Providing Operational GSI and EnKF to the Research Community

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Developmental Testbed Center (DTC)

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Software Systems

- Gridpoint Statistical Interpolation (GSI):
  - Annual community release since 2009
    - 2D-Var
      - Real-Time Mesoscale Analysis (RTMA)
    - 3D-Var
    - 3D hybrid
      - Global Forecasting System (GFS), North American Mesoscale system (NAM, NMM-B), Hurricane WRF (HWRF, WRF-NMM), Rapid Refresh (RAP)/High-Resolution RR (HRRR) (ARW), etc.
    - 4D EnVar (only available from the code repository)
- Ensemble Kalman Filter (EnKF):
  - First beta release in January 2015
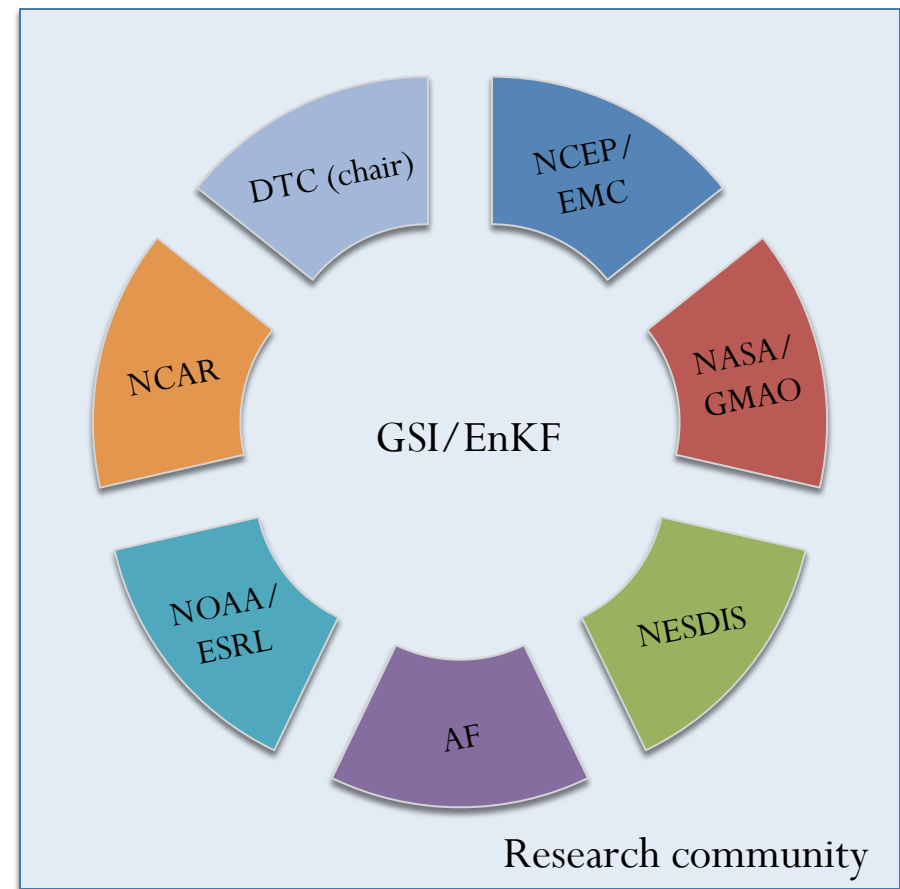 - Formal release scheduled for July 2015 (with GSI)

Close collaboration between DTC & developers is critical to the success of this work!

