Determination of mass changes of Arctic and Antarctic glaciers

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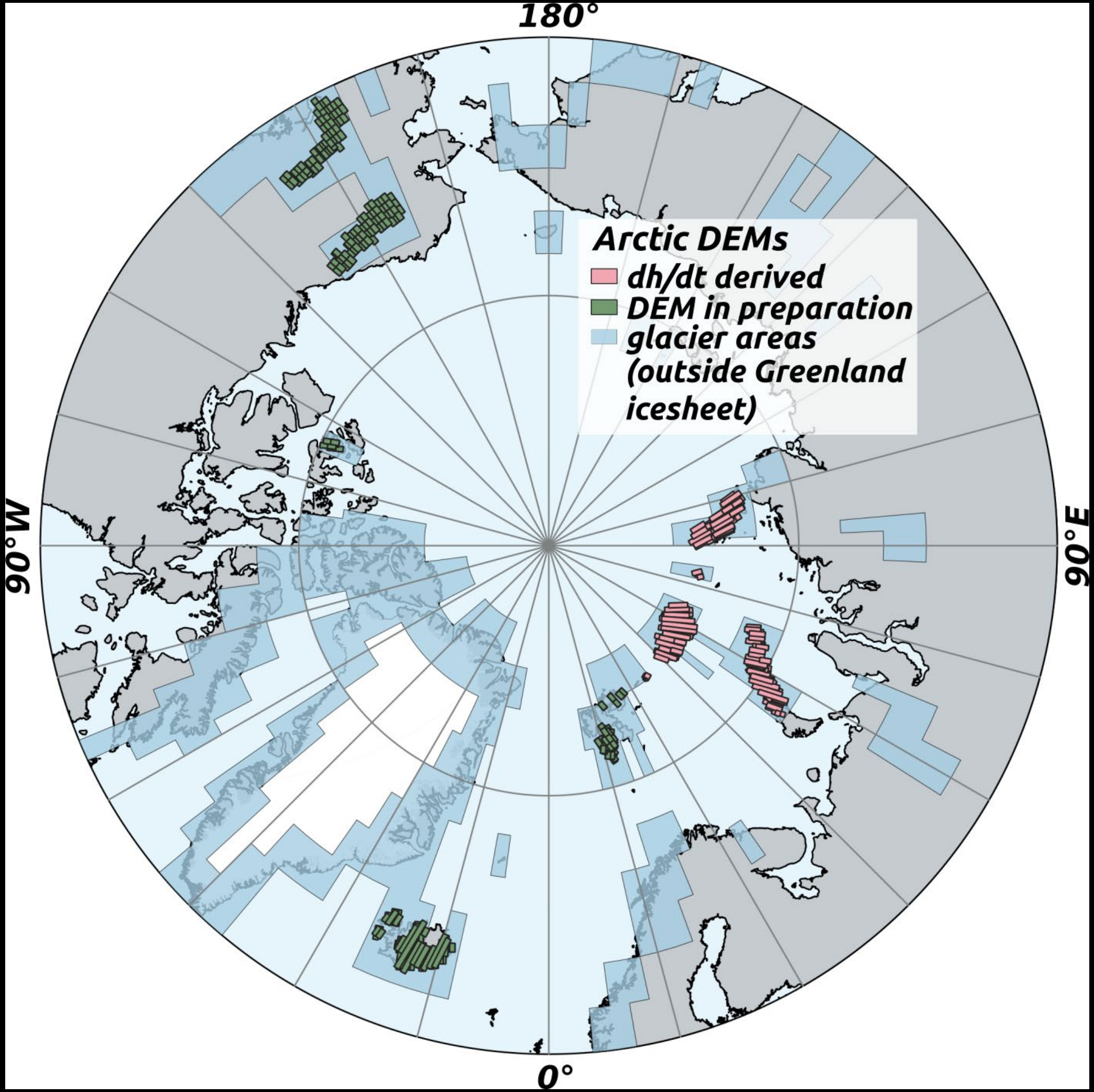
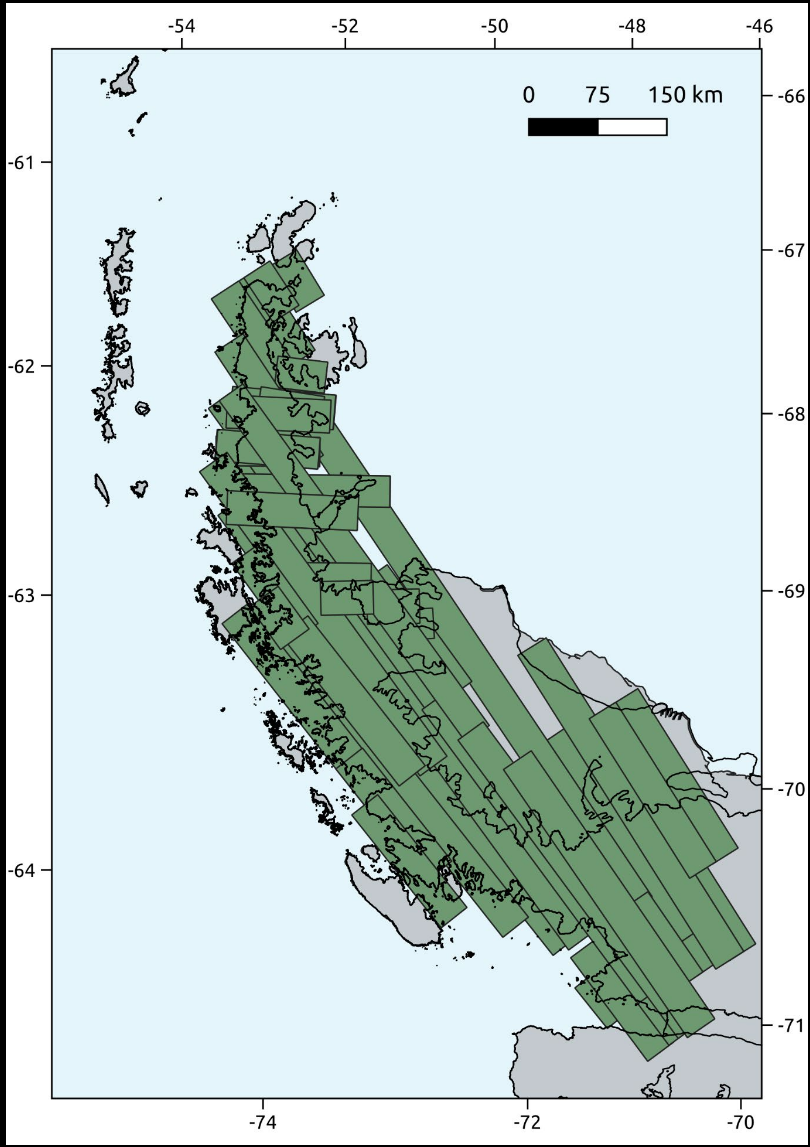
Study Area:
Arctic anAntarctic Penisula





Characteristics

TanDEM-X Mission

Two satellites:

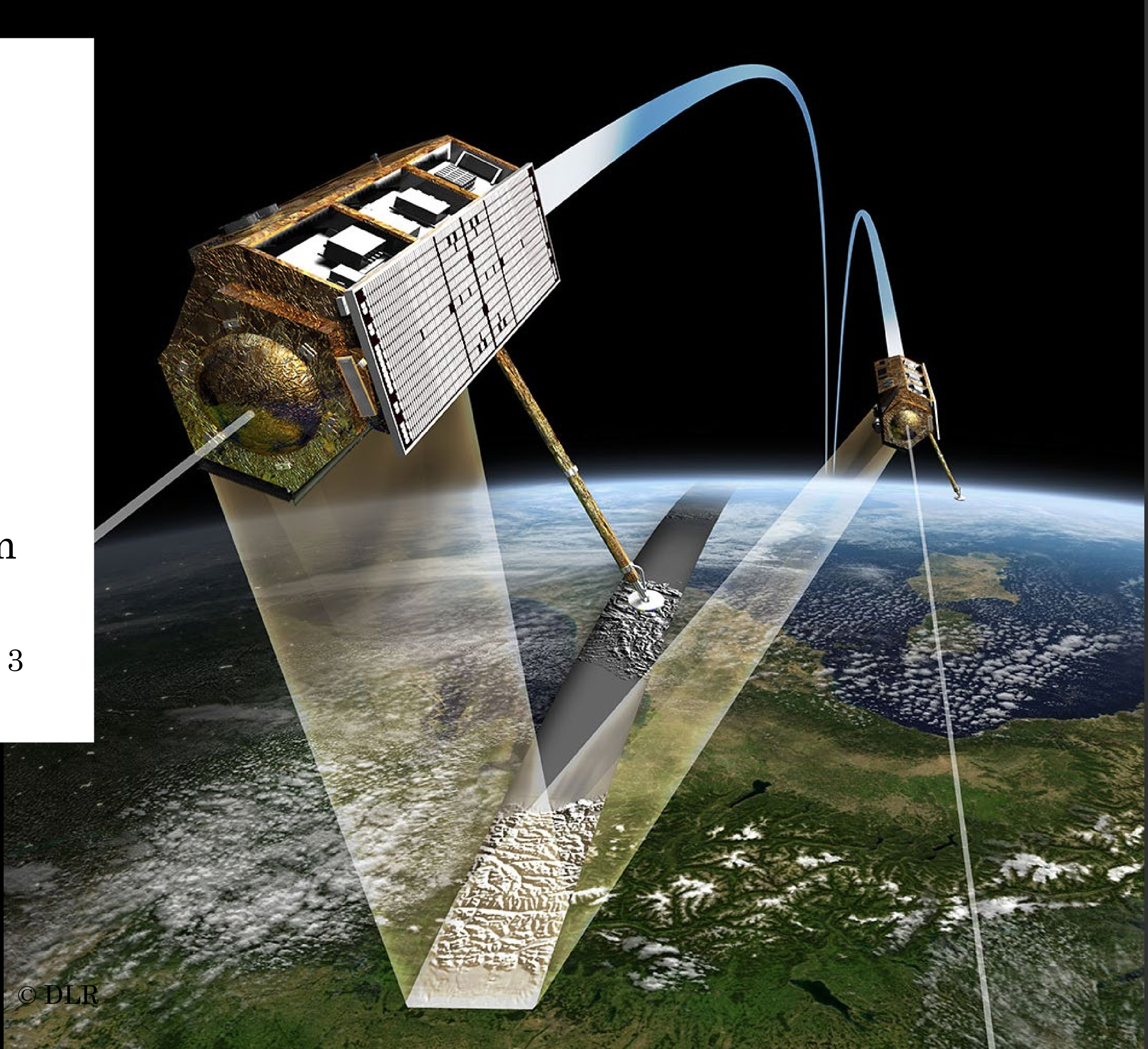
- TerraSAR-X (June 2007)
- TanDEM-X (June 2010)

