

Supplementary Figures for “Ice shelf changes in North Greenland reveal dramatic signs of ongoing ice sheet instability”

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File content.

This file contains supplementary figures S1-S36.

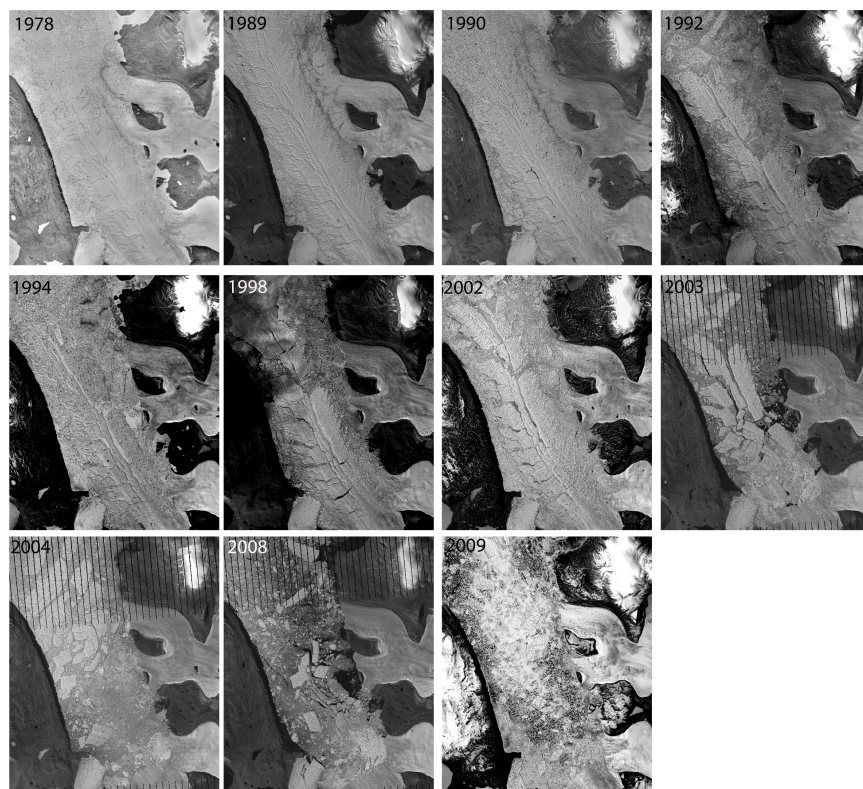


Figure S1. Ostensfeld ice shelf collapse observed using optical imagery from the NASA/USGS Landsat satellites. Black stripes are due to the failure of the Scan Line Corrector in Landsat-7 data.

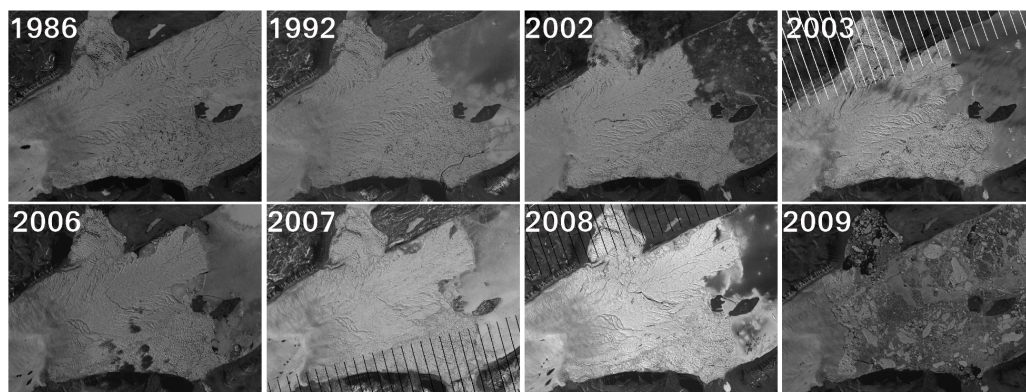


Figure S2. Hagen Bræ ice shelf collapse observed using optical imagery from the NASA/USGS Landsat satellites.

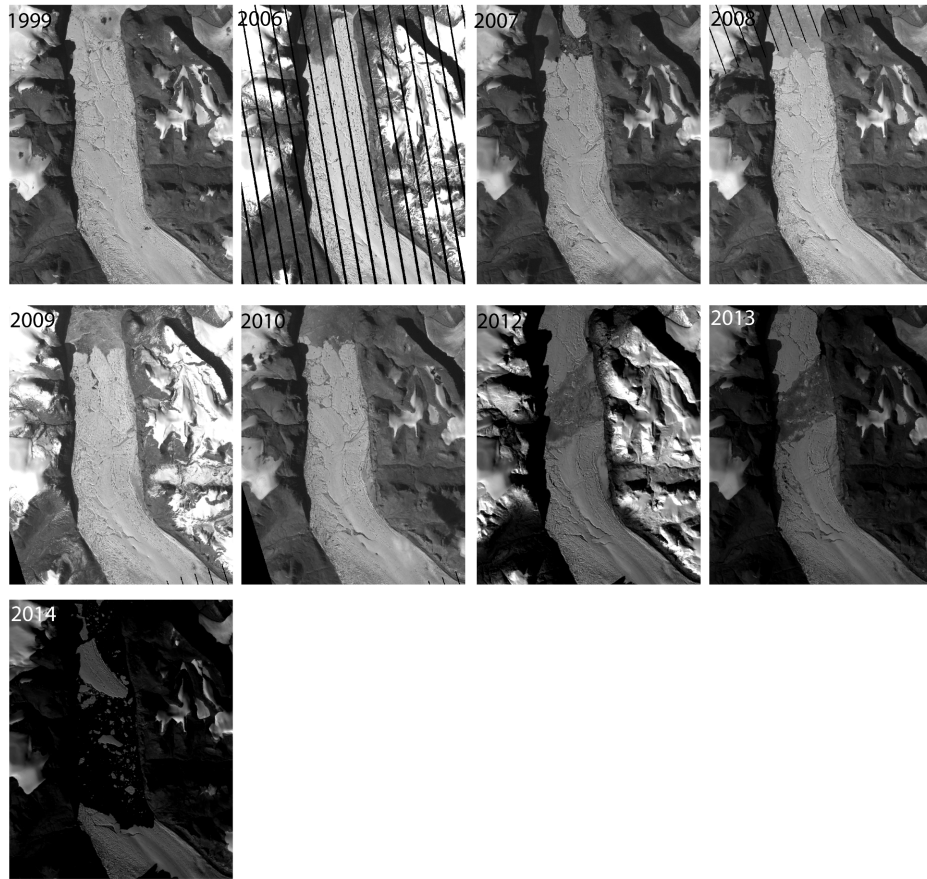


Figure S3. Steensby glacier ice shelf collapse observed using optical imagery from the NASA/USGS Landsat satellites. Black stripes are due to the failure of the Scan Line Corrector in Landsat-7 data.

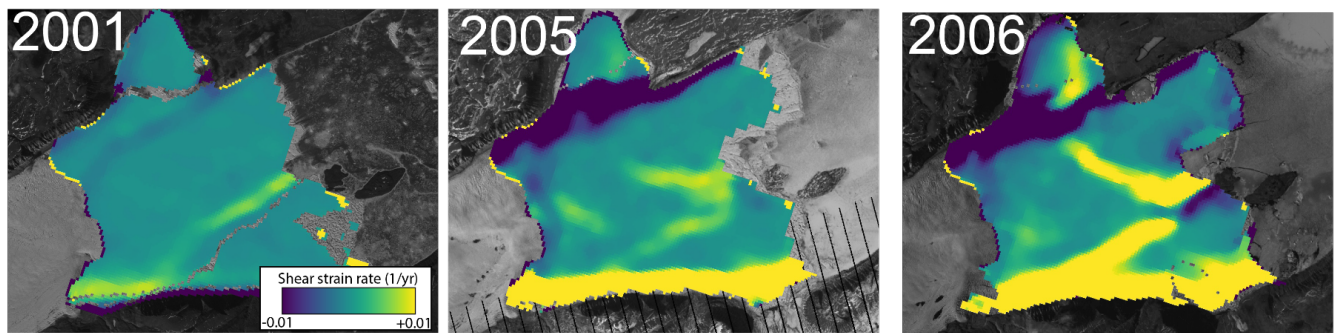


Figure S4. Shear strain rates evolution over Hagen Bræ ice shelf, calculated using yearly surface flow velocity measurements between 2001 and 2007 (Mouginot et al., 2019). Black stripes are due to the failure of the Scan Line Corrector in Landsat-7 data.

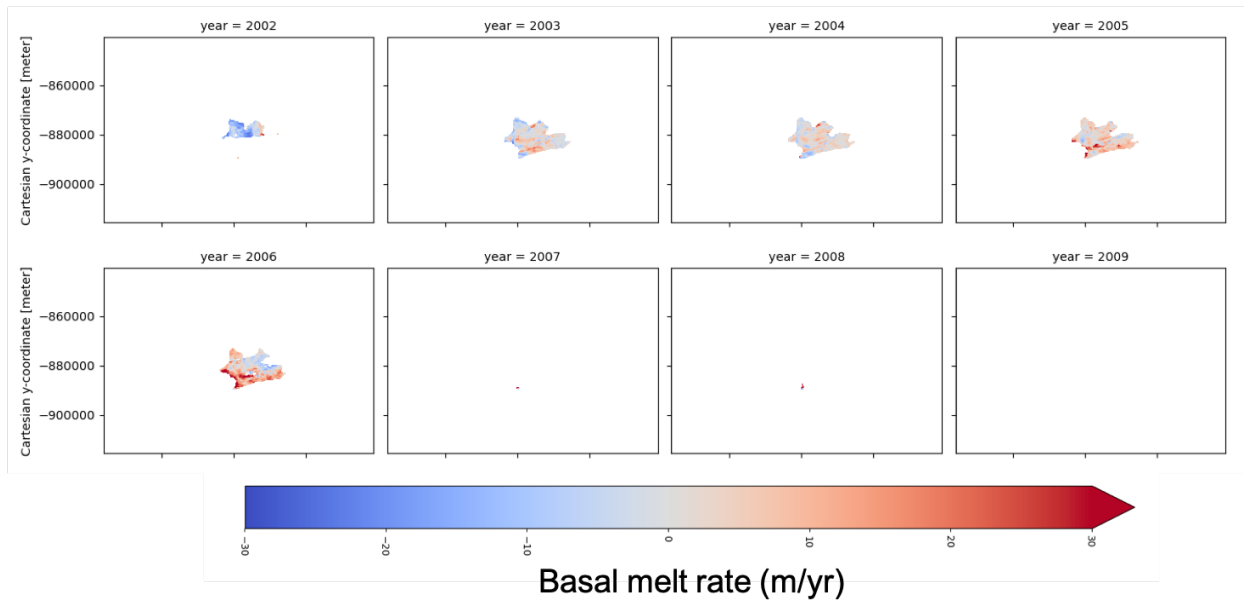


Figure S5. Basal melting observed at the ice shelf of Hagen Bræ between 2002 and 2006.

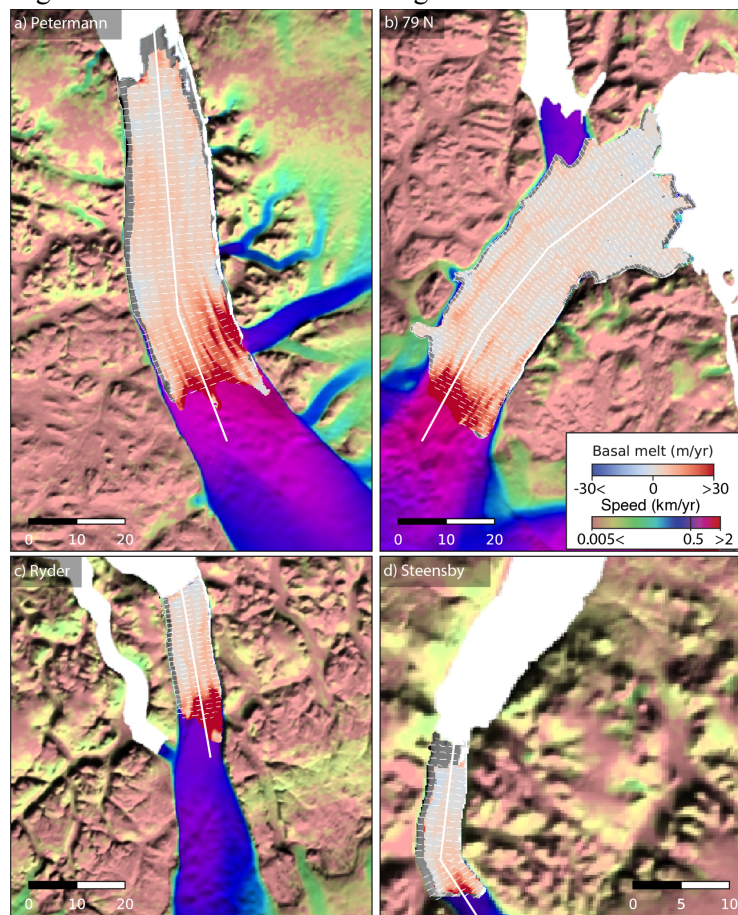


Figure S6. Average basal melt rate map between 2000 and 2021 observed at Petermann, 79N, Ryder and Steensby glacier. The figure shows the position of the flowline and cross-section used to calculate width-averaged basal melt rates in Figure 2.

