

Pliocene inception and growth of the Greenland Ice Sheet in CESM

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NCAR

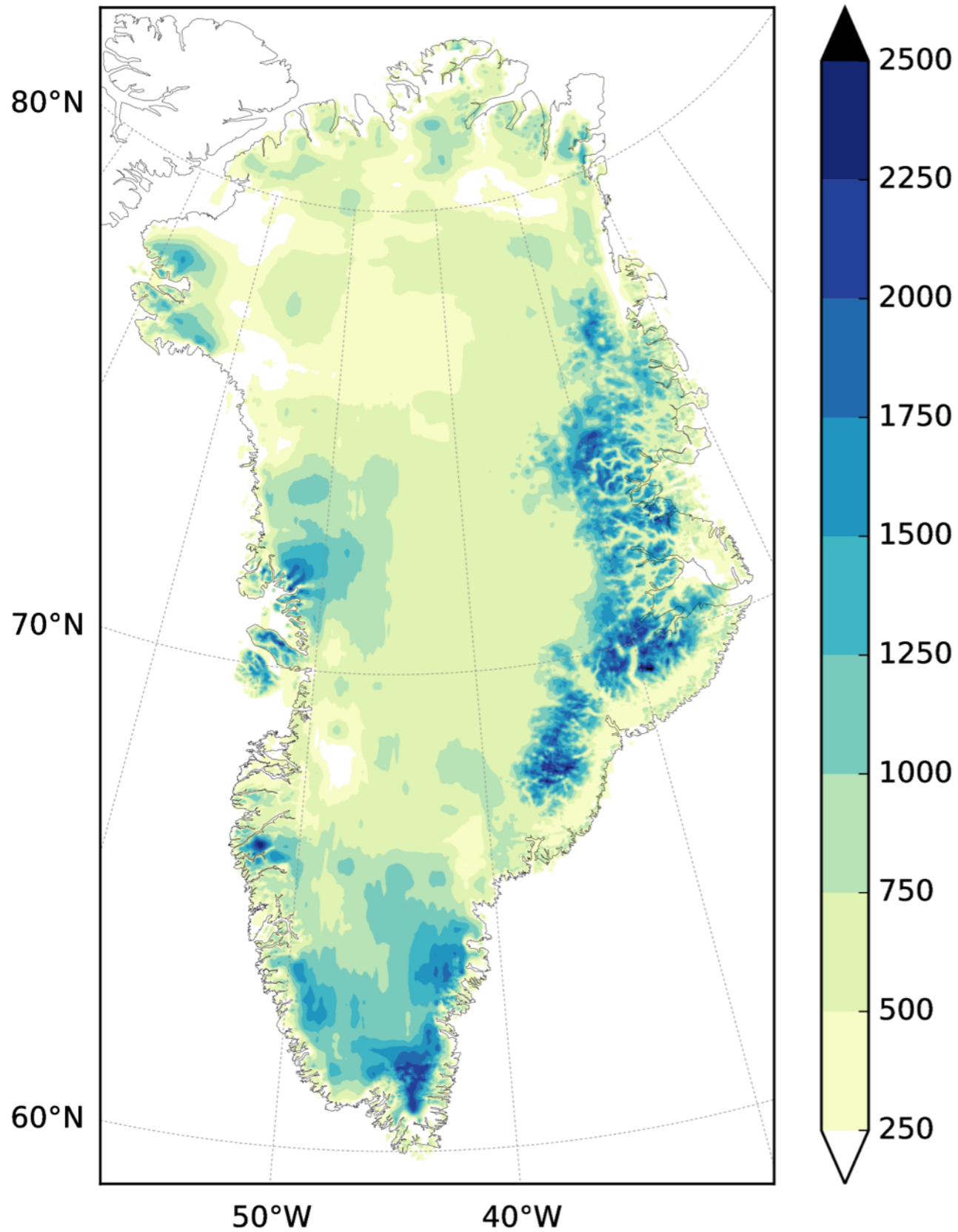
Bette Otto-Bliesner
NCAR

Pliocene

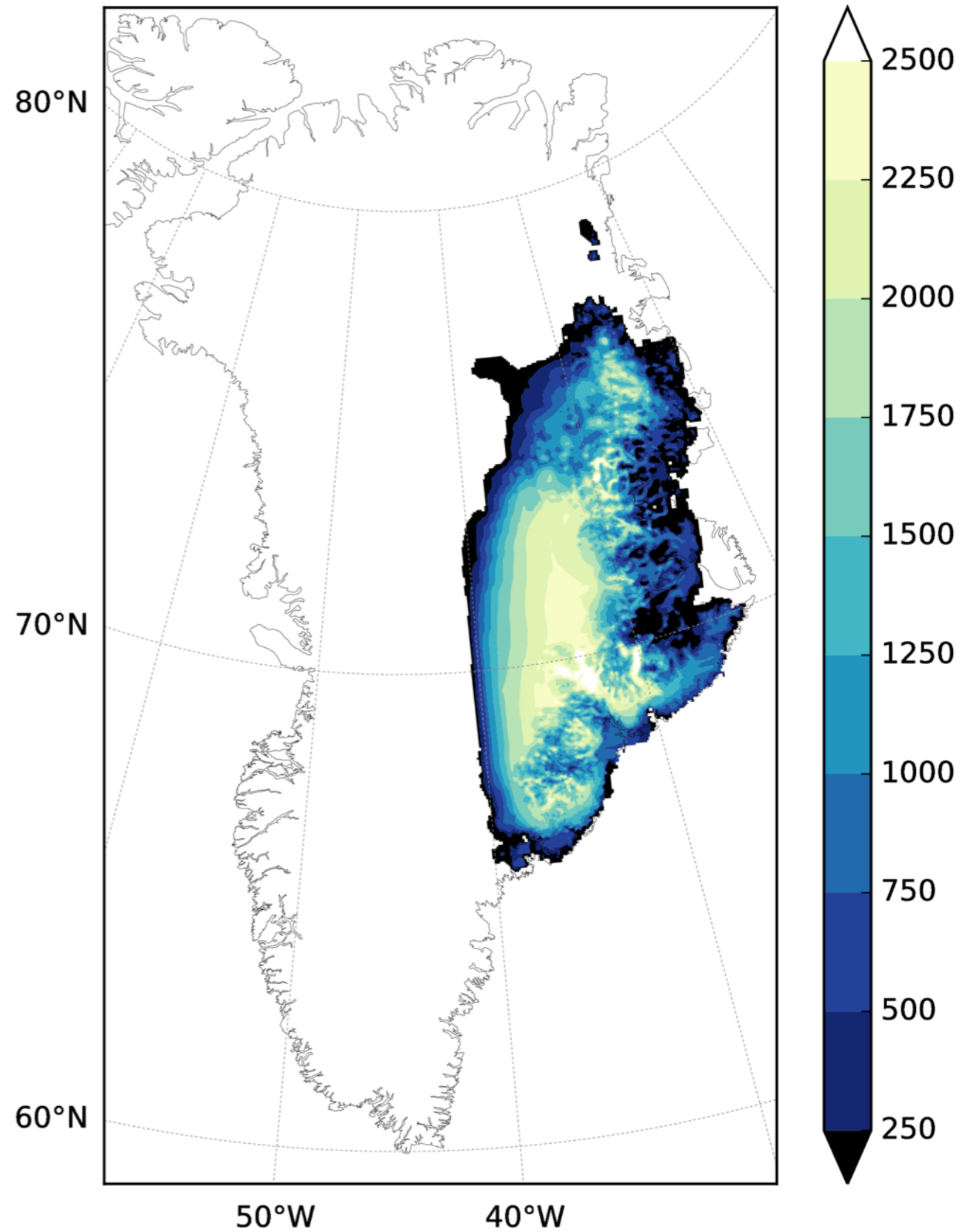
- ~5.3-2.6 Mya
- The global average temperature was approximately 2 to 3 °C higher than today
- The global sea level was 25 ± 5 m higher than present
- Northern hemisphere ice sheets were ephemeral
- Greenland inception around 3.3 ± 3 Mya

Greenland topography [m]

Adjusted bedrock

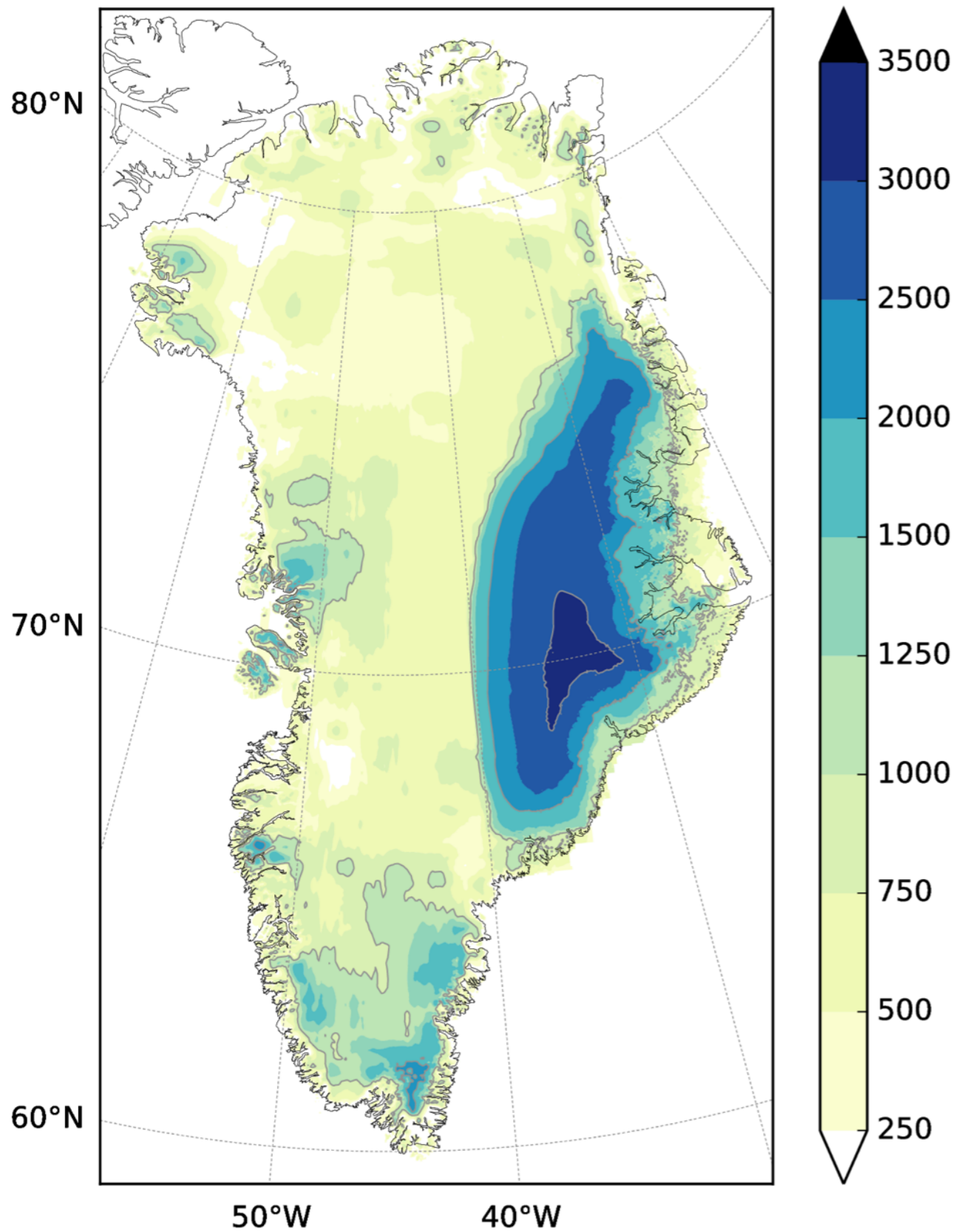


PlioMIP2 ice sheet

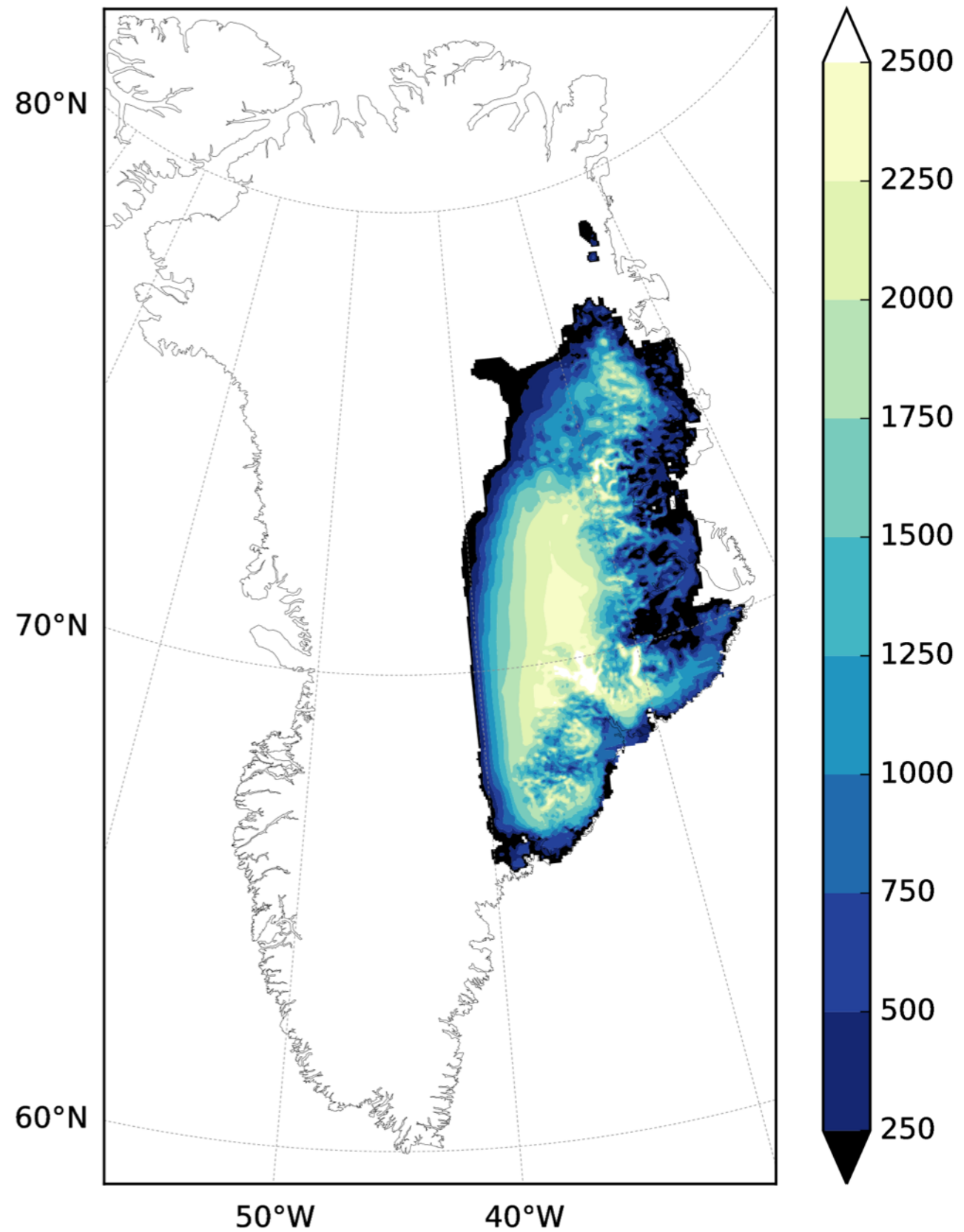


Greenland topography [m]

PlioMIP topography

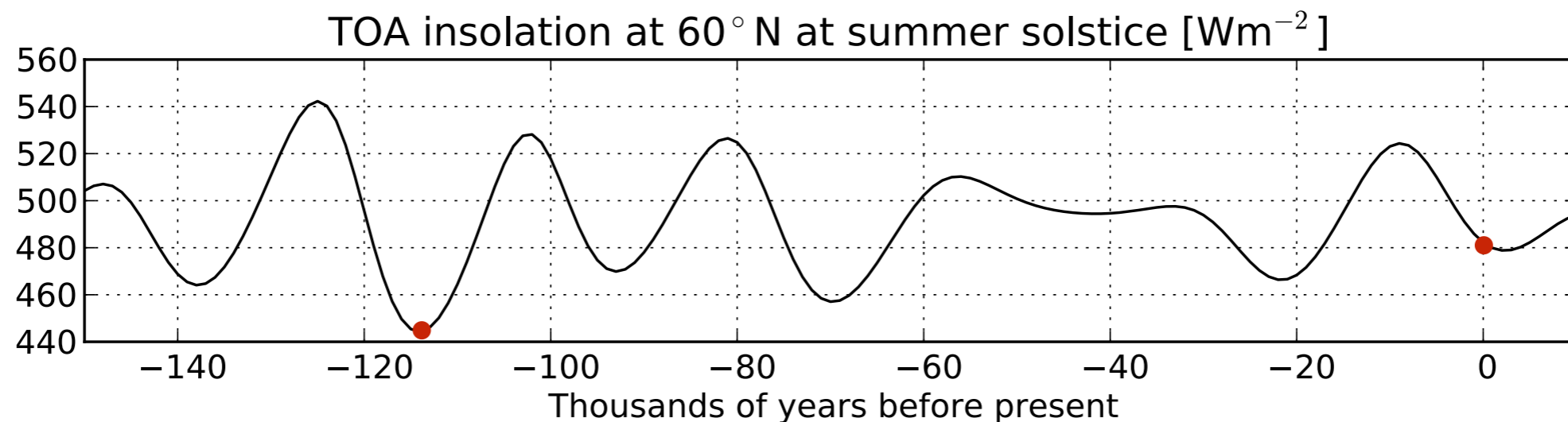


PlioMIP2 ice sheet



Boundary conditions and model setup

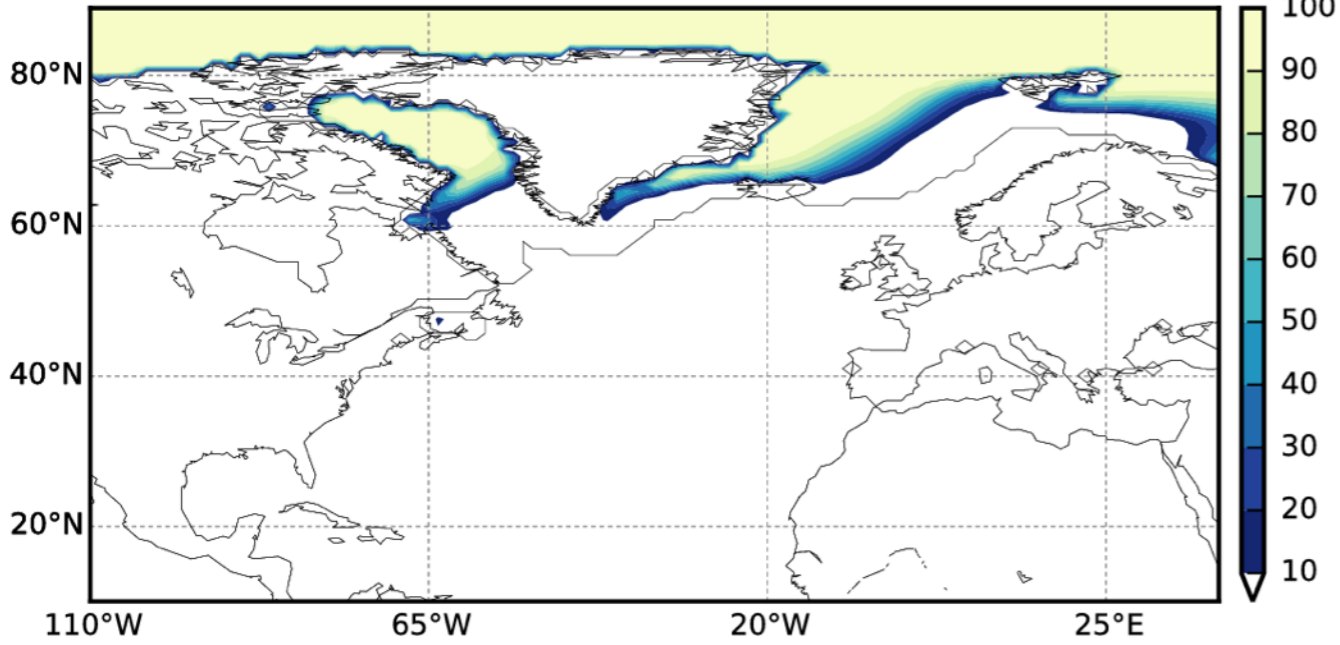
- CESM1.5 (FV1L30), CISM2 (4km high order dynamics)
- Prescribed SST/sea ice from CCSM4 PlioMIP1 simulations
- Two extreme cases in terms of sea-ice distribution
 - i. **Closed BS & CA:** limited NA sea-ice (CCSM4)
 - ii. **Closed CA:** extensive NA sea-ice (CCSM4)
- Initial Greenland ice sheet:
 - i. Bare ground
 - ii. Outline of PlioMIP2 ice sheet but 10m thick
 - iii. Full PlioMIP2 ice sheet (*not discussed here*)
- Low insolation (115 kya), pre-industrial GHG (280 ppmv CO₂)
- Greenland ice sheet replaced by Arctic shrub



