10-12 MAY 2023 ESA-ESRIN

INTERNATIONAL WORKSHOP ON HIGH-RESOLUTION THERMAL EO

TRISHNA

Towards daily evapotranspiration from remote sensing thermal data

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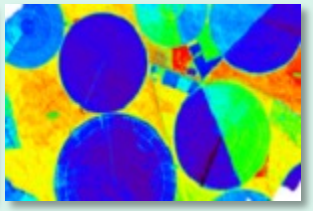
[1]CNES, France; [2]CESBIO, France; [3]IRD, France; [4]INRAE, France; [5]SAC/ISRO, India

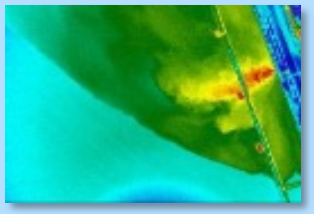
TRISHNA Science & applications

Water mgmt, agriculture

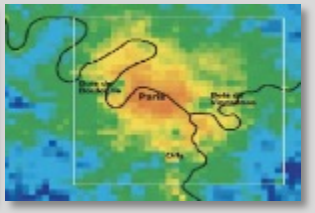
Ecosystem health, drought, fire


Coastal and inland waters



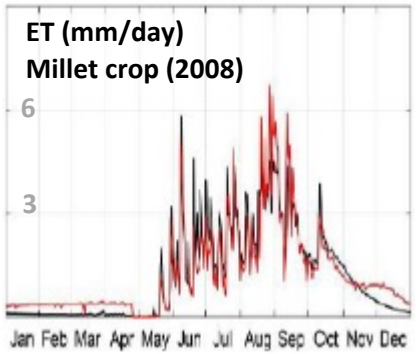

Cryosphere


Urban heat

Solid Earth


Science



Drought episodes

⬇

Impact at soil-plant-atm interface

⬇

Surface temperature **& its dynamics**

Continuity & density of time series

Applications

Rapidly changing processes + Severe potential impacts

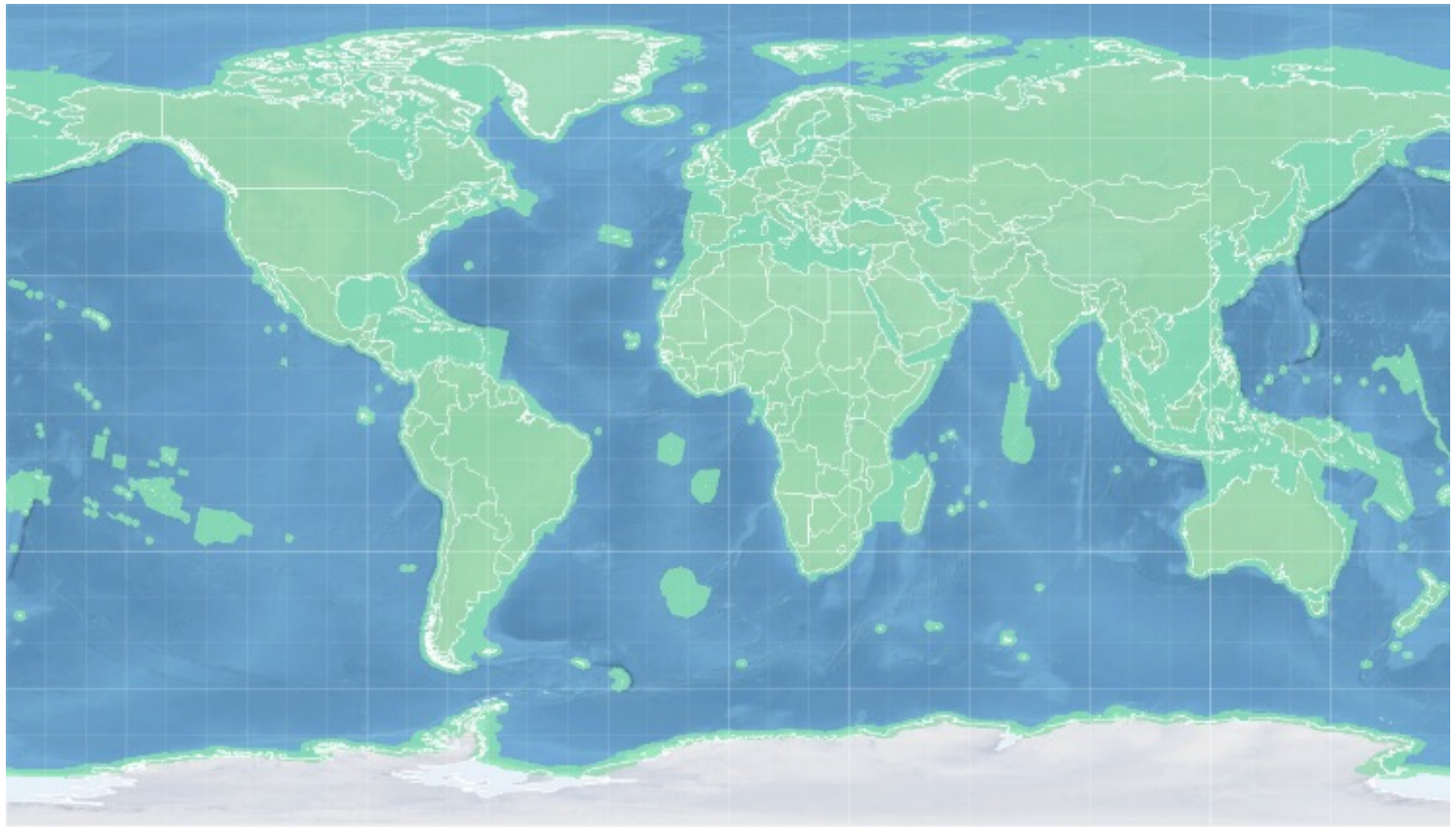
⬇ ⬇

Quick decision-making needed

- Land Surface Temperature
- Vegetation status
- Land Surface Energy Balance
- Evapotranspiration from vegetation

- ✓ **High-repeat**
- ✓ **Field-scale**
- ✓ **Global**
- ✓ **Thermal**
- ✓ **Solar**
- ✓ **Low latency**

TRISHNA - Acquisition mask



Acquisition mask (resolution 60m) :

- ✓ Continental surfaces
- ✓ Coastal areas 100km from the coastline
