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The role of CEVaD, the Evaluation Data Center, in the Italian Nuclear Emergencies Plans

Mauro Magnoni
ARPA Piemonte – Dipartimento Rischi Fisici e Tecnologici
Via Jervis, 30, 10015 Ivrea (TO)

Introduction

- The CEVaD, *Centro di Elaborazione e Valutazione Dati*, an acronym that can be translated into “Evaluation Data Center”, is a scientific committee established by the Italian Law (art. 123, D. Lgs. 230/1995) for the purpose of giving technical advice to the Prime Minister (Civil Protection Department) in case of a nuclear or radiological emergency
- It’s based in Rome and meets at the ISIN emergency room

- It is composed by several experts covering all the most relevant technical fields, coming from different public bodies such as:

  - ISIN (Nuclear Inspectorate)

  - ISS (National Health Institute)

  - INAIL (National Institute for the Occupational Accident Insurance)

  - Fire Brigade

  - Air Force

  - ARPA (Regional Environmental Protection Agency)

- In this Committee the radioprotection and nuclear competences are of course the most important one
- Actually, one of the main task of CEVaD, during a radiological and/or nuclear accident is the evaluation of all the available data in order to make a conservative but reliable dosimetric forecast of the most probable evolution of the emergency in the next future (tipically, for the next 48 hours)

- CEVaD’s advice may be asked by the Italian national and local authorities for any major nuclear or radiological accidents occured in Italy or in the neighboring countries
- However, as all the Italian Nuclear Power Plants and nuclear installations have been shut down many years ago and are now being dismantling, the probability of a severe domestic nuclear disaster can be reasonably excluded

- For that reason the radiological and nuclear risk in Italy is dominated by scenarios involving major nuclear accidents occurred at the Nuclear Power Plants located in the neighboring countries: France, Switzerland, Germany and Slovenja
- Taking into account for this, the National Emergency Plan (firstly issued in 1997, revised in 2010) is now based on scenarios assuming an INES level 7 accident occurring at:

  - St. Alban NPP (France, 2 PWR, 1385 MWe)

  - Krško NPP (Slovenja, PWR, 707 MWe)

Nuclear Power Plants in Europe: in blue those with distance < 200 km from the Italian border

- The source term of the reference accident is very high and is characterized by the release of a significant fraction of the radioactivity inventory of the reactor core

Release fractions

Noble Gases (^{133}Xe, ^{88}Kr)
1
Halogen (^{131}I)
0,075
Alkali Metals (^{137}Cs, ^{134}Cs)
0,075
Tellurium group (^{132}Te)
0,0305
Barium, Strontium, (^{89}Sr, ^{90}Sr, ^{140}Ba)
0,012
Noble Metals (^{103}Ru, ^{106}Ru)
0,0005
Cerium group (^{144}Ce)
0,00055
Lanthanides (^{140}La)
0,00052

^{88}Kr	($\approx 10^{18}$ Bq)
^{89}Sr	($\approx 10^{16}$ Bq)
^{90}Sr	($\approx 10^{15}$ Bq)
^{103}Ru	($\approx 10^{15}$ Bq)
^{106}Ru	($\approx 10^{14}$ Bq)
^{131}I	($\approx 10^{17}$ Bq)
^{132}Te	($\approx 10^{17}$ Bq)
^{133}Xe	($\approx 10^{18}$ Bq)
^{134}Cs	($\approx 10^{16}$ Bq)
^{137}Cs	($\approx 10^{16}$ Bq)
^{144}Ce	($\approx 10^{15}$ Bq)

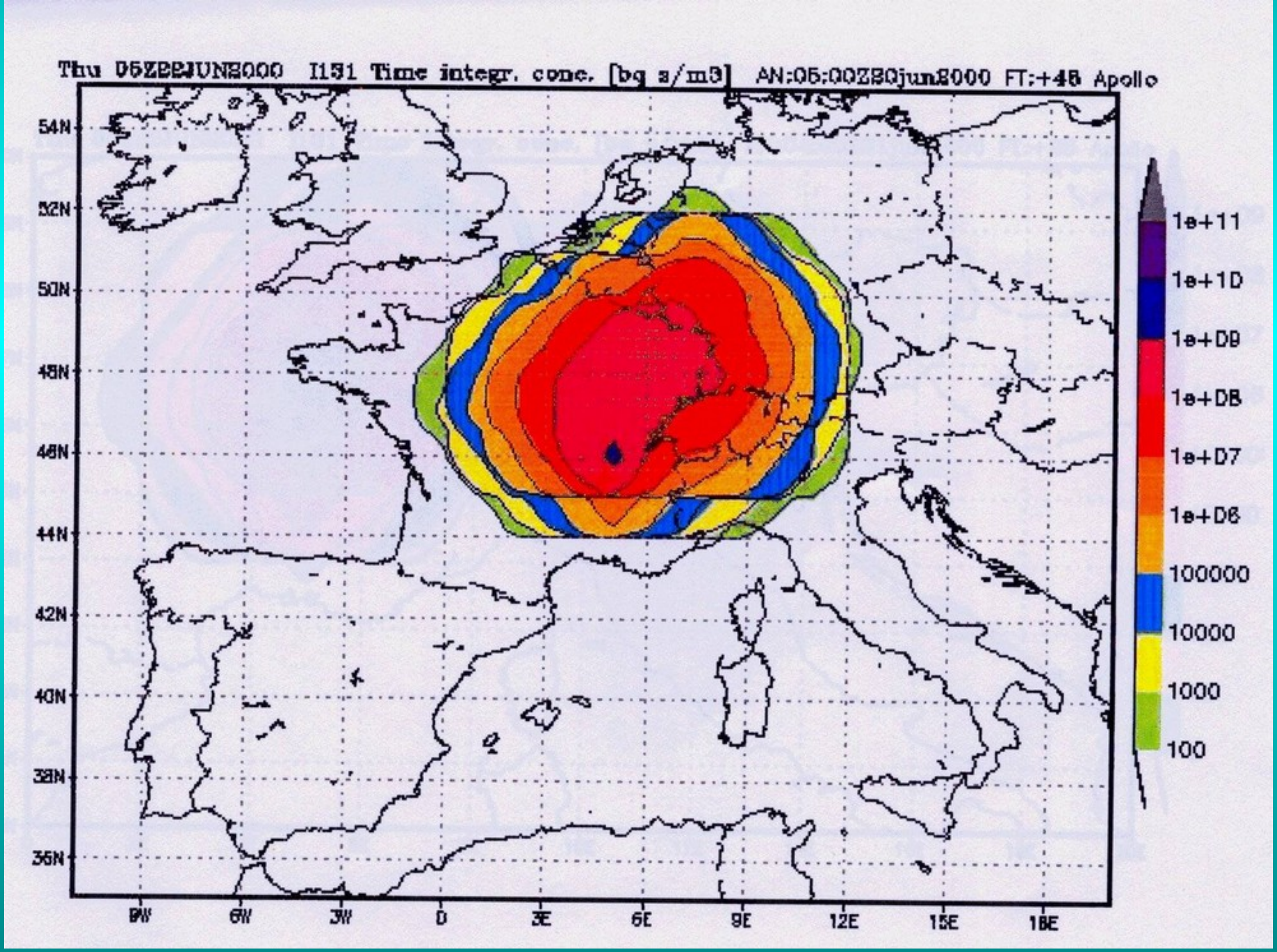
- One of the most important tool available for the CEVaD’s evaluations is a lagrangian software than can be run using as input the meteo data coming from the Meteo European Center of Reading
- It is thus possible to follow the temporal evolution of any “radioactive cloud” released during the accident, the composition of which (the source term, the other fundamental data input) is of course the most difficult task in a real condition

- However, as the available informations at the early stage of an emergency are usually scarce and not reliable, the evaluation of the “exact” source term is not considered a fundamental issue: the software runs are thus usually performed using “standard source terms”: it’s most important to answer to the question “Where ?” than to calculate precisely “How much”

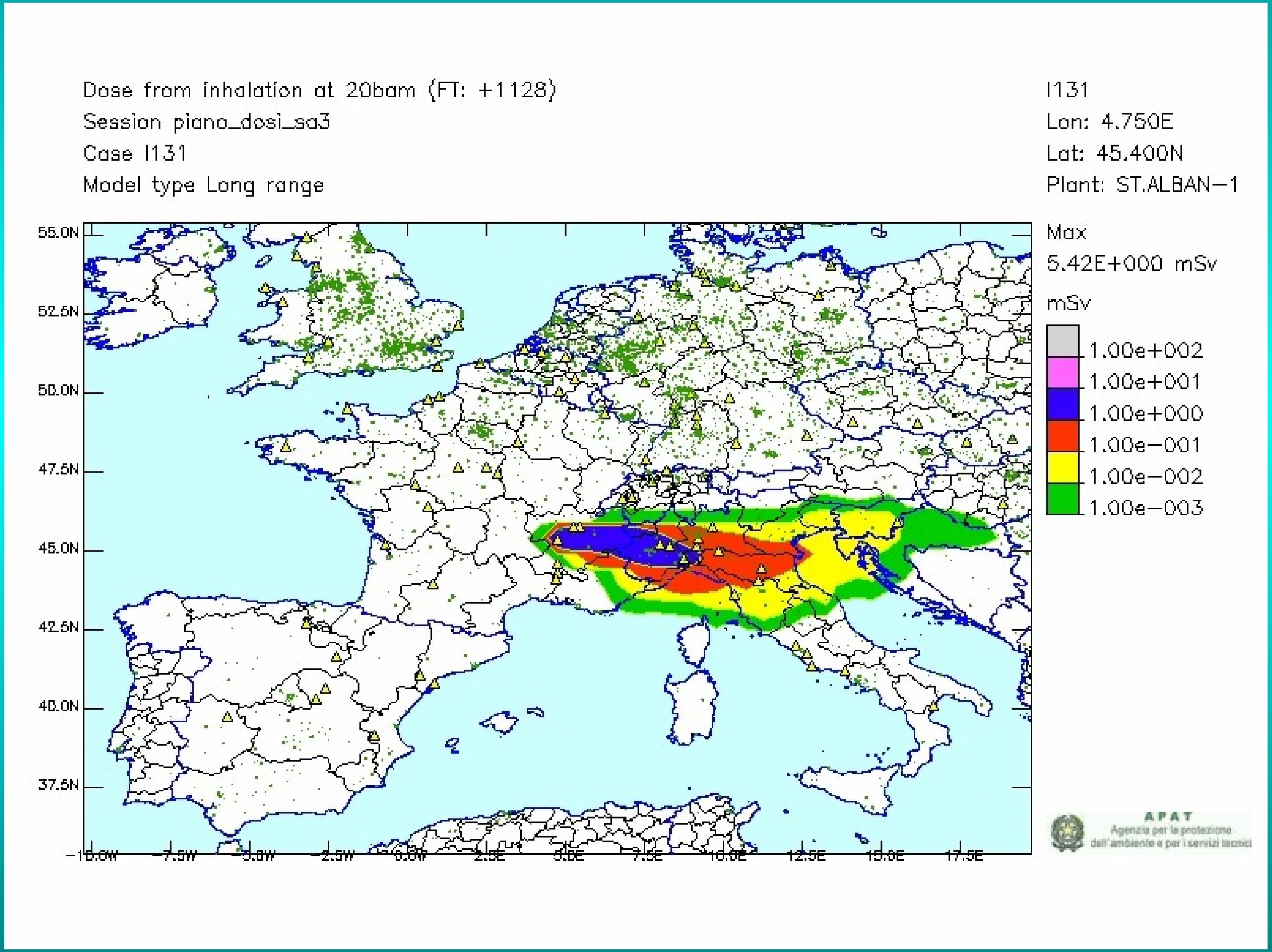
- The software can make the forecast for the next 24 or 48 hours (typically), calculating the integrated activity concentration for all the radioisotope (Bq·s/m^3), identyfing the areas the could be probably affected by the radioactive fallout and estimating the committed effective dose to the population, also distinguishing the different contributions (inhalation and irradiation)
- The identification of the high fallout areas is particularly important for the implementation of countermeasures (for example: food comsuption restrictions)

Typical software simulation of a radioacive release following a sever accident at St. Alban NPP

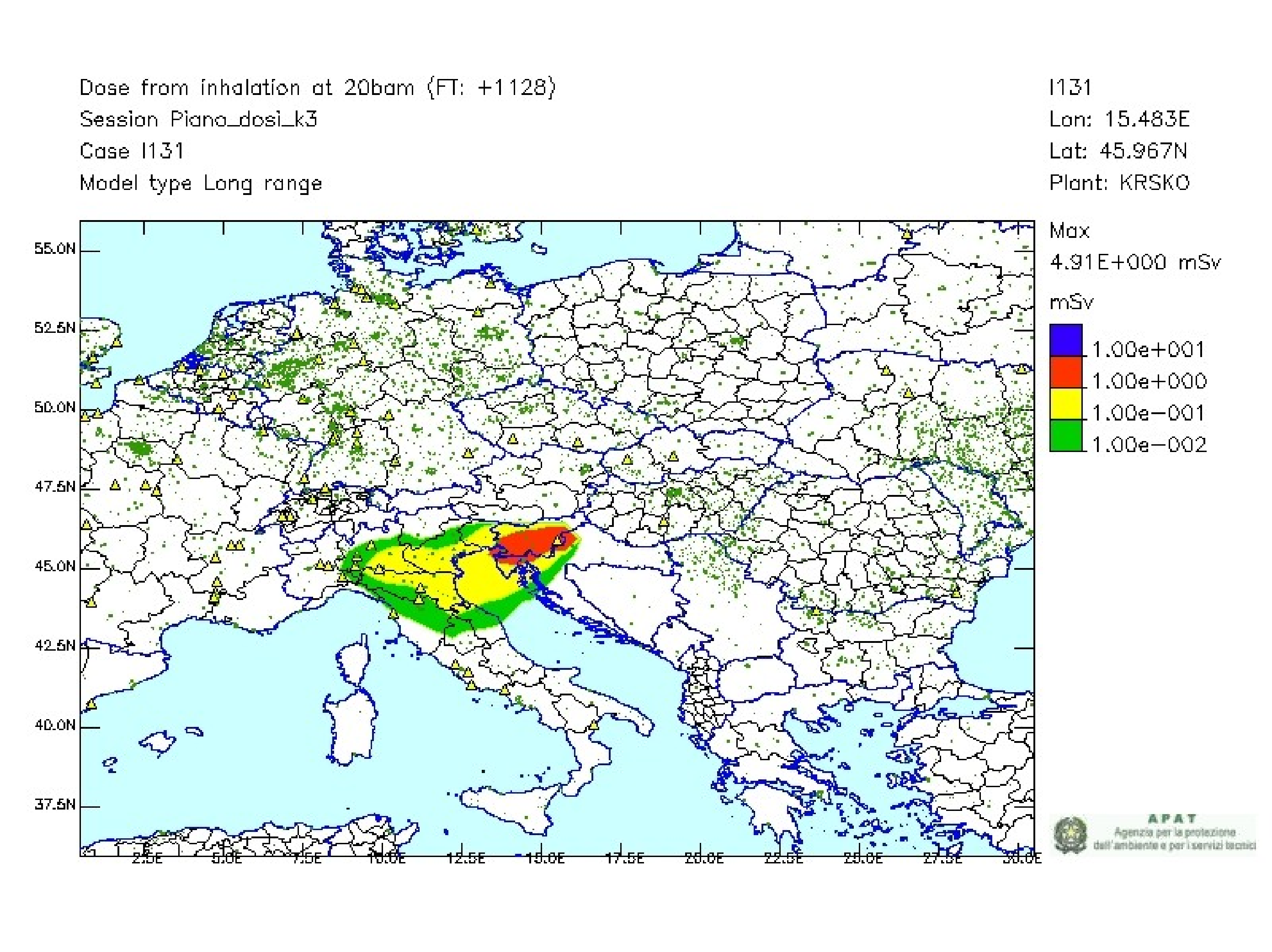
Output data: Bq·s/m^3



St. Alban NPP, ^{131}I committed dose



Krško NPP, ^{131}I committed dose



Dose calculations (^{131}I, maximum values)

	Inhalation Effective Dose (mSv)	Tyroid Equivalent Dose (mSv)
Krško	**Adults: 0.8** **Children: 1.5** **Infants: 1.0**	**Adults: 16** **Children: 27** **Infants: 20**
St. Alban	**Adults: 2.0** **Children: 3.5** **Infants: 2.5**	**Adults: 40** **Children: 70** **Infants: 50**

- The CEVaD use all the available informations gathered from any sources. These informations can be distinguished in two different broad category:

a) External informations: i.e., informations coming from the international emergency networks (IAEA, ECURIE, National Autorities of other States, etc.)

b) Internal informations: i.e. informations produced by the national and regional monitoring networks

