HiResWindow Upgrade Implementation Decision Brief
17 March 2011

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Where the Nation’s climate and weather services begin
Topics

- Summary slide with links to data & displays
- Code upgrades & microphysics change
- Domain changes Guam & Puerto Rico
- Product generation updates
- Statistical at al. results
- Summary & plans for 2012
March 2011 Upgrade of HiResWindow

- Upgrade NMM & ARW to WRF v3.2 with *improved passive advection* in both cores
- Add Guam runs
- Add product generation: High Resolution Ensemble Forecast (HREF), BUFR, and SPC hourly max, fire wx and 80m agl fields.

- Now on [NOMADS](http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/) & [ftp server](http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/) (but not SBN … yet)
- Daily displays of these runs can be seen at:
  - [http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/](http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/) and
  - [http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/](http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/)
- Matt Pyle’s full CONUS NMM runs [ /00 or /12 ] for SPC can be seen at [http://www.emc.ncep.noaa.gov/mmb/mpyle/cent4km/conus/](http://www.emc.ncep.noaa.gov/mmb/mpyle/cent4km/conus/)
HiResW Upgrade Elements - 1

• Update/upgrade codes from WRF Version 2.2 (circa April 2007) to WRF Version 3.2 (circa April 2010)
  – With both cores (NMM and ARW) will now use better conserving schemes for advecting passive variables
    • TKE [turbulent kinetic energy]
    • Water vapor
    • Cloud condensate
    • Hydrometeors
Conservation Properties of NMM Passive Advection Schemes

Mean Column Mass-Equivalence Loading

WRF-NMM Old-Dyn 3-D Adv (vertically force conserved)
WRF-NMM Old-Dyn 2-D Adv only
NMM-B NEW-PD 3-D ADV only

New scheme

Old schemes

Boundary reached

Courtesy Youhua Tang
## Details of NCEP HiResWindow Runs

No Changes with This Upgrade

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<tr>
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<th>WRF-NMM</th>
<th>WRF-ARW</th>
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</table>
HiResW Upgrade Elements - 2

- Microphysics code change - background
  - Received an inquiry from HPC about a persistent (and bogus) precipitation band they observed in the HiResW during their winter experiment,
  - The band was evident in both the production and parallel WRF-NMM runs (though muted in the parallel).
This band was persistent and stationary over many hours (didn’t behave like a lake-effect band).
CTL run, 21 h total precip
Liquid cloud water + rain (color fill, red contour)

Cloud ice + snow (blue contour)

Precip band along boundary

CTL run, cloud XS at 8 h
Microphysics Code Change

• Quick insight from Brad Ferrier led to a test modification of the cloud microphysics allowing ice nucleation to begin at warmer temperatures:
  \[ T_{\text{ice\_init}} \text{ changed from } -15 \text{ C to } -5 \text{ C} \]

• This change worked perfectly, eliminating the specific pathology, and having very small forecast impact over several other test cases.
CTL run, 21 h total precip

EXP run, 21 h total precip
HiResW Upgrade Elements - 3

**Domain Changes**

- Add Guam runs at 00z & 12z as 6th domain covered by the HiResW
  - By agreement with PR
    - Can drop RSM run for Hawaii
    - Guam runs not subject to preemption by hurricane runs
  - Superior first guess for Guam RTMA (will replace downscaled GFS).
- Expand Puerto Rico nest domain to cover Hispaniola for Haiti earthquake recovery support.

