Extreme winds and waves in the Arctic Ocean

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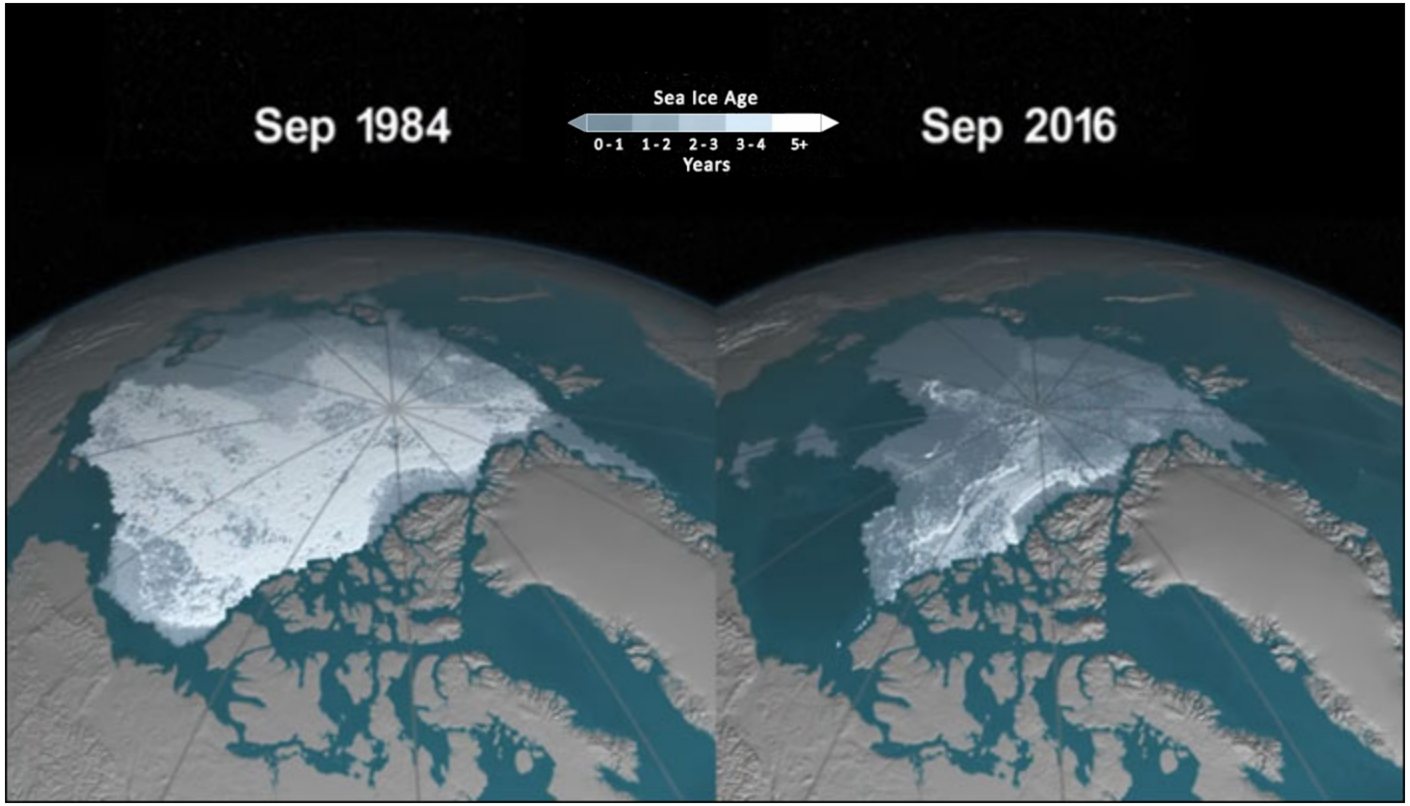
Sea state changes in the Arctic

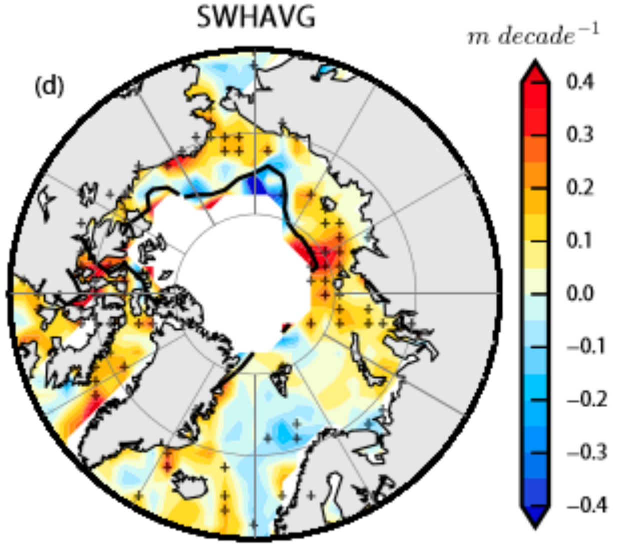
- Declining of sea ice extent
- Increasing fetches
- More energetic surface waves

