CrIS/VIIRS Integration Product and Evaluation

NOAA Satellite and Information Services
National Environmental Satellite, Data, and Information Service

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SUMMARY:

An operational processing system has been developed in NESDIS to collocate and integrate observation and product from The Visible/Infrared Imager/Radiometer Suite (VIIRS) to Cross-track Infrared Sounder (CrIS) observation dataset. The collocated VIIRS observation and product provide the CrIS retrieval processing with extended spectral coverage and sub-pixel spatial resolution information . The collocation algorithms based on look-up table(LUT) is selected to satisfy the processing speed requirement for operational processing. The LUT is defined by the instrument optical characteristic, sampling pattern and the feature of satellite orbit. The CrIS instrument spatial response function is also applied in integration processing to obtain the physical consistence between the observations from two different satellite sensors. A brief review the integration algorithms, the LUT algorithms and the problems existing in operation processing will be given. The product detail, the parameters selection and the product evaluation result are presented.

CrIS-VIIRS integration product:

The present CrIS-VIIRS integration processing system is designed to integrate VIIRS observation and cloud product to CrIS observation &product dataset. The collocated VIIRS observation and cloud product provide CrIS processing with sub pixel level radiance, cloud cover ,cloud height and cloud phase information. Those data are required in cloud clearance radiance algorithms and related product development. The collocated VIIRS radiance products include total radiance, radiance over cloudy area and radiance over clear area within the CrIS FOV. The collocated VIIRS radiance provided the CrIS with extra visible ,near infrared information. The collocated VIIRS cloud fraction is generated from Cloud Mask Intermediate Product. If a cloud is detected, the VIIRS Cloud Mask (VCM) indicates whether its phase is water, ice, or mixed. Cloud Mask IP is produced on he VIIRS Moderate Resolution Geo-location (non-Terrain Corrected) and contains cloud mask data for each pixel(750 m pixel), scan, and granule. Collocated VIIRS height is generated from the Cloud Base Height EDR. The cloud base height is defined as the height above sea level where cloud bases occur. The cloud base heights are horizontal spatial averages over a cell (Cloud Aggregated 6 km x 6 km cell), a square region of the earth's surface. If a cloud layer does not extend over an entire cell, the spatial average is limited to the portion of the cell that is covered by the layer.

VIIRS Channel

VIIRS		
VIIRS Band	Spectral Range (um)	Nadir HSR (m)
DNB	0.500 - 0.900	
M1	0.402 - 0.422	750
M2	0.436 - 0.454	750
M3	0.478 - 0.498	750
M4	0.545 - 0.565	750
I1	0.600 - 0.680	375
M5	0.662 - 0.682	750
M6	0.739 - 0.754	750
I2	0.846 - 0.885	375
M7	0.846 - 0.885	750
M8	1.230 - 1.250	750
M9	1.371 - 1.386	750
I3	1.580 - 1.640	375
M10	1.580 - 1.640	750
M11	2.225 - 2.275	750
I4	3.550 - 3.930	375
M12	3.660 - 3.840	750
M13	3.973 - 4.128	750
M14	8.400 - 8.700	750
M15	10.263 - 11.263	750
I5	10.500 - 12.400	375
M16	11.538 - 12.488	750

	FOV Shape (degrees, Cross Track)	FOV Shape (degrees, In Track)	FOV Matching Band-to-Band, In-track and Cross-track (degrees)
70% of Peak Response Width	> 0.8735	> 0.8735	+/- 0.0206
50% of Peak Response Width	0.942	0.942	+/- 0.0137
10% of Peak Response Width	< 1.100	< 1.100	+/- 0.0206
3% of Peak Response Width	< 1.238	< 1.238	N/A

CrIS FOV Spatial Characteristic

Band	Spectral range [cm^{-1}]	Spectral range [μm]	Band width [cm^{-1}]	Resolution $\Delta\sigma$ [cm^{-1}]	MPD [cm]
LW	650 – 1095	15.4 – 9.1	445	0.625	0.8
MW	1210 – 1750	8.3 – 5.7	540	1.25	0.4
SW	2155 – 2550	4.6 – 3.9	395	2.5	0.2

