Executive Summary

DOI: 10.25923/mn5p-t549

R. L. Thoman[1,2], J. Richter-Menge[3], and M. L. Druckenmiller[4]

[1]Alaska Center for Climate Assessment and Policy, University of Alaska Fairbanks, Fairbanks, AK, USA
[2]International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA
[3]Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks, AK, USA
[4]National Snow and Ice Data Center, University of Colorado Boulder, Boulder, CO, USA

The Arctic Report Card (ARC) provides an annual update on the state of the Arctic's climate and environment as well as highlights of Arctic science news of the past year. ARC2020 features 16 essays, 11 of which provide updates on a wide range of Arctic science topics, from the past year's air temperatures and sea ice conditions to the latest in bowhead whale research. Taken as a whole, across a variety of disciplines and viewpoints, the story is unambiguous: the transformation of the Arctic to a warmer, less frozen, and biologically changed region is well underway. Extreme high temperatures in the Eurasian Arctic in spring and summer 2020 provide a clear demonstration of the strong connections within the Arctic environment that characterize this region. Three closely connected essays examine the acquisition of observational data and their use in modeling to understand physical systems in the Arctic. ARC2020 also marks the publication's 15th anniversary. Two essays reflect back across the evolution of the ARC itself and the tools utilized to help understand the changes in progress. We must report that, like so much else, ARC2020 was altered by the COVID-19 pandemic. A planned essay on the impacts of the changing Arctic on food security from the viewpoints of Indigenous marine mammal hunters from two northwest Alaska communities had to be postponed to a future ARC due to travel and community-related exposure restrictions.

Changes in air temperature and sea ice (extent, volume, and seasonality) are at the root of changes across the Arctic environment. In a year of many extremes, the annual (October to September) SAT anomaly poleward of 60° N was 1.9°C above the 1981-2010 average and was the second highest on record since at least 1900. This marks the 9th of the last 10 years when SAT anomalies were at least 1°C warmer than the 1981-2010 mean. Driving this annual extreme were anomalously warm conditions across much of the Eurasian Arctic for most of the first seven months of 2020 and during the summer over the central Arctic basin. These air temperature extremes both contributed to and in part were caused by extremes in the Arctic sea ice. Sea ice loss in spring 2020 was particularly early in the East Siberian Sea and Laptev Sea regions. During June, ice extent in the Laptev Sea dropped to record low levels for that time of year. More broadly, both winter and summer sea ice extent extremes continued declining trends. In 2020, the end of winter extent was the 11th lowest in the 42-year satellite record and the end of summer extent was the second lowest, 2012 being the record minimum year. Satellite-derived sea ice thickness (available only since 2010) showed both the winter maximum and late summer minimum to be near the lowest in the decade since data collection began.

The terrestrial Arctic environment is very sensitive to air temperature at varying time scales, especially during spring and autumn. The snow cover (or lack thereof) exerts a strong control on weather and climate, as well as on the larger ecosystem, through reflection of incoming solar energy and its insulating effect on the ground's ability to gain or lose heat. Snow accumulation during the 2019/20 winter was above normal across the entire Arctic. However, the exceptional spring warmth across the

Eurasian Arctic resulted in the lowest June snow cover extent in this region since the observational record began in 1967. The May Arctic snow cover extent during the 1981-2020 period is decreasing at a rate of 3.7% per decade, with a much higher rate of loss (15% per decade) for June over this same period.

Variably in the seasonality of snow cover is an important control on wildland fire activity in high northern latitudes. Arctic wildfires occur primarily, though not exclusively, in the boreal forest (Taiga), the world's largest terrestrial biome. In this region wildfires are highly variable in space and time, driven by sub-seasonal drying of fuel over weeks and controlled by climate. Increasing trends in air temperature and fuel availability over the 41-year record (1979-2019) suggest that conditions are becoming more favorable for fire growth, with more intense burning, more fire growth episodes, and greater consumption of fuels. The extreme wildfires in 2020 in Sakha Republic offer another example of the impact of the extreme warm spring and summer air temperatures in the Eurasian Arctic.

Tundra productivity (i.e., greenness) is sensitive to summer air temperature but in complex ways, with other factors playing a significant role, such as the characteristics and timing of the spring snow retreat. In North America, tundra productivity for the 2019 growing season rebounded strongly from the previous year, in tandem with record summer warmth following the cold summer of 2018. Since 2016, greenness trends have diverged strongly by continent; peak summer greenness has declined sharply in North America but has remained above the long-term mean in Eurasia. (Note that unlike other ARC Vital Signs, satellite-based tundra vegetation analysis lags a year behind other essays due to data processing constraints. See ARC2019 for details on surface air temperatures during 2019.)

