

Arctic Oscillation and Polar Vortex Analysis and Forecasts

May 8, 2023

Dear AO/PV blog readers:

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

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

Summary

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

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

- Over the next two weeks predicted troughing/negative geopotential height anomalies centered across Greenland will generally support ridging/positive geopotential height anomalies across Northern Europe, centered across Scandinavia, with troughing/negative geopotential height anomalies centered near Italy and the Balkans this week into early next week and then near Spain later next week. This pattern favors the next two weeks normal to above normal temperatures across Northern Europe including the United Kingdom (UK) with normal to below normal temperatures this week centered in Southeastern Europe and then shifting into Western Europe next week including the UK and the Iberian Peninsula.
- The next two weeks predicted ridging/positive geopotential height anomalies in Scandinavia and over the Urals will anchor troughing/negative geopotential height anomalies across Siberia and Central Asia. This pattern favors normal to above normal temperatures widespread across much of Northwestern and Eastern Asia with normal to below normal temperatures across Siberia and Central Asia the next two weeks.
- The general pattern predicted across North America this week is ridging/positive geopotential height anomalies across much of North America and centered in Central Canada with troughing/negative geopotential height anomalies across the Southwestern United States (US). Then next week the ridging will consolidate in western North America with troughing in Eastern Canada and the Eastern US. This pattern generally favors normal to above normal temperatures across Alaska, Canada and much of the US with normal to below normal temperatures limited to the Southwestern US this week. Then next week normal to above normal temperatures will be concentrated in Alaska, Western Canada and the Western US with normal to below normal temperatures limited to Quebec and parts of the Eastern US.
- In my opinion looks like the atmospheric circulation is racing towards summer with two heat domes along the northern edges of the continents but with lots of uncertainty how the pattern evolves from here.

Plain Language Summary

The model forecasts are signaling that the atmosphere is quickly transitioning to summer mode with the large-scale circulation dominated by heat domes (where surface temperatures are well above normal) with one center over Scandinavia but the dominant one over Canada (e.g., see **Figure 5**). This pattern favors widespread above normal temperatures across the Northern Hemisphere and focused in Northern Europe but especially Canada (e.g., see **Figure 6**).

Impacts

In the previous blog I discussed the lingering effects of the large polar vortex (PV) disruption from February with ongoing “dripping” of warm/positive polar cap geopotential height anomalies (PCHs) from the lower stratosphere to the surface. However, from **Figure 11** it seems to me that is now completed for this year until at least the fall. In its place, it appears to me that the atmosphere is quickly transitioning to its summer configuration with heat domes forming along the northern edge of the continents. I am using the term “heat dome” to describe regions that are maximum centers of mid-tropospheric geopotential height anomalies coupled with surface temperatures that are well above normal. In today’s forecast plots there are two obvious heat domes one centered over Scandinavia and the most dominant of the Northern Hemisphere (NH) centered over Canada (e.g., see **Figures 5** and **6**).

It does seem in many ways that May is turning out to be the inverse of the winter. Scandinavia and especially Canada experienced some of the coldest temperatures relative to normal across the NH this winter and now they are predicted to experience the warmest temperatures relative to normal across the NH. And what I find as an interesting twist snow cover extent (SCE) is currently near normal across Eurasia but well below normal across North America (see **Figure i**) the opposite of this past winter where SCE was above normal across North America but below normal across Eurasia. This is in large part due to the finale in the impacts of the large PV disruption that climaxed with deeply negative AO in late April that returned below normal temperatures to Siberia and has helped to preserve snow cover across Asia. This seems to be also bucking recent trends where Eurasian snow cover has melted more rapidly than North American snow cover in recent springs. The early snowmelt in Asia has contributed to some spectacular heat waves in Siberia in recent summers and if snowmelt continues at a more normal pace across Siberia, it could help retard the development of a heat dome in Siberia.

Daily SCE Departure - May 7, 2023 (Day 127)

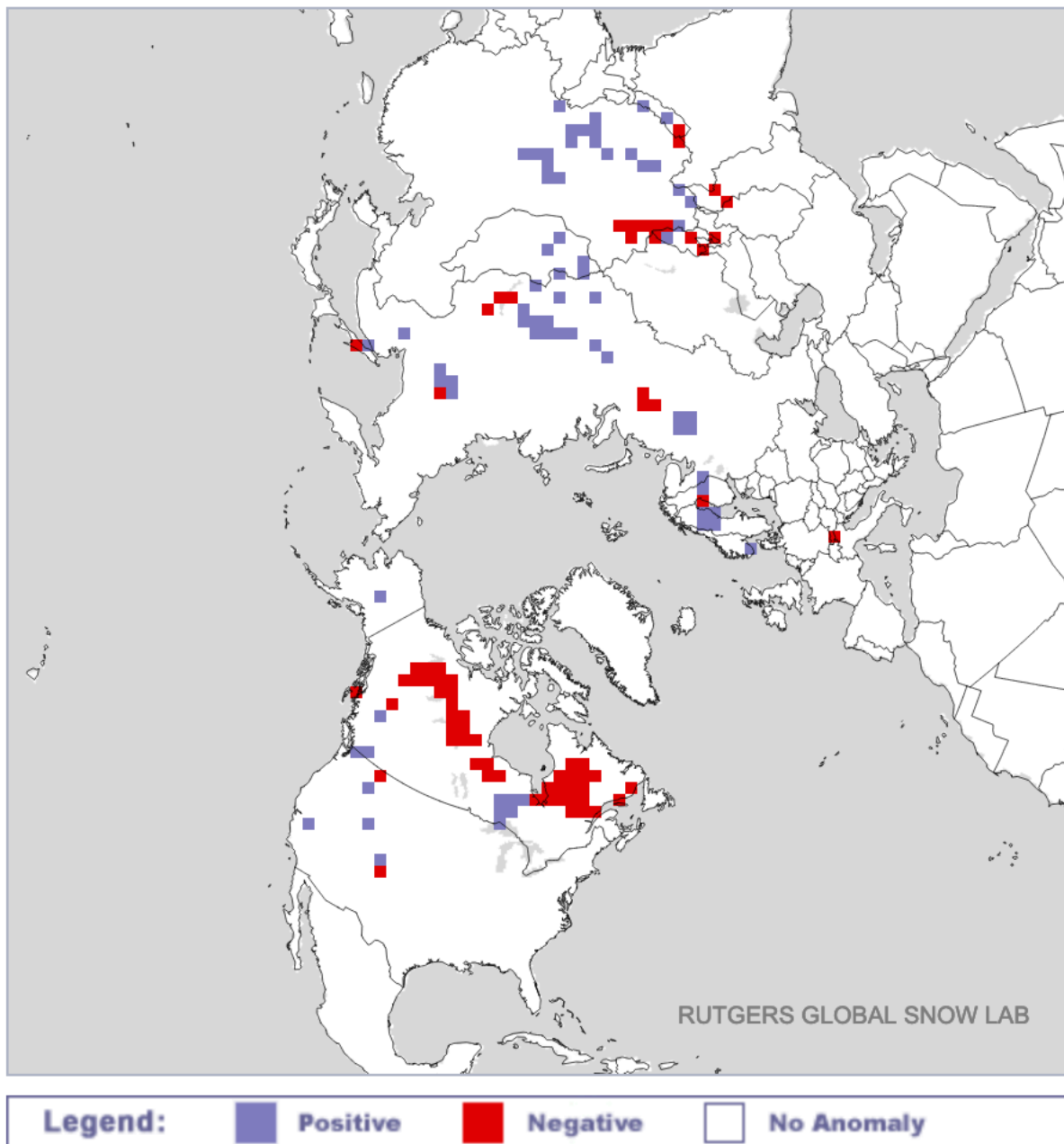


Figure i. Observed snow cover extent anomalies for 7 May 2023. Figure taken from <http://climate.rutgers.edu/snowcover/index.php>

In my opinion recent summers can be in general characterized by ridging/high pressure and above normal temperatures in western North America, eastern North America, especially along the US East Coast, Europe and East Asia. And with ridging and heat along both edges of the continents this has allowed for troughing and more seasonable

temperatures in between both in the center of the North America continent and Western Asia. This pattern is broadly replicated in the latest CFS forecast for June with maybe a US East Coast ridge mostly missing. Though the CFS forecast is therefore consistent with a “trend is your friend” forecast (which I am very fond of) but for now I have a wait and see attitude. But based on the early returns a European and western North America summer heat domes are off to a fast start. As usual I will post a summer temperature forecast for the NH before the month is over.

