Simulation of observation and calibration for Joint OSSEs

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OSSE:Observing Systems Simulation Experiments
http://www.emc.ncep.noaa.gov/research/JointOSSEs/

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.
➢. 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

OSSE Calibration

Calibration of OSSEs verifies the simulated data impact by comparing it to real data impact. In order to conduct an OSSE calibration, the data impact of existing instruments has to be compared to their impact in the OSSE.

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

Joint OSSE Nature Run by ECMWF

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

Andersson, Erik and Michiko Masutani 2010: Collaboration on Observing System Simulation Experiments (Joint OSSE), ECMWF News Letter No. 123, Spring 2010, 14-16.

Low resolution Nature run
Spectral resolution : T511
13 month long. Starting May1st,2005
Vertical levels: L91, 3 hourly dump
Daily SST and ICE: provided by NCEP
Model: Version cy31r1

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

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

Archive and Distribution of the Nature Run

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

User list is maintained by Michiko Masutani (NOAA/NCEP)
contact:michiko.masutani@noaa.gov

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

Complete data set is posted from NASA/NCCS portal

Password protected. Accounts are arranged by **Ellen Salmon (Ellen.M.Salmon@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)

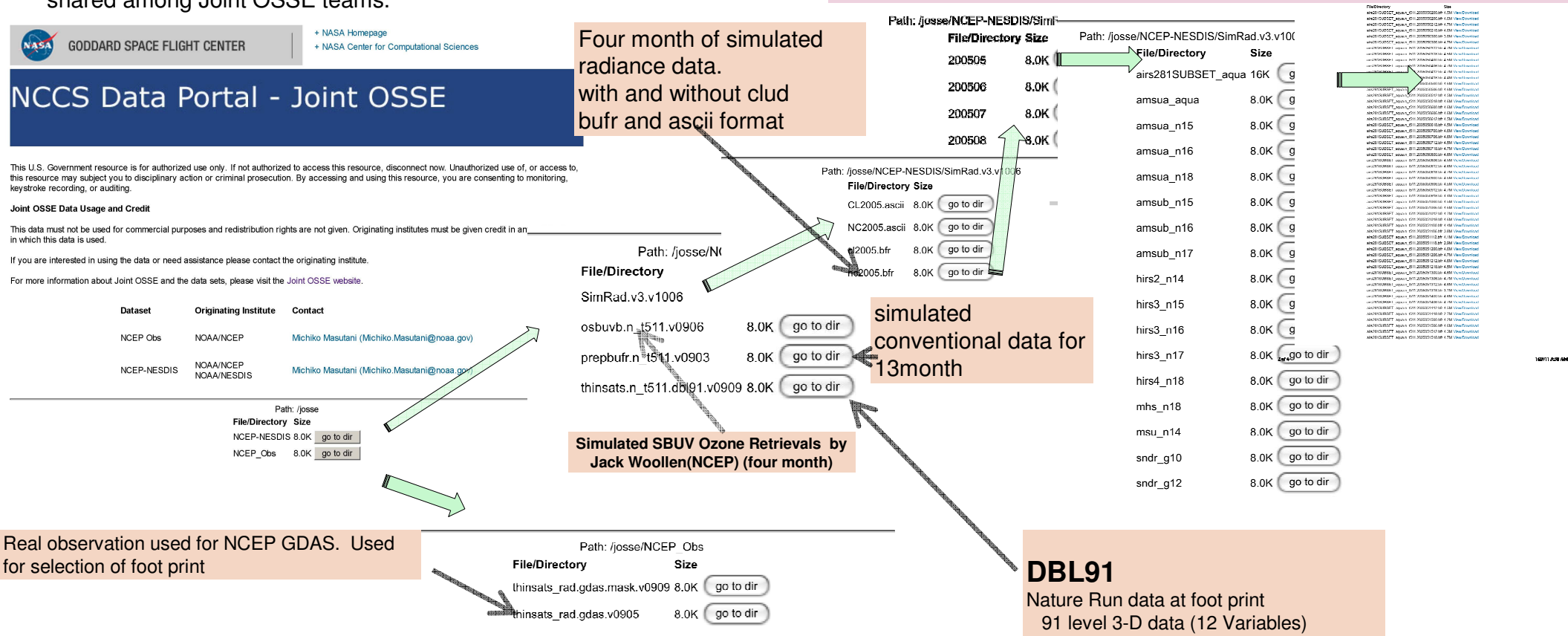
Data Sharing in Joint OSSEs

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.

