

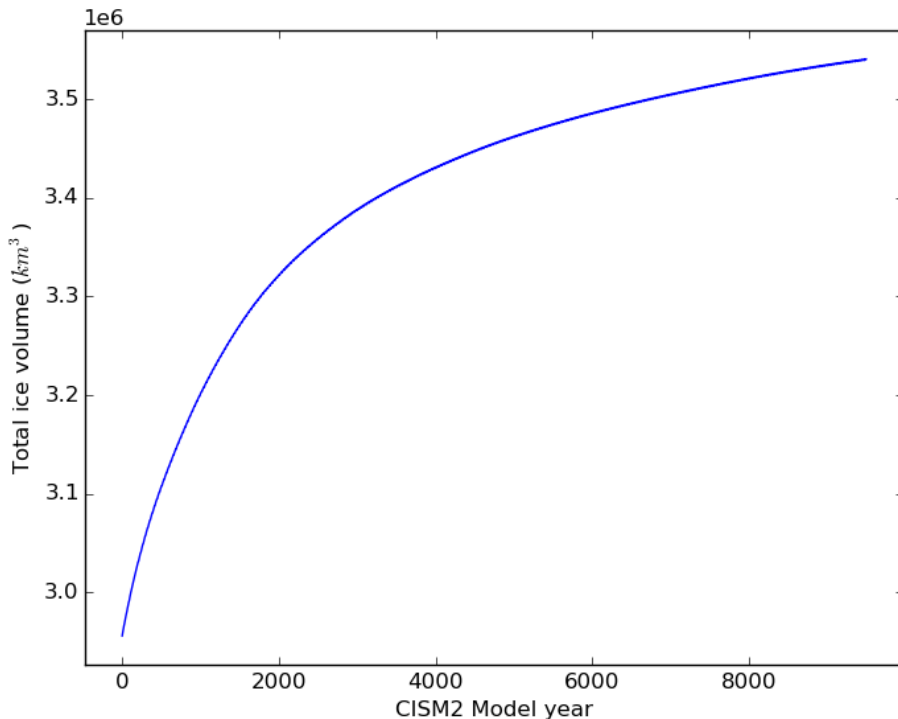
# A efficient 'iterated' technique for spinning up coupled CESM-CISM2

Jeremy Fyke, Bill Sacks, Marcus Löffverström, Keith Lindsay

- **Problem:** Coupled ice-sheet/climate system needs long equilibration but it's too expensive/slow to do with brute force
- **Idea:** 'iterated' spin-up between fully-coupled and 'all-active-but-atmosphere' simulations
- **Implementation, first tests:** Construction of iteration methodology; generation of JG compset; initial testing
- **Next steps:** Solicitation for critical reviews; production simulations; application to 'standard' B compset spin-ups?

# Problem

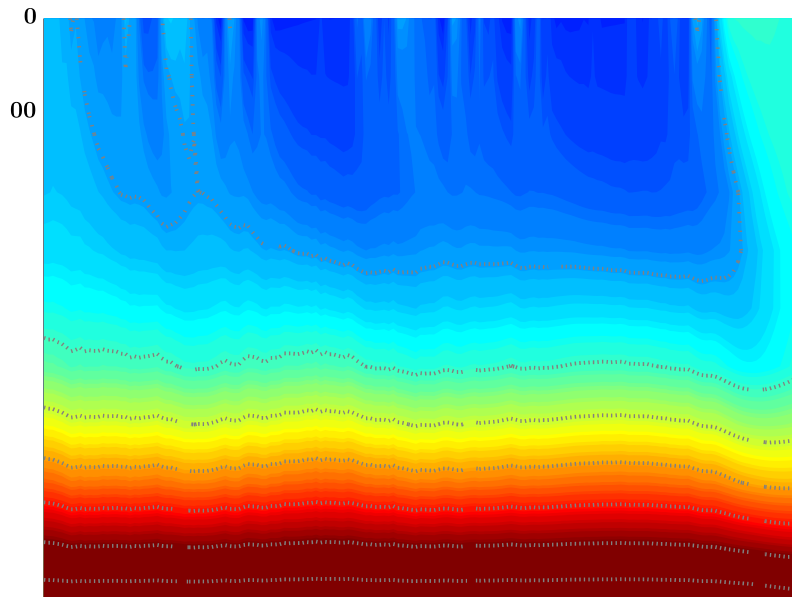
- Spin-ups required so coupled model is in self-consistent equilibrium w/r/t:
  1. System of interest (*ice sheet geometry and thermal state*)
  2. Influencing systems
  3. Feedback loop systems