Wednesday Update

I feel that not much is changed since Monday, but I did want to include in today’s update the most recent 11-15 day GEFS forecast for both the 500 hPa geopotential heights (Figure ii) and surface temperatures (**Figure iii**). The ring of above normal geopotential heights across the mid-latitudes in the GEFS forecast is impressive and is continuous, circumnavigating the NH across the mid-latitudes (see **Figure ii**). And at least to me is reminiscent of the “ring of fire” that I have usurped from plate tectonics (or maybe even thunderstorms surrounding subtropical ridging) to describe above normal geopotential heights encircling the mid-latitudes in the summer months supporting widespread above normal temperatures across the continents of the mid-latitudes.

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 05/10/2023 FCST: 05/21/2023 to 05/25/2023

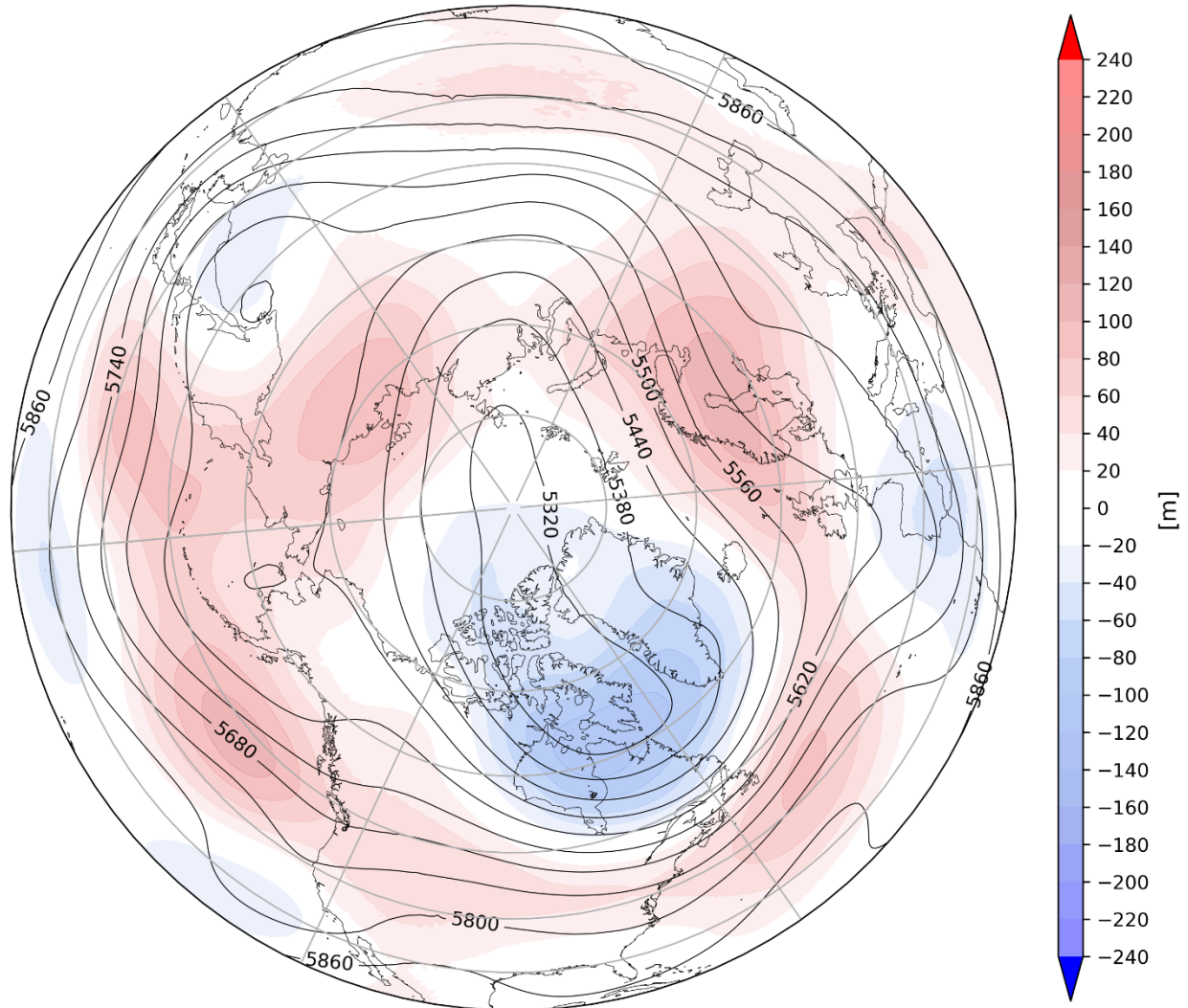


Figure ii. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 21 – 25 May 2023. The forecasts are from the 00z 10 May 2023 GFS ensemble.

And not surprisingly given the geopotential heights forecast above normal temperatures are predicted to be almost universal across the NH mid-latitudes in late May (see **Figure iii**). Only pockets of below normal temperatures are predicted most notable in Northeast Asia. The GEFS forecast might be overdone with below normal temperatures also possible in at least parts of Southwestern Europe, eastern Canada and the Eastern US based on the predicted troughing in mid-tropospheric geopotential heights.

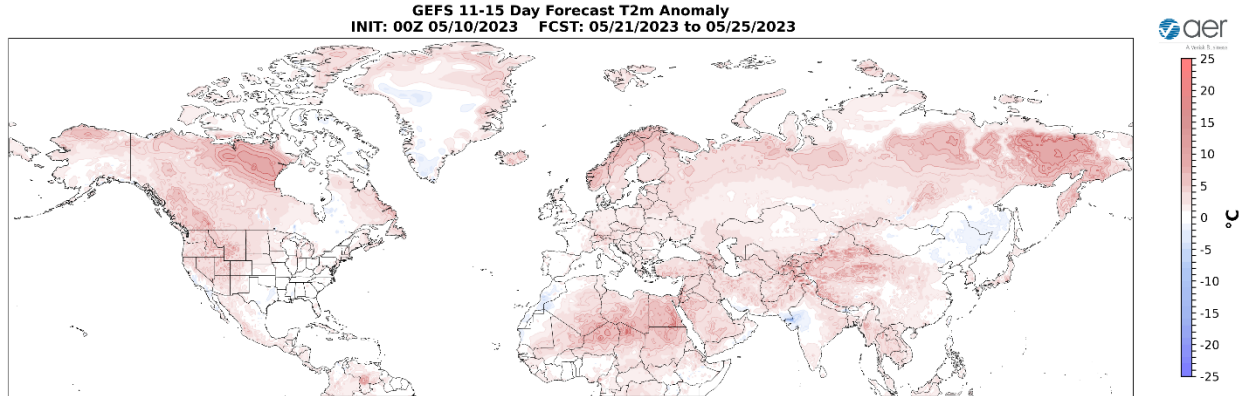


Figure iii. Forecasted surface temperature anomalies (°C; shading) from 21 – 25 May 2023. The forecast is from the 00Z 10 May 2023 GFS ensemble.

