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Testing the impact of stratigraphic uncertainty on spectral analyses of sedimentary time series

Mathieu Martinez (1), Sergey Kotov (1), David De Vleeschouwer (1), Damien Pas (2), and Maximilian Vahlenkamp (1)

(1) MARUM, Universität Bremen, Leobener Str., D-28359 Bremen, Germany (mmartinez@marum.de), (2) Pétrologie sédimentaire, B20, Géologie, Université de Liège, Sart Tilman, B-4000 Liège, Belgium

Spectral analysis has become a key tool for identifying the imprint of astronomical forcing on sedimentary records. In a next step, the identified cycles often contribute to the construction of a precise Geological Time Scale and to an in-depth understanding of past climate changes. Most of spectral analyses (Fast Fourier Transforms, the Multi-Taper Method…) require a constant sample step. Unfortunately, an equally spaced geological data series is, in practice, nearly impossible to obtain from field sedimentary series. Usually, there is a 10% uncertainty on the field measurements of the stratigraphic thickness within sedimentary series. Hence, important uncertainties exist in the actual position of each sample. Another source of uncertainty are errors in a time-space model.

In this study, we explore the impact that the stratigraphic uncertainty on the sample position has on the result of spectral analyses. To simulate this uncertainty, we developed a model based on Monte Carlo randomisation of the distance between each successive point. In this way, the stratigraphic order of the data points is not affected after implementing this model. The application of this model to a theoretical sinusoid series and to several real sedimentary series shows that uncertainties in the actual position of samples can highly reduce the spectral powers of the frequencies ranging from the Nyquist Frequency up to 1/10 of the Nyquist Frequency. We then demonstrate that the precise reconstruction of the Milankovitch cycles in the sedimentary record requires a higher sampling density than previously suggested with, at least, 10 samples per thinnest cycle to be detected, i.e. 10 samples per precession cycle.