Executive Summary

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The Arctic continues to warm faster than the globe overall and in 2024, for the 11th year in a row, Arctic temperature anomalies were higher than the global average. With 2024 on track to be the world's hottest year on record, on the heels of a 2023 record, heightened Arctic warming is even more alarming. The 2024 Arctic Report Card (ARC2024) brings forward direct observations of record-breaking and near-record breaking conditions that combine with stark regional differences to make local and regional experiences of environmental change highly variable for people, plants, and animals. The geographic designation of the Arctic has many definitions (e.g., here are a few). Each ARC2024 essay notes the geography of focus for the observations discussed. ARC2024 provides an annual update on eight Arctic *Vital Signs*, from ocean primary productivity and surface temperatures to tundra greenness and snow cover, and examines three *Indicator* topics on Alaska ice seals, North American caribou, and Arctic lands as sources of global heat-trapping carbon emissions. The ARC2024 *Frostbite* contributed by the Ittaq Heritage and Research Centre in Kangiqtugaapik (Clyde River), Nunavut is a powerful reminder that Arctic Indigenous hunters and harvesters are the region's original researchers, developing complex and nuanced knowledge frameworks that are vital for Arctic Indigenous peoples and contribute to local to global research and observations.

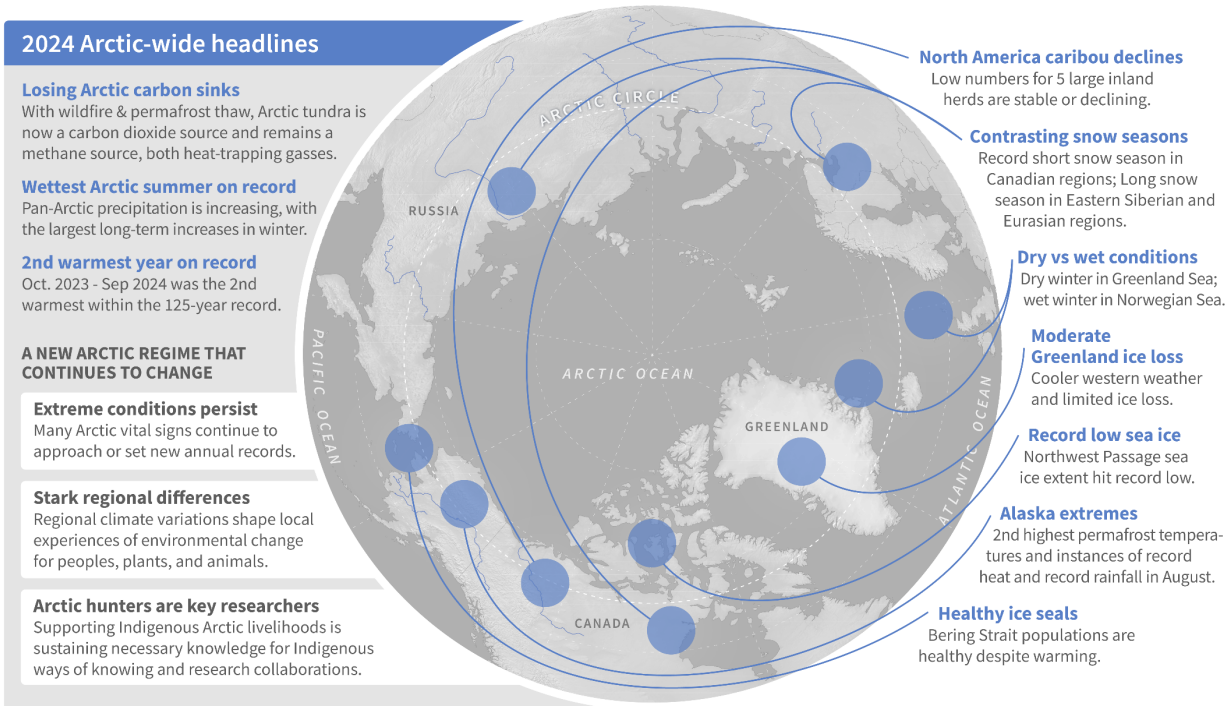

Fig. 1. A sample of notable events and important topics from across the Arctic.

Fig. 2. The ARC2024 map provides a general geographic reference for many locations mentioned in this year's report.

The multidecadal records for many *Vital Signs* suggest that the Arctic exists now within a "new regime", with recent observations that are not always setting new annual records but are still consistently within a more extreme range compared to past baseline records. For example, though the minimum sea ice extent for 2024 was only the sixth lowest on record (beginning in 1979), the last 18 September extents are the 18 lowest within those 45 years. At the same time, the extent of thicker, older ice, which is an important habitat for many species, has remained very low since 2007. Similarly, sea surface temperatures in the Arctic did not climb to record levels in 2024, yet a long-term warming trend is clear and most Arctic Ocean marginal seas were ~2-4°C (3.6-7.2°F) warmer in August 2024 than the 1991-2020 baseline. One more example from the marine environment is overall high primary productivity, including sharp increases in some seas during the 2003-24 observational record.

