Real-time wind power forecasting for grid operations using numerical weather model in Jeju

ECOBRAIN Co., Ltd
Seoul, South Korea

Young-Mi Lee
J. P. Jo / J. K. Park

http://www.ecobrain.net
ecobrain@ecobrain.net

Introduction

This study is the first attempt to estimate the capability of real-time forecasting of potential wind power over Jeju island in HanGyeong, based on the state-of-the-art numerical model and hybrid statistical model module for appropriate target lead time.

Three domains constructing WRF triple-nesting system

	Domain 1	Domain 2	Domain 3
Horizontal Grid	15 km (112X104)	5 km (115X124)	1 km (121X121)
Convection	Kain-Fritsch	Kain-Fritsch	None
Microphysics	WSM6	WSM6	WSM6
Longwave	RRTM	RRTM	RRTM
Shortwave	Dudhia	Dudhia	Dudhia

Objectives

The Research strategy and the main methodologies applied to each procedure

- Technique for real time wind power Prediction from EU and USA
  - Based on numerical weather prediction model, persistence model, statistical model
- Design of process for real time wind power prediction for Korean wind power industry
  - Design of process appropriate for domestic wind farm environment and infra
- Study on the optimization of real time wind power prediction for wind farm operation
  - Numerical weather prediction model WRF
  - Statistical model : ARIMA
  - Statistical model : Neural Network
- Performance evaluation and possibility of its application through case study
  - Prediction accuracy evaluation using observed wind farm data in Korea
  - Comparison with the international guidelines

Methods

Producing high-quality meteorological information

Global Forecasting System data → Fine-scale topography and land use data → Real-time monitoring data from wind farm

input → Physical Model (WRF) → Statistical Adjustment to reduce the systematic error of numerical model → Statistical Model

Output → Mid - term 6-48 hours forecasting

Output → Short - term 0-6 hours forecasting

Wind speed / Wind direction

Power Prediction

New Power Curve based on historical data

Adjustment to reduce the physical error
- Loss according to position
- Variation of wind direction

Wind power prediction information

Optimization

numerical weather model optimization
- optimization of physical parameterizations
  - The planetary boundary layer (PBL) and land surface (LS) processes significantly affect the wind simulation in the low atmosphere because they can determine the stability
- time-lagged ensemble method
  - all ensemble members are pooled within a 24-hour cycle, having the closest initialization time ahead by 6 hours to take the arithmetic mean of values from the ensemble forecast members

Experimental design for the sensitivity test of PBL and LS schemes

Name	PBL schemes		Land Surface schemes	
	YSU	MYJ	Thermal diffusion	Noah
EXP1	O		O	
EXP2	O			O
EXP3		O	O	
EXP4		O		O

Summary of basic statistics derived from observation and the four experiments

		OBS	EXP1	EXP2	EXP3	EXP4
Wind Speed (m/s) Average	Jan	5.2	5.9	6.0	6.1	6.1
	Jul	4.2	4.4	4.5	4.7	4.9
Wind Speed (m/s) Standard Deviation	Jan	4.0	3.8	3.7	3.7	3.8
	Jul	2.6	3.0	2.9	3.9	2.9
Wind Direction (o) Average	Jan	338	340	340	341	344
	Jul	163	175	174	174	176

Statistical model

Short-term prediction by statistical model

ARIMA
- Wind speed history data at 10 minute intervals in wind farm
- Selecting variables for 6 hours ahead prediction
- Derivation of parameters for ARIMA for lead time (Dependent variable : wind speed)
- Development of ARIMA model using parameters
- Wind speed prediction by ARIMA model

Dependent variable
- Error of wind speed by ARIMA

Hybrid model (Neural Network combined with ARIMA)
- Wind speed history data at 1 hour intervals in wind farm
- Derivation of weighting factors for neural network for lead time (Dependent variable : Error of wind speed by ARIMA)
- Development of neural network model using factors
- Adjust of wind speed by ARIMA (Final wind speed = wind speed by ARIMA + error by neural network)
- Wind speed prediction by hybrid model

Dependent and independent variables of neural network model combined with ARIMA

Wind Farm	Definition of variables	Symbol
Dependent variables	Error of predicted wind speed by ARIMA	DIFF
Independent variables	Predicted wind speed by ARIMA	WS_ARIMA
	Wind speed 10 minutes ago	WS_10
	Wind direction 10 minutes ago	WD_10
	The latest pressure	P

Neural network model combined with ARIMA for wind speed prediction

Bias, WS_ARIMA, WS_10, WD_10, P → Bias, Layer1, Layer2, Layer3 → Diff

Results

Economic Value

The economic value of wind power forcasting in the Korean electricity market

Korean electricity market
- Based on CBP(Cost-Based Pool)
- Day-ahead market
- Constrained-on(CON) and Constrained-off(COFF) generation

How many percent can we reduce costs(only COFF) by using wind power prediction system?

Decrease of COFF by using wind power prediction system

5.14 %