Pliocene inception and growth of the Greenland Ice Sheet in CESM

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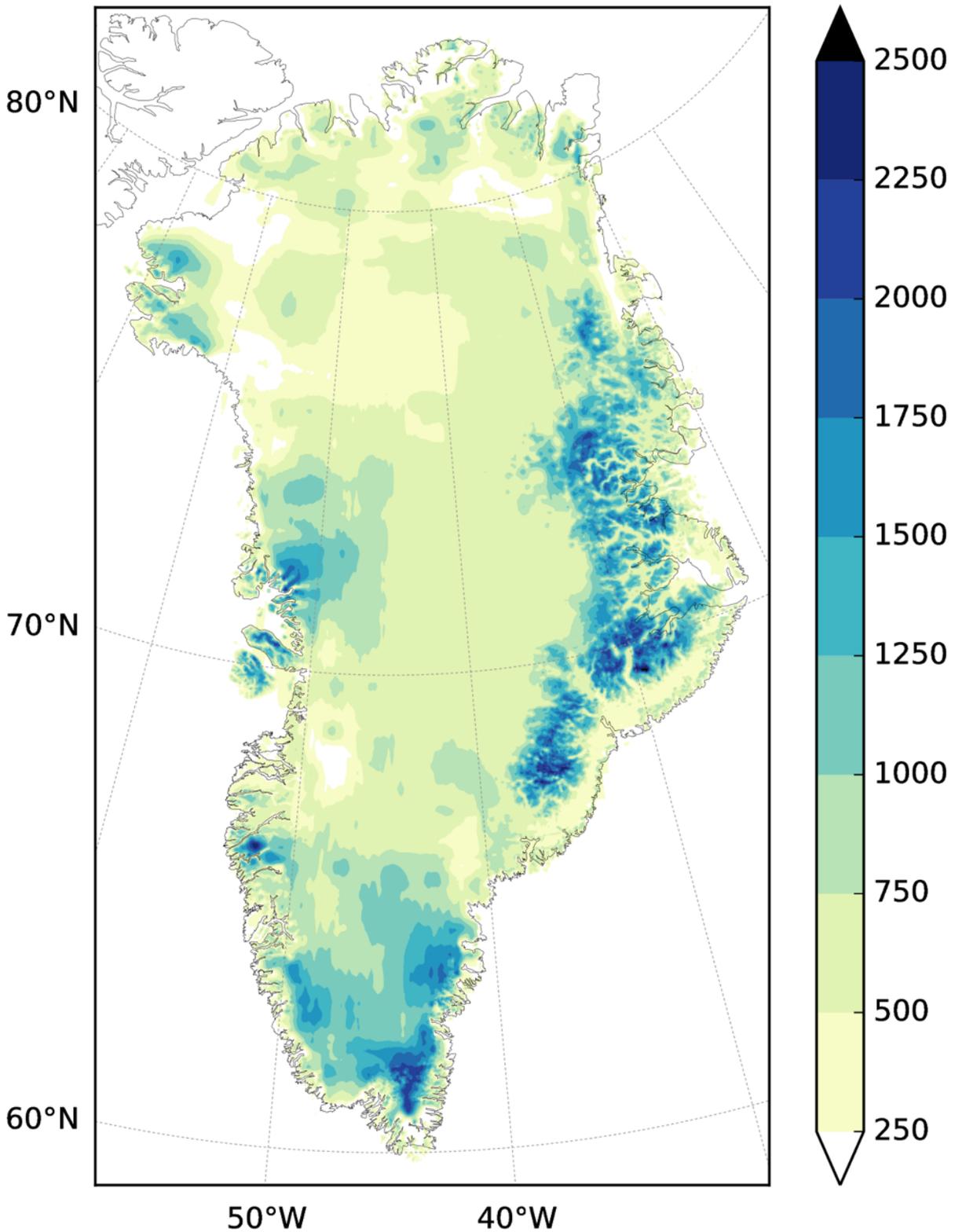
Pliocene

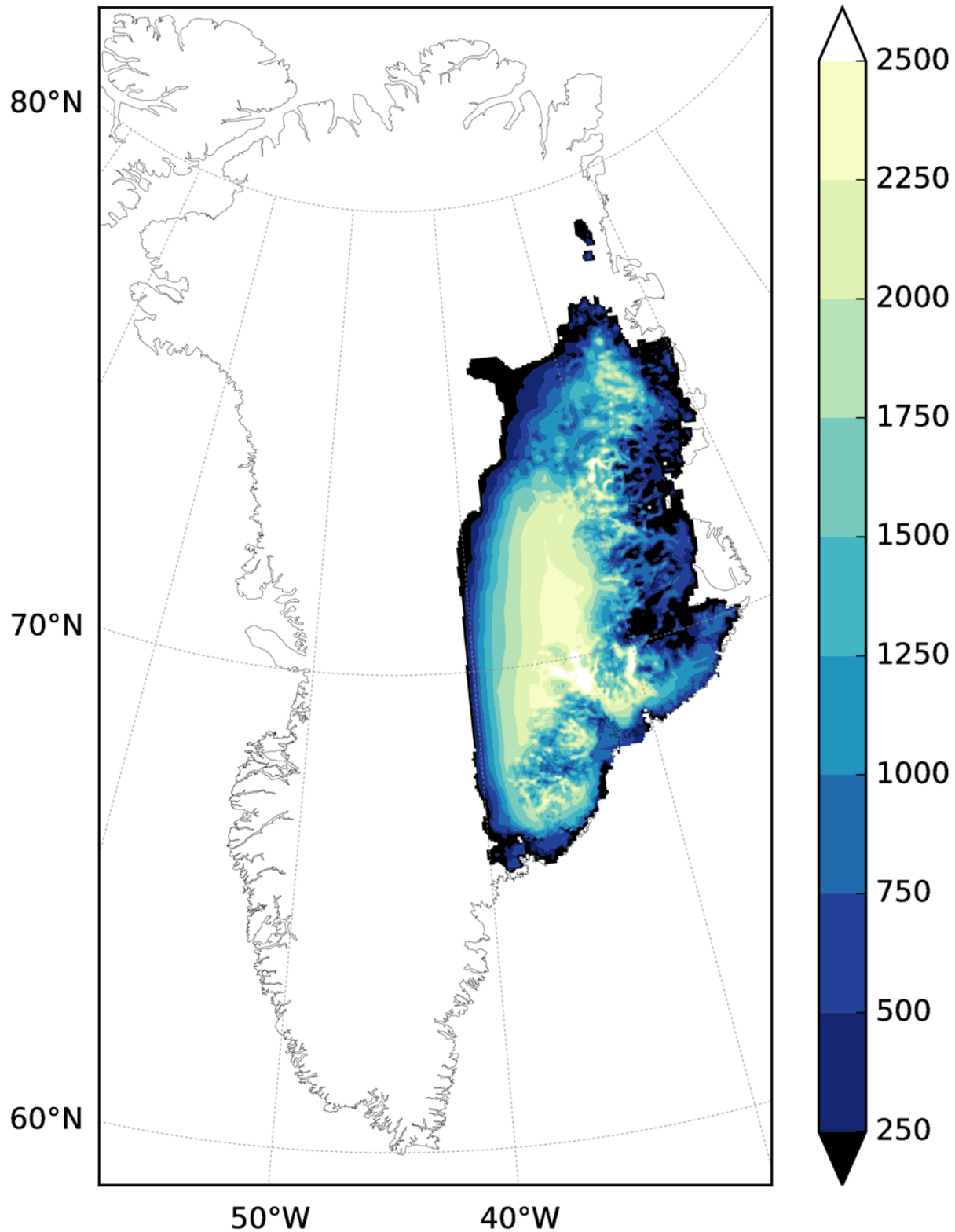
- ~5.3-2.6 Mya
- The global average temperature was approximately 2 to 3 °C higher than today
- The global sea level was 25±5 m higher than present
- Northern hemisphere ice sheets were ephemeral
- Greenland inception around 3.3±3 Mya

Greenland topography [m]

Adjusted bedrock

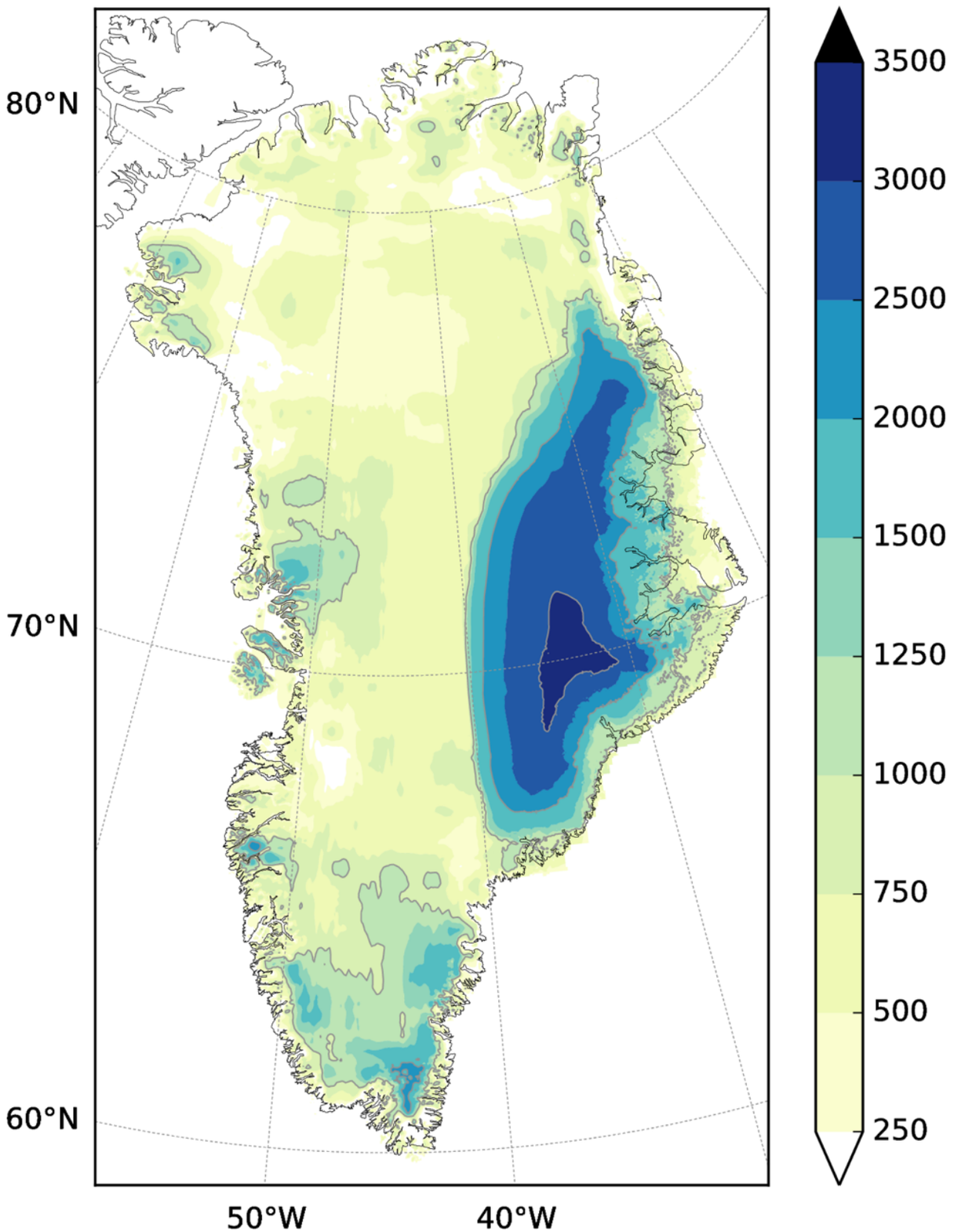


PlioMIP2 ice sheet

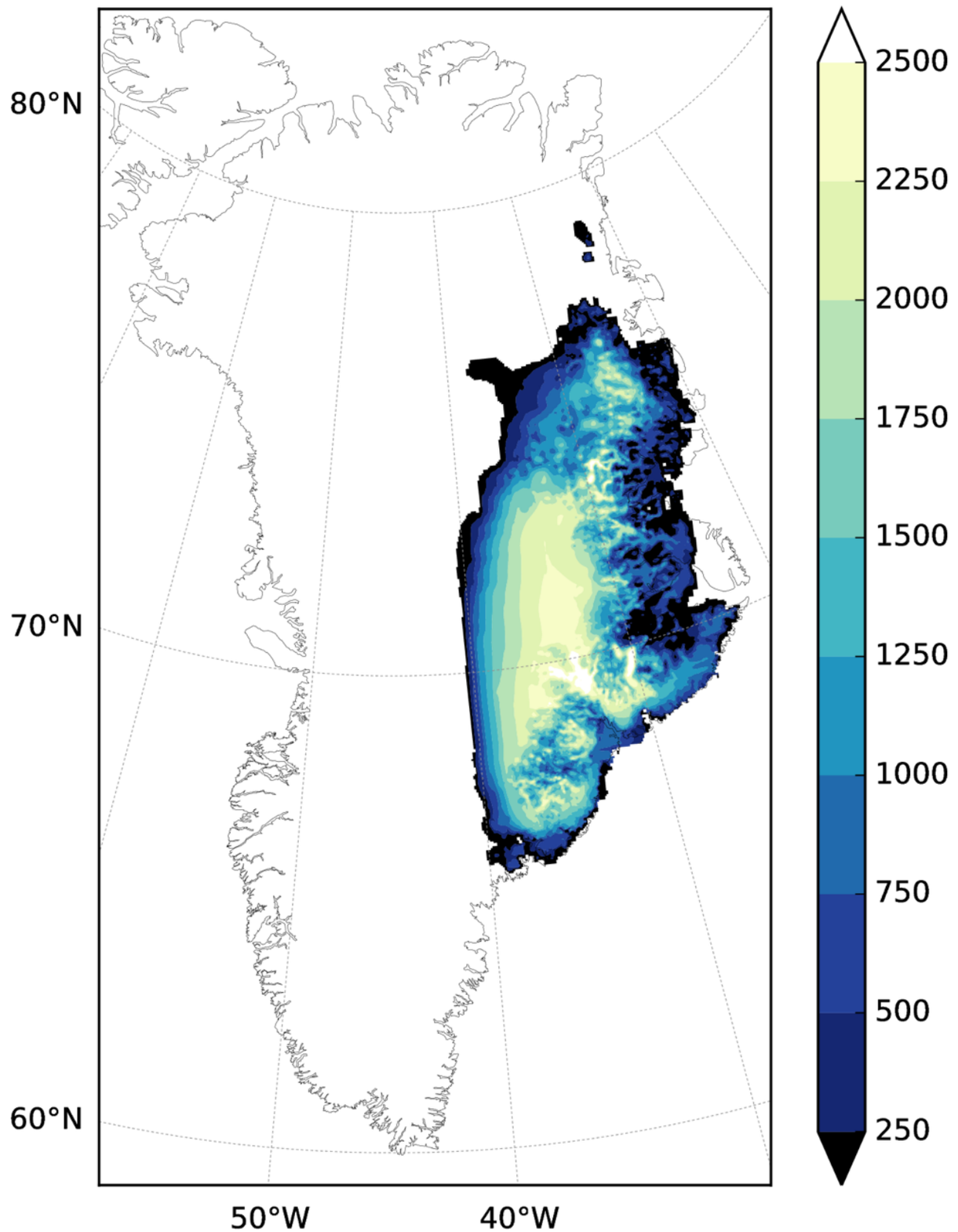


Greenland topography [m]

PlioMIP topography



PlioMIP2 ice sheet



Boundary conditions and model setup

- CESM1.5 (FV1L30), CISM2 (4km high order dynamics)

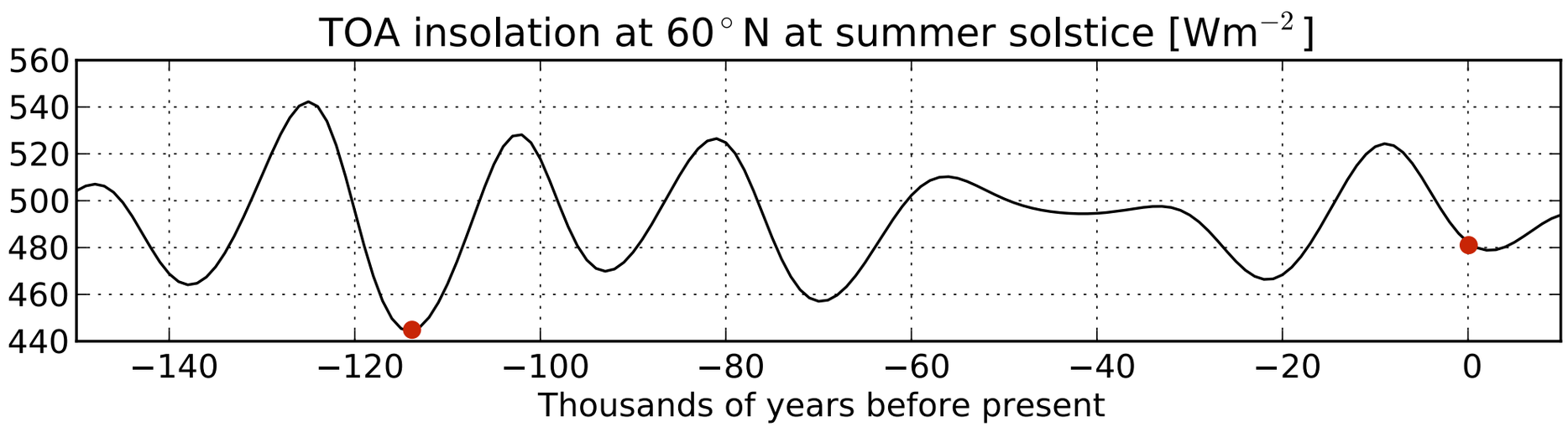
- Prescribed SST/sea ice from CCSM4 PlioMIP1 simulations

