3rd www.erpw2018.com
Rovinj-Rovigno, Croatia
1-5 OCTOBER 2018
ERPW

3rd EUROPEAN RADIOLOGICAL PROTECTION RESEARCH WEEK

YOUNG SCIENTIST SESSION

ENHANCE THE DECISION-MAKING PROCESS TO MINIMIZE THE IMPACT IN AGRICULTURAL AREAS DERIVED FROM A NUCLEAR ACCIDENT

Blanca García-Puerta
Cristina Trueba Alonso
Milagros Montero Prieto

Friday, October the 5th of 2018

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

INDEX

INDEX

1. Introduction

DOCTORAL THESIS

Geographic information technologies applied to study the radiological vulnerability of the agricultural systems in the Peninsular Spain

Thesis directors:- **Cristina Trueba Alonso**. Researcher at CIEMAT

- **Mª Pilar García Rodríguez**. Professor at the Geography Faculty of UCM

With the support of **Milagros Montero Prieto.** Researcher at CIEMAT

Confidence

Coping with uncertainty for improved modelling and decision making in nuclear emergencies

WP4:

Transition to Long-Term Recovery, Involving Stakeholders in Decision-Making Processes.

ANURE PROJECT

Assessment of the Nuclear Risk in Europe – A case study in the Almaraz Nuclear Power Plant, Spain

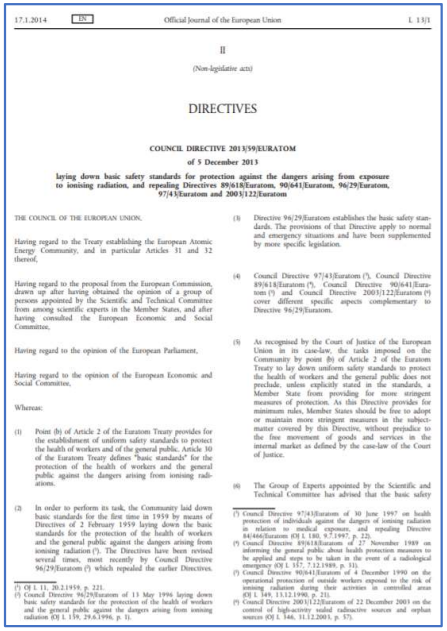
Joint Research Centre (EC/DG JRC) - CIEMAT (2017)

1. Introduction

RADIOLOGICAL OR NUCLEAR EMERGENCY PREPAREDNESS AND RESPONSE

Directive 2013/59/EURATOM of 5 December 2013

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation



17.1.2014 EN Official Journal of the European Union L 13/1

II

(Non-legislative acts)

DIRECTIVES

COUNCIL DIRECTIVE 2013/59/EURATOM

of 5 December 2013

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Atomic Energy Community, and in particular Articles 31 and 32 thereof,

Having regard to the proposal from the European Commission, drawn up after having obtained the opinion of a group of persons appointed by the Scientific and Technical Committee from among scientific experts in the Member States, and after having consulted the European Economic and Social Committee,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the European Economic and Social Committee,

Whereas:

(1) Point (b) of Article 2 of the Euratom Treaty provides for the establishment of uniform safety standards to protect the health of workers and of the general public. Article 30 of the Euratom Treaty defines "basic standards" for the protection of the health of workers and the general public against the dangers arising from ionising radiations.

(2) In order to perform its task, the Community laid down basic standards for the first time in 1959 by means of Directives of 2 February 1959 laying down the basic standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (1). The Directives have been revised several times, most recently by Council Directive 96/29/Euratom (2) which repealed the earlier Directives.

(3) Directive 96/29/Euratom establishes the basic safety standards. The provisions of that Directive apply to normal and emergency situations and have been supplemented by more specific legislation.