NASA/NCCS portal as of January 2011

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



[Plans]
Complete 13month of radiance observation has been simulated and being evaluated.
Ascii data will not be posted for new data but software to conert bufr to ascii data will be provided.
Prepbufr for real data will be posted after sensitive data removed.

Data posted from Joint OSSE Home page

http://www.emc.ncep.noaa.gov/research/JointOSSEs/

Preliminary simulation which need to be verified
Description of data set posted from NASA/NCCS/portal
Software used to simulation

Simulated Radiance

JointOSSEs-> Manual -> NCEP_SimObs->NCEP_SimRad

Software used tosimilate radiance data posted from NCCS portal
CRTM used for simulation. CRTM1.2.2 (Different from the version posted from JCSDA website)

Presentation for verification by Tong Zhu and Haibing Sun
Link to libraries requres
Sample data set

Software to simulate IASI, Metop data has been tested and sample is posted

Simulated TC vital

Michiko Masutani (NCEP/EMC
Guan Ping Liiu (NCEP/EMC)

[Simulation of TC vital]
TC vital was simulated using software originally written by Tim Marchock and currently developed by Guan Ping Lou of NCEP.

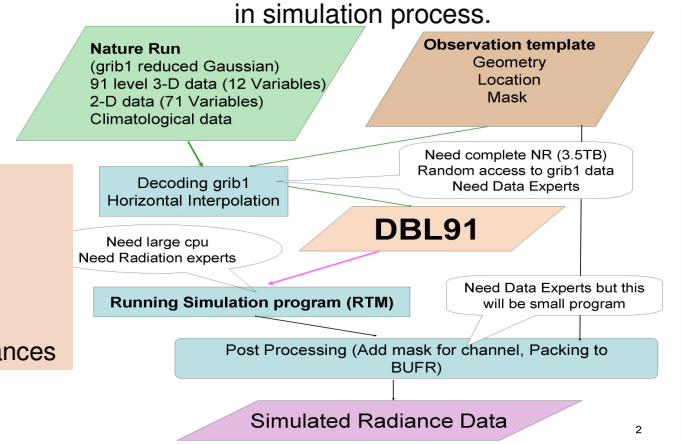
The simulated observation has not been evaluated.

TC-vital for 13 month
The software are posted

Simulated of radiance at NCEP-NESDIS

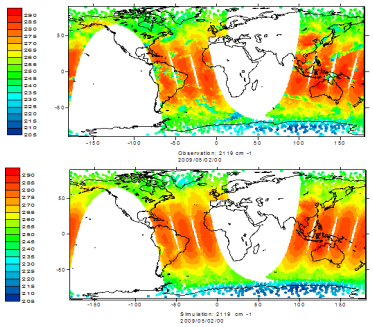
Michiko Masutani and Jack Woollen
NOAA/NWS/NCEP/EMC
Tong Zhu, Haibing Sun, Tom Kleespies, Yong Han, Fuzhong Weng
NOAA/NESDIS
Lars Peter Riishojgaard
JCSDA

Model level profile (DBL91) is saved.
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.



