MOIRA-PLUS use in decision making on the long-term management of contaminated freshwater bodies and catchments

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The MOIRA Decision Suport System

- MOIRA is a computerized Decision Support System (DSS) to help selecting optimal management strategies for different aquatic ecosystems contaminated by radionuclides.
- MOIRA is NOT aimed at emergency situations, but rather at management strategies for the long-term.
- MOIRA is designed to allow for a realistic assessment of the radiological, ecological, economic and social impacts of management alternatives, in a way as rational and complete as possible.
- The system incorporates a decision analysis module based on Multi-Attribute Analysis

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DSS role in optimization of post-accident exisisting situations

- DSS help to analyse the radiological situation in a given area or region, with a panoply of measures to improve the overall post-accident situation.
- ICRP pub. 101, part2: *"all the data, parameters, assumptions, and values that enter into the decision-making process should be presented and defined very clearly. This transparency assumes that all relevant information is provided to the involved parties, and that the traceability of the process is documented properly, aiming for an informed decision"* (para. 34).
- **DSS like MOIRA can play an essential role in this process of informing the optimisation of post-accident management and providing traceability and transparency.**

Elements of MOIRA software

- Validated models for predicting time behaviour of contaminants (^{137}Cs and ^{90}Sr) in lakes, rivers and drainage areas and well as the effect of selected countermeasures to reduce the contamination levels.
  - To analyse complex rivers systems and catchments the it is limited to the definition of not more than 20 river branches and reaches.

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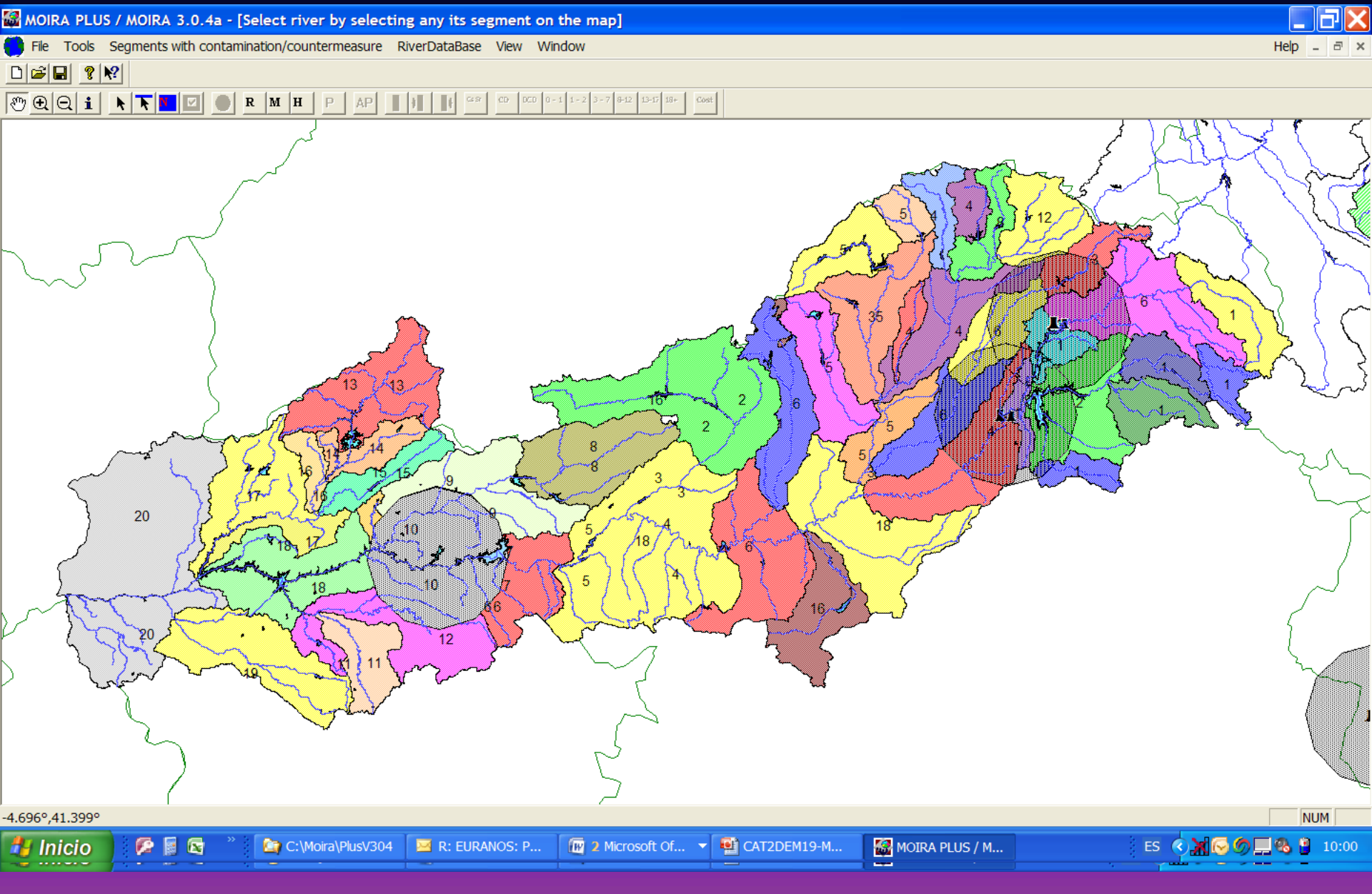
Example: Tagus river



