 24 April 2023 GFS ensemble.

Simultaneously we have the Final Warming or the summer hiatus of the Northern Hemisphere (NH) stratospheric PV. Maybe some disagree with me, but I do think that at least partially it is a dynamic Final Warming. Why this is important is because a

dynamic Final Warming can have an influence on the weather similar to post an SSW as opposed to a radiative Final Warming which does not influence the weather (or at least much less so). My argument is that the recent and ongoing Scandinavian/Ural blocking, positive upward Wave Activity Flux (not shown) all suggest to me a dynamic Final Warming. In addition, the appearance of warm/positive PCHs this week (**Figure i**) in the upper stratosphere also suggests dynamic driving in the stratosphere. Currently with elevated amounts of CO₂ in the stratosphere warm/positive PCHS are not happening without mechanical or dynamical driving. Though it all may be academic because the troposphere is still responding to the SSW from February, therefore I am unsure how the recent Final Warming is making a difference. Perhaps the amplification of the tropospheric response late last week is due to the constructive interference from the SSW and the Final Warming.

Based on **Figures i** and **11** looks like the negative AO pattern could last through at least early May. The whole coupling should wind down soon but I have been premature in predicting its demise already. So, I will put off until the next blog predicting the weather pattern post the tropospheric response to the SSW from February.

Recent and Very Near Term Conditions

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

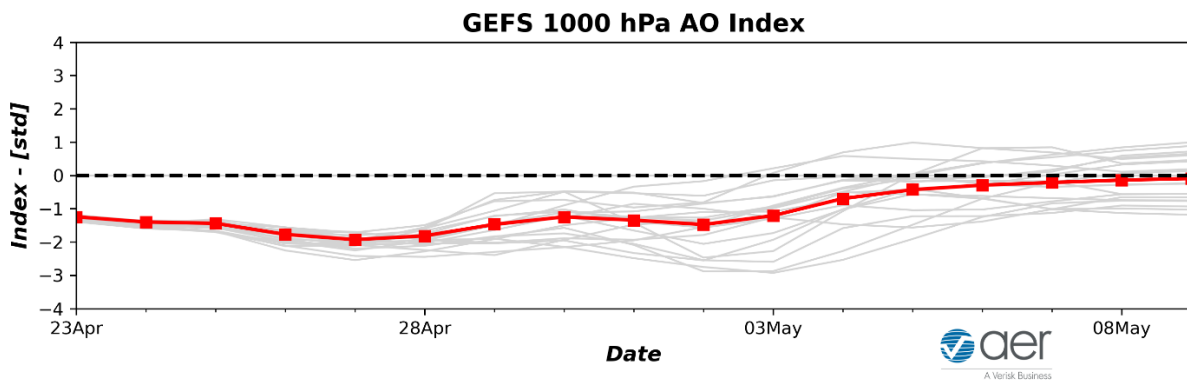


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 24 April 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies centered near Greenland will force troughing/negative geopotential height anomalies across Northern and Eastern Europe with ridging/positive geopotential height anomalies across the Western and Southern Europe (**Figures 2**). This pattern favors normal to below normal temperatures across much of Northern and Eastern Europe including the UK with normal to above normal

temperatures across Western and Southern Europe (**Figure 3**). Predicted ridging/positive geopotential height anomalies across Siberia and Western Asia will force troughing/negative geopotential height anomalies across Eastern Asia and India this period (**Figure 2**). This pattern favors widespread normal to above normal temperatures across Western and Northern Asia with normal to below normal temperatures across East Asia and India (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 04/24/2023 FCST: 04/25/2023 to 04/29/2023

