Abrupt Millennial Variability and Interdecadal-Interstadial Oscillations in a Global Coupled Model : Sensitivity to the Background Climate State

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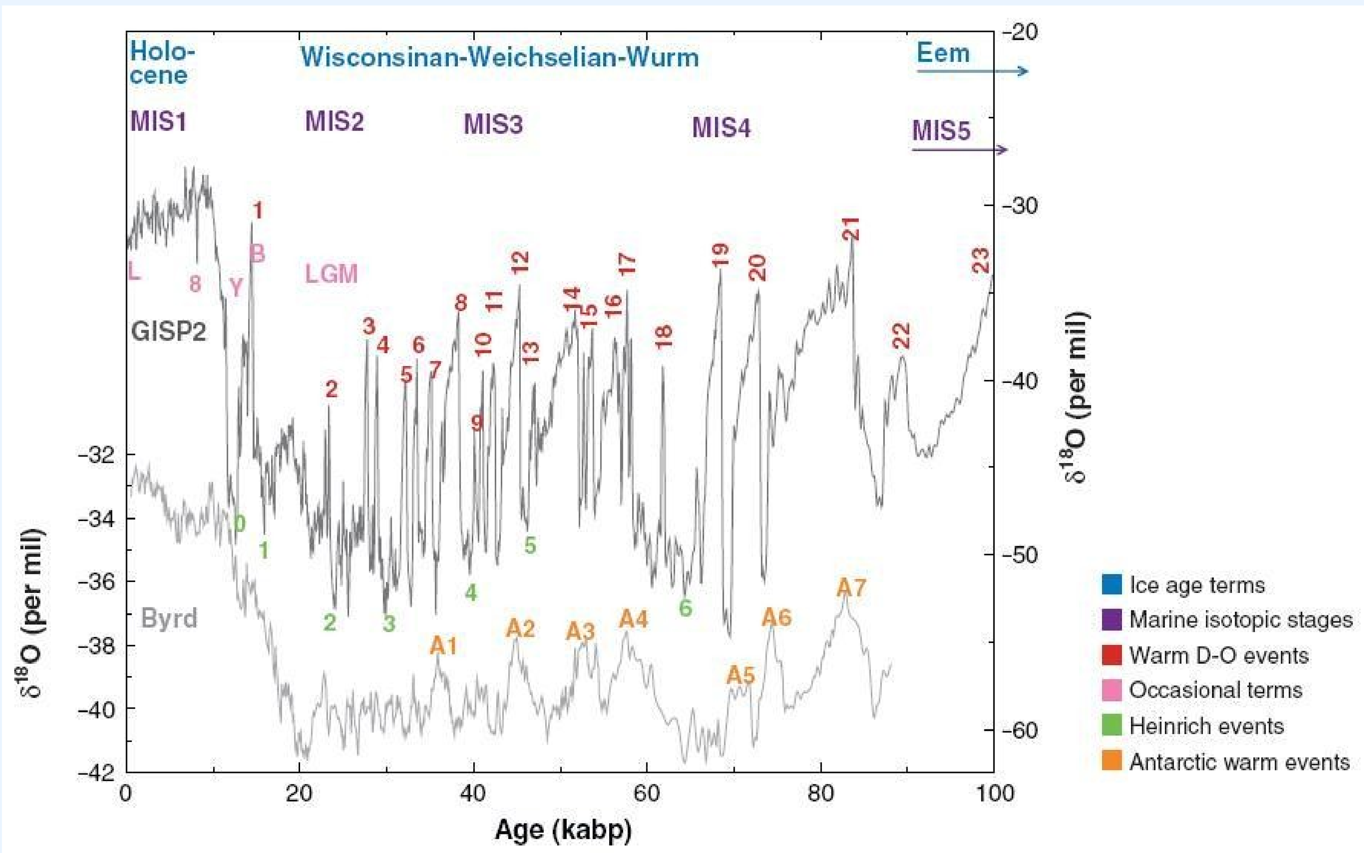
Motivation

