

Mass balance of outlet glaciers in NE Greenland from combined measurements of TanDEM-X and CryoSat-2

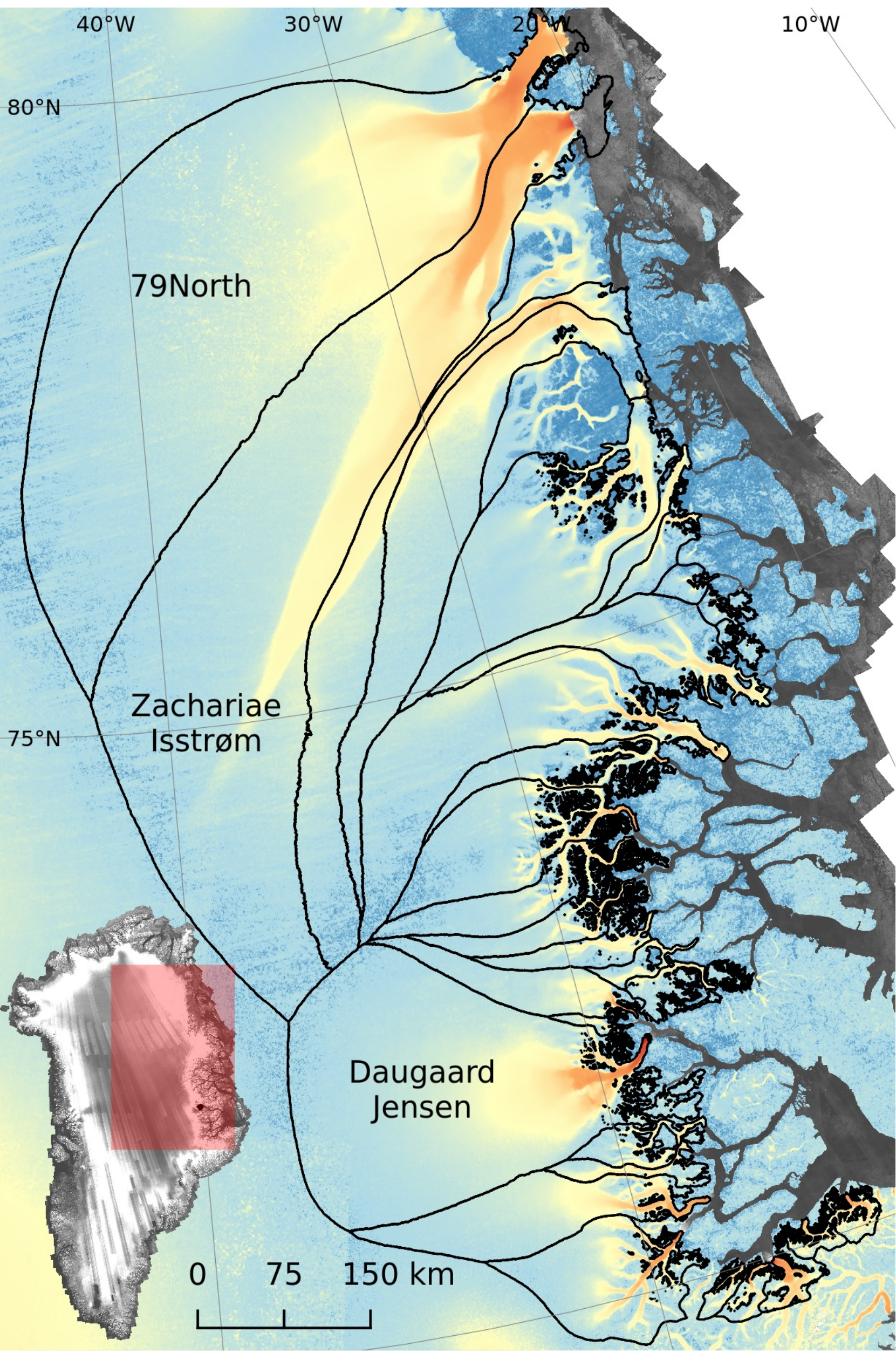
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1. Drainage basin delineation



- The **drainage divides** of ice sheets separate the overall glaciated area into multiple sectors
- For the delineation of individual glacier catchments, a classical **flood-filling watershed algorithm** was adapted to use both elevation (TanDEM-X global DEM) and ice velocity data (Sentinel-1 velocity from Greenland CCI project)
- In regions of fast flow (e.g. $> 20 \text{ m a}^{-1}$) the velocity flowlines are followed and in slower regions the steepest surface slope indicates the drainage direction
- Watershed approaches using only a DEM result in erroneous basin boundaries if catchments for current ice sheet conditions are desired
- Other datasets for drainage sectors are available but aggregate multiple outlet glaciers in one basin [1] or lack detailed methodological description for combining slope information and ice velocities [2]
- We delineated catchments for the Northeast Greenland Ice Sheet for 31 individual outlet glaciers

Drainage basins statistics

| Glacier basin | Area [km ²] | Area fraction of Greenland [%] | Sea level rise potential [m] |
|---------------------------------|-------------------------|--------------------------------|------------------------------|
| Nioghalvfjærdsfjorden (79North) | 109,287 | 6.37 | 0.59 |
| Zachariae Isstrøm | 97,105 | 5.66 | 0.59 |
| Dagaard-Jensen | 51,253 | 2.99 | 0.30 |

Krieger, et al., "Drainage basin delineation for outlet glaciers of Northeast Greenland based on Sentinel-1 ice velocities and TanDEM-X elevations", Submitted.

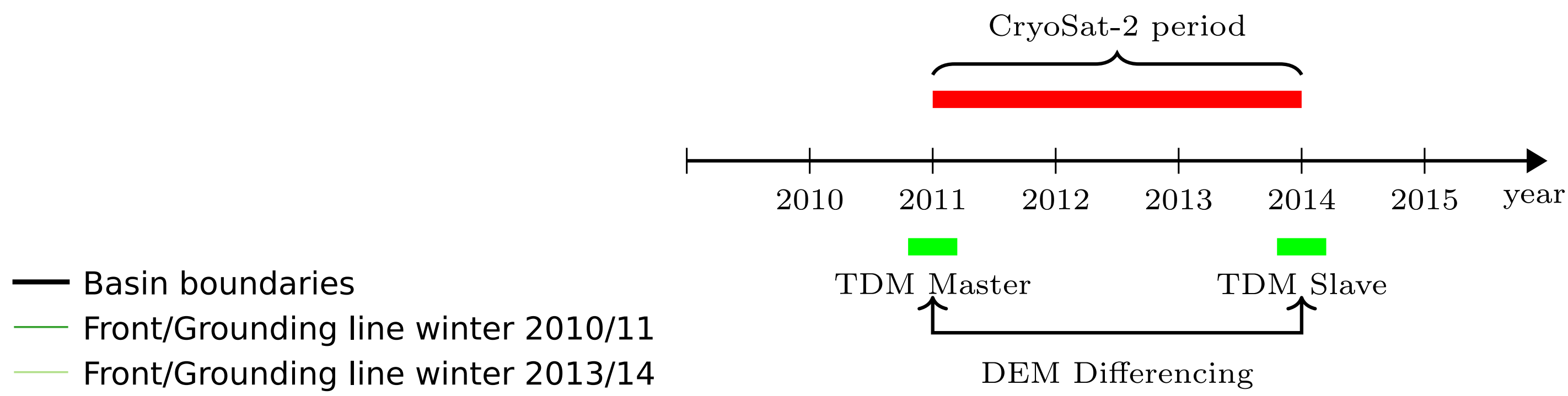
Ice velocity: Nagler, et al. "The Sentinel-1 mission: New opportunities for ice sheet observations." Remote Sensing 7.7 (2015): 9371-9389.

[1] Zwally, et al., "Antarctic and Greenland drainage systems, GSFC cryospheric sciences laboratory." (2012).

