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InSAR and Antarctic ice dynamics

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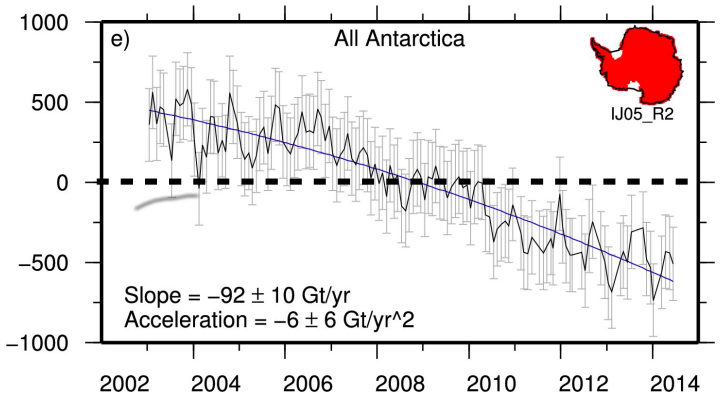
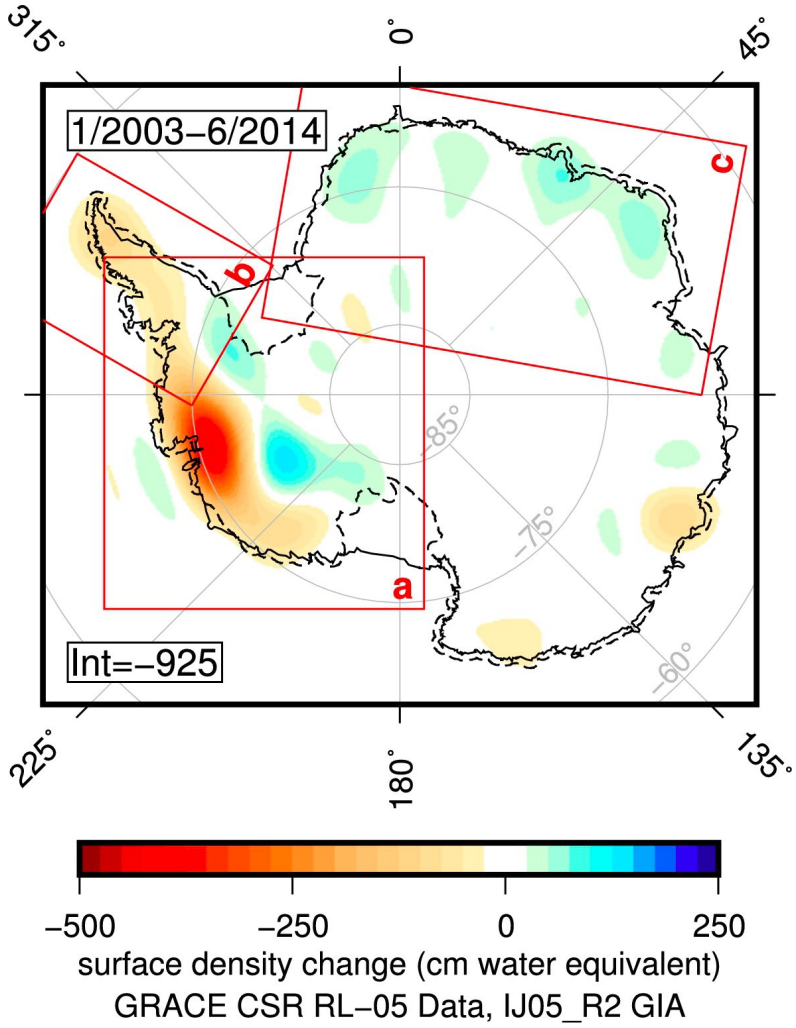
Dark Side of Remote Sensing 2015

Antarctica

- Antarctica losing mass
  → Sea Level Rise
  (0.4 mm/yr)
- Large uncertainties
- Projections: feedbacks





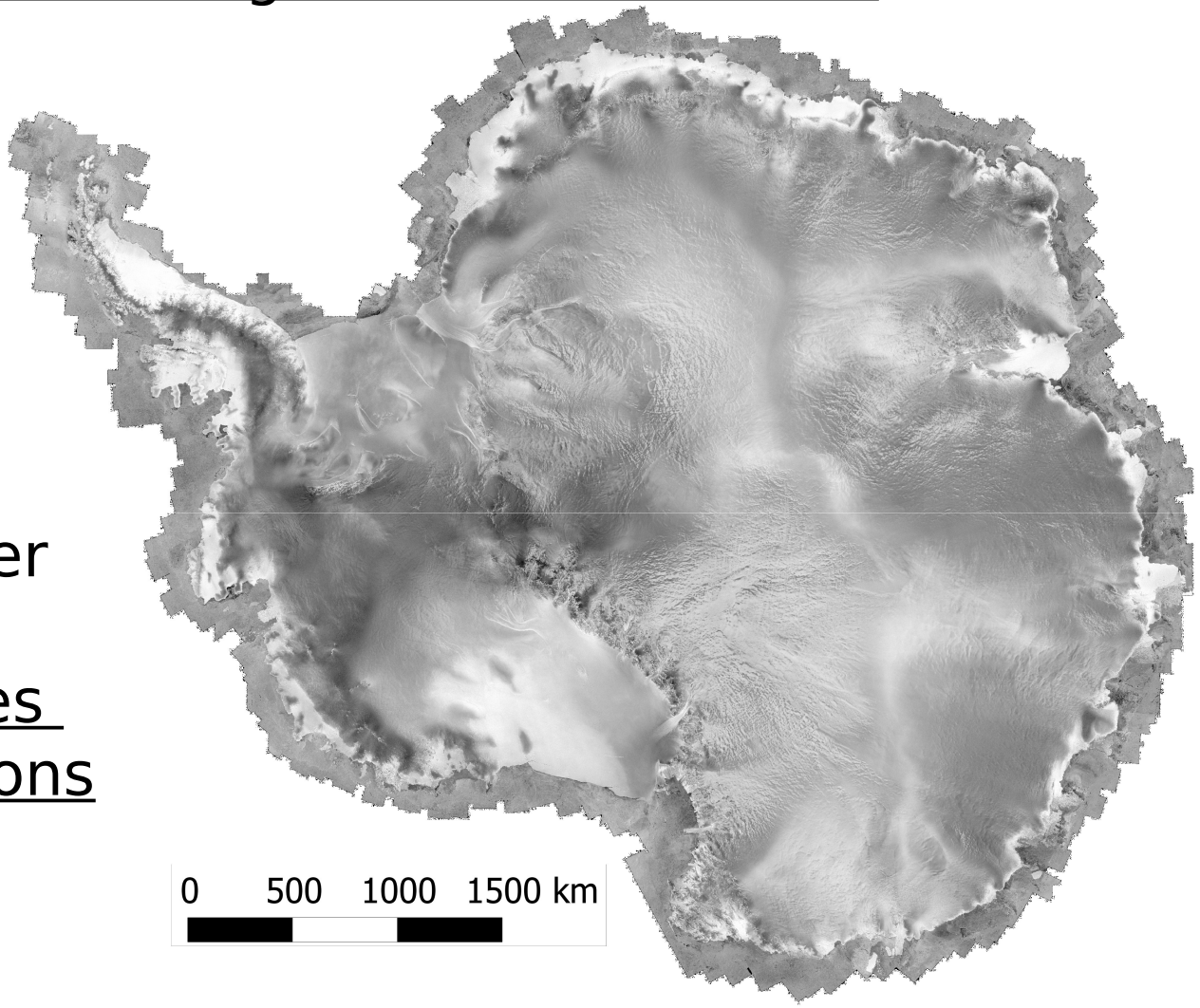
(Harig and Simons. 2015)

Satellite SAR

Major asset for monitoring Antarctic Ice Sheet

- Satellite
  - -continent coverage
  - -time series
- SAR
  - - polar winter
  - - polar cloud cover

