Spring 2005 Upgrade Package for North American Mesoscale (NAM) Decision Brief

Mesoscale Modeling Branch
Geoff DiMego and Eric Rogers
28 April 2005

where the nation’s climate and weather services begin
Spring Upgrade Package

• 3DVar Analysis
  Manuel Pondeca, Dave Parrish, Jordan Alpert, Krishna Kumar, Dennis Keyser, Stacie Bender, Rogers

• Precip Assimilation - Ying Lin

• Prediction Model (Eta Model)
  Brad Ferrier, Ken Mitchell, Mike Ek, Vince Wong, Yu-Tai Hou, Mary Hart, Rogers

• Output Products
  Brad Ferrier, Geoff Manikin, Mike Ek, Ying Lin
Spring Upgrade Package: 3DVar

- Improved use of on-time overland surface temperature observations using 2DVar with anisotropic covariance tied to terrain

- Use of Level II.5 (on-site derived superobs) of 88D radial velocity
Improved Surface Temperature Analysis Within the Eta 3DVar System

**Background:**

- Eta forecasts initialized with the GFS 3DVar analysis were found to be superior to Eta forecasts initialized with the Eta 3DVar analysis
- Assimilation of surface temperature in the Eta 3DVar shown to account for nearly all of the forecast degradation
- It appears that the Eta 3DVar is handicapped by being cast in the step-mountain framework, because Eta is not terrain following, it is difficult to cleanly limit the vertical influence of surface data
- Surface temperatures overland were turned off as a temporary fix since September 2003
- Anisotropic covariances with vertical stability dependence cast in a terrain following coordinate (at least near the surface) is been the long-term goal
Spring Upgrade Solution to Allow Surface Temperatures To Be Turned Back On

- Limit the vertical influence of the surface temperature obs by analyzing these data independently with a 2DVar module
- Advantage: relatively easy to implement the 2DVar module without compromising 3DVar code etc

Implementation:

1) use original 3dvar code to analyze all the observations except for surface temperature
2) at the end of the 3dvar, invoke the 2dvar module to analyze surface temperature
3) resulting 2dvar increments replace those from the 3dvar analysis at the appropriate vertical levels
Specifics of 2DVar Module

- Univariate analysis
- Background error structures prescribed to stretch along contour lines of topography to some extent
- First guess field is the original first guess for the 3DVar taken locally at the first vertical level above the Eta steps
- 2DVar analysis increments replace those from the original 3DVar at the vertical level used to construct the 2DVar first guess field

Main result

- With the modified assimilation system, surface temperature data have a non-negative impact on the model forecast.
12hr/36hr/60hr Fits to Obs from a 5-day 2DVar Test

RMS height error vs. raobs over the COMUS for control Etav-32 (solid) and parallel Etal-32 12, 36, and 60-h forecasts from 200405100000 to 200405200000

RMS relative humidity error vs. raobs over the COMUS for control Etav-32 (solid) and parallel Etal-32 12, 36, and 60-h forecasts from 200405100000 to 200405200000

RMS temperature error vs. raobs over the COMUS for control Etav-32 (solid) and parallel Etal-32 12, 36, and 60-h forecasts from 200405100000 to 200405200000

RMS vector wind error vs. raobs over the COMUS for control Etav-32 (solid) and parallel Etal-32 12, 36, and 60-h forecasts from 200405100000 to 200405200000
Error Correlations for Valley Ob Location
Plotted Over Utah Topography

**Isotropic Correlation:**
obs' influence extends up mountain slope

**Anisotropic Correlation:**
obs' influence restricted to areas of similar elevation

L\text{iso} = 25\text{km} \quad L\text{terr} = \infty \quad 0.25\text{km grid}

L\text{iso} = 25\text{km} \quad L\text{terr} = 400\text{m/km} \quad 0.25\text{km grid}
Level II.5 Wind Test June 2004 48hr

RMS height error vs. radiosonde for CDMUS for all Sta-32 (solid) and all Sta-32 (with assimilation of NEXRAD Level 2.5 radial wind) 48-h forecast from 20340607000 to 20340628000
- 48-h Central Sta-32
- 48-h Parallel Sta-32

RMS relative humidity error vs. radiosonde for CDMUS for all Sta-32 (solid) and all Sta-32 (with assimilation of NEXRAD Level 2.5 radial wind) 48-h forecast from 20340607000 to 20340628000
- 48-h Central Sta-32
- 48-h Parallel Sta-32

