

Georges Lemaître Center for Earth and Climate Research
Formerly Institute of Astronomy and Geophysics George Lemaître
Chemin du Cyclotron 2
1348 Louvain-la-Neuve



PAST CLIMATES, A KEY TO THE FUTURE

Do we have good analogues for the future global warming ?

André Berger and Qiuzhen Yin

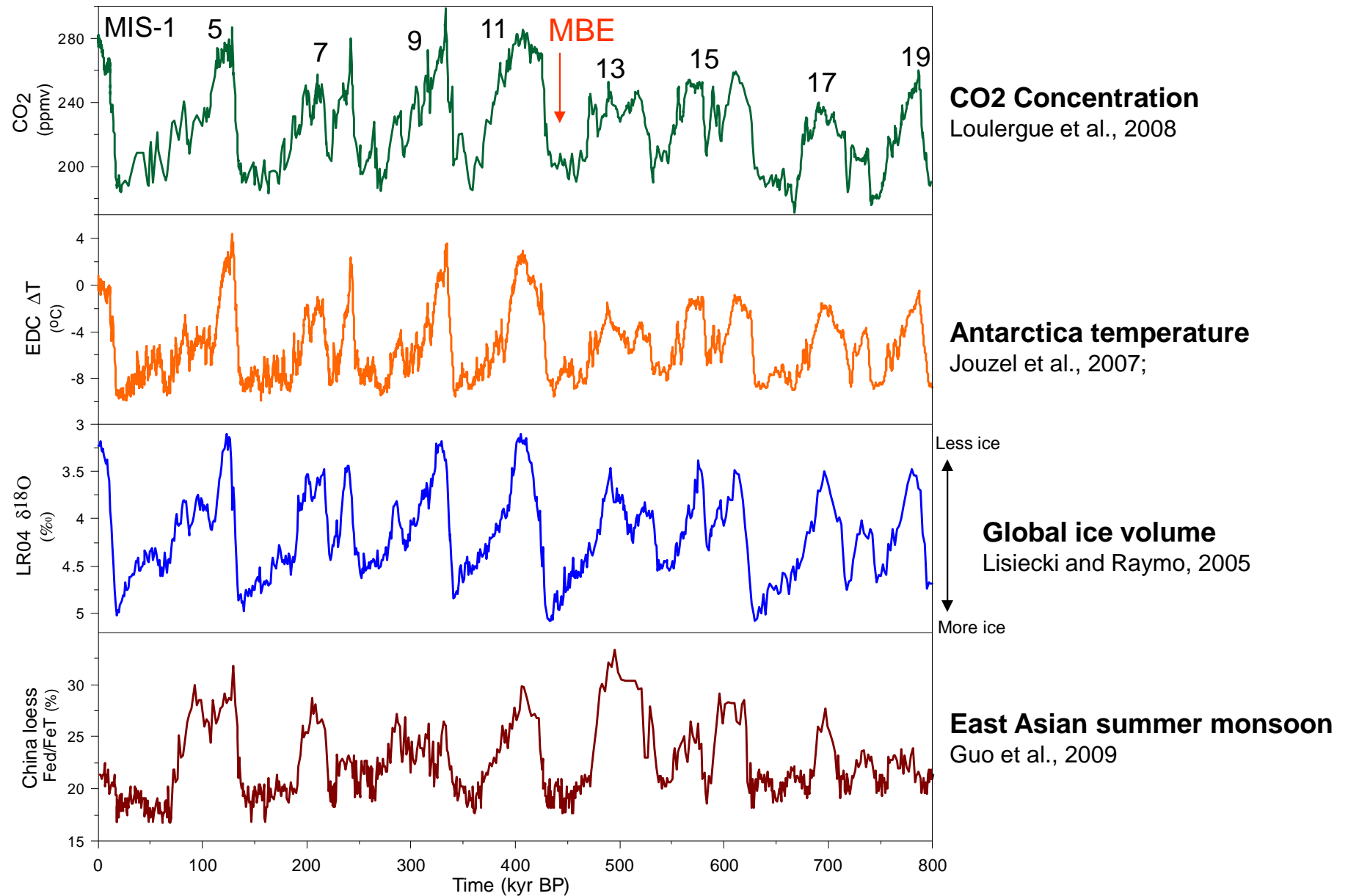
Centenary of the Royal Meteorological Institute of Belgium, September 26-27 2013,
Cinquantenaire Museum, Brussels

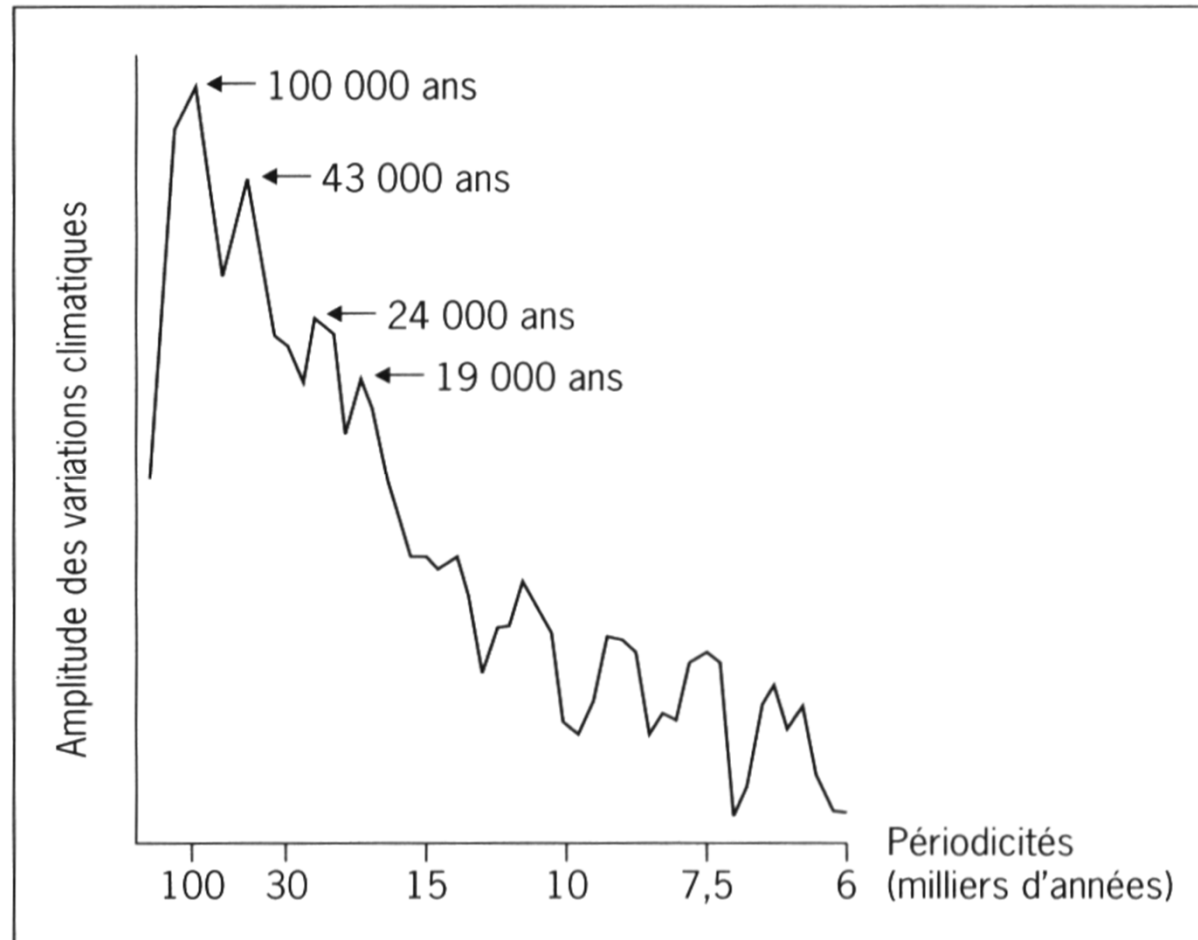
ERC Advanced Grant EMIS 2008-2013



Yin and Berger, *Climate Dynamics*, 2012
Herold et al., *Quat. Science Rev.*, 2012

