Estimate of surface albedo at high spatial resolution using Sentinel-2 and Sentinel-3 products

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1. Introduction

S2 and 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 piloted by French Institute for Livestock (IDELE). The overall objective is to demonstrate that surface albedo can serve as an abatement to mitigate global warming in producing a cooling effect.

2. Materials and Methods

S2 images are MAJA products distributed by Theia (https://www.theia-land.fr/). S3 images were processed by VITO.
S2 HR data (10-20m) are delivered every 5 days. The field of view (FOV) is 15°.
S3 MR data (300m) are produced almost every day. The FOV of 50° provides a sampling of the Bidirectional Reflectance Distribution Function (BRDF).
S3 radiometry was converted to four S2 bands: B2 (blue), B4 (red), B8A (near infrared) and B11 (mid infrared) using PROSAIL [1] simulations, then resampled to S2 grid based on nearest neighbor method.
METEOSAT products from LSA SAF - Downwelling Surface Shortwave Flux (DSSF), Opacity - are considered to obtain half hourly irradiance and atmospheric transmittance.
Surface albedo is measured continuously at the experimental farms using a CNR4 (Fig.1 Fig.2).

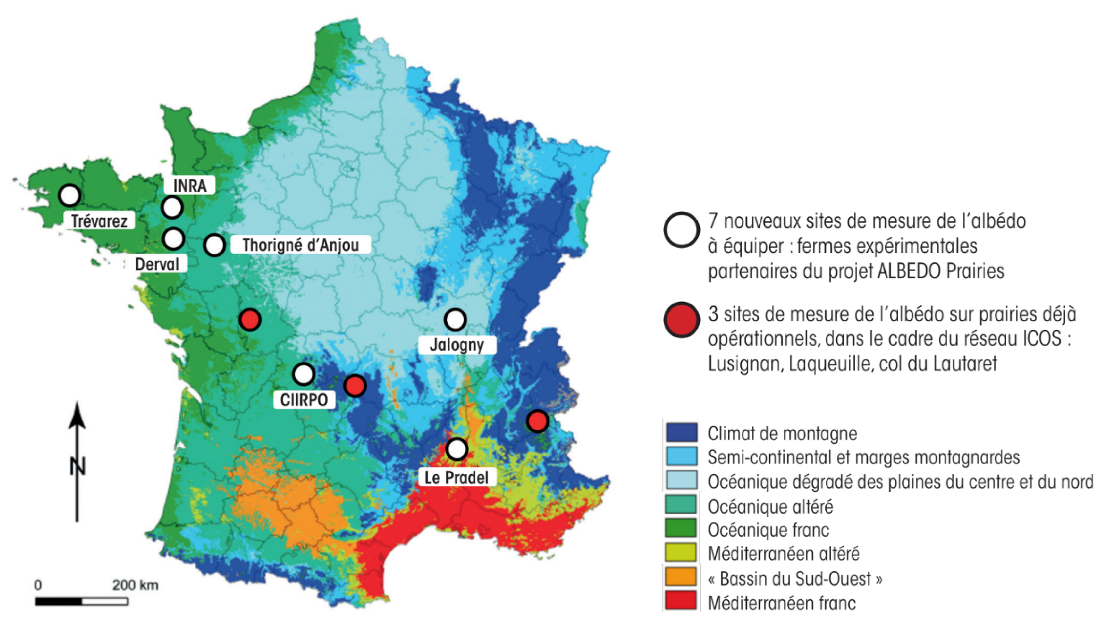


Figure 1: Map of the studied grasslands.

Figure 2: CNR4 on Derval prairie.

3. Albedo

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

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

where θ_s and θ_v are the viewing and solar zenith angles, respectively, ϕ is the relative azimuth between view and sun directions, and ρ is the measured reflectance. S2 and S3 observations are accumulated over time (composite periods of 30 days) with sliding time frame (synthesis period of 10 days). Angular integration of f_1 and f_2 leads to Directional Hemispherical Reflectance (DHR) and Bidirectional Hemispherical Reflectance (BHR). Validation relies on Blue Sky Albedo (BSA), e.g. $a = (1-\alpha)\ a_{DHR} + \alpha\ a_{BHR}$ where α if the diffuse component from MAJA aerosols.

