

High-Latitude Hydroclimatology: Modeling Ice Sheet Surface Mass Balance

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GCEE 6320 Global Climate: Physical Models

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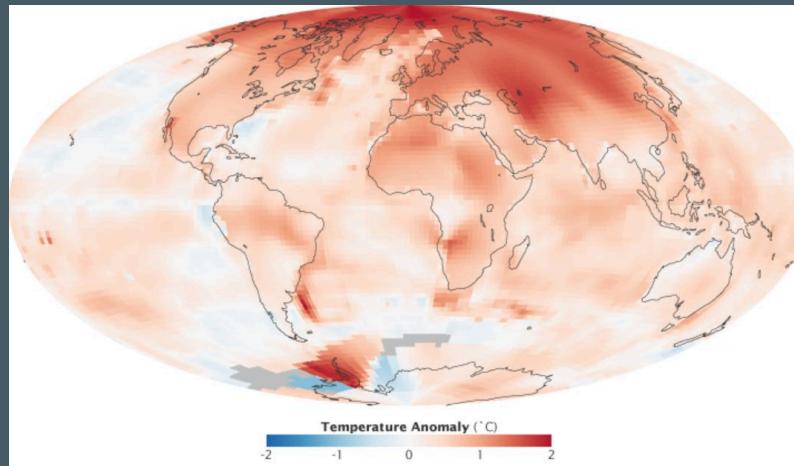
Why do polar regions play a significant role in global climate?

- *The high albedo of snow and ice.*
- *The large amount of carbon stored in permafrost.*
- **The large amount of freshwater stored in glaciers.**



Polar Amplification

- High-latitude regions warm faster than the global average
 - Arctic: 2.5°C
 - Antarctic: 1.5°C
 - Global: 1.1°C
- Factors: Ice-albedo feedback, changes in atmospheric and **oceanic circulation**, and increased greenhouse gases.



https://commons.wikimedia.org/wiki/File:GISS_temperature_2000-09.png

Freshwater Inputs from Land and Ice Sheets

- Freshwater inputs from melting ice sheets and land runoff impact ocean salinity, circulation, and temperature.
- These changes can have far-reaching effects on global climate, marine ecosystems, and sea levels.

Mass Balance of the Polar Ice Sheets

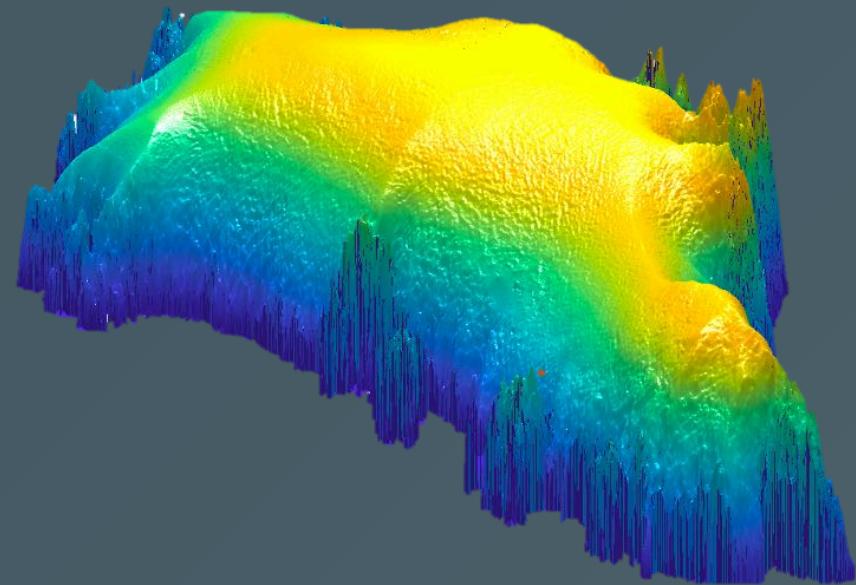
- Importance of ice sheet mass balance for global sea level and climate
- Factors influencing ice sheet mass balance: accumulation and ablation

Observed Changes in Ice Sheet Mass Balance

- Satellite missions for observing ice sheet mass balance (e.g., GRACE, ICESat)
- Recent trends in Greenland and Antarctic ice sheet mass balance

Kalaallit Nunaat (Greenland)

