Paleoclimate and sea-level modeling with CESM2

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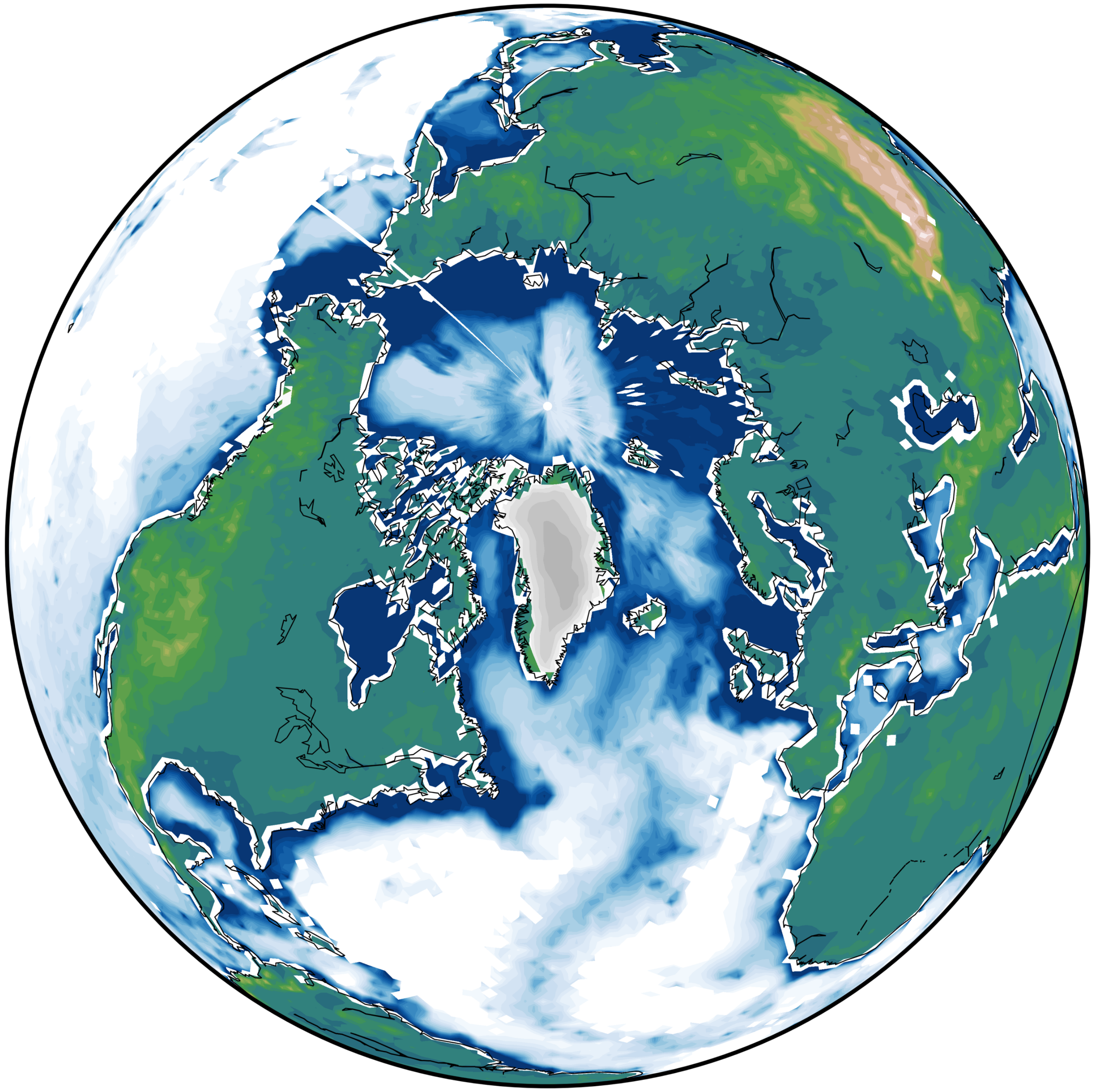
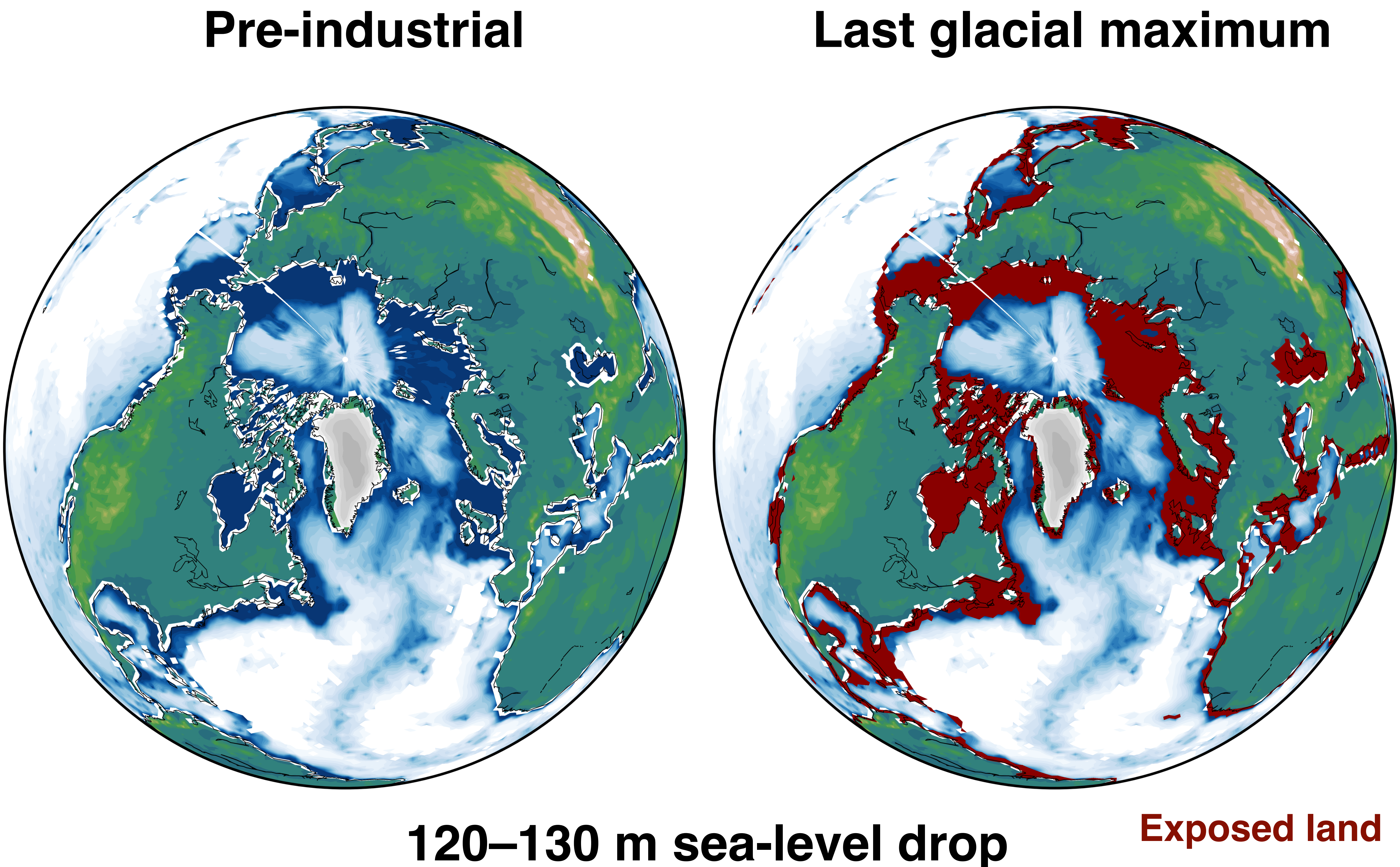
LGM sea-level change

