During the last glacial/interglacial transition the Earth's climate underwent around 14.6 kyr ago rapid changes. Temperature proxies from ice cores revealed the onset of the Bolling/Allerød (B/A) warm period in the north (Steffensen et al. 2008) and the start of the Antarctic Cold Reversal in the south (Stenni et al. 2001). Furthermore, the B/A is accompanied by a rapid sea level rise of about 20 m during meltwater pulse (MWP) 1A (Peltier & G.Fairbanks 2007) whose exact timing is matter of current debate (Hanebuth et al. 2000; Kienast et al. 2003; Stanford et al. 2006, Deschamps et al. 2009). In situ measured CO₂ in the EPICA Dome C (EDC) ice core also revealed at the same time a remarkable jump of 10 ppmv in 230 years (Monnin et al. 2001; Lourantou et al. 2011). Allowing for the age distribution of CO₂ in firn we here show, that atmospheric CO₂ rose indeed by 20–35 ppmv in less than 200 years, which is a factor of 2–3.5 larger than the CO₂ signal recorded in situ in the EDC. Based on the modelled fingerprint and δ¹³CO₂ measured in EDC (Lourantou et al. 2010) we infer that 125 Pg of carbon of terrestrial origin need to be released to the atmosphere to produce such a peak. Most of the carbon might have been activated as consequence of continental shelf flooding during MWP-1A. This impact of rapid sea level rise on atmospheric CO₂ distinguishes the B/A from other Dansgaard/Oeschger (D/O) events, potentially defining the point of no return during the last deglaciation.

Paleo Records during MIS 3 and Termination I

Climate records during MIS 3 and Termination I from top to bottom: relative sea level, CO₂, CH₄ and isotopic temperature proxies (δD or δ¹⁸O) from Antarctica (black) and Greenland (red). (A) MIS 3 data (Ahn & Brück 2008) from the Byrd and GISP2 ice cores. (B) Termination I data from the EDC and NG-RIP ice cores (Monnin et al. 2001; Steffensen et al. 2002). NordGRIP members 2004) on the new synthesised ice core age scale (Lemieux-Dudon et al. 2010). Precious (blue) and nine (cyan) EDC CO₂ data (Monnin et al. 2001; Lourantou et al. 2010). Sea level in MIS 3 from a compilation (magenta) based on coral reef terraces (Thomson & Goldstein 2007), and the synthesis (green) from the Red Sea method (Siddal et al. 2008) and for Termination I from cores (green) on Barbados, U.V. dated and uplift-corrected (Peltier & G.Fairbanks 2007), and coast line migration (magenta) on the Sunda Shelf (Hanebuth et al. 2000). Vertical lines in (B) mark the jump in CO₂ into the B/A as recorded in EDC.

Gas Age Distribution

The evolution of the mean gas age (± 1σ) during the last 20 kyr calculated with a firn densification model including heat diffusion (Goujon et al. 2003). Green diamonds represent the results for the LGM and pre-industrial climate with another firn densification model (Joues & Spahni 2006). Please note reverse y-axis. Top: EDC CO₂ (Monnin et al. 2001; Lourantou et al. 2010). Bottom: EDC CO₂ data (Stenni et al. 2001). All records on the new age scale (Lemieux-Dudon et al. 2010).

Atmospheric CO₂ to Fulfill EDC Data

Simulations of the carbon cycle model BICYCLE for an injection of 125 PgC into the atmosphere. Injected carbon was either of terrestrial (T: δ¹³C = −22.5%) or marine (M: δ¹³C = −8.5%) origin. Release of C occurred between 50 and 300 years. (A) Atmospheric CO₂ from simulations and from ice cores. Spiele Dome (Ahn et al. 2004) (SD, own age scale on top x-axis) and Taylor Dome (Smith et al. 1999) (TD, on revised age scale as in (Ahn et al. 2006)). All CO₂ data synchronised to the CO₂ jump. (B) Simulated CO₂ values of (A) after the application of the gas age distribution potentially recorded in EDC and EDC data. (C, D) Same simulations for atmospheric δ¹³CO₂, cyan dots are new EDC values of (A) after the application of the gas age distribution to the CO₂ jump. (D) Simulated δ¹³CO₂ data of (A) after the application of the gas age distribution potentially recorded in EDC and EDC data. (C, D) Same simulations for atmospheric δ¹³CO₂, cyan dots are new EDC δ¹³CO₂ data (Lourantou et al. 2010).

References

Literatur