Current domains
4.0 km WRF-NMM
5.15 km WRF-ARW

Proposed domains
4.0 km WRF-NMM
5.15 km WRF-ARW
GUAM-RTMA
New System Implemented 28 Sept 2010

Description
- Mercator grid
- 2.5 km resolution
- 193 x 193 grid points
- Use Unified RTMA code
- Use GFS forecasts downscaled to 2.5km as First Guess
- Use Terrain following background-error covariances
- Analyze 2m-T, 2m-q, 10m-u, 10m-v, and psfc
- Compute analysis uncertainty

ISSUE: Downscaled GFS has no diurnal cycle
HiResWindow Guam forecast will be superior

Domain of the Guam NDFD-grid and terrain height in meters
10 m winds, NMM HiresW, 20110310/12Z cycle
f24- f34 (12Z to 22Z - overnight)

Weaker winds shaded
Sample 1 hr Precip Forecasts at 18 hr

NMM Guam from 8 Feb 00z

ARW Guam

NMM Puerto Rico from 2 Mar 06z

ARW Puerto Rico
HiResW Upgrade Elements - 4

• Add / enhance product generation:
  – Add generation of BUFR output (hourly point forecast soundings) for both cores and SPC, fire wx and 80m agl fields.
  – Produce High Resolution Ensemble Forecast (HREF) products (Du 2004).
  – Add simulated radar echo top and hourly maxima of select severe weather forecasting fields for SPC.
  – Add PBL height and other fields for Fire Weather support.
  – Add 80m agl (above ground level) temp, wind, moisture and pressure for wind energy sector.
BUFR output

- Hourly BUFR output from the HiResW was dropped when switching from non-WRF NMM to the WRF-based dual NMM & ARW system back in 2005.
- With this upgrade package, it FINALLY will be restored.
HREF Ensemble Guidance (aka Hybrid)

- 21 SREF members are interpolated to the HiResW output domains (excluding Guam).

- The SREF perturbations are combined with the two HiResW (NMM and ARW) deterministic runs to produce a 44-member “ensemble”.

- Provides higher-resolution probabilistic and ensemble-mean guidance at minimal computational expense.

- Motivated by the Hanson Dam issue in Washington.
24 h observed total ending 0503/12Z

24 h 12km NAM total ending 0503/12Z

24 h HiresW (4 km EAST NMM) ending 0503/12Z

24 h HiresW (5 km EAST ARW) ending 0503/12Z
Probability of Exceeding 4” of Precip in a 24 Hour Period

- period ending 0502/12Z
- period ending 0502/18Z
- period ending 0503/00Z
- period ending 0503/06Z
New HiResEnsFctst (HREF)  
Output Fields from HiResW – 1  

Ensemble Mean & Spread (standard deviation) fields:

- UGRD 10 m above ground
- VGRD 10 m above ground
- UGRD 850 mb
- VGRD 850 mb
- UGRD 250 mb
- VGRD 250 mb
- PRMSL mean sea level
- HGT 500 mb
- RH 850 mb
- RH 2 m above ground
- TMP 850 mb
- TMP 500 mb
- TMP 250 mb
- TMP 2 m above ground
- CAPE surface
- CIN surface
- WIND SPD 10 m above ground
- WIND SPD 850 mb
- WIND SPD 250 mb
- APCP (3 h, 6 h, 12 h, and 24 h accumulations as available for a given forecast range)
New HiResEnsFcst (HREF) Output Fields from HiResW – 2

Ensemble Probability fields:

- TMP 2 m agl  prob < 273
- TMP 2 m agl  prob > 298.8
- TMP 850 mb  prob < 273
- CAPE surface prob > 500
- CAPE surface prob > 1000
- CAPE surface prob > 2000
- CAPE surface prob > 3000
- CAPE surface prob > 4000
- CIN surface prob < -50
- CIN surface prob < -100
- CIN surface prob < -200
- CIN surface prob < -300
- CIN surface prob < -400
- WIND SPD 10 m agl  prob > 12.89
- WIND SPD 10 m agl  prob > 17.5
- WIND SPD 10 m agl  prob > 25.78
- Accumulated Precip probabilities at these thresholds (.01" to 6“ equivalents) for 3 h, 6 h, 12 h, and 24 h (as available at a given forecast range):
  - APCP  prob > 0.25 mm
  - APCP  prob > 1.27 mm
  - APCP  prob > 2.54 mm
  - APCP  prob > 6.35 mm
  - APCP  prob > 12.7 mm
  - APCP  prob > 25.4 mm
  - APCP  prob > 38.1 mm
  - APCP  prob > 50.8 mm
  - APCP  prob > 101.6 mm
  - APCP  prob > 152.4 mm
HREF Mean, ARW & NMM 2m Temperature vs Surface Obs

