Fine Ice Sheet Margins Topography From Swath Processing of CryoSat SARIn Mode Data

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In a nut-shell

What

Developing a dense elevation product from the ESA CryoSat mission so to improve spatial resolution of ice topography over small ice caps and ice sheet margins

Why

Ice topography is connected to climate
High rate of melting and discharge over margins

How

Exploiting the full waveform of CryoSat SARIn mode data (the entire swath)

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Swath Processing

Swath Spatial Coverage

Validation exercise

Conclusions

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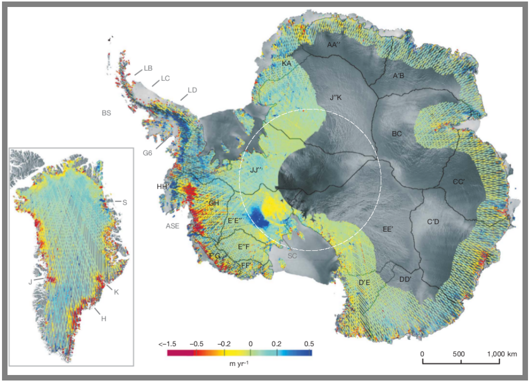
Importance of ice sheet margins

- Localized ice mass loss (concentrated at ice sheet margins)
- Global implications (e.g. sea-level rise)



Rate of change of surface elevation between 2003 and 2007 (Pritchard *et al.*, 2009)

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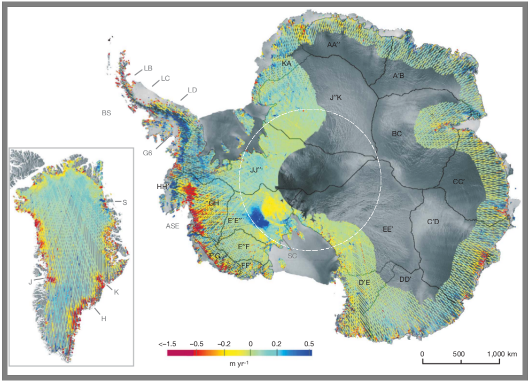

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CryoSat ESA mission

- Continuous monitoring of land and marine ice fields' fluctuations
- SIRAL (SAR Interferometric Radar Altimeter)
- Microwave band, independent on:
  - weather conditions
  - sunlight exposure
- Orbit inclination: 92.02°
- Distinct modes of operations:
  - Low Resolution Mode (LRM)
  - Synthetic Aperture Mode (SAR)
  - Interferometric SAR (SARIn)

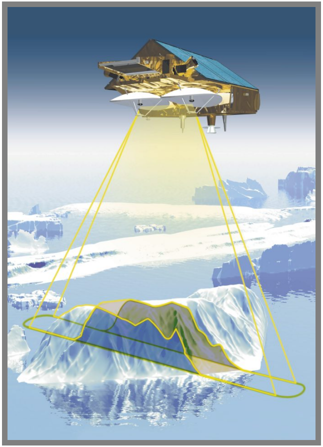

Image credit: EADS Astrium

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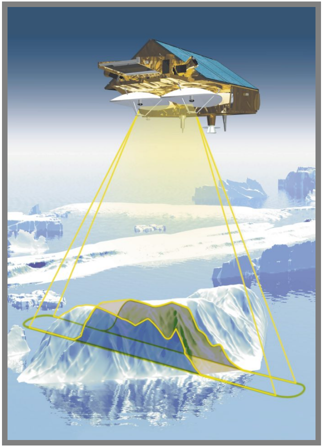

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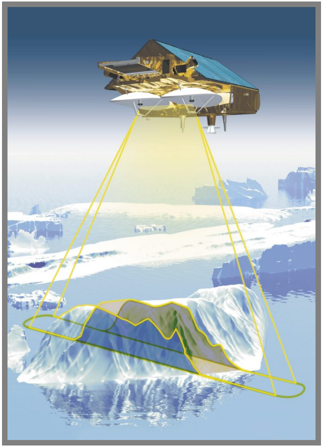

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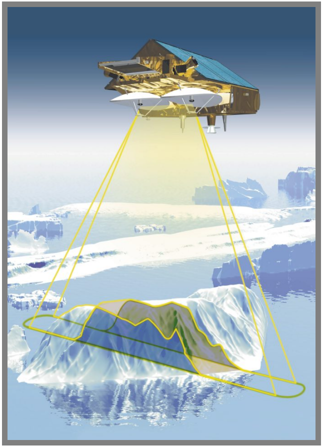