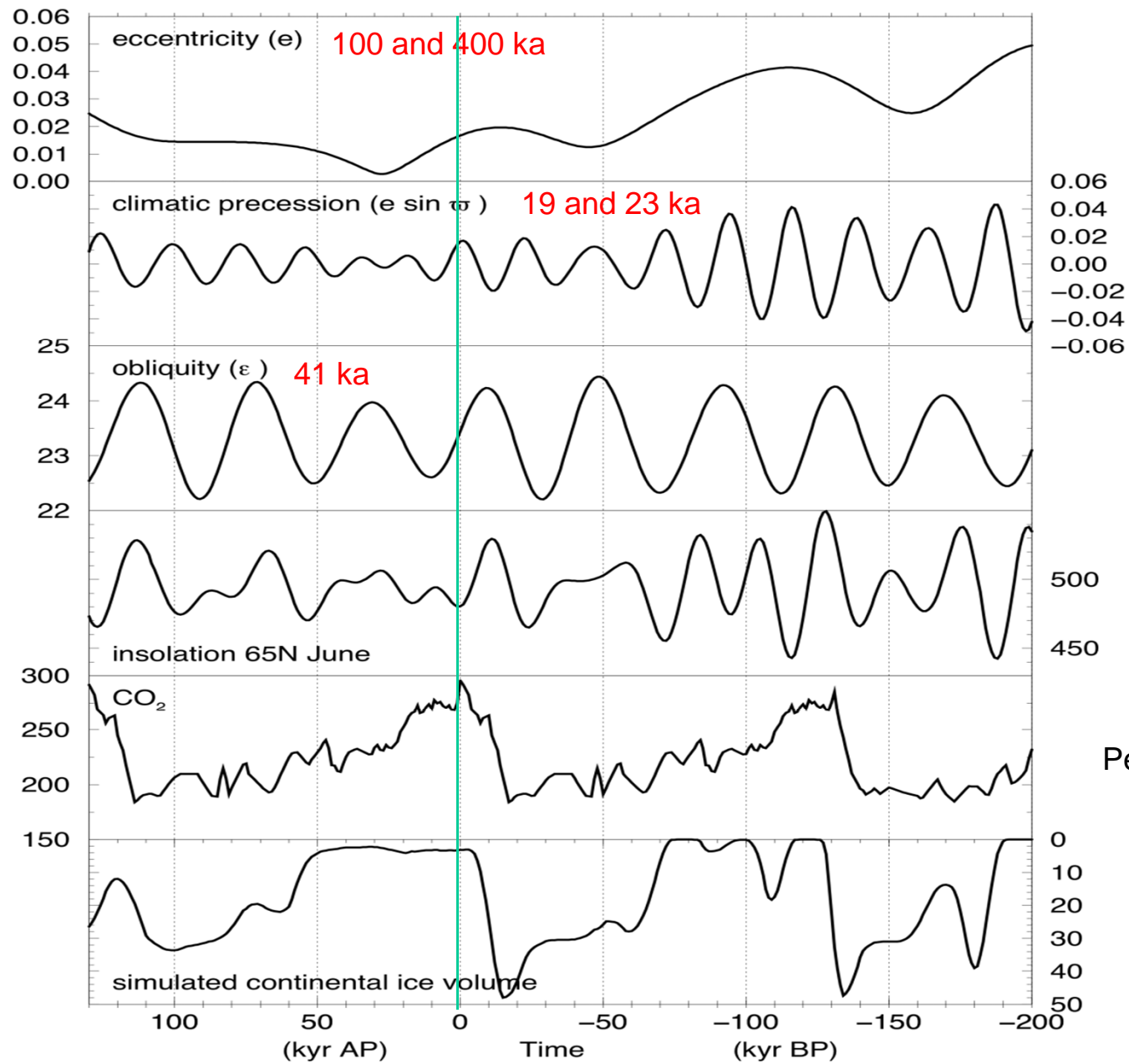
Interglacial diversity in time and space