- 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)

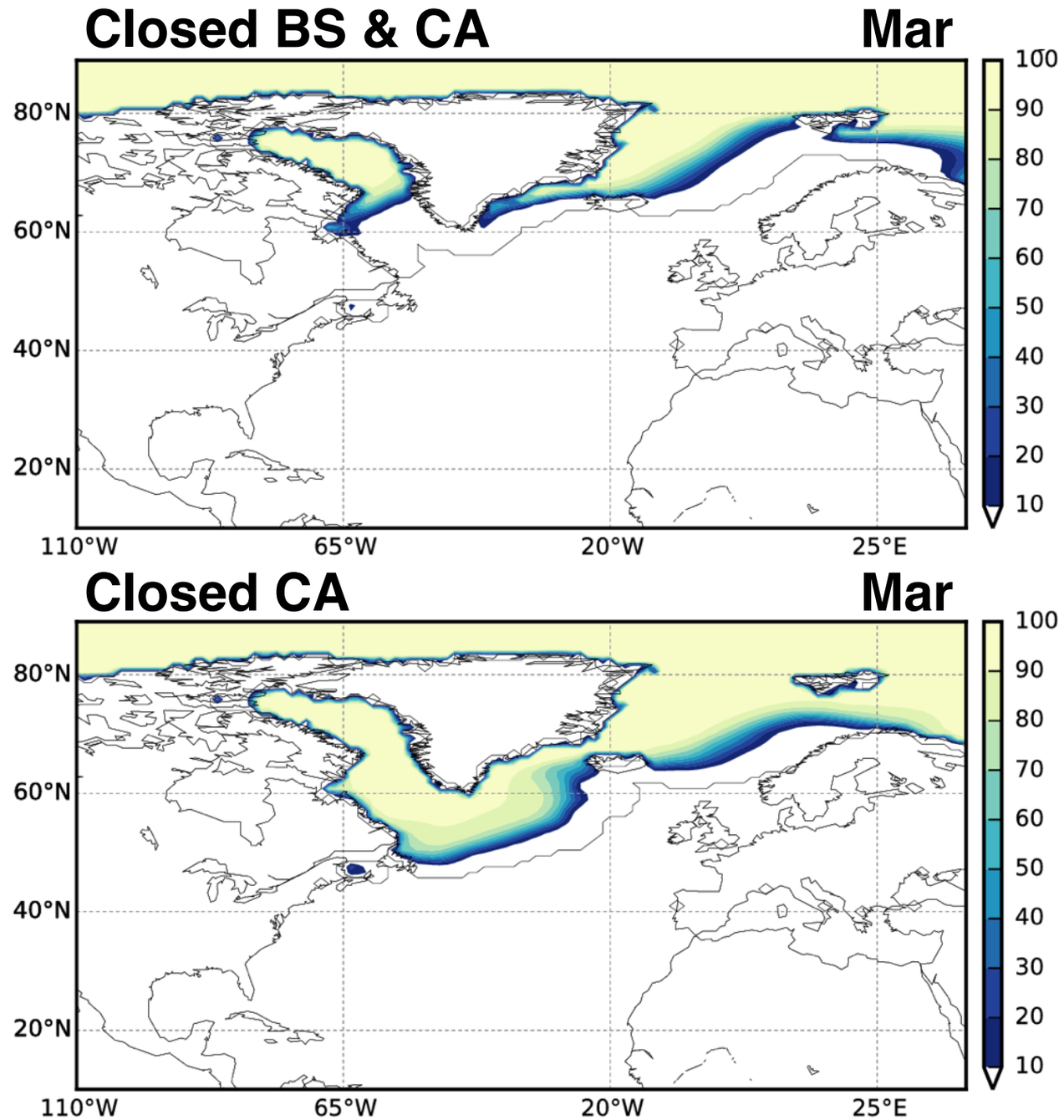
- Initial Greenland ice sheet:
  i. Bare ground
  ii. Outline of PlioMIP2 ice sheet but 10m thick
  iii. Full PlioMIP2 ice sheet (*not discussed here*)

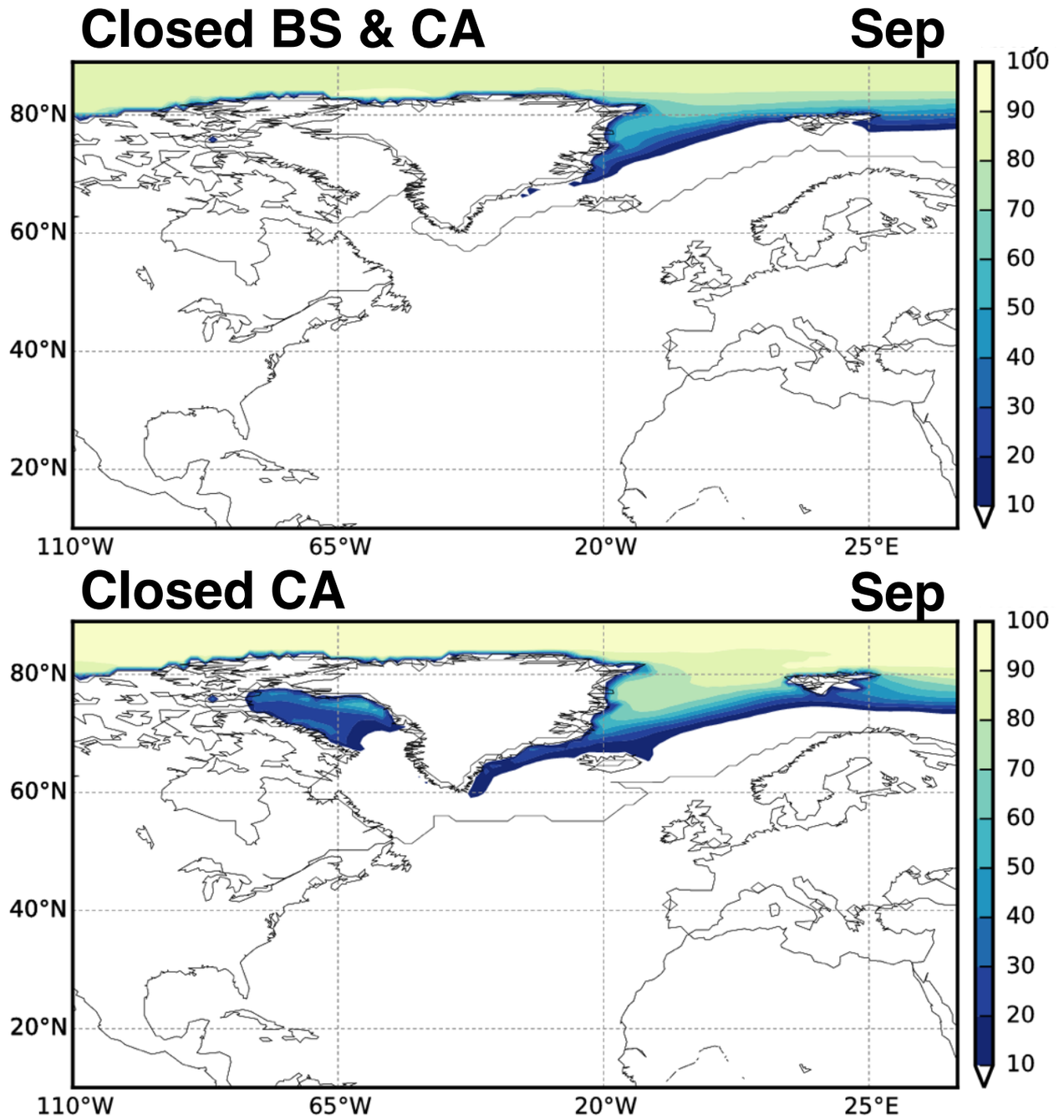
- Low insolation (115 kya), pre-industrial GHG (280 ppmv CO_2)

- Greenland ice sheet replaced by Arctic shrub

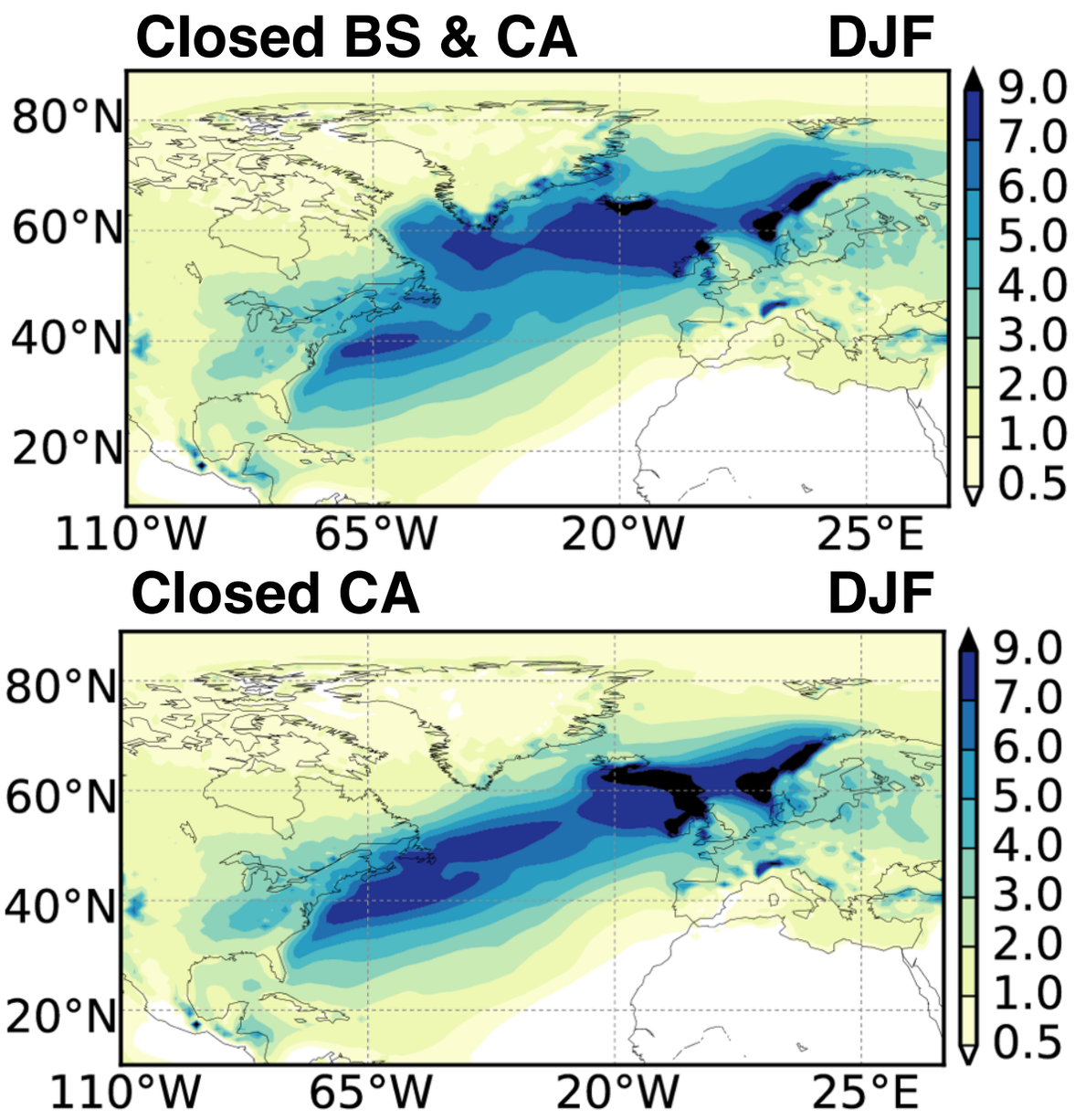


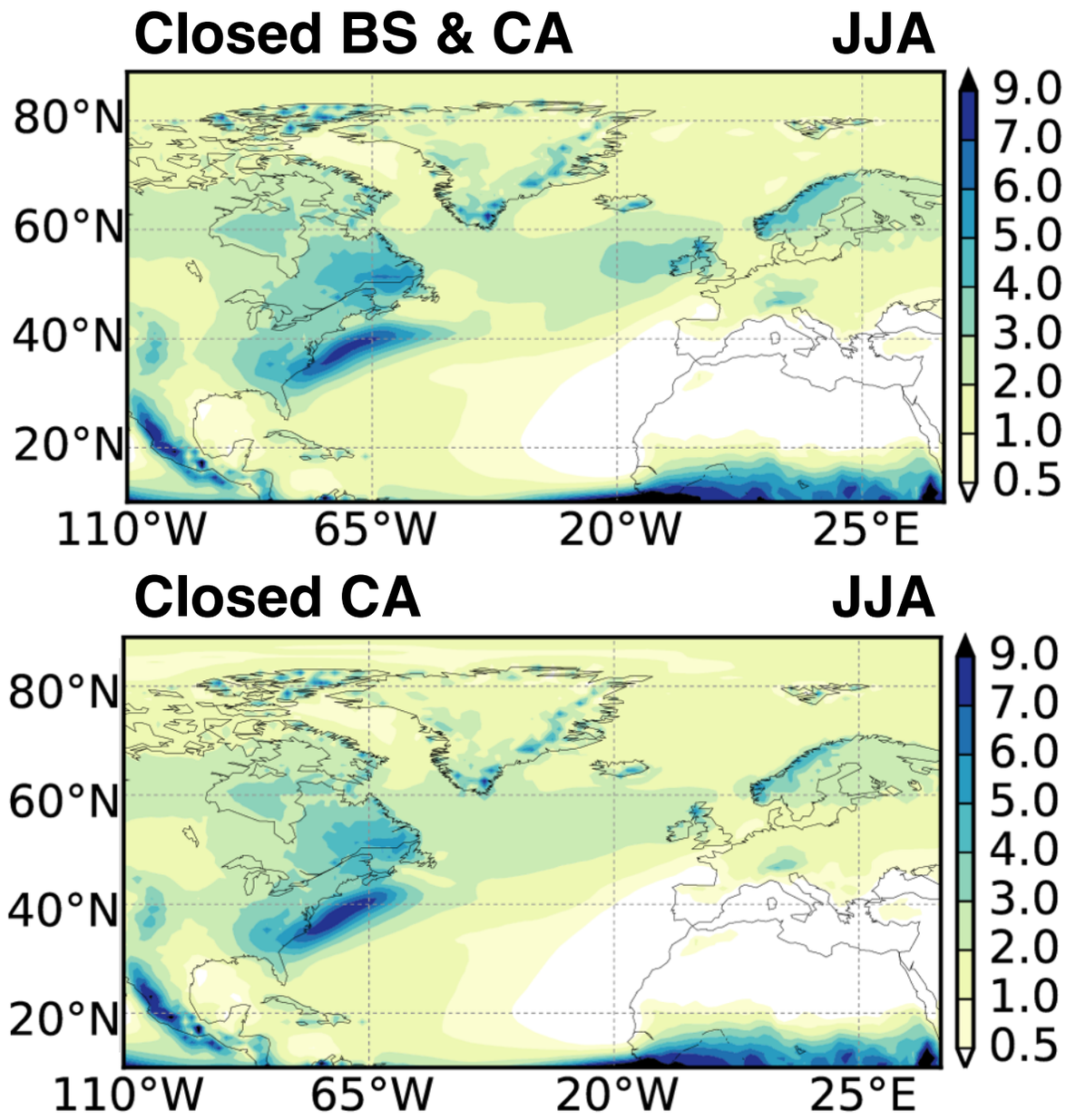
North Atlantic sea-ice [%]