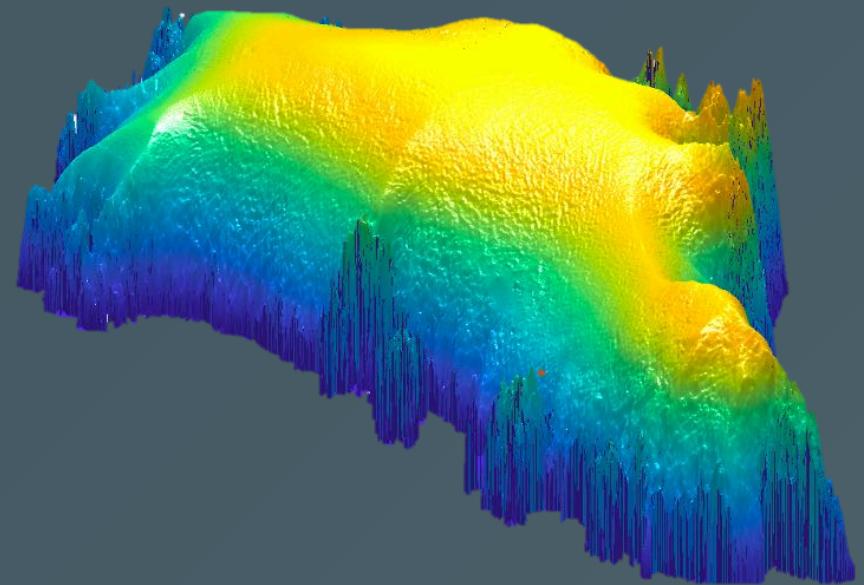
- Populated since ~2500 BC
- ~90% (58,000) Greenlandic Inuit, rest Danish/European
- Autonomous territory of Denmark since 1953
- Self-governed since 2008
- Maintain right to full independence (yet to exercise)



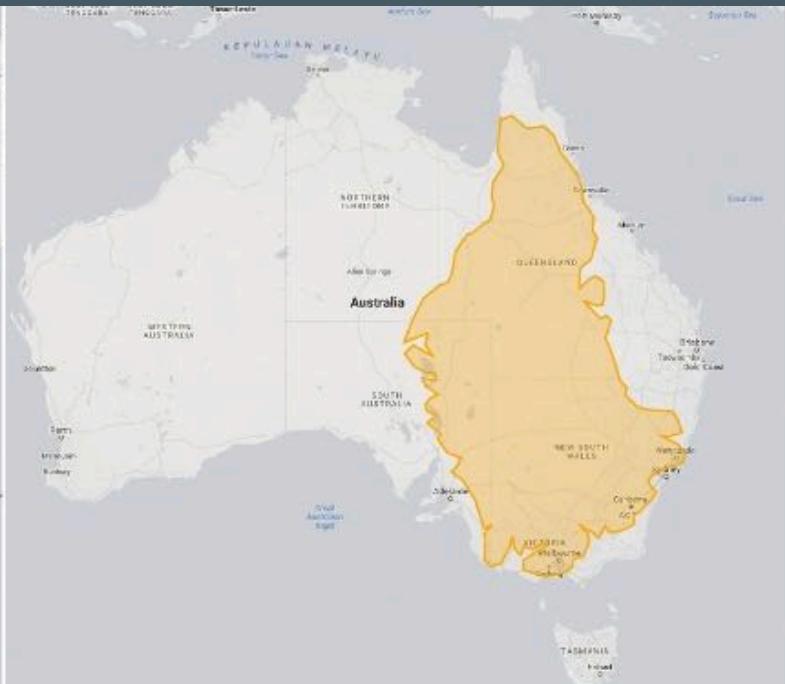
topography: BedMachineV3, Morlighem et al 2017

Kalaallit Nunaat (Greenland)

