A Modeling and Data Assimilation Perspective

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NOAA Satellite Science Week

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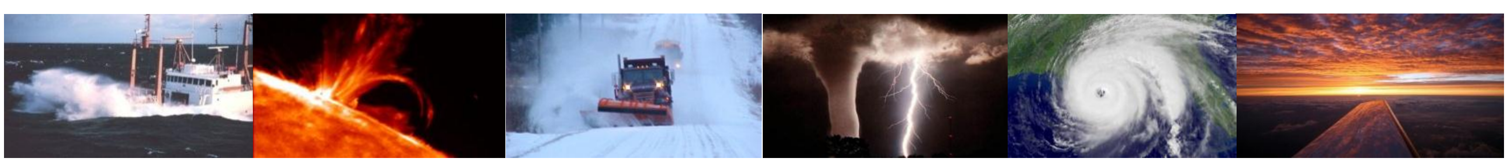
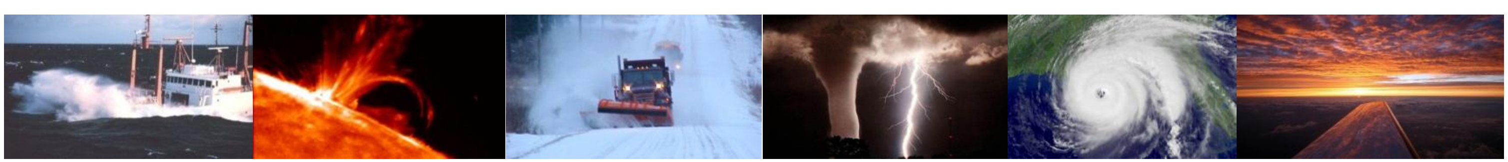


Overview

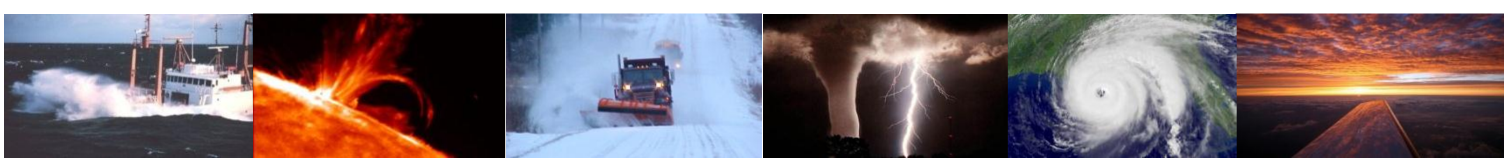
- Background
- Use of Satellite Data in NWP
- Addressing Research to Operations
- Future Directions
- Summary and Goal for Session



Background

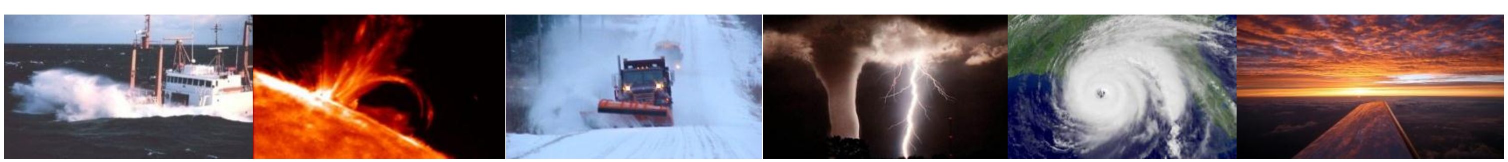
- Critical Components of Environmental Modeling
  - Computing Capability
  - Observations
  - Science
    - Model Development
    - Data Assimilation

