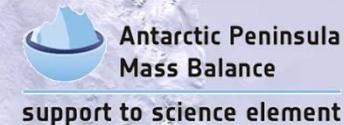


Analysis of CryoSat-2 measurements over the Antarctic Peninsula

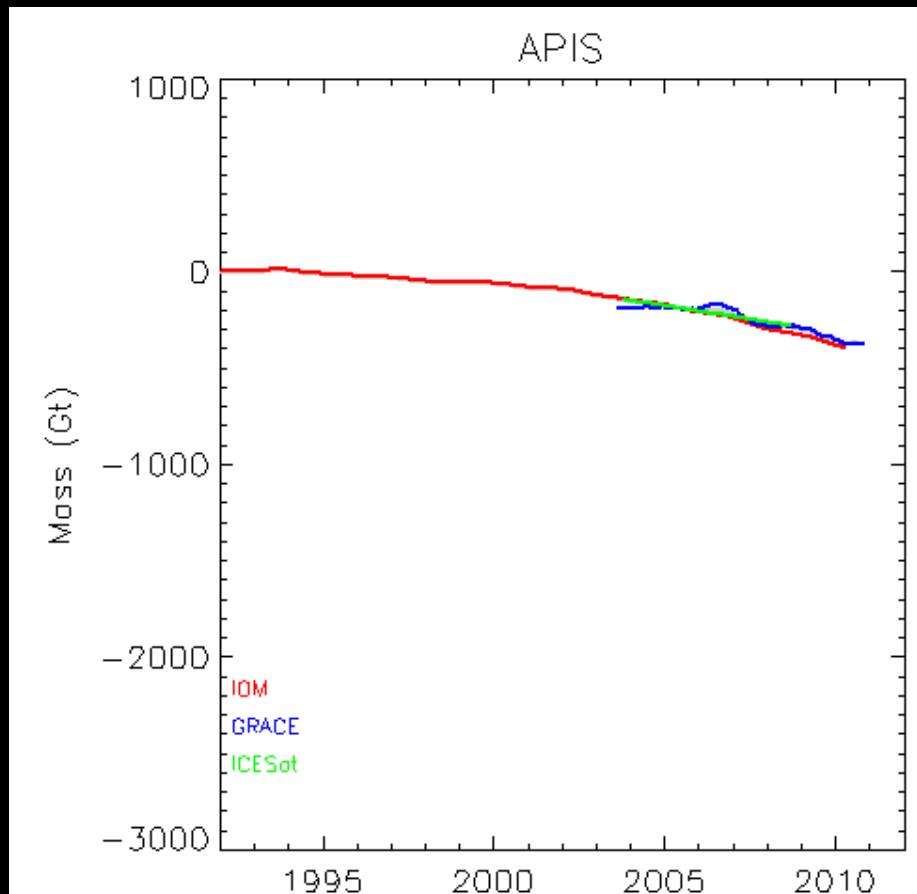
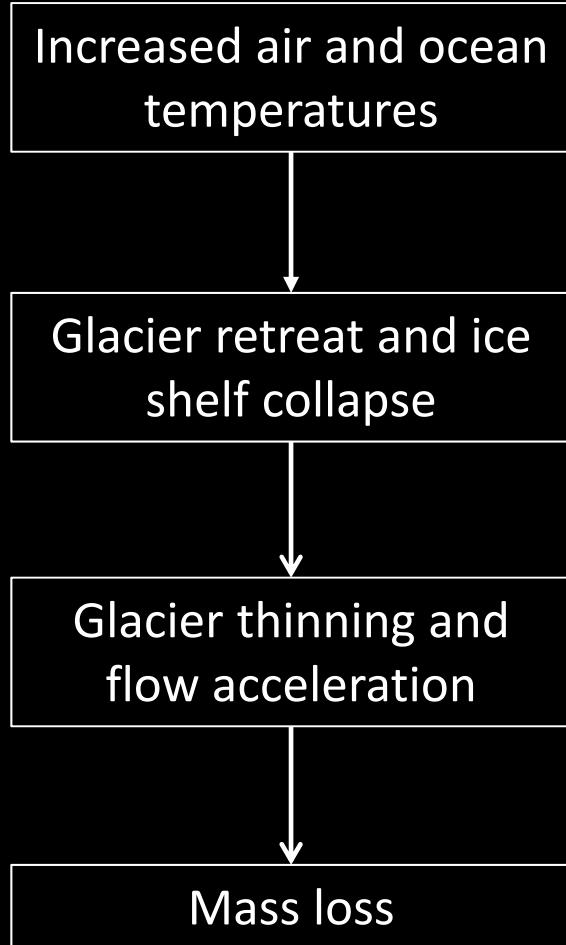
K. Briggs, A. Shepherd,
M. McMillan, A. Sundal,
L. Gilbert, A. Muir, N.
Barrand



Outline

- Background
- Evaluate CryoSat-2 elevation measurements
 - Filtering and validation
 - Spatial patterns
- Elevation change
 - CryoSat-2
 - Comparison with ERS/EnviSat and ICESat

Antarctic Peninsula

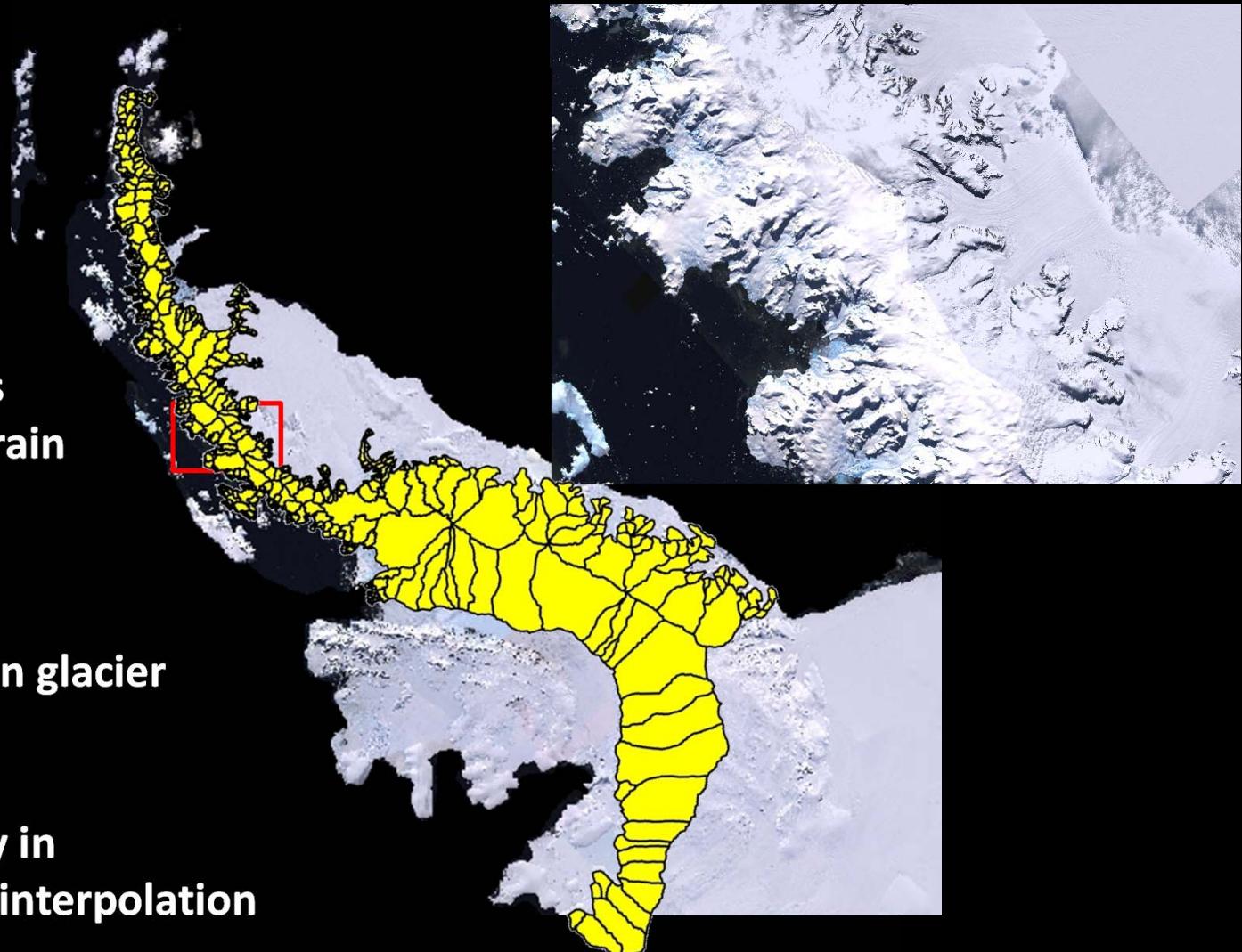


1992-2011 => -20 ± 14 gt/yr
= 25% of AIS mass loss although only 4% of area

Shepherd *et al.*, 2012

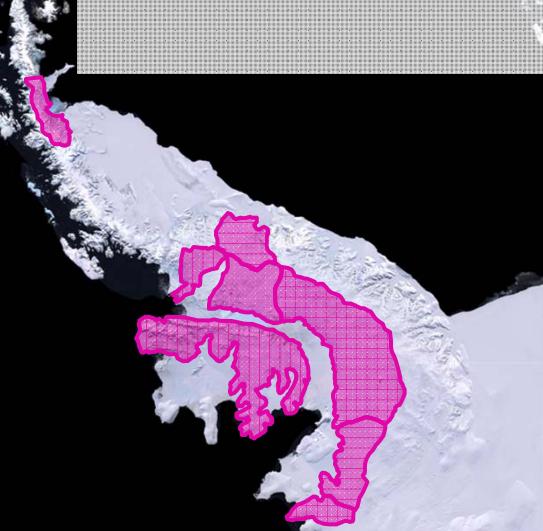
The Peninsula problem

- 2 key difficulties:
 - >1000 basins
 - Complex terrain
- Gaps in data
- Large variability in glacier behaviour
- Large uncertainty in extrapolation and interpolation



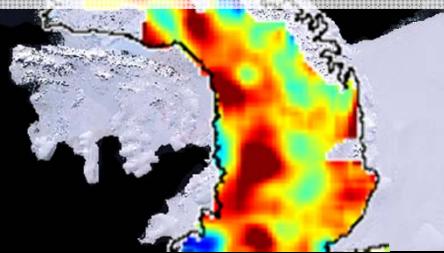
The Peninsula problem

“the Antarctic Peninsula ice sheet would benefit from measurements with greater spatial sampling”
Shepherd *et al.*,(2012)



