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The mechanism of sapropel formation in the Mediterranean Sea: Insight from long duration box-model experiments

Jan Pieter Dirksen and Paul Meijer
Universiteit Utrecht, Universiteit Utrecht, Geowetenschappen, Netherlands (j.p.dirksen@uu.nl)

Periodic bottom water oxygen deficiency in the Mediterranean Sea has led to the deposition of organic rich sediments during geological history, so called sapropels. Although a mechanism linking the formation of these deposits to orbital variability has been derived from the geological record, physics-based proof is limited to snapshot and short time-slice experiments with (Oceanic) General Circulation Models. Specifically, previous modelling studies have investigated atmospheric and oceanographic equilibrium states during orbital extremes (minimum and maximum precession).

In contrast, we use a conceptual box model that allows us to focus on the transient response of the Mediterranean Sea to orbital forcing and investigate the physical processes causing sapropel formation. The model is constrained by present day measurement data, while proxy data offers constraints on the timing of sapropels.

The results demonstrate that it is possible to describe the first order aspects of sapropel formation in a conceptual box model. A systematic model analysis approach provides new insights on features observed in the geological record, such as timing of sapropels, intra-sapropel intensity variations and interruptions. Moreover, given a scenario constrained by geological data, the model allows us to study the transient response of variables and processes that cannot be observed in the geological record. The results suggest that atmospheric temperature variability plays a key role in sapropel formation, and that the timing of the midpoint of a sapropel can shift significantly with a minor change in forcing due to nonlinearities in the system.