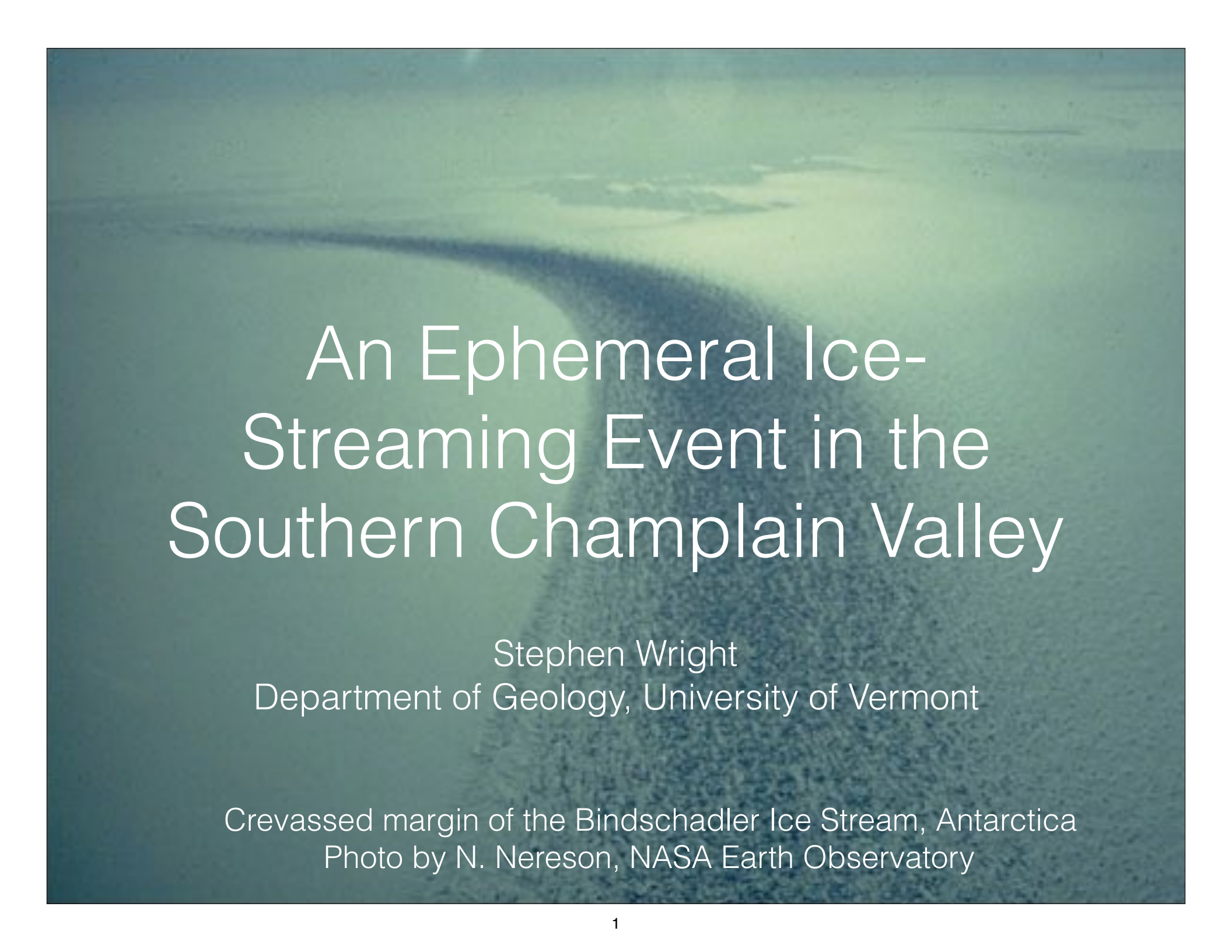
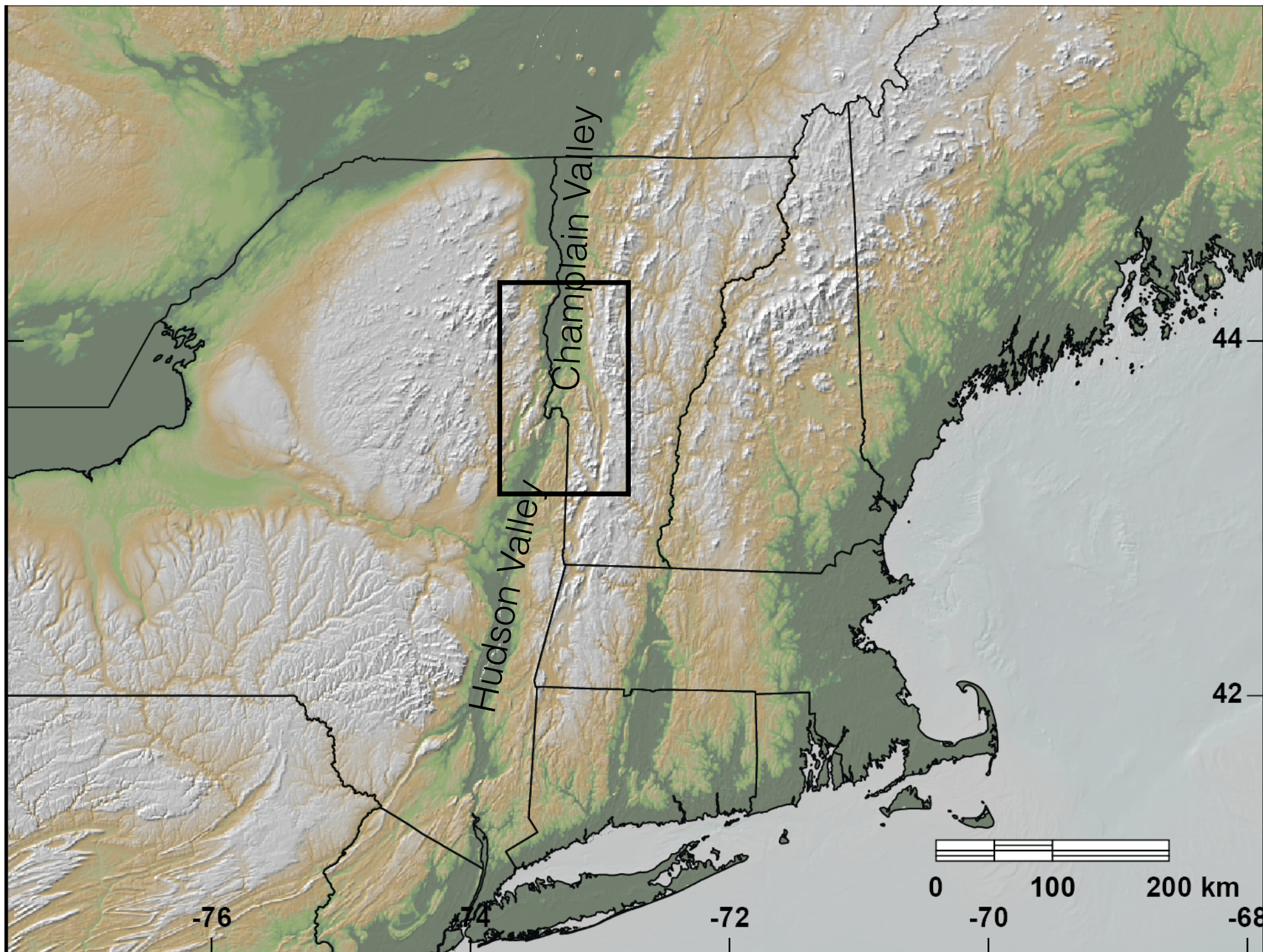




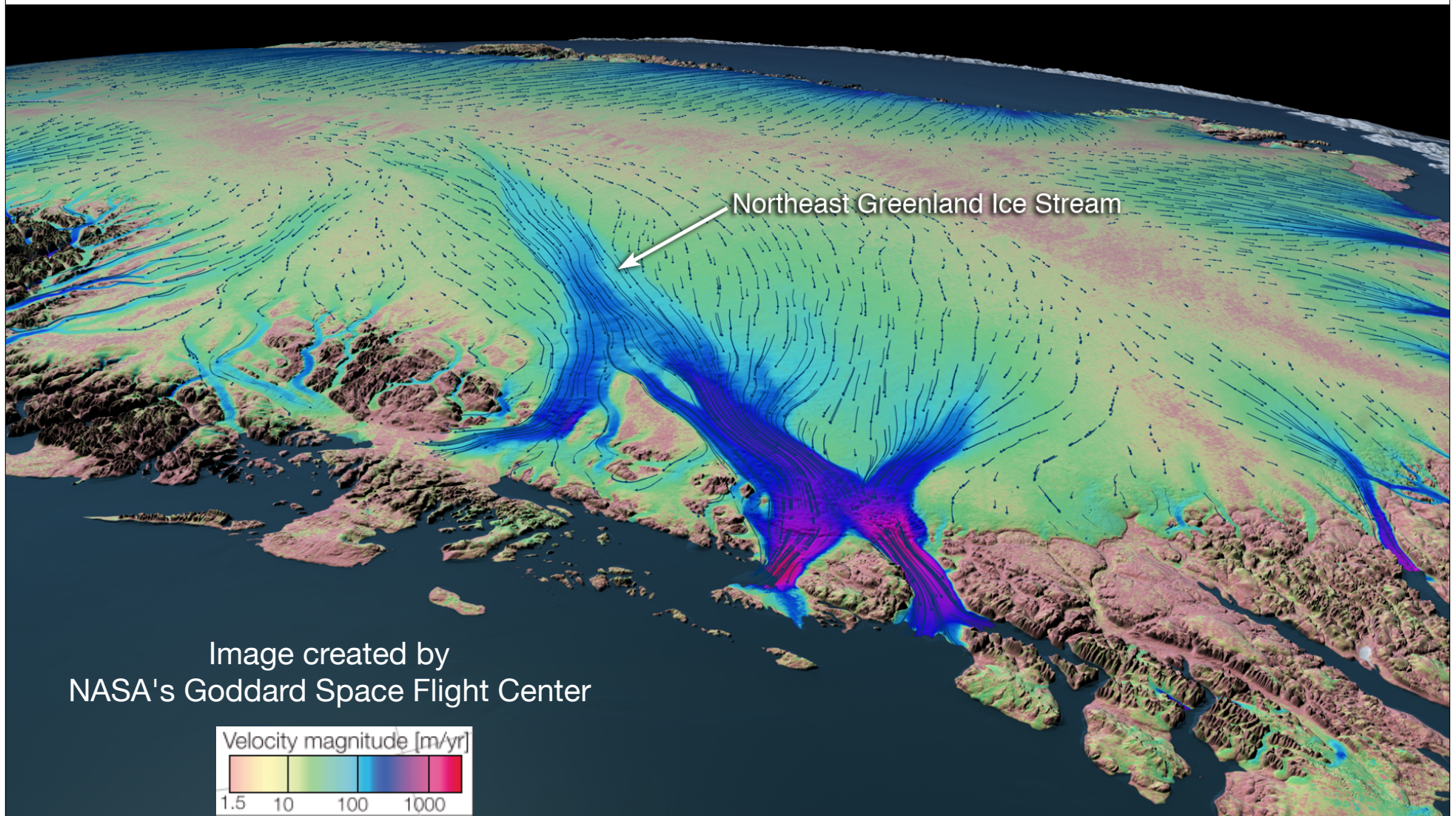
An Ephemeral Ice- Streaming Event in the Southern Champlain Valley

