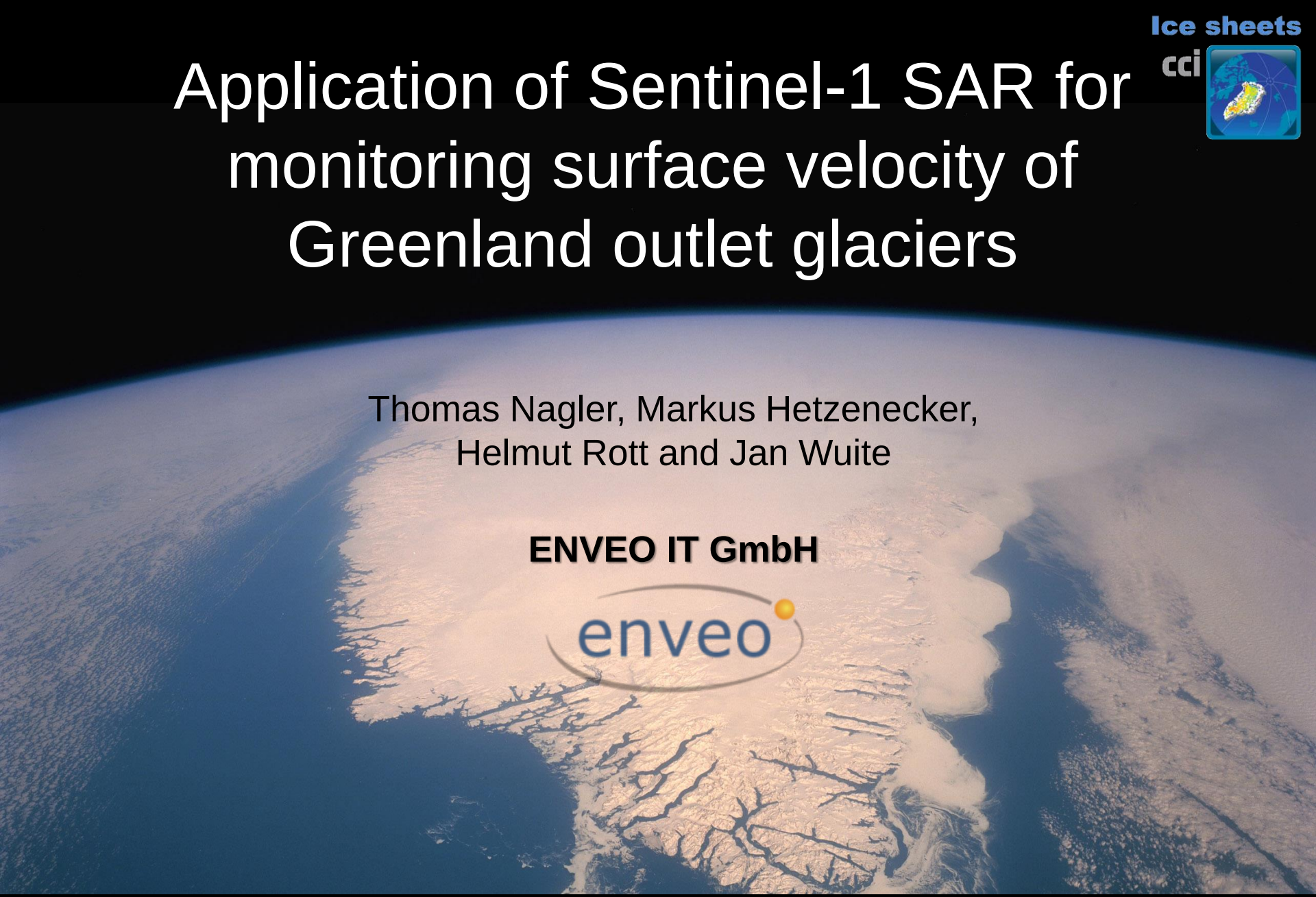
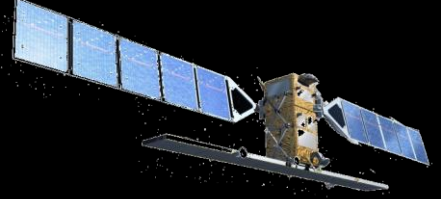
Application of Sentinel-1 SAR for monitoring surface velocity of Greenland outlet glaciers



Thomas Nagler, Markus Hetzenecker,
Helmut Rott and Jan Wuite

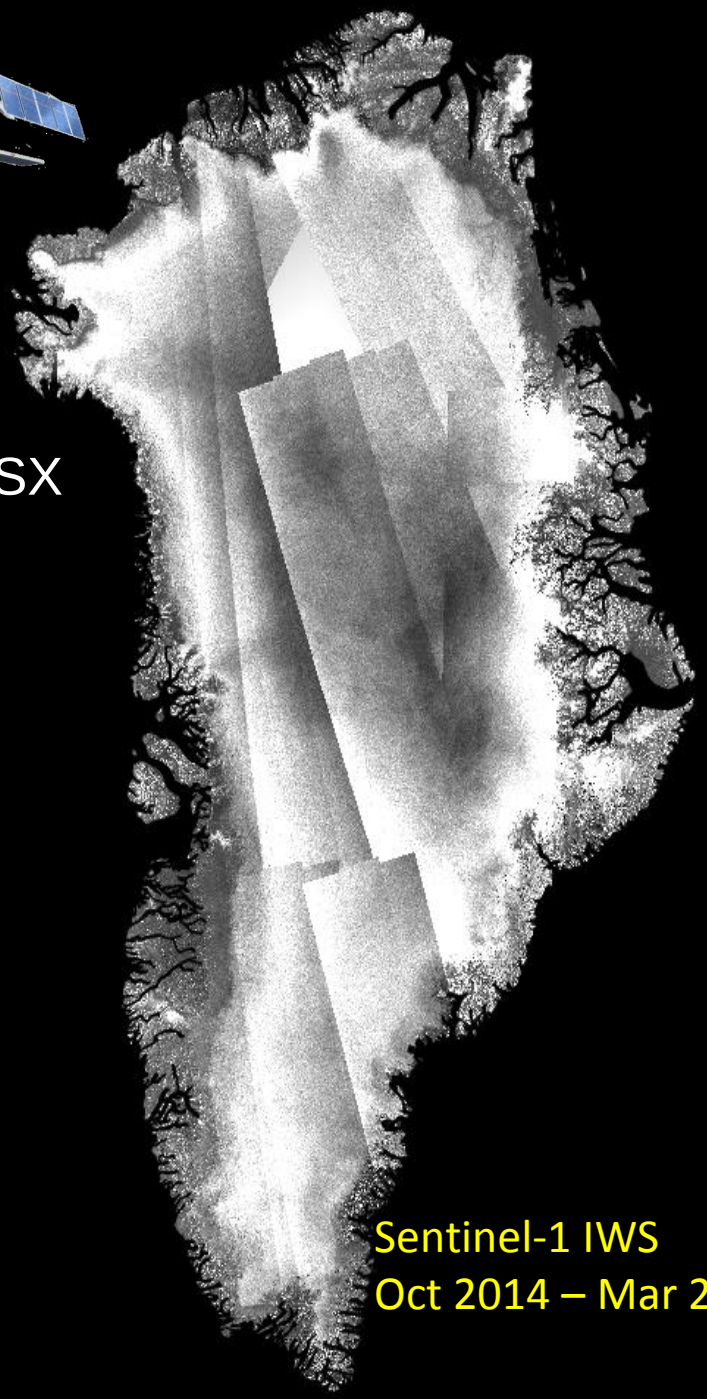
ENVEO IT GmbH

Fringe 2015



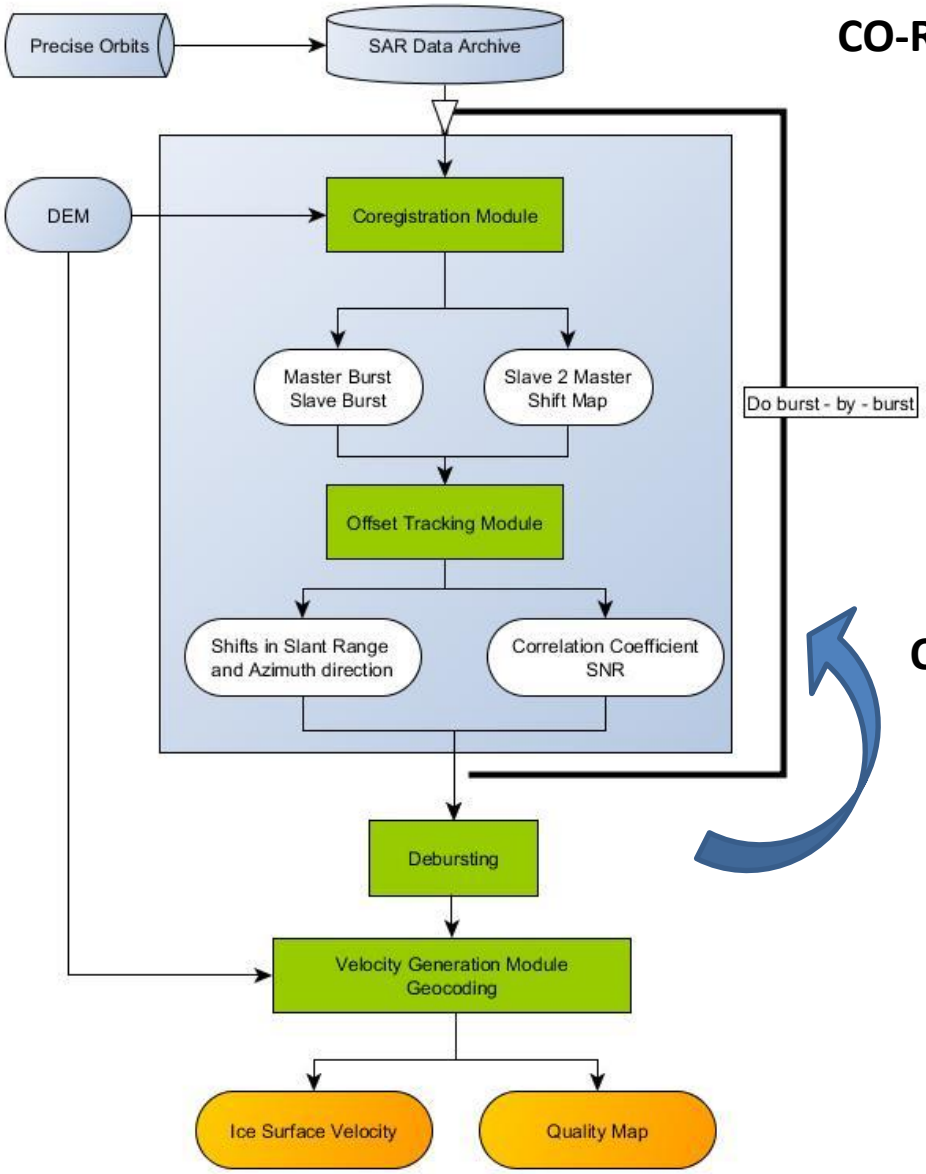
OUTLINE

- Ice Surface Velocity from S1 TOPS data
- Intercomparison of Ice velocity S1 with TSX
- Examples for speed change of outlet glaciers 2007 – 2015
- 12 Days coherence and INSAR
- Ice velocity Map
- Summary and Conclusions



