P2.36 GENERATION OF SIMULATED TOP OF ATMOSPHERE RADIANCE DATASETS FOR GIFTS/HES ALGORITHM DEVELOPMENT

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1. INTRODUCTION

The anticipated launch of the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) 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, a vertical resolution of 1-2 km, and a maximum temporal resolution of 10 seconds. As such, it will produce retrievals of temperature, moisture, and wind with much greater temporal and vertical resolution than is currently available from any existing geostationary instrument.

SSEC/CIMSS is currently tasked with testing and developing the GIFTS fast forward radiative transfer model and retrieval algorithms. In support of this work, numerical model simulations with high spatial and temporal resolution are used to produce a “truth” atmosphere that 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 MM5 simulation of an intense jet streak that occurred across the central Pacific Ocean during 12-13 March 2003. This feature was extensively observed as part of the first Pacific THORPEX Observing System Test (TOST), the 2003 GOES rapid-scan WINDs EXperiment (GWINDEX), and the NOAA NCEP Winter Storms Research Program (WSRP).

2. CASE DESCRIPTION

During 12-13 March 2003, an intense zonally-oriented jet streak with a maximum analyzed wind speed near 100 m s^{-1} (Fig. 1) was located over the north-central Pacific Ocean. This particular jet streak case was selected because it occurred during a day specifically targeted for the study of jet streak dynamics during the Pacific TOST 2003. Observational datasets collected during a NASA ER-2 flight between

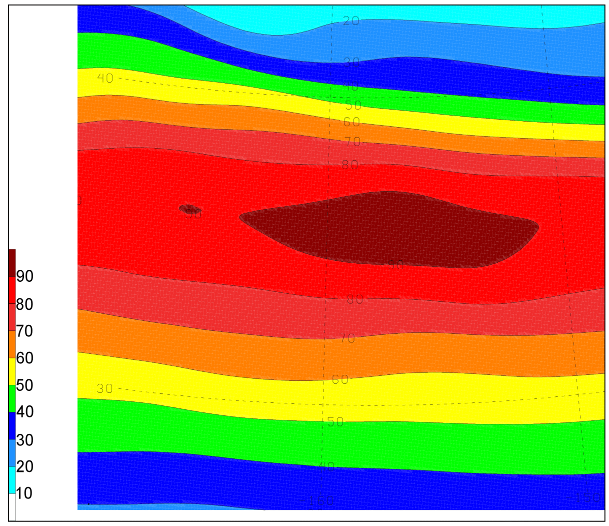

Figure 1. 300 hPa zonal wind isotachs at 0000 UTC 13 March 2003. Isotachs are contoured in m s^{-1} and shaded ever 10 m s^{-1} starting at 10 m s^{-1}.

2100 UTC 12 March and 0400 UTC 13 March included remotely-sensed observations from the NPOESS Aircraft Sounder Testbed-Interferometer (NAST-I), Scanning High-resolution Interferometer Sounder (SHIS), MODIS Airborne Simulator (MAS), and Cloud Physics Lidar (CPL), as well as dropsondes across the jet streak core. Reports specific to the mission flown on 12 March 2003 can be viewed at the 2003 Pacific TOST web page:

http://www.angler.larc.nasa.gov/thorpex/missionsummary/mar12 .

3. INITIALIZATION DATA

Atmospheric fields required to initialize the MM5 and provide lateral boundary conditions during the subsequent simulation were obtained from six-hourly GDAS analyses with 1° x 1° horizontal grid spacing. Each six-hourly GDAS file contains three-dimensional fields of temperature, zonal and meridional components of the horizontal wind, geopotential height, and relative humidity on 26 pressure levels between 1000 and 10 hPa. The GDAS analyses of skin temperature, sea level pressure, soil temperature, soil moisture, surface height and other near-surface atmospheric fields provided the lower boundary conditions for the MM5 simulations.

