The use of High-Resolution Thermal Earth Observation sensors in the security and other interconnected domains

Michele Lazzarini, Omar Barrilero, Adrian Luna, Paula Saameño, Enrique Coiras, Sergio Albani

European Union Satellite Centre

Outline

- European Union Satellite Centre
- Advantages of HR Thermal sensors
- Examples of applications
- New Security Challenges
- Possible user needs
- Conclusions

European Union Satellite Centre

SatCen supports the decision making and actions of the EU in the field of CFSP by providing products and services resulting from the exploitation of relevant space assets and collateral data

EU Agency located in Madrid (Spain)

GEOINT Service Provider

Capability Development

Support to the EU Space Programme

Research, Technology Development and Innovation (RTDI) Unit has to identify and implement new solutions to keep SatCen capabilities at the state-of-the-art

Activities

New Data Sources

- New Payloads
- HAPS and UAVs
- Collateral Data

Innovative Tech

- Big Data & AI
- Digital Platforms
- Digital Twins

EO Applications

- Change Detection
- Object Detection
- Monitoring Tools

New Security

- New Space
- Climate Security
- Transversal Domains

EU Initiatives

- R&I Programmes
- GOVSATCOM
- IRIS²

Ongoing Projects

e-shape

ENTRUSTED

Global Earth Monitor

AI4 copernicus

promenade

enexa

ATLANTIS

SDGs EYES

Cooperation

European Commission

esa

EUROPEAN DEFENCE AGENCY

GEO

Open Geospatial Consortium

BDV

SatCen

Advantages of HR Thermal sensors in the security domain

In the past, one of the main drawbacks in the use of HR Thermal data for Security has been the data availability, in terms of:

- spatial resolution (e.g. limited to > 50 meters spatial resolution for satellite sensors)
- revisiting time (only *ad hoc VHR* airborne thermal campaigns)

Advantanges

Technical

- Day and Night acquisitions
- New products generation
- Sinergy with Optical and SAR data

Enhanced Monitoring (constellation)

- Global coverage
- Reduced revisit time
- Redundancy of data

New Space Actors

- Reduced development phase
- Rapid launch
- Reduced cost

Applications in the security domain

Human activity

- Building Temperature mapping (Urban)
- Industrial activity (e.g. water discharge in proximity of power plants)
- Pattern of life (e.g. migrations hubs)

Disaster monitoring

- Active fire detection, volcano activity (for rescue operations)

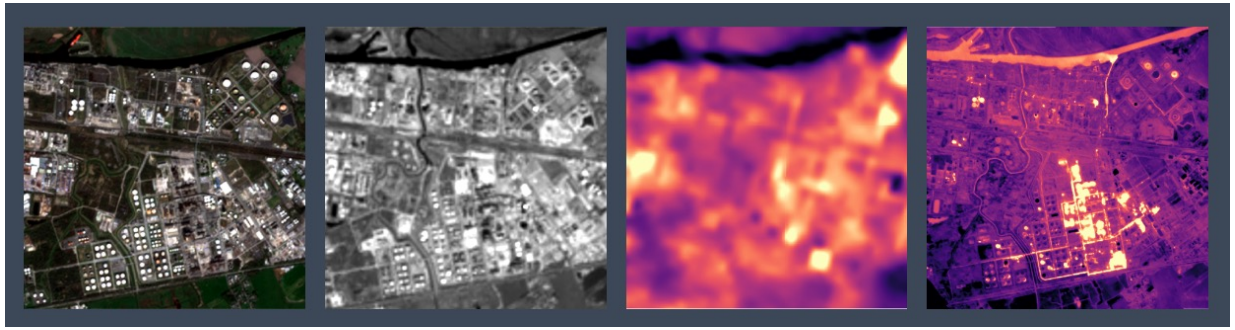
Military activity

- Barracks cooled or heated depending on season, vehicle activities

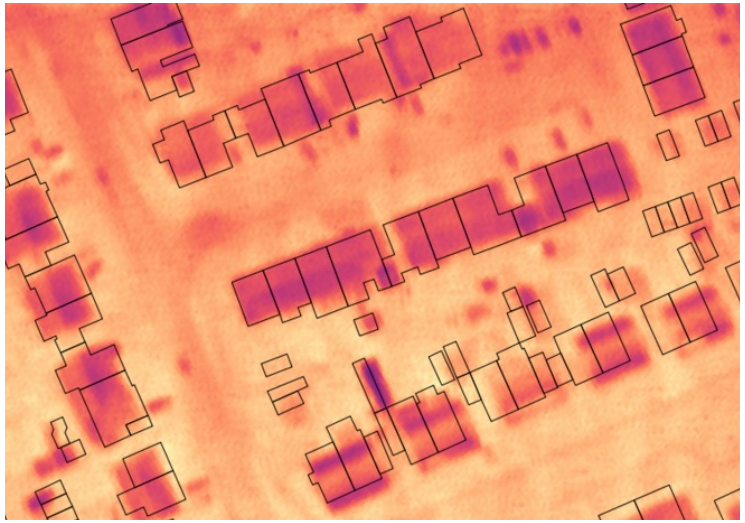
New Security

- Climate Security, Food Security, Water Security, etc.

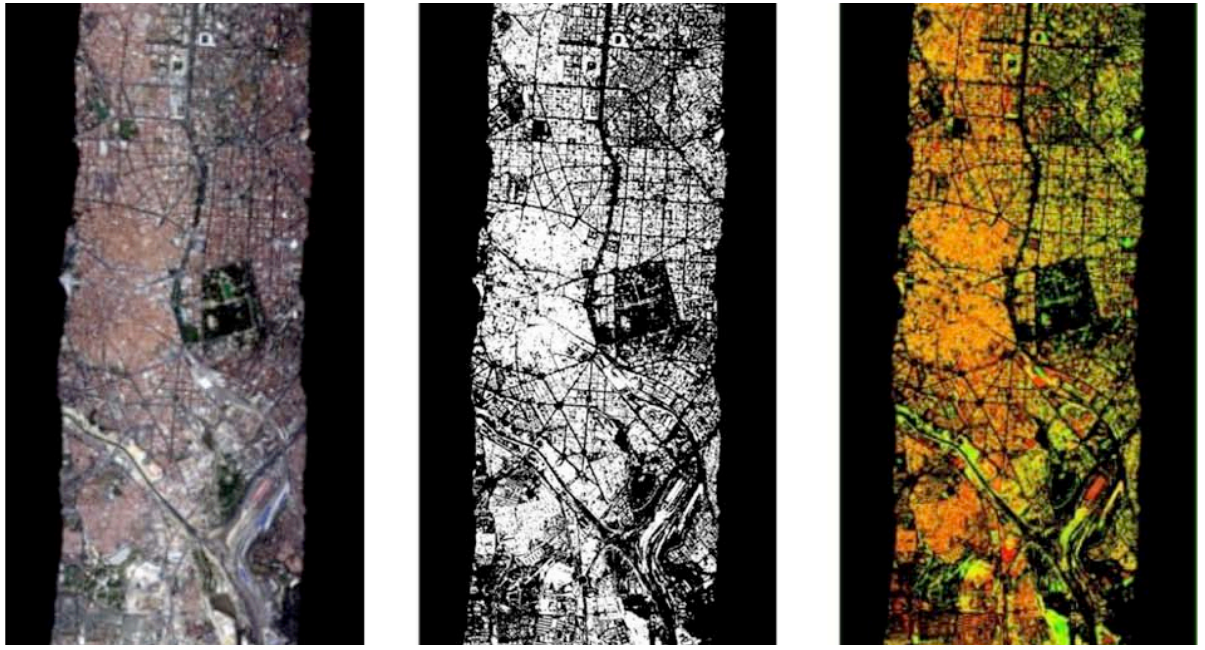
Examples: Building Temperature mapping



Satellite products over an industrial facility
From left to right: Sentinel 2 RGB, Sentinel 2 SWIR, Landsat 8 TIR and simulated thermal image (© *SatelliteVu)*



Simulated satellite thermal images to monitor building insights
© *SatelliteVu*

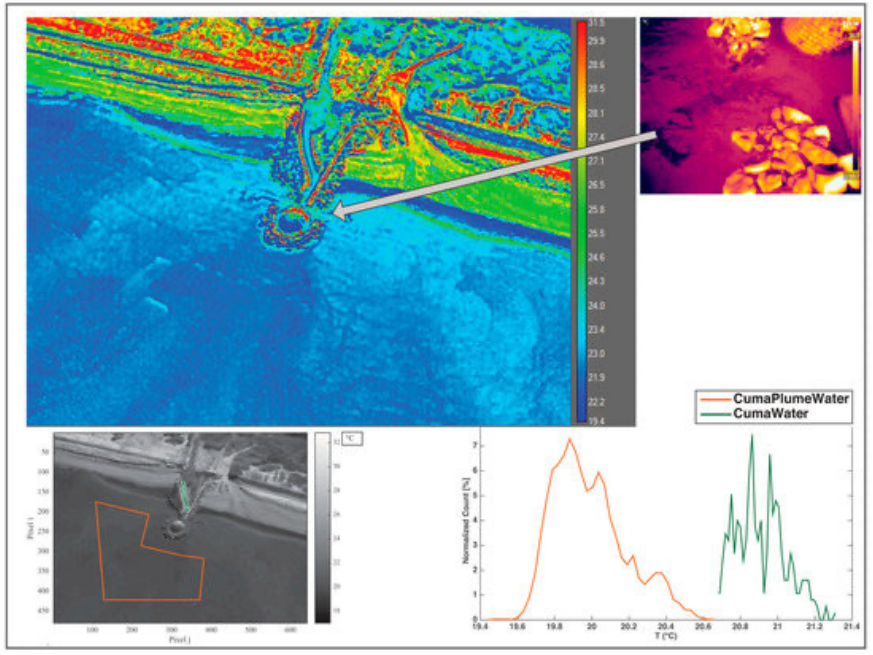


Airborne Hyperspectral Scanner image of Madrid, 2008
From left to right: RGB, Buildings Mask, Thermal Image
(Lazzarini et al., 2011)

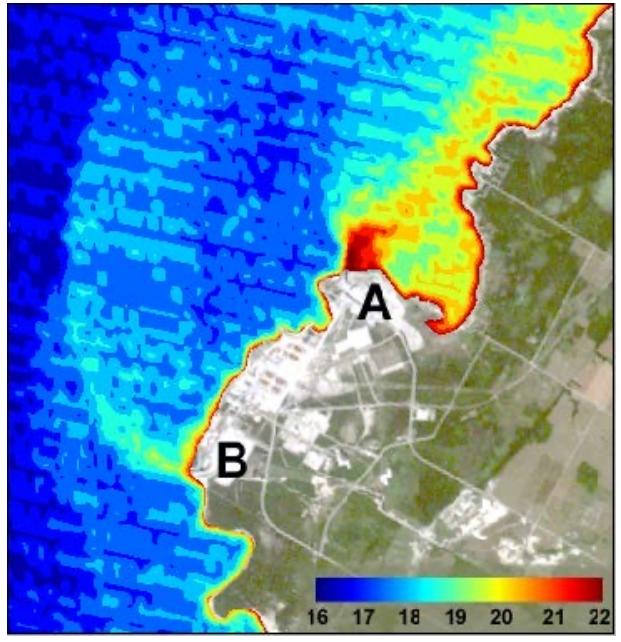
Examples: industrial activity

Monitoring of industrial activity:

- Active/non-active Plants
- Cooling water discharge
- Gas leak detection



Thermal image of a plume with histogram of radiometric temperature for areas of the channel, seawater, and area of the plume; in the upper right side, drone-acquired thermal image of the mixing zone in the channel outlet (Ferrara et al., 2017)



Thermal imagery of the Bruce A and B Nuclear Generating Facilities, acquired by Landsat 5 on August 2, 1988, and calibrated to degrees Celsius (IAEA)

From Classic Security to New Security

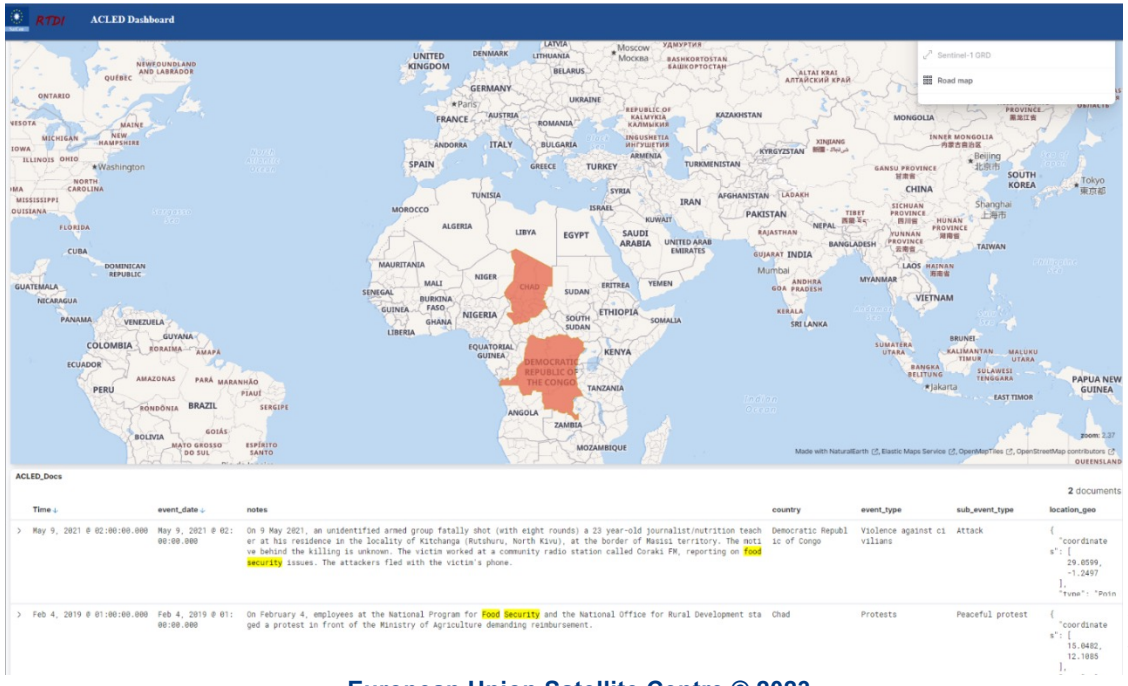
The new security concept considers also the links of different domains with the security of citizens and societies

- **Humanitarian Aid**
- **Contingency Planning**
- **Border Surveillance**
- **Security Surveillance**
- **Critical Infrastructures**
- **Disaster**
- **Climate Change**
- **Resource Scarcity**
- **Environmental Activities**
- **Health Security**
- **Pandemics**
- **Extreme Weather Events**

SatCen

Examples: Climate Security

- Thermal Remote Sensing could provide support to analyze vegetation status, vegetation stress (*e.g. food security*)
- Environmental and climate data need to be integrated with “ancillary” data (*e.g. World Bank[1], ACLED[2], EM-DAT[3]*)
- Machine Learning models should be used to better understand the causalities between them (*e.g. is it possible to correlate droughts with migration?)*



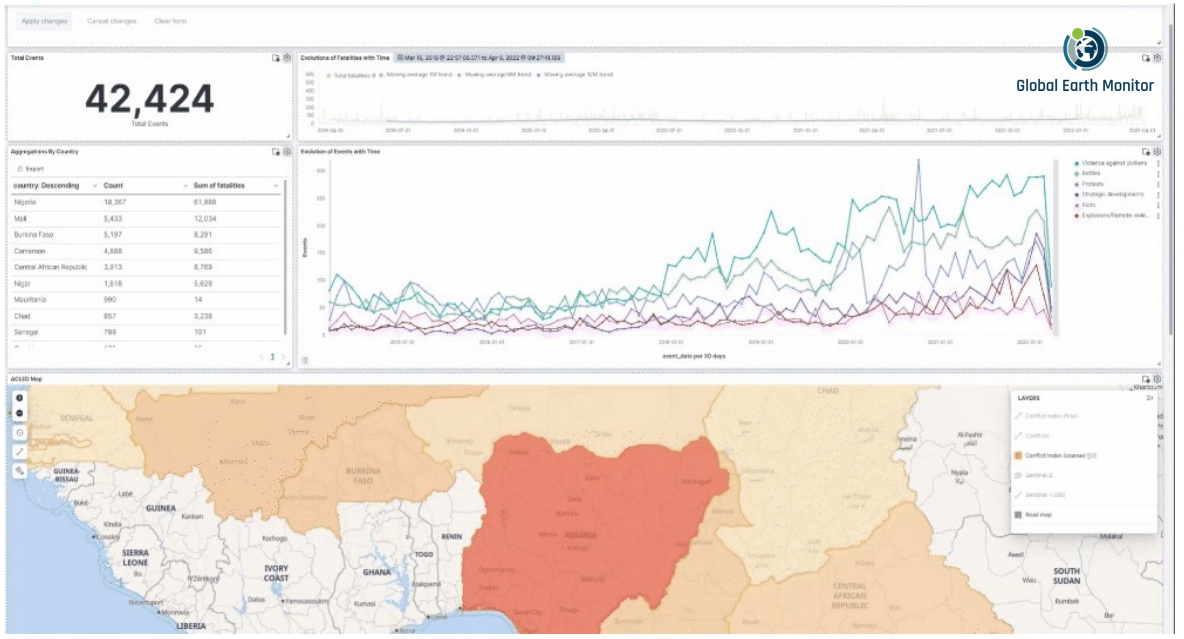
[1] https://data.worldbank.org/
[2] https://acleddata.com/
[3] https://www.emdat.be/database

Examples: Climate Security

SatCen RTDI interface allows users to:

- select relevant variables to be loaded, filtered, aggregated and visualized in the map
- running and visualizing certain ad-hoc analysis (aiming to have an overview about the seasonality, global trends and anomalies of the data)

Initial tests have been done with floods, the interface will continue to ingest new data (e.g. drought, vegetation stress) to offer a more complete overview on climate security issues.



GEM received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no 101004112

Needs from the security domain

Requirements	Should
Spatial Resolution	< 50 m for environmental features (e.g. water bodies) < 5 m for man-made structures (e.g. buildings) < 1 m for vehicle activity
Revisiting Time	Constellations could guarantee a constant monitoring above a specific areas, satellite overpass close to other missions
Temporal Coverage	Day and night acquisitions capability expands acquisition windows
Accuracy	Absolute temperature is important but being able to measure the difference of temperature between objects might be even more important (i.e. relative temperature)
…	…

Conclusions

1. Thermal sensors are offering different applications for the security domain
2. The availability of HR thermal data on a wider scale, coming from public and private actors, would be a game changer
3. New Security is a complex and transversal domain that requires an holistic approach with different data and innovative technology
4. The involvement of users in the design and validation phases is key to succeed in future user uptake of the developed services

SatCen

Thank you!

rtdi@satcen.europa.eu