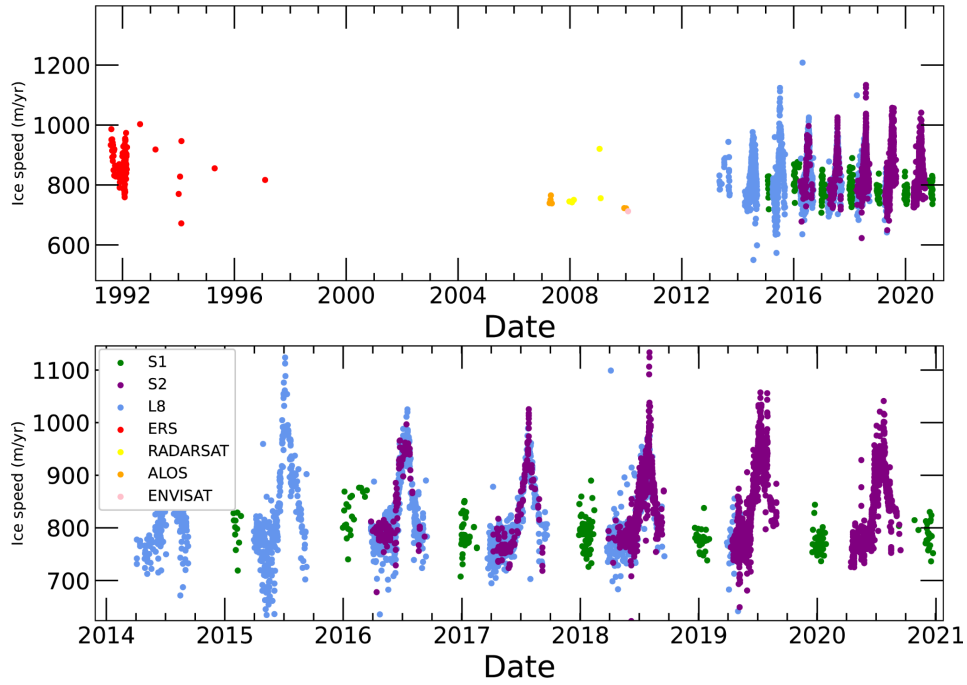


Figure S7. Grounding line ice flow velocity of Ostenfeld glacier. The ice flow velocity is averaged inside a box located close the grounding line of the glacier.

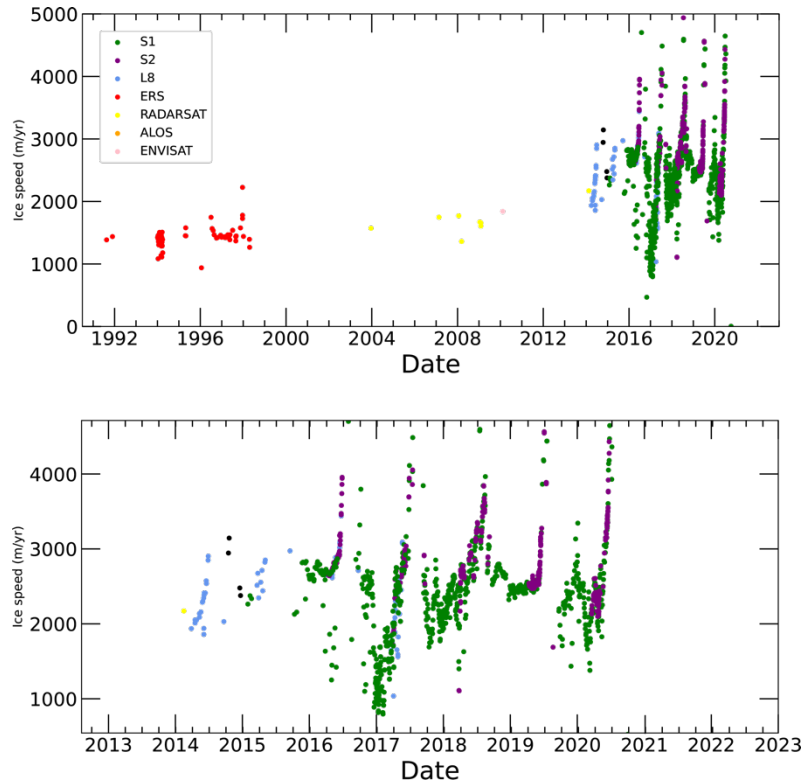


Figure S8. Grounding line ice flow velocity of Zachariae glacier. The ice flow velocity is averaged inside a box located close the grounding line of the glacier.

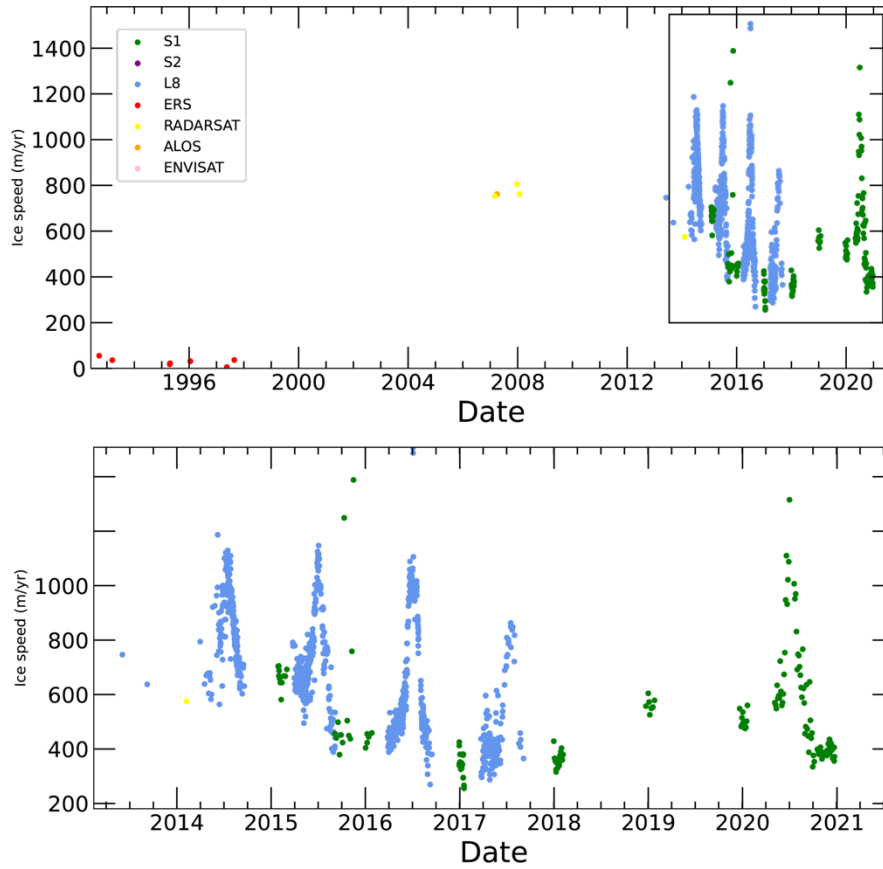


Figure S9. Grounding line ice flow velocity of Hagen Bræ. The ice flow velocity is averaged inside a box located close the grounding line of the glacier.

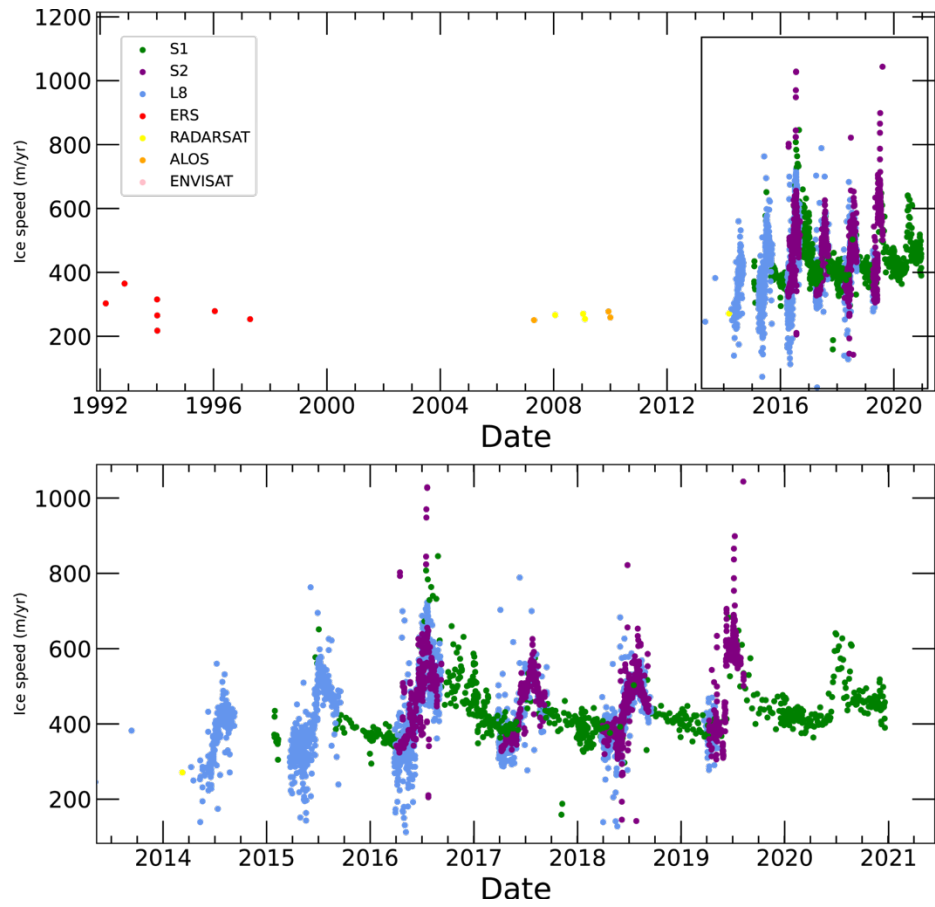


Figure S10. Grounding line ice flow velocity of Steensby. The ice flow velocity is averaged inside a box located close the grounding line of the glacier.

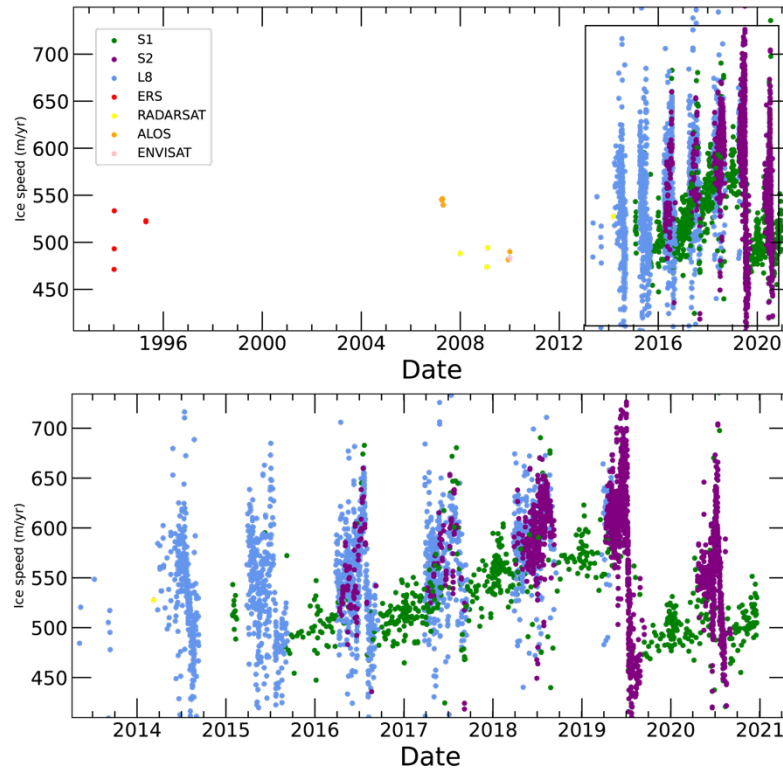


Figure S11. Grounding line ice flow velocity of Ryder glacier.

