RadioClimFire

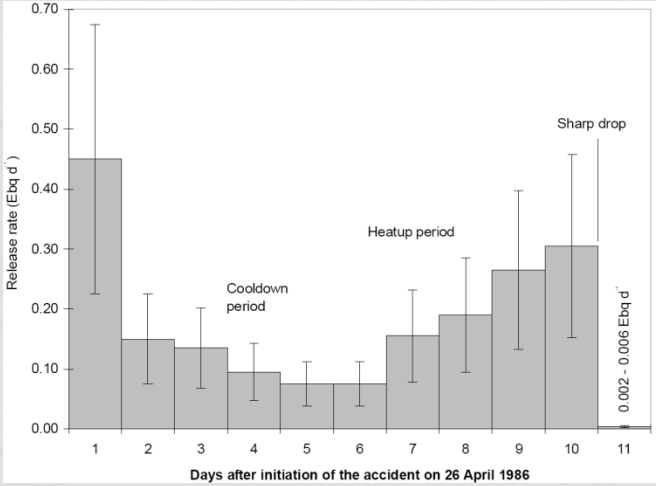
Radioactivity, climate, fire and human health: A second Chernobyl catastrophe about to happen?

NIKOLAOS EVANGELIOU

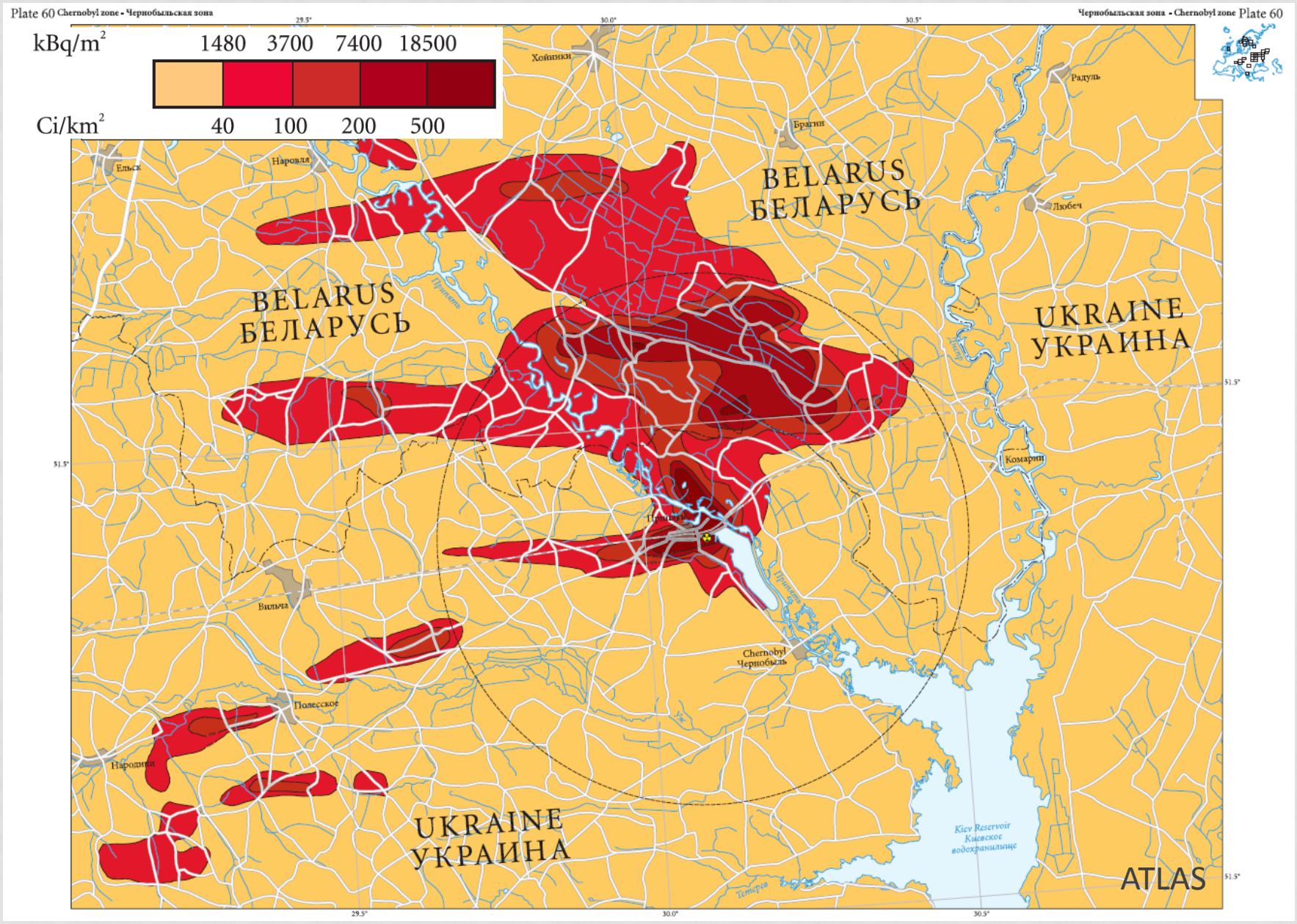
Chernobyl, Ukraine, 26 April 1986

Released radionuclides
still measurable

- ^{90}Sr : 0.22 10^{18} Bq
- ^{137}Cs : 85 10^{15} Bq
- $^{239+240}Pu$: 2.1 10^{15} Bq
- ^{238}Pu : 1.0 10^{15} Bq
- ^{241}Pu : 0.17 10^{18} Bq