Pre-industrial



ICE-6G

LGM sea-level change



ICE-6G

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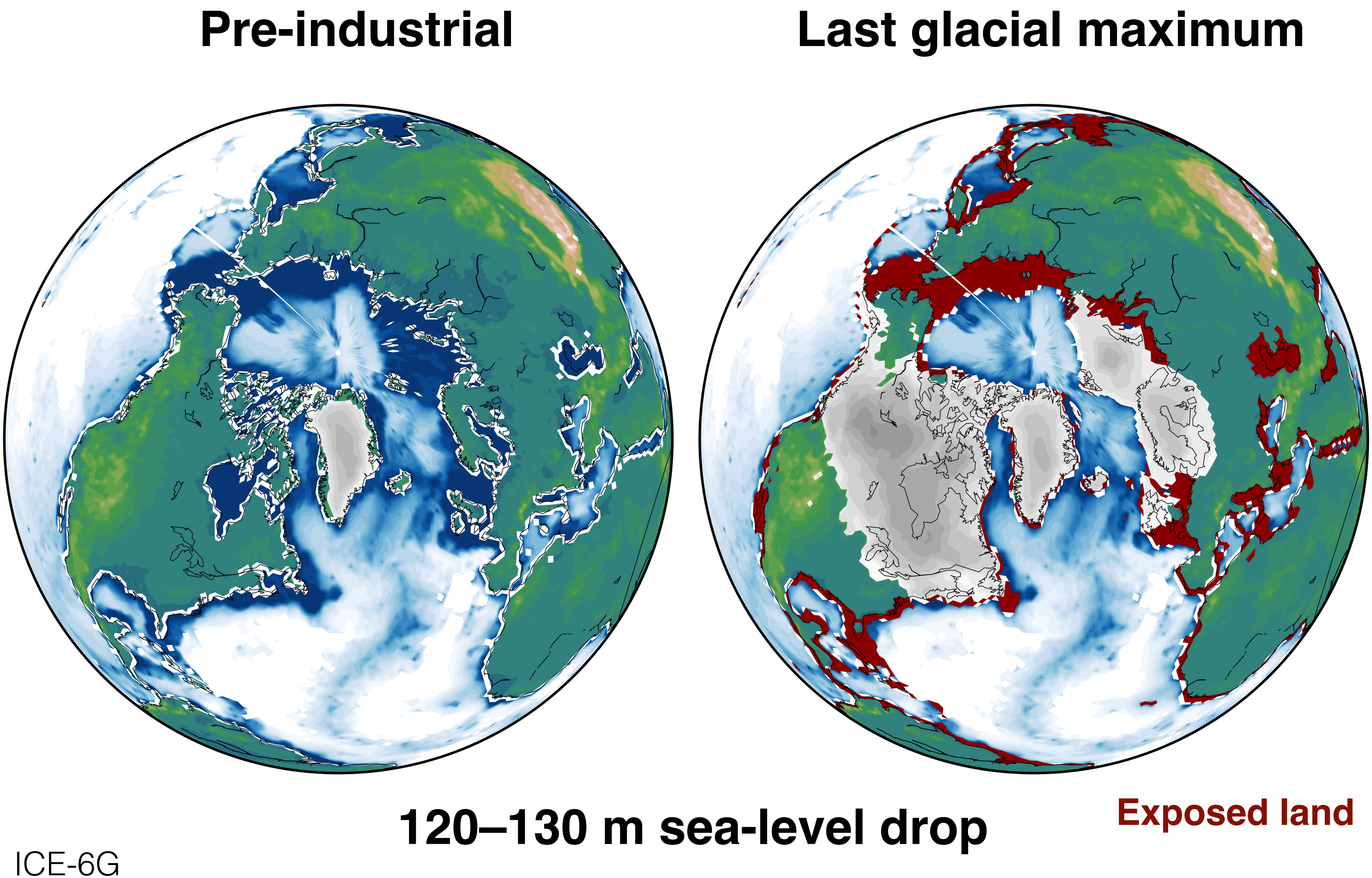
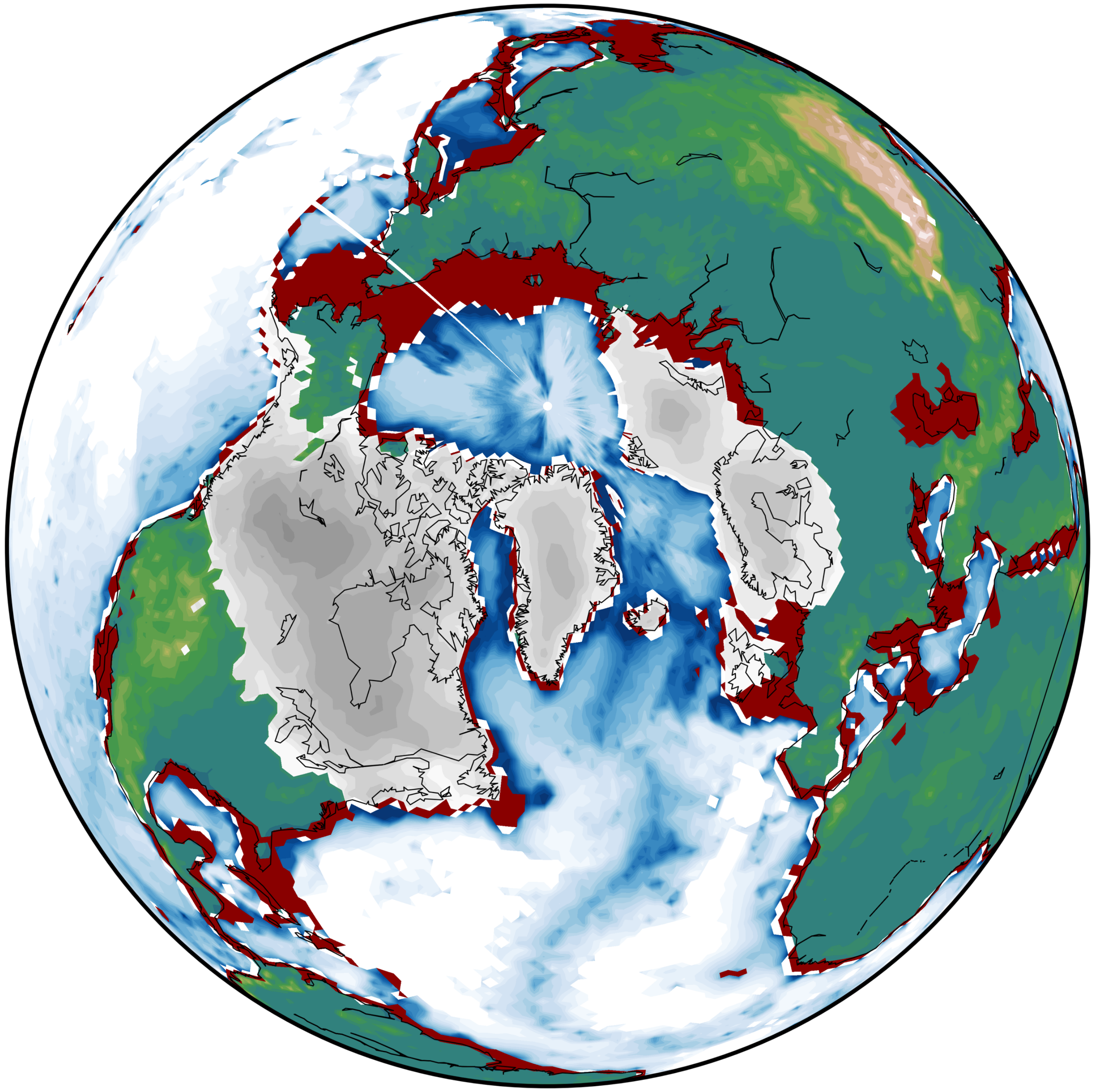


