ESA Climate Change Initiative – Ice Sheets

Validation and inter-comparison of surface elevation changes derived from altimetry over the Jakobshavn Isbræ drainage basin, Greenland – Round Robin results from ESA's Ice_Sheets_CCI (ID #EGU2013-6007)

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Abstract:

In order to ensure long-term climate records, ESA has launched the Climate Change Initiative (ESA CCI), which puts focus on 13 different Essential Climate Variables, one of them being Ice Sheets. In this program, four selected key parameters will be determined for the Greenland Ice Sheet: Surface elevation changes (SEC), surface velocities, calving front locations, and grounding line locations.

This work focuses on SEC, and the goal is to develop the best routine for estimating this by means of radar altimetry. In order to find the most optimal approach we have completed a Round Robin experiment (RR) in which researchers from various European and US institutions have provided SEC estimates derived from either Envisat radar or ICESat laser altimeter data. The test area was Jakobshavn Isbræ drainage basin, and by analyzing, inter-comparing and validating the results, we have found that a combination of repeat-track and cross-over analyses will result in SEC estimates with a high spatial resolution and low error estimates.

Results from Round Robin participants:

The RR participants are named SEC-1, SEC-2, .., SEC-10, and their results (Table 1 and Figure 1) show that:

- SEC-1's Envisat results resolve SEC remarkably well demonstrating the possibilities of radar altimetry for such an analysis.
- Best agreement between ICESat and Envisat repeat-track results found inland. ICESat results best resolve SEC by outlet.
- Due to scarcity of cross-over points, these cannot be used to resolve SEC by outlet.

Validation of the SEC trends were performed with airborne lidar data from NASA's IceBridge and ESA's CryoVex campaigns. They showed (Figure 2):

- Generally good repeat-track results, however best inland where slope effects are smallest.
- Best cross-over results from laser rather than radar altimetry. Believed to result from ICESat's smaller footprint size → can better resolve the actual SEC trend.
- As slope-induced errors in cross-over points can be ignored using data from ascending and descending tracks → overall lowest errors found for cross-over data.

The following inter-comparisons of the RR results were carried out in order to find the most optimal way for estimating SEC throughout GIS:

- Radar vs. laser altimetry → Result: Difference only along ice stream due to slope effects.
- Repeat-track vs. cross-overs → Result: RT has best spatial resolution and XO the lowest errors.
- Time series vs. direct estimation of dH/dt → Result: No difference.

RR participant	Sensor	Method	Observation period	Output parameters
SEC-1	Envisat	Repeat-track	2002 – 2010	dH/dt, time series
SEC-2	ICESat	Repeat-track	2003 – 2009	dH/dt
SEC-3	ICESat	Repeat-track	2003 – 2009	dH/dt, time series
SEC-4	ICESat	Repeat-track	2003 – 2009	dH/dt
SEC-5	ICESat	Repeat-track	2003 – 2009	dH/dt
SEC-6	ICESat	Cross-overs	2003 – 2009	dH/dt
SEC-7	ICESat	Cross-overs	2003 – 2009	dH/dt, time series
SEC-8	ICESat	Cross-overs	2003 – 2009	dH/dt
SEC-9	Envisat	Cross-overs	2003 – 2009	dH/dt, time series
SEC-10	Envisat	Cross-overs	2002 – 2010	dH/dt, time series

Table 1: Information on the Round Robin participants' analyses and observation periods.