- ✓ Coastal waters with bathymetry < 250m
- ✓ Closed seas + Mediterranean Sea
- ✓ Antarctica coastline

TRISHNA Spectral bands and products

Spectral bands

	Band name	Wavelength Center (µm)	Bandwidth (nm)	Purpose
DAY-TIME	Blue	0.485	70	Detection of low clouds
	Green	0.555	70	Coastal, sediments, snow
	Red	0.670	60	Vegetation (LAI, fCOVER, NDVI, …)
	NIR	0.860	40	Vegetation (LAI, fCOVER, NDVI, …)
	WV	0.910	30	Water vapour content estimation
	Cirrus	1.380	30	Detection of thin cirrus clouds
	SWIR	1.610	100	AOD, snow/cloud discrimination, vegetation stress, burnt areas
DAY-TIME NIGHT-TIME	TIR 1	8.65	350	Temperature/emissivity separation
	TIR 2	9.0	350	Temperature/emissivity separation
	TIR 3	10.6	700	Split-window
	TIR 4	11.6	1000	Split-window

Distributed Products

Level 1C

- ✓ TOA reflectances x7 VNIR/SWIR bands
- ✓ TOA radiances x4 LWIR bands
- ✓ Cloud mask

Radiometrically and geometrically calibrated
Orthorectified and resampled on a uniform spatial grid (Sentinel-2 tiles, Copernicus DEM)

Level 2A

- ✓ Surface reflectances x5 VNIR/SWIR bands
- ✓ LST, SST
- ✓ LSE x4 bands
- ✓ Cloud mask, TWVC, AOT

Level 2B

- ✓ Vegetation variables, albedo
- ✓ Evapotranspiration and vegetation stress

Level 3

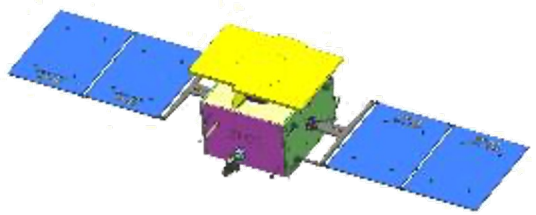
- ✓ Time series of daily evapotranspiration

