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Assessing Stability and Precision of Sea Ice Thickness Retrievals from Satellite Altimetry by a Cross-Over Analysis

Motivation

- While the **accuracy** is a measure of statistical bias, **precision** describes random errors (**Figure 1).**
- We evaluate the **precision** of satellite sea-ice thickness estimates, by an orbit crossover analysis, using trajectories along individual orbits.
- Sea ice thickness is derived from CryoSat-2 and Envisat radar altimeters in the framework of the ESA Climate Change Initiative Project.
- Moreover, differences in stability and precision between sea ice thickness retrievals from the northern and southern hemispheres are evaluated.

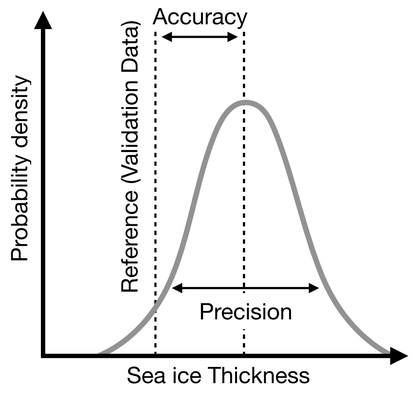

Figure 1: Schematic histogram of satellite ice thickness measurements regarding accuracy and precision.

Data and methods

- Orbit crossovers are determined for each single daily trajectory for CryoSat-2 and Envisat.
- For each crossover location, a search radius of 12.5 km is used to collect SIT measurements in the vicinity of the crossover for each of the two crossing orbits (**Figure 2**).
- The sea ice thickness measurements within the radius are averaged, and the mean sea ice thickness of **orbit 1** is subtracted from the averaged sea ice thickness of **orbit 2**, in order to retrieve the difference for each crossover.

