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Reconstructing orbital eccentricity between 61 and 66 Ma and the influence of Neptune on Earth's climate

Frits Hilgen (1), Jacques Laskar (2), and Christian Zeeden (2)

(1) Department of Earth Sciences, Utrecht University, Utrecht, Netherlands (f.j.hilgen@uu.nl), (2) IMCCE, Observatoire de Paris, Paris, France

Full eccentricity of Earth's orbit cannot reliably be computed by means of numerical astronomical solutions beyond 60 Ma, due to the chaotic nature of the Solar System, but might be reconstructed from cyclostratigraphic archives of astronomical climate forcing. Here we use visual examination of cyclic bedding patterns in the deep marine Zumaia and Hendaye sections to reconstruct eccentricity between 66 and 61 Ma. The reconstructed - simplified - eccentricity curve matches the nominal La2011 solution reasonably well, but not the other La2010 and La2011 solutions. This is not surprising as all these solutions are only reliable back to ∼50 Ma.

The reconstructed eccentricity curve is subsequently compared with eccentricity time series of different astronomical solutions over the last 100 million years. Parts of time series showing a good to excellent fit with the observed cycle patterns are transferred to their "suggested" age by using the stable 405-kyr cycle for recalibration. Remarkably, there is also an excellent fit with a La2010d revised solution with a stable 2.4-Myr cycle. But the fit of this revised solution and also of nominal La2011 with younger cycle patterns between 58 and 50 Ma is not convincing, suggesting that the fit for the early Paleocene is likely due to coincidence. Nevertheless, the revised La2010d solution or the tailored recalibrated eccentricity curves may serve as a target for future tuning on the ∼100-kyr eccentricity scale, and as a template for further improvement of the astronomical solution.

The eccentricity reconstruction also revealed cycle patterns that cannot be explained by the main ∼100- and 405-kyr, or 2.4-Myr eccentricity frequency components. Instead, these point to the presence of a ∼200-kyr cycle that is unrelated to obliquity but reflects a weak eccentricity component. This component consists of 4 to 6 individual components which are all approximately two orders of magnitude weaker than the strongest ∼100-kyr components. The astronomical origin of these weak components will be discussed but likely has to be partly explained by influence of Neptune on Earth's climate.