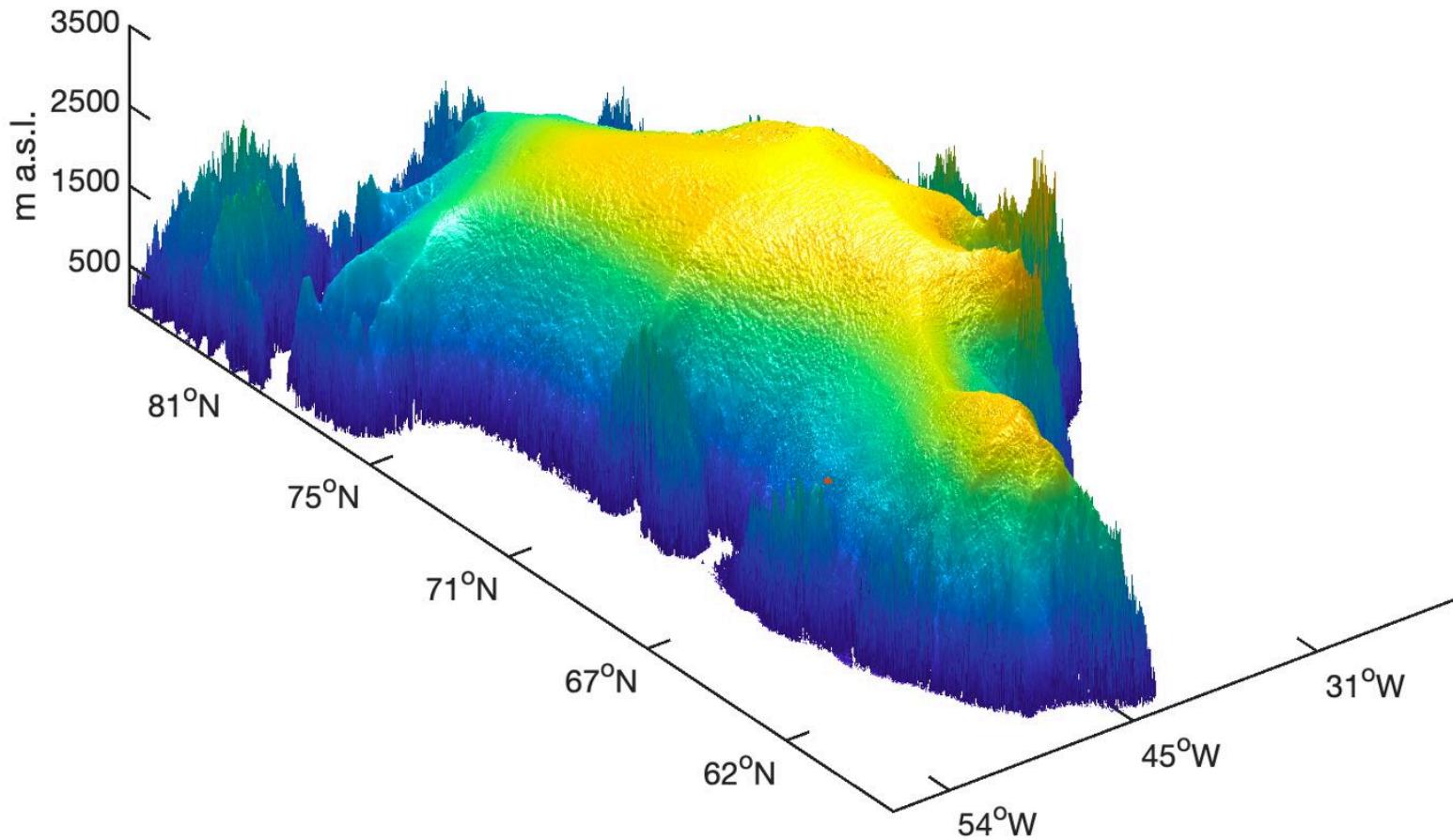
- 2nd largest island on Earth
- Largest island that is not a continent
- ~3000 km (2000 mi) long, 1300 km (800 mi) wide
- ~3 km (2 mi) max thickness
- ~7.2 m (23.6 ft) sea level rise equivalent
- Lowest temperature recorded in Northern Hemisphere: -93°F (-70°C)



