Evaluation of the BRDF normalization HABA algorithm transfer from Sen2like multispectral to EnMAP hyperspectral.

Final Abstract Number: B13G-1615, Monday, 9 December 2024: 13:40 - 17:30

C.J. Guerrero Benavent[1], B. Franch [1,2], I. Moletto-Lobos [1], S. Saunier[3], R. de los Reyes [4], P. Schwind [4], T. Storch [4]

[1] Global Change Unit, Parc Científic, University of València (Paterna), 46980, Spain, cesar.guerrero@uv.es, belen.franch@uv.es, italo.moletto@uv.es,

[2] Dept. of Geographical Sciences, University of Maryland, College Park MD 20742, United States.

[3] Telespazio France, Satellite System and Operation, 26 Avenue JF Champollion, BP 52309, CEDEX 1, 31023 Toulouse, France

[4] German Aerospace Center (DLR), Remote Sensing Technology Institute, Photogrammetry and Image Analysis, Oberpfaffenhofen, 82234 Wessling, Germani

Introduction

- **BRDF (Bidirectional Reflectance Function)** describes the anisotropy properties of a given surface by representing the surface reflectance for different viewing-illumination geometries. This function allows the directional reflectance normalization to a common geometry reducing noise in the time series.
- In the **multispectral domain**, BRDF methods rely on inverting the BRDF coefficients using several observations of a limited period of the same area from various sun-view geometries, what becomes challenging for medium-high resolution sensors with narrow angular sampling. **HABA (High resolution Adjusted BRDF Algorithm)** normalizes the Sen2like product operationally and is based on the coarse resolution MODIS BRDF parameters inferred from **VJB method**.
- There is **limited research concerning the applicability of kernel-based BRDF algorithms in the hyperspectral domain**. This work explores the adaptability of HABA algorithm to the hyperspectral domain based on the hypothesis of high correlated BRDF properties over nearby wavebands.
- First results of an intercomparison exercise based on an angular field campaign over an heterogeneous orange tree plantation in Valencia (Spain) are exposed here. HABA performance is compared to ASD FieldSpec Spectroradiometer field angular measurements using a goniometer and a crane to normalize satellite data from EnMAP.

Methodology

1 HABA (High resolution Adjusted BRDF Algorithm)

BRDF model: *Ross-Li-Maignan model*

$$\rho(\theta_s,\theta_v,\phi) = k_0 + k_1 F_1(\theta_s,\theta_v,\phi) + k_2 F_2(\theta_s,\theta_v,\phi)$$

