

Arctic Oscillation and Polar Vortex Analysis and Forecasts

August 9, 2021

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) 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.

Subscribe to our email list or follow me on Twitter (@judah47) for notification of updates.

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

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to straddle either side of neutral over the next two weeks with mixed pressure/geopotential height anomalies across the Arctic and mixed pressure/geopotential height anomalies across the mid-latitudes. The North Atlantic Oscillation (NAO) is currently positive but is predicted to straddle either side of neutral as pressure/geopotential height anomalies are predicted remain weak across Greenland the next two weeks.
- The next two weeks, ridging/positive geopotential height anomalies coupled with normal to above normal temperatures are predicted to dominate much of

Europe. One exception is predicted troughing/negative geopotential height anomalies coupled with normal to below normal temperatures that will begin near the United Kingdom (UK) this week then move into Scandinavia next week and end in Eastern Europe.

- Over the next two weeks much of Asia will be dominated by ridging/positive geopotential height anomalies coupled with normal to above normal temperatures in Central Asia. A couple of exceptions are troughing/negative geopotential height anomalies coupled with normal to below temperatures in East Asia this week into next week and then troughing/negative geopotential height anomalies coupled with cooler temperatures will enter northwestern Asia the end of next week.
- This general pattern across North America over the next two weeks is ridging/positive geopotential height anomalies coupled with normal to above normal temperatures in southern and eastern North America including the Eastern United States (US) and troughing/negative geopotential height anomalies coupled with normal to below temperatures across Alaska and northern Canada.
- In the Impacts section I share some more thoughts on the summer pattern across the Northern Hemisphere (NH) but end with a thought about the soon to arrive polar vortex.

Impacts

As we enter the last month of summer, seems like many of the same regions that were hot for much of the summer season continue to experience in August above to well above normal temperatures as shown in **Figure i**. These regions include western North America, Central Asia and especially Siberia. Another region that I don't discuss often but seems to be perennially well above normal is North Africa and into the Middle East. This is one region that I would not have guessed ahead of time to be persistently warm relative to normal with most of the fastest warming regions along the northern edges of the Northern Hemisphere continents. I do wonder what is special or peculiar about North Africa that favors it for accelerated warming in the summer months. In contrast so far this month eastern North America, Western Europe and Northeast Asia have been relatively cool. However eastern North America and Western Europe could experience a relatively warmer second half of August.

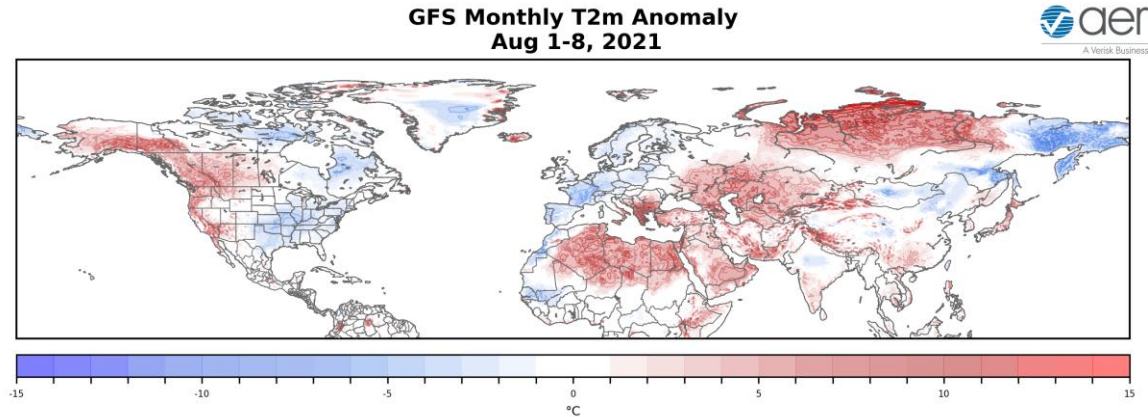


Figure i. Observed surface temperature anomalies (°C; shading) over the NH for 1-8 August 2021 based on GFS analysis.

In the blog, I have expressed my expectation that Arctic sea ice extent will be higher than last summer as we near the annual extent minimum. Over the past several weeks that prediction has looked dubious as sea ice loss was at a record low pace. Well finally sea ice extent seems to be diverging from 2012 and 2020. Two regions that have bucked recent trends with summer temperatures with relatively cool temperatures when compared to recent summers are Eastern Siberia and Alaska. In **Figure ii**, I show the summer temperature anomalies through August 5th and though I wouldn't characterize Eastern Siberia and Alaska as experiencing cold summers, they are closer to normal and cooler than recent summers.

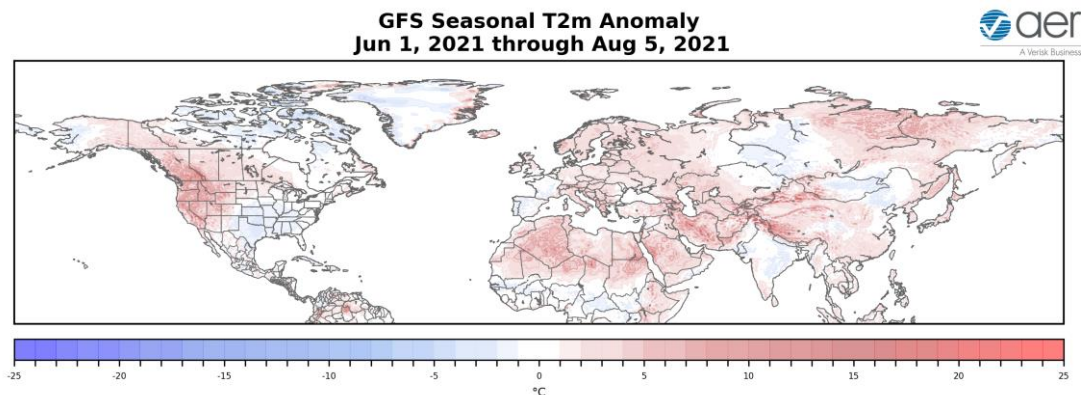


Figure ii. Observed surface temperature anomalies (°C; shading) over the NH for 1 June through 5 August 2021 based on GFS analysis.

