

Recent results and products from remote sensing of ice sheet velocities

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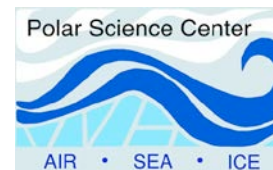
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³ *Institute for Marine and Atmospheric Research, Utrecht University*

⁴ *Geophysical Institute, University of Alaska, Fairbanks*

⁵ *Institute for the Study of Earth, Oceans, and Space, University of New Hampshire*

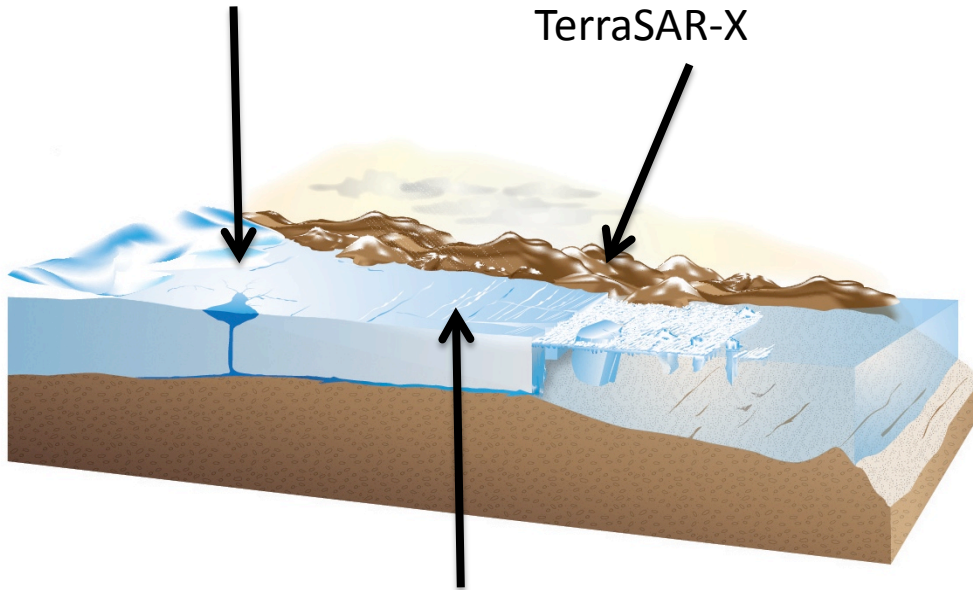


55 study glaciers: Marine-terminating, fast-flowing

Study period: 2009-2013

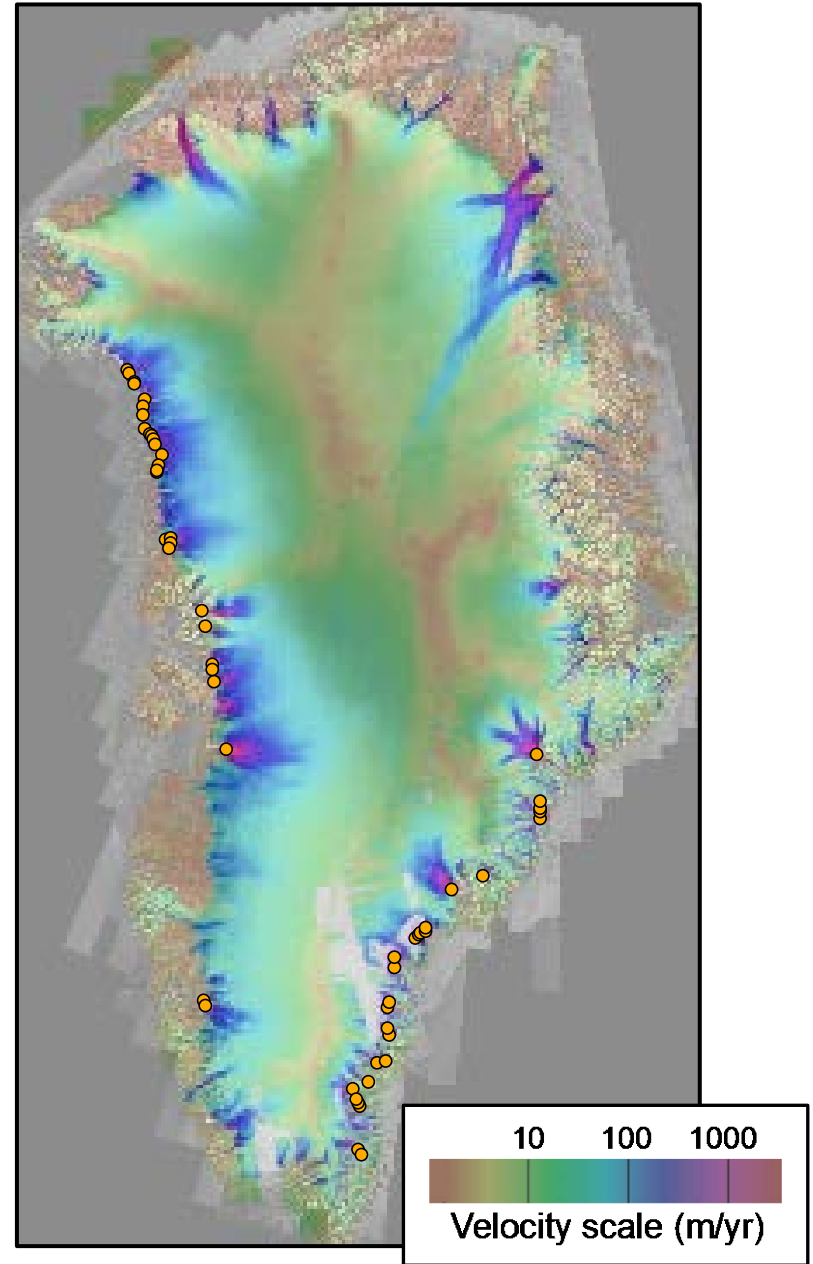
Runoff data:
RACMO2.3

Terminus data:
Landsat 7 and 8
TerraSAR-X



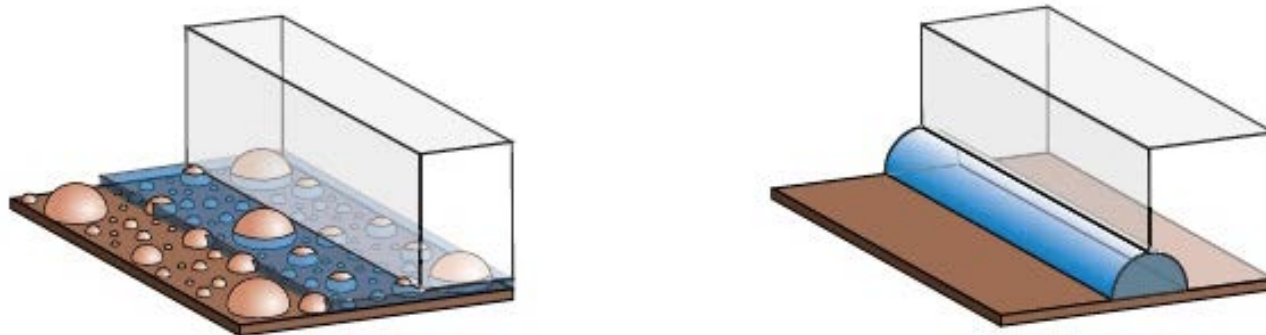
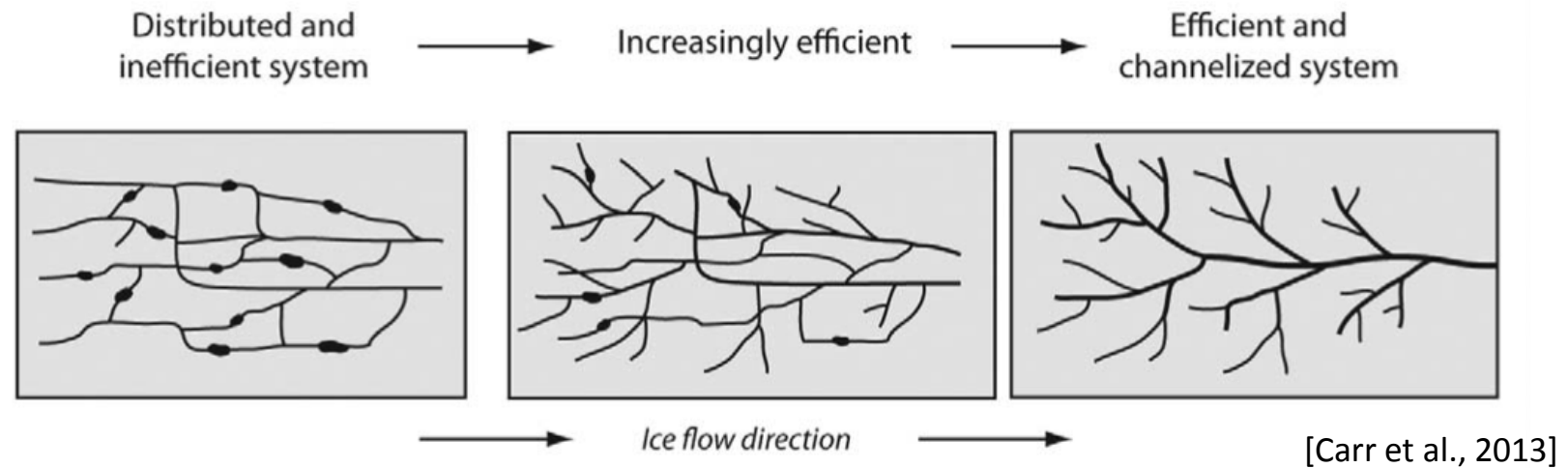
Velocity data:
TerraSAR-X
InSAR & speckle tracking

Distinct patterns of seasonal Greenland glacier velocity -- Moon et al. (2014), GRL