GrIS volume evolution (million km<sup>3</sup>)

# Problem

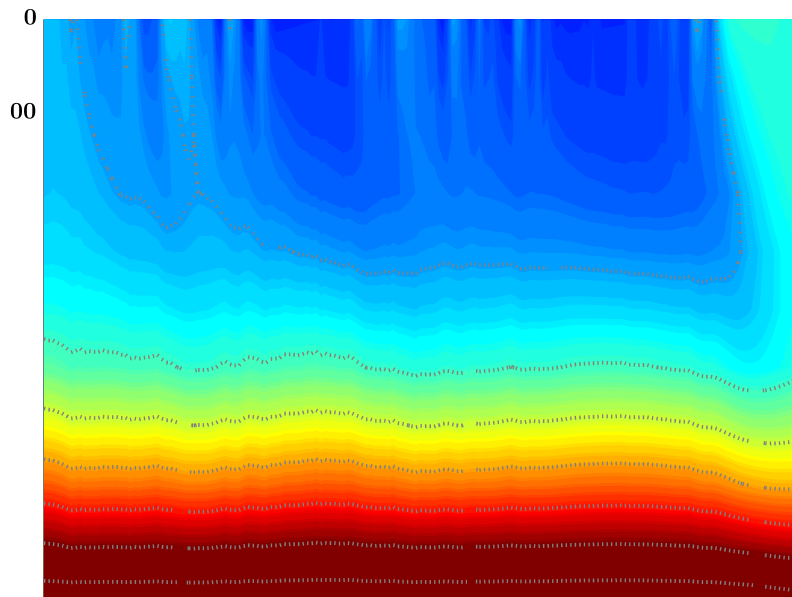
- Spin-ups required so coupled model is in self-consistent equilibrium w/r/t:
  1. System of interest (*ice sheet geometry and thermal state*)
  2. Influencing systems
  3. Feedback loop systems



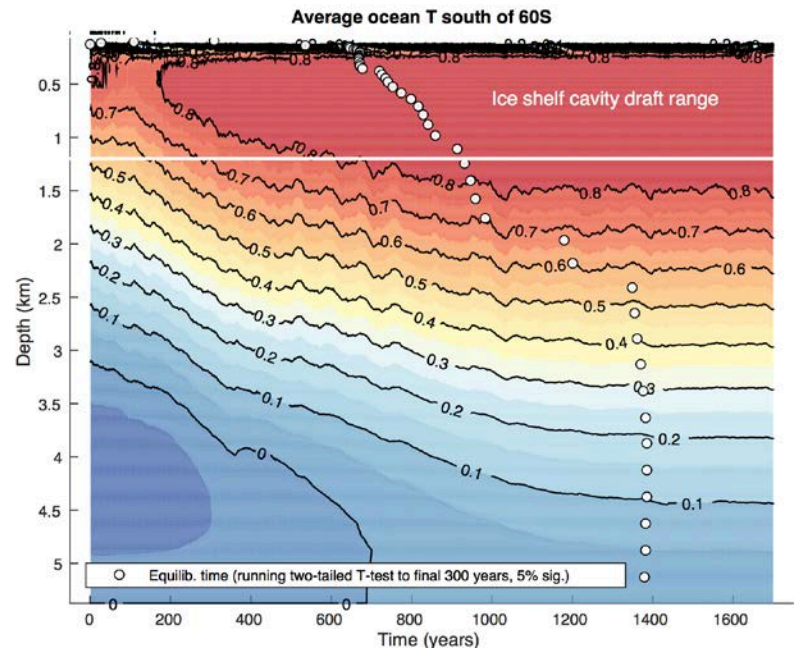
GRIS internal temperature (*Fyke et al., 2014*)

