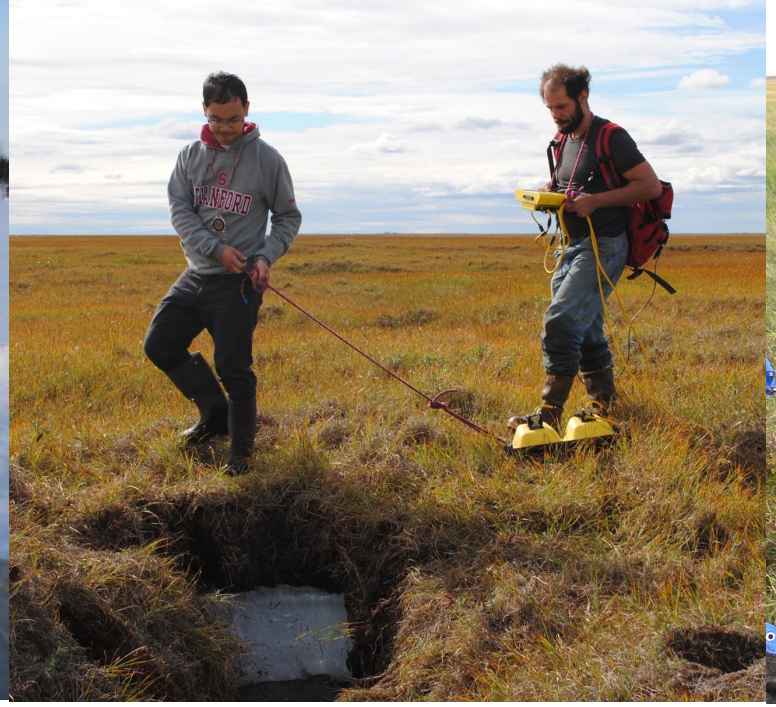
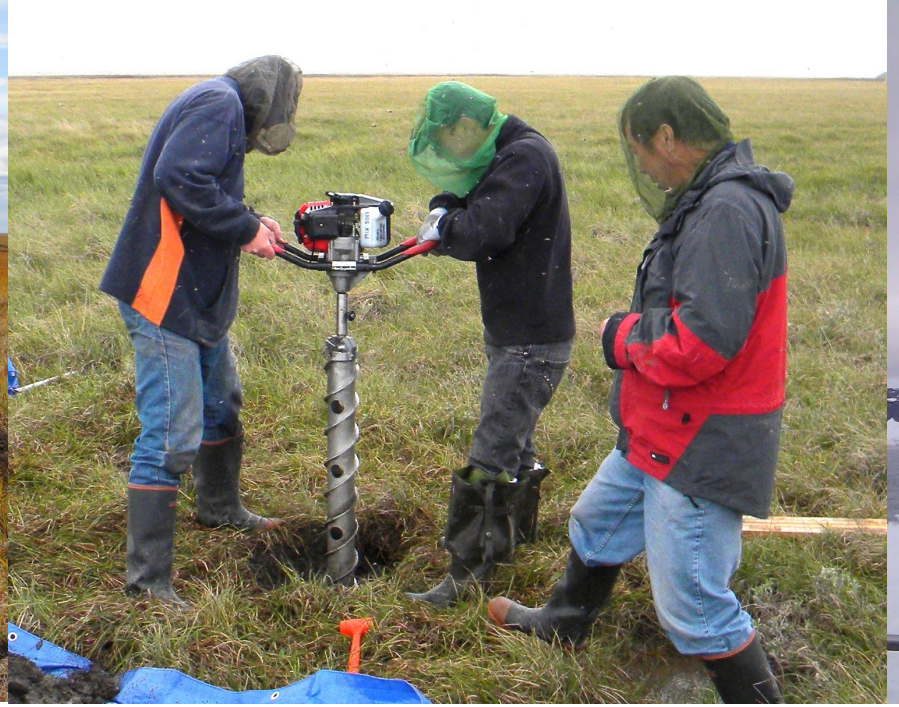





Cryosphere Geophysics and Remote Sensing

Lin Liu

Department of Earth and Environmental Sciences

Faculty of Science, The Chinese University of Hong Kong

Email: liulin@cuhk.edu.hk Website: https://cryocuhk.github.io

About myself

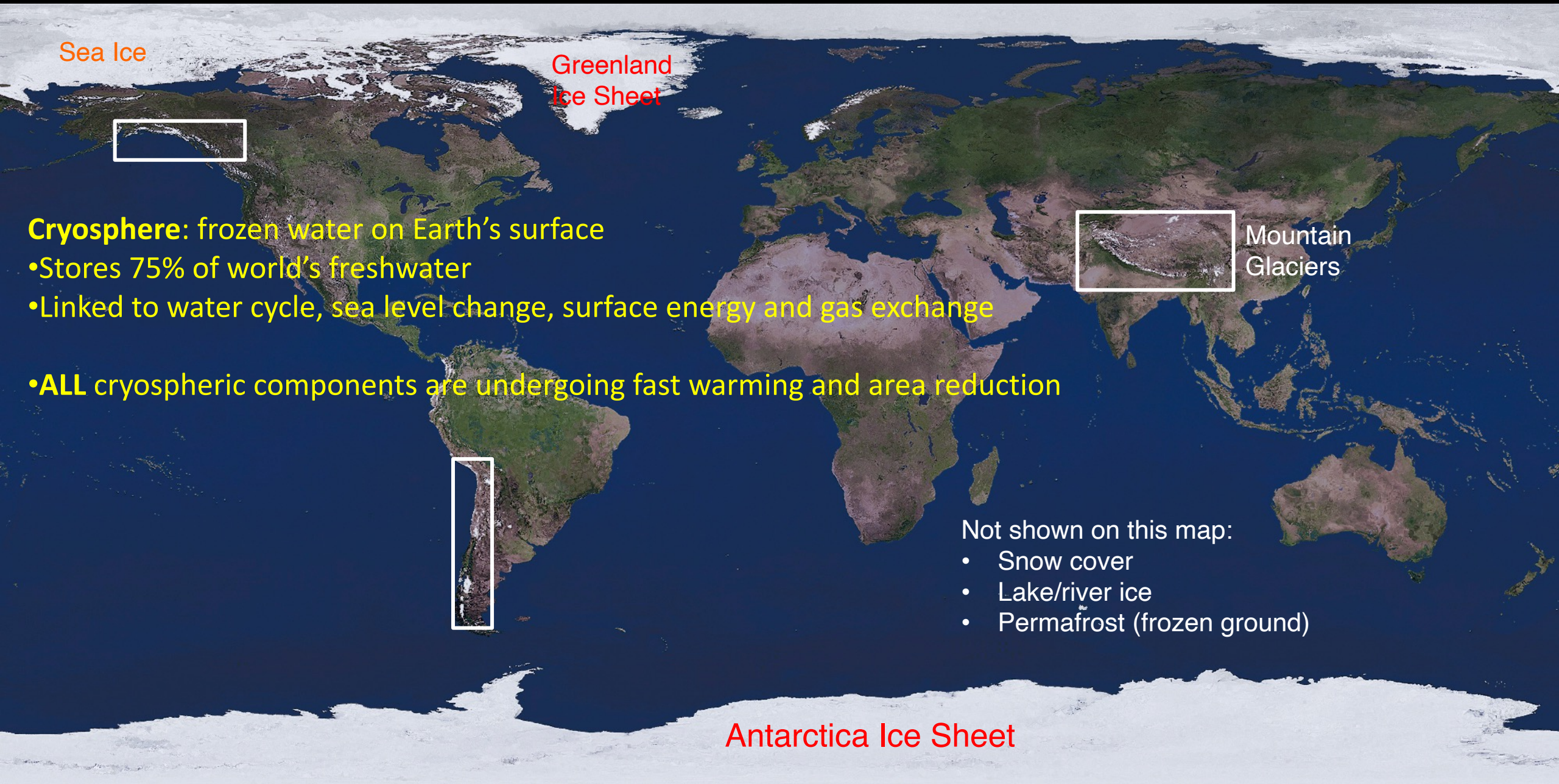
- Bachelor degree in geophysics from Wuhan University (2001-05)
- PhD degree, also in geophysics, from University of Colorado at Boulder (2005-11)
- Thompson Postdoc Fellow, Stanford University (2011-13)
- Joined The Chinese University of Hong Kong (CUHK) in 2014

- We use **geophysical**, **remote sensing**, and **deep learning** methods to study changes of the **cryosphere** (frozen part of the Earth system) in a **warming climate**.