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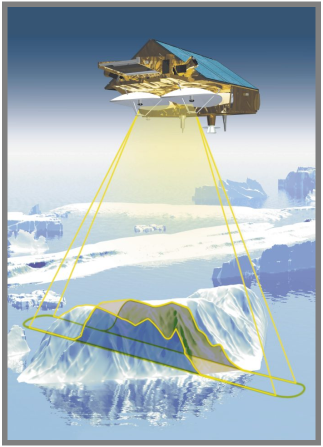

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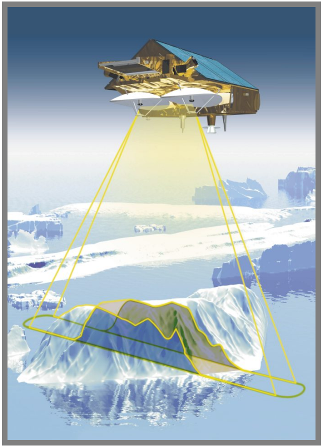
  - **Interferometric SAR (SARIn)**



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Modes of operation

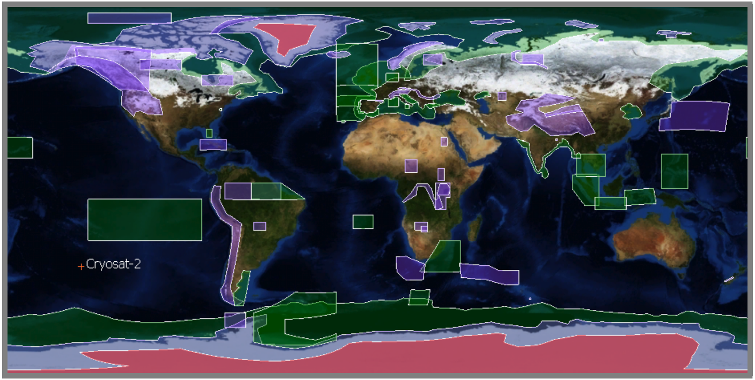
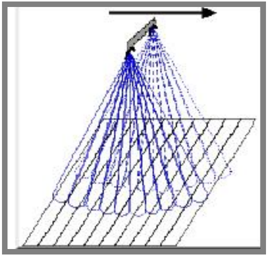


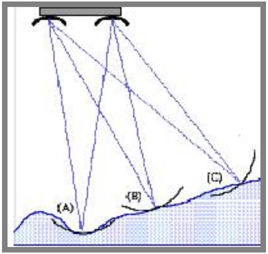
Image credit: ESA

All SARIn areas (purple) are characterized by sloping ice and/or rough topography

SARIn mode



Along track SAR processing



Across track echo location

Image credit: ESA

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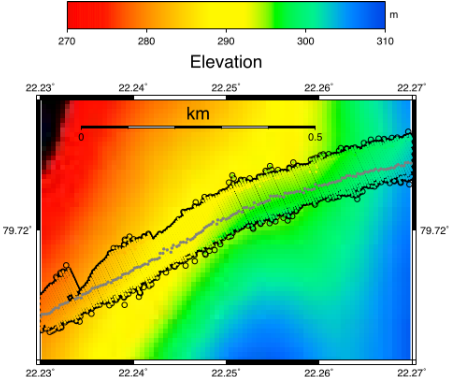
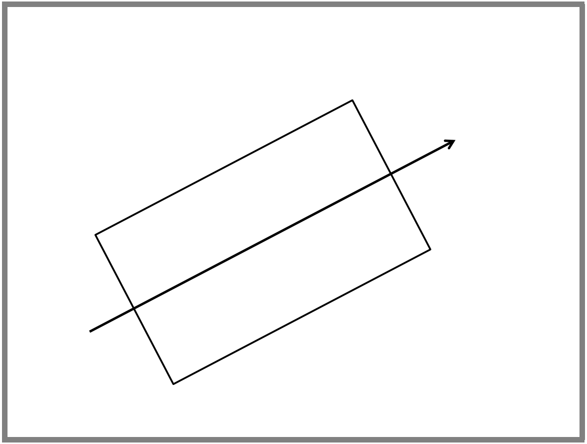
Previous work



Proof of concept using ASIRAS Interferometric Radar Altimeter.
Hawley *et al.*, 2009

