

# Arctic Oscillation and Polar Vortex Analysis and Forecasts

March 16, 2020

*Special blog on winter 2018/2019 retrospective can be found here*  
- <http://www.aer.com/winter2019>

*Special blog on winter 2017/2018 retrospective can be found here*  
- <http://www.aer.com/winter2018>

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

*Special blog on winter 2015/2016 retrospective can be found here*  
- <http://www.aer.com/winter2016>

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) 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.

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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 the next ten days but then return to neutral.
- The current positive AO is reflective of negative pressure/geopotential height anomalies in the Arctic with mostly positive pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is also positive with negative pressure/geopotential height anomalies spread across Greenland and Iceland; and the NAO is predicted to remain positive over the next

ten days before returning to neutral as height anomalies are predicted to finally turn positive across Greenland the last days of March.

- The general circulation pattern over Europe this week is troughing/negative geopotential height anomalies across Northern Europe with ridging/positive geopotential height anomalies across Southern Europe and widespread above normal temperatures. Starting next week, ridging/positive geopotential height anomalies will become focused across Northern Europe with troughing/negative geopotential height anomalies across Southern Europe. This pattern favors normal to above normal temperatures for Northern Europe with normal to below normal temperatures in Central and Southern Europe including the United Kingdom (UK) next week.
- The predicted general pattern for Asia is ridging/positive geopotential height anomalies in much of Asia with troughing/negative pressure/geopotential height anomalies limited to Northern Asia. Next week troughing/negative pressure/geopotential height anomalies will become more widespread across Asia. This pattern favors normal to above normal temperatures across much of Asia except for normal to below normal temperatures in northernmost Asia this week. Next week normal to below normal temperatures will become more widespread with normal to below normal temperatures becoming more regionalized to southern and eastern Asia.
- The predicted pattern for North America is ridging/positive geopotential height anomalies in the Gulf of Alaska and Alaska with normal to above normal temperatures, which will force troughing/negative geopotential height anomalies with normal to below normal temperatures in western North America and Eastern Canada with more ridging/positive geopotential height anomalies with normal above normal temperatures in the Eastern US. However, starting next week, the colder temperatures are predicted to filter into the Eastern US.
- In the Impacts section I discuss the Northern Hemisphere (NH) pattern change.

### ***Impacts***

My apologies for a delayed and shortened blog post but like so many people across the globe, adjusting to the new reality with the spreading coronavirus has been disruptive to my daily routine. I will be transitioning to the spring and summer schedule of bi-weekly updates soon.

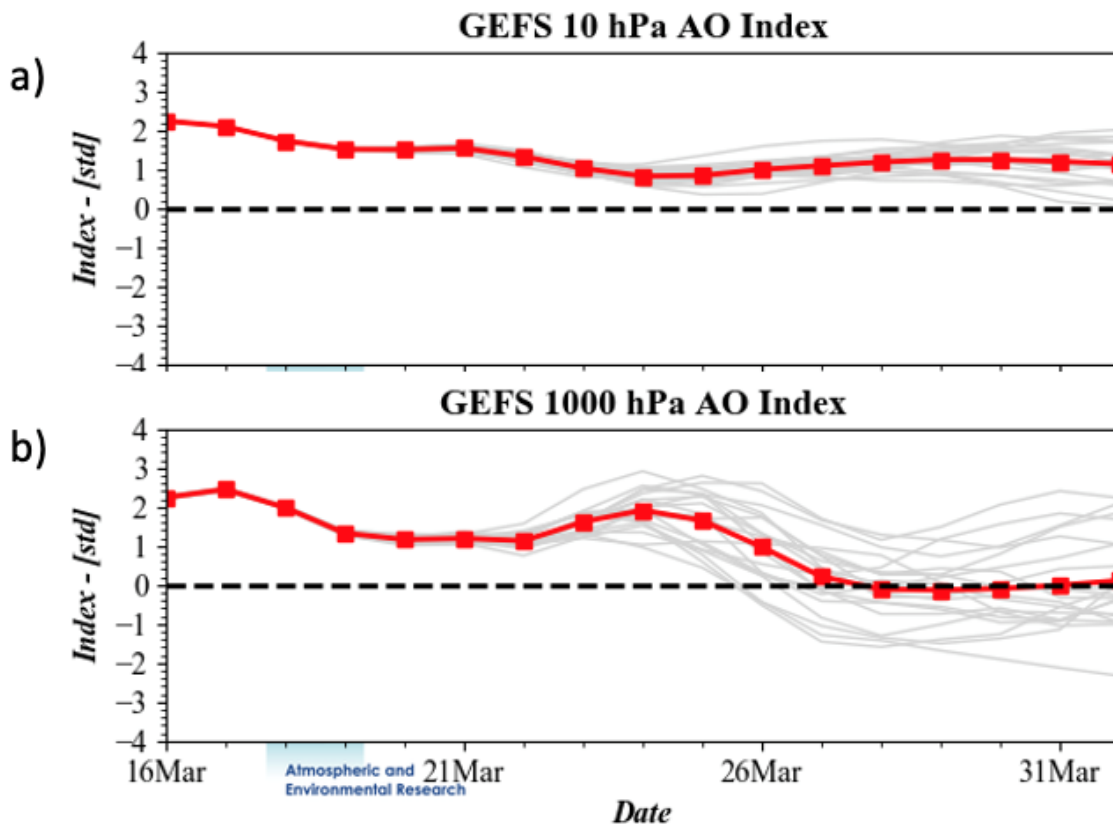
Signs that the dominant weather pattern of the winter with strong low pressure in the Barents-Kara Seas and northwestern Eurasia and a strong stratospheric polar vortex (PV) continue this week. The most important change is the predicted building of high pressure across Northern Europe and Alaska next week (see **Figures 5**). Ridging/high pressure across Northern Europe is helping to force downstream troughing/low pressure in Northern Asia and even Southern Europe (**Figure 5**). This will allow for below normal temperatures across large parts of Asia and Europe that experienced record breaking warm temperatures for much of the winter. Building of

pressures/heights across Northwest Eurasia area also helping to weaken the stratospheric PV and by the end of the month above normal temperatures are predicted in the polar stratosphere, something not seen since December. Persistent predicted ridging/high pressure across Alaska is forcing downstream troughing across Canada. This will help develop a reservoir of below normal temperatures across Canada that is likely to overspread the US at the end of March and into April. Also, if the stratospheric PV continues to weaken not only radiatively but dynamically, this will further support below normal temperatures across northern Eurasia and/or eastern North America.