LGM sea-level change

Last glacial maximum

Traditional approach:

- Ice sheets are static "white mountains" (all PMIP1,2,3 simulations)
- Update topography in discrete steps (e.g. TraCE)



120–130 m sea-level drop

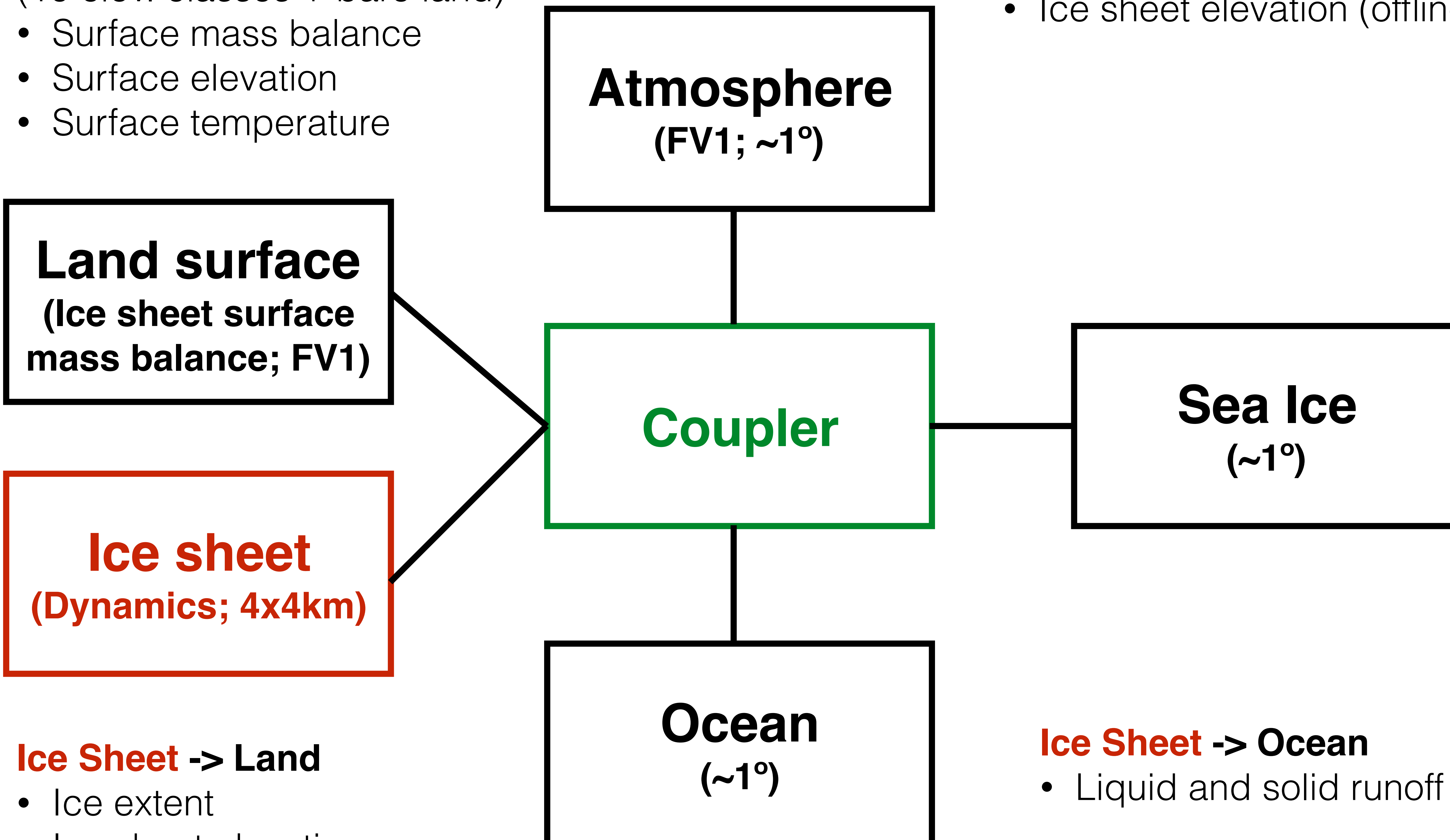
Exposed land

ICE-6G

CESM2 (FV1x1) – CISM2 (4x4 km) two-way coupling

Land -> Ice Sheet
(10 elev. classes + bare land)
- Surface mass balance
- Surface elevation
- Surface temperature

Ice Sheet -> Atmosphere
- Ice sheet elevation (offline)



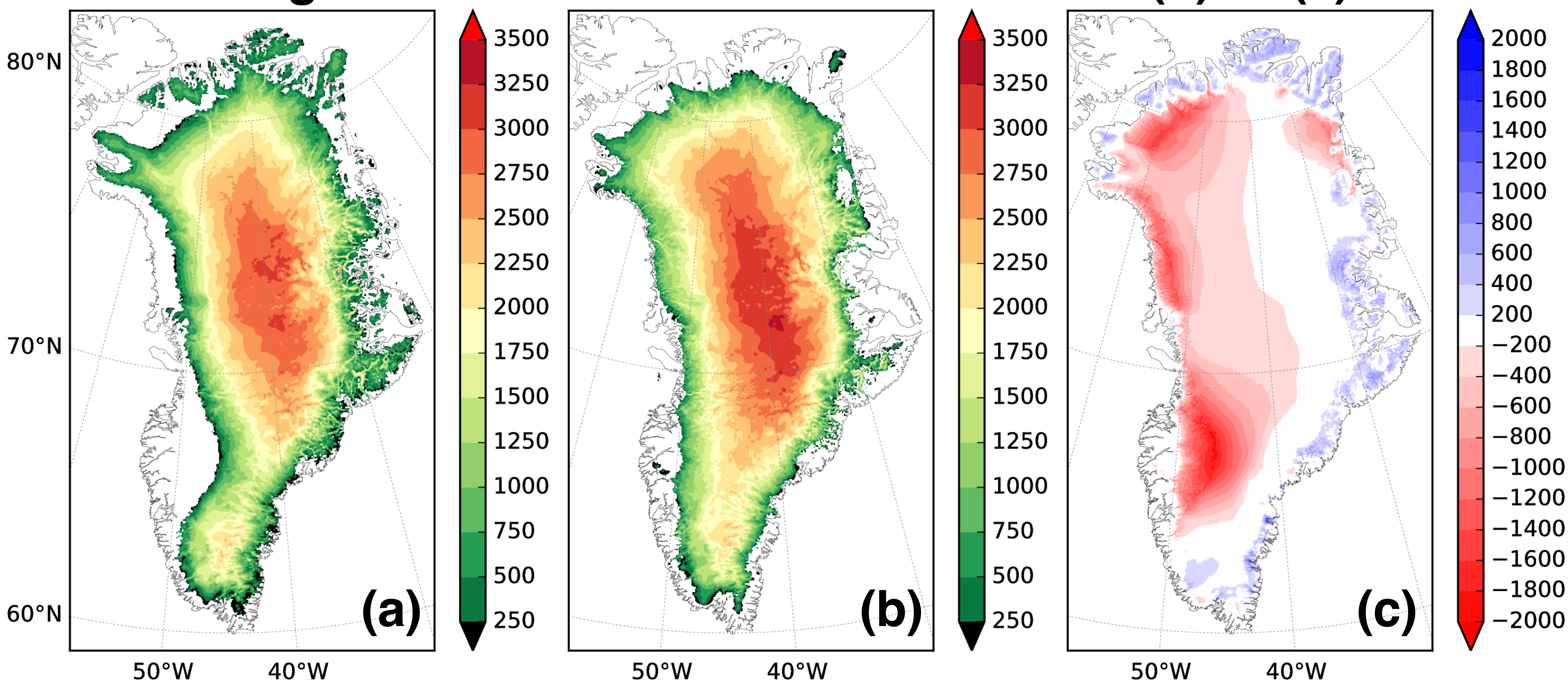
Ice Sheet -> Land
- Ice extent
- Ice sheet elevation
- SMB mask