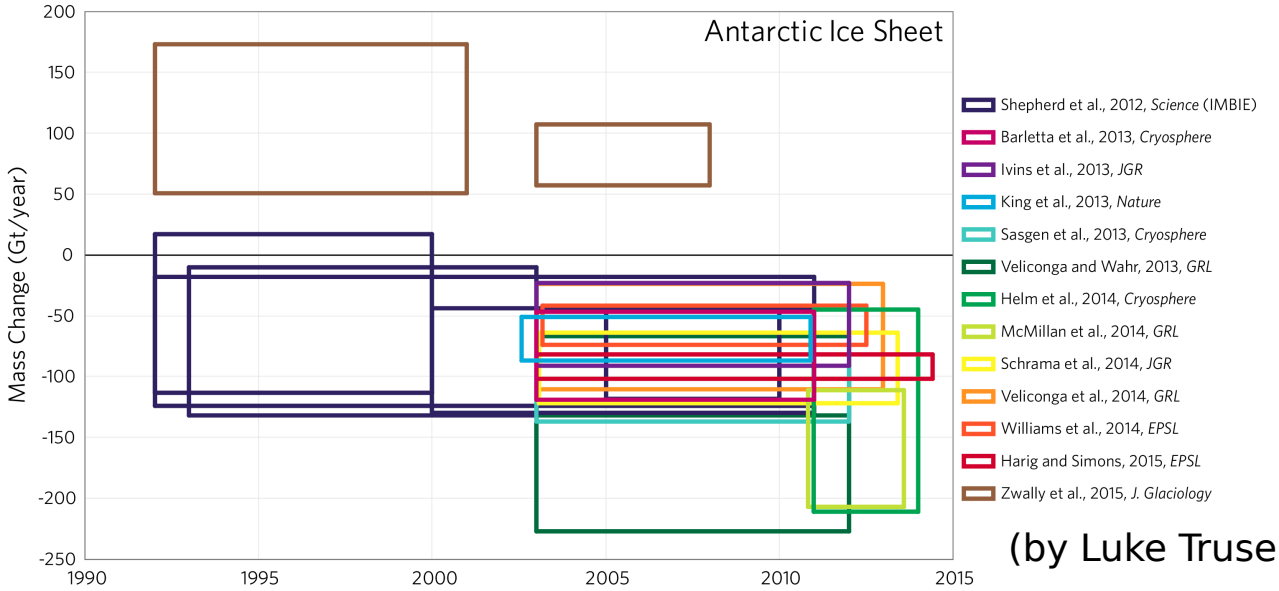
→ current changes
+ model predictions



(Jezek and RAMP-product team 2002)

Antarctic Mass Balance

Large Uncertainties



(by Luke Trusel)