Emerging Arctic Ocean

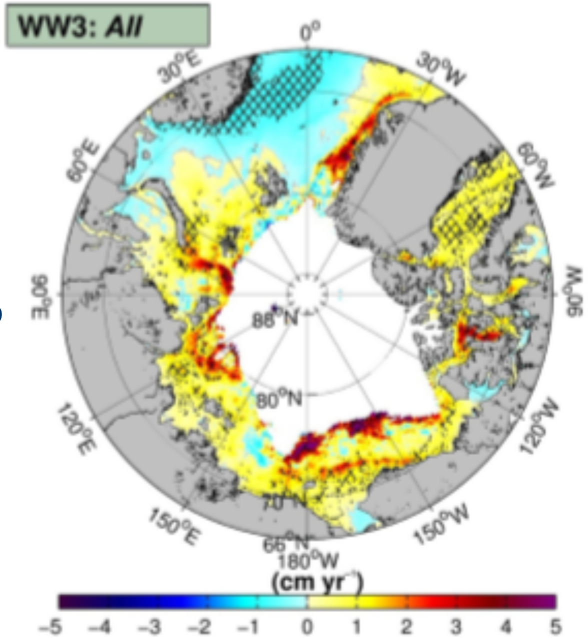


NASA, 2016

Liu *et al.*, 2016



Stopa *et al.*, 2016



Aim

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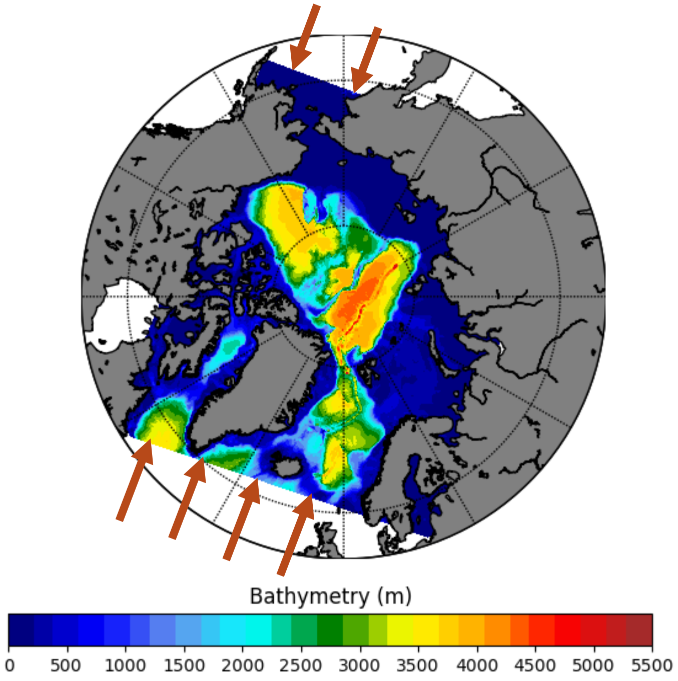
Assess the changes in wind and wave extremes across the Arctic Ocean based on the results of a 28-year (1991-2018) wave hindcast and ERA5 reanalysis.