IASI simulation for 00Z May 2nd 2005
Using template based on usage on 00Z may 2nd 2009
Compared with observation at 00Z May 2nd 2005

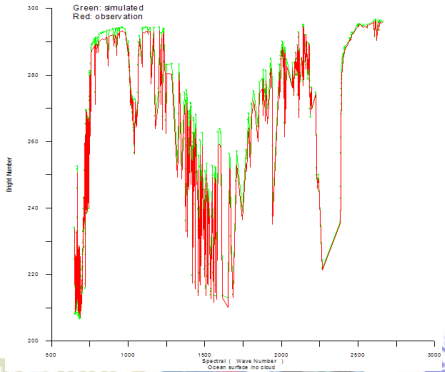
IASI simulation Evolution at Windows channel



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

IASI simulation over ocean (Clear atmosphere)



Remarks

Simulation of radiance is done using CRTM REL-1.2.2 but CRTM REL-2.0.2 is available from ftp://ftp.emc.ncep.noaa.gov/jcsda/CRTM/ We appreciate if anyone can upgrade these code to REL-2.0.2 and share with Joint OSSE.

NCEP will post simulated observation as progress. First we post from NCEP ftp site to be evaluated. After the data is evaluated it will be transferred to NASA NCCS portal. We appreciate any help in evaluation of the simulated observations.

Radiance data are also being simulated by Environment of Canada using RTTOV

- The simulated radiance using CRTM1.2.2, at foot print based on usage by 2005 GDAS is reasonable. The simulated is continued to complete entire period of T511 Nature run.
- Observational error will be added based on method developed by T. J. Kleespies.
- Calibration will be performed for observational errors

OSSE Calibration

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

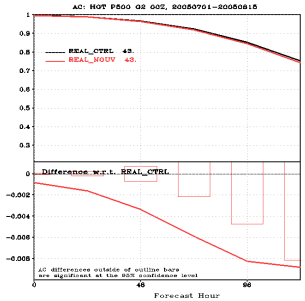
● The calibration includes adjusting observational error.

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

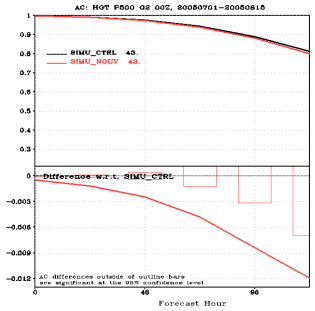
● The results from calibration experiments provide guidelines for interpreting OSSE results on data impact in the real world.

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

Real



Simulated



Data denial experiment for RAOB wind showed simulated wind without observational error has about 1.5 more impact compared to real data.

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.

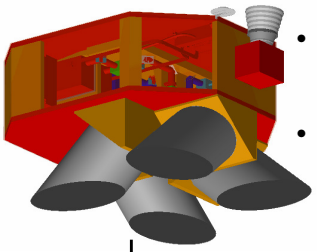
GSI version May 2007.

NCEP upaated OSSE system december 2009) 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

Simulation of Space based Doppler Wind Lidar observation to evaluate Global Wind Observing Sounder (GWOS) Concept

Star Tracker



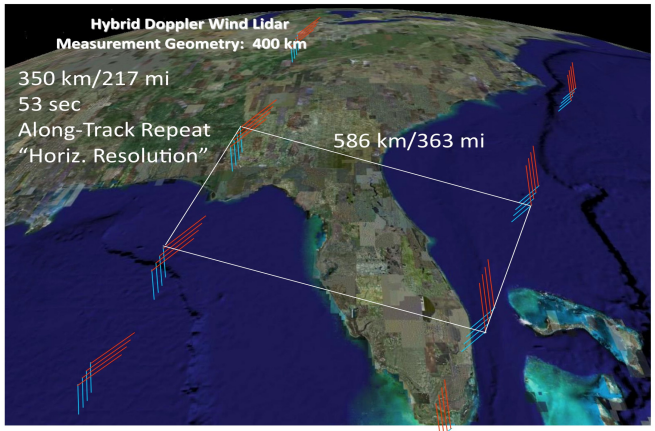
Nadir

Telescope Modules (4)

Dual Technology Sampling

- The coherent subsystem provides very accurate (< 1.5m/s) observations when sufficient aerosols (and clouds) exist.
- The direct detection (molecular) subsystem provides observations meeting the threshold requirements above 2km, clouds permitting.

