CrIMSS Retrieval Algorithm Testing with Proxy Data

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Introduction

The Cross-track Infrared and Microwave Sounder Suite (CrIMSS) will be flying on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) and its Preparatory Project (NPP) satellites. It is designed to produce three Environmental Data Records (EDR) products, i.e., the Atmospheric Vertical Temperature Profiles (AVTP), Atmospheric Vertical Moisture Profiles (AVMP) and atmospheric Pressure Profiles. The CrIMSS EDR algorithm has been extensively tested by Northrop Grumman Space Technology (NGST) with proxy data and the effort is continuing. This presentation will summarize the test methodology, test data, and the test results.

CrIMSS EDR Retrieval Algorithm

- The CrIMSS EDR algorithm was developed by Atmospheric Environmental Research (AER) and modified by NGST to produce AVTP and AVMP EDRs from the Sensor Data Record (SDR) measured by Advanced Technology Microwave Sounder (ATMS) and Cross-track Infrared Sounder (CrIS), using the Numerical Weather Prediction (NWP) surface pressure forecast data and other ancillary information. The Pressure Profile EDR is derived from the retrieved AVMP and AVTP EDRs
- The CrIMSS EDR algorithm was largely based on the heritage EOS AIRS retrieval algorithm with some significant improvements
  - Simultaneous retrieval of atmospheric temperature, moisture and ozone profiles and surface skin temperature and spectral emissivity
  - Fast and accurate Optimal Spectral Sampling (OSS) Radiometric Transfer Model
  - Using the Empirical Orthogonal Functions (EOFs) to characterize and measure the retrieved geophysical parameters
  - Using *a priori* constraints (background and covariance) derived from a blended training dataset composed of NCEP, ECMWF and NOAA88 radiosonde data
- The CrIMSS EDR algorithm consists of 7 modules
  - Initialization
  - Input and Pre-processing
  - Microwave-only (MW) Retrieval
  - Scene Classification
  - Microwave and Infrared Combined (MW+IR) Retrieval
  - Quality Control
  - Output and Post-processing
- The retrieved parameters include
  - Temperature profile (reconstructed from 20 temperature EOFs)
  - Moisture profile (reconstructed from 10 moisture EOFs)
  - Surface temperature
  - Surface MW emissivity (reconstructed from 5 MW emissivity EOFs)
  - Surface IR emissivity (at 12 frequency hinge points)
  - Surface IR reflectance (at 12 frequency hinge points)
  - MW cloud top pressure and cloud liquid water path
  - Ozone profile (reconstructed from 7 EOFs)

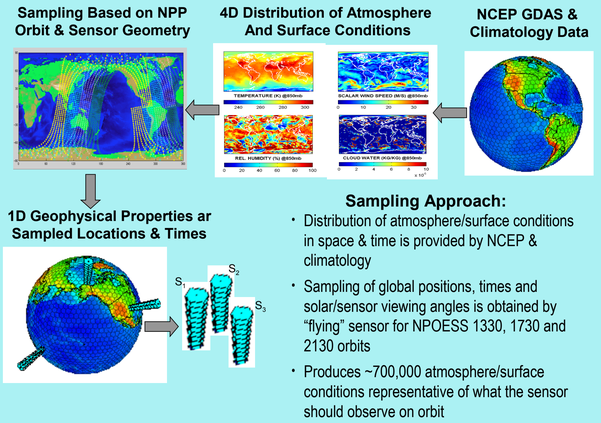
Algorithm Test Methodology and Process

- **Individual algorithm testing**
  - Input test data are the processed Sensor Data Record (SDR) and matching ancillary/auxiliary data
  - To demonstrate the EDR algorithm's performance and performance sensitivity to various environmental conditions and sensor effects
- **Chain algorithm testing**
  - Raw input data included Raw Data Record (RDR) (CrIS, ATMS) and NWP forecast fields (surface pressure) and surface type databases
  - The CrIMSS algorithm chain included SDR and EDR algorithms and other algorithm processing utility functions
    - CrIS SDR algorithm, ATMS SDR algorithm, ATMS SDR B-G re-sampling algorithm, CrIS geolocation algorithm, ancillary input generation utilities (surface pressure and land fraction)
- **Operational code testing vs. science code testing**
  - Operational code testing results are compared to the science code testing results to assess the errors caused by the algorithm's operational implementation in the IDPS
- **Presented here are individual algorithm testing results. Initial algorithm chain testing has been completed and results are still under assessment**

Proxy Data Generation

Simulated Data

- Primary test data source for pre-launch EDR algorithm performance assessment and characterization
- Generated using NGST's end-to-end simulation system which employs:
  - A compilation of global/regional environmental scene datasets
  - Validated radiative transfer models
  - Rigorous models of sensors and spacecraft platforms



Sampling Approach:

- Distribution of atmosphere/surface conditions in space & time is provided by NCEP & climatology
- Sampling of global positions, times and solar/sensor viewing angles is obtained by "flying" sensor for NPOESS 1330, 1730 and 2130 orbits
- Produces ~700,000 atmosphere/surface conditions representative of what the sensor should observe on orbit

- Profiles: Generated on a fixed-pressure grid from 4x daily NCEP tropospheric datasets (temperature, moisture, ozone, cloud liquid water), daily NCEP stratospheric datasets (temperature), UARS climatology database (moisture, ozone) and CIRA-86 climatology database (temperature)
- Clouds: generated from Northrop Grumman's Cloud Scene Simulation Model (CSSM) using NCEP cloud liquid water profiles and other meteorological data as input
- IR emissivity/reflectance: a high-resolution database compiled by Photon Research Associate
- MW emissivity:
  - Over ocean: generated using Weilheit's ocean emissivity model from NCEP wind speed and temperature
  - Over land: generated using Grody's model
- Captured the seasonal and diurnal variability of environmental conditions (twelve days of global scenes)
- Actual sensor scanning geometry from three orbits
- Captured the vertical and/or spatial variability of atmosphere and surface properties
- Spectral variability of surface emissivity represented at 28 frequency hinge points

Real Data

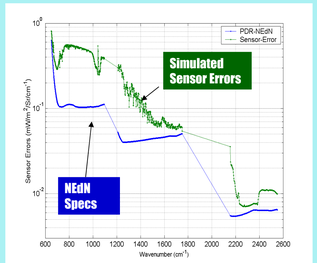
- Complementary test datasets for assessing EDR algorithm performance under real world phenomenology
- Generated using:
  - Calibrated heritage sensor data records with similar characteristics
  - A validated model to map heritage SDRs to NPOESS SDRs
  - A validated source of "truth" EDR datasets

AIRS Dataset

- The proxy data were generated from the EOS sensors (AIRS/AMSU/HSB) measurements (courtesy of Joel Susskind, GSFC)
- One-day's worth of data for 01/15/2003 were provided
- Seven night-time, ocean, least-cloudy scenes (6 min each) were used to test the CrIMSS algorithm's performance. They are co-located to NCEP reanalysis data ("truth") at 0600,1200,1800GTC

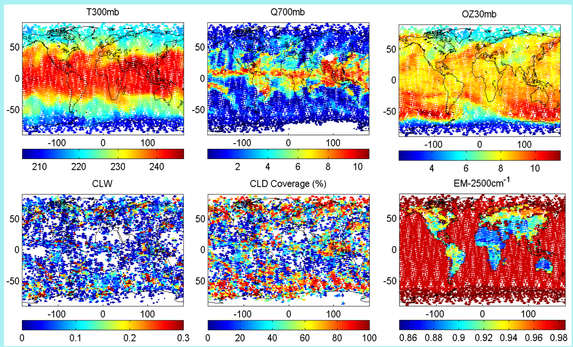
IASI Dataset

- Data collected during the international Joint Airborne IASA Validation Experiment (JAIVEx) from April 15 to May 5, 2007
- Spectrally re-sampled to the CrIS spectral grid



Sensor Model

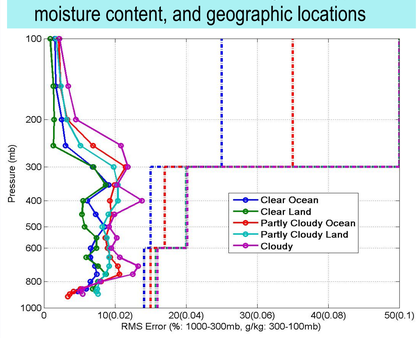
- Noise: NEdN
- Jitter: noise-like error at LOS jitter
- ILS instability
- Spectral uncertainty
- Radiometric uncertainty
- Spatial co-registration errors

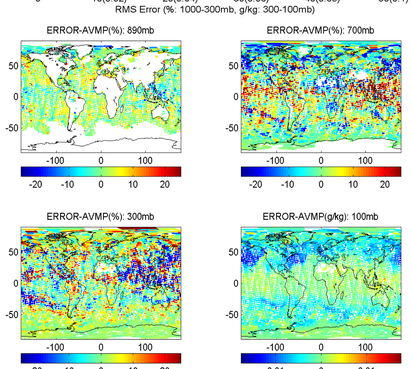


Test Results on Simulated Data

Atmospheric Vertical Moisture Profile EDR

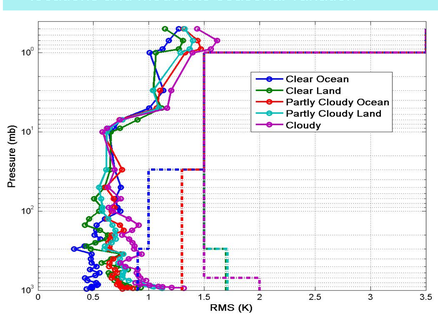
- The retrieved AVMP EDR meets the NPOESS system spec with good margin
- The performance shows small but noticeable variation associated with scan geometry, scene moisture content, and geographic locations

