

April 8, 2019

Special blog on winter 2016/2017 retrospective can be found here
- <http://www.aer.com/winter2017>

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Dr. Judah Cohen from Atmospheric and Environmental Research (AER) recently embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation ([AO](#)). 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 transitioned to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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

Summary

- The Arctic Oscillation (AO) is currently negative and is predicted to remain negative over the next two weeks except for going briefly positive over the weekend.
- The current negative AO is reflective of mostly positive pressure/geopotential height anomalies across the Arctic and negative pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is also negative as currently positive pressure/geopotential height anomalies are spread across Greenland and mostly negative pressure/geopotential height anomalies across the mid-latitudes of the North Atlantic and is predicted to remain mostly negative over the next two weeks.
- Ridging/positive geopotential height anomalies is predicted to be generally positioned across Greenland and/or Northern Europe with troughing/negative geopotential height anomalies across Eastern and Southern Europe. This pattern favors near seasonably cool temperatures across the continent including the United Kingdom (UK) with the best chances of below normal temperatures first across Northern and Western Europe and eventually Southern and Eastern Europe.

- Over the next two weeks, ridging/positive geopotential height anomalies predicted across the Arctic will force troughing/negative geopotential height anomalies with normal to below normal temperatures across Northern Asia especially Siberia, and eventually Western Asia with ridging/positive geopotential height anomalies predicted and normal to above normal temperatures across Central and Eastern Asia.
- Over the next two weeks ridging/positive geopotential height anomalies with relatively mild temperatures across Greenland and much of the North American Arctic are predicted to force troughing/negative geopotential height anomalies and relatively cool temperatures to the south Southern Canada and parts of the United States (US).

Impacts

In the previous blog, I discussed though the multi-decadal trend favors an aggressive advance of the spring season and above normal temperatures, there was no sign of a warm start to spring for the Eastern US and Europe. This was related to high latitude blocking, especially across Greenland and a negative AO/NAO. A strongly negative AO/NAO has been elusive for many of the recent winters, the season a strong negative AO/NAO is most common. I don't have a good reason for the recent scarcity of a strongly negative AO/NAO and I only have a speculative reason for why it is finally occurring in April 2019. This past winter there was a long period of quiet in Wave Activity Flux (WAFz) or poleward heat transport from early January until late March. But in late March the WAF became more active again and initiated a reflective perturbation of the stratospheric polar vortex (PV). This resulted in ridging centered across Alaska both in the stratosphere and the troposphere, but it also resulted in warming polar cap height anomalies (PCHs) in the upper troposphere. Over the past two weeks those positive PCHs have descended into the lower troposphere initiating Greenland blocking and a negative AO/NAO.

Now that the negative AO/NAO pattern is in place how long will it last and what if any are the long-term consequences. The high latitude blocking in the North Atlantic sector but for now focused across Greenland is contributing most strongly to the negative AO/NAO. I would expect this pattern to persist on the order of weeks maybe three or so before breaking down. It does not seem to be associated with a major mid-winter warming or low sea ice in and around Greenland. Both of these conditions could contribute to more persistent Greenland blocking and a negative AO/NAO. Once this circulation breaks down, I would expect a more aggressive period of warming for many locations in the Eastern US, Europe and East Asia.

Therefore, I do expect, once snow cover retreats rapidly, for much of the continents to heat up and for above normal temperatures to be widespread across the mid-latitude continents. I do plan on posting a Northern Hemisphere (NH) summer temperature forecast next month on the blog. Sea ice remains below normal in the Barents-Kara

seas and I think this does favor ridging near Northern Europe once again this summer but of course this is not a guarantee.

Near Term Conditions

1-5 day

The AO is negative (**Figure 1**), with mostly positive pressure/geopotential height anomalies across the Arctic with negative pressure/geopotential height anomalies across the mid-latitudes (**Figure 2**). Geopotential height anomalies are positive across Greenland and negative across the mid-latitudes of the North Atlantic (**Figure 2**) and therefore the NAO is negative.

