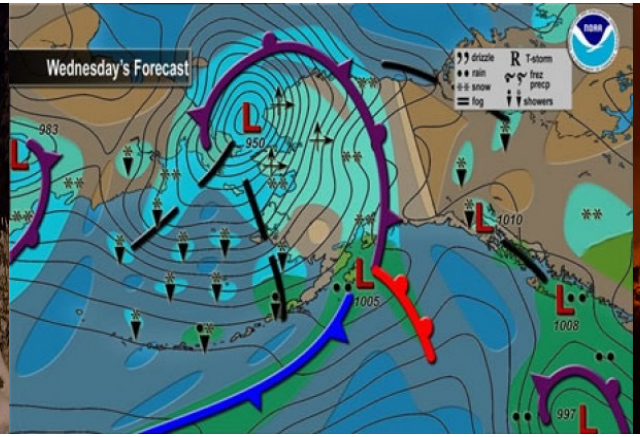
Extreme events in the Arctic:
An assessment of evidence for changes



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Workshop on Arctic Climate and Weather Extremes, Aspen, CO, May **2022**

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Extreme weather and climate events in northern areas: A review

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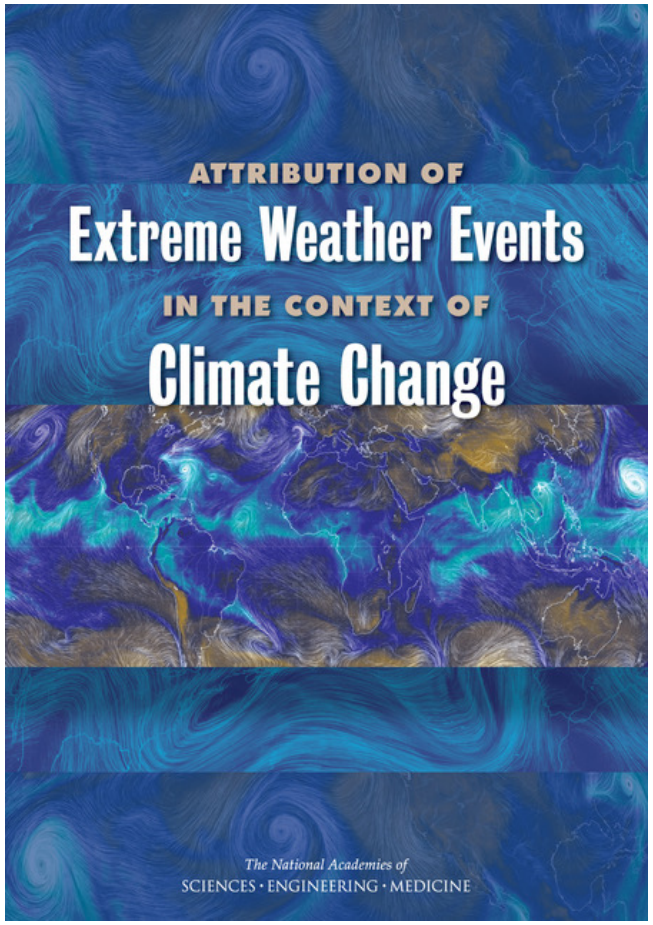
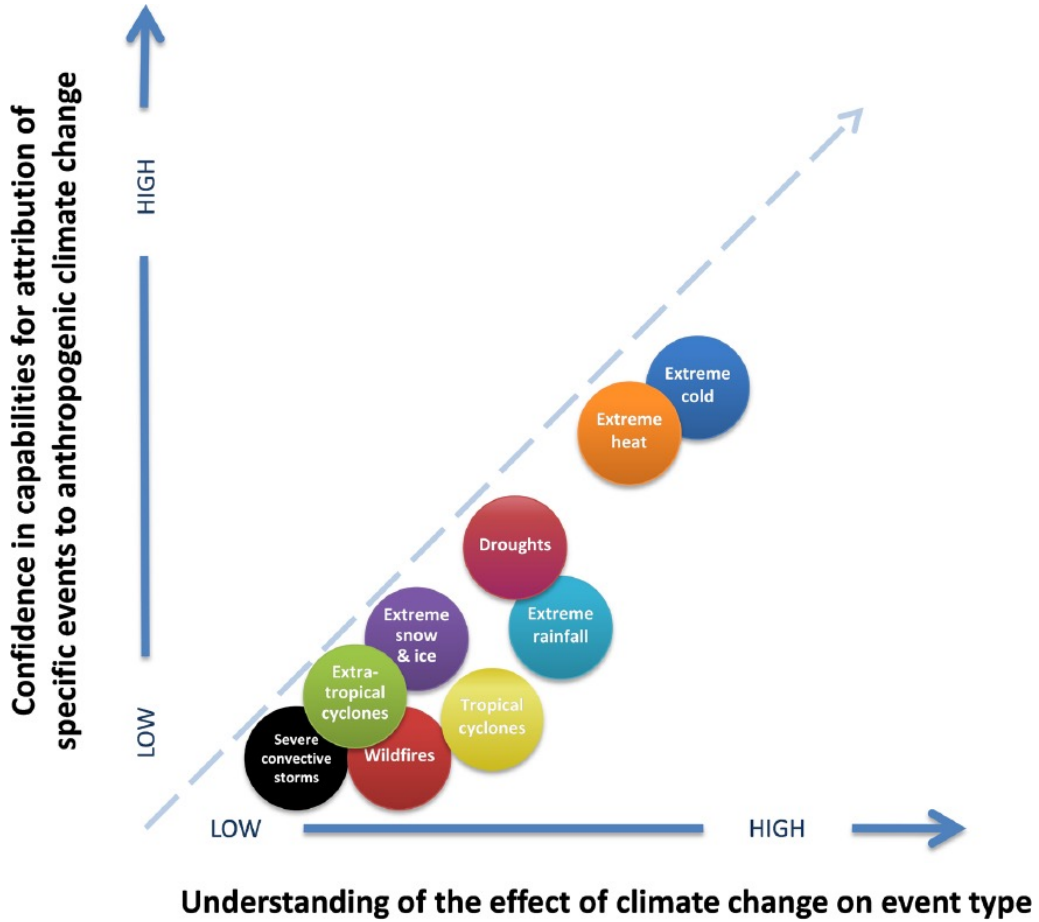
The “global” motivator: National Academies (2016) attribution report





