Tracking forecast performance of WRF-ARW: 2014 Update

Jamie Wolff and Michelle Harrold
National Center for Atmospheric Research/Research Applications Laboratory and Developmental Testbed Center

15th Annual WRF Users’ Workshop
24 June 2014
WRF Version Testing and Evaluation (T&E)

- **End-to-end system:** WPS, WRF, UPP, and MET
- **Test Period:**
  - **Summer** 1 July 2011 – 30 September 2011
  - **Winter** 1 January 2012 – 31 March 2012
- **Simulations:** 48-h cold start forecasts initialized every 36 h (116 total cases) (focus on 00 UTC cases)
- **Domain:** 15-km North American grid
WRF Version T&E, Cont.

- **Physics Suite:**
  
<table>
<thead>
<tr>
<th>Microphysics</th>
<th>WRF Single-Moment 5 scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation SW and LW</td>
<td>Dudhia/RRTM schemes</td>
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<tr>
<td>Surface Layer</td>
<td>Revised MM5 (former option 11)</td>
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<tr>
<td>Land Surface Model</td>
<td>Noah</td>
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<tr>
<td>Planetary Boundary Layer</td>
<td>Yonsei University scheme</td>
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<tr>
<td>Convection</td>
<td>Kain-Fritsch scheme</td>
</tr>
</tbody>
</table>

- **Evaluation:**
  - **Surface and Upper-air BCRMSE, Bias**
    - Temperature, Dew Point Temperature, Wind Speed
  - **Pair-wise differences** \((v3.4-v3.5, v3.5-v3.6, v3.4-v3.6)\)
  - **Statistical (SS)/Practical Significance (PS)**

Verification Regions

Developmental Testbed Center
Version T&E Results

WRFv3.4
WRFv3.4.1
WRFv3.5
WRFv3.5.1
WRFv3.6
CONUS Sfc Temp Bias - Time Series
00 UTC Initializations

Summer

Winter

Larger cold bias

WRFv3.4  WRFv3.4.1  WRFv3.5
WRFv3.5.1  WRFv3.6
**CONUS Sfc Temp Bias - Pair-wise Diffs**

**00 UTC Initializations**

### Lead Time

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<th>f42</th>
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<td>v3.4 *</td>
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<tr>
<td><strong>Winter</strong></td>
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### Practical Significance:

- v3.4 Better
- v3.5 Better
- v3.6 Better
CONUS Sfc Temp Bias - PS % Change
00 & 12 UTC Initializations; Summer

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<td>50%</td>
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Sfc Temp Bias – By Observation Station
00 UTC Initializations; Lead Time=30h (Valid 06 UTC)
Sfc Temp Bias – By Observation Station
00 UTC Initializations; Lead Time=42h (Valid 18 UTC)
Sfc Temp Bias – By Observation Station
00 UTC Initializations; Lead Time 03-48h, every 3h

Summer
Fcst Hr: 03
Valid: 03 UTC

Temperature Bias by Station ID

Config=AFWAOC_WRFv3.4 Season=SUMMER Init=00UTC Fcst Hr=03h
Config=AFWAOC_WRFv3.6 Season=SUMMER Init=00UTC Fcst Hr=03h
Sfc Temp Bias – By Region
00 UTC Initializations; Summer; v3.6
CONUS Sfc Dew Point Bias - Time Series
00 UTC Initializations

Summer

Larger dry bias

time
f03
f06
f09
f12
f15
f18
f21
f24
f27
f30
f33
f36
f39
f42
f45
f48

v3.4
v3.6
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WRFv3.4  WRFv3.4.1  WRFv3.5  WRFv3.5.1  WRFv3.6

Winter

Larger wet bias

WRFv3.4
WRFv3.4.1
WRFv3.5
WRFv3.5.1
WRFv3.6
CONUS Sfc Dew Pt Bias - PS % Change
00 & 12 UTC Initializations; Summer

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<tr>
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<td>v3.4/v3.5</td>
<td>3%</td>
<td>59%</td>
<td>25%</td>
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<tr>
<td>v3.5/v3.6</td>
<td>31%</td>
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<td>38%</td>
<td>59%</td>
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Sfc Dew Pt Bias – By Observation Station
00 UTC Initializations; Lead Time 03-48h, every 3h

Summer
Fcst Hr: 03
Valid: 03 UTC

Dew Point Temperature Bias by Station ID

Conf=AFWAOC_WRFv3.4 Season=SUMMER Init=00UTC Fcst Hr=03h

Dew Point Temperature Bias by Station ID

Conf=AFWAOC_WRFv3.6 Season=SUMMER Init=00UTC Fcst Hr=03h
Sfc Dew Pt Bias – By Region
00 UTC Initializations; Summer; v3.6
CONUS Sfc Wind Speed Bias - Time Series
00 UTC Initializations