Elements of MOIRA software (1)

- Validated models for predicting time behaviour of contaminants (^{137}Cs and ^{90}Sr) in lakes, rivers and drainage areas and well as the effect of selected countermeasures to reduce the contamination levels.
  - To analyse complex rivers systems and catchments the it is limited to the definition of not more than 20 river branches and reaches.
- Models to assess doses to man and biota (fish) and to evaluate dose resulting after implementing countermeasures affecting the direct human exposure to contaminated elements
- A conceptually simple micro-economic approach to assess the economic cost of the different kind of countermeasures implemented

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Elements of MOIRA software (2)

- In lakes, a Lake Ecosystem Index (LEI) to assess the impact of physical and chemical countermeasures on the lake ecological quality (Håkanson et al., 2000).
- Methodologies based on multi-attribute analysis (MAA) techniques for ranking the different feasible interventions accounting for the above-mentioned impacts (Ríos-Insúa et al., 2006).
- Software components implementing the above models and methodologies
- Data storage and analysis tools (Geographical Information System, GIS, and data bases) (Hofman, 2004)

- MOIRA runs in a simple Windows PC (with MapInfo GIS and PowerSim)

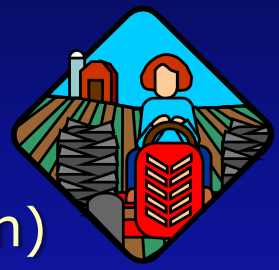
Countermeasures (1)

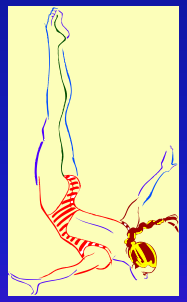
Chemical and Physical (active) countermeasures:

- Reduction of radionuclide remobilisation from sediments (e.g. lake liming).
- Reduction of uptake by aquatic organisms (e.g. potash treatment of water).
- Reduction of uptake by fish by "biological dilution" (e.g. fertilisation).
- Reduction of radionuclide transfer from contaminated drainage areas to water bodies (e.g. dam building in floodplains, soil decontamination, wetland liming).
- Removal of radionuclides from aquatic systems (e.g. dredging).

Countermeasures (2)

- **Social (restrictive) Countermeasures:**
  Restrictions on people's normal living habits.
  - Uses of Water:
    - Drinking
    - Irrigation of crops and pasture (food ingestion)
    - Recreation (e.g. swimming, diving, sunbathing, boating)
  - Uses of Fish:
    - Food
    - Recreation





Countermeasures available for simulation in the MOIRA system

Application of chemical agents (Time dependent)	Application of physical measures (Time dependent)	Application of social restrictions (in user defined periods or based on ccontamination and dose limits)
• Potash treatment • Direct liming • Wetland liming • Fertilisation	• Removal of sediments • Removal of snow and ice • Building flood dykes • Water flow diversion between segments in rivers	• Bans on fish consumption • Bans on water ingestion (with alternative sources of clean water) • Bans on irrigation • Restricted access to contaminated areas