The last glacial period was punctuated by rapid climate swings, know as Dansgaard-Oeschger (DO) events (numbered on the figure), with strong imprint in the North Atlantic sector, suggesting that they were linked with the Atlantic Meridional Overturning Circulation (MOC). These DO events are ubiquitous during the past eight glacial cycles and are associated with the largest and fastest temperature shifts ever recorded in paleoclimate archives, with Greenland warmings of 8°C to 16°C in annual mean within a few decades. While it is generally accepted that the Atlantic Meridional Overturning Circulation (AMOC) is somehow involved, a complete and detailed description of the physical mechanism driving this abrupt millennial variability is still lacking and a number of hypotheses have been proposed (externally forced, intrinsic, deterministic, noise-induced).



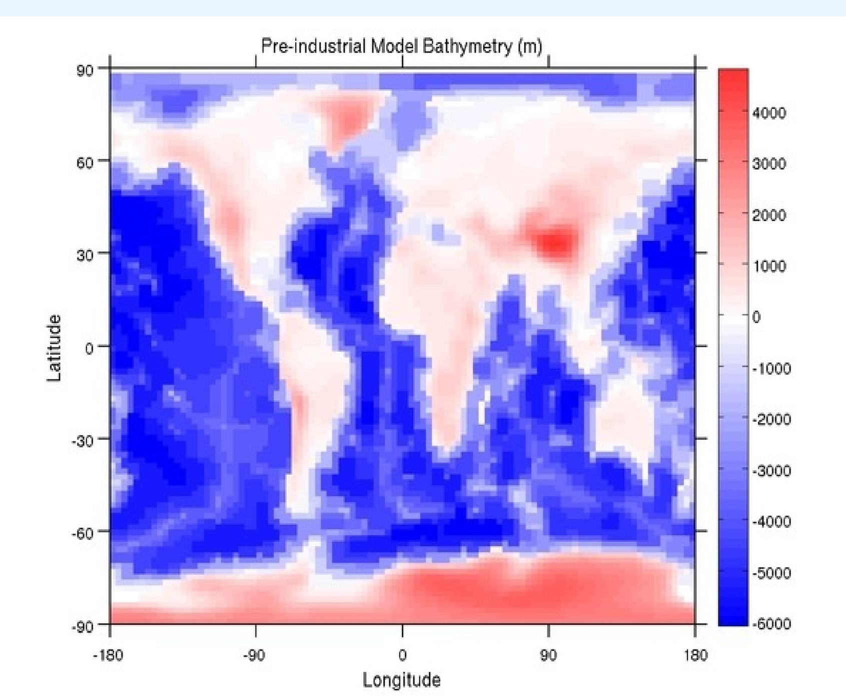
Objective

To determine the the origin of abrupt millennial-scale climate transitions under steady external solar forcing and in the absence of atmospheric synoptic variability in a global coupled model of intermediate complexity