Stephen Wright
Department of Geology, University of Vermont

Crevassed margin of the Bindschadler Ice Stream, Antarctica
Photo by N. Nereson, NASA Earth Observatory

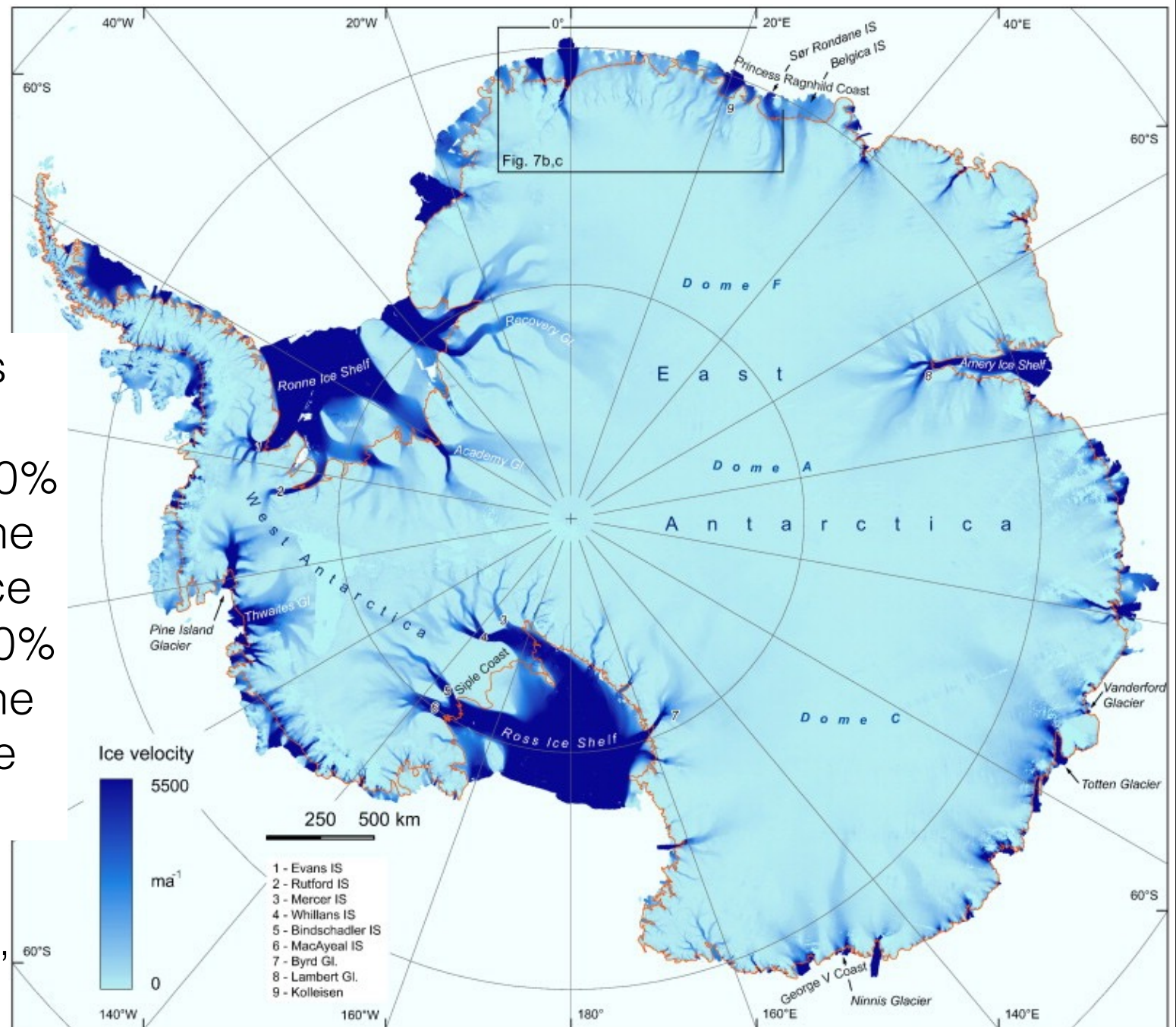


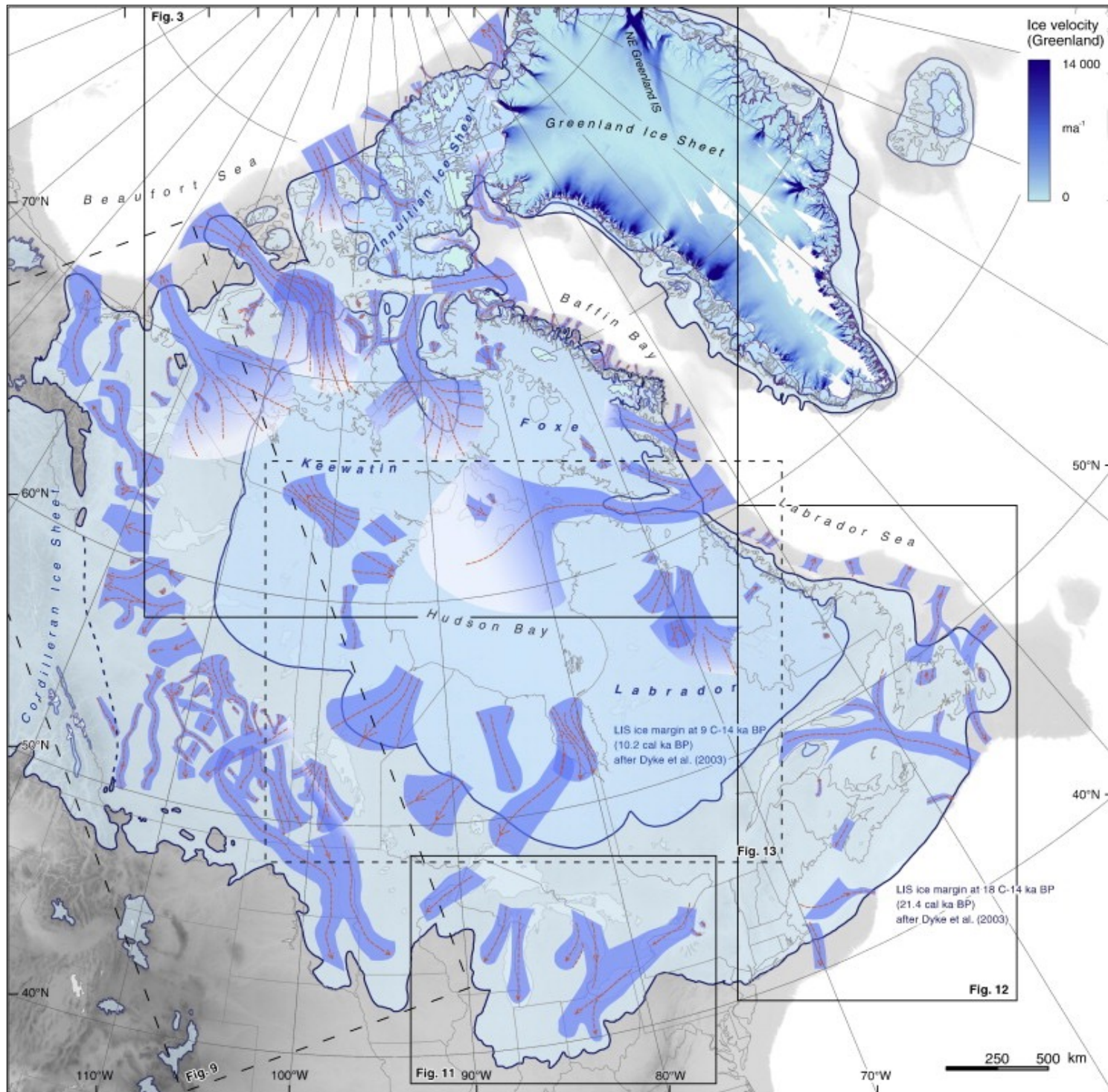
Ice Stream: “A region within a grounded ice sheet in which the ice flows much faster than in regions on either side.” (Paterson, 1994)
Ice streams flow 100’s to 1,000’s m/year compared to the surrounding ice that flows 10’s m/year.



Ice streams currently discharge ~50% of ice from the Greenland ice sheet and ~90% of ice from the Antarctic ice sheet.

Marigold et al., 2015





Modern
Greenland Ice
Streams

Recent
inventory of
**paleo-ice
streams**
around the
perimeter(s) of
the Laurentide
Ice sheet

(Margold et al.,
2015)

How have these paleo-ice streams been identified?

1. Characteristic Shape and Dimensions

Convergent ice flow from the surrounding ice sheet into the ice stream.

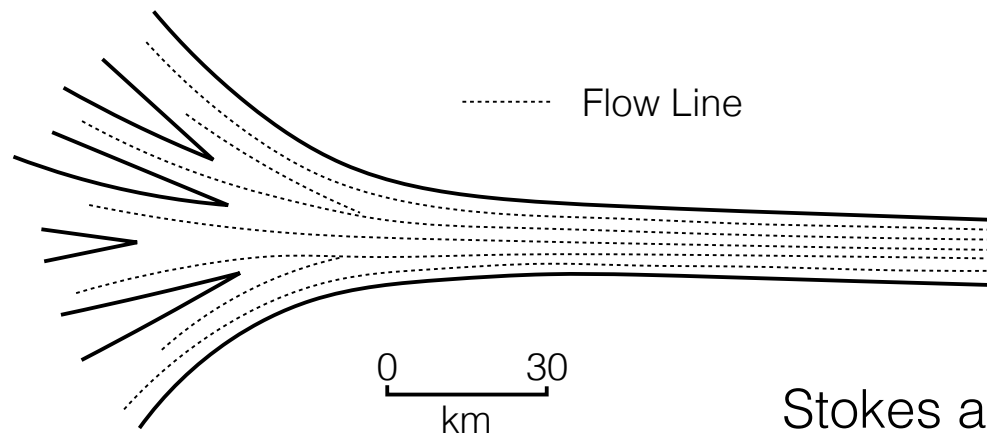
2. Preferentially located in large-scale topographic troughs

3. Underlain by “Soft Beds:” Low-strength rocks/surficial materials

4. Highly elongate, streamlined bed-forms, mega-scale glacial lineations

(1) Characteristic Shape and Dimensions

- Convergent flow lines in the onset zone feeding the ice stream.