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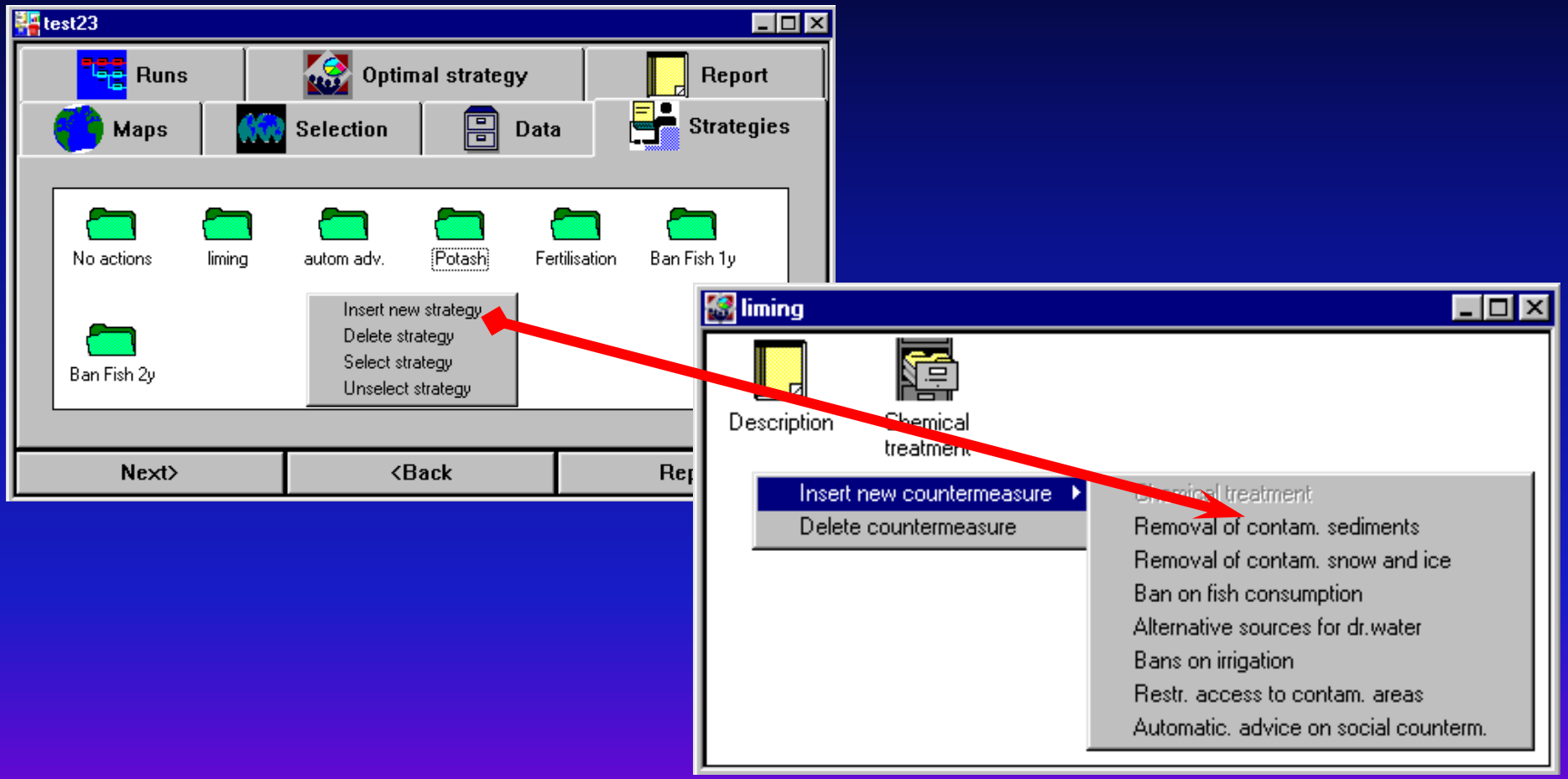
Definition of alternative strategies
(any time-dependent combination of the available countermeasures)