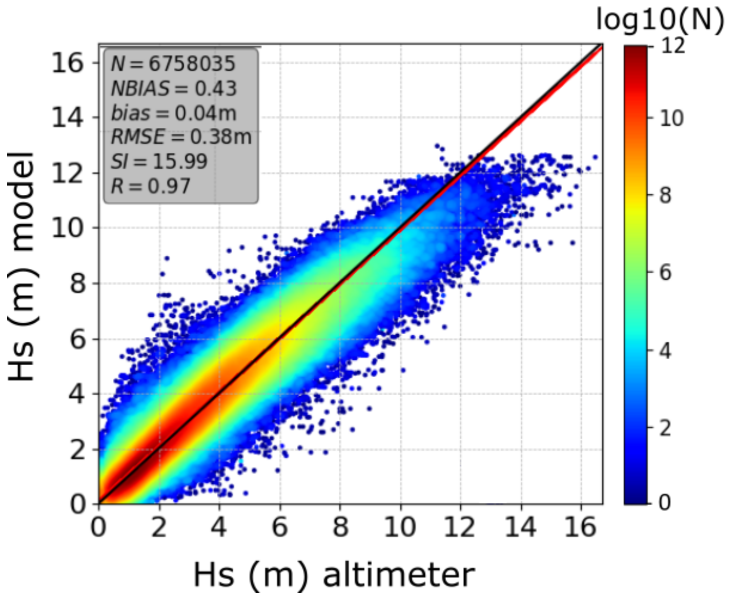
Model Setup

- **WaveWatch III version 6.07**
- **Atmospheric forcing**
  - **CFSR**
  - **ERA-Interim**
  - **ERA5**
- **Source and sink terms**
  - **ST4 (Ardhuin et al., 2010)**
  - **ST6 (Zieger et al., 2015)**
- **Sea ice concentration (land if >25%)**
  - **IFREMER/CERSAT**
  - **NSIDC/NOAA**
  - **GLORYSV4**
  - **ERA-Interim**
  - **ERA5**
- **Spatial resolution**
  - **9 to 22 km**
  - **6 to 16 km**
  - **4 to 13 km**

BC from global model



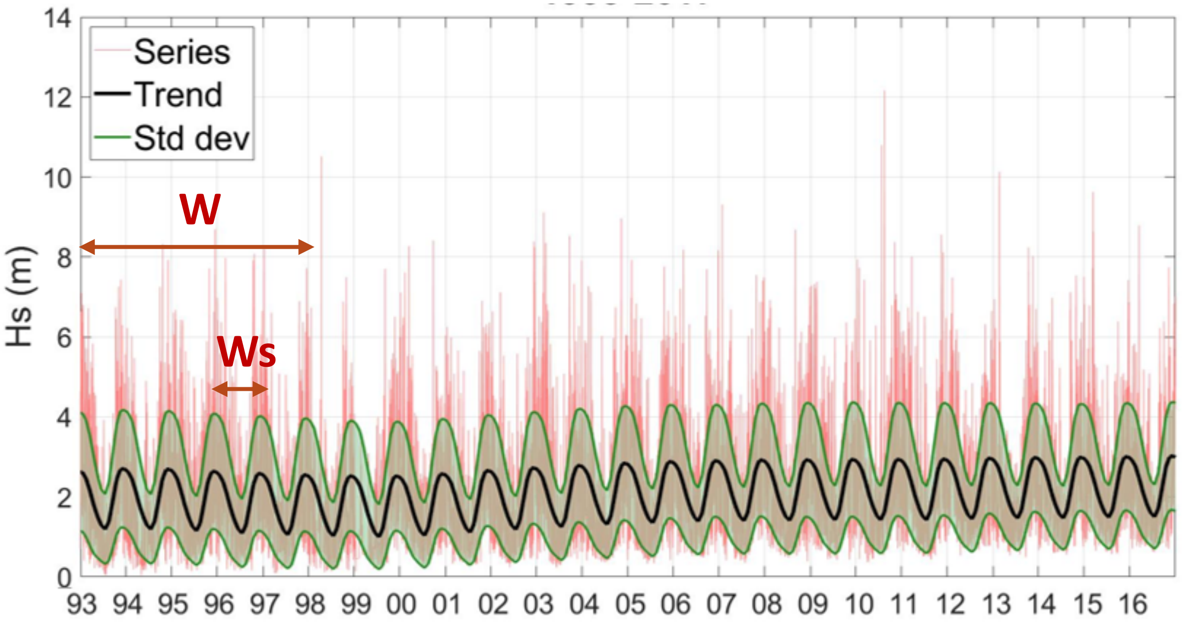
Validation (2012-2016)



