THE USE OF SIMULATED DATA SETS IN ATMOSPHERIC MOTION VECTOR RESEARCH

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Introduction

The Cooperative Institute for Meteorological Satellite Studies (CIMSS), in collaboration with NOAA/NESDIS/STAR is conducting research on satellite-derived atmospheric motion vectors (AMVs) using simulated atmospheric datasets. The simulated datasets, produced by numerical weather prediction (NWP) output, supplies a "true" atmospheric state, which provides the unique opportunity to compare AMVs derived from the simulated image sequence with the "true" model winds. Three cases will be discussed.

One approach uses the current version of the automated CIMSS/NESDIS AMV retrieval code, and is tested with a simulated GOES-R Advanced Baseline Imager (ABI) dataset from the GOES-R Algorithm Working Group (AWG) Proxy team. A 2km horizontal, 5-minute temporal simulation was run (WRF model) for an hour over the east coast of the United States and into the western Atlantic Ocean. Top of Atmosphere Radiances (TOA) radiances for ABI channels 8 through 16, were used to create images for the winds retrieval algorithm. AMVs computed from heritage channels (IRW and WV) are shown.

Another method employs simulated Meteosat-8 images derived from the European Center for Medium-Range Weather Forecasts (ECMWF) global model. The Meteosat-8 images were simulated from a T_L2047 forecast run of the ECMWF global model. The model has an approximate 10km resolution and is re-sampled to 3km to replicate the satellite resolution. Meteosat-8 radiances are calculated using the model profiles of temperature, specific humidity, cloud cover, ice water, liquid water, and the Radiative Transfer for Television and Infrared Sounder (RTTOV) model. AMVs are then calculated in both the simulated 10.8μm (IRW) and 6.2μm (WV) channels using processing strategies currently employed on real Meteosat-8/9 data at CIMSS.

The third approach uses simulated hyperspectral satellite retrieval moisture fields from a future Hyperspectal Environmental Suite (HES). Image triplets of constant pressure level moisture analyses derived from simulated hyperspectral satellite retrievals are used to calculate clear sky AMVs. This simulation encompasses a very large domain that models a geostationary satellite footprint. The WRF model is used to generate simulated atmospheric profiles. TOA are determined using these profiles along with the GIFTS forward radiative transfer model. Single field of view vertical temperature and water vapor retrievals are then calculated from the TOA radiances. If a strong water vapor signal exists in a given analysis, clear sky AMVs can be derived by tracking advecting moisture features in three successive retrieved fields.

GOES-R ABI SIMULATION

Several AMV sets were computed to test the sensitivity of the CIMSS/NESDIS wind retrieval code against changes in calibration, noise, navigation, and striping with the ABI.

The top two AMV plots to the right were calculated from the "Pure" dataset, which consists of unaltered TOA derived from the WRF model. The NOGAPS model was used as the background guess. Mid to upper level AMVs are show in the left image. Mid to low level AMVs are to the right.

The sensitivity tests performed involved altering the TOA by adjusting the calibration, noise, navigation and striping instrument specifications singly and in combinations. The resultant AMV calculation shown to the right and on the bottom is a combination of all adjustments at twice the specification.

Comparisons to the WRF model U and V have been computed for each AMV set. The statistics were generated using AMVs quality controlled using only the Quality Indicator algorithm (qi > 60). A negative speed bias indicates the AMVs are too slow compared to the model. Statistics are shown for AMVs generated with a time step of 15 minutes between each image in the triplet.

Future work includes new simulations with the use of non-heritage AMV channels.
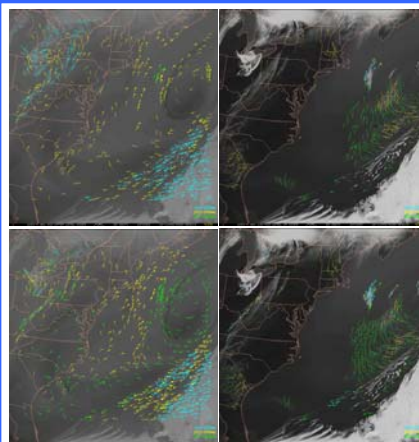
Time Step	Count (All Winds)	Spd Bias(m/s)	V_{RMS}(m/s)
15	1350	-0.40	8.95

Pure AMV. TOA Unaltered.

Time Step	Count (All Winds)	Spd Bias(m/s)	V_{RMS}(m/s)
15	1338	1.10	9.84

CalOffset1K, NoiseFactor1x, NavError1x, Striping1x

Time Step	Count (All Winds)	Spd Bias(m/s)	V_{RMS}(m/s)
15	1293	2.07	9.76

CalOffset2K, NoiseFactor2x, NavError2x, Striping2x

ECMWF SIMULATION

The ECMWF model produced 25 time steps of simulated Meteosat-8 data. One AMV example using 3 time steps is shown. This simulation will be discussed in more detail at the upcoming 9th International Winds Workshop in 2008.

