

Development of a ZigBEE based wireless data transmission system for radon concentration measurement devices



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SUPSI



RADICAL

[RADon: Integrating Capabilities of Associated Labs]

- A 3-year long project approved within the INTERREG program of cross-border cooperation between Italy & Switzerland (Feb. 2011-Feb. 2014)
- Partners:
 - Università dell'Insubria, Dept. of Science & Technology, COMO, Italy
 - SUPSI – Scuola Universitaria Professionale della Svizzera Italiana, Manno, CH
 - Two regional Environmental Agencies:
 - ARPA – Piemonte, Servizio di Radiazioni Ionizzanti, IVREA
 - ARPA – Val d'Aosta, Aosta
- Work plan [essentials]:
 - Monitoring of indoor Radon concentration in buildings with complex architecture with a cluster of “real-time” instruments
 - Optimization of remedial actions [see Linda Panero's talk for an exemplary illustration] based on ventilation
 - Study of the correlation between the Radon Equilibrium Factor and the concentration of fine particulate matter
 - Development of a system for wireless transmission of data from a cluster of “real-time” radon monitoring RADIM5b Devices
 - Off-the-record: Monitoring of a large geographical area of geological interest by a network of remotely controlled devices



How we got started:

Real-time monitoring of a selected number of bank agencies using a set of RADIM5b instruments

- site selection based on the results by a extensive **survey** using passive detectors
- previous **monitoring** exercises based on a single top-class instrument (AlphaGuard)
- main objectives of the our campaign:
 1. Verify the advantages linked to simultaneous measurements in different areas
 2. Verify mitigations effects, whenever it is a due
 3. Study correlations with environmental parameters (T, Relative Humidity, CO₂, Fine/Ultrafine particulate matter)

CAMPAIGN PERFORMED BETWEEN
MARCH 2010 AND JUNE 2011
IN 4 BANK AGENCIES

A short summary of the monitoring campaign

Id	Geo-Position	Mapping report	Start date	End date	Environmental parameter measurement	
1	Northern Italy, big town(a+b)	Radon free (a)/filled (b)	March 29, 2010	April 9, 2010	YES	
2	Northern Italy, big town	Significant radon levels - mitigated				
			• First campaign	June 18, 2010	July 5, 2010	YES
			• Second campaign (ventilation tune-up)	Dec. 20, 2010	Jan. 12, 2011	NO
			• Third campaign (ventilation tune-up)	May 2, 2011	Jun. 27, 2011	NO
3	Central Italy, Granducato, mid-size town	Significant radon levels - mitigated	Sep. 29, 2010	Oct. 16, 2010	NO	
4	Central Italy, radon prone area, small village	Significant radon levels - mitigated				
			• First campaign	May 14, 2010	May 31, 2010	YES
			• Second campaign (ventilation tune-up)	Jul. 21, 2010	Aug. 7, 2010	NO

Exemplary illustration

A focus on agency no.2

- ✧ a three story structure connected by a staircase, no doors :
 - -1: hosting a storage room, the bank caveau and a small room with technical ventilation and air conditioning equipment
 - ground floor: large open space for public and a mid-size back-office
 - +1: a series of small size offices, connected by corridors
- ✧ 6 RADIM5b were positioned:
 - Radim06: Caveau, underground
 - Radim05: storage room, underground
 - Radim12: open space, ground floor
 - Radim11: mid-size office, ground floor
 - Radim07: small-size office, first floor
 - Radim08: Director's office, first floor



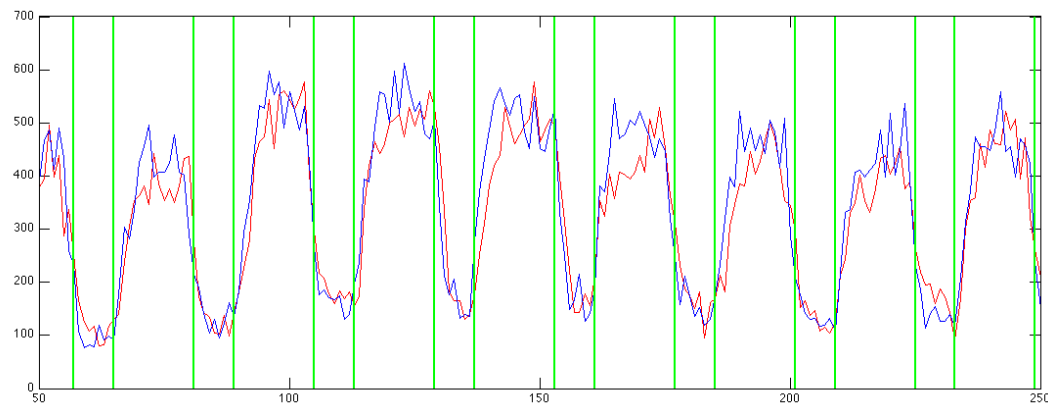
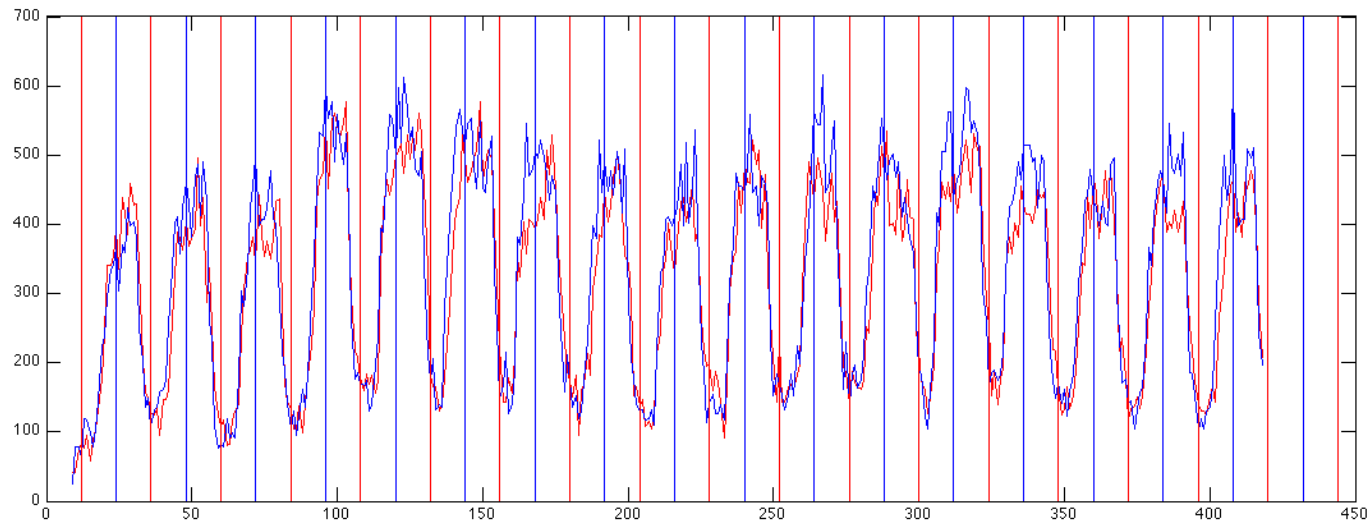
A snapshot from the second & third measurement

✧ motivation:

- Tune-up the ventilation working hours (7am to 6 pm, 24/24, else)
- do not stop the ventilation during the weekend, to gain stability
- see if the time modulation of the concentration changes as a function of the ventilation working hours
- find the optimal settings, namely the minima corresponding to the office working hours