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EnKF System

- Originally developed by NOAA/ESRL in collaboration with the research community
- Contains two separate algorithms
  - Serial Ensemble Square Root (EnSRF) (Whitaker and Hamill, 2005)
    - Parallelization scheme based on NCAR Data Assimilation Research Testbed (DART) toolkit
  - Local Ensemble Transform Kalman Filter (LETKF) (Hunt, 2007)
    - Contributed by Yoichiro Ota, JMA
- Operational as part of the NOAA GFS data assimilation system (GSI-EnKF hybrid)
- Can be used for HWRF, NAM and ARW
  - Being adapted for other models as well
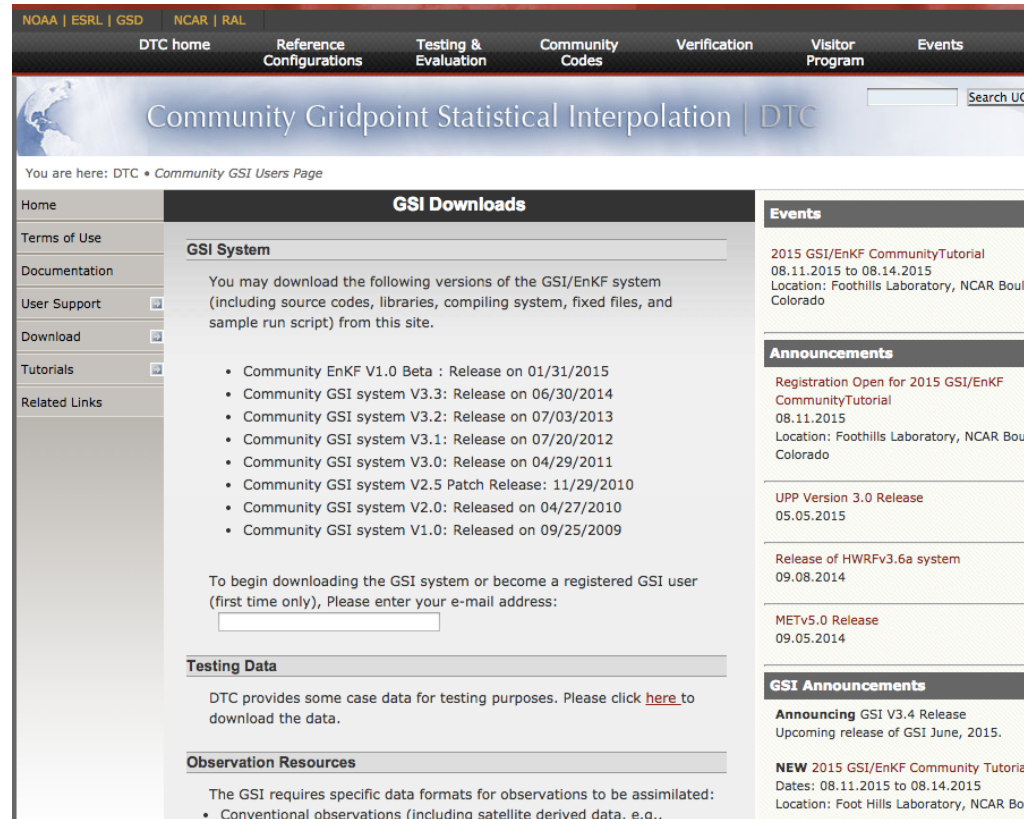
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Code Management and Repository

- Data Assimilation (DA) Review Committee (DRC) created in 2014
  - Transitioned from GSI Review Committee (since 2010), with new membership for EnKF
  - Reviews all code changes committed to the repository
- DTC community code repository
  - DTC and EMC merged GSI and EnKF repo in 2014
  - Mirrors all components residing within EMC's operational repository
  - Contains files not necessarily required by internal EMC users, e.g., libraries
  - Operational implementation and community releases come from trunk snapshots

DTC (chair) · NCEP/EMC · NASA/GMAO · NESDIS · AF · NOAA/ESRL · NCAR · GSI/EnKF · Research community

Direct access to the latest code

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Annual Released Package

- GSI source code
- EnKF source code
- Auxiliary files and reference configurations
- NCEP library source code
- Multiple-platform compilation tool for EnKF, GSI, and libraries
- Simplified run scripts
- Diagnostic and display utilities
- User's Guide
- Testing cases
- Online practice
- User support

- GSI user's webpage: http://www.dtcenter.org/com-GSI/users/index.php
- EnKF user's webpage: under construction
- Both share the same download page