-> twin satellite

Operating altitude: 514 km

Frequency: 9,65 GHz

(X-Band, micro wave , wavelength ~ 3 cm)



TanDEM-X DEM co-registration & elevation change rate calculation

<u>TanDEM-X input A:</u>

*CoSSC-Product (Zink et al. 2016)

*Beginning of observation period

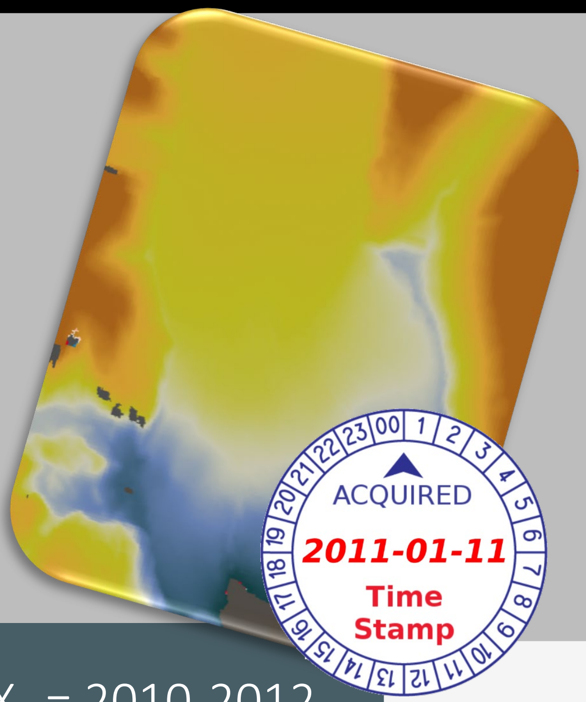
<u>TanDEM-X input B:</u>

*CoSSC-Product (Zink et al. 2016)

*End of observation period

<u>TanDEM-X – TanDEM-X output:</u>

Projected 30x30 m pixel maps of dh/dt [m/a]:

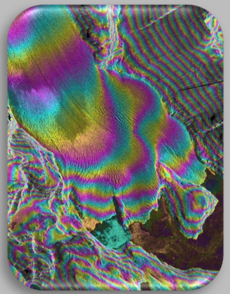


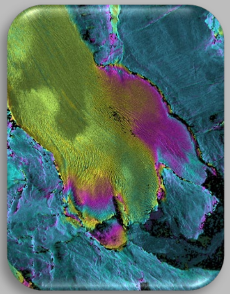
TDX_0 = 2010-2012

TDX_1 = 2016-2018

dh/dt dataset [m/a]

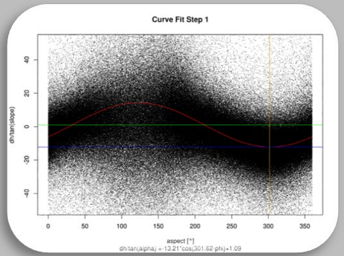
TanDEM-X DEM-processing





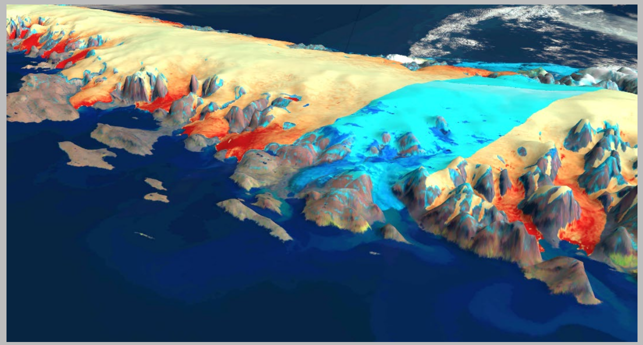
Differential InSAR processing:

- Interferogram calculation based on reference DEM
- Phase unwrapping



Deramping and further corrections:

- Minimizing systematic errors for each DEM strip (Nuth & Kääb 2011, Malz et al. 2018)



Mosaicing, differencing, masking and error assessment

- Combining datatakes to a subregional result

Reference surface for interferogram calculation (DEM)

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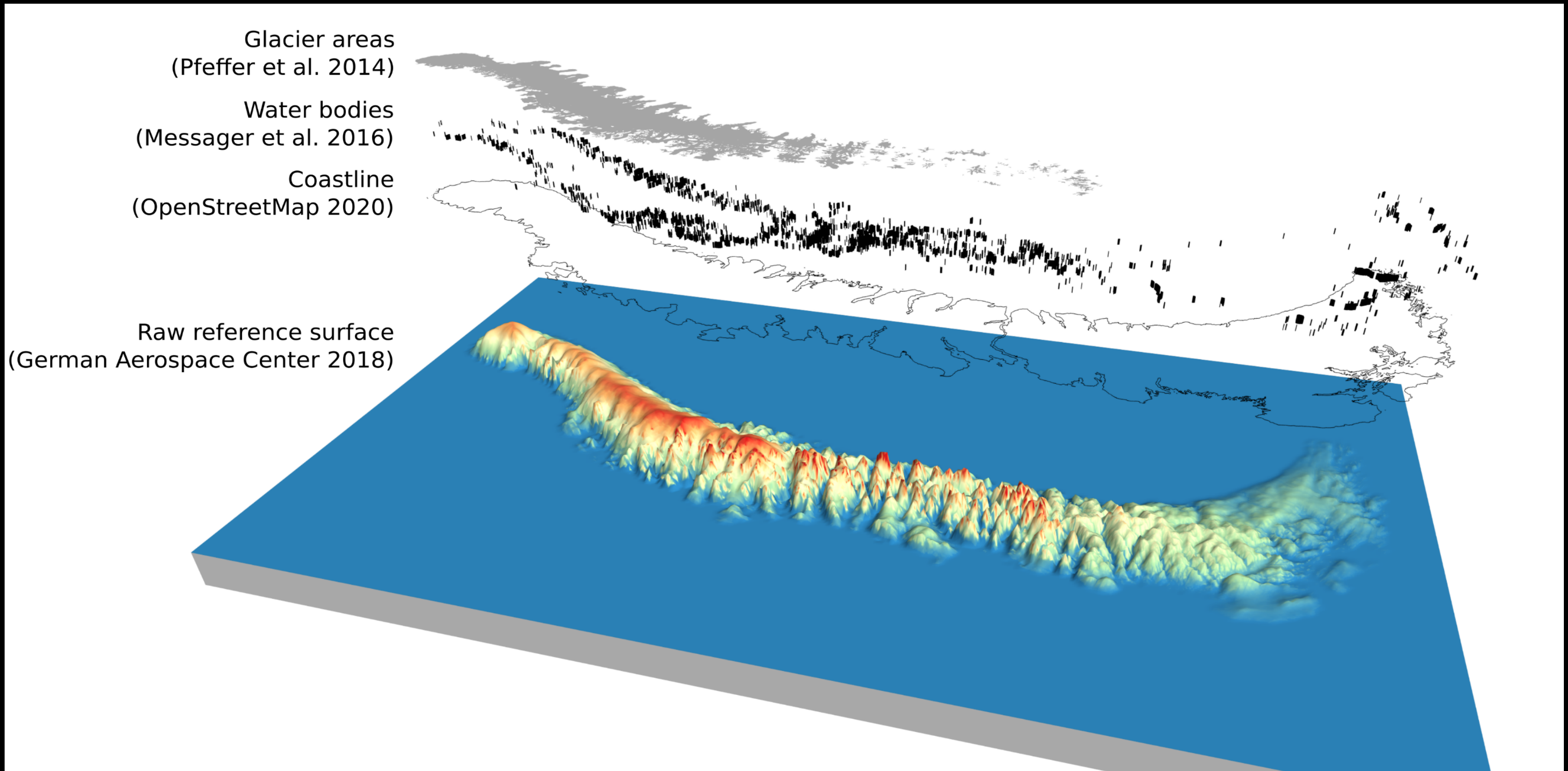
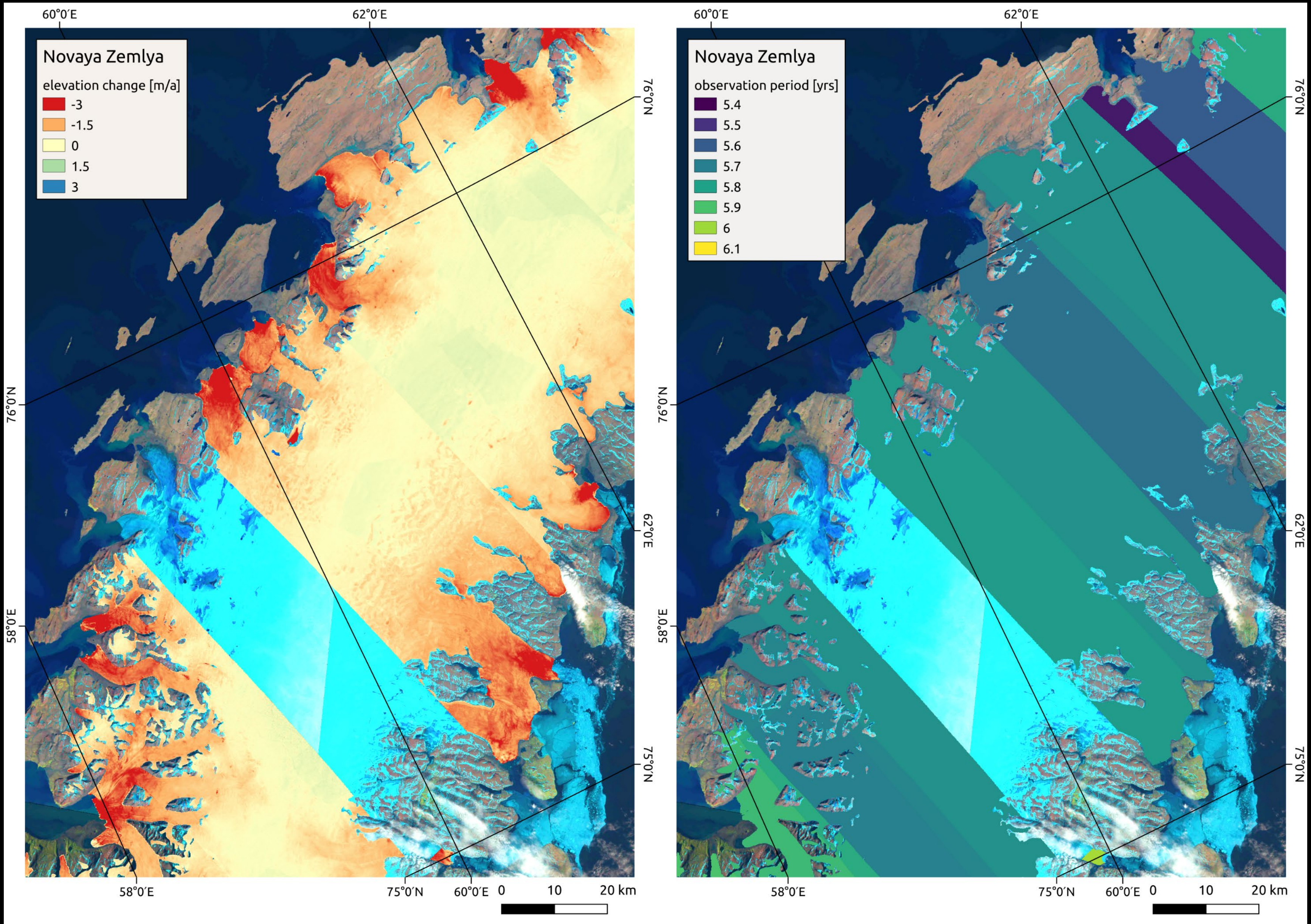


