Scenarios for Energy and Resource Development on the North Slope and Adjacent Seas

Research and Monitoring Prioritization for the NSSI

Climate Change

Summary

The last few decades showed Alaska-wide increases in temperature, with variable trends in precipitation patterns. Overall, projections show warmer temperatures, particularly in winter and fall, and slight increases in annual precipitation.

Climate change acts as an overarching driver of change affecting the environment, landscapes and ecosystems. It may pose risks to infrastructure and creates both challenges and opportunities for human activities. Rising temperatures can affect sea level rise, permafrost thaw and sea ice extent and can result in flooding, erosion and infrastructure damage. Decreasing snow-cover days and delays in freeze-up dates may affect the duration of tundra travel. Changes in precipitation and evaporation rates could affect the available water supply for industry and community use.

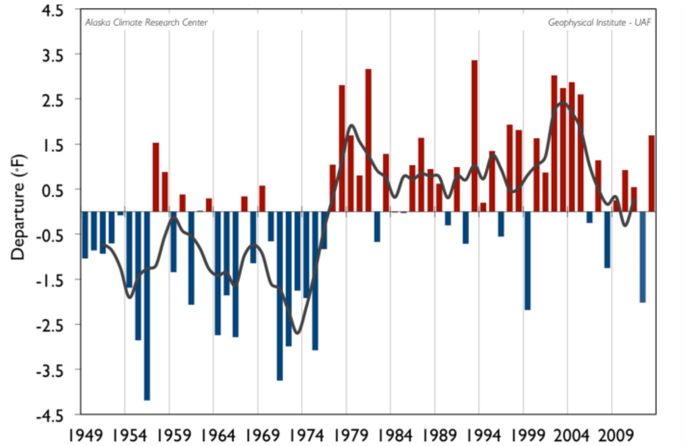

Figure 1. Mean annual temperature departure for Alaska from 1949 to 2013. Source: Alaska Climate Research Center

Overview and Trends

Current and historical observations

A warming trend in Alaska was observed over the last 60 years with a general increase of 1.7°C (3). There are seasonal differences in this trend, with more pronounced warming during the winter and autumn. The shift towards warmer mean temperatures in 1976 corresponds to the phase shift in the Pacific Decadal Oscillation. The North Slope is also warming faster than other regions in Alaska particularly in the last 30 years (2,3).

Precipitation trends varied over the past 90 years with much variation throughout Alaska. An overall increase in precipitation on the North Slope was observed in the last 30 years which was preceded by a negative precipitation anomaly from 1951-1980 (3).

Projections

The graphs and data in this fact sheet come primarily from climate models created by the Scenarios Network for Alaska and Arctic Planning (SNAP) – a research group at the University of Alaska, Fairbanks. More information on SNAP can be found at www.snap.uaf.edu.

These models, which are based on the best available scientific knowledge, provide information about what kind of changes are possible, in terms of warming temperatures, changing patterns of rainfall and snowfall, and shifting seasons. Local knowledge can put this information into context, when it comes to imagining what the future may hold for community residents.

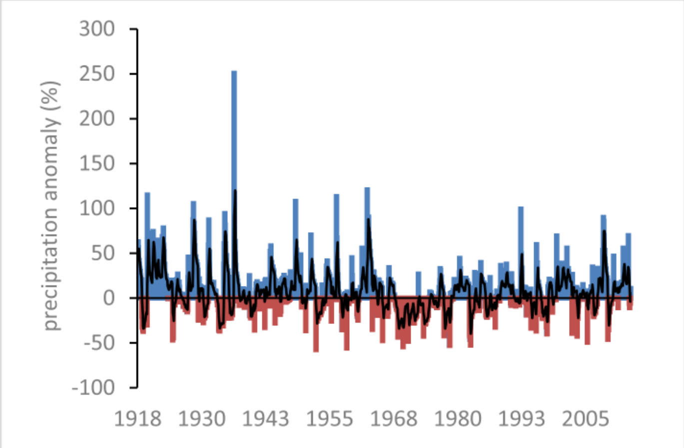

Figure 2. Alaska statewide precipitation anomalies from the 1971-2000 base period. Source: National Climatic Data Center

Temperature

Between the 2010s and the 2040s, July temperatures are projected to increase by less than 1°C, but in January temperatures are projected to increase by more than 2°C. Between 2040 and 2060 temperatures are projected to continue to increase, particularly during winter.

