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Performance Evaluation of the WRF Model for the Short Term Wind Energy Prediction System (SWEPS) for Turkey

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Abstract

Wind energy was one of the fast-growing sector in Turkey during the last decade. As a result of establishing new wind power plants, the accurate prediction of wind energy is becoming more important these days. Our recent studies show that the performance of numerical weather prediction model is the key issue improving microscale model accuracy (Mentes et. al., 2013). Therefore, the main purpose of this study is to evaluate the performance of the WRF model in wind speed and direction prediction for 4 different wind farms located in the west part of Turkey and to compare the results of WRF model with both observations and the results of CFD based models. The WRF domains for these wind farms are constructed as 3 nested domains with the horizontal resolutions starting from 9 km by ratio 3. Each simulation has 72hr time horizon and they are performed for one-year period for each domain area. Although, according to the control run studies, WRF model has better performance than other high-resolution CFD based or physical models for average wind speeds, this study indicate that the performance of WRF model in estimating extreme winds is still evaluated as poor. So our main conclusion is that the WRF Model performance depends on the variation of wind speed accordance with domain choice. Our results also indicate that for inner WRF domain (1 km), the errors are increasing with time horizon of the model. That is, 24hr simulations have fewer errors than 48hr simulations and also 72hr simulations. The second domain solutions, with a coarser resolution (3 km), have better performance than the finest resolution domain for the extreme wind cases.

Objectives

The main objective of this study is to evaluate the success of the WRF model in order to increase the wind speed forecasting accuracy on the western part of Turkey where most of the new wind power plants are located. Analyses of the WRF model is performed as a part of the SWEPS project (Mentes et al. 2013)