References:
*German Aerospace Center (DLR): TanDEM-X - Digital Elevation Model (DEM) - Global, 90m, https://doi.org/10.15489/JU28HC7PUI09, 2018.
*Messager, M. L., Lehner, B., Grill, G., Nedeva, I., and Schmitt, O.: Estimating the volume and age of water stored in global lakes using a geo-statistical approach, Nat Commun, 7, 13603, https://doi.org/10.1038/ncomms13603, 2016.
*OpenStreetMap: Water polygons, https://osmdata.openstreetmap.de/data/water-polygons.html, Accessed: 2020.
*Pfeffer, W. T., Arendt, A. A., Bliss, A., Bolch, T., Cogley, J. G., Gardner, A. S., Hagen, J.-O., Hock, R., Kaser, G., Kienholz, C., Miles, E. S., Moholdt, G., Mölg, N., Paul, F., Radić, V., Rastner, P., Raup, B. H., Rich, J., Sharp, M. J., and The Randolph Consortium: The Randolph Glacier Inventory: a globally complete inventory of glaciers, J. Glaciol., 60, 537–552, https://doi.org/10.3189/2014JoG13J176, 2014.

Reference DEM for InSAR processing:

- TanDEM-X Global 90m DEM with undefined timestamp (German Aerospace Center (DLR) 2018)
- Coastline delineation → OSM waterpolygons (OpenStreetMap 2020)
- Removal of water bodies → HydroLakes dataset (Messager et al. 2016)
- Removal of glacierized areas (during DEM co-registration) → Randolph Glacier Inventory 6.0 (Pfeffer et al. 2014)

DEM-differencing (TanDEM-X – TanDEM-X)



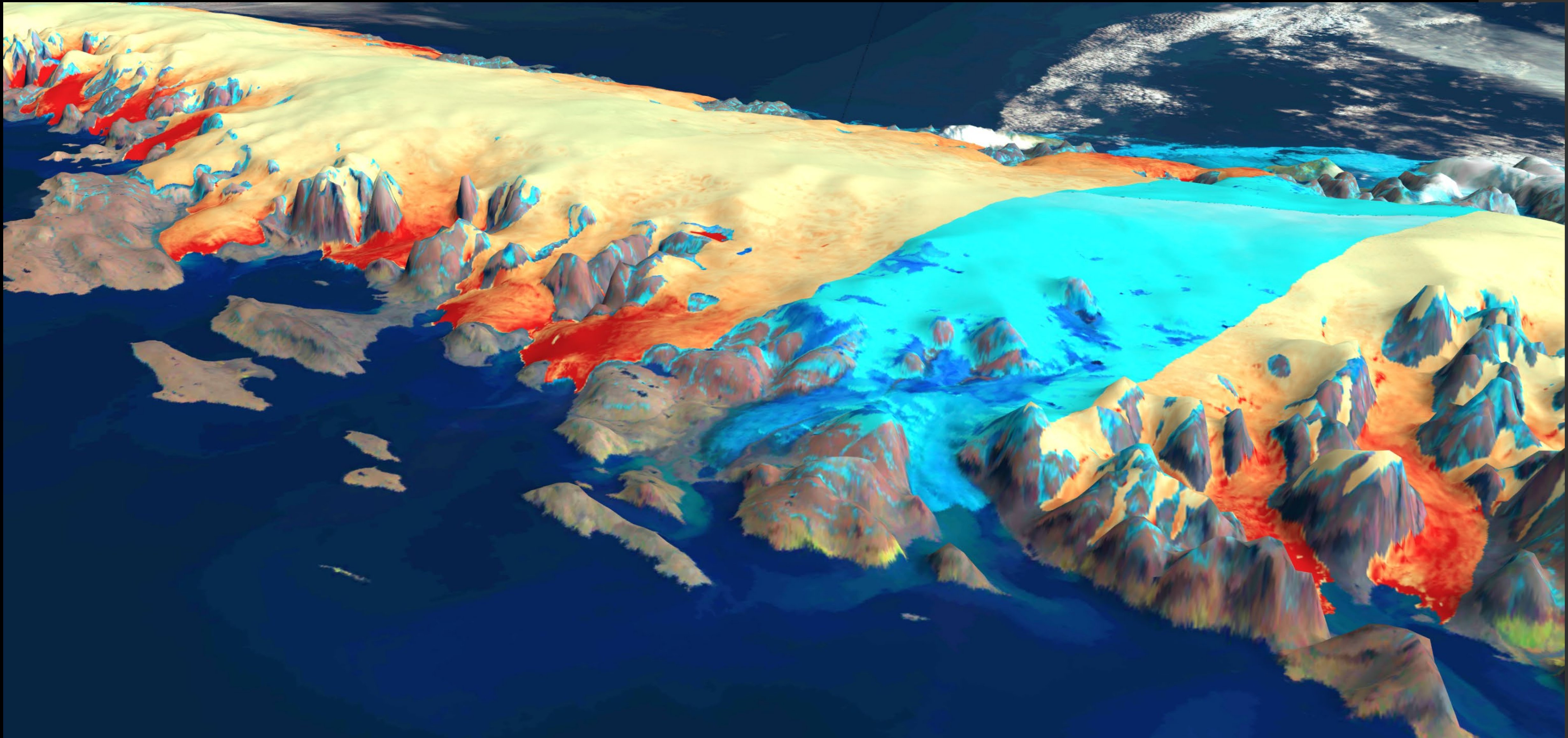
a) Elevation change rate (m/a) b) Observation period (years)

(Background: Landsat-8 image courtesy of the U.S. Geological Survey)

TanDEM-X elevation change:

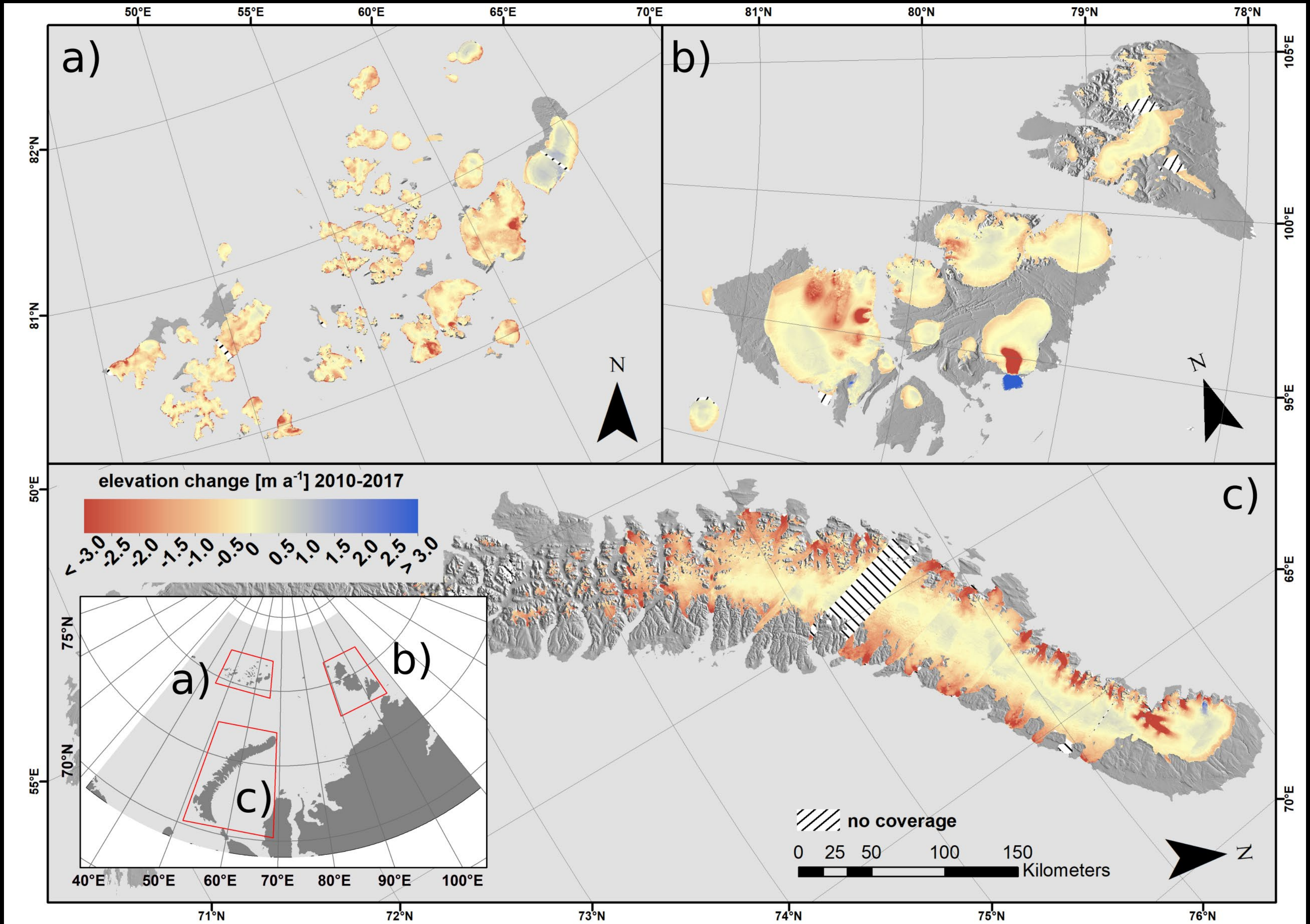
- co-registered elevation and date mosaics at two timesteps
- observation period per pixel

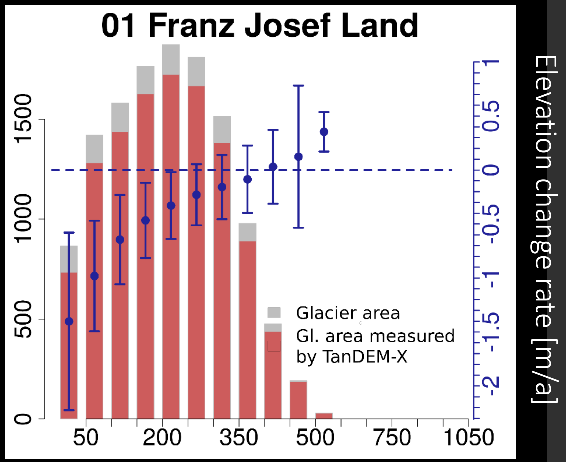
DEM-differencing (TanDEM-X – TanDEM-X)

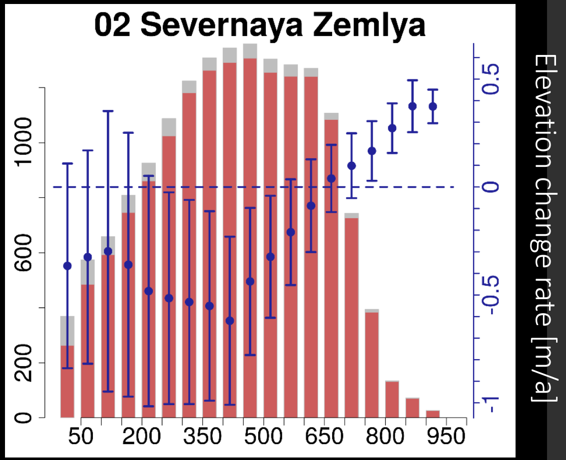


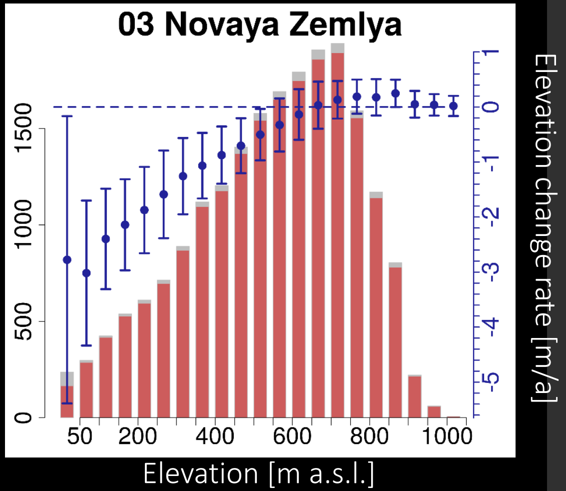
TanDEM-X Global 90m DEM of Novaya Zemlya (German Aerospace Center (DLR) 2018), overlayed by TanDEM-X elevation change rate 2010-2017 (Background: Landsat-8 image courtesy of the U.S. Geological Survey).

Glacier elevation change Russian Arctic archipelagos (2010-2017)