Precipitation

In the coming decades, the greatest change in precipitation is expected in winter and autumn, with smaller increases in precipitation expected during summer. How large these increases will be is highly uncertain (1,3,4).

Snow

Snowfall is projected to increase during the winter. However the duration of snow-cover in Alaska is expected to decrease 30-40% by 2050. The frequency of rain on snow events (5) is also projected to increase, but there are large uncertainties in modeling snow conditions.

Freeze-up and Thaw Date

Freeze-up dates are expected to occur later in autumn, with a greater number of days between the projected day of thaw and day of freeze (4 to 6 days longer from the 2010s to the 2040s). However there is a lot of uncertainty associated with our understanding of impacts of clouds, and the release of heat stored in the ocean (4).

Extreme Events: Storms and Other Phenomena

It is very likely that there will be increases in the frequency and duration of extreme warm events. Projections show that by 2030 extreme warm events will be 3-6 times as frequent, compared to present conditions. In contrast, extreme cold events are expected to decrease. Although storms are projected to become more common in the Bering Sea, the storm frequency and intensity in the Beaufort and Chukchi Seas remain highly uncertain.

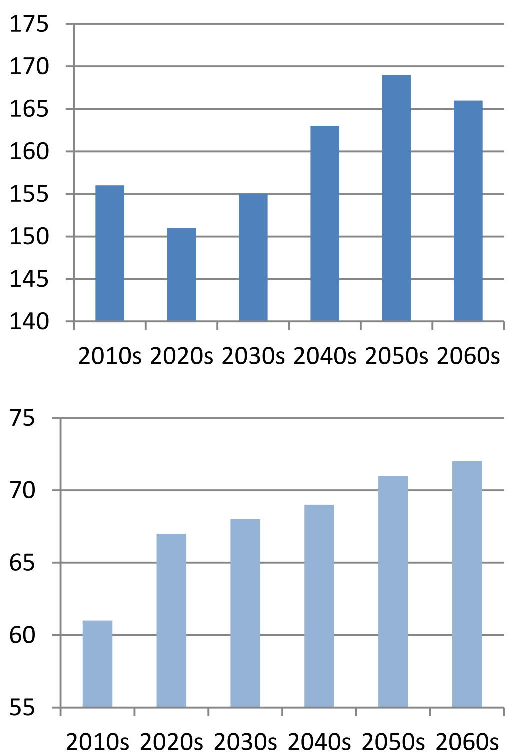

Figure 3. Projected changes in precipitation on the North Slope region in summer (top) and winter (bottom). Precipitation is shown in millimeters of rainwater equivalent.

Sea Level

Melting glacier and ice sheets, ocean thermal expansion and atmospheric pressure play a role in sea level rise in the Arctic. Sea level is projected to increase between 15 and 20 cm by 2040 (4). Sea level rise is expected to be greater in the Beaufort Sea (0.24±.08 m) and Chukchi Sea (0.22±.07 m), and somewhat less pronounced towards the Bering Sea (0.18±.08 m). However there are uncertainties in sea level rise related to differences between models, uncertainties regarding future greenhouse gas emissions and future ice discharge from Greenland and Antarctica. There are also likely to be large variations in local sea level rise related to coastal features and uncertainties in how much water is retained in glaciers, wetlands, and lakes amongst others.

