DEVIATION OF SEA LEVEL OF SEMI-ENCLOSED BASINS FROM THE GLOBAL MEAN: ANALYSIS OF THE MAIN FACTORS ACTING ON THE ADRIATIC, BLACK AND BALTIC SEA

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Abstract
This work analyzes the main factors that are responsible for interannual variability and past centennial trends of the sea level in three semi-enclosed seas: the Adriatic, Black and Baltic Sea. The analysis produces a linear model that is capable to explain most of the sea level variability in the Adriatic and Baltic Sea, but is much less successful in the Black Sea. If such model is forced with a set of CMIP5 simulations it suggests that meteorological forcing is unable to produce a deviation of the regional sea level from the global mean larger than 15cm for the Adriatic and Baltic Sea.

Keywords: Sea level, Mediterranean Sea

The first objective of this study has been to reconstruct the time series of mean sea level in the Black, Adriatic and Baltic seas from tide gauges data extracted from the Permanent Service of Mean Sea Level (PSMSL). Three seamless time series covering the whole period from 1901 to 2009 are computed using tide records from 13 stations in Baltic Sea, 7 stations in the Adriatic Sea and 5 in Black Sea adopting a statistical method based on PCA and Least Square Method (Scarascia and Lionello, 2013). For all the three basins the very high spatial coherency of the involved stations implies that the resulting time series can be considered a reliable representation of mean sea level of the whole basin. The Glacial Isostatic Adjustment (GIA) has been subtracted to the Baltic sea level records (Church and White 2011, Peltier 2004). The comparison between the reconstructed time series and mean sea level from satellite data (covering the period 1993 to 2009) shows very high correlation both at monthly and annual scale where correlation is 0.97 and 0.87 for the Baltic and Adriatic Sea, respectively, while a slightly lower value (0.70) results for the Black Sea.

Past variability has been analyzed taking into account separately different factors that at regional scale determine the sea level anomaly. The factors involved are: the Inverse Barometer effect due to the local Sea Level Pressure (SLP), the steric effects due to sea temperature and salinity variation and finally the contribute due to the effect of the wind. Results show that among all these factors the wind is the largest one (particularly for the Baltic Sea) with the Inverse barometer playing a minor role and the steric effects being almost negligible. In the Black Sea, the effect of the wind has been found to be negligible, and the it has been replaced by an estimate of the effect of the rivers, which has been made assuming that the variability of the Sulina discharge (for which data are available) is representative of the variability of the Danube river and of the other rivers discharging in the Black Sea. The respective annual cycles are showed in Figure 1.

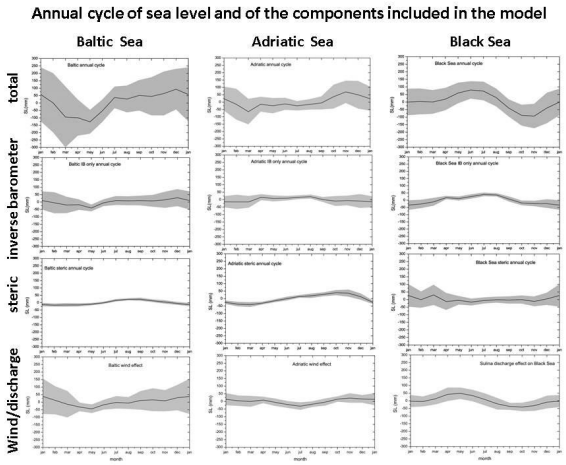

Fig. 1. Annual cycle of Baltic (left column) and Adriatic (middle column) and Black Sea (right column) sea level computed for the period 1945 – 2002. Grey areas show the interannual variability computed as the monthly standard deviation. The upper line refers to the total sea level, while the following lines display the contribution of the various factors.

A linear regression model has been built, which is capable of reconstructing these fluctuations with acceptable accuracy on the basis of analyzed sea level pressure and wind fields. This model has been forced with a set of CMIP5 model sea level pressure and surface wind projections to provide future projections of sea level anomalies at basin scale caused by these factors. However, deviations from the global mean sea level predicted by the linear regression model are small (in the order of 1cm). Though there are good reasons for considering that this result underestimates future deviations, it remains however clear that mechanical forcing due to wind and atmospheric pressure would be unable to provide large deviations. In fact, assuming high end changes of mean sea level pressure (a decrease of 5hPa) and of the wind (an increase of 2m/s of mean wind speed) would imply increases of basin sea level less than 10cm for the Baltic and Adriatic Sea. A similar analysis for the Black Sea, replacing the increase of the wing with a 20% increase of the river discharge would bring a similar conclusion for this basis. If the mass exchange with the world ocean is included in the computation, the overall deviation of the sea level from the global mean remains small, not exceeding the 15 cm for Adriatic and Baltic Sea by the end of 21st century. Presently, results for the Black Sea appears not reliable, and reason for this have to be clarified.

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