Simulation of observation and calibration for Joint OSSEs

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Full OSSEs

There are many types of simulation experiments. Sometimes, we have to call our OSSE a 'Full OSSE' to avoid confusion.

➢A Nature Run (NR, proxy true atmosphere) is produced from a free forecast run using the highest resolution operational model which is significantly different from NWP model used in DAS.

➢Calibrations will be performed to provide quantitative data impact assessment.

compare data impacts between real and simulated data will be performed. Without calibration quantitative evaluation of data impact is not possible.

Advantages

➢Data impact on analysis and forecast will be evaluated.

➢A Full OSSE can provide detailed quantitative evaluations of the configuration of observing systems.

➢A Full OSSE can use an existing operational system and help the development of an operational system

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OSSE Calibration

- In order to conduct calibration all major existing observation have to be simulated.
- The calibration includes adjusting observational error.
- If the difference is explained, we will be able to interpret the OSSE results as to real data impact.
- The results from calibration experiments provide guidelines for interpreting OSSE results on data impact in the real world.
- Without calibration, quantitative evaluation data impact using OSSE could mislead the meteorological community. In this OSSE, calibration was performed and presented.

Existing Data assimilation system and vilification method are used for Full OSSEs. This will help development of DAS and verification tools.

International Joint OSSE capability

- Full OSSEs are expensive
  - Sharing one Nature Run and simulated observation save the cost
  - Share diverse resources
- OSSE-based decisions have international stakeholders
  - Decisions on major space systems have important scientific, technical, financial and political ramifications
  - Community ownership and oversight of OSSE capability is important for maintaining credibility
- Independent but related data assimilation systems allow us to test robustness of answers

New Nature Run by ECMWF

Based on discussion with
JCSDA, NCEP, GMAO, GLA, SIVO, SWA,
NESDIS, ESRL, and ECMWF

Joint OSSE Nature Run

Spectral resolution : T511
Vertical levels: L91
3 hourly dump
Initial conditions: 12Z May 1st, 2005
Ends at: 0Z Jun 1,2006
Daily SST and ICE: provided by NCEP
Model: Version cy31r1

Note: This data must not be used for commercial purposes and re-distribution rights are not given. User lists are maintained by Michiko Masutani and ECMWF

Supplemental low resolution regular lat lon data

1degx1deg for T511 NR
Pressure level data: 31 levels,
Potential temperature level data: 315,330,350,370,530K
Selected surface data for T511 NR:

Two High Resolution Nature Runs

35 days long
Hurricane season: Starting at 12z September 27,2005,
Convective precipitation over US: starting at 12Z April 10, 2006
T799 resolution, 91 levels, one hourly dump
Get initial conditions from T511 NR

Not recommended for OSSE

T511 Nature Run is found to be representative of the real atmosphere and suitable for conducting reliable OSSEs for midlatitude systems and tropical cyclones. (Note: MJO in T511 Nature Run is still weak.)

There are significant developments in high resolution forecast models at ECMWF since 2006 and a more realistic tropics for T799 Nature Run is expected with a newer version of the ECMWF model.

ECMWF agreed to generate a new T799 NR, when the Joint OSSE team has gained enough experience in OSSEs with T511NR and is ready to make the best use of the high resolution Nature Run.

For the time being, the Joint OSSE team will concentrate on OSSEs using the T511 Nature Run.

Archive and Distribution of the Nature Run

To be archived in the MARS system at ECMWF
Accessed by external users. Currently available internally as expver=etwu

Copies for US are available to designated users for research purpose& users known to ECMWF

Saved at NCEP, ESRL, and NASA/ GSFC

Complete data available from portal at NASA/GSFC

Conctact:Michiko Masutani (michiko.masutani@noaa.gov), Harper.Pryor@nasa.gov

Gradsdods access is available for T511 NR. The data can be down loaded in grib1, NetCDF, binary. The data can be retrieved globally or selected region.

Provide IP number to :Arlindo da Silva (Arlindo.Dasilva@nasa.gov)

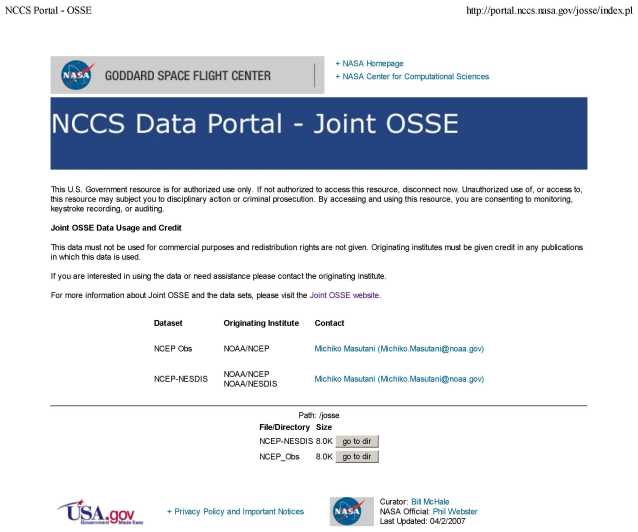
Data Sharing in Joint OSSEs

Simulated observation and other useful data will be shared among Joint OSSE teams.

NASA/NCCS provided dis space for Joint OSSE data sharering
There is a entry created for Joint OSSE
http://portal.nccs.nasa.gov/josse/index.pl

Make entry to each data set and generating institute, and contact person.

People use these data must contact generating institutes.

