Rapid dynamic activation of a marine-based Arctic ice cap

N. Gourmelen[1], M. McMillan[2], A. Shepherd[2,3], A. Dehecq[4], A. Leeson[2], A. Ridout[3], T. Flament[2], A. Hogg[2], L. Gilbert[3], T. Benham[5], M. van den Broeke[6], J. Dowdeswell[5], X. Fettweis[7], B. Noel[6], T. Strozzi[8], T. Nagler[9]

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4 LISTIC, Université de Savoie, Chambéry, France
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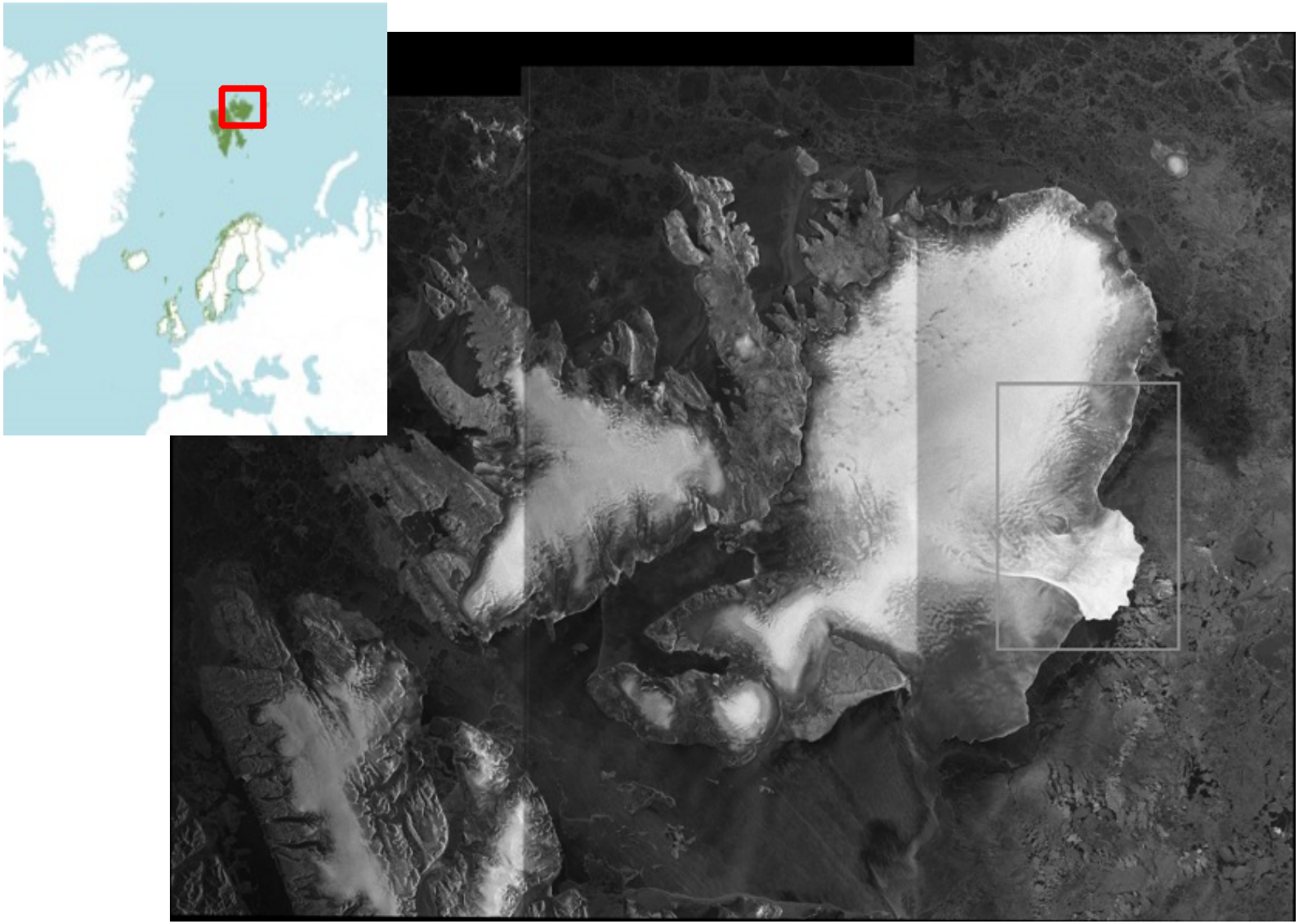
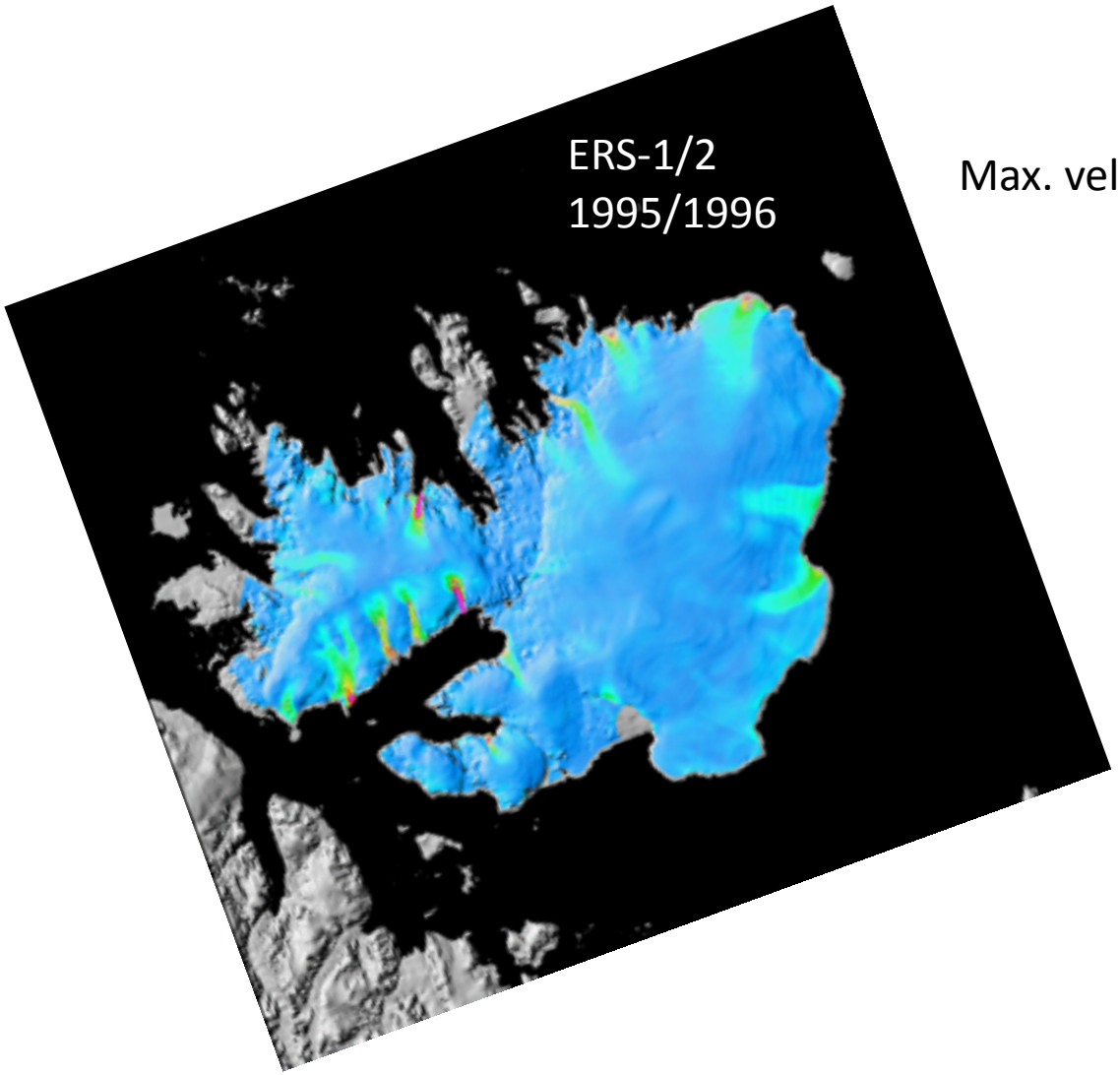
6 Institute for Marine and Atmospheric Research, Utrecht University, Utrecht, Netherlands
7 Department of Geography, University of Liège, Liège, Belgium
8 GAMMA Remote Sensing Research and Consulting AG, Gümligen, Switzerland
9 ENVEO, Insbruck, AT

Austfonna

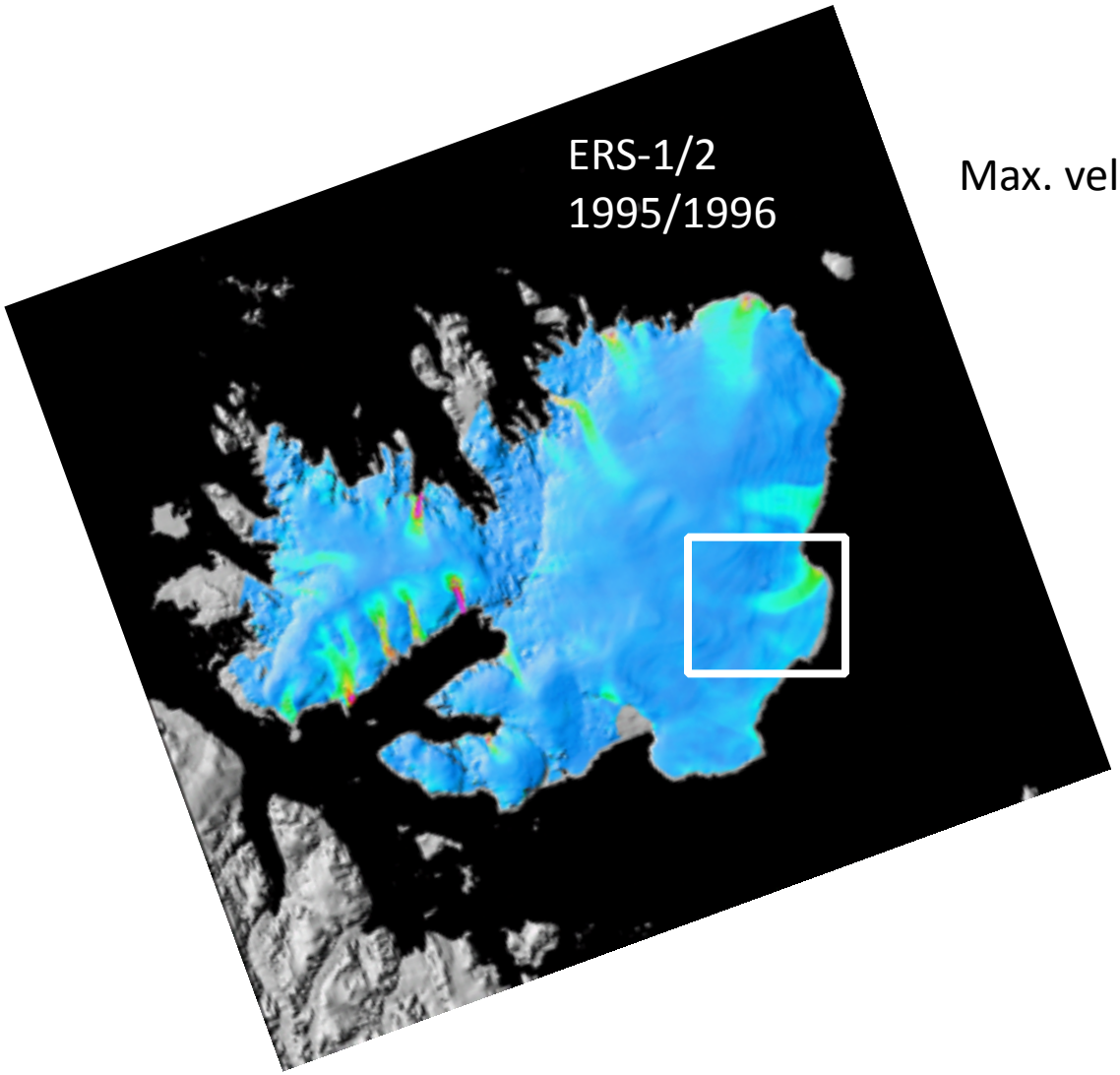


Ice velocity, Austfonna



Max. velocities: 300 m/yr

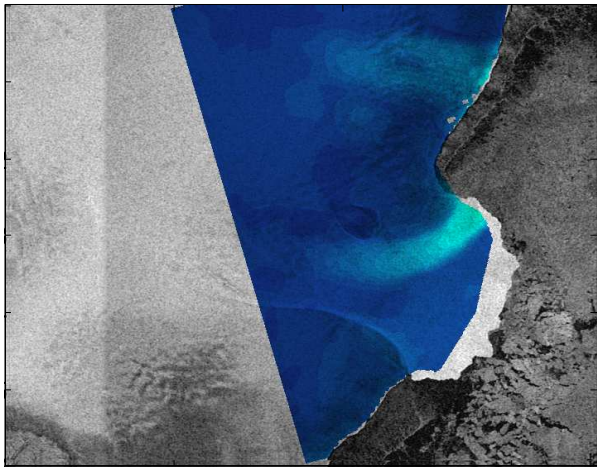
Ice velocity, Austfonna



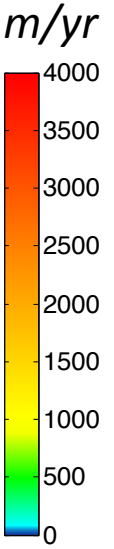
Max. velocities: 300 m/yr

Ice velocity, Basin-3

1995



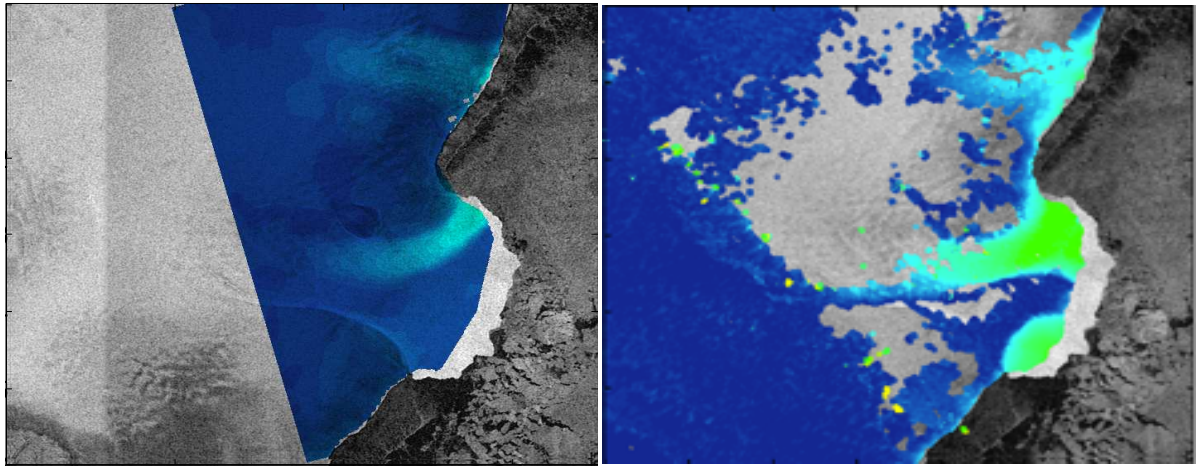
ERS1/2



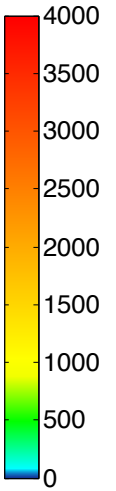
McMillan, Shepherd, Gourmelen et al., 2014