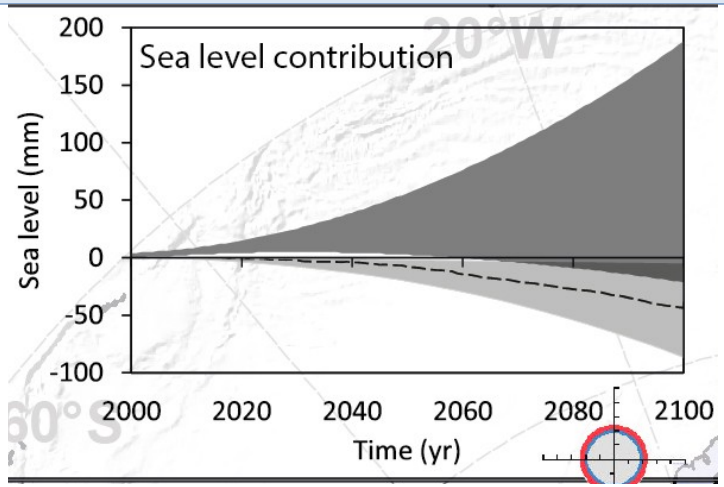
- Satellite Gravimetry

- Satellite Altimetry

- Input-Ouput method:
  Net accumulation – Discharge at Grounding Line

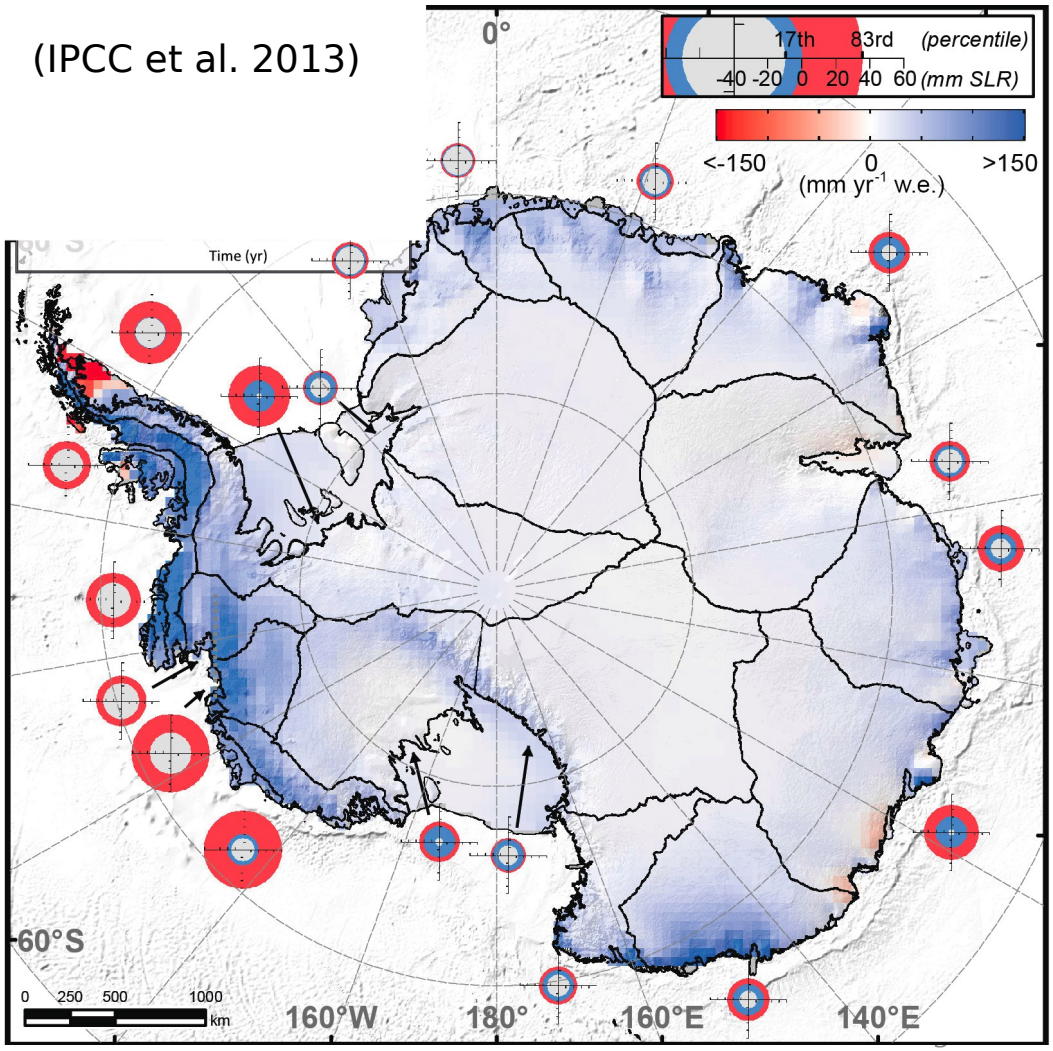
SAR

Projecting future mass loss



Area : Surface Mass Balance – Circle : outflow

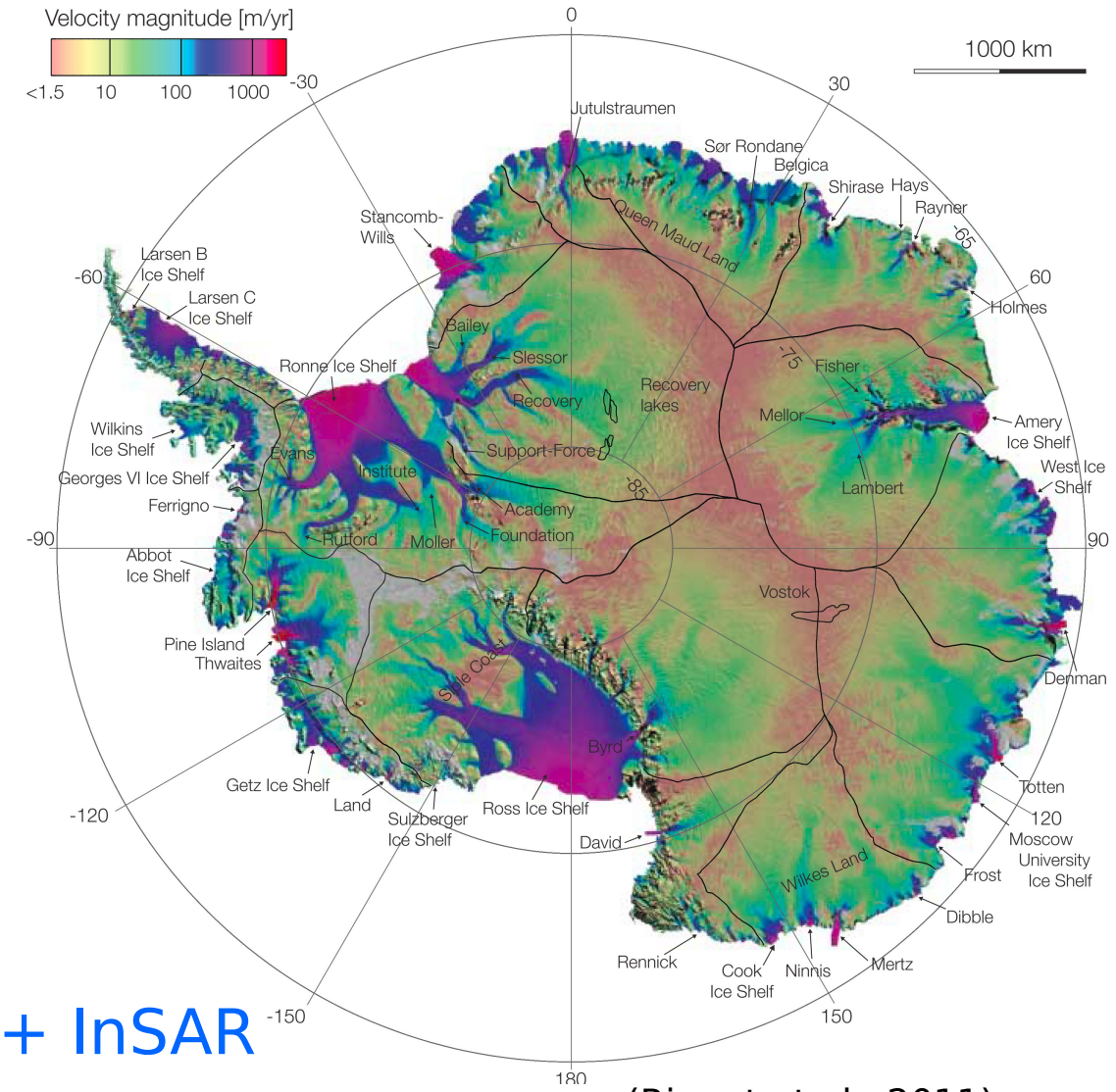
(IPCC et al. 2013)



- Ice sheet models
- Observations:
  - Validation
  - Initialization (inversion)

Observations needed

- Ice velocities
- dv/dt
- Ice elevation (thickness)
- dh/dt
- Calving front + change
- Grounding line position + change



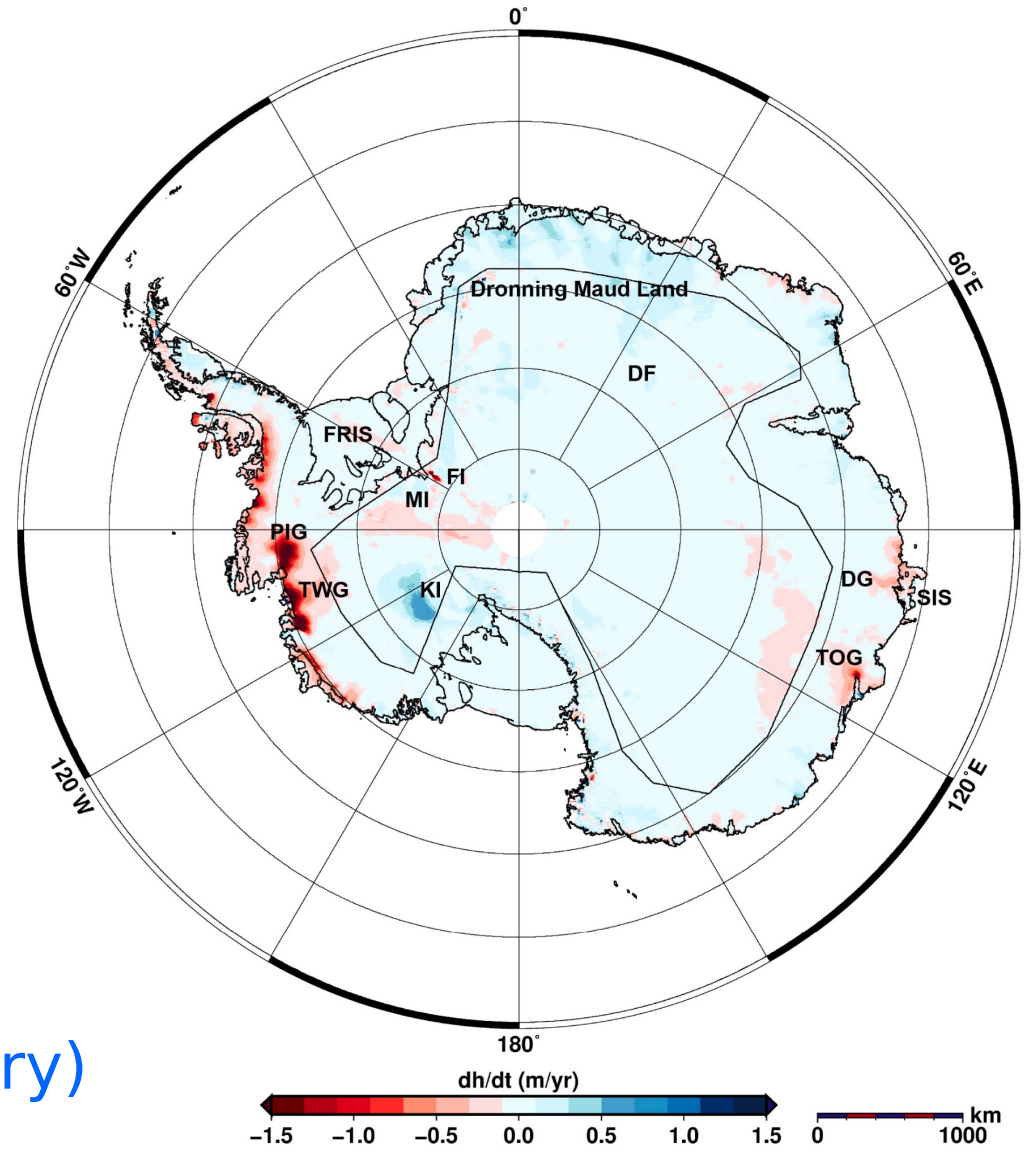
(Rignot et al., 2011)

→ Speckle tracking + InSAR

Observations needed

- Ice velocities
- dv/dt
- Ice elevation (thickness)
- dh/dt
- Calving front + change
- Grounding line position + change

→ Radar altimetry (SAR + Interferometry)