It remains an interesting and open question why high pressure/ridging across Northern Europe bookended the winter months but never during the winter itself.

1-5 day

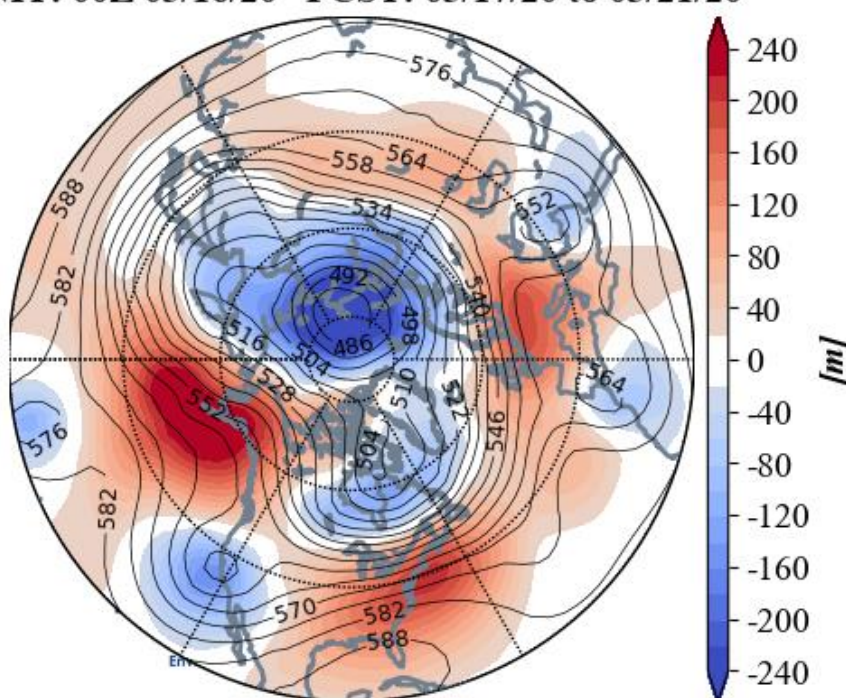
The AO is currently positive (**Figure 1**) with negative geopotential height anomalies across the Arctic and mostly positive geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with mostly negative geopotential height anomalies across Greenland and Iceland (**Figure 2**), the NAO is positive as well.



**Figure 1.** (a) The predicted daily-mean AO at 10 hPa from the 00Z 16 March 2020 GFS ensemble. (b) The predicted daily-mean near-surface AO from the 00Z 16 March 2020 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.

This week ridging/positive geopotential height anomalies with normal to above normal temperatures will dominate Europe including the UK with the exception of Scandinavia where troughing/negative geopotential height anomalies will bring normal to below normal temperatures (**Figures 2 and 3**). Similarly, across Asia, ridging/positive geopotential height anomalies are predicted to dominate much of Asia with troughing/negative geopotential height anomalies confined to the North Slope and the northern Indian subcontinent (**Figure 2**). This pattern favors normal to above normal temperatures across most of Asia with normal to below normal temperatures confined to Northern Siberia and the Tibetan Plateau (**Figure 3**).

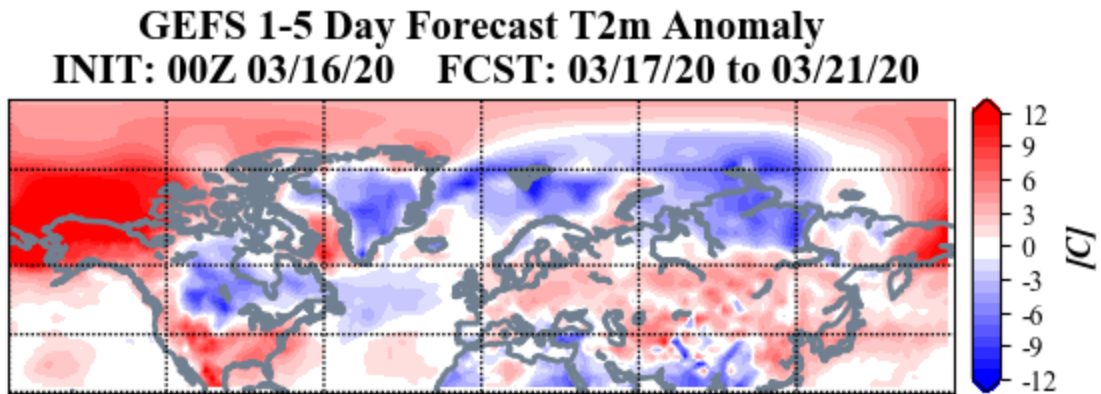
**GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 03/16/20 FCST: 03/17/20 to 03/21/20**



**Figure 2.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 17 – 21 March 2020. The forecasts are from the 00z 16 March 2020 GFS ensemble.

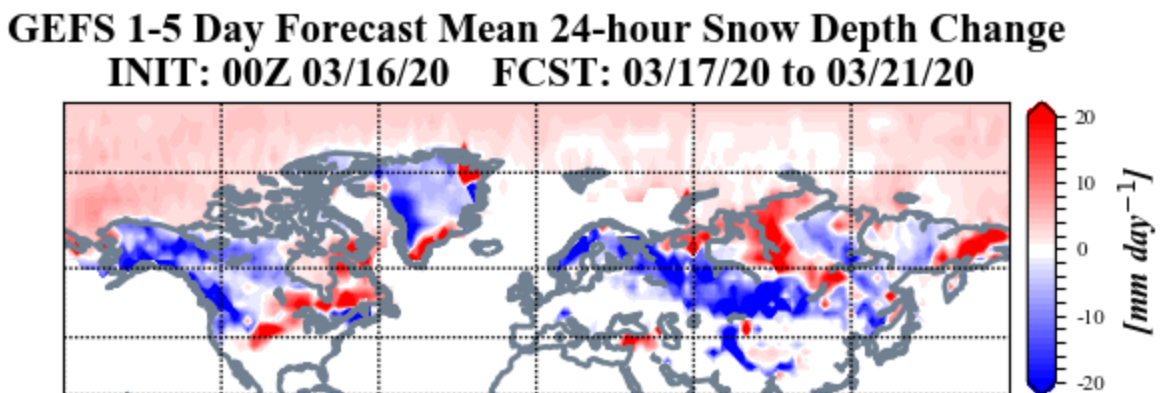
Ridging/positive geopotential height anomalies in the Gulf of Alaska and Alaska are predicted to force troughing/negative geopotential height anomalies in Eastern Canada and western North America with more ridging/positive geopotential height anomalies in

the Eastern US (**Figure 2**). This pattern is predicted to bring normal to above normal temperatures across Alaska, Northwestern Canada and the Eastern US with normal to below normal temperatures across Southwestern and Eastern Canada and much of the Western US (**Figure 3**).