Ice velocity, Basin-3

1995 **2008**



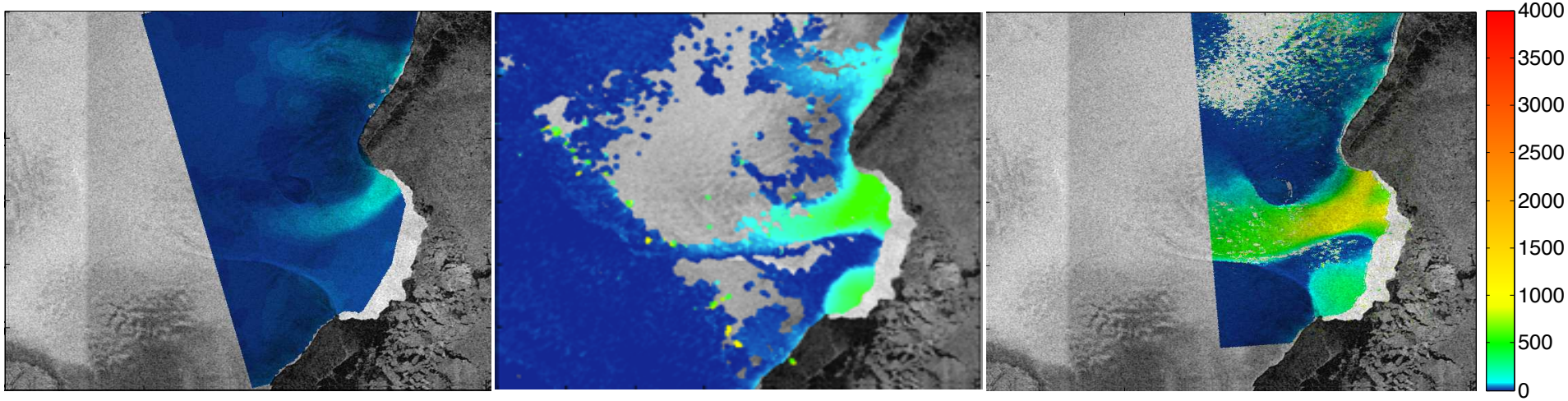
ERS1/2 ALOS



McMillan, Shepherd, Gourmelen et al., 2014

Ice velocity, Basin-3

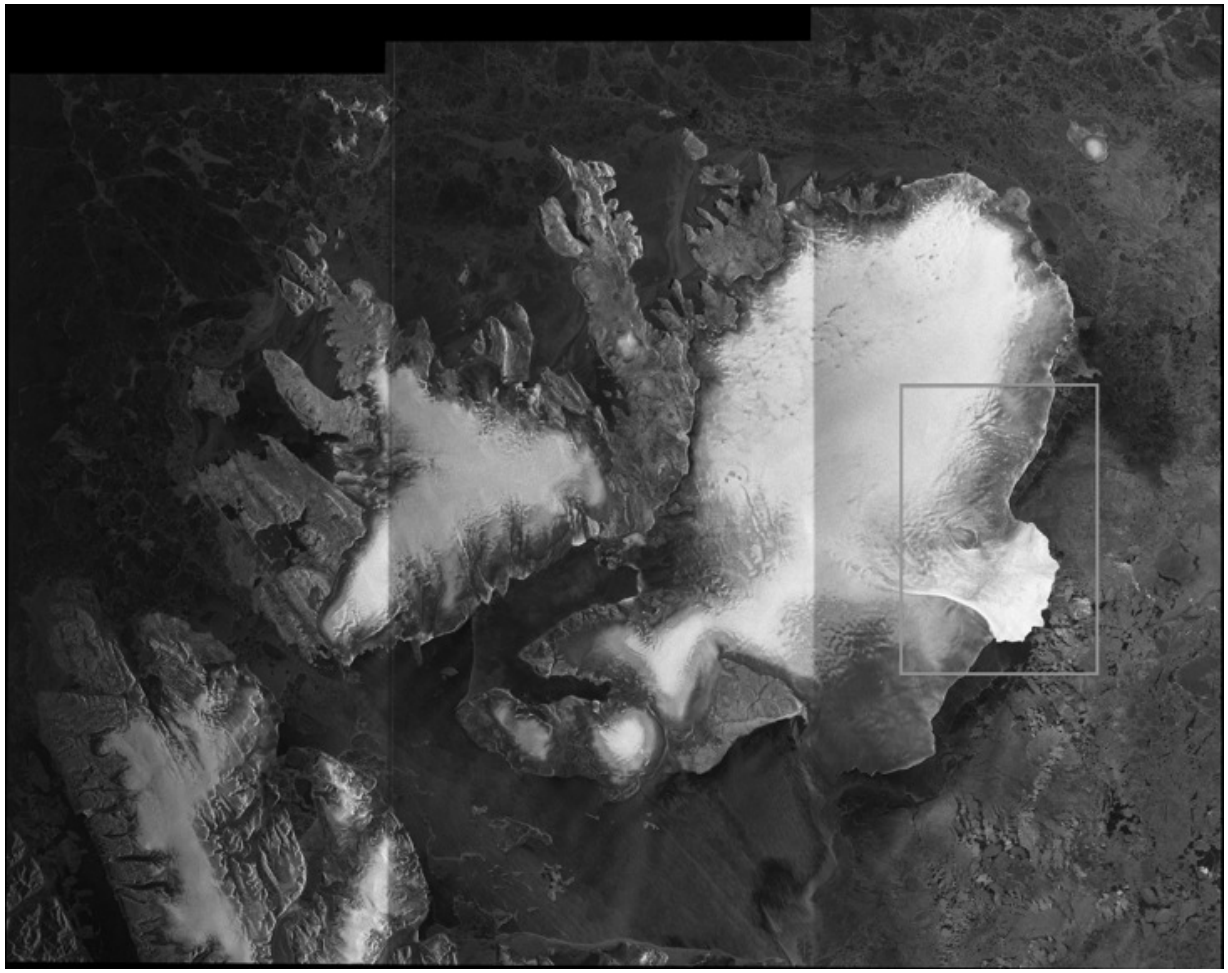
1995 **2008** **2012** *m/yr*



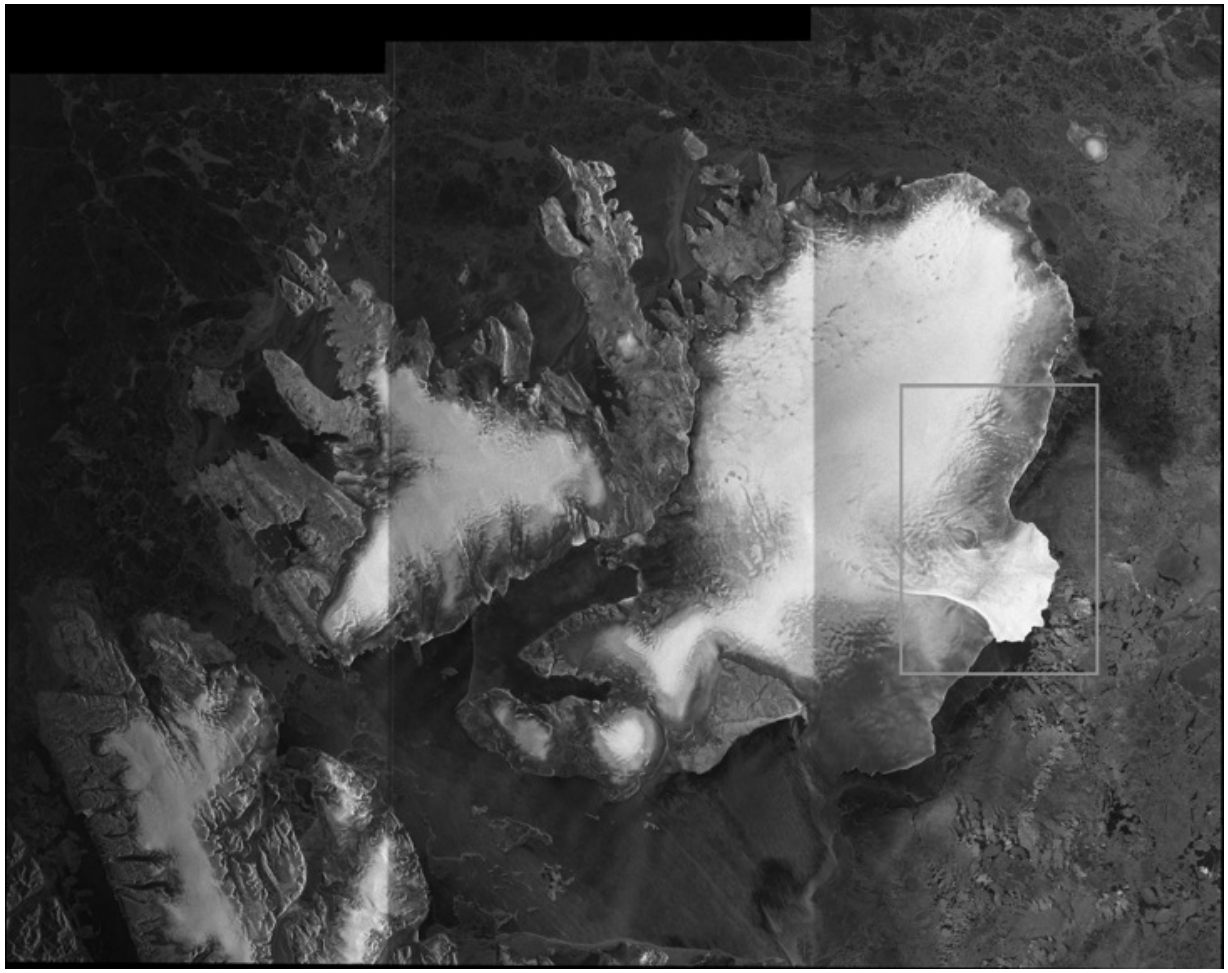
ERS1/2 ALOS TSX

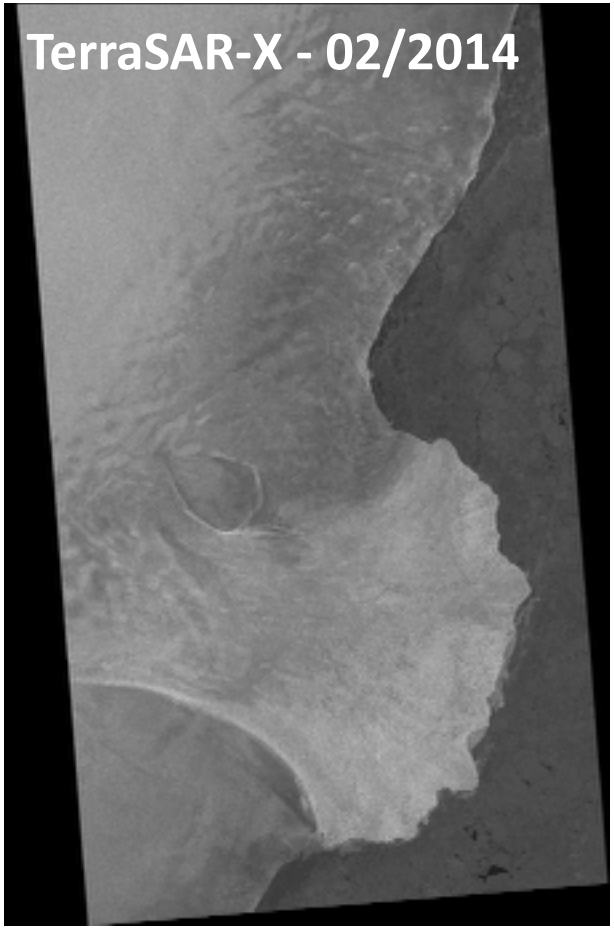
McMillan, Shepherd, Gourmelen et al., 2014