Stanford
University

香港中文大學
The Chinese University of Hong Kong

The cryosphere is an important part of the global Earth system



Cryosphere: frozen water on Earth's surface

- Stores 75% of world's freshwater
- Linked to water cycle, sea level change, surface energy and gas exchange

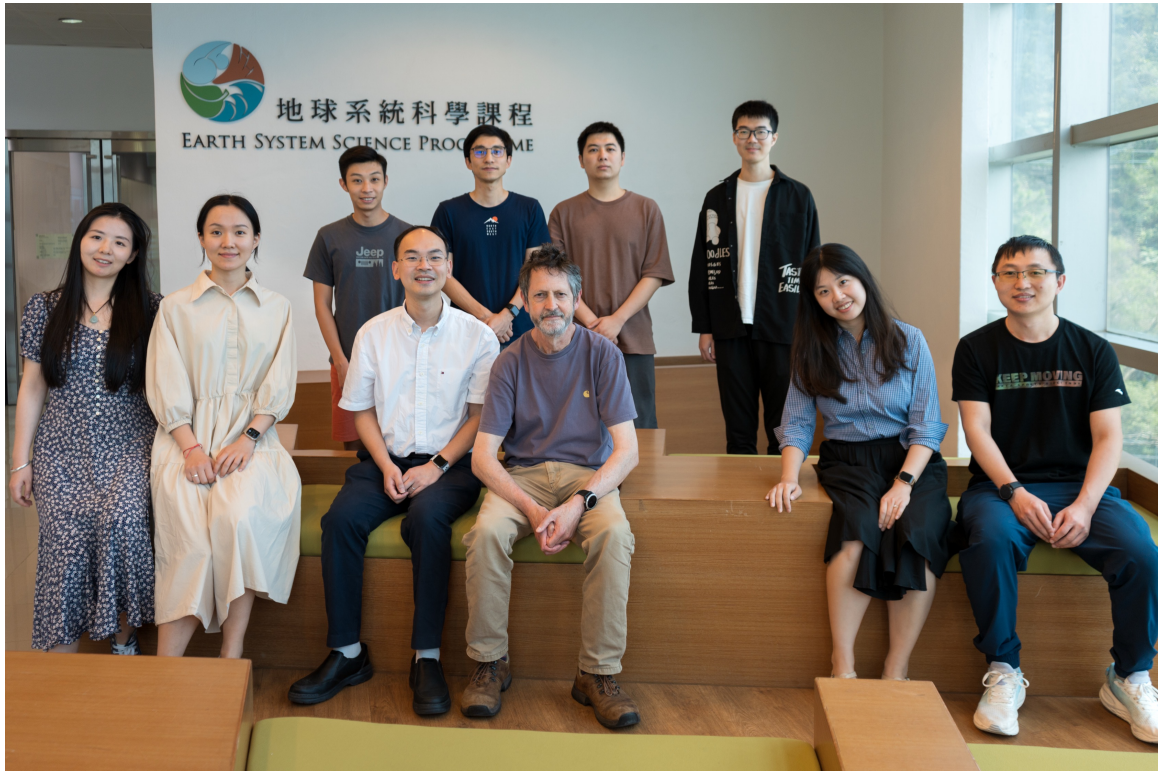
- **ALL** cryospheric components are undergoing fast warming and area reduction

Not shown on this map:

- Snow cover
- Lake/river ice
- Permafrost (frozen ground)

Cryosphere Group @ CUHK

We use geophysical, remote sensing, and deep learning methods to study the cryosphere



Recent research projects

Ice sheet mass loss

Glacial front dynamics

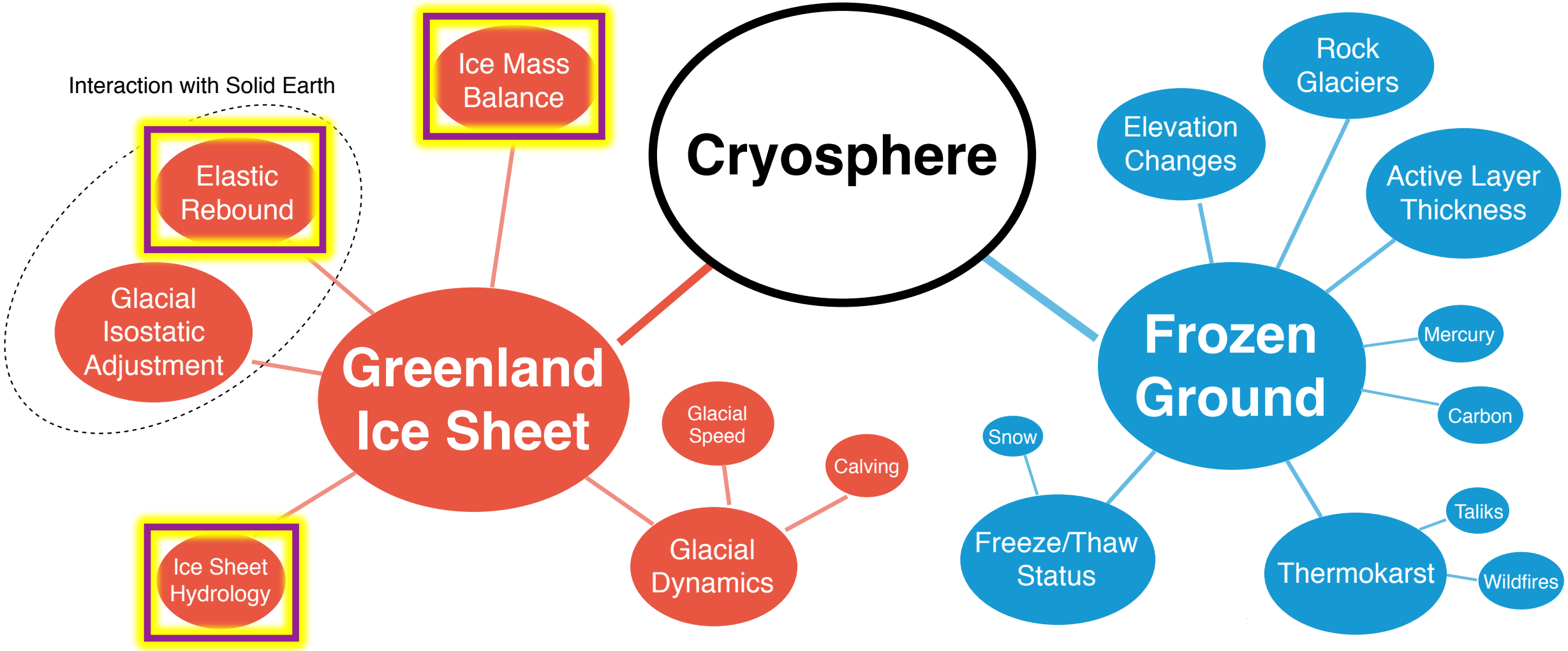
Permafrost degradation

Rock glacier kinematics

+ Greening Antarctica, Martian ice-related landforms

Cryosphere Group @ CUHK

We use geophysical, remote sensing, and deep learning methods to study the cryosphere



Space Geodesy

Satellite Gravity | Altimetry | GNSS | InSAR

Remote Sensing

Optical | Passive & Active Microwave | Deep Learning

Geophysics

Radar | Surface NMR

Article | Open access | Published: 30 October 2024

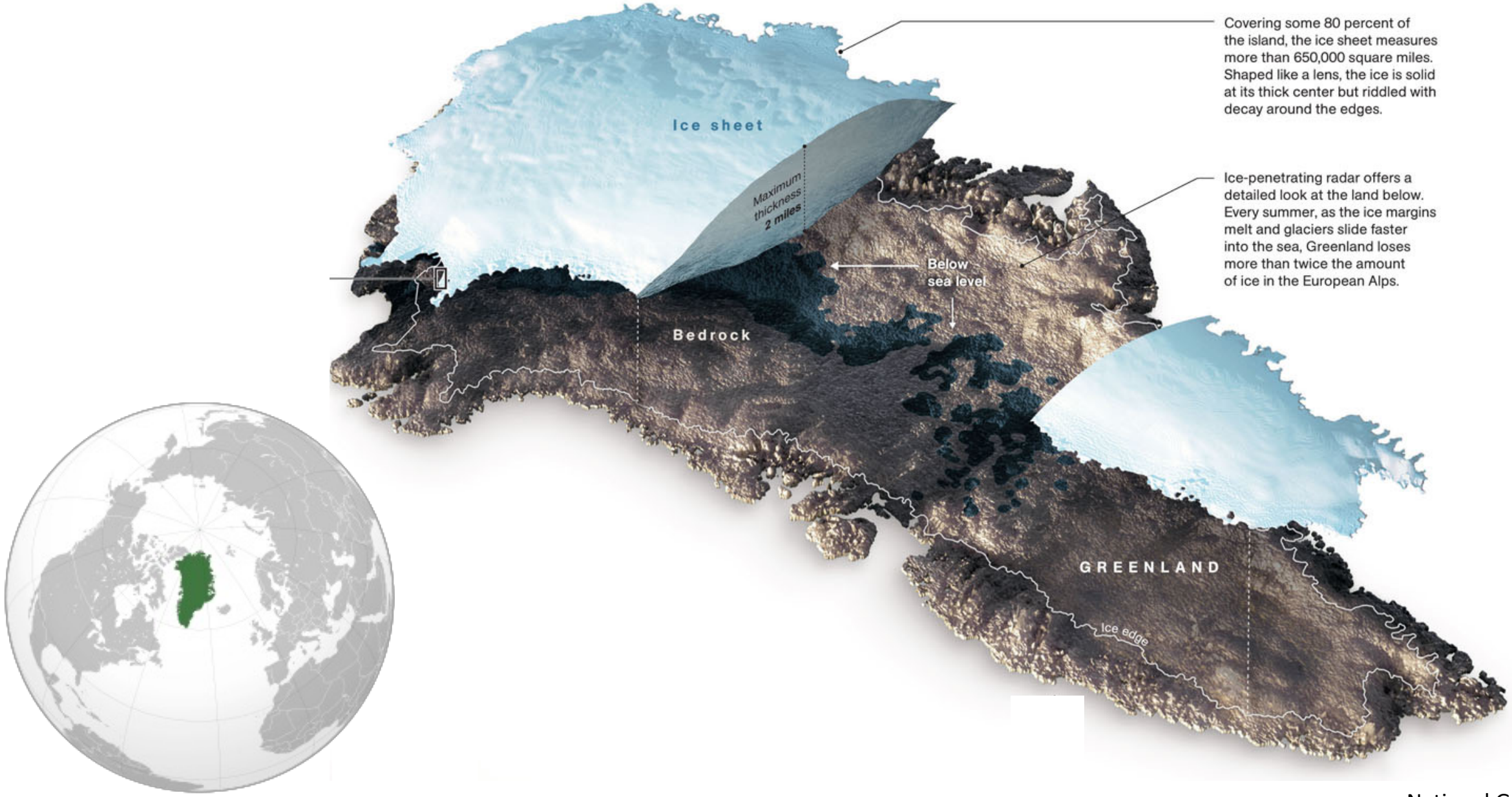
Nature **635**, 108–113 (2024)

