Case studies of extreme events and their implications in the Arctic system

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ARCTEX

Impact of extreme events in the Arctic

The occurrence and severity of extreme environmental events have increased in recent decades. Already, extreme weather and climate conditions are occurring with ever greater frequency and magnitude. While remote, due to teleconnections across different Earth systems, the Polar regions and the changes that take place here have a major impact on global weather and climate patterns. Studies suggest that it is now virtually certain that extreme events in the Polar regions will be more severe and impactful than those previously observed, making it critically important that we recognize these extreme changes and understand the physical processes driving them. For the Arctic, understanding the nature, dynamics and impacts of these extreme events requires an integrated approach. This is because the Arctic is, by nature, an *integrated* and *highly connected system*; governed by *complex interactions* and *teleconnections* between land and sea ice, the ocean and atmosphere.

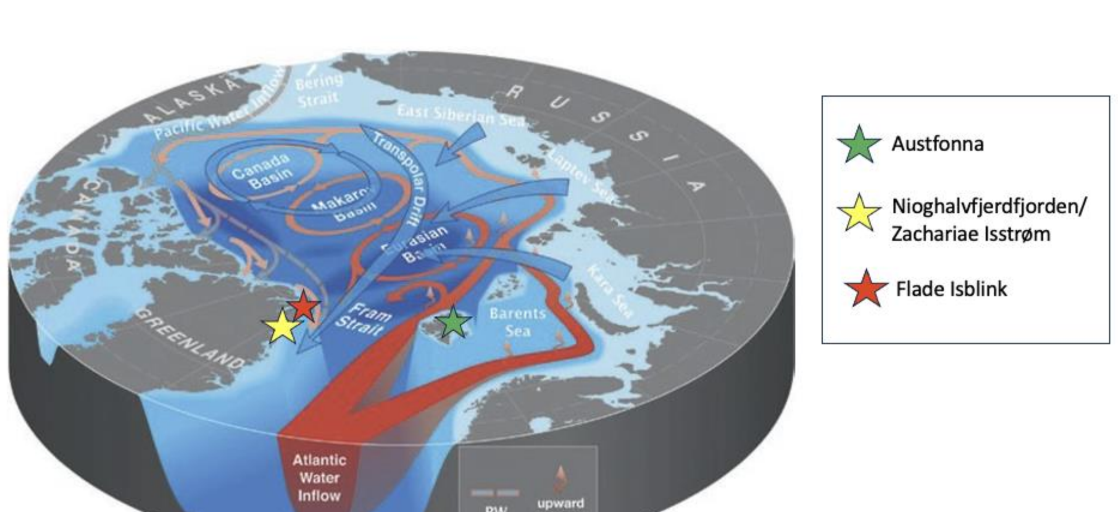
Extreme Arctic events have far-reaching influence on weather patterns and climate variability in other regions of the world. An improved understanding of the mechanism driving these events can help improve weather and climate prediction models, leading to better forecasts and early warnings for extreme weather events globally. Extreme events happen on different spatial and temporal scales and often across domains (e.g., land ice, sea ice, atmosphere, ocean). ARCTEX therefore adopts an integrated methodological approach for resolving the critical "gap" zones between domain-specific EO datasets to gain further process-based insights into the nature and dynamics of the Arctic climate interactions.

Bringing together the remote sensing communities of land- and sea-ice

ARCTEX brings together the land ice and sea ice EO-communities to co-develop datasets targeted at the complex interactions occurring during *extreme events* at the interfaces of these domains to better understand their implications for the global climate dynamics. Within ARCTEX, we will integrate data, expertise, and methodologies from across these disciplines to produce much-needed data to support a comprehensive view of the complex interactions occurring between land and sea ice and develop effective strategies for addressing the grand challenges posed by climate change in polar regions.

Science case study regions

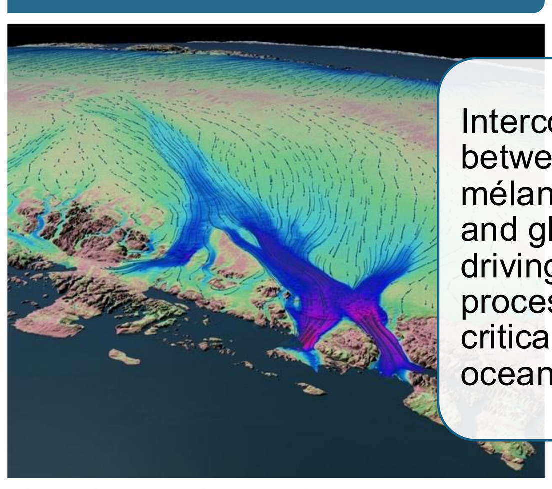
To advance scientific understanding of extremes within the integrated Arctic System, we undertake three high-priority science case studies.