Hays et al., Science 1976

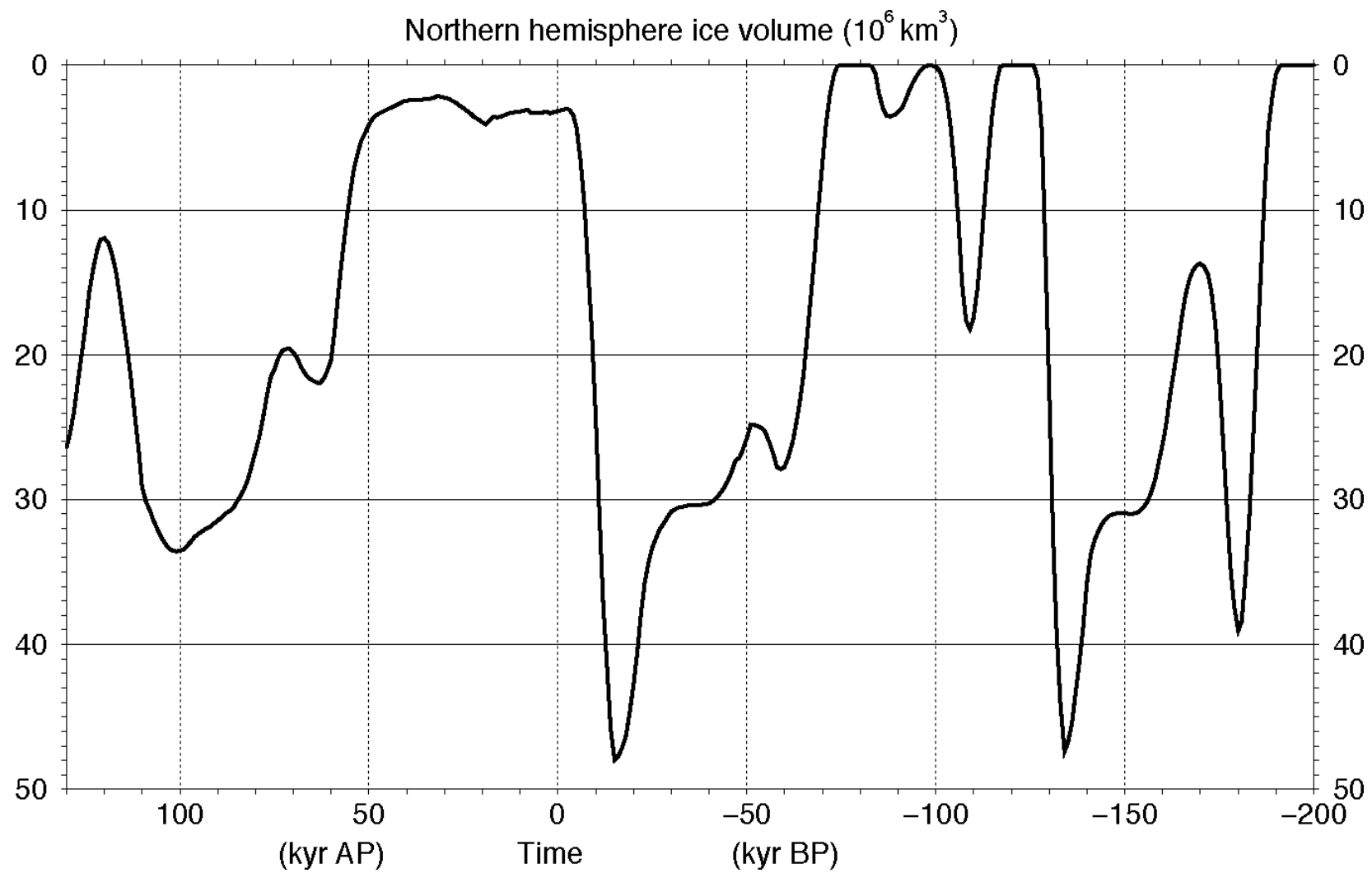
BER/8



Berger, 1978

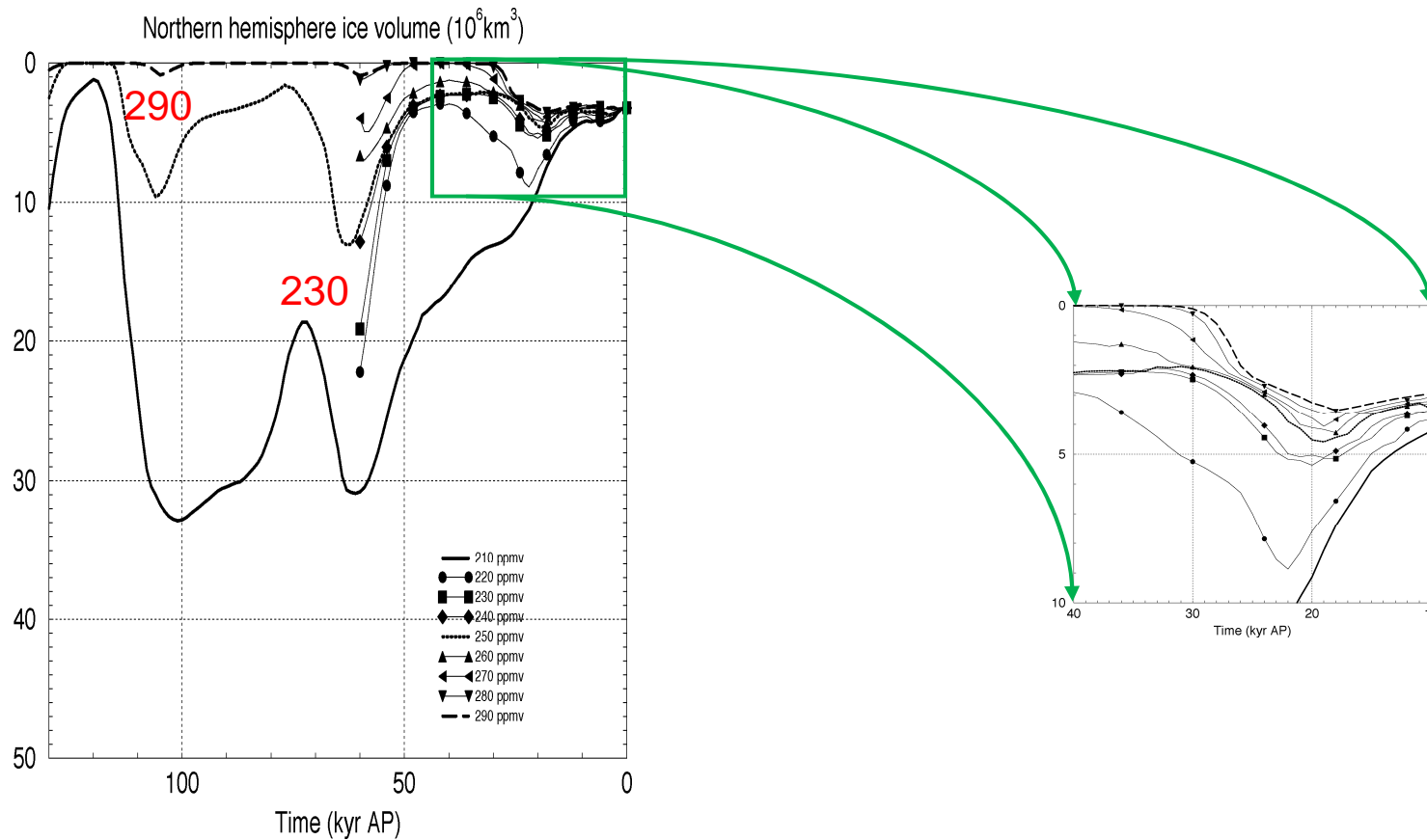
Petit et al., 1999

Berger and
Loutre, 2002



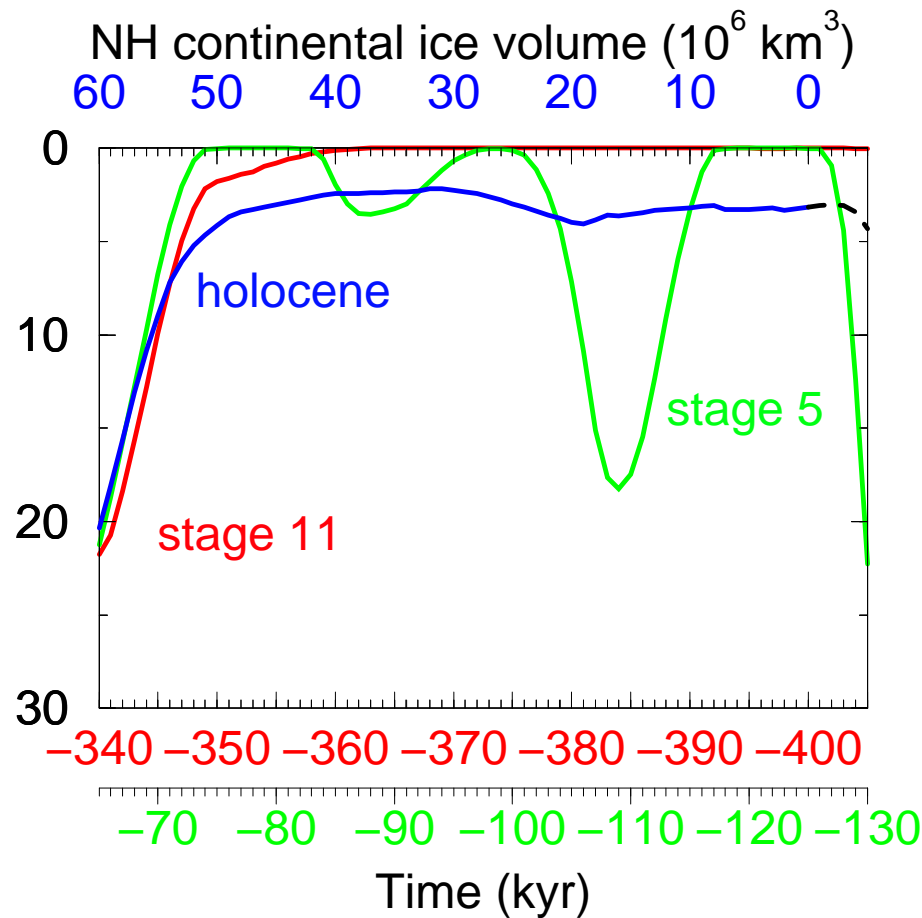
Berger et al., Ambio 1997, Science 2002, Surveys in Geophysics, 2003

