2018 AGU Fall Meeting: C21B-1313

OSPA participant

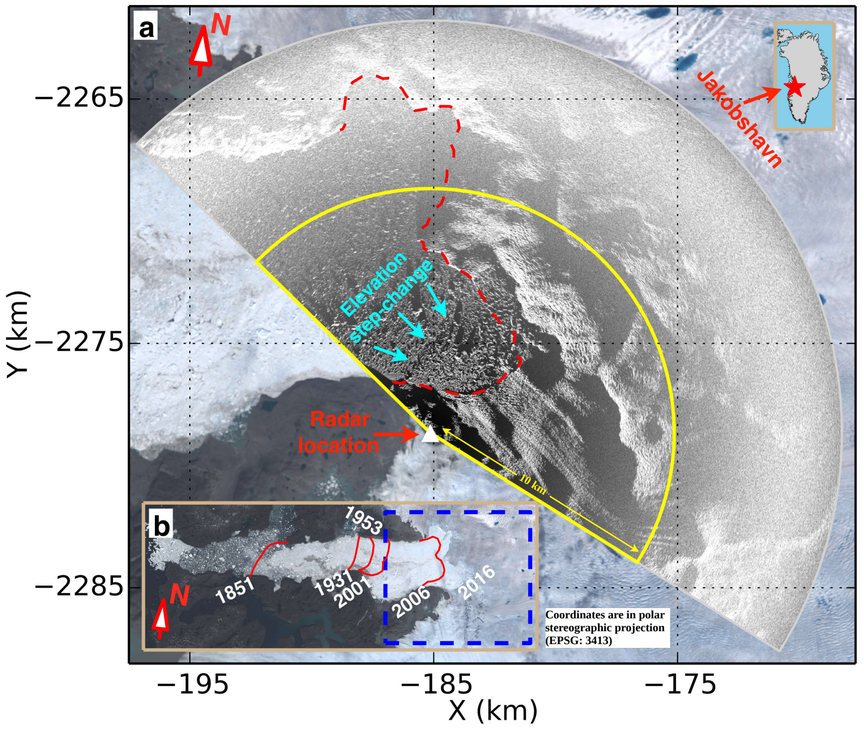
Rapid iceberg calving following removal of tightly packed pro-glacial mélange at Jakobshavn Isbræ, Greenland

Surui Xie[1], Timothy H Dixon[1], David M Holland[2,3], Denis Voytenko[1], Irena Vaňková[2,3]

1. School of Geosciences, University of South Florida, Tampa, FL, USA 2. Courant Institute of Mathematical Sciences, New York University, New York, NY, USA 3. Center for Global Sea Level Change, New York University, Abu Dhabi, UAE Correspondence: SX <suruixie@mail.usf.edu>

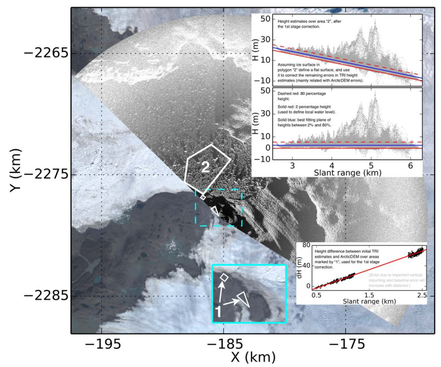
Abstract:

- A new radar-based approach was developed to estimate time-varying elevations near the terminus of Jakobshavn Isbræ.
- No major calving events occurred at Jakobshavn Isbræ over a one-month period from late May to late June 2016.
- An unusually thick mélange wedge that increases in thickness towards the glacier front was observed.
- The extent and thickness of the mélange wedge gradually decreased and large-scale calving began after significant reduction of buttressing force.



