PAPER

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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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Arctic glaciers record wavier circumpolar winds

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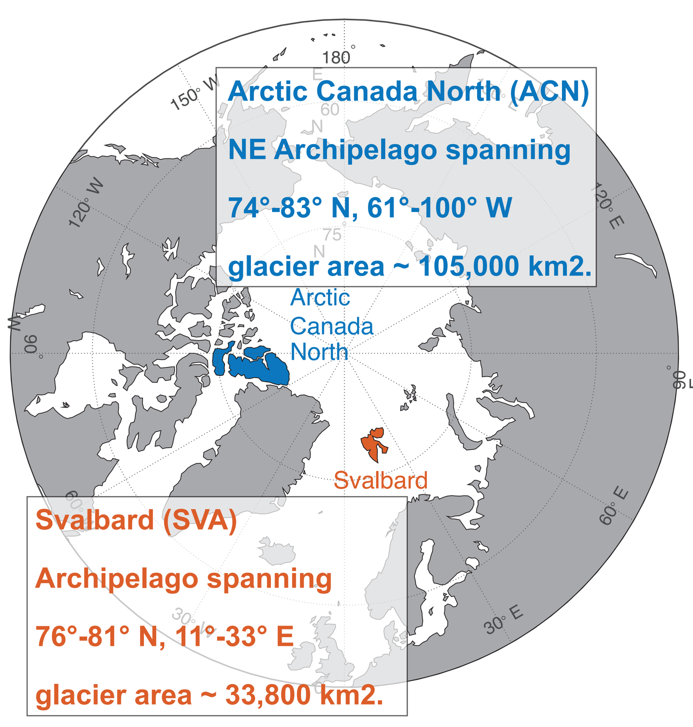
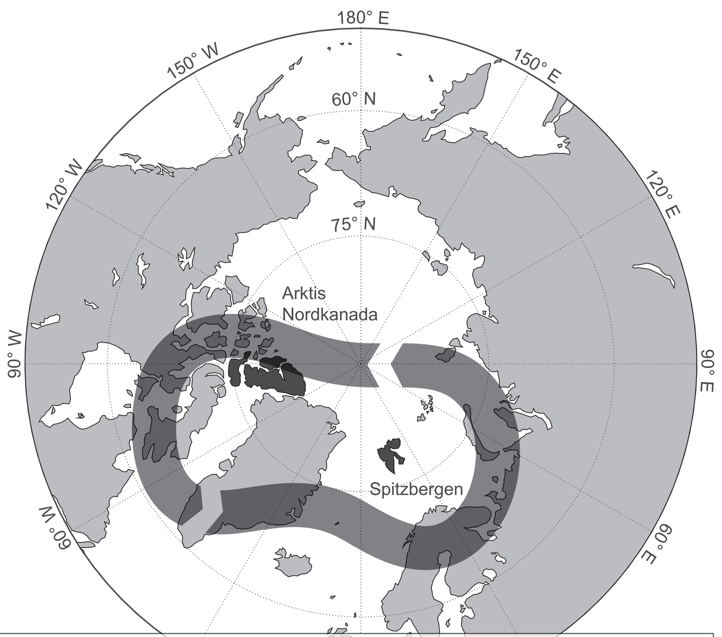
Background

- Anthropogenic global warming and Arctic Amplification leads to a **rapidly melting Arctic cryosphere**.
- It is still debated in the scientific community, if and how much this melting cryosphere **impacts the Northern Hemisphere atmospheric circulation** patterns. Observational sample size is small and model studies show high variance in their outcomes.
- Some publications argue for a **meridionalisation** of the upper-tropospheric winds, while others argue for no causal impact of Arctic Amplification on the Northern Hemisphere circulation [2,3,4].

! Here we focus on two Arctic glaciated archipelagos in order to **link glacier mass change with atmospheric circulation changes**.