Approach

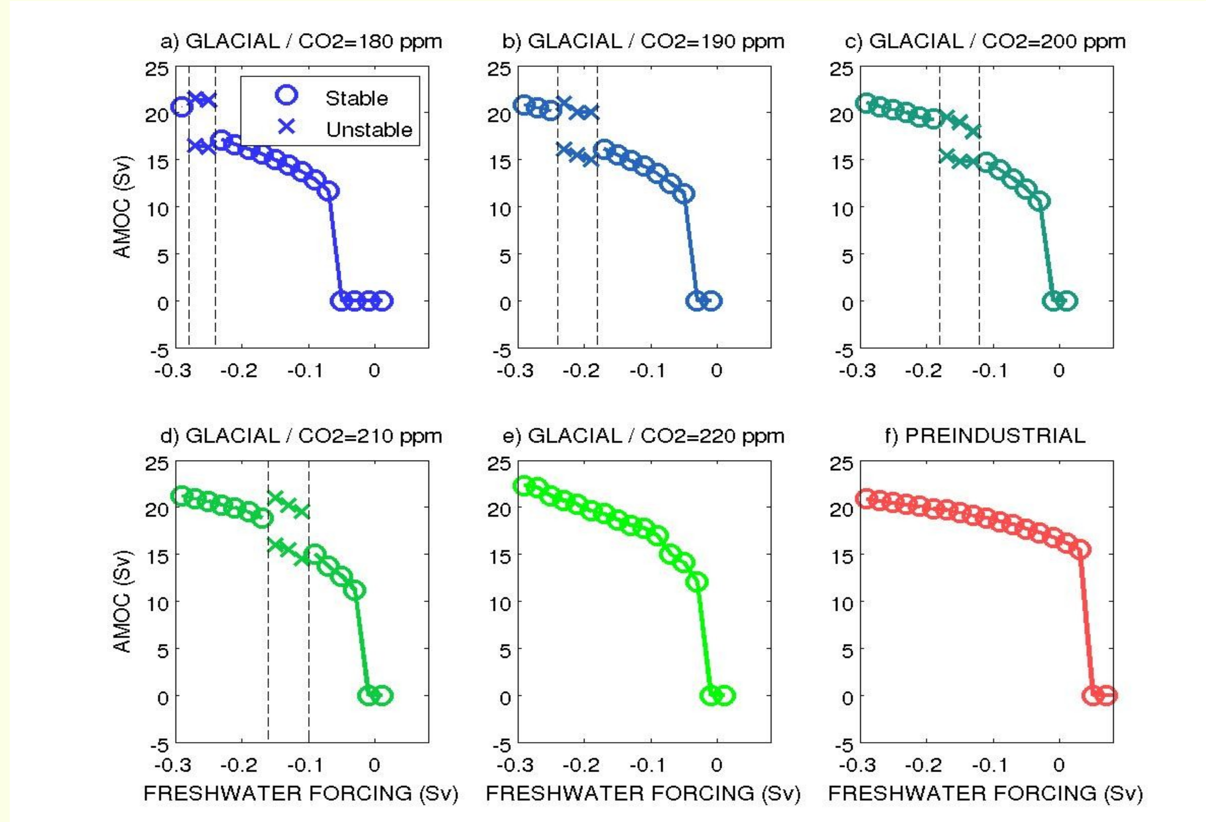
Analyse the sensitivity of the bifurcation structure of the model to the atmospheric CO2 concentration of strength of the hydrological cycle