F_1 =volume – scattering kernel

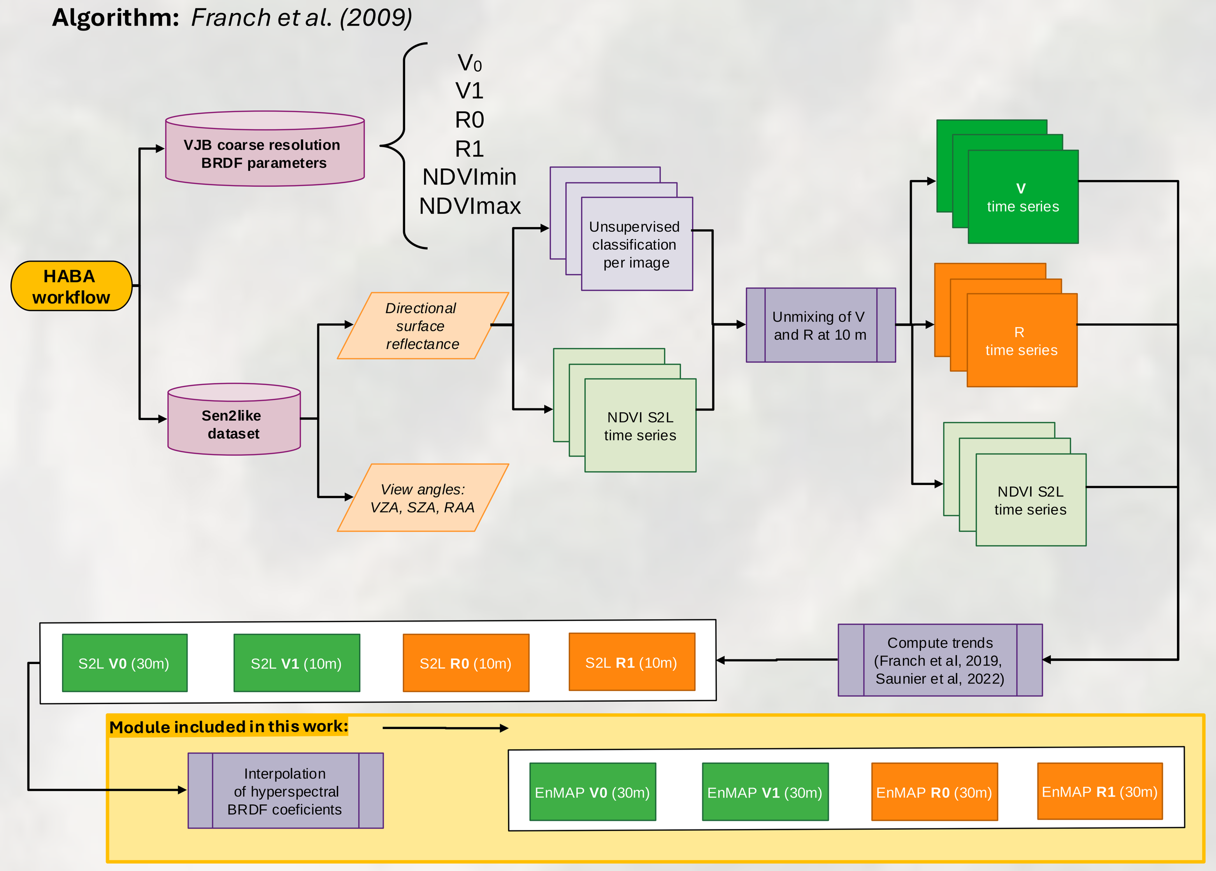
F_2 =geometric kernel

k_0, k_1, k_2 = free parameters

MODIS BRDF parameters, VJB method: *Vermote et al. (2009)*

$$V = k_0/k_1 = V_0 + V_1 NDVI$$
$$R = k_0/k_2 = R_0 + R_1 NDVI$$

Algorithm: *Franch et al. (2009)*

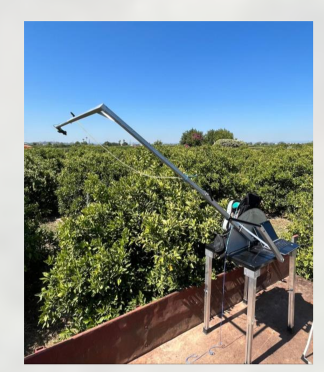


2 Field measurements: angular measurements performed on the Solar Principal Plane (SPP).

2.1 Goniometer measurements: (Tree scale)

8 hourly measurements to collect wide solar zenith angle variation at different view zenith angles: -50, -40, -30, -20, -10, 0, 10, 20, 30, 40, 50.

HOUR GMT +2	SOLAR ZENITH ANGLE
11:00	42.57º
12:00	31.36º
13:00	21.59º
14:00	16.45º
15:00	20.00º
16:00	29.2º
17:00	40.23º
18:00	51.79º



2.2 Crane measurements: (Field scale)

Crane measurements at different solar zenith angles and view zenith angles.

Nadir meaurements (VZA = 0º):

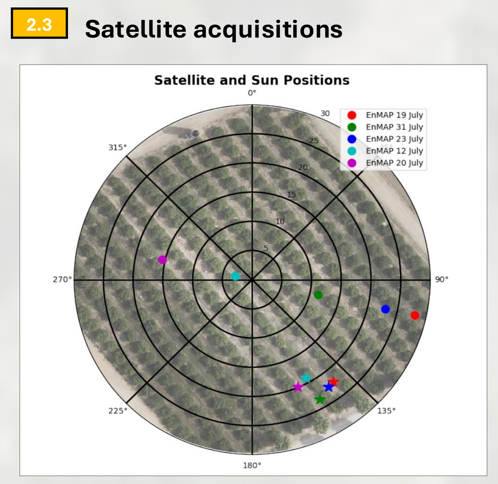
10th July 2024

HOUR GMT +2	SOLAR ZENITH ANGLE
10:37	47.54º
11:30	37.44º
13:10	20.96º
14:30	17.76º
15:30	24.57º
16:30	34.84º
17:23	44.83º
18:18	55.47º

