



 POLITECNICO DI MILANO



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

Branka Cuca

Politecnico di Milano, Italy

Dept. of Architecture, Built Environment and Construction Engineering

G-Ic@rus LAB - Geospatial Information & Content

modelling: Architectural heritage&built environment

- Climate change and need for Energy monitoring of Built environment
- **FP7 project GE20** - 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 CHALLENGES FOR ENVIRONMENT MONITORING IS **CLIMATE CHANGE**

3

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





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

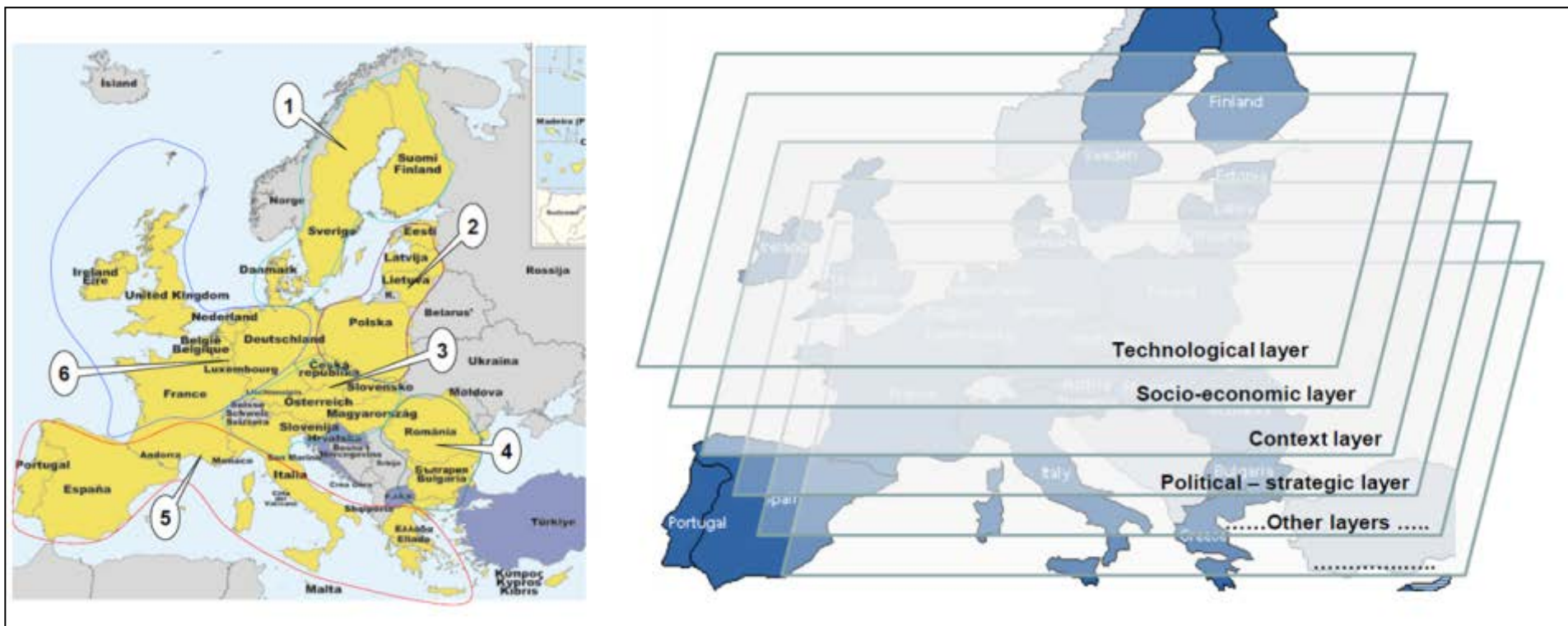
- + GPS/IMU
- + DSMs/DTMs
- + 3D/4D city models
- + Facility management
- + Mobile Mapping
- + Imagery: satellite, aerial, terrestrial (street views)
- + Maps, plans
- + Historic data
- + LBS, “smart” apps
- + Sensors in WEB 2.0
- + Sensors in smart buildings
- + GIS/SIS
- + Visualization/simulation/animation



**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.

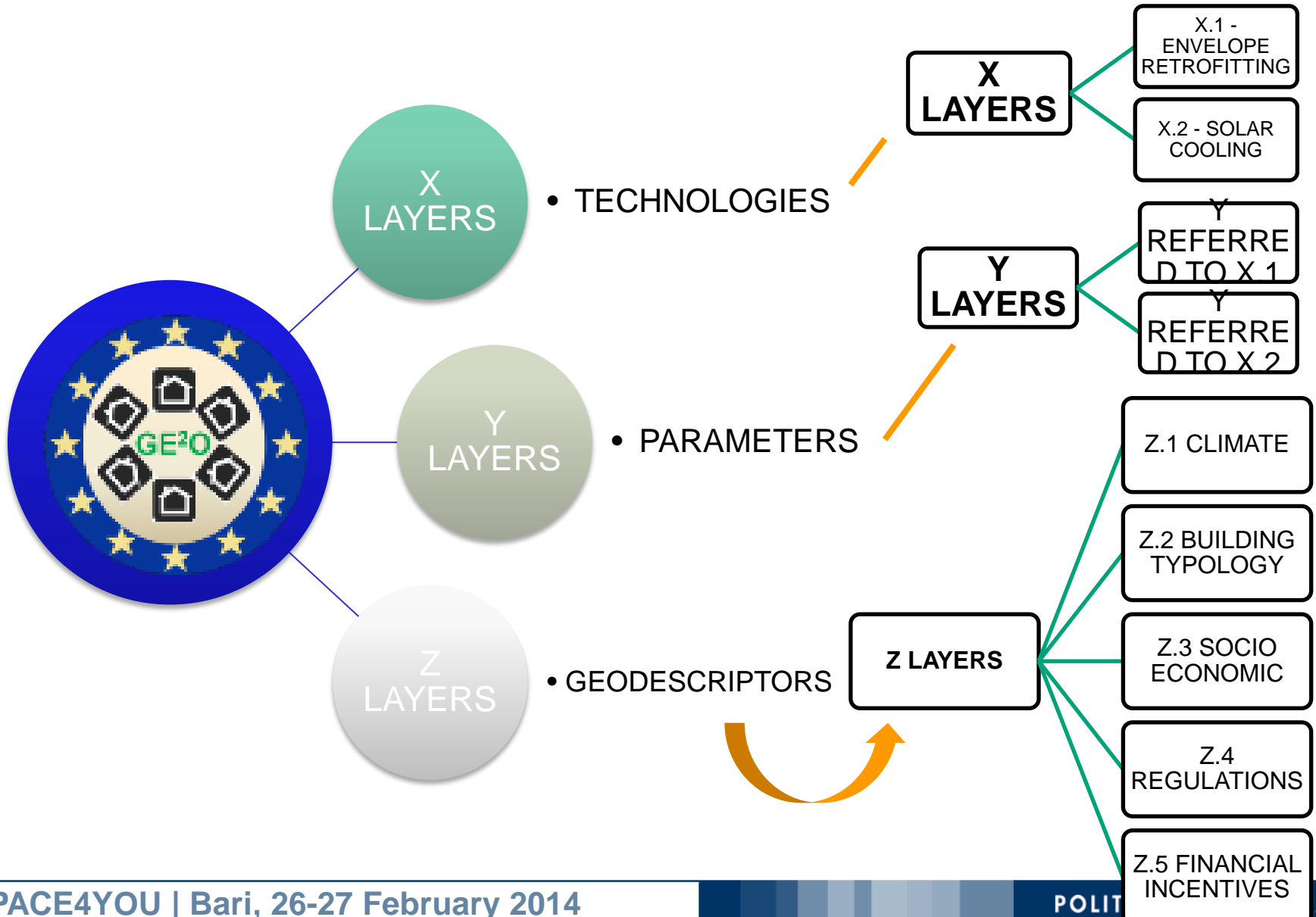


Definition of the correlation proposals for each layers:

exchange between partners for the validation of the proposals.