North Atlantic sea-ice [%]

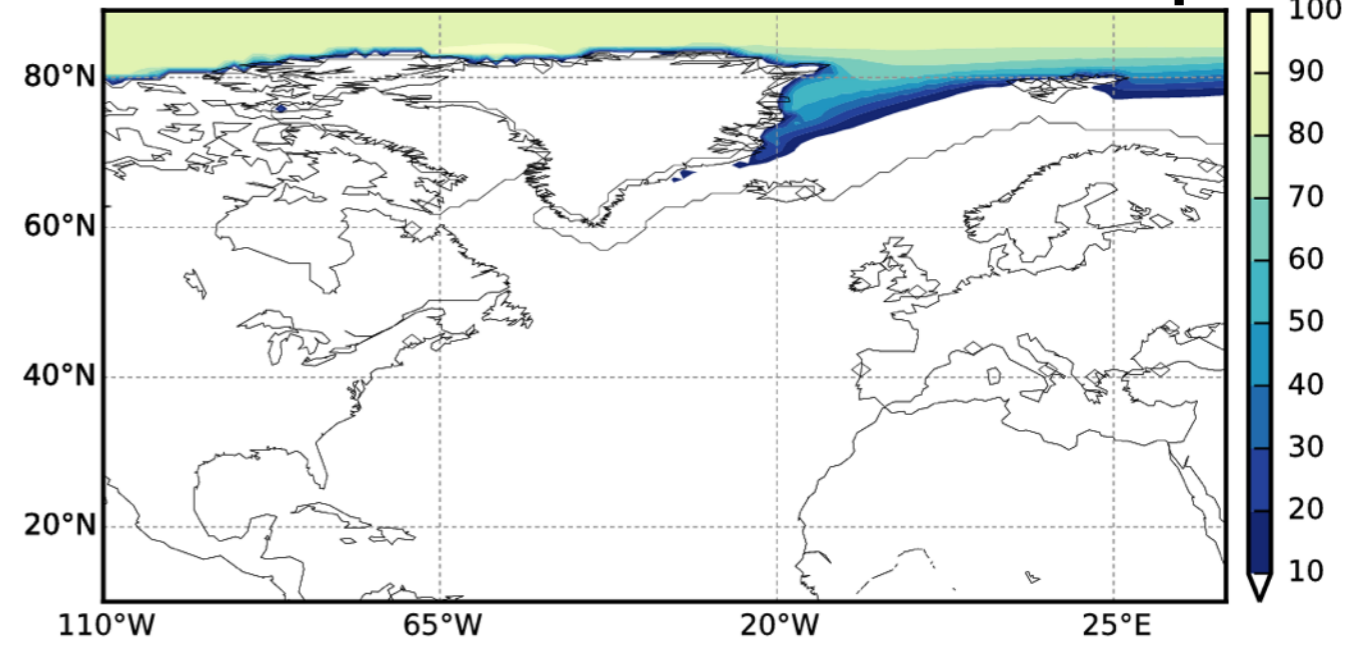
Closed BS & CA

Mar



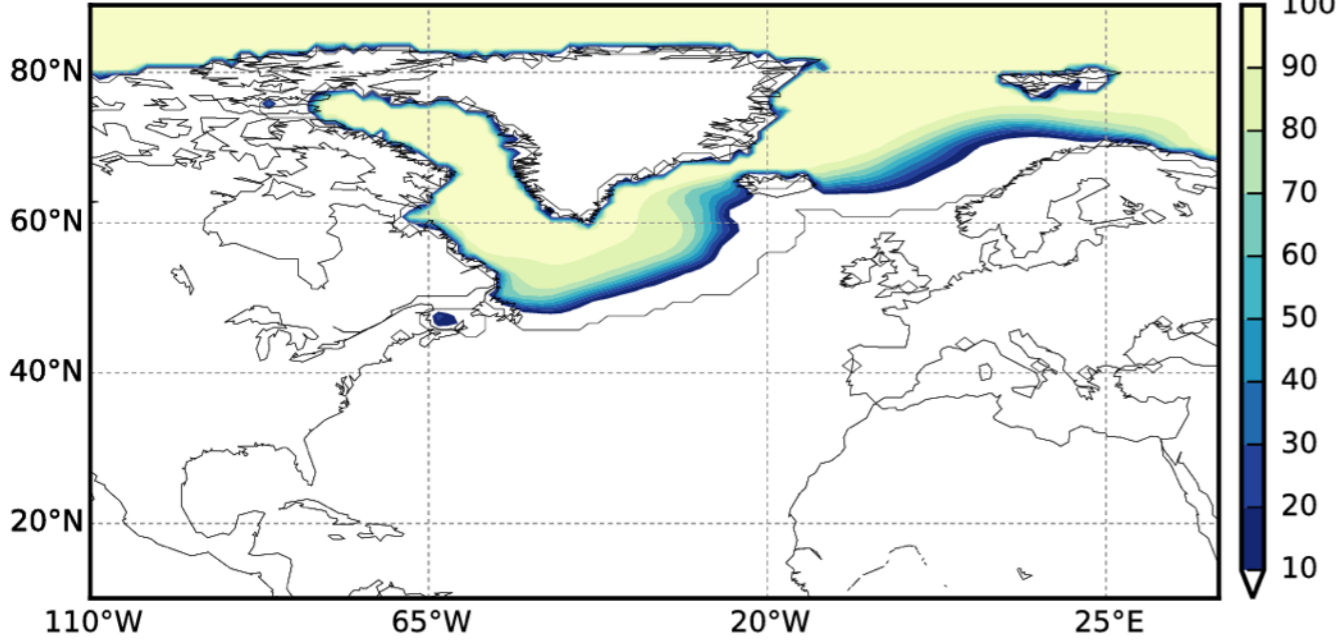
Closed BS & CA

Sep



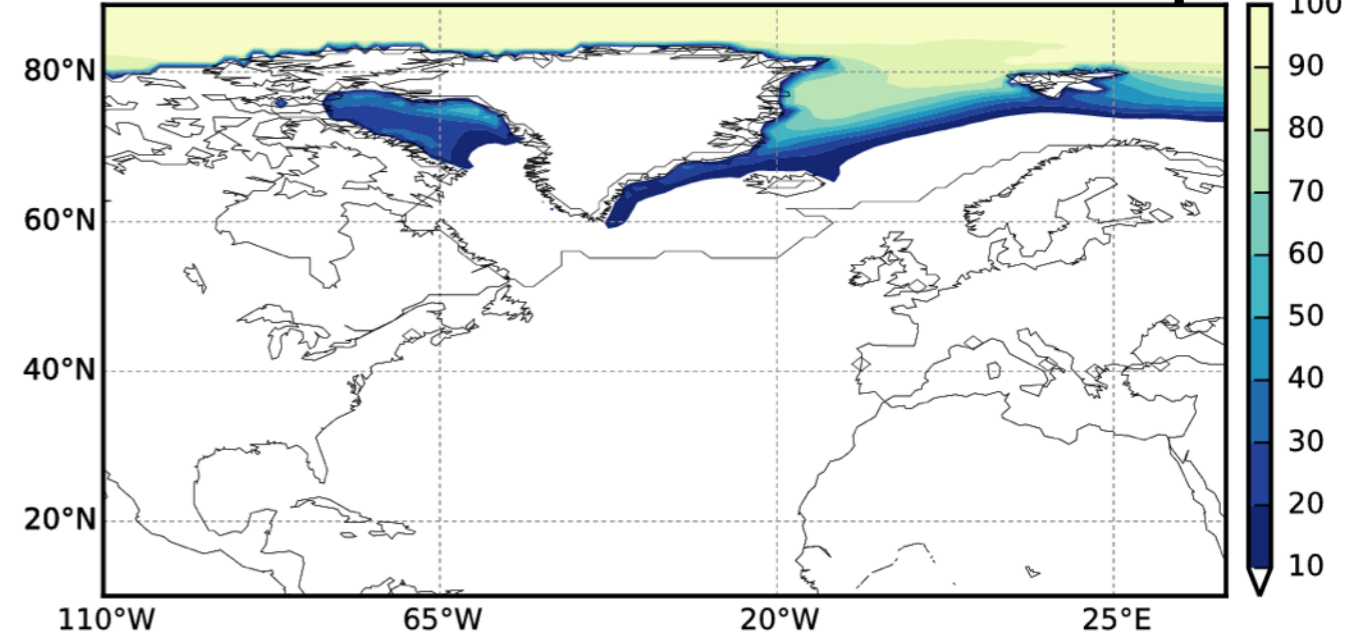
Closed CA

Mar



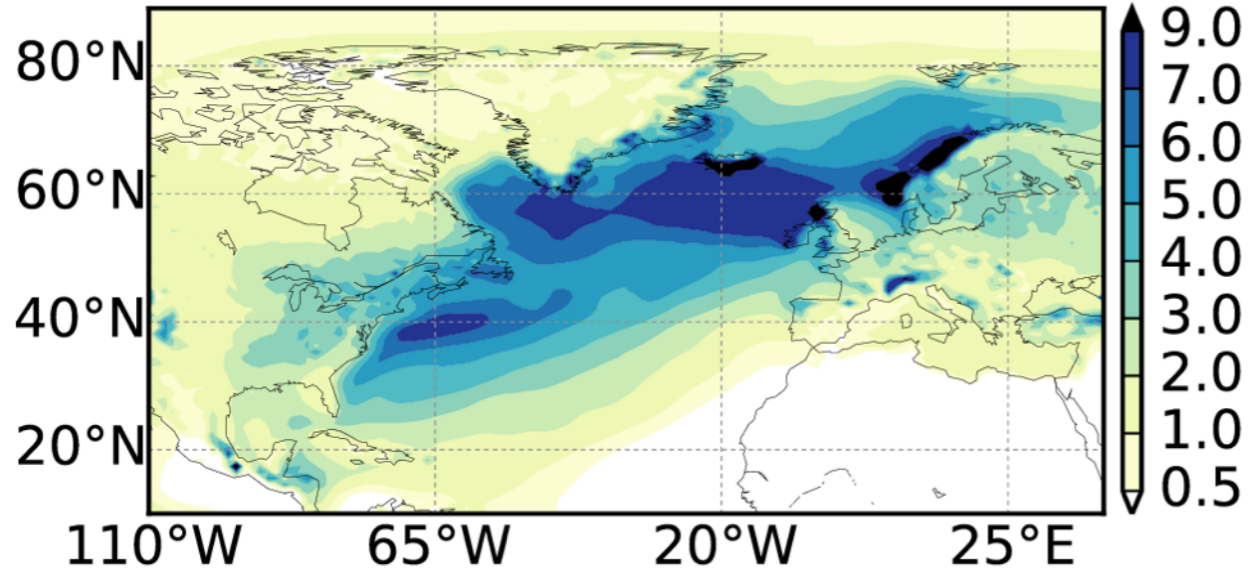
Closed CA

Sep

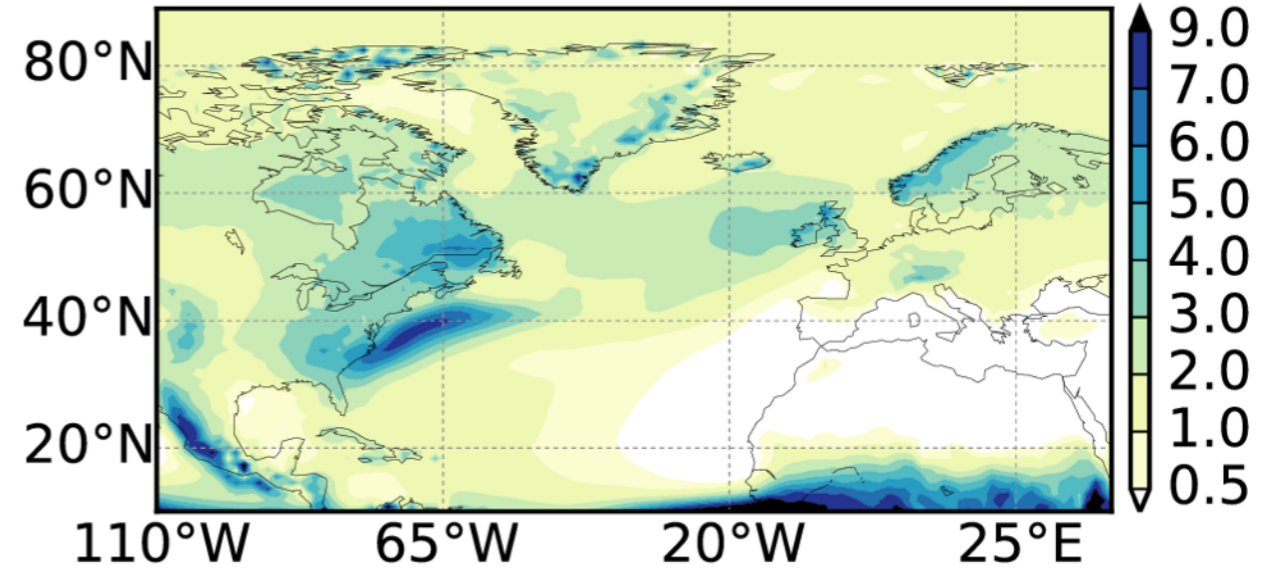


Precipitation [mm/day]

