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We use satellite gravimetry from GRACE and GRACE-FO (2002–2023) to quantify glacier mass balance variability across the Arctic and assess its covariation with permafrost changes under the influence of large-scale atmospheric circulation. GRACE/GRACE-FO reveals spatially heterogeneous anomalies of glacier mass change with significant interannual variability, reflecting the imprint of dominant circulation modes such as the North Atlantic Oscillation. These mass anomalies show statistically significant covariation with changes in active layer thickness, derived from ESA's CCI remote sensing product (2003–2019) and CALM in situ observations (1990–2023), with asynchronous variations between neighboring regions. EOF analysis applied to the GRACE/GRACE-FO time series explains ~75% of the observed Arctic-wide variability when constrained by atmospheric reanalysis data, underscoring the strong sensitivity of gravimetrically detected mass redistribution to synoptic-scale forcing. Our results establish GRACE/GRACE-FO as a key observational constraint on glacier systems of the Arctic, highlighting its critical role in diagnosing and predicting cryospheric responses to a warming and increasingly variable atmosphere.
Meeting homepage
GRACE-FO 2025 Science Team Meeting