Regional deposition

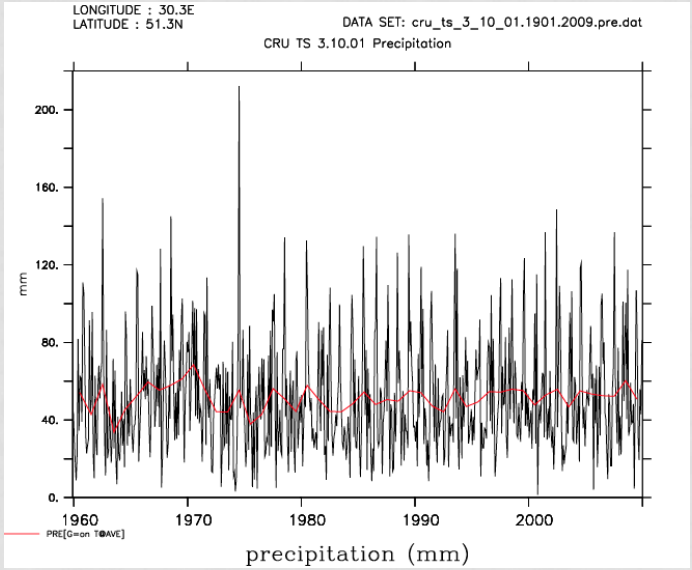


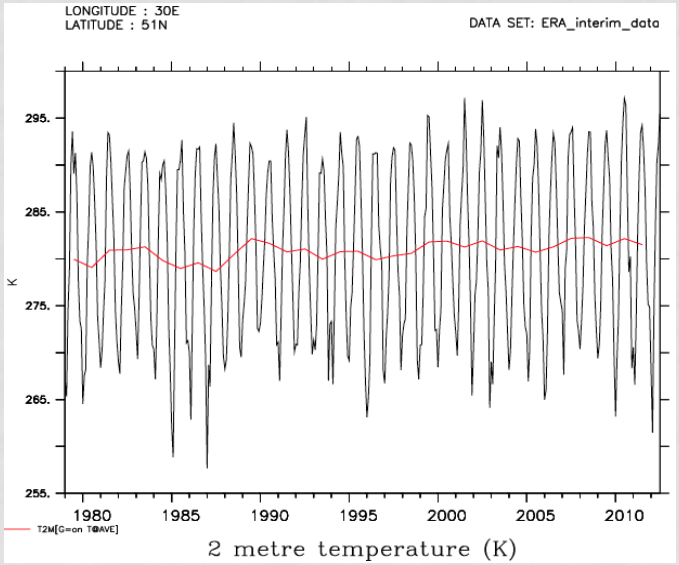
Vegetation in CEZ

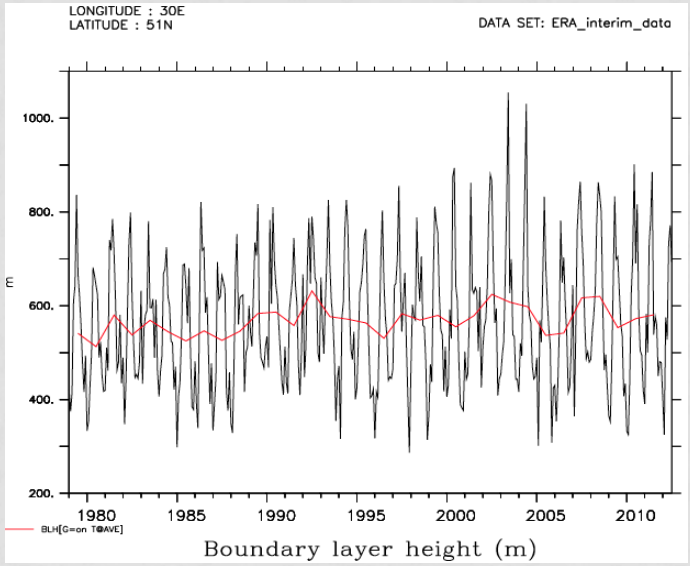
CEZ: 2600 km^2
70 % boreal forest (pine trees)
30 % agricultural land