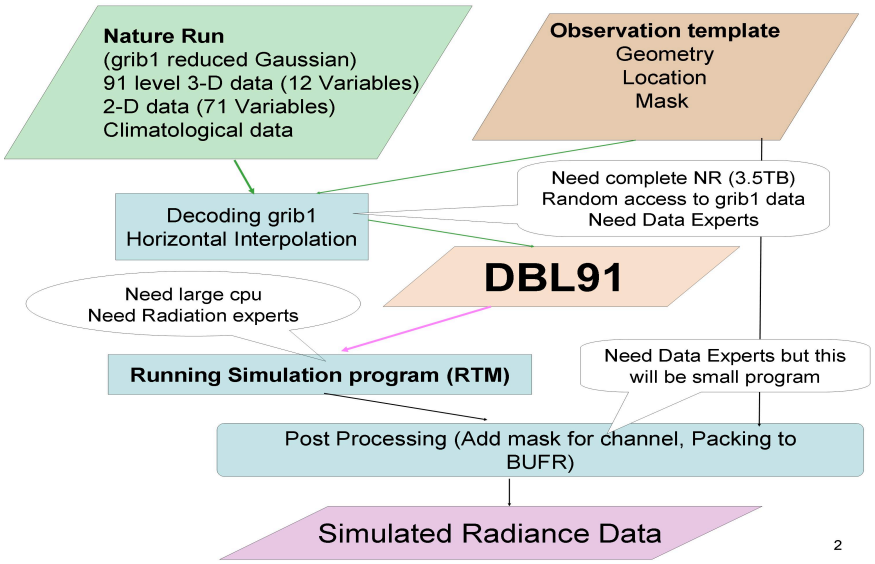


Flexile Radiance data Simulation strategies at NCEP-NESDIS

The DBL91 also used for development of RTM.
DBL91 can be processed for other sampling such as GMAO sampling
DBL91 can be processed for new observation

DWL91 with sampling based on GDAS usage will be posted from NASA portal.

It is an option whether DBL91 to be saved and exchange among various project, or DBL91 to be treated as temporary file produced in simulation process. This depends on size of DBL91 compare to the Nature Run.



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Progress and current plan

Simulation of observational data for calibration

► Ozone data from SBUV
► Conventional data based on NCEP reanalysis quality controlled distribution. (More complete data set compared to operational data)
► Satellite radiance data in 2005 distribution. AMSUA, AMSUB, GOES, HIRS2, HIRS3, AIRS,MSU are being generated at foot print used by NCEP operational analysis.
► Observational error is random error based on error table.
► Limited calibration and validation will be conducted by NCEP and NESDIS for their own use. However, users are expected to perform their own calibrations and validation.

Future Plan
► Observational error based on correlated noise
► Simulation and assimilation of cloudy radiance and let sampling done by assimilation. Cloudy radiance is still under development

DBL91

Nature Run data at foot print
- 91 level 3-D data (12 Variables)
- 2-D data (71 Variables)
- Climatological data
  - All information to simulate Radiances

NR 91 levels of: pres cloudcov cloudice cloudh2o ozone mmr temperature spfhumid

From BUFR satellite file

2005.00	004001	YEAR	YEAR	YEAR
5.00	004002	MNTH	MONTH	MONTH
1.00	004003	DAYS	DAY	DAY
21.00	004004	HOUR	HOUR	HOUR
.00	004005	MINU	MINUTE	MINUTE
3.00	004006	SECO	SECOND	SECOND
168.67	006002	CLON	DEGREES	LONGITUDE
59.77	005002	CLAT	DEGREES	LATITUDE
206.00	001007	SAID	CODE TABLE	SAT IDENTIFIER
570.00	002019	SIID	CODE TABLE	SAT INSTRUMENTS
2.00	005043	FOVN	NUMERIC	BEAM POSITION
1.00	008012	LSQL	CODE TABLE	LAND/SEA QUALIFIER
52.79	007024	SAZA	DEGREE	SAT ZENITH ANGLE
59.83	007025	SOZA	DEGREE	SOLAR ZENITH ANGLE
.00	010001	HOLS	METER	HEIGHT OF LAND SURFACE
813000.00	007002	HMSL	METER	HEIGHT OR ALTITUDE

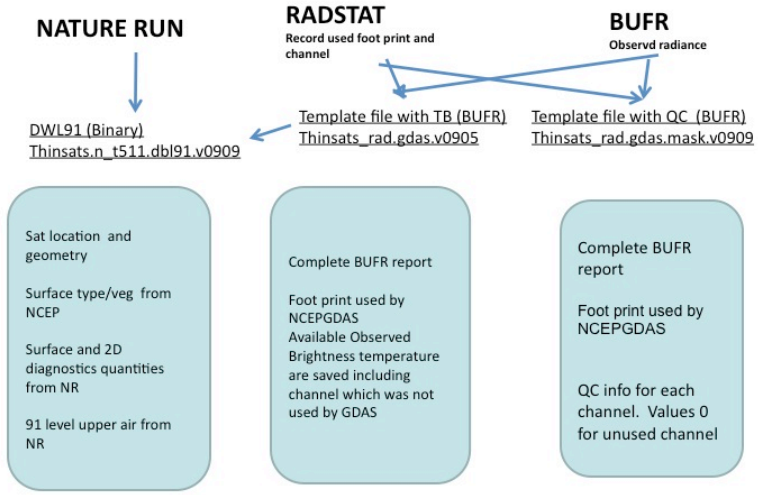
From NCEP Climatology

```
.00000  iv=27 ! low  vegetation cover
.00000  iv=28 ! high vegetation cover
.00000  iv=29 ! low  vegetation type
.00000  iv=30 ! high vegetation type
```