Future climate under constant CO₂ scenarios



Loutre and Berger, Climatic Change, 2000

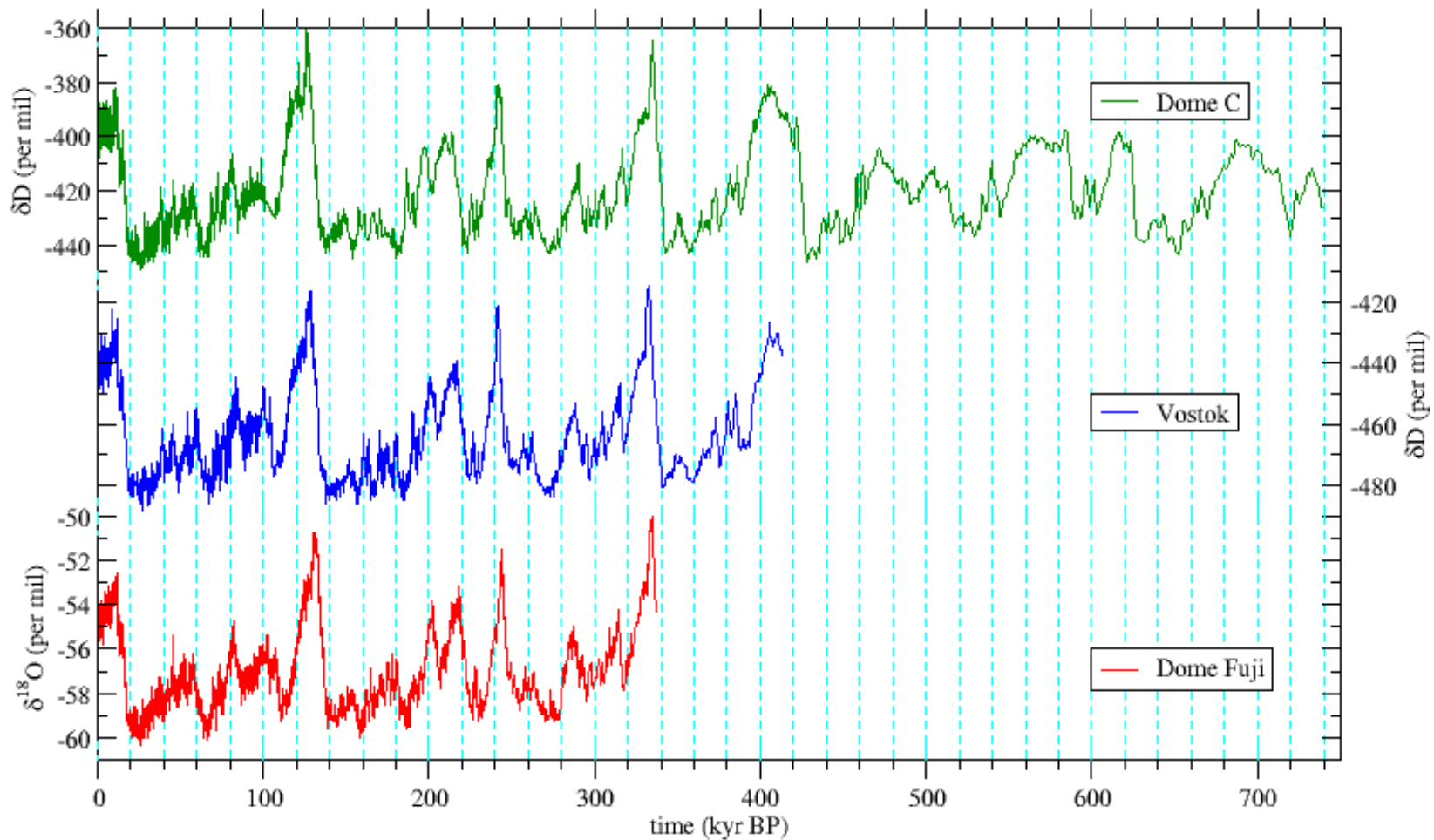
MIS11 : an analogue for the future



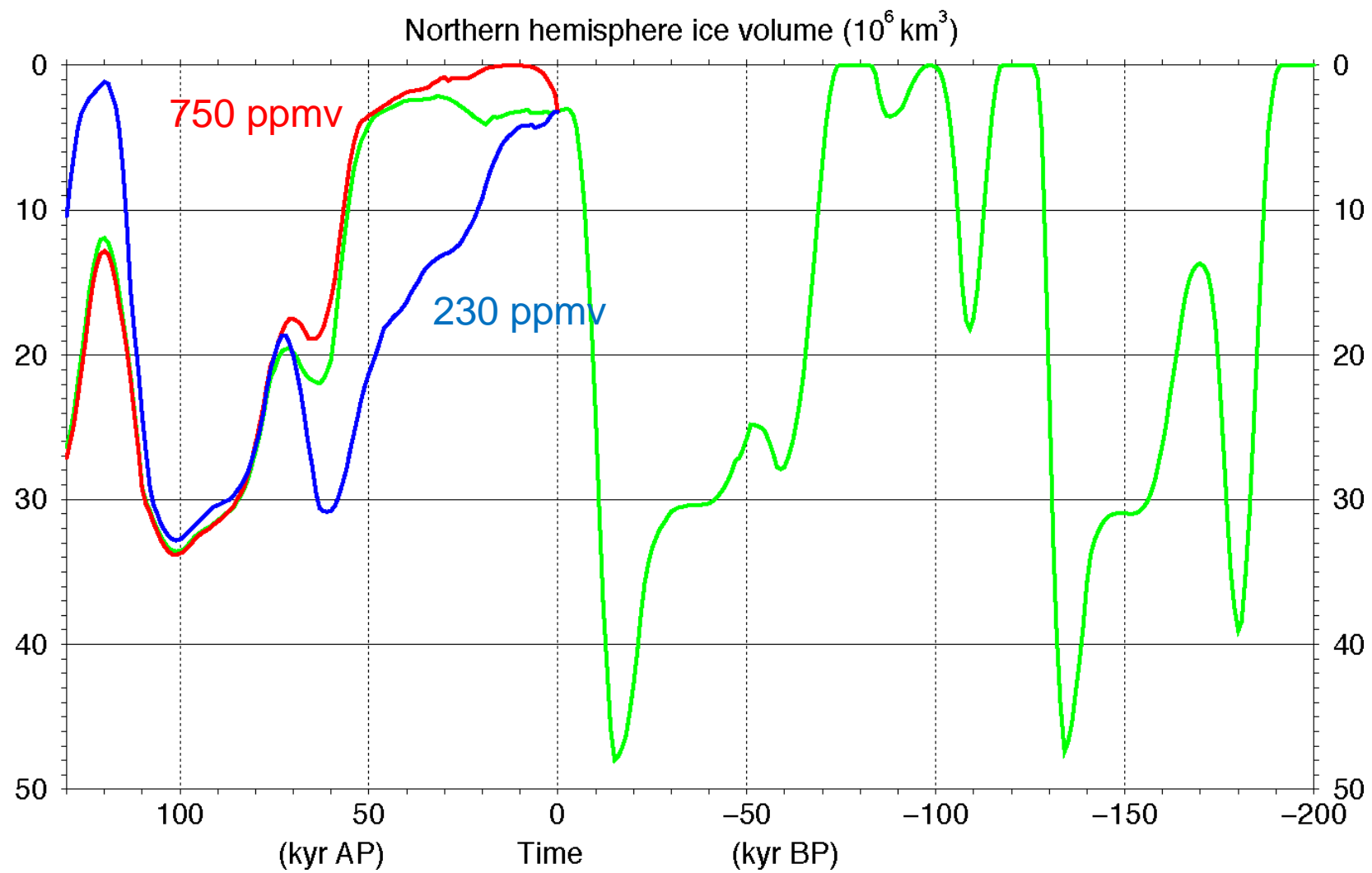
CO₂ = Vostok

Berger and Loutre, in
Droxler et al, 2003

Archives of climate in Antarctica

