Implementation Decision Briefing

HiresWindow v6.1.5

Presented by:

Matthew Pyle
Outline

• Brief HiresW system overview
• Upgrade elements – what is changing and why
• Parallel testing – stats and examples
  – Echo top height and reflectivity
  – Precipitation
  – Surface sensible weather
  – PBL and surface layer
  – Synoptic/upper air
HiresW overview

- Two dynamical cores: WRF-ARW and NMMB
- ~3-4 km, no parameterized convection forecasts
- Twice daily runs to 48 h over CONUS and four non-CONUS domains.

- Complements the NAM nests, helping to provide a variety (multi-model, multi-analysis) of high-resolution model solutions in the NCEP suite, forming a pseudo-ensemble.
HiresW overview

Integration domains and run times (unchanged)

HI/Guam/PR:
3 km NMMB
3.8 km WRF-ARW

06Z,18Z

00Z,12Z

+ Guam
00Z,12Z
Upgrade elements

• Many infrastructure changes, the largest being the direct production of GRIB2 output. Also adds job restartability.

• Model code updates

• Increase in vertical resolution (40 to 50 levels)

• New output products:
  • **High-Resolution Ensemble Forecast (HREF)** – ensemble guidance produced from time-lagged HiresW and NAM nest output
  • Additional fields for aviation and severe weather
## Upgrade elements

<table>
<thead>
<tr>
<th></th>
<th>Current ops (v6.0.12)</th>
<th>Parallel system (v6.1.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model code version</td>
<td>WRFV3.5 (ARW)</td>
<td>WRFV3.6.1 (ARW) + updates</td>
</tr>
<tr>
<td></td>
<td>Aug 2013 trunk (NMMB) + updates</td>
<td>Jan 2015 trunk (NMMB) + updates</td>
</tr>
<tr>
<td>Vertical levels</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Microphysics (ARW)</td>
<td>WSM6</td>
<td>Modified WSM6* (to slow graupel production, benefiting echo top height forecasts)</td>
</tr>
</tbody>
</table>

* Extends certain Grasso et al. (2014) suggestions on improving WSM6 convective cloud anvil – Brad Ferrier provided key guidance
Enhanced vertical resolution, particularly in PBL

40 level
ops
HiresW

9 levels
lowest
~120 hPa

50 level
para
HiresW

16 levels
lowest
~120 hPa
Upgrade elements

Expected benefits to end users from upgrade:

• Improved WRF-ARW echo top height bias (only model improvement targeted in scope of upgrade); also improved WRF-ARW composite reflectivity

• Improved precipitation bias performance

• Better resolution of PBL and surface layer features

• New forecasting tools:
  • Probabilistic HREF guidance
  • Ceiling height (AWC), -10 C reflectivity (lightning proxy)
The High-Resolution Ensemble Forecast (HREF) generates ensemble products from existing deterministic guidance:

- Utilizes multiple cycles of the HiresWindow (WRF-ARW and NMMB) and the NAM nest.
- CONUS-only in this initial implementation, with products to 36 h, four cycles per day.
- Mean, spread, and probability products with an emphasis on aviation and severe weather.
HREF membership overview

-24  -12  0  +12  +24  +36

HiresW - ARW

HiresW - NMMB

NAM CONUS NEST

11 members first 24 h  9 mem 24-36 h
HREF example
probability of exceedance, $\text{REFC} > 30 \text{ dBZ}$

HREF: Prob of Composite Reflectivity $> 30 \text{ dBZ}$ 27H FCST
from 06z Mar 19 2015. Validation Time: 09z 03/20/2015

courtesy Binbin Zhou
Pre-Implementation Testing

• Testing periods:
  • Warm season retro (June 13 - Jul 8, 2014)
  • Cool season retro (Jan 26 – Feb 26, 2015)
  • Real-time testing (early April 2015 to date)

• See improvement in targeted fields (especially echo top height and composite reflectivity in WRF-ARW), but most parallel results are similar in skill to production.
WRF-ARW echo top height

Equitable threat score

Bias

Grid-to-grid verification against radar mosaic

Improvements both to ETS and bias; low bias reduced in 25-45K foot range important for aviation.
Echo top height
1 Jul 2014, 00Z

The para WRF-ARW has broader coverage in 25-40K foot range (pale blue colors)
WRF-ARW composite reflectivity

Grid-to-grid verification against radar mosaic

Equitable Threat Score

Bias

Large bias reduction from:

- **shift from model-generated to post-generated reflectivity**
- WSM6 changes

bias=1
Microphysics-generated reflectivity exaggerates bright-banding effects, which impacts composite reflectivity.

Shift back to post-generated reflectivity produces more reasonable composite reflectivity.

All plots are of composite reflectivity.
CONUS ARW precipitation – all test cases

June 13 – July 8, 2014
Jan 25 – Feb 26, 2015
Apr 4, 2015 -

24/36/48 h precip verification over CONUS

Bias corr
Equitable
Threat Score

Bias=1
CONUS NMMB precipitation – all test cases

June 13 – July 8, 2014
Jan 25 – Feb 26, 2015
Apr 4, 2015 -

24/36/48 h precip verification over CONUS

Ops HiresW
Para HiresW

bias=1
HREF mean precipitation versus component models

24/36 h precip verification over CONUS

June 3, 2015 onward only

- HREF mean
- HiresW (ARW)
- HiresW (NMMB)
- NAM CONUS Nest

Bias corr
Equitable Threat Score

Bias

bias=1
CONUS 2 m temp, 12Z cycle

- ops RMS
- para RMS
- ops bias
- para bias

para slightly cooler
CONUS 10 m winds, 12Z cycle

ops RMS
para RMS
ops bias
para bias

Slight improvement, particularly of overnight winds

Subtle degradation of overnight winds
AK 2 m temp, 06Z cycle

ops RMS  para RMS  ops bias  para bias

Cold bias slightly worse

NMMB  WRF-ARW
AK 10 m winds, 06Z cycle

ops RMS
para RMS
ops bias
para bias

10-M wind RMS and bias (06Z cycle) from 201406141500 to 201508261200

NMMB

WRF-ARW
Thinner near-surface layers improve representation of sharp thermal inversion (but still dramatically underdone)

