Overview of the Thermal Infrared Explorer (TIREX) mission

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ABSTRACT

Increasing anthropogenic pressure and climatic change tightly interact and generate severe environmental impacts. Among them, those on water cycle, biogeochemical cycles, and vegetation development are critical, since they induce a number of feedback effects on human activities and climate. The processes are primarily governed by water and energy budgets, where Surface Temperature is a key signature. New spaceborne Surface Temperature observational techniques that provide both (i) high revisit capabilities and (ii) high spatial resolution will drive significant improvements in the modelling and monitoring of the vegetation/climate system, and in practical applications such as agriculture and water management.

The proposed Thermal InfraRed EXplorer (TIREX) mission aims to fill this gap by combining a high spatial resolution (around 50 m) with a high revisit capability (1 day) in the TIR

The first priority of the TIREX mission lies in the monitoring of the biogeochemical cycles (water and CO_2 particularly) of the continental biosphere (natural and agricultural). Practical applications deal with agriculture and forestry (water stress detection, irrigation management, yield prediction, growth monitoring, droughts and fire risks…), with hydrology (water resources management at the catchment scale, dynamics of blue and green water) and with climate change (carbon monitoring). Improvement in methodologies and related tools (model validations, assimilation design, aggregation schemes) are also expected. A second mission objective focuses on the urban environments, in response to important societal demands, with applications such as urban heat islands and urban microclimates, impact of heat waves, energy consumption, atmospheric boundary layer dynamics and diffusion of pollutants. A third mission objective deals with applications in coastal and water continental areas, key regions to monitor anthropic effects on climate change, pollutants, halieutic resources, etc.

The TIREX mission has a clear "Explorer" nature, as it represents a fully innovative way of addressing the monitoring of surface energy and mass fluxes at global scale from Surface Temerature data, by providing new spaceborne information at the proposed spatial and temporal resolutions.

CONTEXT AND OBJECTIVES

SCIENTIFIC CONTEXT

Global Change as a result from the conjunction of cllimate change and environmental modifications induced by human activities

The surface temperature is a key signature of the surface energy budgets; it can be directly related to the surface energy fluxes, and particularly to the latent heat flux (evapo-transpiration).

Researchers and users have to face a dilemma between spatial and temporal resolutions: systems providing daily observations at low resolution or systems providing high resolution images with poor revisit capabilities.

SCIENTIFIC OBJECTIVES for TIREX

The TIREX mission requirements have been driven by the applications dedicated to the monitoring of energy and water budgets of the continental biosphere.

Agriculture and hydrology: water management (Figure 1)
- Agriculture and natural vegetation productivity
- Biochemical cycles and soil pollution
- Hydrology
- Irrigation

Monitoring the urban environment (Figure 2)
- Urban climatology
- Heat waves
- Urban fluxes

Coastal and continental waters (Figure 3)
- Coastal applications

→ Sea surface tempertaure (SST), air-sea fluxes and winds
→ Submesoscale activity in coastal and open ocean
→ Monitoring of the coastal ocean
- Continental waters (lakes and rivers)

→ Evaporation for lakes, flood plains, monitoring of floods
→ Monitoring of lakes and rivers

Other applications
- Volcanology, Earthquakes, Coalmine fires, Diseases, Security and surveillance

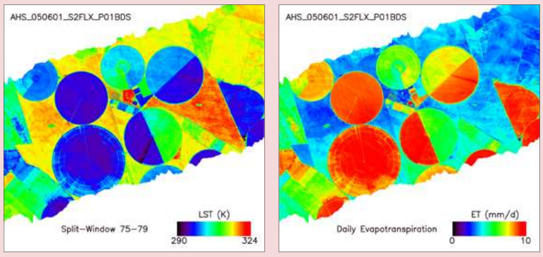


Figure 1: Land Surface Temperature (LST) and daily Evapo-Transpiration (ET) retrieved from Airborne Hypersepctral Scanner (AHS) data over the Barrax agricultural area n the framework of the Sen2flex-2005 campaign.