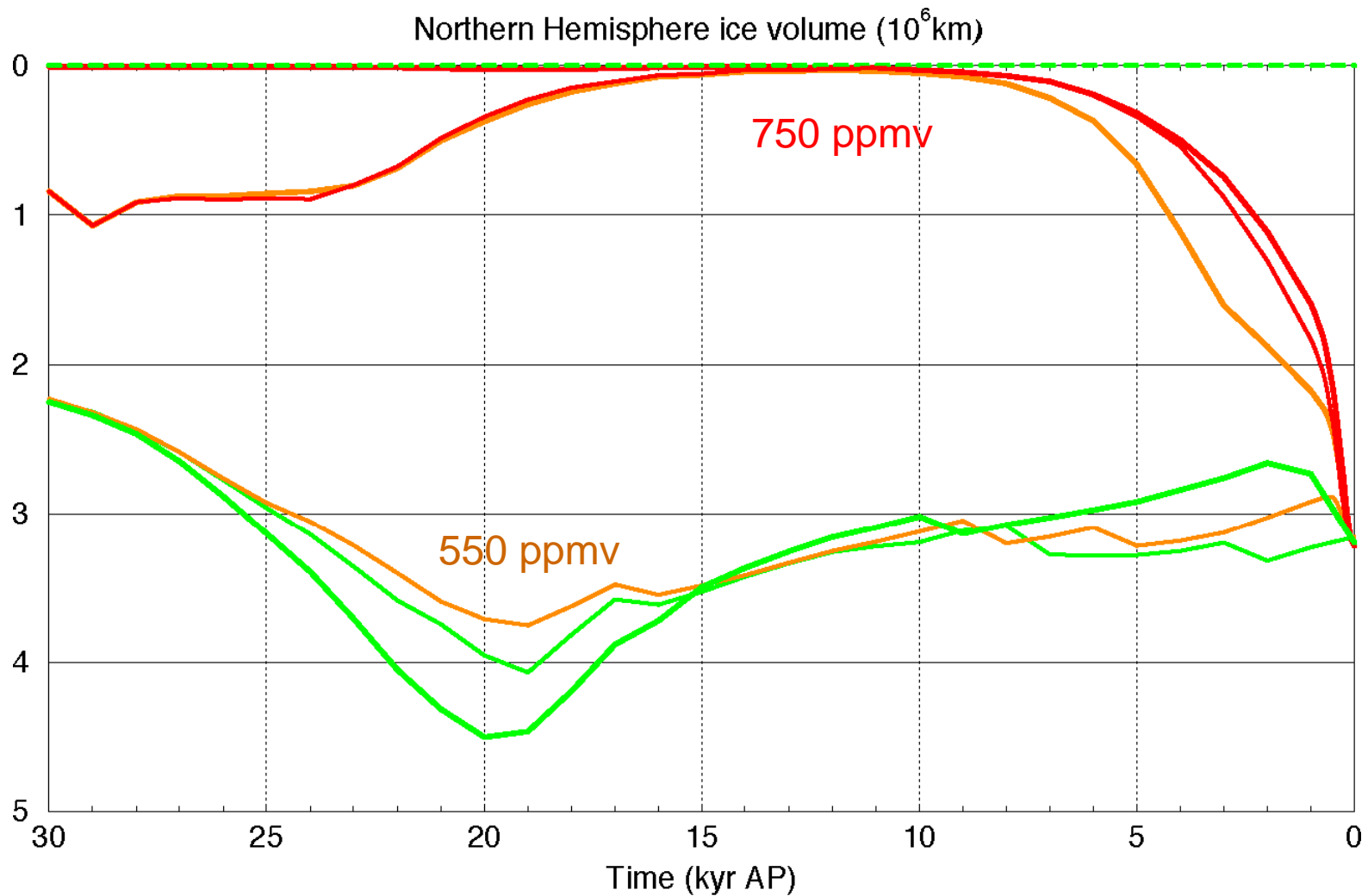


EPICA community members, *Nature*, 2004



Berger and Loutre, 2002

Berger and Loutre, Science 2002

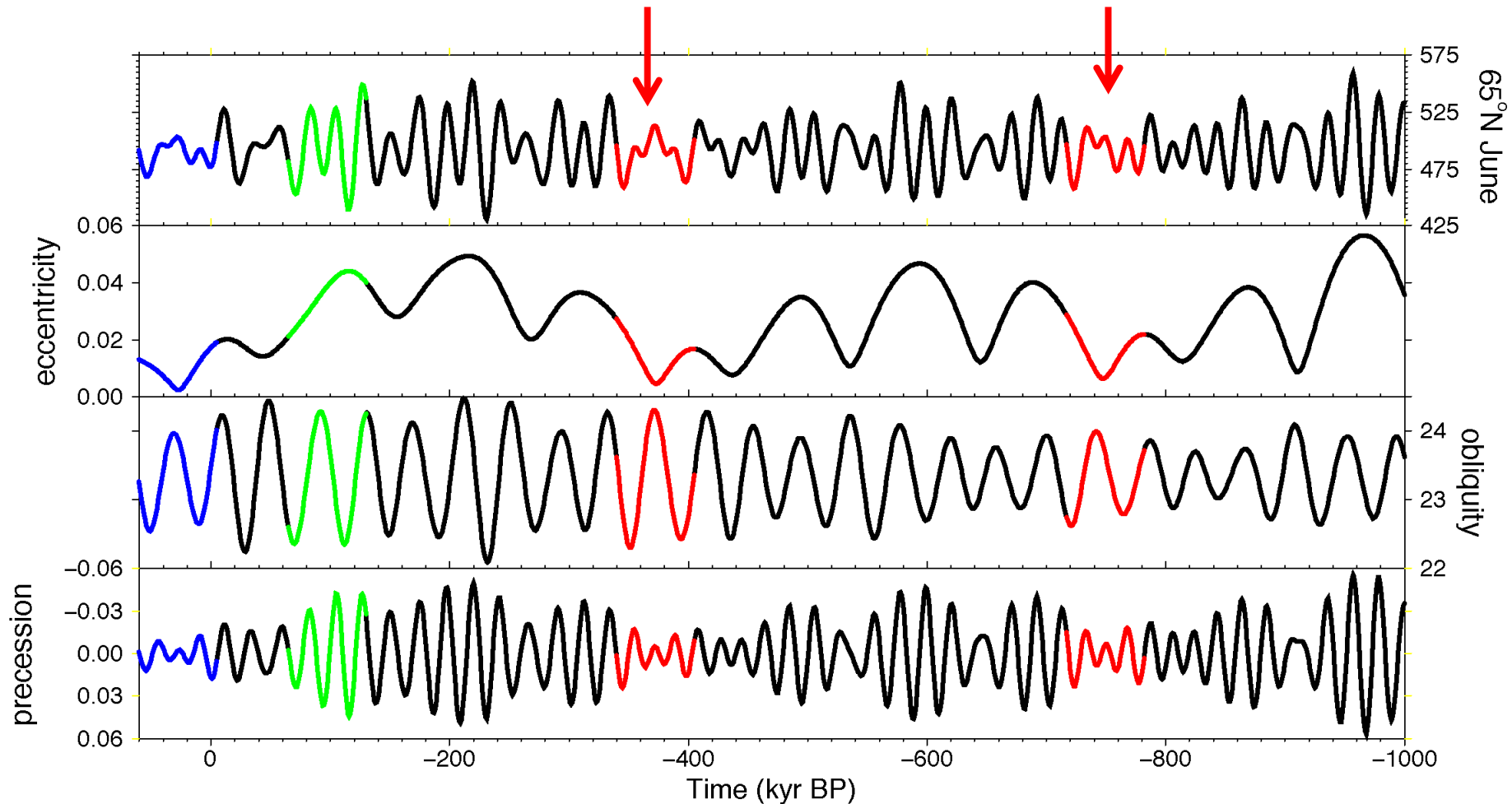


thin line – initial conditions from run –200 – 0

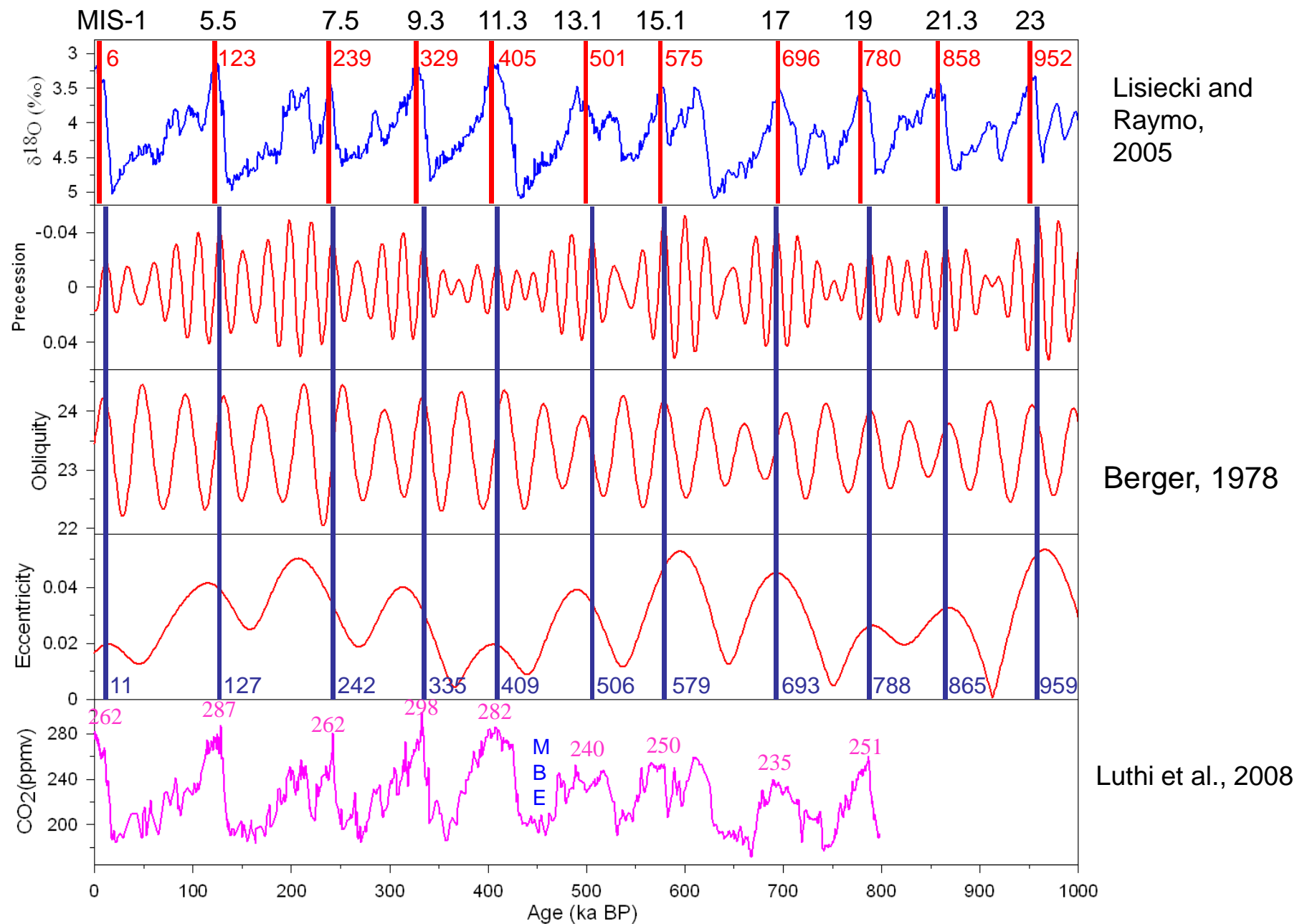
thick line – initial conditions from run –122 – 0

