TRACKING AND NOWCASTING OF HURRICANES: A DATA FUSION APPROACH

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ABSTRACT

1. INTRODUCTION

Dynamical, statistical and dynamical-statistical models used for hurricane track forecasting vary significantly in structure and level of complexity. Previous studies show that different modeling techniques have their own advantageous and disadvantageous (e.g., NHC, 2009). In recent years, ensemble (consensus) models have become more popular.

Ensemble models are obtained by combining the forecasts from a number of models or multiple simulations from a model with different parameterization, initial condition, etc. An ensemble of hurricane tracks consists of a number of realizations (individual hurricane tracks), each of which representing an equiprobable hurricane path that can occur. Using an ensemble of hurricane tracks, one can also assess uncertainties associated with track forecasts through analysis of the spread of the ensemble. Studies have confirmed that a multimodel ensemble approach increases the skill of model predictions. However, decision makers may need to know which ensemble member is more likely to be true, particularly when the ensemble is spread out over a wider area. For example, Nasrollahi et al., 2011 showed that differences of a 20-member ensemble of Hurricane Rita at landfall were nearly 3 degrees (one model with different parameterization). Similar results have been reported in other publications. It is common to derive the hurricane track response by taking the arithmetic mean of simulated ensemble where an equal weight is given to each track forecast. However, strong similarities exist between several models (ensemble members) which may cause biased ensemble response toward models with strong similarities. In this presentation, a methodology is proposed for tracking and Nowcasting hurricane track simulations by weighting ensemble members using the so-called Expert Advice Algorithm and online learning technique (Vovk and Zhdanov, 2009). This methodology is used to simulated ensembles of Hurricanes Katrina, Rita and Gustav.

2. METHODOLOGY

In the following, the Expert Advice algorithm is used for nowcasting of hurricane track based on an ensemble of multimodel forecasts. In this method, ensemble members are weighted and fused together based upon data from previous time steps such that the ensemble response is better than (or at least not worse than) the best model. The concept of prediction using expert advice has been successfully applied in financial sector and game theory (e.g., Vovk and Zhdanov, 2009; Cesa-Bianchi and Lugosi, 2006). The idea is to adapt this methodology and weight and fuse ensemble members (predictors) such that at any given time step, the hurricane track ensemble response is superior to the best model. The term "best model" refers to the model that leads to the least error with respect to observations.

3. RESULTS

In this study, the suggested approach is tested for nowcasting tracks of hurricanes Rita, Katrina and Gustav. As an example, Figure 1 displays the cumulative loss (error) of each ensemble member (hurricane track predictor) compared to observed data (case study: Hurricane Rita) – error in degree distance. Each line is the cumulative loss for each expert also considered as each model (the figure shows 19 predictors). In Figure 1, the leaner's cumulative loss (Expert Advice (EA) algorithm) is presented with a thick red line. The figure shows that the EA's cumulative loss is less than the cumulative loss of the ensemble mean and ensemble weighted average.

4. CONCLUSIONS

A data fusion technique (Expert Advice Algorithm) is used to derive the response of hurricane simulations. The results show that merging simulations using the EA algorithm leads to less error in hurricane track analysis. This indicates that the approach can be used in real-time for nowcasting of hurricane tracks as simulations become available. As shown in the example, the expert advice algorithm is superior to the arithmetic mean of the ensemble simulations as well as the ensemble weighted average. Similar results have been observed for Hurricanes Katrina and Gustav (not shown). This algorithm is very efficient and can be applied in real-time for nowcasting of not only hurricane tracks but also deriving ensemble response of other weather variables.

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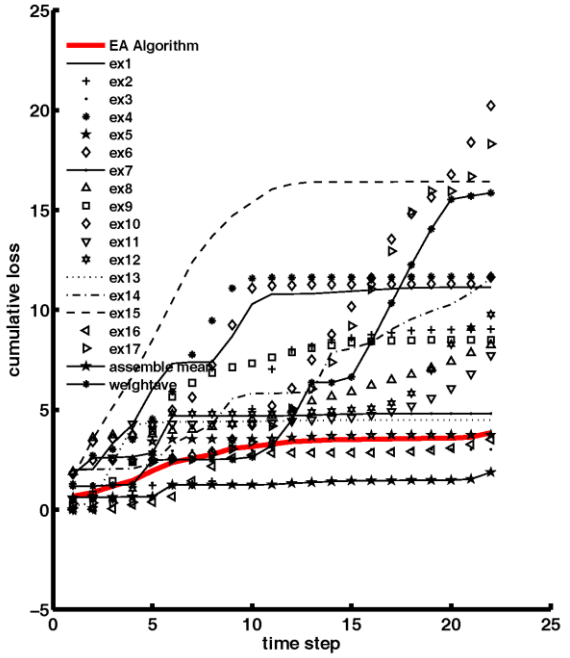

Fig. 1: Cumulative loss (error) of simulated Hurricane Rita tracks (error in degrees distance). Each line is the cumulative loss for each hurricane track predictor (here, 19 predictors). The Expert Advice (EA) algorithm is presented with a thick red line.

5. REFERENCES

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