3D MODEL STRUCTURE





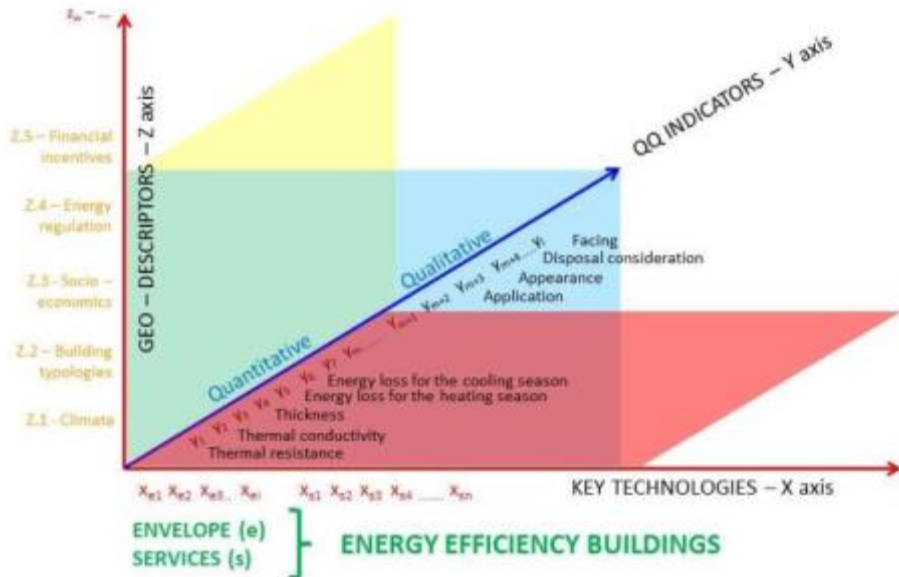
ITERATIVE PROCESS

AVAILABLE DATA AT EU LEVEL



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 ECONOMIC ASPECTS CORRELATIONS

Z.4 REGULATIONS CORRELATIONS

Z.5 FINANCIAL INCENTIVES CORRELATIONS



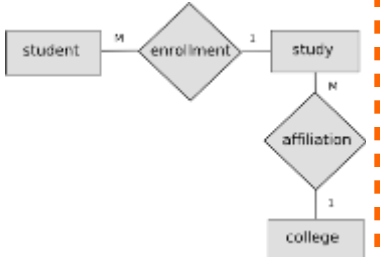
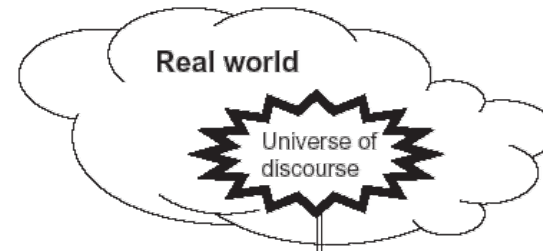
CONCEPTUAL SCHEMA



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

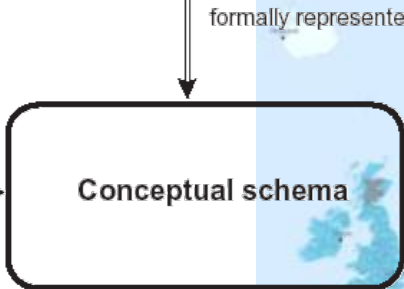
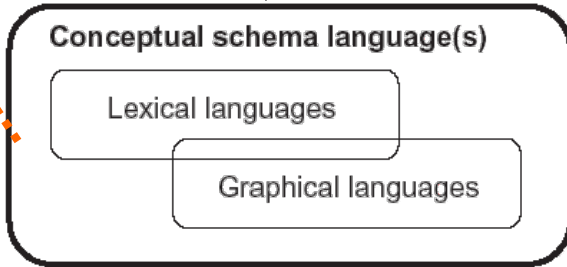
Real situation:
CLIMATE CHANGE

3D

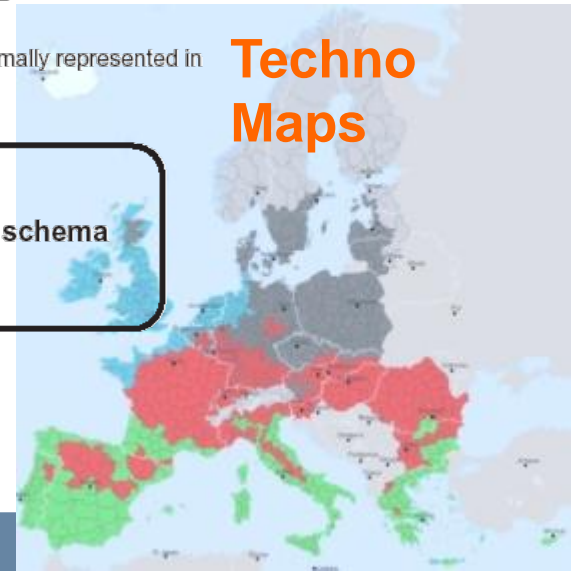


Conceptual formalism

Conceptual model



Techno Maps



provides concepts for describing

basis for one or more

formally represented in

provides formal language for representing

ISO 19101 Reference model: From reality to conceptual schema



ROW/
COLUMN
SYSTEM



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



Technological
Geo-MAP

Z.1 - Climate

Column

Row

Italy

ITE CENTRO (I)
Latina **ROW 1**

ITC NORD-OVEST
Milano **ROW 2**

Z.1.1 Heating Degree Days
Z.1.2 Cooling Degree Days
Z.1.3
Z.1.4
Z.1.5

GeoCluster Mapping Tool

Layer

GeoCluster

Geo2O-Plans

Heating Degree Days

Cooling Degree Days

Annual modern energy on a south or...

Annual modern energy on a north or...

Aug. ambient temperature over year

Aug. ambient temperature over heating

Aug. ambient temperature over cooling

Maximum ambient temperature over...

Aug. ground / water temperature over...

Aug. ground / water temperature over...

Aug. ambient wet bulb temperature over...

Aug. ambient temperature during daylight

Aug. solar irradiation during daylight

Legend

Heating Degree Days (Index of temperature...

Index value

0 1000

1000 1750

1750 2500

2500 3250

3250 4000

4000 4750

Applied Filters

Add a filter...

Heating Degree Days

250 4750

2013 © GeoCluster - EU FP7 Project - All Rights Reserved - Geo2O 1.1.1.04

Geo2O Website



THEMATIC MAPS EXAMPLE: Cooling degree days

Browser address bar: <http://www.geoclusters.eu/ge20/>

Browser tabs: MSN Italia: H..., GE20 Ma..., GeoCluster D..., INSPIRE Geo..., lineage - Wo...

File Modifica Visualizza Preferiti Strumenti ?

Converti SeleZIONa

GeoCluster Mapping Tool

Layer

- Geo-Descriptor
- Default
 - EU Territorial Units (NUTS3)
 - GE20 Pilots
- Climate
 - Heating Degree Days
 - Cooling Degree Days
 - Annual incident energy on a south
 - Annual incident energy on a south
 - Avg. ambient temperature over year
 - Avg. ambient temperature over hea
 - Avg. ambient temperature over coc
 - Maximum ambient temperature ov
 - Avg. ground / water temperature o
- Thermal Insulation
- Solar Cooling
- Background Layers

Ge20 Map

Open filters box | Download KML | Print

Scale = 1:28M
Lon/Lat: 4.94 / 51.36

Legend

Cooling Degree Days

Cooling Degree Days (base air temperature bizee software: 26°C).
Unit [DD] (Read more)

- No value
- 0 - 12
- 12 - 13
- 13 - 16
- 16 - 21

Applied Filters

Cooling Degree Days:

Other filters are available.
Click on "Open filters box" button to manage all filters.

2013 © GeoCluster - EU FP7 Project - All Rights Reserved - Ge20 1.2.2 r50

GE2C



THEMATIC MAPS EXAMPLE: Building Use - Residential

GeoCluster Mapping Tool

Layer

- Geo-Descriptor
- Default
 - EU Territorial Units (NUTS3)
 - GE2O Pilots
- Climate
- Building Typology
 - Age of Construction
 - Use Residential
 - Use Residential - Single
 - Use Residential - Apartment Flats**
 - Use - Non-residential - WIP
 - Constructive Elements - WIP
 - U Value Existing - Wall
 - U Value Existing - Roof
- Thermal Insulation
- Solar Cooling
- Background Layers

Ge2O Map

Open filters box | Download KML | Print | Feedback

Data ©2013 GeoCluster
GE2O Website

Legend

Use Residential - Apartment Flats
Use - Residential > Apartment Flats.
Unit [building] (Read more)