- 550 (M06)
- 750 (M07)
- Jouzel et al., 1983 (B52)
- Jouzel et al., 1983 – initial volume = 0 (B43)
- 550 (M10)
- 750 (M11)
- Jouzel et al., 1983 (B40)

Astronomical parameters : an analogue for the future

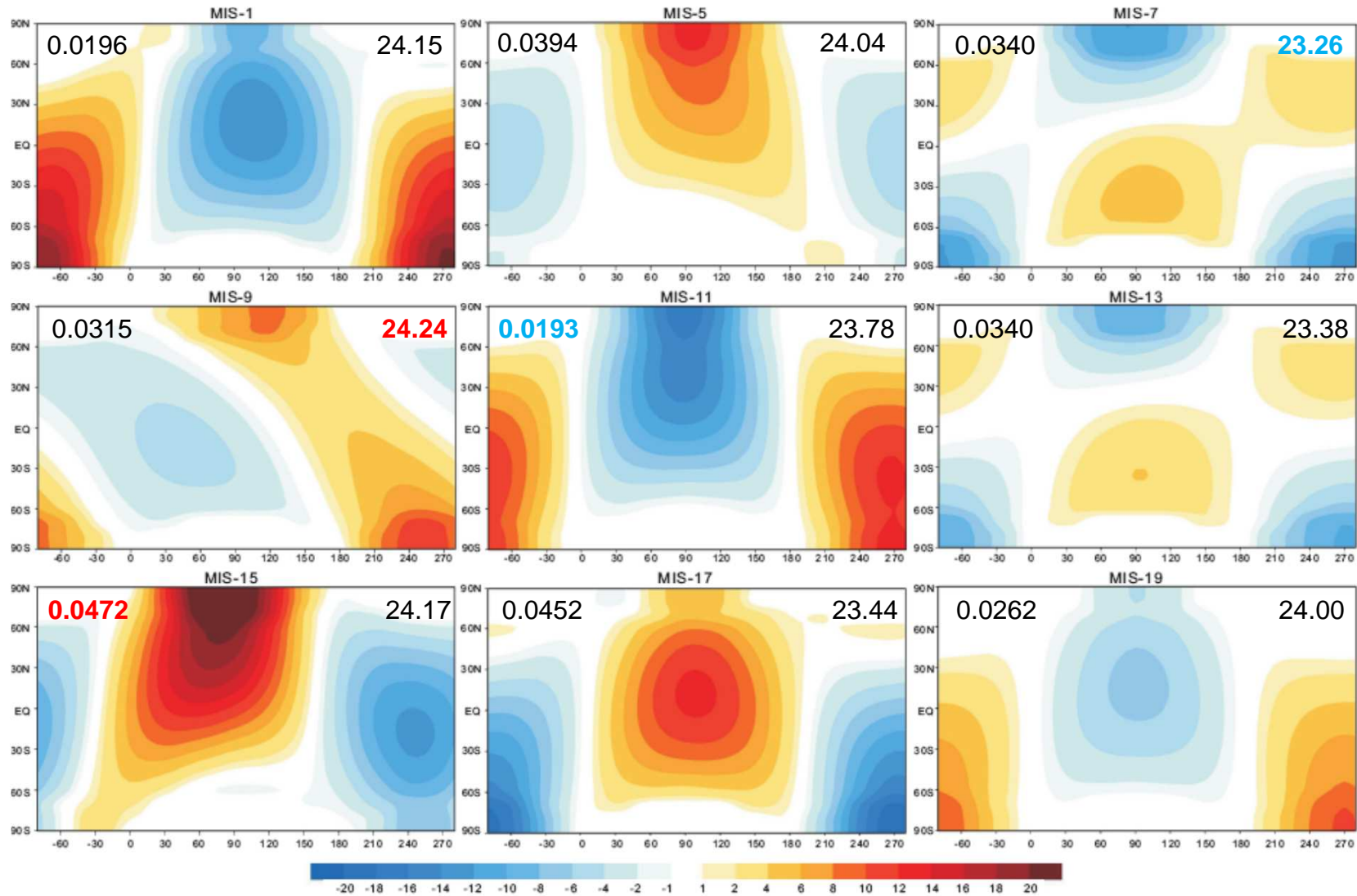


Berger, 1978



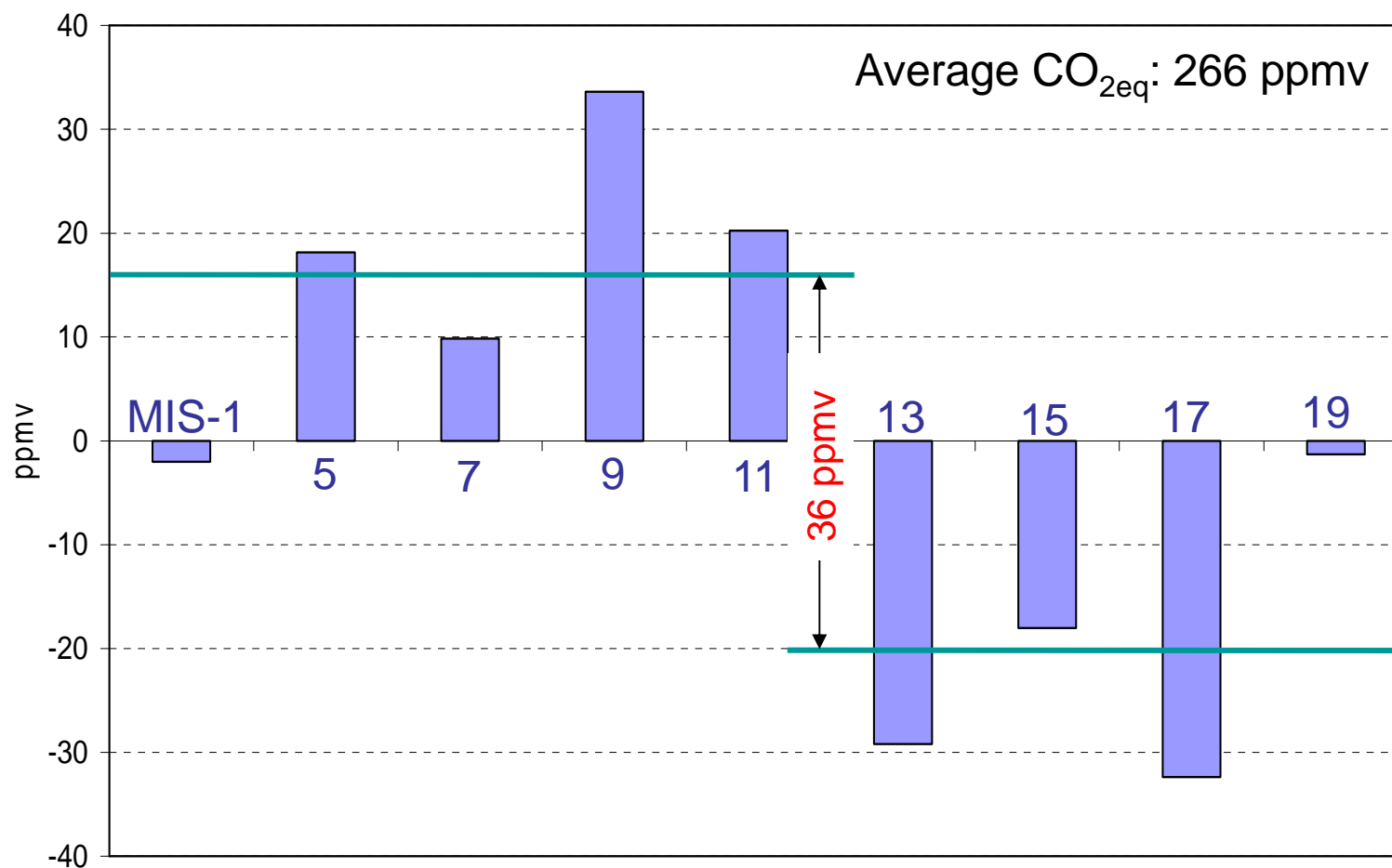
Scenarios as in Yin and Berger, Nature Geoscience, 2010