**Figure 3.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 17 – 21 March 2020. The forecast is from the 00Z 16 March 2020 GFS ensemble.

Trouging and/or cold temperatures are predicted to bring new snowfall to parts of Northern Siberia, Turkey, Eastern Canada and the US Northern Plains (**Figure 4**). Warm temperatures are predicted to result in snowmelt for large swaths of Europe, Asia and North America (**Figure 4**).



**Figure 4.** Forecasted snowdepth anomalies ( $\text{mm}/\text{day}$ ; shading) from 17 – 21 March 2020. The forecast is from the 00Z 16 March 2020 GFS ensemble.

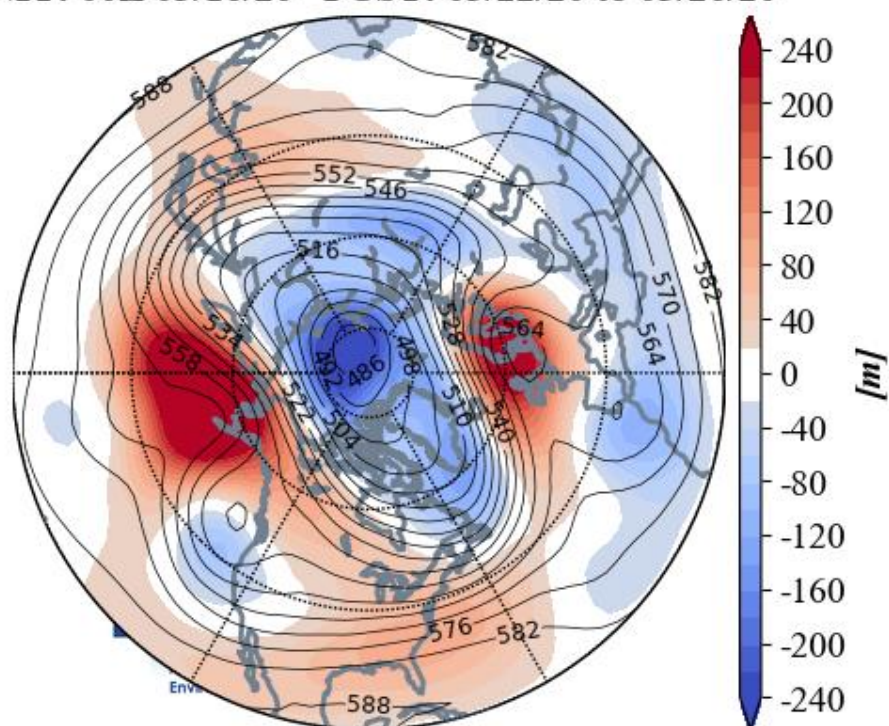
*Mid-Term*

*6-10 day*



The AO is predicted to remain positive (**Figure 1**) as negative geopotential height anomalies continue to dominate the Arctic with mostly positive geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with negative geopotential height anomalies predicted across Greenland (**Figure 2**), the NAO is predicted to remain positive as well.

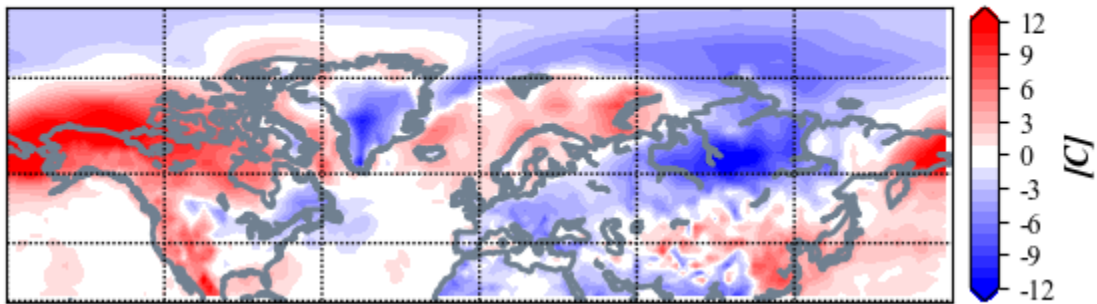
**GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 03/16/20 FCST: 03/22/20 to 03/26/20**



**Figure 5.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 22 – 26 March 2020. The forecasts are from the 00z 16 March 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to stretch across Northern Europe forcing troughing/negative geopotential height anomalies to the south across Southern Europe this period (**Figures 5**). **This pattern will favor** normal to below normal temperatures for much of Central and Southern Europe including the UK with normal to above normal temperatures for Northern Europe (**Figure 6**). Troughing/negative geopotential height anomalies previously confined to Northern Asia will become more widespread this period with ridging/positive geopotential height anomalies mostly confined to Southern and Eastern Asia (**Figure 5**). This is predicted to yield normal to below normal temperatures for most of Northern Asia **with** normal to above temperatures in Southern and Eastern Asia (**Figure 6**).

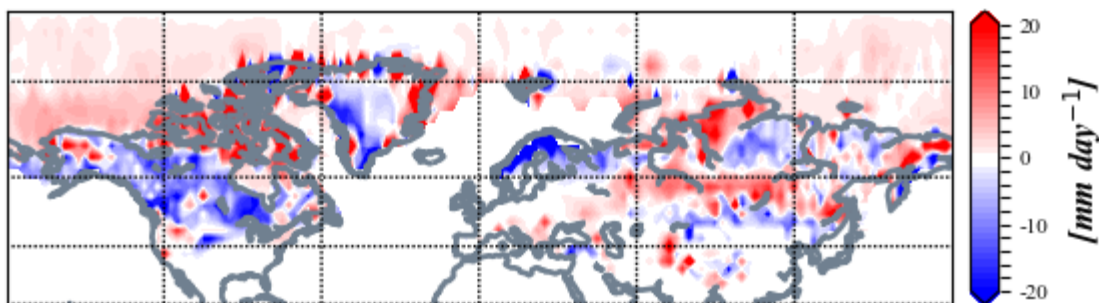
**GEFS 6-10 Day Forecast T2m Anomaly**  
**INIT: 00Z 03/16/20 FCST: 03/22/20 to 03/26/20**



**Figure 6.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 22 – 26 March 2020. The forecasts are from the 00Z 16 March 2020 GFS ensemble.

