POLITECNICO DI MILANO





Spatial information for monitoring and management of built environment in support to European Energy efficiency Policies

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G-Ic@rus LAB - Geospatial Information & Content modelling: Architectural heritage&built environment

- Climate change and need for Energy monitoring of Built environment
- **FP7 project GE2O** - Geo-clustering to deploy the potential of Energy efficient Buildings across EU
- **RL SINOPIAE project**: Focus on T° increase in urban areas and the energetic dispersion of buildings
- Concluding remarks

ONE OF THE MAIN CHALLANGES FOR ENVIRONMENT MONITORING IS CLIMATE CHANGE

Commission Directive 2012/27/EU on energy efficiency
Energy efficiency of Resources
Energy efficiency in Buildings
→ Smart Cities

challenges are increasing rapidly

Research community is called to propose innovative and sustainable **solutions**

In response to
KYOTO PROTOCOL
INNOVATION UNION
EU2020
EU2050 TARGETS
…

ENERGY EFFICIENCY FOR BUILT ENVIRONMENT

Local authorities to propose and implement **holistic problem-solving approaches,** integrating the most appropriate technologies and policy measures. This would involve ambitious and pioneer measures in **buildings, energy networks and transport**.

Buildings New buildings & Refurbish of the existing buildings

Energy networks

Heating and Cooling

- New cost effective biomass, solar thermal and geothermal app.
- Innovative hybrid heating and cooling
- Highly efficient co- and tri-generation and district heating/cooling

Electricity

- Smart grids
- Smart metering and energy management systems.
- Smart appliances (ICT, domestic apps), lighting and equipment
- foster local RES electricity production (PV and wind applications).

Transport

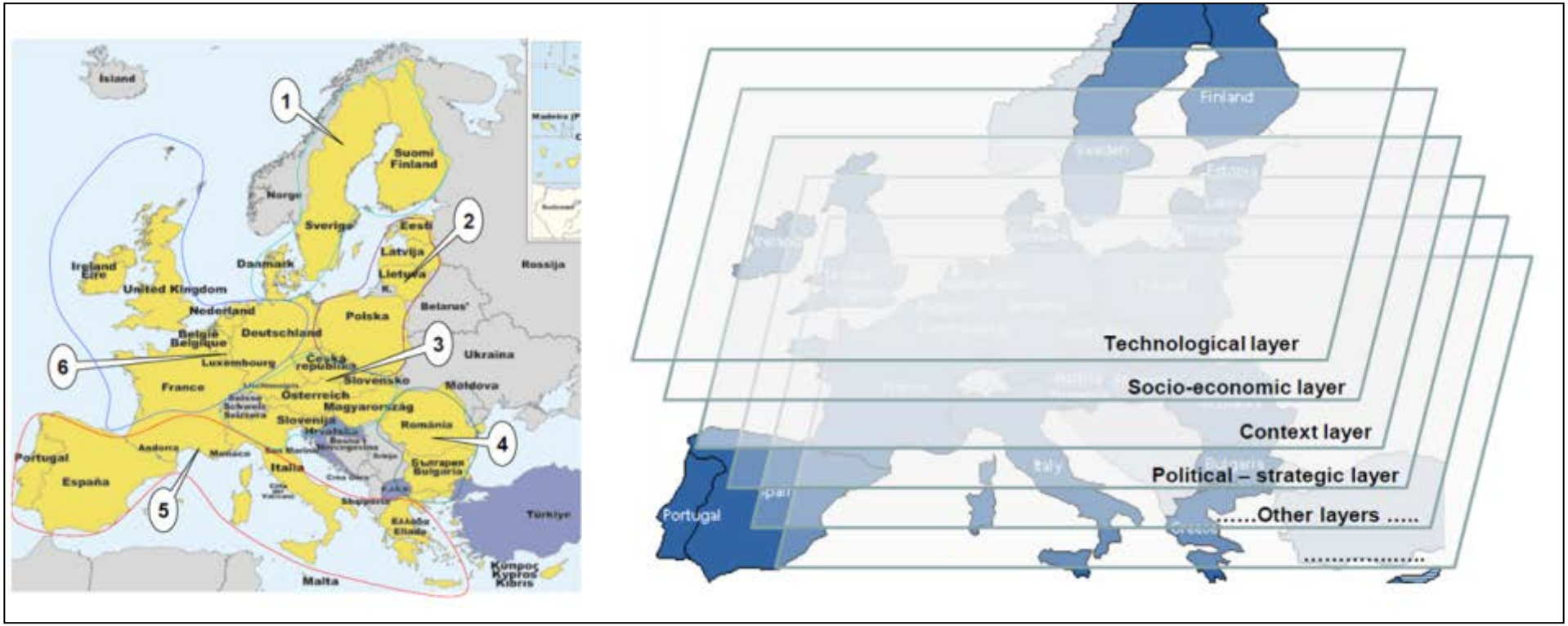
- low carbon public transport and individual transport systems
- Sustainable mobility: advanced smart public transport, intelligent traffic management

Geospatial technologies

+ GPS/IMU
+ DSMs/DTMs
+ 3D/4D city models
+ Facility management
+ Mobile Mapping
+ Imagery: satellite, aerial, terrestrial (street views)
+ Maps, plans
+ Historic data
+ LBS, “smart” apps
+ Sensors in WEB 2.0
+ Sensors in smart buildings
+ GIS/SIS
+ Visualization/simulation/animation

NEED FOR DATA INFRASTRUCTURE ON EUROPEAN LEVEL

The concept of "Geo-clusters" regards virtual trans-national areas where strong similarities are found in terms of climate, culture, behaviour, construction typologies, economy, energy price and policies, gross domestic product, etc.



Geo-cluster map is not based on fixed geographic regions, but is to be considered as a multi-dimensional and dynamic tool.

STEP BY STEP

Analyses of available data across EU

availability, granularity (NUTS level in EU), homogeneity, …

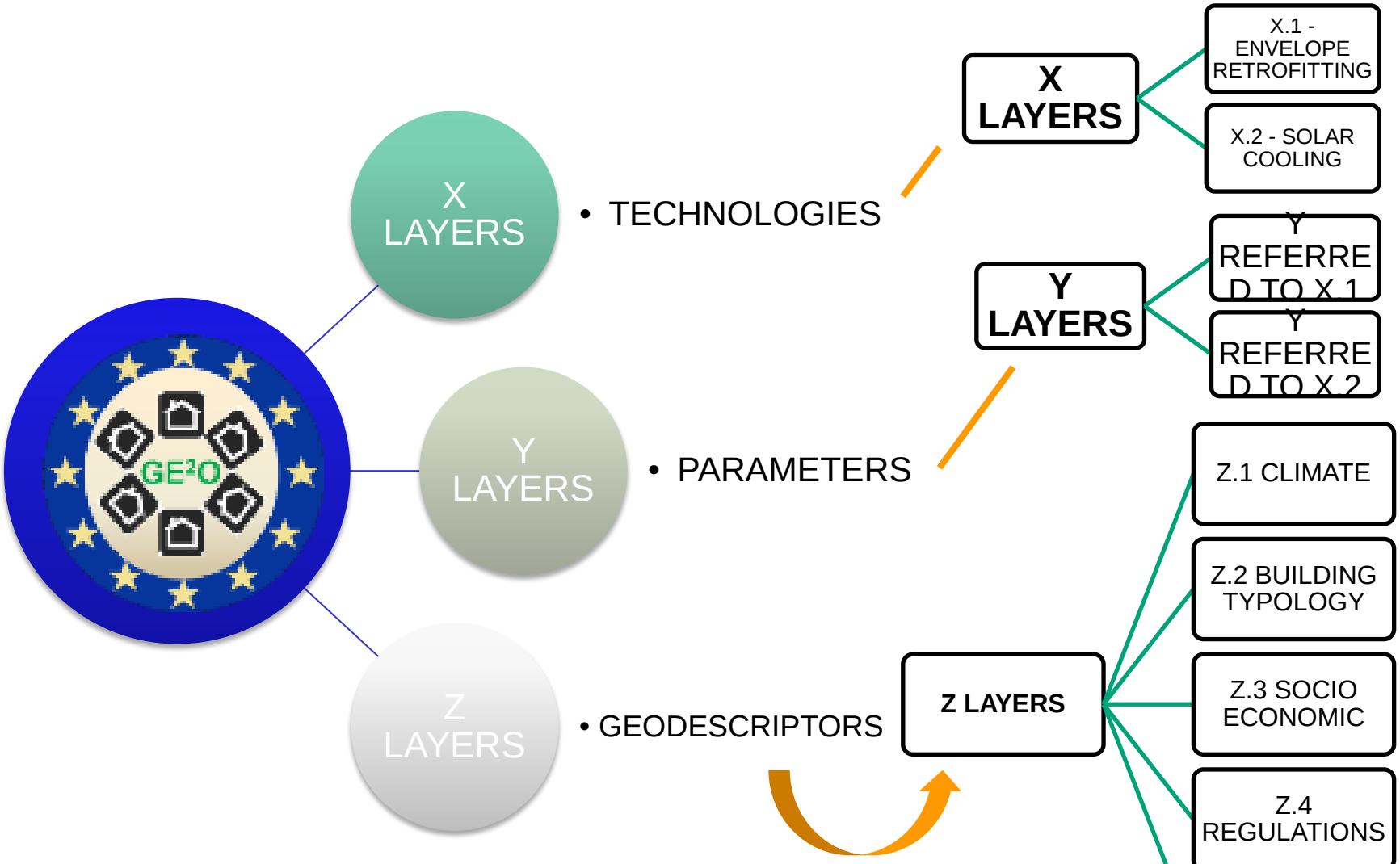
Identification of their respective structure (layers and sub-layers):

to easily identify the term of the correlations.

Definition of the correlation proposals for each layers:

exchange between partners for the validation of the proposals.

3D MODEL STRUCTURE



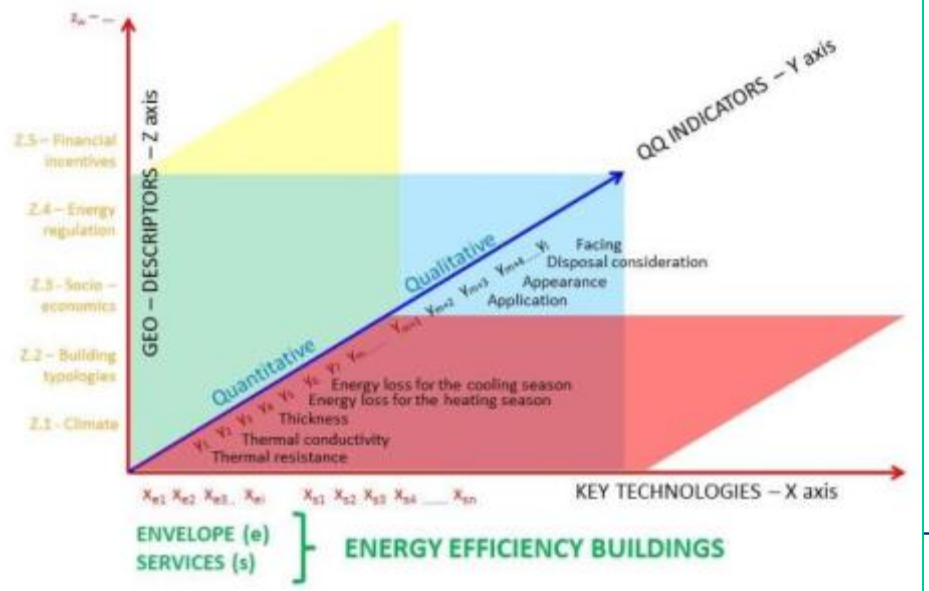
ITERATIVE PROCESS

AVAILABLE DATA AT EU LEVEL

GE²O

MAPPING TOOL

The 3D matrix exemplification in the XYZ axis



2 PILOT CASE AREAS: BENELUX AND MEDITERRANEAN

X1 ENVELOPE RETROFITTING CORRELATIONS

X2 SOLAR COOLING CORRELATIONS

Z Layers results : GEO-DESCRIPTORS

Z.1 CLIMATE CORRELATIONS

Z.2 BUILDING TYPOLOGY CORRELATIONS

Z.3 SOCIO ECONOMIIC ASPECTS CORRELATIONS

Z.4 REGULATIONS CORRELATIONS

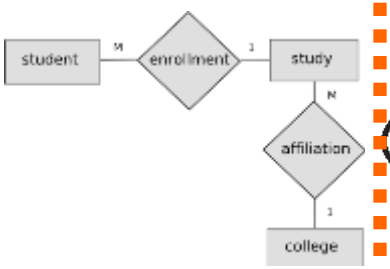
Z.5 FINANCIAL INCENTIVES CORRELATIONS

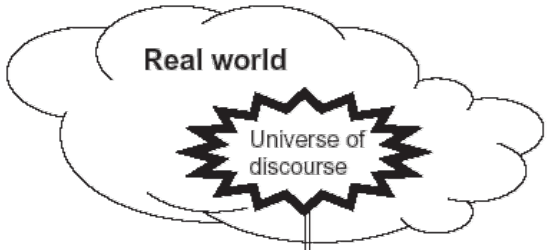
CONCEPTUAL SCHEMA

Conceptual formalism: rules, constraints, functions, processes and other elements that make up a **conceptual schema language**