Framing the Arctic as in a "new regime" underscores that the region today is dramatically changed from even a decade or two ago, yet it must not imply that the Arctic climate has stabilized under human-caused warming. Projections of climate change for the next several decades are clear: change will continue. Every year the Arctic Report Card includes observations that bring sometimes surprising and often sobering news about the Arctic environment. This year, the *Indicator* essay on carbon cycling notes that permafrost warming trends continue, with Alaska observations showing the 2nd warmest permafrost temperatures on record. The essay also discusses a multidecadal increase in wildfires across North American permafrost regions, with wildfires now an urgent, annual concern for Arctic residents.

These changes together are pushing the Arctic into uncharted territory; the Arctic tundra region has shifted to being a global source of carbon dioxide (CO_2) rather than a carbon sink, and the region continues to be a methane (CH_4) source as well. Both powerful heat-trapping gasses, the transition to acting as a source for both CO_2 and CH_4 is of global concern as societies struggle to rein in emissions and align with the international Paris Agreement goal to limit warming. Common understandings of the timing and character of Arctic seasons are also now challenged. For example, over the past 15 years, Arctic snow melt has commonly occurred 1-2 weeks earlier in May and June for both North America and Eurasia as compared to historical conditions.

Focusing on annual and long-term averages, however, can mask another key characteristic of the Arctic today: stark regional differences that can make it challenging to plan for certain weather conditions and create strongly contrasting experiences of Arctic change. Even with above average snow accumulation for the 2023/24 winter and a longer than average snow season in Eurasian Arctic regions, portions of central and eastern Arctic Canada had the shortest snow season in the 26-year record. Despite the Arctic experiencing the second warmest summer on record overall, weather patterns brought cooler conditions to western Greenland and the Greenland Ice Sheet experienced only modest ice loss. Losing only 55 ± 35 Gt of ice mass during September 2023-August 2024, this was the lowest annual ice loss since 2013. Late fall (October-December) 2023 saw drier conditions than usual over the East Greenland and Barents Seas, while just southeast of this area conditions were wetter than usual over northern Eurasia. Tundra greenness is another good example. While the 2024 circumpolar average greenness value was the second highest in the 25-year record, continuing a recent sequence of high greenness values, smaller zones across the Siberian tundra were anomalously brown.

The Arctic works as a complex, connected system. Some system connections are easier to see. For example, the Chukchi Sea west of Alaska experienced cooler than normal spring and summer air temperatures, low sea surface temperature for August 2024, and the persistence of an unusually long-lived zone of sea ice, which was formed by strong convergence and deformation in spring. There is little doubt that these conditions fed into each other, revealing how regional air temperatures, water temperatures, and ocean dynamics shape ice conditions that in turn have consequences for marine life and coastal communities. But we must refrain from extrapolating any one year's apparent connections to predict long-term system change; instead we must follow the story of long-term observations. For example, ice seal populations, including ringed, bearded, spotted, and ribbon seals, across the Bering to Chukchi Seas remain healthy despite dramatic long-term warming and sea ice loss within their habitat. Yet, ringed seal diets are showing an increase in saffron cod and decrease in Arctic cod, which is predicted with warmer water. We do not yet know how seals' adaptive capacities are being limited or enhanced by the complex ecological changes and shifts they are experiencing. Continued monitoring and collaboration across topics, organizations, and communities is necessary.

The Arctic environment of 2024 is already dramatically changed from decades past and change will continue for decades to come. For some plants and animals, these changes may prove devastating. North American migratory tundra caribou numbers have decreased by 65% since a peak in the 1990s and early 2000s. While the generally smaller coastal herds of the western Arctic have seen some recovery over roughly the last decade, previously large inland herds are continuing a long-term decline or remain at the lowest populations noted by Indigenous elders. The ability of caribou to adapt to climate change by moving to new regions can also be limited by roads and development. Herds like the Bathurst Herd in north central Canada are under serious threat, a grave concern for local peoples whose food security has been tied to these animals since time immemorial.

Arctic residents are responding in the moment to the changes underway, and the deep observational skills of those like the Indigenous hunters in the Kangiqtugaapik region are helping their communities understand, prepare, and take action. While we can hope that many plants and animals will find pathways for adaptation, as ice seals in the Bering Strait have so far, hope is not a pathway for preparation or risk reduction. Only the strongest actions on mitigating heat-trapping gas emissions, with almost all human-produced emissions created outside of the Arctic, will allow us to minimize risk and damage into the future. Support for observations, collaboration, and adaptation is required in every scenario. In our connected Earth system, we all have a role to play to minimize risk, support adaptation, and foster collaboration to realize the best possible outcomes within the challenging pathway ahead.

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