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Changes in the Mediterranean Sea climate in relation to changes in the freshwater budget: a numerical modelling study

N. Skliris, S. Sofianos and A. Lascaratos

Ocean Physics And Modeling Group, University of Athens, Greece

(nskliris@oc.phys.uoa.gr / Phone: +30-210-7276839)

The response of the Mediterranean Sea to changes in the freshwater budget is investigated in a process-oriented study, using the POM model. The model is first integrated using values of the Nile and Ebro rivers runoff, as well as of the Dardanelles freshwater input, typical of the fifties. The model reaches a steady state representative of that existing in the Mediterranean prior to the major damming period after 90 years of integration. Then the model is integrated using the reduced river runoff values typical of the after-damming period. The additional impact of decadal scale trends in the precipitation rate as well as of intense surface cooling periods/events on the thermohaline circulation during the last 40 years were also examined. The model results show that the dramatic reduction of the Nile freshwater input and to a lesser extend the reduction of the freshwater input from the Dardanelles Straits induced a large increase in the sea surface salinity in the Aegean and Levantine basins in the late sixties/early seventies, in agreement with observations. Furthermore, the Ebro runoff reduction during the same period further enhanced the salinity increase in the Levantine basin as higher salinity surface waters of the western basin reached the eastern basin via the Atlantic Water circulation. This saltier surface layer in the vicinity of the Rhodes Gyre favoured the preconditioning for the formation of the Levantine Intermediate Water, resulting in about 40% increase of its formation rate. According to the model, freshwater budget changes explain about 95% of the observed salinity increase in the Western Mediterranean Deep Water (WMDW) over the last 40 years. The WMDW changes are shown to be partially (about 50%) originated in the eastern basin (mainly due to the Nile river damming) and imported to the western basin by the LIW circulation, and partially

(about 50 %) produced locally, as a consequence of increasing surface salinity in the WMDW formation site (i.e. due to the decreasing precipitation and to the reduction of the Ebro River runoff). On the other hand, the salt increase in the surface layer is proved to be insufficient to produce alone the two climatic transient events in the deep waters of the Eastern Mediterranean in the late sixties and early nineties, respectively. Anomalous strong winter cooling was found to play an important role during these events, resulting in large deep water formation and thus allowing the propagation of the increased surface salinity signal to the deep layers.