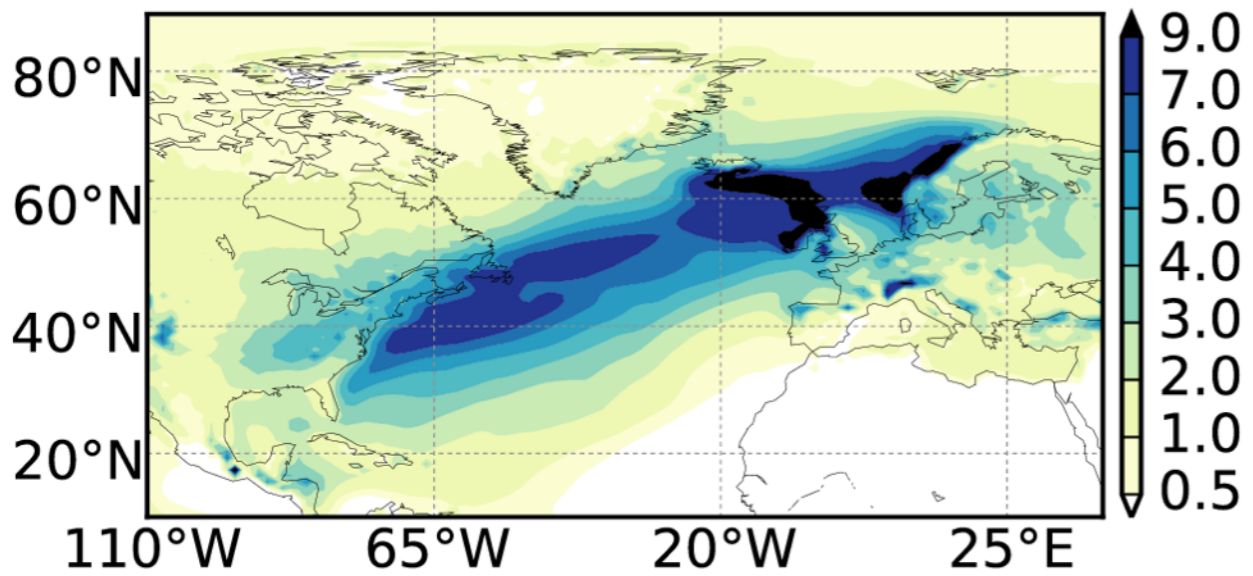
Closed BS & CA DJF



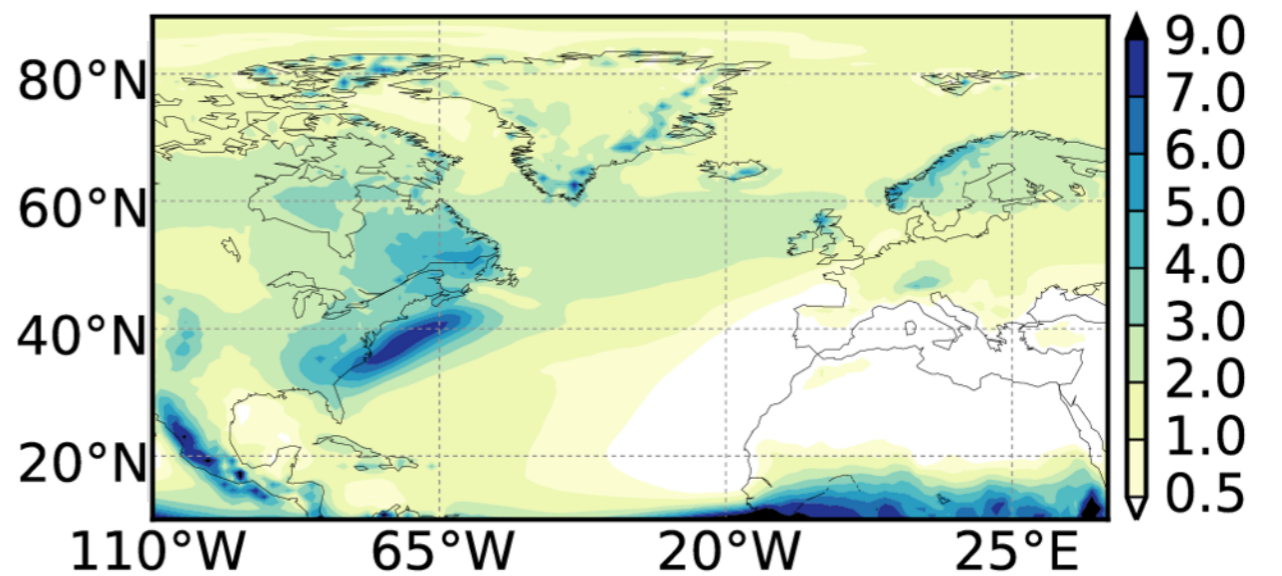
Closed BS & CA JJA



Closed CA DJF

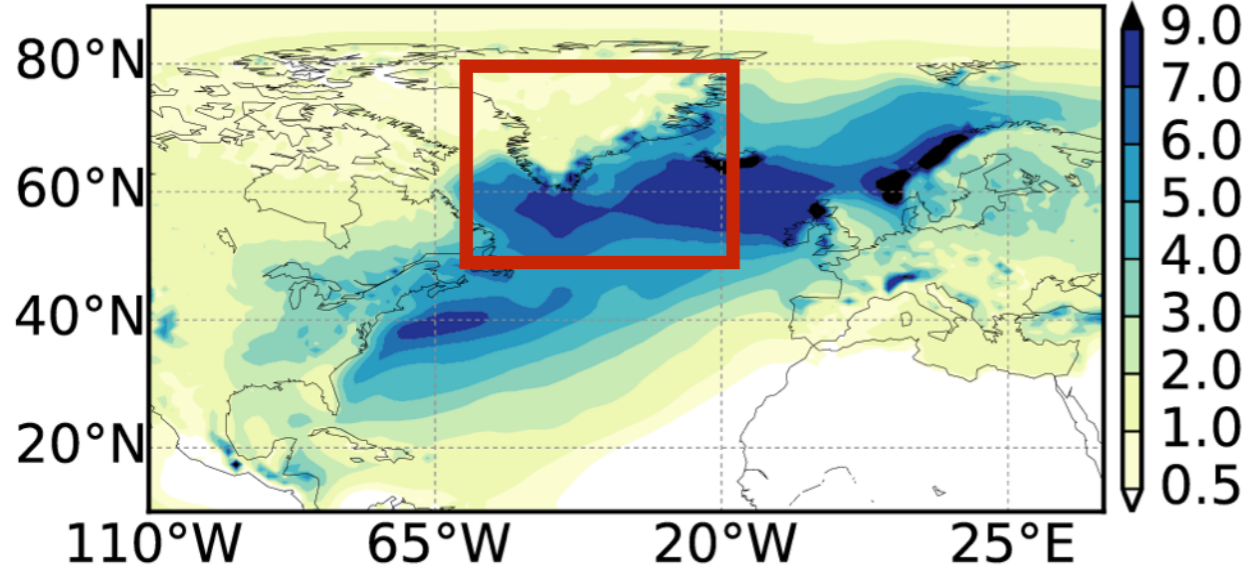


Closed CA JJA

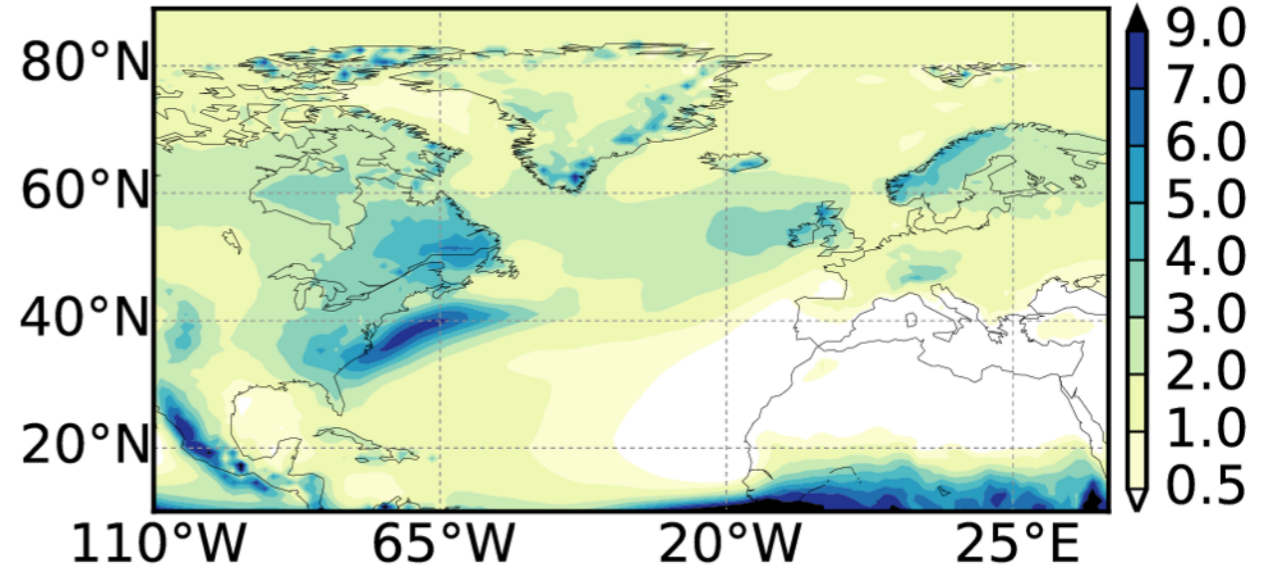


Precipitation [mm/day]

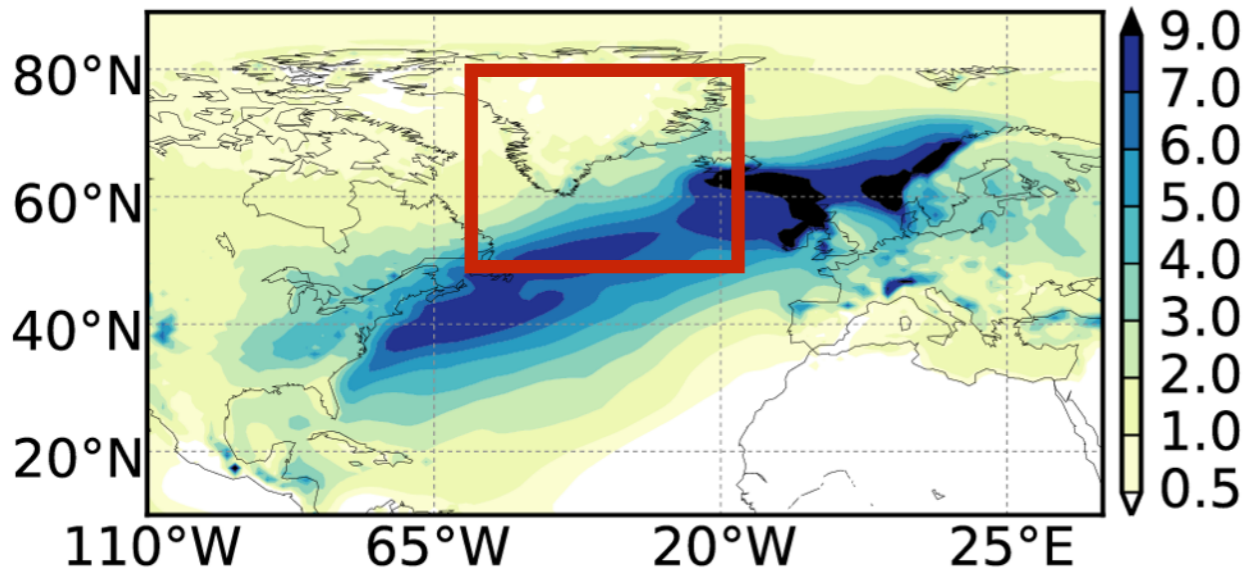
Closed BS & CA DJF



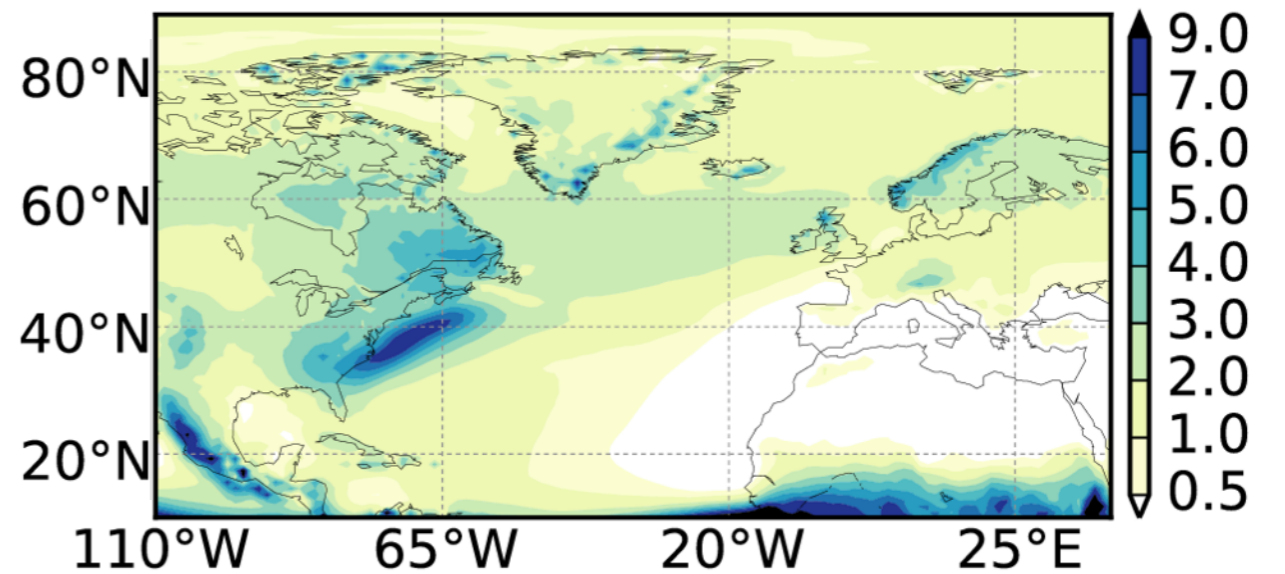
Closed BS & CA JJA



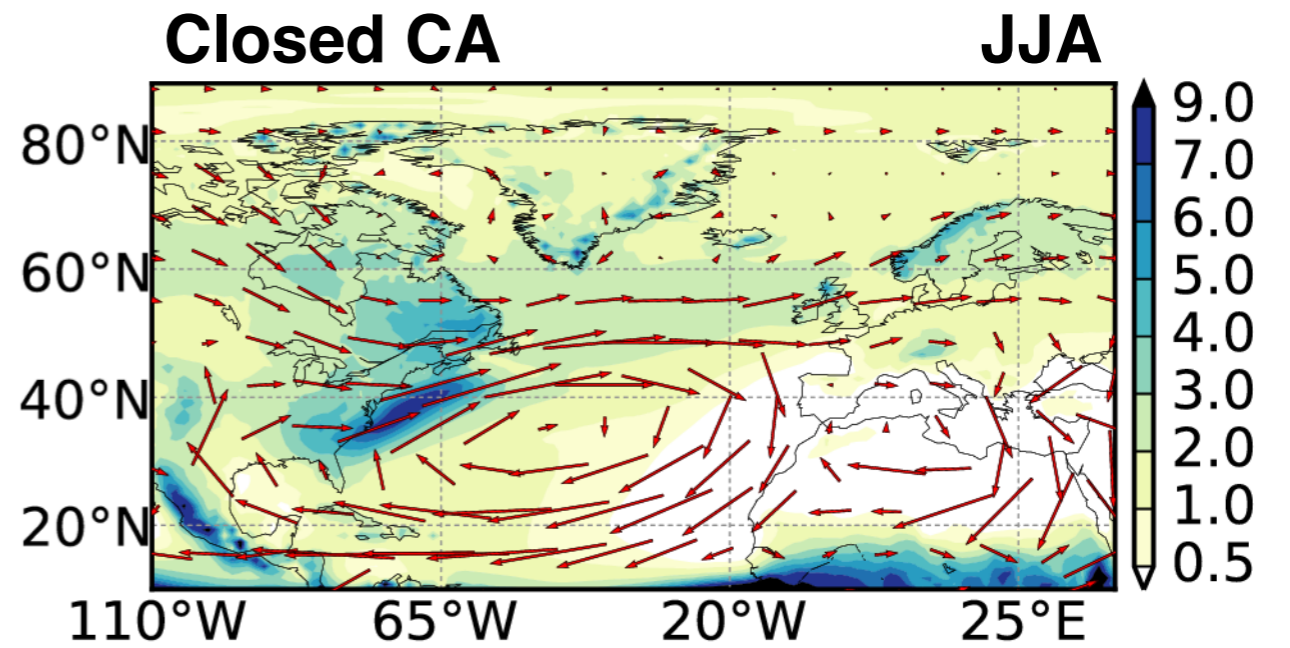
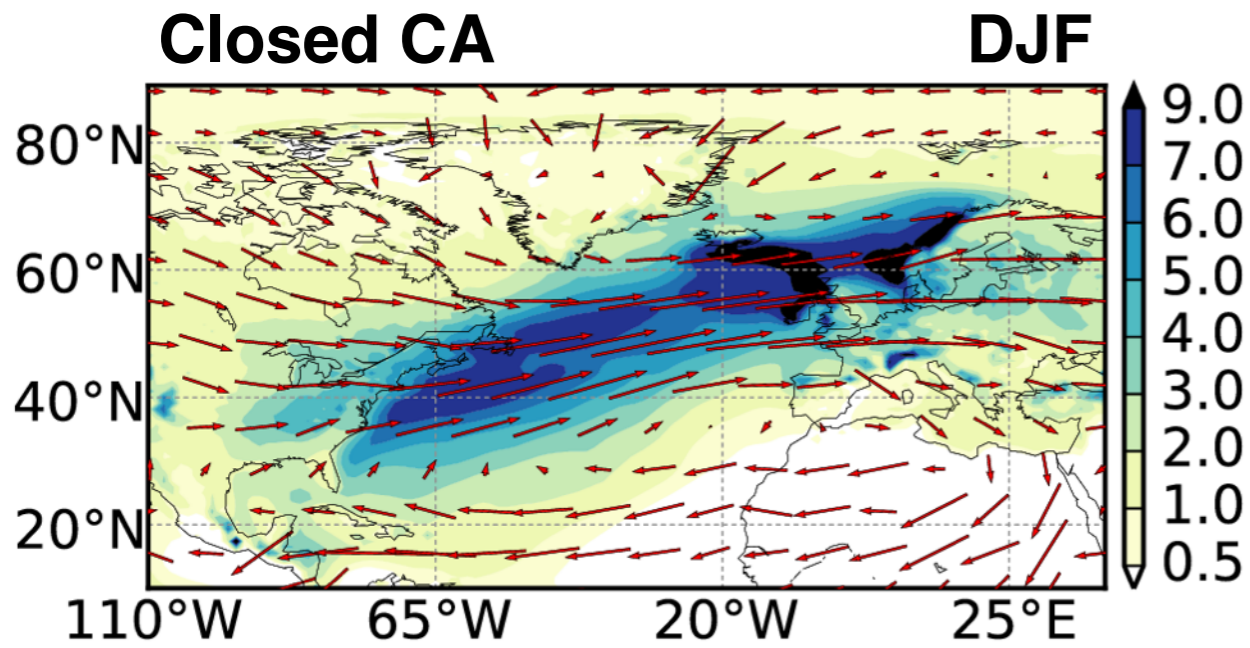
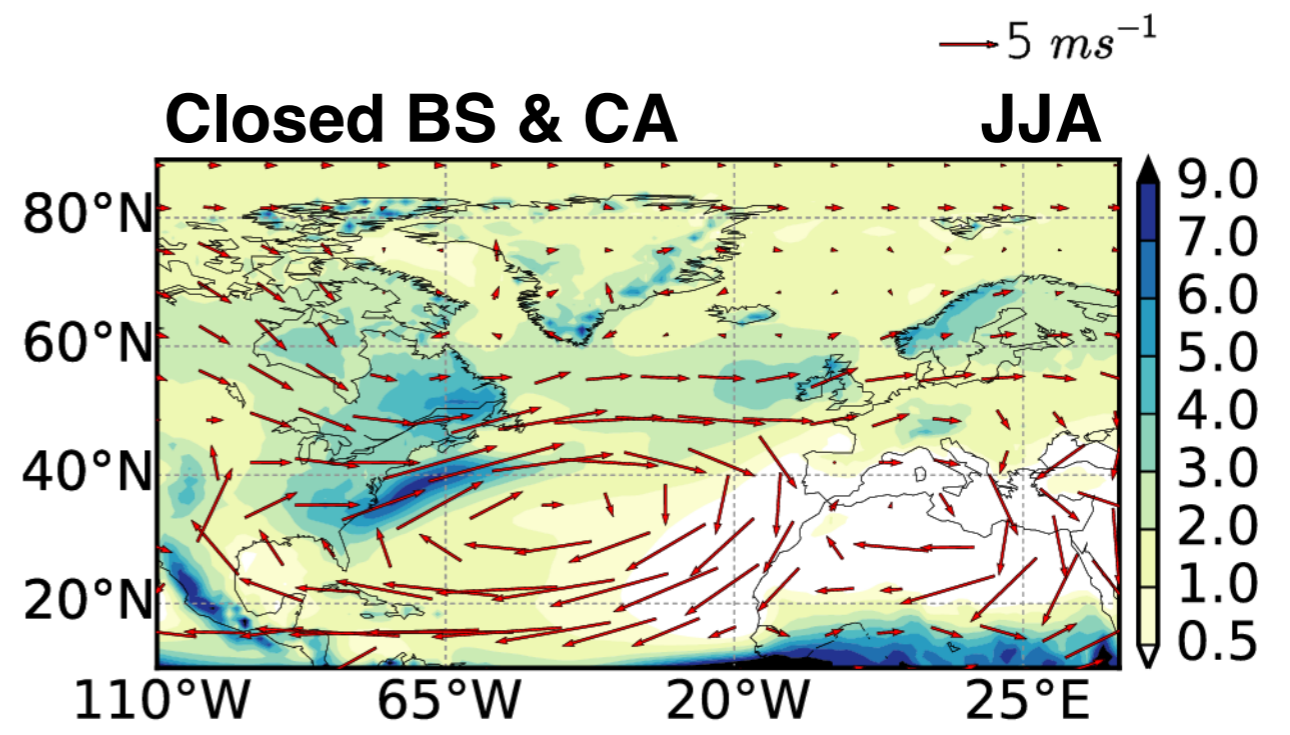
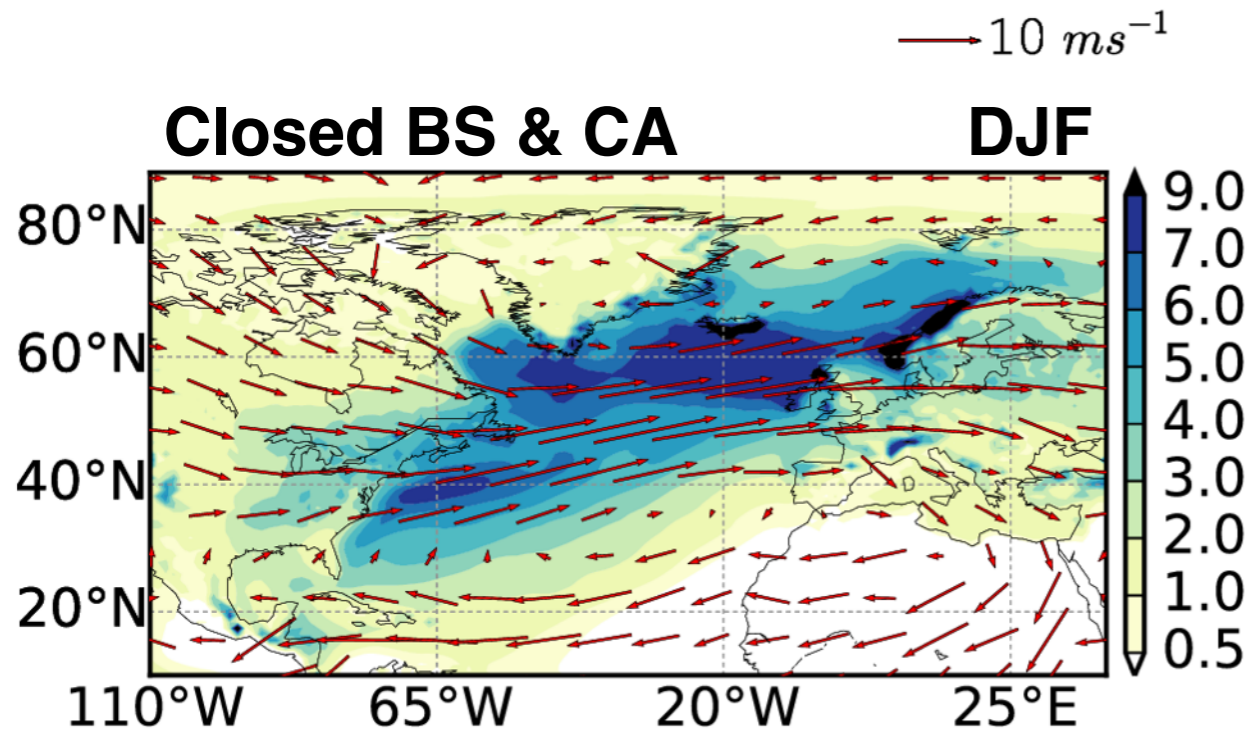
Closed CA DJF



