

Arctic Oscillation and Polar Vortex Analysis and Forecasts

April 11, 2022

Dear AO/PV blog readers:

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

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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Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to pop into positive territory next week and then trend negative again with mostly positive pressure/geopotential height anomalies across the Arctic including the North Atlantic side of the Arctic this week and the last week of April but mostly negative next week with mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is also negative and is predicted to also pop positive and then negative as pressure/geopotential height anomalies are predicted to vacillate across Greenland the next two weeks.
- This week the predicted pattern for Europe is ridging/positive geopotential height anomalies for Western Europe forcing troughing/negative geopotential height anomalies over Eastern Europe but starting next week the pattern is predicted to

transition to troughing/negative geopotential height anomalies over Western Europe with ridging/positive geopotential height anomalies across Eastern Europe. This pattern favors normal to above normal temperatures across Western Europe including the United Kingdom (UK) with normal to below normal temperatures across Eastern Europe but then next week the pattern will begin to transition to normal to below normal temperatures across Western Europe including the UK with normal to above normal temperatures across Eastern Europe.

- The general pattern across Asia this week is ridging/positive geopotential height anomalies across Western Asia forcing downstream troughing/negative geopotential height anomalies across Eastern Asia. However next week the pattern is predicted to transition to troughing/negative geopotential height anomalies across Northern Asia with ridging/positive geopotential height anomalies across Southern Asia. This pattern favors normal to above normal temperatures across Western Asia with normal to below normal temperatures across Eastern Asia this week. However next week the pattern will transition to normal to below normal temperatures across Northern Asia with normal to above normal temperatures across Southern Asia
- The general pattern this week across North America is ridging/positive geopotential height anomalies across Alaska, the Gulf of Alaska and the Eastern United States (US) with troughing/negative geopotential height anomalies across western North America. However, the next week the ridge/trough pattern will migrate eastwards and then transition to troughing/negative geopotential height anomalies across Alaska and the Gulf of Alaska with ridging/positive geopotential height anomalies across the Southern US. The pattern favors normal to above normal temperatures in Western Canada and the Western United States (US) with normal to above normal temperatures across Alaska, Eastern Canada and the Eastern US. Then next week normal to below normal temperatures will become widespread across much of North America with normal to above normal temperatures mostly confined to Western Canada and the Western US.
- In the *Impacts* section I continue to discuss my expectations of the impacts of the polar vortex (PV) disruption that is resulted in a Final Warming, though the impacts are more analogous to a classical sudden stratospheric warming (SSW) across the Northern Hemisphere (NH).

Plain Language Summary

The large polar vortex disruption is behaving like a sudden stratospheric warming in both the stratosphere and the troposphere. This includes high latitude blocking including Greenland blocking/high pressure that favors colder and/or stormier weather across Europe and Northern Asia and eastern North America. I expect the see-saw swing in temperatures across the Northern Hemisphere to continue for at least a few more weeks before a more summery pattern takes hold.

Impacts

The large PV disruption last month and its related impacts on the tropospheric circulation and weather continue to be a dominant story over the next two weeks and likely beyond two weeks. If we look at the observed temperatures so far for the spring season (see **Figure i**), I would argue that the imprint or influence of the PV disruption is clear including relatively cold temperatures across Northern Asia, east of the Rockies in North America and even in parts of Europe.

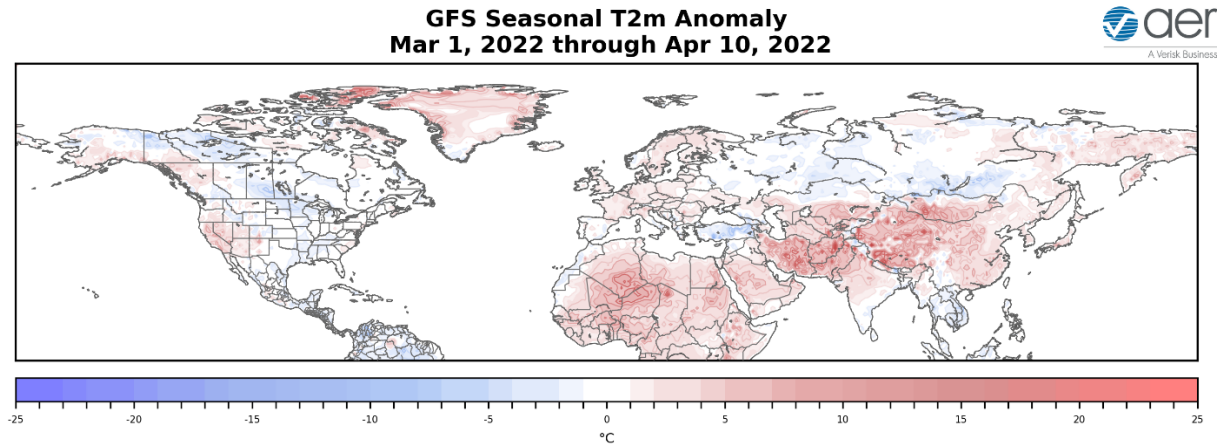


Figure i. Observed surface temperature anomalies ($^{\circ}\text{C}$; shading) from 1 March – 10 April 2022 based on the GFS analysis.

As I discussed in the most March blogs the relationship between the Final Warming and the tropospheric circulation of this March is likely to be similar to that of March 2016 that had a long-lasting connection with the tropospheric circulation across the NH for much of the spring.

The large PV disruption has resulted in a stratospheric circulation with high pressure over the Arctic region and low pressure across the mid-latitudes (see **Figure 13**). Since late March we have observed and will likely continue to observe periodically or episodically the circulation of high latitude high pressure or blocking with low pressure across parts of the mid-latitudes descend or “drip” into the troposphere characterized by a negative AO, NAO and relatively cold temperatures and even snowfall across parts of Europe, Northern Asia and North America. Once such event occurred at the end of March with another event ongoing. This is producing some impressive relatively cold temperatures and snowfall especially across North America this week into next week.

Though the atmospheric circulation is continuous or persistent in the stratosphere it is episodic in the troposphere. Therefore, next week the AO/NAO are predicted to transition back to positive signaling an overall milder temperature pattern across the NH mid-latitudes. The GFS is predicting a mild week across Eurasia mid-month

(see **Figure 6**), which is more sensitive than North America to the phase of the AO/NAO. However, based on the latest polar cap geopotential height anomalies (PCHs) forecast in **Figure 11**, another episode of warm/positive PCHs “dripping” down from the stratosphere to the troposphere is possible at the end of April. And that is why I believe we are starting to see more atmospheric characteristics consistent with a negative AO including high pressure in the Central Arctic (see **Figure 8**) and relatively colder temperatures across Northern Asia and even Western Europe (see **Figure 9**) heading into the last week or so of April.

I can see this see saw or back and forth between mild and cooler weather for a few more weeks until the influence from the stratospheric PV disruption runs its course or fades. But eventually I do expect that we will see a more consistent pattern of relatively warm temperatures widespread across the mid-latitudes and follow the trend of recent summers.