Angular meaurements (VZA = 40º, 20º, 0º, 20º, 40º): 15th July 2024

HOUR GMT +2	SOLAR ZENITH ANGLE
10:19 – 11:18	51.54º - 40.24º
13:40 – 16:00	18.76º - 29.88º
17:23 – 18:21	45.14º - 56.35º

2.3 Satellite acquisitions



DATE - HOUR GMT +2	VIEW ZENITH ANGLE	SOLAR ZENITH ANGLE
12/07/2024 - 13:29	2.9º	22.19º
19/07/2024 - 13:11	28º	23.41º
20/07/2024 - 13:36	15.5º	22.37º
23/07/2024 - 13:15	22.9º	19.07º
31/07/2024 - 13:21	11.4º	19.84º

2.4 Drone LIDAR measurements

3 Post-processing

- **Compute** goniometer and crane **hyperspectral** BRDF coefficients using multiple observations data.
- **Simulate** S2like **reflectance** with ASD goniometer measurements, **compute multispectral** goniometer BRDF coefficients and interpolate hyperspectral ones.
- **Normalize** EnMAP observations with all the different derived BRDF coefficients and compare.

Normalization equation

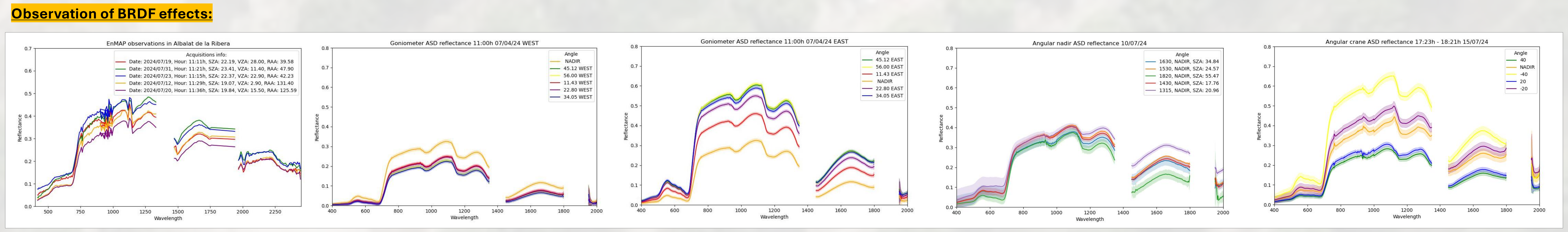
$$\rho_{norm}(\theta_{snorm},\theta_{vnorm},\phi_{norm}) = \rho(\theta_s,\theta_v,\phi)\,\frac{1 + VF_1(\theta_{snorm},\theta_{vnorm},\phi_{norm}) + RF_2(\theta_{snorm},\theta_{vnorm},\phi_{norm})}{1 + VF_1(\theta_s,\theta_v,\phi) + RF_2(\theta_s,\theta_v,\phi)}$$

Relative difference equation

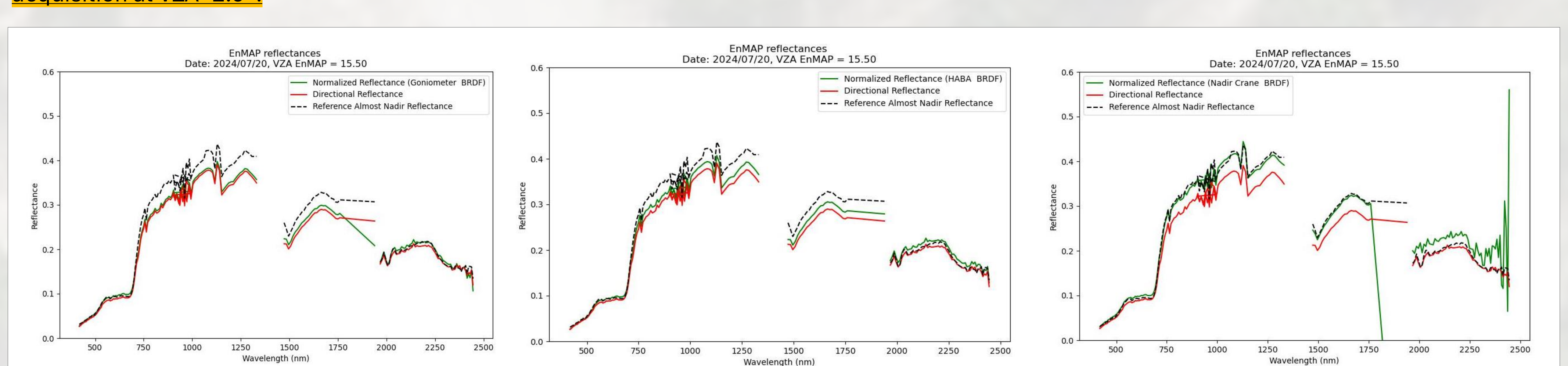
$$\Delta\rho = \frac{\rho_{reference} - \rho}{\rho_{reference}} \cdot 100$$

