Clim. Past Discuss.,
https://doi.org/10.5194/cp-2017-131-SC1, 2018

Climate of the Past Discussions

CPD

Interactive comment

Interactive comment on "Orbital forcing of terrestrial hydrology, weathering and carbon sequestration during the Palaeocene-Eocene Thermal Maximum" *by* Tom Dunkley Jones et al.

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Received and published: 3 January 2018

Review comment on: "Orbital forcing of terrestrial hydrology, weathering and carbon sequestration during the Palaeocene-Eocene Thermal Maximum" by Dunkley Jones et al. Comments by Mike Clare, National Oceanography Centre Southampton.

This manuscript presents a valuable new study across the PETM at the Zumaia section from the deep marine Basque Basin, Spain. While the Zumaia section is already well-studied, the paper presents a new higher-resolution isotopic profile through the Zumaia section that contributes an enhanced chronostratigraphy, and attempts to explain when and how the Earth recovered from a major warming perturbation during the PETM.

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Discussion paper

This study's novelty is underpinned by new high resolution data and frequency analysis coupled with numerical modelling, and its focus on how the Earth system could recover so quickly from such a major and rapid warming event. The authors point to enhanced carbon burial rather than silicate weathering in isolation, which is an important new finding. The following outlines my main comments on the paper.

Modify title to focus on the recovery phase of PETM:

While the title of the manuscript references orbital forcing across the PETM, my view is that the novelty (and importance) of this paper is the focus of the text itself – on the recovery of the PETM, including when and how the global system could recover (through enhanced carbon burial). To that end, this is an important study that attempts to address how systems can recover from major perturbations – apparently much quicker than previously thought. My first suggestion is that the authors modify the title to more appropriately reflect the content and import of the paper.

Outline differences with previous studies more clearly:

The carbon isotope profiles match very closely with the previous work of Schmitz et al. (1997), but now provide a much higher temporal/vertical resolution. This is needed to isolate key environmental signals, and provides the basis for more robust age modelling. As there are many previous studies of the PETM at Zumaia, it is unsurprising that there is some disagreement in interpretations. For instance, the timing of the PETM onset disagrees with Schmitz et al. (2001). As this paper focusses on the recovery and not the onset (at least that is my take on it), I do not view this as a major issue, but it should be recognised in the text. This is a common issue where multiple groups work on the same datasets. It is helpful for the reader to know where such differences occur for a fair comparison between studies, however.

Recognition of external sediment input (via sediment gravity flows) and consider how that might affect results of frequency analysis:

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Discussion paper

For the authors' approach to work perfectly, they require a complete, continuous and uninterrupted sequence of background sedimentation (preferably with a uniform sedimentation rate). Clearly, the real world rarely (if ever!) provides such a situation; hence, the authors have selected an expanded, well exposed and near-continuous section at Itzurun beach, Zumaia (see the myriad papers on the Zumaia section that have gone before this contribution and explain why it is such a good place to study the PETM). This is a sensible approach and they recognise that there is a non-uniform sedimentation rate. They need to go one step further, however, in tackling the fact that the sequence is not uninterrupted. There are several thin bedded largely muddy (Bouma Ta/Tb-missing) turbidites that represent the input of allochtonous material transported by down-slope turbidity currents (and are thicker and more abundant up-dip, e.g. at the Ermua section; Schmitz et al., 2001). This punctuation of the sequence needs to be clearly recognised and discussed as it has the potential to affect any interpretation of isotopic or elemental profiles. In particular, turbidites that include a component of detrital quartz (which is seen at Zumaia) may affect Si/Fe ratios in a way that is different to the background trend. Previous work that looked at the vertical/temporal distribution of turbidites within the Zumaia sequence (Palaeocene-mid Eocene) by Clare et al. (2015; EPSL) and Clare et al. (2016; Advances in Natural Hazards) demonstrated that the turbidite recurrence conforms to a Poisson distribution form, however (i.e. they are randomly distributed). Thus, as these turbidites are random in the stratigraphic sequence, I would not expect there to be any systematic signal in these turbidites in the Fourier frequency analysis performed by the authors – instead this would be manifested as random noise (reducing the strength of the background signal). Thus, I suspect the authors' work is robust, but perhaps as a thought experiment, the authors could consider generating a synthetic "perfect" signal and blending it with randomly interspersed elevated Si values to see how that affects the outcome of the frequency analysis? Does this account for the fact that there is barely any statistical significance at $p=0.1$ for cycles with a period of <1m in Figure 3? This would also be assisted with some comment on how many cycles are needed for robust Fourier analysis – exactly how robust is the analysis?

Rapid recovery of PETM at Zumaia – faster than terrestrial sites:

There is a convincing correlation between CIE at Zumaia and other sites based on new cyclostratigraphic framework - in particular the Big Horn terrestrial soil carbon record. It is curious that the recovery is quicker at Zumaia than the terrestrial records. I would have expected that the marine record would lag behind the terrestrial one so this is a very interesting result.

References:

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