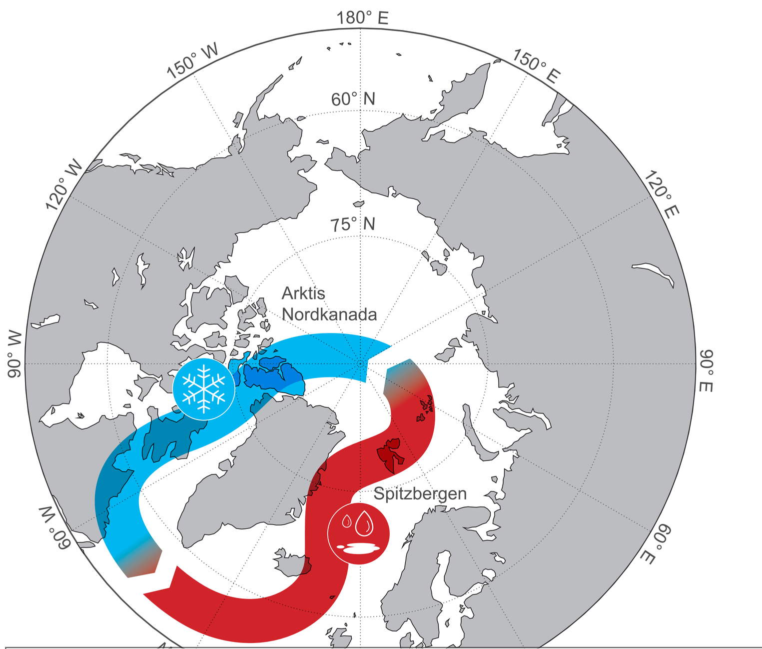




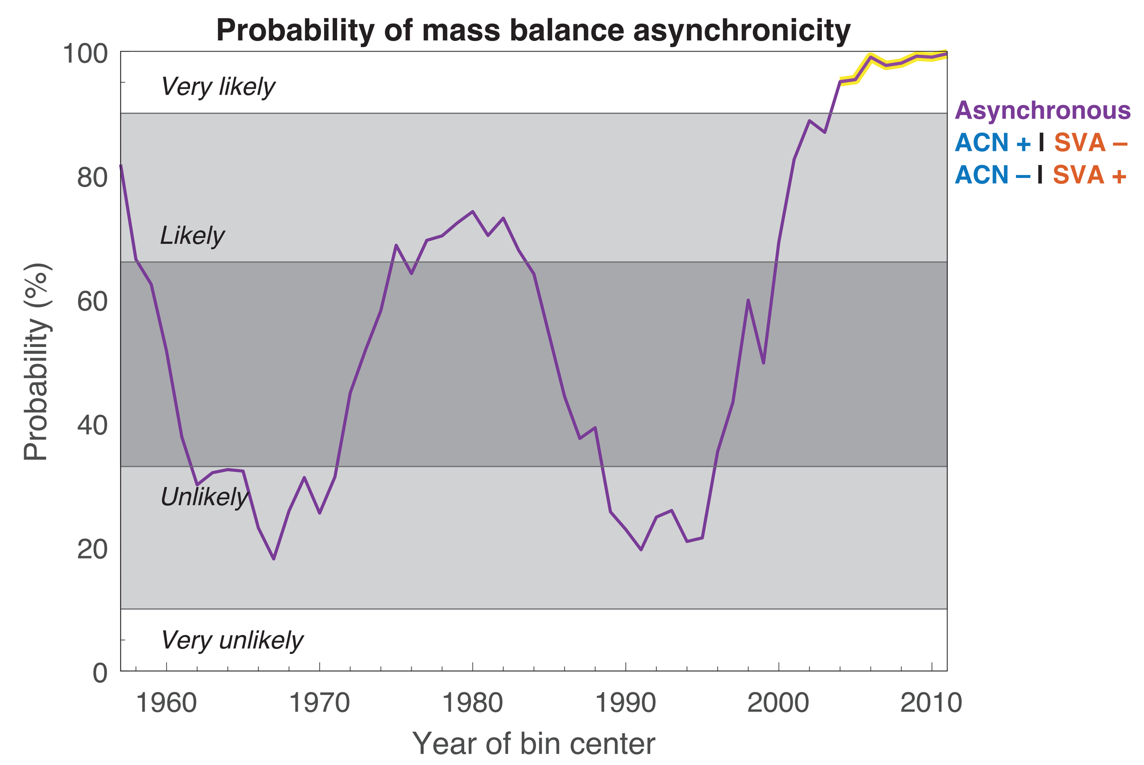
Common zonal upper-tropospheric circulation patterns pre-2000 C.E.