topography: BedMachineV3, Morlighem et al 2017

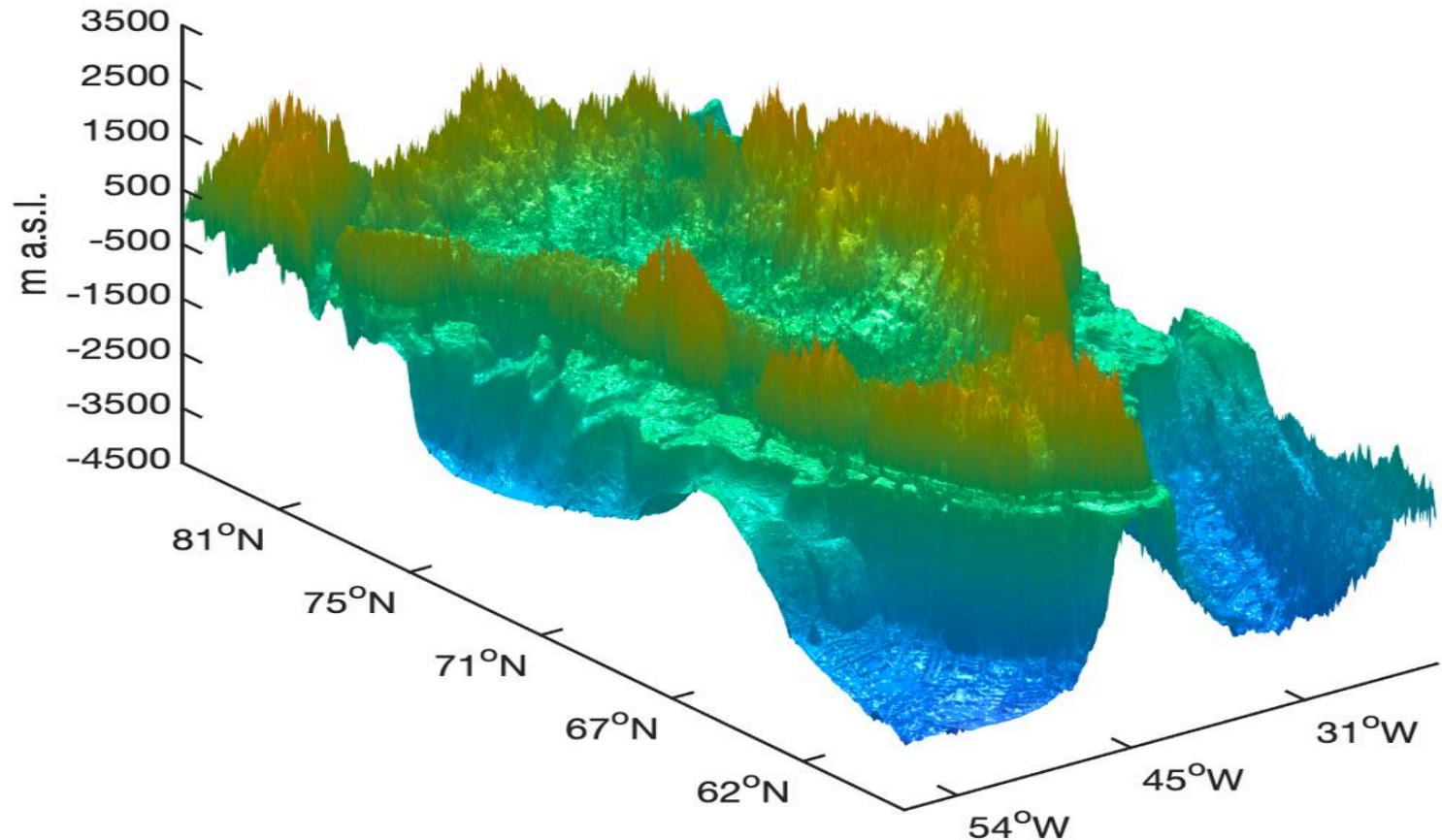