1-5 day

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

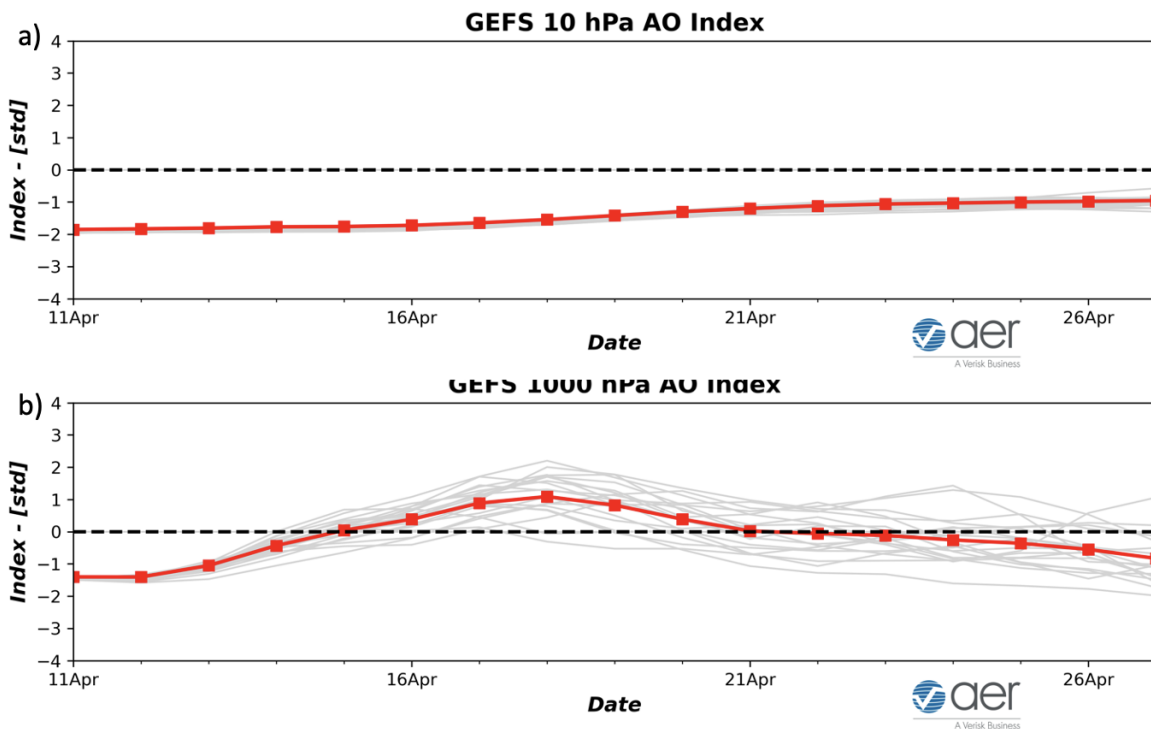


Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 11 April 2022 GFS ensemble. **(b)**The predicted daily-mean near-surface AO from the 00Z 11 April 2022 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Trouching/negative geopotential height anomalies in the central North Atlantic will support ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Eastern Europe **(Figures 2)**. This will result in normal to above normal temperatures across Western Europe including the UK with normal to below normal temperatures across Eastern Europe including Turkey **(Figure 3)**. Eastern European troughing will support ridging/positive geopotential height anomalies across Western Asia with troughing/negative geopotential height anomalies across Eastern Asia this period **(Figure 2)**. This pattern favors normal to above normal temperatures across Western Asia with normal to below normal temperatures across Eastern Asia **(Figure 3)**.

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 04/11/2022 FCST: 04/12/2022 to 04/16/2022

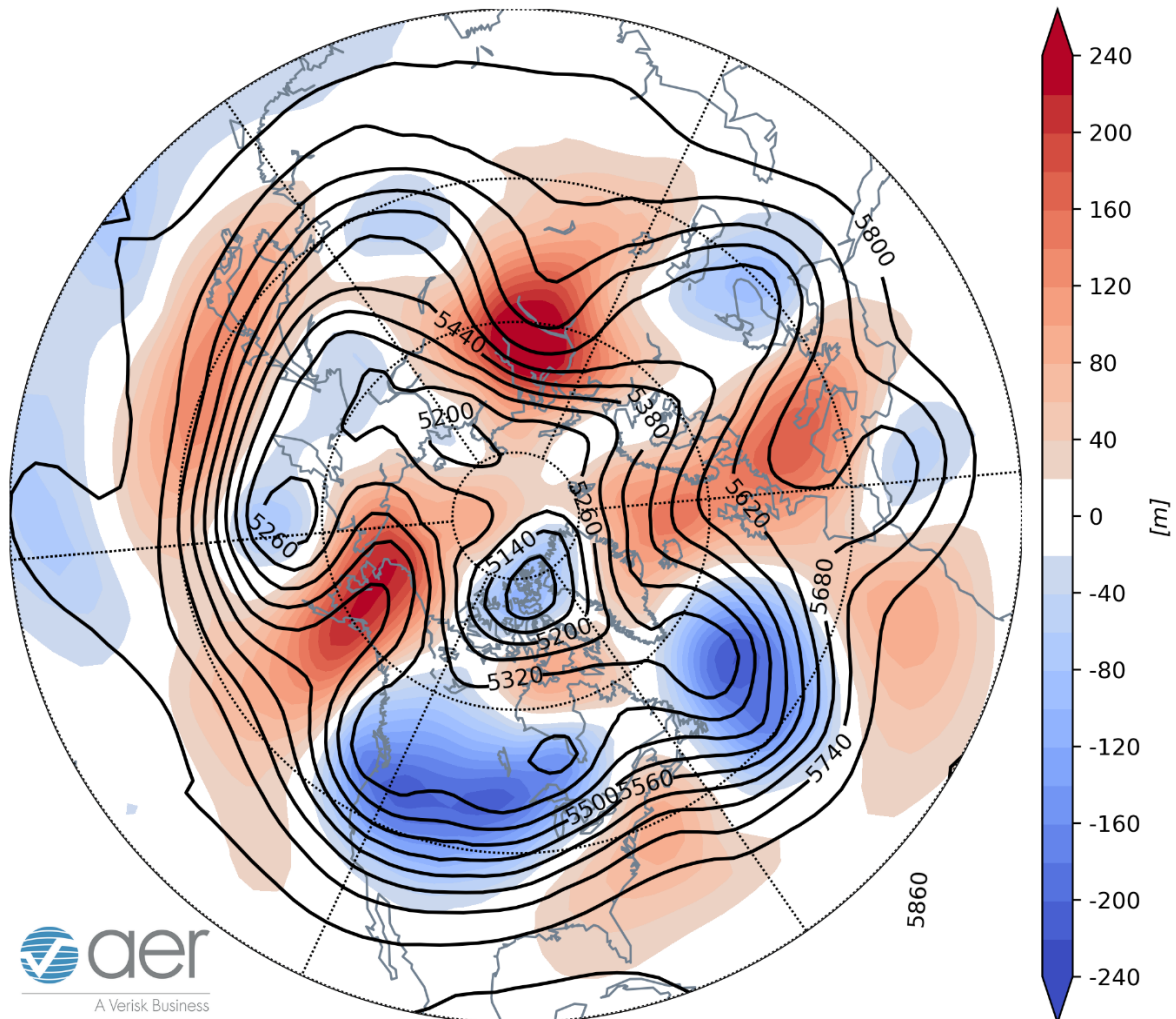


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 12 – 16 April 2022. The forecasts are from the 00z 11 April 2022 GFS ensemble.

