

March 11, 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 transition to a fall/winter schedule, postings are once every week. Precipitation forecasts will be replaced by snow accumulation forecasts along with more 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 over the next two weeks but trend towards neutral mid- to late-month.
- The current positive AO is reflective of mostly negative pressure/geopotential height anomalies across the Arctic and positive pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is positive as currently weakly negative pressure/geopotential height anomalies are spread across Greenland and mostly positive pressure/geopotential height anomalies across the mid-latitudes of the North Atlantic and is predicted to remain positive over the next two weeks.
- Ridging/positive geopotential height anomalies with normal to above normal temperatures dominate Southern Europe while troughing/negative geopotential height anomalies with normal to below normal temperatures dominate Northern Europe including the United Kingdom (UK). However, over the next two weeks ridging will expand northward across Europe allowing mild temperatures to spread across much of Europe.
- In general, ridging/positive geopotential height anomalies with normal to above normal temperatures dominate much of Asia with troughing/negative geopotential height anomalies with normal to below normal temperatures

confined to Eastern Siberia, Northeast Asia, Northwestern India and Pakistan. Over the next two weeks the troughing with relatively cold temperatures are predicted to become more widespread across Siberia while ridging with relatively mild become widespread across the remainder of Asia.

- This week ridging/positive geopotential height anomalies with relatively mild temperatures are predicted to be centered across eastern North America with troughing/negative geopotential height anomalies and relatively cold temperatures across southwestern Canada and the Western United States (US). However next week the pattern is predicted to reverse with ridging/positive geopotential height anomalies and relatively mild temperatures across western North America and troughing/negative geopotential height anomalies and relatively cold temperatures in eastern North America.
- In the *Impacts* section, I discuss the implications of a new, relatively minor polar vortex (PV) disruption predicted for next week.
- I will be transitioning to the spring and summer schedule of posting a new blog every two weeks possibly as early as next week. Starting with this blog I will stop updating the ice and snow in the *Surface Boundary Conditions* section.

Impacts

Though the stratospheric PV split back in early January has dominated the PV behavior this winter, there have been other more minor PV disruptions back in November and early December. Those minor PV disruptions are referred to as “reflective’ disruptions as the vertical energy transfer from the troposphere to the stratosphere rather than being absorbed in the polar stratosphere, which is typical leading up to a major mid-winter warming (MMW; where the zonal mean zonal wind reverses from westerly to easterly at 60°N and 10 hPa), the energy is reflected back down into the troposphere. These events are characterized by warming and ridging/positive geopotential height anomalies centered near Alaska with an elongation of the stratospheric PV into eastern North America. Similar behavior is predicted for the stratospheric PV for next week (see **Figure i**). This is quickly followed by ridging in Alaska and downstream troughing across central and eastern North America in the troposphere. With these events the cold temperature anomalies are centered in central and eastern North America. More details on these events are provided in [Kretschmer et al. 2018](#).

Initialized 00Z 10 hPa HGT/HGTa 11-Mar-2019

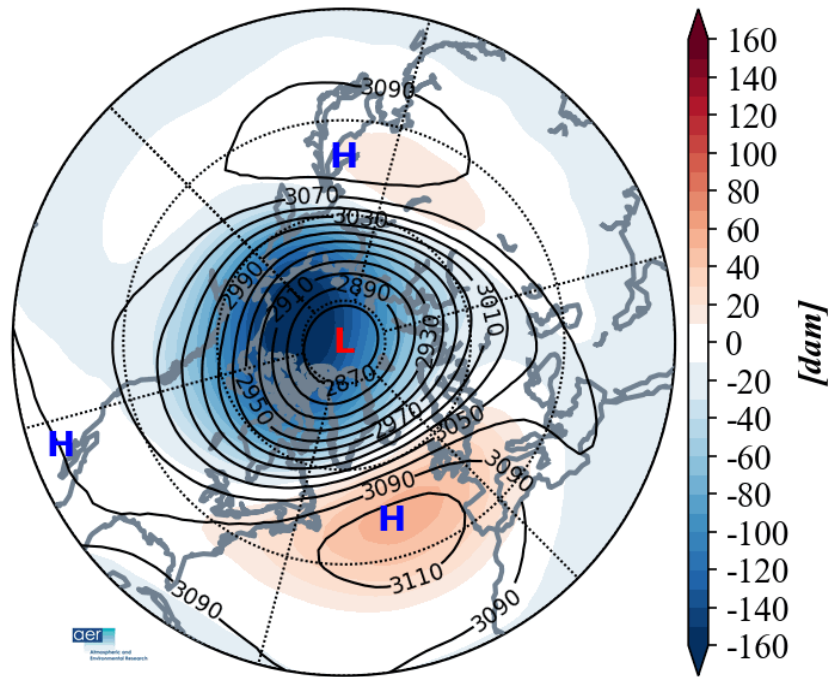


Figure i. Animation of predicted 10 mb geopotential heights (dam; contours) and temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for 11-27 March 2019.

It is my impression that these events are more common in the early part of the winter and, possibly like this winter, act as precursors to large PV disruptions. But we do seem to have another possible example of these reflective PV disruptions here in mid-March. The impact from these PV disruptions is focused across North America with warming across Alaska and cold temperatures across central and eastern Canada and the US. Weaker anomalies exist across Eurasia with relatively mild temperatures for Europe and cold temperatures in Siberia (see **Figure ii**). This broad temperature anomaly pattern across the Northern Hemisphere (NH) is predicted for next week (see below **Figure 6**).