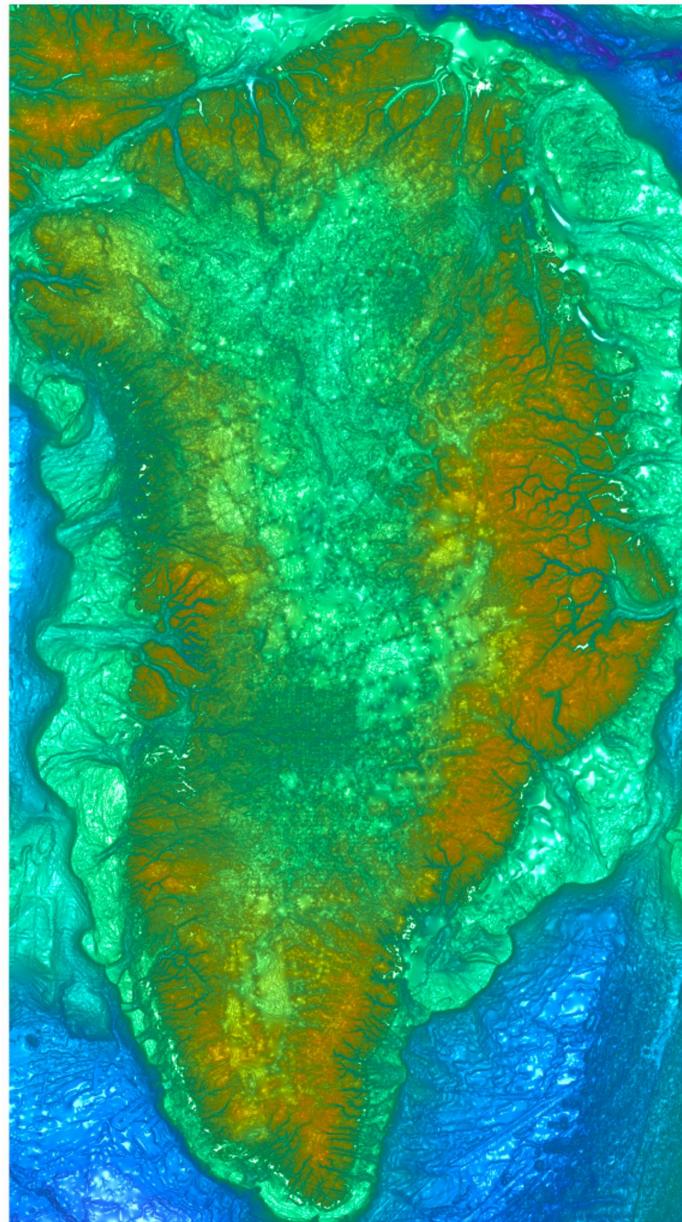
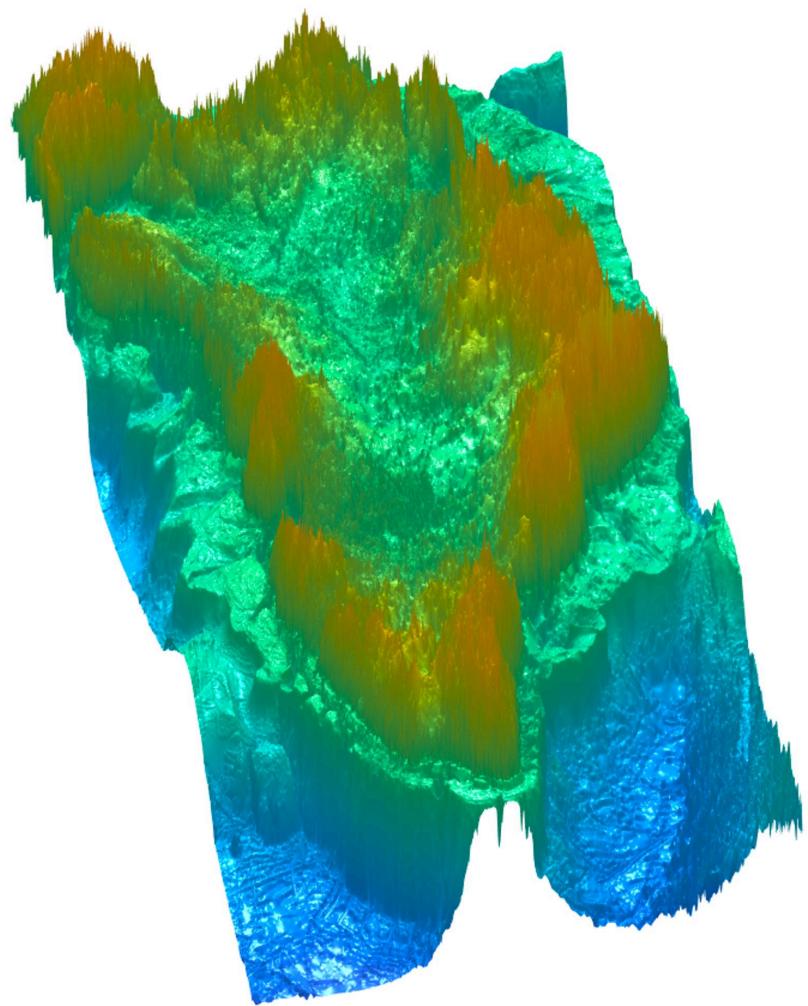
Ice sheet surface topography