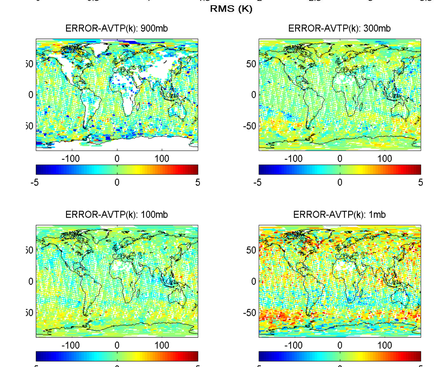




Atmospheric Vertical Temperature Profile EDR

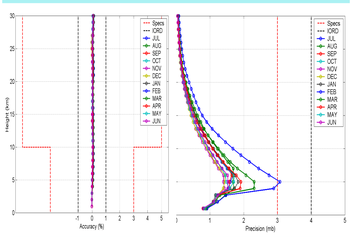
- The retrieved AVTP EDR meets the NPOESS system spec with good margin
- The performance shows small but noticeable variation associated with scan geometry and locations and moderate seasonal variation





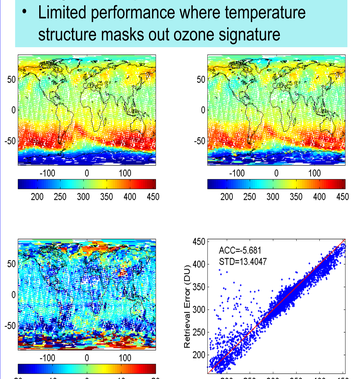
Pressure Profile EDR

- The retrieved PP EDR meets the accuracy and precision requirements
- Measurement precision shows substantial seasonal variation

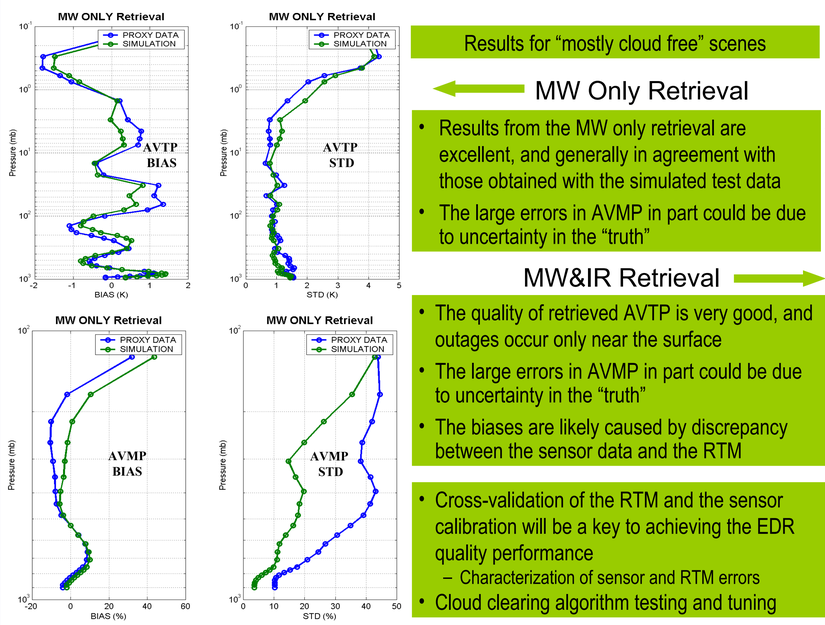


Ozone Profile IP

- Reasonable accuracy
- Large ozone spatial features resolved
- Limited performance where temperature structure masks out ozone signature



Test Results on Real Data



Results for "mostly cloud free" scenes

MW Only Retrieval

- Results from the MW only retrieval are excellent, and generally in agreement with those obtained with the simulated test data
- The large errors in AVMP in part could be due to uncertainty in the "truth"

MW&IR Retrieval

- The quality of retrieved AVTP is very good, and outages occur only near the surface
- The large errors in AVMP in part could be due to uncertainty in the "truth"
- The biases are likely caused by discrepancy between the sensor data and the RTM

- Cross-validation of the RTM and the sensor calibration will be a key to achieving the EDR quality performance
  - Characterization of sensor and RTM errors
- Cloud clearing algorithm testing and tuning

Conclusions

- The CrIMSS EDR retrieval algorithm has demonstrated excellent performance on simulated test data and the retrieved moisture, temperature and pressure profile EDRs all meet the NPOESS/NPP EDR quality requirement specifications
- The algorithm also demonstrated promising performance on limited testing using the test data derived from real AIRS/AMSU/HSB measurements. Some preliminary testing with IASI data is also being performed (by AER)
- The algorithm is currently under "chain testing" to verify its functional performance and operational implementation at IDPS