

Atmospheric Blocking in 2020: Slow Out of the Gate.

The year 2020 featured a slow start in blocking activity for both the Northern and Southern Hemispheres. The year began with warm-neutral conditions in place over the eastern Tropical Pacific Ocean if we characterize the phase of El Niño and Southern Oscillation (ENSO). These conditions held into the summer, but the arrival of La Niña-like conditions by September were noted. It was clear by December that 2020 – 2021 would be a full-blown La Niña year. According to NASA and NOAA, the year 2020 tied the year 2016 as the warmest on record continuing a string of very warm years globally. A hot summer for Siberia was driven by blocking including the first 100° F day above the arctic circle.

A cold spring over North America and Eastern Europe and Western Russia can be attributed to a year that ramped up quickly in terms of blocking activity after late March. This occurred at a time when the worst pandemic in a century was sweeping the world. For the second consecutive year, the central USA and upper Midwest experienced unusual October snow, in some places the worst in more than 100 years.

For the fifth consecutive year, we perform an overview the blocking occurrences in 2020 using the University of Missouri blocking event archive (<http://weather.missouri.edu/gcc>). We will examine the blocking occurrences for each region of the Northern Hemisphere (NH) and Southern Hemisphere (SH) separately, and discuss a few recent trends in blocking activity. The NH did start out slow, but a very active spring made up the difference. The SH started extremely slow, but picked up steam in May. This kept up the string of active blocking years globally (e.g., Kononova and Lupo 2020; Lupo, 2021).

a. The Northern Hemisphere

In 2020, the year began slow as January – March produced only eight relatively weak and short-lived events. For the year, there were 43 NH events, which is close to the early 21st century mean (38 +/- 8.5 events). The persistence and strength (10 days and BI = 3.12) of 2020 blocking events was similar to their climatological mean for early 21st century blocks. For the NH, the year 2020 began with a strongly positive Arctic Oscillation Index (AO) over the first three months (Jan – Mar) of the year (https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/month_ao_index.shtml). In fact, these three months were the 2nd strongest positive set of three months since 1950, trailing only winter 1988-1989. A positive AO indicates NH flow that is strongly zonal or characterized by low amplitude waves in the jet stream. This accounts for the weak blocking at the start of 2020. The flow was weakly negative overall for the rest of 2020, but strongly negative in December.

Over the Atlantic Region (80° W – 40° E longitude) in 2019, there were 16 blocking events that occurred which was at the regional mean occurrence for the early part of the 21st century. These events were also as persistent and strong as their climatological counterparts, and these were distributed across the Atlantic Region. Thus, the occurrence of blocking was not very remarkable for this region. Three blocking events lasted for 16 days or more, two from mid-March – late-April and one from late September through early October. The former two occurred over western Europe and resulted in Eastern European and western Russian cold during spring (Fig. 1a), the latter fall event occurred over Eastern Europe

resulting in warmer than normal conditions for Eastern Europe (not shown). The mid and late-April blocking was a very strong one (BI = 4.76) and associated with a concurrent Pacific Region event.

The Pacific Region (140° E- 100° W) showed a little more remarkable variability in spite of the occurrence of 12 blocking events in 2020 which is close to normal for the early 21st century. Most of these, however, occurred during the spring months (6), and only three events occurred within the Pacific over the last half of the year. These events were slightly less persistent (-11%), but a little stronger than their climatological means (+5%). Another unusual occurrence was that 10 of 12 of these events occurred east of the International Dateline, many occurring in the Gulf of Alaska, a region known for producing cold weather across the central USA when blocking exists there (Nunes et al. 2017). Four blocking events occurred within the Alaska Gulf from late March to the end of May. The mid-April event was quite strong (BI = 4.79) and was part of the double blocking event described for the Atlantic region. The result was Alaska was a bit warmer than normal, but the north central and northeastern USA and Canada were cooler than normal (Fig. 1a). This occurred in association with the COVID-19 inspired lockdowns, causing many to remark on the cooler conditions coinciding with the lack of economic activity. Many people thought there might be a link, but the atmospheric carbon dioxide did not drop during this time. In the central USA, early May featured a late frosty period from the 9th to the 12th. In Columbia, we set a record low of 36° F on 11 May and tied the record low on two other days. Another Gulf of Alaska region blocking was associated with unusual cold and snow in late October for the upper and central Midwest. Many places saw their snowiest late October in almost 110 years.