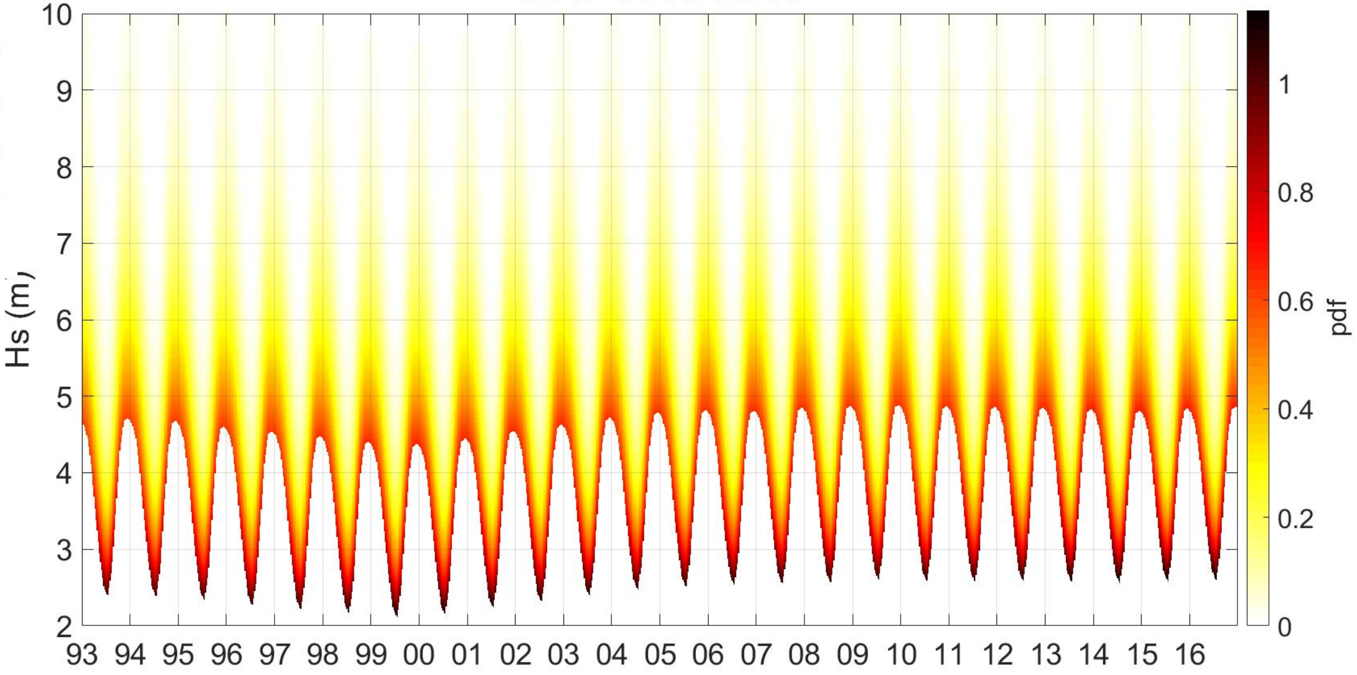
TS EVA – seasonal

Transformed stationary (TS) method (Mentaschi *et al.*, 2016)

1. Transform the non-stationary time series y(t) into a stationary series x(t)
2. Performing a stationary EVA
3. Back-transforming the resulting extreme value distribution into a time-dependent one.