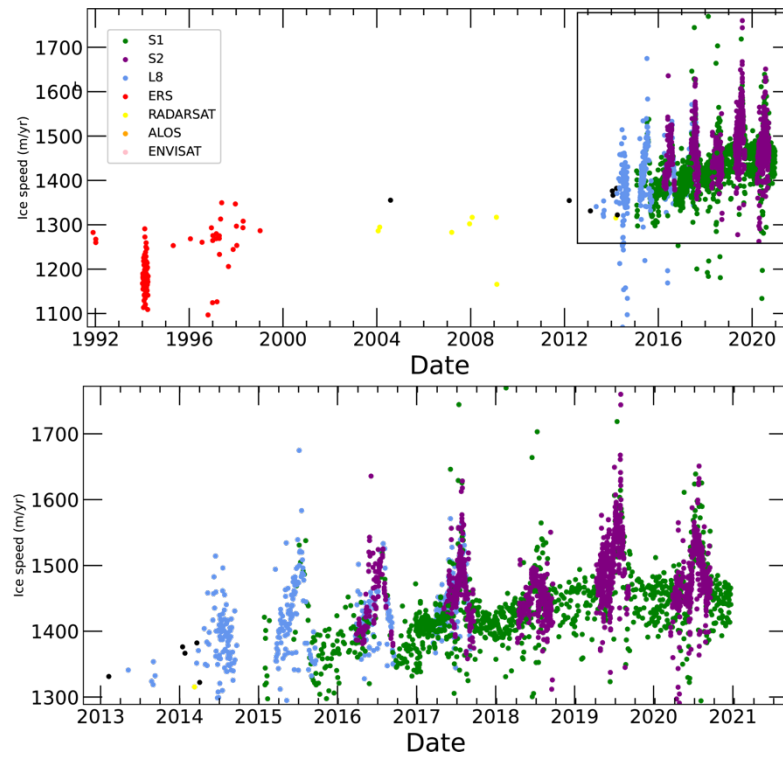


Figure S12. Grounding line ice flow velocity of 79N glacier. The ice flow velocity is averaged inside a box located close to the grounding line of the glacier.

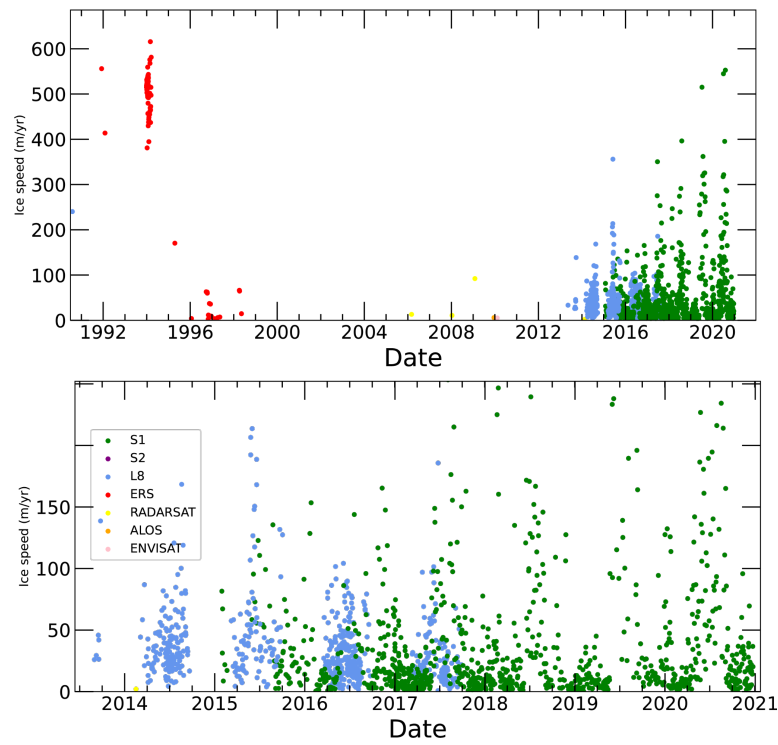


Figure S13. Grounding line ice flow velocity of Bistrup Bræ glacier. The ice flow velocity is averaged inside a box located close to the grounding line of the glacier.

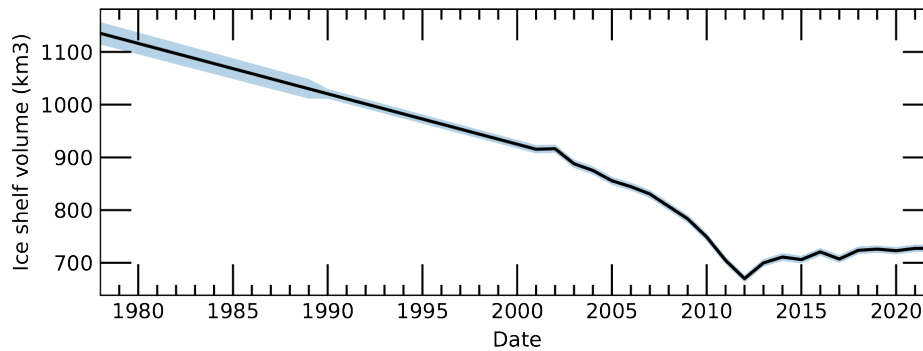


Figure S14. Total ice shelf volume change observed on the period 1978 - 2022.

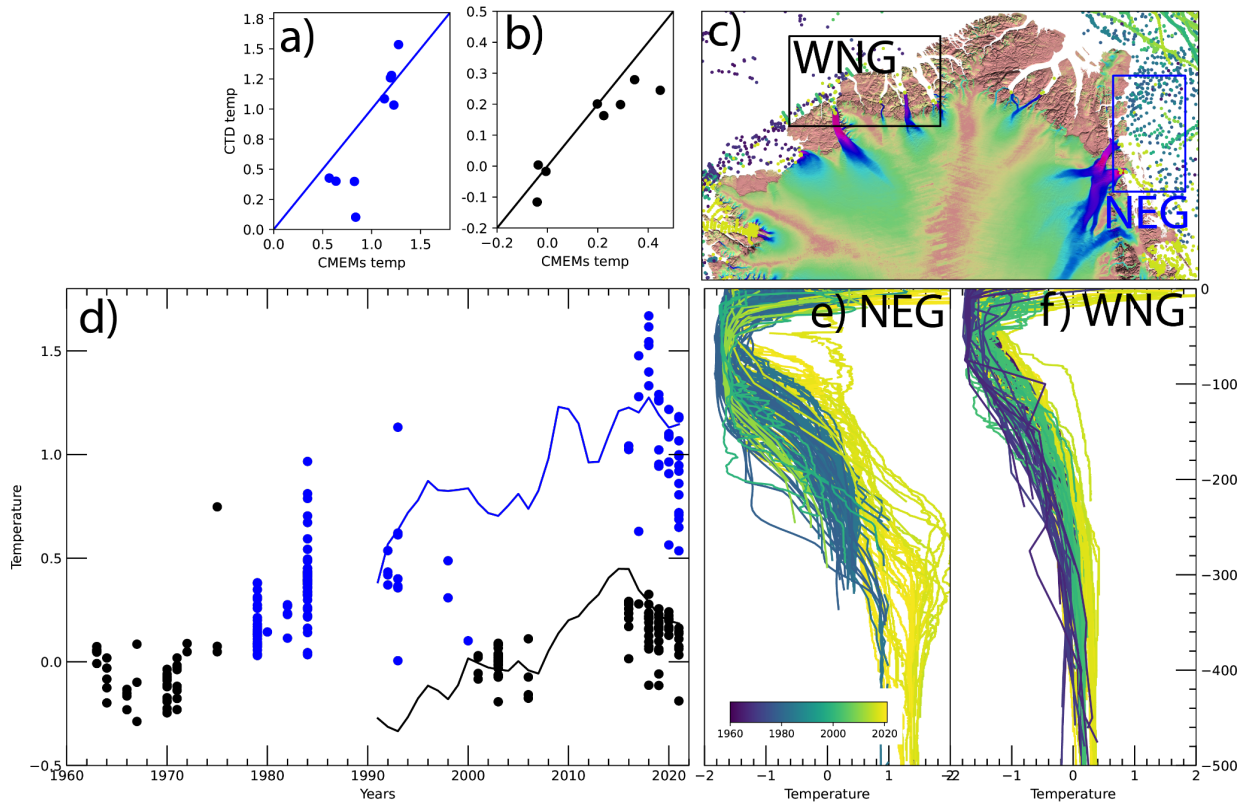


Figure S15. Ocean conditions from in-situ CTD measurement and ocean physics reanalysis data. a) and b) are showing the fit between in-situ and data reanalysis, c) is showing the location of the CTD measurements across North and Northeast Greenland with the bounding box location used to calculate average potential temperature (d). (e) and (f) show the CTD temperature profiles within each bounding box.

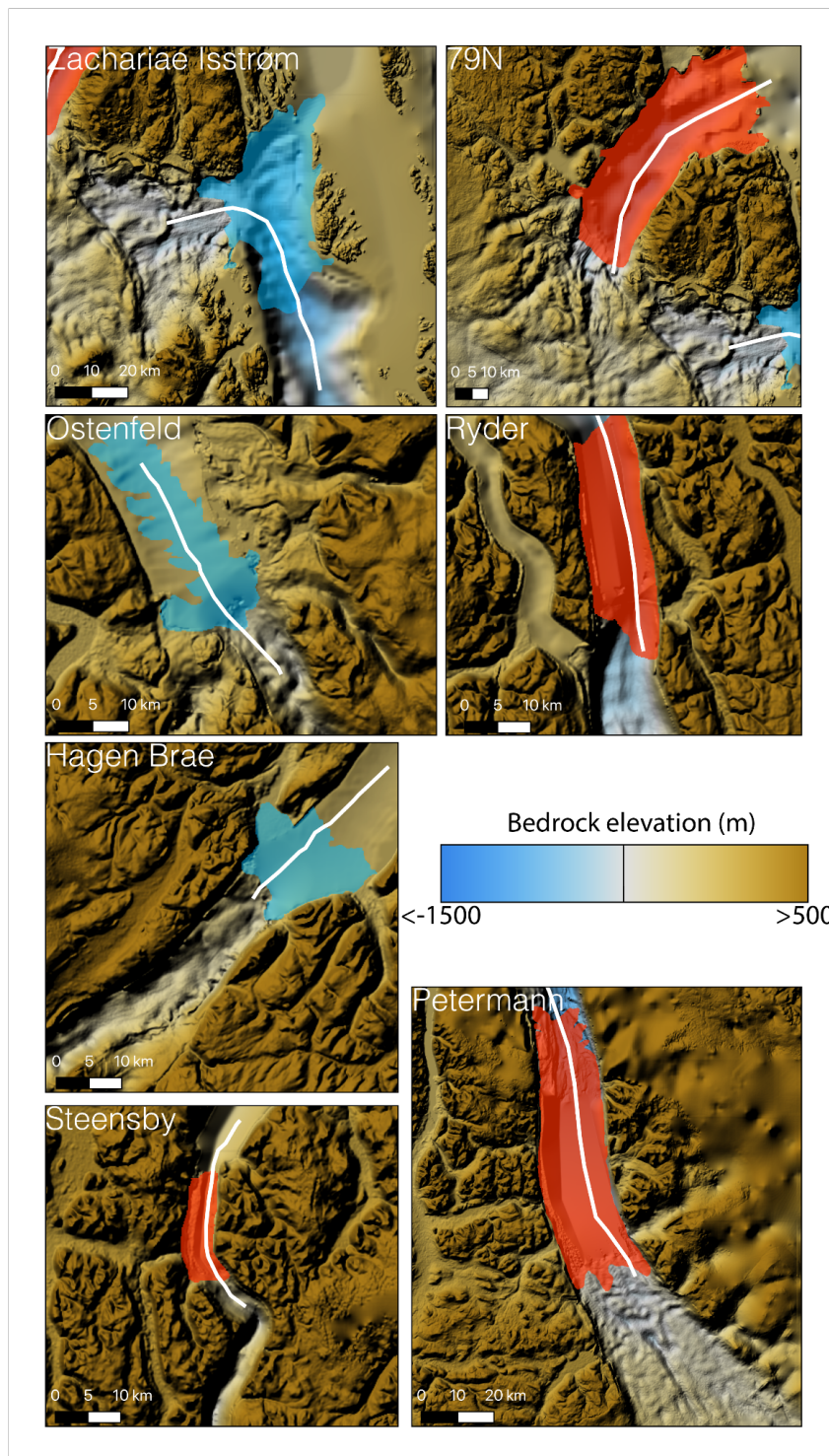


Figure S16. Bedrock and bathymetry of the glaciers and ice shelves of North Greenland. The bedrock elevation source is from BedMachine v3 (Morlighem et al., 2017). Ice shelves that have collapsed are shown in blue color, and still standing ice shelves are represented in red. The white line shows the flowline profiles that are used in Fig S14-S19.