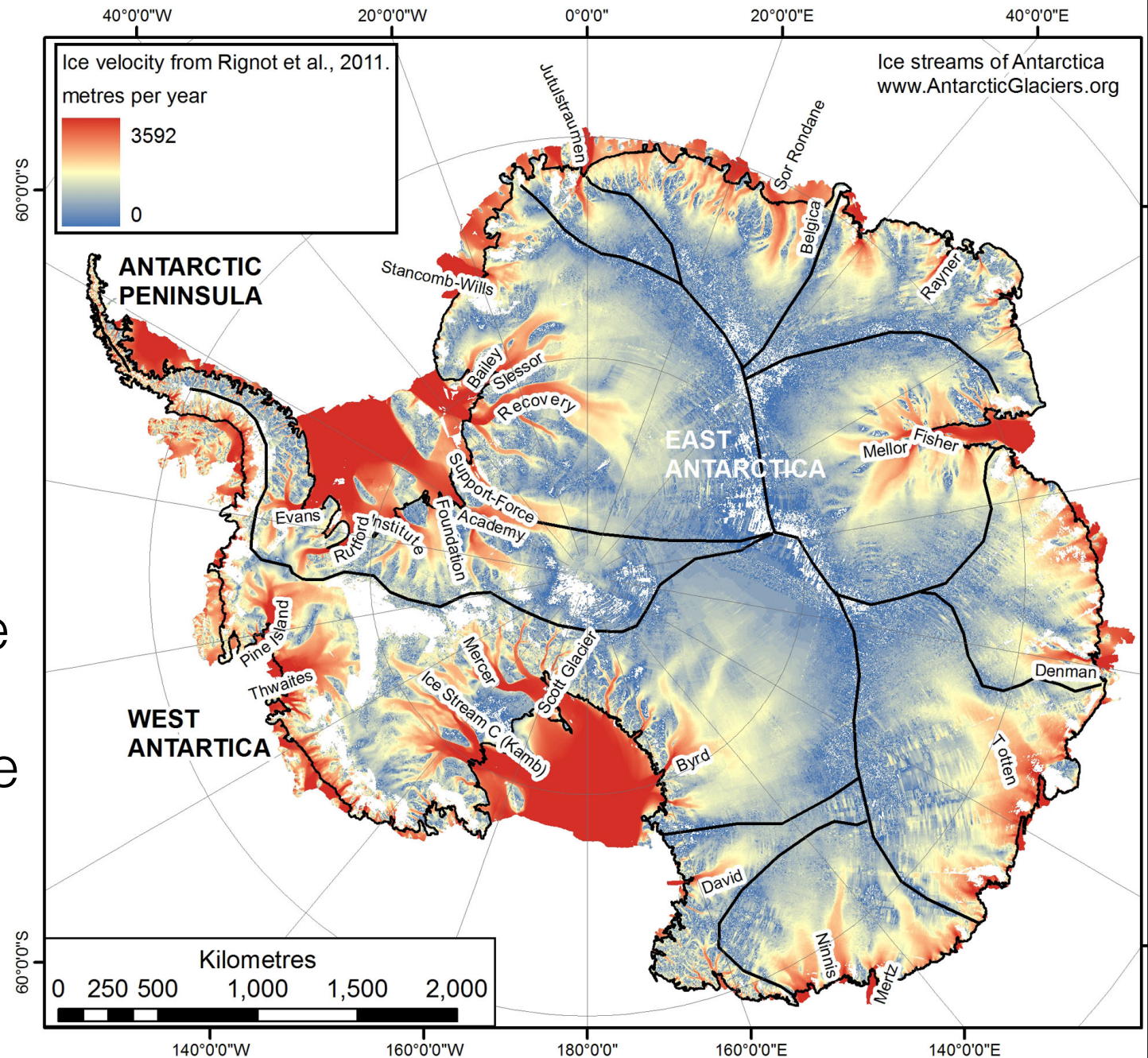


Stokes and Clark, 1999

- Dimensions are generally >20 km width, >150 km length.

Antarctic Ice Streams

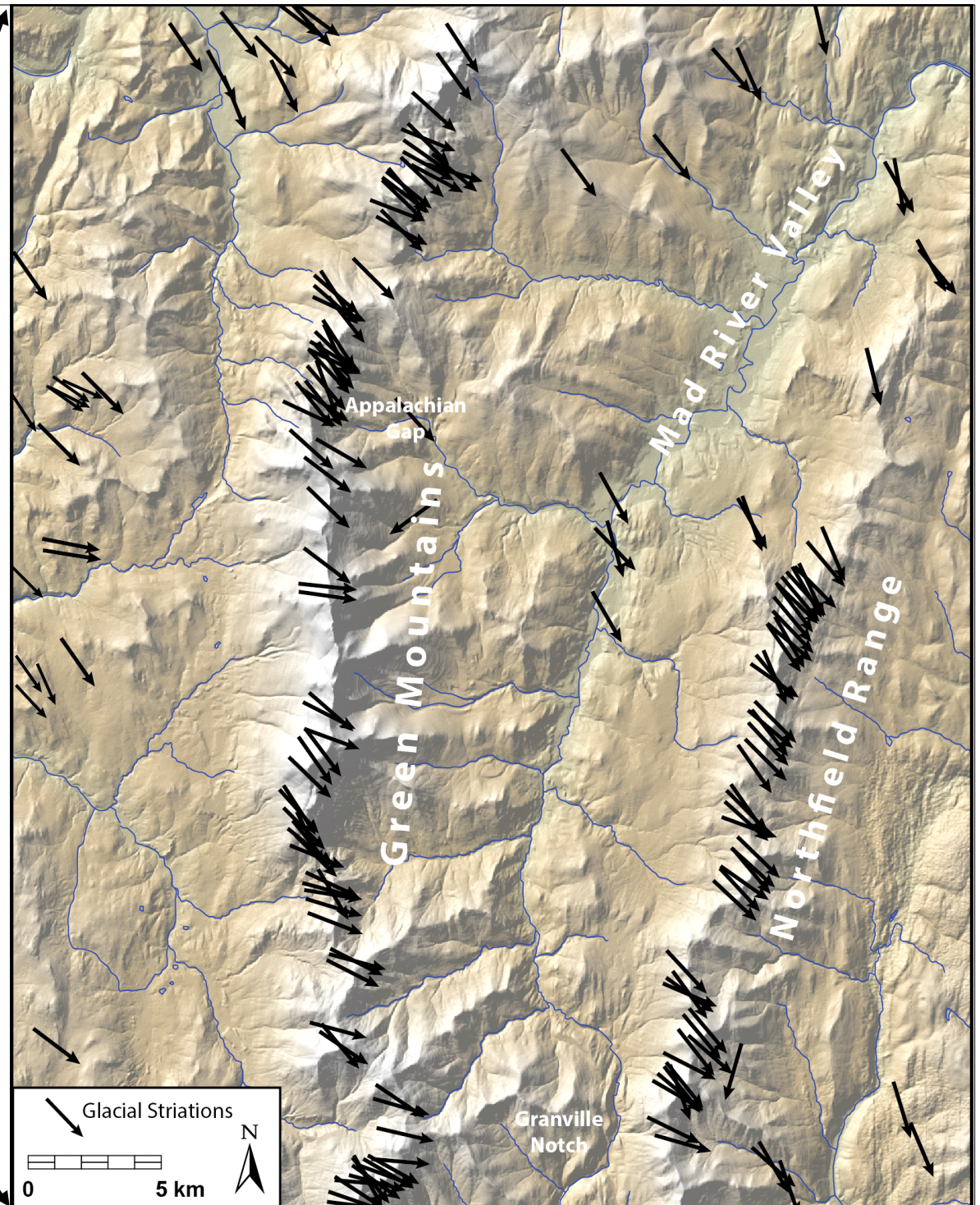
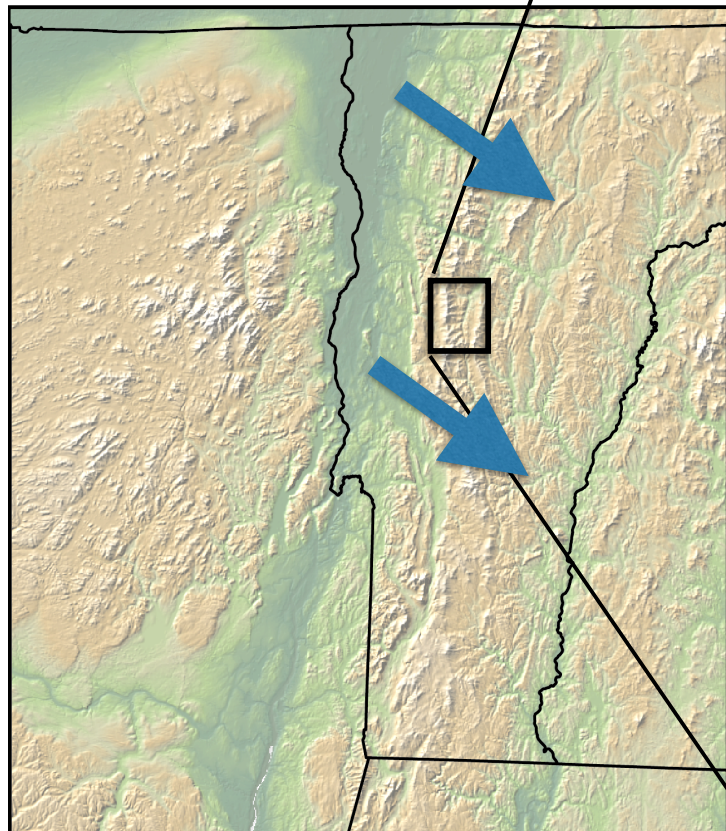
The large discharges of ice via ice streams are sustained by converging ice flow from the surrounding ice sheet.



