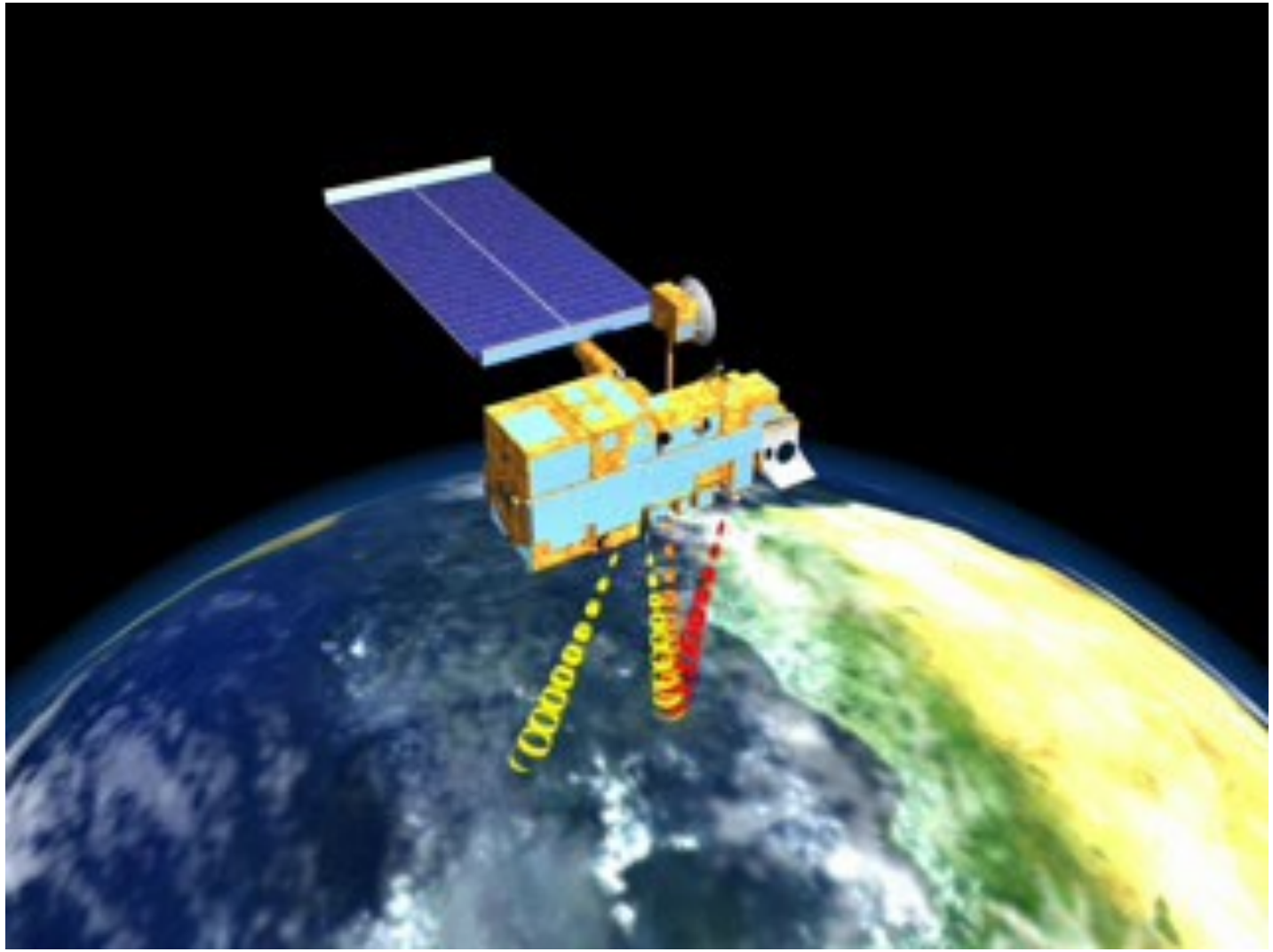
Remote Sensing for Healthy Urban Systems

CIVIS BIP Healthy Urban Systems HUb4

Prof. Sébastien Gadal

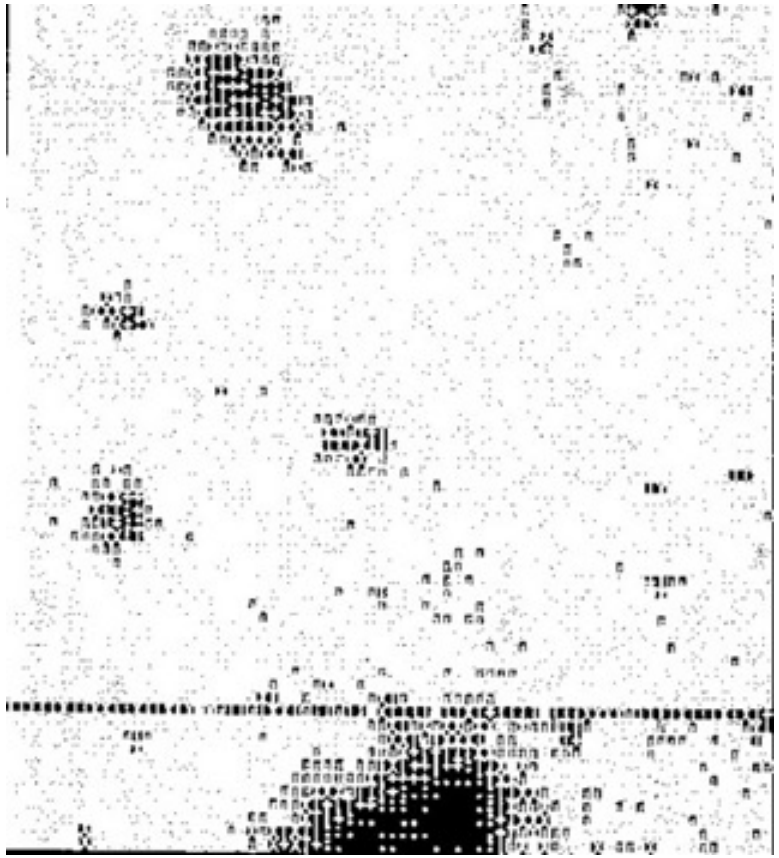
Aix-Marseille Univ., CNRS, ESPACE UMR 7300, Univ., Nice Sophia Antipolis, Avignon Univ., 13545 Aix-en-Provence, France
sebastien.gadal@univ-amu.fr

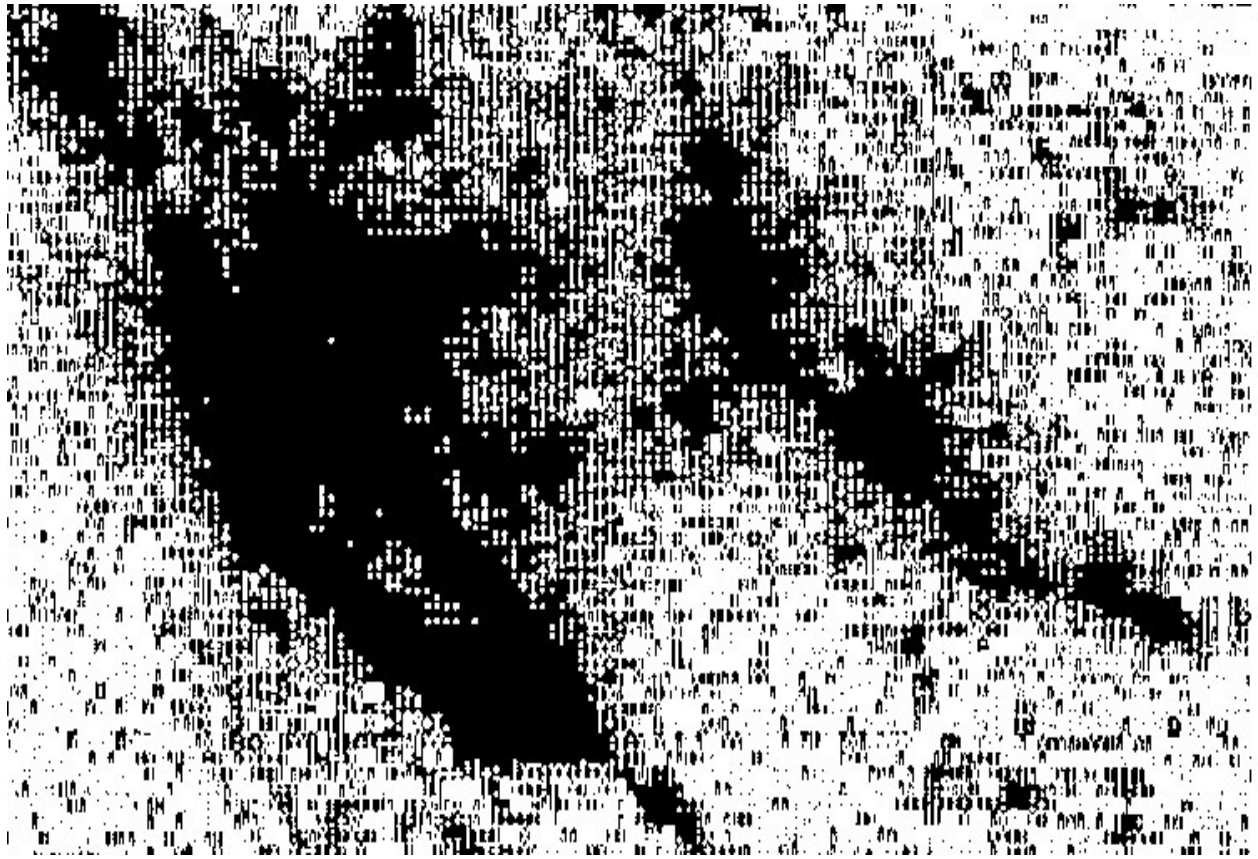
What Remote Sensing is?



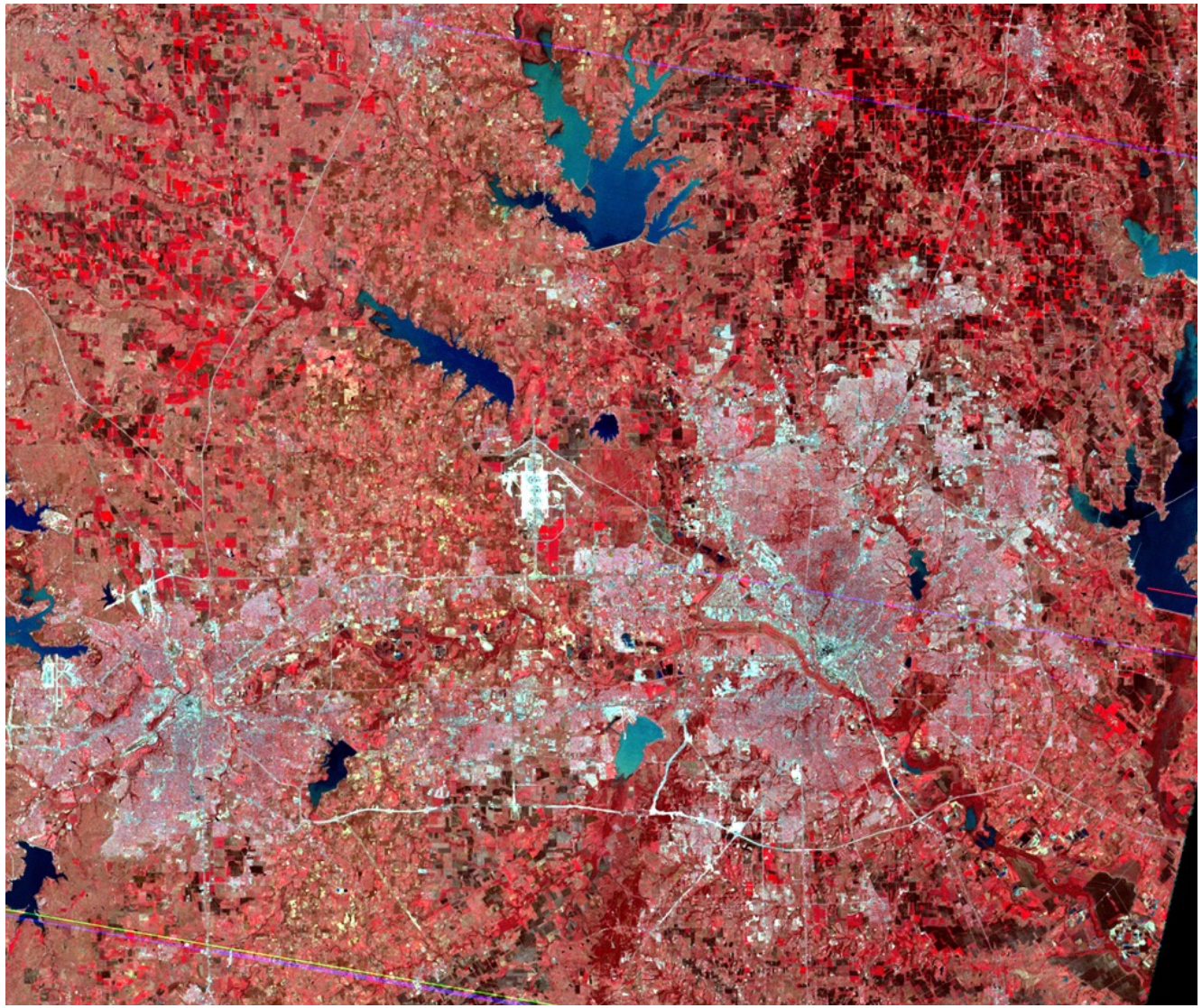
What Remote Sensing is?

