

Ice dynamics from Earth observations

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Geographical Sciences

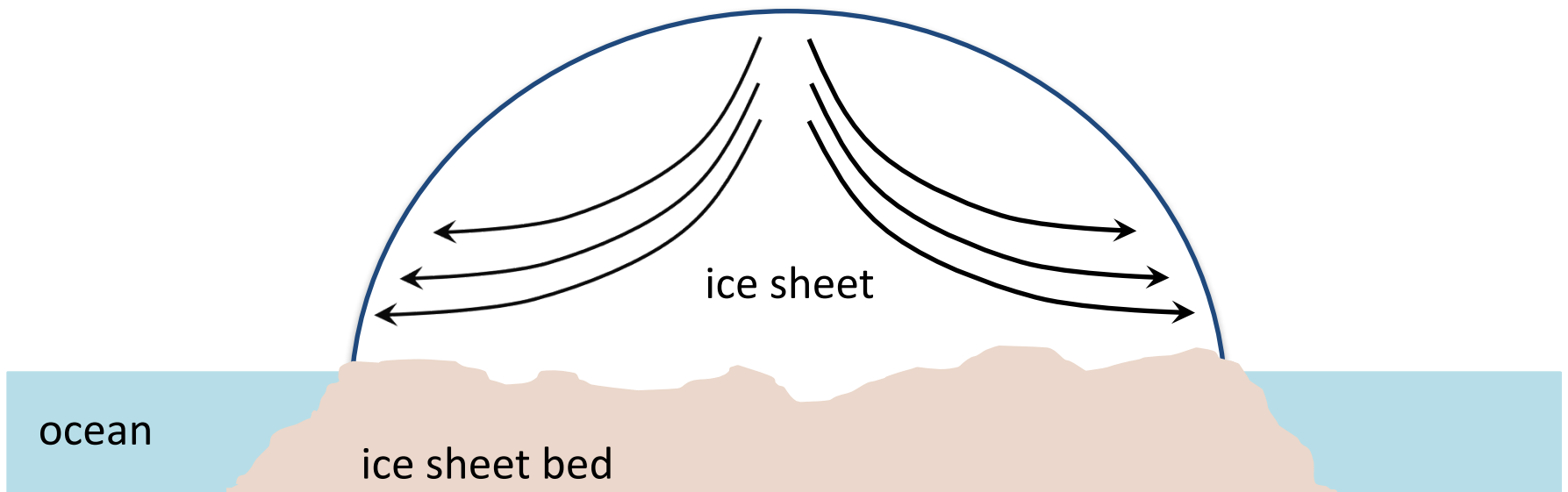
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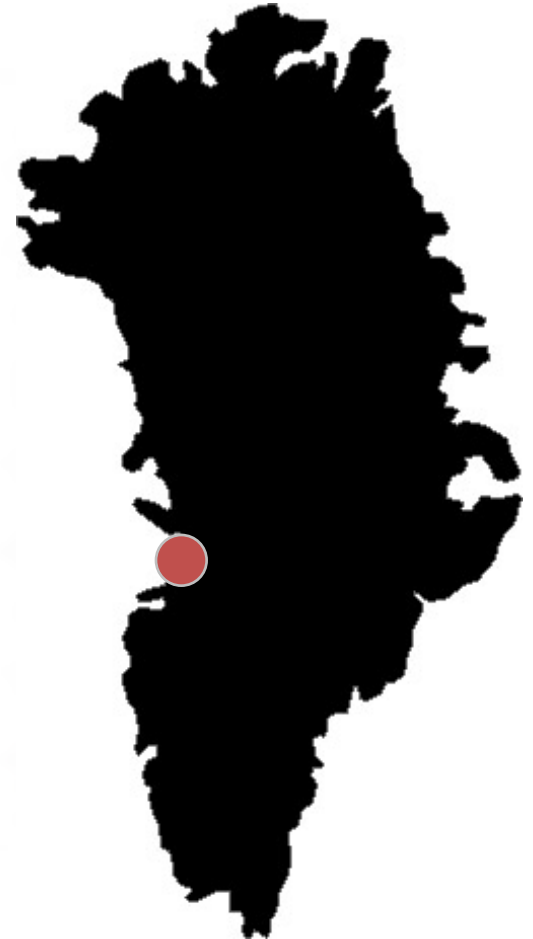
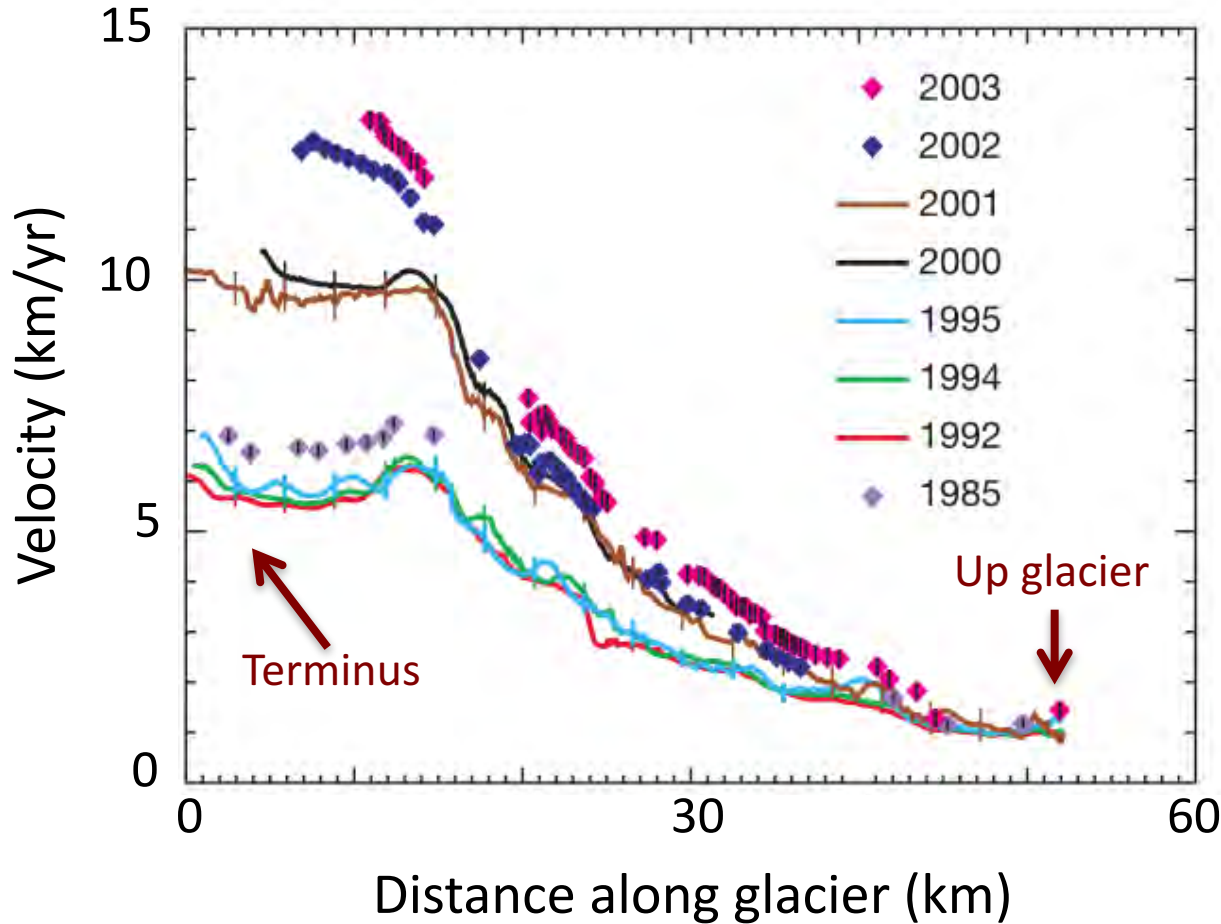
“When you have mapped the ice sheets once your career will be over because they don’t change very quickly.”

- A well-known glaciologist, circa 1995



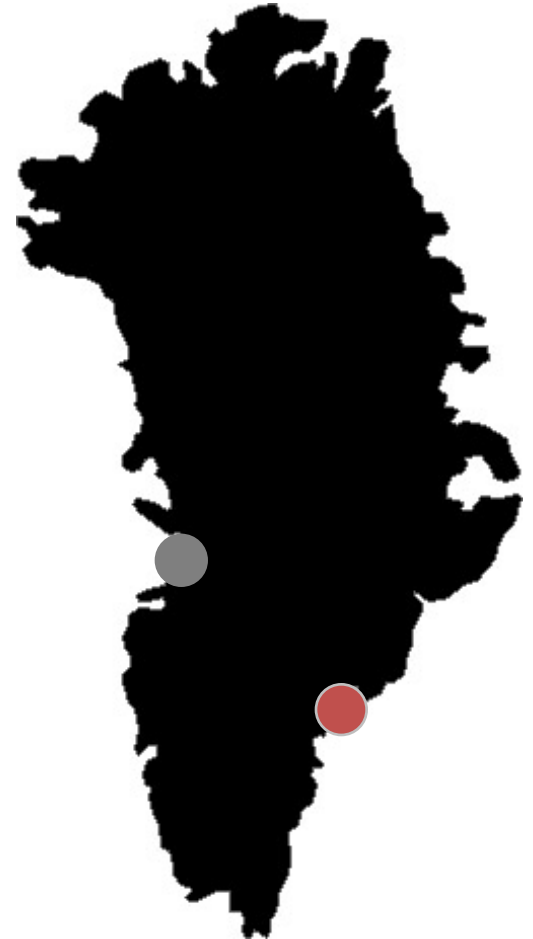
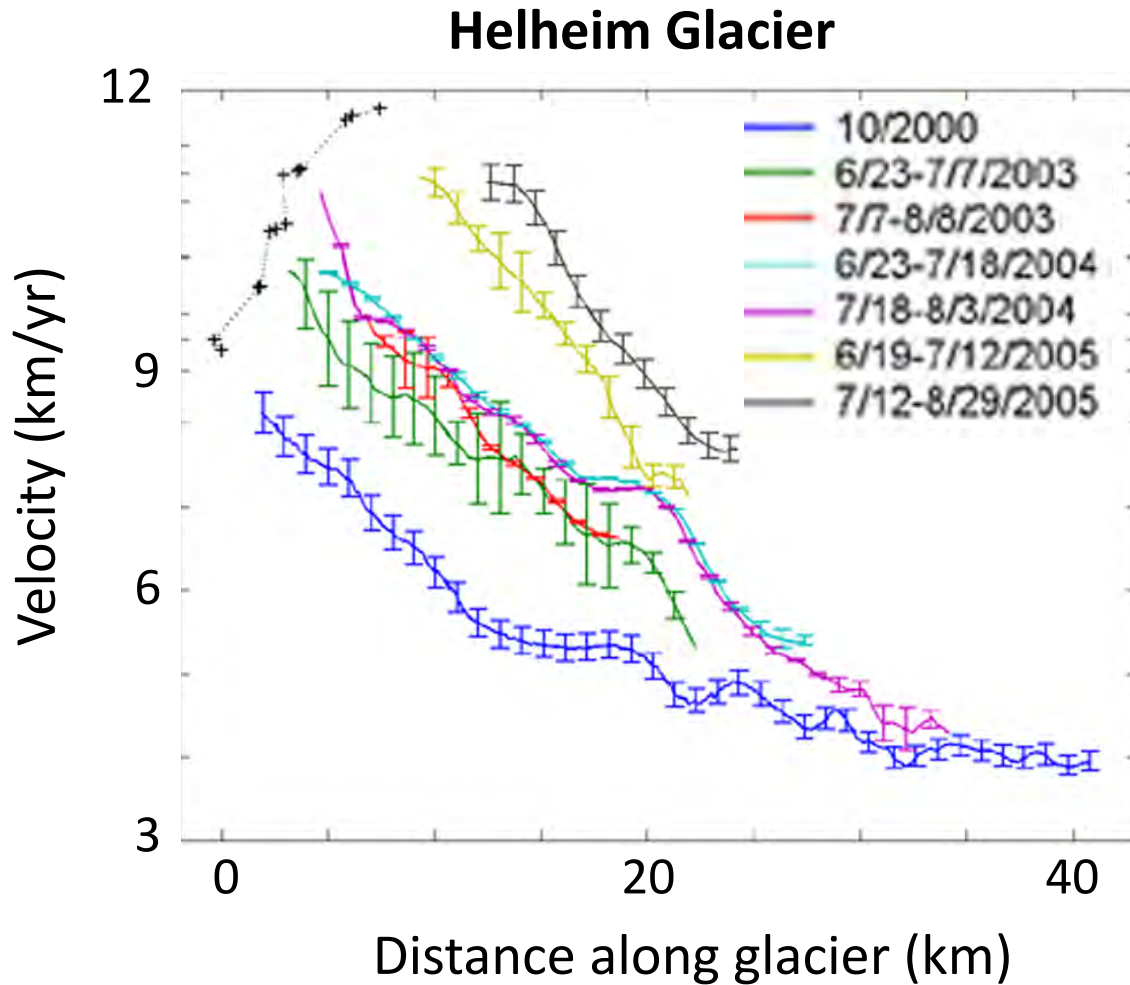
First look at Greenland glacier velocities

Jakobshavn Isbræ



[Joughin et al., *Nature*, 2004]

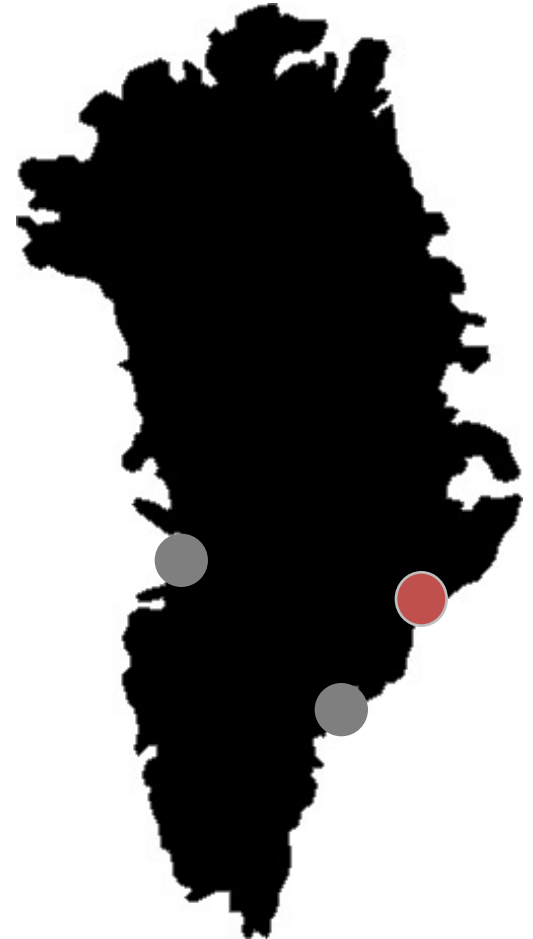
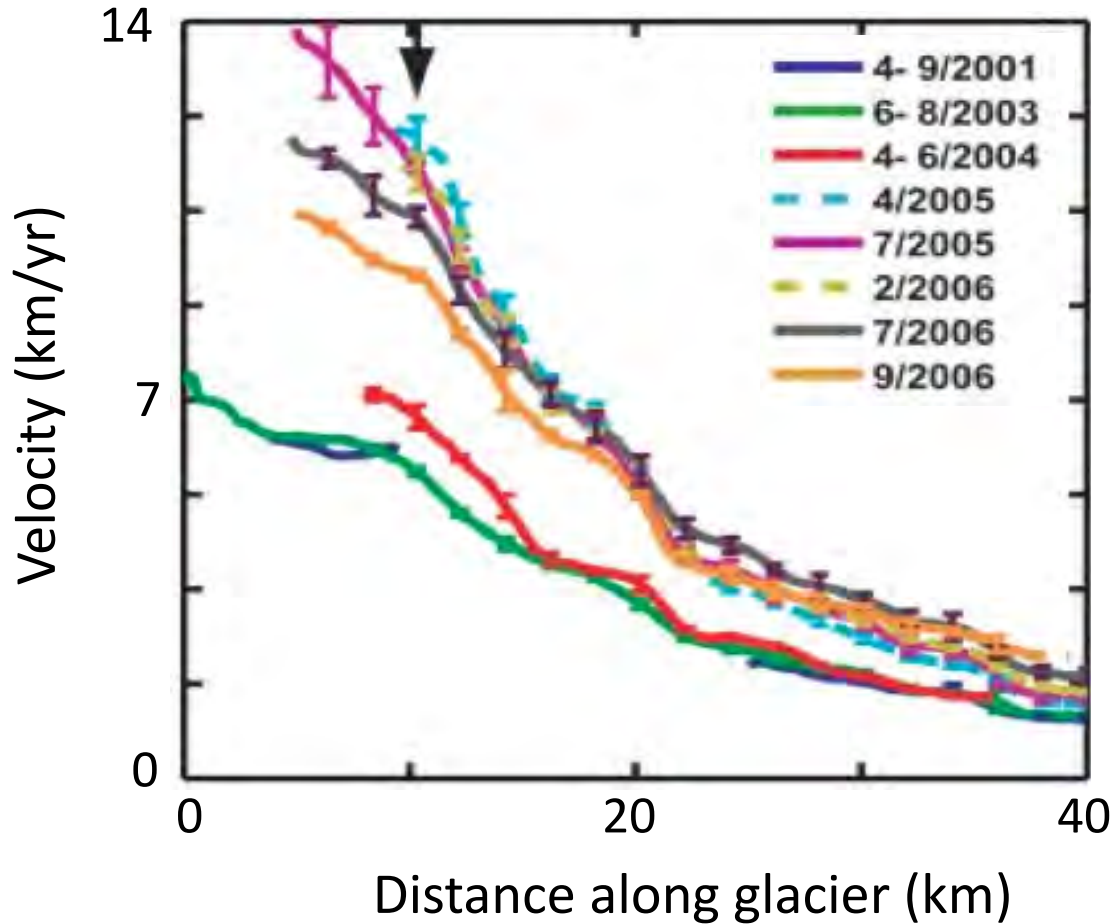
First look at Greenland glacier velocities



[Howat et al., *GRL*, 2005]

