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SIMULATION OF AN IHOP CONVECTIVE INITIATION CASE FOR GIFTS FORWARD MODEL AND ALGORITHM DEVELOPMENT

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1. INTRODUCTION

The Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) is scheduled for launch in November 2005, and represents a significant advance in the ability to image and sound the atmosphere from a geosynchronous orbit. GIFTS is targeted at a horizontal resolution of 4 km, vertical resolution of 1-2 km, and maximum temporal resolution of 10 seconds. As such, it will allow much more rapid and high-resolution retrievals of temperature, moisture, and wind than are available with any current geostationary instrument.

After the recent commitment of funds to the GIFTS mission by NOAA, NASA, and Navy, plans are underway at SSEC/CIMSS to test and develop a GIFTS forward radiative transfer model and retrieval algorithms. In support of this work, high spatial and temporal-resolution numerical model simulations are used to produce a "truth" atmosphere, which is then passed through the GIFTS fast forward radiative transfer model to generate simulated top of the atmosphere radiances. Retrievals of temperature, water vapor and winds generated from these radiances are subsequently compared with the original simulated atmosphere to assess retrieval accuracy.

In this paper, we present results from current work, which involves a high-resolution mesoscale numerical simulation of a case of convective initiation that occurred on 12 June 2002 during the International H_2O Project (IHOP) intensive observing period. This simulation is designed to realistically depict very high-resolution water vapor features and late-day convection over the Oklahoma/Kansas border, and will be used to assess GIFTS ability to observe fine-scale water-vapor features, and thus to demonstrate GIFTS utility in increasing lead-time for forecasts of convective initiation. In addition, GIFTS top of atmosphere radiances derived from atmospheric profiles of temperature and water vapor will be used in ongoing development of GIFTS derived products, including stability and turbulence.

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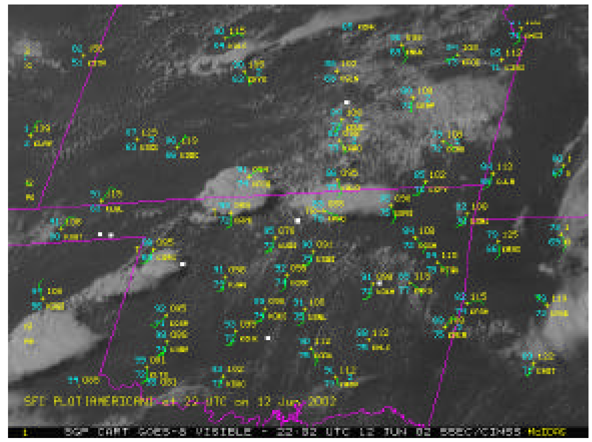

Figure 1: GOES-08 visible image of convective initiation occurring over Kansas and Oklahoma at 2200 UTC 12 June 2002. The satellite image is overlaid with surface observations valid at the same time.

2. CI CASE DESCRIPTION

Convection first occurred at approximately 2100 UTC on 12 June 2002 along a weak low-level trough that stretched southwest to northeast across western Oklahoma. Figure 1 depicts this convection as observed by the GOES-08 visible channel at 2200 UTC 12 June. This particular case was selected because it occurred during a day specifically targeted for study of convective initiation during IHOP 2002. Special observational datasets collected during an intensive observing period between 1600 and 2300 UTC included cross-dryline flights by Proteus, King Air, and P3 aircraft, three-hourly radiosonde launches, and 5-minute imagery from GOES-11. The Forecast Systems Lab Rapid Update Cycle (RUC) model was run at 10 km grid spacing, producing 3-hourly analyses over the length of the IHOP 2002 experiment. Reports specific to the convective missions on 11 and 12 June 2002 can be viewed at the UCAR JOSS IHOP web page:
http://www.joss.ucar.edu/cgi-bin/catalog/ihop/report/index

3. MM5 CONFIGURATION AND PRELIMINARY SIMULATION RESULTS

Simulated atmospheric fields are generated using the 5th generation Penn State/NCAR Mesoscale Modeling system (MM5) version 3.5. MM5 simulations are initialized using a combination of the

