Estimation of surface albedo at high spatial resolution merging Sentinel-2 and Sentinel-3 observations

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Jérémy Auclair[1], Jean-Louis Roujean[1], Eric Ceschia[1], Morgan Ferlicoq[1], Julien Michel[1], Olivier Hagolle[1], Pierre Mischler[2], and Jonathan Leon Tavares[3]

[1]CESBIO, 18 avenue Édouard Belin, 31055 Toulouse, France

[2]Institut de l'Élevage (IDELE), 19 bis rue Alexandre Dumas, 80096 Amiens, France

[3]VITO, Boeretang 200, 2400 Mol, Belgium

1. Introduction

Sentinel-2 (S2) and Sentinel-3 (S3) satellites ensure a global coverage of the Earth surface at a high resolution (HR) and a moderate resolution (MR), respectively, and at different time frequency. Their fusion allows a mapping of the surface albedo at an advanced level of detail to monitor landscape components. Herein, the focus is on French grasslands investigated in the context of the project ALBEDO-prairies supported by the French Institute for Livestock (IDELE). The overall objective is to demonstrate that surface albedo can serve as an abatement to mitigate global warming and to support a favorable strategy for a sustainable agriculture.

2. Materials and Methods

S2 images are from MAJA products distributed by Theia (https://www.theia-land.fr/). S3 images were put at our disposal by VITO.

S2 HR data (10-60m) are acquired every five days with a narrow field of view (FOV) of (15°).

S3 MR data (300m) are acquired almost every day with a wide FOV (50°). This allows to sample the Bidirectional Reflectance Distribution Function (BRDF) to infer surface albedo.

S3 radiometry is converted to four S2 bands: B2 (blue), B4 (red), B8A (near infrared) and B11 (mid infrared) using PROSAIL [1] simulations and resampled to S2 grid based on nearest neighbor method.

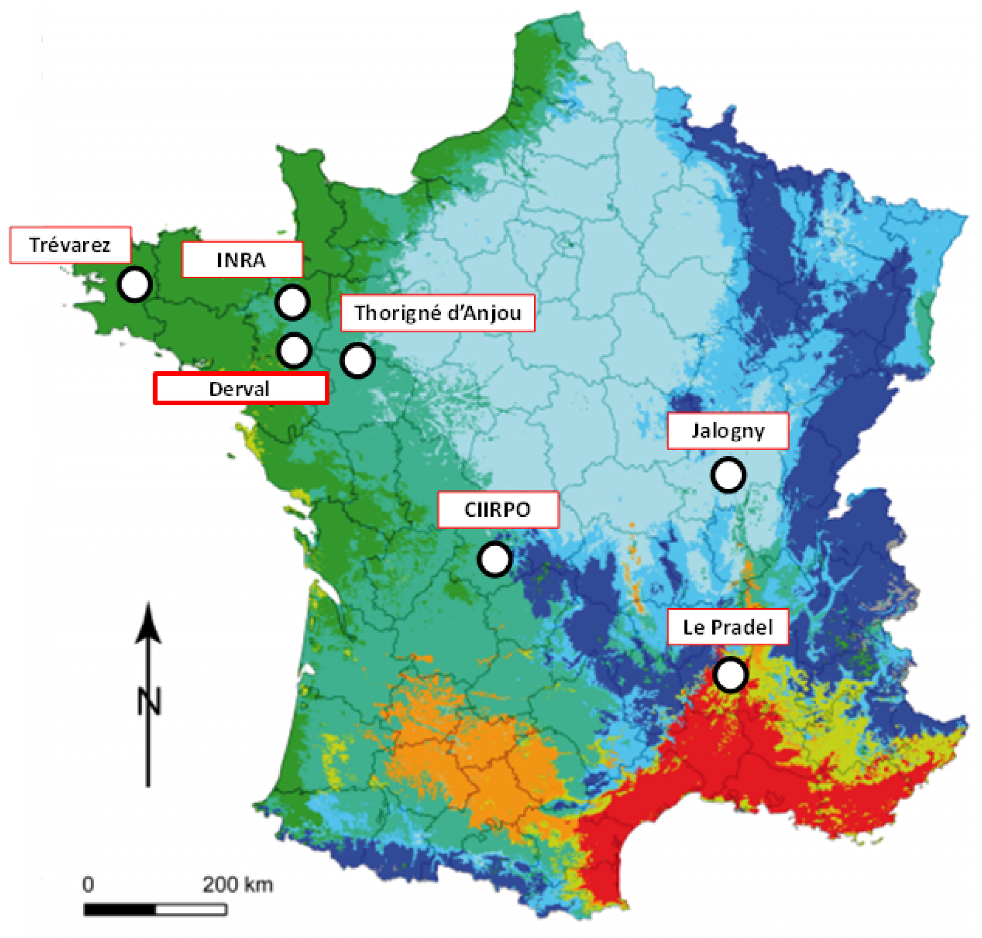

Figure 1: Map of the studied grasslands.