Ocean surface temperatures (SSTs) in the Arctic during spring and summer are strongly tied to sea ice presence or absence as well as ocean currents and atmospheric parameters. August 2020 mean SSTs were ~1-3°C warmer than the 1982-2010 August mean over most of the Arctic Ocean. Exceptionally warm SSTs in the Laptev and Kara Seas distinguished August 2020 SSTs, coinciding with the early loss of sea ice in this region. The strong interannual variability in spatial patterns of SST bears a close relationship to early summer sea ice concentrations because the regions of low sea ice area allow more direct solar heating of the exposed surface waters. August mean SSTs show statistically significant warming trends for 1982-2020 in most regions of the Arctic Ocean that are ice-free in August. Also tied to sea ice and ocean temperature conditions is productivity at the bottom of the marine food web. During July and August 2020, a ~600 km long region in the Laptev Sea of the Eurasian Arctic showed much higher primary productivity (~2 times higher for July and ~6 times higher for August) than the same months of the 2003-2019 multiyear average.

Air temperatures, storminess, sea ice and ocean conditions are major factors in permafrost coastal erosion. Permafrost coasts in the Arctic make up more than 30% of Earth's coastlines. A high proportion of Arctic residents live in the coastal zone, where industrial, commercial, tourist, and military presences are also expanding. Since the early 2000s, erosion of permafrost coasts in the Arctic has increased at nearly all observational sites where data extending back to approximately 1960 or 1980 are available. Permafrost coasts along the US and Canadian Beaufort Sea experienced the largest increase in erosion rates, ranging from +80 to +160%, when comparing data from the 1980s and 2000s with the 2010s.

The Greenland ice sheet is the largest Northern Hemisphere remnant of the Pleistocene glaciation, holding enough water to raise the global sea level by 7.4 meters. High regional variability in temperatures, albedo, and ice loss characterized the 2019/20 season across the Greenland ice sheet. Overall, during September 2019-June 2020, the ice sheet experienced higher ice loss than the 1981-2010 average but lower than the record 2018/19 loss. Glaciers and ice sheets outside of Greenland also continued a trend of significant ice loss, dominated largely by ice loss from Alaska and Arctic Canada.

As an example of the impact of changing conditions on marine mammals, ARC2020 includes an essay on bowhead whales, one of the iconic megafauna of the Arctic and the only "true" arctic baleen species, with a range confined to icy sub-arctic and arctic waters. They have been a staple resource for coastal Indigenous peoples from the Russian Far East to Greenland for millennia. Nearly hunted to extinction by commercial whaling in the 19th and 20th centuries, populations in the Pacific Arctic and East Canada/West Greenland region are thought to have now recovered to early 19th century levels. The population size of bowheads in the Pacific Arctic has increased in the past 30 years likely due to increases in ocean primary production as well as the northward transport of the zooplankton on which they feed.

Observations are the backbone of scientific inquiry. While remote sensing provides vital large-scale data, many important parameters can only be gathered in situ. For nearly half a century, NOAA's Barrow Observatory, just northeast of Utqiaġvik, Alaska, has observed the atmosphere and terrestrial system from what was intended to be a temporary building. After years of planning, a new facility opened in 2020, enabling the Observatory to continue existing work and affording greater collaboration with other researchers. The 2019/20 period also brought the greatest international research effort conducted in the Arctic sea ice pack in more than 20 years, the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC). Focused on data gathering to improve understanding of the physical processes occurring at high latitudes, this legacy dataset will enable research to improve modeling and predictive capabilities for years to come.

2020 marks the 15th year of the ARC. In 2006 it was clear that the Arctic was changing. However, the complexity of change was less understood and the rapidity of change that would occur in just a few years, highlighted by the (then) record-smashing low September 2007 sea ice extent, was unanticipated. In concert, an analysis of data products used to support the ARC over the course of its 15 years, along with a newly developed custom ARC data portal, reveals that the evolution of tools and available data has advanced the quality and accessibility of observations. Another important development of the last 15 years is the strengthened commitments to collaborate with the Indigenous peoples of the Arctic so that their integrated, cumulative, holistic understanding of the Arctic environment acquired over many generations critically contributes to today's shared understanding of the changes occurring across the region.

Consistent with past ARCs, across the ARC2020 essays runs the theme of variability, both in time and place. While sometimes referred to as "the new normal," in reality, most parts of the Arctic environmental system are continuing to change very rapidly, with each ARC providing a snapshot of "where things are now." As the past 15 years of ARCs have vividly demonstrated, the Arctic of yesterday is different from today, and the Arctic of today is not predictive of tomorrow.

Acknowledgments - Past and Present Arctic Report Card Editors

While NOAA has supported the production of the Arctic Report Card since 2006, the content from year to year is formally arranged by a small group of dedicated editors that support the efforts and fruition of the Report Card, from inception in June to the press release in December. This team of Arctic scientists brings their unique backgrounds in shaping the Report Card, providing a rigorous internal review of the

essays, refining the content by identifying systems-level linkages, and providing a guiding eye and vision for the highly praised Arctic Report Card videos and website.

On behalf of the NOAA Arctic Report Card production team, thank you to past and present Editors for your dedication and service to this hallmark publication.

James E. Overland (2006 - 2017)
Jacqueline Richter-Menge (2006 - 2020)
Martin O. Jeffries (2011 - 2016, 2018, 2019)
Jeremy T. Mathis (2016)
Emily B. Osborne (2017, 2018)
Matthew L. Druckenmiller (2019, 2020)
Richard L. Thoman (2020)

Please visit the Arctic Report Card's Meet the Editors webpage to learn more about a few of these Editors.

December 7, 2020