Use of Satellite Data in NWP

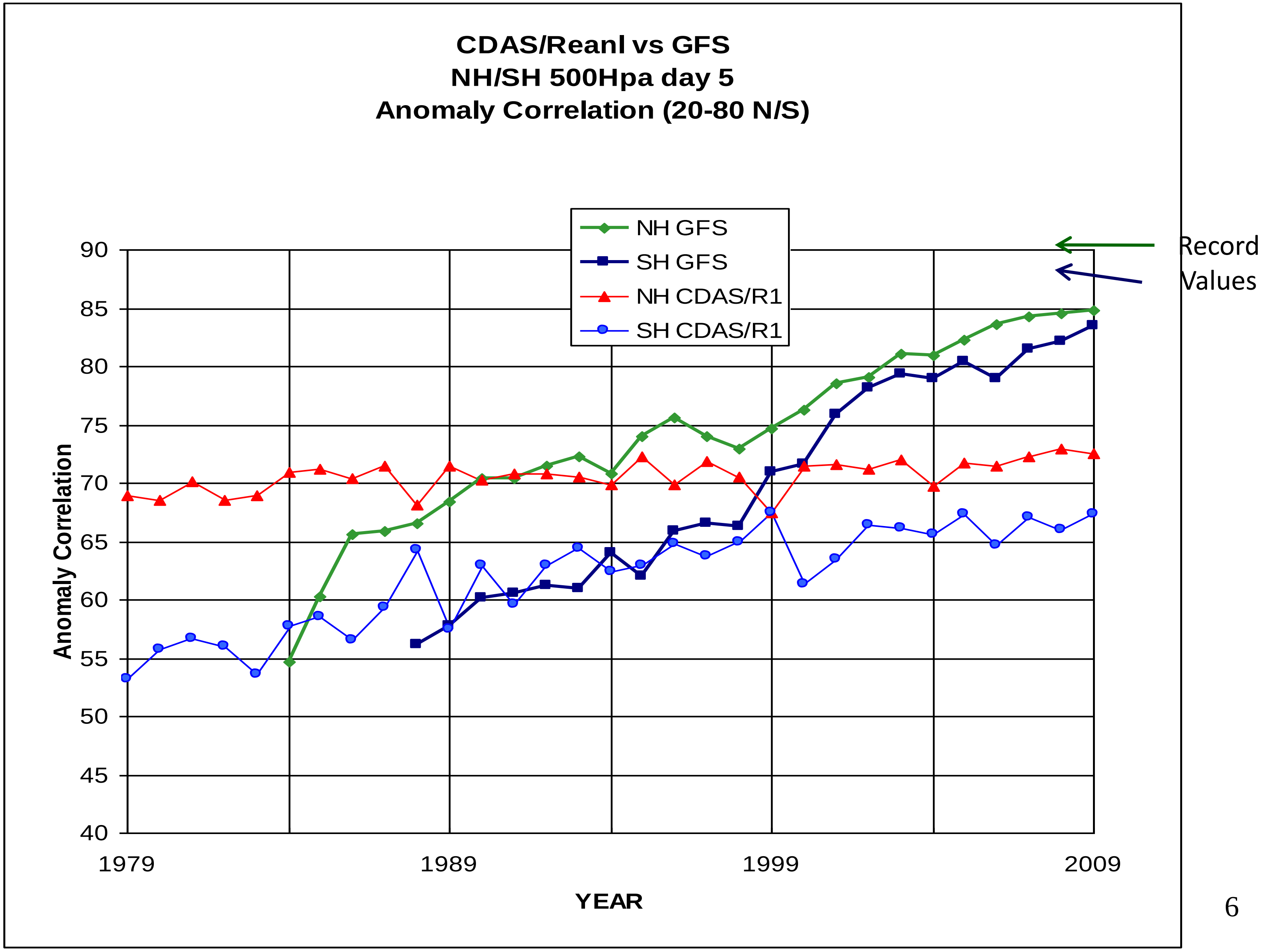


Sensor Data Assimilated

- HIRS sounder radiances
- AMSU-A sounder radiances
- AMSU-B sounder radiances
- AIRS* sounder radiances
- IASI sounder radiances
- GOES sounder radiances
- GOES, Meteosat, GMS winds
- GOES precipitation rate
- SSM/I precipitation rates
- TRMM* precipitation rates
- SSM/I ocean surface wind speeds
- ERS-2* ocean surface wind vectors
- Quikscat* ocean surface wind vectors
- JASON ocean surface altimetry
- AVHRR SST
- AVHRR vegetation fraction
- AVHRR surface type
- Multi-satellite snow cover
- Multi-satellite sea ice
- SBUV/2 ozone profile & total ozone
- MODIS* polar winds
- GPS Radio Occultation
  - COSMIC, METOP/GRAS, GRACE,* SAC-C*, TerraSAR-X*
- SSMIS
- OMI*
- AMSR/E*
- MSG Seviri



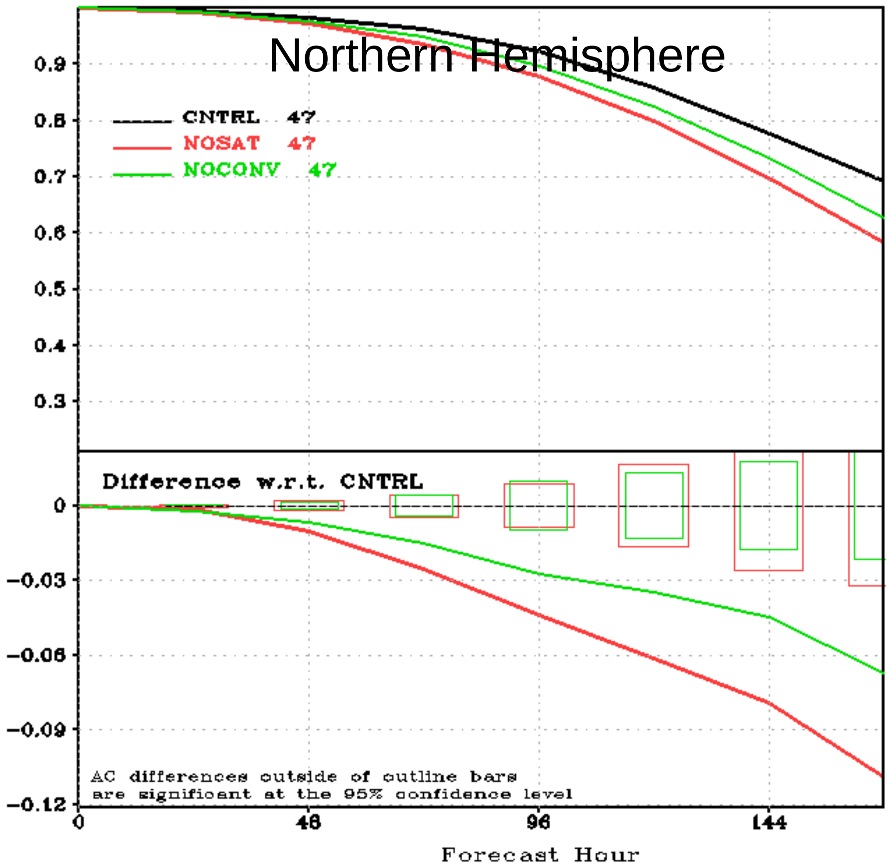
Assimilation of Satellite Radiances Leads to Improved GFS Performance

