Joint Center for Satellite Data Assimilation: Science and Collaborative Opportunities

Presented by

James G. (Jim) Yoe

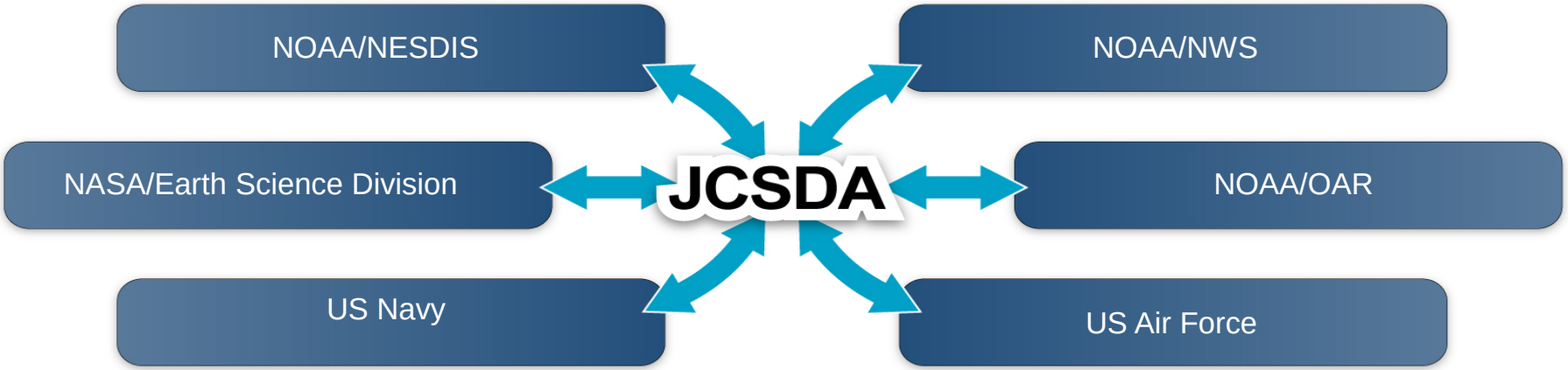
NWS/NCEP
Chief Administrative Officer, Joint Center for Satellite Data Assimilation (JCSDA)

Contributions from:
Sid Boukabara, NOAA NESDIS and NWS Directed Research Teams, JCSDA-funded External Teams

Overview

1. **Introduction to the JCSDA**
2. Scientific Highlights
3. Opportunities for Collaboration
4. Summary

JCSDA Partners, Vision, Mission



Vision:

An interagency partnership working to become a world leader in applying satellite data and research to operational goals in environmental analysis and prediction

Mission:

To accelerate and improve the quantitative use of research and operational satellite data in weather, ocean, climate and environmental analysis and prediction models.

JCSDA Modes of Operation

- **Partner's In-Kind Research**
  - Undertaken independently by partners, overlapping with JCSDA priorities
  - Results/deliverables made available and shared with/between partners
- **Directed research (short-term return-on-investment expected)**
  - Carried out by the partners
  - Mixture of dedicated and leveraged funding
- **External research (near-term return-on-investment expected)**
  - Peer-reviewed Grants/Contracts
  - Open to the broader research community
- **Visiting scientist program (see www.jcsda.noaa.gov)**
  - Initiate or strengthen involvement with the Joint Center
  - Wide-open to data assimilation scientists from everywhere
  - Short-term (a few weeks/months) and Long-term (a few years) VS
    - Identify host at JCSDA partner institution; work on JCSDA-relevant topic

Key JCSDA Accomplishments

- Community Radiative Transfer Model (CRTM) shared by all partners
- A robust (benchmarked) O2R infrastructure through the JIBB (and S4) supercomputers open to JCSDA external researchers
- Numerous new satellite data assimilated operationally, e.g.
  - Microwave: AMSU and MHS (radiances, new QC,…), SSMI/S, Windsat, Jason-2
  - AIRS, IASI, and CrIS hyperspectral IR radiances,
  - GPSRO sensors (COSMIC, GRAS, GRACE),
  - MODIS (winds and AOD),
- Advanced sensors tested for operational readiness, e.g.
  - ASCAT, OSCAT,
  - MLS,
  - SEVIRI (radiances),
  - Assessment of the impact of FY3 data (MWTS, MWHS)
- Accelerated Readiness to assimilate new sensors (example of NPP/ATMS)
- Improved use of sensors already assimilated operationally
- Global Observing System Impact Assessment (Data Denial Studies)

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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

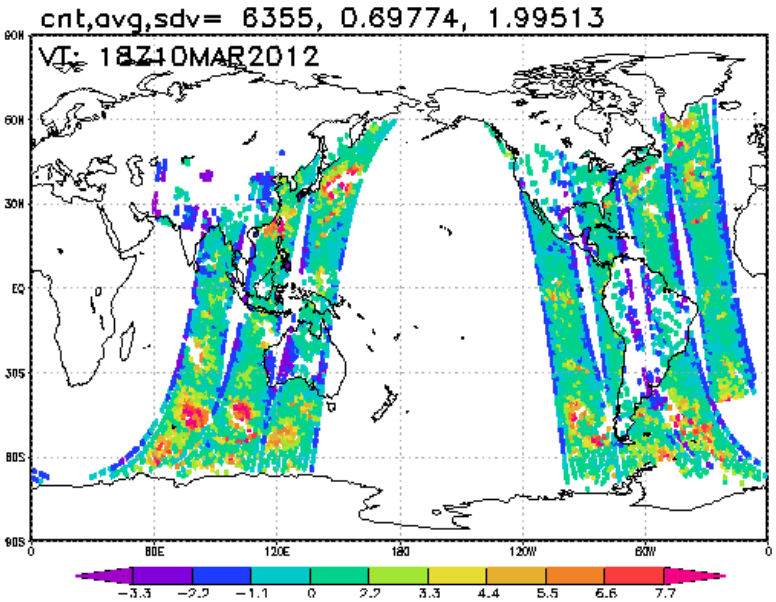
• Education and Research: reanalysis, climate studies, air quality forecasting, and a radiative tool for students

CRTM Future Development

• SBUV for ozone data, GPM, Aquarius, SMOS,

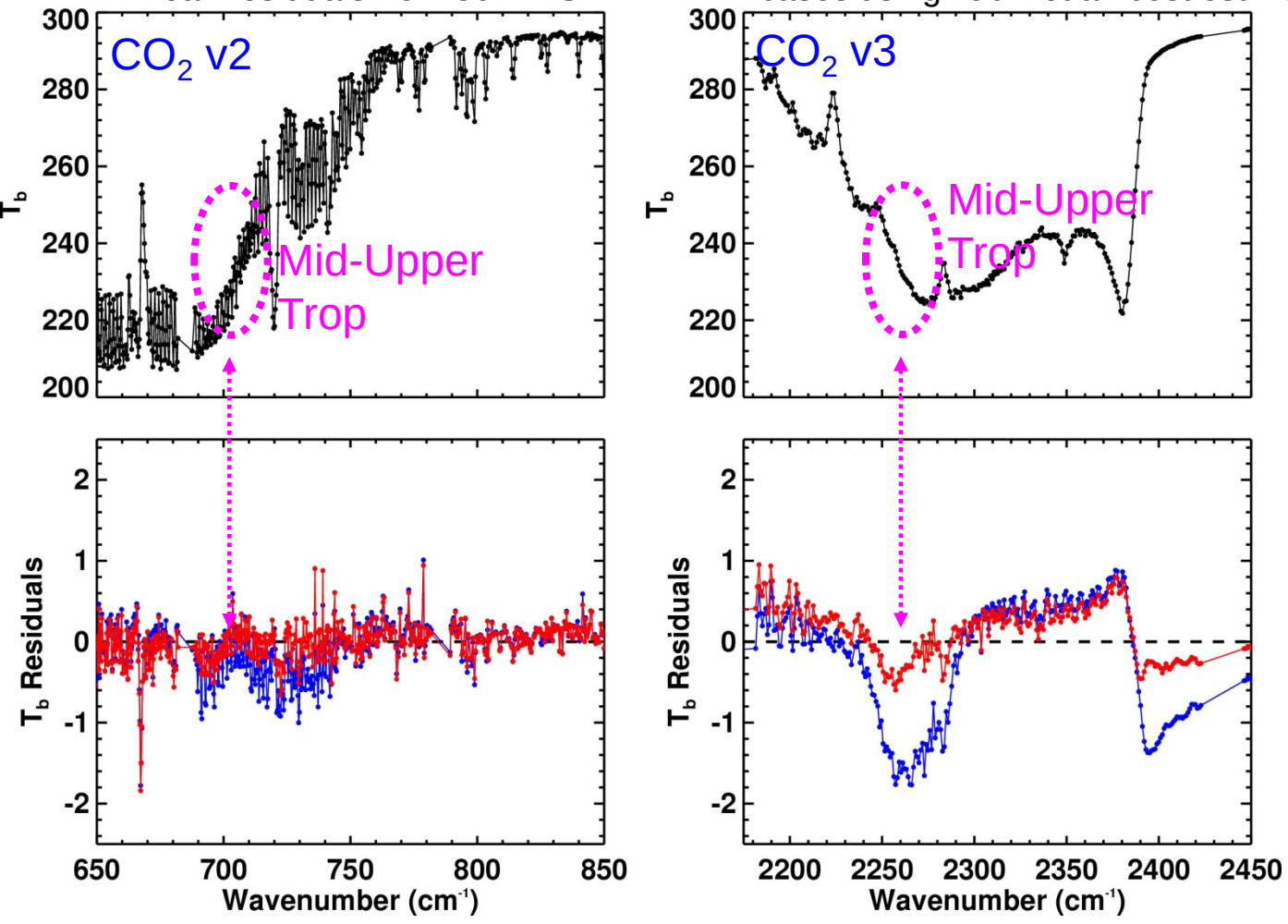
•Studying feasibility of active sensors including Radar and Lidar space measurements

ATMS Ch. 4 (O-B) GDAS



Line-By-Line and Spectroscopy

Mean residuals from 36 AIRS ARM TWP cases using Tobin et al. best estimate sonde profiles



Previous version (2006)

- No P/R line cpl
- HITRAN 2000 CO2 parameters

Latest version (2011)

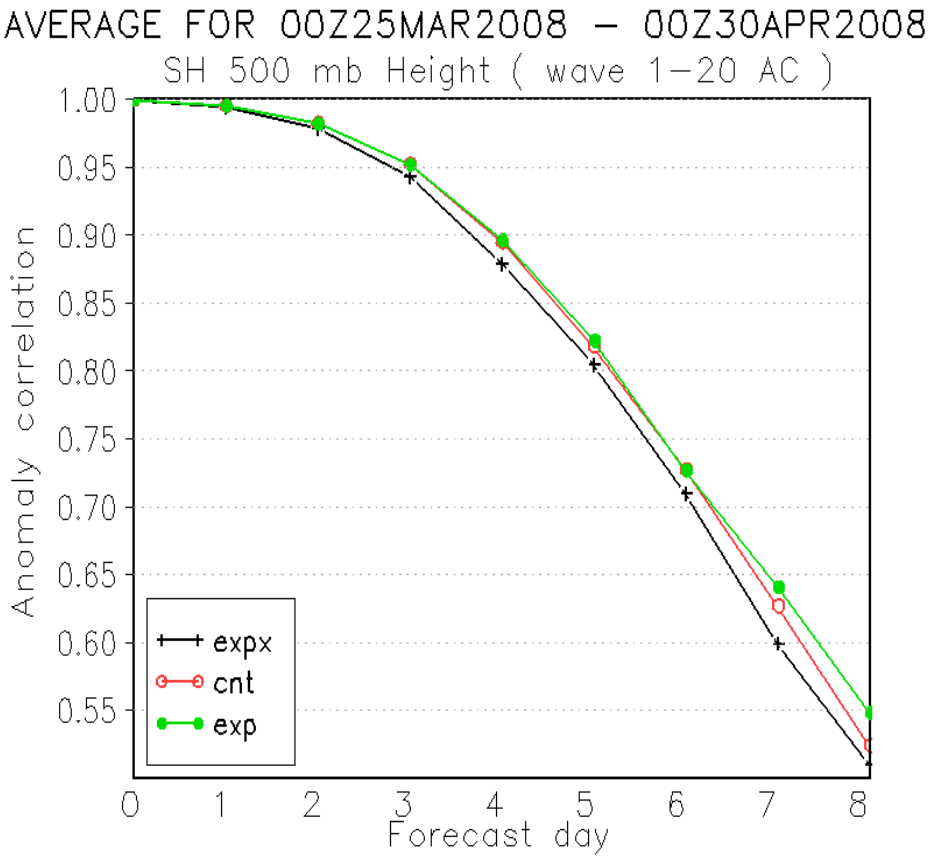
- P, Q and R line coupling
- Lamouroux et al. widths and line coupling
- Tashkun positions, intensities
- Updated CO2 and H2O continua

Improved agreement (Obs - Calc) and consistency across spectral bands!

(slide courtesy of V. Payne, formerly AER Inc.)

GPS RO Assimilation

- AC scores (the higher the better) as a function of the forecast day for the 500 mb gph in Southern Hemisphere
- 40-day experiments:
  - expx (NO COSMIC)
  - cnt (old RO assimilation code - with COSMIC)
  - exp (updated RO assimilation code - with COSMIC)

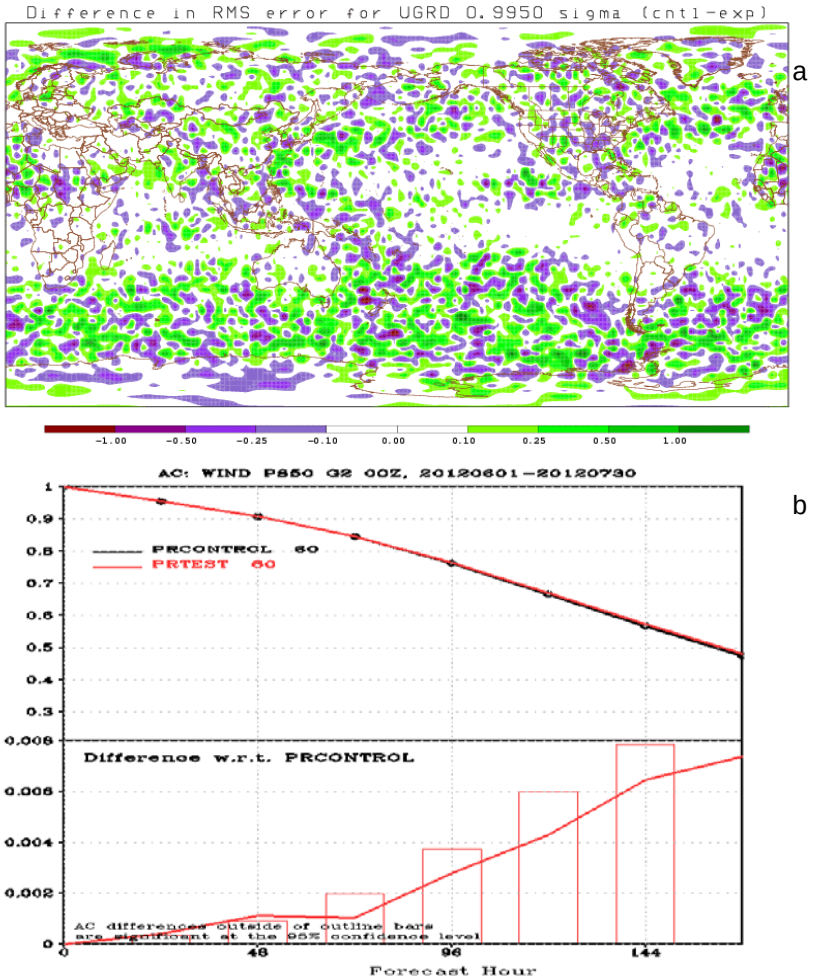


COSMIC provides 8 hours of gain in model forecast skill starting at day 4

Plots courtesy of L. Cucurull. Internal JCSDA project.

OSCAT Data Assimilation

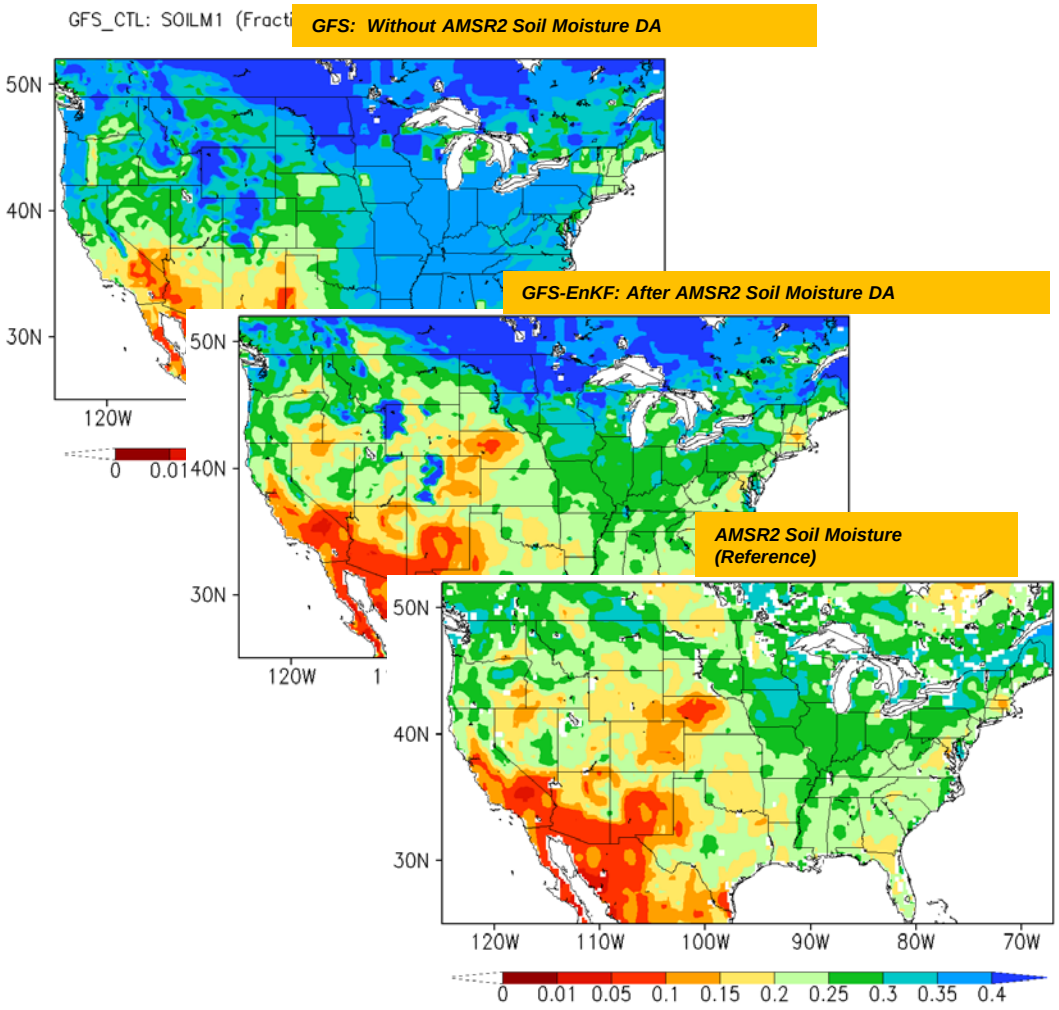
- Effort has led to current parallel testing of OSCAT DA in the GDAS system
- Both NESDIS and KNMI OSCAT data investigated
- Pre-assessment of data is necessary to optimize and characterize filtering, thinning, biases and observation error estimates
- Errors in wind direction has a bigger effect on A/C than intensity



Impact assessment of the OSCAT scatterometer data assimilation. These plots represent the forecast impact (b) and verification results (a) of OSCAT winds experiments. *They represent the change in anomaly correlation and RMS (increase or decrease) of the surface wind speed at 0.995 sigma level. The impact, globally, at 48 hours lead time is mixed, but overall positive. Plot courtesy of Li Bi, Riverside Inc, JCSDA Active Sensors data assimilation scientist.*

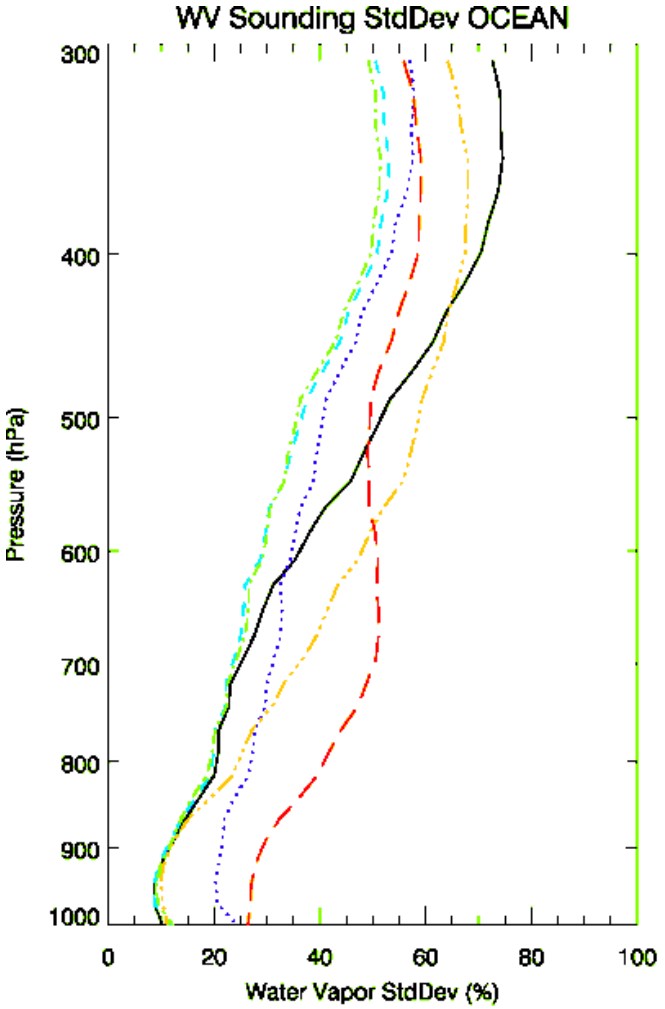
AMSR2 Land Data Moisture Assimilation

- **Assimilation of Satellite Soil Moisture Product from AMSR2 in NCEP Global Forecast System.**
- **Effort led by Weizhong Zheng and Michael Ek (NOAA/NCEP/EMC).**
- **Make use of soil moisture data generated in NESDIS (Zhan et al. 2012)**
- **This is a JCSDA Directed Research project.**



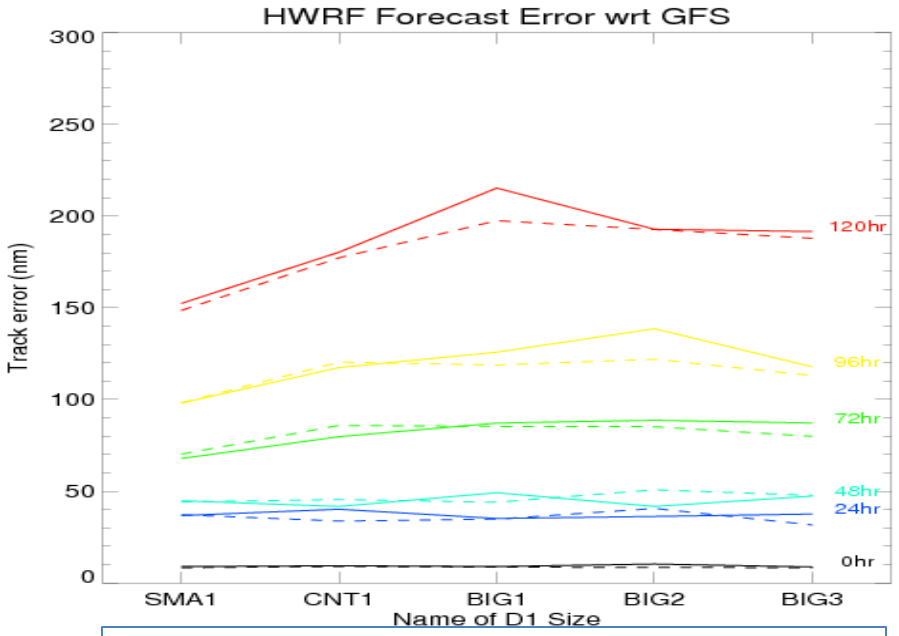
AMSR-2 Information Content Assessment for NWP Radiance Assimilation

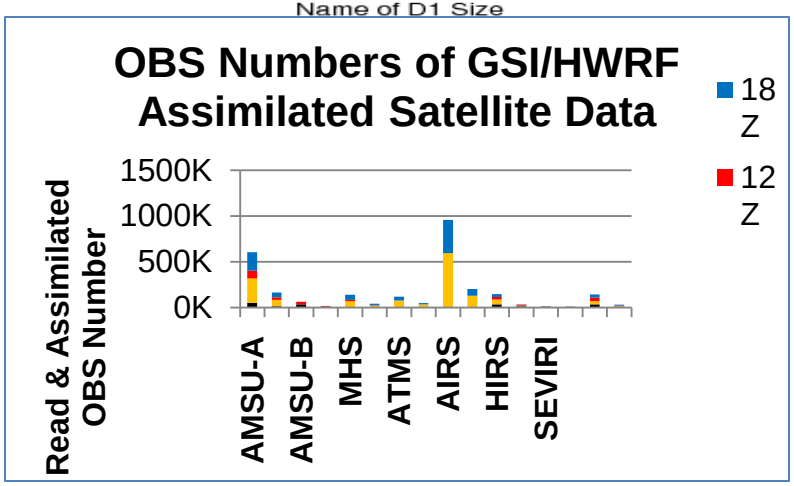
- **Data assimilation of GCOM-W AMSR-2: These data are currently not assimilated within NOAA systems.**
- **One perceived shortcoming of AMSR2 in NWP is that it does not have sounding channels.**
- **Recent effort showed that the multitude of imaging channels makes it possible to perform tropospheric moisture sounding.**
- **Information content analysis indicate that AMSR-2 lower troposphere moisture sounding is as good as AMSU/MHS and ATMS up to 700 mbar and as good as SAPHIR and MHS alone, up to 450 mbar.**
- **All microwave channels from AMSR-2 will be tested for assimilation purposes with potential impacts on global and regional forecasts (such as Hurricanes).**
- **Work in progress**



Regional Data Assimilation (HWRF)

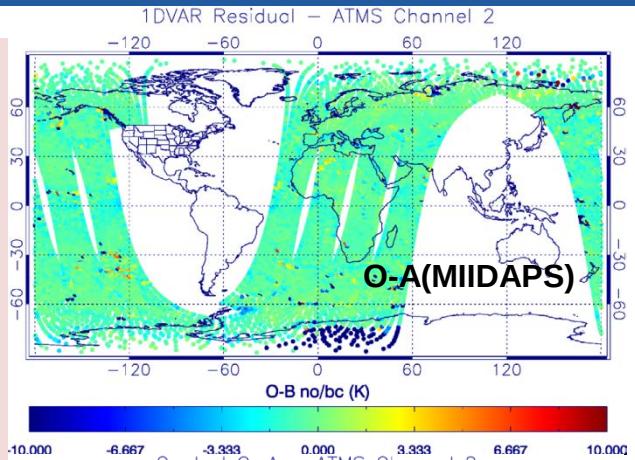
- Study to assess satellite data assimilation in HWRF
- As part of this study, impact assessment of boundary conditions on forecast skills
- It appears that boundary conditions have an overwhelming effect on regional forecasts
- The approach to be tested relies on global data assimilation with regional data sampling emphasis

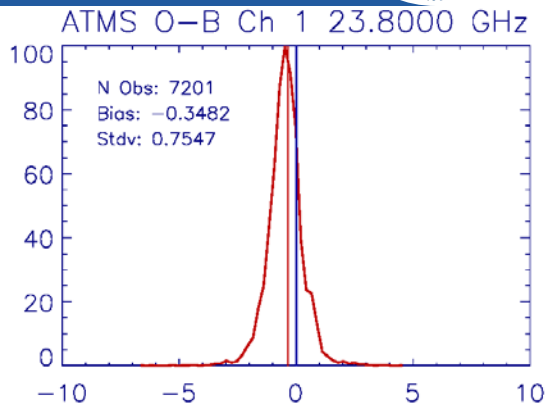


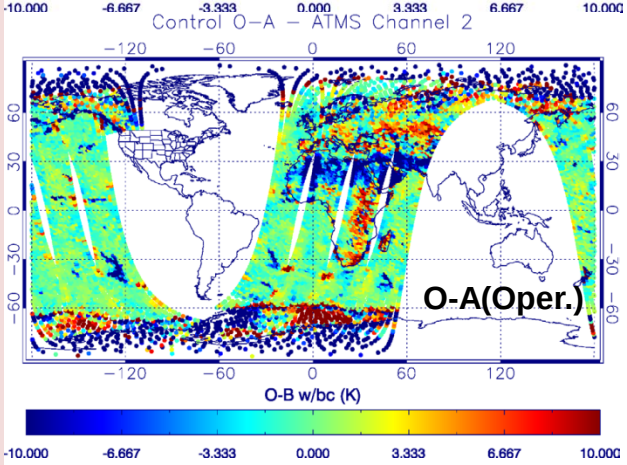


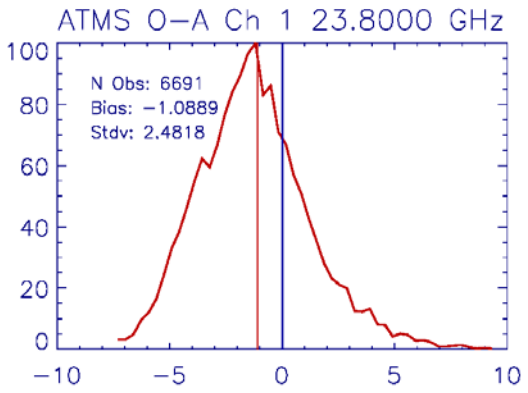
1DVAR Pre-Processing (MIIDAPS)

- **Efforts are on going to:**
  - Use 1DVAR as a pre-processor to NWP for quality control purposes
  - QC of satellite data, rain and ice detection, coast contamination,
  - RFI for imagers, etc)
  - based on MiRS technology (significant leverage)
  - Implement dynamically-retrieved emissivity in the NWP to allow assimilation of surface –sensitive channels
  - Assess assimilating sounding products in cloudy/rainy conditions







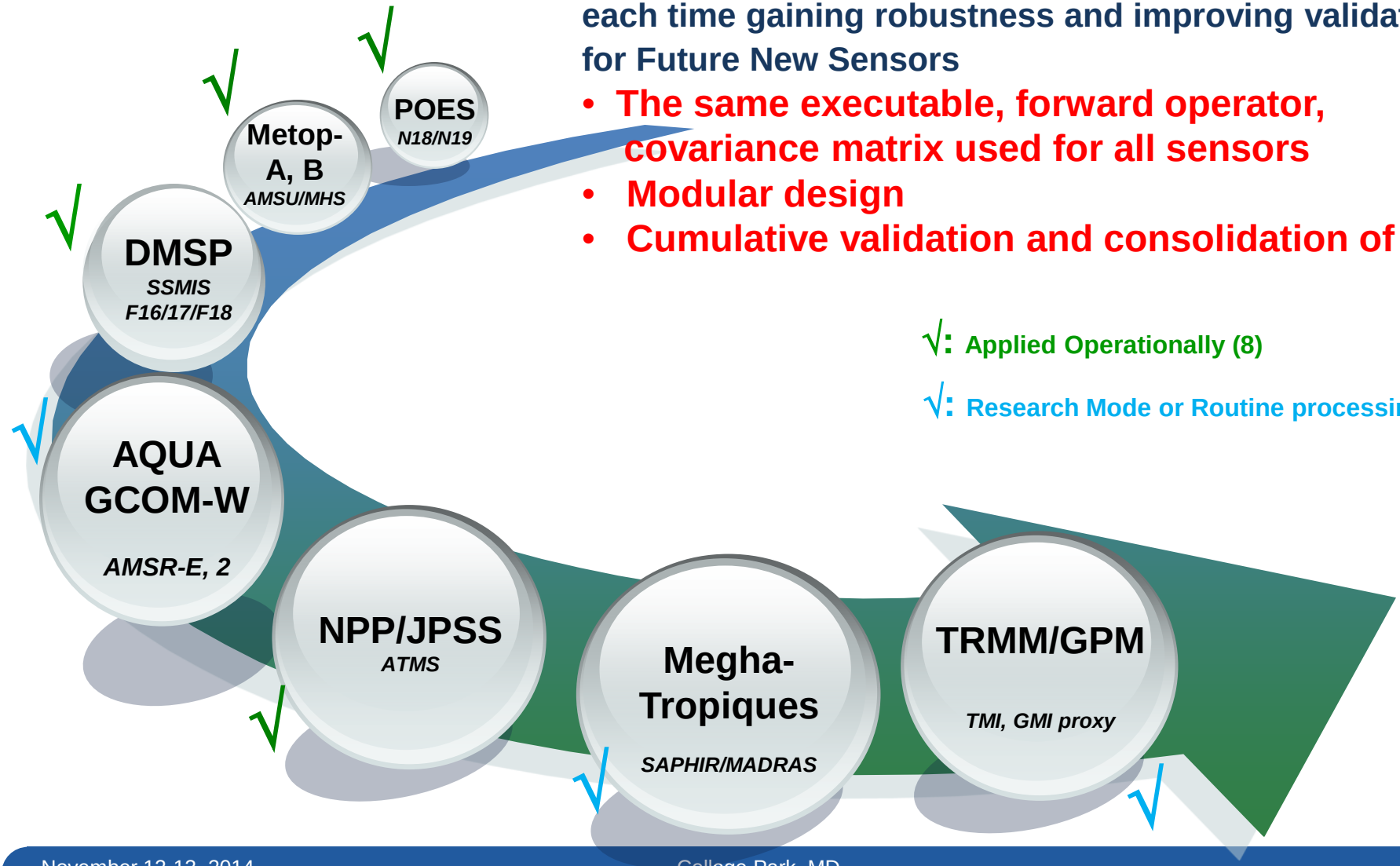


Goal is to have a community QC tool for satellite data assimilation pre-processing:
extend the MIIDAPS to all Sensors (IR & MW, geo/Pol)

Applicability of MiRS & MIIDAPS – Sensors-

MiRS is applied to a number of microwave sensors, each time gaining robustness and improving validation for Future New Sensors

- The same executable, forward operator, covariance matrix used for all sensors
- Modular design
- Cumulative validation and consolidation of MiRS



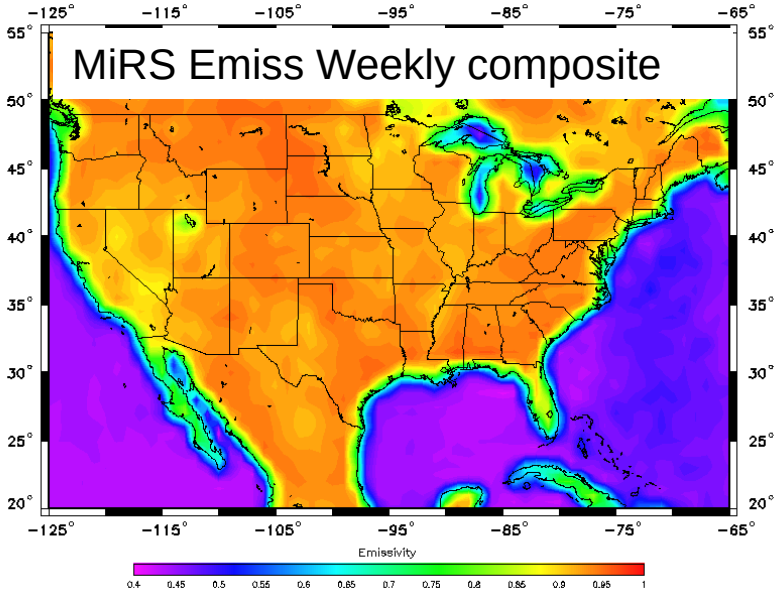
√: Applied Operationally (8)

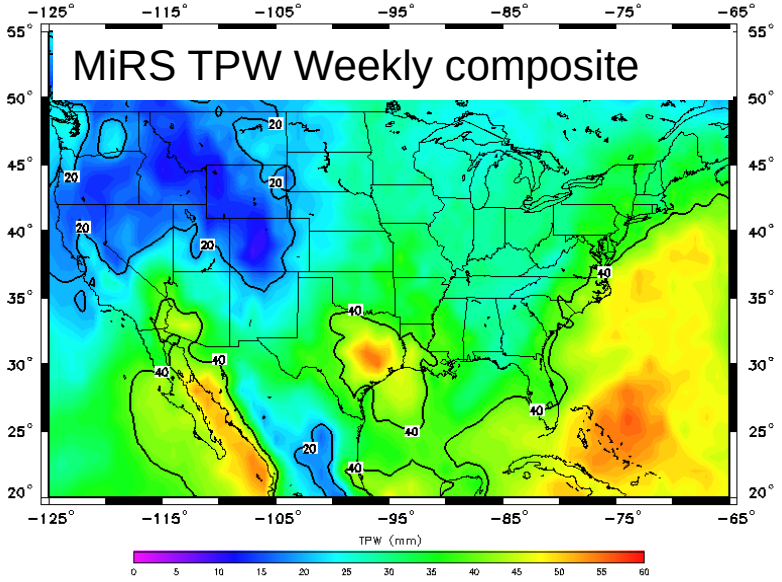
√: Research Mode or Routine processing (3)

Mixed Pixel Handling

(Coast, Partial beam filling)

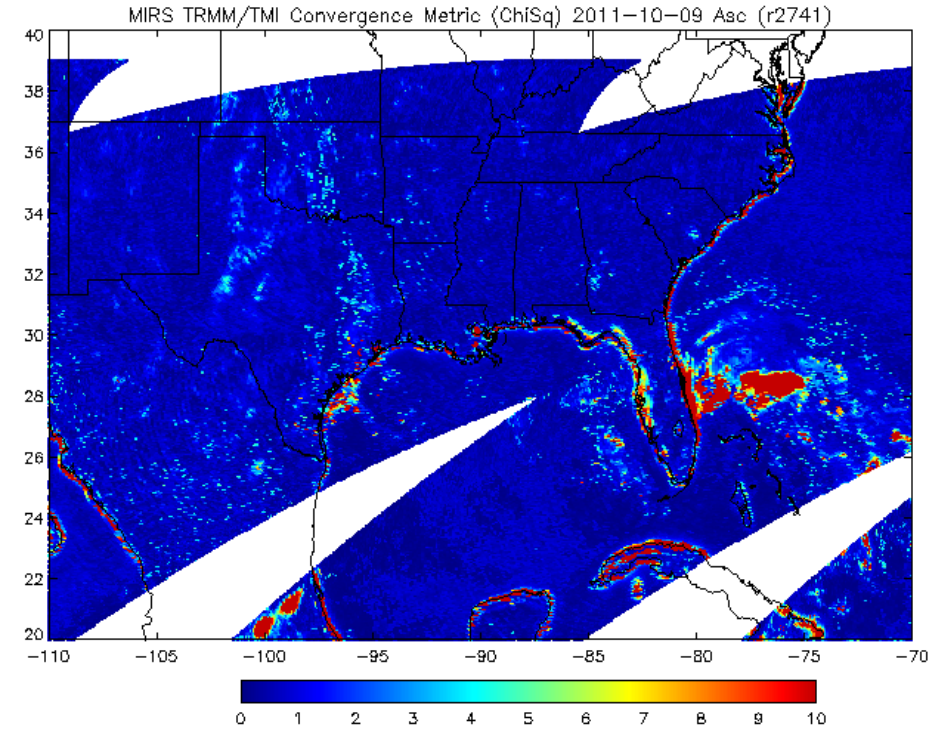
- Emissivity is highly variable,
- Especially when rain is present, or when it rained a before
- Also at the coastal and sea-ice transitions.
- It is also highly variable on a footprint-by-footprint level, in heterogeneous areas (rivers, coasts, mountains, etc)
- MiRS include emissivity in state vector, along with hydrometeor
- Rely on physical constraints and forward operator/Jacobian to distinguish emisssivity and hydrometeor signals



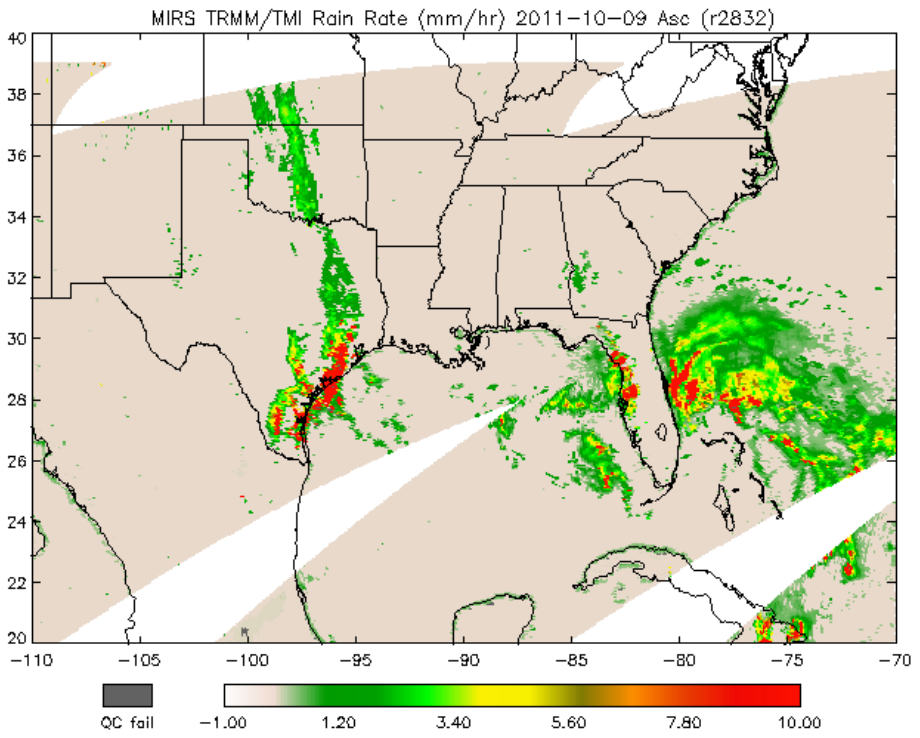


MiRS Rainfall from TMI data: TMI/GPROF 2A12

Errors in retrievals (due to coastal contamination for example, or heavy rain not easily simulated by CRTM) are detectable. Important QC aspect.



TRMM-2A12 Rainfall Rate (GPROF)

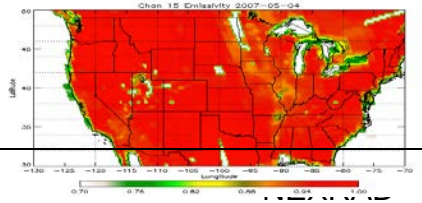


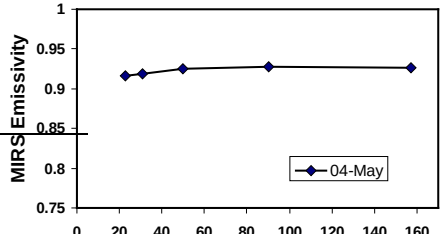
MiRS TRMM/TMI RR

Importance of Emissivity in Rain Cases

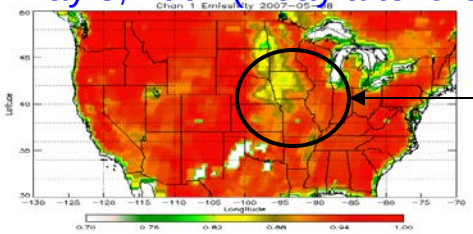
Emisivity at 23 GHz | Emisivity at 89 GHz | Emisivity Spectra (20-160 GHz)

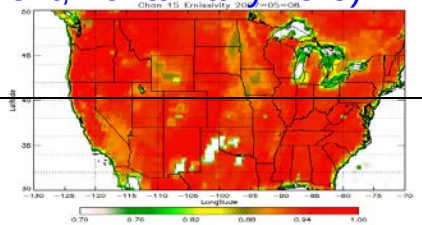
May 4, 2007 (before the event)

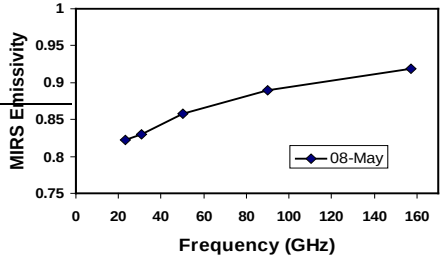




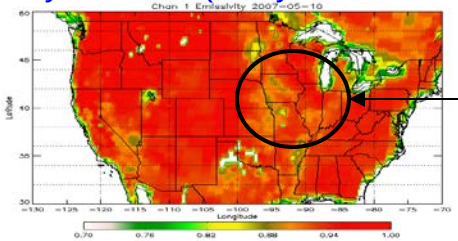
May 8, 2007 (1 day after the event, no rain anymore)

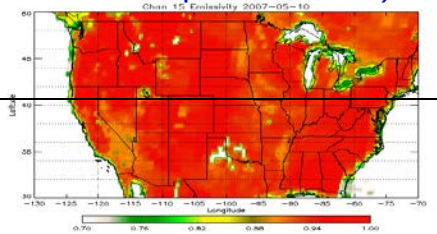


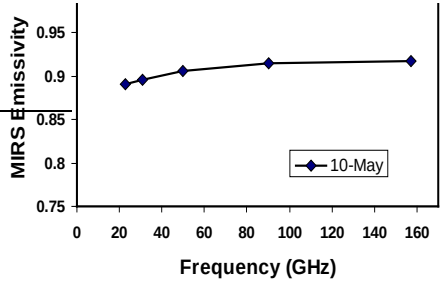




May 10, 2007 (3 days after event, emiss back to previous state)



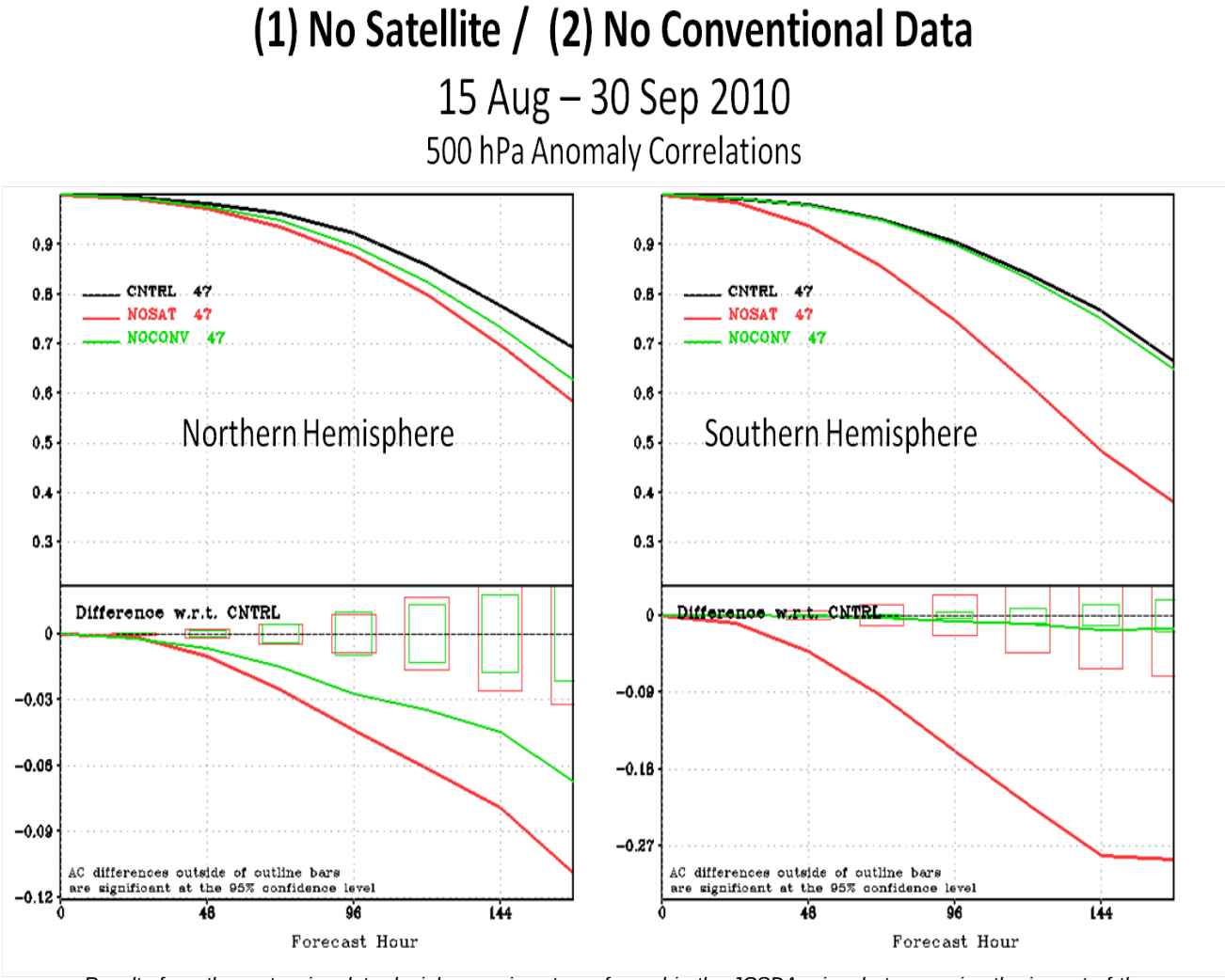




- MIRS responds to surface wetness variations before (May 4), right after the storm (May 8) and later (May 10). Note the emissivity depression at 21 GHz and the inverted emissivity spectra on May 8, 2007.
- Physically-consistent behavior noticed in the emissivity variation

OSE Activities / Impact Assessment

- An extensive assessment of the global observing system impact on NOAA forecast system has been undertaken.
- The impact assessment was done wrt satellite data (collectively &individually: microwave AMSU, MHS, GPS, hyperspectral IR, AMVs, etc) as well as conventional data.
- Satellite data as a group, had a very significant impact which surpasses the conventional data impact (by a wide margin), especially in the southern hemisphere.
- The impacts of individual classes of sensors did not add up to the significant impact above.



Results from the extensive data denials experiments performed in the JCSDA, aimed at assessing the impact of the global Plots courtesy of J. Jung.

OSSE Activities / Hypothetical Sensors

- **Sponsor-funded OSSE activities have been undertaken in FY13:**
  - Wind Lidar OSSE effort funded by NASA
  - Hyperspectral Geo sensor OSSE funded by NESDIS
  - DoD-requested OSSE in support of DMSP-follow on decision making

- **A new OSSE activity has been initiated in NOAA and JCSDA is playing a significant role**
  - In support of H. Sandy funded mitigation strategy
  - To explore value of several hyperspectral sensors
  - To explore value of GPS RO future configurations

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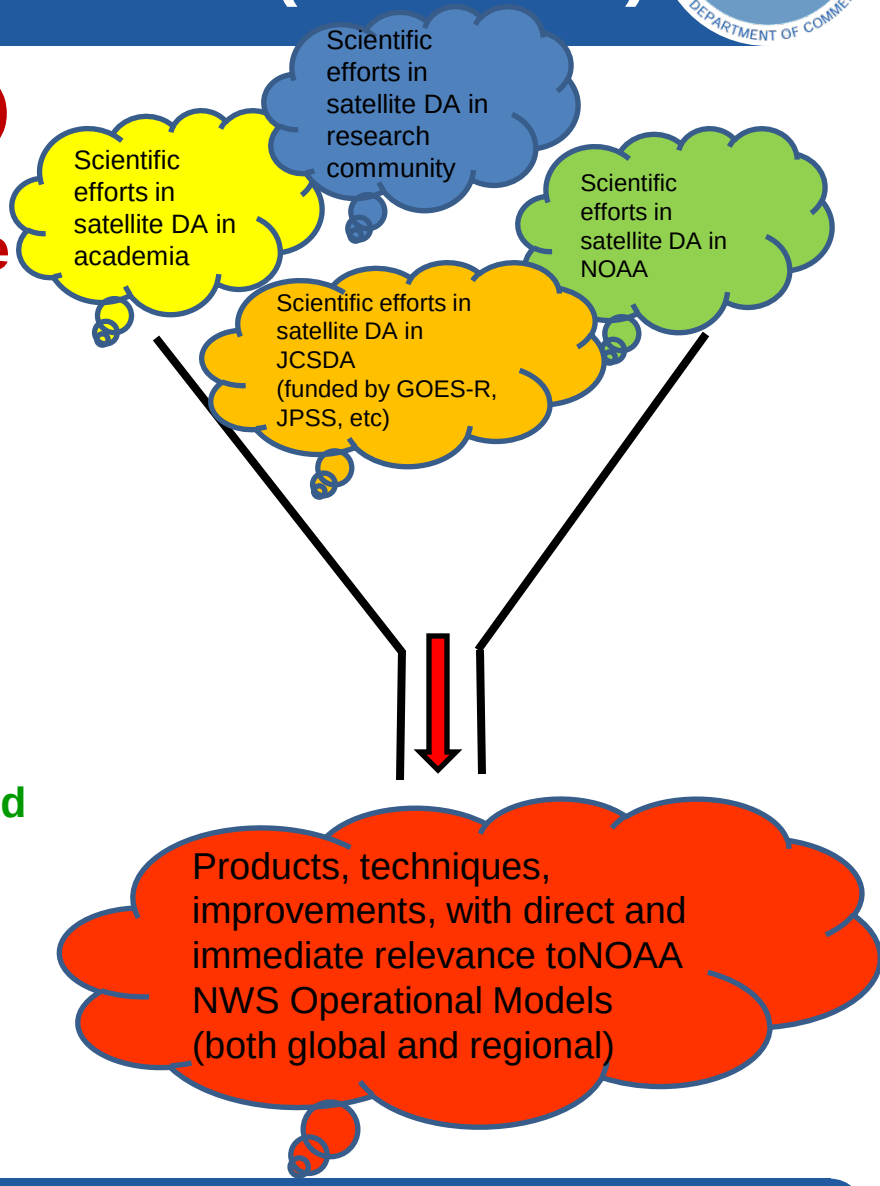
JCSDA External Research Program

- JCSDA committed to engage the external research community to benefit from outside expertise in satellite data assimilation
- Internal JCSDA partners NOT eligible
- Priorities Reviewed Each Cycle
- JCSDA acquired IT resources recently (supercomputer), made available to JCSDA external partners to test their science improvement on JCSDA partner systems and codes (O2R)
- The external research program is executed through (every year):
  - NOAA Federally-Funded Opportunity FFO (grants);
  - NASA ROSES announcement (contracts)
- ~50 projects funded since 2004
- Next FFO call will be for FY15 (announcement in Fall 2014).

JIBB Overarching Objectives (O2R/R2O)

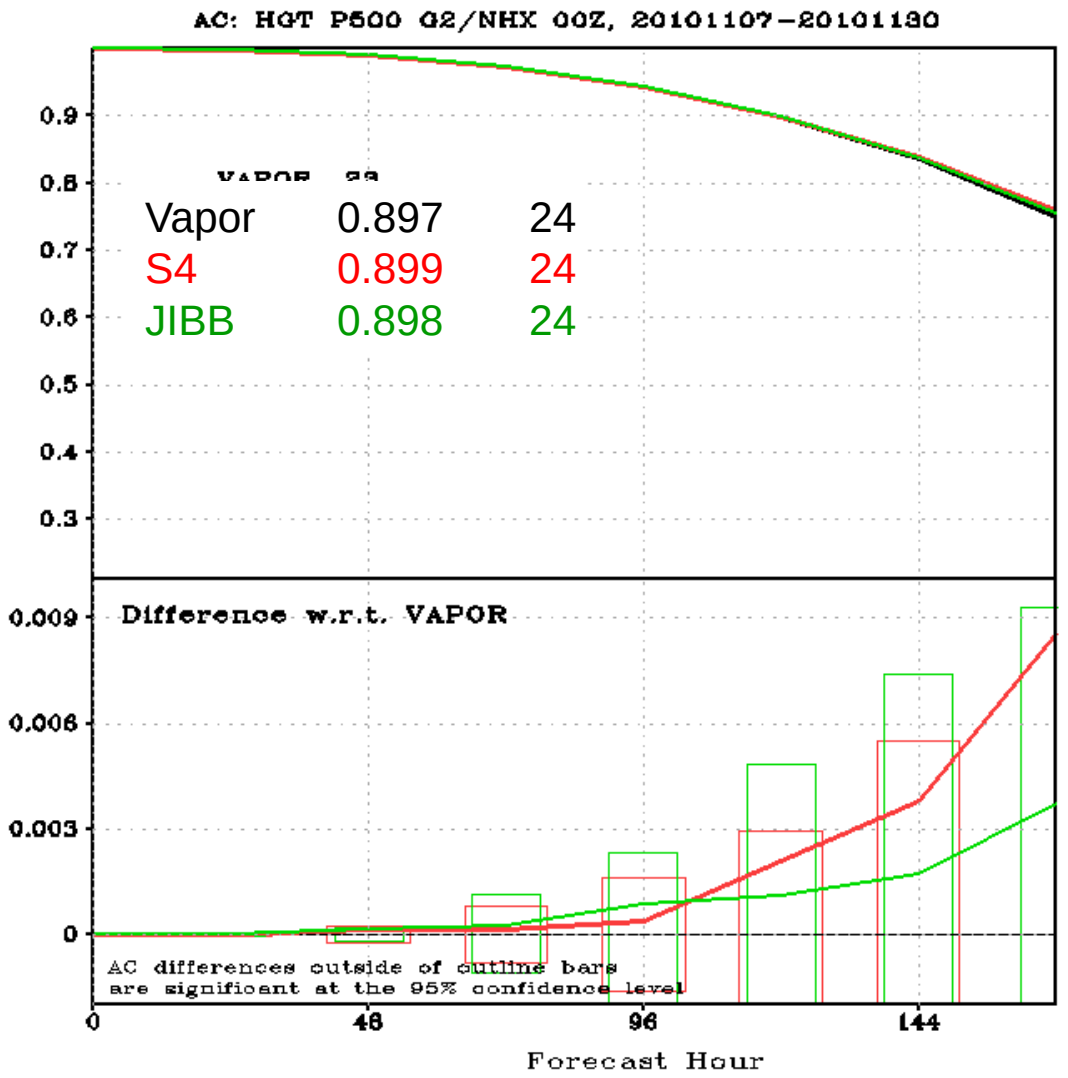
- **The JCSDA Supercomputer (JIBB) and NOAA's Supercomputers (S4 for NESDIS and Zeus for NWS) are a key component in the O2R strategy of the JCSDA for the NOAA partner.**

- **JIBB strategy aims at *'funneling'* the JCSDA data assimilation activities into an environment**
  - **Conducive for innovation and research, and**
  - **Relevant to Operations by *making sure* activities use operational models (which allows immediate benefits)**
  - **Offers an R2O path**



Benchmarking of O2R Infrastructure

- NOAA Global Satellite Data Assimilation System (GDAS) was implemented on the JCSDA supercomputer (JIBB) and the NESDIS Supercomputer (S4).
- Tests have been undertaken to compare results to those on the JCSDA machine (JIBB) and the NOAA R&D machine Vapor
- *performances comparison between a series of runs between S4-based, JIBB-based and Vapor-based supercomputers show that correlation performances are consistently similar.*
- *This allows us to declare that the O2R is ready*



Plot courtesy of (J. Jung, JCSDA PI)

Training, Education & Outreach

- Monthly Seminar Series on DA
- Summer colloquium in satellite data assimilation (3-year cycle)
  - Next one planned for summer 2015
- Annual JCSDA workshop on satellite data assimilation.
  - Next one planned for May 13-15 2015
- Joint Workshops w/ Other Programs &International Partners.
  - DTC-JCSDA joint workshop/tutorial, ECMWF-JCSDA workshop
- JCSDA Newsletters (quarterly)
  - Highlight achievements by JCSDA scientists (internal/external)
  - Disseminate results and promote collaboration
- NOAA co-sponsoring a DA tenured position at UMD.
  - Long-term benefit to JCSDA partners: training DA experts)
- Active web site: jcsda.noaa.gov

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Summary

- JCSDA is Interagency Partnership preparing US operational users to benefit from new data as soon as possible after launch
- Scientific Activities of JCSDA are diverse: RT, Ocean, Land, Aerosol, Cloudy Assimilation, etc.
- JCSDA activities have had clear impact on operational activities in all partners
  - Joint systems and code (CRTM, LIS, GSI)
  - Additional sensors (ATMS, OSCAT, AIRS, MODIS, COSMIC, IASI, SSMI/S)
  - Ongoing improvements to assimilation methodology and diagnostics
- The O2R capability established in JCSDA consolidates the R2O linkage between NWP community and research community
- Increased collaboration both internally (between partners), nationally and internationally, always welcome and sought
  - VSP and new JCSDA computing are vehicles to strengthen or establish this collaboration