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WAVELET ANALYSIS FOR TIDAL GAUGES INCLUDING TSUNAMI DATA

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ABSTRACT

The separation of tidal from non-tidal contents in tide gauge records are in general done by designing high pass or band pass filtering techniques. However, there is always a tradeoff between losing some valuable contents of the signal while trying to remove the tide. In this work, wavelet decomposition technique was applied as a tool to minimize the influence of tidal contents. Several parameters were set and applied to several types of wavelets in various temporal series and frequency ranges for two tidal gauges including tsunami data. The goal was to find the most appropriate wavelet parameter and type, to distinguish tsunami data from tidal contents. Our results show that the application of wavelets in comparison to conventional methods yields to lesser RMS errors before the arrival of the tsunami wave and therefore produces minor data loss after applying. The procedure introduced can be applied at any tide gauge data for tidal analysis with wavelet decomposition techniques.

INTRODUCTION

There are many methods to separate tidal disturbances from water level changes. The simplest method is Least-square linear regression analysis. Prior works are done by Roeloffs (1988) and Huichuan and Zhugang (1991) suggest two main tidal component response coefficients to estimate the response of earth tides for water level changes. Further works are done by Chengmin (1988) and Rojstaczer (1988) suggested that water level changes due to earth tide are dependent on frequency, and the coefficient are a function of frequency. The latter suggests that the least-squares linear regression analysis cannot thoroughly remove the disturbance from a record, due to the fact that we are not dealing with one long period oscillation.

A more robust and precise technique for separation would be the application of wavelet decomposition techniques. By applying this technique at any time series, the series will be decomposed by various scale resolution wavelets to approximate and detailed components. This gives us an opportunity to better distinguish desired from undesired signals.

The principal purpose of this study is to apply wavelet decomposition techniques for separating tidal contents from tide gauge including tsunami data.

A suitable wavelet that we have chosen from this study for Mumbai is the symlet2 (or daubechies2), which in its 5th level of decomposition has improved RMSE and amplitude, 39.37% and 10.14% respectively (see Figure 1). The blue signal is the TASK Filtered signal and the red signal is the Mumbai tide gauge data filtered by symlet-2 (or db2) wavelet at level 5. There is a small downdraft at the beginning of the tsunami wave arrival after filtering by this wavelet. This phenomenon is consistency with eye-witness reports in the Makran region (Kakar et al., 2015). After the small downdraft, the first peak amplitude of the red signal is smaller in comparison to TASK software, but the second downdraft is greater than TASK Filtered data, creating a greater amplitude amplification of %10.14.

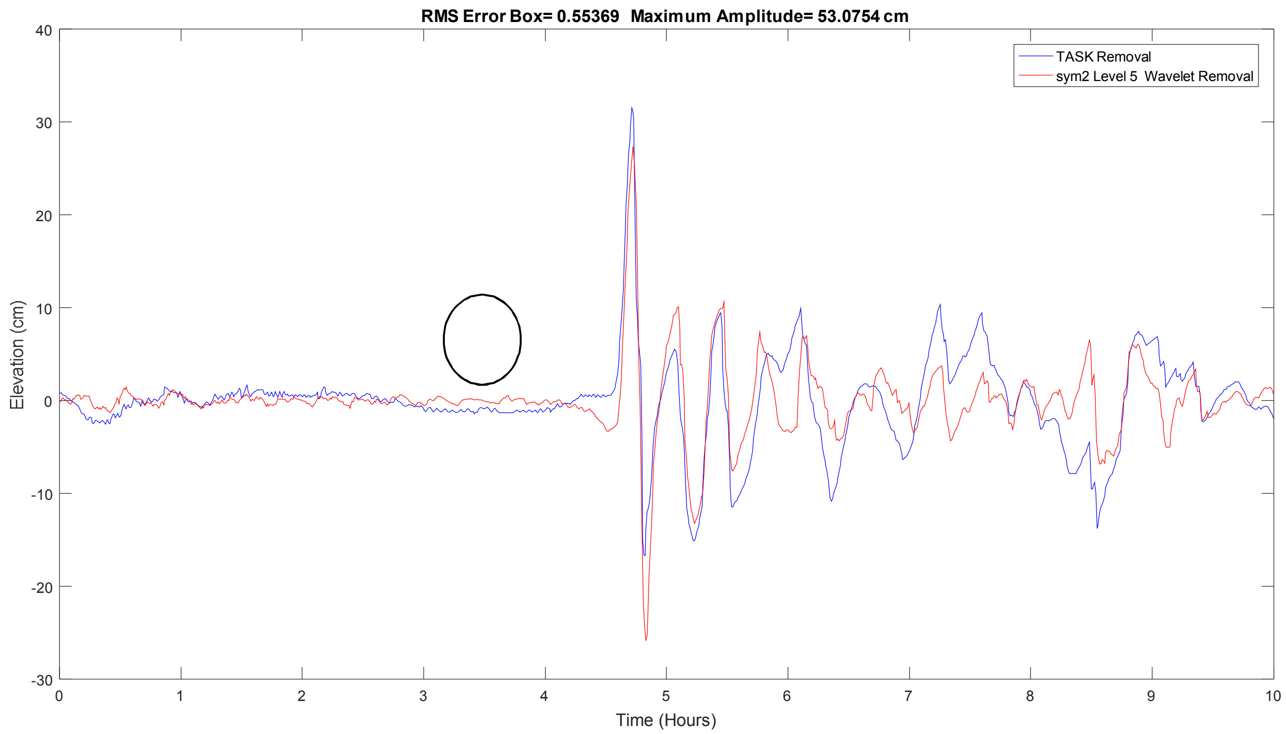

Figure 1. Implementation of most suitable Wavelet Parameter on the Mumbai tide gauge data. Subtracting the Symlet-2 wavelet in its 5th level of decomposition from the raw Mumbai tide gauge data resulted in the red signal. This signal suggests a small downdraft right before the arrival peak of the tsunami wave (black circle).

CONCLUSIONS

The fact that we can decompose any time series by various scale resolution wavelets to approximate and detailed components, has aided us to minimize and separate the effects of tidal contents from tsunami data with greater extends. Our results have yielded in lesser RMS error for the part before the arrival of the tsunami wave in Mumbai and more amplification in the amplitudes of Mumbai and Karachi comparing the previous results obtained by TASK software. We represent wavelet decomposition technique as robust tool for application on tidal tide gauges in order to separate tidal from non-tidal data. Moreover, we have detected a downdraft before the arrival of the tsunami wave which is consistent with the testimonies of elders whom have witnessed the Makran tsunami.

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