ENSEMBLE WIND SPEED FORECASTING SYSTEM FOR MARINE CONSTRUCTION SITE

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1. Introduction

A forecast is the estimation of the future state of the atmosphere by using the observations of the current state of atmosphere. As the atmosphere is a chaotic system, tiny errors in the initial state will be amplified as large errors in the forecast. Since we can never observe every detail of the atmosphere's initial state, we can never create a perfect model. So instead of running a single forecast, the computer model is made to run a number of times with different initial conditions. This set of forecasts is called as ensembles. The ensemble forecasts give the forecaster a much better idea on the likelihood of the occurrence of a weather event in the days ahead. ECMWF[1] produces 51 forecasts, of which one is the control forecast produced with the best available data and unperturbed models. The other 50 forecast are produced with the slight perturbations of initial conditions and the models as shown in Figure1. The need for an accurate forecasting system is very crucial in order to minimize the risk caused by bad weather events and to ensure construction site safety. The construction industry loses huge amount of money because of the delays and failures caused by bad weather conditions. Wind speed of more than 10m/s in the construction site is dangerous.

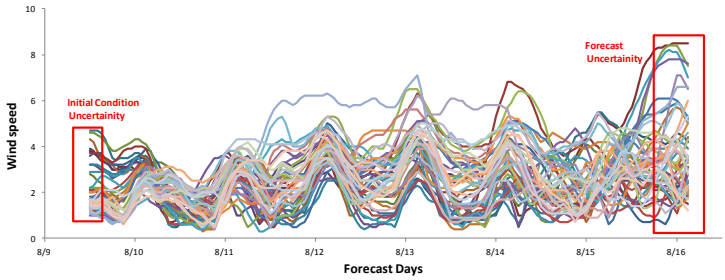

Figure1: Schematic Diagram illustrating ensemble forecasting

2. Study Site and Period

In this study we use the ensemble forecasting wind speed data from three sites namely Site1 Naha, Site2 Kanazawa and Site3 Hitachinaka in Japan as shown in Figure2. JMA[2] has developed a new high resolution ensemble forecasting system that runs once a week (every Thursday) with 50 members, which are composed of a set of 24 members (Tuesday) and a set of 26 members (Wednesday) from 23rd March 2017 (JMA, 2017). These data are downloaded from JMA website from dates 26th June 2017 to 1st November 2017. Japan Meteorological Agency Global Spectral Model (GSM) with the resolution of 20km is used as the Observational data for evaluation and verification of the utilization of the current ensemble forecasting system in construction site.

Figure2: Location of Study site

3. Evaluation of Ensemble Forecasting

In this study the ensemble forecasting is evaluated by the following measures: (i) Exploratory Plots (ii) Ensemble mean performance (iii) Consistency.

3.1 Exploratory Plots An ensemble usually includes the control forecast which is the one starting from the analysis of the atmospheric conditions and the other ensemble members are then generated by adding perturbations to the analysis. Many studies have shown that using the mean of an ensemble as a deterministic solution produces the most accurate results. In order to analyze this, relationship between the ensembles mean and observational data & control forecast and observational data, the correlation scatter plot histogram is plotted as shown in Figure3.

