Status of O2R and R2O Activities at JCSDA and NESDIS

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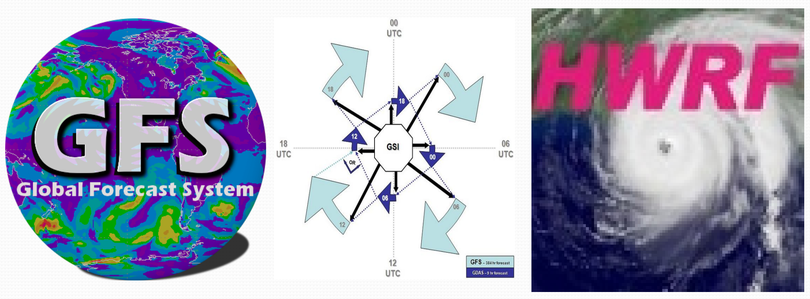
Supported NOAA Operational Models

The primary missions of the Joint Center for Satellite Data Assimilation (JCSDA) are to coordinate and accelerate research on satellite data application, and to integrate the mature science into NOAA's current state-of-the-art Numerical Weather Prediction (NWP) assimilation systems and forecast models. An efficient Operations to Research and a Research to Operations (O2R-R2O) environment is currently available on JCSDA super computers S4 and JIBB and NOAA R & D super computer Theia which are linked to the NCEP's model and assimilation subversion control repositories.



JCSDA's O2R paradigm follows NOAA NCEP systems intimately. Key O2R efforts are currently ongoing to have NCEP's 2016 Hybrid-4D-ENSVAR operational systems ported in a research environment on the NESDIS-University of Wisconsin supported S4 and JIBB supercomputer systems. Benchmark tests are in progress with the high resolution T1534L64 (~13 km)/T574L64 GSI Hybrid-4D-ENSVAR on S4 Intel processors. Also, a low resolution research and development (R & D) version of the NCEP's 2016 GDAS system (both 3D & 4D-HYBRID ENSVAR) at T670 resolution of the GFS (SL), GSI (T254) and ENKF (T254) systems are being benchmarked for the JCSDA users to perform multiple experiments on JCSDA O2R environment. HWRF v3.7a DTC version has been ported to the S4 environment. Tests are performed for the hurricane Gonzalo. The automated ROCOTO scheduler system with the NOAA HWRF operational system will be implemented in the near future.

Semi-Lagrangian GFS Model GSI & ENKF Grids

JCAP=1534 # 1st segment wave number (0-240hr)
JCAP2=574 # 2nd segment wave number (240-384 hr)
LONB=3072; LATB=1536;
DELTIM=450 (T1534) #for running week-1 LONB2=1152; LATB2=576;
DELTIM2=900 #for running week-2 at T574
DTPHYS=225 (Physics, ½ the time step of the model time step for 1st seg)
DTPHYS2=450 (Physics, ½ the time step of the model time step for 2nd seg)

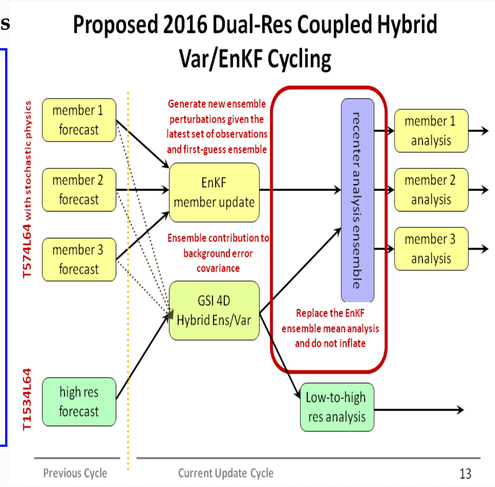
GSI Analysis and ENKF Grids

JCAP_ENKF=574	(T574) LEVS_ENKF=64	LONB_ENKF=1152
LATB_ENKF=576	LONA_ENKF=1152	LATA_ENKF=576
DELTIM_ENKF=900	DTPHYS_ENKF=450	

JCAP_A=574	NLAT_A=578	NLON_A=1152

GFS Model Physics Updates

- Convective gravity wave upgrade,
- Tracer adjustment upgrade
- *Corrections to land surface to reduce summertime warm, dry bias over Great Plains*
- Improved icing probability products and new icing severity product
- *Hourly output through 120-hr forecast*
- *5 more levels above 10 hPa*

