Building Time Series Model for Wind Power Forecast

Jiaying Liu, Lingling Chen, Yuxin Zhao
Jiayingliu@gwu.edu | lling_chen@gwu.edu | yuxin@gwu.edu

THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

ABSTRACT

The purpose of our research is to build a model to forecast wind power. We describe detailed information approach to the wind power forecast by using the data from Global Energy Forecasting Competition 2012. The task was to predict 24-hour ahead hourly power generation at 7 wind farms. The problem was addressed by extracting time and weather related features. These features were used to build our autoregressive integrated moving average (ARIMA) models. After applying this model and deriving our conclusions, we also provide some recommendations for further improvement of wind power forecasting.

INTRODUCTION

- **Background**

Wind power, as an example of "environment-friendly" renewable resource with several advantages like cost-effectiveness and non-pollution, are increasingly popular in these years. The demand for predictive accuracy of wind forecast is increasing. Many mathematicians and statisticians spare no effort in promoting wind power forecast models. However, the importance of time series character of wind power data is not highlighted by most of the previous research. So we pay more attention to this time series character and apply time series specific model-ARIMA to forecast wind power.

- **Summary**

Our analysis includes six tasks, including data gathering, data pre-processing, data importing and smoothing, model fitting, model examination, and model application. In this process, we build an ARIMA to forecast wind power. Then we apply this model to test whether it is useful to test out-sample data and refit the parameter to find the better model.

DATA PROBLEM

- **Data Gathering**

Data applied in our research is from "GEFCom2012 – Wind Forecast" including three years' energy data of 7 wind farms from the same region of the world. The dataset contains historical power measurements for those wind farms and the meteorological forecasts of wind component at the level of those wind farms.

- **Data Pre-processing**

We examine the datasets and check whether there are missing values or outliers. Then we define data types by category or numeric.

- **Data Import**

After importing data into R and applying package "ggplot2", we obtained the original time series plot.

- **Data Smoothing**

To smooth the data and make it stationary, we apply the function of log and diff and finally get new data.

METHODOLOGY

Time Series: ARIMA

- **A Short Introduction to ARIMA**

ARIMA stands for auto-regressive integrated moving average and is specified by these three order parameters: *(p, d, q)*. The process of fitting an ARIMA model is sometimes referred to as the Box-Jenkins method.

- **Steps of Building ARIMA Model**

❑ **Task1. Data pre-processing:** missing value? Outliner?
❑ **Task2. Data Smoothing:** DIFF and LOG

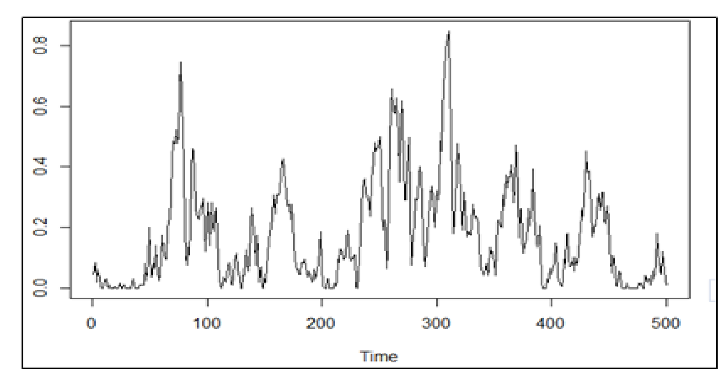


Figure1. The time series plot of original data.

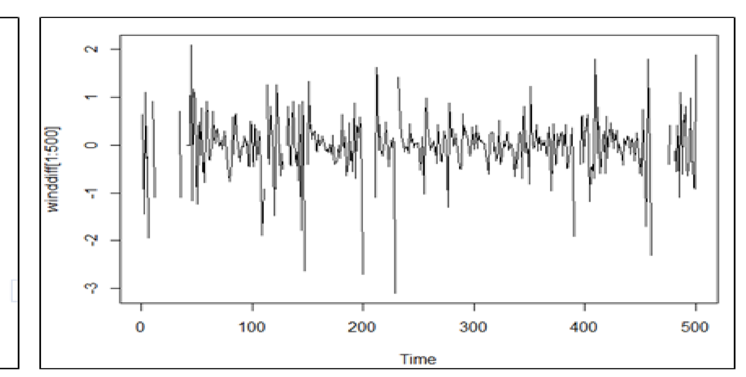


Figure2. The plot of stationary data.

❑ **Task3. Model Fitting:** PACF,ACF and AUTO.ARIMA

The ACF is used to estimate value of parameter q in MA(q)
PACF is used to decide the value parameter p in AR(p) model

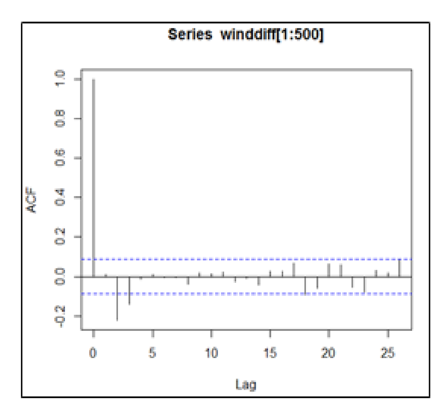


Figure3. The plot of ACF.

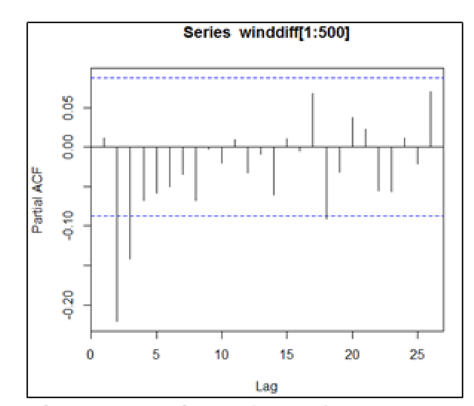
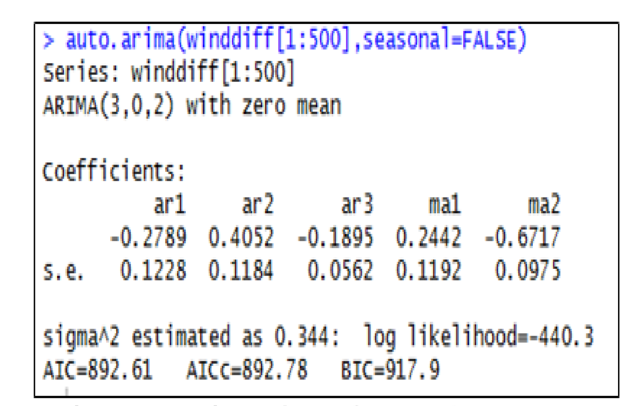


Figure4. The plot of PACF.



```
> auto.arima(winddiff[1:500],seasonal=FALSE)
Series: winddiff[1:500]
ARIMA(3,0,2) with zero mean

Coefficients:
          ar1     ar2      ar3     ma1      ma2
      -0.2789  0.4052  -0.1895  0.2442  -0.6717
s.e.   0.1228  0.1184   0.0562  0.1192   0.0975

sigma^2 estimated as 0.344:  log likelihood=-440.3
AIC=892.61   AICc=892.78   BIC=917.9
```

Figure5. The plot of AUTO.ARIMA.

❑ **Task4. Model Reliability Examination**

To examine the reliability of our ARIMA (3,0,2) model, we use the ACF and PCF of residuals of our model.