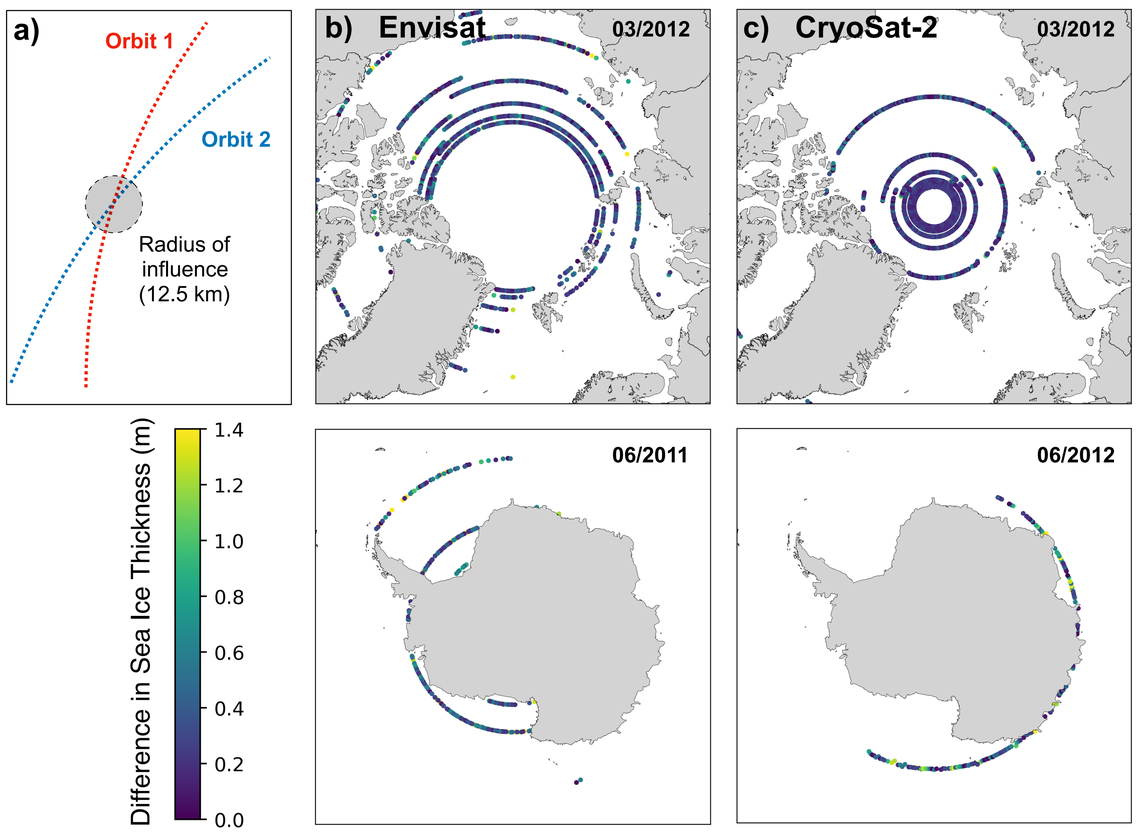

Figure 2: **a)** Scheme of the crossover analysis. Orbit 1 Sea Ice Thickness (SIT) and orbit 2 SIT are averaged within a radius of 12.5 km around the crossover. Then, orbit 1 mean SIT is subtracted from orbit 2 mean SIT. **b)** All Envisat Arctic and Antarctic crossovers within 24 h for 1 month. **c)** All CryoSat-2 Arctic and Antarctic crossovers within 24 h for 1 month.

Arctic vs. Antarctic

- Figure 4 shows histograms of the thickness differences between the sea ice thickness of orbit 2 and orbit 1 within the 12.5 km radius around the crossover for CryoSat-2 and Envisat over Antarctic sea ice.
- 1. Crossovers were collected over the periods 2002-2012 (Envisat) and 2010-2017 (CryoSat-2)
- 2. Crossovers were collected during October-April (Arctic), and April-October (Antarctic) respectively.

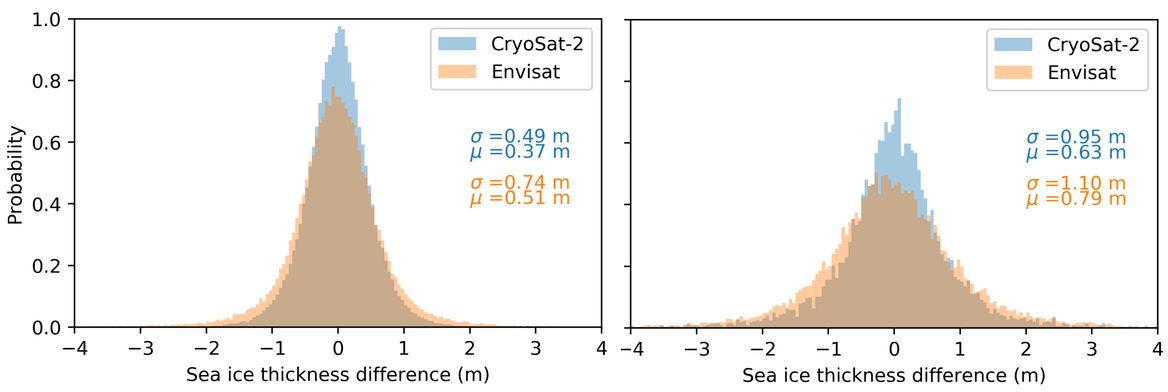

Figure 4: Binned crossover sea ice thickness differences for Envisat and CryoSat-2 with mean absolute differences (μ) and standard deviation of differences (σ), derived over the periods 2002-2012 and 2010-2017 for Envisat and CryoSat-2, respectively.

Orbit crossovers over Arctic sea ice

- **Figure 3** shows monthly histograms of the differences between the sea ice thickness of orbit 2 and orbit 1 within the 12.5 km radius around the crossover for CryoSat-2 and Envisat over Arctic sea ice.
- Monthly statistical parameters of the orbit crossover analysis over Arctic sea ice, using CryoSat-2 (2010-2017) and Envisat (2002-2012) measurements, can be found in **Table 1**.

