A record of fluctuations in thermocline ^{14}C from Soledad Basin, Mexico?

Proposal to the LDEO Climate Center

Lex van Geen, April 30 2007

Summary

The Climate Center funded in the previous round a 1-day cruise to Soledad Basin, an anoxic borderland basin off the Pacific margin of southern Baja California to collect PDO/ENSO proxy records. Closer examination of existing ^{210}Pb and ^{14}C data from this site in preparation for this cruise has revealed what appear to be large fluctuations in the ^{14}C content of the waters where planktonic foraminifera form their shell over the past 2000 years. The idea isn't as far-fetched as it may seem as Marchitto et al. (*Science*, in press) recently produced a spectacular record of such fluctuations from a nearby region over longer time scales. To make the most of the box core and gravity core material that we expect to collect at the end of August 2007, I request here supplementary funding for an additional 24 AMS^{14}C dates that would test the thermocline ^{14}C-fluctuation hypothesis and, if nothing else, significantly reduce the uncertainty of the age models for our PDO/ENSO proxies. The work could have far-reaching implications for our understanding of ocean circulation and climate along the west coast of the Americas if the new radiocarbon data are consistent with previous observations.

Background

Soledad Basin (25.2 ^{o}N; 112.7 ^{o}W) is a semi-enclosed anoxic embayment 50 km off the west coast of southern Baja California where laminated sediments have been accumulating at remarkably steady rate of ~110 cm/kyr over the past 10,000 years (van Geen et al., *Paleoceanography*, 2003). Nothing prepared us, therefore, for new results showing several rapid shifts of up to ~500 calendar years in the upper ~250 cm of the record – the combination of a multi-core and a gravity core collected in 1999 (Fig. 1). Equally disturbing was the occurrence of seemingly 500-yr old planktonic forams at a depth in the multicore containing an unmistakable excess in ^{210}Pb (half-life of 22 years). It was comforting to observe, however, bomb-radiocarbon in the two shallowest samples from this section. After exploring all possible scenarios, including sediment disturbance or a dating artifact, the large team of colleagues (Yan Zheng, John Crusius, Tom Marchitto, Joe Ortiz, Tim Baumgartner among others) involved in this effort has come to the conclusion that large fluctuations in the ^{14}C content of near-surface waters off Baja California may be the least implausible explanation. The idea that there may have been large fluctuations in the ^{14}C content of surface and/or thermocline waters of the equatorial Pacific has been raised previously on the basis of coral records (Druffel et al., *J. Geophys. Res.*, 1993; Guilderson et al. *J. Geophys. Res.*, 1998) – but the most striking supporting evidence was recently provided by a detailed study of benthic ^{14}C ages in a nearby core raised from 700 m on the open margin (Fig. 2). In this study, Marchitto et al. (*Science*, in press) calculated the age of the sediment independently by correlating with the GISP isotope record a detailed record of diffuse spectral reflectance of the Baja California core obtained on board ship (Ortiz et al., *Geology*, 2003). The main conclusion from this work is that the two periods of rapidly rising atmospheric CO2 during the last deglaciation corresponded to a time of when bottom water at 700 m depth

was much older than today, probably because of ventilation of an isolated water mass from the Southern Ocean.

The hypothesis is that if such large fluctuations occurred 10-15 kyr ago in this particular locations, it is plausible that they occurred more recently – especially because of the strong contrast in composition between northern and southern shallow thermocline water in the region. To test this hypothesis, I propose to obtain a resolution ^{14}C planktonic record from the new cores that will be collected at the end of August (forams have largely dissolved in the upper portion of the 1999 cores – though most of the data in Fig. 1 are from samples that had been picked years ago). If inconsistent with the previous observations (i.e. a steady trend in ^{14}C is observed this time around), the new data – along with better/higher resolution porosity/^{210}Pb data will at least serve to constrain new PDO/ENSO proxy records. If consistent with previous observations, on the other hand, the results will open the door to a whole new direction of paleoceanographic research and will form the basis of an exciting NSF proposal.

The cruise on board RV Francisco de Ulloa (CICESE) has been scheduled for the last days of August. Participants, including Frontiers of Science/FOSTOR-supported undergraduate Laura Seidman, will (dis)embark from Puerto San Carlos.

