Supplement of

Brief Communication: Accelerated glacier mass loss in the Russian Arctic (2010-2017)

Christian Sommer et al.

Correspondence to: Christian Sommer (chris.sommer@fau.de)

Table S 1 DEM corregistration statistics on non-glacierized areas for each subregion. $S_{glacier}$ refers to glacier areas with equal or less than 50° slope while $S_{no\text{-}ice}$ includes all areas (outside glaciers, ocean or lakes) with equal or less than 50° slope which were used during the corregistration. $\sigma_{\Delta h/\Delta t}$ and $\sigma_{\Delta h/\Delta t\ AW}$ are the total and glacier area-weighted standard deviations (2-98% quantile filtered) of $S_{no\text{-}ice}$ within 5° slope bins (methods section).

Region	$S_{glacier}$ <= 50° [km²]	$S_{no\text{-}ice}$ <= 50° [km²]	$\sigma_{\Delta h/\Delta t}$ [m a^{-1}]	$\sigma_{\Delta h/\Delta t\ AW}$ [m a^{-1}]
Franz Josef Land	12470	2565	0.279	0.135
Severnaya Zemlya	16444	15128	0.076	0.068
Novaya Zemlya	22073	19130	0.117	0.077

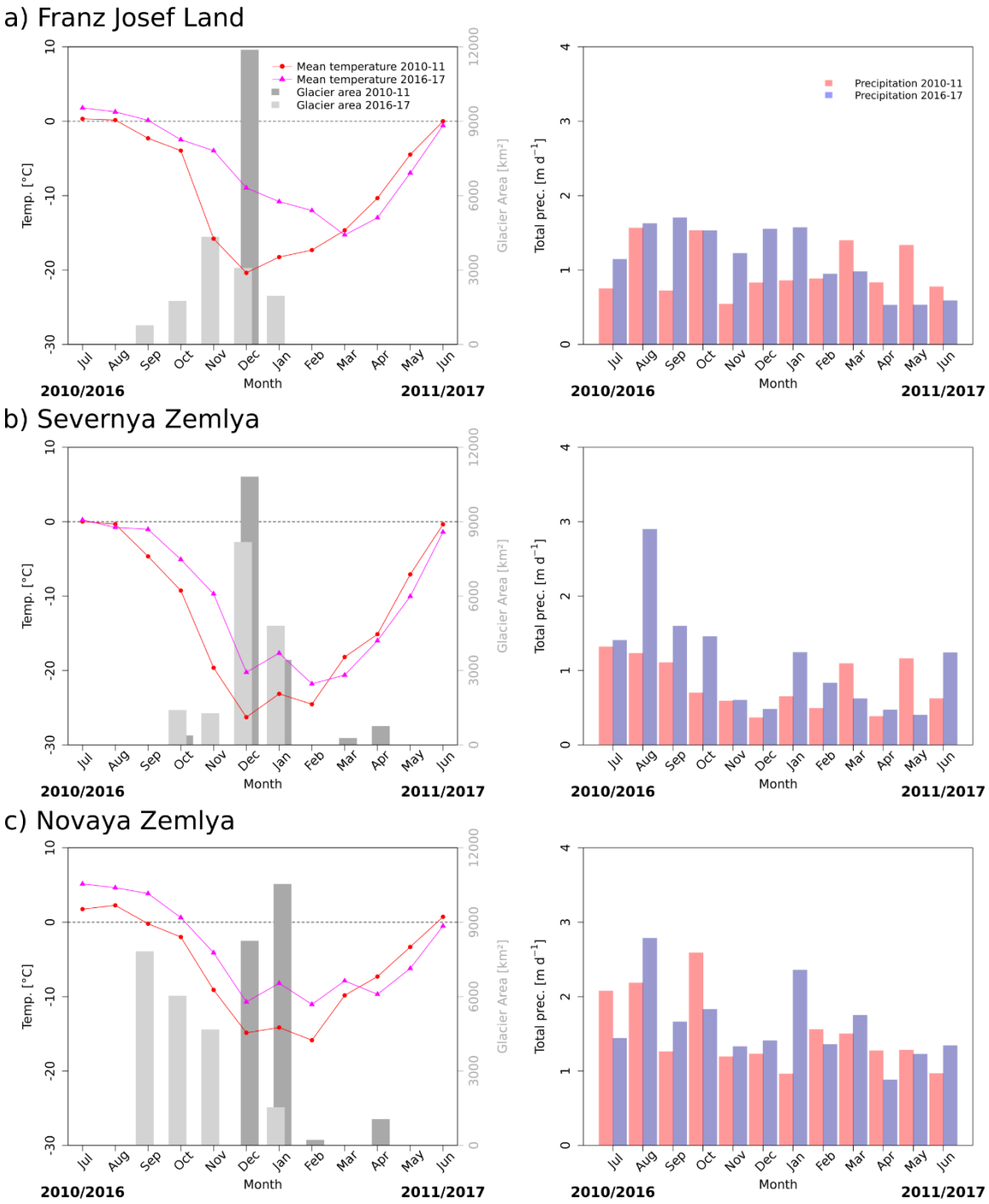

Figure S 1 Average monthly skintemperatures and total precipitation in meters per day of the Russian Arctic archipelagos during years with TanDEM-X acquisitions, derived from ERA5 reanalysis. Gray bars show the glacier area covered by TanDEM-X during winter 2010/11 and winter/autumn 2016/17.