- No value
- < 5000
- 1500.. 5000
- 5000.. 10000
- 10000.. 25000
- 25000.. 50000

Applied Filters

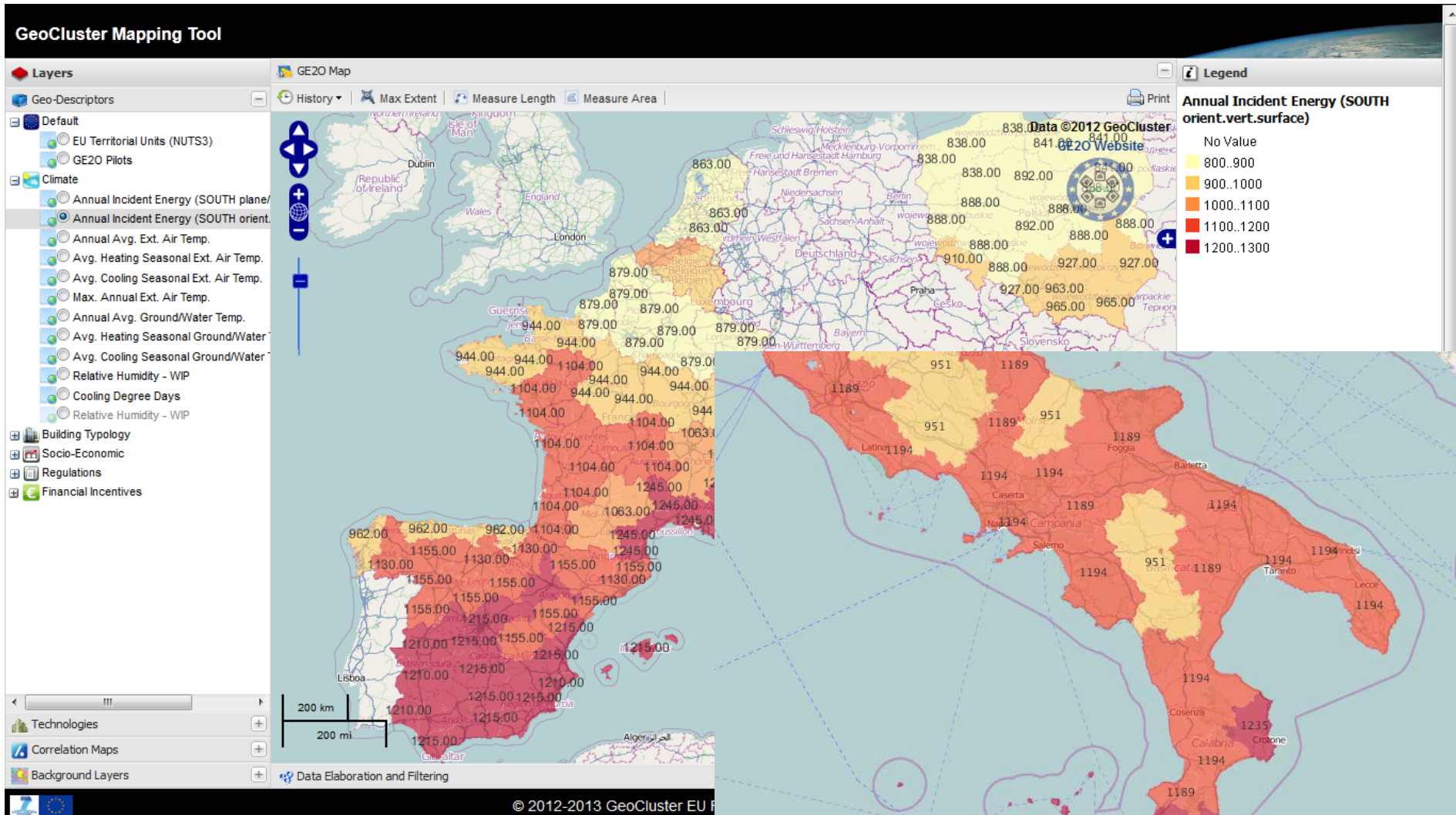
Nr. of flat-apartments:
0 220000

Other filters are available.
Click on "Open filters box" button to manage all filters.

Scale = 1 : 28M
Lon/Lat: -19.01 / 54.50

2013 © GeoCluster - EU FP7 Project - All Rights Reserved - Ge2O 1.2.2 r50

GE2O Website





THEMATIC MAPS EXAMPLE: METADATA GE2O INSPIRE COMPLIANT

http://www.geoclusters.eu/ge2o-network/srv/en/main.home

File Modifica Visualizza Preferiti Strumenti ?

Converti Seleziona

INSPIRE Geoportal GeoCluster Discover...

Home | Administration | Contact us | Links | About |

User: Branka Cuca Logout

WHAT?
hdd

WHERE?

Map navigation tools: Home, Previous, Next, Full Screen, Print

- Any -

Search [Reset](#) [Advanced Options](#)

Applications
Datasets

FIND INTERACTIVE MAPS, GIS DATASETS, SATELLITE IMAGERY AND RELATED APPLICATIONS

Aggregated results matching search criteria : 1-1/1 (Page1/1), 0 selected
Select : [all](#), [none](#) [actions on selection](#)

Z.1.1 HEATING DEGREE DAYS

Abstract Heating Degree Days
Keywords GeoCluster, GE2O, GEOSERVER, heating degree days

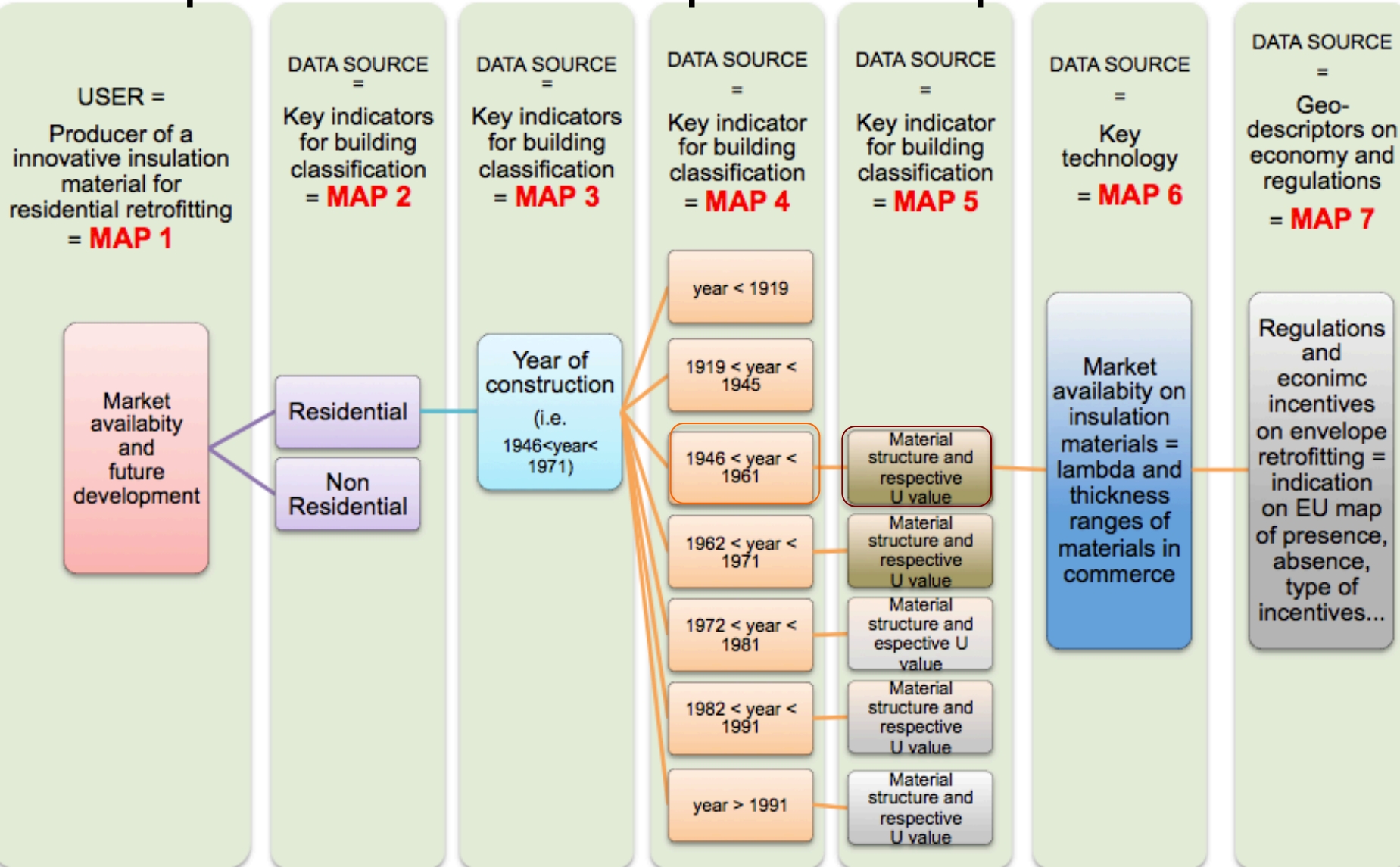
[Metadata](#) [Interactive Map](#) [Create](#) [Edit](#) [Delete](#) [Other actions](#)