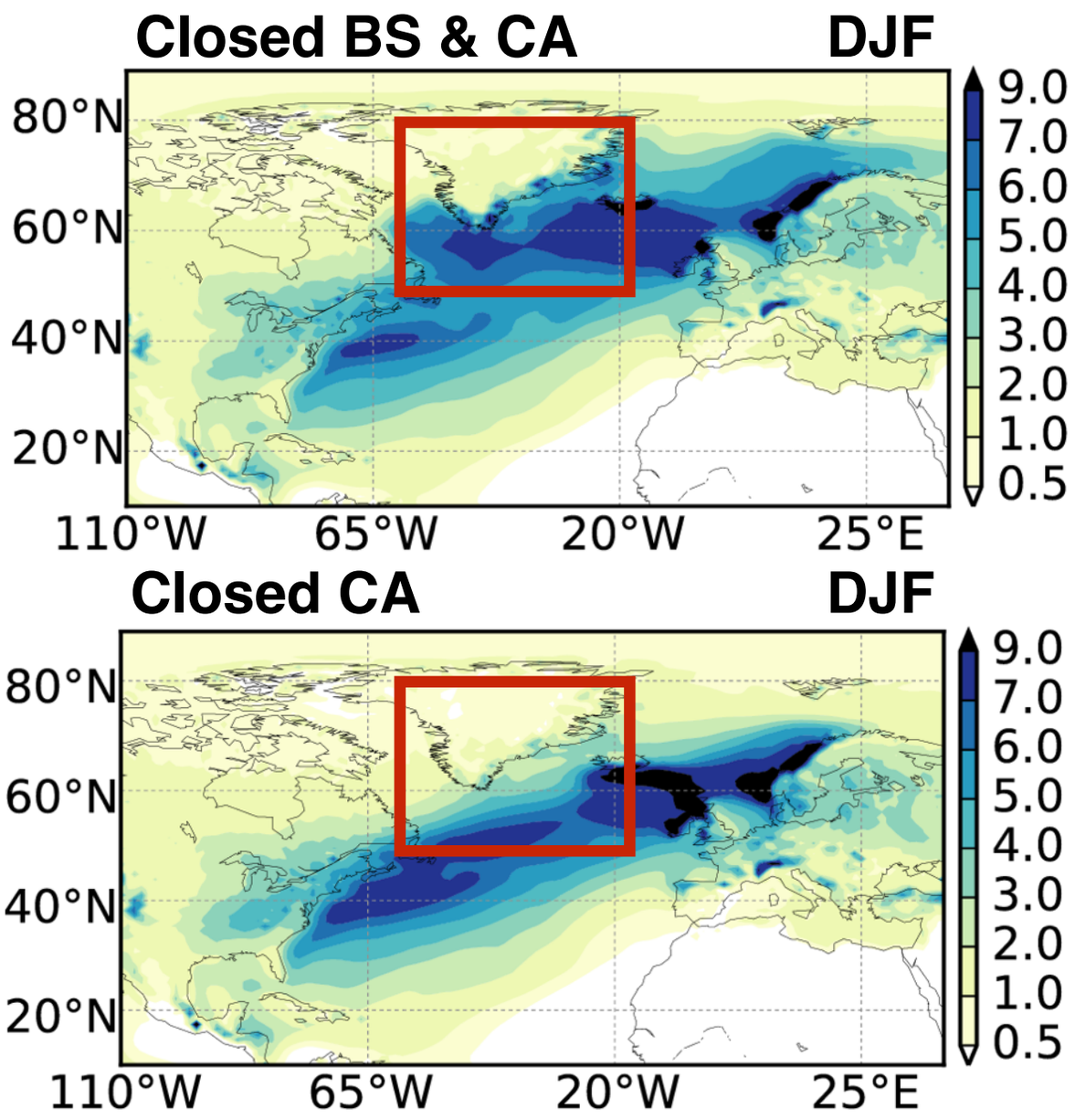


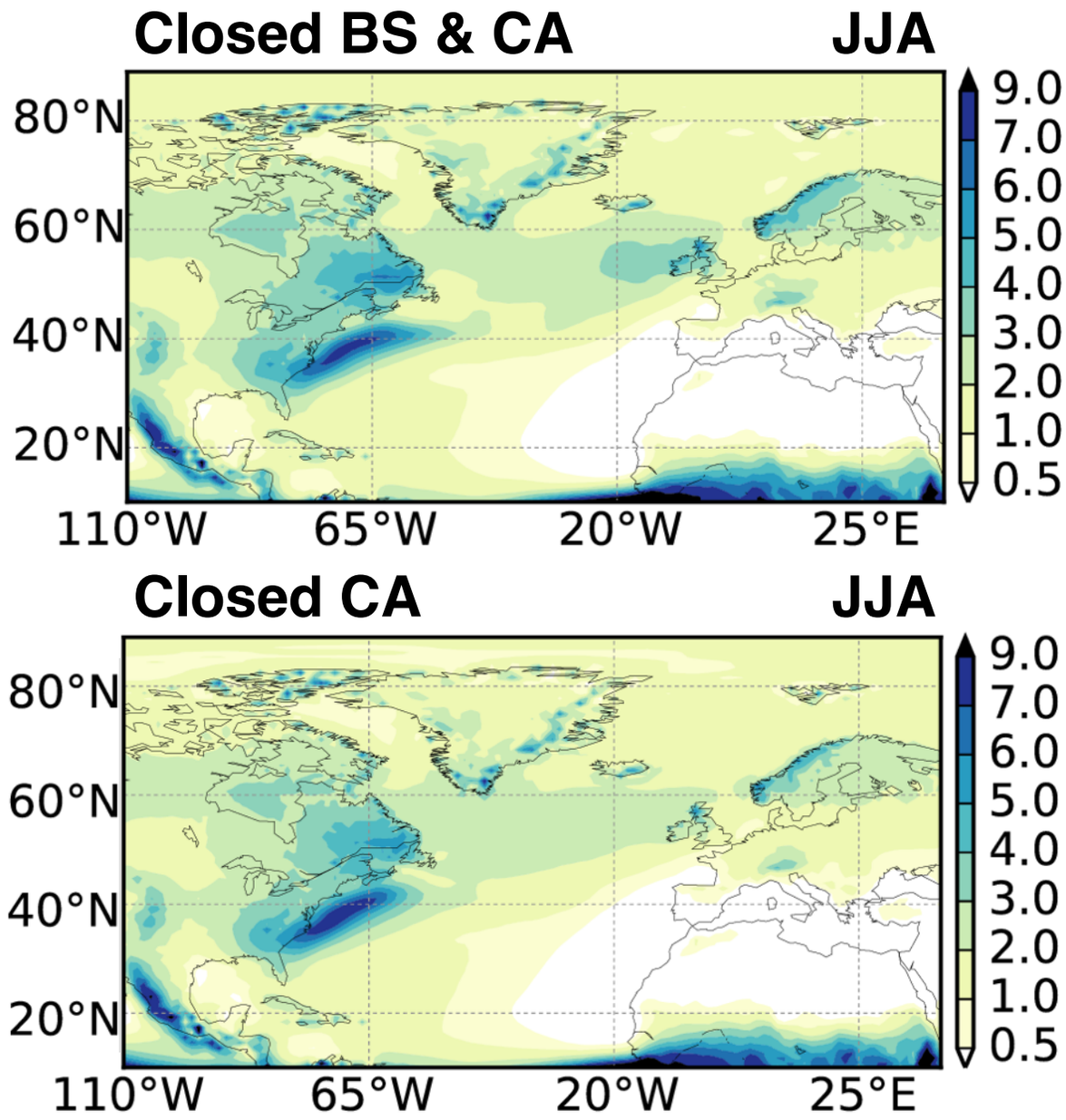
Precipitation [mm/day]



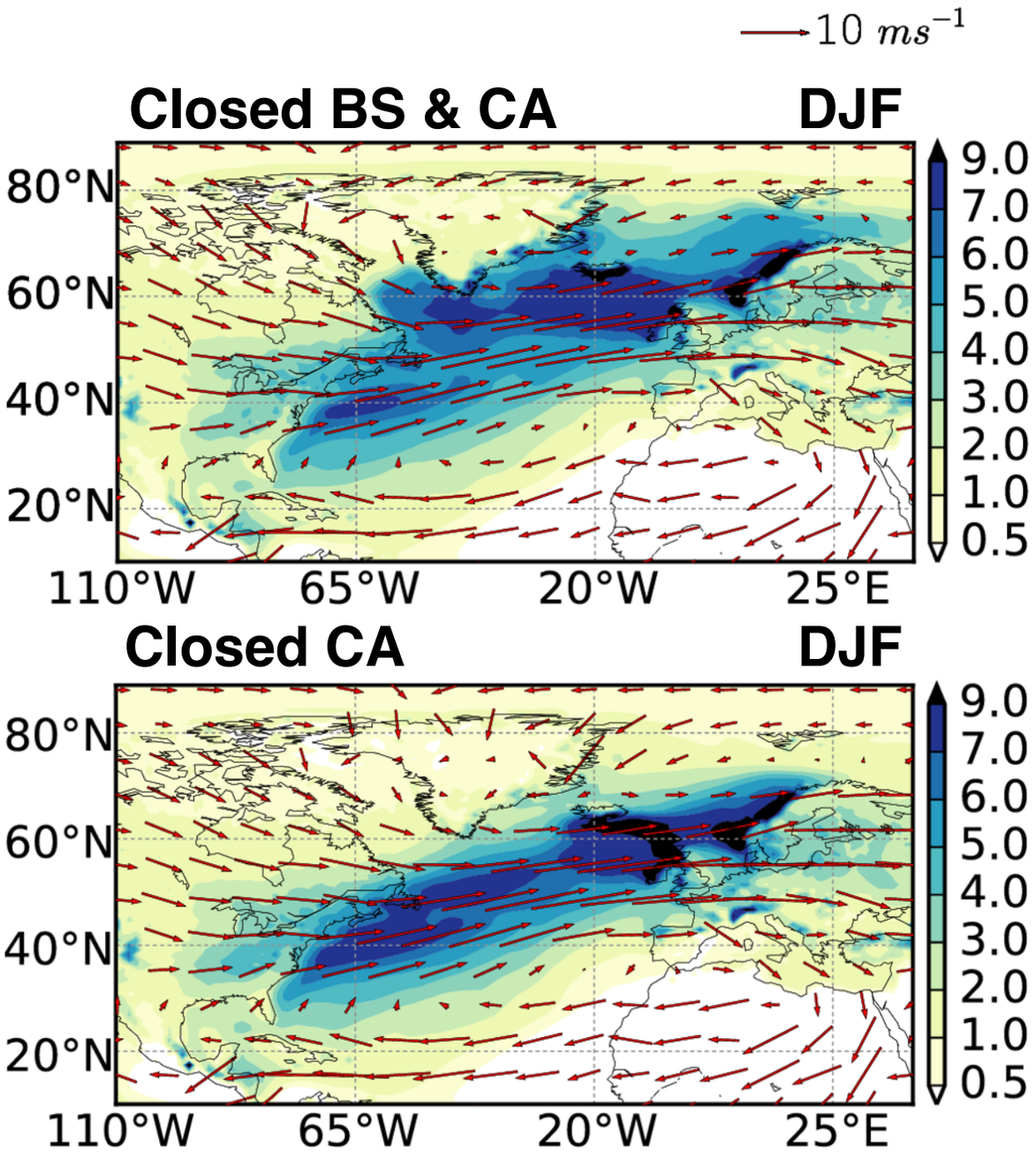


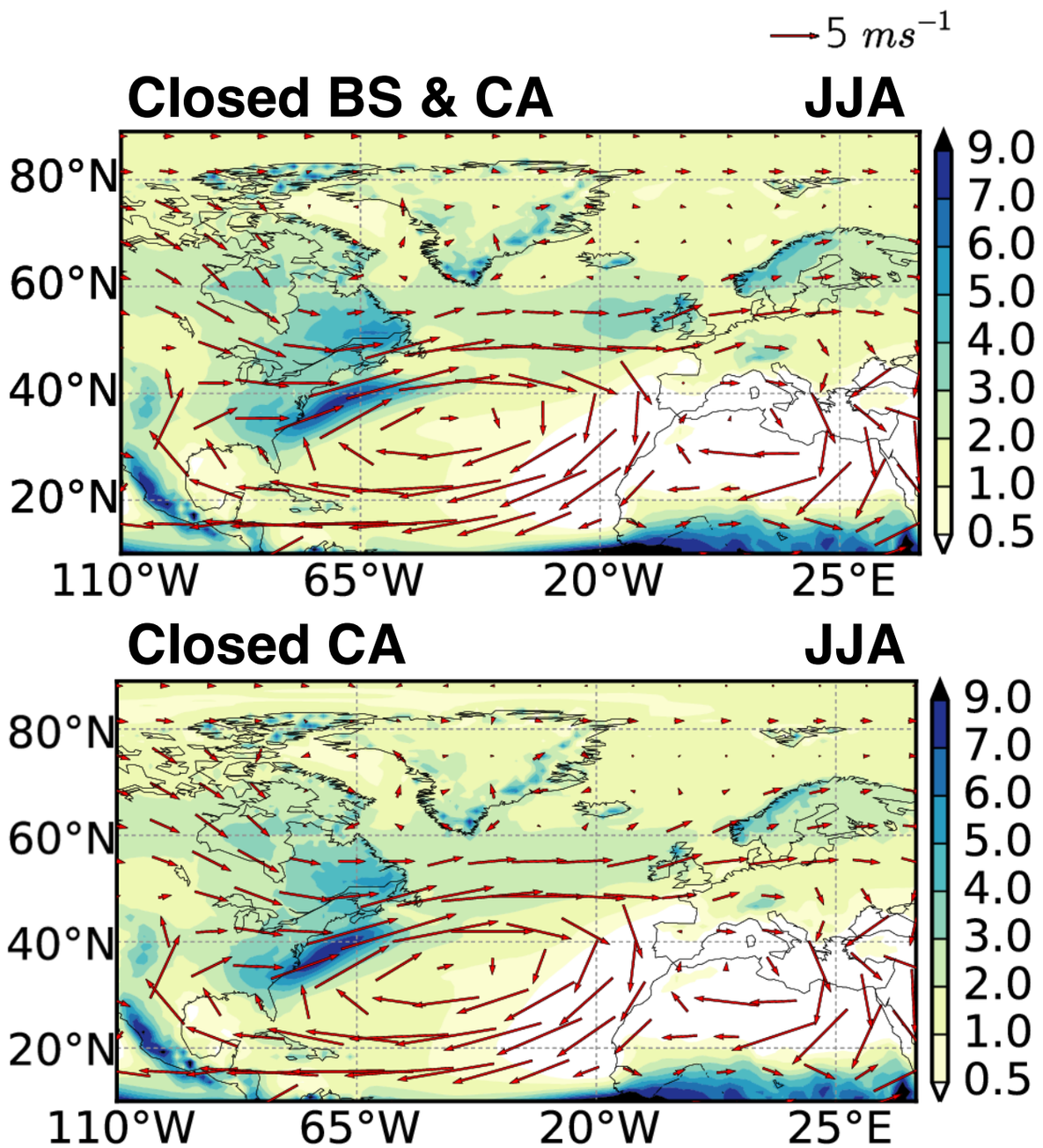
Precipitation [mm/day]