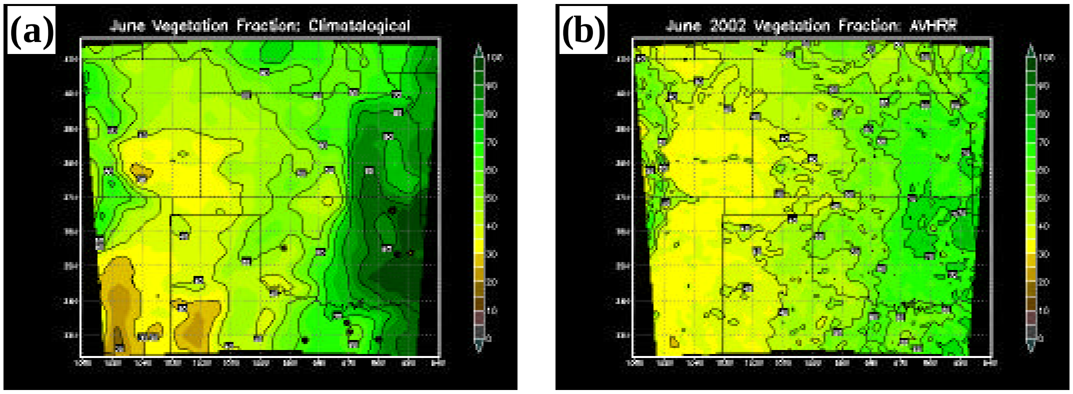

Figure 2: Plots of vegetation fraction from MM5 data ingest system. (a) Climatological vegetation fraction typically used in MM5 (b) Vegetation fraction derived from AVHRR NDVI.

aforementioned 10 km RUC analyses, 1-degree grid spacing AVN model output (for soil moisture and sea-surface temperatures), and an estimate of photosynthetically active vegetation fraction derived from the Advanced Very High Resolution Radiometer (AVHRR) Normalized Difference Vegetation Index (NDVI) product. Differences between the climatological vegetation fraction normally used in MM5 and the AVHRR-derived vegetation fraction are plotted in figures 2a and 2b respectively. Effects of radiation on the temperature tendency for both cloudy and clear air are computed using the RRTM long-wave radiation scheme (Mlawer et al 1997) and Dudhia short-wave (1989). Simulations are initialized directly from the ingest analyses and observations and no nests are used. Approximate horizontal coverage in the model is similar to that of the above GOES-08 satellite image.

At the time of submission of this document, sensitivity testing is underway to determine the optimal model configuration and data ingest/data assimilation procedure. Preliminary results indicate that the MM5 was able to effectively generate convection on 12 June. However, the timing and horizontal extent of the convection varies considerably depending on the choice of physical parameterization, initialization time, and nudging weights. A series of plots of lower-trophospheric water vapor, winds, and cloud depicting initiation of convection from a simulation performed on 11 June is shown in figure 3. Comparison between simulated atmospheric fields and satellite imagery reveals that the modeled convection occurred too early in central Kansas, while the robust convective complex in western Oklahoma in the model never developed significantly in reality. However, for the purposes of this

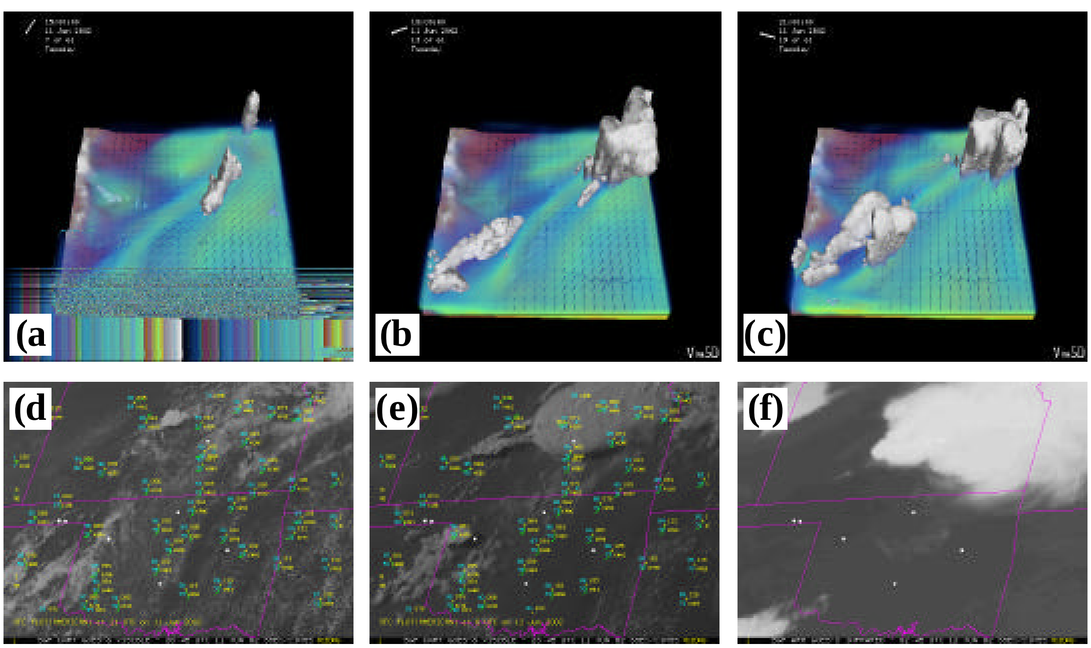

Figure 3: Preliminary results from a simulation of convective initiation during 11–12 June 2002 with comparison to GOES-08 imagery. The sequence of images in (a)–(c) shows a sharpening low-level water vapor gradient over northern Texas and subsequent convective initiation. (a) 1500 UTC (b) 1800 UTC (c) 2100 UTC (d) Visible imagery 2045 UTC 11 June (e) Visible imagery 2345 11 June (f) Infrared imagery 0245 12 June 2002.