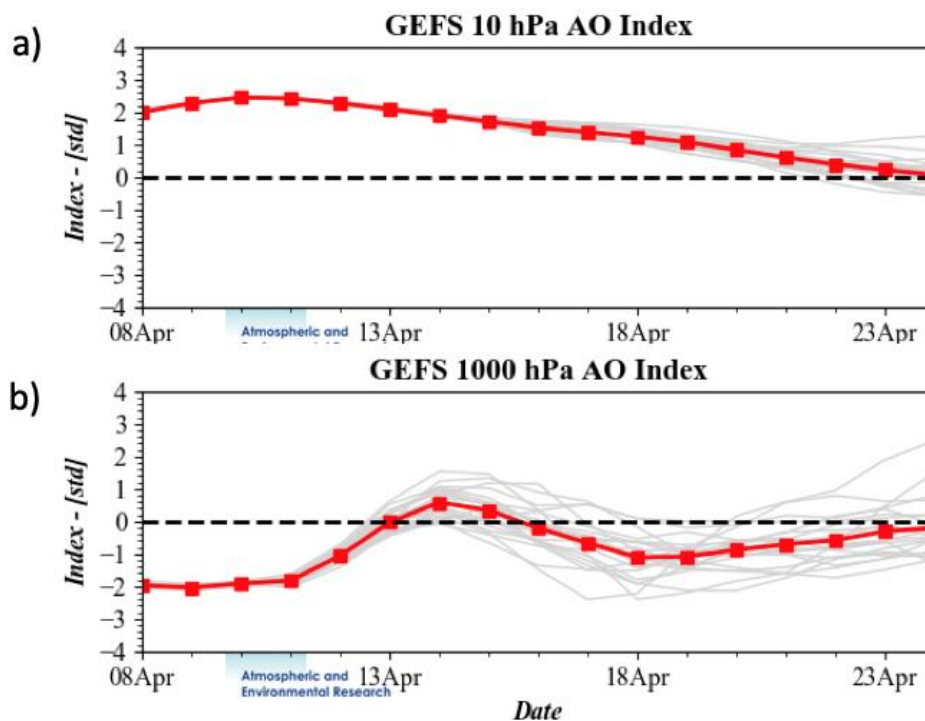


Figure 1. (a) The predicted daily-mean AO at 10 hPa from the 00Z 8 April 2019 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 8 April 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies spread across Greenland and Iceland are forcing troughing/negative geopotential height anomalies spread across Western and Southern Europe (**Figure 2**) and are predicted to result in mostly normal to below normal temperatures for Western and Northern Europe including the UK (**Figure 3**). However, southwesterly flow will yield normal to above normal temperatures across Eastern and Southern Europe (**Figure 3**). Ridging/positive geopotential height

anomalies centered over Northwest Russia will force troughing/negative geopotential height anomalies across much of Siberia and East Asia (**Figure 2**). This pattern is predicted to yield widespread normal to below normal temperature for Siberia except for Eastern Siberia and Northeast Asia with normal to above normal temperatures for Western Russia including the Middle East, Central Asia and Southeast Asia (**Figure 3**).

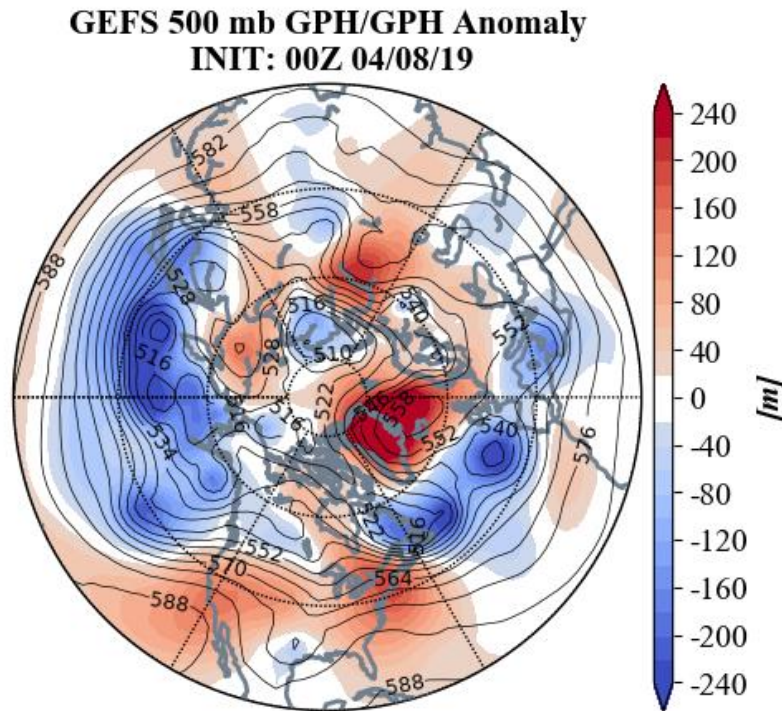


Figure 2. Observed 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) for 00Z 8 April 2019.