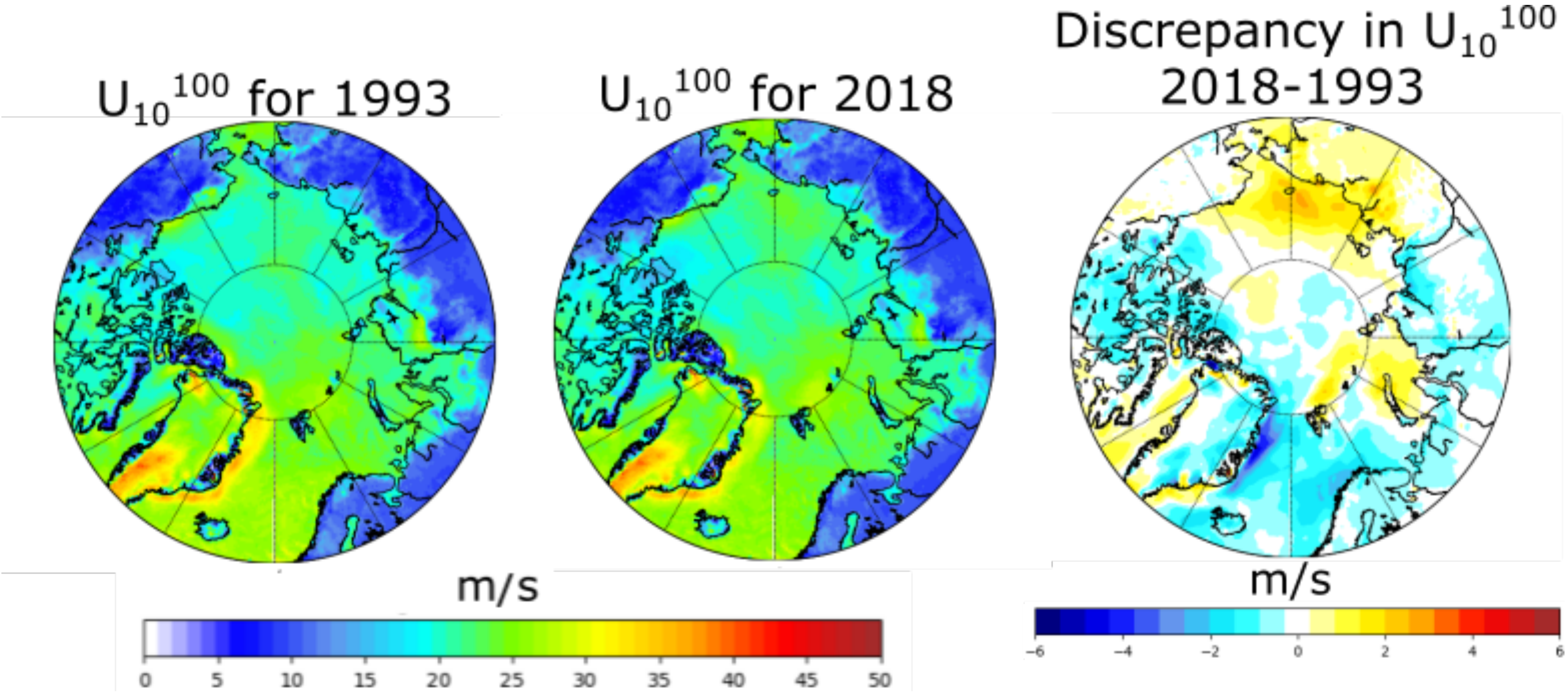
GPD



$$x(t) = f(y, t) = \frac{y(t) - T_y(t)}{S_y(t)}.$$