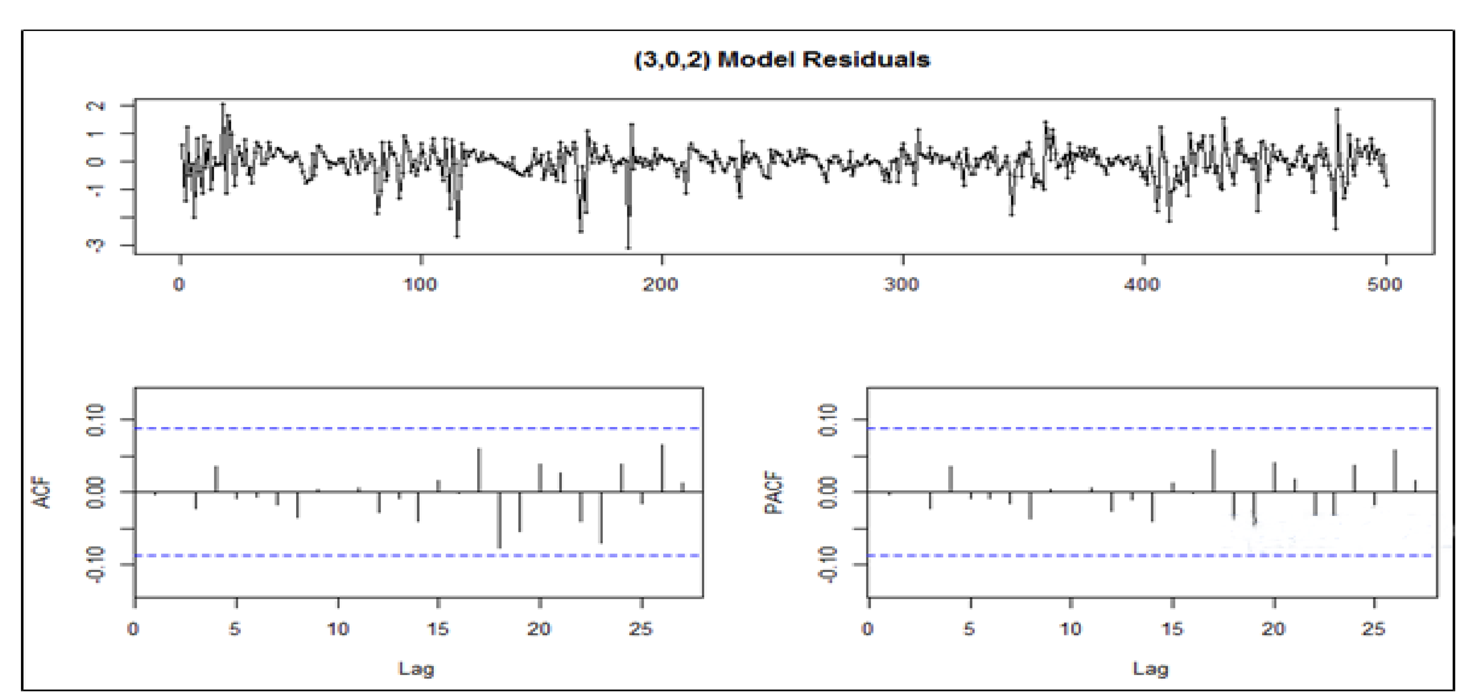


Figure4. The plot of Residuals.

❑ **Task5. Model Application**

We are going to forecast a short-term (24 hours) result. The blue line in the figure is forecast result. The black line is the original result. Perfectly predict the trend of wind power.