Real situation:
CLIMATE CHANGE

3D





defined in

Conceptual formalism

provides concepts for describing

Conceptual model

basis for one or more

formally represented in

Conceptual schema language(s)

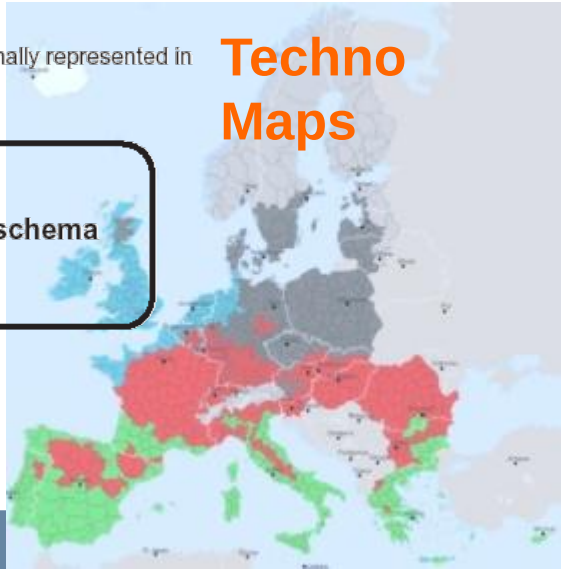
Lexical languages

Graphical languages

provides formal language for representing

Conceptual schema

Techno Maps



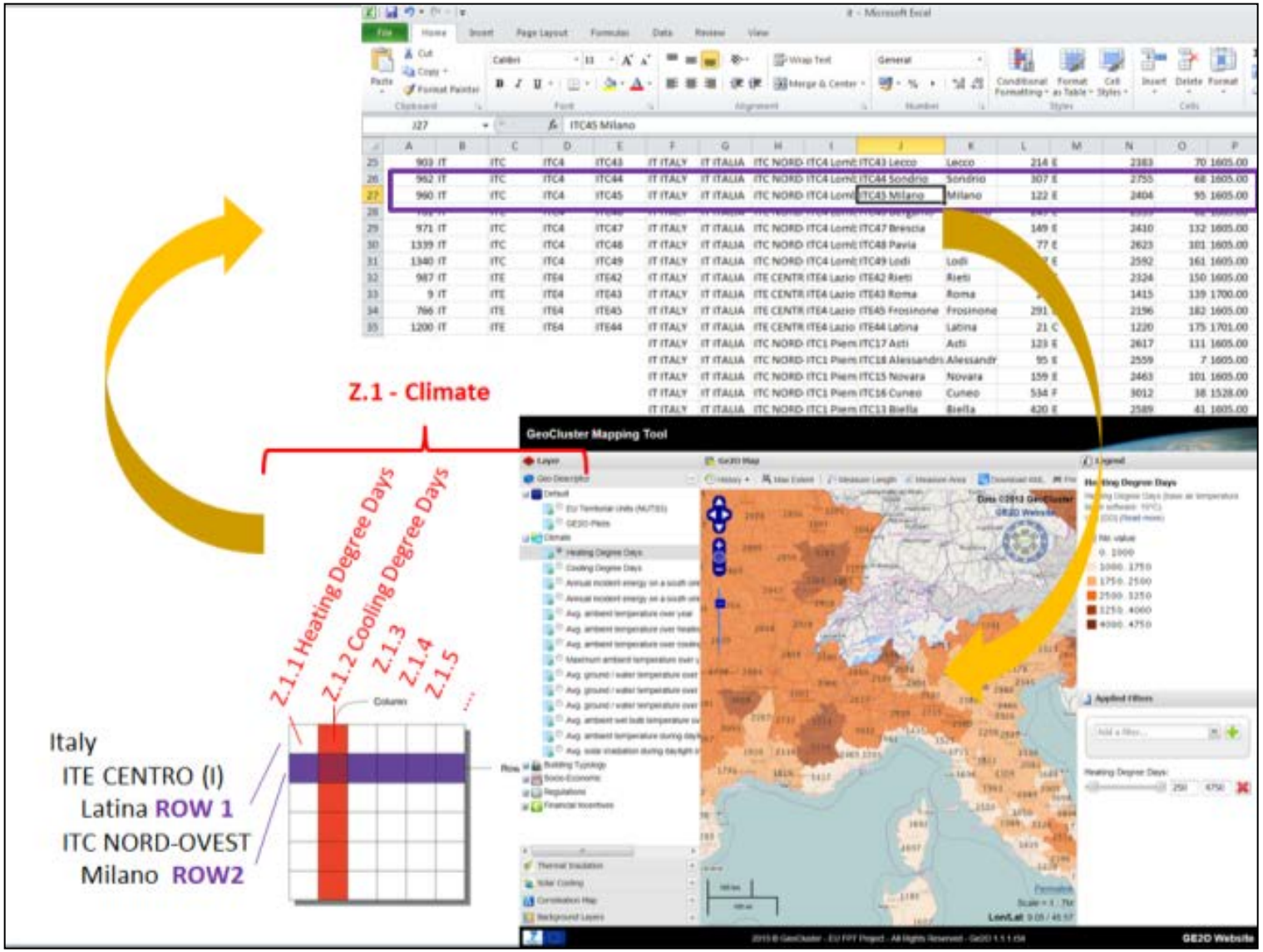
ISO 19101 Reference model: From reality to conceptual schema