Results

Observation of BRDF effects:



Normalization of EnMAP reflectances: normalization of all EnMAP observations to the angular configuration of the 12th acquisition at VZA=2.9º.



Date	Spectral Range	Δρ (%) (Dir.)	Δρ (%) (Norm. Gon.)	Δρ (%) (Norm. Gon. Int.)	Δρ (%) (Norm. Nadir Crane)	Δρ (%) (Norm. Crane)	Δρ (%) (Norm. HABA)
2024/07/19 SZA = 23.41º VZA = 28º	VISIBLE	-33.1	-15.82	-17.71	-27.61	-38.37	-29.69
	NIR	-5.2	-4.64	3.75	12.96	-8.11	-2.69
	SWIR1	1.6	12.55	10.94	10.24	-2.33	4.3
	SWIR2	0.5	13.11	11.29	-1.18	-4.03	3.27
2024/07/31 SZA = 19.84º VZA = 11.4º	VISIBLE	-39.5	-30.30	-31.02	-34.89	-41.86	-36.75
	NIR	-12.5	-7.83	-7.92	-2.40	-14.42	-10.63
	SWIR1	-17.5	-11.43	-12.09	-11.27	-19.70	-15.22
	SWIR2	-15.8	-9.15	-9.66	-4.094	-18.10	-13.36
2024/07/23 SZA = 19.07º VZA = 22.9º	VISIBLE	-56.8	-38.22	-39.78	-48.20	-62.11	-51.87
	NIR	-16.4	-7.23	-7.64	-2.01	-20.02	-13.20
	SWIR1	-12.2	-1.34	-2.64	-1.94	-16.26	-8.51
	SWIR2	-15.1	-2.61	-3.82	-6.77	-19.53	-11.1
2024/07/20 SZA = 22.37º VZA = 15.5º	VISIBLE	5.7	-1.46	-2.31	-4.83	6.81	-0.32
	NIR	10.5	8.94	7.28	0.60	13.75	6.75
	SWIR1	11.9	8.79	7.86	1.35	13.58	7.22
	SWIR2	2.3	-0.5	-3.02	-18.00	3.50	-4.04

Conclusions

- The described field measurements have allowed to successfully retrieve the different scale anisotropy properties of the orange tree field.
- The **linear interpolation of the BRDF multispectral parameters** has demonstrated to be an **efficient and precise method to retrieve the hyperspectral BRDF parameters**, remarking the feasibility to adapt the HABA algorithm to the hyperspectral domain working towards an operational BRDF normalization algorithm for the upcoming CHIME mission.
- Angular crane measurements reduced the effectiveness of the BRDF correction, what could be caused by the position uncertainties when moving the crane or the non negligible deviation from the real SPP.

References

Vermote, E.; Justice, C.O.; Breon, F.M. Towards a Generalized Approach for Correction of the BRDF Effect in MODIS Directional Reflectances. IEEE Trans. Geosci. Remote Sens. 2009, 47, 898–908.

Franch, B., Vermote, E., Skakun, S., Roger, J. C., Masek, J., Ju, J., ... & Santamaria-Artigas, A. (2019). A method for Landsat and Sentinel 2 (HLS) BRDF normalization. Remote Sensing, 11(6), 632.

Acknowledgements

This project was supported by:

COFRUT-MONITOR (ref AGROALNEXT/2022/046 funded by the Generalitat Valenciana

Copernicus Hyperspectral Imaging Mission for the Environment (CHIME) L2 Algorithms and Processors Prototyping and Development (ref 4000142258/23/I-AG funded by ESA)

Financiado por la Unión Europea NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia