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MODELING OF OCEAN TIDES AT THE BELGIAN COAST BY MEANS OF HARMONIC ANALYSIS : AN OPTIMIZATION APPROACH

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1. INTRODUCTION : THE TIDES PHENOMENON

The oceanic tides are one of the tidal phenomena, which are caused by the mutual attraction and the motion of celestial bodies (mainly the Moon and the Sun) relative to the Earth. The oceanic tides make the water level regularly go up and down at a certain place in a body of water subject to the tides (seas, rivers, ...). At the Belgian coast the tidal range (i.e. : the difference between the high-water and low-water level) varies from about 4.5 to 5 meters and the period between two consecutive maxima (or minima) in the waterlevel variation is about 12 h (i.e. a so-called "semi-diurnal" tidal type)

2. THE HARMONIC ANALYSIS OF TIDES

As the tides are caused by the relative motion of the Moon and the Sun with respect to the Earth, it can be assumed that the periodicities of this motion can be found back in the tidal effects on Earth. Moreover the ocean tides are affected by the shape of the seas in which they occur. Due to non-linear effects on the propagation of tidal waves in shallow water, "compound tides" and "overtides" are generated, having frequencies composed of "astronomical" frequencies. Therefore the harmonic method of tidal modeling considers the tidal variation of the local waterlevel as a superposition of components ("tidal constituents" or "tidal waves") with frequencies apearing in the lunar and solar motion relative to the Earth, as well as frequencies which are linear combinations of these astronomical frequencies. The latter components are called "shallow water tides".

By harmonic analysis of observations of the local water level during a certain period, amplitudes and phase angles are estimated for the components which are assumed to build up the tidal signal.

3. AN OPTIMIZATION APPROACH TOWARDS HARMONIC TIDAL MODELING

The harmonic model of the tides is formulated as the superposition of a noise term and a linear combination of deterministic trigonometric functions of time, the coefficients of this linear combination remaining to be determined by harmonic analysis. To set up a particular model one selects a certain set of frequencies to define the deterministic time functions. This selection is normally based upon a spectral analysis of the local tidal observations. In this paper we will point out which components constitute the "optimum" set to represent Belgian coastal tides by means of a stepwise analysis of the variance of the tidal signal. Given a certain set of constituents, the F-test is applied to reveal the significance of the decrease of the residual variance by adding an extra constituent to the model formulation. Moreover this procedure allows to select the constituent which yields the most significant decrease of the residual variance when including it in the model formulation. In this way the "optimum" model formulation can be obtained.

4. CONCLUSIONS

By means of harmonic analysis of tidal observations, at the Belgian coast and the analysis of the variance, the significance of the individual contributions of tidal constituents is determined, as well as the optimum set of tidal constituents to model the tidal water level variations as a function of the number of constituents contained in the set. Finally some order statistics of the residual signal are determined to reveal its distribution.

Eight years of hourly-observed waterlevels are analysed at three different locations along the Belgian coast (Nieuwpoort, Oostende, Zeebrugge).