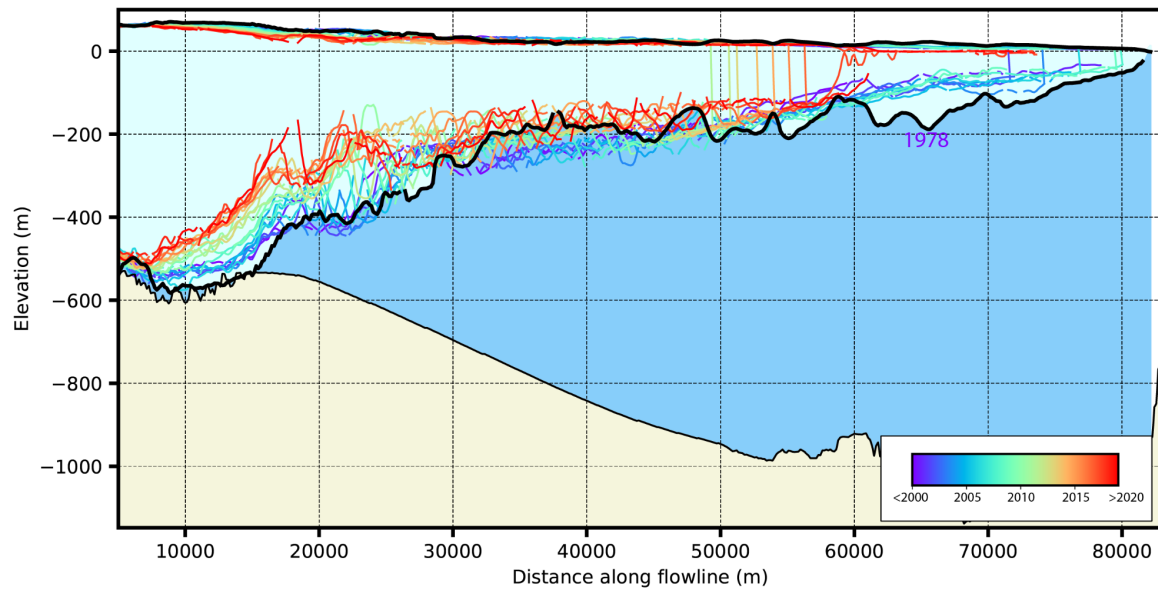


Figure S17. Thinning of Petermann ice shelf along flowline between 1978 and present (see Fig S13).

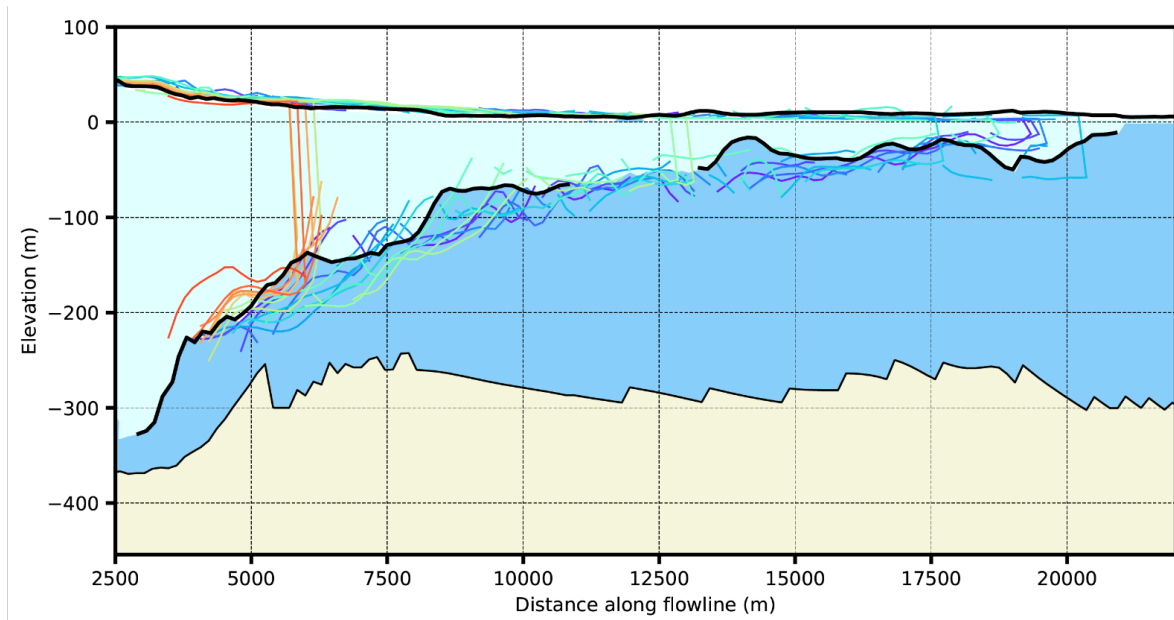


Figure S18. Thinning of Steensby ice shelf along flowline between 2001 and present (see Fig S13).

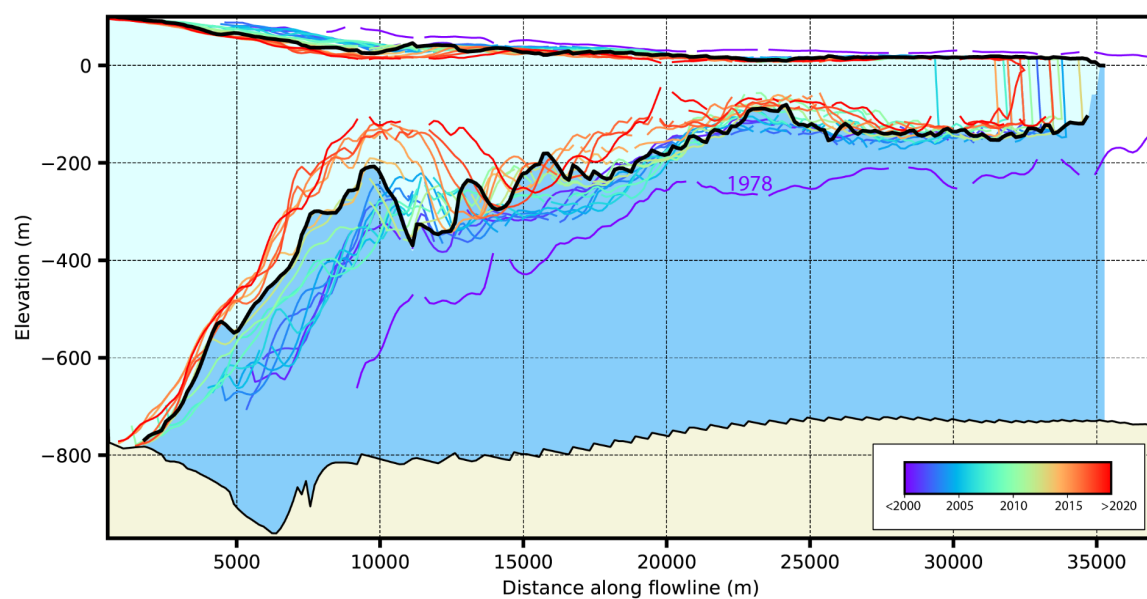


Figure S19. Thinning of Ryder ice shelf along flowline between 1978 and present (see Fig S13).

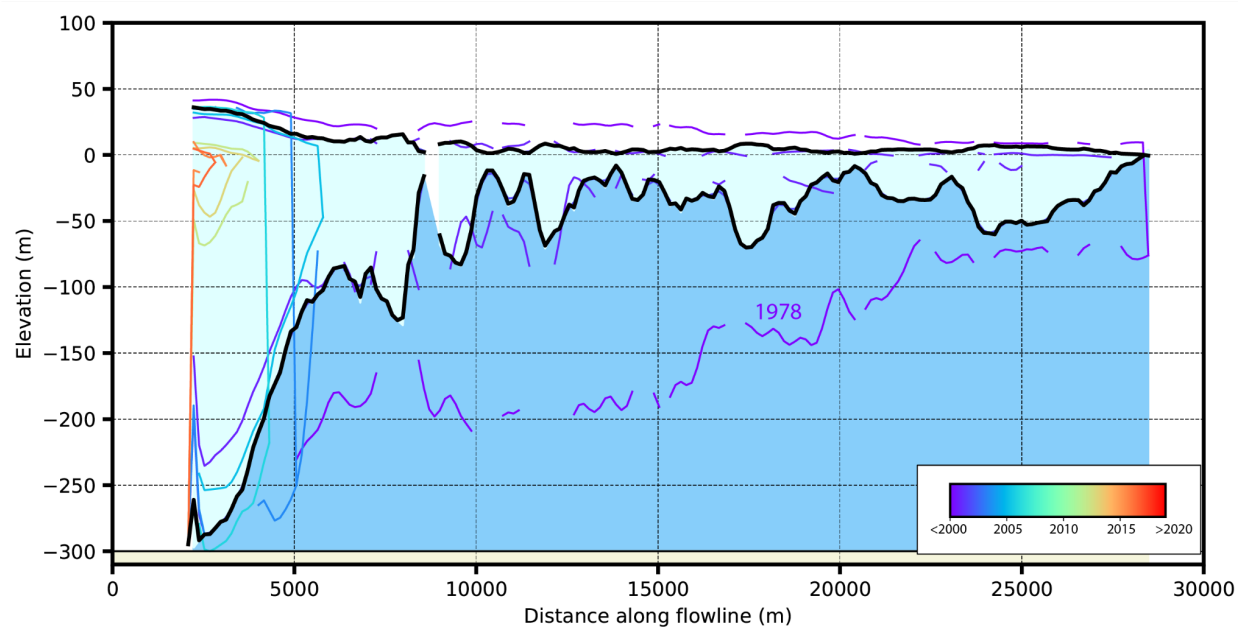


Figure S20. Thinning and collapse of Ostenfeld ice shelf along flowline between 1978 and present (see Fig S13)

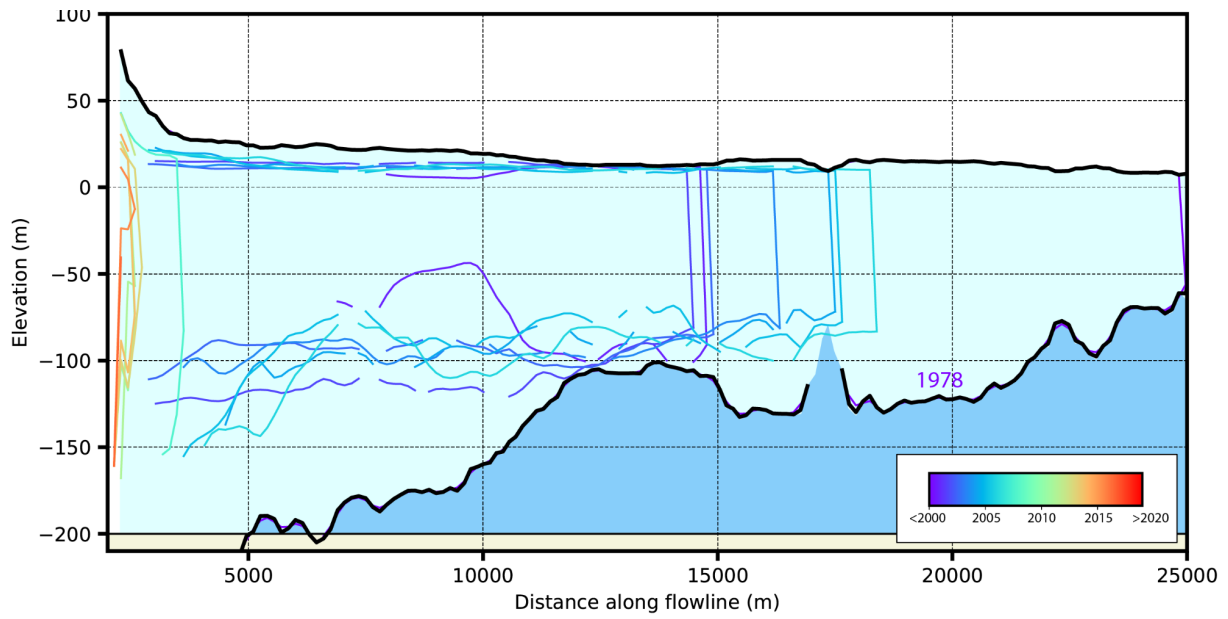


Figure S21. Thinning and collapse of Hagen Brae ice shelf along flowline between 1978 and present (see Fig S13)

