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Variations of the seasonal sea level cycle in Southern Europe

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The seasonal cycle, a prominent feature in all climatic parameters, has widely been considered to be fairly constant in time. However, interdecadal and climatic changes are likely to affect the seasonal cycles as well as the mean values of sea level.

In the Mediterranean Sea, the inter-decadal variability of the seasonal cycle displays spatial coherence (Zerbini et al. 1996; Tsimplis and Spencer, 1997). Most part seems to be related with atmospheric forcing, with the main factor being the wind rather than the atmospheric pressure.

The data set consists on tide gauge monthly data from the Mediterranean Sea and the Atlantic Iberian coast. The meteorological contribution to sea level has been quantified using the output of a barotropic oceanographic model forced by wind and atmospheric pressure (Guedes Soares et al. 2002). Finally air surface temperature, mean sea level atmospheric pressure, geostrophic wind and air-sea heat fluxes available from ECMWF ERA-40 Reanalysis are used for comparison with the sea level data.

The mean seasonal sea level cycle has amplitudes of 3-7 cm and 1-3 cm for the annual and semi-annual signals respectively, with standard errors of 0.5 cm. Annual cycle reaches its maximum values between October and November, while the semi-annual cycle peaks in February. In average, the mean seasonal cycle accounts for the 20% of the total variance of monthly sea level records.

Atmospherically-induced seasonal sea level reaches up to 4 cm and 2 cm for the annual and semi-annual signals respectively. Maximum amplitudes take place in both cases in the eastern basin. Phases for the two harmonics vary spatially more than three months over the domain.

The consequences of the direct atmospheric forcing on the mean seasonal cycle are

an increase and a sooner annual cycle and a decrease in the amplitude of the semi-annual cycle. The semi-annual cycle in the atmosphere has roughly the same phase as the semi-annual cycle in the ocean in this region, so the residuals (observations minus atmospherically-induced sea level) have reduced semi-annual cycle in around 25%.

The seasonal sea level cycle is unsteady in time with large variations in amplitudes and phases. Decadal changes in annual and semi-annual signals are consistent among most stations, although regional differences are also noted. After removing the atmospheric pressure and wind effects the seasonal cycle of the residual records is primarily steric. Long term variations are now consistent between Adriatic and western Mediterranean but show different patterns in the Atlantic and the Strait of Gibraltar.

The temporal variability of the atmospherically-induced seasonal cycle is mainly related to changes in meridional wind, especially in the Atlantic and Adriatic. On the other hand the variations of the seasonal cycle of the residual series are related to changes in atmospheric variables.

References

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