1

Owner: branka.cuca


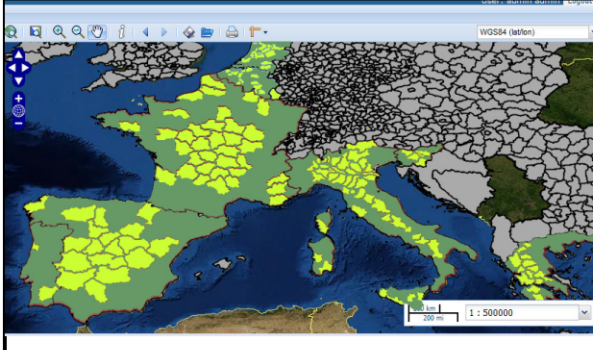
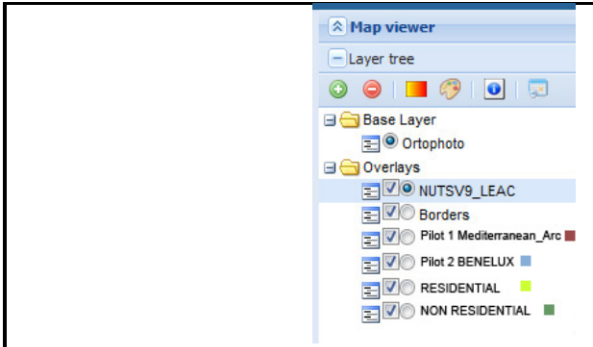
145%

Mind map with tree structure example on the first path





Path example as an illustration of the mapping tool functionalities

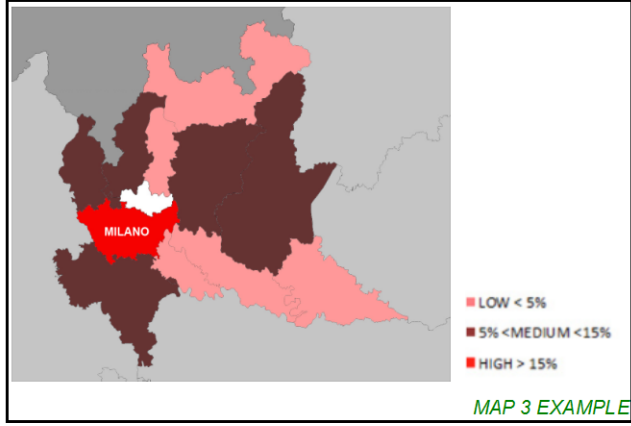
<p>QUERIES</p>	<p>My industry is located here, I would like to individuate where the market development areas are compared to my position</p>		<p>My product is an innovative product especially for external residential wall retrofitting and I have to check the potential market for residential building</p>			
<p>USER 1 = PATH 1</p>	<p>STEP 1</p> <p>User insert his geographical coordinates</p>	<p>></p> <p>Tool processes the localization</p>	<p>MAP 1</p> <p>EU map with a point on the user coordinates</p>	<p>STEP 2</p> <p>Building use</p>	<p>></p> <p>Tool processes the Z data from building classification</p>	<p>MAP 2</p> <p>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)</p>
<p>ALGORITHMS</p>	<p>algorithm for the geographical coordinates</p>		<p>∇</p>	<p>algorithm to allocate number and right icon at NUTS 3 level for building classification</p>		<p>∇</p>
<p>MAPS</p>	 <p>MAP 1 EXAMPLE</p>		 <p>MAP 2 EXAMPLE</p>			
<p>PRACTICAL SUGGESTION, PROPOSALS AND INDICATIONS FOR DATA, ICON, COLOURS FOR THE TOOL</p>	 <p>Map viewer</p> <ul style="list-style-type: none"> Layer tree Base Layer <ul style="list-style-type: none"> Ortophoto Overlays <ul style="list-style-type: none"> NUTSV9_LEAC Borders Pilot 1 Mediterranean_Arc Pilot 2 BENELUX RESIDENTIAL NON RESIDENTIAL 					

∴ FAKE DATA ∴

My product is easily applicable on masonry wall and all the technological 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



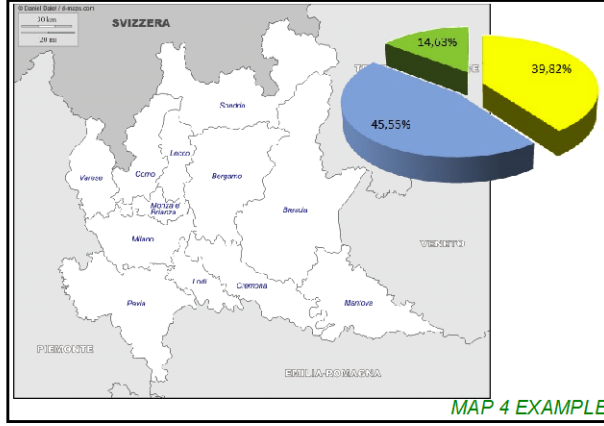
DATA EXAMPLE FOR ITALIAN CONSTRUCTION PERIOD CLASSIFICATION

	Before 1919	DATA COLLECTED AT NUTS 3 LEVEL
	1919 - 1945	
	1946 - 1961	
	1962 - 1971	
	1972 - 1981	
	1982 - 1991	
	> 1991	

My product is easily applicable on external masonry 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



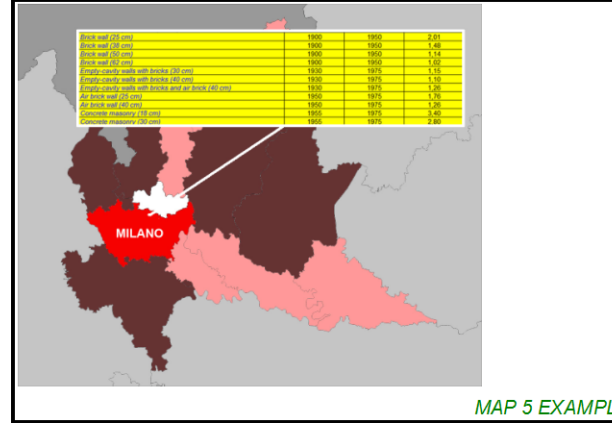
DATA EXAMPLE FOR ITALIAN STRUCTURE MATERIALS USED

	Bearing wall	DATA COLLECTED AT NUTS 3 LEVEL
	Reinforced concrete	
	Other	

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

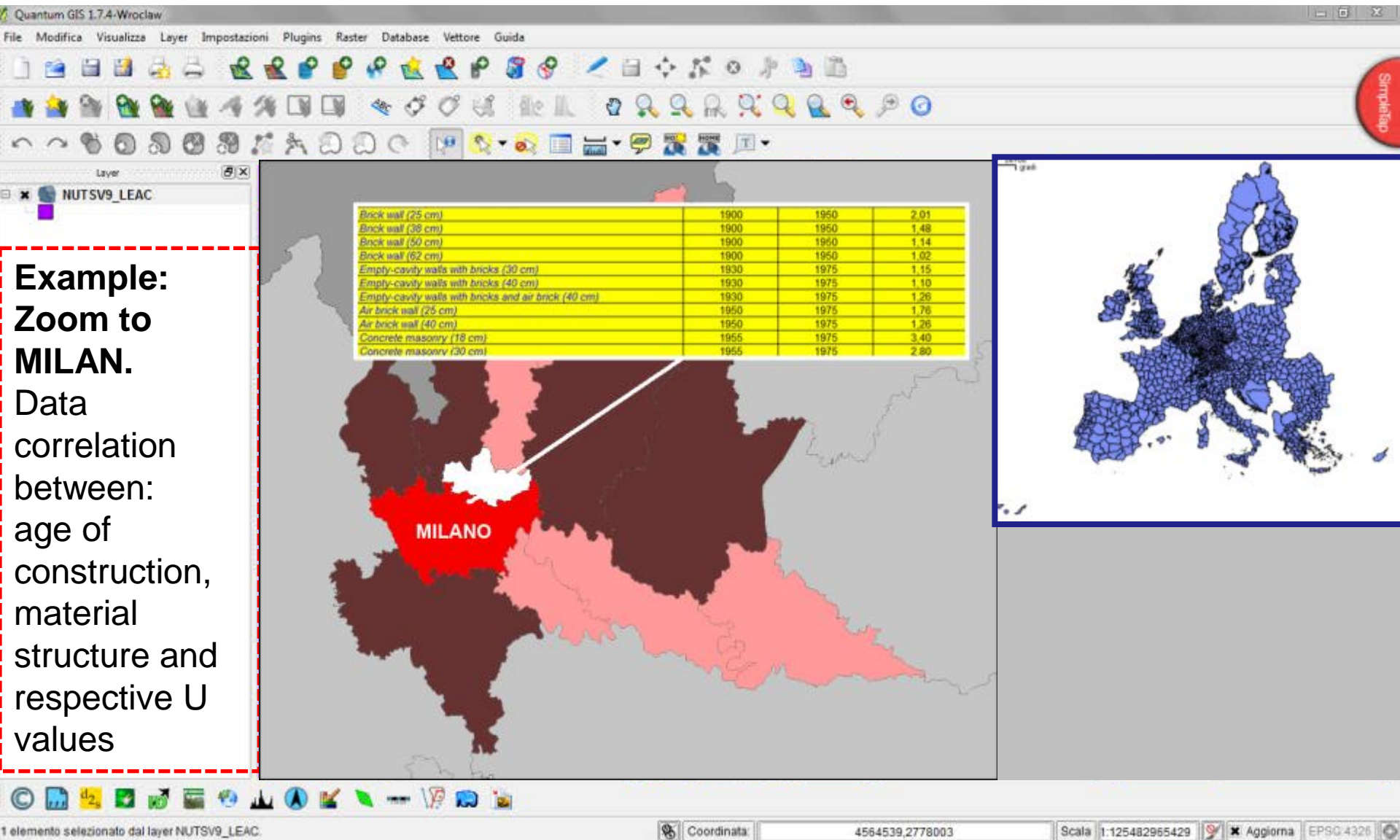
correlation between previous data on structure, construction date and U value assumed