Ice Sheet -> Ocean
- Liquid and solid runoff

Example of new capability — Greenland deglaciation

Ice thickness [m]

Last Interglacial | **Pre-industrial** | **(b) — (a)**

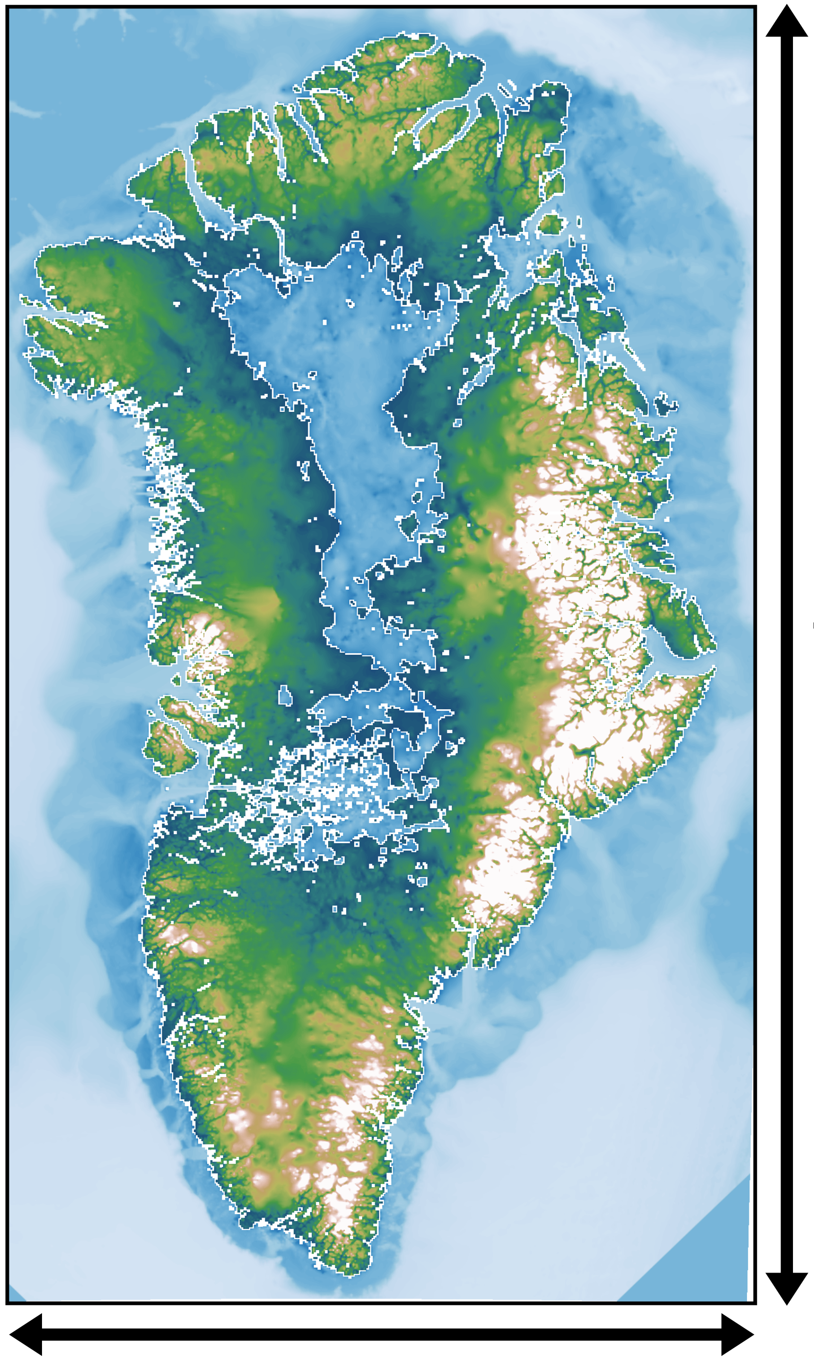


year 3000 | **year 0** | **~1.5 m sea-level rise**

(High summer insolation)

Example of new capability* — glacial inception

Default CISM2 domain



704

416

(416 x 704)

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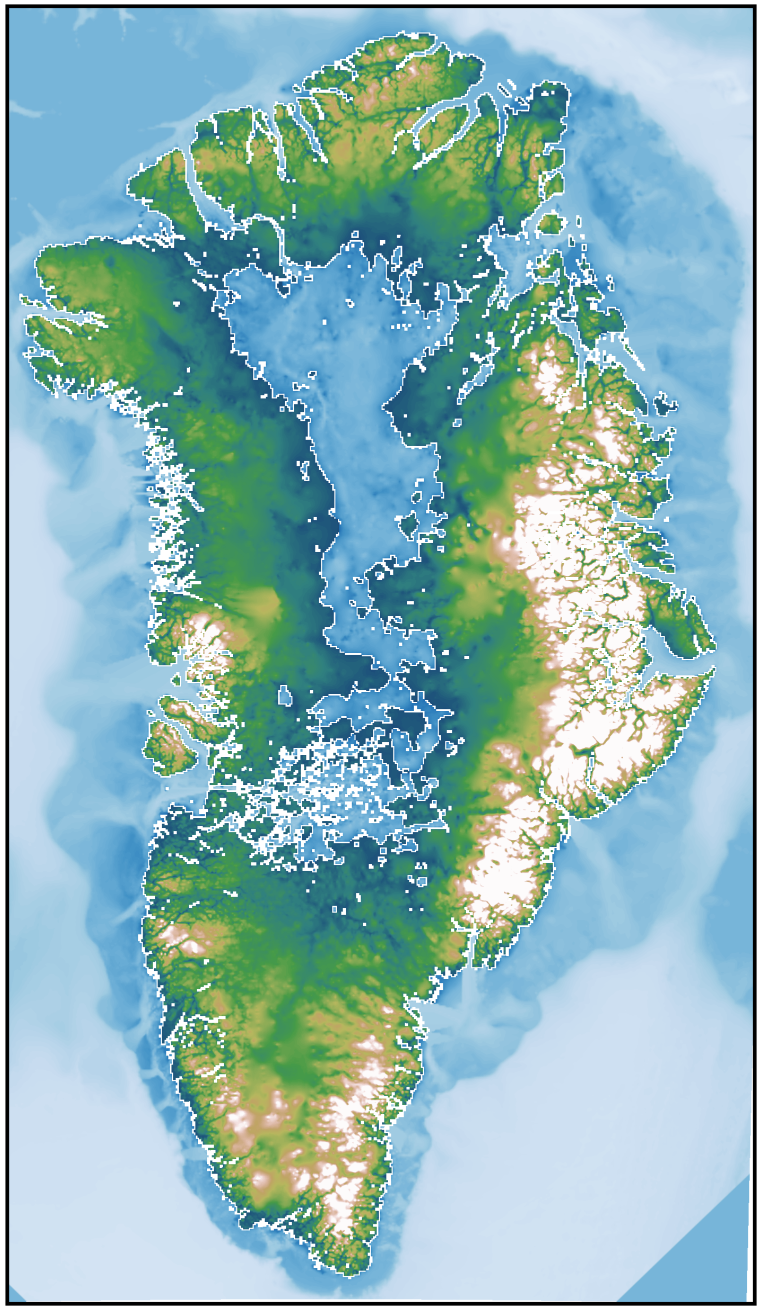