Across North America the general pattern is ridging/positive geopotential height anomalies across Alaska and Gulf of Alaska supporting troughing/negative geopotential height anomalies across Western Canada and Western US with ridging/positive geopotential height anomalies across Eastern Canada and the Eastern US (**Figure 2**). The trough/ridge pattern will favor normal to below normal temperatures across northern Alaska, Western Canada and the Western US with normal to above normal temperatures in Eastern Canada and the Eastern US (**Figure 3**).

GFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 04/11/2022 FCST: 04/12/2022 to 04/16/2022

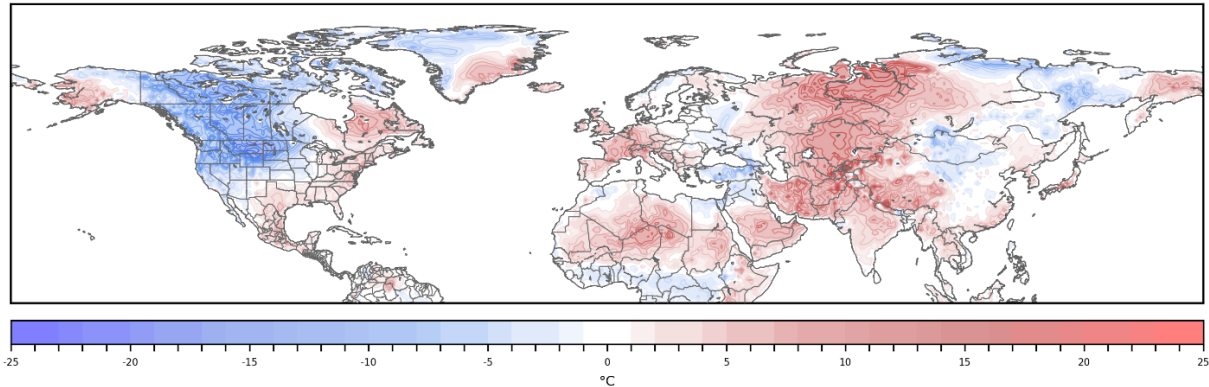


Figure 3. Forecasted surface temperature anomalies (°C; shading) from 12 – 16 April 2022. The forecast is from the 00Z 11 April 2022 GFS ensemble.

A negative AO pattern will support late season snowfall across East Asia Tibet/Southwest China, widespread across Central Canada, the Cascades, the Rockies and the US Northern Plains with snowmelt across northern Eurasia, Alaska and parts of Canada (**Figure 4**). Portland Oregon has recorded its first measurable April snowfall and North Dakota could see up to three feet of snow this week!

GEPS 1-5 Day Forecast SNOD Change
INIT: 00Z 04/11/2022 FCST: 04/12/2022 to 04/16/2022

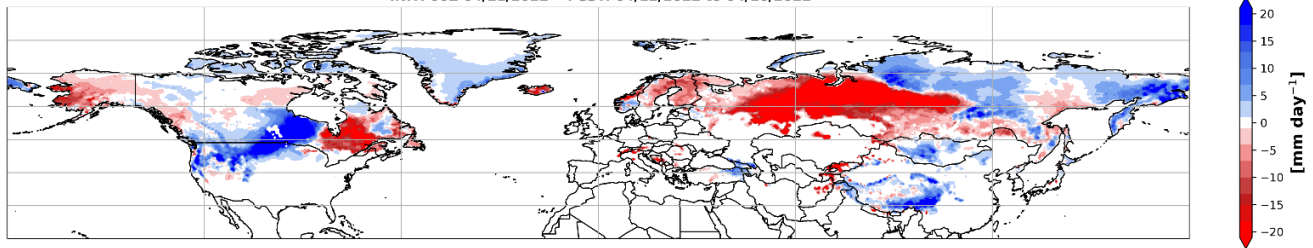


Figure 4. Forecasted snow depth changes (mm/day; shading) from 12 – 16 April 2022. The forecast is from the 00Z 11 April 2022 GEPS ensemble.

Mid-Term

6-10 day

The AO is predicted to pop into positive territory this period (**Figure 1**) as geopotential height anomalies turn mostly negative across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And as geopotential height anomalies turn weakly negative across Greenland (**Figure 5**), the NAO is predicted to also enter positive territory this period.

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 04/11/2022 FCST: 04/17/2022 to 04/21/2022

