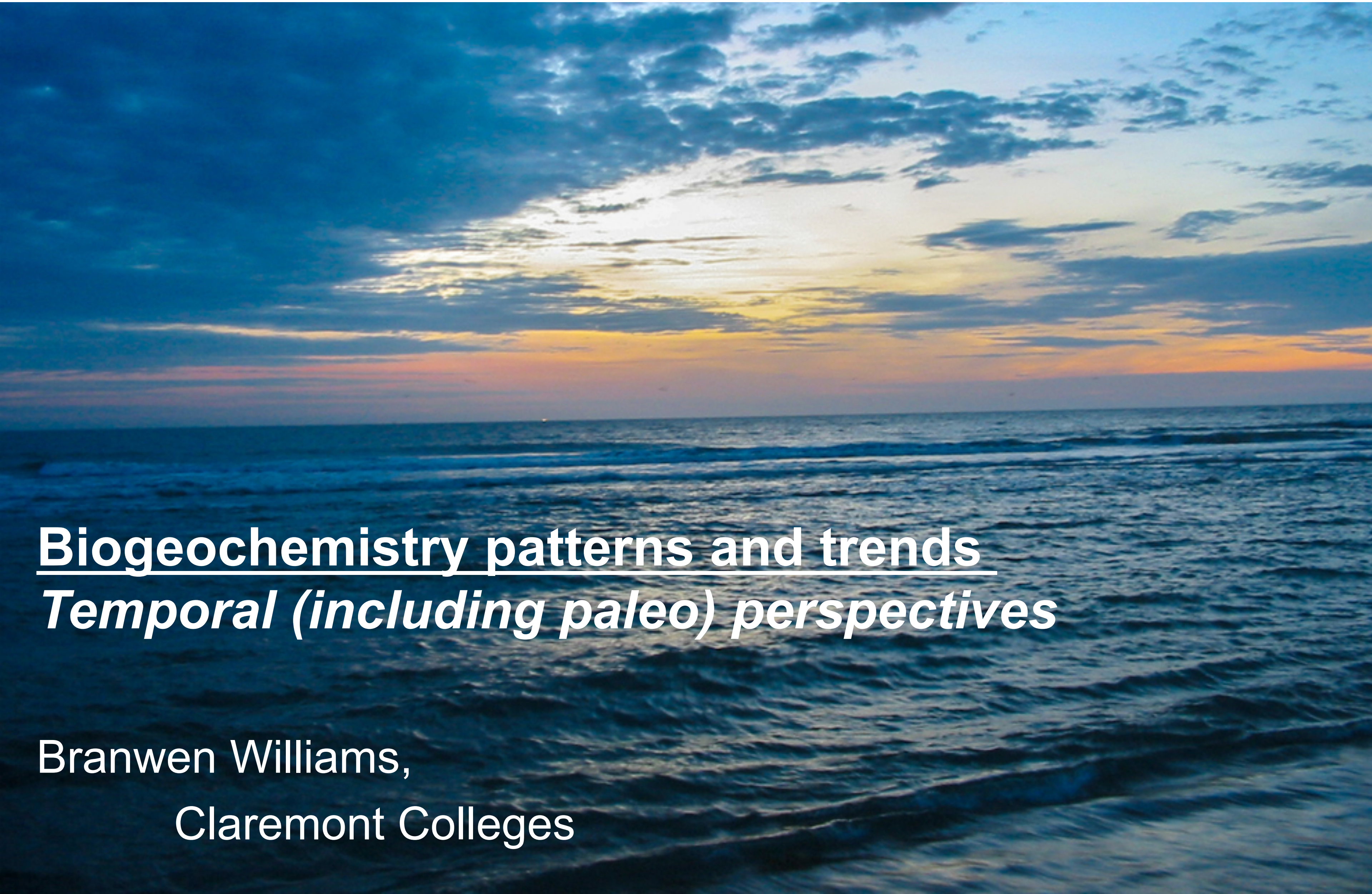
2018 Ocean Acidification PI Meeting



Biogeochemistry patterns and trends

Temporal (including paleo) perspectives

Branwen Williams,
Claremont Colleges

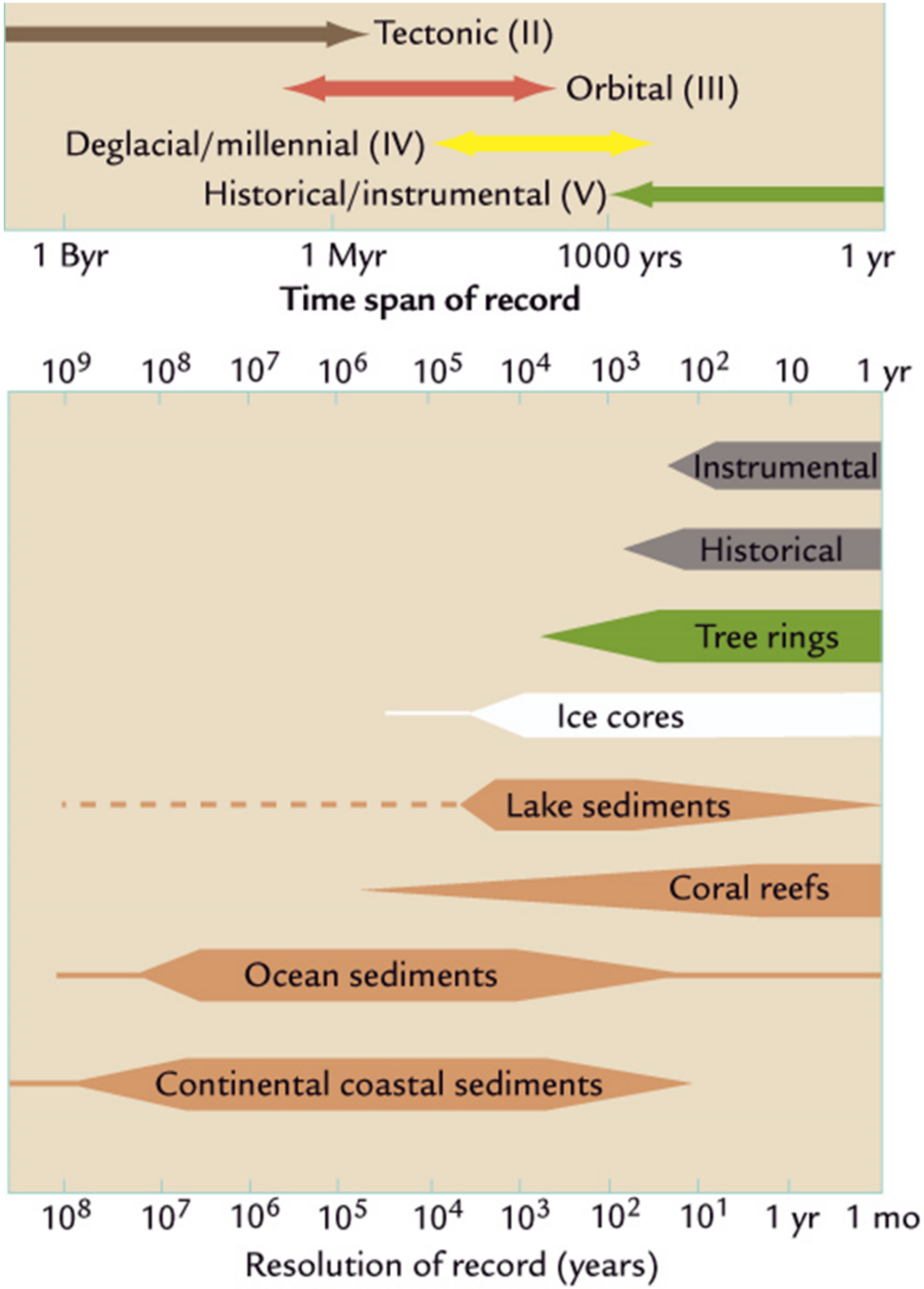
Scale

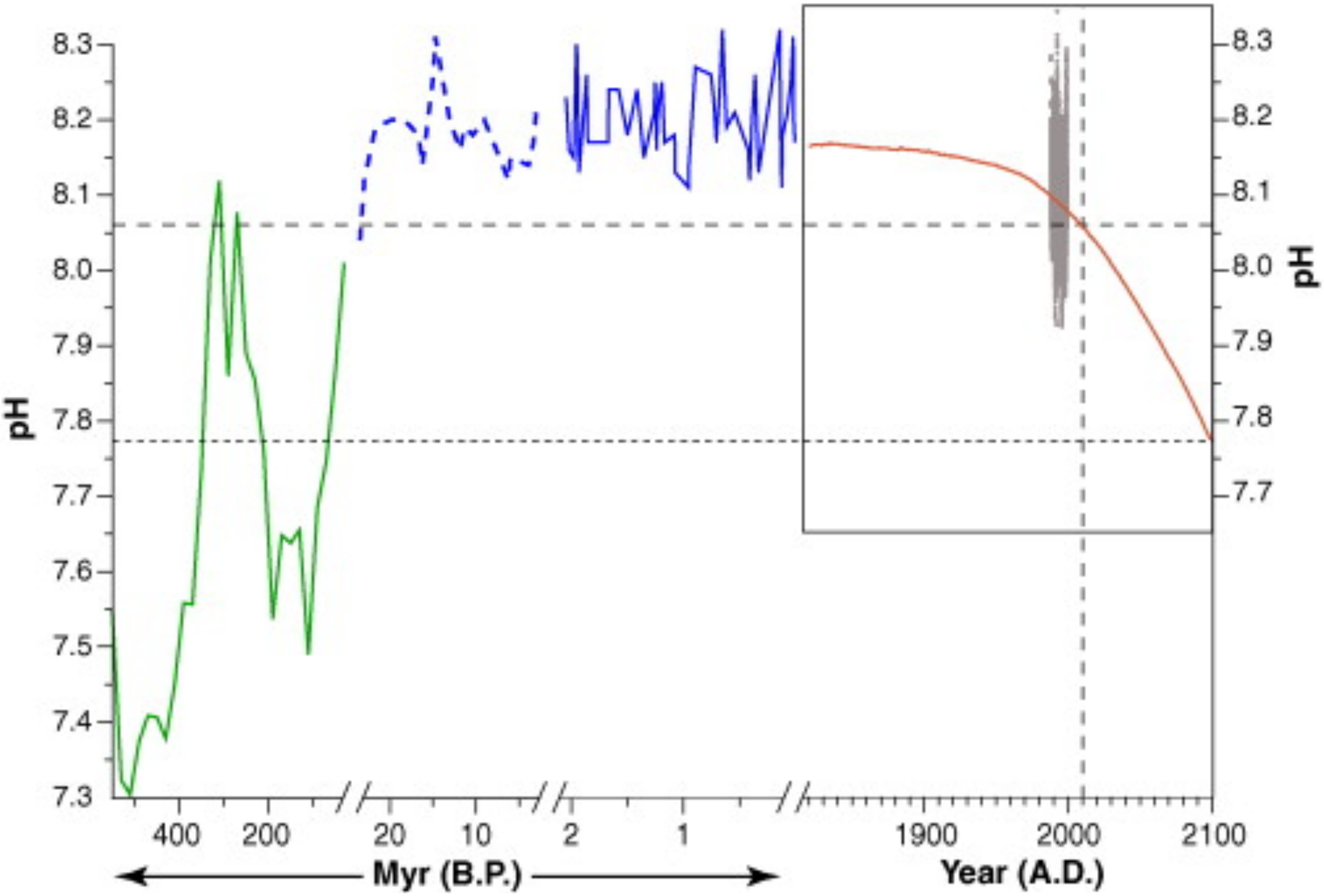
Deep-time

Analog

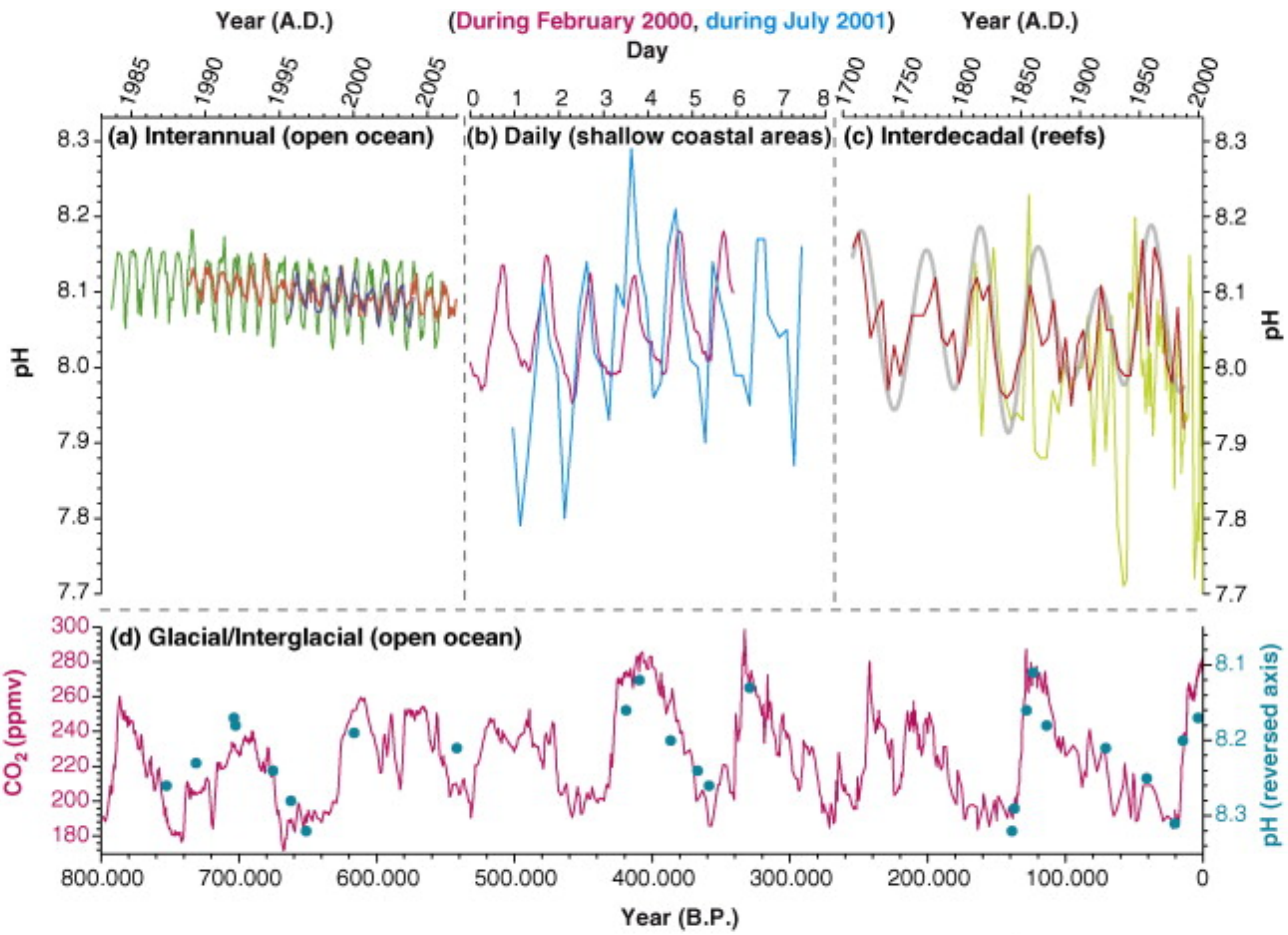
Modern