EE for buildings: EU Geo-portal
http://www.geoclusters.eu/ge2O/

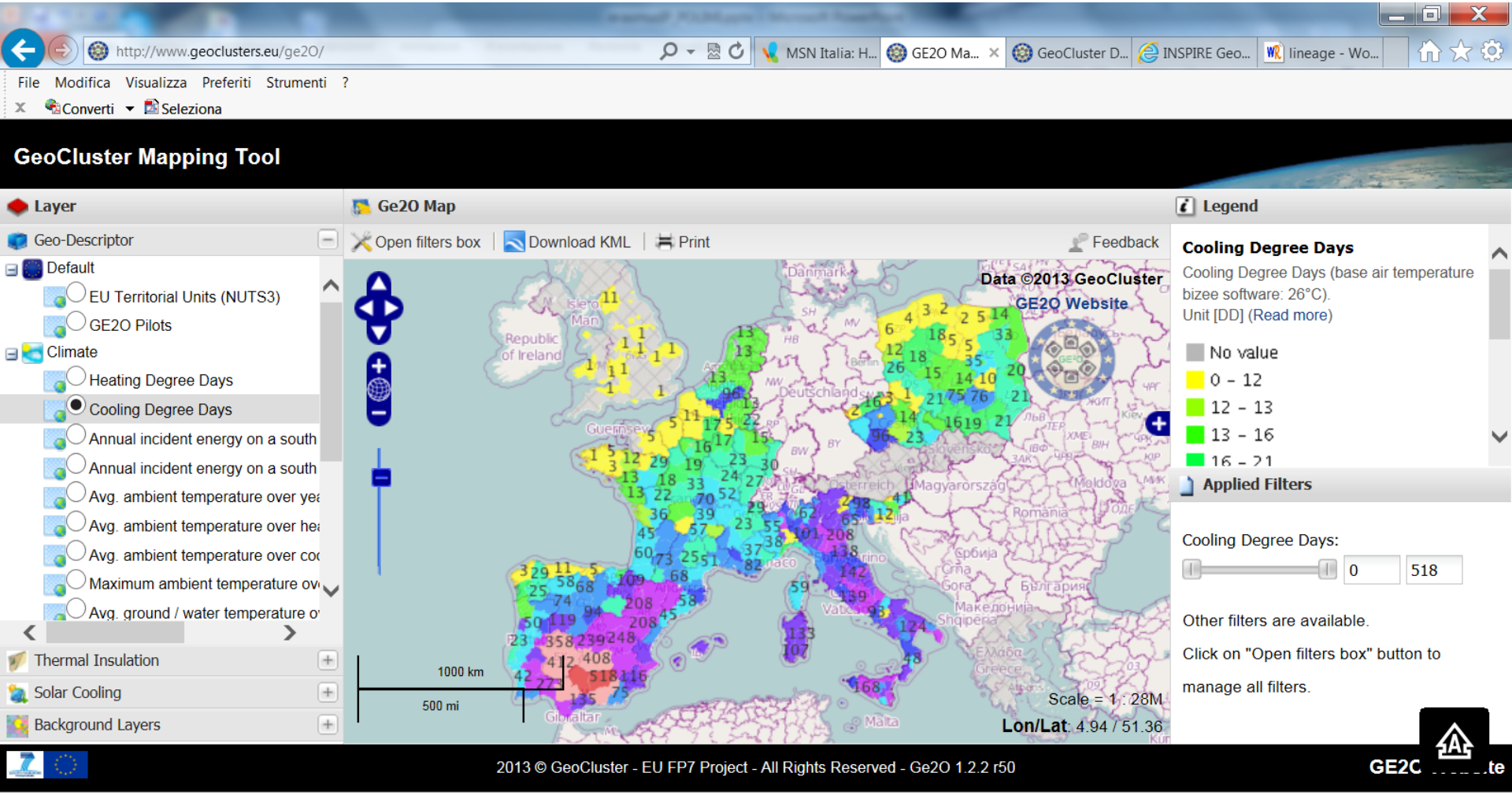
ROW/ COLUMN SYSTEM

NUTS 3 VECTORS : every geo-unit is described by a vector of elements

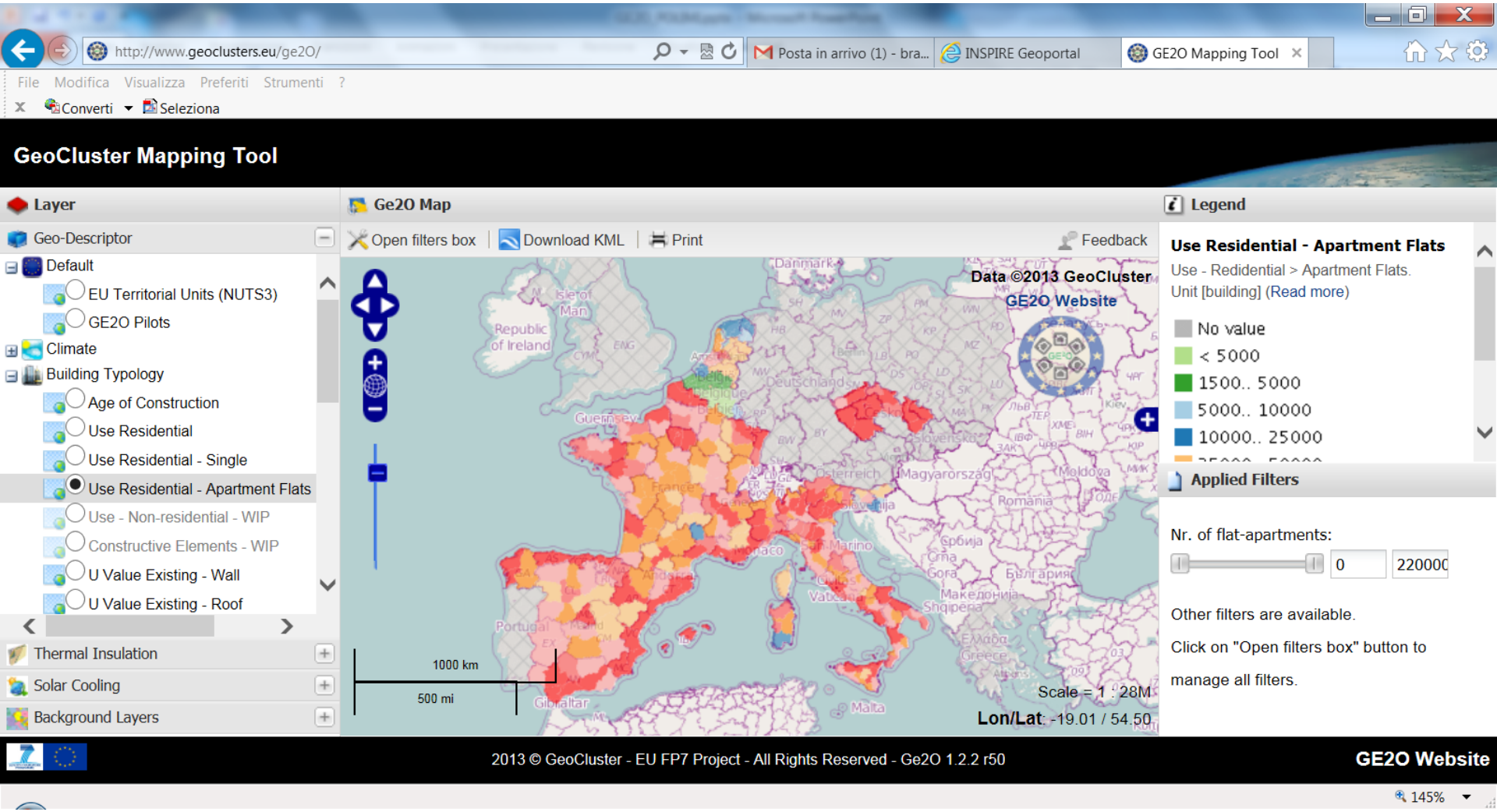
Technological Geo-MAP



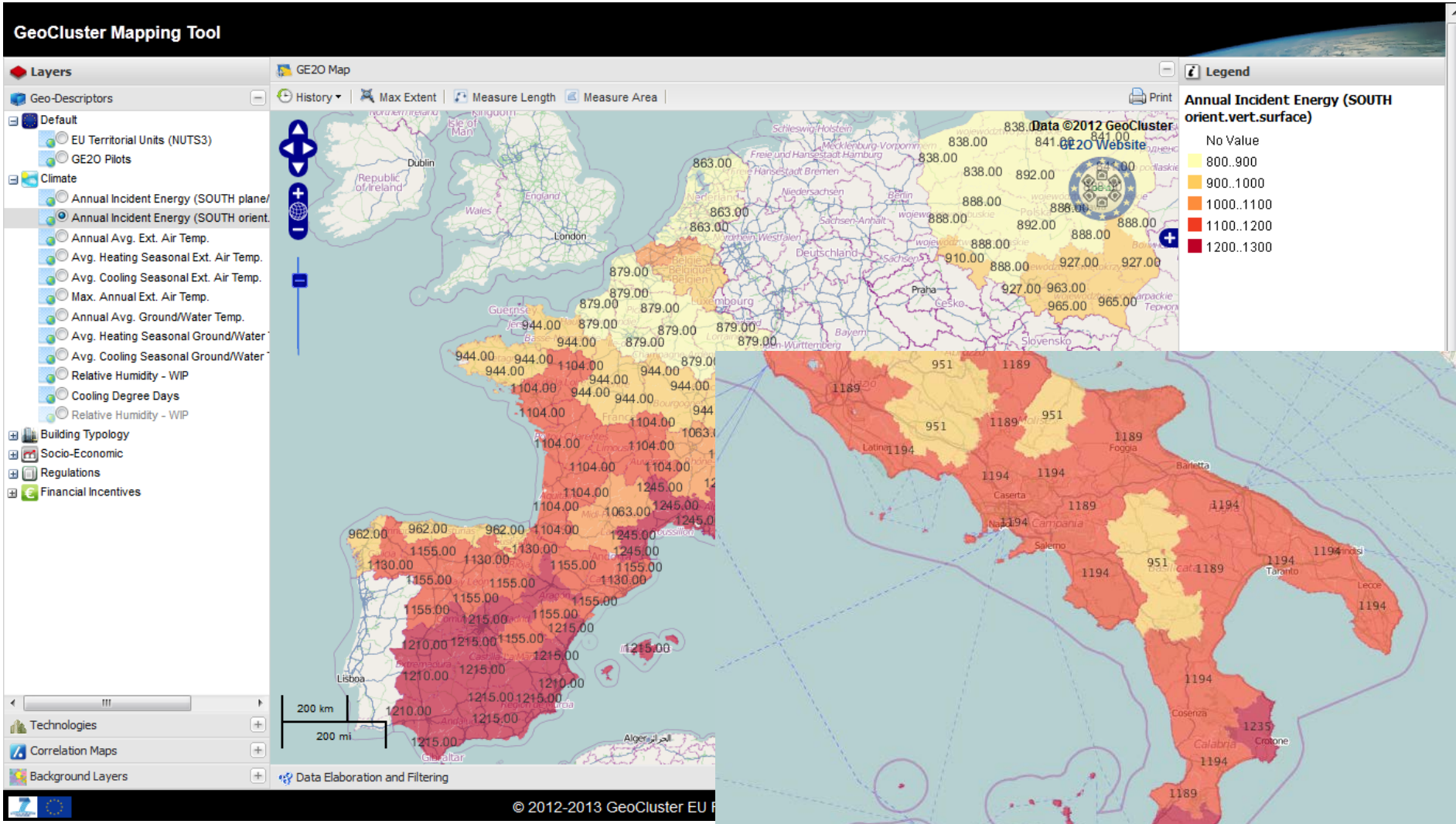
THEMATIC MAPS EXAMPLE: Cooling degree days



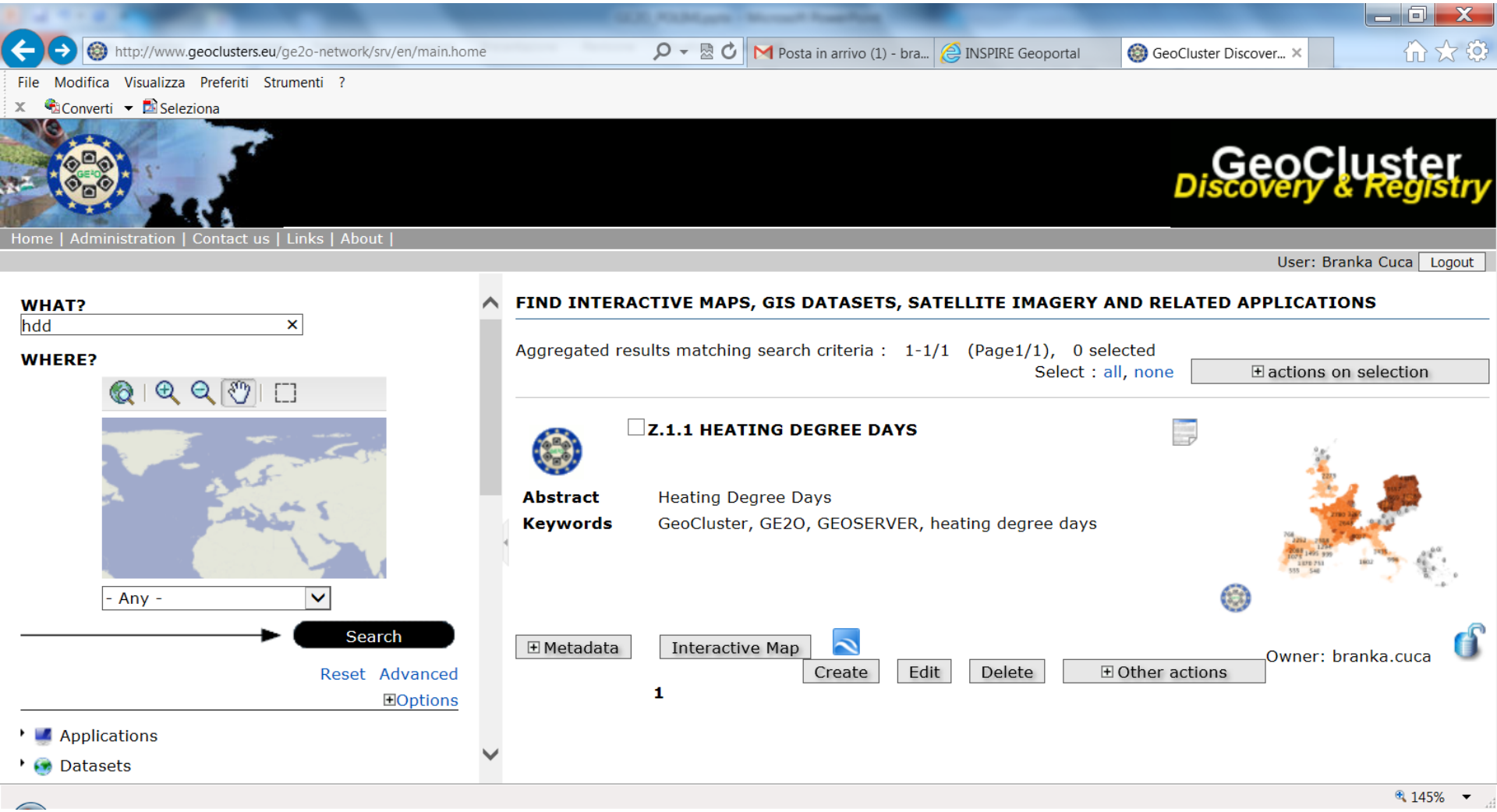
THEMATIC MAPS EXAMPLE: Building Use - Residential