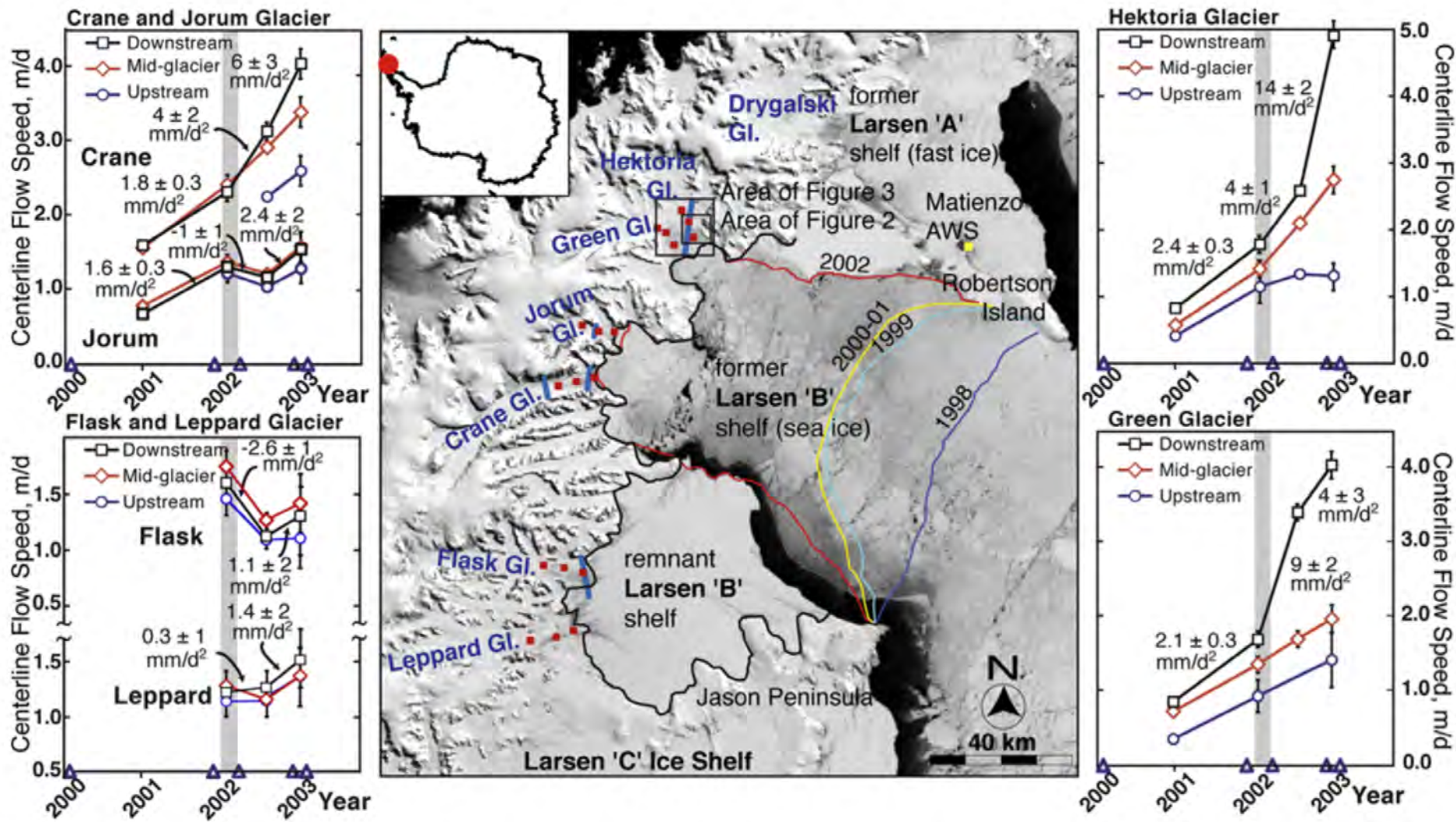
First look at Greenland glacier velocities

Kangerdlugssuaq Glacier

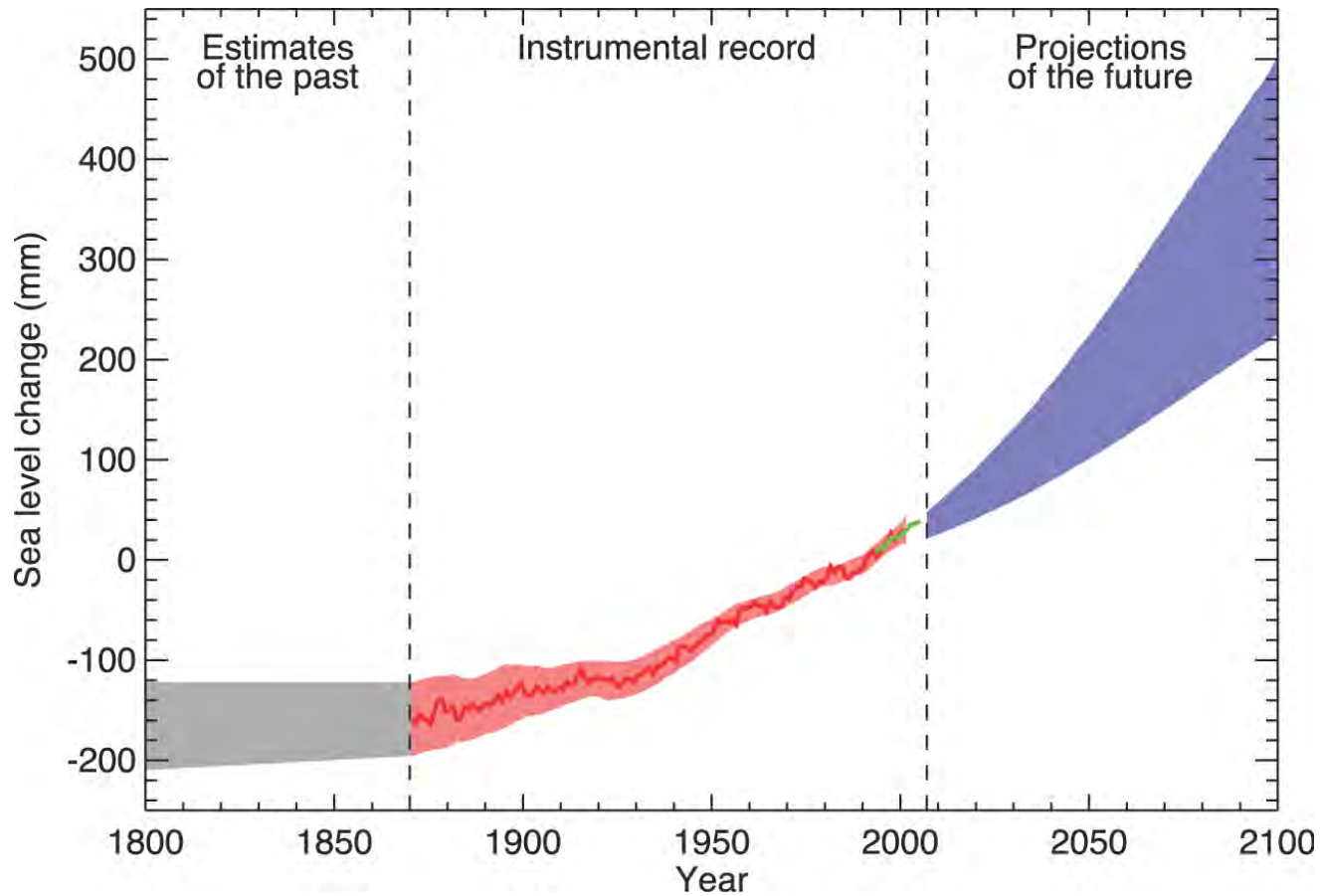


[Howat et al., *Science*, 2007]

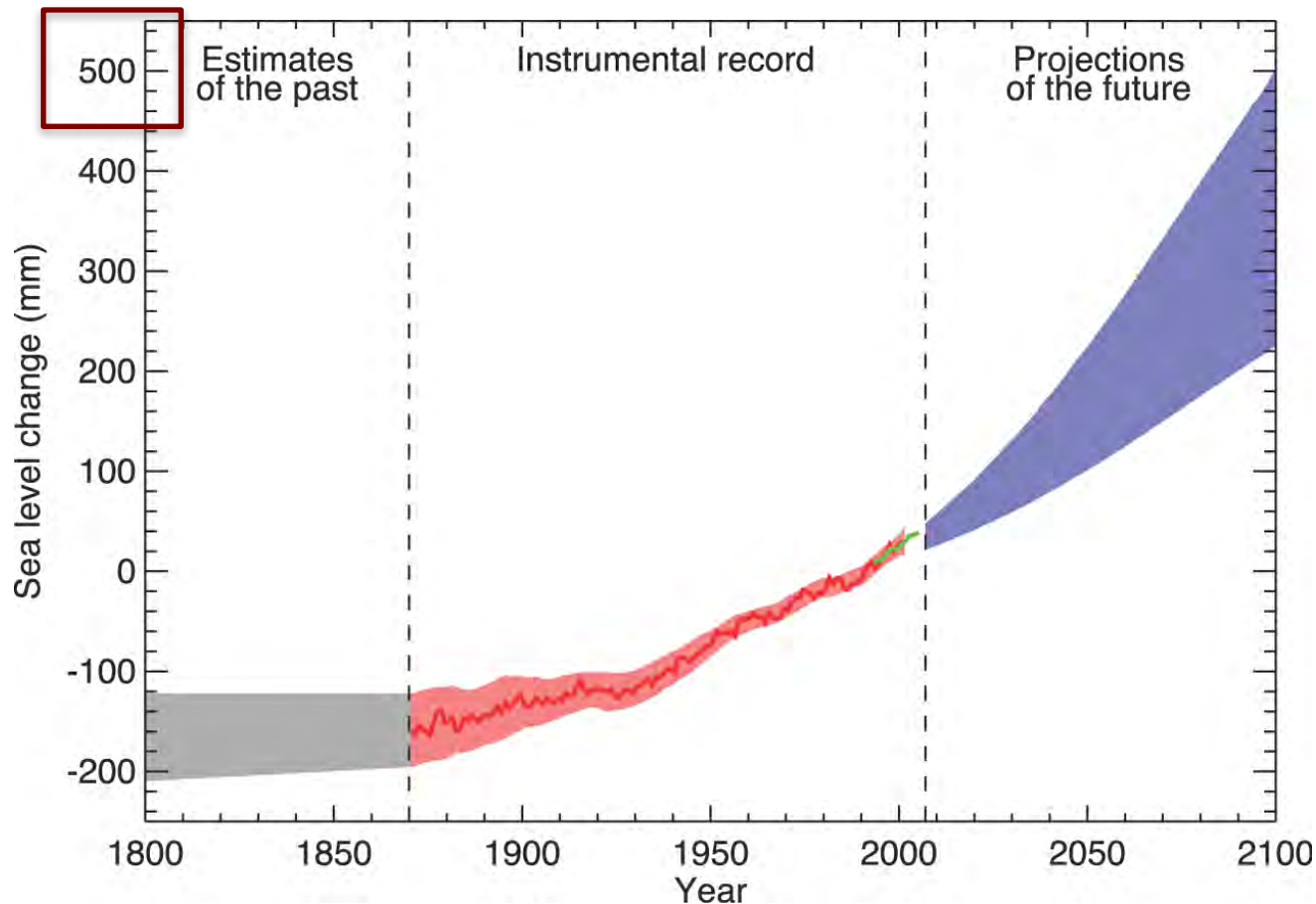
Rapid speedup in Antarctica



Projections for future sea level rise

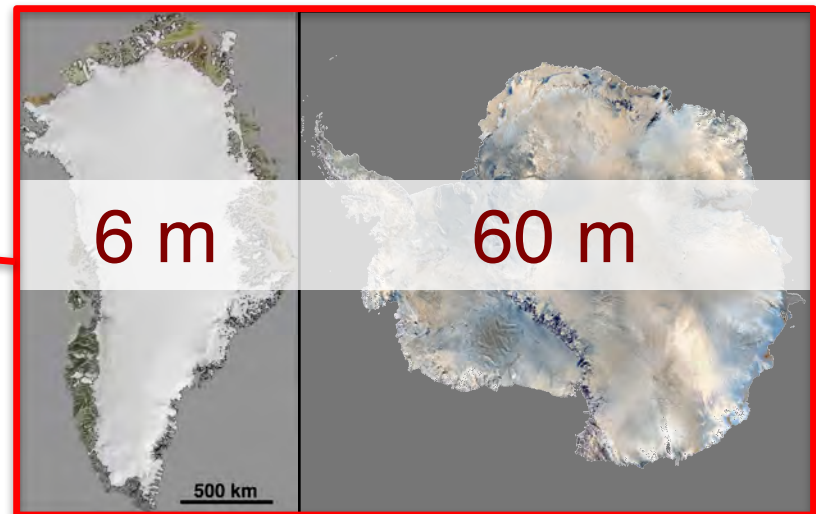
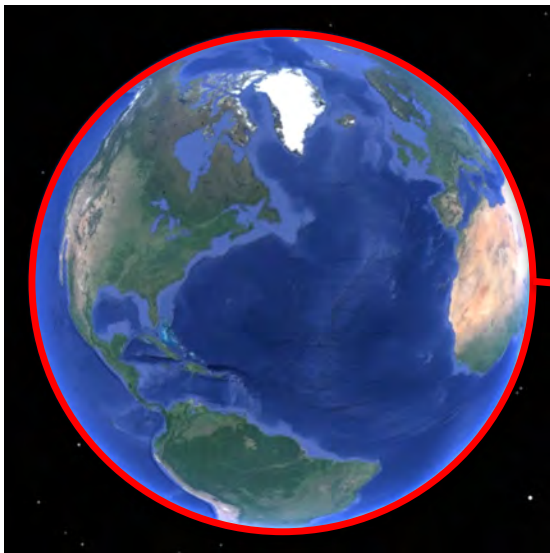


Projections for future sea level rise

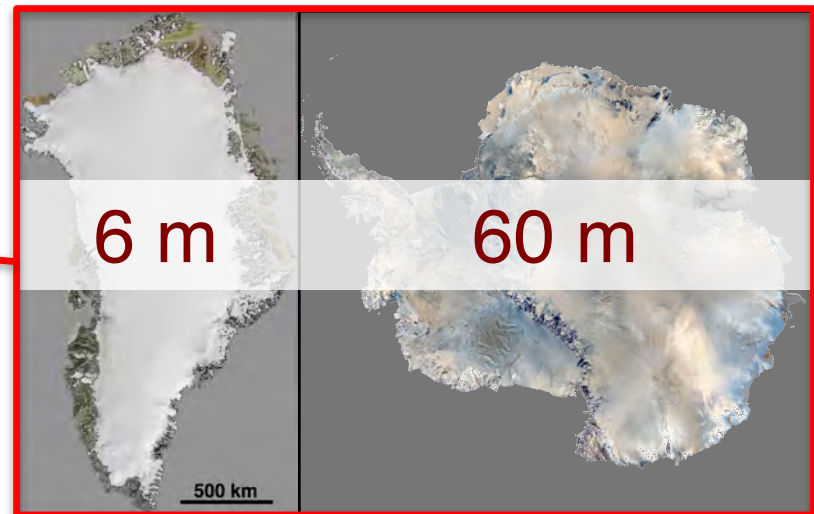
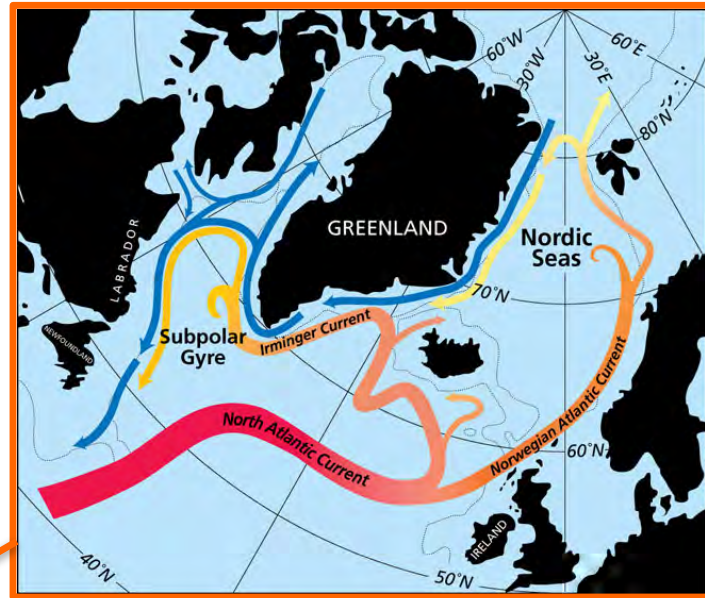


“Dynamical processes related to ice flow not included in current models... Understanding of these processes is limited and there is no consensus on their magnitude.”