CrIS Channel Frequency

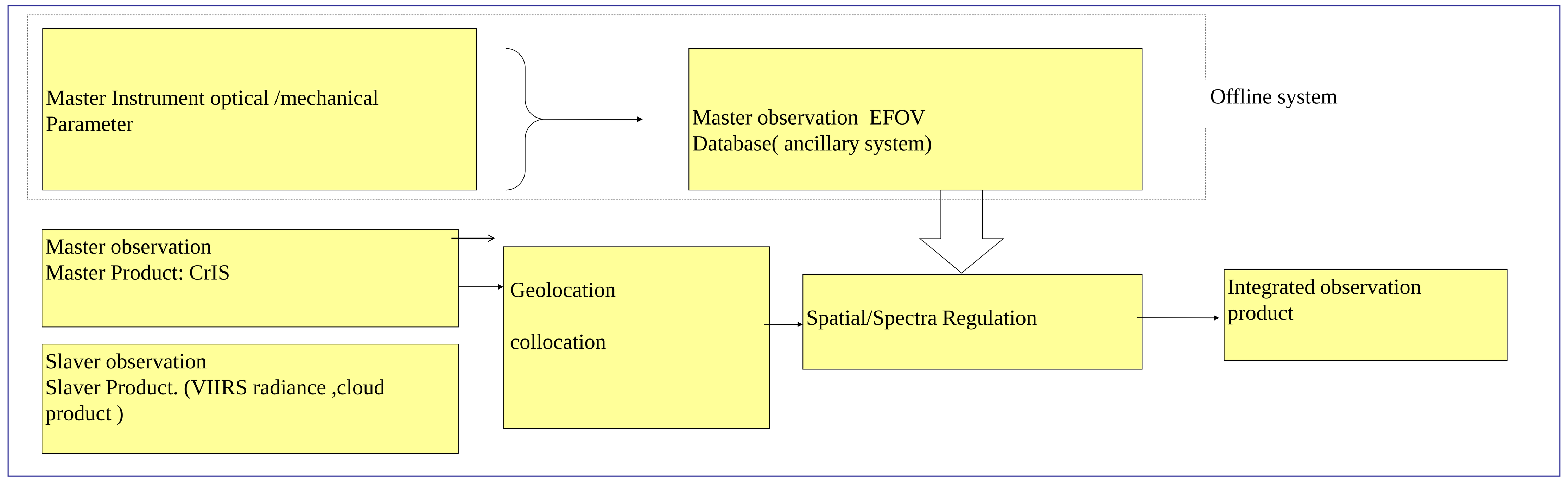
METHODOLOGY

The CrIS-VIIRS collocation processing includes two basic steps: observation collocation and observation regulation.

Collocation: Observation collocation processing is to search VIIRS observations/products that are spatially collocated, temporally concurrent and geometrically aligned to CrIS. The collocation between CrIS and VIIRS is accomplished with observation geo-location information(spatial Searching algorithms). The offline pre-calculated Look-up-Table(LUT) is applied in the collocation processing to satisfy the processing speed requirement.

Regulation : Indentify all collocated VIIRS observations and regulate the collocated VIIRS observations/products to the same CrIS physical represented "Target". The observation point with higher spatial resolution(VIIRS) is mapped to spatial response function with lower spatial resolution (CrIS) to get the contribution weight of the collocated points. The point with non zero weight will be collocated and averaged with the contribution weight. The Master instrument is the instrument onto whose footprints the slaver views are to be overlain.

Data Flow



Collocation LUTs

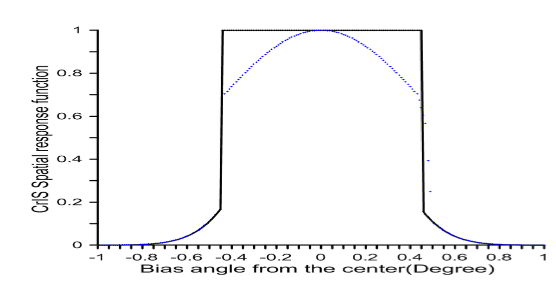
The collocation algorithms with the look up table(LUT) is selected in present CrIS-VIIRS collocation basing on the fact that present VIIRS and CrIS are aboard the same observation platform and LUT method can provide fast and robust processing. The Nagle (1998) proposed a general algorithm that can be used to co-locate the observation from two different sensors aboard the same or different vehicles. For the same platform collocation, the relative position between Master(CrIS) and slaver observation(VIIRS) keep relatively fixed, The collocation with LUT doesn't require Satellite orbit and altitude information. The problem of relative position shifting due to the different sensor optical design sampling pattern can be resolve with multiple LUTs. The LUTs for the collocation between VIIRS observation/product and CrIS is trained with the real observation dataset. Multiple tables(At present 16 tables) are obtained with different relative position shifting due to the scan mirror rotate period difference. The LUTs include the most of the influence factors, such as instrument installation parameter. The LUP table keeps the relative scan line index and FOV index of all collocated VIIRS observation. In the LUT training processing, the collocated VIIRS point is identified with the CrIS observation spatial response function (SRF) of effective field of view (EFOV).