DATA EXAMPLE FOR ITALIAN Uvalue classification

See excel BUILDING CLASSIFICATION_POLIMI_data from Tabula

::: REAL DATA for Lombardy region :::





EEA IMPLEMENTATION BY GE2O DATA

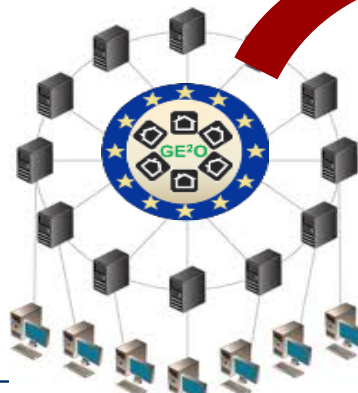
EEA
DATA and
SERVICE

+
IR HR
SENTINEL-3
HEAT ISLAND
10m terrain
resolution

+
to be added
by GE2O
DATA and

Heating degree days>> CLIM047 >>Nov 2012

The screenshot shows the EEA Data services overview website in Internet Explorer. The browser address bar shows <http://www.eea.europa.eu/themes/urban/dc>. The page features a search bar and a 'Browse catalogue' section with tabs for 'All data products', 'Datasets', 'Maps', 'Interactive maps', 'Indicators', and 'Graphs'. A large line graph titled 'heating degree days' is displayed, showing a fluctuating orange line with a downward trend. Below the graph, a green banner reads 'Heating degree days (CLIM 047) - Assessment published Nov 2012'. A 'GeoCluster Mapping Tool' window is overlaid on the bottom left, showing a map of Europe with various data layers selected in the legend, including 'Heating Degree Days' and 'Annual Heating Degree Days'. A large red arrow points from the map area towards the line graph.





GE20: TOWARD LOCAL GEOCLUSTERING GEOSPATIAL DATA for Urban Heat Island monitoring and planning policies in the cities

EEA
DATA and
SERVICES

→ can be
implemented
by GE20 DATA
and SERVICE

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

Urban environment — European Environment Agency (EEA) - Windows Internet Explorer

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

File Modifica Visualizza Preferiti Strumenti ?

Interactive maps and dat... Raccolta Web Slice Siti suggeriti

Networks Eye on Earth Events Subscriptions Mobile Contact us EEA homepage in your language

European Environment Agency

Search Europe's environment... Advanced search

Topics Data and maps Indicators Publications Multimedia Press room About

You are here: Home / Environmental topics / Urban environment

Urban environment

Change language

Urban environment data service

Featured article

Europe is a Union of cities and towns; around 75% of population of the EU have chosen urban areas as their place to live. But impacts of urbanisation extend, beyond city borders. Europeans have adopted urban lifestyles and they use city amenities such as cultural, educational or health services.

More



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.



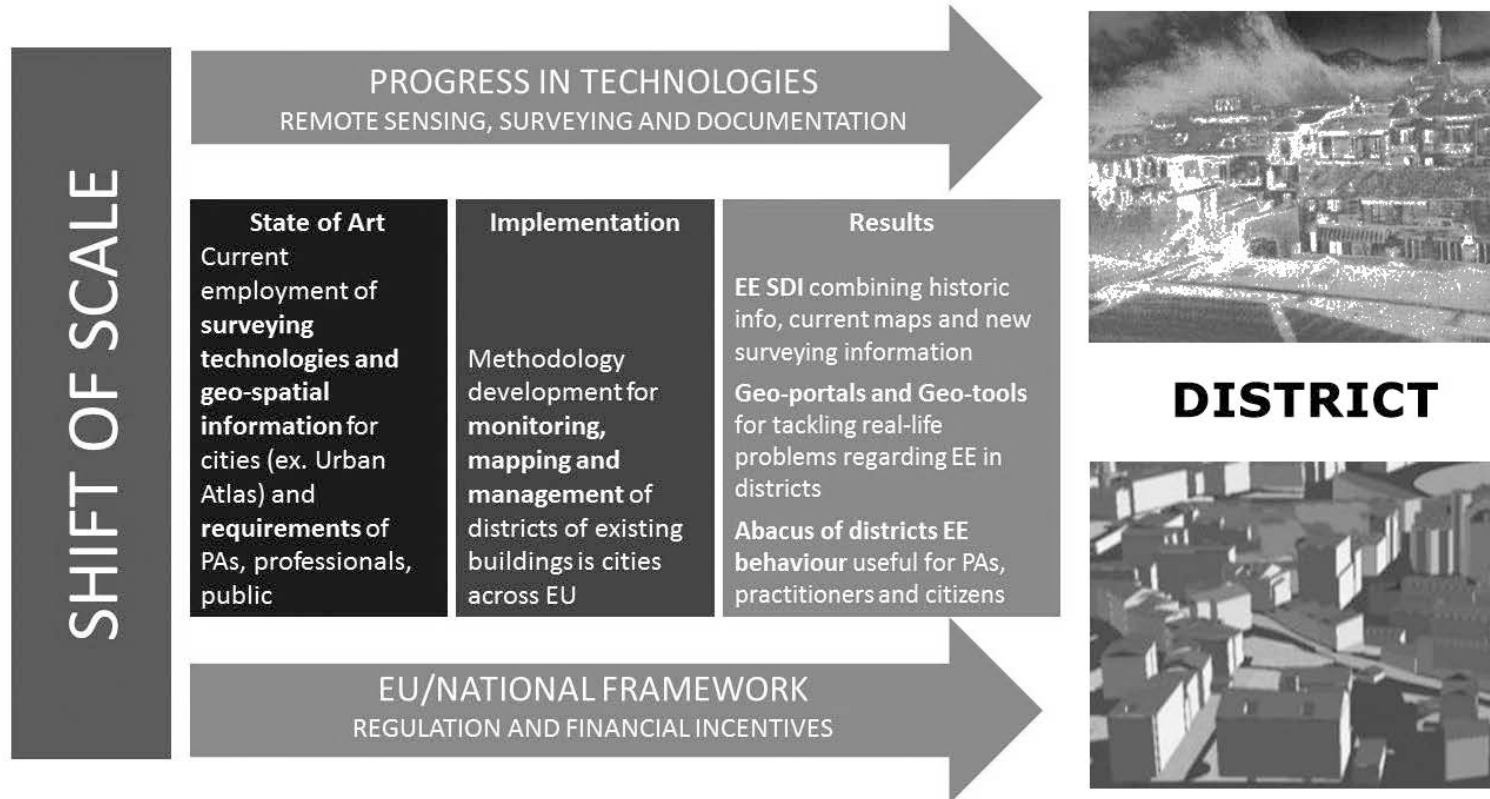
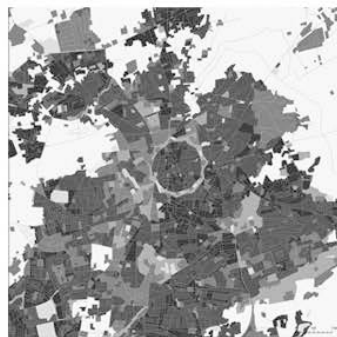
EO/COPERNICUS Services for monitoring of Built Environment: URBAN ATLAS

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.