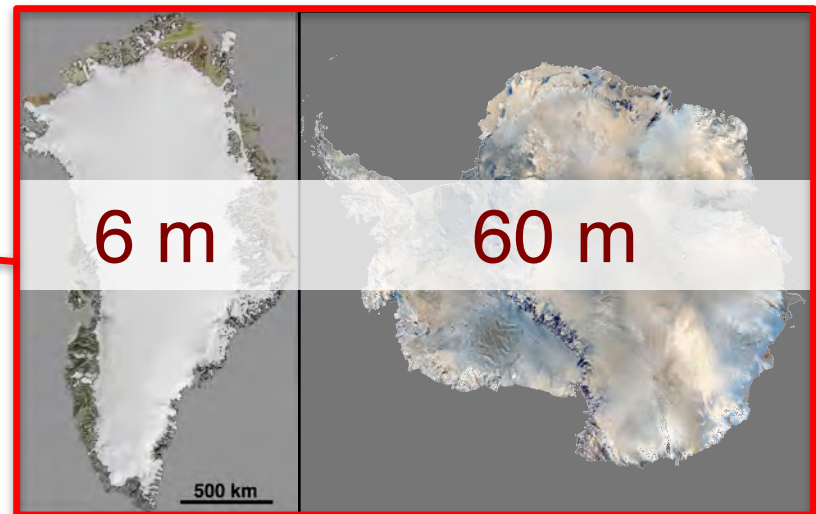
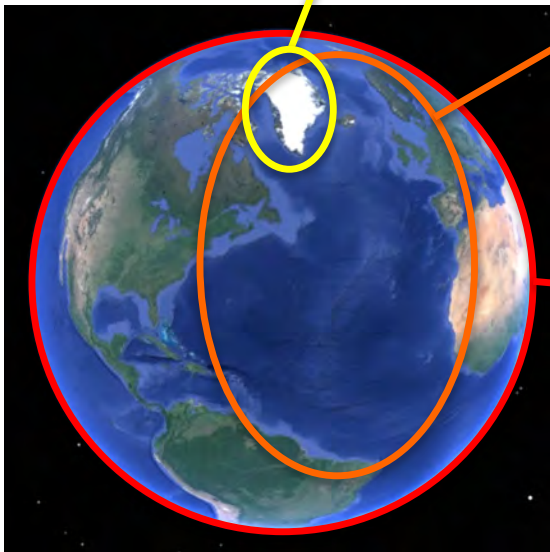
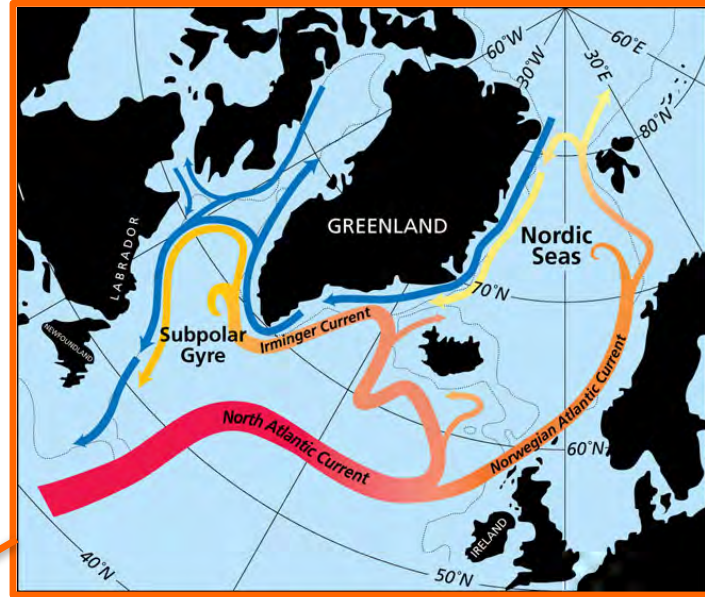
Impacts of ice mass loss



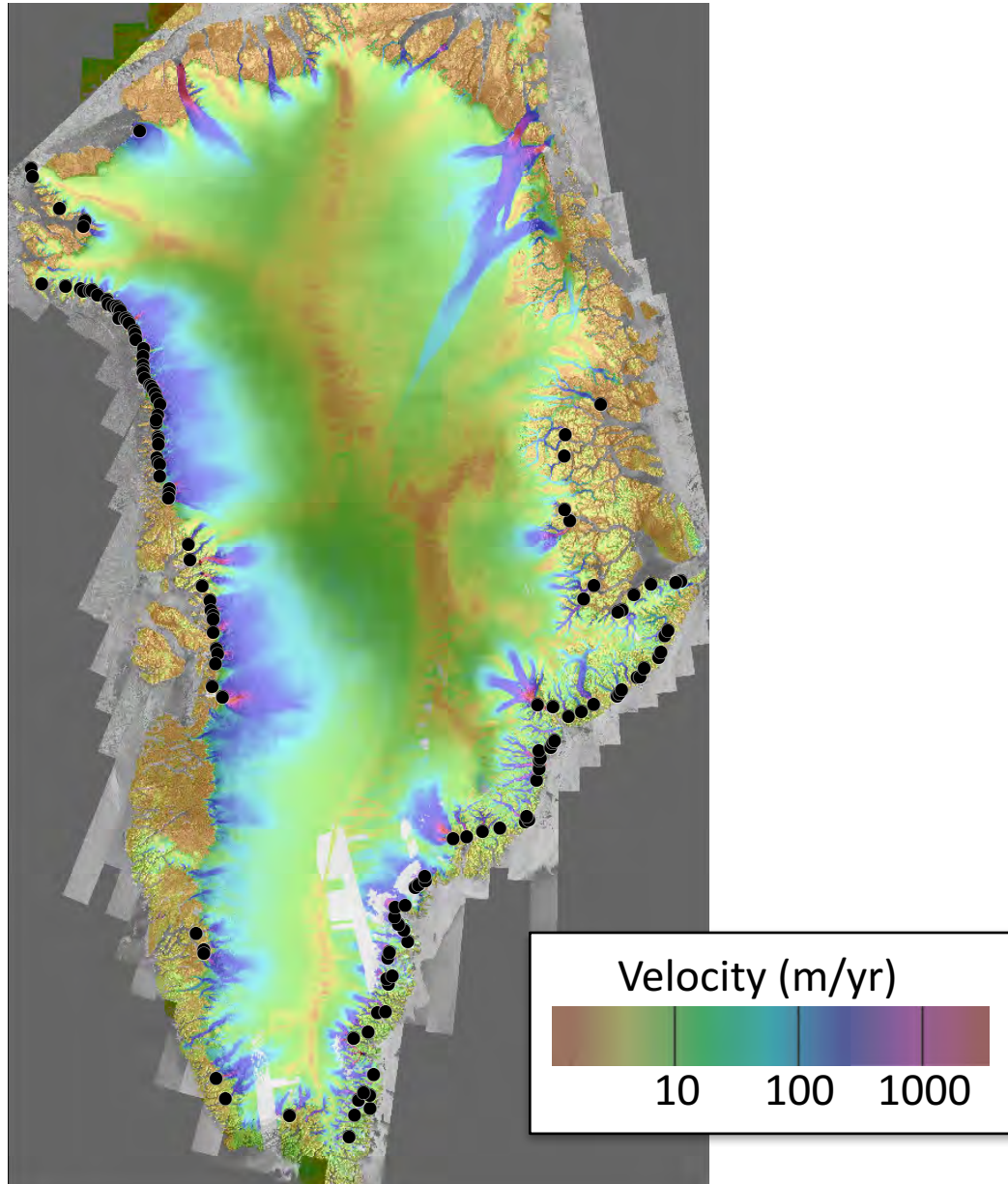
Local to global impacts of ice sheet change



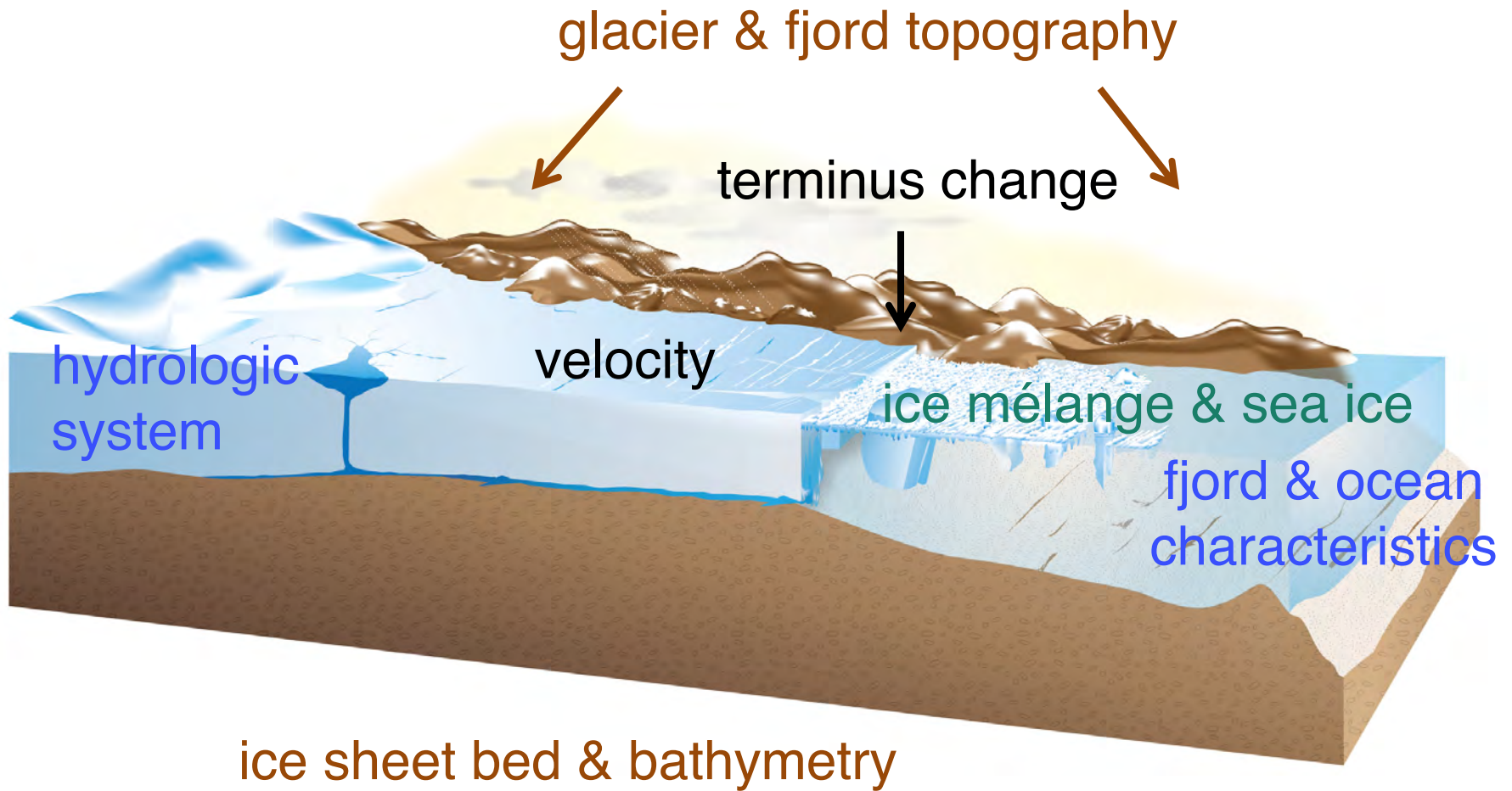
Local to global impacts of ice sheet change



Focus on areas of large, rapid change



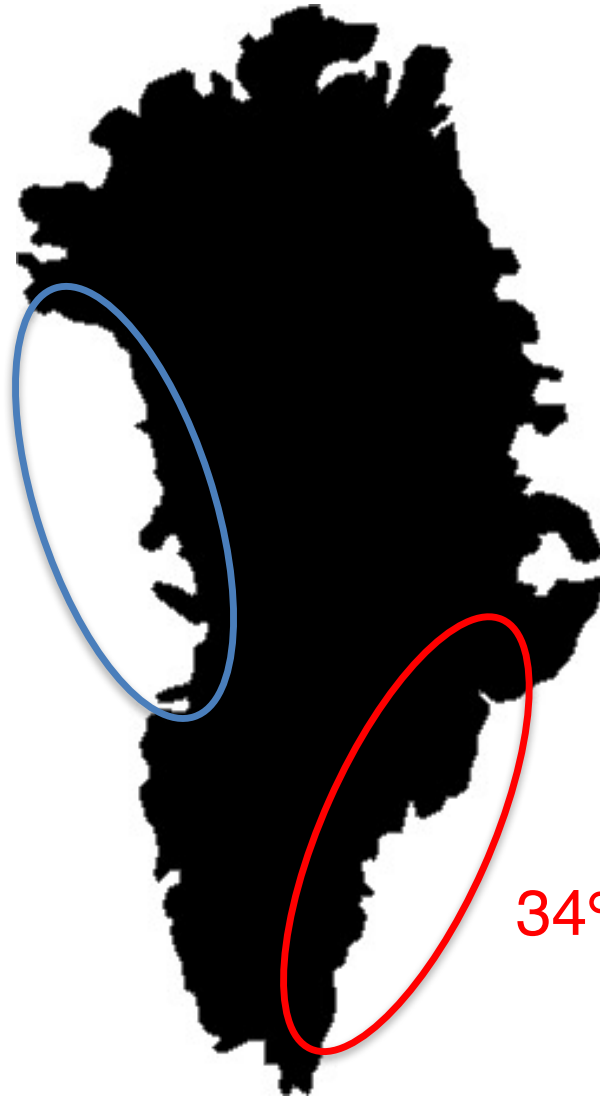
A connected ice-ocean system



Multi-year velocity changes

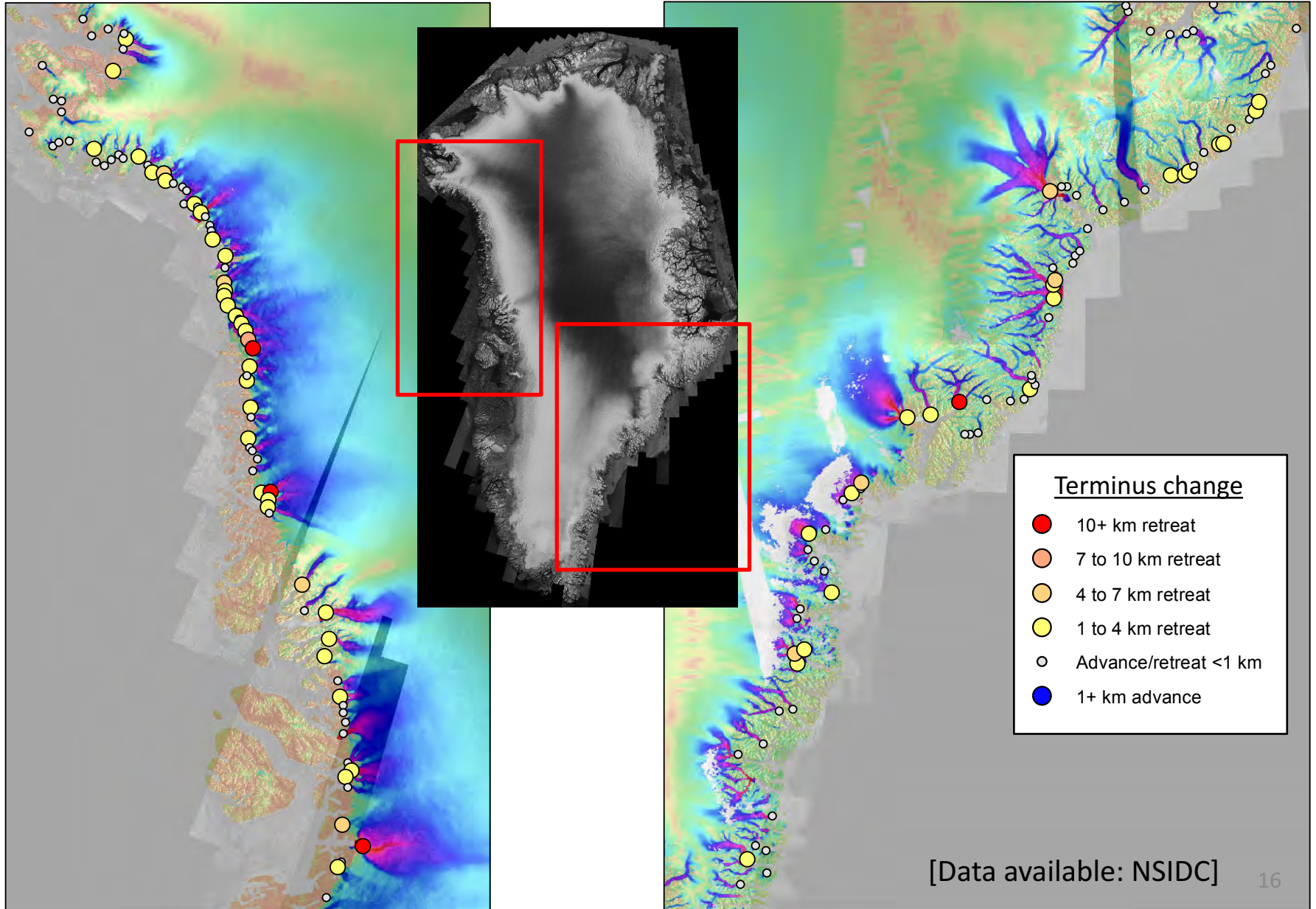
2000-2010 changes:

28% speedup

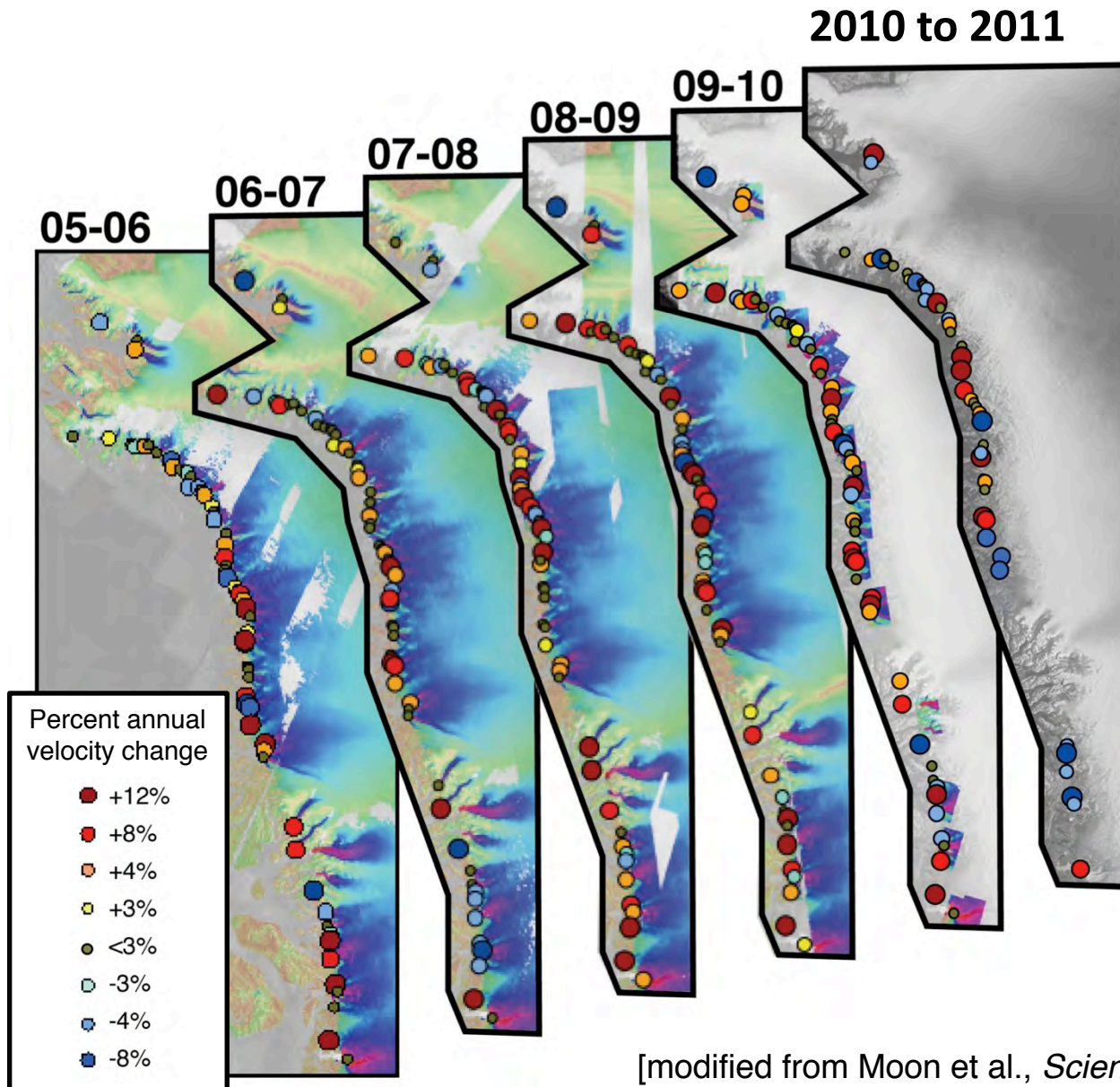


34% speedup

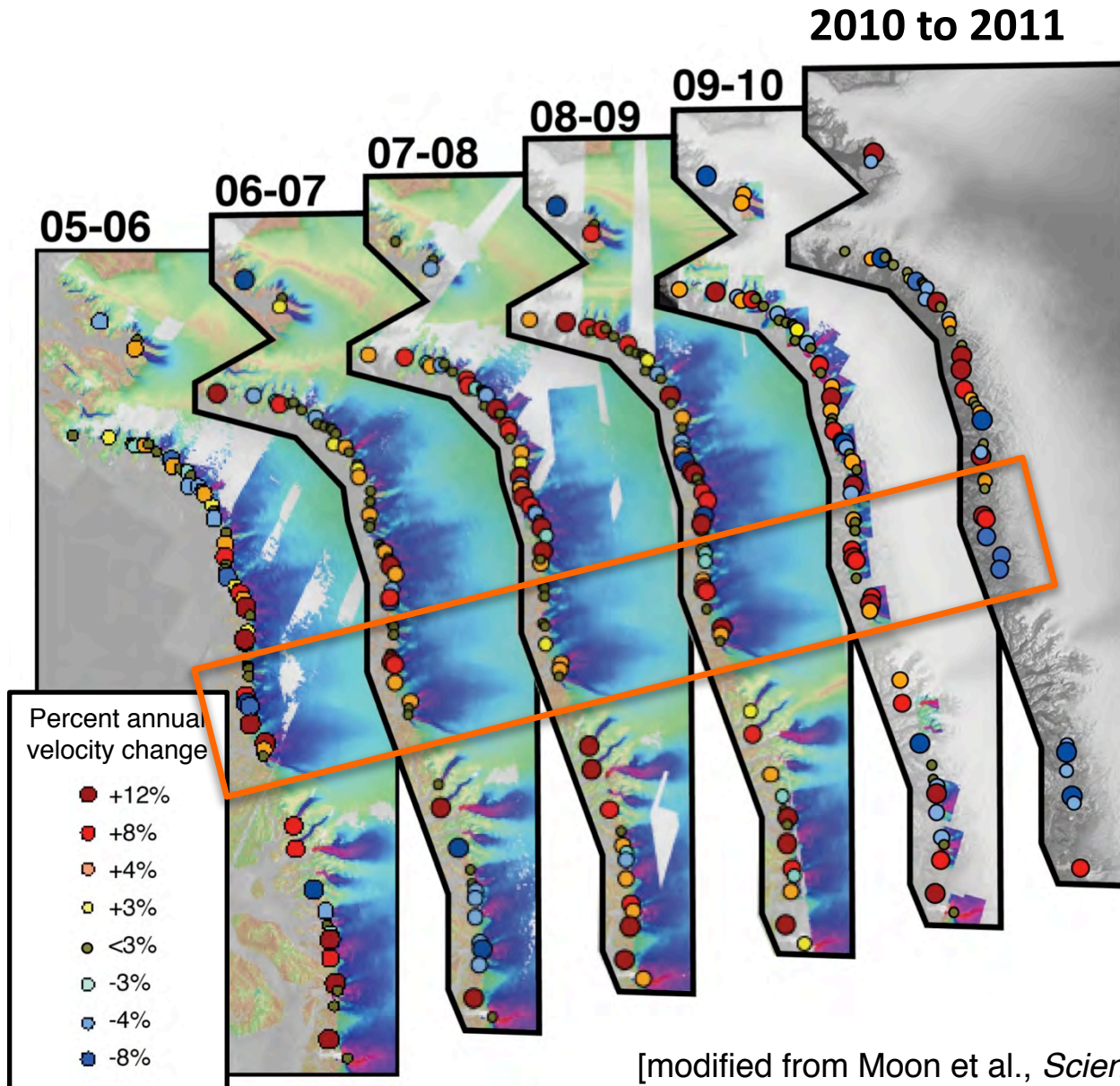
Widespread retreat (1992/93-2009/10)



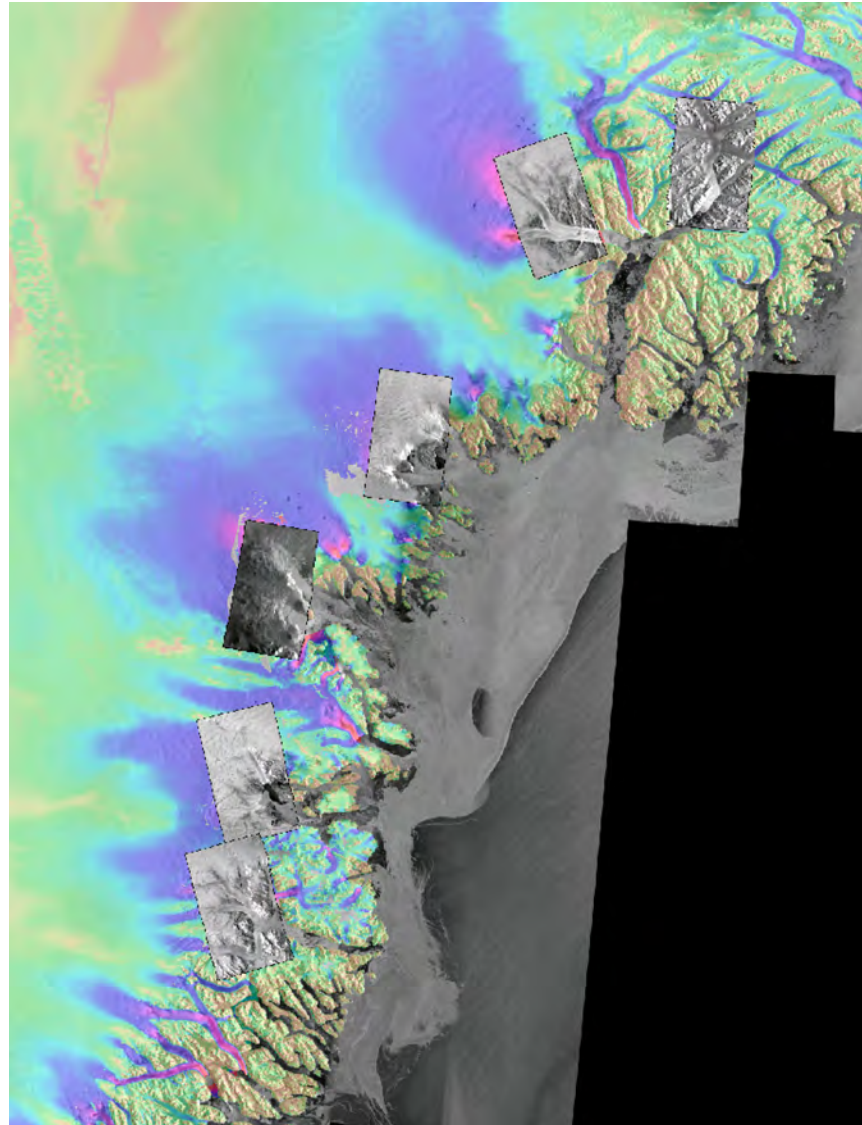
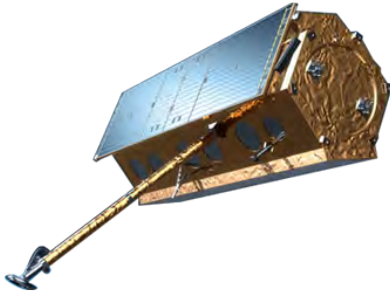
Local variability in space and time



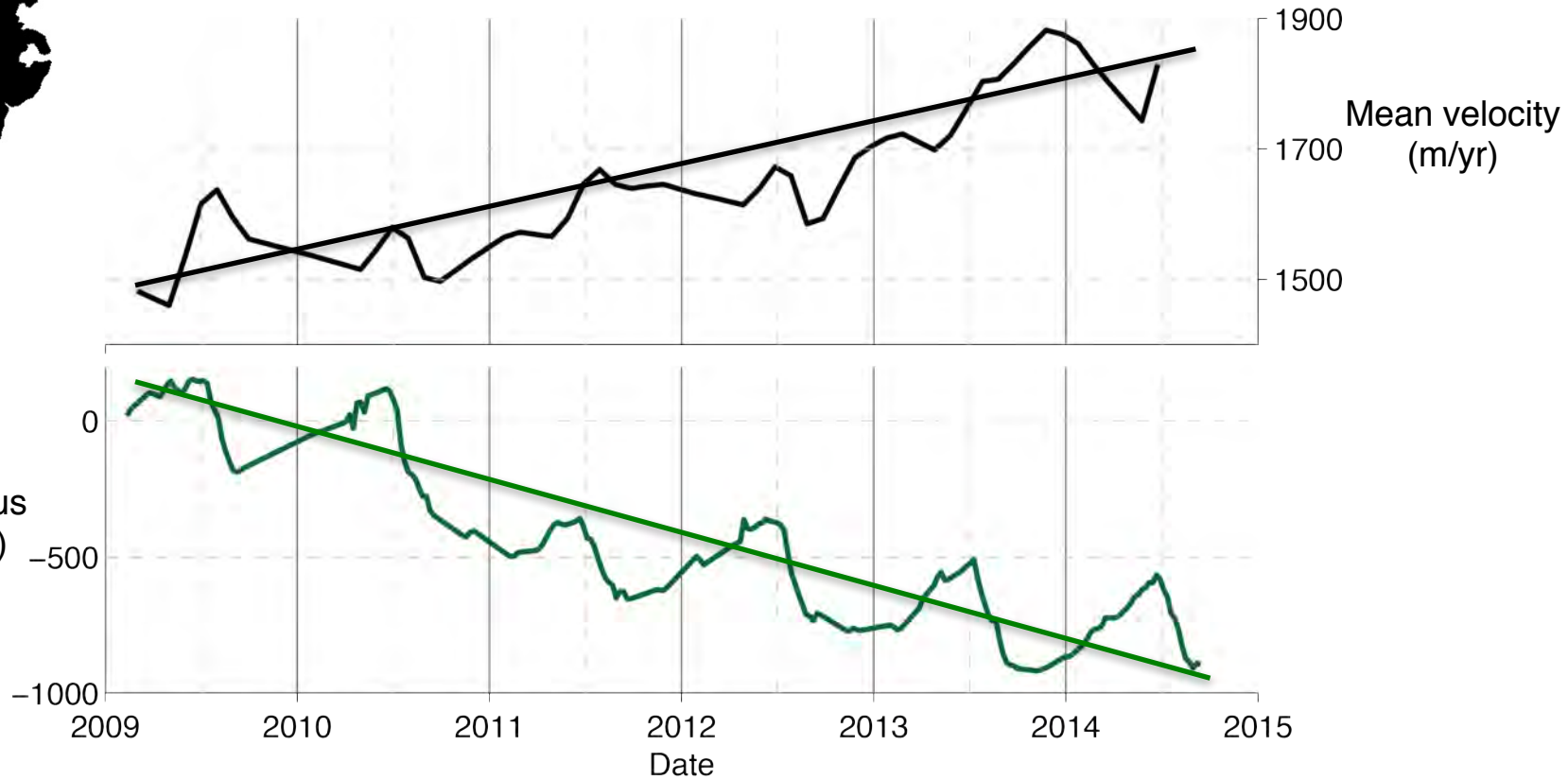
Local variability in space and time



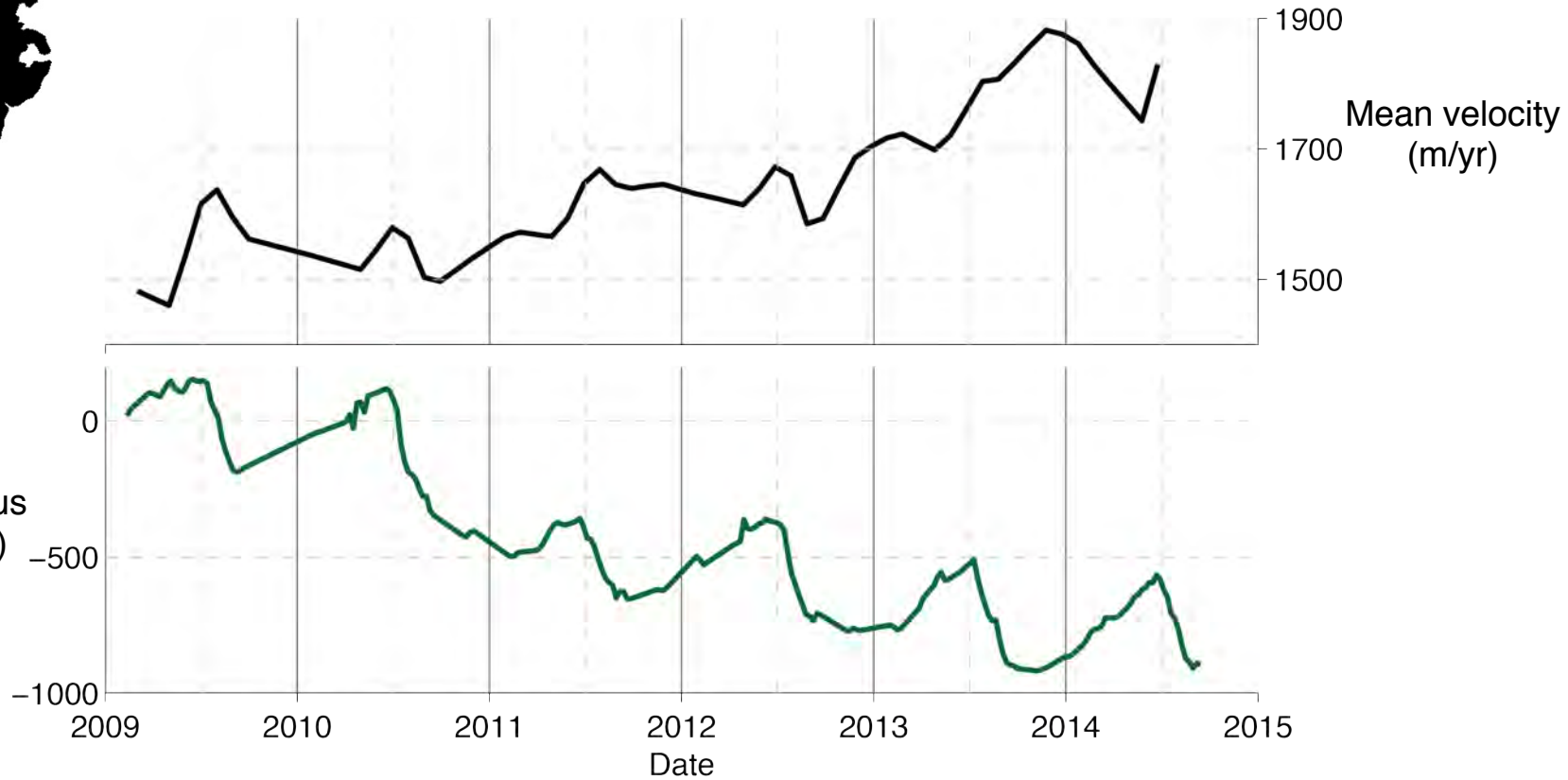
Improving temporal resolution



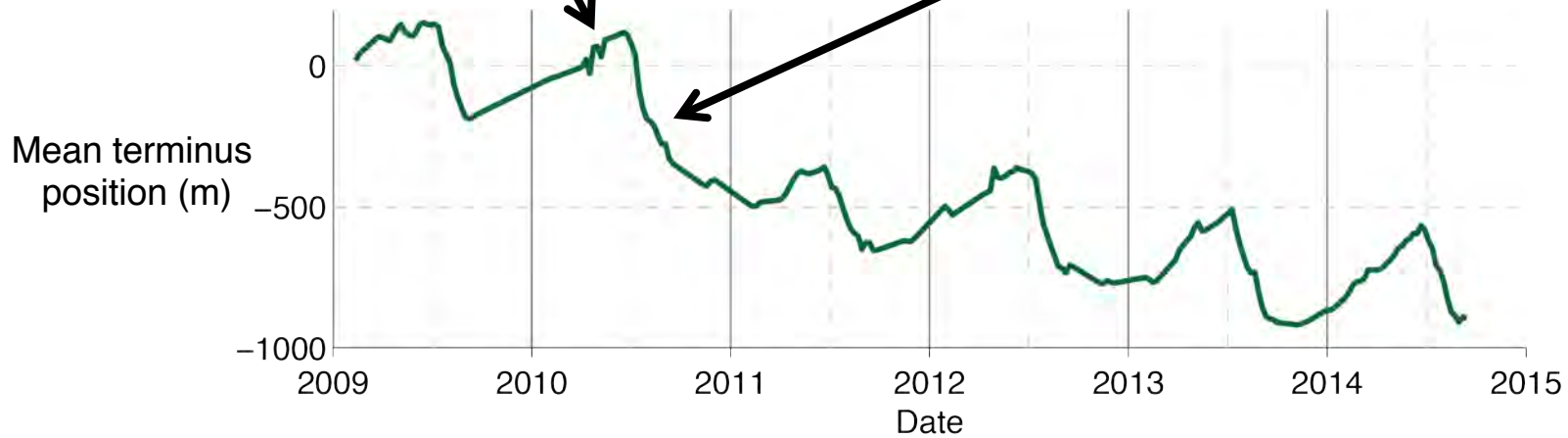
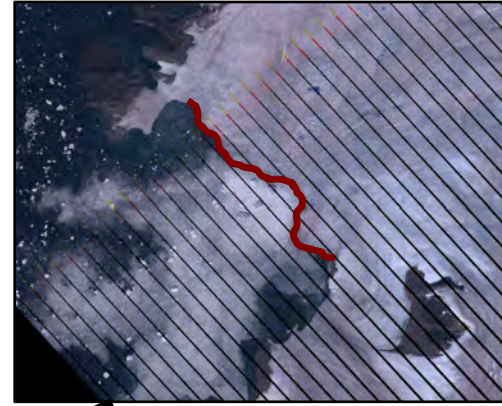
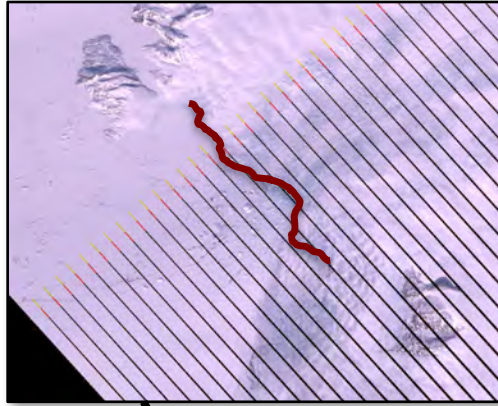
Long-term speedup linked to retreat



Seasonal patterns respond to different forcing?