Mass Budget Method

< 50 % coverage

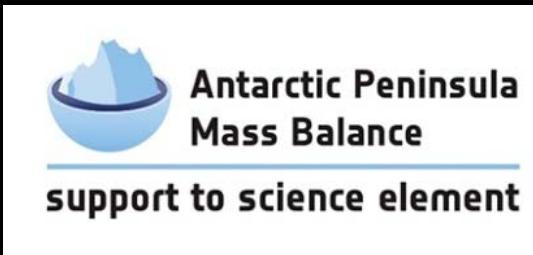


**Radar Altimetry
(ERS/EnviSat)**
< 50 % coverage

Gravimetry
100% coverage
Low spatial resolution

APMB Project

- 2013 to 2015
- 10 institutions
- dm/dt of APIS
- Altimetry, Gravimetry and Mass Budget Method
- Combine and reconcile techniques
- Maximise data coverage
 - optimise techniques
 - use new datasets (e.g. CryoSat-2)



CryoSat-2 Data Integrity –Approach

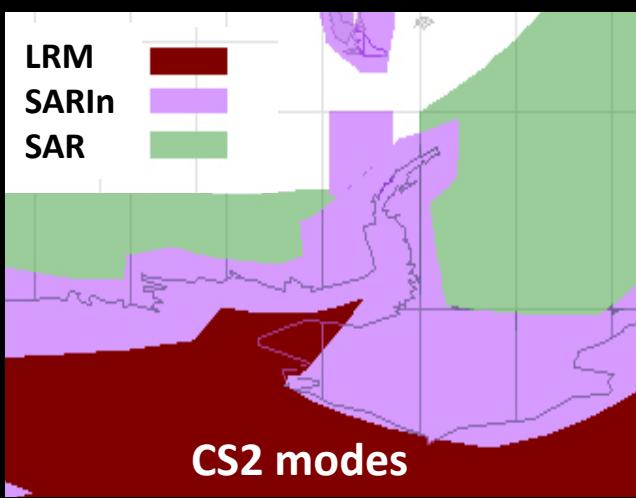
- Evaluate elevation measurements
- APIS terrain pushes CS2 limits
- CS2 data quality flags
- Aim: develop an objective classification system of good and bad data
- Approach (so far):
 - Nadir filter
 - Validation with ATM
 - DEM Comparison & clip



CryoSat-2 Data

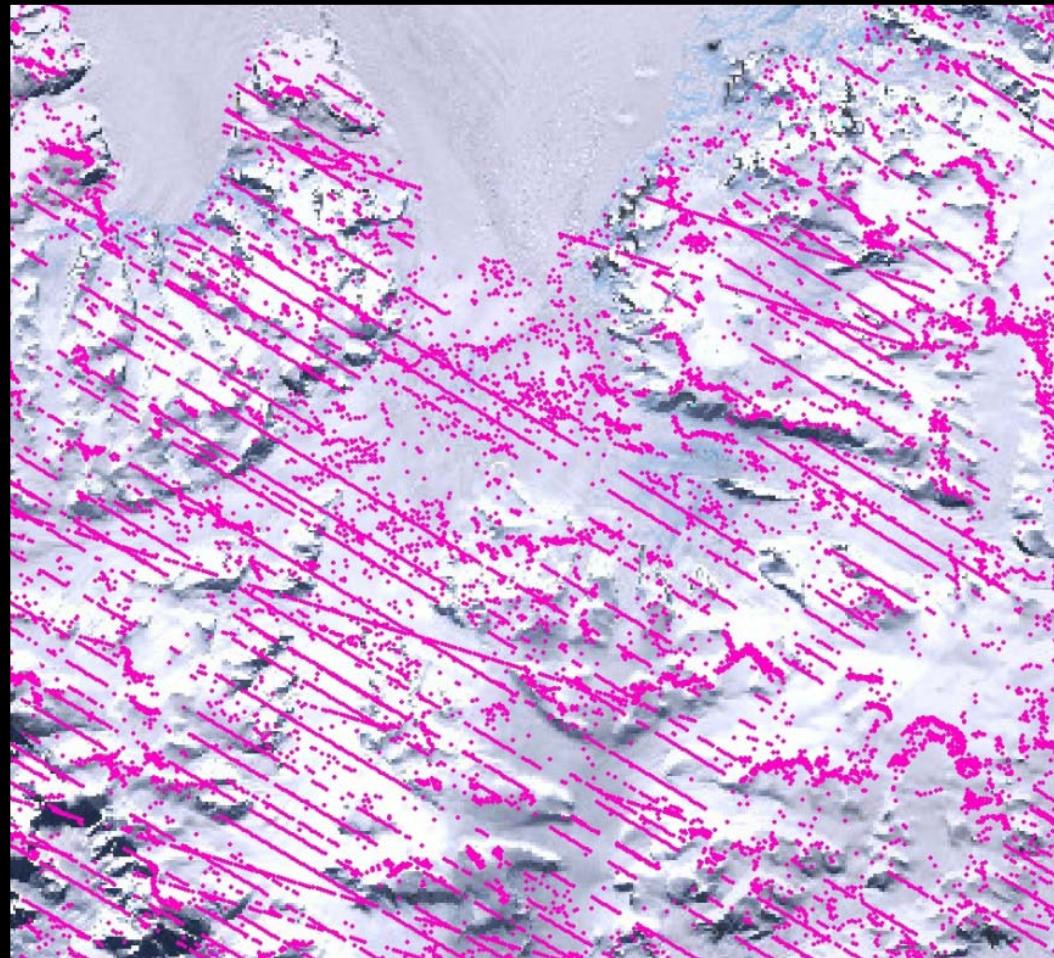
SARIn mode data
January 2011 to January 2013
N data points: 680319