Vertical bedrock shifts reveal summer water storage in Greenland ice sheet

Jiangjun Ran ✉, Pavel Ditmar, Michiel R. van den Broeke, Lin Liu, Roland Klees, Shfaqat Abbas Khan, Twila Moon, Jiancheng Li, Michael Bevis, Min Zhong, Xavier Fettweis, Junguo Liu, Brice Noël, C. K. Shum, Jianli Chen, Liming Jiang & Tonie van Dam

Photo: Thomas Nylen

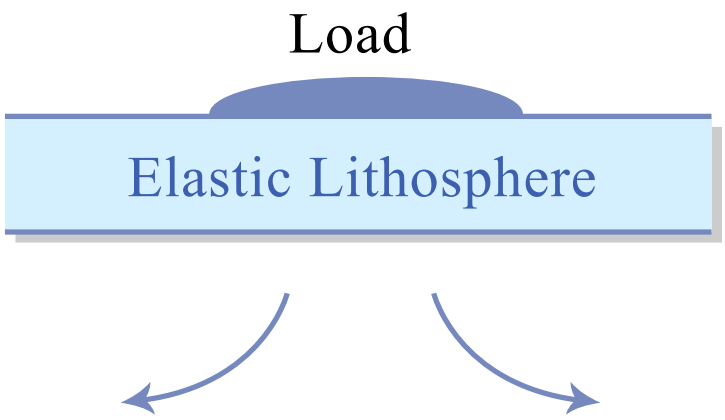
Greenland contains ice that could raise global sea level by 6 m



National Geographic

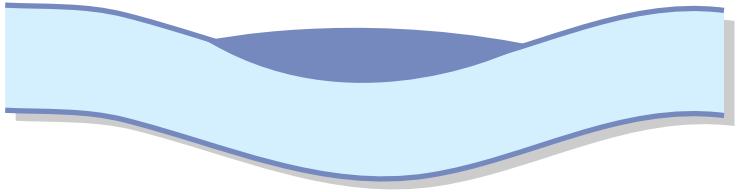
Solid earth deforms in response to surface loading

1. Start of Glaciation



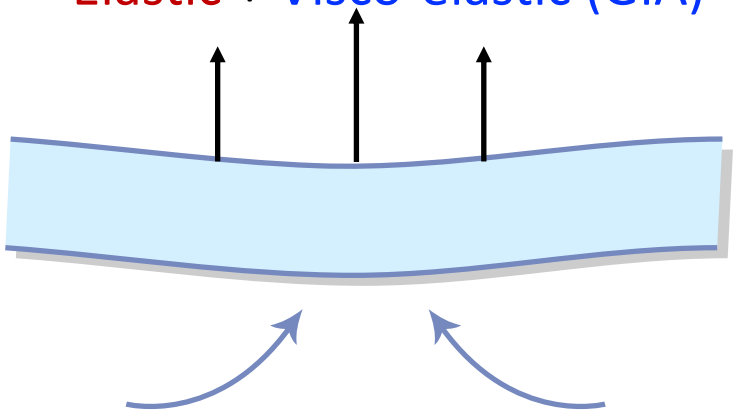
Glacial Isostatic Adjustment (GIA)

2. Load causes subsidence



3. Ice loss causes uplift

Elastic + Visco-elastic (GIA)



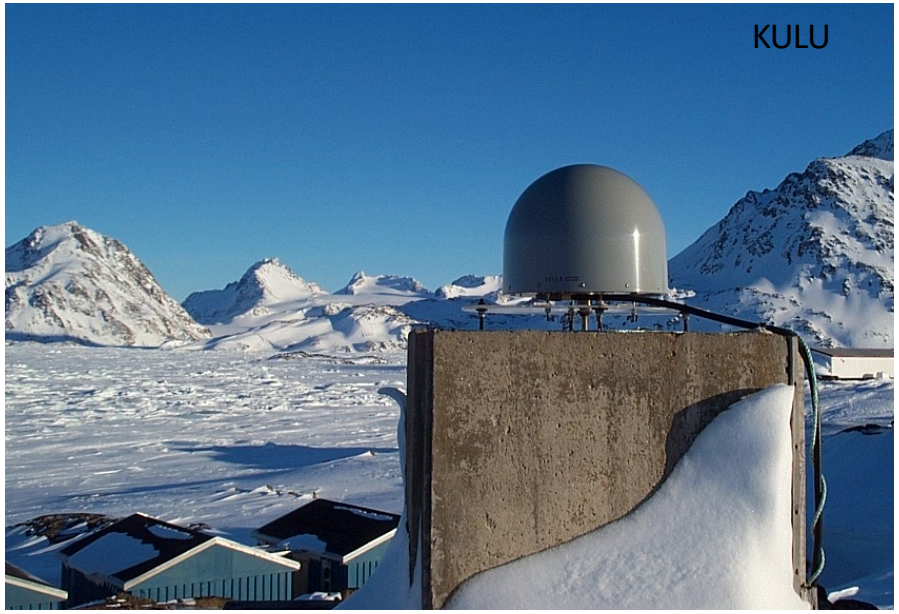
Viscous mantle flows back

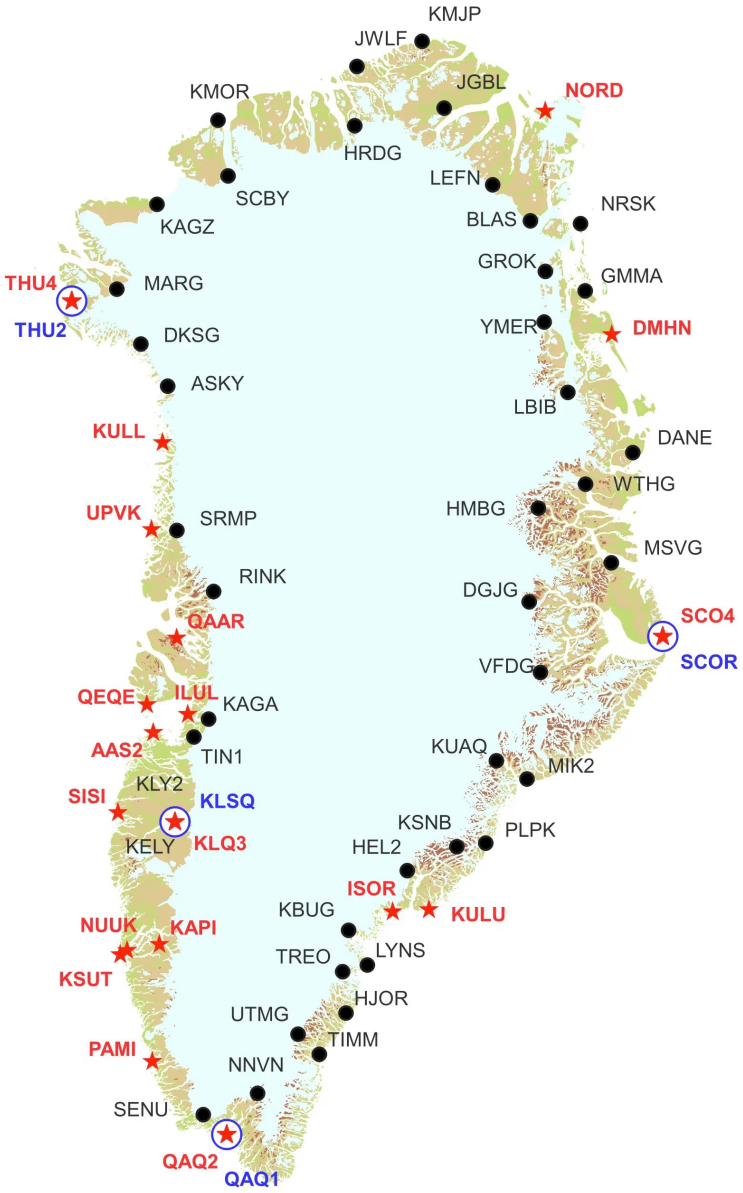
Weighing ice mass

Constraints placed by elastic crustal deformation measurements:

- average over large areas; within ~10 km radius
- provide estimates of present-day **mass** variability

