O2R and R2D Activities at JCSDA and NESDIS : Status Report

13th JCSDA Technical Review & Science Workshop on Satellite Data Assimilation
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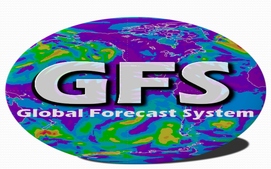
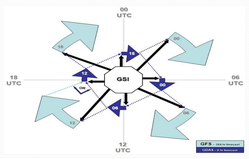
Supported NOAA Operational Models

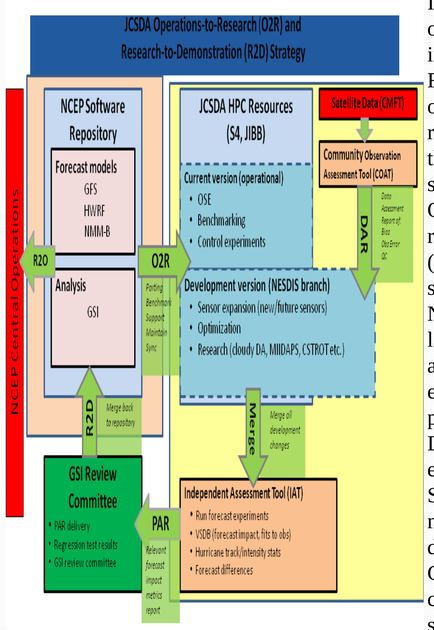
The primary missions of the Joint Center for Satellite Data Assimilation (JCSDA) are to coordinate and accelerate research on satellite data application, and to integrate the mature science into NOAA's current state-of-the-art Numerical Weather Prediction (NWP) assimilation systems and forecast models. This is accomplished using efficient Operations to Research and a Research to Demonstration (O2R-R2D) environment currently available on JCSDA super computers S4 and JIBB and NOAA R & D super computers Zeus and Theia which are linked to the NCEP's subversion control repository.





JCSDA's O2R paradigm follows NOAA NCEP systems intimately. Key O2R efforts are currently ongoing to have NCEP's future Hybrid-4D-ENSVAR operational systems ported in a research environment on the NESDIS-University of Wisconsin supported S4 and JIBB supercomputers and on NOAA's Zeus/Theia R & D HPC systems. As an integral part of O2R on R & D HPC systems, benchmark runs with NCEP's 2015 operational high resolution T1534L64 (~13 km)/T574L64 GSI Hybrid-3D-ENSVAR were performed on the upgraded S4 system. Also, a low resolution research and development (R & D) version of the NCEP's 2015 GDAS system (both 3D and 4D-HYBRID ENSVAR) at T670 resolution of the GFS (SL), GSI (T254) and ENKF (T254) systems was benchmarked for the JCSDA users to perform multiple experiments on JCSDA O2R environment.

Description of the O2R-R2D Environment



Block diagram of JCSDA Operations-to-Research (O2R) and Research-to-Demonstration strategy.

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In the JCSDA O2R and R2D strategy, first the original satellite data is converted using an interactive Community Multi-purpose Formatting Toolkit (CMFT) tool into NCEP's operational BUFR format to 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) resulting 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, the JCSDA development changes are carefully merged to NCEP's software repository trunk after generating a comprehensive performance assessment report (PAR) using the results from the independent assessment tools (IAT) following all the NCEP R2O protocols.

Semi-Lagrangian GFS Model GSI and ENKF Grids

NCEP Operational T1534 GDAS/GFS model implemented in 2015

JCAP=1534 # 1st segment wave number (0-192 hr)

JCAP2=574 # 2nd segment wave number (192-384 hr)

JCAP3=190 # 3rd segment wave number (384-540 hr)

GFS Model (Semi-Lagrangian)

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)