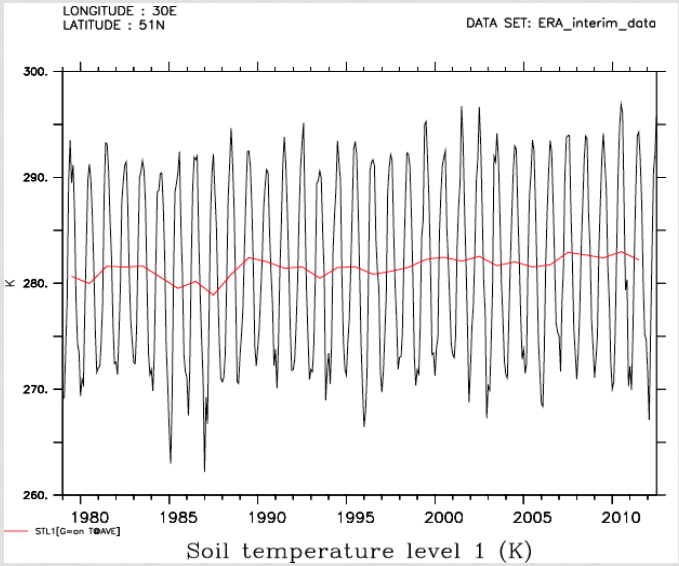
Red forest

Precipitation, temperature, BLH in the Chernobyl NPP

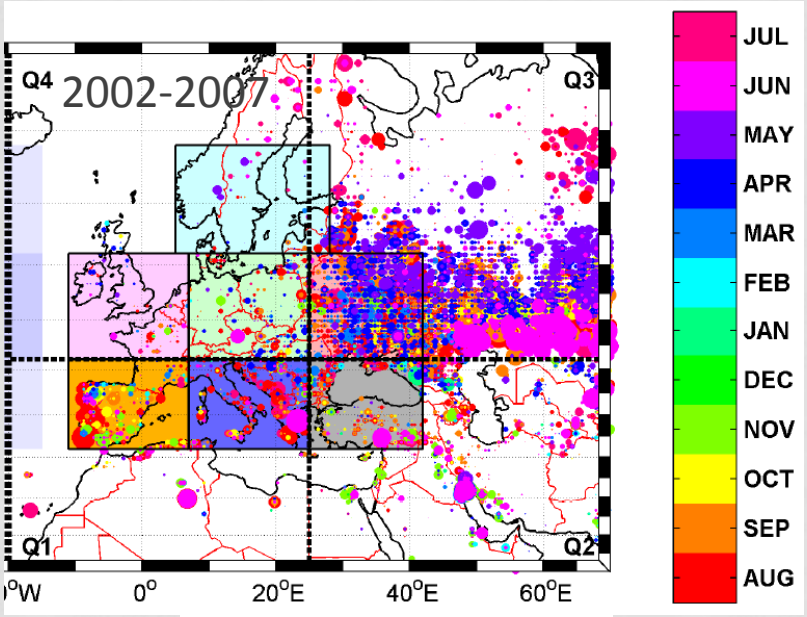




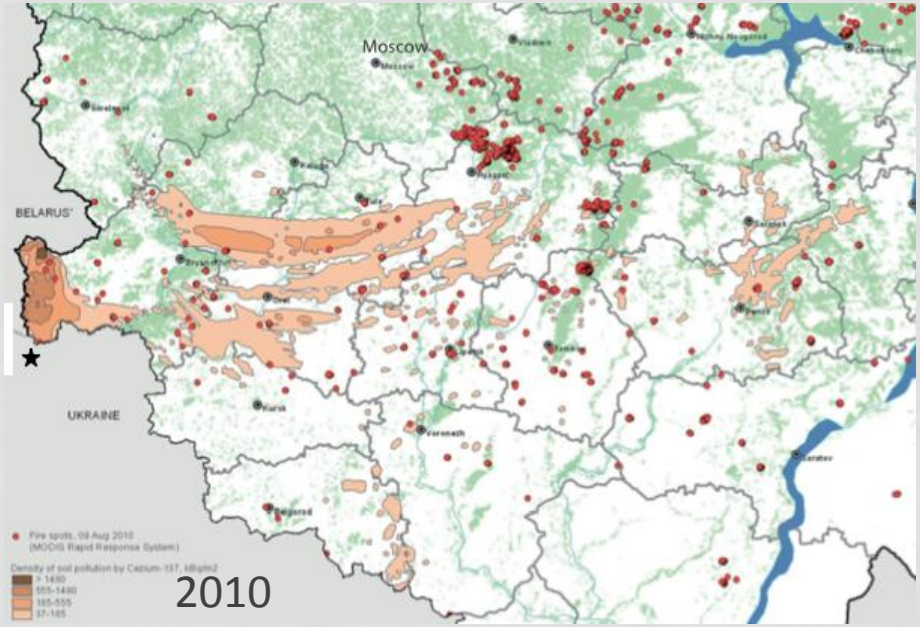




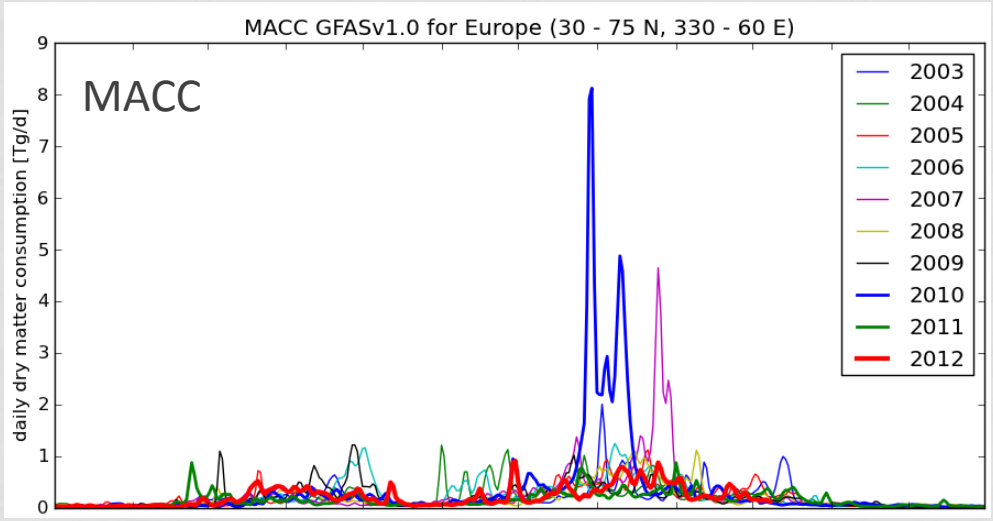
Fire distribution over Europe



Barnaba et al., 2012

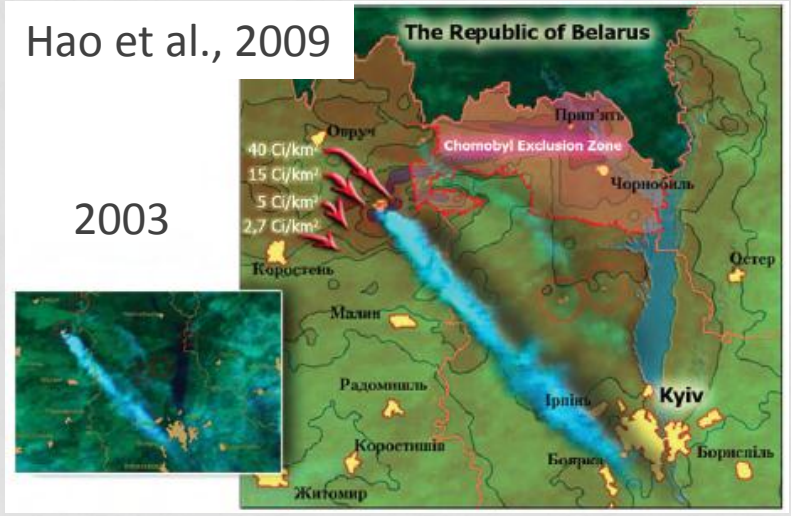


MODIS satellite

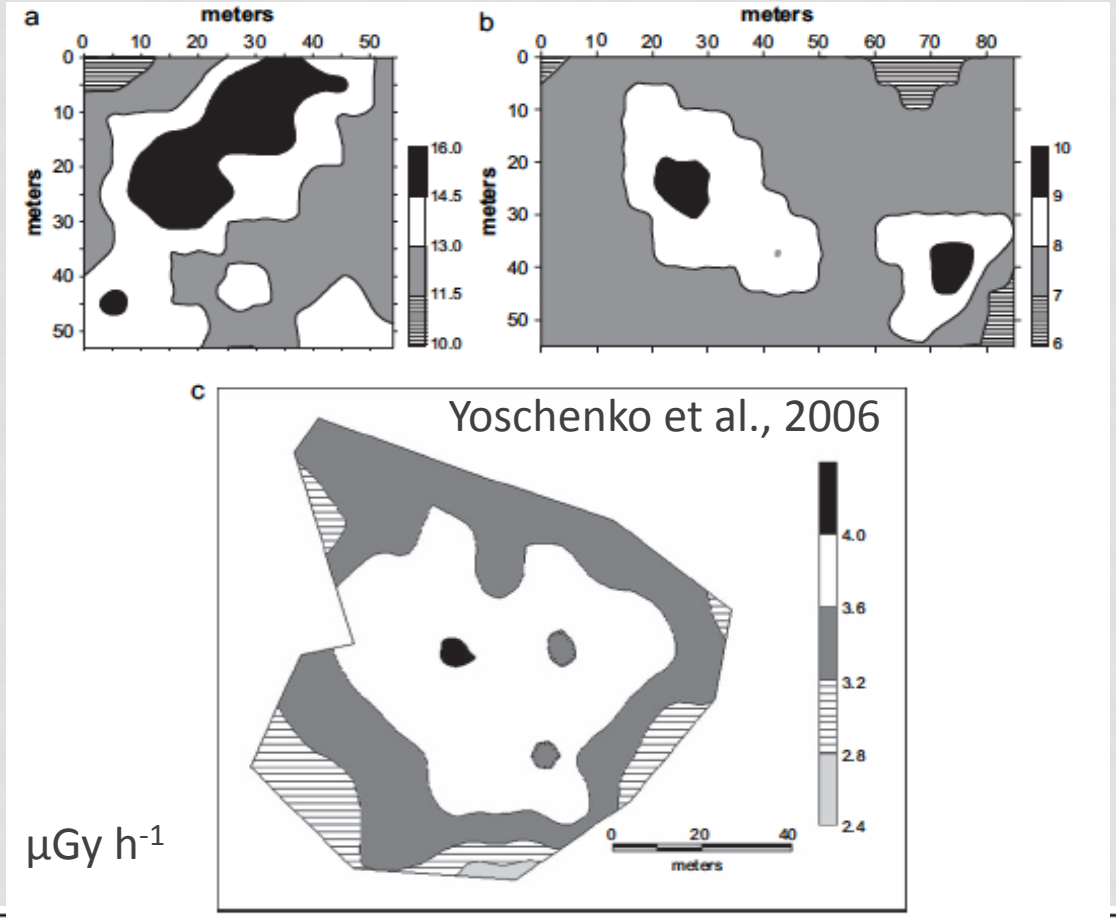


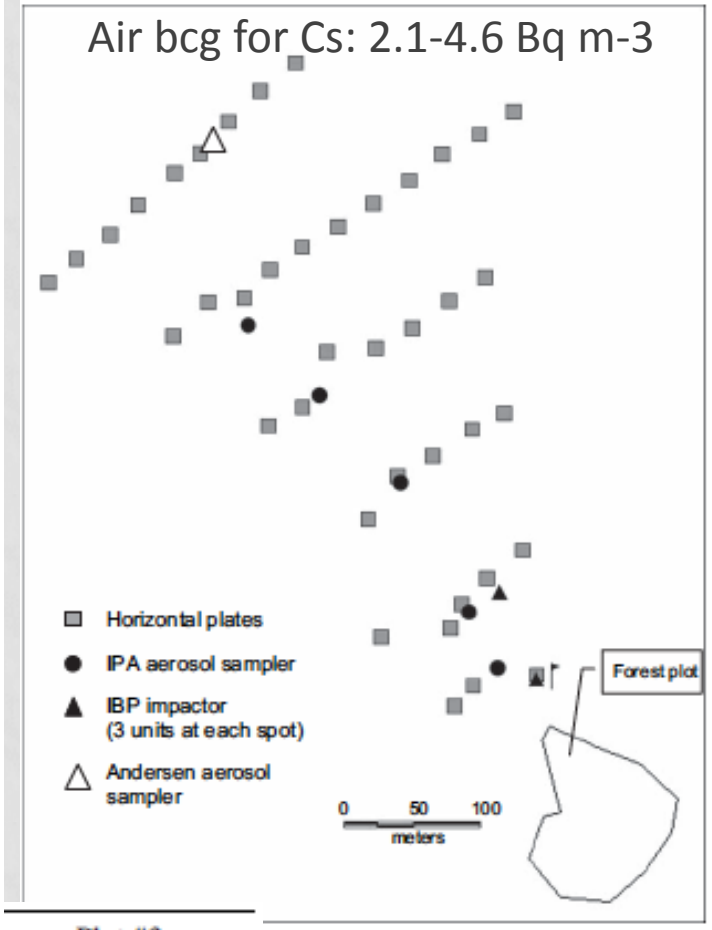
Hao et al., 2009

2003



How much cesium might be redistributed after fires?

