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Progresses and future plans for OSSE/NPOESS

Michiko Masutani¹, John C. Woollen¹, Stephen J. Lord¹, John C. Derber¹
G. David Emmitt², Thomas J. Kleespies³, Joseph Terry⁴, Haibing Sun³
Sidney A. Wood², Steven Greco², Robert Atlas⁴, Mitch Goldberg³
Jim Yoe³, Wayman Baker¹, Christopher Velden³, Walter Wolf³
Steve Bloom⁴, Genia Brin⁴, Christopher O'Handley²

NOAA/NWS/NCEP/EMC¹, Simpson Weather Associates²
NOAA/NESDIS³, NASA/GSFC/DAO⁴

<http://www.emc.noaa.gov/research/osse>

1. INTRODUCTION

The future National POES System (NPOESS) is scheduled to fly during the 2007-2010 period. For the next 10 years, a considerable amount of effort must take place to define, develop and build the suite of instruments which will comprise the NPOESS. The forecast impact of current instruments can be assessed by Observing System Experiments (OSEs), in which already existing observations are denied or added to observations from a standard data base. However, the impact of future instruments must be assessed with experiments using simulated observations. These experiments are known as Observing System Simulation Experiments (OSSEs). (Atlas, 1997, Atlas 2002)

This project is a collaboration among the National Centers for Environmental Prediction (NCEP), NASA/Data Assimilation Office (DAO), Simpson Weather Associates (SWA), and the National Environmental Satellite, Data and Information Service (NESDIS). Through this collaboration, the data assimilation and modeling communities can be involved in instrument design and can provide information about the expected impact of new instruments. Furthermore, through the OSSEs, operational data assimilation systems will be ready to handle new data in time for the launch of new satellites. This process involves preparation for future data volumes in operations, the development of the data base and data-processing (including formatting) and a quality control system. All of this development will accelerate the operational use of data from the future instruments (Lord et al. 1997).

In this paper progress and future plans for OSSE for NPOESS is described. The procedure to simulate the observational data and calibration of OSSE system is summarized. In particular, the results from Doppler Wind Lidar (DWL) impact test are described.

2. NATURE RUN

For the OSSE, a long integration of an atmospheric general circulation model (GCM) is required

to provide a proxy "true atmosphere" for the experiment. This is called the "nature run" (NR). The NR needs to be sufficiently representative of the actual atmosphere and different from the model used for the data assimilation. In calibration, the observational data for existing instruments is simulated from the NR. Then forecast and analysis skill for real and simulated data are compared.

For this project, the nature run was provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). The description and evaluation of the nature run is provided by Becker et al. (1996). A one month model run was made at resolution T213 and 31 levels starting from 5 February 1993. The version of the model used for the nature run is the same as for the ECMWF reanalysis.

The nature run was found to be representative of the real atmosphere but with a few exceptions (Masutani et al. 1999, Wood 2001, and Atlas and Terry 2002). Low level marine stratocumulus required some adjustment. In addition, sea surface temperature (SST) is fixed throughout the period for the nature run. However, a localized warm anomaly in the southern hemisphere (SH) appeared in late February in the real SST. This difference in SST could potentially cause some inconsistent results in OSSE calibration and verification.

An alternative NR is being processed with Finite-Volume Community Climate Mode (FVCCM) and the evaluation is posted by Atlas and Terry (2002). The calibration and initial OSSEs for DWL are being conducted by NASA/DAO (Atlas 2002). The new nature run starts in September 1999 and covers the hurricane season. OSSE using FVCCM nature run will be also pursued by NCEP once ECMWF nature run is fully exploited and foundation of OSSE has been established.

3. SIMULATION OF OBSERVATIONS

Details of procedures to simulate observational data are described in Masutani et al. (2002a) and Lord et al. (2002) and their references. The initial simulation of conventional data done by NASA/DAO uses real observational data distributions available in February 1993, including ACARS and cloud motion vectors (CMV, Atlas and Terry 2002). TOVS level 1B radiance data (T1B) is simulated by NOAA/NESDIS the procedure is

Corresponding authors address: Michiko Masutani,
NOAA/NWS/NCEP/EMC, 5200 Auth Rd. Camp Springs, MD
20746. E-mail: michiko.masutani@noaa.gov.

described in (Masutani 2001). The strategies to include correlated error to T1B is presented by Kleespies (2001). DWL has been simulated by SWA and details are described in Masutani(2002b)

CMV is based on the NR wind fields and with their present density, as well as the Atmospheric Infrared Sounder (AIRS), will be included in the calibration. AIRS will be used as one of the advanced sounders in the calibration.

3.1 Simulation of AIRS radiances

The AIRS simulation package was originally developed by Evan Fishbein of Jet Propulsion Laboratory (JPL). The simulation (i.e. forward calculation) is based on radiative transfer code developed by Larrabee Strow (UMBC). The package was modified by Walter Wolf to generate thinned radiance data sets in the BUFR format. The effort to provide AIRS data to NWP centers in near-realtime is being led by Mitch Goldberg (NESDIS). Because the AIRS instrument was not launched until May 2002, the NESDIS AIRS near-real time system has been based on simulated data. The NCEP AVN six-hour forecasts are used to specify the state variables needed for the forward calculation. The simulation package runs in real time and products (thinned radiances and retrievals) are produced in near-real time. This same package is being used to generate AIRS radiances for the OSSE (Goldberg et al. 2001).

3.2 Simulation of Cloud Motion Vectors

For calibration and initial DWL OSSE CMVs are simulated at the location of observed data which are used on observed cloud cover and satellites data as 1993. For more realistic evaluation, the present density of CMVs at the NR cloud location is being simulated by SWA and NASA/DAO (O' Handley et al. 2001, Atlas and Terry 2002). Satellite view cloud fraction with 5% to 25 % is assumed to be a potential tracer. Slow bias and image registration error will be included. The error statistics will be obtained from the NOAA/NESDIS Office of Research and Applications Forecast Products Development Team (NESDIS, 2002).

