DEVELOPING A SPECTRAL CORRELATION BASED METHOD FOR MITIGATING ANGULAR MISMATCH EFFECTS IN INTERCALIBRATION USING A BENCHMARK HYPERSPECTRAL SENSOR

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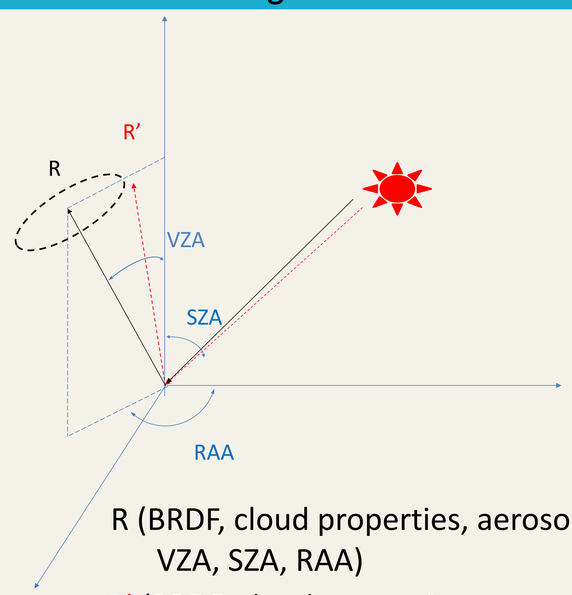
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Abstract

The CLARREO Pathfinder (CPF) mission will implement a state-of-the-art intercalibration method for transferring CPF's in-orbit Système Internationale (SI)-traceable reference to the shortwave channel of the Clouds and the Earth's Radiance Energy System (CERES) and the reflective solar bands of the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the NOAA-20 satellite platform with a targeted intercalibration methodology uncertainty of 0.3% (k=1). In order to achieve such a high intercalibration accuracy, the CPF intercalibration measurements to be scheduled need to closely match those from CERES and VIIRS in time, space, angles, and wavelength. Despite's CPF's two-axis pointing capability to match its boresight line of sight to that of a target sensor, there will be finite residual differences in angular samplings of the two instruments. The potential angular mismatch between CPF and the target sensors can introduce systematic errors in the intercalibration results, and therefore needs to be corrected using a rigorously designed algorithm. The CPF intercalibration team has been developing a correction method for mitigating the impact of these angular anisotropic effects in the CPF-VIIRS and CPF-CERES intercalibration. The method explores the spectral correlation relationship between the reflected solar radiances from the same surface target that would be measured by CPF at two adjacent angles. Our studies have shown that the spectral information based on CPF measurements can be used to accurately predict the spectral radiance or reflectance difference due to a given mismatch in the viewing and solar geometry. The hyper-spectral information can also be used to provide scene stratification without using any auxiliary data, which is critical to reduce the angular correction uncertainty. The angular correction relationship can be well established using simulated CPF-like top-of-atmosphere spectral radiances observed at all sorts of viewing geometry and solar angles and for different scenes. Intensive radiative transfer simulations have been completed using a state-of-art radiative transfer model developed by the CPF team members. The implementation of the algorithm on high-fidelity event simulation data and the characterization for the angular adjustment uncertainty will be presented.

Intercalibration Angular Mismatch Errors



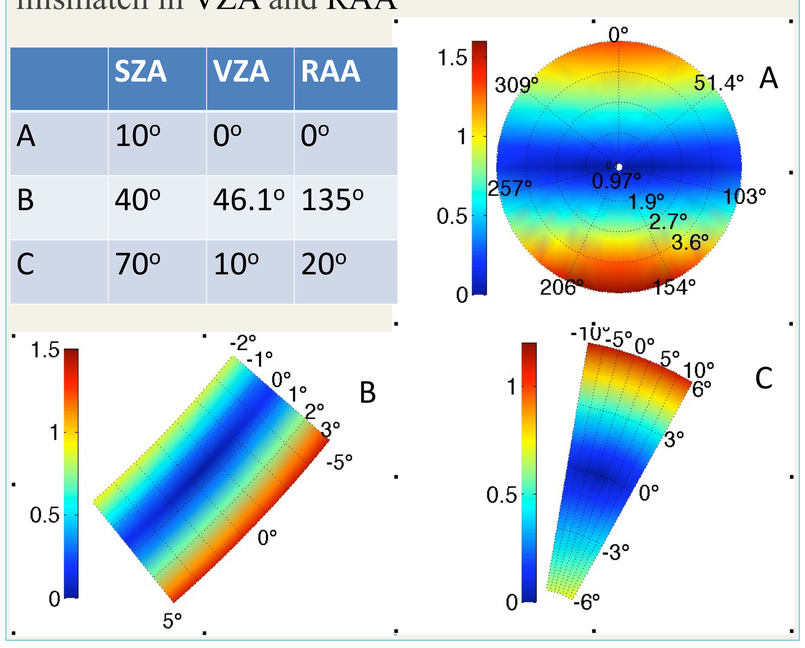
R (BRDF, cloud properties, aerosol, … VZA, SZA, RAA)

