A web-based interactive 2D and 3D GIS application to find the best place to live in a city, using open data and open source software

Carolina Arias Muñoz, Simone Corti, Monia Elisa Molinari, Daniele Oxoli, Gabriele Prestifilippo

GEOlab (Geomatics and Earth Observation laboratory), Politecnico di Milano Como Campus, Como, Italy

Eng. Carolina Arias Muñoz

MSc degree in Environmental and Geomatics Engineering.
PhD student in Environmental and Infrastructure Engineering

Dr. Monia Elisa Molinari

MSc degree in Environmental and Geomatics Engineering.
PhD in Earth Sciences

Eng. Daniele Oxoli

MSc degree in Environmental Engineering.
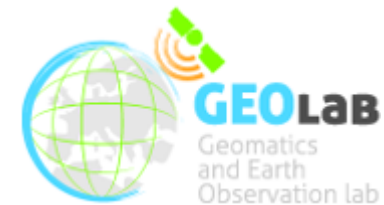PhD student in Environmental and Infrastructure Engineering

Eng. Gabriele Prestifilippo

MSc degree in Computer Science and Engineering

Simone Corti

Computer technician, linux system administrator and web developer

WebGIS, Volunteered Geographic Information (VGI) and Geo Big Data.

What is City Focus?

- Is a web-based interactive 2D and 3D GIS application to find the best place in a city to live, or to pass shorter staying

- The user can select among different criteria and decide their importance by assigning weights to each of them

- The application provides thematic maps on the places which better fit the user's preferences

How is City Focus different from other apps?

- Most of the existing apps:

http://teleport.org   http://www.findyourspot.com   http://where2roost.com

focus on finding a city to live and not on identifying a suitable place within a city.

- The existing apps also allow searching for places to live by specifying few parameters such as apartment or house prices.

- City focus help to perform this task in an automatic as well as user-friendly way avoiding long and hand-made search on the Web.

- City Focus takes into account environmental conditions, that existing apps do not consider.

- The app exploits exclusively open data as well as Free and Open Source Software (FOSS) for its implementation by enabling continuous improvements while minimizing development costs.

MYGEOSS: Innovative Apps in the environmental and social domains

- City Focus is a Winner of the MYGEOSS third call for innovative Apps, launched by the European Commission

- The aim: Development of innovative applications (mobile or web-based) using openly available or crowd-generated data in different domains **addressing citizens' needs**

- MYGEOSS is a two-year project (2014-16) by the European Commission to develop Global Earth Observation System of Systems based smart Internet applications

http://digitalearthlab.jrc.ec.europa.eu/app/57752

MYGEOSS
APPS FOR YOUR
ENVIRONMENT

City Focus Data

Case Study: Milan, Italy

Repository	License	Link
Open Data Lombardia	Italian Open Data License v.2.0 (IODL 2.0) (http://www.dati.gov.it/iodl/2.0)	https://www.dati.lombardia.it
Dati Comune Milano	Italian Open Data License v.2.0 (IODL 2.0) (http://www.dati.gov.it/iodl/2.0)	http://dati.comune.milano.it
OpenStreetMap	Open Data Commons Open Database License (ODbL) (http://opendatacommons.org/licenses/odbl)	https://www.openstreetmap.org
ISTAT	CC-BY 3.0 (https://creativecommons.org/licenses/by/3.0/it)	http://www.istat.it
GEOSS data core	/	https://www.earthobservations.org/geoss_dsp.shtml

City Focus Data

Environmental conditions

- Air Quality
- Low Temperature
- Medium Temperature
- High Temperature

Near to Transportation

- Train and Metro Stations
- Bus Stops

Population Density

- Low Population Density
- Medium Population Density
- High Population Density

City Focus Data

Near to Services

- ATMs
- Banks
- Coffee Shops
- Hospitals
- Pharmacies
- Police Stations
- Post Offices
- Supermarkets
- Veterinary Clinics