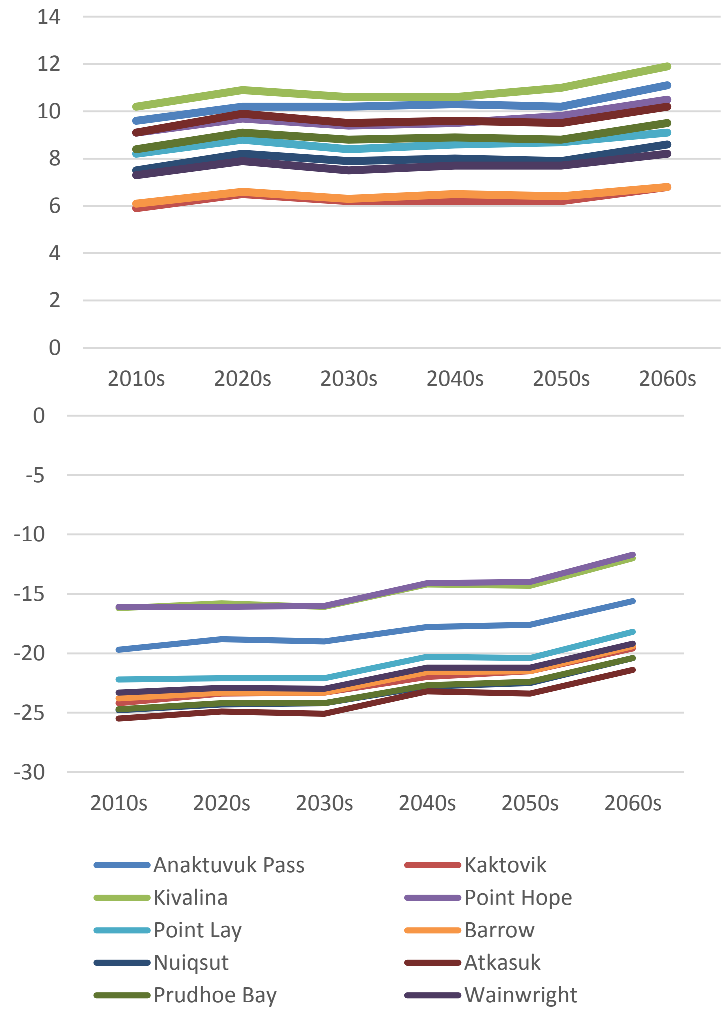

Figure 4. Temperature projections for July (top) and January (bottom) for the North Slope. Source: SNAP

Uncertainties

Predictions about climate change – like most predictions -- can never be 100% accurate. Not only are models not perfect representations of the real world, but as we all know, real weather patterns are highly variable over time. In order to show long-term climate change trends more clearly, these graphs and tables show mean projections from five different models, averaged over ten-year periods. Even so, when discussing climate change, it is usually helpful to talk about a range of possible futures (or scenarios) that may occur.

Other sources of uncertainty include natural variability, (including short-term weather patterns and longer fluctuations such as the Pacific Decadal Oscillation), natural events (e.g. volcanic eruptions), how models represent tiny particles called aerosols (which impact cloud formation and precipitation), and our ability to predict land use-change over time. Incomplete understanding of the carbon cycle, and biogeochemical feedbacks also affects climate models.

Although estimations of future greenhouse gas emissions play a large role in how models predict climate over the latter part of the century, some climate variables are less sensitive than others to which estimations are selected.

Driver interactions

Resource development

With rising temperatures, the stability of structures on land can be impacted by permafrost thaw. Thawing frozen ground may be unstable and release contaminants, subsequently affecting the locations for future infrastructure development and waste sites. Increasing temperatures and decreasing days of snow depth cover could reduce the duration when ice-roads and airstrips can be used, thus affecting transportation.

Changing precipitation and temperature patterns may affect hydrologic cycles, affecting water availability for industry use. Infrastructure close to rivers may see changes in flooding conditions as winter conditions affect the timing and severity of winter ice breakup (6). Heavy rain events during summer are also expected to become more common. Sea level rise and changes in sea ice may impact offshore and coastal infrastructure, potentially leaving them vulnerable to flooding, erosion and winter storms.