● = high ◎ = medium ○ = low	Capabilities of Climate Models to Simulate Event Class	Quality/Length of the Observational Record	Understanding of Physical Mechanisms that Lead to Changes in Extremes as a Result of Climate Change
Extreme cold events	●	●	●
Extreme heat events	●	●	●
Droughts	◎	◎	◎
Extreme rainfall	◎	◎	◎
Extreme snow and ice storms	◎	○	◎
Tropical cyclones	○	○	◎
Extratropical cyclones	◎	○	○
Wildfires	○	◎	○
Severe convective storms	○	○	○

Our "Arctic assessment":

1) *How strong is the evidence for recent changes?*
2) *What is the level of confidence in future changes?*

Weather and climate variables:

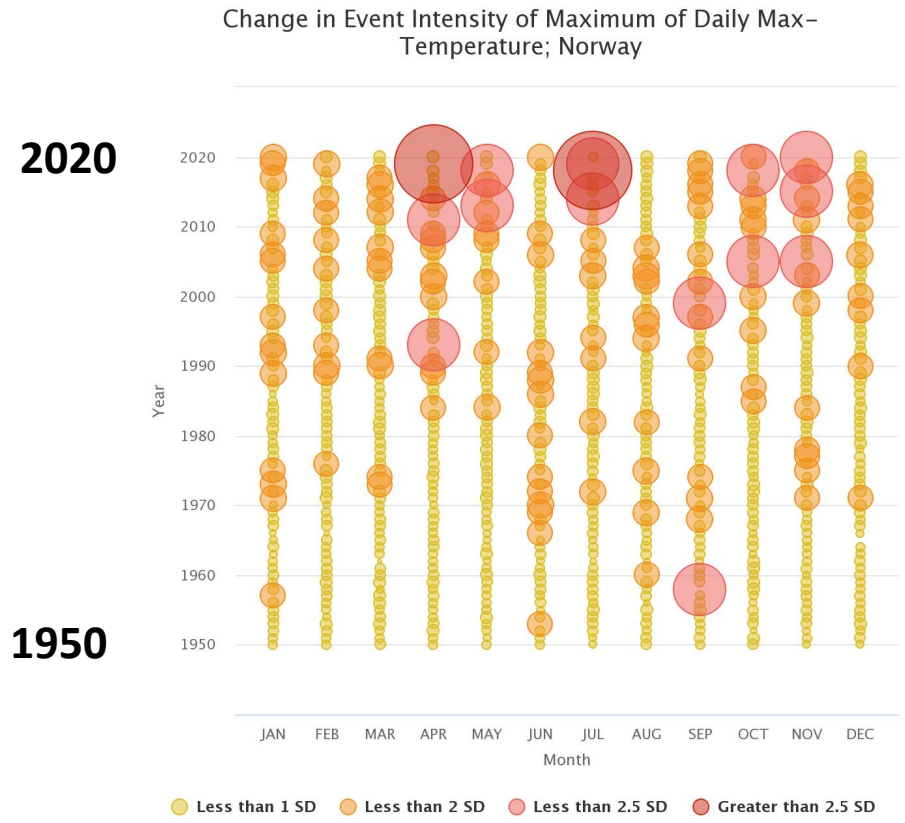
Temperature extremes
Heavy precipitation
Snow
Freezing rain
Atmospheric blocking
Cyclones
Wind

Impacts:

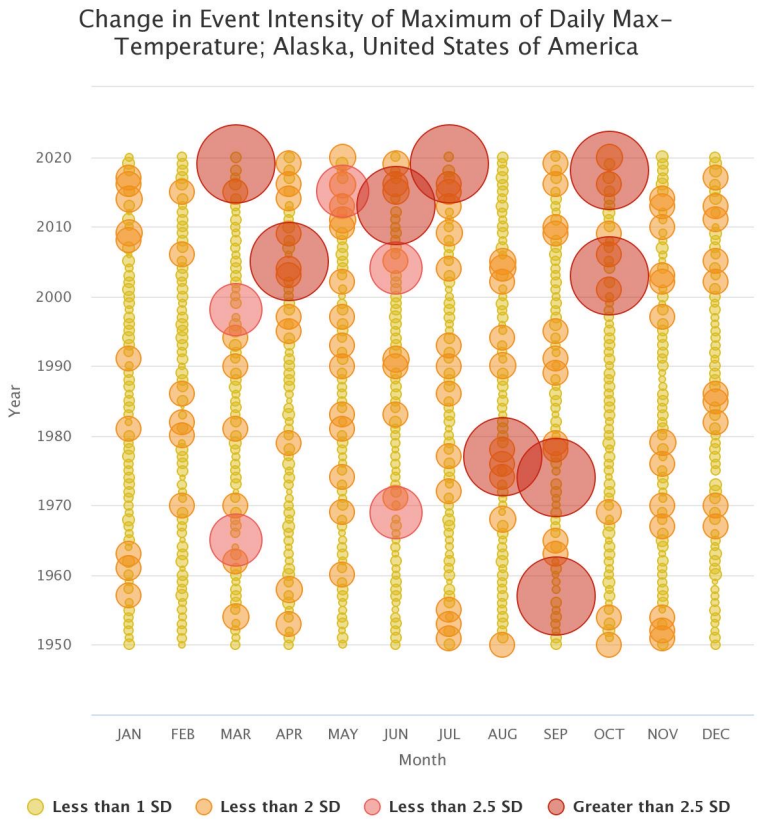
Sea ice (rapid loss events)
Greenland Ice Sheet (melt events)
Inland flooding
Coastal flooding and erosion
Drought
W ildfire
Marine ecosystems
Terrestrial ecosystems

The hottest days are becoming more frequent

Norway



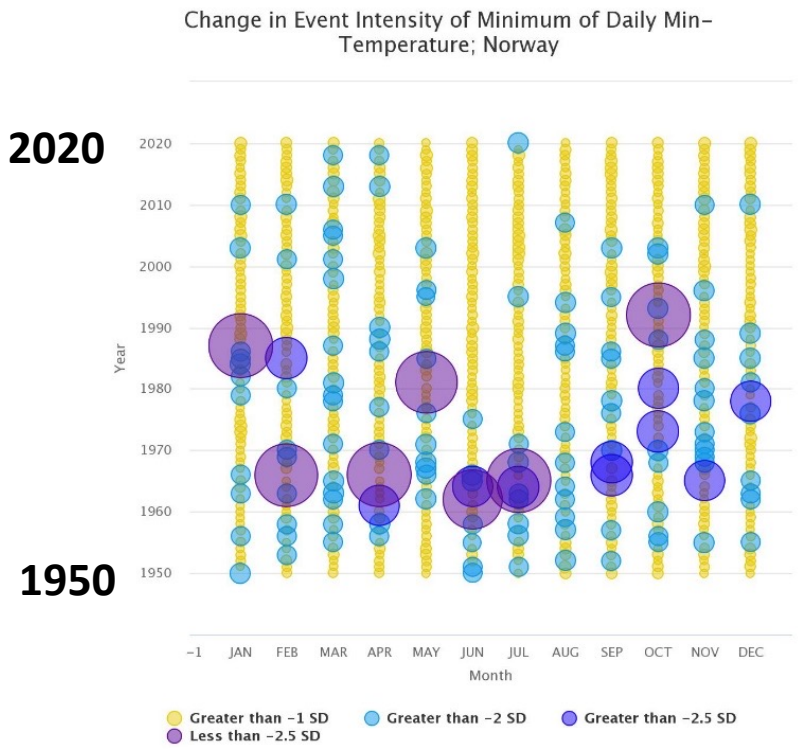
Alaska



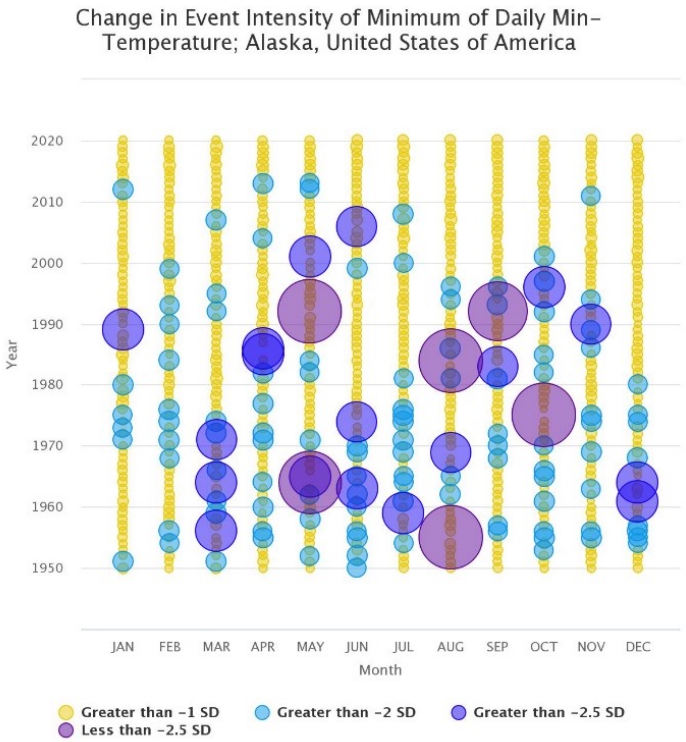
https://climateknowledgeportal.worldbank.org/