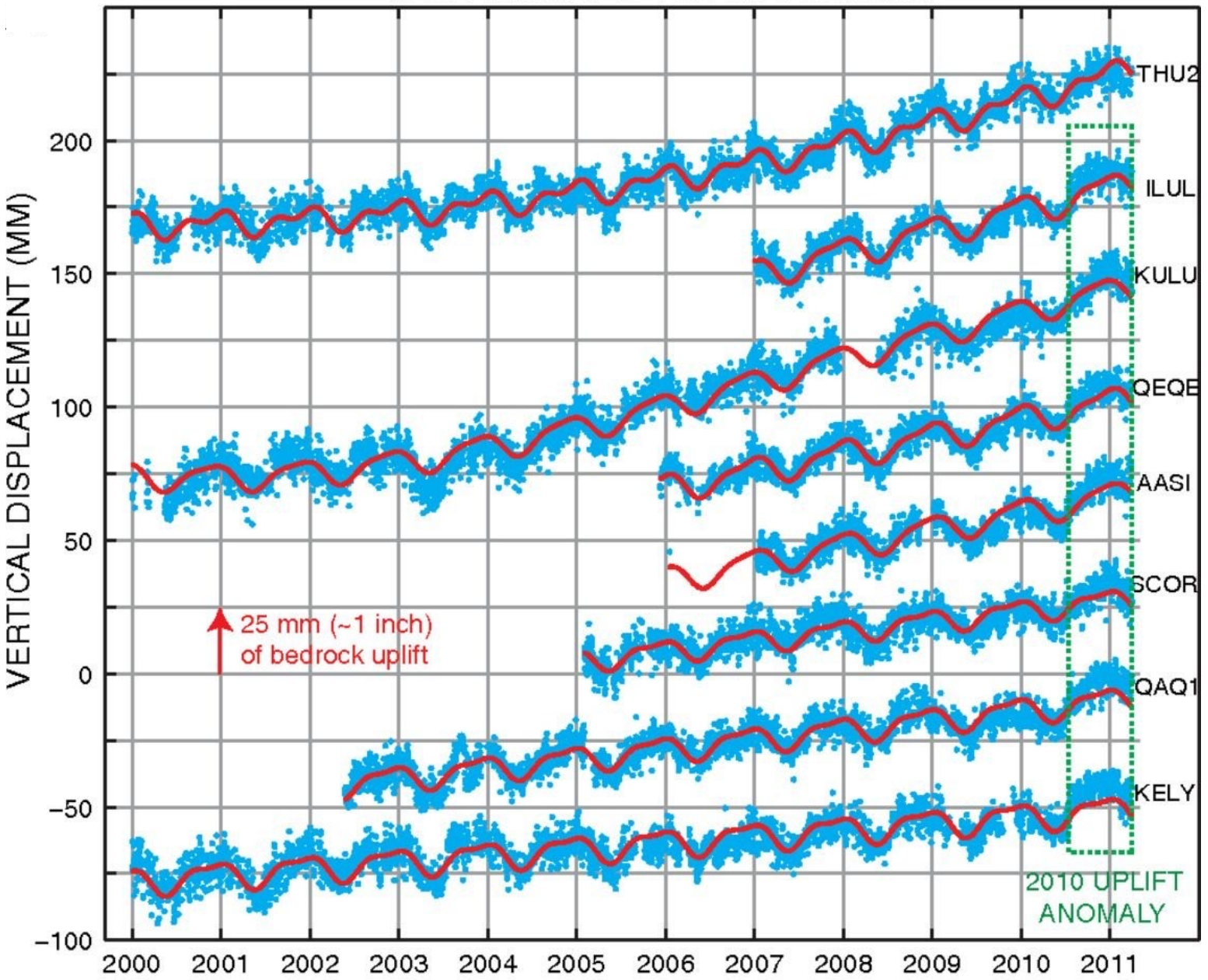
Greenland GNSS network (GNET): 65 continuous sites mounted on bedrock near ice

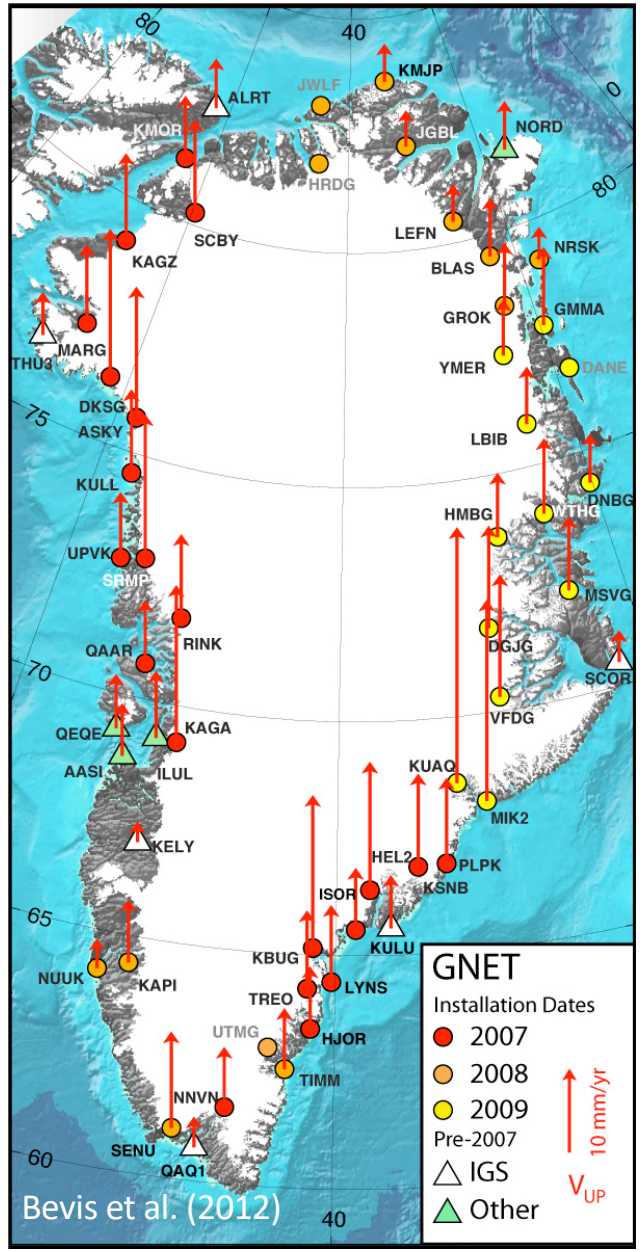




Established by OSU, U of Luxembourg, UNAVCO, Technical U of Denmark (DTU Space), funded by NSF and the Danish Government

All GNSS stations went up due to present-day ice melting





How does meltwater move within & out of ice sheet?

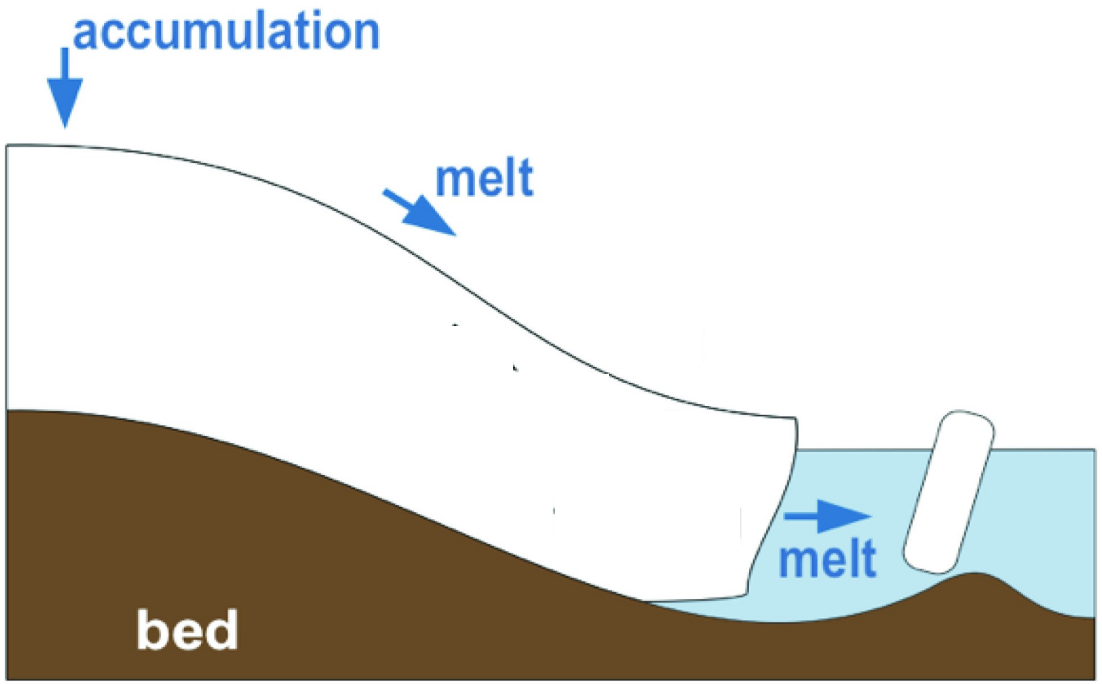
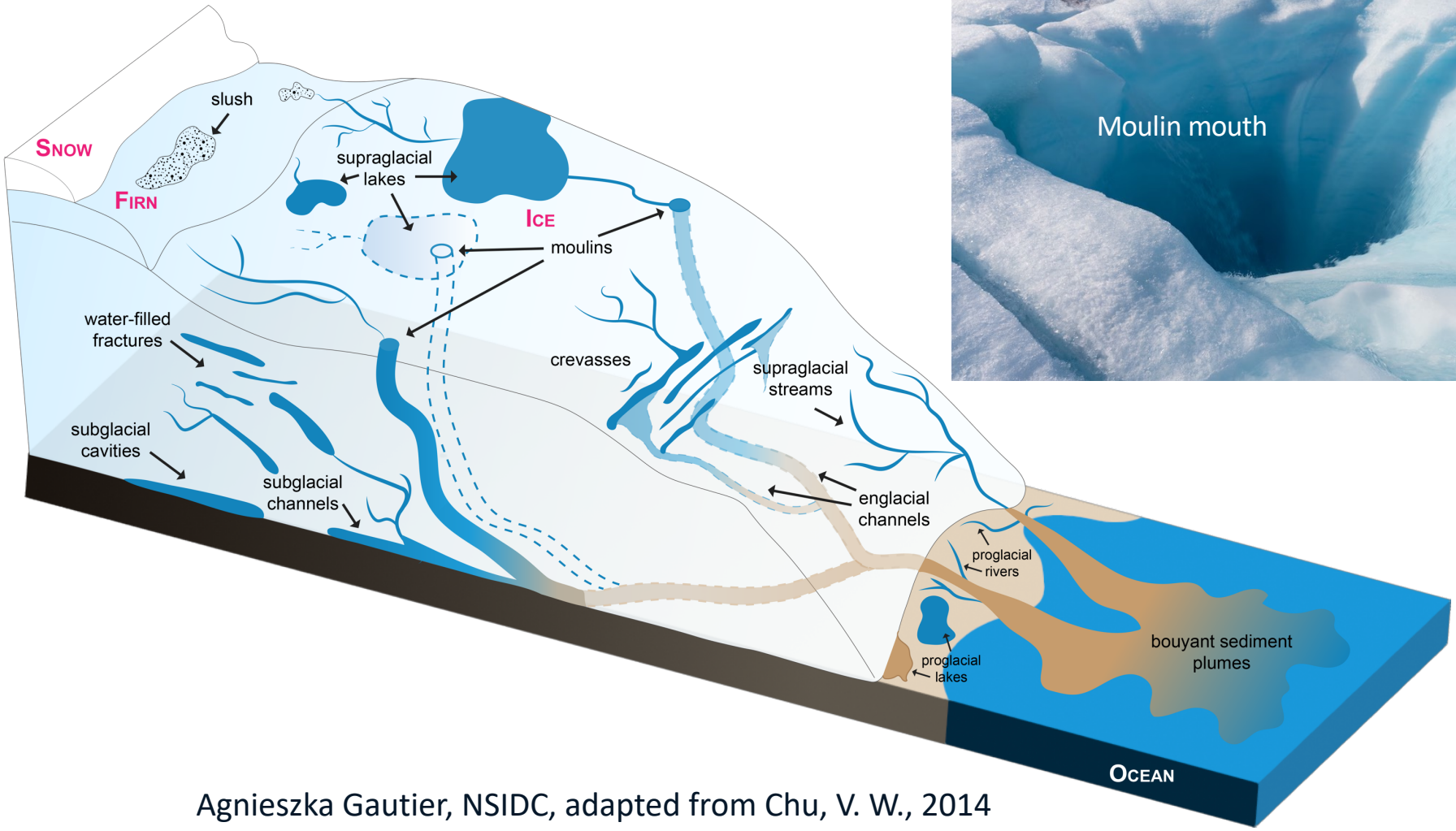