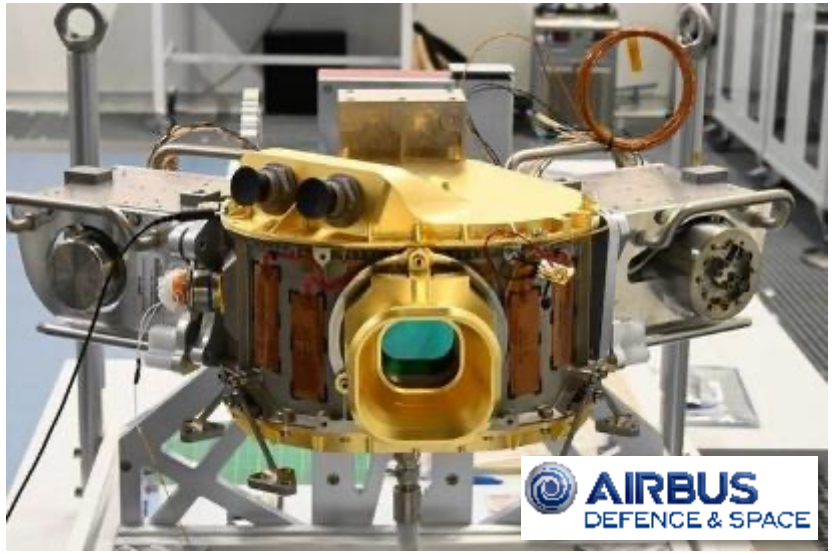
TRISHNA Mission Design

TRISHNA Project status: updates

- TRISHNA mission approval by ISRO: January 2023
- **Mean Local Time at Descending Node: 12:30 PM +/- 5mn**
- On-going series of technical face-to-face meetings:
  - bus/instrument interfaces
  - ATBDs
- TIR instrument: Critical Design Review planned end of 2023
- System Interfaces Performance & Validation Review: Q3 2023

LSTM
SBG
TRISHNA





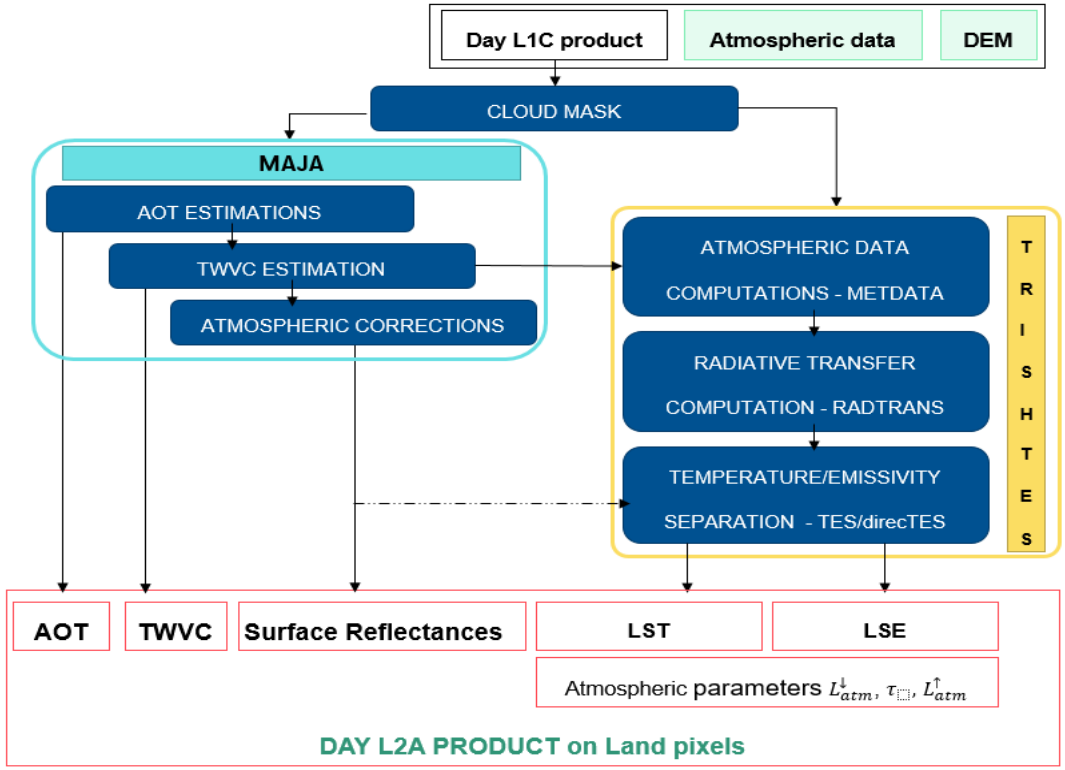
Cryostat (Engineering Model, not sealed)