Ridging/positive geopotential height anomalies dominate the North American Arctic with troughing/negative geopotential height anomalies to the south across Southern Canada with more ridging across much of the US (**Figure 2**). This pattern is predicted to result in normal to above normal temperatures for Alaska, Northern Canada and much of the US with normal to below normal temperatures for Eastern Canada and New England (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 04/08/19 FCST: 04/09/19 to 04/13/19

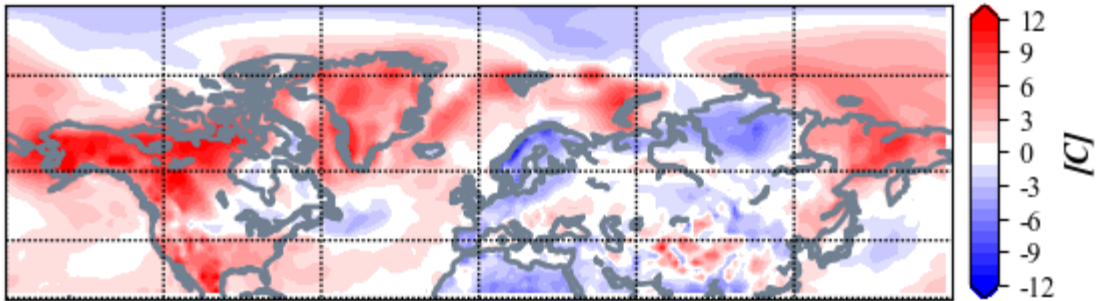


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 9 – 13 April 2019. The forecast is from the 00Z 8 April 2019 GFS ensemble.

With the steady decline of snow cover across the NH, snowmelt will be widespread with the exception of new snowfall in regions of deep troughs including Northern Siberia, Southern and Eastern Canada, the Northern US Rockies and the Northern Plains of the US (**Figure 4**).

GEFS 1-5 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 04/08/19 FCST: 04/09/19 to 04/13/19

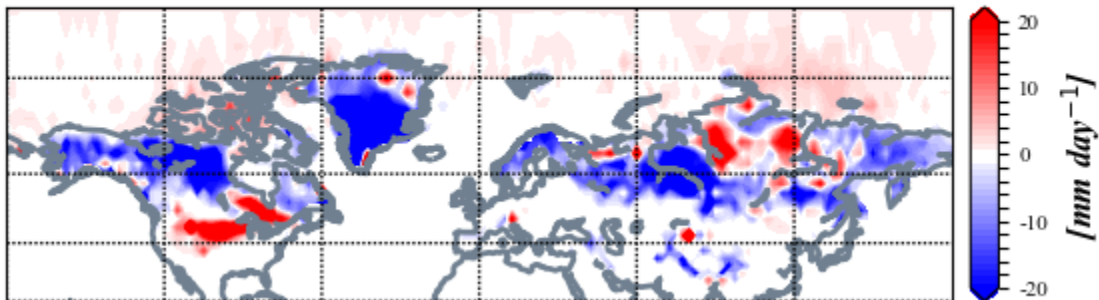


Figure 4. Forecasted snowfall anomalies (mm/day ; shading) from 9 – 13 April 2019. The forecast is from the 00Z 8 April 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to briefly transition from negative to positive next week (**Figure 1**) as negative geopotential height anomalies penetrate the Central Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5a**). And with

positive geopotential height anomalies across Greenland, the NAO will likely remain negative next week.

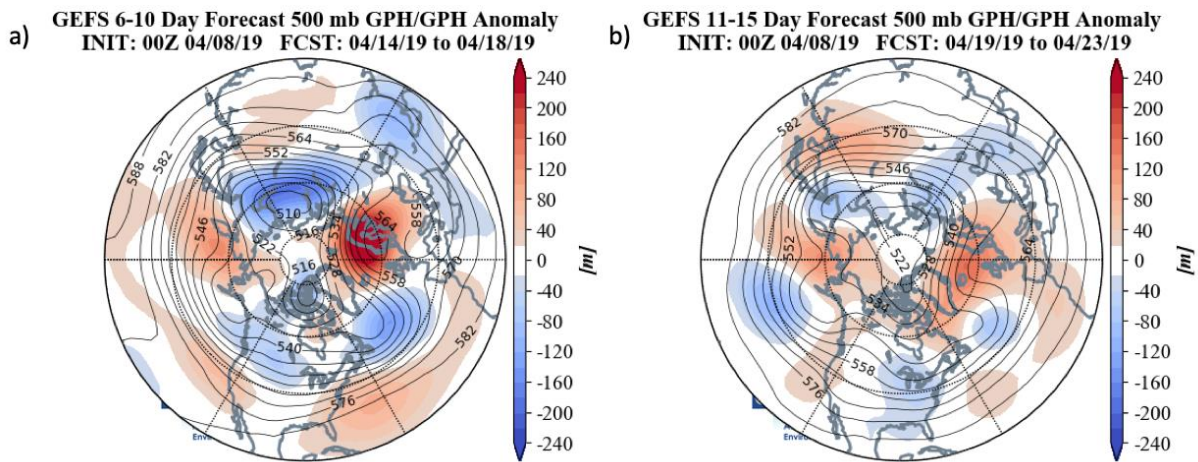


Figure 5. (a) Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 14 – 18 April 2019. (b) Same as (a) except averaged from 19 – 23 April 2019. The forecasts are from the 8 April 2019 00z GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to become more focused across Scandinavia with troughing/negative geopotential height anomalies across Southern Europe next week (**Figure 5a**). This pattern is predicted to result in widespread normal to below normal temperatures across Europe including the UK except for normal to above temperatures across Scandinavia (**Figure 6**). Scandinavian ridging/positive geopotential height anomalies will help to anchor troughing/negative geopotential height anomalies across Northern and Western Asia with more ridging across Central and East Asia (**Figure 5a**). This is predicted to yield widespread normal to above normal temperatures for most of Northern and Western Asia but especially Siberia with normal to above normal temperatures across the Middle East, Central and East Asia (**Figure 6**).