# Problem

- Spin-ups required so coupled model is in self-consistent equilibrium w/r/t:
  1. System of interest (*ice sheet geometry and thermal state*)
  2. Influencing systems
  3. Feedback loop systems



GRIS internal temperature (*Fyke et al., 2014*)

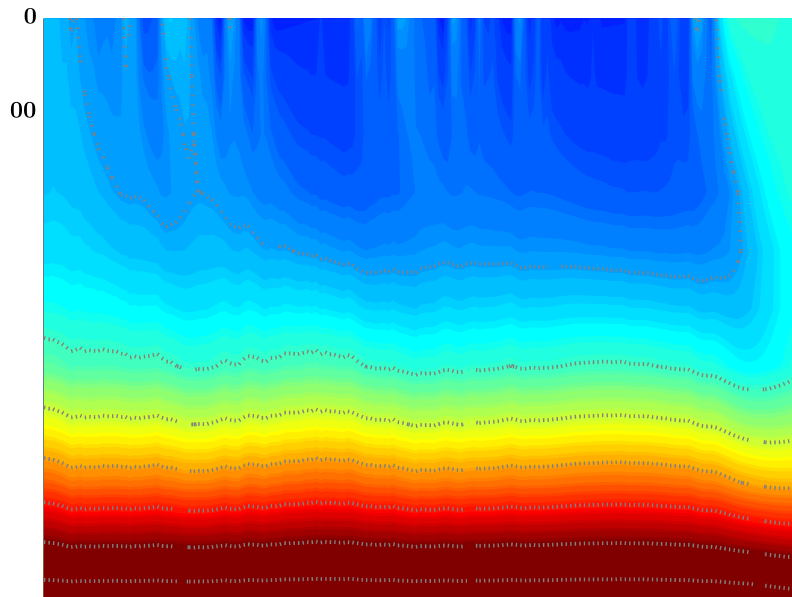


CESM LE Southern Ocean temperature equilibration

# Problem

- Spin-ups required so coupled model is in self-consistent equilibrium w/r/t:

1. System of interest (*ice sheet geometry and thermal state*)
2. Influencing systems
3. Feedback loop systems



GRIS internal temperature (*Fyke et al., 2014*)

## Problem

Coupled ice-sheet/climate system needs long spin-up ***but*** CESM-CISM too expensive+slow to do via brute force (*~24M cpu hrs, 500 days*)

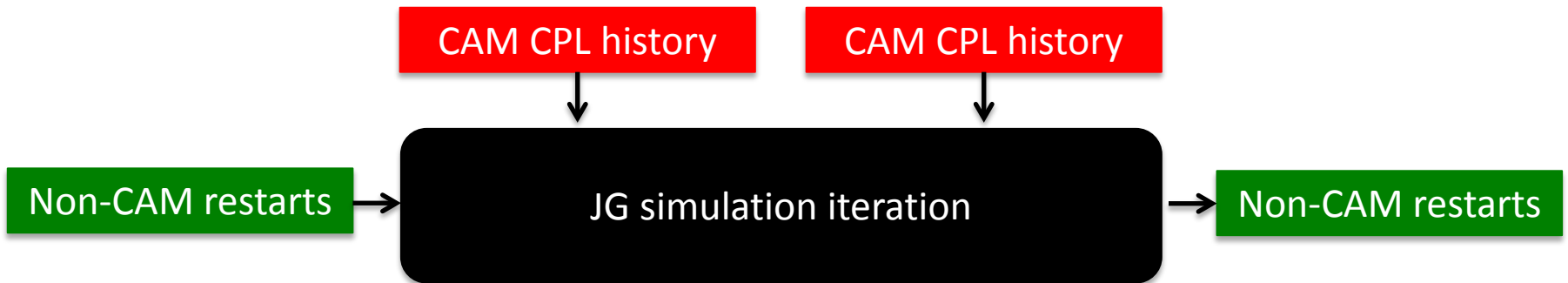
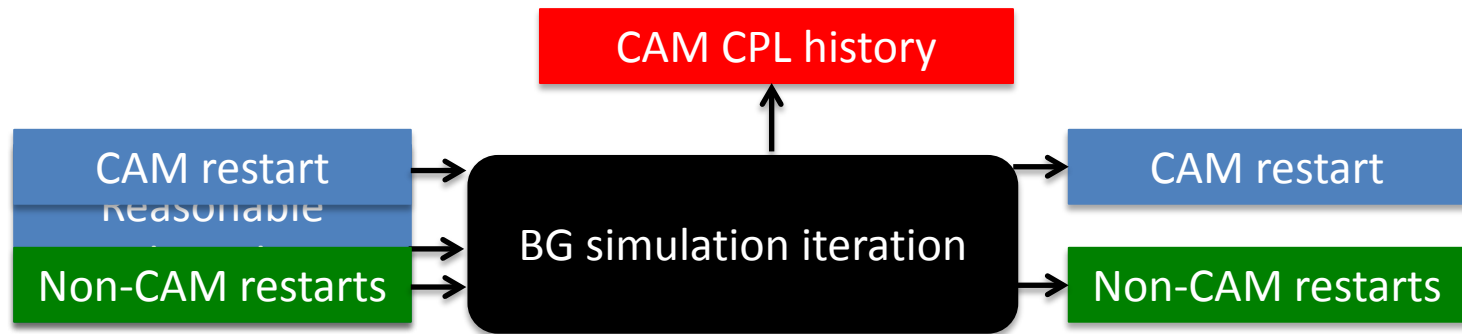