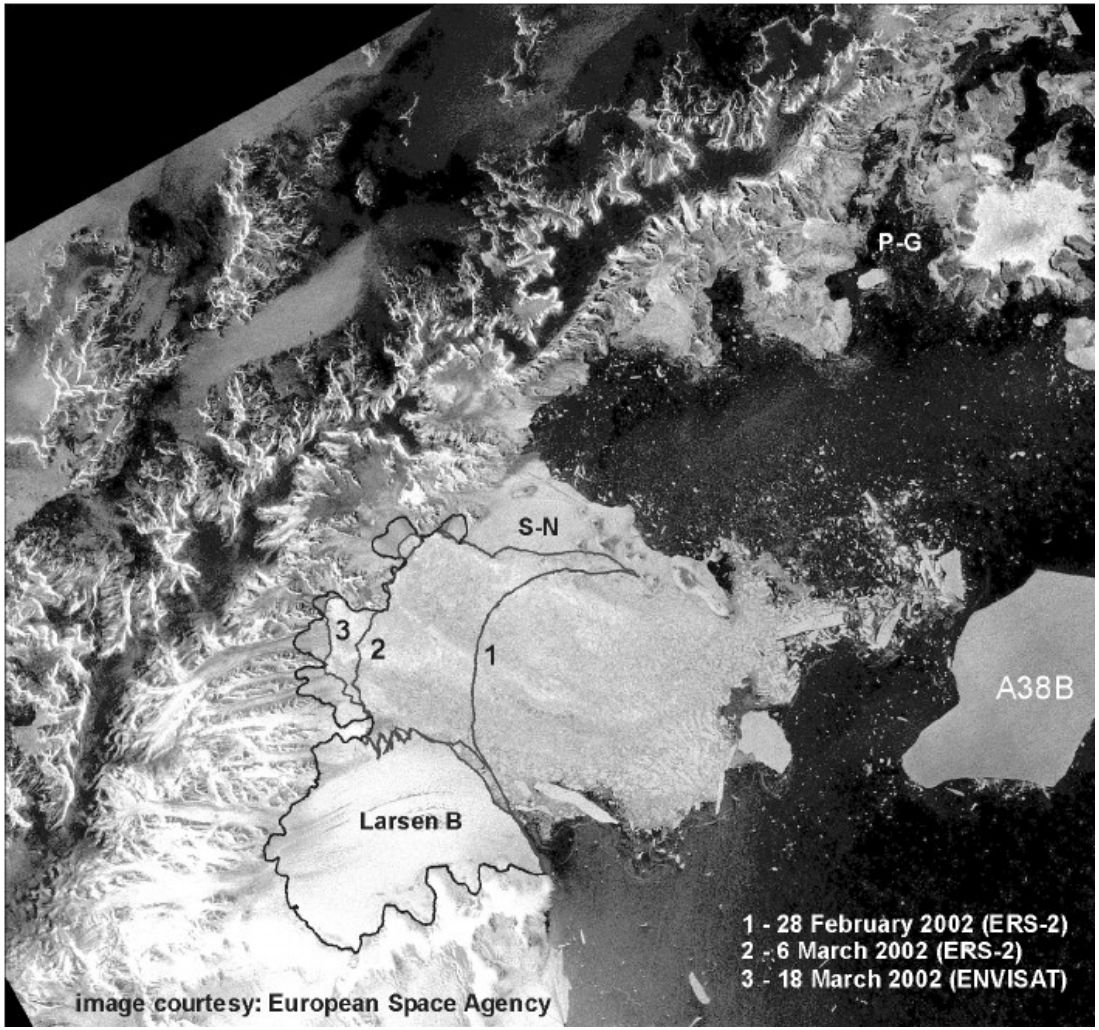
(Helm et al., 2014)

Observations needed

- Ice velocities
- dv/dt
- Ice elevation (thickness)
- dh/dt
- Calving front + change
- Grounding line position + change

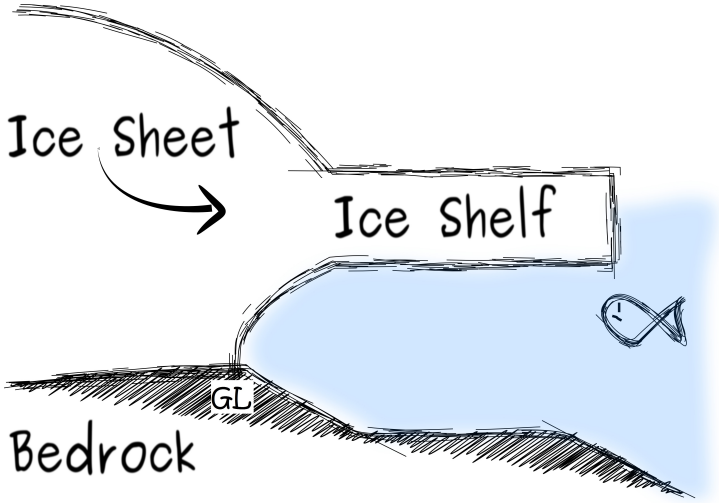
→ SAR imagery

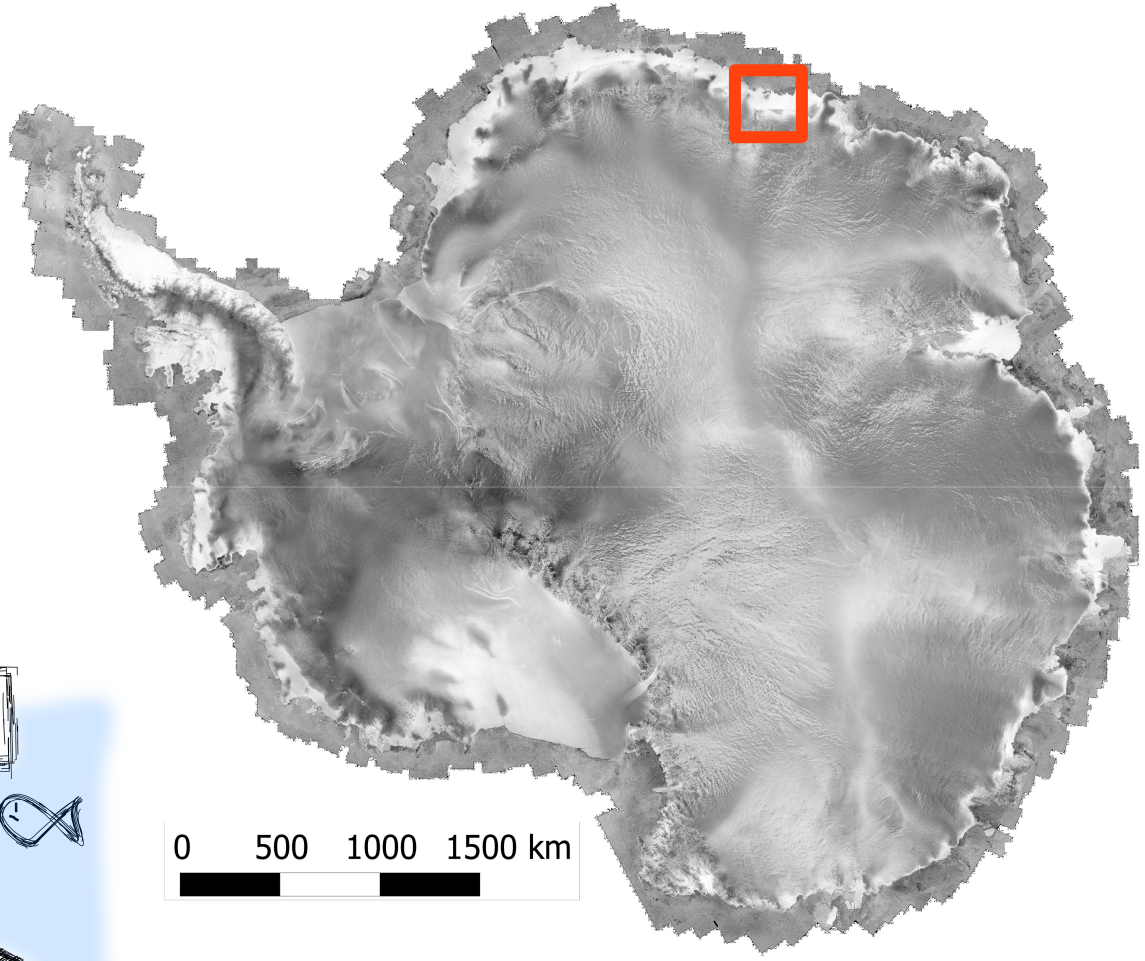
Disintegration of Larsen B



(Rack et Rott., 2003)