RMS temperature error vs. radiosonde for CDMUS for all Sta-32 (solid) and all Sta-32 (with assimilation of NEXRAD Level 2.5 radial wind) 48-h forecast from 20340607000 to 20340628000
- 48-h Central Sta-32
- 48-h Parallel Sta-32

RMS vector wind error vs. radiosonde for CDMUS for all Sta-32 (solid) and all Sta-32 (with assimilation of NEXRAD Level 2.5 radial wind) 48-h forecast from 20340607000 to 20340628000
- 48-h Central Sta-32
- 48-h Parallel Sta-32

Z

T

RH

wind
Sample Distribution (not yet complete) of Level II.5 Radial Wind Superobs Sites with Build 6.1

879055 wind obs at 110 radar sites as of 1 April

1112881 wind obs at 131 radar sites as of 26 April

Build 6.1 fixes problem with superobs lat-long
Spring Upgrade Package: Precipitation Assimilation

Simplified / streamlined precipitation assimilation procedures in NAM Data Assimilation System (NDAS). Reasons:

- Original method evolved in step over the years with increasingly more sophisticated microphysics; had become too contrived/cumbersome

- Streamlining makes method more forward-compatible with future modeling systems (WRF or ESMF)

- Streamlining makes precipitation assimilation more robust - some previous EDAS failures linked to attempts to create precipitation not forecast by Eta
Precipitation Assimilation Changes

1. Cease attempts to create precipitation when model precipitation is less than observed

2. Continue to reduce latent heat and moisture fields when model precipitation is greater than observed

3. Use observed precipitation directly in driving the land surface physics
Impact of Simplifying Precipitation Assimilation

• Neutral to slightly positive impact on QPF precipitation scores and near surface & upper air forecast fit to observations

• More-moist soil – old method tends to have a dry bias during assimilation because model precipitation did not exactly replicate observed QPF
24 hour NDAS precip falling onto soil ending 12Z 27 Mar 2005
Long-term Impact on Soil Moisture Fields:
snapshot of top 1-m soil moisture availability

NAM

NAMX – wetter
Spring Upgrade Package: Prediction Model (Eta)

- Noah LSM upgrades in the NAM prediction model (Eta)
- To address low-level temperature and humidity biases & drift during different seasons
  - Summer: warm/dry bias during day, typically over areas with larger greenness fractions
  - Summer: drying trend in PW and low level moisture with forecast range
  - Winter: cold bias during night, typically under calm/clear conditions especially over snowpack, and during day over shallow/melting snowpack
LSM changes (more) relevant to warm season

- Use **high-resolution** (1-km vs 1 deg) vegetation and soils data bases with more classes - Unifies with WRF-Noah LSM and responds to EPA / CMAQ request

- **Retuned** canopy conductance and other vegetation parameters - ops had been tuned to higher values to maintain reasonable evaporation rates given low soil moisture bias which is removed by Ying Lin’s new precipitation assimilation procedures

- **Lowered roughness length** for heat to reduce skin temperature, and hence lower diagnosed 2-m air temp
  - But no significant change to sensible heat flux
    - due to compensating effects on exchange coefficient and near-surface temperature gradient
  - No significant change to latent heat flux
    - primarily because LE largely affected by canopy conductance, which is much larger than aerodynamic conductance (especially in regions with large greenness fraction)
USGS 24-class high-resolution (1-km) vegetation data set replaces old SiB 13-class 1-degree data set
New STATSGO 16-class high-resolution (1-km) soils database replaces old Zobler 9-class 1-degree data set
New 1-deg TBOT (soil temperature) data base replaces old (global) 2.5-degree data set.

Old 2.5-deg mapped to 12-km grid.

New 1-deg TBOT (soil temperature) data base replaces old (global) 2.5-degree data set.

Old 2.5-deg mapped to 12-km grid.

Necessary to adjust TBOT for a given terrain elevation (standard lapse rate = 6.5C/km). For model “cold start”, soil temperature states similarly adjusted for different model grid/terrain (ties in with soil moisture re-scaling).
Soil Moisture Re-scaling

-Necessary to re-scale soil moisture since Eta with the old soils needed to restart Eta with the new soils.

-To preserve surface evaporation (with respect to plant stress) in going from the old (Zobler) to new (STATSGO) soils, convert soil moisture contents in order to maintain relative saturation.

\[ \Theta_{\text{sat}} = 0.404 \]
\[ \Theta = 0.263 \]
\[ \Theta = 0.310 \]
\[ \Theta_{\text{sat}} = 0.476 \]

Soil type A
e.g. sand

Soil type B
e.g. clay

Relative saturation = 0.65

BUT...
Soil Moisture Spin-up

BUT... the subsequent evolution of soil moisture will be different for one soil type versus another, so model spin-up is important.