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Community Users

- 8 code releases since 2009
- On-site training:
  - 5 GSI residential tutorials
    - 2013: co-hosted with EMC and JCSDA at NCWCP
  - 3 GSI instructional sessions
  - 1 BUFR/PrepBUFR tutorial
  - 1 EnKF instructional session
  ~400 participants from U. S. and international communities
- 2 GSI workshops
  - NCAR, Boulder, CO
  - NCWCP, Maryland, MD
- Registered users:
  - ~1300 (up to April, 2015)
  - Additional registered through the HWRF community release
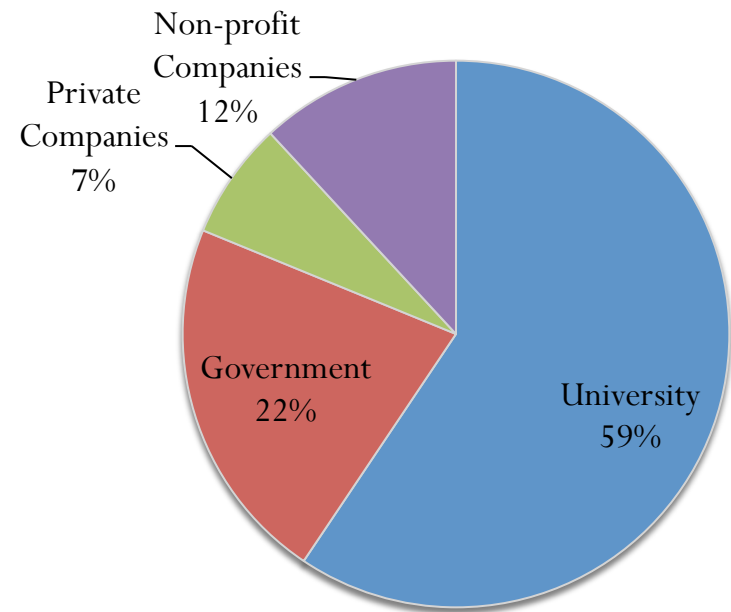
Affiliation of registered users
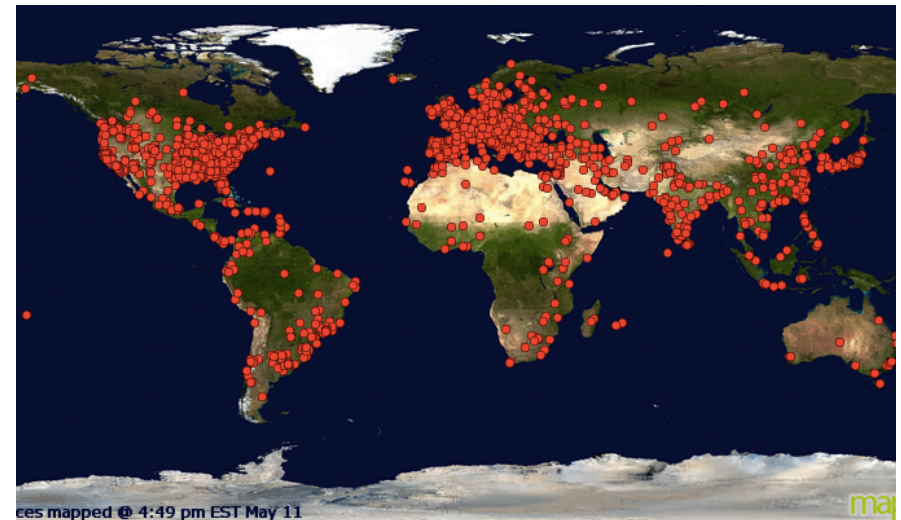
Who is accessing the GSI User's Webpage?

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Observations Types (I): GSI v3.4/EnKF v1.0*

- Radiosondes
- Pibal winds   **Conventional**
- Synthetic tropical cyclone winds
- Conventional aircraft reports
- ASDAR aircraft reports
- MDCARS aircraft reports
- Dropsondes
- Surface land observations
- Surface ship and buoy observation
- Wind profilers: US, JMA
- Tall tower winds   **Satellite retrievals**
- SSM/I wind speeds
- MODIS IR and water vapor winds
- GMS, JMA, METEOSAT, and GOES cloud drift IR and visible winds
- GOES hourly IR and cloud top winds
- QuikSCAT, ASCAT, and OSCAT wind speed and direction
- AVHRR winds
- Doppler wind Lidar data

- EUMETSAT and GOES water vapor cloud top winds
- METAR cloud observations
- SSM/I and TRMM TMI precipitation estimates
- Doppler radial velocities
- VAD (NEXRAD) winds
- Radar Reflectivity Mosaic   **Radar**
- Tail Doppler Radar (TDR) radial velocity and super-observation
- Flight level and Stepped Frequency Microwave Radiometer (SFMR) High Density Observation (HDOB) from reconnaissance aircraft
- GPS precipitable water estimates   **GPS**
- GPS Radio occultation (RO) refractivity and bending angle profiles
- SBUV ozone profiles, MLS (including NRT) ozone, and OMI total ozone
- SST   **Ozone, SST, TCvital, aerosol,…**
- Tropical storm VITAL (TCVital)
- PM2.5
- MODIS AOD

* Release scheduled for July 2015

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Observations Types (II): GSI v3.4/EnKF v1.0