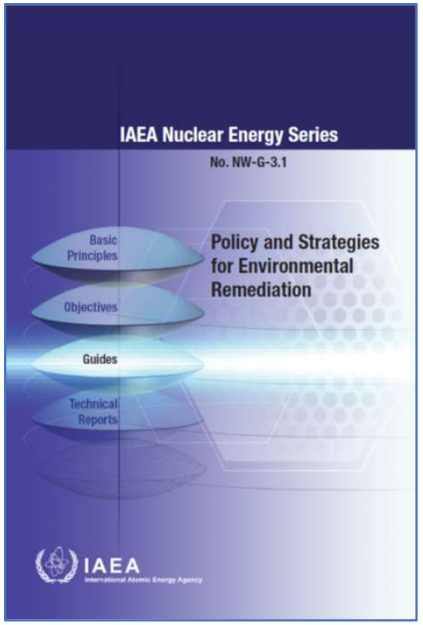
(4) Council Directive 97/43/Euratom (3), Council Directive 89/618/Euratom (4), Council Directive 90/641/Euratom (5) and Council Directive 2003/122/Euratom (6) cover different specific aspects complementary to Directive 96/29/Euratom.

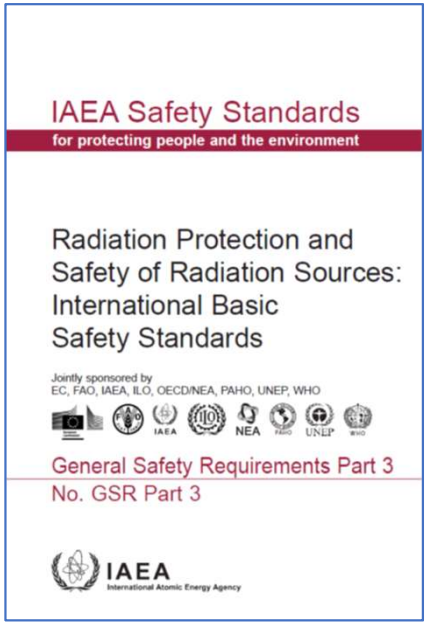
(5) As recognised by the Court of Justice of the European Union in its case-law, the tasks imposed on the Community by point (b) of Article 2 of the Euratom Treaty to lay down uniform safety standards to protect the health of workers and the general public does not preclude, unless explicitly stated in the standards, a Member State from providing for more stringent measures of protection. As this Directive provides for minimum rules, Member States should be free to adopt or maintain more stringent measures in the subject-matter covered by this Directive, without prejudice to the free movement of goods and services in the internal market as defined by the case-law of the Court of Justice.

(6) The Group of Experts appointed by the Scientific and Technical Committee has advised that the basic safety

(1) OJ L 11, 20.2.1959, p. 221.
(2) Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159, 29.6.1996, p. 1).
(3) Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure, and repealing Directive 84/466/Euratom (OJ L 180, 9.7.1997, p. 22).
(4) Council Directive 89/618/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency (OJ L 357, 7.12.1989, p. 31).
(5) Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas (OJ L 349, 13.12.1990, p. 21).
(6) Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (OJ L 346, 31.12.2003, p. 57).

International recommendations





ADAPTATION TO THE SPANISH REGULATIONS → **REQUIREMENTS FOR THE PREPAREDNESS ORIENTED TO THE POST-ACCIDENT MANAGEMENT**

1. Introduction

OBJECTIVE

To elaborate **risk maps** related to radioactive contamination caused by an accidental release with off-site consequences for the **medium and long term**

Pathway: **Food chain**

Radiological risk analysis

Prioritization maps to apply actions

Preparedness and Response Emergency Plans

Agricultural systems recovery after a nuclear accident

DECISION-MAKING PROCESS

WHEN?

Stages of implementation
- Planification
- Recovery

WHY?

Rationalization of the planned actions

Minimize the risk through the food-chain

HOW?