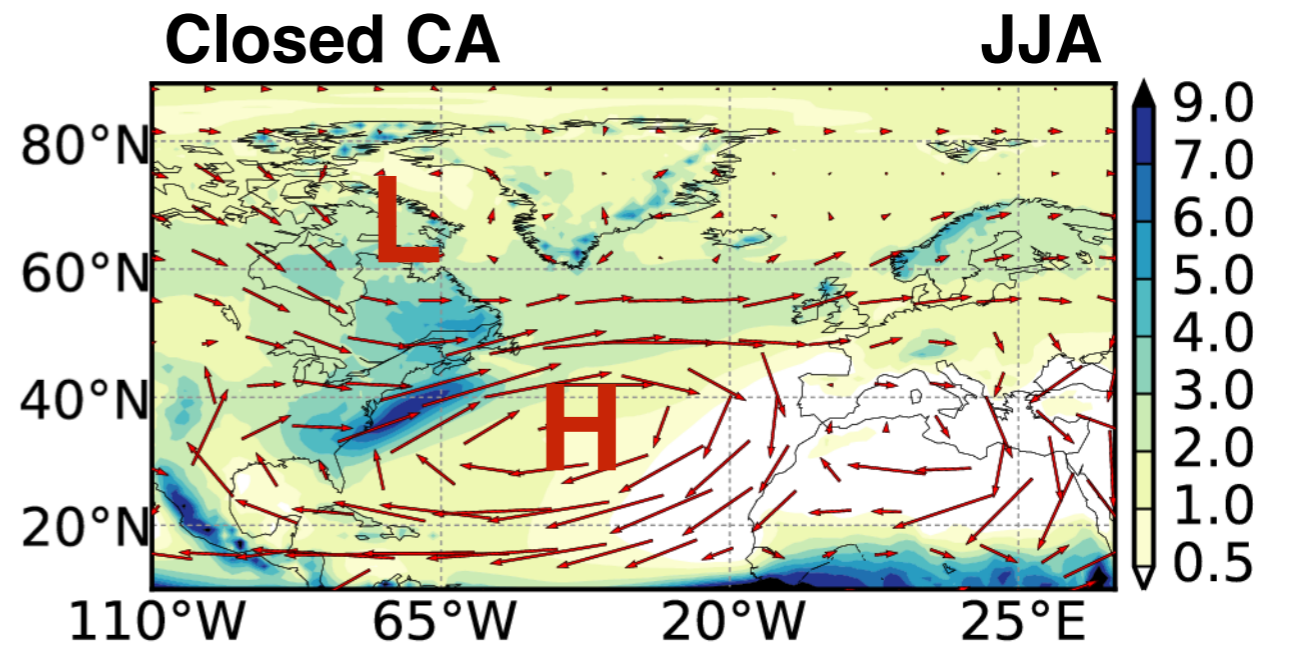
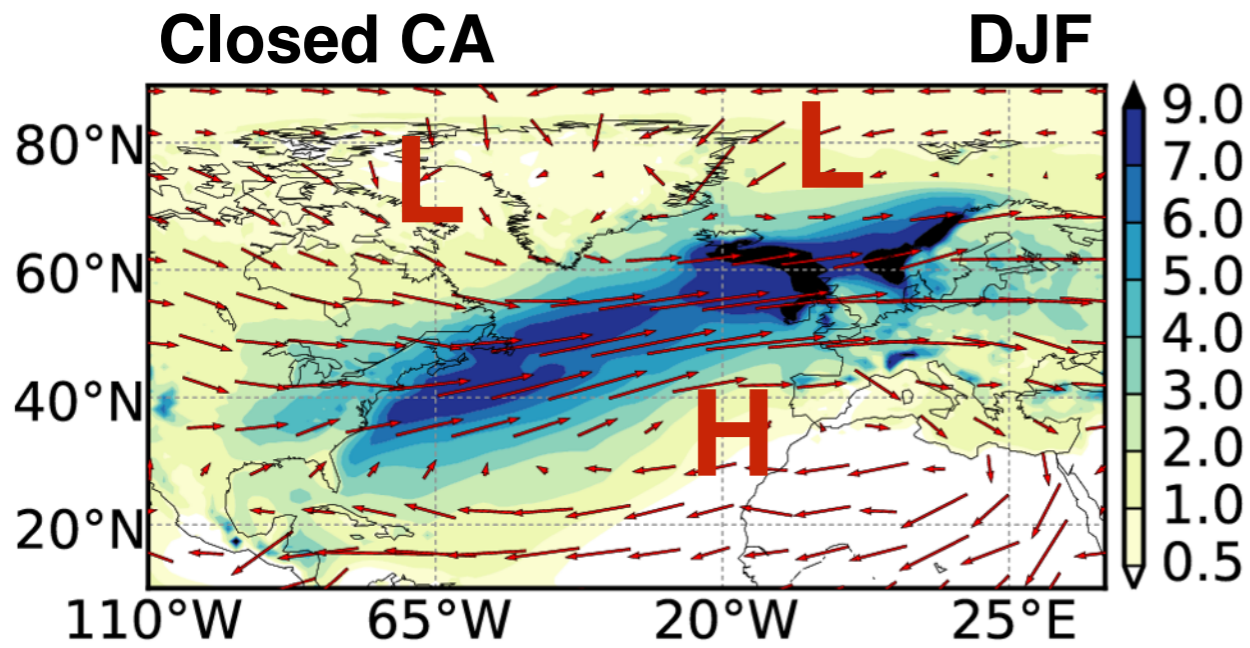
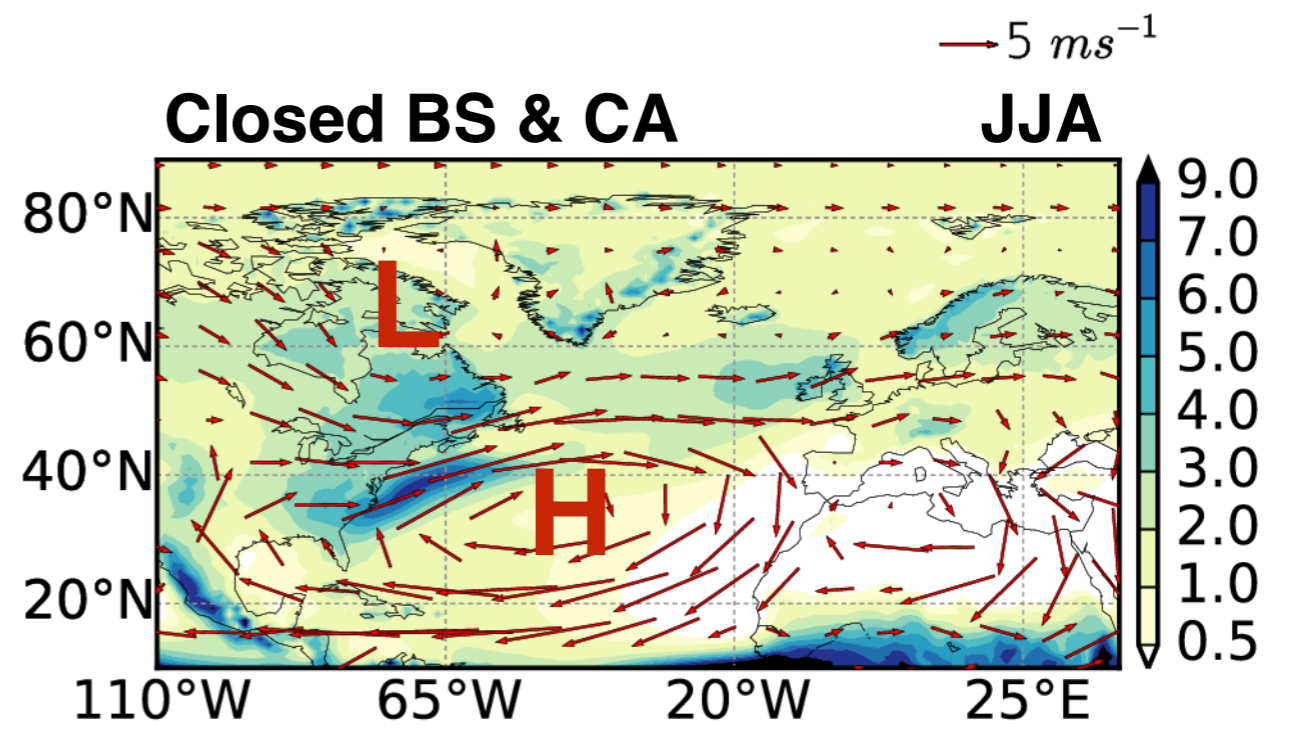
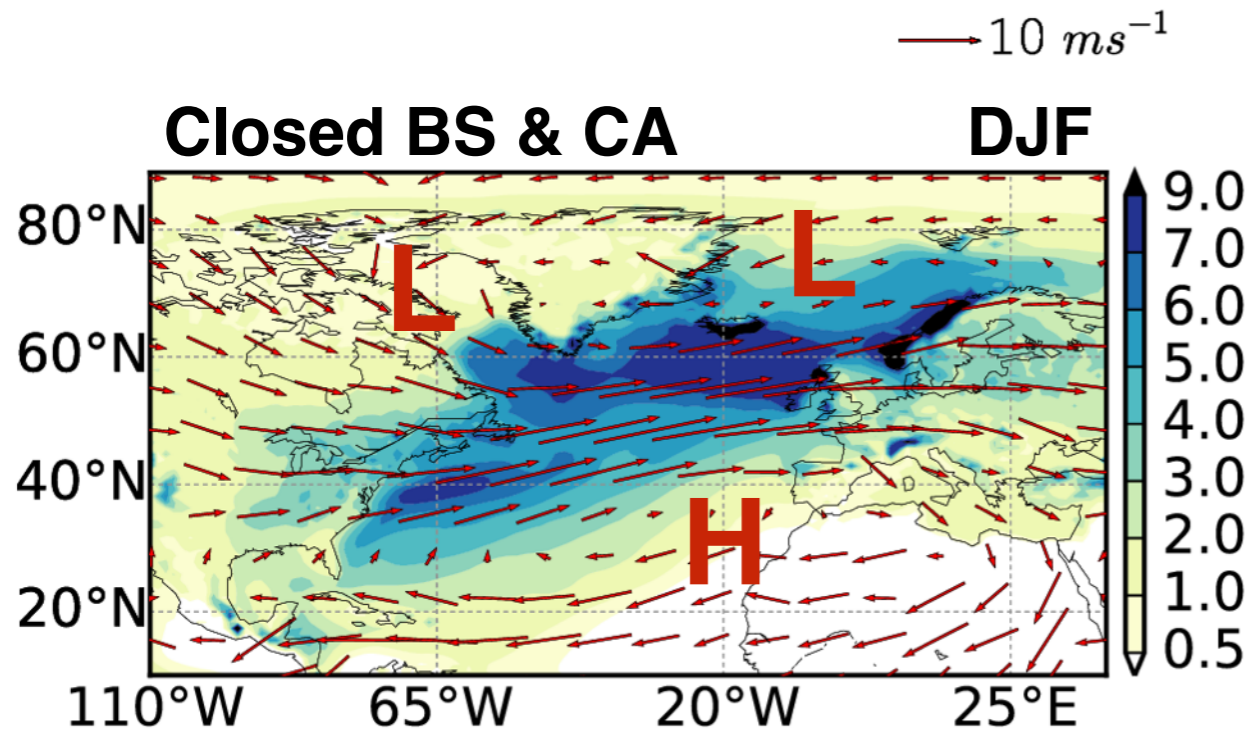
Closed CA JJA



Precipitation [mm/day]

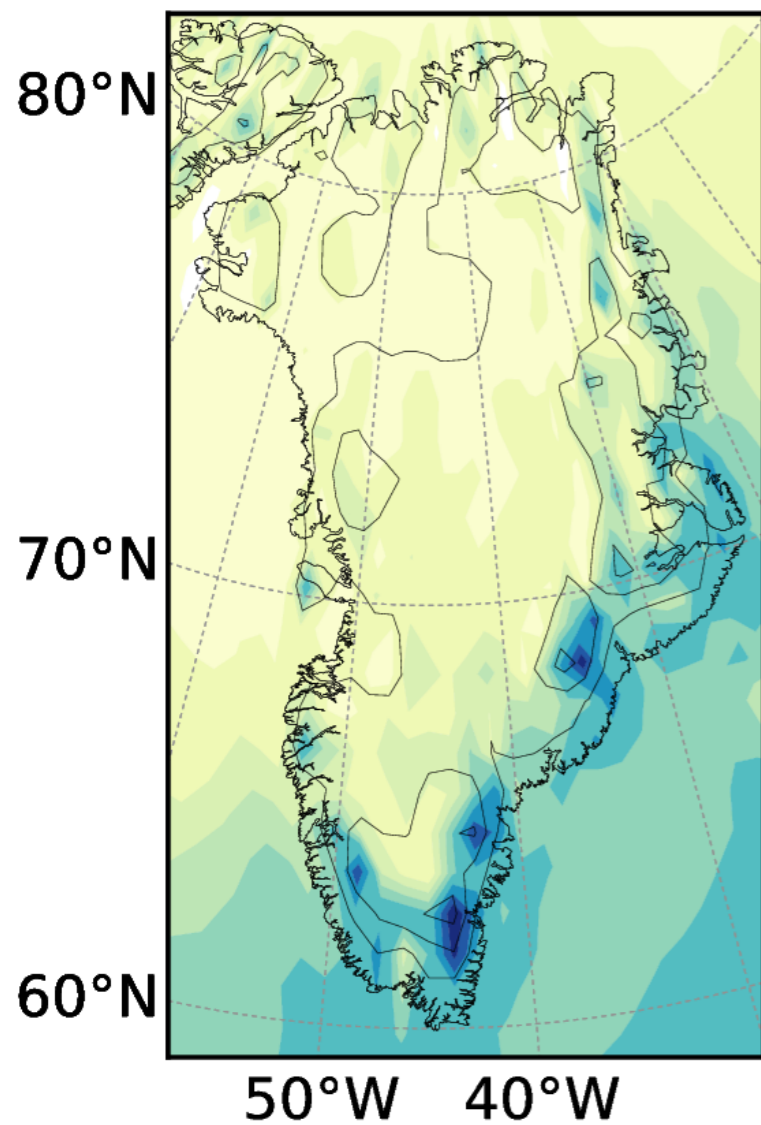


Precipitation [mm/day]

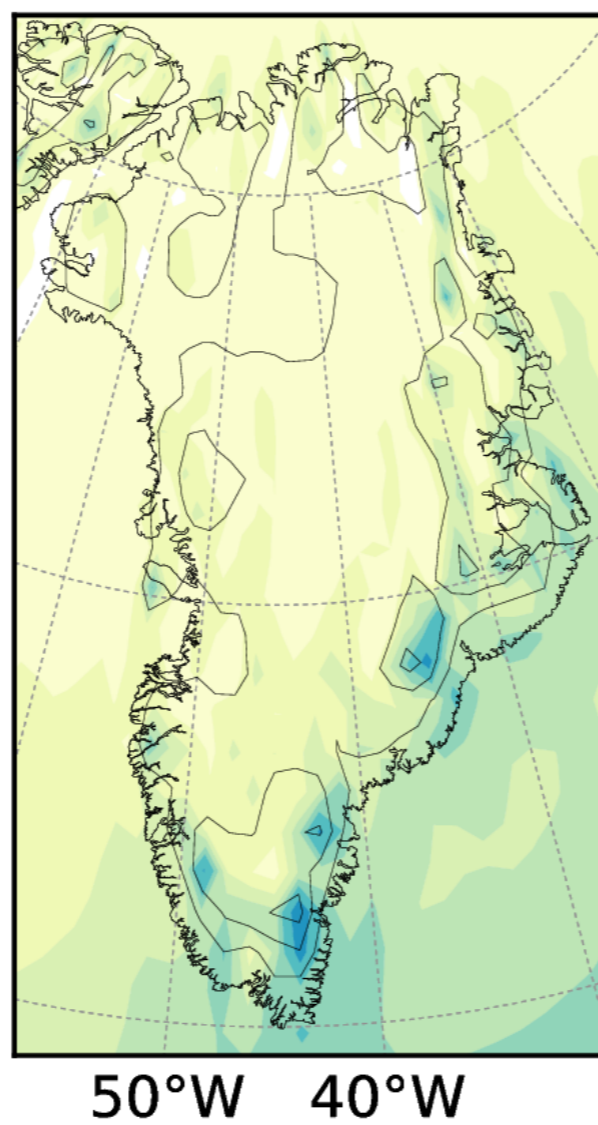


Greenland annual precipitation [mm]