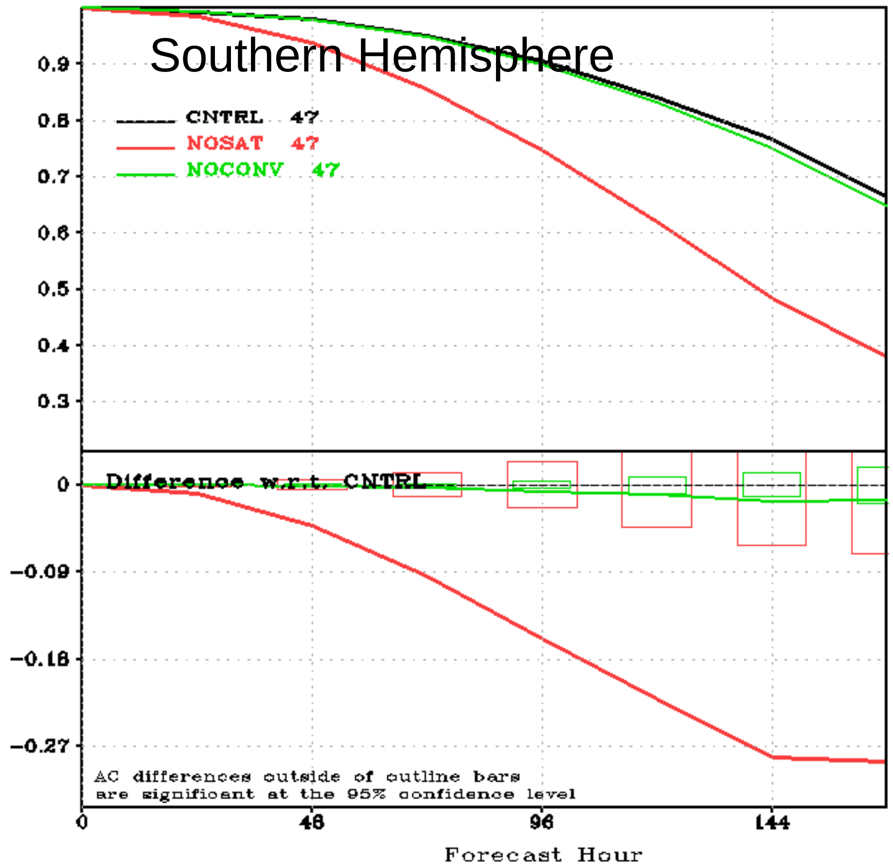


(1) No Satellite / (2) No Conventional Data

15 Aug – 30 Sep 2010

500 hPa Anomaly Correlations

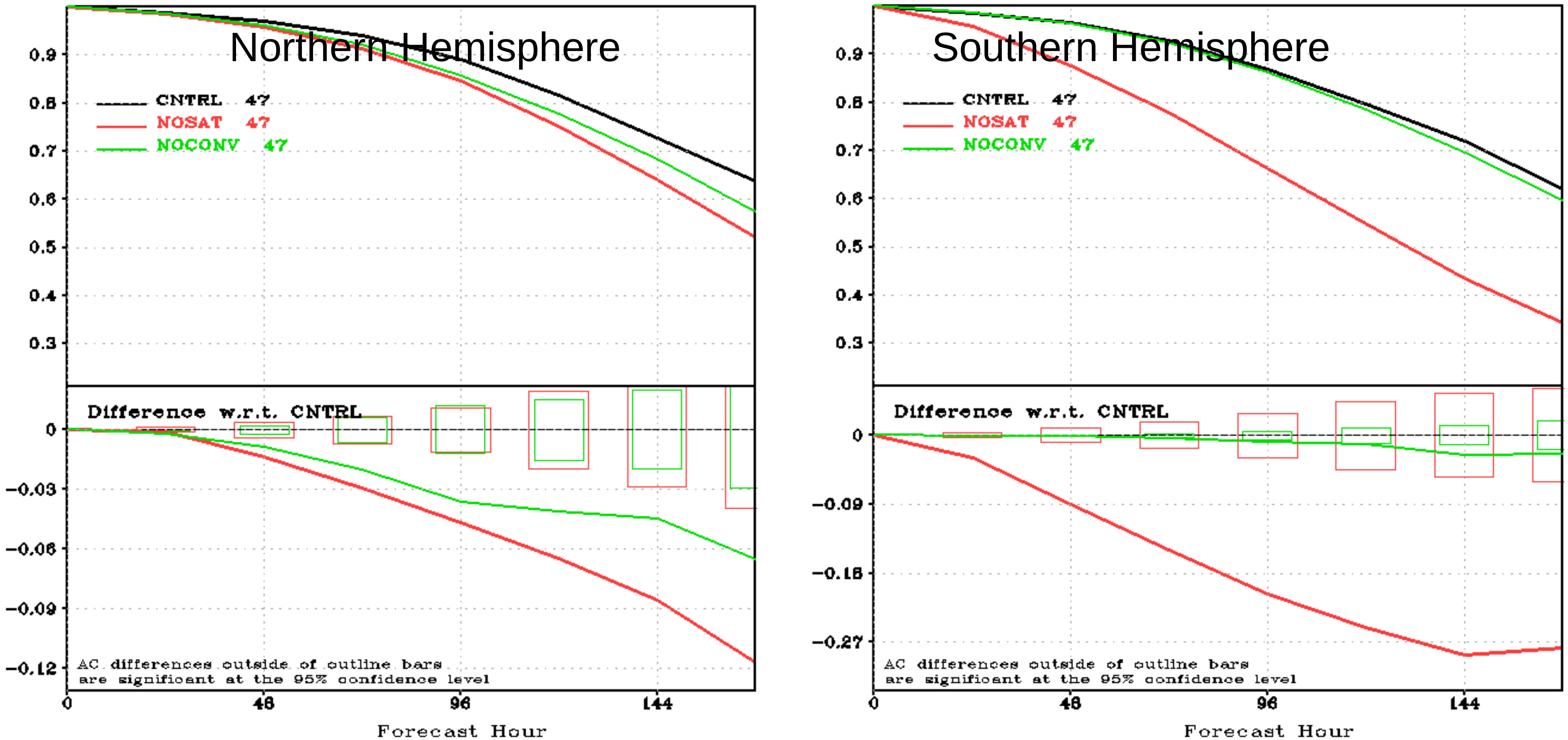




(1) No Satellite / (2) No Conventional Data

15 Aug – 30 Sep 2010

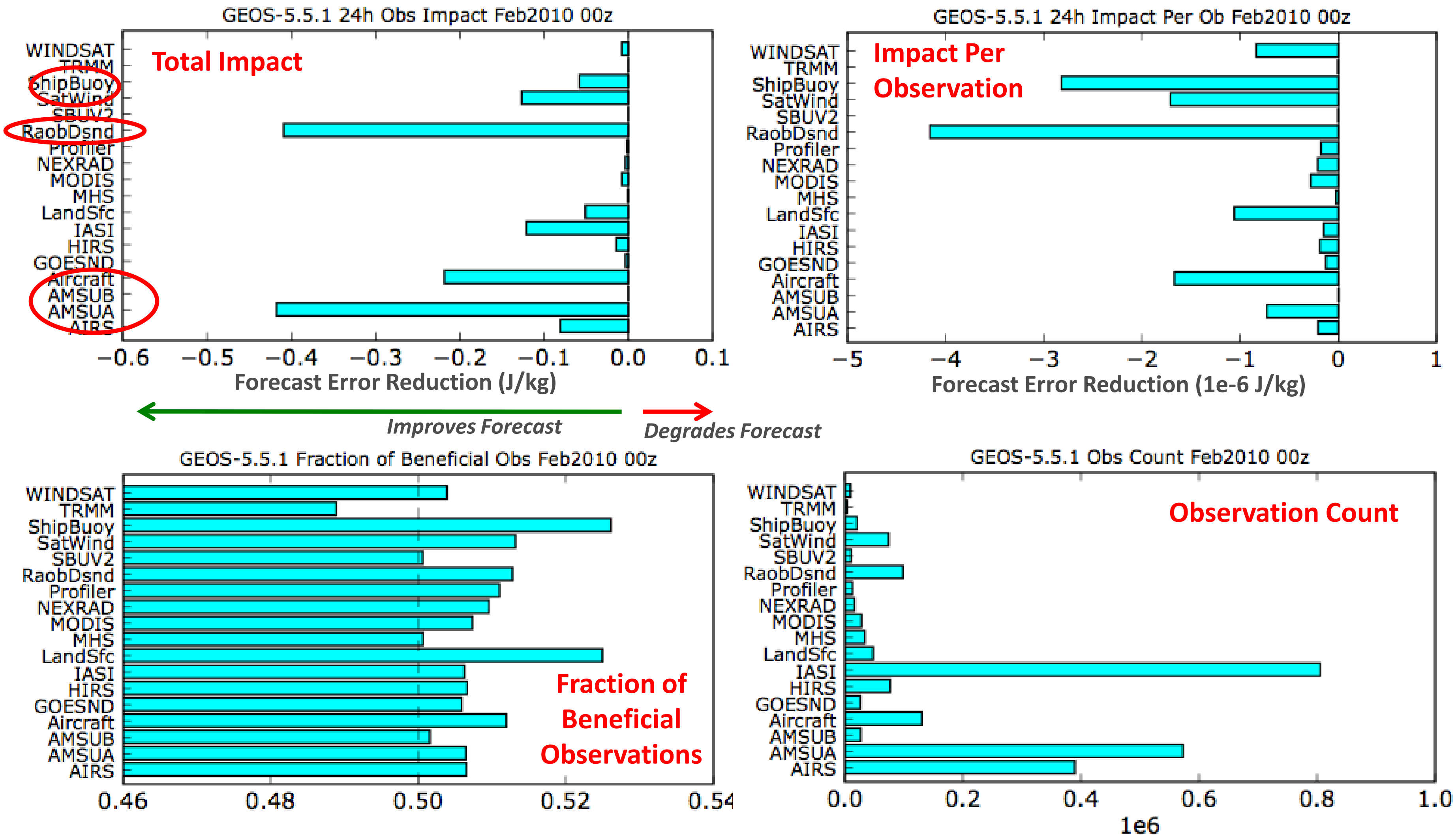
1000 hPa Anomaly Correlations