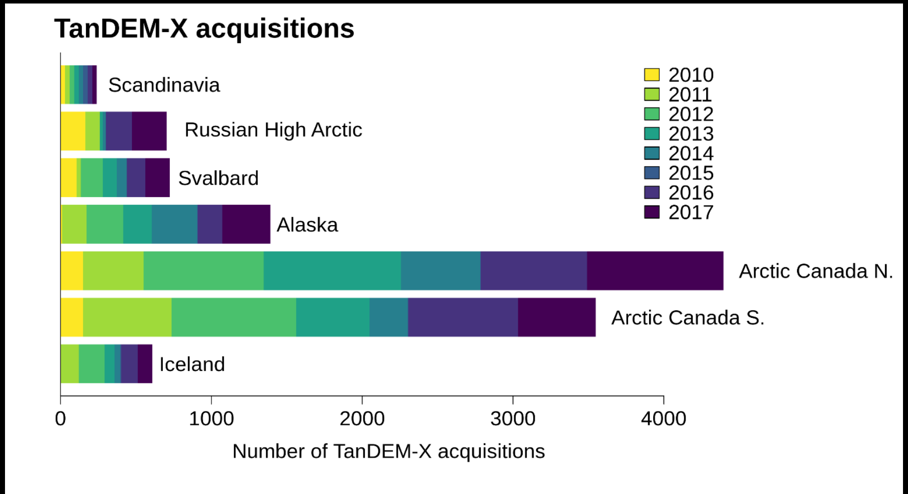


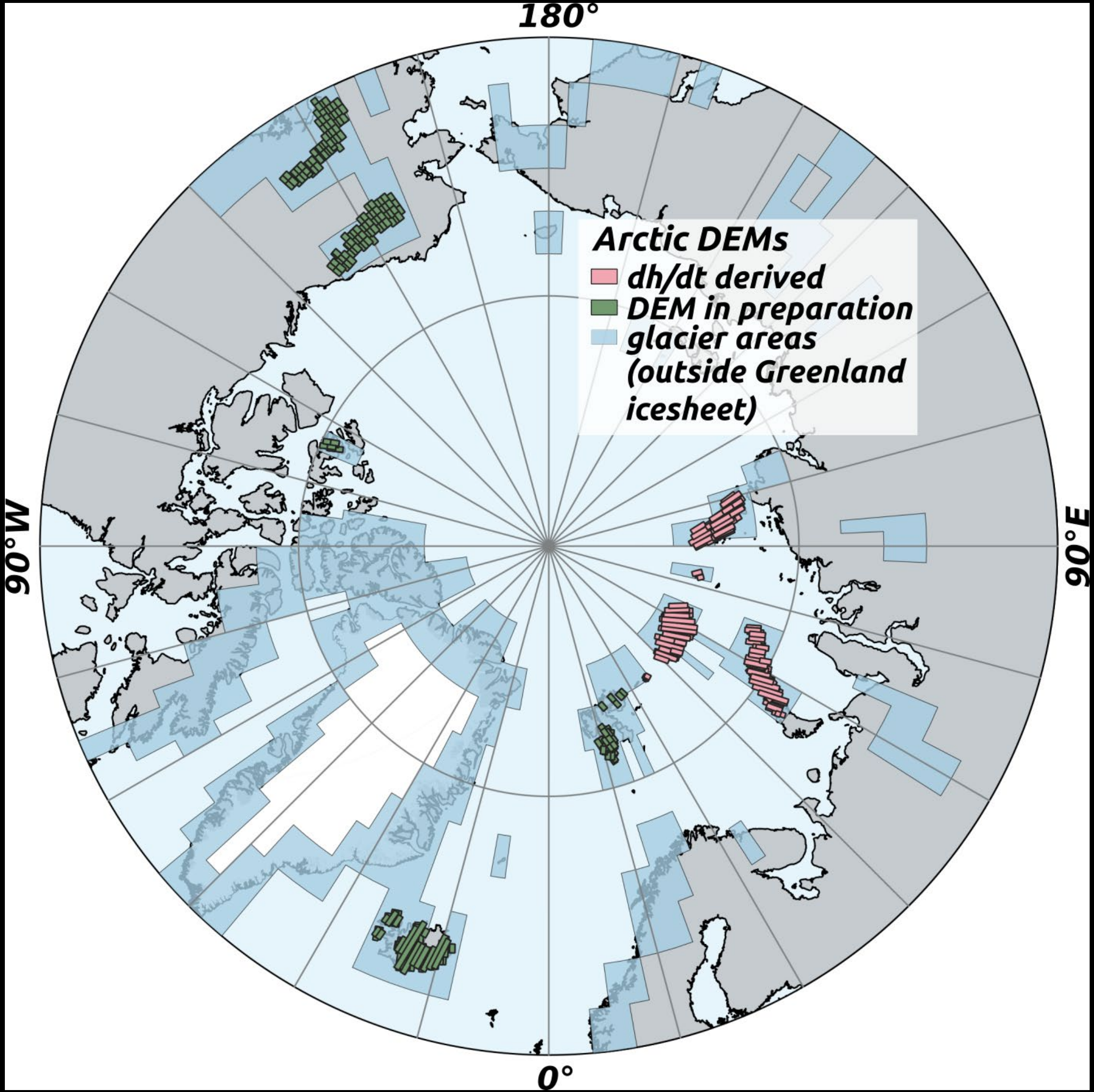


Glacier elevation change rates (m/a) TanDEM-X – TanDEM-X of: a) Franz Josef Land, b) Severnaya Zemlya and c) Novaya Zemlya (Sommer et al. 2020).

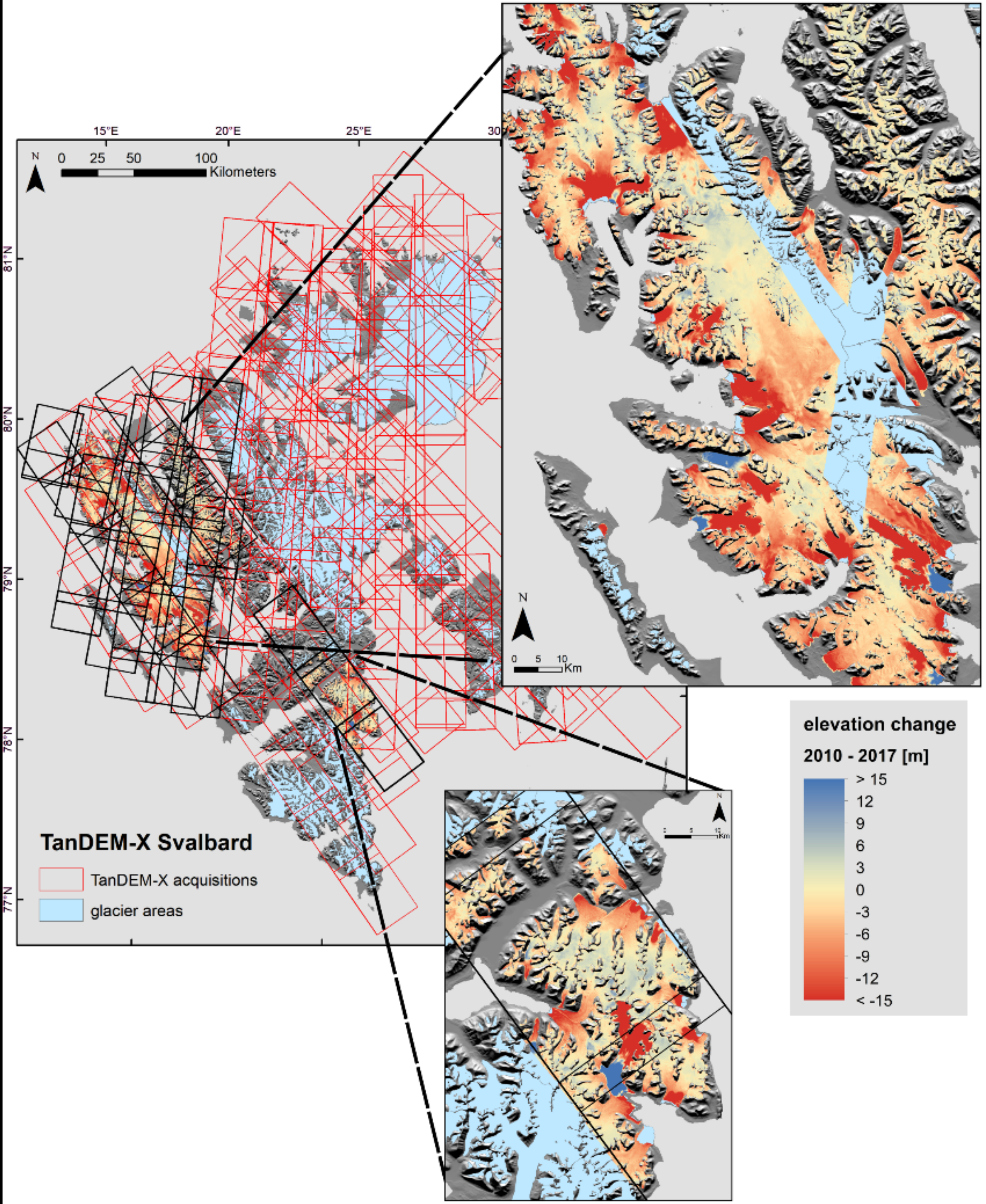
TanDEM-X processing of High Arctic

- TanDEM-X data in preparation for Svalbard, Iceland & Alaska
- Elevation (and mass) change rate derived: Russian Arctic (Sommer et al. 2020)
- Upcoming areas: Arctic Canada & Northern Asia