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4. MM5 SIMULATIONS

In order to determine the optimal MM5 model configuration for this case, sensitivity studies were performed using different combinations of physical parameterizations. For each simulation, three two-way interactive nested domains with 50 vertical levels and horizontal grid spacings of 36 km, 12 km, and 4 km, respectively, were used. The geographical region covered by these domains is shown in Fig. 2. Each simulation was initialized at 1200 UTC 11 March 2003 and allowed to spin-up for 33 hours before the start of the ER-2 flight at 2100 UTC 12 March 2003. Such a long spin-up period was chosen in order to allow sufficient time for the MM5 simulation to properly generate realistic fine-scale cloud and moisture features from the original coarse-resolution GDAS analyses.

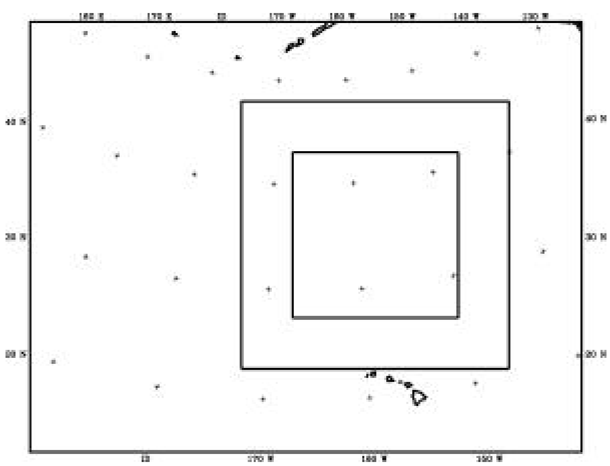

Figure 2. Aerial coverage of the MM5 domains used for this simulation. The innermost domain represents the region of interest for the present study.

The primary objective of this case study was to achieve a high degree of realism between the observed and MM5-simulated cloud fields. Since observations of cloud microphysical properties are not available for this case, a subjective comparison between the simulated and observed GOES IR fields was undertaken in order to determine which MM5 simulation performed best. Based upon this comparison, it was determined that the following configuration of physical parameterizations produced the most realistic simulation of the observed cloud field:

- Goddard microphysics
- Eta planetary boundary layer
- RRTM/Dudhia radiation
- Grell cumulus convection scheme on the outer two domains with explicit cumulus (no cumulus parameterization) on the innermost 4-km domain.

Figure 3 compares the 10.7 micron brightness temperatures (commonly referred to as the infrared (IR) channel) observed by the GOES-10 satellite to the MM5-simulated IR field. Although the small-scale details of the simulated IR field differ from what was observed by the GOES-10 satellite, it is evident that the simulation successfully captured the primary observable features, namely, the cyclonic circulation north of the jet axis (refer to Fig. 1), the broad low-level cellular cumulus field across the middle of the domain, and the cooler cloud tops associated with the enhanced cumulus towers southeast of the mid-latitude cyclone.