● CryoSat



Nadir Filtering

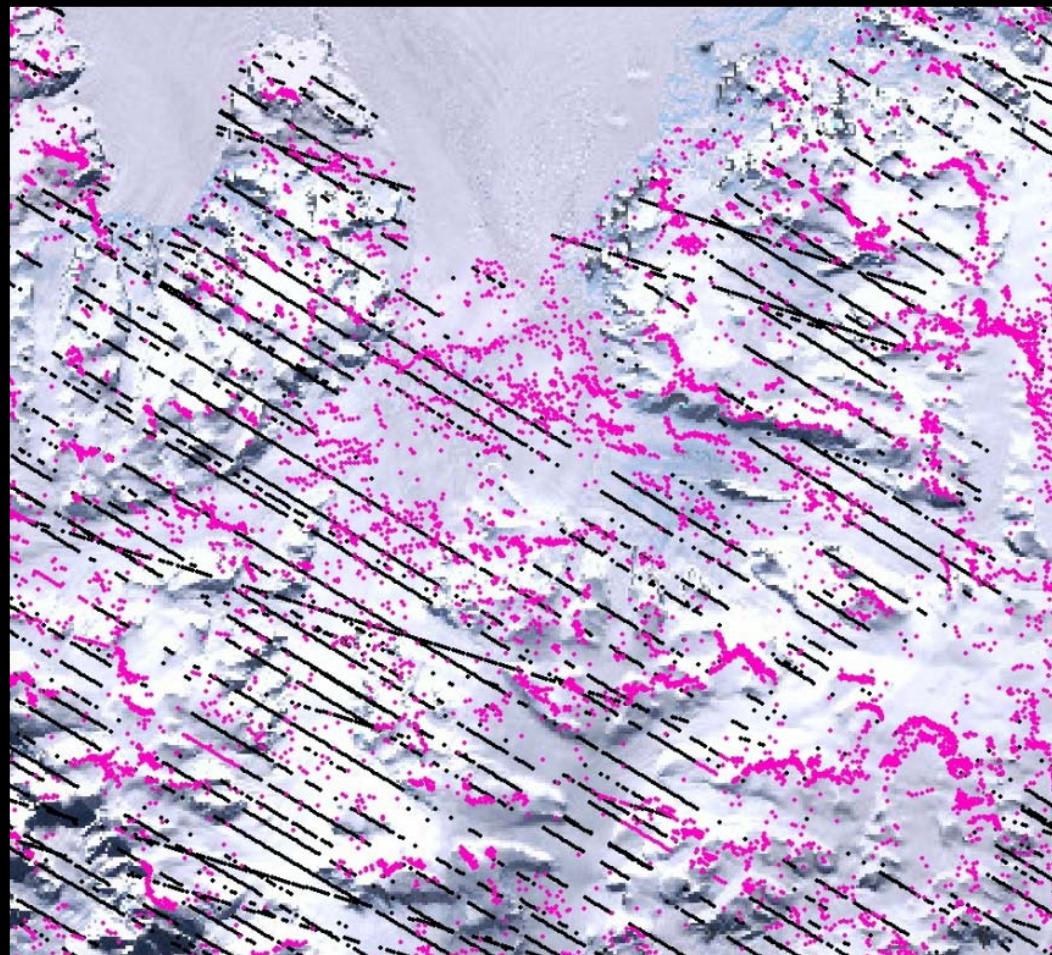
- CryoSat



Mercator Ice Piedmont,
Mobil Oil Inlet

Nadir Filtering

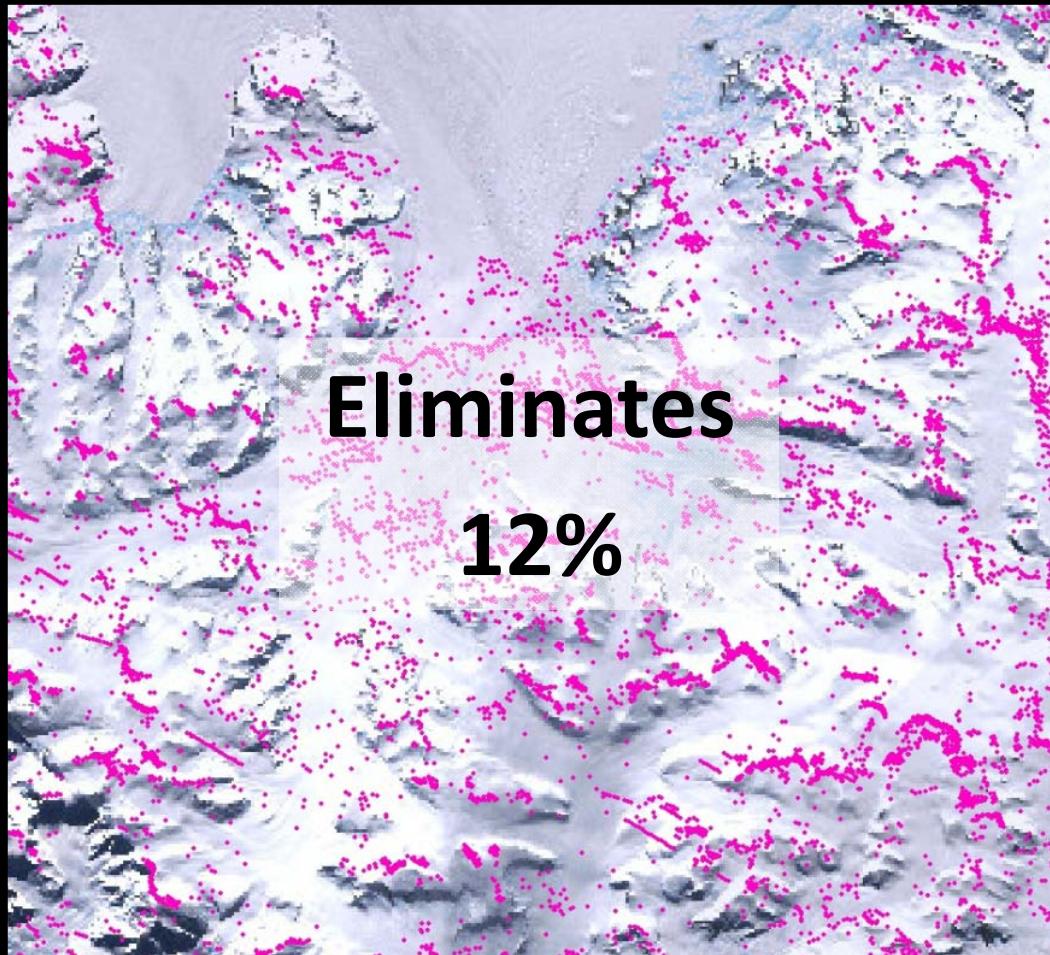
- CryoSat - good
- CryoSat - bad



Mercator Ice Piedmont,
Mobil Oil Inlet

Nadir Filtering

● CryoSat



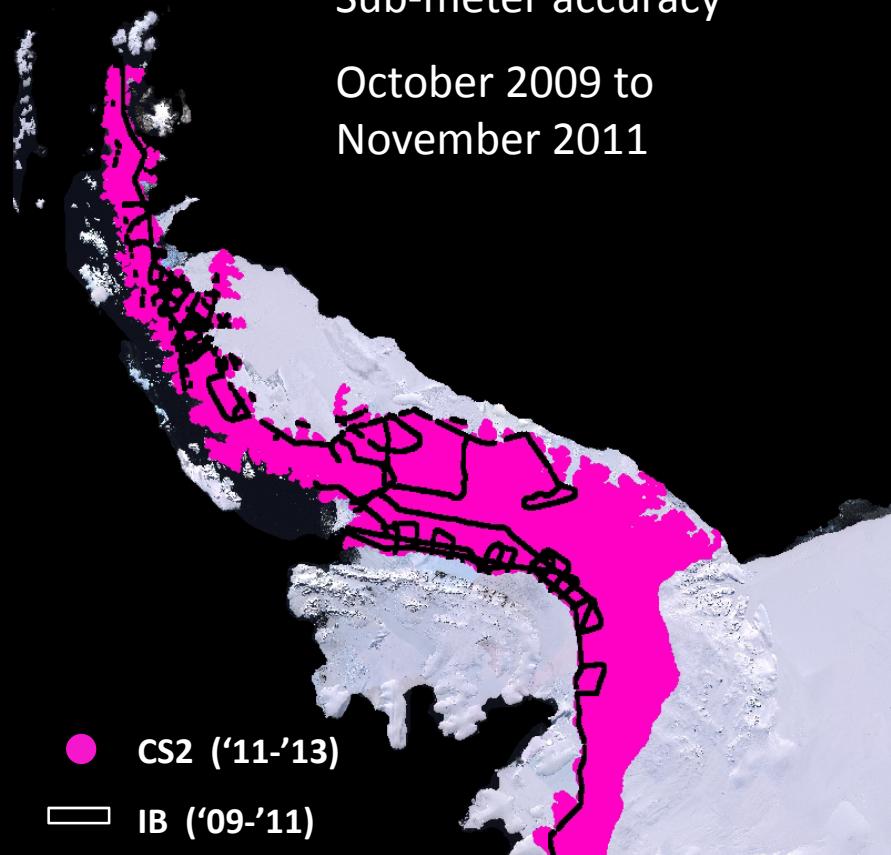
Mercator Ice Piedmont,
Mobil Oil Inlet

Ancillary Datasets

IceBridge ATM

Sub-meter accuracy

October 2009 to
November 2011



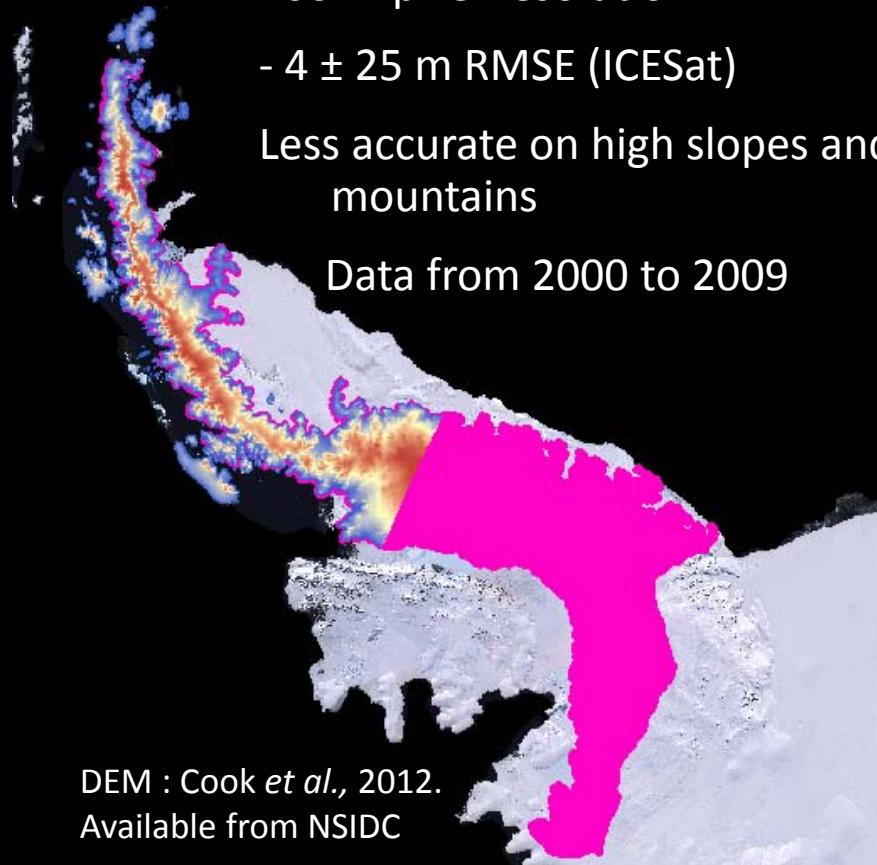
Cook -ASTER GDEM

100 m pixel resolution

- 4 ± 25 m RMSE (ICESat)

Less accurate on high slopes and
mountains

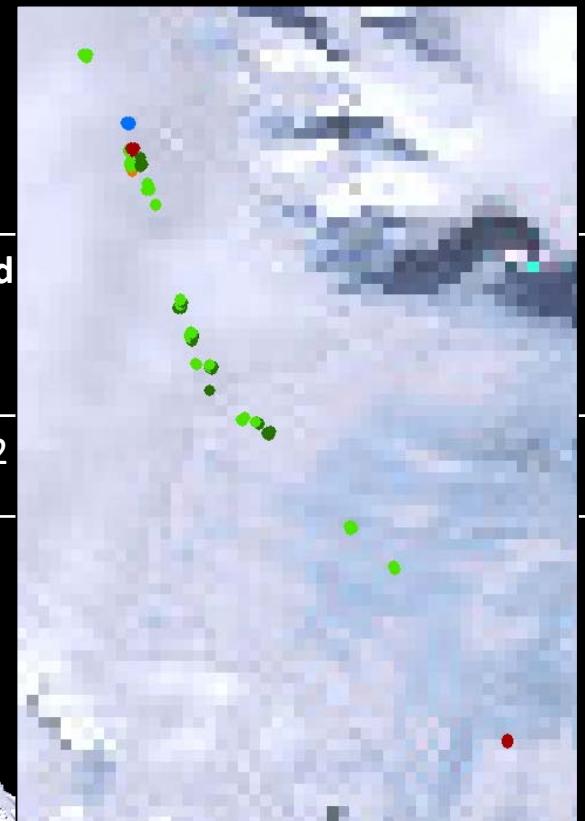
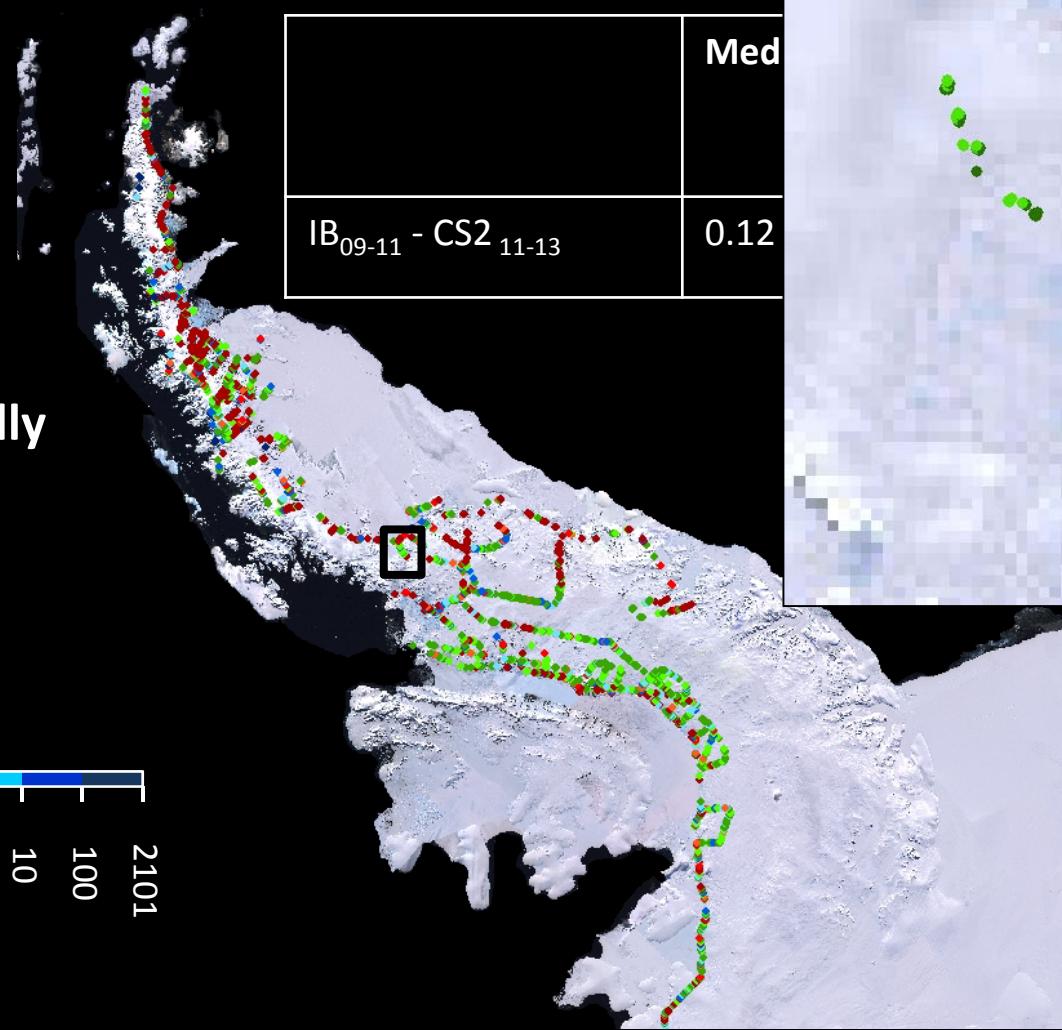
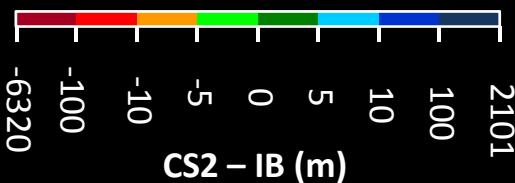
Data from 2000 to 2009



