NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service

# Overview of NOAA/NESDIS Satellite Data Assimilation Activities in Support of the U.S. Joint Center for Satellite Data Assimilation (JCSDA)


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- **Motivation:**
  - Interest in NOAA/NESDIS to Accelerate/Optimize use of satellite data
  - Use NOAA DA tool for data-fusion purposes (pilot project):

- **Approach: Activities in NOAA/NESDIS in support of JCSDA include**

  - Develop Tools needed to facilitate the use of satellite data
    - **Spectr. LBL, RT, Active Simulator, Emissivity, (CLBLM, CRTM, CASM & CSEM)**
    - **Satellite Data Thinning & Representation Optimization (CSTROT)**
    - **General Satellite QC Tool (MIIDAPS)**

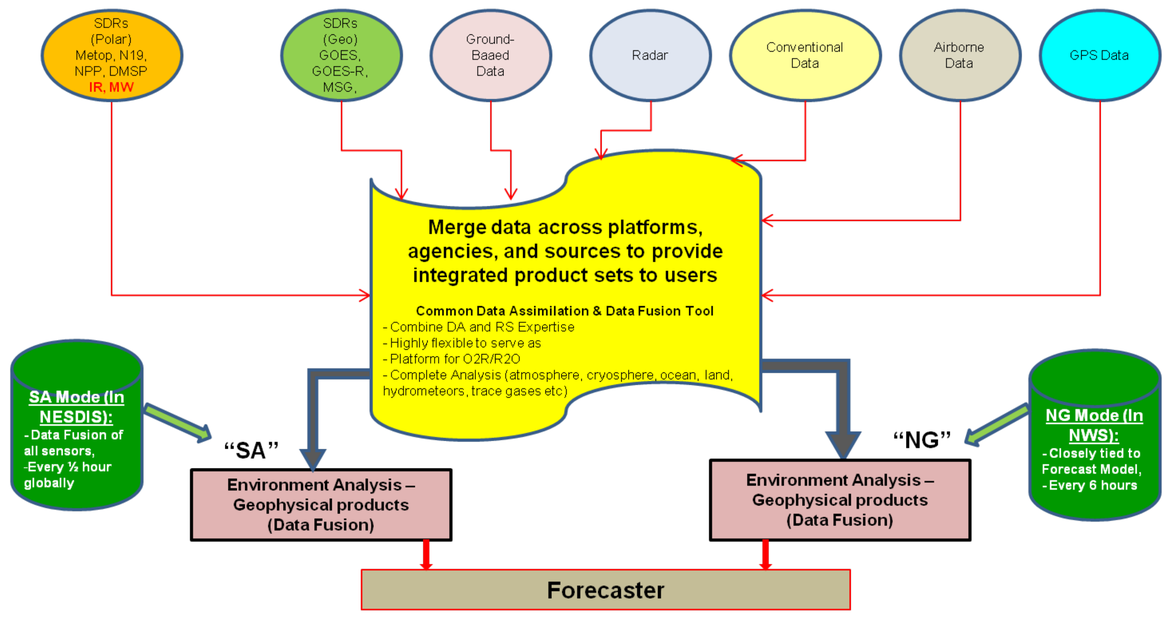
  - Accelerate/Optimize use of satellite data on NOAA Systems
    - **Existing Sensors: ATMS,SSMIS, AMSR2, etc**
    - **New Sensors: HIMAWARI,ISS-RAPIDSCAT, GPM, SAPHIR, Etc**
    - **Advance DA Science to allow more satellite data to be used (cloudy/rainy, ..)**

  - Observing Systems Impact Assessments
    - **Data Impact Studies**
    - **OSSEs**

  - Reach out to external research community
    - **FFO**
    - **Visiting Scientists, Etc**
    - **O2R Environment (S4 and JIBB Support and Upgrade)**

## Use of NOAA DA (GSI) as Data Fusion Tool

*(Satellite, Conventional, ground based, Airborne, etc)*

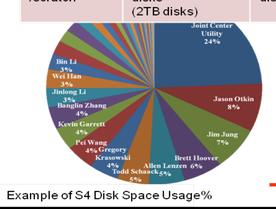



**This project aims to merge Remote Sensing and DA Expertise for both Data Fusion and DA Purposes**

## S4: O2R/R2O Environment

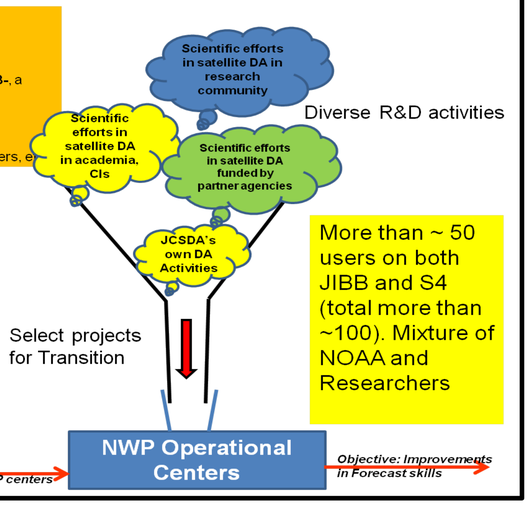
- Goal: Accelerates the use of satellite data in NWP centers
- How: Build a solid O2R environment for a successful R2O
- Ensures resources are in place: supercomputer –**S4&JIBB-**, a software integration team, etc.
- Operations-consistency
- O2R Beneficiaries : FFO JCSDA projects, Academic partners, e

| S4 | New | Existing |
|---|---|---|
| Compute cores | 1,600 Intel E5-2680v2 2.8 GHz | 3,072 AMD 2.2 GHz |
| Storage /data | ~1,050 TB | 200 TB |
| Storage /scratch | /scratch – 180 disks (2TB disks) | /scratch1-5 – 48 disks each |




Example of S4 Disk Space Usage%

Infrastructure & External Research Outreach




## Data Being Assimilated/Assessed

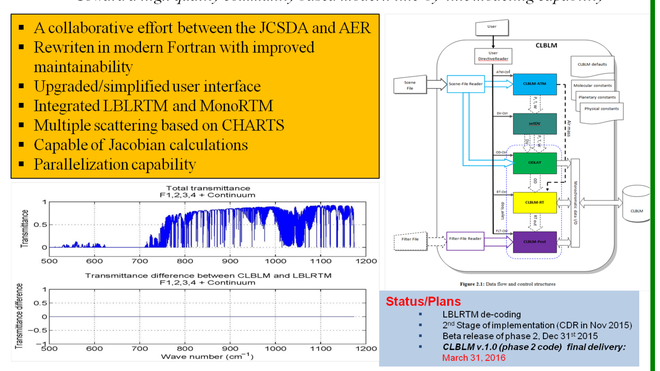
- **New Sensors Data Assimilation:**
  (new QC, error optimization, impact assessment on NOAA forecast systems)
  - HIMAWARI-8 AHI (Dry run for GOES-R ABI)
  - GPM /GMI
  - Megha-Tropiques SAPHIR (WV Sounder)
  - ISS-RAPIDSCAT (Scatterometer)
  - GCOMW AMSR2
- **Existing Sensors optimization:**
  (QC, Surface-sensitive channels assimilation, pre-processing, dynamic emissivity, cloud-impacted data assimilation, etc)
  - ATMS
  - SSMIS
  - AMSU
  - MHS

# Tools to Facilitate Satellite Data Usage

## Development of the Community Line-by-Line Model (CLBLM)

*Toward a high quality community based modern line-by-line modeling capability*

- A collaborative effort between the JCSDA and AER
- Rewriten in modern Fortran with improved maintainability
- Upgraded/simplified user interface
- Integrated LBLRTM and MonoRTM
- Multiple scattering based on CHARTS
- Capable of Jacobian calculations
- Parallelization capability