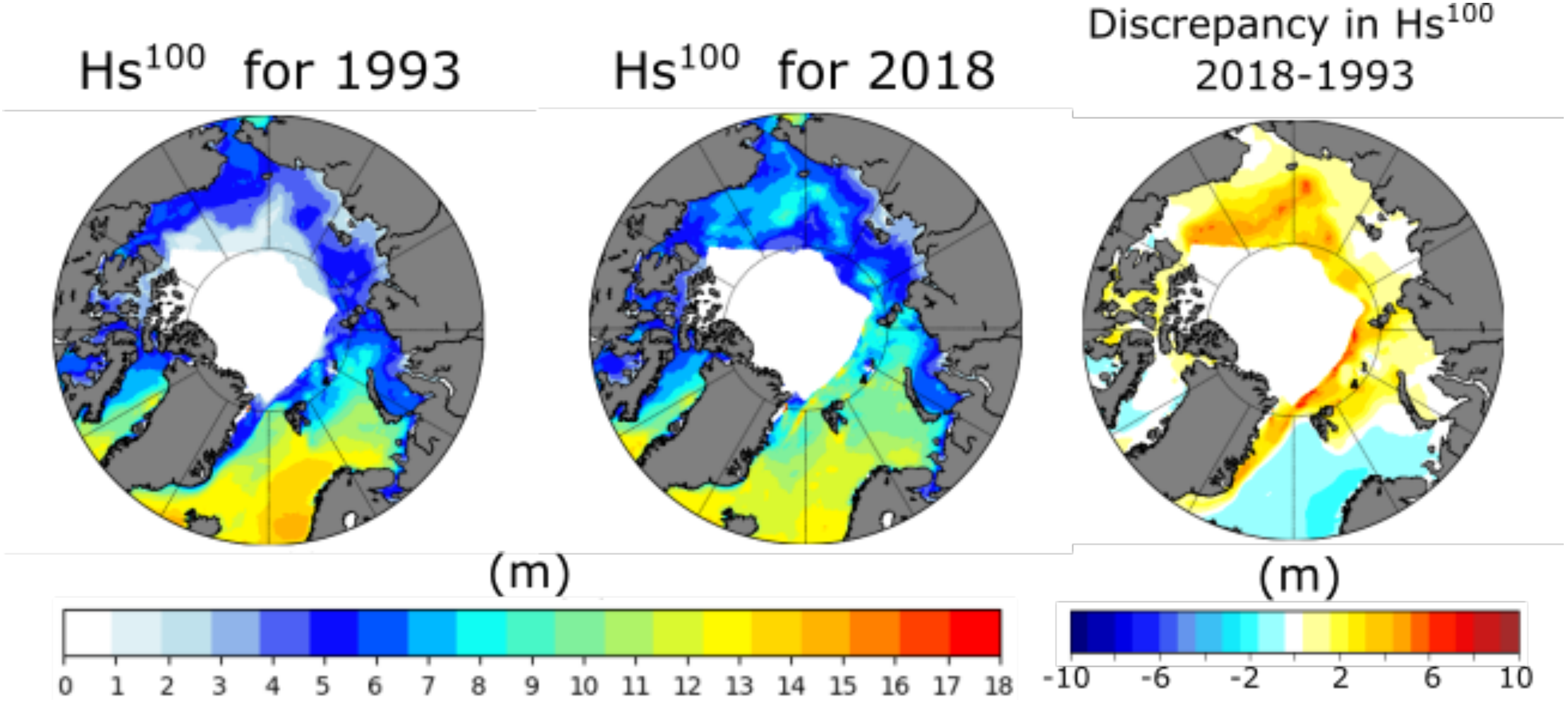
Non-seasonal TS EVA – Results

Non-seasonal TS EVA
POT(90thP)

