The Spectral Information Based Angular Correction Methodology for Satellite Intercalibration Applications

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Introduction

- To achieve high-accuracy corrections for intercalibration sampling differences resulting from mismatched sun-view geometry angles, an angular correction algorithm has been developed for the Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder (CPF) mission. This algorithm uses spectral correlation relationships to estimate differences in spectral radiances measured at different angles.

- The methodology can be extended to intercalibration analysis between multispectral sensors measuring band radiances across a broad spectral region.

- Inter-calibration analyses have often been limited to cases identified using simultaneous nadir overpass or strict ray-matching techniques. The angular correction allows for more relaxed angle-based collocation criteria, thereby enhancing the number of usable intercalibration samples. Furthermore, implementing the angular correction algorithm improves intercalibration accuracy in applications where angular mismatch errors have not been explicitly addressed previously.

CPF Based Angular Correction Application

The application of angular correction on CPF measurements

CPF
Radiance r_{θ,ϕ,θ_0}

⇩

Prediction

$$r_{\theta+\Delta\theta,\phi+\Delta\phi,\theta_0+\Delta\theta_0} = \mathbf{A}_{\theta,\phi,\theta_0,\Delta\theta,\Delta\phi,\Delta\theta_0} r_{\theta,\phi,\theta_0} + r_{\theta,\phi,\theta_0}$$

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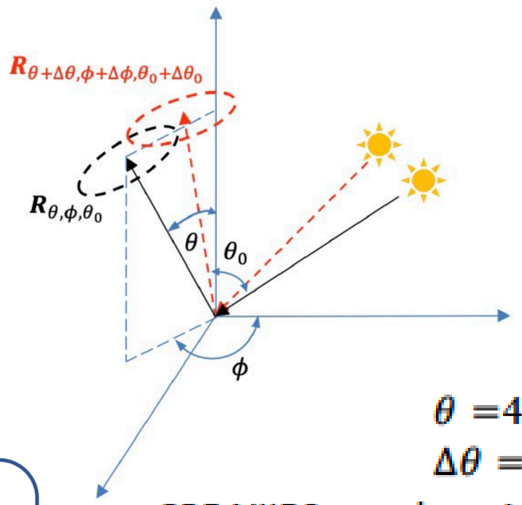
Target radiance
$r_{\theta+\Delta\theta,\phi+\Delta\phi,\theta_0+\Delta\theta_0}$

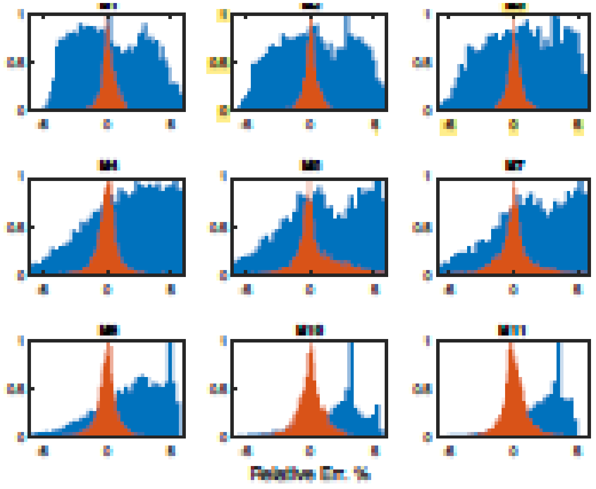


CPF instrument

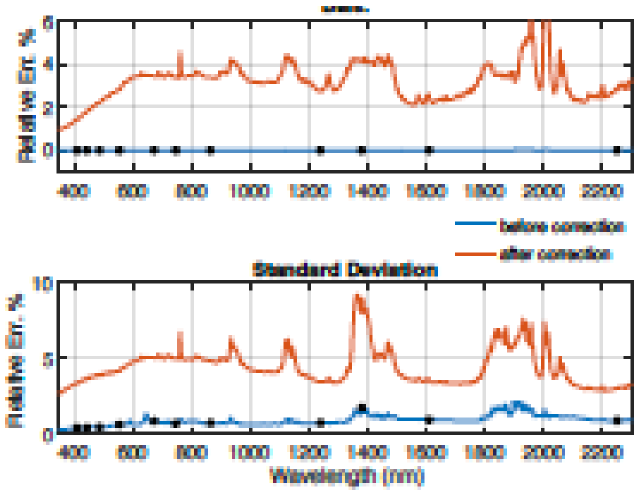
Spectral Range	350 nm – 2300 nm
Spectral Sampling/Resolution	3 nm/6 nm
Swath Width	70 km at nadir
Spatial Resolution	0.5 km

