Meteorological forcing and sea-level variability in the Aegean Sea

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The non-tidal variability of sea-level has been extensively studied and associated with geostrophic wind and atmospheric pressure (PALUMBO and MAZZARELLA, 1982; GARRETT and TOULANY, 1982; LASCARATOS and GACIC, 1990). Nevertheless no studies involving the regionally coherent component of the wind have been published for the area of interest.

The Data Hourly sea level values, daily values of atmospheric pressure, and wind vector data, from five permanent stations, of Hellenic Navy Hydrographic Service and National Meteorological Service in the Aegean Sea are analyzed. The data set covers a four year period (1984-1987). The wind speed and direction data are transformed into north-south (NS) and east-west (EW) components. The data set is divided in one year long time series that are consequently analyzed.

Methodology and Results

The cross correlation of atmospheric pressure, between stations, is high (>0.9) and the coherence significant for all frequencies. The analysis of the NS wind component gives significant cross corellation coefficients and coherence for variations with period >3.5 days. The analysis of the EW wind component gives, in general, statistically insignificant results. The cross correlation coefficients for the sea level data are also significant as well as is the coherence for periods >4.5 days.

Principal component analysis is performed in sea-level, atmospheric pressure and NS wind component. The first two components account for about 95% of the variability. The first PCA mode is found to correspond to the "in phase" oscillation of the whole Aegean (fig. 1). The second PCA mode corresponds to an oscillation with 180° phase difference between the North and the South part of the basin. The response of the sea level to the atmospheric pressure forcing is found to be non-isostatic.

The first two principal components are then compared through spectrum and cross-spectrum analysis. The first principal component spectrum peaks at 0.015 cycles/day for the three variables. The peak associated with the wind spectrum is found to be broader (fig 2). The cross spectrum of pressure and sea level gives statistically significant coherence in all frequencies. The coherence of NS-wind component to sea level is significant only for variations with periods from 2.5 to 9 days. In this range wind advances the sea level by ≈ 130°.

The second PCA component peaks for pressure and sea-level at 0.03 cycles/day and at 0.045 cycles/day for the NS wind component. The wind peak is broader and the energy of its spectrum more evenly distributed. The cross spectrum shows that the second PCA component of wind speed is incoherent with both pressure and sea level. On the other hand the cross spectrum of pressure and sea level shows significant coherence for periods from 2.7-6 days.

Conclusions

The Aegean sea is found to oscillate in two principal modes that together account for ≈ 95% of the total variance. The variability is associated mainly to the first PCA pressure component. At intermediate frequencies, associated with synoptic activity in the area, the first PCA component of the coherent part of the regional wind is found to play an important role. Future research will investigate whether the reconstruction of the time series based on their eigenvalues can be advantageous in regression models for the prediction of mean sea level.

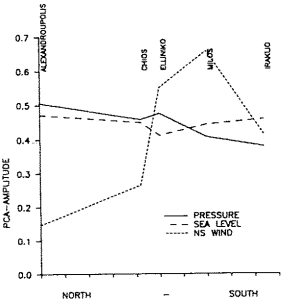

Fig.1 The first PCA component

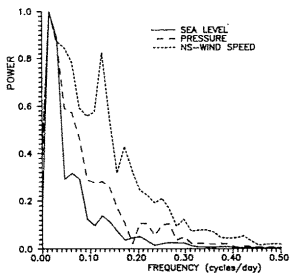

FIG.2 Normalized power spectrum of pressure, sea level and NS-wind component.The normalizing factors are respectively : 865.6 cm², 702.8 mbar², 448.6 (m/sec)²

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