Diurnal 2–m Temp 16 Feb 2011 to 16 Mar 2011

- HREF has Lowest RMS & Good BIAS
New Output Fields from HiResW

- Hourly maxima (saved in the model) provide insight into time period between output times for rapidly evolving fields, and first four of these are relatively new SPC favorites:
  - 1000 m reflectivity
  - updraft velocity below 400mb
  - downdraft velocity below 400mb
  - updraft helicity over 2-5 km AGL layer
  - 10 m wind speed
  - 2 m temperature
  - 2 m RH

- Hourly minima of:
  - 2 m temperature
  - 2 m RH

- 80 m AGL U + V wind
- 80 m AGL temperature
- 80 m AGL spec humidity
- 80 m AGL pressure
- Radar echo top height (18 dBZ level)
- Richardson Number based PBL height
- Transport Wind
- Ventilation Rate
Instantaneous 1000 m AGL simulated reflectivity
Instantaneous 1000 m AGL simulated reflectivity, f23

Instantaneous 1000 m AGL simulated reflectivity, f24
Hourly maximum 1000 m AGL simulated reflectivity, f24
Sample Fire Wx Fields

PBL H forecast from HIRES NMM run vt 2011031606F12

Transport wind speed forecast from HIRESNMM run vt 20110316

Min 2m RH forecast from HIRES NMM run vt 2011031606F12

Ventilation rate forecast from HIRES NMM run vt 2011031606F12
HiResW Upgrade Testing

• Thus far have run the updated code for three separate periods, totaling about 115 days:
  – June 2009 (warm season)
  – a ~40 day period in Dec 2009 - Jan 2010 (cold season)
  – a transition period from mid-April to early June 2010 (spring)
HiResW testing precipitation results

– The most dramatic improvement in the test results is a reduction of the high precipitation bias in the current HiResW (esp. for heavier thresholds).

– NMM shows a net ETS improvement (except at 0.01”/24 h) mostly due to improvements in the warm season. Bias much improved.

– ARW changes have a fairly neutral impact on ETS all seasons, but bias made nearly perfect.
ALL tests
WESTNMM
30 h fore
ALL tests
WESTARW
30 h fore

nwprod
nwtest
ALL tests
EASTNMM
36 h fore

nwprod
nwttest
A number of 7"+ bullseyes
Bullseyes muted, with only a few regions showing 3”+ and greater coverage of light precipitation.
Stage II multi-sensor (not shown) is a bit heavier with a 3”+ region along the AZ/NM border, but model runs are heavier than either analysis.
HiResW Testing Upper-Air Results

• NMM shows big improvement in warm season CONUS, little impact in cold season. Overall (all cases) neutral to positive, except for AK.

• ARW shows big improvement in cold season, smaller improvement in warm season. Overall a positive impact.

• The following plots cover all test periods.
HiResW Testing Surface Results

• In an overall sense, a decidedly mixed bag. More improvements to bias than to RMS.

• 2 m T signals clearest: In winter/spring, para ARW warmer than prod ARW, while para NMM is cooler than prod NMM at night. Most pronounced AK/West.

• 2 m Td is least improved (most degraded) surface field.

• 10 m V generally shows the smallest impact from the upgrade.
Subjective Summary Surface Statistics

combined June 2009, 20091213-20100123 (winter), 20100415-20100602 (spring)

<table>
<thead>
<tr>
<th></th>
<th>2m T</th>
<th>2m Td</th>
<th>10m V</th>
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<td></td>
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<td>bias</td>
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<td>WESTN</td>
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- para better (11)
- para worse (10)
- neutral (15)
Summary

• Updated model codes significantly improve upon the well-known HiResW high bias in precipitation.

