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The evolution of a large glacier surge of Vavilov Ice Cap, Severnaya Zemlya, since 2013

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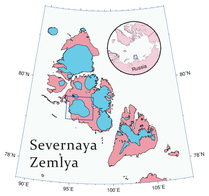
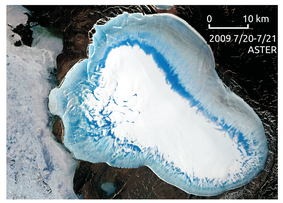
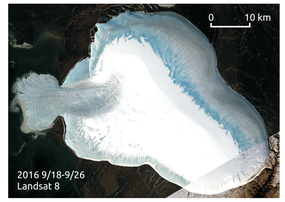
Background and motivation

- Vavilov Ice Cap, Severnaya Zemlya, Russia
  - Destabilized in 2013
  - Rapid change of velocity and elevation
  - Maximum speed of 26 m/day in early 2016
  - No previous surge records

Collapse Video
Youtube: "Vavilov Collapse"

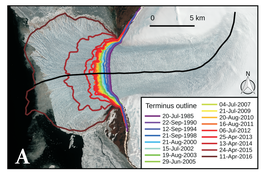


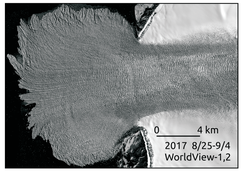


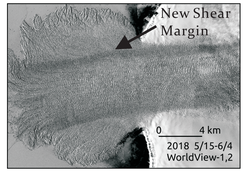


Is this a surge?
Or a birth of an ice stream?

Why did a new shear margin form in 2017/18?
The role of subglacial hydrology?
The role of calving front?
Why did the glacier speed up again in 2018?







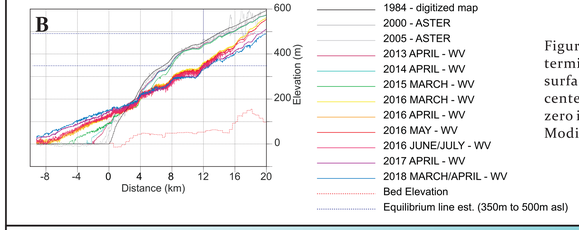
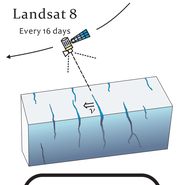


Figure. A) Propagation of the terminus; and B) the change of surface elevation at the glacier centerline over time. Distance zero is the 1985 frontal position. Modified from Willis et al. (2018).

Methods and datasets

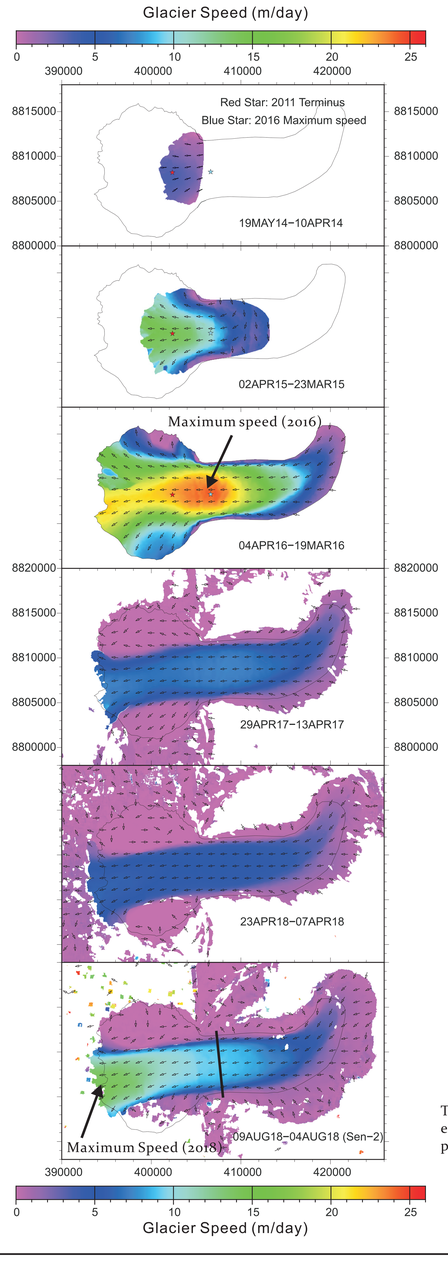
- Pixel Tracking: amplitude correlator in ISCE (Rosen et al., 2012) using:
  - Landsat 8 OLI-B8 (2013-18)
  - Sentinel-2 A/B Band 4 (2017-18), 5-day repeat
  - WorldView-1, -2, -3 (2015-18)
  - Future plan: including Sentinel-1 A/B for winter speed
- Elevations:
  - WorldView (WV)-1, -2, -3 (2015-18), 2-m DEMs processed by SETSM
  - ICESat returns over bare bock, used correct WV elevations
  - Bed elevations derived from airborne radio sounding, 25-m resolution
  - Russian cartographic map from 1984
- All methods available in CARST Software on Github