Figure modified from van den Broeke et al., 2009

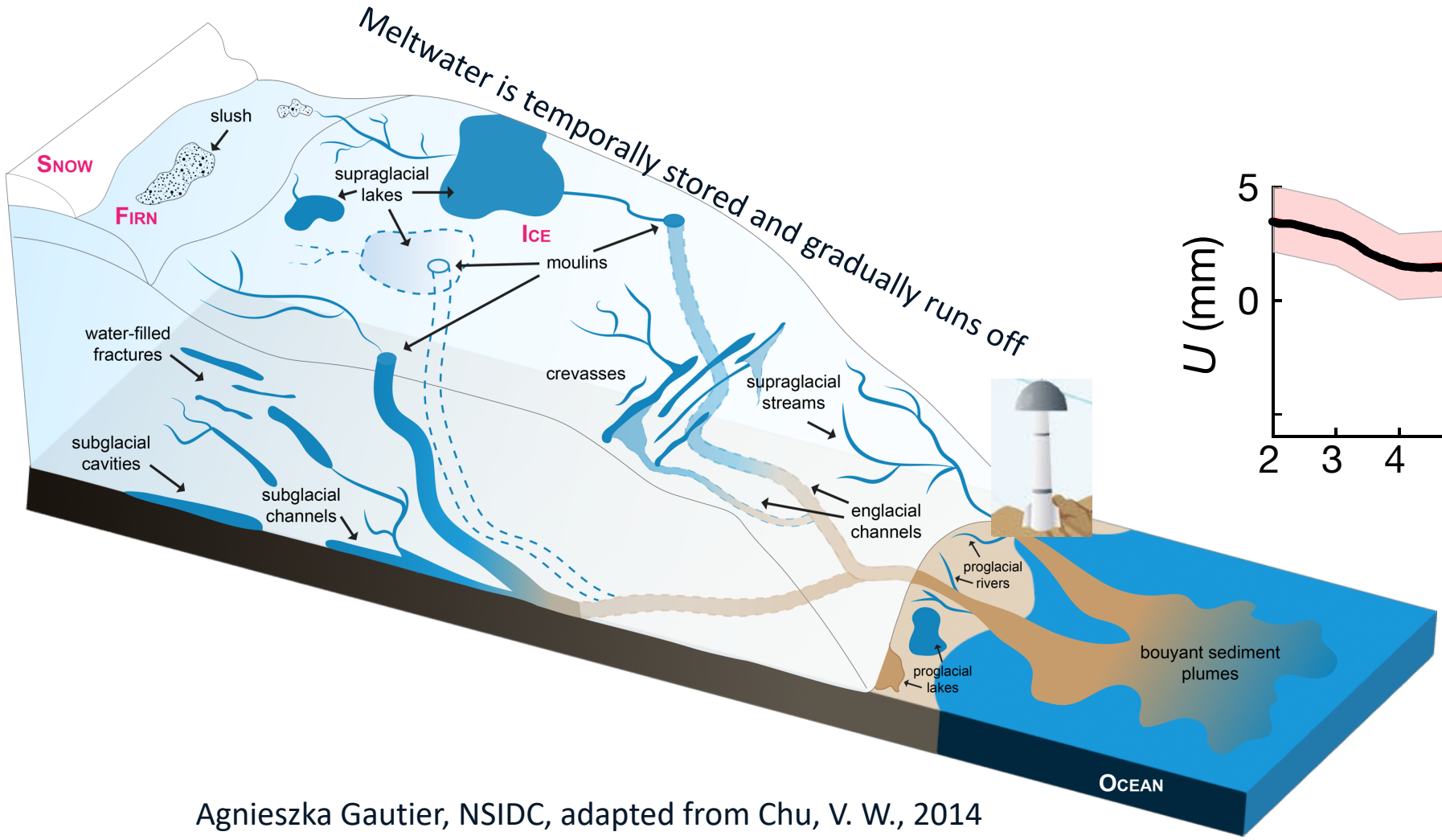
How does meltwater move within & out of ice sheet? Complex processes poorly studied

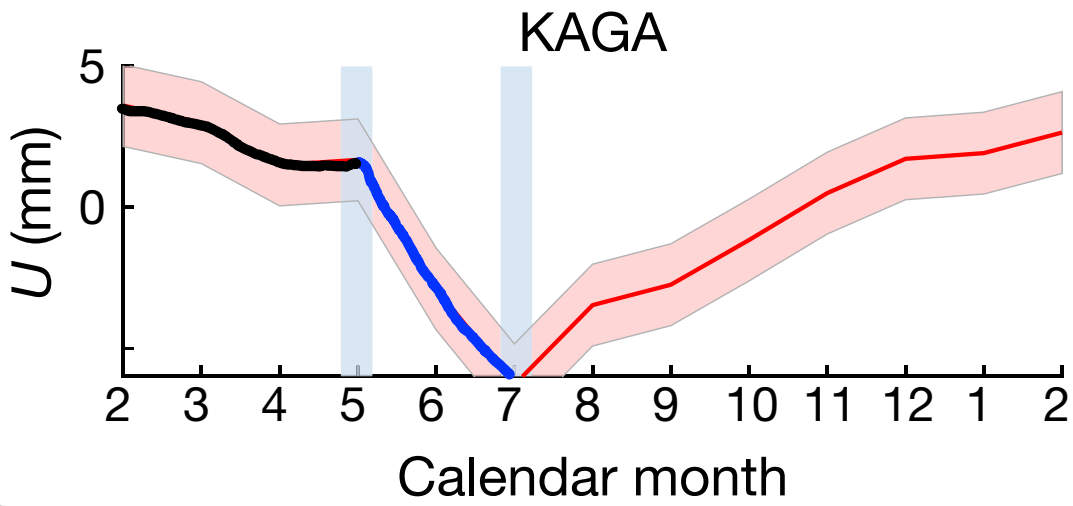


Agnieszka Gautier, NSIDC, adapted from Chu, V. W., 2014

Our idea: use vertical loading deformation to infer buffered water storage

- Early summer: meltwater accumulates & gradually migrates towards GNSS -> **subsidence**
- Late summer: efficient water drainage (through complex pathways) into ocean -> **uplift**

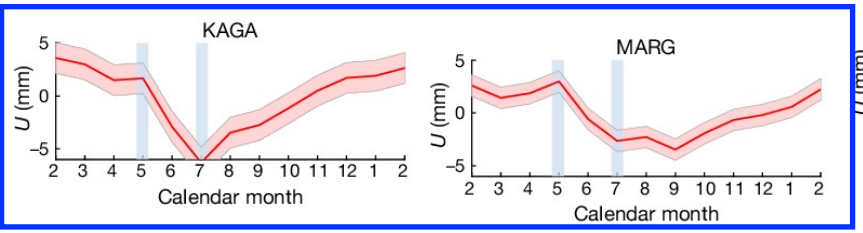


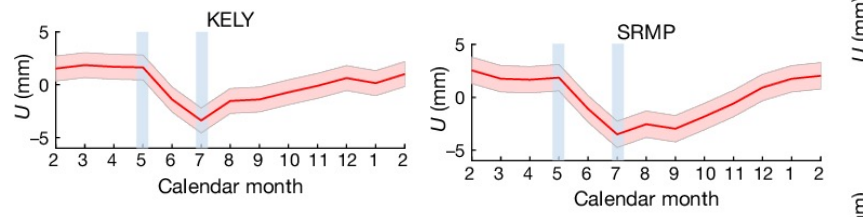


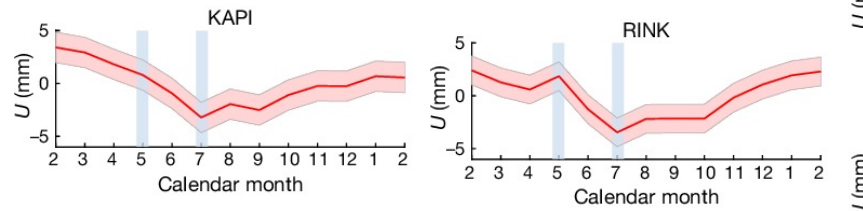
Ran et al., 2024

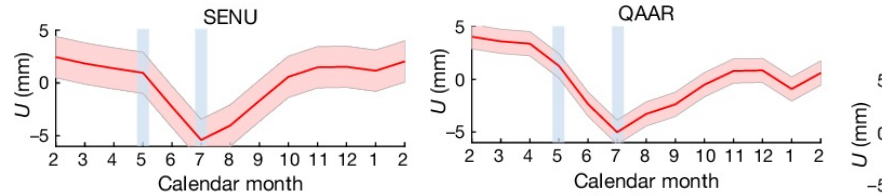
Agnieszka Gautier, NSIDC, adapted from Chu, V. W., 2014