OPTIMIZATION principle

AIM

EFECTIVENESS
Long term

INDEX

2. Case study

HYPOTHETICAL SEVERE ACCIDENT IN ALMARAZ NPP WITH OFF-SITE CONSEQUENCES

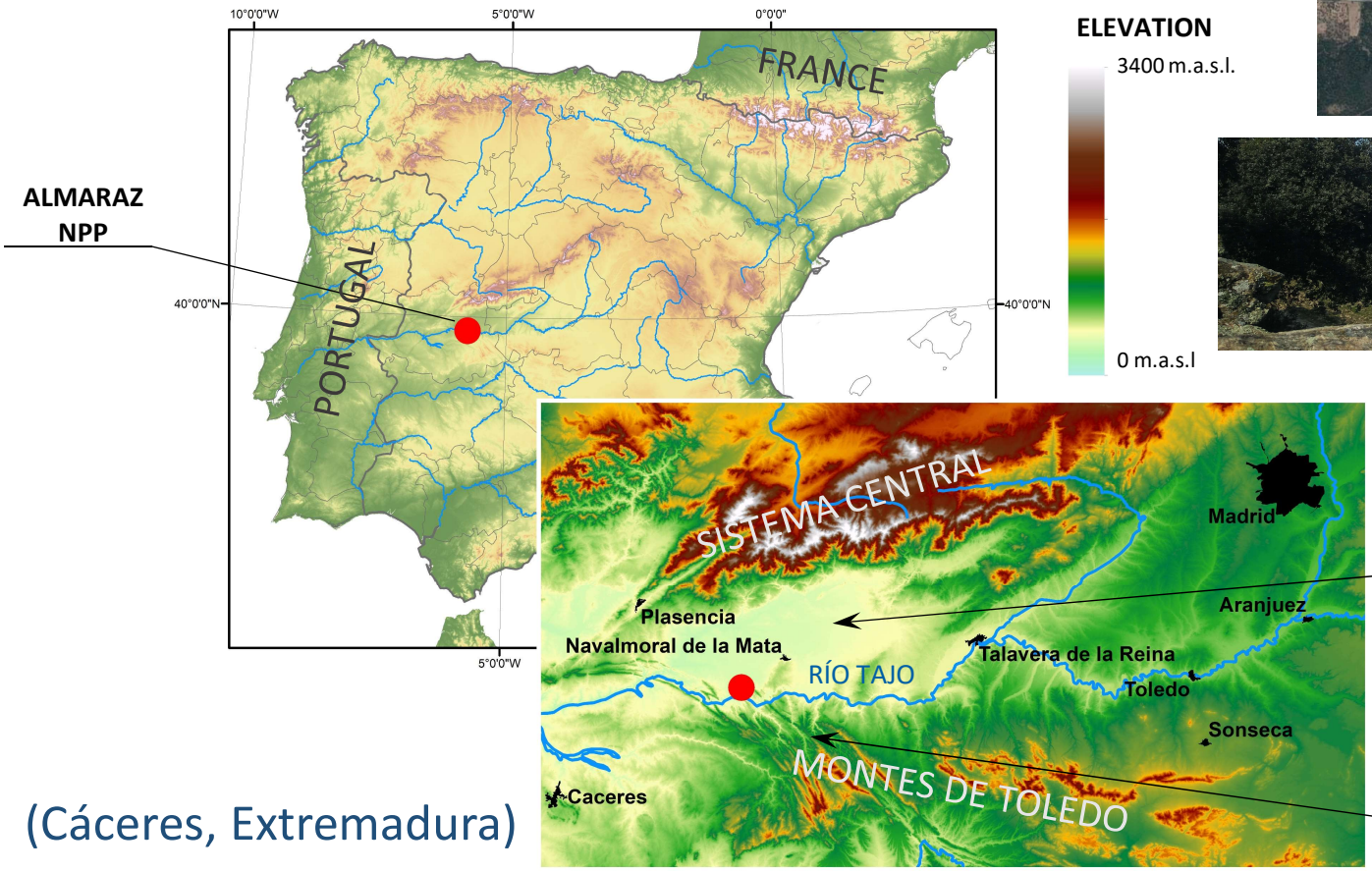
Geopolitics faction

Portuguese border

Orography

Tajo river valley

Environment



(Cáceres, Extremadura)

INDEX

3. Methodology

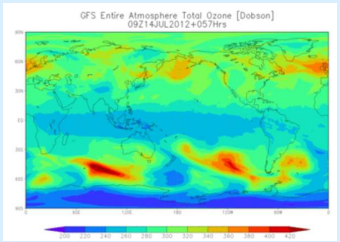
ANURE Project

DISPERSION AND DEPOSITION MODELLING

INITIAL DATA

Meteorological data

Global Forecast System (GFS)



Weather forecast model produced by the National Centers for Environmental Prediction (NCEP)

5 year period (2012 to 2016)