- SBUV: n17, n18, n19
- HIRS: metop-a, metop-b, n17, n19
- GOES_IMG: g11, g12
- AIRS:aqua
- AMSU-A: metop-a, metop-b, n15, n18, n19, aqua
- AMSU-B: metop-b, n17
- MHS: metop-a, metop-b, n18, n19
- SSMI: f14, f15
- SSMIS: f16, f18
- AMSRE: aqua
- SNDR: g11,g12, g13
- IASI: metop-a, metop-b
- GOME: metop-a, metop-b
- OMI: aura
- SEVIRI: m08, m09, m10
- ATMS: NPP
- CRIS: NPP

Satellite Radiance

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Other Update:

- Sat wind thinning algorithm update

- Update to aircraft data usage:
  - Inflated observation error to the AIREP near surface data
  - Update to the variational aircraft temperature bias correction

- Update to soil adjustment

- Update to Cloud analysis

- Added capability to use surface data uselist

- Added NSST (Near-Surface Sea Temperature) calculation for SST analysis

- Code changes for building a 4D EnVar capability

- Added real single radiance observation test capability:

- 2D-Var surface analysis capability update:
  - Improved quality control for temperature observations via buddy check and a terrain-aware gross error adjustment
  - Use of new observations (e.g. sky cover data and METOP-B ASCAT winds)
  - New analysis variables (total cloud amount, lowest cloud base, 2m Td, min and max 2m T, significant wave height, pmsl, 10m wind speed)
  - Ability to perform separate analyses for most of analysis variables over land and water (and merge the two)
  - Retuning/adjustment of background errors

- Code cleanup and optimization, e.g., reducing memory usage and improving threading.

- Bug fixes and others

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Code Test

- Repository code tests
  - Multiple platforms/compilers (DTC)
  - Multiple operational configurations (EMC)
- Pre-implementations (operational centers, e.g., EMC, AF,…)
- DTC community tests
  - Functionally similar testing environment
    - End-to-end system and archived operational data and background files
    - Can be tuned to operational setup (model versions, workflow, namelists)
  - Facilitate community development tests
    - DTC Visitor Program
  - Pre-release tests: testing GSI/EnKF, as well as libraries and scripts
  - Independent code tests in support of operational applications, providing recommendation for pre-implementation tests and identifying research areas
    - Existing capabilities
    - Developmental community research

Observation Impact Study: Ozone
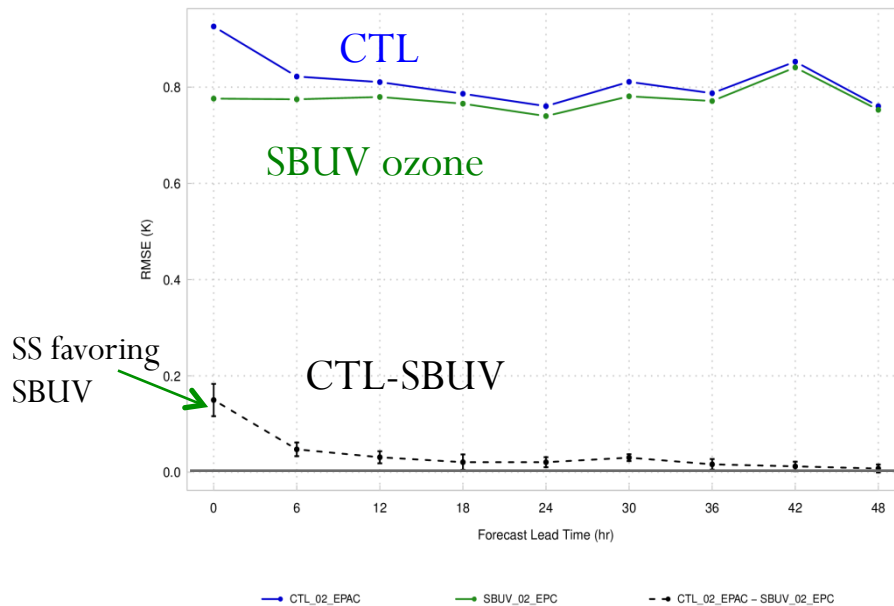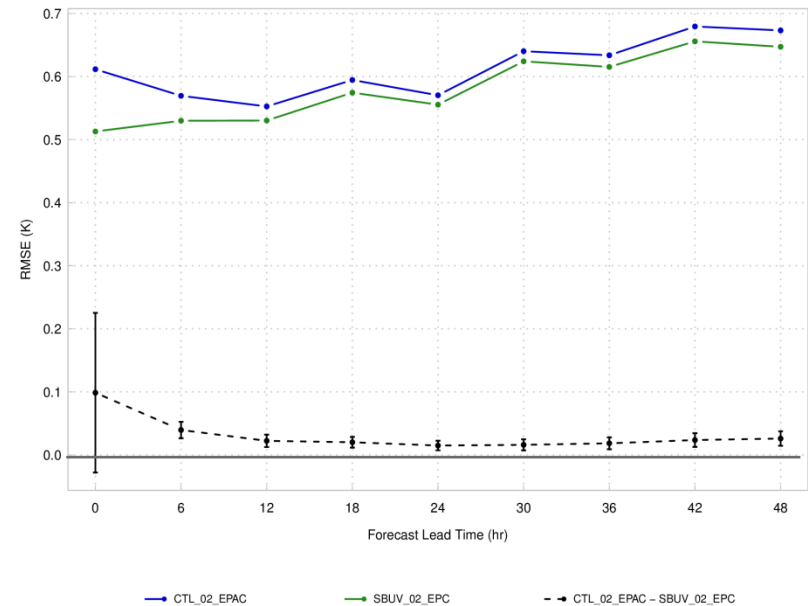
RMSE of temperature forecasts at 50 hPa and 500 hPa