Set parameters for analysis grid

JCAP_A=574

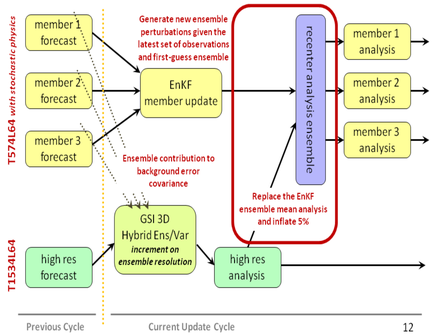
NLAT_A=578

NLON_A=1152

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

- T1534 Semi-Lagrangian (~13km)
- Use of high resolution daily SST and sea ice analysis
- High resolution until 10 days
- Physics
  - Radiation modifications – McICA
  - Dissipative heating and boundary layer modifications
  - Reduced drag coefficient at high wind speeds
  - Convective gravity wave drag
  - Compute and output frozen precipitation fraction
  - Land Surface
    - Soil moisture nudging to CFSv2 climatology
    - Small modifications to surface roughness, etc.

Current 2015 Dual-Res Coupled Hybrid Var/EnKF Cycling



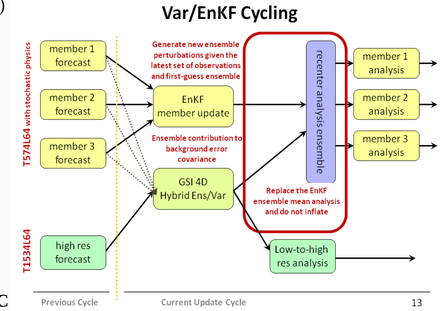
Courtesy: Rahul Mahajan NCEP/EMC

GSI Analysis Highlights

- T574 analysis for T1534 deterministic
- Single scale background error (for efficiency)
- Code optimization
- Observations
- GPSRO enhancements – METOP-B and improved use
- Updates to radiance assimilation
  - Assimilate SSM/IS UPP LAS data –
  - CRTM v2.1.3 - completed (GSI r29733)
  - New bias correction
  - Additional satwind data – hourly GOES, EUMETSAT
- EnKF modifications
  - Stochastic physics
  - T574L64 EnKF ensembles

Source: NCEP/EMC

Proposed 2016 Dual-Res Coupled Hybrid Var/EnKF Cycling

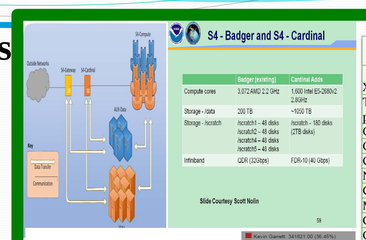


Courtesy: Rahul Mahajan NCEP/EMC

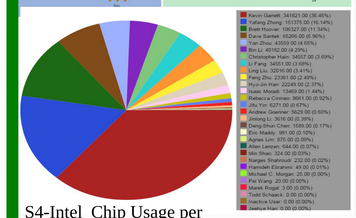
S4 – JIBB System Upgrades

A major expansion to the supercomputer S4 under the NOAA Sandy Supplemental Grant was completed in late July 2014 and the system is now available to researchers. The S4 expansion entailed an addition of a new S4 system called S4-Cardinal with 1,600 Intel E5-2680v2 2.8GHz compute cores, ~1050 TB disk storage with 180 scratch disks (2TB disks) and infiniband FDR-10 (40 Gbps) for networking in addition to S4 – Badger. The upgrade will initially result in two separate systems for ease of continuing operations and in the immediate future we will begin working on merging the two systems into a single system.

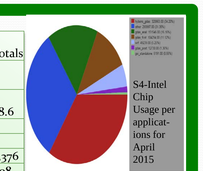
JCSDA's supercomputer JIBB based at NASA/GSFC also went through an expansion in March 2014. This includes the Intel Xeon Chip Sandy Bridge X5660 2.80 GHz, with 332.8 GFLOPs/node), 20.8 GFLOPS/core, 1,920 compute cores (120 nodes, 16 cores/node), 7.68 memory TiB (4 GiB Mem/node), 2.6 clock rate GHz and FSB or Mem I/O of 3x1066 MHZ with ~39.9 TFLOPs. The total number of JIBB compute cores is 5,376 (408 nodes), with 14.59 Memory TiB and ~78.6 TFLOP.