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

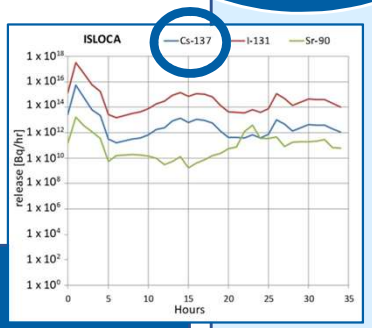
Source term

Release pattern of an **ISLOCA type accident**
(Interfacing Systems Loss-Of-Coolant Accident)

Selected from the results of the SOARCA methodology (State-Of-the-Art Reactor Consequence Analyses) Surry NPP (Virginia, EEUU), as surrogate,

Applied to the Almaraz inventory:

^{90}Sr, ^{131}I, ^{137}Cs

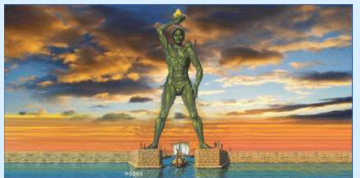


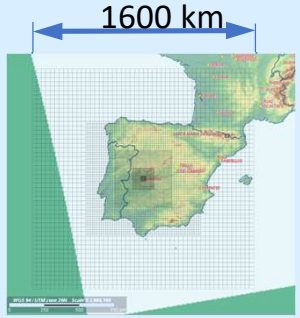
Duration of release 35 hours
+
48 more hours for prognosis purposes → deposit

1 release and deposition simulation per day (random hours)

SOFTWARE

JRODOS





Atmospheric dispersion model **RIMPUFF** + **STATISTICAL TOOL** Module

RESULTS

1825 possible simulations,
for each radionuclide 1383 are valid
due to the lack of meteorological data

1383 total deposit values per grid cell (Bq/m^2)

3. Methodology

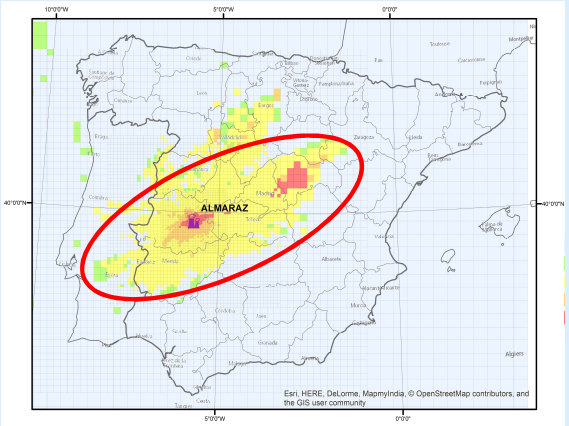
1383 activity concentration values of the total deposit of ^{137}Cs → **Which is the most representative value in each cell**

1) Deposition category

Contamination level	Activity concentration deposited (kBq/m^2)	Deposit category
Non-contaminated	<10	1
Slightly contaminated	10* – 100	2
Contaminated	100 – 1000	3
Heavily contaminated	1000 – 10000	4
Extremely contaminated	>10000	5

SOURCE: Nordic Guidelines and Recommendations
*Lower level is not defined.

2) The most frequent deposit category: Mode



DEPOSIT CATEGORY:

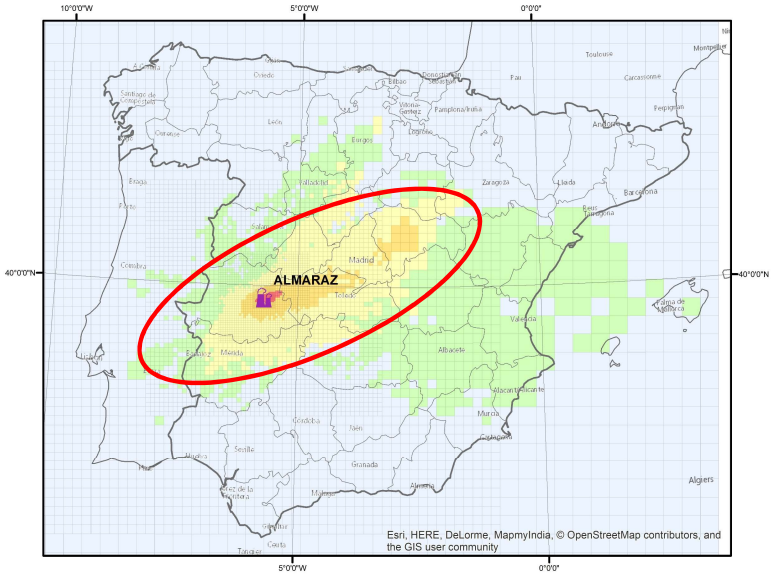
- Category 1: <10 kBq/m2
- Category 2: 10 - 100 kBq/m2
- Category 3: 100 - 1.000 kBq/m2
- Category 4: 1.000 - 10.000 kBq/m2
- Category 5: >10.000 kBq/m2
- Computational grid

