Overview of the high spatial and temporal resolutions MISTIGRI mission in the Thermal Infrared

Jean-Pierre Lagouarde, Michel Bach, Gilles Boulet, Xavier Briottet, Selma Cherchali, Isabelle Dadou, Gérard Dedieu, Olivier Hagolle, Frédéric Jacob, Françoise Nerry, et al.

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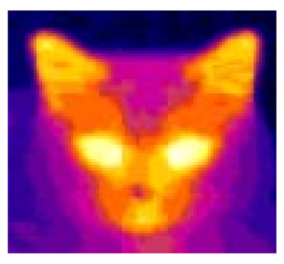
MISTIGRI



- **MISTIGRI** = **Mi**cro**S**atellite for **T**hermal **I**nfraRed **Gr**ound Surface **I**maging
- Cooperation between France (CNES) and Spain (Univ. Valencia)

- High spatial resolution (~ 50m)
- High revisit capacities (1 day)

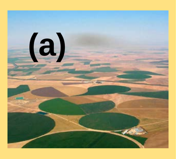
- Definition and consolidation of mission specifications during a A phase (sept 2009 - end 2011)

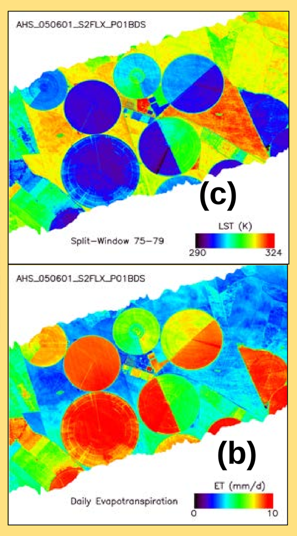
SCIENTIFIC OBJECTIVES

Monitoring of energy and water budgets of continental biosphere

- **Agriculture/forestry/natural vegetation productivity/ irrigation**
- **Biogeochemical cycles / carbon budgets / soil pollution**
- **Hydrology/ water management**

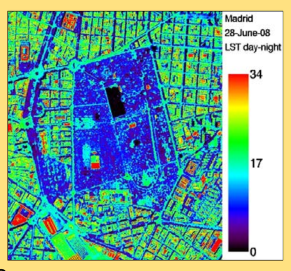
Actual evapotranspiration map (c) derived from surface temperature (b) over Barrax area (southern Spain, a)





Urban environment monitoring

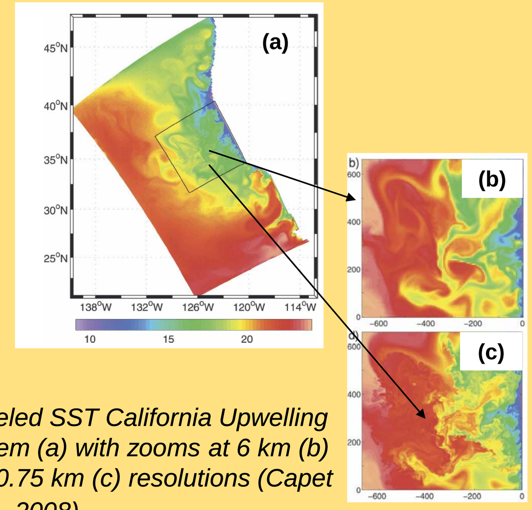
- **Urban climatology and heat waves / pollutants diffusion and air quality / anthropogenic fluxes**
- **Urban heat island (UHI) / welfare, health of inhabitants**
- **Urban hydrology**



Difference between daytime and nightime LST over the Madrid city (DESIREX, 2008) retrieved from Airborne Hypersepctral Scanner (AHS) data (Sobrino et al., 2009)

Monitoring of coastal and continental waters

- **Monitoring of the coastal areas**
- **Submesoscale activity in coastal and open ocean**
- **Monitoring of lakes and rivers / floods**
- **Air-sea fluxes, GHG, biogeochemical cycles**
- **Lagunaes / estuaries / deltas**
- **Biological activity and productivity / discharges / water quality**



Modeled SST California Upwelling System (a) with zooms at 6 km (b) and 0.75 km (c) resolutions (Capet et al., 2008)