θ =45.0°, ϕ=135.0 °, and θ_0 = 42.5°
$\Delta\theta$ =2.5°, $\Delta\phi$=5.0 °, and $\Delta\theta_0$= 2.5°

CPF-VIIRS angular mismatch error



Spectral difference

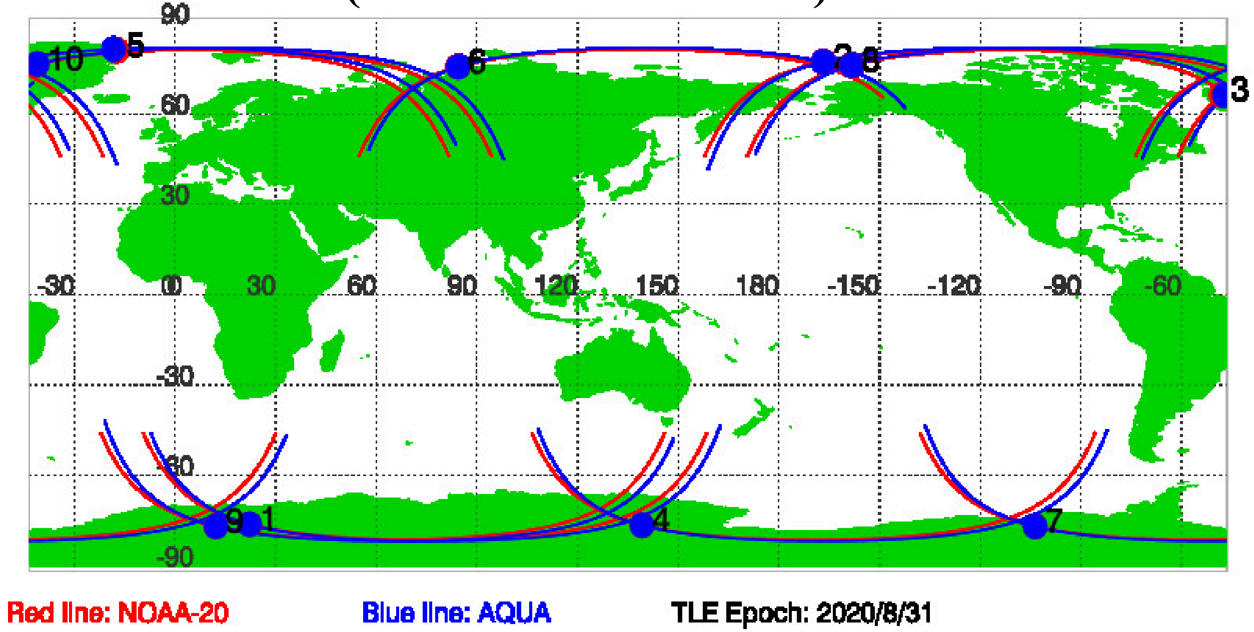


Extension for MODIS-VIIRS inter-cal applications

- Inter-calibration between MODIS and VIIRS measurements requires the use of collocated observations.