Surface quantities from Nature Run

```
 31  1 Sea-ice cover [(0-1)]
 32  2 Snow albedo [(0-1)]
 33  3 Snow density [kg m**-3]
 34  4 Sea surface temperature [K]
 44  5 Snow evaporation [m of water]
 45  6 Snowmelt [m of water]
 50  7 Large-scale precipitation fraction [s]
 57  8 Downward uv radiation at the surface [w m**-2 s]
 58  9 Photosynthetically active radiation [w m**-2 s]
 59 10 Convective available potential energy [J kg**-1]
 78 11 Total column liquid water [kg m**-2]
 79 12 Total column ice water [kg m**-2]
129 13 Geopotential [m**2 s**-2]
136 14 Total column water [kg m**-2]
137 15 Total column water vapour [kg m**-2]
141 16 Snow depth [m of water equivalent]
142 17 Stratiform precipitation [m]
143 18 Convective precipitation [m]
144 19 Snowfall (convective + stratiform) [m of water equ
145 20 Boundary layer dissipation [W m**-2 s]
146 21 Surface sensible heat flux [W m**-2 s]
147 22 Surface latent heat flux [W m**-2 s]
148 23 Charnock
151 24 Mean sea-level pressure [Pa]
152 25 Surface pressure [pa]
159 26 Boundary layer height [m]
164 27 Total cloud cover [(0 - 1)]
165 28 10 metre U wind component [m s**-1]
166 29 10 metre V wind component [m s**-1]
167 30 2 metre temperature [K]
168 31 2 metre dewpoint temperature [K]
169 32 Surface solar radiation downwards [W m**-2 s]
172 33 Land/sea mask [(0, 1)]
175 34 Surface thermal radiation downwards [W m**-2 s]
176 35 Surface solar radiation [W m**-2 s]
177 36 Surface thermal radiation [W m**-2 s]
178 37 Top solar radiation [W m**-2 s]
179 38 Top thermal radiation [W m**-2 s]
180 39 East/West surface stress [N m**-2 s]
181 40 North/South surface stress [N m**-2 s]
182 41 Evaporation [m of water]
186 42 Low cloud cover [(0 - 1)]
187 43 Medium cloud cover [(0 - 1)]
188 44 High cloud cover [(0 - 1)]
189 45 Sunshine duration [s]
195 46 Lat. component of gravity wave stress [N m**-2 s]
196 47 Meridional component of gravity wave stress [N m**
197 48 Gravity wave dissipation [W m**-2 s]
198 49 Skin reservoir content [m of water]
205 50 Runoff [m]
206 51 Total column ozone [Dobson]
208 52 Top net solar radiation, clear sky [W m**-2]
209 53 Top net thermal radiation, clear sky [W m**-2]
210 54 Surface net solar radiation, clear sky [W m**-2]
211 55 Surface net thermal radiation, clear sky [W m**-2]
235 56 Skin temperature [K]
238 57 Temperature of snow layer [K]
243 58 Forecast albedo [(0 - 1)]
244 59 Forecast surface roughness [m]
245 60 Forecast log of surface roughness for heat
```

DBL91 file structure – information for simulating radstat satellites



Experts for data handling and experts of RTM are different people.

The DBL91 also used for development of RTM.
DBL91 can be processed for other sampling such as GMAO sampling
DBL91 can be processed for new observation

It is an option whether DBL91 to be saved and exchange among various project, or DBL91 to be treated as temporary file produced in simulation process. This depends on size of DBL91 compare to the Nature Run.

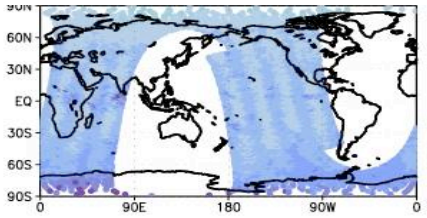
Simulation of HIRS3 radiance from NOAA16

M Masutani (NCEP)

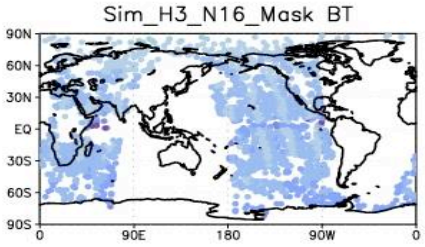
Latest version of CRTM (1.2.2) is used for simulation
DBL 91 was generated at foot print used by NCEP GDAS
All information in GDAS bufr files are copied to simulated radiance file.
Channel which are not used by GDAS was marked in diag file.
Masked out to generate masked radiance data.

Template data

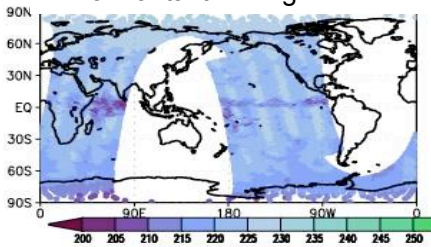
Observed radiance with horizontal thinning



Horizontal and vertical thinning



Horizontal thinning



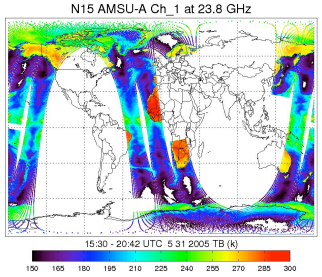
HIRS3 NOAA 16 Ch=4 May 2nd 00z (f12)

Simulation of AMSU-A/B
Tong Zhu (NESDIS)

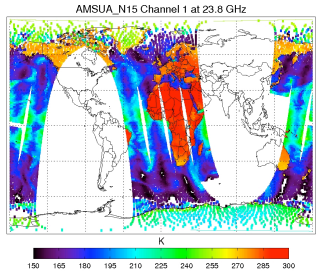
- AMSU-A on NOAA15 and 16, AMSU-B on NOAA15, 16, and 17 radiances were simulated for the same 13 months.
- 6-Hourly radiance data has been simulated, with the data coverage consistent with the operational GSI data ingest time.
- Update the simulation by using NR output ice coverage data.
- Angular dependences and channel correlations have been calculated. More validation study is necessary.

