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## SUMMARY

A simulation system is developed to support pre-launch preparations for the Crosstrack Infrared Sounder (CrIS) near real-time processing and distribution system. CrIS will fly on the NPOESS satellite series that is dedicated to the operational meteorology and climate monitoring. It will replace the AIRS and HIRS as the next generation operational infrared remote sensor to provide improved measurements of the temperature and moisture profiles in the atmosphere. The CrIS observation simulation system will emulate the instrumental and orbital characteristics of the CrIS instrument on NPOESS. The utilities of this system are: (1) to provide simulated observation radiances that support NOAA Unique product (cloud clearing and trace gases) development and testing, (2) to provide a robust data distribution environment for development and testing of the CrIS data sub-setting system, (3) to allow for a smooth transition of the CrIS NOAA Unique Product processing system from the development environment to the operational environment, and (4) to provide simulated observation radiances for instrument's effect evaluation on NWP. This poster presents the simulation methods, procedure and result for CrIS and ATMS (Advanced Technology Microwave Sounder) that comprise the CrIMMS (The Cross track Infrared and Microwave Sounder Unit).

## CrIS(Cross-track Infrared Sounder)

CrIS is a Michelson interferometer infrared sounder cover spectral range of 3.9 to 15.4. Three infrared spectral bands are defined. Radiance data from sensor detectors will be interpolated and remapped to a standard set of spectral channel wave number. (1305 output bins are defined in user's spectral grids). The CrIS instrument is designed to observe the ground with an instantaneous field of view which map to a nadir footprint of 14km on the ground from an altitude of 833km. The CrIS observation is used to construct vertical profiles of atmospheric temperature, moisture and pressure. The key performance parameters of CrIS are summarized in Table 1

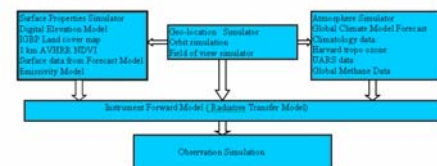
Sensor Parameter	Guaranteed Value	Sensor Parameter	Guaranteed Value
LWIR Band	850-1095 cm <sup>-1</sup>	LWIR Band-Average NEΔN (mW / m <sup>2</sup> sr cm <sup>-1</sup> )	0.132
MWIR Band	1210-1750 cm <sup>-1</sup>	MWIR Band-Average NEΔN (mW / m <sup>2</sup> sr cm <sup>-1</sup> )	0.044
SWIR Band	2150-2550 cm <sup>-1</sup>	SWIR Band-Average NEΔN (mW / m <sup>2</sup> sr cm <sup>-1</sup> )	0.006
LWIR Spectral Resolution	< 0.625 cm <sup>-1</sup>	Absolute Radiometric Uncertainty	< 0.45% (LWIR) < 0.6% (MWIR) < 0.8% (SWIR)
MWIR Spectral Resolution	< 1.25 cm <sup>-1</sup>	Number of FOVs	3 x 3
SWIR Spectral Resolution	< 2.5 cm <sup>-1</sup>	FOV Diameter (Round)	14 km
FOV Motion (Jitter)	< 50 urad / axis	ILS Uncertainty	< 1.5% FWHM
Mapping Accuracy	< 1.45 km	Spectral Accuracy	< 5 ppm

**Advanced Technology Microwave Sounder:** ATMS is a fellow-on instrument to AMSU. The primary new ATMS feature are a reduced hardware package and improved gap coverage and spatial resolution. ATMS provide observation for 22 microwave channels. The frequencies covered range from 23 GHz to as 183 GHz. It contains all the channels of AMSU-A and AMSU-B plus several additional channels. The ATMS beams total scan during the earth view section is a 105.45 with 96 scan position. The beam width are three channel groups ( CH1-2, CH3-16 and CH17-22) are 5.5, 2.2 and 1.1 degree. ATMS synchronize the scanning with CrIS every 8seconds.

## METHODOLOGY

- Geolocation generator simulate all instrument state parameters.
- Surface Properties Generator simulate the surface radiative properties.
- Atmosphere simulator. ECMWF reanalysis model provide the 'Nature Run' data. Nature Run data and Climate data are combined to simulate the 'real' atmosphere.
- Fast radiative transfer model works as CrIS instrument forward model to generate simulated CrIS observation.