Continuous/cycled Etax tests during July-August 2004 showed that higher latent heat fluxes (vs control Eta) over eastern CONUS die down after about 1 month of cycling, as land states settle in with their own new vegetation and soil parameters.

In August, Etax still had higher latent heat flux than control Eta, but difference significantly less than July.
July 2004 observed daily latent heat flux

- Comparisons with offline Noah LSM suggested lower canopy conductance

- Leaf Area Index adjusted down, Rs-min increased
Reduced Warm Bias
Eastern CONUS, August 2004

Mean 2-M Temp vs. sfc obs (12Z cycle) over the Eastern US for ctl Eta-32 and parallel Eta-32 (with 32-km ETAY Noah LSM v2.8 SUPERPARALLEL) forecast from 200408010000 to 200408312359

2-m temp
Higher Relative Humidity - Eliminated Drift

Eastern CONUS, August 2004

Mean 2-M RH vs. sfc obs (12Z cycle) over the Eastern US for ctl Eta-32 and parallel Eta-32 (with 32-km EtaY Noah LSM v2.8 SUPERPARALLEL) forecast from 200408010000 to 2004080312359

Too moist during day but no growth in bias with forecast range
Reduced Warm Bias
Western CONUS, August 2004

Mean 2-M Temp vs. sfc obs (12Z cycle) over the Western US for ctl Eta-32 and parallel Eta-32 (with 32-km ETAY Noah LSM v2.8 SUPERPARALLEL) forecast from 200408010000 to 200408312359

- Observed mean
- Control Eta-32
- Parallel Eta-32

2-m temp

16C

28C
Relative Humidity – Reduced Dry Bias

Western CONUS, August 2004

Mean 2-M RH vs. sfc obs (12Z cycle) over the Western US for ctl Etz-32 and parallel Etz-32 (with 32-km ETAY Noah LSM v2.8 SUPERPARALLEL) forecast from 200408010000 to 200408312359

- Green line and markers: Observed mean
- Blue line and markers: Control Etz-32
- Pink line and markers: Parallel Etz-32

Y-axis: Mean 2-M RH
X-axis: Forecast Hour
For patchy snow cover, changes to parameters:

- snow cover fraction (less snow depth for 100% cover)
- snow albedo (yields higher)
- surface skin temperature (higher via non-snow cover)
- snow sublimation (reduced)

Surface emissivity (for snow only):

- $L_{up} = \varepsilon_s \sigma T^4$, $\varepsilon_s = 1.0, 0.95, 0.90$.

PBL: in very stable conditions when PBL depth diagnosed as lowest Eta model level, impose lower limit on eddy diffusivity up to (and one level above) inversion height (positive impact previously shown)
Previous Eta Bundle included ONLY the effect of patchy snow cover on surface skin temp and sensible heat flux … NOW the effect of patchy snow cover applies ALSO to latent heat flux.
Offline (uncoupled N-LDAS) results show the effect of the various cold-season changes to the Noah LSM.
Slightly reduced night time cold bias

Mean 2-M Temp vs. sfc obs (12Z cycle) over the Eastern US for ctl Eta-32 and parallel Eta-32 (with 32-km ETA superparallel with snow emiss=0.95) forecast from 200402020000 to 200402292359

2-m 4C temp
Feb 2004
Eastern CONUS

\[ \varepsilon_s = 0.95 \]
Feb 2004 monthly downward longwave
-generally a low bias
-low-level clouds can have a significant effect on night time surface cooling
PHYSICS “WHEEL OF PAIN”
Spring Upgrade Package: Prediction Model (Eta)

- Modified radiation scheme to “see” thicker clouds by removing upper limit for cloud water mixing ratio when computing optical depths

- Modified cloud cover fraction formulation to allow for more partial cloudiness (had been too binary)
AFWA, CLAVRX total cloudiness (%)
(12Z 13 December 2004)

041213/1200UTC AFWA CLOUD COVER
041213/1200UTC CLAVR CLOUD COVER

Many thanks to Mary Hart – First cloud verifications
Eta, EtaX scores from AFWA, CLAVRx

00&12Z Cloud Fraction (%) analyses from 20041212 – 20050110 verified from 32-km Grid 221 over CONUS

EQTS

Heidke Skill Score
January Frontal Case
Rogers & Manikin
Shelter temperature valid 12Z 1/3/2005
Improved frontal position in ETAX initial conditions
Shelter temperature valid 18Z 1/4/2005
Improved frontal position in ETAX forecast
1. PRECIPITATION THREAT AND BIAS SCORES