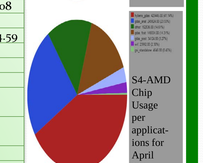
	JIBB part 1	JIBB part 2	JIBB part 3	Totals
Xeon Chip	West-mere	West-mere	Sandy Bridge	
TFLOPs (gen. purpose)	6.5	32.3	39.9	78.6
GFLOPs/node	134.4	134.4	332.8	
GFLOPS/core	11.2	11.2	20.8	
Cores	576	2,880	1,920	5,376
Nodes	48	240	120	408
Cores/node	12	12	16	
Memory TiB	1.15	5.76	7.68	14.59
GiB Mem/core	2	2	4	
GiB Mem/node	24	24	64	
Clock Rate GHz	2.8	2.8	2.6	
FSB or Mem I/O	3x 1066 MHz	3x 1066 MHz	3x 1066 MHz	
Sockets/cores	dual/"six"	dual/"six"	dual/eight	
FLOPS per clock	4	4	8	
TFLOP (gen-purpose) calculation	6.5	32.3	39.9	78.6
GPU or coprocessor type	none	none	none	
Vendor	Dell	Dell		
Deployed GA	11-Jan	11-Jul	Mar-14	



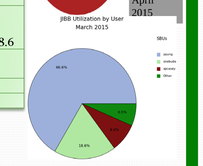
S4-Intel Chip Usage per users for April 2015



S4-Intel Chip Usage per applications for April 2015

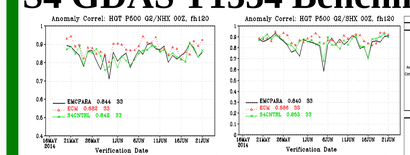


S4-AMD Chip Usage per applications for April 2015

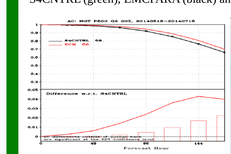


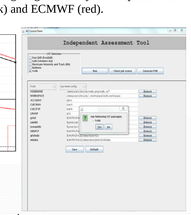
Courtesy: Fred Reitz and Jim Jung

S4 GDAS T1534 Benchmark Results



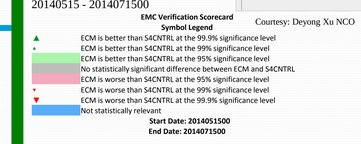
Anomaly correlation (AC) time series from 16 May 2014 – 21 Jun 2014 of 5-day 500-hPa NH & SH geopotential height against analysis computed from S4CNTRL (green), EMCPARA (black) and ECMWF (red).

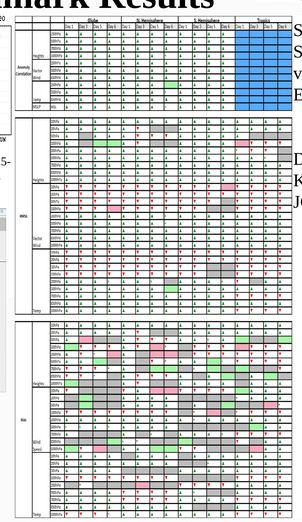




S4CNTRL (T1534) versus ECMWF
Dieoff curve for AC Global 500 hPa
20140515 - 2014071500

Courtesy: Deyong Xu NCO





Score Card of S4CNTRL versus ECMWF

Data Courtesy: Kevin Garrett, JCSDA

Summary of O2R-R2D Efforts

JCSDA supports in 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, Hurricane Weather Research and Forecasting (HWRF), regional North American Mesoscale (NAM) with the NAM Data Assimilation System (NDAS), Hybrid Co-ordinate Ocean Model (HYCOM) and Land Information System (LIS) models. The JCSDA R2D to R2O conduit mainly will involve a comprehensive end-to-end assessment of the input satellite data to the GSI, 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 available on JCSDA O2R environment. The 2016-2017 version of GDAS will be used to carry out data assimilation (DA) and forecast experiments on JCSDA's multiple research projects such as 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 2015-2016 version will be ported on to S4/JIBB as soon as the new Global system testing is completed.

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