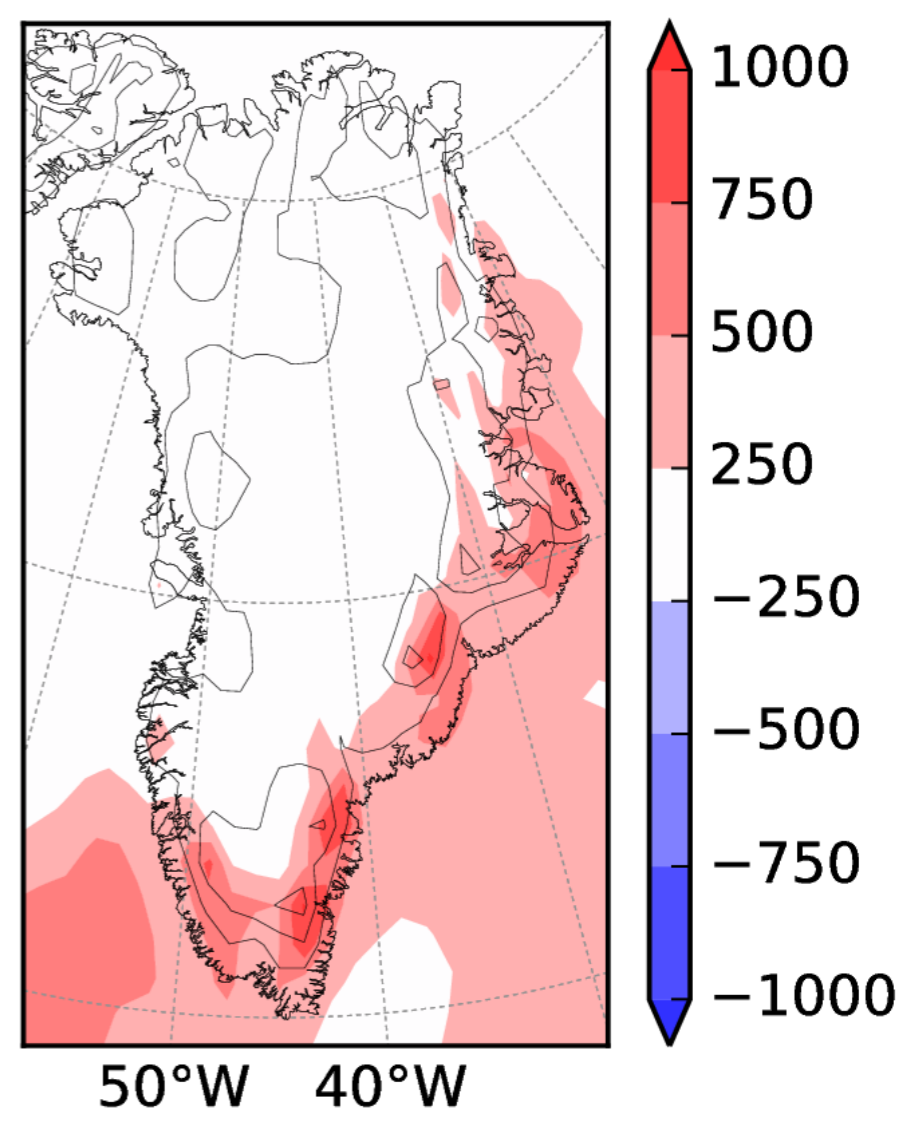
Closed BS & CA



Closed CA



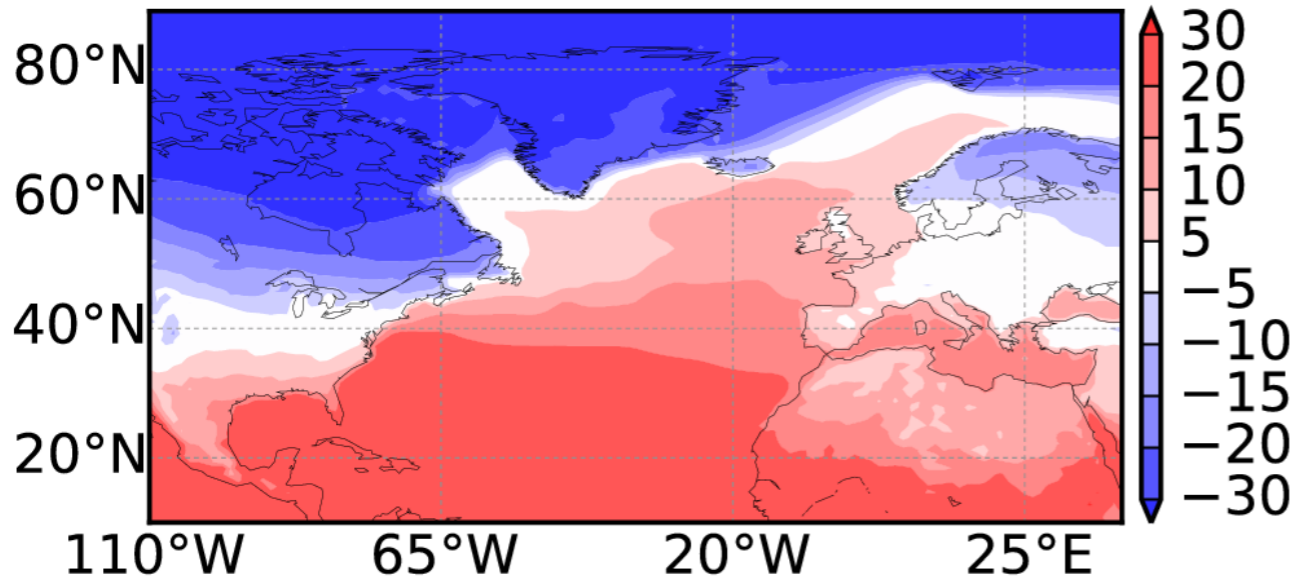
Panel 1 – Panel 2



Surface temperature [degC]

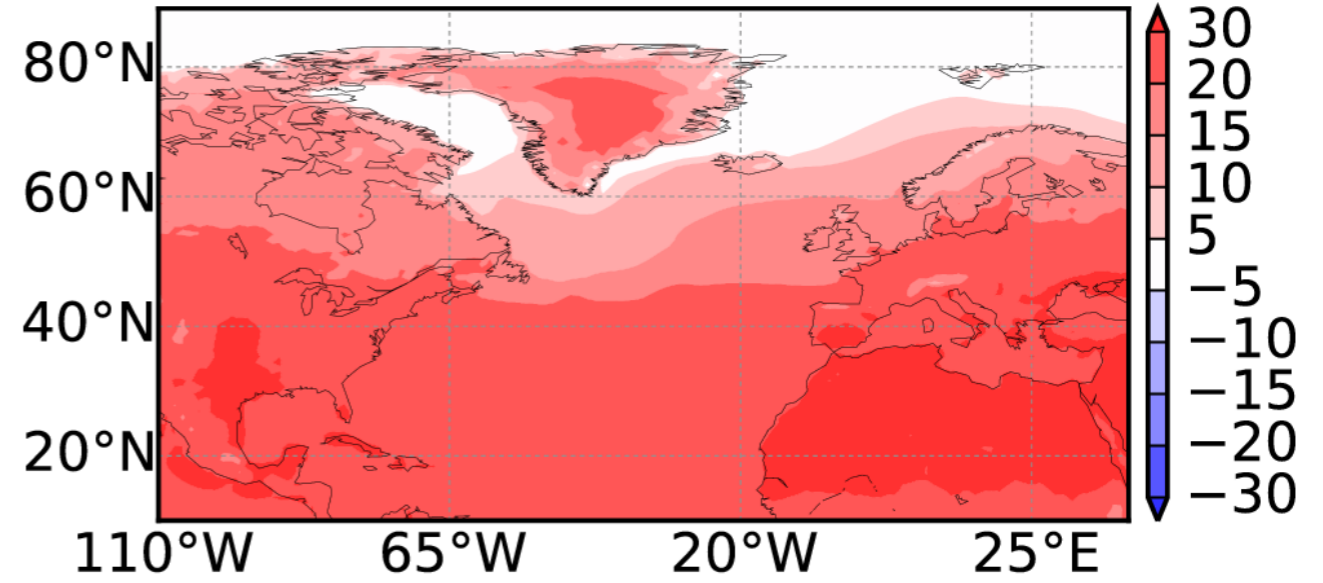
Closed BS & CA

DJF



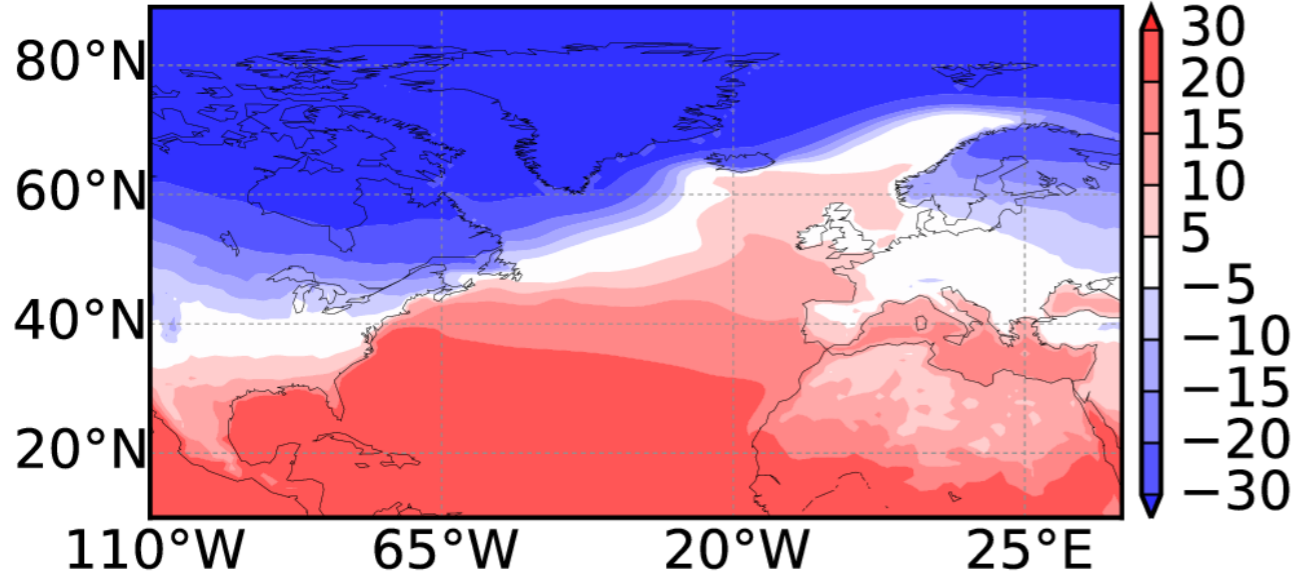
Closed BS & CA

JJA



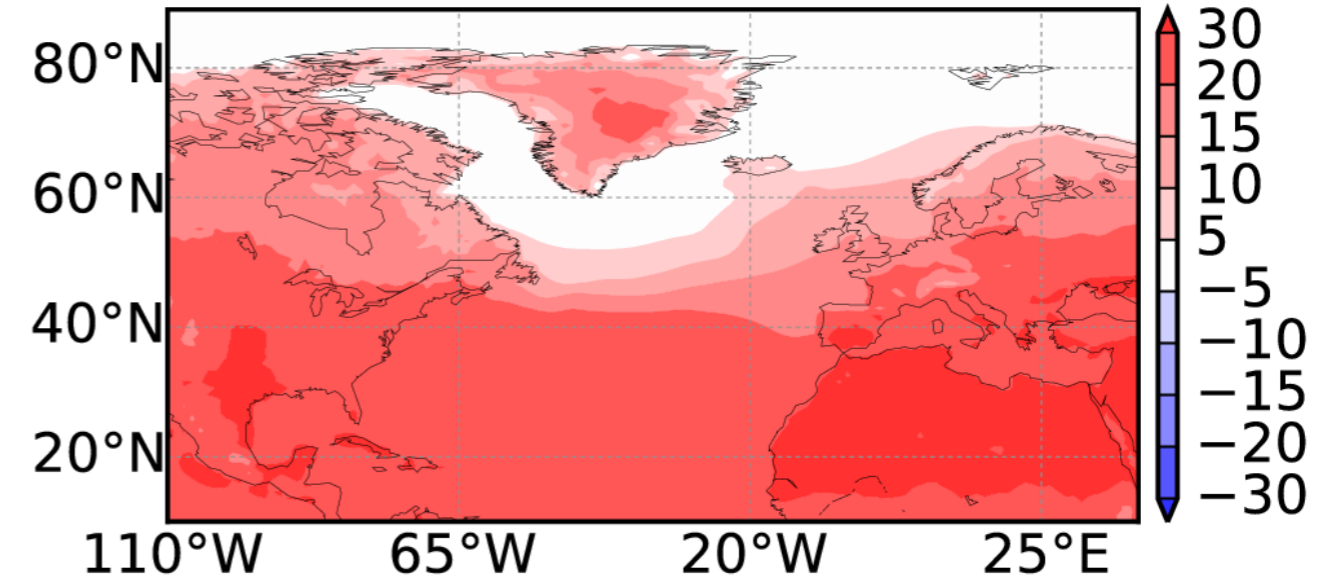
Closed CA

DJF

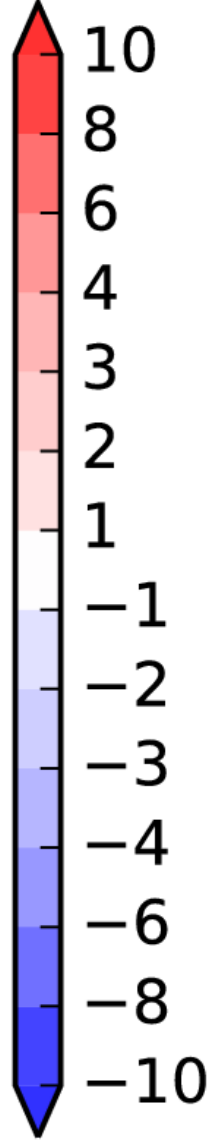
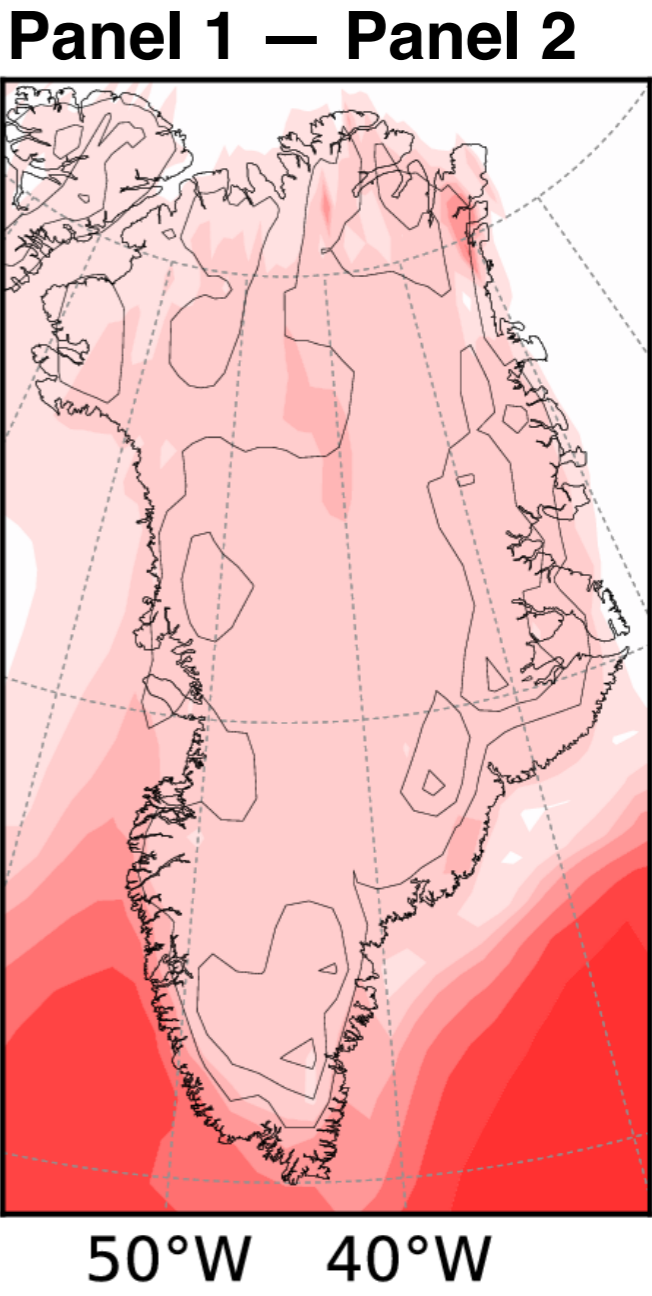
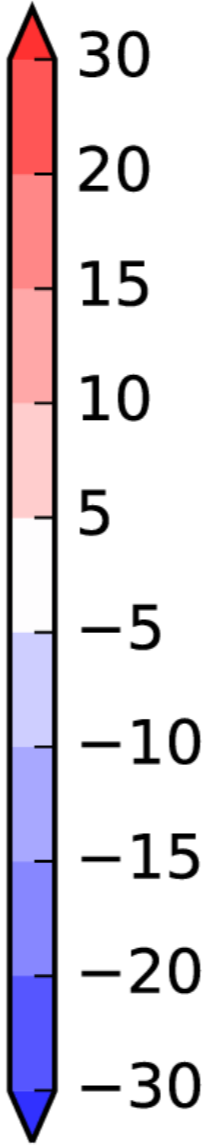
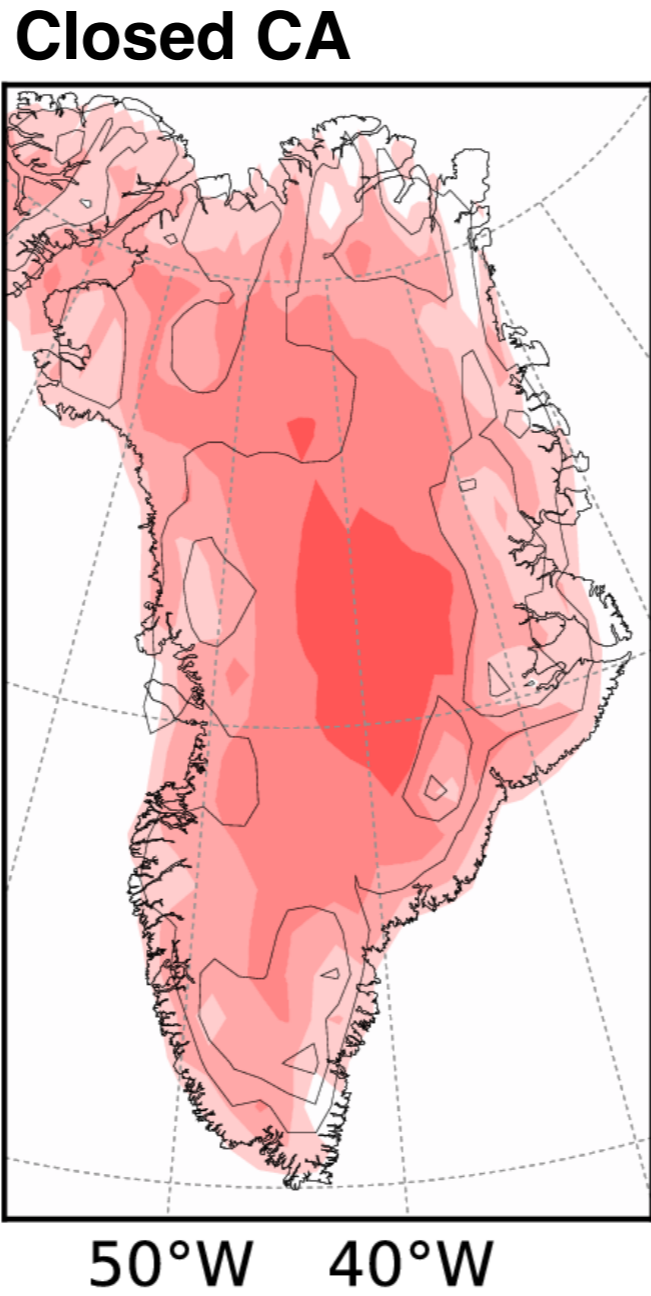
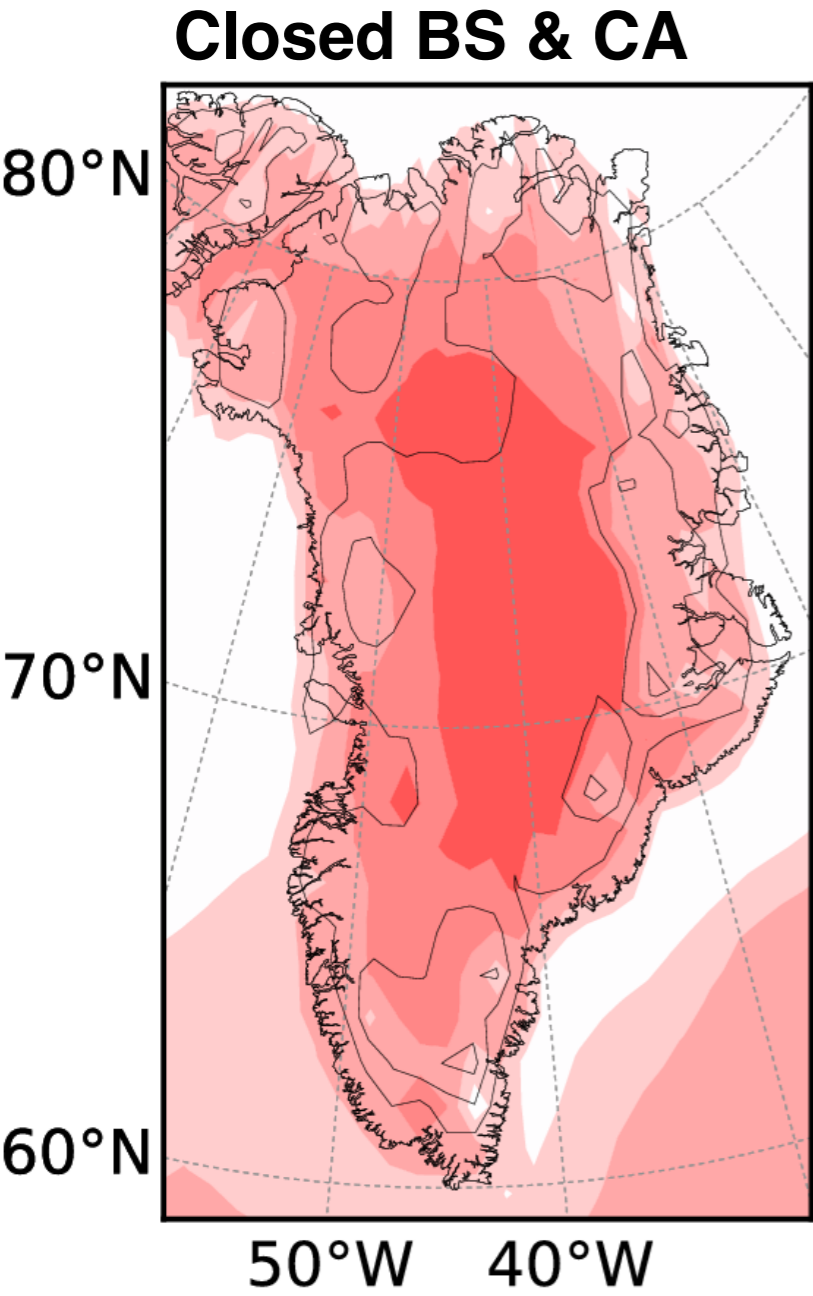