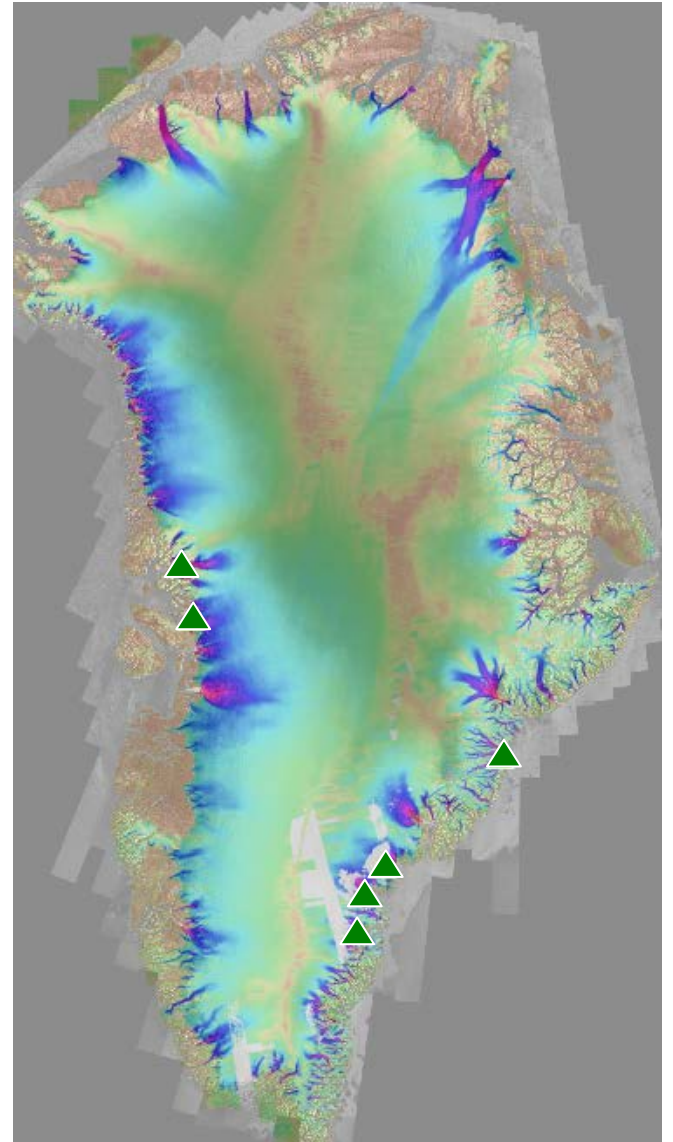
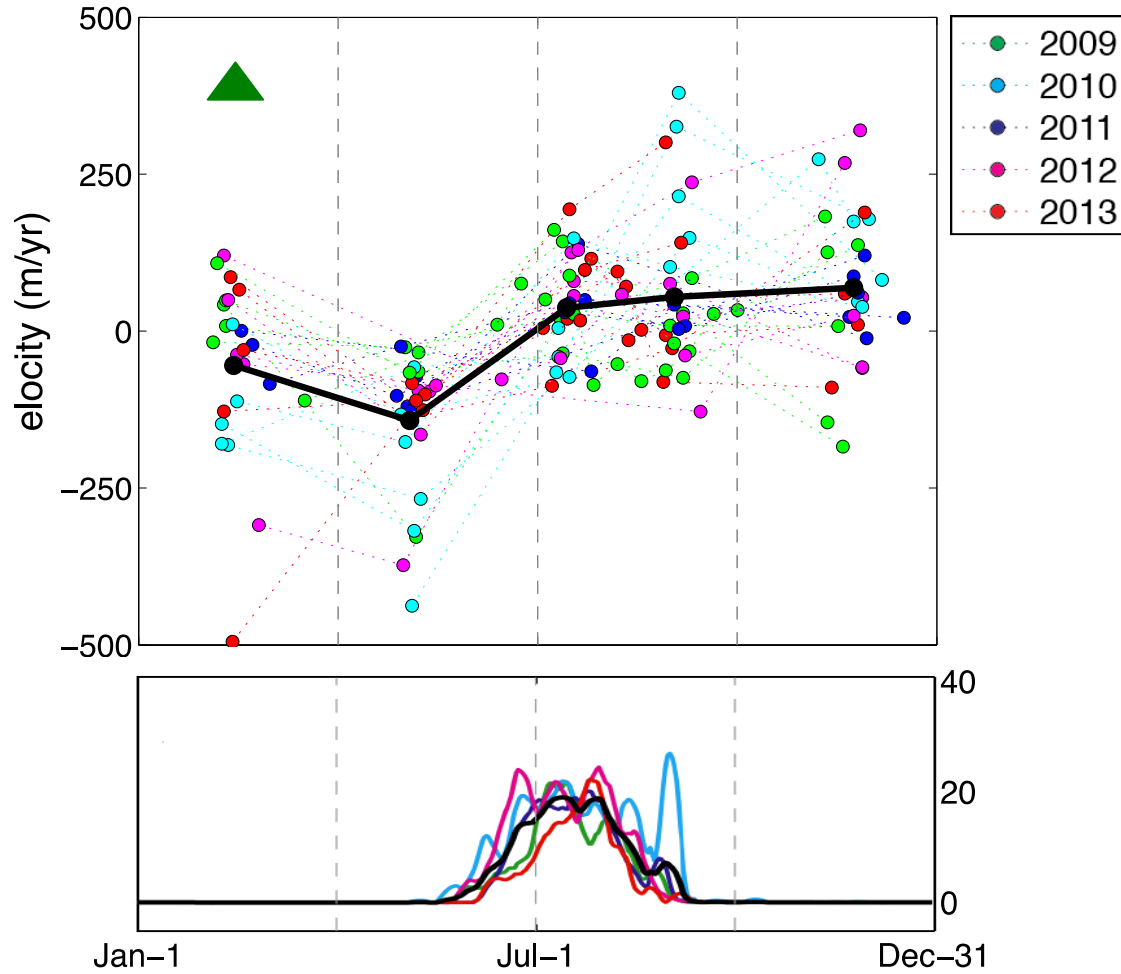
Mechanisms for speedup

1. Terminus retreat with reverse slope bed
2. Increase in basal water pressure

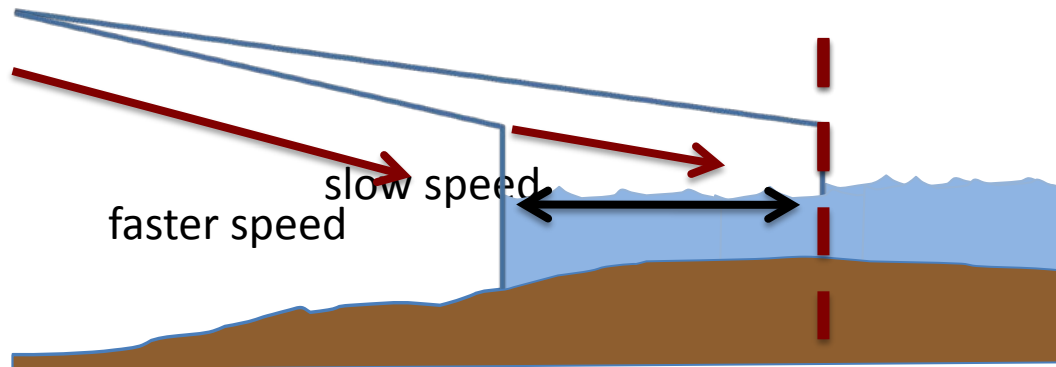
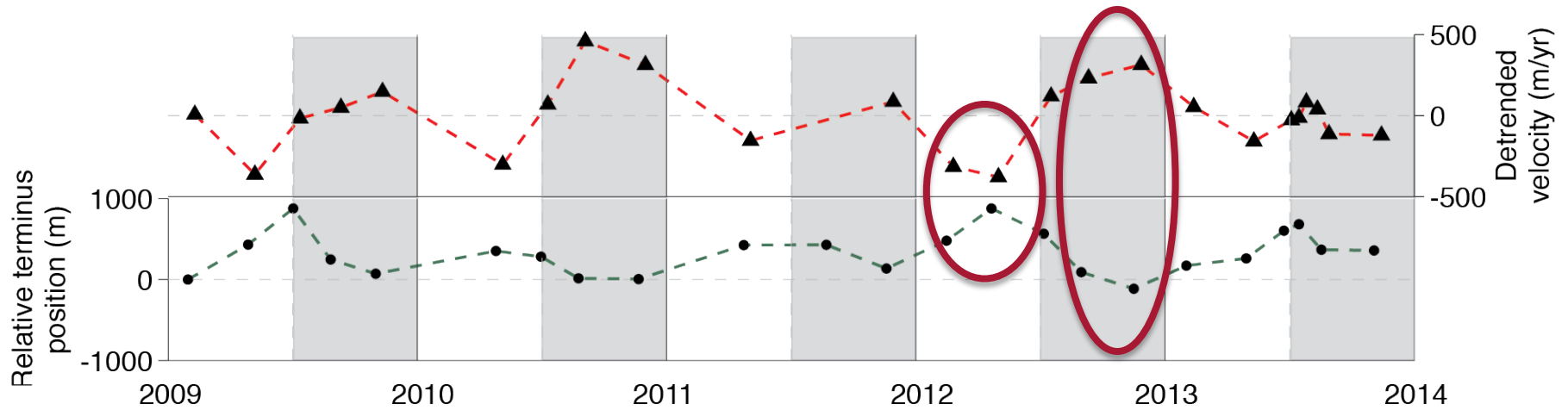


[Creyts and Clarke, 2010]