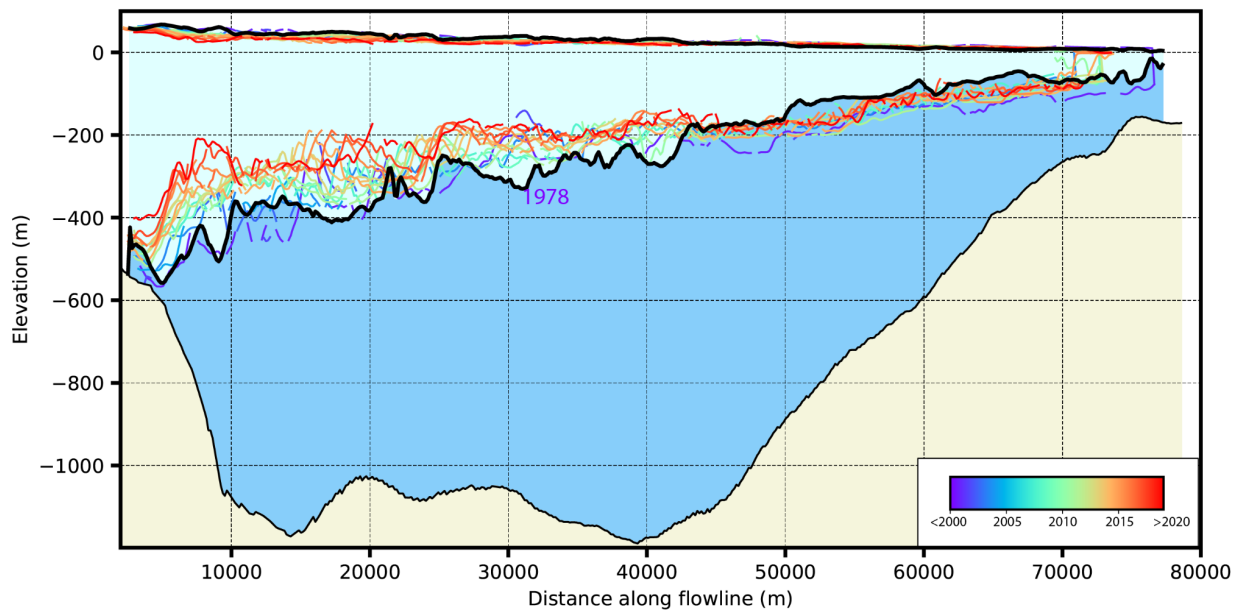


Figure S22. Thinning of 79N ice shelf along flowline between 1978 and present (see Fig S13).

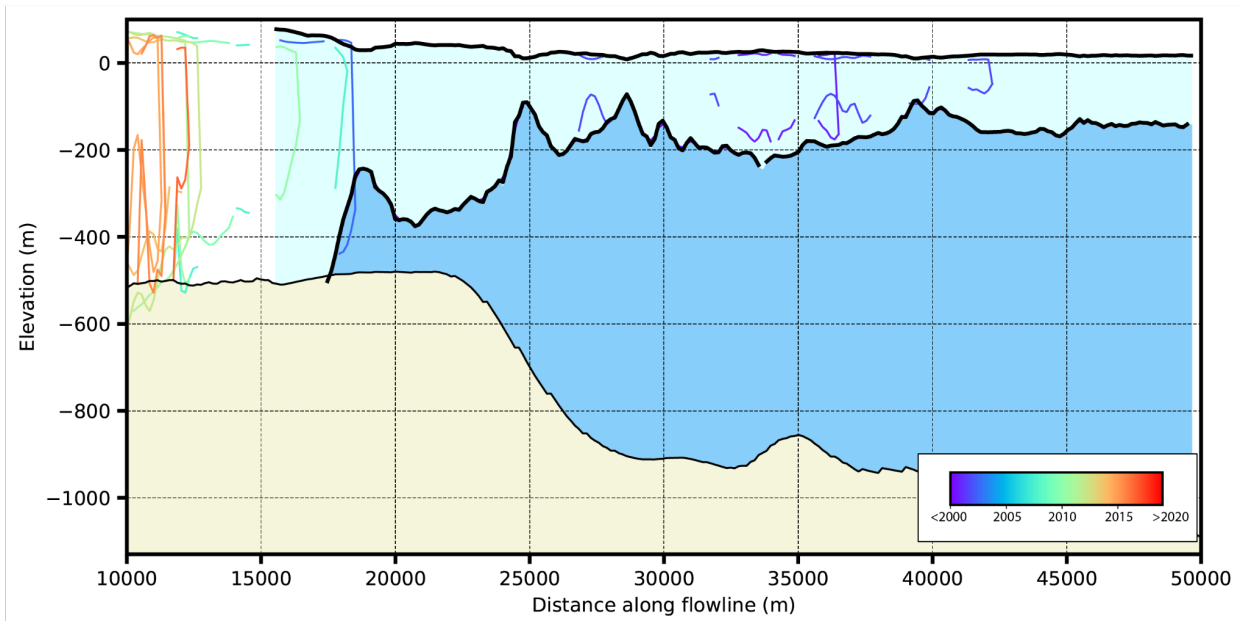


Figure S23. Thinning and collapse of Zachariæ Isstrøm along flowline between 1978 and present (see Fig S13).

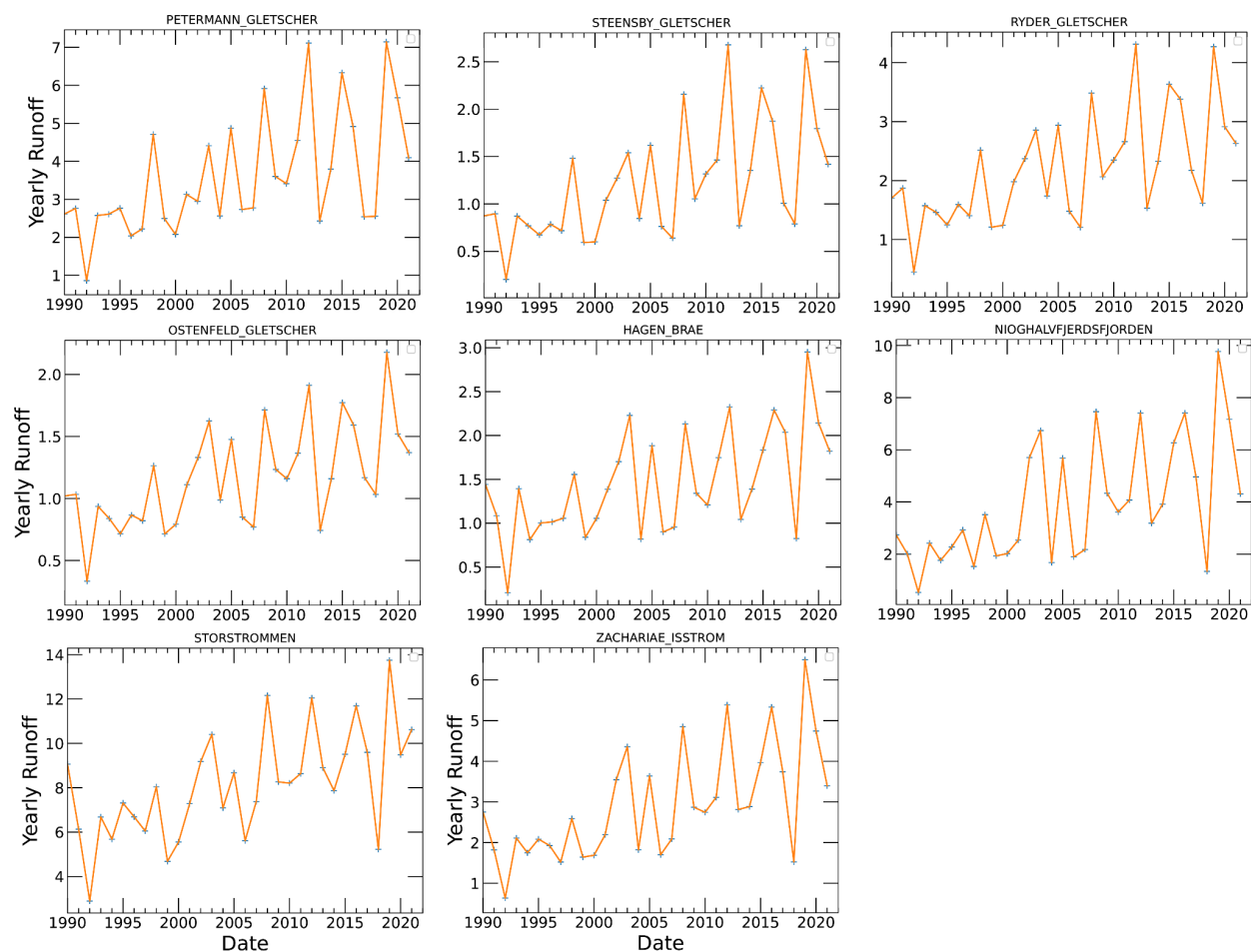


Fig. S24. Yearly evolution of the runoff extracted from the MAR model output over each glacier drainage basin (Mouginot et al., 2019).

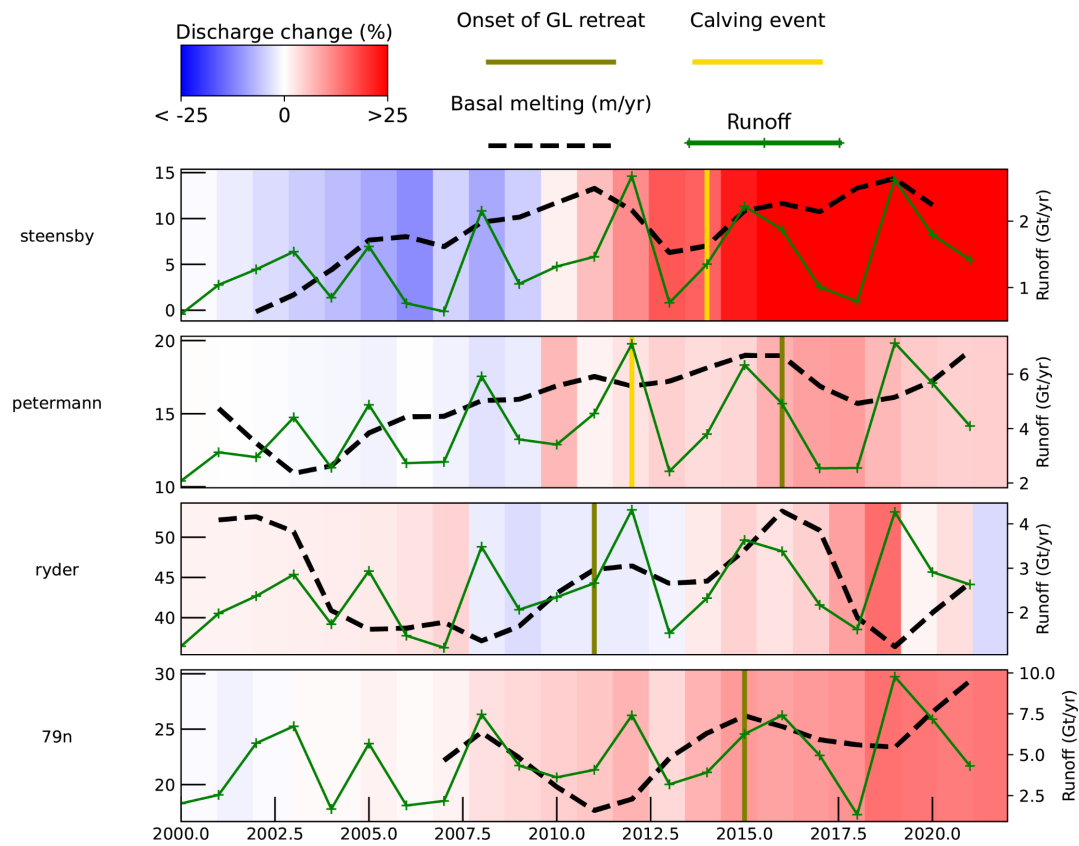


Fig. S25. Glaciers dynamical response to ice shelves changes (a-d). Changes in ice discharge is represented in % relative to the average of 1970-2000, and color coded from blue to red. Ice shelf melt rate evolution is represented as black dotted line. Calving events and onset of GL retreat are noted as vertical blue and yellow bars respectively. e) Changes in runoff for each glacier drainage basin is represented in green.