Validation

CryoSat/IceBridge comparison

where CS2 point
< 50 m horizontally
of IB point



Background

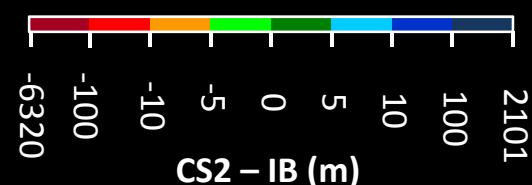
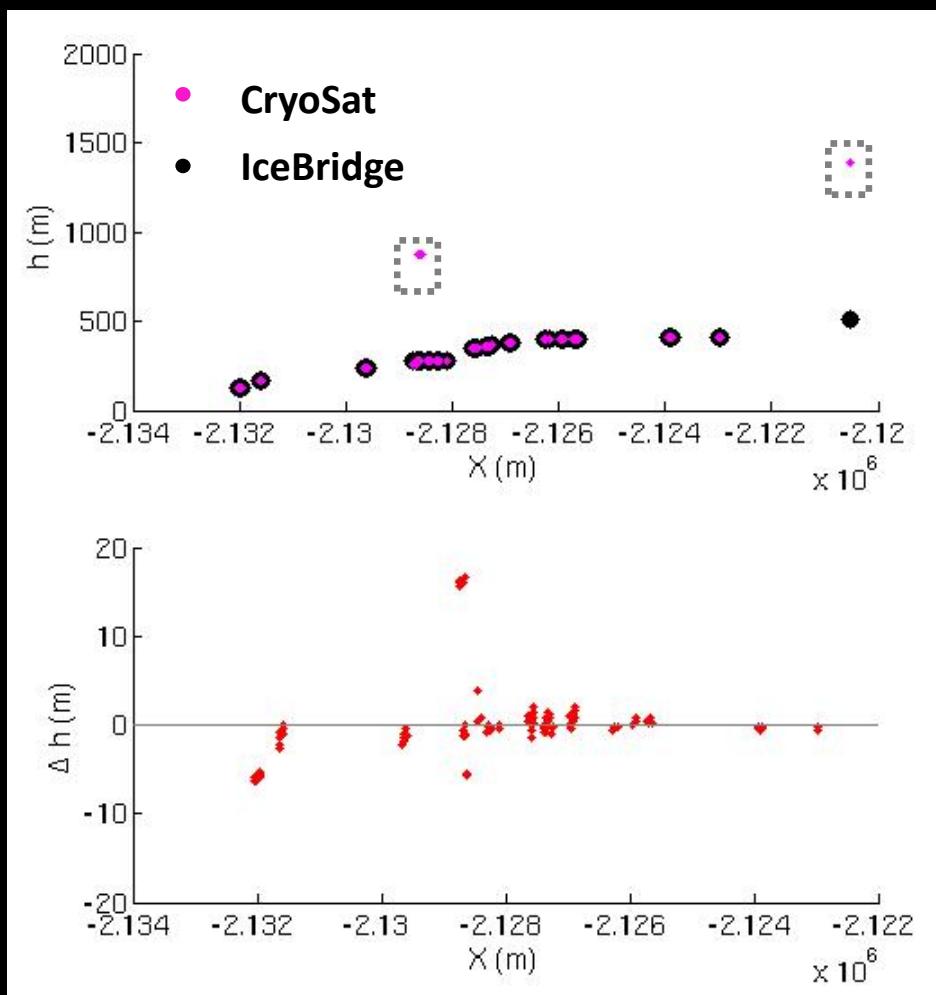
Data Integrity