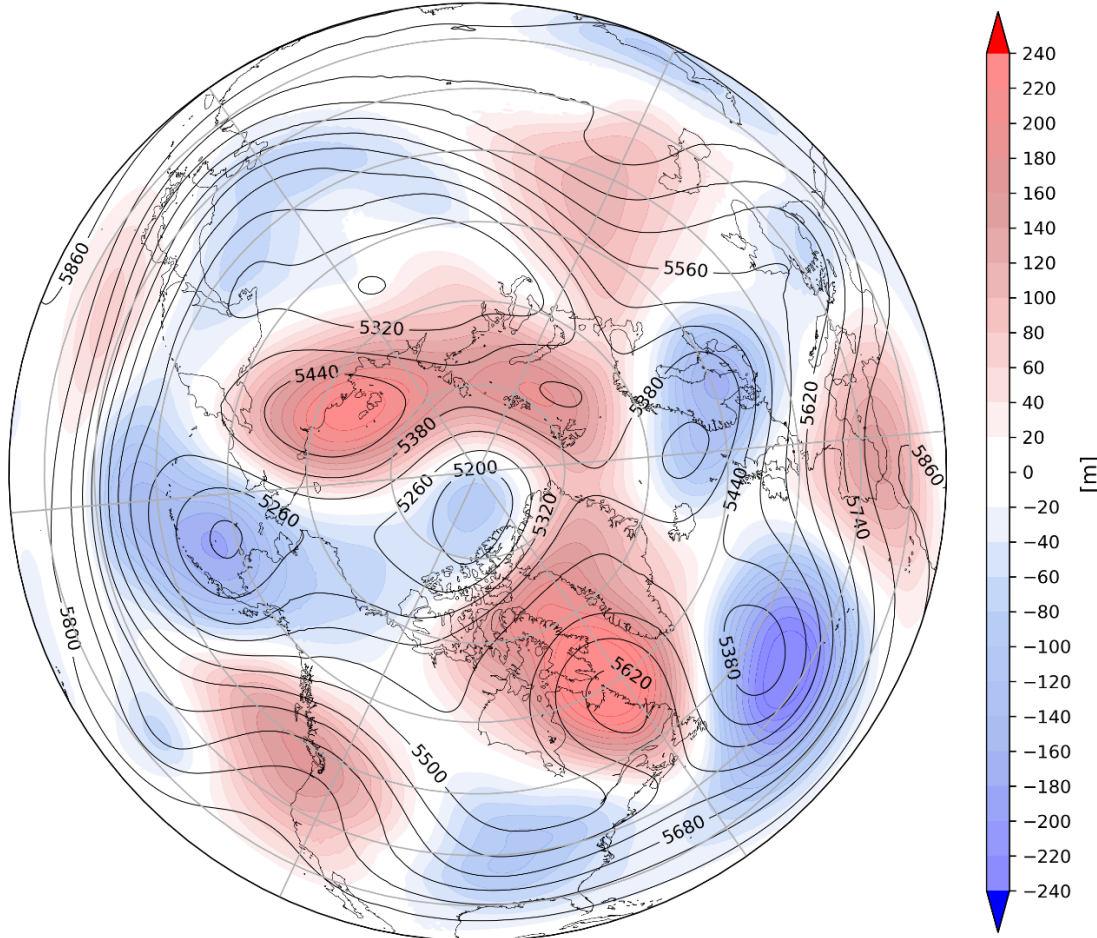


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 25 – 29 April 2023. The forecasts are from the 00z 24 April 2023 GFS ensemble.

The pattern this week across North America is ridging/positive geopotential height anomalies centered along the West Coast of North America and Baffin Bay forcing troughing/negative geopotential height anomalies across the Eastern US and Alaska this period (**Figure 2**). This pattern will favor normal to above normal temperatures across much of Canada and the Western US with normal to below normal temperatures

across Alaska, Northwestern and Southcentral Canada and the Eastern US (**Figure 3**).

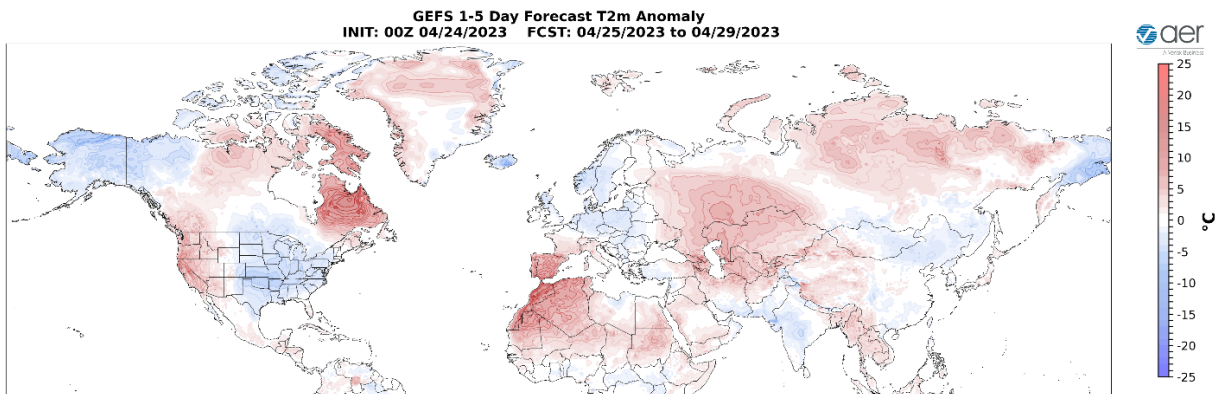


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 25 – 29 April 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Mostly normal to wet conditions are predicted across Europe and Asia with the exceptions of normal to dry conditions across Northern and Eastern Europe, India and parts of Northeast Asia this week (**Figure 4**). Mostly normal to wet conditions are predicted across Canada and the US with the exceptions of normal to dry conditions across the coastal ranges of Alaska and Canada and the Southeastern US (**Figure 4**).

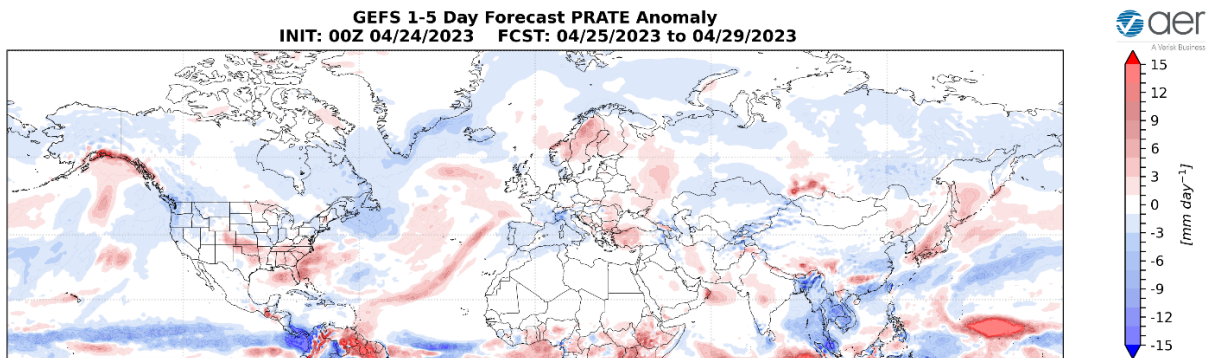


Figure 4. Forecasted precipitation rate (mm/day; shading) from 25 – 29 April 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Near-Term

1-2 week

With mostly positive geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 5**), the AO should remain negative this period (**Figure 1**). With predicted positive

pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely remain negative this period as well.