4a.6: Indirect impact of ozone assimilation using the Grid-point Statistical Interpolation data assimilation system for regional applications.
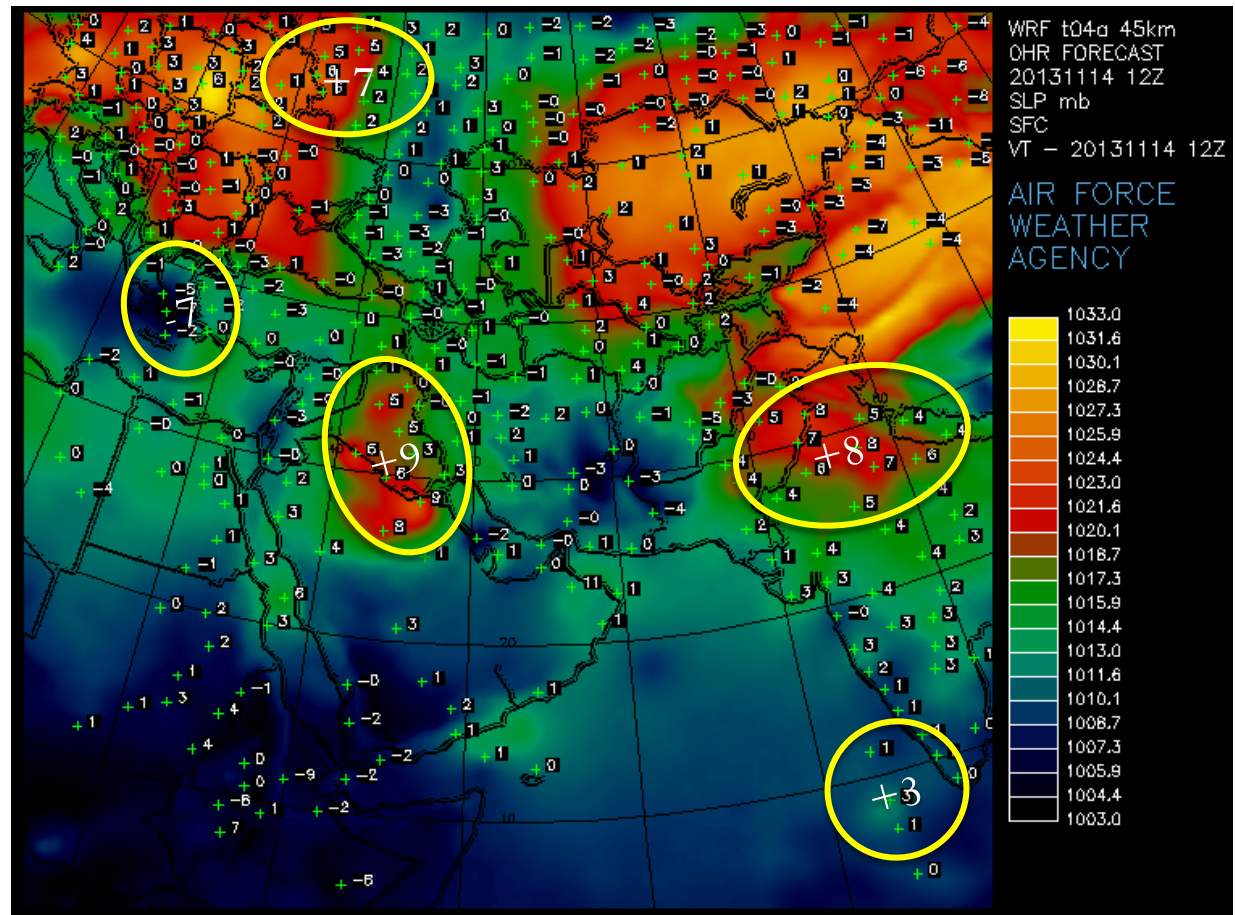Kathryn Newman, 8:30-10:30am, Wednesday, 17 June

