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THE HYPERSPECTRAL ENVIRONMENTAL SUITE (HES) SIMULATION STUDY USING MM5 DATA

Chian-Yi Liu*, Jun Li*, Timothy J. Schmit@
*Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin-Madison
@ NOAA/NESDIS, Office of Research and Applications
Madison, Wisconsin

1. INTRODUCTION

The Hyperspectral Environment Suite (HES) is currently scheduled to be lunched in 2013. A atmospheric temperature and moisture sounding profile retrieval algorithm has been developed for processing the HES under both clear and cloudy skies through brightness temperature (BT) through eigenvector regression with all the spectral channels. Trade-off studies have been performed according to HES radiances from a set of global radiosonde profiles. These studies include the spectral coverage, spectral resolution, spatial resolution, temporal resolution, and signal-to-noise ratio (Li et al., 2003). The HES could be a GIFTS-like 2 waveband infrared Michelson interferometer or an AIRS-like 3 waveband grating dispersive sounder with spectral resolution between 0.5 cm^{-1} and 2.5 cm^{-1}. Mesoscale model analyses can provide atmospheric profile data with high temporal and spatial resolutions. The atmospheric cube data from the output of PSU/NCAR Mesoscale Model 5 (MM5) version 3.5 (Grell et al., 1994) from THe Observing system Research and Prediction EXperiment (THORPEX) were used as "truth" atmosphere for the simulation study. The truth atmospheric profile which is used to generate the simulated HES top of atmosphere radiances by a fast forward model (Hannon et al., 1996). Retrieved atmospheric temperature, moisture, ozone profiles and surface skin temperature are then compared with the model profiles ("truth") to calculate mean bias, and rms for demonstrating the capability of the HES. A similar study was shown by Sun et al. (2004) but in clear skies only.

2. SIMULATION OF THE HES RADIANCE

The atmospheric cube data corresponds to the time period from March 13 2003 0000 UTC to 0330 UTC in THORPEX. The time step for the successive cube data is half hour. Output has 9 (3 by 3) cubes in every half hour, each cube comprises a 128 x 128 array of pixels, each pixel contains atmospheric profiles, surface conditions and cloud parameters. Within the 128x 128 arrays, each pixel is 4km square, The cube data includes atmospheric profiles (air temperature, water vapor and ozone) at 101 vertical pressure levels from 0.05 to 1100 hPa. Surface properties (surface skin temperature, surface pressure and surface altitude) and cloud properties (cloud top with respect to liquid and ice, liquid water path and ice water path, and the concentration and effective diameters of five condensate types: rain, liquid, ice, snow and graupel) (Posselt et al., 2003) are also included.

The clear sky detection is simply determined by testing for the existence of either liquid or ice. The HES radiances are simulated by the clear sky fast forward model (Hannon et al., 1996). The spectral regions of longwave band (650-1200cm^{-1}) and short middlewave band (1650-2250cm^{-1}) with a spectral resolution of 0.625 cm^{-1} are assumed for HES in the radiance simulation. Figure 1 shows the clear-sky BT images of 0330 UTC on 13 March 2002 for the four selected HES channels.

3. SIMULATION ON THE HES SOUNDING RETRIEVALS

The algorithm for retrieving the atmospheric temperature, moisture, ozone profiles and surface skin temperature from the simulated HES radiances is a two-step procedure, a Principle Component Regression (PCR; Huang and Antonelli, 2001) followed by a non-linear physical retrieval method (Li and Huang 1999; Li et. al, 2003). The regression retrieval is used as the first guess in the physical retrieval. 312 channels out

Corresponding author address: Chian-Yi Liu, Space Science and Engineering Center, University of Wisconsin-Madison, 1225 West Dayton Street, Madison, WI 53706; e-mail: cyliu@ssec.wisc.edu