Ridging/positive geopotential height anomalies in the Gulf of Alaska and Alaska are predicted to persist and force troughing/negative geopotential height anomalies in Eastern Canada and the west coast of North America with more ridging/positive geopotential height anomalies in the Eastern US (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across Alaska, Northern Canada and the Southeastern US with normal to below normal temperatures across Southern and Eastern Canada and much of the US (**Figure 6**).

**GEFS 6-10 Day Forecast Mean 24-hour Snow Depth Change**  
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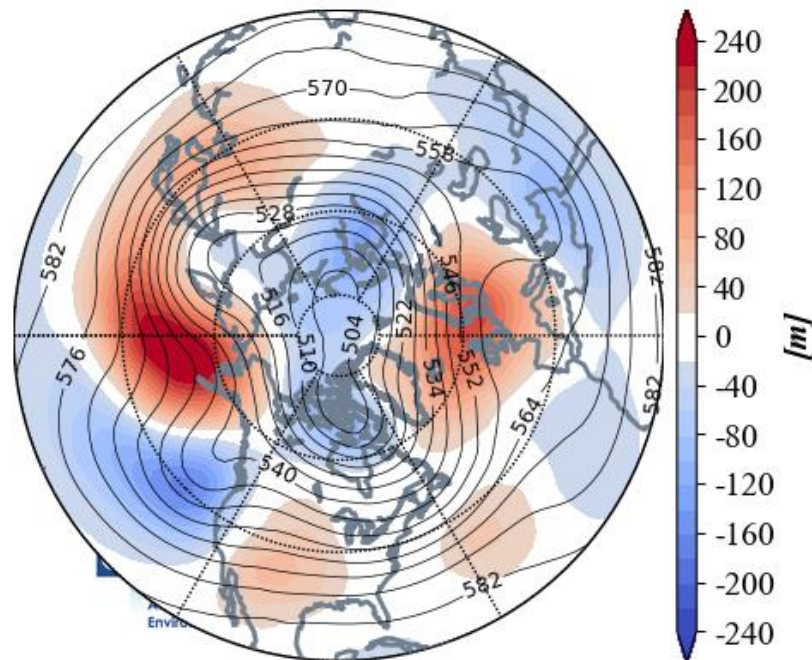
**Figure 7.** Forecasted snowdepth changes ( $\text{mm}/\text{day}$ ; shading) from 22 – 26 March 2020. The forecasts are from the 00Z 16 March 2020 GFS ensemble.

Troughing and/or cold temperatures will support the potential for new snowfall across the higher elevations of Southern Europe and Northern Asia, Eastern Canada and the Western US (**Figure 7**). Snowmelt is predicted in Northern Europe, Canada and the US Plains (**Figure 7**).

11-15 day

With mostly negative geopotential height anomalies predicted for the central Arctic but positive geopotential height anomalies across Alaska and Greenland (**Figure 8**), the AO is predicted to be neutral this period (**Figure 1**). With predicted weak positive pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is likely to remain neutral as well.

**GEFS 11-15 Day Forecast 500 mb GPH/GPH Anomaly**  
**INIT: 00Z 03/16/20 FCST: 03/27/20 to 03/31/20**

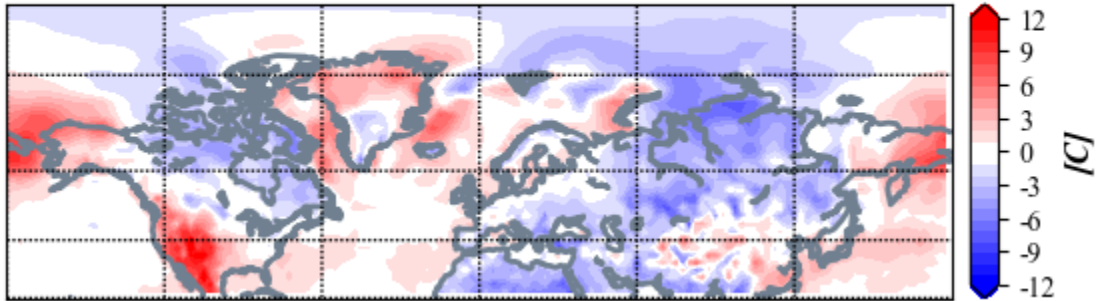


**Figure 8.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 27 – 31 March 2020. The forecasts are from the 00z 16 March 2020 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted across Northern and Western Europe with troughing/negative geopotential height anomalies across Southern and Eastern Europe this period (**Figures 8**). This pattern favors normal to above normal temperatures for Northern and Western Europe including the UK with normal to below normal temperatures in Southern and Eastern Europe this period (**Figures 9**). Troughing/negative geopotential height anomalies will continue to become more widespread this period with ridging/positive geopotential height anomalies confined to Southeast Asia (**Figure 8**). This pattern favors normal to below normal temperatures for Western and Northern Asia with normal to below normal temperatures for Southern and Eastern Asia (**Figure 9**).



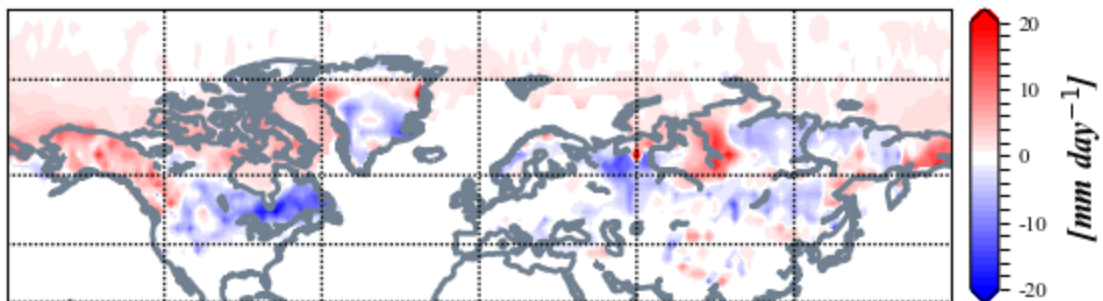
**GEFS 11-15 Day Forecast T2m Anomaly**  
**INIT: 00Z 03/16/20 FCST: 03/27/20 to 03/31/20**



**Figure 9.** Forecasted surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) from 27 – 31 March 2020. The forecasts are from the 00z 16 March 2020 GFS ensemble.