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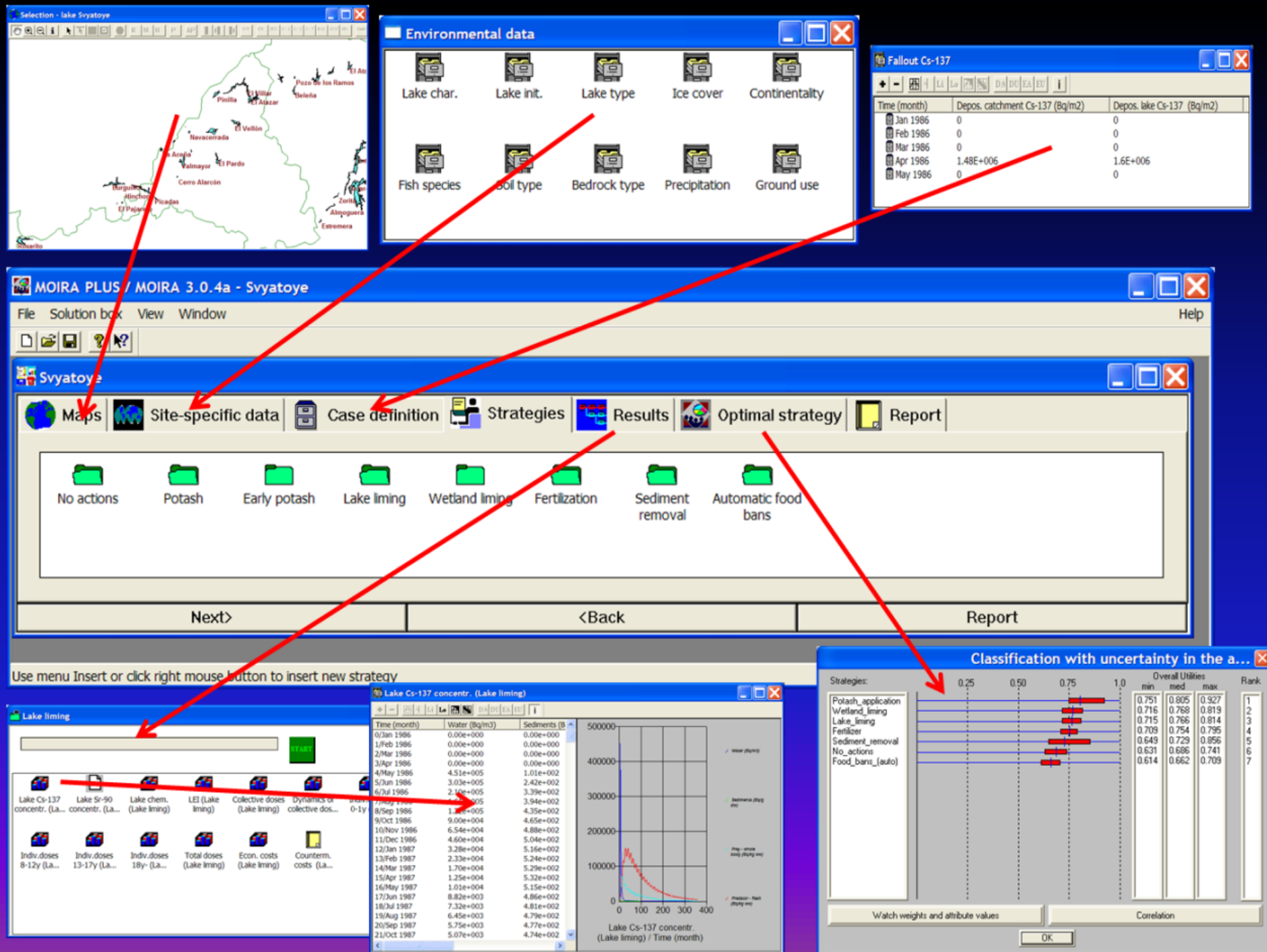
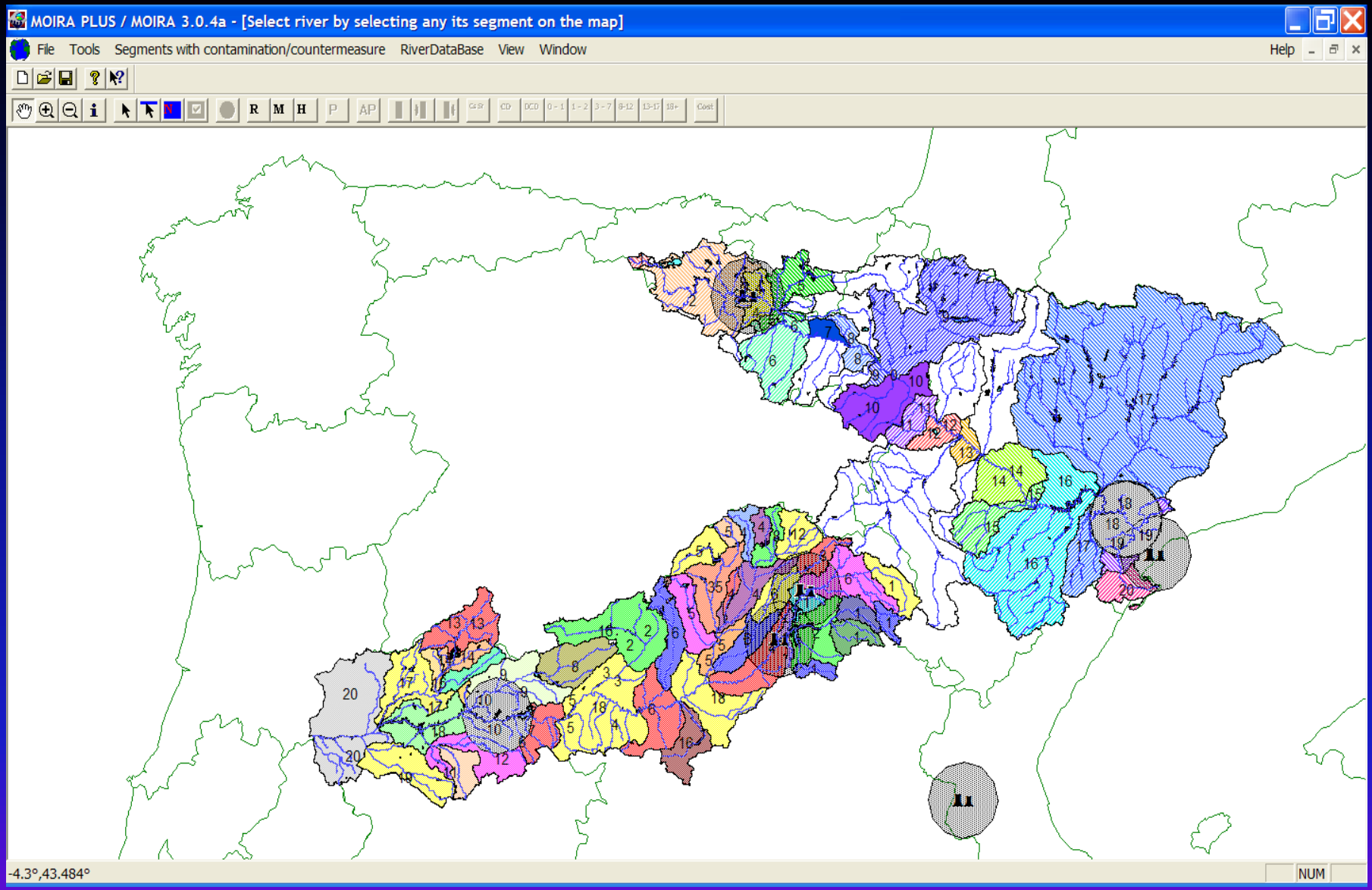