4. DATA ASSIMILATION SYSTEM

The data assimilation system at NCEP is based on the "Spectral Statistical Interpolation" (SSI) of Parrish and Derber (1992), which is a three-dimensional variational analysis (3-D var.) scheme. T1B is used (McNally et al., 2000, Derber and Wu 1998) for data assimilation and the March 1999 version of NCEP's operational Medium Range Forecast (MRF) and data assimilation system are used for the data impact test. Line of sight (LOS) winds from instruments such as DWL are directly used in the data assimilation.

The following upgrades of the NCEP operational data assimilation system are in progress.

- Development of situation-dependent background error covariances for global and regional systems (Purser and Parrish, 2000).

- Bias correction of background field.
- Improved moisture background error covariances.
- Development of cloud analysis system.

More detailed calibration will be completed with the 1999 operational system. Evaluation of AIRS data and further work will be conducted with the 2002 operational data assimilation system.

5. CALIBRATION FOR OSSE

Calibration experiments help to validate the OSSE system (Masutani et al. 2002a). Similar data withdrawal impact experiments are run for real and simulated observations. A full suite to test the impact of removing various conventional data sources has been conducted. These experiments include withdrawal of rawinsonde winds, rawinsonde temperatures and T1B data. In the NH, real and simulated impacts are consistent. In the SH, the impacts show some inconsistency. This problem has been investigated.

5.1 TOVS data

The larger impact of T1B in simulations is expected because of the lack of measurement error in the simulated T1B data. Under-estimation of the cloud effect in the simulation is another possible reason for the large impact in the simulation. The large analysis impact in the tropics may be related to the bias between the NCEP model and the nature run. Including a bias correction in the data assimilation is being considered (Purser and Derber, 2001).

5.2 Anomalous SST.

It is noted that there is a localized large warm anomaly in the south Pacific at the end of February in the real SST (R-SST). However, SST in the NR is fixed throughout the OSSE period to that of February 5 (FEB5-SST). Assimilation with FEB5-SST with real observed data and assimilation with R-SST with simulated data are performed to test the impact of SST variability. The results showed that the localized anomaly in R-SST caused larger impact of T1B in real data in SH. The simulation experiment with constant SST can produce impact of T1B data when the SST variability is small. These experiments clearly demonstrate that data impact depends on the variability of SST. In fact in the NH, without large difference in SST fields, simulated and real T1B show similar impact.

The results also showed the similarity between real and simulated experiments in responses to two different SSTs. Therefore simulated experiments could demonstrate data impact with slowly varying SST, although the data impacts are not identical.

5.3 Surface data

It is found that surface data in simulated experiments have much more impact than experiments

with real data. One of the reasons suspected was that NR surface height is much smoother of NR compared to the real surface. However,

Another reason is that the NR does not include various errors related to surface type. Constant SST used for NR described in 5.2 also contributes to too optimistic surface data. In the SH simulated ocean surface data seems to easier to be assimilate.

Further error for surface data is being added and evaluated to achieve closer impact between real and simulated experiments.

5.54 Large scale error

In order to test sensitivity to observational error, the difference between observation and analysis (o-a) from the real data assimilation is used as the error for the simulated data. This error will give a large-scale correlated error. With (o-a) error, the rejection statistics of simulated experiments become closer to those for real data. With random error too little data are rejected by quality control. However, simply adding (o-a) error reduced the skill too much. Designs for correlated observed error for T1B data and for improving observational error for conventional data are being investigated (Kleespies 2001).

6. DOPPLER WIND LIDAR (DWL) IMPACT TESTS

DWL has been one of the main instruments to be tested by OSSE. The results from OSSE using T106 ECMWF model is summarized in Baker et al (1995). A set of experiments in this OSSE to determine the relative impact of several generic wind lidar data configurations have been completed (Lord et al. 2002, Masutani 2002b).

The bracketing OSSE (Emmitt 1998) is performed and the impact of clustered versus distributed data products are examined. The results for full tropospheric scanning and non-scanning instruments and have analyzed. The former can be considered an optimal DWL instrument and the latter a minimal instrument. Each DWL configuration provides positive impact to wind forecasts but impacts are consistently larger and more significant with the optimal instrument.

DWL needs to be tested with AIRS and high density CMVs. Various sampling and data processing strategies will be tested. Adaptive observing strategies are investigated for more efficient use of DWL. The systematic error needs to be added (Emmitt 2001).

7. OTHER INSTRUMENTS TO BE TESTED BY OSSE

AIRS and CMV data are being simulated by NESDIS, and OSEs and OSSEs will be performed. DWL needs to be evaluated with these new higher density data.

Other instruments considered for simulation are:

- Advanced Scatterometer
- Cross track Infrared Sounder (CrIS)
- Geostationary Imaging Fourier Transform Spectrometer (GIFTS)

- Conically scanning Microwave Imager/Sounder (CMIS)
- Advanced Technology Microwave Sounder (ATMS)

The decision depends on the results from OSSEs with AIRS and CMV data and resource available.

8. IDEALIZED OSSE EXPERIMENTS

It is important to evaluate how the OSSE system responds to the "perfect" observation system in which the entire world is covered with good quality data. This ideal situation helps us to examine the amount of improvement available to our global observing system and which instruments can provide the most effective impact. After techniques for producing simulated data have been developed and validated, producing any simulated observations is relatively straightforward. With idealized system new techniques for superobbing will be developed (Purser et al. 2001) to handle the large volume of future data more effectively.

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