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

John Walsh

International Arctic Research Center
University of Alaska Fairbanks

Workshop on Arctic Climate and Weather Extremes, Aspen, CO, May 2022
Extreme weather and climate events in northern areas: A review

John E. Walsh, Thomas J. Ballinger, Eugénie S. Euskirchen, Edward Hanna, Johanna Mård, James E. Overland, Helge Tangen, Timo Vihma

a International Arctic Research Center, University of Alaska, Fairbanks, Alaska, USA
b Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska, USA
c School of Geography and Lincoln Center for Water and Planetary Health, University of Lincoln, Lincoln, UK
d Department of Earth Science, Uppsala University, Uppsala, Sweden
e NOAA Pacific Marine Environmental Laboratory, Seattle, Washington, USA
f Norwegian Meteorological Institute, Oslo, Norway
g Finnish Meteorological Institute, Helsinki, Finland
h The University Centre in Svalbard, Longyearbyen, Norway
The “global” motivator: National Academies (2016) attribution report
<table>
<thead>
<tr>
<th>Extremes</th>
<th>Capabilities of Climate Models to Simulate Event Class</th>
<th>Quality/Length of the Observational Record</th>
<th>Understanding of Physical Mechanisms that Lead to Changes in Extremes as a Result of Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme cold events</td>
<td>●</td>
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<tr>
<td>Extreme heat events</td>
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<tr>
<td>Droughts</td>
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<tr>
<td>Extreme rainfall</td>
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<tr>
<td>Extreme snow and ice storms</td>
<td>○</td>
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<tr>
<td>Tropical cyclones</td>
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<tr>
<td>Extratropical cyclones</td>
<td>●</td>
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<tr>
<td>Wildfires</td>
<td>○</td>
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<td>○</td>
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<tr>
<td>Severe convective storms</td>
<td>○</td>
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</tbody>
</table>
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:                                Impacts:

Temperature extremes                                         Sea ice (rapid loss events)
Heavy precipitation                                           Greenland Ice Sheet (melt events)
Snow                                                            Inland flooding
Freezing rain                                                   Coastal flooding and erosion
Atmospheric blocking                                           Drought
Cyclones                                                       Wildfire
Wind                                                           Marine ecosystems

Terrestrial ecosystems
The hottest days are becoming more frequent

Norway

Alaska

https://climateknowledgeportal.worldbank.org/
The coldest days 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

<table>
<thead>
<tr>
<th></th>
<th>Evidence for recent change</th>
<th>Confidence in future change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature extremes</td>
<td>● ● ●</td>
<td>● ● ●</td>
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<tr>
<td>Heavy precipitation</td>
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<tr>
<td>Snow</td>
<td>● ●</td>
<td>● ●</td>
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<tr>
<td>Freezing rain</td>
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<td>● ●</td>
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<tr>
<td>Atmospheric blocking</td>
<td>●</td>
<td>●</td>
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<td>Cyclones</td>
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<tr>
<td>Wind</td>
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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
- Wildfire
- Marine ecosystems
- Terrestrial ecosystems
Increases in Rapid Sea Ice Loss Events

   -- 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

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<tr>
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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?