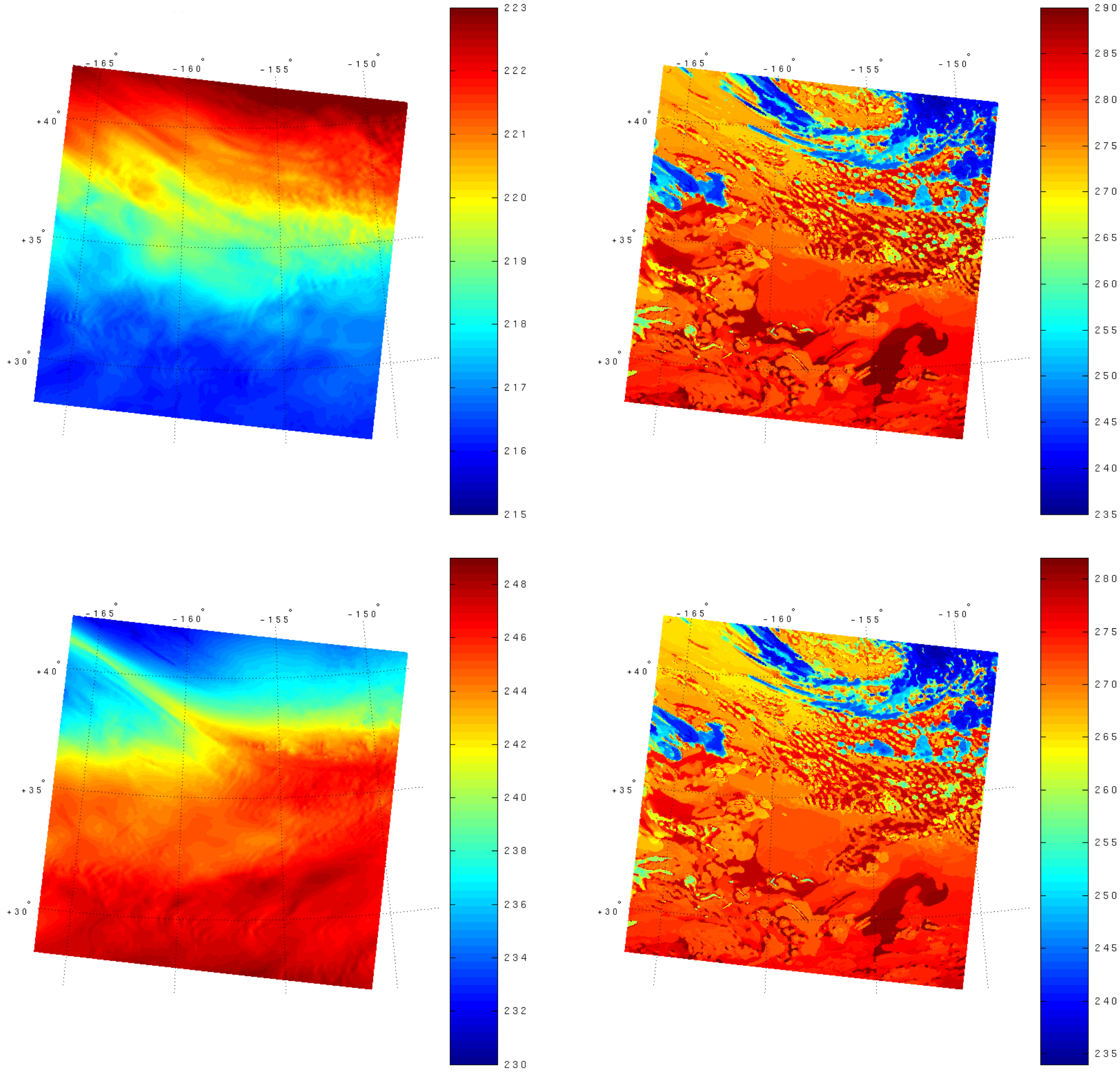

Figure 1. The simulated HES brightness temperature images of 0330 UTC on 13 March, 2003 at 685.5 cm^{-1} (upper left), 900.0 cm^{-1} (upper right), 1650.4 cm^{-1} (lower left), and 2100.1 cm^{-1} (lower right).

of 2005 channels in total, optimally selected from both the CO_2 (685-810 cm^{-1}) and the water vapor (1665-2000 cm^{-1}) absorption regions, as well as the IR window region, are used in the physical retrieval procedure to improve the regression retrieval accuracy. In the regression procedure, the regression coefficient is calculated from 12867 and 15376 training profiles and corresponding calculated HES BTs with noise added for clear and cloudy skies, respectively. The 14bit HES noise from Technical Requirement Document (TRD) is used in the simulation. The training set is also from the MM5 model output.