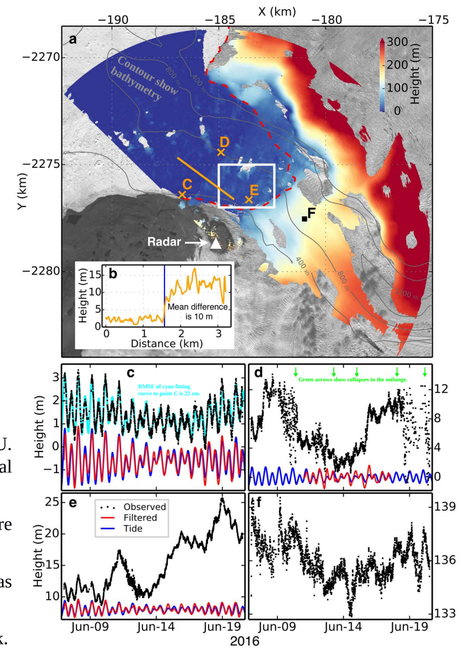
TRI set-up at Jakobshavn Isbræ:

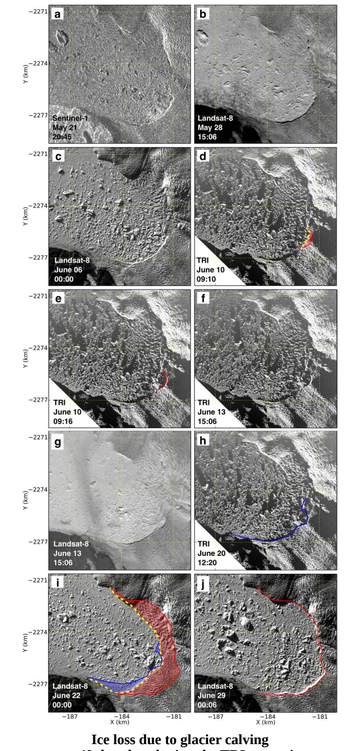
1) The terrestrial radar interferometer (TRI) used is a real-aperture radar operating at Ku-band (1.74 cm wavelength), and is sensitive to line-of-sight (LOS) displacement of ~1 mm.
2) The antennas are rigidly attached to a rack structure, which sits on a motor that rotates around a fixed vertical axis. The instrument was protected by a radome to eliminate disturbance from wind and rain.
3) Scanned arc: 170°; Repeat time: 2 min; Maximum distance: ~17 km; Campaign period: 7 June to 20 June in 2016.
4) The resolution of range measurement is ~1 m, the azimuth resolution varies linearly with distance. All results were resampled into 10 m × 10 m pixel spacing maps.
5) To minimize water vapor effects, data within 10 km of the radar were used.



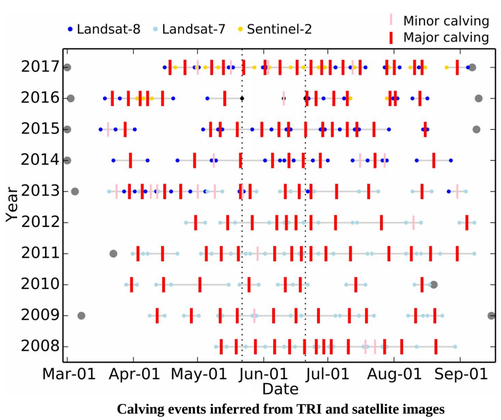
TRI-derived elevations:

1) Use the ArcticDEM (Polar Geospatial Center at U. Minnesota) to correct errors due to imperfect vertical mounting of radar and baseline error.
2) Tide-induced elevation changes of the the mélange are well represented by TRI-derived elevation time series.
3) A 10 m elevation step-change in the mélange was observed.
4) The mélange was unusually thick, hundreds of m thick.





Ice loss due to glacier calving over 40 days bracketing the TRI campaign.