Closed CA

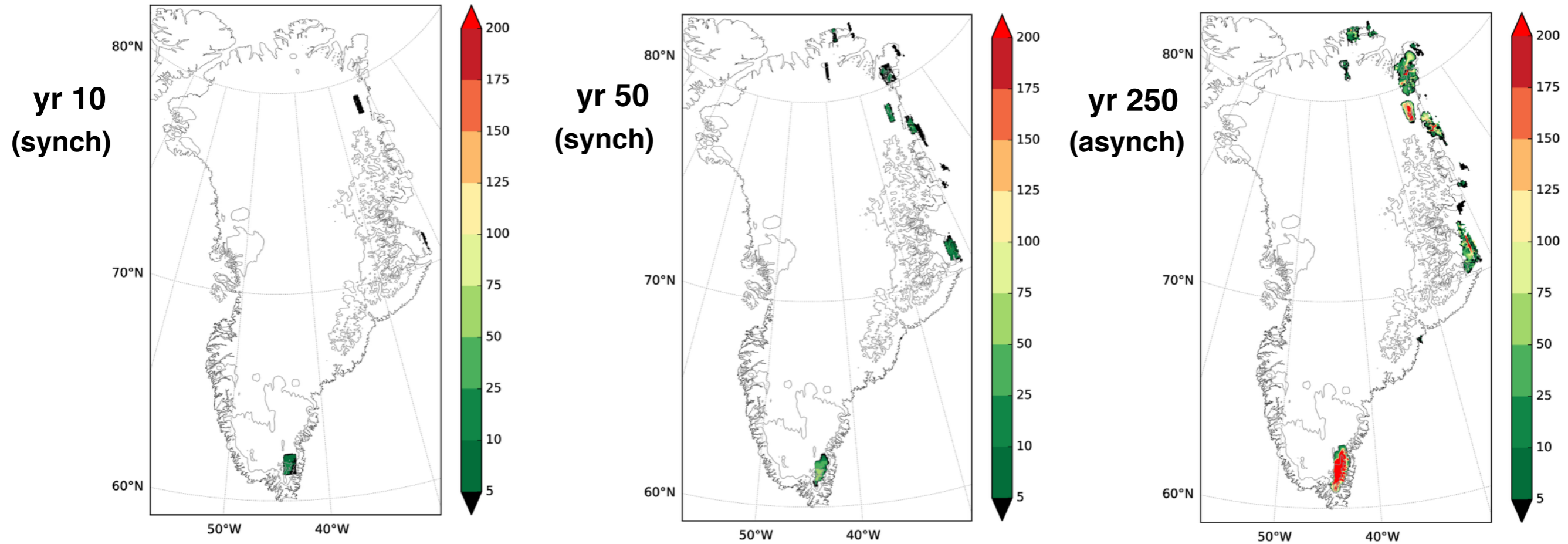
JJA



Greenland summer (JJA) temperature [degC]



Glacial inception — free running (closed CA)



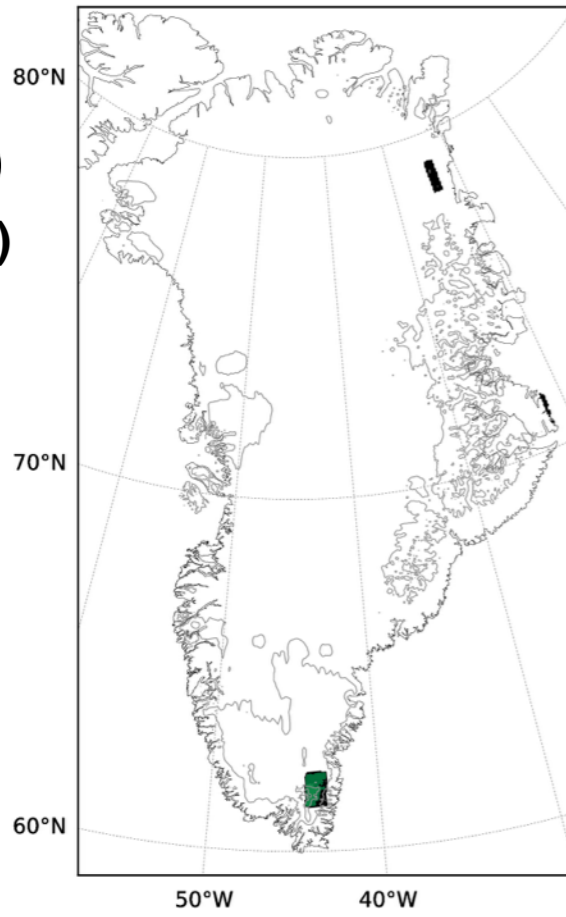
synch: yrs 0-50

10 yr asynch: yrs 50-550

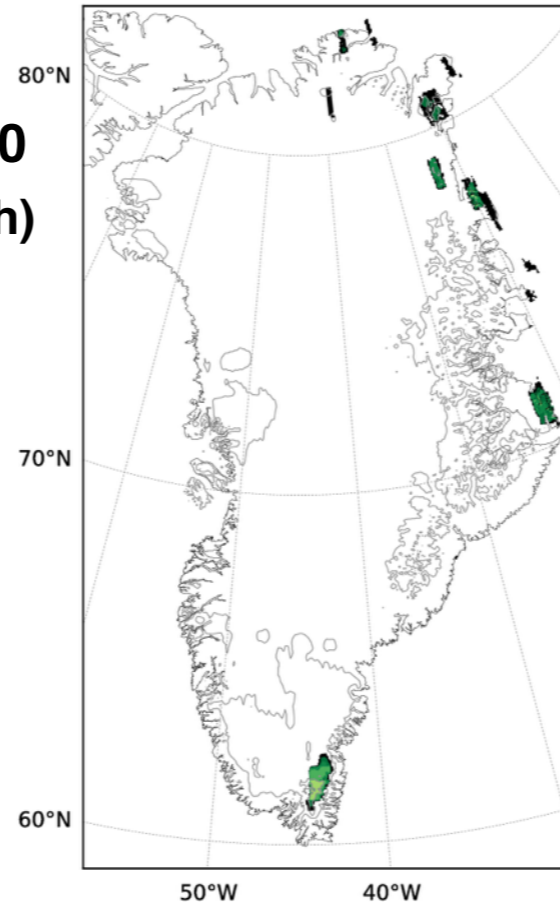
20 yr asynch: yrs 550-inf

Glacial inception — free running (closed CA)

