A REGIONAL OBSERVING SYSTEM SIMULATION EXPERIMENT (OSSE) FOR EVALUATING THE POTENTIAL IMPACTS OF ATMS / CRIS

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Introduction

The Advanced Technology Microwave Sounder (ATMS) and the Crosstrack Infrared Sounder (CrIS) will be deployed aboard each satellite of the **National Polar-orbiting Operational Environmental Satellite System (NPOESS)**, a program operated jointly by NASA, NOAA, and the U.S. Department of Defense. Deployment of the NPOESS satellites will be preceded by the NPOESS Preparatory Project (NPP) satellite, scheduled to be launched in 2010.

The ATMS and the CrIS are expected to provide improved global atmospheric profiles of temperature, humidity, and pressure over microwave sensors currently in operation, such as the Advanced Microwave Sounding Unit (AMSU). Current microwave and infrared sounders have a temperature uncertainty of 1.6 °C km^{-1}, and a moisture uncertainty of 25% per 2 km. The combined operation of ATMS and CrIS is expected to reduce the temperature uncertainty to less than 1.6 °C km^{-1}, and the moisture uncertainty to 15% per 2 km (Bloom 2001).

OSSE Methodology

The OSSE framework is illustrated in Figure 1. The nature run (NR) is a proxy for real atmospheric and land surface conditions, and is based on a "free run" of a numerical forecast model. From the NR, synthetic observations representative of current and future observing systems are extracted. Two data-assimilating models are used for the NR and data sensitivity simulations to avoid the "fraternal twin problem", which results from the simulation – and subsequent assimilation – of synthetic observations using a single model, which causes an unrealistically low error bias for the assimilation of the prospective sensor data.

Two NRs were produced by NCEP (Masutani et al. 2006) and were based on the European Centre for Medium-Range Forecasting (ECMWF) model with spectral resolutions of T511 (Δx ~ 40 km) and T799 (Δx ~ 25km). From these NR datasets, we identified a mesoscale weather event – a squall line along the U.S. coast of the Gulf of Mexico – with which to conduct an OSSE of the ATMS / CrIS system. However, as the resolution of the ECMWF NRs were not sufficient for producing synthetic datasets representative of the ATMS / CrIS system, a regional-scale NR (RSNR) was simulated using a nested grid configuration (Δx_1 = 9 km, Δx_2 = 3 km) of the MM5.

The WRF model is used to assimilate the synthetic observations. Table 1 and Figures 2 and 3 summarize the configuration of the MM5 and the WRF model simulations.

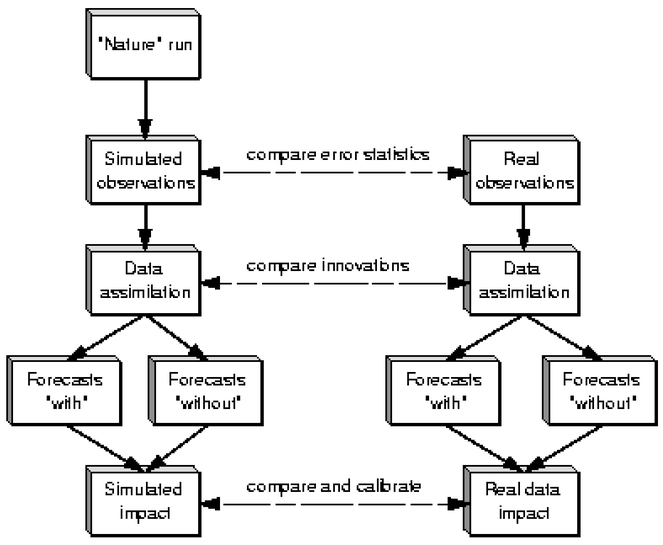


Figure 1. Components of an OSSE compared with those of an observing system experiment (OSE). Adapted from Lord et al. (1997).

	MM5	WRF
initial conditions / boundary conditions	ECMWF T799 NR	ECMWF T511 NR or T799 NR
grid dimensions	9-km: 553 × 521 3-km: 661 × 511	9-km: 421 × 331 3-km: 493 × 445
microphysics scheme	simple ice	simple ice
planetary boundary layer scheme	Blackadar	Yonsei Univ.
cumulus scheme (9-km)	Kain-Fritsch	Kain-Fritsch

Table 1. Model configurations

Figure 2. MM5 grid configuration

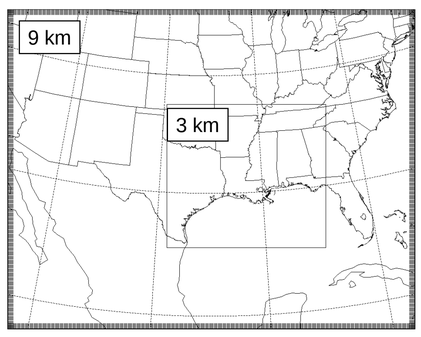


Figure 3. WRF grid configuration

Steps and Results of OSSE Procedure

The MM5 RSNR is performed for the period of 00 UTC 02 May to 00 UTC 04 May "2006", with focus over the U.S. Gulf Coast and the squall line identified from the ECMWF NRs.