Other applications

- **Vulcanology**
- Risk assessment, coalmine and peat fires, epidemic outbreaks…
- **... cf.** ESA Fuegosat Synthesis Study, 2010

Ref : Lagouarde et al., IJRS, 2012, in press

REMOTE SENSING CONTEXT

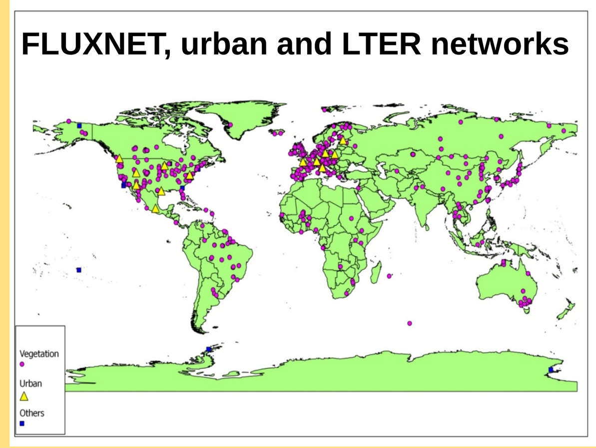
Need of a mission combining high resolution and high revisit in the TIR

Landsat TM/ETM+	16 days	60 - 120 m
LDCM	16 days	**100 m**
ASTER	16 days	90 m
Meteosat MSG, GOES	15mn	**2.5 – 5 km**
AVHRR	2-4/day	1 km
MODIS	1/day	1 km

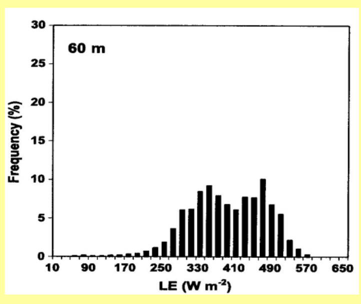
STRATEGY of the MISSION

Mission based on a network of experimental sites worldwide (similarity with Venμs strategy)

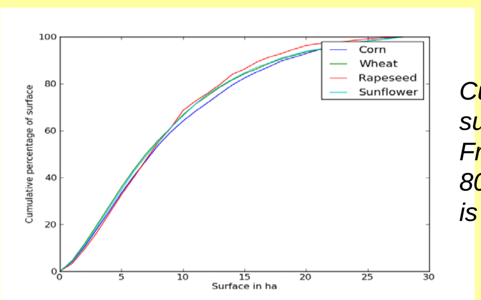
FLUXNET, urban and LTER networks



SPATIAL RESOLUTION (~ 50 m)



A 60 m resolution allows one to discriminate the contribution to actual evaporation of 2 crops in Iowa (after Kustas et al., 2004)



Cumulative histogram of plot surfaces for 4 crops, in S-W France (statistics based on 80 000 plots): 75 % of surface is made of plots > 5ha

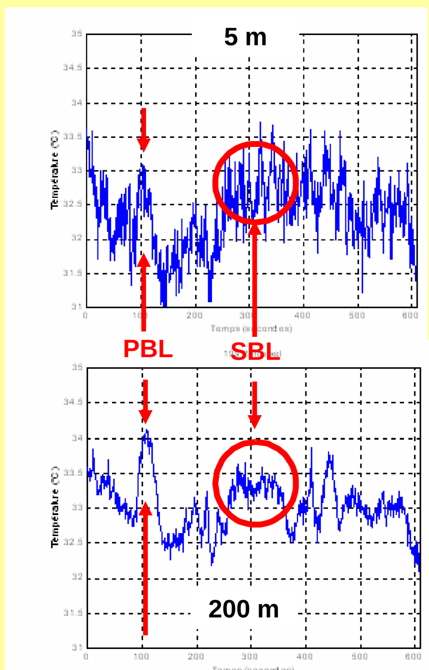
Upper limit of the resolution imposed by the **mean size of fields** to be observed

Kustas et al., 2004, Garrigues et al., 2006, Agam et al., 2007, LDCM…

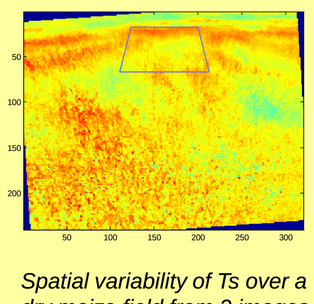
< 100m

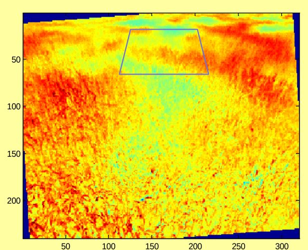
Lower limit of the resolution must cope with temporal fluctuations of surface temperature induced by surface (SBL) and planetary (PBL) boundary layers atmospheric turbulence

> 40m



Impact of PBL and SBL turbulence on temporal fluctuations of Ts (pine forest) at 5 and 200 m spatial resolutions

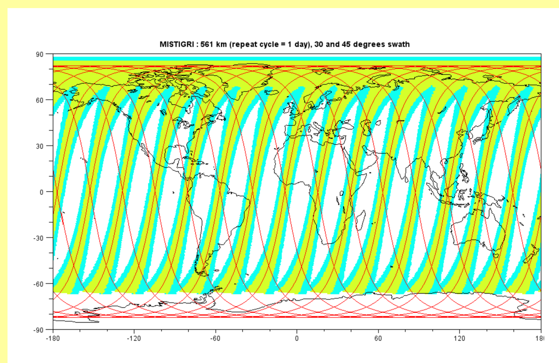




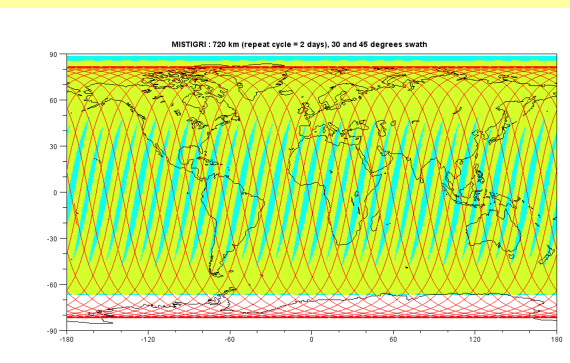
Spatial variability of Ts over a dry maize field from 2 images of a 20mn sequence at 10 Hz (the area approx. indicates a 100 m pixel)

Ref : Lagouarde et al., 2012, IGARSS Munich & Lagouarde et al., RSE submitted

ORBIT and ACCESSIBILITY



561 km, 1 day

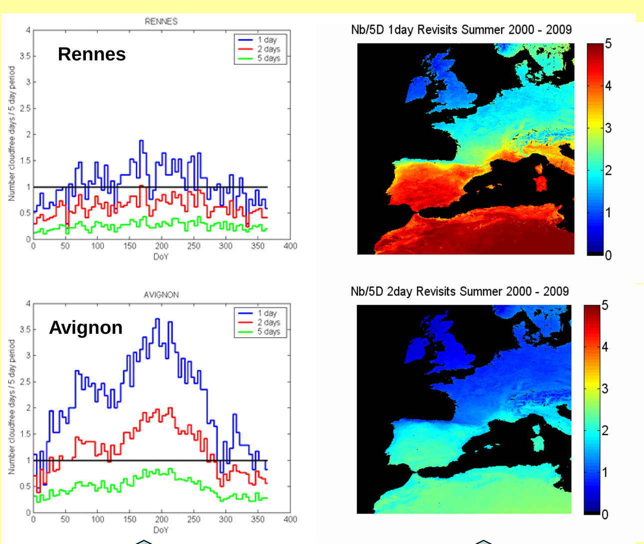


720 km, 2 days

REVISIT and OVERPASS TIME

Revisit imposed by both the temporal variability of observed processes (fluxes, drying events) and the cloudiness (data availability)

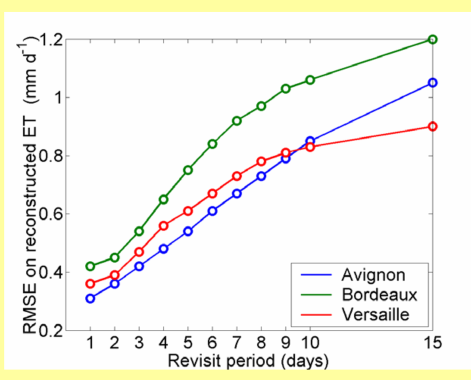
Number of cloudfree days per 5 day-periods, for different revisits