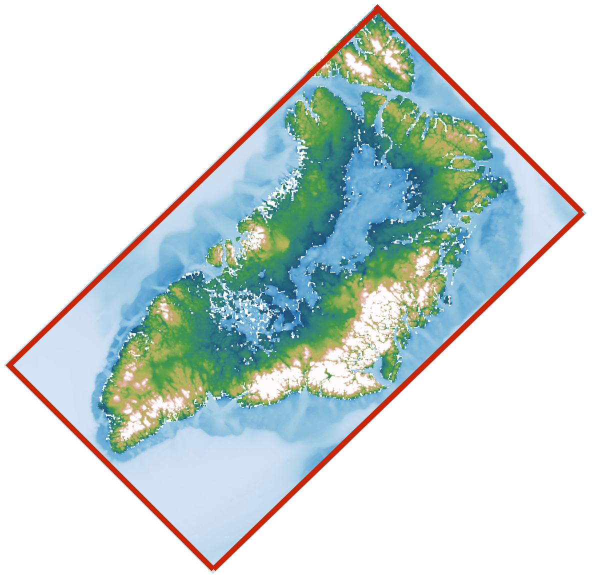

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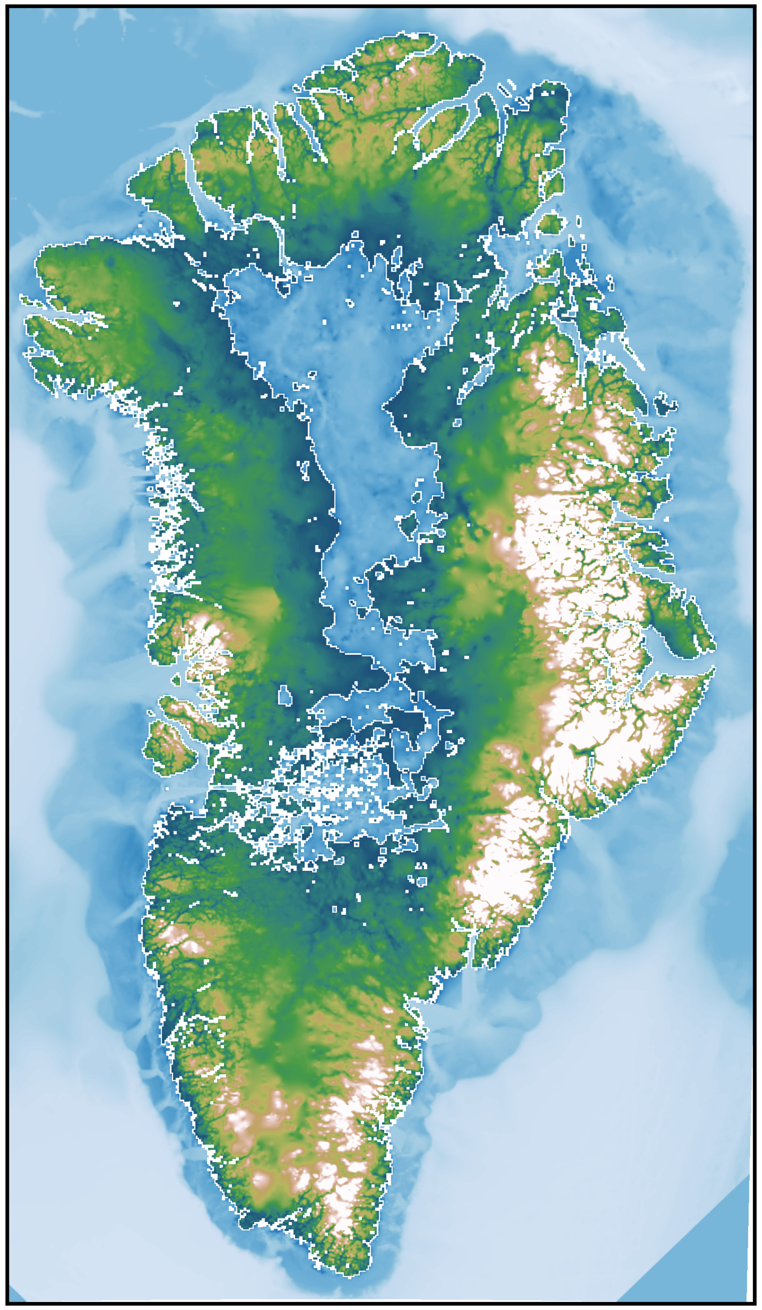