## Data Flow



## Geolocation Simulator

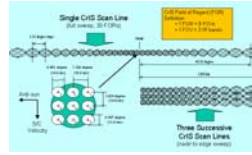
Geolocation simulator creates all instrumental state parameters used in observation simulation. These include all pointing, satellite location, solar ephemeris and geolocation parameters. Geolocation simulator include orbit simulator and Field\_of\_view location simulator.

## Orbit simulator

The current operational concept for NPOESS consists of a constellation of spacecraft flying at an altitude of 833 km in three sun-synchronous (98.7 degree inclination) orbital planes with equatorial nodal crossing times of 0530, 0930, and 1330 local solar time (LST), respectively. The afternoon (1330) spacecraft will carry CrIS observation system. Keplerian orbit elements are set according to the spacecraft orbit requirement.

## Field\_of\_view location simulator

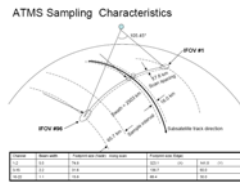
Footprint position is evaluated from the CrIS viewing angle relative to the platform coordinate system and the time of the measurement.. A typical CrIS measurement scan sequence consists of 34 interferometer sweeps including 30 earth scenes plus 2 deep space and 2 ICT(the internal Calibration Target) measurements (these numbers include both forward and reverse sweeps). One scan of the CrIS sensor will take about 8 seconds. The instrument can perform a new measurement (sweep) every 200 ms, Each scan is comprised of 918 interferograms.



The geolocation simulation based on: The spacecraft ephemeris and attitude; The instrument scan pattern and measurement sequence; The instrument optical system characteristic; DEM model.

## The objectives of simulation:

- 1: Geodetic longitude and latitude of the Earth located center of each FOV
- 2: Footprint pattern at the surface (pixel semi-minor and semi-major axes)
- 3: The line of sight (LOS) slant angle of the located measurement and solar..



## Surface Properties Simulation

Surface properties: skin temperature, surface pressure, land fraction, topography, microwave and infrared emissivities and reflectivities. Surface skin temperature and surface pressure are got from "Nature run". Topography, land fraction is from DEM model.

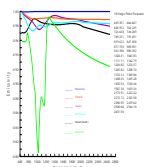
## Infrared Emissivities and Reflectivities for CrIS

The radiative properties is obtained basing on the surface material properties. Eight materials are used to describe surface composition. The contribution of each material is determined by land fraction, the amount of vegetation, the types of vegetation defined by the International Geosphere Biosphere Programme (IGBP) land use surface classification, Vegetation amount and water surface fraction are determined from AVHRR NDVI data(IKM) and the sampled DEM water.

## Infrared Emissivities and Reflectivities Model (CrIS):

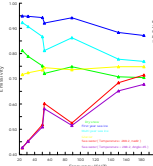
All materials except sea water are assumed to be Lambertian emitters in the infrared. The material and the emissivity model used in simulation are described in TabLand Figure 1.

Surface Composition	EMISSIVITY MODEL
Sea water	The Hansen four stream emissivity model (Hansen et al., 1983) is used to determine the emissivity of sea water. The model depends on frequency, emission angle and wind speed.
Vegetation:	Integrated from CERES emissivity. The CERES values are backscattered spectra inverse function of the 11 CERES channels and are derived from the Johns Hopkins University Spectral Library.
Green/Conifer forest	
Deciduous forest	
Ice/Sea ice/Water	
Snow	Usher Emissivity!
Urban/Quartz	Quartz infrared handbook (Wolfe & Zeman 1978)



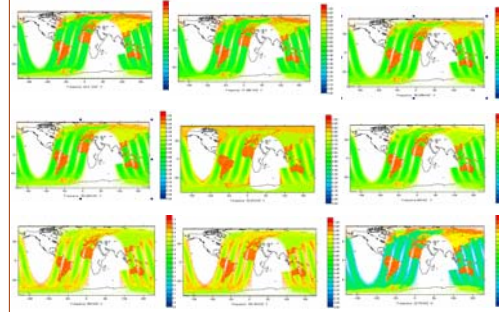
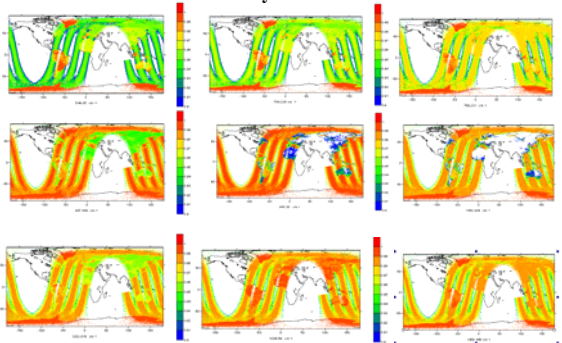
## Microwave Emissivities and Reflectivities Model (ATMS):

The model surface types are land, sea water and four kinds of ice: first-year sea ice, multi-year sea ice, glacial ice and dry snow. Land fraction, skin temperature and latitude are used to assign a model in simulation.



SURFACE COMPOSITION	MODEL
Sea water	L=0.97 T=271.12
Land	L=0.97 T=273.16
Snow:	L=0.97 T=273.16 La within 70
Glacier	L=0.97 T=273.16 La within 70
First year sea ice	L=0.97 256k-T=271.12
Multi year sea ice	L=0.97 T=265k

## Infrared/Microwave Emissivity:



## Atmosphere Simulator

Atmosphere simulator generate the temperature, water vapor, liquid water, trace gas profiles and cloud. Those trace gases include ozone, methane, carbon monoxide and carbon dioxide.. The ECMWF forecast, NCEP GDAS/AVN9 (or OSSES nature run), the UARS climatology and the Harvard troposphere ozone climatology are adopted to define the atmosphere profile and cloud amount. Temperature, humidity and liquid water are provided at the forecast levels. UARS climatology data consists of monthly and zonal averaged means and variances of temperature and 18 other species including water vapor, ozone, methane and carbon monoxide. Harvard troposphere ozone climatology contains monthly troposphere ozone values in 13 pressure levels.

## Temperature Profile

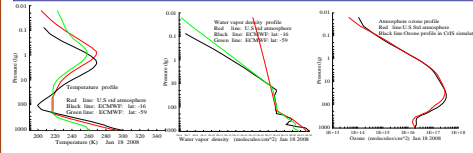
Temperature profile is obtained from forecast and the UARS temperature climatology data. Two profiles are combined with a tie point at the top of forecast pressure levels.

## Water Vapor profile

Relative humidity is from forecast and UARS Climatology data.

## Ozone profile

Ozone data is provided by the UARS climatology for the upper stratosphere and mesosphere. The Harvard climatology provides a better estimate for the troposphere. Two data sources are combined at 100 hPa to obtain the ozone profile used in radiance simulation.



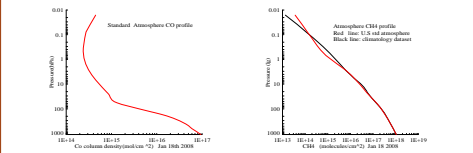
## Methane Profile

The atmosphere methane profile is provided by Gunson *et al.*, (1990).

Atmospheric carbon monoxide profiles are taken from the U.S. standard atmosphere.

## Carbon monoxide

A model developed by S. Leroy is used (Fishbein et al.2001) to simulate carbon dioxide profile. This model is based on measurements of CO2 at ground stations and a realistic representation of meridional and vertical transport.

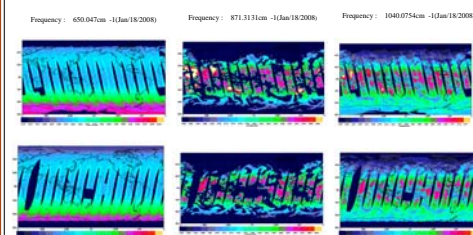


## Clouds

•The cloud liquid water and cloud fraction are provided by the forecast data. The clouds are stratified into three groups, high, middle and low (300 hPa, 500 hPa). There are two different algorithms in cloud processing: 1: All clouds are assumed to be opaque and Lambertian reflectors. The cloud emissivity is normal distribution [0.5,0.9]. 2: The cloud radiative characteristics are calculate and parameterization with general atmosphere observation information and the thin cloud emissivity is used to adjust the forecast cloud fraction. The observation radiance is the weighted average of clear sky and cloud radiance.

## Instrument Forward Model( Radiative transfer model)

CrIS/ATMS Fast Forward Model provided by UMBC. This fast transmittance model is based on methods developed and used by Larry McMillan, Joel Susskind, and others. (Larry M. McMillan et al. 1976, 1995). Hybrid PFAST/OPTRAN algorithm is developed with kCARTA line by line model. The Fast Forward Model are developed basing on the Pre-launch spectral response function. Instrument noise model is used to simulate the instrument noise.



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Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2008.