Task 3.3: Code Management, testing and support for the GSI data assimilation system

3.3.1: Community Coordination and Support
Hui Shao, Hans Huang
Shared costs with other partners: Ming Hu, Don Stark (funded by NOAA)

3.3.2: Testing and evaluation of DA systems in AFWA regional applications
   a. Perform baseline GSI tests
   b. Perform baseline EnKF tests (SOW Appendix 1)

Kathryn Newman, Chunhua Zhou, Hui Shao, Hans Huang
GSI Code Management

- GSI development and support is ordinated through the GSI Review Committee.

- Development and community effort coordination - committee meetings
  - Dec 9, 2011, Camp Springs, MD
  - Sept 22, 2011, telecon
  - June 28, 2011, Boulder, CO

- Code review - email alias (gsi_review_committee@rap.ucar.edu)
  - ~1 week for review, ~1-2 days for code commit
  - 29 code change tickets (Mar, 2011-Feb, 2012)
    - 6 tickets from non-EMC developers
    - 1 ticket returned to developer for further tests

Meeting minutes and code review tickets can be found at the GRC wiki (committee members only).
The DTC GSI repository is synced with NCEP/EMC repository at least weekly.

The DTC GSI repository also contains some community feature including multiple platform compilation utility released to public annually.

Applications may use different revisions in the trunk (“snapshot”).

Use tags or branches for: Release, new development, bug fix …
### Community GSI Release

<table>
<thead>
<tr>
<th>Release Version</th>
<th>GSI Tag/Revision</th>
<th>Release Time</th>
<th>Documentation</th>
<th>Residential Tutorial</th>
<th>Helpdesk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta release v1.0</td>
<td>Com-r41 EMC-Q1FY09</td>
<td>Jun, 2009</td>
<td>No</td>
<td>No</td>
<td>Friendly users only</td>
</tr>
<tr>
<td>Official release v1.0</td>
<td>Com-r41+ EMC-Q1FY09</td>
<td>Sep, 2009</td>
<td>GSI Users’ Guide v1.0</td>
<td>Lectures in WRFDA tutorial, July, 2009; Instructional session during WRF workshop, June, 2009</td>
<td>All users</td>
</tr>
<tr>
<td>Beta release v2.0</td>
<td>Com-r101 EMC-Q1FY10</td>
<td>Feb, 2010</td>
<td>No</td>
<td>No</td>
<td>Friendly users only</td>
</tr>
<tr>
<td>Official release v2.0</td>
<td>Com-r101+ EMC-Q1FY10</td>
<td>Apr, 2010</td>
<td>GSI Users’ Guide v2.0</td>
<td>June 28-30, 2010</td>
<td>All users</td>
</tr>
<tr>
<td>Beta release v3.0</td>
<td>Com-r593 EMC-r12534</td>
<td>Feb, 2011</td>
<td>No</td>
<td>No</td>
<td>Friendly users only</td>
</tr>
<tr>
<td>Official release v3.0</td>
<td>Com-r593+ EMC-r12534+ (EMC)</td>
<td>Apr, 2011</td>
<td>GSI Users’ Guide v3.0</td>
<td>June 29-July 1, 2011</td>
<td>All users</td>
</tr>
</tbody>
</table>

- Starting from 2011, community GSI release uses the latest trunk code:
  - Code is well tested before being committed, due to the implementation of the GRC review procedure
- Critical update to GSI Users’ Guide:
  - Expanded existing contents
  - Two new chapters: *GSI Applications* and *BUFR and PrepBUFR*
Community GSI Support

- 2011 summer tutorial 28-30 June, 2011:
  - 31 participants
  - 13 Lectures (speakers from NCEP, NASA, NCAR, ESRL and DTC)
  - 4-h basic practice
  - 1-day optional advanced practice
- First GSI Workshop 28 June, 2011
  - 50 participants
- GSI-hybrid Workshop*, Nov 11, 2011, Miami, FL
- BUFR/PrepBUFR webcast Tutorial*, Dec 13
  - Extended data format support to general GSI users and HFIP community

* Supported by HFIP
GSI – WRFDA Comparison

- **GSI:**
  - Current NCEP operational DA system (global/regional)
  - Following NAM configuration, AFWA partial cycling
  - Conventional Data: GFS PrepBUFR files (NCEP QC)
  - Background errors generated using GEN_BE-GSI
    - ~NCEP BE code for NAM but more user friendly

- **WRFDA:**
  - Current AFWA operational DA system
  - AFWA configuration, AFWA partial cycling
  - Conventional Data: AFWA “little_r” data files
    - Observation numbers vary due to cut-off time difference at spin-up (-6h) and analysis time.
  - Background errors generated using GEN_BE-WRFDA
Setup

- WRFv3.3 + comGSI v3.0 or WRFDA v3.3
- T44 domain (right)
- Aug. 18, 2010 – Sept 18, 2010
- Data: conventional data including GPS RO refractivity
- 15km horizontal resolution, 57 vertical levels, 10 hPa model top
- 3 hour time window
- Verification: METv3.0.1
- Background Errors generated using gen_be tool
  - Generated from 1 mo WRF ARW v3.3 run using GFS input, 48 h WRF fcst w/no DA.
  - BE generated from 24h-12h, using NMC method
- gen_be for GSI vs. WRFDA use different methods for BE generation – leading to difficult straight comparison of parameters
Data