Recent and Very Near Term Conditions

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

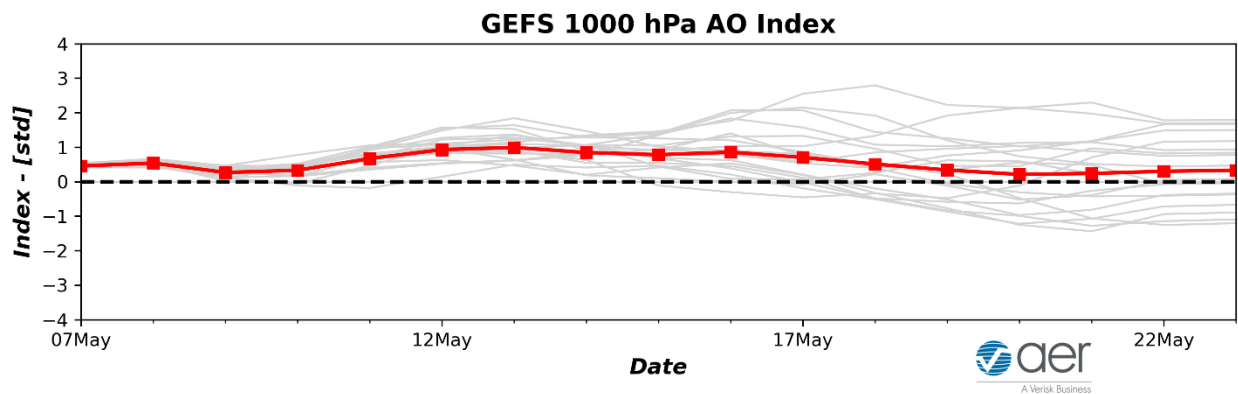


Figure 1. The predicted daily-mean AO at 1000 hPa from the 00Z 8 May 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies centered across Greenland will force ridging/positive geopotential height anomalies across Northern Europe but centered over Scandinavia with troughing/negative geopotential height anomalies centered across Italy (**Figures 2**). This pattern favors normal to below normal temperatures across Northern Europe including the UK with normal to below normal temperatures across Southeastern Europe (**Figure 3**). Predicted ridging/positive geopotential height anomalies across Scandinavia will force troughing/negative geopotential height

anomalies across Siberia that trails southwestward towards the Black Sea with ridging/positive geopotential height anomalies across Central and East Asia this period (**Figure 2**). This pattern favors normal to above normal temperatures across Northwestern, Central and Eastern Asia with normal to below normal temperatures across Siberia, Southwestern Asia and Southern China (**Figure 3**).

GEFS 1-5 Day Forecast 500 hPa Anomaly
INIT: 00Z 05/08/2023 FCST: 05/09/2023 to 05/13/2023

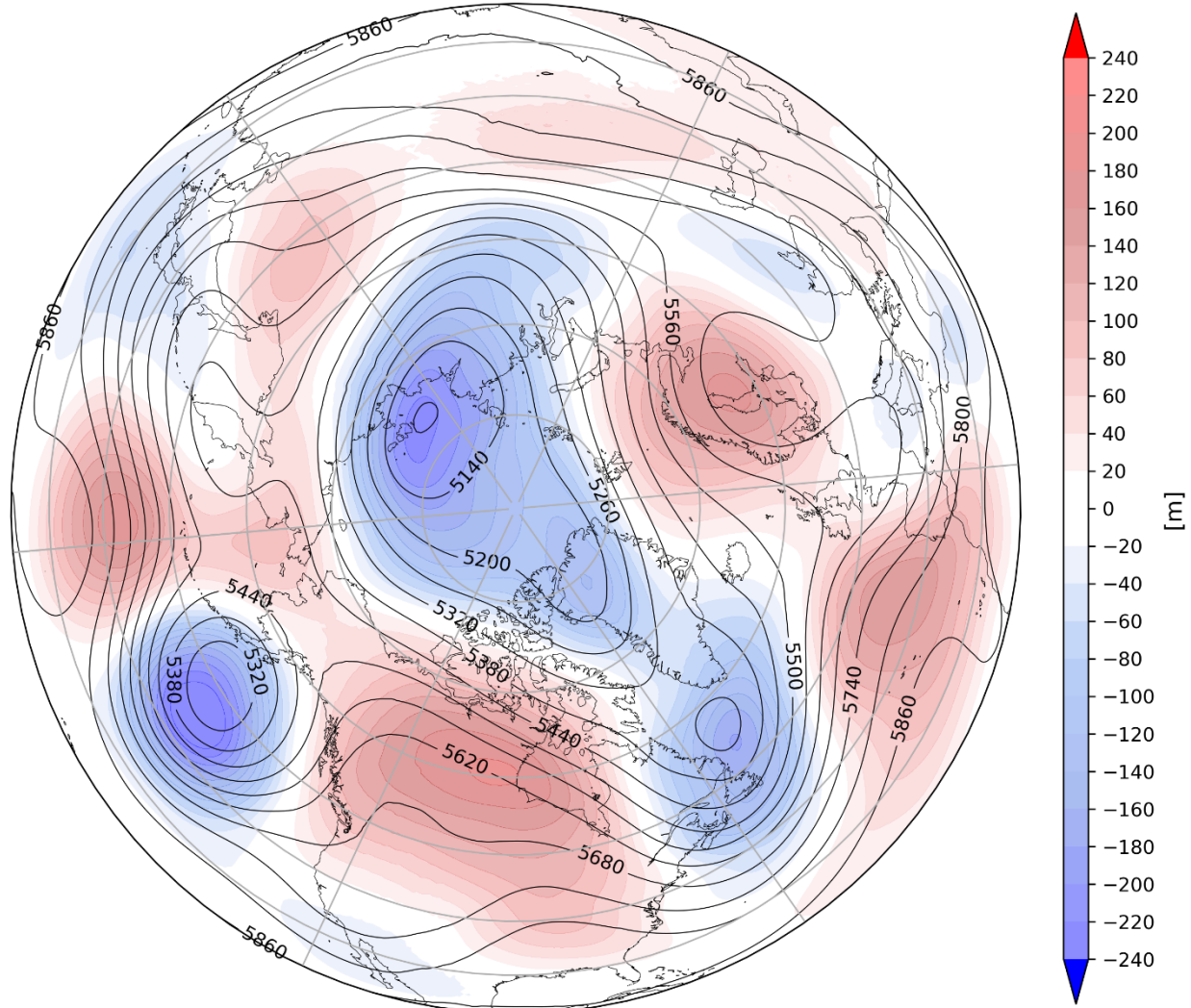


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 9 – 13 May 2023. The forecasts are from the 00z 8 May 2023 GFS ensemble.

The pattern this week across North America is ridging/positive geopotential height anomalies centered in Central Canada with troughing/negative geopotential height anomalies in Baffin Bay and the Southwestern US this period (**Figure 2**). This pattern

will favor widespread normal to above normal temperatures across much of Alaska, Canada and the US with normal to below normal temperatures limited to Northern Alaska, Elsmere Island and the Southwestern US (**Figure 3**).