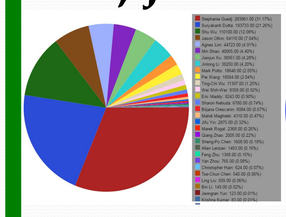


GSI Analysis Updates

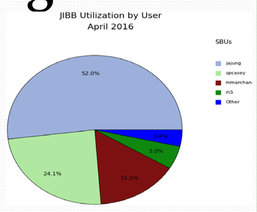
- 3D to 4D ensemble covariances
- Increase in ensemble contribution from 75% to 87.5%
- Reduction of horizontal localization length scales in the troposphere
- Removal of additive inflation
- Code optimization
- Limit moisture perturbations for improved minimization
- Inclusion of ozone cross-covariances
- Removal of time component for data selection
- 4D thinning of AMVs
- Aircraft temperature bias correction
- All sky microwave radiances
- CRTM upgrade

Source: NCEP/EMC

S4, JIBB and Theia Usage Stats

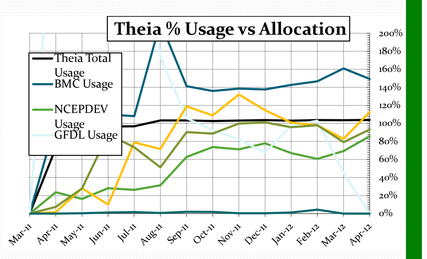


S4-Intel Chip stats per user and application for April 2016



JIBB usage stats per user for April 2016

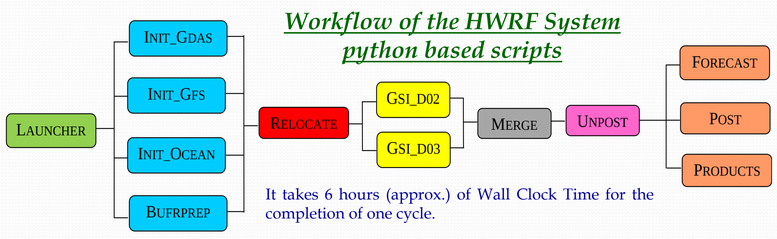
S4 Intel Nodes CPU utilization (%) for April 2016

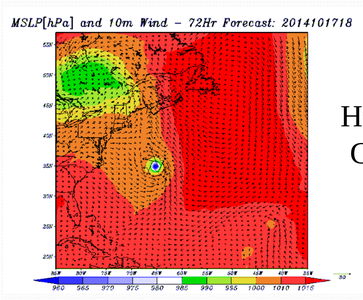


NESDIS Theia usage versus Allocation stats per user for March 2015 – April 2016

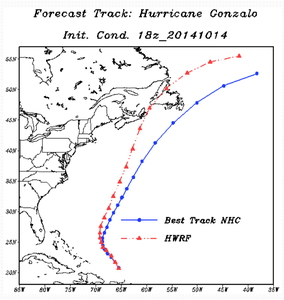
Hurricane WRF :: v3.7a on S4

- Primitive Equation, Non-Hydrostatic Coupled Atmosphere-Ocean Model; Rotated Latitude-Longitude Projection with E-grid staggering. Variable Vertical Levels depending on the ocean basin.
- An outer domain (80^0 x 80^0, ≈ 18km.), two telescopic two-way interactive nested domains (12^0 x 12^0, ≈ 6km. and 7.1^0 x 7.1^0, ≈ 2km.) and 61 levels in vertical.
- **Simplified Arakawa-Schubert Scheme** (Cumulus Parameterization); **Ferrier-Aligo** (Cloud Microphysics); **GFDL Model Scheme** (Surface Flux Calculations); **NOAH** (Land Surface Model); **RRTMG** (Radiation Physics Scheme); **GFS PBL** (PBL Parameterization).