Sentinel-1a over Svalbard, 22/04/2014

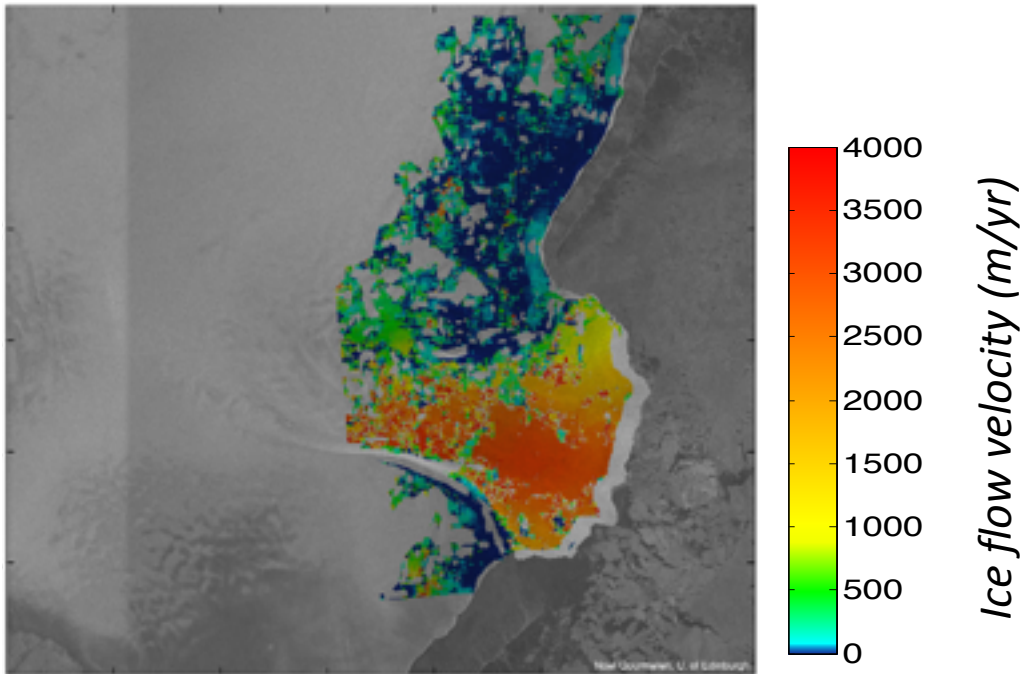


Sentinel-1a over Svalbard, 22/04/2014



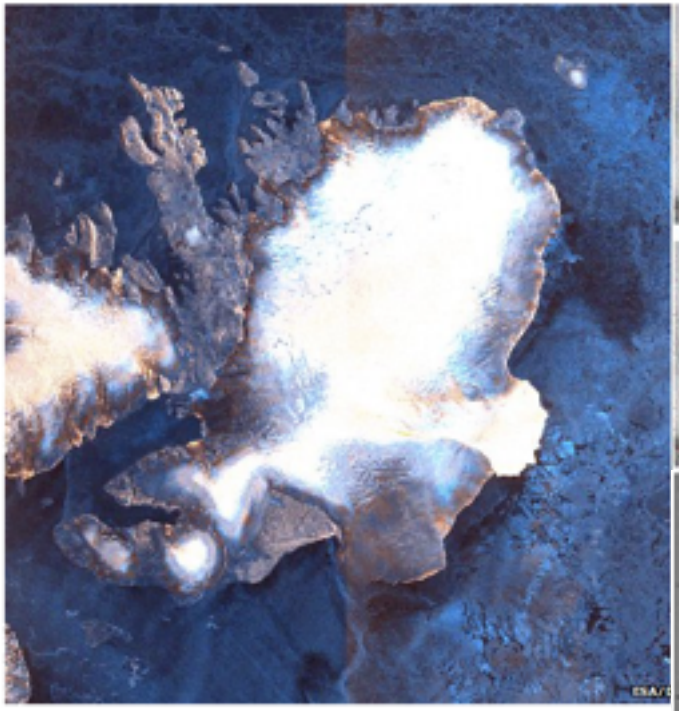


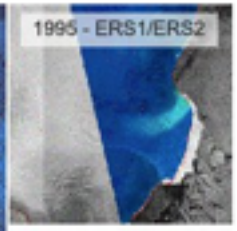
Sentinel-1a, 2014

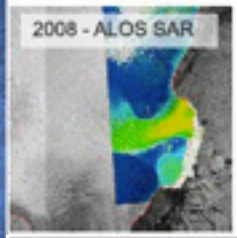


Sentinel satellite spies ice cap speed-up

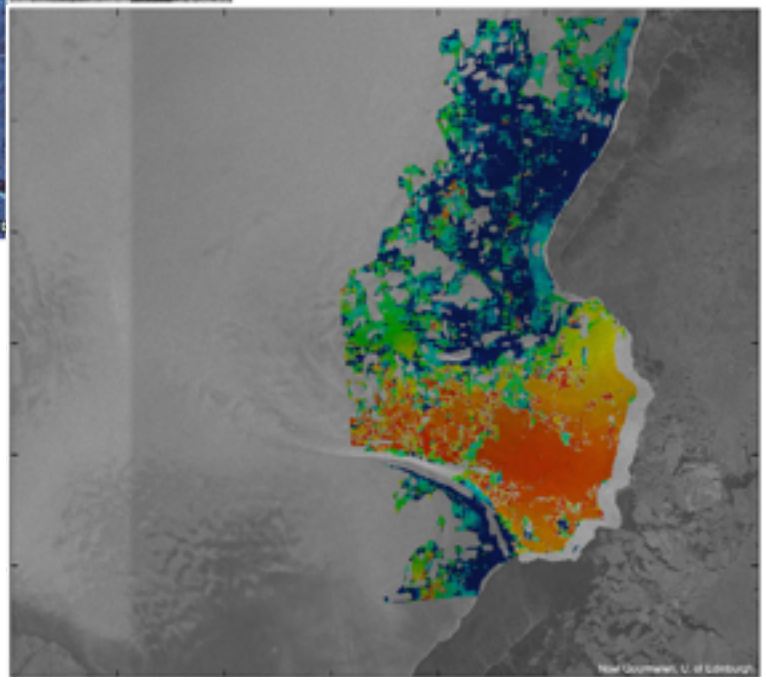
By Jonathan Amos
Science correspondent, BBC News

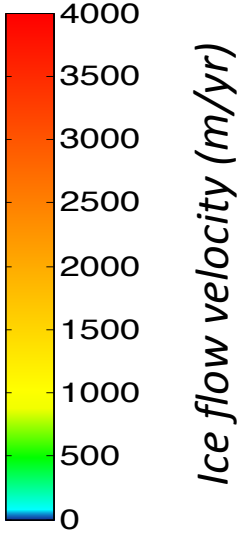






Sentinel-1a, 2014





Sentinel-1a, IW mode availability

Display 1 to 5 of 5 products

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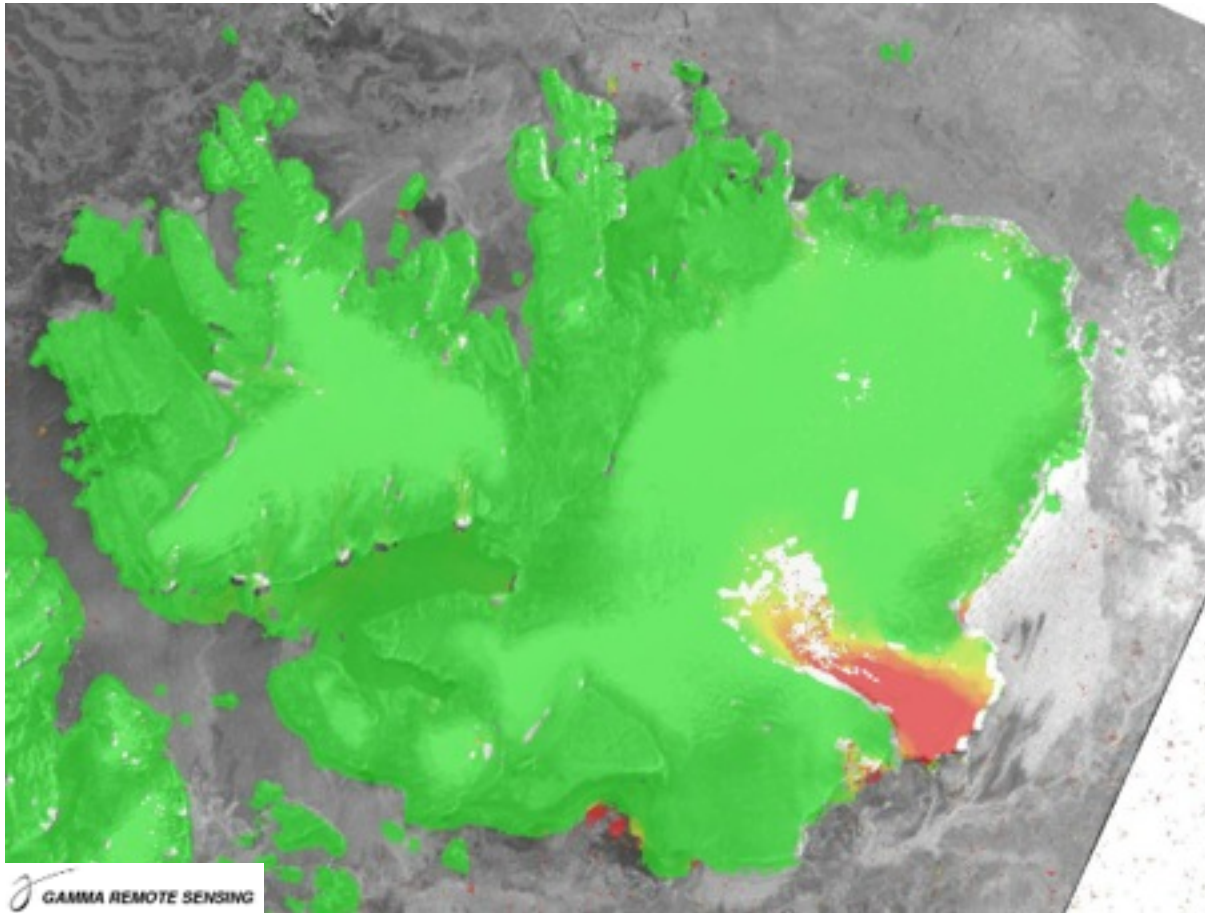
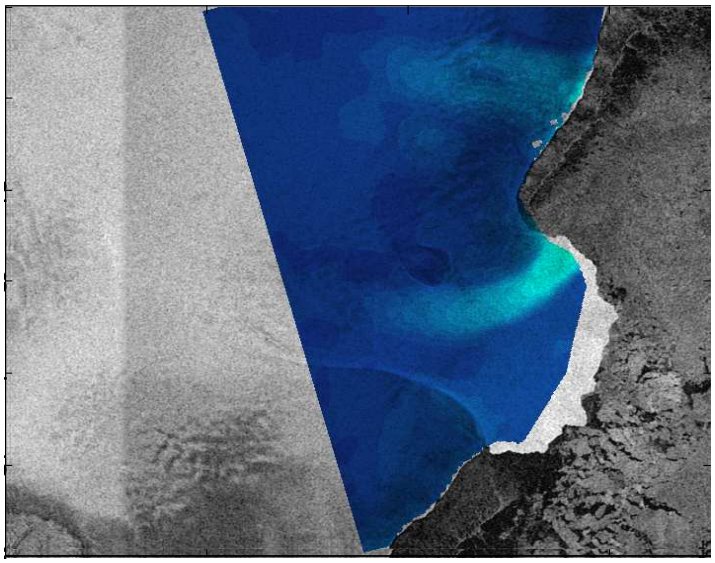
Sentinel-1a, 2015 Basin-3 velocity