Sentinel-1 IWS
Oct 2014 – Mar 2015

Ice Surface Velocity from SAR TOPS mode data



CO-REGISTRATION:

Non-Stationary Areas (Icesheets)

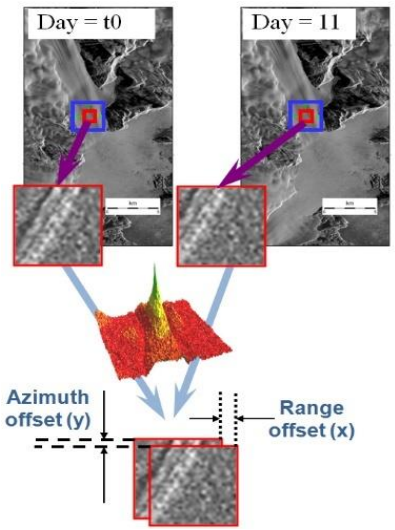
Geometric Co-registration
of Master and Slave Bursts :
DEM, Precise Orbits

1st Refinement of Azimuth Shifts:
Incoherent OT all Bursts

2nd Refinement of Azimuth Shifts:
ESD in Overlaps of adjacent Bursts

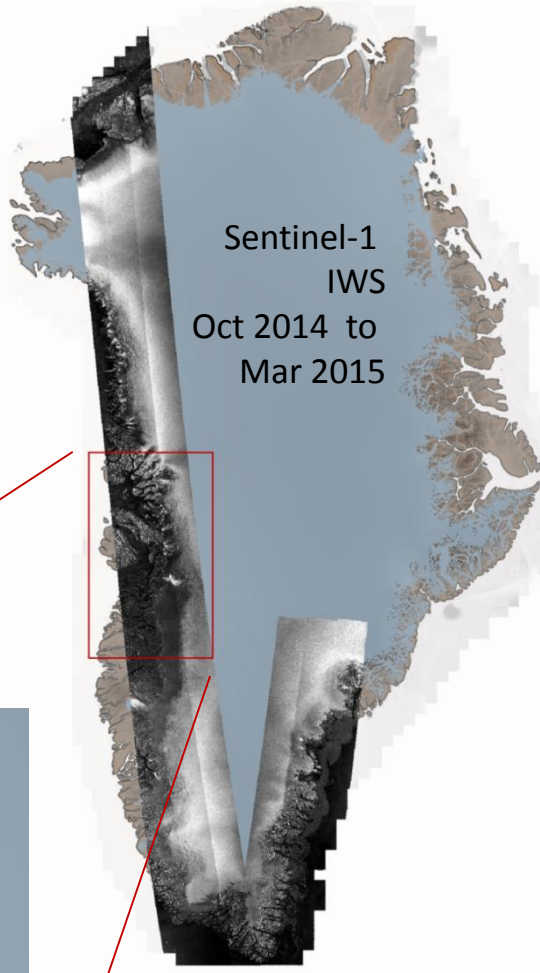
Master and Slave Burst by Burst
Co-registration

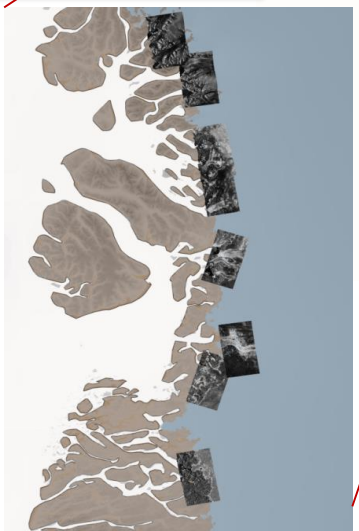
OFFSET TRACKING:



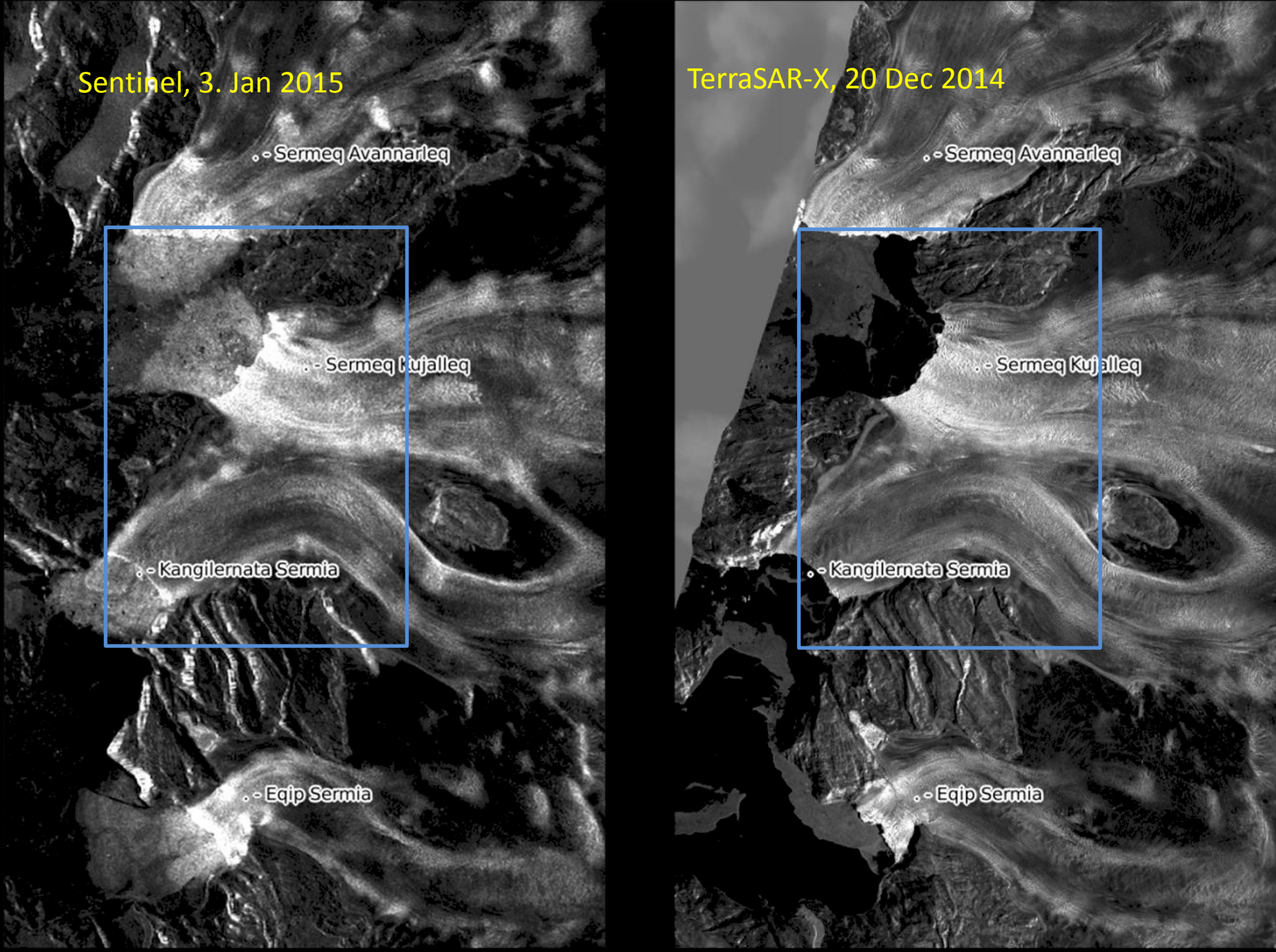
Characteristics of Sensors and Data sets