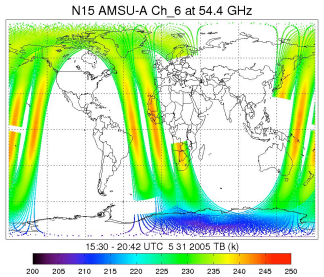
Comparison With Observation
1800 UTC 31 May 2005

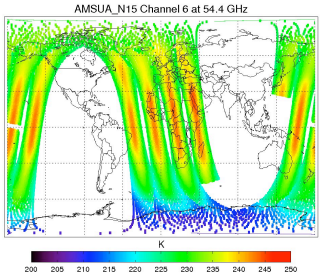
Observation



Simulation







Simulation GOES Radiance for OSSE

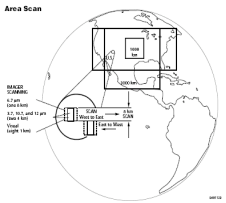
Tong Zhu (CIRA/CSU), Fuzhong Weng (NOAA/NESDIS), Michiko Masutani (NOAA/EMC),
Steve Load (NOAA/EMC), Jack Woollen (NOAA/EMC),
Thomas J. Kleespies(NOAA/NESDIS), Yong Han(NOAA/NESDIS), Quanhua, Liu (QSS), Sid Boukabara (NOAA/NESDIS)

Advanced Baseline Imager (ABI) will be flown on the next generation of NOAA Geostationary Operational Environmental Satellite (GOES)-R platform. The sensor will provide enhanced spatial, temporal information for atmospheric moisture, wind and many surface properties. A joint Observation System Simulation Experiments (OSSE) project was started recently to study the impacts of GOES-R ABI measurements on numerical weather prediction.

In this poster, we will present some results of the simulation of GOES radiances based on OSSE nature run output and the evaluation against observations. A case study will be performed to analysis ECMWF T511 natural run results. ABI instrument properties and geometry factors are simulated based on current GOES and MSG SEVIRI sensors. The JCSDA Community Radiative Transfer Model (CRTM) is used to simulate ABI radiances with the natural run atmospheric profiles. The simulated radiances are evaluated by comparing with current GOES observations.

GOES-R ABI Band		Central Wavelength (μm)	Current GOES Band	
1 (blue)	1 km	0.47		
2 (red)	0.5 km	0.64	1	1 km
3	1 km	0.86		
4	2 km	1.38		
5	1 km	1.61		
6		2.26		
7		3.9	2	4 km
8		6.185		
9		6.95	3	4 km
10		7.34		
11		8.5		
12	2 km	9.61		
13		10.35	4	4 km
14		11.2		
15		12.3	5 (G08)	4 km
16		13.3	5 (G12)	4 km

Current GOES Imager IR band has 4 km horizontal resolution (FOV), GOES Sounder has 10 km resolution. A full disk scan has total 10,080,910 observation points, and takes about 26 min. GOES-R ABI sensor will has 1km/2 km resolution.



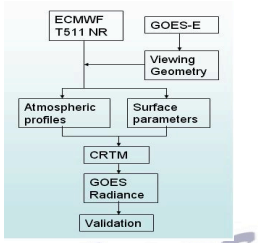
Radiance Simulation Design

Objective

GOES data is simulated to test impact of GOES in simulation experiments in comparison with impact of real data.

OSSE for GOES will serve as a calibration for GOESR OSSE.

Radiance Simulation Flow Chart



Steps:

1. The OSSE Nature Run data is come from ECMWF T511 13-month simulation. The data set contains 91 vertical levels variables, which are then horizontally interpolated to observation points without vertical interpolation. Selected model level data and all surface data are included.

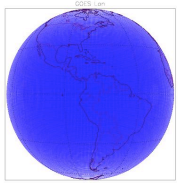
2. CRTM model is used to simulate GOES-12 Imager, Sounder, MSG SEVIRI, and GOES-R ABI measurements.

3. Perform validations of the simulated radiances with statistical analysis and comparison with real observations.

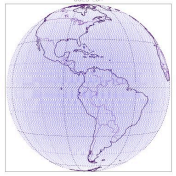
GOES-EAST Observation Locations

A full disk scan of GOES-12 Imager has total 10,080,910 observation points with 4 km resolution. However, Current NCEP/GSI model only take a thinned 1x1 degree GOES-12 dataset. In this study, we extract GOES-12 Imager observation locations (lon/lat) at 20 km and 60 km resolutions. The Nature Run data is interpolated on to these two different resolution locations.