And the impact of close to seasonable and even slightly below normal temperatures stretching from Eastern Siberia to the Canadian Archipelagos is helping to preserve sea ice in the North American sector of the Arctic as seen in **Figure iii**; sea ice from Eastern Siberia to northwest Greenland is near normal for this time of year. In contrast sea ice

extent adjacent to Northwest Asia, Western and Central Siberia is well below normal. In these regions summer temperatures have been well above normal especially the western two thirds of Siberia and the impact on melting sea ice is apparent.

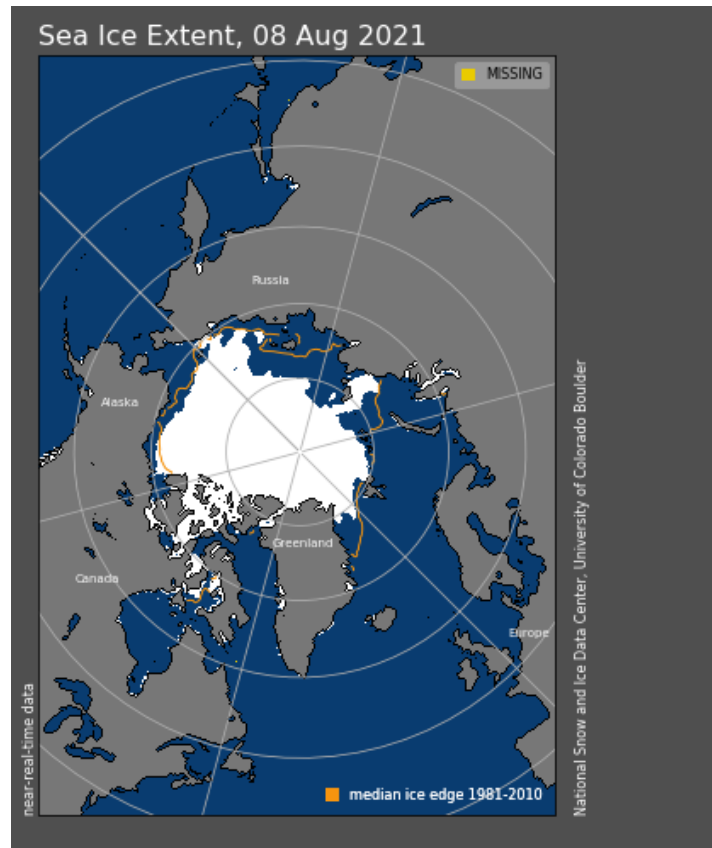


Figure iii. Observed Arctic sea ice extent on 8 August 2021 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image courtesy of National Snow and Ice Data Center (NSIDC).

I do think that the minimum Arctic sea ice extent should be safely above the record low of 2012 and even higher than last summer. But sea ice is relatively thin, and a strong Arctic cyclone could still cause a large and rapid reduction in Arctic sea ice. And with the return of the polar vortex imminent, I can't resist saying this. Based on our understanding of the relationship between sea ice extent anomalies and the strength of the winter polar vortex, below normal sea ice extent on the North Atlantic side of the Arctic with relatively more extensive sea ice on the North Pacific side of the Arctic, is the sea ice extent anomaly pattern most favorable for weakening the polar vortex. But admittedly I am getting ahead of myself.

1-5 day

The AO and NAO are predicted to be near neutral this week (**Figure 1**) as geopotential height anomalies are predicted to be mixed and/or weak across the Arctic and across Greenland with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**).

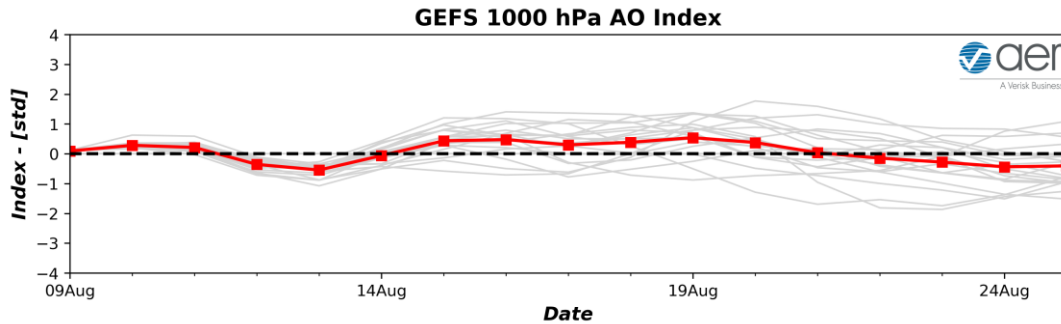


Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 9 August 2021 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Ridging/positive geopotential height anomalies are predicted to dominate Europe this week with troughing/negative geopotential height anomalies limited to the British Isles (**Figure 2**). This will favor widespread normal to above normal temperatures across much of Europe except for normal to below normal temperatures across the UK (**Figure 3**). The general pattern across Asia this period is ridging/positive geopotential height anomalies across much of Asia with regional troughing/negative geopotential height anomalies in Kazakhstan and Eastern Asia (**Figure 2**). This pattern favors normal to above normal temperatures across much of Asia with normal to below normal temperatures in Kazakhstan and Eastern Asia (**Figure 3**).