(Margold et al.,
2015)

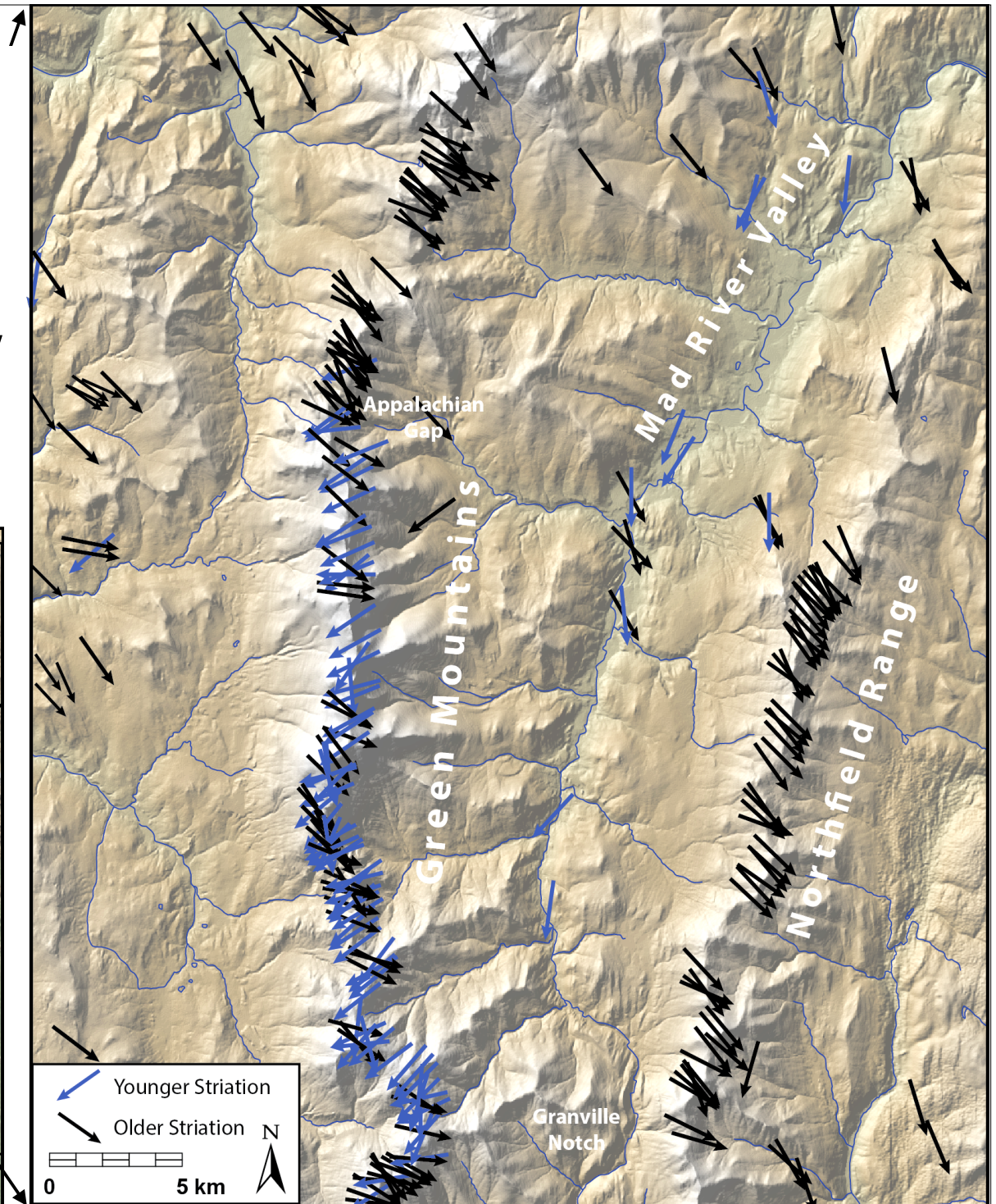
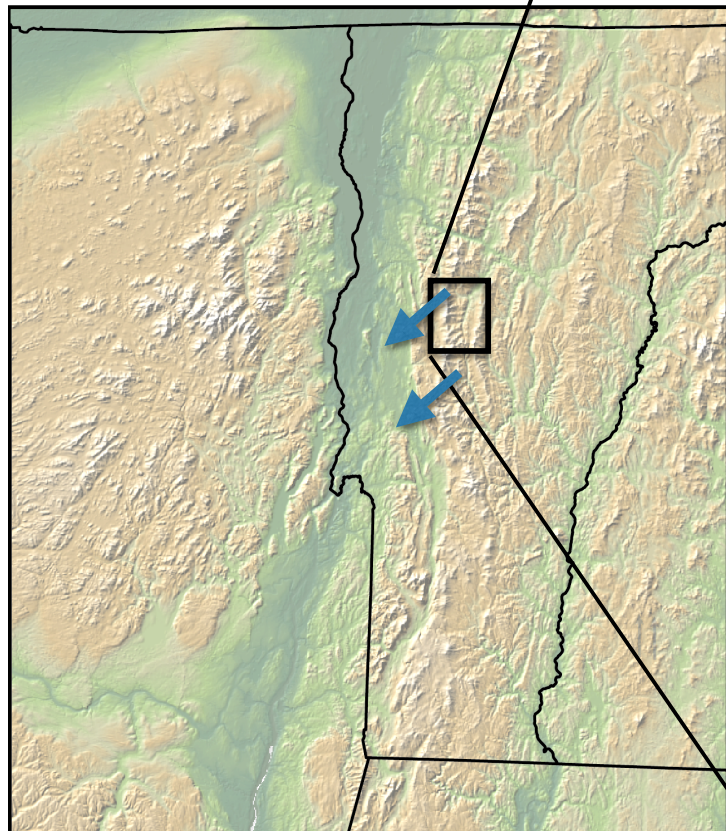


Regional ice sheet
flow across
Vermont was from
northwest to
southeast.



Converging Ice Flow into the Champlain Valley

A younger set of striations indicate that ice sheet flow shifted to the southwest, into the Champlain Valley.

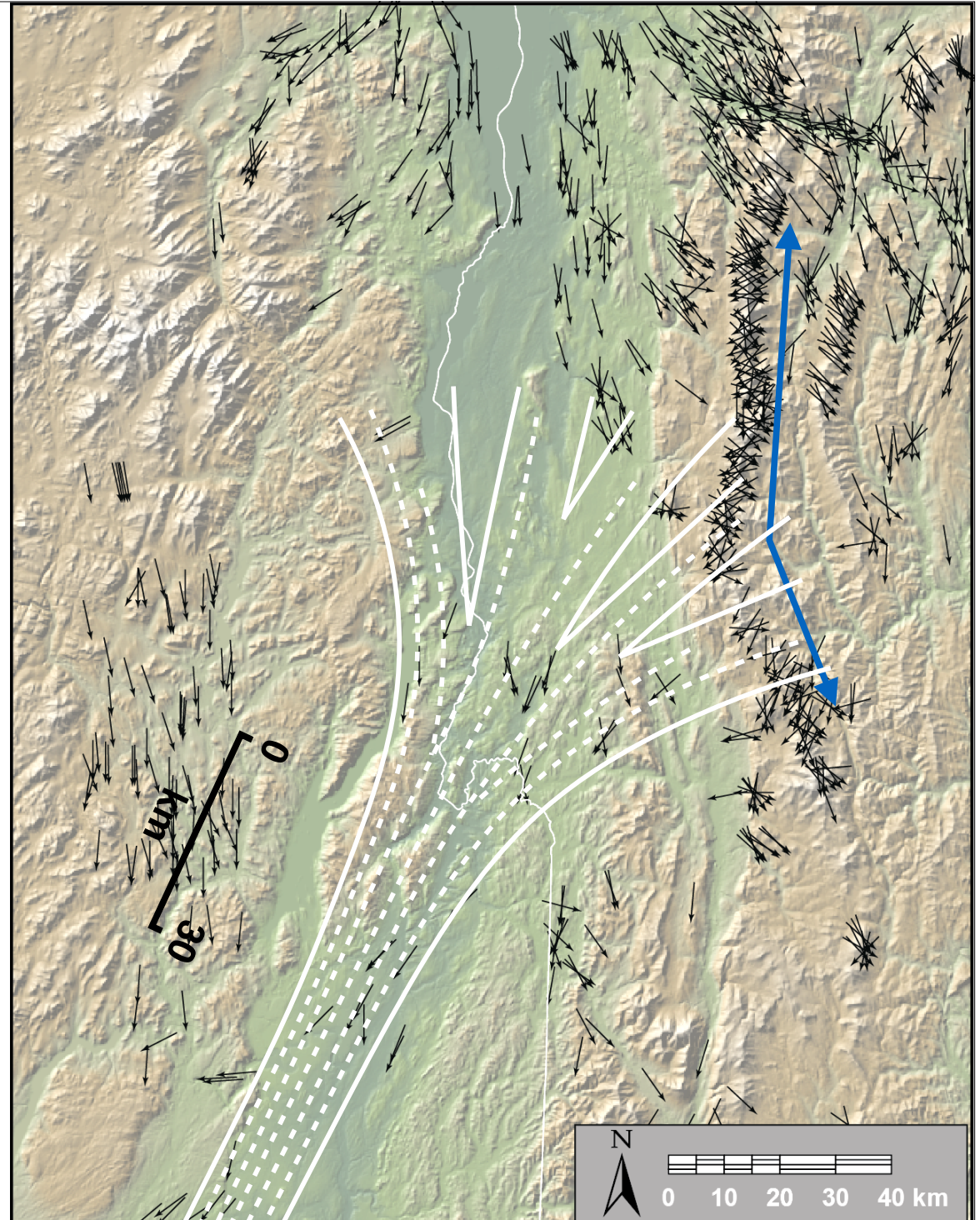


Compilation of glacial striations from areas surrounding the southern Champlain valley and the northern Hudson River valley.

Extent of SW-directed striations in the Green Mountains

“Typical” shape of an ice stream with convergent onset zone superimposed over the lower Champlain and upper Hudson River valleys.