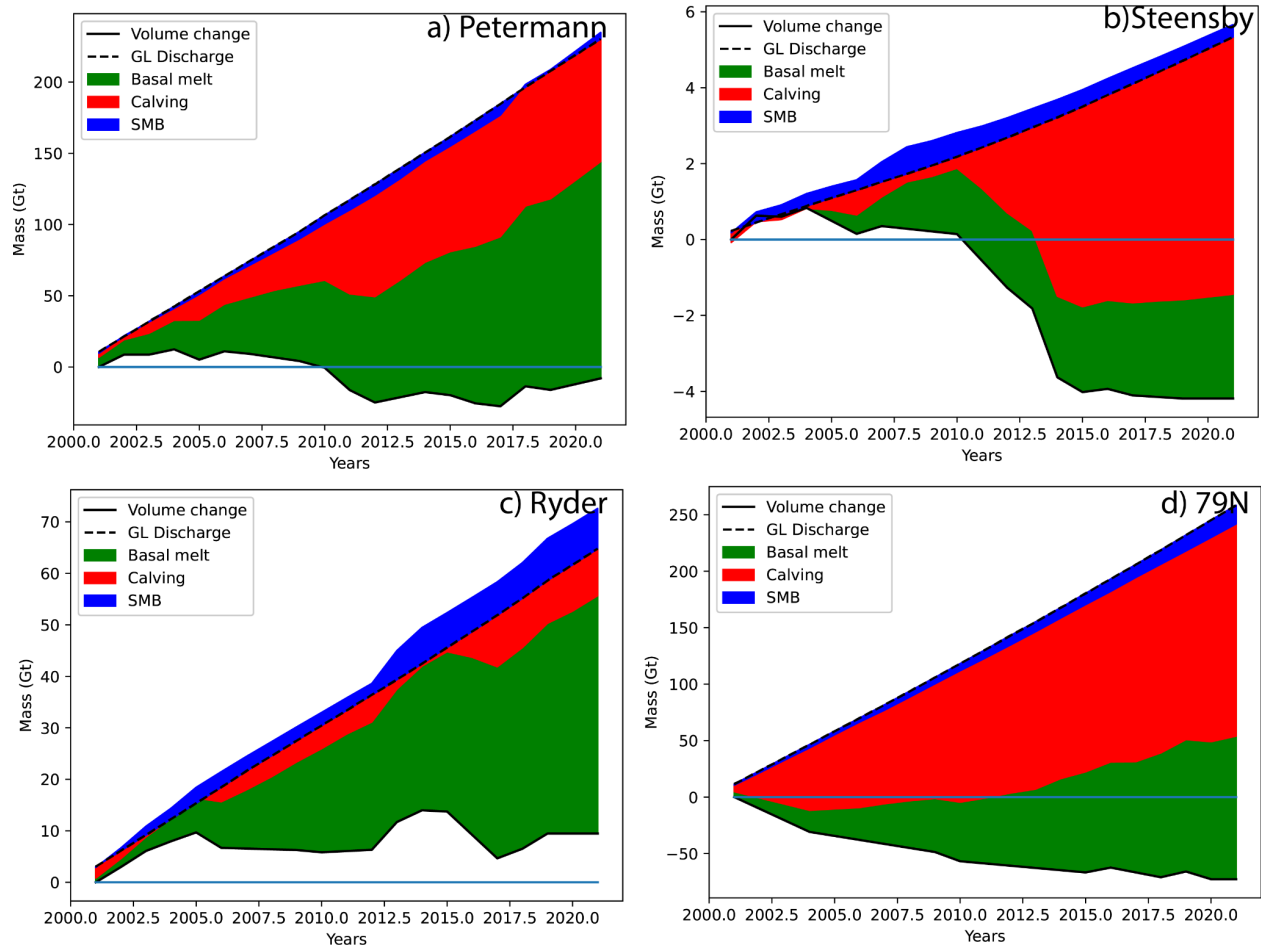


Fig S26. Ice shelf mass balance partitioning evolution for Petermann (a), Steensby (b), Ryder (c) and 79N (d).

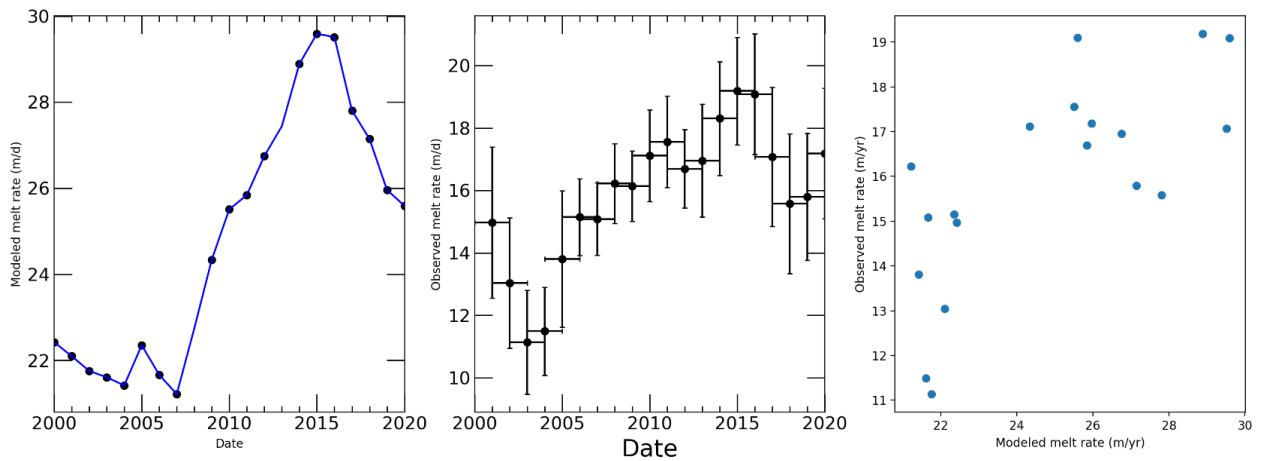


Fig S27. Modeled melt rate using the parametrization from²⁶ and neglecting subglacial water discharge (left), observed melt rates (center) and comparison between the two calculations (right).

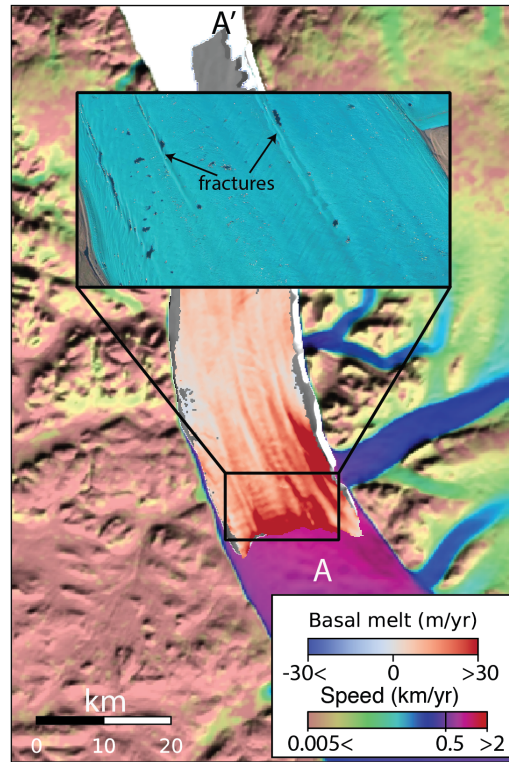


Fig S28. Basal melt rate averaged after 2015 over the Petermann ice shelf. The inset shows a Landsat-8 optical image from 2019 with a zoom at the grounding line highlighting the presence of large along flow fractures¹⁸.

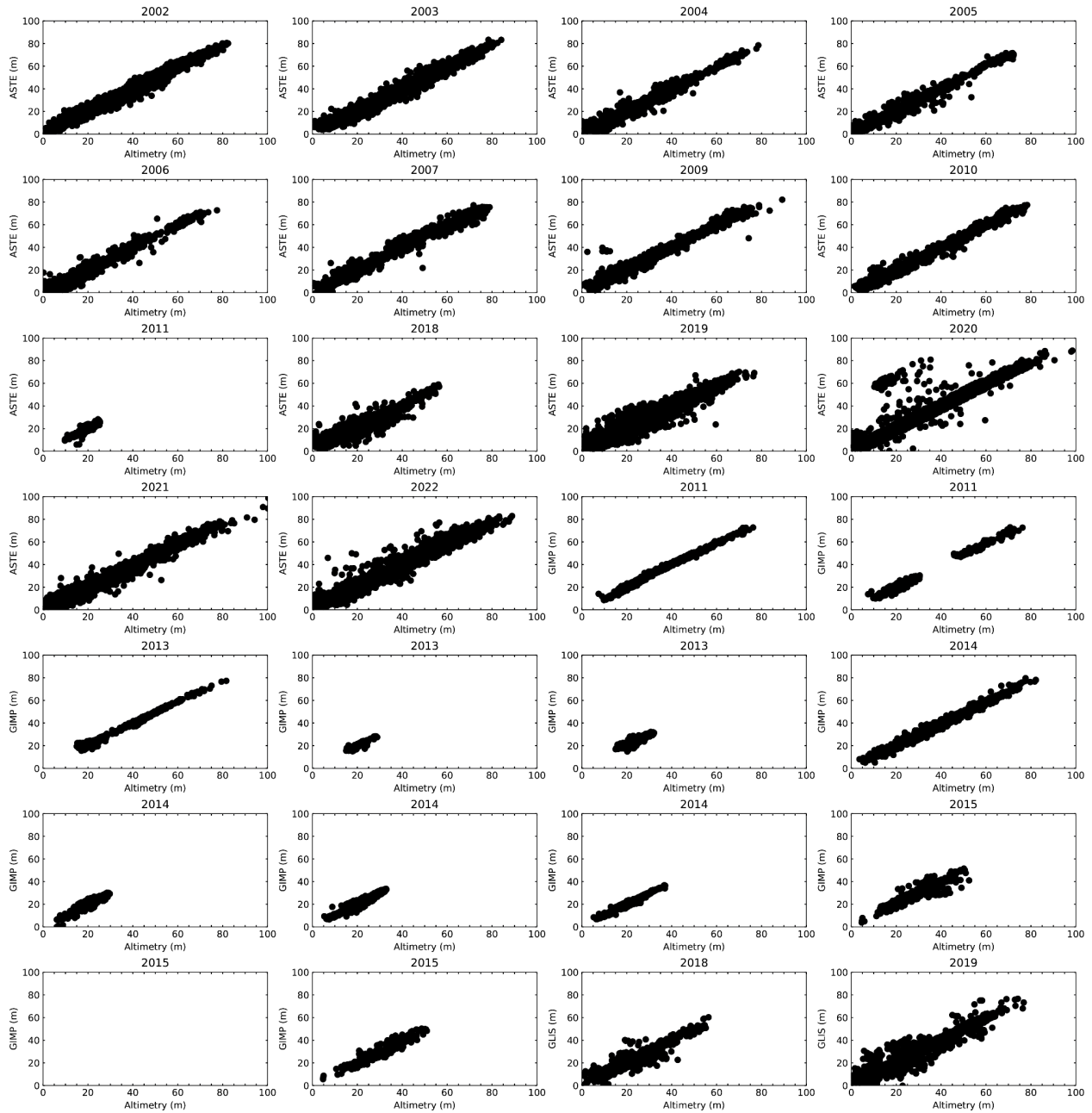


Figure S29. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Petermann ice shelf. Empty plot corresponds to years without overlap with altimetry data.