WEIGHTING

3) Probability of the deposit category mode within the 1383 simulations

GIS

DEPOSIT SEVERITY



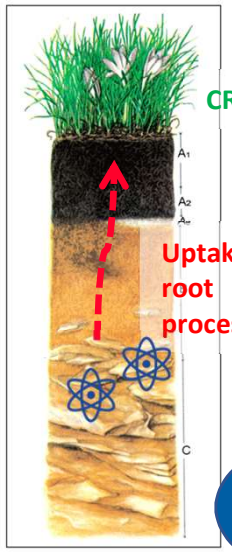
SEVERITY DEPOSITION INDEX:

- 1: Min. Severity
- 2: Low Severity
- 3: Med. Severity
- 4: High. Severity
- 5: Max. Severity

3. Methodology

^{137}Cs BEHAVIOUR IN THE AGRICULTURAL SYSTEM

Soil profile

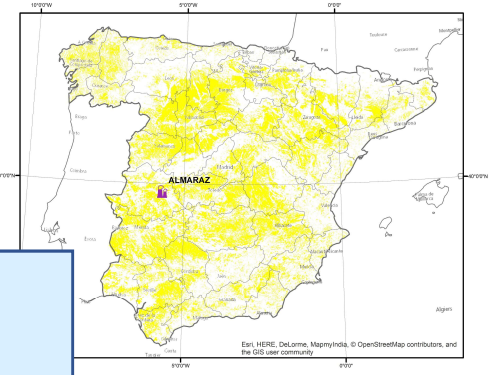


SOURCE: ANE. INSTITUTO GEOGRÍAFICO NACIONAL

Soil-to-plant Transfer Factor (TF): Rainfed cereals → grain

Texture	Mean	Std. dev.	Min.	Max.
Sandy	$3{,}90 \times 10^{-2}$	3,3	$2{,}00 \times 10^{-3}$	$6{,}60 \times 10^{-1}$
Loamy	$2{,}00 \times 10^{-2}$	4,1	$8{,}00 \times 10^{-4}$	$2{,}00 \times 10^{-1}$
Clay	$1{,}10 \times 10^{-2}$	2,7	$2{,}00 \times 10^{-4}$	$9{,}00 \times 10^{-2}$
Organic	$4{,}30 \times 10^{-2}$	2,7	$1{,}00 \times 10^{-2}$	$7{,}30 \times 10^{-1}$

(Temperate climate values)
SOURCE: REP. 472 IAEA 2010



SOURCE: CLC 2012

Adjusted transfer factor according to the K content:

$$TF\_Cs_{Adjusted} = \left(\frac{TF_{Max} - TF_M}{0{,}1 - K_{Final}}\right) \times (K - K_{Final}) + TF_M$$