Selection - lake Svyatoye
Environmental data
Lake char.
Lake init.
Lake type
Ice cover
Continentality
Fish species
Soil type
Bedrock type
Precipitation
Ground use
Fallout Cs-137
Time (month)
Depos. catchment Cs-137 (Bq/m2)
Depos. lake Cs-137 (Bq/m2)
Jan 1986 0 0
Feb 1986 0 0
Mar 1986 0 0
Apr 1986 1.48E+006 1.6E+006
May 1986 0 0
MOIRA PLUS / MOIRA 3.0.4a - Svyatoye
File
Solution box
View
Window
Help
Svyatoye
Maps
Site-specific data
Case definition
Strategies
Results
Optimal strategy
Report
No actions
Potash
Early potash
Lake liming
Wetland liming
Fertilization
Sediment removal
Automatic food bans
Next>
<Back
Report
Use menu Insert or click right mouse button to insert new strategy
Lake liming
START
Lake Cs-137 concentr. (La...
Lake Sr-90 concentr. (La...
Lake chem. (Lake liming)
LEI (Lake liming)
Collective doses (Lake liming)
Indiv.doses 8-12y (La...
Indiv.doses 13-17y (La...
Indiv.doses 18y- (La...
Total doses (Lake liming)
Econ. costs (Lake liming)
Counterm. costs (La...
Lake Cs-137 concentr. (Lake liming)
Time (month)
Water (Bq/m3)
Sediments (B
Lake Cs-137 concentr. (Lake liming) / Time (month)
Classification with uncertainty in the a...
Strategies:
Overall Utilities
min
med
max
Rank
Potash_application 0.751 0.805 0.927 1
Wetland_liming 0.716 0.768 0.819 2
Lake_liming 0.715 0.766 0.814 3
Fertilizer 0.709 0.754 0.795 4
Sediment_removal 0.649 0.729 0.856 5
No_actions 0.631 0.686 0.741 6
Food_bans_(auto) 0.614 0.662 0.709 7
Watch weights and attribute values
Correlation
OK