✧ instrument positioning: 6 RADIM5b's as of the first campaign

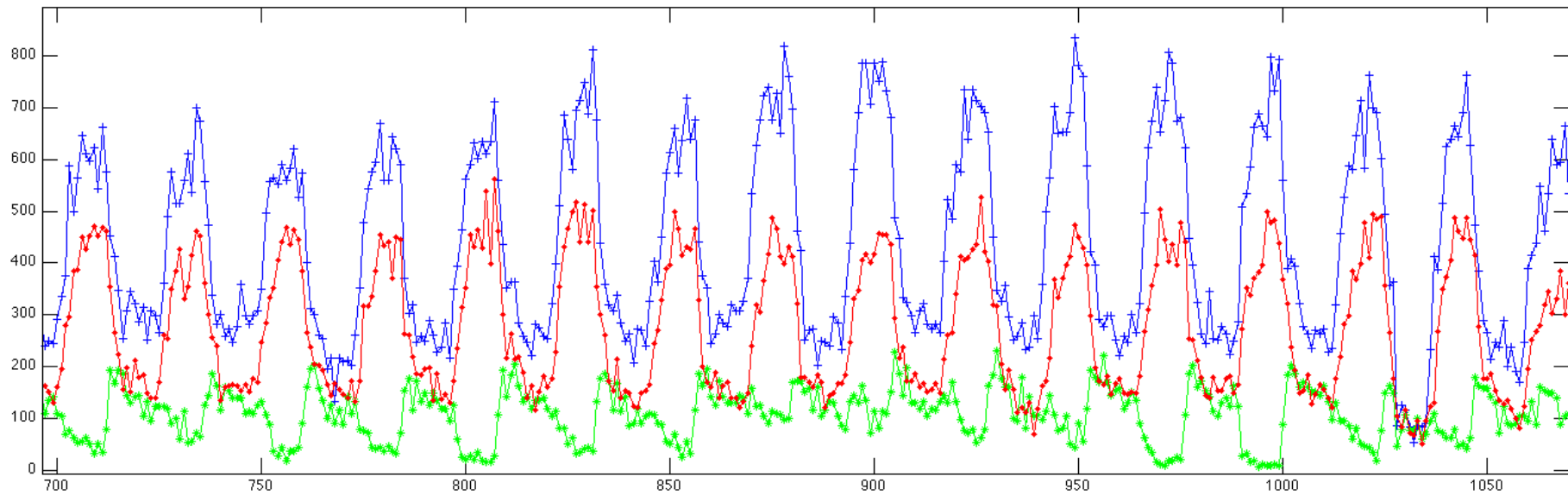
Hourly concentration (Bq/m³) at the ground floor (second campaign):



Colour coding:

- midnight
- midday
- working hours (9-17)

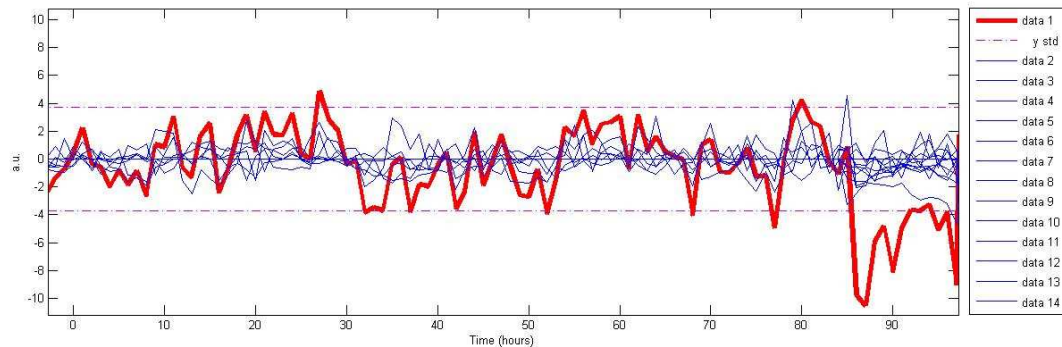
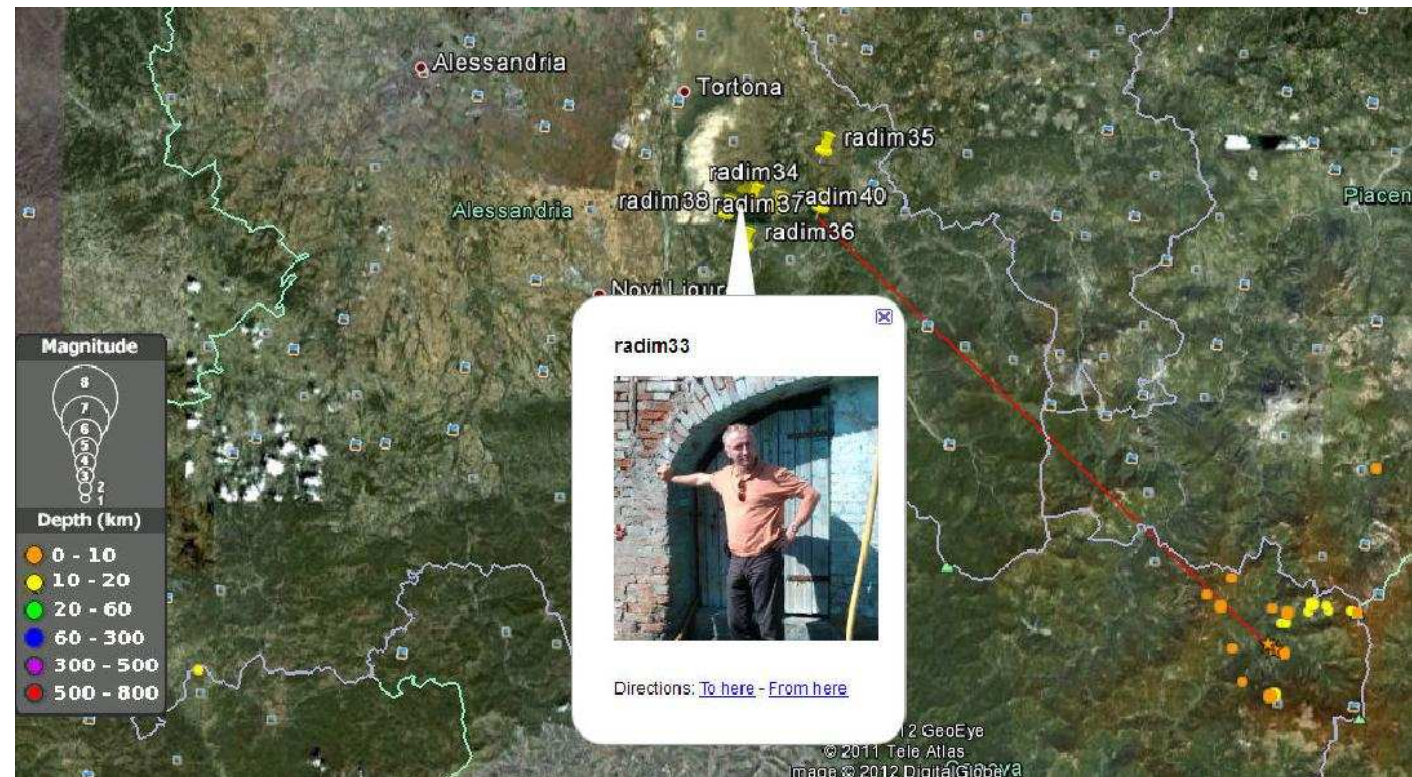
And find out flaws in the ventilation system....