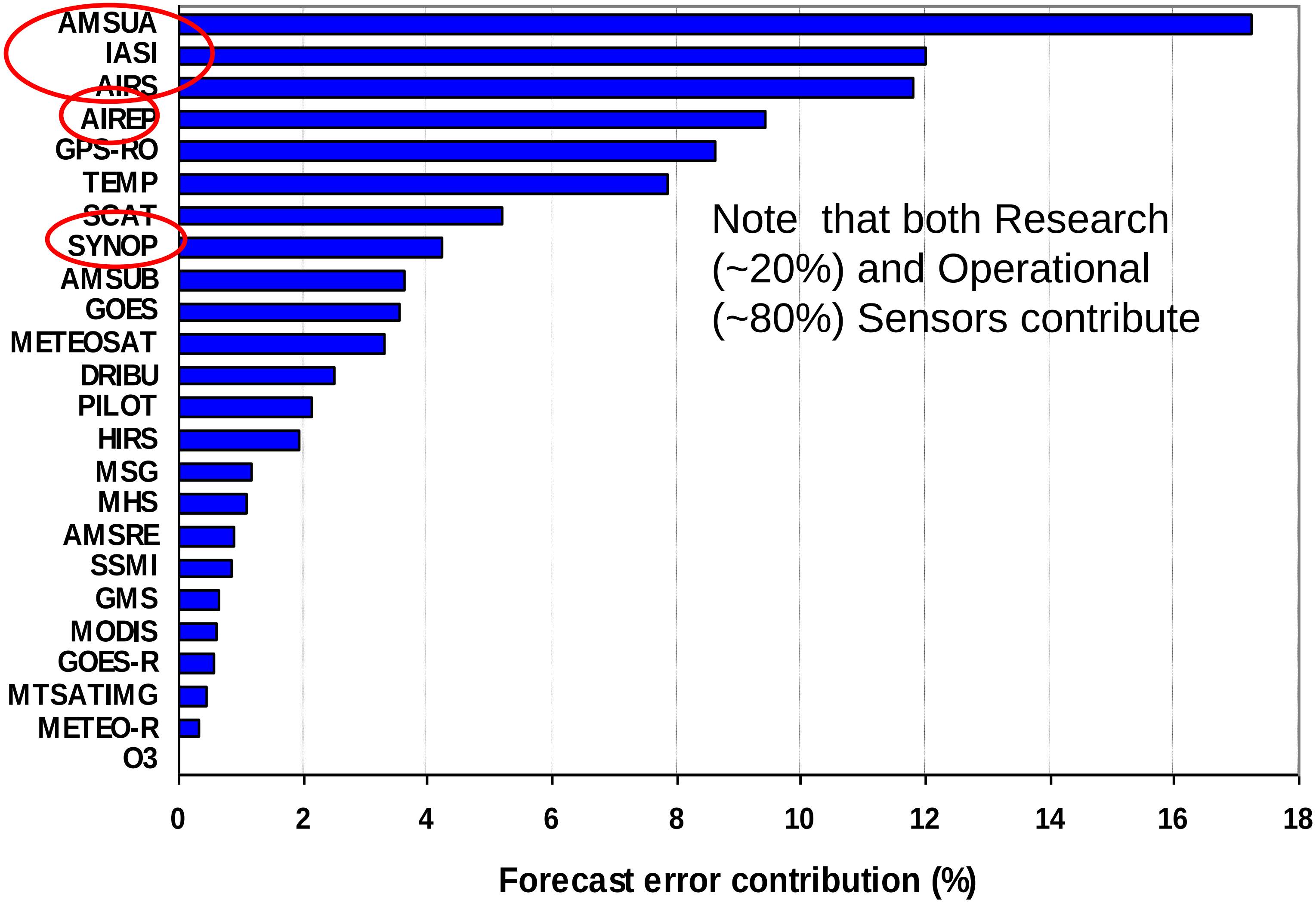
Impacts of Various Observing Systems in GEOS-5.5.1

Ron Gelaro, GMAO

24-hr Forecasts from 00z Analyses on 28 Jan – 02 March 2010
Adjoint-Based Global Forecast Error Measure



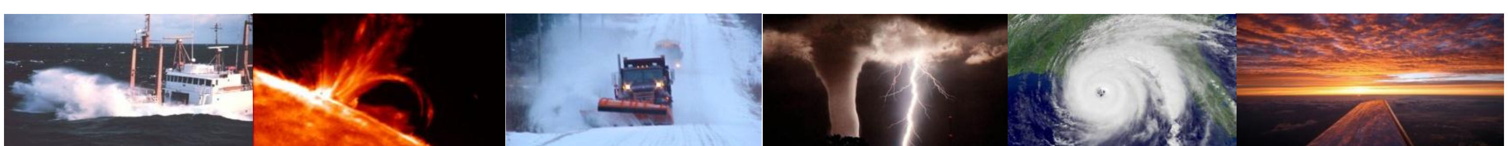
Adjoint-based Observation Impact Analysis from the European Center