Fig. 5. Insolation at each interglacial (NHS at P) minus the insolation calculated from the orbital parameters averaged over the last 9 interglacials $e = 0.0328$ $obl = 23.82$



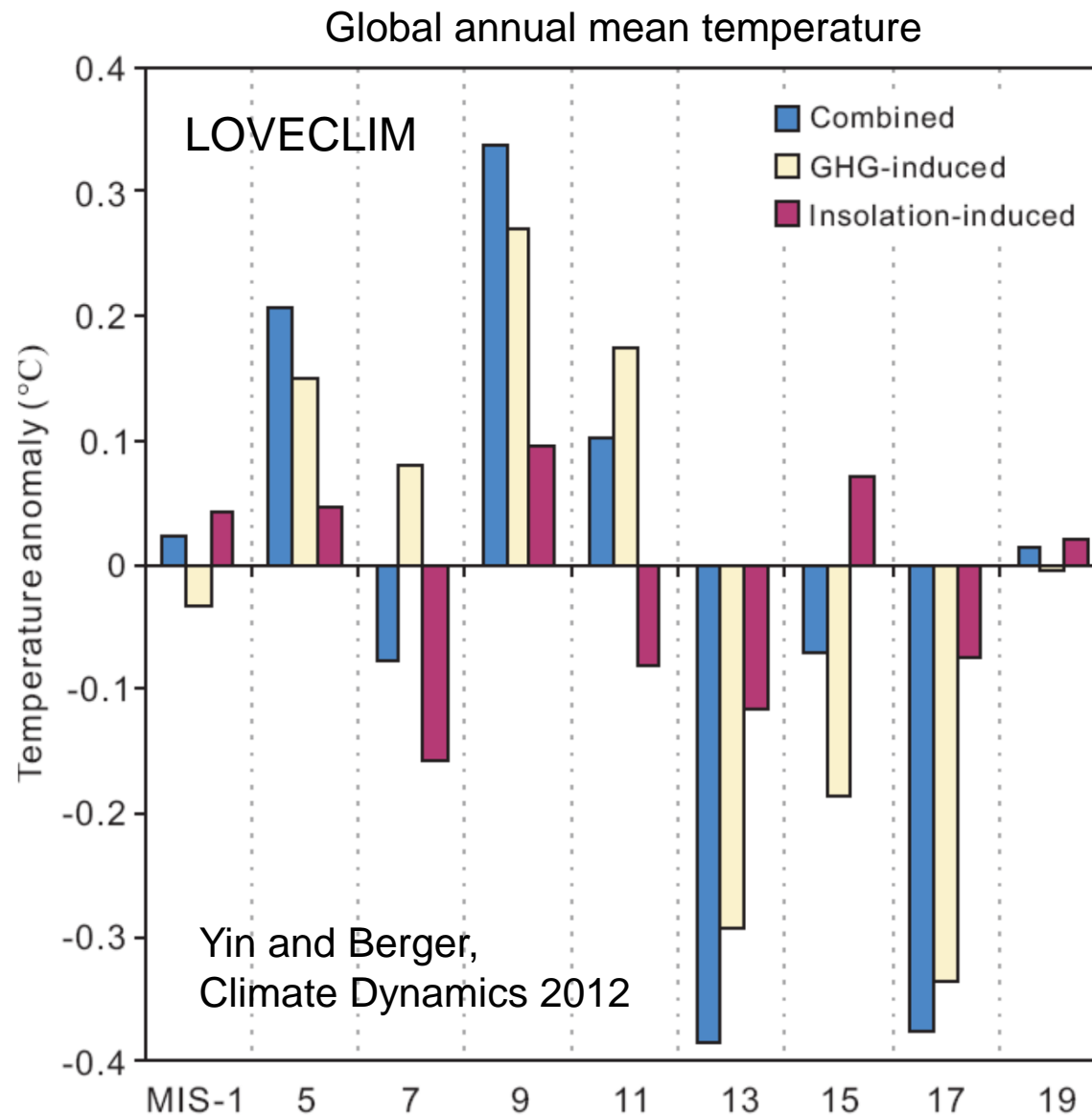
Berger, 1978; Yin and Berger, 2012

CO₂eq deviation from the average of the last 9 interglacials

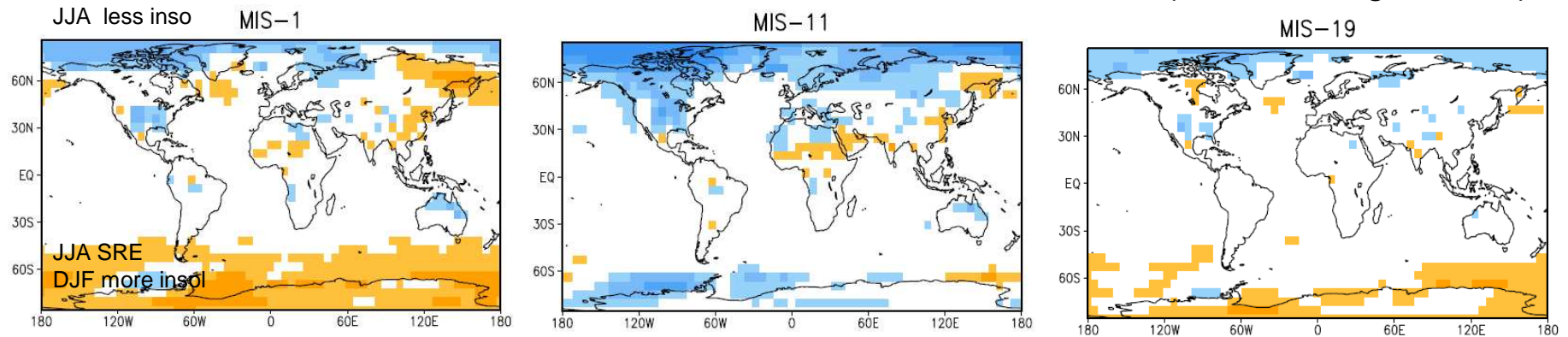


EPICA community members, Nature, 2004; Yin and Berger, Nature geoscience, 2010

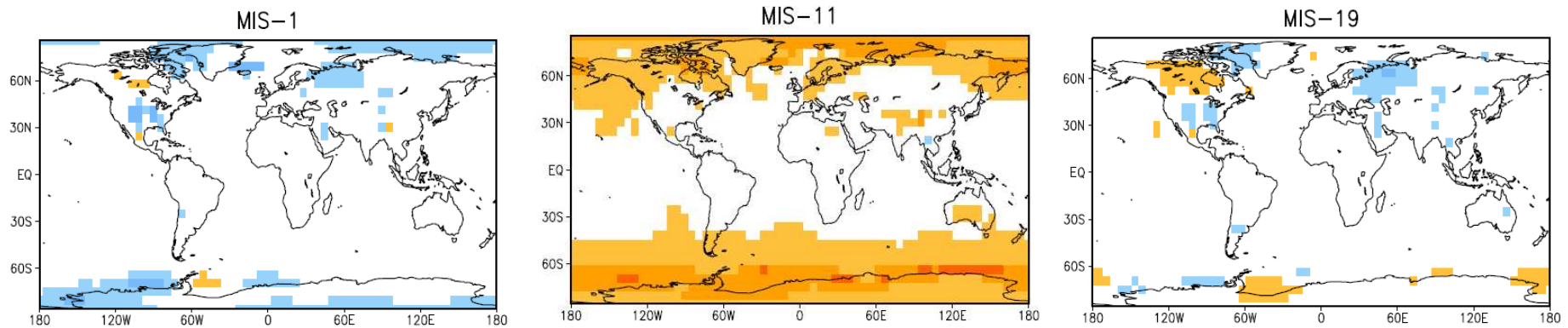
Relative importance of GHG and insolation on the warmth intensity is different from one interglacial to another.