[2] Mouginot, et al. "Fast retreat of Zachariae Isstrøm, northeast Greenland." Science 350.6266 (2015): 1357-1361.

2. Surface elevation change

- Surface elevation change (SEC) was processed from bistatic TanDEM-X (TDM) acquisitions in **winter 2010/11 and winter 2013/14** for the termini of 3 major outlet glaciers in Northeast Greenland
- CryoSat-2 Repeat Altimetry Analysis was performed between **Jan. 2011 and Jan. 2014** in Low resolution mode for the ice sheet interior and SARIn mode at the ice sheet margins

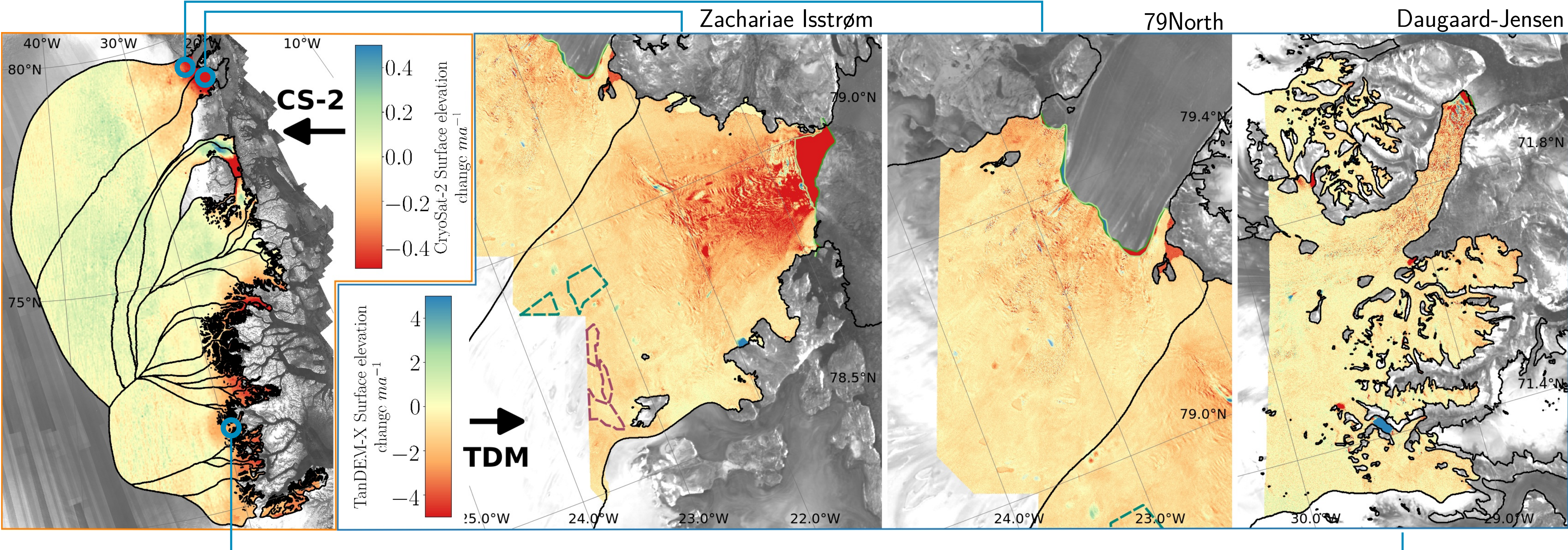


TDM - CS-2 comparison

$$\Delta h = SEC_{TDM} - SEC_{CS2}$$

- SEC was processed independently for each sensor
- Sources of errors for TDM include seasonal effects, the signal penetration and the vertical co-registration of the individual scenes
- The TDM and CS-2 SEC rates are in good agreement in areas of flat terrain

| TDM temporal separation | $\mu_{\Delta h}$ [m] | $\sigma_{\Delta h}$ [m] |
|-------------------------|----------------------|-------------------------|
| 3 years + 4 days | -0.14 | 0.33 |
| 3 years + 31 days | -0.18 | 0.33 |



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