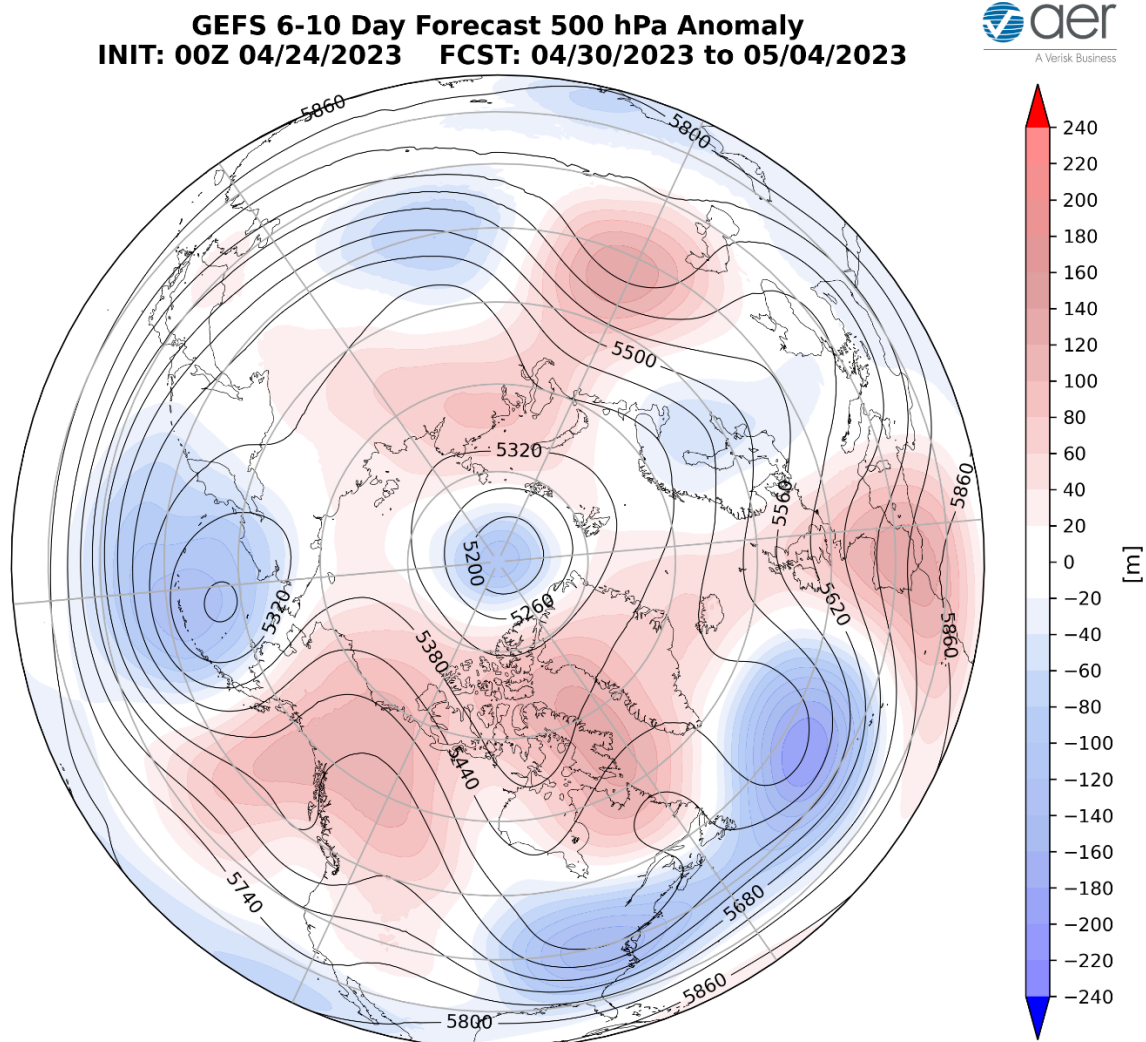


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 30 April – 4 May 2023. The forecasts are from the 00z 24 April 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered near Greenland will continue to support troughing/negative geopotential height anomalies across Central and Eastern Europe with ridging/positive geopotential height anomalies across the Western Europe this period (**Figure 5**). This pattern should continue to favor normal to above normal temperatures across Western Europe including the UK with normal to below normal temperatures across Central and Eastern Europe (**Figures 6**). Persistent ridging/positive geopotential height anomalies across Western Asia and Siberia will anchor troughing/negative geopotential height anomalies in Central to Eastern Asia and India this period (**Figure 5**). The pattern favors widespread normal to above normal

temperatures across Western, Northern and Eastern Asia with normal to below normal temperatures limited to Central Asia, India and Eastern Siberia this period (**Figure 6**).

