Performance Assessments of the Cross-Track Infrared and Microwave Sounder Suite (CrIMSS Environmental Data Records (EDR))

Lihang Zhou[1], Christopher D. Barnet[1], Degui Gu[3], Nick Nalli[2], Murty Divakarla[2], Guang Guo[2]
[1]NOAA/NESDIS [2]Dell Perot Systems [3]Northrop Grumman Aerospace Systems (NGAS)
Thanks for the contributions from the SOAT members

Introduction

- The Cross-track Infrared Sounder (CrIS) and the Advanced Technology Microwave Sounder (ATMS) are two of the instruments that make up the suite of sensors on the NPOESS Preparatory Project (NPP), that was successfully launched on Oct 28th, 2011.
- Together, CrIS and ATMS will produce three Environmental Data Records (EDRs) including the Atmospheric Vertical Temperature Profile (AVTP), Atmospheric Vertical Moisture Profile (AVMP), and the Atmospheric Vertical Pressure Profile (AVPP). The AVTP and the AVMP are both Key Performance Parameters (KPPs).
- CrIMSS algorithm has been developed, implemented and the EDR performance has been assessed and characterized with the simulated global synthetic data sets, as well as the proxy data sets generated from AIRS and IASI.
- The first light for ATMS and VIIRS occurred on 8 and 21 November 2011, and ATMS tuning is underway. The first light for CrIS has been scheduled in January 2012.
- Currently estimate a beta-stage CrIMSS validation report tentatively scheduled for delivery at the end of June.
- Early assessments will be using matched ECMWF fields, during which time global operational RAOBs will be acquired for characterization against "in situ" data.

Algorithm Overview

The CrIMSS EDR retrieval algorithm is an iterative physical retrieval algorithm that simultaneously estimates the geophysical states of both the atmosphere and the surface from the infrared and microwave radiances measurements. It combines a fast and accurate radioactive transfer model, a classical constrained inversion model, and a heritage cloud-clearing algorithm to meet the stringent requirements on both latency and accuracy.

The algorithm is normally executed on two distinct stages to fully exploit the radiometric information contained in the microwave and infrared radiance data. In the first stage, retrievals are performed using only the ATMS microwave data and on CrIS Field of Regard which consists of an array of 3x3 CrIS Field of Views (FOV). Since the microwave sensor penetrates through clouds, this step produces a reasonable estimate of the atmosphere and surface states

In the second stage, the algorithm performs an inversion by combining the CrIS infrared data and the ATMS microwave data in a maximum likelihood approach that minimizes a cost function on either a single CrIS FOV or a cluster of CrIS FOVs, depending on cloudiness of the scene. Cloud clearing is a key component of the second-stage processing, and accuracy of the cloud-cleared infrared radiance determines the final quality of its output. The cloud-clearing algorithm adopted by the CrIMSS algorithm has consistently shown good performance on both real and simulated data, and the combined retrieval results usually have much improved quality over the microwave-only first stage retrieval results.

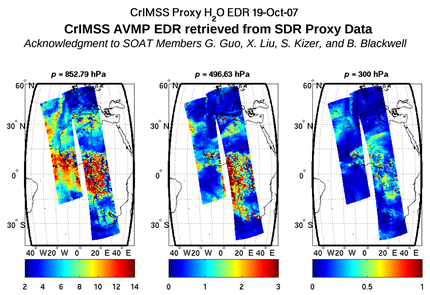
Plans for CrIMSS SDR/EDR Maturity (new sensor, new forward model, new EDR alg.)

Event	Date	ATMS SDR	CrIS SDR	CrIMSS EDR
Launch	Oct 2011			
ATMS SDR Review	Feb 2012	Provisional		
Exelis Packet #33	Mar 2012		Beta	
EDR Beta report	Jun 2012			Beta
ATMS SDR report	Jul 2012	Validated		
Exelis Packet #34	Aug 2012		Provisional	
EDR Provisional	Oct 2012			Provisional
CrIS SDR Validated	Nov 2012		Validated	
End of EDR ICV	April 2013			Stage.1
EDR updates	Oct 2013			Stage.2
EDR updates	Oct 2014			Stage.3

CrIMSS EDRs

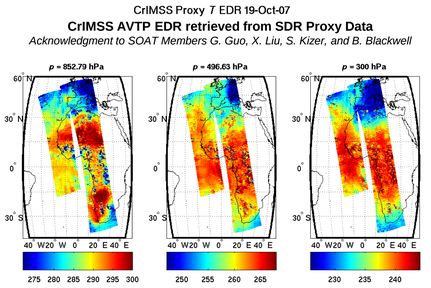
AVMP: Used for initialization of high-resolution NWP models, atmospheric stability, etc.

