Inter-comparison of AFWA Operational Configurations using WRFv3.3.1 and WRFv3.4

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AFWA Configuration Testing

**DTC 2012 AFWA testing and evaluation**

- Impact assessment of WRF-ARW version upgrade (WRFv3.3.1/WRFv3.4)
- Performance assessment of two land surface input data sets (LIS2.7.1/LIS3.3)

*in a functionally similar operational environment*

- Data assimilation (WRFDA 3DVAR) and 6-hr warm start
- AFWA operational input datasets
- AFWA operational namelist options
AFWA Configuration Testing

Flowchart of the 6-hr “warm start” spin-up

Seasonal BE were generated from 2-week-long cold-start runs
Experimental Design

- **End-to-end system:** WPS, WRFDA, WRF, UPP, and MET

- **Test Period:** 1 July 2011 – 29 June 2012
  48-h warm start forecasts
  initialized every 36 h (244 cases)

- **Domain:** single 15-km CONUS grid
  56 vertical levels

- **Numerical experiments:**
  - WRFDAv3.3.1 + WRFv3.3.1 w/ LoBCs from LIS w/ Noahv2.7.1
  - WRFDAv3.4 + WRFv3.4 w/ LoBCs from LIS w/ Noahv2.7.1
  - WRFDAv3.4 + WRFv3.4 w/ LoBCs from LIS w/ Noahv3.3
Evaluation Matrix

- **Surface and Upper Air** [(BC)RMSE, bias]
  Temperature, Dew Point Temperature, Wind speed

- **Precipitation** (Gilbert skill score, frequency bias)
  3-h and 24-h accumulations (vs. Stage II analysis)

- **GO Index**
  weighted RMSE across variables, domain and lead time

- **Statistical Assessment**
  - confidence intervals (CI) at the 99% level
  - statistical significance (SS) and practical significance (PS)
Surface Verification: Bias v3.4 - v3.3.1

**00 UTC initialization**

- **Surface temperature**
  - v3.4: colder – larger cold bias

- **Surface dew point temp**
  - v3.4: colder during cold-bias hours, warmer during warm-bias hours – larger bias

- **Surface wind speed**
  - v3.4: smaller high bias; no differences are PS
A bug was found last week in the PrepBufr datasets used for verification, which may have exaggerated the cold temperature bias, especially for summer.
Surface Temperature: Bias

WRF v3.3.1

00 UTC 12 h forecast

00 UTC 48 h forecast

valid at 12 UTC

valid at 00 UTC
Surface Temperature: Bias

WRF v3.4

00 UTC 12 h forecast

Median Temperature Bias

cold bias

valid at 12 UTC

00 UTC 48 h forecast

Median Temperature Bias

cold bias

valid at 00 UTC
Surface Temperature: Bias

|v3.4| – |v3.3.1|

00 UTC 12 h forecast

Median Temperature Bias - Difference

00 UTC 48 h forecast

Median Temperature Bias - Difference

v3.4 better  v3.3.1 better
valid at 12 UTC

v3.4 better  v3.3.1 better
valid at 00 UTC
Surface Dew Point: Bias

**WRF v3.3.1**

00 UTC 12 h forecast

00 UTC 48 h forecast

**Median Dew Point Temperature Bias**

**valid at 12 UTC**

**valid at 00 UTC**

cold / dry bias

warm / wet bias
Surface Dew Point: Bias

WRF v3.4

00 UTC 12 h forecast

Median Dew Point Temperature Bias

cold / dry bias
valid at 12 UTC

00 UTC 48 h forecast

Median Dew Point Temperature Bias

warm / wet bias
valid at 00 UTC
Surface Dew Point: Bias

| v3.4 | – | v3.3.1 |

00 UTC 12 h forecast

Median Dew Point Temperature Bias - Difference

v3.4 better

valid at 12 UTC

00 UTC 48 h forecast

Median Dew Point Temperature Bias - Difference

v3.4 better

valid at 00 UTC
### Surface Temperature: Bias v3.4 vs v3.3.1

pair-wise differences for **bias** by initialization time, lead time, and season

<table>
<thead>
<tr>
<th>Surface Temperature</th>
<th>00 UTC Initializations</th>
<th>12 UTC Initializations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f03</td>
<td>f06</td>
</tr>
<tr>
<td><strong>00 UTC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td>v3.3.1</td>
<td>v3.3.1</td>
</tr>
<tr>
<td><strong>Summer</strong></td>
<td>v3.3.1</td>
<td>v3.3.1</td>
</tr>
<tr>
<td><strong>Fall</strong></td>
<td>v3.3.1</td>
<td>v3.3.1</td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td>v3.3.1</td>
<td>v3.3.1</td>
</tr>
<tr>
<td><strong>Spring</strong></td>
<td>v3.3.1</td>
<td>v3.3.1</td>
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</tbody>
</table>

**SS** (light shading) and **PS** (dark shading)
### Surface Dew Point: Bias v3.4 vs v3.3.1

pair-wise differences for *bias* by initialization time, lead time, and season

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</tr>
<tr>
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<td>v3.4</td>
</tr>
<tr>
<td>Spring</td>
<td>v3.3.1</td>
<td>v3.3.1</td>
</tr>
</tbody>
</table>

**SS (light shading) and PS (dark shading)**
Upper Air Temperature: v3.4 vs v3.3.1

pair-wise differences for **RMSE and bias** by initialization time, lead time, and season

| Upper Air Temperature | Annual | | | | Summer | | | | Fall | | | | Winter | | | | Spring | | | |
|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                       | F12    | F24    | F36    | F48    | F12    | F24    | F36    | F48    | F12    | F24    | F36    | F48    | F12    | F24    | F36    | F48    |
| 850                   | v3.5.1 | v3.3.1 |        |        | v3.3.1 |        |        |        | v3.3.1 |        |        |        | v3.3.1 |        |        |        |
| 700                   | v3.3.1 |        |        |        | v3.3.1 |        |        |        | v3.3.1 |        |        |        | v3.3.1 |        |        |        |
| 500                   |        |        |        |        | v3.3.1 | v3.3.1 |        |        | v3.3.1 |        |        |        | v3.3.1 |        |        |        |
| 400                   |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 300                   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   |
| 200                   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   |
| 150                   | v3.3.1 | v3.3.1 | v3.3.1 | v3.3.1 | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   |
| 100                   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   | v3.4   |

v3.4 temp is generally colder – smaller warm bias at upper levels except 150 mb
GO Index: v3.4 vs v3.3.1

- v3.3.1 more skillful during summer
- v3.4 more skillful during winter
- comparative for annual, spring and fall
- outlier cases: v3.3.1 better than v3.4

N<1 *baseline configuration has higher skill*

N>1 *comparison configuration has higher skill.*
Summary of Results

- Most PS pair-wise differences are noted in temperature and dew point temperature bias
  - **Surface temperature and dew point:** WRFv3.3.1 is generally favored.
  - **Upper air temperature:** Mixed results dependent on vertical levels.

- No PS pair-wise differences are noted in **wind speed**. The SS differences favor WRFv3.4.

- No SS differences are noted in **precipitation skills**.

- **GO Index:** WRFv3.3.1 is more skillful during summer, and WRFv3.4 is more skillful during winter
http://www.dtcenter.org/config/

THANK YOU!