Methodology for Verification of Mesoscale Model Predictions and Analyses with Atmospheric Boundary Layer Profilers

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OUTLINE

• Introduction
• Area of Study
• Modeling System
• Profiler Measurement System
• Analysis Procedure
• Results
• Summary and Conclusions
• Future Studies
INTRODUCTION

• Atmospheric circulations in complex terrain
• Help improve mesoscale modeling and forecasting of boundary layer structure
• Applications in air quality studies
MODELING SYSTEM

Penn State/NCAR Mesoscale Model Ver 5 (MM5)  
Four-Dimensional Data Assimilation (FDDA)

• Three Domains (30-, 10-, and 3.3 km grid spacing)

• Full physics with land surface model component

• Continuous Real-Time (RT)-FDDA with updated final analyses

• Data sources include automated mesonet surface stations & upper air measurements, satellite cloud motion vectors, 404-MHz profiler (924-MHz not included)
# PROFILER MEASUREMENT SYSTEM

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>924 MHz</td>
</tr>
<tr>
<td>Wavelength</td>
<td>0.331 m</td>
</tr>
<tr>
<td>Beam width</td>
<td>10°</td>
</tr>
<tr>
<td>Configuration</td>
<td>3 beam</td>
</tr>
<tr>
<td>Beam directions</td>
<td>1 vertical &amp; 2 orthogonal</td>
</tr>
<tr>
<td>Beam elevations</td>
<td>1 @ 90° &amp; 2 @ 66.4°</td>
</tr>
<tr>
<td>Range resolution</td>
<td>55 m</td>
</tr>
<tr>
<td>Height of 1st gate</td>
<td>124 m</td>
</tr>
<tr>
<td>Number of gates</td>
<td>54</td>
</tr>
</tbody>
</table>
MM5/RT-FDDA
Grid Box

Profiler Beam
Configuration
MM5/RT-FDDA Grid Box

Profiler Beam Configuration

Model & Profiler
ANALYSIS PROCEDURE
(model)

• Domain 3 RT-FDDA output files (1-h)
  – U wind component*
  – V wind component*
  – W wind component

• Spatial Interpolation from Domain 3
  – Horizontal bi-linear to profiler locations
  – Vertical interpolated to 40 profiler measurement levels between 120 & 2000 m

*coordinates may be rotated to align with airport runway or axis of mountain valley
ANALYSIS PROCEDURE
(profiler)

• QC criteria for profiler measurements
  – Accepted when SN level > -20 dB
  – Deleted when magnitude W > 2 m s\(^{-1}\)
  – Deleted when consensus < 10 returns

• Averaged two 25-min periods in each hour
ANALYSIS PROCEDURE
(40 subsets from model & profiler)

• Computed Bias, Root-Mean-Square Differences (RMSD), & Corr. Coeff. for RT-FDDA output and profiler measurements

• Averaged Bias & RMSD into 3-h intervals & 5 vertical levels AGL

  120 – 400 m *(diurnal)*  1200 – 1600 m *(transition)*
  400 – 800 m *(diurnal)*  1600 – 2000 m *(ambient flow)*
  800 – 1200 m *(ridge top)*  120 – 2000 m *(all layers)*
Summer 2000

Vertical Velocity (cm/s)
(Computed from Profiler)

Vertical Velocity (cm/s)
(from RT-FDDA Final Analysis)
COMPARISONS WITH RESPECT TO HEIGHT
(linear correlation of vertical motions)

<table>
<thead>
<tr>
<th>Level</th>
<th>Height (AGL)</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120 - 400 m</td>
<td>.57</td>
</tr>
<tr>
<td>2</td>
<td>400 - 800 m</td>
<td>.85</td>
</tr>
<tr>
<td>3</td>
<td>800 - 1200 m</td>
<td>.84</td>
</tr>
<tr>
<td>4</td>
<td>1200 - 1600 m</td>
<td>.79</td>
</tr>
<tr>
<td>5</td>
<td>1600 - 2000 m</td>
<td>.67</td>
</tr>
</tbody>
</table>
## SEASONAL COMPARISONS
(linear correlation of vertical motions)

<table>
<thead>
<tr>
<th>Season</th>
<th>All Hours</th>
<th>Without Transition Periods*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 2000</td>
<td>.49</td>
<td>.53</td>
</tr>
<tr>
<td>Summer 2003</td>
<td>.70</td>
<td>.79</td>
</tr>
<tr>
<td>Fall 2003</td>
<td>.56</td>
<td>.70</td>
</tr>
<tr>
<td>Winter 2003-4</td>
<td>.68</td>
<td>.84</td>
</tr>
</tbody>
</table>

* Omitted 3-h times at sunset & sunrise
SUMMARY AND CONCLUSIONS

• Atmospheric boundary-layer profiler provided an independent data source to carry out verification of the MM5/RT-FDDA final analyses
• The verification methodology used bias and RMSD statistics for subsets in eight different time periods and five different layers
• Results from subsets help identify times and levels for evaluating model performance
FUTURE STUDIES

• Develop strategy for locating boundary layer profilers in RT-FDDA model domain
• Investigate specific cases
• Include 3D wind fields from Doppler weather radar measurements
• Apply other statistical methods