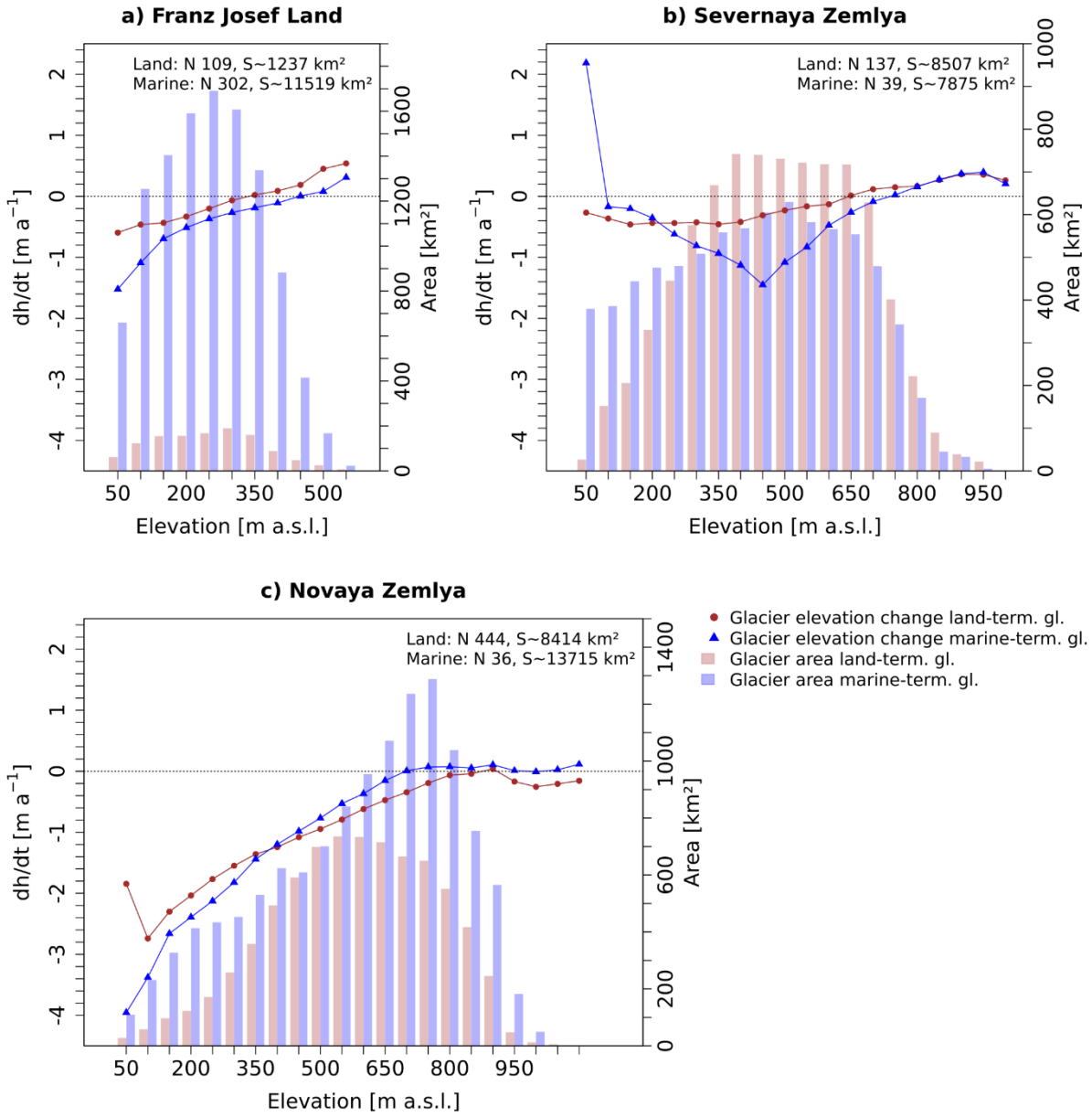

Figure S 2 Hypsometric distribution of elevation changes of land-terminating (brown dots) and marine-terminating (blue triangles) glaciers on Franz Josef Land (a), Severnaya Zemlya (b) and Novaya Zemlya (c). Respective glacier areas per elevation bin are shown as bars. The positive and less negative average elevation change rates below 450 m a.s.l. of marine-terminating glaciers on Severnaya Zemlya are caused by thickening in the ablation zones of some outlet glaciers (Academy of Sciences Ice Cap) and glacier surge activity (Vavilov Ice Cap). Elevation changes on Novaya Zemlya were corrected for SAR signal penetration.

