A Rapid Prototyping Capability Experiment to Evaluate CrIS / ATMS Observations for Urban Modeling Applications
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PROJECT GOAL
The goal of this project is to evaluate the potential for data from the Advanced Technology Microwave Sounder (ATMS) and the Crosstrack Infrared Sounder (CrIS) to impact forecasting of a significant mesoscale weather event over a major urban center along the coast of the Gulf of Mexico.

BACKGROUND
The Advanced Technology Microwave Sounder (ATMS) and the Crosstrack Infrared Sounder (CrIS) will be deployed as part of a suite of atmospheric sensors aboard each satellite of the National Polar-orbiting Operational Environmental Satellite System (NPOESS), a program operated jointly by NASA, NOAA, and the Department of Defense. Deployment of the NPOESS satellites will be preceded by the NPOESS Preparatory Project (NPP) satellite, scheduled to be launched in 2009. The NPP serves as an environmental study for NASA, and a risk reduction study for NPOESS. The ATMS, in conjunction with the CrIS, shall provide improved global atmospheric profiles of temperature, humidity, and pressure compared to microwave sensors currently in operation.

METHODOLOGY
A global-scale NR has been performed by European Center for Medium-Range Weather Forecasting (ECMWF) over a period representative of 01 May 2005 – 31 May 2006, using the ECMWF model with a T511 spectral grid (Δx ~ 40 km). Ongoing work by NASA’s Global Modeling and Assimilation Office (GMAO) and NOAA’s Environmental Modeling Center (EMC) indicate that atmospheric disturbances simulated by this NR resemble realistic baroclinic systems and tropical cyclones. To supplement the initial 13-month NR, two additional high-resolution NRs (HRNRs) have been performed over separate periods with the ECMWF model on a T799 spectral grid (Δx ~ 25 km) for the periods representative of 27 September – 01 November and 10 April – 15 May.

It is expected that realistic atmospheric disturbances will be simulated during the HRNRs, as with the original NR. Case events of large mesoscale systems (i.e. mid-latitude baroclinic system, see Figure 1; tropical cyclone) will be selected from one or both of the HRNR periods based upon a review of data from the original NR (Figure 2), with a population center along the coast of the Gulf of Mexico serving as a study site. Possible study sites with significant populations include Houston / Galveston, TX, Tampa Bay, FL, and the North Central Gulf Coast. The final choice of a study site will depend largely on the placement of the case event system during an HRNR.

An Observing System Simulation Experiment (OSSE) methodology will be adopted in order to characterize the uncertainties associated with the measurement, instrument, and retrieval processes. Within the OSSE framework (Figure 1), an NR is a proxy for real atmospheric and land surface conditions.

Figure 1. MODIS Aqua visible-wavelength image for the afternoon of 30 April 2005. An intense convective squall line tracks across the northern coast of the Gulf of Mexico.

Figure 2. Example of ECMWF NR sea-level pressure data from date representing 10 April 2006, during which the NR simulates a baroclinic cyclone over the Midwest with trailing front over the lower Mississippi Valley.
It is based on a “free run” of a global-scale forecast model. For an OSSE, it is very important that different data-assimilating models be used to generate the NR and subsequent sensitivity tests. The basis for using separate models for performing the OSSEs is to avoid the replication of results that could occur with using the same configurations within the same model, as the correlated biases will introduce a false optimism. This result is a “fraternal twin” problem, in which a low error bias between models does not realistically portray the error bias expected with the assimilation of the prospective sensor data. Using different models with inherently different physics parameterizations avoids this problem.

The OSSE methodology (Figure 3) will be based on the procedures adopted by NASA Global Modeling and Assimilation Office (GMAO) and NOAA Environmental Modeling Center (EMC). The overall goal is to examine the potential impact of these future sounding instruments on city-centric mesoscale modeling in one or two case studies.

Figure 3. Methodology employed for the Observing Simulation System Experiment.

A regional, mesoscale nature run (RSNR) will be produced using the MM5, and will serve as “truth” for our modeling experiments. The RSNR will be a nest simulation (Figure 4) within one of the larger scale NRs produced from the ECMWF model. Our primary experiment will assimilate synthesized CrIS and ATMS data, as well as synthetic “conventional observations”, all provided by the RSNR in a cycling mode using the Earth System Modeling Framework (ESMF)-enabled Weather Research and Forecast (WRF) model. To simulate observations from the candidate sensors, error and bias characteristics may be adopted from the NPOESS Aircraft Sounder Testbed (NAST), in which prototypes of the ATMS and the CrIS were tested aboard aircraft.

The WRF model is used in addition to the MM5 to avoid the fraternal twin problem that can contaminate OSSE studies. Experiments to be performed with the WRF model are:

1) Exclusion, or denied assimilation, of all observation datasets.
2) Exclusion of rawinsonde data only.
3) The assimilation of all available datasets and simulated ATMS / CrIS data.
4) #1 with the inclusion of synthetic ATMS / CrIS data.
5) #2 with the inclusion of synthetic ATMS / CrIS data.

**SOCIETAL BENEFITS**

We expect that data transmitted from the ATMS and the CrIS will greatly supplement the existing networks of surface observations and upper-air observations in the analysis of atmospheric temperature, humidity, and pressure; enhance the quality of data assimilated into operational forecast models; and subsequently help to improve the simulation of weather on regional and local scales. ATMS and CrIS shall improve the initial conditions in operational forecast models, thereby increasing the skill of official weather forecasts. Society benefits through planning and decision-making related to the activities of local governments, commercial entities, and communities.

The precipitation products and land surface predictions resulting from this project will be of critical importance to real-world applications such as weather and climate prediction, flood prediction, and water supply. This proposal will build on existing initiatives, such as the NASA GMAO and JCSDA, that seek to advance operational weather forecasting needs, and operational hydrological forecasting initiatives like the NOAA Advanced Hydrologic Prediction System (AHPS).

**ACKNOWLEDGEMENTS**

The researchers gratefully acknowledge Lars-Peter Riishojgaard, of the Joint Center for Satellite Data Assimilation and NASA/GMAO, for his collaboration in this project, the ECMWF for producing nature run data, and the NOAA/EMC for arranging access to the ECMWF nature run data.