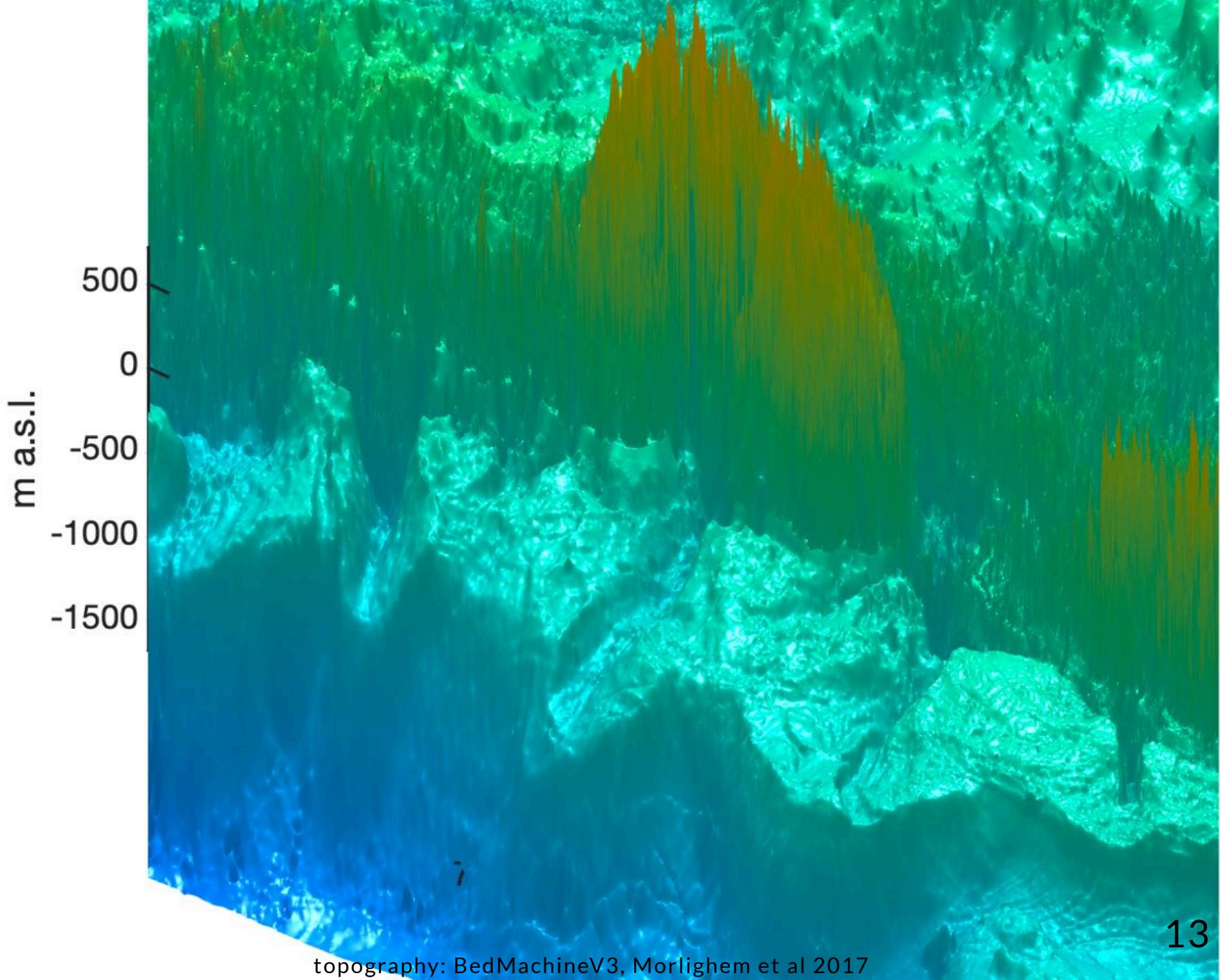
topography: BedMachineV3, Morlighem et al 2017