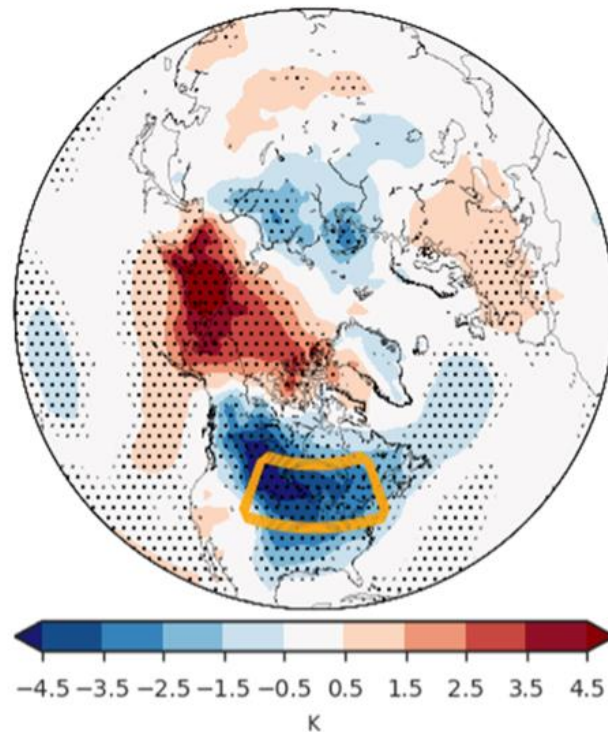


Figure ii. Composites of near-surface temperature anomalies for adays when a relective PV disruptions occurs. Significant values ($\alpha=0.05$) are indicated with dots.

In my previous blogs I did discuss the possibility that the cold start to March in the Eastern US was also related one of these reflective PV disruptions but was unsure given the still ongoing influence from the major PV disruption from early January. However, the influence from the PV split seems to have ended and if there is a stratospheric connection to the cold in eastern North America for next week it is more likely related to this recent minor PV disruption rather than the earlier major PV disruption.

The impact on temperatures from the reflective PV disruptions are much shorter than from absorbing PV disruptions and are only on the order of days to maybe as long as two weeks. Therefore, the cold in eastern North America could be limited to just next week and the models are predicting a trend to milder temperatures by the end of the week and over the following weekend. However, if the cold temperatures in eastern North America are related to the minor stratospheric PV, then I can see the relatively cold temperatures lingering in the Eastern US even beyond next weekend based on the predicted configuration of the PV. As far as Europe, the reflective PV disruptions do not favor cold temperatures. Also, with a positive AO and negative/cold polar-cap geopotential height anomalies (PCHs) predicted into the foreseeable future, it is hard for me to envision any consistently cold temperatures through at least the end of March across Europe.

Near Term Conditions

1-5 day

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

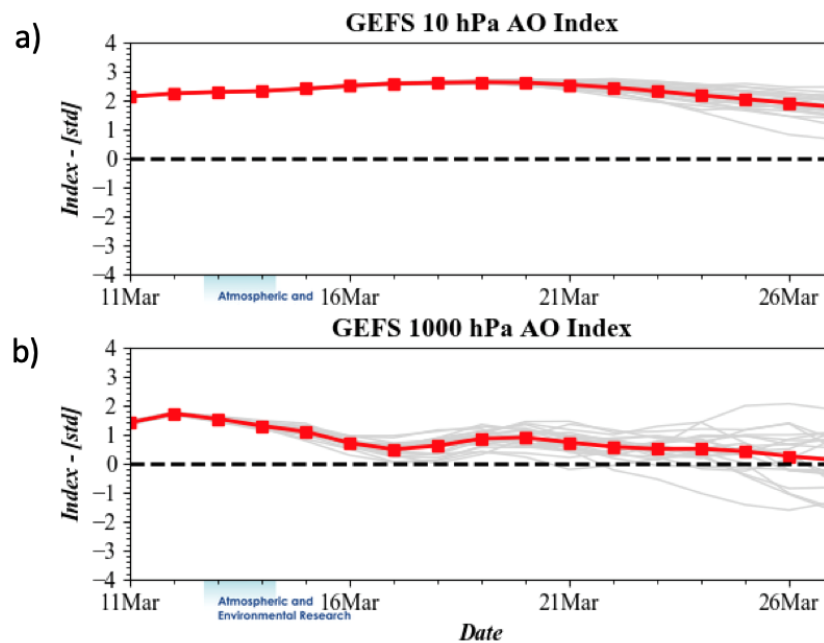


Figure 1. (a) The predicted daily-mean AO at 10 hPa from the 00Z 11 March 2019 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 11 March 2019 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies spread across Southern Europe with troughing/negative geopotential height anomalies spread across Northern Europe (**Figure 2**) are yielding mostly normal to above normal temperatures for Southern Europe with normal to below normal temperatures across Northern Europe including the UK (**Figure 3**). Ridging/positive geopotential height anomalies centered over Central Asia with troughing/negative geopotential height anomalies confined to Eastern Siberia, Northeast Asia, northwestern India and Pakistan (**Figure 2**). This pattern is predicted to yield widespread normal to above normal temperature for Asia with normal to below normal temperatures confined to Eastern Siberia, Japan, Northwest India and into Pakistan (**Figure 3**).