TRISHNA L2 processings & associated CAL/VAL

Emilie Delogu, CNES
Thomas Vidal, ACRI-ST
Sébastien Marcq, CNES
Vincent Rivalland, CESBIO

Surface temperature & emissivity retrieval: comparison of algorithms (Poster 112)
Mathematical review of TES for operational use (Poster 172)
New instrumented site for futur thermal missions (Oral 166)
IR emiss. estim. from VIS-NIR refl. by neural network compair to TES (Oral 168)

***LaCrau* RADCALNET station + meteo & surface fluxes**



L2A processing flowchart during daylight over land
Dedicated processings are foreseen for day/night/land/water

Work overview of the TRISHNA ecosystem stress team (1/2)

Team leader: Gilles Boulet, IRD / CESBIO

ATBD

L2 (day of acquisition) and L3 (daily values on a running window) ET based on 3 main tools:

- **EVASPA**: contextual Energy Budget ensemble platform (Albert Olioso, oral 250)
- **STIC**: single pixel Energy Budget model (Kaniska Mallick, oral 108)
- **SimpKcET**: simple Water Budget model forced by meteo., soil (available water) and Remote Sensing data, for interpolation and flagging of EVASPA (Gilles Boulet, poster 201)

CAL/VAL

Network of EC towers with TIR cameras / directionality issue tackled (Sam Mwangi, Gilles Boulet, poster 199); ET product intercomparison (Jordi Etchanchu, poster 189)

Hydrology

Assimilation of ET (TIR) into hydrological models

Forest

Assesment of contextual models over mediterranean forests for fire risk assesment (Victor Penot, poster 125)

Work overview of the TRISHNA ecosystem stress team (2/2)

Team leader: Gilles Boulet, IRD / CESBIO

Malegaon vineyard site
Maharashtra (2021-)

Bowen ratio tower
Karnataka (2023-)

H_2O/CO_2 flux partitioning

µlysimeters

Current issues

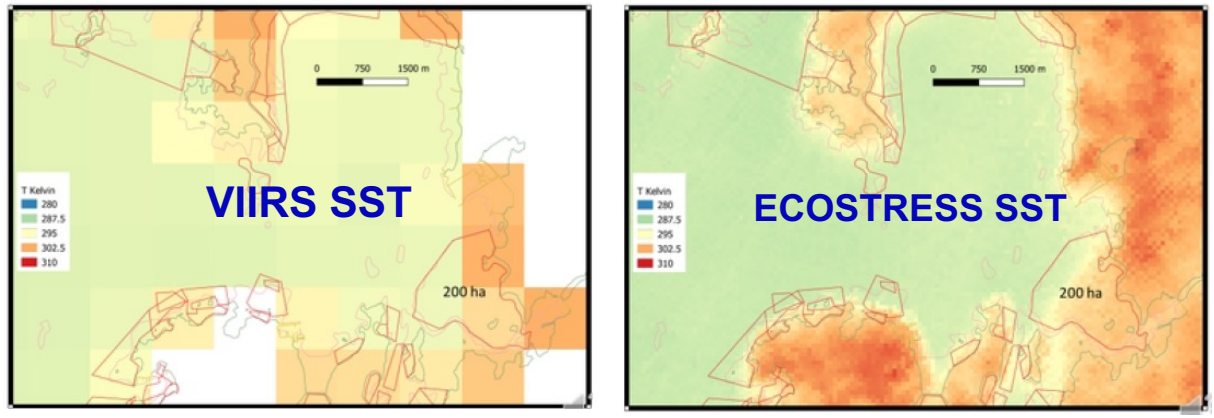
- heterogeneity in LST/refl. in a given scene, key assumption for EVASPA contextual model
  - Statistical analyis to estimate uncertainties (Nesrine Farhani, poster 212)
  - Use of Water Balance (SimpKcET) model as a benchmark to test the relevance of the dry edge
- ET in mountains

Work overview of the TRISHNA Coastal & inland waters team

Team leader: Emmanuelle Autret, IFREMER

Introducing the ISRO-CNES TRISHNA mission for high resolution SST obs. in coastal ocean and continental waters (poster 223)

Intertidal shellfish beds
Galicia, NW Spain



← *From GHRSST 2021 meeting presentation: SST at 70-m scale from ECOSTRESS on the Space Station: Application to Complex coasts and Intertidal Flats (David S Wethey, Nicolás F Weidberg, Sarah A Woodin)*

Eléa Paul, IFREMER — TRISHNA in coastal ocean: building a ref. validation algorithm calibration dataset (poster 224)

Laura Orgambide, IFREMER — Designing new ultra high res. coastal SST products for TRISHNA (oral 222)

Coast HF station

Saildrone

ECOSCOPA station

Waverider buoy

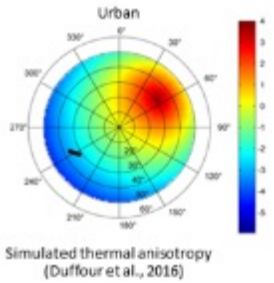
Work overview of the TRISHNA urban team

Team leader: Laure Roupioz, ONERA

Improving urban LST/LSE

➔ Generate LST and LSE estimations accounting for urban surface impacts

- TES adapted to urban environment *(Michel et al. 2021)*
- Investigation of 3D impact and directional effects



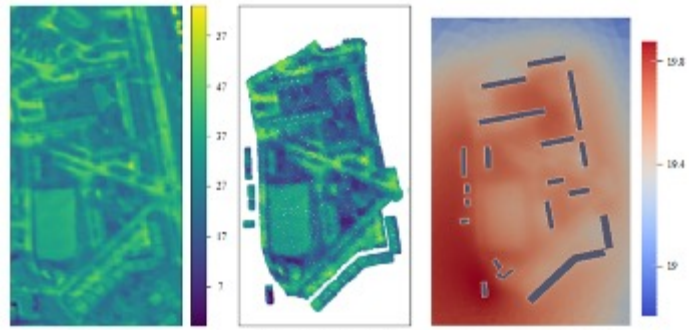
Simulated thermal anisotropy (Duffour et al., 2016)

➔ DART-SOLENE chaining (Oral presentation 131: Roupioz et al. 11/05 16h55)

Air temperature estimation

➔ How to move from a LST to air temperature distributions?

Development of an approach to integrate TIR in an urban microclimate model *(Bouyer et al. 2022, Rodler et al. TRISHNA days 2022)*

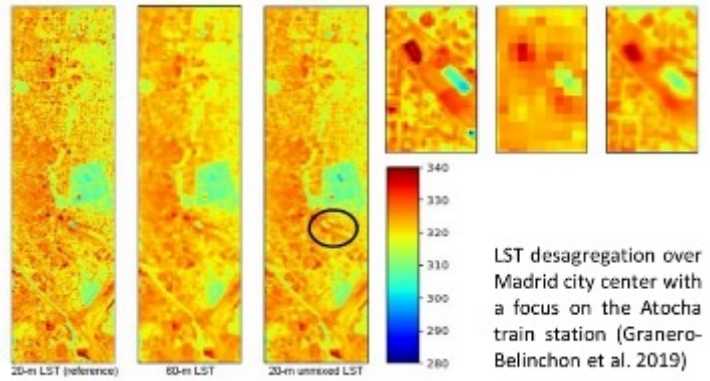

Land Surface Temperature (°C) | LST integration in Solene-MC | Air temperature (°C)

LST disaggregation

➔ How to improve LST maps spatial resolution?

Good results from 60 to 20m with regression methods but limitations at higher scale *(Granero-Belinchon et al., 2019, Michel et al. TRISHNA days 2022)*

Also testing AI approaches


LST desagregation over Madrid city center with a focus on the Atocha train station (Granero-Belinchon et al. 2019)

+ CAMCATT 2021 field experiment

(Posters 226 & 227, 10/05 18h)

RÉPUBLIQUE FRANÇAISE

ONERA THE FRENCH AEROSPACE LAB

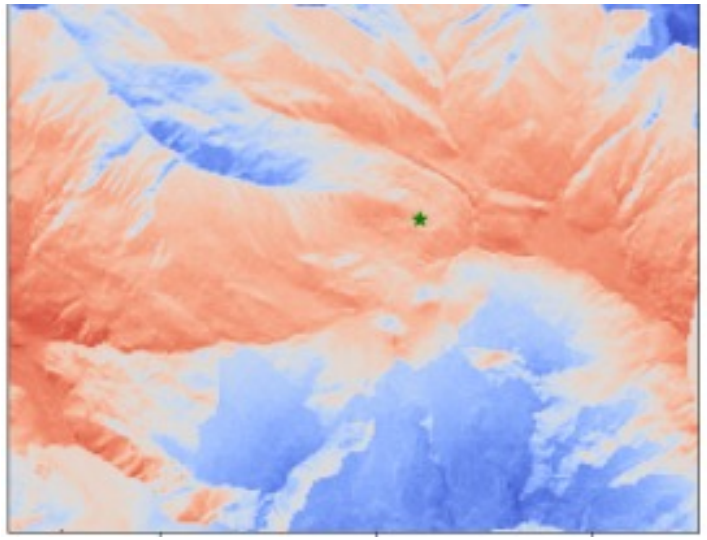
Work overview of the TRISHNA Cryosphere team