Standard vs Swath elevation product



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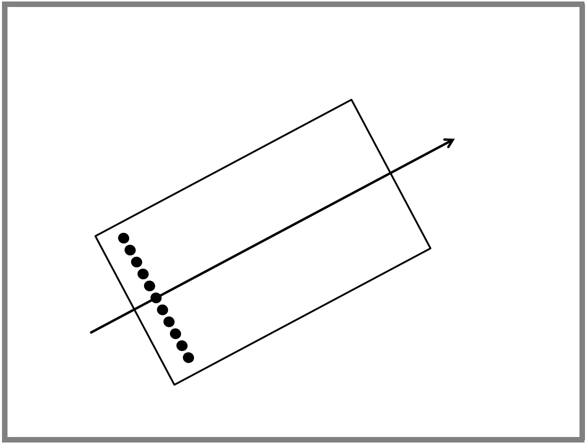

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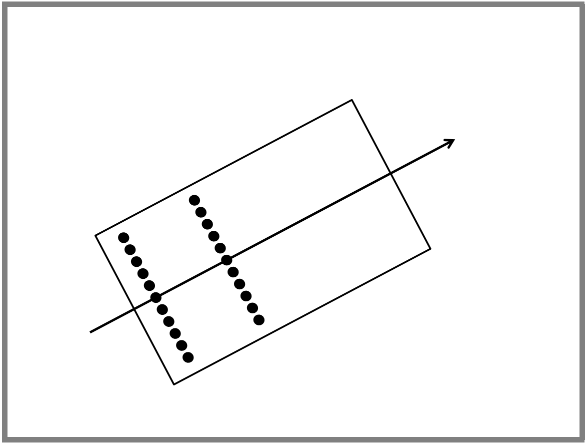

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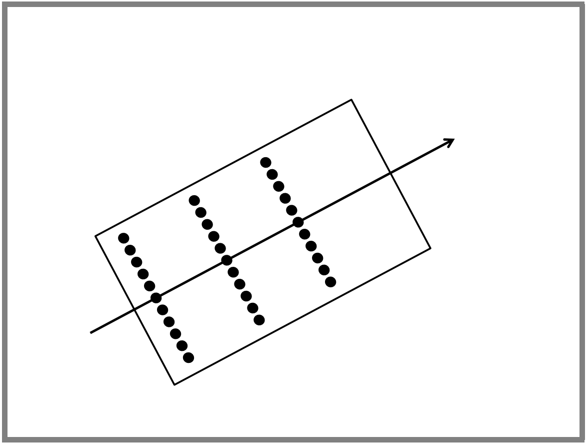

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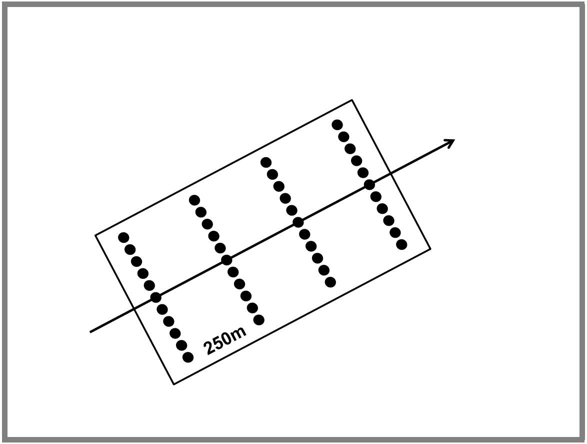
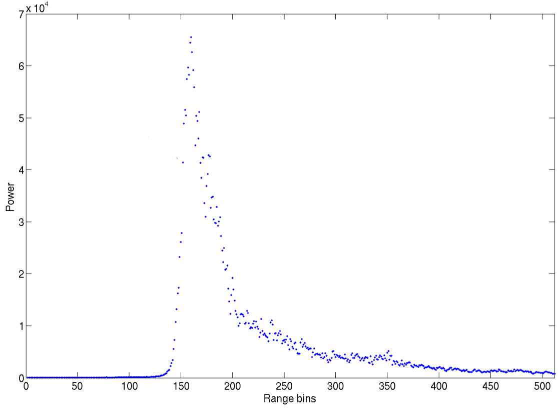