Seasonal terminus change – sea ice link

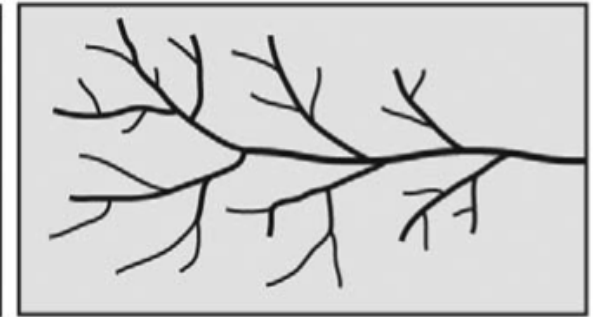
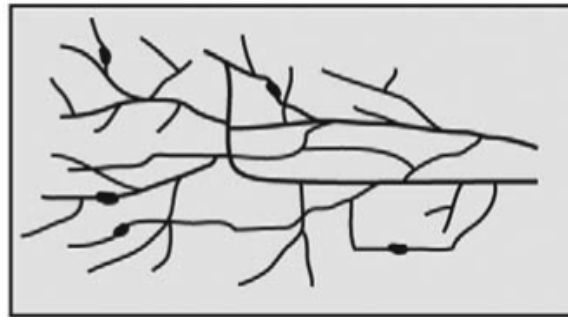
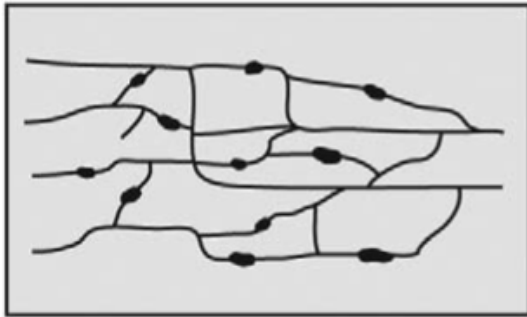


Hydrology-induced speedup

Distributed and inefficient system

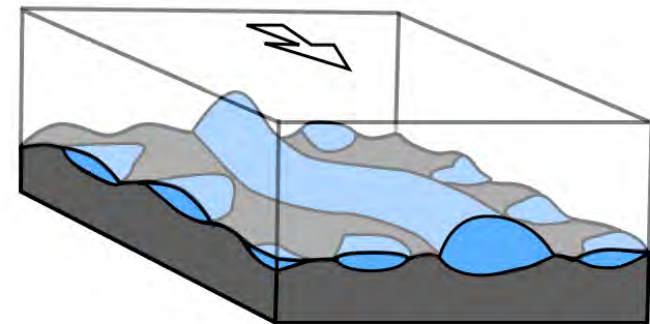
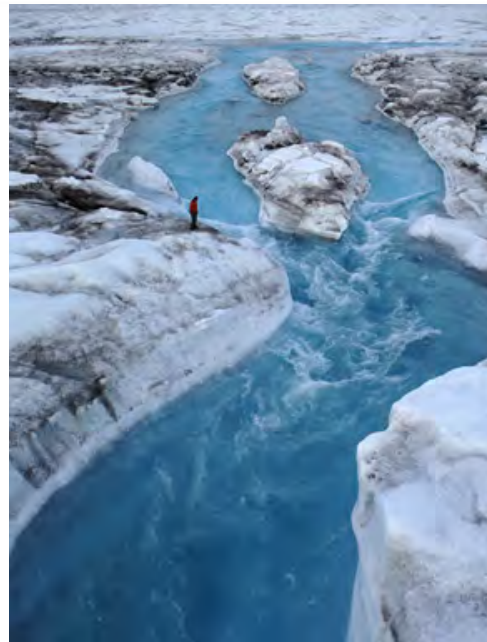
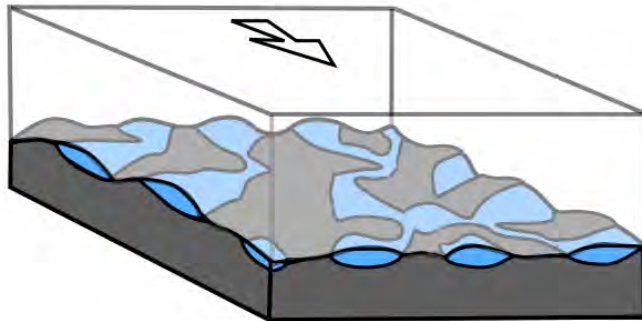
Increasingly efficient

Efficient and channelized system



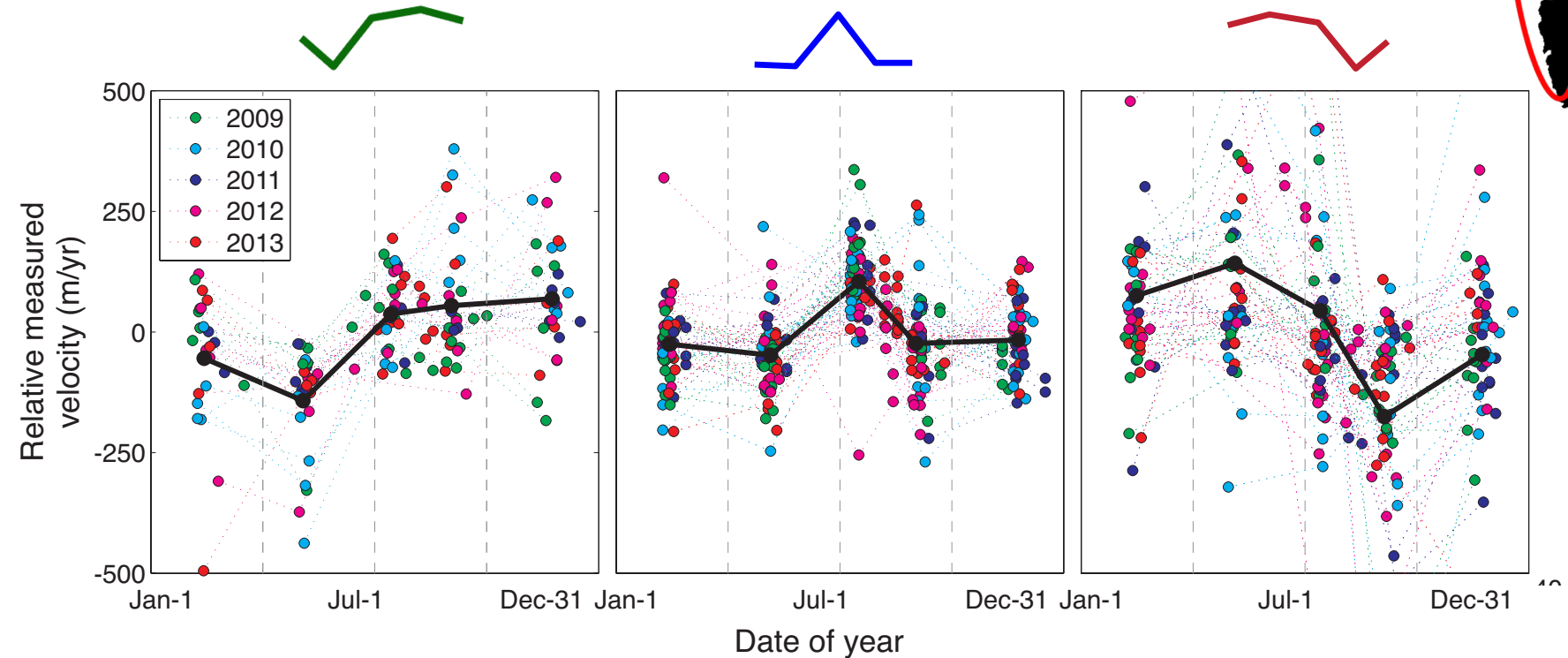
Ice flow direction

[Carr et al., 2013]

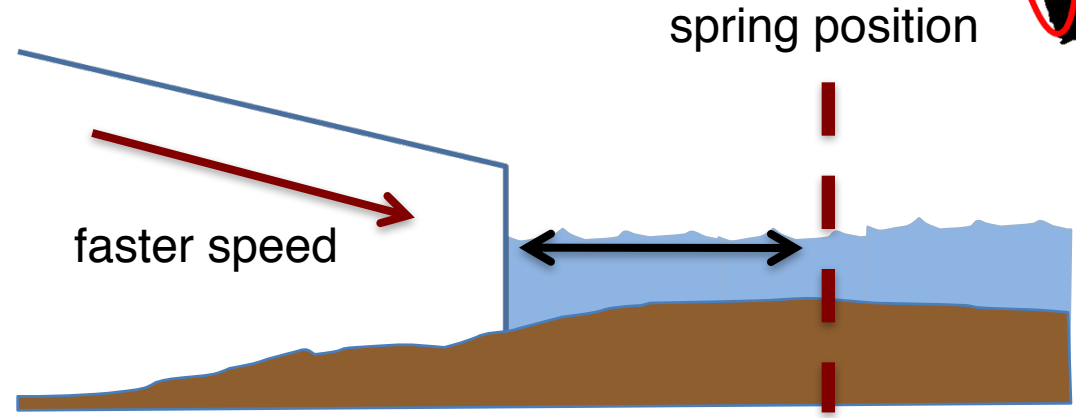
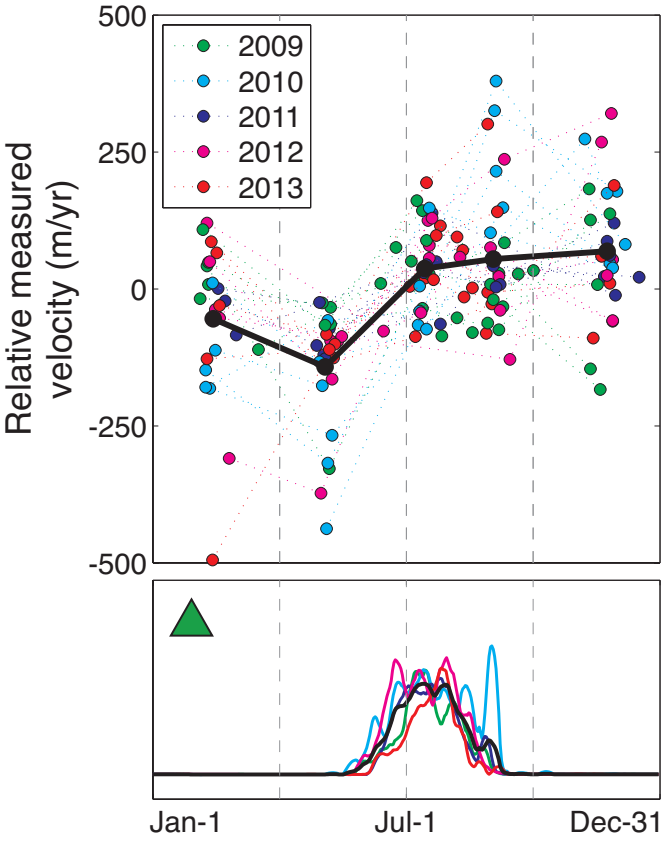


[Diagrams: I. Hewitt]

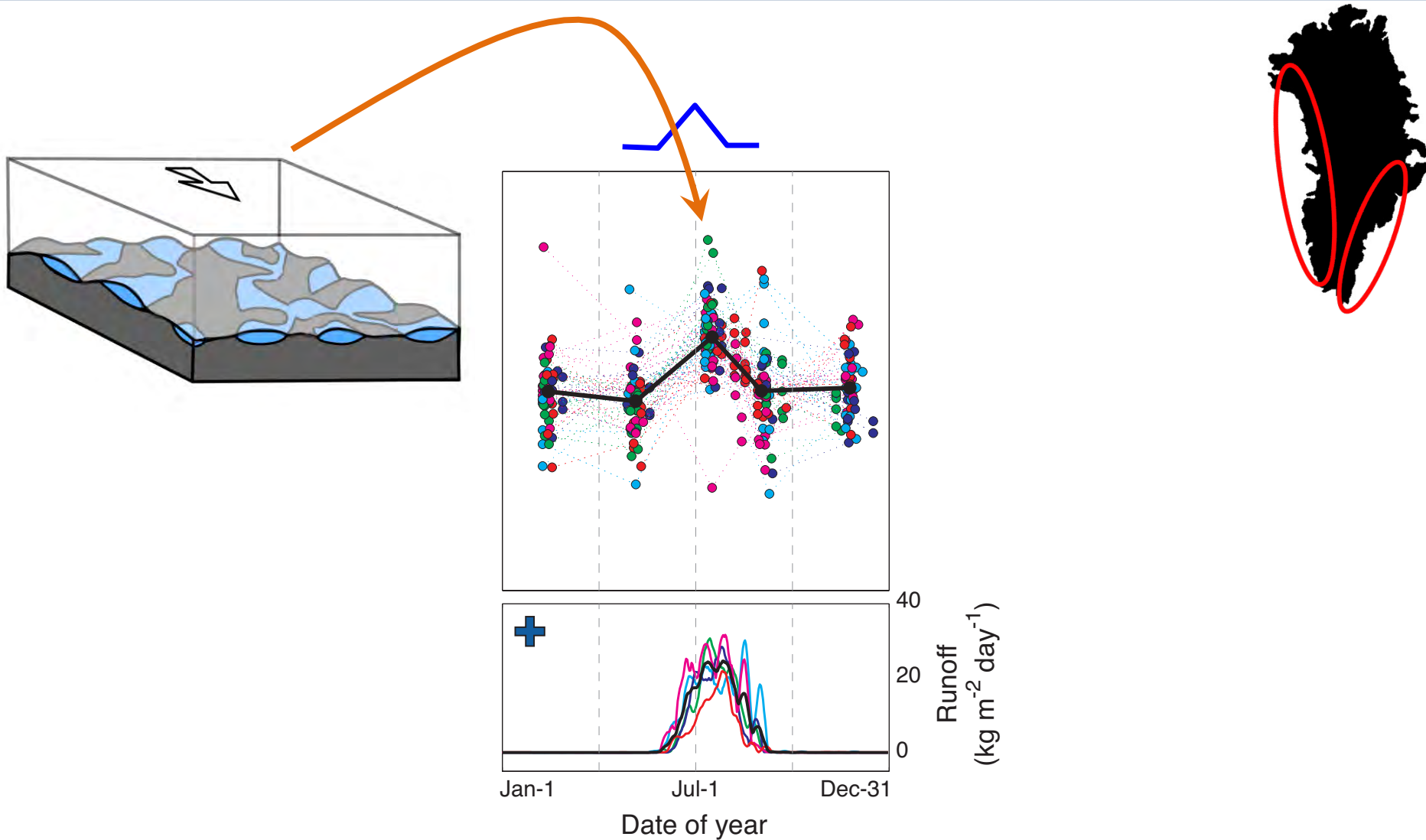
Distinct seasonal velocity patterns



Velocity linked to terminus change

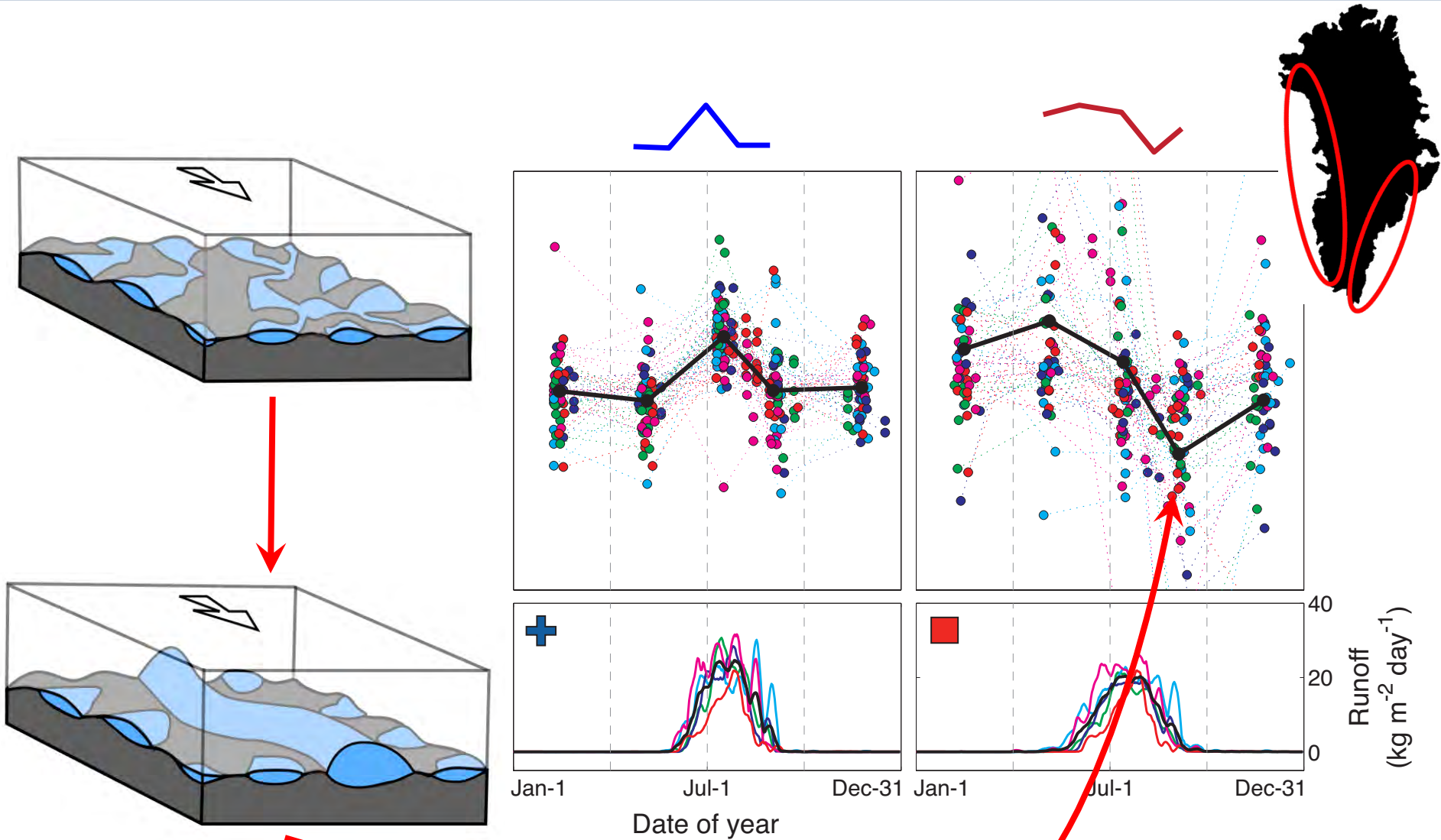


Velocity linked to subglacial hydrology



[Diagrams: I. Hewitt]