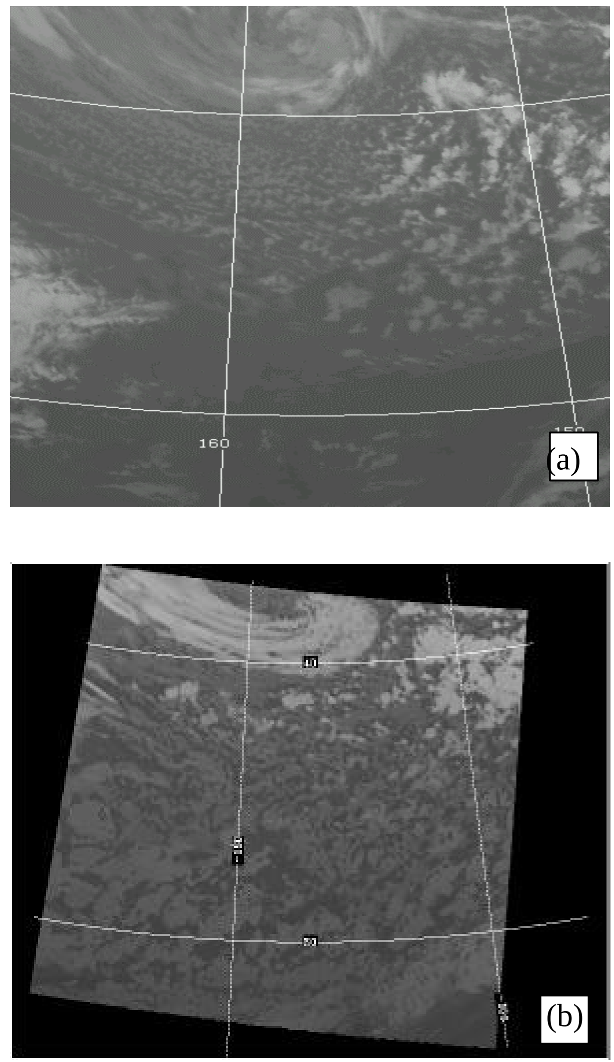

Figure 3. (a) Observed and (b) MM5 simulated GOES-10 10.7 micron brightness temperatures at 2100 UTC 12 March 2003.

5. RADIANCE SIMULATION AND RETRIEVALS

To generate simulated GIFTS top of the atmosphere radiances, UW-CIMSS has developed a fast forward radiative transfer model specifically tailored to the GIFTS satellite. Profiles of temperature and water vapor mixing ratio used by the radiative transfer model are provided by the MM5 simulation. Fig. 4 illustrates the ability of the MM5 to capture small-scale water vapor features in the lower atmosphere. Profiles of effective particle sizes for five condensate species (rain, snow, graupel, ice crystals, and liquid water) are also needed. Following Mitchell (2002), the effective particle sizes are calculated using the water vapor mixing ratio and number concentrations for each condensate species. For this simulation, the Goddard microphysics scheme explicitly calculated the number concentrations for ice and cloud water while the number concentrations for the other variables were estimated using a gamma distribution. Each of these profiles, along with cloud top pressure, liquid and ice water paths, and profiles of ozone, are ingested into the radiative transfer model to generate top of the atmosphere radiances in the GIFTS spectral range. These radiances are then used to retrieve profiles of atmospheric temperature and water vapor, which are then compared with the original atmospheric fields to assess the robustness of the retrieval methods.

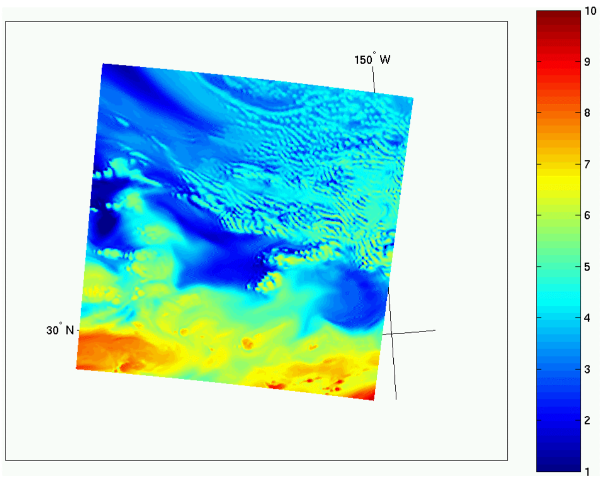

Figure 4. Simulated 850 hPa water vapor mixing ratio at 0200 UTC 13 March 2003.

6. CONCLUSIONS

UW-CIMSS is currently developing and testing the fast forward radiative transfer model and concurrent atmospheric retrieval methods in preparation for the upcoming launch of the GIFTS satellite. As part of this initiative, UW-CIMSS is using output from high-resolution MM5 simulations to demonstrate the projected ability of GIFTS to remotely sense small-scale water vapor structure and gradients. Better resolution of water vapor structure will increase the number and quality of wind vectors generated from water vapor gradient tracking. Preliminary results indicate that the MM5 model was able to realistically simulate the large-scale cloud features associated with the evolution of an intense jet streak across the north-central Pacific Ocean.

ACKNOWLEDGEMENTS

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REFERENCES

Mitchell, D. L., 2002: Effective diameter in radiation transfer: General definition, applications, and limitations. *J. Atmos. Sci*, **59**, 2330-2346.