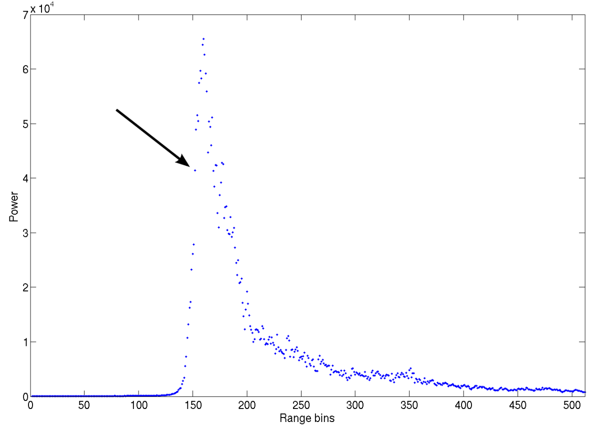
Standard vs Swath elevation product

Waveform example



Standard vs Swath elevation product

Waveform example with POCA highlighted



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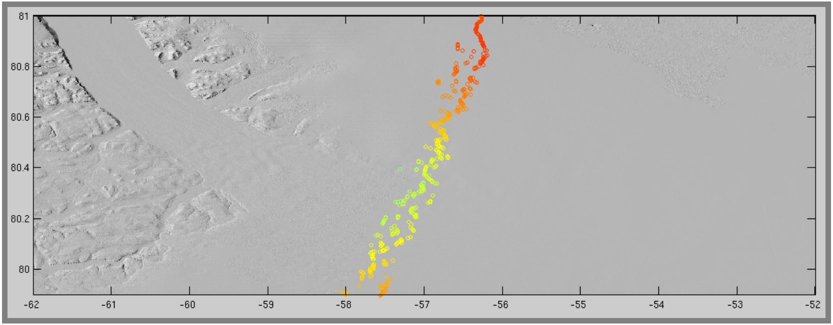
Standard vs Swath Spatial Coverage

Petermann - standard processing - 1 track



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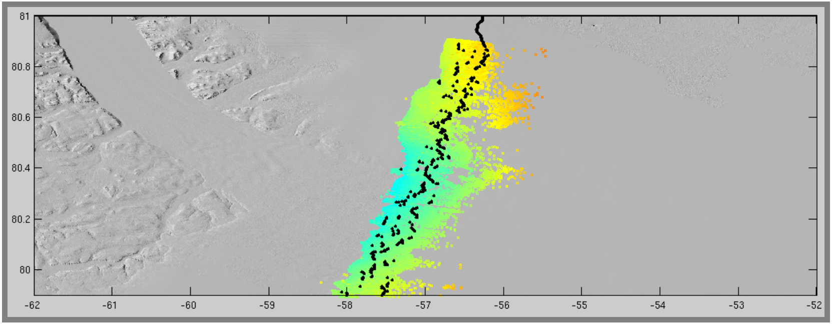

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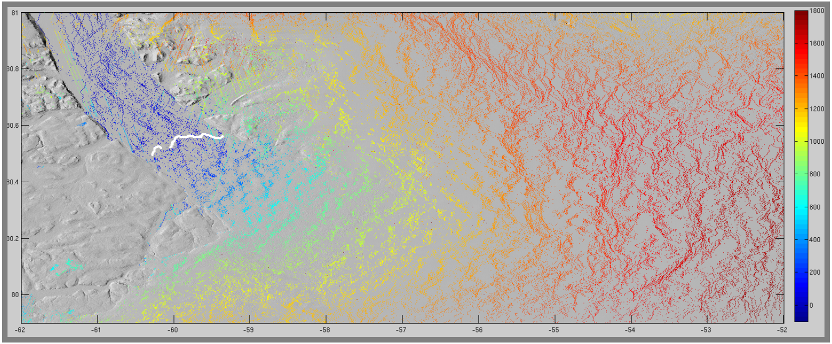