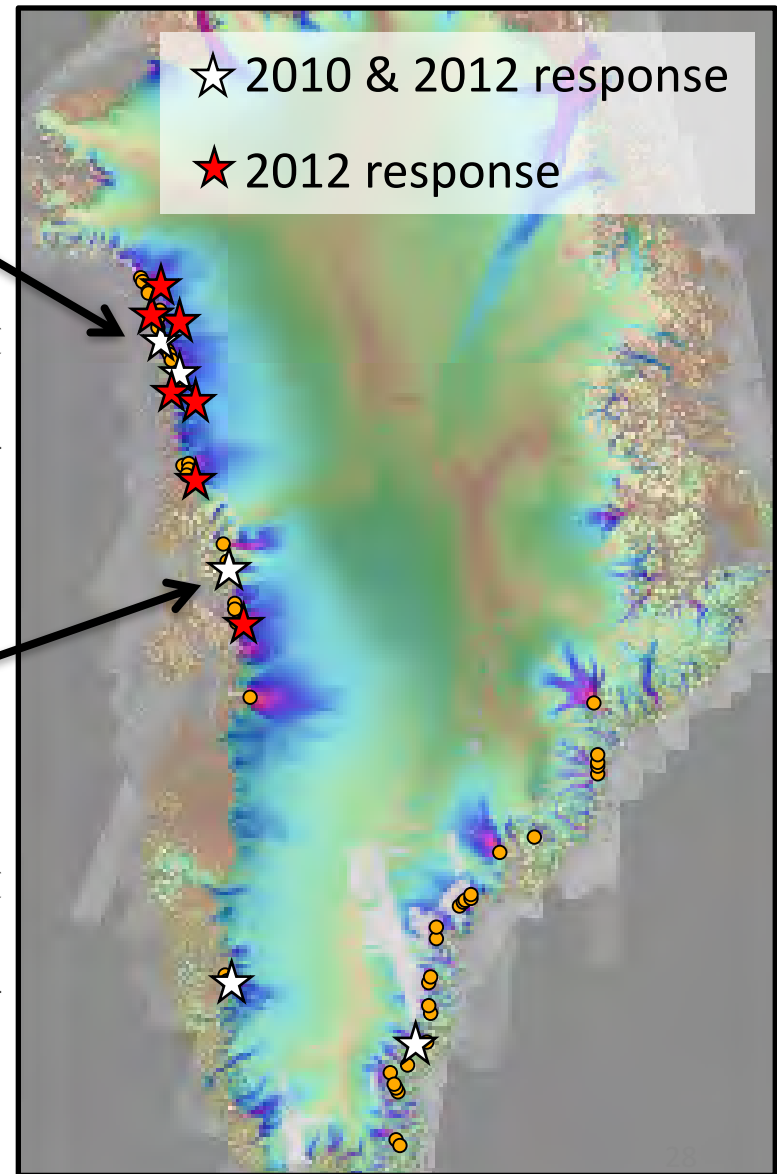
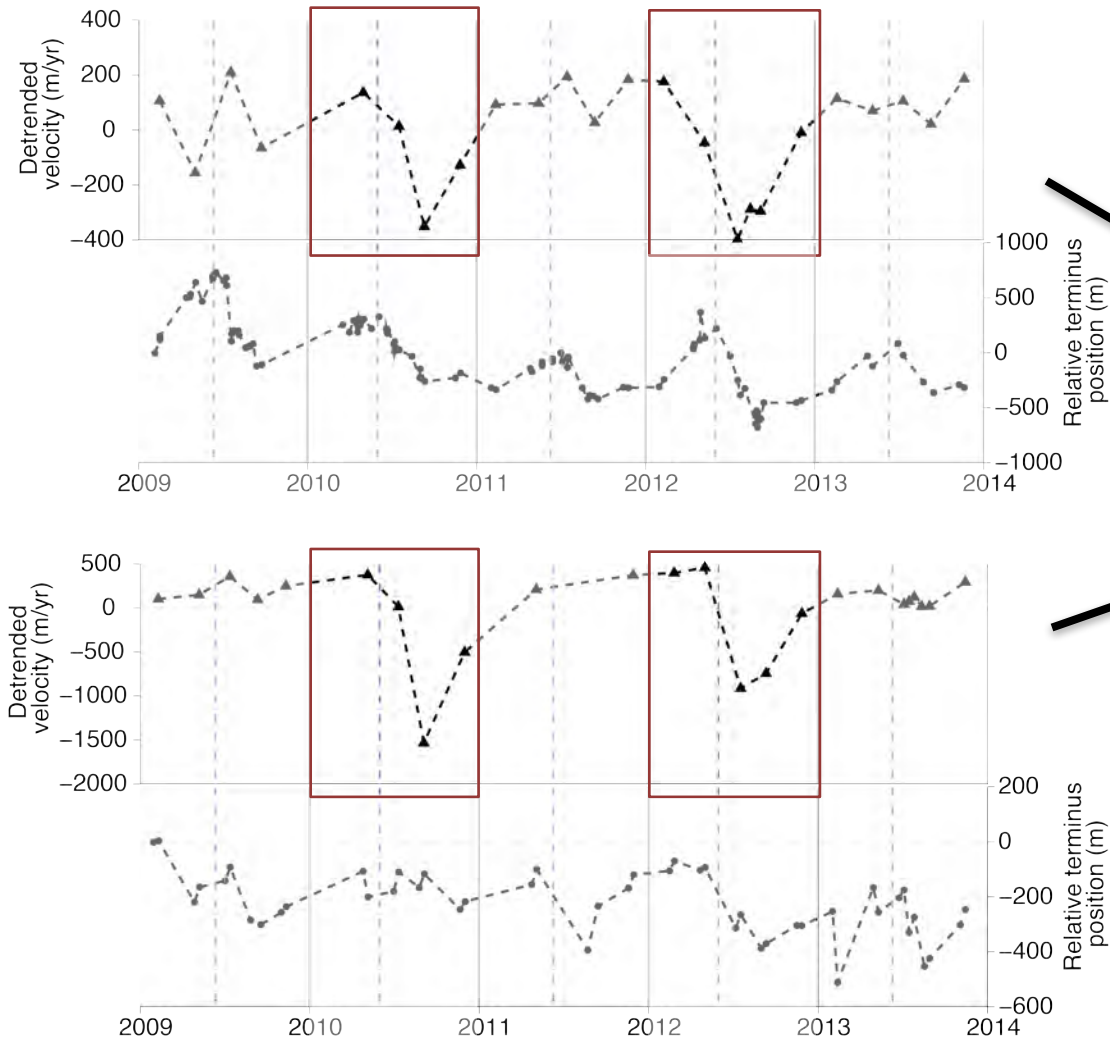
Velocity linked to subglacial hydrology



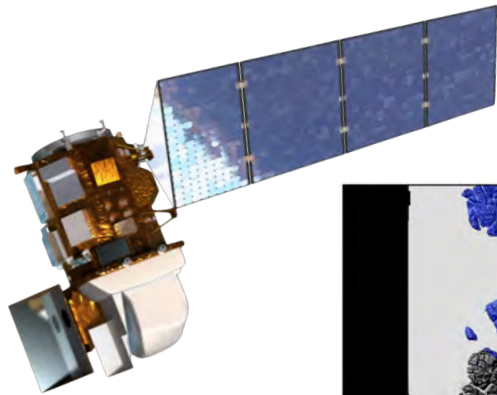
[Diagrams: I. Hewitt]

[Moon et al., *GRL*, 2014] ²⁷

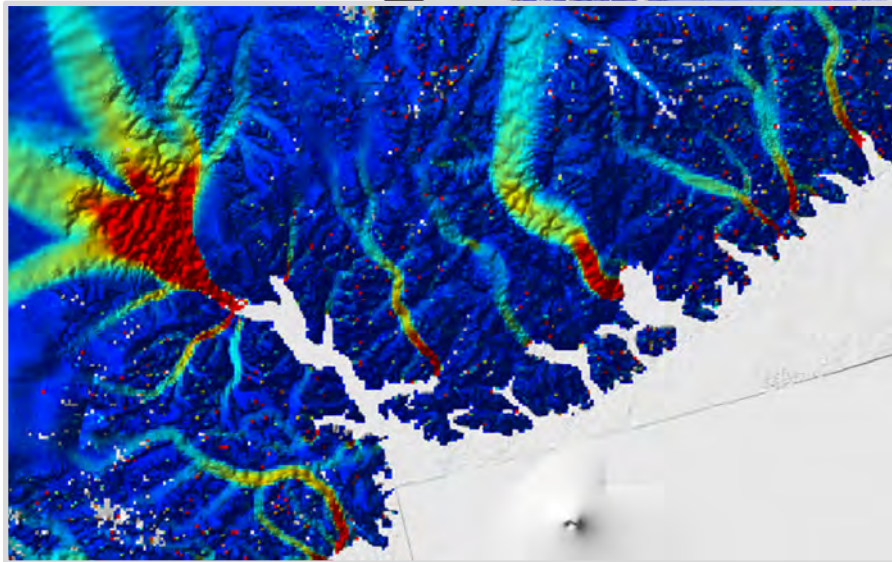
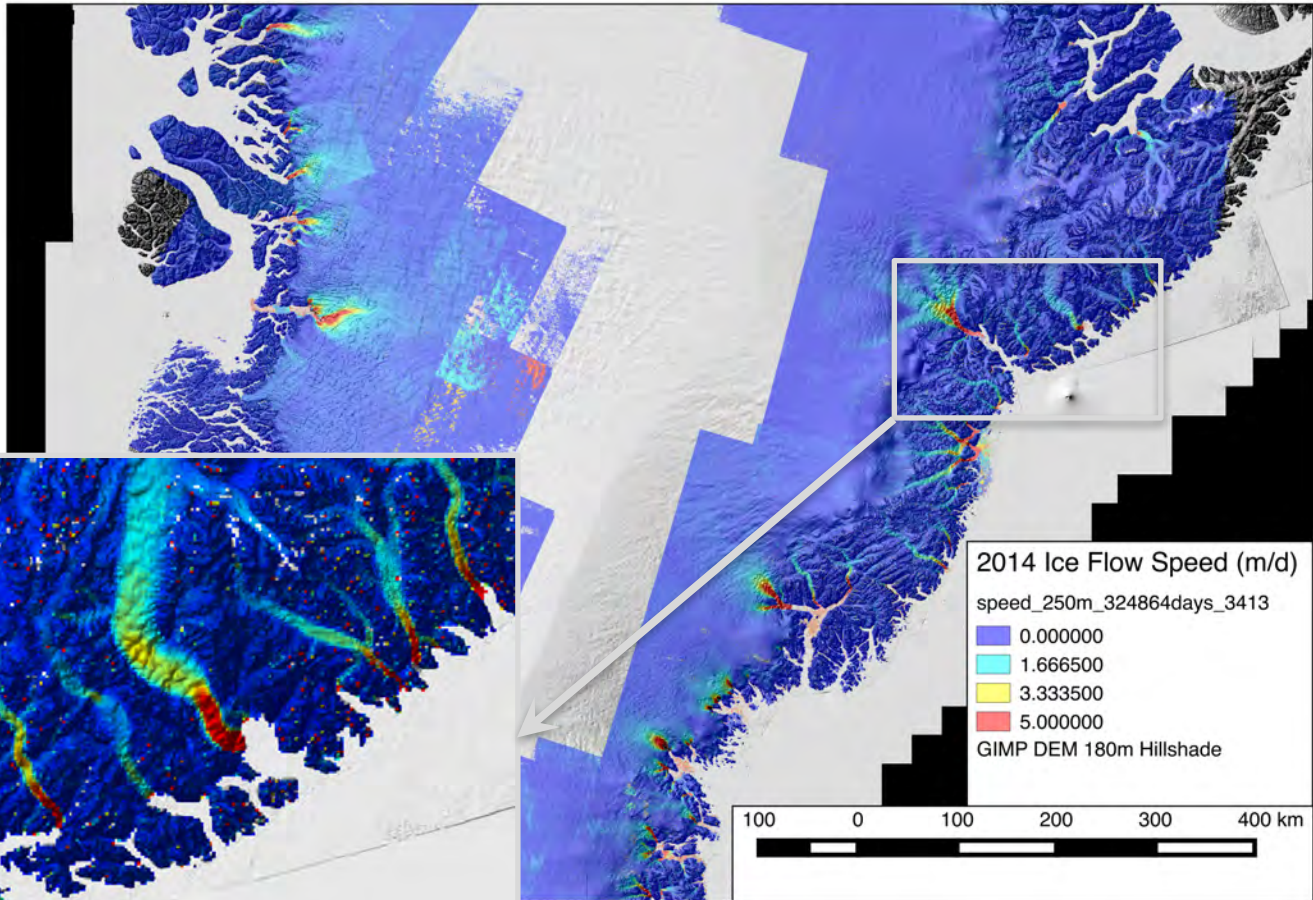
Velocity reflecting surface melt changes



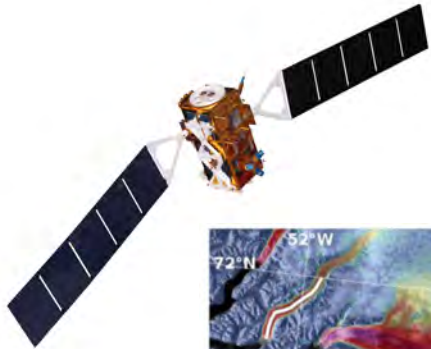
More improvements in space/time measurements



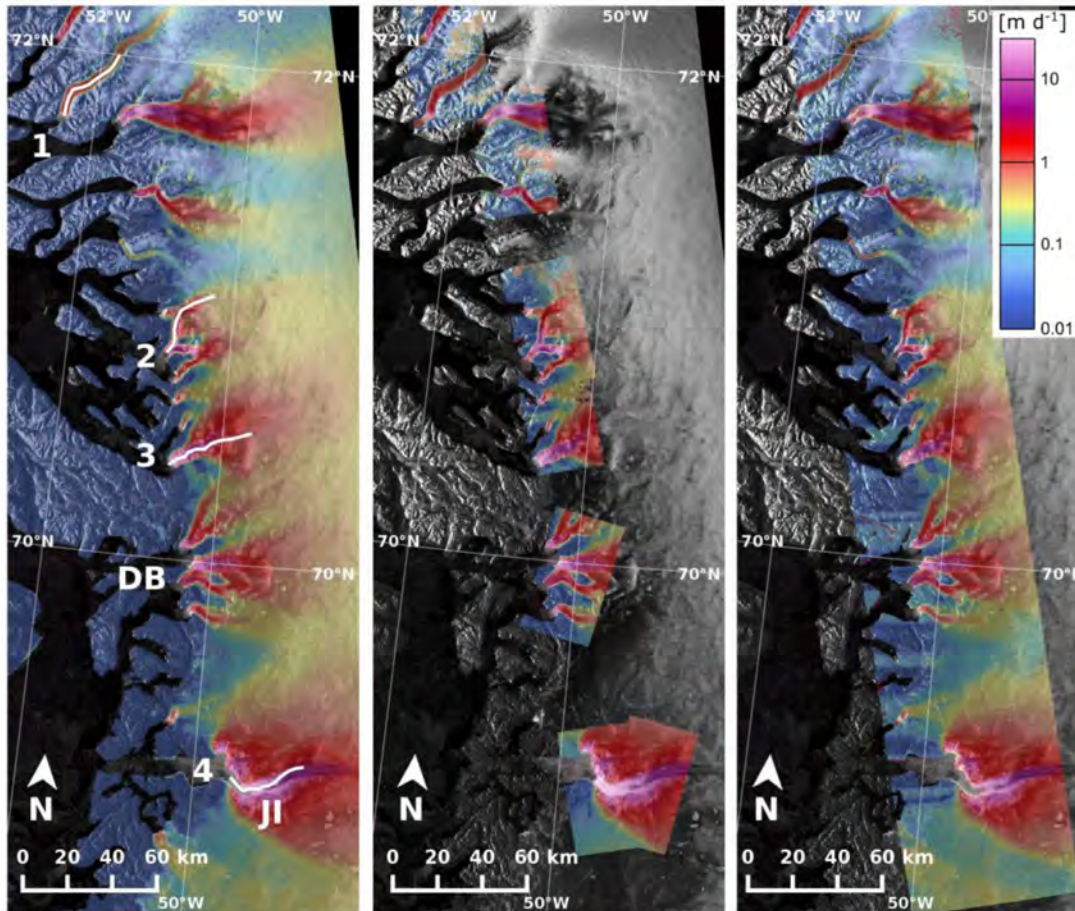
Landsat 8 to ice surface velocity (globally).



Multiple satellites on the task



Sentinel 1 radar-derived velocities.