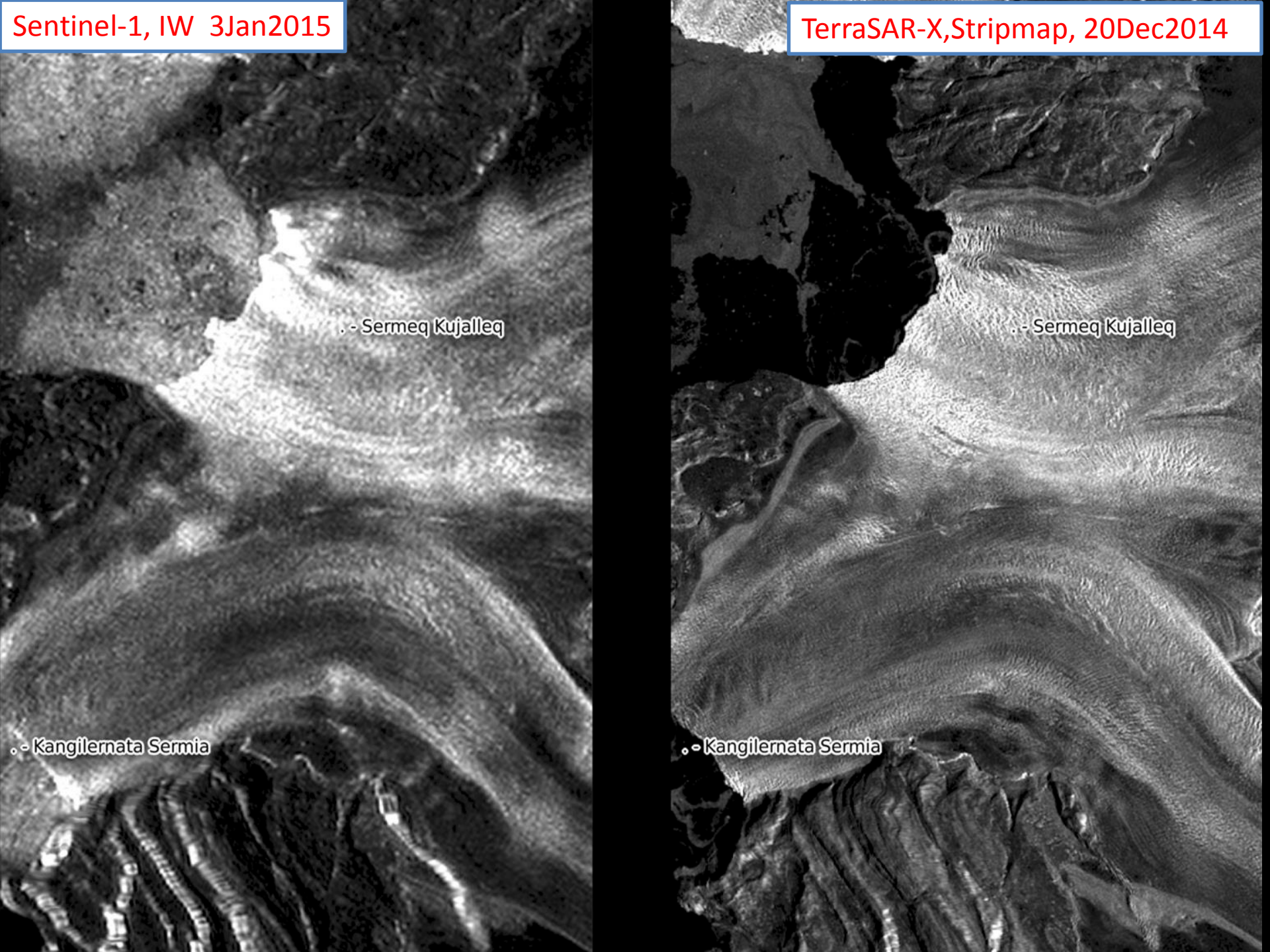
SAR Platform	Sentinel -1	TerraSAR-X / TDX	ALOS
Launch	April 2014	June 2007, 2010	Jan 2006 – Apr 2011
Sensor	C -band SAR	X -band SAR	PALSAR / band
Mode / Product	IWS / SLC	Stripmap / SLC	Fine Beam / SLC
Resolution	3 x 22m	1.2 × 3.3m	4 x 3 m
Repeat cycle	12d	11d	46d
Swath width	250km	30 km	70 km



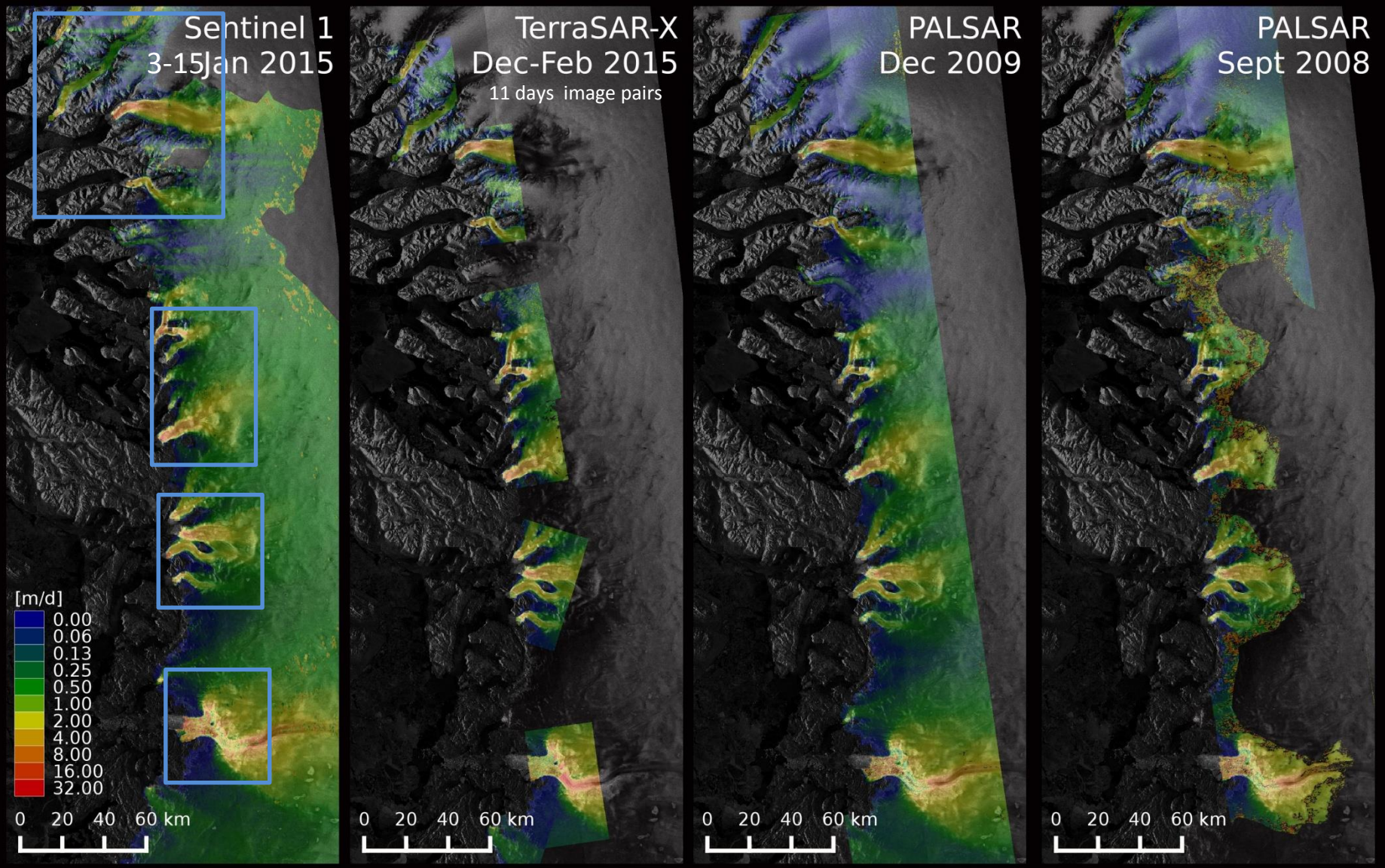


TerraSAR-X
STRIPMAP
Dec 2014
Jan/Feb
2015


Sentinel, 3. Jan 2015
Sermeq Avannarleq
Sermeq Kujalleq
Kangilernata Sermia
Eqip Sermia
TerraSAR-X, 20 Dec 2014
Sermeq Avannarleq
Sermeq Kujalleq
Kangilernata Sermia
Eqip Sermia


Sentinel-1, IW 3Jan2015
. - Sermeq Kujalleq
. - Kangilernata Sermia
TerraSAR-X,Stripmap, 20Dec2014
. - Sermeq Kujalleq
. - Kangilernata Sermia

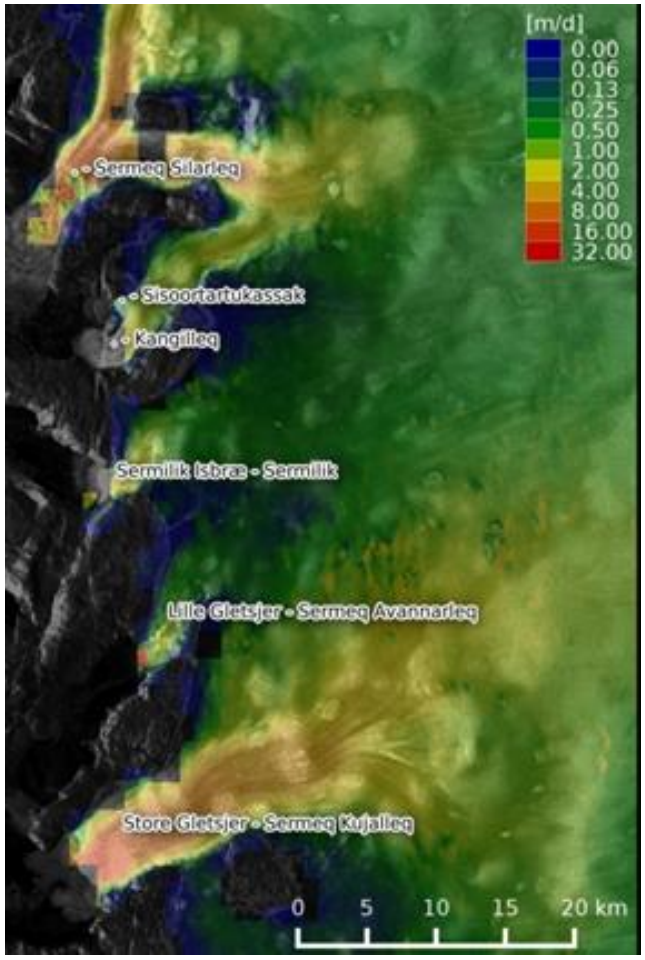
Sentinel 1 Ice Surface Velocity & Comparison to TSX and PALSAR