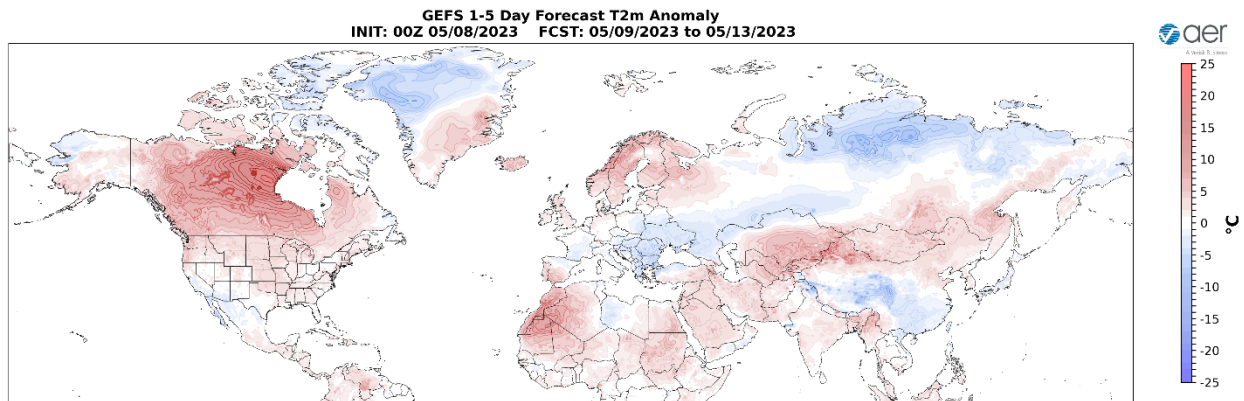


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 9 – 13 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across the Balkan States and Southeast Asia this week (**Figure 4**). Mostly normal to dry conditions are predicted across Canada and the US with the exceptions of normal to wet conditions across the coastal ranges of Alaska and the Western and Central US (**Figure 4**).

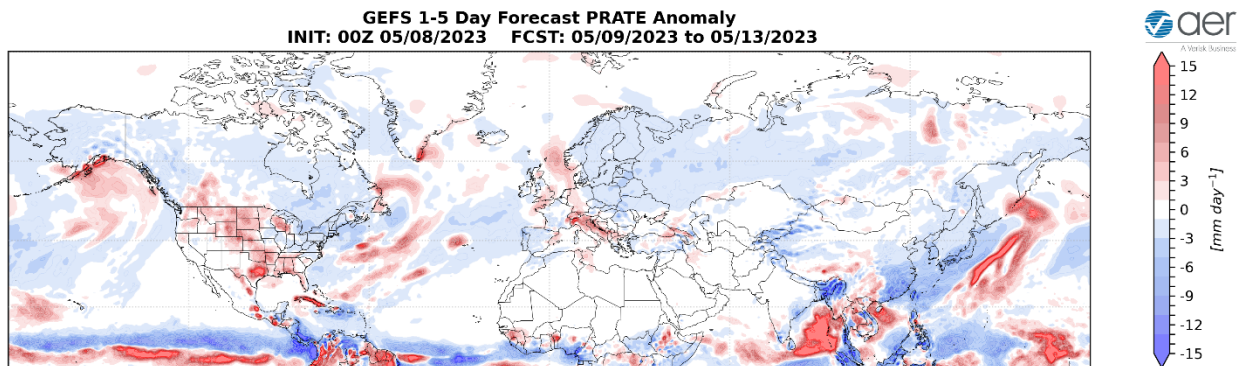


Figure 4. Forecasted precipitation rate (mm/day; shading) from 9 – 13 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Near-Term

1-2 week

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

should remain positive this period (**Figure 1**). With predicted negative pressure/geopotential height anomalies across Greenland (**Figure 5**), the NAO will likely remain neutral to positive this period as well.

GEFS 6-10 Day Forecast 500 hPa Anomaly
INIT: 00Z 05/08/2023 FCST: 05/14/2023 to 05/18/2023

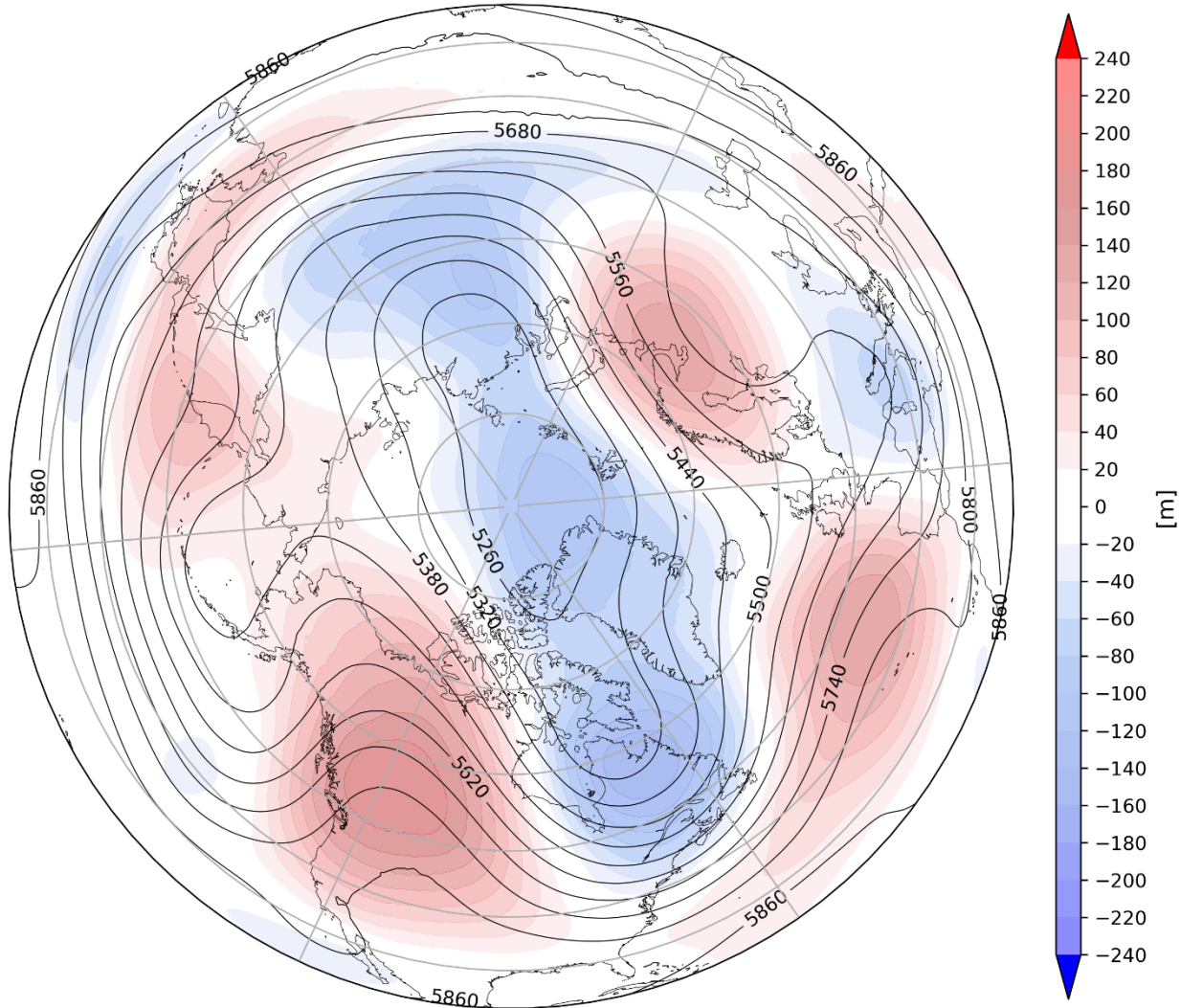


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 May 2023. The forecasts are from the 00z 8 May 2023 GFS ensemble.