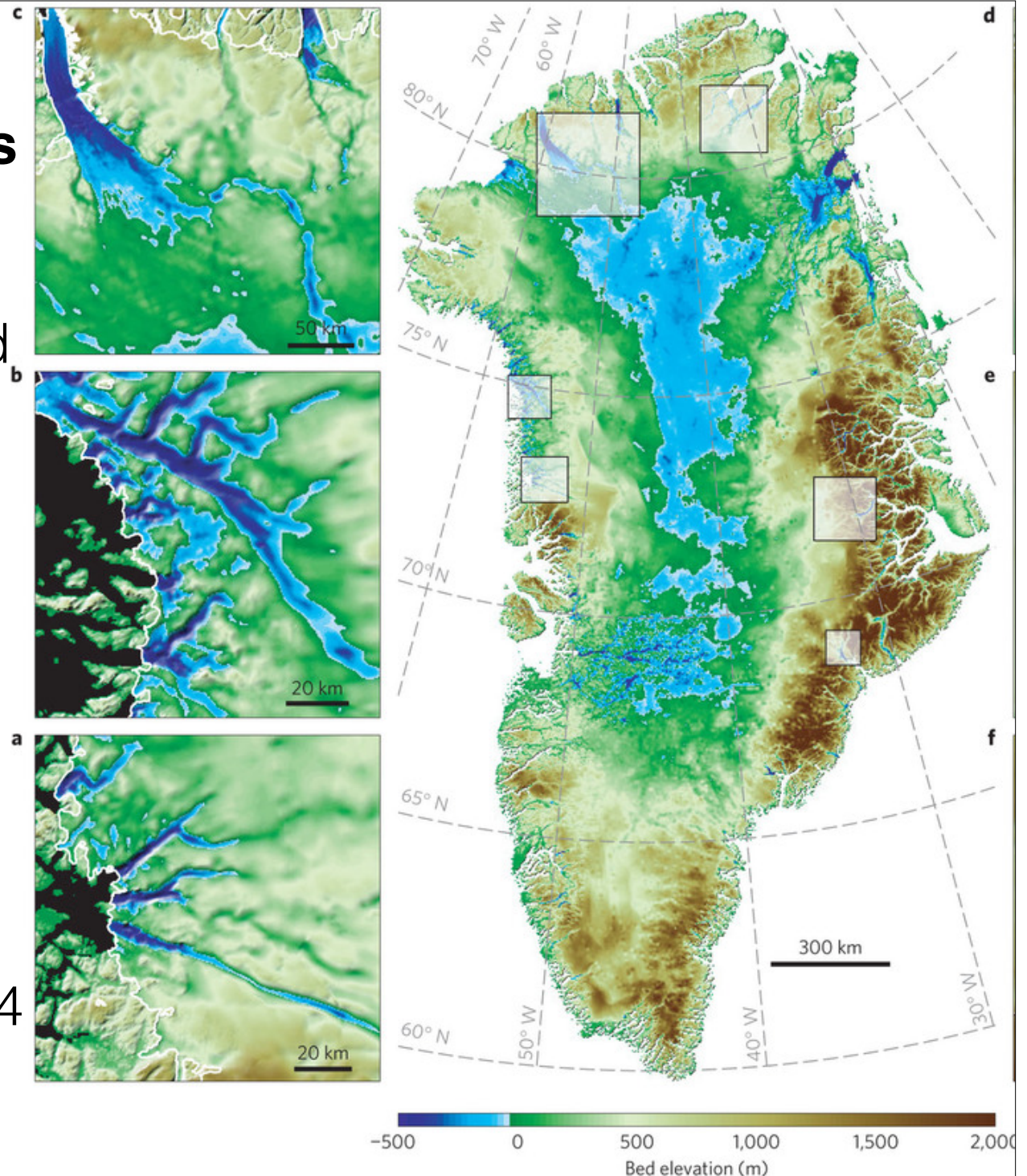
Note similar scale.



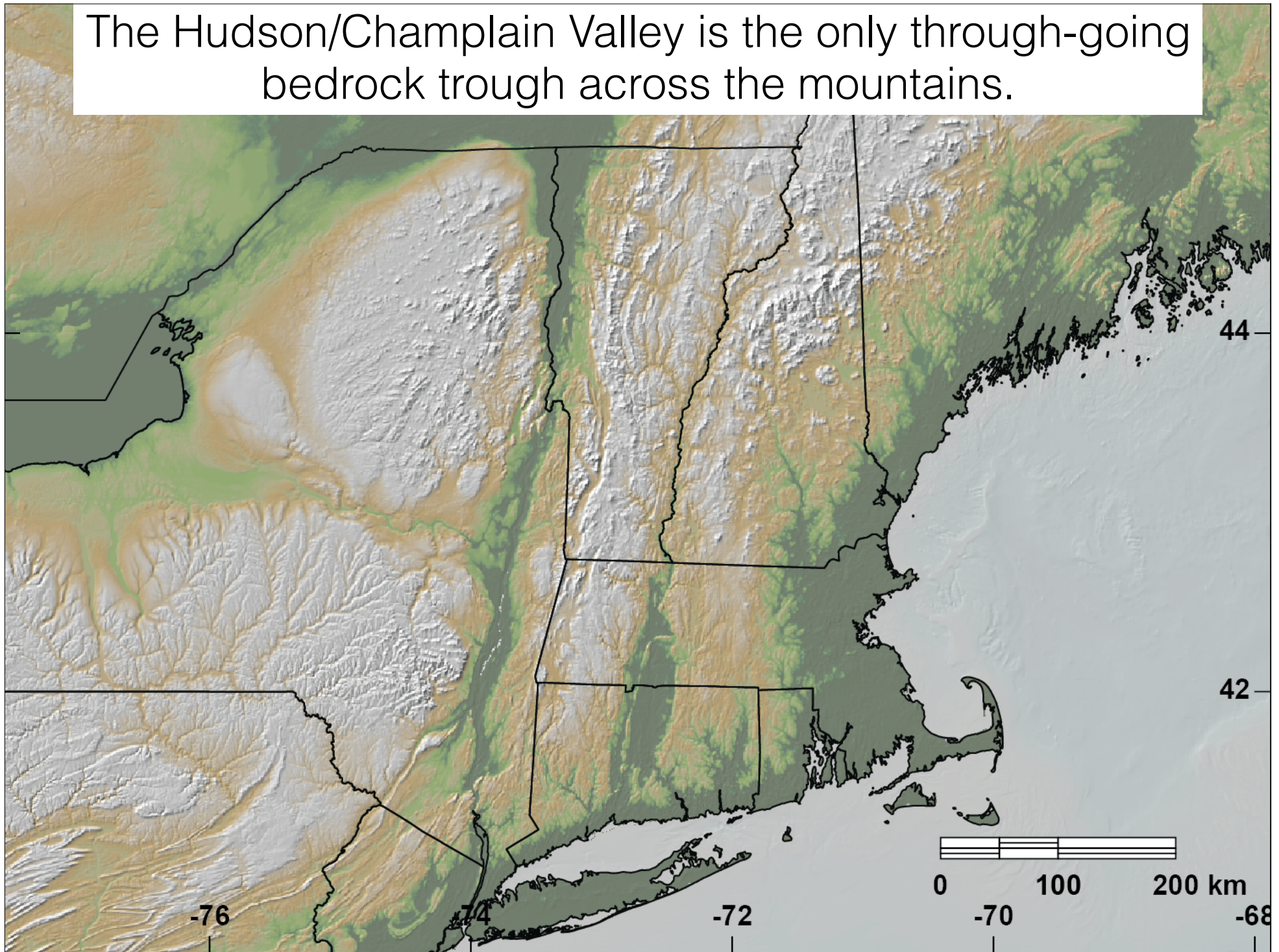
(2) Bedrock Troughs

Most modern ice streams are localized in substantial bedrock troughs.

Morlighem et al., 2014



The Hudson/Champlain Valley is the only through-going bedrock trough across the mountains.