GEFS 1-5 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/09/2021 FCST: 08/10/2021 to 08/14/2021

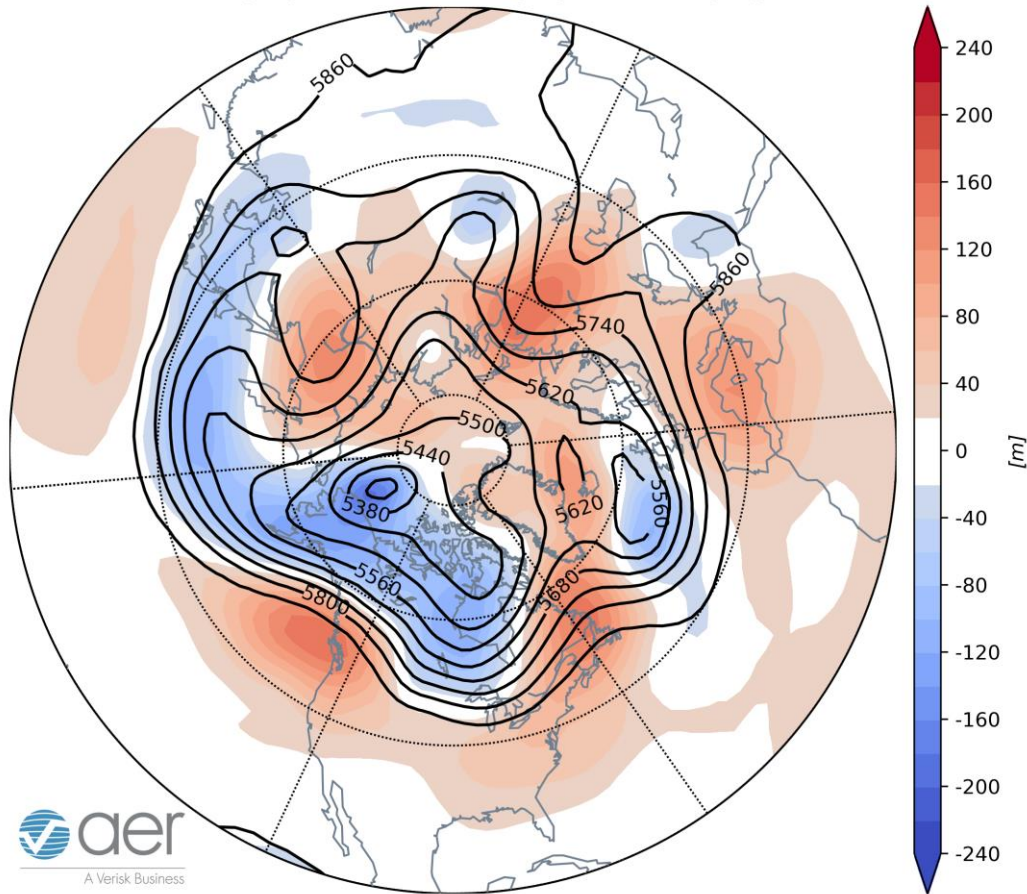


Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 10 – 14 August 2021. The forecasts are from the 00z 9 August 2021 GFS ensemble.

The general pattern this week is ridging/positive geopotential height anomalies across much of the US, Southwestern and Eastern Canada with troughing/negative geopotential height anomalies across Alaska, Northern and Central Canada (**Figure 2**). This pattern is predicted to bring normal to above normal temperatures across much of the US, Southwestern and Eastern Canada, with normal to below normal temperatures across Alaska, Northern and Central Canada (**Figure 3**).

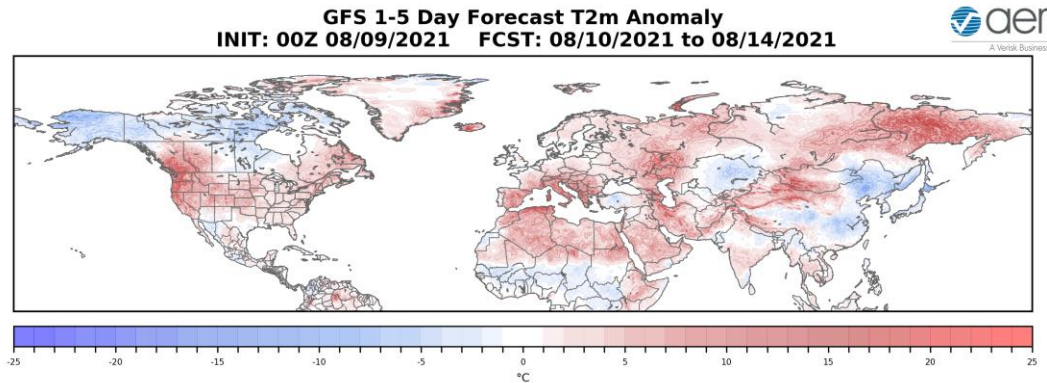


Figure 3. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 10 – 14 August 2021. The forecast is from the 00Z 9 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation across Southern and Eastern Asia (**Figure 4**). Normal to below normal precipitation is predicted for much of North America with the exceptions of normal to above normal precipitation in Southeastern Alaska, Florida, the Great Lakes into the Canadian Maritimes (**Figure 4**).

