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Statistical Comparison of Ensemble Based Storm Surge Forecasting Models

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Abstract : Storm surge is an abnormal water level caused by a storm. Accurate prediction of a storm surge is a challenging problem. Researchers developed various ensemble modeling techniques to combine several individual forecasts to produce an overall presumably better forecast. There exist some simple ensemble modeling techniques in literature. For instance, Model Output Statistics (MOS), and running mean-bias removal are widely used techniques in storm surge prediction domain. However, these methods have some drawbacks. For instance, MOS is based on multiple linear regression and it needs a long period of training data. To overcome the shortcomings of these simple methods, researchers propose some advanced methods. For instance, ENSURF (Ensemble SURge Forecast) is a multi-model application for sea level forecast. This application creates a better forecast of sea level using a combination of several instances of the Bayesian Model Averaging (BMA). An ensemble dressing method is based on identifying best member forecast and using it for prediction. Our contribution in this paper can be summarized as follows. First, we investigate whether the ensemble models perform better than any single forecast. Therefore, we need to identify the single best forecast. We present a methodology based on a simple Bayesian selection method to select the best single forecast. Second, we present several new and simple ways to construct ensemble models. We use correlation and standard deviation as weights in combining different forecast models. Third, we use these ensembles and compare with several existing models in literature to forecast storm surge level. We then investigate whether developing a complex ensemble model is indeed needed. To achieve this goal, we use a simple average (one of the simplest and widely used ensemble model) as benchmark. Predicting the peak level of Surge during a storm as well as the precise time at which this peak level takes place is crucial, thus we develop a statistical platform to compare the performance of various ensemble methods. This statistical analysis is based on root mean square error of the ensemble forecast during the testing period and on the magnitude and timing of the forecasted peak surge compared to the actual time and peak. In this work, we analyze four hurricanes: hurricanes Irene and Lee in 2011, hurricane Sandy in 2012, and hurricane Joaquin in 2015. Since hurricane Irene developed at the end of August 2011 and hurricane Lee started just after Irene at the beginning of September 2011, in this study we consider them as a single contiguous hurricane event. The data set used for this study is generated by the New York Harbor Observing and Prediction System (NYHOPS). We find that even the simplest possible way of creating an ensemble produces results superior to any single forecast. We also show that the ensemble models we propose generally have better performance compared to the simple average ensemble technique.

Keywords : Bayesian learning, ensemble model, statistical analysis, storm surge prediction
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