Alaskan NMMB run
Valid 12Z 28 Jan 2015
Slightly improved PBL height forecasts (valid 00Z)

AK NMMB

AK WRF-ARW

~9 m reduction avg RMS error

~18 m reduction avg RMS error
RMS errors at 48 h forecast time for CONUS - ARW

All 00Z cycle test runs

OPS ARW

PARA ARW
Summary

• The parallel HiresW system improves upon the biggest complaints from the 2014 upgrade: echo top height and composite reflectivity in the CONUS WRF-ARW run.

• Also improved are precipitation bias and PBL structure.

• Hints of an enhanced NMMB cool season cold bias will be monitored with an eye on physics developments addressing a similar concern in the NAM.

• By most other metrics, though, forecast skill is little changed.

• HREF helps pave the path to an ensemble-based future, and adds value today as a new forecasting tool.
Backup Slides
# CPU Usage (model jobs)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Ops model tasks (nodes)</th>
<th>Para model tasks (nodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NMMB / ARW phase1 nodes</td>
<td>NMMB / ARW phase2 nodes</td>
</tr>
<tr>
<td>CONUS</td>
<td>525(33 nodes) / 592(37)</td>
<td>696(29 nodes) / 816(34)</td>
</tr>
<tr>
<td>Alaska</td>
<td>496(31) / 540(34)</td>
<td>672(28) / 720(30)</td>
</tr>
<tr>
<td>HI</td>
<td>45(3) / 48(3)</td>
<td>72(3) / 67(3)</td>
</tr>
<tr>
<td>PR</td>
<td>80(5) / 80(5)</td>
<td>136(6) / 105(5)</td>
</tr>
<tr>
<td>Guam</td>
<td>42(3) / 63(4)</td>
<td>72(3) / 72(3)</td>
</tr>
</tbody>
</table>
Horizontal interpolation of reflectivity (and echo top height) changed from \textit{bilinear}…
...to nearest neighbor to retain slightly more fine-scale detail
Individual HREF members
hourly max 1000 m AGL reflectivity valid 15Z 13 July
Probability of hourly max 1000 m REFD > 40 dBZ

Radar ~15Z 13 July

15 h HREF probability of exceedance product
Individual HREF members
24 h precipitation total valid 20150611/12Z
24 h precipitation total valid 20150611/12Z

HREF mean

CCPA verification
Individual HREF members
24 h precipitation total valid 20150617/12Z (TS Bill)
24 h precipitation total valid 20150617/12Z

HREF mean

CCPA verification
Typhoon 07W (Dolphin) approaching Guam
36 h forecast valid 12Z 14 May 2015

Echo top height (ft)

- Mostly 30-35K in eyewall region
- More extensive 35-40K heights in para, some 40-45K (red)
Typhoon 07W (Dolphin) approaching Guam
36 h forecast valid 12Z 14 May 2015

1000 m AGL reflectivity

Not identical, but overall signatures much more similar than for echo top height
NMNB echo top height

Grid-to-grid verification against radar mosaic

Equitable threat score

Bias

Little change in the 25-45K foot range important for aviation.
NMMB composite reflectivity

Equitable Threat Score

Bias

Grid-to-grid verification against radar mosaic

Ops HiresW

Para HiresW

bias=1
CONUS ARW precipitation – by region

Para HiresW
Ops HiresW

West

bias=1

East
CONUS NMMB precipitation – by region

West

East

bias=1
CONUS ARW precipitation – by season

Warm (May-August)

Cool (Jan/Feb,Apr)

Para HiresW
Ops HiresW

bias=1
CONUS NMMB precipitation – by season

Warm (May-August)

Cool (Jan/Feb, Apr 2015)
CONUS visibility, 12Z cycle

- ops RMS
- para RMS
- ops bias
- para bias

Visibility error (12Z cycle) from 201406141500 to 201508291200

NMMB

WRF-ARW
Slightly improved convective PBL height forecasts (valid 00Z)

CONUS NMMB

CONUS WRF-ARW

~10 m reduction in RMS error

~11 m reduction in RMS error
Thinner near-surface layers improves representation of thermal inversion (but still dramatically underdone)

Representation of shallow arctic air

WRF-ARW valid 12Z 28 Jan 2015
ops WRF-ARW

para WRF-ARW

Model and observed 1 km AGL radar, 00Z 1 Jul 2015
Model and observed 1 km AGL radar, 03Z 1 Jul 2015

ops
WRF-ARW

para
WRF-ARW
RMS errors at 48 h forecast time for CONUS – NMMB

All 00Z cycle test runs

OPS NMMB

PARA NMMB
RMS errors at 42 h forecast time for AK – NMMB

All 06Z cycle test runs

OPS NMMB

PARA NMMB

RH*
RMS errors at 42 h forecast time for AK - ARW

All 06Z cycle test runs

OPS ARW

PARA ARW

RH*