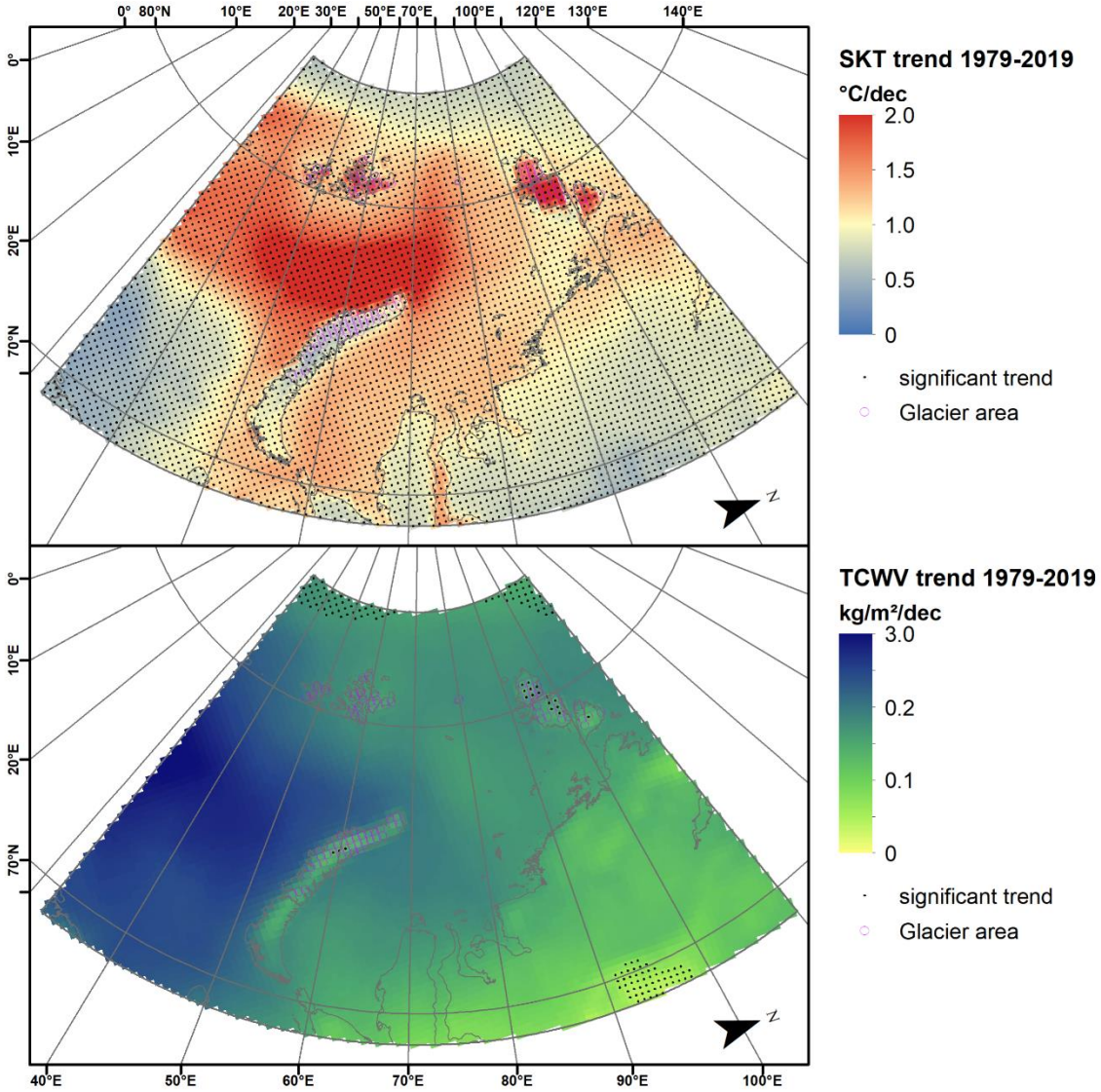

Figure S 3 Decadal trends in skintemperature (SKT) (a) and total column water vapor (TCWV) (b) between 1979 and 2019, derived from ERA5 reanalysis. Small gray dots show raster cells with significant trend (P < 0.05) while magenta circles represent cells with glacier areas.