Near to Nature

- Parks
- Dog Parks
- Green Areas
- Natural Water

Landuse Type

- Industrial or commercial units
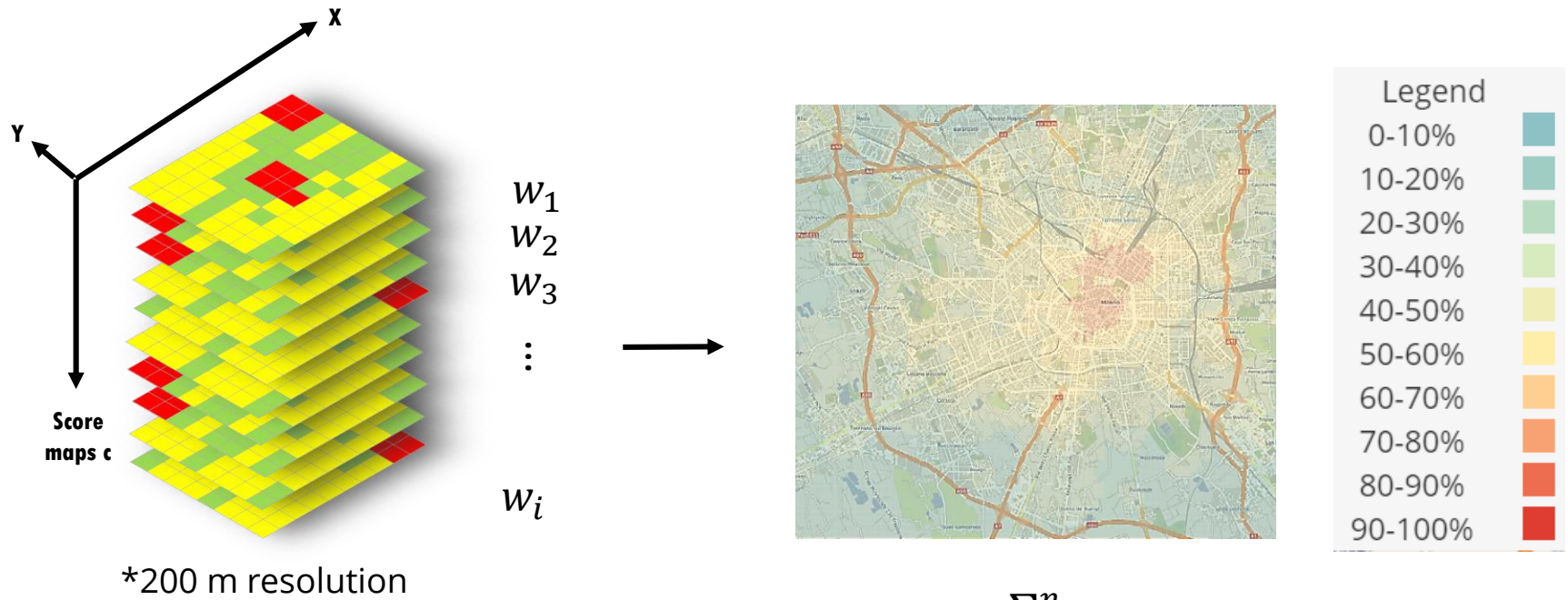- Continuous urban fabric
- Discontinuous urban fabric

Near to Education

- Universities
- High Schools
- Primary Schools
- Secondary Schools
- Kindergartens

Application principle

The output consists of a raster computed as a weighted average of the score maps representing the user's selected criteria. The final map is then displayed with an intuitive color gradient, enabling the user to identify the best places within the city which better fits his/her preferences.

w_1
w_2
w_3
⋮
w_i

Score maps c

*200 m resolution

Legend
0-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
70-80%
80-90%
90-100%

Final Map $\qquad r = \dfrac{\sum_{i=1}^{n} w_i c_i}{\sum_{i=1}^{n} w_i} \quad \{r \in \mathbb{R} \mid 0 \leq r \leq 1\}$

Data Processing

A. Data cleaning

B. Score maps creation

Data Processing

A. Data cleaning

Downloaded data → Reprojection → Projected data → Buffers → Cleaned data

Data Processing

B. Score maps creation

Score maps from **point layers**

| Point layers | → | Quartic kernel density function | → | Spatial concentration maps | → | Normalization | → | Score maps |