# Idea

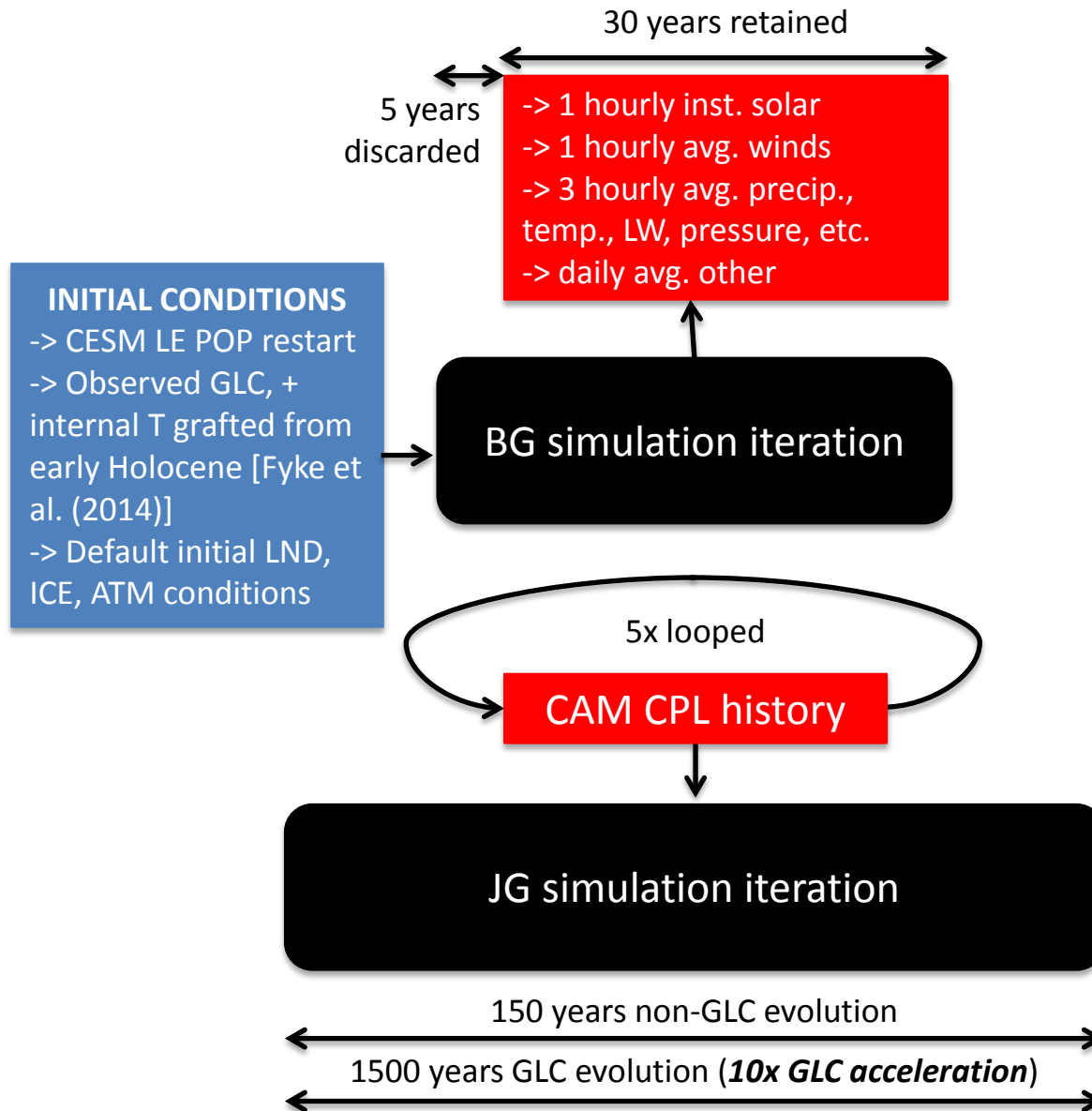
- **Observation: CAM is bottleneck**
  - CAM most expensive CESM component
  - coupled spin-up length dictated by non-CAM components
  - expense of coupled spin-up largely dictated by CAM expense
- **Solution: minimize CAM cycles**
  - Generate climatology with BG simulation
  - Replace prognostic CAM with DATM ('JG' simulation)
  - Source DATM data, restarts from previous BG simulation
  - Perform long-(er) JG simulation under DATM forcing