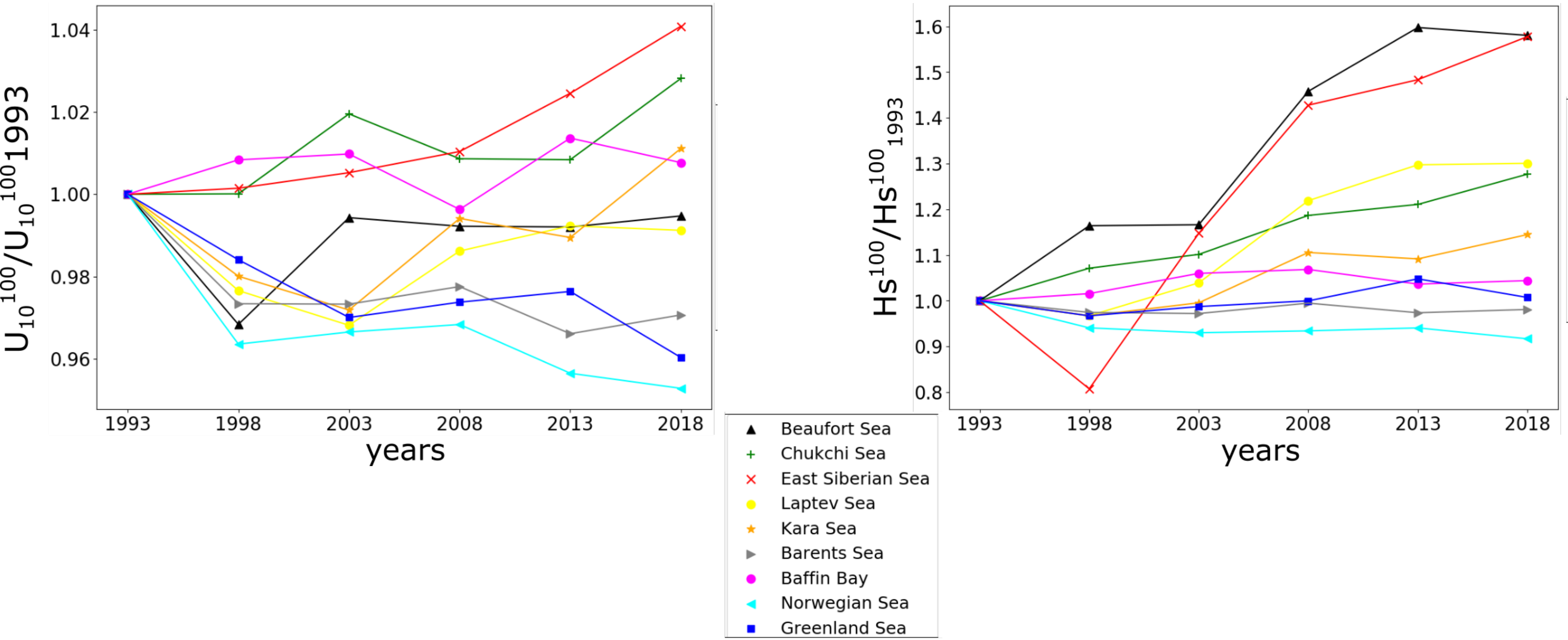


Non-seasonal TS EVA – Results

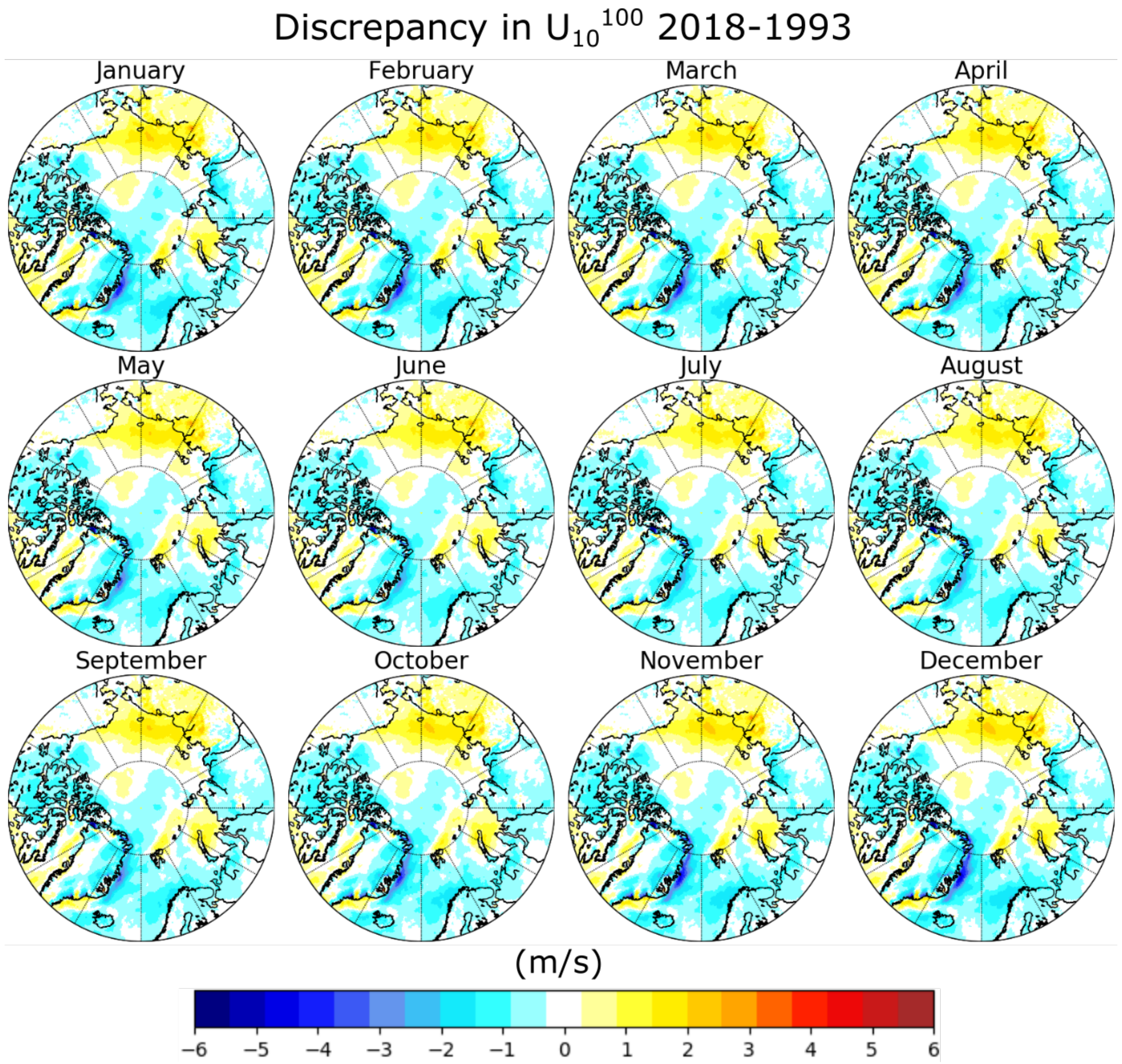
Non-seasonal TS EVA
POT(90thP)