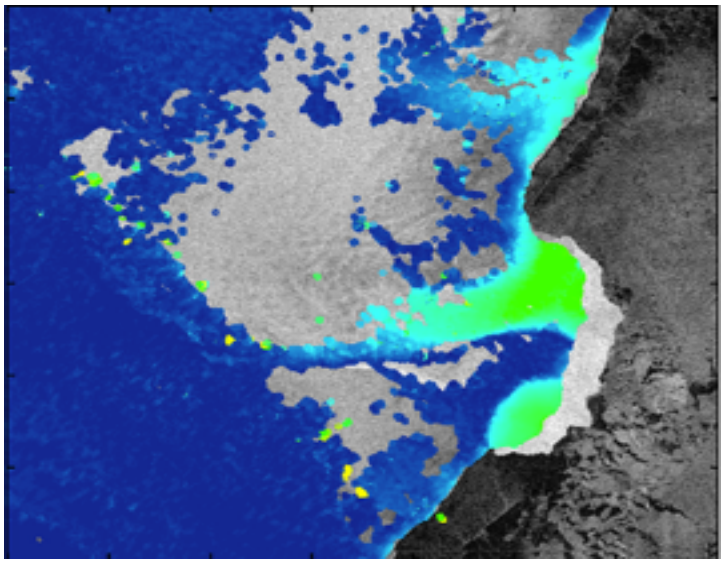
200 km

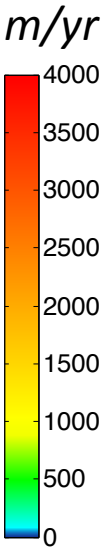
0 m/yr 2500

1995
ERS1/2

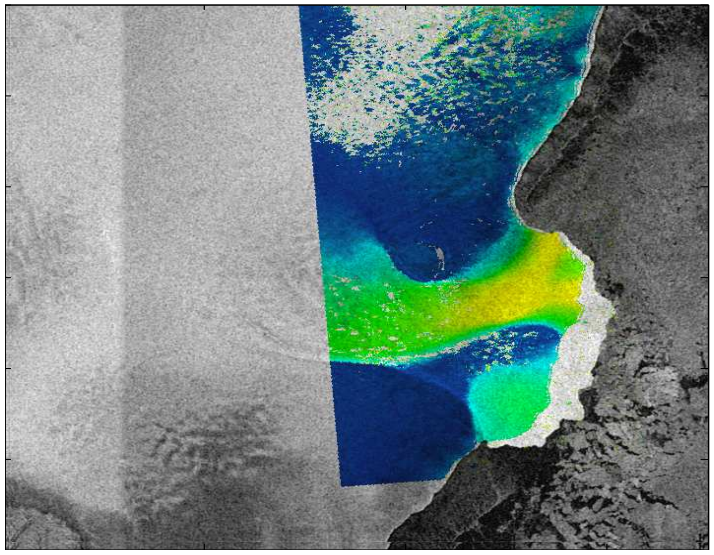


2008
ALOS

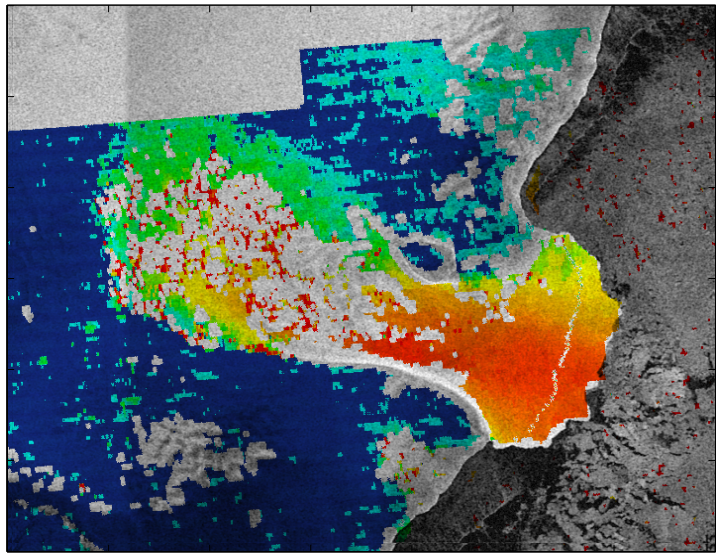




2012
TSX



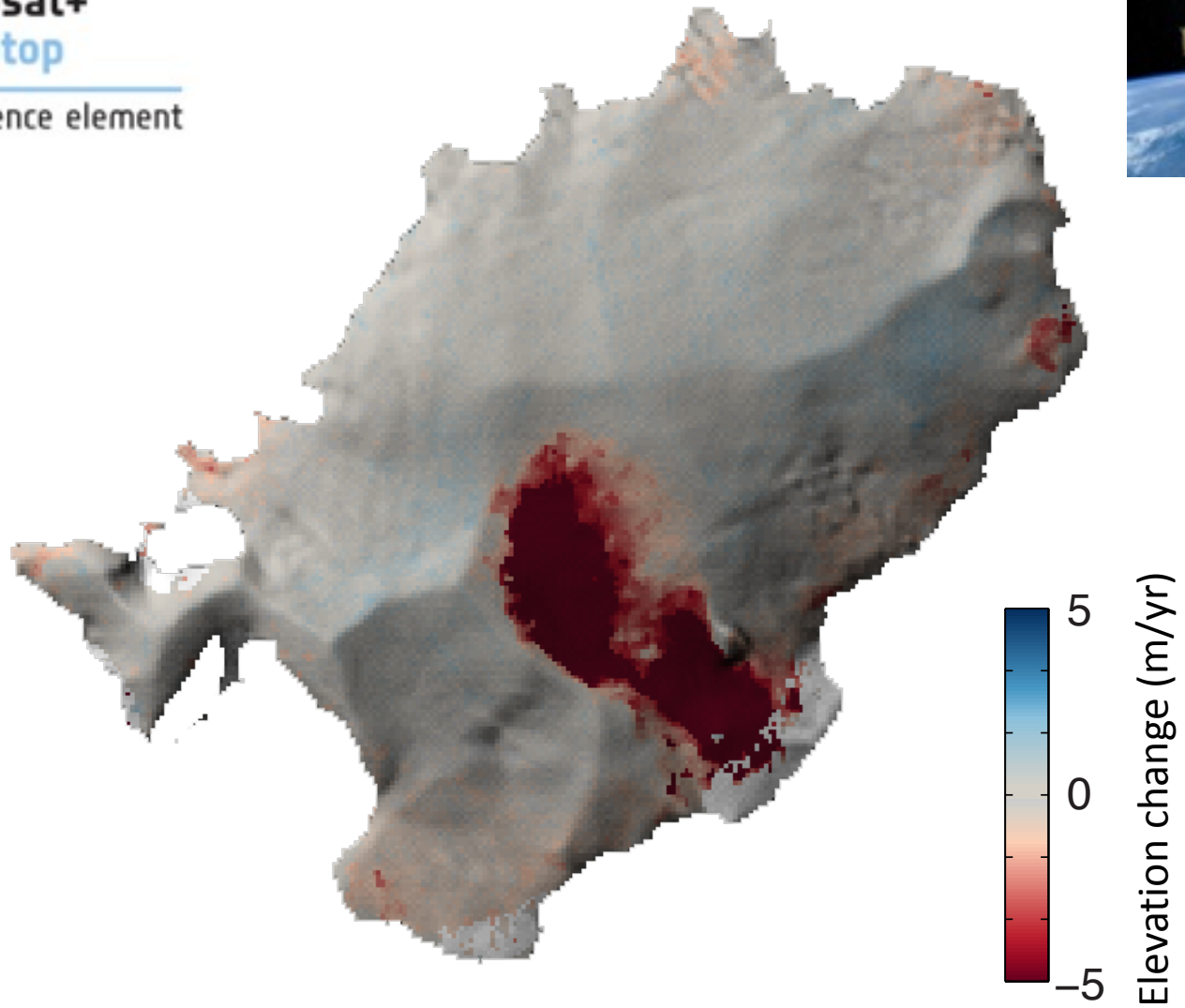
2015
S1a



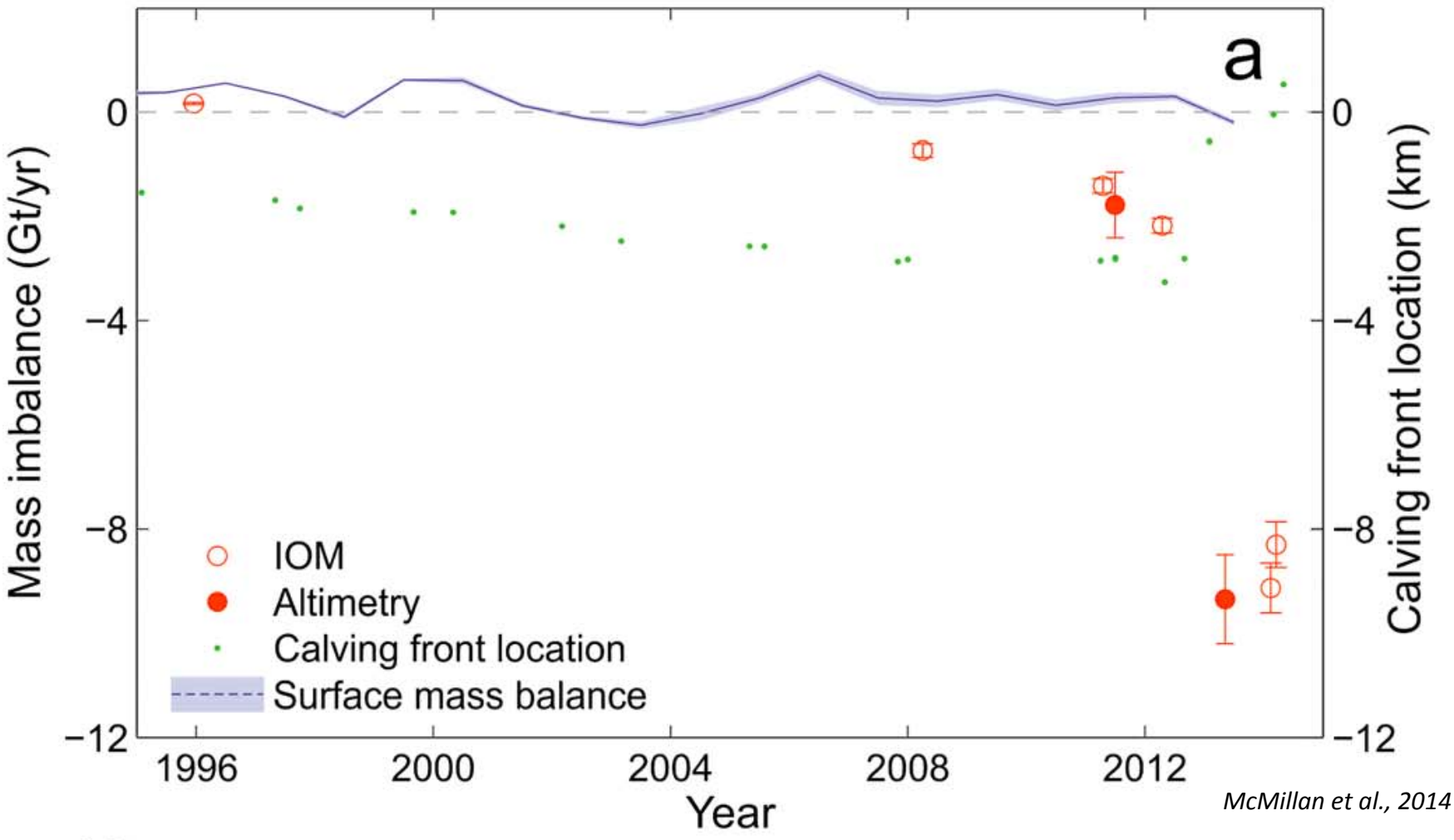
McMillan, Shepherd, Gourmelen et al., 2014

Austfonna, Elevation change, 2010-2015

cryosat+
cryotop
support to science element

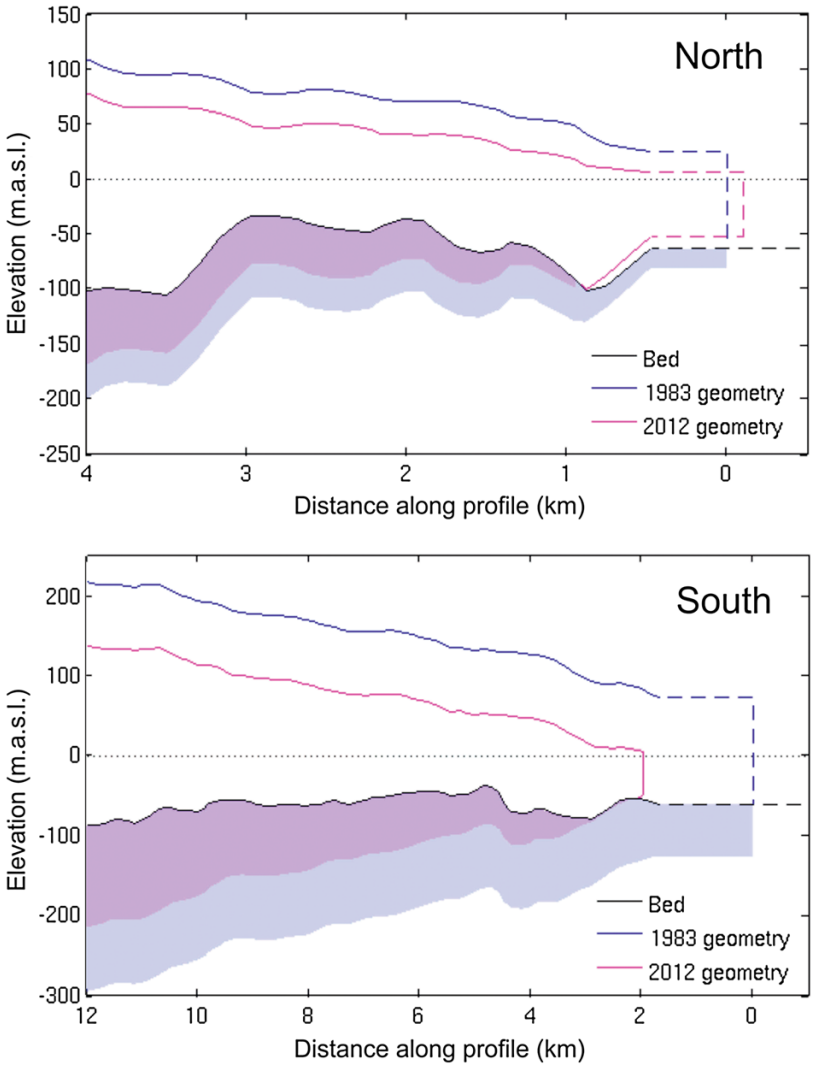


Austfonna, Mass Imbalance



McMillan et al., 2014

Loss of floatation



McMillan et al., 2014

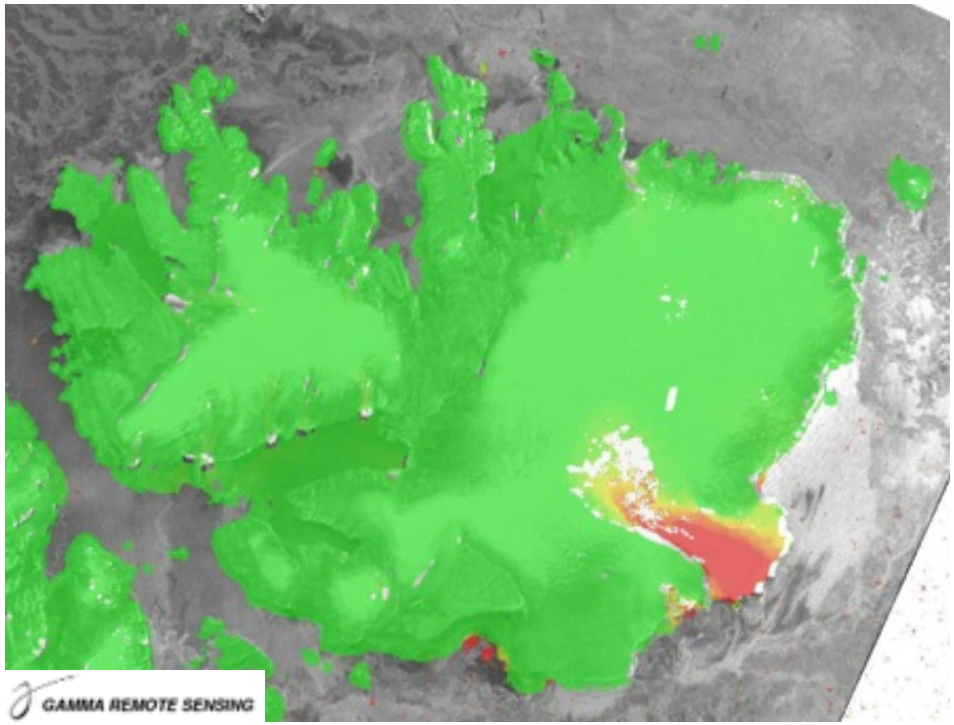
Conclusions

- Sentinel-1a reveals Basin-3 ice discharge increased 45-folds over the last 2 decades
- CryoSat SARIn reveals rapid thinning (up to 40m/yr)
- Activation initiated at the ocean front, possibly from ocean warming, and propagated inland to the entire basin
- Destabilisation still ongoing
- Sentinel acquisition plan will allow continuous monitoring of ice loss