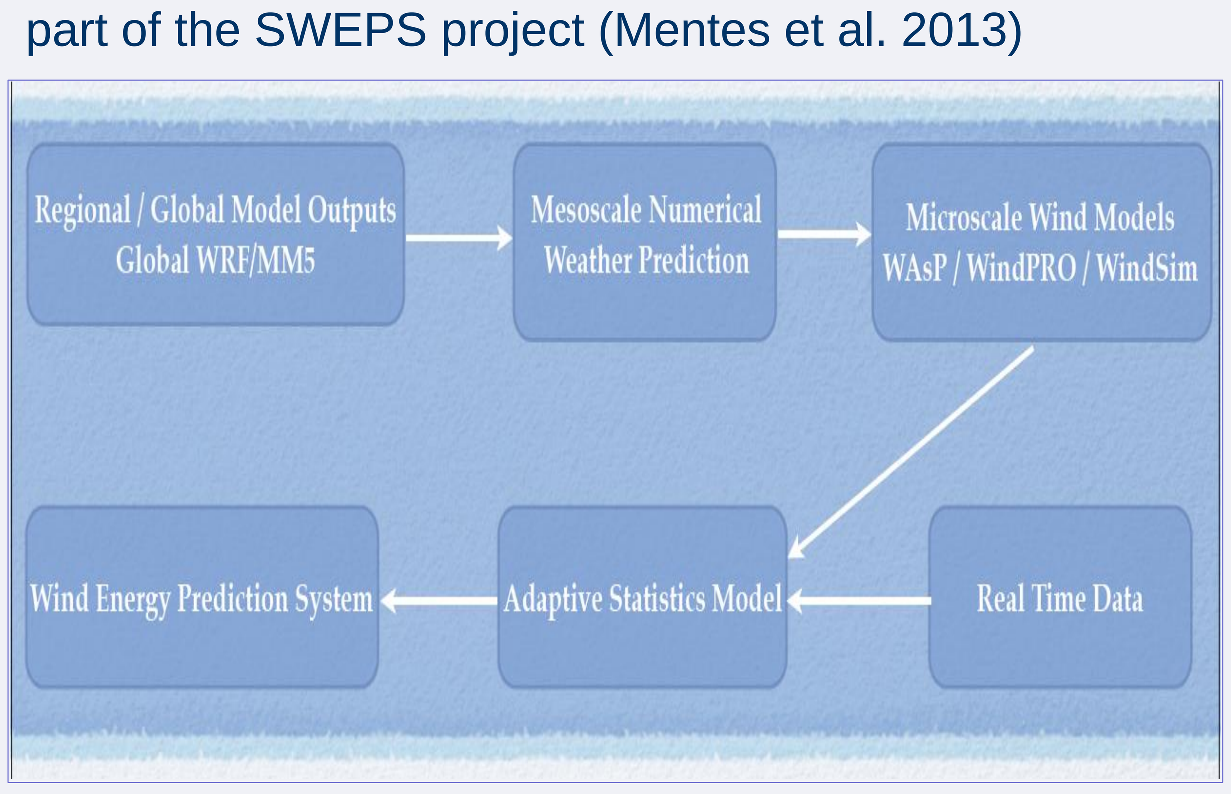

Figure 1. Short term Wind Energy Prediction System (SWEPS)

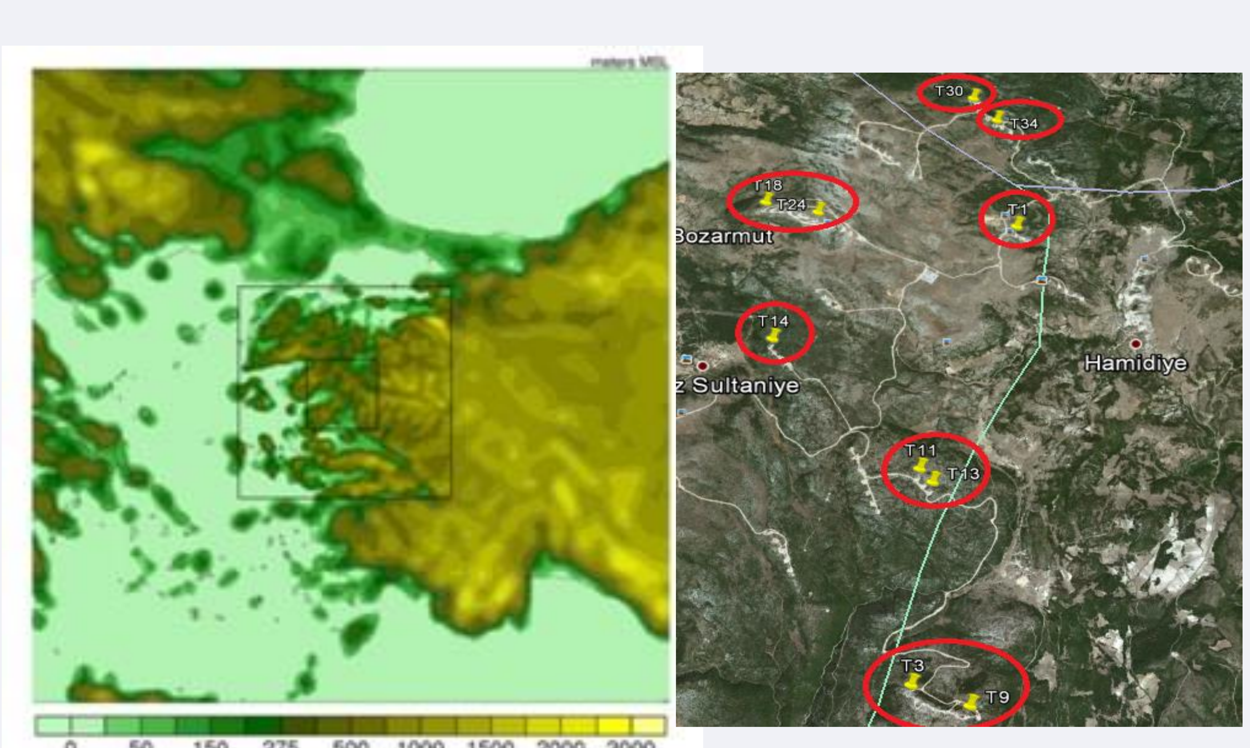

Figure 2. WRF Model Domain for Soma Region (Left Frame: Reference Domain, Right Frame: Turbine Locations)

Methods

Table 1. The selected options of the WRF Model for the Simulations of Soma Region- Reference Domain

(Settings)	WRF
PBL Scheme	YSU
Cloud Physics Scheme	WSM 3-Class Sample Ice
Cumulus Scheme	Kain Fritsch (9 km)
Nested domain	9-3-1 km
Grid numbers	100x100x45 (9 km) 100x100x45 (3 km) 100x100x45 (1 km)
Vertical levels	45
Time	72 hours
Data	ECMWF Forecast data 0.25 degree Resolution

