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Three dimensional hydrodynamic modeling of the Caspian Sea

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Abstract

The three dimensional General Estuarine Transport Model (GETM) is applied to simulate the hydrodynamics of the Caspian Sea. The effects of realistic meteorological forcing and river inflows are considered. The model results including salinity, temperature and sea level variations are compared against observational data, demonstrating the ability of the numerical model in reproducing the Caspian Sea hydrodynamics. Seasonal variability of the thermohaline structure of the Caspian Sea is studied using the model simulations. Furthermore, the performance of the applied vertical adaptive coordinates is evaluated against sigma coordinates. It is shown that the application of adaptive coordinates leads to better resolved thermohaline structures and improved simulations.

Introduction

The Caspian Sea, having a volume of 78,000 km^3 and a surface area of 3.8×10^5 km^2 is the largest inland water body on Earth and accounts for nearly 40 percent of the total lacustrine waters of the world. The sea is commonly divided into three parts, the Northern, Middle and Southern Caspian (Fig. 1). Each of these parts has its own unique physical and biological conditions. The southern basin which consists of 39% of the whole volume has a maximum water depth of 1024 m and is distinguished for its more saline and warmer water. The central basin with a maximum depth of 788 m accounts for 36% of the whole volume and is separated from the Southern Caspian by a sill. The Northern Caspian is basically a very shallow extension of the Middle Caspian and has a maximum depth of 20 m. This part is renowned for having the freshest water due to the Volga and Ural rivers discharge and its icing event in winter.

Despite its importance, researches on the Caspian Sea are limited compared to other lakes. These studies have been mainly concentrated on sea level fluctuation due to its influence on oil industry. A few researches have been carried out to understand the physical characteristics of the Caspian Sea including its general circulation and thermohaline structure using numerical models. Ibrayev et al. [1] applied a three-dimensional primitive equation model including sea ice thermodynamics and air-sea interaction to study seasonal circulation and water mass variability in the Caspian Sea. Kara et al. [2] studied the main oceanic features of Caspian Sea by applying an eddy resolving model, HYCOM. The model results were used to examine the seasonal sea surface circulation and heat and freshwater fluxes. The impact of evaporation, precipitation and river inflows on the upper ocean quantities including sea surface temperature, salinity and circulation was also investigated. Recently, Kitazawa and Yang [3] analyzed the water circulation and thermohaline structure of the Caspian Sea by means of a three