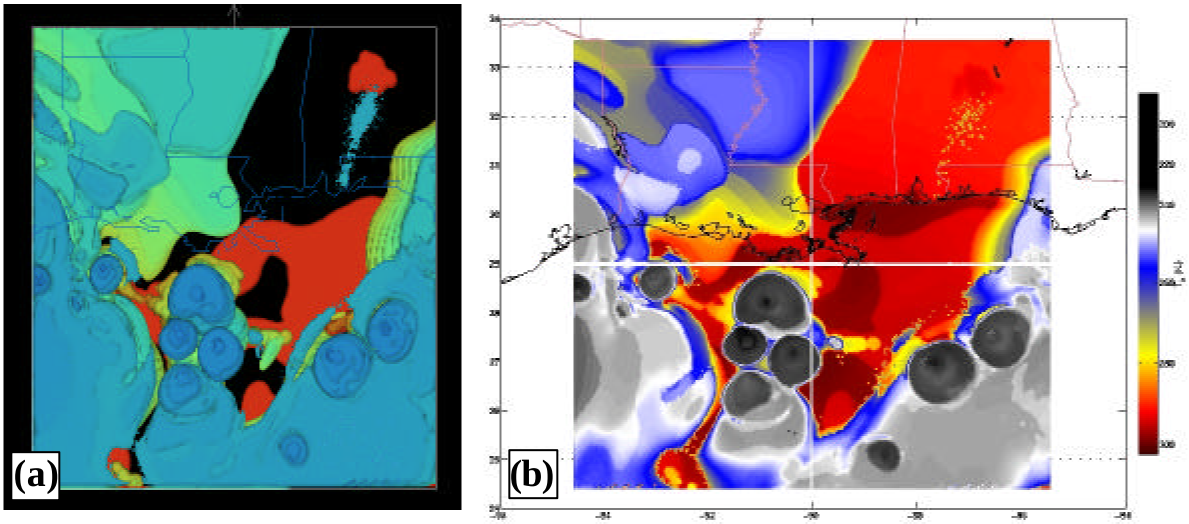

Figure 4: (a) Top view of total cloud liquid and ice mixing ratio from a numerical simulation, shaded from blue to red from the upper troposphere to the surface, respectively. (b) Top of the atmosphere brightness temperatures output from the GIFTS fast forward radiative transfer model shaded from warm (lower troposphere) in red to cold (upper troposphere) in black.

work, the convective initiation following a period of general clear skies represented in the MM5 simulation effectively demonstrates GIFTS ability to resolve small-scale changes in water vapor gradient.

3. RADIANCE SIMULATION AND RETRIEVALS

To generate simulated GIFTS top of the atmosphere radiances, UW-CIMSS has developed a fast forward radiative transfer model. This model ingests atmospheric profiles of temperature, water vapor mixing ratio, liquid and ice cloud, and ozone, and generates top of atmosphere radiances in the GIFTS spectral range. These radiances are then used to retrieve atmospheric temperature, water vapor, and winds, which are then compared with the original atmospheric fields to assess the robustness of the retrieval method. Conversion of atmospheric fields to radiances is exemplified in figure 4, while an assessment of retrieval accuracy is shown in figure 5.

4. CONCLUSIONS

UW-CIMSS is currently occupied with development and testing of the GIFTS fast forward radiative transfer model and concurrent atmospheric retrieval methods in preparation for launch of GIFTS late in 2005. As part of this initiative, UW-CIMSS is using output from a high-resolution simulation of convective initiation that occurred during IHOP 2002 to demonstrate GIFTS projected ability to remotely sense the small-scale water vapor structure and gradients. Preliminary results indicate that, although the MM5 numerical model was unable to simulate the exact timing and location of convection, it sufficiently resolves the development of convection proceeding from low-level moisture convergence, and can thus be effectively used for GIFTS demonstration purposes.

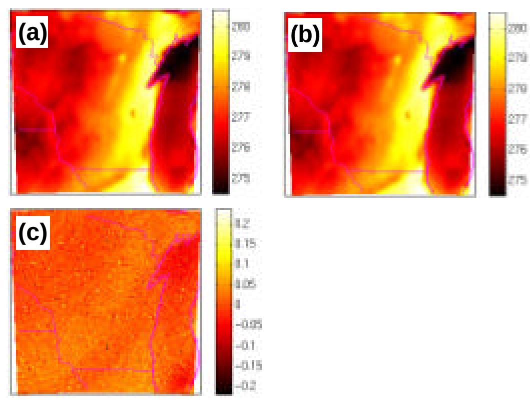

Figure 5: (a) Surface skin temperature (K) from an atmospheric numerical simulation. (b) Skin temperature retrieved from simulated top-of-atmosphere radiances derived from the atmospheric simulation. (c) Difference (a) – (b) depicting the level of retrieval accuracy.

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