GEFS 500 mb GPH/GPH Anomaly
INIT: 00Z 03/11/19

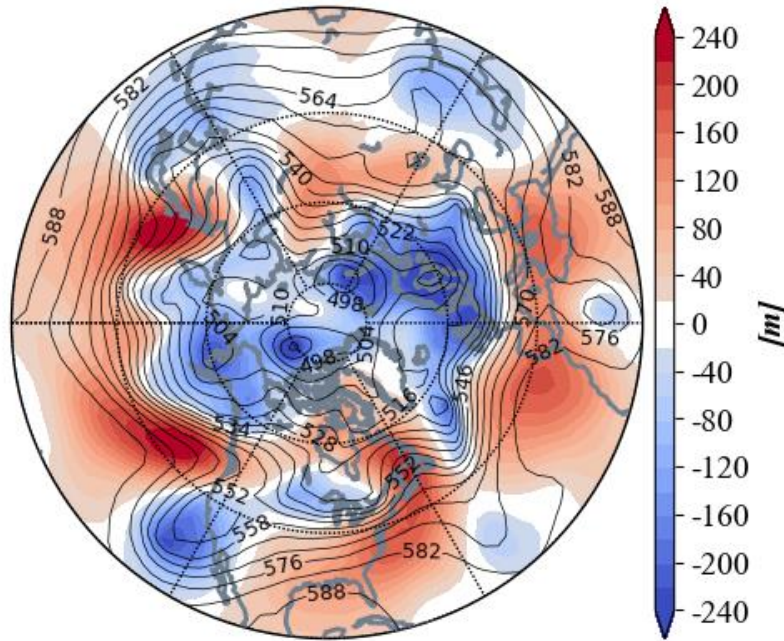


Figure 2. Observed 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) for 00Z 11 March 2019.

Ridging/positive geopotential height anomalies dominate eastern North with troughing/negative geopotential height anomalies in western North America but especially the Western US (**Figure 2**). This pattern is predicted to result in normal to above normal temperatures for Alaska, Eastern Canada and the Eastern US with normal to below normal temperatures for Southwest Canada and the Western US (**Figure 3**).

GEFS 1-5 Day Forecast T2m Anomaly
INIT: 00Z 03/11/19 FCST: 03/12/19 to 03/16/19

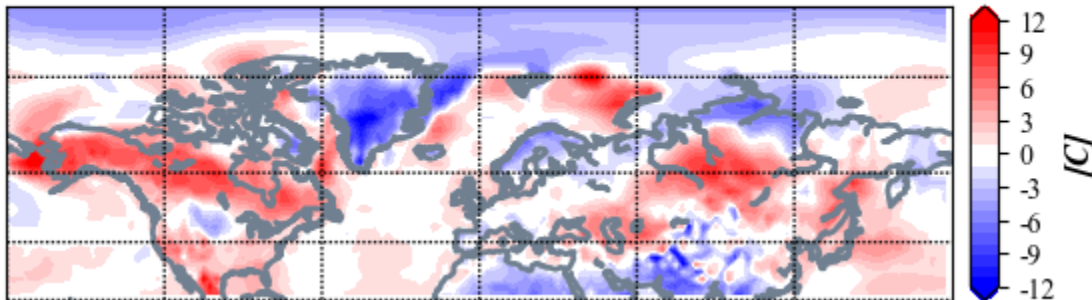


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 12 – 16 March 2019. The forecast is from the 00Z 11 March 2019 GFS ensemble.

With the steady decline of snow cover across the NH, snowmelt will be widespread with the exception of new snowfall in parts of Scandinavia, the Alps, Siberia, the Tibetan Plateau, Alaska, Northern Canada and the Northern Plains of the US (**Figure 4**).

GEFS 1-5 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 03/11/19 FCST: 03/12/19 to 03/16/19