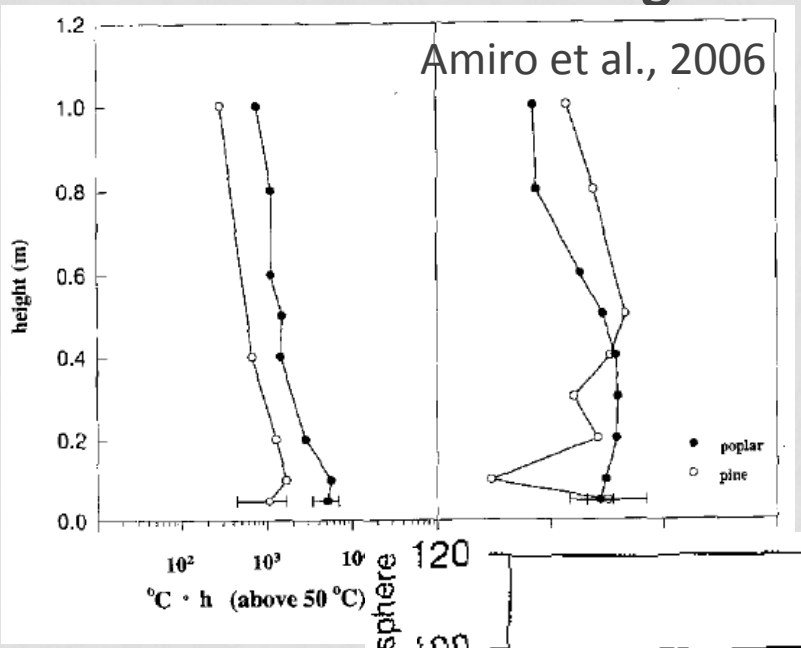


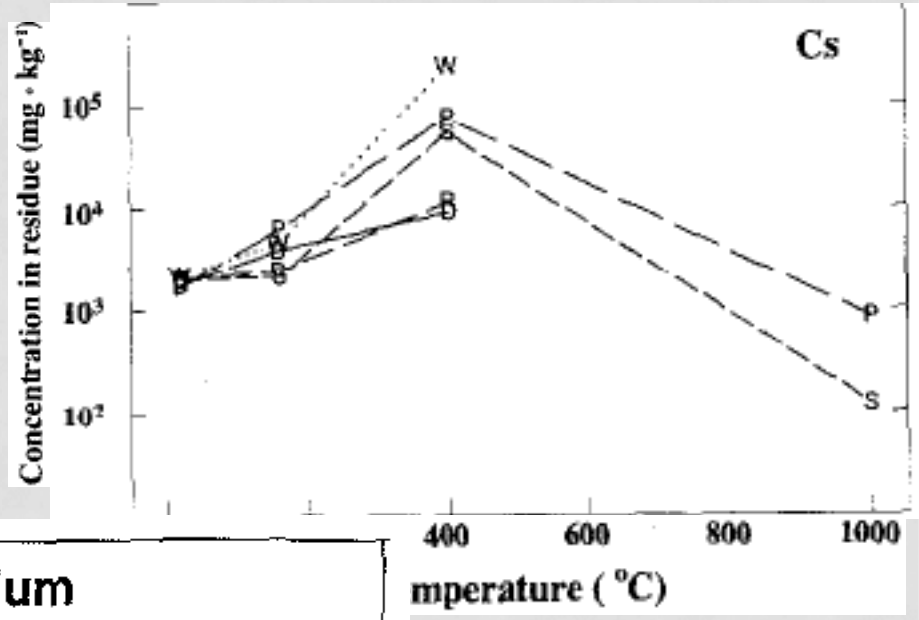


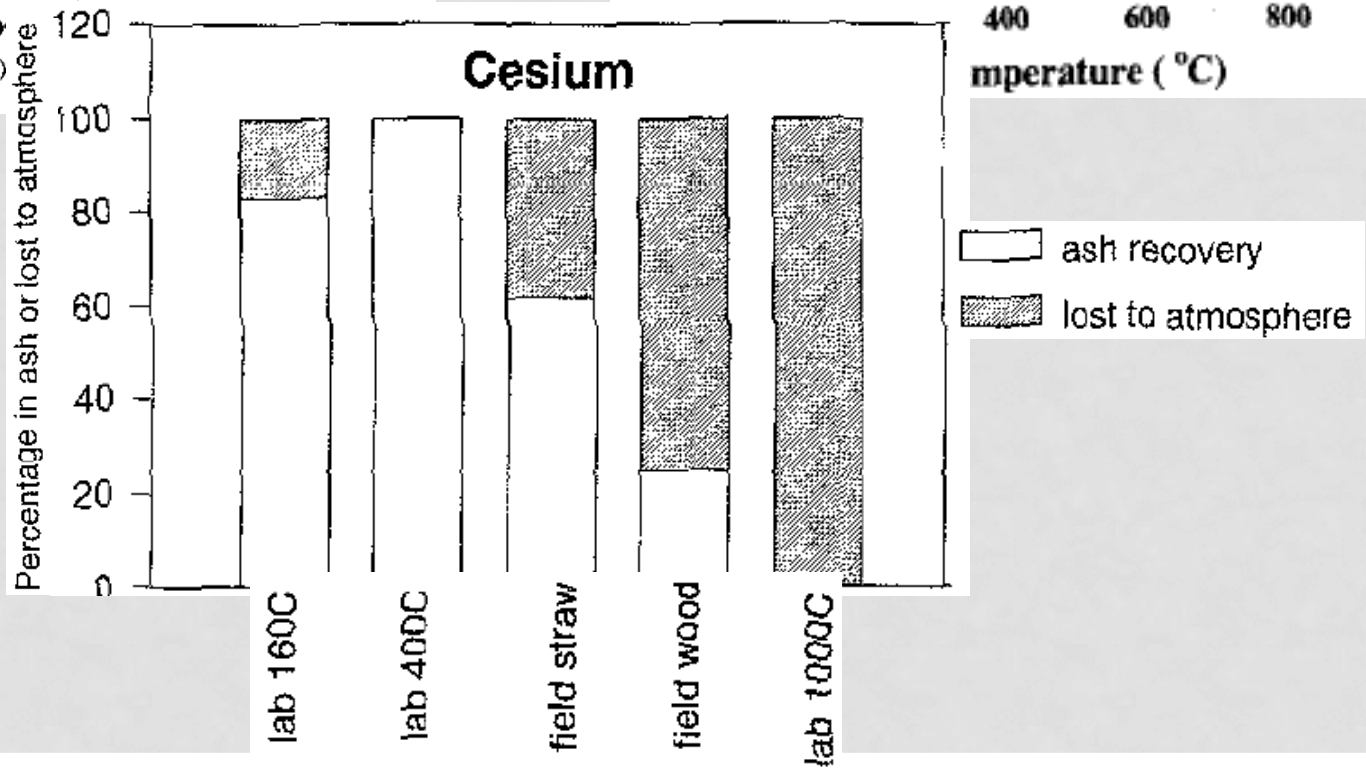
	Plot #1	Plot #2	Plot #3
Area (m^2)	3600	5400	8770
Land type	Wildland (grass)	Wildland (grass)	Forest
Vegetation species	*Elytrigia repens* (L.) Nevski (85%)	*Elytrigia repens* (L.) Nevski (85%)	*Pinus silvestris*
Vegetation height (m)	0.5	0.2	15
Biomass density (kg m^{-2})	0.4	0.3	24
Litter density (kg m^{-2})	0.7	1.25	2.3
Dose rate range (µGy h^{-1})	10–16	6–10	2–4

Redistribution 4 %

How much cesium might be redistributed after fires?







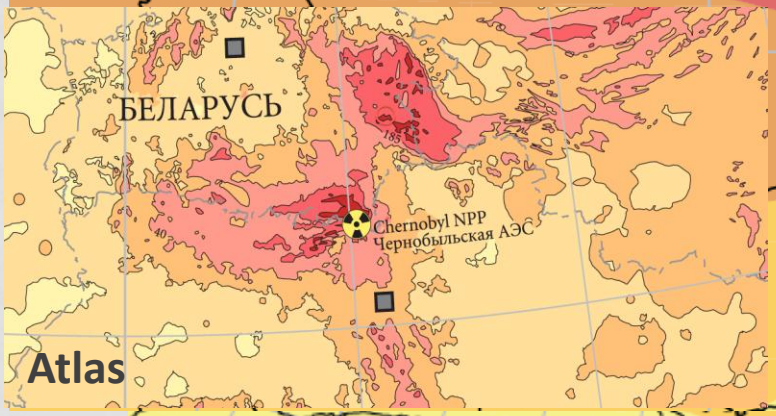
How much cesium might be redistributed after fires?