Reproduced from Carmack et al. (2015)

In each case, we will perform an integrated process study to advance our current knowledge of how extreme events in the Arctic impact the interactions between the atmosphere, ocean, sea ice and land ice. The three science cases focus on three of the most important marine-affected glaciers and ice caps in the Atlantic sector of the Arctic Ocean:

79N Glacier



Interconnections between extreme mélange conditions and glacier dynamics, driving feedback processes across the critical zone for ice-ocean interactions.

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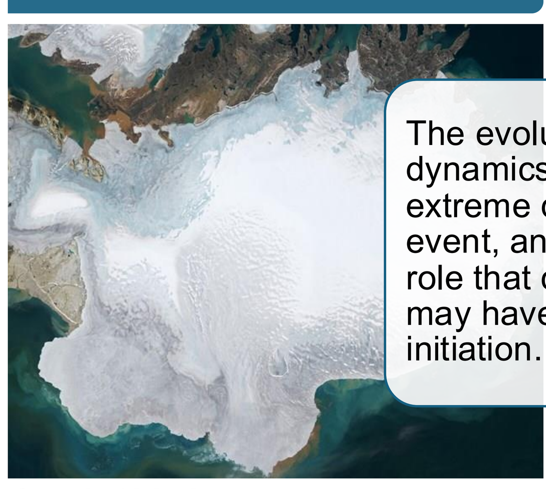
Austfonna ice cap



The evolution and dynamics of an extreme destabilization event, and the potential role that climate forcing may have played in its initiation.

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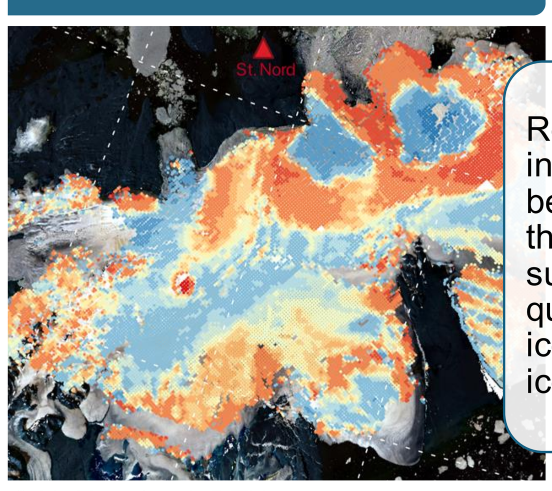
Flade Isblink ice cap



Relationship between sea ice dynamics, including polynya events, and the behavior of outlet glaciers surrounding the ice cap as well as the ice cap's surface mass balance, with a focus on quantifying the impact of sea ice variability on glacier flow rates and ice thickness changes.

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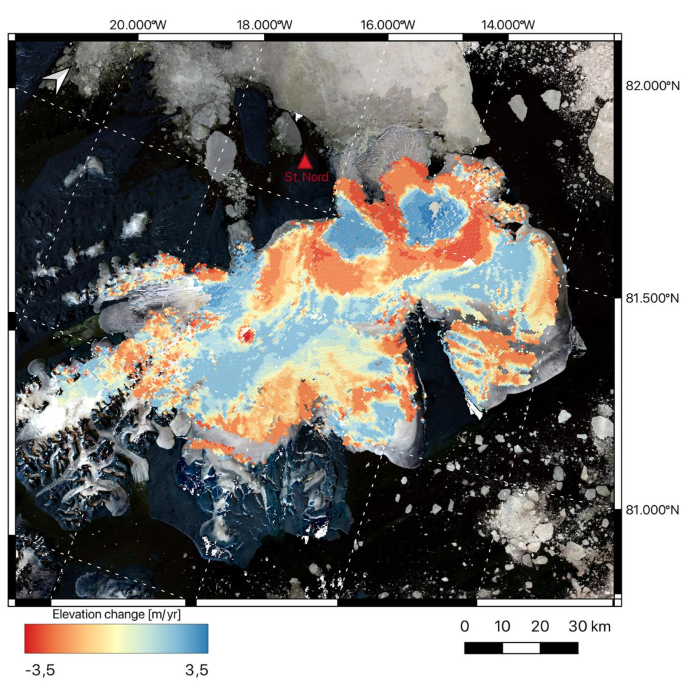
Each of the three science cases will focus on area-specific processes and extreme events, but by choosing three areas that are all situated in the same region of the Arctic Ocean, we may investigate possible links and common themes between the processes and responses between them.