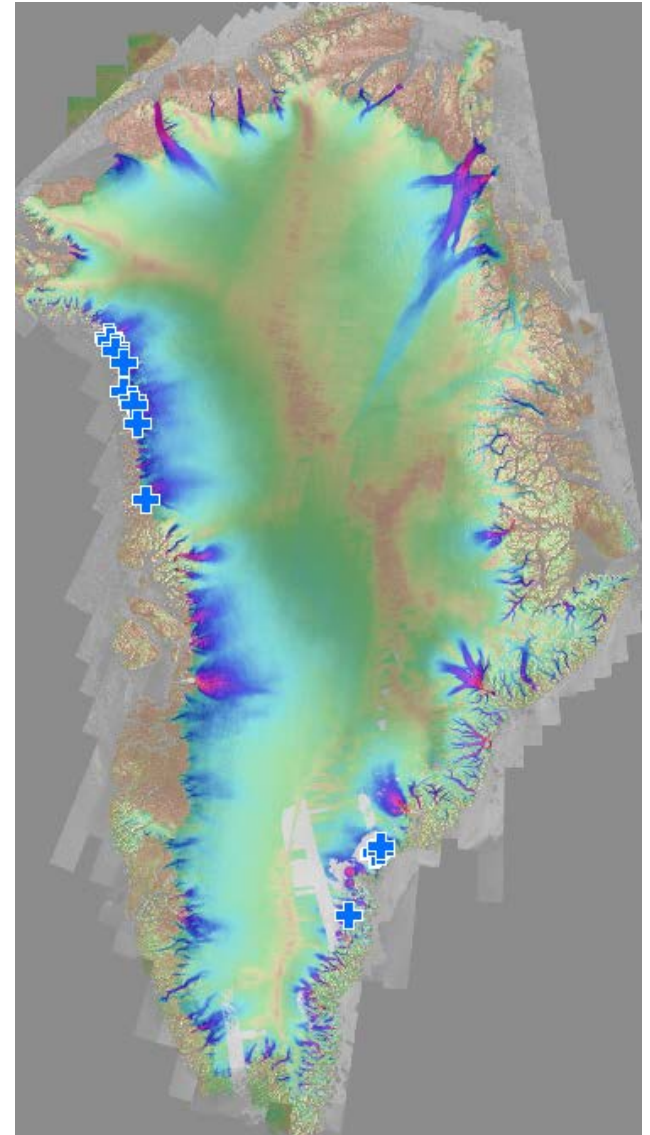
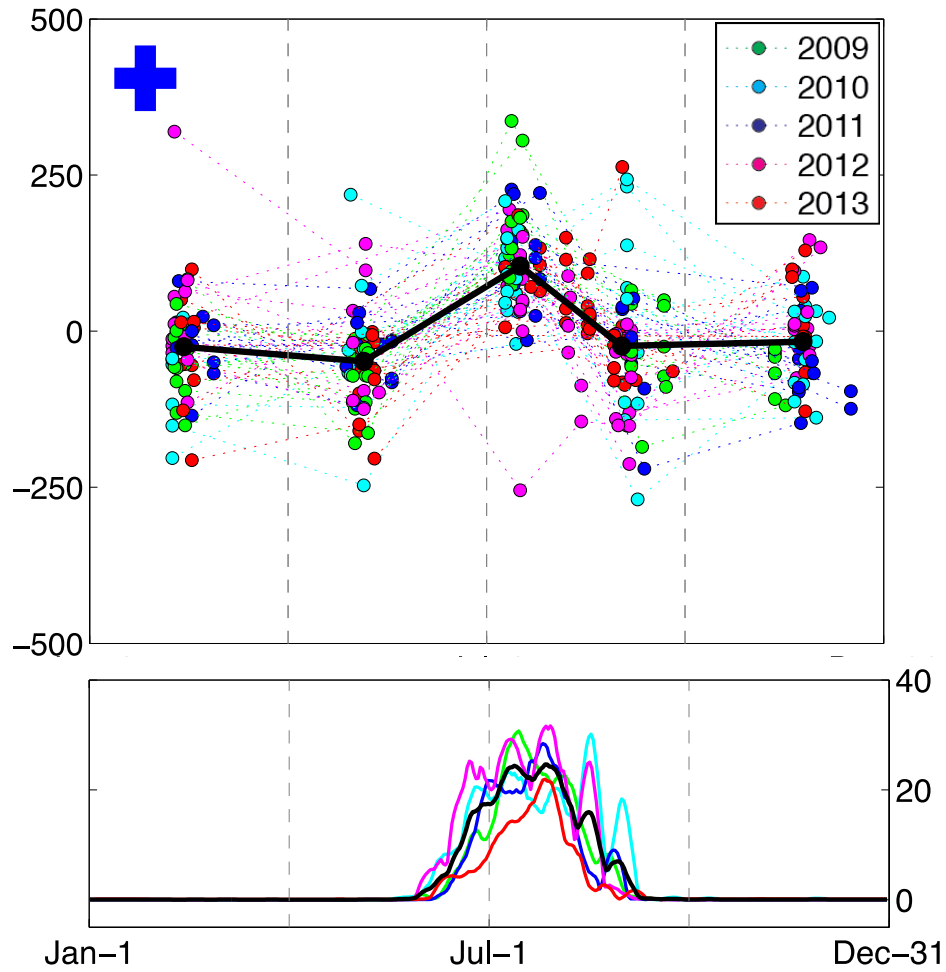
Type 1: Sustained summer speedup



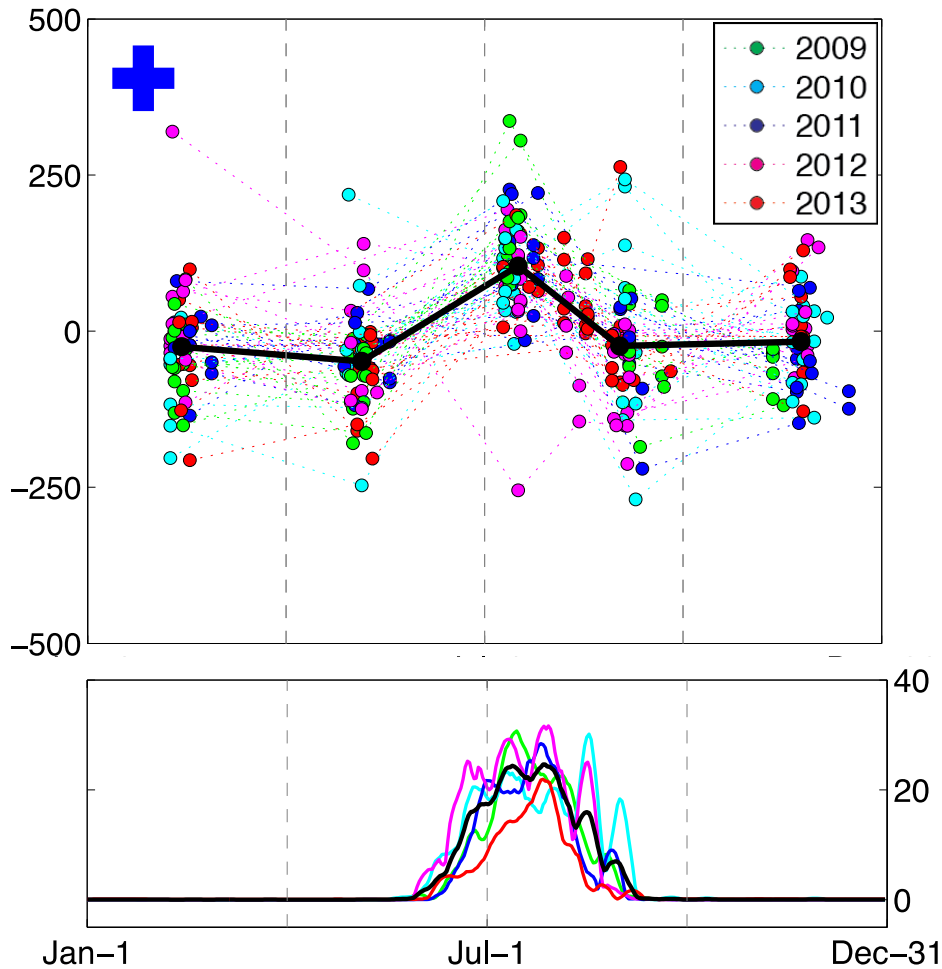
Type 1: High sensitivity to terminus



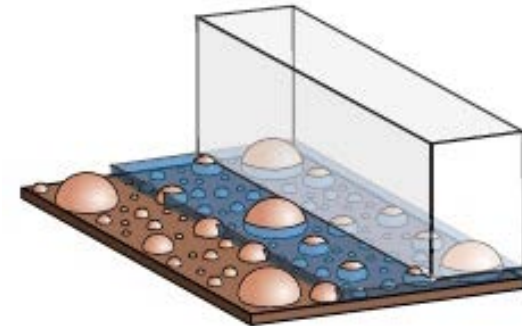
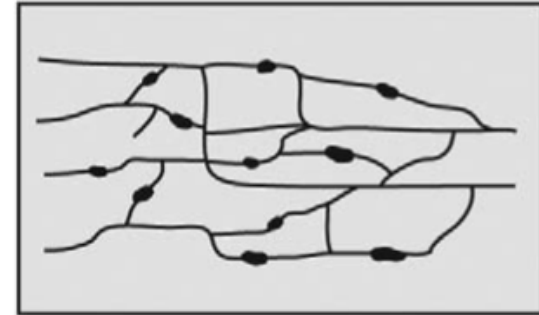
Type 2: Distributed network