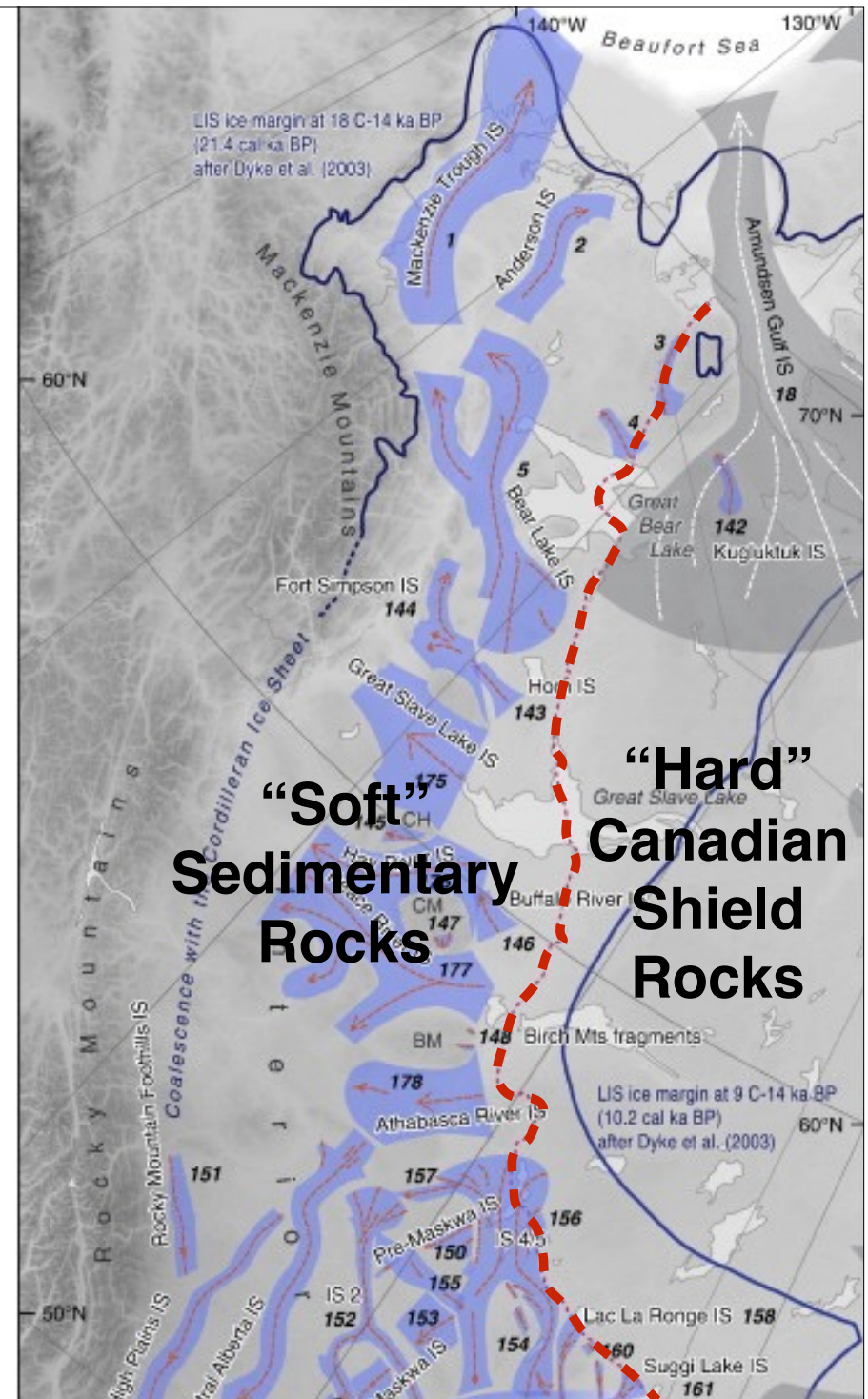


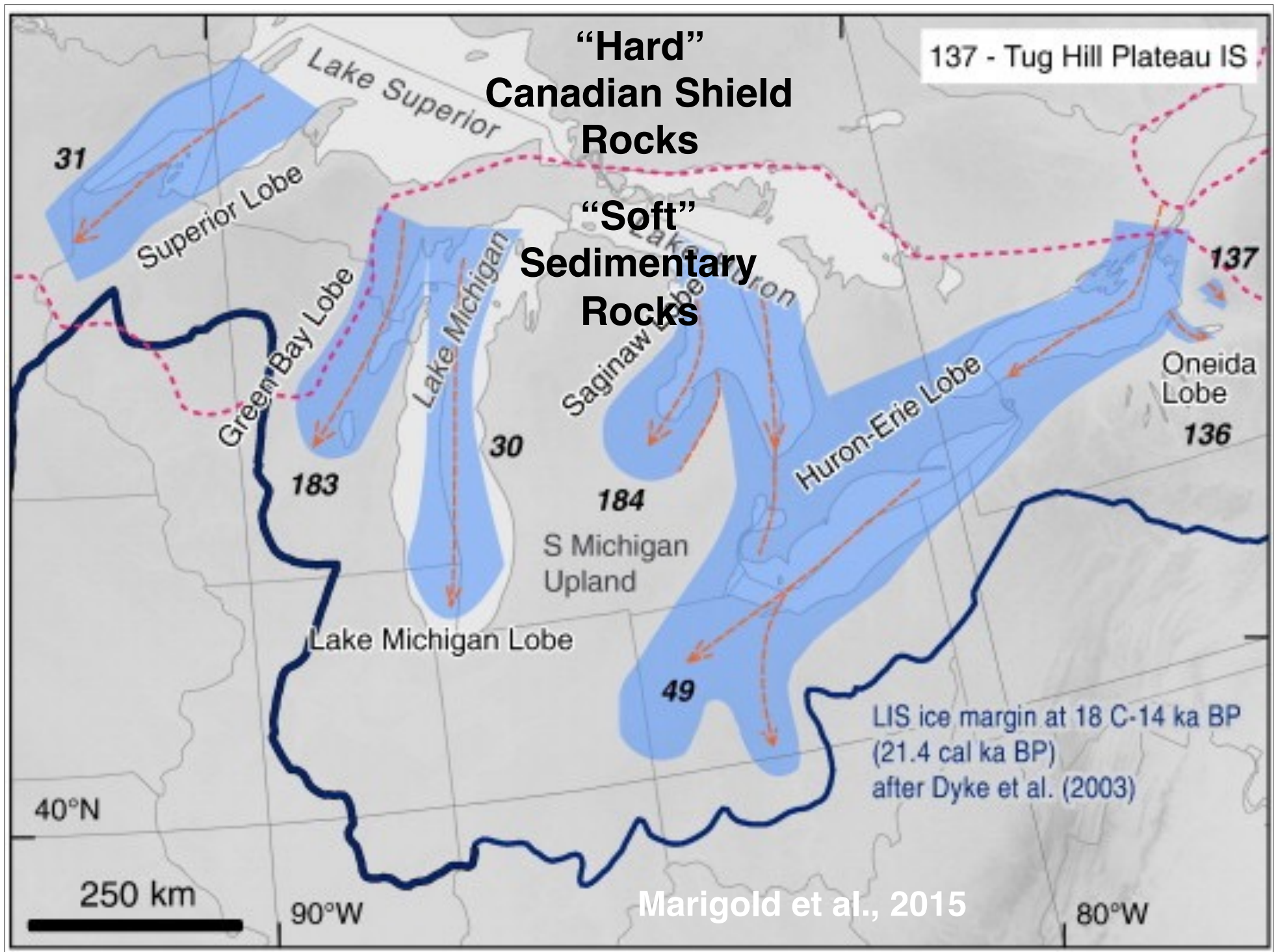
(3) “Soft Beds”

Ice Streams are commonly underlain by weak clay/ calcite-rich rocks that produce weak tills.

Paleo-ice streams in the western interior shown in blue.

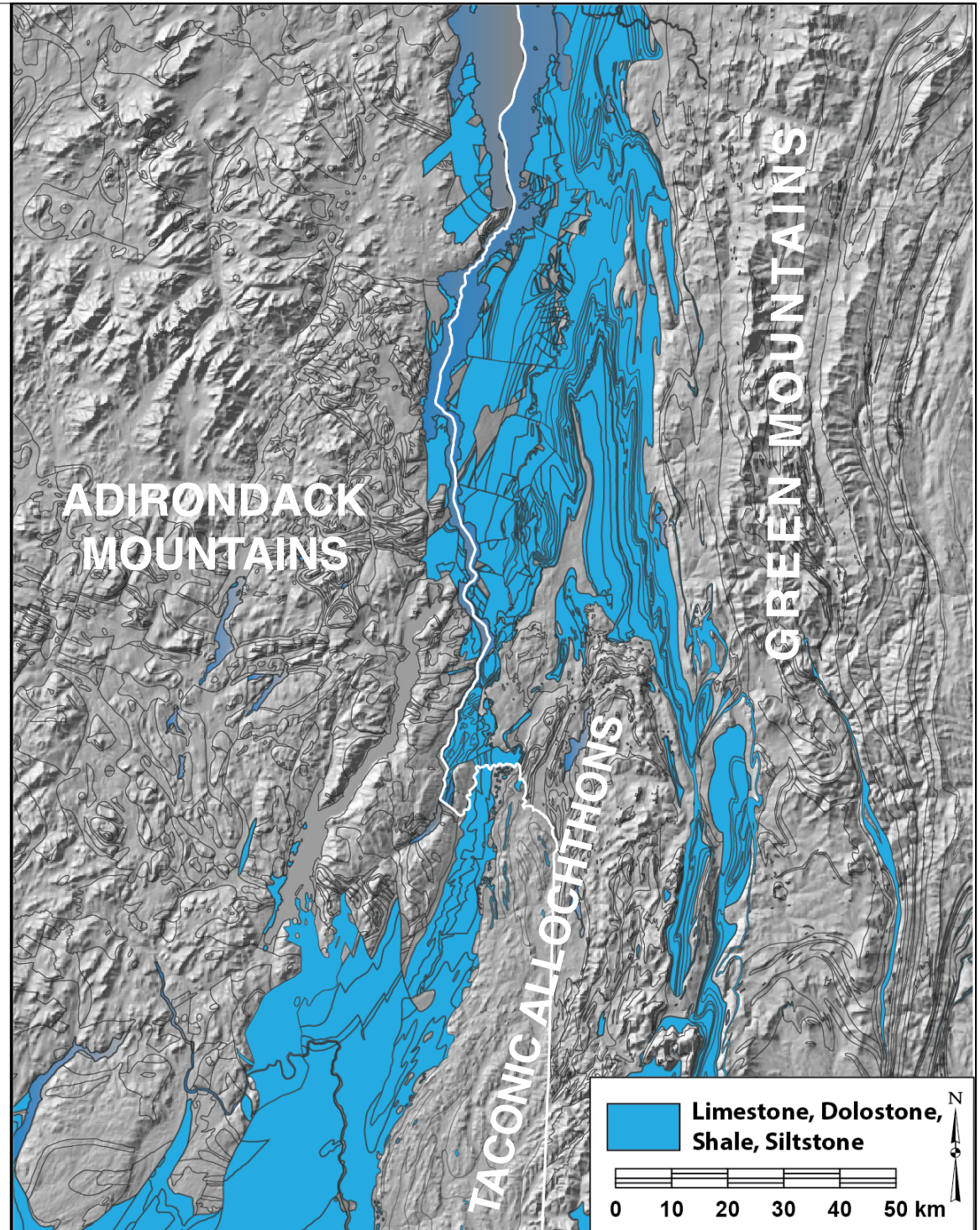
Marigold et al., 2015





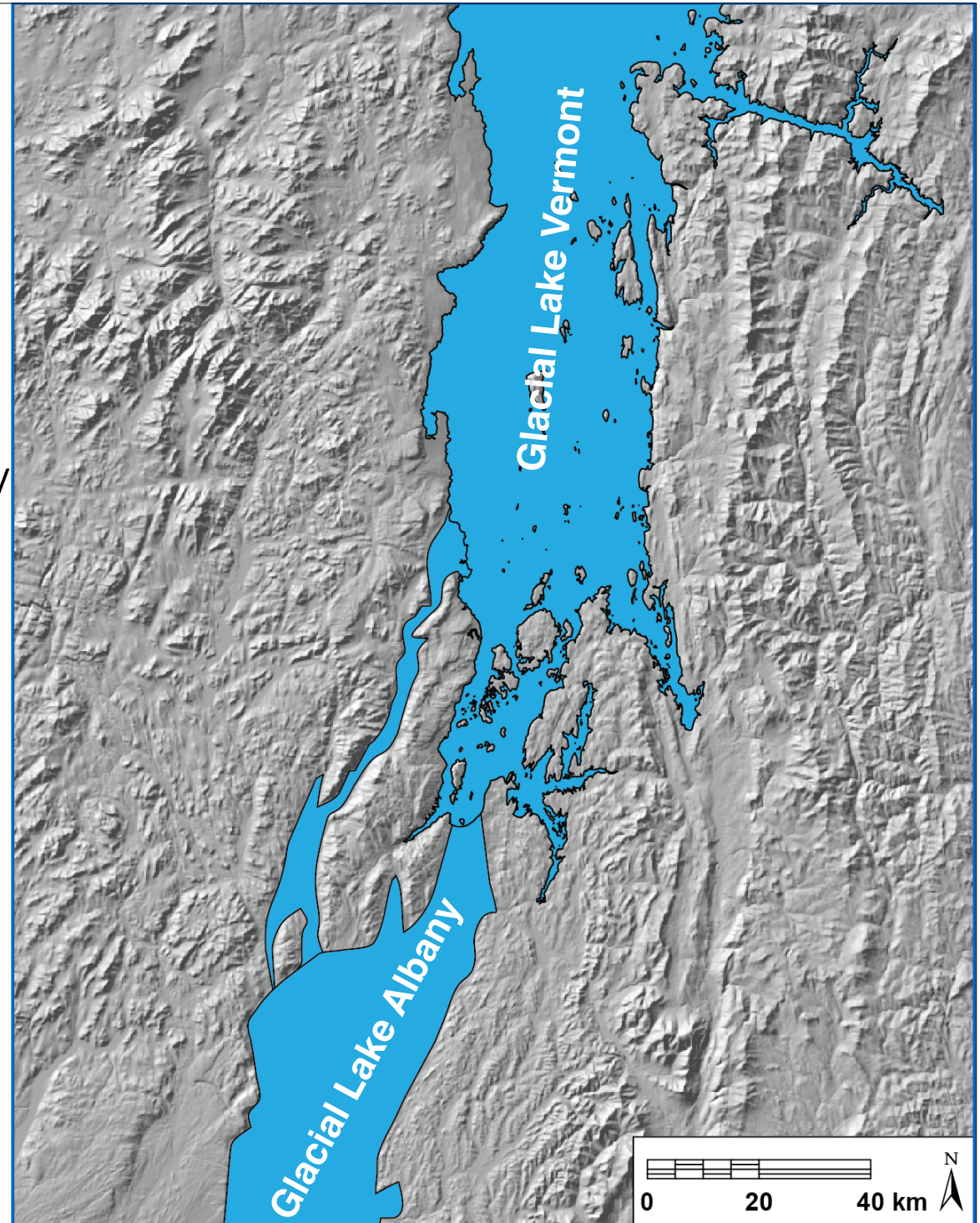
“Soft Beds”

The Champlain and Hudson River valleys are bordered by metamorphic rocks, but underlain by easily erodible sedimentary rocks largely composed of “weak” carbonate and clay minerals.