SOURCE: TEMAS PROYECT

K
Nutrient
^{137}Cs Competitor

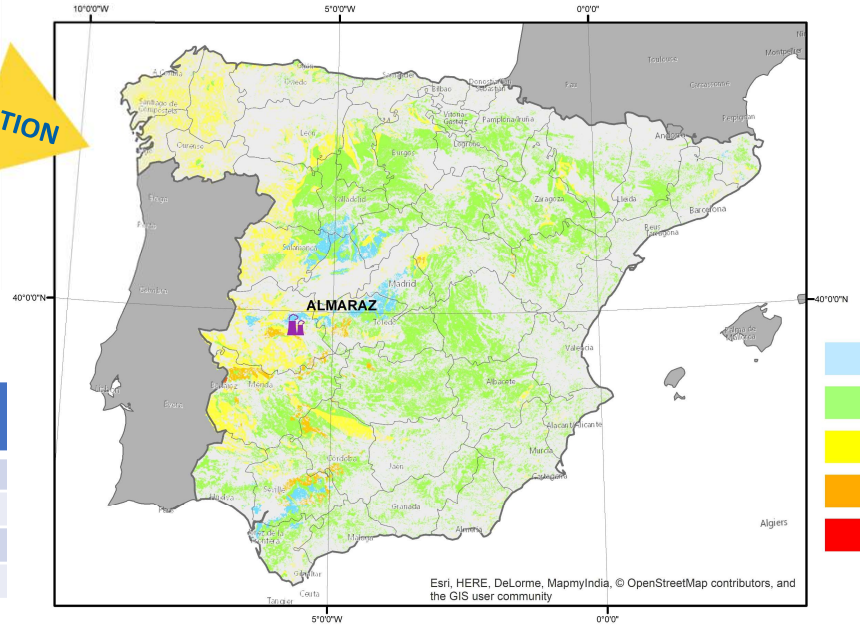
CATEGORIZATION

- TF_{Max} TF maximum value
- TF_M TF medium value
- K Medium value K content for each soil group (cmol/kg), from the Spanish soil profiles database.
- K_{Final} Aimed K content, which depends on the clay content, under →

Clay content	K_{Final} [cmol/kg]
0 – 10 %	0,6
10 – 20%	0,9
20 – 30 %	1
> 30%	1,1

GIS

RADIOLOGICAL VULNERABILITY



VULNERABILITY: (TF RANGE)

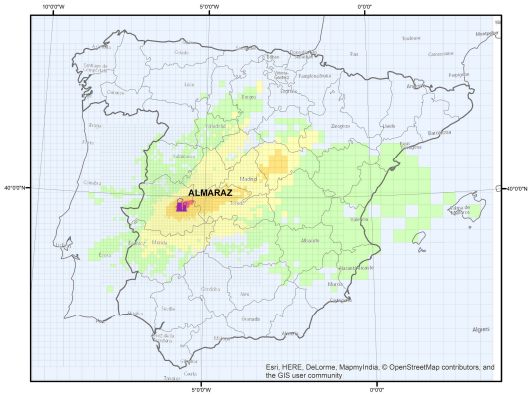
- 1: Min. Vuln. (<0,02)
- 2: Low Vuln. (0,02-0,12)
- 3: Med. Vuln. (0,12-0,5)
- 4: High Vuln. (0,5-0,6)
- 5: Max. Vuln. (>0,6)

3. Methodology

RADIOLOGICAL RISK MAP FOR THE FOOD-CHAIN EXPOSURE PATHWAY

PRIORITISATING RECOVERY ACTIONS

DEPOSIT SEVERITY



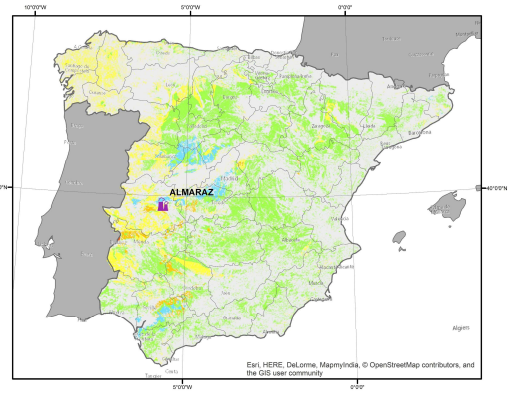
SEVERITY DEPOSITION INDEX:

- 1: Min. Severity
- 2: Low Severity
- 3: Med. Severity
- 4: High. Severity
- 5: Max. Severity

Possible combinations

Deposit Index Weighted \ Vulnerability Index	Min. Vuln.	Low Vuln.	Med. Vuln.	High Vuln.	Max. Vuln.
Min. Severity	5	5	5	5	5
Low Severity	5	5	4	4	4
Med. Severity	5	4	4	3	3
High Severity	5	4	3	2	2
Max. Severity	5	4	3	2	1