End user's experience (1)

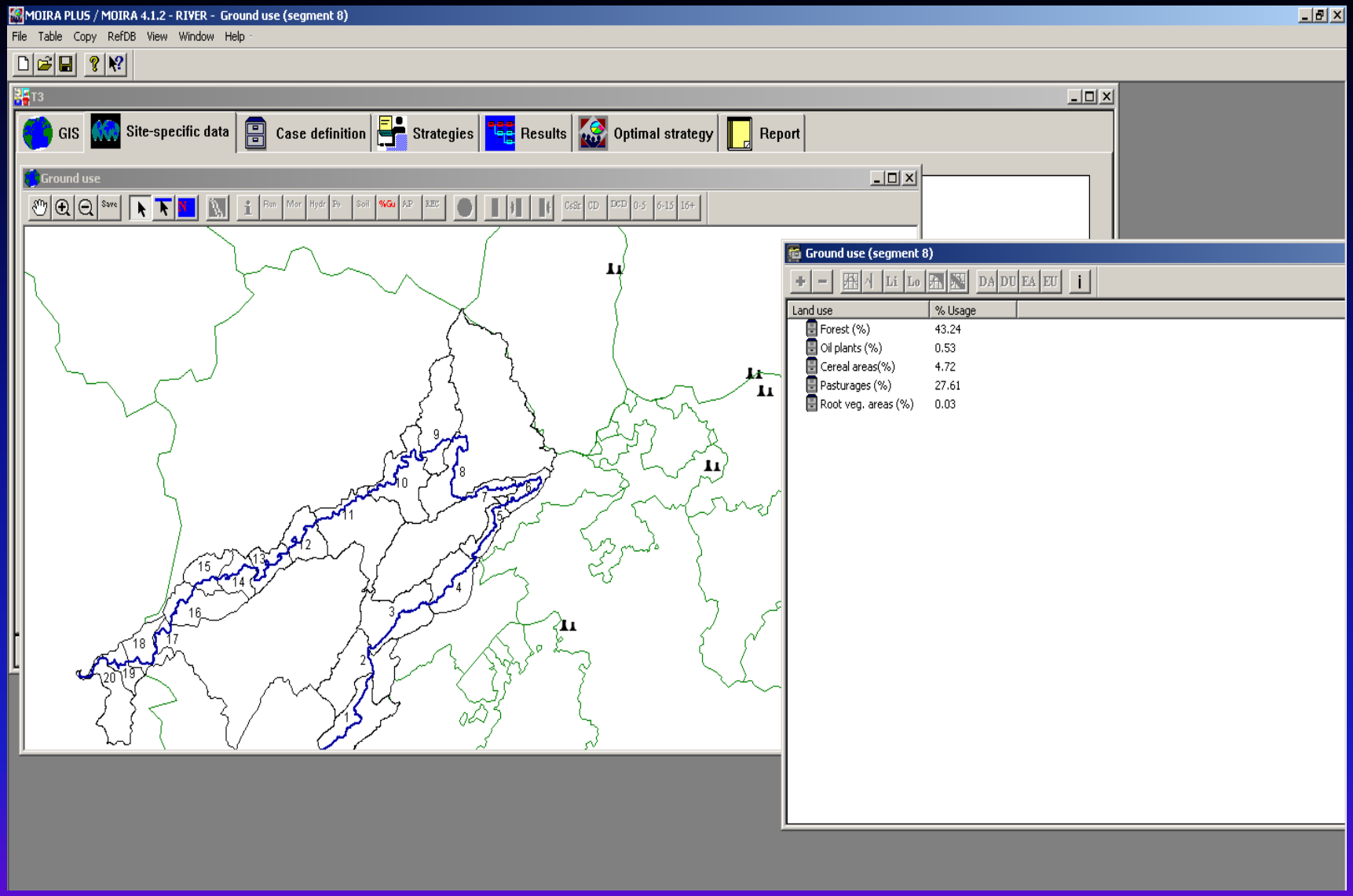
- EVANET-HYDRA network (Monte et al., 2005a)
- EURANOS project (Raskob, 2007)
  - Installation at Nuclear Safety Council (Spain)
  - Customized with regional and local characteristics and data
  - Exercise in two phases assuming a significant contamination of freshwater bodies in Spain (Gallego et al, 2009)
  - Also, different partners installed the system, tested it and evaluated its functionality, ease of usage, and results obtained.



