Brief summary of the workshop

- 35 presentations under the themes

1. Perspectives from the changing Arctic climate system
2. Observed and modelled extreme climate and weather events
3. Large-scale feedbacks, processes and teleconnections
4. Synoptic and meso-scale systems, air-ice-sea interaction, and driving mechanisms
5. Attribution, future projection and impacts

Six overarching questions

- What are the physically based metrics that can consistently detect extreme events at different temporal and spatial scales?
- What are the large-scale atmosphere, ocean, and sea ice settings and underlying processes/mechanisms for conditioning occurrence of extremes?
- What are the regional or local scale atmospheric and oceanic drivers for occurrence of extremes?
- What are the feedback processes between large-scale and regional scale systems and across the atmosphere, sea ice, and ocean to cause extreme events?
- How do the long-term changes (past + future) in the Arctic/global climate system impact the processes mentioned above?
- Where are the sources of predictability of extreme events at different temporal and spatial scales?

• What are the physically based metrics that can consistently detect extreme events at different temporal and spatial scales?

Challenges in metrics:

- How should we define an event as extreme (e.g. polar low, AR). Is every event extreme or is it extreme within its classification? Might that change in time? Do you define an extreme by the impact on some socioeconomic metric or by the geophysical condition metric? And how does the time and space over which an event occurs fit into that?

- Tresholds related to tipping points. Do we know them?

- changing interannual variability for some variables/regions/seasons

- results on factors affecting extremes may be sensitive to the variable we select: same population of events may include extremes with respect to several variables: e.g., moist-air intrusion anomalies, SEB anomalies, ice concentration anomalies

- Metrics: [event type x % (strength) x location x scale] x global change

• What are the large-scale atmosphere, ocean, and sea ice settings and underlying processes/mechanisms for conditioning occurrence of extremes?
• What are the regional or local scale atmospheric and oceanic drivers for occurrence of extremes?

Role of ongoing/expected large-scale changes from the point of view of extremes
- sea ice and terrestrial snow decline?
- changes in AMOC, atlantification?

Preconditions deserve attention. Can we robustly identify the preconditions that really play a role for the extreme events?

What are the ultimate drivers? E.g.: Tropical convection, Rossby wave trains, Polar Vortex, jet stream, tropospheric circulation, heat and moisture advection, precipitation, …

Relationships between preconditions and ultimate drivers?

• What are the feedback processes between large-scale and regional scale systems and across atmosphere, sea ice, and ocean to cause extreme events?

Arctic Amplification: is the role of atmospheric and oceanic transports underestimated?

More attention needed on combined effects and interactions of dynamics and thermodynamics

Extremes resulting from cumulative impacts (e.g. ice and snow thickness) perhaps particularly sensitive to feedbacks?

Sea ice decline -> locations where extremes (e.g. Polar lows) occur will change.
Changes in the large scale create new boundary conditions / opportunities for small-scale extremes to occur.
Regional sea ice change -> remote extremes

Extreme events are good test cases for models, with respect to parameterizations, interactions and feedbacks.

• How do the long-term changes (past + future) in the Arctic/global climate system impact the processes mentioned above?

Decrease in meridional temperature gradient, but simultaneously increase in specific humidity gradient -> if no circulation changes, less transport of dry heat but more moisture transport.

Many preconditions for processes resulting in extreme events will change.
E.g. thinner sea ice -> more sensitive to extremes.
Warming -> changes in precipitation, snowfall, rainfall, snow thickness, …

Even if less heat transport, its impacts on ice extent/concentration may be larger due to thinner sea ice.

• Where are the sources of predictability of extreme events at different temporal and spatial scales?

Long memory of the ocean -> increased predictability of extremes.

Stratosphere and downward propagation -> enhanced predictability

Are the problems of the forecasting system in the mean state or variability?

Changes in predictability

Predictability due to heat capacity of snow and ice -> less predictability when snow and ice will melt.

In the case of many events, predictability will not change: e.g. how many Polar lows there will be in the coming winter?

Way forward

In general: more communication needed between

- scietific disciplines
- scientists addressing different time scales (weather and climate)
- scietists and stakeholders dealing with socio-economic impacts of weather and climate extremes

Review / perspective paper

- Session tomorrow

Our collaboration should continue also after it!