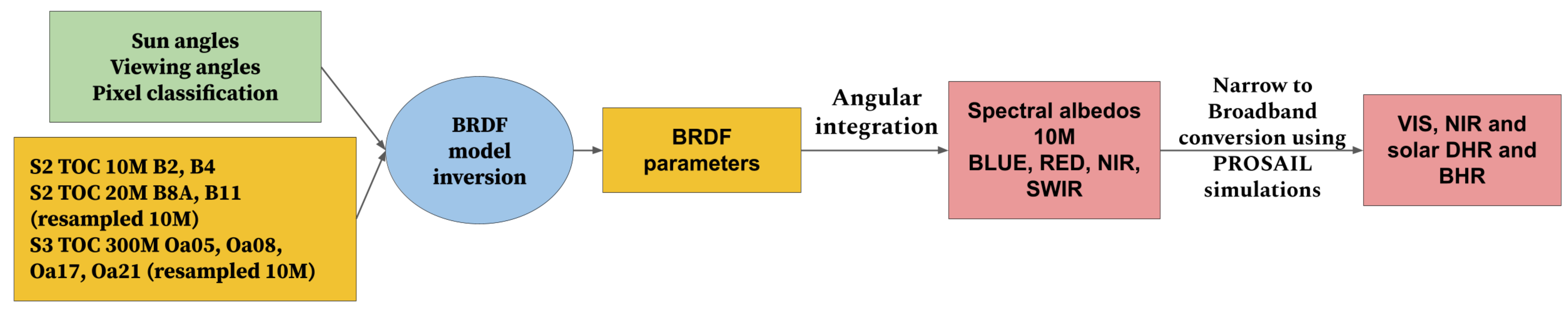


Figure 3: Flowchart of the albedo processing chain.

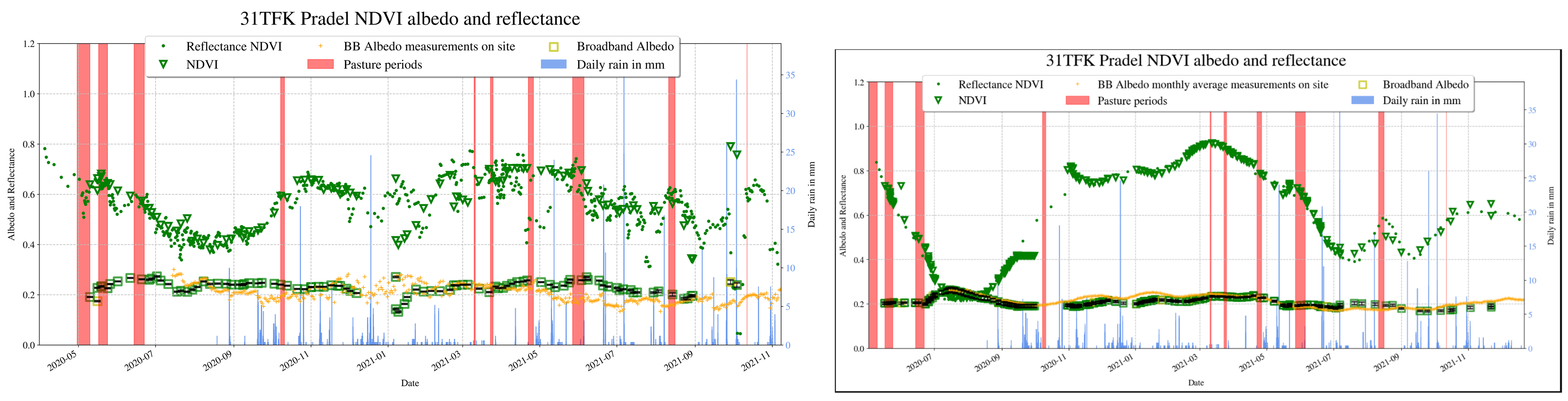
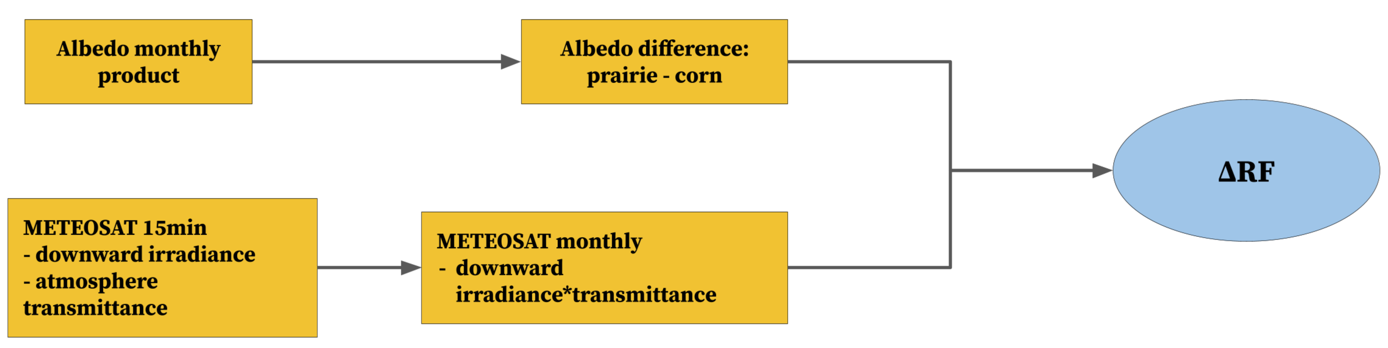