MOIRA-PLUS customisation: the Tagus and Ebro rivers in Spain

End user's experience (2)

- Implementation and application in the "Pays de Montbéliard" region in North-Eastern France.
- Crossed by the Doubs river: single source of potable water for the population
  - also used for agriculture, livestock, fish farming, recreation including fishing and use of shores, etc.
- As part of the strategy of the territory to identify natural an technological threats, MOIRA has been used to study the vulnerability of the freshwater environment of the region and the potential consequences for the population in case of radioactive contamination.



MOIRA-PLUS customisation: the Doubs river in France (Biguenet et al., 2011)

End user's experience (3)

- Application to assess the impact of ^{137}Cs contamination of Chernobyl origin to 10 lakes and 18 rivers in Italy (Monte, 2011a)
  - Although high values of fish and water consumptions were hypothesised, very low doses to public from the fresh water pathway following the accident were calculated.

- **In all applications the system show its flexibility for customisation and application to different scenarios**

Summary

- MOIRA is a user-friendly software system, based on scientific and theoretical foundations, intended to give support to decisions on management strategies to reduce the dose via aquatic pathways in the long-term.
- MOIRA evaluates and offers a rapid insight on the effectiveness of several types of countermeasures, taking into account radiological, ecological, social and economic consequences.
- It has been used and applied in different countries to different purposes with positive impressions

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Practical conclusions (1)

- Successful operational use requires that **background environmental and socio-economic information** are **prepared in advance and maintained** over time.
- Generic typical environments can be useful to get generic results, but site specific peculiarities are relevant!
- Capacity to assess the economic cost of implementing countermeasures was considered very positive, but **representative data are necessary**.

Practical conclusions (2)

- Some models should be added (for instance: dose to workers implementing countermeasures)
- Self-learning is possible. However, some users would acknowledge more complete documentation and reference test cases
- MOIRA complements JRODOS-HDM to analyse the long-term strategies. Some users suggested integration of both systems
- **In summary: MOIRA is a good tool, but with possibilities to improve**

Conclusion on the applications of MOIRA (1)

- In Spain, the exercise unveiled the need of a better interface and understanding between agencies and stakeholders
- MOIRA allowed them to get a very close idea of the magnitude of the expected problems.
- Increased awareness and knowledge among stakeholders, and prepare plans for certain countermeasures.

Conclusion on the applications of MOIRA (2)

- In France: will also be used to discuss with different stakeholders (local professionals responsible of water management, local representatives, civil safety associations, firemen, police, etc.) the needs concerning radiation monitoring systems for water and food, drinking tap water, communication issues …
  - and also to identify sensible points that should be included in the Geographical Information System of the territory which is used to identify and foresee natural and technological threats

Final conclusions

- MOIRA proved to be a **helpful tool** for decision making in such scenarios.
- Help to **public reassurance**
  - realistic evaluation of the social, economical, and ecological impact of possible recovery strategies.
- Aid **cross-agency interaction** and common understanding of all related issues.
- **Technical assistance**: evaluation of behaviour of contamination in the long-term, sampling strategy, etc.
- Similar conclusions can be applicable to other DSS applicable to emergency preparedness and post-accident rehabilitation

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Many thanks for your attention!

Questions

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