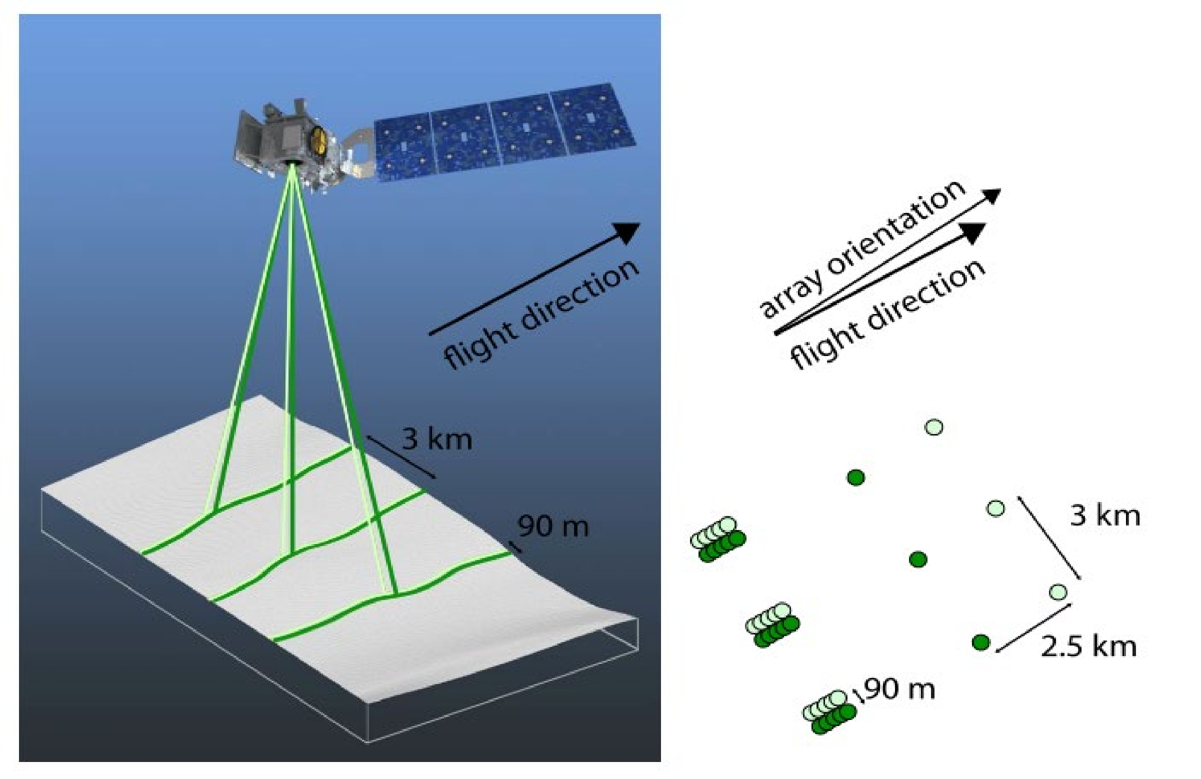




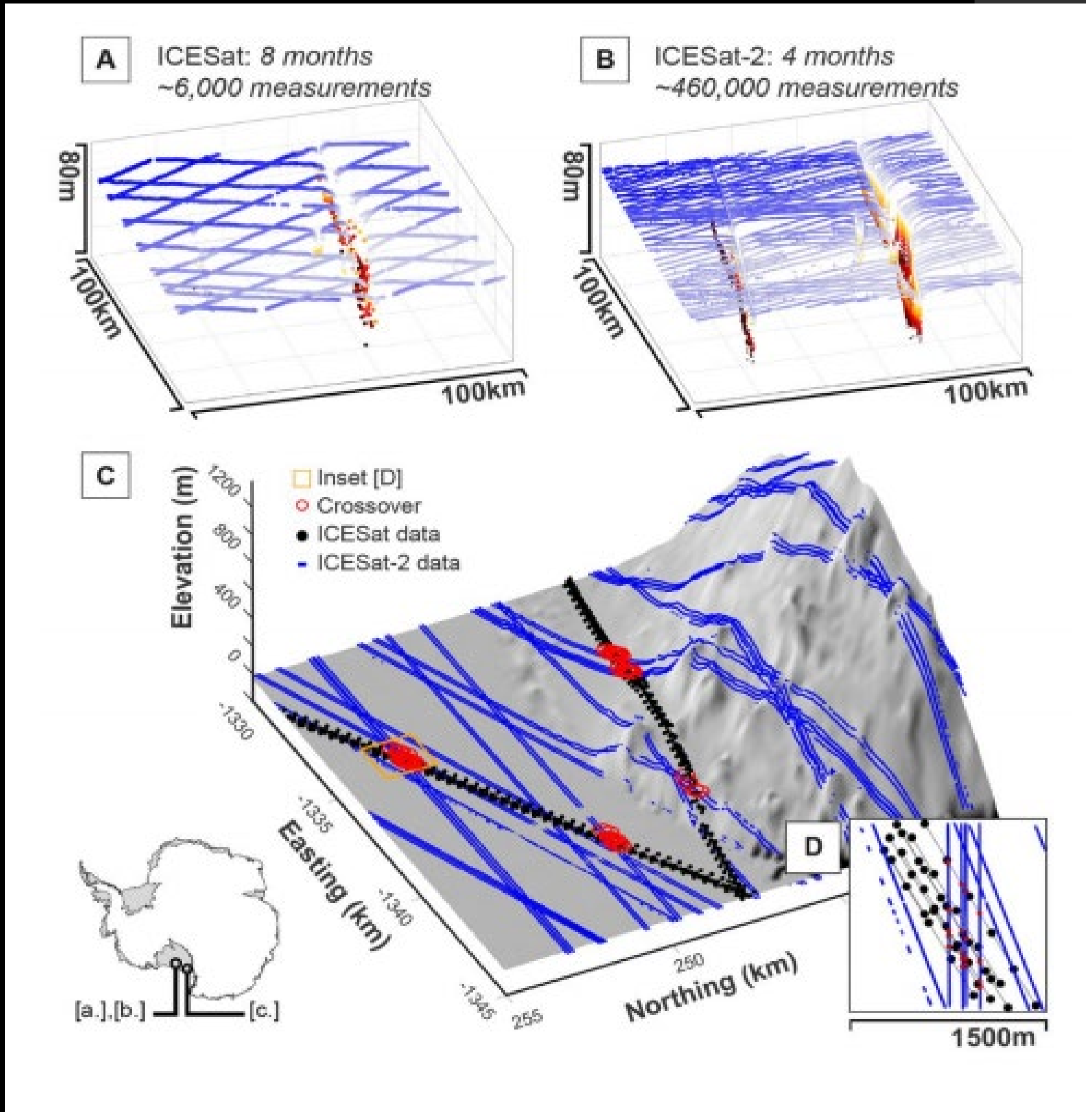
Preliminary Results Svalbard TanDEM-X



ICESat/ICESat-2

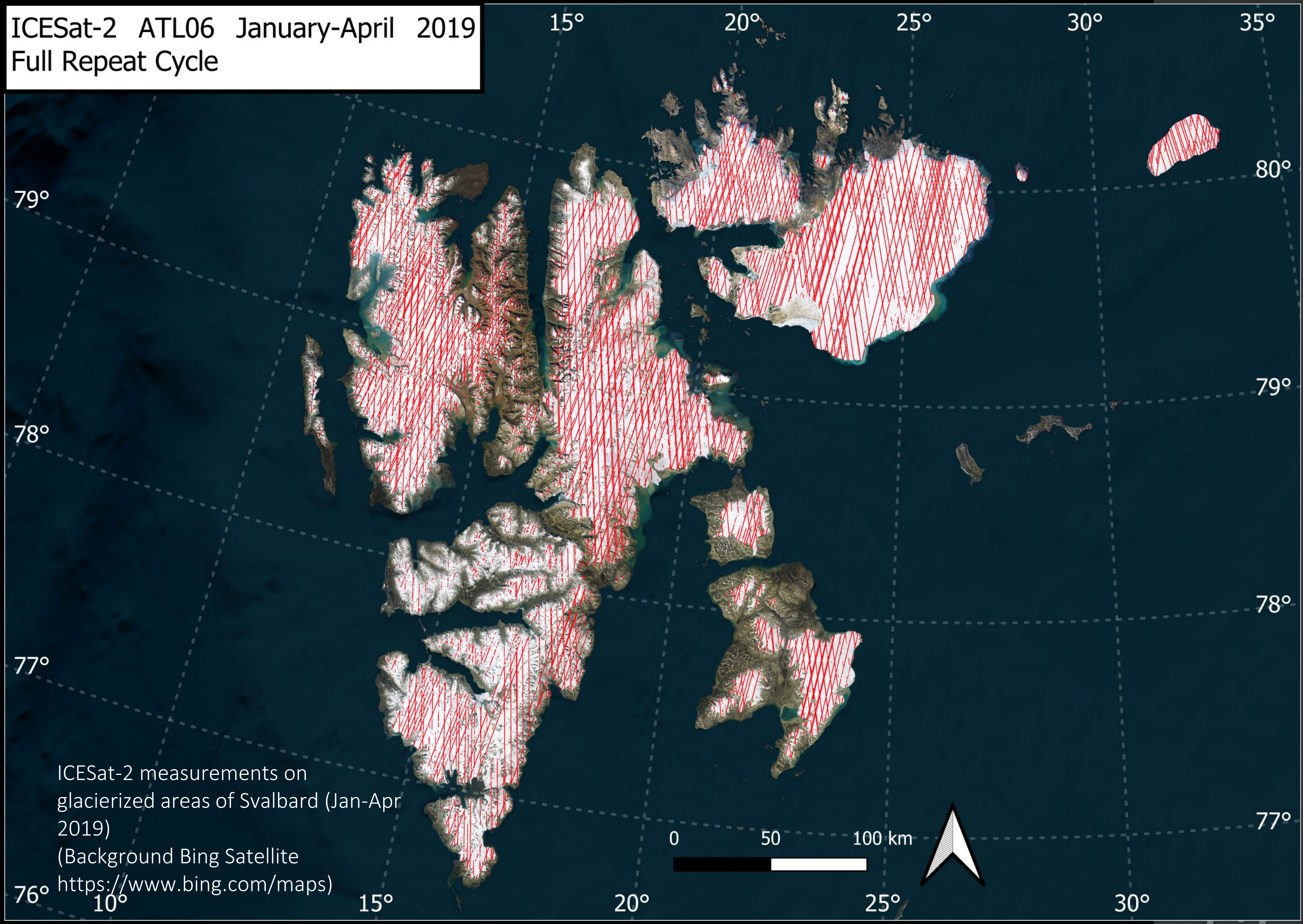


Source: Neumann et al. 2018

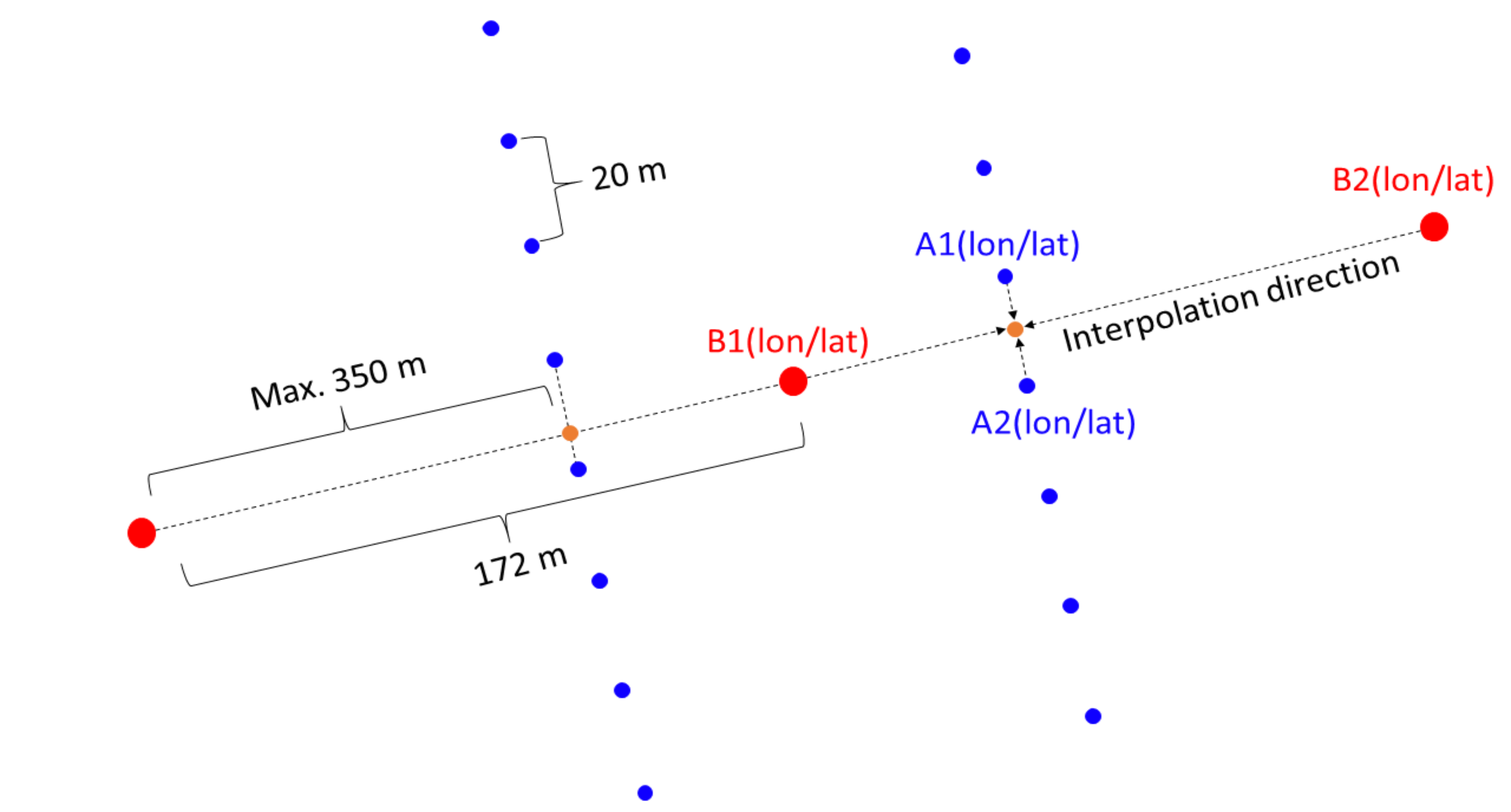


Elevation accuracy assessment

- Uncertainty due to SAR signal penetration
- Comparison to absolute elevation measurements (e.g. ICESat-2 laser altimetry)



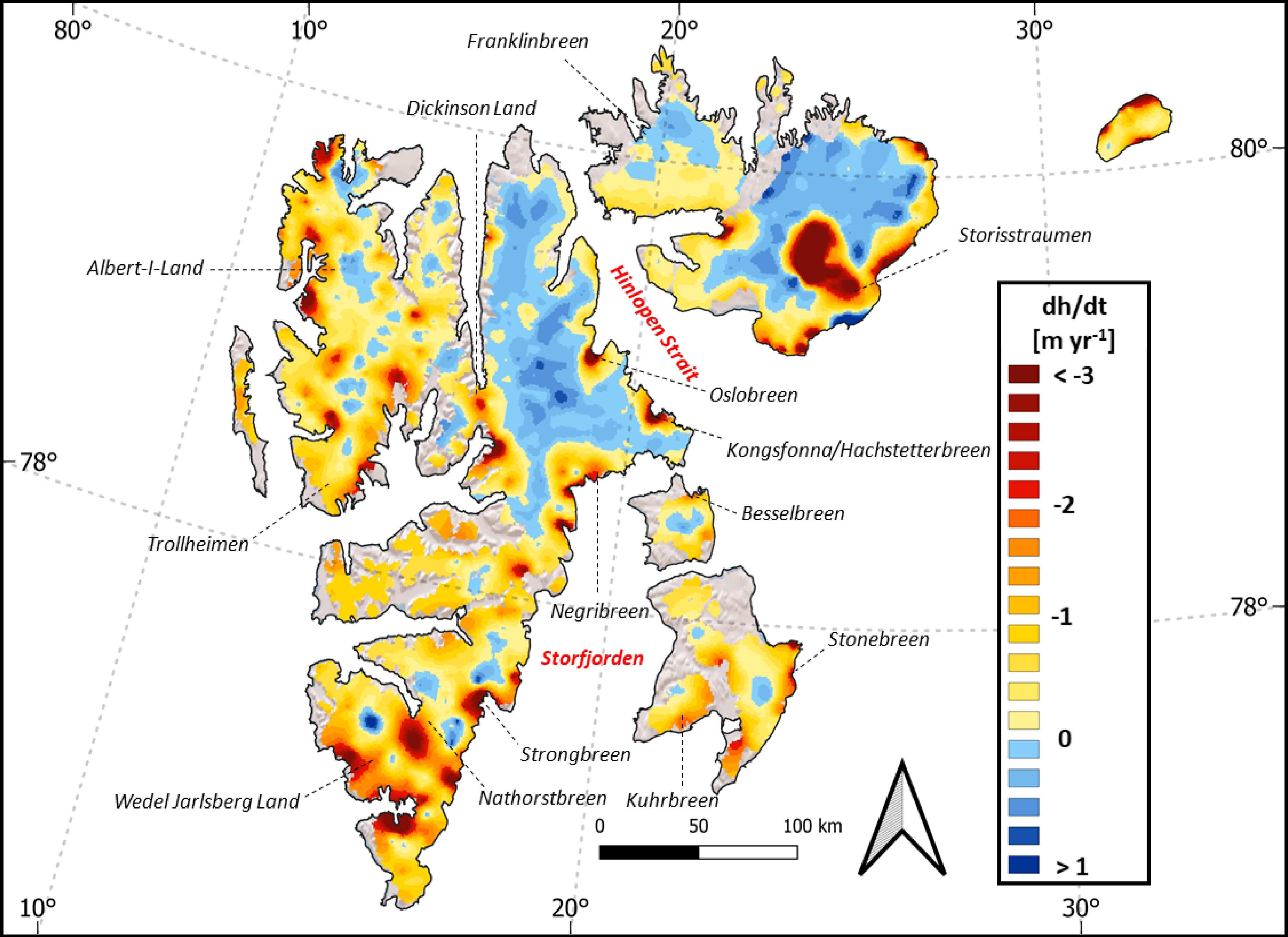
Crossover Analysis



‚captoolkit‘: F. Paolo, J. Nilsson, A. Gardner, T. Sutterly (https://github.com/fspaolo/captoolkit)

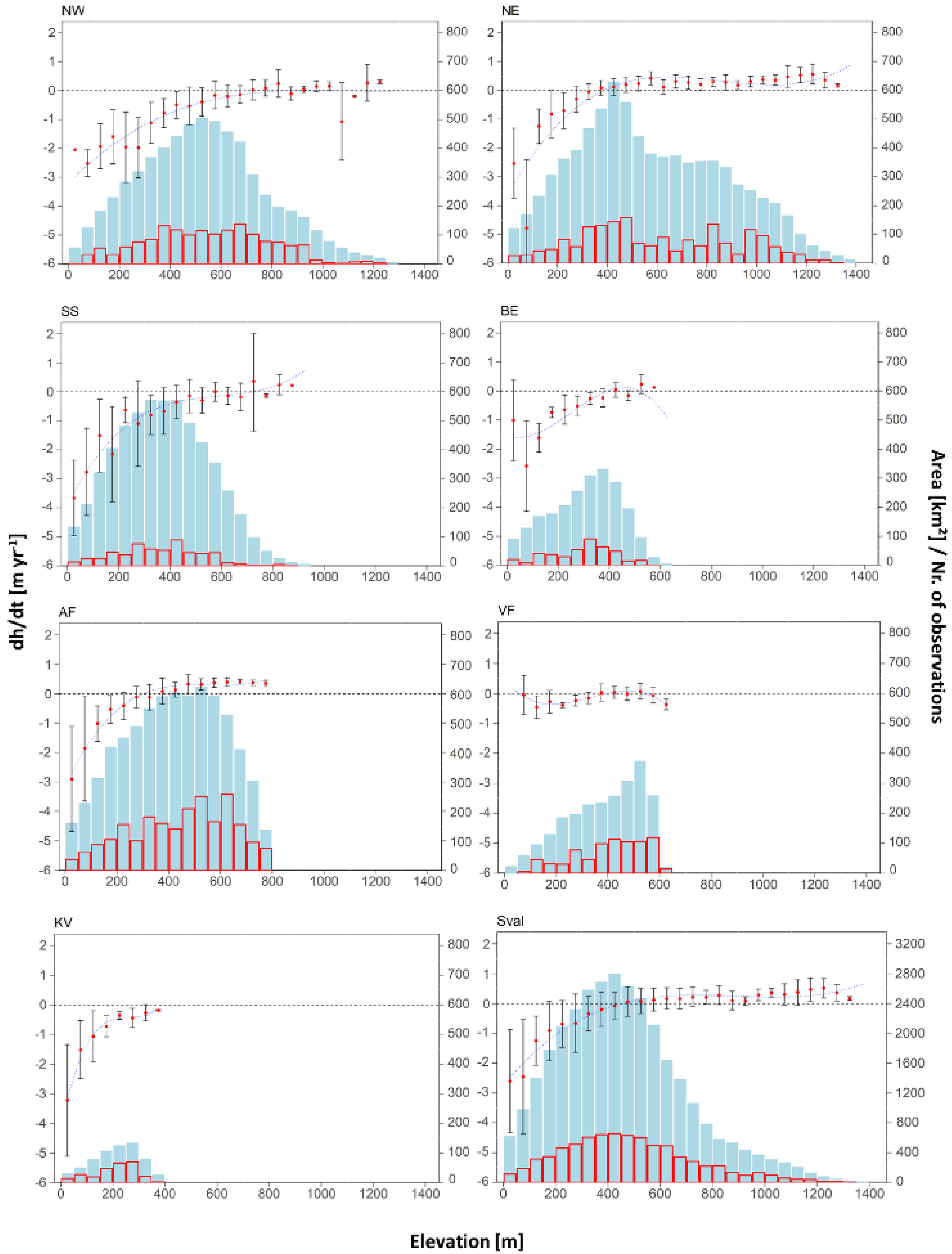
ICESat (2)