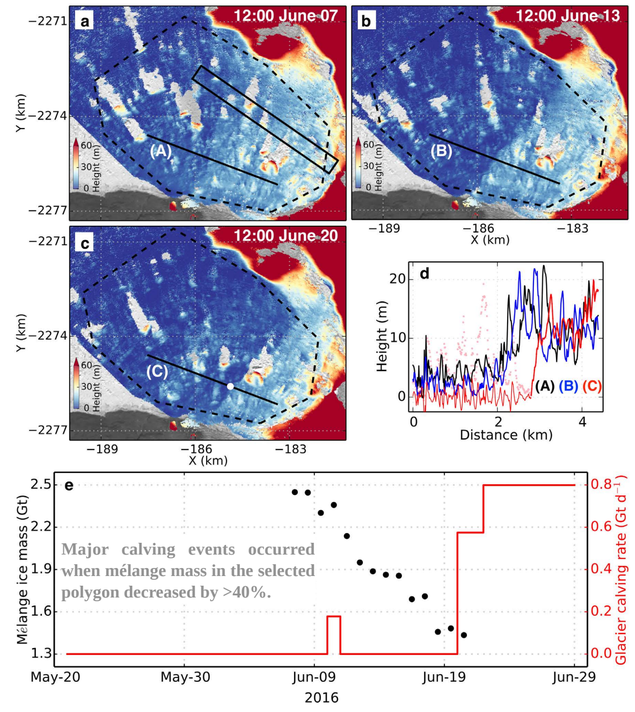


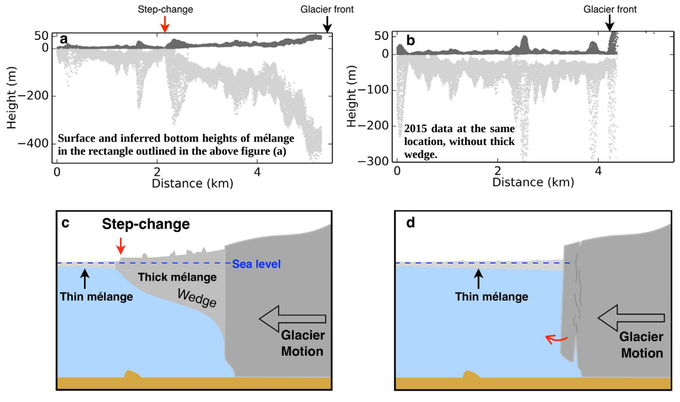
Calving events inferred from TRI and satellite images

A period of glacier quiescence:

1) In a month between 21 May 2016 and 20 June 2016, no major calving events (defined as block size >0.25 km^2 and causing significant mélange motion) occurred. This is unusually long compared to other years at the same time of year.
2) A sequence of calving-like events (collapses of tightly-packed mélange) moved the elevation step-change towards the glacier.
3) Major calving events occurred when large amount of mélange advected away by calving-like collapses.

For elevation change and calving-like collapse movies, please watch on Surui's tablet.





Our conclusion: Thick pro-glacial mélange suppresses iceberg calving.

References

Amundson et al. (2010) Ice mélange dynamics and implications for terminus stability, Jakobshavn Isbræ, Greenland. *J. Geophys. Res.*
Amundson & Burton (2018) Quasi-static granular flow of ice mélange, *J. Geophys. Res. Earth Surf.*
Burton et al. (2018) Quantifying flow and stress in ice mélange, the world's largest granular material. *Proc. Natl. Acad. Sci. USA.*
Cassotto et al. (2015) Seasonal and interannual variations in ice melange and its impact on terminus stability, Jakobshavn Isbræ, Greenland. *J. Glaciol.*
Holland et al. (2008) Acceleration of Jakobshavn Isbræ triggered by warm subsurface ocean waters, Nat. Geosci.
Voytenko et al. (2015) Multi-year observations of Breiðamerkurjökull, a marine-terminating glacier in southeastern Iceland, using terrestrial radar interferometry, J. Glaciol.
Todd & Christoffersen (2014) Are seasonal calving dynamics forced by buttressing from ice mélange or undercutting by melting? Outcomes from full-Stokes simulations of Store Glacier, West Greenland. *The Cryosphere.*
Walter et al. (2012) Oceanic mechanical forcing of a marine-terminating Greenland glacier. *Ann. Glaciol.*
Werner et al. (2008) GAMMA's portable radar interferometer, Proc. 13th FIG Symp. Deform. Meas. Anal.
Xie et al. (revision submitted) Rapid iceberg calving following removal of tightly packed pro-glacial mélange.

Acknowledgements

Denise Holland at the Center for Global Sea Level Change in New York University Abu Dhabi organized the field logistics. Fanghui Deng at the University of South Florida is thanked for helpful discussions. This research was partially supported by NASA grant NNX12AK29G to T.H.D. D.M.H. acknowledges support from NYU Abu Dhabi grant G1204, NSF award ARC-1304137, and NASA Oceans Melting Greenland NNX15AD55G. ArcticDEM provided by the Polar Geospatial Center under NSF-OPP awards 1043681, 1559691, and 1542736.