A series of 12-h WRF simulations are conducted throughout the T799 NR period of 12 April to 17 May "2006" for the purpose of calculating background error statistics, based on the Parrish and Derber (1992) method. The background error statistics are used to calibrate the WRF experiments simulated the squall line event.

Analysis \ Forecast	12 UTC (Day 1)	00 UTC (Day 2)	12 UTC (Day 2)	00 UTC (Day 3)
00 UTC (Day 1)	12h forecast	24h forecast	-	-
12 UTC (Day 1)	-	12h forecast	24h forecast	-
00 UTC (Day 2)	-	**24h - 12h error**	12h forecast	24h forecast
12 UTC (Day 2)	-	-	**24h - 12h error**	12h forecast
00 UTC (Day 3)	-	-	-	**24h - 12h error**

Two different WRF control runs are performed, using the ECMWF T799 and T511 NR datasets as the initial conditions (IC) and boundary conditions (BC), respectively. In using the T511 NR data, the WRF experiments reflect the realistically imperfect nature of modeling the exact atmosphere, represented here by the MM5 RSNR forced by the T799 NR dataset.

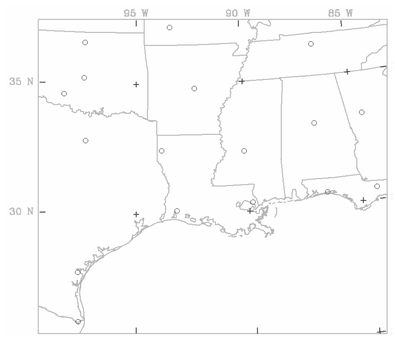
Synthetic upper-air soundings are extracted from the MM5 RSNR and used in a WRF assimilation experiment.

Available synthetic ATMS / CrIS orbit data overlying the WRF grid are retrieved for the period of 0730 UTC to 1000 UTC on 02 May.

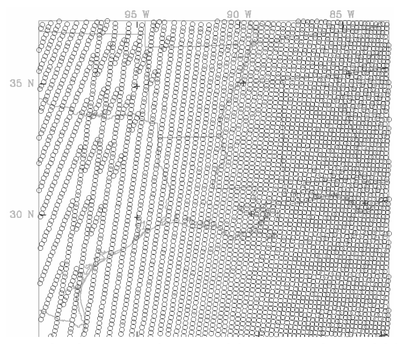
Points of the scan area derived from the synthetic orbit data are thinned to closely match the grid points of the WRF 3-km domain.

T and $\boldsymbol{T_d}$ data are extracted from the 3-km grid of the MM5 RSNR and matched to the thinned scan area across the WRF 3-km grid, and are assigned satellite retrieval errors of ±1 K and ±2 K, respectively.

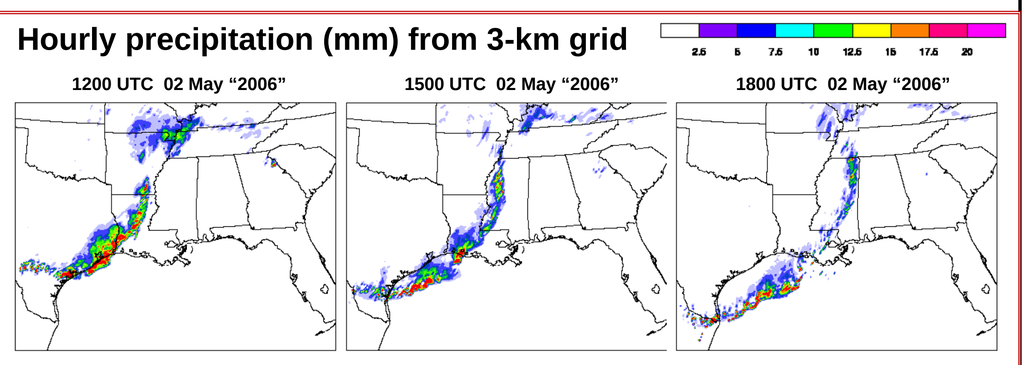
The ***T*** and $\boldsymbol{T_d}$ data, representing ATMS / CrIS synthetic observations, are assimilated into the WRF 3DVAR at 0900 UTC 02 May for another WRF experiment.



