THE INFLUENCE OF ATMOSPHERIC PRESSURE VARIATIONS ON THE CIRCULATION IN THE LEVANTINE BASIN

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Abstract

An analysis of the results from a previous high-resolution climatological simulation of the circulation in the southeastern Levantine Basin indicated that the model was able to reproduce the predominant alongshore direction of the flow and typical magnitude of the speed of the observed currents at various points along the shelf and slope, but missed the timing of the seasonal cycle of the speed. In order to identify the source of this problem, a coarser resolution basinwide model was run with atmospheric pressure forcing included. This additional surface forcing factor partially rectified this deficiency.

Keywords: coastal circulation, inverse barometer effect, eastern Mediterranean, numerical models

Introduction

Within the framework of the Mediterranean Forecasting System Pilot Project (MFSPP) (1), a high-resolution (2 km horizontal grid, 30 layer) model was run with climatological forcing for the southeastern corner of the Levantine Basin (2). The model was one-way nested in a coarser resolution (5 km, 30 layer) model of the Levantine, Aegean and part of the Ionian basins (3). Long term measurments at various points along the continental shelf and slope (4) indicate that the circulation in this regions is mainly alongshore (northward) with a distinct seasonal cycle in the current speed. Typical monthly mean values range from around 10 cm/s over the inner shelf to 20 cm/s and more over the outer shelf and slope. The inner shelf current speed had two maxima – in February and in July – while the outer shelf currents had a single pronounced peak in June/July. A comparison between the model results and the observed currents showed that he model was able to reporduce the predominant direction of the flow throughout the year as well as typical speeds. However there was a lag of one to two months in the simulated seasonal cycle of the speed. One possible factor that may account for this discrepency is the absence of atmospheric pressure forcing (the inverse barometer effect) in the simulations.

Model description and experiments

Atmospheric pressure forcing is not simply a localized affect due to the relatively large spatial scale of synoptic pressure systems. To properly account for this process the basinwide circulation must be studied. Therefore for the purposes of this investigation we used a model that covered the entire Levantine and part of the Ionian basins (the region east of 24°E and south of 37°N). The model used was the Princeton Ocean Model (POM) which is a three dimensional, primiitve equations, free surface model with a terrain following vertical (sigma) coordinate (5). The horizontal grid spacing was 0.05° (4.6 – 5.5 km) and 24 sigma layers were used in the vertical. Surface forcing consisted of monthly mean climatological wind stress and heat fluxes based on the 15 year ECMWF reanalysis as well as the monthly mean climatological fresh water flux as computed in (3). Monthly mean atmospheric pressure was computed from the same meteorological data set. Lateral boundary conditions at the open boundaries were specified from the eighth year of a climatological simulation with the MFSPP full Mediterranean model – the OGCM (1). Our model was first run for four years using initial conditions taken from 10 Jan of the OGCM simulation using the climatological wind stress and heat flux. In the control run, this simulation was continued for an additional two years. In the second simulation the model was also initialized from the end of the fourth year of the spin up run and again integrated for two years as in the control run but with the addition of the atmospheric pressure forcing.

Results

In both the high-resolution simulations of (2) and the coarser resolution runs of (3) the models were able to reproduce many of the obsrved climatological features of the circulation in this region including sub-basin scale features as welll as some of the mesoscale variability. Of particular interest were the variations in the free surface height with contrasts between cyclonic and anticyclonic eddies of as much as 10 – 20 cm. In the case of the inverse barometer effect an increase (decrease) of 1 hPa in atmospheric pressure corresponds to a lowering (rising) of the free surface of the sea by roughly 1 cm. Across the Levatine basin monthly mean horizontal pressure contrasts range from 1 – 2 hPa in the winter to as much as 5 – 6 hPa in the summer. Thus we would expect the influence of the atmospheric pressure forcing to be most pronounced during the months of July and August. Upon comparing the final year of our control and pressure forcing runs we find that indeed the largest domain wide mean and root mean square (rms) free surface differences occur in July with values of 2.8 and 4.7 cm, respectively. Over our previous high-resolution model domain in the southeastern corner the maximum mean and rms differences also occur in July with values of 2.2 and 3.3 cm, respectively. Furthermore, the mean free surface height differences between the eastern and western halves of the full domain were larger in the atmospheric pressure forcing run than in the control run throughout the year. Due to the lower pressure in the east, these differences were as much as 3 cm larger in the month of July. Finally, the simulated seasonal cycle of the current speed over the southeastern shelf and slope is in closer agreement with the observations than in our previous high-resolution simulations.

References

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