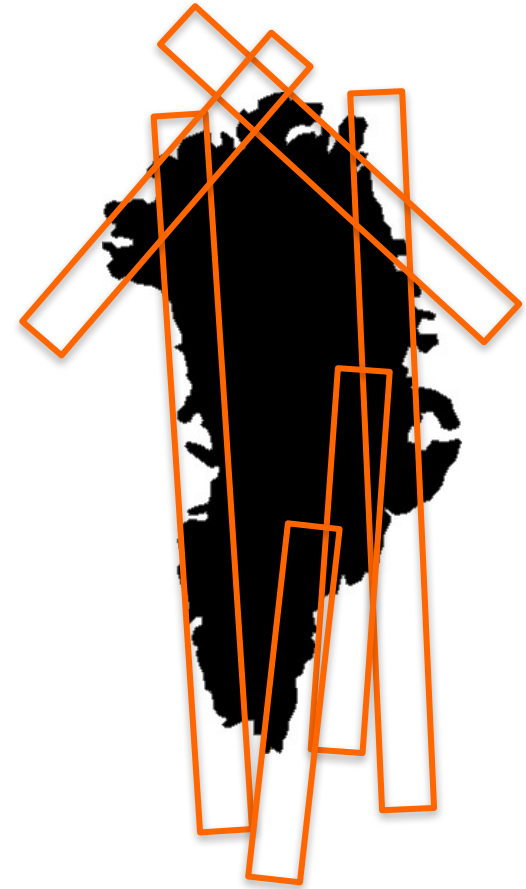


(a)

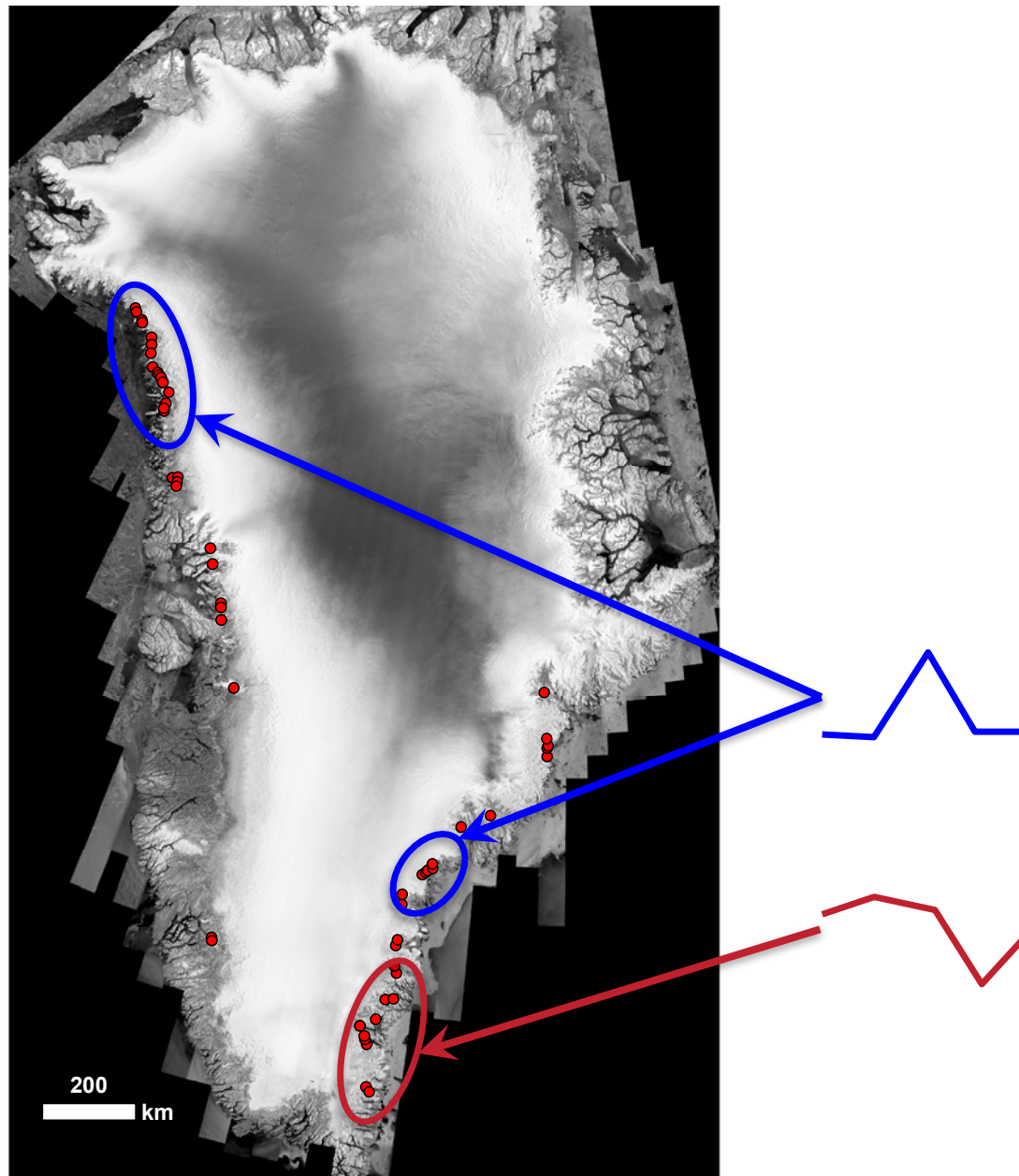
(b)

(c)

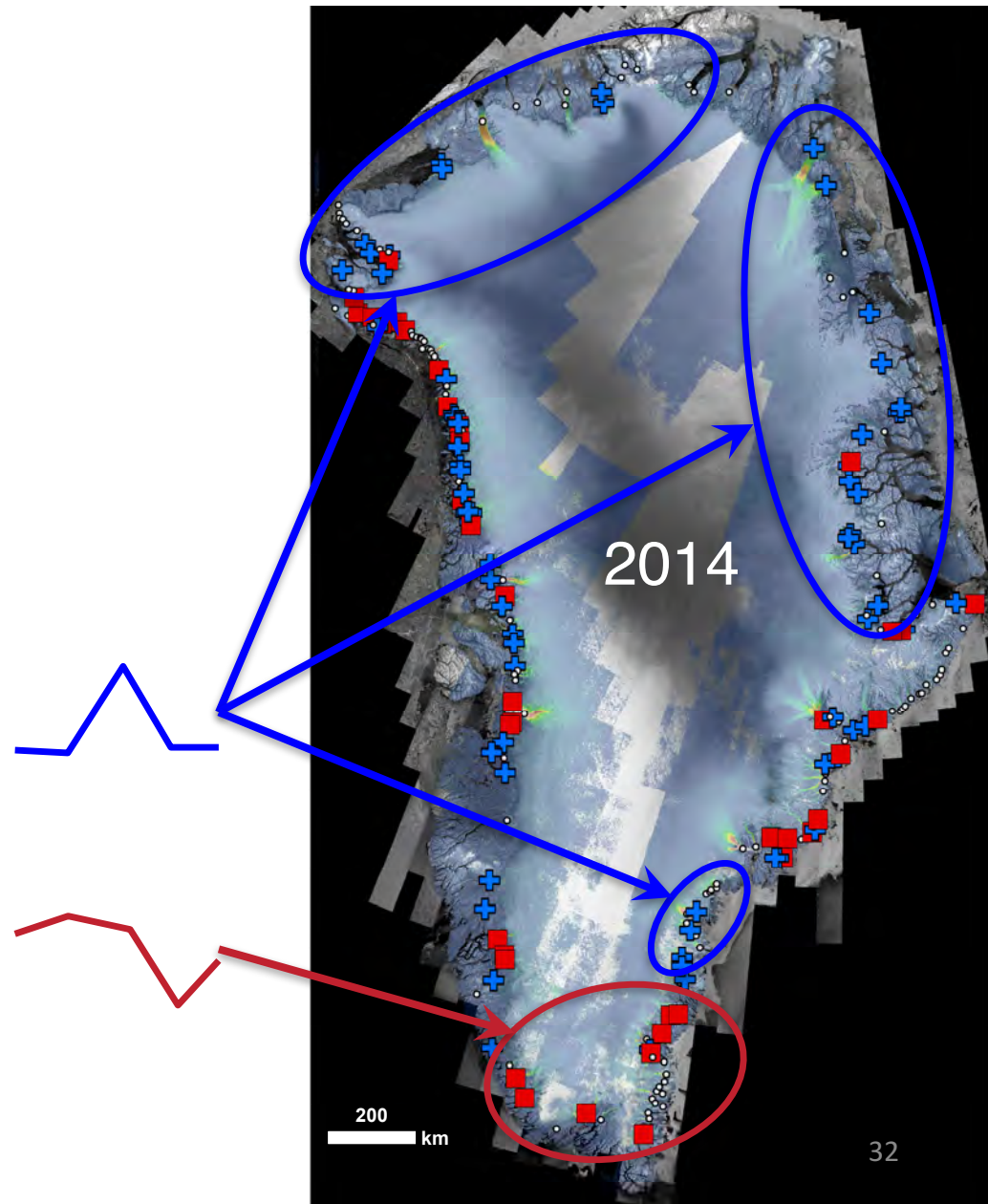
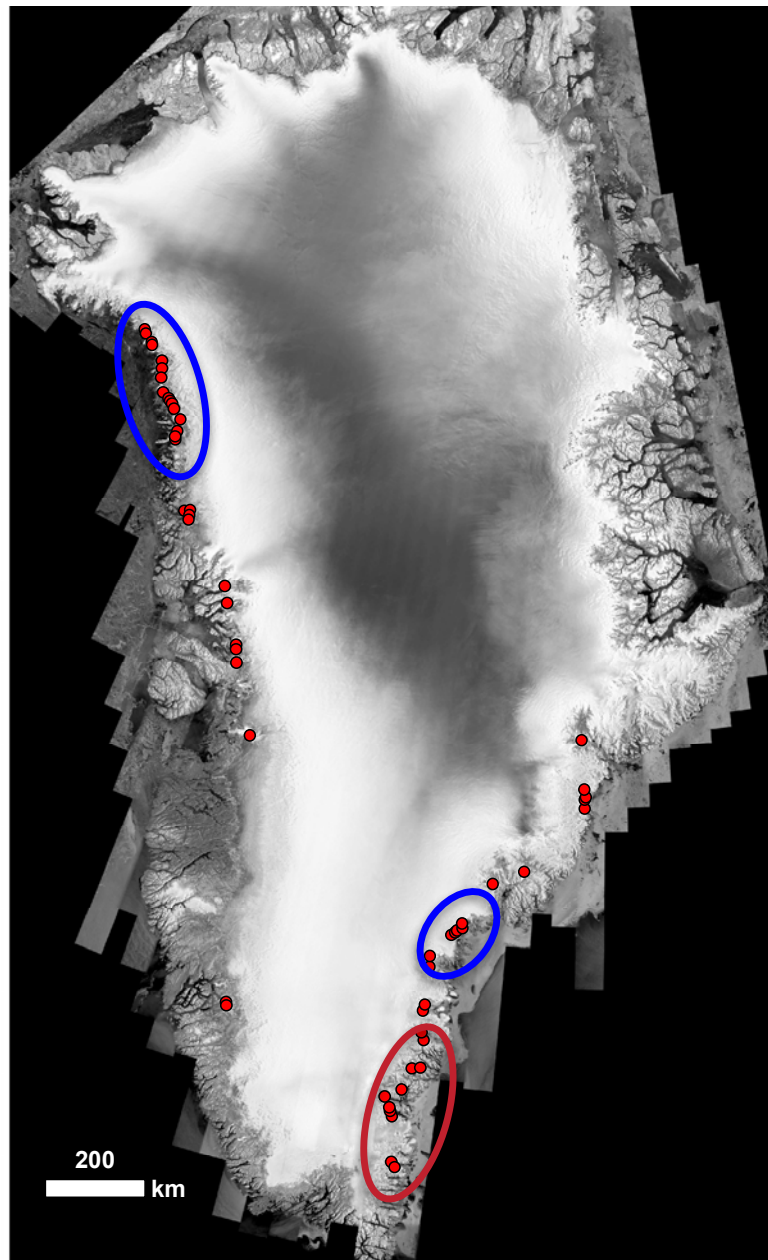
[Nagler et al., *RS*, 2015]



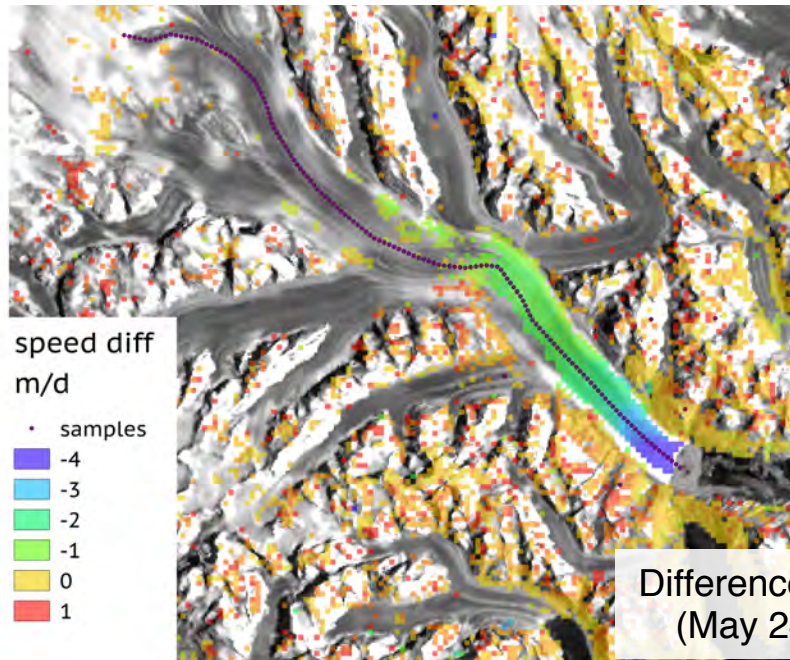
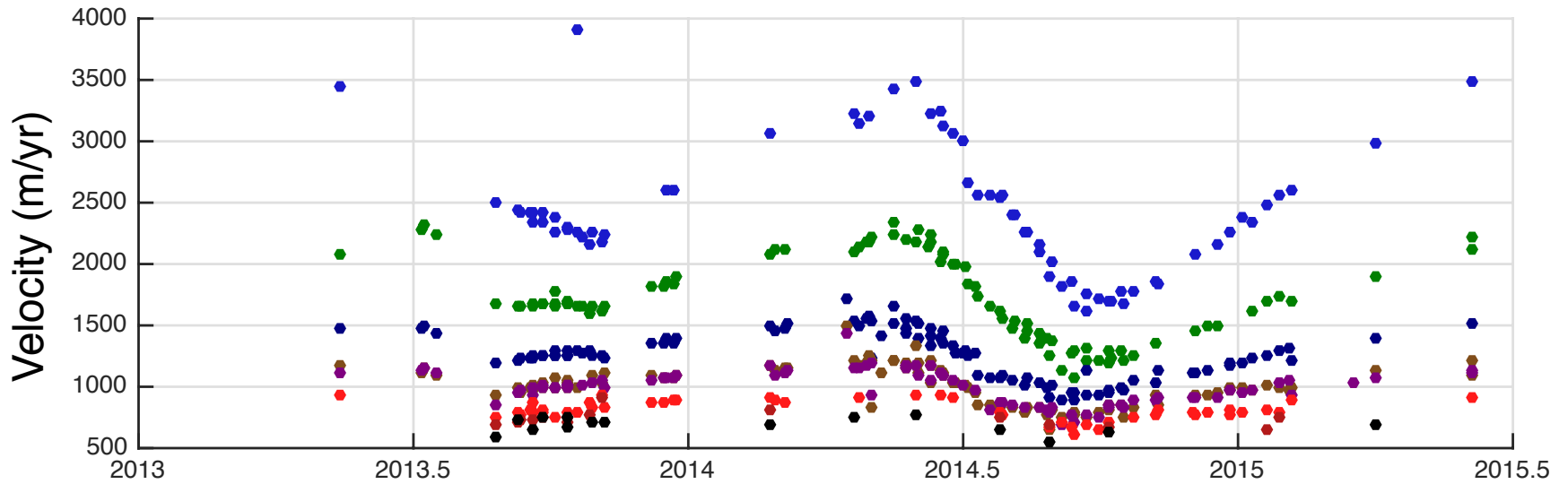
From regional to ice sheet wide analysis



From regional to ice sheet wide analysis



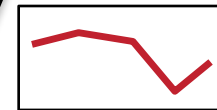
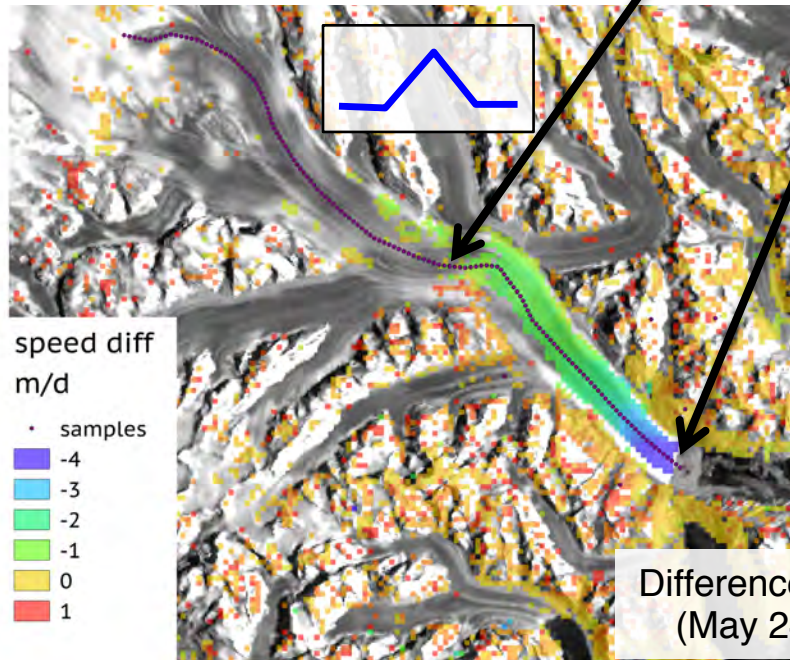
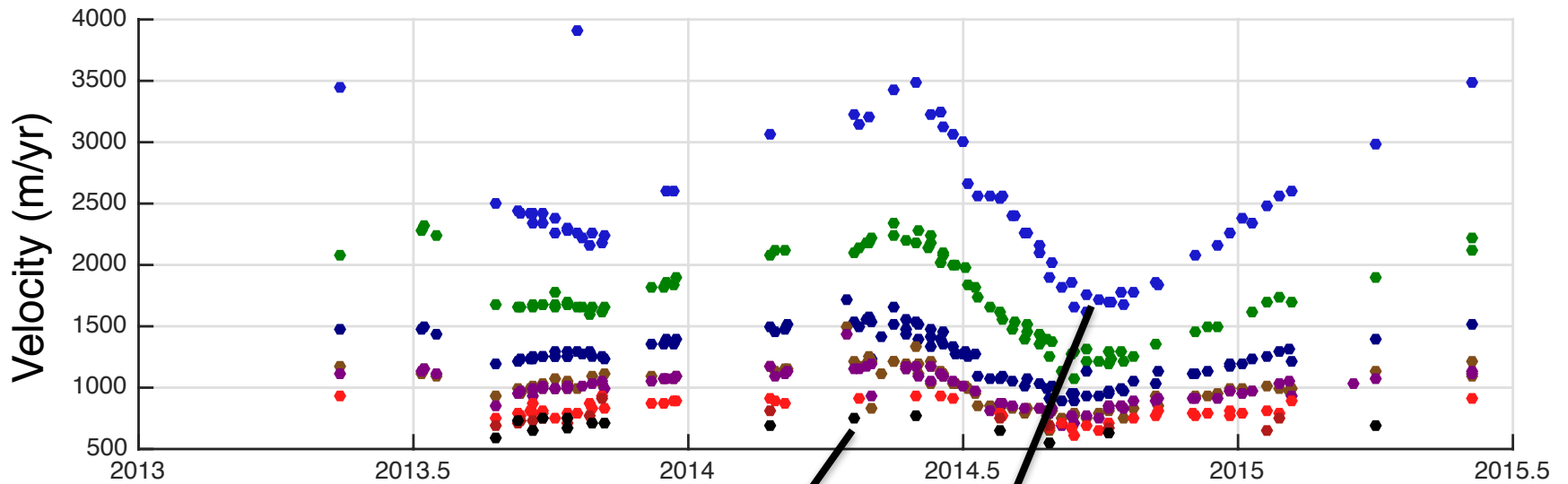
Answering questions across space and time



Differences during 2014 summer to fall:
(May 24-June 9) to (Sep 6-Sep 22)



Answering questions across space and time



Differences during 2014 summer to fall:
(May 24-June 9) to (Sep 6-Sep 22)

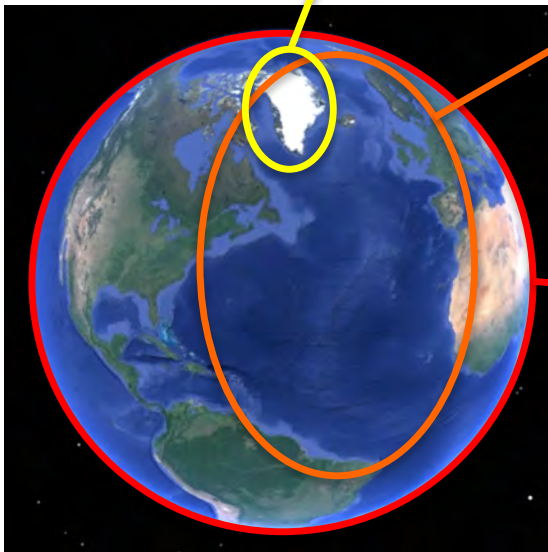
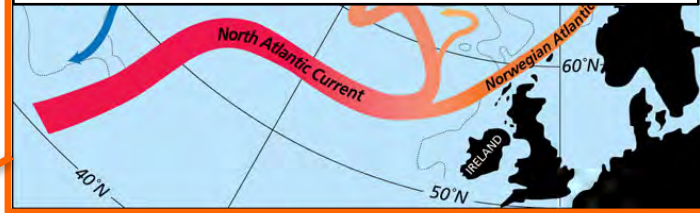


Progress at all scales. For example...