Climate regimes





Pelejero et al, 2010, Trends in Ecology and Evolution



Pelejero et al, 2010, Trends in Ecology and Evolution

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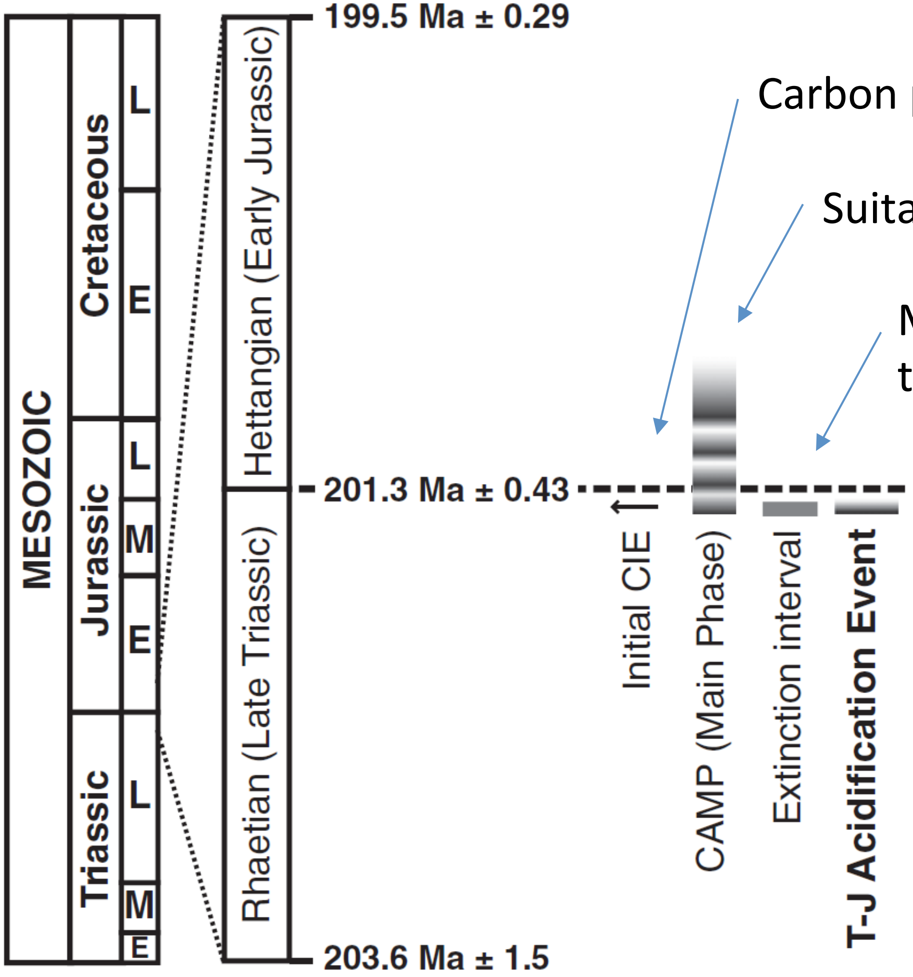

Carbon perturbation event

Suitable trigger

Mass extinction, selective toward acid-sensitive organisms

CIE = Carbon Isotope Excursion

