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Estimation of return periods for extreme sea levels: an empirical improvement of the joint probabilities method with examples from the French Atlantic coast and Cornwall

P. A. Pirazzoli (1), A. Tomasin (2)

(1) CNRS – Laboratoire de Géographie Physique, 1 Place Aristide Briand, 92195 Meudon cedex, France (E-mail: pirazzol@ cnrs-bellevue. fr)

(2) Università di Venezia & CNR-ISMAR, S. Polo 1364, 30125 Venezia, Italy (E-mail; tomasin@unive.it)

The joint probability method (JPM) to estimate the probability of extreme sea levels (Pugh and Vassie) has been applied to the hourly records of 13 tide-gauge stations of the tidally dominated Atlantic coast of France (including Brest, since 1860) and, for comparison, to three stations of southern Cornwall (including Newlyn, since 1916). The cumulative total length of the available records (over 426 equivalent full years) is variable from 1 to 130 years when single stations are considered. It appears that heights estimated with the JPM are almost systematically greater than the extreme heights recorded. Statistical analysis shows that this could be due: 1) to surge-tide interaction (that may tend to damp surge values that occur at the time of the highest tide levels), and 2) to the fact that major surges often occur in seasonal periods that may not correspond to those of extreme astronomical tides. For long enough records, when estimations with other computing methods (e.g. Gumbel) can be attempted, deviations between estimations of extreme values and the records may reach several decimetres, suggesting that some assumptions of the extreme value theory may not be fully satisfied by the records of the sea-level archive and that the results of these estimations, though reliable in some cases, may be only approximate in other cases.

We have determined at each station empirical correction coefficients, that take into account the above two factors separately, or together, and estimated return periods for

extreme water levels also at stations where only short records are available. Extreme levels with estimated return times of 10, 50 and 100 years, respectively, are finally proposed at all stations.

Because astronomical tide and surges have been computed (or corrected) in relation to the yearly mean sea level, possible changes in the relative sea-level of the past, or foreseeable in the future, can be considered separately and easily added to (or deduced from) the extremes obtained. Changes in climate, on the other hand, may modify surge distribution and hence return times of extreme sea levels and should be considered separately.