Using SNO observations means limited application scope since these SNOs mainly locate in the high-latitude region

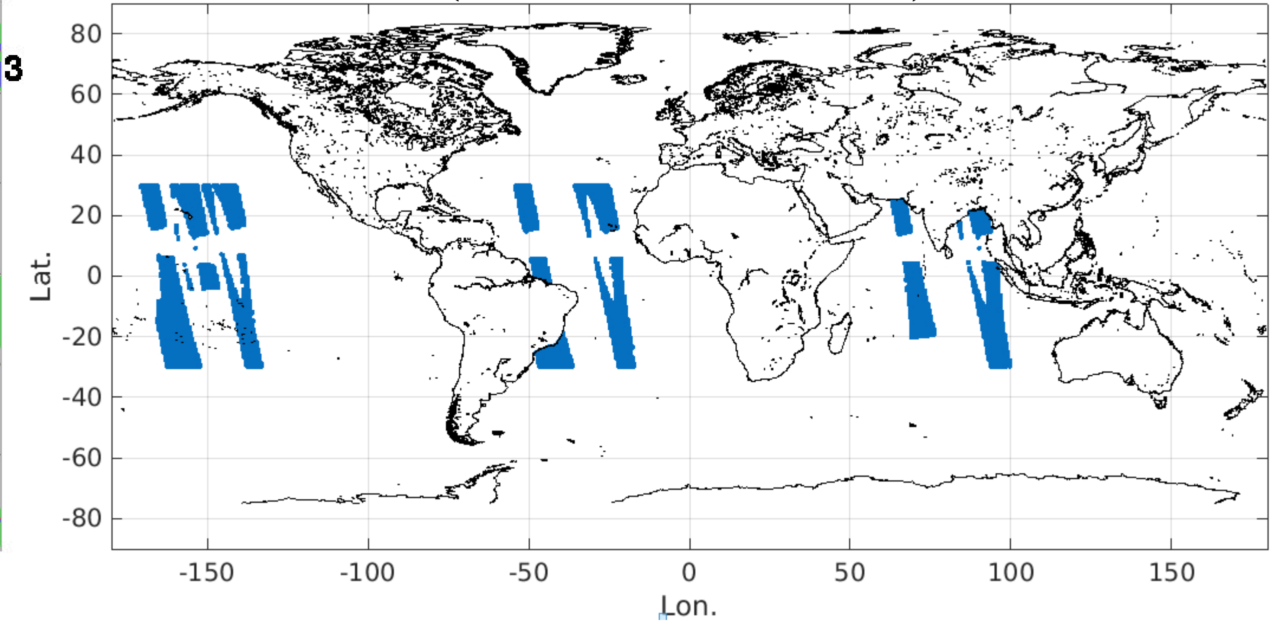
NOAA-20 and AQUA collocation events
SNOs only 10 collocated samples
(09/01/2020-09/12/2020)



Courtesy of GSICS web-based SNO prediction tool

Using non-SNO data requires the angular correction for sun-view geometry difference between MODIS and VIIRS measurements.

NOAA-20 and AQUA collocation events
sun-view mismatch < 5 º over ocean only
(09/01/2020-09/12/2020)

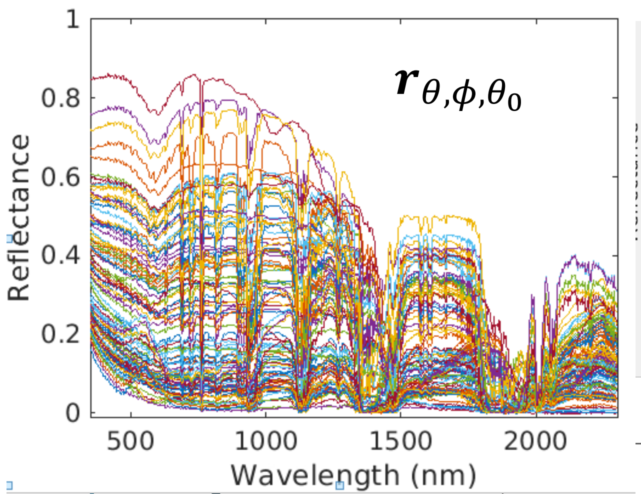


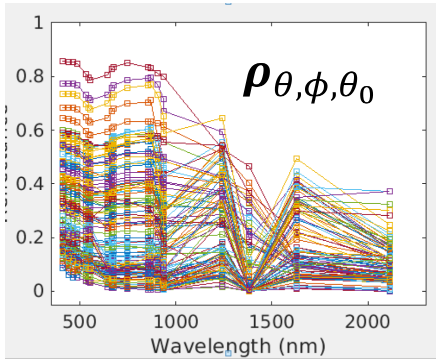
Explore the spectral correlation relationship to address the angular difference between MODIS and VIIRS