`v.kernel, radius 1200 m`

15 min walking distance aprox
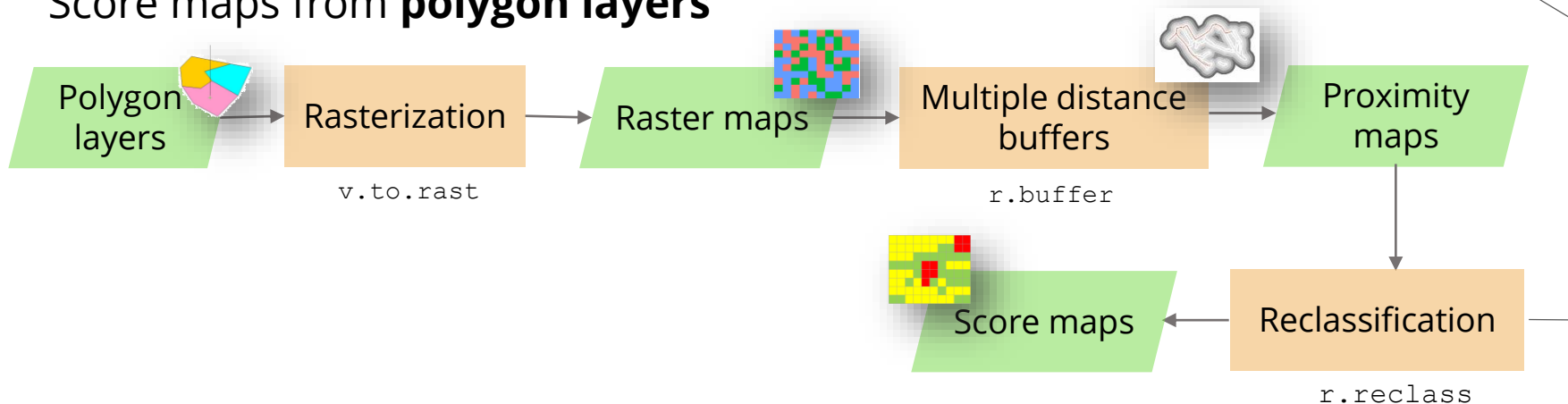
`r.mapcalc`

Services (hospitals, banks, post offices, etc.)
Education (universities, kindergartens, primary schools, etc.)
Transportation (train and metro stations, bus stops) information.

Data Processing

Natural data such as parks, green areas, natural waters, etc.

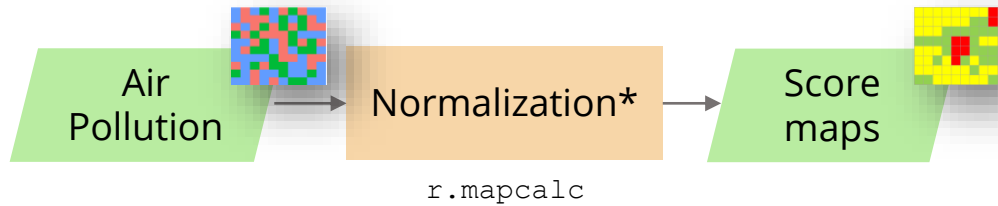| Distance d [m] classes	Score
d = 0	1
0 < d ≤ 400	0.75
400 < d ≤ 800	0.50
800 < d ≤ 1200	0.25
d > 1200	0

Score maps from **polygon layers**

Polygon layers → Rasterization → Raster maps → Multiple distance buffers → Proximity maps → Reclassification → Score maps

`v.to.rast`

`r.buffer`

`r.reclass`

Data Processing

GRASS GIS — The world's leading Free GIS software

PY

Score maps from **raster layers**

*High scores on less polluted areas

Air Pollution → Normalization* → Score maps

r.mapcalc

**score 1 to the cells within the category of interest

T°, pop, landuse layers → Reclassification → High / Industrial / Medium / Continuous / Low / Discontinuous → Reclassification → Score maps

r.Reclass

r.Reclass
0 or 1 **

Classes	Category
MIN ≤ x < ⅓*MAX	low
⅓*MAX ≤ x < ⅔*MAX	medium
⅔*MAX ≤ x ≤ MAX	high

Temperature (high, medium, low)

Population density (high, medium, low)

Land use (Industrial or commercial units, Continuous urban fabric, Discontinuous urban fabric)

Air pollution (PM2,5)