Persistent troughing/negative geopotential height anomalies centered near Greenland will continue to support ridging/positive geopotential height anomalies across Northern Europe with troughing/negative geopotential height anomalies across Southern Europe and centered in the Adriatic Sea this period (**Figure 5**). This pattern should continue to favor normal to above normal temperatures across Northern Europe including the UK

and western Spain and Portugal with normal to below normal temperatures across much of Southern Europe (**Figures 6**). Persistent ridging/positive geopotential height anomalies across Scandinavia will anchor troughing/negative geopotential height anomalies in Siberia and Central Asia with ridging/positive geopotential height anomalies in East Asia this period (**Figure 5**). The pattern favors normal to above normal temperatures across Western and Eastern Asia with normal to below normal temperatures across Siberia and Central Asia this period (**Figure 6**).

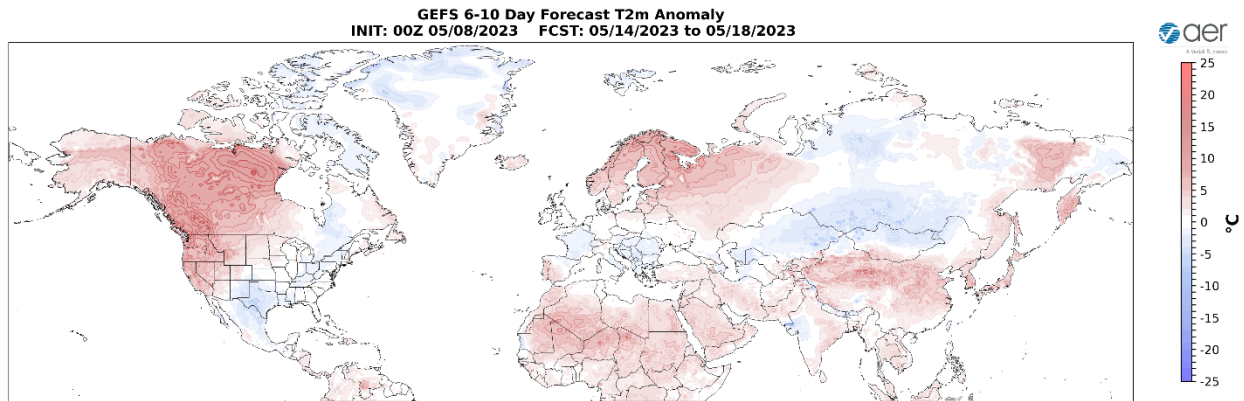


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 14 – 18 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies are predicted to consolidate in Western Canada but dominate all of western North America forcing troughing/negative geopotential height anomalies in Eastern Canada and the Eastern US this period (**Figure 5**). This pattern favors normal to above normal temperatures across Alaska, much of Canada and the Western US with normal to below normal temperatures limited to Quebec and the Eastern US (**Figure 6**).

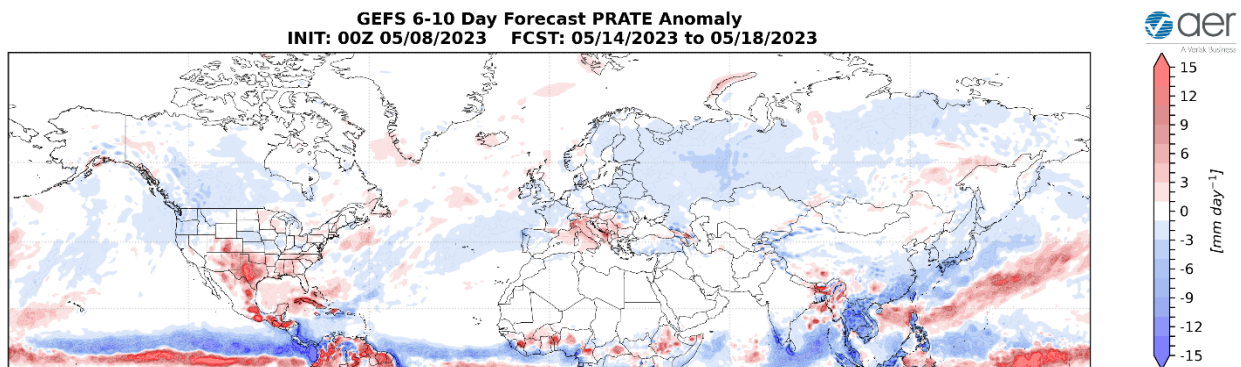


Figure 7. Forecasted precipitation rate (mm/day; shading) from 14 – 18 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across the Mediterranean but centered on Italy and parts of Southeast Asia this period (**Figure 7**). Mostly normal to dry conditions are predicted across Alaska, Canada and the Northwestern US with normal to wet conditions across the Southern US and along the US East Coast (**Figure 7**).

3-4 week

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

GEFS 11-15 Day Forecast 500 hPa Anomaly
INIT: 00Z 05/08/2023 FCST: 05/19/2023 to 05/23/2023

