Objective of the Research

Demonstrate via Observing System Simulation Experiments (OSSEs) the potential utility of flying high spatial resolution AIRS class IR sounders on future LEO and GEO missions. The study simulates and analyzes radiances for 3 sounders with AIRS spectral and radiometric properties on different orbits with different spatial resolutions. 1) “Control run” 13 km AIRS spatial resolution at nadir on LEO in Aqua orbit 2) 5 km spatial resolution AIRS sounder at nadir – “ARIES” 3) 5 km spatial resolution sounder on a GEO orbit – radiances simulated every 72 minutes

Generation of Model Truth Data Used in the Experiments

These experiments use forward model products, including simulation of a simulated severe storm in the Atlantic Ocean over a 12 day period July 29 to August 10, 2005. Bob Atlas and co-workers at AOML generated the model products every 6 minutes at a 1 km spatial resolution over a moving roughly 4.5° latitude x 4.5° longitude spatial domain covering the simulated track of the center of the storm. The 1 km spatial resolution values provided by the model included surface pressure, surface skin temperature, temperature profile, water vapor profile, and cloud cover (0 or 1) at all model vertical levels. Tom Pagano and William Matthews at JPL generated three sets of "model truth" values of parameters for each experiment by averaging the 1 km model values in the spatial domain over the instrument Fields of View (FOVs) and then taking the 3 km FOV average every 12 hours for LEO and every 72 minutes for GEO. LEO observations were simulated for instruments with the current 13 km AIRS FOV and also for a proposed LEO AIRS-like instrument (ARIES) with a 2 km FOV. The observations were also simulated for other AIRS-like instrument with a 5 km FOV in a GEO orbit.

We used the "model truth" data both to simulate radiance observations and also to evaluate the accuracy of the retrieved products. We simulated AIRS-like radiances for each FOV using the operational Advanced Radiative Transfer Algorithm (RTA) and adding actual AIRS channel random noise values. Radiance observations of IR satellite instruments in a FOV are sensitive to the amounts of fractional cloud cover of clouds with different cloud top pressures in that FOV as seen from above. The "model truth" provides values of cloud cover within contiguous groups of pressure intervals. We developed and used methodology to simulate cloud cover in these distinct contiguous pressure groups to simulate amounts of cloud cover at different pressures, as seen from above, while making sure that the total cloud cover of all clouds, as seen from above, does not exceed 1.

Summary

These experiments clearly show the potential of flying higher spatial resolution sounders in both LEO and GEO orbits. Retrieval error structures are similar for all experiments. Percentages of accepted cases at 2 km resolution are poorer than those at lower spatial resolution. This is misleading because there are many more cases at 2 km spatial resolution including many more overcast cases. Spectral coverage of retrievals, as well as the representation of realistic cloud structures of the storm, improved dramatically with decreasing size of the FOV from 2 km to 500 mb or lower. The QC'd retrievals to Bob Atlas at AOML for use as input to OSSE Data Assimilation experiments.

Retrieval Algorithm Used in the Experiments

We analyzed simulated channel radiance data for all three experiments in an identical fashion using the operational AIRS Version-6 AIRS Only (AO) retrieval algorithm. Version-6 AO was used because we did not simulate observations for an atmospheric sounding IR sounder such as ALEXIS. AIRS Version-6 AO uses Neural-Net guess coefficients which were trained on observed AIRS cloudy radiances to generate the first guess of the retrieved state. We used the same coefficients for this experiment and they performed extremely well beneath 300 mb. This shows that our simulation methodology, including the generation of multi-layer cloud structures, were determined consistently with the observed radiances and the retrieved state. Version-6 AO uses Quality Control (QC) methodology which assigns to each FOR a pressure down to which the retrieval is considered to be of high quality. Cloud products are generated and are plotted for each FOR. Temperature and water vapor profile products are generated for each FOR, but are used only from the top of the atmosphere down to the lowest altitude accepted by the QC methodology. Consequently, both percent yield and spatial coverage will decrease to some extent at higher pressures as compared to lower pressures. Higher spatial resolution increases the spatial coverage of acceptable retrievals as a result of more cloud variability in the FOVs. Higher spatial resolution also allows for the ability to better resolve features varying in space such as cloud cover and temperature

Spatial Coverage and Values of Accepted Retrievials for August 5, 2005, 02

The figures below show truth and retrieved values of cloud parameters and 500 mb and 300 mb specific humidity and temperature. Cloud fractions and cloud top pressure are retrieved for multiple cloud layers in each Field of Regard. We plot effective single layer cloud fraction and pressure for each Field of Regard where the cloud cover is given by the sum of all cloud fractions as seen from above, and the cloud top pressure is given by the average of all the different cloud pressures in the Field of Regard weighted by their cloud fraction.

Model Storm Track

HQE 20 00h August 5 2005 02.00 UT 26.4N 66.9W

The figures above show Nature Run truth values of T(p) and q(p) for the 5 km GEO experiment for each sample every 12 hours. The period starts at the lower right. The storm begins to intensify around August 3 02. The locations of the center of the storm are clearly observed as a function of time.