dh/dt

Summary

Validation

CryoSat/IceBridge comparison



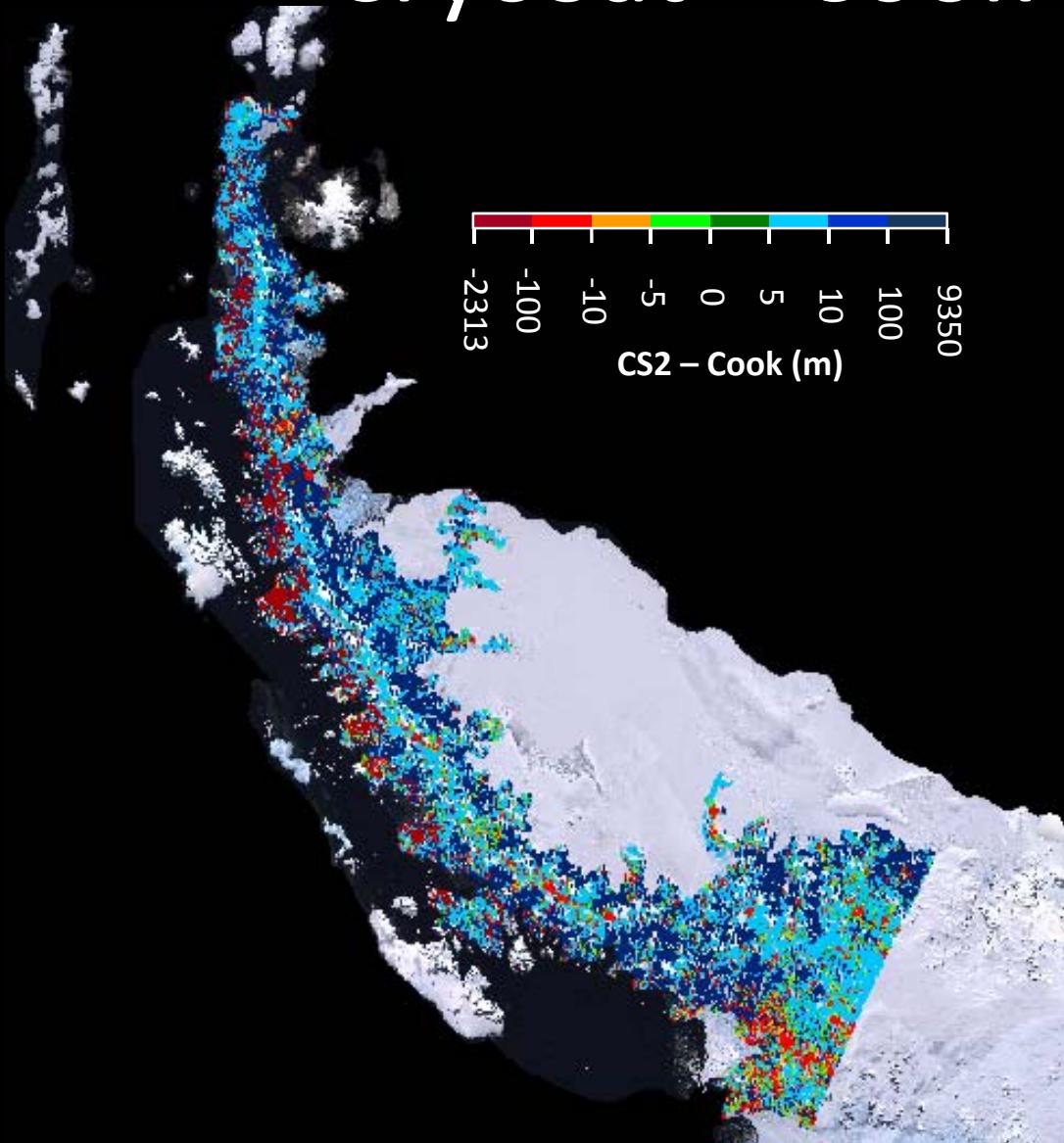
Background

Data Integrity

dh/dt

Summary

CryoSat – Cook DEM Filter



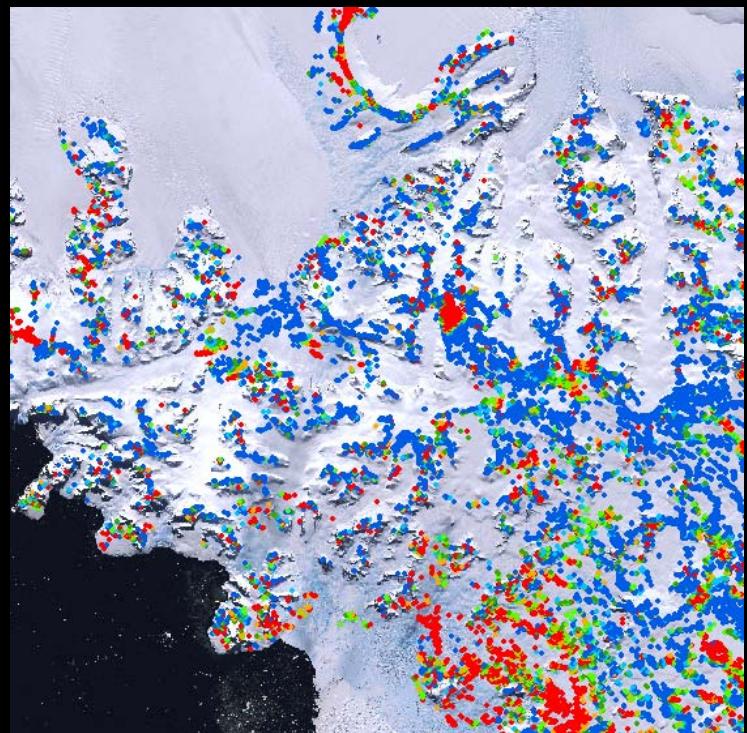
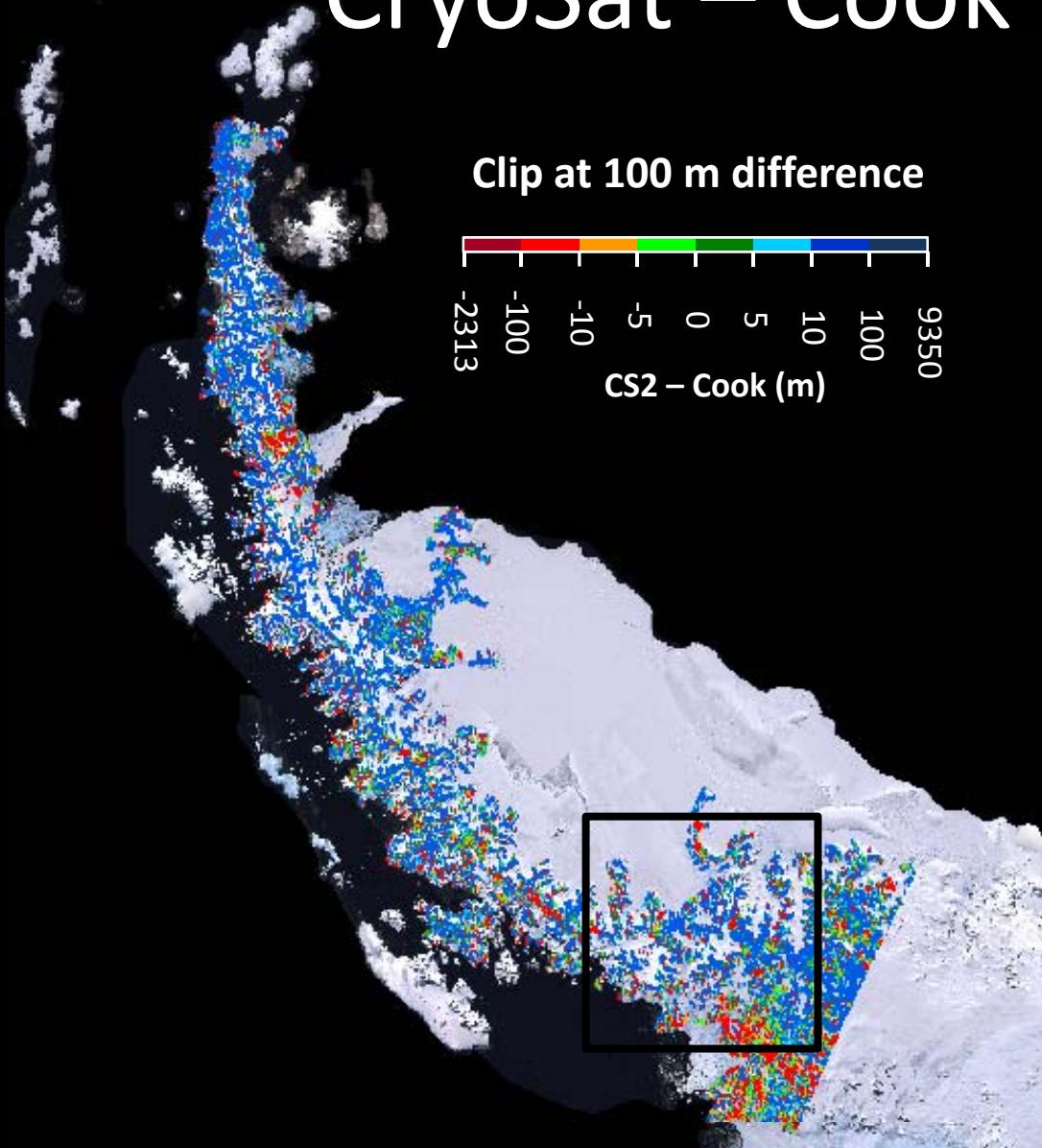
Background