CAMP = Central Atlantic magmatic province

Greene et al., 2012, ESR

Scale
Deep-time
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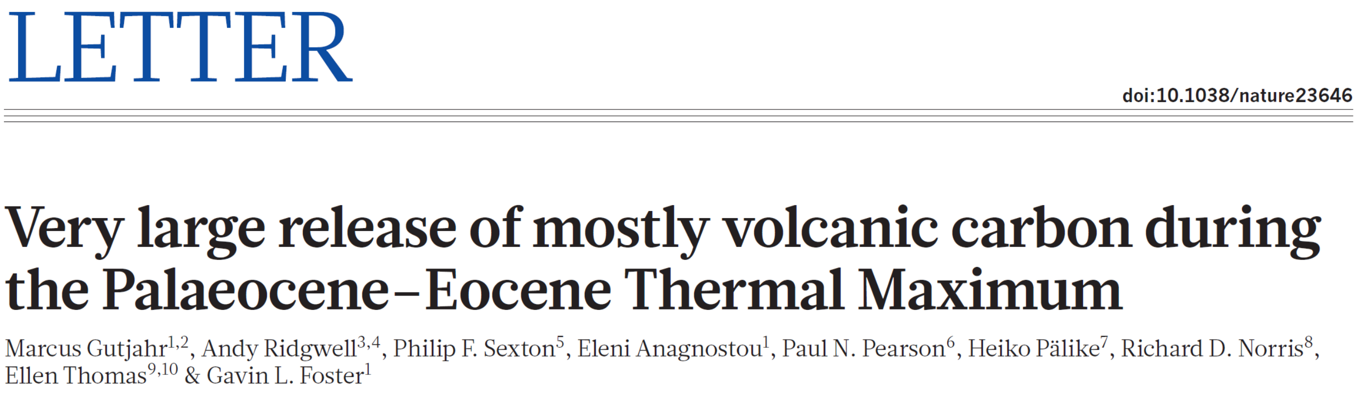
Climate regimes



LETTER

doi:10.1038/nature23646

Very large release of mostly volcanic carbon during the Palaeocene–Eocene Thermal Maximum

Marcus Gutjahr[1,2], Andy Ridgwell[3,4], Philip F. Sexton[5], Eleni Anagnostou[1], Paul N. Pearson[6], Heiko Pälike[7], Richard D. Norris[8], Ellen Thomas[9,10] & Gavin L. Foster[1]

Up to 10,000 petagrams of carbon

Supports volcanic trigger (North Atlantic Igneous Province

pH decrease of 0.18 to 0.56 units

Peak atmosphere CO_2 of 2176 µatm (range 1507 – 4080)