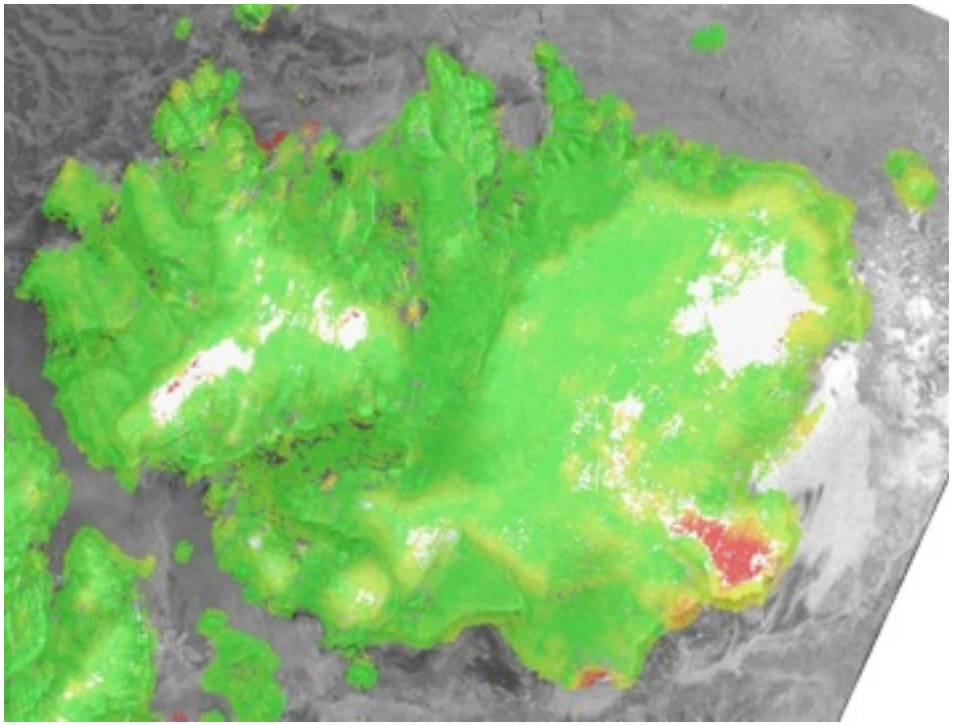
Sentinel, results so far

Sentinel-1 offset tracking: Svalbard

Sentinel-1 IW SLC
19/31.01.2015 – 20.01/02.01.2015
10 m ground-resolution



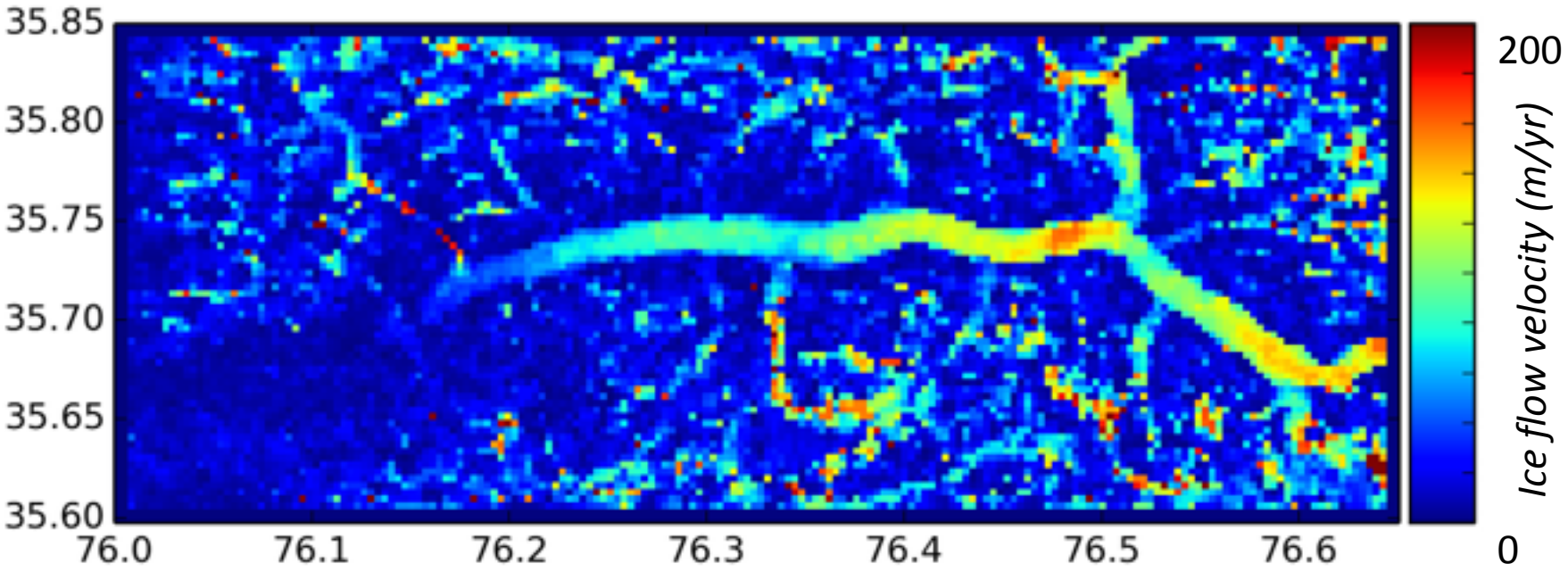
Sentinel-1 EW GRDM
19/31.03.2015
40 m ground-resolution



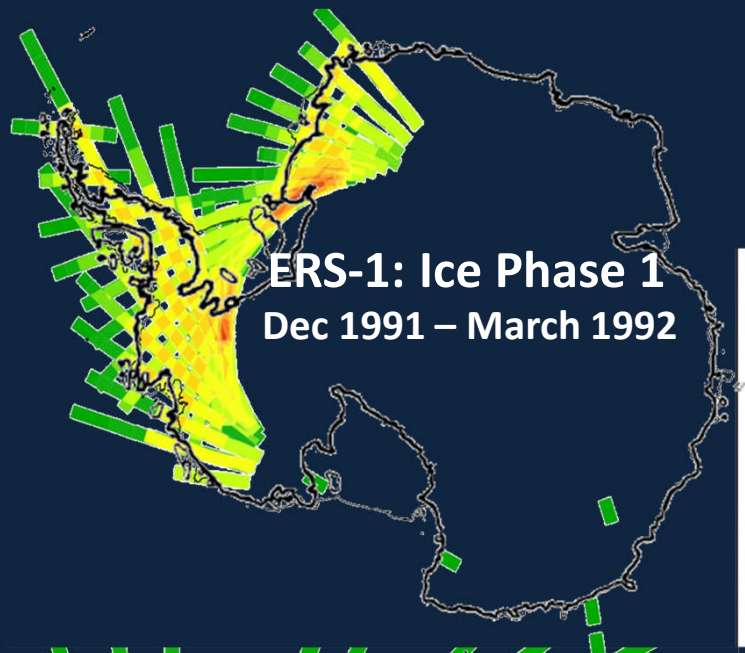
200 km

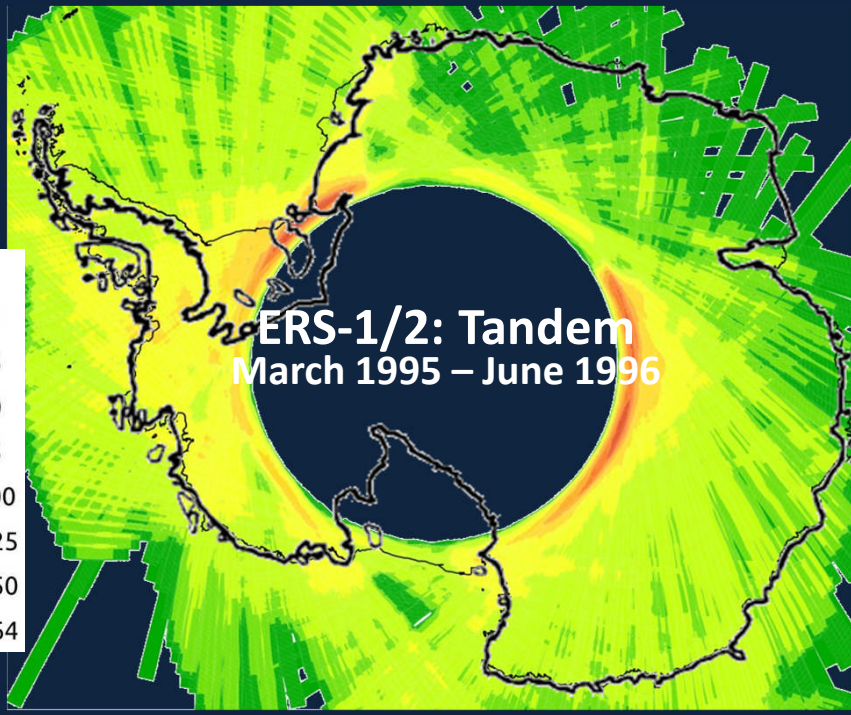
Sentinel, results so far - Mountain glaciers

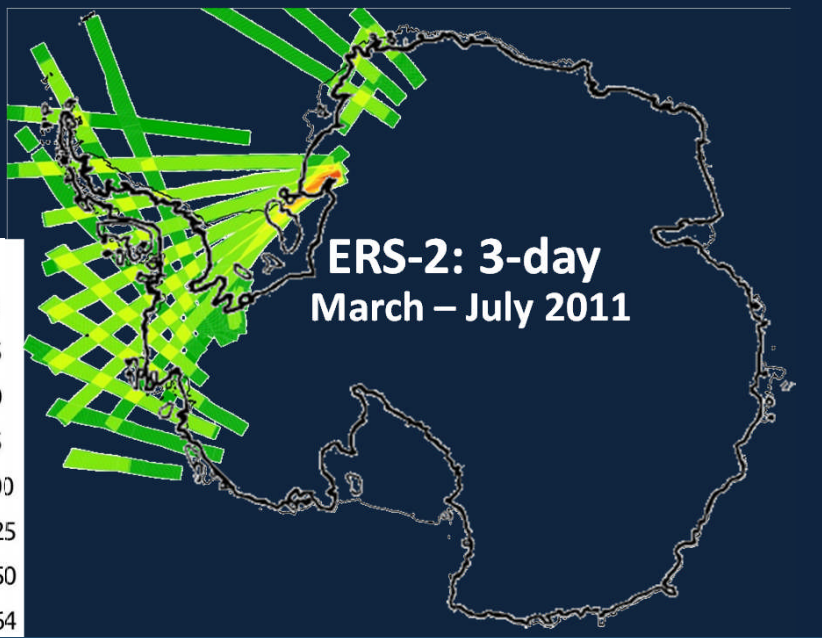
Baltoro Glacier, Karakoram mountain range