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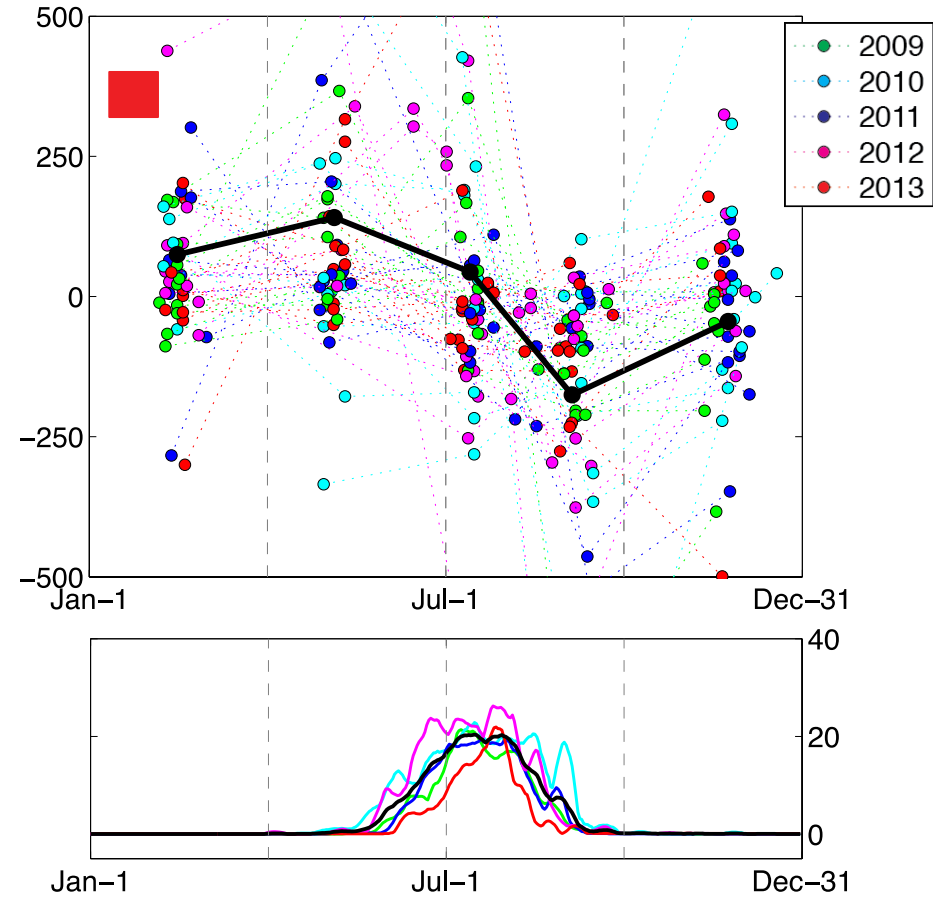
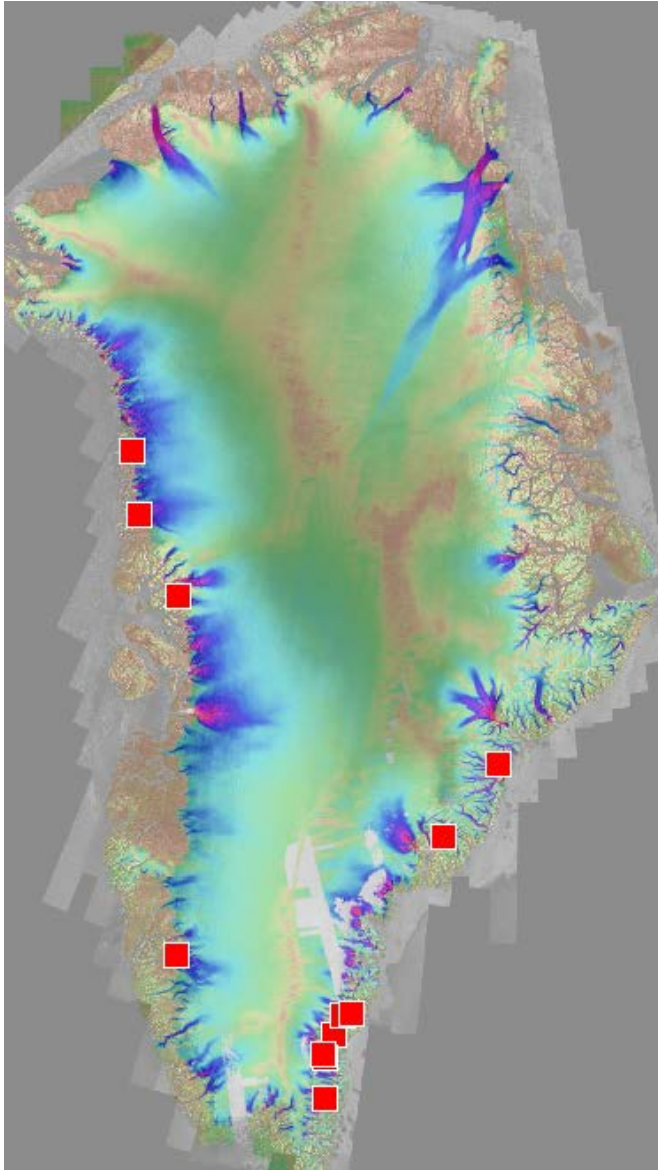


Distributed and inefficient system



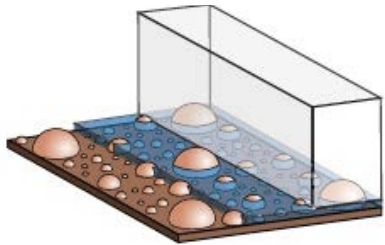
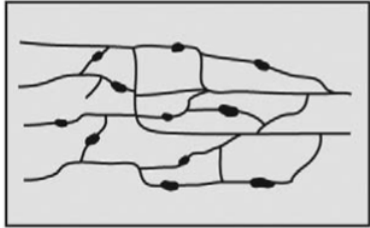
Velocity is determined by runoff *without* distributed—channelized switch.

Type 3: Channelized drainage evolves

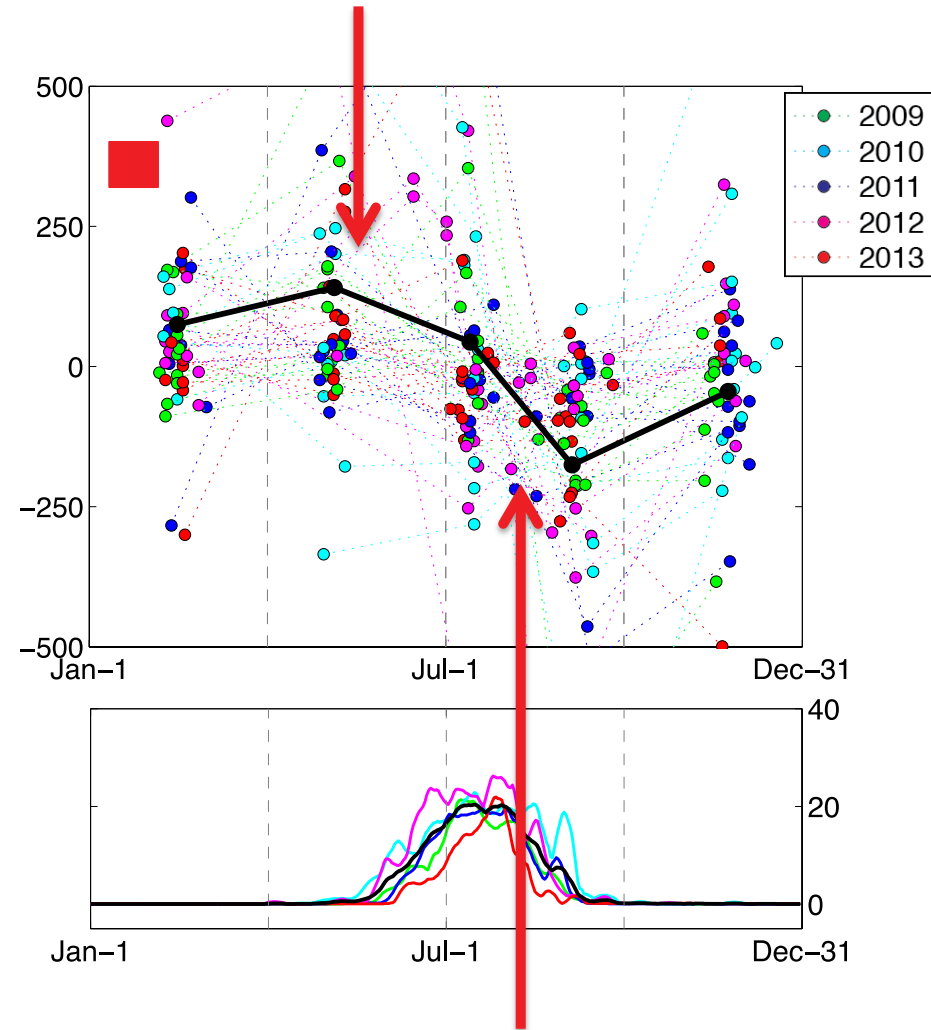
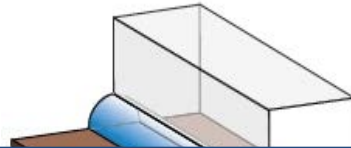