<table>
<thead>
<tr>
<th>Region</th>
<th>24-84 hour forecasts</th>
<th>24-84 hour forecasts</th>
<th>24-84 hour forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONUS</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Eastern US</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Western US</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>24-h forecasts</th>
<th>36-h forecasts</th>
<th>48-h forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONUS</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Eastern U.S.</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Western U.S.</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>48-h forecasts</th>
<th>60-h forecasts</th>
<th>84-h forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONUS</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Eastern U.S.</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
<tr>
<td>Western U.S.</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
<td>Eta-12 parallel</td>
</tr>
</tbody>
</table>

2. UPPER AIR RMS STATISTICS (12, 24, 48, 60, and 84-h forecasts)

<table>
<thead>
<tr>
<th>Region</th>
<th>CONUS temperature RMS error</th>
<th>RMS error Bias</th>
<th>CONUS relative humidity RMS error</th>
<th>RMS error Bias</th>
<th>CONUS height RMS error</th>
<th>RMS error Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alaska</th>
<th>vector wind RMS error</th>
<th>Bias</th>
<th>Alaska relative humidity RMS error</th>
<th>Bias</th>
<th>Alaska height RMS error</th>
<th>Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NAM vs NAMX Quantitative Verification Statistics

Summer : 17 July – 31 August 2004
(NDAS-only spin-up run started 15 June 2004)
Spring : 21 March -24 April 2005
24-h QPF Bias (bottom), Equitable Threat (top)
NAM = Red solid
NAMX = Blue dashed
Winter : Forecast vs observations

• Height and wind RMS vs raobs : CONUS and Alaska
• Temperature and RH bias vs raobs : CONUS and Alaska
• 2-m Temperature / RH vs surface obs : East CONUS, West CONUS, Alaska
CONUS Winter: Height and Vector Wind RMS Error;
NAM = Solid black, NAMX = Dashed Red

24-h 48-h 84-h
CONUS Winter: Temperature and RH Bias Error; NAM = Solid black, NAMX = Dashed Red

Temperature bias error vs. rhums over the CONUS for ops NAM and pll NAM 24-h forecast from 200412140000 to 200503311200

Temperature bias error vs. rhums over the CONUS for ops NAM and pll NAM 48-h forecast from 200412140000 to 200503311200

Temperature bias error vs. rhums over the CONUS for ops NAM and pll NAM 84-h forecast from 200412140000 to 200503311200

RH bias error vs. rhums over the CONUS for ops NAM and pll NAM 24-h forecast from 200412140000 to 200503311200

RH bias error vs. rhums over the CONUS for ops NAM and pll NAM 48-h forecast from 200412140000 to 200503311200

RH bias error vs. rhums over the CONUS for ops NAM and pll NAM 84-h forecast from 200412140000 to 200503311200

T

R

H

24-h

48-h

84-h
Alaska Winter: Height and Vector Wind RMS Error;
NAM = Solid black, NAMX = Dashed Red
Alaska Winter: Temperature and RH Bias Error;
NAM = Solid black, NAMX = Dashed Red
Winter Mean 2-m Temperature vs Obs; Obs=Green; NAM = Cyan; NAMX = Magenta

East CONUS

West CONUS

Alaska
Winter Mean 2-m RH vs Obs; Obs=Green; NAM = Cyan; NAMX = Magenta
Spring: Forecast vs observations

- Height and wind RMS vs raobs: CONUS and Alaska
- Temperature and RH bias vs raobs: CONUS and Alaska
- 2-m Temperature / RH vs surface obs: East CONUS, West CONUS, Alaska
CONUS Spring: Height and Vector Wind RMS Error;
NAM = Solid black, NAMX = Dashed Red

---

**Height Error vs. Model Level for NAM**

- 24-h: Solid black
- 48-h: Dashed Red

**Vector Wind Error vs. Model Level for NAM**

- 24-h: Solid black
- 48-h: Dashed Red

---

24-h

48-h

84-h
CONUS Spring: Temperature and RH Bias Error;

NAM = Solid black, NAMX = Dashed Red

Temperature bias error vs. range over the CONUS for NAM and NAMX 24-h forecast from 2005033112000 to 200504021200

Temperature bias error vs. range over the CONUS for NAM and NAMX 48-h forecast from 2005033112000 to 200504021200

Temperature bias error vs. range over the CONUS for NAM and NAMX 84-h forecast from 2005033112000 to 200504021200

RH bias error vs. range over the CONUS for NAM and NAMX 24-h forecast from 2005033112000 to 200504021200

RH bias error vs. range over the CONUS for NAM and NAMX 48-h forecast from 2005033112000 to 200504021200

RH bias error vs. range over the CONUS for NAM and NAMX 84-h forecast from 2005033112000 to 200504021200

24-h 48-h 84-h
Alaska Spring: Height and Vector Wind RMS Error. NAM = Solid black, NAMX = Dashed Red.