Ice sheet bed topography

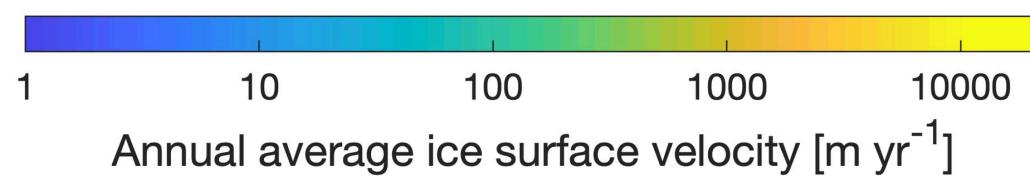
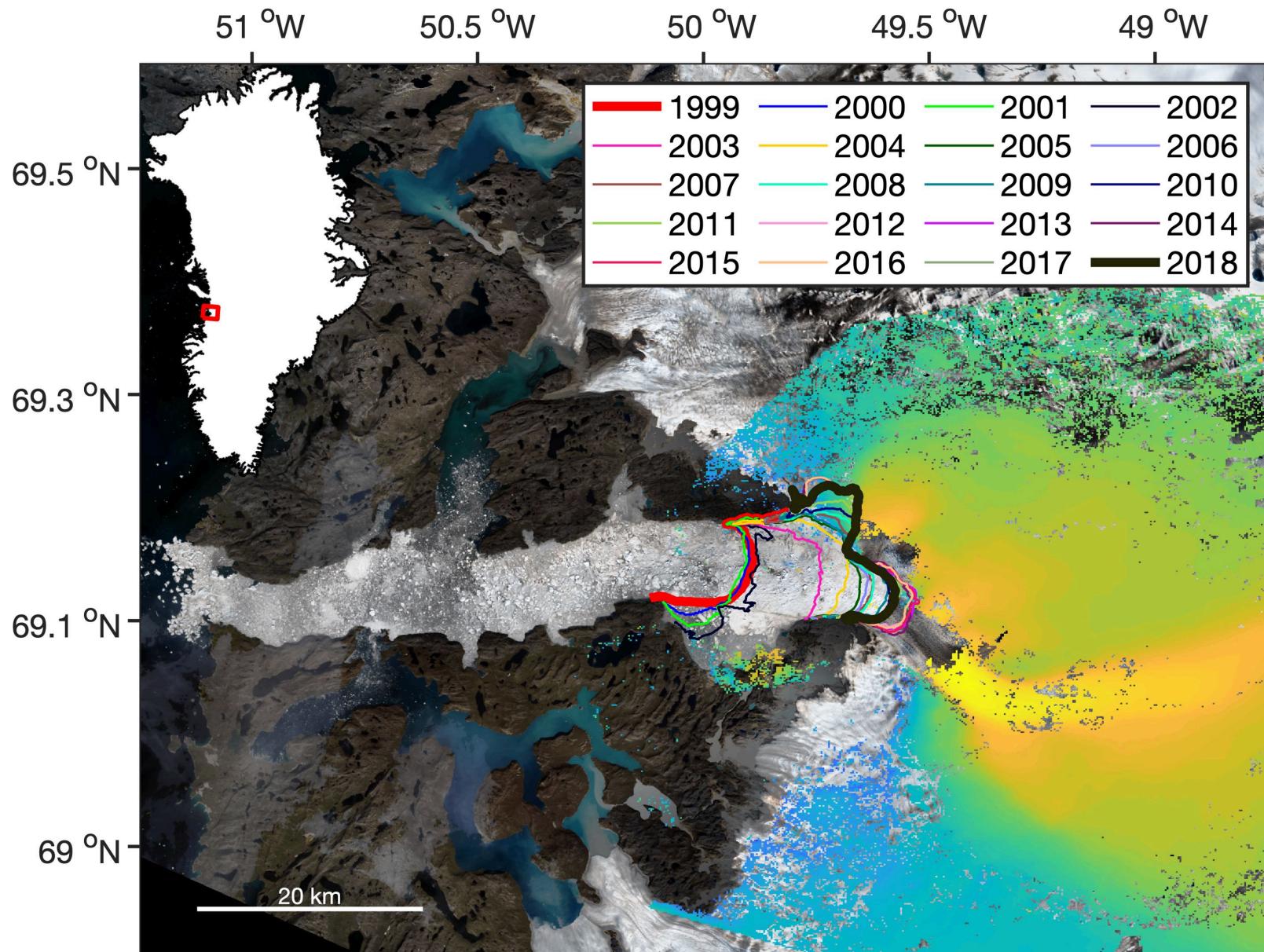