Application architecture

Server

Client

Petascope

rasdaman
raster data management

NASA World Wind

Application architecture

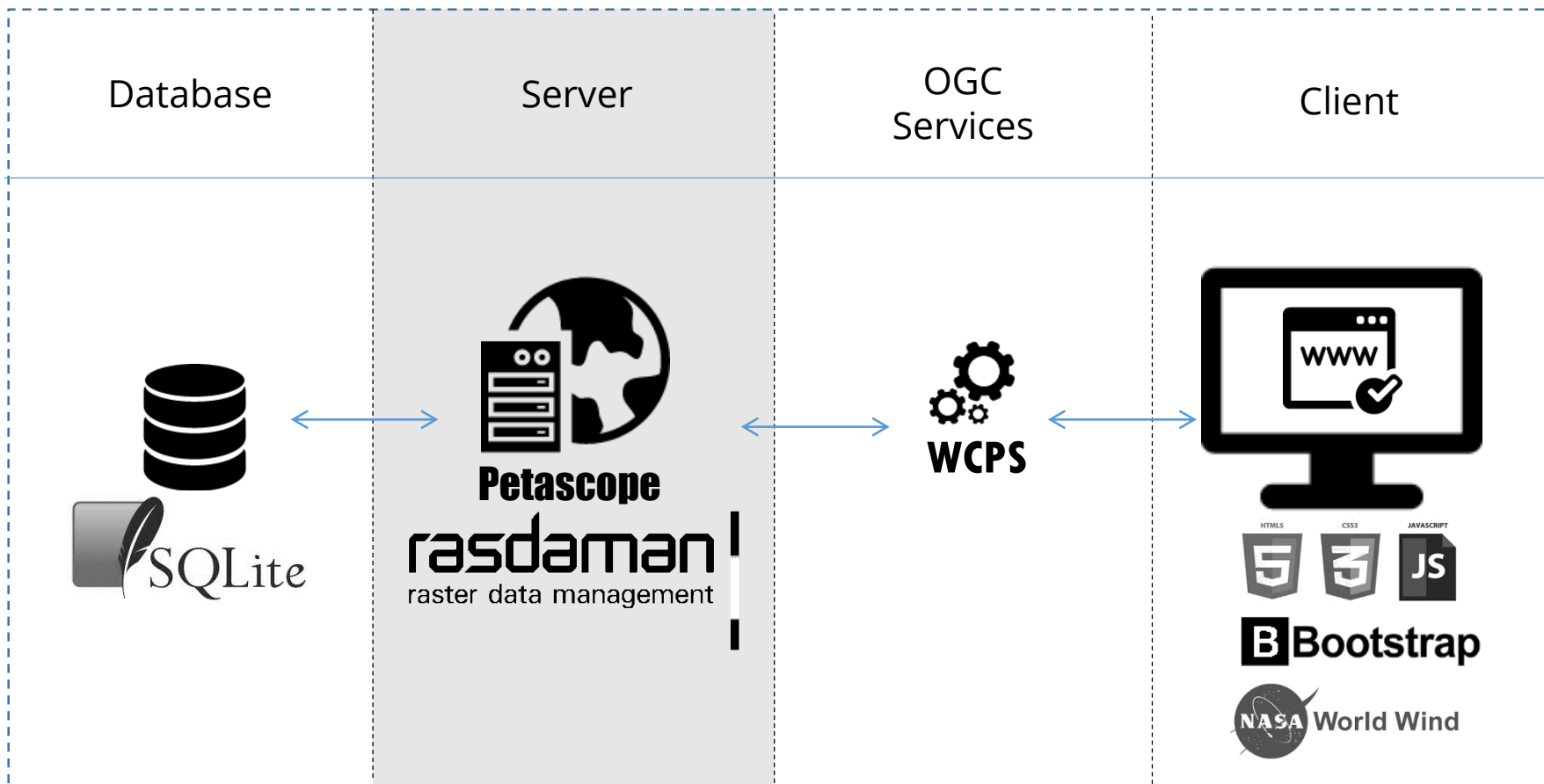**rasdaman**
raster data management

Rasdaman ("raster data manager") is an Array DBMS, that is: a Database Management System which adds capabilities for storage and retrieval of massive multi-dimensional arrays, such as sensor, image, and statistics data.