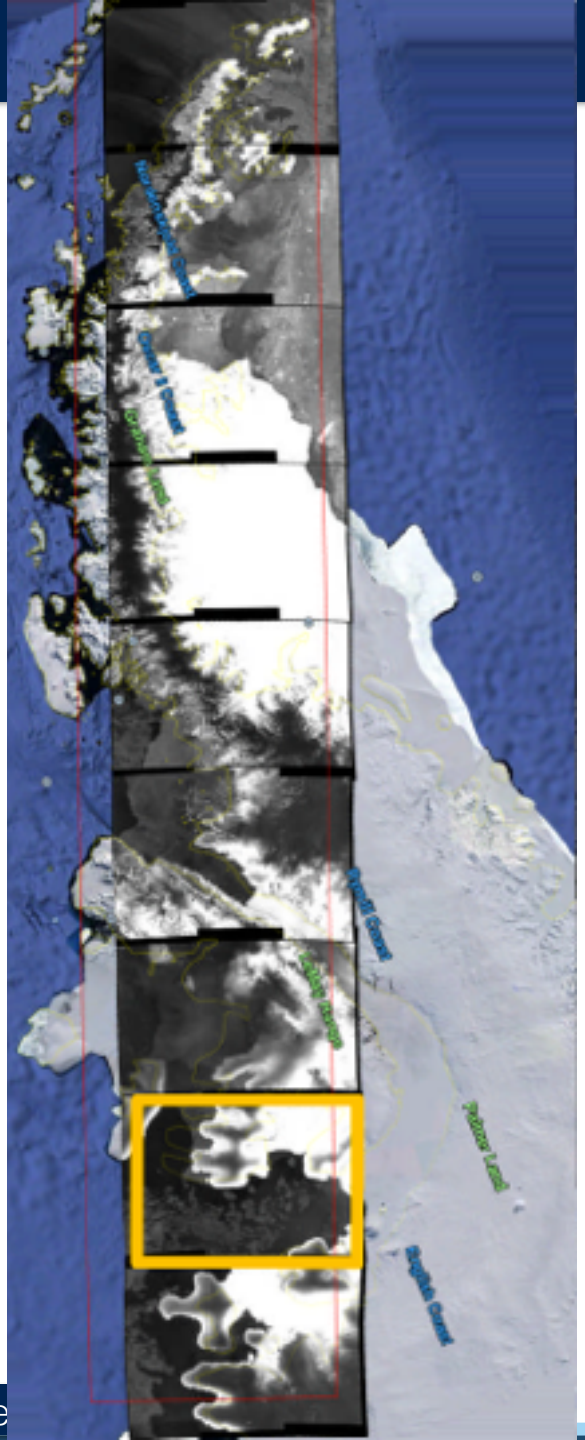
Historical SAR Ice Sheet SAR Coverage



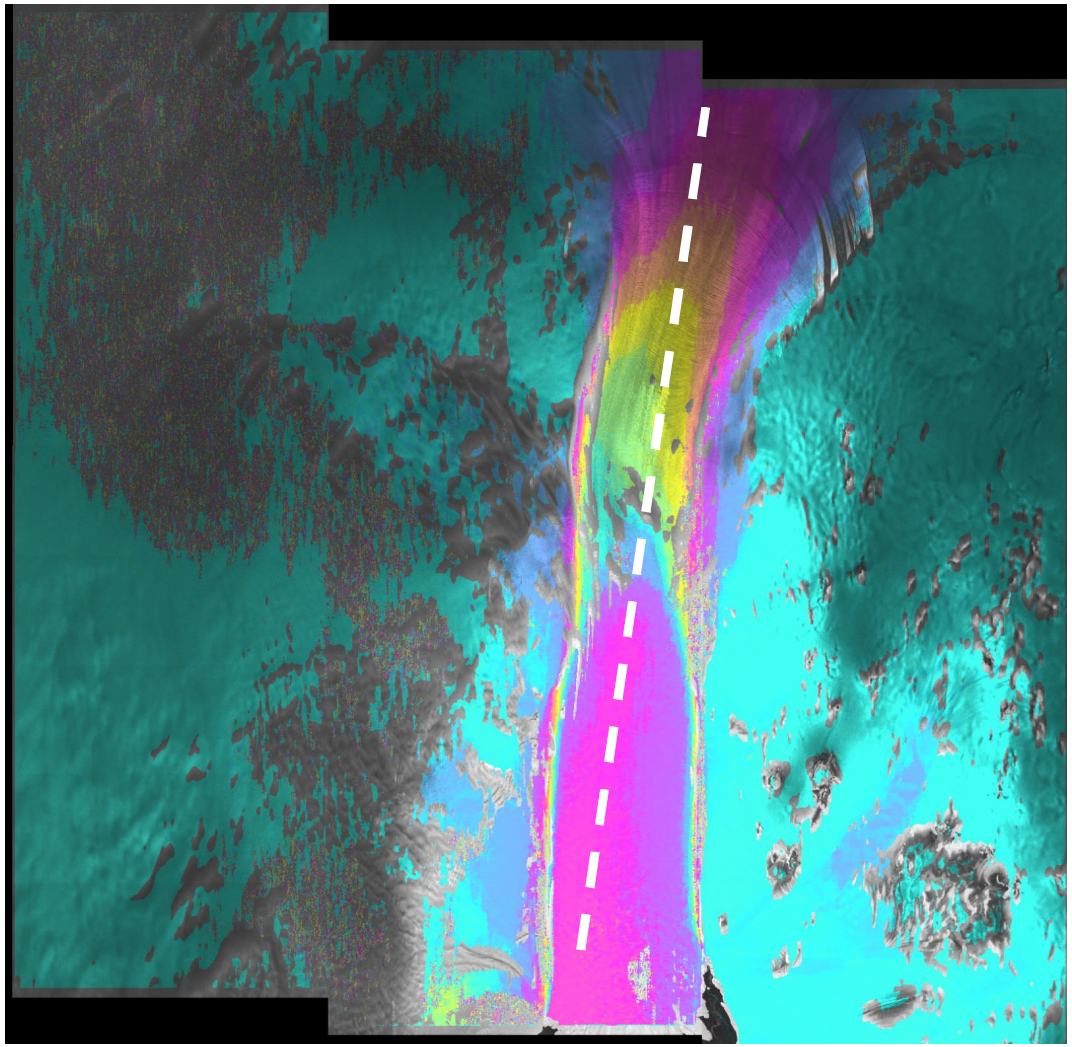




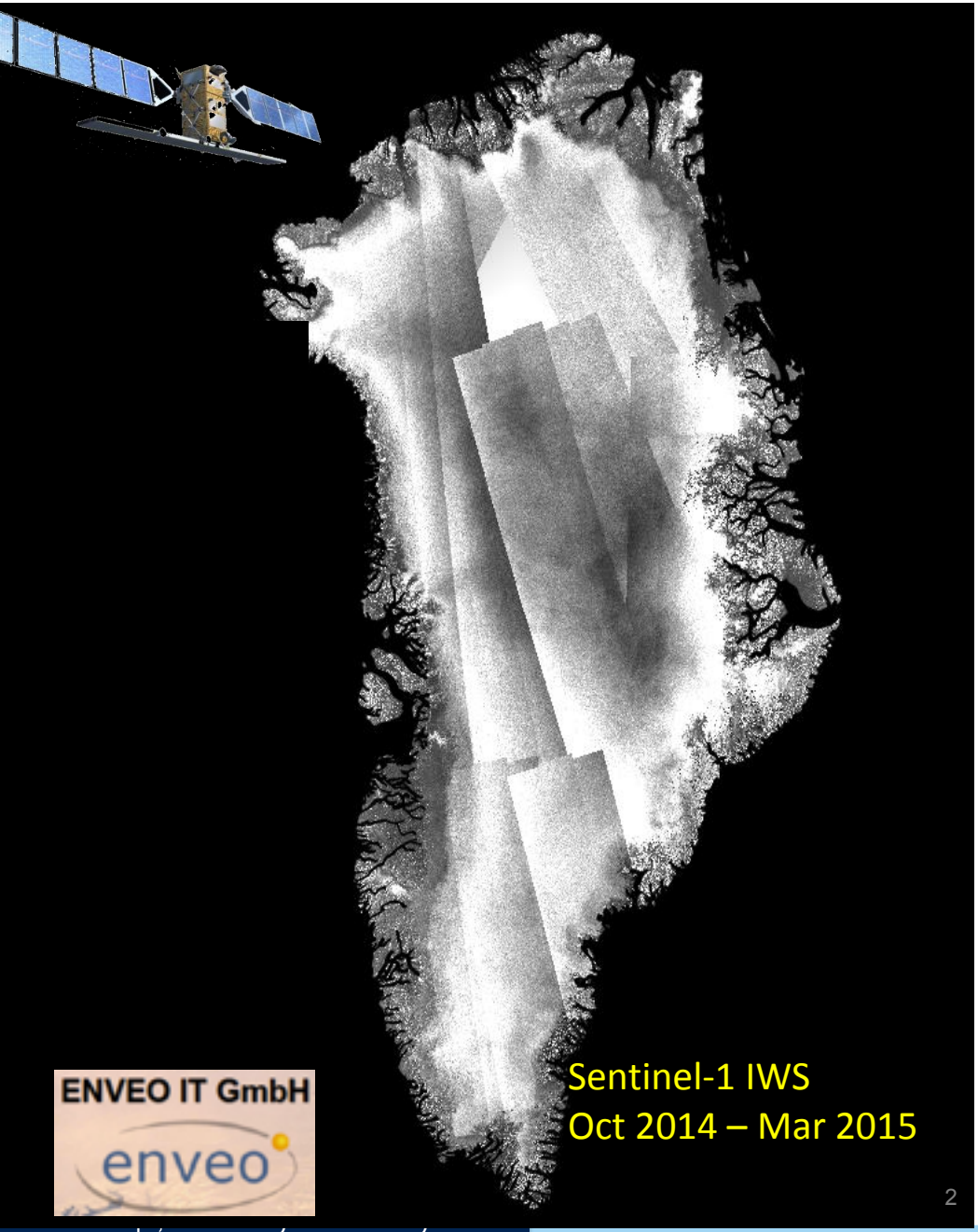
Sentinel, results so far - Antarctica

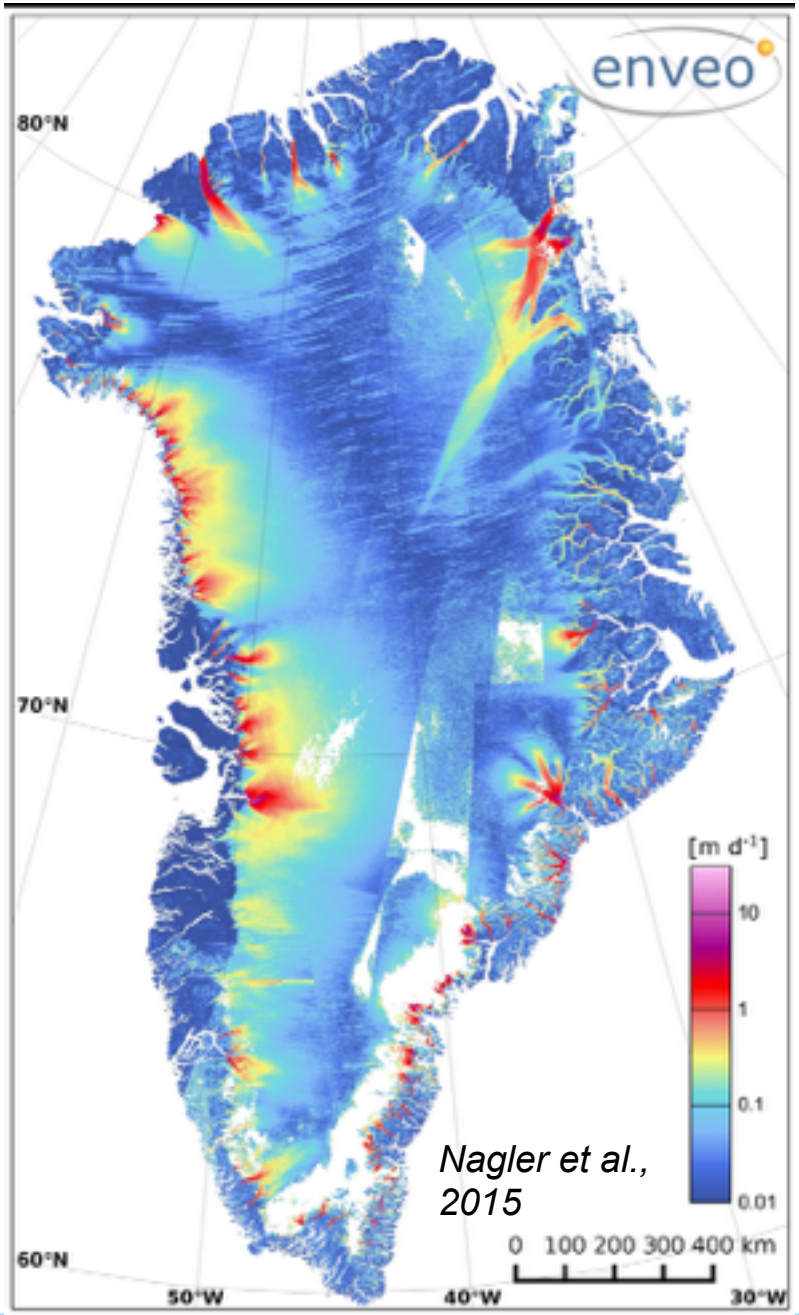


Pine Island Glacier, West Antarctica



Sentinel, results so far - Greenland





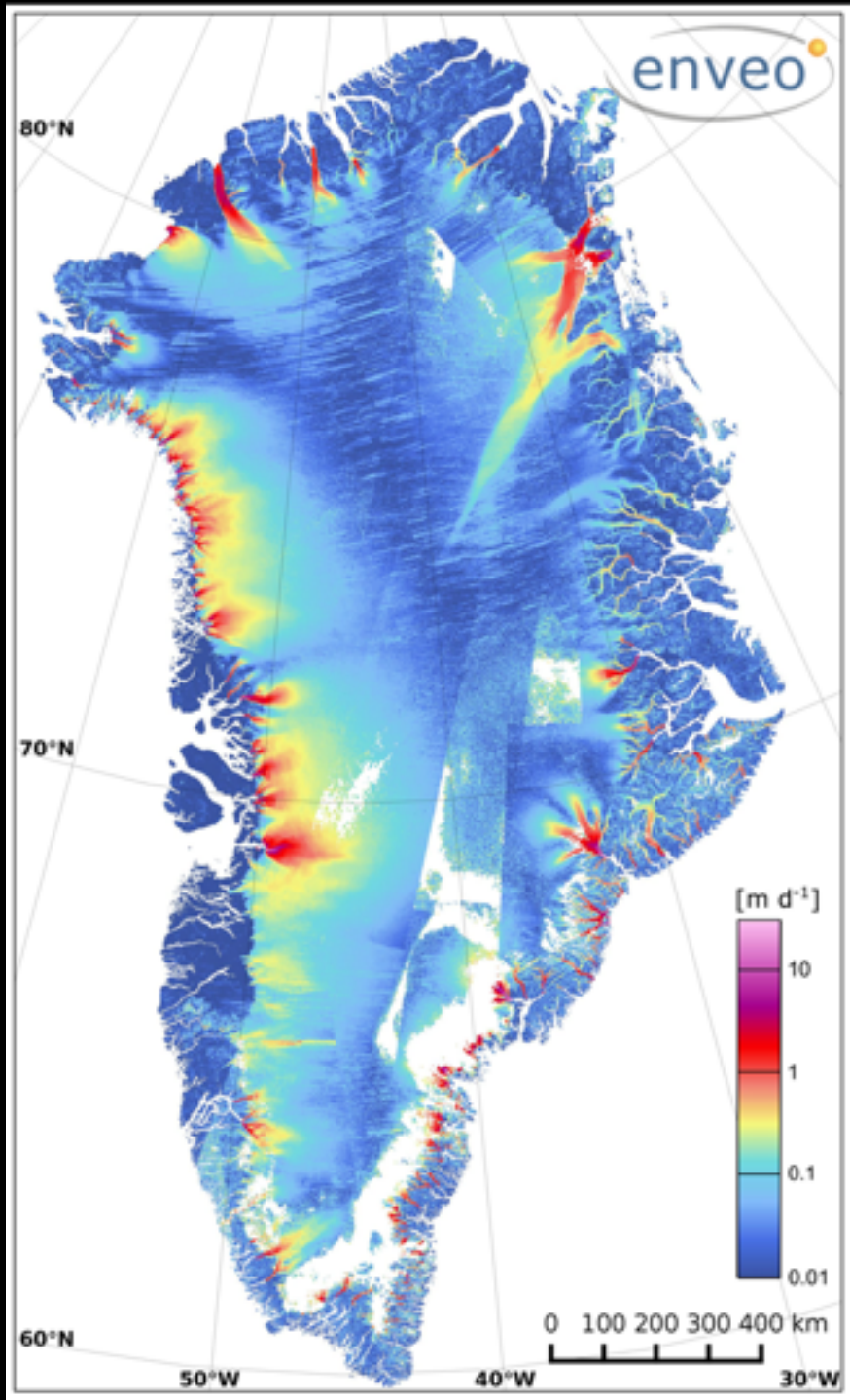