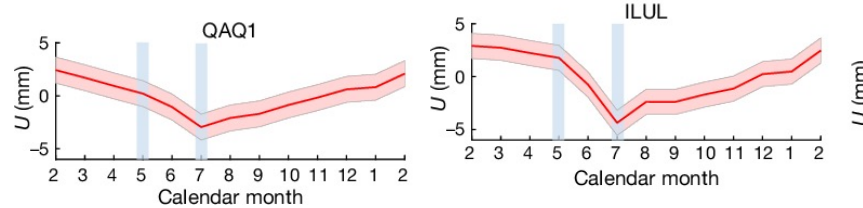
Common seasonal variability across 22 GNSS sites

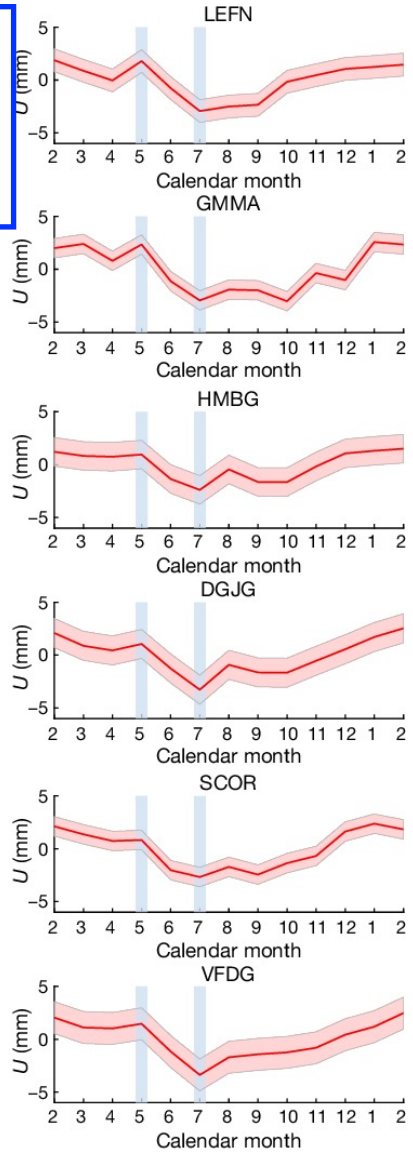


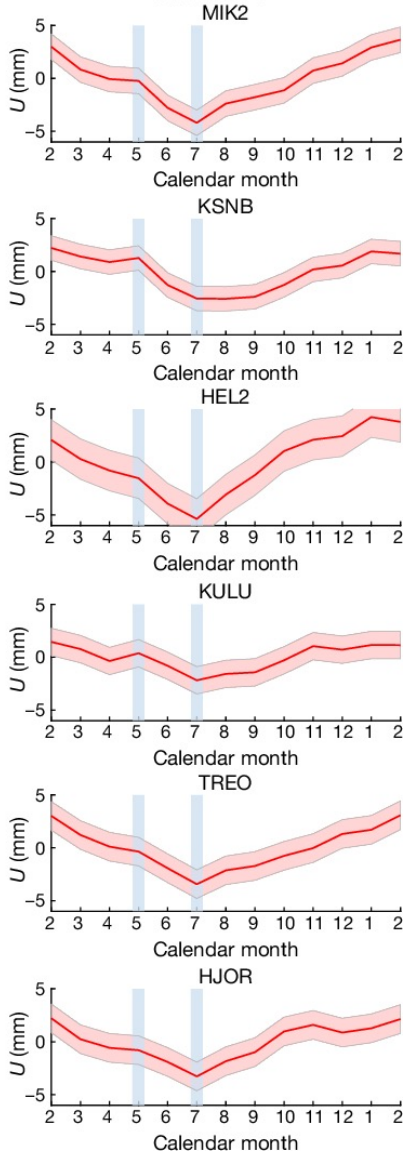


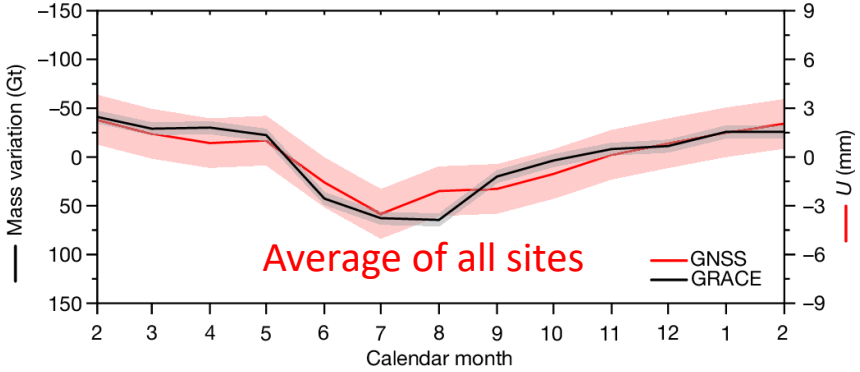


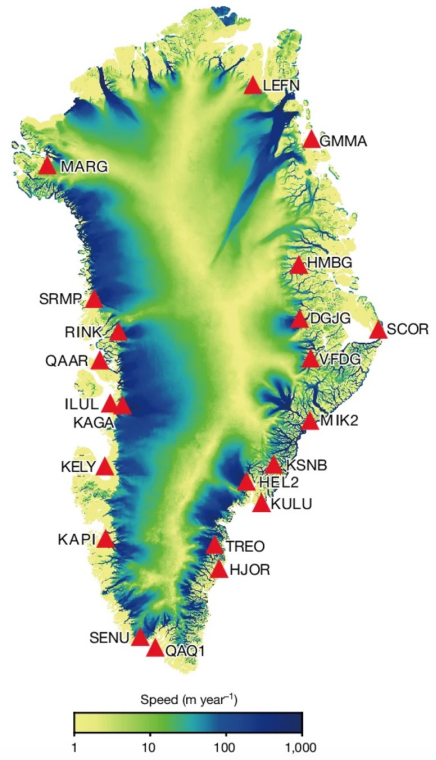






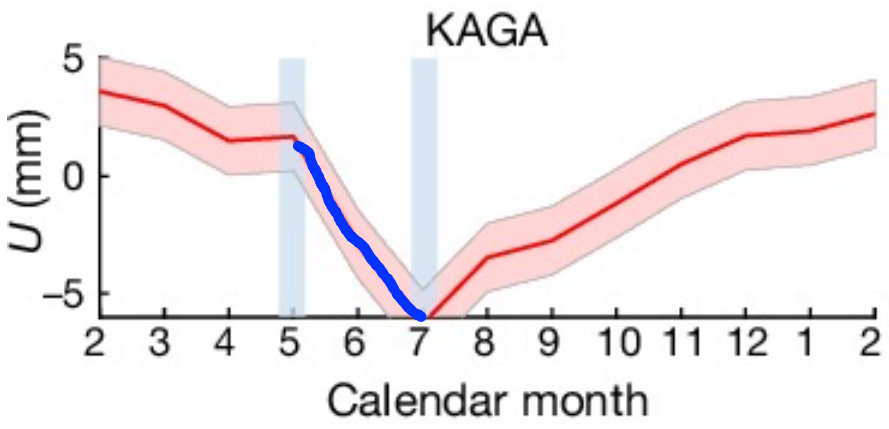


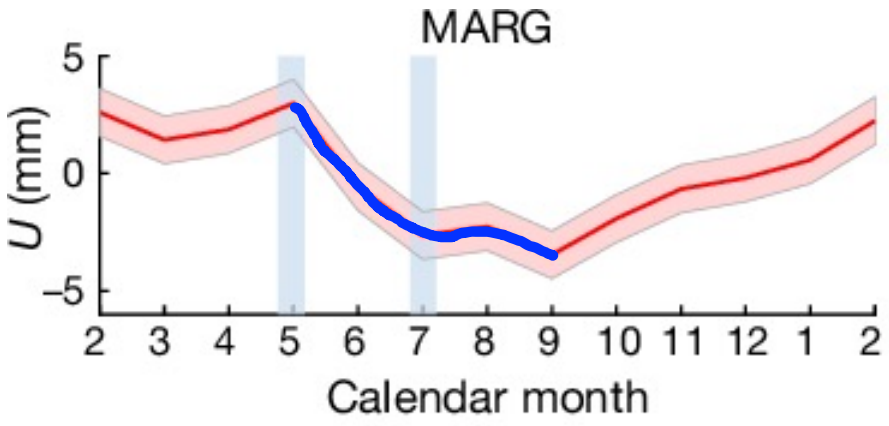


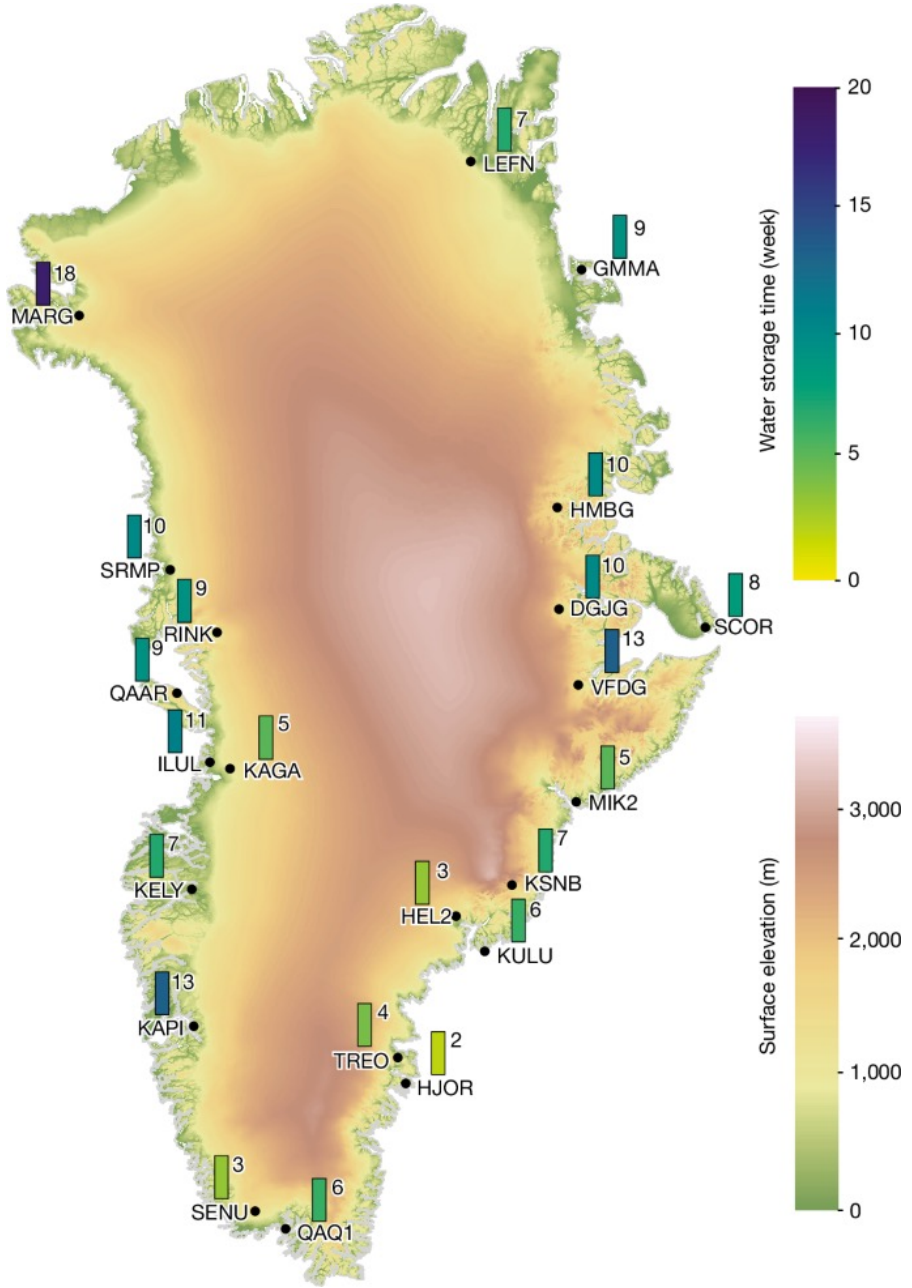


Ran et al., 2024

Duration of early-summer subsidence gives ‘water storage time’





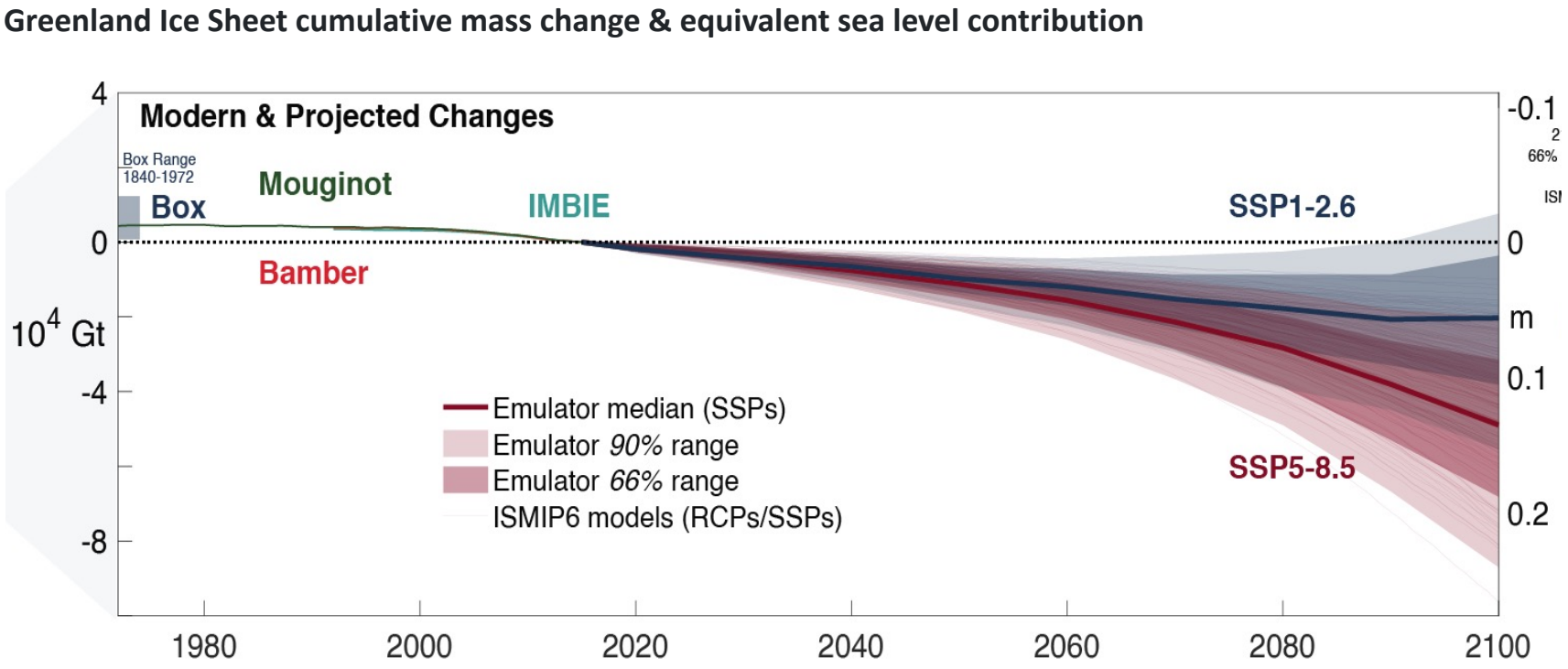


Ran et al., 2024

Key take-aways from this work