RESULTS

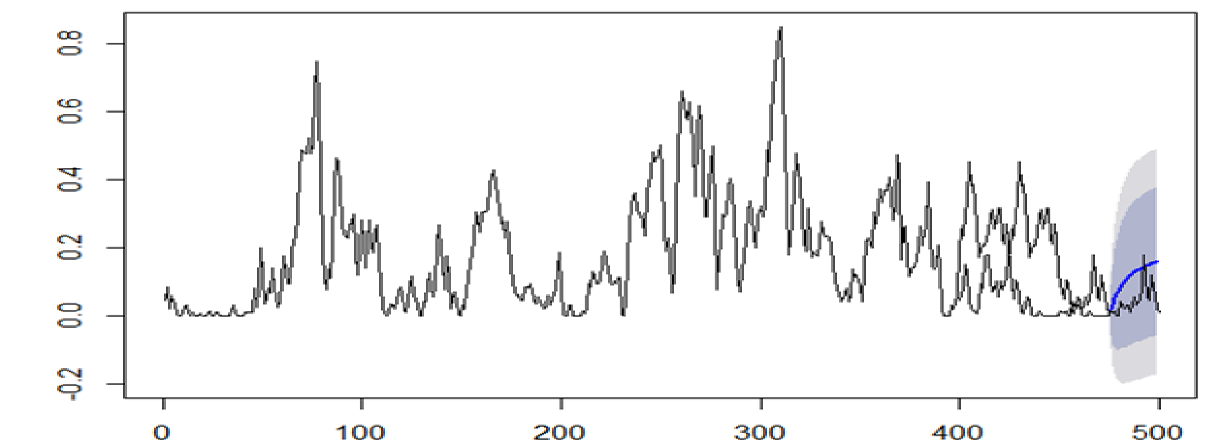


Figure7. The predict result of farm1.

This figure shows the predict result of farm1 by ARIMA(3,0,2).

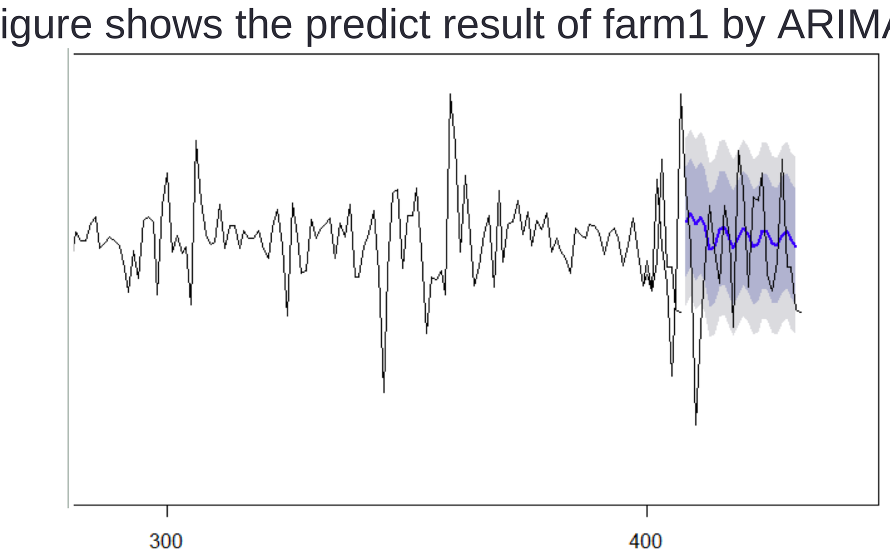


Figure8. The adjusted predict result of farm1.

This figure shows the predict result of farm1 by adjusted model ARIMA(3,0,15).

farm	Final model
farm1	ARIMA(3,0,15)
farm2	ARIMA(9,0,0)
farm3	ARIMA(3,0,15)
farm4	ARIMA(3,0,5)
farm5	ARIMA(3,0,12)
farm6	ARIMA(1,0,6)
farm7	ARIMA(3,0,10)

Table1. The final models for all farms.

Because of the space limitation, we just show the visual results for farm1.This table shows final model for all 7 farms.

CONCLUSIONS/RECOMMENDATIONS

- **Conclusions**

ARIMA is suitable for wind power forecast. Though not accurate enough, our prediction data always have the same trends with true data.

- **Recommendations**

Exponential smoothing, add more variables: latitude and longitude, humidity, temperature