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Multi-Model approach to reconstruct the Mediterranean Freshwater Evolution

Dirk Simon (1), Alice Marzocchi (2), Rachel Flecker (2), Dan Lunt (2), Frits Hilgen (1), and Paul Meijer (1)

(1) Utrecht University, Geosciences, Utrecht, Netherlands (d.simon@uu.nl), (2) University of Bristol, School of Geographical Sciences, Bristol, United Kingdom

Today the Mediterranean Sea is isolated from the global ocean by the Strait of Gibraltar. This restricted nature causes the Mediterranean basin to react more sensitively to climatic and tectonic related phenomena than the global ocean. Not just eustatic sea-level and regional river run-off, but also gateway tectonics and connectivity between sub-basins are leaving an enhanced fingerprint in its geological record. To understand its evolution, it is crucial to understand how these different effects are coupled.

The Miocene-Pliocene sedimentary record of the Mediterranean shows alternations in composition and colour and has been astronomically tuned. Around the Miocene-Pliocene Boundary the most extreme changes occur in the Mediterranean Sea. About 6% of the salt in the global ocean deposited in the Mediterranean Region, forming an approximately 2 km thick salt layer, which is still present today. This extreme event is named the Messinian Salinity Crisis (MSC, 5.97-5.33 Ma).

The gateway and climate evolution is not well constrained for this time, which makes it difficult to distinguish which of the above mentioned drivers might have triggered the MSC. We, therefore, decided to tackle this problem via a multi-model approach:

(1) We calculate the Mediterranean freshwater evolution via 30 atmosphere-ocean-vegetation simulations (using HadCM3L), to which we fitted to a function, using a regression model. This allows us to directly relate the orbital curves to evaporation, precipitation and run off. The resulting freshwater evolution can be directly correlated to other sedimentary and proxy records in the late Miocene. (2) By feeding the new freshwater evolution curve into a box/budget model we can predict the salinity and strontium evolution of the Mediterranean for a certain Atlantic-Mediterranean gateway. (3) By comparing these results to the known salinity thresholds of gypsum and halite saturation of sea water, but also to the late Miocene Mediterranean strontium record, we can infer how the connectivity between global ocean and the Mediterranean must have changed through time in order to cause the MSC. (4) Such a connectivity evolution will give us the basis to understand the interplay between eustatic sea-level and regional tectonic changes in the Gibraltar region.

Here we present the detailed method, the results and the applications of this multi-model approach.