R' (BRDF, cloud properties, aerosol, … VZA+ΔVZA, SZA+ΔSZA, RAA+ΔRAA)

Estimation of potential angular mismatch errors R' - R (relative %) as function of ΔVZA, ΔRAA

Simulated CPF-VIIRS I1 band inter-cal error due to mismatch in VZA and RAA

	SZA	VZA	RAA
A	10°	0°	0°
B	40°	46.1°	135°
C	70°	10°	20°

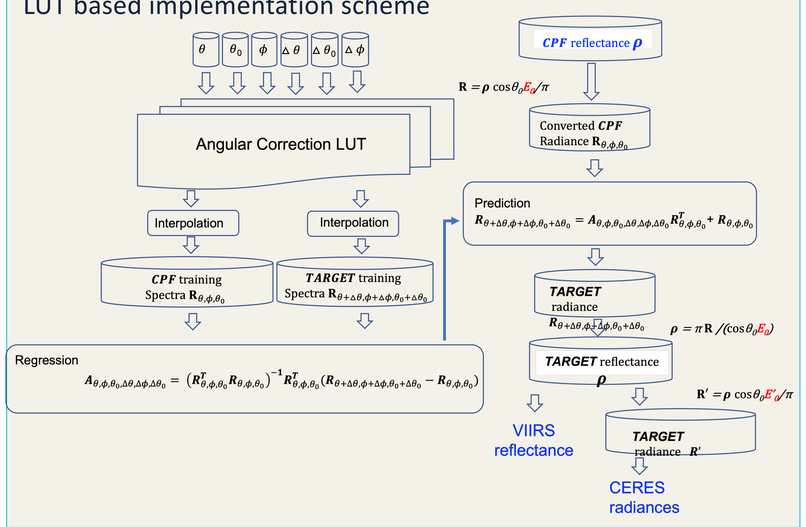


Angular Correction Algorithm

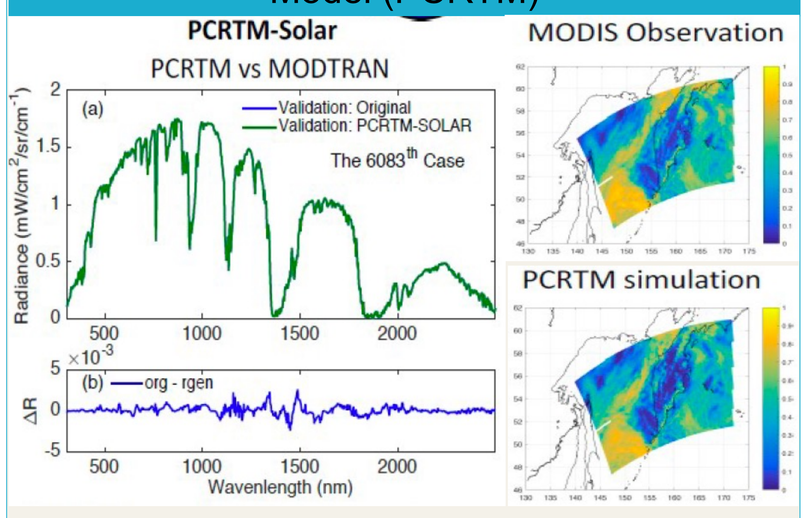
Utilizing the correlation relationship between on-axis CPF spectra and collocated off-axis CPF spectra