'Hot Burn' — Mean Temperature 660°C 48 kg of air-dry heather yielded 0·95 kg of ash (2·05%)			
	Total Bq before burning	*Total Bq after burning*	*Smoke loss %*
^{137}Cs	152 000	99 300	39
^{134}Cs	22 000	15 000	35
'Cool Burn' — Mean Temperature 550°C 50·1 kg of air-dry heather yielded 2·2 kg of ash (4·4%)			
	Total Bq before burning	*Total Bq after burning*	*Smoke loss %*
^{137}Cs	120 000	106 000	12
^{134}Cs	23 000	21 000	11

Horill et al., 1995

How important is the altitude

in PBq



Atlas

Kyiv

Chernobyl NPP

CUMULATIVE TOTAL DEPOSITION

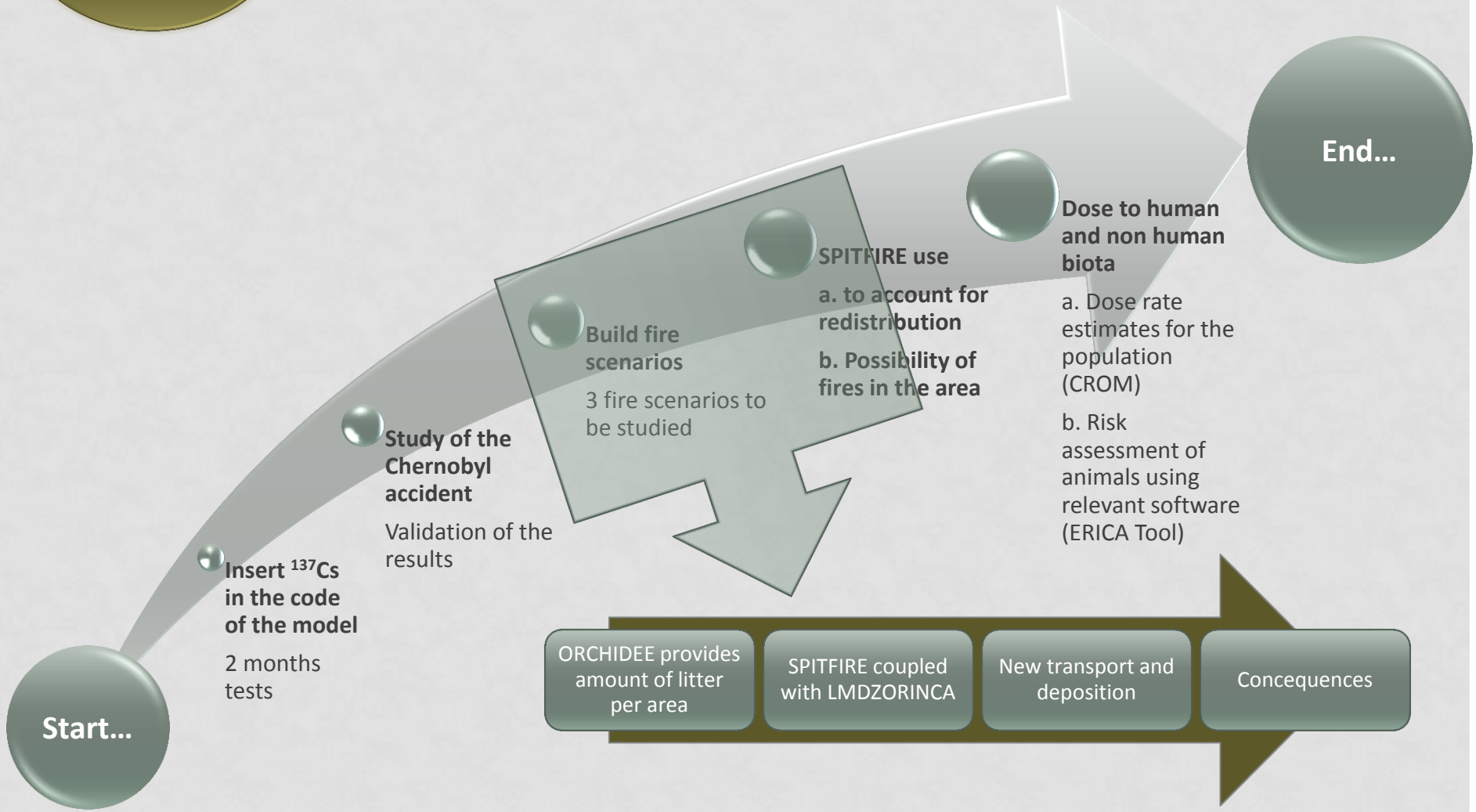
kBq/m2

Goals…

- Assessment of the transport and deposition of ^{137}Cs after fire scenarios
- Assessment of the risk of contamination of major human urban centers in Ukraine, Belarus and Russia due to contaminated smoke originating from forest fire in contaminated areas
- Assessment of the biological and public health consequences of such contamination.
- Forecast of the risk and areas that are particularly likely to suffer from further contamination due to forest fire
- Report of the risk to human health and the level of morbidity due to increased contamination arising from forest fires
- Address of the effects of increased contamination arising from forest fires on abundance and diversity of animals by using reference organisms inhabiting the area and modeling applications

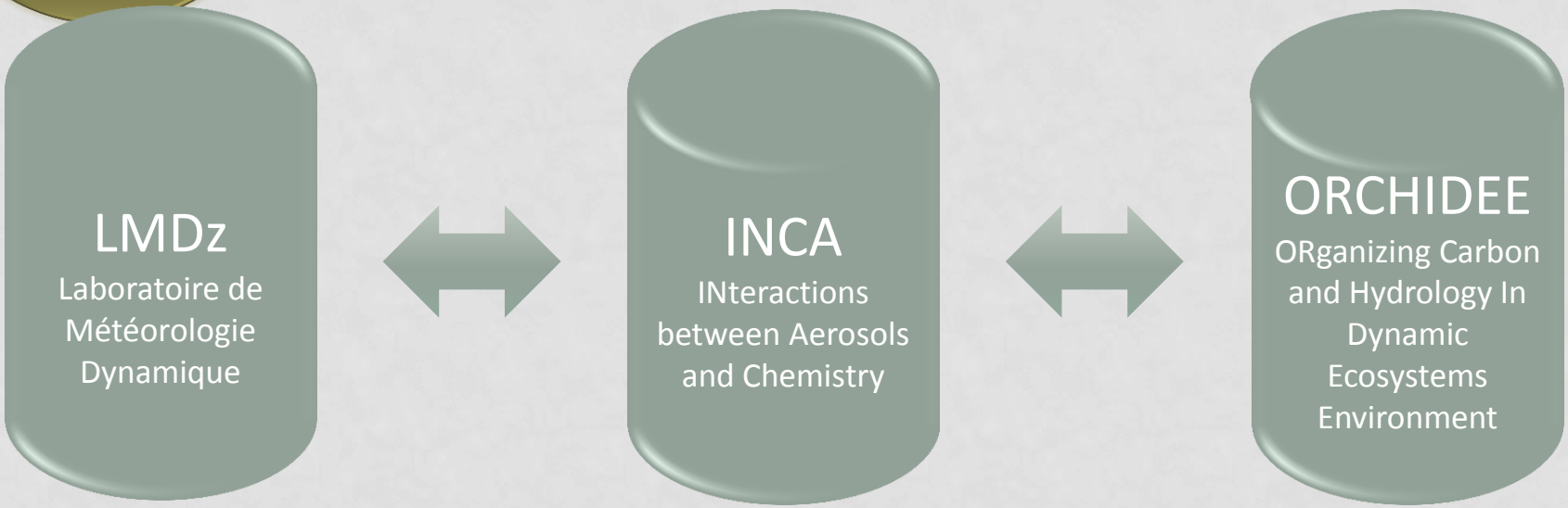
RadioClimFire

Mapping the route to the final destination…



LMDZORINCA

Model description



GCM

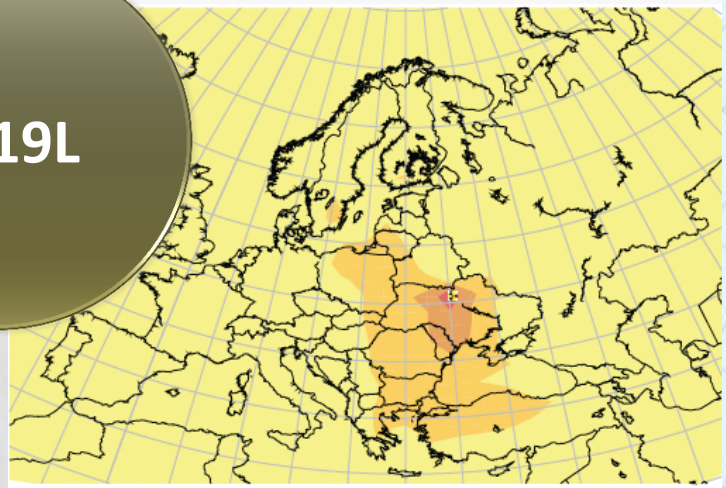
- Offers the possibility of zoom

Chemistry model

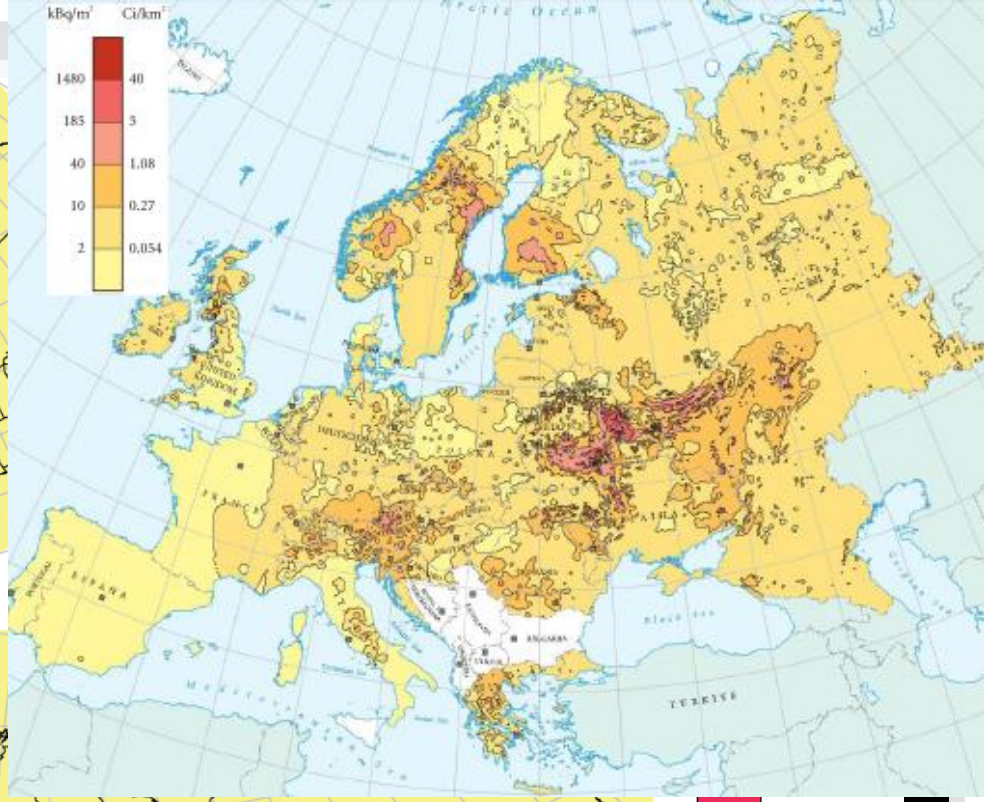
- Can run in nudged mode of ECMWF meteorology

Vegetation model

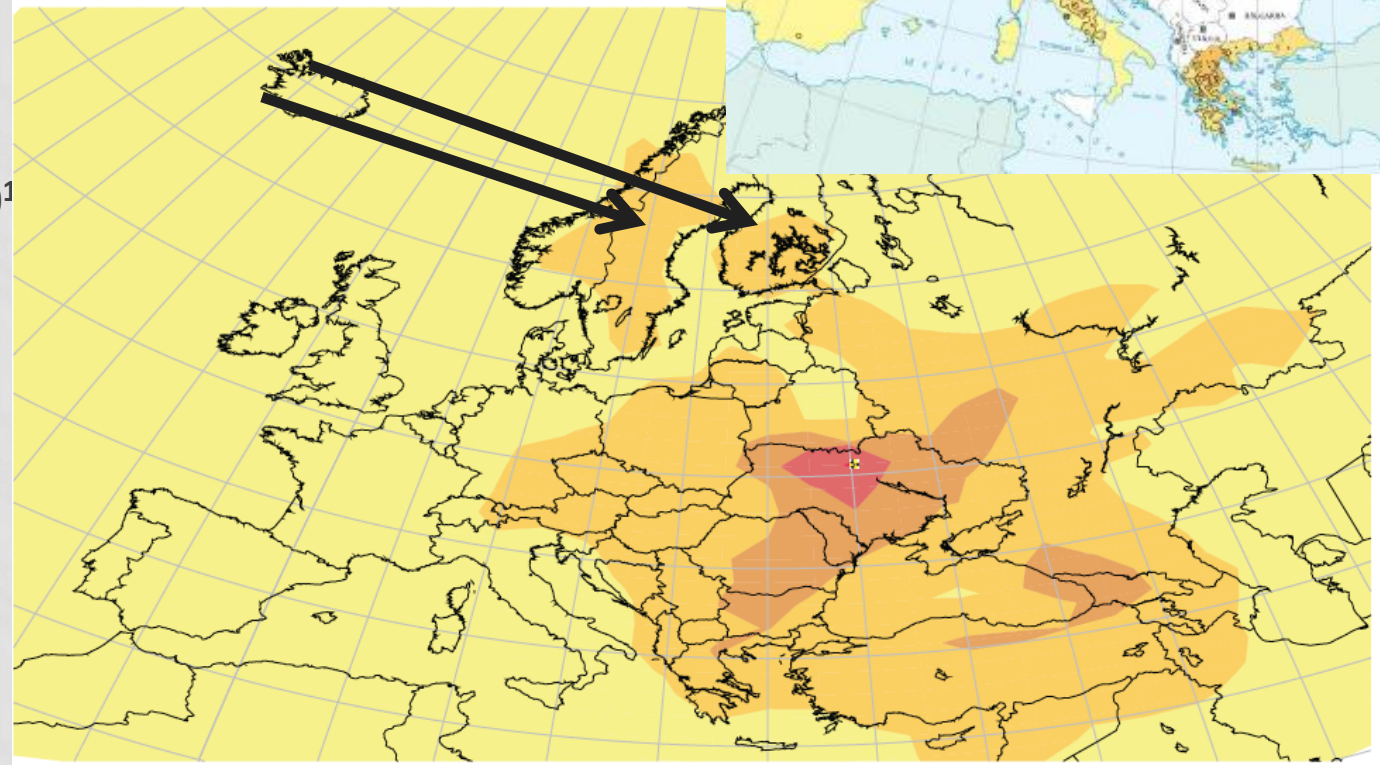
RG19L



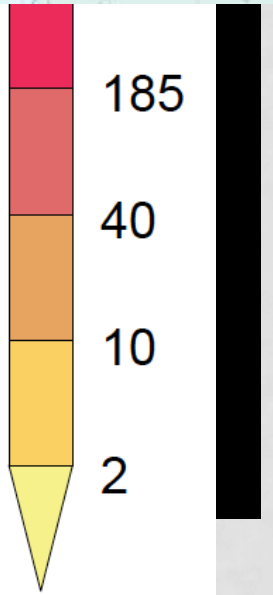
CUMULATIVE DRY DEPOSITION



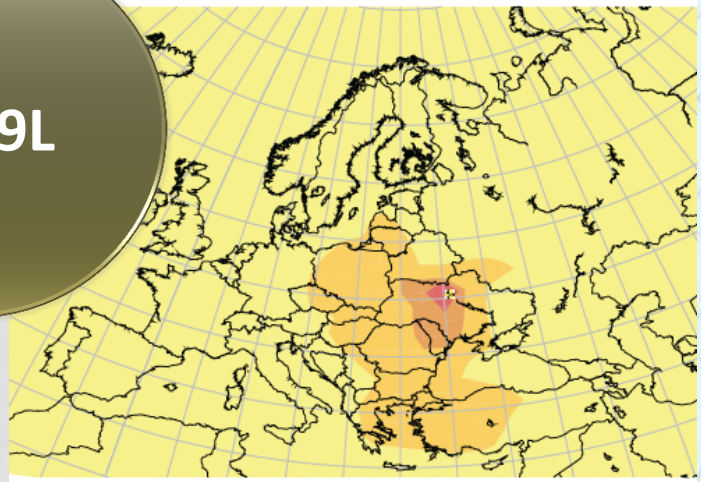
in PBq (10¹



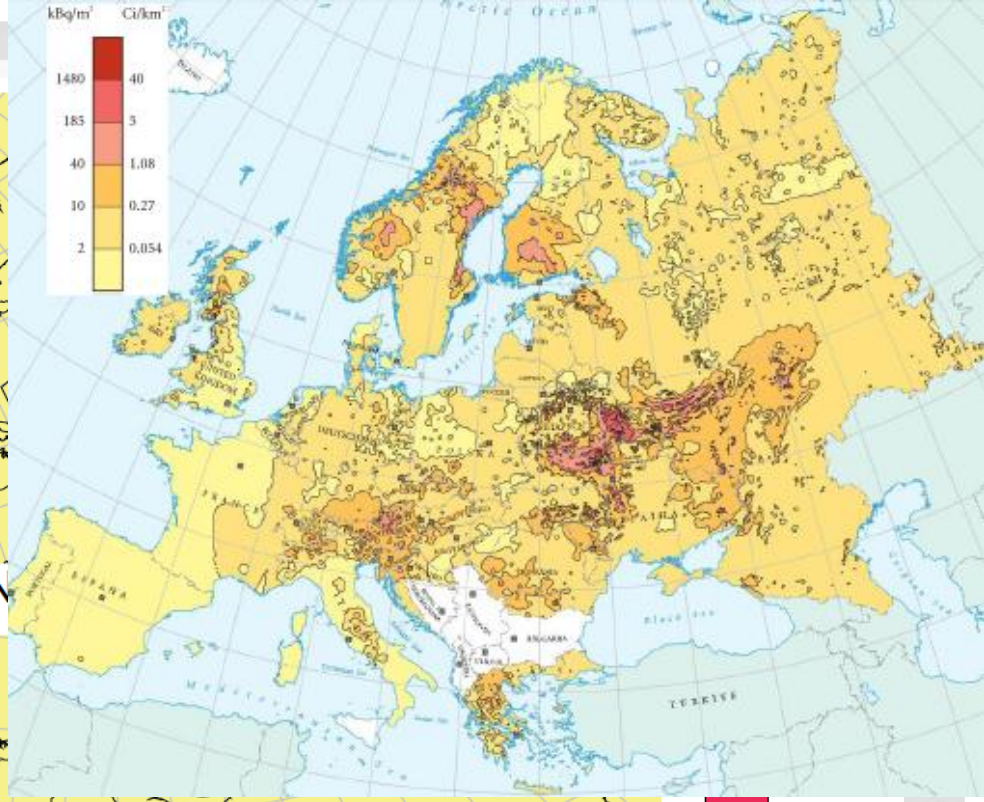
CUMULATIVE TOTAL DEPOSITION



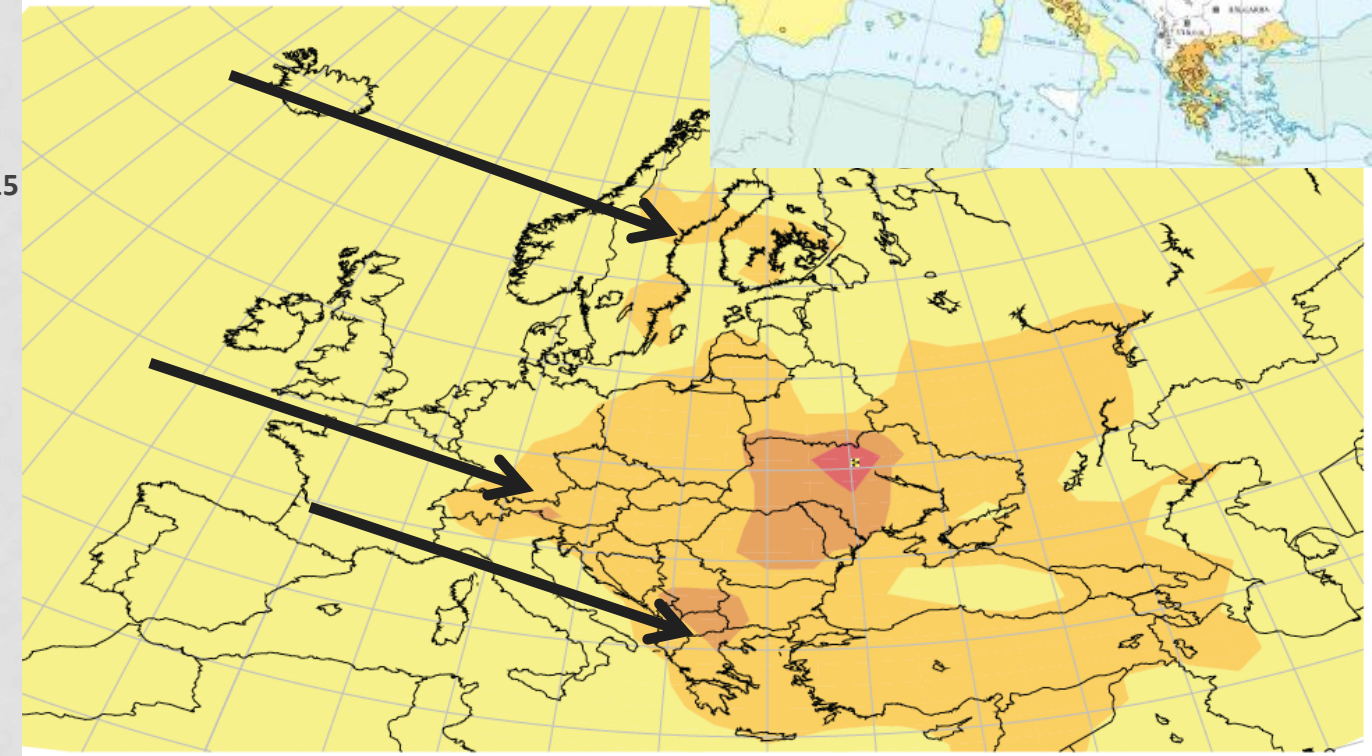
RG39L



CUMULATIVE DRY DEPOSITION



in PBq (10^{15}