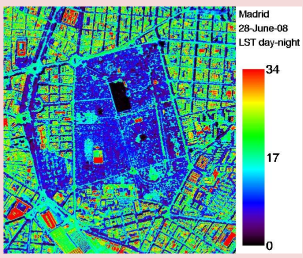


Figure 2: Difference between LST at day and LST at night over the Madrid city (DESIREX-2008) retrieved from AHS data

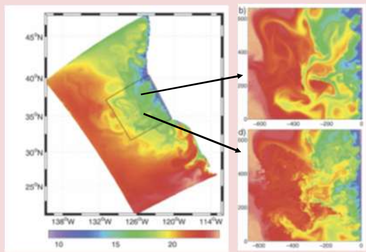


Figure 3: Modelled Sea Surface Temperature (SST) fields in the California Upwelling System at T=30 days over a large area (left) and over a zoom (black box) with a horizontal resolution of 6 km (right, top), 0.75 km (right, bottom).

MISSION CONCEPT

OVERPASS AND REVISIT TIME: daily observations

SPATIAL RESOLUTION: 50 meters

FIELD OF VIEW: greater than 25 km

BANDS CONFIGURATION: multiespectral TIR + VNIR

VIEW ANGLE: constant (<35º)

PERFORMANCES

Radiometric noise: 0.3 K @290K
Absolute calibration: <1K
Multitemporal-registration: <0.3 pixel

Band name	Central wavelength (nm)	Bandwidth (nm)
VIS 1	450	40
VIS 2	670	40
VIS 3	865	40
VIS 4	910	20

Band name	Central Wavelength (µm)	Band width (µm)
TIR 1	8.9	0.5-1
TIR 2	10.6	0.5-1
TIR 3	12.0	0.5-1

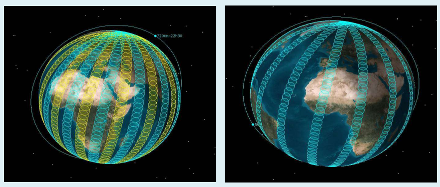
MISSION ARCHITECTURE

Technical baseline: technical studies and trade-off performed by CNES with the support of the French company TAS Cannes for the Payload concept during the MISTIGRI mission phase 0.

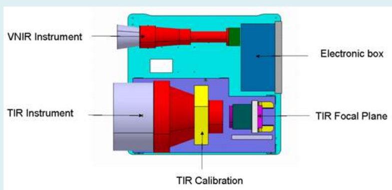
TIR camera: "off the shelf" ULIS microbolometer.

System based on two satellites on a 2 days repeat cycle orbit at an altitude of 720 km. One day revisit is provided by the tow satellites placed in opposite way on the same orbit.

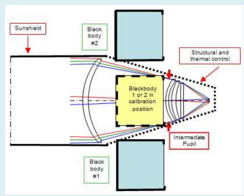
Observation scenario:
- To observe sites (25 km × 25 km) or contiguous transects up to 700 km long (day or night time).
- To observe up to 145 sites on the day and night time of the same orbit.
- The number of potential sites comes up to an amount of about 1200 sites observable every day.



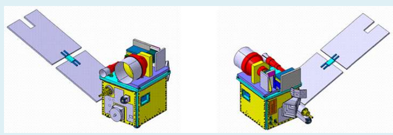
Coverage capacity for an altitude of 720 km (left) and an altitude of 560 km (right)



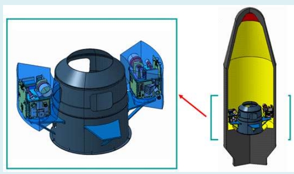
CAD view of the instrument



Calibration system diagram



CAD view of the preliminary in orbit satellite configuration



TIREX satellite in SOYUZ ASAP launch configuration