$$\Delta R = A^T R \qquad A = (RR^T)^{-1} R \Delta R^T$$

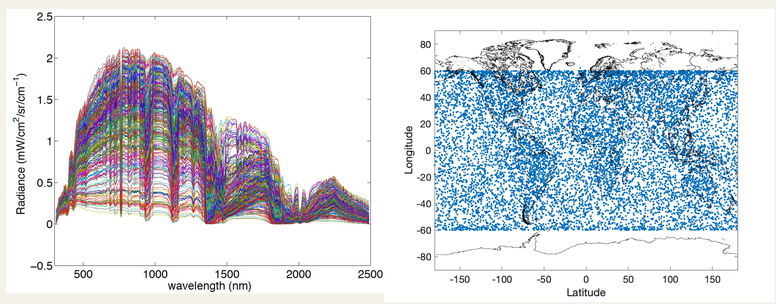
LUT based implementation scheme



Construction of Angular Correction LUT Using Principal Component based Radiative Transfer Model (PCRTM)



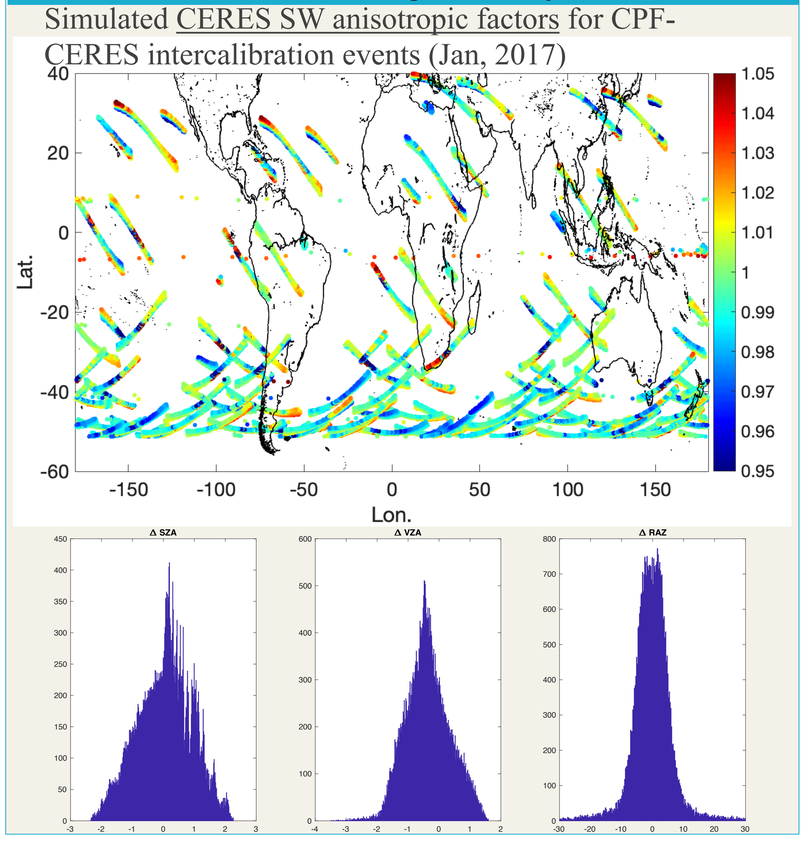
The PCRTM based CPF simulator can efficiently produce hyper-spectral TOA radiance or reflectance that matches the real observations.