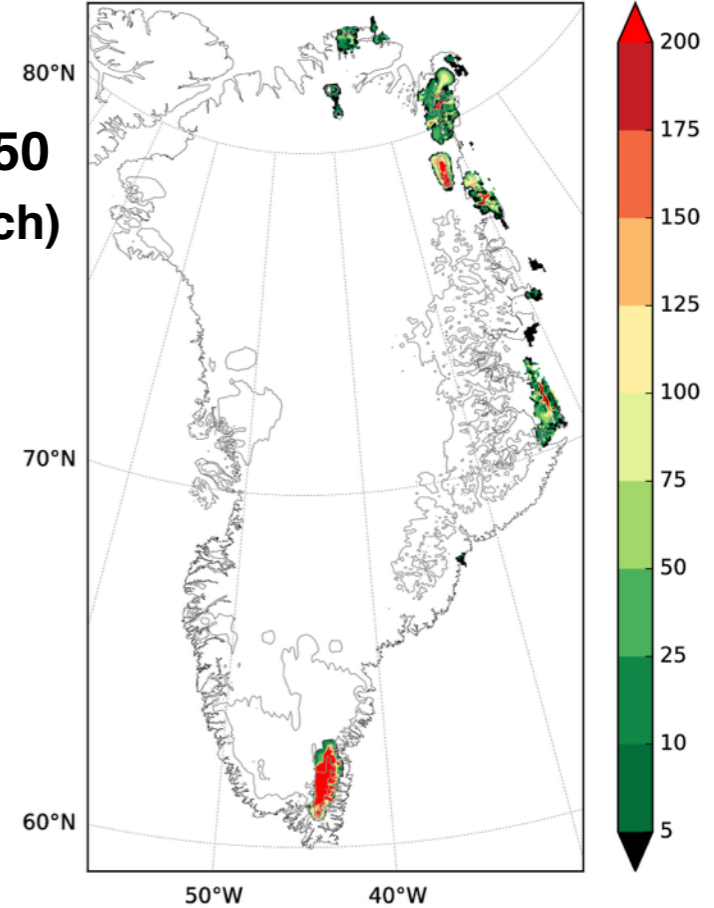
**yr 10
(synch)**



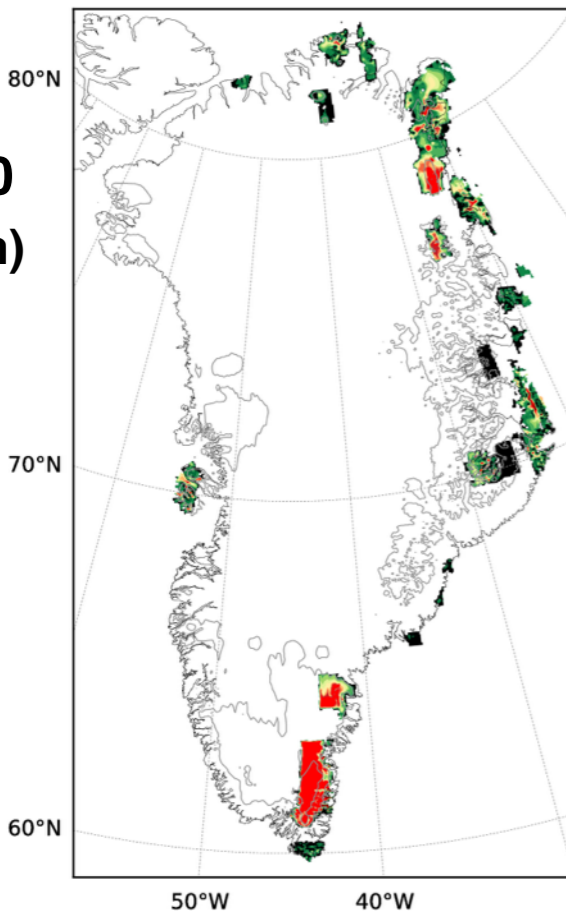
**yr 50
(synch)**



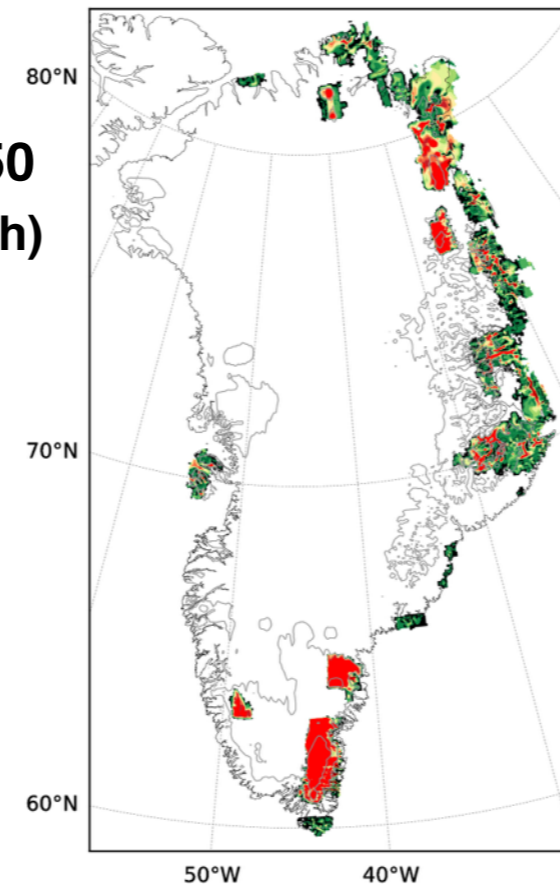
**yr 250
(asynch)**



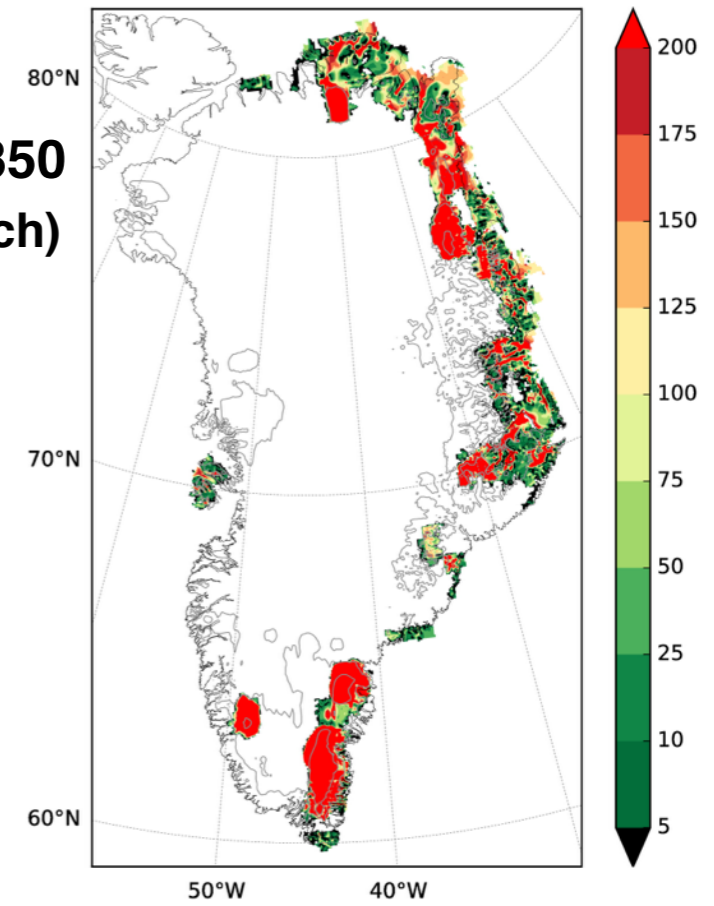
**yr 500
(asynch)**



**yr 750
(asynch)**

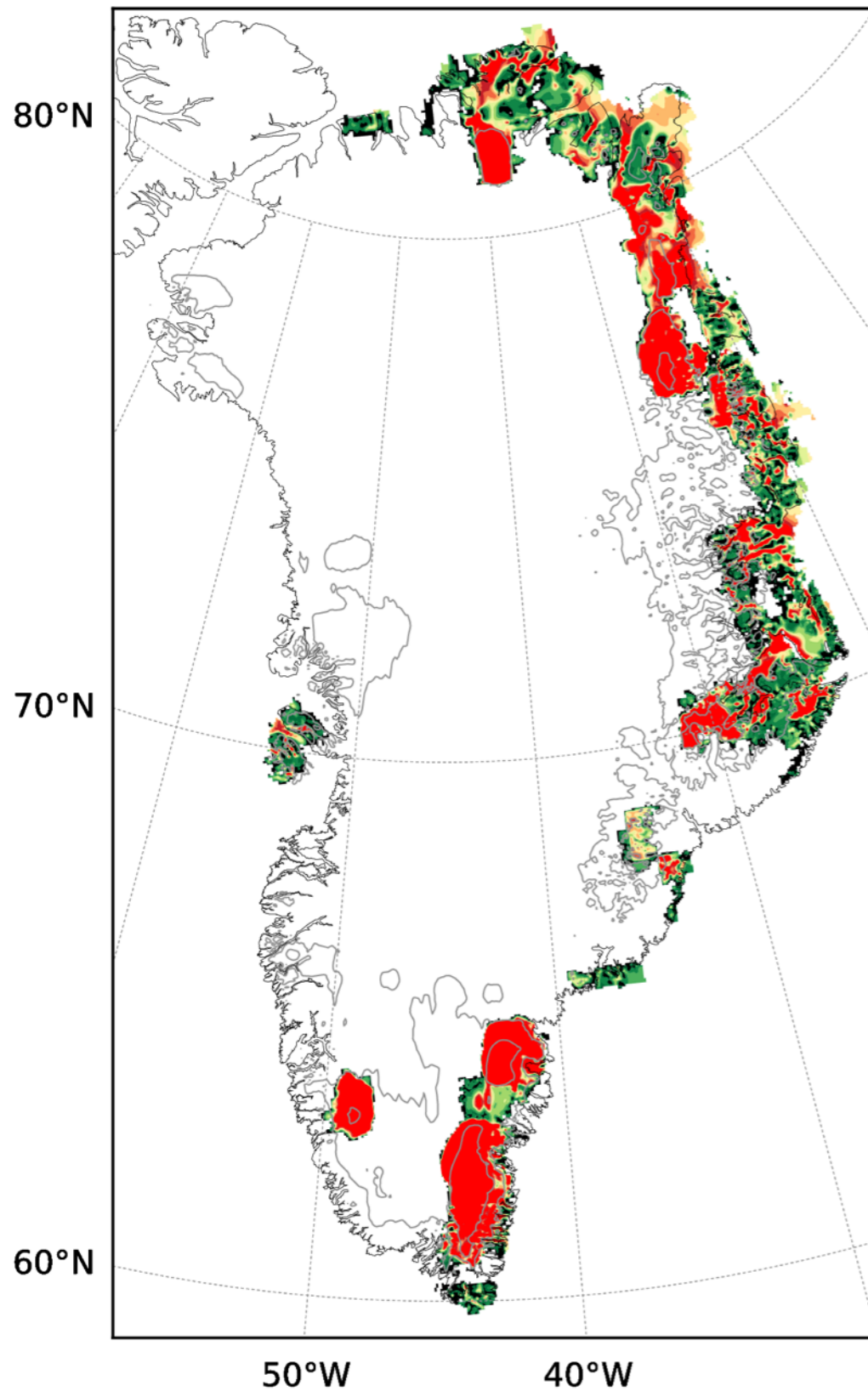


**yr 1350
(asynch)**

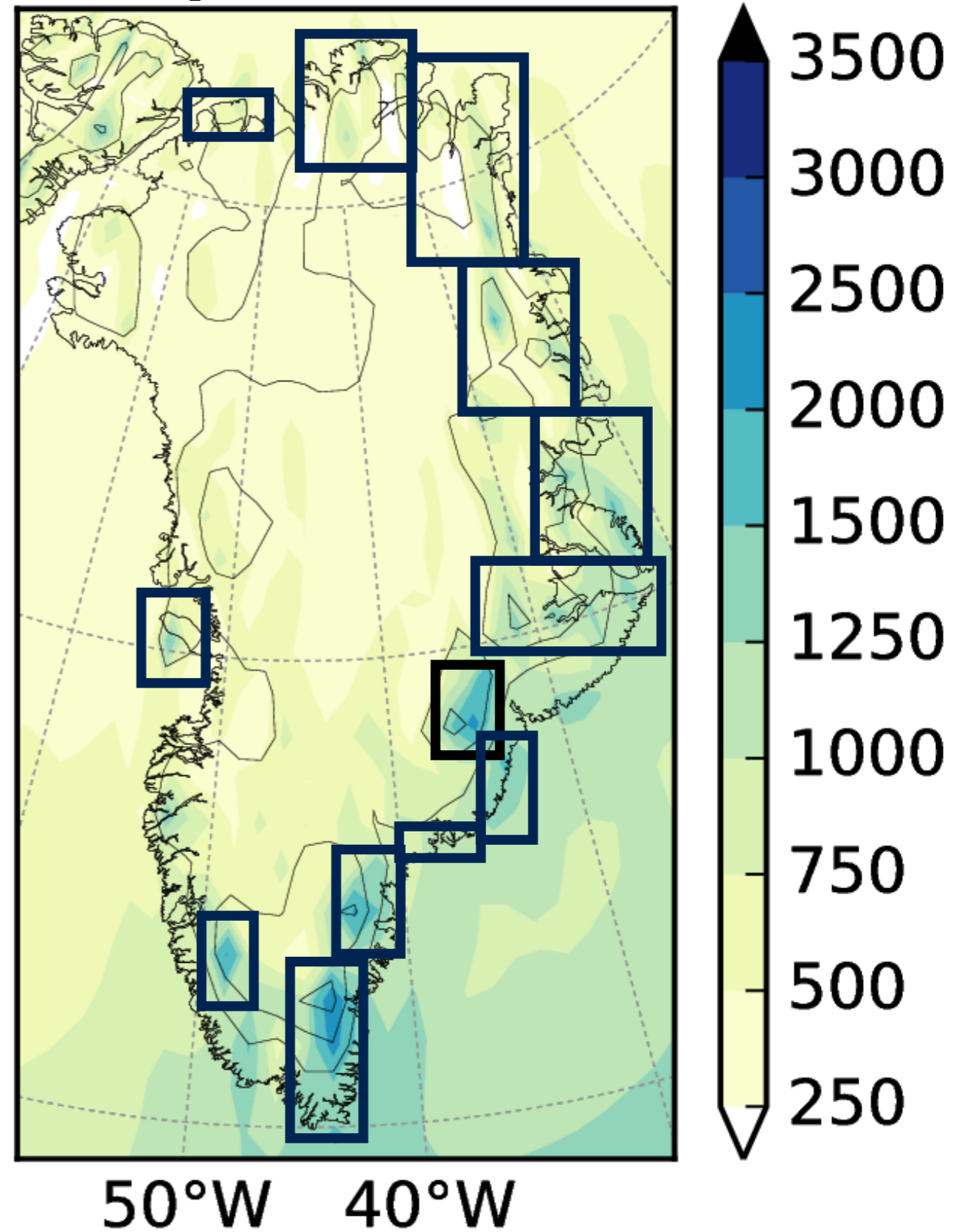


Glacial inception — free running (closed CA)

yr 1350

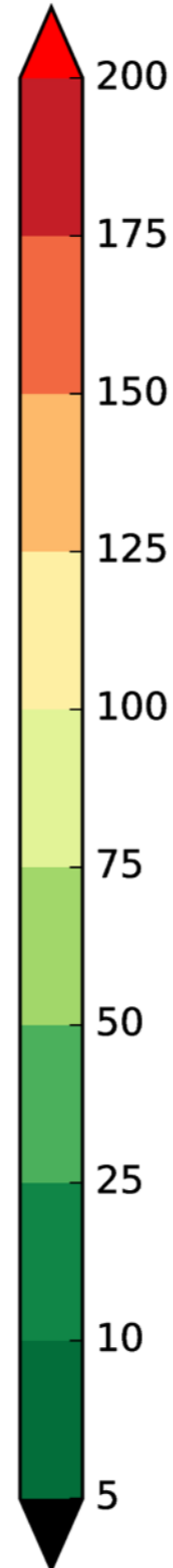
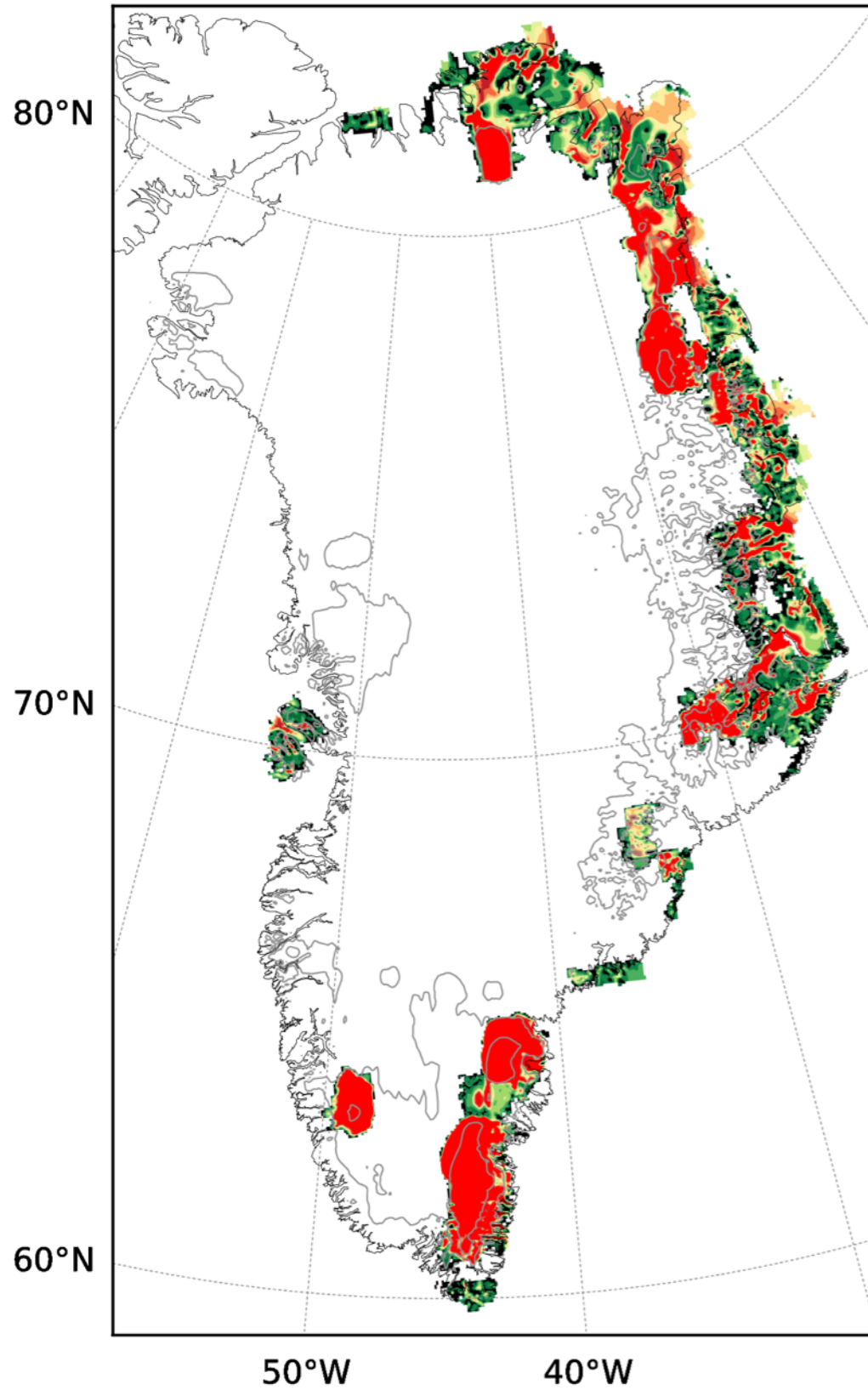


inception

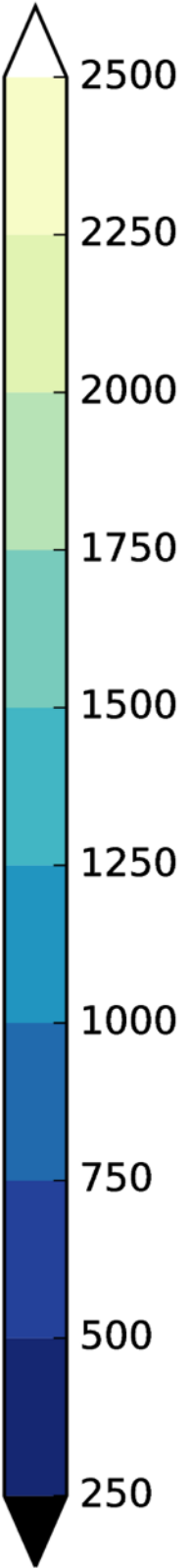
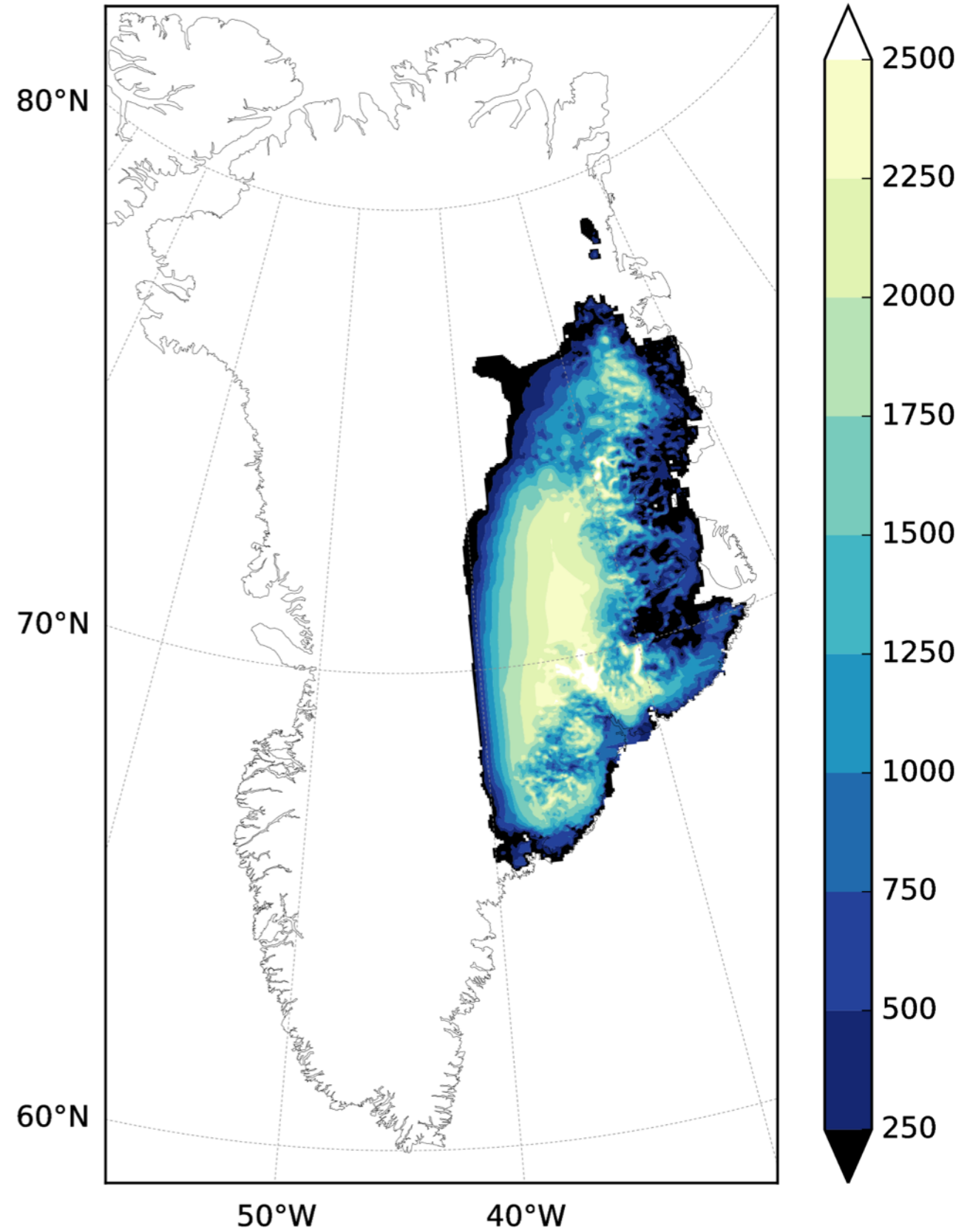


Glacial inception — free running (closed CA)

yr 1350

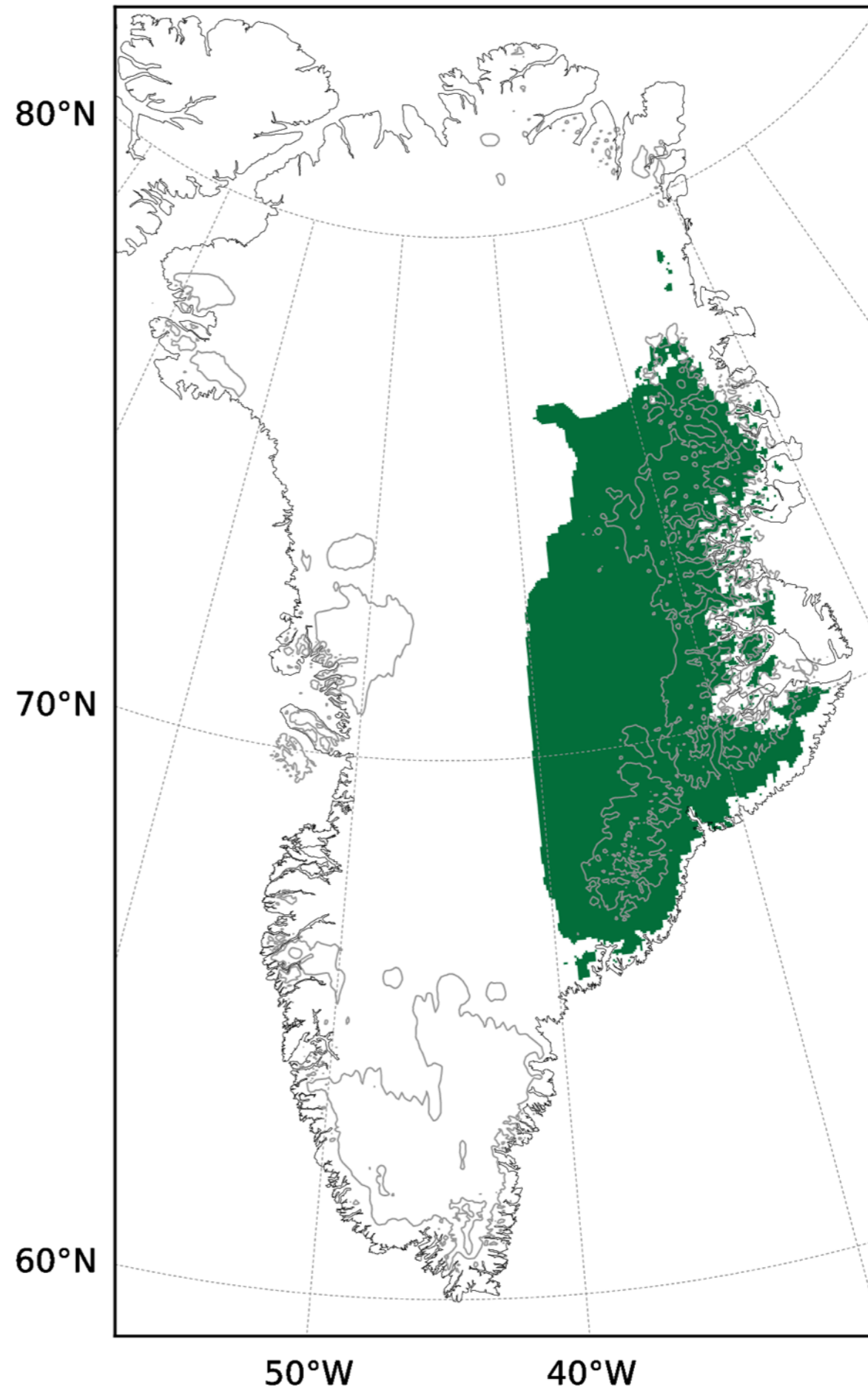


PlioMIP2

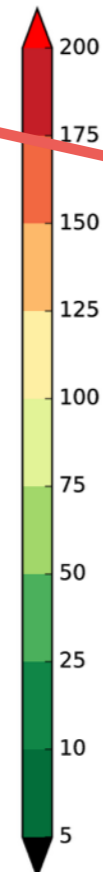
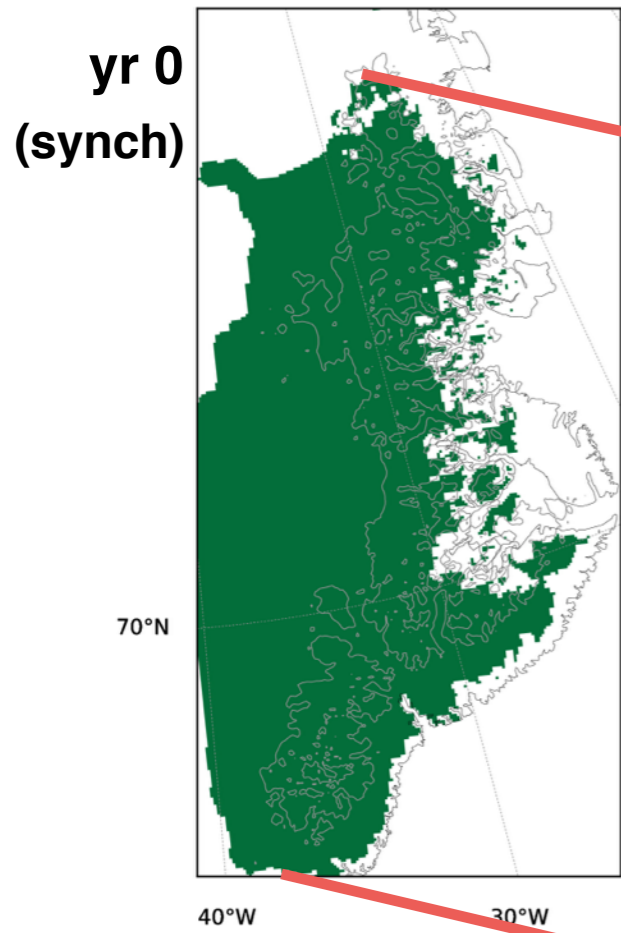