- GSI has much more sounding data at 00z & 12z (cut-off time)
- GSI missing SSMI/airep/geoamv data
- WRFDA missing pibal/sat winds/gpsrf*
- No METAR data for GSI (GSI QC on GFS)

<table>
<thead>
<tr>
<th>Observation type and variable</th>
<th>2010090918</th>
<th>2010091000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRFDA</td>
<td>GSI</td>
</tr>
<tr>
<td>sounding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>162</td>
<td>83</td>
</tr>
<tr>
<td>V</td>
<td>158</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>54</td>
<td>58</td>
</tr>
<tr>
<td>Q</td>
<td>42</td>
<td>29</td>
</tr>
<tr>
<td>metar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>468</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>463</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>561</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>364</td>
<td>641</td>
</tr>
<tr>
<td>geoamv</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>1833</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>1833</td>
<td></td>
</tr>
<tr>
<td>airep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>307</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>306</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>303</td>
<td></td>
</tr>
<tr>
<td>ships</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>V</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Q</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>P</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Ssmi retrieval</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPW</td>
<td>1353</td>
<td></td>
</tr>
<tr>
<td>Wind speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pibal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sat wind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gpsrf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>565</td>
<td></td>
</tr>
</tbody>
</table>
Partial Cycling Scheme

Spin-up cycle

GFS, Navy SST, Agrmet

WPS

WRFDA /GSI

WRF

T – 6hr

FCST cycle

Obs

WRFDA /GSI

WRF

Forecast

T – 0hr
Verification against ECMWF

- Pair-wise differences favor WRFDA over GSI for low level TMP and Q (not shown) RMSE and Bias.
- SS differences favor WRFDA at lowest levels for all forecast times up to 48 hrs.
  ✓ Verification of forecasts generated during spin-up cycle show similar results (not shown)
    ✓ SS differences favoring WRFDA for low level T and Q (significantly more sfc data during WRFDA spin-up cycle than GSI)
    ✓ SS differences present for all forecast times (06-54 hr)
Pair-wise differences favor GSI over WRFDA for upper level winds V and U (not shown) RMSE.

SS differences present through 36 hr forecast (no SS differences at 48 hr).

Analysis time shows WRFDA is SS favored compared to ECMWF analysis for low level winds, however GSI is SS favored for 250-70 hPa (not shown).

Verification of forecasts generated during spin-up cycle show similar results (not shown).

SS differences favoring GSI for upper level winds (U and V) present through 30 hr forecast.
WRFDA vs GSI: Conclusions

- Observation data differences as well as differences in BE generation methods between GSI and WRFDA lead to significant differences between the systems, therefore making an ‘apples to apples’ comparison impossible.

- PrepBUFR observations vs. filtered AFWA observations verification showed similar results, with slight favor toward DA system assimilating the observations used in the verification.

- ECMWF analysis verification showed WRFDA was SS favored for low level T and Q, whereas GSI was SS favored for upper level winds.

- Spin-up verification results echoed results of ECWMF for 00Z/12Z.
  - Eliminating cut-off time issue does not greatly impact results.

- ‘Mixed bag’ of results show neither DA system stands out, but rather depends on application and available data.
Regional EnKF Baseline Tests

Period of performance: July 1, 2011 - June 30, 2012

Ongoing efforts:

- DART-EnKF benchmark conventional run
- Case Study: Hurricane Dean
  - 2007081512-2007082500 (10 da)
- Domain: T8 (see below)
- Horizontal resolution: 45km

Conventional observations assimilated
Centered at 2007081512

<table>
<thead>
<tr>
<th>DART-EnKF</th>
<th>U</th>
<th>V</th>
<th>T</th>
<th>DP</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIOSONDE</td>
<td>662</td>
<td>662</td>
<td>2482</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAT</td>
<td>4744</td>
<td>4744</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>METAR</td>
<td>271</td>
<td>271</td>
<td>712</td>
<td>2950</td>
<td></td>
</tr>
<tr>
<td>SHIP</td>
<td>78</td>
<td>78</td>
<td>83</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>SYNOP</td>
<td>102</td>
<td>102</td>
<td>182</td>
<td>182</td>
<td>77</td>
</tr>
<tr>
<td>AIREP</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PILOT</td>
<td>1385</td>
<td>1385</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Preliminary Results - 24hr FCST vs. ERA

- Benchmark DART-EnKF tests show system is working and verification shows reasonable forecast scores below 70 hPa (T & U above 70 hPa needs more investigation).
- DART-EnKF assimilating conventional data only does not beat the WRFGFS benchmark… Future work to assimilate more observations
EnKF Baseline: Ongoing Efforts

- Collaborating with NCAR/MMM to set up a test plan to assimilate radiance data with DART-EnKF
  - Added capability to assimilate additional sensors beyond AMSU-A
    - AMSU-B
    - MHS
- Sensitivity testing of DART-EnKF runs with and without additional radiance data against:
  - Variational data assimilation runs with same radiance data assimilated
  - ECMWF reanalysis (ERA-interim)
FY2012 Proposed Work (appendix)

- Code management
  - Continue to facilitate R2O transitions
- Boulder GSI Repository maintenance
- Community support
  - Code release
  - Tutorial
- DA benchmark testing
- Comparison of NOAA EnKF and DART EnKF