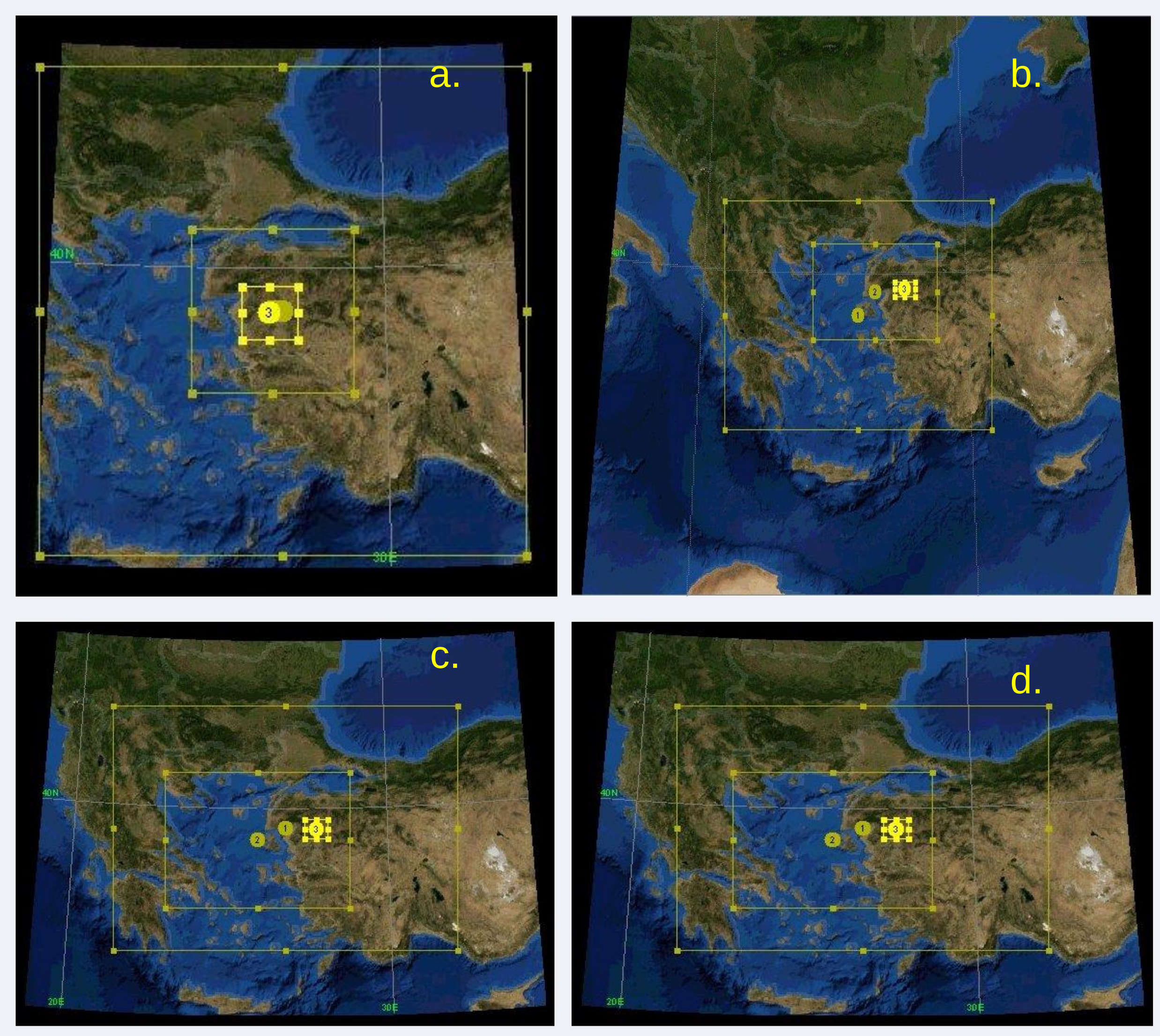

Figure 2. WRF Model Domain Configurations for Soma Region

a. Domain 1 b. Domain 2 c. Domain 3 d. Domain 4