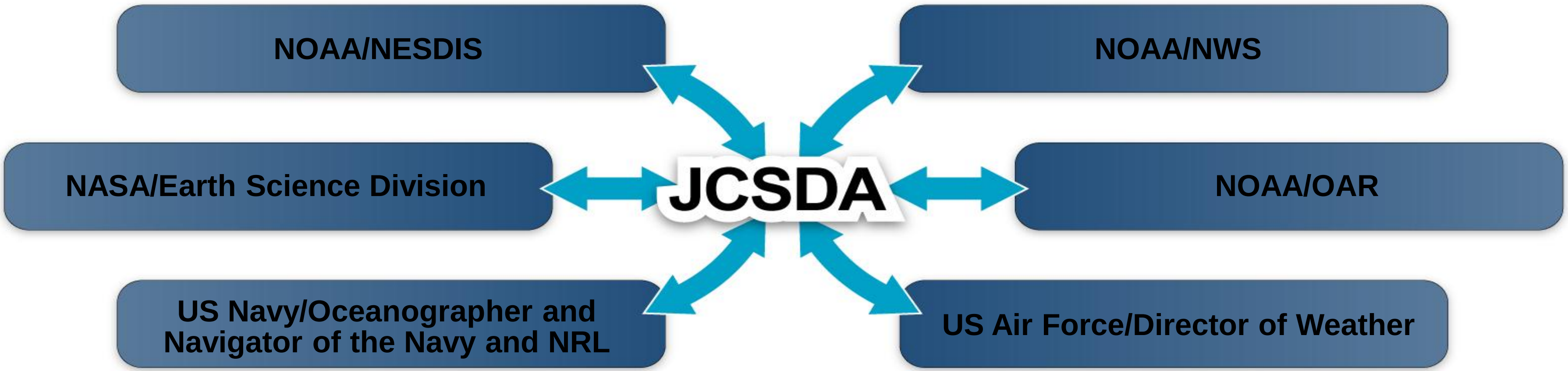
Note that both Research (~20%) and Operational (~80%) Sensors contribute

(Contribution (%) to Total Forecast Error Reduction)

Addressing Research to Operations



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 Science Priorities

Overarching goal: Help the operational services improve the quality of their prediction products via improved and accelerated use of satellite data and related research. ***R2O***

Science Priority Areas:

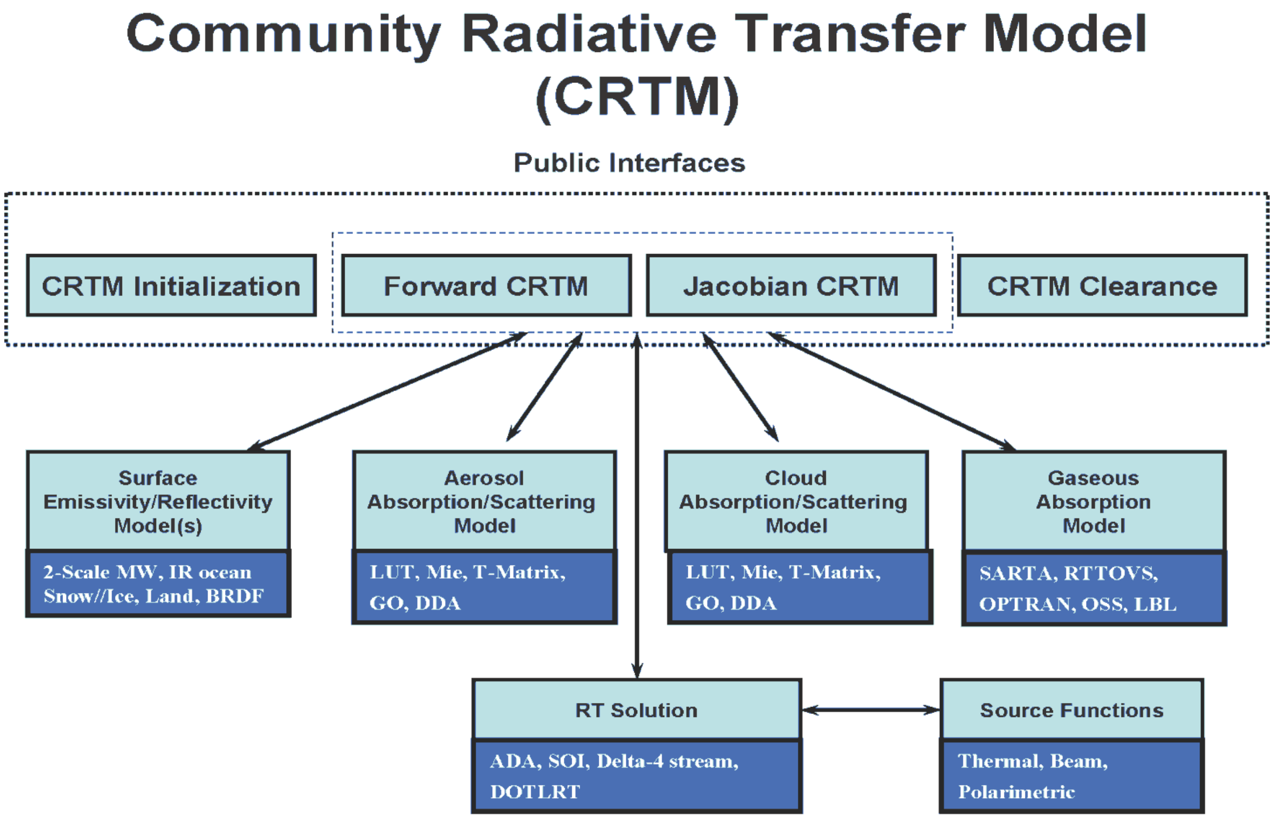
- Radiative Transfer Modeling (CRTM)
- Preparation for assimilation of data from new instruments
- Clouds and precipitation
- Assimilation of land surface observations
- Assimilation of ocean surface observations
- Atmospheric composition; chemistry and aerosol

These are addressed using a variety of Resources: JCSDA Partner in-kind; JCSDA Base, and Satellite and other Program