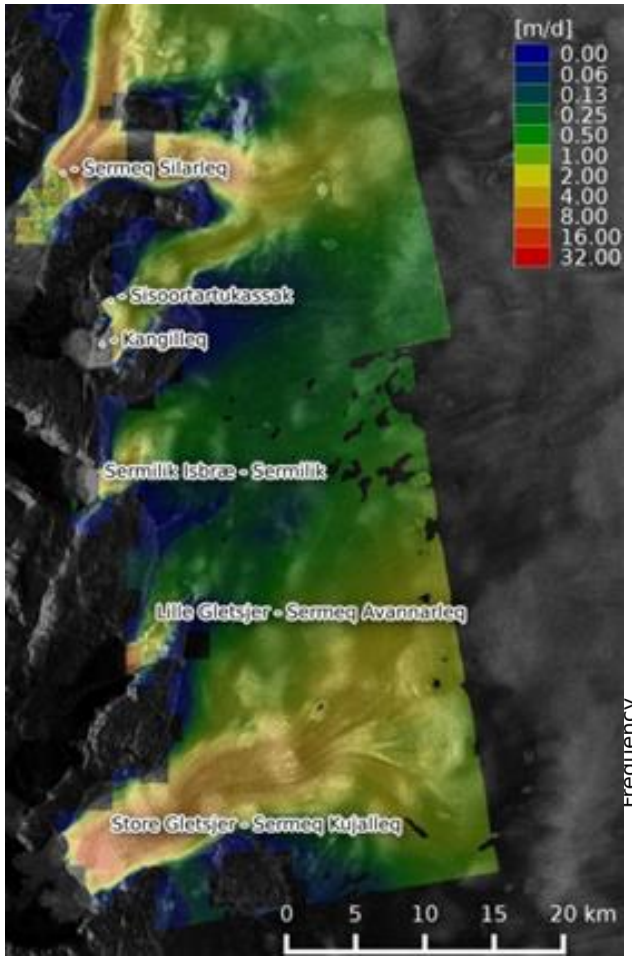


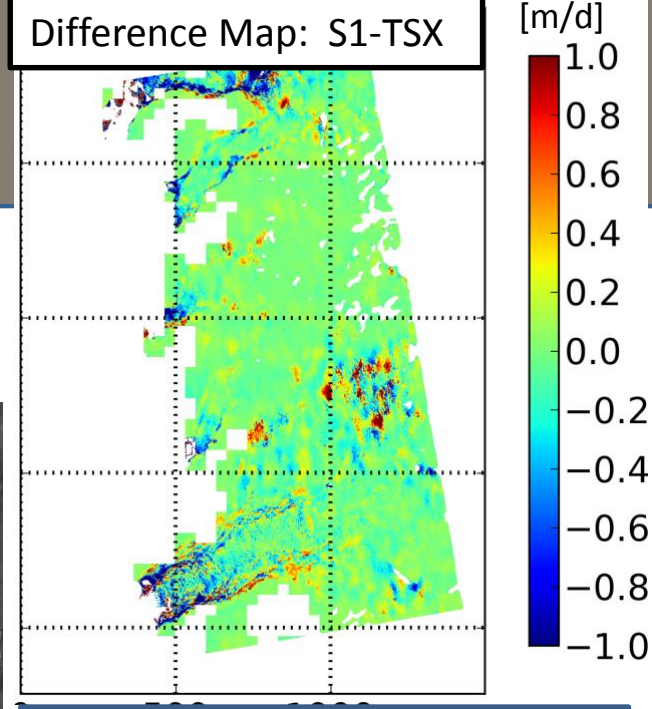
Horizontal Ice Surface Velocity Sentinel-1 versus TSX

SENTINEL-1
(3 – 15. Jan 2015)

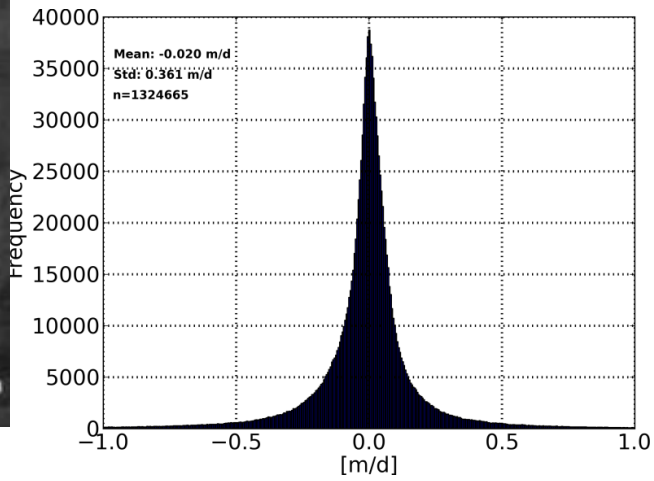
TerraSAR-X
(9 -20 Dec 2014)







Ice Velocity S1-TSX :
Mean Difference = -0.02 m/d
Std: 0.36 m/d

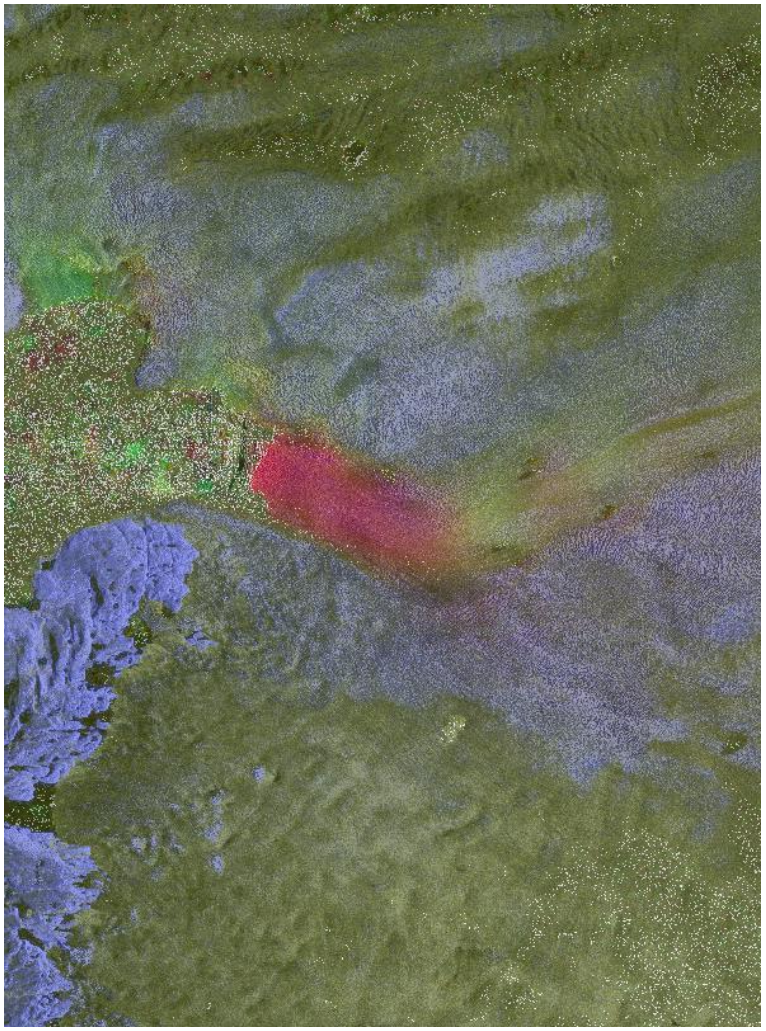


Iterative Offset Tracking of Fast Glaciers

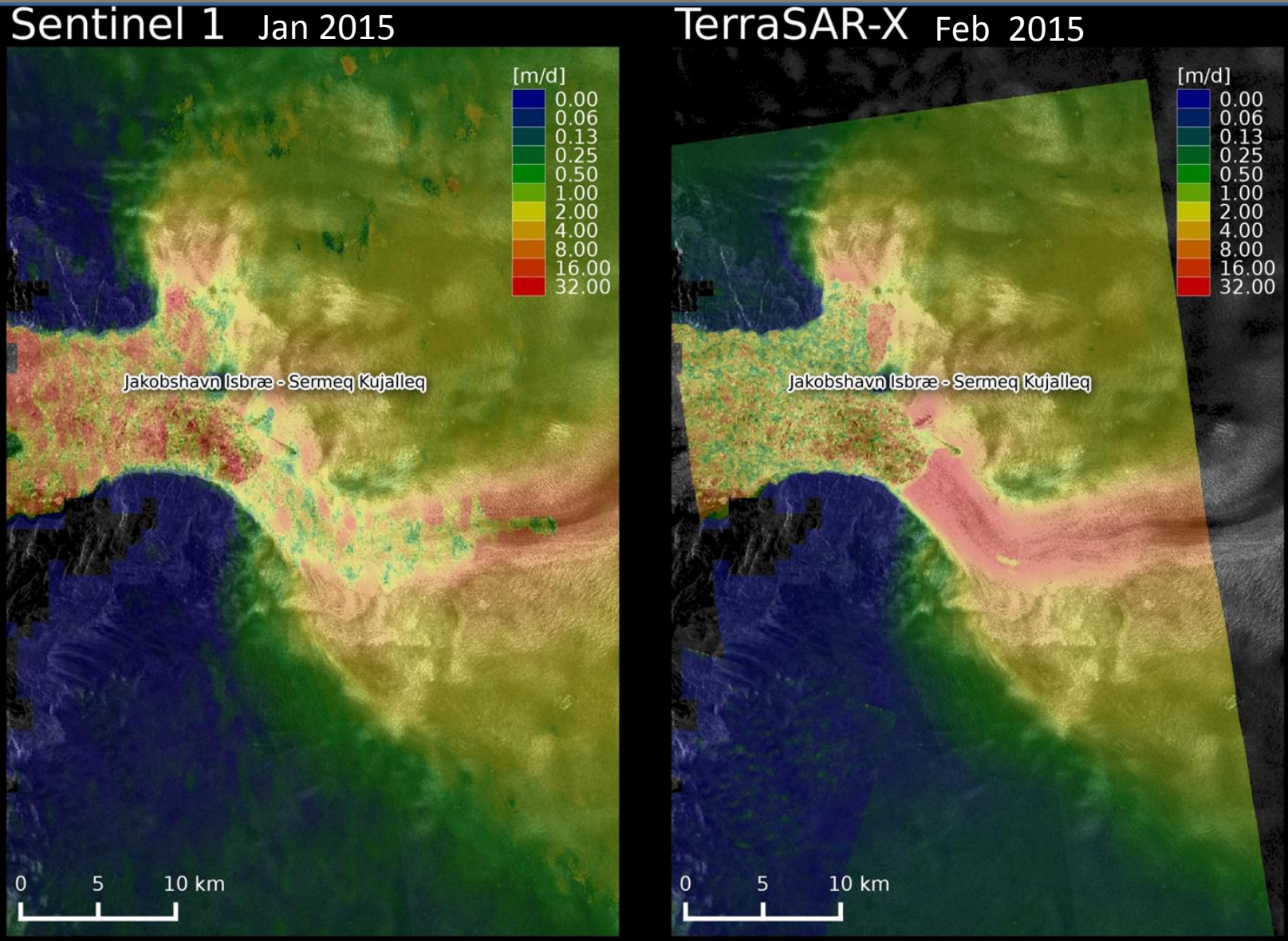
Iterative Procedure:

- Calculate shifts with a coarse sampling and without sub-pixel matching
- Where no matching found: Estimate shifts based on neighbours from previous run and apply coarse offset matching, until no improvement is observed
- Use coarse resolution offset map for final matching with small matching windows and sub-pixel matching

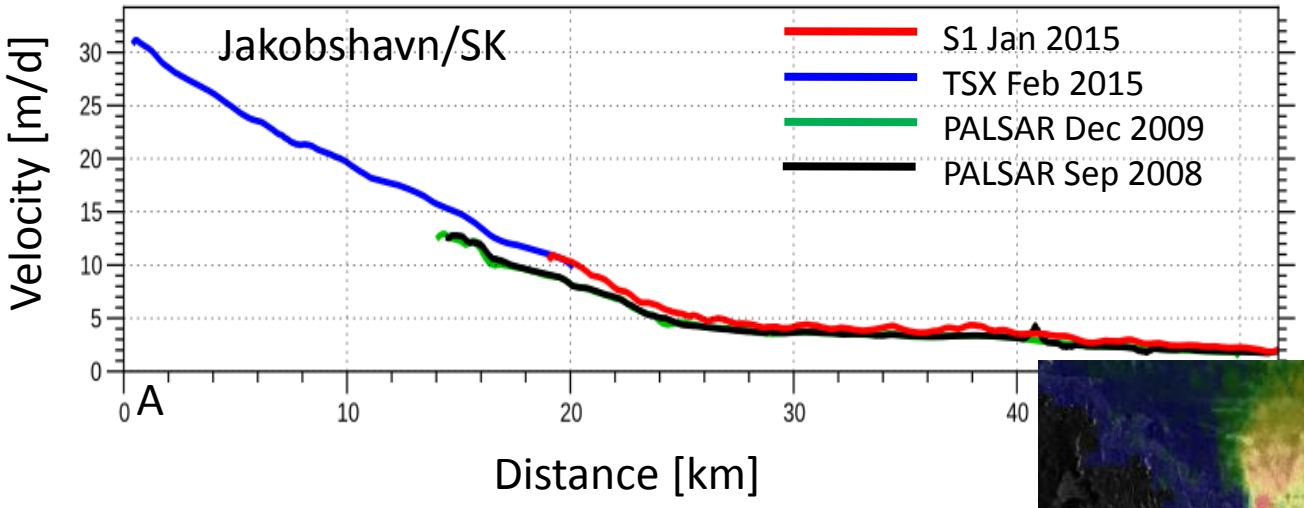
Image sequence of the iterative calculation of a very fast glacier (e.g. Jakobshavn glacier; ca. 30 m/d)