Roi Baudouin Ice Shelf



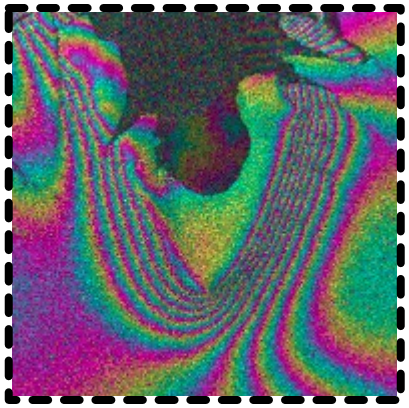


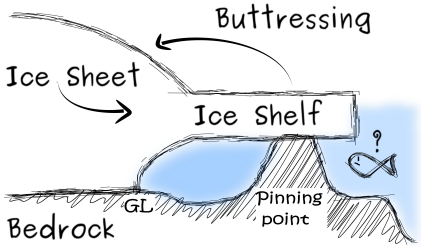
Radarsat mosaic (Jezek and RAMP, 2002)

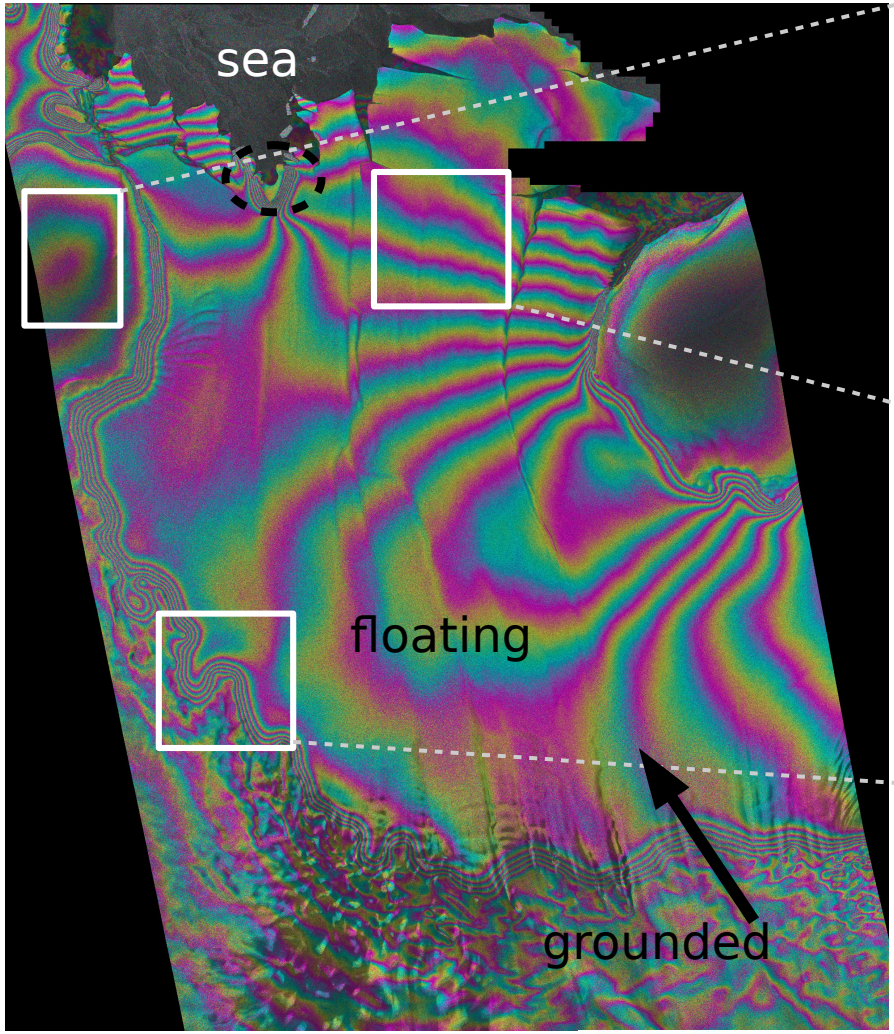
RBIS: Interferogram

Flattened interferogram

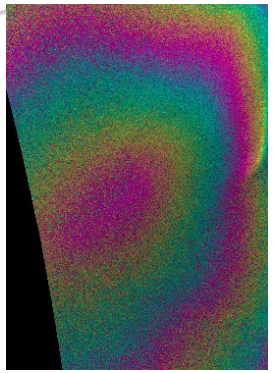
- ERS 1/2
- 1 day apart
- 1996



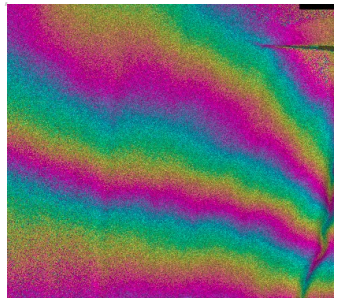




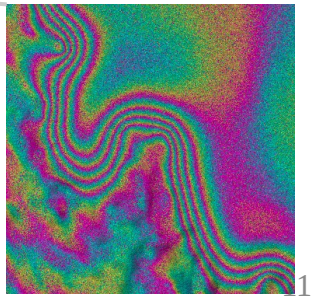
Topographic fringes



Motion fringes



Tidal fringes



(I.a) Ice velocity

1) InSAR
- ERS 1/2 of 1996
- Remove topography
- grounded vs floating
- Ascending + descending
- 50m

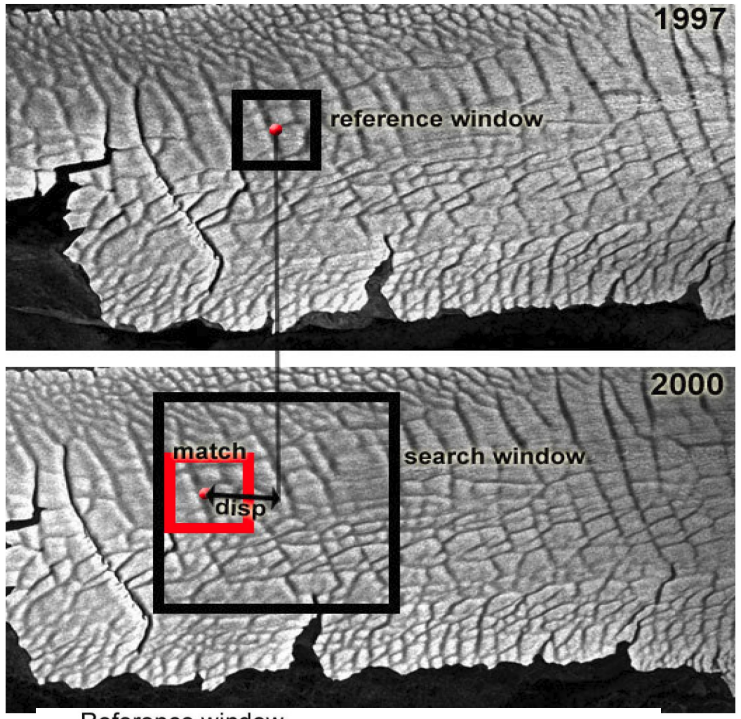
2) Speckle tracking

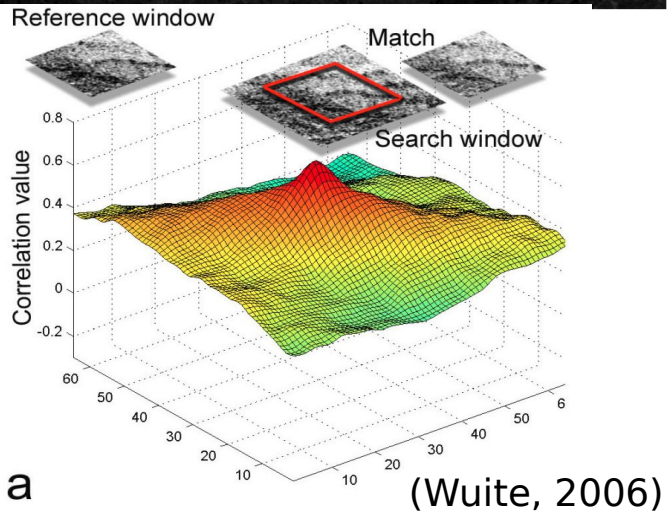
≈ Feature tracking

(i) co-registration

(ii) Cross-correlation of intensity

→ 2D displacement
- ALOS-PALSAR of 2010
- 125m





(Wuite, 2006)

