SEA LEVEL VARIATIONS IN MELLIEHA BAY, MALTA

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Abstract

Sea level variations in the northwestern coastal area of Malta are studied by a set of 2-minute sampled observations in Mellieha Bay. These measurements constitute the longest time series of simultaneous water level and meteorological parameters in the Central Mediterranean. Tidal and non-tidal oscillations are analysed over a wide range of frequencies. Large amplitude fluctuations, known locally as the 'milghuba', carry substantial energy in the long wave frequency band 0.2–5cph. Strong seasonal non-eustatic fluctuations in the MSL are characterised by a high in the last months of the year followed by a typical sharp fall to a minimum in February/March.

Keywords: sea level, tides, waves, time series

The Maltese Archipelago, consists of a group of small islands aligned in a NW-SE direction, located close to the southeastern margin of the Sicilian shelf. The islands are located at an oceanographically strategic position for studying the influence of the Sicilian Channel in the exchange flow between the two principal basins of the Mediterranean Sea. The sea level data in the small Mellieha embayment (≈ 1.5x3Km) cover the period June1993-December1996 (43 months). These measurements constitute the first set of digitised sea level recordings in the Maltese Islands and were collected as part of an ongoing research programme that will now form part of MedGLOSS. Submitting the data to a tidal harmonic analysis by a least square procedure [1] based on 61 constituents yields a maximum range of only 20.6cm, on average, with a predominance of the semidiurnal constituent (M2=6.04cm, 55°; S2=3.77cm, 62°; K1=0.7cm, 53°; O1=0.78cm, 56°) and a Form Number of 0.15. The contribution of the solar radiation tidal input is high (S_2 is 62.4% of M_2), which is typical of the Mediterranean. The main diurnal constituents K_1, O_1 and P_1 are relatively weaker in the region of the Maltese Islands compared to the Sicilian shore to the North. These diurnal constituents cause the minor diurnal inequalities.

Spectral analysis on the full data set is performed by using a Kaiser-Bessel spectral window with 50% overlap. Different window sizes are used for the lower and higher frequencies to permit an optimal resolution of the long-period and short-period components respectively. Three main frequency bands are noted: (i) the low frequency (long-period) band (LB) in the range 0 - 0.8cpd (T(hours)>30); (ii) the tidal frequency band (TB) in the range 0.8 - 4.8cpd (30>T(hours)>5); (iii) the long wave frequency (short-period) band (SB) in the range 4.8cpd and upwards (T(hours)<5). The energy distribution at different frequencies is expressed as a percentage of the total energy in the records (Table 1). The low frequency signals carry 57.3% of the total energy. This explains that variations in atmospheric pressure associated with mesoscale meteorological phenomena produce a predominant effect on the sea level in the synoptic and sub-synoptic time scales. However, the response of the sea is non-isostatic [2] and carries the signature of oceanographic conditions in the region as well as that of non-local forcing resulting from intra-basin differences. Tidal energy inputs (35.8%) mainly result from the semi-diurnal component (32.7%). The high frequency (>4.2cpd) inputs, are due to long period waves in the form of coastal seiches, and contribute by 6.6%. This figure is an average of the seiche energy over the whole time span covered by the data series and greatly underestimates the real energy carried by these large amplitude oscillations which occur as transient events lasting only for relatively short spans of time (from a few hours to a couple of days).

Table 1. Percentage energy distribution in Mellieha Bay.

Frequency Band	%
Low frequency (<0.8cpd)	57.3
Diurnal (0.8-1.2cpd)	3.0
Semidiurnal (1.8-2.2cpd)	32.7
Quarter diurnal (3.8-4.2cpd)	0.06
High frequency (>4.2cpd)	6.6
Other	0.36

The phenomenology and generation of these non-tidal short period sea level fluctuations, known by local fishermen as the 'milghuba', are extensively covered in [2]. These oscillations have now been observed to occur all along the Northern coast of the Maltese archipelago. From the Malta Channel Experiment [2] it is inferred that the longer period signals are associated to longitudinal, latitudinal and mixed stationary modes that develop on the highly irregular shaped continental shelf. The higher frequency coastal seiches are characterised not only by eigenmodes pertaining to inlets and bays on the coastal perimeter, but also by open sea modes in the nearshore shelf areas.

The seasonal signal in the MSL, studied by monthly averages, is characterised by a sea level maximum which generally occurs in October, while a minimum occurs in March (Fig. 1). The maximum range between the extreme levels can reach up to 0.35cm. However, the differences in size and phase of the fluctuations as well as the occurrence of fast variations (such as the sharp rise in sea level in May 1996) are indicative of considerable interannual variability. Comparison with sea level data covering the period May 1990 to May 1991 in the Grand Harbour (only within a few kilometres of distance from Mellieha Bay) show that during that year the rise to maximum sea level in October was more gradual, while the minimum occurred in January rather than March.

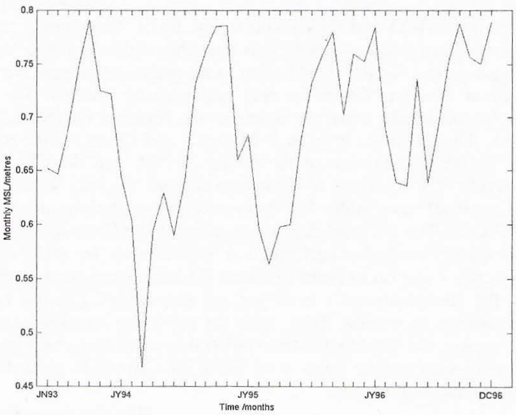

Figure 1. Seasonal fluctuations of monthly MSL in Mellieha Bay (Jun93 / Dec 96).

The seasonal signal is also present, though less energetic, in the atmospheric pressure. However, with the Inverse Barometer correction, the MSL still retains a large part of its variability. Other factors besides air pressure must thus be responsible. Seasonal winds and the piling of water onshore as a result of storm surges can greatly contribute to the seasonal sea level variations [3]. The MSL variations in Malta are however found to be practically unrelated to the wind. Sea water temperature and baroclinic phenomena such as steric effects can also be important factors. Using an ECMWF climatology of net surface heat fluxes for the Mediterranean, it is found that steric effects produce changes in the MSL that have the right phase compared to observations, but which are only about half in size to the actual variations [4]. A great part of the seasonality observed in Malta is thus believed to be non-local in nature and to predominantly carry the signature of differences in meteo-marine conditions in the two main Mediterranean basins. The simultaneous basin-wide sea level observations within MedGLOSS will be useful to assess the extent to which this seasonal variability can be attributed to adjustments in the mass balance of the whole Mediterranean Sea.

Références

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