Model

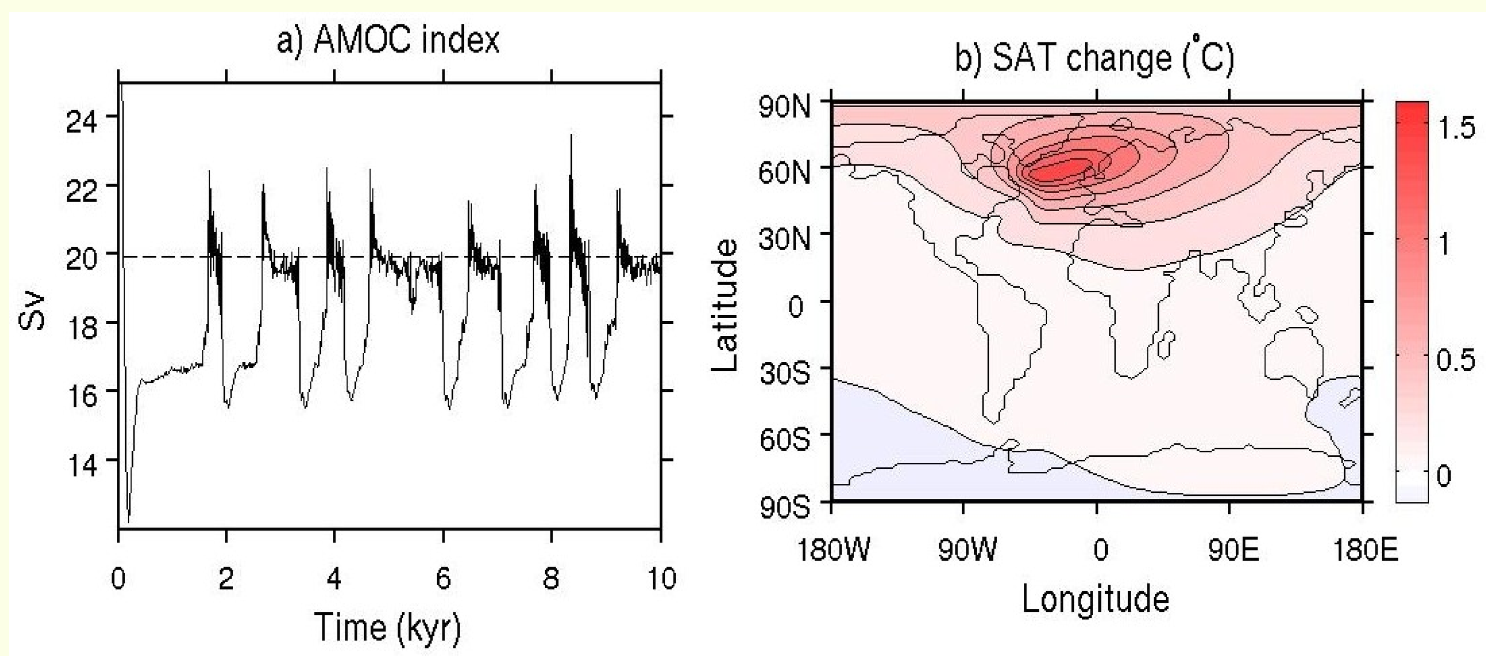


- Uvic, version 2.8
- Global configuration
- 1.8° (lat) x 3.6° (lon) resolution, 19 vertical levels
- Ocean GCM
+ Atmosphere EMBM
+ Dynamic-thermodynamic sea ice
+ Land surface
+ Dynamic vegetation

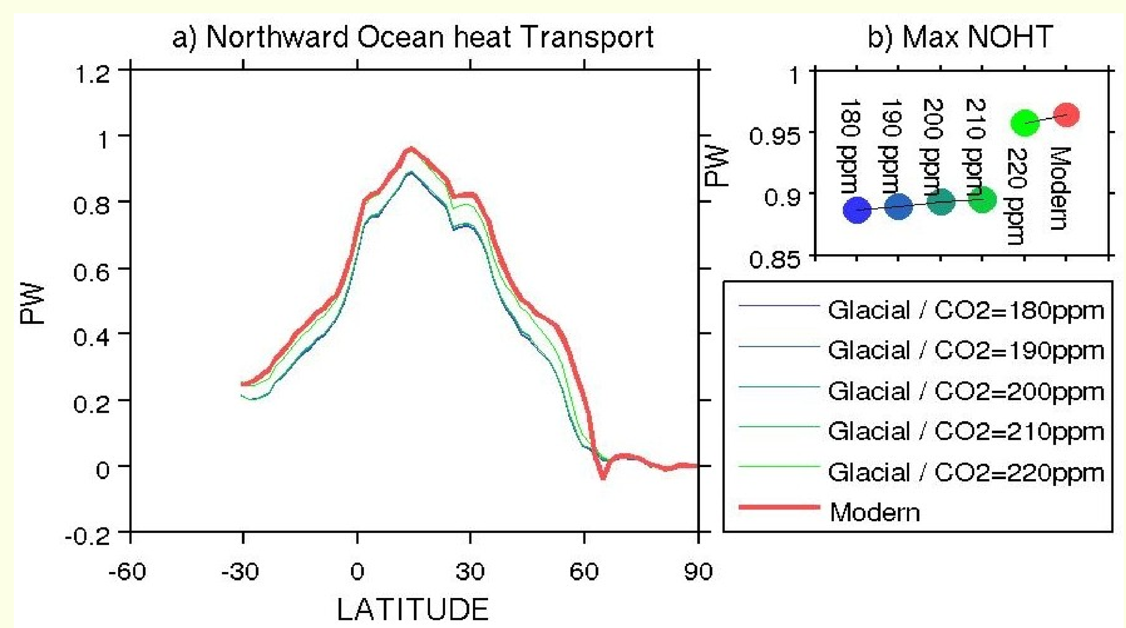
1/ Abrupt millennial-scale climate variability