# Implementation



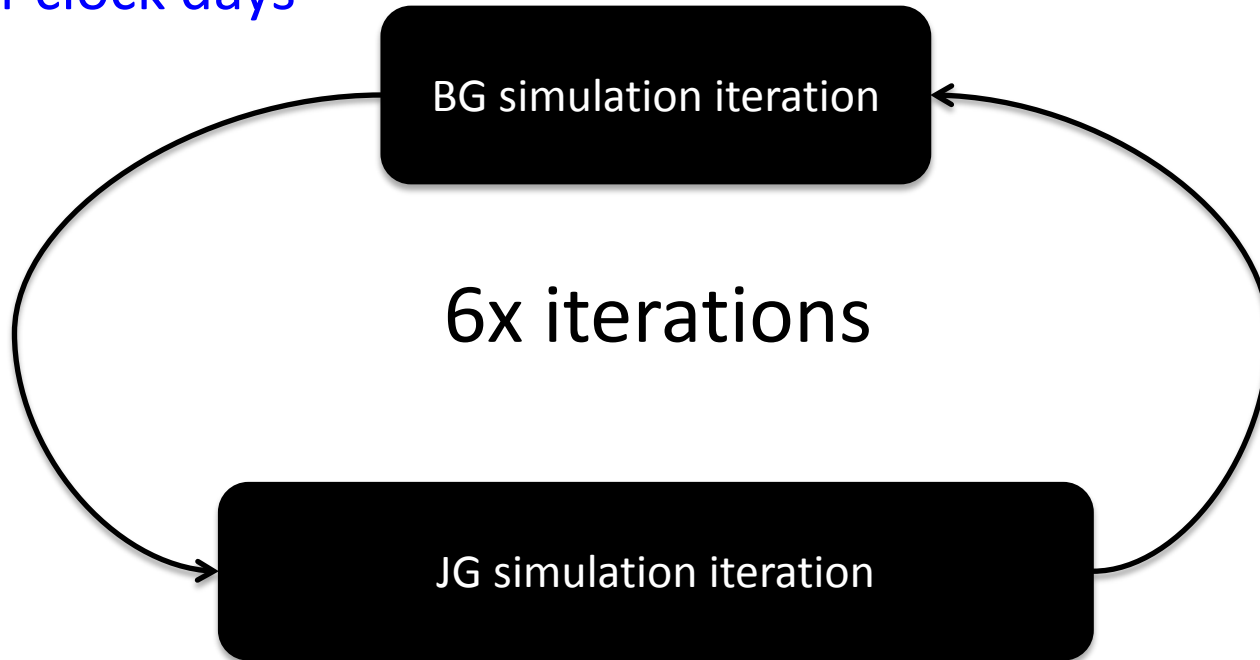
# Implementation





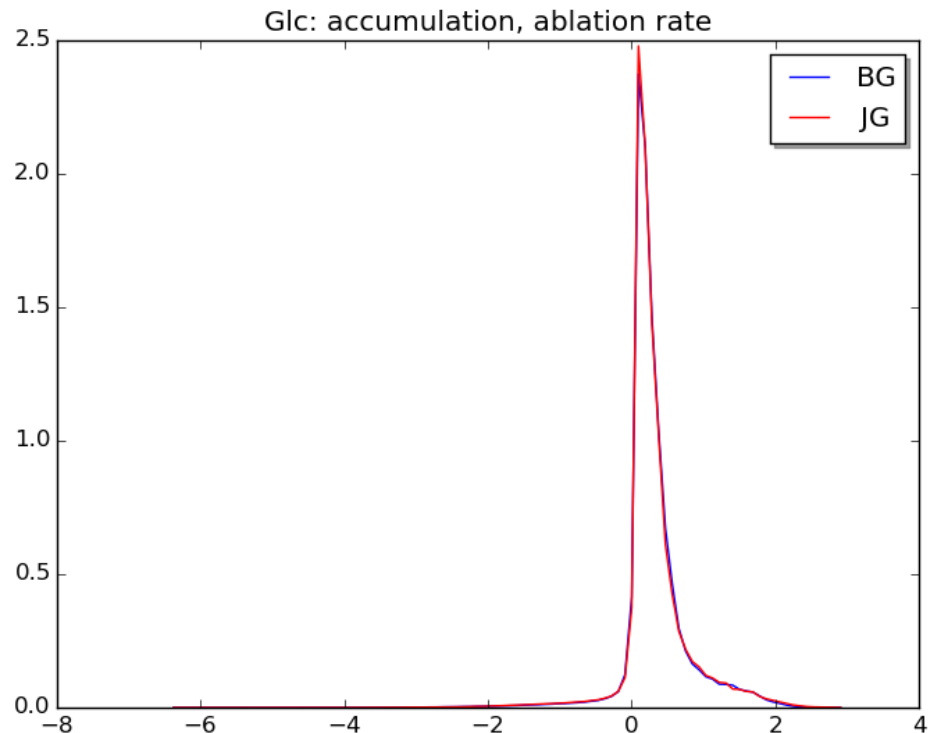
# Implementation

- 9210 years GLC years (*'the Holocene'*)
- 1110 OCN/CICE/LND/ROF years (*good enough for AMOC?*)
- 210 ATM years
- ~940,000 core hours (compare to 2.4M hours for BG + 10x GLC acceleration, 24M hours with pure brute force)
- ~25 wall-clock days