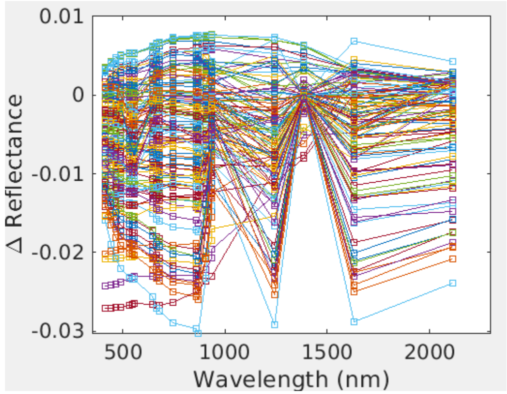
$$\boldsymbol{r}_{\theta+\Delta\theta,\phi+\Delta\phi,\theta_0+\Delta\theta_0} = \mathbf{A}_{\theta,\phi,\theta_0,\Delta\theta,\Delta\phi,\Delta\theta_0}\boldsymbol{r}_{\theta,\phi,\theta_0} + \boldsymbol{r}_{\theta,\phi,\theta_0}$$

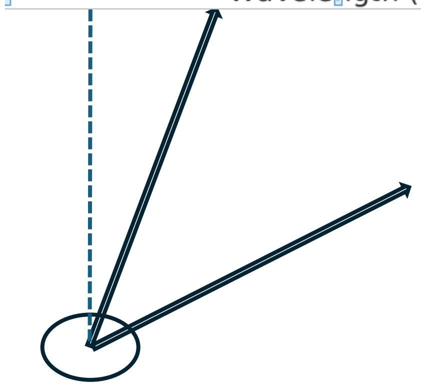
$$\boldsymbol{\rho}_{\theta+\Delta\theta,\phi+\Delta\phi,\theta_0+\Delta\theta_0} = \boldsymbol{A}_{\theta,\phi,\theta_0,\Delta\theta,\Delta\phi,\Delta\theta_0} \cdot \boldsymbol{\rho}_{\theta,\phi,\theta_0} + \boldsymbol{\rho}_{\theta,\phi,\theta_0}$$

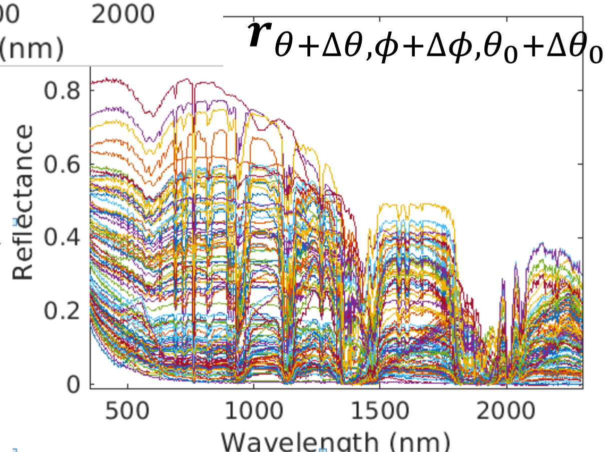
$$\Delta\boldsymbol{\rho} = \boldsymbol{\rho}_{\theta+\Delta\theta,\phi+\Delta\phi,\theta_0+\Delta\theta_0} - \boldsymbol{\rho}_{\theta,\phi,\theta_0}$$

