Evidence for 3 rapid CH_4 release events during the last deglaciation

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At three different times during the last deglaciation, there were negative excursions in benthic δ13C at mid-depth in the North Atlantic coinciding with rapid increases in atmospheric pCO_2 (about 12 ppmv in ~150 years [1]). Using a hierarchy of ocean models, we have investigated two broad hypotheses to explain these observations: (i) Successive weakenings of the organic carbon pump, possibly through changes in the ocean circulation; (ii) Methane release events, possibly due to destabilization of marine clathrates or thawing permafrost.

Based on mass balance, using idealized models, we concluded that methane releases appear the most consistent with the observed increases in atmospheric pCO_2 and the amplitudes of the three δ13C excursions. However, methane release cannot be responsible for the entire deglacial CO_2 increase, as it would make the ocean-atmosphere system isotopically lighter than observed. Hence, the background CO_2 increase throughout the deglaciation must be driven by other processes, and the methane releases are superimposed.

Using three-dimension ocean simulations, we asked what would be likely signatures of methane release events in the δ13C and 14C records throughout the oceans, and what frequency of sampling would be needed to resolve them. In our model experiments, we first released tracers at the ocean surface in 150-year pulses. Then, we examined pseudo-time series of these tracers at various locations at the surface and ocean floor, as might be inferred from sediment cores. In the Atlantic, where deep waters are formed, the individual pulses are clearly discernible above ~2500 m. A somewhat lower time sampling resolution is needed at mid-depth sites (200-300 years) than close to the surface (100-200 years), because the pulses become broader in time, as the tracers are advected into the ocean interior. At lower resolution, the pulses merge into one broad excursion which has been observed in many records. Thus, the results underline the potential for overprinting of ocean circulation proxies by carbon input from external sources.

[1] Marcott et al. (2014), *Nature* **514**, 616-619