Neural Network for meteotsunami detection in Lake Michigan

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Meteorological tsunamis or meteotsunamis are long waves in the tsunami frequency band induced by atmospheric perturbations of wind and pressure [Monserrat et al. 2006]. Meteotsunamis with large wave height have been observed worldwide, and frequently occur in some specific basins such as Lake Michigan, Nagasaki Bay, the Balearic Islands or the Adriatic Sea. In particular, during the past decades meteotsunamis have been observed causing casualties and property loss in Lake Michigan [Ewing et al. 1954; Bechle et al. 2015]. Today, many efforts are being made to develop meteotsunami warning systems around the world [Šepić and Vilibić 2009], however, no meteotsunami warning system has yet been implemented in Lake Michigan.

The purpose of this project is to develop a pattern recognition algorithm to detect meteotsunamis whose wave heights exceed a certain threshold in Lake Michigan harbors. Specifically, a neural network will be developed to detect meteotsunamis in Calumet Harbor (Chicago, IL) employing atmospheric observations as inputs. The atmospheric observations consist of high resolution (1 minute) pressure and wind data obtained from the Automated Surface Observing System (ASOS) weather stations around Lake Michigan, as well as reflectivity imagery from 2006 to 2015.

Meteotsunamis are caused by high frequency (order of minutes) perturbations of pressure and wind. Hence, in this project, preprocessing high-pass filters with different cutoff frequencies will be tested for the atmospheric input of the neural network. On the other hand, traveling speed and propagation direction of the atmospheric perturbation dictate the relationship between the atmospheric forcing and the lake bathymetry, thus determining the wave height growth. This dependency of wave height to the atmospheric perturbation speed and direction will be accounted following 2 approaches: (1) precalculate speed and direction and input their value to the neural network; (2) leave the “calculation” of speed and direction to the neural network by inputing pressure and wind observations from a group of ASOS stations with their corresponding relative location.

The Neural Network will be designed by comparing the overall accuracy, Prob. Missclassification, and Prob. False Alarm of 1 and 2 hidden-layer networks with 1 – 10 hidden nodes (100 possible network layouts). All networks will be tested with 2 outputs (2-class classification problem). Deep neural network designs will not be considered due to relatively small amount of inputs (about 10 – 50 inputs). The quality of the outcome will be evaluated against the accuracy of an existing meteotsunami warning system in the Adriatic Sea [Šepić and Vilibić 2009].

The timeline I have established for the project is as follows:

**April 11:** (1) Download atmospheric and water level data and convert to adequate format to input to the neural network. (2) preprocess atmospheric and water level data (High-pass filter). (3) Preliminary Neural Network development.

**April 23:** Test different Neural Network structures. Obtain results: Confusion matrix, ROC curve, etc…

**April 30:** (1) Write report. (2) Prepare presentation.
References:


Monserrat, S., and A. Rabinovich (2006), Meteotsunamis: atmospherically induced destructive ocean waves in the tsunami frequency band, Natural Hazards and Earth System Science, 6, 1035-1051.