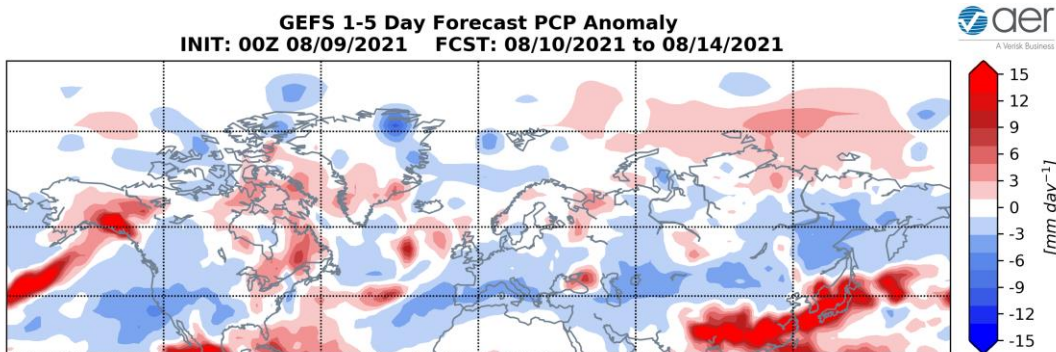


Figure 4. Forecasted precipitation anomalies (mm/day; shading) from 10 – 14 August 2021. The forecast is from the 00Z 9 August 2021 GFS ensemble.

Mid-Term

6-10 day

The AO is predicted to continue to straddle neutral this period (**Figure 1**) as geopotential height anomalies remains mixed across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 5**). And with normal to slightly above normal geopotential height anomalies continuing across Greenland (**Figure 5**), the NAO is predicted to also remain neutral to slightly negative this period.

GEFS 6-10 Day Forecast 500 mb GPH/GPH Anomaly
INIT: 00Z 08/09/2021 FCST: 08/15/2021 to 08/19/2021

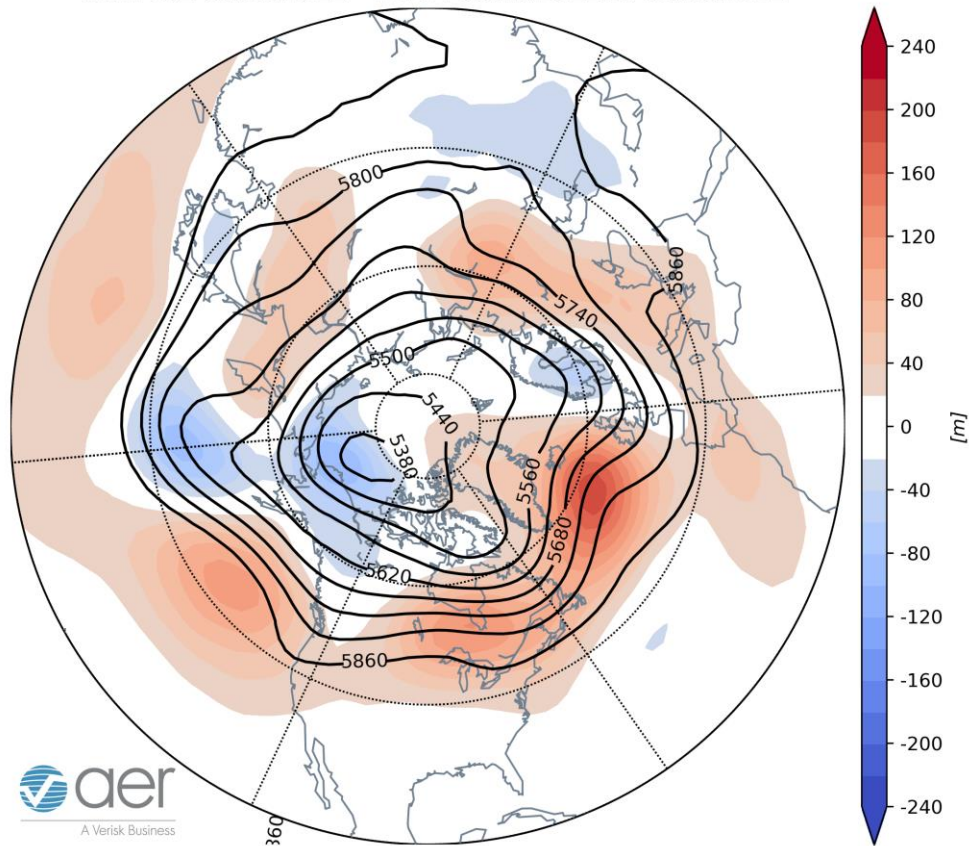


Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 15 – 19 August 2021. The forecasts are from the 00z 9 August 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to persist across much of Europe with troughing/negative geopotential height anomalies across Northwestern Europe especially Scandinavia this period (**Figures 5**). This will favor widespread normal to above normal temperatures across Southern and Eastern Europe with normal to below normal temperatures across Northern and Western Europe including the UK (**Figure 6**). Ridging/positive geopotential height anomalies are predicted across much of Asia with only regional troughing/negative geopotential height anomalies across parts of Central and Eastern Asia (**Figure 5**). This pattern favors normal to above normal temperatures widespread across Asia with normal to below normal temperatures in regional pockets of Central and East Asia (**Figure 6**).

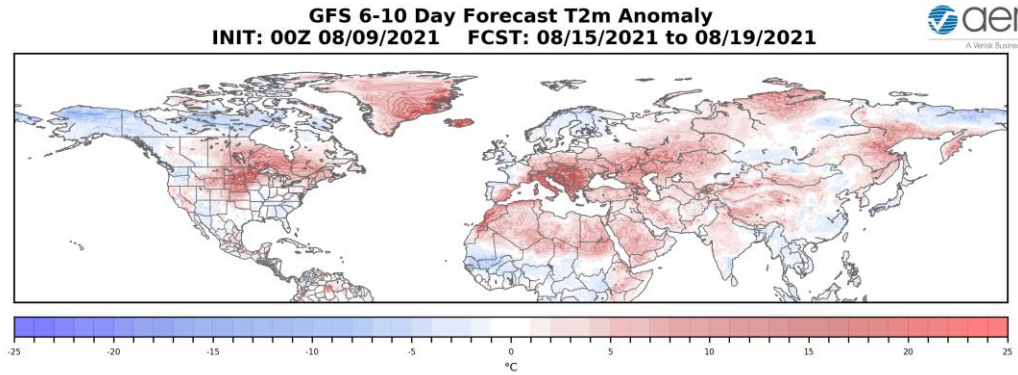


Figure 6. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 15 – 19 August 2021. The forecasts are from the 00Z 9 August 2021 GFS ensemble.