Type 3: Channelized drainage evolves

Distributed and inefficient system

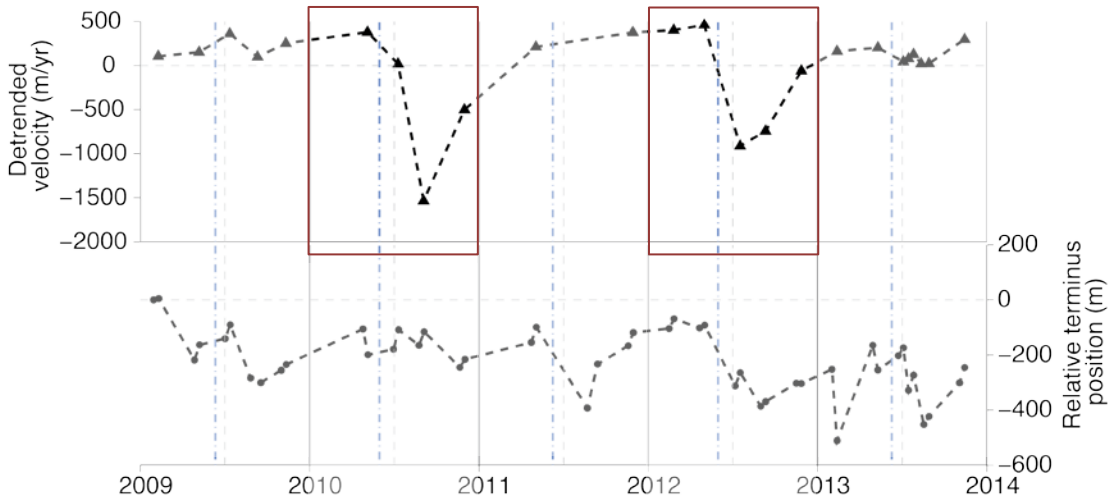


Efficient and channelized system

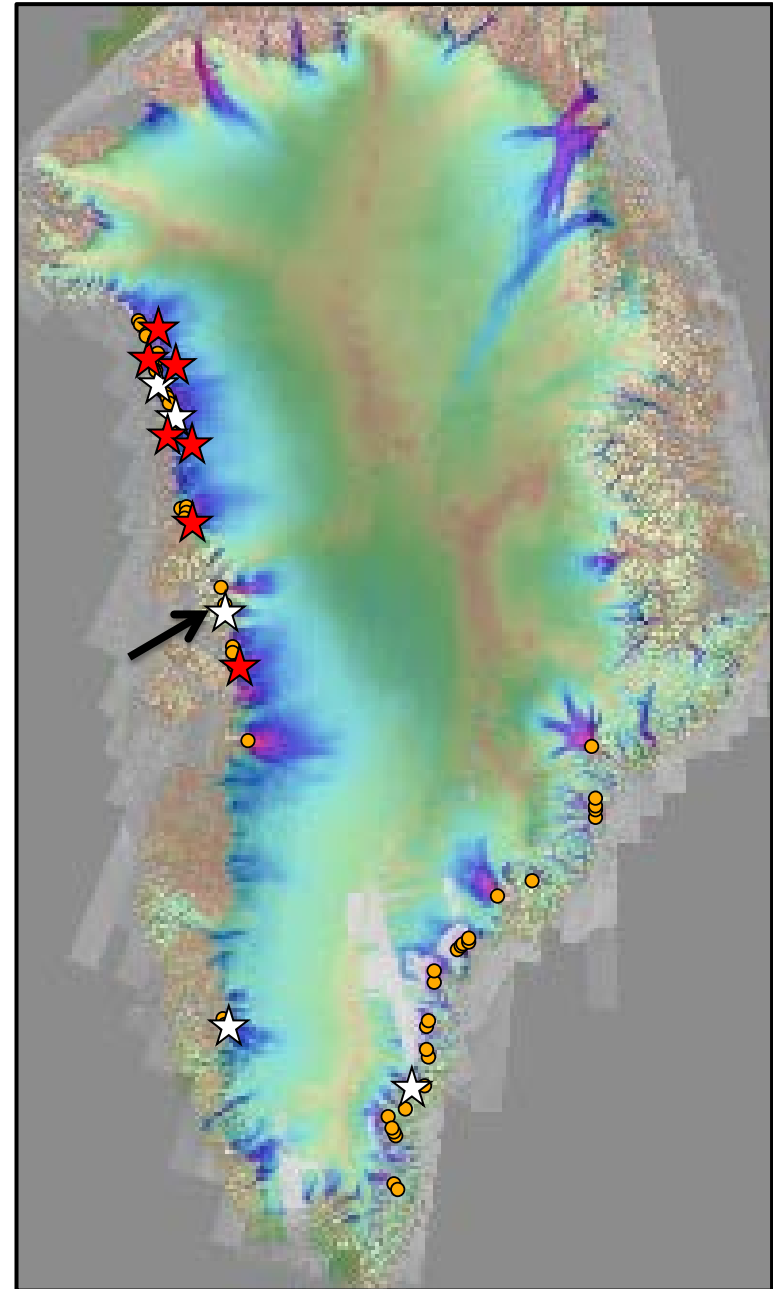


Velocity is determined by runoff *with* distributed—channelized switch.

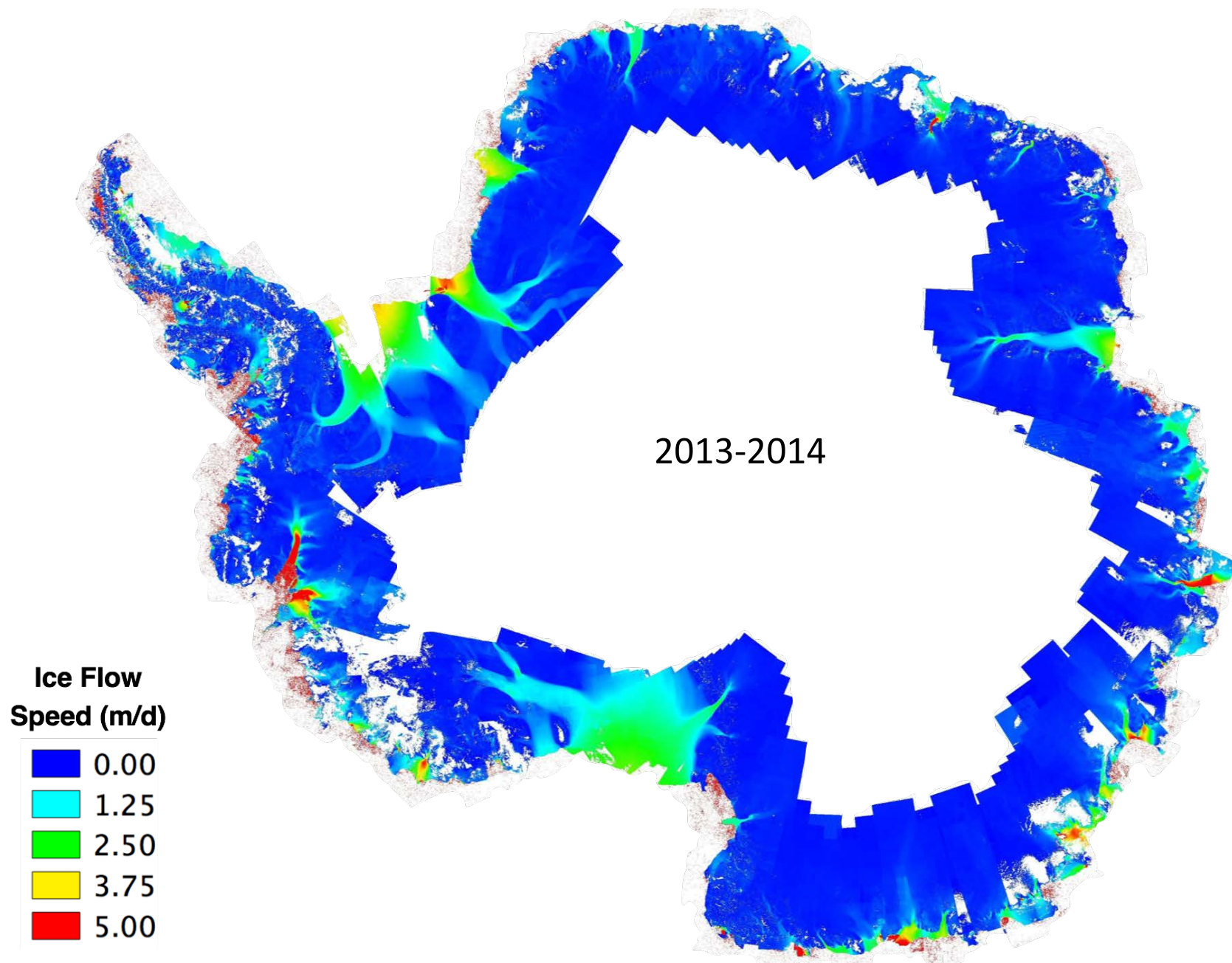
A closer look at seasonal velocity patterns