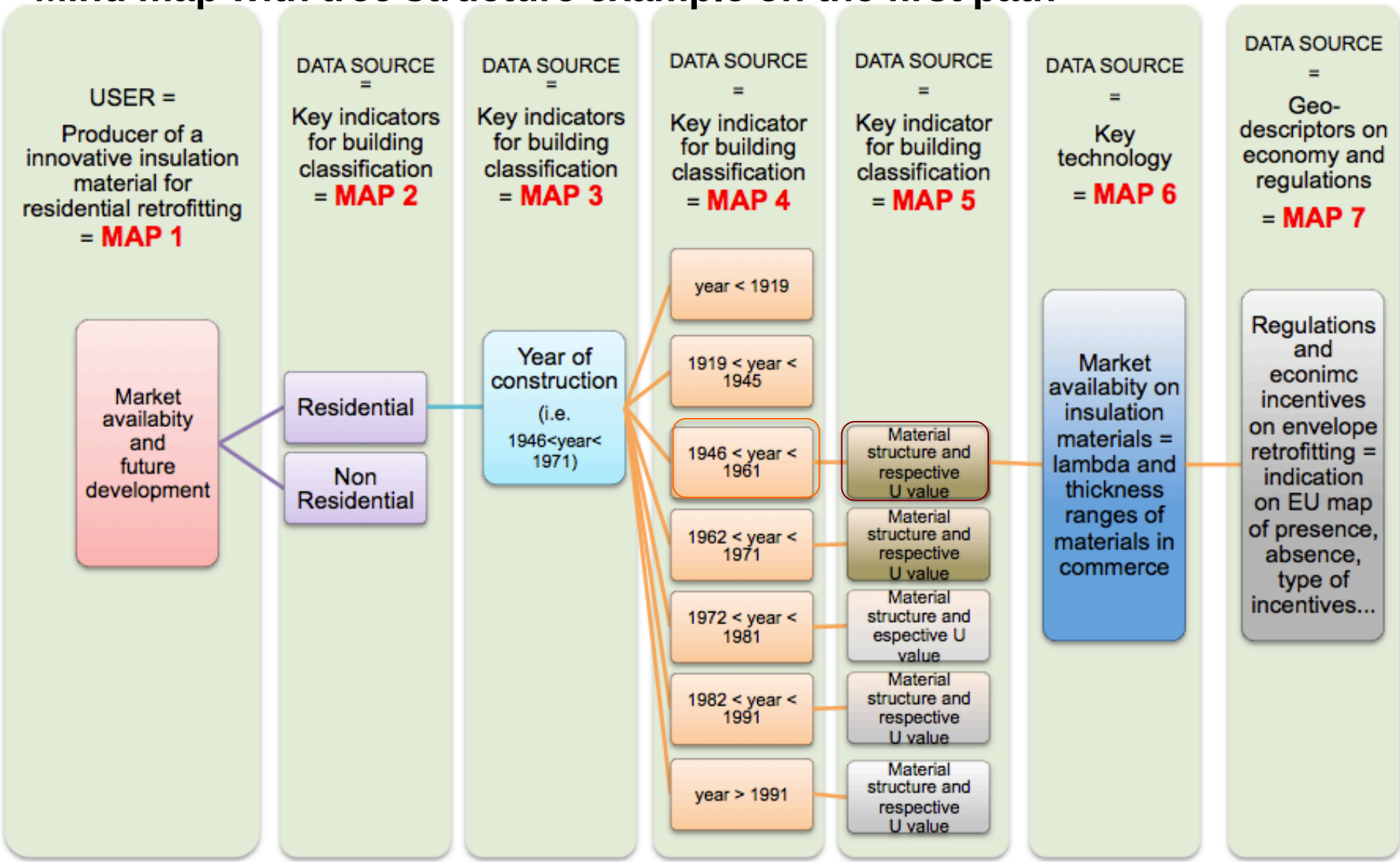
THEMATIC MAPS EXAMPLE: Annual incident energy



THEMATIC MAPS EXAMPLE: METADATA GE2O INSPIRE COMPLIANT

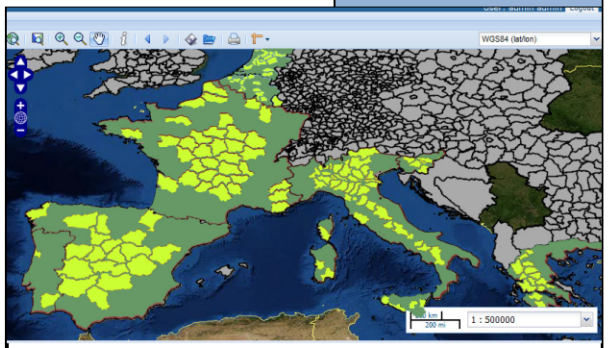
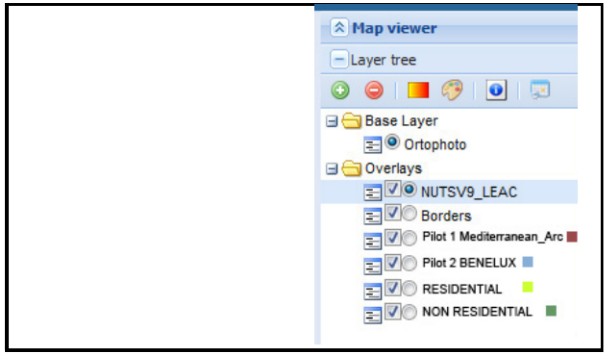


Mind map with tree structure example on the first path



START

Path example as an illustartion of the mapping tool finctionalities

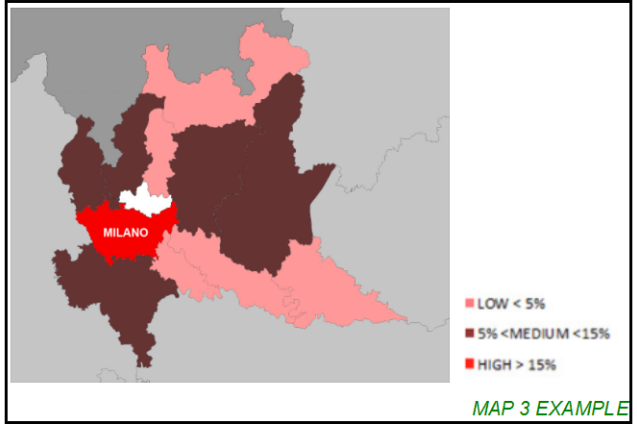
QUERIES	My industry is located here, I would like to individuate where the market development areas are compared to my position			My product is an innovative product expecially for external residential wall retrofitting and I have to check the potential market for residential building		
	STEP 1	>	MAP 1	STEP 2	>	MAP 2
USER 1 = PATH 1 >	*User insert his geographical coordinates*	Tool processes the localization	*EU map with a point on the user coordinates*	*Building use*	Tool processes the Z data from building classification	*EU map with two different ICON AND ITS OWN DATA NUMBER for the building use at NUTS 3 level (ICON RESIDENTIAL with DATA, ICON NON RESIDENTIAL with DATA)*
ALGORITHMS		*algorithm for the geographical coordinates*	v		*algorithm to allocate number and right icon at NUTS 3 level for building classification*	v
MAPS	 *MAP 1 EXAMPLE*			 *MAP 2 EXAMPLE*		
PRACTICAL SUGGESTION, PROPOSALS AND INDICATIONS FOR DATA, ICON, COLOURS FOR THE TOOL						

::: FAKE DATA :::

My product is easily applicable on mansory wall and all the technolocical constructive solutions diffused after the second war world, how many residential buildings have been constructed i.e. between 1946 and 1971?

STEP 3	>	MAP 3
Data of construction	Tool processes the Z data from building classification	Lombardia map example on the period of construction 1946 <y < 1962

algorithm to allocate right colours for building construction period

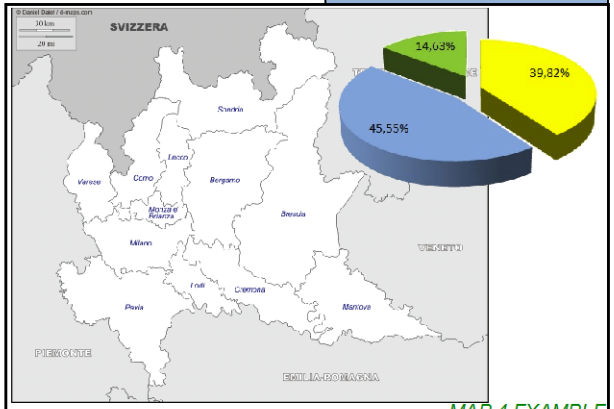


MAP 3 EXAMPLE

My product is easily applicable on external mansory wall, how many residential buildings have these conditions?

STEP 4	>	MAP 4
Building classification in function of the material used for the structure	Tool processes the Z data from building classification	EU map with different colours at NUTS 3 level in function of structure material used

correlation between previous data on structure and construction date

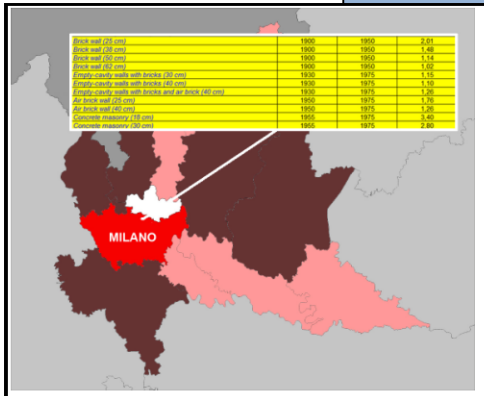


MAP 4 EXAMPLE

With these characteristics, the thermal transmittance of the external wall could be considered equal to? I need this information to design correctly the Uvalue that I would like to reach with the envelope retrofitting

STEP 5	>	MAP 5
Uvalue of the envelope in function of the structure	Tool processes the correlation between STEP 3 and STEP 4 to give as output the STEP 5	Lombardia map example with the indication of hypothetical Uvalue for the external wall diffused in the period of construction considered

correlation between previous data on structure, construction date and U value assumed



MAP 5 EXAMPLE

DATA EXAMPLE FOR ITALIAN CONSTRUCTION PERIOD CLASSIFICATION

	Before 1919
	1919 - 1945
	1946 - 1961
	1962 - 1971
	1972 - 1981
	1982 - 1991
	> 1991