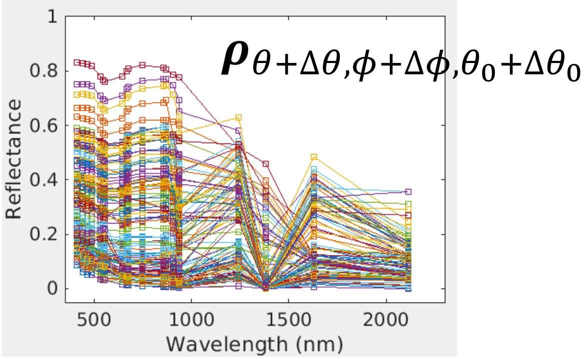










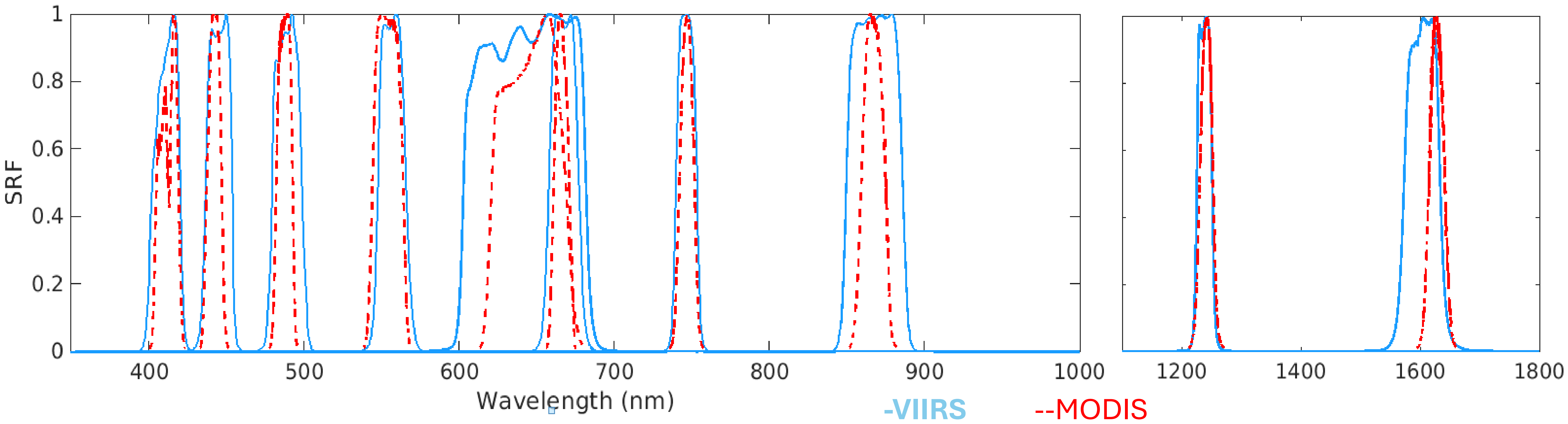


The application leverages the CPF training database by converting CPF spectral reflectance $\boldsymbol{r}_{\theta,\phi,\theta_0}$ into MODIS and VIIRS band reflectance $\boldsymbol{\rho}_{\theta,\phi,\theta_0}$

There are 20 MODIS measurement bands and 15 VIIRS bands within the CPF spectral range. MODIS and VIIRS keep a significant portion of the spectral information.