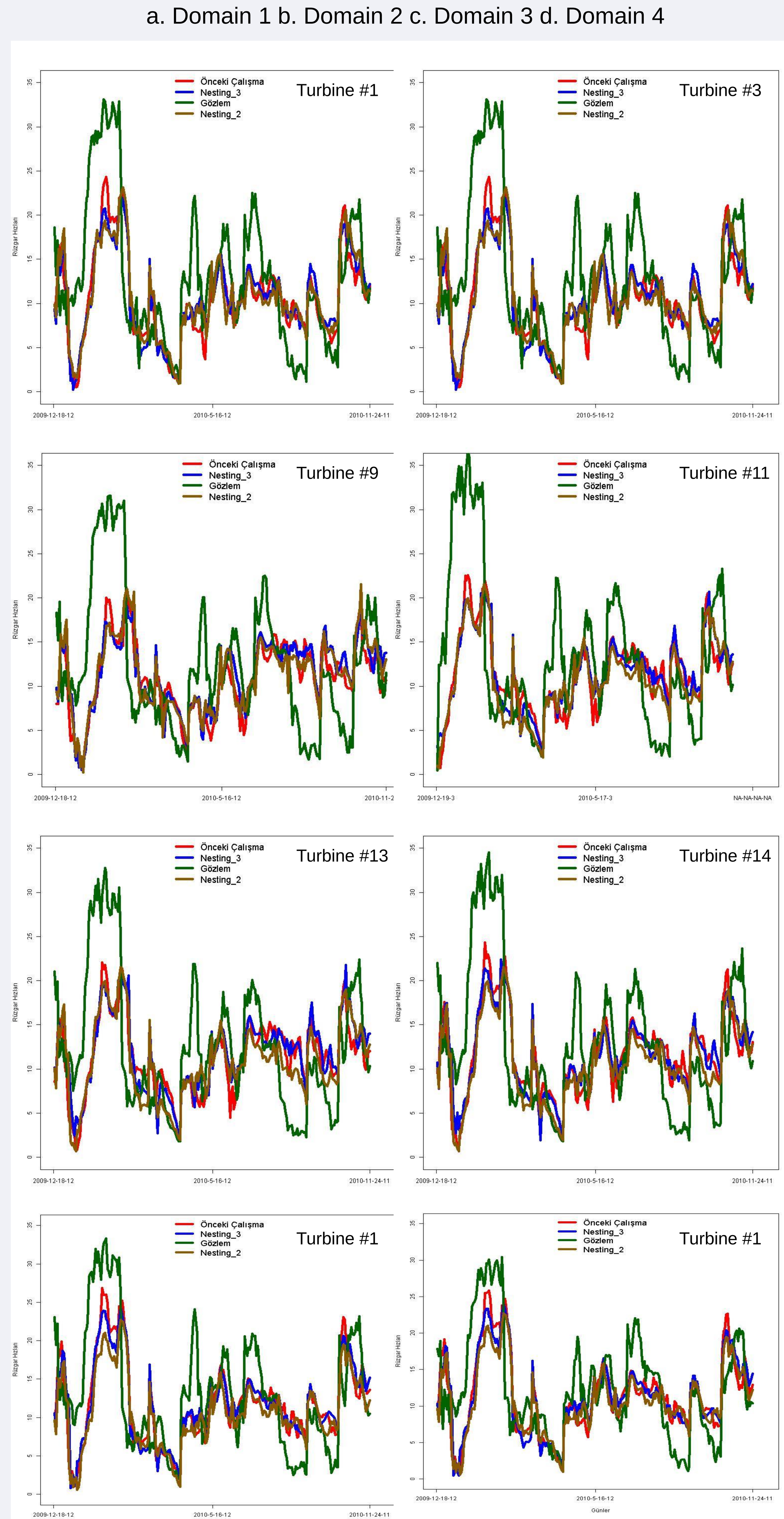

Figure 3. WRF Model Wind Speed Comparisons with observations obtained from turbine locations

