**CSQ-21 Summary**

| Question | Knowledge Advancement Objectives | Geophysical Observables | Measurement Requirements | Tools & Models | Policies / Benefits |
|---|---|---|---|---|---|
| **What physical processes drive ice dynamic variability, and how does the dominance of these processes differ between the different Polar regions?** | Determine what physical processes drive ice dynamic variability. | • Ice speed measurements on all glaciers and ice streams globally<br>• Ocean temperature change<br>• Ice surface melt and runoff<br>• Calving front location<br>• Grounding line location<br>• Surface elevation change | Ice speed measurements at as fine temporal resolution as possible (weekly), with enough sensitivity to measure change in speed<br><br>Multi-decadal record of change required over last 30-40-years, updating continuously in NRT<br><br>High (100 m) spatial resolution for all components. | EO satellite datasets.<br><br>Auxiliary data including bed topography under all land ice, and regional climate model data estimating surface mass balance, surface melt and runoff.<br><br>Ocean temperature change, throughout full water column | Climate change adaptation and mitigation policy.<br><br>IPCC monitoring.<br><br>Improve future projections of ice mass loss, which remain the greatest uncertainty in future sea level rise projections. |
| | Determine how the dominance of these processes differs between the different Polar regions, including Northern hemisphere vs South, glaciers vs ice sheets. | As above. | As above. | As above. | |

**CSQ-21 Narrative**

Ice dynamics, which relates to the change in the rate of ice flow, are responsible for approximately one third of all ice mass loss on the Greenland Ice Sheet, and almost all (98%) ice mass loss on the Antarctic Ice Sheet (Slater et al., 2020). Ice dynamic change is primarily concentrated in the marine terminating regions of the ice sheets, which are often also be grounded below present-day sea level. The IPCC reports consistently state that the largest remaining uncertainty in the ice sheet contribution to sea level rise is linked to ice dynamics, where the speedup of glaciers can lead to imbalance and then instability, through the Marine Ice Sheet Instability (MISI) and Marine Ice Cliff Instability (MICI) mechanisms. In Antarctica ice dynamics are thought to be largely driven by incursions of warm, deep circumpolar water onto the continental shelf, which causes enhanced melt (Dutrieux et al., 2014). More recently, the very high temporal resolution (weekly) satellite observations from operational ESA-EC missions such as Sentinel-1a and -1b, have enabled short-term, seasonal changes in ice speed the be better characterized on the Greenland Ice sheet, and observed for the first time in Antarctica (Wallis et al., 2023). This enables short-term ice dynamics to be studied in more depth, providing further insight on the speed with which changes in ice speed can occur, and enabling us to better understand the physical processes driving this change in different regions of the world.

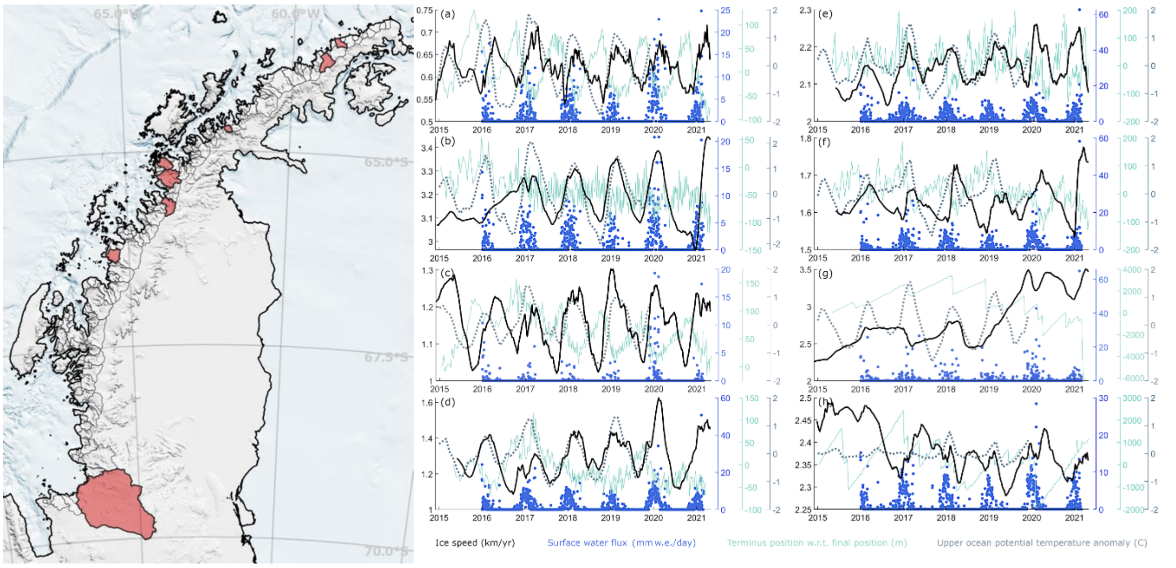


*Fig. 3: Highlight glaciers' time series of ice speed, surface water flux, terminus position and ocean temperature anomaly. a–h, Time series of Kalman-smoothed ice speed (black solid line), RACMO2.3p2 surface water flux (snowmelt plus rain; blue dots)43,52, terminus position with respect to the final position (green solid line) and upper-ocean (110 m) potential temperature anomaly (grey dashed line)56. Time series are shown for unnamed north Bone Bay (a), Gavin Ice Piedmont (b), Leonardo (c), Hotine (d), Trooz (e), Keith (f), Cadman (g) and Fleming (h) Glaciers. Highlight glaciers in a–f were selected based on their large seasonal ice speed variability (autocorrelation values of 0.648, 0.314, 0.586, 0.703, 0.575 and 0.575, respectively), to give a spread of locations along the west AP, and to show a range of faster and slower mean ice speeds. w.r.t., with respect to; w.e., water equivalent. From Wallis et al., 2023.*

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