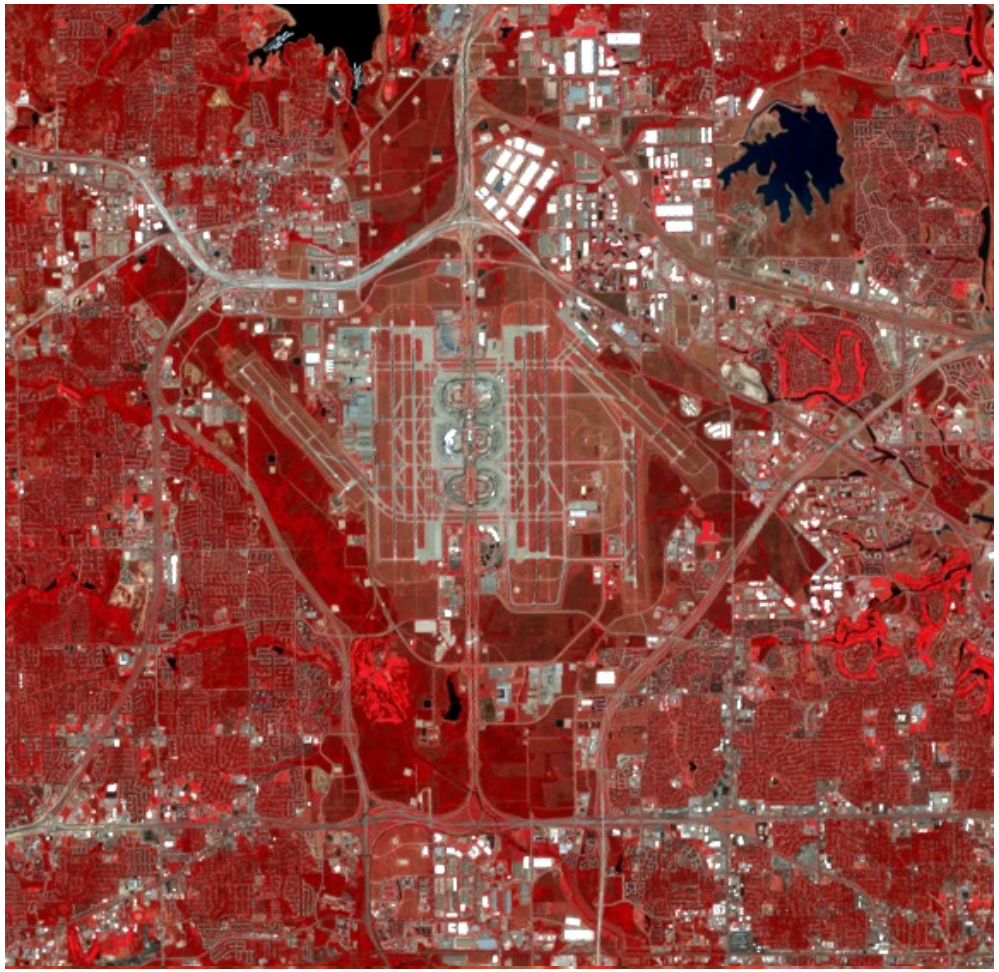
1974: appearance of the first civilian and military digital images (Landsat 1 MSS) (DMSP)First DMSP images used for reconnaissance of North American metropolises (1974).





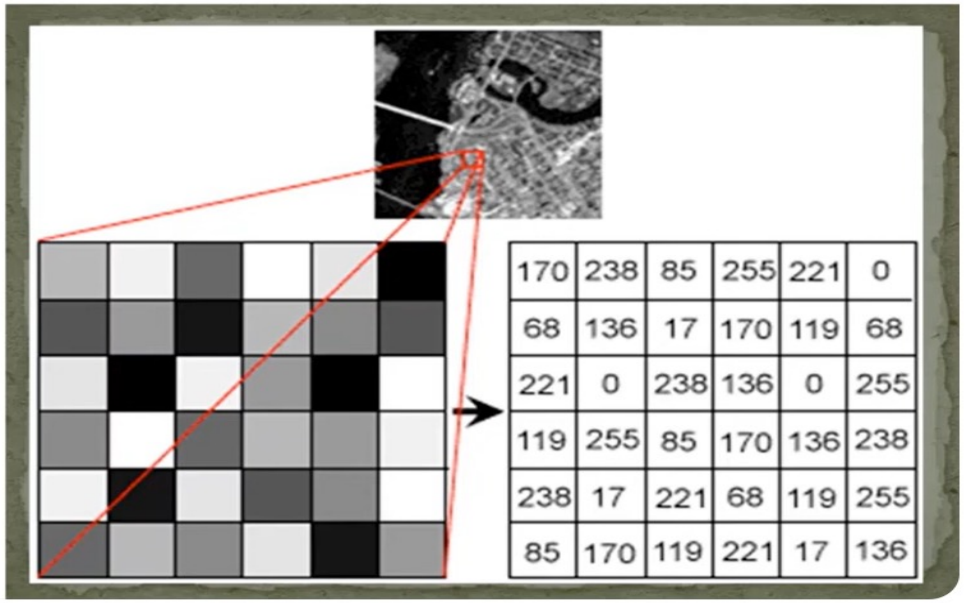
What Remote Sensing is?





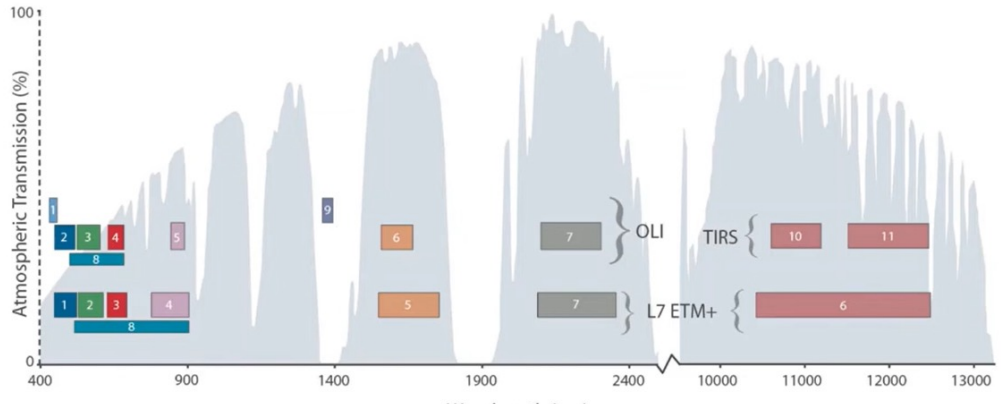
First Landsat 1 MSS image March 12, 1974 (color composition), Dallas airportMarch 12, 1974 (color composite), Dallas August 31, 2013 (color composite, Dallas airport

What Remote Sensing is?

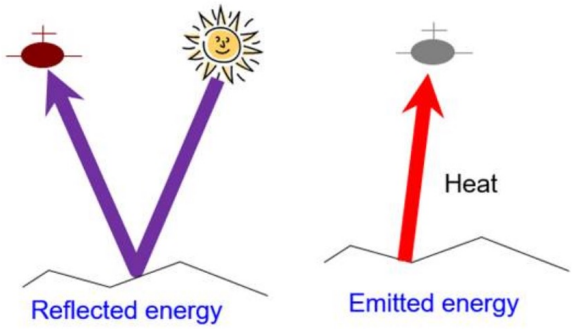


Multispectral remote sensing

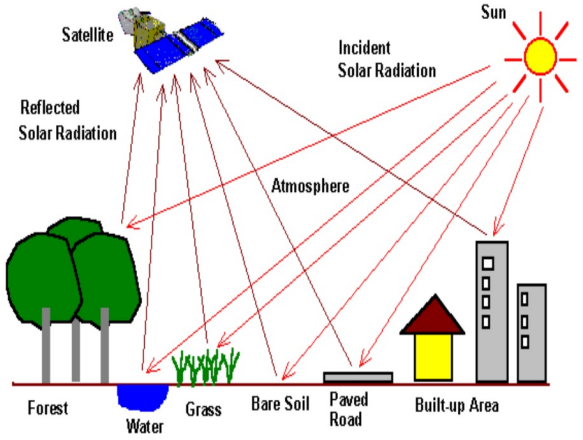
	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

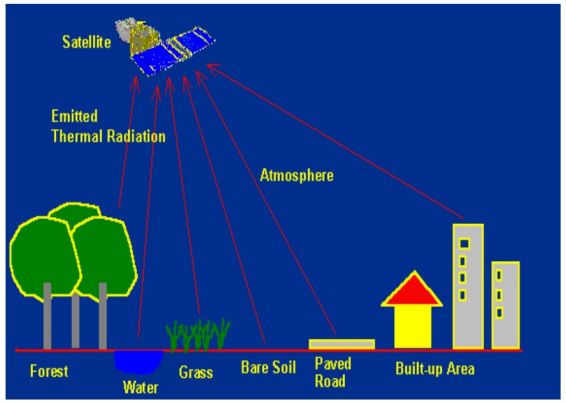


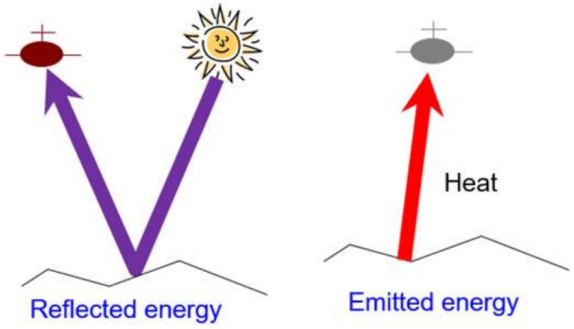
6

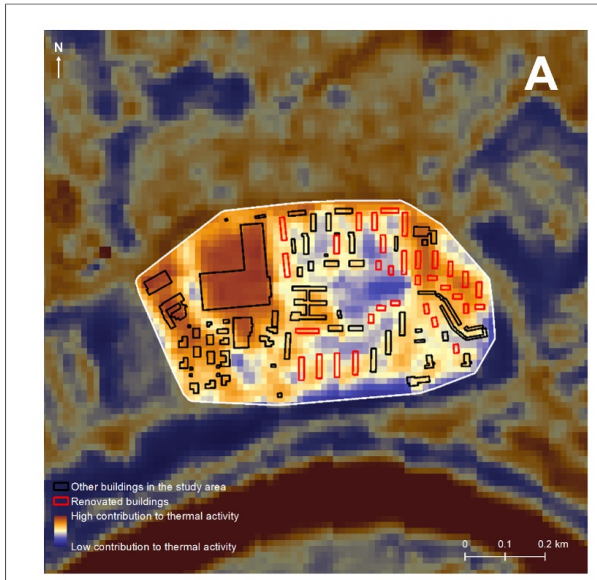


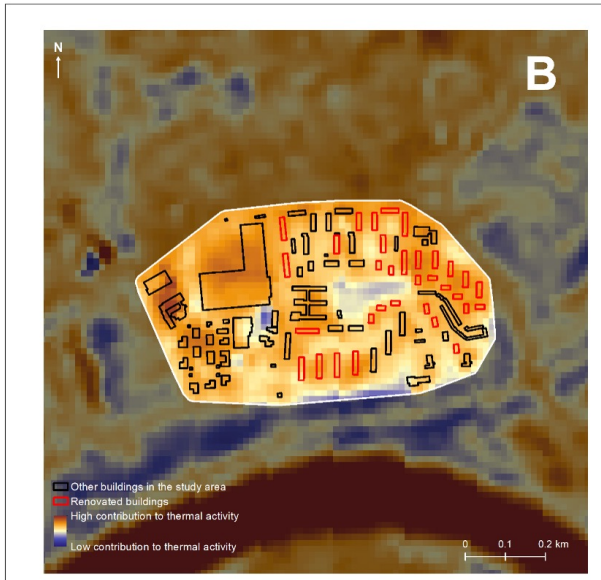
What Thermal Remote Sensing is?