Bedrock displacement gives a new source of info on buffered water storage within the Greenland Ice Sheet

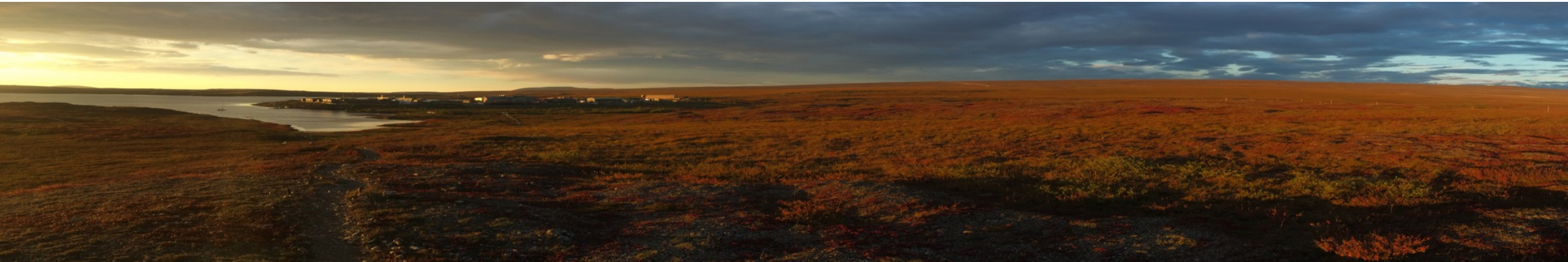
- Vertical subsidence up to 5 mm, needs careful removal of other nuisance contributors
- Water storage generally peaks in July and gradually decreases thereafter
- Storage duration is about two months, shorter in southeast Greenland
- Can constrain & improve regional climate models, as none considers buffered water, toward better projection



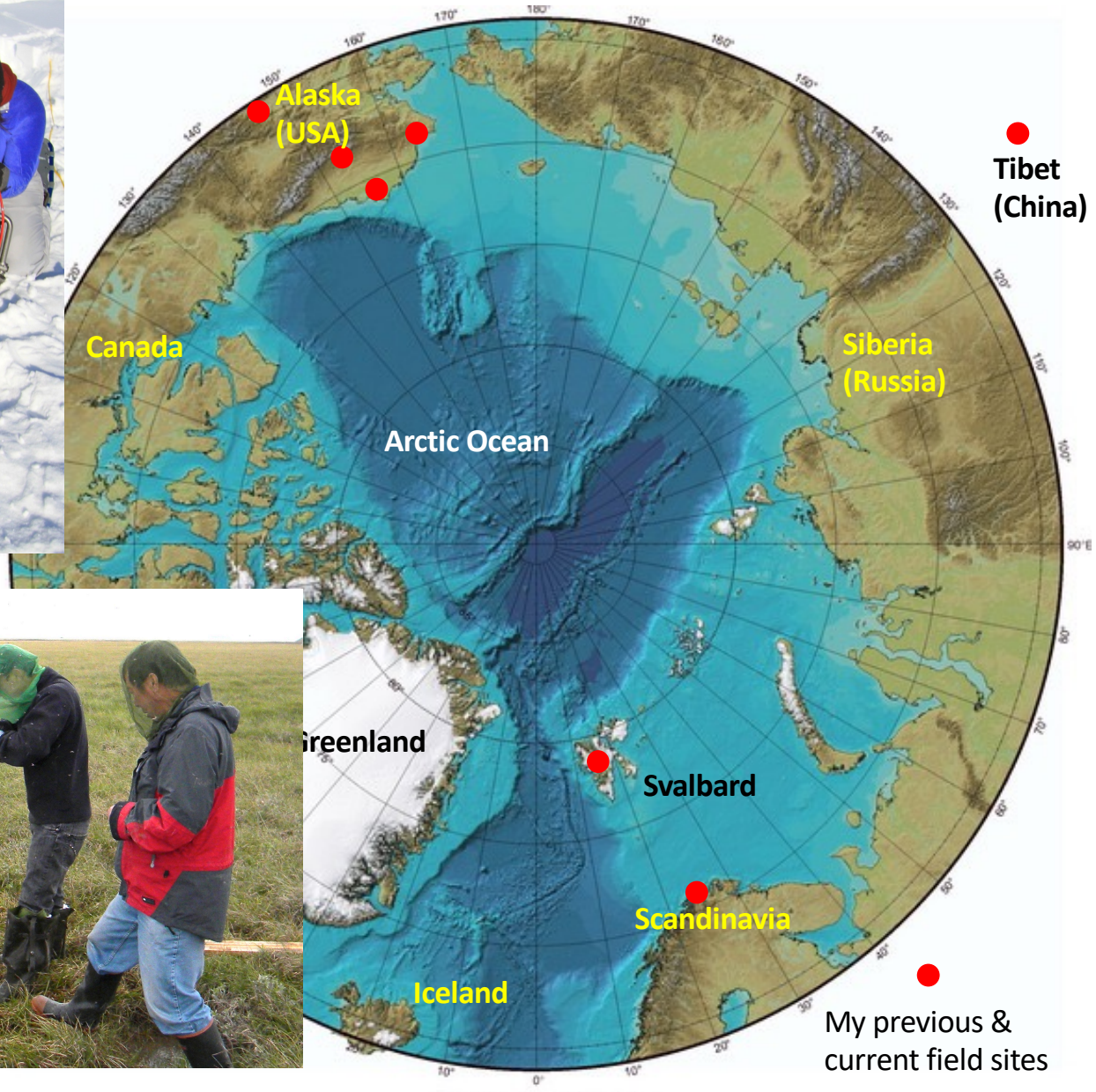
IPCC AR6 (2021)