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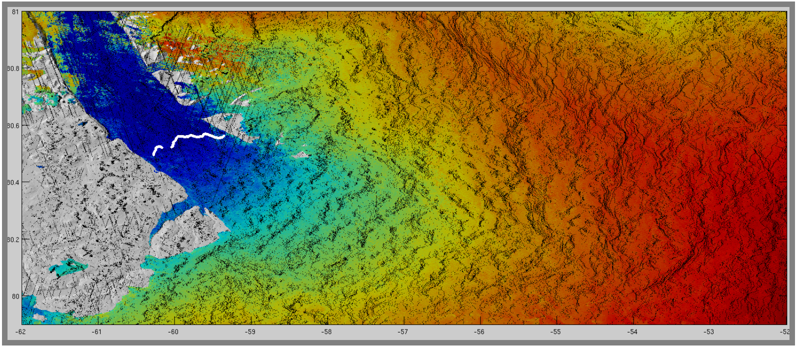
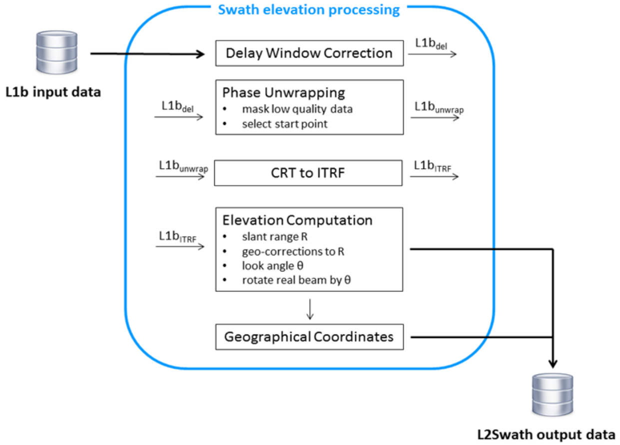
Petermann - swath processing



Processing scheme



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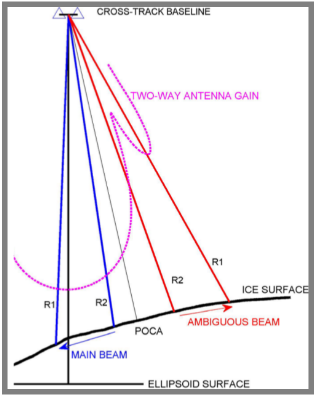
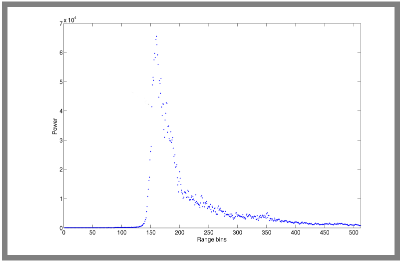
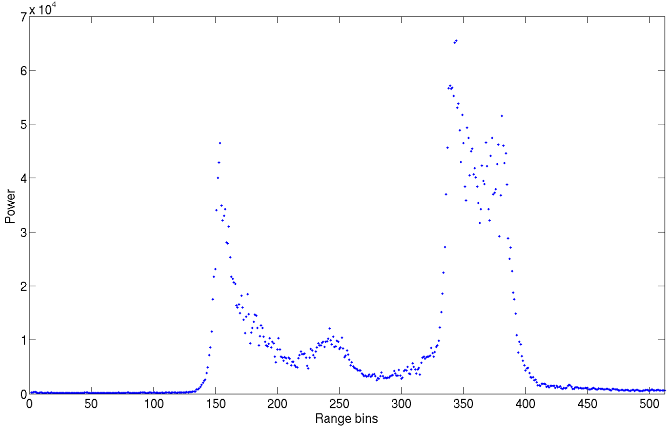
Suitable surface conditions (Gray *et al*, 2013)





Ideal surface conditions:
slope $\in$ [0.5,2] degrees

Non-suitable surface conditions - 1



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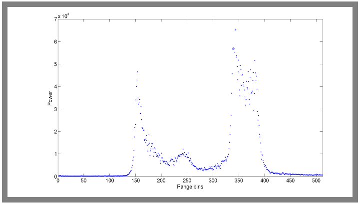

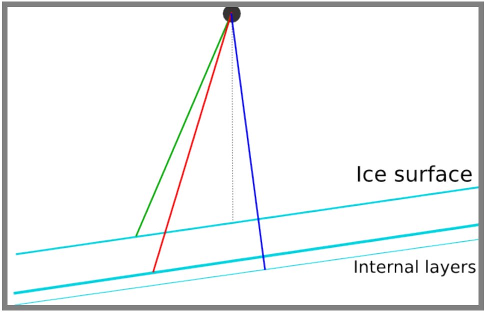

Multiple reflections (e.g internal layers, rocks)

- **Mask 1**: correlation with optimal power waveform

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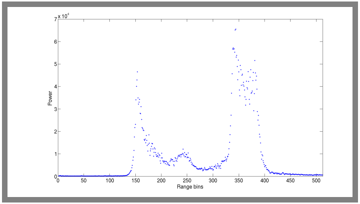