In-depth Diagnostics of Real-time Performance: SLP issues

Sea Level Pressure (SLP) is not an analysis variable, nor a forecast variable:

- Both DA and DA beyond (post-processing) investigated

SLP derived from GSI analysis:
RMSE=2.9, Bias=1.0

GSI SLP "Analysis" minus observation @ 12Z 20131114

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Inconsistency between Control and Diagnostic Variables

- Geopotential height (ϕ): prognostic variable in ARW; no update from GSI
- Lowest model level pressure perturbation (P) used in the AF post processing system for MSLP calculation; not dry air mass (μ) or surface pressure (Ps) perturbation directly from GSI

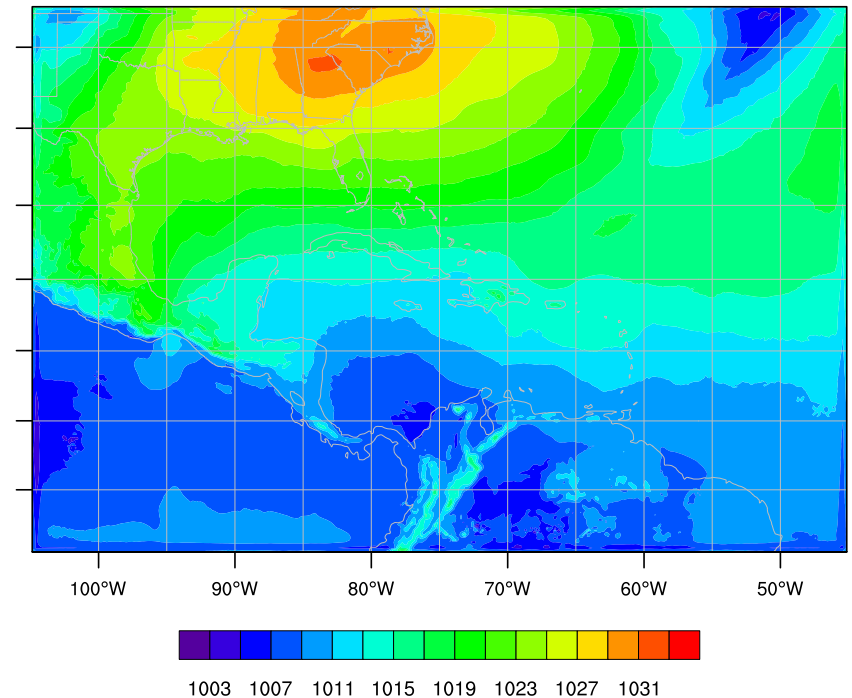|	GSI	"Rebalance"	WRF-ARW
Control/ Prognostic variables	ΔT ΔP_s Δq $\Delta \mu$	T μ q	ϕ μ θ
Computed/ diagnostic variables	$\Delta \theta$ *(from ΔT)*	P α ϕ	α P

- Derive the missing variables from GSI analysis prior to running ARW
  - Full fields (being used by RAP)
  - Increments