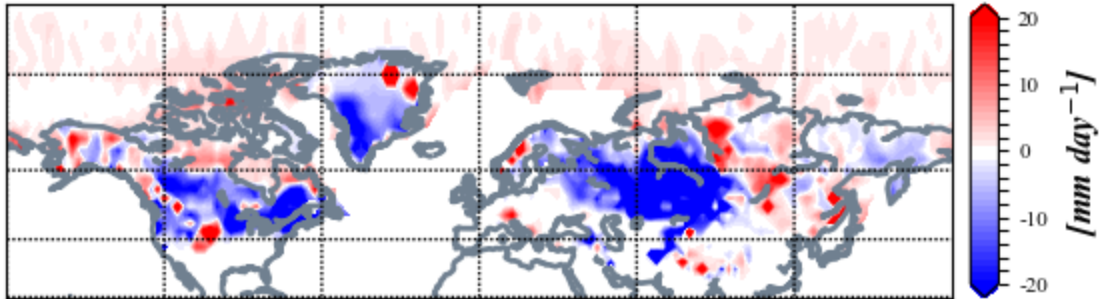


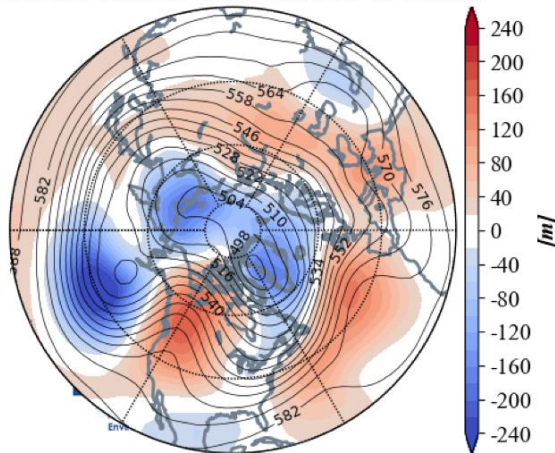
Figure 4. Forecasted snowfall anomalies (mm/day; shading) from 12 – 16 March 2019. The forecast is from the 00Z 11 March 2019 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to remain positive next week (**Figure 1**) with mostly negative geopotential height anomalies across the Arctic and positive geopotential height anomalies across the mid-latitudes of the NH (**Figure 5a**). And with negative geopotential height anomalies across Greenland, the NAO will likely be positive next week as well.

a) GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 03/11/19 FCST: 03/17/19 to 03/21/19



b) GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 03/11/19 FCST: 03/22/19 to 03/26/19

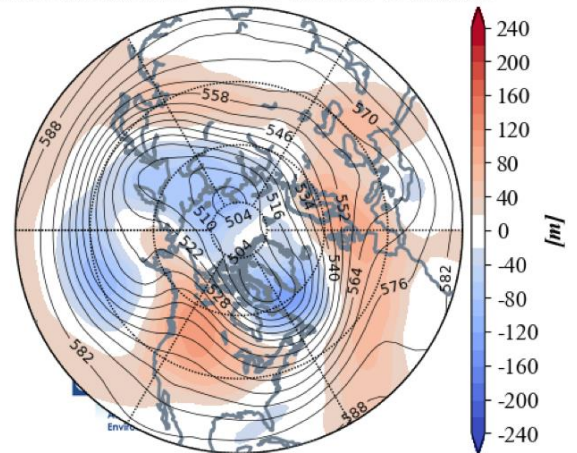


Figure 5. (a) Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 March 2019. (b) Same as (a) except averaged from 22 – 26 March 2019. The forecasts are from the 11 March 2019 00z GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to become more widespread across Europe this period with troughing/negative geopotential height anomalies confined to Scandinavia and Western Europe (**Figure 5a**). This pattern is predicted to result in normal to above normal temperatures widespread across Southern and Central Europe with normal to below normal temperatures for western Scandinavia and Western Europe including the UK (**Figure 6**). The overall pattern across Asia is predicted to persist with ridging/positive geopotential height anomalies in Central and East Asia with troughing/negative geopotential height anomalies across Northern Asia, including most of Siberia, and Southwestern Asia (**Figure 5a**). This is predicted to yield normal to below normal temperatures for most of Siberia and normal to above normal temperatures for Central and East Asia (**Figure 6**). Residual troughing/negative geopotential height anomalies from the Middle East and across to Northern India (**Figure 5a**) are predicted to yield normal to below normal temperatures for parts of the Middle East, Northern India and Pakistan (**Figure 6**).

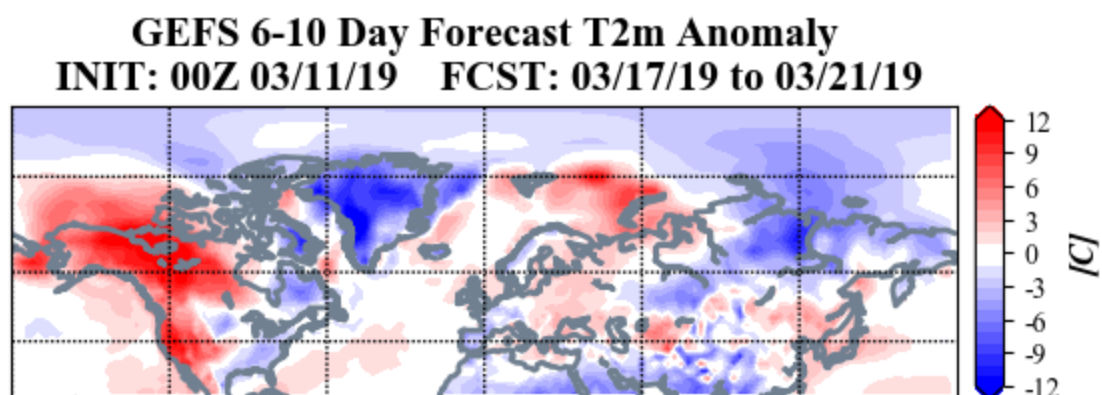


Figure 6. Forecasted surface temperature anomalies (°C; shading) from 17 – 21 March 2019. The forecasts are from the 00Z 11 March 2019 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to return to western North America with troughing/negative geopotential height anomalies in Eastern Canada and the Eastern US (**Figure 5a**). This pattern is predicted to bring normal to above normal temperatures across much of Alaska, Western Canada and the Western US with normal to below normal temperatures for Eastern Canada and the Central and Eastern US (**Figure 6**). It does seem to me the pattern reversal predicted across North America is related to a minor PV disruption as discussed in the *Impacts* section.