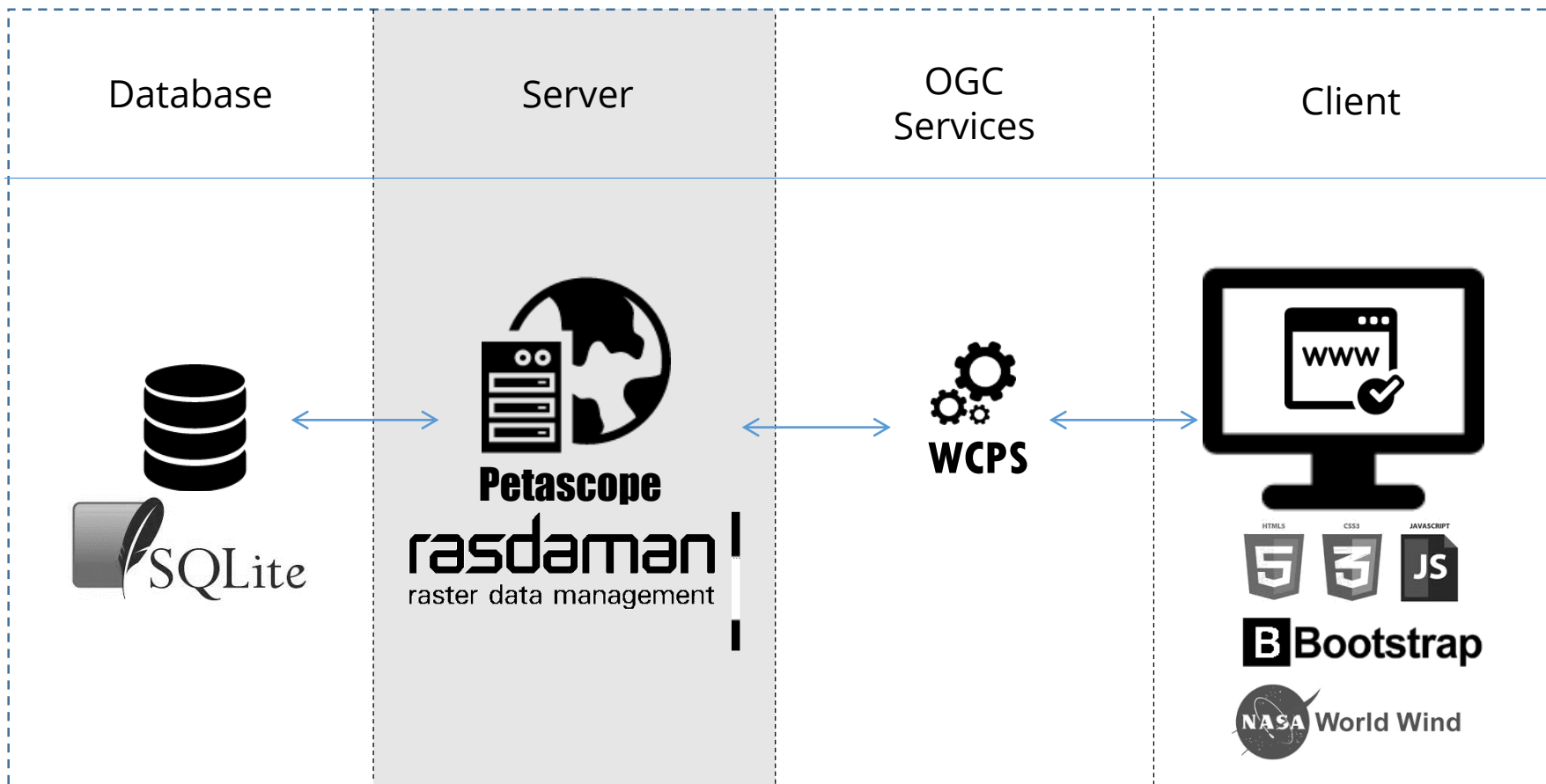**NASA World Wind**

3D Virtual Globe – Open Source and customizable

✓ **WebWorldWind** is a 3D virtual globe API for HTML5and JavaScript.
✓ **WebWorldWind** is different than a 3D globe like Google Earth because it is a library and API rather than a stand-alone application.
✓ This enables it to be included in any web page or web application as a component.