The coldest days have been have been lost

Norway

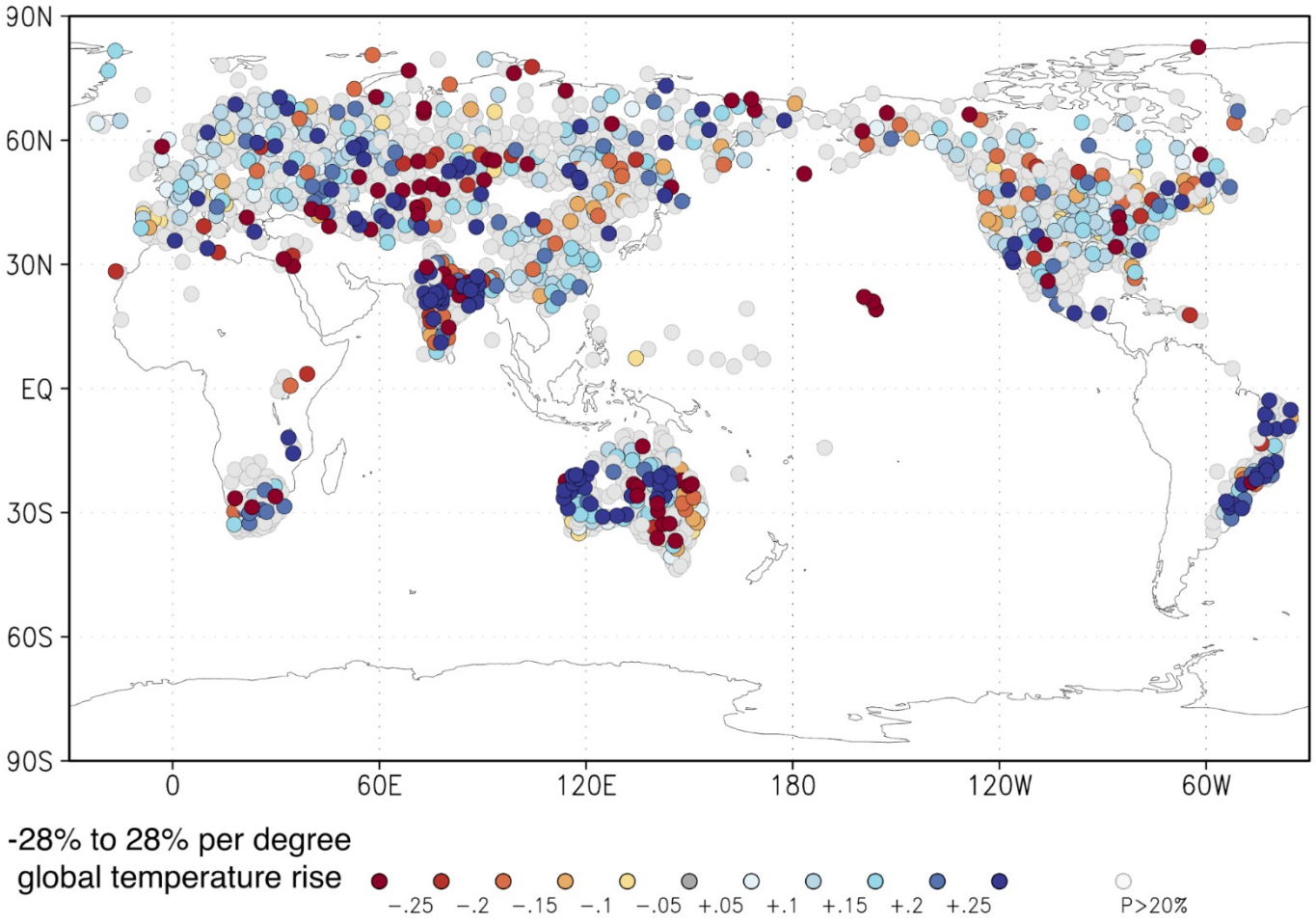


Alaska



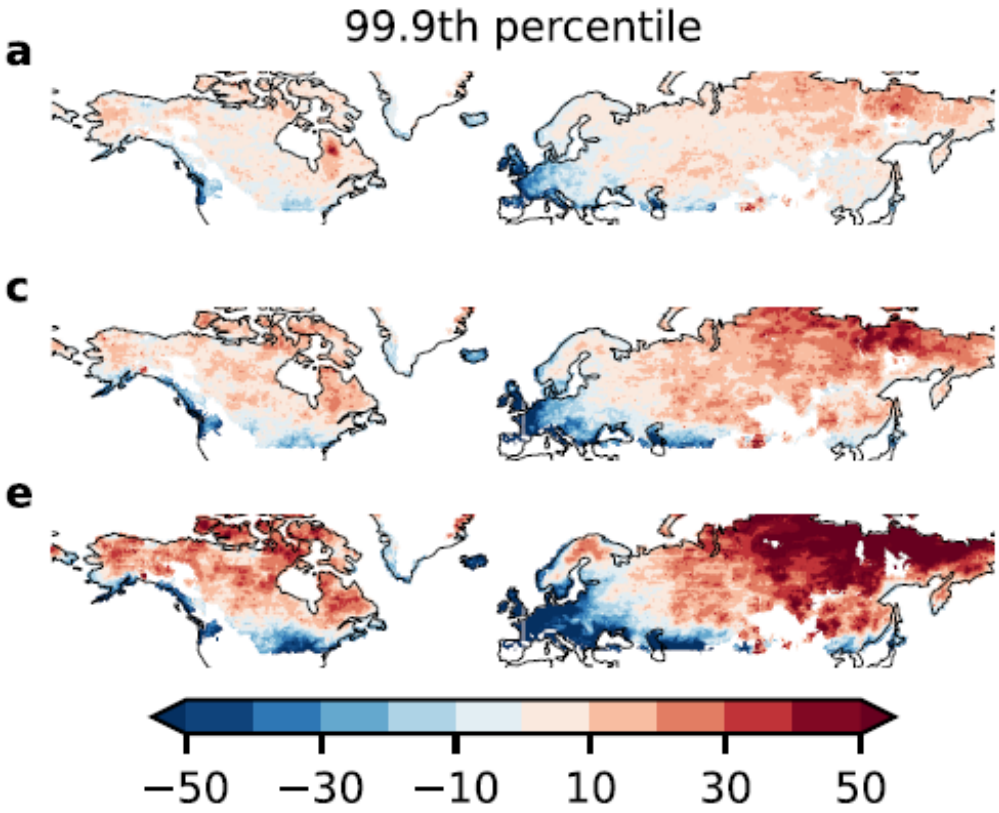
https://climateknowledgeportal.worldbank.org/