GEFS 6-10 Day Forecast T2m Anomaly
INIT: 00Z 04/08/19 FCST: 04/14/19 to 04/18/19

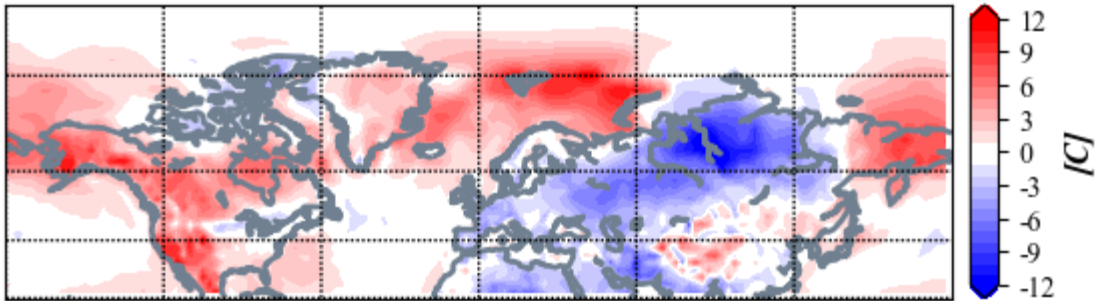


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 14 – 18 April 2019. The forecasts are from the 00Z 8 April 2019 GFS ensemble.

Trouching/negative geopotential height anomalies are predicted to be centered across Central Canada with ridging/positive geopotential height anomalies along the West and East Coasts of the US (**Figure 5a**). This pattern is predicted to bring normal to above normal temperatures across much of Alaska, Canada, the Western US and the Eastern US with normal to below normal temperatures for the Central US and parts of the Northeastern US (**Figure 6**).

GEFS 6-10 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 04/08/19 FCST: 04/14/19 to 04/18/19

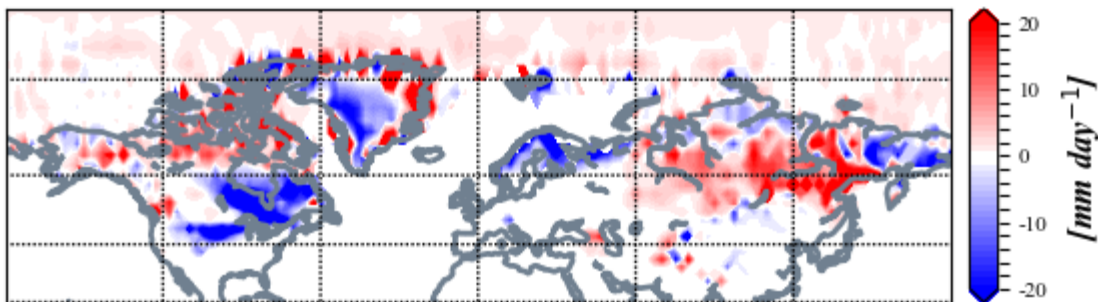


Figure 7. Forecasted snowfall anomalies (mm/day; shading) from 14 – 18 April 2019. The forecasts are from the 00Z 8 April 2019 GFS ensemble.

Widespread snowmelt is predicted to continue with new snowfall confined to Siberia, the Tibetan Plateau, Alaska and Northern Canada (**Figure 7**).

11-15 day

With mostly positive height anomalies predicted for the Arctic, especially the North American Arctic (**Figure 5b**), the AO is likely to remain negative this period (**Figure 1**). With predicted mostly positive pressure/geopotential height anomalies across Greenland, the NAO is likely to be neutral to negative this period (**Figure 1**).

Ridging/positive geopotential height anomalies previously confined to Northern Europe are predicted to expand across Central Europe this period with weak troughing/negative geopotential height anomalies confined to Southeastern Europe (**Figure 5b**). This pattern is predicted to result in normal to above normal temperatures for Northern and Central Europe including the UK with normal to below normal temperatures for Southeastern Europe (**Figure 8**). Little change is predicted for the circulation across Asia with Scandinavian ridging/positive geopotential height anomalies anchoring troughing/negative geopotential height anomalies across Northern and Western Asia with more ridging across Central and East Asia (**Figure 5b**). This pattern favors normal to above normal temperatures for Central and East Asia with normal to below normal temperatures for Northern and Western Asia including the Middle East (**Figure 8**).