Analysis of hourly solar irradiance data from INRA AGROCLIM network 1993-2009, over 2 locations in France and for 3 revisit assumptions

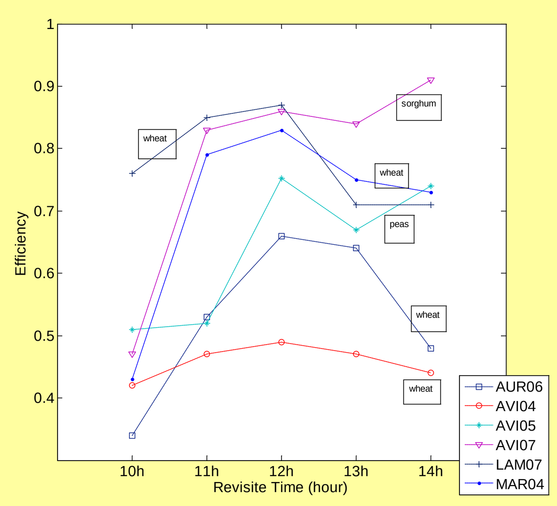
Analysis of MODIS cloud masks (2000-2009 over Europe for summer (June 1st - August 31st), for 2 revisit assumptions

Revisit also imposed by the performances and accuracy expected from models (and by frequency and duration of stress periods)



Analysis of the impact of the revisit on the accuracy of daily AET retrievals (based on a simulated dataset 1950 – 2100, A1B IPCC scenario, with a selection of cloudfree days)

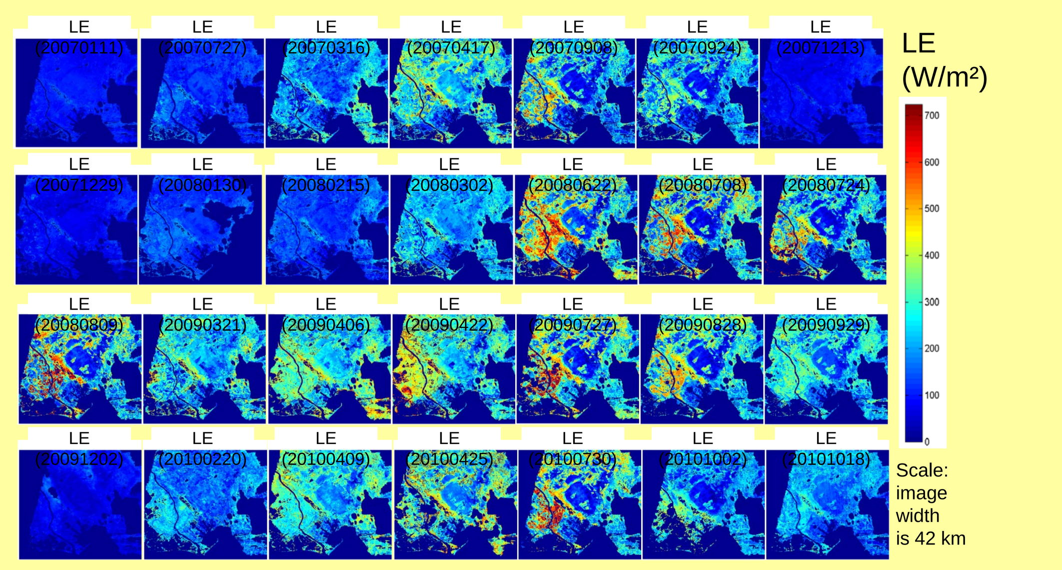
Overpass time around 12 UTC best suited for fluxes monitoring



Sensitivity of the efficiency of reconstruction of daily evapotranspiration (from simulation of AET time series) to time of acquisition (Delogu et al., 2012, Gentine, 2007)

Ref : Olioso et al., Lagouarde et al., Boulet et al., RAQRS III, 2012 Valencia; Delogu et al., HESSD 2012

DEVELOPMENT of AET ALGORITHMS



Mapping latent heat flux (LE) over Crau plain (S-E France) from LANDSAT–7 data

Ref : Olioso et al., 2012, TOSCA Conf., Paris

INSTRUMENT

Band	Central wavelength (μm)
TIR-3	10.3
TIR-4	11.5
TIR-1	8.6
TIR-2	9.1

TIR instrument :

- Uncooled ULIS microbolometer 640x480 array (25μm pitch)
- NedT 0.5K (0.2K aimed at)
- Absolute accuracy = 1K

A simulator has been built to specify channels and to evaluate accuracy of Ts derived from TES algorithm. Merging TIR1 and TIR2 for reducing noise currently investigated.

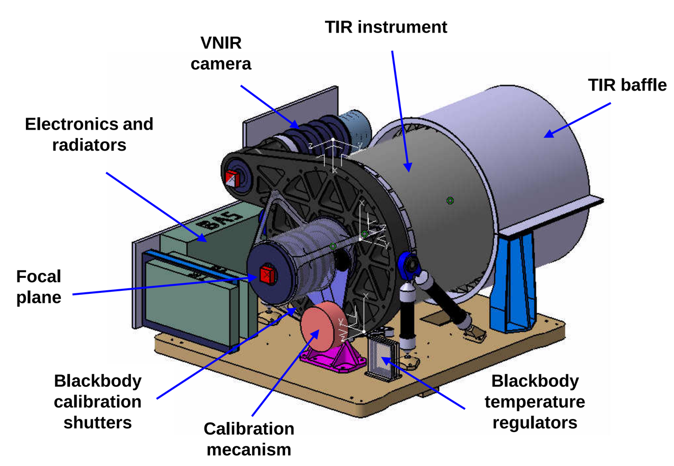
VNIR instrument:

- 1D CCD array
- 4 bands

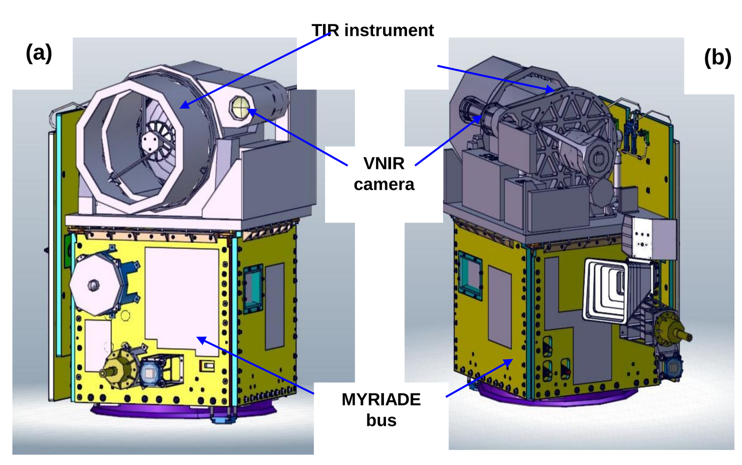
Use:
- TIR registration
- cloud detection
- vegetation indices
- surface emissivity first guess for TES
- disaggregation of TIR

Band	Central wavelength (μm)
Blue	0.450
Red	0.670
Near-InfraRed	0.865
Near-InfraRed	0.910

Ref : Lesaignoux et al., 2012, RSE submitted; Briottet, 2012, TOSCA Conf., Paris



TIR and VNIR instrumental layout



MISTIGRI satellite view (a: front, b: back) showing the VNIR-TIR instrument installed on the MYRIADE platform (in yellow)

MISSION ARCHITECTURE

Instrumental concept

- Satellite 1.5 slow down (pitch rotation of the platform)
- On-ground TDI-like binning (30 lines)
- On-board blackbodies for TIR calibration (283 and 313K)

Platform

- Compatibility of the **MYRIADE** CNES platform with the mission
- Myriade data storage 16 Gbits

Feasibility study

- Evaluation of performances of microbolometers and of the TIR instrument currently being performed at CNES
- First instrumental design proposed by TAS

Ground segment

- Already largely existing
- Venμs developments

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