Trends in wettest day of year



Source: NOAA/NCEI/GHCN-D stations with at least 50 years of data via the KNMI Climate Explorer.

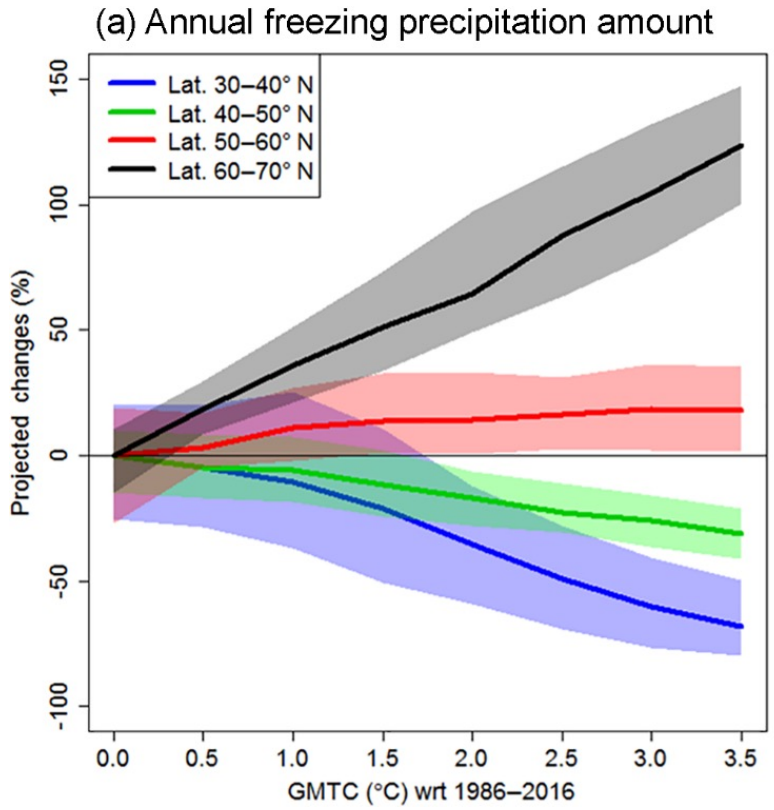
Projected changes in extreme daily snowfall (CMIP6 SSP5-8.5)



Quante et al. (2021*, Nature Sci. Rep.)*

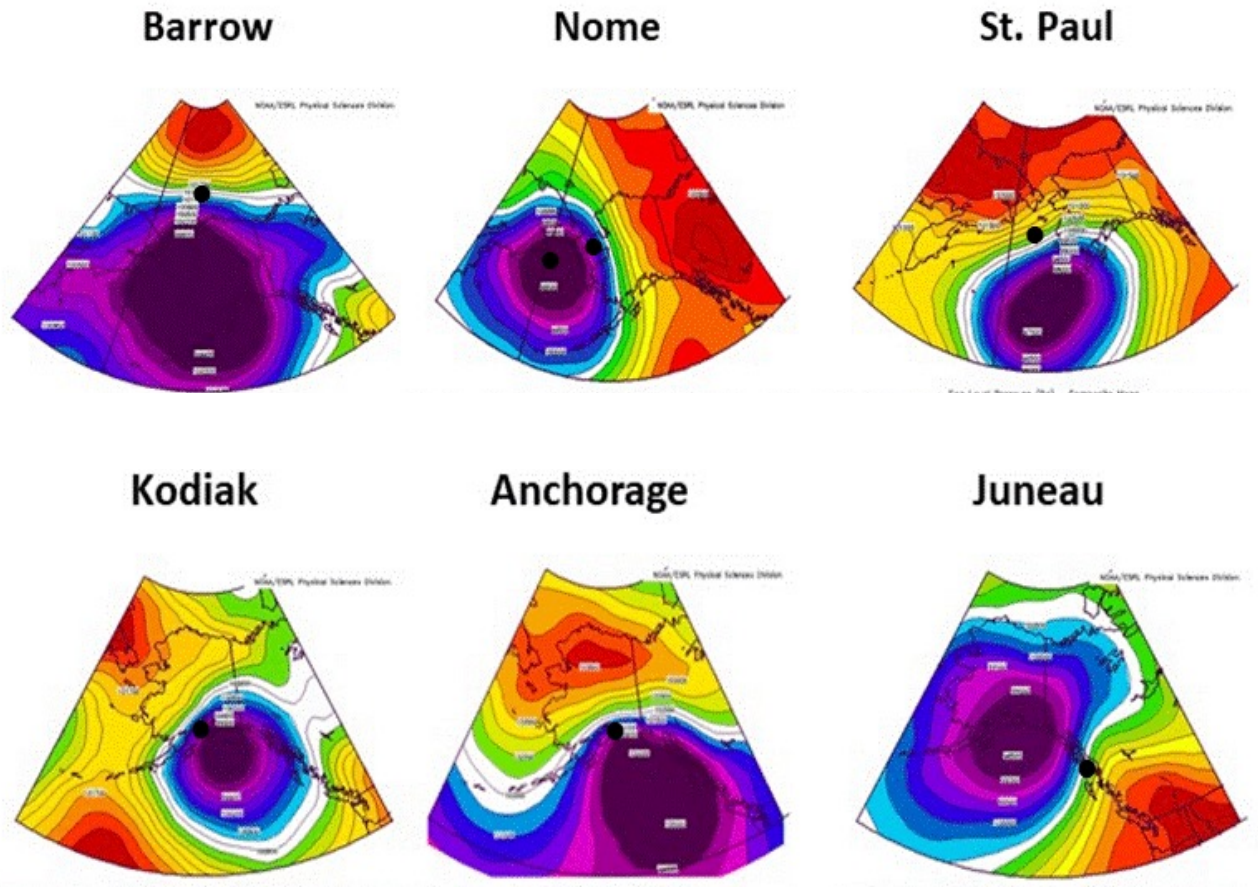
Freezing rain events are projected to increase in high latitudes