GEFS 6-10 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 03/11/19 FCST: 03/17/19 to 03/21/19

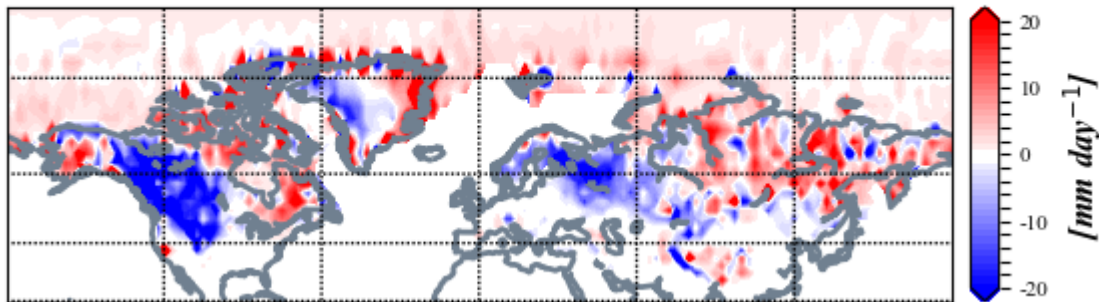


Figure 7. Forecasted snowfall anomalies (mm/day; shading) from 17 – 21 March 2019. The forecasts are from the 00Z 11 March 2019 GFS ensemble.

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

11-15 day

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

Ridging/positive geopotential height anomalies are predicted to continue their expansion across Europe this period with weak troughing/negative geopotential height anomalies confined across parts of Southern Europe (**Figure 5b**). Therefore, normal to above normal temperatures are predicted for much of Europe including the UK with normal to below normal temperatures confined to Southwestern Europe (**Figure 8**). Troughing/negative geopotential height anomalies across Northern Asia are predicted to become more widespread covering much of Siberia with ridging/positive geopotential height anomalies predicted for Central and East Asia (**Figure 5b**). This pattern favors normal to below normal temperatures for much of Siberia with normal to above normal temperatures for Central and East Asia (**Figure 8**). Residual troughing/negative geopotential height anomalies across Northern India (**Figure 5a**) are predicted to yield normal to below normal temperatures for Northern India and Pakistan (**Figure 6**).

GEFS 11-15 Day Forecast T2m Anomaly
INIT: 00Z 03/11/19 FCST: 03/22/19 to 03/26/19

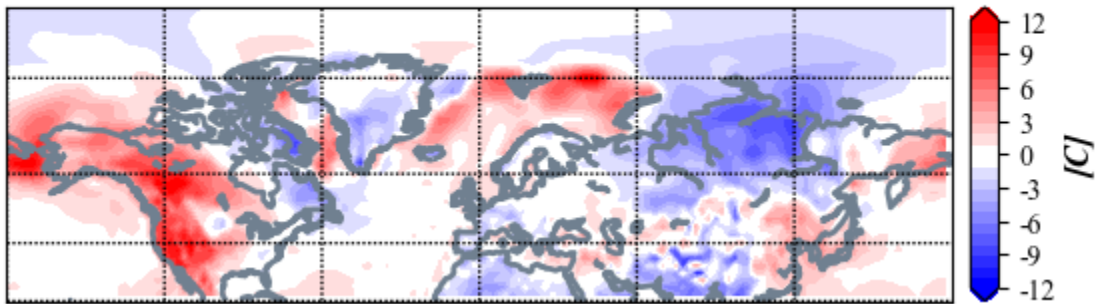


Figure 8. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 22 – 26 March 2019. The forecasts are from the 00Z 11 March 2019 GFS ensemble.

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

GEFS 11-15 Day Forecast Mean 24-hour Snow Depth Change
INIT: 00Z 03/11/19 FCST: 03/22/19 to 03/26/19

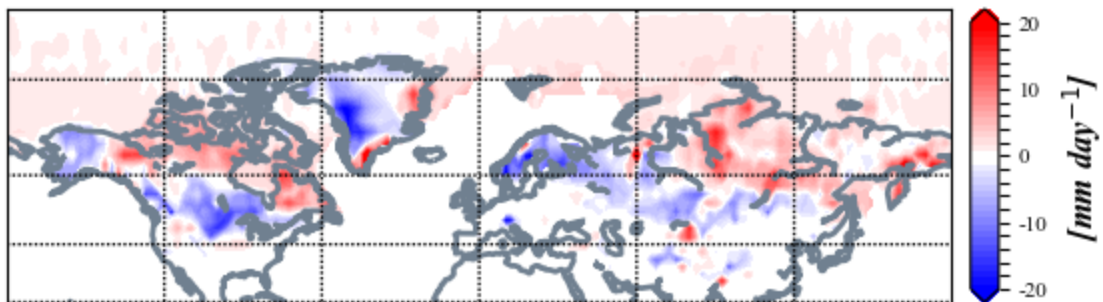


Figure 9. Forecasted snowfall anomalies (mm/day ; shading) from 22 – 26 March 2019. The forecasts are from the 00Z 11 March 2019 GFS ensemble.

Once again widespread snowmelt is predicted to continue with new snowfall confined to parts of Siberia and Northern 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 both the stratosphere and the troposphere (**Figure 10**). The below normal PCHs in the mid stratosphere are consistent with a predicted positive stratospheric AO for the next two weeks (**Figure 1**) while the predicted below normal PCHs in the lower troposphere are consistent with a positive AO also predicted for the next two weeks (**Figure 1**).