GWOS 4 beam coverage



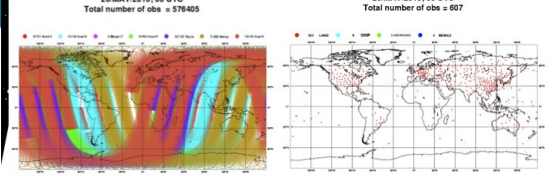
1

Upper-air observation requirements for NWP

- Numerical weather prediction requires independent and global observations of the **mass** (temperature) and **wind** fields
- The global three-dimensional **mass field is well observed from space**
- **No existing space-based observing system provides vertically resolved wind information** => horizontal coverage of wind profiles is sparse
- The lack of wind measurements is widely believed to be one of the main limiting factors for progress in NWP skill at all temporal ranges
  - Especially critical as we progress to smaller and smaller scales where wind/mass balance assumptions break down

4

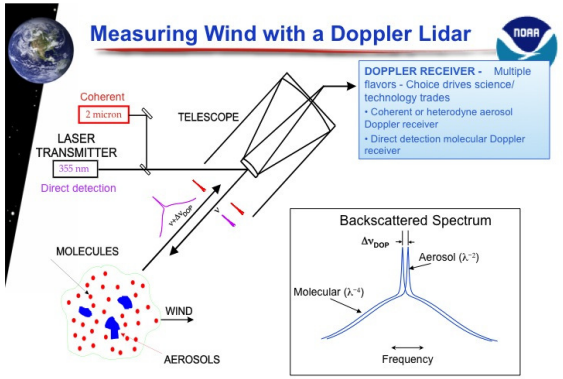
Current Upper Air Mass & Wind Data Coverage



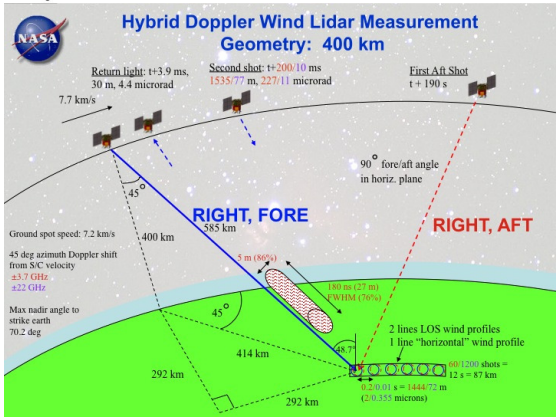
Vertically resolved Mass Observations

Vertically resolved Wind Observations

Measuring Wind with a Doppler Lidar



5



3

Wind Lidar OSSEs

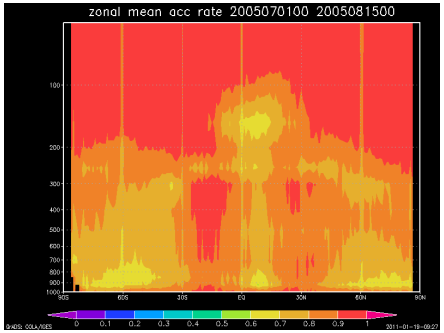
- Impact experiments carried out as part of NASA-NOAA Joint OSSE collaboration
  - –Common Nature Run supplied by ECMWF
    - •(comprehensive validation presented at past AMS meetings)
  - –Shared simulation of reference observations; contributions by NESDIS, GMAO, NCEP, et al.

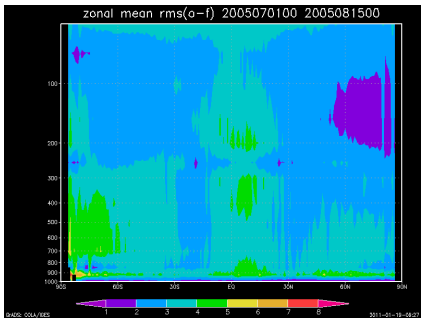
- Wind Lidar OSSE project funded by NASA (Kakar and Lee) under ROSES 2007

OSSE for GWOS DWL

Lars Peter Riishojgaard, Zaizhong Ma
Michiko Masutani, Jack Woollen,
Dave Emmitt, Sid Wood, Steve Greco

15 IOAS-AOLS Tuesday, 25 January 2011: 9:15 AM
2.5 Observing System Simulation Experiments for a US Wind Lidar space mission



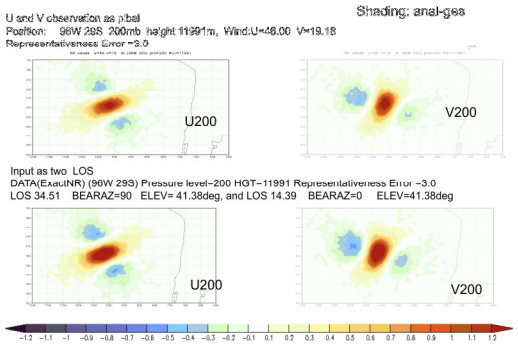


Development of DWL assimilation systems

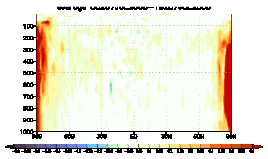
Zonal mean, time averaged rejection rate.

Zonal rime mean (obs-guess)

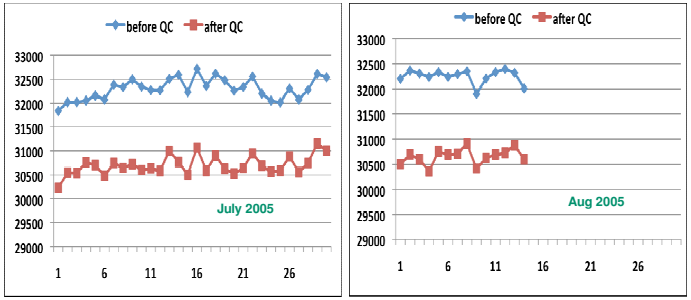
• DWL data will be assimilated as Line Of Sight (LOS) wind component. Two LOS observation like U and V must produce very similar impact as one vector wind U and V. i.e. Two LOS observation at close location by GWOS will produce a vector wind like impact.



•Variational quality control improve the performance in polar region. (The figure shows a zonally averaged improvement V on day three. Cint=0.05 and maximum is about 0.5m/s in both poles.)



Number of lidar observations per analysis cycle (shown only for 00Z)



Total rejection rate around 6%

Experiment setup

- NCEP GFS at T-126 horizontal resolution
- "OSSE period": July 01-Aug 15, 2005 (simulated)
  - –Five-day forecast launched every day at 00Z
  - –Most observing systems used for routine operational NWP included, except GPSRO and IASI
- Four experiments, all verified against Nature Run
  - –Simu_ctrl: NCEP GFS analysis assimilating the "observation" data from NR
  - – Simu_nouv: CTRL without raob (220, 221 and 232)
  - – Simu_nonw: CTRL without all wind
  - – Sinu_dwl : CTRL + hybrid Satellite lidar wind data

- **Simu_ctrl**: NCEP GFS analysis assimilating the "observation" data from NR

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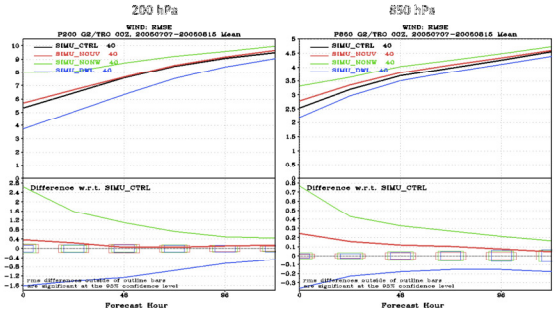
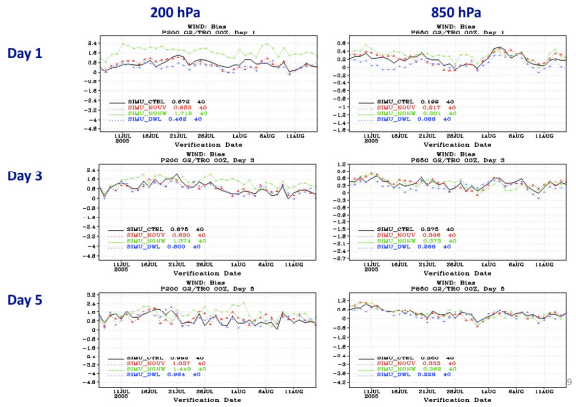
- **Sinu_dwl** : CTRL + hybrid Satellite lidar wind data

