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Orbital Tuning and re-Tuning; Art and Science

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It is difficult to imagine a situation in which (a) a geological record built up at a constant rate or (b) a geological deposit built up at a rate that was independent of climate. In addition all geological proxies for climate parameters are subject to both observational noise, and non- stationarity in their relationship with climate. Hence considerable judgement is needed in first selecting geological records that will be amenable to "tuning" to a record of the changing distribution of solar insolation as calculated by an astronomer, and then in carrying out the operation. Tuning a geological record to an incorrect insolation record, or to the wrong time interval in a correct insolation record, or to a simplified "caricature" of the true insolation record can all provide considerable insights in some circumstances. Nevertheless from the point of view of the geological time scale it is important to carry out the procedure correctly, with the best available astronomical data. It is also important that one can use the tuning to verify the astronomical calculations. We have recently re-tuned a number of records on the basis of the new calculations discussed by Laskar (2001). Astronomical Solutions for Paleoclimates Studies. Eos Trans. AGU, 82(47), Fall Meet. Suppl. Abstract U11A-01. In the Pliocene re-tuning is generally straightforward and uninformative because the astronomical changes are small and the tuning is so unambiguous that little judgement is required. In the Early Miocene and Oligocene the situation is more interesting. During this time available data suggests that the climatic variability is dominated by 41-thousand year (ky) obliquity cycles but attaining a correct tuning requires identification of the weaker precession signal and making use of the longer-term (100-ky and 400-ky) eccentricity modulation. A surprising aspect of the tuning published by us in 1999 was that between 20 and 24 My ago there was long-term (about 1.1 My) modulation of the obliquity signal that matched that predicted; this match broke down in the earlier part of the record. Re-tuning the records for this interval required a slight "stretching" to take account of the fact that 400-ky eccentricity maxima in the Oligocene are around 100 ky older than in the previous astronomical solution. This obviously required the addition of a very small number of additional obliquity cycles; thus it was necessary to make a judgement anew regarding the interpretation of each cycle. This in turn enables us to assess the degree of robustness of the tuning. The fact that in the new tuning the amplitude modulation of the obliquity signal between 20 and 24 My ago still matches the calculated obliquity modulation is not surprising, since in this time-window the amplitude envelope of obliquity has moved back in age to about the same extent as the eccentricity signal, as a result of the new calculations. However, the fact that the re-tuned data demonstrates a 1.1 My amplitude modulation of the obliquity signal that now remains in phase with the calculated signal all the way back to 30 My ago, despite the fact that the re-tuning did not entail significant re-interpretation of the record, strongly suggests both that the new solution represents an "improvement" and that the coherence with this long-term modulation constitutes a very strong independent validation of this approach to geological time scale development.

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