Team leader: Ghislain Picard, univ. Of Grenoble Alpes

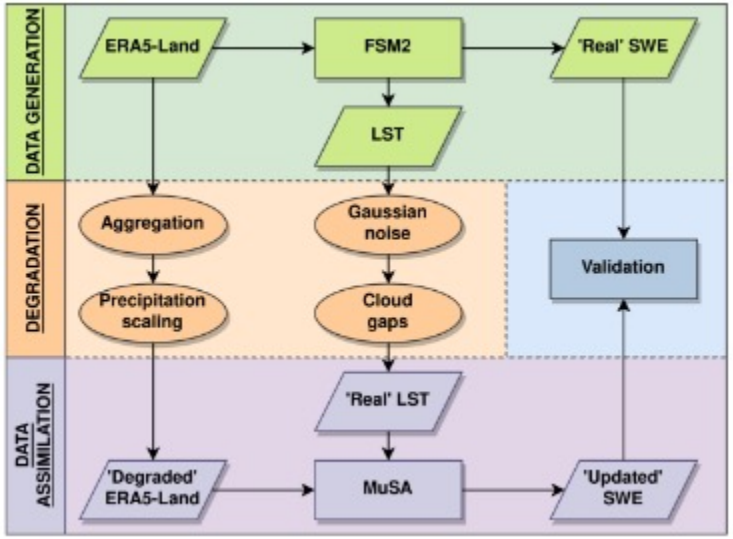
Sara Arioli, IGE	Towards a better understanding of snow surf. temp. variability in mountain regions (oral 205)
Ghislain Picard, IGE	Modeling surface temperature of snow-covered mountaineous areas at spatial resolution of TRISHNA, SBG & LSTM (poster 258)
Alexei Kouraev, CESBIO	Water dynamics and ice cover in Eurasian lakes from multi-satellite and in situ obs. (poster 170)

Observation

Modeling



Data assimilation



From Arioli et al., International workshop on High-res thermal EO – ESRIN, 10-12 May 2023

TRISHNA Scientific products and processings

Points of attention:

- ❖ Dealing with thermal infrared signal: directional anisotropy — Julien Michel, oral 142
- ❖ Image by image data products → time series
- ❖ Continuous time series of daily evapotranspiration
- ❖ Timeliness
- ❖ « Side variables » are a crucial part of the performance: albedo, downward fluxes
- ❖ Inter-operability
- ❖ Data volume !!

Meet the TRISHNA team in the workshop

Bimal K. Bhattacharya, SAC / ISRO
TRISHNA P.I.
Vegetation, evapotranspiration

Jean-Louis Roujean, CNRS / CESBIO
TRISHNA P.I.
Directional anisotropy

Philippe Gamet, CNES / CESBIO
TRISHNA Project scientist

Gilles Boulet, IRD / CESBIO
TRISHNA Ecosystem stress team leader
Hydrology, evapotranspiration

Laure Roupioz, ONERA
TRISHNA Urban monitoring team leader

Philippe Maisongrande, CNES
CNES Land program manager

Albert Olioso, INRAE
Ecosystem stress, forest

Emmanuelle AUTRET, IFREMER
TRISHNA Coastal and inland waters team leader

Corinne Salcedo, CNES
TRISHNA System manager

Kaniska Mallick, LIST
Assimilation of LST

Ghislain Picard, IGE
Cryosphere team leader
Snow in the polar regions

Delphine Leroux, CNES
Downstream applications

Sébastien Marcq, CNES
TRISHNA Mission performance

Mark Irvine, INRAE
TRISHNA CAL/VAL

Emilie Delogu, CNES
TRISHNA level 2 processings

And also: Vincent Rivalland, Kathrin Naegeli, Alexei Kouraev, Jennifer Adams, Sara Arioli, Nesrine Fahrani, Elea Paul, Laura Orgambide, Thomas Vidal, Julien Michel

THANK YOU FOR YOUR ATTENTION

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TRISHNA Project Scientist