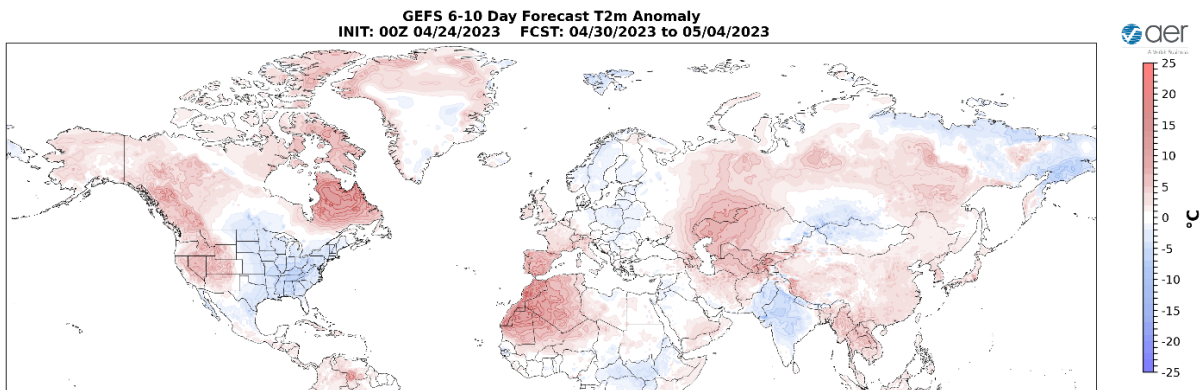


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 30 April – 4 May 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered in Western North America and Baffin Bay continue to anchor troughing/negative geopotential height anomalies in the Eastern US this period (**Figure 5**). This pattern favors normal to above normal temperatures across Alaska, Canada and the Western US with normal to below normal temperatures limited to Southcentral Canada and the Eastern US (**Figure 6**).

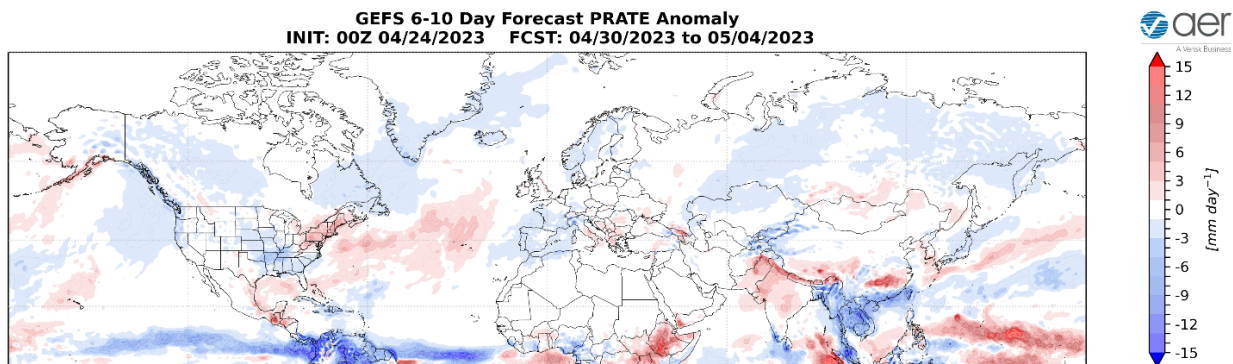


Figure 7. Forecasted precipitation rate (mm/day; shading) from 30 April – 4 May 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Mostly normal to wet conditions are predicted across Europe and Asia with the exceptions of normal to dry conditions across Southeastern Europe, the Tibetan Plateau, India and Southeast China this period (**Figure 7**). Mostly normal to wet conditions are predicted across Canada and the US with the exceptions of normal to dry conditions across the Northeastern US border and along the Gulf of Mexico (**Figure 7**).