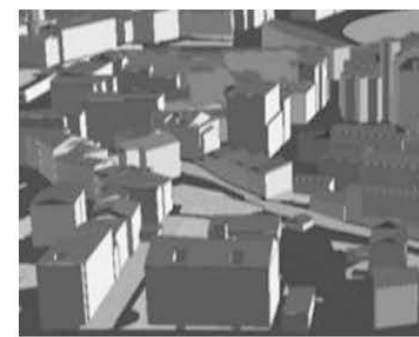
<http://www.eea.europa.eu/data-and-maps/data/urban-atlas#tab-methodology>



CITY



DISTRICT





1992



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



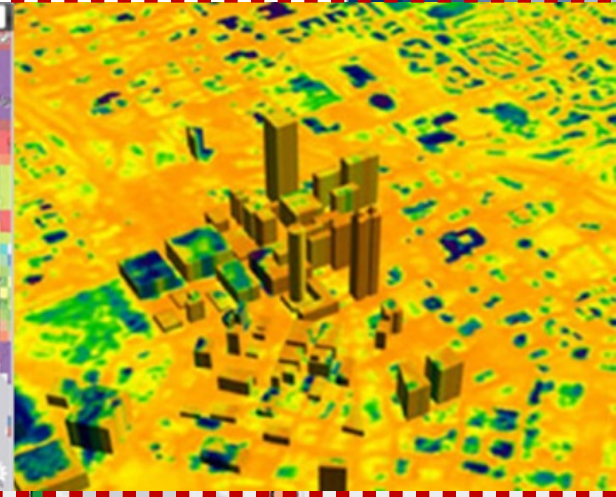
2010



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



Dettagli Legenda

Share of green and blue urban areas 2006 [%]

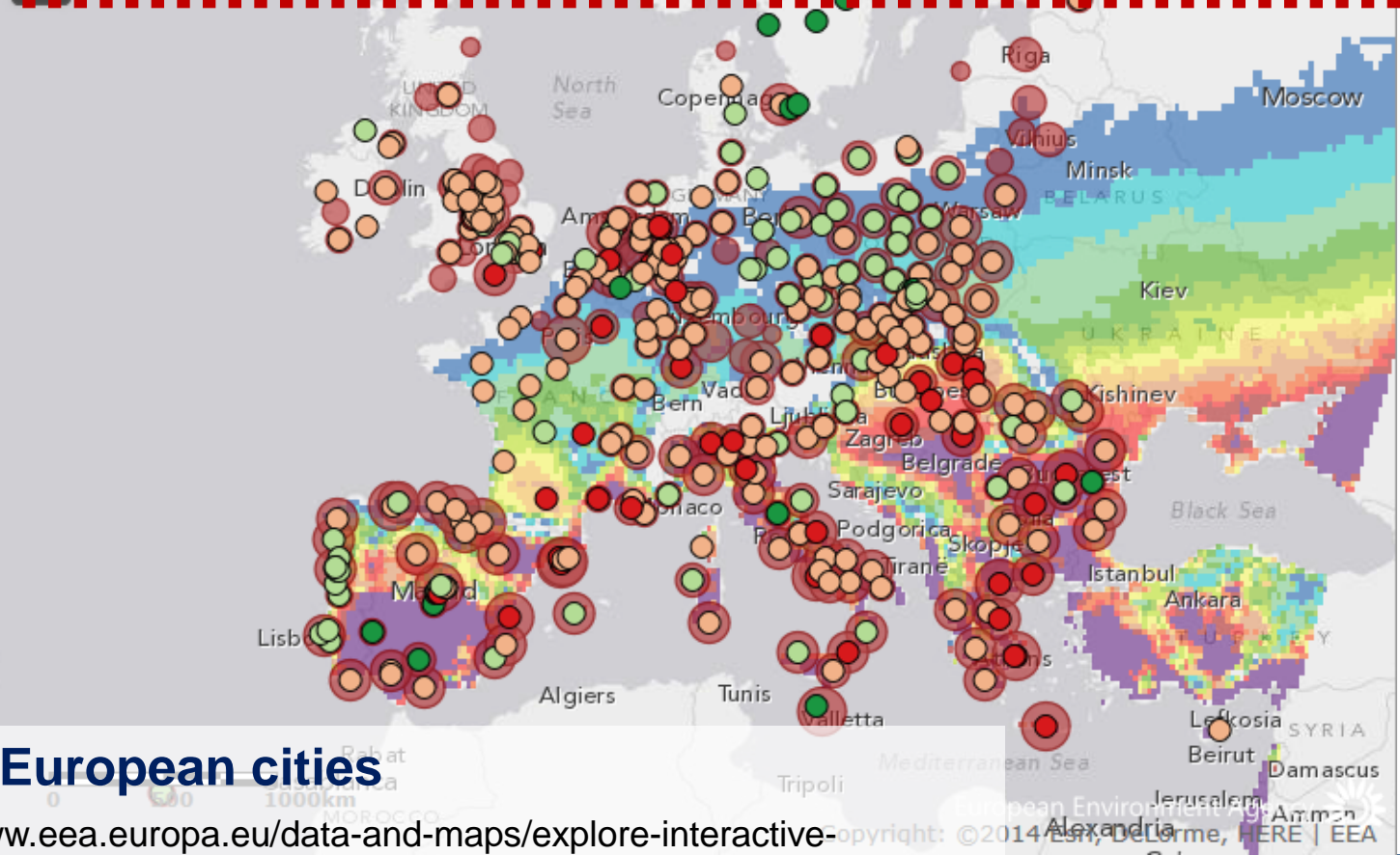
- < 20
- 20-29
- 30-39
- > 39

Population density 2004 [inh/km2]

- < 3 000
- 3 000 - 4 000
- 4 000 - 5 000
- 5 000 - 10 000
- > 10 000

HotDaysWarmNights_2071_2100

Number of combined tropical nights (> 20C) and hot days (> 35C) 2071-2100



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, Mapping 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

Algorithm implementation for 3D texturized modelling

•Research lines regarding Built Environment Monitoring

Objectives

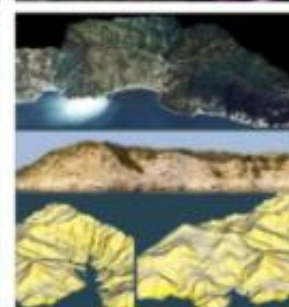
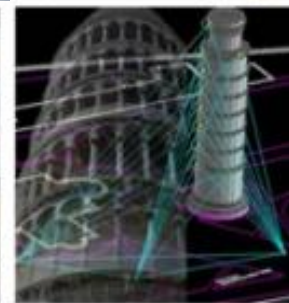
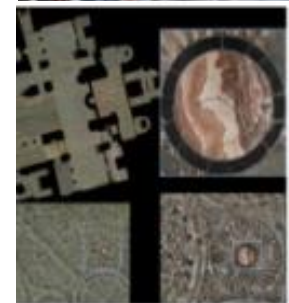
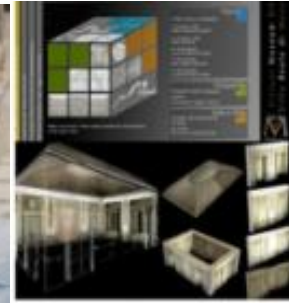
Strategies for re-use and re-cover of existing built environment both from typological point of view but also considering technological and energetic performance issues.

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)

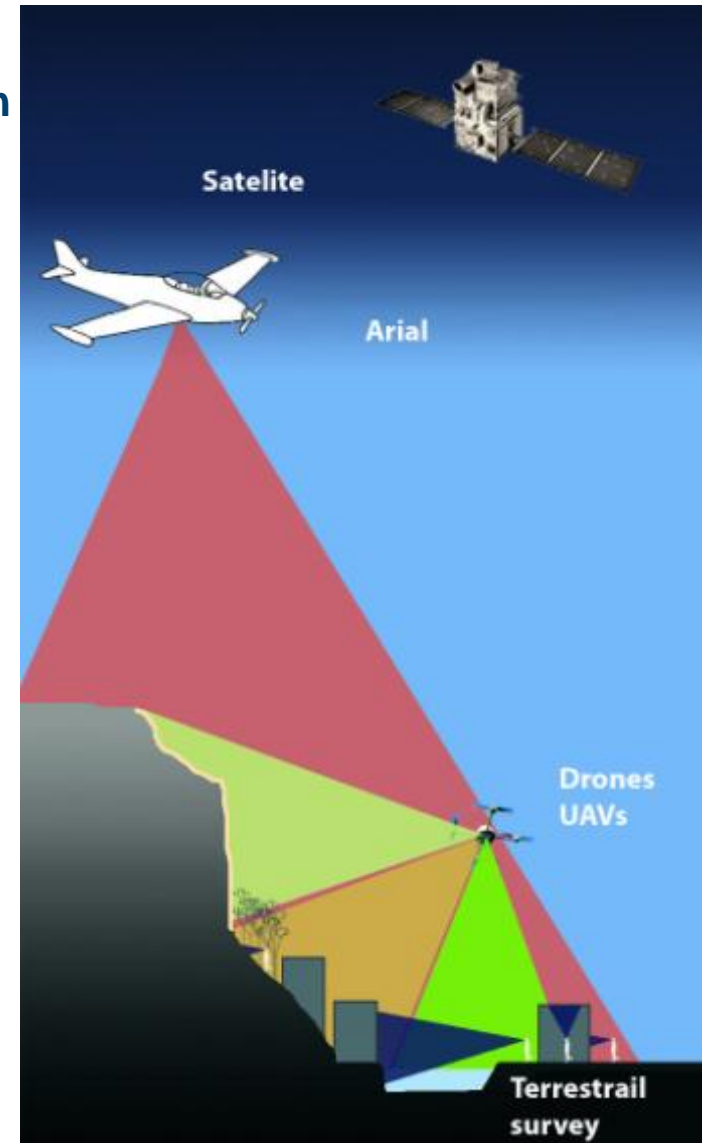
Correlation between the Temperature increase in urban areas and the energetic dispersion of buildings

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 retrofiting; impact on overall climate change.