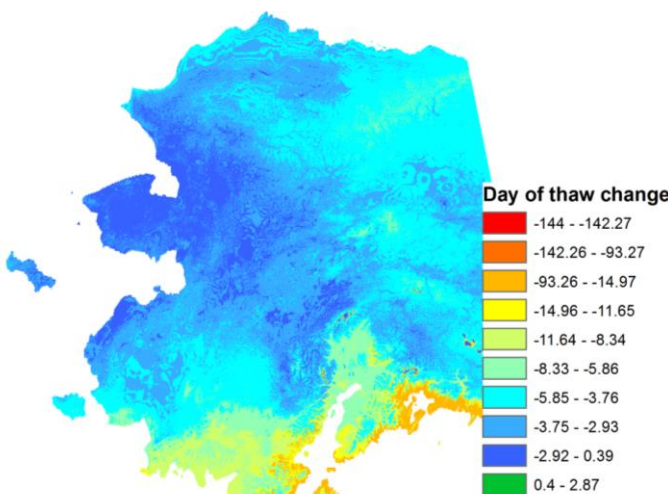

Figure 5. Projected change in day of thaw between the 2010s and the 2030s. Most of the North Slope is projected to experience spring thaw 1-6 days earlier than historical averages.

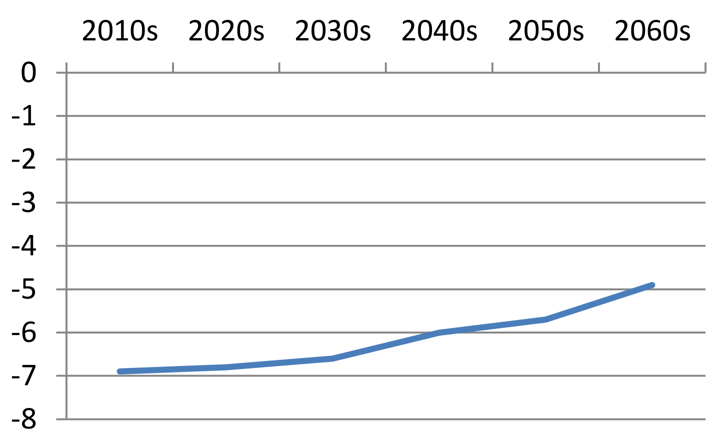

Figure 6. Projected permafrost conditions: average ground temperature at one meter below the surface across the North Slope.

Other interactions

Warming temperatures and changing precipitation patterns may have broad scale impacts on Arctic ecosystems, but may also affect weather at lower latitudes. Ecosystem impacts could result from changing vegetation, permafrost thaw, and changes to lake and stream flow. Rising sea level can cause salt water contamination in coastal habitats.

In the marine ecosystem, warming temperatures and precipitation changes can affect sea ice melt and formation and disrupt the timing of phytoplankton blooms. Ocean acidification is also an increasing risk to marine ecosystems.

Both terrestrial and marine species may suffer from heat stress, and species distributions may change. This results in habitat loss for some species, and a northward shift for some temperate species. Milder climates may also result in insect and invasive species outbreaks.

Community impacts from warming temperatures include increasing risk of damage to buildings and infrastructure from erosion, permafrost degradation, and sea level rise. Changes to hydrology can affect access to clean water. Changing animal and plant distributions can impact subsistence activities and food security. Warming temperatures also affect sea ice conditions, which in turn affect the safety, timing and duration of marine subsistence hunting.

Monitoring

The National Weather Service maintains a list of meteorological stations that record temperature and precipitation. The USGS Climate and Permafrost Monitoring Network, in collaboration with BLM and USFWS, the National Parks Service and the Arctic Long Term Ecological Research Network also monitor environmental data – this may include additional information such as wind direction, speed, and atmospheric pressure. Snow cover properties are not as widely monitored throughout Alaska although there are some remote-sensing products to monitor snow.

References

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