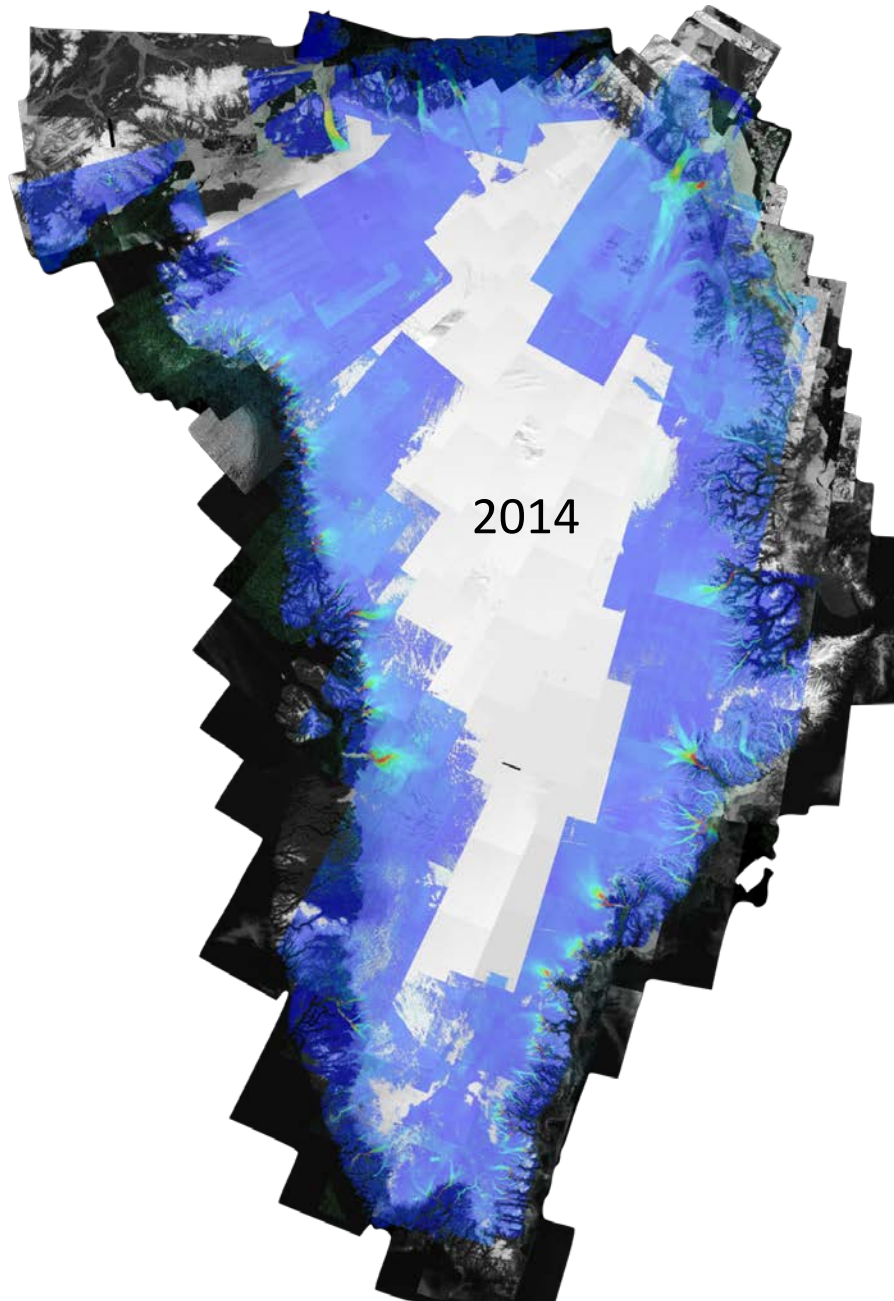
- 2010 & 2012 response: 5 glaciers
- 2012 response: 7 glaciers
- Regional distribution of seasonal terminus behavior suggests that supraglacial or englacial water storage may be important.
- Initial look consistent with along-glacier evolution of hydrology system.



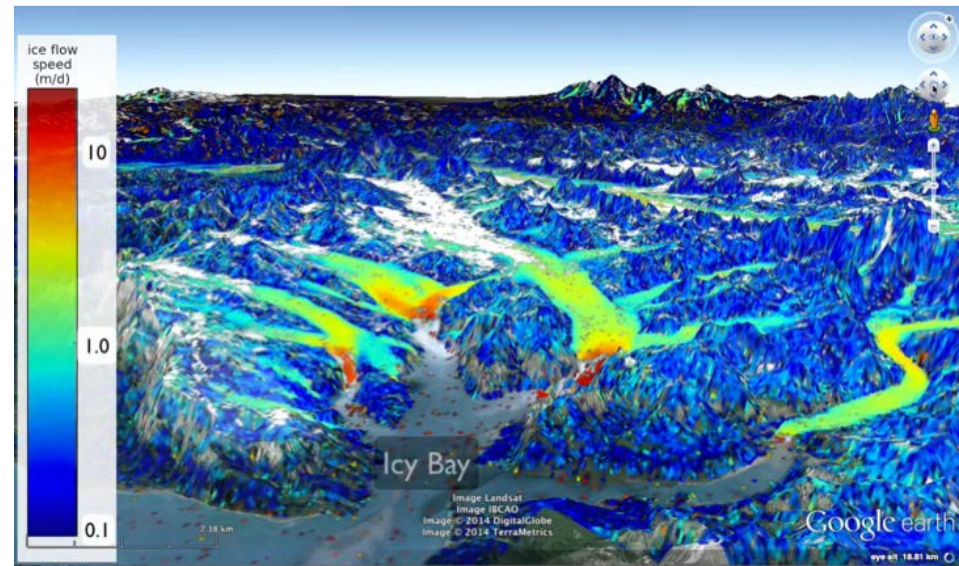
Measuring broad-area surface velocity with Landsat 8



Excellent spatial and temporal coverage



Southeast Alaska (March 2014)



- Taking advantage of Landsat 8's improved radiometric resolution and geolocation accuracy
- Creating both annual mosaics and seasonal scale time series
- Fast processing speed for near real time measurements

Pairing Landsat 7 and Landsat 8

2001 to 2014

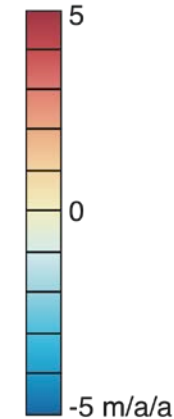
Ice stream D

Ice stream E

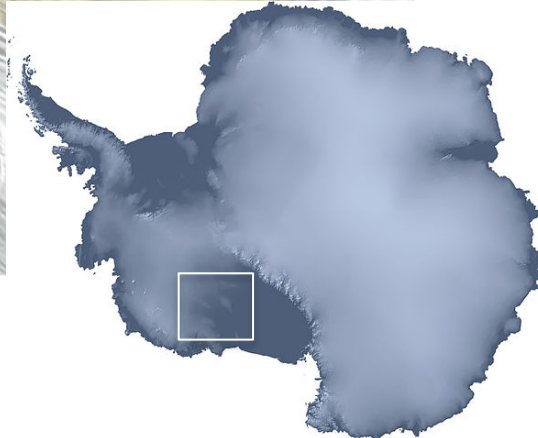
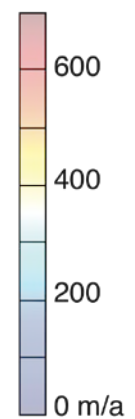
“There is variability in flow rate on any time scale you care to consider--from hours to decades to centuries. Pretty cool.”

- Christina Hulbe

rate of change
L8 - L7



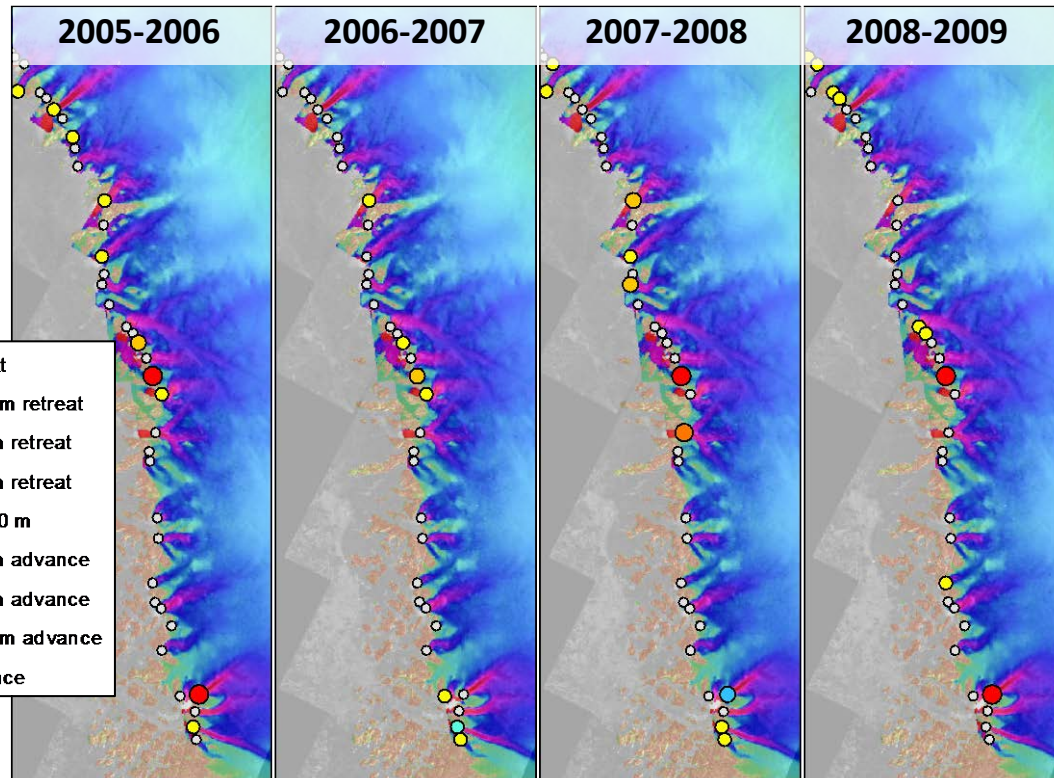
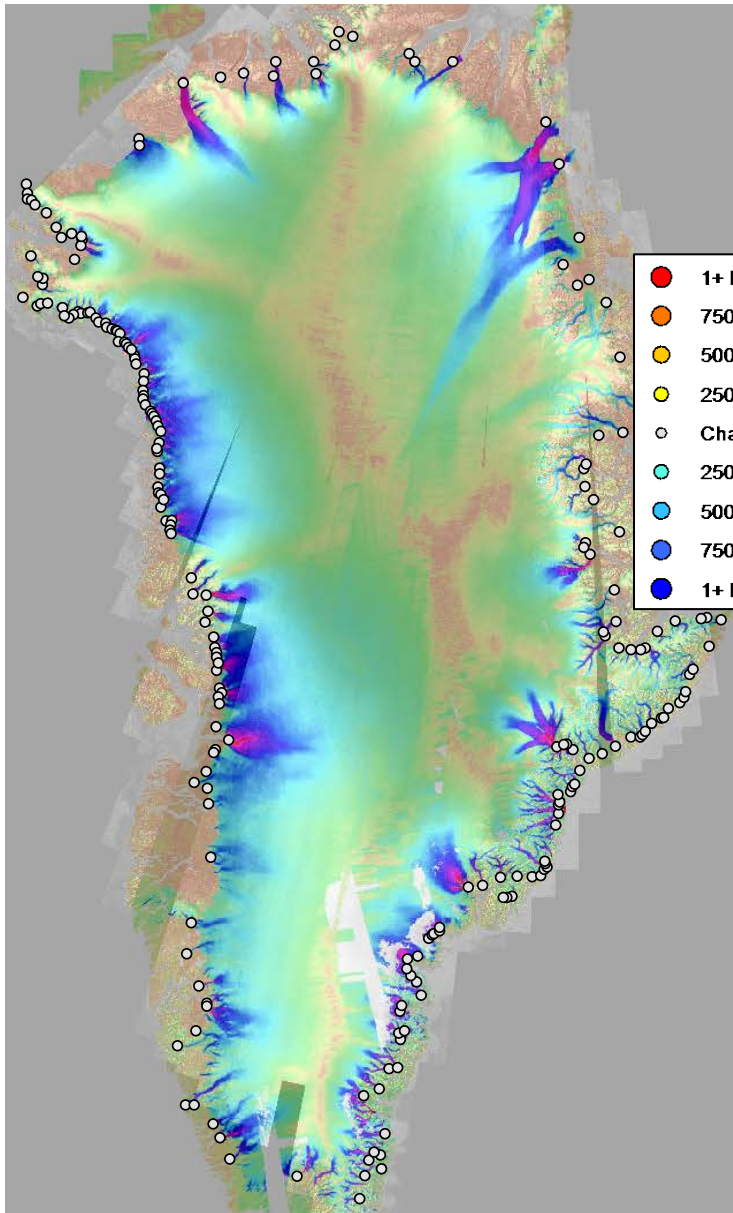
speed
Landsat 8