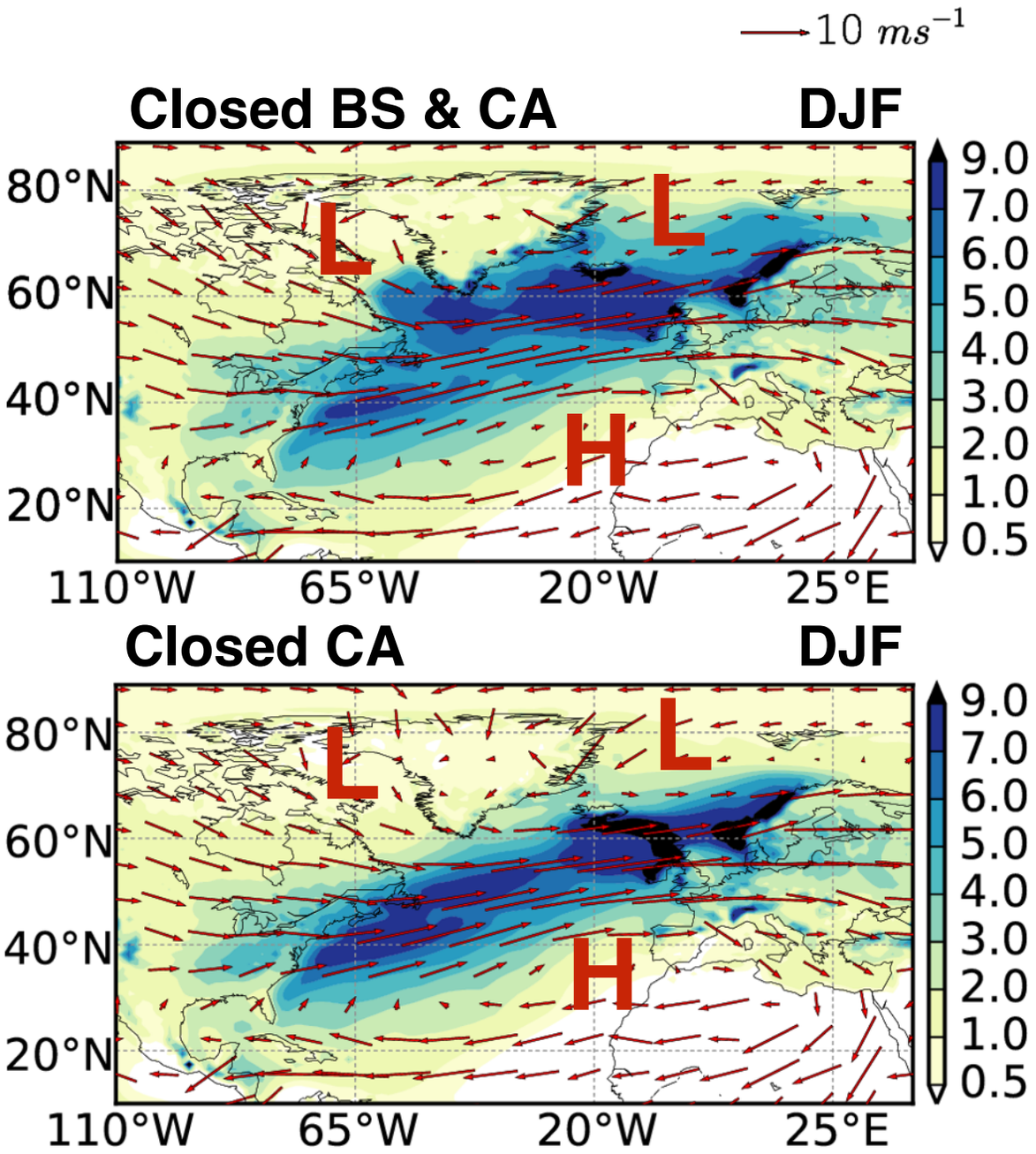


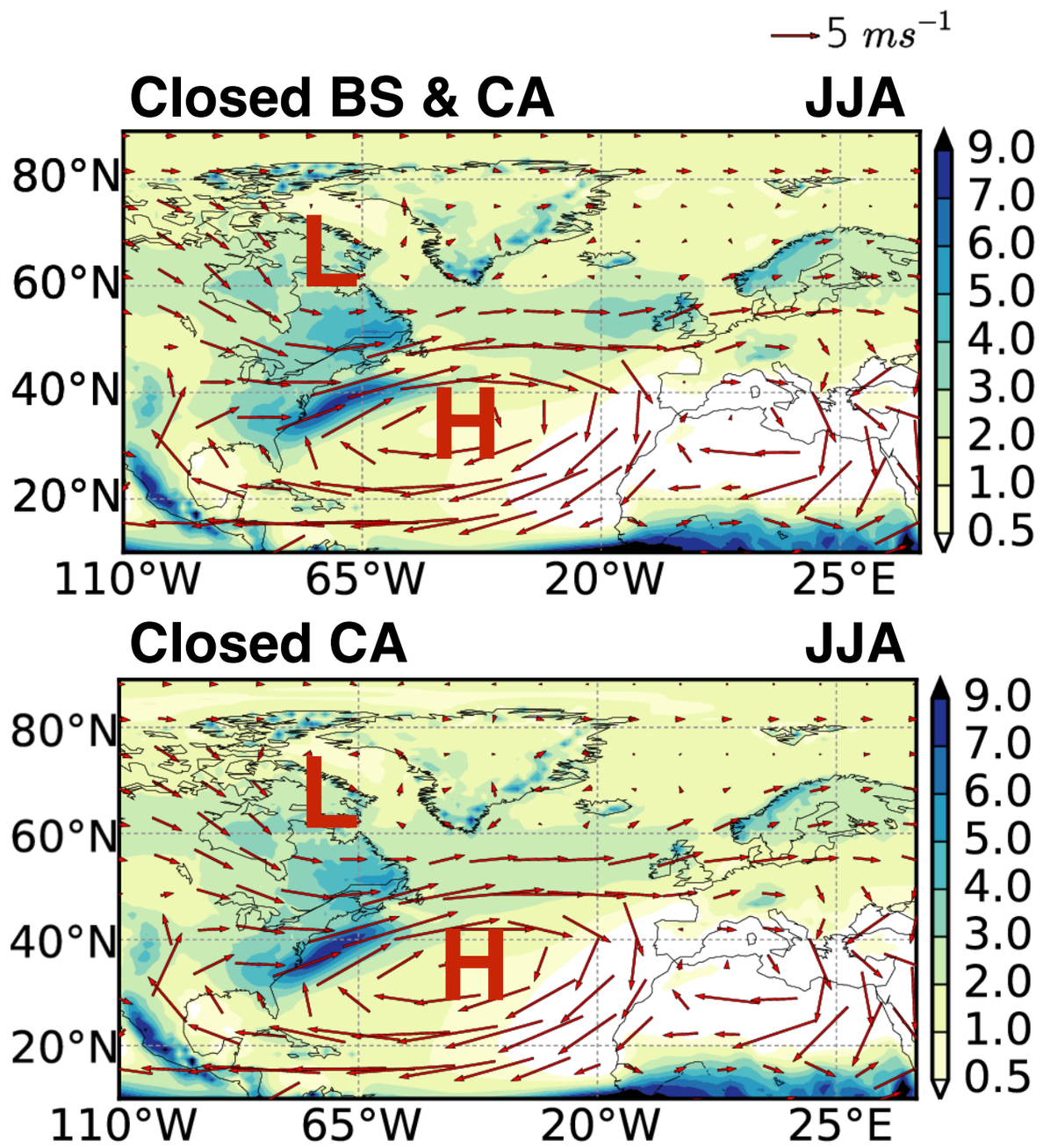
Precipitation [mm/day]



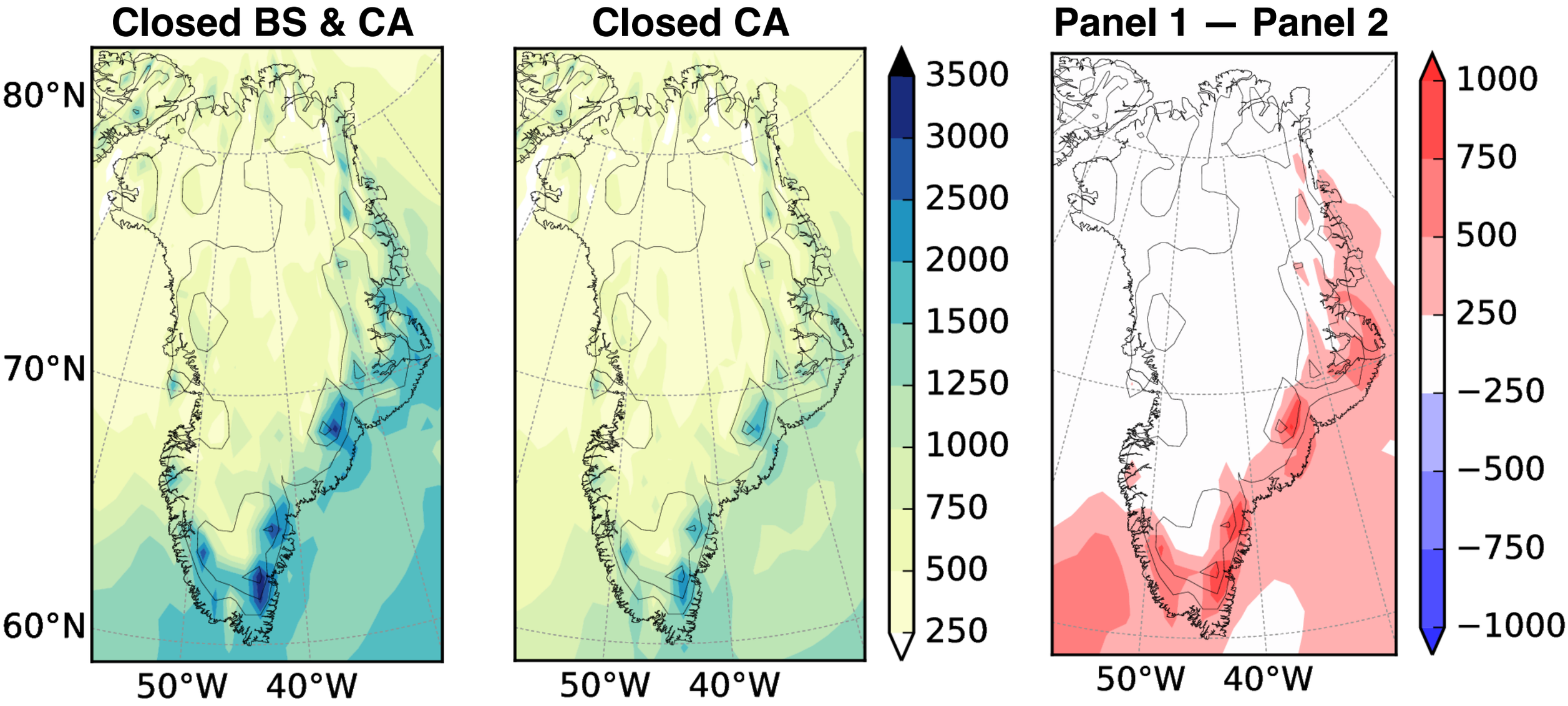


Precipitation [mm/day]

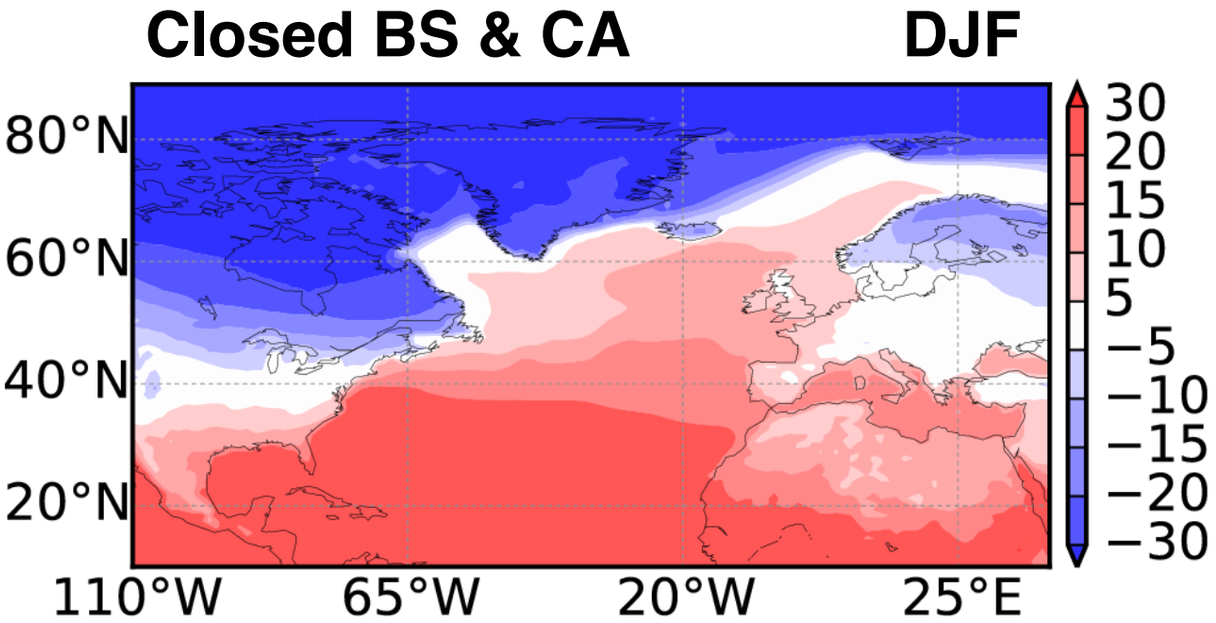


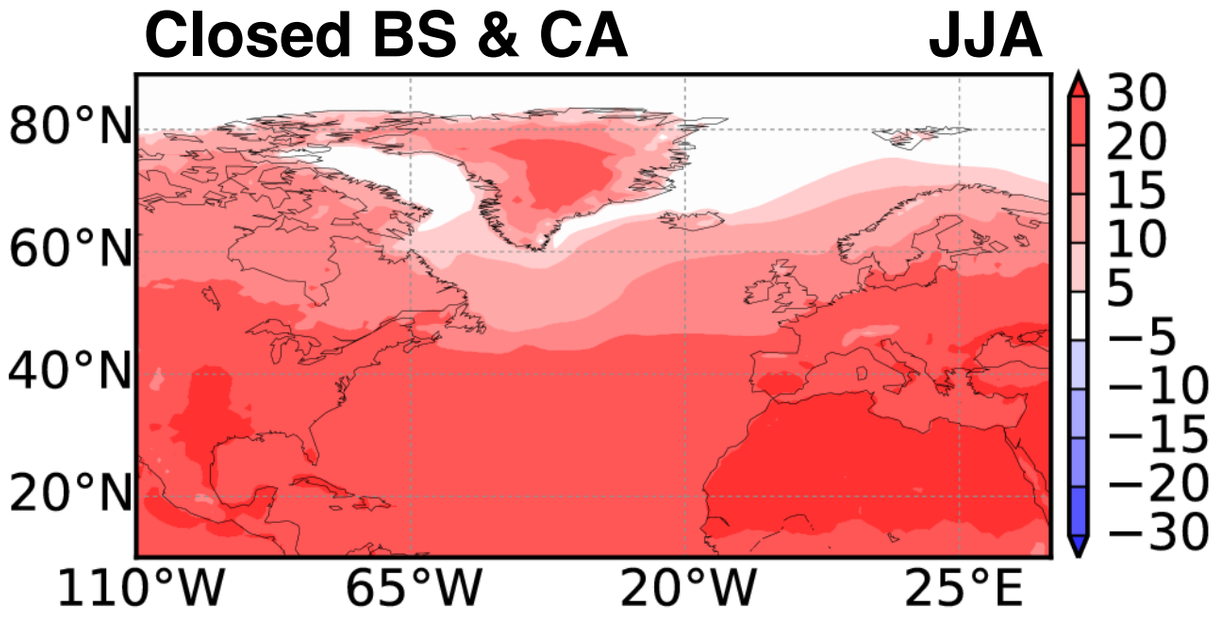


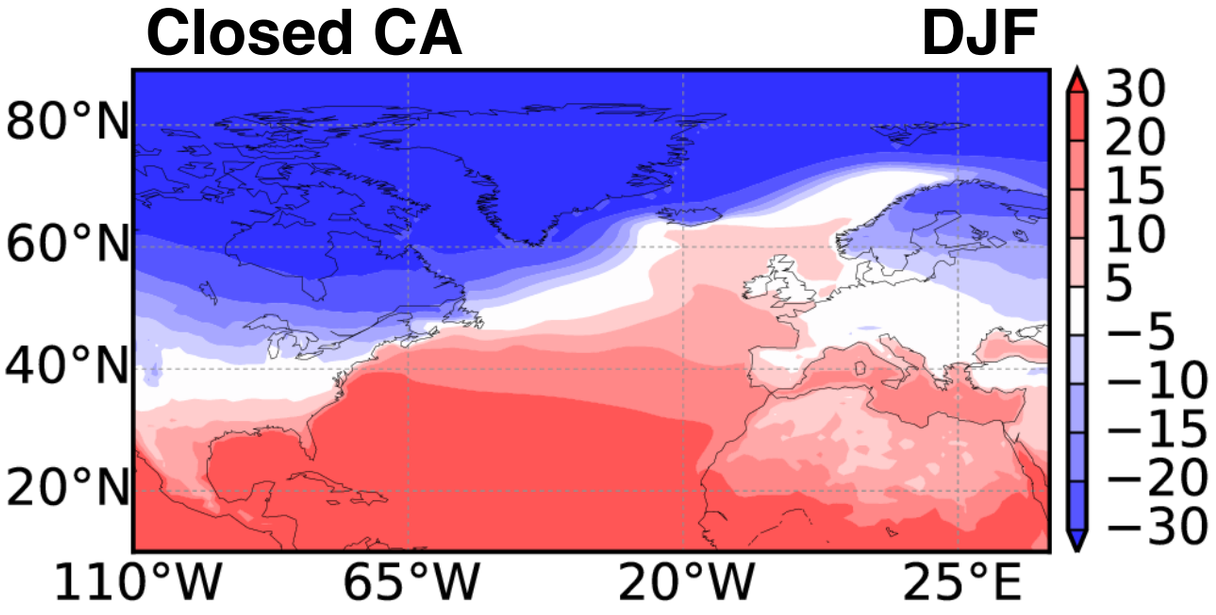
Greenland annual precipitation [mm]