The other big story associated with the Pacific and Continental Region was the strong heat that occurred over Northern Siberia, especially over the second half of the year. For October 2020, the temperature was more than 10° C above the 1981-2010 normal (not shown) for northern Siberia and the adjacent Arctic Ocean. On 20 June 2020, Verkhoyansk, Russia, which is above the Arctic Circle, recorded their first 100° F day (Lupo, 2021 and references therein) on record. This was associated with a warmer than normal June (Fig. 1b) and a blocking event that dominated the region for the last part of June, bringing the hot dry weather.

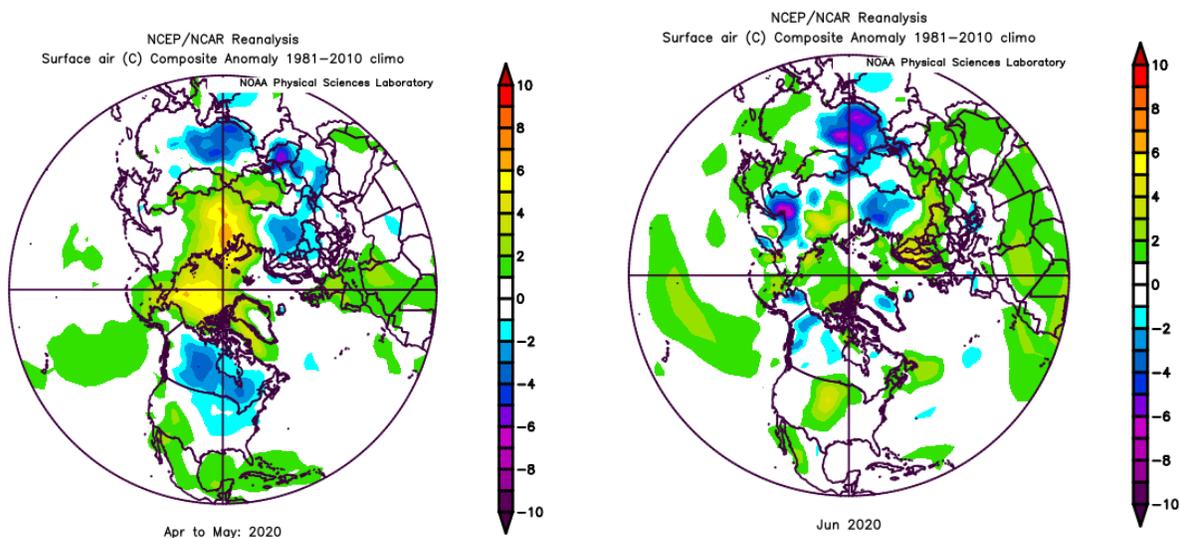


Figure 1. The Northern Hemisphere surface temperature anomaly (°C) for a) April – May 2020 (left), and b) June 2020 (right).

In 2020, the Continental Region (40° – 140° E, 100° W – 80°W) was quite active experiencing 50% more blocking events typical in a year for the early 21st century. These were interspersed throughout the year and occurred mainly over Russia and Siberia (14 of 15), resulting in the hot conditions described above. A weak, short-lived blocking occurred over North America in the latter part of May resulting in cloudy cool conditions for the time of year. As shown in many studies, the occurrence of blocking over North America is comparatively rare, and this was the first one over North America in four years! The Continental events were a bit more persistent (+11%) and stronger than the typical 21st century climatological Continental event.

b. The Southern Hemisphere

Like the NH, the SH in 2020 got off to a late start in terms of blocking activity. In fact, since 1970 only 1994 (May 24th) had a later date for the appearance of the first event which this year formed on 10 May near the International Dateline. Once the year got started, however, the occurrences (18) were quite close to normal by December. The SH featured blocking events that were 10% less persistent, but 10% stronger than those typical for the early 21st century. In fact, this year the BI was 3.14 in the SH which trails 2015 and 2016 for years in which BI was greater than 3.00 and the number of occurrences were average or greater. Of these 2020 events, 17 events were Pacific Region events. The Indian Ocean region was shut out for the first time since 2016 and the second time since 2004. These years also featured only one Atlantic Region Blocking event. The one event that occurred in the Atlantic Region was part of a busy Spring, occurring in early October. Just over two thirds of the blocking events were West Pacific events versus East Pacific events. This is typical. Also, the East Pacific Events were quite strong compared to normal.