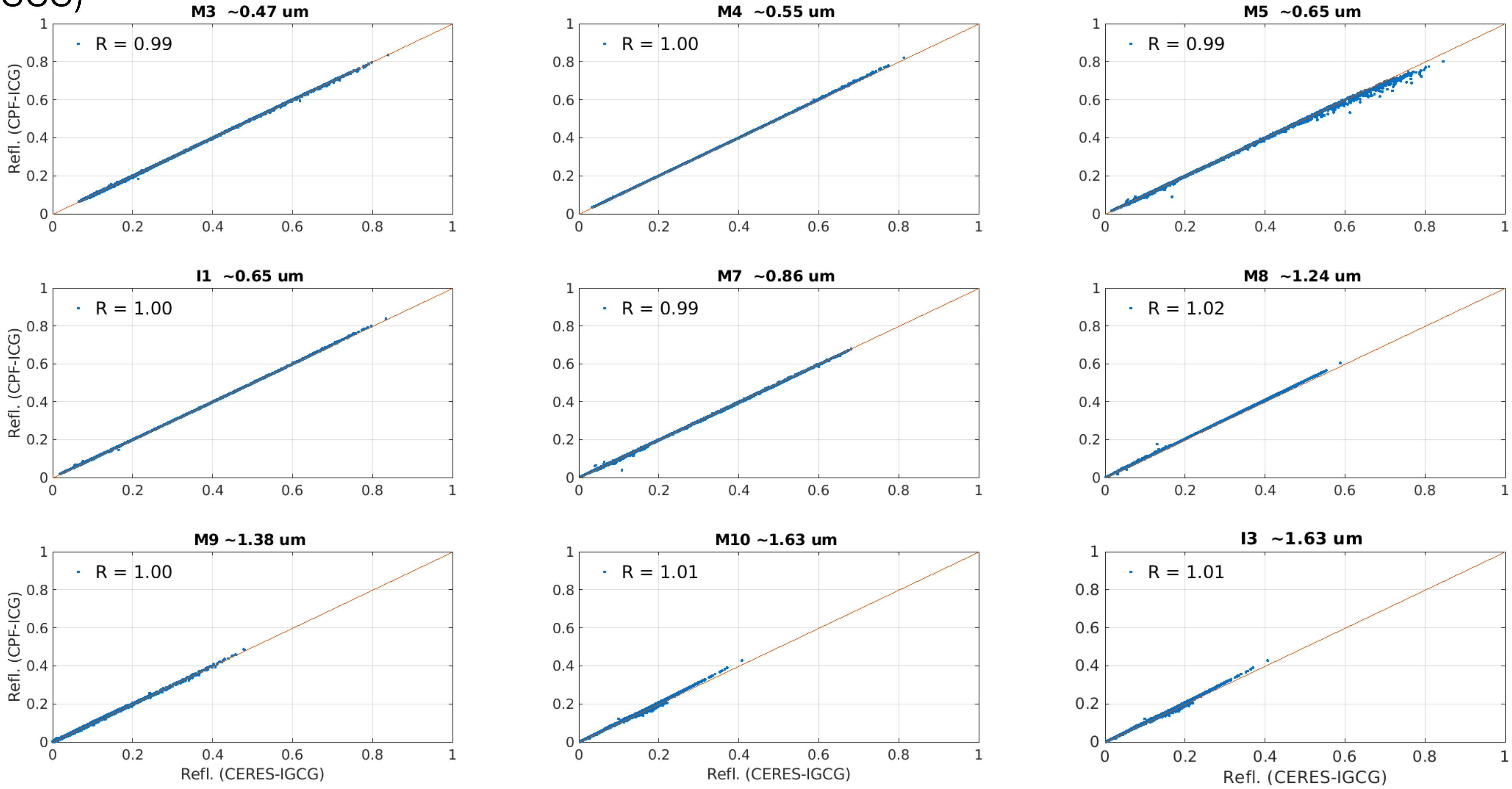
Account for both angular mismatch and instrument response difference

- A significant part of the difference between collocated MODIS and VIIRS observations stems from variations in their spectral response functions (SRFs).
- The angular correction algorithm need to capture the angular mismatch signal while accounting for SRF-related differences.