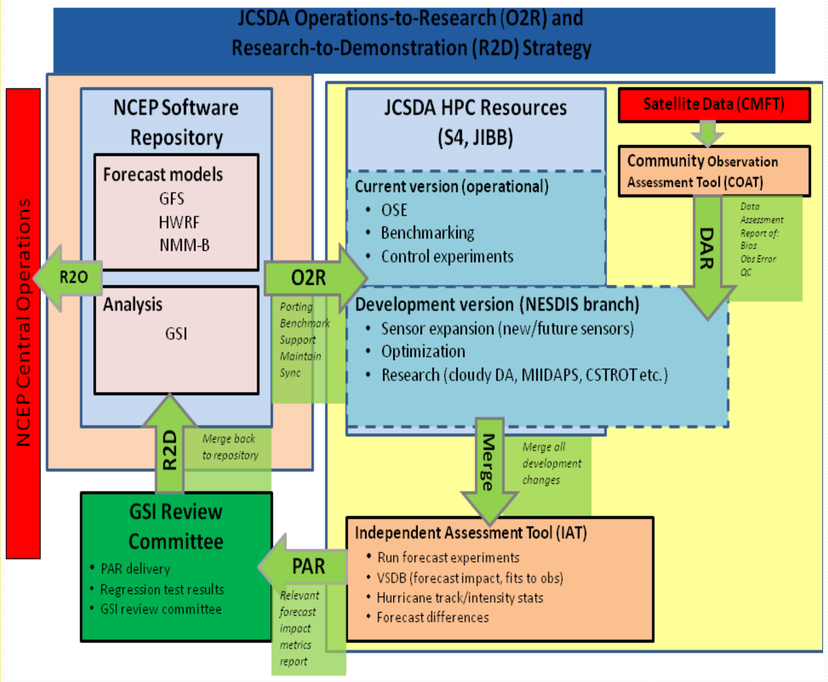




Hurricane Gonzalo

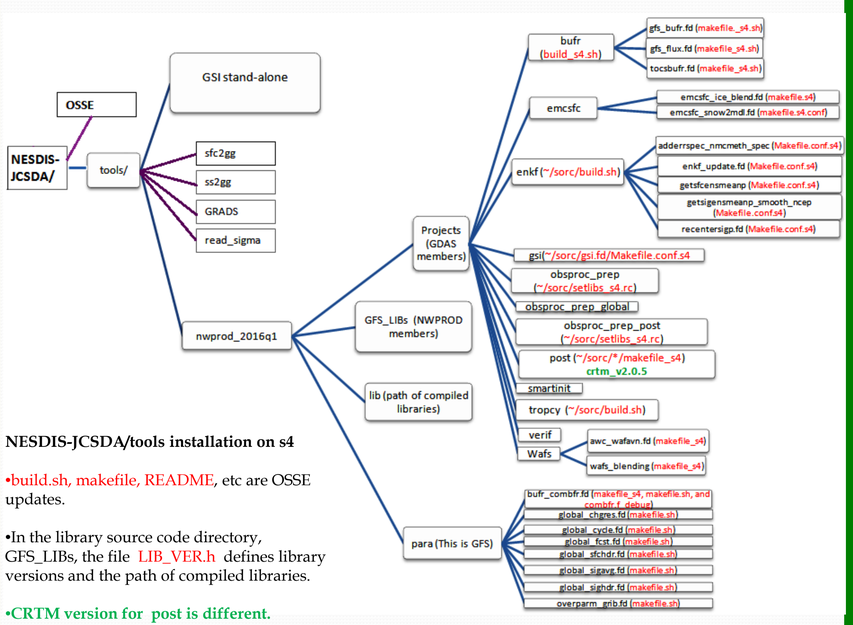


Description of the O2R-R2O Environment



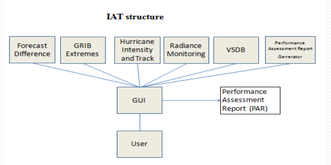
In the JCSDA O2R and R2O strategy, first we convert the original satellite data into NCEP's operational BUFR format using an interactive Community Multi-purpose Formatting Toolkit (CMFT) tool. We then begin a wide-ranging pre-assimilation data assessment of the bias, observation error, QC and other statistical characteristics using the Community Observation Assessment Tool (COAT), which results in a complete data assessment report (DAR). Next, the JCSDA's development subversion branch that is fully linked to the NCEP's subversion control repository uses the latest synced versions of GSI to carry out DA and forecast experiments on multiple sensor expansion (new/future sensors) research projects AMV DA, Geo radiance DA, Cloudy DA in support of the data gap mitigation effort, multiple usage of CRTM, improve SSMI/S DA to increase the impact and the new satellite GCOM-W AMSR2 DA, GPM data, MIIDAPS 1DVAR preprocessor into the GSI etc. Finally, after generating a comprehensive performance assessment report (PAR) the JCSDA development changes are carefully merged to NCEP's software repository trunk using the results from the Independent Assessment Tools (IAT), following all the NCEP R2O protocols.