Exploiting and expanding on the current EO-data portfolio

While time series have been created for a range of essential climate variables in the Arctic, the temporal and spatial sampling of such climate data records is suboptimal for studying climate extremes occurring over short time scales and the inter-connected impacts related to these. A typical temporal sampling of the climate data records is annual or in the best case, monthly. Hence, existing datasets are not adequate for studying rapidly evolving extreme events taking place in a matter of weeks or even days. To accurately document changes associated with any extreme event and attribute cause and effect between different parameters, it is necessary to develop d*atasets* to capture this shorter-term variability and their covariances.

Data examples and first results



***Surface elevation changes** over Flade Isblink Ice Cap from swath-processed CryoSat-2 data*
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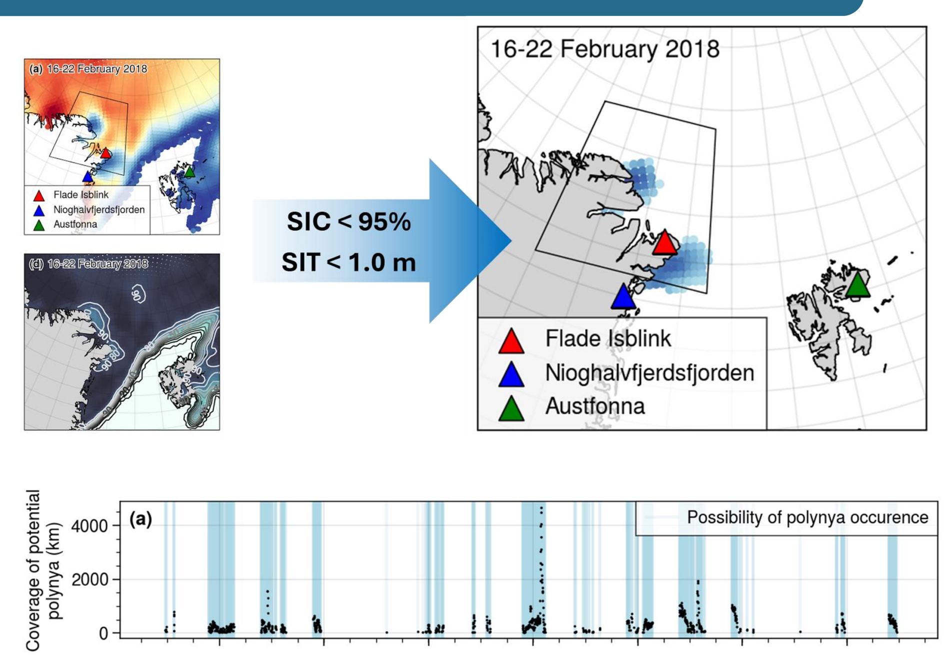
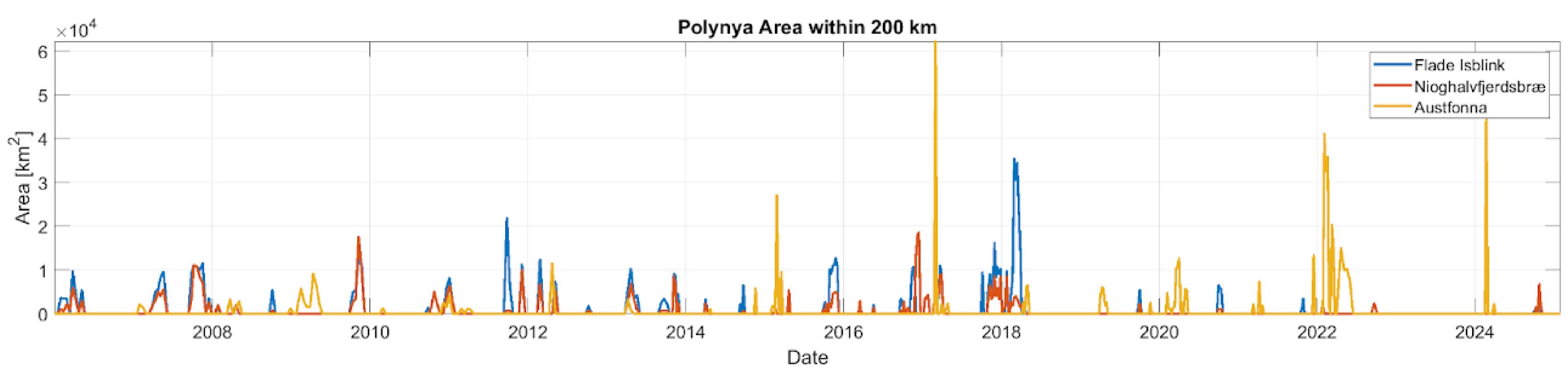
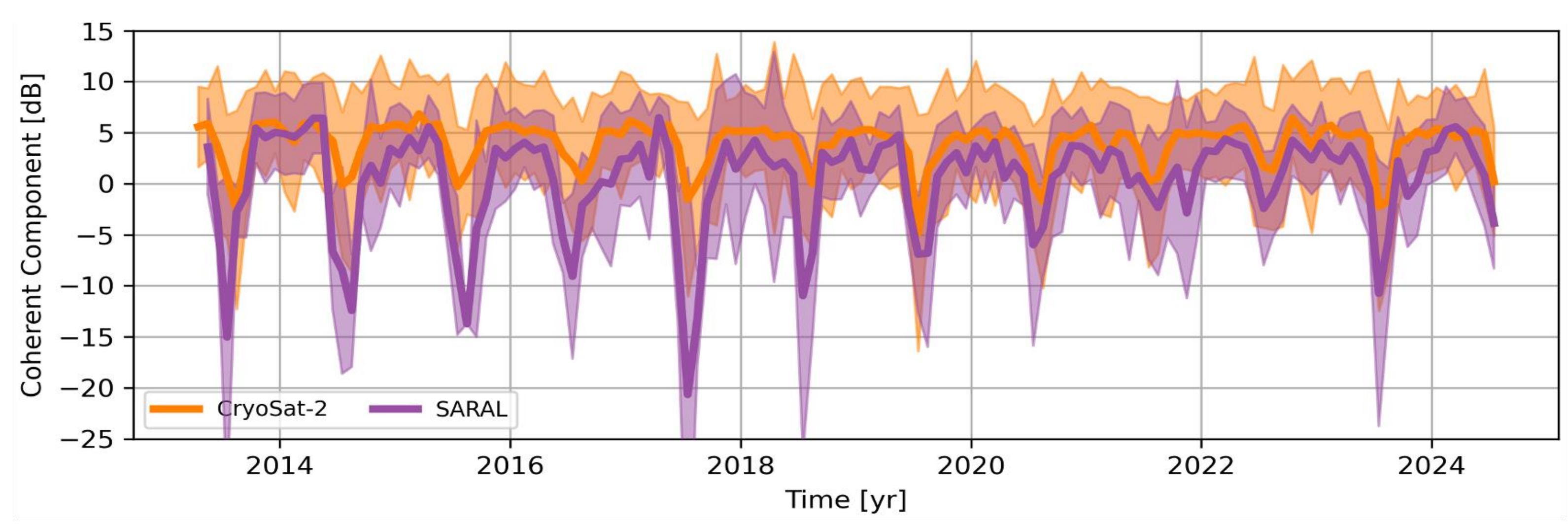