The pattern across North America is predicted to rotate west with ridging/positive geopotential height anomalies continuing in Alaska but with troughing/negative geopotential height anomalies in the Gulf of Alaska, much of Canada and even the Eastern US with more ridging/positive geopotential height anomalies in the Western US (**Figure 8**). This pattern is predicted to favor normal to above normal temperatures across Alaska, and the Southern and Western US with normal to below normal temperatures for much of Canada and the Northern and Eastern US (**Figure 9**).

**GEFS 11-15 Day Forecast Mean 24-hour Snow Depth Change**  
**INIT: 00Z 03/16/20 FCST: 03/27/20 to 03/31/20**



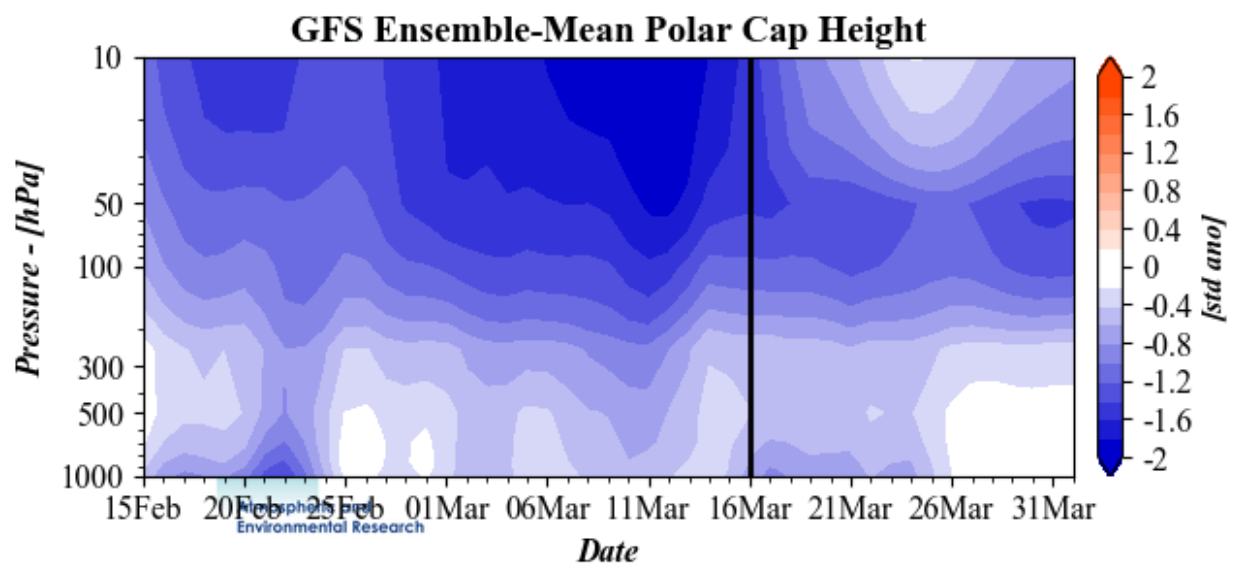
**Figure 10.** Forecasted snow depth changes ( $\text{mm}/\text{day}$ ; shading) from 27 – 31 March 2020. The forecasts are from the 00z 16 March 2020 GFS ensemble.

Troughing and/or cold temperatures could support new snowfall across parts of Northern and Eastern Asia, the Tibetan Plateau, Alaska and Western Canada (**Figure 10**). Snowmelt is predicted for parts of Asia, Southeastern Canada and the Northern US (**Figure 10**).

Longer Term

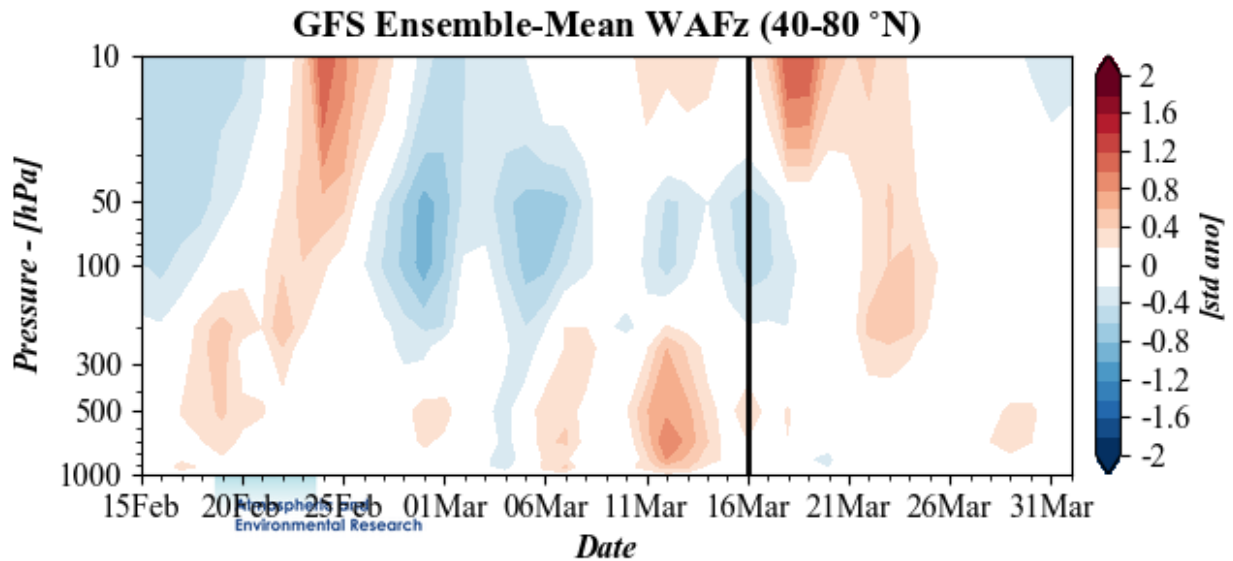
30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to below normal PCHs in both the troposphere and stratosphere (**Figure 11**). The predicted cold tropospheric PCHs are consistent with a predicted positive surface AO (**Figure 1**). Though the predicted downward propagation of cold PCHs from the strong stratospheric PV to the surface has been fairly consistent since late December, this plot is suggestive that it may finally end with the arrival of astronomical spring. Something that it showed last week but is now pushed off by another week.