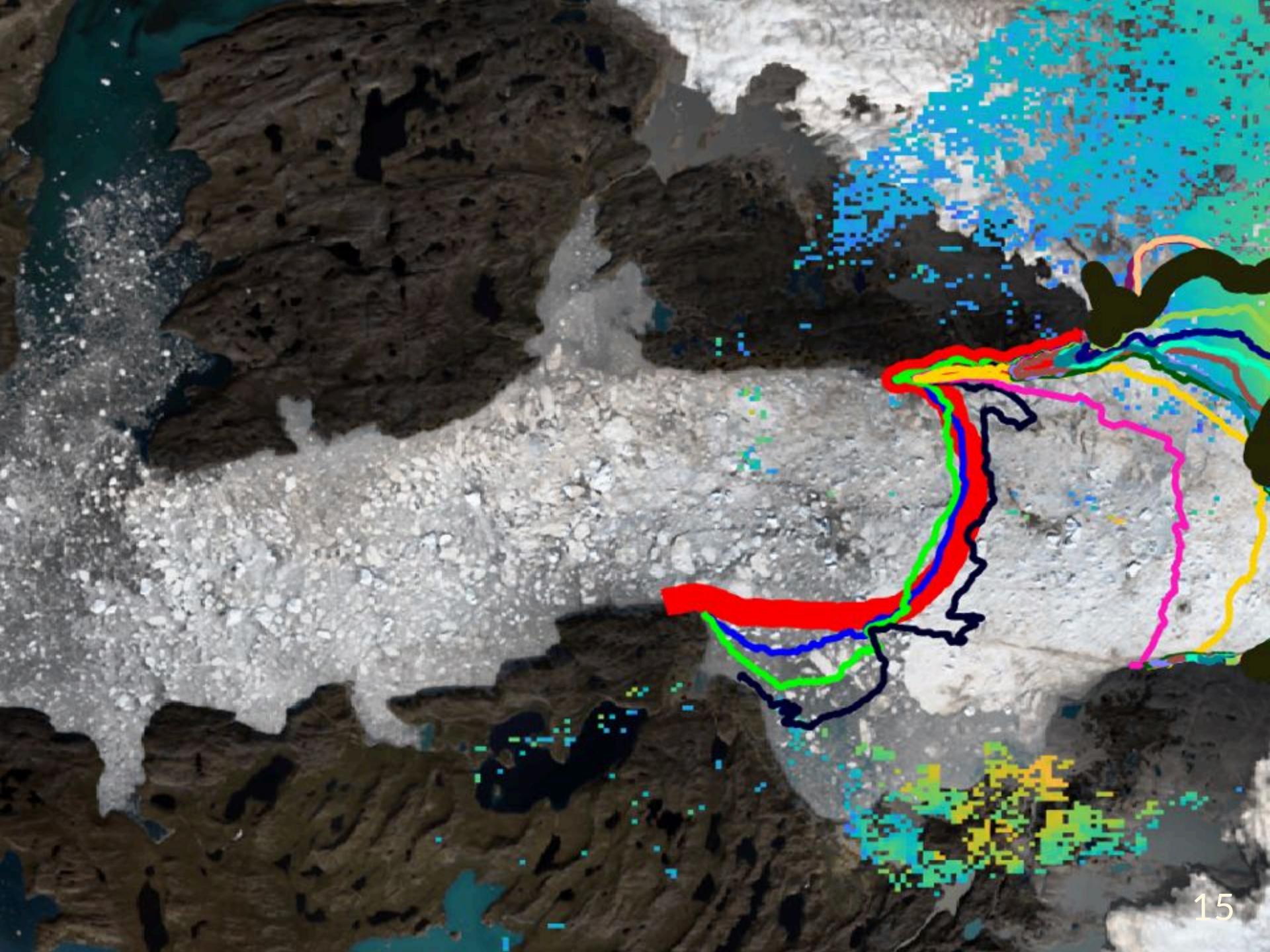


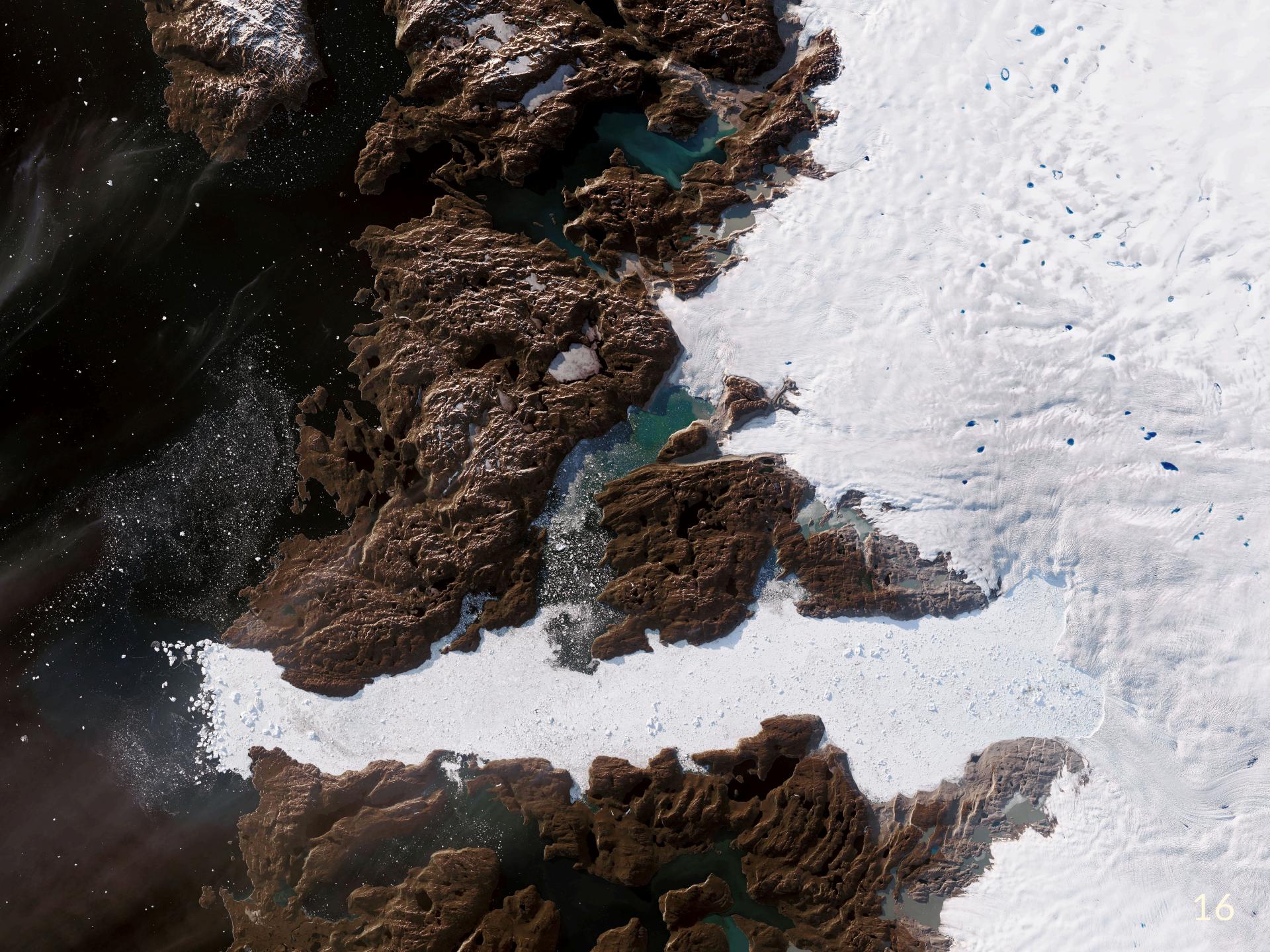
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Recap and Takeaway Messages

- High-latitude hydroclimatology is critical for understanding global climate change
- Climate models are essential tools for studying hydroclimatic processes
- Polar amplification, sea ice, permafrost, and freshwater inputs play key roles
- Ice sheet mass balance research helps predict sea level rise