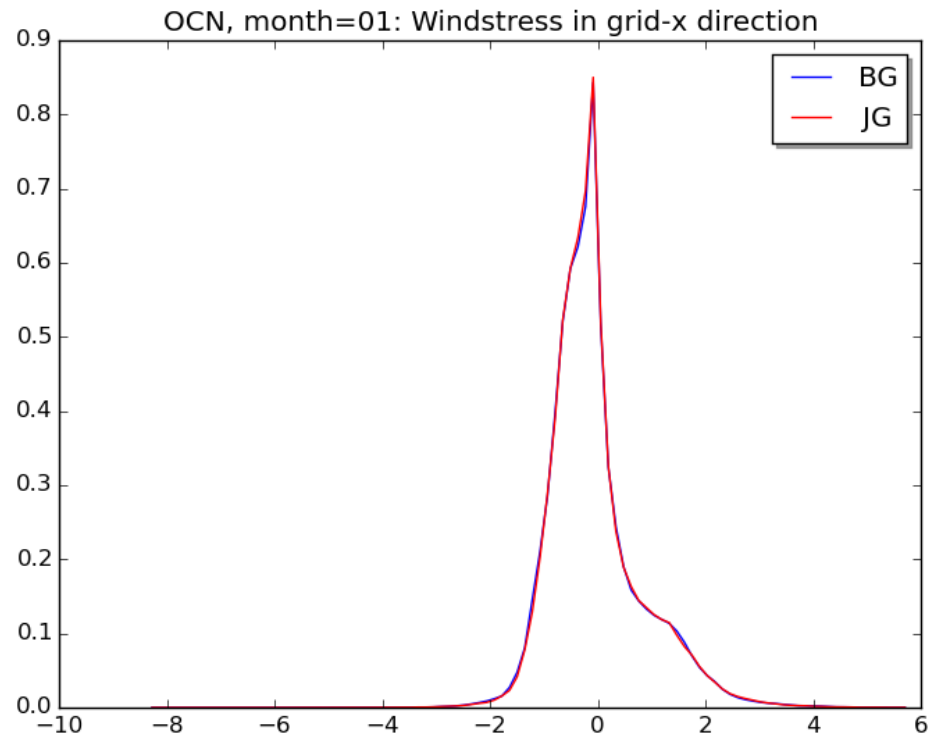
# First tests

- **Currently at 'development' JG/BG iteration #5, have developed:**
  - Iteration driver scripts
  - JG compset configuration
  - Correct DATM behavior:
    - Under simultaneous OCN+CICE+LND+ROF+GLC
    - With multiple BG-sourced custom data input streams
  - Data management processes
  - Initial condition generation
- **Latest iteration: first evaluation**
  - Comparison of 2D diagnostic fields in non-CAM components:  
BG->JG transition reasonable based on comparison of diagnostic distributions