24-h

48-h

84-h
Alaska Spring: Temperature and RH Bias Error
NAM = Solid black, NAMX = Dashed Red
Spring Mean 2-m Temperature vs Obs
Obs=Green; NAM = Cyan; NAMX = Magenta

East CONUS

West CONUS

Alaska
Spring Mean 2-m RH vs Obs; Obs=Green; NAM = Cyan; NAMX = Magenta

Mean 2-M RH vs. sfc obs (126 cycle) over the Eastern US for ops Eta-12 and pli Eta-12 (with with winter 2005 Eta change package) forecast from 200503110000 to 200504241200

Mean 2-M RH vs. sfc obs (126 cycle) over the Western US for ops Eta-12 and pli Eta-12 (with with winter 2005 Eta change package) forecast from 200503110000 to 200504241200

Mean 2-M RH vs. sfc obs (126 cycle) over Alaska for ops Eta-12 and parallel Eta12 (with with winter 2005 Eta change package) forecast from 200503110000 to 200504241200

East CONUS  West CONUS  Alaska
Summer : Forecast vs observations

• Height and wind RMS vs raobs : CONUS and Alaska
• Temperature and RH bias vs raobs : CONUS and Alaska
• 2-m Temperature / RH vs surface obs : East CONUS, West CONUS, Alaska
CONUS Summer: Height and Vector Wind RMS Error;
NAM = Solid black, NAMX = Dashed Red

- RMS height error vs. raobs over the CONUS for all NAM (solid) and all NAM 24-h forecast from 200407170000 to 200408311200
- RMS height error vs. raobs over the CONUS for all NAM (solid) and all NAM 48-h forecast from 200407170000 to 200408311200
- RMS height error vs. raobs over the CONUS for all NAM (solid) and all NAM 84-h forecast from 200407170000 to 200408311200

- RMS vector wind error vs. raobs over the CONUS for all NAM (solid) and all NAM 24-h forecast from 200407170000 to 200408311200
- RMS vector wind error vs. raobs over the CONUS for all NAM (solid) and all NAM 48-h forecast from 200407170000 to 200408311200
- RMS vector wind error vs. raobs over the CONUS for all NAM (solid) and all NAM 84-h forecast from 200407170000 to 200408311200

Z

V

24-h

48-h

84-h
CONUS Summer: Temperature and RH Bias Error

NAM = Solid black, NAMX = Dashed Red
Alaska Summer: Height and Vector Wind RMS Error; NAM = Solid black, NAMX = Dashed Red

Z

24-h

48-h

84-h
Alaska Summer: Temperature and RH Bias Error;

NAM = Solid black, NAMX = Dashed Red

Temperature bias error vs. raobs over Alaska for ops NAM and pl1 NAM 24-h forecast from 200407170000 to 200408311200

Temperature bias error vs. raobs over Alaska for ops NAM and pl1 NAM 48-h forecast from 200407170000 to 200408311200

Temperature bias error vs. raobs over Alaska for ops NAM and pl1 NAM 84-h forecast from 200407170000 to 200408311200

Relative Humidity bias error vs. raobs over Alaska for ops NAM and pl1 NAM 24-h forecast from 200407170000 to 200408311200

Relative Humidity bias error vs. raobs over Alaska for ops NAM and pl1 NAM 48-h forecast from 200407170000 to 200408311200

Relative Humidity bias error vs. raobs over Alaska for ops NAM and pl1 NAM 84-h forecast from 200407170000 to 200408311200

24-h

48-h

84-h
Summer Mean 2-m Temperature vs Obs;
Obs=Green; NAM = Cyan; NAMX = Magenta

Mean 2-M Temp vs. sfc obs (000 cycle) over the Eastern US for sfc Rta-12 and pl1 Rta-12 (with with winter 2005 Ntc change package) forecast from 200408170000 to 200408311200

Mean 2-M Temp vs. sfc obs (000 cycle) over the Western US for sfc Rta-12 and pl1 Rta-12 (with with winter 2005 Ntc change package) forecast from 200408170000 to 200408311200

Mean 2-M Temp vs. sfc obs (000 cycle) over Alaska US for sfc Rta-12 and parallel Rta-12 (with with winter 2005 Ntc change package) forecast from 200408170000 to 200408311200