**Figure 11.** 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 16 March 2020 GFS ensemble.

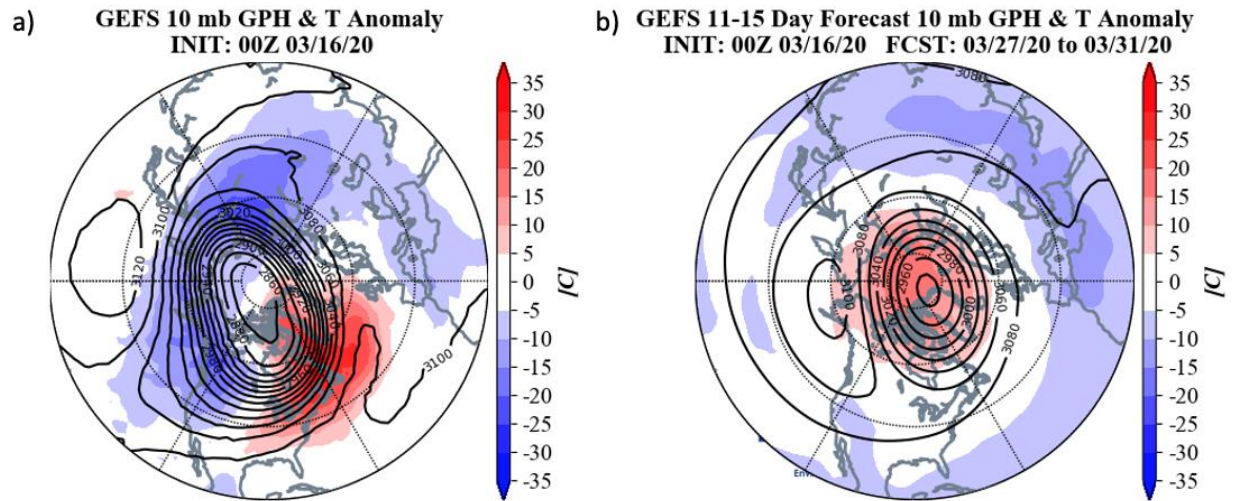
The plot of vertical Wave Activity Flux (WAFz) or poleward heat transport forecast shows only weak negative and positive anomalies over the next two weeks (**Figure 12**). Though positive weak WAFz anomalies are predicted for the upcoming week (**Figure 12**).



**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 16 March 2020 GFS ensemble.

The stratospheric AO is currently positive (**Figure 1**) consistent with a relatively strong PV (**Figure 1**). The GFS predicts some relatively minor disrupting of the PV through the end of the month with changes in the position of the PV and increased polar stratospheric warming with some decreases in the overall positive stratospheric AO starting this week.

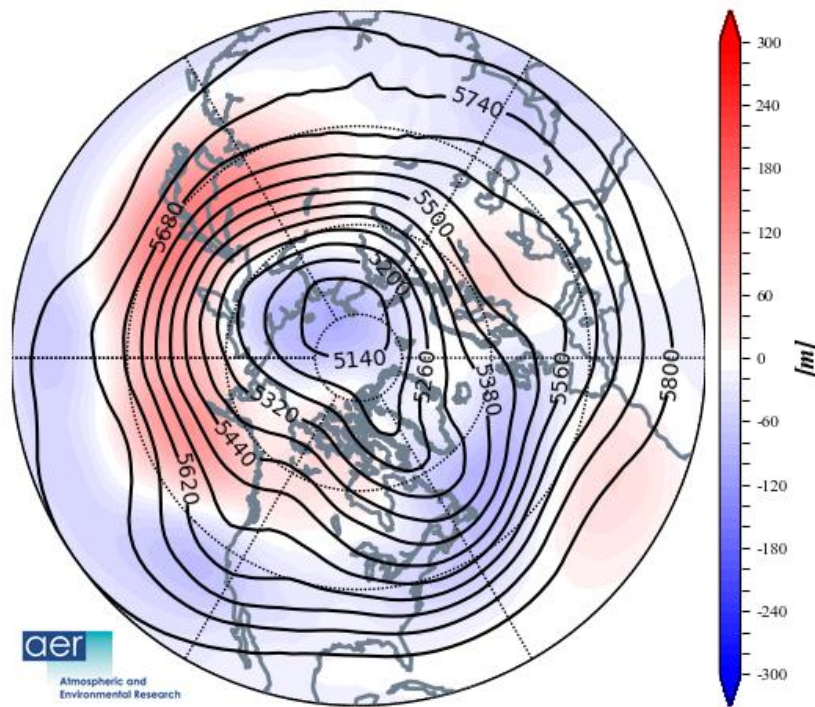
Currently the stratospheric PV is centered near the North Pole (**Figure 13**) with the largest negative temperature departures in the polar stratosphere located over northern Eurasia and into Western Canada (**Figure 13**). The PV is elongated along an axis from Siberia to Canada. This is the same axis of the coldest temperatures predicted at the surface the next week or so.



**Figure 13.** (a) Analyzed 10 mb geopotential heights (dam; contours) and temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere at 00Z 16 March 2020 . (b) Same as (a) except forecasted averaged from 27 – 31 March 2020. The forecasts are from the 00Z 16 March 2020 GFS operational model.

Over the next two weeks, the PV center is predicted to drift from the North Pole towards Canada and Greenland (**Figure 13**). Warming currently across the northern North Atlantic is predicted to spread across the entire Arctic (**Figure 13**) related to weak positive WAFz this week. The tropospheric pattern is becoming more favorable for triggering positive WAFz pulses that are likely to continue to weaken the stratospheric PV.

**CFS 500 hPa Forecast Anomaly Apr 2020  
Valid as of 16 Mar 2020**

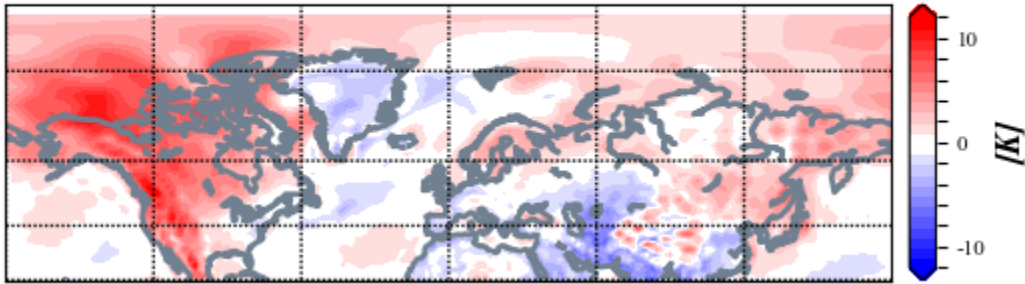


**Figure 14.** Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for April 2020. The forecasts are from the 00Z 16 March 2020 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and the surface temperatures (**Figure 15**) forecast for April from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Northern Europe, East Asia, Gulf of Alaska and Western Canada with troughing in Western and Southern Europe into the Middle East and Western Asia, Eastern Siberia, Eastern Canada and much of the US (**Figure 14**). This pattern favors relatively mild temperatures for Northern Europe, much of Northern Asia and western North America with seasonable to relatively cold temperatures for Central and Southern Europe, Western and Southern Asia, Southeastern Canada and the Northeastern US (**Figure 15**).