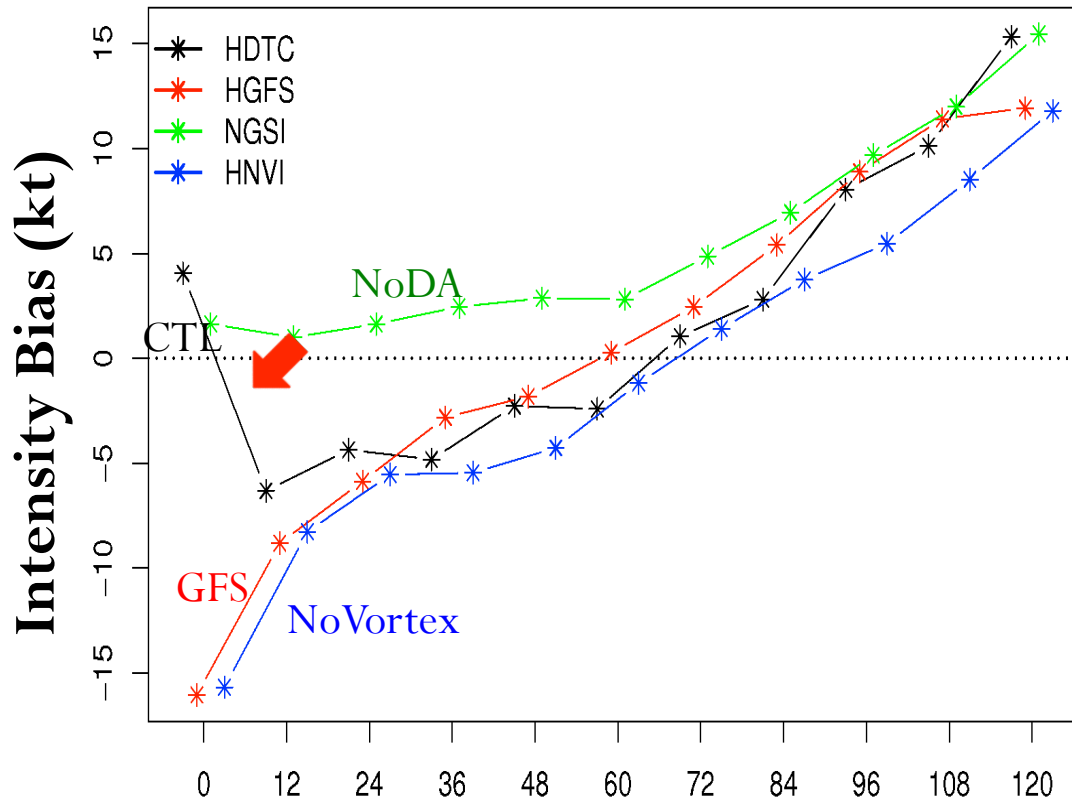Developmental Testbed Center

Resulting MSLP Field

MSLP (UPP using P'):
WRF-ARW v3.6
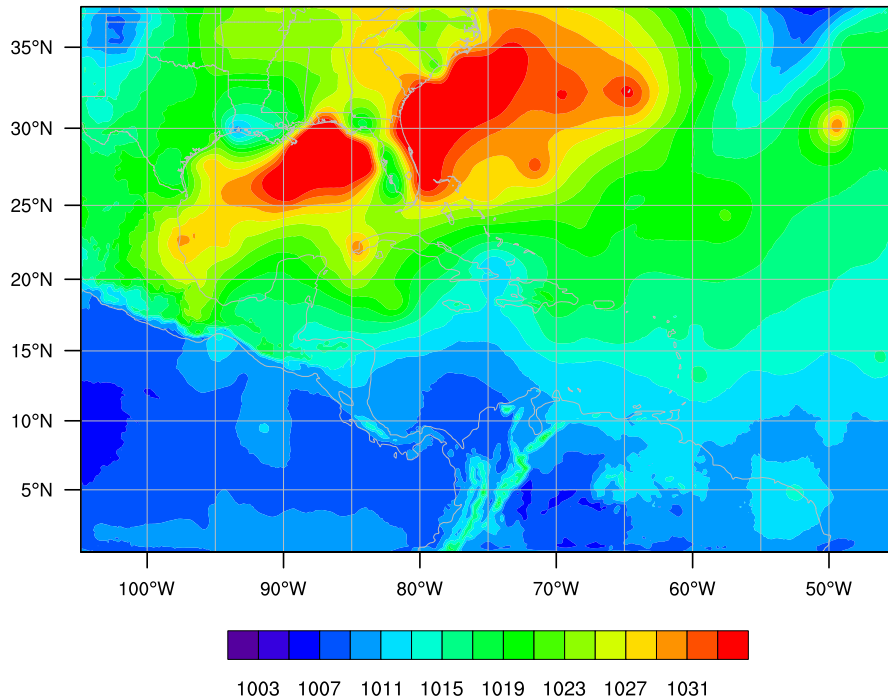
MSLP (UPP using P'):
WRF-ARW v3.6 w/ rebalance

Retrospective Study: Tropical Cyclone (TC) Inner-Core DA

HDTC: control as 2014 ops.