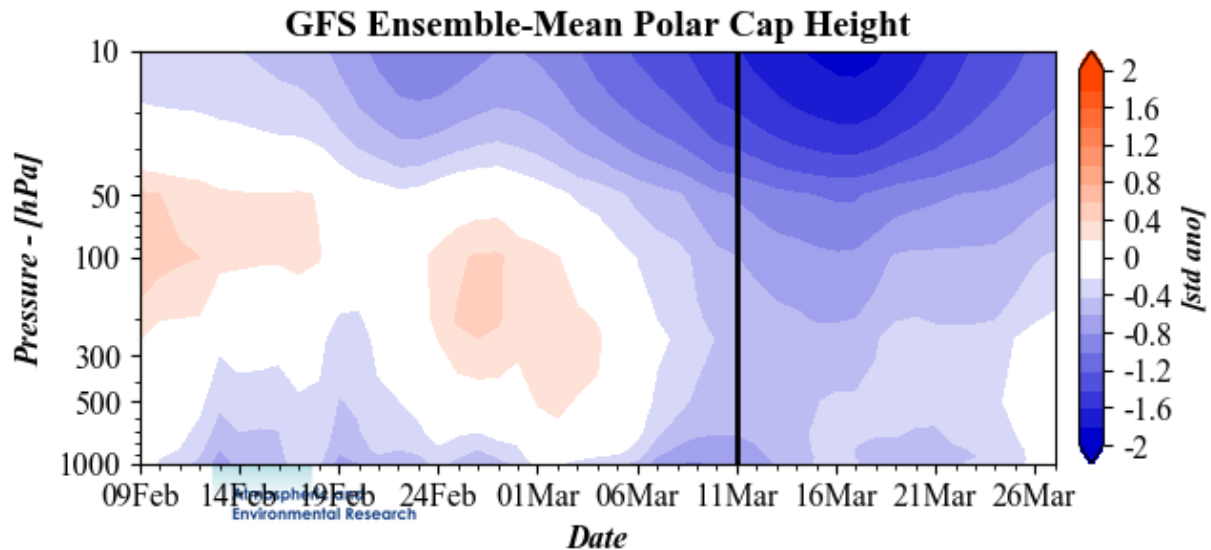


Figure 10. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecasts are from the 00Z 11 March 2019 GFS ensemble.

The negative PCHs throughout the stratosphere and troposphere suggest that any influence from 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 has ended.

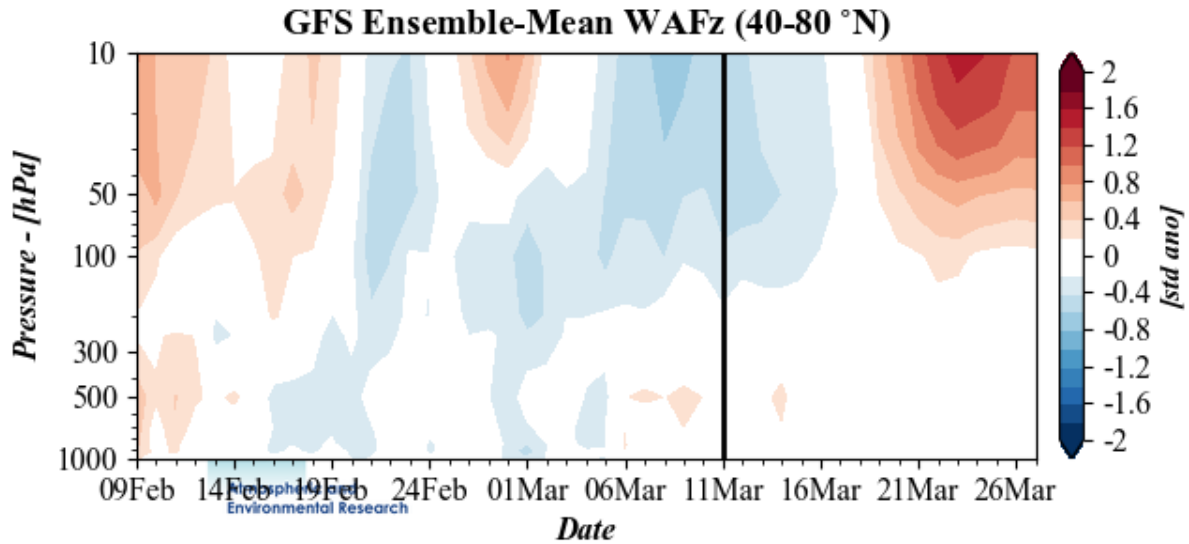


Figure 11. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 11 March 2019 GFS ensemble.

The plot of Wave Activity Flux (WAFz) or poleward heat transport shows mostly below normal WAFz for this week but a new robust pulse for next week (**Figure 11**). The negative WAFz this week is predicted to further cool the stratospheric PCHs that couples to the troposphere this week. Negative PCHs in the troposphere and the positive AO favor relatively mild temperatures across the mid-latitudes.