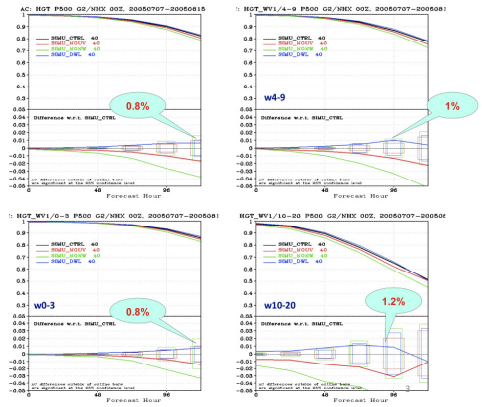
RMSE: 200, 850hPa Wind error in tropics



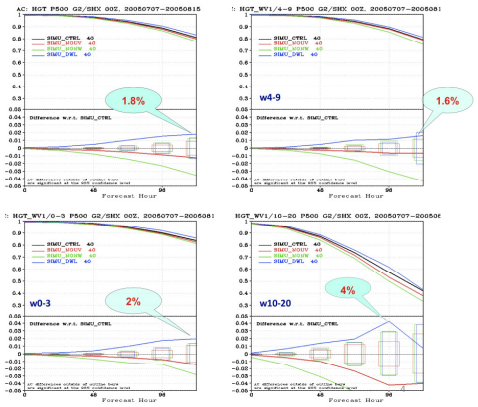
Bias: 200hPa, 850hPa Wind in tropics



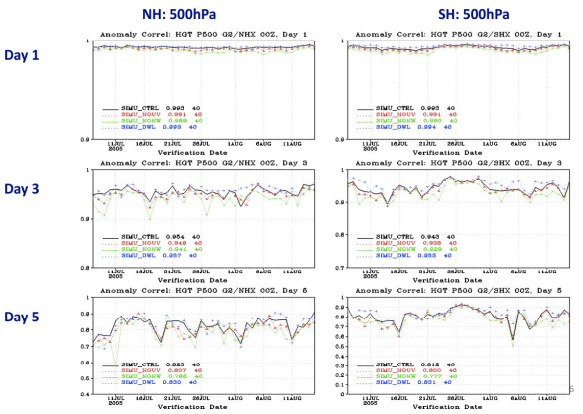
Anomaly Correlation: NH500hPa Geopotential Height