Take-home message

- The annual ice mass loss of these two regions is significant, equivalent to 44 billion tons of water.
- Both glaciers should generally be exposed to the same air mass characteristics at about the same point in time. This seems to have been the case for the last 50 years of the 20th century.
- **Since the year 2000**, concurrent with an increase in warming, **the two glaciers each experience a different kind of air mass at the same time**: In years where Canadian glaciers experience an increased melting rate, the Norwegian glaciers melt less, and vice versa.
- Our theory suggests that with strong Arctic warming, the boreal summer westerly winds become weaker and more air masses can come in from the north and south. In other words, **the stream of westerly winds gets wavier.**



Common zonal upper-tropospheric circulation patterns post-2000 C.E.



Probability of having asynchronous mass loss anomalies for 15 running mean melting seasons in our reconstructions.

Data & Methods

Methods

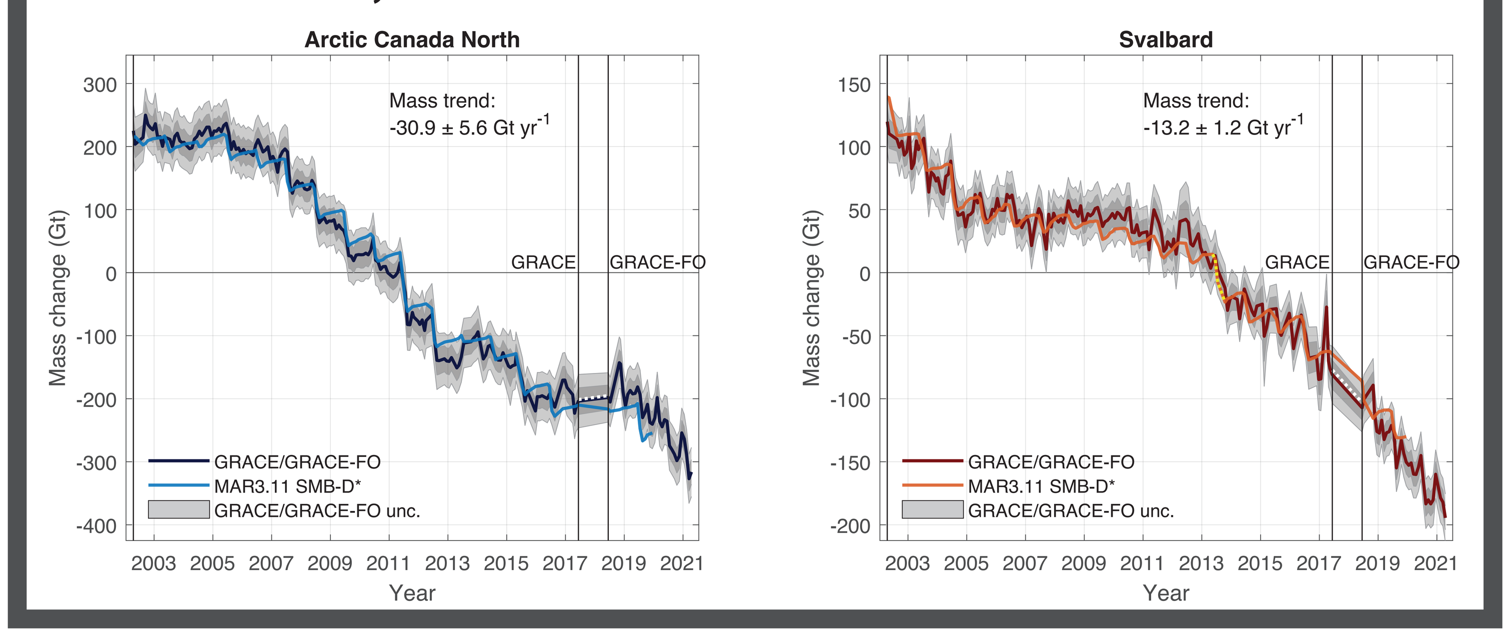
- Observation of mass balances in Arctic Canada North and Svalbard
- Validation and uncertainty estimate of surface-mass balance
- Historic reconstruction of surface-mass balance & categorization
- Analysis of large-scale circulation and atmospheric drivers of mass balance