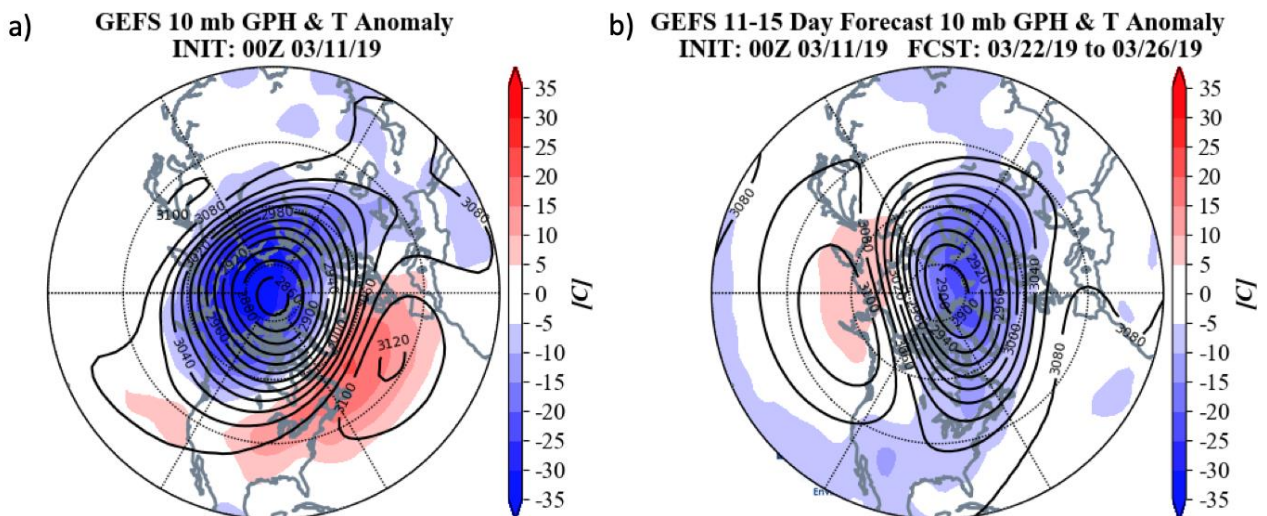


Figure 12. (a) Analyzed 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 11 March 2019. (b) Same

as (a) except forecasted averaged from 22 – 26 March 2019. The forecasts are from the 00Z 11 March 2019 GFS operational model.

The stratospheric PV is currently centered close to the North Pole and is predicted to remain there over the next two weeks (**Figure 12**). However, the WAFz pulse for next week is predicted to cause warming with high pressure near Alaska and an elongation in the stratospheric PV along an axis from Siberia through Eastern Canada and into the Northeastern US. The coldest temperatures in the stratosphere are focused along this axis and starting next week temperatures in the troposphere are also predicted to lie along this same axis.

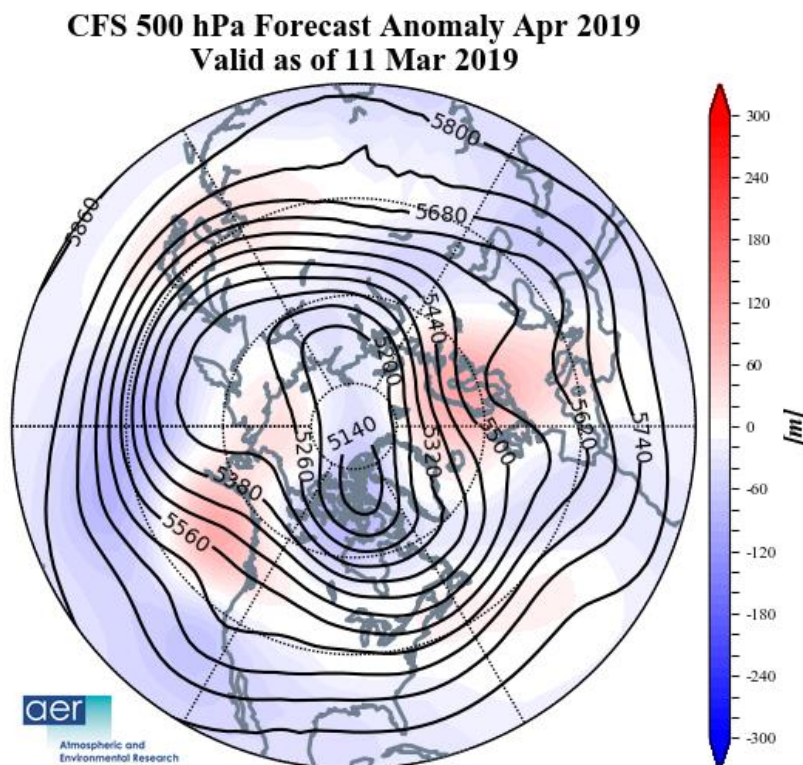


Figure 13. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for April 2019. The forecasts are from the 11 March 2019 CFS.

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

relatively mild temperatures for much of Europe, East Asia and western North America (Figure 14).