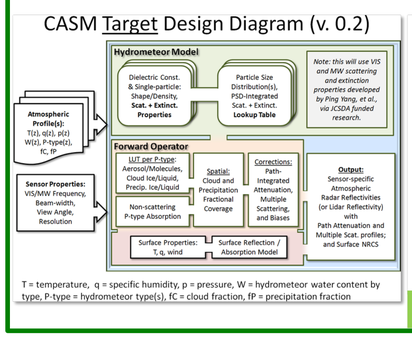



**Status/Plans**
- LBLRTM de-coding
- 2nd Stage of implementation (CDR in Nov 2015)
- Beta release of phase 2, Dec 31st 2015
- ***CLBLM v.1.0 (phase 2 code) final delivery:*** March 31, 2016

## The Community Active Sensor Model (CASM)

**Purpose**: The Community Active Sensor Module (CASM) will enable the Community Radiative Transfer Model (CRTM) to simulate active microwave and active visible remote sensing observations.

CASM facilitates the assimilation of all-weather active-sensor observations, such as the Global Precipitation Measurement mission (GPM) Dual-frequency Precipitation Radar (DPR), either directly or through pre-processing using (MIIDAPS).



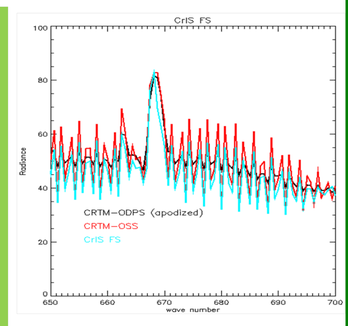

CASM forward modeled radar reflectivities (Black line), compared to GPM-DPR observations (Red line).

## CRTM

**CRTM Mission**
- Satellite radiance simulation and assimilation for passive MW, IR, & Visible sensors of NOAA,NASA,DoD satellites, and others (200 sensors)
- Simulation of clear/cloudy/precipitating scenes, globally

**CRTM Applications**
- Data assimilation in supporting of weather forecasting
- Physical retrieval algorithm for products
- Stability and accuracy monitoring of satellite observations
- Research: reanalysis, climate studies, air quality forecasting, and a radiative tool for students

**CRTM On-going Development**
- New sensors: Acquarius, SMOS, SMAP, ..
- New Cloud Optical Table
- RT Solver Optimization
- Multiple Aerosol Models for GOCART and CMAQ apps




*Comparison of CrIS unapodized measurement, CRTM-OSS and CRTM-ODPS simulations*

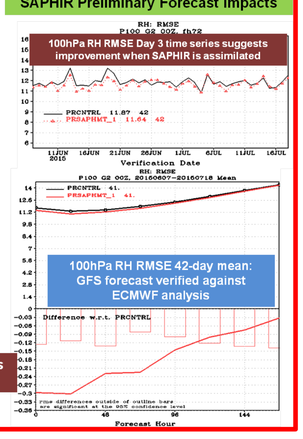
**The CRTM-OSS allows for:**
- Unapodized radiance simulation for better spectral sampling sensitivity,
- Monochromatic scattering to avoid optical path scaling problem because of polychromatic issue.

# Examples

## SAPHIR Data Assimilation

- **The NOAA GDAS has been extended to assimilate brightness temperatures from SAPHIR L1A2 data**
- **Preliminary results**
  Indicate that the assimilation of SAPHIR has a neutral impact on the global forecast, with noticeable improvement in moisture at upper levels
- **Assimilation is done in clear-sky conditions over ocean.**
  – Algorithms have been developed to retrieve cloud, ice, and/or emissivity for filtering and quality control

**SAPHIR Preliminary Forecast Impacts**



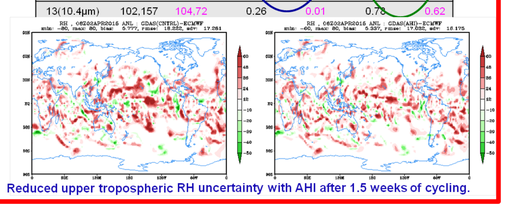

**Improvement (reduction in RMSE) in upper level RH when SAPHIR is assimilated, pronounced for short-mid range forecast times**

## Himawari (AHI) Radiance Assimilation

**Objective:**
- Assimilation of Himawari AHI data in NOAA system.
- Readiness for the usage of GOES-R ABI data.
- Explore the use of radiances from Geo (WV, T and surface sensing channels), in addition to AMVs

| Chan | N obs (O-B) | N obs (O-A) | Bias no/bc (O-B) | Bias no/bc (O-A) | Stdv (O-B) | Stdv (O-A) |
|---|---|---|---|---|---|---|
| 7(3.8μm) | 104,125 | 105,399 | -0.09 | -0.03 | 0.73 | 0.67 |
| 8(6.2μm) | 83,611 | 107,737 | 0.29 | -0.01 | 0.96 | 0.89 |
| 9(6.9μm) | 83,754 | 107,484 | 0.34 | -0.01 | 0.95 | 0.87 |
| 10(7.3μm) | 94,423 | 108,186 | 0.36 | -0.01 | 0.89 | 0.84 |
| 11(8.6μm) | 102,218 | 103,504 | 0.27 | 0.01 | 0.78 | 0.63 |
| 12(9.6μm) | 96,081 | 105,746 | 0.39 | 0.03 | 0.83 | 0.61 |
| 13(10.4μm) | 102,157 | 104,72 | 0.26 | 0.01 | 0.78 | 0.62 |

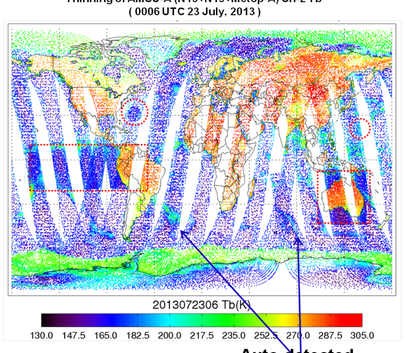
**Status:**
- Reduced Biases and std deviations in O-A
- Reduced Humidity fields differences with ECMWF



Reduced upper tropospheric RH uncertainty with AHI after 1.5 weeks of cycling.

## Community Satellite data Thinning and Representation Optimization Tool (CSTROT)

Thinning of AMSU-A (N15+N19+Metop-A) Ch-2 Tb
( 0006 UTC 23 July, 2013 )




**Objective of CSTROT:**
- Develop a new thinning scheme to optimize satellite data usage in GSI data assimilation for both global and regional modeling systems.

**CSTROT Functions:**
- **Thinning options**:
  - using Standard Deviation
  - using regression
  - by skipping points
- **Representation options**:
  - Random points
  - Closest point
  - Averaging
- **Nested domain options:**
  - by target regions
  - by domain size

**Specified**: Two target regions; Two domain areas

**Auto detected**: Higher density in higher variation regions associated with cloudy, frontal system, moisture tongue.

**The tool will allow an optimal information content extraction while optimizing computation time**

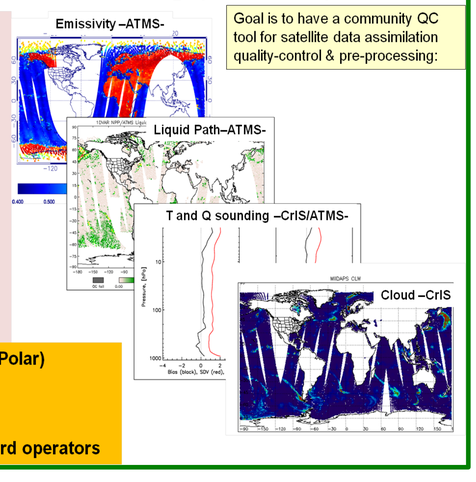
**CSTROT is an "intelligent" thinning tool to optimize satellite data selection in DA.**

Universal QC & Pre-Processing Tool:

## Satellite Pre-Processing (MIIDAPS)

- **Benefits:**
  - Quality control based on non-convergence
  - Detection of rain and ice contamination,
  - Coast contamination ,
  - RFI for imagers
  - Dynamically-retrieved emissivity to allow assimilation of surface-sensitive channels
  - Provide sounding products in cloudy/rainy conditions
  - Allows background adjustment to fit obs

Goal is to have a community QC tool for satellite data assimilation quality-control & pre-processing:




**MIIDAPS valid for MW, IR (Geo, Polar)**

**Extension to Active sensors**

**Uses CRTM and CASM as forward operators**