• Other verifications also show some improvement:
  – upper air significantly improved for ARW, slightly better for NMM.
  – surface biases generally better, but seasonal challenges remain.

• Provides new runs, new fields and new forms of guidance requested by and/or promised to the field:
  – high-resolution guidance for Guam [and Haiti]
  – hourly BUFR output
  – high-resolution probabilistic guidance for flood forecasting
  – new fields beneficial for severe weather and air quality forecasts
  – new fields beneficial for fire weather and wind energy forecasts
Plans For 2012 HiResWindow

• Use Guam forecast as first guess for RTMA
• Upgrade ARW to Version 3.3
• Replace NMM with NMMB
• Some or all of the following:
  – Increase resolution to ~2 km
  – Expand to full CONUS – new schedule:
    • CONUS, Hawaii & Guam at 00z and 12z
    • Alaska, Puerto Rico-Hispaniola at 06z an 18z
  – Improve Initialization of HiResWindow runs
    • GSI using all available data & mini-NDAS
    • GSI adapted specially for Level II 88D winds
    • Digital filter with Level II 88D reflectivity (ala RUC/RR)
  – Start generating HRRRE-TL [Time Lagged]
Bonus / Background Materials
Height bias error vs. raobs over the SPC domain for NWPRD and NWTEST 42-h forecast from 200906010000 to 201006021200

Temperature bias error vs. raobs over the SPC domain for NWPRD and NWTEST 42-h forecast from 200906010000 to 201006021200

Relative humidity bias error vs. raobs over the SPC domain for NWPRD and NWTEST 42-h forecast from 200906010000 to 201006021200
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**Winter period**

**June 2009**

**Spring period**
WEST diurnal 2m T
20091213 - 20100123

RED = ops run
BLUE = para run

2-M Temp error (06Z cycle) from 200912130600 to 201001230600

2-M Temp error (06Z cycle) from 200912130600 to 201001230600

ARW

NMM
RED = ops run
BLUE = para run
AK diurnal 2m T
Spring 2010

RED = ops run
BLUE = para run
EAST diurnal 2m Td
Spring 2010

RED = ops run
BLUE = para run
WEST diurnal 10 m V
20091213 - 20100123

RED = ops run
BLUE = para run

10-m wind RMS and bias (06Z cycle) from 200912130000 to 201001230000
ARW
NMM
Development CONUS 4 km runs
04/03-09/27: 36 h forecast T rms

Root-mean-square temperature error (K)

WRF-NMM V2
(“SPC run”)
Development CONUS 4 km runs 04/03-09/15: 36 h forecast V rms
High Resolution Rapid Refresh Ensemble (HRRRE) Time-Lagged [TL] System

• Example: Ensemble member combination for 06Z cycle run

  4 NAM-nest cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively
  4 HRW-ARW cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively
  4 HRW-NMM cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively
  4 Pyle-SPC cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively
  6 HRRR cycles, weighted 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, respectively

Forecast range could be extended beyond 12 hr without HRRR

Like VSREF soon-to-be-known-as the NARRE-TL for Time Lagged NARRE
Charter Test Plan Case reruns

• Alaskan operational failure cases rerun:
  – 20090115/18Z
  – 20091112/18Z
  – no issues

• 20090508 bow echo case - details changed, but retain bowing convective system in parallel.

• 20091007 precipitation case - little apparent improvement in skill (but smaller false alarm over OK for NMM).
20090508/00Z case

Prod ARW

Para ARW
20090508/00Z case
24 h precipitation valid 20091008/12Z

CPC verif

Ops NMM

Para NMM
24 h precipitation valid 20091008/12Z

CPC verif

Ops ARW

Para ARW