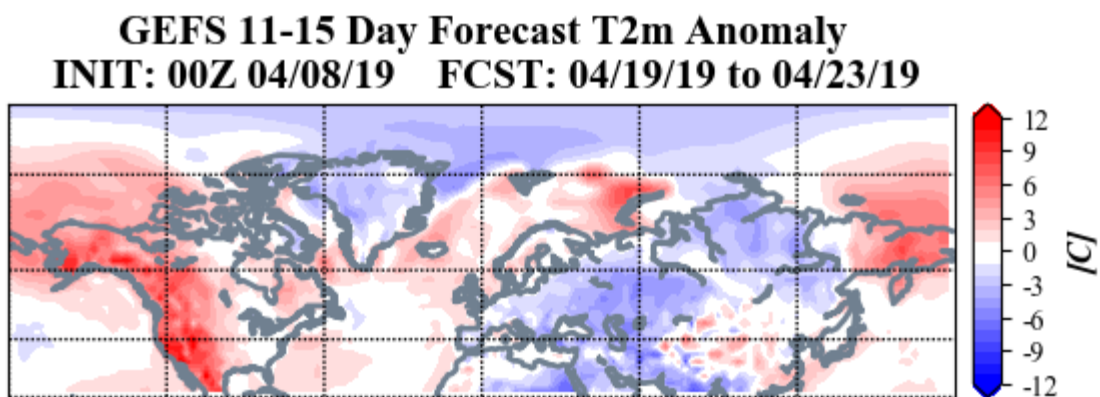


Figure 8. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 19 – 23 April 2019. The forecasts are from the 00Z 8 April 2019 GFS ensemble.

Ridging/negative geopotential height anomalies are predicted for northern and western North America with troughing/negative geopotential height anomalies in Southeastern Canada and the Eastern US (**Figure 5b**). This will favor normal to above normal temperatures across Alaska, Northern Canada and the Western US with normal to below normal temperatures for Southern and Eastern Canada and the Eastern US (**Figure 8**).

GEFS 11-15 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 04/08/19 FCST: 04/19/19 to 04/23/19

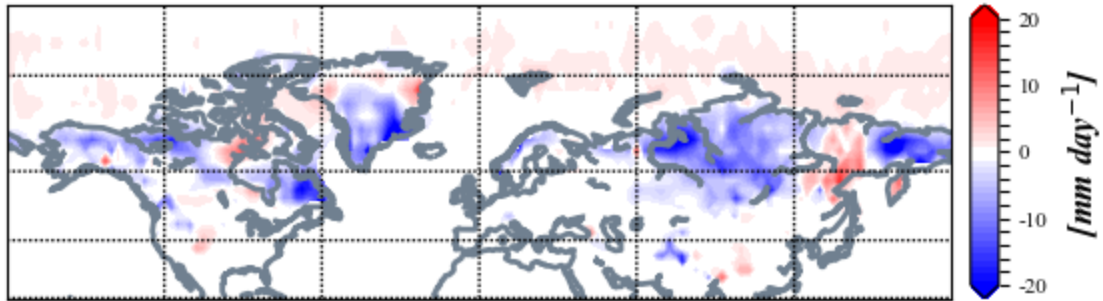


Figure 9. Forecasted snowfall anomalies (mm/day; shading) from 19 – 23 April 2019. The forecasts are from the 00Z 8 April 2019 GFS ensemble.

Once again widespread snowmelt is predicted to continue with potential new snowfall confined to parts of Siberia, the Tibetan Plateau the Central US and Eastern Canada (**Figure 9**).

Longer Term

30-day

The latest plot of the polar cap geopotential heights (PCHs) currently shows normal to below normal PCHs in the stratosphere and the upper troposphere with normal to above normal PCHS in the lower troposphere (**Figure 10**). The below normal PCHs in the stratosphere are consistent with a predicted positive stratospheric AO for the next two weeks (**Figure 1**) while the predicted above normal PCHs in the lower troposphere are consistent with a negative AO predicted for the next two weeks (**Figure 1**). The positive PCHs in the lower troposphere descended from the upper troposphere (**Figure 1**). The genesis of the positive PCHs might be related to a reflective pulse of vertical energy transfer back in late March.