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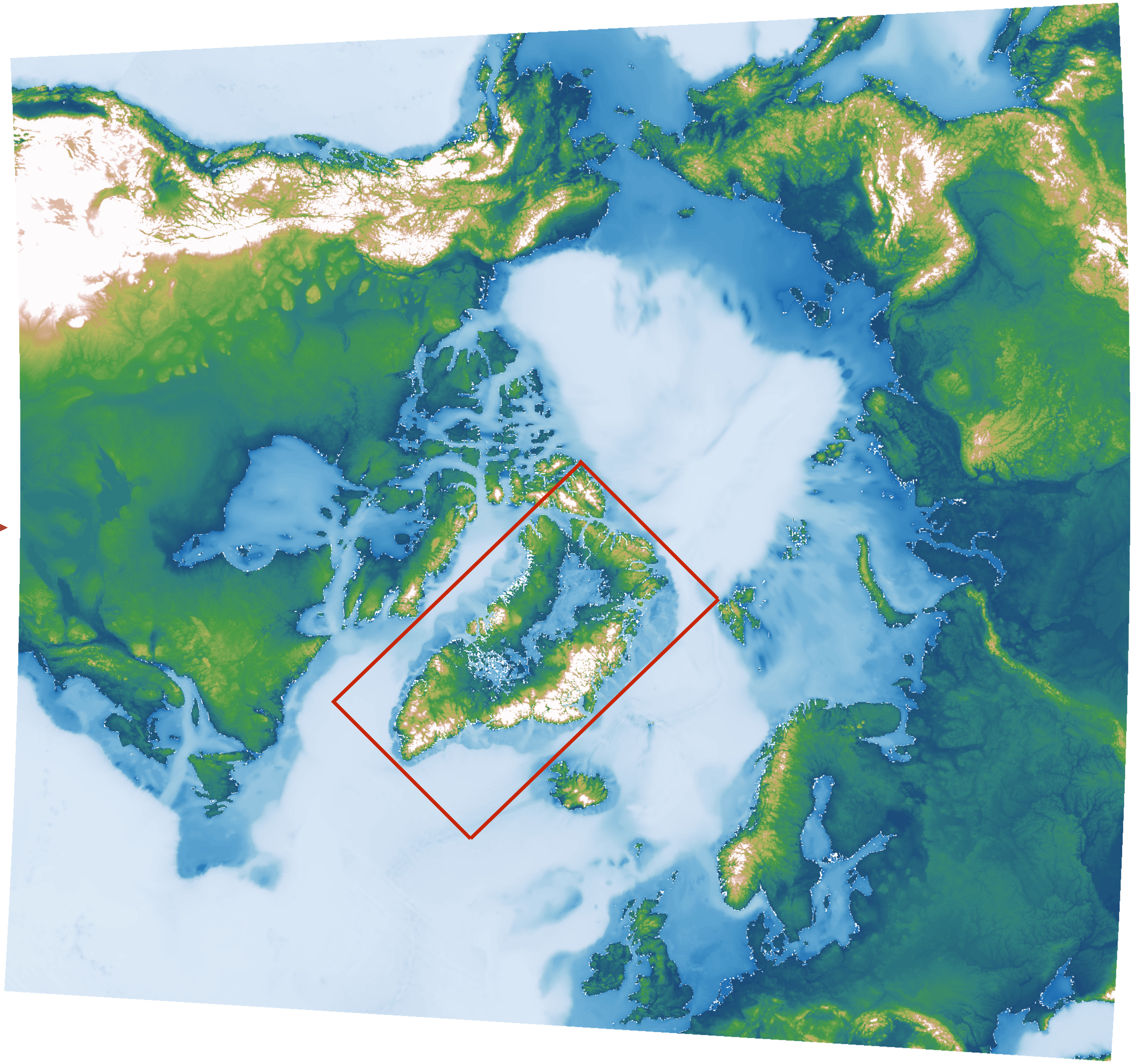
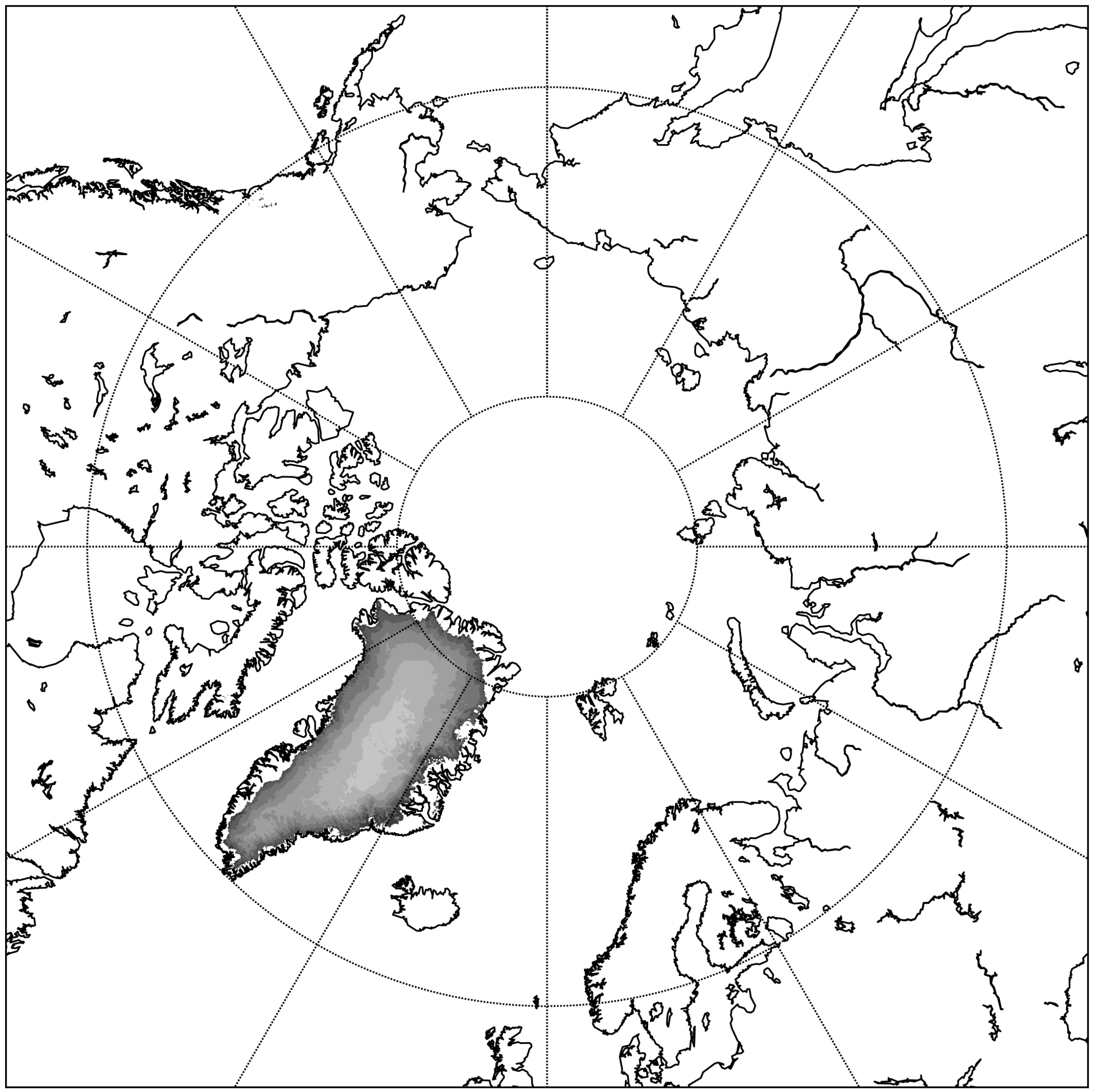