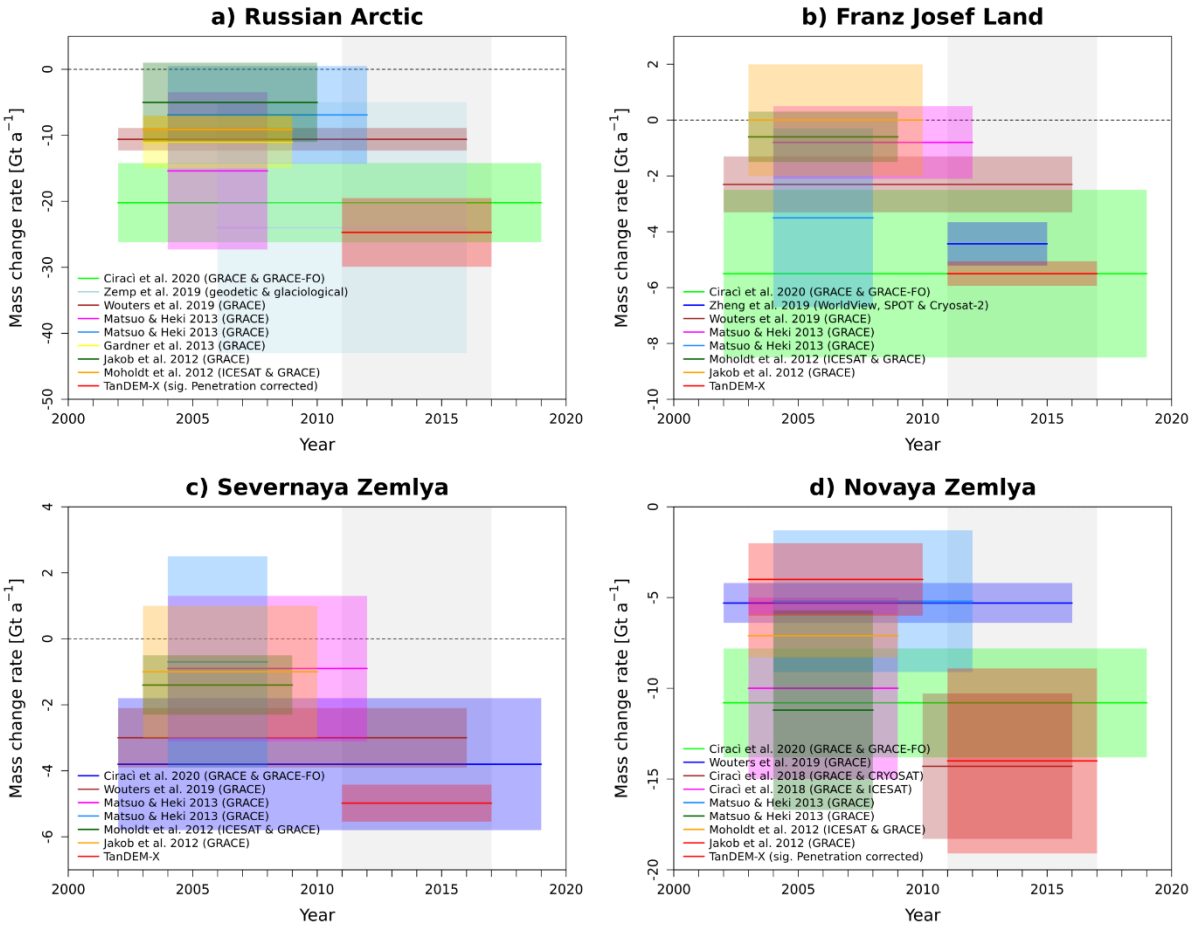

Figure S 4 Comparison of glacier mass change measurements in the entire Russian Arctic, Franz Josef Land, Severnaya Zemlya and Novaya Zemlya derived from Gravimetry (GRACE) and Altimetry (ICESAT, CRYOSAT). The method by Zemp et al. (2019) uses extrapolation based on glaciological and geodetic samples. For Novaya Zemlya the signal penetration corrected glacier mass change by TanDEM-X is shown.

References

Ciracì, E., Velicogna, I. and Sutterley, T.: Mass Balance of Novaya Zemlya Archipelago, Russian High Arctic, Using Time-Variable Gravity from GRACE and Altimetry Data from ICESat and CryoSat-2, Remote Sensing, 10(11), 1817, doi:10.3390/rs10111817, 2018.

Ciracì, E., Velicogna, I. and Swenson, S.: Continuity of the Mass Loss of the World's Glaciers and Ice Caps From the GRACE and GRACE Follow-On Missions, Geophys. Res. Lett., 47(9), doi:10.1029/2019GL086926, 2020.

Copernicus Climate Change Service (C3S): ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate. Copernicus Climate Change Service Climate Data Store (CDS), [online] Available from: https://cds.climate.copernicus.eu/cdsapp#!/home (Accessed 5 November 2020), 2017.

Gardner, A. S., Moholdt, G., Cogley, J. G., Wouters, B., Arendt, A. A., Wahr, J., Berthier, E., Hock, R., Pfeffer, W. T., Kaser, G., Ligtenberg, S. R. M., Bolch, T., Sharp, M. J., Hagen, J. O., van den Broeke, M. R. and Paul, F.: A Reconciled Estimate of Glacier Contributions to Sea Level Rise: 2003 to 2009, Science, 340(6134), 852–857, doi:10.1126/science.1234532, 2013.