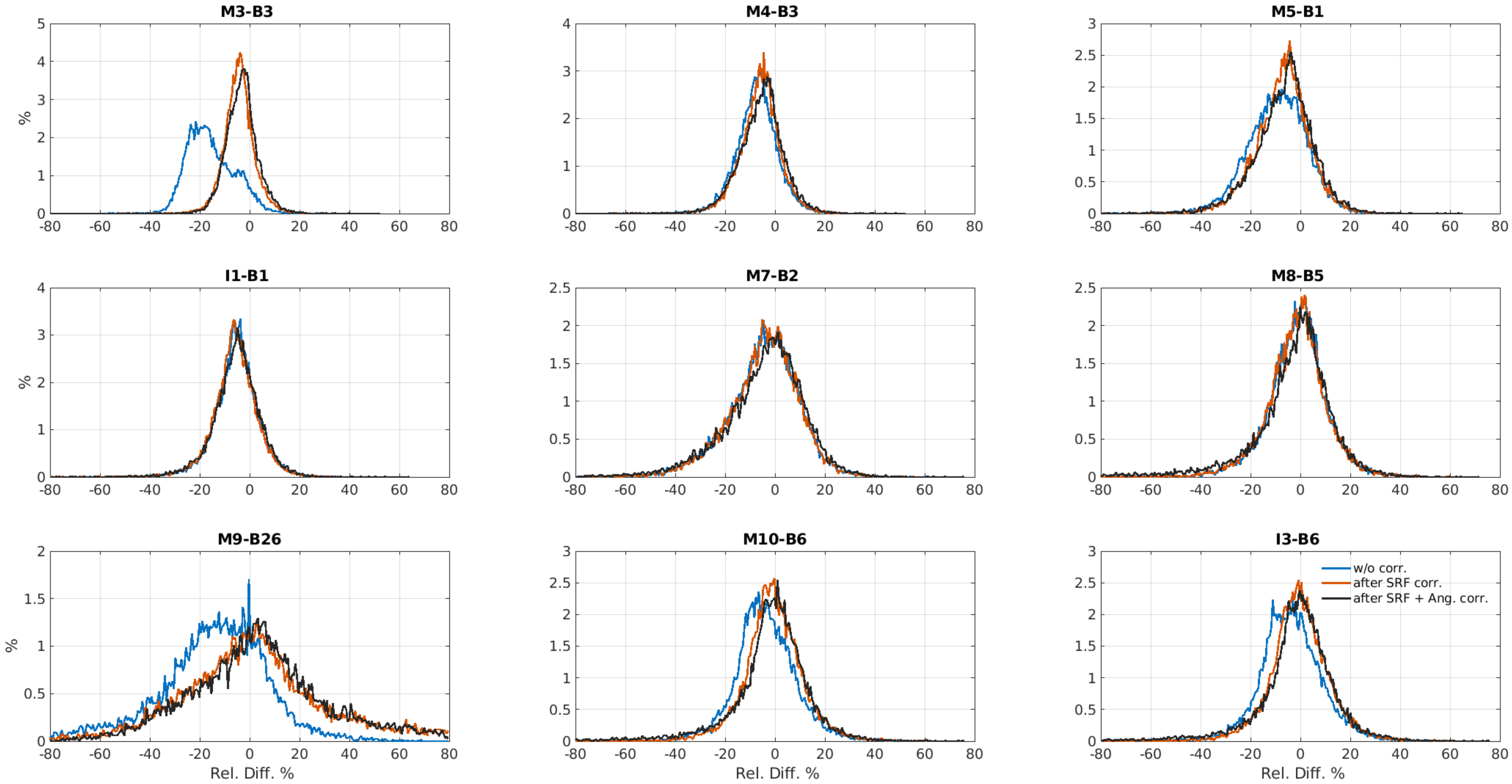
Validation the correction for the MODIS-VIIRS instrument response difference

- The CPF inter-cal algorithm based results have been compared with the results using the Spectral Band Adjustment Factors (SBAF) provided by the CERES Imager and Geostationary Calibration Group (CERES - IGCG)



Resolve angular difference in addition to the instrument response difference

Case study (VIIRS-MODIS inter-cal events over tropical ocean April 2024)



Summary

- The core part of the inter-calibration algorithms developed for the CPF mission is based on the utilization of the spectral correlation relationship to accurately predict the target measurements that can be mismatched in spectral and angular domain.
- The methodology and the reference data base developed for the CPF mission can be extended for other inter-calibration applications, providing a effective mean to relax the collocation criterion and therefore greatly increase the scope of the usable measurement samples .
- The application on MODIS-VIIRS inter-calibration has been demonstrated. The capability of using the is method to effectively resolve the small angular mismatch difference from the instrument response difference has been validated.