Six sites of prairie were equipped with CNR4 to measure the surface albedo every 10 minutes from sunrise to sunset.

Figure 2: CNR4 on Derval Prairie.

3. Albedo Processing Chain

Surface albedo is calculated from BRDF parameters k_i in adapting the method described in [2] :

$$\rho(\theta_s, \theta_v, \phi) = k_0 + k_1 f_1(\theta_s, \theta_v, \phi) + k_2 f_2(\theta_s, \theta_v, \phi)$$

$$\mathbf{R} = \mathbf{F}\mathbf{k}, \qquad \left(\mathbf{F}^T\mathbf{F} + \mathrm{c}_{ap}^{-1}\right) k = \mathbf{F}^T\mathbf{R} + \mathrm{c}_{ap}^{-1} k_{ap}$$

where θ_s and θ_v are the viewing and solar zenith angles, respectively, ϕ is the relative azimuth between view and sun directions, $\mathbf{R}$ is the solution to the linear least square inverse problem, $\mathbf{F}$ is the design matrix and c is the covariance matrix with ap standing for a priori information. S2 and S3 observations are accumulated over time (composite periods of 30 days) with sliding time frame (synthesis period of 5 days). BRDF model is inverted against S2+S3 observations using a recurrent method with a priori information. The kernels f_1 and f_2 are integrated over viewing angles and solar angles to obtain Directional Hemispherical Reflectance (DHR) and Bidirectional Hemispherical Reflectance (BHR). Blue Sky Albedo (BSA) writes : $a = (1-\alpha)\, a_{DHR} + \alpha\, a_{BHR}$ where α if the diffuse component estimated from MAJA aerosols.

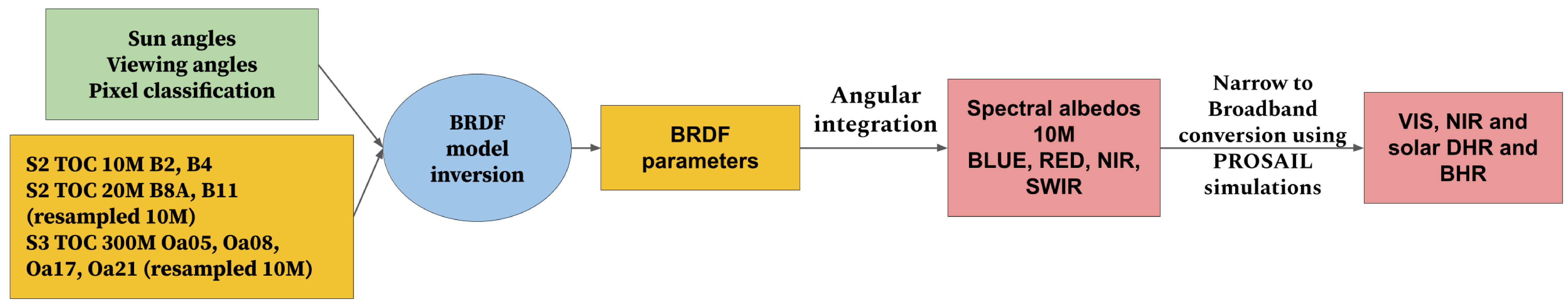

Figure 3: Flowchart of the albedo processing chain.

