Accurate Collocation of VIIRS Measurements with CrIS

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Abstract: A state-of-the-art high-spatial-resolution imager and a high-spectral-resolution sounder, the Visible Infrared Imaging Radiometer Suite (VIIRS) and the Cross-track Infrared Sounder (CrIS) respectively, are both residing on the Suomi National Polar-Orbiting Partnership (SNPP) and future Joint Polar Satellite System (JPSS) satellites. Specifically, VIIRS is a whiskbroom scanning imaging radiometer, collecting visible and infrared imagery of the Earth through 22 spectral bands between 0.412 μm and 12.01 μm. These bands include 16 moderate resolution bands (M-bands) with a spatial resolution of 750 m at nadir, 5 imaging resolution bands (I-bands) with a 375 m spatial resolution nadir, and 1 panchromatic day-night band (DNB) with a 750 m spatial resolution. In contrast to VIIRS, CrIS has much higher spectral resolution including 1105 spectral channels with three infrared bands, but the spatial resolution (~14 km at nadir) is coarser than that of VIIRS and does not have the solar spectral bands. The combination of VIIRS and CrIS on SNPP and JPSS provides an opportunity to quantify the trade-offs between spatial and spectral coverage and, furthermore, to quantify the added value of atmospheric (and surface) retrievals from a combined multisensor, multiwavelength retrieval approach.

In addition, inter-calibration of CrIS and VIIRS at similar spectral regions is important, with appropriate optimization, this method is not only very fast and efficient but also can be convolved with VIIRS SRFs to simulate VIIRS I5 radiances for comparison purposes. Given the nature of hyper-spectral radiances, the CrIS spectrum can be integrated with VIIRS spectral response function (SRF) to simulate VIIRS radiances as:

\[
\int \nu S_{\nu} d\nu = \int \nu S_{\nu} d\nu + \nu \nu S_{\nu} d\nu
\]

Examples of CrIS and VIIRS images

The CrIS Spatial Response Function

When collocating CrIS FOV footprint with VIIRS measurements, the CrIS FOV is treated as a 0.967° circle. There is no weighting assigned in the circle. In other words, all the collocated VIIRS pixels are treated equally in the CrIS FOVs.

Compute line-of-sight (LOS) vector

In ECEF or ECR

The image map of CrIS-VIIRS BT differences indicates the collocation algorithm works well. The BT differences around land-sea contrast region is very small. The large differences are located at cloudy region, which is caused by cloud moving due to CrIS and VIIRS observational time differences.

Collocating CrIS and VIIRS

The collocation problem is simplified as, checking the angle between CrIS and VIIRS LOS vectors. If the CrIS FOV is overlapped with the VIIRS measurements, the angular difference between CrIS and VIIRS LOS vectors is less than the half-aperture of the CrIS FOV, that is, 0.967°/2. The conical approach is accurate, more easy to implement, and much easier to apply in computation. More important, with appropriate optimization, this method is not only very fast and efficient but also can meet accuracy requirements.

Summary: Given that the fact that CrIS and VIIRS will continue to be onboard the same platform of future Joint Polar Satellite System (JPSS) satellites for the next decade, it is desirable to develop spatial collocation between CrIS and VIIRS in details to facilitate the applications that need combine measurements from two sensors. In this study, an accurate and fast collocation method is developed to locate VIIRS measurements within CrIS instantaneous field of view (IFOV) directly in celestial space is proposed. We demonstrate that this method is accurate and precise in essence and much easier to apply in computation. More important, with appropriate optimization, this method is not only very fast and efficient but also can meet accuracy requirements. Finally, this collocation method can be applied to a wide variety of satellites on different satellites, for example, CrIS with AIRS on different polar orbiting satellite and CrIS and GOES imager on geostationary platform.