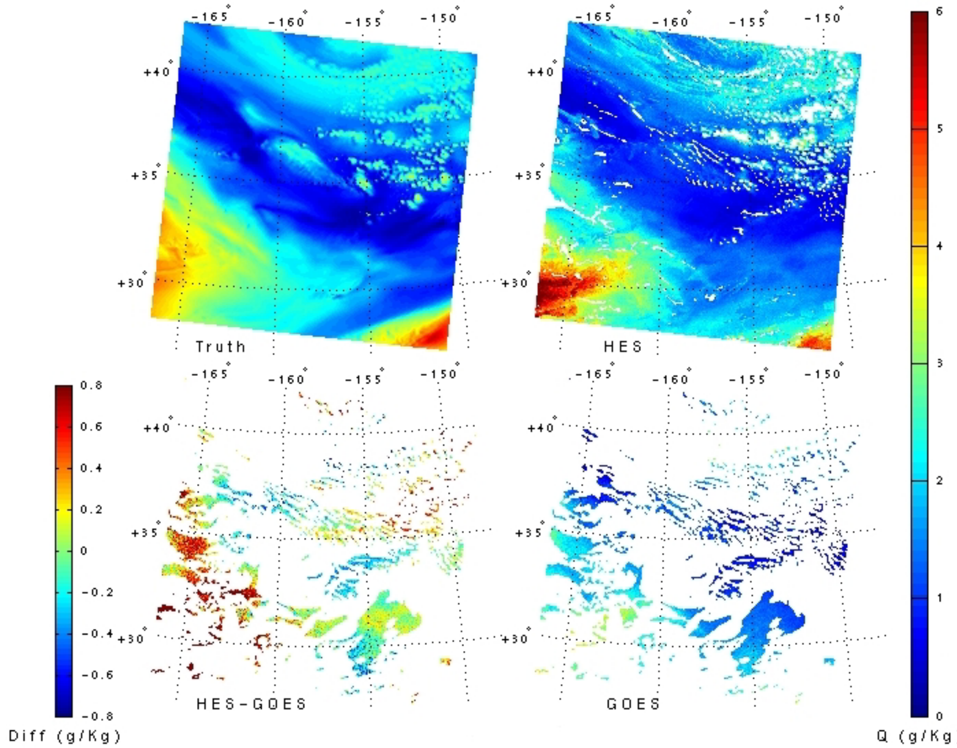

Figure 2. Model analyses (upper left), the HES retrievals (upper right), current GOES sounder (lower right), and the differences between the HES and current GOES sounder (lower left) of 700 hPa water vapor mixing ratio at 0230 UTC on 13 March 2003.

Figure 2 shows an example of the MM5 Model analyses ("truth"), HES retrievals and the difference between the "truth" and retrievals of 700 hPa water vapor mixing ratio (g/Kg) at 0230 UTC on 13 March 2003. The mesoscale features and the gradients of water vapor on both clear, and thin and high cloudy skies are well identified by the HES retrievals. Simulation is also conducted for the current Geostationary Operational Environmental Satellite (GOES) Sounder with 18 sepctral bands under clear skies (see lower right panel in Figure 2). The current GOES radiances provide less information about the vertical structure of the atmospheric temperature and moisture. It demonstrates the advantage of the future HES over the current GOES Sounder with spectral widths on the order of tens of wavenumbers infrared channels.

Figure 3 left panel shows the temperature retrieval mean bias at total 101 vertical pressure levels from the HES regression on both clear and some cloudy skies. Figure 3 right panel is the same as left panel but for water vapor mixing ratio retrieval at 0030 UTC 13 March 2003. The EOF regression retrieval accuracy of air temperature and water vapor mixing ratio on clear skies is better cloudy skies. The advantage of the HES on depicting the temporal/spatial features will be demonstrated by movie loops at the time of poster presentation.

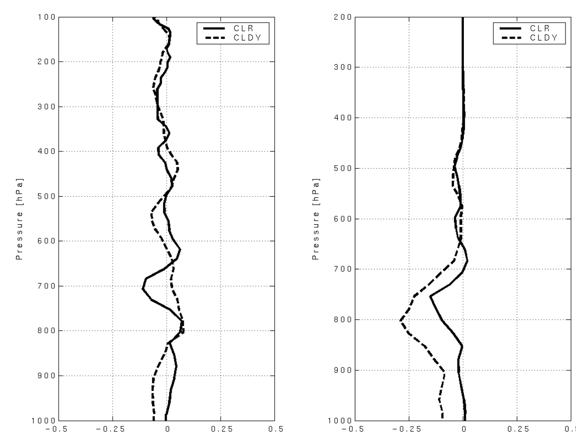

Figure 3. Vertical temperature (left panel) and moisture mixing ratio (right panel) profiles bias at 0030 UTC on 13 March 2003. Solid line: the HES EOF regression retrieval on clear skies; dash line: the HES EOF regression retrieval on some cloudy skies.

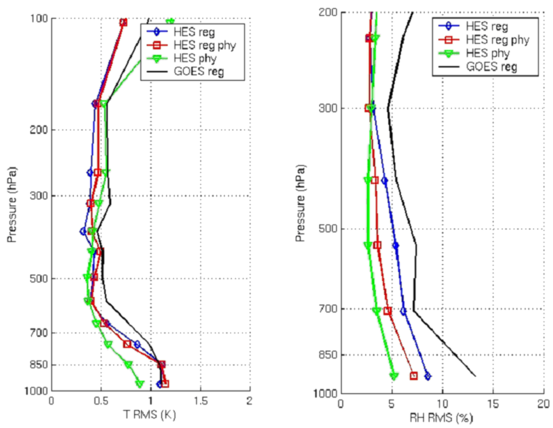

Figure 4. Temperature (left panel) and water vapor RH (right panel) retrieval rmse at 1km and 2km vertical resolutions, respectively. Blue line: the HES EOF regression retrievals; red line: HES EOF regression physical retrievals; green line: HES physical retrieval with one-hour early model analyses as the first guess; black line: GOES-12 regression retrievals.

4. SUMMARY

The retrieval results from simulations using MM5 numerical model data show that the HES enables monitoring the evolution of detailed temperature and moisture structures. The retrieval accuracy of air temperature and water vapor is better than 1 K for temperature and 10% for water vapor relative humidity (Figure 4). This is a significant improvement over current GOES sounder. Future work includes further simulations using MM5 cube data in both clear and cloudy skies and more ABI (Schmit and Gurka, 2002; Schmit et al., 2004) simulations using MM5 data.

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