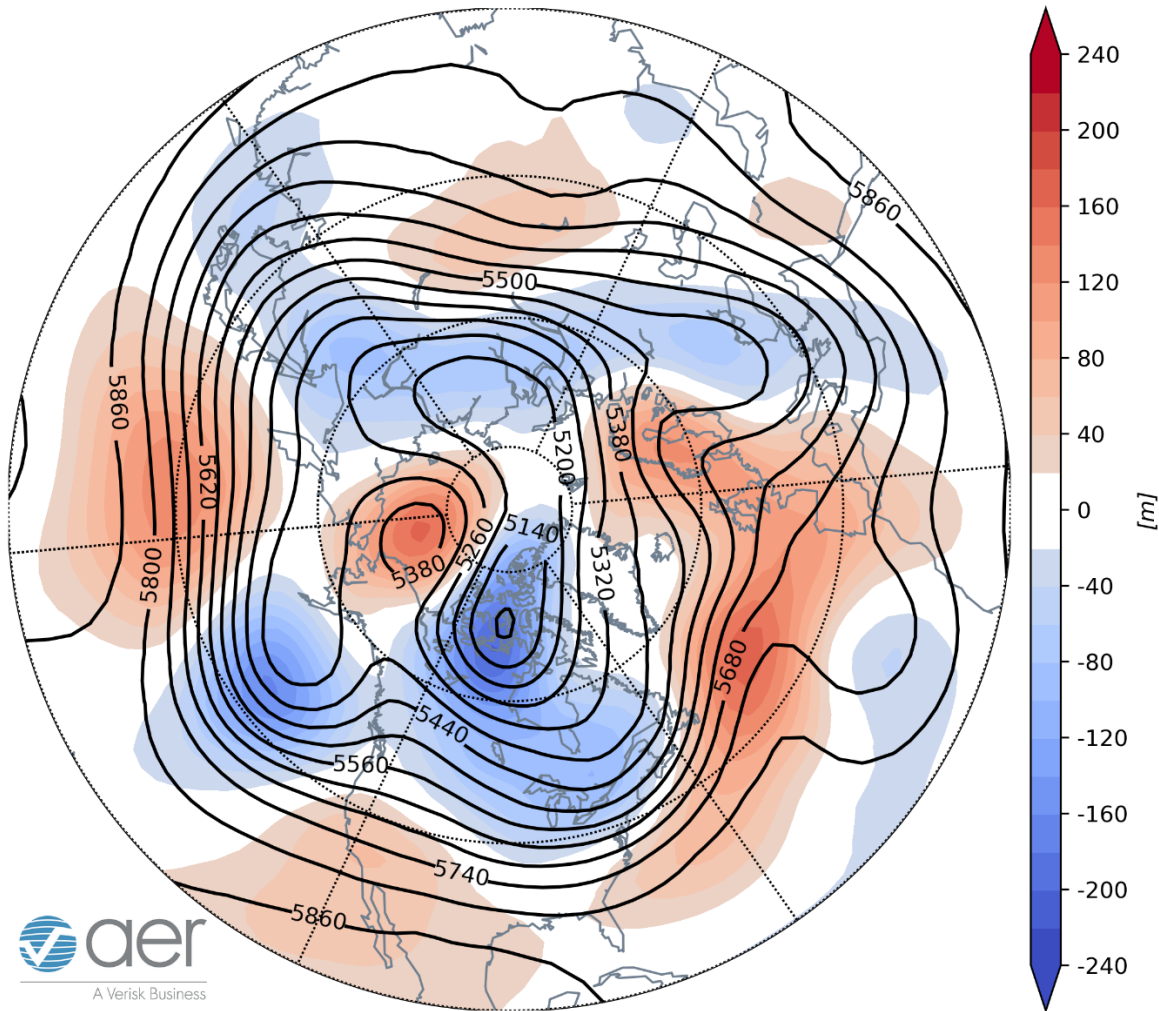


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 April 2022. The forecasts are from the 00z 11 April 2022 GFS ensemble.

Ridging/positive geopotential height anomalies across Western Europe with troughing/negative geopotential height anomalies across Eastern Europe are predicted to persist this period (**Figures 5**). This will result in normal to above normal temperatures across Western Europe including the UK with normal to below normal temperatures across Eastern Europe and Turkey (**Figure 6**). The pattern across Asia is predicted to transition to troughing/negative geopotential height anomalies across Northern Asia with ridging/positive geopotential height anomalies across Southern Asia this period (**Figure 5**). This pattern favors widespread normal to above normal temperatures widespread across much of Asia with normal to below normal temperatures limited to pockets of Southwestern and Eastern Asia (**Figure 6**).

GFS 6-10 Day Forecast T2m Anomaly
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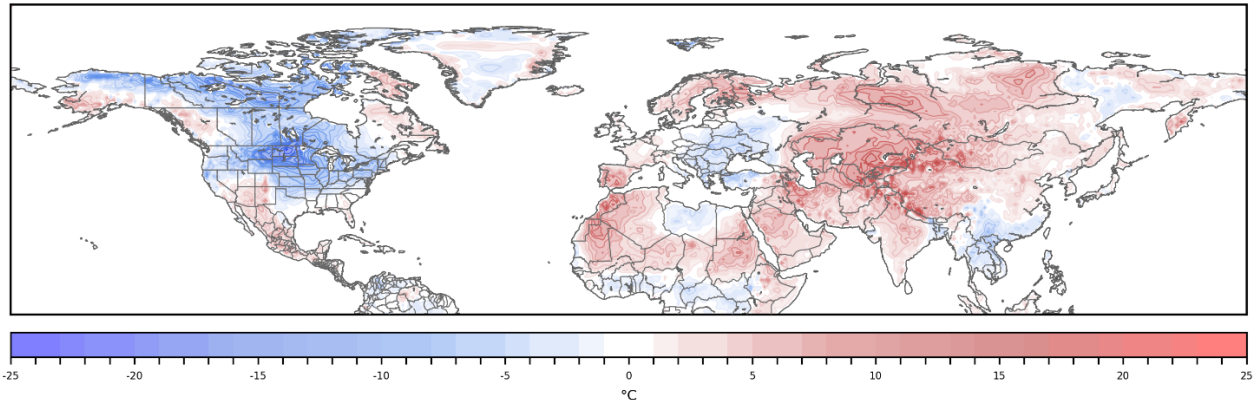


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 17 – 21 April 2022. The forecasts are from the 00Z 11 April 2022 GFS ensemble.

Persistent ridging/positive geopotential height anomalies north of Alaska will support troughing/negative geopotential height anomalies across much of Canada and the Northern US with ridging/positive geopotential height anomalies across the southern US (**Figure 5**). This will favor normal to below normal temperatures across northern Alaska, much of Canada and the Northern and Eastern US with normal to above normal temperatures across southern Alaska, the West Coast of Canada and the Southwestern US (**Figure 6**).

GEPS 6-10 Day Forecast SNOd Change
INIT: 00Z 04/11/2022 FCST: 04/17/2022 to 04/21/2022

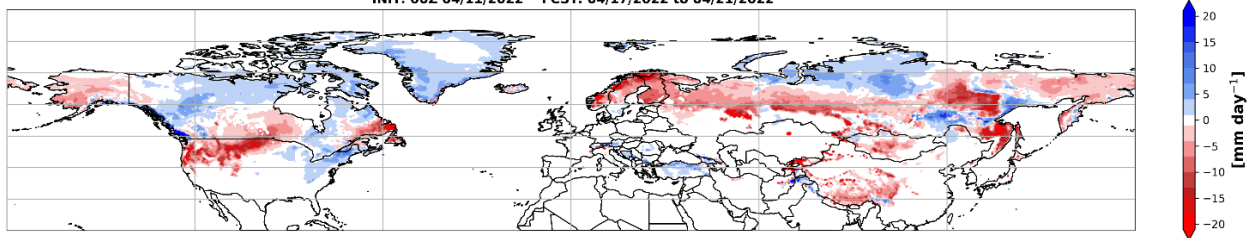


Figure 7. Forecasted snow depth changes (mm/day; shading) from 17 – 21 April 2022. The forecast is from the 00Z 11 April 2022 GEPS ensemble.

Late season snowfall is possible across parts of Siberia, Turkey, Northern and Eastern Canada and the Northeastern US with snowmelt across northern Eurasia, Alaska the Western US and the Plains of the US and Canada (**Figure 7**).

11-15 day

Positive geopotential height anomalies are predicted to return to the Central Arctic this period (**Figure 8**), therefore the AO should trend negative (**Figure 1**). With predicted weak and mixed pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is predicted to be near neutral this period.

GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
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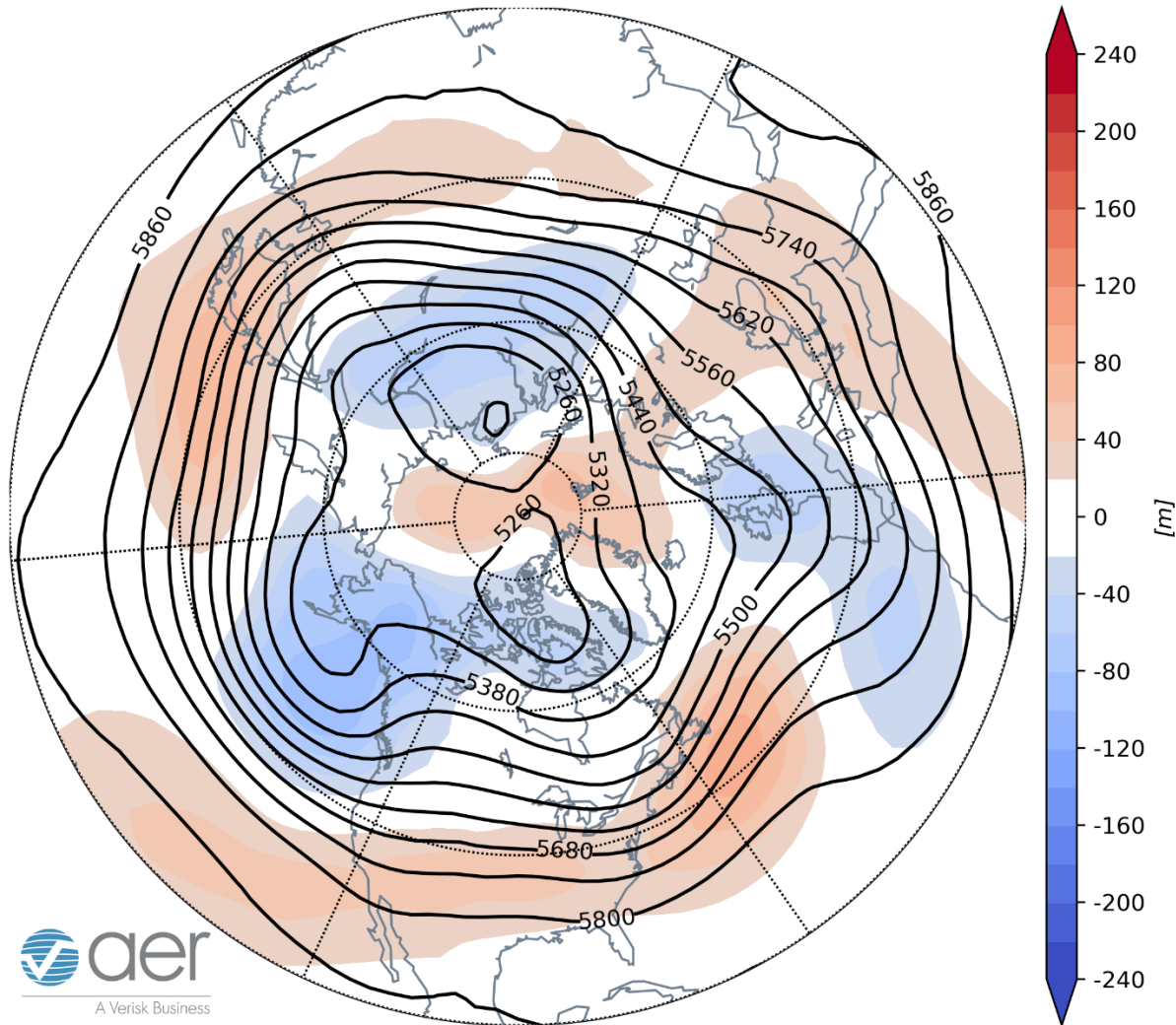


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 22 – 26 April 2022. The forecasts are from the 00z 11 April 2022 GFS ensemble.

The return of ridging/positive geopotential height anomalies across the central Arctic will support new troughing/negative geopotential height anomalies across Western Europe with downstream ridging/positive geopotential height anomalies across Eastern Europe this period (**Figure 8**). This pattern favors more normal to below normal temperatures widespread across Western and Central Europe including the UK with

normal to above normal temperatures across the Eastern Europe (**Figures 9**). The pattern of troughing/negative geopotential height anomalies across Northern Asia with ridging/positive geopotential height anomalies across Southern Asia is predicted to amplify this period (**Figure 8**). This pattern favors widespread normal to below normal temperatures across Siberia with normal to above normal temperatures across Western and Southern Asia (**Figure 9**).

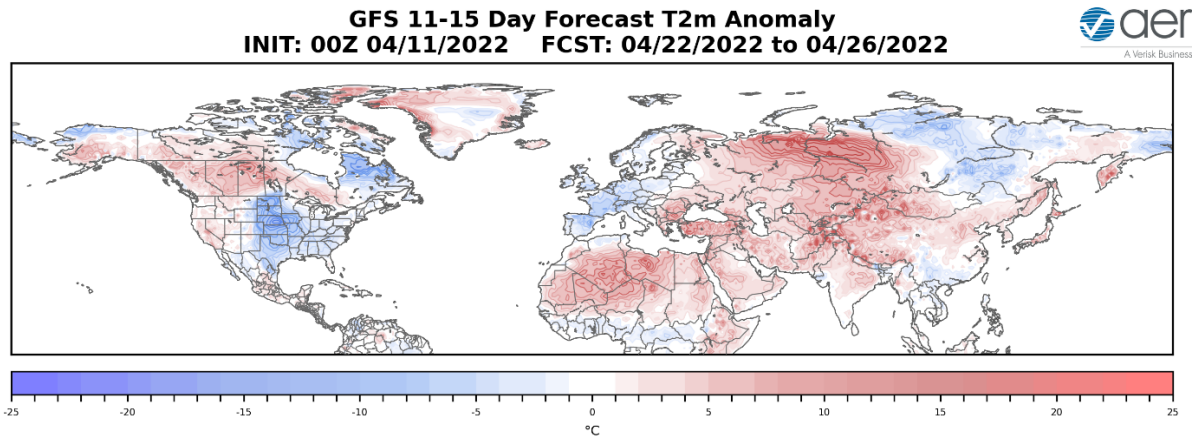


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 22 – 26 April 2022. The forecasts are from the 00z 11 April 2022 GFS ensemble.

The pattern across North America is predicted to transition to troughing/negative geopotential height anomalies across Alaska, the Gulf of Alaska and Western Canada and the Western US with ridging/positive geopotential height anomalies across Central Canada and the Southern US with residual troughing/negative geopotential height anomalies across Eastern Canada and the Eastern US this period (**Figure 8**). This pattern favors normal to below normal temperatures across northern Alaska, Eastern Canada and the Central and Eastern US with normal to above normal temperatures in southern Alaska, Western and Central Canada and the Western US (**Figure 9**).