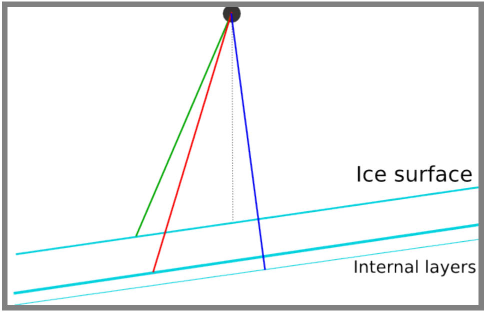

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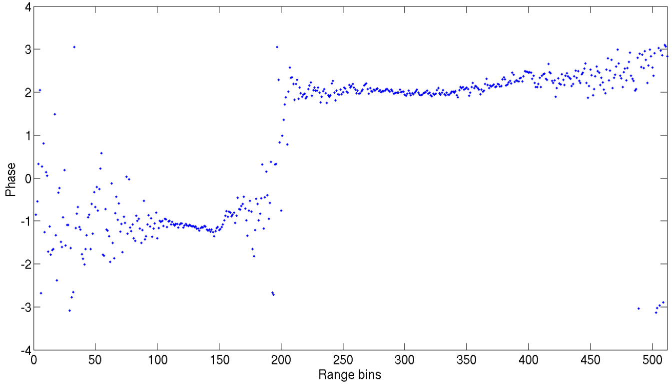
Non-suitable surface conditions - 2



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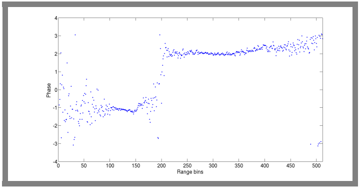

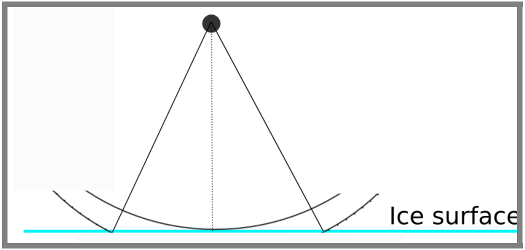

Flat surface ⇀ multiple contributions to same 'bin'

- **Mask 2**: correlation with linear/quadratic fit

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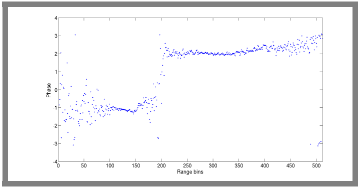

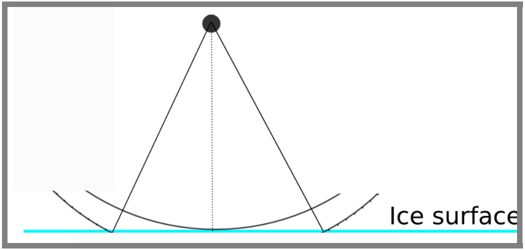

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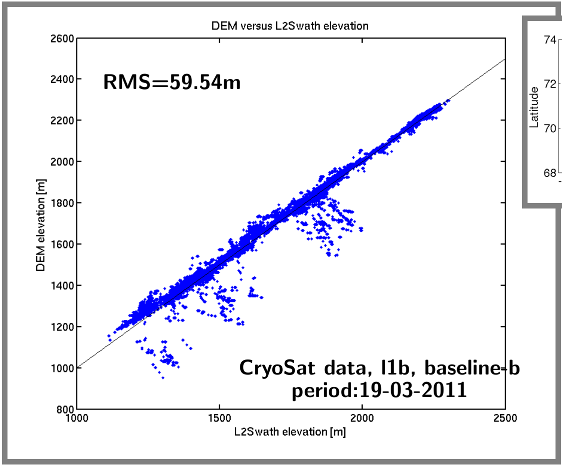
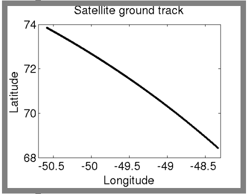
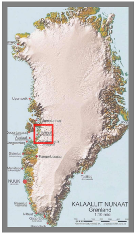
Validation against ICESat DEM