4. Results on French Prairies

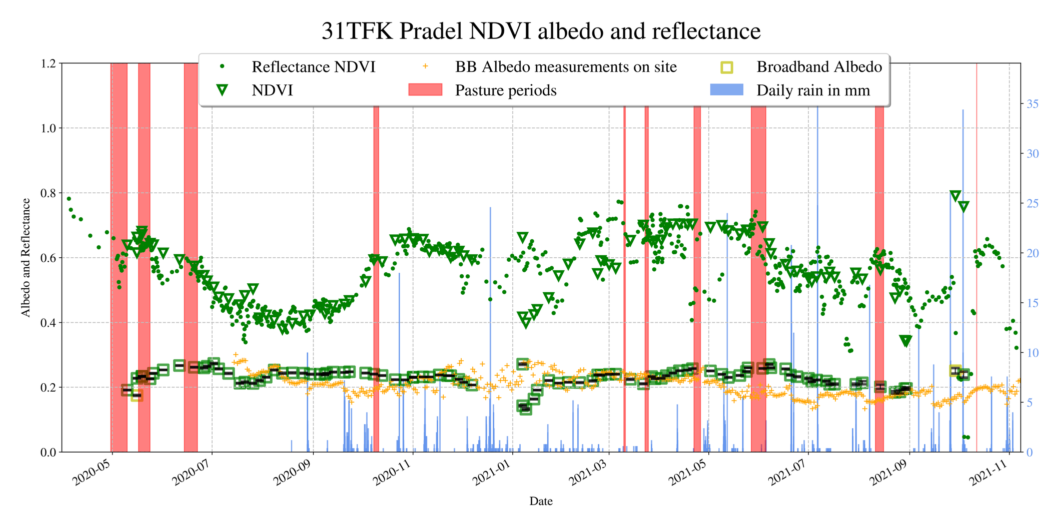

Figure 4: Time series of surface albedo for the prairie of Pradel.

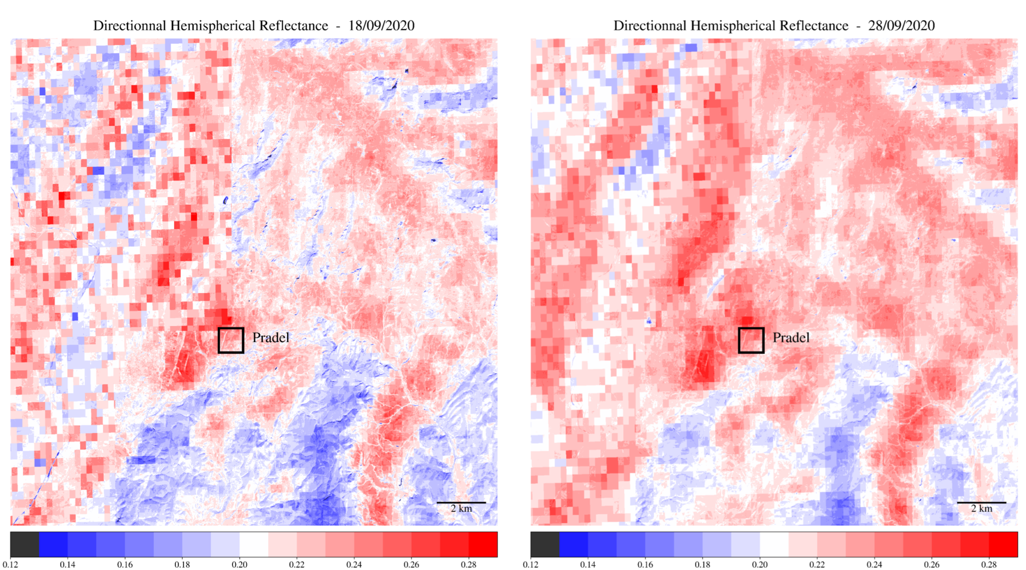

Figure 5: Maps of albedo S2+S3 for an area of 20 km by 20 km around Pradel.

Figure 4 shows times series of BSA over the prairie of Pradel (see Figure 1). S2+S3 and CNR4 BSA show a good agreement in intensity. Calculated bias (0.018) and standard deviation (0.041) between S2+S3 and CNR4 BSA fall within acceptable range. Major discrepancies occur after heavy rainfalls. In this case, ground-based albedo shows a depletion not always well reported by the satellite due to the lack of observations. Also, the representativeness may be limited after a rainfall episode since set of measurements is noisy, which could also explain the differences.

The link between BSA and pasture periods recorded by farmers (red bands) is not conspicuous, neither agricultural events are easily detectable from BSA estimates contrarily to NDVI (Figure 4).

Figure 5 reveals short-term variability of landscape BSA between September 18th and 28th 2020. The dominance of S3 images is conspicuous on the left part where local patterns are less reproduced. This is bound to happen during periods of high cloud coverage, reducing clear S2 images availability.

5. Conclusions and Future work

This work is a preparation to the future mapping of TRISHNA albedo. The accuracy assessment of surface albedo product is encouraging although the fusion between S2 and S3 - S3 replaced by TRISHNA - could be improved with weights dependent on the spatial resolution. A 30m resolution could be a good trade-off, preserving a spatial accuracy compliant with the crop scale.

6. Acknowledgments

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7. References

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