Results

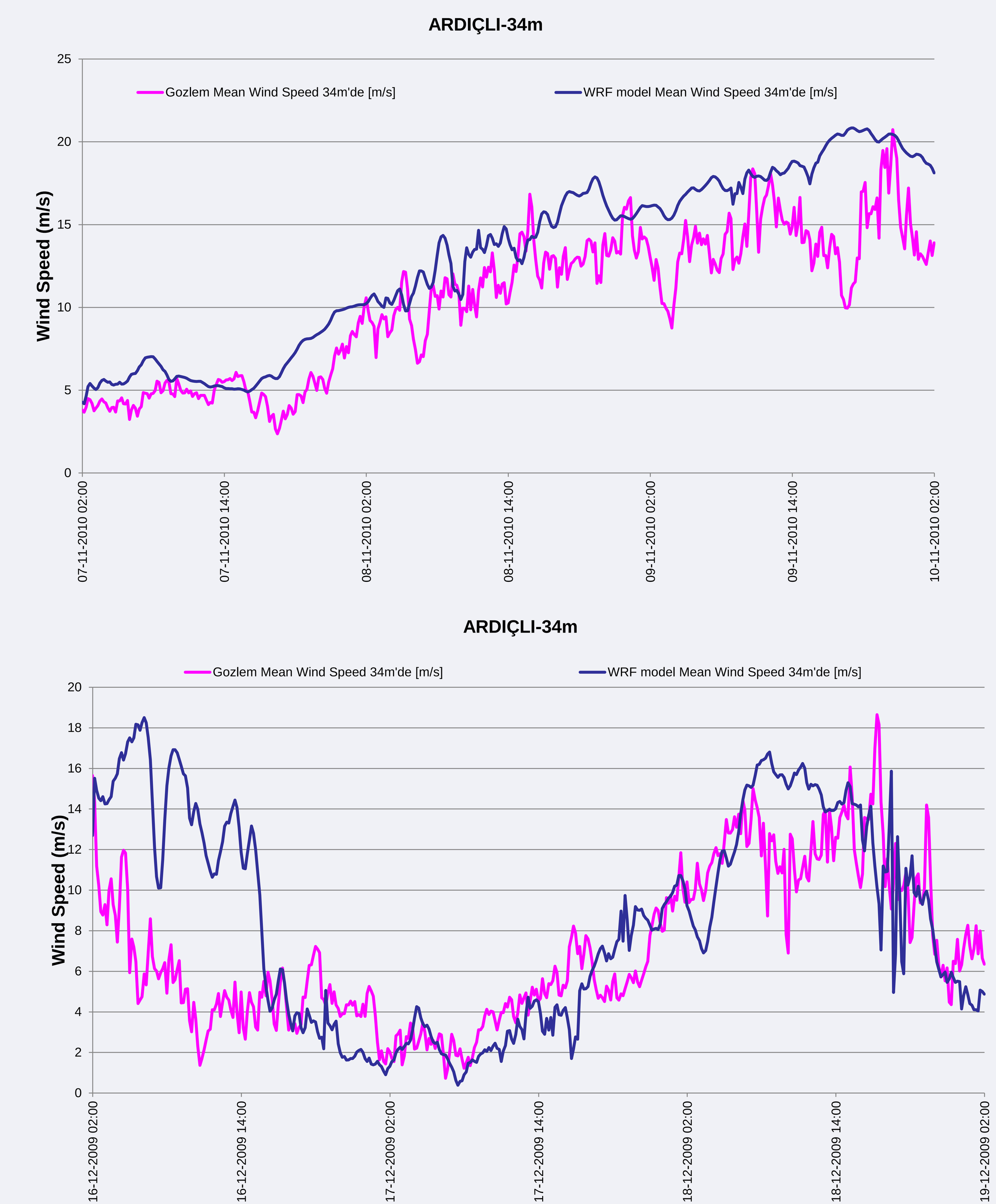

Figure 4. Time Series of WRF Model Wind Speed Comparisons with mast observations

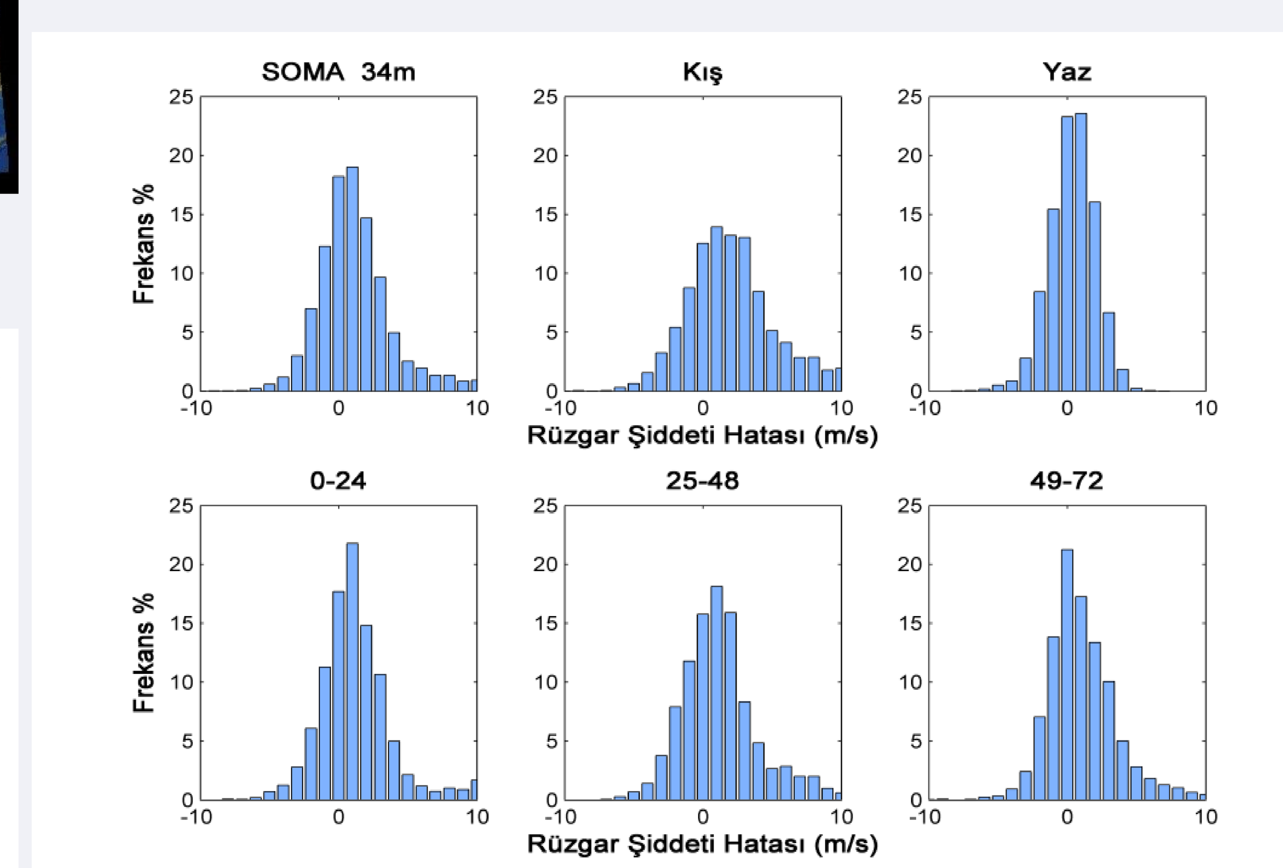

Figure 5. Error histograms of WRF Model Wind Speed Comparisons with mast observations

Conclusions

Wind speed results of the WRF model are compared to the control run for four different domain designs by means of normalized root mean square error (nRMSE). These results are visualized as time series in order to indicate the importance of domain choice on hourly variation of wind speed. Results for each turbine were evaluated as 24, 48, and 72-hourly and also seasonally. The results show that domain choice is important for modeling of extreme winds as much as physics options. Although, according to the control run studies, WRF model has better performance than other high-resolution CFD based or physical models for average wind speeds, this study indicate that the performance of WRF model in estimating extreme winds is still evaluated as poor. So our main conclusion is that the WRF Model performance depends on the variation of wind speed accordance with domain choice.

References

Mentes S., Tan E., Unal E., Unal Y.S., Barutcu B., Efe B., Ozdemir E.T., Onol B., and Incecik S., The Development of a Short Term Wind Energy Forecast System (SWEPS) in Manisa, Turkey by using the WRF Model, Submitted to Renewable Energy (2013).

Acknowledgements

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