Jacob, T., Wahr, J., Pfeffer, W. T. and Swenson, S.: Recent contributions of glaciers and ice caps to sea level rise, Nature, 482(7386), 514–518, doi:10.1038/nature10847, 2012.

Matsuo, K. and Heki, K.: Current Ice Loss in Small Glacier Systems of the Arctic Islands (Iceland, Svalbard, and the Russian High Arctic) from Satellite Gravimetry, Terr. Atmos. Ocean. Sci., 24(4–1), 657, doi:10.3319/TAO.2013.02.22.01(TibXS), 2013.

Moholdt, G., Wouters, B. and Gardner, A. S.: Recent mass changes of glaciers in the Russian High Arctic: GLACIER MASS CHANGES, RUSSIAN ARCTIC, Geophys. Res. Lett., 39(10), n/a-n/a, doi:10.1029/2012GL051466, 2012.

Wouters, B., Gardner, A. S. and Moholdt, G.: Global Glacier Mass Loss During the GRACE Satellite Mission (2002-2016), Front. Earth Sci., 7, 96, doi:10.3389/feart.2019.00096, 2019.

Zemp, M., Huss, M., Thibert, E., Eckert, N., McNabb, R., Huber, J., Barandun, M., Machguth, H., Nussbaumer, S. U., Gärtner-Roer, I., Thomson, L., Paul, F., Maussion, F., Kutuzov, S. and Cogley, J. G.: Global glacier mass changes and their contributions to sea-level rise from 1961 to 2016, Nature, 568(7752), 382–386, doi:10.1038/s41586-019-1071-0, 2019.

Zheng, W., Pritchard, M. E., Willis, M. J., Tepes, P., Gourmelen, N., Benham, T. J. and Dowdeswell, J. A.: Accelerating glacier mass loss on Franz Josef Land, Russian Arctic, Remote Sensing of Environment, 211, 357–375, doi:10.1016/j.rse.2018.04.004, 2018.