Data from the third campaign, showing that the ventilation circuit [on from 7am to 6 pm] is introducing a nice anti-correlation, pumping out the Radon from the underground area [blue data] and re-filling the first floor [green data]... so that when the ground floor/underground are at minimum the first floor is at max and the values gets closer....

Geo measurement campaign 2011

RADIMs located
70km away from
seismic activities



Very optimistic expectation, but
correlation with showers only
observed

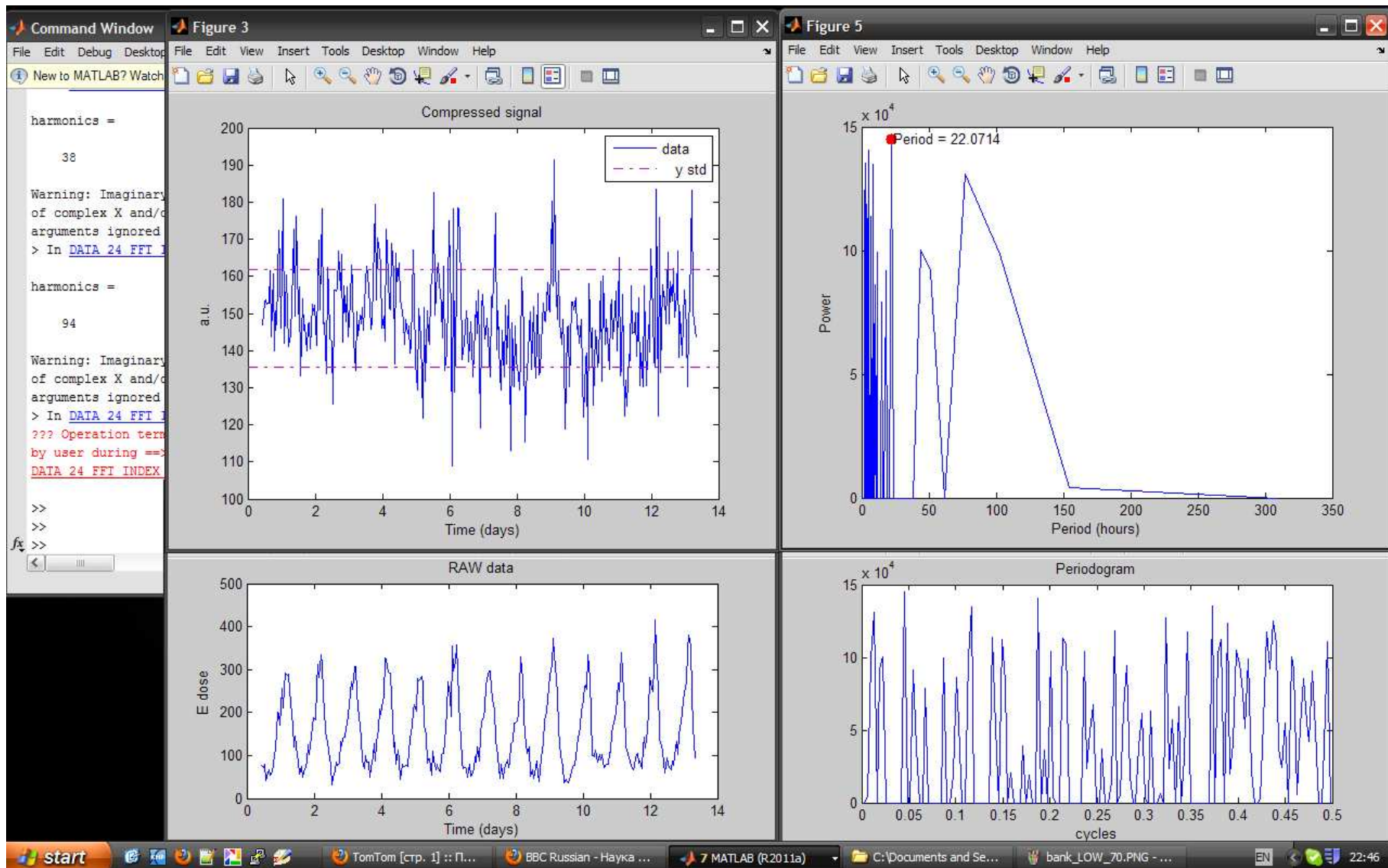


Geo measurement campaign 2011

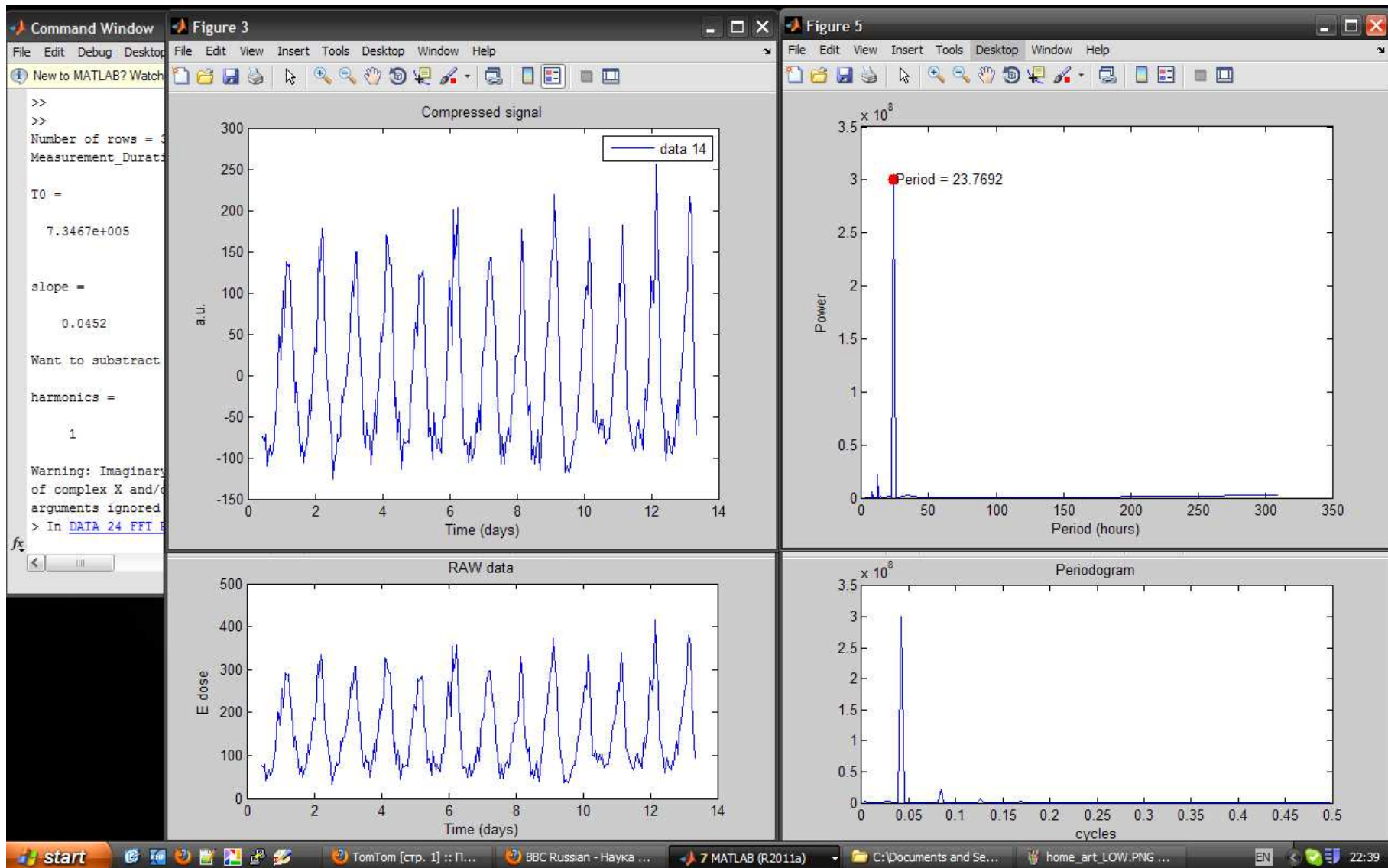
data manipulation example

based on discrete FFT

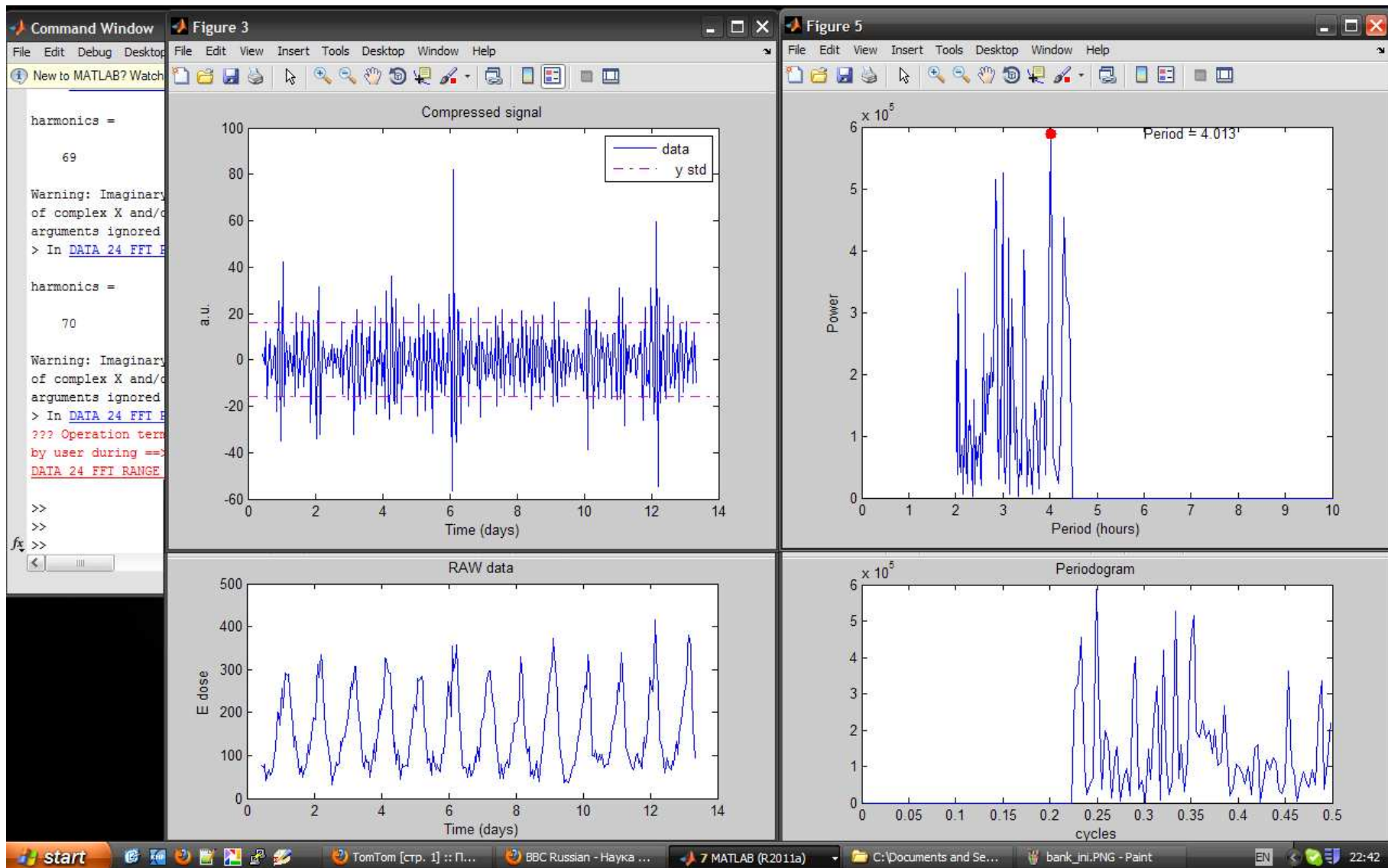