East CONUS

West CONUS

Alaska
DGEX vs DGEXX Quantitative Verification Statistics

Winter : 1 January – 20 March 2005
Spring : 21 March - 24 April 2005
Two parallel cycles / day
(00z Alaska and 06Z CONUS)
CONUS Winter: Height and Vector Wind RMS Error;
DGEX = Solid black, DGEXX = Dashed Red

114-h Forecast

186-h Forecast
CONUS Winter: Temperature / RH Bias Error; DGEX = Solid black, DGEXX = Dashed Red

Temperature bias error vs. raobs over the CONUS for the DGEX and parallel DGEX
114-h forecast from 200501010000 to 200503301200

Temperature bias error vs. raobs over the CONUS for the DGEX and parallel DGEX
186-h forecast from 200501010000 to 200503301200

Temperature bias error (deg C)

RH bias error vs. raobs over the CONUS for the DGEX and parallel DGEX 114-h forecast from 200501010000 to 200503301200

RH bias error vs. raobs over the CONUS for the DGEX and parallel DGEX 186-h forecast from 200501010000 to 200503301200

RH bias error (%)
Alaska Winter: Height and Vector Wind RMS Error; 
DGEX = Solid black, DGEXX = Dashed Red

120-h Forecast

192-h Forecast
Alaska Winter: Temperature / RH Bias Error; DGEX = Solid black, DGEXX = Dashed Red

Temperature bias error vs. ranks over Alaska for the DGEX and parallel DGEX 120-h forecast from 200501010000 to 200501021200

- DGEX 120-h forecast
- DGEXX 120-h forecast

Temperature bias error (deg C)

Pressure level (mb)

-2.1 -1.8 -1.5 -1.2 -0.9 -0.6 -0.3 0.0 0.3

RH bias error vs. ranks over Alaska for the DGEX and parallel DGEX 120-h forecast from 200501010000 to 200501021200

- DGEX 120-h forecast
- DGEXX 120-h forecast

RH bias error (%)

Pressure level (mb)

-2.4 -1.6 -0.8 0.0 1.6 2.4 3.2 4.0

120-h Forecast

Temperature bias error vs. ranks over Alaska for the DGEX and parallel DGEX 192-h forecast from 200501010000 to 200501031200

- DGEX 192-h forecast
- DGEXX 192-h forecast

Temperature bias error (deg C)

Pressure level (mb)

-2.5 -1.8 -0.9 -0.6 -0.3 0.0 0.3 0.4

RH bias error vs. ranks over Alaska for the DGEX and parallel DGEX 192-h forecast from 200501010000 to 200501031200

- DGEX 192-h forecast
- DGEXX 192-h forecast

RH bias error (%)

Pressure level (mb)

-3.6 -2.7 -1.8 -0.9 -0.6 -0.3 0.0 1.8 2.7 3.6

192-h Forecast
Winter Mean 2-m Temperature vs Obs; Obs=Black; DGEX = Blue; DGEXX = Red

East CONUS

West CONUS

Alaska
CONUS Spring: Height and Vector Wind RMS Error;
DGEX = Solid black, DGEXX = Dashed Red

RMS height error vs. raobs over the CONUS for the DGEX and parallel DGEX 114-h forecast from 200503310000 to 200504241200

RMS height error vs. raobs over the CONUS for the DGEX and parallel DGEX 186-h forecast from 200503310000 to 200504241200

RMS vector wind error vs. raobs over the CONUS for the DGEX and parallel DGEX 114-h forecast from 200503310000 to 200504241200

RMS vector wind error vs. raobs over the CONUS for the DGEX and parallel DGEX 186-h forecast from 200503310000 to 200504241200

114-h Forecast

186-h Forecast
CONUS Spring: Temperature / RH Bias Error; DGEX = Solid black, DGEXX = Dashed Red

Temperature bias error vs. rhobes over the CONUS for the DGEX and parallel DGEX 114-h forecast from 200503210000 to 200504241200

Temperature bias error vs. rhobes over the CONUS for the DGEX and parallel DGEX 186-h forecast from 200503210000 to 200504241200

RH bias error vs. rhobes over the CONUS for the DGEX and parallel DGEX 114-h forecast from 200503210000 to 200504241200

RH bias error vs. rhobes over the CONUS for the DGEX and parallel DGEX 186-h forecast from 200503210000 to 200504241200

114-h Forecast

186-h Forecast
Alaska Spring: Height and Vector Wind RMS Error;
DGEX = Solid black, DGEXX = Dashed Red