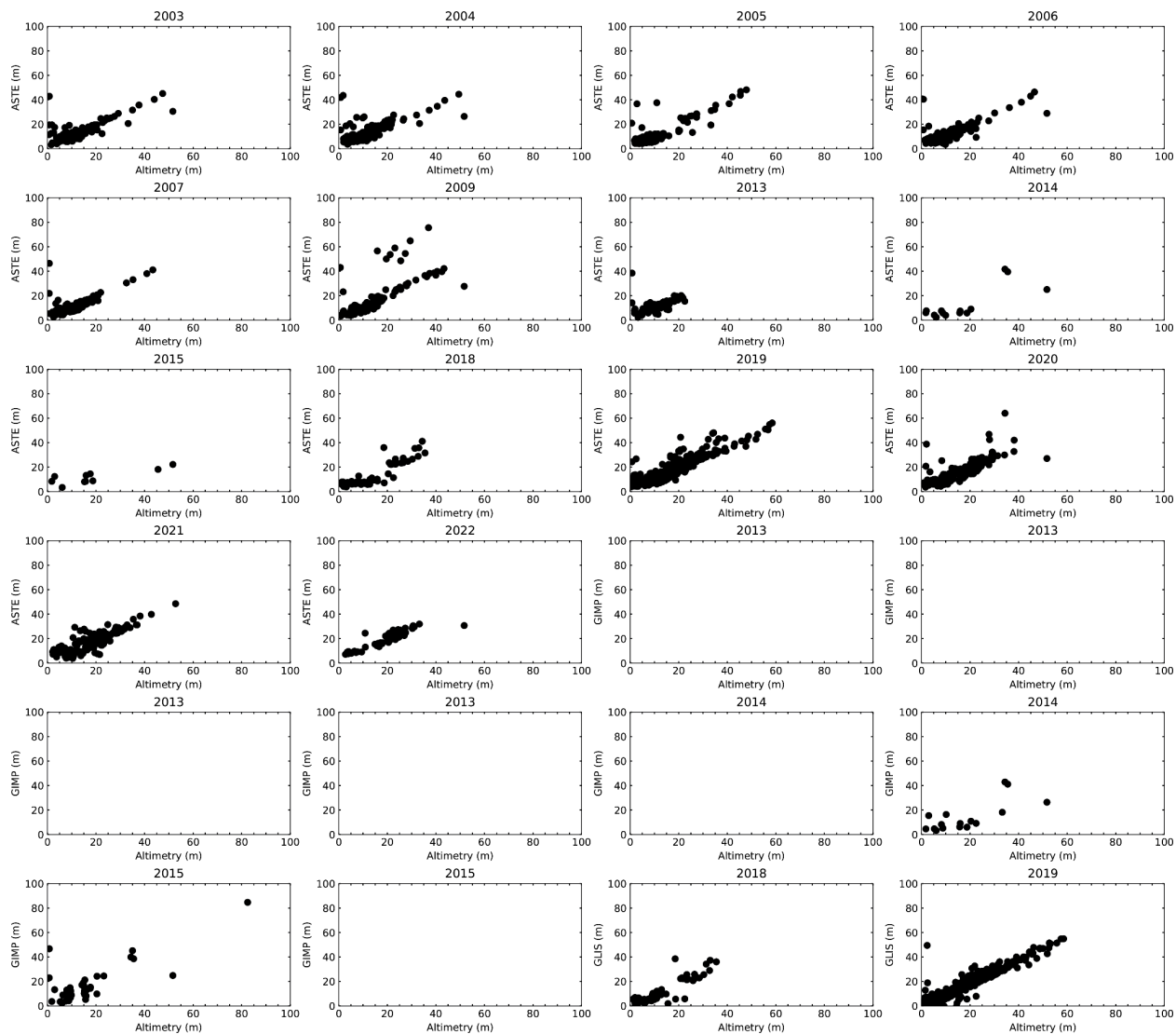


Figure S30. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Steensby ice shelf. Empty plot corresponds to years without overlap with altimetry data.

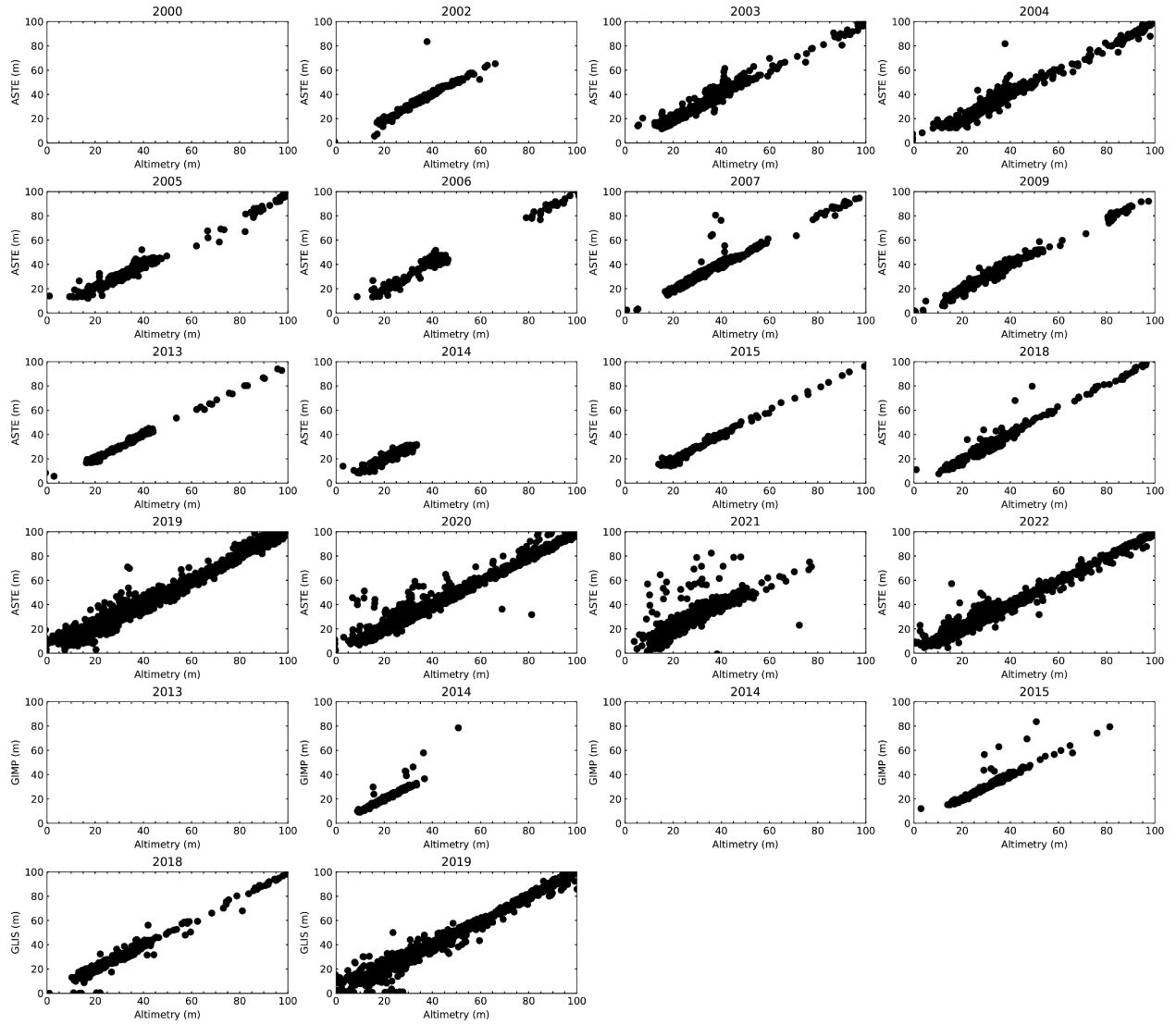


Figure S31. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Ryder ice shelf. Empty plot corresponds to years without overlap with altimetry data.

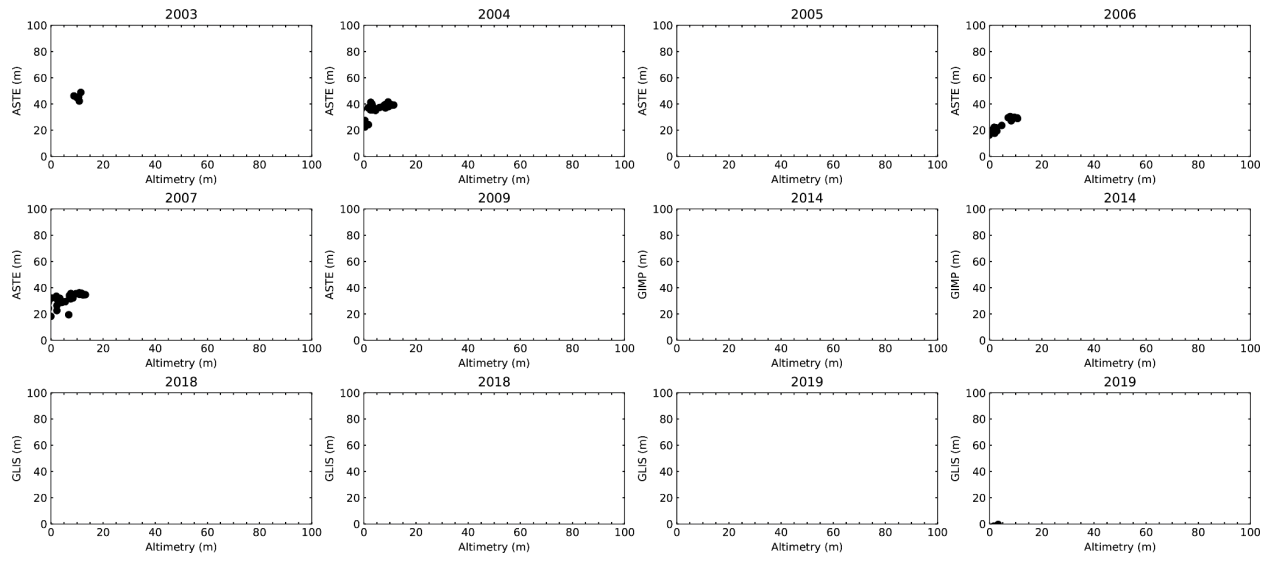


Figure S32. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Ostenfeld ice shelf. Empty plot corresponds to years without overlap with altimetry data.

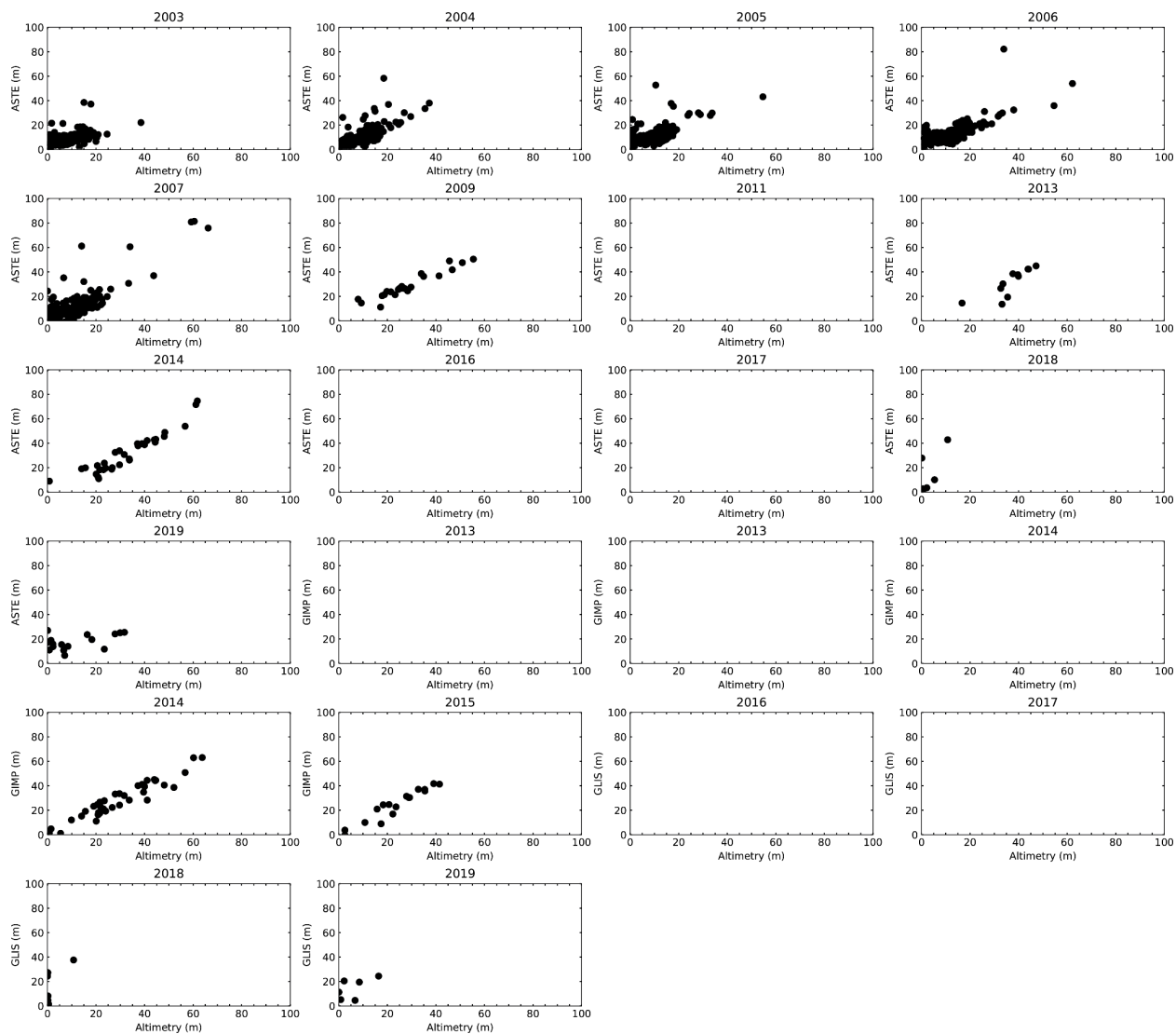


Figure S33. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Hagen Bræ ice shelf. Empty plot corresponds to years without overlap with altimetry data.

