RÉPUBLIQUE FRANÇAISE
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Thesis Title

"Characterization of Directional Effects in Thermal InfraRed :Preparation to the TRISHNA mission"

Objectives

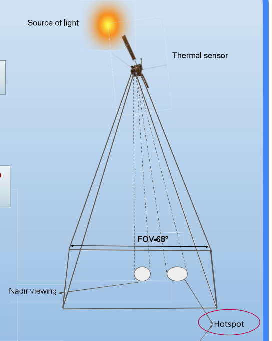
- ***Understanding of the physics behind directional effects and factors that primarily drive them***
- ***Different combinations of BRDF kernels (hot spot, emissivity) will be tested with the proper data sets***
- ***Field campaigns implemented** - Aim is to build a database of TIR BRDF for different vegetation types, also depicted by SCOPE 1D and DART 3D (mock-up in construction)*
- ***Calibration of the BRDF coefficients of parametric model with SCOPE 1D and DART 3D models***
- ***Several inversion BRDF model procedures to be tested in accounting for TRISHNA orbital pass***

Context

Pressure on water supply for irrigation !

Global scale Regional scale Plot scale	Optimized management And consumption of water	Evaporation of water from soils; Transpiration of plants; Local climate	Land Surface Temperature (LST) and its dynamics

Precision required on LST is ~1 K to detect water stress



The TRISHNA mission

(ISRO-CNES, launch in 2026 for 5 years)

Targeted objectives

- Detect and monitor water stress (design driver): optimize irrigation, manage consumption, water saving, drought, etc
- Other main topics: urban, cryosphere, coastal areas and inland waters

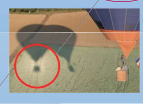
Characteristics:

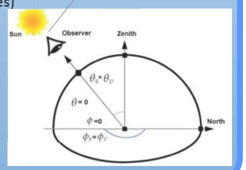
Spectral bands: 5 VNIR + 2 SWIR + 4 TIR

Temporal: revisit time (3 times / 8 days at equator and more towards the poles)

Spatial: 60 meters

Directional : wide FOV (+/-34°), 12:30 PM => **anisotropic effects expected !**





Two strategies: Correction or discard the data in the presence of directional effects?

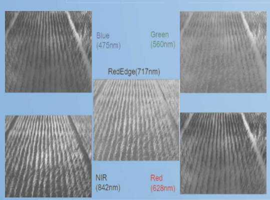
This depends if we know how to correct it and also its impact.

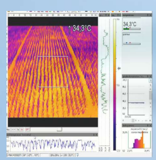
Methodology

- Meteosat - 3 km Spatial resolution, 15 minutes temporal resolution datasets provide scope for a detail study of Diurnal Temperature cycle (DTC) in directional effects.
- To cross-calibrate DART using TIRAMISU (in-situ) experiment BRDF datasets (time series of optical and thermal vegetation images) acquired over the crop growing season.
- Simulated datasets from DART-EB could a generate large BRDF continuum to do model inversions of the parametric models in consideration (KDM -Kernel Driven Models and DTC - Diurnal Temperature cycle models)
- A semi-empirical kernel-driven (KDM) model KDMs impose constraints on physical coefficients to best fit the empirical values and also computationally efficient.

In-Situ Measurements

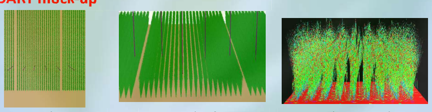
Overview of the Nawagam site





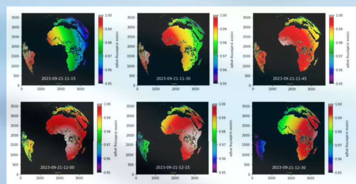
Optical and Thermal Images of rice crop

DART mock-up

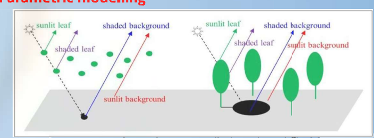


Rice crop mock-up top view — Rice crop mock-up front view — DART-EB simulation - vertical temperature profile over rice crop

MeteoSat Satellite Datasets:



Parametric modelling



Four component of vegetation scene contributing to the modelling [2]

$T(\theta_s, \theta_v, \Delta\varphi) = f_{iso} + f_{BaseShape} K_{BaseShape}(\theta_v) + f_{Hotspot} K_{Hotspot}(\theta_s, \theta_v, \Delta\varphi, \text{width})$

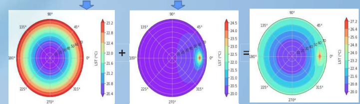
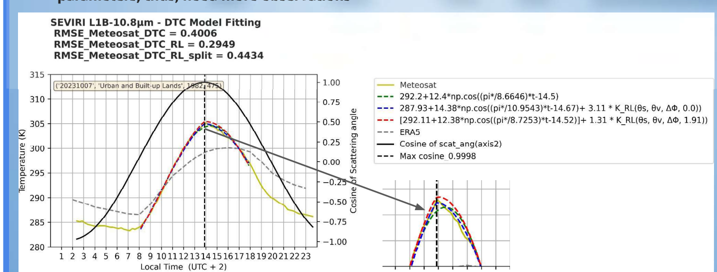


Illustration of parametric Kernel Driven Model to characterize BRDF

Results

- Hotspot conditions are tracked using scattering angle equation $\cos\xi = \cos(\theta_s).\cos(\theta_v) + \sin(\theta_s).\sin(\theta_v).\cos(\varphi_s - \varphi_v)$
- Solar peak , directional conditions, and thermal inertia are considered to completely understand thermal anisotropy.
- DTC + TRD (Thermal Radial Directionality) model's performance is better. However, **DTC +TRD has six retrieval parameters, thus, need more observations**



Meteosat thermal band 10.8 µm DTC Model fittings

Future Scope

- **Identify the existing datasets to extract a priori information needed for the model inversions to correct TRISHNA directional effects**
- **To understand directional effects at different spatial resolutions.**
- **Angular normalization techniques in Thermal Domain at TRISHNA resolution.**

References

1. Duan, S.-B., Li, Z.-L., Tang, B.-H., Wu, H., Tang, R., Bi, Y., & Zhou, G. (2014b), *https://doi.org/10.3390/rs6043247*
2. Biao Cao, Jean-Louis Roujean, Jean-Philippe Gastellu-Etchegorry, Qinhuo Liu, Yongming Du, Jean-Pierre Lagouarde, Huaguo Huang, Hua Li, Zunjian Bian, Tian Hu, Boxiong Qin, Xueting Ran, Qing Xiao (2021),*https://doi.org/10.1016/j.rse.2020.112157*
3. Roselyne Lacaze, Jean-Louis Roujean (2001), *https://doi.org/10.1016/S0034-4257(00)00193-0*

Contact : chandrika.pinnepalli@univ-tlse3.fr , jean-louis.roujean@univ-tlse3.fr , mark.irvine@inrae.fr

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