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

![Graph of TOA insolation at 60°N at summer solstice (Wm$^{-2}$)](image-url)
North Atlantic sea-ice [%]
Precipitation [mm/day]
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 CA

DJF

Closed BS & CA

JJA

Closed CA

JJA
Greenland summer (JJA) temperature [degC]

Closed BS & CA

Closed CA

Panel 1 — Panel 2
Glacial inception — free running (closed CA)

**synch:** yrs 0-50
**10 yr asynch:** yrs 50-550
**20 yr asynch:** yrs 550-inf
yr 1350

Glacial inception — free running (closed CA)
Glacial inception — free running (closed CA)

yr 1350

PlioMIP2
synch: yrs 0-50
10 yr asynch: yrs 50-inf
Glacial inception — PlioMIP2 outline (10m)

**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

[Map showing glacier distribution and extent over a 10m resolution grid at 450 years ago.]
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