Ridging/positive geopotential height anomalies are predicted to continue to dominate southern and eastern North America with troughing/negative geopotential height anomalies confined to Alaska and Northwestern Canada (**Figure 5**). This pattern is predicted to bring normal to above normal temperatures across much of Southern and Eastern Canada, the Western and Northern US with normal to below normal temperatures across Alaska, Northwestern Canada and the Southeastern US (**Figure 6**).

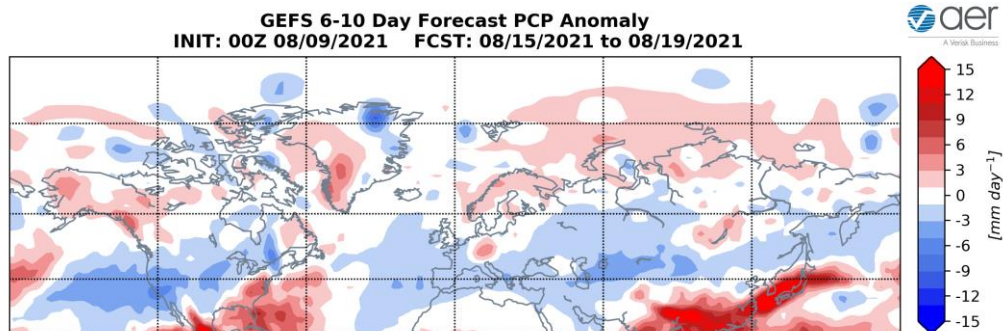


Figure 7. Forecasted precipitation anomalies (mm/day; shading) from 15 – 19 August 2021. The forecasts are from the 00Z 9 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia with the exceptions of above normal precipitation in Scandinavia, Central Europe and Southern and Eastern Asia (**Figure 7**). Normal to below normal precipitation is predicted for much of North America except for normal to above normal precipitation in Western Alaska, the Alaskan Panhandle, Northwest Canada, the Southeastern US and the US Mid-Atlantic States (**Figure 7**).

11-15 day

With persistent mixed and/or weak geopotential height anomalies predicted across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 8**), the AO should remain near neutral this period (**Figure 1**). With predicted weak pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO is forecasted to remain near neutral this period as well.

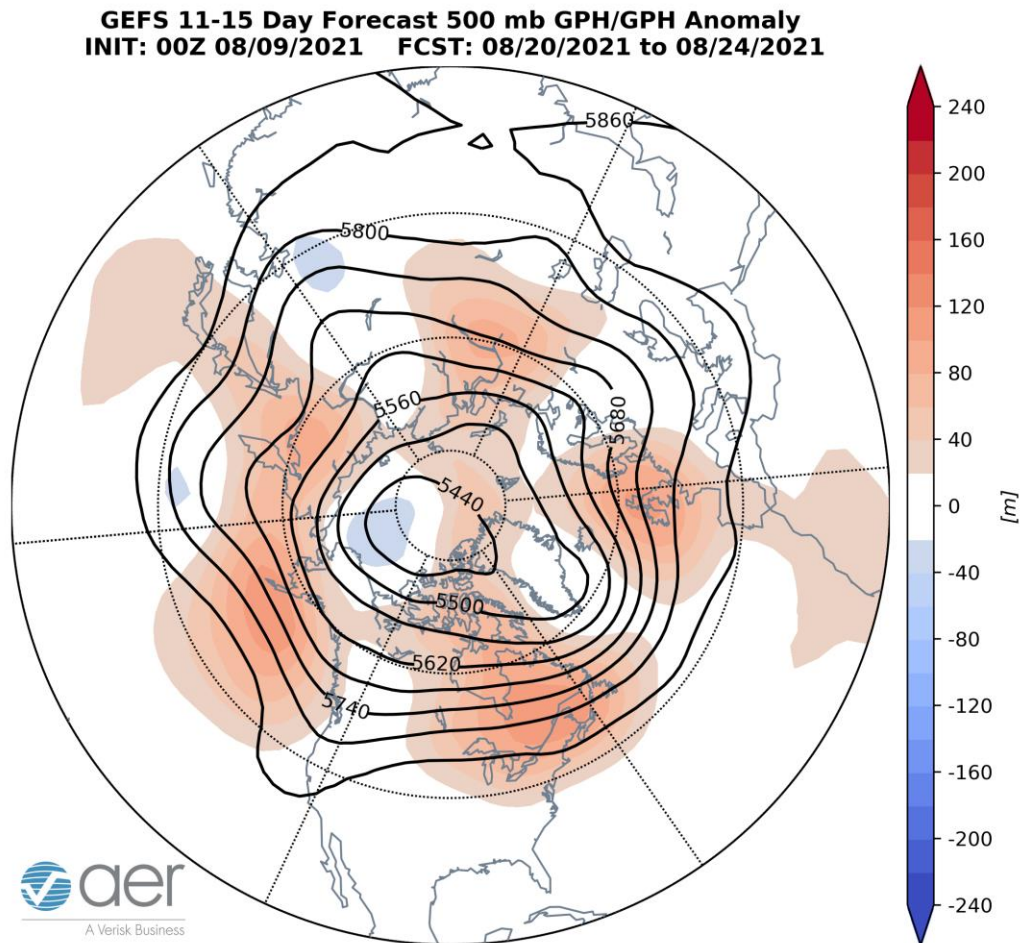


Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 20 – 24 August 2021. The forecasts are from the 00z 9 August 2021 GFS ensemble.