Data

GRACE/GRACE-FO SATELLITE mass change
- GFZ RL06, CSR RL06 and JPL RL06 data sets
- Time period 2002–2021
- Optimal combination (AV RL06) using uncertainties
- GIA correction ICE6G Model
- Hydrological correction

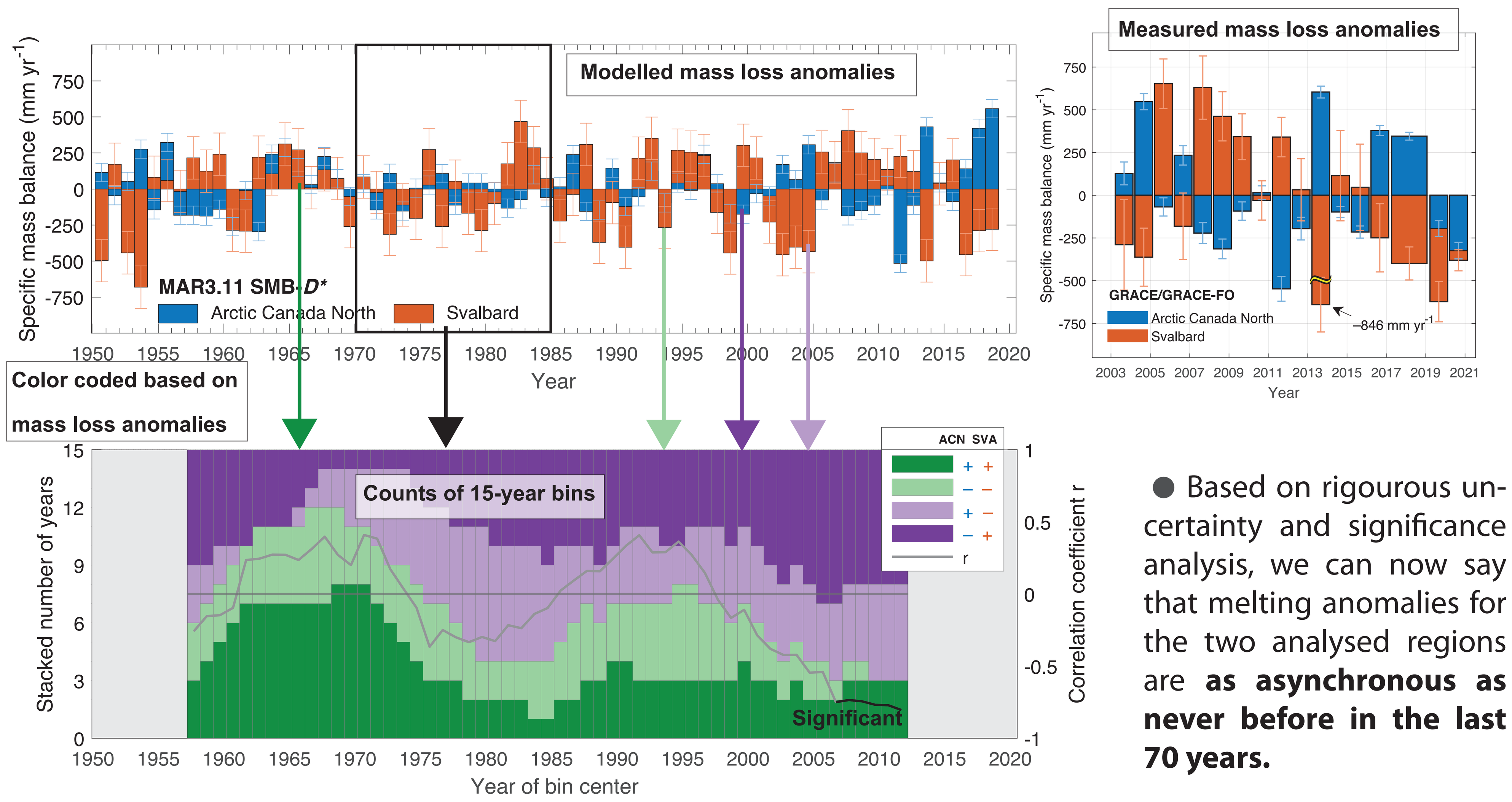
Regional surface-mass balance model
- MAR3.11 forced by ERA5 reanalysis
- Time period 1950–2019
- ~ 15 km horizontal resolution
- Alternatives:
  MAR3.11 forced by NCEP, RACMO2.3p1 forced by ERA5 reanalysis