RMS height error vs. ranches over Alaska for the DGEX and parallel DGEX 120-h forecast from 200503210000 to 200504241200
DGEX 120-h forecast
DGEXX 120-h forecast

RMS vector wind error vs. ranches over Alaska for the DGEX and parallel DGEX 120-h forecast from 200503210000 to 200504241200
DGEX 120-h forecast
DGEXX 120-h forecast

RMS height error vs. ranches over Alaska for the DGEX and parallel DGEX 192-h forecast from 200503210000 to 200504241200
DGEX 192-h forecast
DGEXX 192-h forecast

RMS vector wind error vs. ranches over Alaska for the DGEX and parallel DGEX 192-h forecast from 200503210000 to 200504241200
DGEX 192-h forecast
DGEXX 192-h forecast

120-h Forecast
192-h Forecast
Alaska Spring: Temperature / RH Bias Error;
DGEX = Solid black, DGEXX = Dashed Red

Temperature bias error vs. obsvs over Alaska for the DGEX and parallel DGEX 120-h forecast from 200503210000 to 2005042441200
DGEX 120-h forecast
DGEXX 120-h forecast

Temperature bias error vs. obsvs over Alaska for the DGEX and parallel DGEX 192-h forecast from 200503210000 to 2005042441200
DGEX 192-h forecast
DGEXX 192-h forecast

RH bias error vs. obsvs over Alaska for the DGEX and parallel DGEX 120-h forecast from 200503210000 to 2005042441200
DGEX 120-h forecast
DGEXX 120-h forecast

RH bias error vs. obsvs over Alaska for the DGEX and parallel DGEX 192-h forecast from 200503210000 to 2005042441200
DGEX 192-h forecast
DGEXX 192-h forecast

120-h Forecast
192-h Forecast
Spring Mean 2-m Temperature vs Obs;
Obs=Black; DGEX = Blue; DGEXX = Red

East CONUS
West CONUS
Alaska
Example of 500mb Height Differences
Impact of Upgrades on DGEX
Ops and parallel DGEX 120-h forecast valid 06Z 4/17/05

Parallel DGEX warmer along SE coast
too cold
No clouds to associate with the warmer temps, so LSM related
Ops and parallel DGEX 180-h forecast valid 18Z 4/17/05

2-M TEMP DGEX 180H FCST VALID 18Z 19 APR 2005

OPS

Parallel DGEX warmer along SE coast

too cold > 28

PLL
obs temps > 28
Spring Upgrade Package: Products

• Changes to output products coming from NAM
  – Improved surface visibility computation by including convective precipitation rate
  – Precip going into LSM
  – Added clear-sky radiation fluxes to output for use by Air Quality Forecast System
24-h Visibility and Surface Hydrometeors (NAMX)

(Stoelinga-Warner) (mm h\(^{-1}\)) (g kg\(^{-1}\))

(g kg\(^{-1}\)) (g kg\(^{-1}\)) (g kg\(^{-1}\)
Inadvertently failed to account for convective precip in NAM, but is accounted for in NAMX.
NCEP Service Center Evaluations
SPC Steve Weiss

- No Evaluation of Retrospective Runs
- Real-Time Parallel Runs – SPC compared to operational NAM during period March 21 through April 15
  - SPC focused on fundamental fields used by SPC forecasters during the preparation of severe weather outlooks, although the short-range fields in the 6-12 hour time frame can impact convective watch decisions as well. In addition to basic synoptic pattern evolution of 500 mb heights, vorticity, temperature, surface pressure and 10m winds, SPC focused on kinematic fields related to vertical shear (jet streaks/axes of maximum wind at 500 and 850 mb, bulk vertical shear in lowest 6 km, and storm-relative helicity in lowest 3 km) and thermodynamic parameters associated with instability (lowest 30 mb BL dew point, MUCAPE and MLCAPE). On most occasions, the synoptic pattern forecasts and jet structures were comparable between the operational and parallel runs, and differences between the two runs were minor from an SPC perspective.
The largest differences were associated with low level moisture, as the parallel run consistently exhibited a more rapid northward progression of moisture inland from the Gulf of Mexico during the return flow phase over the plains in the wake of retreating surface ridges across the southeastern states. As a result, the NAM parallel BL dewpoint values were often 3-8 degrees F higher than the operational values, and this effect typically extended well inland on the leading edge of the moisture return. Comparison of the NAM parallel forecasts with verifying 2m dewpoints from METAR sites usually indicated the predicted dewpoints were too high. Within the zones of increased low level moisture in the parallel runs, larger values of MUCAPE and MLCAPE were often found when compared with CAPE forecasts from the operational run. The differences were typically on the order of 500 J/kg. General precipitation areas in the two runs were often rather similar, although when differences were observed they usually showed earlier and somewhat heavier convective precip in the parallel runs. We did note that the parallel run occasionally exhibited more structure and organization in the 3-hour accumulated precipitation field compared to the operational run, although we did not focus on specific QPF issues.
• Since no access to PFC soundings from the parallel runs, SPC cannot comment on the vertical profile of low level moisture. However, there was a noticeable enough difference between the BL dewpoint values in the two runs coupled with the apparent increased moisture bias of the parallel run to raise questions about possible causes of the enhanced moisture return (advection, land-surface processes, etc.). We hope EMC will explore this aspect of NAM performance and identify processes contributing to the forecasts of increased low level moisture.