# First tests

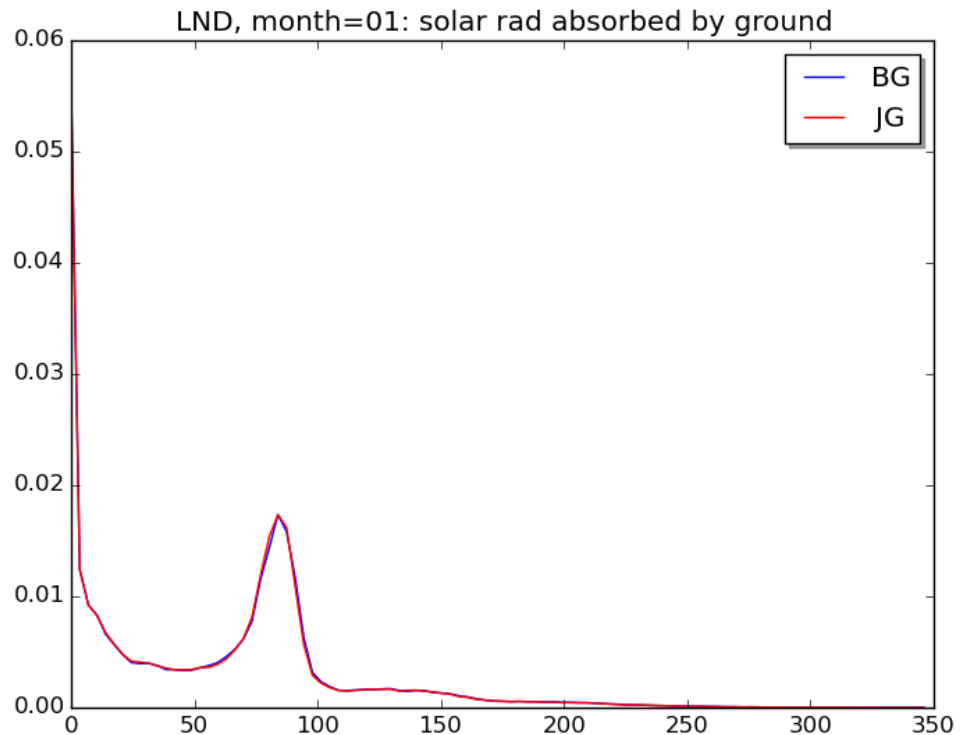
- **Currently at 'development' JG/BG iteration #5, have developed:**
  - Iteration driver scripts
  - JG compset configuration
  - Correct DATM behavior:
    - Under simultaneous OCN+CICE+LND+ROF+GLC
    - With multiple BG-sourced custom data input streams
  - Data management processes
  - Initial condition generation
- **Latest iteration: first evaluation**
  - Comparison of 2D diagnostic fields in non-CAM components:  
BG->JG transition reasonable based on comparison of diagnostic distributions