(Uses DA and vortex init)

Spin down in first 6 hours

Why? How to improve?

Remove DA (NGSI)

Improved bias

Remove Vortex Init (HNVI)
Remove both (HGFS)

No spin down, but low bias

P9: Regional applications of the GSI-Hybrid Data Assimilation for high-resolution tropical storm forecasts: tackling the intensity spin-down issue in 2014 HWRF.

Chunhua Zhou, poster session 2:00-3:30pm, Wednesday, 17 June

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GSI Diagnostics in MET

- Model Evaluation Tools (MET) v5.1 (planned release fall 2015) will include GSI diagnostics capabilities

- Reformat binary GSI diagnostic output files (conv, rad)

- Ability to threshold, filter, subset and produce statistics on diagnostic output

AMSU-A n19 Ch 10 O-B
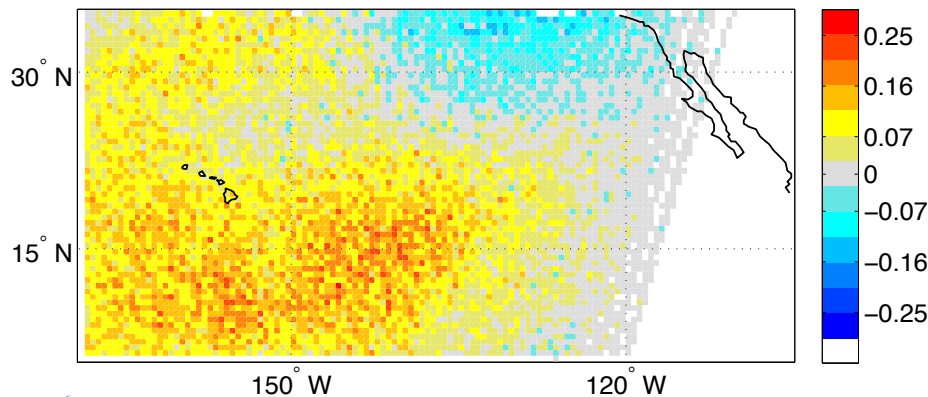
O-B: Conventional Temperature Obs

(MET is developed by the DTC verification team)

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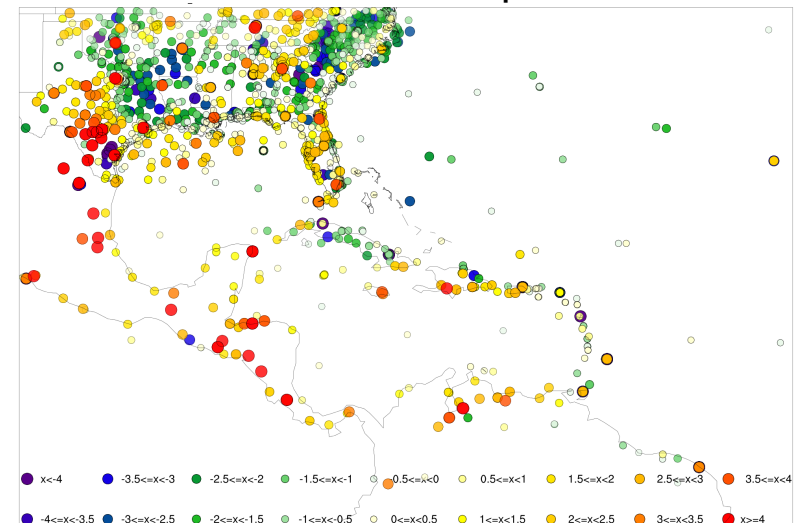
Future Plans

- 2015 Annual code release is scheduled for early July 2015
  - Community GSI v3.4, EnKF v1.0
  - Annual onsite tutorial (including hands-on practical sessions), Foothill Lab, Boulder, CO:
    - GSI: August 11-13, 2015
    - EnKF: August 13-14, 2015
- Beyond 2015 released code:
  - 4D Hybrid EnVar*
  - All weather radiance data assimilation
    - Microwave*
    - Infrared (under development)
  - New data instruments and types
- Continue to provide community support and testing and evaluation of new development and in-depth study of operational/research issues
  - EnVar for regional applications
  - High resolution and frequent update DA
- Encourage community contributions and collaborations

* Currently available in the GSI/EnKF repository

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