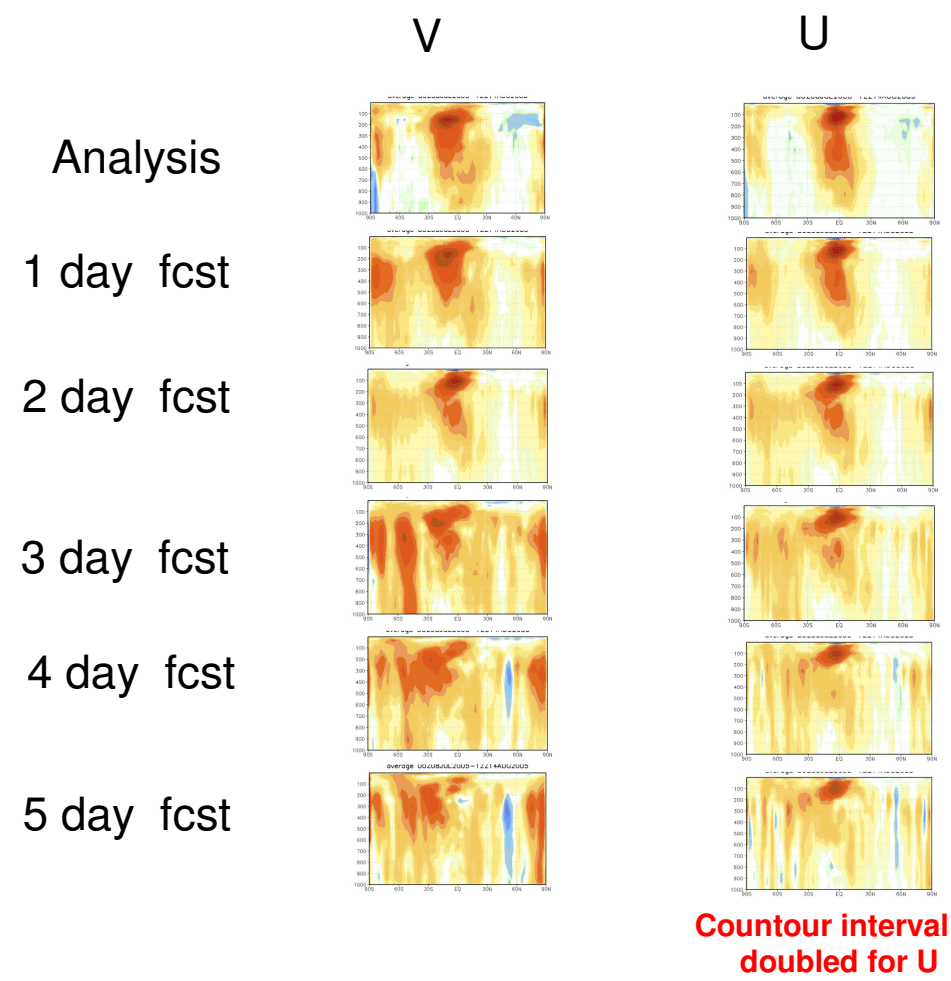
Anomaly Correlation: SH500hPa Geopotential Height



Anomaly Correlation: 500hPa Geopotential Height



Zonally and time averaged improvementby DWL
Reduction of the distance from the Nature run



Summary and conclusion

- The lack of vertically resolved wind observations continue to be a major shortcoming of the Global Observing System
  - Space-borne wind lidar is the best option to meet this need
- A comprehensive OSSE system has been developed under the Joint OSSE collaboration
- Initial results simulating expected impact of GWOS observations on NCEP GFS system are very encouraging
  - Small positive impact in NH extratropics (summer)
  - Larger positive impact in SH extratropics (winter)
  - Very large positive impact in tropics; implications for hurricane forecasting

Outlook

- Extend simulation into hurricane season (several Atlantic hurricanes in Nature Run “Oct 2005”)
- Experiment in opposite season (NH winter/SH summer)
- Increased horizontal resolution (T-382 and higher)
- Detailed case studies
- Separate assessments of the impacts of Direct Detection and Coherent Detection
- Impact of one, two or four telescopes on spacecraft
- Other orbits, e.g. different altitude, lower inclination
- Impact on applications other than NWP, e.g. chemical transport models

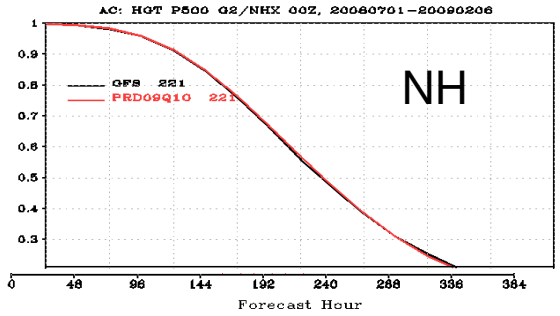
Note on Data impact depend on forecast skill metric

Evolution of GFS Forecast Skill

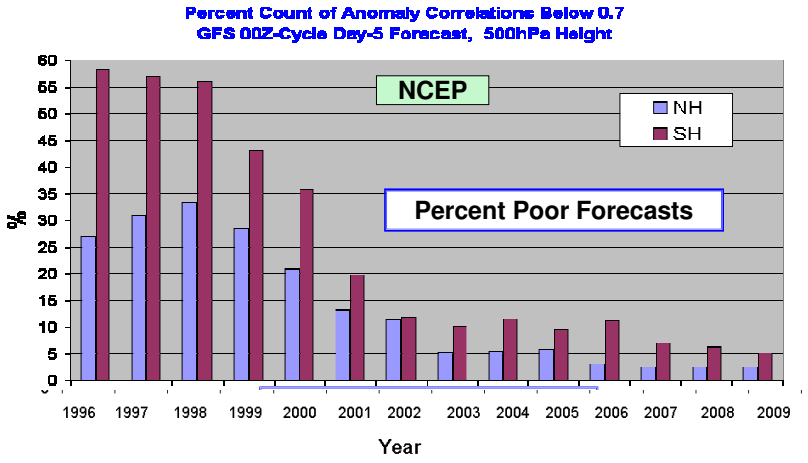
S. Lord and Fanglin Yang (NCEP/EMC)

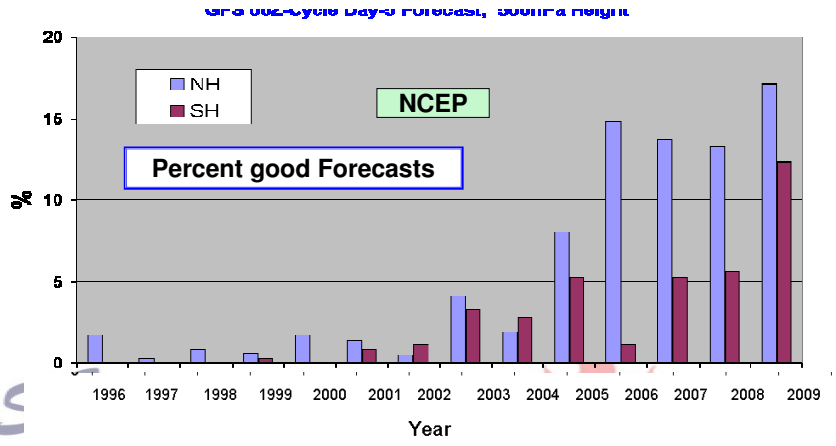
Does It Make a Difference to How Forecasters Use Product?

500 hPa Anomaly Correlation



- "But th ..."
- Are these differences in scores important to users?
- Can more sensitive measures of forecast performance be developed?





Summary

•The Joint OSSE Nature runs have been evaluated, posted and made available to research community
•Four month of simulated radiance (used in 2005) and ozone data at NCEP-NESDIS are posted from NASA/NCCS portal.
•Radiance data for complete 13 month period is being evaluated,
•The complete 13month long imulated conventional observation were been posted from NASA /NCCS portal.

Related presentations

15 IOAS-AOLS Tuesday, 25 January 2011: 9:15 AM
2.5 Observing System Simulation Experiments for a US Wind Lidar space mission

15 IOAS-AOLS Wednesday, 26 January 2011: 9:15 AM
4.4 A preliminary assessment of UAS data impact on tropical cyclone track forecasts based on a global OSSE system

Tuesday, 25 January 2011: 1:45 PM
3.2 Establishing an aerosol backscatter climatology at .355 and 2.06um for the Global Wind Observing System (GWOS) using CALIPSO data and models

Tuesday, 25 January 2011: 8:30 AM
2.2 Technology and data utility challenges for a Doppler Wind Lidar on the International Space Station

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.

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

•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.

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 at ESRL. GMAO also provided code to add random error to simulated data.