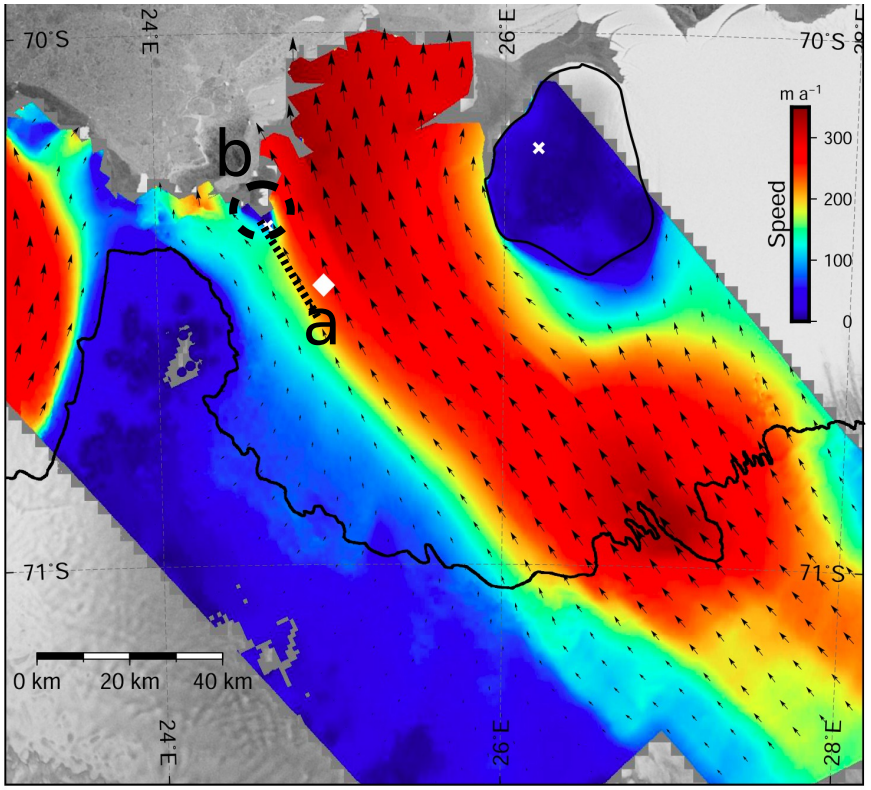
(I.a) Ice velocity

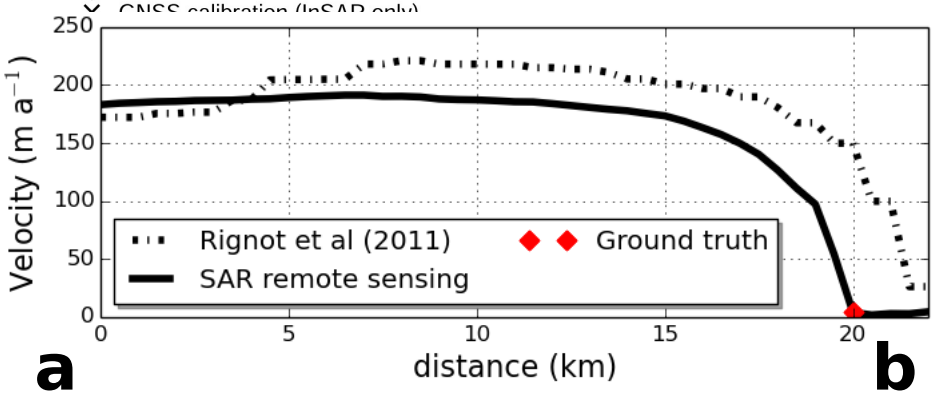
1) InSAR
   - ERS 1/2 of 1996
   - 50 m

2) Speckle tracking
   - ALOS-PALSAR of 2010
   - 125 m

3) Mosaic
   - 125 m

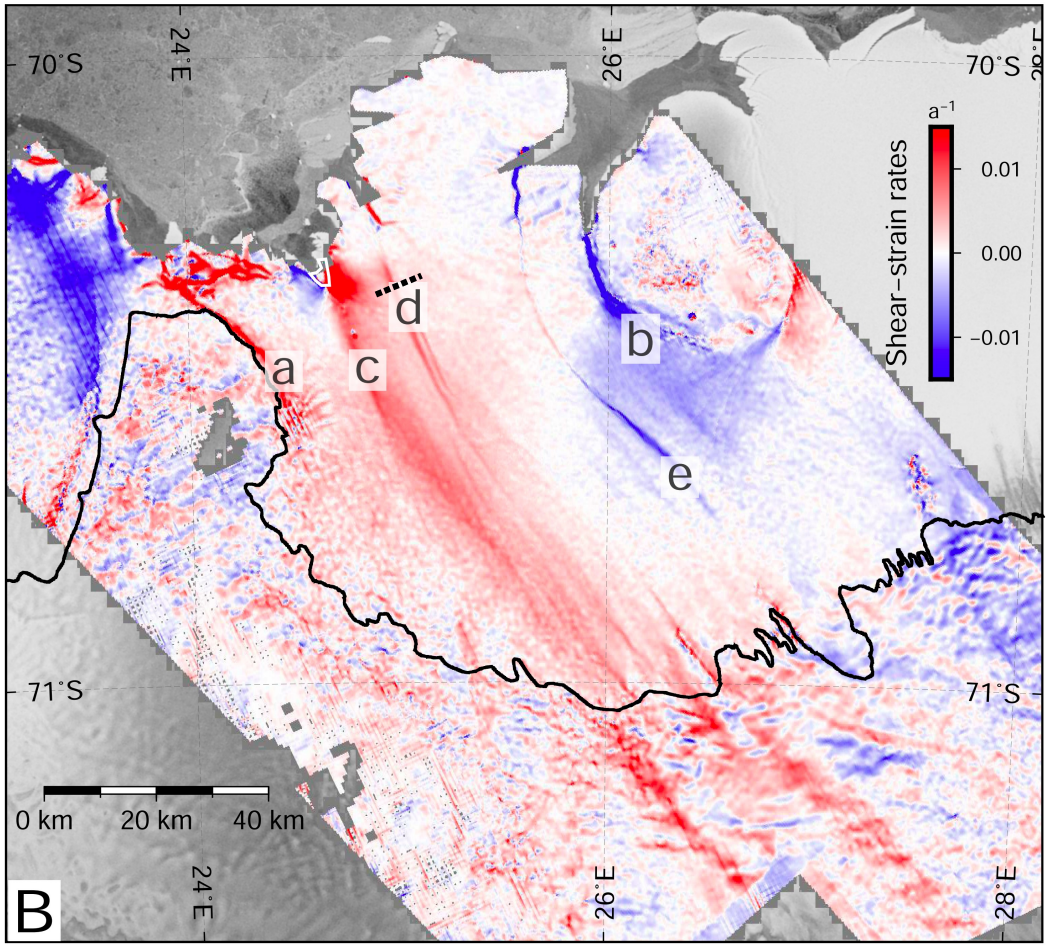
(vs 900m, continent-wide)
   - Error to GPS (37 points):
     -5.2 ± 4.5 m a^{-1}