- While the “external informations” are continuosly collected by ISIN, the National Nuclear Autority, by means of the standard institutional links (there is always an operator working 24 hours a day), the flow of the “internal informations”, coming from the domestic radioactivity networks is progressively activated as the emergency develops
- Let’s spend a few words about the organization of this information flow

tworks

We have two different types of networks:

1) γ dose rate measurements network (automatic)
2) A network of Regional Laboratories

Real time γ rays monitoring network

- A network based on gamma-ray counters is operating at National level: about 80 gamma probe are distributed all over Italy, measuring continuously the gamma dose rate
- The γ dose rate network works at National level as one but is made up by several regionally based sub-networks
- In case of emergency, all the data collected by the networks are almost immediately made available by ISIN to the EURDEP Platform

The ARPA Piemonte γ dose rate emergency network

- The γ dose rate is continuously measured (every 10 minutes) by means of 29 high sensitive (10 nSv/h) Geiger-Mueller counters distributed all over the Region, especially along the French and Switzerland border

The RESORAD Network

- It’s a network of environmental radioactivity laboratories, mainly belonging to the 21 Regional Environmental Protection Agency (ARPA/APPA)
- Most of these laboratories were established in 1987 by the Ministry of Health after the Chernoby accident
- They are able to perform low-level environmental radioativity measurements (standard equipment: HPGe detectors)

- In case of emergency, the standard first CEVaD request to the labs will be almost certainly to execution of high sensitive measurements on atmospheric particulate
- The particulate (usually the TPS fraction, Total Suspended Particulate) is collected onto a paper or glass fiber filter by a pump (a typical flow rate of 30 l/min is good enough)
- After collection, the filter is counted with HPGe detector (efficiency 30 %) for a time suitable to reach a reasonable sensitivity (Minumum Detectable Activity, MDA)

Minimum Detectable Activity (Currie's formula, 1968)

$$MDA = \frac{4.65 \cdot \sigma_B}{\varepsilon \cdot y_\gamma \cdot V \cdot t_C}$$

ε: photoelectric efficiency

σ_B: background standard deviation

y_γ: γ yield

V: Volume of air sampled

t_C: counting time

Requested sensitivity:

MDA = 0.1 Bq/m^3

for ^{137}Cs

- It can be easily demonstrated that such sensitivity is enough to have a very good radioprotection
- Assuming a “Chernobyl like” radioactive cloud composition, we can assure that we are able to detect all the most relevant γ emitting radionuclides involved in the accident

Radionuclide	MDA (mBq/m^3)	Inhalation dose (nSv) 24 hours exposure
^{99}Mo	22	7
^{95}Zr	**179**	**206**
^{95}Nb	99	37
^{103}Ru	73	45
^{106}Ru	**810**	**10100**
^{110m}Ag	90	199
^{125}Sb	193	195
^{131}I	**60**	**207**
^{132}Te	35	37
^{132}I	87	4
^{134}Cs	**80**	**270**
^{137}Cs	**100**	**531**
^{140}Ba	**293**	**408**
^{140}La	146	6.2
Total Inhalation Dose (nSv)		**12310**

Radioactivity in atmosphere: measurement protocols

- The most demanding constrain during an emergency, is the time needed t $(t = t_S + t_C)$ to produce a reliable data. We can thus try to optimize the sensitivity of the measurements (MDAs),
- t_S= *sampling time*
- t_C= *counting time*

We can use the Currie's formula:

- Calculating:

$$\frac{\partial MDA}{\partial t_C} = 0$$

we have the algebraic equation:

$$\frac{1}{(t - t_C)^2 \cdot \sqrt{t_C}} - \frac{1}{2 \cdot (t - t_C) \cdot (t_C)^{3/2}} = 0$$

the solution of which gives:

$$t_C = \frac{t}{3}$$

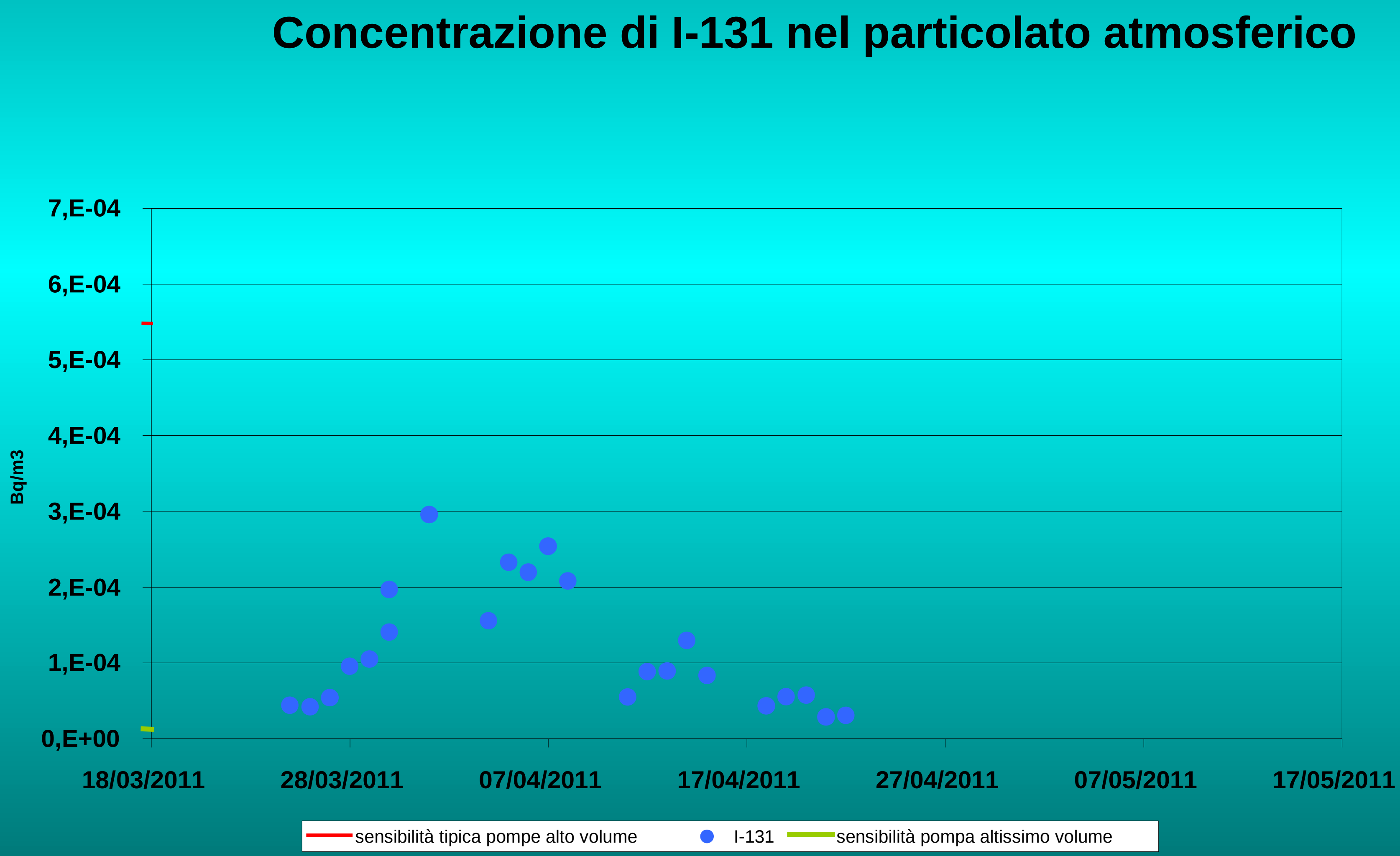
1. **sampling time $t_S = (2/3) \cdot t$**
2. **counting time $t_C = (1/3) \cdot t$**