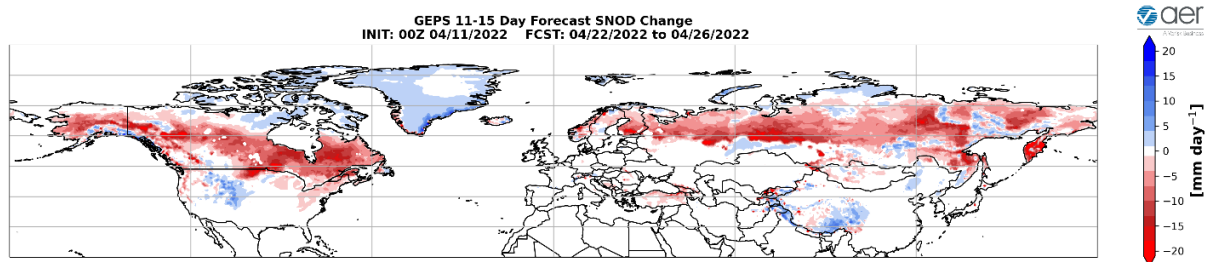


Figure 10. Forecasted snow depth changes (mm/day ; shading) from 22 – 26 April 2022. The forecast is from the 00Z 11 April 2022 GEPS ensemble.

Consistent with the positive AO pattern, snowmelt is predicted to become more widespread across Eurasia and North America with new snowfall limited to parts of the Tibetan Plateaus, Siberia, southern Alaska, Northern Canada and the US Rockies (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows warm/positive PCHs throughout the stratosphere and troposphere. Warm/positive PCHs are predicted to persist in the stratosphere for the foreseeable future (**Figure 11**). The largest positive departures are in the mid-stratosphere and is related to a significant disruption of the PV last month (**Figure 11**). Meanwhile the warm/positive PCHs in the lower troposphere are predicted to transition to cold/negative PCHs next week (**Figure 11**).

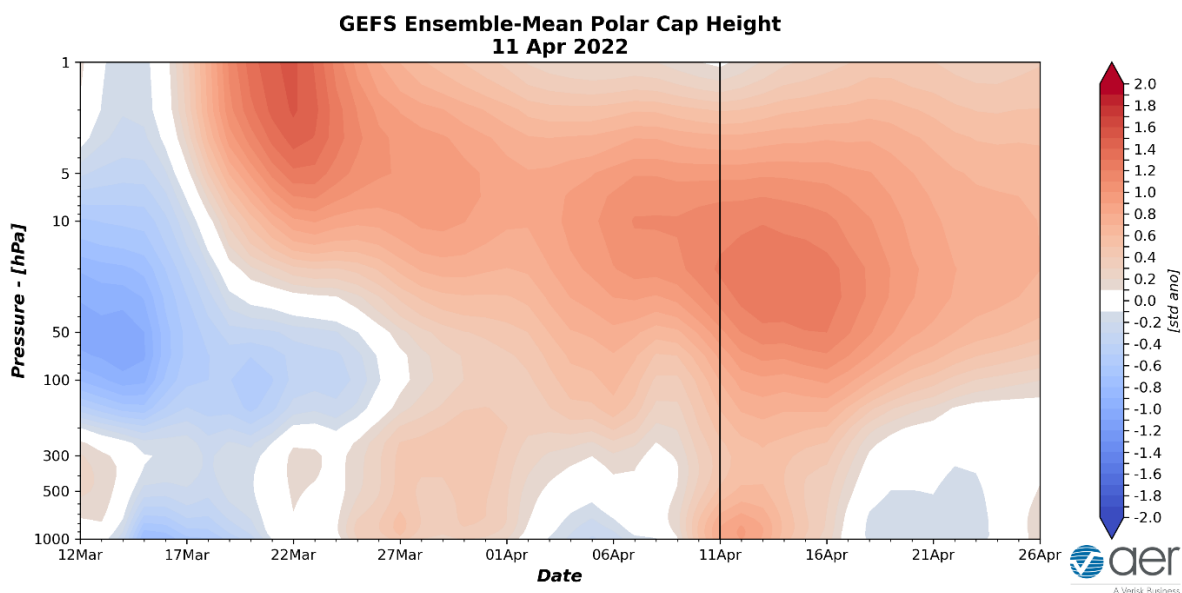


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 11 April 2022 GFS ensemble.

The normal to above normal PCHs predicted this week in the lower troposphere are consistent with the predicted negative surface AO this week (**Figure 1**). The AO is predicted to transition next week to positive as PCHs become colder/more negative in the lower troposphere.

Though vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport to the upper stratosphere is now blocked by easterly winds (**Figure 12**), more positive WAFz anomalies are predicted this week into the upper troposphere and lower stratosphere and will continue to support relatively warm PCHs in the lower stratosphere.

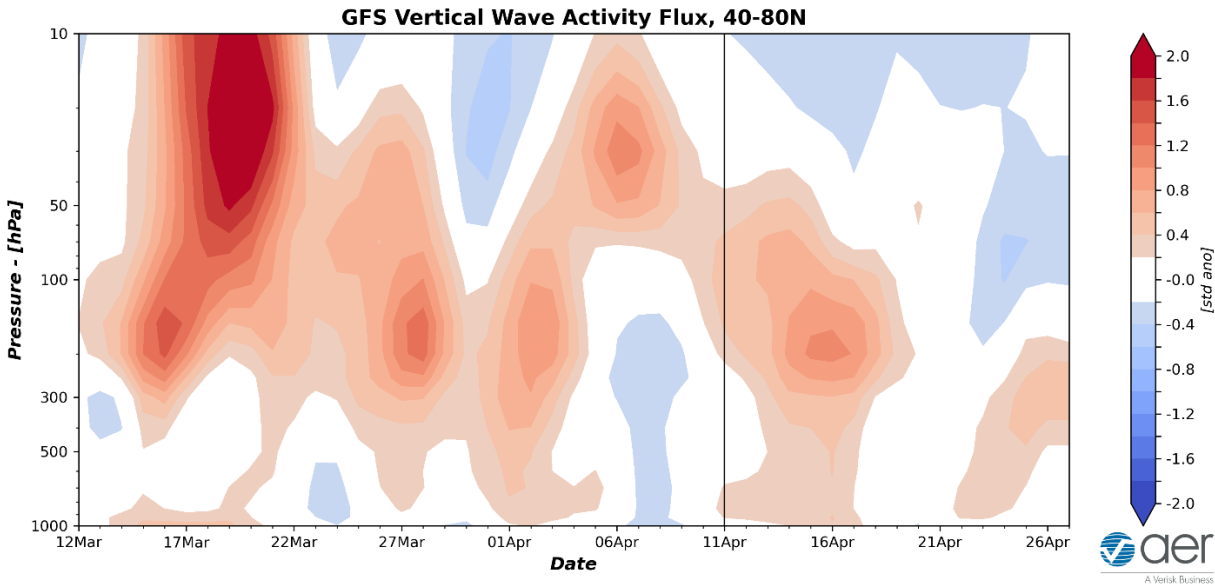


Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 11 April 2022 GFS ensemble.

The large pulses of WAFz last month resulted in an early Final Warming (but is analogous to a major sudden stratospheric warming where the zonal winds at 60°N and 10hPa reverse from westerly to easterly only temporarily) and is predicted to persist the negative stratospheric AO (**Figure 11**).

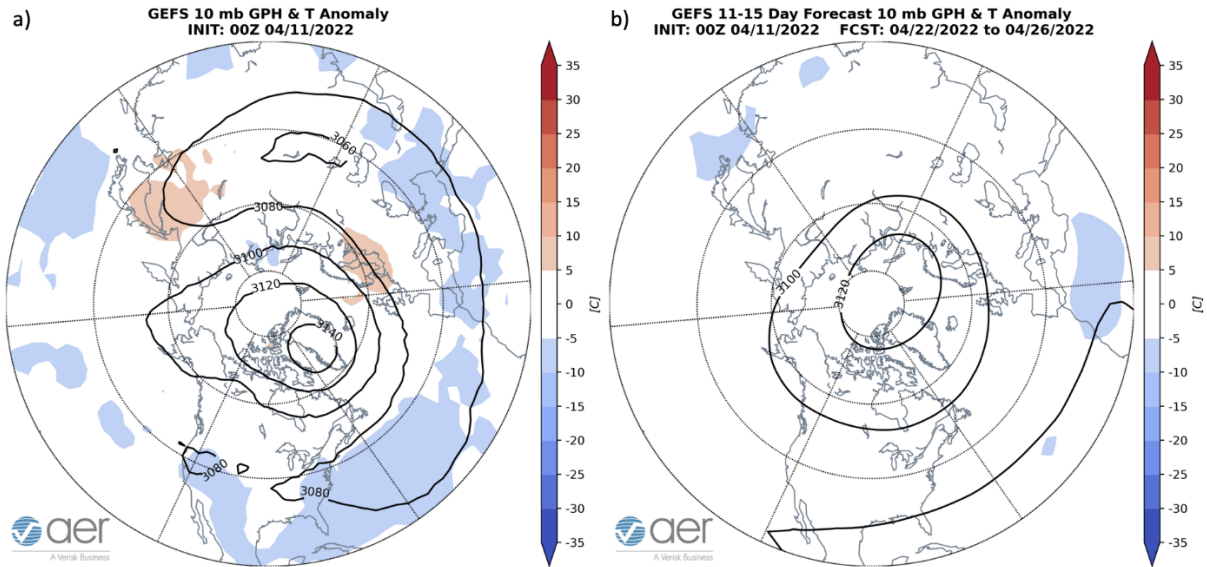


Figure 13. (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere averaged for 11 April 2022. (b) Same as (a) except forecasted averaged from 22 – 26 April 2022. The forecasts are from the 00Z 11 April 2022 GFS model ensemble.

The PV is disrupted because of the strong pulses of WAFz last month (**Figure 12**) with the PV center displaced into Central Asia with troughing spread across much of mid-latitudes and ridging centered across Greenland (**Figure 13a**). Little is predicted to change across the polar stratosphere over the next two weeks with a high-pressure center migrating close to the North Pole for its perennial summer position (see **Figure 13b**).

**CFS 500 hPa Forecast Anomaly May 2022
Valid as of 11 Apr 2022**

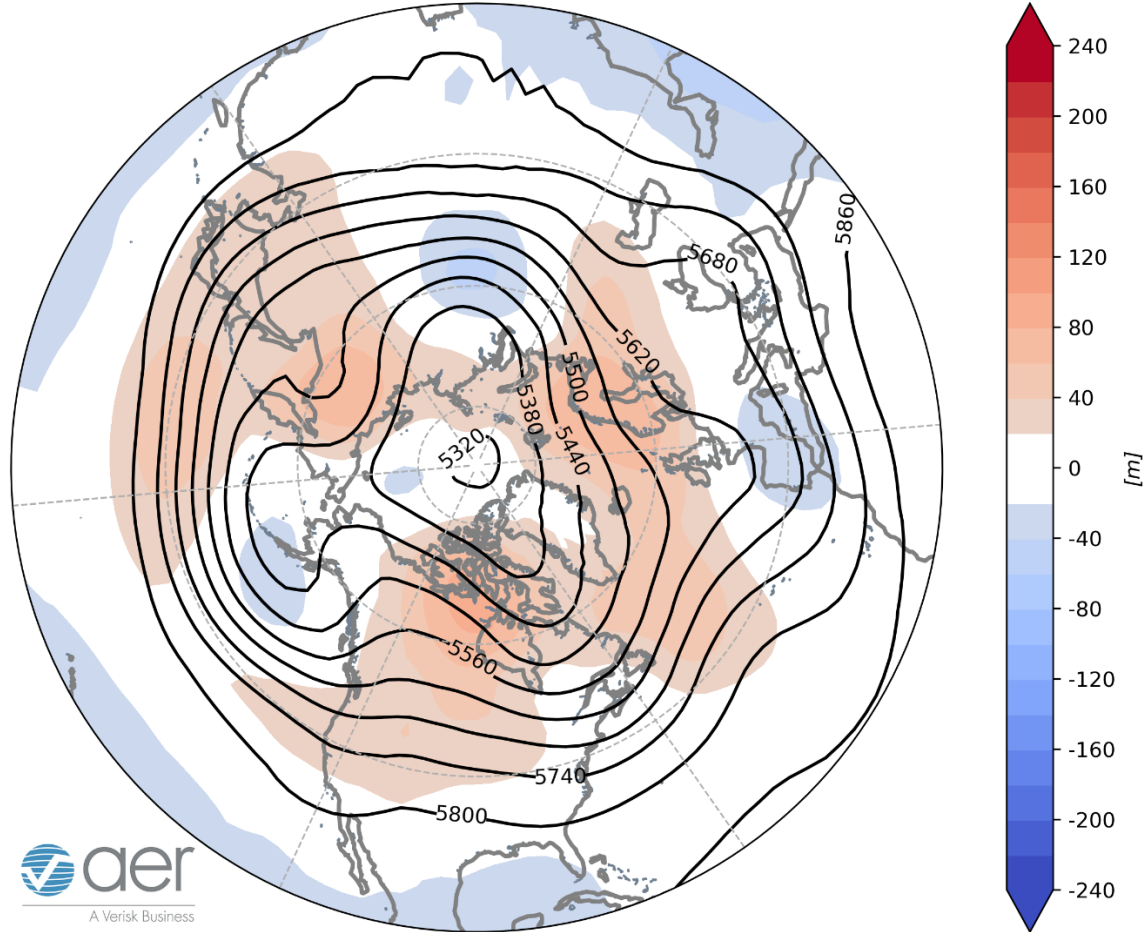


Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for May 2022. The forecasts are from the 00Z 11 April 2022 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for May (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered over the central North Atlantic, Scandinavia, East Asia and Central Canada with troughing across Southern Europe, Central Asia, the Aleutians, the Gulf of Alaska into the west coast of Canada and the Northeastern US (**Figure 14**). This pattern favors seasonable to relatively warm temperatures across Northern Europe, Northern and Eastern Asia, Alaska, Western Canada and the Western US with seasonable to relatively cool temperatures across Western and Southern Europe, Central Asia, Eastern Canada and the Eastern US (**Figure 15**).

