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Interactive Comment

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

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Review of submission of "Astronomical calibration . . . closing the middle Eocene gap" by Thomas Westerhold, Ursula Röhl et al. submitted to Climates of the Past; Summer 2015

Recommendation: Accept, but suggest adding a clearer summary table and figure

Summary This detailed magneto-C13-cycle study of a well-documented expanded pelagic Late Eocene succession is a landmark paper, because it fills an important void in assembling a high-resolution Cenozoic time scale. As one of the team that was involved in a temporary age model for chrons C13r-C21n for the GTS2012 Eocene age model, we relied on a smoothed spline fit in the interval from 34 to 48 Ma that

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incorporated selected radio-isotopic dates constraining polarity zone ages. But, the selection of those radio-isotopic dates and placement relative to the bases of polarity chrons was partly subjective; plus the assumption of a smoothed spline-fit through a 14-myr span was intended to be a temporary age model pending detailed and verified cycle stratigraphy. Westerhold et al. (2014, “Orbitally tuned timescale and astronomical forcing in the middle Eocene to early Oligocene”, Clim. Past 10: 955-973) had filled a major part of that gap, and this new contribution by Westerhold et al. completes the coverage. It now remains to see how their cycle-scaled polarity scale fits into other studies, such as the debated Green River array of dated/re-dated volcanic ash beds and polarity zones. The level of documentation in the main paper and the supplemental data tables is superb, and will enable any future investigator to verify interpretations, pinpoint discrepancies and/or propose alternative age models. There are some items that I recommend either clarifying or including in the final version.

Main suggestions: (1) Nature of cyclicity in the cored records The authors display composite color images of ODP cores in 130 or 80-meter intervals against magnetic-inclination and carbon-isotope logs (and against magnetic susceptibility in the supplemental figures). It would be useful to focus on one or two intervals to highlight how the 405-kyr and other orbital-climate cycles are displayed in the visual appearance of typical cores. Are precession and short-eccentricity cycles apparent within the 405-kyr envelope to an observer?

(2) Relationship of planktonic carbon-isotope composition and eccentricity The assignment of 405-kyr cycles is based on the assumed relationship that lighter (more negative) δ13C peaks are correlated to La2011 eccentricity maxima. The supplement says that this relationship is “based on several high profile studies, including modeling of carbon cycle and Earth’s orbit interaction” with several cited references. However, it would greatly aid a reader if one or two sentences can summarize the cause-effect of why long-term eccentricity envelopes on climate cycles would affect the carbon-isotope composition of marine plankton in this way.

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(3) 100-kyr short-eccentricity The 405-kyr long-eccentricity cycle is generally considered to be the modulation of the amplitude of the ca. 100-kyr short-eccentricity cycles, in turn a modulation of precession orbital-climate cycles. Even though the astronomical solution is not considered reliable beyond ca. 40 Ma, it would seem that the ca. 100-kyr cycles could also be interpreted and tallied in this study. Indeed, in the Danian, the 100-kyr cycles at Zumaia and other sections are used as a higher-resolution scaling factor.

(4) Summary table and figure The current set of tables gives age models for the polarity boundaries at each Site; but there is no single "best estimate" that can be used to make a reference time scale for polarity chrons, spreading rates, microfossil datums, etc. Please provide in bold a set of selected or averaged ages for these chrons and datums, plus the uncertainty. Plus, including an enlarged vertical-scale timescale figure showing chrons, climate events with perhaps a generalized carbon-isotope curve, microfossil events and the interpreted/named 405-kyr cycles plotted against a numerical time scale for the interval of chrons C22-C18 would be an ideal summary. For stratigraphic placement of events within chrons, such as microfossil datums, use percent-from-base, rather than percent-from-top, because one usually goes forward in geologic time. I also prefer using basal ages for reversed-polarity chrons, rather than tabulating these as top-ages of the underlying/preceding normal-polarity chrons. NOTE: The comparison table of chron durations should also include uncertainties for the CK95 (derived from their supplement table on uncertainties on anomaly widths; which is partly included in GTS2012 Table 5.2). Also, include some remarks on why some cycle-derived durations are significantly longer, but others are significantly shorter, in a non-systematic pattern compared to CK95 (therefore also the spline-fit GTS2012 that used CK95 anomaly widths). The implication is either that spreading rates in the reference profiles were irregular, or, more probable, that the uncertainties in placing boundaries between marine magnetic anomalies in the CK95 model need to be incorporated with the new cycle-durations to make a better estimate of widths.

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Please also note the supplement to this comment:
http://www.clim-past-discuss.net/11/C986/2015/cpd-11-C986-2015-supplement.pdf

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