[from Christina Hulbe]

Forthcoming MEAsUREs dataset for ice front position

Locations for target glaciers

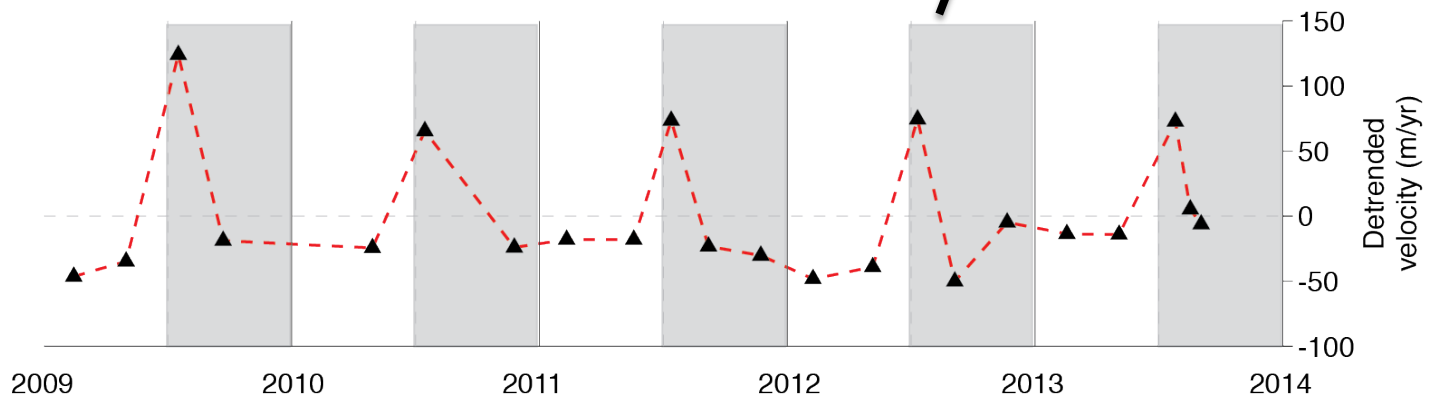
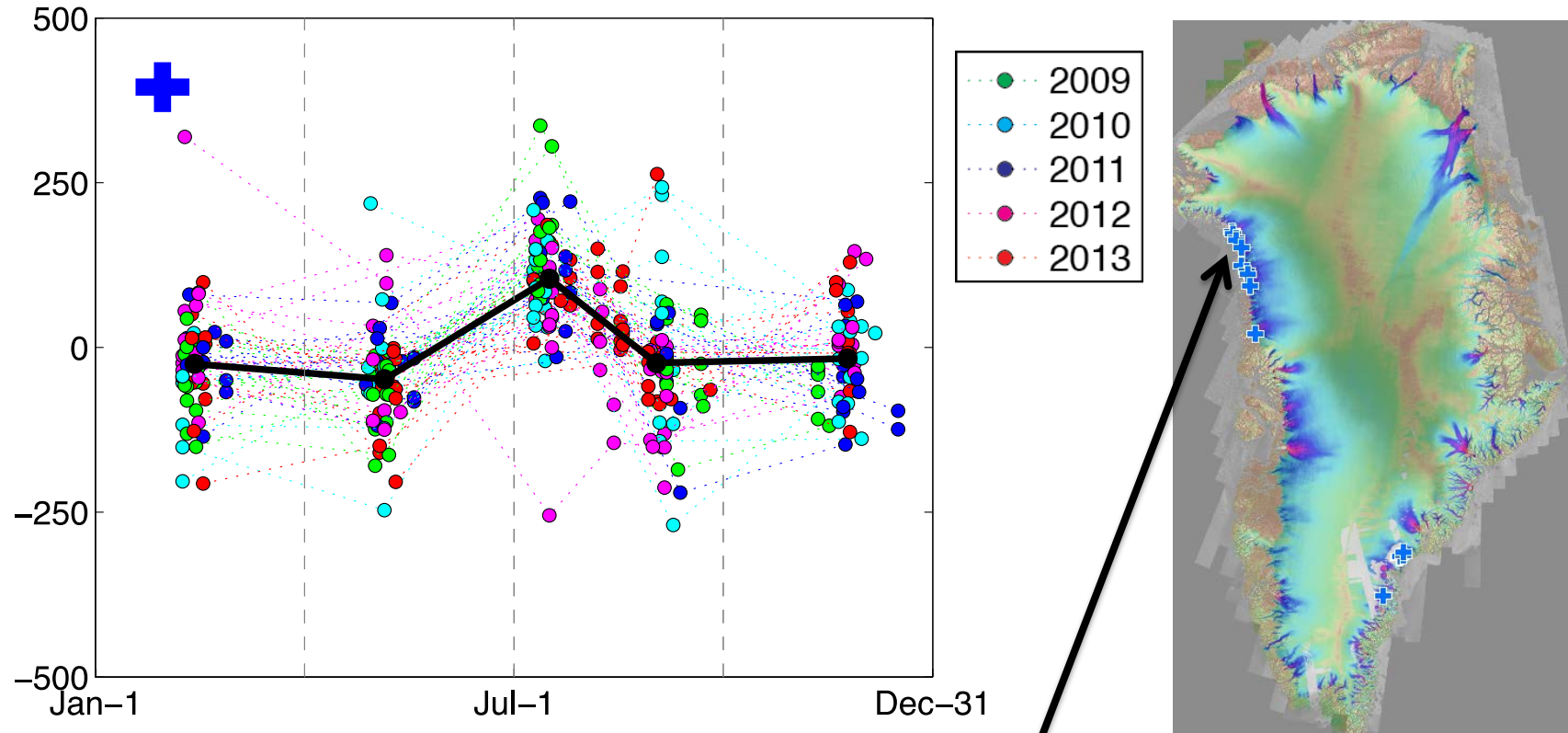


- Terminus position maps for: 2000/01 and annually 2005/06 – 2009/10
- 228 glaciers
- Land- and marine-terminating
- Making Earth System Data Records for Use in Research Environments (MEAsUREs), hosted at the NSIDC (nsidc.org/data/measures)