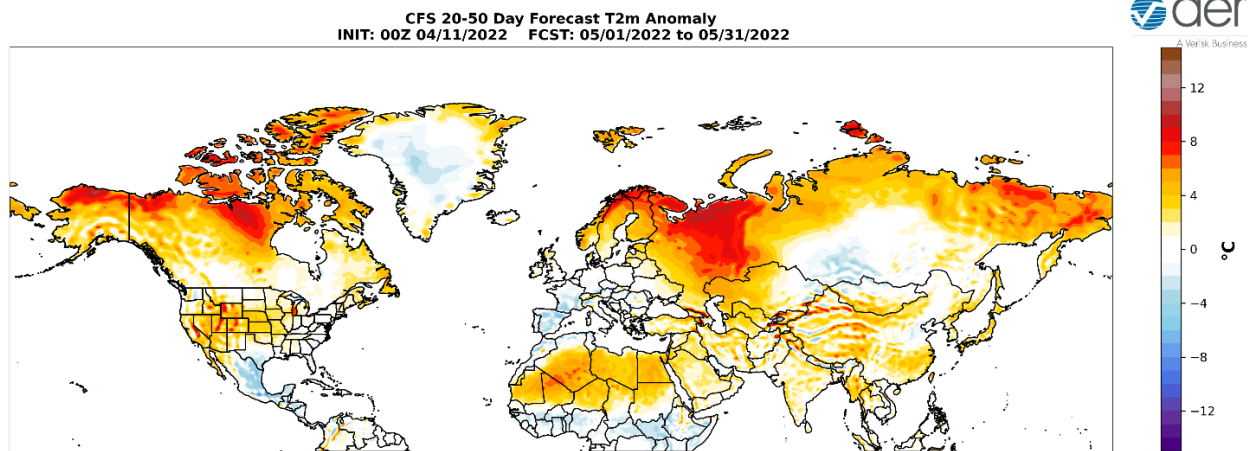


Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for May 2022. The forecasts are from the 00Z 11 April 2022 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak to possibly moderate La Niña conditions (**Figure 16**) and La Niña conditions are expected through the spring. 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. Not my expertise but the SST pattern in the North Pacific are strongly resembling a negative Pacific Decadal Oscillation (PDO) pattern that favors colder temperatures across northwestern North America and milder temperatures across southeastern North America.

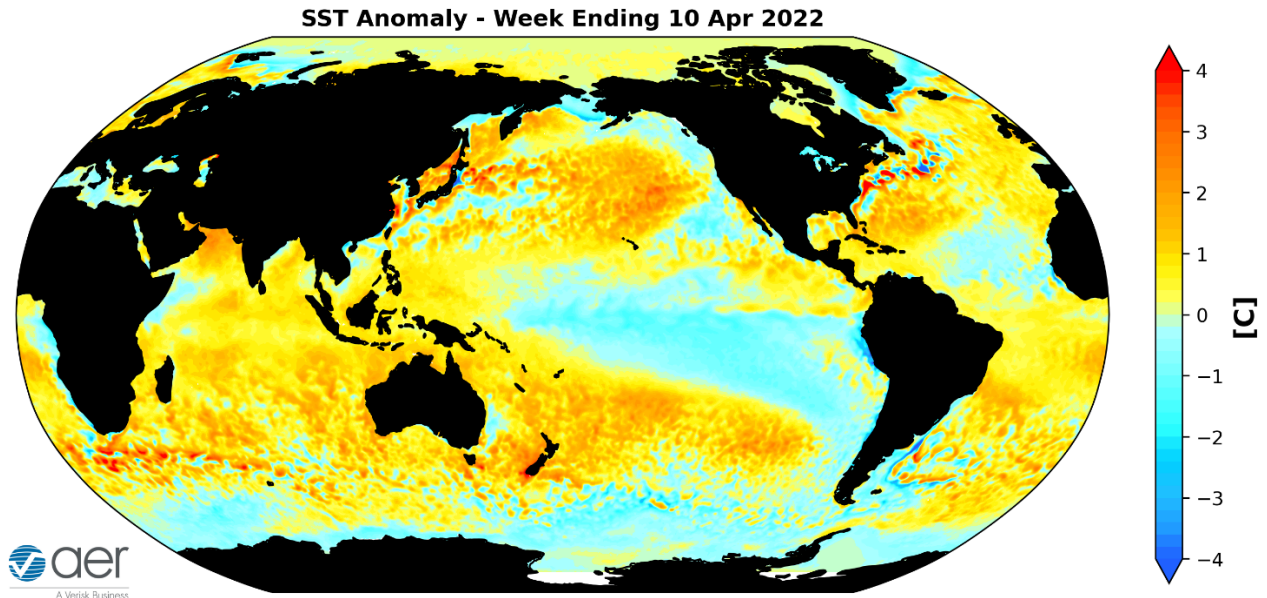


Figure 16. The latest weekly-mean global SST anomalies (ending 27 March 2022). Data from NOAA OI High-Resolution dataset.

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. Therefore it is hard for me to see that the MJO is likely influencing the weather across North America. But admittedly this is outside of my expertise.

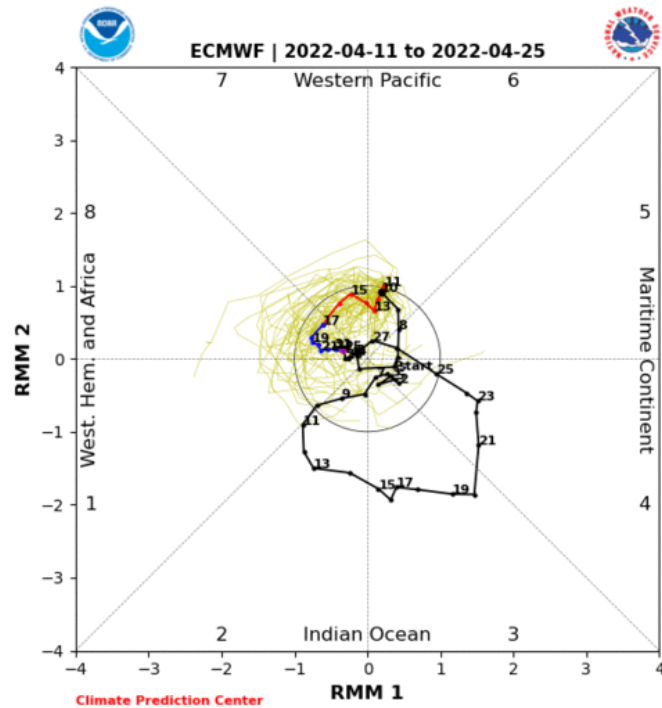


Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 11 April 2022 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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!