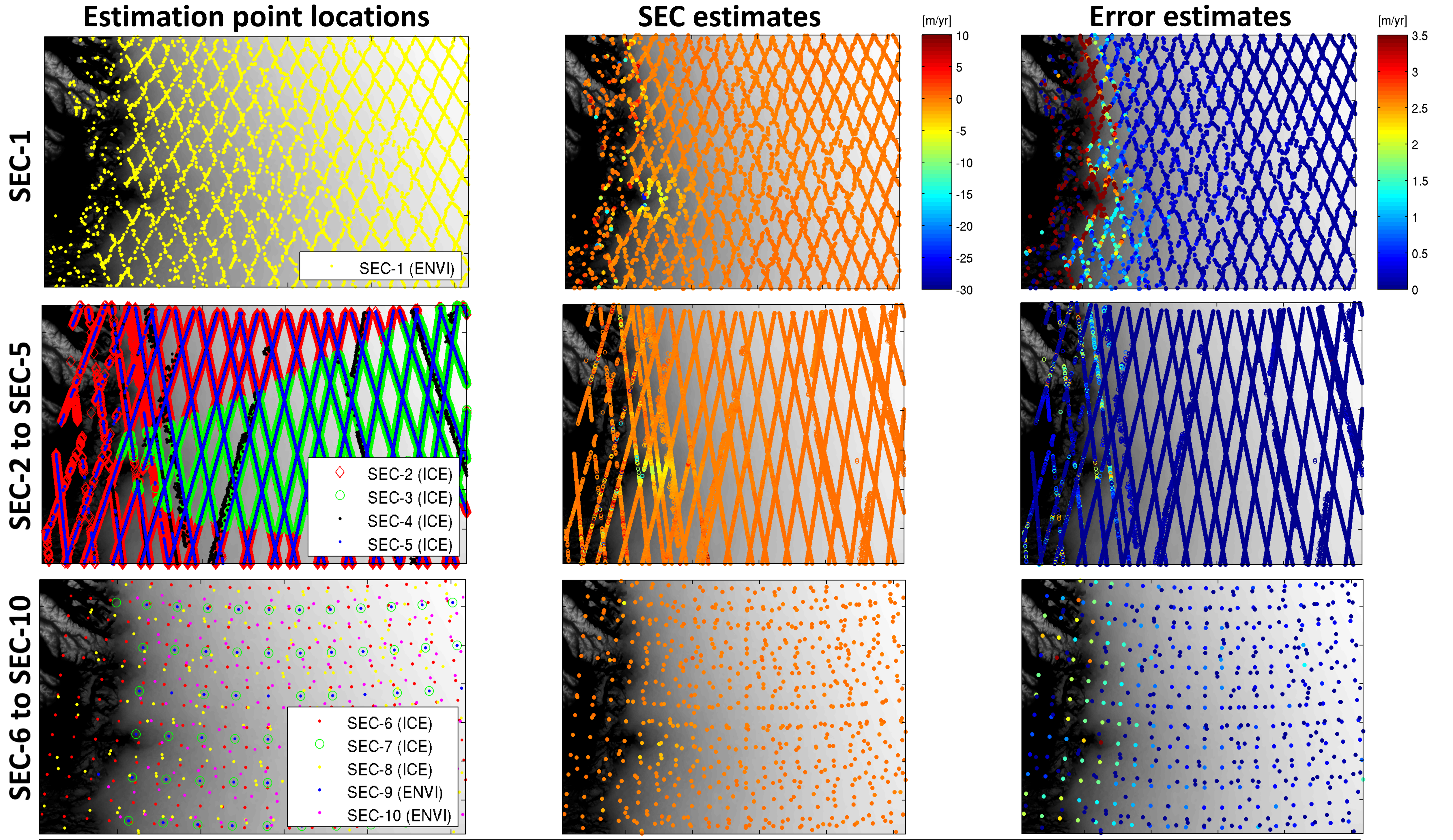

Figure 1: Results of the Round Robin analysis split up depending on the method and choice of altimeter. 'ENVI' refers to the use of Envisat data and 'ICE' to ICESat. See Table 1 for details on the method.
***Columns*: Left: Location of RR participants' estimation points, middle: dH/dt, right: Standard errors.**
***Rows*: Top + middle: Repeat-track method; Bottom: Cross-over method. The same colorbar applies for all dH/dt and error plots.**

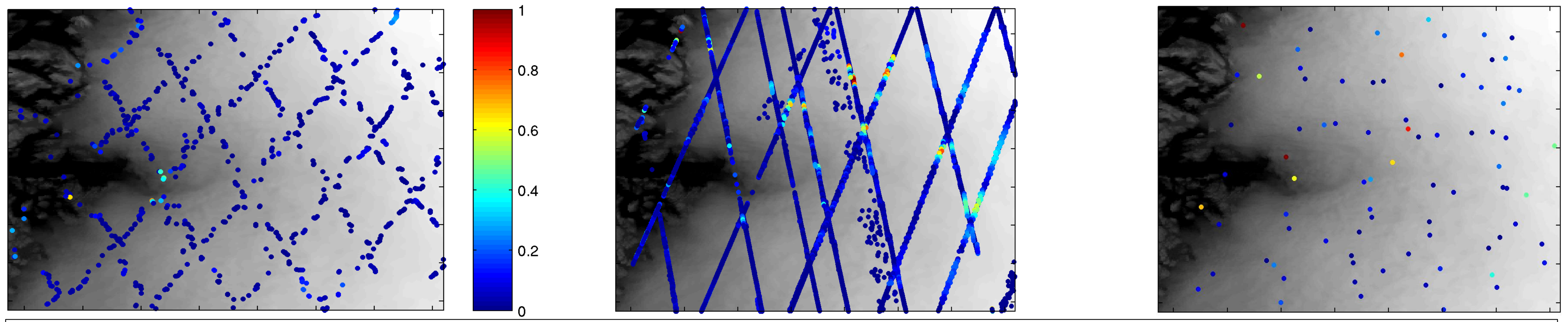

Figure 2: Validation with lidar data, i.e. scaled SEC differences between the lidar and RR dH/dt trends. The lidar trends cover the same time span as the observations, i.e. 2003 – 2009 and 2002 – 2010, respectively: SEC-1 (left), SEC-2 to SEC-5 (middle) and SEC-6 to SEC-10 (right).

Conclusions:

- Generally smaller ICESat than Envisat errors. Probably due to ICESat's smaller footprint size → more realistic resolution of actual SEC trend.
- SEC-1's radar results show large potential for the use of radar altimetry to derive SEC throughout the Greenland Ice Sheet including its margins.
- Most optimal SEC estimates can be obtained by combining repeat-track (high spatial resolution) with cross-overs (low errors in cross-over points). This allows for obtaining reliable values both inland and in areas with a rough surface topography such as by the ice margin.