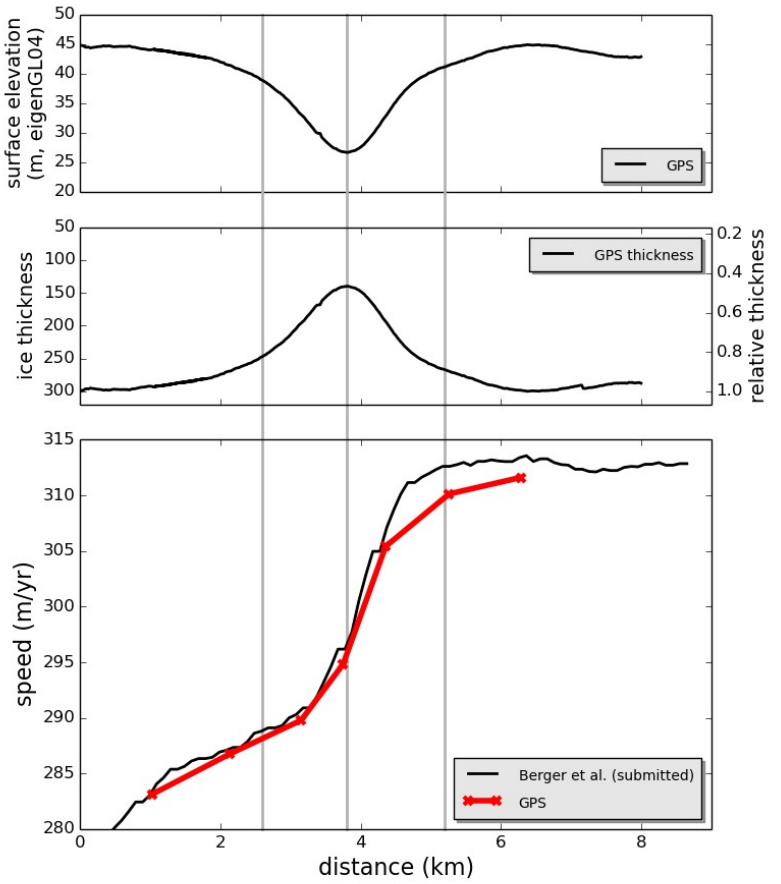




(I.b) Use of velocities

(1) Shear-strain rates





(Berger et al, in rev)

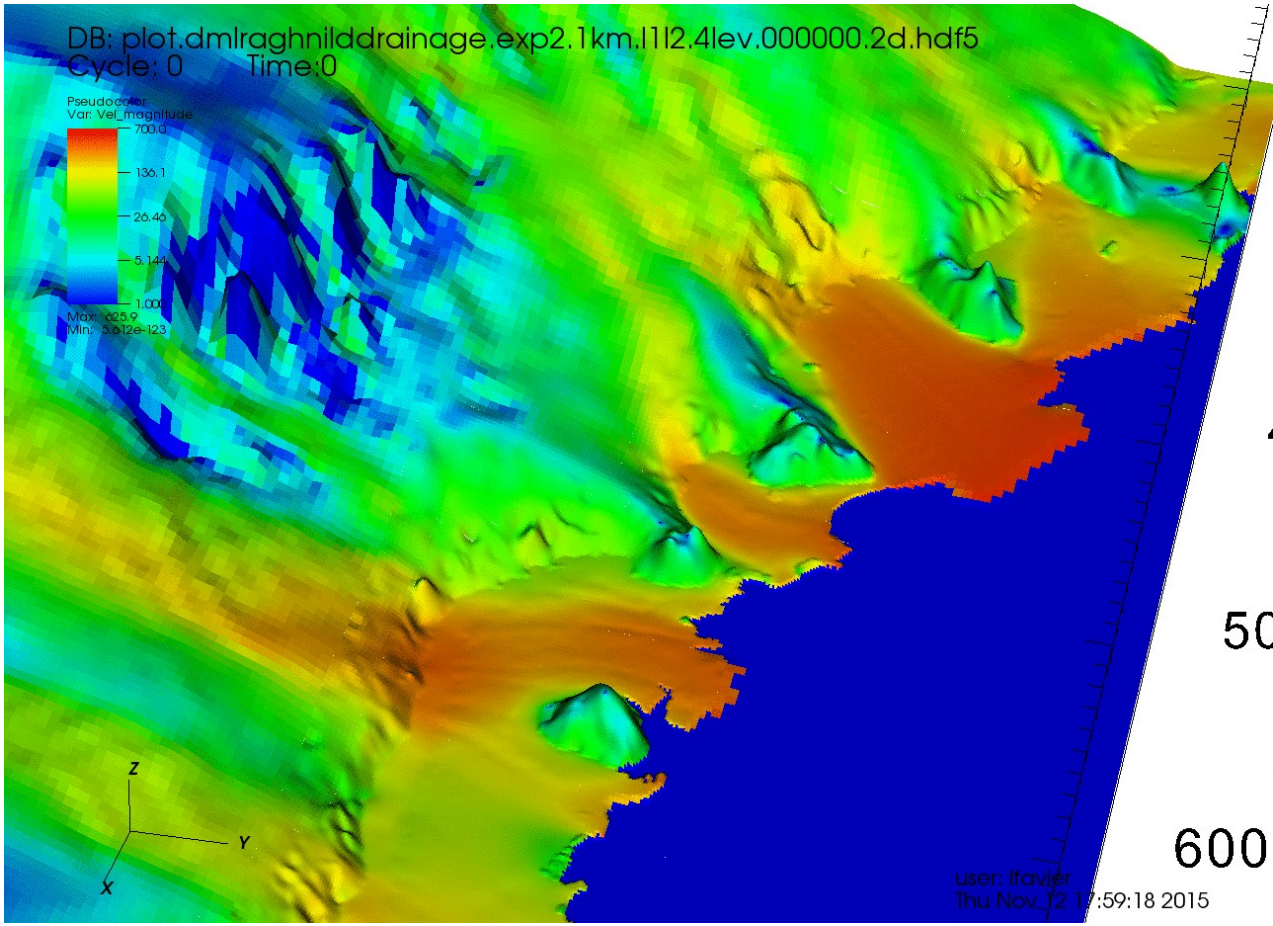
(I.b) Use of velocities

(2) Ice flow model

Observed velocity inverted for:

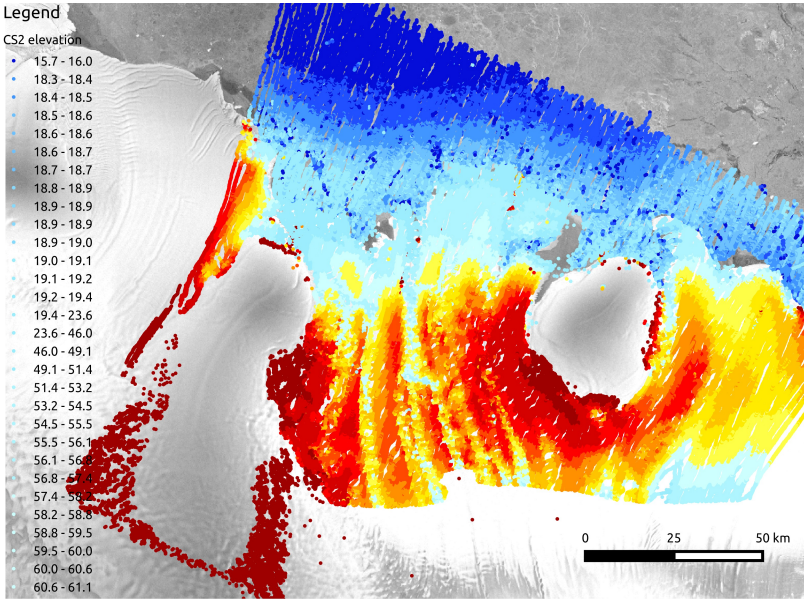
- Ice rigidity
- Basal friction

Prognostic modelling

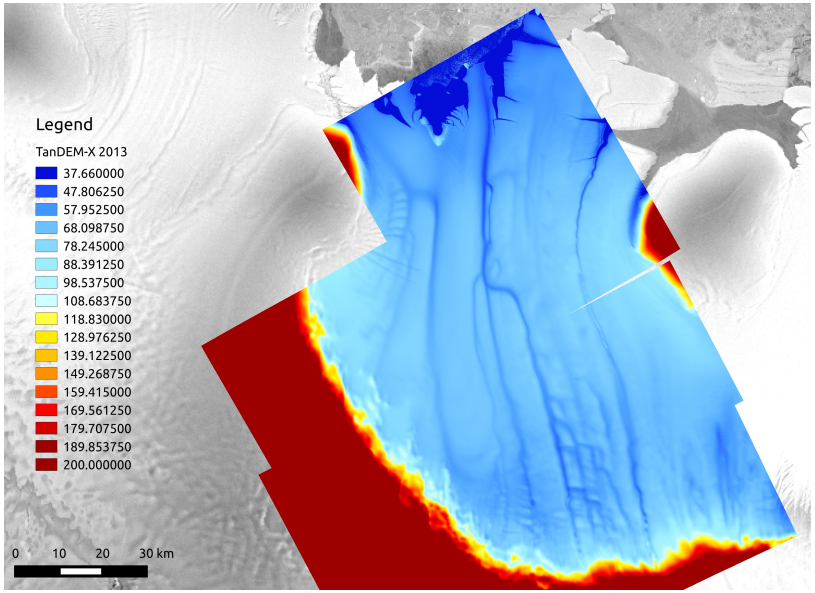


(II.a) Ice Topography

1) InSAR :
   - TandemX of 2013 & 2014
   - 10 m (vs 900m, continent-wide)
2) Radar Altimetry: Cryosat 2 of 2012-...



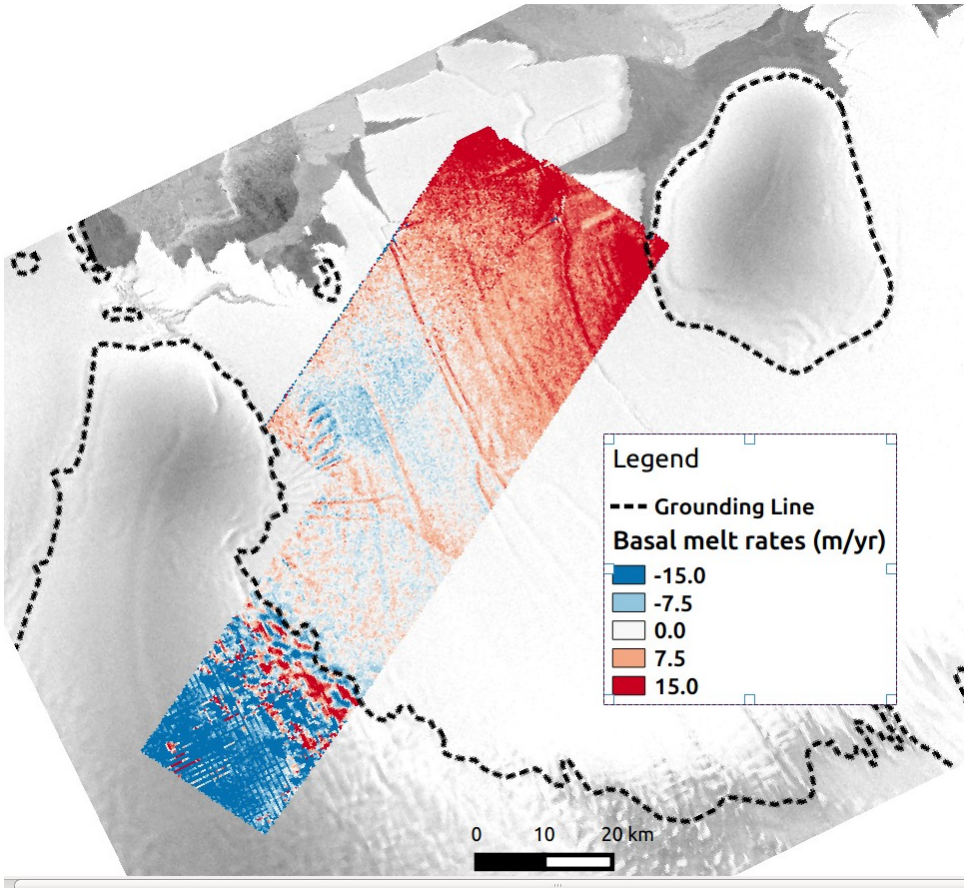
Cryosat2



TandemX (2013)

(II.b) Use of Topography

DH/DT
Mass conservation
→ Basalt melt-rates



Outlook

- SAR to study ice dynamics in Antarctica
    - Essential
    - Many applications
    - Still under-development

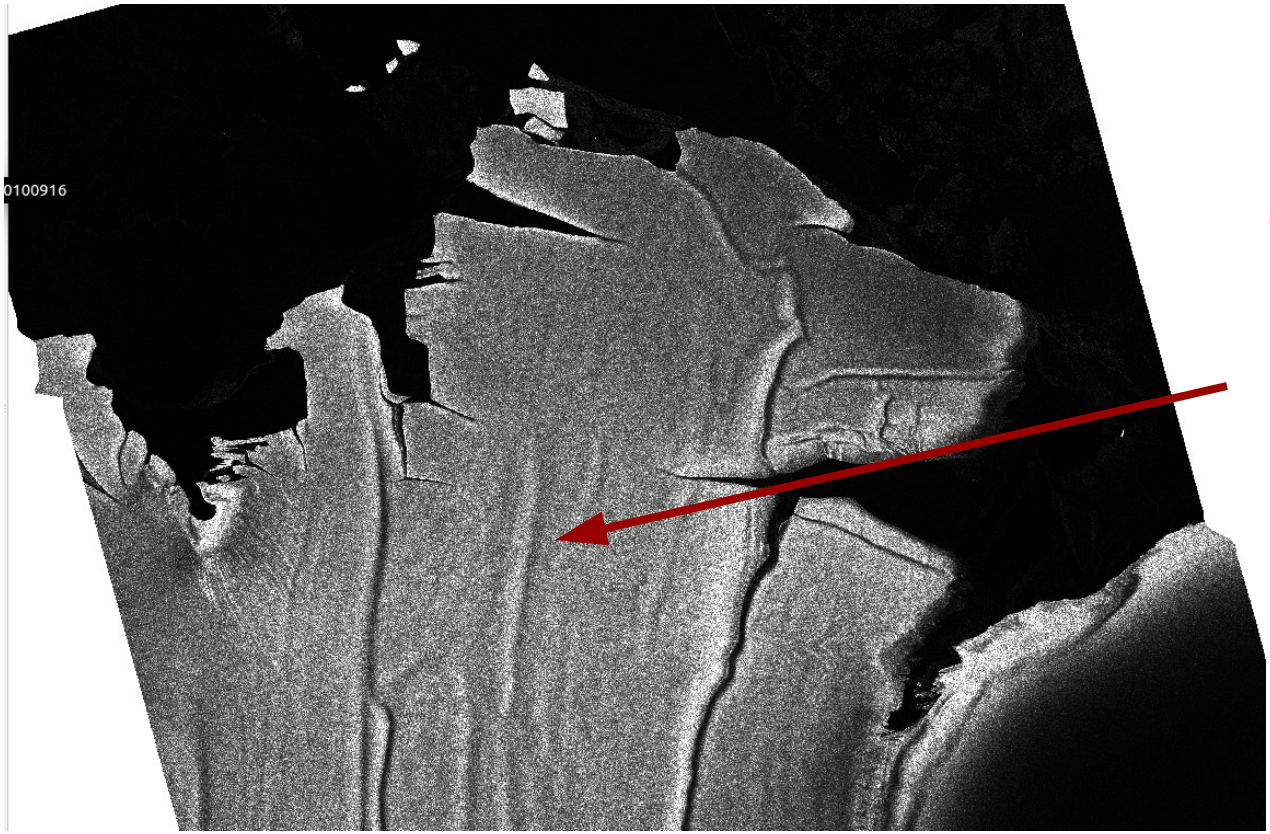
<u>Limitations :</u>

- Access to suitable data
    - Coherence
    - Ascending-descending
    - Price/proposals
- Lack of control/calibration points

Take-home message

Always look at the bright side of life

SAR



Because it is (n)ice