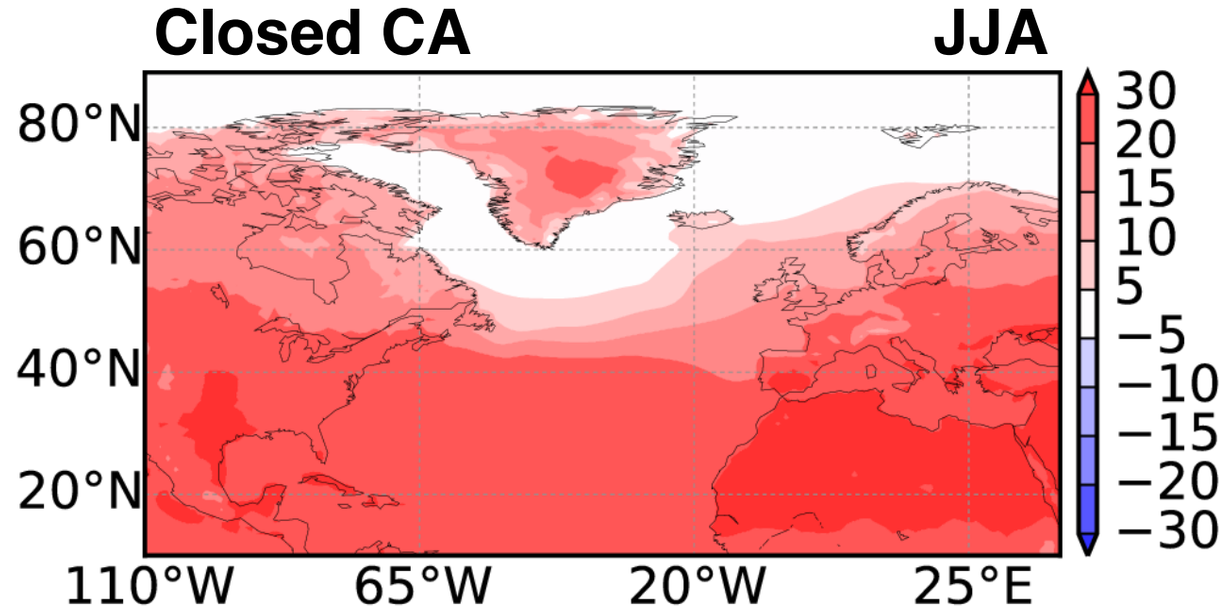


Surface temperature [degC]

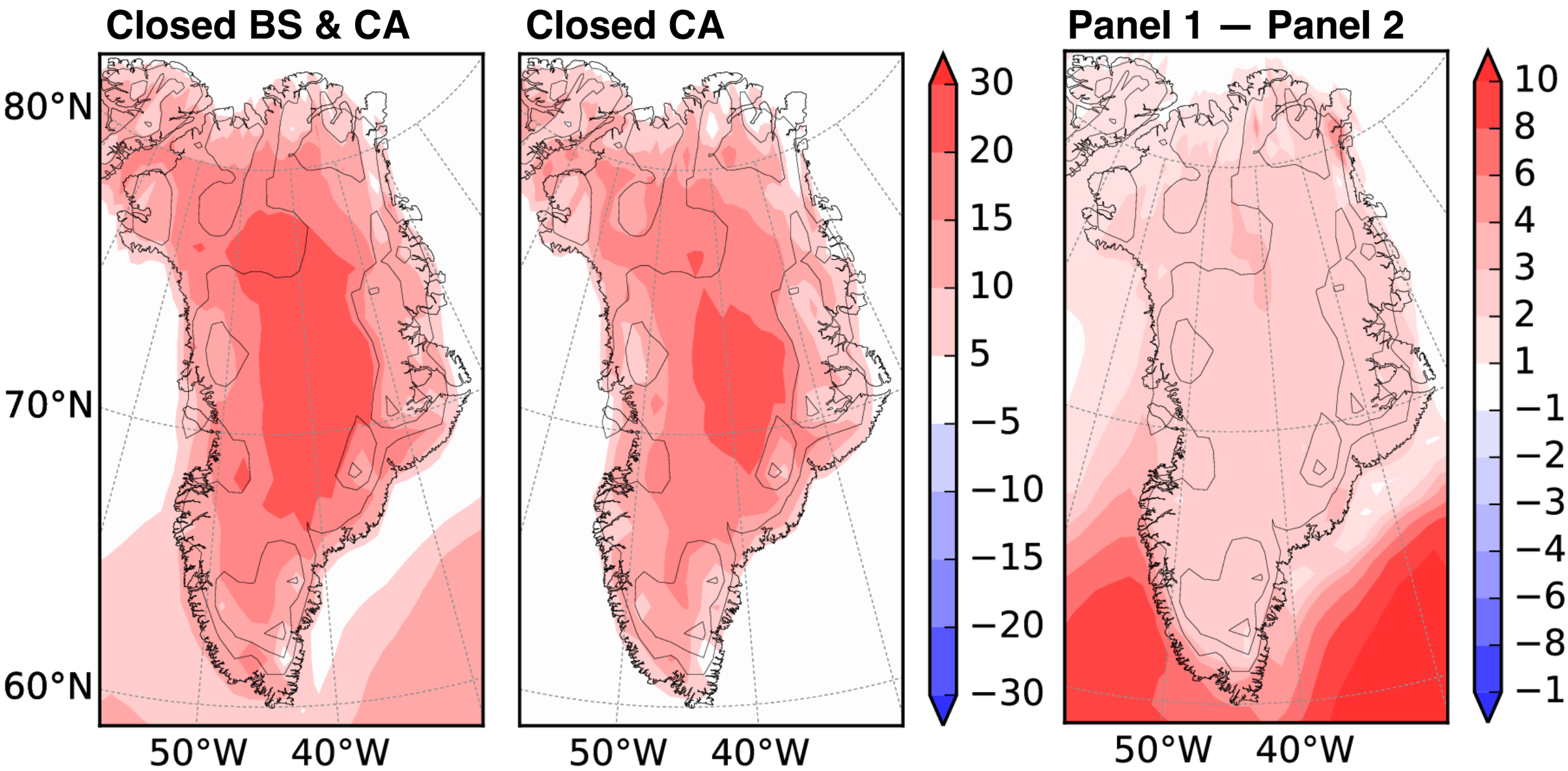






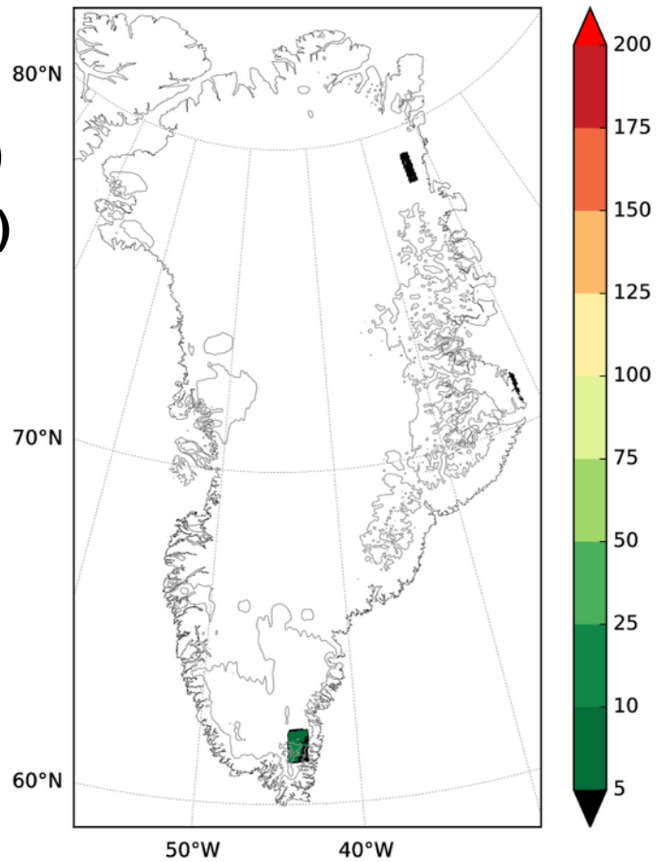


Greenland summer (JJA) temperature [degC]

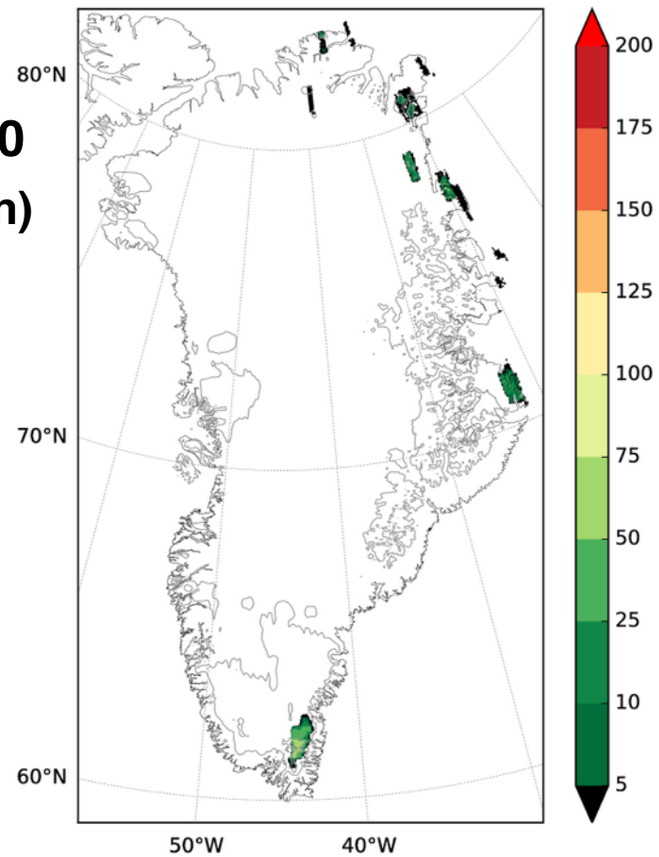


Glacial inception — free running (closed CA)

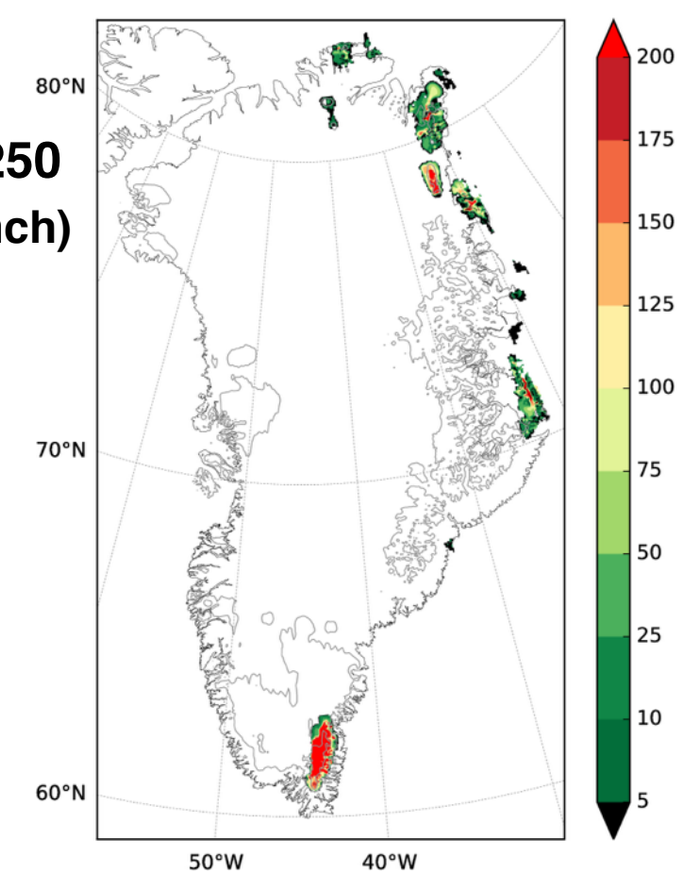
yr 10
(synch)



yr 50
(synch)



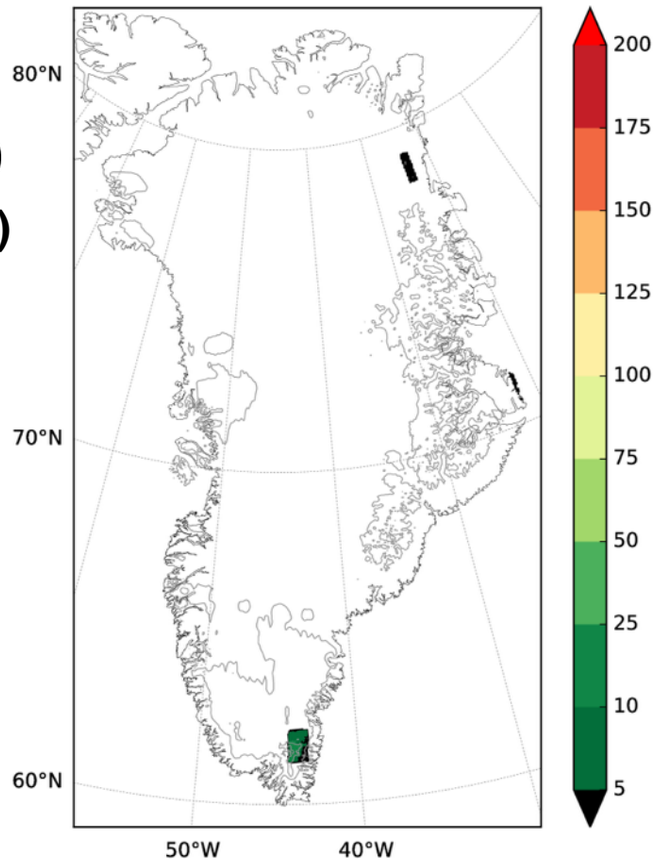
yr 250
(asynch)



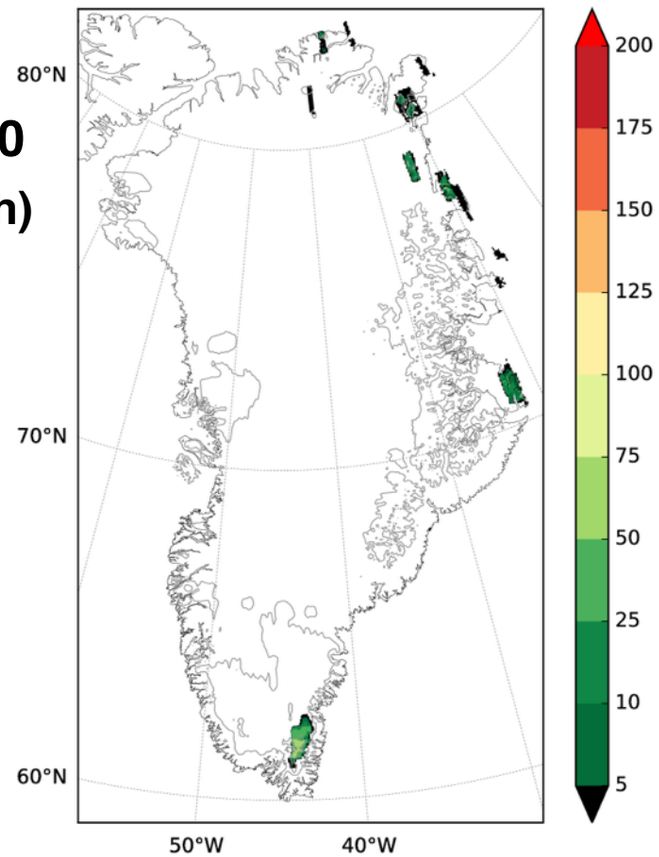
synch: yrs 0-50
10 yr asynch: yrs 50-550
20 yr asynch: yrs 550-inf

Glacial inception — free running (closed CA)

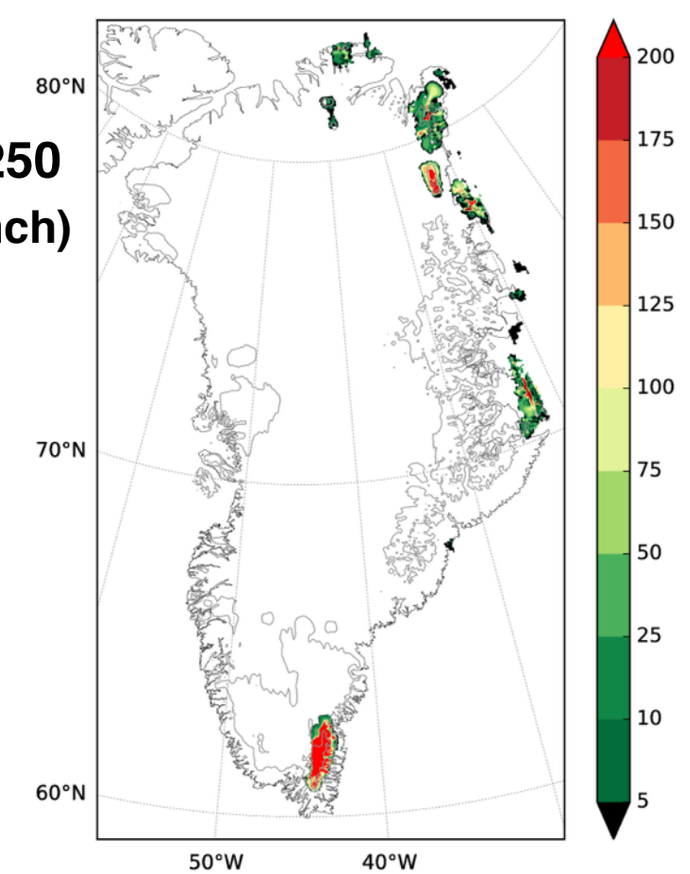
yr 10 (synch)



