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Lessons from the Arctic—The Need for Environmental Observations

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INTRODUCTION

In the United States, the processes of responding to natural emergencies or managing our natural resources evolved from a long history of awareness and understanding derived from observations and monitoring, combined with assessment through established and accepted analytical methods. From weather forecasts to managing fisheries, our nation has relied on expert knowledge of historical norms and understanding the consequences of deviating from those norms. Management of traffic, water usage, industrial emissions, food additives, and nearly every other aspect of life in today's society is regulated based on society's concurrence that population health, sustainable resources, and a civil society are maintained through environmental measurement and analysis. In light of our nation's dependence on environmental monitoring to enhance safety, security, and resource allocations, it is contrary to our collective consciousness to eliminate the essential source of information that is critical to enable informed decisions. Environmental observations are essential for awareness and responding to changes, threats, and sustainable use. As a means of highlighting the importance of, and need for, environmental observations, the Arctic provides a compelling focus, through past examples of societal responses driven by federally supported monitoring, and illustrations of the vulnerabilities arising from the loss of environmental observations.

ROLE AND BENEFITS OF FEDERALLY SUPPORTED OBSERVING NETWORKS

The National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service (NWS) was established shortly after the American Civil War to benefit commerce and to provide information on potential storms. Over the years, the NWS grew in size and responsibilities to provide forecasts of floods, droughts, hurricanes, and other extreme events as well as routine weather dynamics. Industry, commerce, law enforcement, and entertainment became increasingly dependent on reliable weather projections. Since Alaska became part of the United States in 1959, NOAA's weather forecasts and other essential services were extended to include an Arctic component. As weather records and observations of extreme events accumulated over decades, engineering design criteria and construction evolved to more appropriately consider local environmental conditions, improving resilience and reducing maintenance and replacement costs. NOAA Fisheries also plays the essential role of assessing stocks and productivity of marine ecosystems. Their surveys and analyses are crucial for setting catch limits and ensuring sustainable fisheries.

The U.S. Geological Survey Water Resources Division initiated stream gauge and groundwater monitoring in 1889 primarily for the purpose of characterizing water resources for irrigation and hydropower. As the need and technology advanced, priorities expanded to include flood control and water resource management. Such information became critical in assessing in-stream flows, riverine navigation, water use permitting, pollution detection and clean-up, and protection of ecosystems and wildlife.

The U.S. Environmental Protection Agency (EPA) has been responsible for monitoring and observing environmental conditions and enforcing regulations to prevent contamination of our nation's land, water, and air. The EPA maintains a network of stations across the nation, including Alaska, to monitor air quality, thereby assuring compliance with the Clean Air Act. The purpose of this network is to protect public health by measuring air pollutants and issuing risk assessments as necessary. These data have been essential to identify sources of pollution and to enable communities to make informed decisions regarding protection of public health.

NASA has provided satellite observations of Earth for decades. These have been critical in expanding our process understanding, which is gained from the point or plot scales to continental and global scales. Reconciling satellite-borne Earth observations with ground truth and modeling studies has enabled validation of seasonal and longer-term trends of land use, crop inventory, coastal erosion, marine fisheries, carbon emissions, and many other processes inherent to national, food, and energy security. Satellite observations have permeated almost every aspect of our lives including resource management, navigation, real estate sales, and weather prediction; such observations are critically important in a modern society. In the Arctic, NASA has been at the forefront of monitoring the changes in sea ice that have emerged as a bellwether for change in an environment with accelerating military relevance and industrial opportunities.

IMPORTANCE OF ENVIRONMENTAL INFORMATION

Risk management and hazard mitigation remain the greatest justification for accurate environmental monitoring. According to the NOAA National Center for Environmental Information, during the period 1980 – 2024 the U.S. experienced 403 weather and climate disasters, each of which caused damages of at least $1 billion (including 27 events alone in 2024) with total costs exceeding $2.915 trillion (Smith and Katz, 2013; NCEI, 2025). Predictions and awareness of extreme environmental events are the best defense in terms of infrastructure damage and lives lost. While we do not have the ability to prevent such disasters, with ample warning, we can prepare and in some cases mitigate property damage.