DATA COLLECTED AT NUTS 3 LEVEL

DATA EXAMPLE FOR ITALIAN STRUCTURE MATERIALS USED

	Bearing wall
	Reinforced concrete
	Other

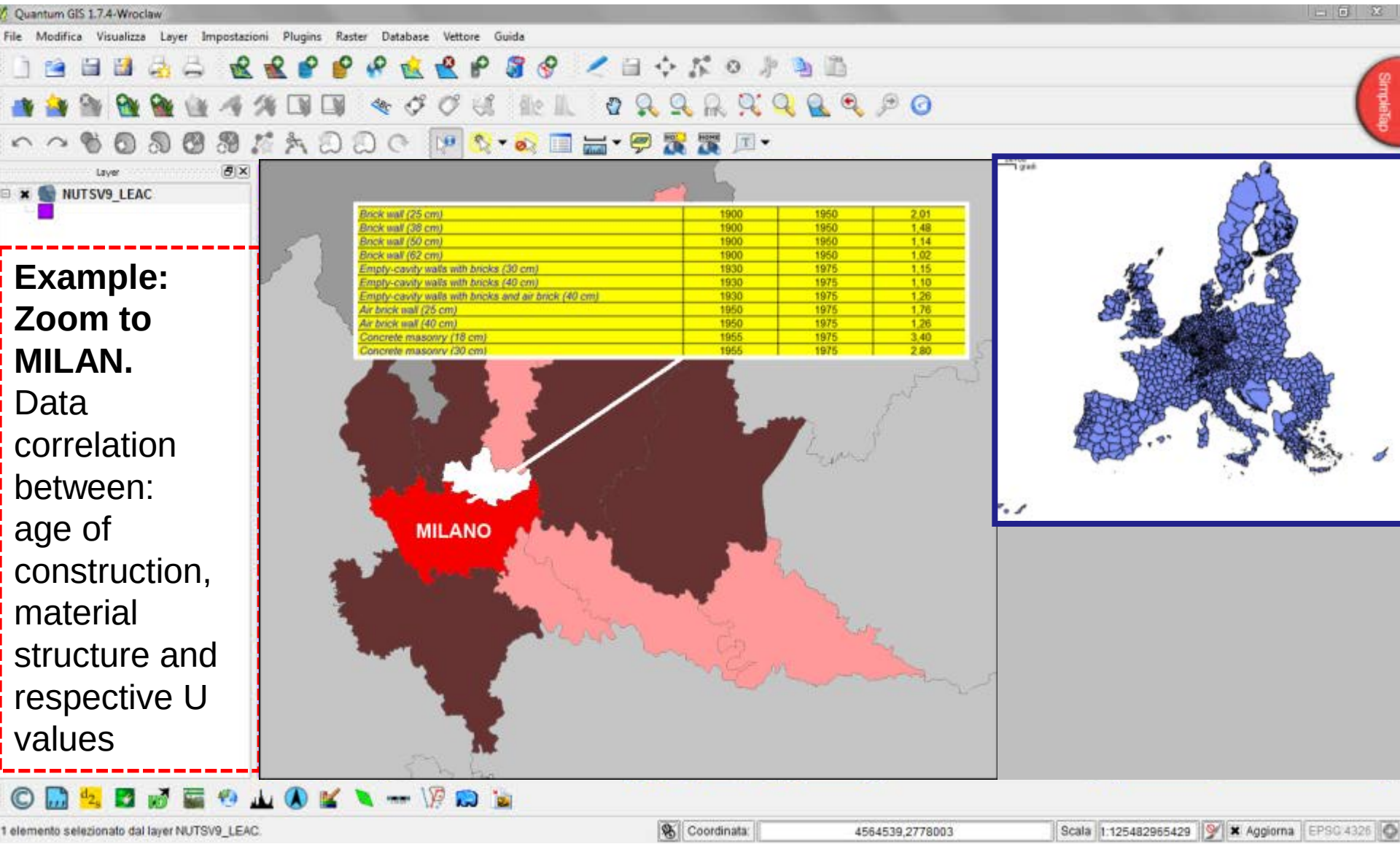
DATA COLLECTED AT NUTS 3 LEVEL

DATA EXAMPLE FOR ITALIAN Uvalue classification

See excel BUILDING CLASSIFICATION_POLIMI_ data from Tabula

::: REAL DATA for Lombardy region :::

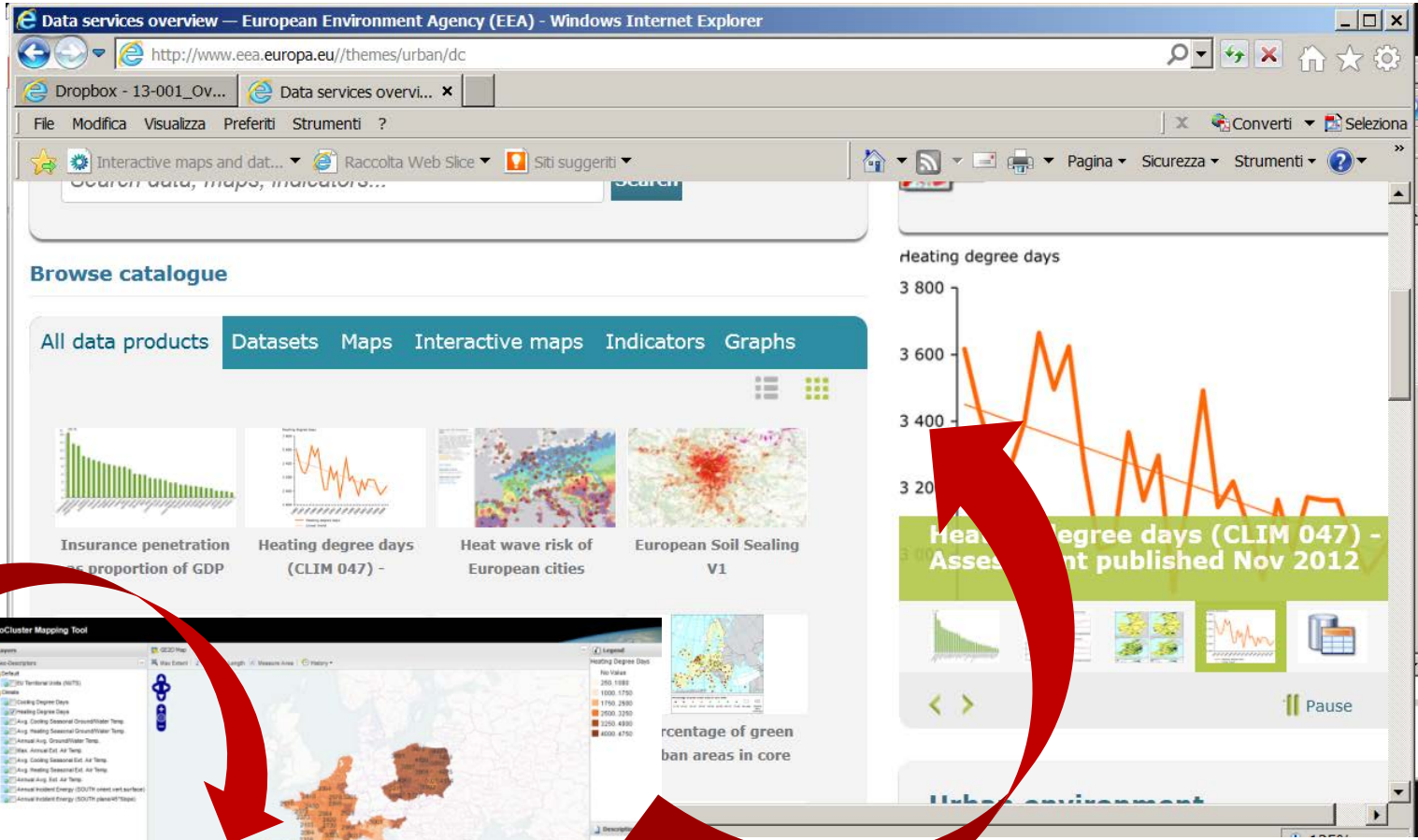
Example: Zoom to MILAN.
Data correlation between: age of construction, material structure and respective U values



EEA IMPLEMENTATION BY GE2O DATA

EEA DATA and SERVICE + IR HR SENTINEL-3 HEAT ISLAND 10m terrain resolution + to be added by GE2O DATA and

Heating degree days>> CLIM047 >>Nov 2012



EEA ENERGY THEME URBAN ENVIRONMENT THEME

Source: http://www.eea.europa.eu/themes/urban

GE2O: TOWARD LOCAL GEOCLUSTERING

GEOSPATIAL DATA for Urban Heat Island monitoring and planning policies in the cities

EEA DATA and SERVICES

→ can be implemented by GE2O DATA and SERVICE

→ share DATA and SERVICE at a local level (municipality) to address retrofitting policies

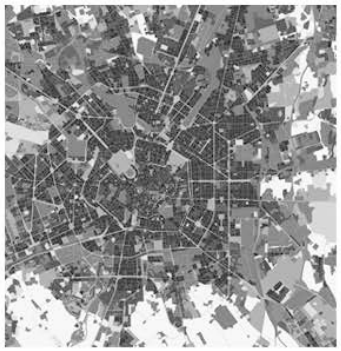
EO/COPERNICUS Data for monitoring of Built Environment

The effective feedback of energy consumption can actually increase **public awareness** and help to reduce it significantly.
From a remote sensing perspective, one method to improve energy efficiency is to use **thermal sensors** to identify temperature anomalies or what could be called **"Hot Spots"** in urban structure where the heat is lost in significant values. **Thermal infrared (TIR) remote sensing or *Thermography*** can be useful to provide: **(i) land cover classifications; (ii) urban heat island analysis; (iii) residential heat loss/waste heat mapping; and (iv) roof moisture surveys**, and so on.
(Darby, S., Hay, G.J. et al, Weng, Q. Voogt, J.A.&Oke, T.R.)

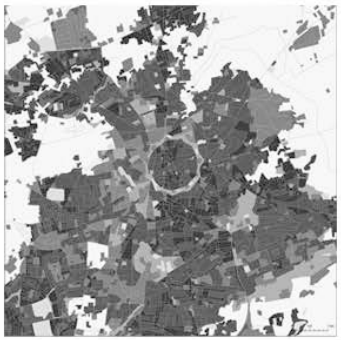
According to "**Global IR Imaging Market (2012-2017) - Forecast, Trend and Analysis Segmentation by Spectrum Range, Applications and Geography**", the value of IR imaging market was $2183 million in 2011 and is expected to reach **$3861 million in 2017**. In Europe, many cities in UK have already employed TIR sensors in their areal coverage, considering it valuable for energy consumption mapping.

EO/COPERNICUS Services for monitoring of Built Environment: URBAN ATLAS

One practical example of using the remote sensing technologies for mapping of cities is European Urban Atlas **initiative, part of the** local component of the EO/Copernicus Land monitoring services**.** http://www.eea.europa.eu/data-and-maps/data/urban-atlas#tab-methodology