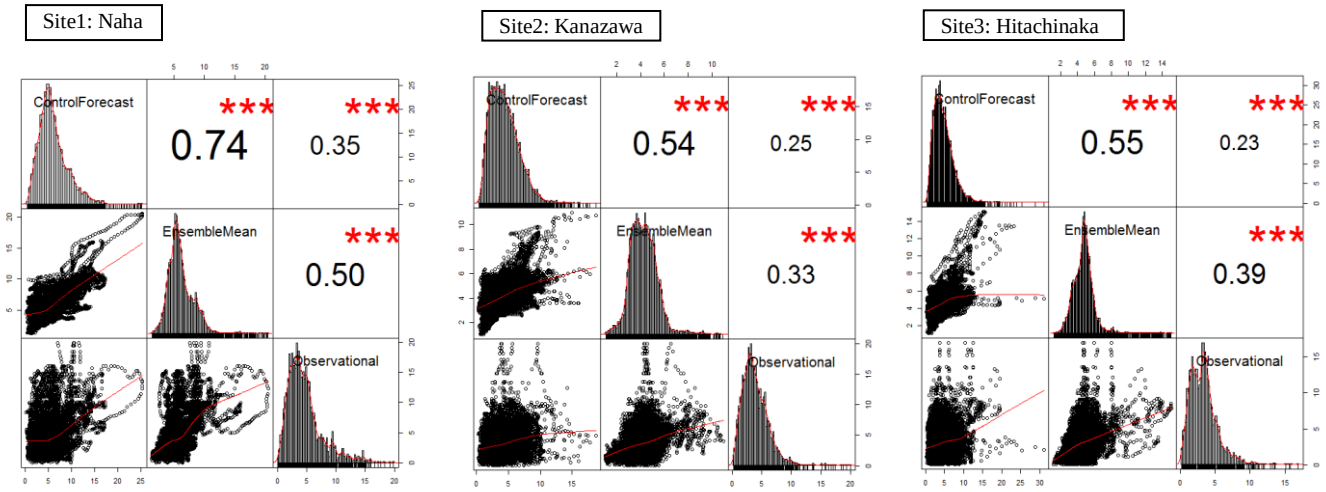

Figure3: Correlation, Scatter plot and Histogram plot between the ensemble mean and observational data & ensemble control and observational data in Site1, Site2, and Site3 respectively.

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3.2 Ensemble mean performance In order to evaluate the ensemble performance RMSE and Correlation Coefficient for different forecast days are plotted. The Root Mean Square Error (**RMSE**) is a frequently used measure of the difference between values predicted by a model and the values actually observed from the environment that is being modeled. Figure4 shows the RMSE values for the 7-day ensemble forecast system which indicates that a good ensemble model performance. Correlation, often measured as a correlation coefficient indicates the strength and direction of a linear relationship between two variables. Figure5 indicates the Correlation of ensemble predicted value with observed value. In all the three sites it is observed that for the 7-day forecast system, there is a strong linear relationship between ensemble member and observational values.

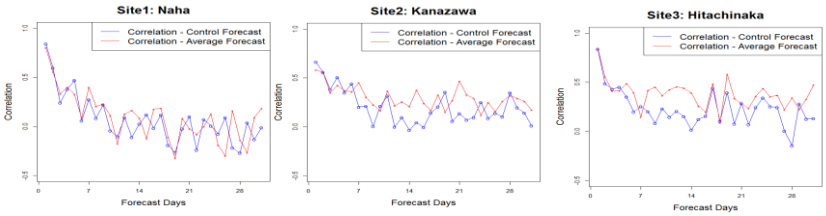

Figure4: Correlation between ensemble mean & Observational data and ensemble control & Observational data.

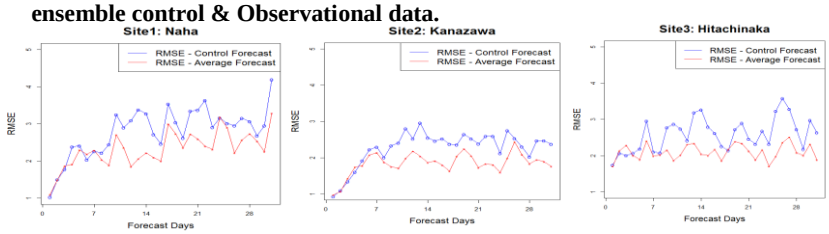

Figure5: RMSE between ensemble mean & Observational data and ensemble control & Observational data.

3.3 Consistency The rank histogram measures how well the ensemble spread of the forecast represents the true variability (uncertainty) of the observations. From Figure6, it can be seen that for the 7th day forecast in all the three sites, indicates that the ensemble member underestimates the observations whereas for the long-range forecast like the 21st day forecast and 28th day forecast, it is observed to have a flat histogram showing that the observations is indistinguishable from other ensemble members. Thus the ensemble forecasting for short-range forecasting appears to be not so good and this could be because of the smaller standard deviation for short-range forecasting as shown in Figure7 and in such cases control forecast is found to be good, whereas for the ensemble forecasting appears to be good for long-range forecasting system.