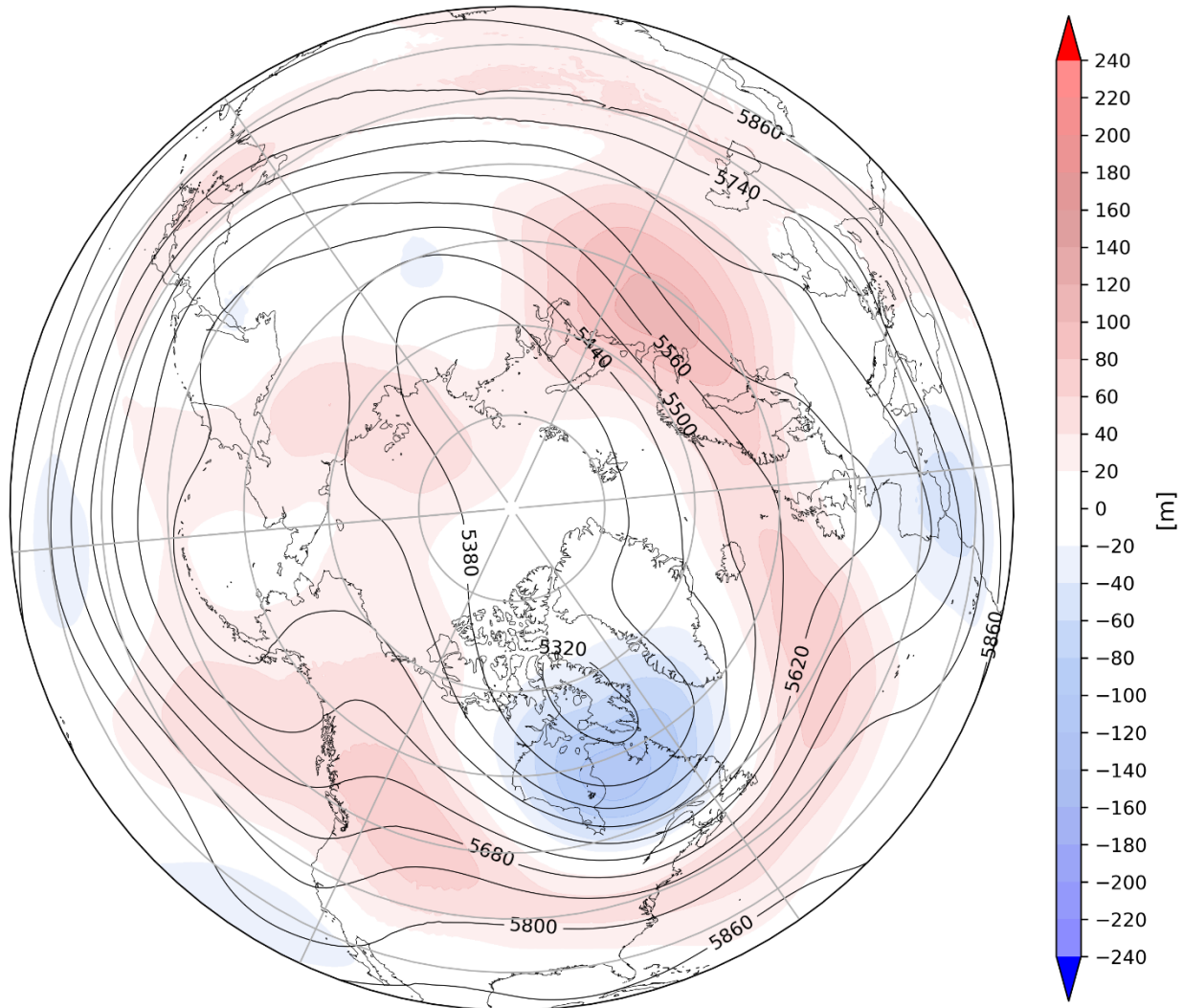


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 19 – 23 May 2023. The forecasts are from the 00z 8 May 2023 GFS ensemble.

Ongoing albeit weakening troughing/negative geopotential height anomalies centered near Greenland will continue to favor ridging/positive geopotential height anomalies across Northern Europe with troughing/negative geopotential height anomalies across Southern Europe but centered across the Iberian Peninsula this period (**Figure 8**). This pattern should favor normal to above normal temperatures across Northern and Eastern Europe with normal to below normal temperatures in Western Europe including the UK this period (**Figures 9**). Persistent ridging/positive geopotential height anomalies across Scandinavia and now the Urals will continue to anchor troughing/negative geopotential height anomalies across Siberia and into Northeast Asia this period (**Figure 8**). The predicted pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to parts of Southern Siberia and into Northeast Asia this period (**Figure 9**).

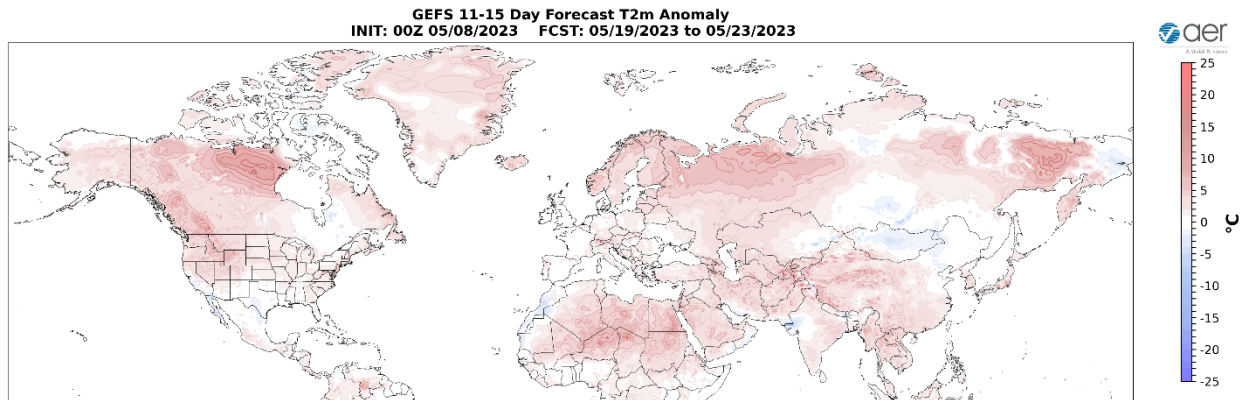


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 19 – 23 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered in Alaska, Western Canada and the Western US will continue to anchor troughing/negative geopotential height anomalies across Eastern Canada and the Northeastern US this period (**Figure 8**). This pattern favors normal to above normal temperatures across Alaska, much of Canada and the US with normal to below normal temperatures limited to Quebec and the Southcentral US (**Figure 9**).

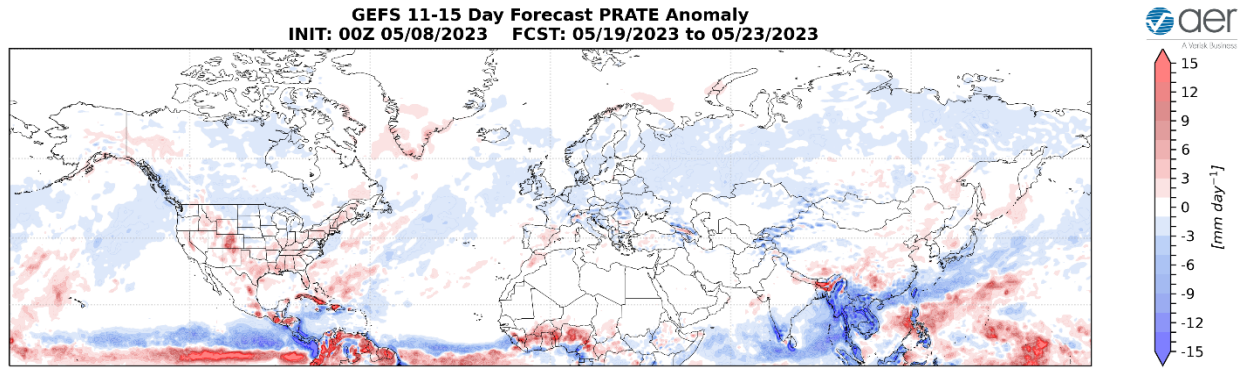


Figure 10. Forecasted precipitation rate (mm/day; shading) from 19 – 23 May 2023. The forecast is from the 00Z 8 May 2023 GFS ensemble.

Mostly normal to dry conditions are predicted across Europe and Asia with the exceptions of normal to wet conditions across Spain and China this period (**Figure 10**). Mostly normal to dry conditions are predicted across Canada and the Northcentral US with normal to wet conditions across the US Rockies and the Southern and Eastern 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 stratosphere and troposphere (**Figure 11**). However, next week warm/positive PCHs are predicted to re-emerge in the troposphere (**Figure 11**).