Why I am excited about cryospheric geophysics and remote sensing

- Innovative and combined use of state-of-the-art methods, inc. artificial intelligence
- Study dramatic changes in various cryospheric systems from interdisciplinary perspectives
- High societal impacts: global climate change, sea level rise, etc.



Time for action!



香港中文大學
The Chinese University of Hong Kong

中大率領香港科學家首次參加中國南極考察

CUHK leads Hong Kong scientists to participate in China's Antarctic expedition

Milestone underscores city's growing contribution to national and global scientific endeavors

China's 41st Antarctic Expedition 2024–2025

Great Wall Members

Jiying Li (HKUST) Martin Tsui Lin Liu Alex Chow

18 December 2024 – 7 January 2025

Zhongshan Member

Zhaoliang Chen

9 December 2024 – 1 March 2025

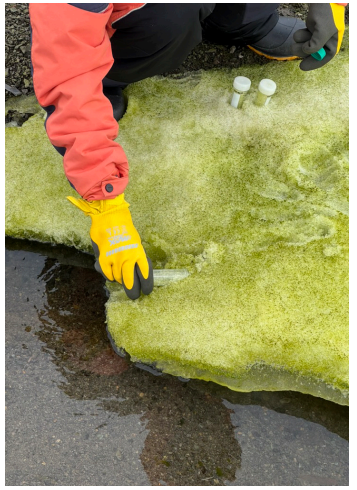
Xuelong 2/Ross Sea

Michael Pittman

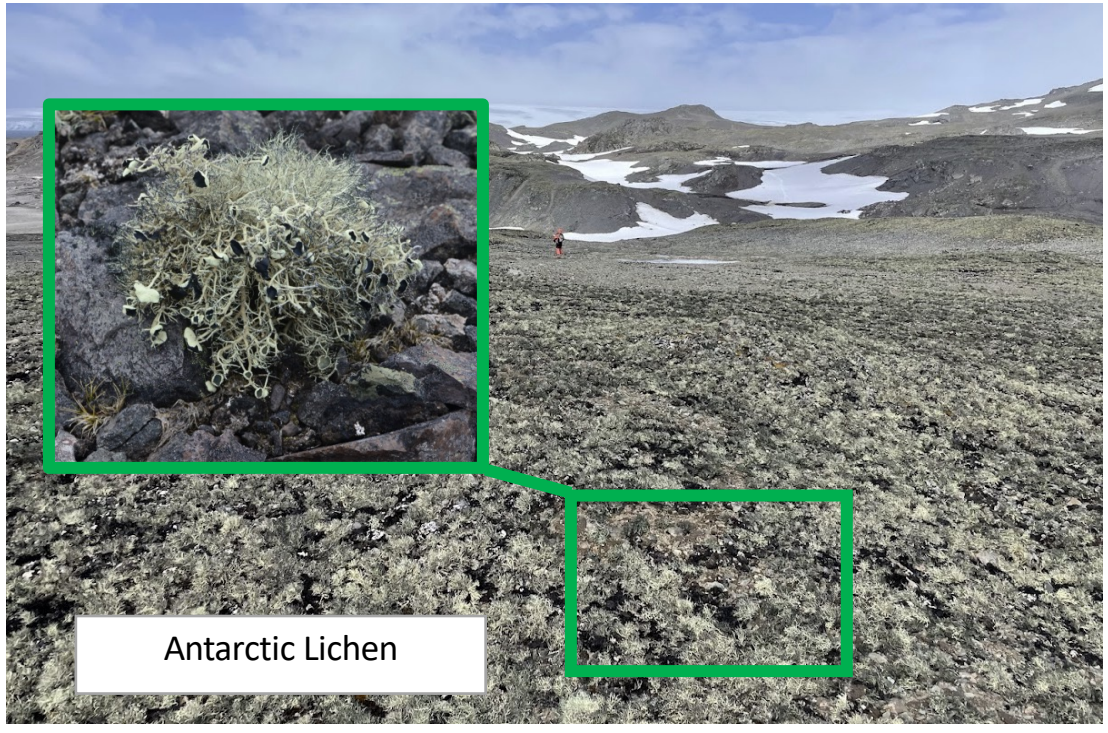
March–April 2025

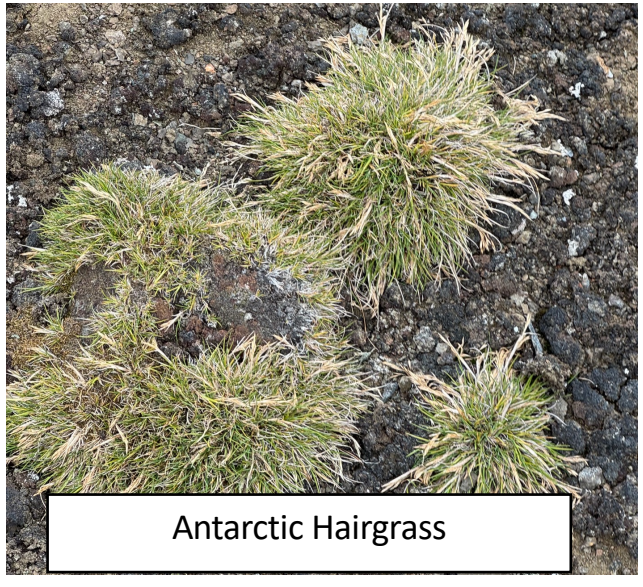
Can you believe this lush landscape is Antarctica?!

We investigate how bio-hydro-geochemical system changes in polar critical zones



Seemly barren land, but we found flouring flora and microbes





Exciting Discoveries & Opportunities Await Hong Kong Scientists

- Strengthen collaboration with the **Polar Research Institute of China** and key international partners

- CUHK plans to lead scientific teams to participate in
  - *China's 15th Arctic Ocean Scientific Expedition in summer 2025*
  - *China's 42nd Antarctic Expedition in December 2025*
  - *Future expeditions*

- Our team will develop an **autonomous & intelligent system** by integrating in-situ, remote sensing sensors and AI, towards holistic, continuous, long-term & real-time monitoring of elemental changes land-water-life interface.

What kind of PhD students I am looking for

- A driving curiosity to understand how the Earth system, esp. the cryosphere works
- Self-motivated
- Independent but capable of working in a team
- Willing to tackle challenging problems

What I can offer you

- Share my passion of science & vision about cryosphere, geophysics, remote sensing, deep learning
- Train you as an independent scholar through frontier research projects
- International perspectives and professional network
- Always ready to help
- Looking forward to learning from you

Want to learn more about my research?

- Talk to me and my students this week
- Visit my group website
- Send me an email for any questions

liulin@cuhk.edu.hk

cryocuhk.github.io

Reference

- Khan, S. A., et al., (2020), Centennial response of Greenland's three largest outlet glaciers, *Nature Communications*, 11, 5718.

- Liu, L., Khan, S. A., van Dam, T., Ma, J. H. Y., and Bevis, M. (2017), Annual variations in GPS-measured vertical displacements near Upernavik Isstrøm (Greenland) and contributions from surface mass loading, *Journal of Geophysical Research: Solid Earth*, 122, 677–691.

- Ran, J., Ditmar, P., Liu, L., Xiao, Y., Klees, R., and Tang, X. (2021), Analysis and mitigation of biases in Greenland ice sheet mass balance trend estimates from GRACE mascon products, *Journal of Geophysical Research: Solid Earth*, 126, e2020JB020880.

- Ran, J., Ditmar, P., van den Broeke, M., Liu, L., …, and van Dam, T. (2024), Vertical bedrock shifts reveal summer water storage in Greenland ice sheet, ***Nature***, 635, 108–113.

- Zhang, B., Yao, Y., Liu, L., and Yang, Y. (2021), Interannual ice mass variations over the Antarctic ice sheet from2003 to 2017 were linked to El Niño-Southern Oscillation, *Earth and Planetary Science Letters*, 560, 116796.

- And more publications https://cryocuhk.github.io/publications