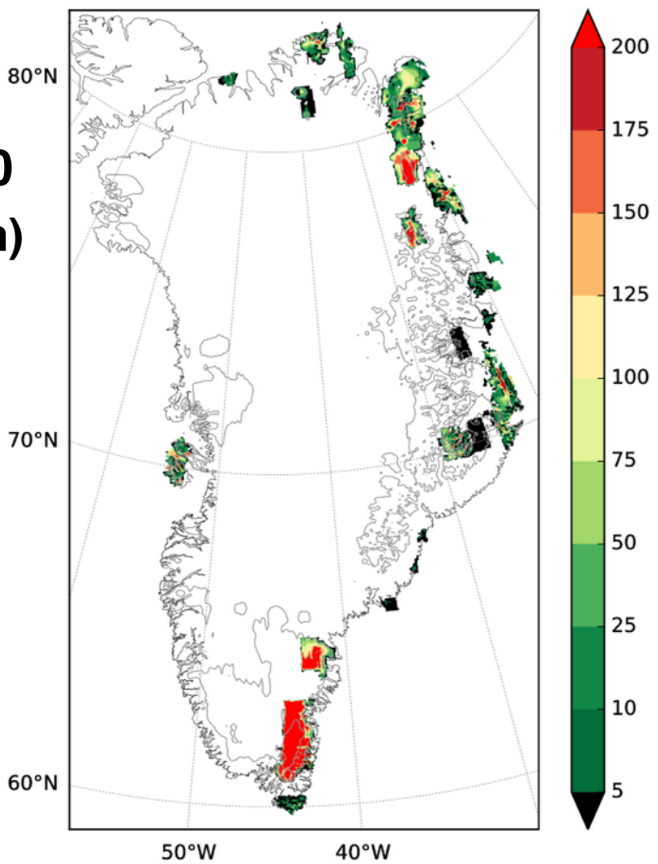
yr 50 (synch)



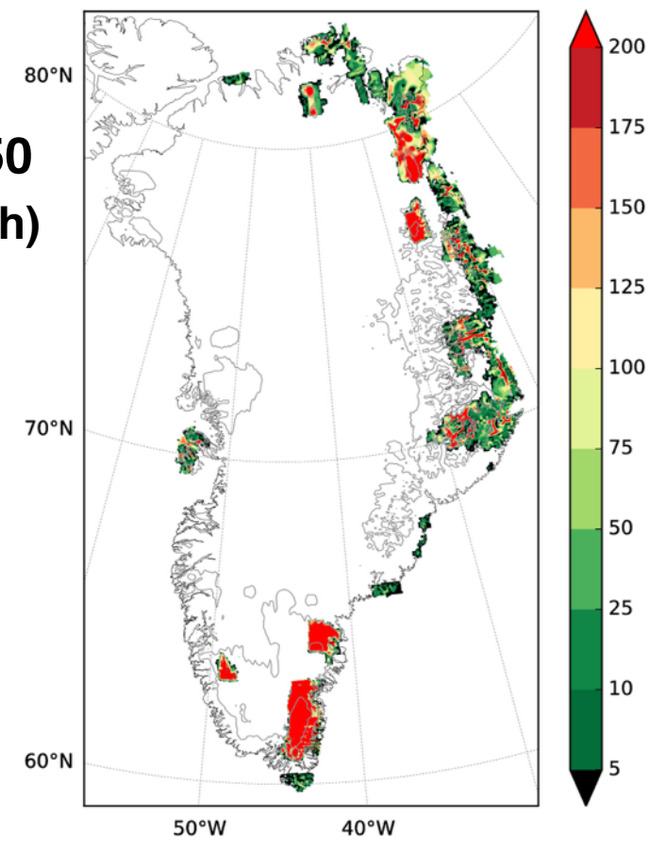
yr 250 (asynch)



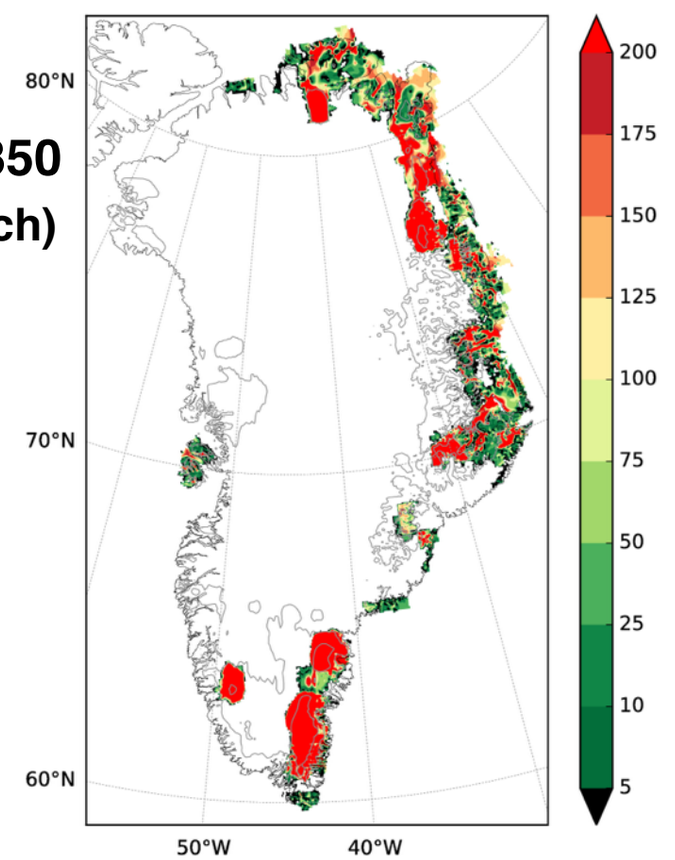
yr 500 (asynch)



yr 750 (asynch)

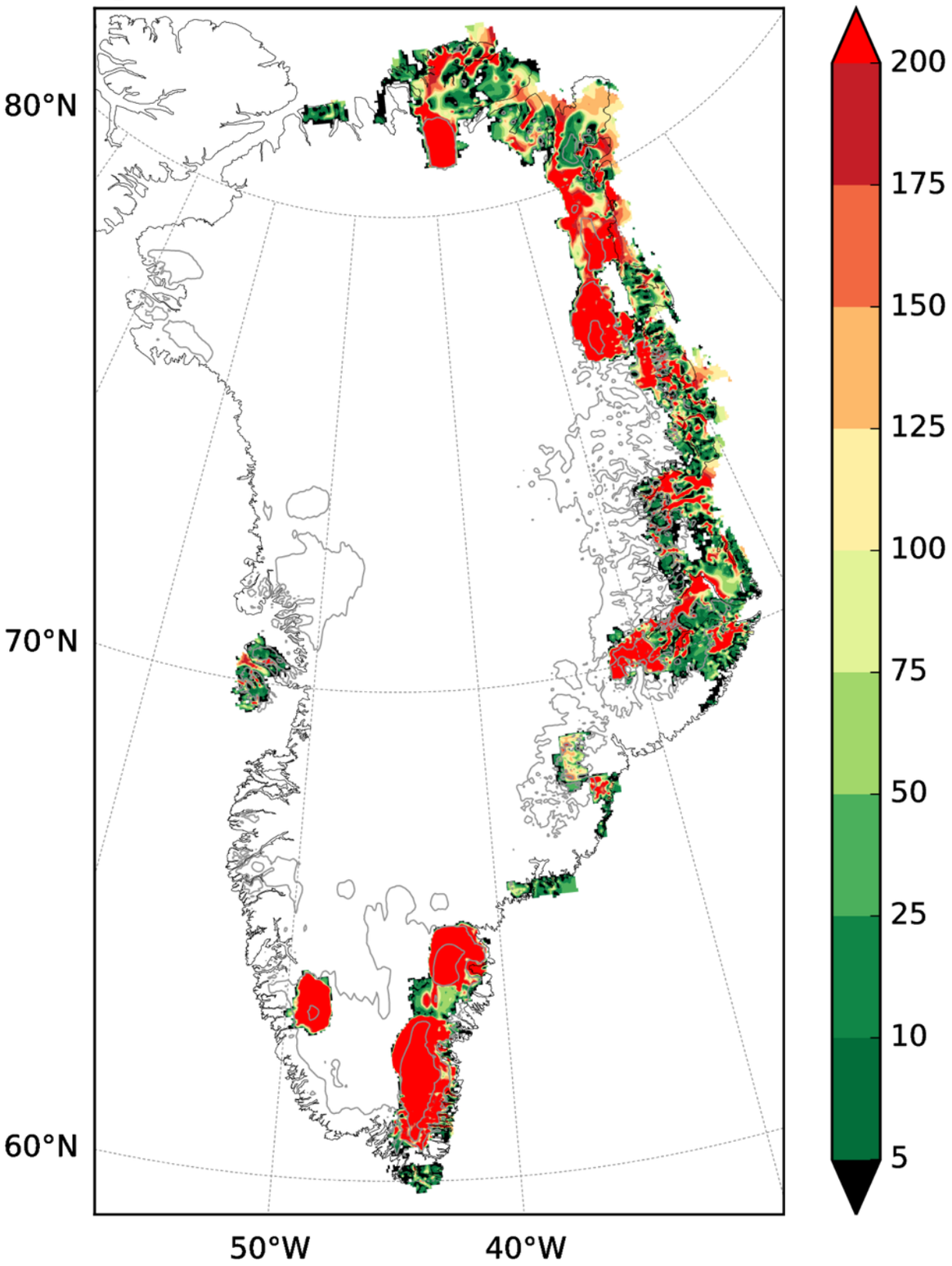


yr 1350 (asynch)

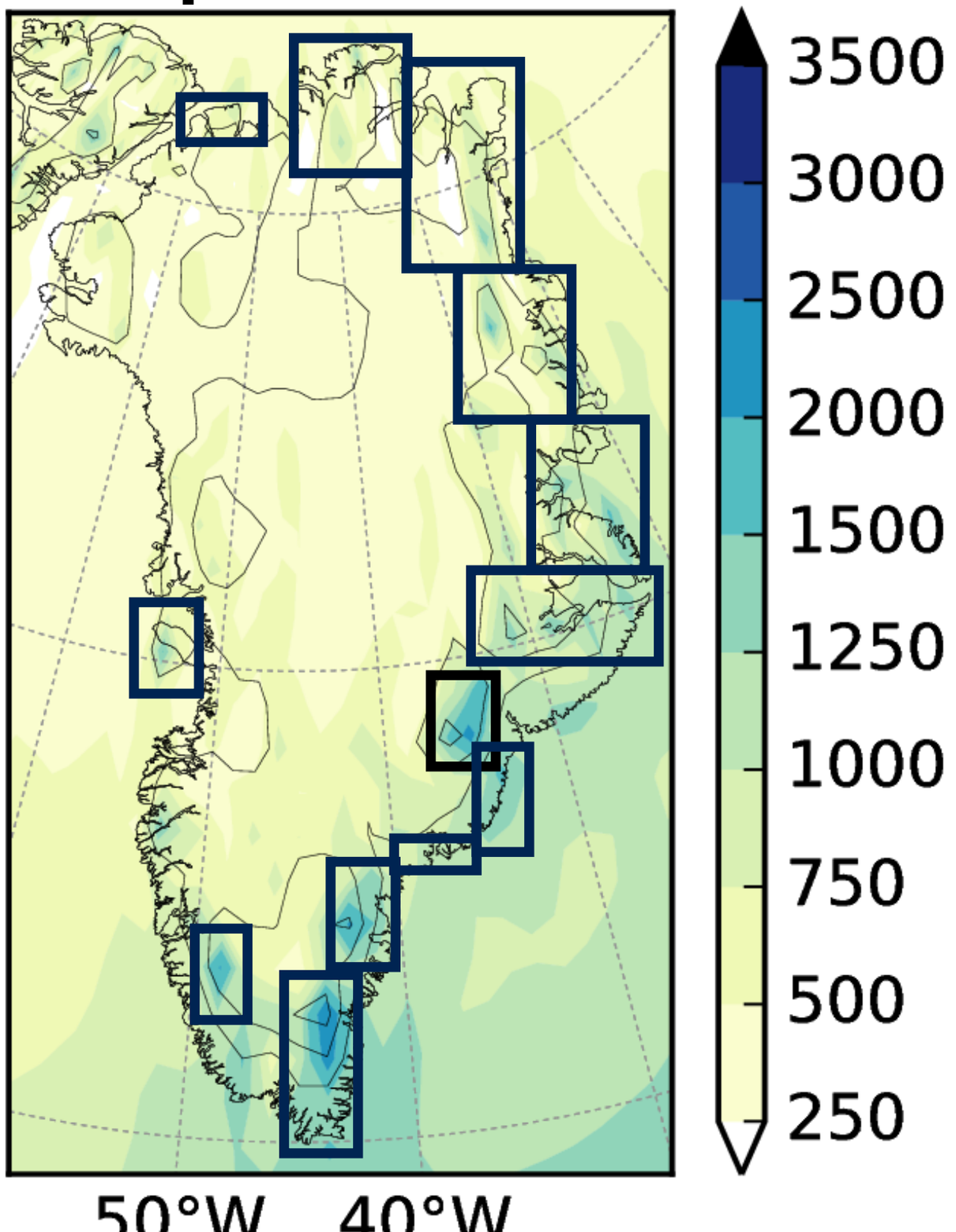


Glacial inception — free running (closed CA)