SST warming 3.6°C

Peak emission rate 0.58 pg carbon per year

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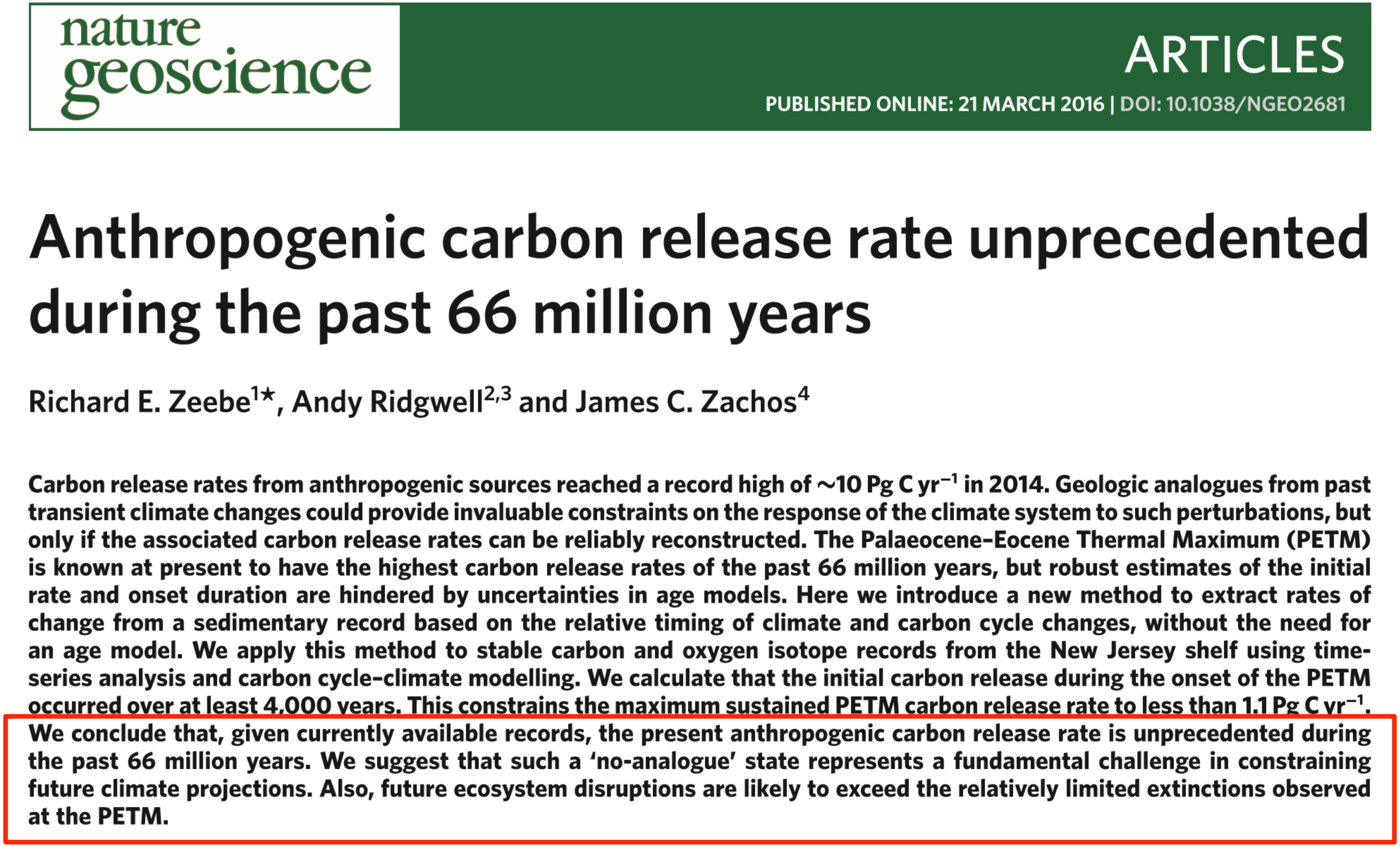

nature geoscience

ARTICLES

PUBLISHED ONLINE: 21 MARCH 2016 | DOI: 10.1038/NGEO2681

Anthropogenic carbon release rate unprecedented during the past 66 million years

Richard E. Zeebe[1]*, Andy Ridgwell[2,3] and James C. Zachos[4]

Carbon release rates from anthropogenic sources reached a record high of ∼10 Pg C yr^{-1} in 2014. Geologic analogues from past transient climate changes could provide invaluable constraints on the response of the climate system to such perturbations, but only if the associated carbon release rates can be reliably reconstructed. The Palaeocene–Eocene Thermal Maximum (PETM) is known at present to have the highest carbon release rates of the past 66 million years, but robust estimates of the initial rate and onset duration are hindered by uncertainties in age models. Here we introduce a new method to extract rates of change from a sedimentary record based on the relative timing of climate and carbon cycle changes, without the need for an age model. We apply this method to stable carbon and oxygen isotope records from the New Jersey shelf using time-series analysis and carbon cycle–climate modelling. We calculate that the initial carbon release during the onset of the PETM occurred over at least 4,000 years. This constrains the maximum sustained PETM carbon release rate to less than 1.1 Pg C yr^{-1}. We conclude that, given currently available records, the present anthropogenic carbon release rate is unprecedented during the past 66 million years. We suggest that such a 'no-analogue' state represents a fundamental challenge in constraining future climate projections. Also, future ecosystem disruptions are likely to exceed the relatively limited extinctions observed at the PETM.

Scale

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Analog?

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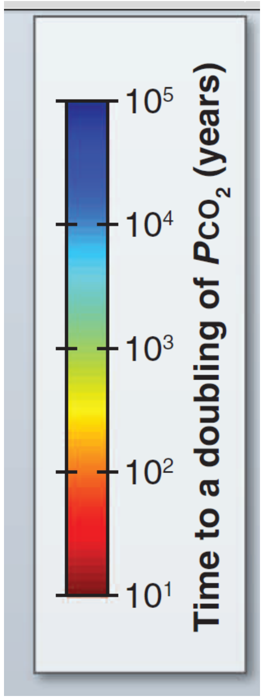