Greenland Ice Sheet

Surface Velocity

Sentinel-1
January – March 2015

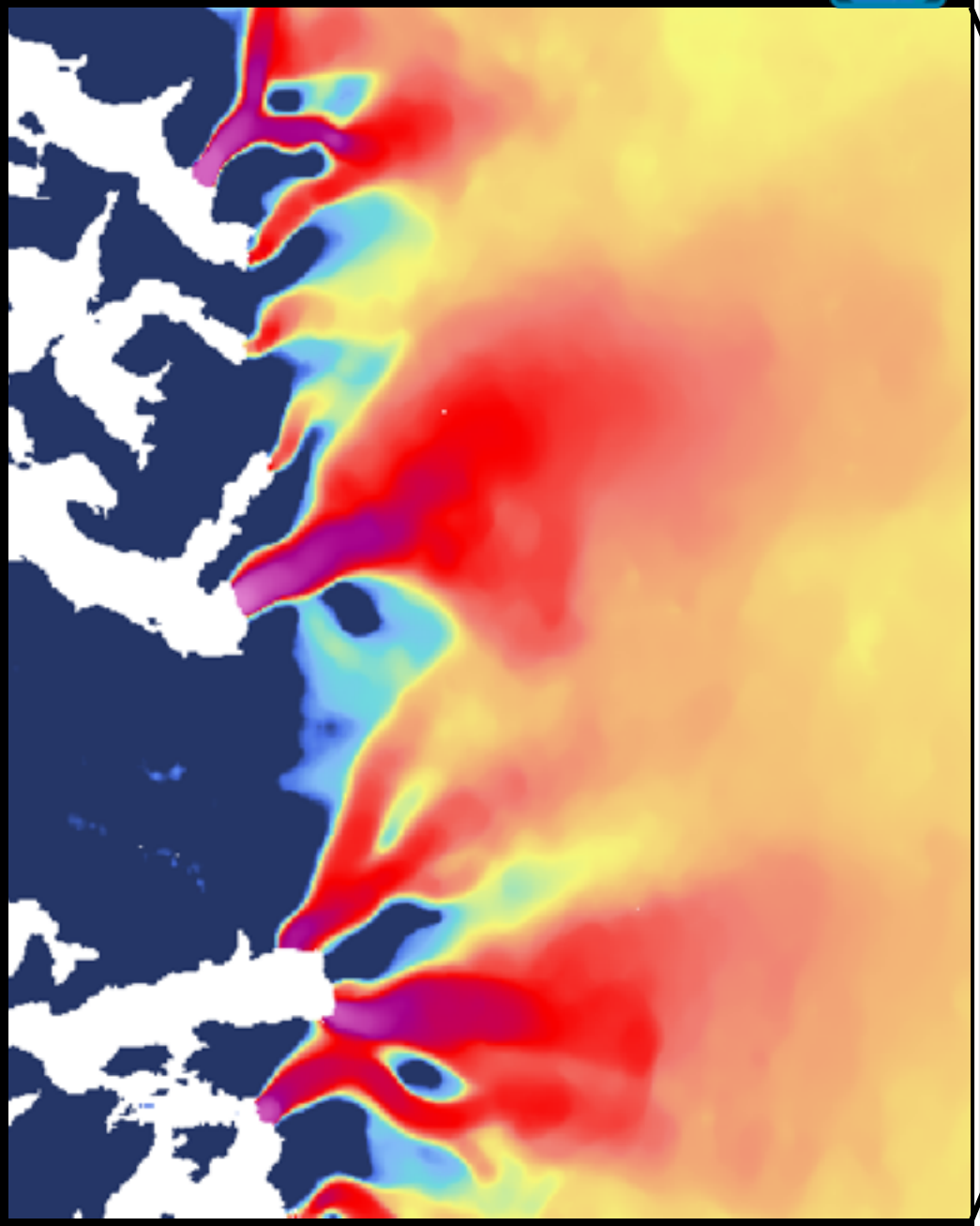
28 tracks
~900 slices
~28000 bursts

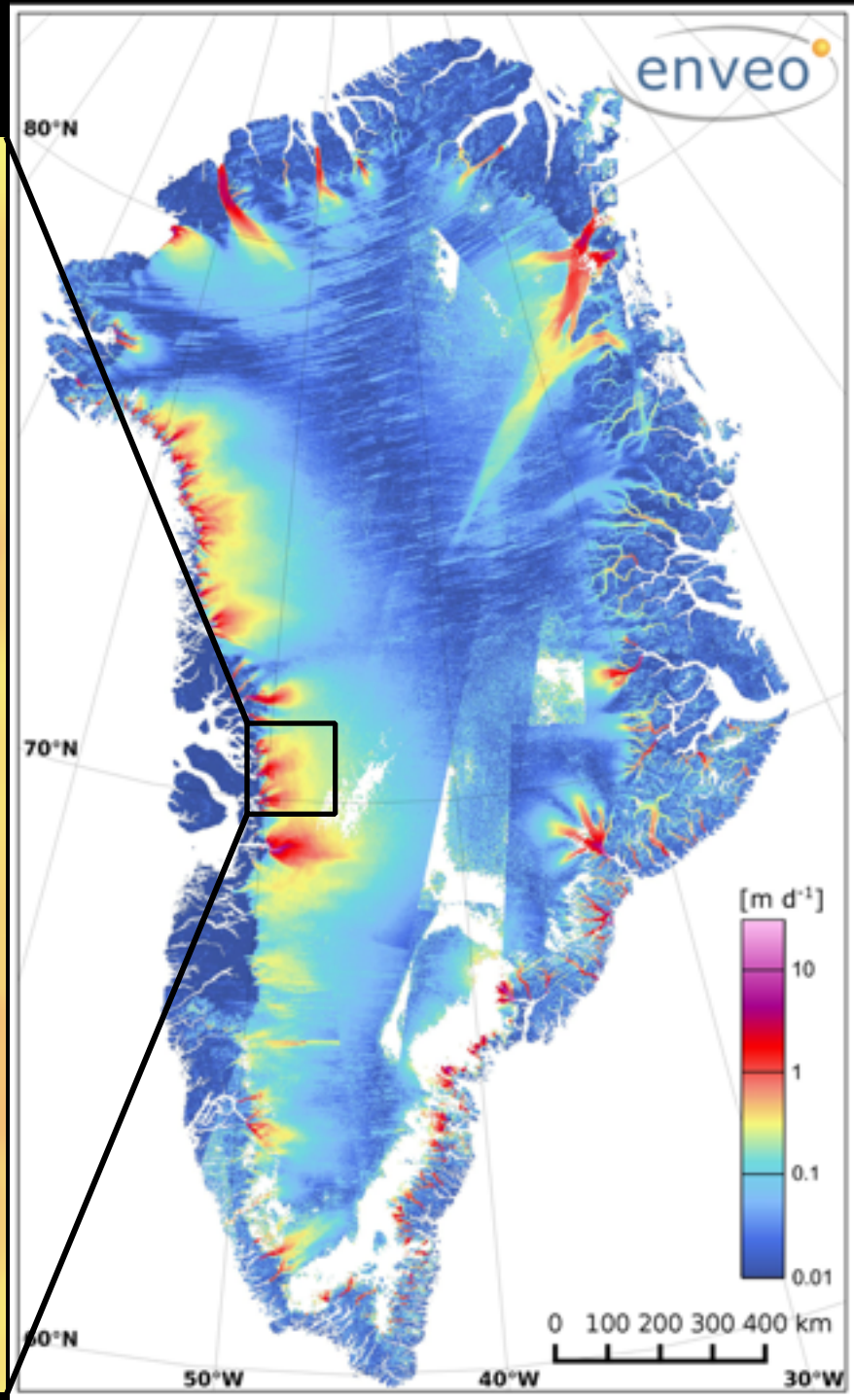
IV Product
v_E, v_N, v_{dz}
250 m pixel spacing



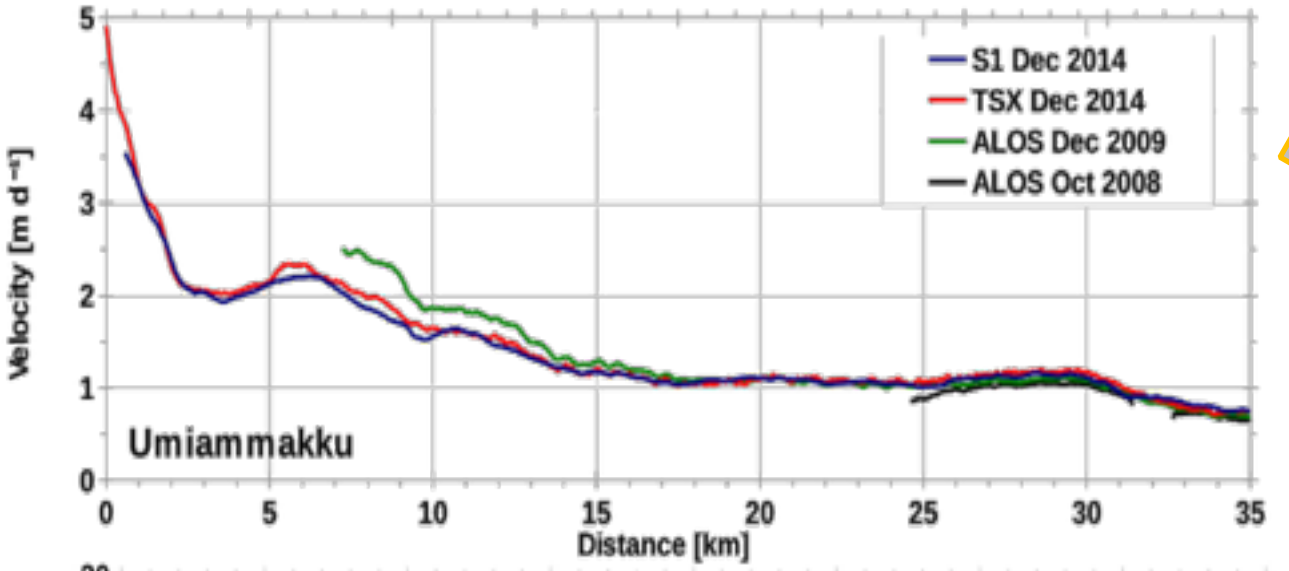
Nagler et al. *The Sentinel-1 Mission: New Opportunities for Ice Sheet Observations.* Remote Sensing 7/ 2015