Observation regulation : Master Observation EFOV SRF

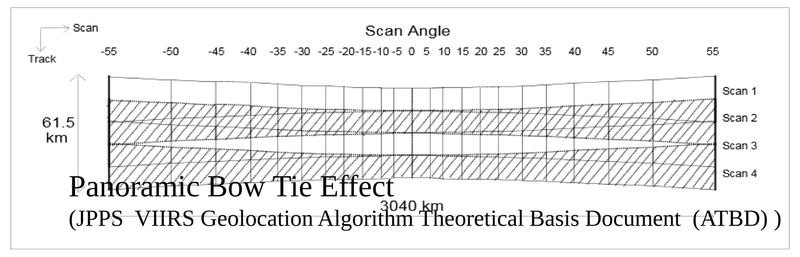
The instrument observation is contributed by all the points within the effective field of view (EFOV). The EFOV is defined as effective area swept by the sensor observation beam during the integration time. The physical collocation required the collocated observation and physical variables have the same spatial and physical representivity. The same spatial representivity required the collocated physical variable are from the same coverage area. The same physical representivity required the contribution weight of the individual point to the collocated physical variable are same. For the observed radiance , the contribution weight of the individual point within the coverage is the convolution product of the spatial response function (SRF) of instrument instantaneous field of view (IFOV) and the integration time. In the ollocation processing, the master instrument EFOV SRF is used to identify all collocated slaver observation within the EFOV and assign a weight for spatial regulation. A physical CrIS SRF model which fit the instrument PSF requirement is applied to obtain the EFOV and EFOV SRF. The model parameters are optimized with spatial collocated M13,M15,M16 radiance from VIIRS and the spectral convoluted M13,M15,M16 radiance from CrIS.

VIIRS Bow Tie Effect

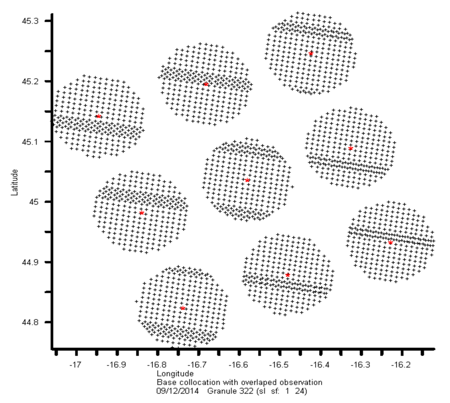
VIIRS Geolocation Algorithm apply three pixel aggregation modes to minimize variation of the horizontal sampling interval(HIS) in the along-scan direction and "bow-tie deletion" method to remove the called the "bow-tie" effect which leads to scan to scan overlap. But scan to scan overlapping still exist in the moderate resolution observations and products. Present VIIRS "Bow-tie Deletion" processing can't totally remove the overlap observation. In the collocation algorithms, A equal space grid is used in LUT generation to control the bow tie overlapped VIIRS point.

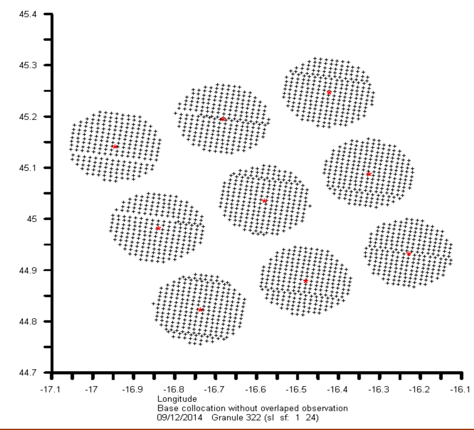


CrIS Spatial response function



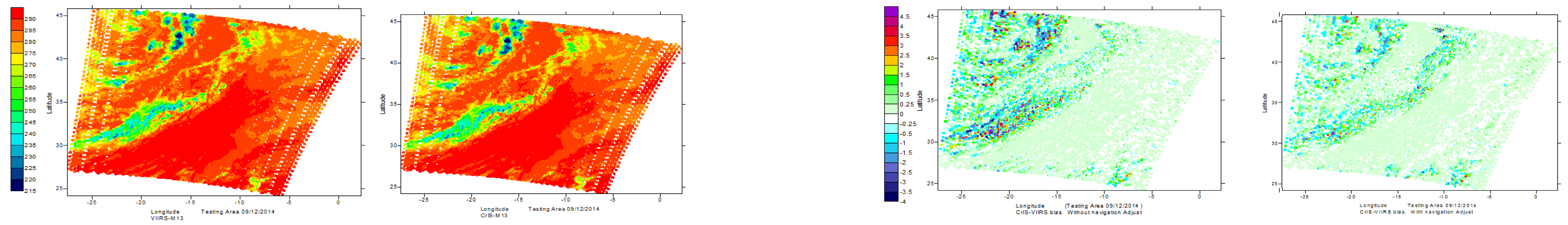
Panoramic Bow Tie Effect
(JPPS VIIRS Geolocation Algorithm Theoretical Basis Document (ATBD))





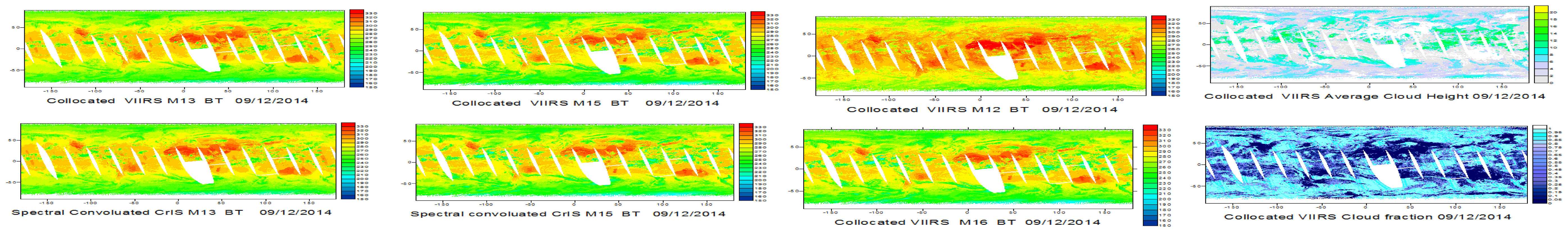
CrIS-VIIRS collocation Validation, Problems and algorithms Adjustment :

In CrIS-VIIRS collocation, the comparison between the spatial collocated VIIRS M13,M15,M16 radiance and the VIIRS M13,M15,M16 radiance generated from convolution of CrIS hyper spectral resolution radiance with spectral response functions can be used for algorithms validation. Given the correct CrIS spatial response function and VIIRS spectral response function, the collocated radiance from VIIRS and convoluted radiance from CrIS have same spatial and spectral resolution and should equal to each other. This conclusion rely on the accuracy of VIIRS and CrIS geo-location data. Validation case show the inconsistent geo-location information exist. The accuracy of VIIRS geo-location has been comprehensively evaluated through the correlation between the GCP data sets from Landsat and the measurements from VIIRS band 1, the mean errors of VIIRS geo-location is about 26m in the track direction and 13m in the scan direction. The designed specification for CrIS geolocation accuracy is less than 1.5km for all the FOVs. A CrIS geo-location adjustment algorithms is added to the collocation algorithms to improve the collocate dataset quality.



Product :

The physical collocation algorithms will be used in CrIS-VIIRS observation and product collocation processing. The present operation products include the CrIS cloud fraction from VIIRS, CrIS cloud Height from VIIRS and VIIRS total radiance/radiance over cloudy area/ radiance over clear area within the CrIS FOV. The product will provide in real time with operation mode.



Conclusion: CrIS-VIIRS physical based collocation algorithms and processing system are developed at NOAA/NESDIS/STAR to support the CrIS retrieval processing development. CrIS-VIIRS Collocation Processing system provide CrIS processing system with sub-pixel radiance and cloud information from VIIRS observation and product. The collocation product include collocated VIIRS total radiance, cloud/clear radiance, cloud fraction and cloud height. `

Reference:

[1] Haibing Sun ,Walter wolf, Co-location algorithms for satellite observations. (14th Conference on Satellite Meteorology and Oceanography p6.25 2007)

[2]Algorithms for the Processing of Integrated Satellite Observations and rapid Collocations, 2008 SPIE Optical Engineering and Applications. Sun, H. et al.