WRF-Simulated Atmospheric Profile Datasets Used to Support GOES-R Research Activities

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INTRODUCTION

SSEC/CIMSS at the University of Wisconsin-Madison has been tasked with testing and developing the forward radiative transfer model and retrieval algorithms for the next generation of geostationary infrared sensors, including the Advanced Baseline Imager (ABI), which will be launched as part of GOES-R. In support of this work, sophisticated numerical weather prediction models, such as the Weather Research and Forecasting (WRF) model, have been used to generate realistic high-resolution atmospheric profile datasets for a variety of locations and atmospheric conditions. These datasets, which are treated as the "truth" atmosphere, are subsequently passed through the forward radiative transfer model to generate simulated top of the atmosphere (TOA) radiances. Various algorithm working groups use the resultant proxy datasets as part of their algorithm development projects. The datasets are also used to test proposed processing systems in order to assure that the products generated by the algorithms are available to users within the required data latency windows.

WRF MODEL

WRF model output serves as the main component of the simulated atmospheric profile datasets ingested by the forward radiative transfer model. Simulated fields used by the forward model include the surface temperature, the atmospheric temperature, and the mixing ratios for water vapor, cloud water, rain water, ice, snow, and graupel. Effective particle diameters are calculated for each microphysical species using a method adopted from Mitchell (2002). Total liquid and total ice water paths are calculated using the appropriate mixing ratios.

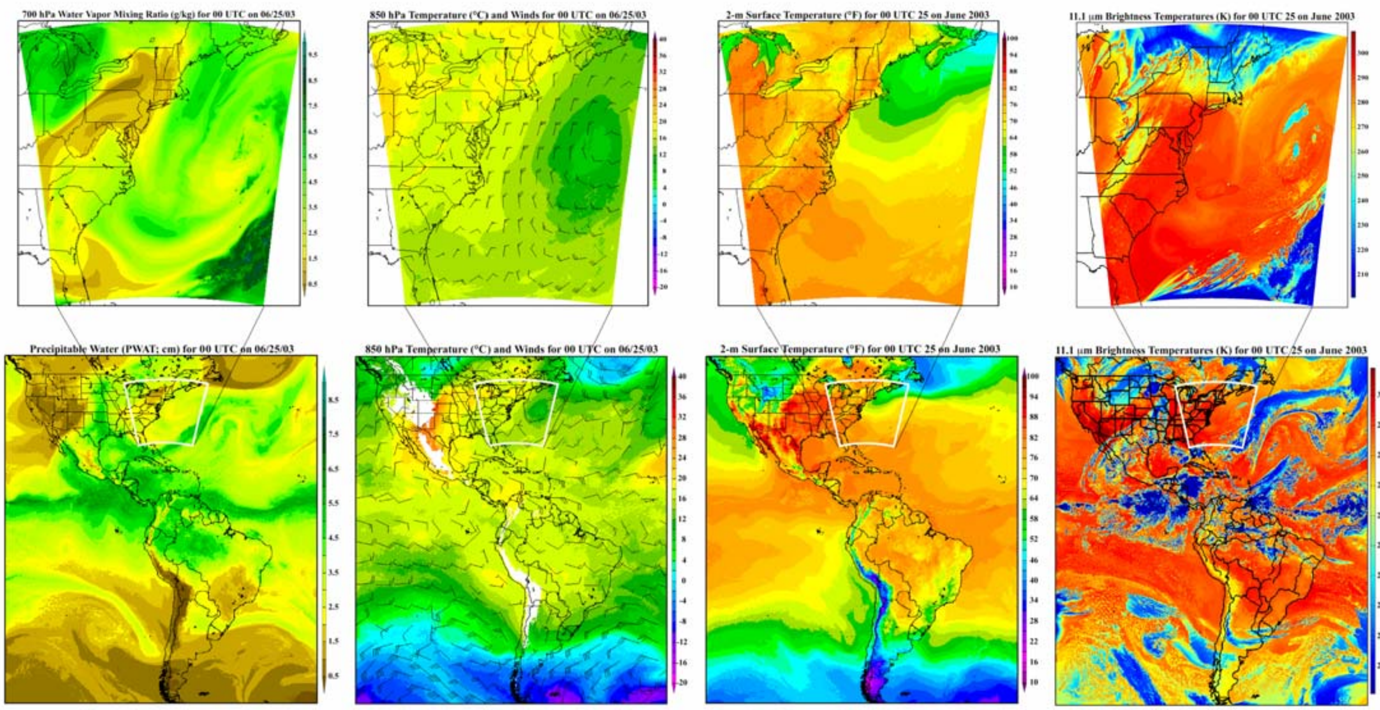
Version 2.1 of the WRF model was used to produce two realistic simulations of the atmospheric conditions present on 24 June 2003. The first simulation was designed to represent the geographical region to be viewed by GOES-R. The simulation contained a single 1580 x 1830 grid point domain with 8-km horizontal grid spacing and 50 vertical levels. In order to provide an additional dataset with very high spatial resolution, a second simulation was performed over a sub-region of the larger domain. This simulation contained a single 1070 x 1070 grid point domain with 2-km horizontal grid spacing and 50 vertical levels.