**CFS T2m Forecast Anomaly Apr 2020  
Valid as of 16 Mar 2020**

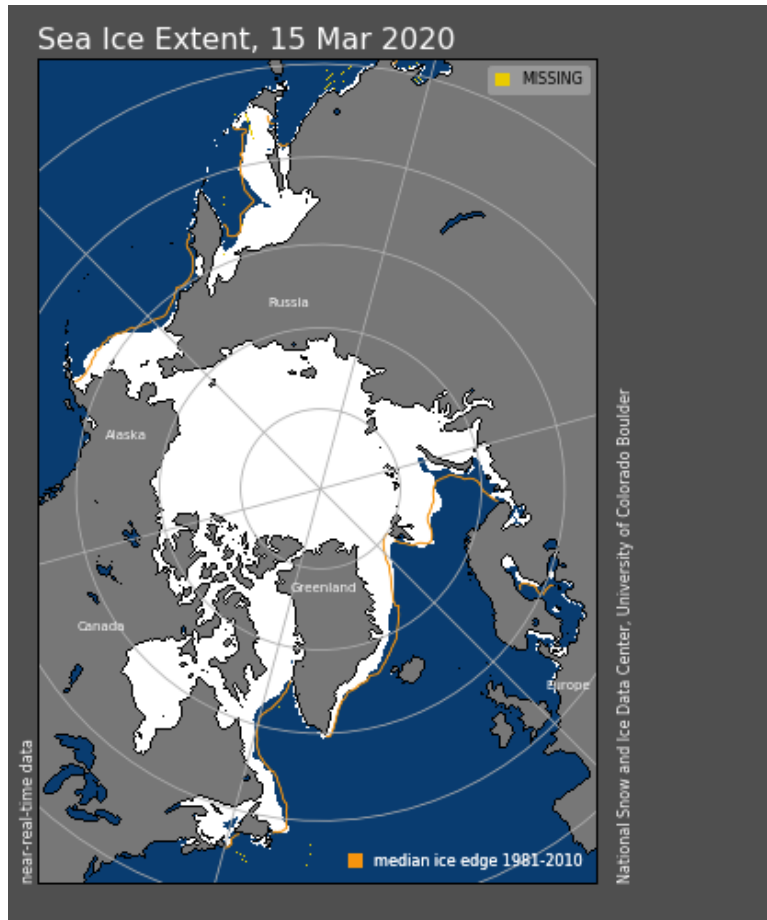


**Figure 15.** Forecasted average surface temperature anomalies ( $^{\circ}\text{C}$ ; shading) across the Northern Hemisphere for April 2020. The forecasts are from the 00Z 16 March 2020 CFS.

*Surface Boundary Conditions*

*Arctic sea ice extent*

The positive AO has been conducive to sea ice growth for much of the winter and Arctic sea ice extent remains higher than recent winters. We are likely very close to the seasonal maximum extent in Arctic sea ice and it should start to retreat shortly. Overall sea ice extent is near normal throughout the Arctic and negative anomalies exist mostly in seas outside of the Arctic.

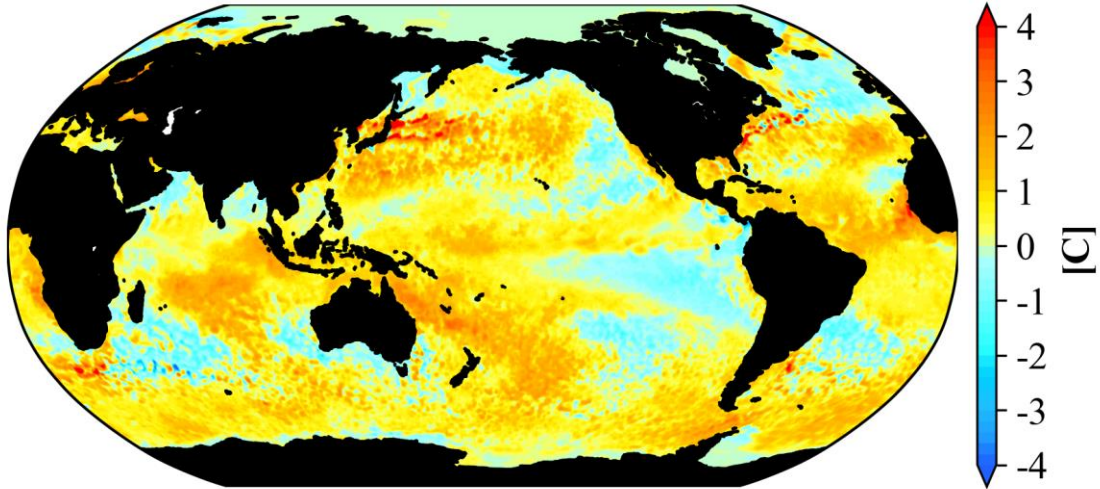


**Figure 16.** a) Observed Arctic sea ice extent on 15 March 2020 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010.