Reduced to ~20 km, 403239 points



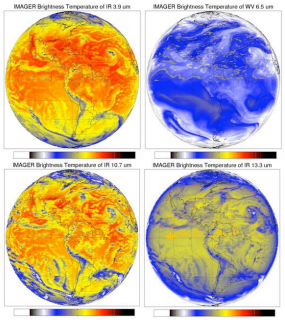
Reduced to ~60 km, 40323 points



Simulation of GOES-12 Imager

Simulated GOES-12 Imager 4 bands with ECMWF Nature Run output data at 0300 UTC October 1, 2005.

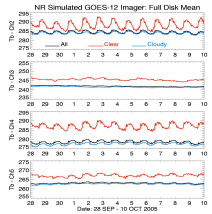
It is found that the water vapor band, 6.5 μm, is most accurate band simulated by CRTM model.



Time series of hourly, full disk mean brightness temperature of the simulated GOES-12 Imager 4 bands from September 28 to October 10, 2005.

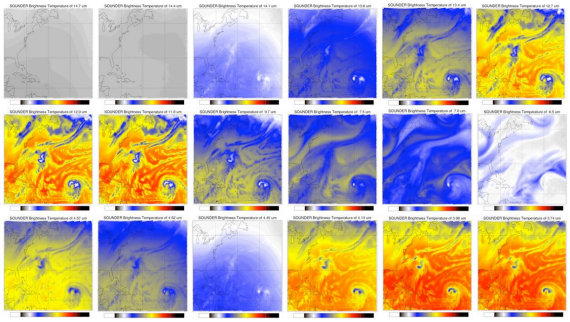
Under clear sky conditions, the brightness temperatures are warmer than that of cloudy conditions. The daily change under clear conditions is apparent.

Black lines are total points mean Tb, red lines are the mean Tb over clear sky condition, and the blue lines are the mean Tb over cloudy condition. Clear sky condition is defined as where total cloud coverage (TCC)< 0.1, and cloudy condition is where TCC > 0.1



Simulation of GOES-12 Sounder

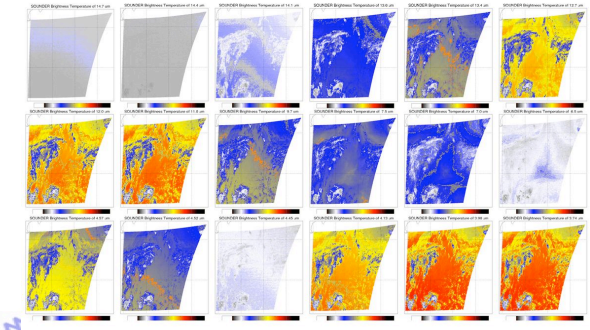
Simulated Radiances



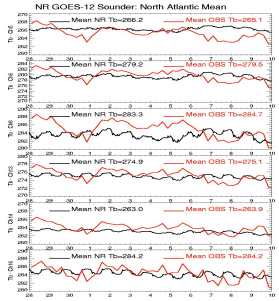
In nature Run, there is hurricane generated on September 27. At 1200 UTC October 1, it is located at about 43 W, 20N. The high moisture air mass associated with the hurricane is shown clearly.

The observed GOES-12 Sounder

Observed GOES-12 18 bands on 0230 UTC October 01, 2005 for North Atlantic Ocean section.



Time Series of Mean Tb



Observed vs. simulated GOES-12 sounder for the mean Tb over North Atlantic Ocean region.

Black lines are mean Tb from NR simulated, and the red lines are the mean Tb from observation.

They should not be the same but similar statistical features are important.

Progress

Preliminary simulation of GOES from T511NR has completed for entire Nature Run period (13 month)

Future Work

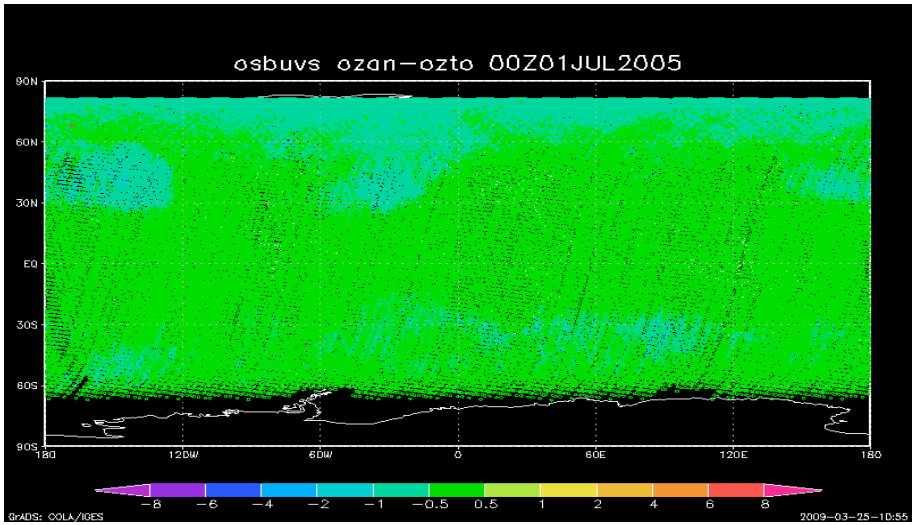
Simulate GOES-R ABI radiances from Nature Run data,

Perform NWP model simulations to investigate the impacts of GOES-12 and GOES-R measurements.

Conduct impact test using data assimilation system

Simulated SBUV Ozone Retrievals
Jack Woollen(NCEP)

Simulating the SBUV retrievals involves converting the 91 level ozone concentrations from the nature run into 12 layers of ozone amounts (DU). The plot checks the conversion by comparing the NR total ozone values with the total profile ozone derived by summing the simulated layer values.