Parameter	IORD-II	NGAS SY15-0007
AVMP Partly Cloudy, surface to 600 mb	Greater of 20% or 0.2 g/kg	14.1% ocean, 15.8% land and ice
AVMP Partly Cloudy, 600 to 300 mb	Greater of 35% or 0.1 g/kg	15% ocean, 20% land and ice
AVMP Partly Cloudy, 300 to 100 mb	Greater of 35% or 0.1 g/kg	0.05 g/kg ocean, 0.1 g/kg land and ice
AVMP Cloudy, surface to 600 mb	Greater of 20% of 0.2 g/kg	15.8%
AVMP Cloudy, 600 mb to 300 mb	Greater of 40% or 0.1 g/kg	20%
AVMP Cloudy, 300 mb to 100 mb	Greater of 40% or 0.1 g/kg	0.1 g/kg



AVTP: Used for initialization of high-resolution NWP models, atmospheric stability, etc.

Parameter	IORD-II	NGAS SY15-0007
AVTP Partly Cloudy, surface to 300 mb	1.6 K/1-km layer	0.9 K/1-km ocean, 1.7 K/1-km land/ice
AVTP Partly Cloudy, 300 to 30 mb	1.5 K/3-km layer	1.0 K/3-km ocean, 1.5 K/3-km land/ice
AVTP Partly Cloudy, 30 mb to 1 mb	1.5 K/5-km layer	1.5 K/3-km
AVTP Partly Cloudy, 1 mb to 0.5 mb	3.5 K/5-km layer	3.5 K/5-km
AVTP Cloudy , surface to 700 mb	2.5 K/1-km layer	2.0 K/1-km
AVTP Cloudy, 700 mb to 300 mb	1.5 K/1-km layer	1.5 K/1-km
AVTP Cloudy, 300 mb to 30 mb	1.5 K/3-km layer	1.5 K/3-km
AVTP Cloudy, 30 mb to 1 mb	1.5 K/5-km layer	1.5 K/5-km
AVTP Cloudy, 1 mb to 0.05 mb	3.5 K/5-km layer	3.5 K/5-km

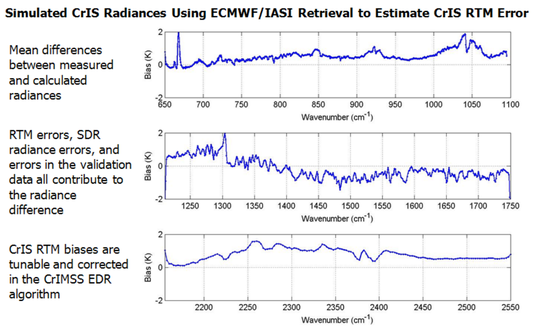


AVPP: Pressure product is a EDR product (derived from AVTP and AVMP) that requires validation. CO and CH_4 are experimental (P^3I) products derived by science community from SDRs (not part of IPO-funded Cal/Val program).

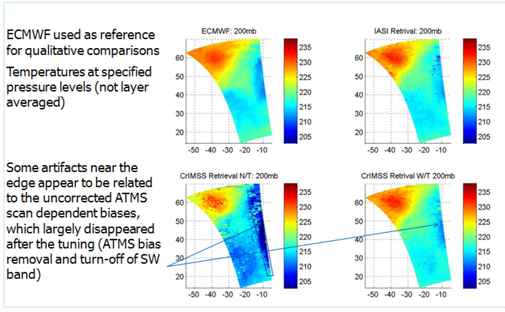
Parameter	IORD-II	NGAS SY15-0007
Pressure Profile	4 hPa threshold, 2 hPa goal	3 hPa (with precip and Psurf error exclusions)
CH4 (methane) column	1% precision, ±5% accuracy	n/a
CO (carbon monoxide) column	3% precision, ±5% accuracy	n/a