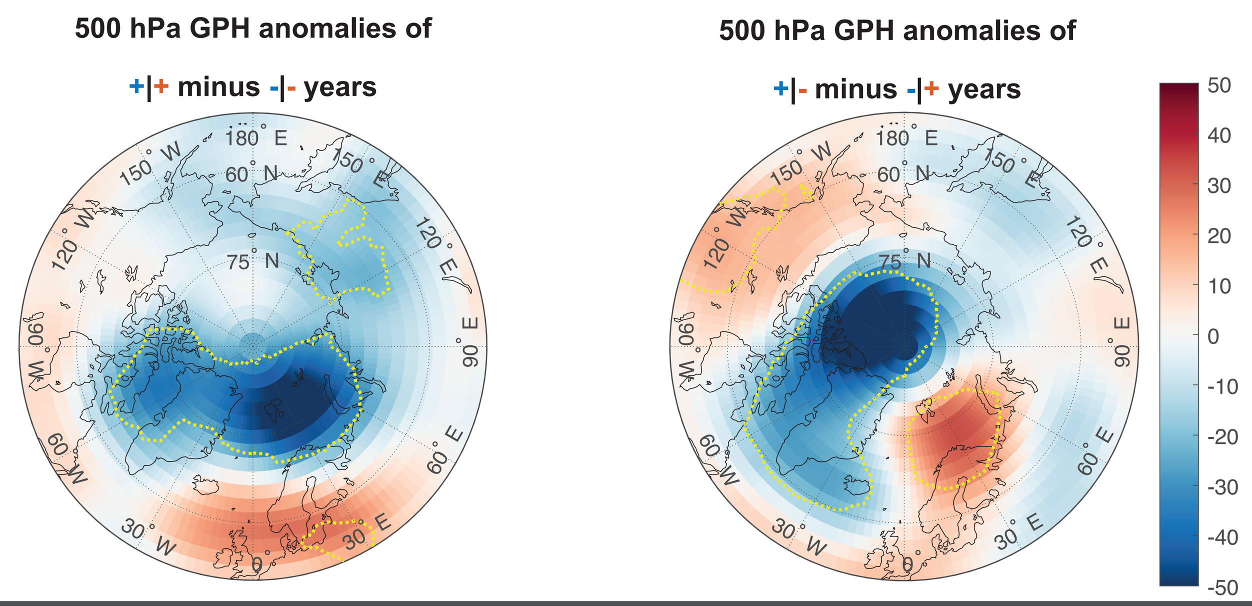
Climate reanalysis
- ERA5 reanalysis 1979–2020
- Augmented with ERA20C 1950–1978
- NCEP reanalysis 1948–2020



Results

- **Subtracting the general trend** from the mass change time series leaves us with **mass loss anomalies** that we attribute to **meteorological forcing** rather than external climate forcing.
- The anomalies for each region show high interannual variability. Modelled anomalies back to 1950 allow us to infer about **decadal variability**. We see decades with synchrous mass loss anomalies in the 1960s and 1990s. **After 2000 C.E. years with asynchrous mass loss anomalies are dominating the records.**





- Based on rigourous uncertainty and significance analysis, we can now say that melting anomalies for the two analysed regions are **as asynchronous as never before in the last 70 years.**
- Correlation and composite analysis with atmospheric circulation fields show us a related shift in circulation from zonal flow for synchronous mass loss summers versus **meridional circulation patterns for summers with asynchronous melting anomalies.**

[1] Sasgen, I., Salles, A., Wegmann, M., Wouters, B., Fettweis, X., Noël, B.P. and Beck, C. (2022) Arctic glaciers record wavier circumpolar winds. Nature Climate Change, 12, 249-255, https://doi.org/10.1038/s41558-021-01275-4.
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