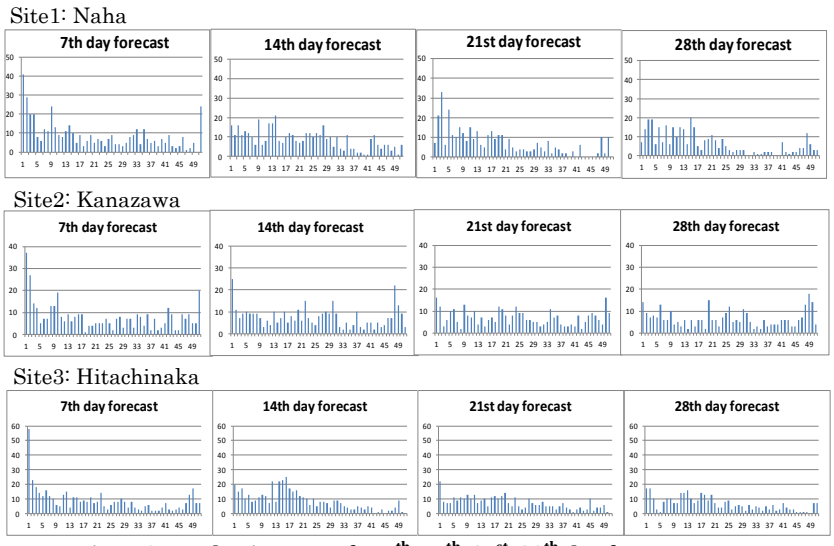

Figure6: Rank Histogram for 7th, 14th, 21st, 28th day forecast system

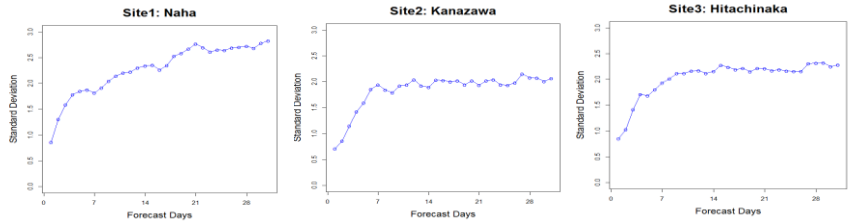

Figure7: Standard Deviation of ensemble mean & Observational data

4. Prediction of critical event in Construction Site

For Site1 Naha, that is more prone to typhoon, the probability of prediction of the typhoon (that brings strong winds) by 7-day, 14-day, 21-day and 28- day forecast system is as shown in the Figure8. For Typhoon.No.21 that brought strong winds by 21-23 October 2017, the probability of the prediction by 21-day forecast (blue), 14-day forecast (red), 7-day forecast (green) is found to be nearly 0.5 and for the Typhoon.No.22 that brought strong winds by 27-29 October 2017, the probability of the prediction by 28-day forecast (blue), 21-day forecast (red), 14-day forecast (green), is found to be nearly 0.5. This indicates that the new high resolution ensemble forecasting system gives good early prediction results for stronger winds that are critical for construction site. Thus the new ensemble forecasting could help in construction safety, efficient resource planning and effective construction & maintenance scheduling.

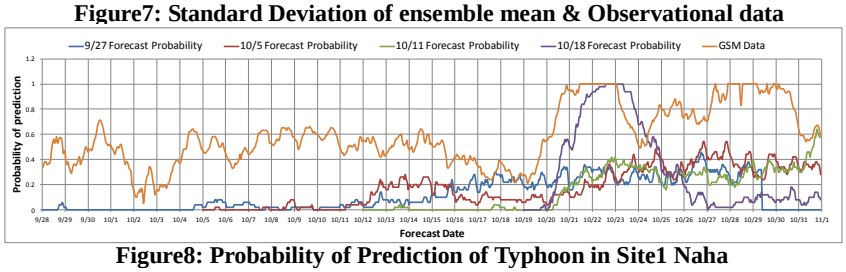

Figure8: Probability of Prediction of Typhoon in Site1 Naha

5. Conclusion

The performance of the new high resolution ensemble forecast system has been checked for the predictions of critical event like typhoon. Since the data from 28th July 2017 to 1st November 2017 were used, there were some restrictions because of the smaller datasets and in future this research is planned to be extended for long-term forecasting system.

References

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