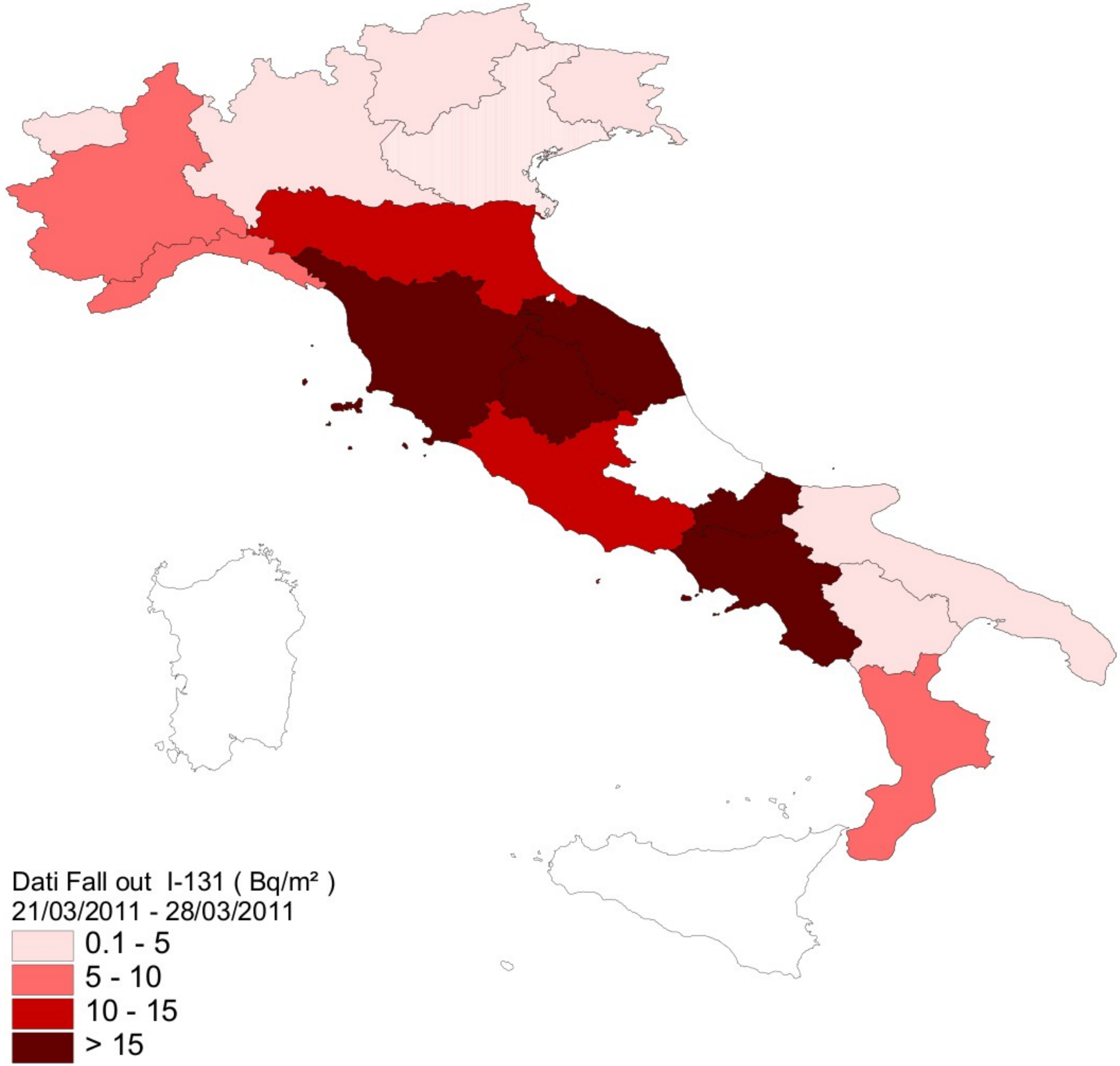
The Fukushima experience in Italy

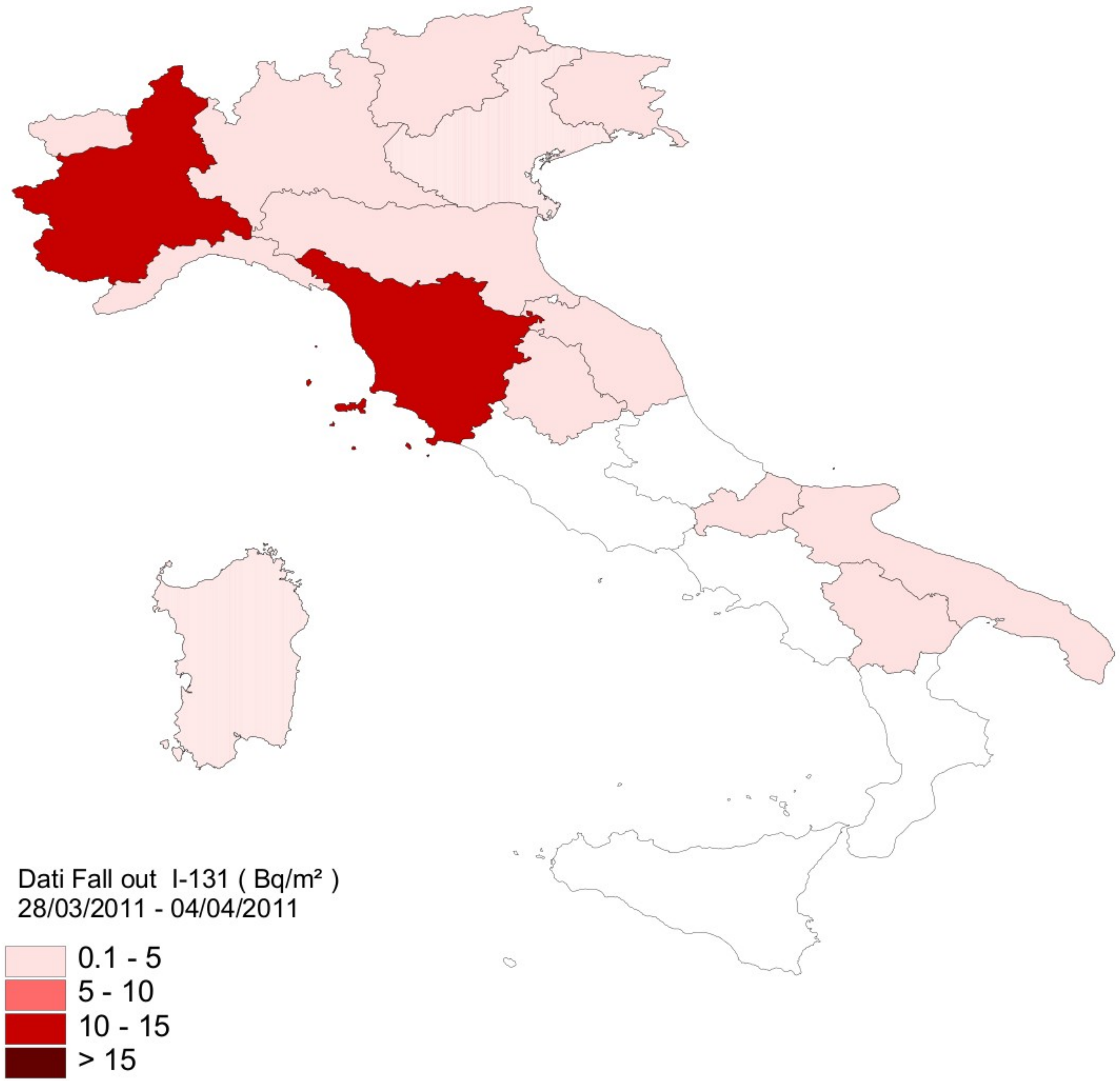
- Approximataly two weeks after the Fukushima disaster, a weak “radioactive cloud reached Europe: it’s was the time to test in real condition the performances of the laboratories of the RESORAD network
- They were told to perform γ spectrometry (HPGe) on :
- - atmospheric particulate samples
- - wet and dry depositions (fallout)

- The results of the test was quite good
- Almost all the laboratories were able to send the data and showed the capability of performing low-level radioactivity measurements
- In particular, traces of ^{131}I were detected all over Italy
- A deposition map of the time evolution of the Fukushima ^{131}I fallout was produced (from 21rst March 2011 to 26th April 2011)

Atmospheric ^{131}I, in Piedmont: low level measurements (MDA ≈ 10^{-5} Bq/m^3)