- Range of background climate conditions for which abrupt millennial scale climate transitions (i.e deep-decoupling oscillations) emerge between two *unstable* states of the Atlantic MOC.



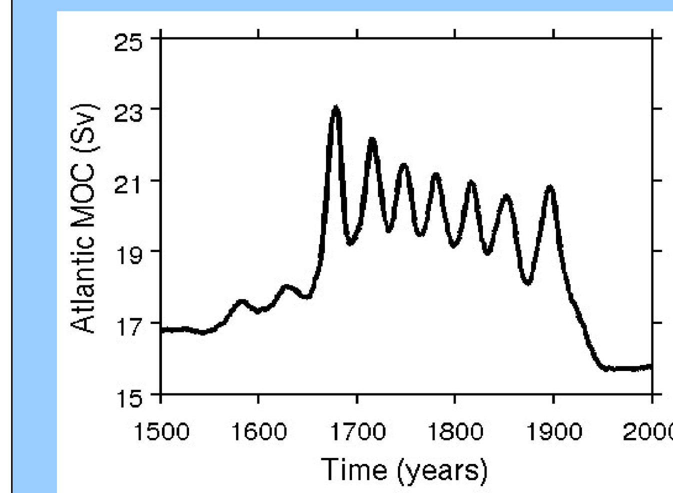
- Warmer climates are more stable : Why ?



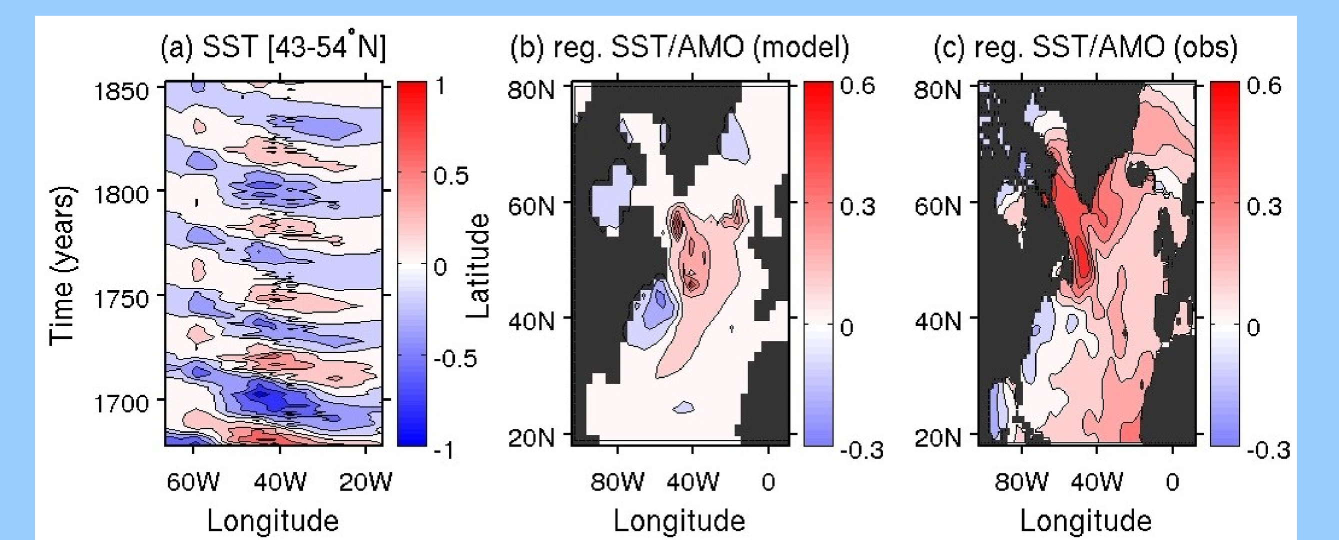
- Weaker oceanic heat transport in the Atlantic basin for cold climates
- Reduced negative feedback between the temperature and the Atlantic MOC