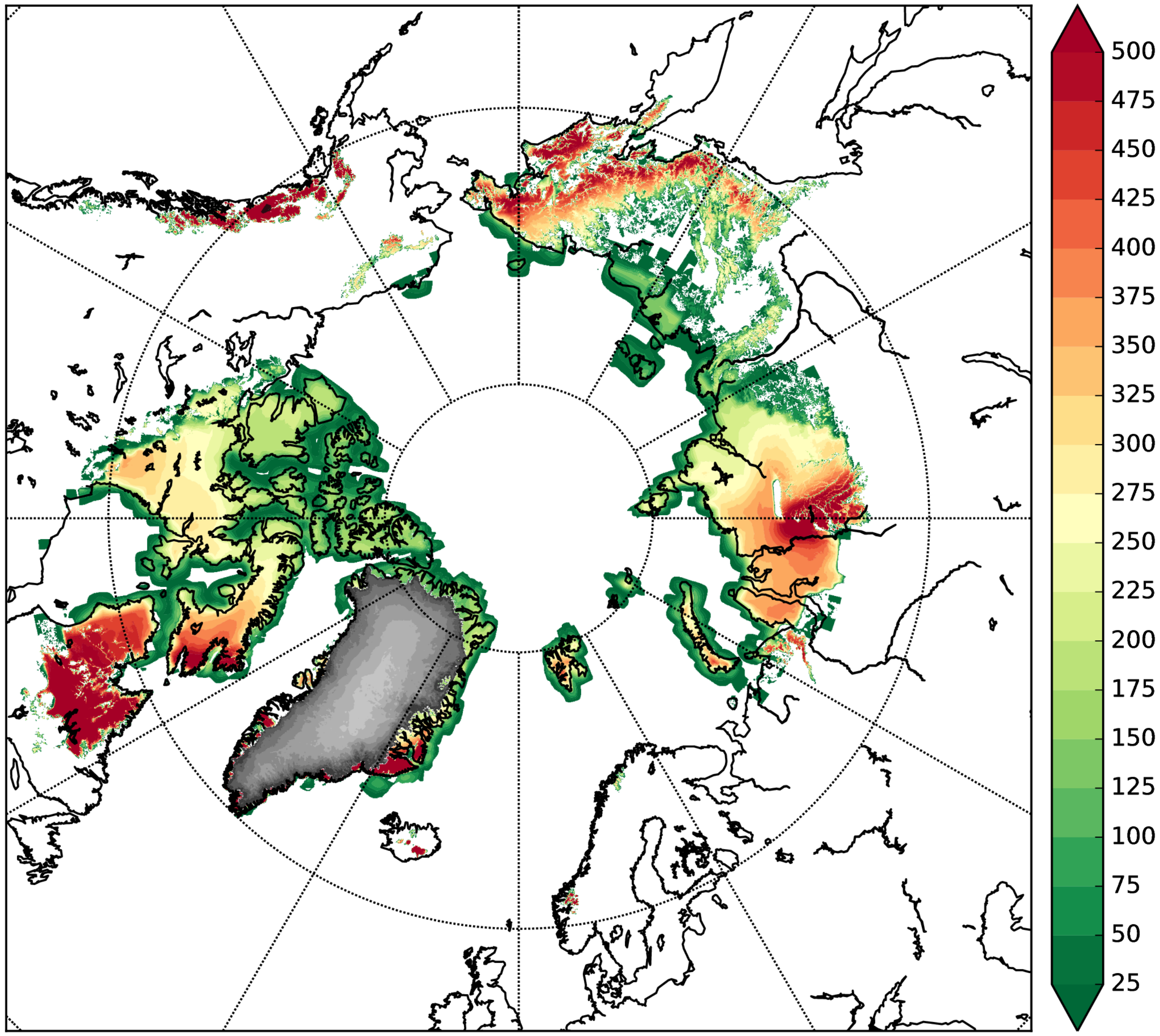
(2400 x 2080)

Example of new capability* — glacial inception

Initial condition (PI)



Ice thickness year 1000



116 ka forcing protocol

Not supported by default!

~7.7 m sea-level equivalent

Pros and cons of a coupled Earth System/Ice-Sheet model

Static ice sheets:

+ Forgiving of climate biases (to certain degree)

Dynamic ice sheets:

- Sensitive to climate biases/ feedbacks (background and self-induced; Ts, Precip,…)

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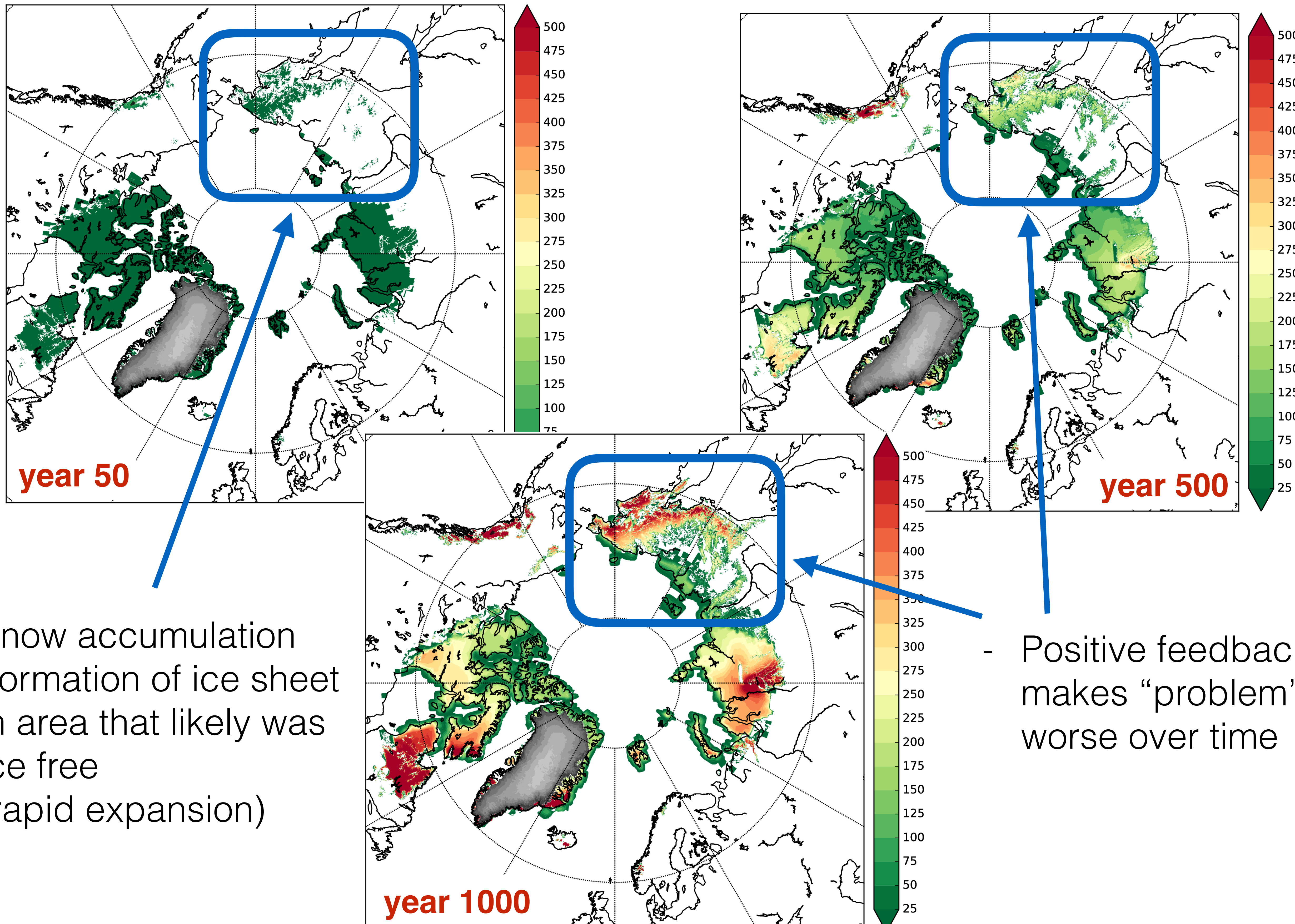
Sensitive to climate biases/feedbacks



- Snow accumulation
- Formation of ice sheet in area that likely was ice free (rapid expansion)

- Positive feedback makes “problem” worse over time

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- Only "old" questions can be explored

- Can be unrealistic (e.g. RCP8.5)

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+ Potentially more realistic (depends on application)

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- Surface mass balance calculated in land model