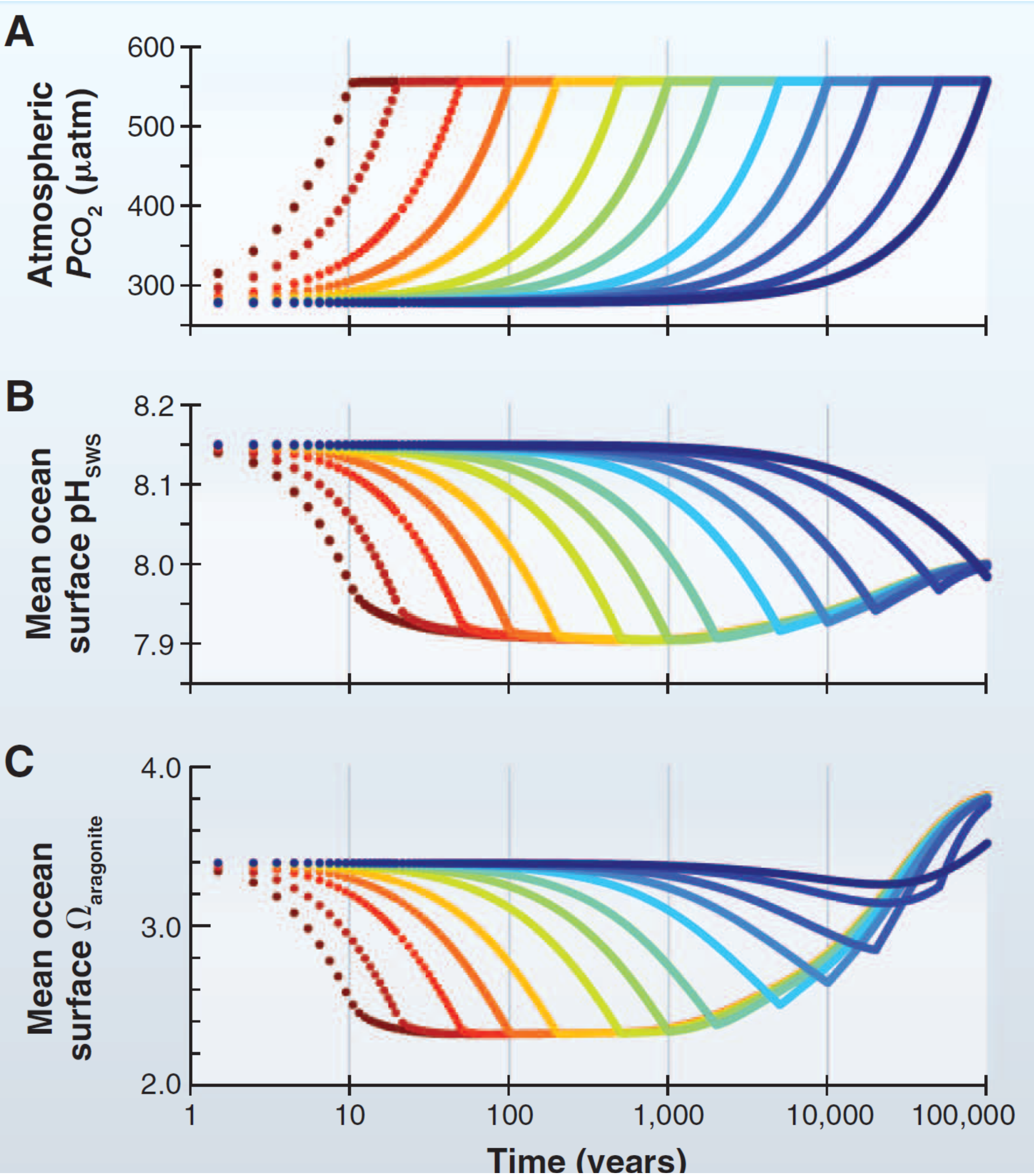

Fig. 3. The trajectories of mean ocean surface pH and aragonite saturation ($\Omega_{aragonite}$) become progressively decoupled as the rate of atmospheric P_{CO_2} change increases. The four panels show the results of a series of experiments in an Earth system model (*2*). (**A**) Prescribed linear increases of atmospheric P_{CO_2} (on a $\log_{10}$ scale) from ×1 to ×2 preindustrial CO_2, with the different model experiments spanning a range of time scales (but experiencing the same ultimate CO_2 change). (**B**) Evolution of mean surface pH in response to rising CO_2. (**C**) Evolution of mean surface $\Omega_{aragonite}$.

Hönish et al., 2012, Science

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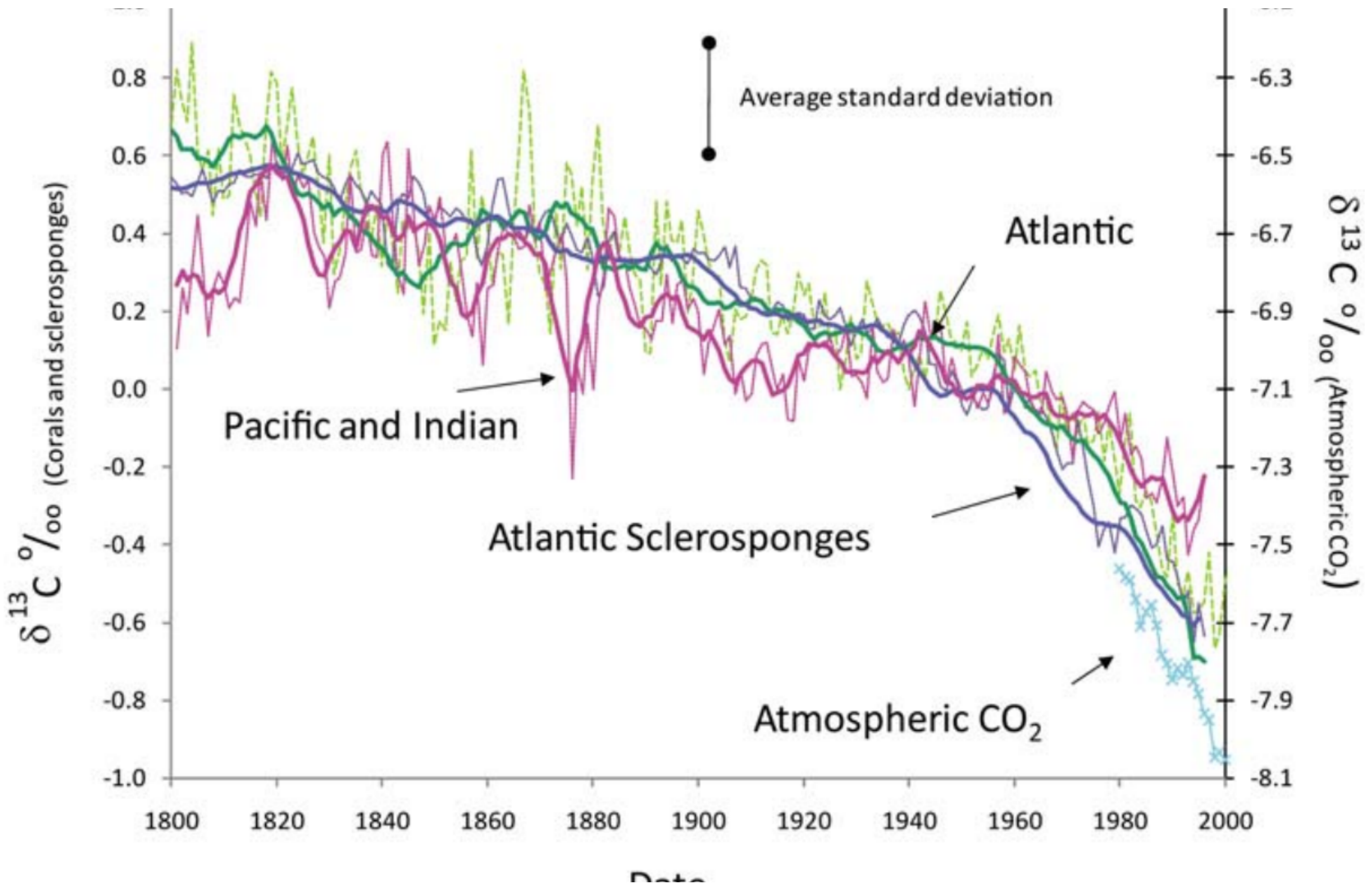