CITY



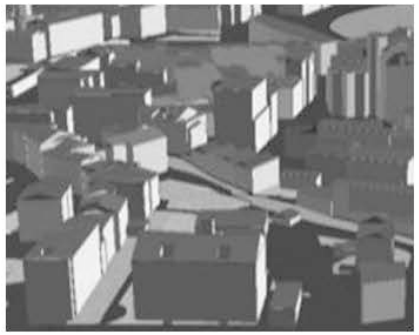
SHIFT OF SCALE

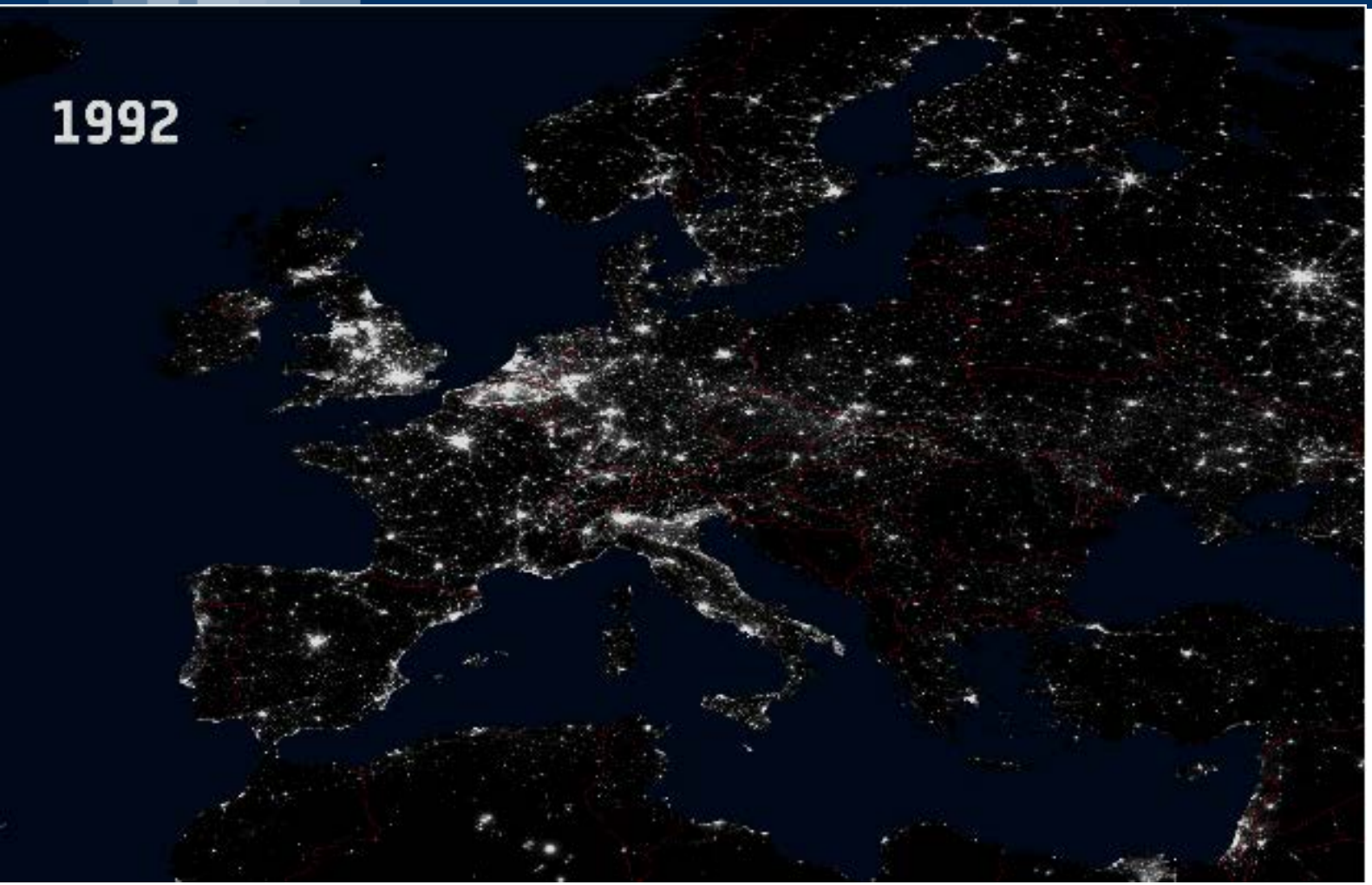
PROGRESS IN TECHNOLOGIES
REMOTE SENSING, SURVEYING AND DOCUMENTATION

State of Art	Implementation	Results
Current employment of **surveying technologies and geo-spatial information** for cities (ex. Urban Atlas) and **requirements** of PAs, professionals, public	Methodology development for **monitoring, mapping and management** of districts of existing buildings is cities across EU	**EE SDI** combining historic info, current maps and new surveying information **Geo-portals and Geo-tools** for tackling real-life problems regarding EE in districts **Abacus of districts EE behaviour** useful for PAs, practitioners and citizens

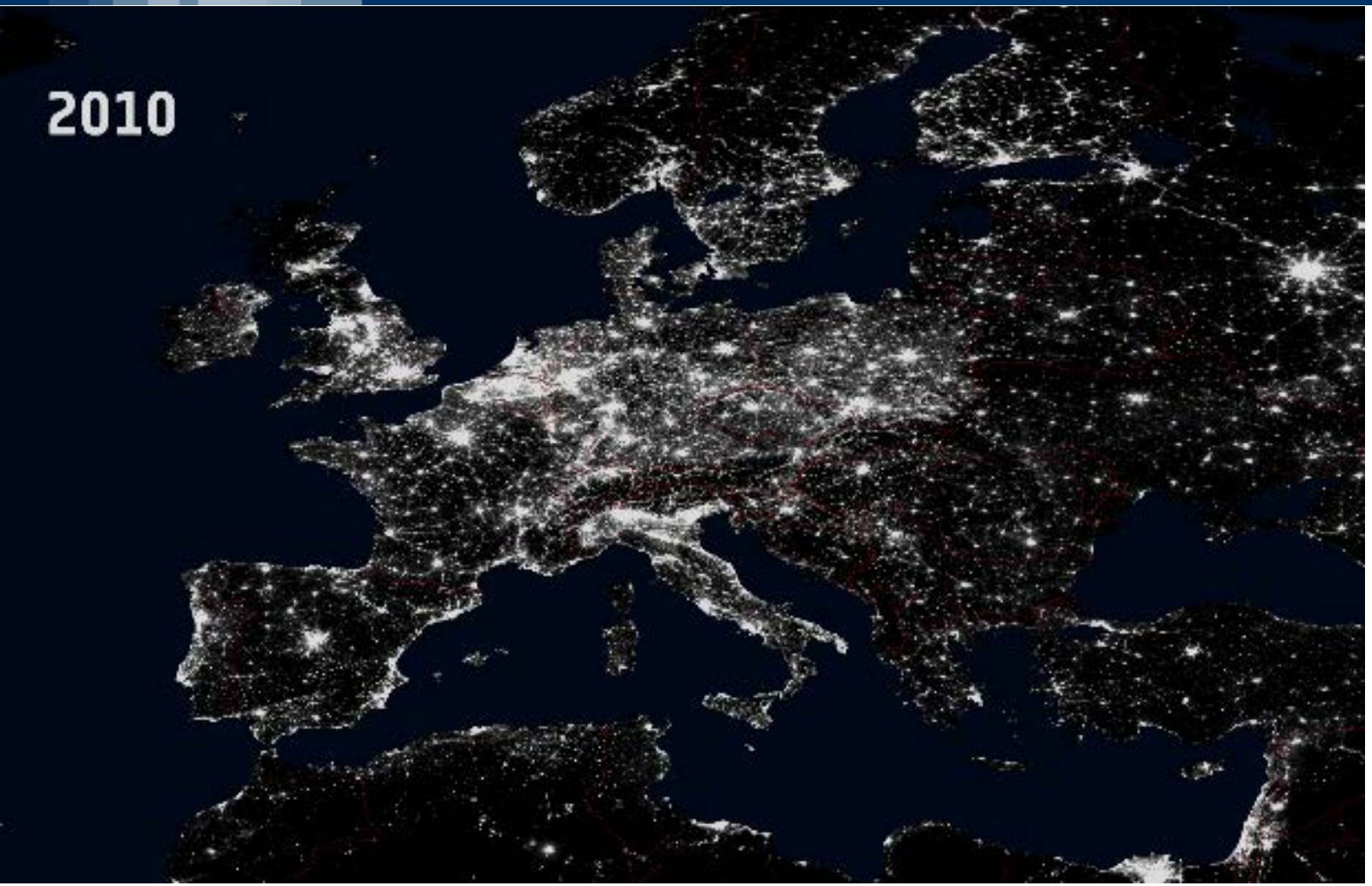
EU/NATIONAL FRAMEWORK
REGULATION AND FINANCIAL INCENTIVES

DISTRICT

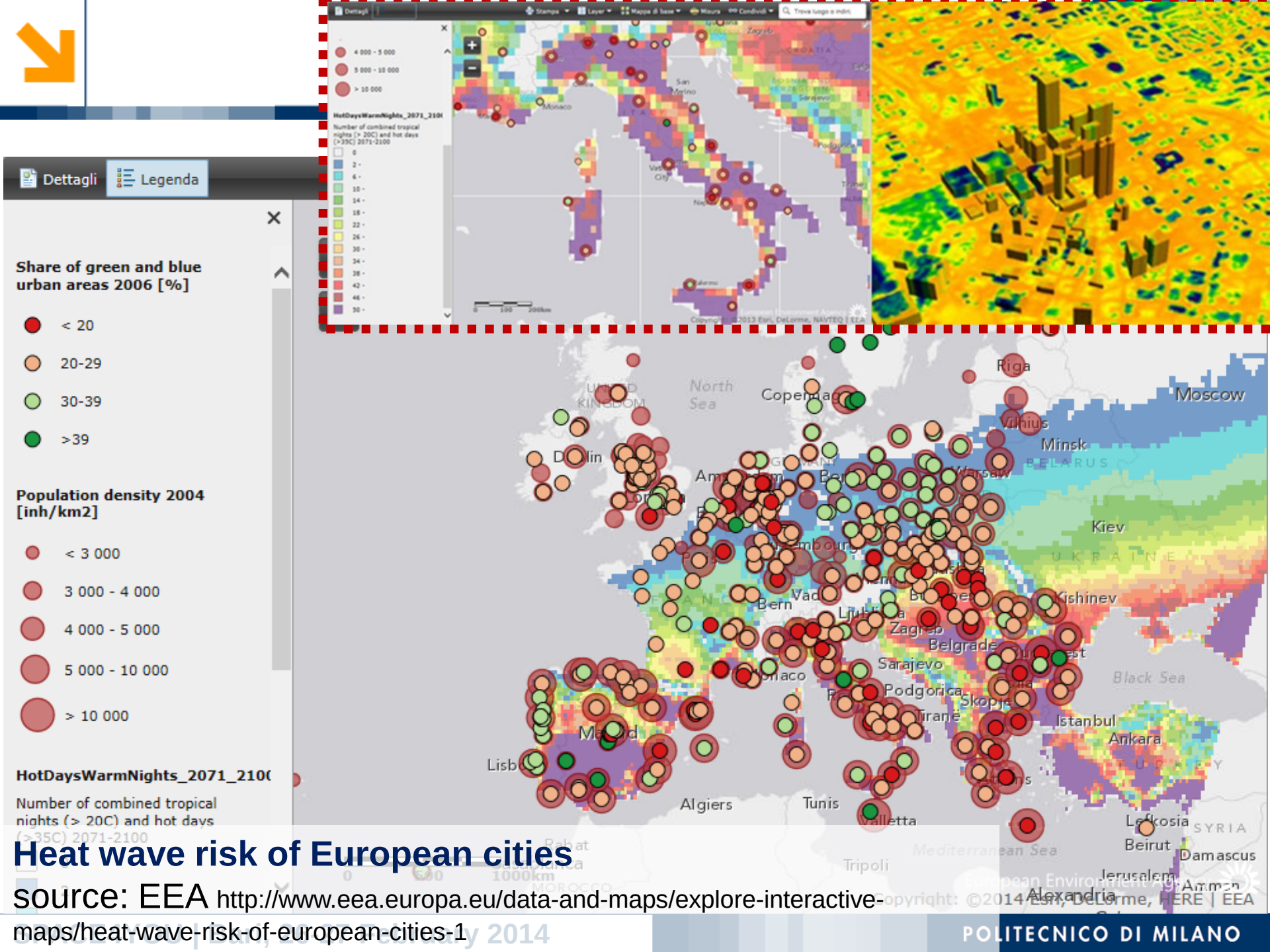




Europe at night, 1992 (images acquired by United States' DMSP satellites)
Source: European Space Agency
http://www.esa.int/Our_Activities/Observing_the_Earth/Earth_from_Space_Night_lights



Europe at night, 2010 (images acquired by United States' DMSP satellites)
Source: European Space Agency
http://www.esa.int/Our_Activities/Observing_the_Earth/Earth_from_Space_Night_lights



Heat wave risk of European cities

source: EEA http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/heat-wave-risk-of-european-cities-1

RL SINOPIAE project

G-Icarus Lab

Methodologies and advanced techniques of recording and surveying of urban environment at urban scale (building-district-urban scale): Laser Scanner, Photogrammetry, Remote sensing, Napping and Monitoring.
Image matching methodologies using Multi-spectral and RGB image blocks (Object Recognition and Reconstruction)
Development of UAV multi-sensor platforms for data acquisition
Development of open source platform, SDI, webGIS, GeoDB
Algorith implementation for 3D texturized modelling