### *SSTs/El Niño/Southern Oscillation*

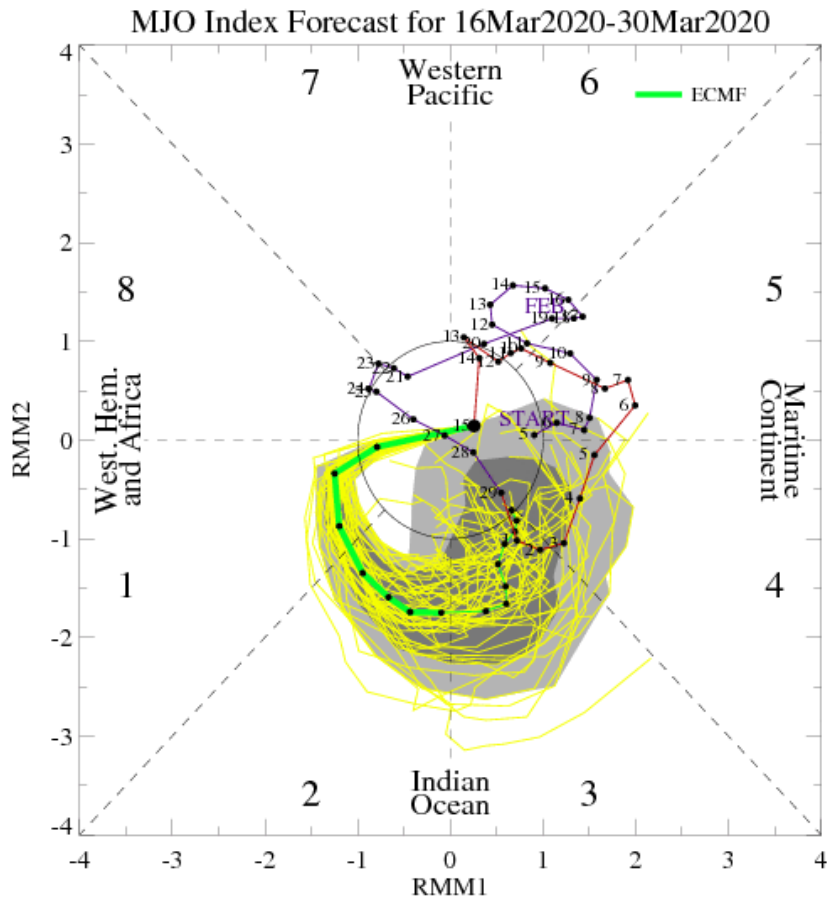
Equatorial Pacific sea surface temperatures (SSTs) anomalies are cooling slightly but neutral El Niño/Southern Oscillation (ENSO) conditions seem most likely this spring (**Figure 17**). Observed SSTs across the NH remain well above normal especially near Alaska and in the Gulf of Alaska and the western North Pacific though below normal SSTs exist regionally especially west of South America and south of Iceland. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

## SST Anomaly - Week Ending 15 Mar 2020



**Figure 17.** The latest weekly-mean global SST anomalies (ending 15 March 2020). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 18**). The forecasts are for the MJO to emerge to phase one and then quickly phases two and three. MJO phases one through three favor ridging in Western Canada and troughing elsewhere. MJO does not seem to be contributing to the weather patterns across North America in the short term.

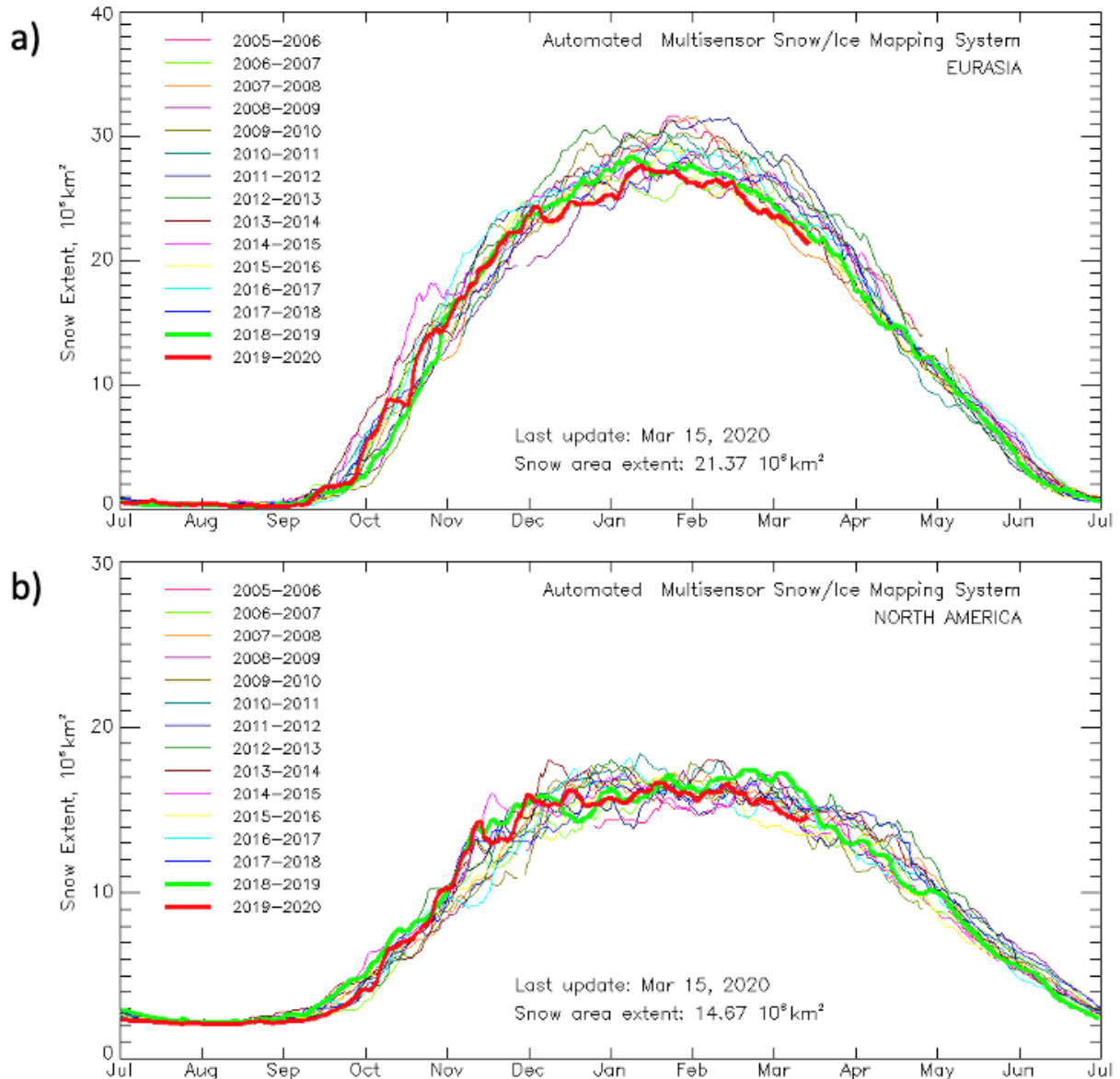


**Figure 18.** Past and forecast values of the MJO index. Forecast values from the 00Z 16 March 2020 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>

### Northern Hemisphere Snow Cover

Snow cover declined across Eurasia and remains near decadal lows. Snow cover extent is clearly in its seasonal decline. Relative low snow cover extent favors above normal temperatures.



**Figure 19.** Observed Eurasian (top) and North American (bottom) snow cover extent through 15 March 2020 (not updated). Image source: [https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow\\_extent\\_plots.html](https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_plots.html)

North American snow cover actually increased slightly, due to new snowfall in the Western and Central US and is now near decadal means. Regardless snow cover extent is in its seasonal decline. If the melting accelerates this could contribute to a warm spring.