Recent troughing/negative geopotential height anomalies previously in Western Europe are predicted to sweep into Eastern Europe with ridging/positive geopotential height anomalies taking their place in Western Europe this period (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Europe including the UK except for normal to below normal temperatures across Northeastern Europe (**Figures 9**). Ridging/positive geopotential height anomalies are predicted to remain widespread across Asia except for weak troughing/negative geopotential height anomalies in Northeastern and Northwestern Asia this period (**Figure 8**). This pattern

favors widespread normal to above normal temperatures across much of Asia but especially Central Asia except for normal to below normal temperatures across Northwestern Asia and parts of East Asia including Eastern China (**Figure 9**).

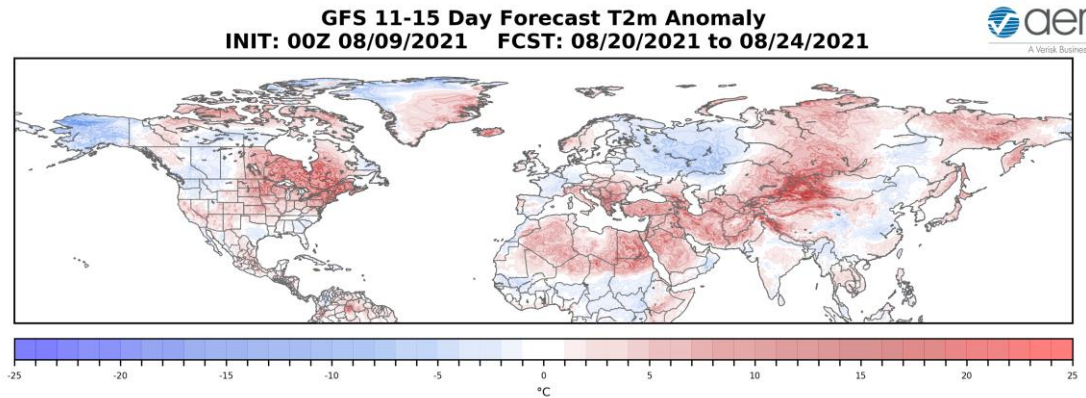


Figure 9. Forecasted surface temperature anomalies ($^{\circ}\text{C}$; shading) from 20 – 24 August 2021. The forecasts are from the 00z 9 August 2021 GFS ensemble.

The general pattern of ridging/positive geopotential height anomalies across eastern North America with weak troughing/negative geopotential height anomalies across Alaska and Western Canada is predicted to persist with troughing now extending into the Western US this period (**Figure 8**). This pattern favors normal to above normal temperatures for much of the US and Canada but especially the Northeastern US and Eastern Canada with normal to below normal temperatures across Alaska, pockets of Western Canada, the Northwestern US and the Gulf of Mexico States (**Figure 9**).

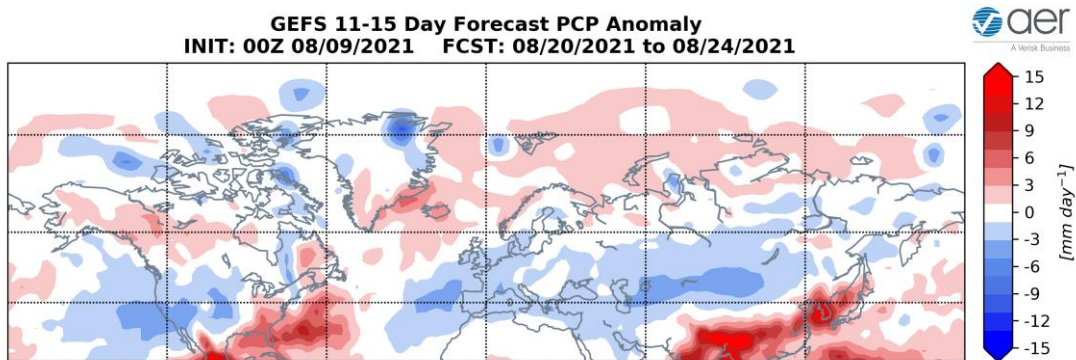


Figure 10. Forecasted precipitation anomalies (mm/day; shading) from 20 – 24 August 2021. The forecasts are from the 00z 9 August 2021 GFS ensemble.

Normal to below normal precipitation is predicted for Eurasia except for above normal precipitation across Norway and Southeast Asia (**Figure 10**). Normal to above normal precipitation is predicted for much of North America with normal to above normal

precipitation in Alaska, Northwest Canada, the Eastern US and the Canadian Maritimes (**Figure 10**).

Longer Term

30-day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows normal to cold/negative PCHs in the upper stratosphere and right near the surface with warm/positive PCHs in the mid to low stratosphere and most of the troposphere (**Figure 11**).

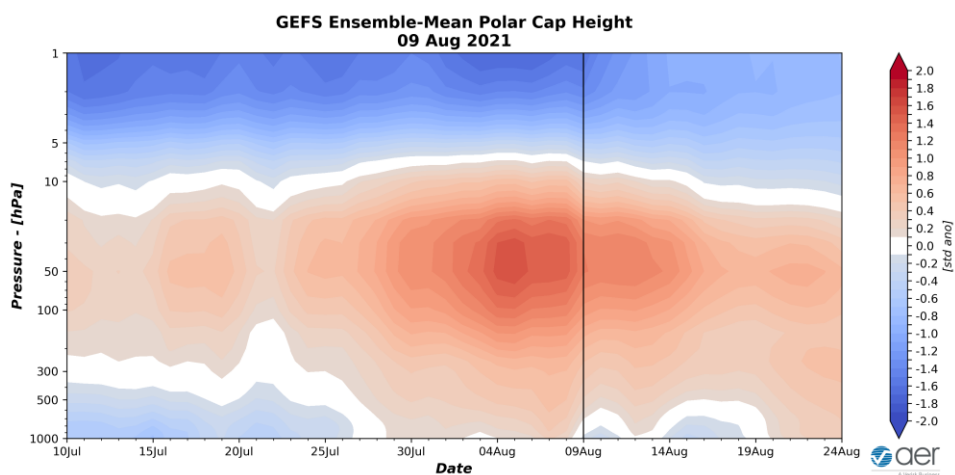


Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 9 August 2021 GFS ensemble.