3-4 week

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

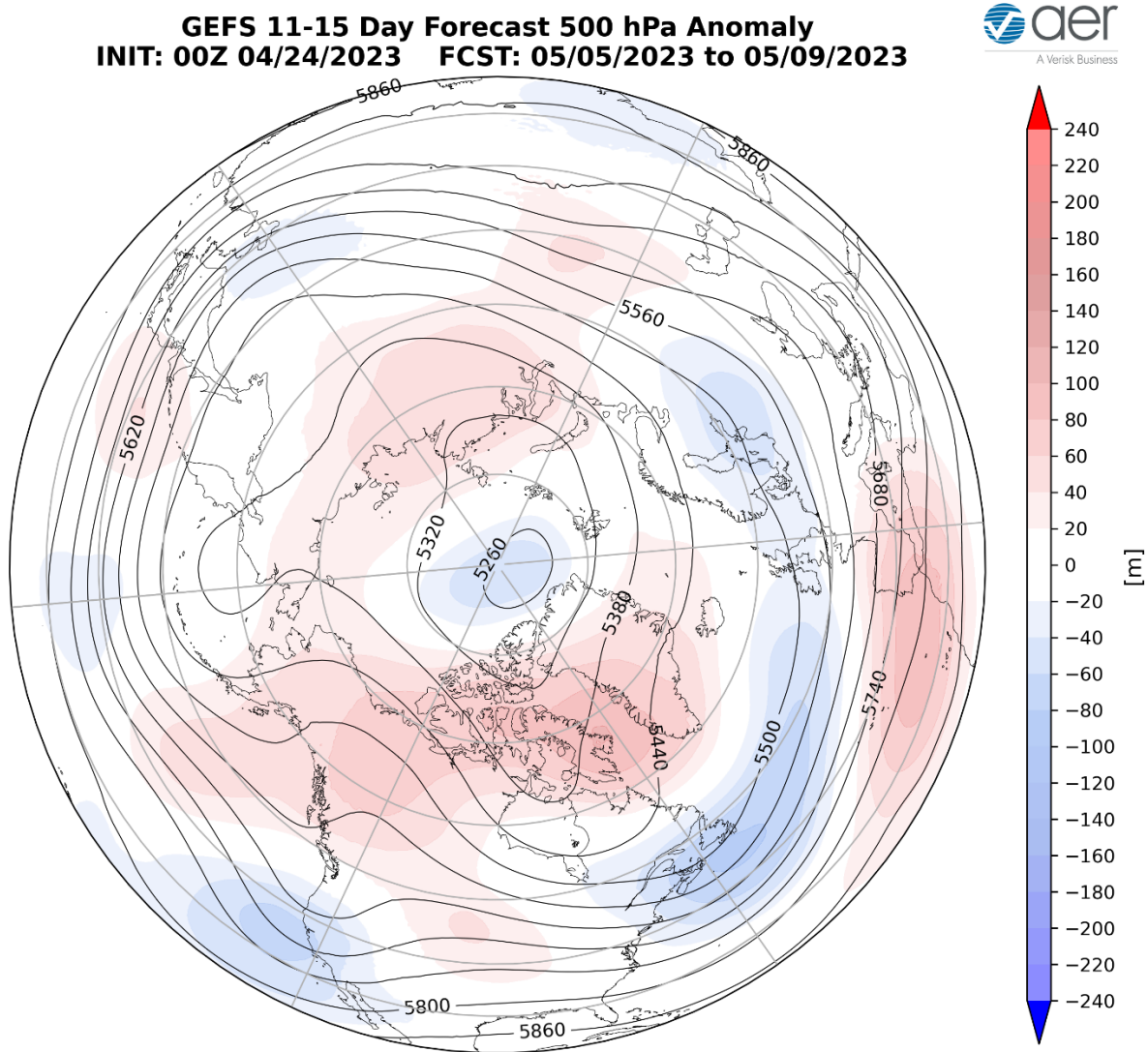


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 5 – 9 May 2023. The forecasts are from the 00z 24 April 2023 GFS ensemble.

Ongoing albeit weakening ridging/positive geopotential height anomalies centered near Greenland will continue to favor troughing/negative geopotential height anomalies

across Northern and Eastern Europe with ridging/positive geopotential height anomalies centered across Southwestern Europe this period (**Figure 8**). This pattern should continue to favor normal to above normal temperatures across Western and Southern Europe including the UK with normal to below normal temperatures in Central and Eastern Europe (**Figures 9**). Persistent ridging/positive geopotential height anomalies across Western Asia and Siberia will continue to anchor troughing/negative geopotential height anomalies in Eastern Asia and India this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures in India, East Asia and Eastern Siberia this period (**Figure 9**).

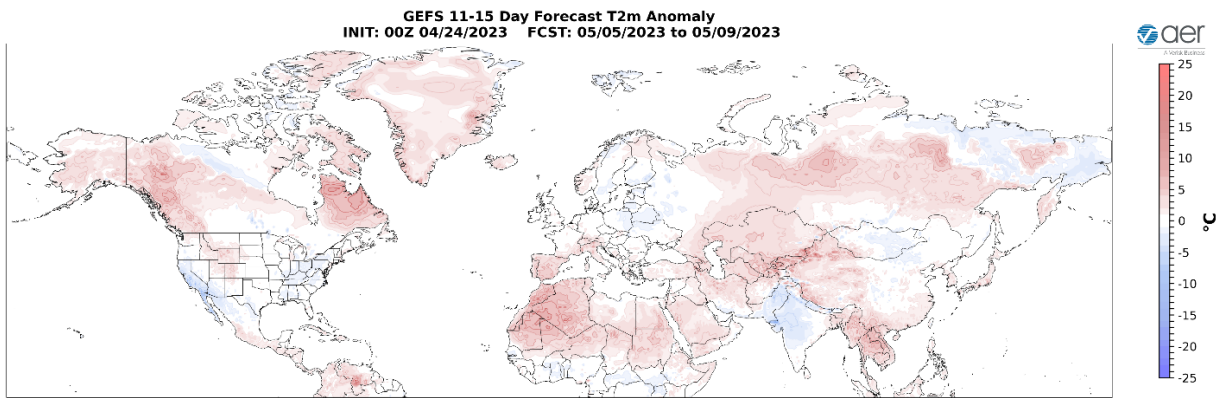


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 5 – 9 May 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered in Alaska, Western Canada and Baffin Bay will continue to anchor troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US with troughing/negative geopotential height anomalies coming ashore along the US West Coast this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, much of Canada and the US Rockies with normal to below normal temperatures across Nunavut, Southeastern Canada and the Western and Eastern US (**Figure 9**).

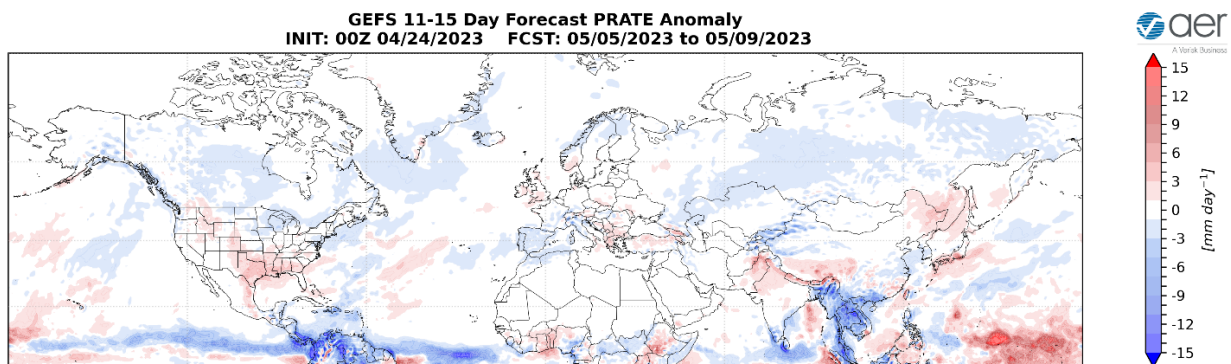


Figure 10. Forecasted precipitation rate (mm/day; shading) from 5 – 9 May 2023. The forecast is from the 00Z 24 April 2023 GFS ensemble.

Mostly normal to wet conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across the Balkans, Northern India and parts of Northeast Asia this period (**Figure 10**). Mostly normal to wet conditions are predicted across Canada and the US with normal to dry conditions across the US Rockies and the Southeastern US (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs in the upper stratosphere and warm/positive PCHs in the lower stratosphere and troposphere (**Figure 11**). However, over the next two weeks cold/negative PCHs are predicted to descend through the stratosphere while warm/positive PCHs are predicted to persist in the troposphere (**Figure 11**). The persistent warm/positive PCHs in the troposphere seem to be a continuation of “dripping” of warm/positive PCHs from the stratosphere into the troposphere commonly observed following major sudden stratospheric warming (SSW), which occurred back in mid-February.

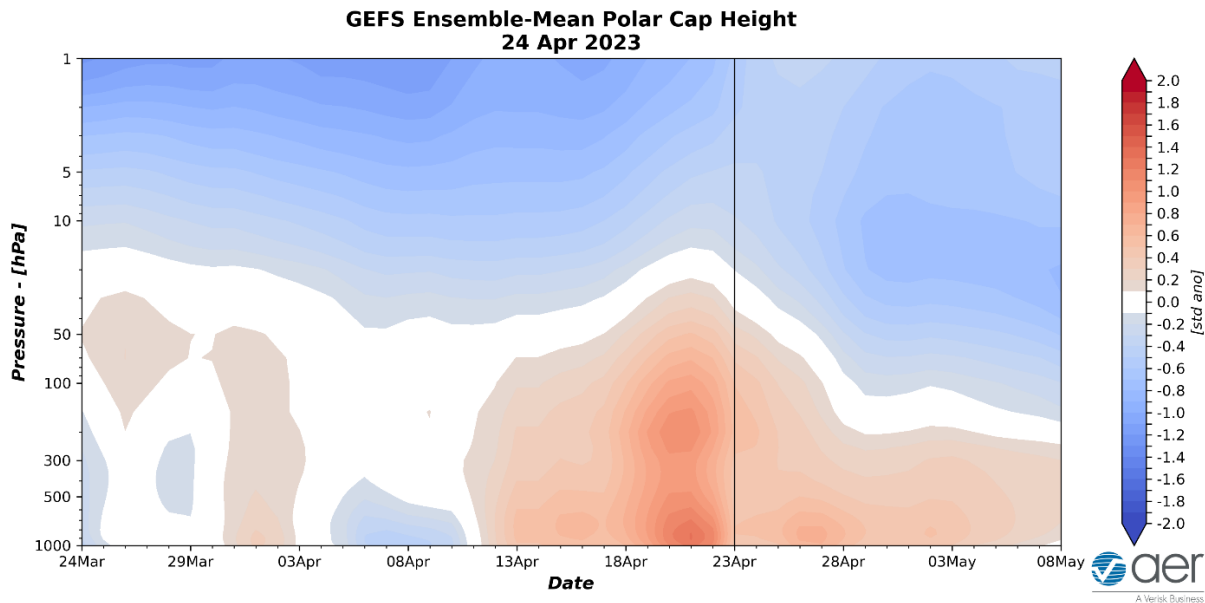


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 24 April 2023 GFS ensemble.

The predicted warm/positive PCHs in the troposphere this week (**Figure 11**) are consistent with the predicted negative surface AO the next two weeks (**Figure 1**). However, the AO is predicted to become closer to neutral next week (**Figure 1**) coinciding when the warm/positive PCHs are predicted to weaken in the troposphere (**Figure 11**).

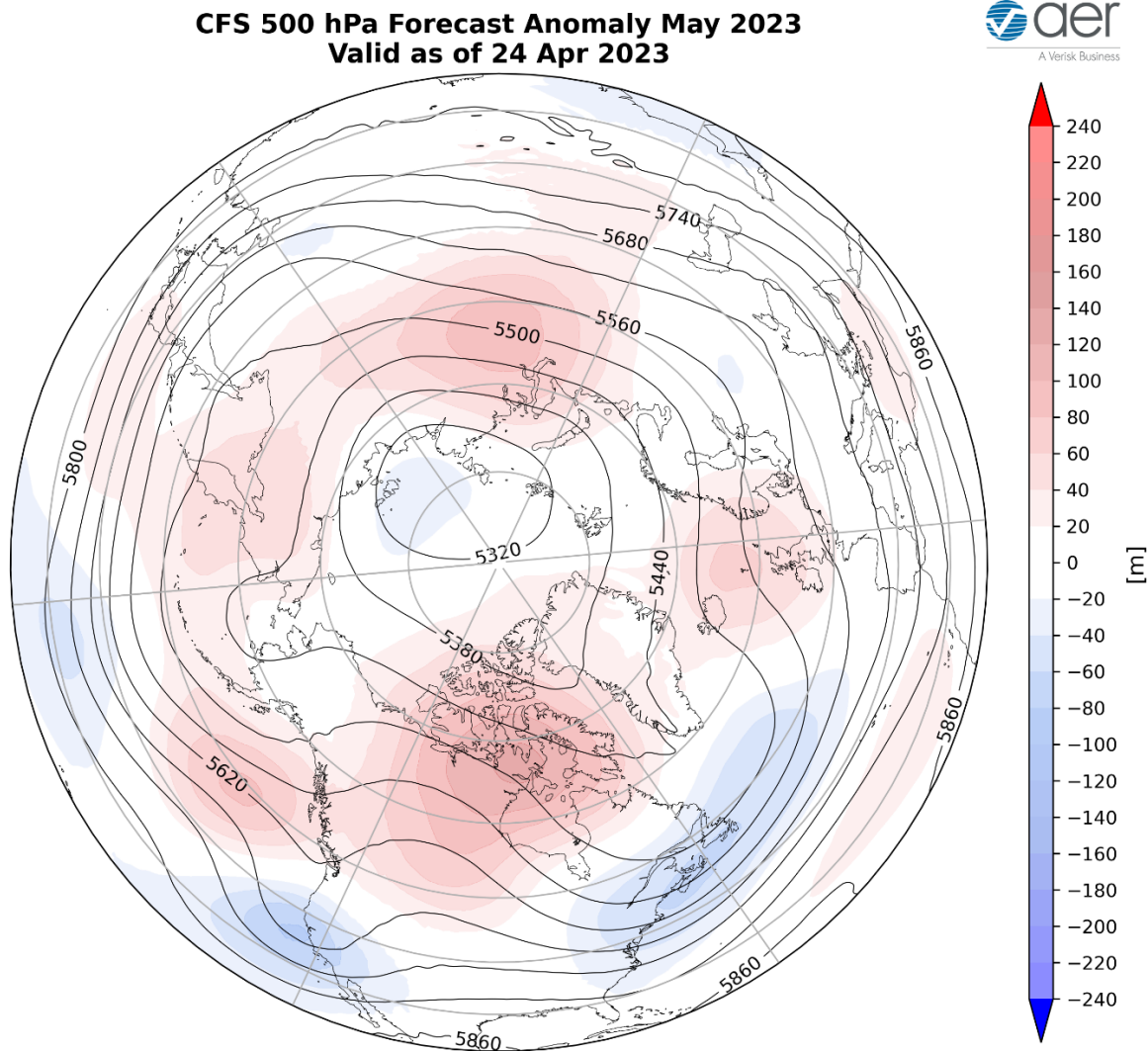


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for June 2023. The forecasts are from the 00Z 24 April 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and surface temperatures for May (**Figure 13**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Northwestern Europe, Siberia and Central Canada with troughing across Eastern Europe, East Asia, Eastern Canada and the Western and Eastern US

(Figure 12). This pattern favors seasonable to relatively warm temperatures across Western and Northern Europe, Northern and Central Asia, Alaska, much of Canada, and the US Rockies with seasonable to relatively cool temperatures across Central and Eastern Europe, East Asia, India and the Western and Eastern US (Figure 13).

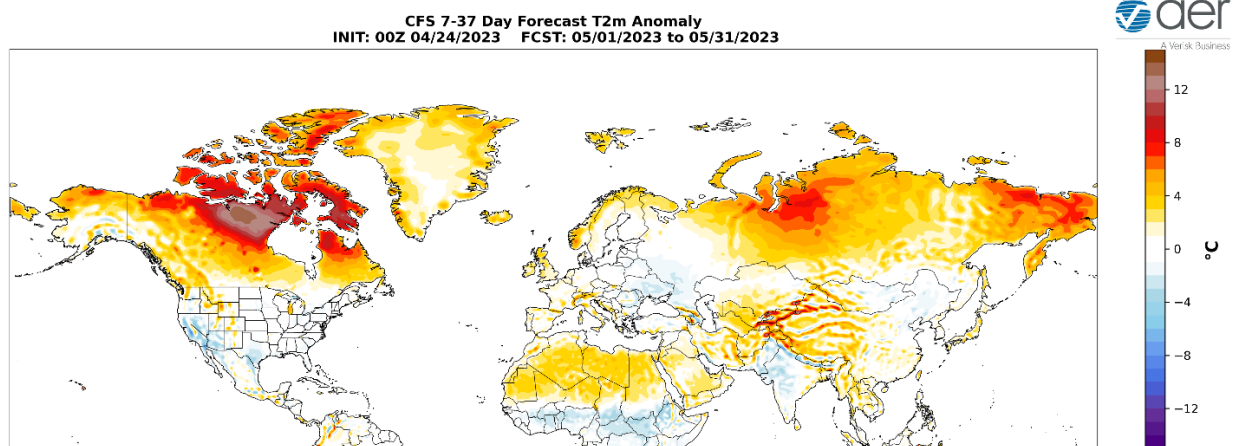


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for June 2023. The forecasts are from the 00Z 24 April 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are above normal indicating that the transition from La Niña to El Niño is complete (Figure 15) and El Niño 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 South Pacific.

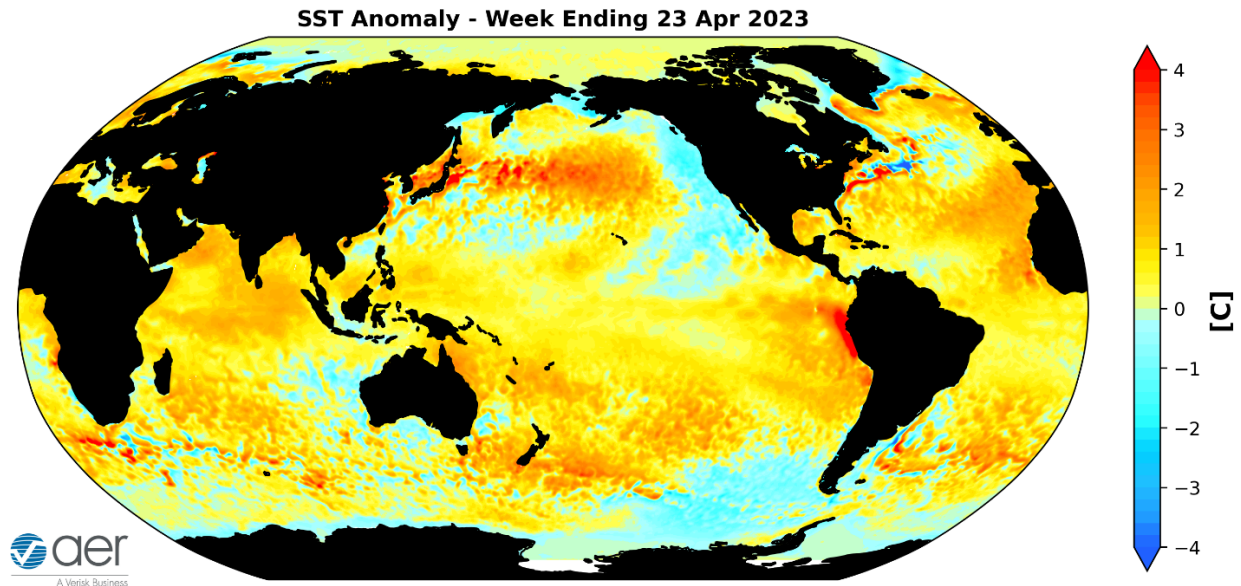


Figure 14. The latest weekly-mean global SST anomalies (ending 23 April 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently phase one of the Madden Julian Oscillation (MJO) is favored (**Figure 16**). The forecasts are for the MJO to quickly weaken to where no phase is favored and then emerge into phase five. Phase one favors ridging in western Canada and troughing over the US. Phase five favors troughing over Canada and ridging over the US. Seems that the MJO could be having some influence on the weather across North America in the very short term and not long term but then seems to wane. But admittedly this is outside of my expertise.

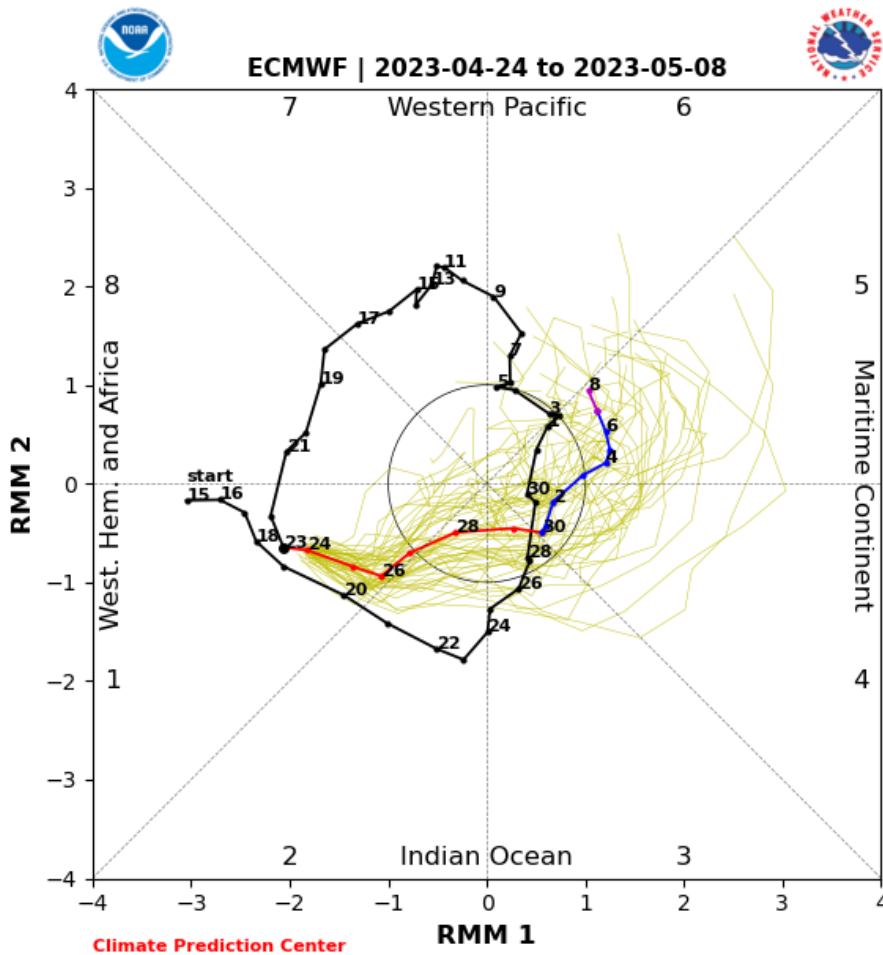


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 24 April 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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/clivar_wh.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 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.

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