In the following, we provide several examples that demonstrate the importance of high-latitude observations, with an emphasis on the Arctic. The examples include adverse impacts of reduced observations as well as success stories in which observational monitoring has enabled policies that provide economic and societal benefits. With these examples as background, we then assess the challenges and associated risks of reduced observational monitoring by key federal agencies in the U.S.

Weather Forecasts and Warnings

Today's weather forecasts rely heavily on computer forecast models, which in turn, require accurate depictions of the initial state from which a forecast is made. Arctic upper-air observations have been shown to improve Arctic weather and sea ice forecasts (Jung et al., 2025), midlatitude weather forecasts (Sato, et al., 2017) and, in a recent defense research initiative of the Office of Naval Research, Arctic cyclone (storm) forecasts. A striking recent example of the importance of Arctic observations for storm forecasts is ex-typhoon Halong, which produced devastating winds and storm-surge flooding in villages along Alaska's southwestern coast in October 2025. While these small, isolated communities require several days of advance warning to prepare and evacuate prior to a major storm event, computer weather models shifted Halong's forecast track by more than 300 miles only 1.5 days before the storm struck the coast. In the months prior to Halong, cuts to the rawinsonde network had led to the elimination of balloon launches at several key locations in western and northern Alaska. Communication issues arising from staffing shortages compounded the data gaps, with five of 13 NWS-operated monitoring stations offline immediately prior to the storm. Not coincidentally, global model forecasts of the NWS and the European Center for Medium-Range Weather Forecasting showed notable decreases of skill in September 2025 compared to a year earlier. With Arctic coastlines becoming increasingly vulnerable to storms as the open water season lengthens (Kettle N. P., et al., 2025), and as the observational network degrades, the economic and societal benefits of forecast-based warnings of Arctic storms are becoming increasingly apparent.

Fisheries Management

Based on surveys of fish populations, marine ecological measurements, and corresponding analyses, the United States turned the corner on ending chronic overfishing — rebuilding 39 fish stocks since the year 2000. Led by NOAA, the successes include rebuilt stocks in every region of the country — from the Bering Sea to the mid-Atlantic and the Gulf of Mexico. The Magnuson-Stevens Act, first passed in 1976 and reauthorized in 2007, serves as landmark legislation for reducing overfishing and rebuilding stocks, which strengthens the value of fisheries to our economy. In the Arctic, NOAA conducts annual research and stock assessments in the Bering Sea and in the high Arctic to guide decisions for sustainable management of Alaskan and Arctic fisheries and co-manages species that are important for subsistence with Alaska Native organizations. The Alaskan pollack and crab fisheries are prime examples of effective fishery management based on systematic monitoring and assessment through data analysis and modeling.

Loss of Sea Ice

Sea ice limits Arctic marine navigation by surface vessels and by submarines used by the military. Sea ice in the Arctic has been monitored globally by satellites since the 1970s and regionally by ship and coastal reports as far back as the 1700s. Satellite monitoring has enabled the documentation of a climatically and navigationally consequential loss of sea ice over the past several decades. Summer sea ice extent has declined by more than 40% since 1980, with corresponding increases in the open water season of two to three months in the waters offshore of Alaska. Ice thickness measurements have shown that the remaining sea ice is markedly thinner than in prior decades, creating new opportunities for transits by ice-capable vessels and altering the environment for submarine operations in the Arctic. LNG (liquified natural gas) is now transported routinely by Russian tankers through the eastern Arctic seas, Bering Strait, and the Bering Sea.

The Ozone Hole

Stratospheric ozone shields humans and other forms of life from harmful ultraviolet radiation. In the late 1970s and early 1980s, monitoring of stratospheric ozone by satellites and surface-based balloon launches showed an alarming decrease in ozone concentrations over southern high latitudes. The decrease, most apparent in spring, came to be known as the "ozone hole" and, through ancillary research and measurements of stratospheric chemistry, was traced to man-made fluorocarbons. In response to the scientific information, international policymakers agreed to a ban on the most harmful of the fluorocarbons. The ban, the Montreal Protocol, came into effect in 1989. Ozone levels stabilized by the mid-1990s and began to recover in the 2000s. In 2019, NASA's satellite measurements showed that the ozone hole was the smallest ever since it was first discovered in 1982. Recovery was projected to continue over the present century, with the ozone hole expected to reach pre-1980 levels by around 2075. The ozone hole and its recovery represents a science-to-policy success story. Without the monitoring that was in place in the 1970s and 1980s, the Antarctic ozone hole would have expanded further and there would likely have been significant depletion of stratospheric ozone in the Northern Hemisphere, where significant populations would have been vulnerable to the increased u-v radiation.

