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SYNTHETIC GOES-R AND NPOESS IMAGERY OF MESOSCALE WEATHER EVENTS

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1. INTRODUCTION

One of the most important advantages of Geostationary Operational Environmental Satellite-R (GOES-R) will be the relatively small temporal sampling rate--5 min—combined with a horizontal footprint of 2 km. Current satellites are unable to provide this type of data. For this reason, synthetic observations are being generated from a numerical cloud model (Colorado State University/Regional Atmospheric Modeling System: CSU/RAMS) in combination with an observational operator that contains radiative transfer algorithms. The first step is to demonstrate that realistic synthetic images can be generated for GOESR and the NPOESS VIIRS sensor. The emphasis of this study is on mesoscale weather events such as severe storms, tropical cyclones, and lake effect snow. These types of events require high temporal resolution of GOES-R and the very high spatial resolution of NPOESS.

2. RAMS OVERVIEW

The numerical cloud model used for this study was RAMS43 (Pielke et al. 1992).The following features of RAMS were used to simulate the mesoscale weather events:

•The model was run non-hydrostatically and compressible (Tripoli and Cotton 1982).
•Momentum was advanced using a leapfrog scheme while scalars were advanced using aforward scheme. Both methods used second order advection.
•Vertical and horizontal turbulence coefficients
were parameterized using the Smagorinsky (1963) deformation based eddy viscosity with stability modifications (Lilly 1962).
•Hydrometeors were predicted with a two-moment bulk microphysical scheme (Meyers et al. 1997). Mass mixing ratio and number concentration were prognosed for six of the seven hydrometeor types while the mean diameter was diagnosed. Cloud droplet mass mixing ratio, however, was predicted using a one-moment scheme. (Work is ongoing to include cloud droplets into the two-moment scheme.) The following hydrometeor species were included in the simulation: Cloud droplets, rain droplets, aggregates, graupel, hail, snow, and pristine ice. Both graupel and hail are mixed phased; that is, liquid water may exist on the surface of each particle. Snow and pristine ice are each divided into five habit categories: Columns, hexagonal, dendrites, needles, and rosetta.
•Other prognostic variables were the three components of velocity--u, v, w; perturbation Exner function, pi*; total
water, r_{t}; and ice-liquid potential temperature, theta_{il} (Tripoli and Cotton 1981).
•RAMS uses the Arakawa fully staggered C grid (Arakawa and Lamb 1981).
•Perturbation Exner function tendencies, used to update the momentum variables, were computed using a time split scheme—similar to Klemp and Wilhelmson (1978).
•Lateral boundaries used the Klemp-Wilhelmson condition; that is, the normal velocity component specified at the lateral boundary is effectively advected from the interior.
•A wall with friction layers was specified at the top boundary.
•Land Ecosystem Atmospheric Feedback model, version 2 (LEAF2) (Walko et al. 2000) was employed.

3. OBSERVATIONAL OPERATOR OVERVIEW

The observational operator used for computing brightness temperatures was developed at the Cooperative Institute for Research in the Atmosphere (Greenwald et al. 2002). It consists of three main components: radiative transfer models, hydrometeor optical (or single-scatter) property models, and a gas extinction model. The specific components are the following:

•Radiative transfer model at infrared wavelengths: Delta-Eddington 2-stream method (Deeter and Evans 1998).
•Radiative transfer model at solar wavelengths:Spherical Harmonic Discrete Ordinate Method (SHDOM; Evans 1998).
•Cloud optical property models at all wavelengths: Based on anomalous diffraction theory (Mitchell 2000; Mitchell 2002; Greenwald et al. 2002) applied to both liquid and ice particles.
•Gas extinction model at proposed GOESR/VIIRS wavelengths;Optical Path TRANsmittance (OPTRAN; McMillin et al. 1995);Spherical Harmonic Discrete Ordinate Method (SHDOM; Evans 1998) for radiative transfer at solar wavelengths.
•Radiative transfer model at infrared wavelengths using a Delta-Eddington 2-stream method (Deeter and Evans 1998).

4. SYNTHETIC GOESR IMAGES

As an example, the 8 May 2003 severe weather event that occurred over the central plains of the United States was simulated using the CSU/RAMS model. Figures 1 and 2 show synthetic 2km GOESR at 10.35 µm and 400 m VIIRS at 11.02 µm. Imagery shown in Fig. 1 was generated from data simulated in grid 3—horizontal grid spacing was 2 km-- during the RAMS simulation. Similary, Fig. 2 was generated from grid 4 that had horizontal grid spacings of 400 m.

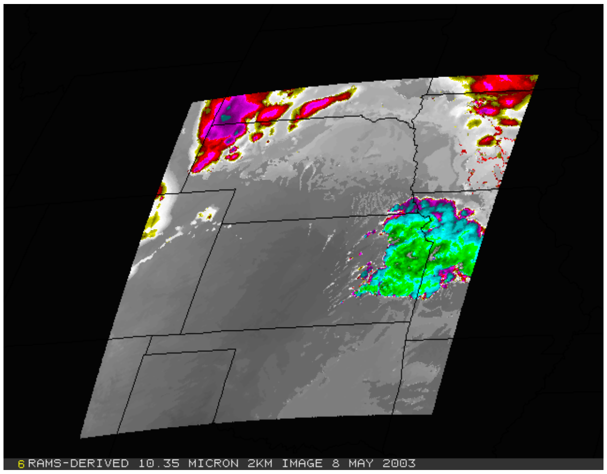

Figure 1: Synthetic 2 km GOESR 10.35 μm image.

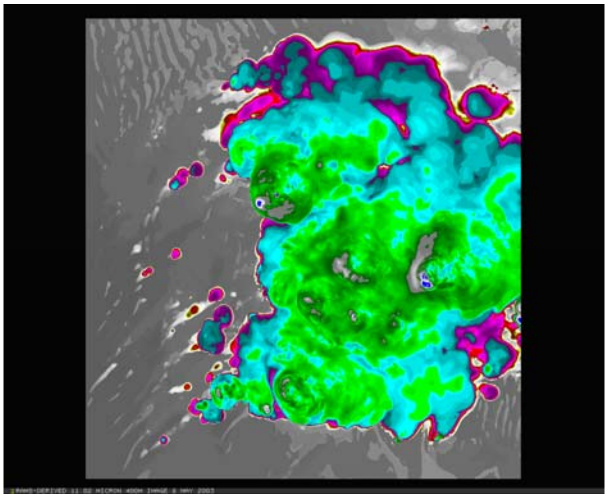

Figure 2: Synthetic 400 m VIIRS 11.02 μm image.

5. Future Plans

The numerical model/radiative transfer simulations will be performed for the other case studies. Synthetic GOES-R imager data will be generated for mesoscale product development. Data assimilation studies will first be performed using an identical twin approach, followed by real-data tests with AIRS and other hyperspectral IR data sets.

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