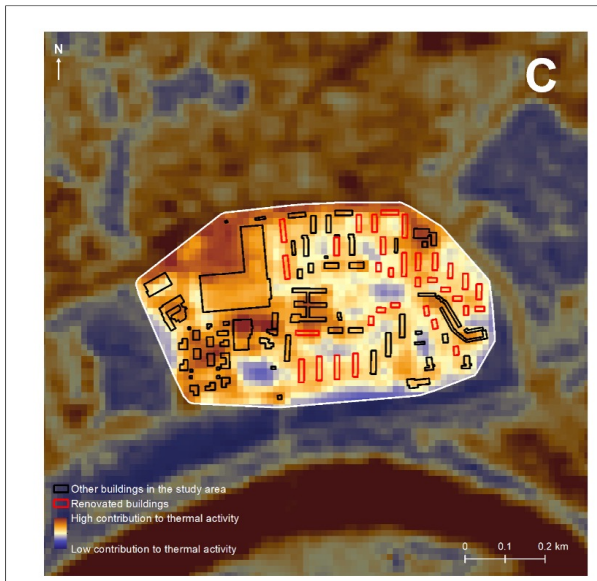


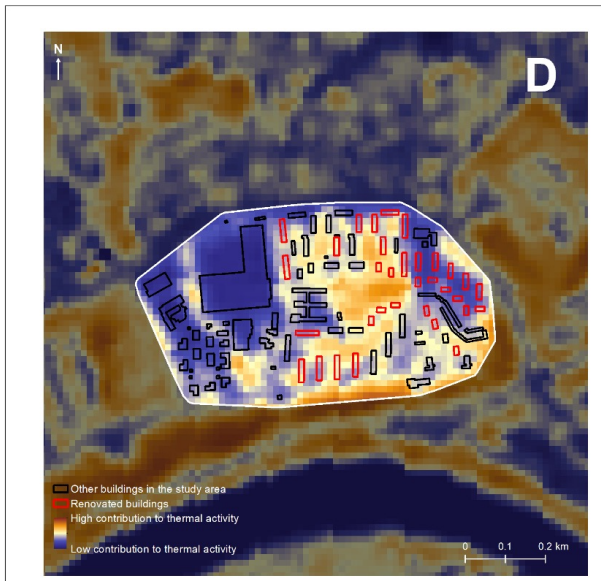




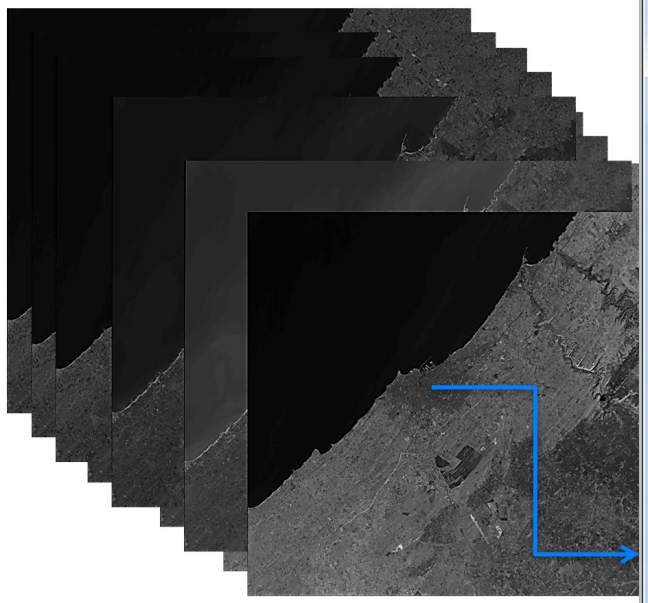




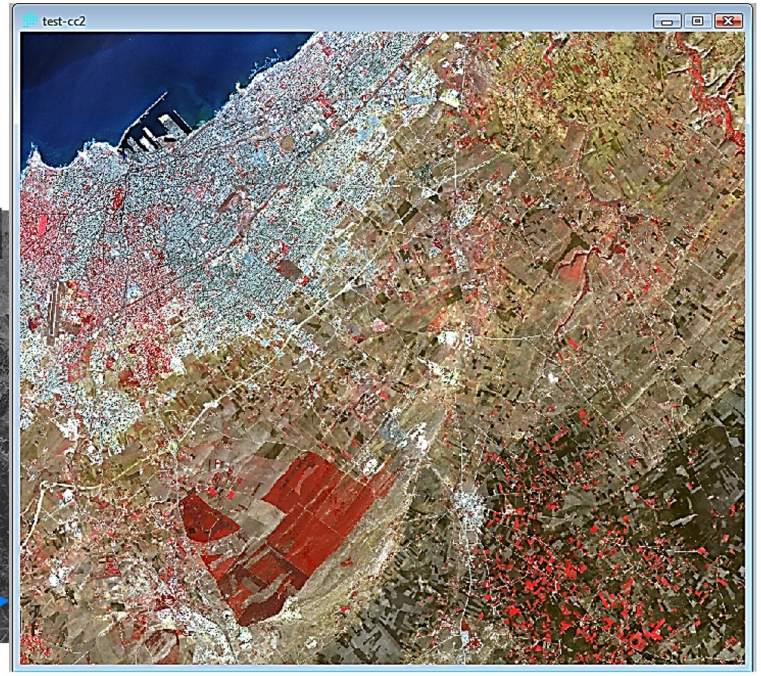




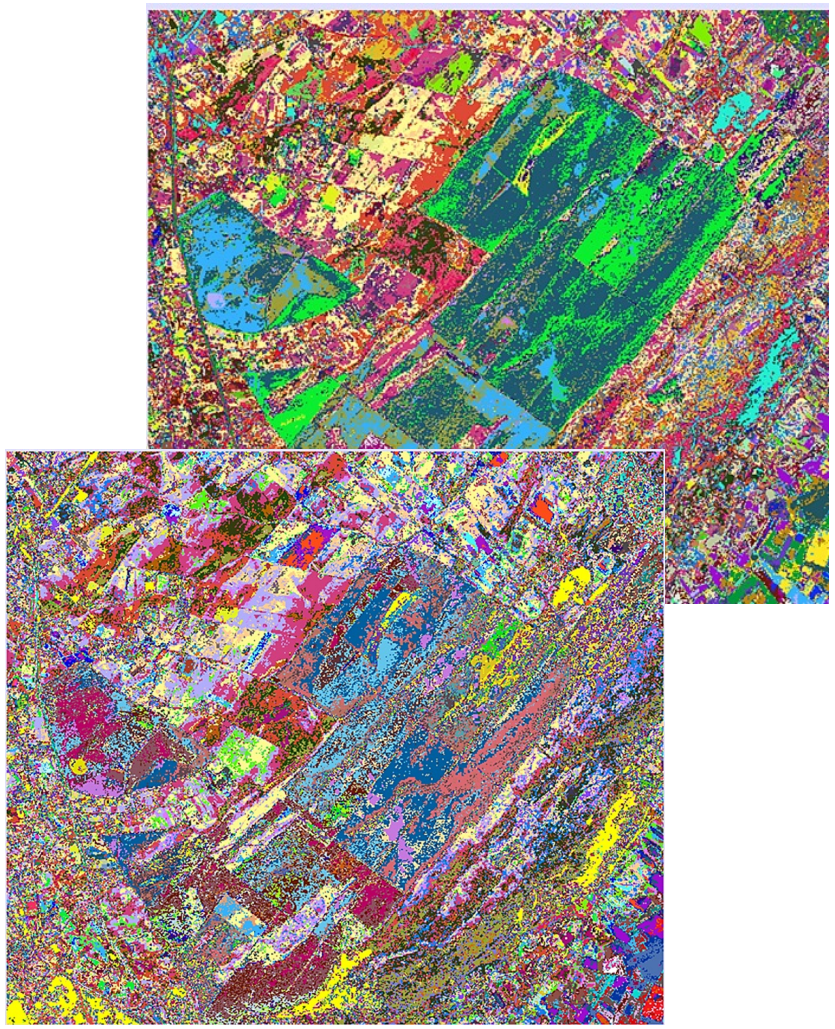
What Remote Sensing is: Spectral data processing



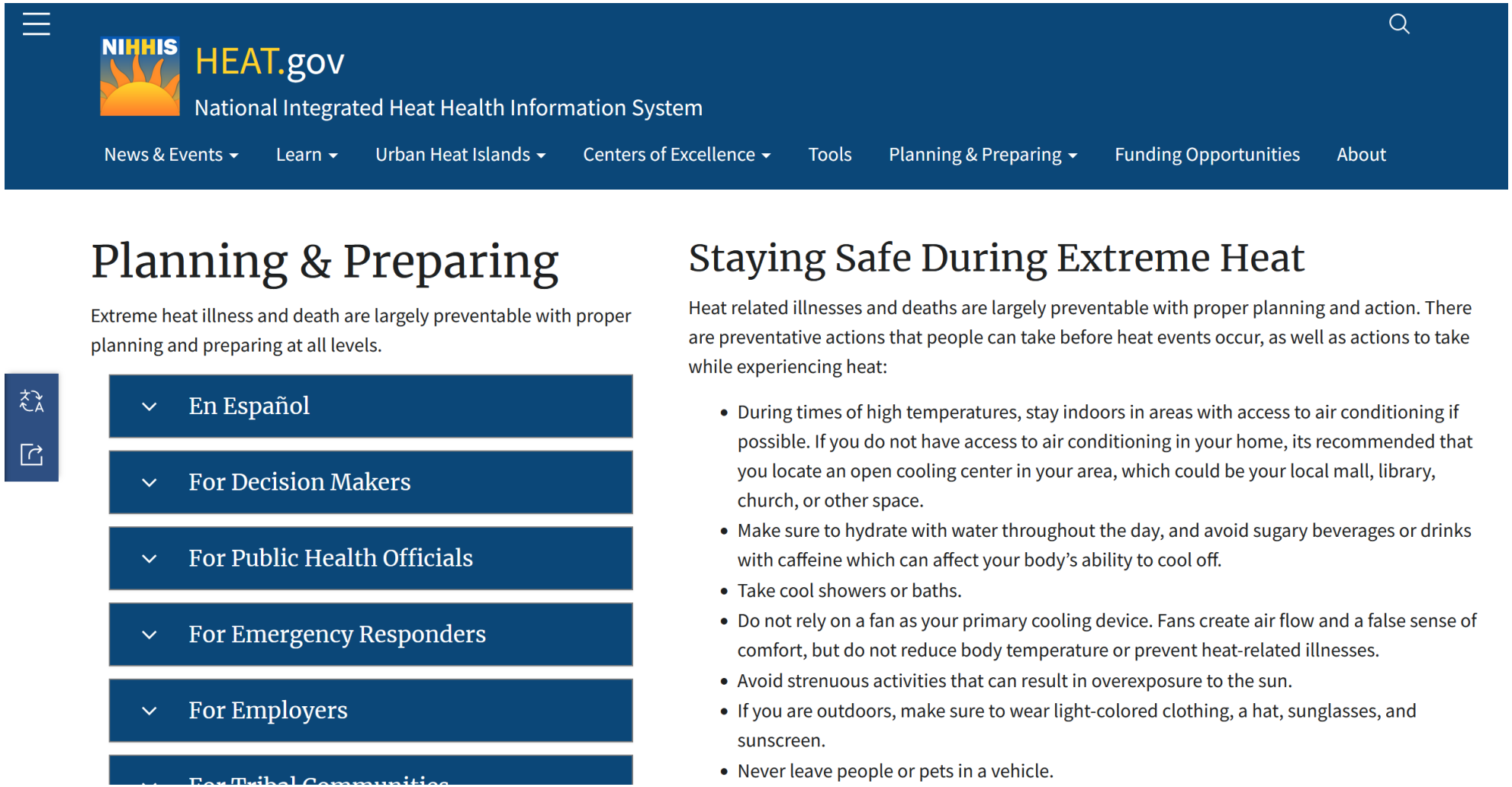
Multi-spectral Spot 5 data, Casablanca, Maroc ,
Sébastien Gadal, C3ED



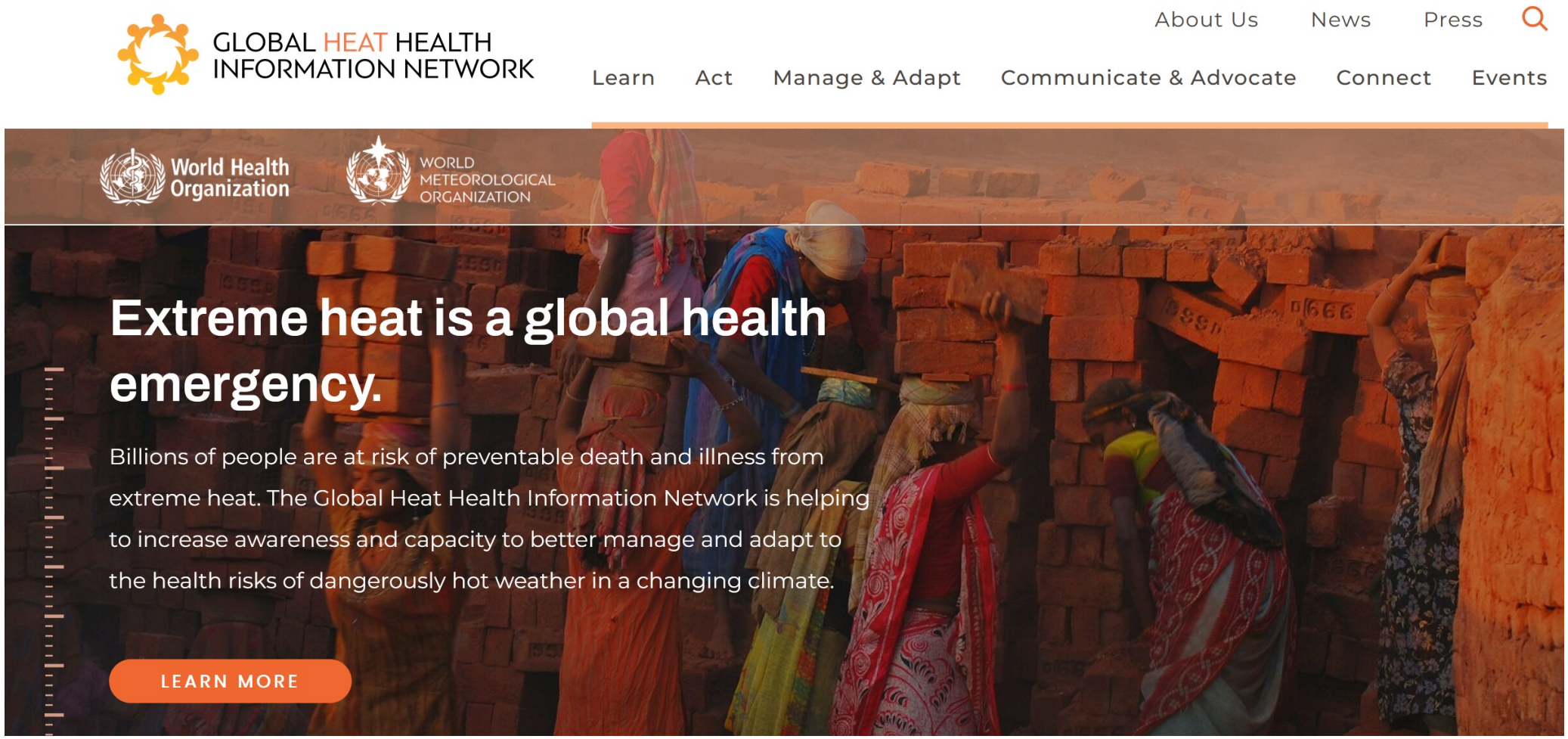
Sébastien Gadal, C3ED,



Remote Sensing and Heat Health Systems



Remote Sensing and Heat Health Systems



Remote Sensing and Heat Health Systems

The Indian-French TRISHNA mission

Monitoring our ecosystem health from space

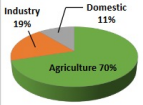
Philippe GAMET (CNES/CESBIO, Philippe.Gamet@cnes.fr), Jean-Louis ROUJEAN (CNRS/CESBIO), Bimal K. BHATTACHARYA (ISRO/SAC), Philippe MAISONGRANDE (CNES), K. R. MANJUNATH (ISRO/URSC)
Corinne SALCEDO (CNES), Dheeraj ADLAKHA (ISRO/SAC), Laurence BUFFET (CNES), Thierry CARLIER (CNES), Jean-Louis RAYNAUD (CNES), Sébastien MARCQ (CNES), Emilie DELOGU (CNES), Renaud BINET (CNES)
Mark IRVINE (INRAE), Gilles BOULET (IRD/CESBIO), Emmanuelle AUTRET (IFREMER), Laure ROUPIOZ (ONERA), Ghislain PICARD (IGE), Pascal ALLEMAND (LGL)

TRISHNA: what for ?

- +2 billions people by 2050
  - Pressure on energy and food
  - Pressure on transboundary basins
  - Population in fluvial & coastal zones
- Biodiversity / pressure on the habitat
  - In Rivers, wetlands, coastal zones
  - Modified by dams, pollution
- Global warming +2deg by 2050
  - Impact on Carbon and water cycles
  - Extreme events: droughts, floods, storms, fires

United Nations SUSTAINABLE DEVELOPMENT GOALS

Global freshwater use

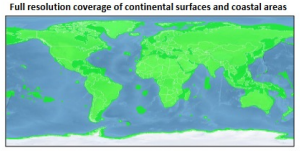


Source: FAO, 2017

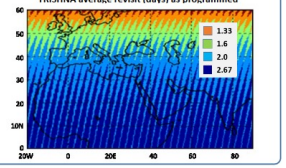
Need for reliable metrics, homogeneous along time and on every scale from global to regional → TRISHNA = Frequent *AND* high-resolution measurements of the surface temperature & its dynamics

Mission design

Full resolution coverage of continental surfaces and coastal areas



TRISHNA average revisit (days) as programmed



Mission datasheet

Band name	Wavelength Center (nm)	FWHM (nm)
Blue	485	70
Green	555	70
Red	670	60
NIR	860	40
WV	910	30
Cirrus	1380	30
SWIR	1610	100
TIR 1	8.65	0.35
TIR 2	9.0	0.35
TIR 3	10.6	0.7
TIR 4	11.6	1.0

Spectral Bands

- ISRO/CNES cooperation, launch 2025, 5-year lifetime
- Scientific & operational applications
- Focus on **ecosystem stress and water use** + **coastal & inland waters**
- Global coverage of continental and coastal areas
- 60 meters nadir spatial resolution (VIS-NIR-SWIR-TIR)
- 5 VNIR bands + 2 SWIR bands + 4 LWIR bands
- Revisit : 3 acquisitions at equator per 8 days period
  761km-8day orbit reducing hot spot constraints in intertropical zone
- ± 34° scan angle, 1030km swath
- Mean Overpass time : 1 PM (LTDN)
- NeDT 0.2K
- Indo-French(*) Joint Science Team (*) with other contributors
  Synergies with ECOSTRESS, SBG, LSTM science & application teams
- Free and open data policy for worldwide scientific community
- Level-2 products include reflectance, LST, LSE, EvapoTranspiration & Stress Index

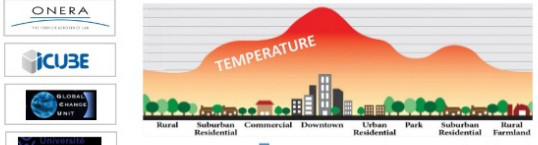
TRISHNA Products

All products also include quality flags

Level 1C *Top-of-atmosphere, Radiometrically and geometrically calibrated Orthorectified and resampled on a uniform spatial grid (Sentinel-2 tiles, Copernicus DEM)*

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

Urban microclimate monitoring



Urban Heat Island (UHI)

Air Temperature
Rugosity, Wind
Radiative trapping
Impermeability of the soils

Themes: Hydrology, building heat model, urban climatology

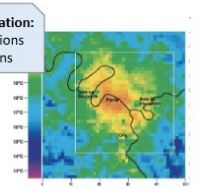
What TRISHNA brings:

- High revisit, global coverage
- LST, LSE
- Type of soil
- Rugosity

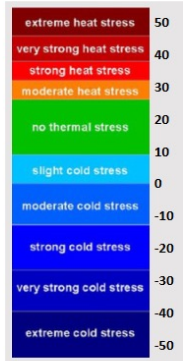
→ Exogenous data + **Remote Sensing data** + urban microclimatology model → **Air Temperature**

Connection with population health, comfort and safety

Urban population:
2008: 3.3 Billions
2050: 5 Billions

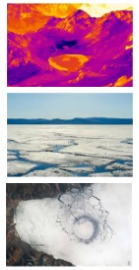


AVHRR Aug. 9, 2003 UHI over Paris (Do usset, 2007)



UTCI : Universal thermal confort index
www.utci.org

Cryosphere



Area	What is at stake	What TRISHNA brings
Sea ice, Ice sheets Ice caps	• Snow-melt runoff and debris thickness estimation	TEMPERATURE (Day & Night)
Snow & Glaciers	• Snow cover change & metamorphism at sub-watershed scale	EMISSIVITY
Permafrost Seasonally frozen ground	• Modelling snow energy fluxes	Snow and Ice Albedo
River & lake ice	• Snow mass, Snow Water Equivalent (SWE), Snow depth	Snow cover

Remote Sensing and Heat Health Systems

Vilnius University

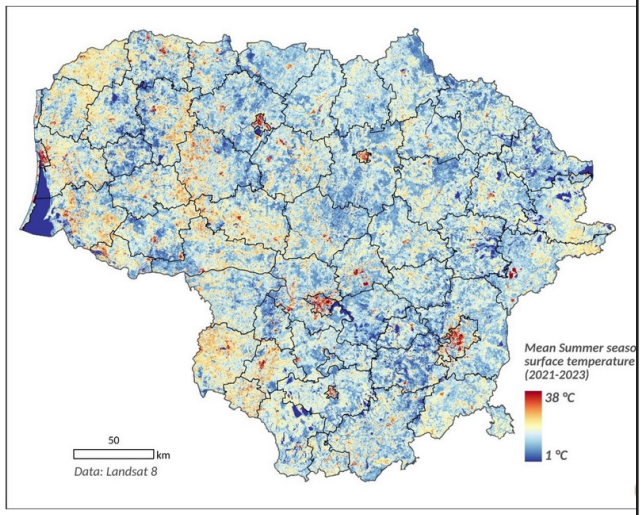
ABOUT VU STUDIES RESEARCH INTERNATIONAL COOPERATION BUSI

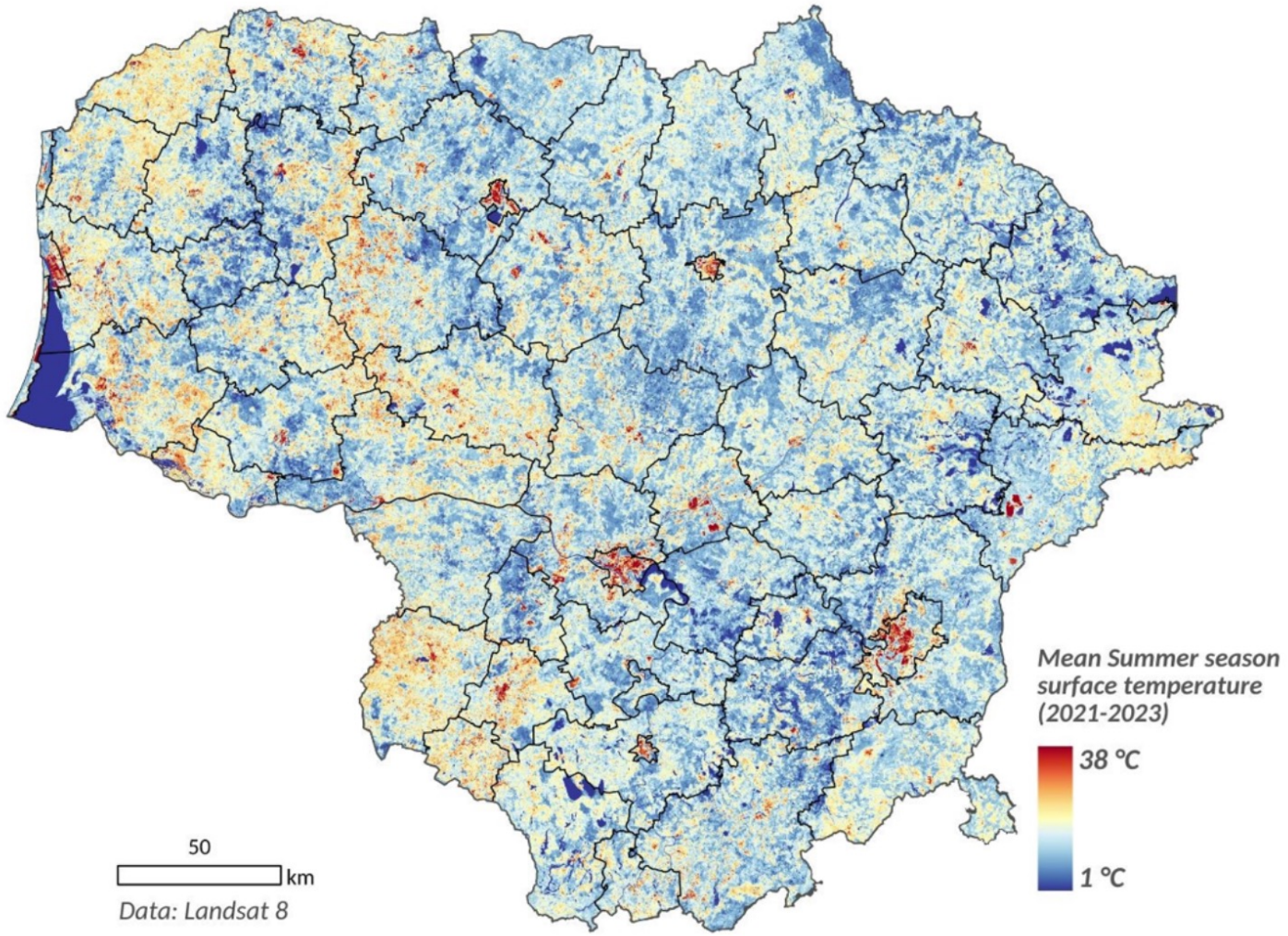
rates are growing every year. In addition to its life-threatening

Monitoring urban heat islands from satellites

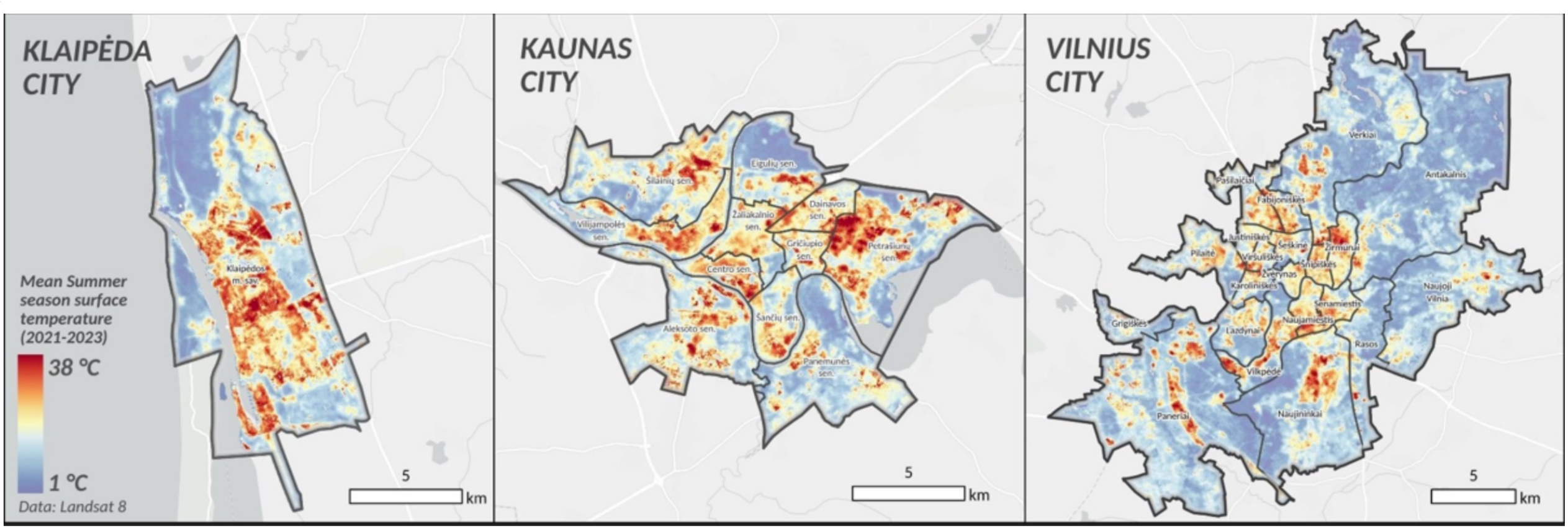
The formation of heat islands is usually monitored by measu
and their suburbs or by systematically using vehicle-based te

One of the newest methods for monitoring thermal distributi
island effect much easier, as they point to increasing near-su
far-infrared sensors installed on Earth observation satellites,
within these bands. For example, NASA Landsat's thermal inf
territory from 2021 to 2023: it is evident that the major cities –
surrounding areas are cooler on average.

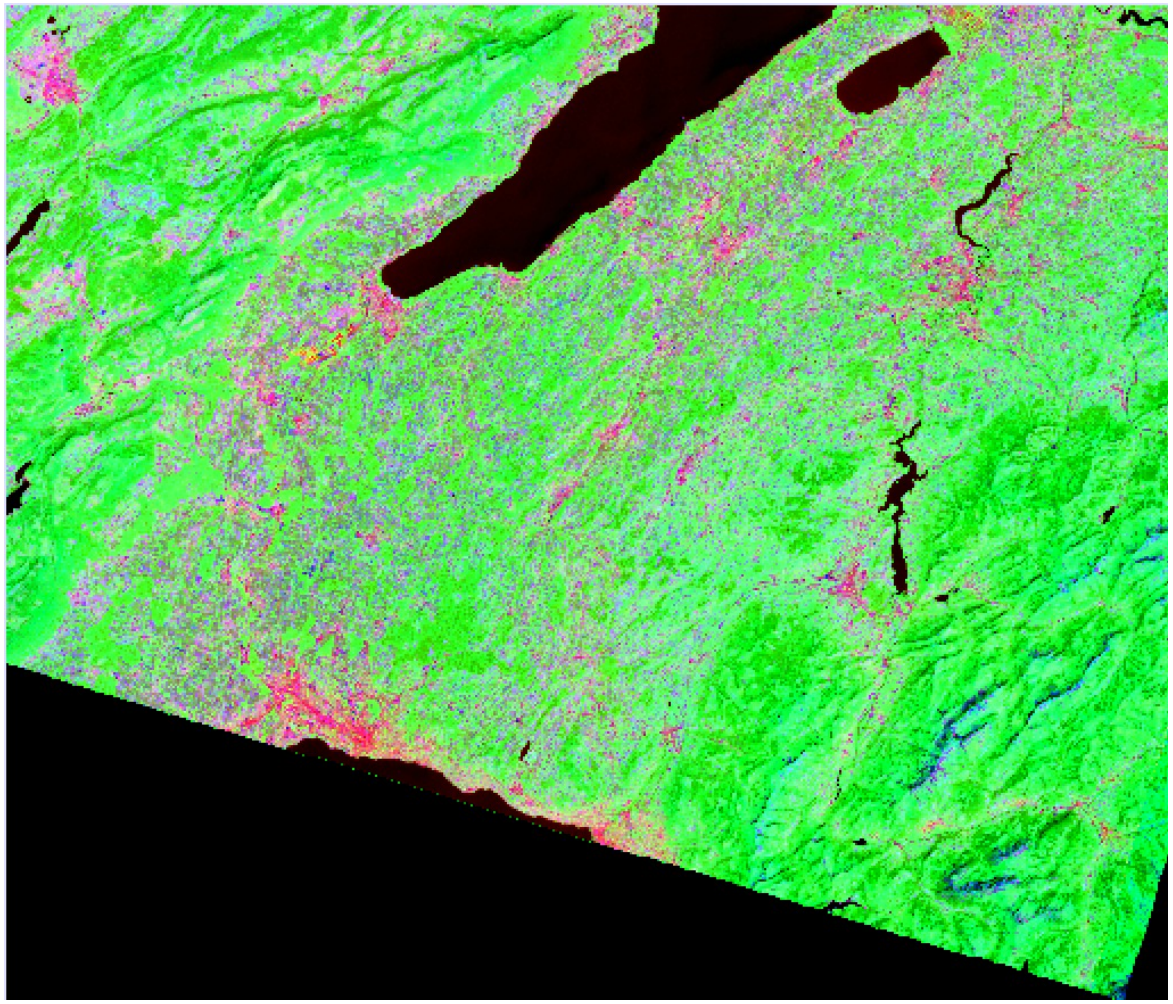


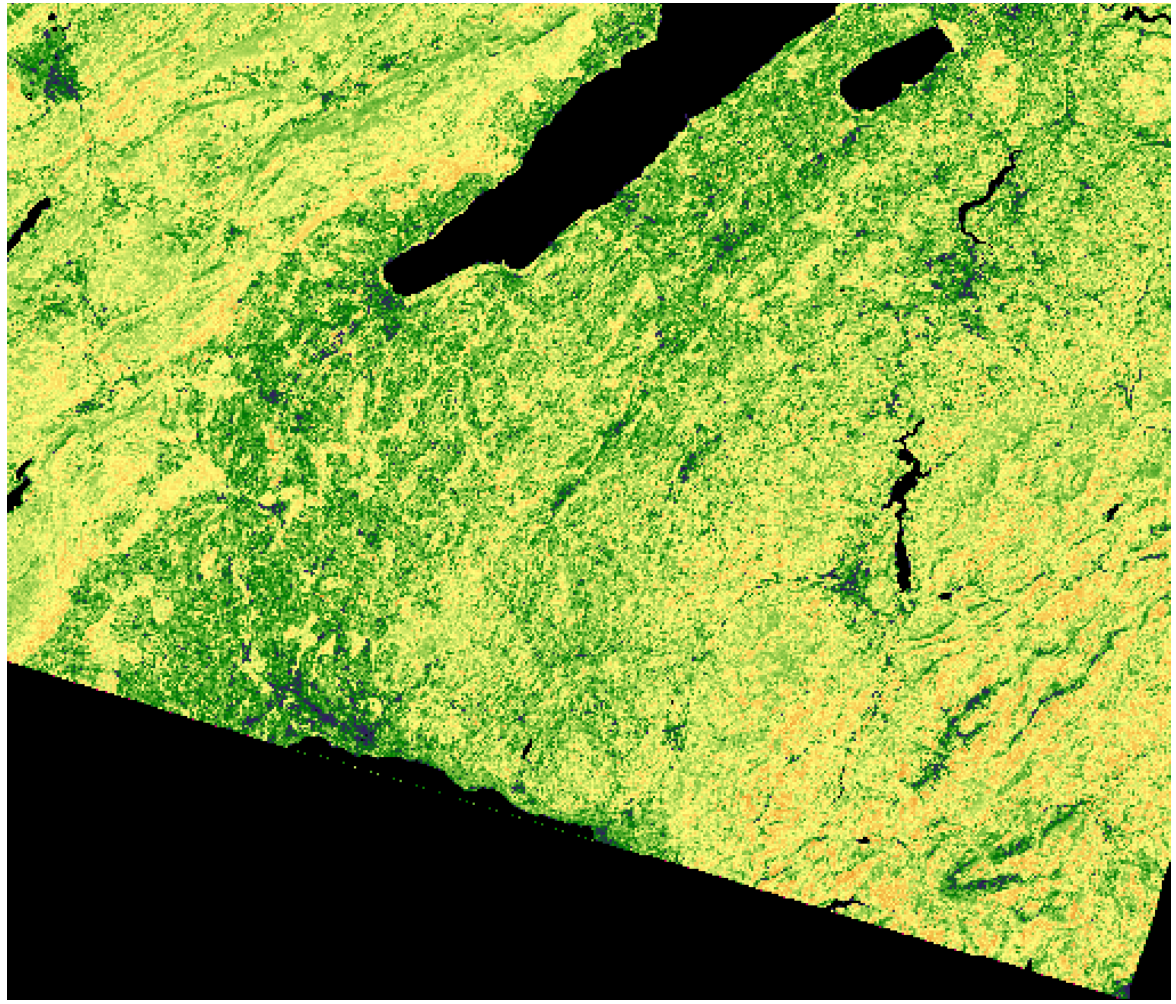


Remote Sensing and Heat Health Systems

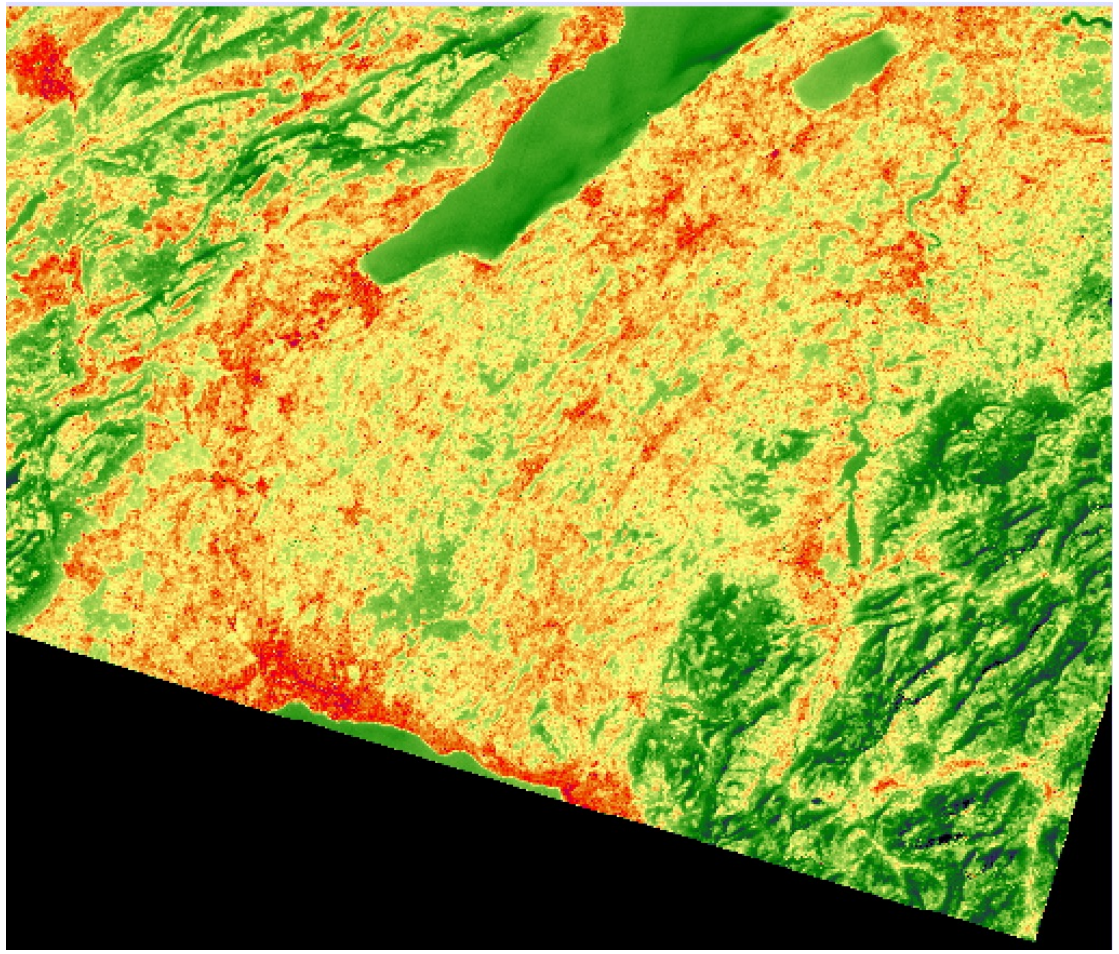


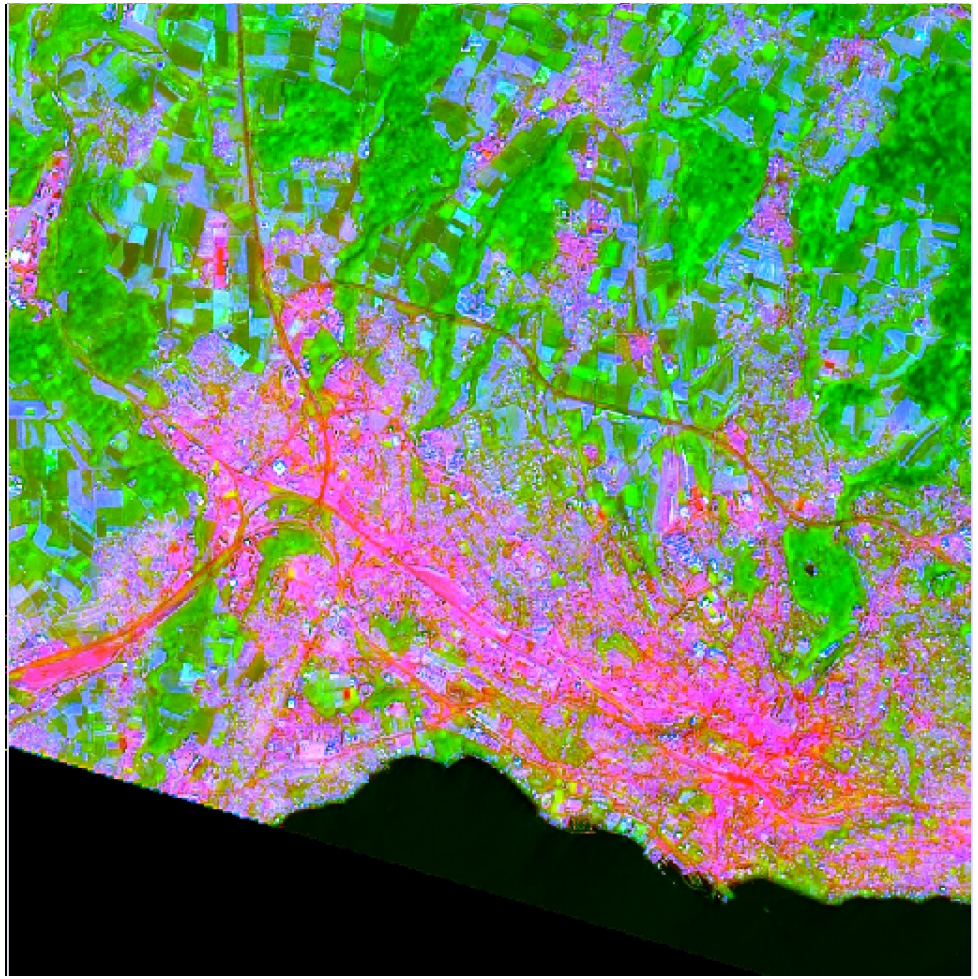
Remote Sensing Thermal Emissions of Lausanne



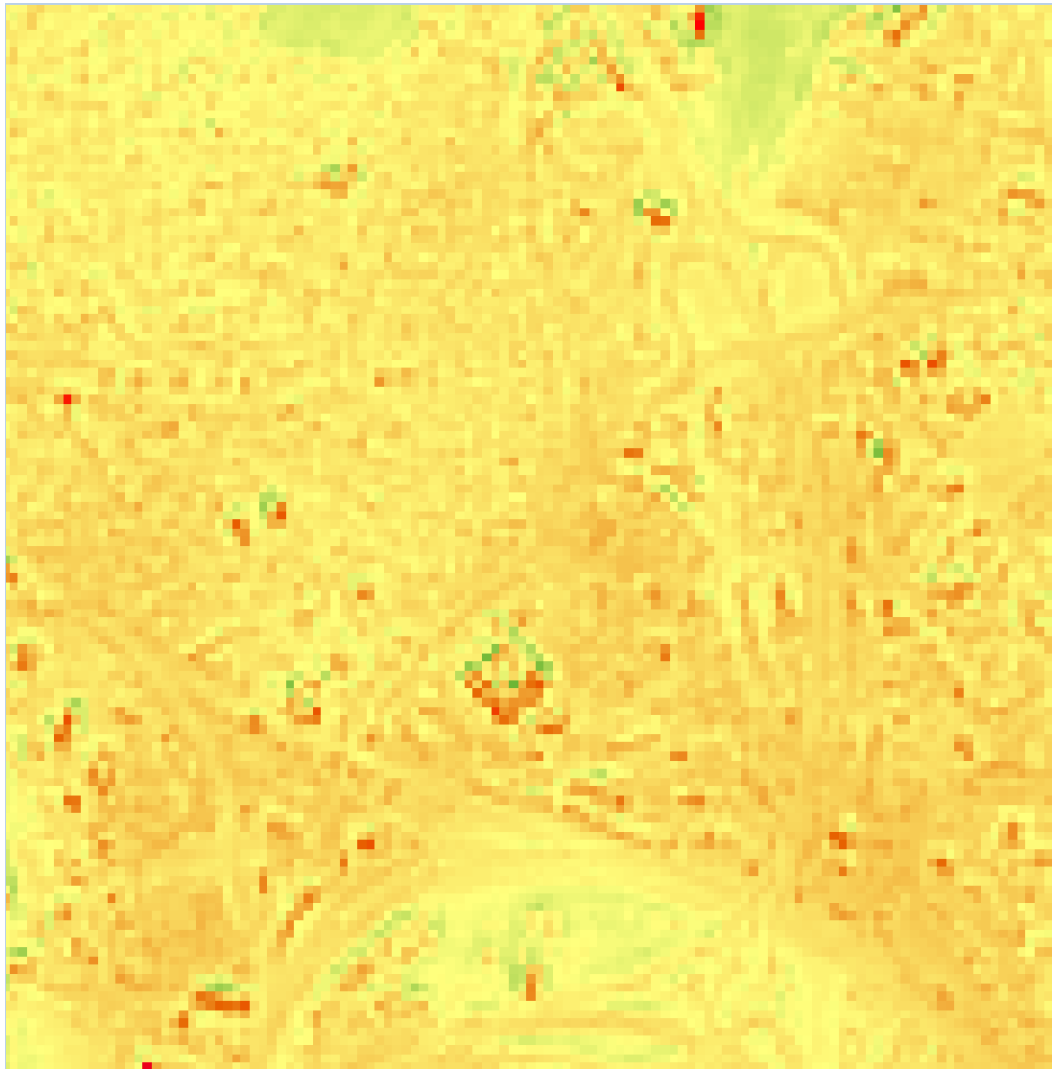


Remote Sensing Thermal Emissions of Lausanne



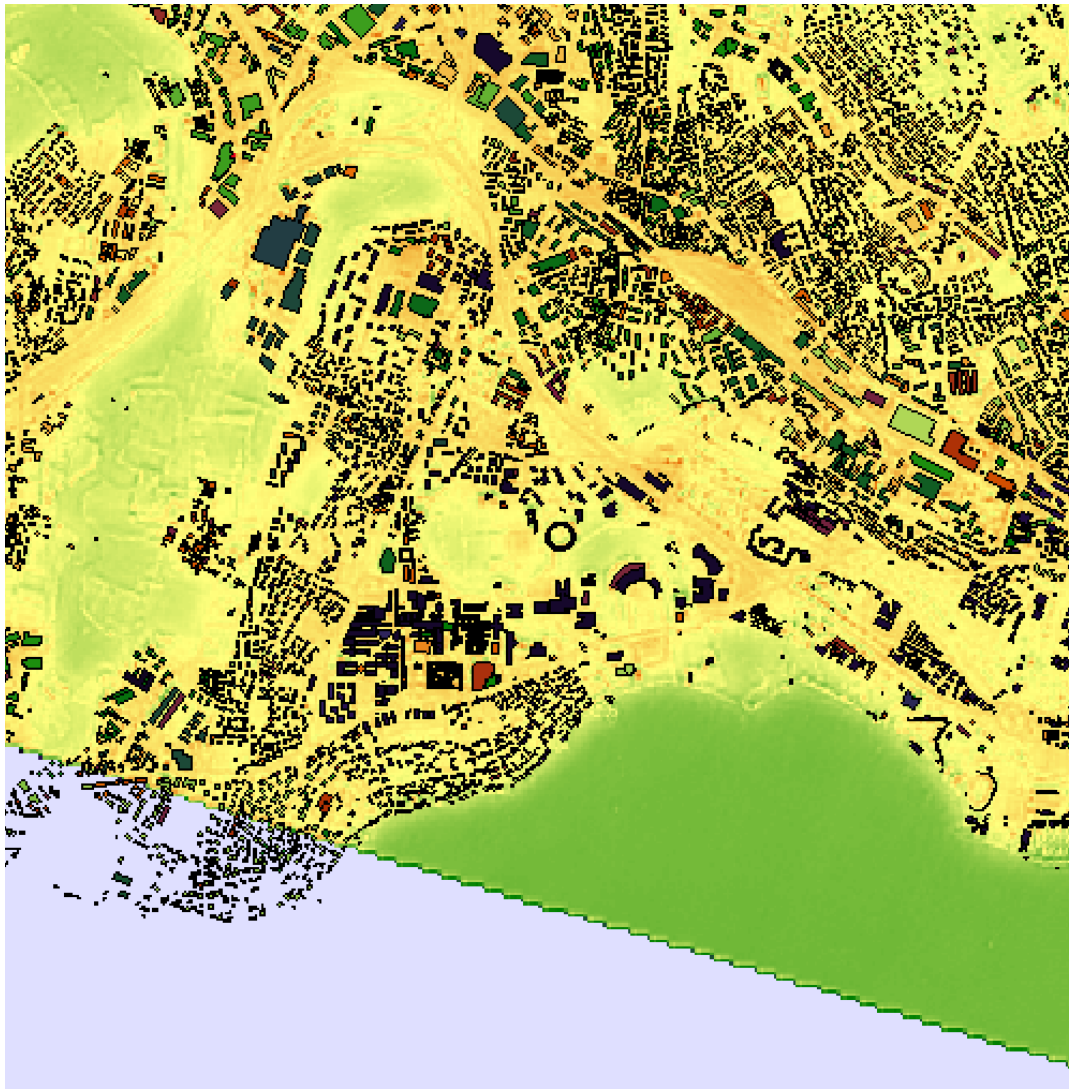


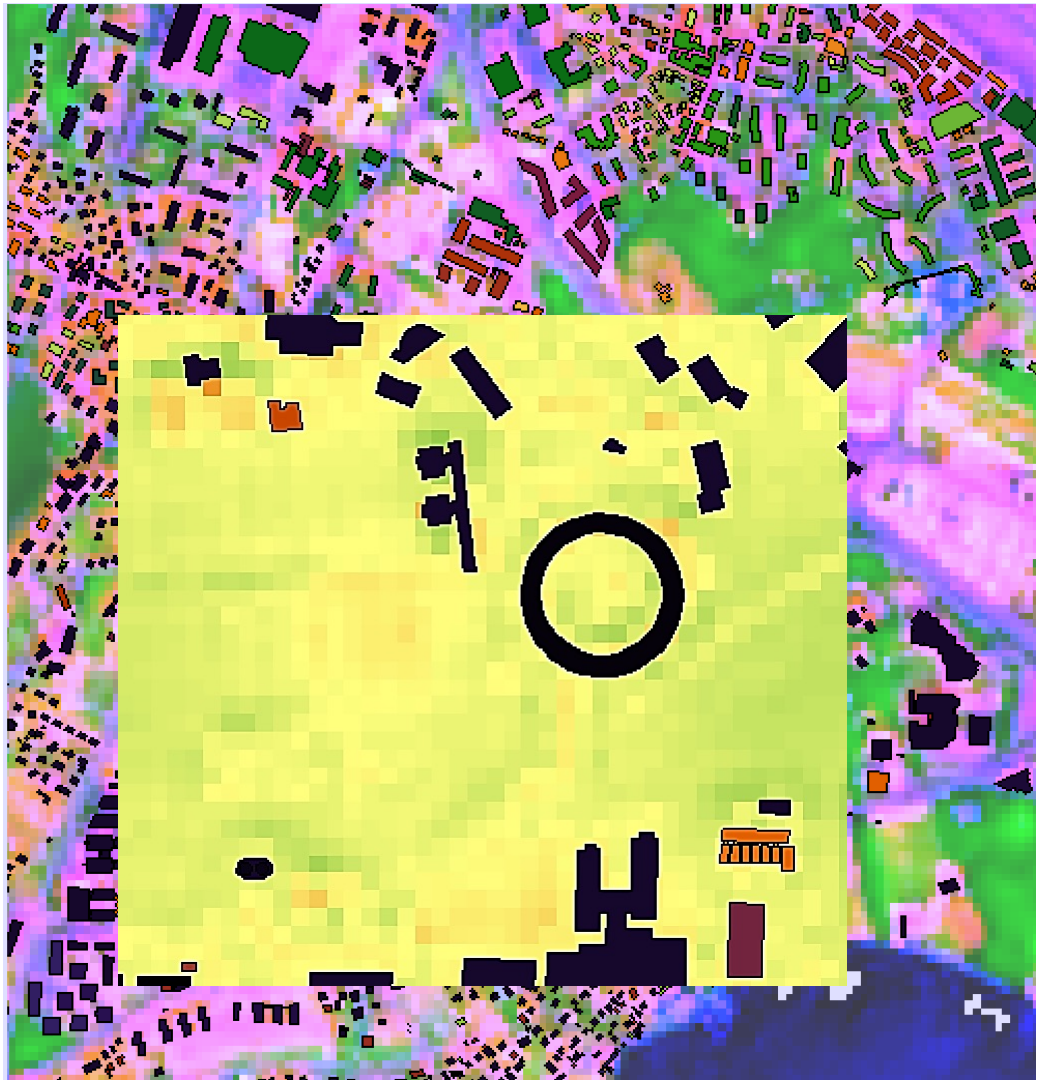
Remote Sensing Thermal Emissions of Chavanne



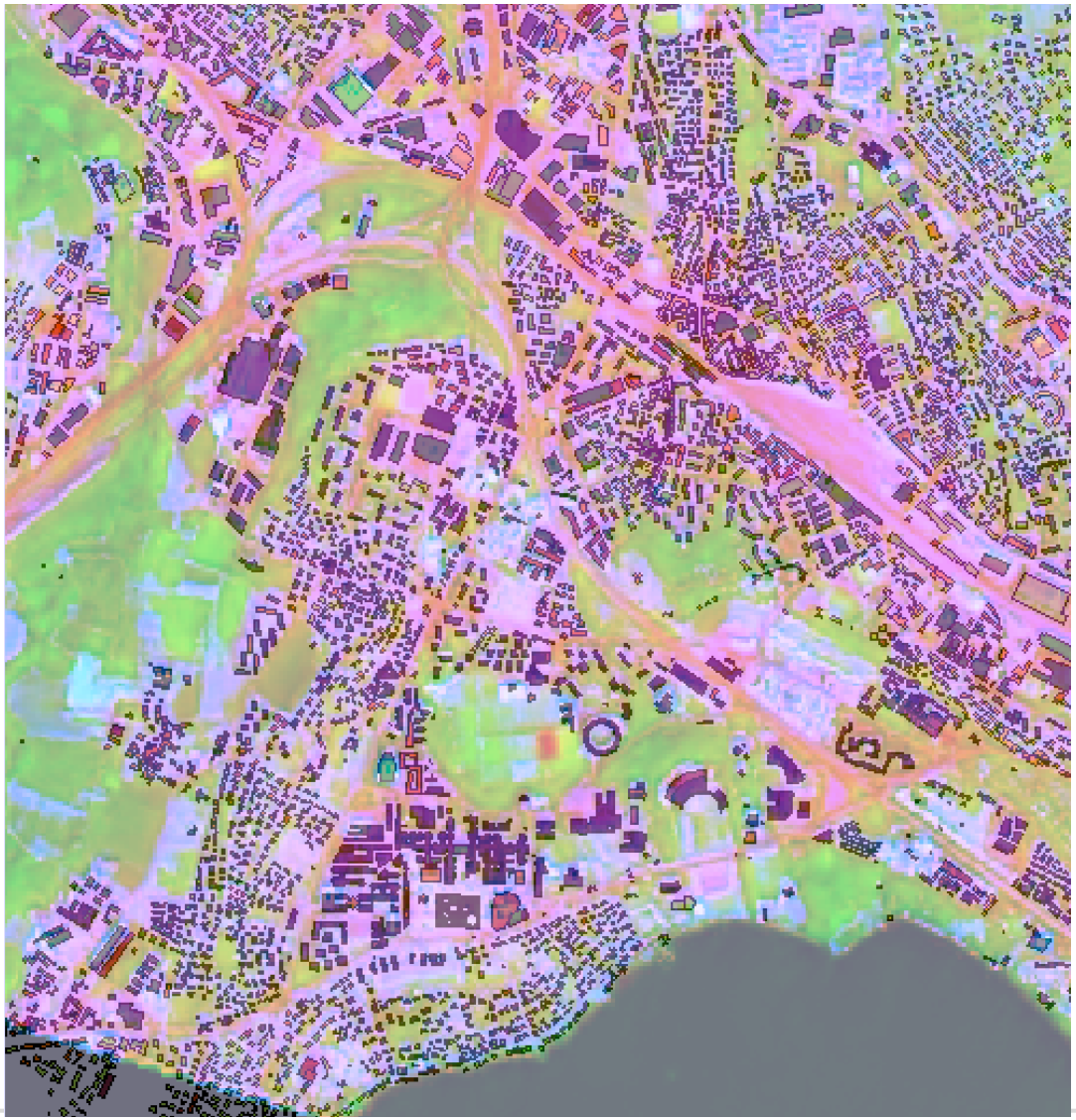
Heat Islands Thermal Emissions and Urban Morphologies

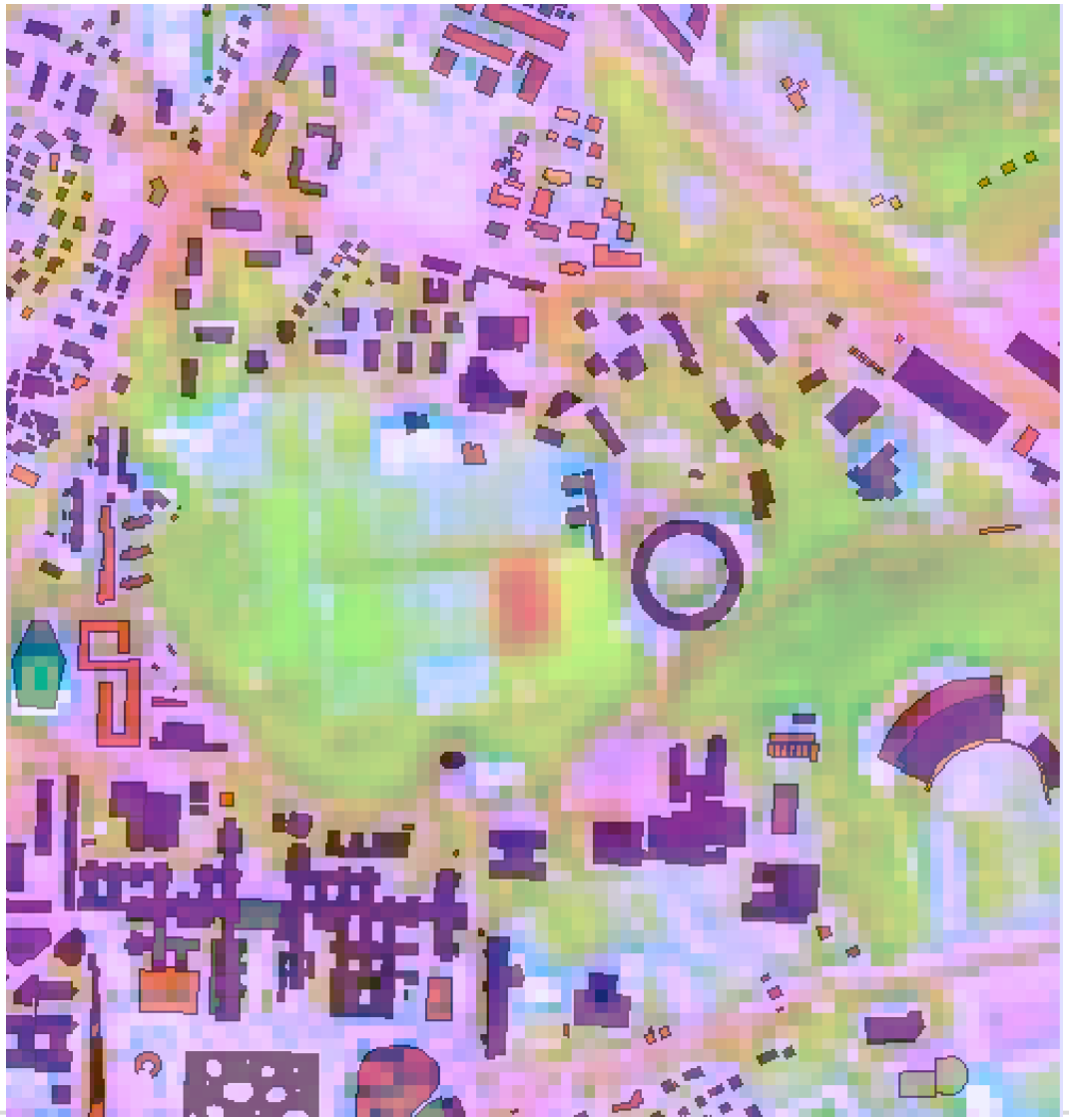
Heat Islands Thermal Emissions and Urban Morphologies





The Goose Game: Search for Heat Hot Spots Invisible to the Human Eye





ESPACE cnrs AVIGNON UNIVERSITÉ Aix*Marseille université UNIVERSITÉ CÔTE D'AZUR

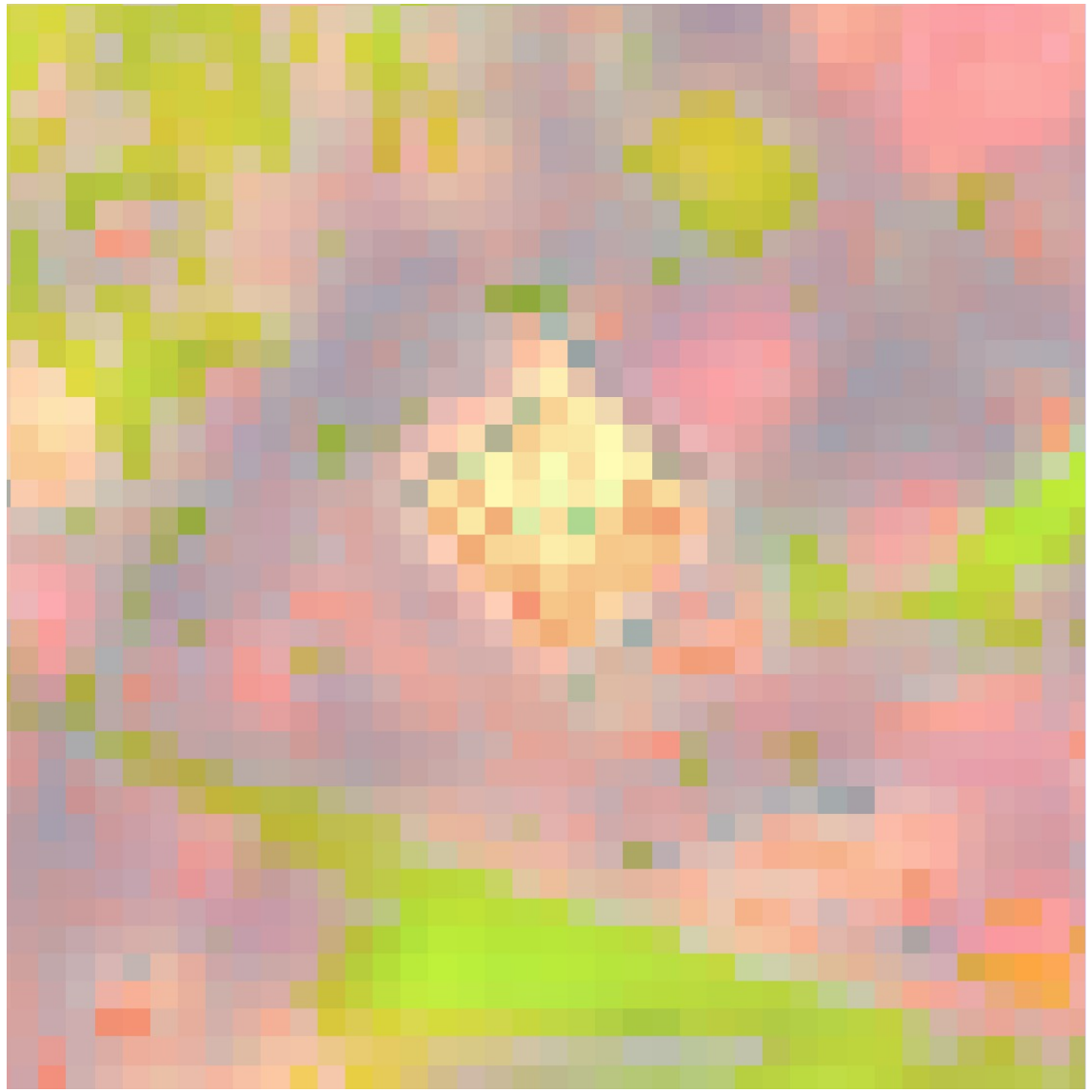
Population exposures of Chavanne's Heat Islands

- Measuring the thermal and temperatures
- Mapping thermal emissions

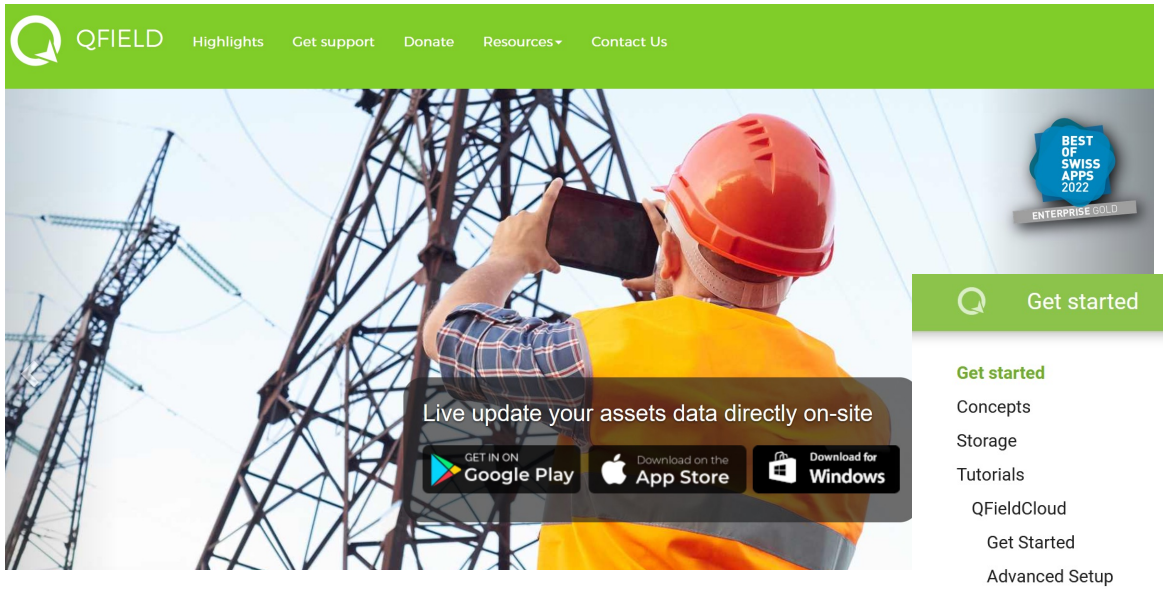
- Urban morphologies
- Population census

- Urban structures
- Vegetations

- On field data

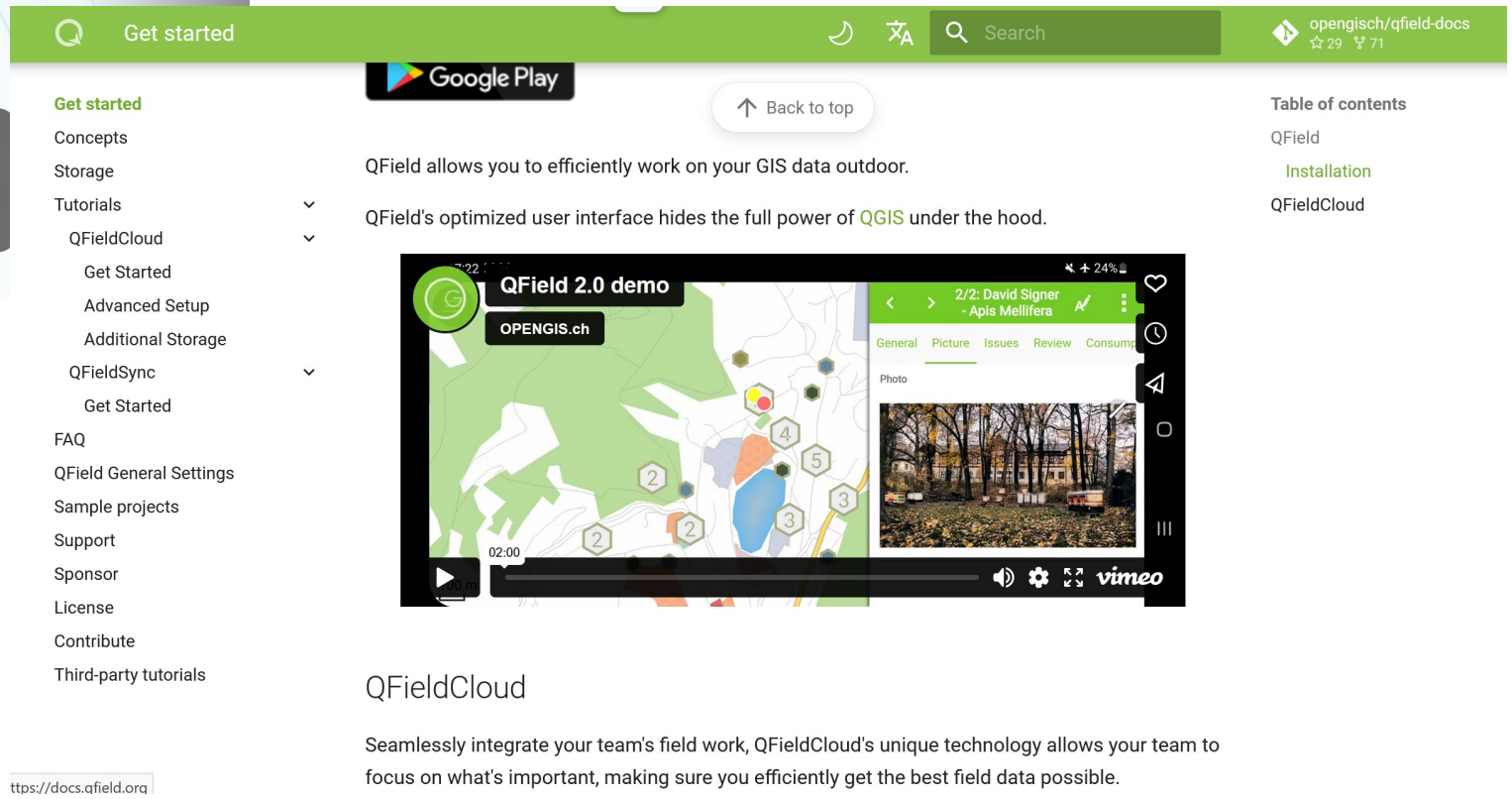


Data on field acquisition



https://docs.qfield.org/get-started/

https://vimeo.com/695452246



Data on field acquisition

Create a new project

A QFieldCloud project contains all project files and changes.

Name *

Chavanne

Only letters, numbers, underscores, hyphens and dots are allowed.

Only letters, numbers, underscores, hyphens and dots are allowed.

Description

UHI exposures modelling

Owner *

sgadal

The project owner can be either you or any of the organization you are member of.

☐ Is public

Projects marked as public are visible to (but not editable by) anyone.

☑ Overwrite conflicts

If enabled, QFieldCloud will automatically overwrite conflicts in this project. Disabling this will force the project manager to manually resolve all the conflicts.

◉ Create a project with a `.qgs` file with OpenStreetMap as a base layer

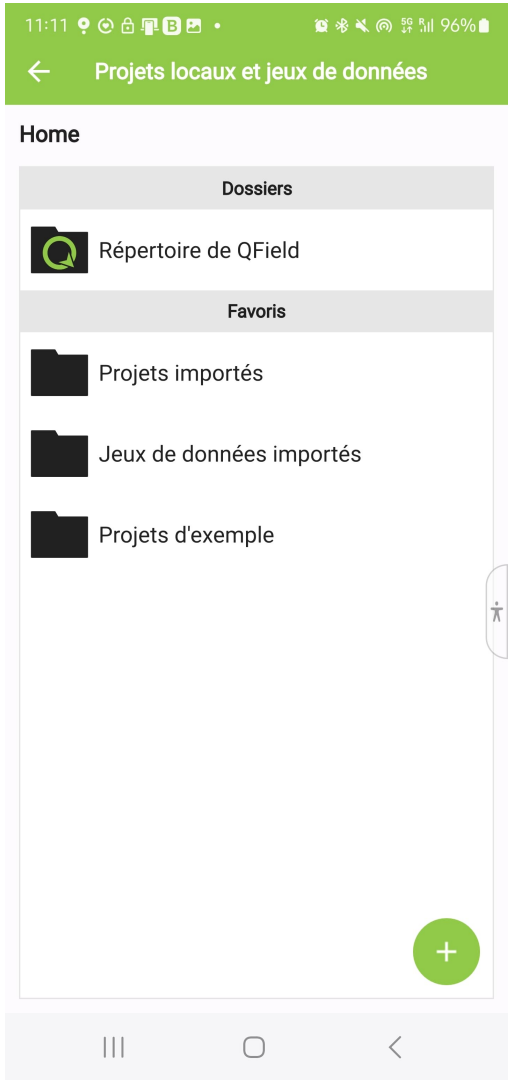
You can still add more layers and files in QGIS from a local directory on your PC and upload them via QFieldSync.

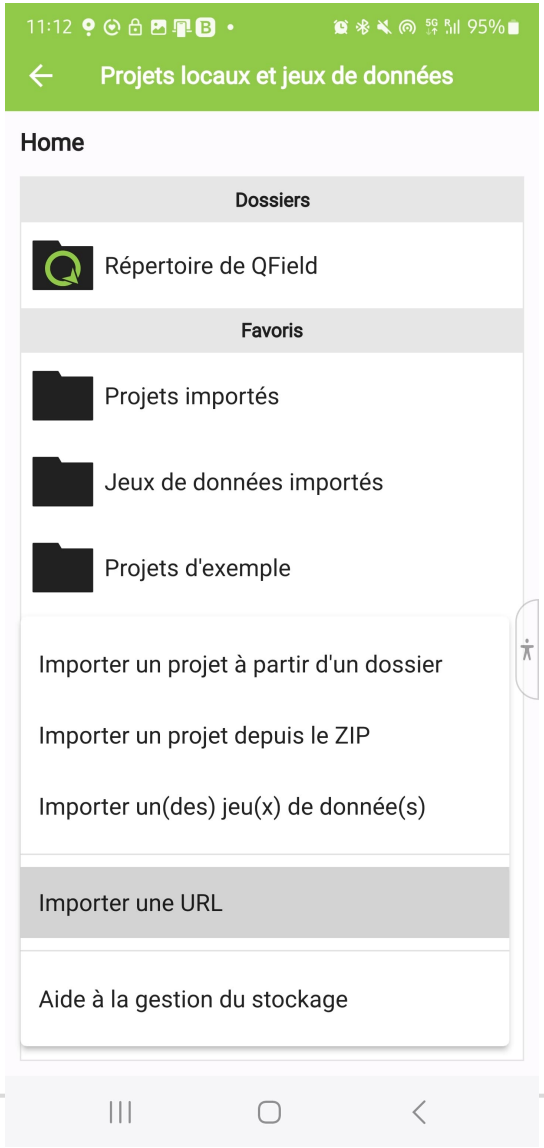
○ Create a new empty project

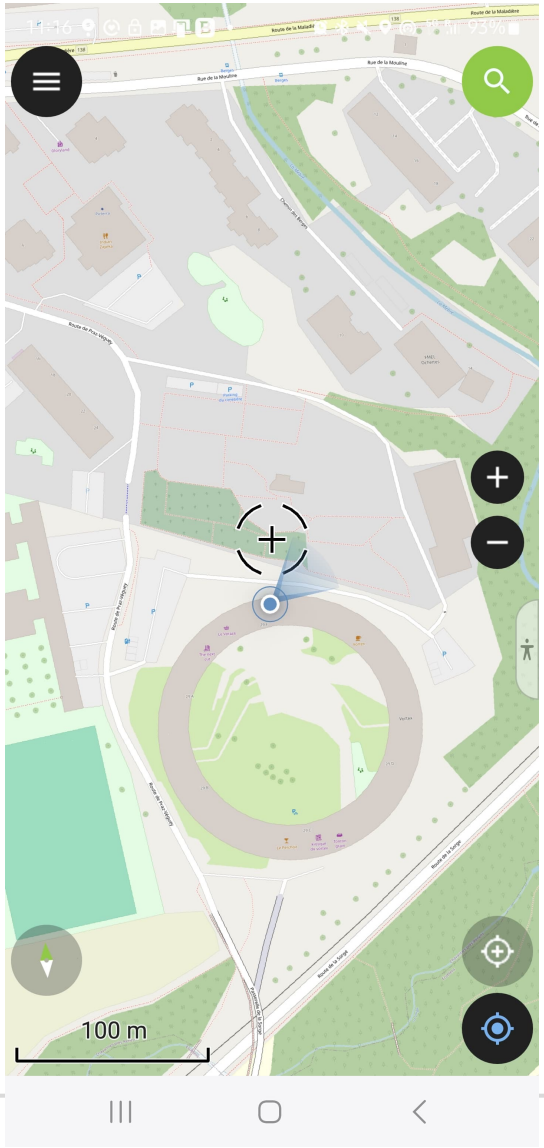
You will be responsible for moving all the project-related files within the selected local directory on your PC, with the project file at its root, and upload them via QFieldSync.

Create

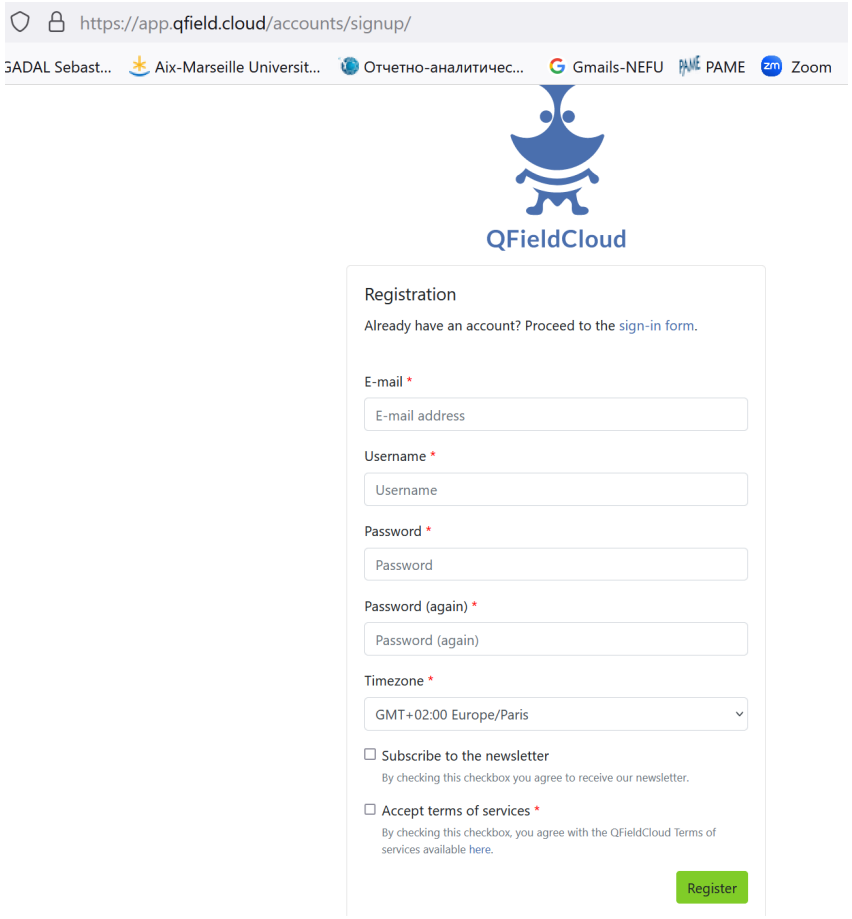
Data on field acquisition

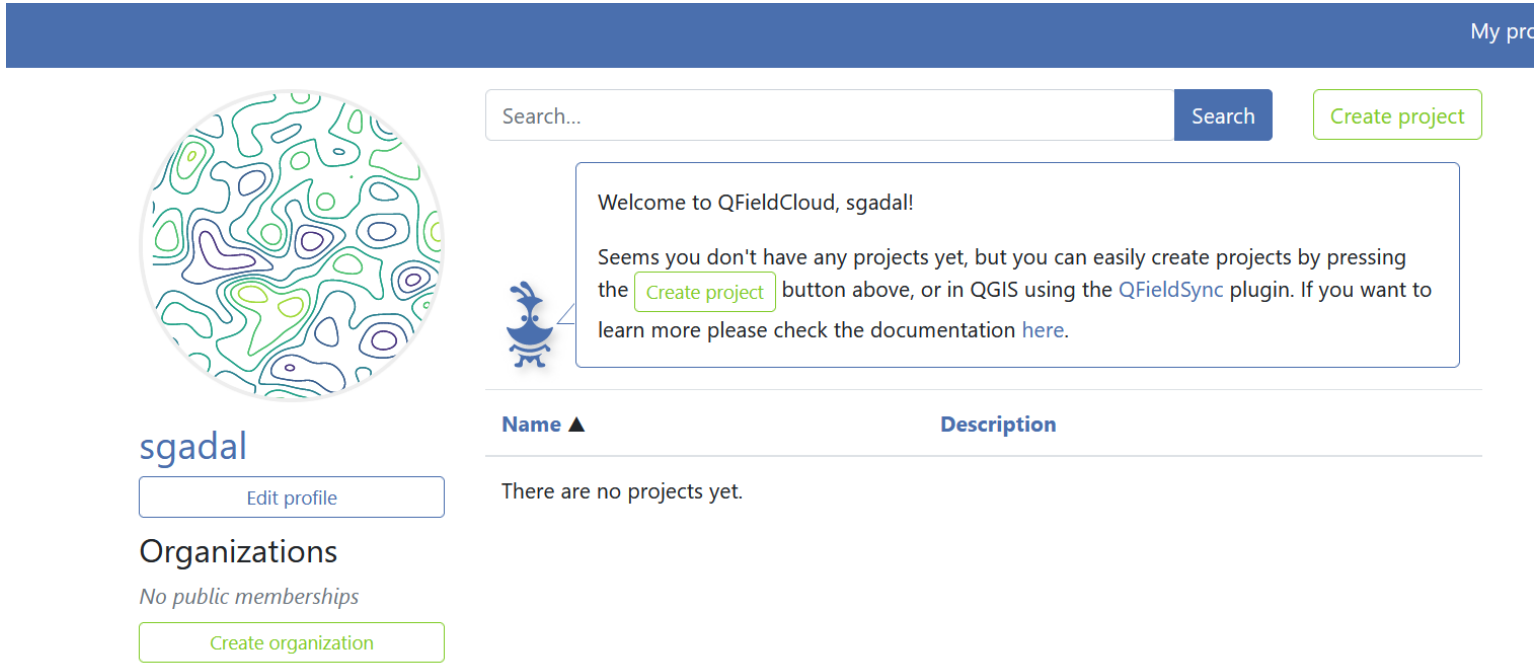




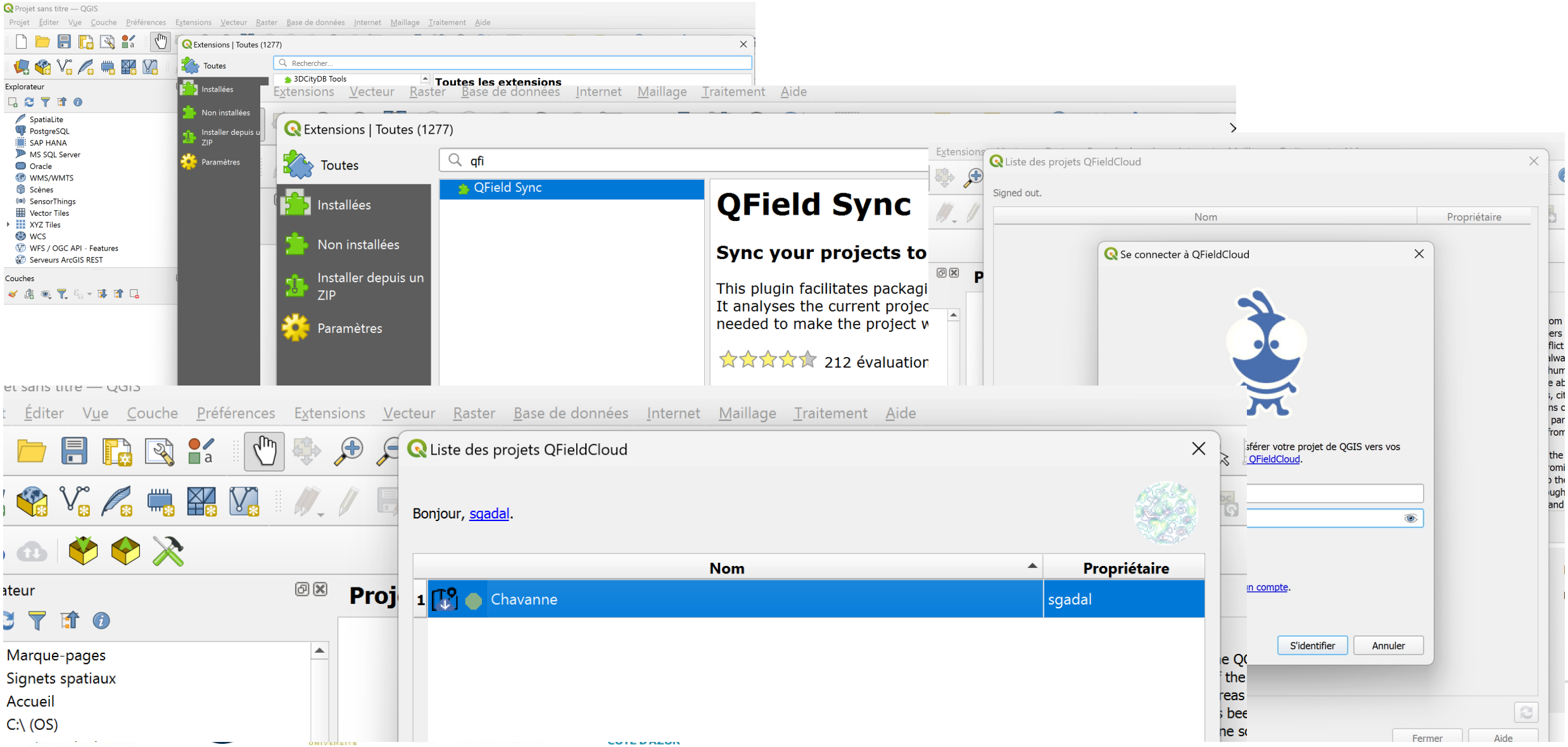


Data on field acquisition

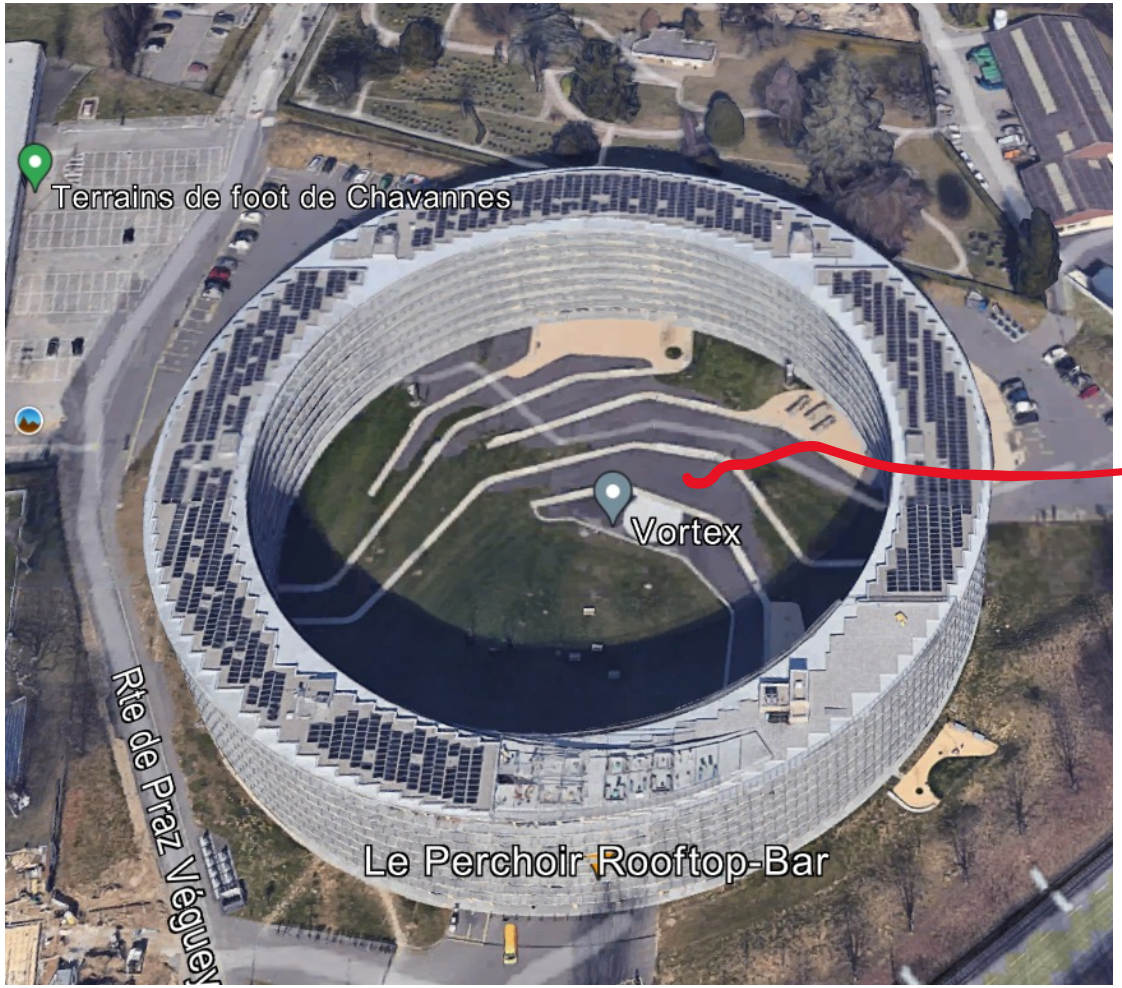


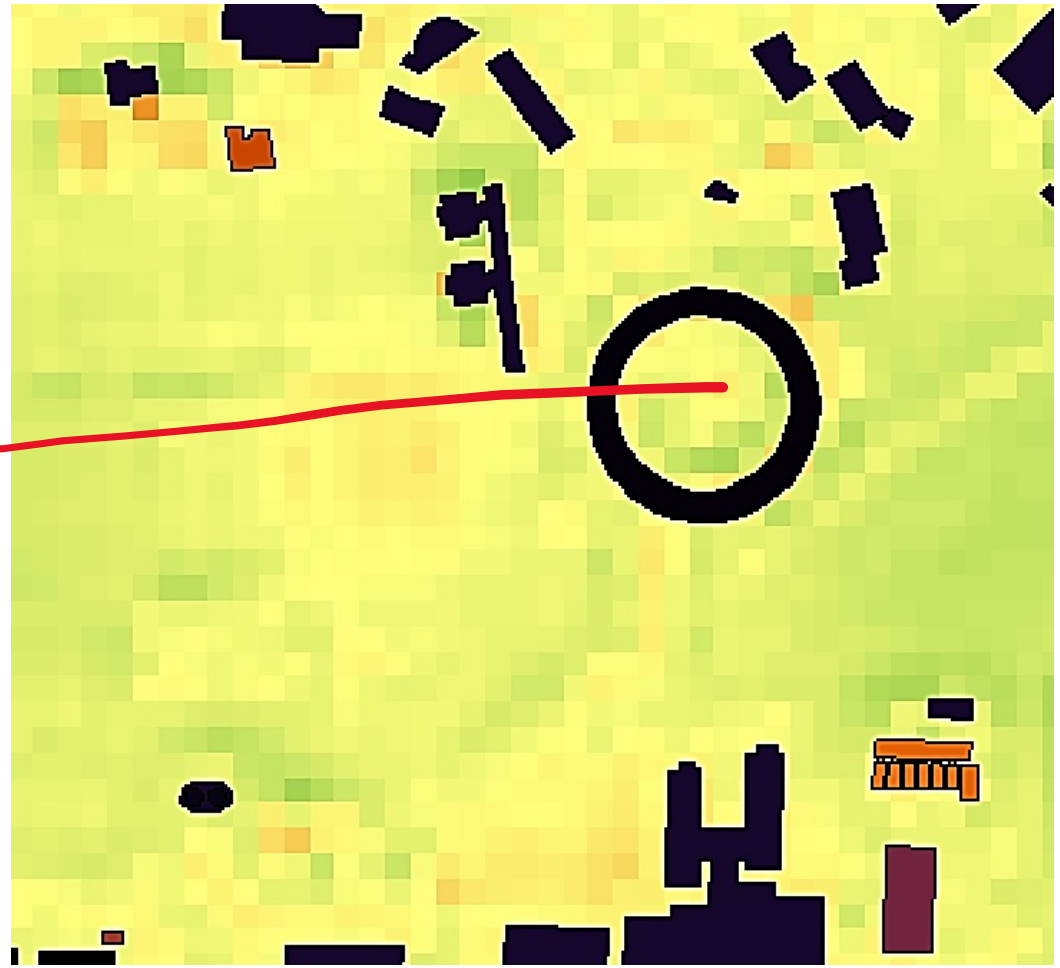


Linking geographic databases among QGIS and QField



Go for it!


Terrains de foot de Chavannes
Vortex
Rte de Praz Véguey
Le Perchoir Rooftop-Bar



Prof. Habil. Dr. Sébastien Gadal

sebastien.gadal@univ-amu.fr

https://cv.hal.science/sebastien-gadal