TOWARDS CLIMATIC MODELLING OF THE CASPIAN SEA THERMO-HYDRODYNAMICS

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Abstract

Three-dimensional primitive equation models including sea ice thermodynamics and air-sea interaction are used to study seasonal circulation and water mass variability in the Caspian Sea under the influence of realistic mass, momentum and heat fluxes. The models successfully simulate sea-level changes and baroclinic circulation and mixing features, partially verified with observed data.

Keywords : Sea Level, Currents, Circulation Models.

The isolated Caspian Sea, under the influence of large rivers and atmosphere-ocean-land interactions, is extremely sensitive to regional climatic variability. With a large catchment area extending towards the Urals and Caucasia, river runoff dominates the water budget. Annual precipitation is about one third of the runoff or evaporation, which are roughly comparable in magnitude and would individually account for about 1 m/yr of sea level change. The water budget drives inter-annual, inter-decadal and longer term variations in sea level [1,2].

The water budget variability, which depends on external factors as well as on the atmosphere - sea interaction, most probably is the key phenomenon influencing the physical state of the sea. Changes in water balance lead to significant changes in stratification of the upper waters, which can result in overturning or eutrophicated conditions in the deep basin, phenomena known to have occured in the past [1,3]. Seasonal variation in sea level is about 30 cm, while interannual variation in the twentieth century alone has been in the range of 300 cm. The water input is either compensated by surface evaporation (increased when flat areas are flooded) or balanced by sea level changes.

The strategy for studying the Caspian sea thermo-hydrodynamics is based on successive development of models capable to represent the physical state of the sea from intra- to interannual timescales, to answer the following yet unresolved questions: What is the three-dimensional general circulation of the sea? What thermodynamical processes are specific for the Caspian Sea in controlling the seasonal sea level changes and how sensitive is the energy transformation cycle to variations of atmospheric forcing?

3D primitive equation models including sea ice thermodynamics and air-sea interaction have been developed and applied to study the seasonal circulation and water mass variability in the Caspian Sea under the influence of realistic mass, momentum and heat fluxes. River discharges, precipitation, radiation and wind stress are specified in the model. The evaporation rate, sensible and latent heat fluxes at the sea surface are computed interactively by an atmospheric boundary layer sub-model, using the ERA40 atmospheric data and model generated SST. The model simulated sea surface topography is verified with observed sea level data. Model heat and water budgets confirm climatological estimates. Experiments performed with variations in external forcing suggest a sensitive response of the circulation and the water budget to atmospheric and river forcing. The most important issue from the model is connected with transformation of water and energy in sea - atmosphere system. In the warm period solar energy is accumulated in the sea and transmitted to the atmosphere through thermal radiation, sensible and latent heat fluxes. Latent heat flux by evaporation is a stabilizing mechanism acting against sea level rise.

The seasonal cycle of wind stress is crucial in producing the basin circulation, resulting in cyclonic gyres in December-January; west to southwestward Ekman drift accompamied by an upwelling front in the east, coastal jets along the western and eastern shelf regions in February-July, and transitional types in August-November. Upwelling along the eastern shelf is a persistent feature in summer, also confirmed by satellite data [4], subject to active exchange and mixing across the front.

Considering the general lack of observational data of the Caspian Sea currents the first drifter experiment hasstarted in October 2006, in the framework of the NATO SfP / MACE project. The three surface buoys deployed in the cooling period indicate mainly cyclonic circulation in the mid and south Caspian sub-basins, with smaller embedded cyclonic / anticyclonic eddies, as predicted by models and also confirmed by satellite data.

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