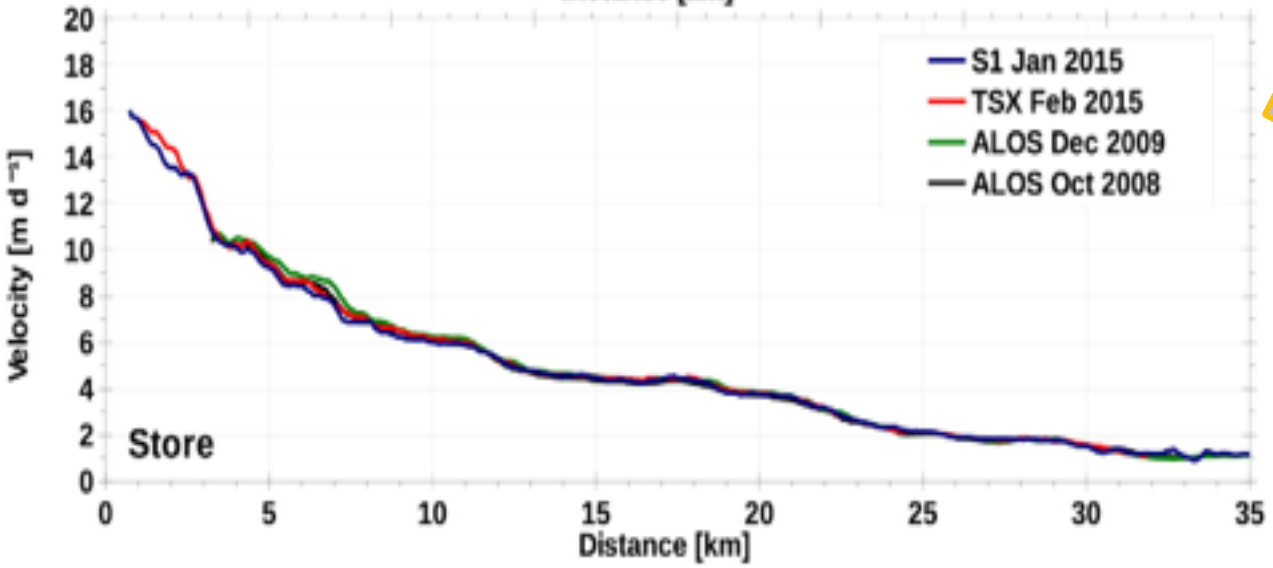
Greenland Ice Sheet

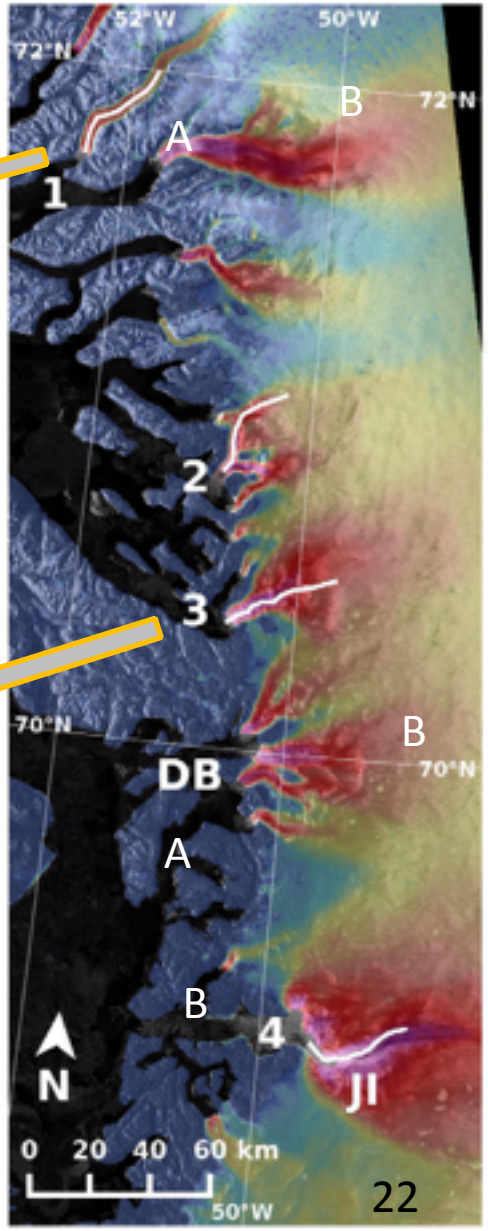




Length-Profiles S1 versus TSX & PALSAR Store Glacier and Umiammakku Glacier

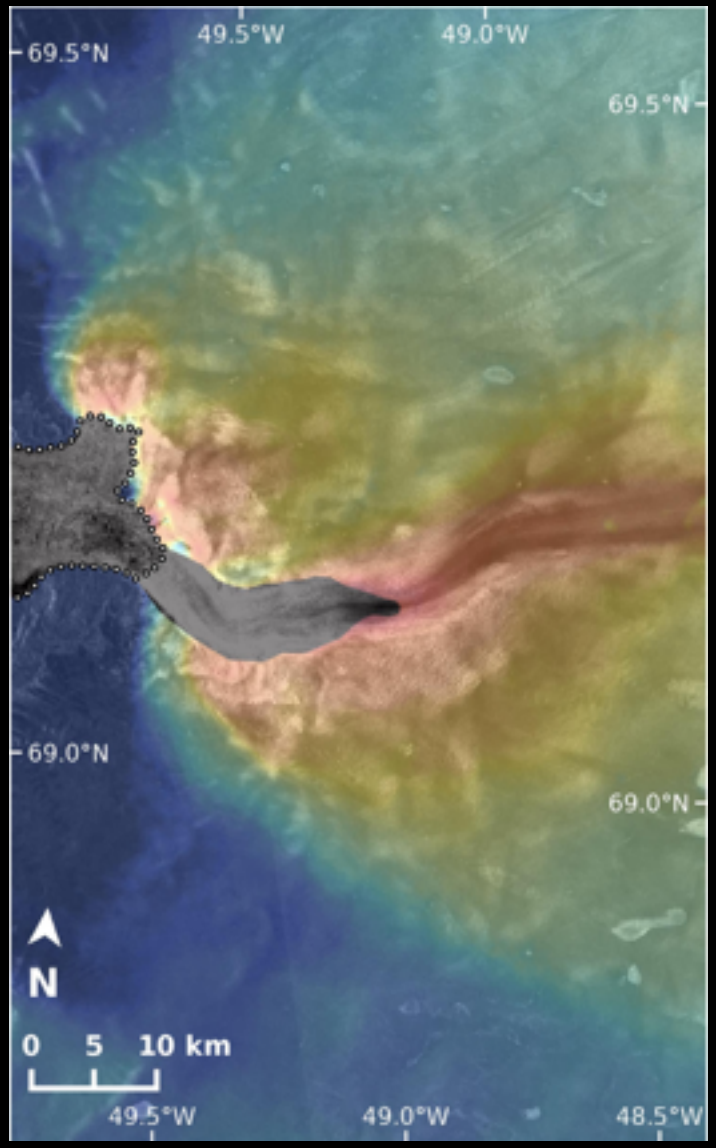




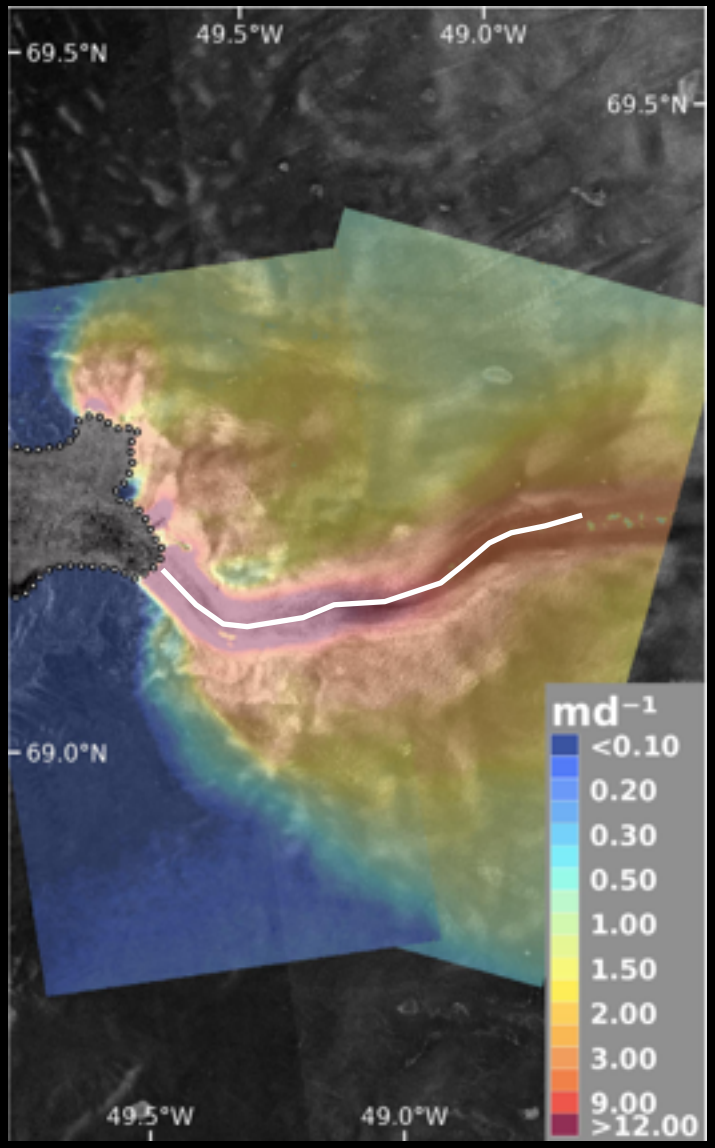


Intercomparison of Sentinel-1 and TSX Jakobshavn Isbrae

Sentinel-1 3-15 January 2015



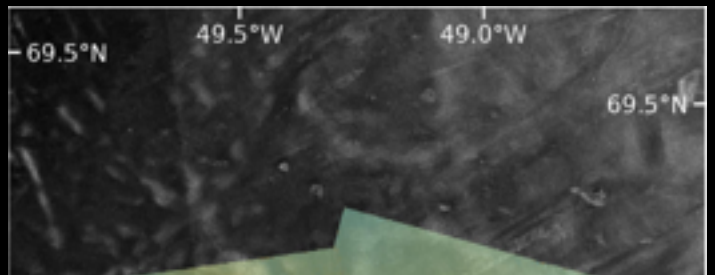
TerraSAR-X, 8-19 February 2015

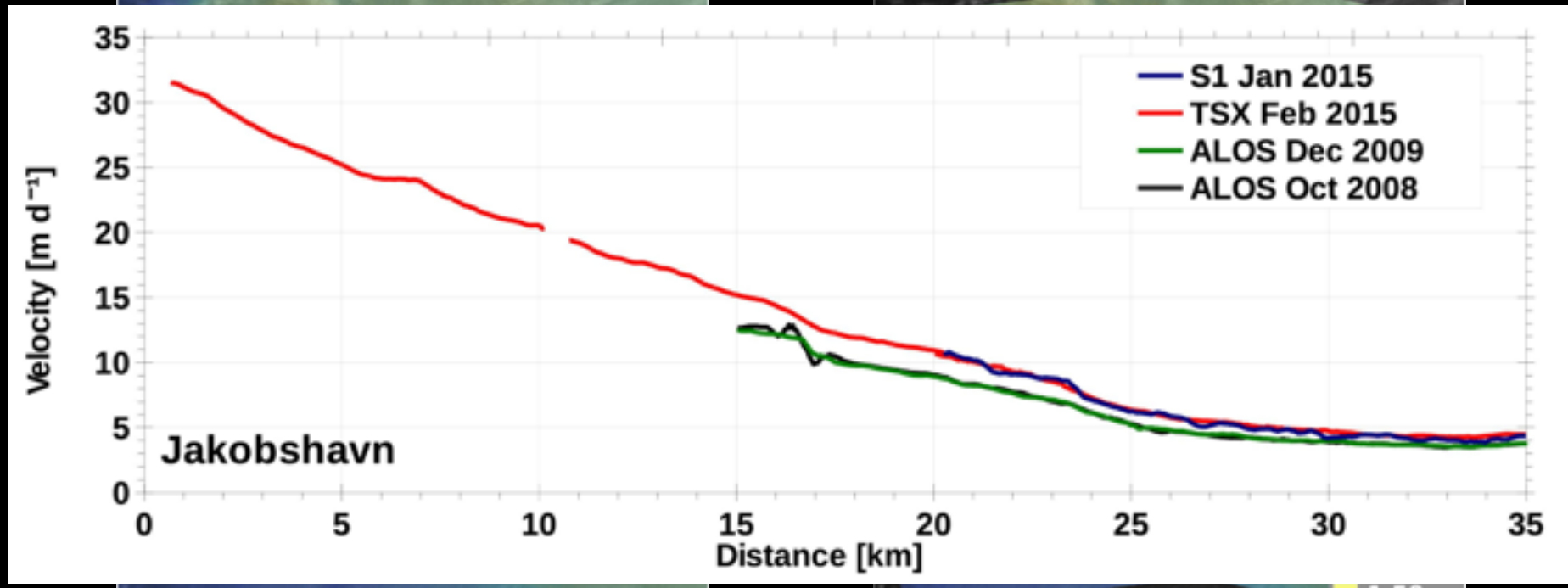


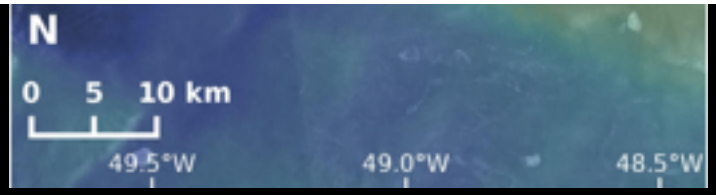
Intercomparison of Sentinel-1 and TSX Jakobshavn Isbrae

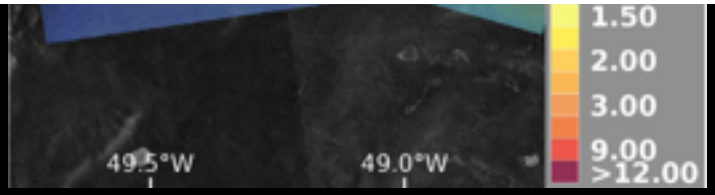
Sentinel-1 3-15 January 2015

TerraSAR-X, 8-19 February 2015







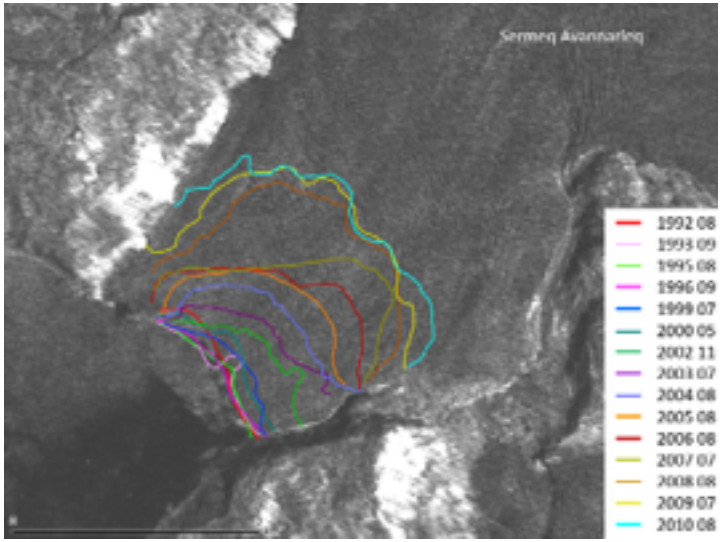


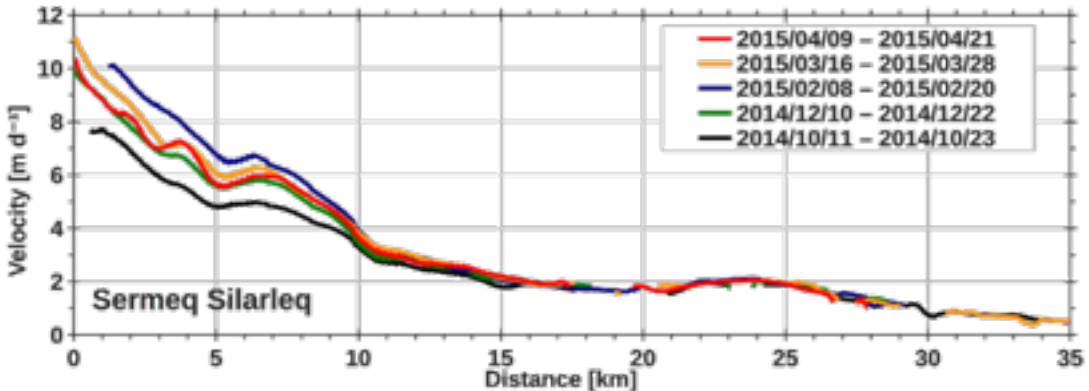
Monitoring Greenland Margins with Sentinel-1with 12 days repeat

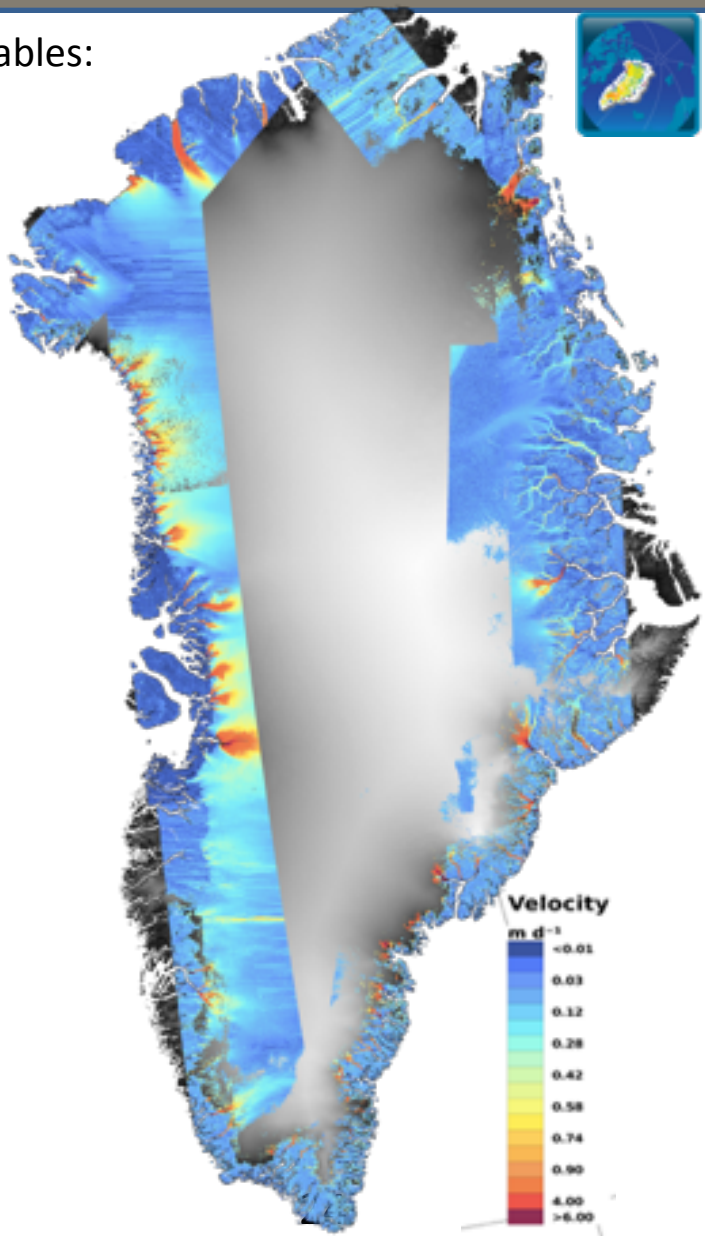
Systematic monitoring of Greenland Margins with 12 days repeat enables:

- Cumulative yearly discharge -> accurate sea level contribution
- Observation of short term velocity variations of outlet glaciers
- Variations of Calving fronts

Example from ERS/ENVISAT







Thank you!