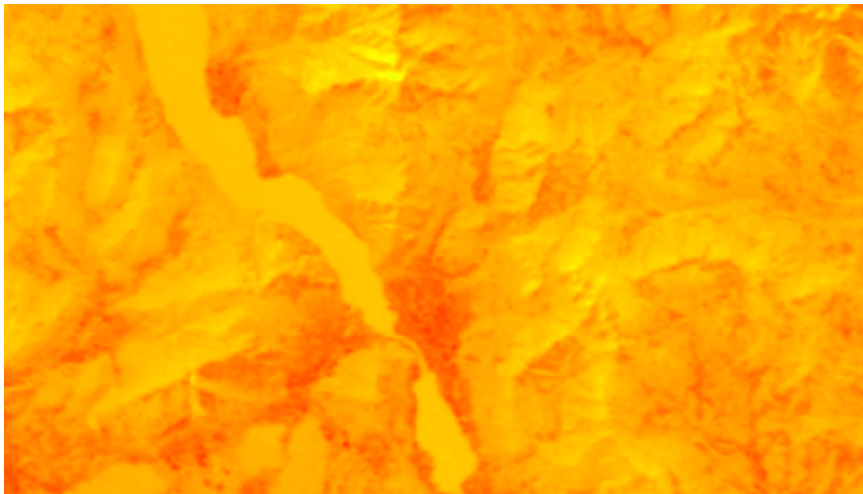




Detection of heat loss in buildings with different technologies to address the energy efficiency policies at the district or building scale

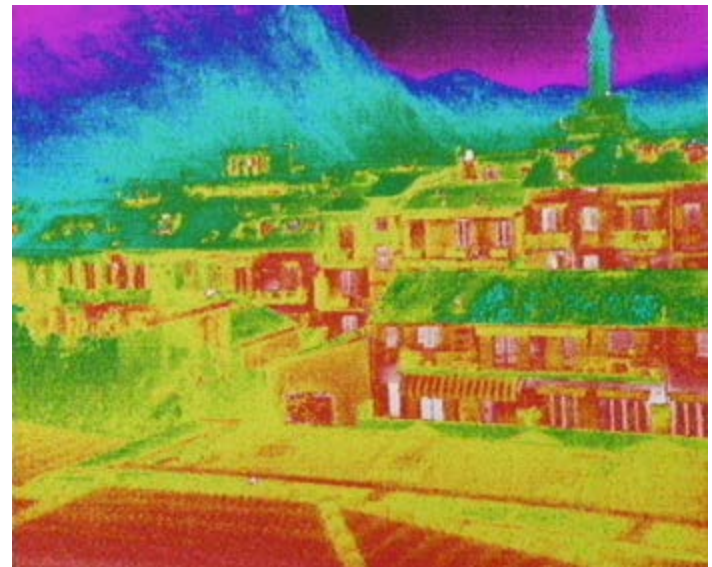
City level experiment

Satellite thermal images



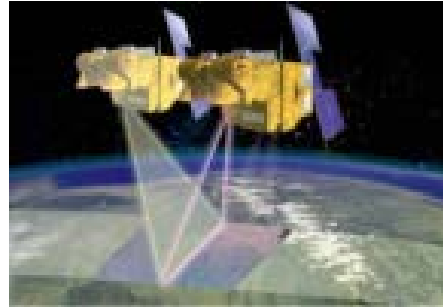
Coordinata: Scala:

TIR at high resolution (UAV)



Thermal / RGB Image acquisition platforms

Satellite images



> 700 km

Aerial images



UAVs



Close-range images



< 1 m





Milan (Politecnico)

Building façade between via Ponzio and via Golgi

2 monitoring campaigns (winter and summer)





Milan (Politecnico)

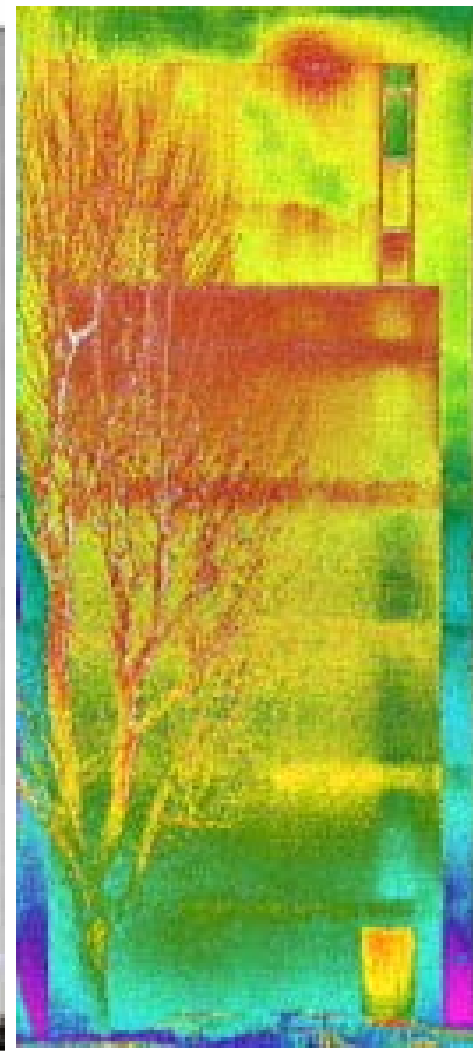
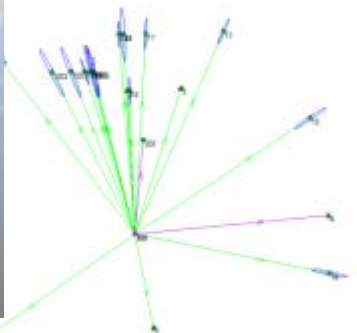
Winter 2012



Hand held FLIR Tau 640 (focal 19 mm)
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



Milan (Politecnico)

Summer 2013

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



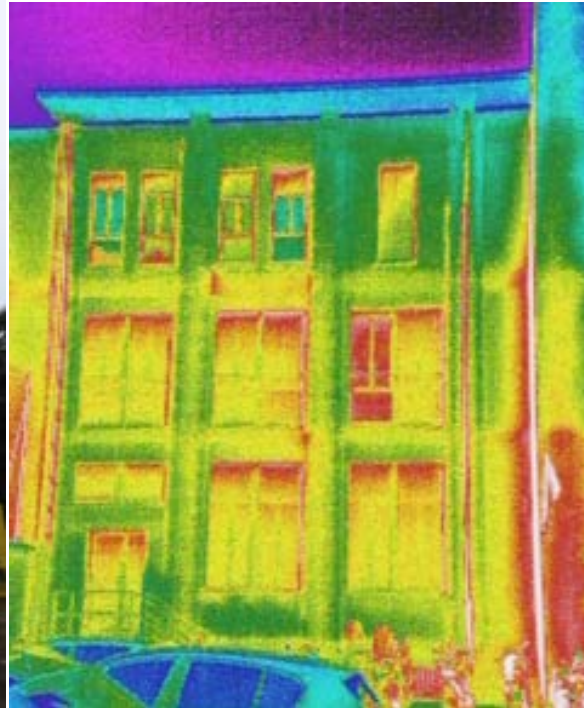
	Sony NEX-5N	FLIR Tau 640
Information	RGB	TIR
Focal length	16 mm	19 mm
Resolution (pix)	4912 x 3264	640 x 480 pixel
Pixel size	4.88 μ m	17 μ m