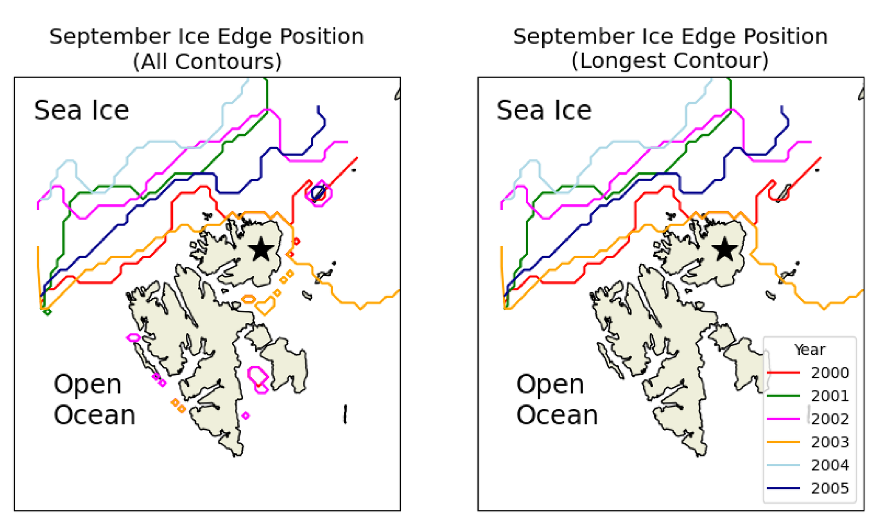
*Example of CS2SMOS merged sea ice thickness data and OSI SAF sea ice concentration, as well as the detected **polynya** utilizing the specified threshold and bounding box.*



*Examples of the time series of **polynya area** within 200 km of the center of each case study site, for 2006-2024, derived from ice charts.*



***Towards surface conditions** at Flade Isblink from CryoSat-2 and SARAL : Coherent component = Coherent Power / Incoherent Power. Following methodology of Scanlan et al., 2023*



*Position of **September ice edge** in six consecutive years (2010-15) at the 30% isoline.*

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