yr 1350

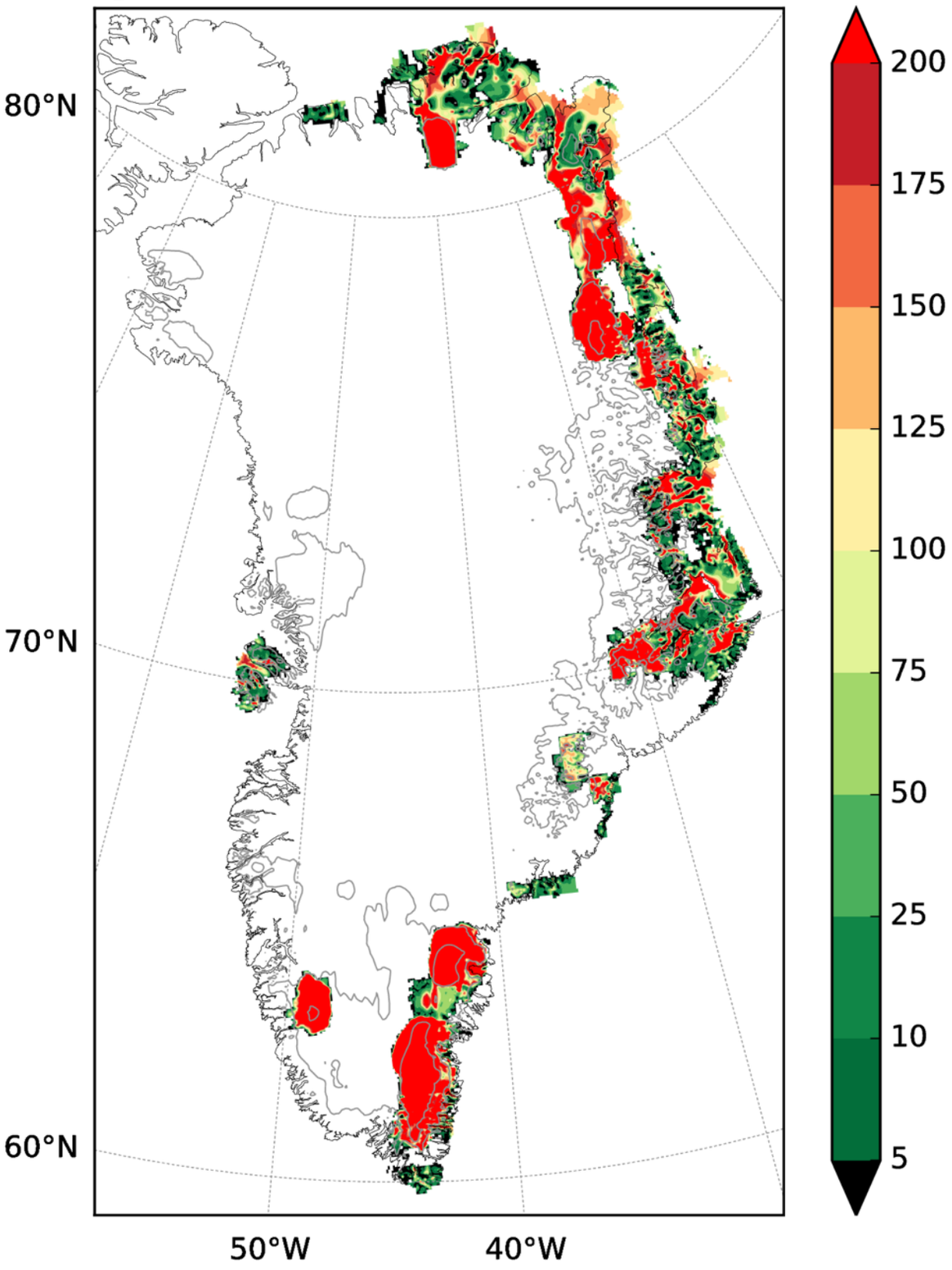


inception

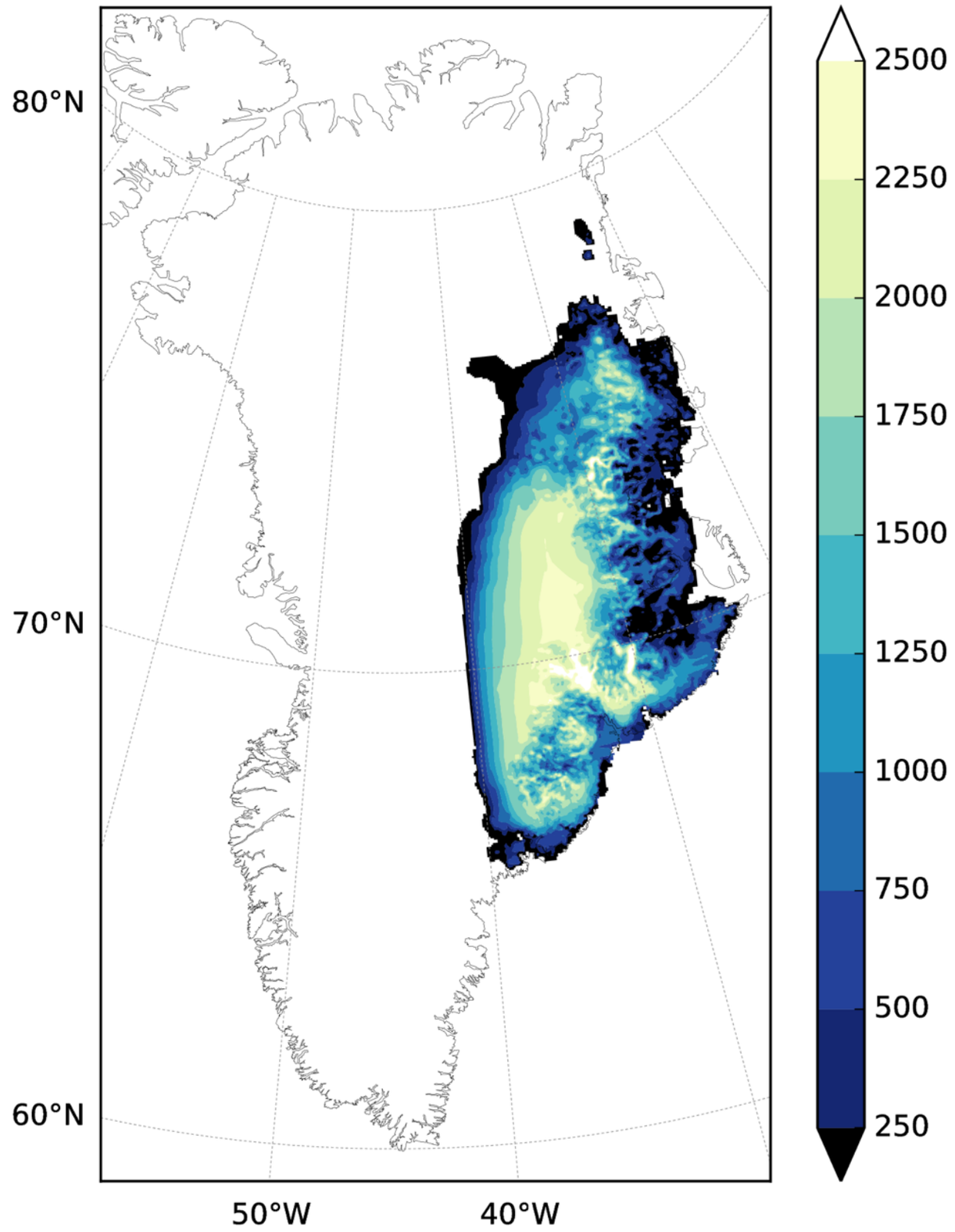


Glacial inception — free running (closed CA)

yr 1350

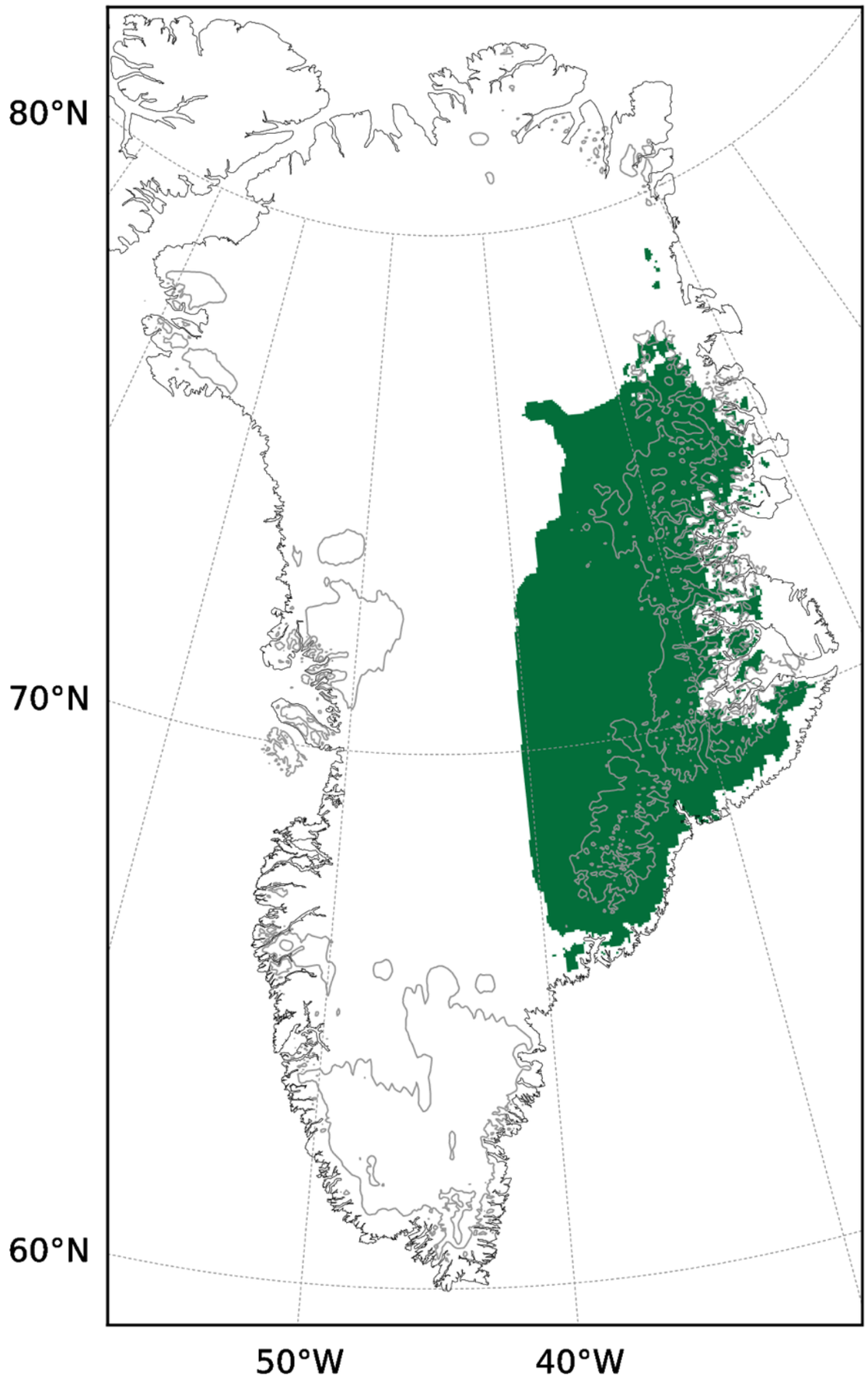


PlioMIP2



Glacial inception — PlioMIP2 outline (10m)

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



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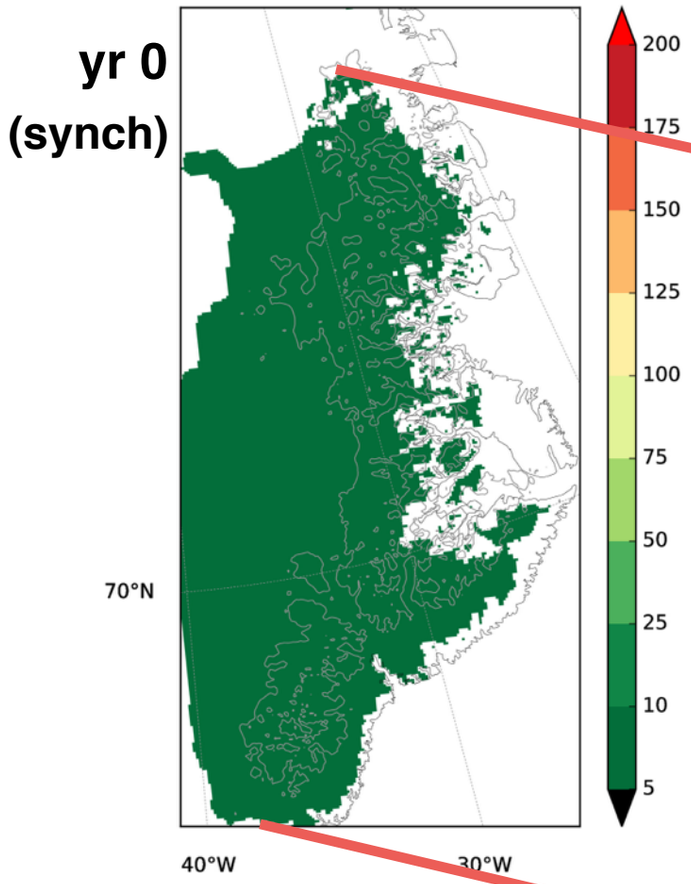
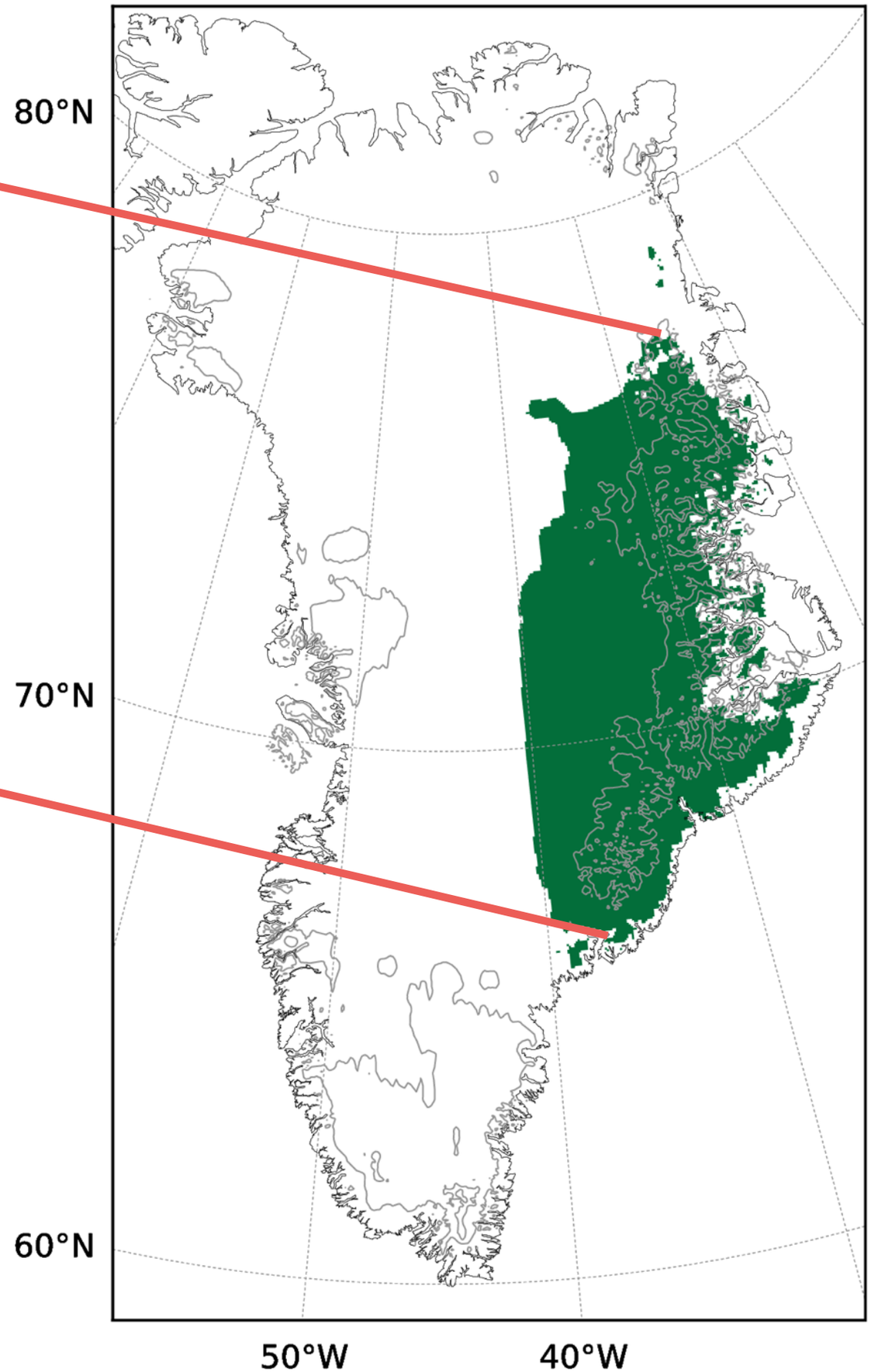
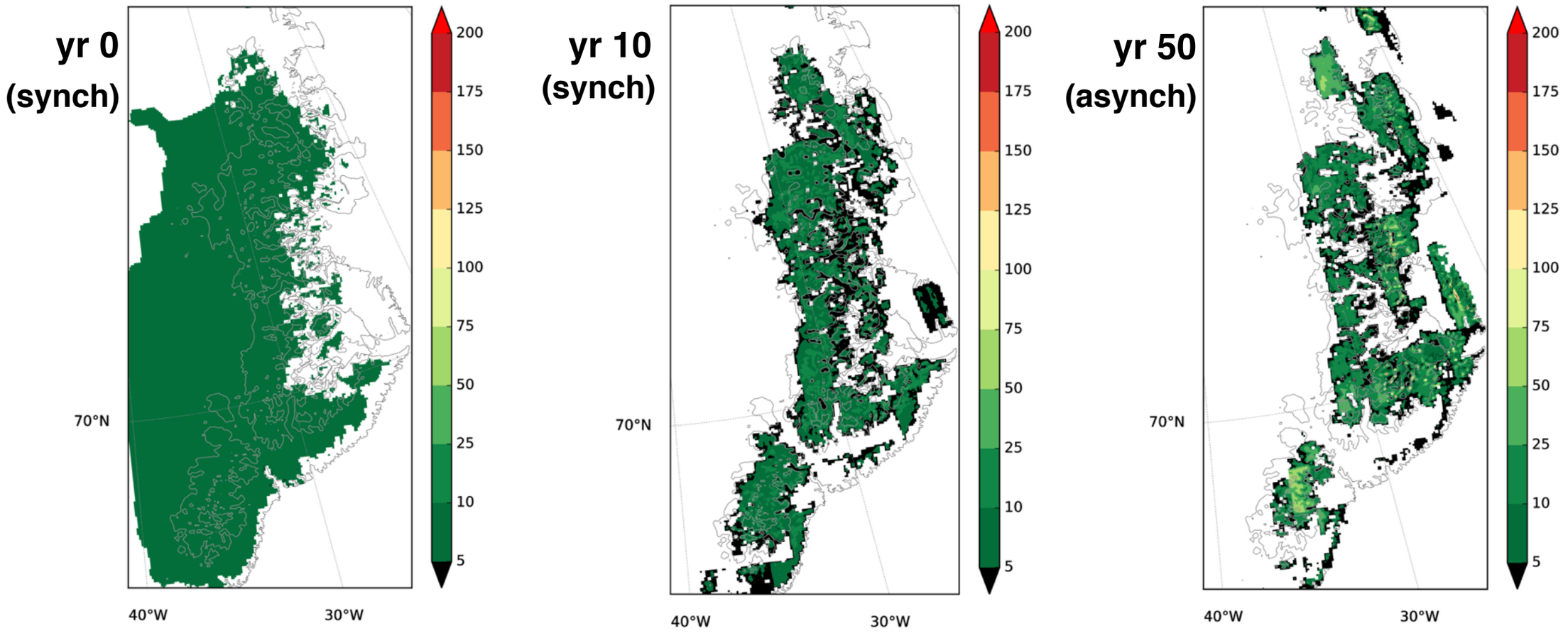