-- primarily in colder and higher-elevation areas



From Jeong et al., 2019, Nat. Haz. and Earth Sys. Sci., Fig. 6.

Composites of sea level pressure fields associated with highest-wind events at Alaska coastal sites (10-20 events per site)



from Redilla et al. (2019, Atmos. Cli. Sci.)

Weather and climate variables

	Evidence for recent change	Confidence in future change
Temperature extremes	●●●	●●●
Heavy precipitation	●	●●●
Snow	●●	●●
Freezing rain	-	●●
Atmospheric blocking	●	●
Cyclones	●	●
Wind	●	●

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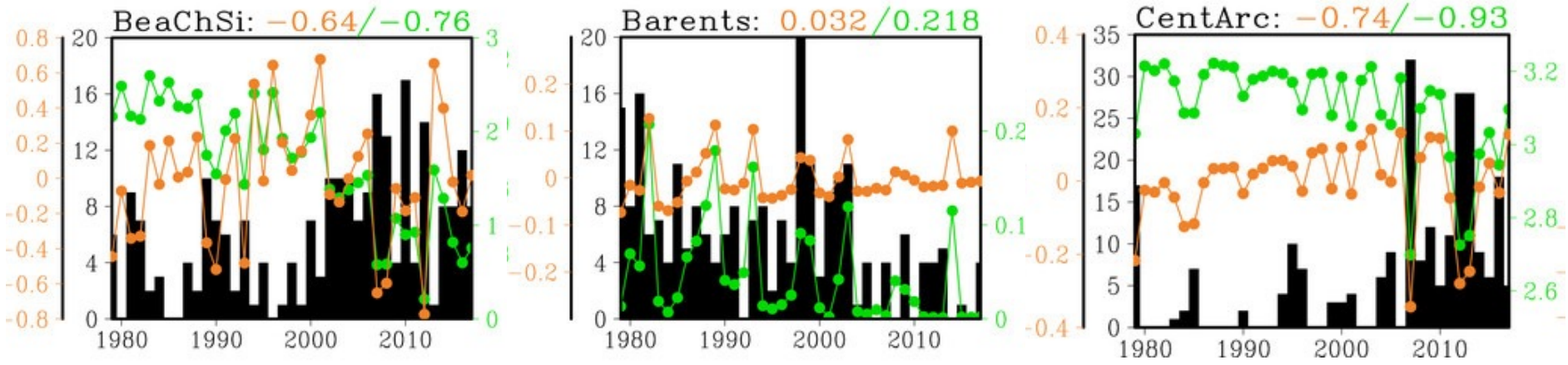
Drought
Wildfire
Marine ecosystems
Terrestrial ecosystems

Increases in Rapid Sea Ice Loss Events

Interannual time scales -- Holland et al. (2006, *Geophys. Res. Lett.*)
-- Doscher and Koenigk (2012, *Ocean Sci.*)
-- others

Synoptic (days) time scale -- Wang et al. (2020, *J. Climate*)