Lecco (Oggiono Campus) | January 2013

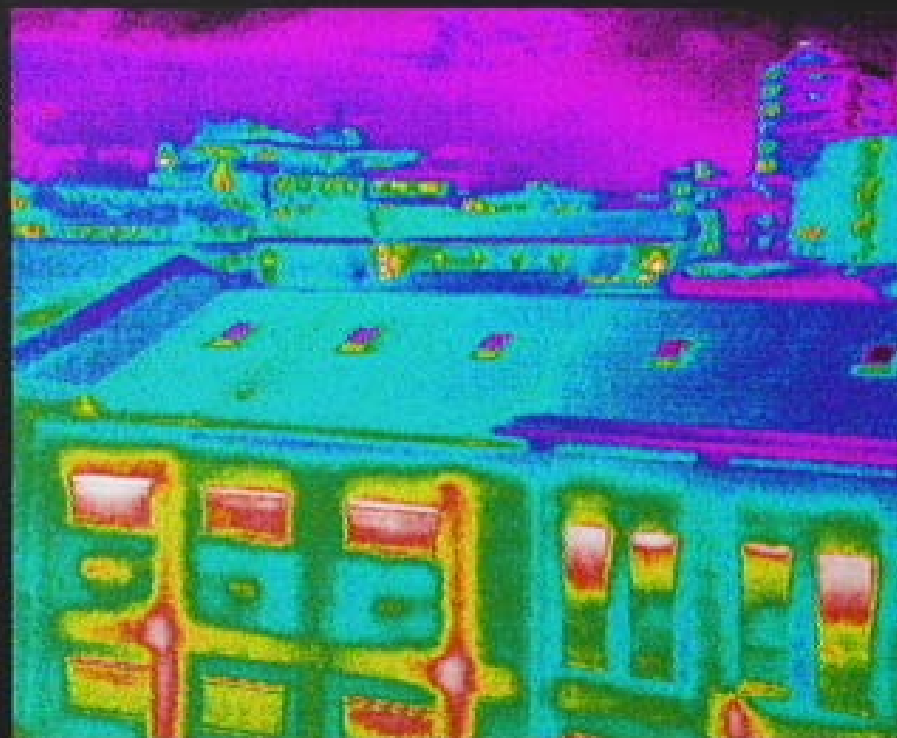
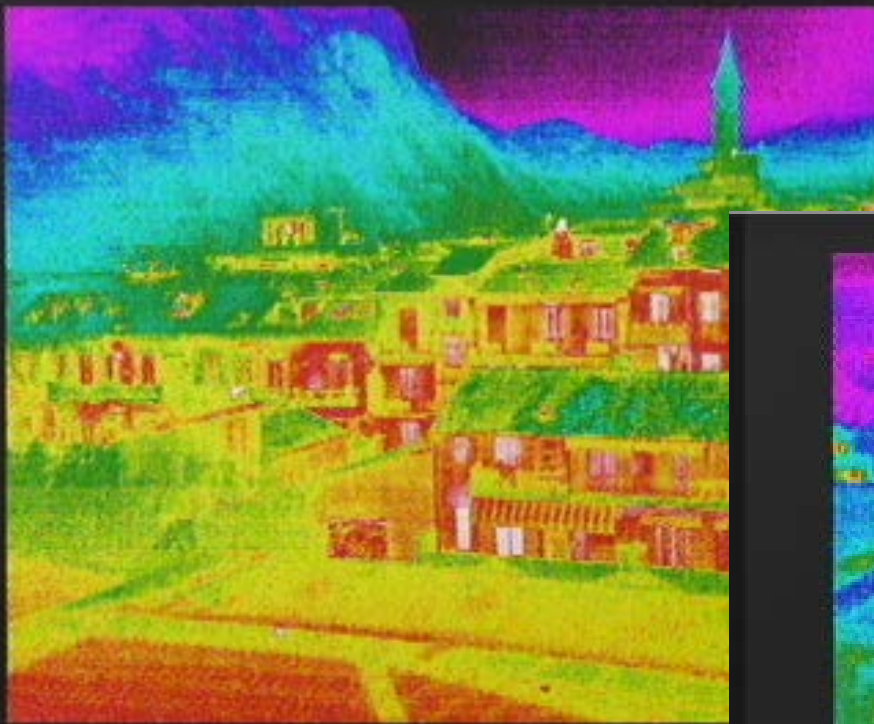
Building in Via Marco D'Oggiono (and other buildings)





Lecco (Oggiono Campus) | January 2013

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

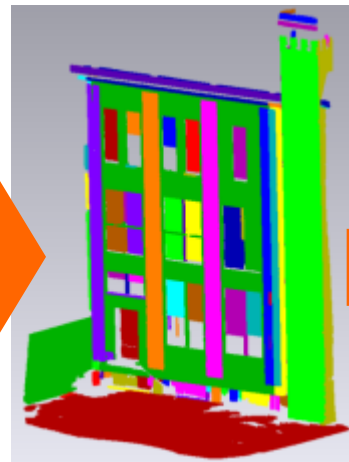
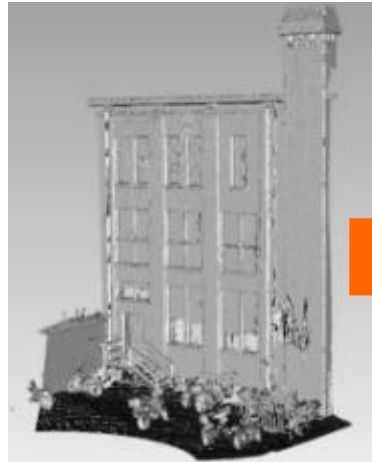
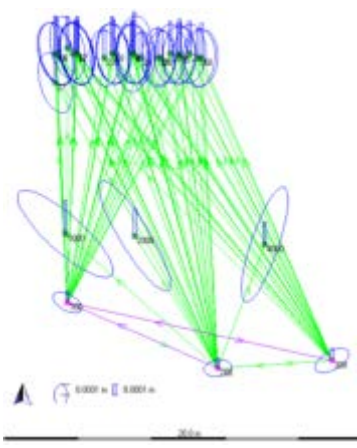
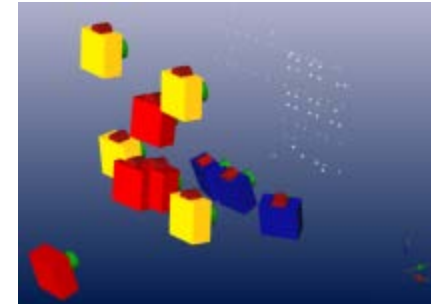
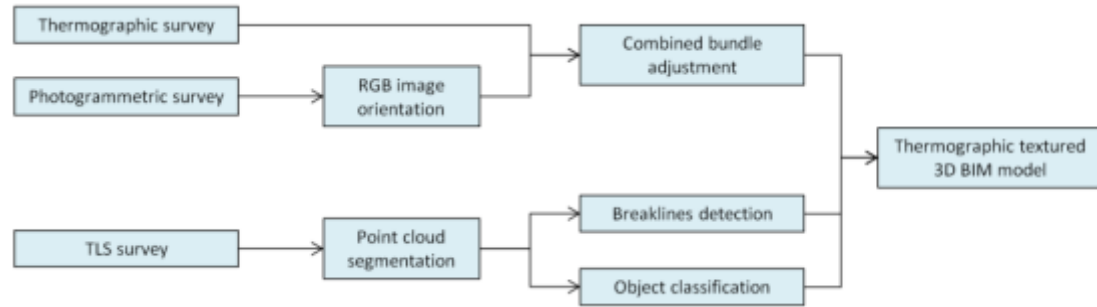




Lecco (Oggiono Campus)

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

Would you believe they're all the same?



Birds' beaks come in all sorts of shapes and sizes. Some are for fishing. Others for boring holes or filtering food from water. In fact nature has come up with lots of different types of beaks. But basically they're all the same material.

Glass is like that too. It comes in every shape and size. For every imaginable purpose. And with widely differing properties, as Schott has proved. We've developed glass that transmits lasers. Glass for cleaning up effluent. Glass

that will stand up to extremes of temperature. In fact we left nature behind long ago. There are only about 8,600 different types of bird, but Schott makes more than 50,000 special glass products.

If you'd like to know

more about special glass and Schott, write to Schott Glaswerke, Dept. ZMK/SE 1 6500 Mainz, West Germany.

 **SCHOTT**
No. 1 in Europe for Special Glass.



“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

**THANK YOU
FOR YOUR KIND
ATTENTION !**

Would you believe they're all the same?



Birds' beaks come in all sorts of shapes and sizes. Some are for fishing. Others for boring holes or filtering food from water. In fact nature has come up with lots of different types of beaks. But basically they're all the same material. _____ Glass is like that too. It comes in every shape and size. For every imaginable purpose. And with widely differing properties, as Schott has proved. We've developed glass that transmits lasers. Glass for cleaning up effluent. Glass that will stand up to extremes of temperature. In fact we left nature behind long ago. There are only about 8,600 different types of bird, but Schott makes more than 50,000 special glass products. _____ If you'd like to know more about special glass and Schott, write to Schott Glaswerke, Dept. ZMK/SE1 6500 Mainz, West Germany.



LOWE LUMBERT