• There is a chance that in operational return flow situations the higher values of moisture/instability in the parallel version could lead to an erroneous early introduction of severe potential if forecasters are unaware of the possible bias in the NAM model forecasts. However, SPC forecasters will continue to consult the SREF and GFS guidance in their decision-making process, and pay close attention to evolving NAM model characteristics through the warm season and convey any new observations to EMC.
Recommendation: Implement as proposed

Although SPC has concerns about the recent observations of excessive return flow moisture and instability in the NAM parallel performance, this characteristic is likely not a “show stopper” in an overall NWS sense, and SPC will offer cautious support to move ahead with the implementation.
NCEP Service Center Evaluations

HPC Pete Manousos

- Real-Time Parallel Run Evaluation Comments:

HPC forecasters experience has subjectively indicated the parallel NAM QPF does seem to outperform (by a small margin) the operational version. Differences in mass fields between the two versions do not typically become manifest until about f60 and tend to be subtle. Precipitable water values in the parallel version seem to be about .1" higher than the operational version (which was in the noise level compared to the observations). Additionally, the parallel NAM has been a little more progressive by about a half degree lon (and slightly weaker by about 30dm) at 500mb than the operational version with cut off lows moving across the CONUS. This latter tendency met with mixed review internally at HPC.

Objective statistics generated for QPF indicated for light amounts (less than 1 inch), there are no real difference in threat scores. There is some improvement for thresholds of 1 inch or greater in the day 1 time frame. However, differences are minimal between the two versions for days 2 and 3 at the same thresholds. The parallel version did exhibit a slightly higher bias (closer to 1) than the operational version, but by day 3 differences in bias are negligible.
NCEP Service Center
Evaluations - HPC

- Recommendation: Implement as proposed

- Thank you very much (NCO & EMC) for getting this output in NAWIPS near real time. It allowed many more forecasters to be involved in the evaluation than in recent upgrades.
Real-time AWC evaluation of NAM/NAM-Parallel

Wind, turbulence diagnostics (Ri, Ellrod, TKE generation, etc.), RH (in most areas) and stability indices (LI, K) all slightly better for NAM-Parallel

RH areas ≥ 90% are smaller over the California coastal waters at 0.982 sigma in the NAM-Parallel.

RH areas ≥ 90% are smaller at all lower levels (< 850 hPa) over the upper Midwest for the NAM-Parallel. At 850 hPa this reverses with the NAM-Parallel having more areas ≥ 90%. At 700 hPa and above RH areas ≥ 90% are smaller for the NAM-Parallel. Could be case dependent.

In upslope areas of the Rockies and during Gulf Coast return flow situations, the NAM-Parallel shows smaller areas of RH ≥ 80%. After F36, the NAM-Parallel shows areas of RH ≥ 80% that do not exist in the operational NAM.

After F24, the NAM-Parallel stability indices were more unstable than the operational NAM.
NCEP Service Center
Evaluations - AWC

• Recommendation: Implement as proposed

• AWC acknowledges EMC and NCO personnel for developing and arranging dataflow for the real-time NAM-Parallel evaluation
Summary

• 3DVar changes
  – Sfc Temps: no negative impact, safe to turn back on
  – LII.5 88D winds: minimal impact on performance statistics

• Precip Assimilation
  – More robust, more accurate & moist soil moisture

• Prediction Model changes
  – Rad & cloud: more partial cloudiness and better absorption
  – LSM changes: soil & veg better defined, reduced 2-m temperature biases, less drying trend with more low level moisture overall

• Impacts to DGEX minor but generally positive

• Thoroughly tested: 3 seasons, real-time and retrosp.

• NCEP Service Centers recommend implementation

• Request NCEP Director concurrence to implement