Geo measurement campaign 2011



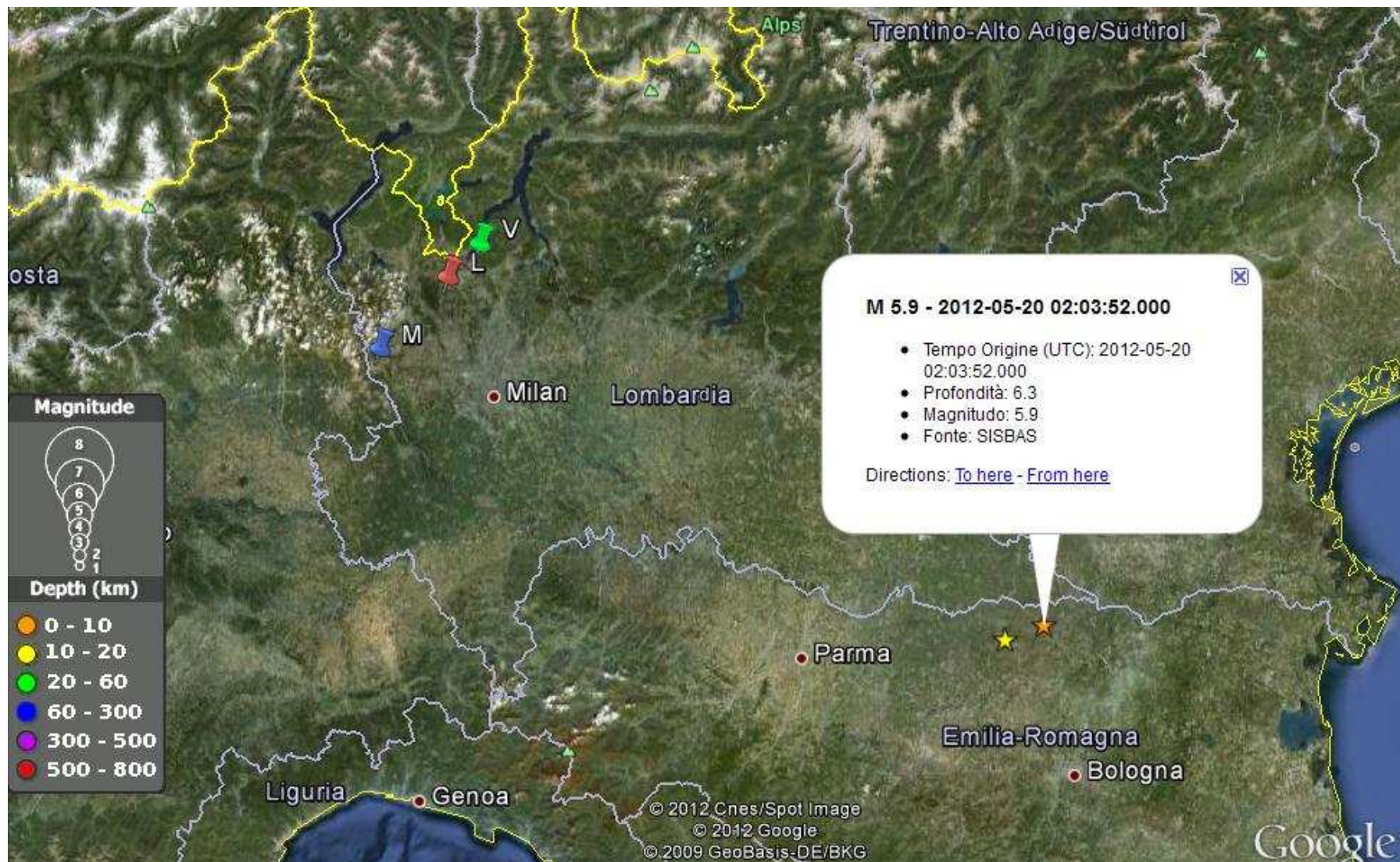
Geo measurement campaign 2011



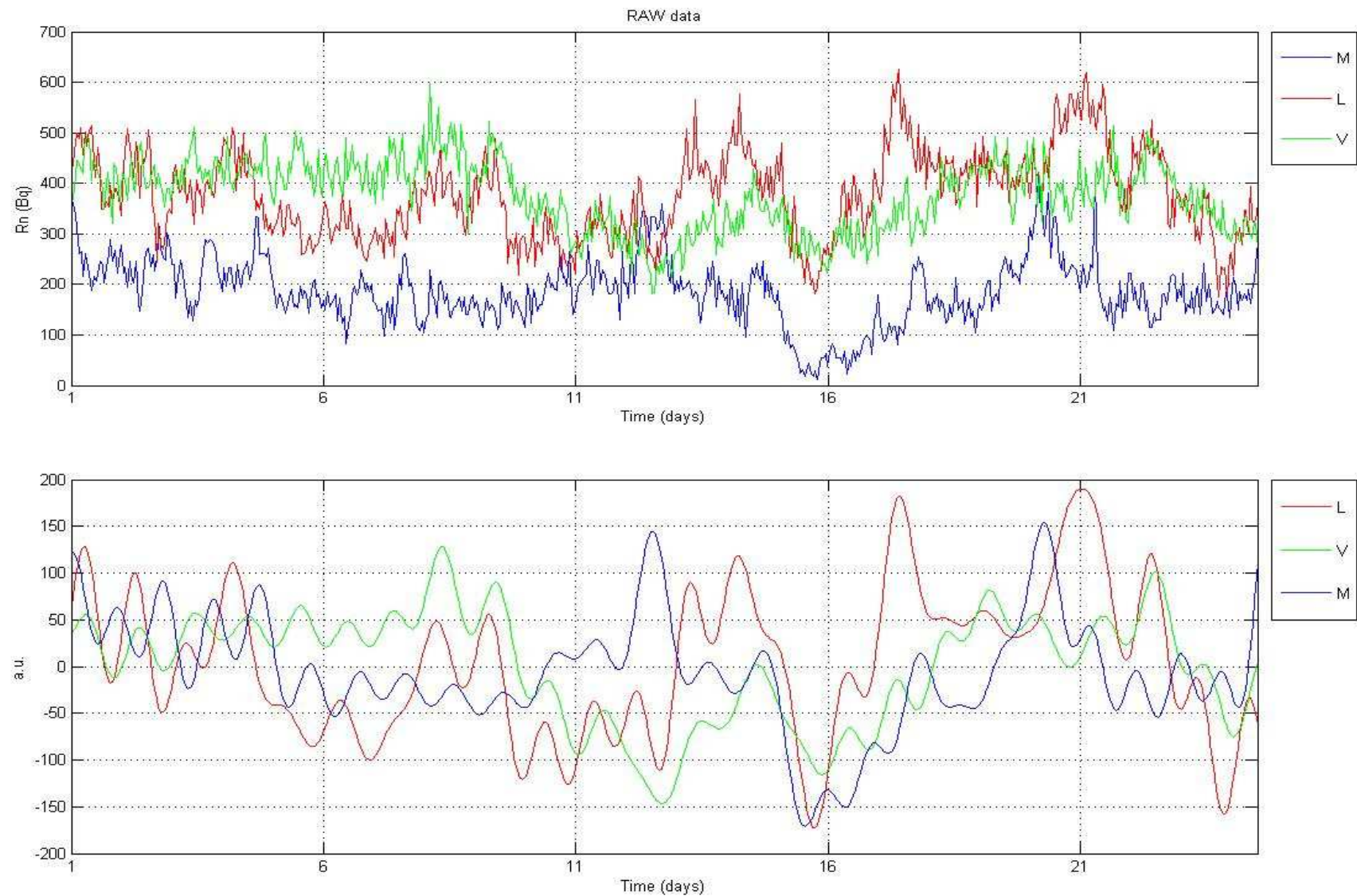
Geo measurement campaign 2011



In home of 3 campaign



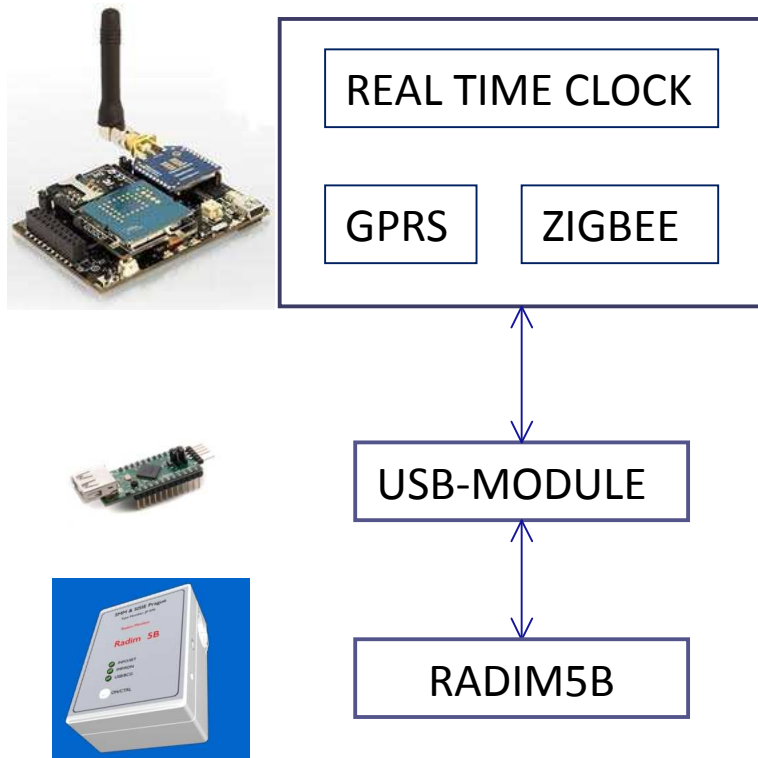
In home of 3 campaign



Current Geo campaign 2012



Architecture of WASPMOTE ACCESS POINT module



System features:

Core microcontroller	ATmega1281
Core memories	8KB SRAM, 4KB EEPROM, 128KB Flash, SD card 2GB
Radio module	Xbee type socket(802.15.4, ZigBee, Wi-Fi, Bluetooth, GSM/GPRS, 3G, RFID).
External interfaces	UART, SPI, I2C, PWM, USB, GPIO
Power supply	Lithium Batteries
Software	Open Source API
Manufacturer	Libelium
Pricing	147 Euro

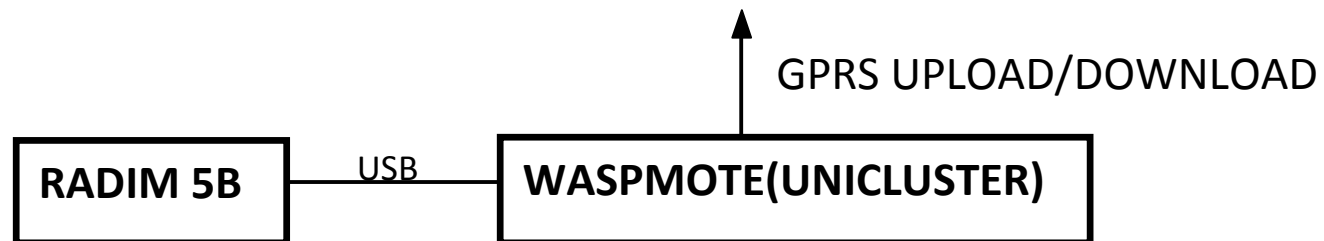


Architecture of WASPMOTE

The development of a module (RADIM+) is the next: implementing the data transmission between cluster of RADIM5b and a web-server is based on WASPMOTE, a development platform by Libelium (<http://www.libelium.co>). WASPMOTE is based on the ZigBee mesh networking protocol (<http://www.zigbee.org>), which is specifically designed for low-data rate, low-power applications. Moreover, WASPMOTE can integrate:

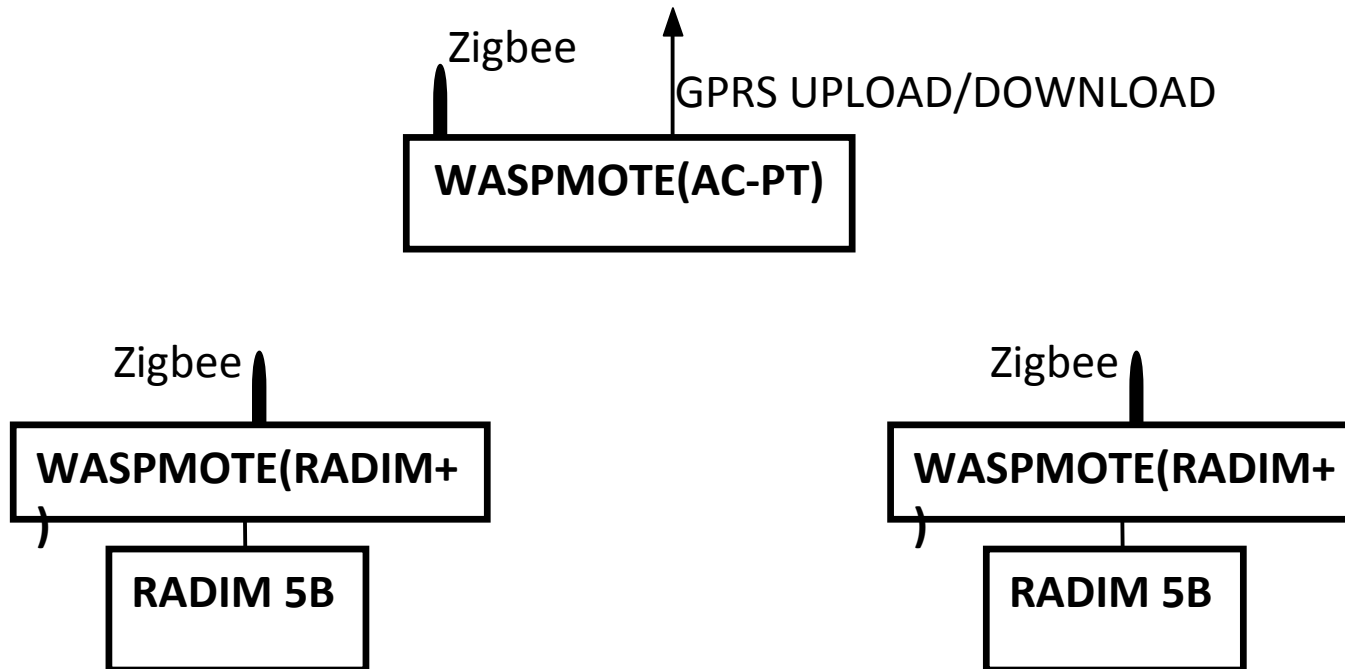
- A module for an USB interface to the RADIM
- Sensor modules for temperature, humidity and pressure measurements
- GPS module for geo-positioning
- GSM (Global System for Mobile communications) / GPRS (General Packet Radio Service) module to enable communication using the mobile telephone network.

MODE 1



- Up to 24 measures(min is one upload per hour, max is one upload per day)
- Remote set of wakeup time interval
- Remote reset(clear error) of the RADIM5B
- Put on/off RADIM5B remotely

MODE 2

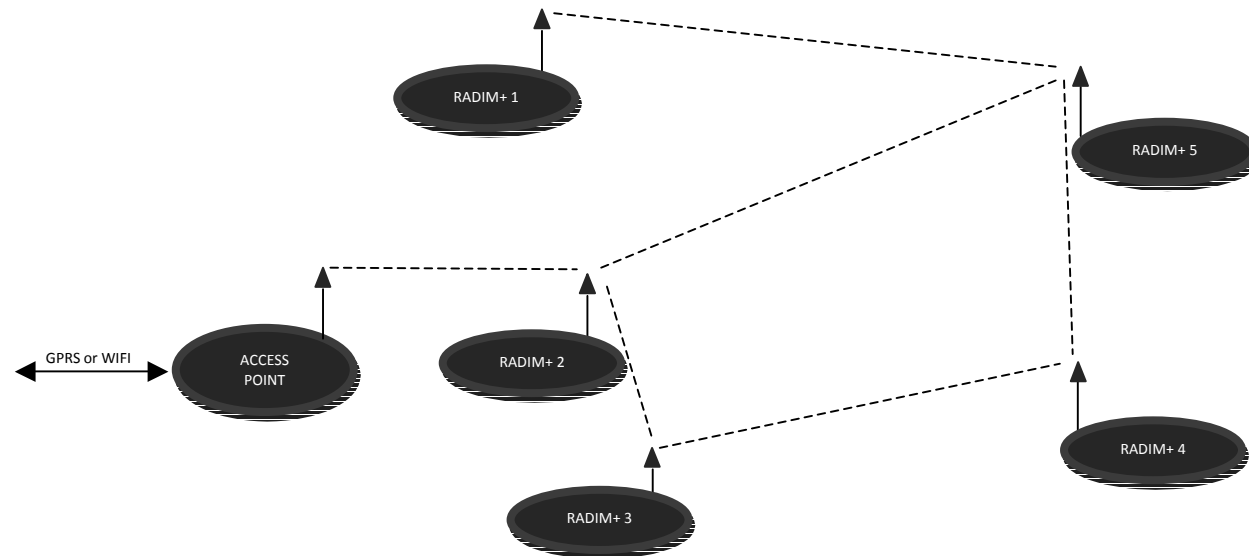


- Up to 24 measures (one upload per day max.)
- Remote set of wakeup time interval

