Using WRF- ARW for Wind Energy Applications in New Zealand and Australia

Mike Green
June 2009
Wind Farm Development

Combining different modeling techniques
Wind Farm Development

An example: Identification of ‘best’ sites in the Wellington region

Accounting for the wind resource, terrain and slope limitations, residential areas, and other constraints.
The Aims of WRF Modeling for Wind Resource Assessment

- Creation of wind maps

- Generation of ‘virtual’ wind climates

- To assist in generation of synthesized long term data sets by combining observations and WRF output using Measure Correlate Predict (MCP) techniques.
New Zealand and Australia Weather
Typical Frontal Passage over New Zealand
Dealing with Complex Terrain - using GIS

From WRF (1 km)

Based on a 100 m DEM
Dealing with Complex Terrain

Grid configuration – smaller 3 km grid

nested grid configuration

1 km resolution mean speed wind map

small 3 km grid

over-prediction

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June 2009
Dealing with Complex Terrain

Grid configuration – large 3 km grid

nested grid configuration

1 km resolution mean speed wind map

accurate prediction
Dealing with Complex Terrain

Boundary conditions – grid nest design

1 km resolution (4 nested grids) (smoothing on boundary)

1 km resolution (3 nested grids and nest-down from the 3 km grid) (no smoothing on boundaries)

Site of interest

5000 ft

stronger winds and higher amplitude wave structure
Two New Zealand Case Studies

- WRF-ARW (version 3.0x)
- 27, 9, 3 and 1 km nested grid configuration, 37 vertical levels
- Microphysics: WSM 3-class (3)
- LW, SW radiation: RRTM, Dudhia (1)
- Surface Layer: Monin-Obukhov (1)
- Land surface: 5-layer thermal (1)
- Boundary Layer: Mellor-Yamada-Janic (2)
- Cumulus: Kain-Fritsch (1)

Site 1: East Coast, North Island (1060 m - complex)
Site 2: West Coast, North Island (500 m - complex)
Case Study 1: East Coast, North Island

### Statistical Analysis

<table>
<thead>
<tr>
<th></th>
<th>Hourly Mean Speed</th>
<th>Hourly u-component</th>
<th>Hourly v-component</th>
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### Wind Rose Comparison

**Observed** vs **Modelled**
Case Study 2: West Coast, North Island

**Statistical Analysis**

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<tr>
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**Wind Rose Comparison**

- **Observed**
- **Modelled**

WRF Workshop
June 2009
Two Australian Case Studies

- WRF-ARW (version 3.0x)
- 27, 9, 3 km nested grid configuration, 37 vertical levels
- Microphysics: WRF Single-Moment 6-class (6)
- LW, SW radiation: RRTM, Dudhia (1)
- Surface Layer: Eta Similarity (2)
- Land surface: Noah temperature/moisture (2)
- Boundary Layer: Yonsei University scheme (1)
- Cumulus: Kain-Fritsch (1)

Site 3: South Australia (380 m - medium complexity)
Site 4: New South Wales (820 m - complex)
Case Study 4: South Australia

**Statistical Analysis**

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**Wind Rose Comparison**

- Observed
- Modelled
## Case Study 3: Inland New South Wales

### Statistical Analysis

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### Wind Rose Comparison

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![Wind Rose Comparison Graphs](image-url)
Conclusions

• Using GIS to generate terrain datasets allows for increased control of representation of complex terrain features for wind energy applications.

• Long term WRF simulations in complex terrain requires careful grid nesting design.

• Using nest-down in complex terrain can result in very different flow structure than with ‘standard’ nested grid configuration.

• Australian wind farm wind climates are influenced more by physical processes so are more sensitive to WRF physics scheme options compared to New Zealand sites.