The overall predicted warm/positive PCHs in the lower stratosphere and upper troposphere are predicted to descend to the surface later this week and again next week (**Figure 11**). Weak and alternating anomalies of PCHs in the lower troposphere are consistent with the predicted weak and straddling neutral surface AO this week and into next week (**Figure 1**).

**CFS 500 hPa Forecast Anomaly Aug 2021
Valid as of 09 Aug 2021**

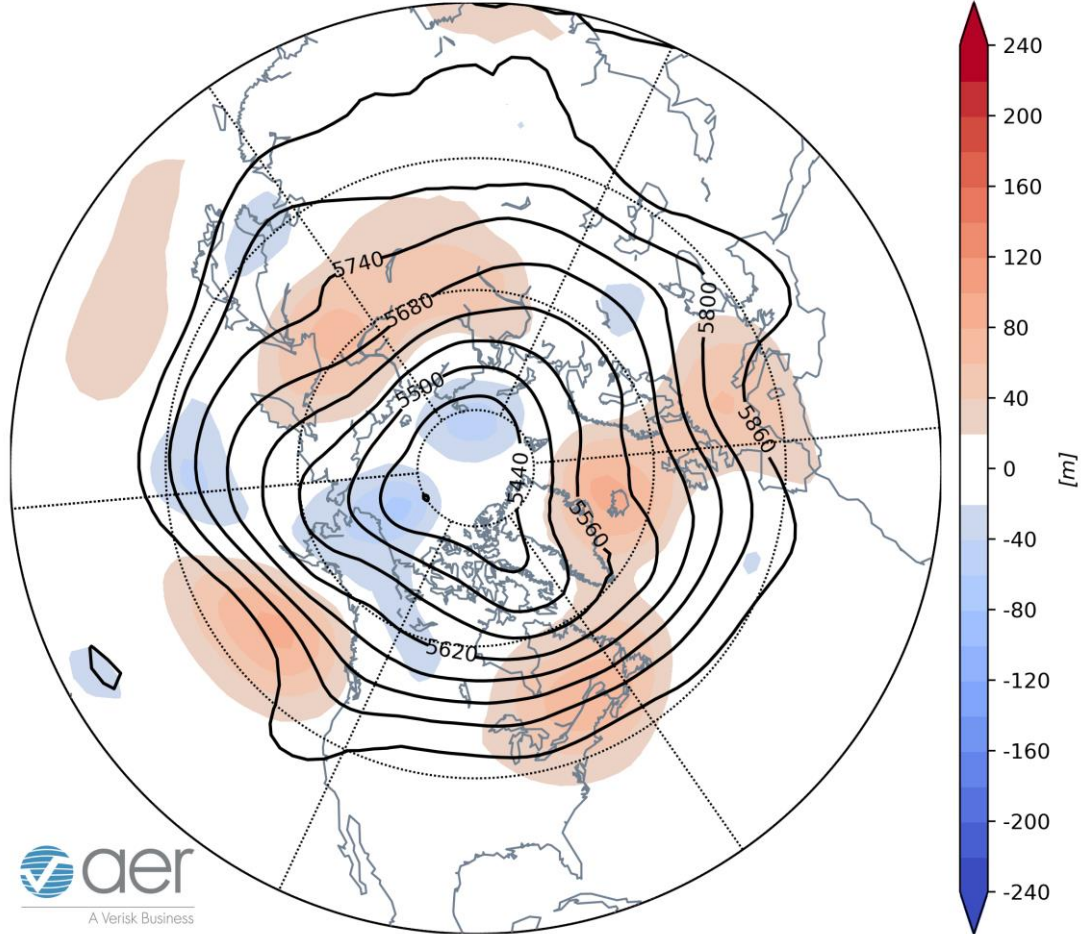


Figure 12. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for September 2021. The forecasts are from the 00Z 9 August 2021 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 12**) and the surface temperatures (**Figure 13**) forecast for September from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Scandinavia and the Barents-Kara Seas, the Dateline, and Eastern Canada with troughing in Southern Europe, Siberia, along the west coast of North America (**Figure 12**). This pattern favors seasonable to relatively cool temperatures for Southern Europe, Northern Asia including Siberia and the Western US with seasonable to relatively warm temperatures for Northern Europe, Southern and Eastern Asia, Alaska, much of Canada and the Eastern US (**Figure 13**).

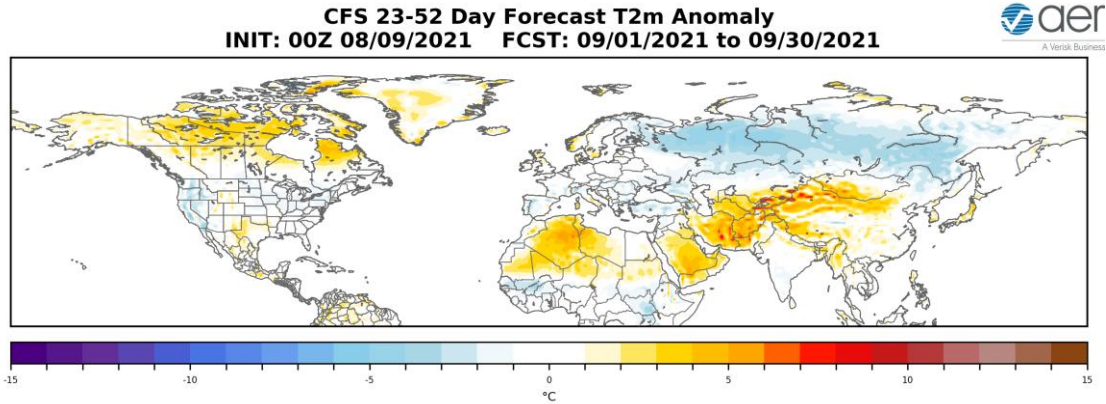


Figure 13. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for September 2021. The forecasts are from the 00Z 9 August 2021 CFS.