**Summer**

- WRFv3.4
- WRFv3.4.1
- WRFv3.5
- WRFv3.5.1
- WRFv3.6

**Winter**

- WRFv3.4
- WRFv3.4.1
- WRFv3.5
- WRFv3.5.1
- WRFv3.6

Larger high bias
CONUS Sfc Wind Speed Bias - PS % Change
00 & 12 UTC Initializations; Summer

<table>
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<td>v3.4/v3.5</td>
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<tr>
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<td>41%</td>
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Sfc Wind Speed Bias – By Observation Station
00 UTC Initializations; Lead Time 03-48h, every 3h

Summer
Fcast Hr: 03
Valid: 03 UTC

v3.4

Wind Bias by Station ID

v3.6

Wind Bias by Station ID
Sfc Wind Speed Bias – By Region
00 UTC Initializations; Summer; v3.6
Summary
(Focus on Summer Season)

- Surface Temperature
  - Strongest cold bias occurs around 00 UTC regardless of version
  - v3.6: Larger cold bias during overnight hours; Improvement of cold bias during daytime hours

- Surface Dew Point Temperature
  - Strong wet bias during the daytime hours; Dry bias near sunrise
  - v3.6: Larger wet bias during daytime; Improved bias overnight

- Surface Wind Speed
  - Large high bias during the overnight hours
  - v3.6: Some degradation during daytime hours; Maintained improvement overnight

While there was an improvement in daytime (15-21 UTC) temperature bias, dew point temperature and wind speed biases at these times were negatively impacted with v3.6
Acknowledgments: The Developmental Testbed Center is funded by the National Oceanic and Atmospheric Administration (NOAA), the Air Force Weather Agency (AFWA), the National Center for Atmospheric Research (NCAR) and the National Science Foundation (NSF). NCAR is sponsored by NSF.
Additional Slides for Reference
(Winter Season)
CONUS Sfc Temp Bias - PS % Change
00 & 12 UTC Initializations; Winter

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<tr>
<td>v3.4/v3.6</td>
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<td>25%</td>
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Sfc Temp Bias – By Region
00 UTC Initializations; \textbf{Winter}; v3.6
Sfc Temp Bias – By Observation Station
00 UTC Initializations; Lead Time 03-48h, every 3h

Winter

v3.4

Temperature Bias by Station ID

v3.6

Temperature Bias by Station ID

Config=AFWAOC_WRFv3.4 Season=WINTER Init=00UTC Fct=03h
Config=AFWAOC_WRFv3.6 Season=WINTER Init=00UTC Fct=03h
CONUS Sfc Dew Pt Bias - Pair-wise Diffs
00 UTC Initializations

### Practical Significance:
- v3.4 Better
- v3.5 Better
- v3.6 Better

<table>
<thead>
<tr>
<th>Lead Time</th>
<th>f03</th>
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**Valid:**
- 12 UTC Overnight
- 00 UTC Daytime
- 12 UTC Overnight
- 00 UTC Daytime

**Day 2:**
- v3.4 * Better
- v3.5 * Better
- v3.6 * Better
CONUS Sfc Dew Pt Bias - PS % Change
00 & 12 UTC Initializations; Winter

<table>
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Sfc Dew Pt Bias – By Observation Station
00 UTC Initializations; Lead Time 03-48h, every 3h

Winter

v3.4

Dew Point Temperature Bias by Station ID

v3.6

Dew Point Temperature Bias by Station ID

Config=AFWAOC_WRFv3.4 Season=WINTER Init=00UTC Fcst Hr=03h

Config=AFWAOC_WRFv3.6 Season=WINTER Init=00UTC Fcst Hr=03h
Sfc Dew Pt Bias – By Region
00 UTC Initializations; Winter; v3.6
CONUS Sfc Wind Speed Bias - Pair-wise Diffs
00 UTC Initializations

Valid: 12 UTC

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Practical Significance: **v3.4 Better v3.5 Better v3.6 Better**
CONUS Sfc Wind Speed Bias - PS % Change
00 & 12 UTC Initializations; Winter

<table>
<thead>
<tr>
<th>No Diff</th>
<th>New</th>
<th>Old</th>
</tr>
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<tr>
<td>v3.4/v3.5</td>
<td>9%</td>
<td>63%</td>
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<td>0%</td>
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<tr>
<td>v3.4/v3.6</td>
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<td>63%</td>
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</table>
Sfc Wind Speed Bias – By Observation Station 00 UTC Initializations; Lead Time 03-48h, every 3h

Winter

v3.4

Wind Bias by Station ID

v3.6

Wind Bias by Station ID

Config=AFWAOC_WRFv3.4 Season=WINTER Init=00UTC Fcst Hr=03h

Config=AFWAOC_WRFv3.6 Season=WINTER Init=00UTC Fcst Hr=03h
Sfc Wind Speed Bias – By Region
00 UTC Initializations; Winter; v3.6