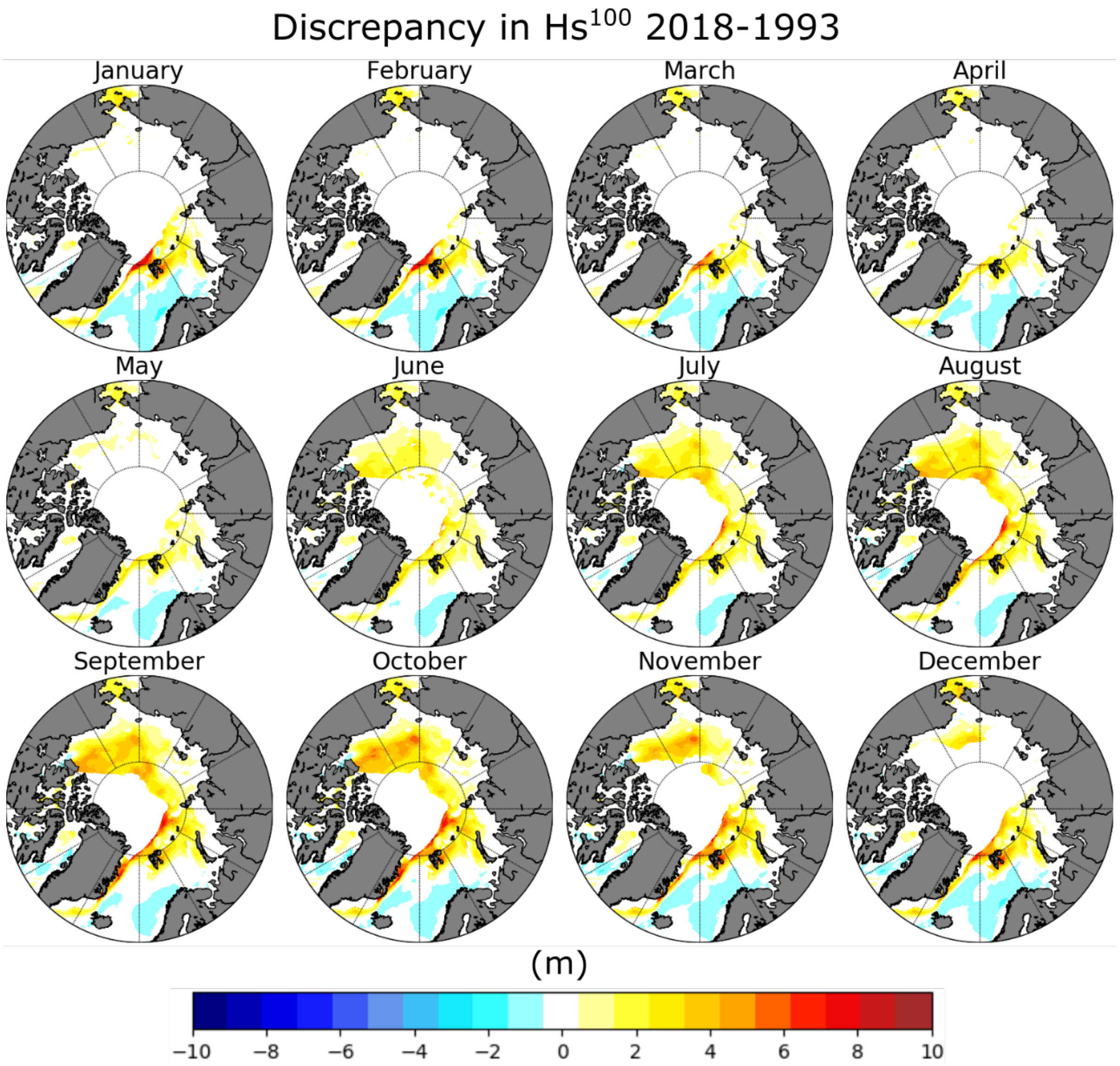


Non-seasonal TS EVA – Results



Seasonal TS EVA - results





Conclusions

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- **28-year wave hindcast was performed and a non-stationary EVA was applied to evaluate the extreme winds and waves across the Arctic Ocean**
- **The non-seasonal approach showed an increase in H_s^{100} areal-averages of approximately 60% in the Beaufort and East Siberian seas for the period between 1993-2018.**
- **At the same time, extreme winds have only increased by 4% in the same region.**
- **Therefore, the changes in extreme winds cannot explain the changes in extreme waves. This makes evident that the sea ice melting has primary responsibility for these dramatic changes in extreme waves.**
- **The seasonal approach of the TS EVA allowed a deeper understanding of the regional changes in the extremes throughout the year and how much the extreme winds and waves have increased over the past decades.**