Surface Boundary Conditions

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are close to normal and we continue to observe neutral conditions (**Figure 14**) and neutral conditions are expected through the summer. Observed SSTs across the NH remain well above normal especially in the Baltic Sea, Gulf of Alaska, the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the Southern Hemisphere. Warm SSTs in the Gulf of Alaska may favor mid-tropospheric ridging in the region.

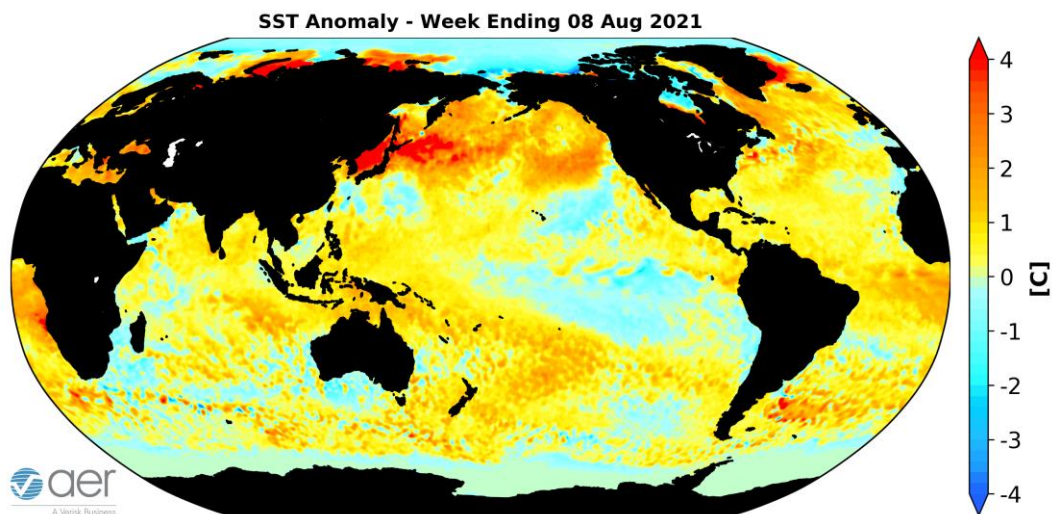


Figure 14. The latest weekly-mean global SST anomalies (ending 8 August 2021). Data from NOAA OI High-Resolution dataset.

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 15**). However the forecasts are for the MJO to strengthen into phases one and two before weakening again where no phase is favored. Phases one and two are related to ridging across the US and Eastern Canada with troughing in Alaska and Northwestern Canada. Therefore it is likely that the MJO is contributing to the predicted weather pattern across North America the next two weeks but admittedly this is outside of my expertise.

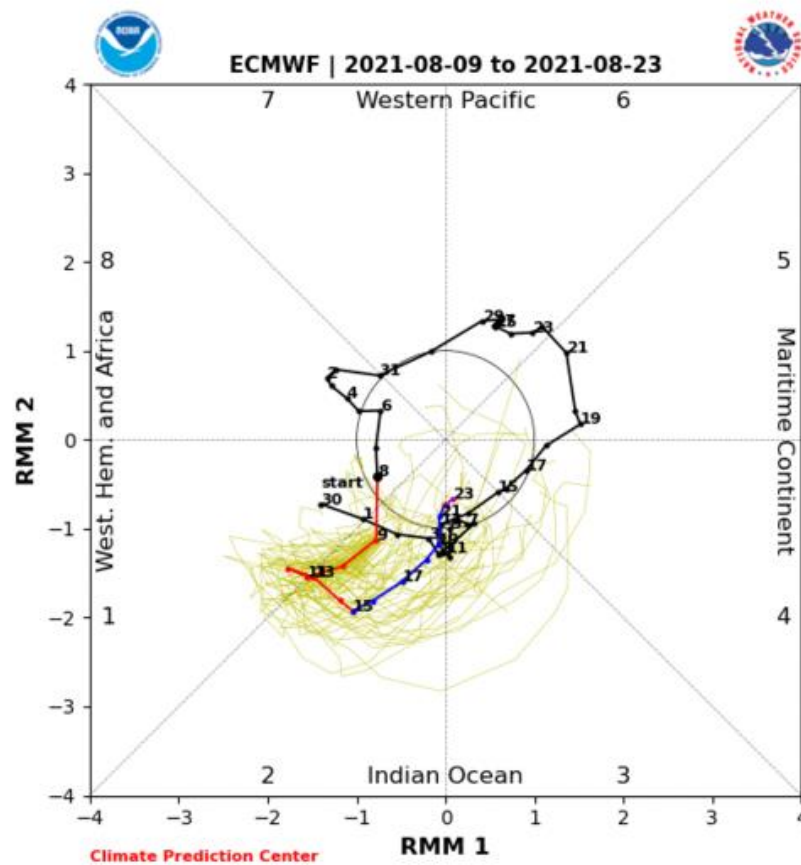


Figure 15. Past and forecast values of the MJO index. Forecast values from the 00Z 9 August 2021 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model “spread” is denoted by the gray shading. Sector numbers indicate 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>