Figure 2. Changes in the $\delta^{13}C$ with respect to age for corals from the Atlantic and the Pacific/Indian Oceans compared to published data from sclerosponges [*Böhm et al.*, 1996; *Swart et al.*, 2002; *Waite et al.*, 2007] as shown in Figure 1.

Swart et al., 2010, GRL

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5. Discussion

5.1. Atmospheric pCO_2 and SST- Not the Only Drivers of Surface pH

Coral-derived ocean pH in the Sargasso Sea

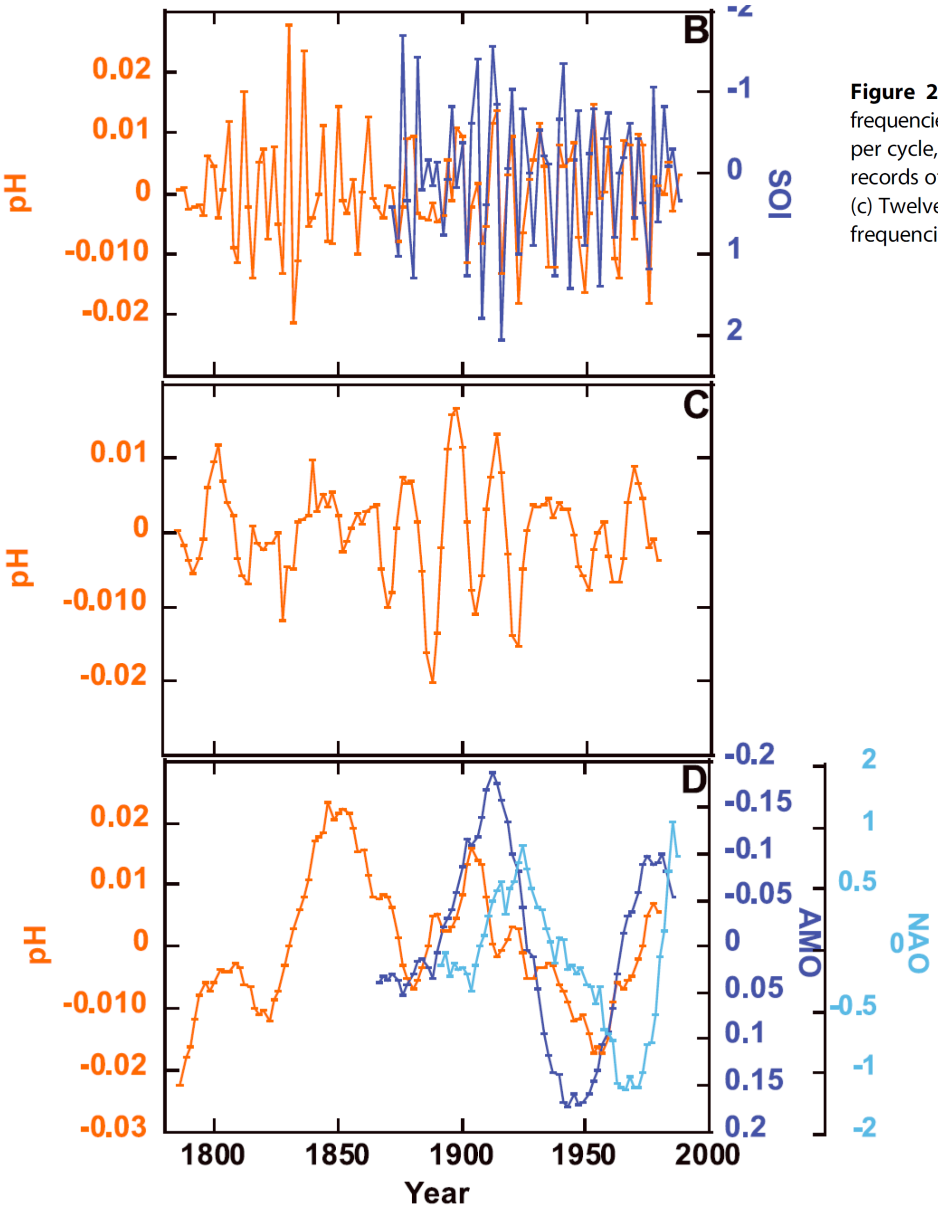

Figure 2. (a) Power spectral analysis of the total Bermuda pH record with frequencies with high power identified (shaded) as 4–8 years per cycle, 12–24 years per cycle, and 24–200 years per cycle. (b) Four to eight year band-pass filtered records of pH (orange) and the Southern Oscillation Index (SOI, blue) versus time. (c) Twelve to 24 year band-pass filtered records of pH (orange). (d) >24 year frequencies of pH (orange) and the AMO (dark blue) and the NAO (light blue).