Data Integrity

dh/dt

Summary

CryoSat – Cook DEM Filter



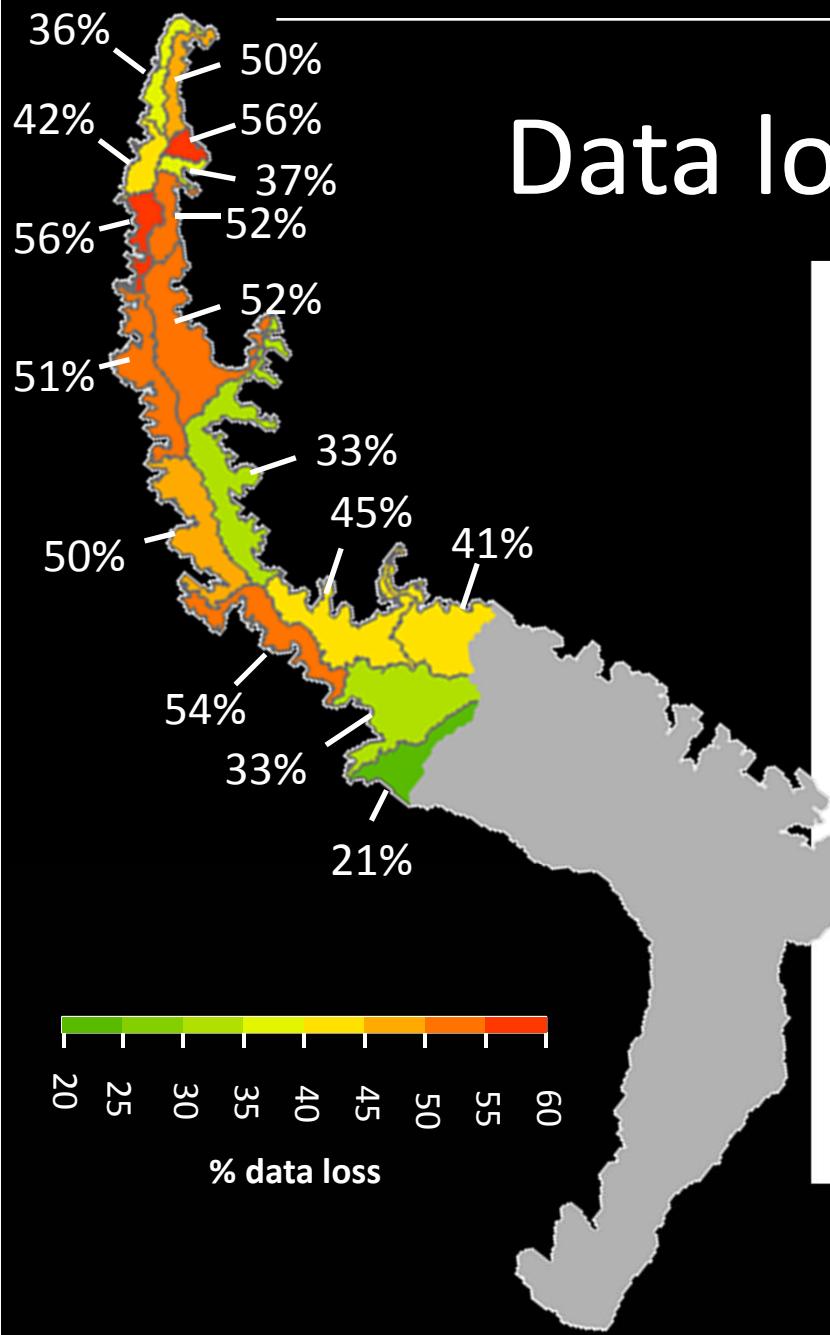
Eliminates 16% of the
data points

Background

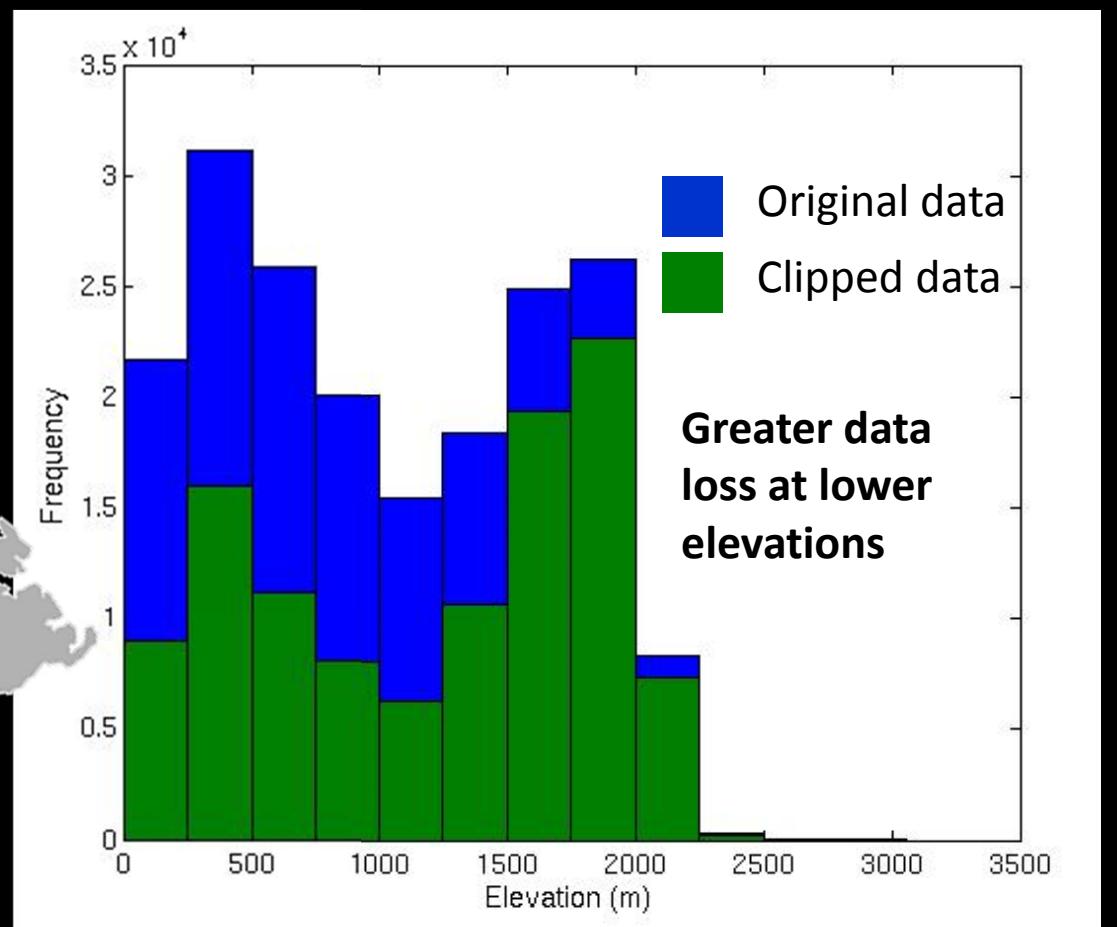
Data Integrity

dh/dt

Summary



Data loss distribution



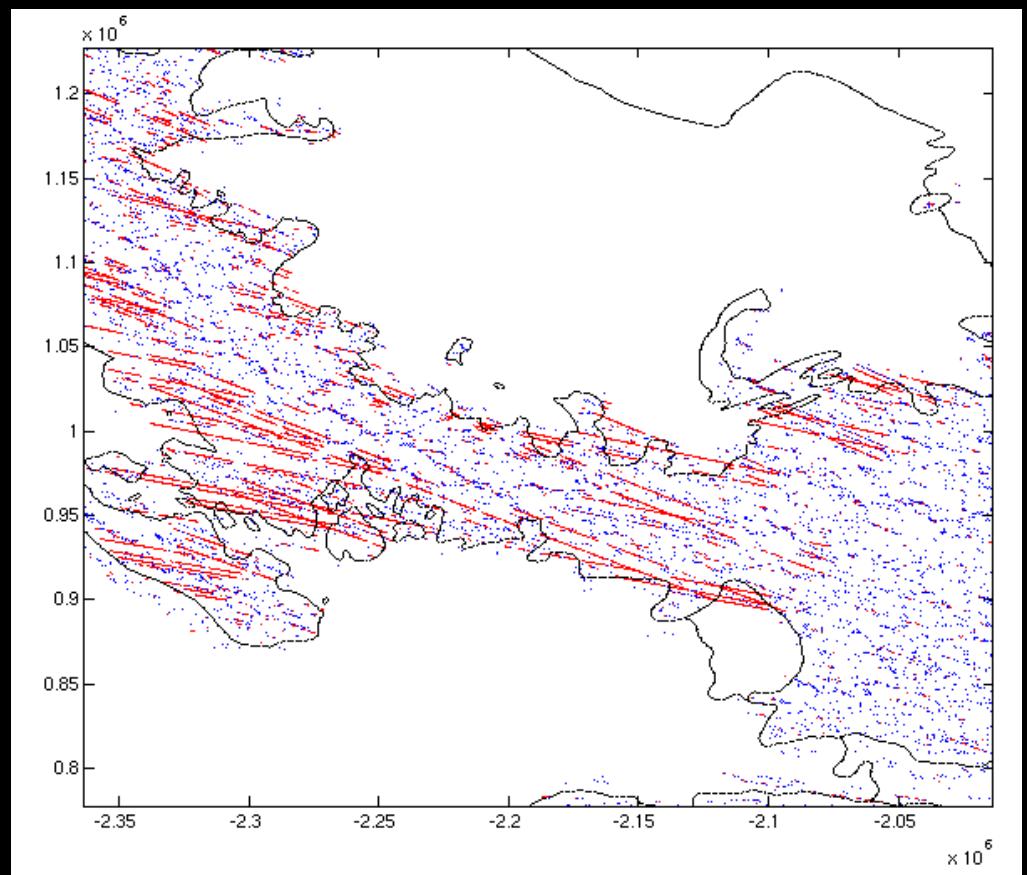
Next Steps

Next :

- additional filtering (e.g. by slope)
- validate (penetration?)

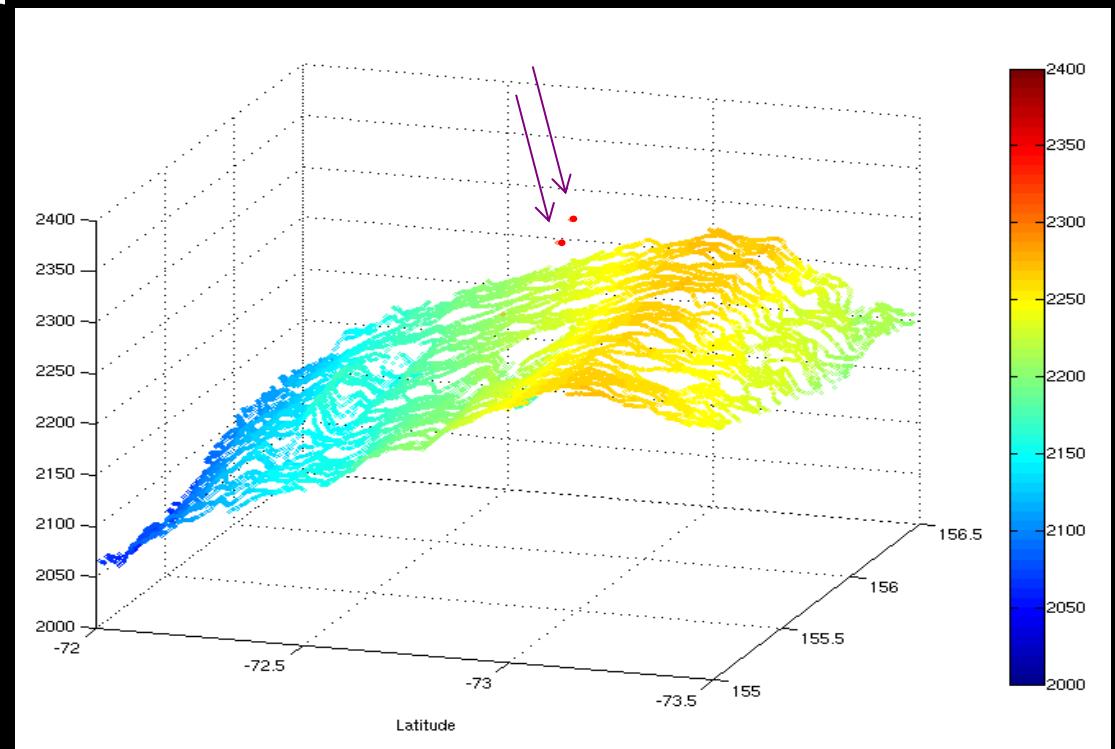
SARIn dh/dt processor

- Records where echo location reverts to nadir are identified and removed



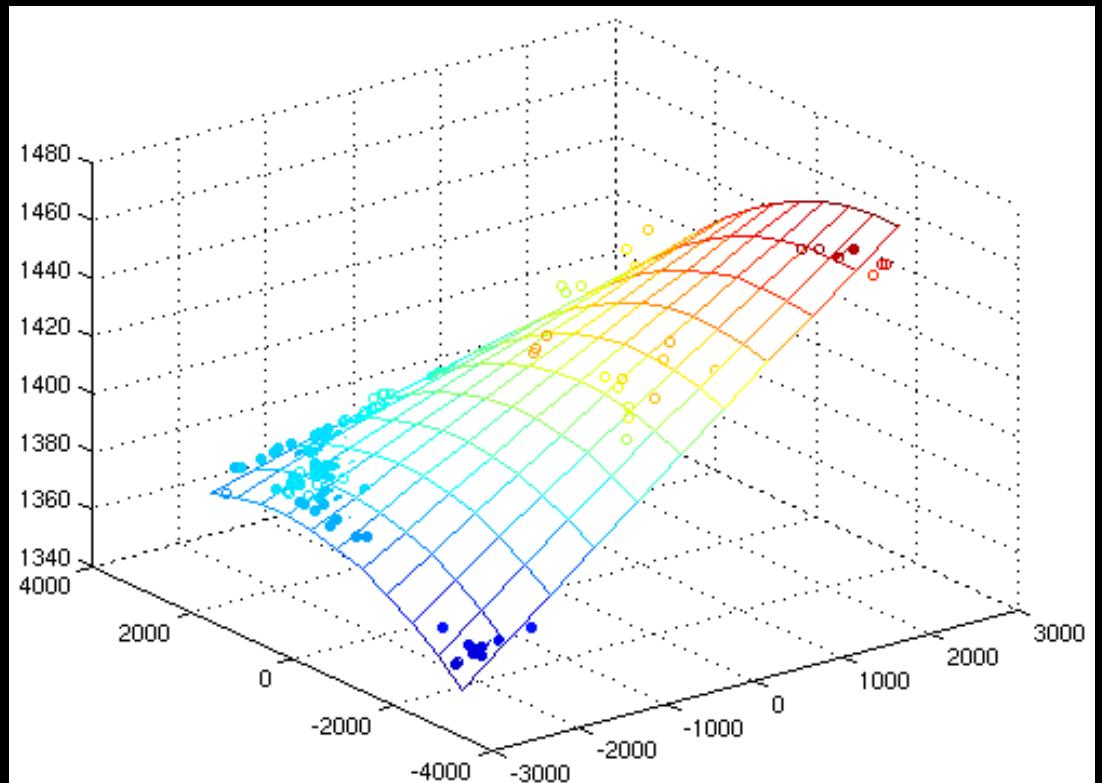
SARIn dh/dt processor

- Records where echo location reverts to nadir are identified and removed
- Gross elevation outliers identified and removed



SARIn dh/dt processor

- Records where echo location reverts to nadir are identified and removed
- Gross elevation outliers identified and removed
- Grid-based dh/dt solution. Solve simultaneously for a quadratic model of h and dh/dt.