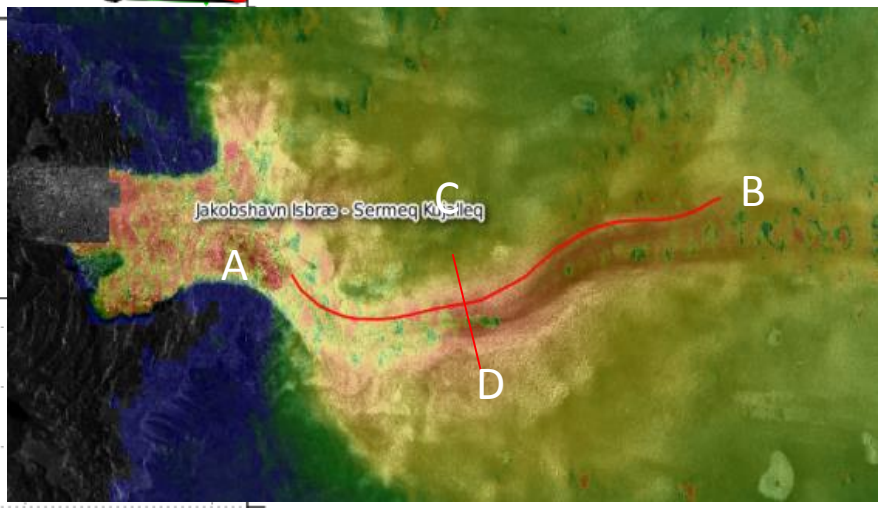


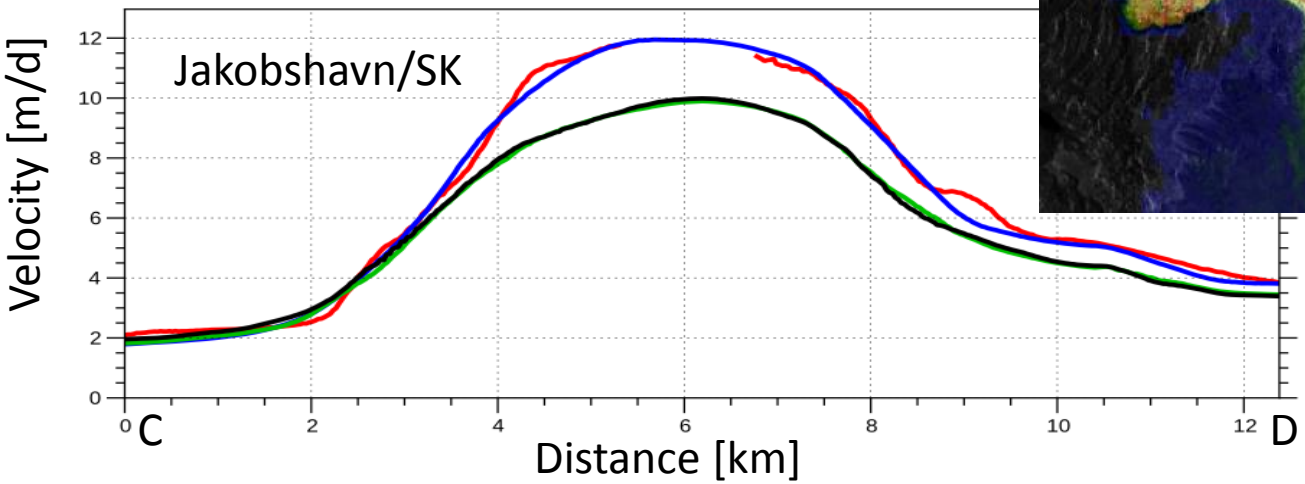
Intercomparison of Sentinel-1 and TSX



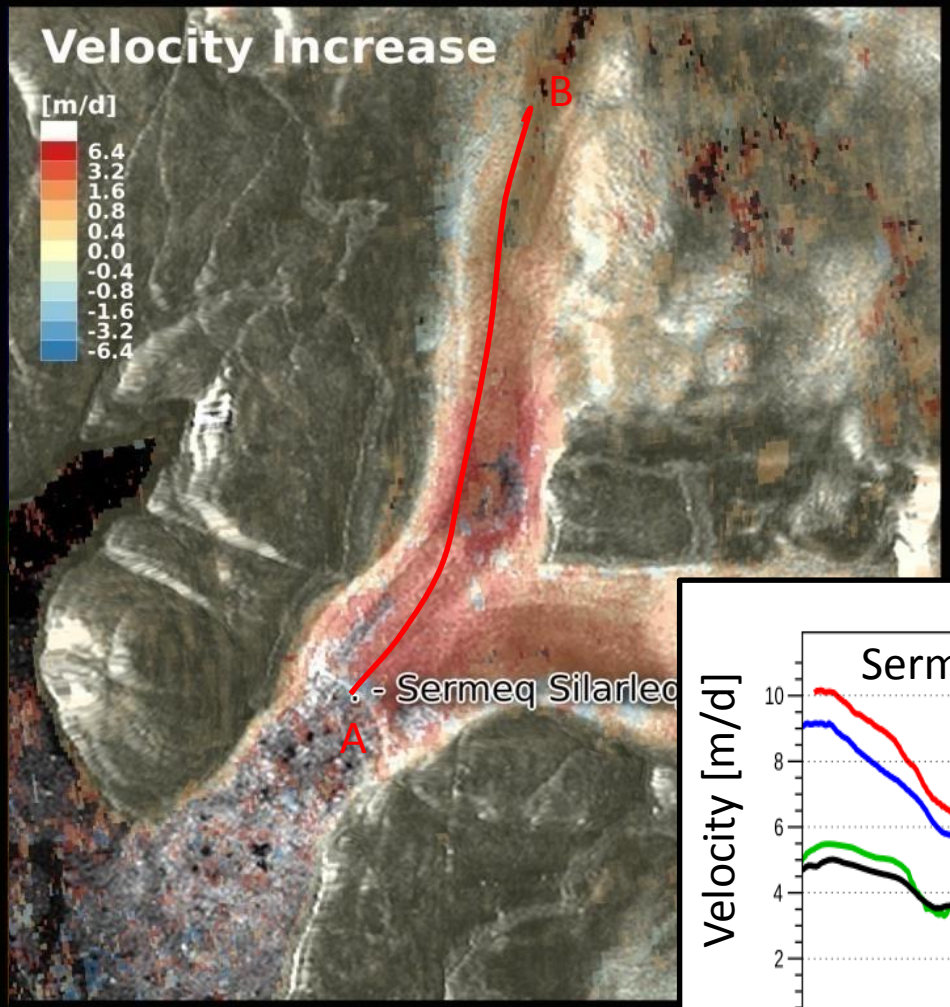
Length-Profiles S1 versus TSX & PALSAR

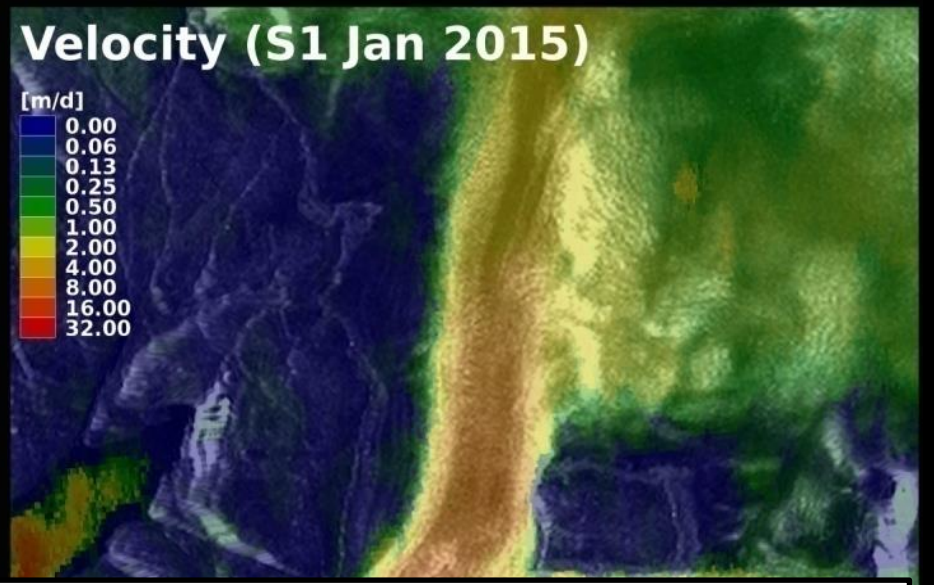


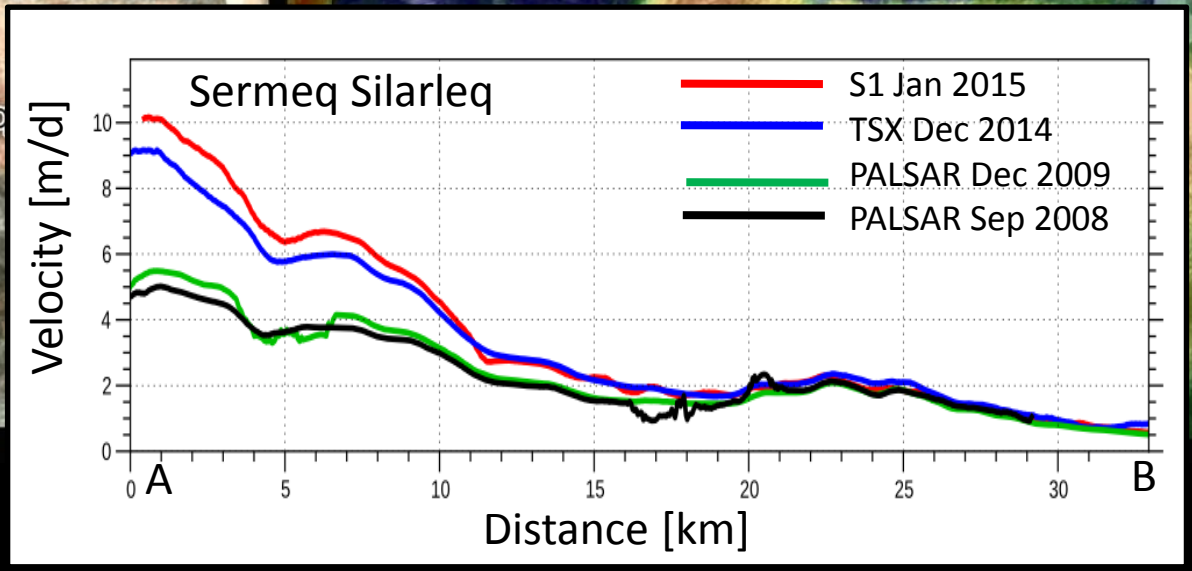




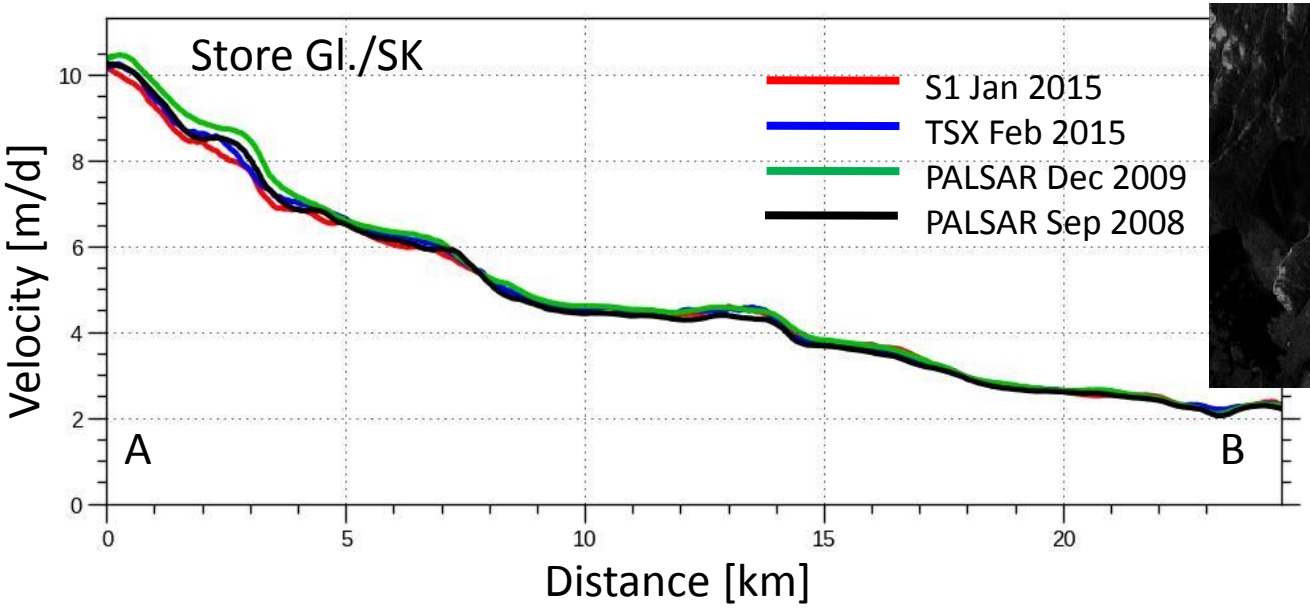
Sermeq Silarleq – Increase of Speed 2008-2015