2016 GDAS Processing System on S4 & JIBB

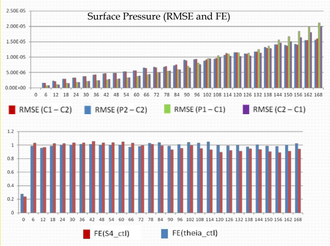


JCSDA Independent Assessment Tools

Functional Equivalence Tests to compare GDAS package on multi-platforms



Function Equivalent on Forecast only :
- Control run on Theia (C1): using gfs analysis to run gfs forecast
- Perturb run on Theia(P1): using perturb gfs analysis to run gfs forecast
- Control run on S4 (C2): using same gfs analysis to run gfs forecast
- Perturb run on S4 (P2): using same perturb gfs analysis to run gfs forecast



Functon Equivalent (Butterfly) test
- Initial conditions: siganal.$CDATE
- Run cntl on Theia (C)
- Run cntl on S4 (D)
- Perturb each F_i in the last significant digit:
  - Nominally after the 6th decimal digit for 32-bit reals.
  - For each value $F_i(x)$, construct a distribution.
  - Gaussian distribution with width being $|F_i(x)/1.e6|$
  - Randomly select perturbation from that distribution.
  - Perturbed "siganal.2013070100" for t, ps, and z(vorticity), and d(divergence) at each level.
- Run pertub on Theia.
- Use the sigf$fhr.gfs.$CDATE
- Compute butterfly vector: RMSE (P-C) (β) and RMSE(D-C) (δ)

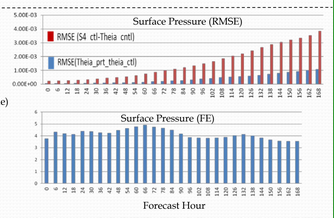
$$\beta_j = \left[\frac{w(P_j - C_j)^2}{w}\right]^{\frac{1}{2}} \qquad \delta_j = \left[\frac{w(D_j - C_j)^2}{w}\right]^{\frac{1}{2}}$$

- Compute dimensionless difference butterfly number vector

$$v_j = \delta_j / \beta_j$$

- For a functionally equivalent requirement, must be largely less than 10.

Function Equivalent on gdas cycling :
(using same IC to run parallel for 1 cycle)
- Control run on Theia
- Perturb run on Theia
- Control run on S4



The IAT structure comprises of existing packages leveraged from NCEP EMC and the GFS Dropout team and newly developed JCSDA tools through a user GUI interface. The structure of this tool is designed for easy use by the users of multi components on multi-platforms when carrying out their performance assessments of assimilation and forecast experiments. An option to generate a performance assessment report containing their chosen list of plots is also available.

Summary of O2R-R2O Efforts

JCSDA supports the Research to Operations (R2O) target implemented by the National Centers for Environmental Prediction (NCEP) for the Global Forecast System (GFS) / Global Data Assimilation System (GDAS) with the Grid point Statistical Interpolation (GSI) analysis system and Hurricane Weather Research and Forecasting (HWRF). The JCSDA R2D to R2O conduit will mainly involve a comprehensive end-to-end assessment of the input satellite data to the GSI, and an objective analysis of the outputs from the GDAS/HWRF assimilation and GFS/HWRF forecast experiments using a complete Independent Assessment Tools (IAT) package.

O2R efforts are ongoing to have the NCEP's 2016-2017 high resolution T1534 (13KM) Semi-Lagrangian (SL), T574 GSI and 4D-HYBRID-ENSVAR systems ready for performing multiple experiments within the JCSDA O2R environment. The 2016-2017 version of GDAS on Theia have been used to carry out data assimilation (DA) and forecast experiments on JCSDA's multiple research projects. These projects include MIIDAPS 1DVAR preprocessor into the GSI, AMV DA, Geo radiance DA, Cloudy DA in support of the data gap mitigation effort, multiple usage of CRTM, improve SSMI/S DA to increase the impact and the new satellite GCOM-W AMSR2 DA, GPM data etc.. HWRF DTC version 3.7a employing Python scripts have recently been ported on to S4 and efforts are ongoing to test the HWRF operational version using the ROCOTO scheduler system along with the NOAA 2016 GDAS system.