Dati Fall out I-131 (Bq/m²)
21/03/2011 - 28/03/2011
0.1 - 5
5 - 10
10 - 15
> 15


Dati Fall out I-131 (Bq/m²)
28/03/2011 - 04/04/2011
0.1 - 5
5 - 10
10 - 15
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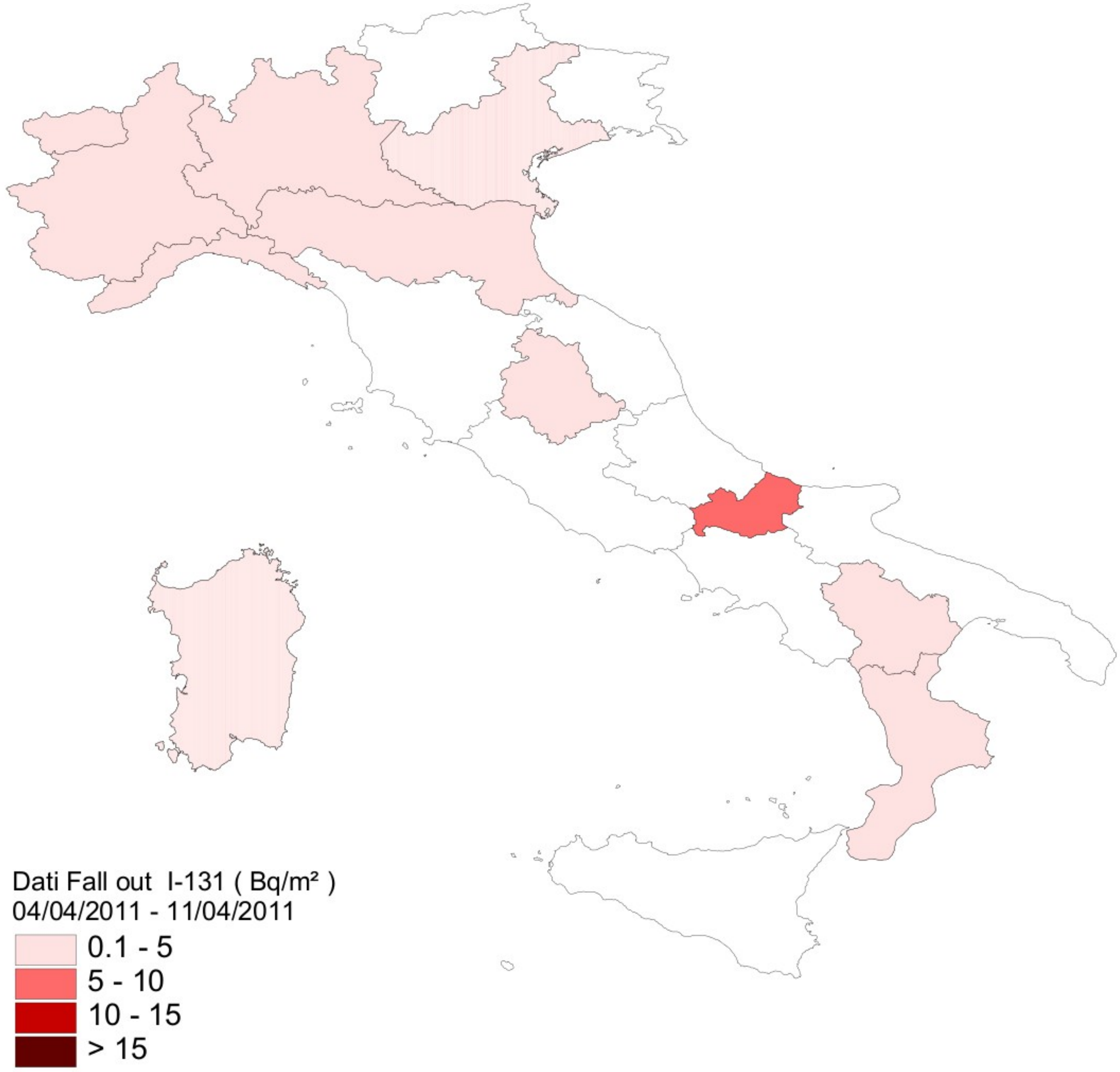
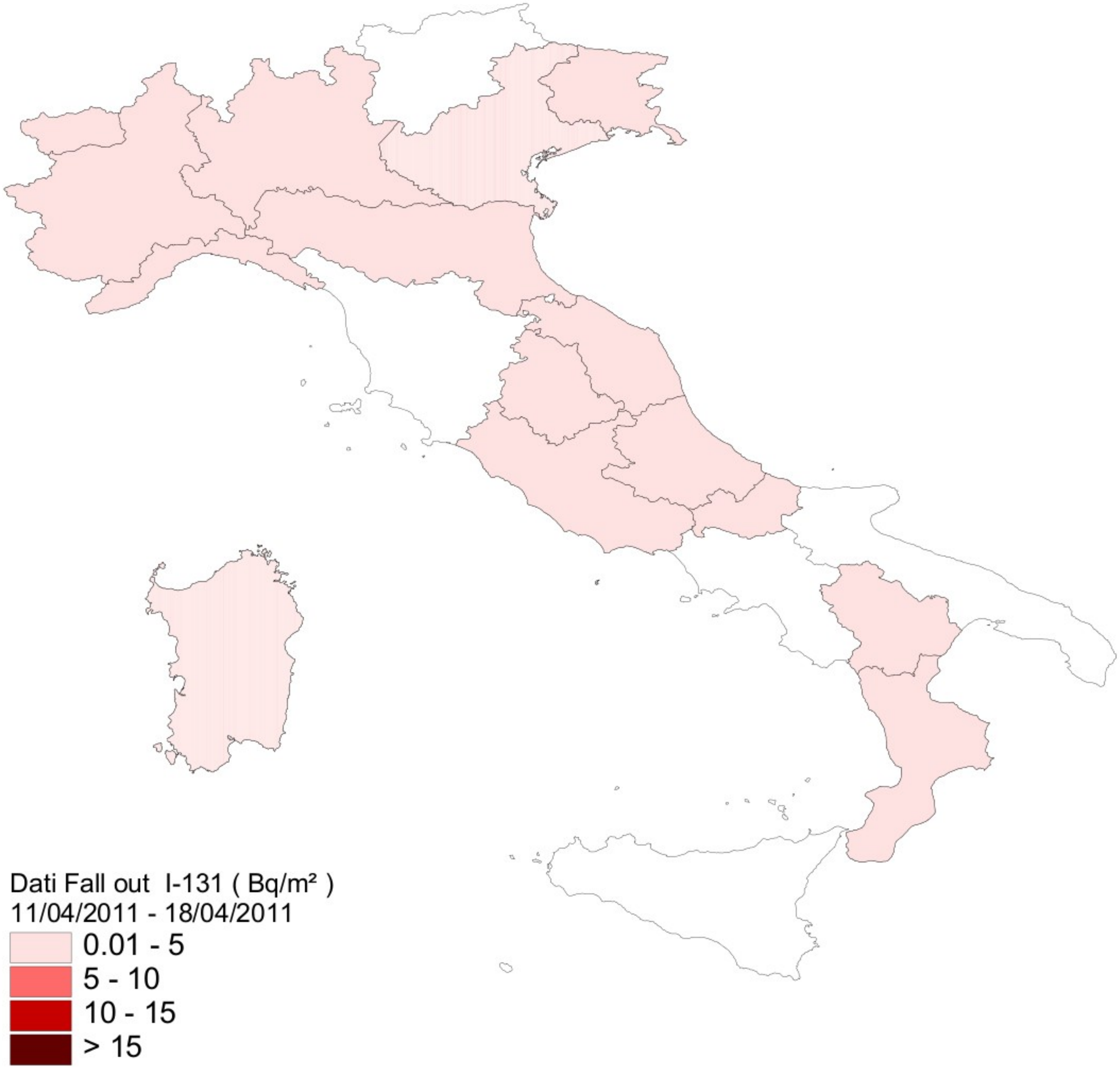
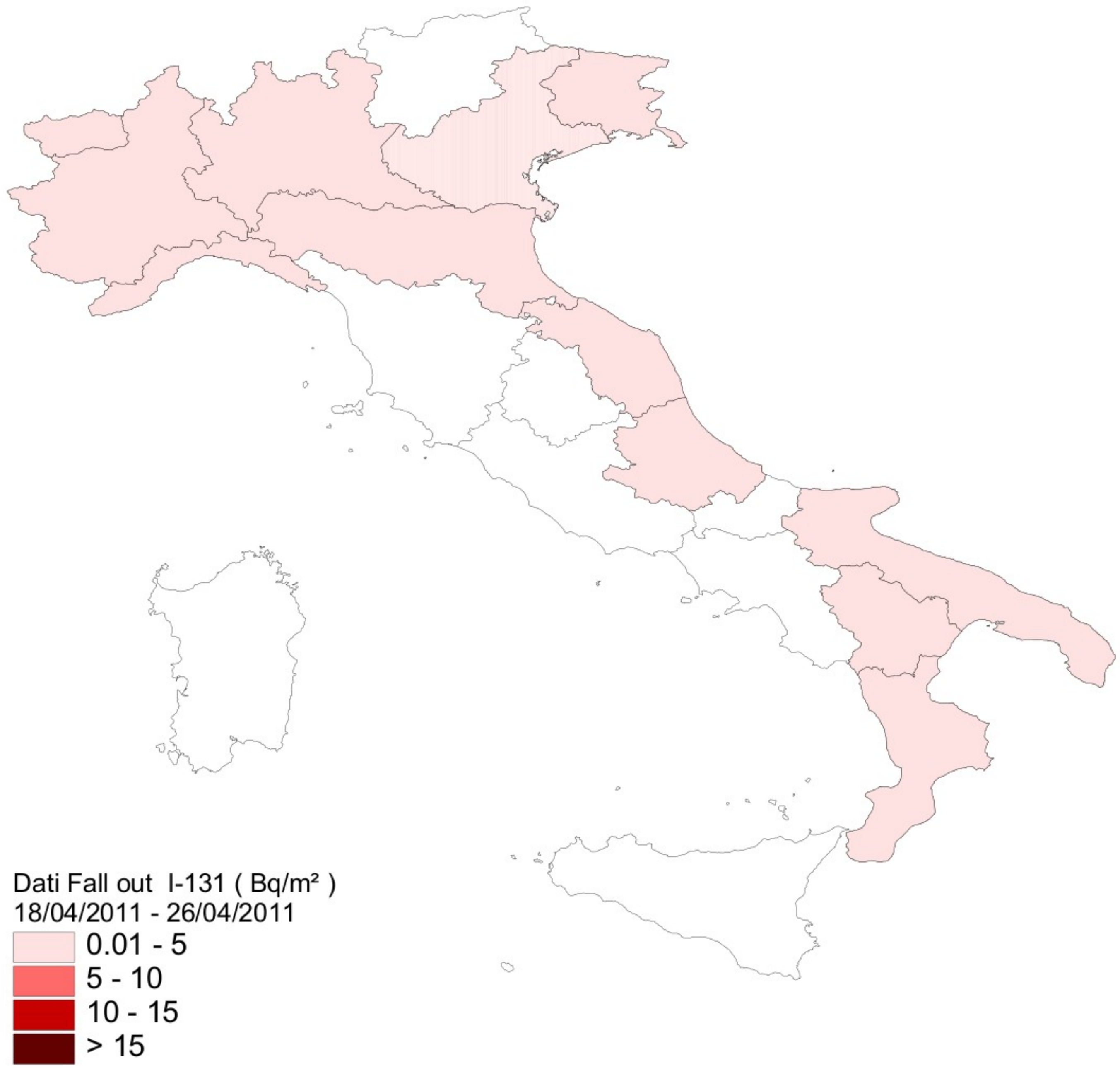

Dati Fall out I-131 (Bq/m²)
04/04/2011 - 11/04/2011
0.1 - 5
5 - 10
10 - 15
> 15


Dati Fall out I-131 (Bq/m²)
11/04/2011 - 18/04/2011
0.01 - 5
5 - 10
10 - 15
> 15


Dati Fall out I-131 (Bq/m²)
18/04/2011 - 26/04/2011
0.01 - 5
5 - 10
10 - 15
> 15

Thank you for your kind attention!

- The CEVaD manual