Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

SWOT's Sea Surface Height Observations in Sea Ice Zones: **A First Look and Comparison with ICESat-2**

[SMAPS Project]

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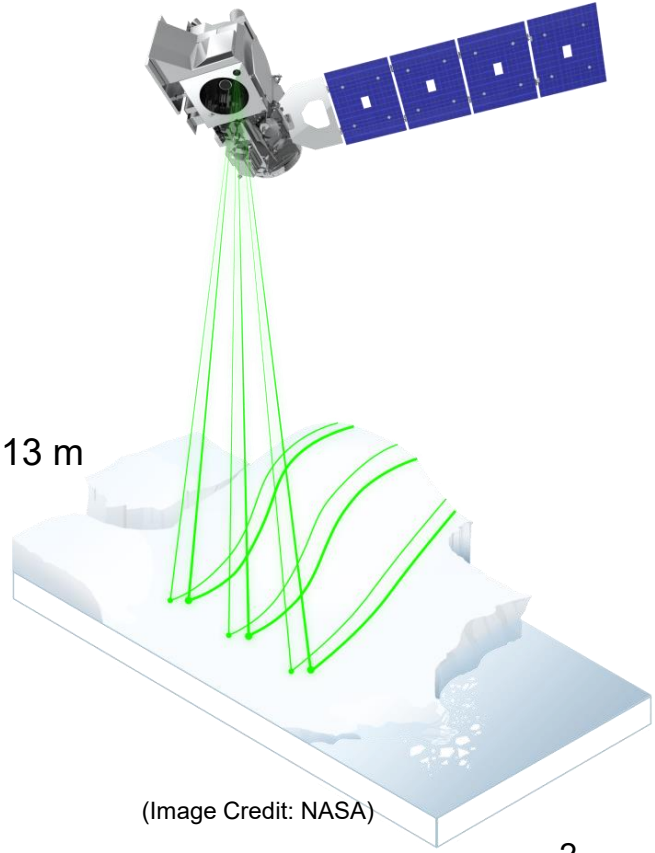
Datasets

SWOT L2 low-rate (LR) Unsmoothed data with 250 m pixel resolution
Version C
both orbit phases, ~ 1 year (04/2023 – 04/2024)
some additional data from the expert product (interpolation required)

ICESat-2 sea-ice data set (ATL07, Rel 006)

- photon-counting laser altimeter; 6 individual beams; footprint size ~ 13 m
- distance between the observation points: ~ 70 cm
- 91-days orbit repeat cycle
- impacted by clouds



(Image Credit: NASA)

Comparison points

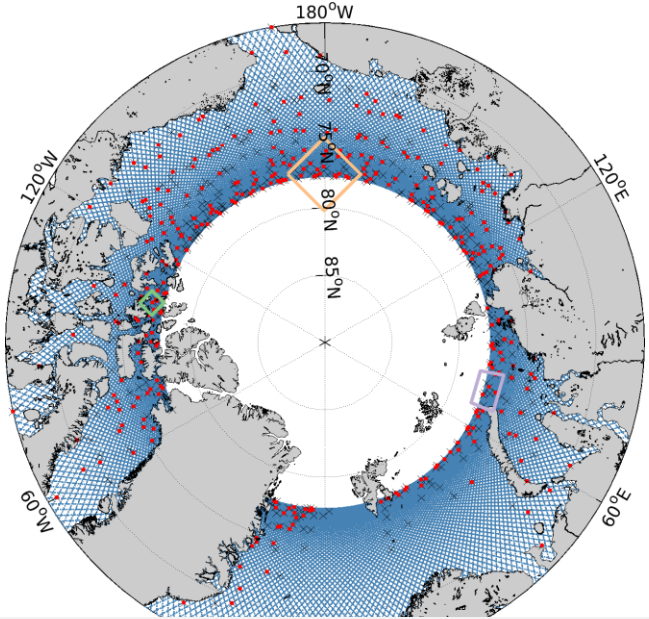
- Finding data close in space and time (sea-ice drift!)

- ➢ max. time difference of 30 minutes
- ➢ science phase: 400 locations (04/2023-06/2023)
- ➢ cal/val phase: 147 locations (07/2023-04/2024)

Quantitative comparison:

- Interpolation of the SWOT data onto the ICESat-2 observation points (strong beams)

Crossover locations
SWOT science phase 07/2023-04/2024



***Blue lines**: SWOT groundtracks (science phase)*

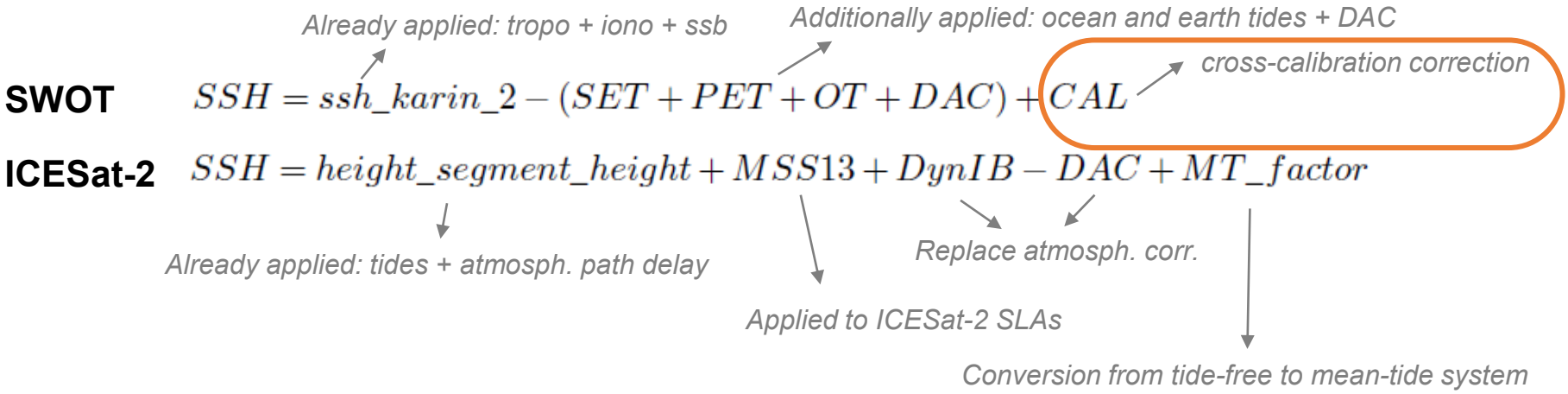
***Black crosses**: crossovers with ICESat-2 groundtracks (only sea-ice areas (icecon>15%) and cloud-free conditions) #640*

***Red dots**: usable crossovers (30-minutes time interval) #400*

Dataset harmonization

Pre-processing of datasets is necessary:

- Using the same references (mean sea surface, tidal system)
- Applying same geophysical corrections (ocean tides, DAC, …)
- Smoothing the ICESat-2 along-track data to consider differences in spatial resolution



SWOT calibration correction (*CAL*)

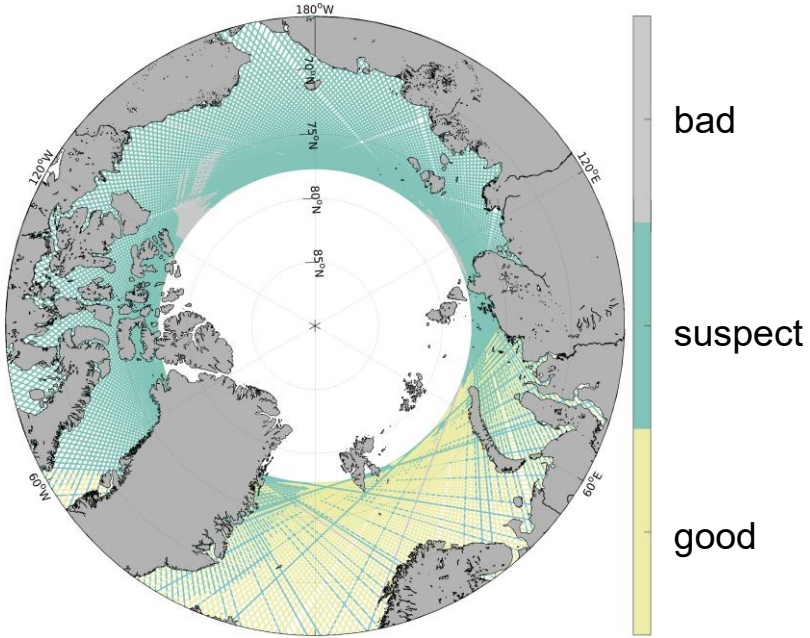
- SWOT data has to be corrected by a roll-correction (calibration correction)
- "*height_cor_xover*" is derived from open water crossovers and is part of the expert dataset (Version C)
- In the Arctic this correction is flagged "bad" or "suspect" (due to the large distance to the closest open water crossover)

➢ "Good" and "suspect" data are used for the comparison

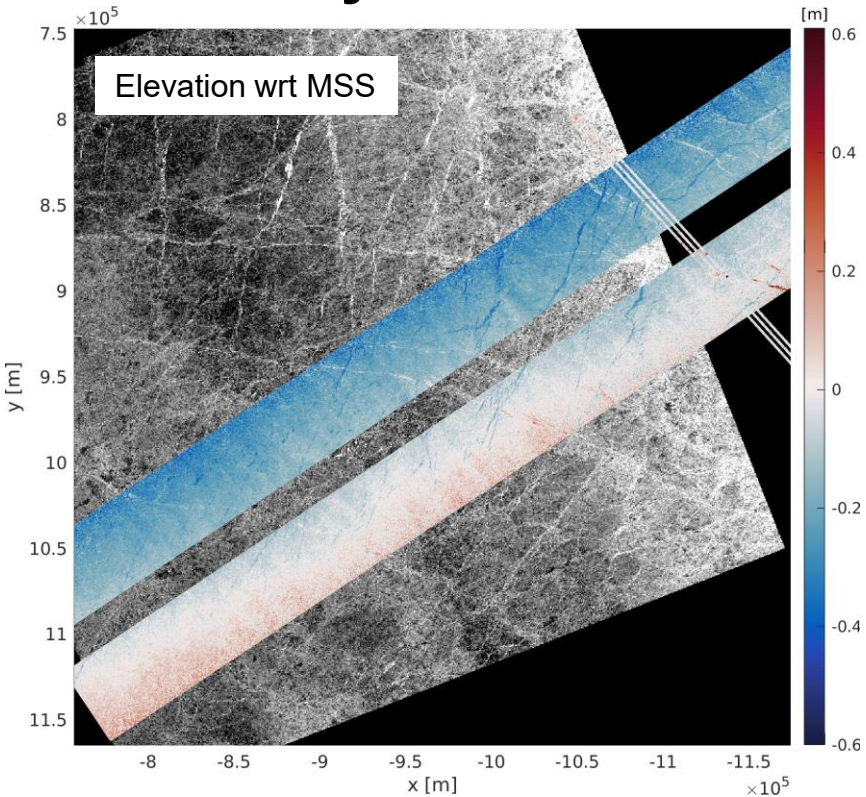
height_cor_xover_qual

projected to the satellite ground track

Januar 2024



Case study – Chukchi Sea



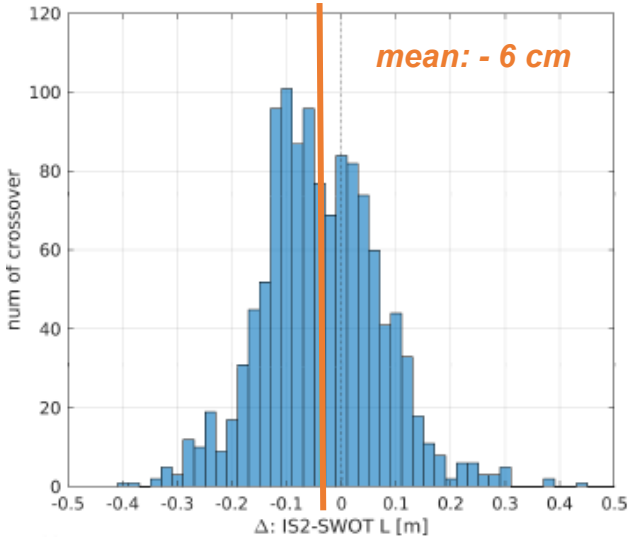
- Ice structures can be nicely seen in the SWOT data (in comparison with Sentinel-1 SAR image)
- significant cross-track gradient visible in SWOT due to imperfect calibration correction

- Quality of correction is very different between the different overflights and locations.

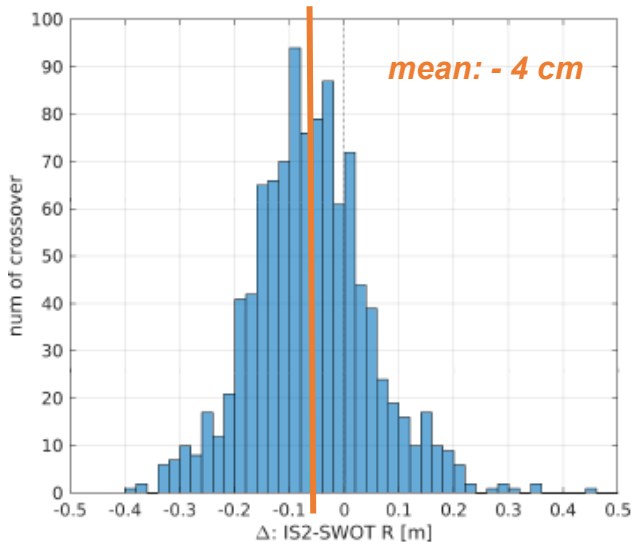
SWOT systematic errors

Offsets between ICESat-2 (IS2) and SWOT (per pass and swath side)

left swath



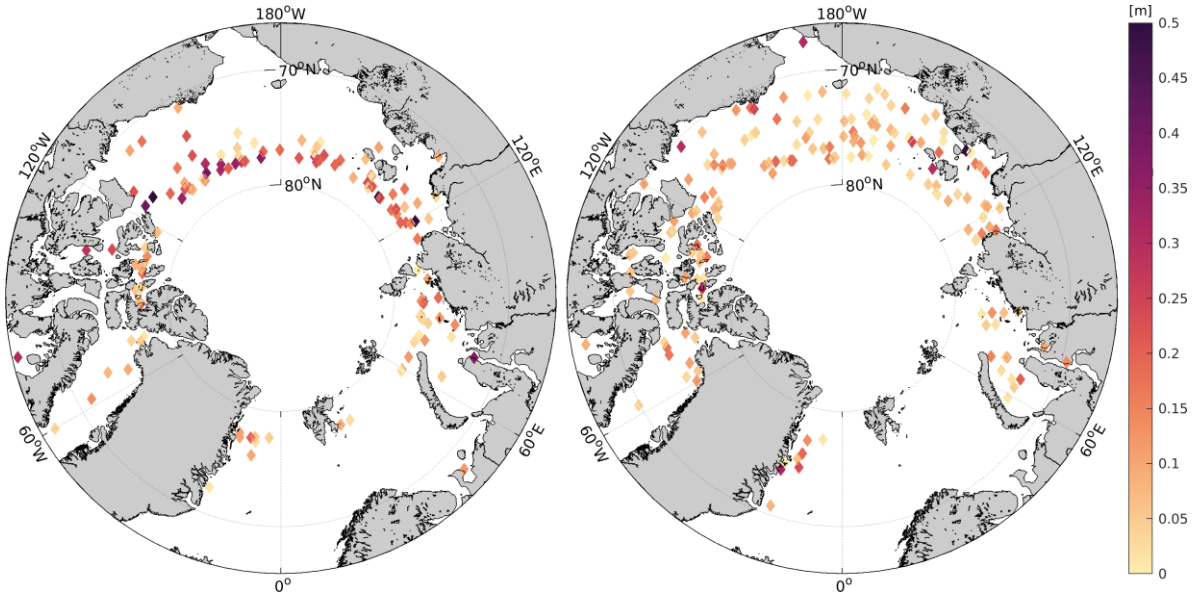
right swath



- not all passes affected
- left and right swath affected differently

SWOT systematic errors

mean differences of ICESat-SWOT residuals of left and right swath

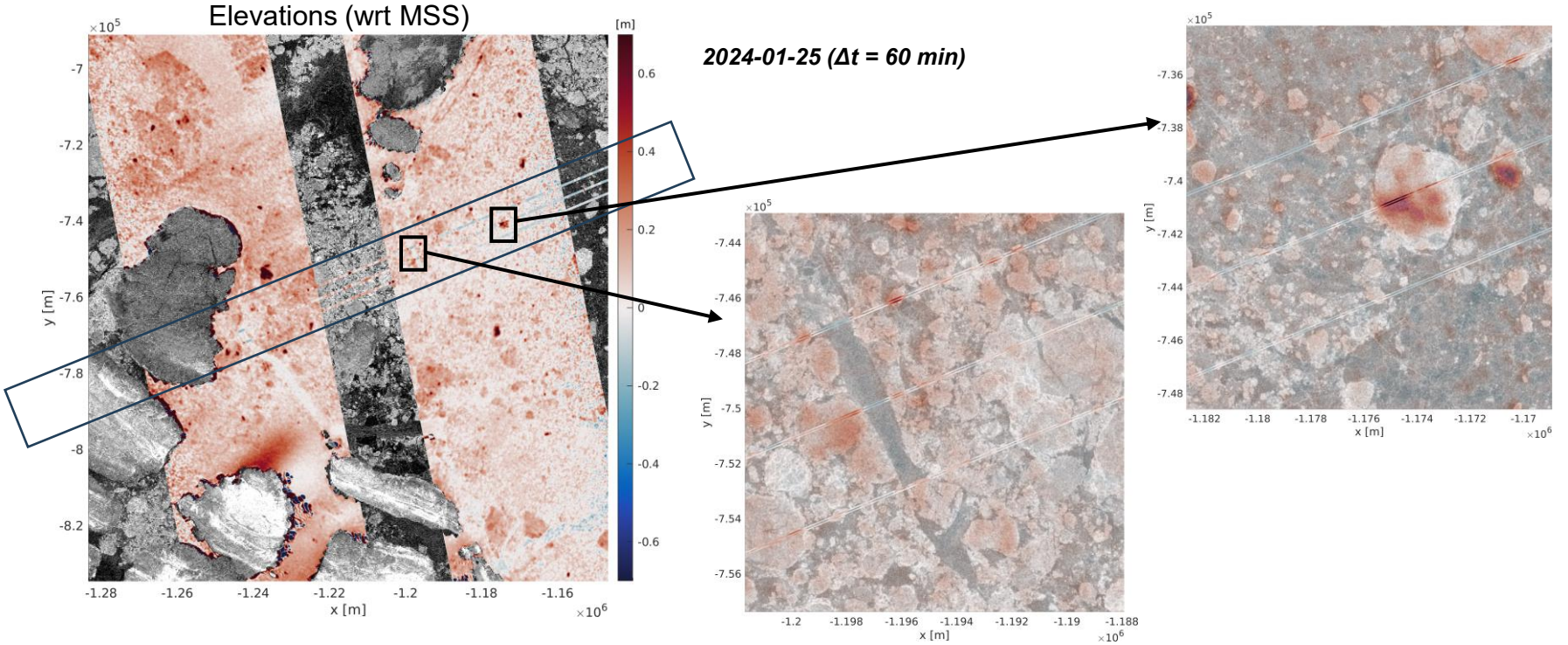


Jan/Feb.

other months

- up to 0.5 m
- mainly in Arctic winter

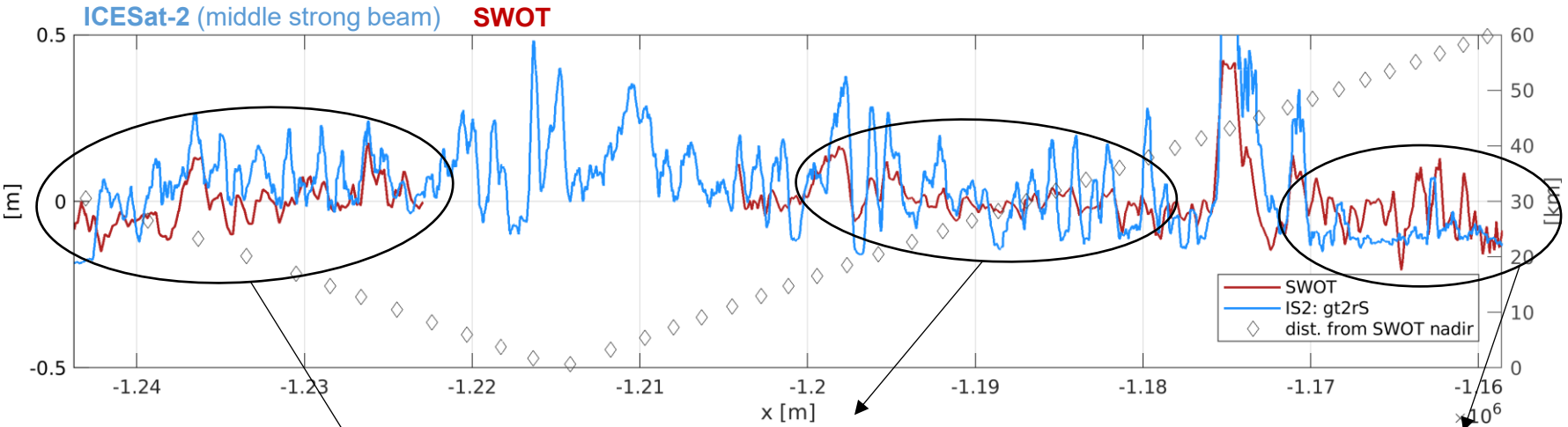
Case study – Canadian Archipelago



Case study – Canadian Archipelago

Along-track height comparison

[zero-centred by reducing mean difference per swath side]