Background

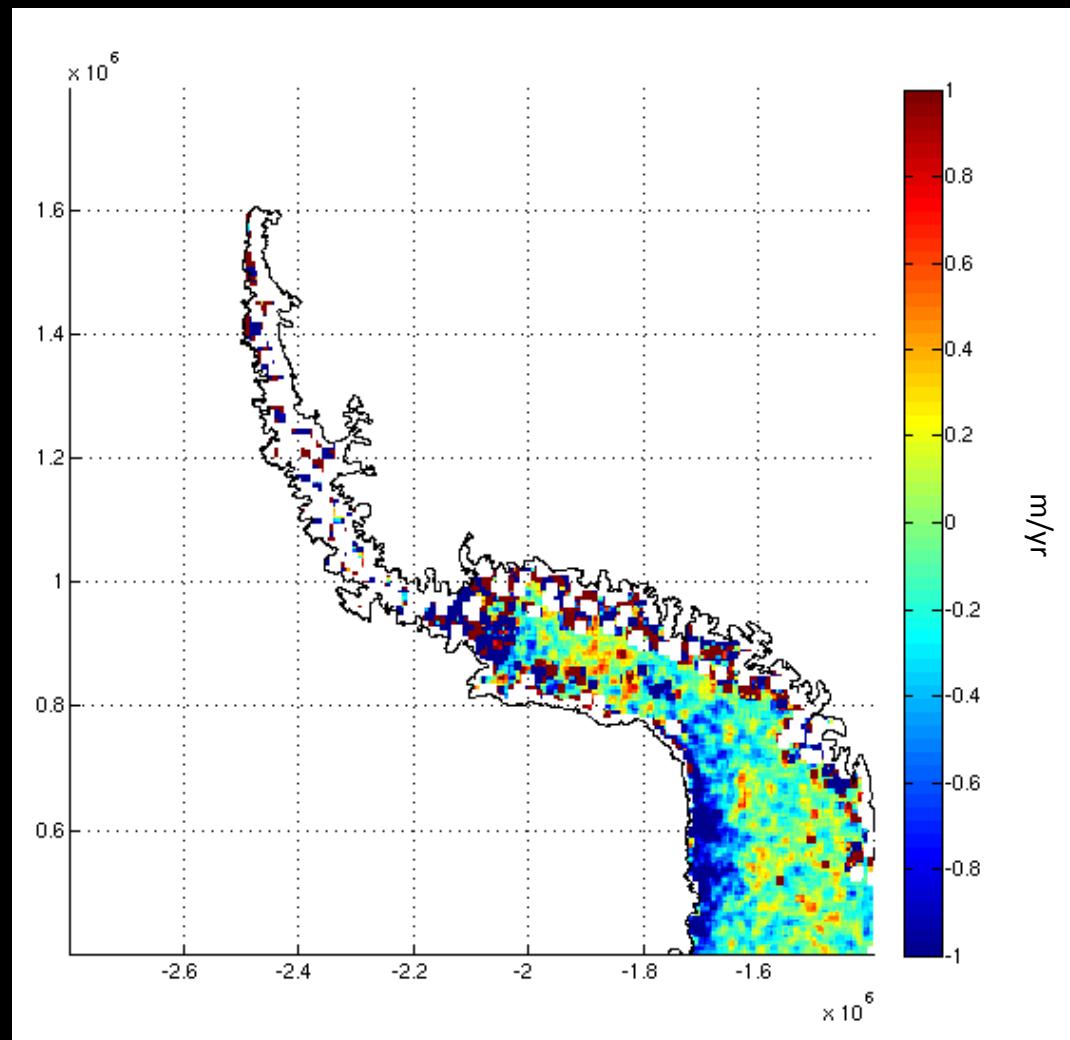
Data Integrity

dh/dt

Summary

Preliminary dh/dt coverage

CryoSat-2
5 km grid
2011 to 2013

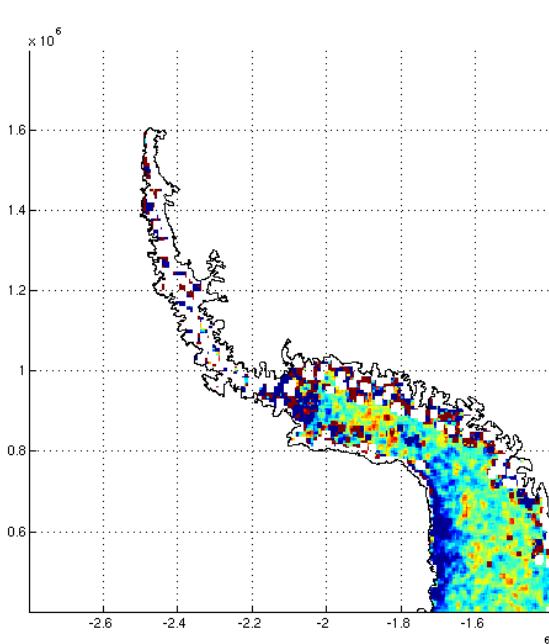
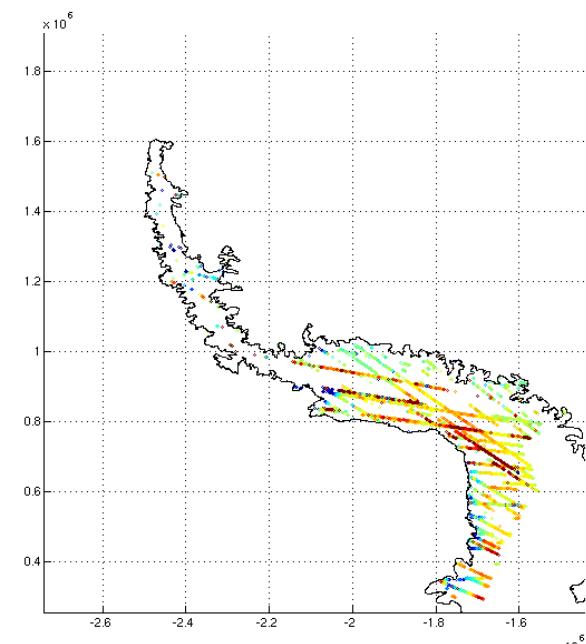
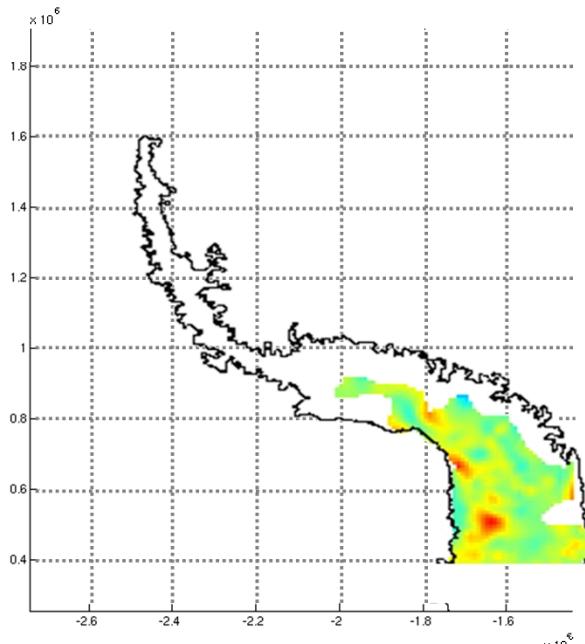


Preliminary dh/dt results

ERS/EnviSat
X-over
1992 to 2010

ICESat
Rpt track
2003 to 2008

CryoSat-2
Rpt track
2011 to 2013

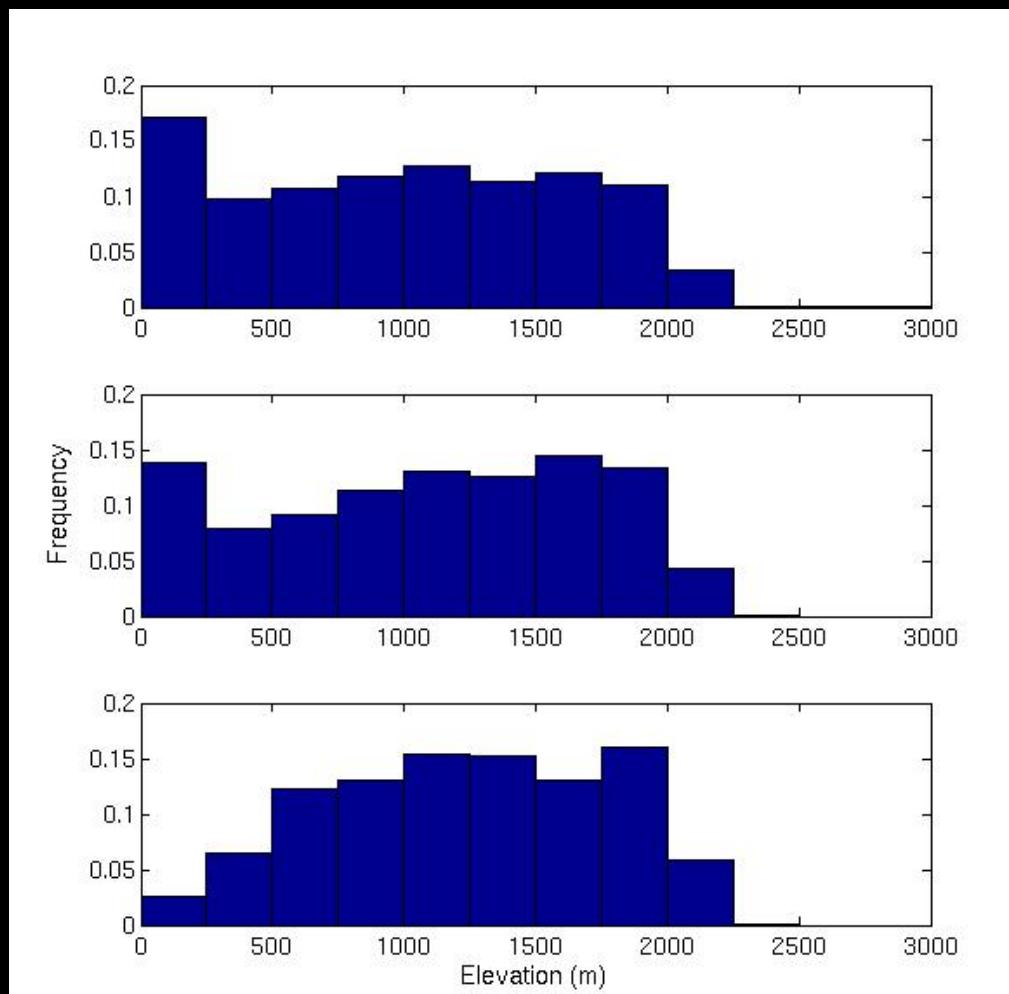


dh/dt (m/yr)

