Mechanisms behind climate oscillations in full-glacial simulations

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Dansgaard-Oeschger events (D-O events) are millennial-scale oscillations between cold stadial climates and warm interstadial climates. Li and Born, 2019

From Greenland ice cores
Millennial scale variability in climate models

Bohm et al. 2015

Klockmann et al. 2018
AMOC response to forcing

Warm mode

Cold mode

Overturning circulation strength

Forcing

Rahmstorf et al. 2005

Barker & Knorr 2021
Stochastic dynamics

Ganopolski and Rahmstorf, 2002
Deterministic dynamics

Birchfield and Broecker 1990
AMOC stability as a potential well

Böhm et al. 2015

Dijkstra 2013
Experimental design

- **Last Glacial Maximum** (LGM - 21 ky) background conditions equity simulation

- **Meltwater history** derived from GLAC-1D ice sheet reconstruction, routed and spread over the ocean

- Six **snapshots** of meltwater discharge of the early last deglaciation were chosen

- They were used as **fixed forcing** for 10,000 years

**HadCM3@Bristol**
Coupled ocean-atmosphere GCM

*Atmosphere* → 2.5°×3.75°×19 layers regular grid

*Ocean* → 1.25°×1.25°×20 layers regular grid
Oscillations in LGM simulations

[a] NGRIP Temperature (°C) vs Simulation years

[b] Filtered NGRIP Temperature (°C)

[c] PSD (W Hz⁻¹) vs Harmonics frequency (yr⁻¹)

[d] Winter Mixed Layer Depth (m)

[i] Cold mode

[ii] Meridional mode

[iii] Zonal mode

[Simulation years 1000 2000]

[Surface Air Temperature at NGRIP (°C)]
Visualising stable states
Reviewing the different components

We produced a framework to study millennial-scale variability.

Large Review of different physical components involved in abrupt climate changes.

- **Fast physics** – No clear increase of inter-annual variability prior to a state switch, but a decadal-scale salinity pump in cold mode. Resonance phenomenon?

- **Slow physics** – Slow reorganisation of salinity in the Atlantic, leading to weaker North-South and vertical density gradients. Is it enough to modify the potential?

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Thank you!