Community Radiative Transfer Model

Supports over 100 Sensors

- GOES-R ABI
- Metop IASI/HIRS/AVHRR/AMSU/MH
- TIROS-N to NOAA-18 AVHRR
- TIROS-N to NOAA-18 HIRS
- GOES-8 to 13 Imager channels
- GOES-8 to 13 sounder channel 08
- Terra/Aqua MODIS Channel 1-10
- MSG SEVIRI
- Aqua AIRS, AMSR-E, AMSU-A,HSE
- NOAA-15 to 18 AMSU-A
- NOAA-15 to 17 AMSU-B
- NOAA-18/19 MHS
- TIROS-N to NOAA-14 MSU
- DMSP F13 to15 SSM/I
- DMSP F13,15 SSM/T1
- DMSP F14,15 SSM/T2
- DMSP F16-20 SSMIS
- Coriolis Windsat
- TiROS-NOAA-14 SSU
- FY-3 IRAS, MWTS,MWHS,MWRI
- NPP/JPSS CrIS/ATMS



Contributions by all JCSDA partners, and used by all JCSDA partners. Provides basis for other JCSDA science priorities, and model for collaboration, sharing, and re-use.

(Courtesy of F. Weng, JCSDA Chief Scientist)

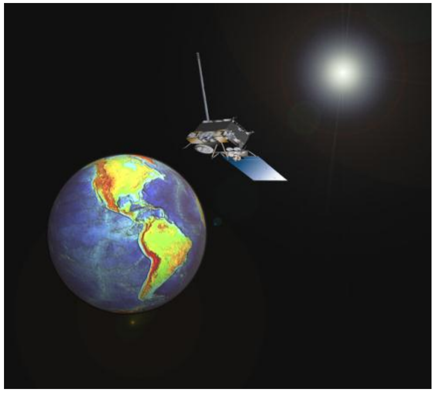
JCSDA Access to Computing

- Before 2011: Limited Computing Resources
  - Limited availability on ops/parallel machines
  - Limited opportunity for internal and external researchers in support of R2O
- Now: Dedicated Computer System
  - "JCSDA in a Big Box" = JIBB
  - Provided by NASA and NOAA and hosted at GSFC
  - Science Integration Support provided by NESDIS and other Partners
  - Offers Operational models, GSI, CRTM, etc.
  - O 2 R at work

Future Directions

Historical GEO Role

- Limited use for model initialization
- Principally used by forecast community: became the "eyes" for the forecaster
  - Timely access a key

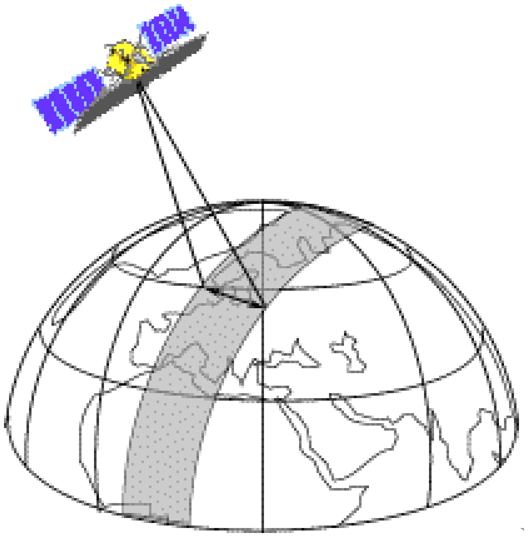


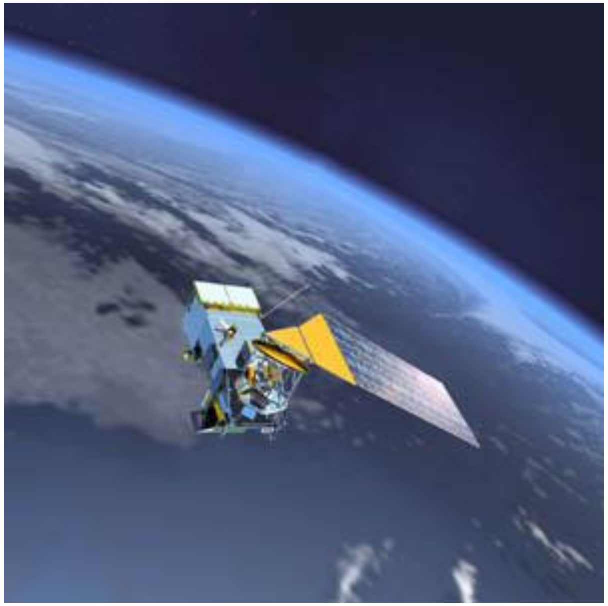
"The greatest single advancement in observing tools … was unquestionably the advent of the geosynchronous meteorological satellite. If there was a choice of only one observing tool for use in meeting the responsibilities of the NHC, the author would clearly choose the geosynchronous satellite with its present day associated accessing, processing, and displaying systems …"

Sheets, R.C., 1990. The National Hurricane Center – Past, Present, and Future. *Wea. Forecasting*, 5: 185-232.

Historical LEO Role

- Higher spatial resolution
- The backbone of the Global Observing System for numerical models – Sounder Data
- Was not readily available to the forecaster in "real time"

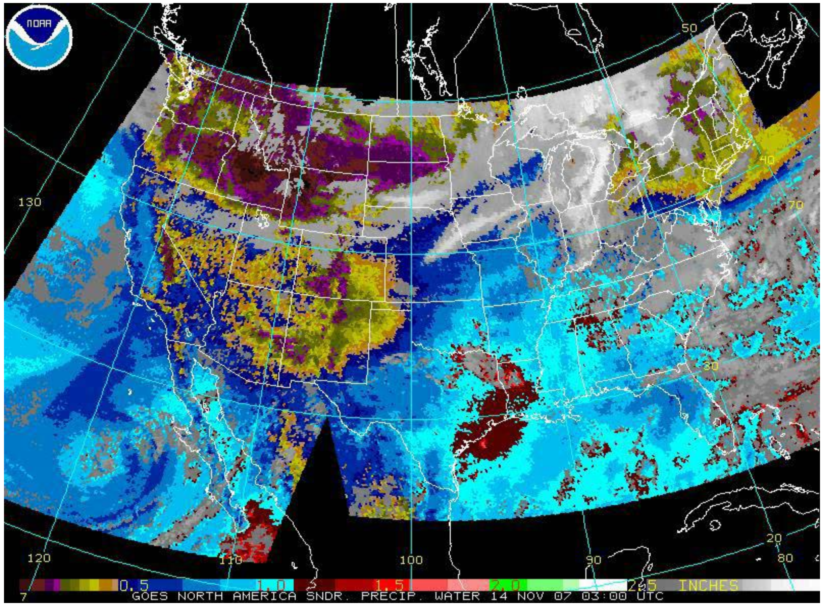




Today

- Distinction is becoming blurred
  - LEO data more readily available in "real time" for forecaster applications
  - GEO used quantitatively in numerical models (winds, land surface, SST)
  - GEO now providing "Derived Product Images"
- Instrument and product research and development still outpace operational use
- Supports the need for the JCSDA and other Testbeds, Proving Ground