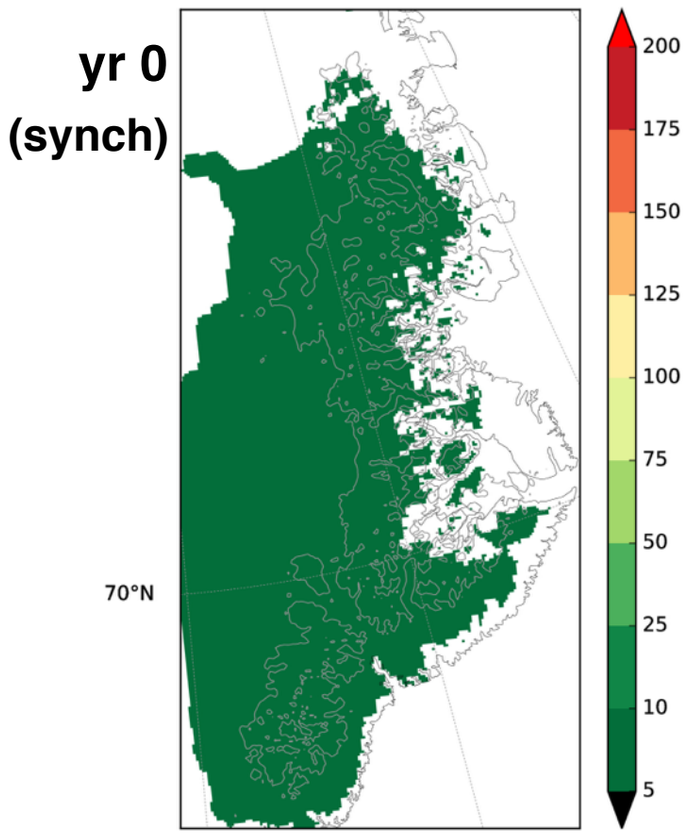
synch: yrs 0-50

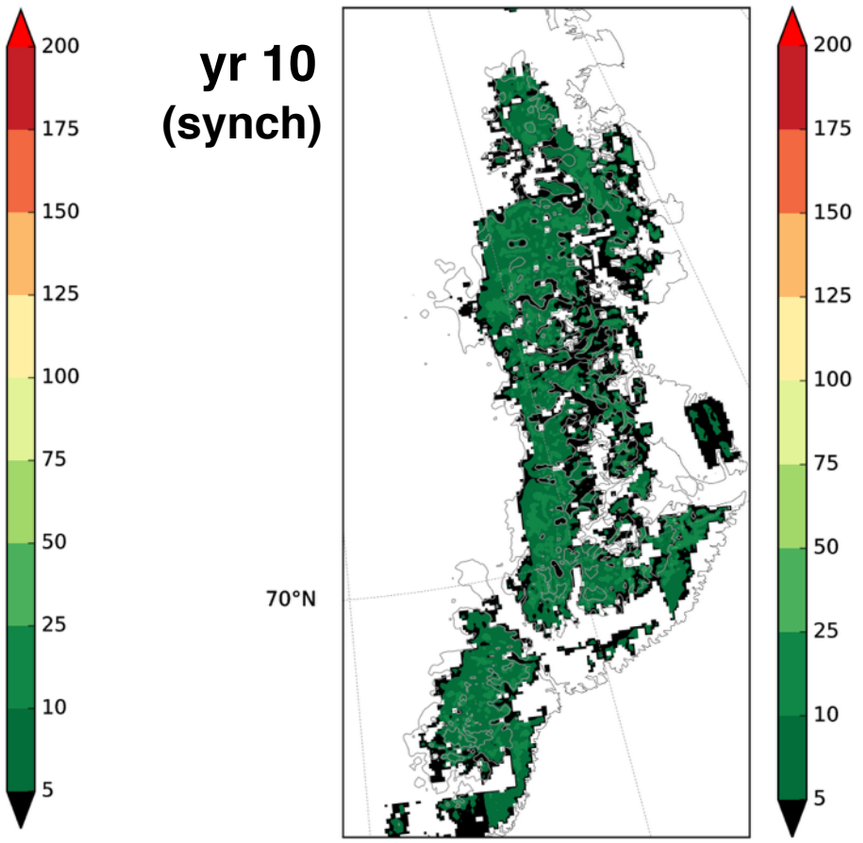
10 yr asynch: yrs 50-inf

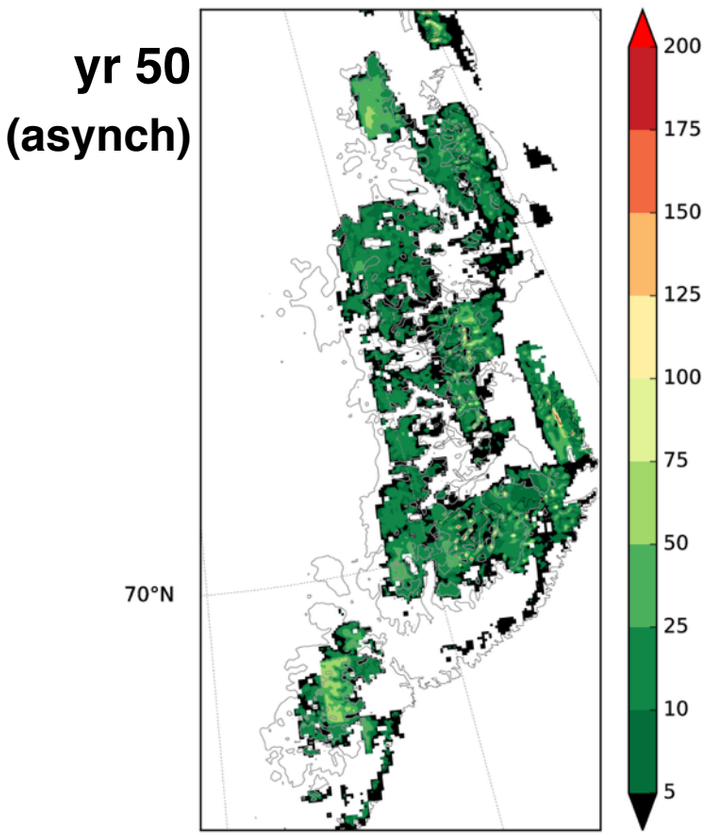
Glacial inception — PlioMIP2 outline (10m)

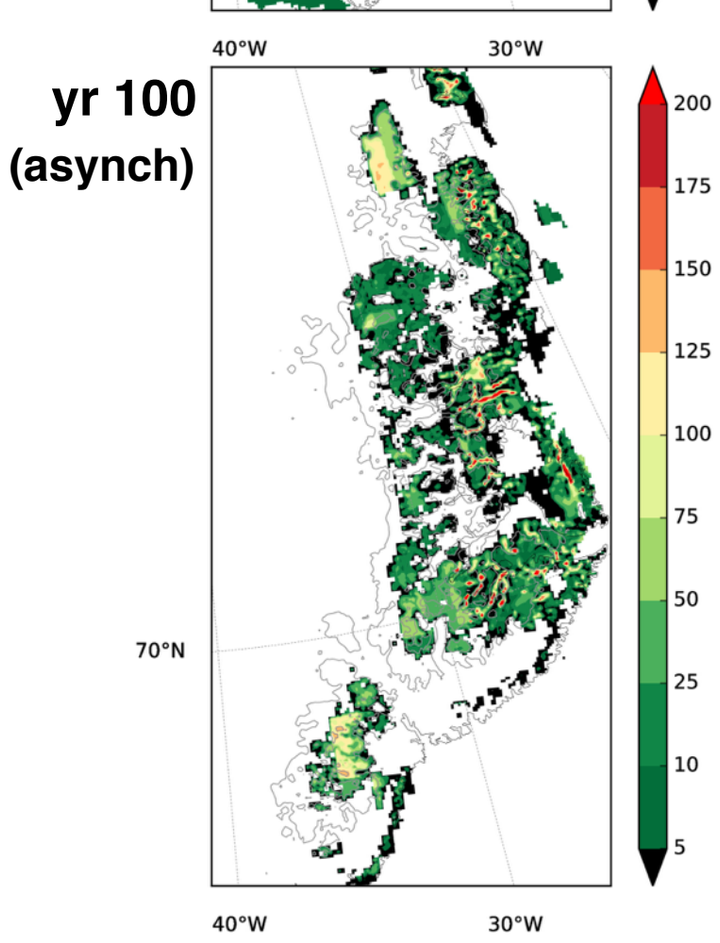


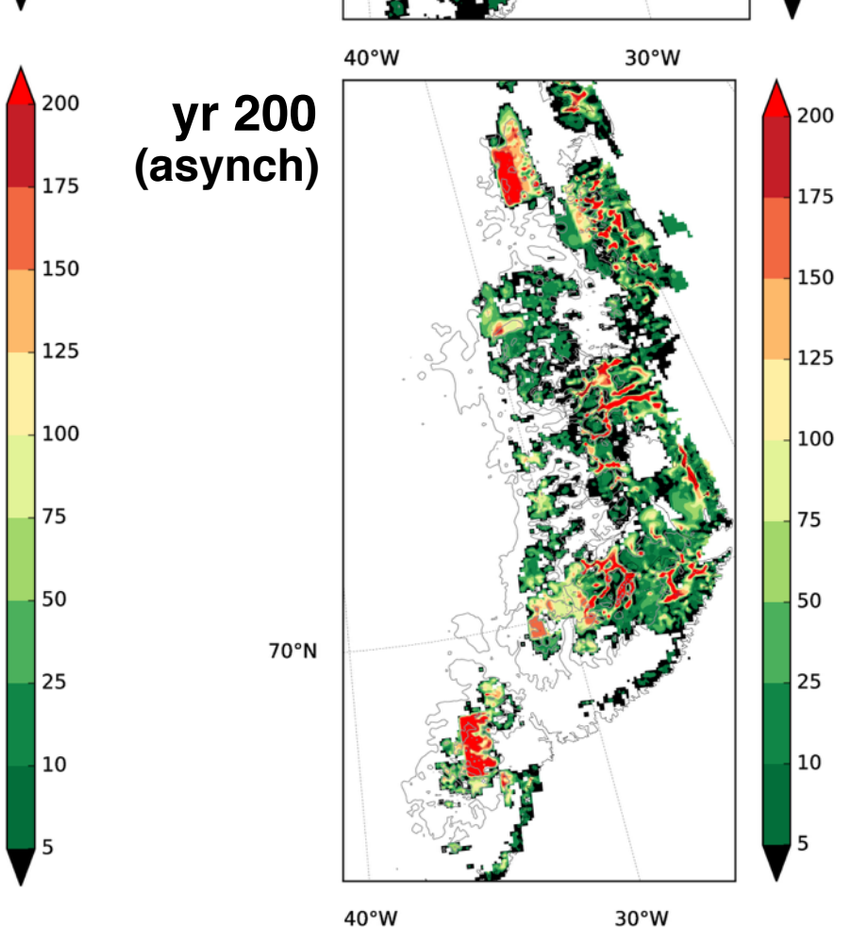
Glacial inception — PlioMIP2 outline (10m)

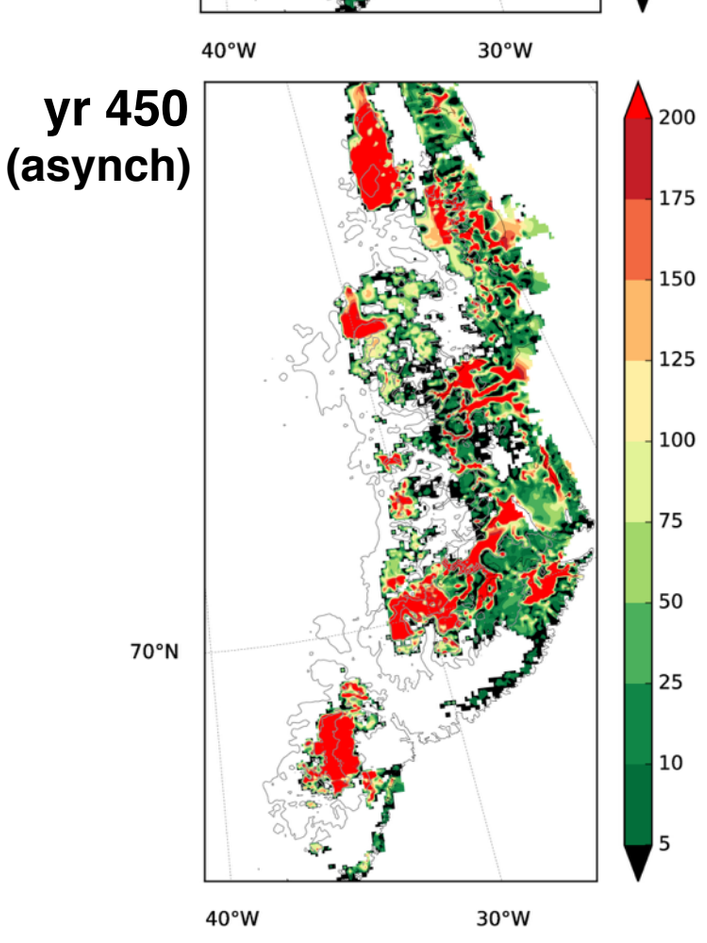






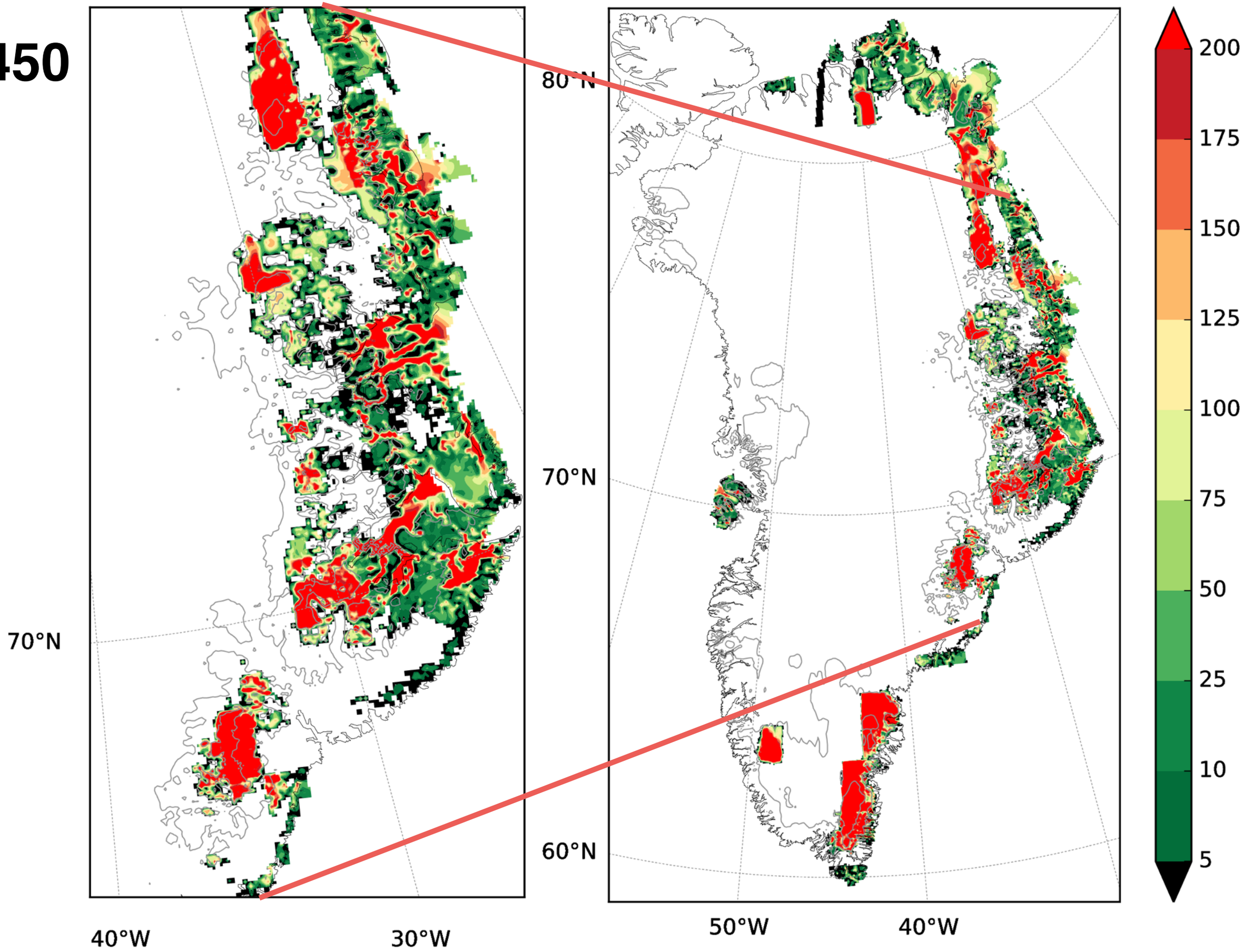






Glacial inception — PlioMIP2 outline (10m)

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