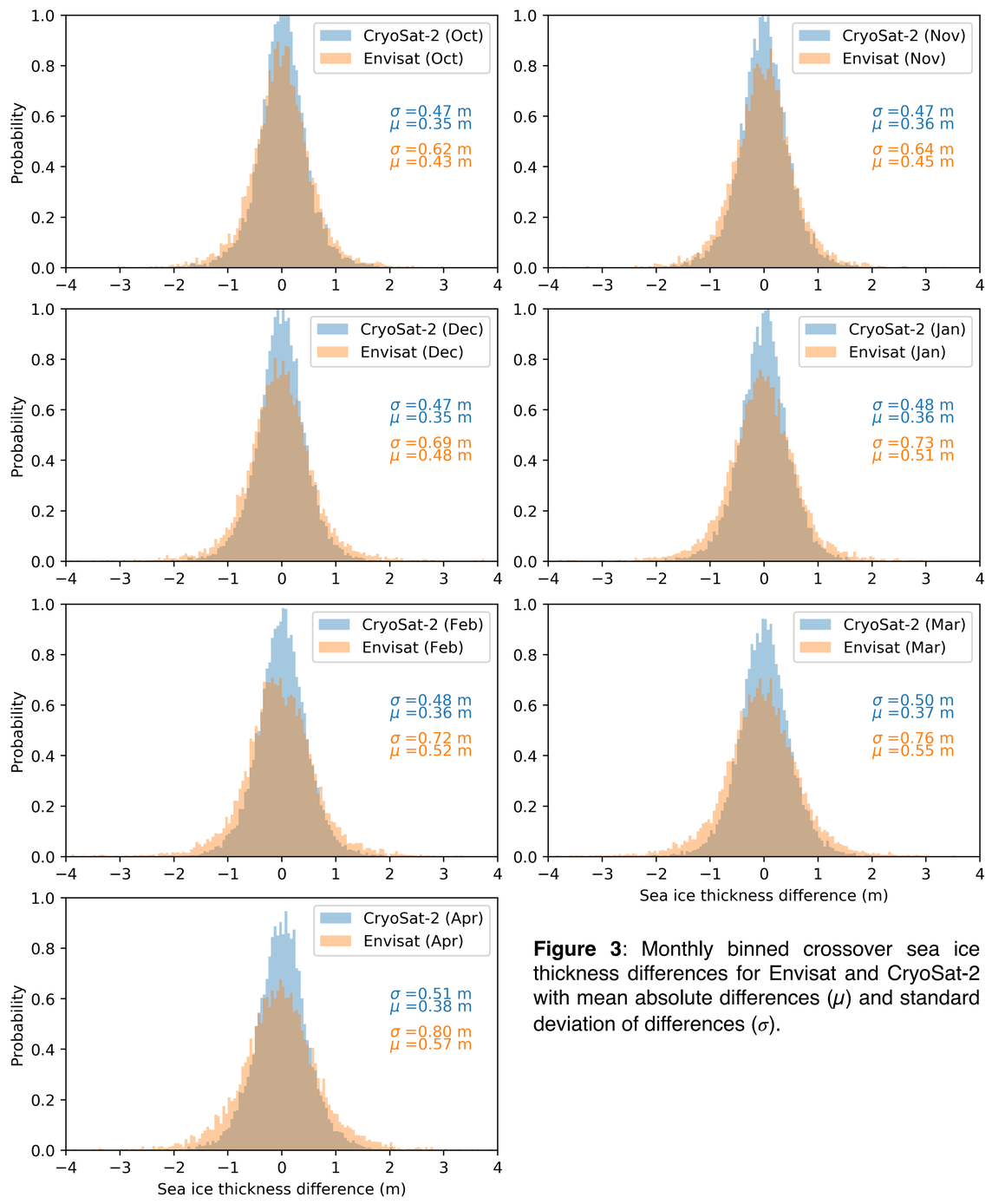

Figure 3: Monthly binned crossover sea ice thickness differences for Envisat and CryoSat-2 with mean absolute differences (μ) and standard deviation of differences (σ).

Table 1: Monthly standard deviation, mean difference, and mean absolute difference of Envisat and CryoSat-2 crossovers in the Arctic.

	Envisat (2002-2012)			CryoSat-2 (2010-2017)		
Month	Stddev (m)	Mean Difference (m)	Mean Absolute Difference (m)	Stddev (m)	Mean Difference (m)	Mean Absolute Difference (m)
October	0.62	-0.0075	0.43	0.47	0.0156	0.35
November	0.64	-0.0164	0.45	0.47	-0.0072	0.36
December	0.69	-0.0391	0.48	0.47	-0.0198	0.35
January	0.73	-0.0294	0.50	0.48	-0.0059	0.36
February	0.72	-0.0444	0.52	0.48	0.0043	0.36
March	0.76	-0.0450	0.55	0.50	0.0054	0.37
April	0.80	-0.0412	0.57	0.51	-0.0006	0.38
All	**0.74**	**-0.0331**	**0.51**	**0.49**	**-0.0015**	**0.37**

Conclusions

- The mean absolute difference is **0.37 m** for CryoSat-2 and **0.51 m** for Envisat, implying that CryoSat-2 sea ice thickness retrievals exceed Envisat in precision.
- For both Envisat and CryoSat-2, the mean absolute difference slightly increases from the beginning of the winter season in October to the end of April in the northern hemisphere.
- The stability and precision in the Arctic is significantly higher than in the Antarctic. For CryoSat-2, The mean absolute difference between crossover orbits is **0.37 m** in the Arctic, and **0.63 m** in the Antarctic.

References

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