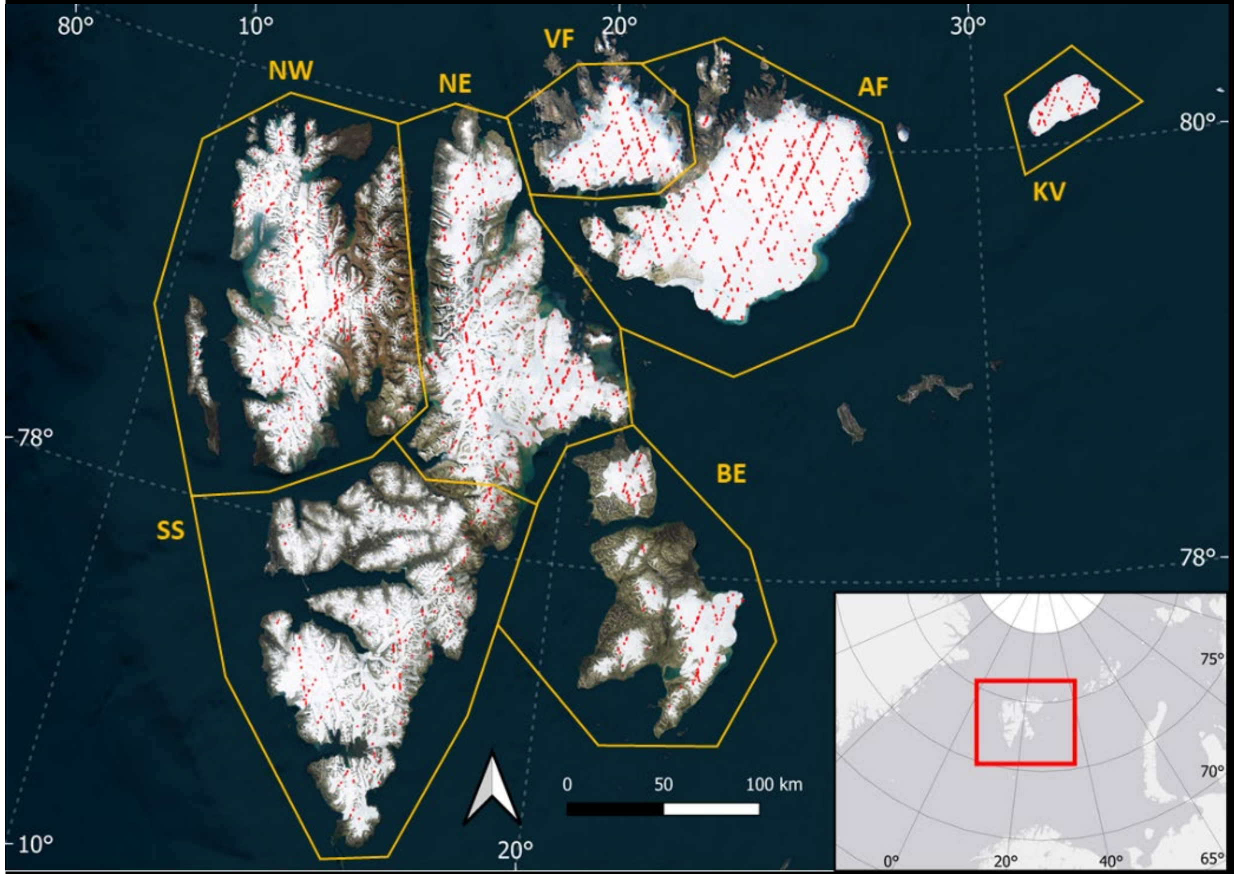
Results Svalbard



Sochor et al. 2021

ICESat (2) Results Svalbard





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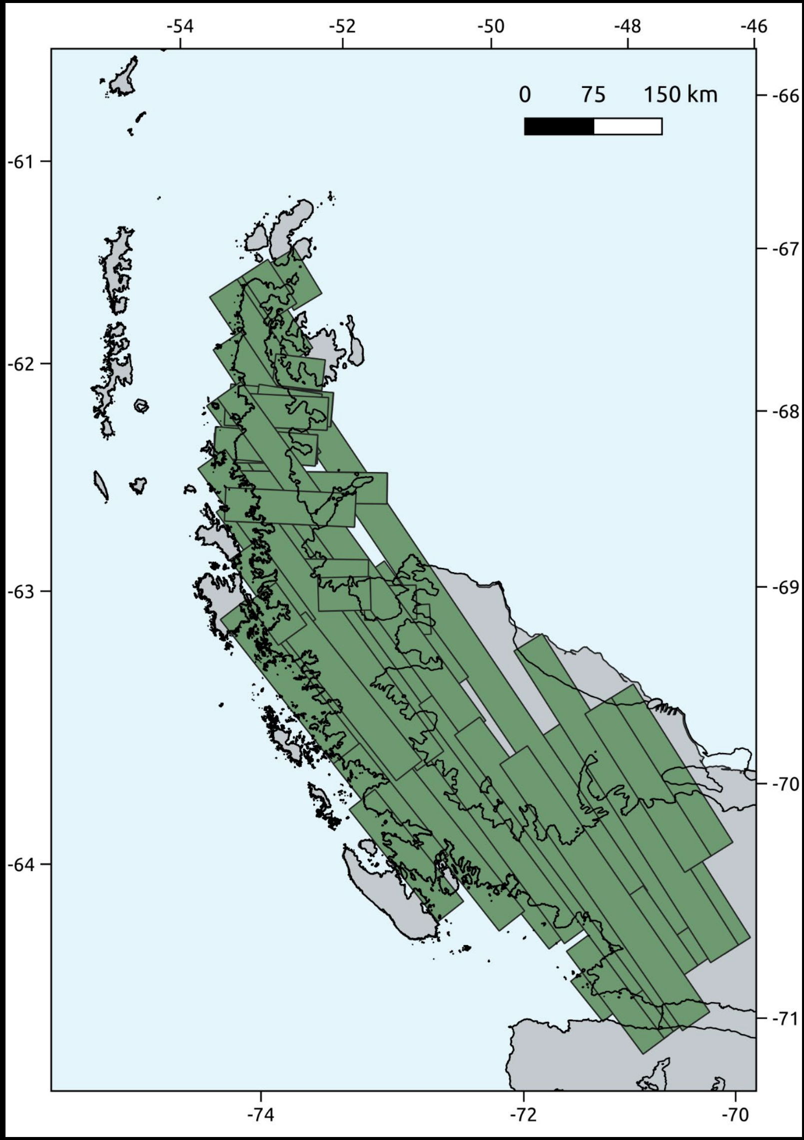
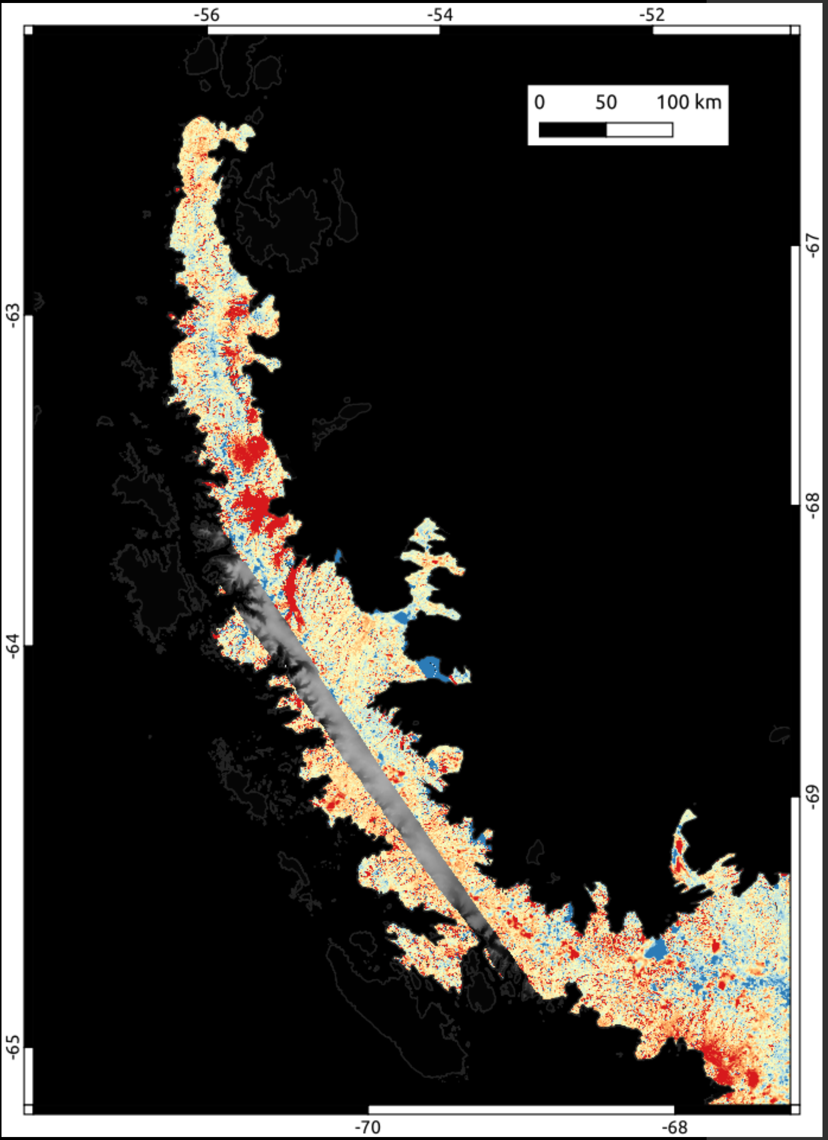
Antarctic Peninsula glacier elevation change

(very preliminary results)

- Observation period ~2013-17
- Spatial coverage: Antarctic peninsula & South Shetland Islands (Shahateet et al. 2021)
- Nearly no ice-free areas for referencing





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Shahateet, K., Seehaus, T., Navarro, F., and Braun, M.: First geodetic mass balance estimate of the bulk of the South Shetland Islands ice caps, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-2758, https://doi.org/10.5194/egusphere-egu21-2758, 2021.

Sommer, C., Seehaus, T., Glazovsky, A., and Braun, M. H.: Brief communication: Accelerated glacier mass loss in the Russian Arctic (2010–2017), The Cryosphere Discuss. [preprint], https://doi.org/10.5194/tc-2020-358, in review, 2020.