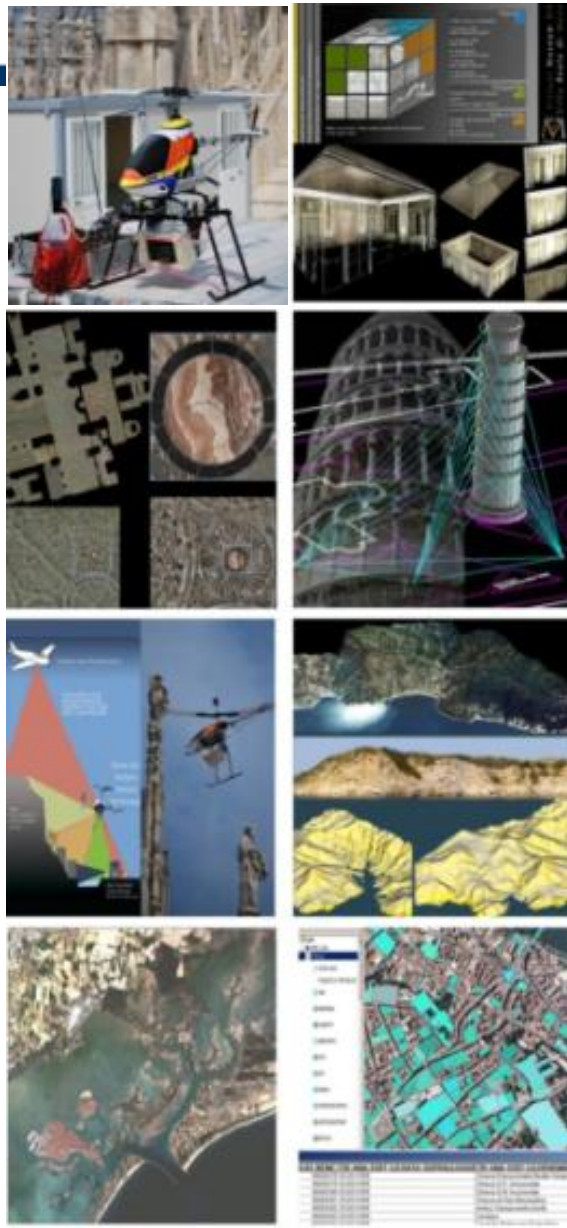
•Research lines regarding Built Environment Monitoring

Objectives

Strategies for re-use and re-cover of existing built environment both from typological point of view but also considering technological and energetic performance issues.
Identification and experiments of sustainable technologies for energetic requalification of existing buildings, considering national and international laws and standards

Methodologies

Building Meteorology and contribution of urban surfaces to the Urban Heat Island (UHI) effect phenomena
Correlation between energy dispersion, technologies used and UHI effect and possibilities for its mitigation



Objective of SINOPIAE (POLIMI team)

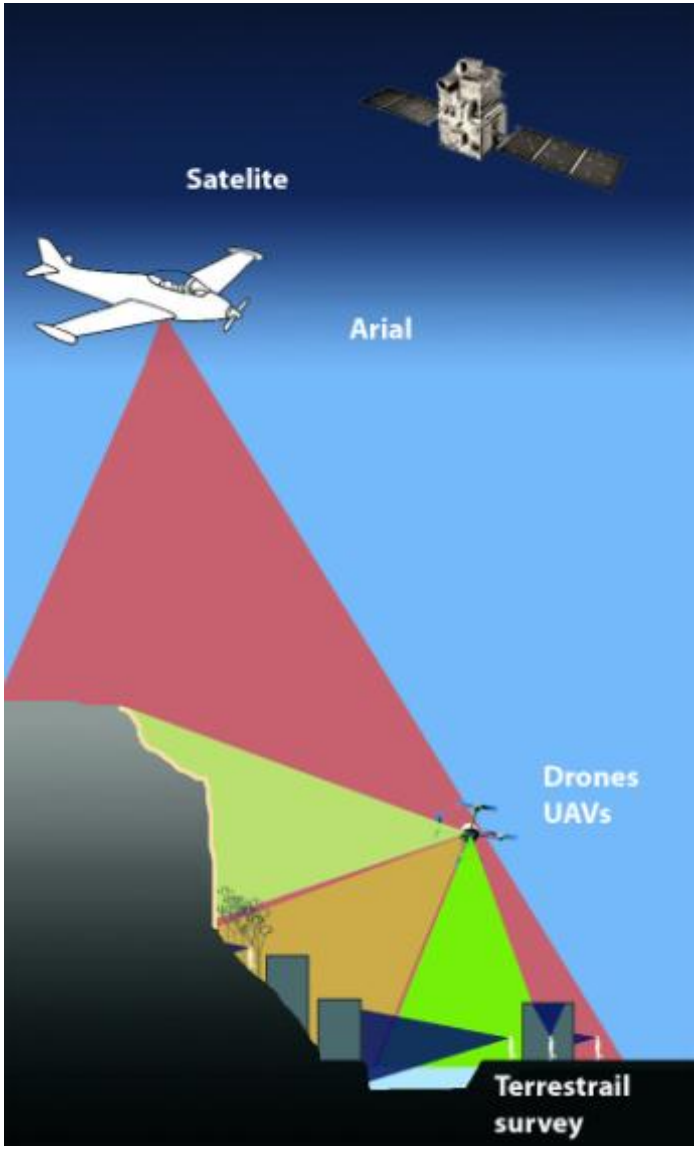
Correlation between the Temperature increase in urban areas and the energetic dispersion of buildings

Innovation:

- New instruments for control and monitoring at urban – district – building scale
- Development of multi-sensor UAV platforms (Polimi)

Copernicus (GMES) Services in response to Grand challenges of Horizon2020

- Energy management and Monitoring (heat island, implementation of Urban Atlas, urban energy dispersion models)
- Orientation of actions, directives and policies regarding retrofitting; impact on overall climate change.



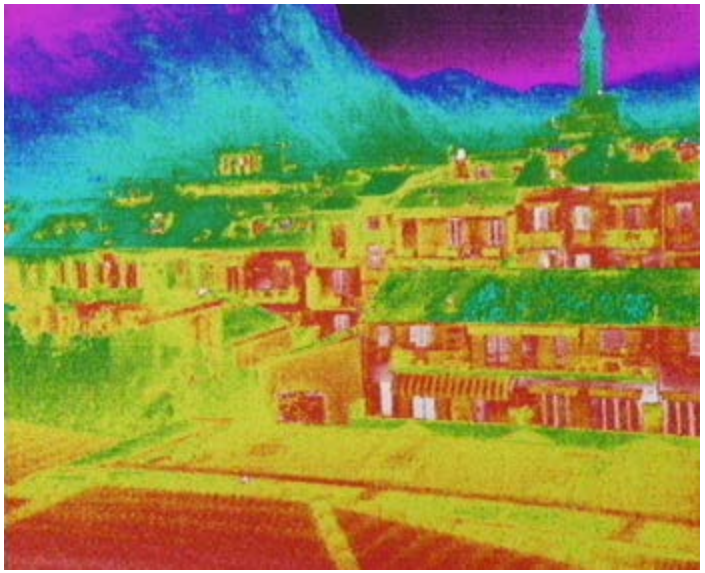
Requirements and preliminary monitoring campaigns

Detection of heat loss in buildings with different technologies to address the energy efficiency policies at the district or building scale

City level experiment

Satellite thermal images

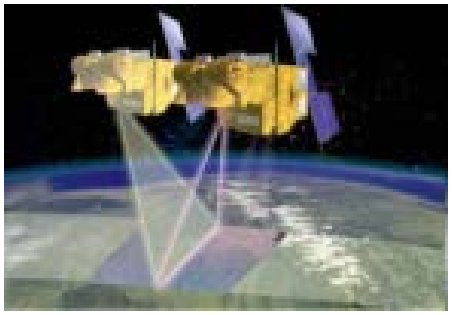
TIR at high resolution (UAV)



Requirements and preliminary monitoring campaigns

Thermal / RGB Image acquisition platforms

Satellite images



Aerial images

UAVs

Close-range images

> 700 km

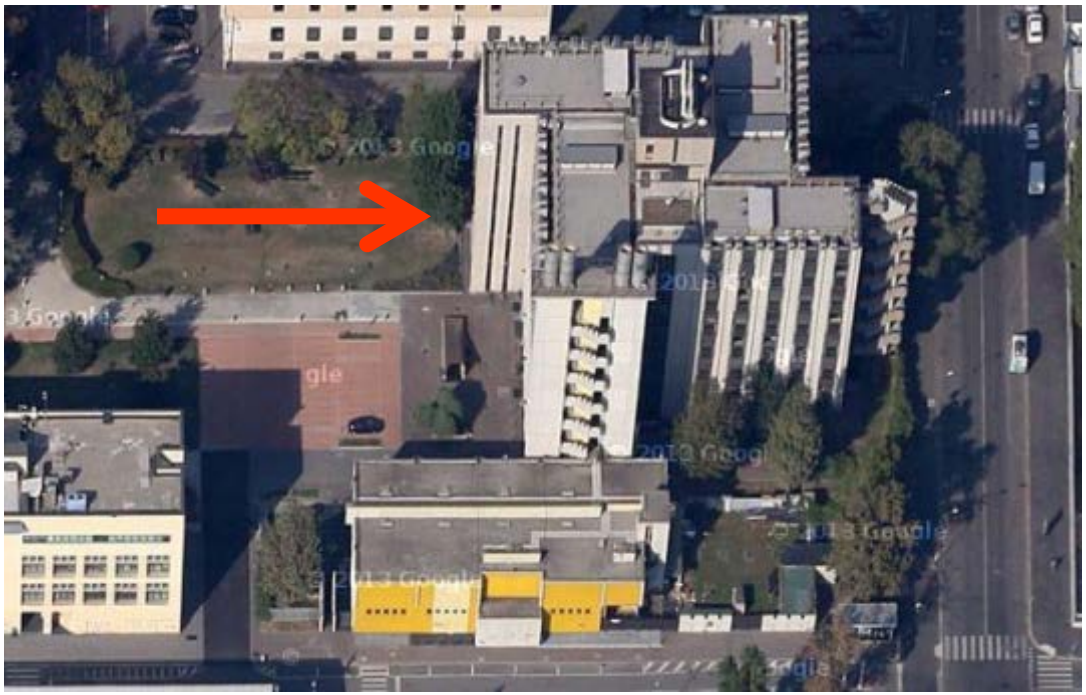
< 1 m

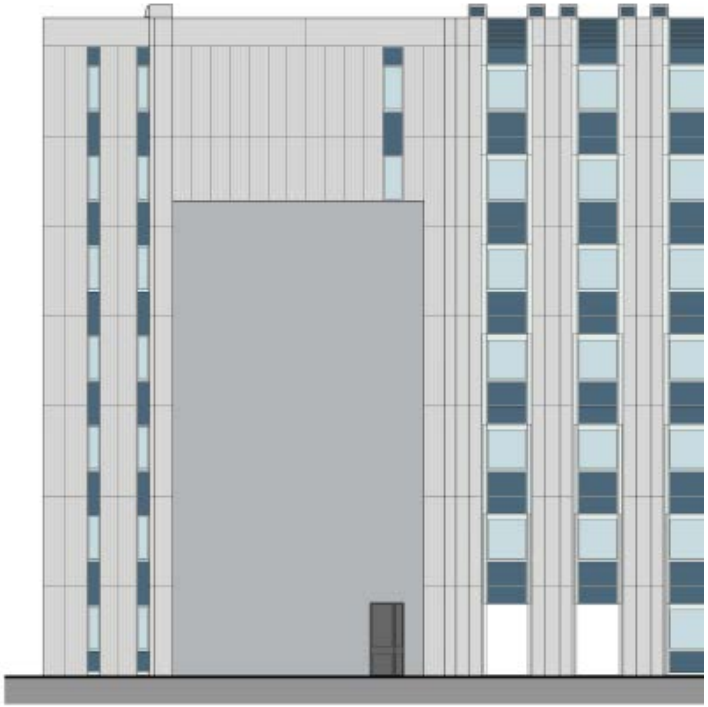
Requirements and preliminary monitoring campaigns: 2 case studies Milan and Lecco

Milan (Politecnico)

Building façade between via Ponzio and via Golgi

2 monitoring campaigns (winter and summer)





Requirements and preliminary monitoring campaigns

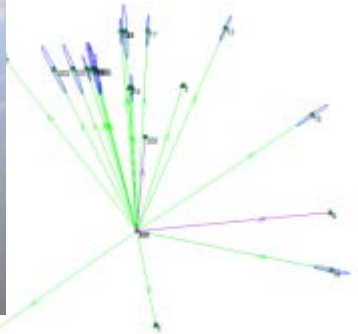
Milan (Politecnico)

Winter 2012

Hand held FLIR Tau 640 (focal 19 m
Integration with RGB images and laser data

RGB orthophoto → GSD = 2 mm
IR orthophoto → GSD = 2 cm

Temperature values ??