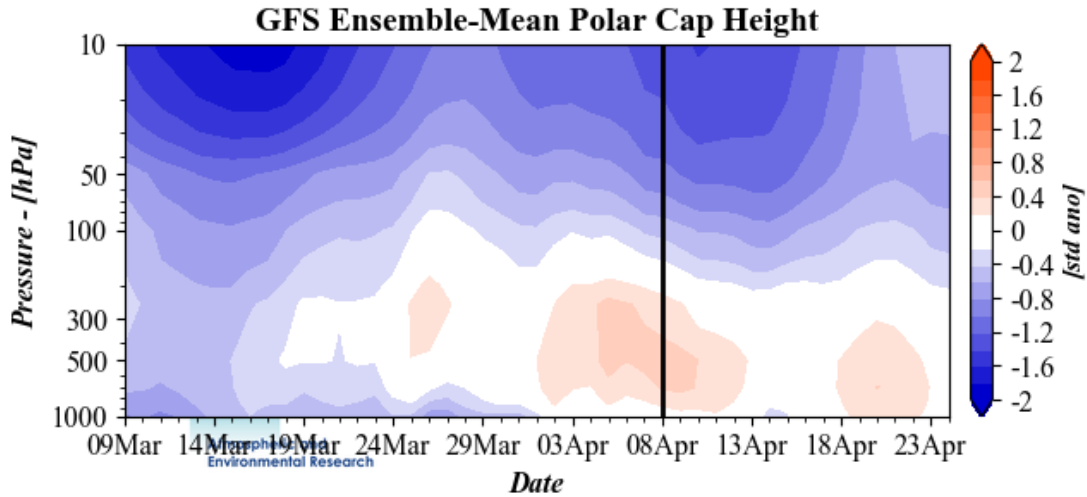


Figure 10. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 8 April 2019 GFS ensemble.

The negative PCHs throughout the stratosphere are a cumulative result of the lack of Wave Activity Flux (WAFz) or poleward heat transport since the sudden stratospheric warming (SSW) and a major mid-winter warming (MMW; where the zonal mean zonal wind reverses from westerly to easterly at 60°N and 10 hPa) back in early January. The negative PCHs in the stratosphere are likely to persist until at least next fall.

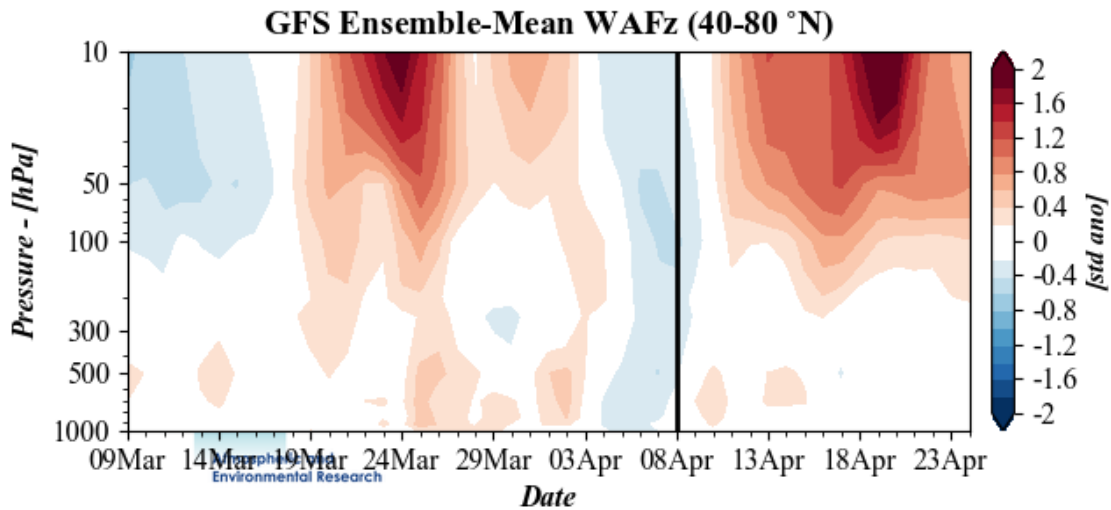


Figure 11. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 8 April 2019 GFS ensemble.

The plot of WAFz or poleward heat transport shows a new pulse of WAFz beginning this week and extending into next week (**Figure 11**). So, despite the near record strong westerly winds in the stratosphere and stratospheric PV, the winds are predicted to quickly decelerate, and a Final Warming is predicted to occur by mid-April.