-1

+1

Elevation distribution of dh/dt measurements



Barrand DEM elevation

CryoSat-2 elevation distribution

ICESat elevation distribution

Summary

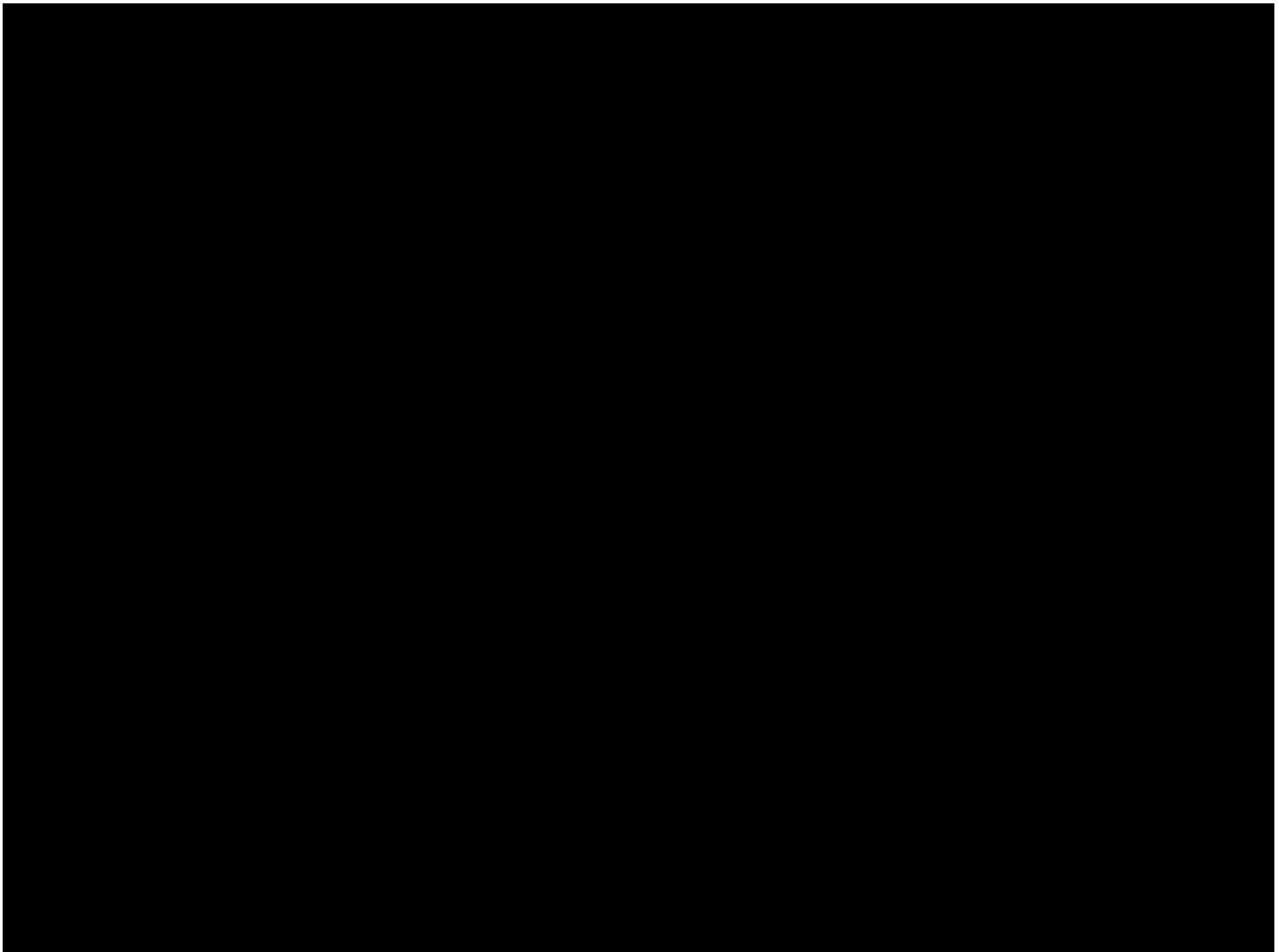
- Developing objective filtering method:
 - Nadir (-12%)
 - DEM (-16% - North)
- Data loss over narrow glaciers and low elevations
- CryoSat-2 data generally very accurate
 - 0.12 m median difference CS2 and ATM
- Preliminary repeat track CS2 results
- Compare well to other dh/dt results
- CS2 more representative sampling than ICESat at low elevations



Thanks and Acknowledgements

- **ESA** for their funding and CryoSat-2 data
- **Nick Barrand** for providing a detailed map of Antarctic Peninsula drainage basins.
- **Martin Horwath** for providing an image of APIS dm/dt from GRACE.
- **Cook, A. J., T. Murray, A. Luckman, D. G. Vaughan, and N. E. Barrand.** 2012. *Antarctic Peninsula 100 m Digital Elevation Model Derived from ASTER GDEM*. Boulder, Colorado USA: National Snow and Ice Data Center.
- **Krabill, W. B.** 2010. *IceBridge ATM L2 Icessn Elevation, Slope, and Roughness*. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.





Scambos *et al.*, (in prep): 2003-2008 <1000m -20.8 gt/yr
>1000m -2.7 gt/yr

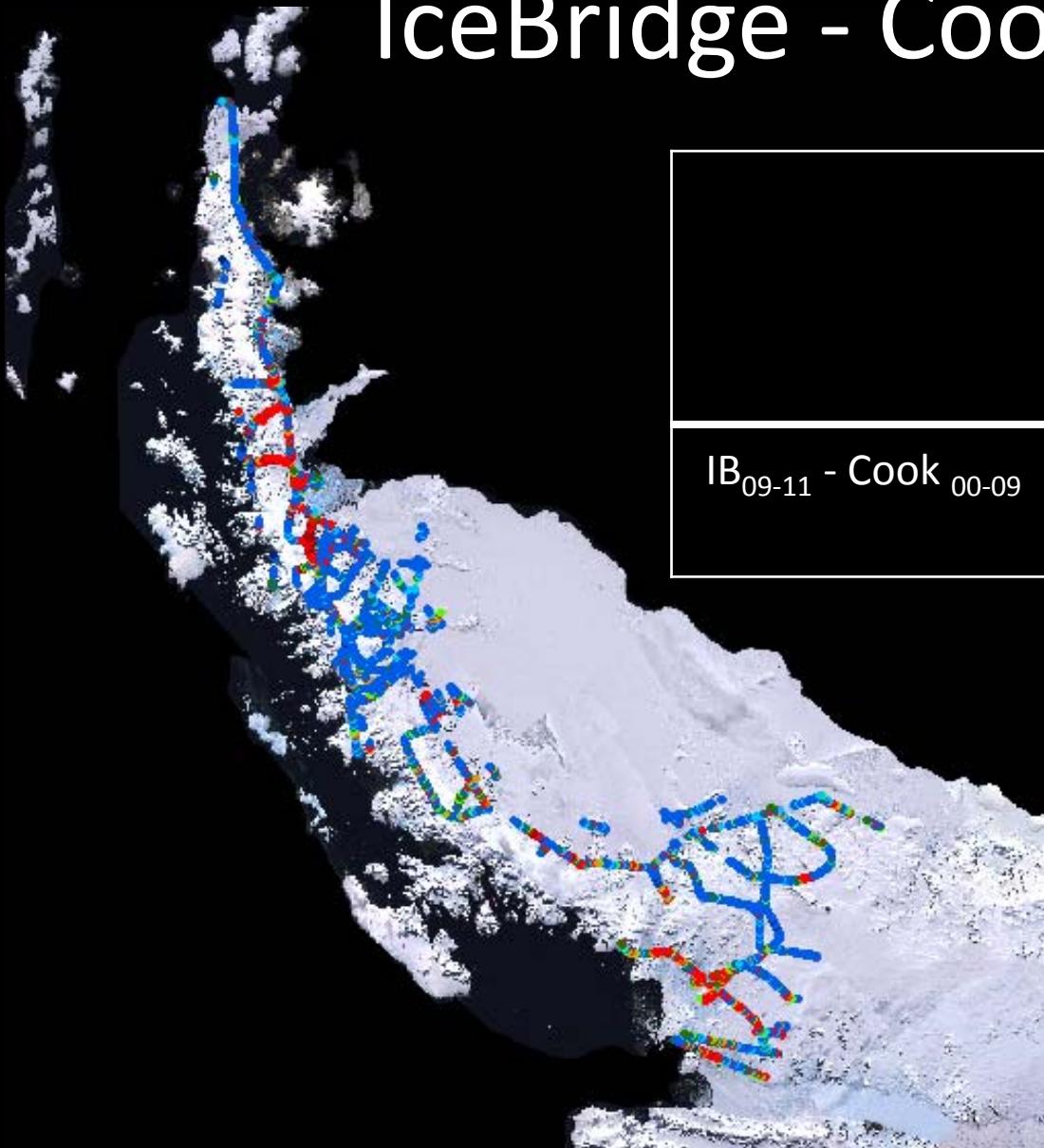
Background

Data Integrity

dh/dt

Summary

IceBridge - Cook DEM



	Median (m)	Std (m)	% data within 100 m
IB ₀₉₋₁₁ - Cook ₀₀₋₀₉	15	34	97

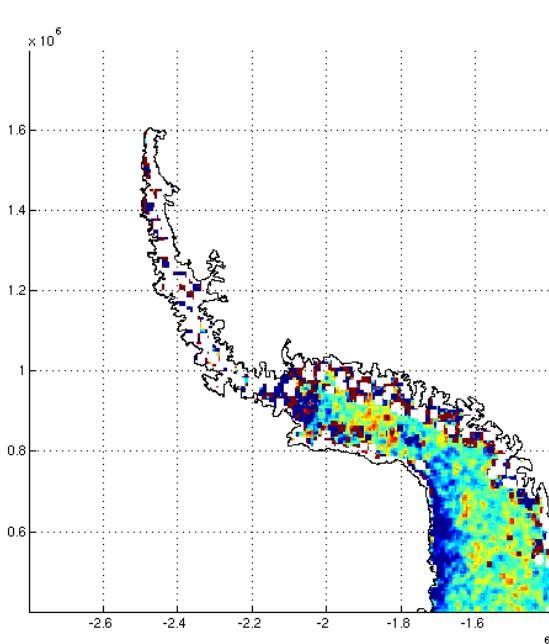
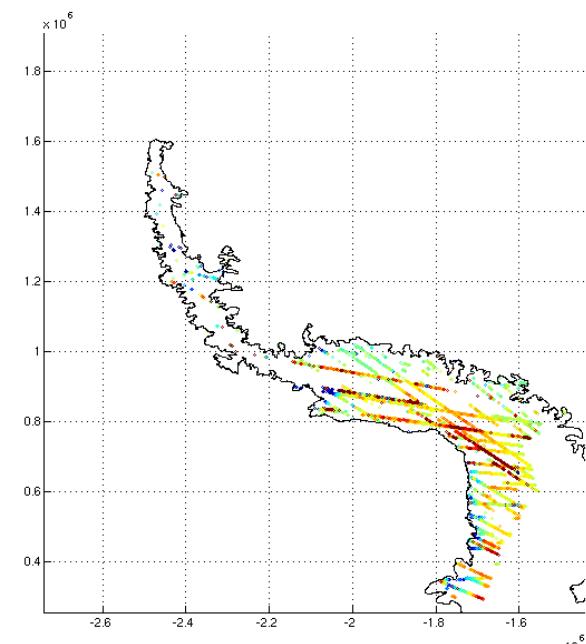
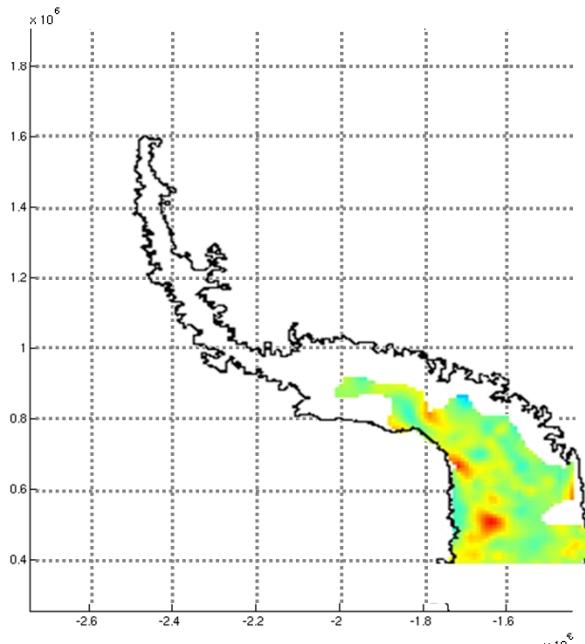


Preliminary dh/dt results

ERS/EnviSat
X-over
1992 to 2010

ICESat
Rpt track
2003 to 2008

CryoSat-2
Rpt track
2011 to 2013



dh/dt (m/yr)

-1

+1