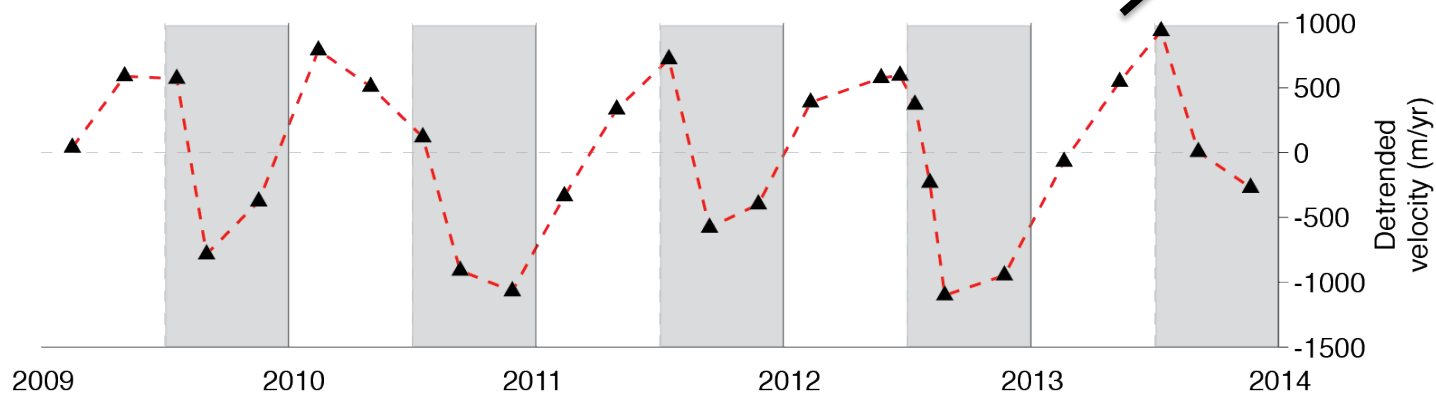
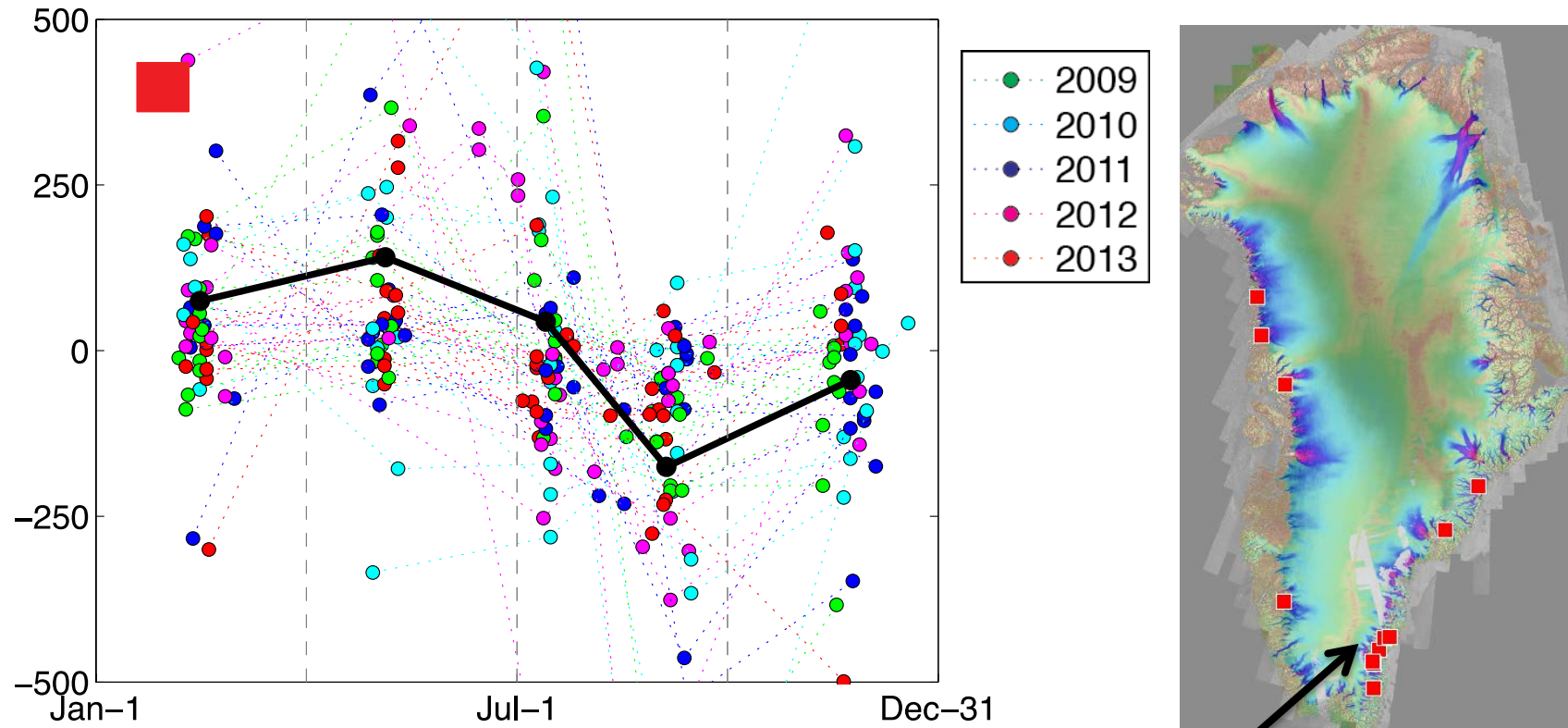
Summary

- Seasonal velocity patterns:
 - High sensitivity to seasonal terminus behavior for some glaciers, but more glaciers respond primarily to changes in the hydrologic system
 - Signature velocity patterns for glaciers **with** distributed--channelized switch and glaciers **without** distributed--channelized switch
 - Hydrologic link has dynamic implications for annual melt, supra/englacial water storage, along-glacier evolution of hydrology
- Glacier and ice sheets surface velocities from Landsat 8
- Forthcoming MEAsUREs dataset for annual terminus positions for Greenland

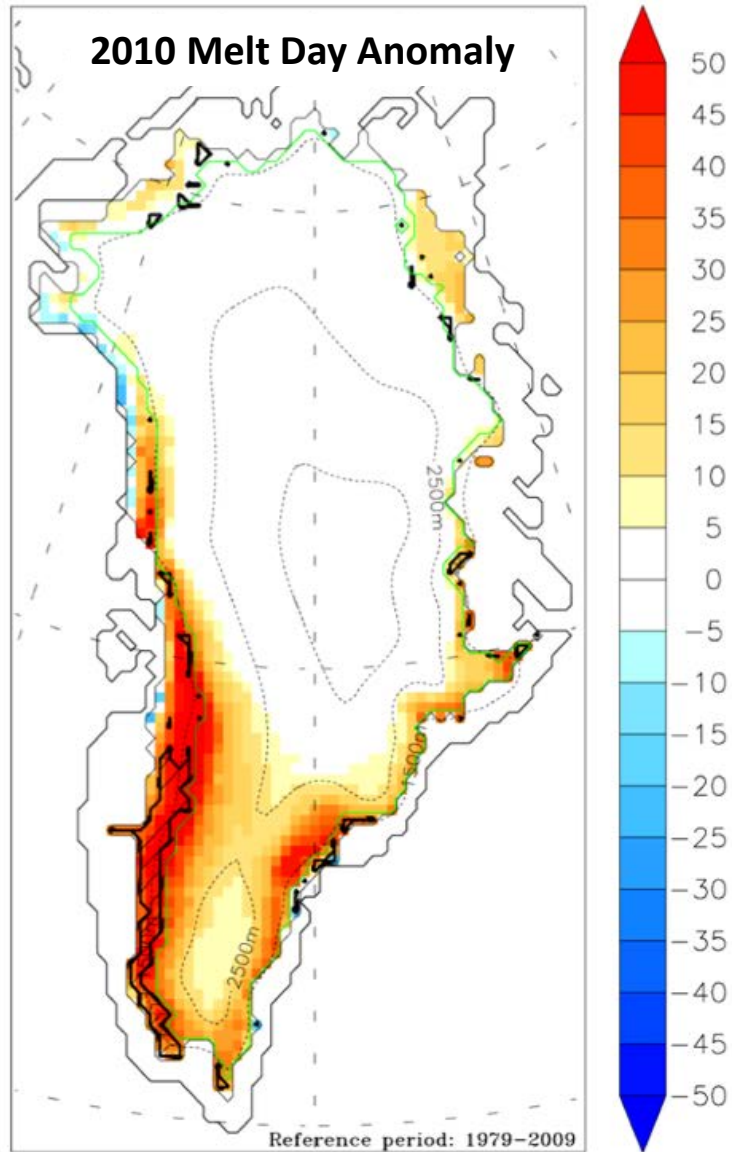
Type 2: Summer spike



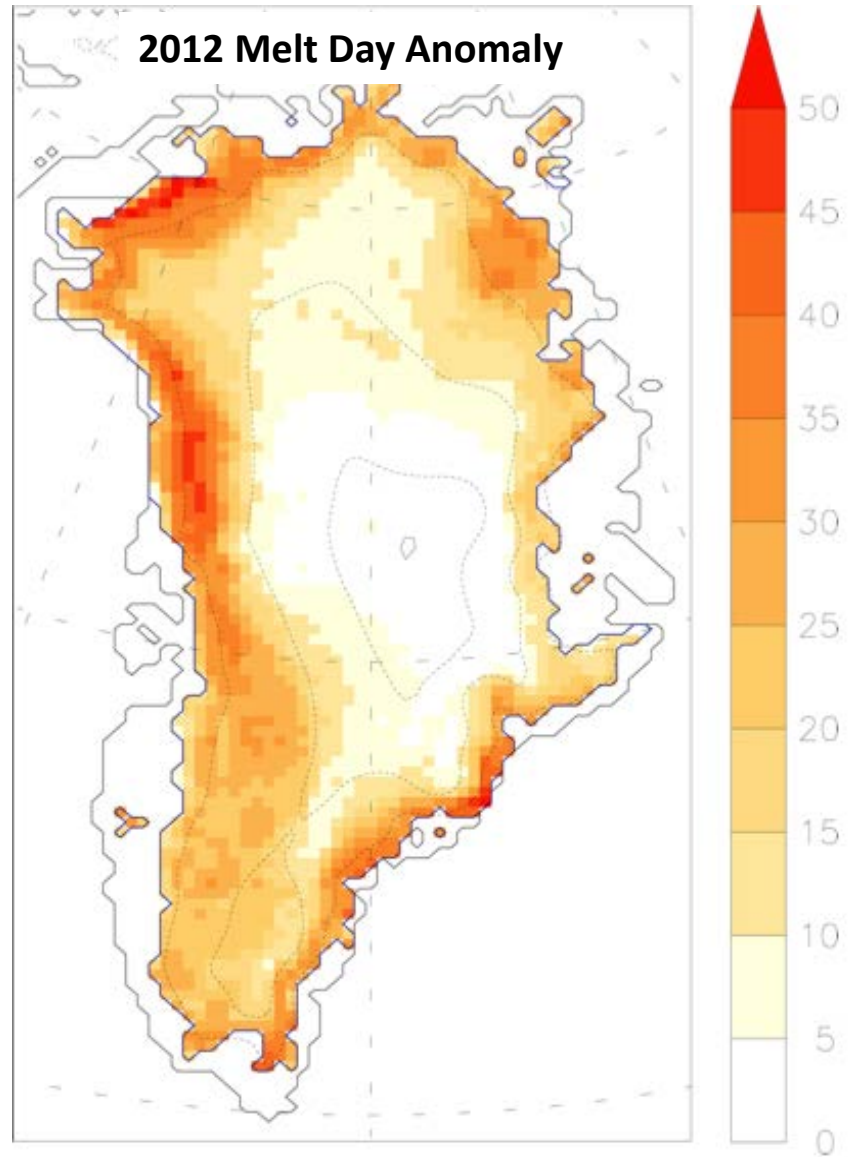
Type 3: Late summer deceleration



Record Greenland surface melt: 2010 & 2012



[Tedesco et al., 2011]



[Tedesco et al., 2013]