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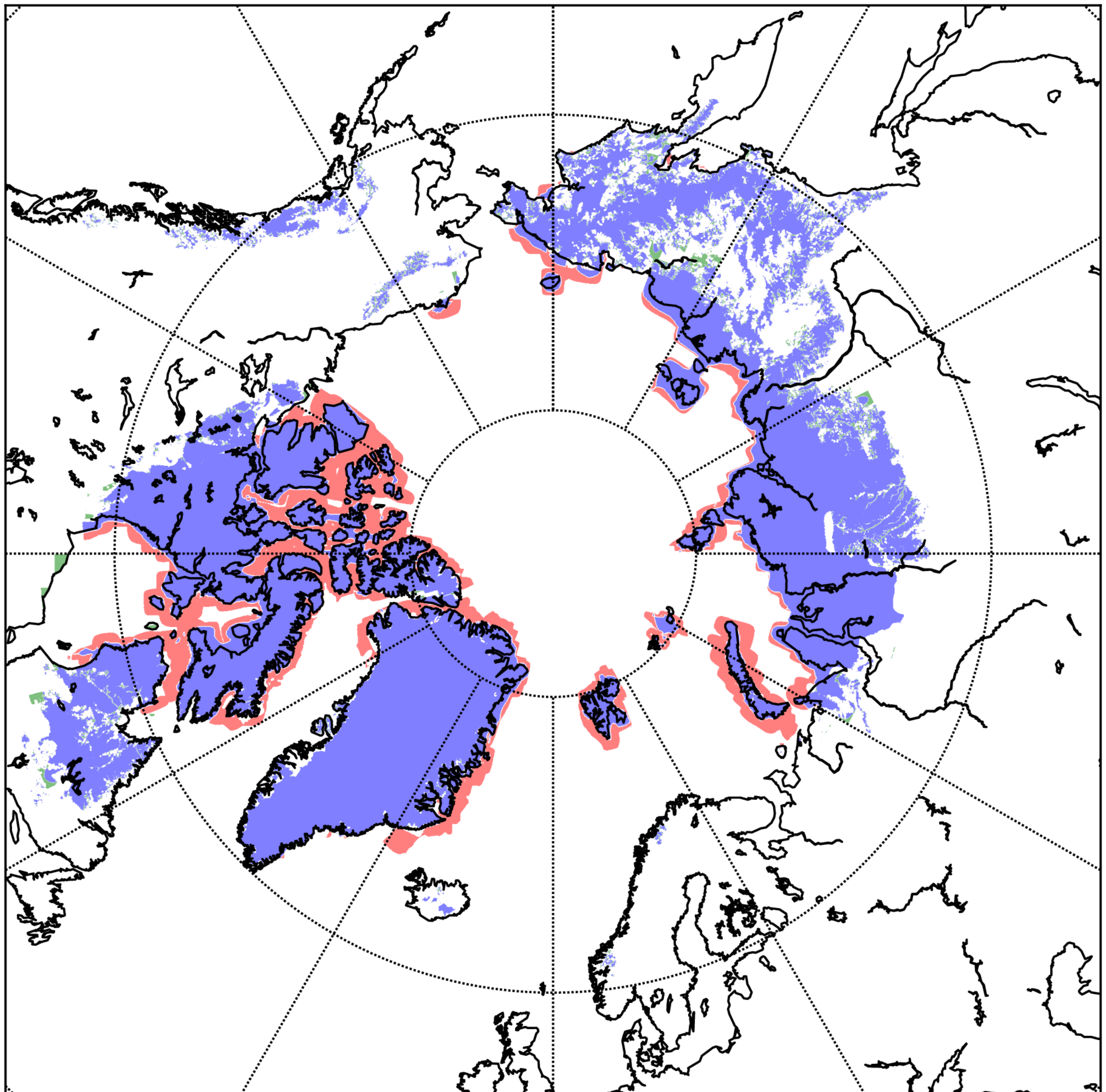

Blue: grounded ice
Red: floating ice

SMB in **blue** areas
No SMB in **red** areas

Challenges when moving forward

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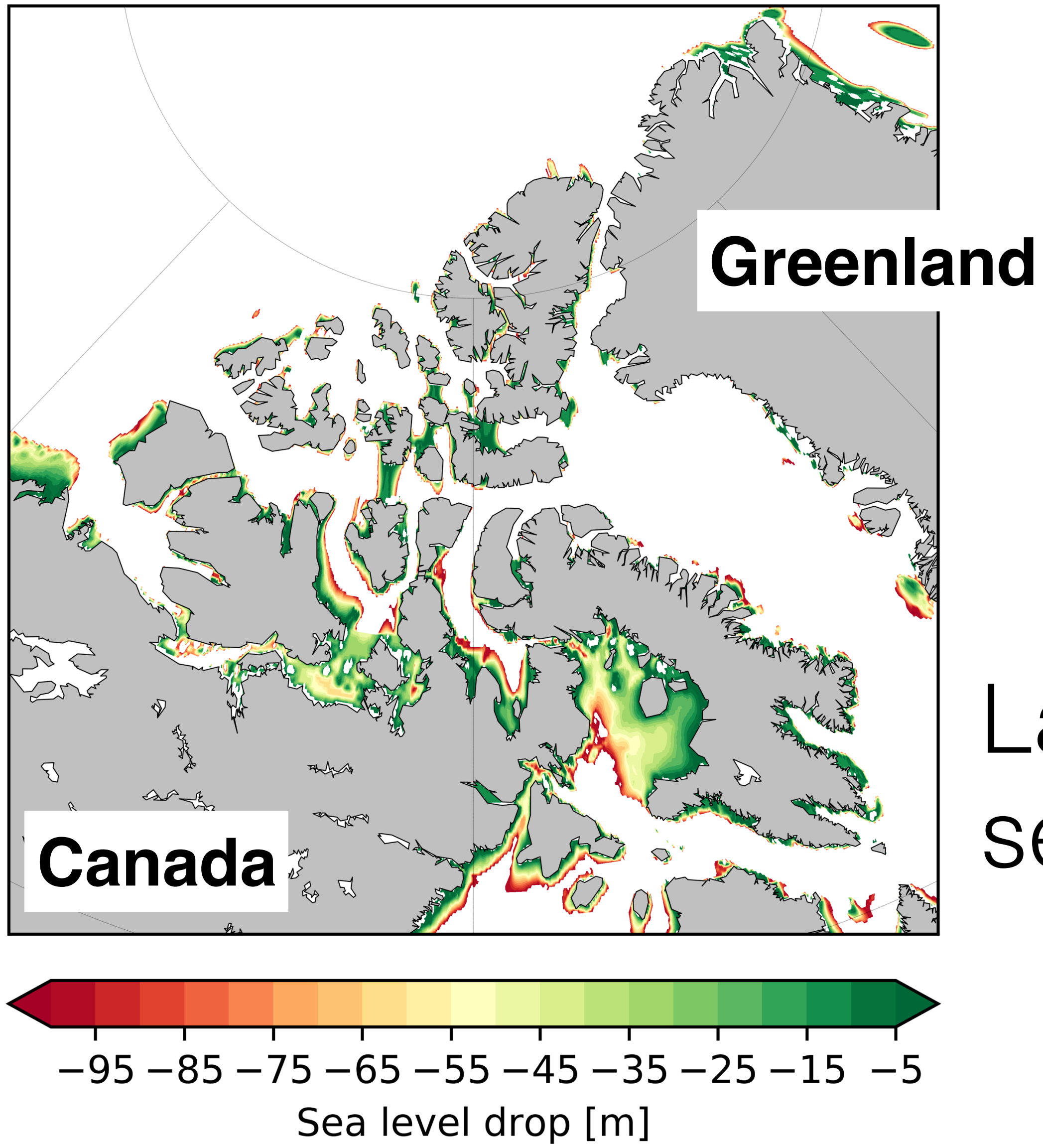
(new mapping/grid files have to be created)
- Perhaps sufficient to update (say) every 100 years?
- Infrastructure has to be put in place



Land exposed by sea-level drop

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- Spun-up CESM2-CISM2 (Greenland) initial state
- Infrastructure to generate CISM2 grids outside of Greenland
  - My scripts can perhaps be a starting point

Questions