



Mapping CrIS Spectral Radiances of CO2 and Water Vapor to VIIRS

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Introduction

Effective satellite remote sensing of cloud properties requires measurements in specific spectral channels for a given scene. The Clouds and the Earth's Radiant Energy System (CERES) Project uses the infrared water vapor (WV) and CO2 channels (6.72 μm , 7.33 μm , 13.3 μm , 13.6 μm , 13.9 μm , and 14.2 μm) available on the Terra and Aqua Moderate Resolution Imaging Spectroradiometers (MODIS) for cloud detection and characterization. A key CERES objective is to create a climate data record (CDR) of clouds and radiative effects that is consistent in time, and across satellite platforms. Unfortunately, The Visible Infrared Imaging Radiometer Suite (VIIRS) on board S-NPP (Suomi-National Polar-Orbiting Partnership) lacks the WV and CO2 channels which could create CDR discontinuities if not adequately mitigated in some way. One possibility is to recreate the MODIS-like channels using the Cross-track Infrared Sounder (CrIS), a hyperspectral instrument flown coincidentally with VIIRS on S-NPP.

Objectives

- Use CrIS data to produce MODIS-like CO2 and WV radiances coincident with VIIRS
- Employ the mapping software in ATOVS and AVHRR Pre-processing (AAPP) package provided by Satellite Application Facilities for Numerical Weather Prediction (NWP SAF).
- Validate the method by comparing mapped central wavelength 10.763 μm from CrIS with channel M15 from VIIRS and with direct comparisons to AQUA-MODIS.

Data

- S-NPP VIIRS NETCDF4 product (VNP0203IMD_SS) from NASA GSFC, September 19, 2015
- CrIS SDR products (GCRSO and SCRIS) from NOAA CLASS, September 19, 2015
- Relative Spectral Response (RSR) from MODIS Characterization Support Team (ex. 27.tv.1pct.det for 6.72 μm , <https://mcst.gsfc.nasa.gov/calibration/parameters>)

Approach

CrIS data, which is a Fourier transform spectrometer with 1305 spectral channels, covers wavenumbers 650-1095 cm^{-1} (713 channels, sampling 0.625 cm^{-1}), 1210-1750 cm^{-1} (433 channels, sampling 1.25 cm^{-1}), and 2155-2550 cm^{-1} (159 channels, sampling 2.5 cm^{-1}). The radiance L_{λ} at the central wavelength λ_c can be calculated by the following equation:

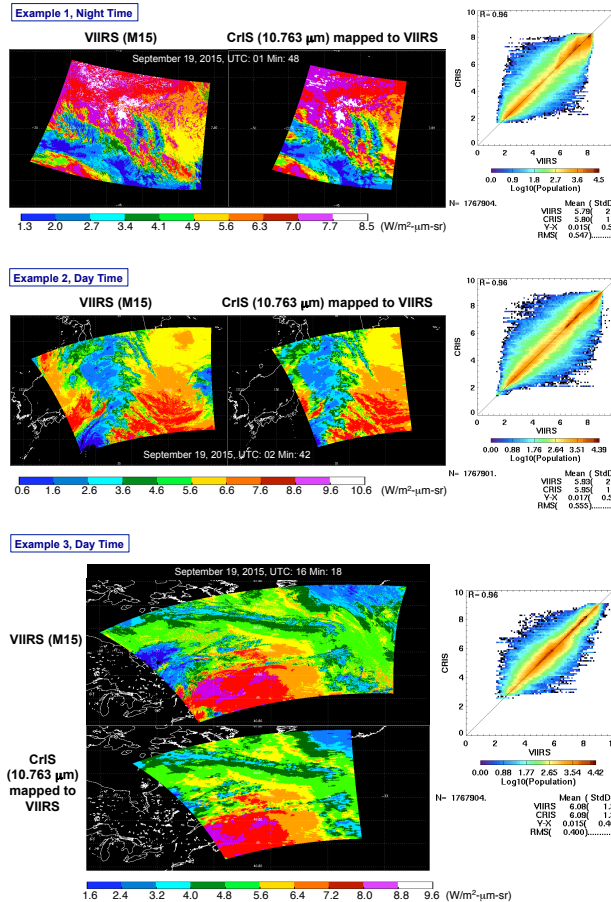
$$L_{\lambda} = \sum_i I_i R_i / \sum_i R_i$$

where I_i is the radiance of CrIS at channel i , and R_i is the relative spectral response (RSR) provided by MODIS Characterization Support Team (see Reference section) for the same channel. To optimize the accuracy of the radiance calculation, trapezoidal approximation was used. Each CrIS field of view (FOV) with CO2 and WV radiances calculated above is mapped to VIIRS pixels using the NWP SAF AAPP mapping software. Due to the coarse CrIS spatial resolution, some VIIRS pixels do not have CrIS mapped values. Therefore a regional average filling method was applied to those VIIRS pixels, limited to the width of the CrIS swath. The mapped radiances of CO2 and WV from CrIS were then appended to the original VIIRS product.

Results

To validate the accuracy of the mapping method, radiances from both VIIRS (M15) and CrIS (10.763 μm) were examined.

Radiance (10.763 μm , IR) Comparisons between VIIRS and CrIS



Daily Statistics, Day & Night

Radiance (10.763 μm) Mean and Standard Deviation for CrIS and VIIRS

September 19, 2015

W/m ² -μm-sr	CrIS	VIIRS	Difference of CrIS - VIIRS
MEAN	5.807	5.786	0.021
STDEV	2.202	2.237	0.510

Correlation between VIIRS (M15) and CrIS (10.763 μm) mapped to VIIRS: R = 0.9737

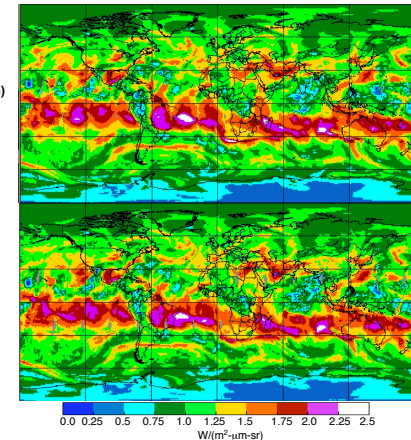
Radiance (6.72 μm , WV) comparisons between MODIS and CrIS

Global maps of WV (6.72 μm) radiances

One day: September 19, 2015, Day & Night

MODIS (6.72 μm)

CrIS (6.72 μm) mapped to VIIRS



Summary & Future Work

- This method can be used to restore MODIS-like radiances (CO2 & WV bands) from VIIRS, by mapping CrIS to VIIRS.
- CrIS does not cover full VIIRS swath. The coverage is about 1800 km out of 2400 km VIIRS swath with about 300 km un-covered on each side of the swath.
- Calibrate the mapped channels with corresponding MODIS channels.
- Test CrIS mapped CO2 and WV bands with CERES cloud algorithms.

References

<https://mcst.gsfc.nasa.gov/calibration/parameters>
https://nwpsaf.eu/site/download/documentation/aapp/NWPSAF-MF-UD-011_viiirs-cris-mapping.pdf