CFS T2m Forecast Anomaly Apr 2019 Valid as of 11 Mar 2019

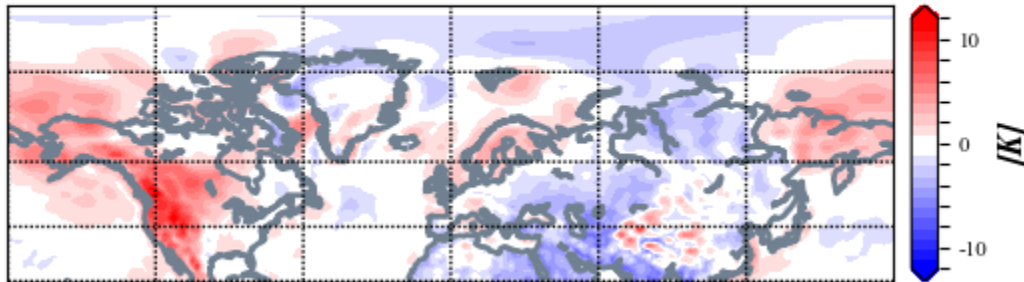


Figure 14. Forecasted average surface temperature anomalies ($^{\circ}\text{C}$; shading) across the Northern Hemisphere for April 2019. The forecasts are from the 11 March 2019 CFS.

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 10 Mar 2019

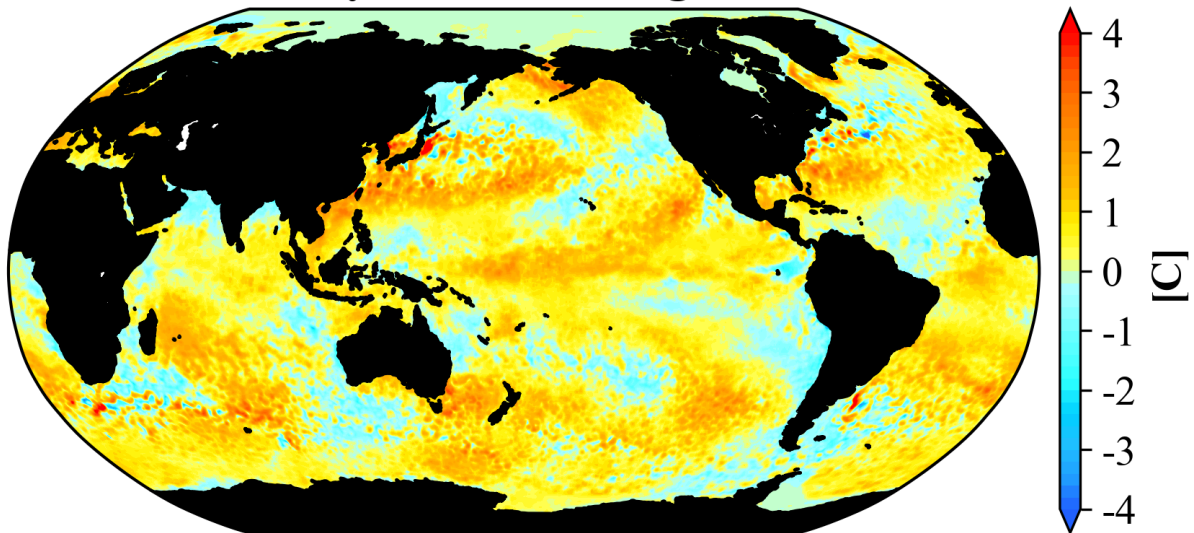


Figure 16. The latest weekly-mean global SST anomalies (ending 10 March 2019). Data from NOAA OI High-Resolution dataset.

Currently phase four of the Madden Julian Oscillation (MJO) is favored (**Figure 14**). However the MJO is expected to transition quickly to where no phase is favored. Little influence on North American weather is expected from the MJO in the near term.

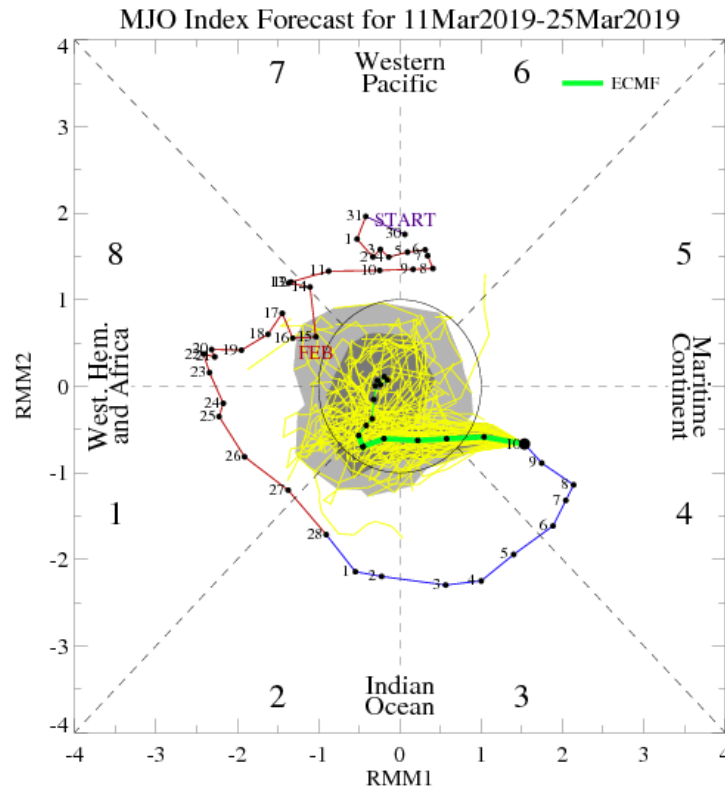


Figure 17. Past and forecast values of the MJO index. Forecast values from the 00Z 4 March 2019 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>