MODELLING THE IMPACT OF THE NILE DAMMING ON THE MEDITERRANEAN THERMOHALINE CIRCULATION

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Abstract

Changes in the Mediterranean intermediate/deep water characteristics are investigated in relation to the Nile damming in a process-oriented study. Results show that the drastic Nile runoff reduction induced a large salinity increase in the Levantine surface layer in the sixties/seventies, which enhanced the LIW production rates and salinity. This in turn resulted in the production of saltier and larger amounts of deep waters in the Adriatic and the Gulf of Lions. It also functioned as a strong preconditioning to the formation of deep waters in the Southern Aegean (EMT), following two very cold winters in the early 90's.

Keywords: Numerical modelling; river discharge; thermohaline circulation

Introduction

After building the Aswan Dam in 1964, the runoff of the Nile was drastically reduced (by more than 90%), affecting the salt budget of the Mediterranean Sea. Important changes in the characteristics of the deep waters of both the Eastern and Western Mediterranean basins during the last four decades have been associated with this event [1, 2]. The response of the Mediterranean Sea and the various sub-basins to the Nile damming is investigated in this study, using the POM model. The results are compared with previous studies and observational data, and mechanisms involved in changes of the deep water mass characteristics are investigated.

Results and discussion

The model is first integrated using climatological atmospheric forcing, derived from the ECMWF reanalysis, and values of the Nile runoff typical of the pre-damming period and reaches a steady state after 75 years of integration. Then the model is integrated using the reduced runoff values, typical of the after-damming period, to reach a new steady state (after 75 years of integration). Results show that the Nile damming induced a large increase in the surface layer salinity in the Aegean and Levantine basins exceeding 0.1 psu in the early seventies, in agreement with observations [1]. This saltier surface layer in the vicinity of the Rhodes Gyre favoured the preconditioning for the formation of the LIW, resulting in about 30% increase of its formation rate. Intermediate waters became saltier, and as they were transported westward they reduced the stability of the water column in the deep-water formation sites, namely the Southern Aegean, the Southern Adriatic and the Gulf of Lions. Thus saltier and larger amounts of dense waters were formed filling the deep parts of the Mediterranean. Salinity changes become perceptible in the deep layers of the western basin about 7-8 years after the Nile damming (Fig. 1) when the increased salinity signal reaches the Gulf of Lions via the LIW circulation. Results indicate that the Nile damming explains about 45% of the observed salinity increasing trend during the last 40 years in the WMDW. This trend is rapidly slowing down after 20 years of simulation and is almost vanished by about 2030 when a new quasi-steady state of the Mediterranean thermohaline circulation is reached. The time-scale of the Mediterranean system response to the Nile damming is in agreement with simplified box model results [2]. Furthermore, results demonstrate that the Nile damming played an important role in the long-term salt preconditioning of the surface/intermediate layers of the Cretan and Levantine Seas, contributing in triggering the two eastern Mediterranean transients [1]. Although the results indicate an increase in the deep layer salinity the model is not able to reproduce the large salinity increasing trends in the Levantine deep waters during the two transients.

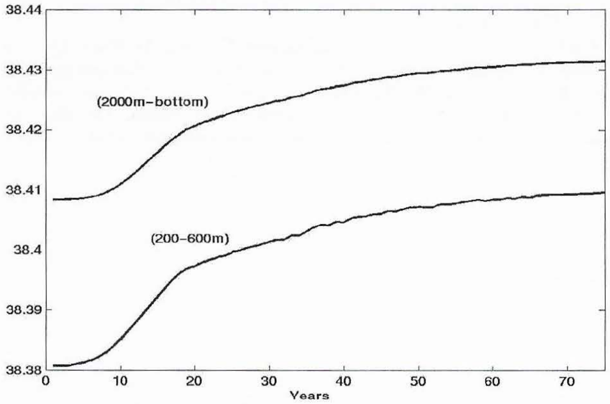

Fig. 1. Evolution of the model annual mean salinity (psu) in the Western Mediterranean basin after the Nile damming for the layers: 200-600m and 2000m-bottom.

To investigate the effect of surface cooling, the experiment was repeated imposing a -1°C drop in the SST in the Levantine for ten years corresponding to 1965-1975 (when a continuous decrease in the mean winter SST of the Levantine is observed in the data [3]) and a -2°C drop in the SST of the Aegean during the winters of 1992 and 1993. Results show that during the first period LIW formation occurs in a larger area of the northern Levantine whereas deep water formation occurs now inside the Rhodes Gyre, propagating the signature of increased salinity towards the deep layers of the Levantine. Similarly, the intense surface cooling related to the cold winters of 1992 and 1993 was found to play a crucial role in the second transient, increasing the Cretan Deep Water formation rate by an order of magnitude. The newly formed water, which outflows from the Cretan Arc straits, is much more saline and warmer than the previous existing EMDW resulting in large increasing trends in both the temperature and salinity of the deep layers.

References

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