development, spinup procedure, and initial synchronous multi-millennial simulations of a coupled ice sheet / global climate model

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synopsis

• model set-up
  – ice and climate model descriptions
  – mass balance generation and downscaling
  – surface air temperature bias correction
• spin-up procedure
• present model performance
• initial equilibrium-\(\text{CO}_2\) simulations
model description: UVic ESCM
model description: PSUI

- 3D thermomechanical
- ‘heuristic’ combination of shallow ice approximation and vertically averaged shelfy-stream velocities
- implementation of Schoof (2007) grounding line parameterization
• climate model: 3.6°(lon) x 1.8°(lat)
• ice models: 20 km²
coupling

UVic ESCM passes:
• surface mass balance
• sub-shelf melting rate
  (currently non-interactive)
• boundary temperatures

ice model returns:
• revised elevation
• revised surface albedo
• ice sheet distribution
• oceanic heat/moisture fluxes
surface mass balance

- surface mass balance generated by the climate model using energy-moisture balance model and a dynamic sub-grid elevation binning scheme
SAT bias correction

1. obtain monthly SAT bias from NCEP/ERA40 & UVic ESCM long-term monthly mean SAT 1970-2001

2. within EMBM, remove monthly bias from
   – surface air temperature used to calculate sensible heat flux in EMBM
   – saturation specific humidity
   – snow/rain decision
spinup procedure

1850

LGM
model performance, present-day equilibrium: geometry
model performance, present-day equilibrium: melt extent

melt extent: $25 \times 10^7 \text{ km}^2$: orders of magnitude too high!
melt extent: $3 \times 10^5 \text{ km}^2$: near bottom end of 1990-2009 melt extent range
model performance, present-day equilibrium: surface mass balance

Ettema et al. (2009)
GIS SMB: 469 ± 41 Gt/yr

Van den Berg et al. (2006)
AIS SMB: 2520 ± 30 Gt/yr

modelled SMB: 445 Gt/yr

modelled SMB: 2500 Gt/yr
elevated-$\text{CO}_2$ simulations
conclusions

- major ice sheet/climate model coupling complete
- monthly bias correction within EMBM a way to minimize (significant) spurious climate model-derived ice sheet evolution trends
- ice spinup with model-derived glacial/interglacial endmembers a way to minimize forcing discontinuity for ‘future’ simulations
- present model performance compares reasonably with previous modelling and observations
- initial simulations suggest threshold on GIS stability at 4xPAL, and a robust AIS, given constant basal melting