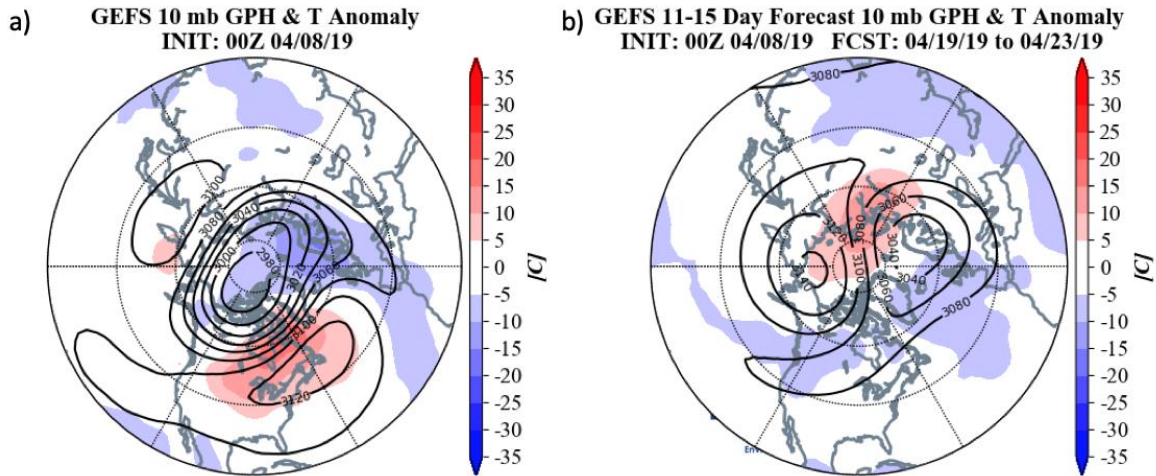


Figure 12. (a) Analyzed 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for 8 April 2019. **(b)** Same as **(a)** except forecasted averaged from 19 – 23 April 2019. The forecasts are from the 00Z 8 April 2019 GFS operational model.

The stratospheric PV is currently relatively strong and centered close to North Pole (**Figure 12**). The stratospheric PV is predicted to significantly weaken over the next two weeks while shifting towards Scandinavia due to the strong WAFz pulse and also the increasing solar radiation. Eventually the increasing solar radiation will lead to the collapse of the stratospheric PV known as the Final Warming.

CFS 500 hPa Forecast Anomaly May 2019
Valid as of 08 Apr 2019

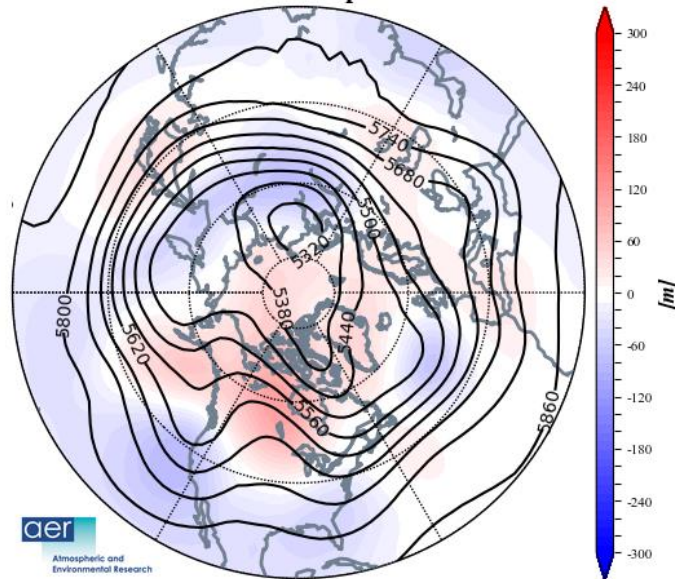


Figure 13. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for May 2019. The forecasts are from the 8 April 2019 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 13**) and the surface temperatures (**Figure 14**) forecast for May from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging centered across Northern Europe, East Asia, the Gulf of Alaska and Central Canada with troughs in the Eastern Mediterranean, Siberia, the Western US, Eastern Canada and the Eastern US (**Figure 13**). This pattern favors cold temperatures for Southern Europe, the Middle East, Siberia, Eastern Canada and the Eastern US with relatively mild temperatures for Northern Europe, Central Asia and western North America (**Figure 14**).

CFS T2m Forecast Anomaly May 2019
Valid as of 08 Apr 2019

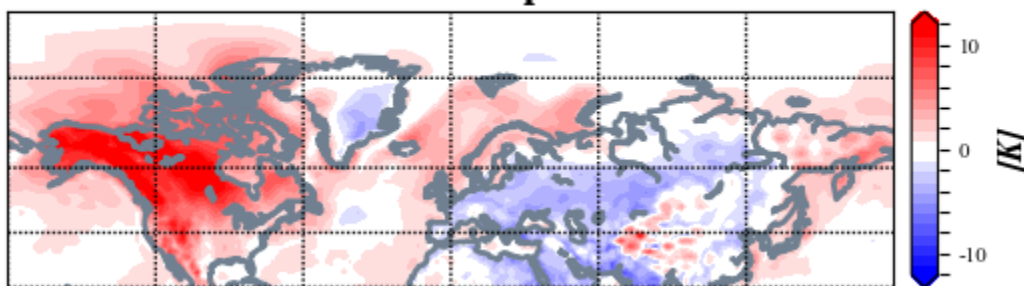


Figure 14. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for May 2019. The forecasts are from the 8 April 2019 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies remain warm and NOAA has declared the return of El Niño conditions (**Figure 13**). Observed SSTs across the NH remain well above normal though below normal SSTs exist regionally. Cold SSTs south of Iceland and in the subtropics of the North Atlantic with above normal SSTs in the mid-latitudes are thought to favor a positive NAO.