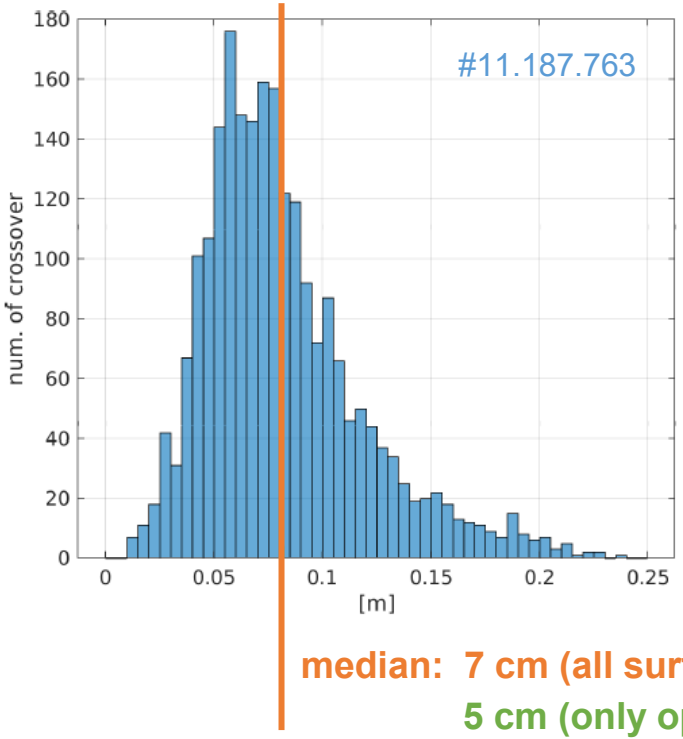
Similar behavior, but with an unremoved trend

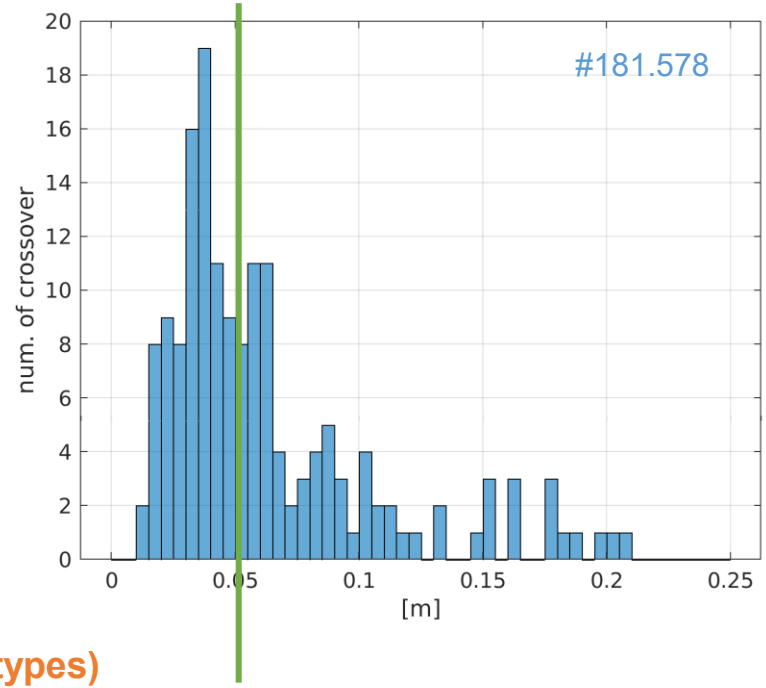
Similar behavior, but dampened in SWOT

High noise in SWOT

➢ **Standard deviation of this comparison: 9.3 cm**

Quantitative Results – Standard deviations





median: 7 cm (all surface types)

5 cm (only open water / according to ATL07 surface flag)

Conclusion and next steps

- In general, good agreement between SWOT and ICESat-2, as well as with the SAR imagery, especially for larger-scale surface elevations
- Remaining problems with SWOT cross-calibration correction and high noise at the outer edges of the swaths (last 5-10 km)
- The quantitative comparison (after reference and geo-correction harmonization) shows agreement of a few cm with better results if less sea-ice is present (leads and summer months)

Open tasks:

- Investigation of the latest SWOT LR products (version D) and high-rate (HR) products
- Development/improvement of SWOT surface type classification (lead detection)
- Improvement of SWOT-dedicated corrections for sea-ice areas

More Information: Discussion Paper in Copernicus „The Cryosphere“
https://egusphere.copernicus.org/preprints/2025/egusphere-2025-3046/