FUNDING CUTS AT FEDERAL AGENCIES HARMS OBSERVATIONS AND MONITORING

As noted in the discussion of Arctic storms, staff buyouts at the NWS have already forced cutbacks in core operations (including radiosonde launches) and left multiple forecast offices shorthanded. Several observing tools and data products have been decommissioned, including the NOAA-18 polar orbiter; legacy polar operational environmental satellites data; and National Centers for Environmental Information portals like the Global Ocean Currents Database and the Marine Environmental Buoy Database access site. The climate.gov team was also laid off, reducing public climate communication and some data access. In addition to firing hundreds of workers, ceasing some weather balloon launches and cutting research on climate and weather disasters, NOAA has abruptly terminated monitoring of seismic stations that provide critical data to the Alaska and Hawaii Tsunami Warning Centers. Further proposals for budget cuts target NOAA's research arm, known as Oceanic and Atmospheric Research (OAR).

NASA

NASA's proposed 2026 budget includes the steepest science cuts on record for this agency and would terminate or defer dozens of Earth-observing missions—most notably parts of the Earth System Observatory, including the Atmospheric Observing System and surface biology and geology missions. Cuts would also eliminate the Landsat Next project, the primary US land-imaging continuity upgrade. These changes would shift NASA towards a scaled-down approach. If NASA's new budget is enacted, we will lose near-term aerosol and cloud, as well as surface biology- and plant health-related, satellite measurements. These changes would also delay or eliminate next-generation land observations that resource managers rely on.

EPA

The EPA has begun eliminating its Office of Research and Development (ORD) and is executing a large reduction-in-force. The budget plan for 2026 also eliminates or slashes 16 state categorical grants (air and water program funds), which means fewer state/local monitors, inspections, and special studies. Multiple grants, including the Solar for All program and other environmental justice-oriented awards, have been canceled. Even now, Office of Research and Development cuts are stalling field research on wildfire smoke sensors, polyfluroalkyl substances, and other public-health studies.

U.S. Geological Survey

The U.S. Geological Survey's 2026 budget eliminates the Ecosystems Mission Area (its biological research arm)—which would terminate many wildlife, fisheries, invasive-species, and disease surveillance field programs—and restructures or defers Landsat Next while keeping Landsats 8 and 9 running. Separately, budget pressure is already ending support for some streamgages in state networks, reducing flood, ice jam, and water supply data.

CONCLUSIONS

Our nation's essential reliance on the continued collection and open access to current and historical systemic environmental observations is readily apparent. The ability to protect infrastructure, resources, and lives requires expert insights and robust models to project impending dangers. Such capabilities, based upon analyses of historical time series, are the foundation of wise management of resources, informed decision making, and prudent policy formulation that benefit all residents of our nation.

It is incumbent upon our government to maintain the infrastructure and workforce required to collect these critically important observations, conduct the analyses needed to place the conditions within the realm of normal or extreme, and make such analyses available to the public in a form that is accurate and easy to understand correctly. Our policymakers, scientists, and the public must invest in monitoring efforts to maintain a society where informed decisions lead to sustainable management.

In 2032–33, the international polar research community will convene the Fifth International Polar Year. The four preceding International Polar Years established much of our understanding of Arctic and Antarctic biology and geophysics and our understanding of the role that the polar regions play in global dynamics. The historical data and existing knowledge are not adequate to protect our citizens, our societies, and our environment. The 5th International polar year will provide a unique opportunity for great scientific advances through international collaborations, but we must maintain the robust scientific projects, programs, and agencies that we have built over the past century. We must also continue to invest the resources necessary to understand these rapidly changing regions and their connection with the rest of our planet.

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