SST Anomaly - Week Ending 06 Apr 2019

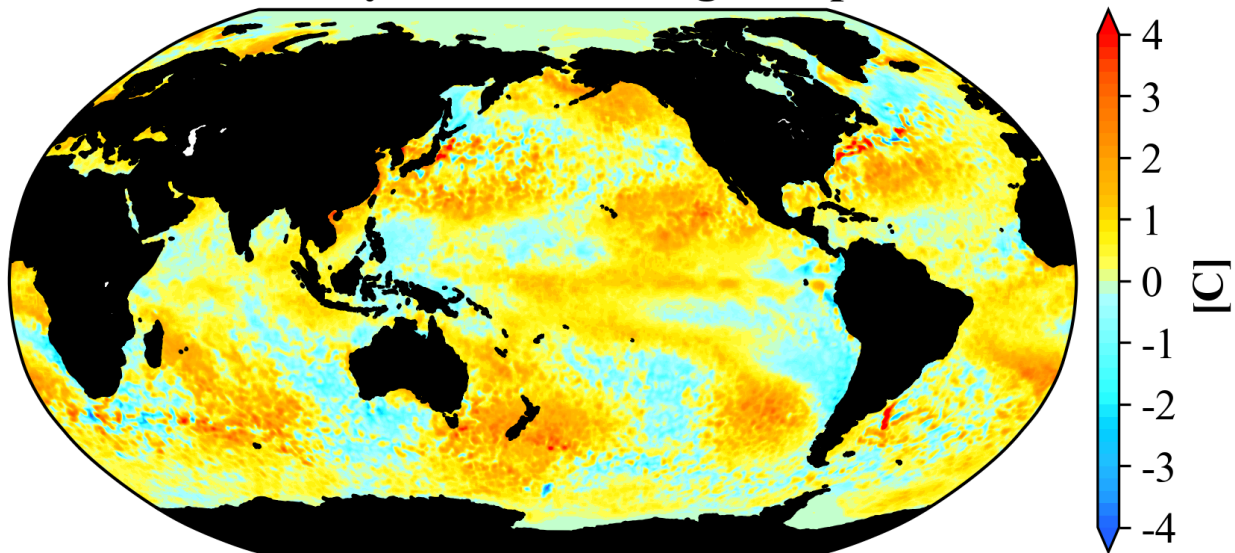


Figure 16. The latest weekly-mean global SST anomalies (ending 6 April 2019). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 14**). And the forecasts are for no phase of the MJO to be favored over the much of the next two weeks. Little influence on North American weather is expected from the MJO in the near term.

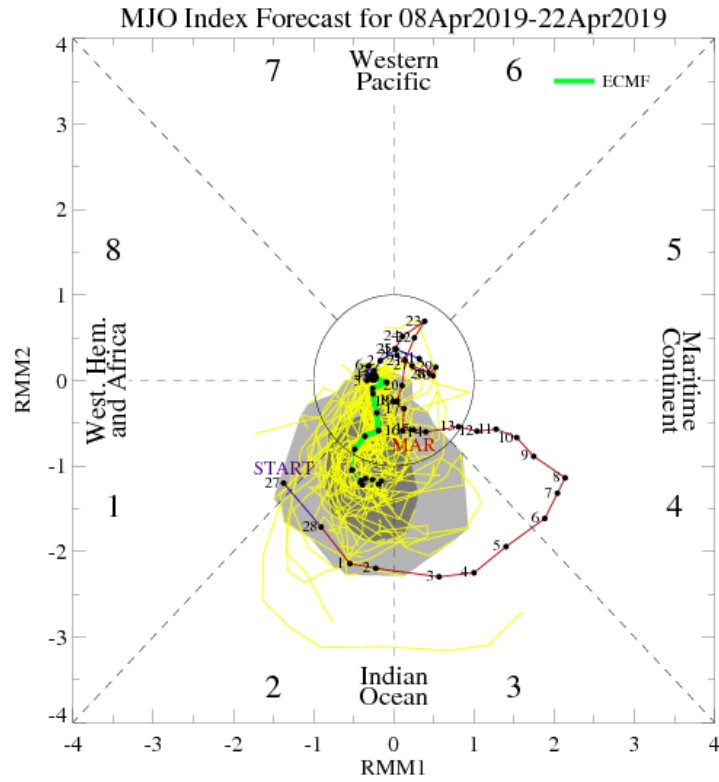


Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 8 April 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>