RADIOLOGICAL VULNERABILITY

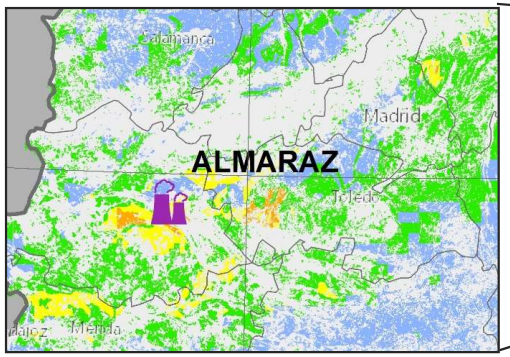


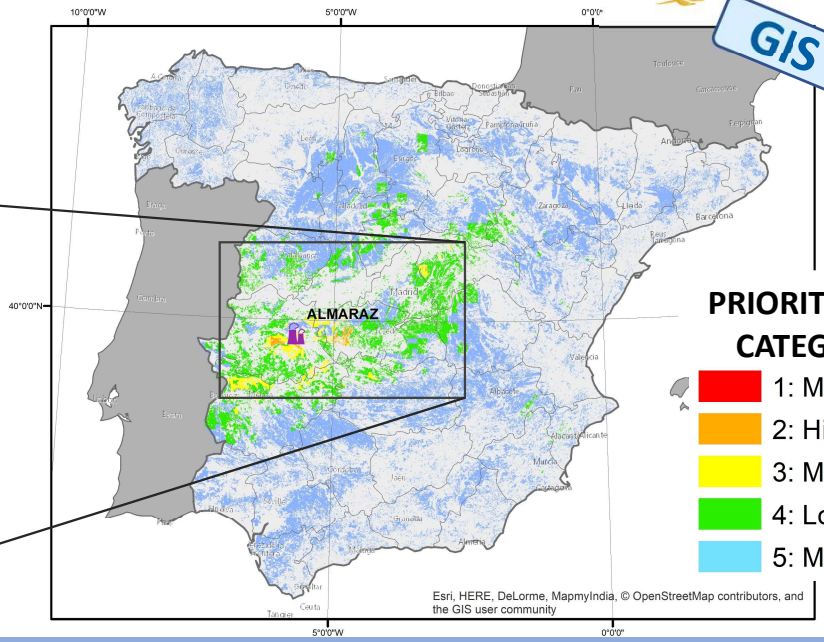
VULNERABILITY (TF RANGE)

- 1: Min. Vuln. (<0,02)
- 2: Low Vuln. (0,02-0,12)
- 3: Med. Vuln. (0,12-0,5)
- 4: High Vuln. (0,5-0,6)
- 5: Max. Vuln. (>0,6)

^{137}Cs PRIORITISATION MAP FOR THE RECOVERY

GIS





PRIORITISATION CATEGORIES

- 1: Max. Priority
- 2: High Priority
- 3: Med. Priority
- 4: Low Priority
- 5: Min. Priority

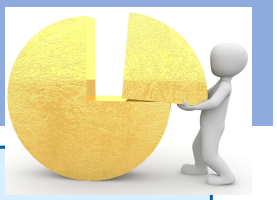
ACTIONS RECOVERY FOR THE LONG-TERM

Agricultural practices

- ➢ **Adding K**
- ➢ **Fertilisers**
- ➢ **Ploughing**: deep, skim and burial, shallow…

INDEX

4. Conclusions



ACHIVES

- Developed methodology to define **radiological risk for the food chain**.
- Importance of the **local specificity**.
- Applicability of this methodology to any **European region**.
- **Decision-making** tool: Rationalization of the **recovery plans** → **Optimization** principle application.

NEXT STEPS

- Study the **contaminated products** and the **effects** on the **customers**.
- Work on the **soil-to-plant transfer factor** values → more adapted to the **Mediterranean** environment.
- Take into account the **yield** and the real **production** of the crops.
- Polish the **prioritisation index categories** for the actions to be taken facing the recovery.
- Study different **agricultural practices** to reduce the contamination **effects** on the **crops**, and therefore along the **food-chain pathway**.

3rd www.erpw2018.com
Rovinj-Rovigno, Croatia
1-5 OCTOBER 2018
ERPW

3rd EUROPEAN RADIOLOGICAL PROTECTION RESEARCH WEEK

YOUNG SCIENTIST SESSION

ENHANCE THE DECISION-MAKING PROCESS TO MINIMIZE THE IMPACT IN AGRICULTURAL AREAS DERIVED FROM A NUCLEAR ACCIDENT

THANK YOU FOR YOUR ATTENTION!

blanca.garciapuerta@ciemat.es

Friday, October the 5th of 2018

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas