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Climate of the Past
Discussions

Interactive comment on "Astronomical calibration of the geological timescale: closing the middle Eocene gap" *by* T. Westerhold et al.

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Reply to Interactive comment of Referee J. Ogg on "Astronomical calibration of the geological timescale: closing the middle Eocene gap" by T. Westerhold, U. Röhl, T. Frederichs, S. Bohaty, and J. Zachos.

We thank James Ogg for his time and effort to review our manuscript and providing very helpful suggestions to improve the submitted manuscript.

Here we would like to comment on the four suggestions of J. Ogg: (1) J. Ogg asked for separate zoom in figure(s) on Sites 702 and 1263 to show possible expression of precession and short-eccentricity cycles on core images in some intervals. The hierarchical expression of cyclicity can be commonly seen in the well-known Paleocene

and Maastrichtian Zumaia section. Attached Fig. 1a zooms into the 166 to 180 rmcd interval at Site 1263 ranging from a 2.4 Myr minimum at approximately 168 rmcd to a more pronounced short eccentricity cyclicity below. The figure includes the spliced images as well as the images from Holes 1263A and 1263B. Slight color differences in the images of Holes 1263A and 1263B are related to aperture setting changes during the offshore image acquisition. Therefore the difference in color between the holes is an artefact, and also cannot easily be corrected for. There is no clear expression of precession although slight changes in color occur on decimeter level. The short eccentricity cycles appear a bit darker at d13C minima corresponding to eccentricity maxima, similar to the observations in Lourens et al. (2005) for the early Eocene. Core images of Site 702B (Fig. 1b) are bright white with no apparent expressions of precession or short eccentricity cycles. The figure shows Cores 702B-12X and 702B-13X, time equivalents to the 1263 images of Fig. 1a. In general, core-box images taken during ODP times ("table layout images") suffer from severe unequal lighting. Because of this most cores are darker in the upper right corner (see 702B-12X in Fig. 1b). We are currently working on new procedures in collaboration with Roy Wilkens (Hawaii) to minimize this effect, but the pure white carbonate-rich sediment images of 702B are currently difficult to correct. We will attach this new figure (1a and 1b) to the supplement of a revised version of the manuscript.

(2) The manuscript does not present planktonic carbon isotope data, but bulk sediment (carbonate) isotope data. We will add the following to the supplement of the revised manuscript: "The strong 405-kyr cycle in benthic and bulk d13C data as well as simulated d13C results from a resonance associated with the long residence time of carbon in the ocean (Broecker and Peng, 1982; Ma et al., 2011; Pälike et al., 2006a). Periodic changes in oceanic d13C on Milankovitch time scales are likely caused by changes in weathering induced carbon input changing the burial ratio of CaCO3 to organic carbon (Cramer et al. 2003, Ma et al. 2011). An increase in weathering intensity and riverine carbon supply will increase the burial ratio of CaCO3 to organic carbon leading to a decrease in d13C (minima, lighter values in bulk d13C). During eccentricity max-

ima weathering intensity and nutrient supply is enhanced leading via the biosphere productivity feedback to lighter bulk d13C values in the stable carbon isotope records."

(3) Our approach is to only apply minimal tuning of the records. Adding more tuning tie points could be done, but would already introduce much more characteristics of the target curve into the record. At the same time the improvements on absolute ages on magnetostratigraphic chrons or subchrons will be minimal. For the revised manuscript we suggest not to increase the number of tie points.

(4) J. Ogg asks for a summary table and figure. This is a very good advice and in the revised manuscript we will incorporate a new table exhibiting the current best estimates for polarity chrons including their uncertainty. We will also draw an enlarged vertical-scale timescale figure showing chrons, climate events, a generalized carbon-isotope curve, microfossil events, and the labelled 405-kyr cycles for the interval of chrons C22-C18. As suggested by J. Ogg we will change the stratigraphic placement of events within chrons in the revised version using percent-from-base, rather than percent-from-top, and use basal ages for reversed-polarity chrons. In addition we will also add the CK95 uncertainties and some remarks on obvious differences between cycle-derived durations and the spline-fits used for previous GPTS constructions. In the discussion of the revised manuscript we will also bring in a few sentences dealing with the implications of this comparison.

Interactive comment on Clim. Past Discuss., 11, 1665, 2015.

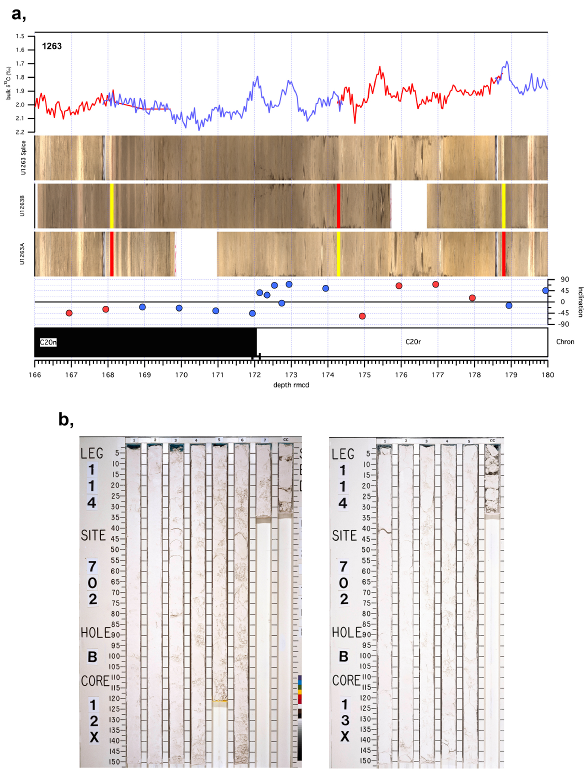

Fig. 1. Close up of 1263 and 702B