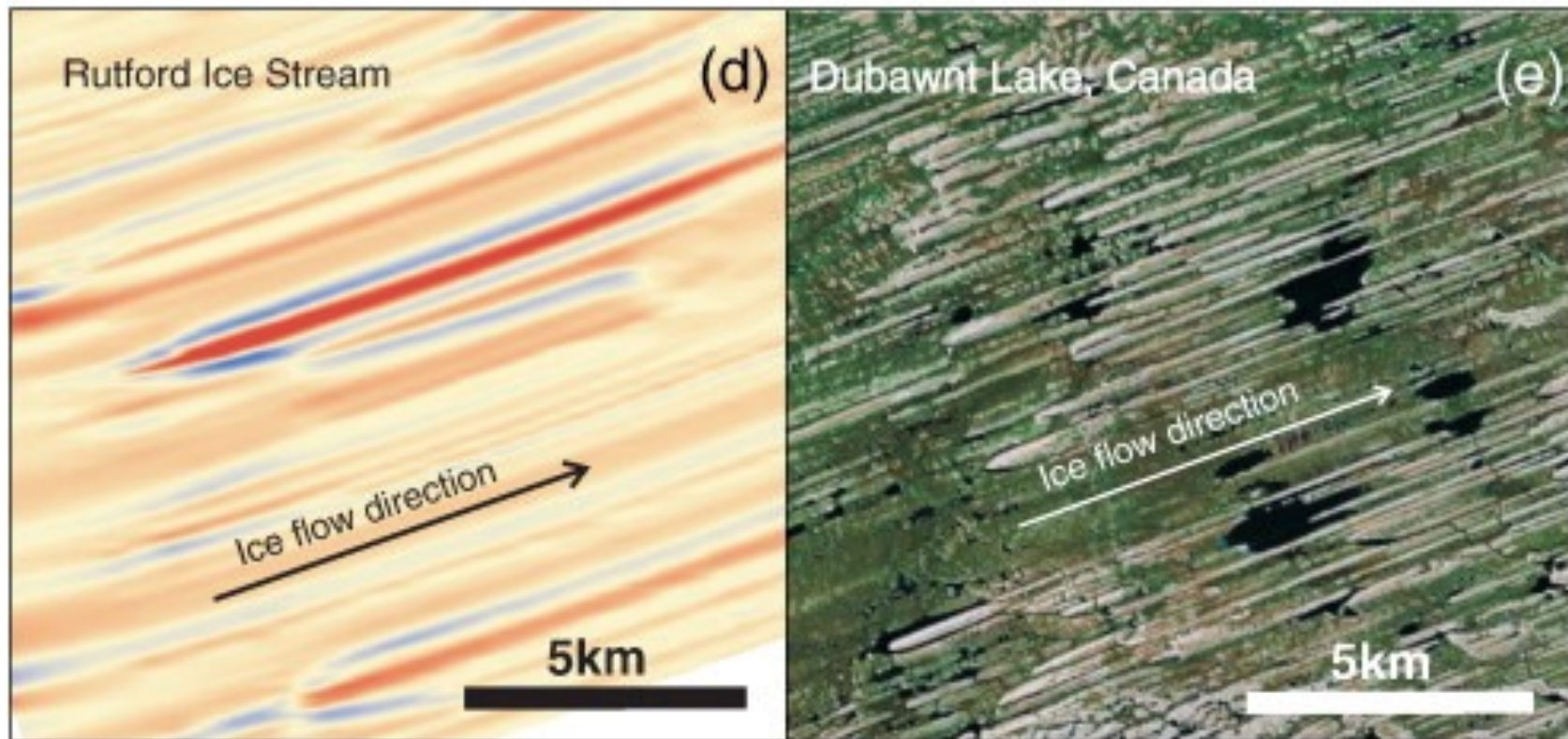
“Soft Beds”

- At the end of the previous glacial period the Champlain and Hudson valleys were likely occupied by glacial lakes, Paleo-Glacial Lakes Albany and Vermont.
- Similar to today, these valleys were mantled with lacustrine sediments largely derived from the underlying limestones, dolostone, siltstones, and shales.
- These weak, fine-grained lacustrine sediments were incorporated into the till.



(4) Streamlined Bed-forms

- “Mega-scale glacial lineations”
- Drumlins, flutes, etc. with Length/Width Ratios $> 10:1$