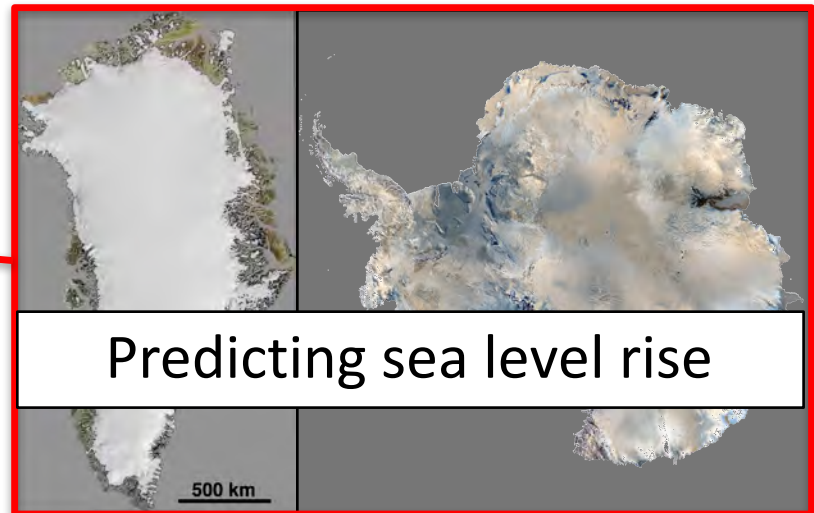
Location
& timing



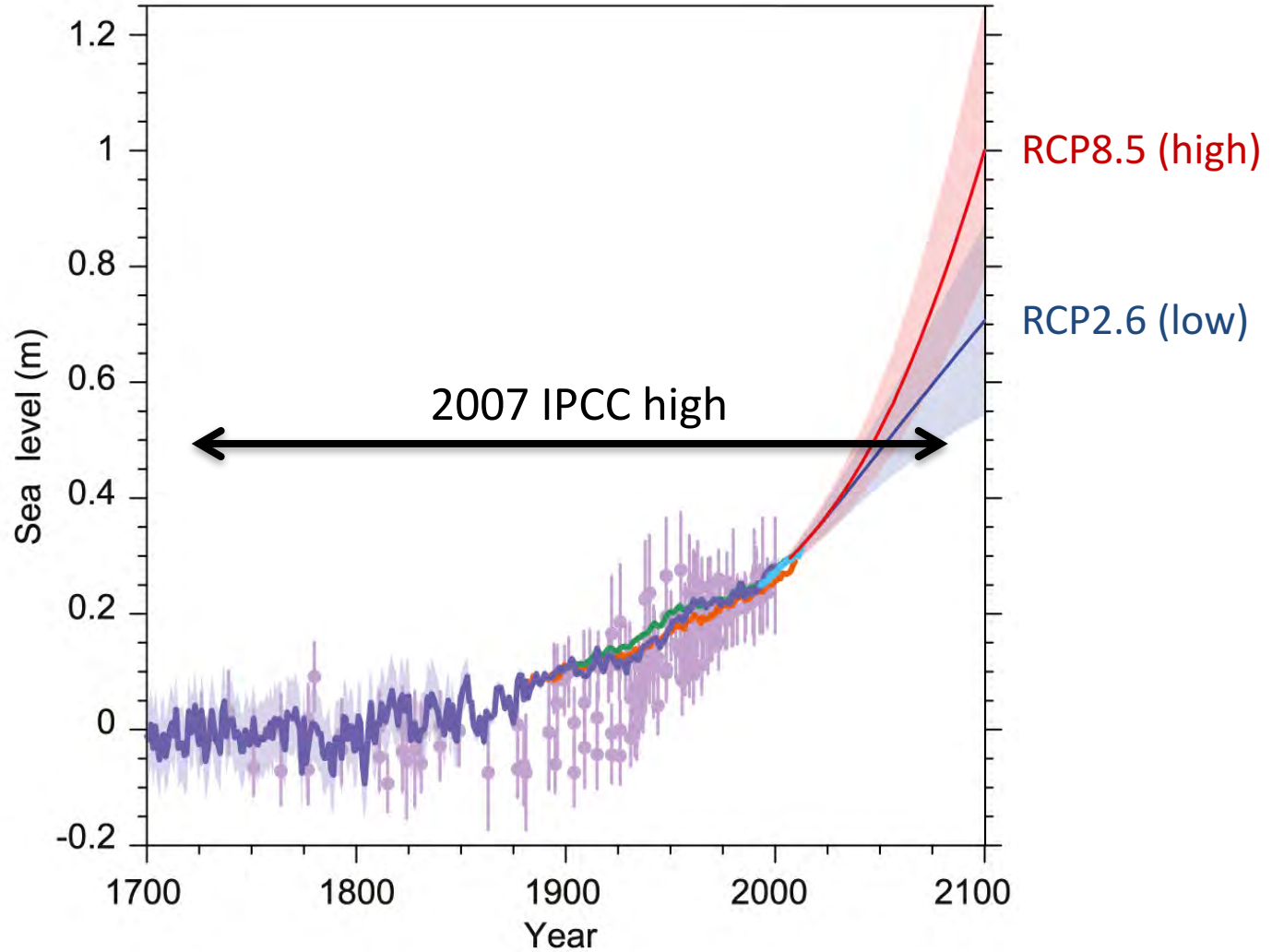
Understanding mass loss
& freshwater flux



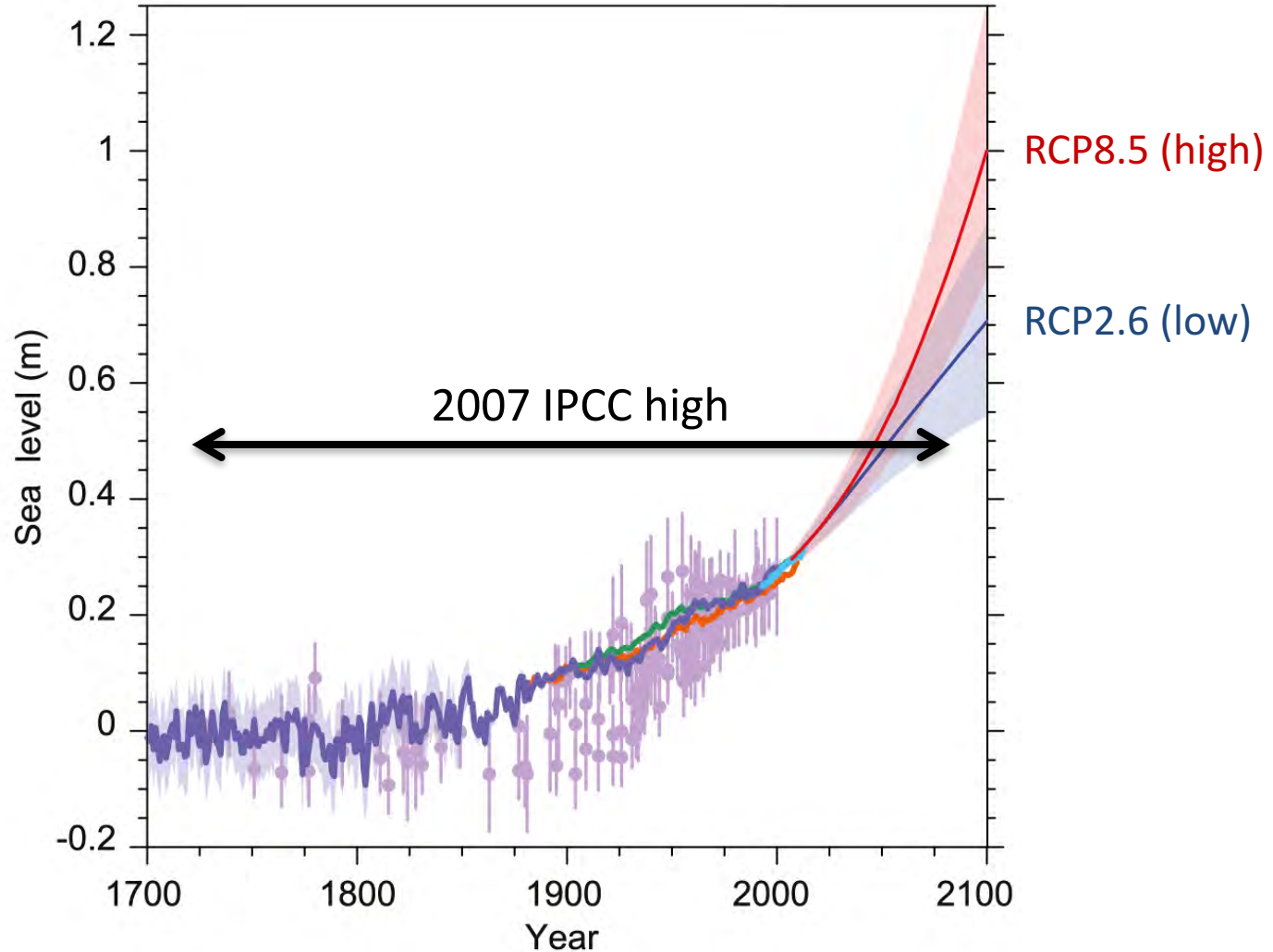
Predicting sea level rise



New projections of future SLR

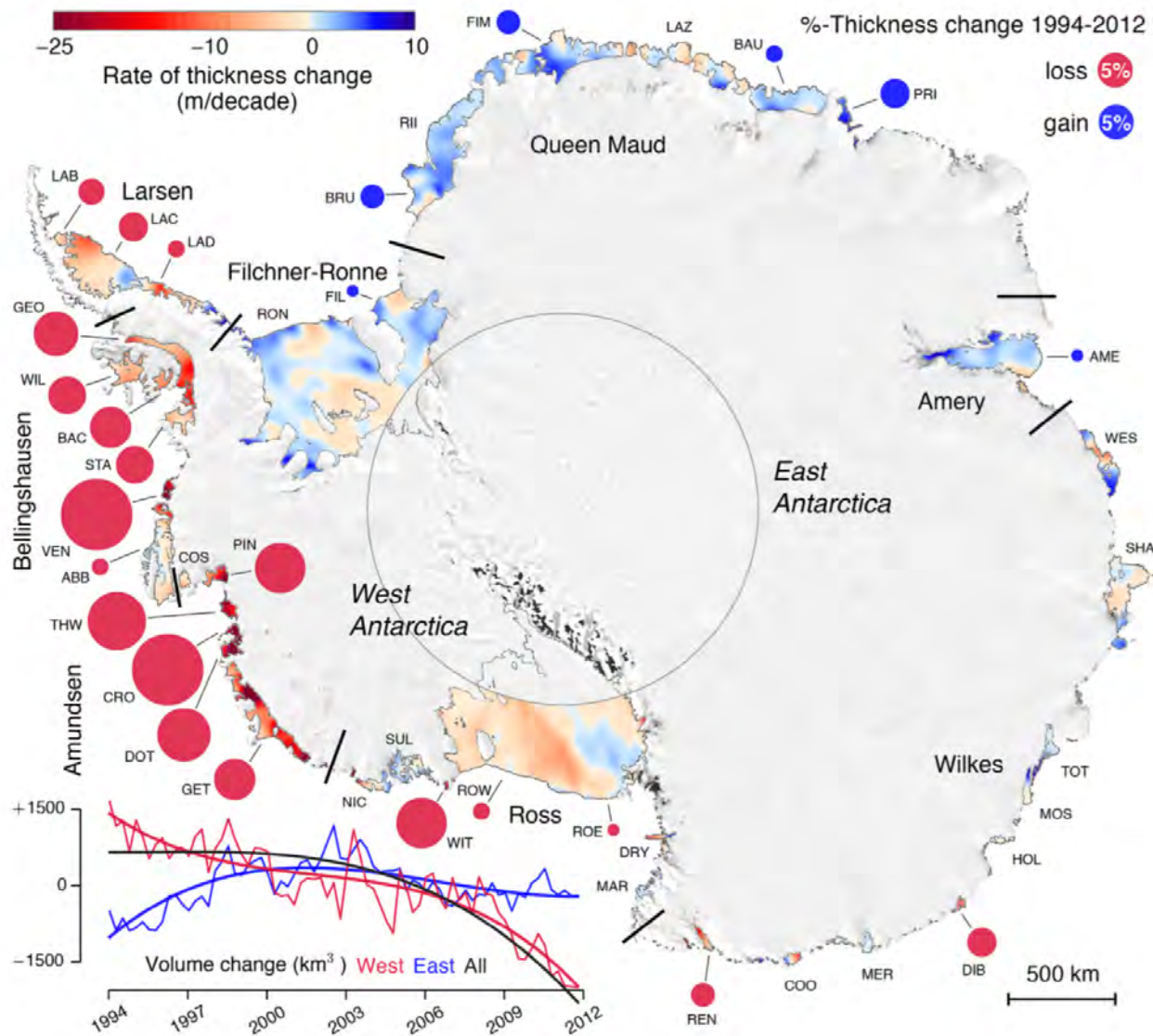


New projections of future SLR



Many of the IPCC 2013 conclusions regarding sea level rise and mass loss from ice sheets only have *medium confidence*.

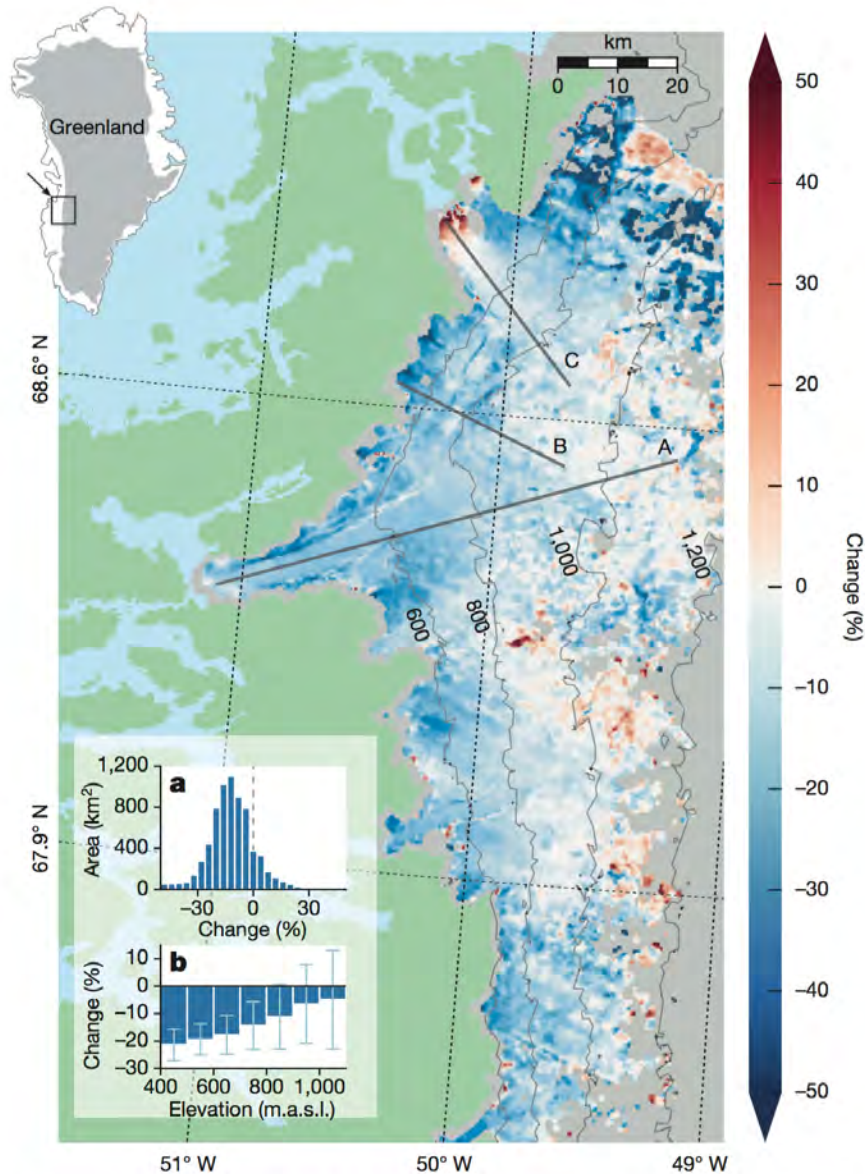
Expect more velocity changes to come



[Paolo et al., *Science*, 2015]

Look where others aren't

2007-14 compared to 1985-94



Thank you & be in touch!

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