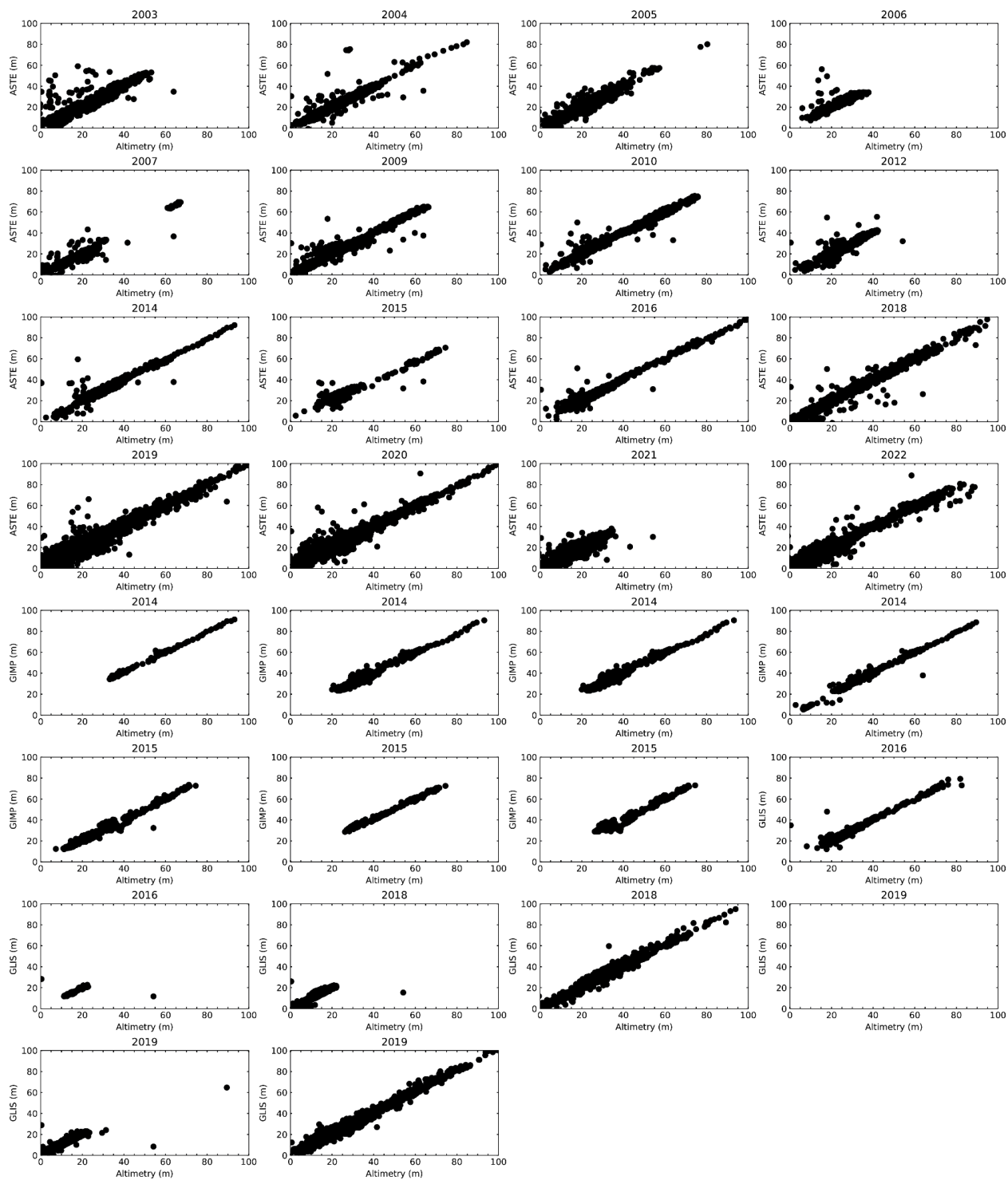


Figure S34. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the 79N ice shelf. Empty plot corresponds to years without overlap with altimetry data.

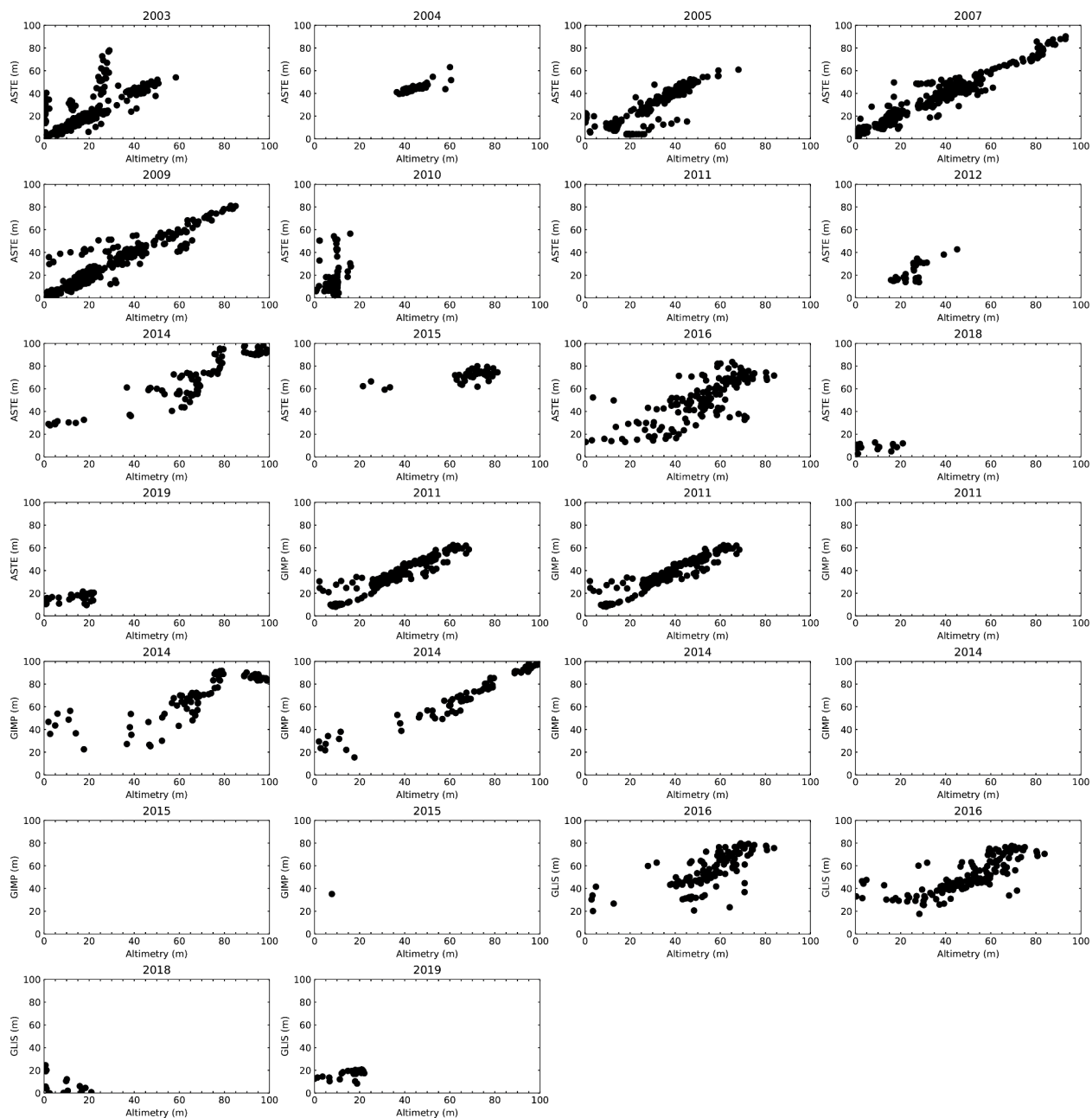


Figure S35. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Zachariae ice shelf. Empty plot corresponds to years without overlap with altimetry data.

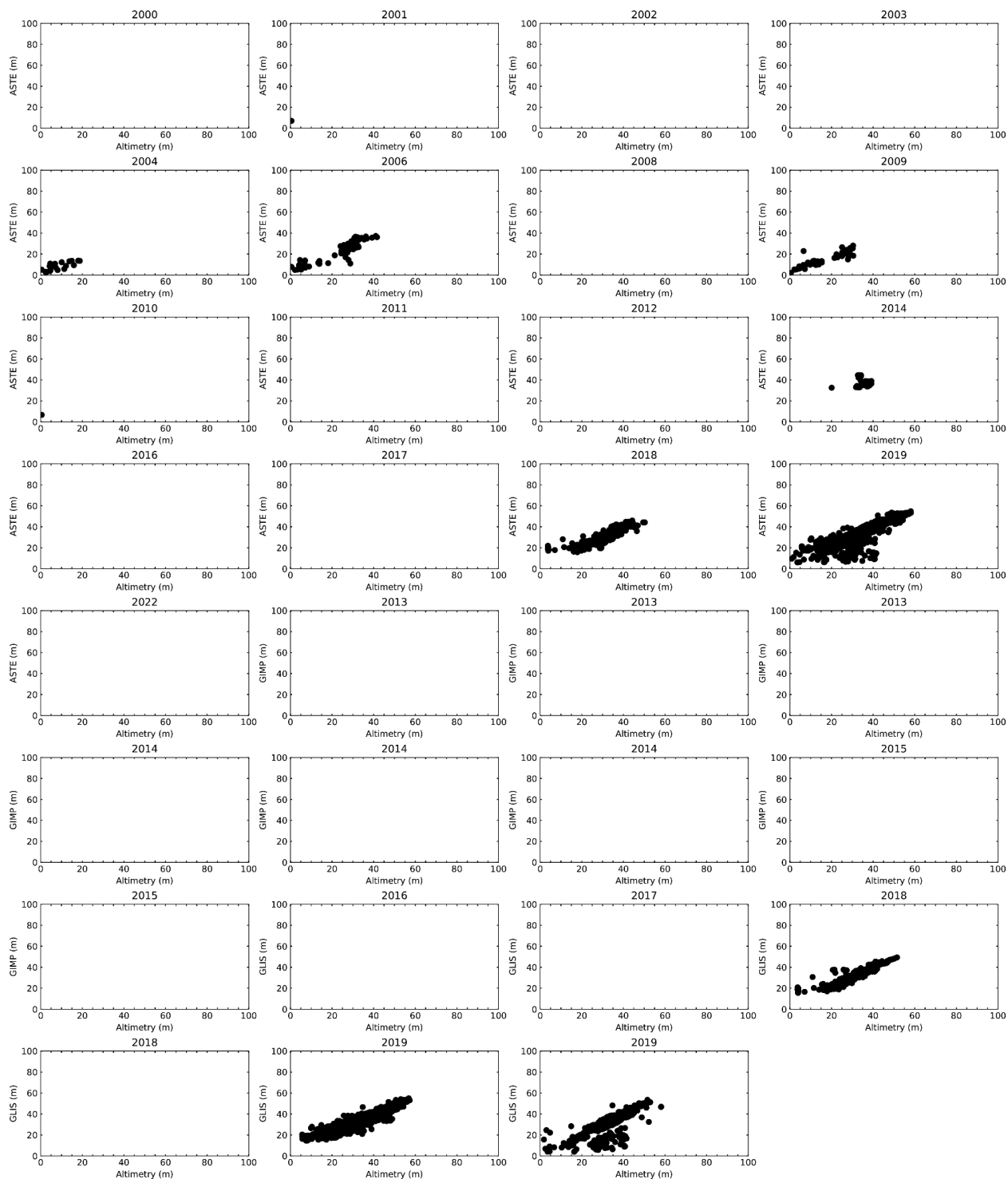


Figure S36. Fit in surface elevation between ASTER (ASTE), GIMP and GLISTIN-A (GLIS) DEMs and yearly reference DEMs assembled using a combination of Altimetry data (see Material and Methods) over the Størestrommen ice shelf. Empty plot corresponds to years without overlap with altimetry data.