Not masked

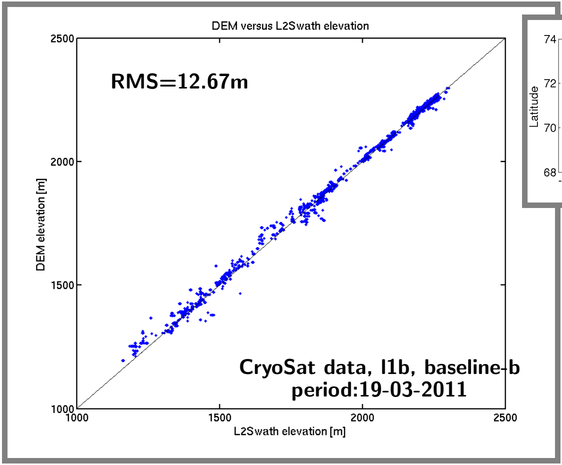


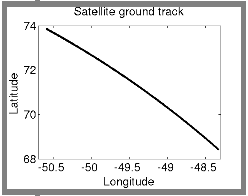


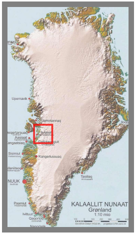


Validation against ICESat DEM

Masked with correlation

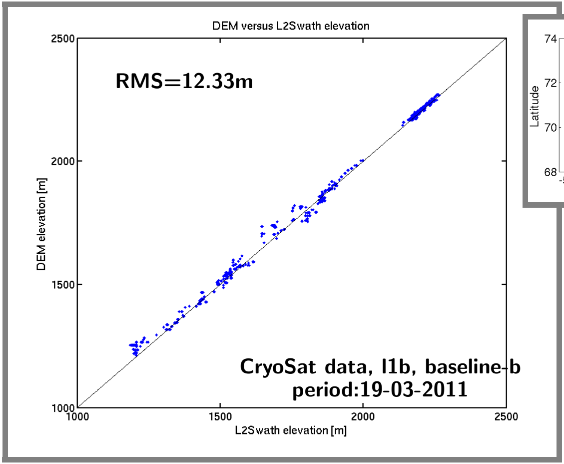


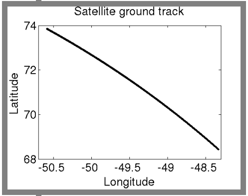


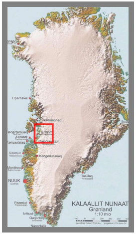


Validation against ICESat DEM

Masked with correlation and phase fit

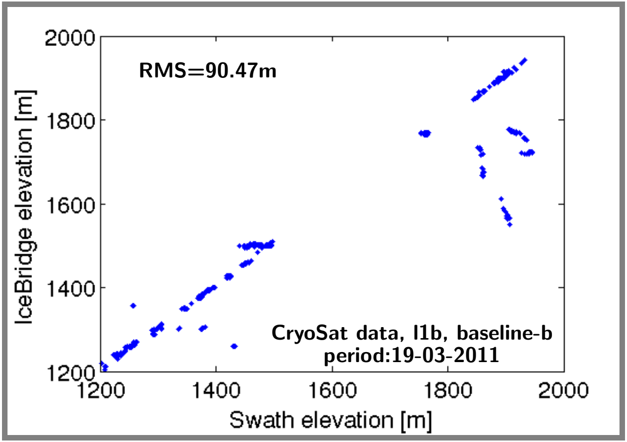


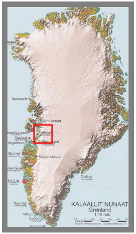




Validation against IceBridge

Not masked





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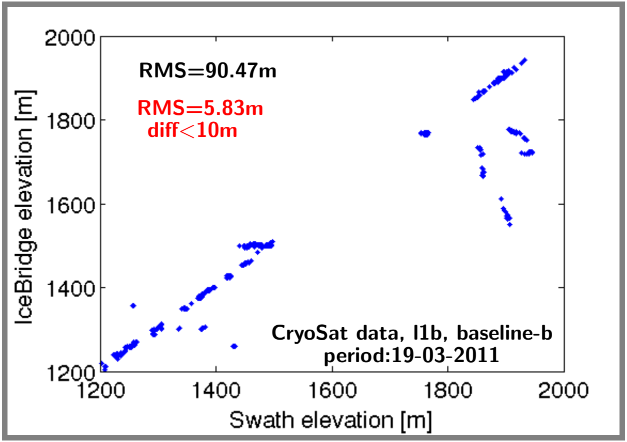

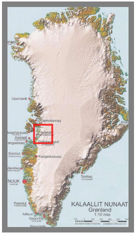

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