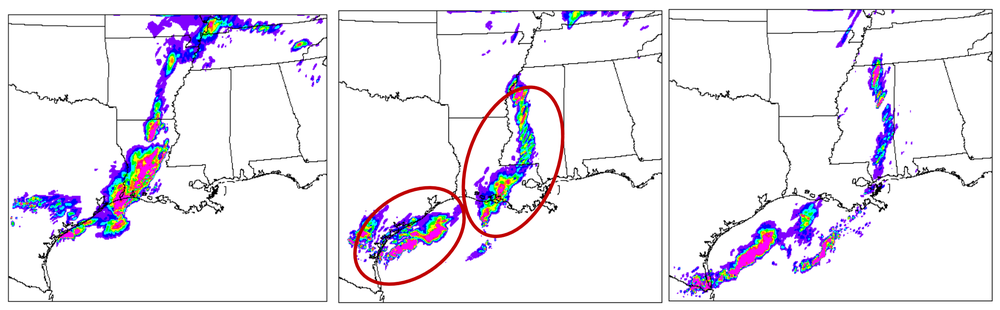
Rawinsonde network within WRF 3-km grid area



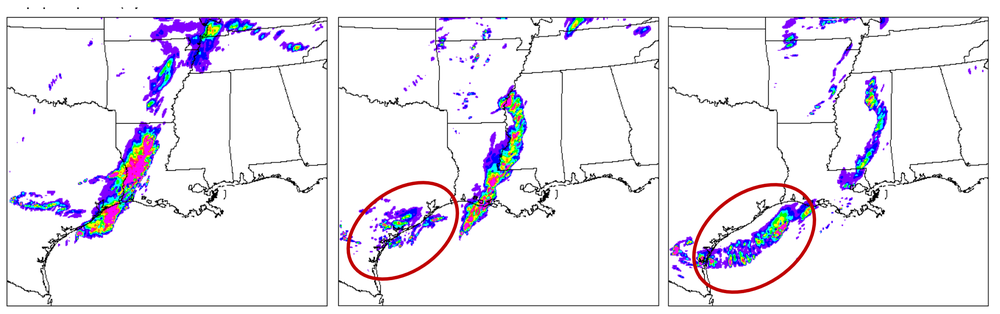
Synthetic ATMS / CrIS orbit scan points within WRF 3-km grid area.



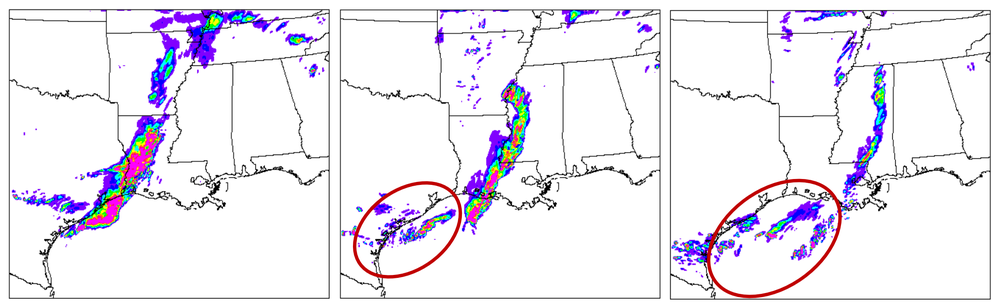
MM5 RSNR. Intense squall line tracks along the Texas and Louisiana coast. The squall line weakens over land, yet maintains a singular structure. Note: synthetic observations are extracted from this simulation.



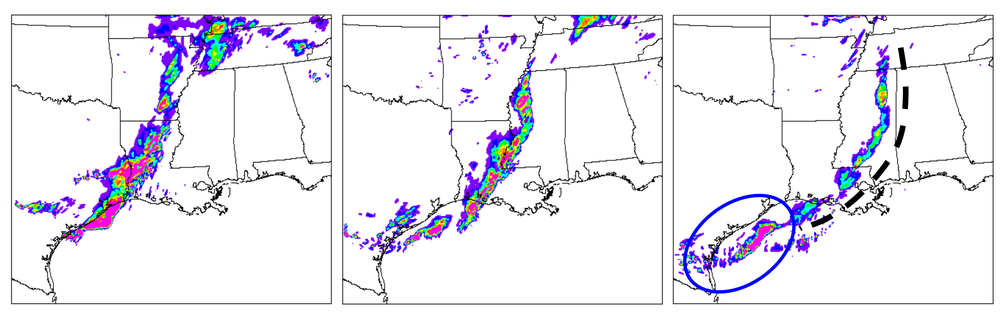
WRF control run with T799 IC/BC. The squall line breaks into two segments near the Louisiana coast, as the north segment slightly outpaces the south segment. Otherwise, this WRF simulation closely resembles the MM5 RSNR, as each uses the T799 NR for initial conditions and boundary conditions.



WRF control run with T511 IC/BC. The squall lines breaks into two segments and the precipitation output is reduced for the entire squall line. Though results do not closely resemble the MM5 RSNR, this WRF simulation may better represent present-day mesoscale modeling capabilities.



WRF experiment with synthetic rawinsonde data. Precipitation output is further reduced over the Gulf of Mexico, perhaps due to an inbalance of rawinsonde data availability between land and water. Squall line structure more closely resembles that depicted in the WRF T799 control simulation. IC / BC: T511 NR.



WRF experiment with synthetic ATMS / CrIS data. Compared with other WRF simulations, the precipitation field more closely resembles the MM5 RSNR with respect to output and placement, especially over water. The structure of the entire squall line is more contiguous in nature. IC / BC: T511 NR.

References

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Acknowledgements

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