Figure 4: Time series of albedo for Pradel.

Figure 4 shows results for above method and Pradel (left) and monthly mean albedo with S2 only after a directional conversion (data extended from 15° to 75°) using PROSAIL simulations (right).

4. Radiative forcing

Monthly DSSF (clear and cloudy sky cases) are weighted by the difference of albedo Δa between prairie and corn to estimate the radiative forcing difference $\mathbf{\Delta RF}$ (Figure 5).



$$\Delta a \sum^n \frac{\int DSSF * t}{n} = \mathbf{\Delta RF}$$

n is the number of days of the month, t is the atmospheric transmittance.

Figure 5: Flowchart of the radiative forcing calculation

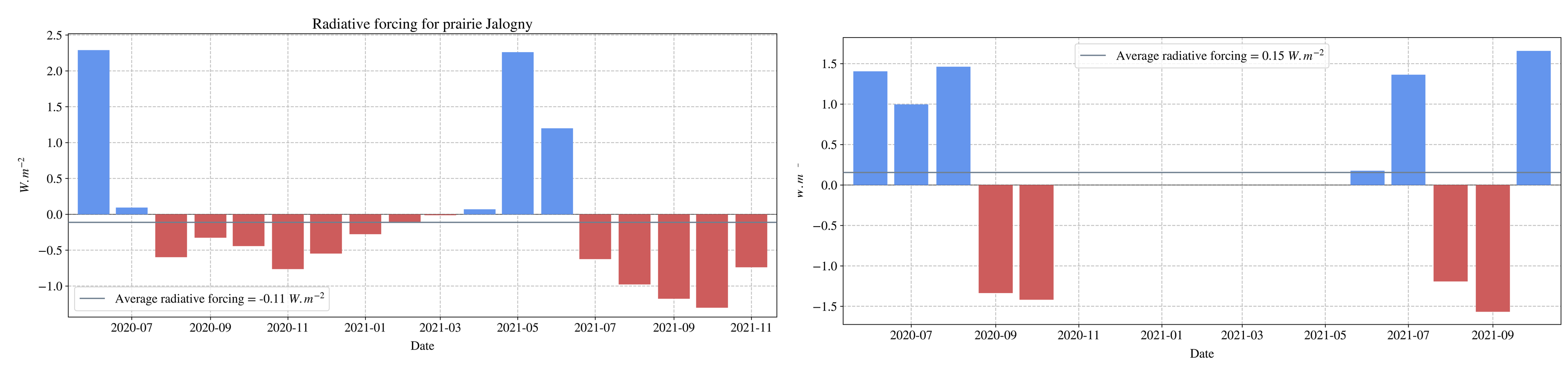


Figure 6: Radiative forcing at Jalogny (left) and Mourier (right) stations.

Figure 6 shows $\mathbf{\Delta RF}$ between prairie and corn over years at Jalogny and Mourier (CIIRPO) (Fig. 1). The prairie is more reflective at the onset but the trend is reversing when corn crop develops. Results show that there is on average no clear positive effect of the transition to prairie for livestock. This effect is highly dependent on the climatic environment and the weather of the year.

5. Conclusions and Future work

This work compares two major land units for livestock (prairie / corn). In regard to climate mitigation, a prairie does not produce a cooling effect compared to corn. But it has a longer lifespan and a solar albedo above bare soil ones. Estimate over French territory and conversion in carbon equivalence will highlight the beneficial effect of prairies for a sustainable agriculture.

6. References

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7. Acknowledgments

We would like to thank the CASDAR (Compte d'affection Spécial au Développement Agricole et Rural) program for funding the project.