Geophysical Research Abstracts
Vol. 16, EGU2014-11148, 2014
EGU General Assembly 2014

A high resolution ocean model of restriction of the Mediterranean-Atlantic connection: Changes in Mediterranean circulation and water characteristics

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A high resolution parallel ocean model is set up to examine how the sill depth of the Atlantic connection affects circulation and water characteristics in the Mediterranean basin. An analysis of the model performance, comparing model results with observations on the present-day Mediterranean, demonstrates its ability to reproduce observed water characteristics and circulation (including deep water formation). A series of experiments with different sill depths in the Atlantic-Mediterranean connection is used to assess the sensitivity of Mediterranean circulation and water characteristics to sill depth. Basin-averaged water salinity and, to a lesser degree, temperature rise when the sill depth is less and exchange with the Atlantic is lower. Lateral and interbasinal differences in the Mediterranean are, however, largely unchanged. The strength of the upper overturning cell in the western basin is proportional to the magnitude of the exchange with the Atlantic, and hence to sill depth. Overturning in the eastern basin and deep water formation, on the other hand, are little affected by the sill depth.

The model results are used to interpret the sedimentary record of the Late Miocene preceding and during the Messinian Salinity Crisis. In the western basin a correlation exists between sill depth and rate of refreshment of deep water. On the other hand, because sill depth has little effect on the overturning and deep water formation in the eastern basin, the model results do not support the notion that restriction of the Atlantic-Mediterranean connection may cause lower oxygenation of deep water in the eastern basin. However, this discrepancy may be explained by simplifications in the surface forcing and a different bathymetry than that in the Late Miocene. We also tentatively conclude that blocked outflow, as found in experiments with a sill depth $\leq$ 10 m, is a plausible scenario for the second stage of the Messinian Salinity Crisis during which halite was rapidly accumulated in the Mediterranean.

With the model setup and experiments, a basis has been established for future work on the sensitivity of Mediterranean circulation to changes in (palaeo-)bathymetry and external forcings.