OSSE Observation Simulation and Experiment Verification Developments

Jack Woollen (NCEP)

- ❑ New simulation of run history PREPQC files with QC information
- ❑ Simulation of SBUV BUFR ozone observations
- ❑ Create simulated BUFR AMSUa, AMSUb, and GOES files (w/Tong Zhu)
- ❑ Updated version of DBL91 files produced with GSI h/v thinning info
- ❑ Optimized experiment cycle script provides 15:1 production speedup
- ❑ Suru fit files/plots adapted for OSSE calibration experiments
- ❑ Scatter fit plots developed for experiment comparisons
- ❑ Radiance fit plots to examine results of bias correction experiments

OSSE Calibration

● In order to conduct calibration all major existing observation have to be simulated.

● The calibration includes adjusting observational error.

● If the difference is explained, we will be able to interpret the OSSE results as to real data impact.

● The results from calibration experiments provide guidelines for interpreting OSSE results on data impact in the real world.

● Without calibration, quantitative evaluation data impact using OSSE could mislead the meteorological community. In this OSSE, calibration was performed and presented.

Progress in Calibration at ESRL-NCEP

ESRL and NCEP are working on calibration using data denial method and fits to observation.

Using simulated data by GMAO and additional data from NCEP.

Focused on July-August 2005.

GSI version May 2007.

NCEP is working on upgrading OSSE system to newer GSI to accommodate DWL and flow dependent error covariances. Some calibrations will be repeated.

- Data denial tests are run for synthetic obs subsets of similar data types
- Analysis impact (global RMS difference in control and data denial analysis) is calculated for synthetic obs and compared to analysis impact for data denial with real archived data from July 2005
- Standard deviation of synthetic errors are adjusted, errors are regenerated
- New data denial case is run and compared to real data, errors adjusted, etc
- Repeat until analysis impact matches real data analysis impact, or until satisfied that calibration is not possible

A Calibration Example (RAOB)

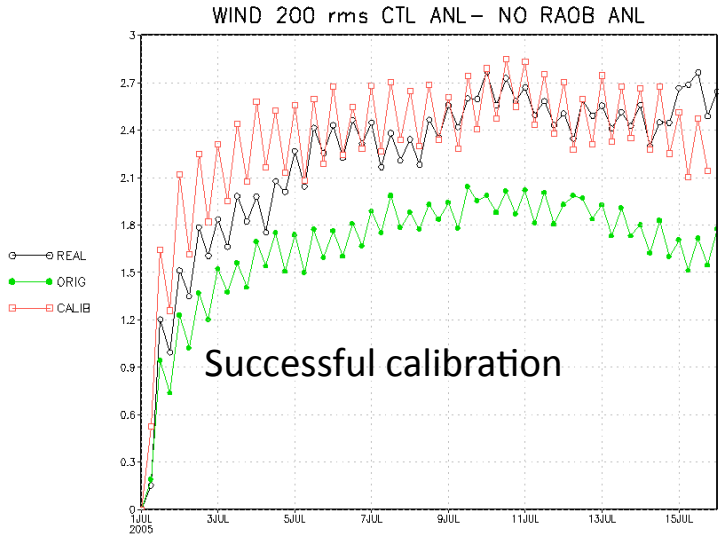
Nikki Prive, Yuanfu Xsi (ESRL)

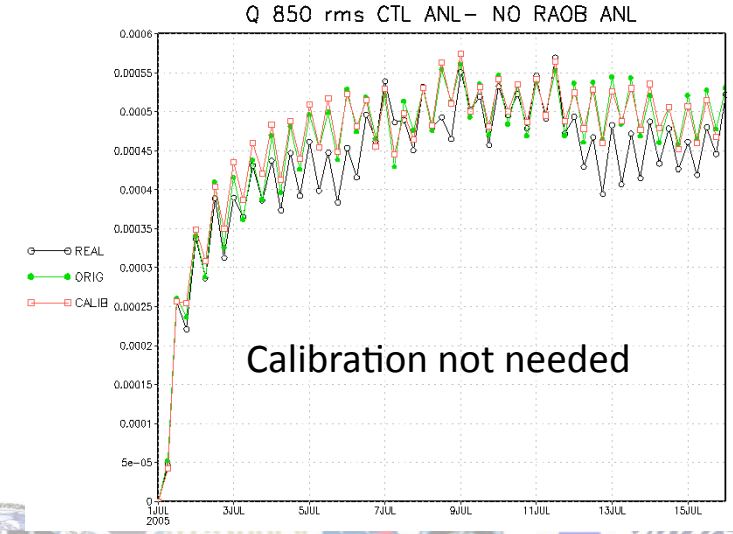
- All RAOB/sonde types (120, 132, 182, 220 232) simultaneously tested. Error standard deviation adjusted at individual height levels for each obs type (T, RH, wind).
- RH and Wind most successfully calibrated.
- T is reasonably but not 'perfectly' calibrated.
- Some levels were not able to be calibrated:

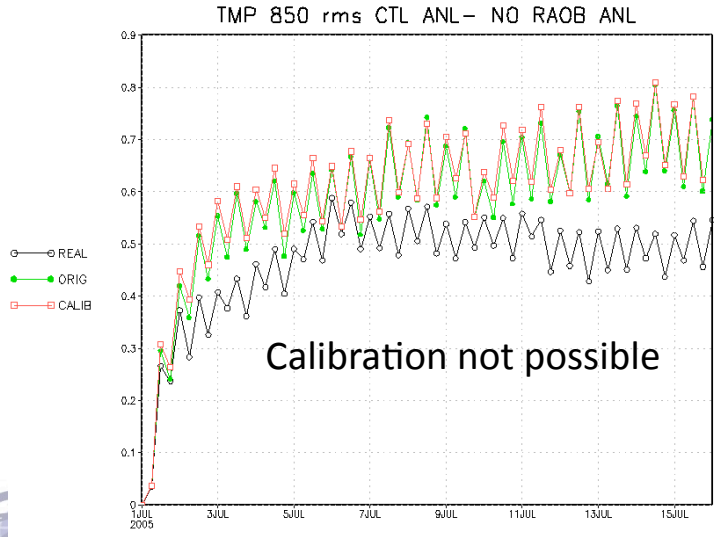
  T below 800 mb, above 150 mb

  Q above 250 mb

  Wind above 100 mb







Fit files storage and display

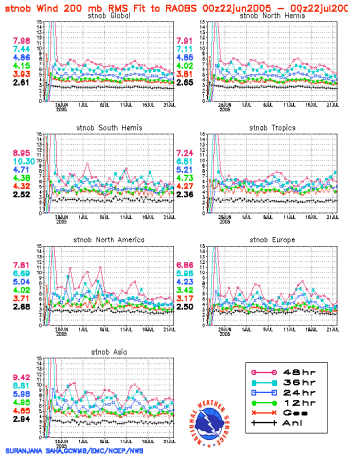
Jack Woollen (NCEP)

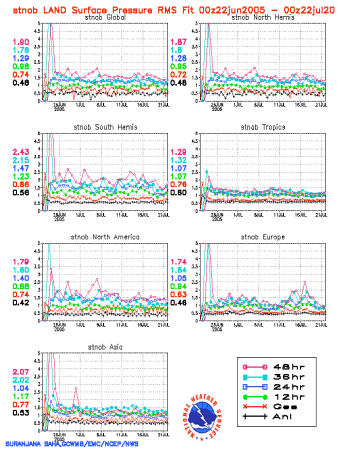
NCEP operational fit files contain rms, means, and counts of ob-bg

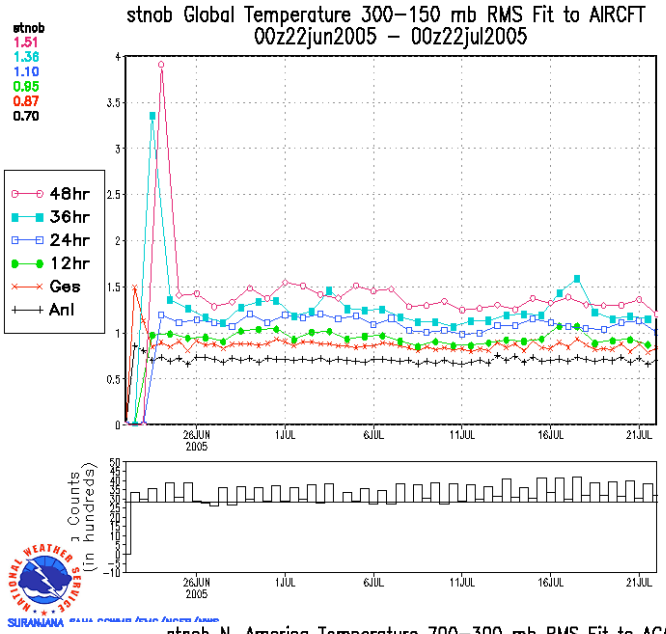
Seven regions: GL, NH, SH, TR, NA, EU, AS

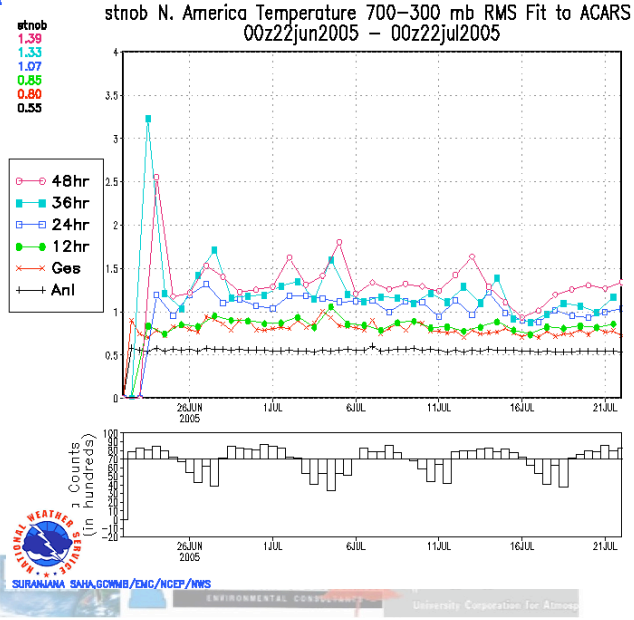
RAOB ps, 21 levels of q,t,u,v,z, 7 regions
SURF ps from adpsfc and sfcshp, 7 regions
ACFT t,z,u,v,spd, 1000-700,700-300,300-150, 7 regions
ACAR t,z,u,v,spd, 1000-700,700-300,300-150, NA only

Filenames have the form fnn.type.date, ie f00.raob.2005070100
Each file has fits for 1 lead time, 1 datatype, 7 regions, 1 valid time
GRADS combines these files to produce time series or scatter fit plots
Suru plots create f00,f06,f12,f24,f36,f48 for raob surf acft acar
.5 MB contains the complete set of Suru fit files for 1 year