Budget: 24 NOSAMS 14C analyses @$249 ea.
Total: $5976

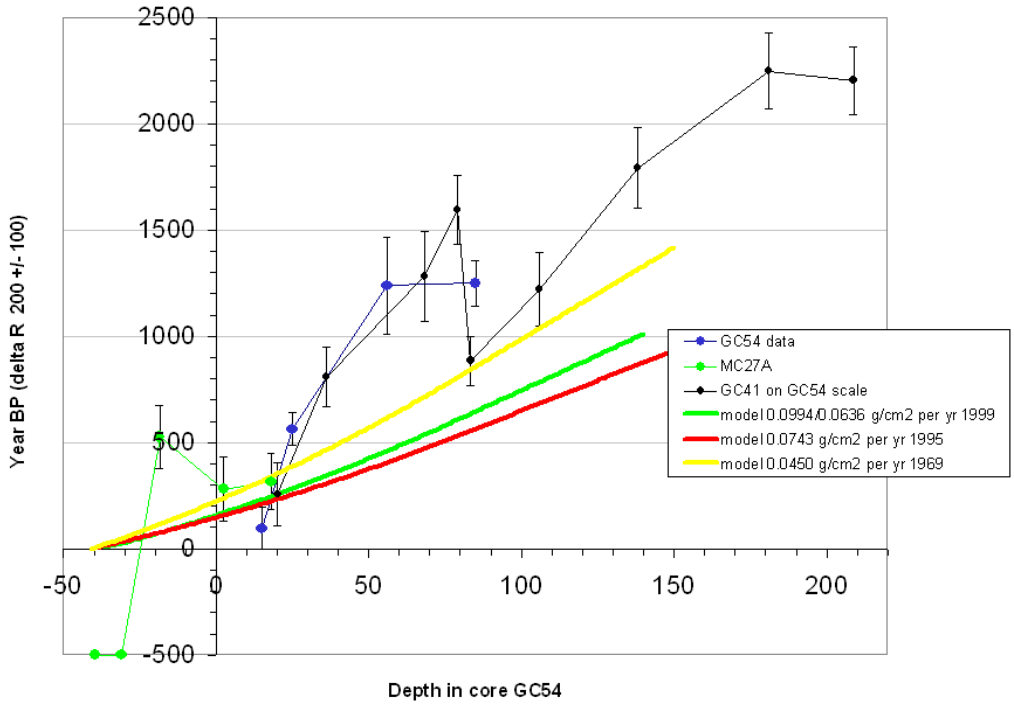

Figure 1 Comparison of calendar ages as a function of depth inferred from planktonic AMS 14C ages assuming a fixed reservoir age of 600±100 years. The record is a composite of one 210Pb-dated multicore dated (MC27A) and two parallel gravity cores (GC41 and GC54) from the bottom of Soledad Basin.

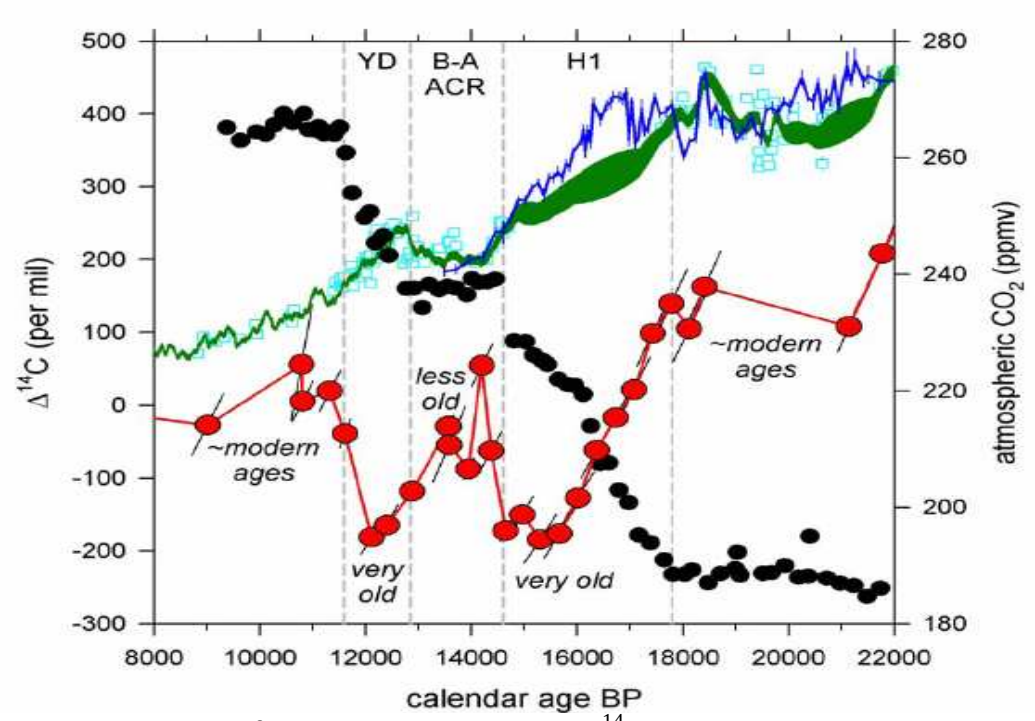

Figure 2 Baja California intermediate water $\Delta^{14}C$ during the last deglaciation (red) compared to atmospheric $\Delta^{14}C$ (dark green, cyan, and blue) and atmospheric CO2 from Antarctica Dome C placed on GISP2 timescale (black). Dashed gray lines show ages of Bølling-Allerød (B-A) and Younger Dryas (YD) boundaries based on GISP2 δ18O record and start of Heinrich event 1 (H1). From Marchitto et al. (*Science*, in press – i.e. not for distribution).