CrIS Biases Estimates

Test CrIMSS with IASI
Courtesy to Degui (NG)



Retrieved Temperature Profiles Generally Consistent with NWP Forecast: 200mb



EDR Performance Assessments Activities by Phases:

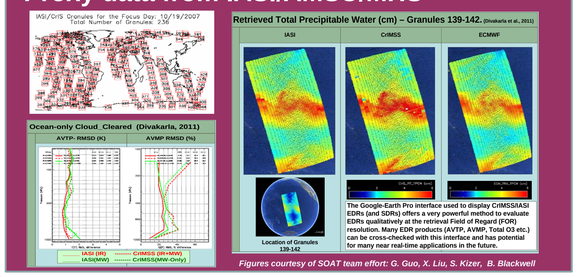
Pre-launch:

- The CrIMSS Algorithm has been tested with:
  - Global synthetic datasets
  - Proxy Datasets
- Methods for evaluation are ready.
- Proxy Data Package for 19 Oct 07 "Focus Day" generated by SOAT (LaRC, MIT, NASA, and NOAA).

Early Orbit Checkout (EOC):

- Characterize SDR biases and tuning, and evaluate the EDR quality performance by:
  - Model comparisons.
  - Simultaneous nadir overpass (SNO).
  - Inter-compare with operational AIRS and/or IASI products.
  - PCA analysis of noise characteristics and instrument monitoring.

Proxy data from IASI/AMSU/MHS



Figures courtesy of SOAT team effort: G. Guo, X. Liu, S. Kizer, B. Blackwell

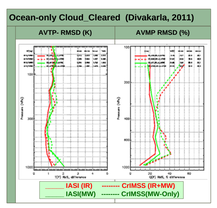
Intensive Cal/Val – Long-Term Monitoring

- Operational RAOBs
  - Useful for long-term characterization and global latitude representation.
  - Tony Reale's NOAA Products Validation System (NPROVS).
- Dedicated RAOBs.
  - Useful for regional characterization.
- Intensive Field Campaigns.
  - Useful for SDR cal/val.
  - Scientific campaigns of opportunity.
  - NOAA Aerosols and Ocean Science Expeditions (AEROSE) (Nalli et al. 2011, BAMS).
  - Linkage to GOES-R program.

Pre-Launch Characterization of CrIMSS Algorithm

Summary:

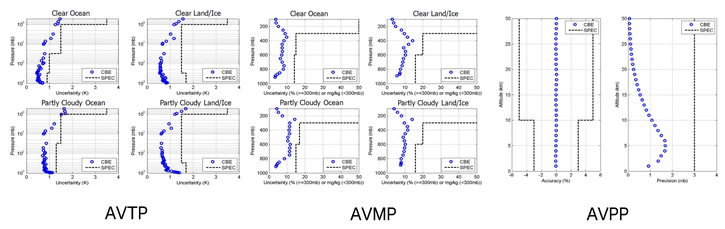
- CrIMSS algorithm shows that the AVTP, AVMP, and AVPP algorithms satisfy requirements based on the global synthetic datasets.
- CrIMSS Algorithm demonstrates good convergence based on testing with proxy data from AIRS and IASI.
- SOAT team is getting ready for launch with datasets and methods of evaluation.

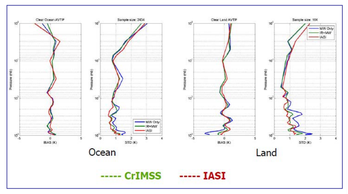


IASI (IR + MW) (Solid Red); CrIMSS (IR+ MW) (Dotted Red)
IASI (MW) (Solid Green); CrIMSS (MW) (Dotted Green)

Courtesy to Murty Divakarla, NOAA/NESDIS

CrIMSS Algorithm Performance Based on the Global Synthetic Data sets





Clear Sky and Night Time CrIMSS EDR Performance
13.6% of total retrievals (2538/18584)

IASI Proxy results – [Gu et al. NGAS]