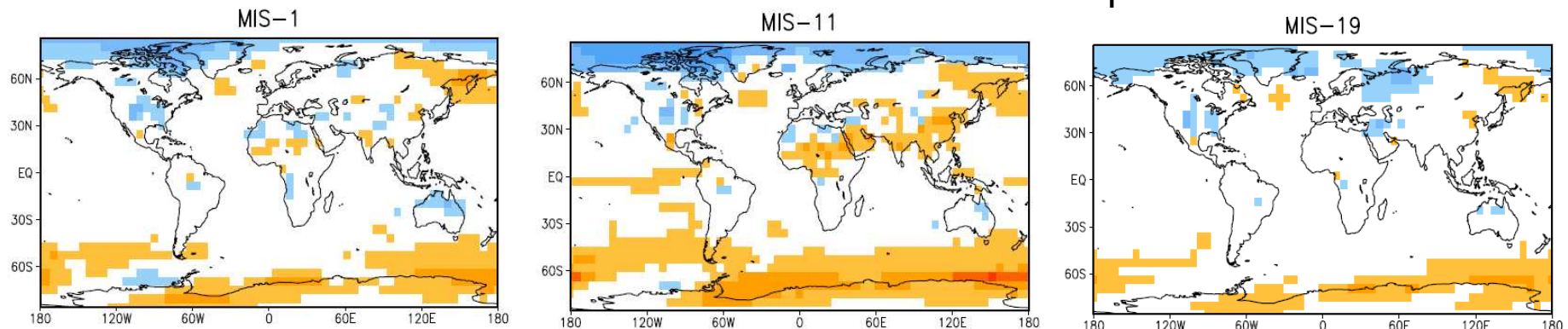
Insolation-induced annual temperature (Yin and Berger, 2012)



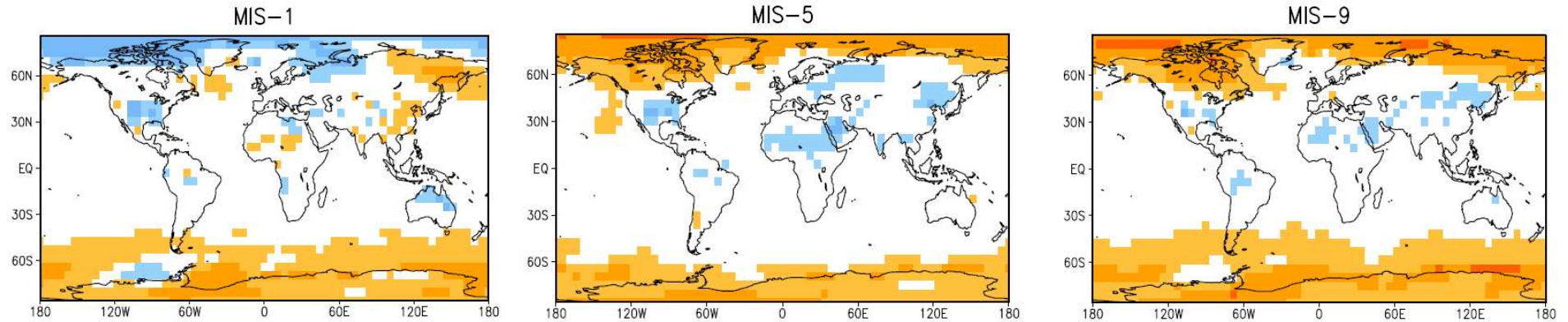
GHG-induced annual temperature



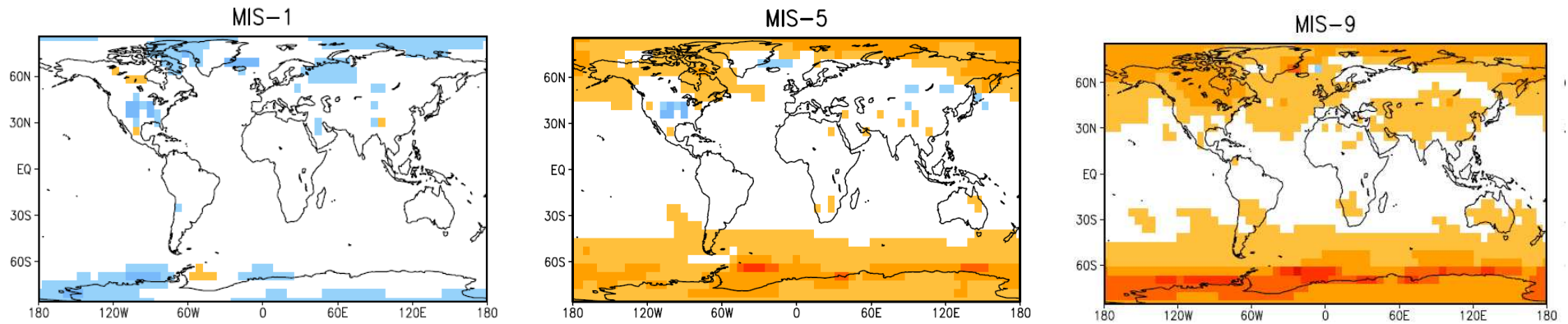
Insolation and GHG induced annual temperature



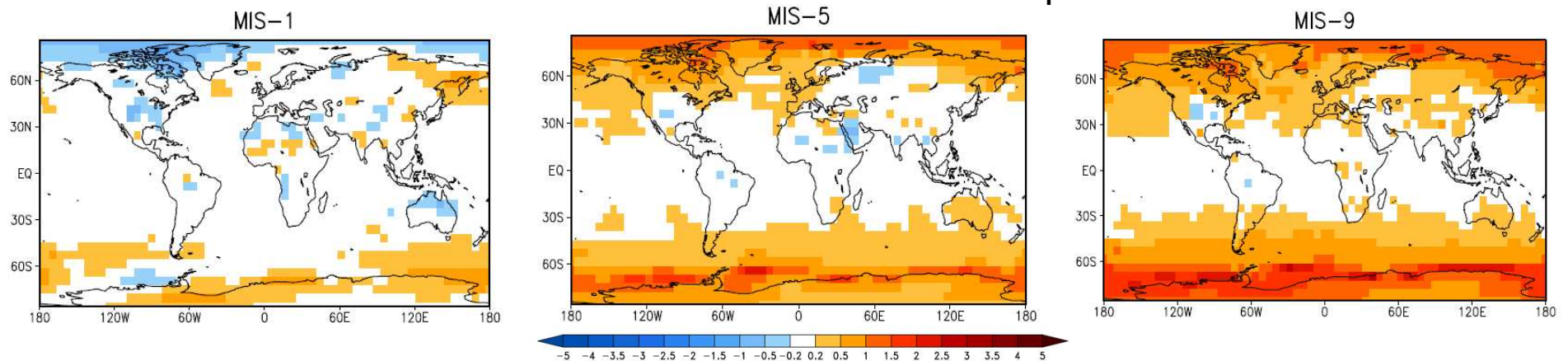
Insolation-induced annual temperature (Yin and Berger, 2012)



GHG-induced annual temperature



Insolation and GHG induced annual temperature



ANALOGUES

MIS-19 is the best analogue of MIS-1. If MIS-11 is used, we must care that its insolation and CO₂ play a significant opposite role, a situation different from MIS-1.

For the Anthropocene, MIS-5 and MIS-9 may be accepted provided care is taken that the astronomical forcing is totally different