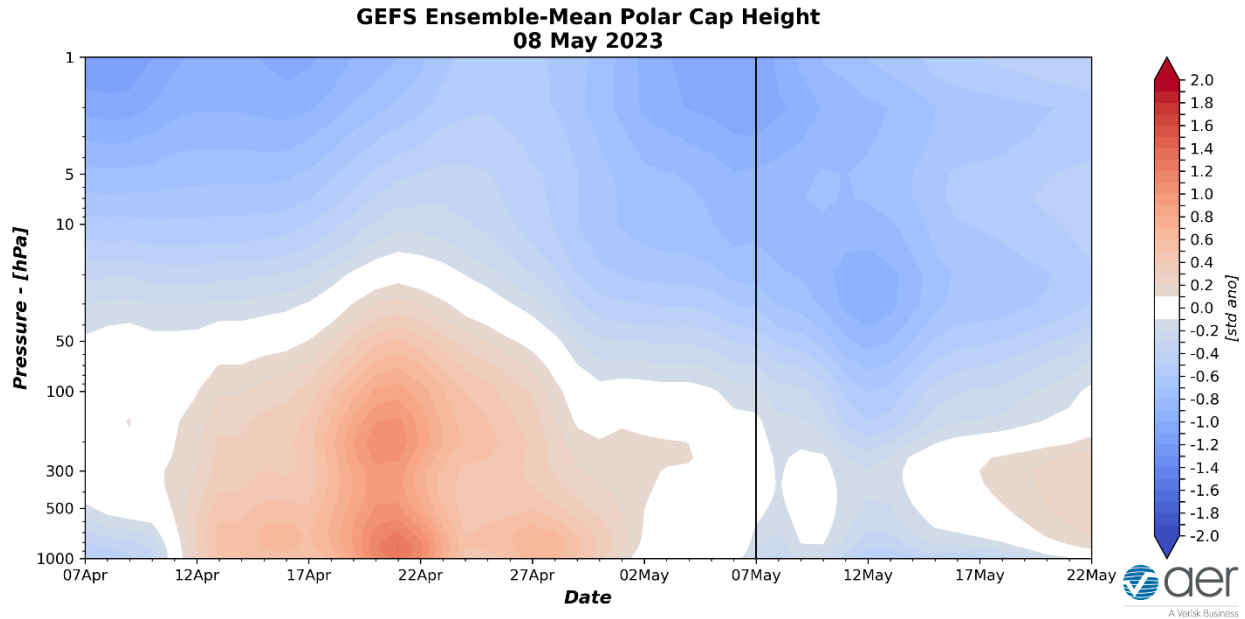


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 8 May 2023 GFS ensemble.

The predicted cold/negative PCHs in the troposphere this week and into next week (**Figure 11**) are consistent with the predicted positive surface AO the next two weeks (**Figure 1**). However, the AO is predicted to become closer to neutral later next week (**Figure 1**) coinciding with the predicted re-emergence of warm/positive PCHs in the troposphere (**Figure 11**).

CFS 500 hPa Forecast Anomaly Jun 2023
Valid as of 08 May 2023

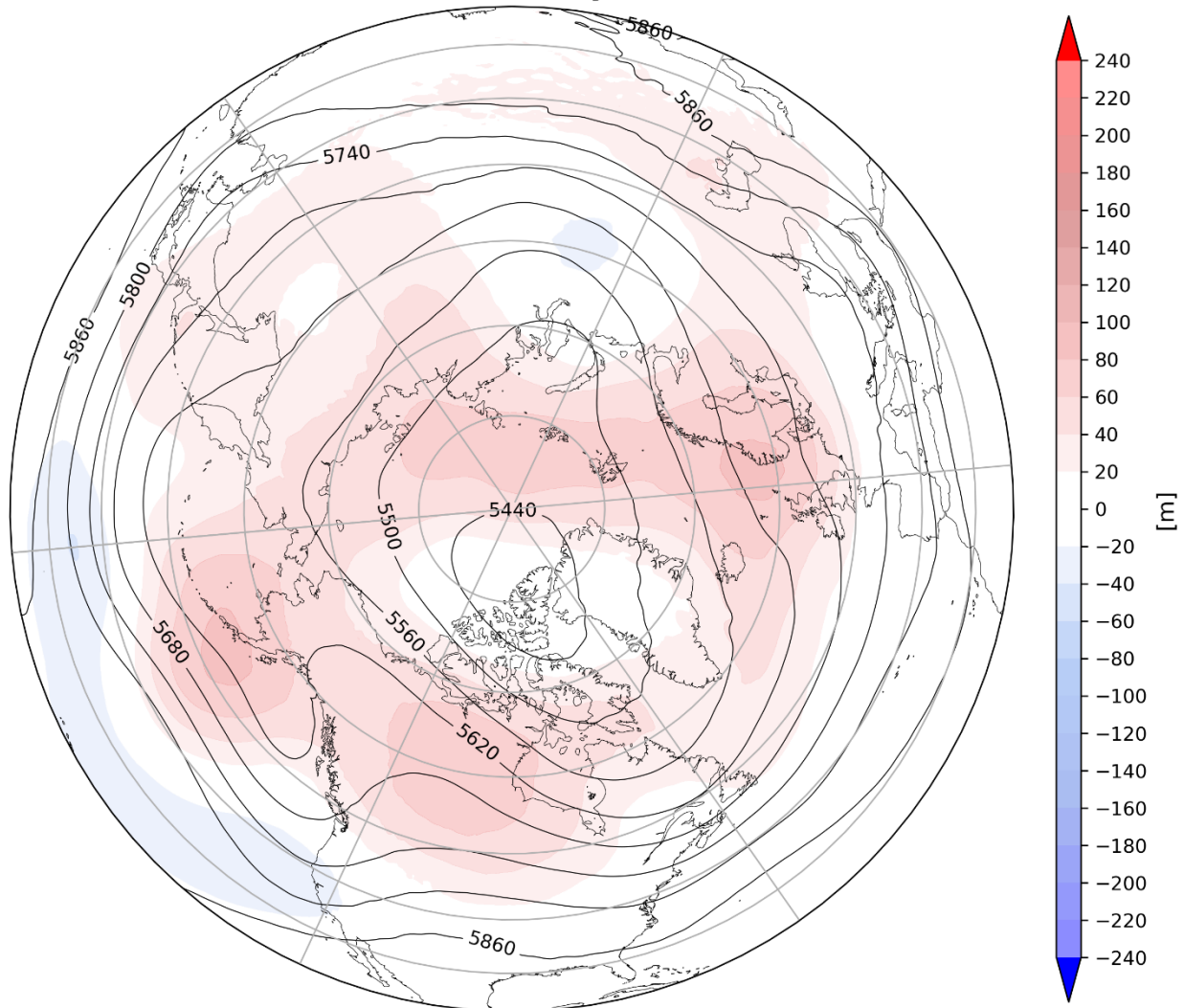


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for June 2023. The forecasts are from the 00Z 8 May 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and surface temperatures for June (**Figure 14**) 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, Alaska, Western and Central Canada and the Central US with troughing across Southern Europe, the Urals, Eastern Canada and the Western and Eastern US (**Figure 13**). This pattern favors seasonable to relatively warm temperatures across Northern and Eastern Europe, Northern, Central and Eastern Asia, Alaska, much of Canada, and the US Rockies with seasonable to relatively cool temperatures across Southwestern Europe, the Urals, Kazakhstan, the Southwestern and Central US (**Figure**

14).

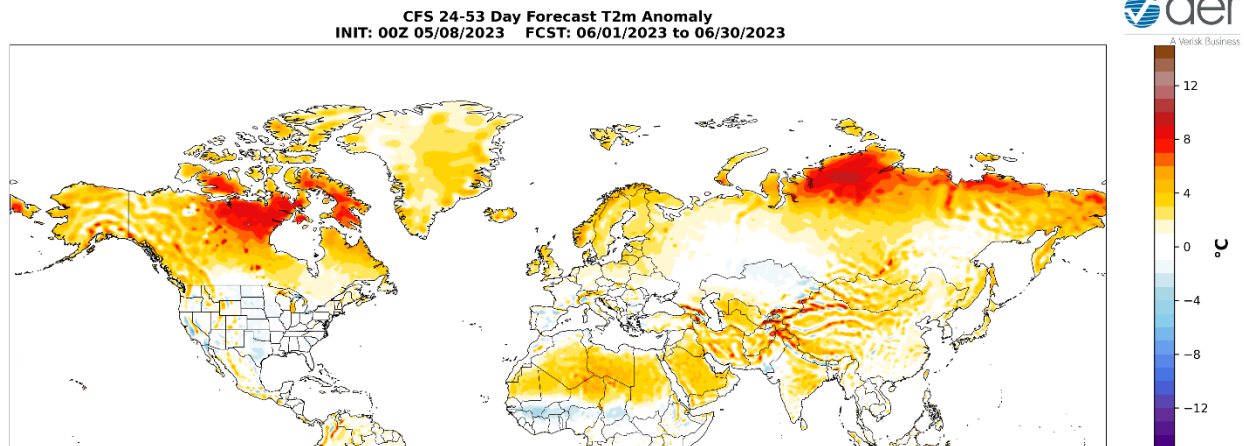


Figure 13. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for June 2023. The forecasts are from the 00Z 8 May 2023 CFS.