Glacial inception — PlioMIP2 outline (10m)

synch: yrs 0-50
10 yr asynch: yrs 50-inf



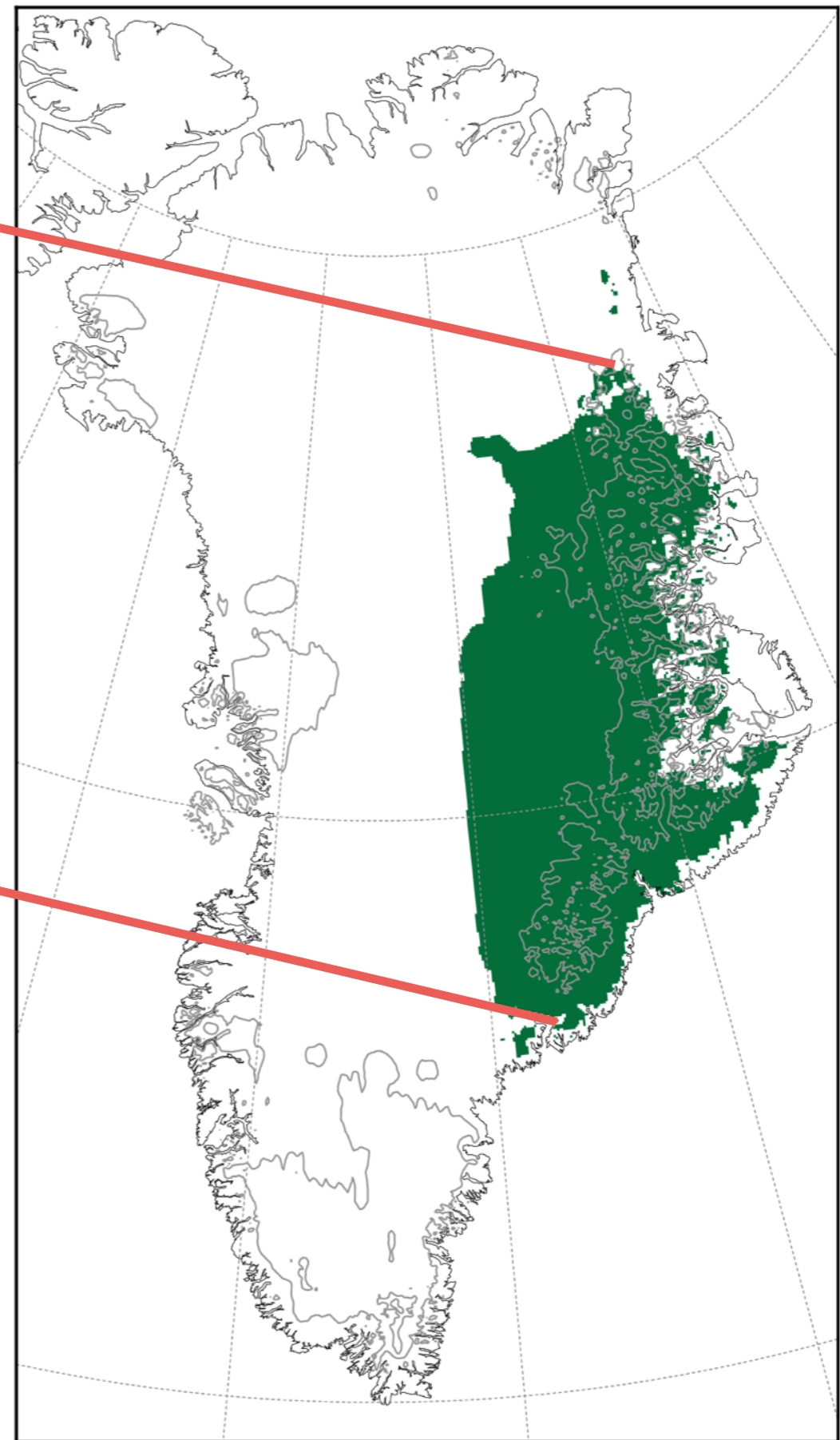
Glacial inception — PlioMIP2 outline (10m)



80°N

70°N

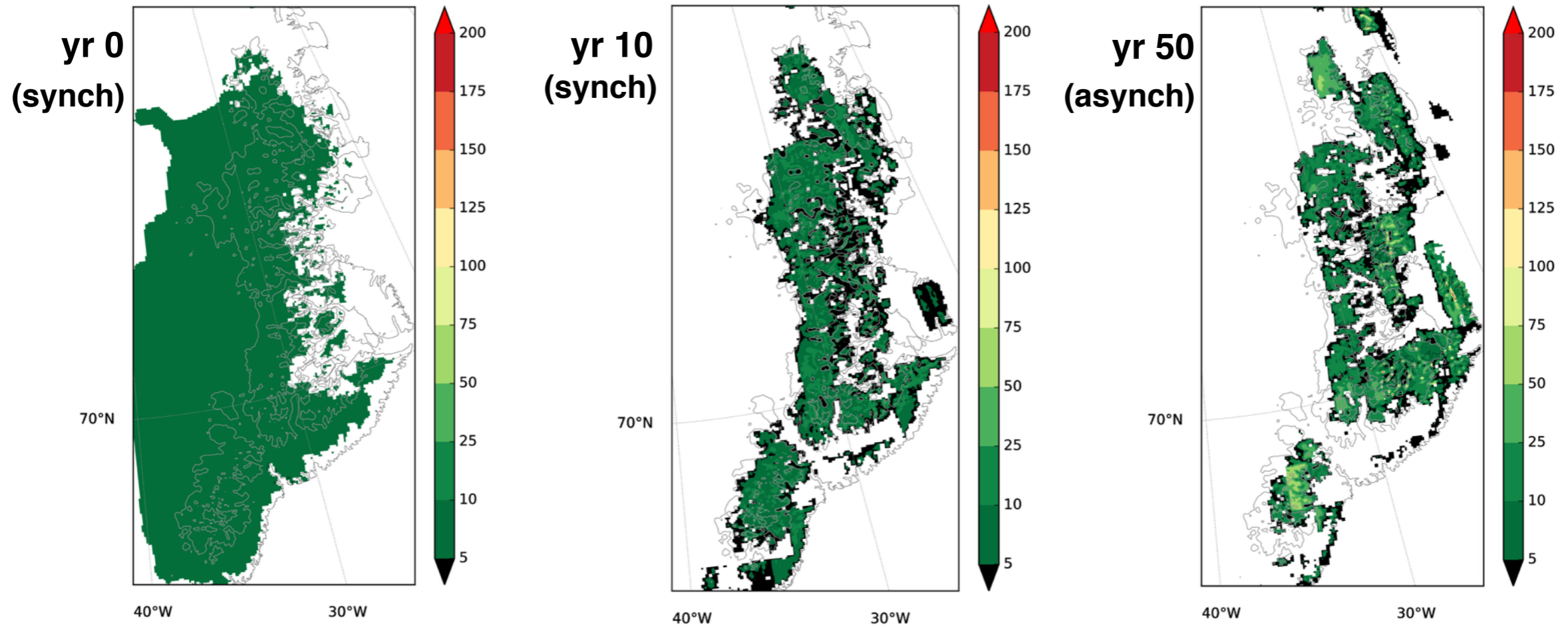
60°N



synch: yrs 0-50

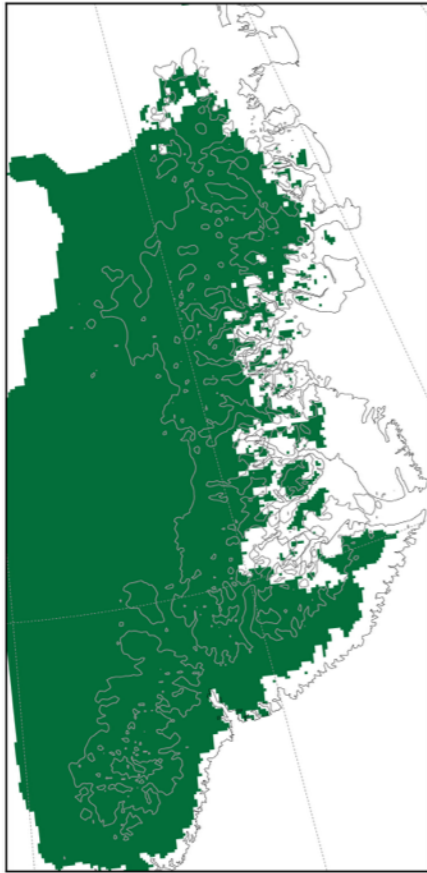
10 yr asynch: yrs 50-inf

Glacial inception — PlioMIP2 outline (10m)

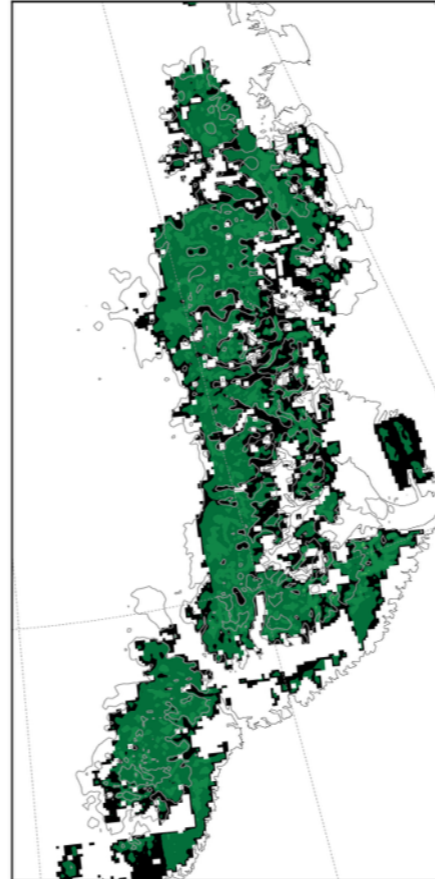


Glacial inception — PlioMIP2 outline (10m)

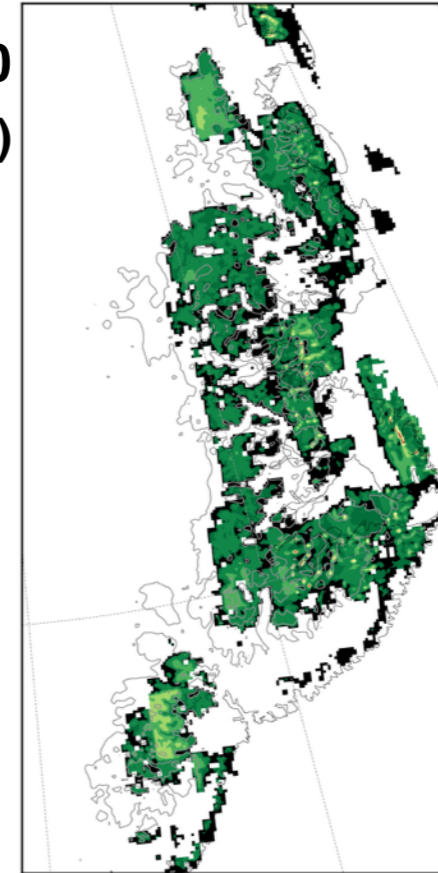
yr 0
(synch)



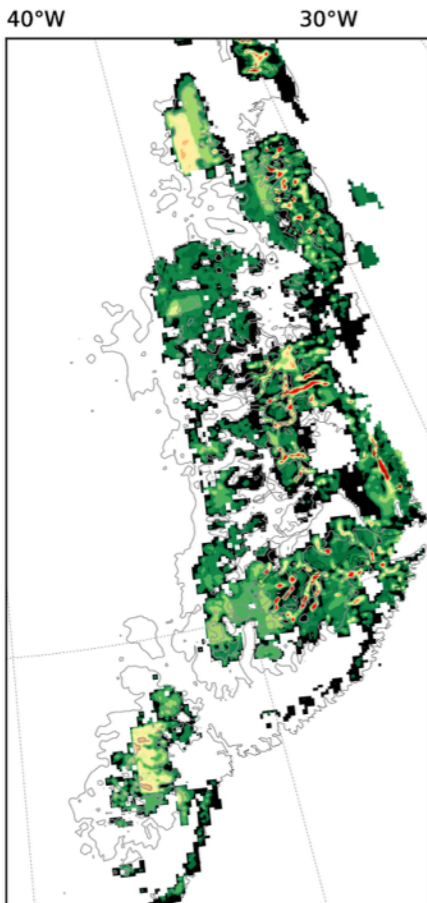
yr 10
(synch)



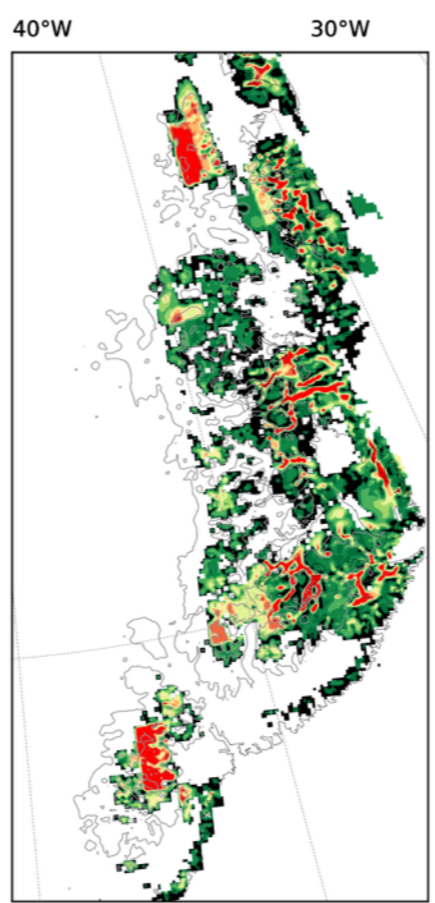
yr 50
(asynch)



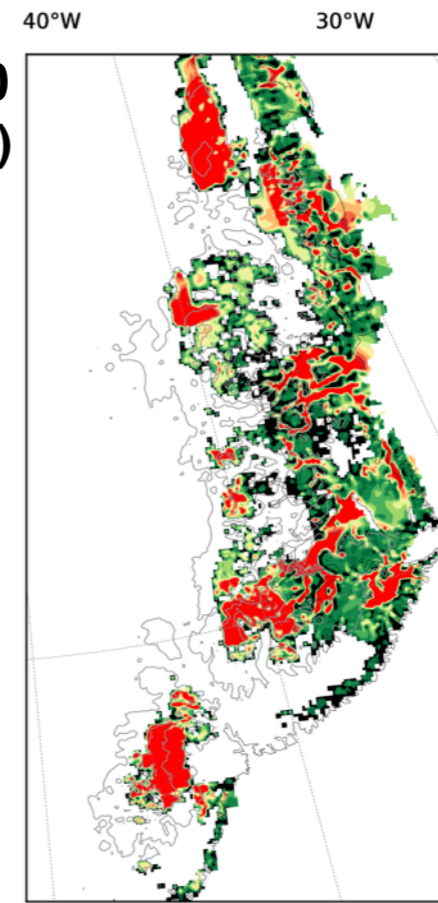
yr 100
(asynch)



yr 200
(asynch)

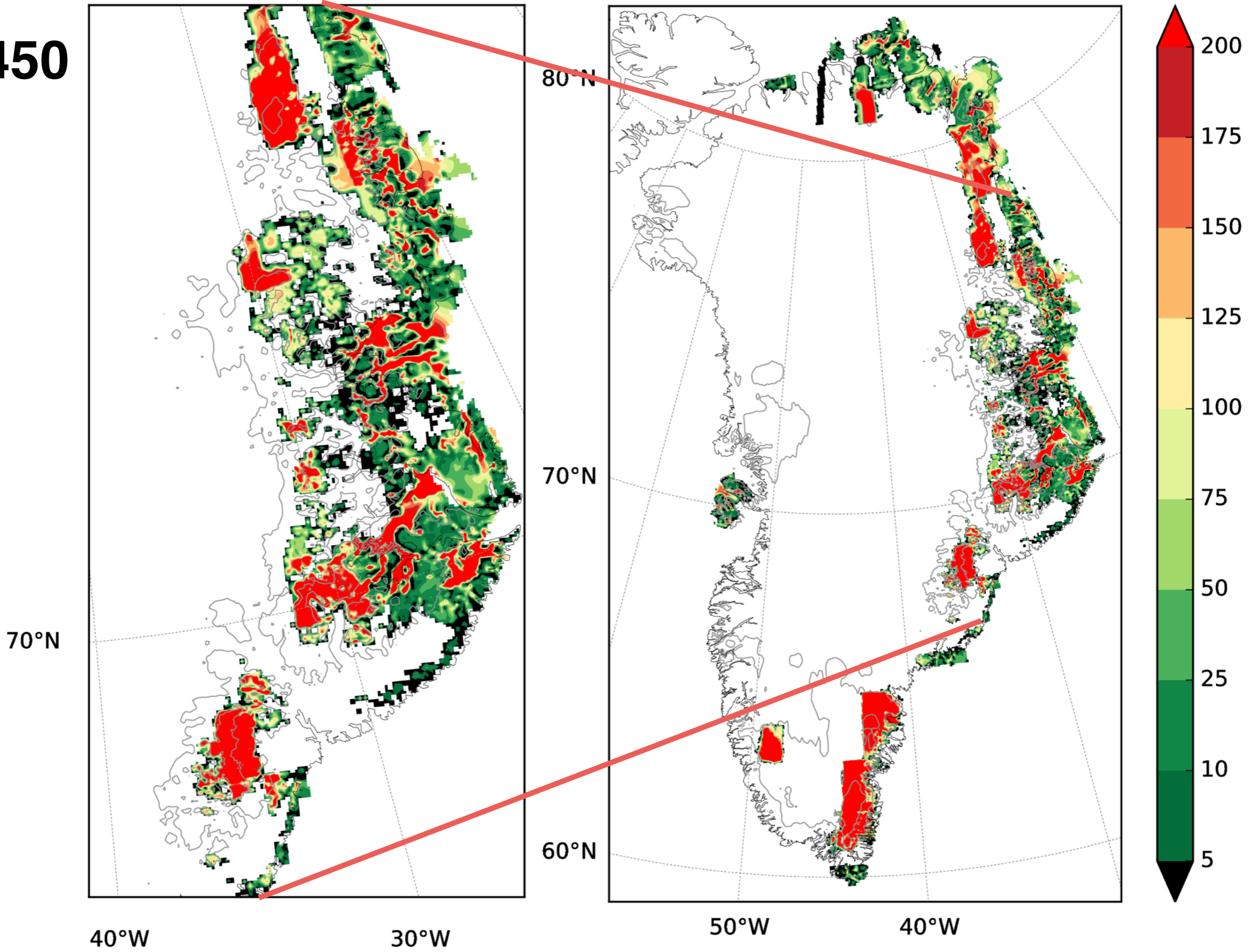


yr 450
(asynch)



Glacial inception — PlioMIP2 outline (10m)

yr 450



Summary and conclusions

Atmospheric conditions:

- Meridional position of Atlantic stormtrack sensitive to sea-ice extent
- Greenland surface temperature

Conventional inception:

- Relatively easy to grow ice in the eastern and southern parts of the continent
- Eastern mountain range captures Atlantic precipitation

10m PlioMIP2 inception:

- Albedo not sufficient to sustain an ice sheet in continental interior
- Ice growth on mountain range, possibility for ice flow into valley