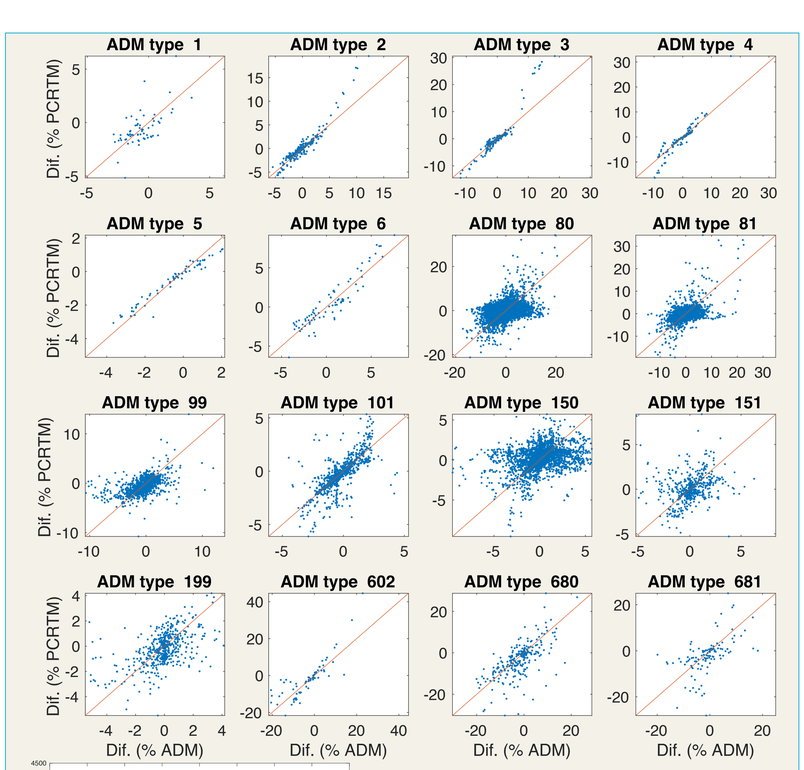


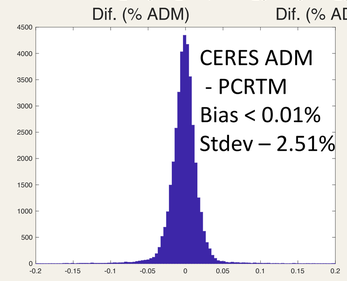
LUT contains 21x24x37 VZAxSZAxRAA units. Each units contain more than 10K spectral samples simulated using globally distributed geophysical parameters from various other data products.

Intercomparison study between CERES ADM and PCRTM based high fidelity simulations

Simulated CERES SW anisotropic factors for CPF-CERES intercalibration events (Jan, 2017)





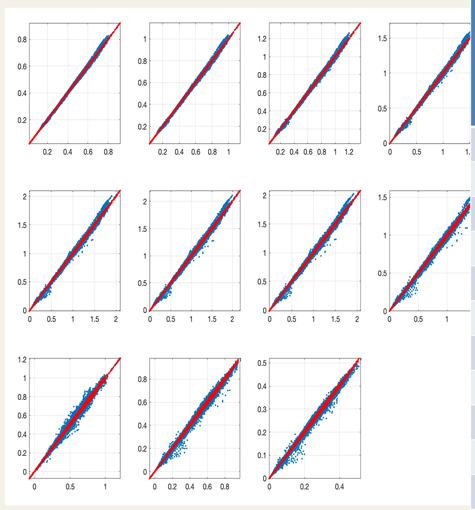


The estimation for CPF-CERES difference due to angular mismatch based on the PCRTM simulation agrees well with that based on CERES ADM, especially for groups with ADM type associated with small uncertainty.

CERES ADM – PCRTM (Rel Err. %)

ADM type	Bias %	Stdev %	R coef.	# samples
1	-0.04	1.27	0.64	62
2	-0.23	1.22	0.95	227
3	-0.51	3.05	0.94	176
4	0.12	2.21	0.93	126
5	0.26	0.64	0.98	84
6	-0.04	1.17	0.93	81
80	0.03	2.51	0.39	25890
81	0.02	2.35	048	6647
99	-0.01	2.12	0.50	1135
101	0.07	1.29	0.64	922
150	-0.11	2.26	0.30	3134
151	-0.03	2.22	0.25	558
199	-0.11	2.80	0.36	541
602	-1.49	5.80	0.84	70
600	1.41	6.14	0.67	268
681	1.10	6.95	0.55	116

Validation for the CPF-VIIRS Angular Correction Using high fidelity simulation results



VIIRS bands	Angular Mismatch Diff. (%) Before Corr.	Angular Mismatch Diff. After Corr.
1	-0.1899	0.0078
2	-0.1838	0.0107
3	-0.1755	0.0141
4	-0.1495	0.0208
5	-0.1574	0.0214
6	-0.1637	0.0212
7	-0.1614	0.0221
8	-0.1651	0.0253
9	0.0162	0.0320
10	-0.1765	0.0418
11	-0.1925	0.0422

X – mean spectral radiance (VIIRS angles) @ the center wavelength of VIIRS M bands; Y – (Blue dots) mean spectral radiance (CPF angles)@ the center wavelength of VIIRS M bands; (Red dots) mean spectral radiance after angular correction Unit mW·**sr**$^{-1}$·cm^{-2} /cm^{-1} /nm

Conclusion and future work

- PCRTM based angular correction algorithm has been developed and validated using both the simulation-based study and compared with CERES ADM results.
- The algorithm will be further validated using various available hyper-spectral sensor measurements.

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