Application architecture

Database	Server	OGC Services	Client

City Focus relies on a standard installation of RASDAMAN with a SQLite database backend

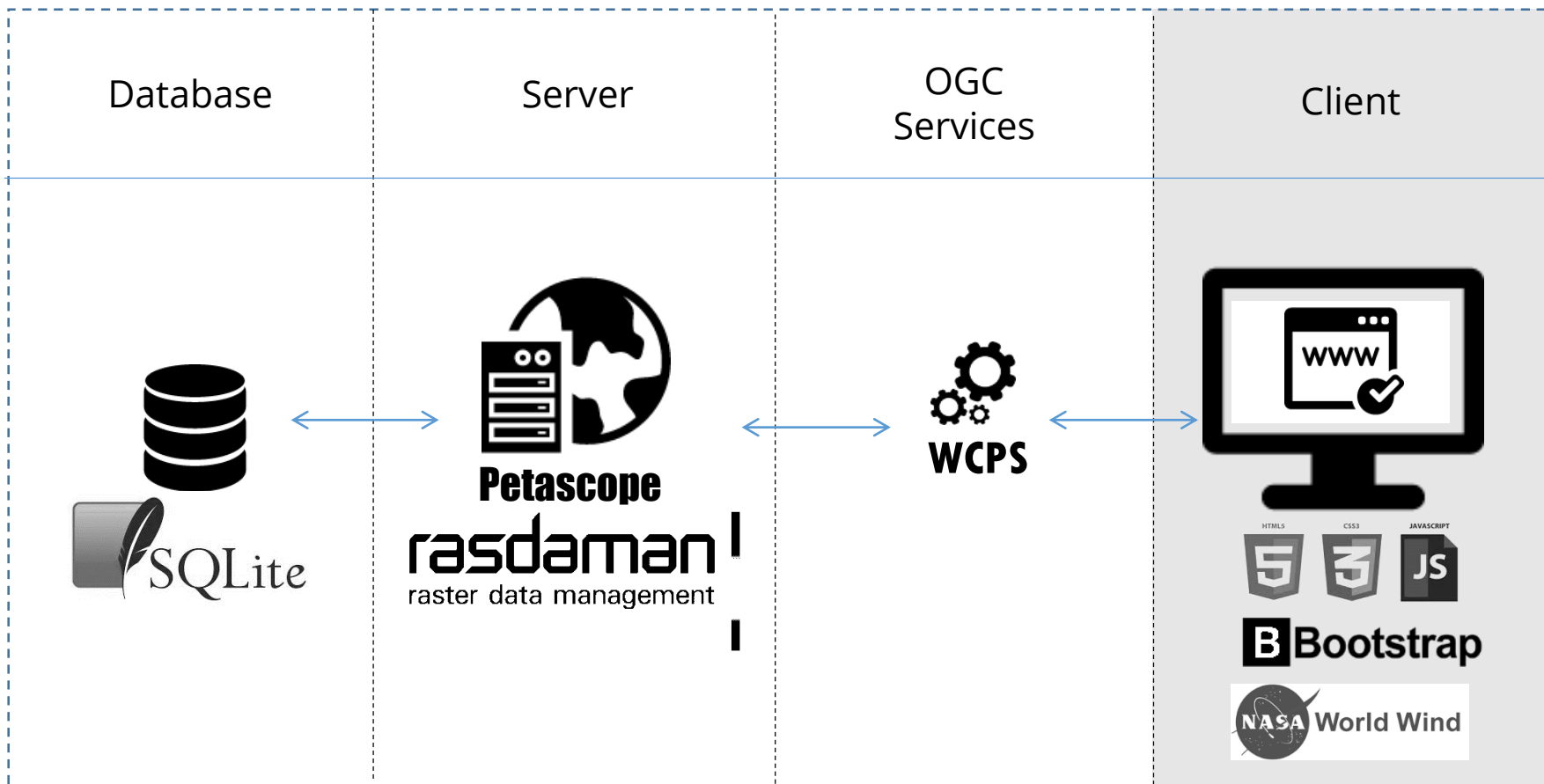# Application architecture

Database	Server	OGC Services	Client

Data are accessed over the web by the Petascope component of RASDAMAN, translating the incoming WCPS request into RASDAMAN rasql language queries and generating the output map