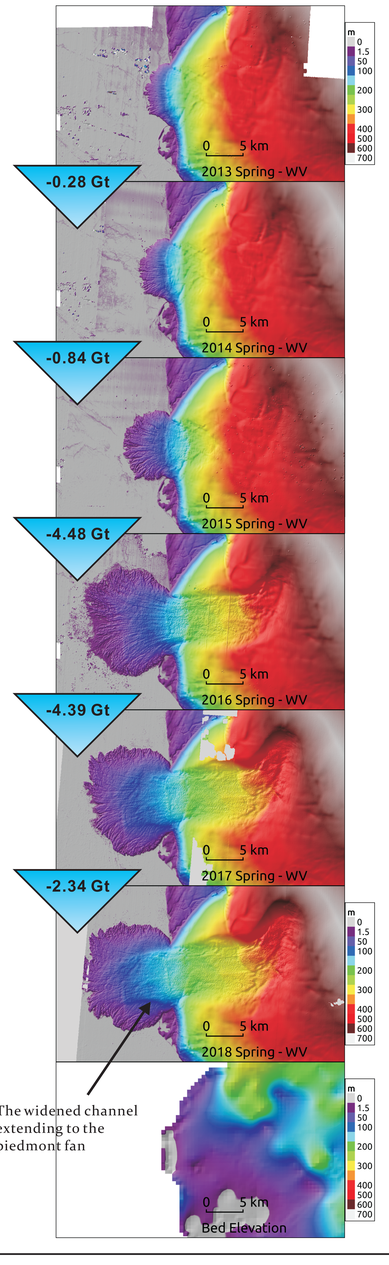
CARST on Github

Birth of an ice stream

Glacier Velocity



Elevation Change



Force balance model

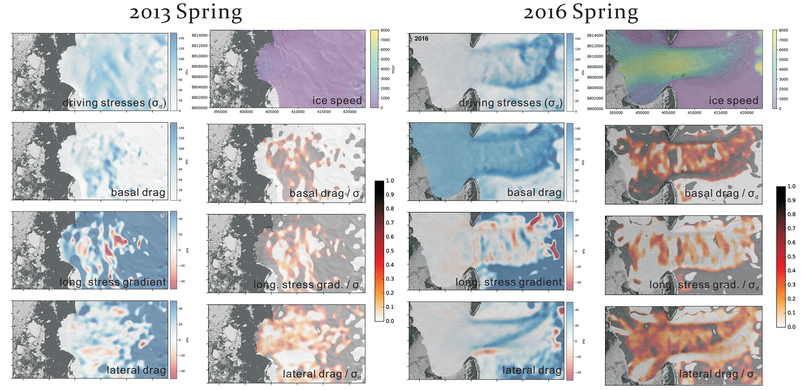


Figure. Components of the ice force balance model for 2013 spring and 2016 spring. Axes are in meters. Note how the spatial patterns of resistive forces vary over time, especially the increase of the ratio of lateral drag to driving stresses. From Willis et al. (2018). See Van Der Veen & Whillans (1989) for more details on the model.

Discussion

Evidence that the driving mechanism has changed:
- The shift in location of max speed in 2018
- New shear margins in the piedmont lobe
- Smaller width between shear margins
- Wider collapse channel

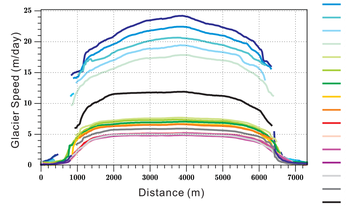


Figure. The change of glacial speed across the channel (profile indicated by a black line at the 2018 speed pattern) over time.

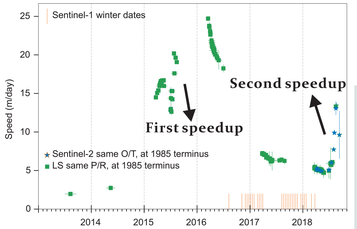


Figure. the evolution of the glacier speed over time. Note the speed dropped twice in the first speedup.

– 2013-16 speedup: the removal of buttress force (terminal moraine on land) at front
[Glacier mass unleashed]
– 2018 speedup: ocean-ice (calving?) dynamics, perhaps initiated when seawater temperate was high (or the removal of the buttress sea ice)
[Calving terminus pulled the ice steam]

Conclusion

- Both speedup events show features that don't fit to a surge pattern.
- In 2018 its marine-terminating front started to dominate the process of ice wasting - a mechanism that takes place at most ice streams.
- We propose a mechanism for fast mass wasting of land ice that can be triggered and maintained once the terminus reaches the ocean.

Refs.
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