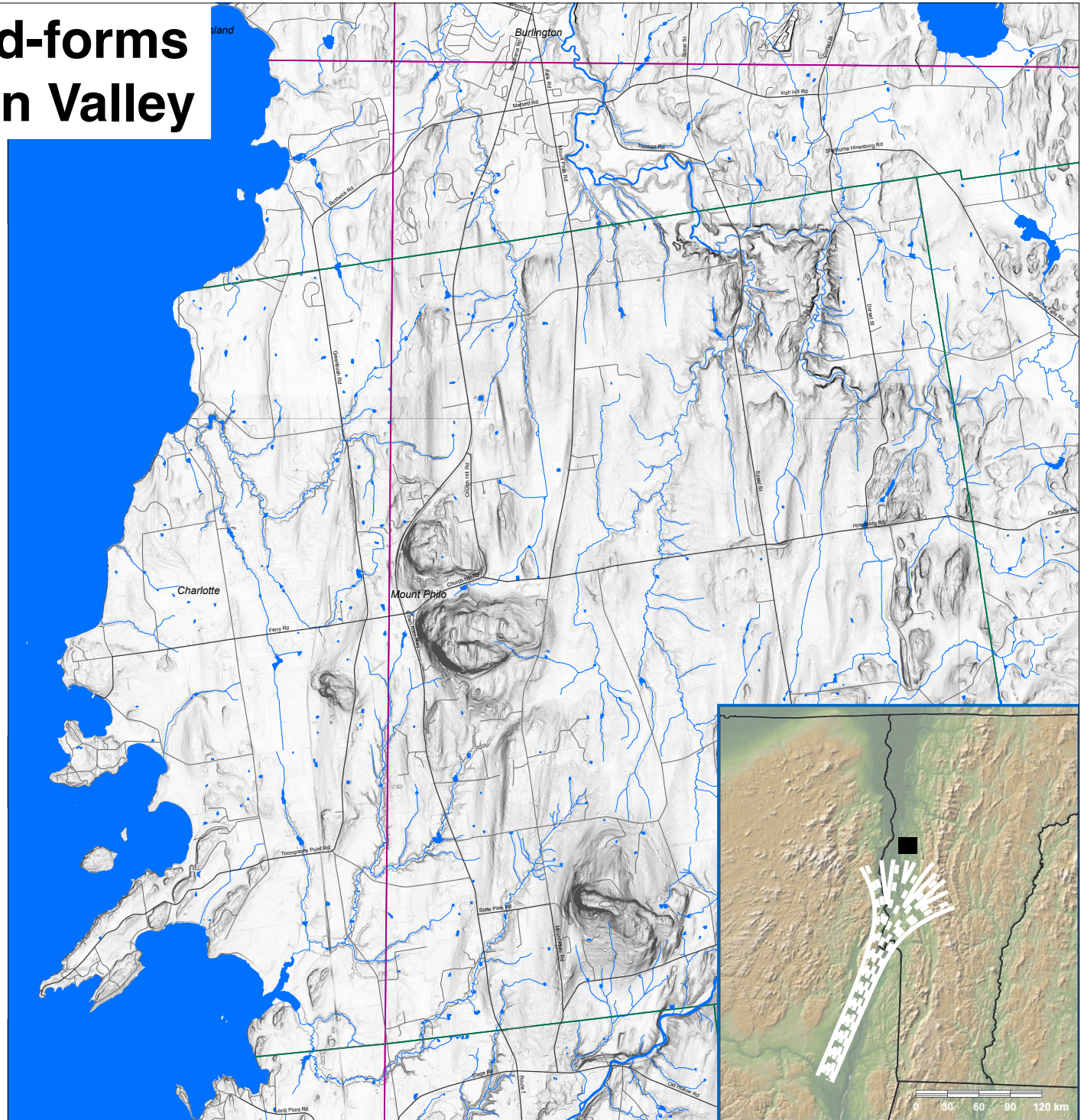


Marigold et al., 2015

Streamlined bed-forms in the Champlain Valley

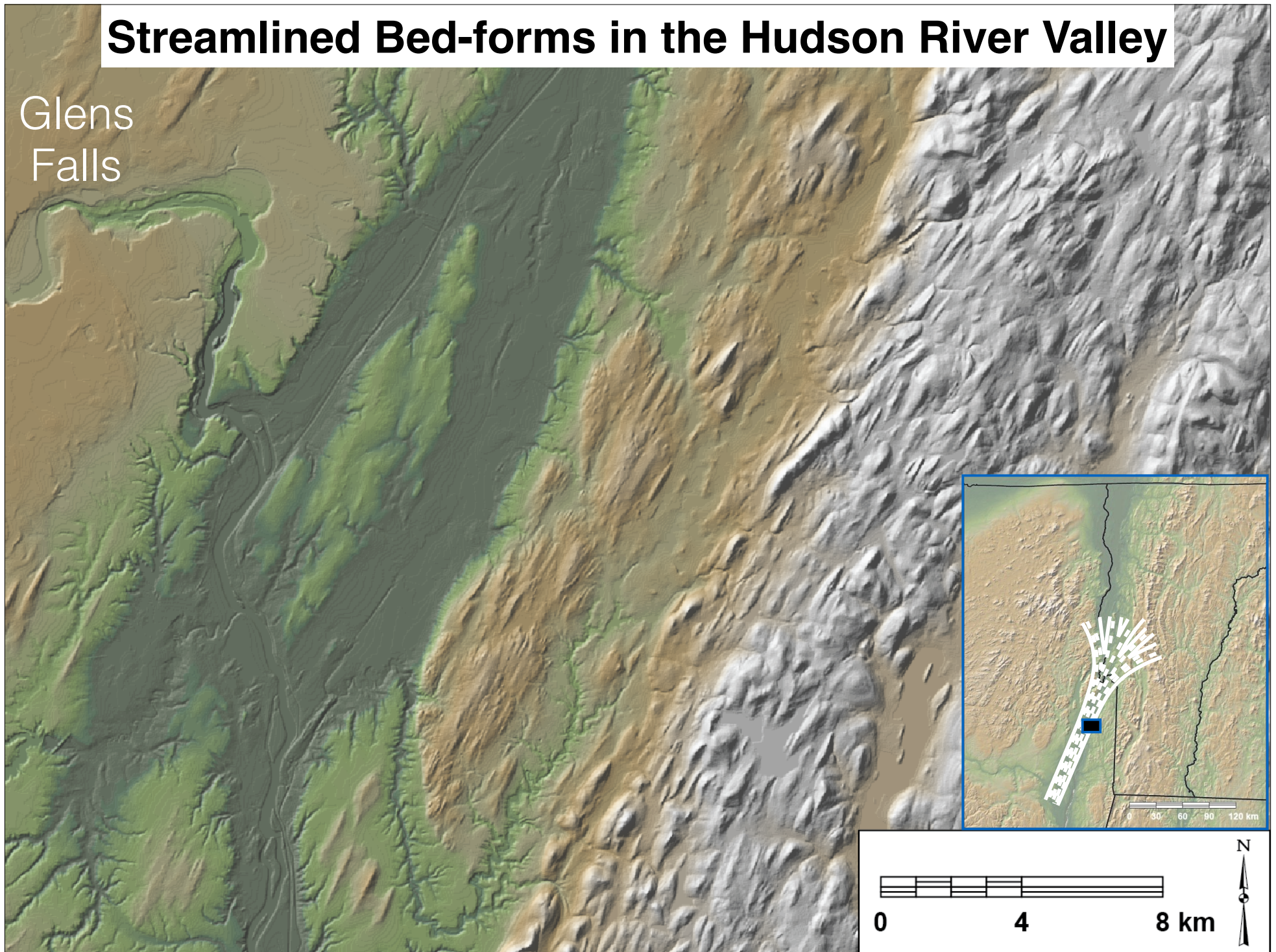
In the Champlain and Hudson River valleys many glacial landforms (till and bedrock) are mantled by thick sequences of lacustrine and marine sediments.

Lidar hillside image of Charlotte, VT in the Champlain Valley (Springston, 2015)



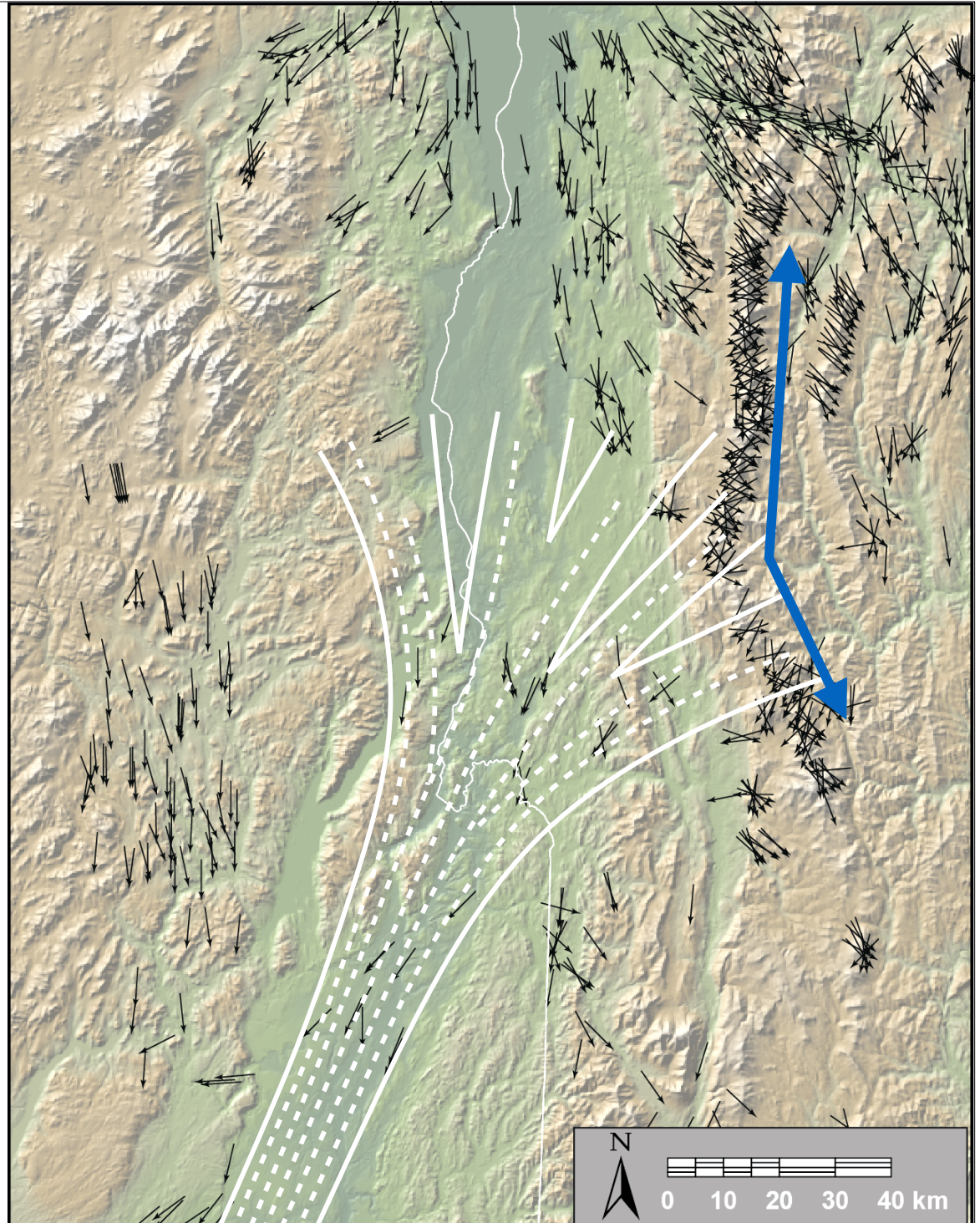
Streamlined Bed-forms in the Hudson River Valley

Glens
Falls



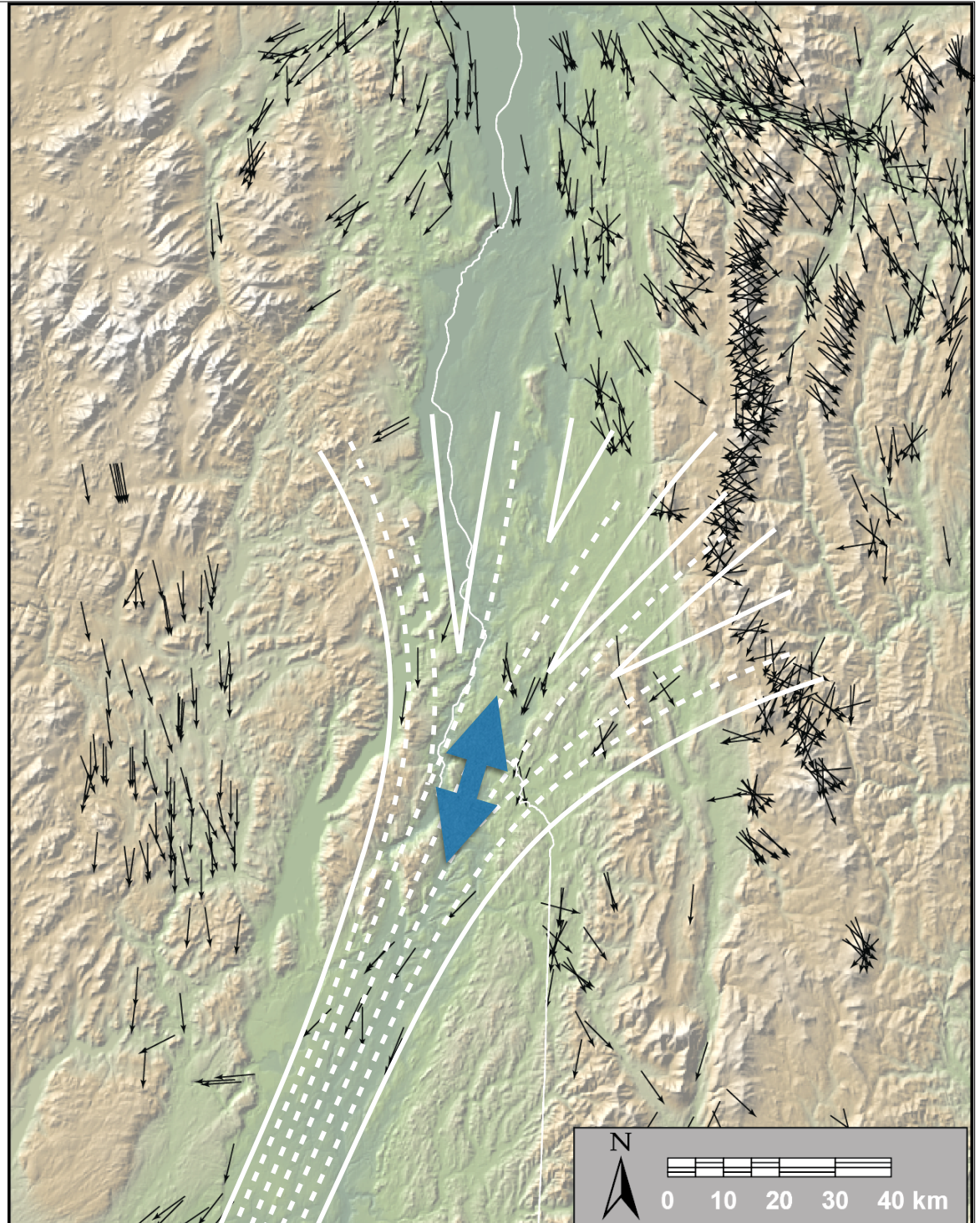
Ephemeral Ice Stream

- “Ephemeral” implies that this postulated ice stream was relatively short-lived, only active for 10’s to several 100’s of years.
- Extent of SW-directed striations across the Green Mountains is limited.
- SW-directed striations aren’t overprinted by any younger striations implying that this part of the Green Mountain range emerged from the ice shortly after SW-flow ceased.



What initiated fast ice flow in this area?

- Modern ice streams have very low effective shear stresses at their base, ~ 10 kPa.
- Bedrock drainage divide lies between Whitehall and Fort Ann.
- High water pressure along this adverse slope in combination with the lessening overburden pressure from the thinning ice sheet may have led to low effective pressures at the base of the ice sheet.
- High basal water pressure may have also been driven by a warming climate.



Conclusions

- Converging ice flow indicated by striations
- Characteristic shape and dimensions of modern ice streams
- Major topographic trough across the mountains.
- Rocks and lacustrine sediments underlying these valleys are the source materials for weak basal tills.
- Streamlined bed-forms