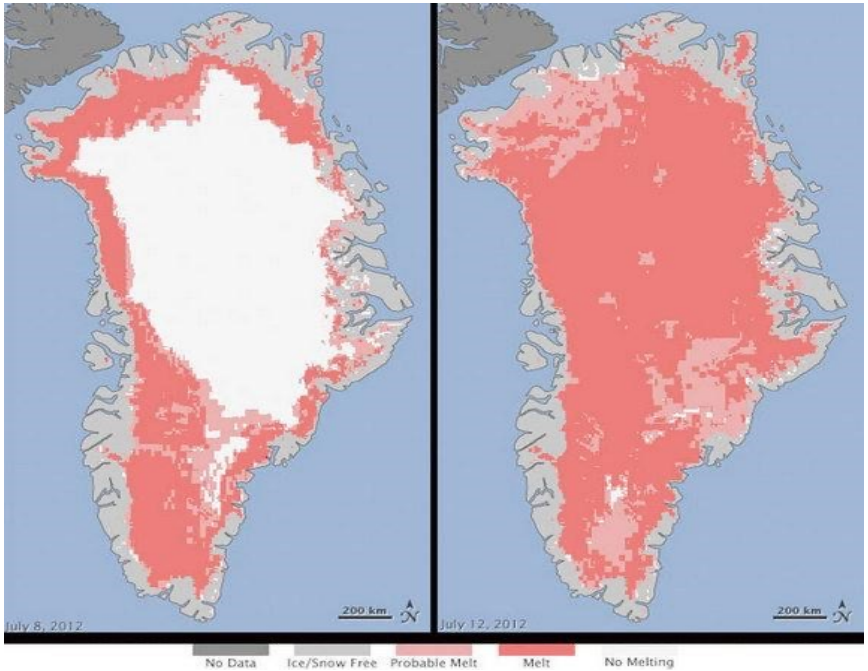


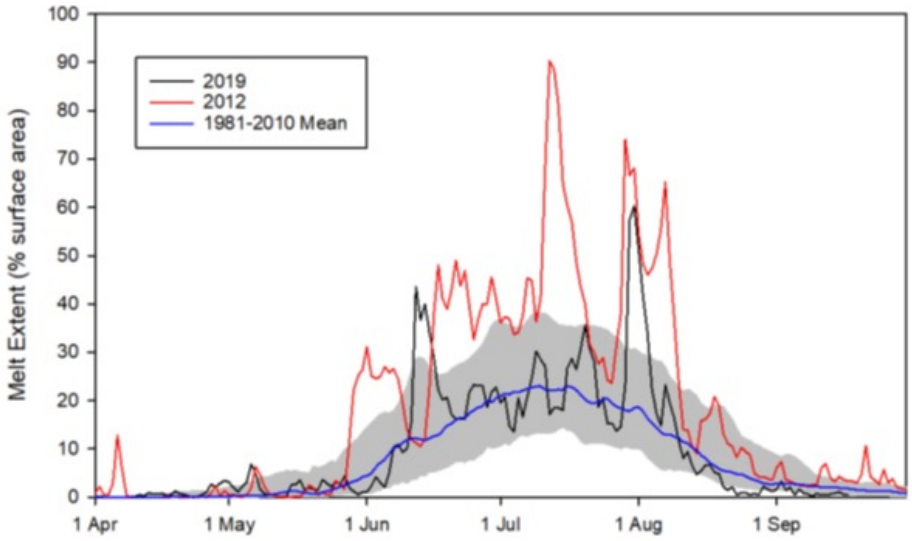
Black bars: Large Daily Sea Ice Loss Events (Wang et al., 2020)

Greenland ice sheet melt events

2012

July 8 **July 12**





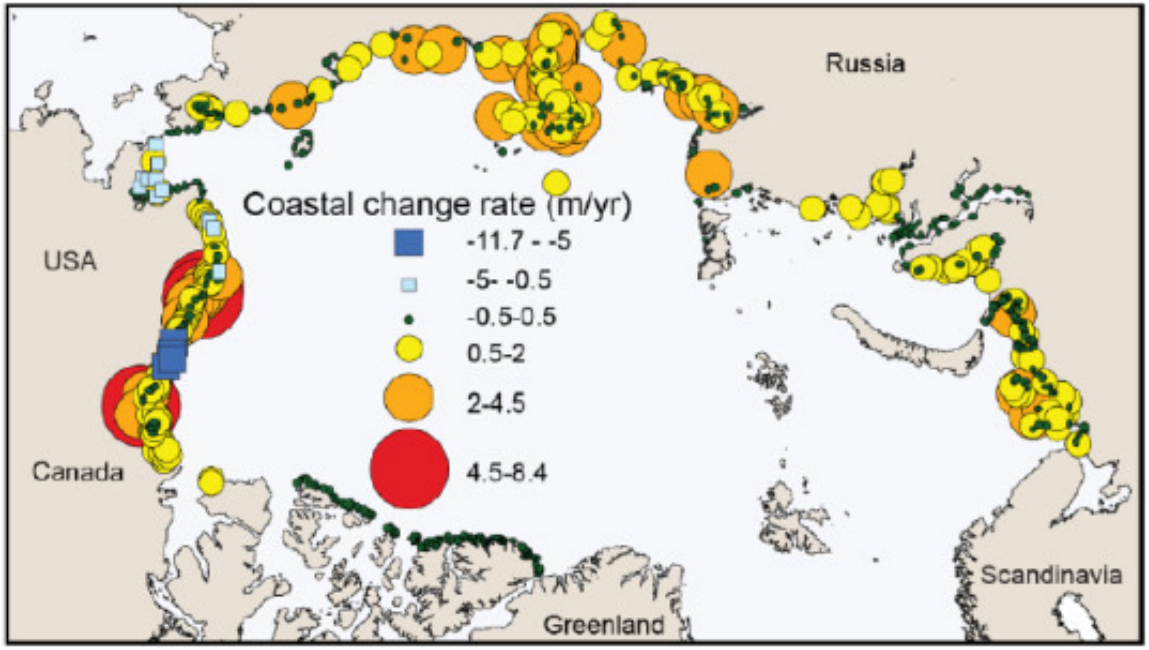
from E. Hanna, Lincoln Univ.

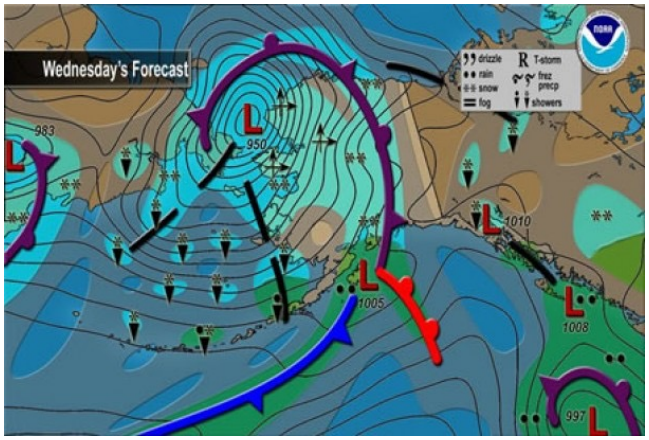
Flooding driven by heavy rain

Snow melt/ice jam flooding

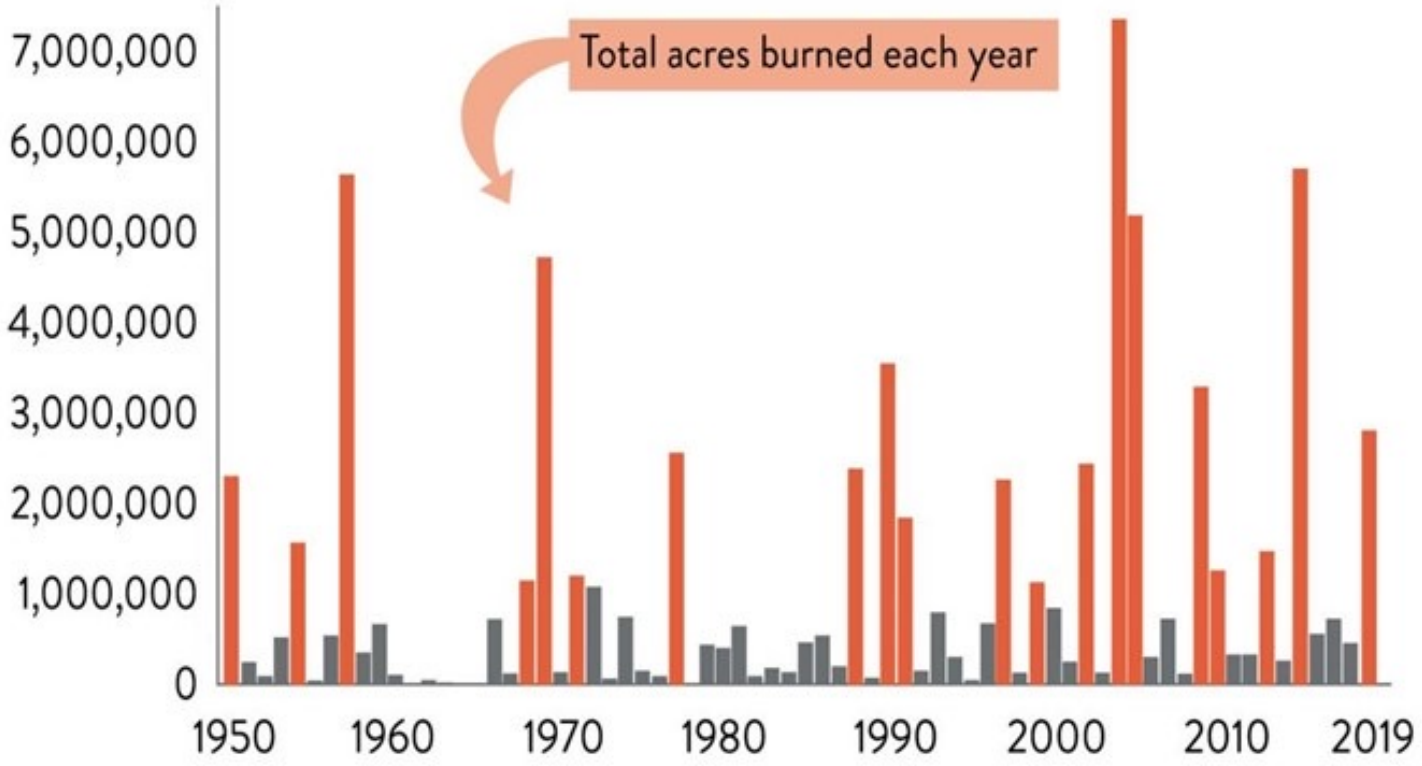
Coastal flooding

Coastal erosion – driven largely by storm events





Increasing frequency of severe wildfire years (?)



from Thoman and Walsh, Alaska's Changing Environment (2019)

Impacts

	Evidence for recent change	Confidence in future change
Sea ice (rapid loss events)	●●●	●●●
Greenland ice sheet (melt events)	●●	●●●
Inland flooding	-	●
Coastal flooding and erosion	●●●	●●●
Drought	-	●
Wildfire	●●	●●
Terrestrial ecosystems	●	●●●
Marine ecosystems	●	●●●

Questions for possible discussion at workshop:

- **Are revisions of this assessment in order?**
- **Should the list of variables/impacts be modified?**
- **Are there better metrics?**
- **Are there more objective methods for this type of assessment?**