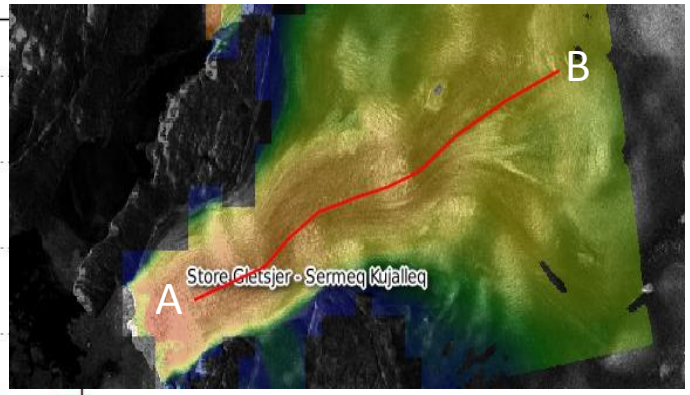


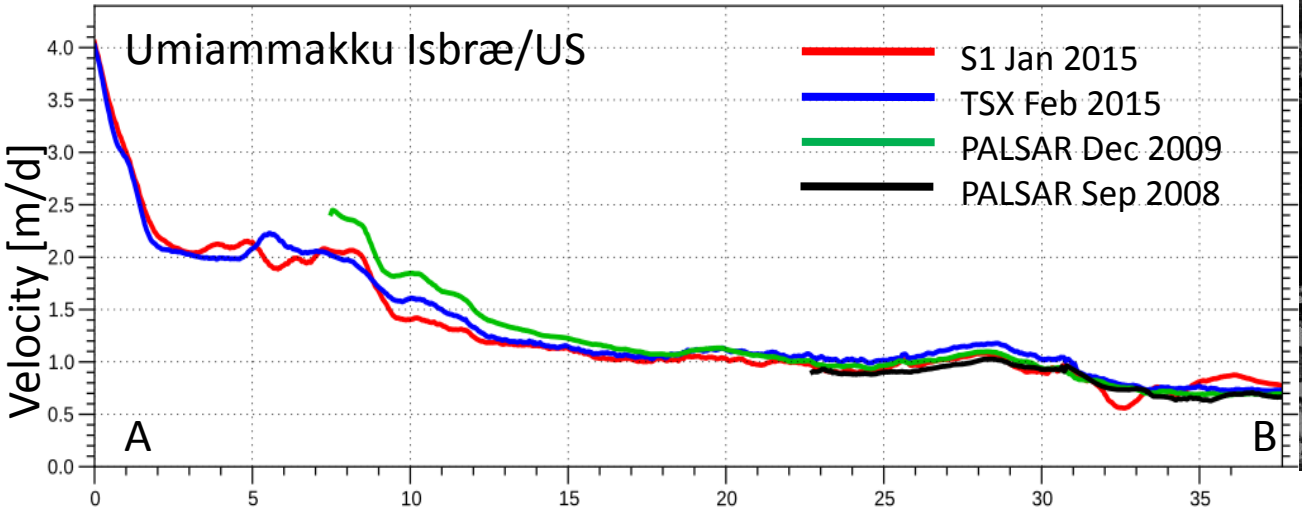


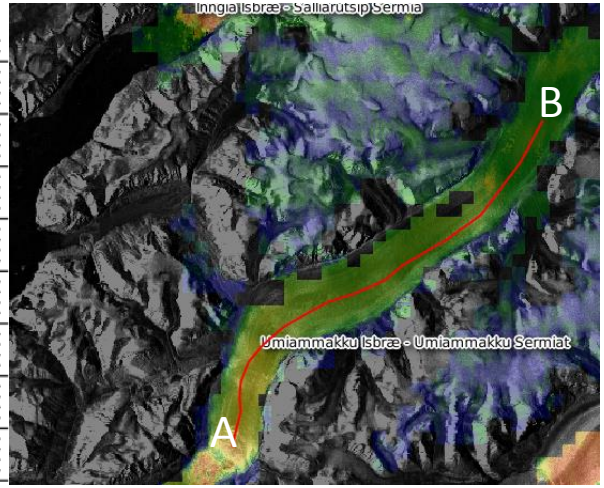


Length-Profiles S1 versus TSX & PALSAR

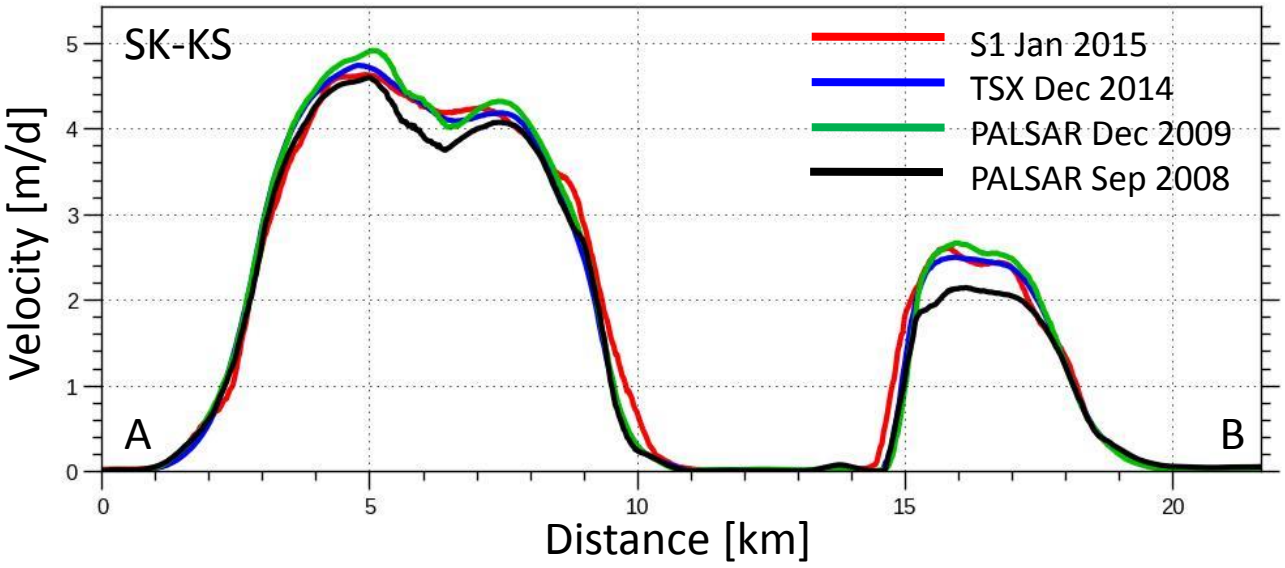


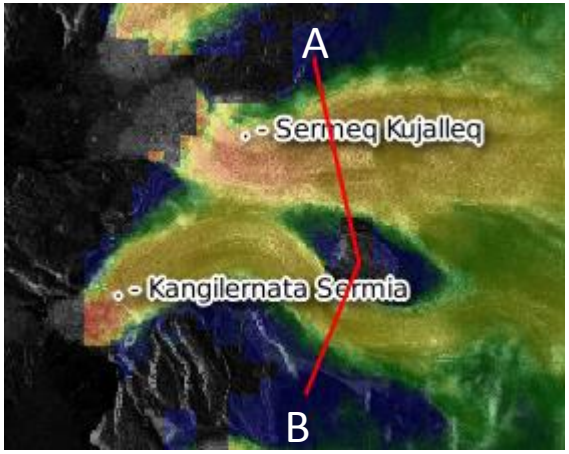


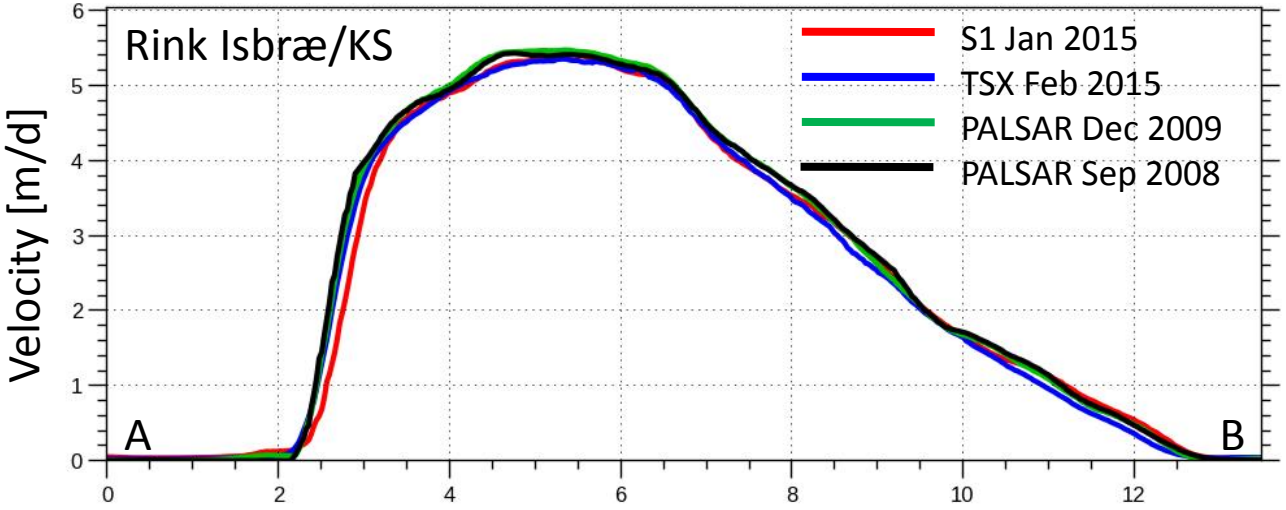


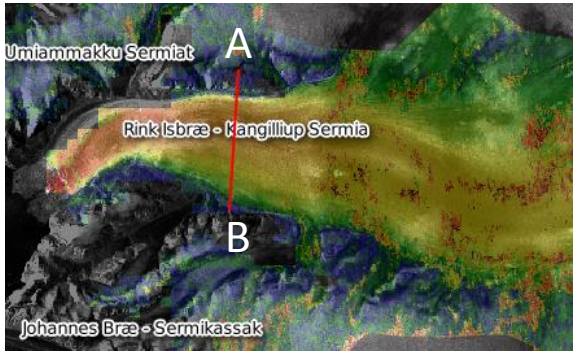


X-Profiles S1 versus TSX & PALSAR

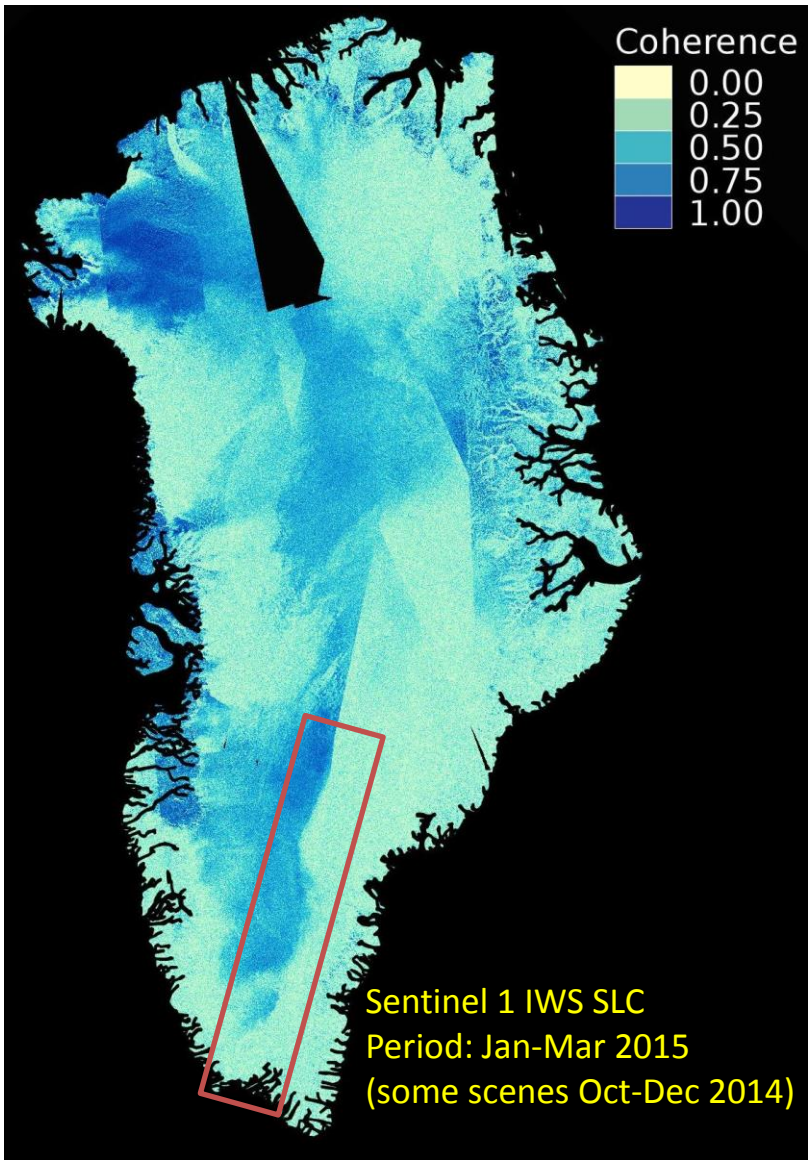




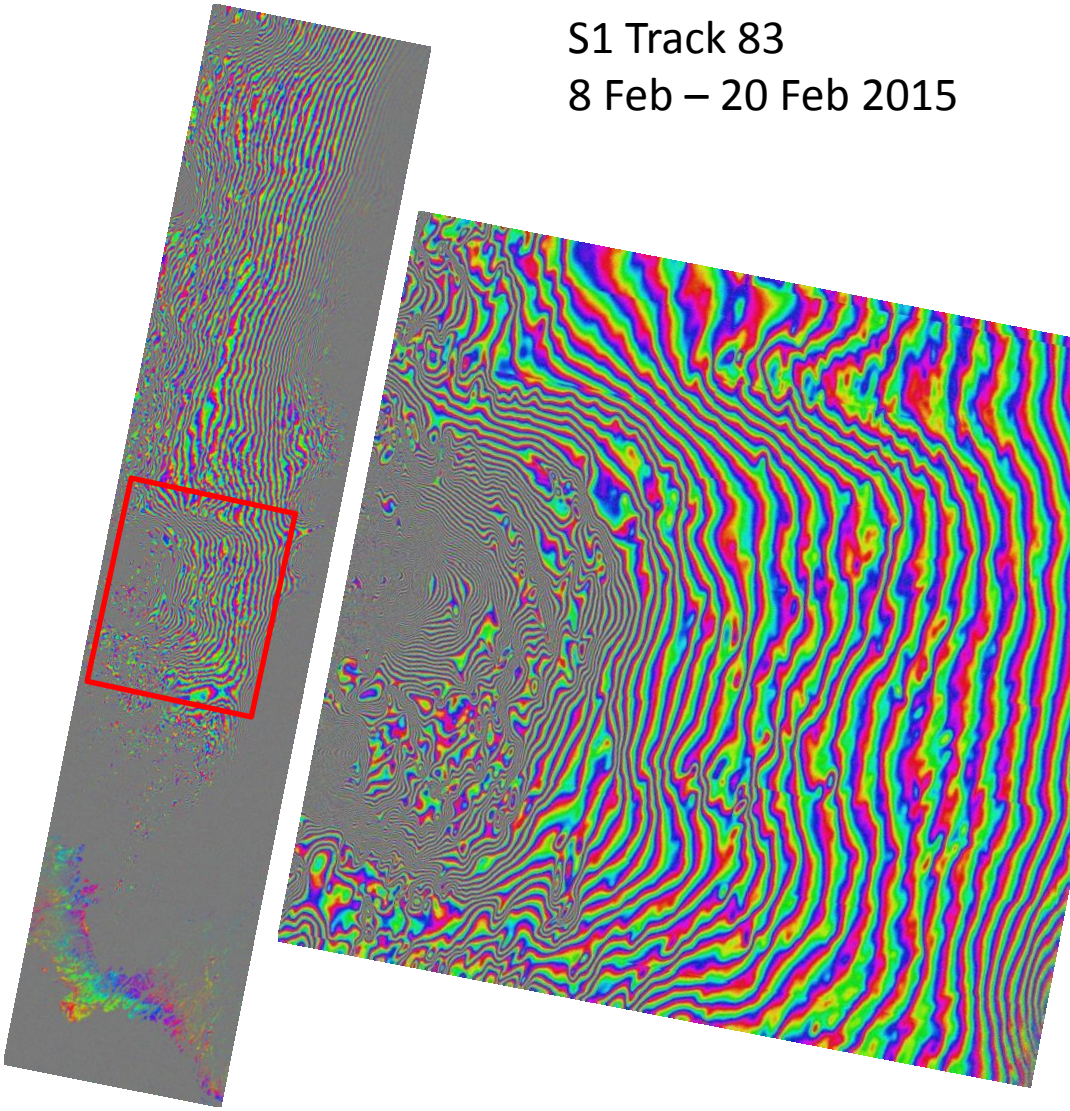




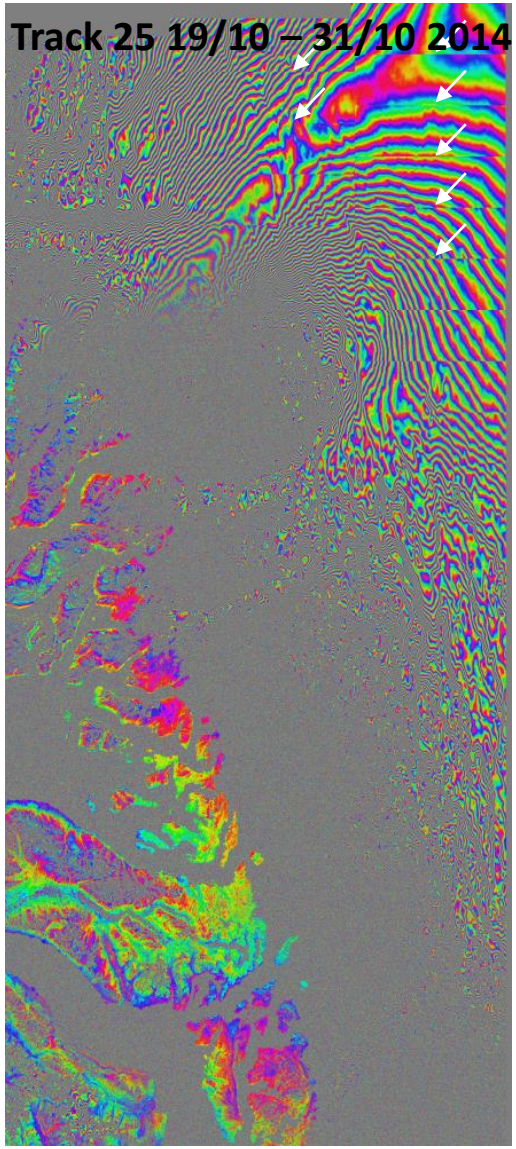
12 days Coherence over GIS



S1 Track 83
8 Feb – 20 Feb 2015



Examples for 12 days Interferograms

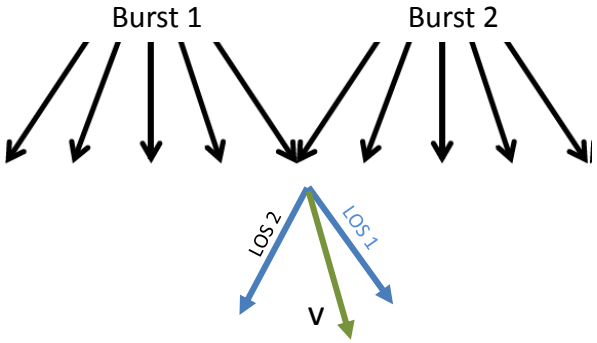


Coregistration:

- Geometric
- Precise orbits

Icesheet

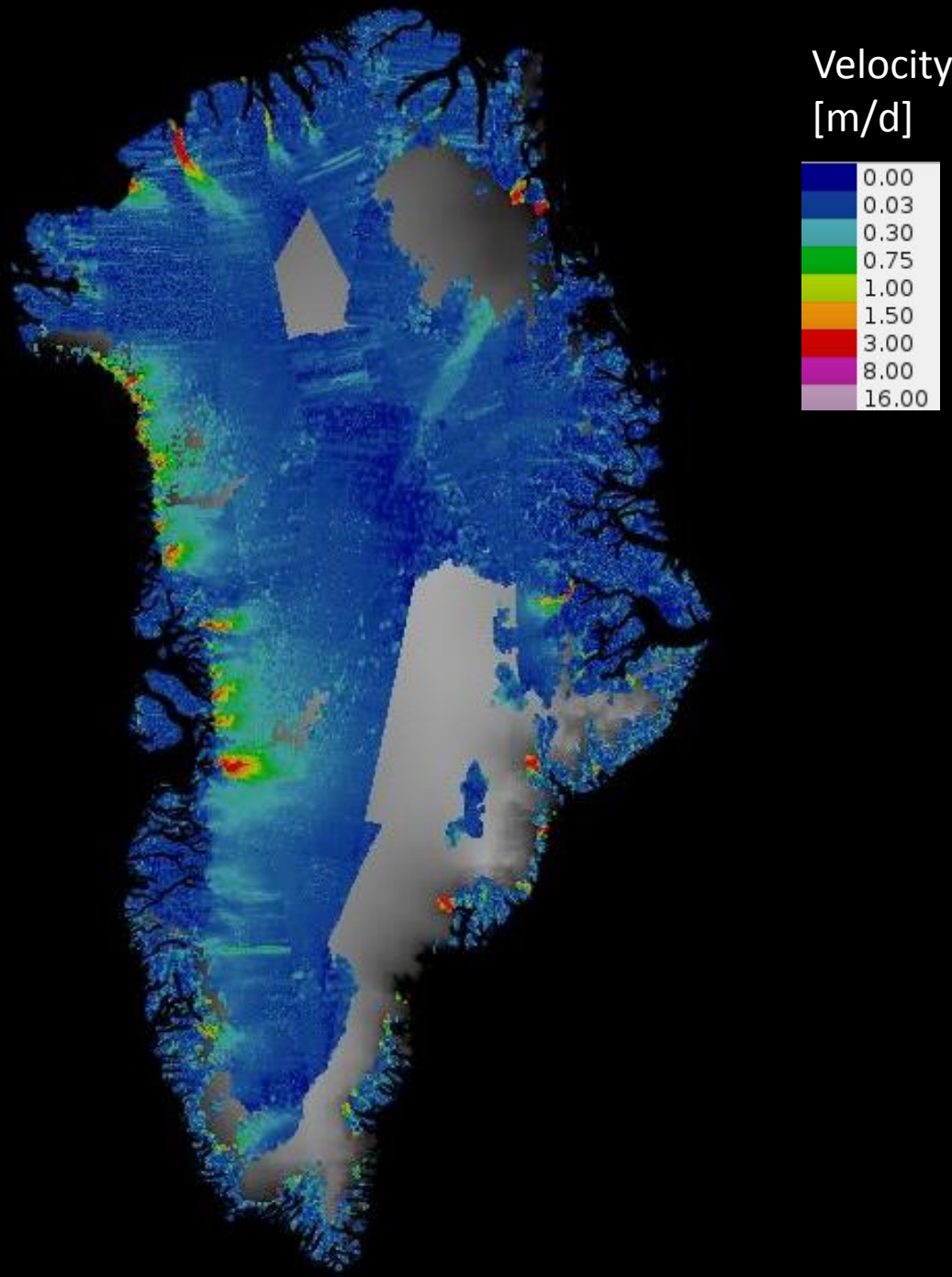
- Fringes well developed over some regions
- Significant phase jumps at burst and swath interfaces might occur:
  - Azimuth motion
  - Different LOS direction at burst interfaces



- Further developments needed to use this information

Greenland Ice Sheet

Sentinel-1 Ice Surface Velocity Map v_h



Sentinel 1 IWS SLC
Period: Jan-Mar 2015
(some scenes Oct-Dec 2014)
~700 Scenes
~19 000 bursts

Summary and Conclusions

- Sentinel-1 IWS has excellent capabilities for regular repeat mapping of ice sheets velocities.
- Ice velocity maps from Sentinel-1 IWS agree very well with TerraSAR-X data acquired at the same period. Main differences are observed in shear zones, where higher resolution provides better results.
- SAR TOPS Interferometry: during winter coherence over 12 days is suitable for generating interferograms. Further developments are needed to retrieve velocity from TOPS InSAR to compensate for variable LOS direction within bursts and phase jumps at burst interfaces due to azimuth motion.
- 1st Sentinel-1 velocity map of Greenland has been generated using data from January to March acquisitions (3 repeat acquisitions for most tracks). We recommend to acquire at least 2 independent repeat image pairs per campaign.