Goodkin et al., 2015, GRL

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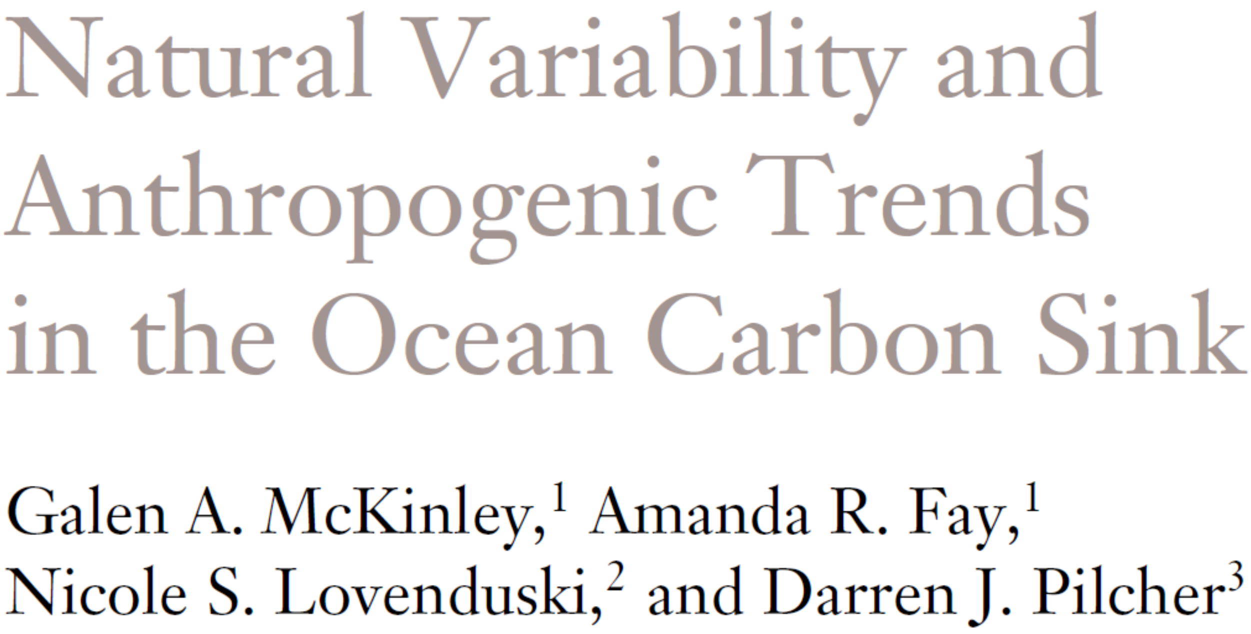
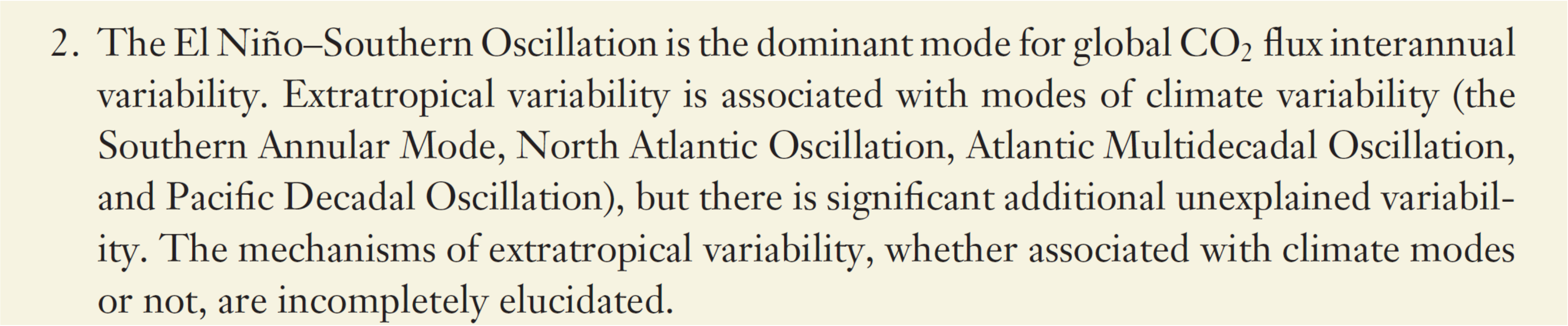


Natural Variability and Anthropogenic Trends in the Ocean Carbon Sink

Galen A. McKinley,[1] Amanda R. Fay,[1]
Nicole S. Lovenduski,[2] and Darren J. Pilcher[3]



2. The El Niño–Southern Oscillation is the dominant mode for global CO_2 flux interannual variability. Extratropical variability is associated with modes of climate variability (the Southern Annular Mode, North Atlantic Oscillation, Atlantic Multidecadal Oscillation, and Pacific Decadal Oscillation), but there is significant additional unexplained variability. The mechanisms of extratropical variability, whether associated with climate modes or not, are incompletely elucidated.