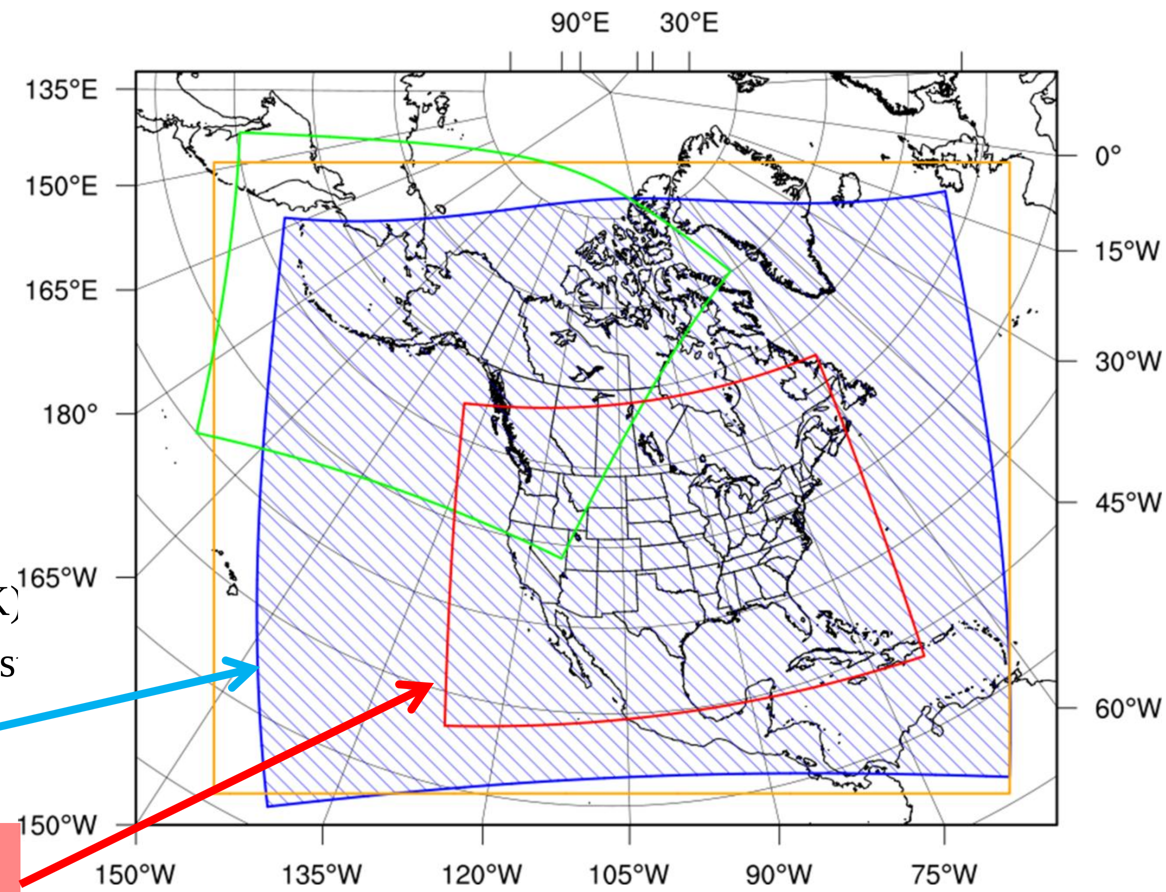
NOAA-18 Image of CA fires



GOES Sounder-Derived Precipitable Water

Recent Modeling Advances

- Rapid Refresh – May 1, 2012
  - 13 km WRF and GSI with RUC features
  - Increased domain
  - Introducing experimental North American Rapid Refresh Ensemble using Time Lagged (NARRE-TL)
    - 10 members
    - 2 output grids (US,AK)
    - 12 km, 12 hour forecas

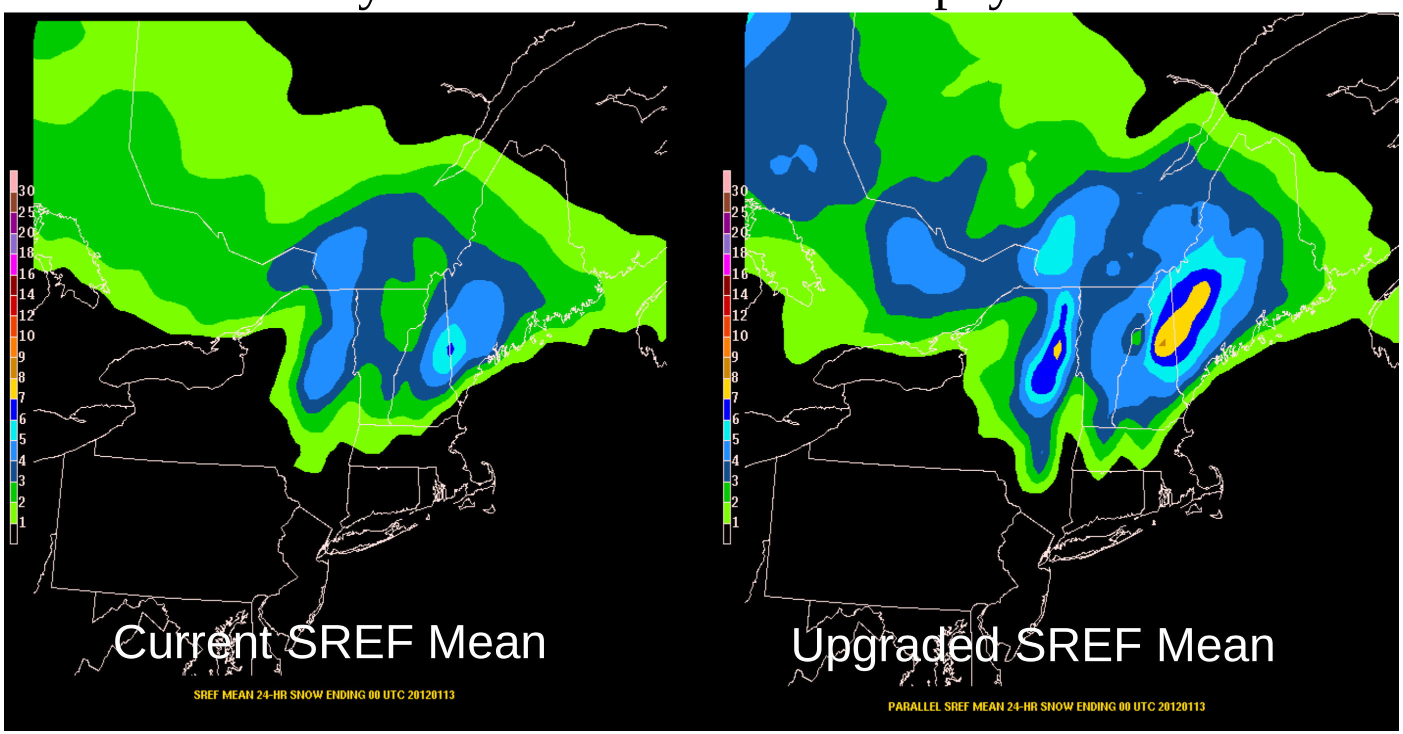


13 km Rapid Refresh Domain

Former RUC Domain

Recent Modeling Advances (cont'd)

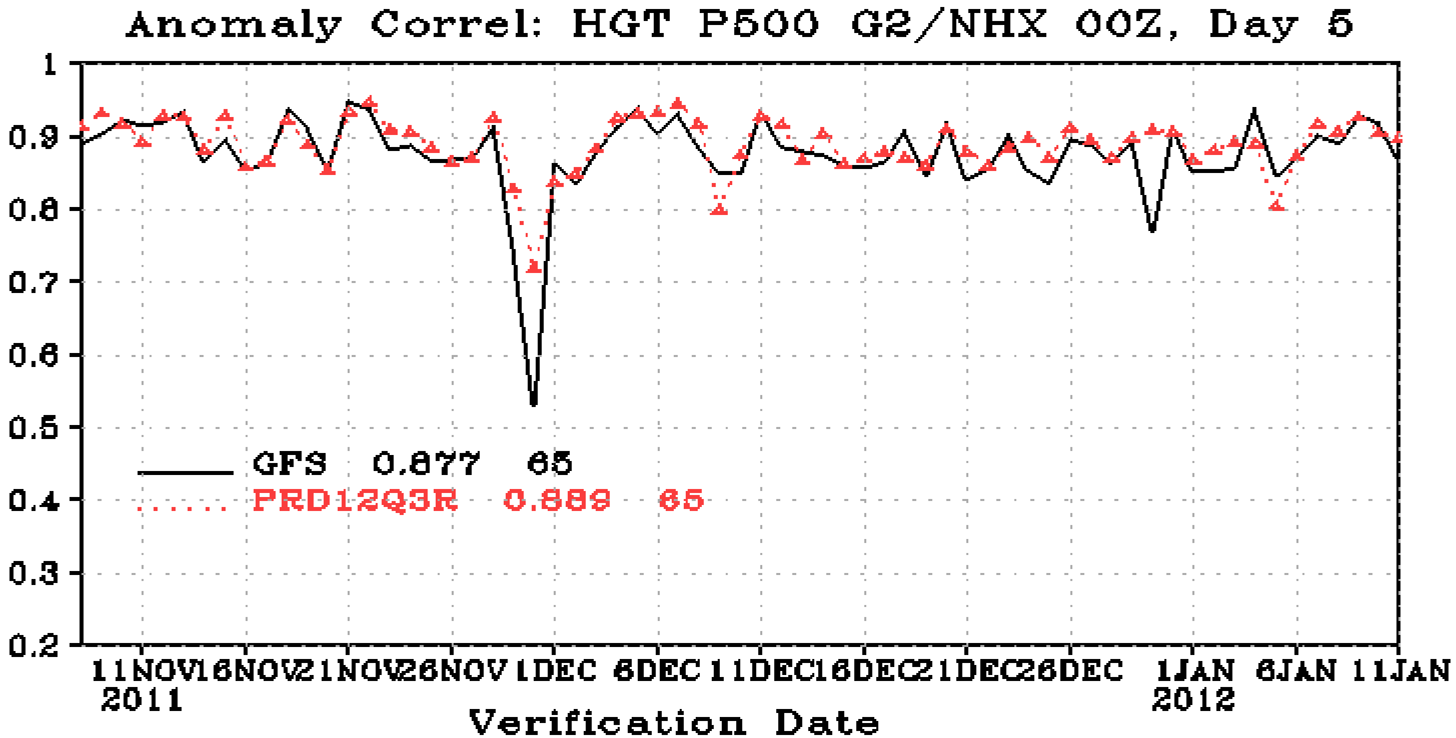
- SREF Upgrade – June, 2012
  - eliminate Eta and RSM models and add new NEMS-based NMMB model
  - Model upgrade (two existing WRF cores from v2.2 to version 3.3)
  - Resolution increase (from 32km to 16km)
  - More diversity for initial conditions and physics



Advanced Data Assimilation System

- GSI Hybrid EnKF-3DVAR Upgrade – May, 2012
  - EnKF hybrid system
  - Add GOES-13 data
  - Add Severi CSBT radiance product
  - New version of Forecast model

EnKF Hybrid GDAS Package Parallel - Northern Hemisphere



Summary and Session Goal

- Summary:
  - Environmental models and analyses have become increasing accurate and reliable, and provide the basis of much of NOAA’s science-based services for forecasting and warning.
  - Data assimilation is a crucial component for successful environmental modeling, to be balanced with basic science, model development, observations, and computing
- Session Goal:
  - Gain insight as to how the projects to be presented in this session may contribute to operational NWP and other environmental modeling

Background for OSEs

- Models Used: NOAA/NCEP Operational GDAS/GFS (May 2011 version)
- T574L64 operational resolution
- Two Seasons Tested
  - Aug-Sept 2010 (Summer)
  - Dec 2010-Jan 2011 (Winter)
- Cycled experiments
- 7 Day forecast at 00Z

Caution: These results look only at the medium-range weather forecast skill, through the anomaly correlation. There are other metrics that should be accounted for when making decisions, including but not limited to: wind RMS, precip scores, hurricane track and intensity forecast skills and other regional-scale critical parameters. Other non-obvious considerations should also play a role in making decisions, including redundancy of the observing system and the desired robustness, the temporal and spatial coverage which allows the proper detection of storms, and other extreme weather events, etc