INVESTIGATING THE ROLE OF MECHANISMS LEADING TO STAGNATING DEEP WATER IN THE EASTERN MEDITERRANEAN

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Abstract

An ocean general circulation model is used to study the effect of several mechanisms that could have led to to stagnating deep water and thus formation of sapropels in the eastern Mediterranean.

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During the early Holocene, the Mediterranean circulation has undergone considerable changes. These changes are reflected in the occurrence of organic-rich marine sediment (called sapropels) in the eastern Mediterranean, which indicate the presence of oxygen depleted deep waters. The relative isolation of the basin together with a good coverage of available proxy data make this region an ideal test bed for modelling past climate changes.

The work presented here is a first step towards elucidating the mechanisms responsible for the formation of the sapropels. A regional version of the ocean general circulation model MPIOM (has been set up for the Mediterranean. This model was forced with daily atmospheric data derived from equilibrium time slice simulations with the global coupled atmosphere-ocean-dynamical vegetation model ECHAM5/MPIOM/LPJ (Mikolajewicz et al. 2007) for 9000 years before present. As the forcing data set has a length of 100 years, interannual as well as decadal variability are contained in the model forcing. The model derived river-runoff and ocean hydrography were used as additional forcings, the latter used as boundary condition at the Atlantic margin of the regional ocean model. Starting from homogeneous water, the model has been integrated for several centuries until a quasi-steady-state was reached. For the early Holocene, the runoff from the Nile is increased in comparison with present day conditions due to the enhanced African monsoon. The Bosphorus is assumed to be closed for this time period. These changes in freshwater input largely compensate each other in their effect on the upper-ocean salinity in the Levantine basin. The amplified seasonal cycle with reduced incoming short-wave radiation in winter leads to a general cooling. The enhanced summer warming is restricted to the uppermost layers. The model simulates the Adriatic as the main source of deep water for the eastern Mediterranean. Convection in the northern Aegean is strongly enhanced. Deep water ventilation rates show a marked decadal variability due to variations in the forcing. The obtained steady-state for 9000 years before present serves as baseline state for several perturbation experiments, which aim at elucidating potential mechanisms leading to stagnant deep water in the eastern Mediterranean. These experiments show that a sudden onset of an outflow from the Bosphorus or and or a sudden surface warming due to a reorganization of the Atlantic meridional overturning circulation are more effective to reduce the deep ventilation of the eastern Mediterranean, than a gradual freshening of the inflow from the Atlantic due to melting ice sheets. The vertical mixing reduces the effect of the initial perturbation and ventilation of the deep water slowly increases. An initial perturbation is sufficient to produce stagnant deep water for several centuries. In order to keep the deep water stagnant over several millennia, a strong initial perturbation needs to be combined with a weak, but permanently acting change forcing, e.g. the freshening due to the melting ice sheets.

References

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