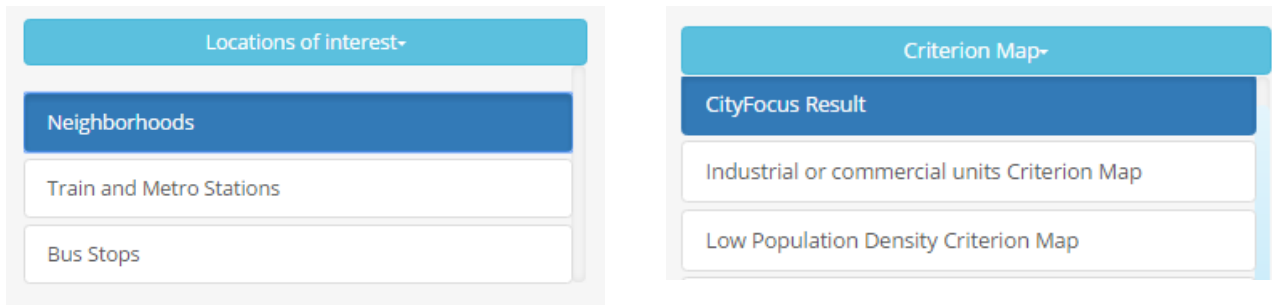# Application architecture

Database	Server	OGC Services	Client

Combining jQuery and Web WorldWind, it is possible to retrieve maps from RASDAMAN through the WPCS and show them to the end-user.

Application architecture

- Criteria vector layers "locations of interest" are added into the application as geojson

- The final map, as well as the criteria raster layers "criterion map" are «painted» by coloring a grid (vector version of the score maps) using the values of the retrieved csv files from the WCPS requests
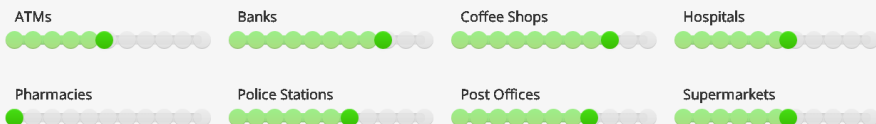
- The POST WCPS request is of the form:

```
for a in (atms), b in (banks), c in (cafe), d in (hospitals) … z in (discontinuous)
    return encode ( ( (a*50 + b*50 + c*80 + d*70 … z*80)/180.4), "csv") )
```

What is City Focus?

1 Select your criteria and assing weights

Near to Services

ATMs	Banks	Coffee Shops	Hospitals

Pharmacies	Police Stations	Post Offices	Supermarkets

2 Click to create your map!

Find Your Place!

3 Check your map

5 Check each criterion map

6 Locations of interest▾

Navigate through the locations of interest

Legend
- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%

Selected Criteria

ATMs - **50%**
Banks - **80%**
Coffee Shops - **80%**
Hospitals - **60%**
Police Stations - **60%**
Post Offices - **70%**
Supermarkets - **60%**
Veterinary Clinics - **60%**
Free Wifi - **70%**
Parks - **80%**
Dog Parks - **80%**
Green areas - **50%**
Natural W___ - **60%**

4 Use map controls

7 Reset

Start Again!

CITY FOCUS

Future Developments

- Possibility for users to get a glimpse of the changing environment within a city through trend maps or graphs (e.g. temperature changes in the last five years, etc.)

- Add the name of best scored city blocks from the final map (i.e. the cells with the highest scores) by means of geocoding.

- Take more advantage of the 3D functionalities (e.g. elevate cells according to cells values)

- Add user-administration functionalities to gather information about user preferences: useful for urban management and marketing analytics purposes

- Add information about house sale/rent prices as well as customize criteria for different potential customers (e.g. accommodation booking website, etc.)

- As a first case study, we considered the city of Milan. In the future, other Italian as well as European cities are planned to be included.

Check the application on:

http://muvias.eoapps.eu/cityfocus/application.html

And the documentation /source code:

GitHub https://github.com/GabrielePrestifilippo/CityFocus

Thank you for your attention!