Another hand held FLIR camera for building inspection → T° values

Requirements and preliminary monitoring campaigns

Milan (Politecnico)

Summer 2013

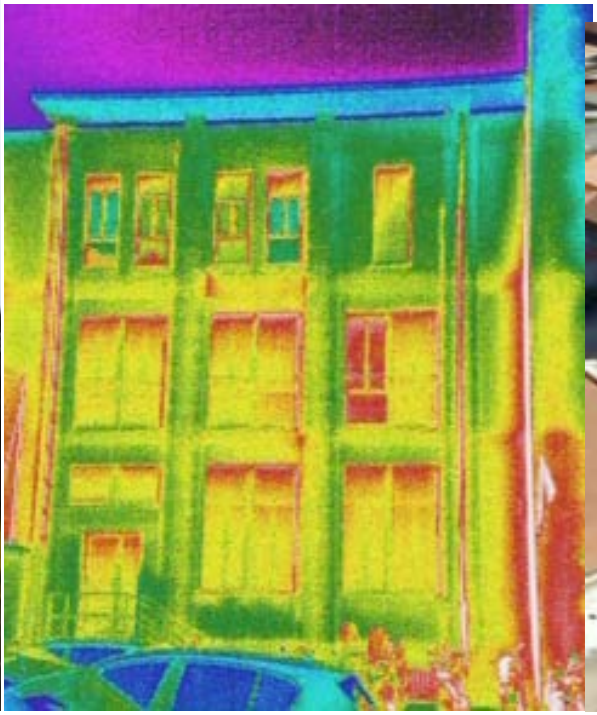
RGB and IR cameras on UAV (Falcon 8)
Problem → 2 different flights

	Sony NEX-5N	FLIR Tau 640
Information	RGB	TIR
Focal length	16 mm	19 mm
Resolution (pix)	4912 x 3264	640 x 480 pixel
Pixel size	4.88 µm	17 µm

Requirements and preliminary monitoring campaigns

Lecco (Oggiono Campus) | January 2013

Building in Via Marco D'Oggiono (and other buildings)



Requirements and preliminary monitoring campaigns

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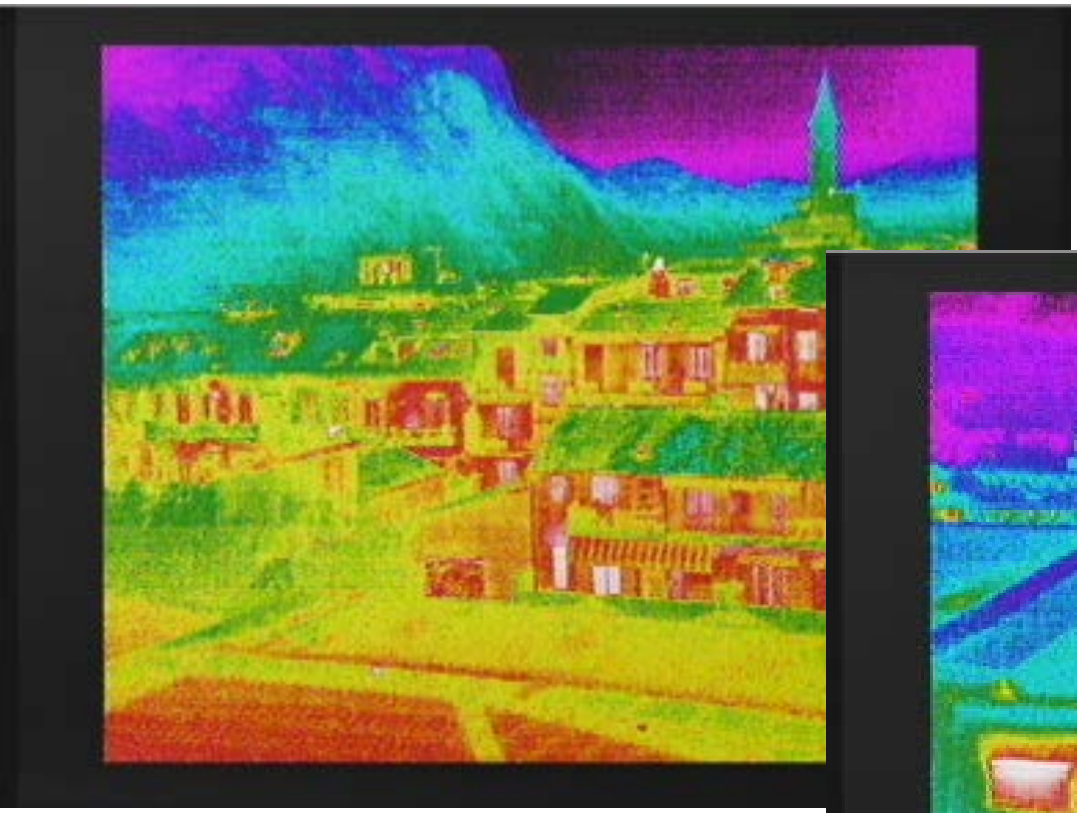
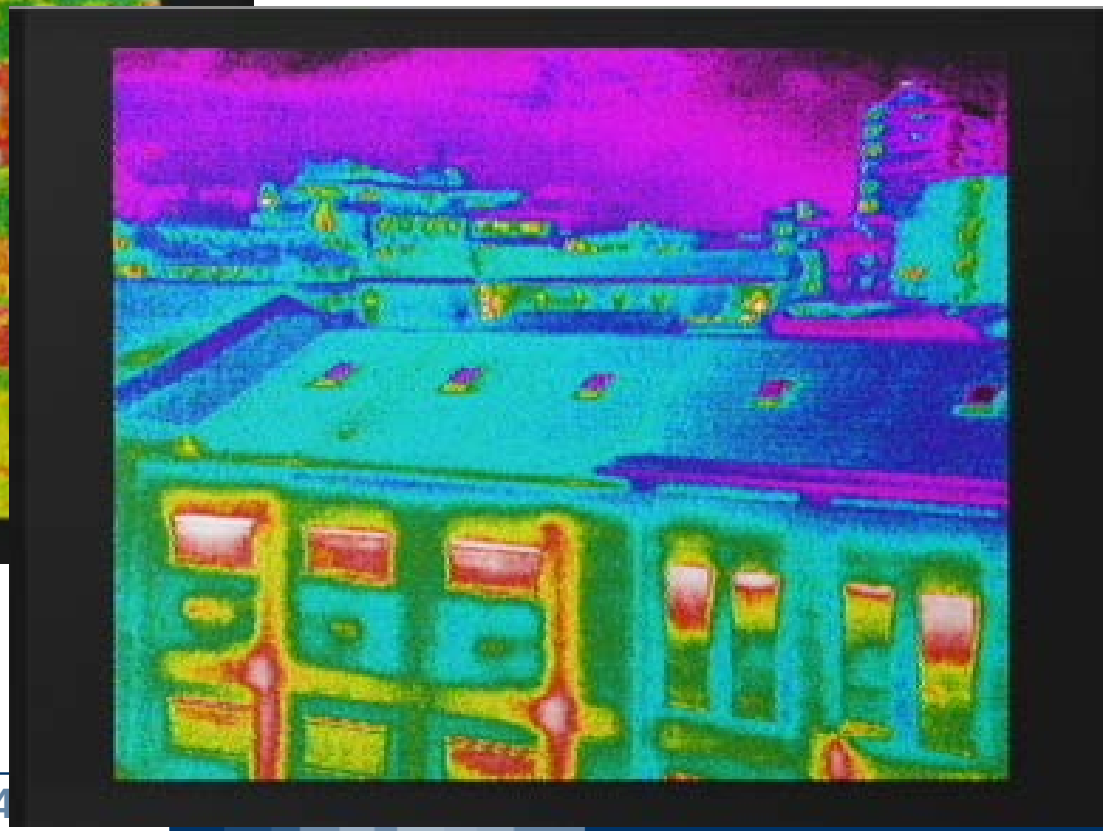
Building in Via Marco D'Oggiono (and other buildings)



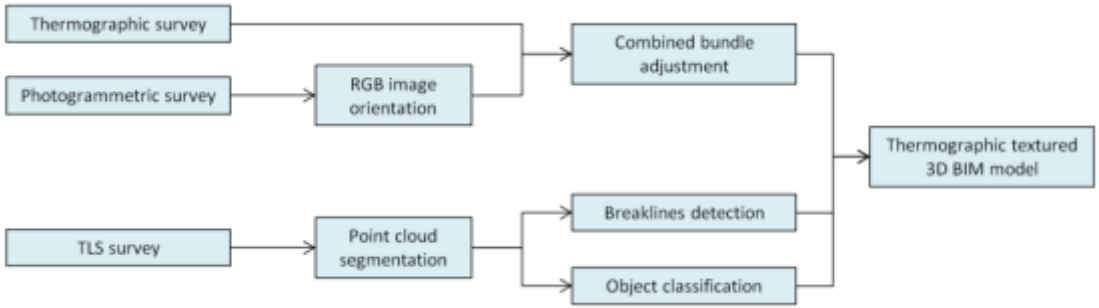


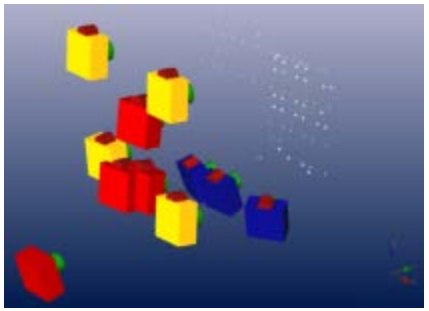
Requirements and preliminary monitoring campaigns

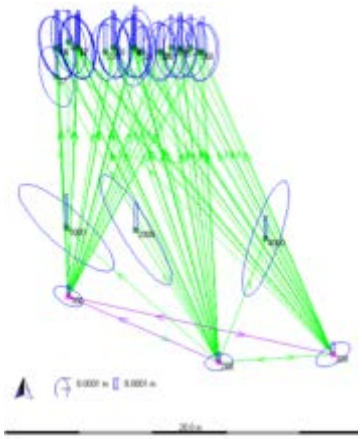
Lecco (Oggiono Campus)

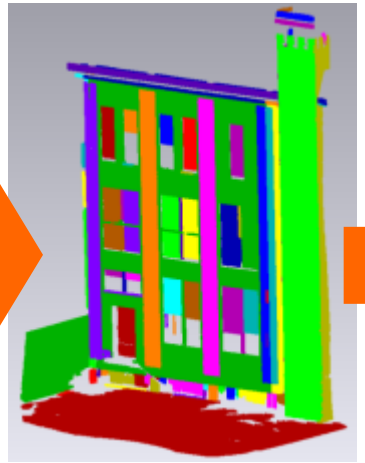
Photogrammetric data processing
Image orientation
IR texture mapping

Towards a BIM/GIS integration for Energy Efficiency of Buildings









"It is not the strongest of the species that survives,
nor the most intelligent.
It is the one that is the most adaptable to change."

— *Charles Darwin*

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**THANK YOU
FOR YOUR KIND
ATTENTION !**