MODE 3

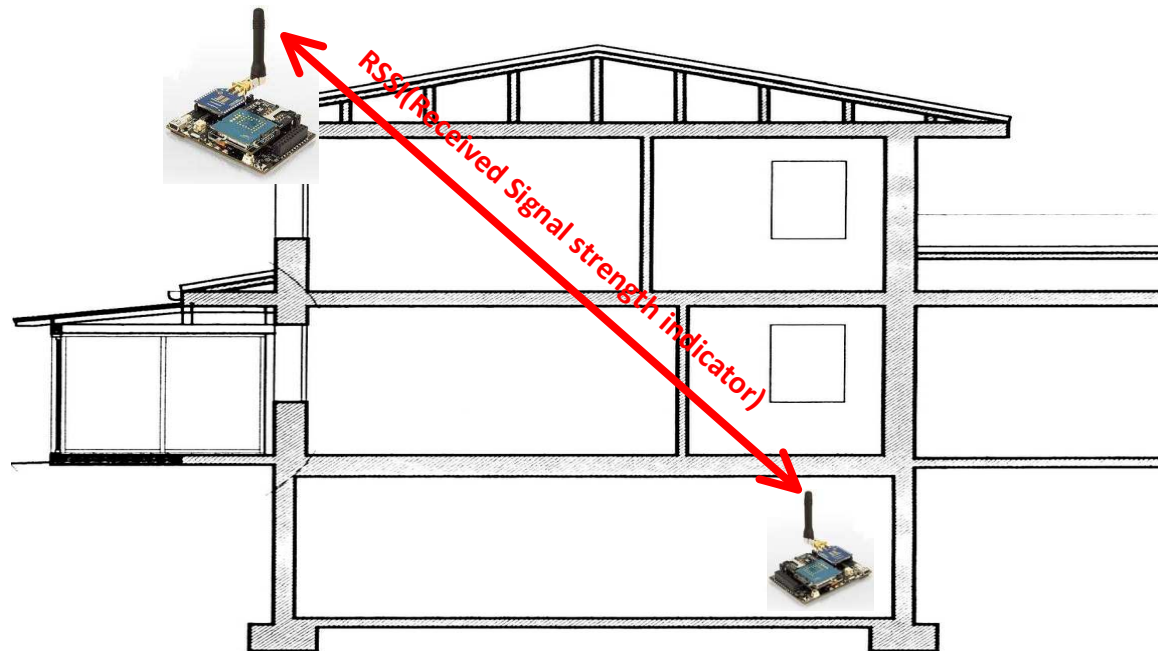
Features of the MODE3 complete configuration:

- Remote definition of the Network configuration
- Multi hop protocol
- GPS module and sensors board implementation



ZIGBEE signal quality control

Program able to measure the signal strength of the zigbee module trasmission to be sure for proper installation.





The main functionality of WEB server

- Two-way communication
- Data validation and analysis
- Measurement campaign management

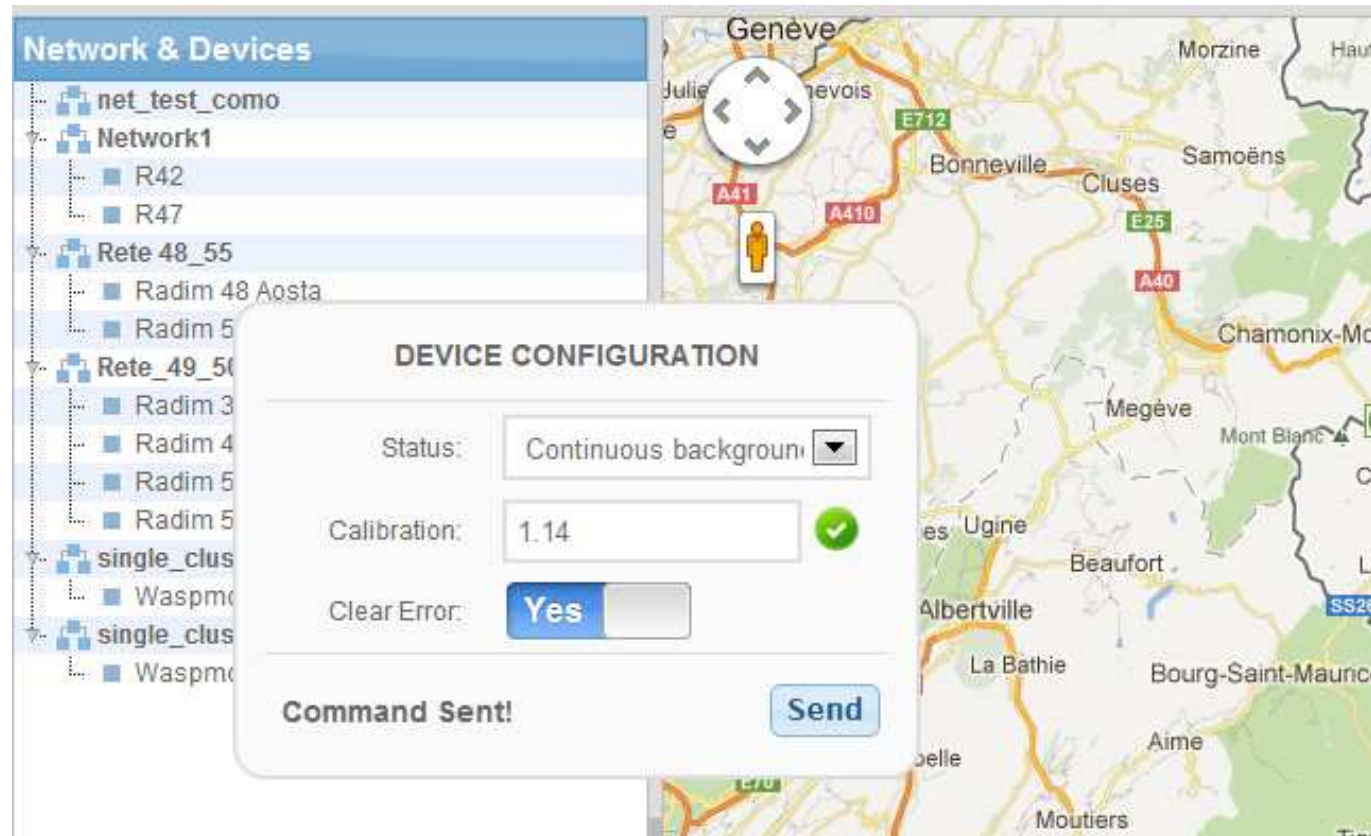
Two-way communication

Receive data: The received radon data are stored on database and shown to the user through a chart directly on the map



Two-way communication

Send data: The Radim's or Network parameters can be remotely configured by sending all settings from web server



Data validation and analysis

The received data automatically validated by appropriate validation profiles or certified user can change the validation status of a single sampled data as well.

Session Details

Info Session

Start Time:	09/05/2012 12:22:50	Background:	2
End Date:	09/06/2012 12:22:50	Calibration:	1.16
Latitude:	45.7353184	Altitude:	N/A
Longitude:	7.3136122	Battery:	73%

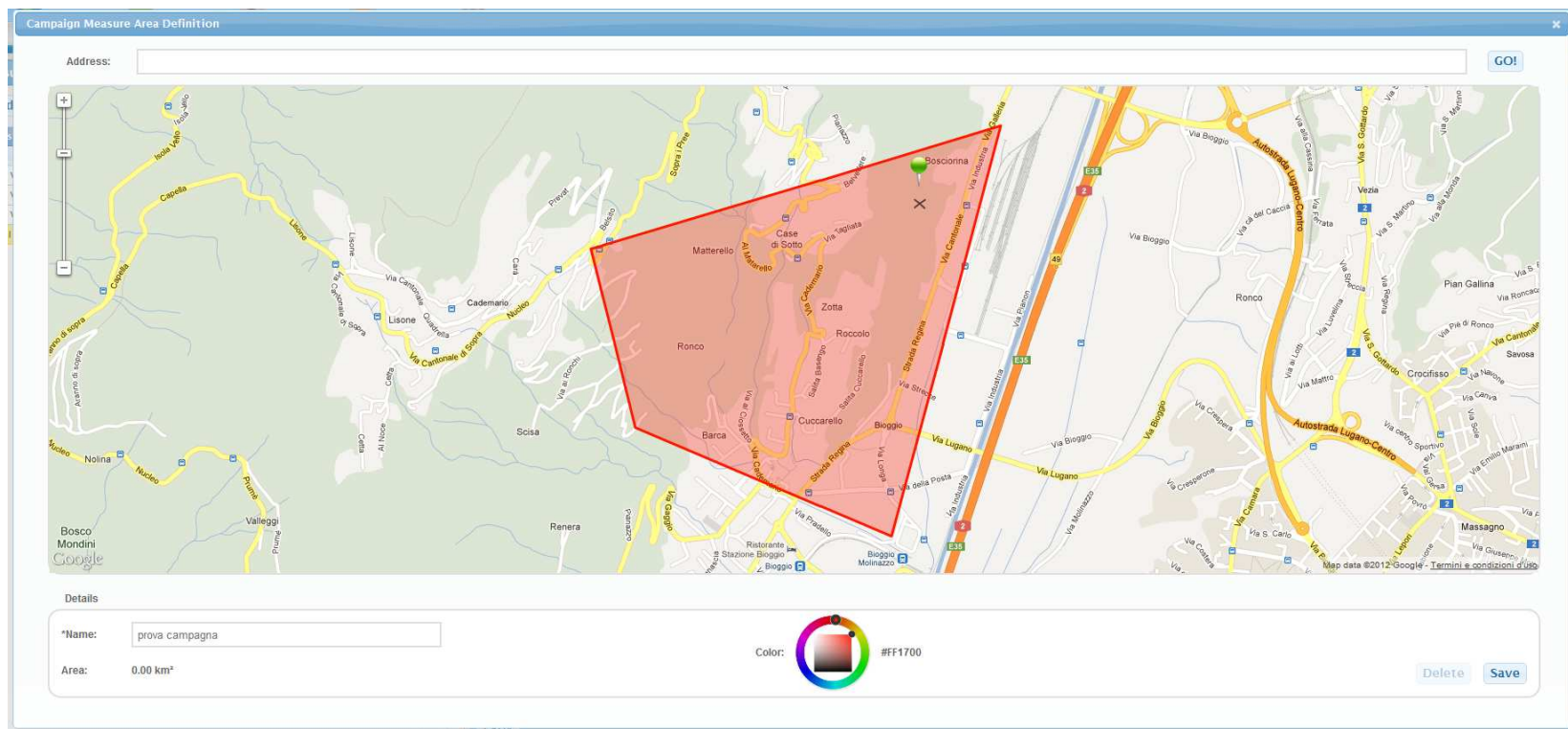
Radon - Page (2/2) ◀▶

Record	Date	Time	Temp [°C]	Concentration [Bq/M3]	Impulses	Validation Status	Value Is Valid?
13	09/06/2012	00:22:50	23	48.84	18	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
14	09/06/2012	01:22:50	23	30.53	12	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
15	09/06/2012	02:22:50	23	15.26	7	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
16	09/06/2012	03:22:50	23	9.16	5	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
17	09/06/2012	04:22:50	24	45.79	17	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
18	09/06/2012	05:22:50	24	45.79	17	Automatically Validated	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
19	09/06/2012	06:22:50	24	21.37	9	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
20	09/06/2012	07:22:50	24	45.79	17	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
21	09/06/2012	08:22:50	24	42.74	16	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
22	09/06/2012	09:22:50	24	15.26	7	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
23	09/06/2012	10:22:50	24	3.05	3	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
24	09/06/2012	11:22:50	24	12.21	6	Automatically Validated	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

Save

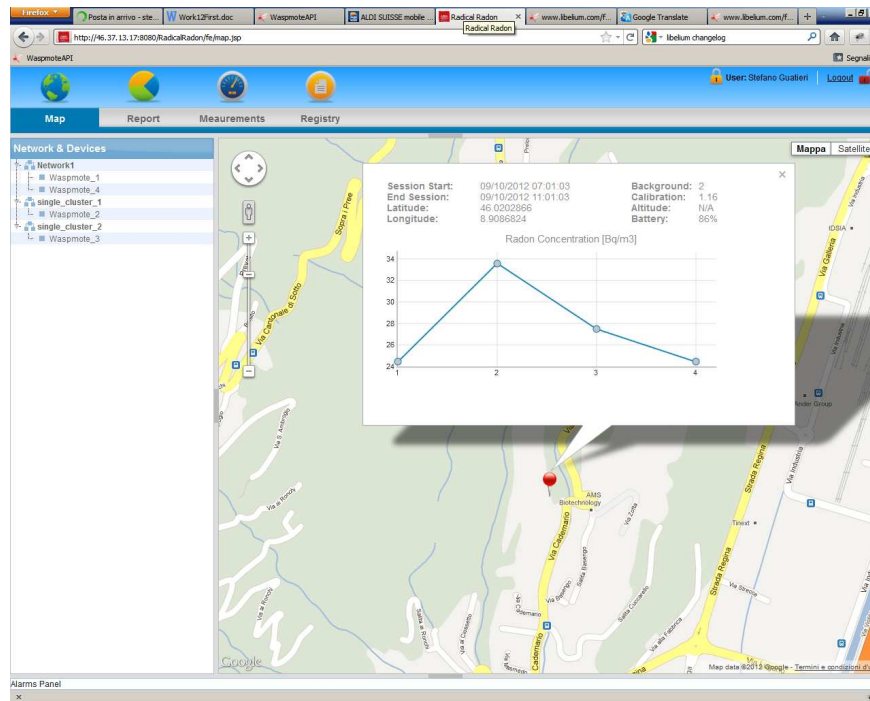
Measurement campaigns management

To define and manage simultaneous measurement campaigns, drawing directly on map the geographic area of interest and to put on one or more of the RADIM5B



Thanks for your attention!

To be continued...



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