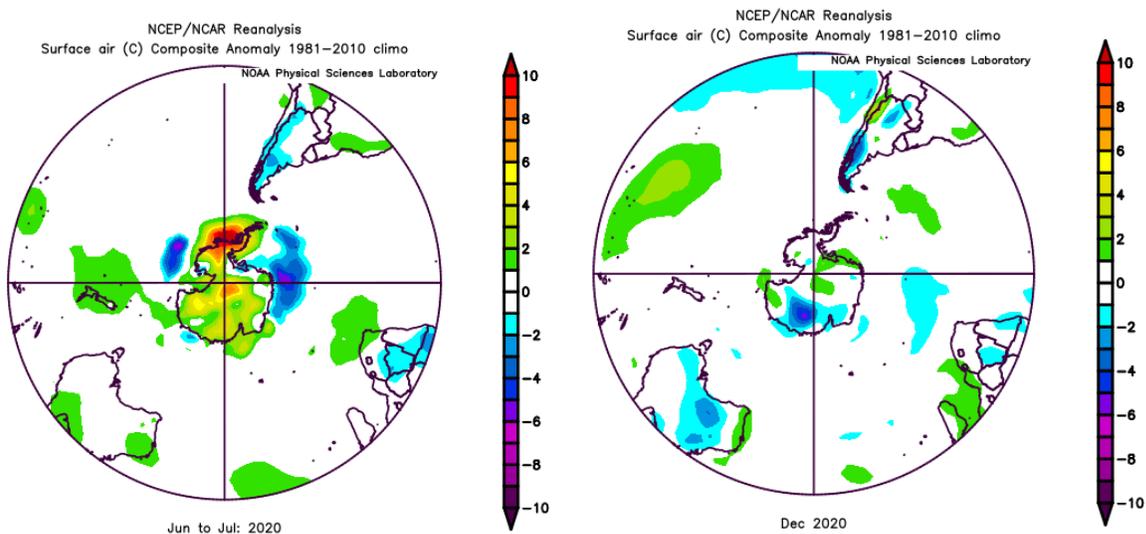


Figure 2: The Southern Hemisphere surface temperature anomaly (°C) for a) June – July 2020 (left), and b) December 2020 (right).

The SH weather was relatively quiet during 2020, and as such there is not much to report. As expected, blocking at or near the International Dateline resulted in a warm New Zealand (May and December – see Fig. 2b). The southern part of South America experienced a cold winter, as three blocking

events occurred off the west coast of the continent (Fig. 2a) from mid-June to mid-July. One of these was particularly strong and persistent resulting in the coldest weather from late June to early July. Last year ended with record setting heat and forest fires over Australia, but 2020 finished up cool. The cool May and December (Fig. 2b) over Australia was likely the result of the New Zealand blocking.

In summary, the number of blocking events occurring globally in 2020 was 61 events compared to the global normal of 55 events. This can be considered a typical year. The year 2019 finished quietly, and this lack of blocking activity stretched into early 2020. In fact, the SH had the 2nd latest start on record. Within the NH, the Atlantic and Pacific Region blocking character was near normal. Only the Continental Region was a little more active than typical, and the first blocking event occurred over North America since 2016. In the SH, the blocking activity was dominated almost exclusively by the Pacific Region as only one event occurred outside of this region. Blocking in the SH likely drove the cooler winter for South America, but outside of this, there were not any extremes associated with blocking. In the NH, a cool spring and late October were associated with late frosts and some early snow in the central and upper Midwest. The early snow was the most in over 100 years, and likely associated with blocking in the Gulf of Alaska. Continental and west Pacific blocking drove very warm conditions in Northern Siberia, including the first 100° F recorded above the Arctic Circle. The slow start to the blocking year and NH extremes occurred within the backdrop of the COVID-19 pandemic, and therefore did not receive as much attention this year.

References:

Kononova, N.K., and A.R. Lupo, 2020: Dynamics of the global atmospheric circulation and climate change. *Atmosphere*, **11(2)**, 14 pp. doi:10.3390/atmos11030255.

Lupo, A.R., 2021: Atmospheric Blocking Events: A Review. *Annals of the New York Academic of Sciences*, in press, early online release, doi:10.1111/nyas.14557.

Nunes, M.J., A.R. Lupo, M.G. Lebedeva, Y.G. Chendev, and A.B. Solovyov, 2017: The occurrence of extreme monthly temperatures and precipitation in two global regions. *Papers in Applied Geography*, DOI: 10.1080/23754931.2017.1286253.

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