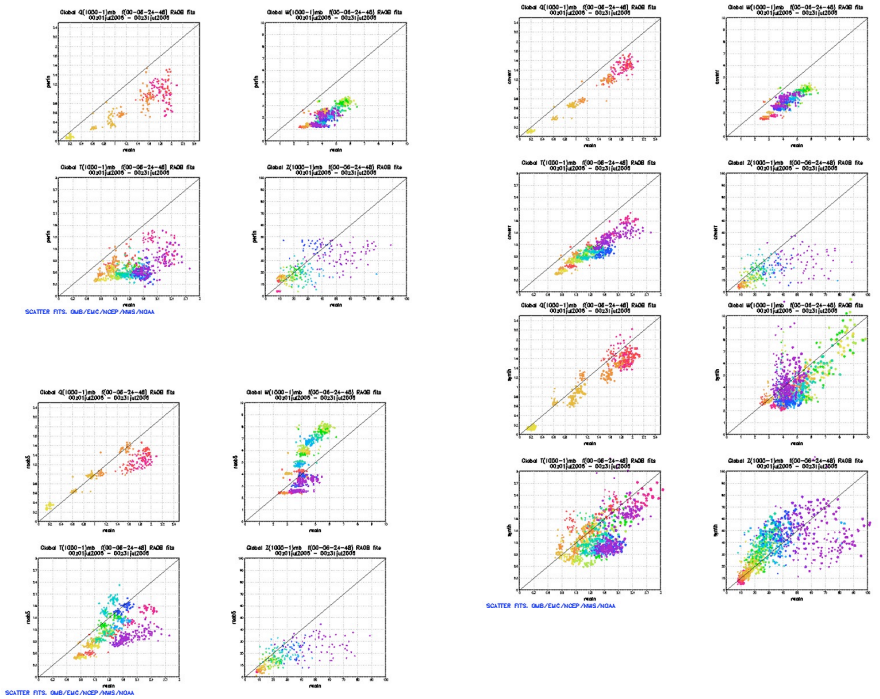
Scatter Fit Comparison Plots

Jack Woollen (NCEP)

Need to compare two experiments – use scatter plot
Compare all levels and forecast lengths for each variable
Comparison with real data case is relevant for calibration
Forecast lengths out to 5 days or more can be added
Develop a simple way to denote levels and forecast length

Analysis and Forecast fit scatter plot comparison with realn

Fits between each calibration run are compared with the realn case on a scatter plot. Each dot compares two global average RMS fits for 1 variable, 1 forecast length, one level, and one synoptic time. Dots are plotted for every case where the realn run coincides in space/time with a calibration run.

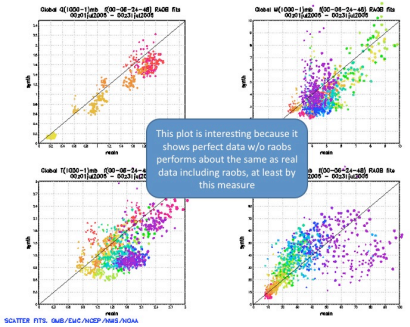


Summary of Calibration Experiments

realn - real data run, 3jul-15jul
perfn - perfect data run, 22jun-15jul
cnverr - simulated data with small errors, 1jul-18jul
raob5 - simulated data with bigger raob errors, 1jul-18jul
stnob - like cnverr w/sat bias correction initially zero, 22jun-22jul
gsitest - like raob5 with modified GSI error specs, 1jul-18jul
synth - simulated perfect data but w/o radiosondes, 3jul-15jul
synt2 - simulated perfect data, 3jul-15jul

Pressure levels indicated by dot colors

200	green	10	purple
250	yellow/green	20	purple
300	yellow	30	dark purple
500	dark yellow	50	dark blue
700	orange	70	medium blue
850	red	100	light blue
1000	magenta	150	aqua



Forecast length indicated by dot size - longer length - bigger dot

Summary

The Nature runs have been posted and made available to research community

Initial calibration was conducted using GMAO radiance data and other simulated data at NCEP-NESDIS during July 2005.

The initial simulated data will be ready for selected instruments in near future. (target is February 2010)

Software to simulation of further radiance system at NCEP-NESDIS are nearly ready.

Simulated conventional data and DBL91 has been posted from NASA portal.

Comments on OSSE Calibration

●OSSE funding should include simulation of calibration data and calibration of OSSE. OSSE funding tends to expect that calibrated OSSE system already exists.

● Calibration and simulation of basic observation effort has to be done sharing OSSE resources.

● **Without calibration, quantitative evaluation data impact using OSSE could mislead the meteorological community**.

Remark on Joint OSSEs

Using Full OSSE, various experiments can be performed and various verification metrics can be tested to evaluate data impact from future instruments and data distributions.

It was noted that that while OSSEs can be overly optimistic about the impacts of new observations evaluated in the current data assimilation system, advances in data assimilation skill usually allow us to make better use of observations over time. These advances may, to some extent, be an offsetting factor in that they can help achieve greater impact from new observations in the long run. (From ECMWF Workshop summary)

Theoretical predictions have to be confirmed by full OSSEs. The results are often unexpected. OSSE results also require theoretical back ups.

OSSE capability should be broadly based (multi-agency) to enhance credibility and to save costs

Acknowledgement

The nature runs for Joint OSSEs were produced by Dr. Erik Andersson of ECMWF. We appreciate GMAO to provide initial satellite data for calibration. GMAO also provided code to add random error to simulated data.