→ Reduced stability of cold climates = existence of abrupt millennial variability

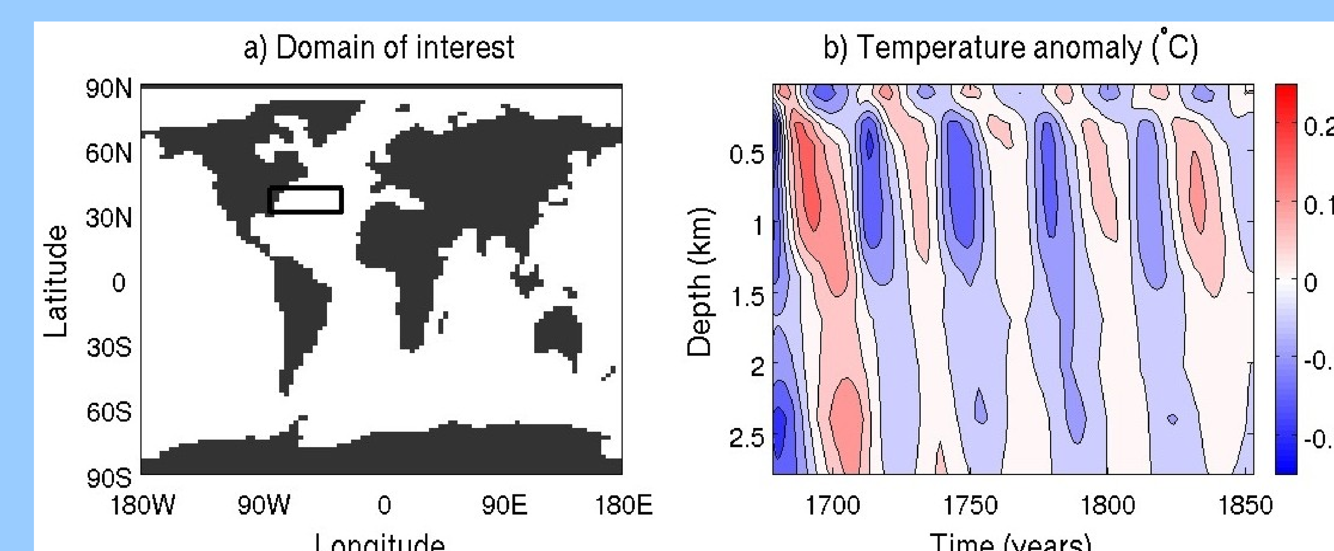
2/ Interdecadal-interstadial climate variability



- Occurs only during warm interstadials
- Instability develops when the Atlantic MOC is strong enough
- Westward propagating Thermal-Rossby waves set the period



- Quarter period vertical phase shift characteristic of the *large-scale* baroclinic instability mechanism in the western boundary current area



- Oscillation cycle results from an interplay between out of phase variations of zonal and meridional basin-scale pressure gradients
- Fingerprint of interdecadal variability similar to that obtained in ocean-only models forced by fixed surface buoyancy fluxes

References

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