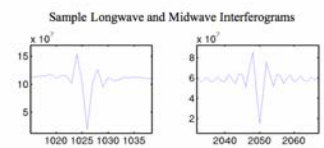
FAST FORWARD RADIANCE MODEL

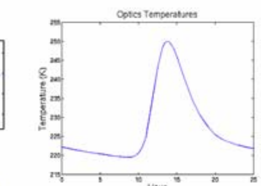
The clear sky forward model is a LBLRTM based Pressure Layer Optical Depth (PLOD) fast model. Regressions are made from line-by-line transmittance calculations obtained using LBLRTM at fixed pressure levels. Radiances are output at 0.6 1/cm resolution in the spectral range from 587 to 2250 1/cm. For cloudy conditions we sum the various mixing ratio profiles from the WRF output to determine cloud boundaries for either one or two cloud layers. Mixing ratios are converted to visible optical depths and effective particles sizes, which are used to look up the spectral transmittance and reflectance values from tables provided by Ping Yang. For cloudy profiles the downwelling radiance is assumed to be the same as the upwelling radiance when calculating the surface reflection term. For clear sky conditions, the upwelling radiances are converted to downwelling radiances using pre-computed ratios from a two stream approximation.

INSTRUMENT SIMULATION MODEL

The TOA radiances generated by the forward model are the primary input to the GOES-R instrument model. Other inputs include detector gains and offsets for each of the 16384 detectors in the array. The optics model then adds the instrument background contribution, a phase shift, a spectral smearing, and a spectral shift. The spectral smearing and shift are due to self apodization by the instrument optics. The sample interferograms (LW and SMW) plotted below are simulated GOES-R raw uncalibrated observations. The instrument model calculates the effect of the optics near the edge of the focal plane where the optical path distance of the sampling laser and the radiances do not match. The instrument model also applies the detector responsivity, numerical filter, variations in detector gains, individual detector offsets, and a Gaussian distribution of noise equivalent radiances. The simulated interferograms are used to test calibration and science processing algorithms.







EMISSIVITY

In order to increase the realism of the infrared emission spectrum over land, a global emissivity database developed at SSEC is used to characterize the surface infrared properties below each of the NWP profiles prior to computing the top of atmosphere radiances. The latitude and longitude of each profile is used to select the appropriate emissivity from the gridded emissivity database. The database is derived from a combination of high spectral resolution laboratory measurements of selected materials and multi-year MODIS (MOD11) observed land surface emissivities at 3.7, 3.9, 4.0, 8.5, 11.0 and 12.0 micron wavelengths.

DIURNAL EFFECTS

The temperature of the instrument optics follows a diurnal pattern as the amount of solar illumination on various instrument components changes over the orbital path. The change in the optics temperature is used to model the background contribution by the instrument to the interferogram signal. For the 24 hour dataset the optics temperatures are varied according to the temperature plot displayed above.

SUMMARY

The WRF model has been used to generate physically realistic atmospheric profile datasets that are subsequently passed through the GIFTS forward and instrument models to generate simulated TOA radiances and interferograms. The simulated datasets are used to provide a realistic estimate of the impact that data from a geostationary interferometer as part of the GOES program will have on various research efforts. The data is designed to help advance wind vector determination research and single field of view retrieval algorithms. The massive size of the datasets also provides the data processing systems working group with a realistic volume of data.

ACKNOWLEDGEMENT This work was supported by NOAA federal grant NAO7EC0676.

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