The top two plots to the right are simulated Meteosat-8 images. To the left is the 6.2μm channel (WV), to the right the 10.8μm channel (IRW). The black bands in the images are the result of the data being supplied in 4 quadrants. Below the simulated data are the corresponding real Meteosat-8 images.

Several different AMV sets were produced. One run allowed the U and V wind components to be more than 50m/s different than the model background. In practice this is usually 10m/s. Other AMV sets were produced after each quality control step in the CIMSS/NESDIS operational processing strategy. Finally, each of these AMV sets were created using the ECMWF as the background model and then with the NOGAPS.

The AMV images are the result of the entire CIMSS/NESDIS processing suite. The major components of the quality control system are the Quality Indicator (qi) and the Recursive Filter (rff). Both assign quality flags to each AMV. On top are AMVs produced with the ECMWF model background. Below, with the NOGAPS. Qualitatively and quantitatively these AMVs are very similar. V_{rms} differences of 0.3m/s was observed between these sets.

Future work will include more detailed comparisons between the AMVs and model backgrounds.
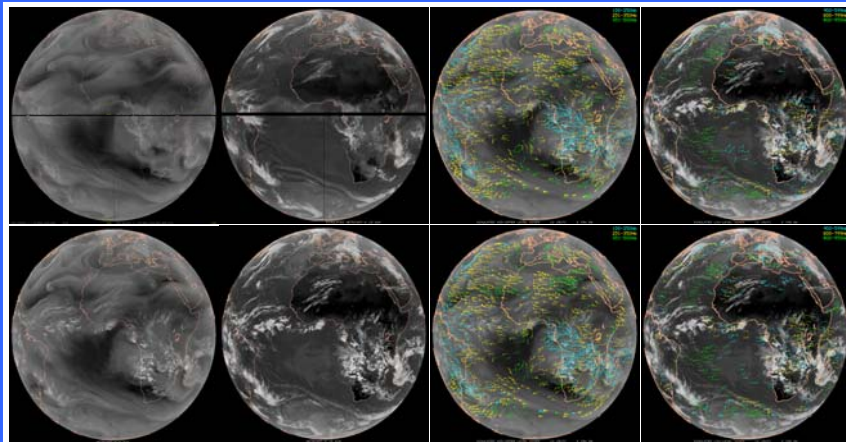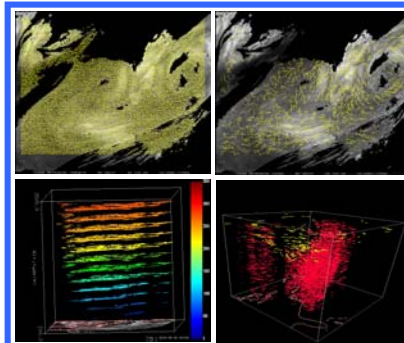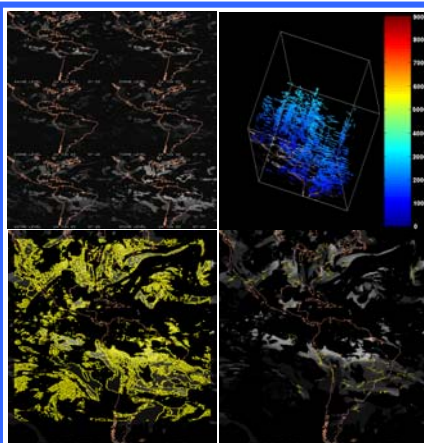

HES SIMULATION

A requirement from the GOES-R Risk Reduction program was to process a full disk HES retrieval AMV simulation. Shown to the right, in the first box are the results. The spatial resolution for the FULLDISK case is 8km. The temporal resolution is 40 minutes. The 6 panel image shows example retrieved WV at various levels. Black is cloud. Grey is differing amounts of WV. We look at the 729mb WV slice below. Numerous targets are available to the tracking algorithm. Next to the targets are the raw AMVs at 729mb. Only 1092 raw AMVs were successfully tracked from 27934 targets. The 3D plot shows all of the raw AMVs processed.

To show how the resolution affected the FULLDISK case, a small subset (OCEANWINDS) of this simulation is shown in the 2nd box of images. The spatial resolution is approximately 2km, and the temporal resolution is 30 minutes. The target locations and raw winds are at 729mb. 1912 AMVs were observed in this limited region. The IDV plot on the left again shows the vertical potential of the AMVs.

The IDV image with just the red and yellow AMVs is designed to show the limited depth of the current GOES Imager clear sky WV AMVs (yellow), compared to the retrieved clear sky AMVs (red).

Future work may include comparisons with simulated GOES-R ABI channels. It will contain 3 WV bands that will sense deeper into lower levels. The current GOES imager contains only 1.

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