# First tests

- **Currently at 'development' JG/BG iteration #5, have developed:**
  - Iteration driver scripts
  - JG compset configuration
  - Correct DATM behavior:
    - Under simultaneous OCN+CICE+LND+ROF+GLC
    - With multiple BG-sourced custom data input streams
  - Data management processes
  - Initial condition generation

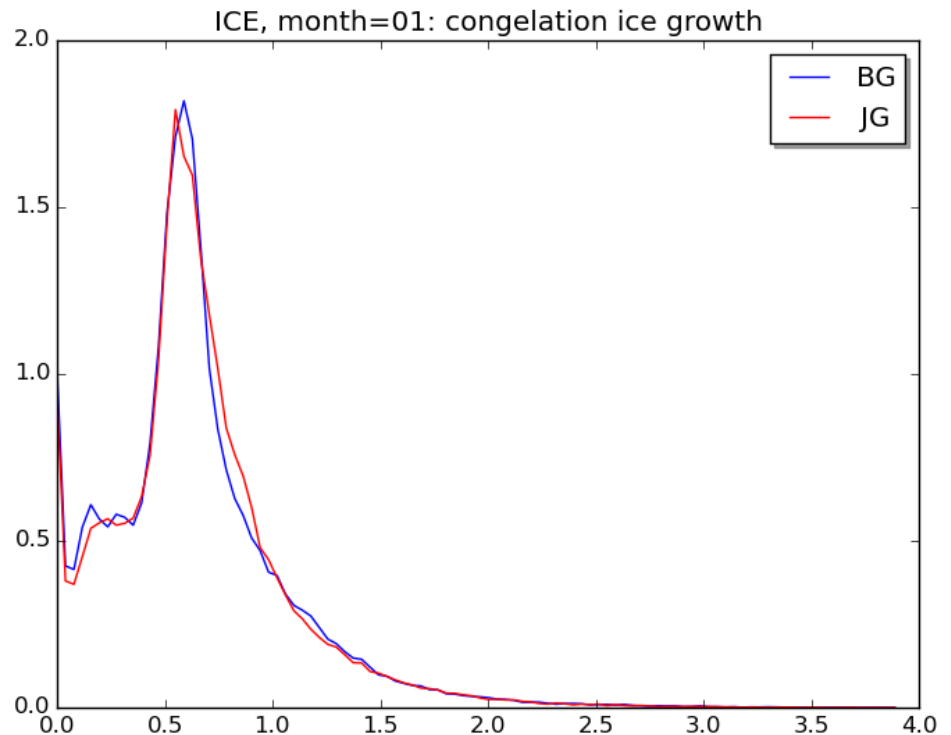
- **Latest iteration: first evaluation**
  - Comparison of 2D diagnostic fields in non-CAM components: BG->JG transition reasonable based on comparison of diagnostic distributions



# First tests

- **Currently at 'development' JG/BG iteration #5, have developed:**
  - Iteration driver scripts
  - JG compset configuration
  - Correct DATM behavior:
    - Under simultaneous OCN+CICE+LND+ROF+GLC
    - With multiple BG-sourced custom data input streams
  - Data management processes
  - Initial condition generation

- **Latest iteration: first evaluation**
  - Comparison of 2D diagnostic fields in non-CAM components:  
BG->JG transition reasonable based on comparison of diagnostic distributions



# Next steps

- **So far:**
  - Iterative 'JG/BG' simulation technique developed and implemented
  - *I claim* that technique:
    - Can generate self-consistent coupled ice-sheet/climate preindustrial initial conditions
    - Allows for pre-Holocene ice sheet history inclusion
    - Provides means to cheapen CESM/CISM spin-ups to 'tenable' CPU-hr/wallclock-time values
  - Development/testing reaching mature state
- **What's next:**
  - ***Comments/criticisms desired!***
  - Start production spin-up simulations
  - Generate robustly spun-up, self-consistent preindustrial coupled model state
  - Use of scheme for 'standard' B production spin-ups?
    - *Given increase in computing power, ~1M CPU-hr simulations 'mundane'*
    - *JG/BG approach may permit frequent full spin-ups*