Boundary Forcings

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are above normal, especially along the South America coast, indicating that the transition from La Niña to El Niño is complete (**Figure 14**) 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, the eastern North Atlantic and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

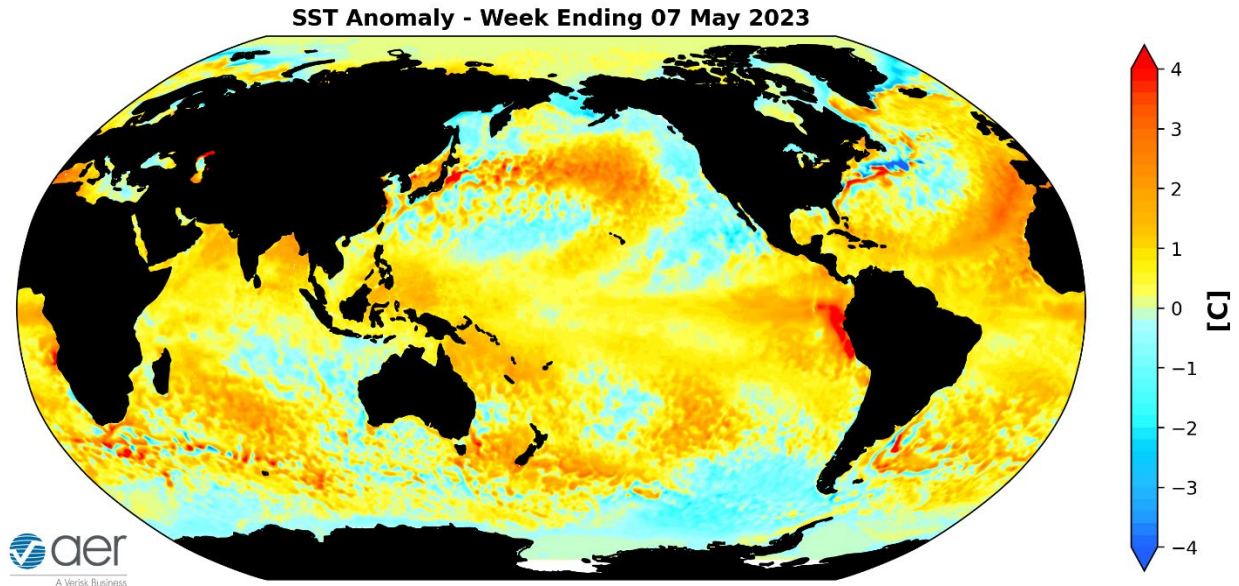


Figure 14. The latest weekly-mean global SST anomalies (ending 7 May 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently phase five of the Madden Julian Oscillation (MJO) is favored (**Figure 16**). The forecasts are for the MJO to quickly transition into phases six and then seven. Phases five and six favor troughing over Canada and ridging over the US. Seems that the MJO is having minimal influence on the weather across North America in the short term. But admittedly this is outside of my expertise.

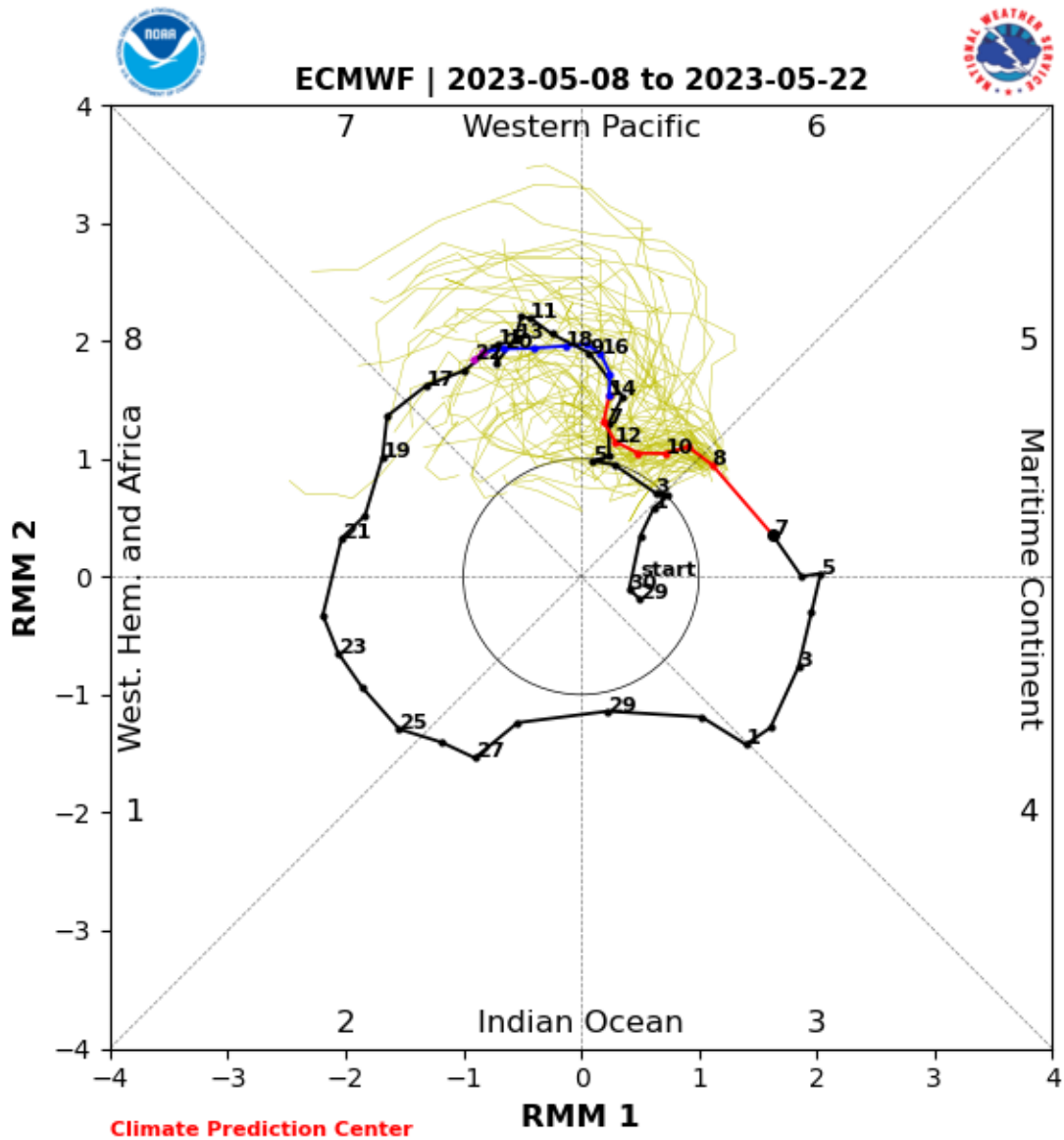


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 8 May 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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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