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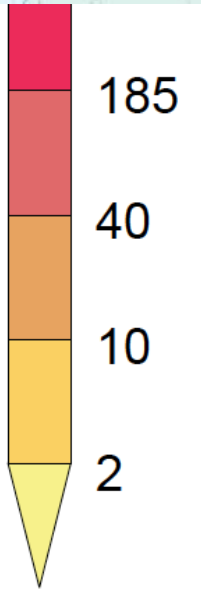
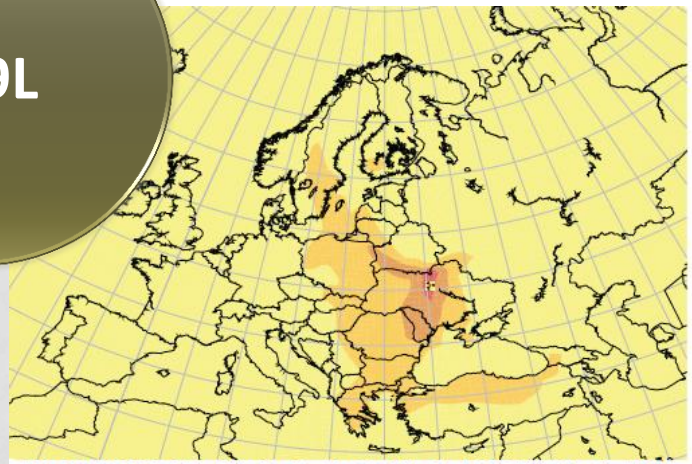
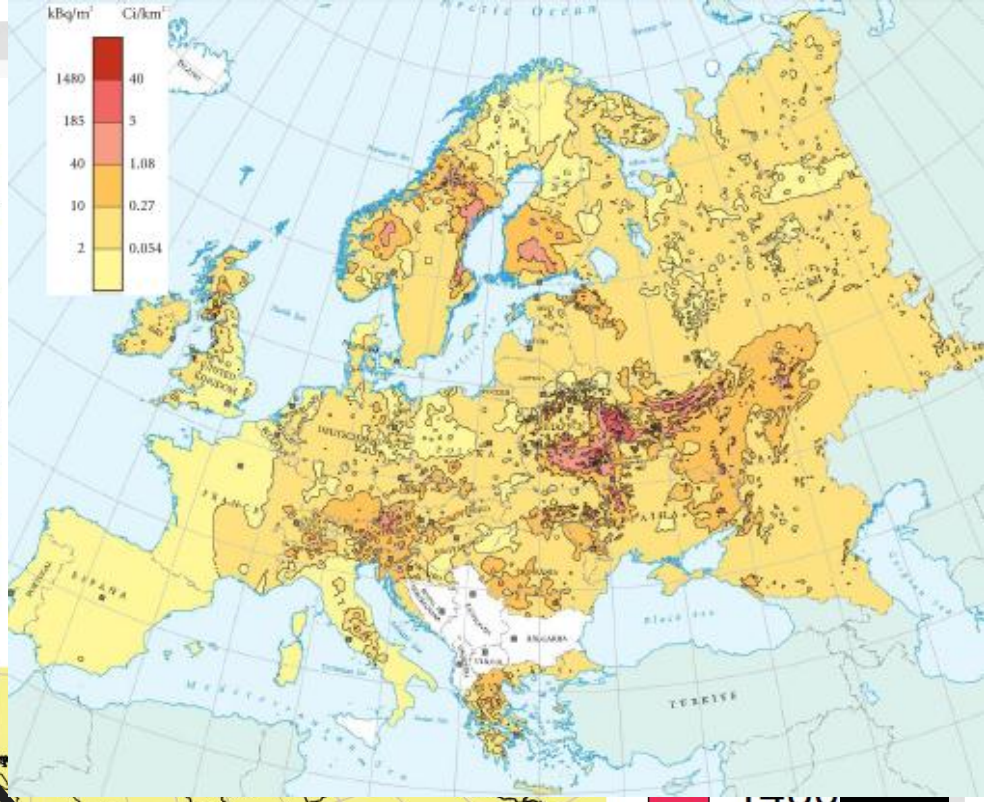


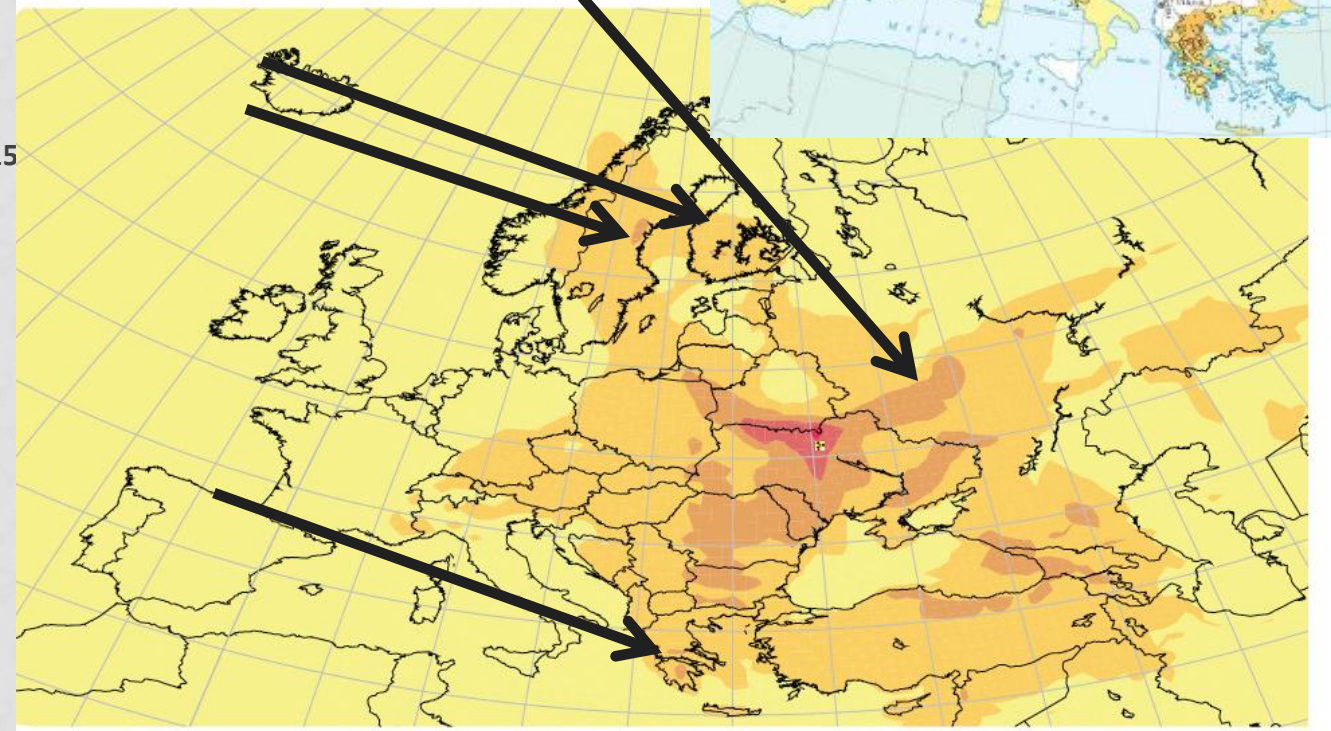
Z19L



CUMULATIVE DRY DEPOSITION



in PBq (10^{15}



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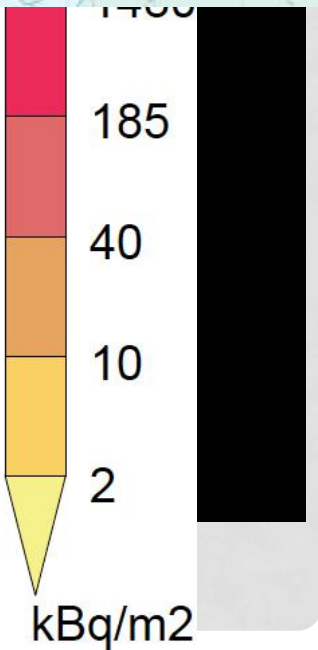
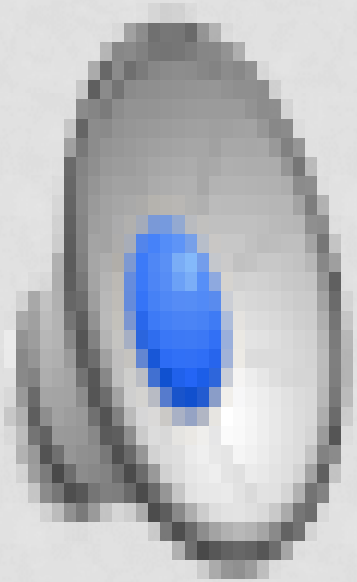


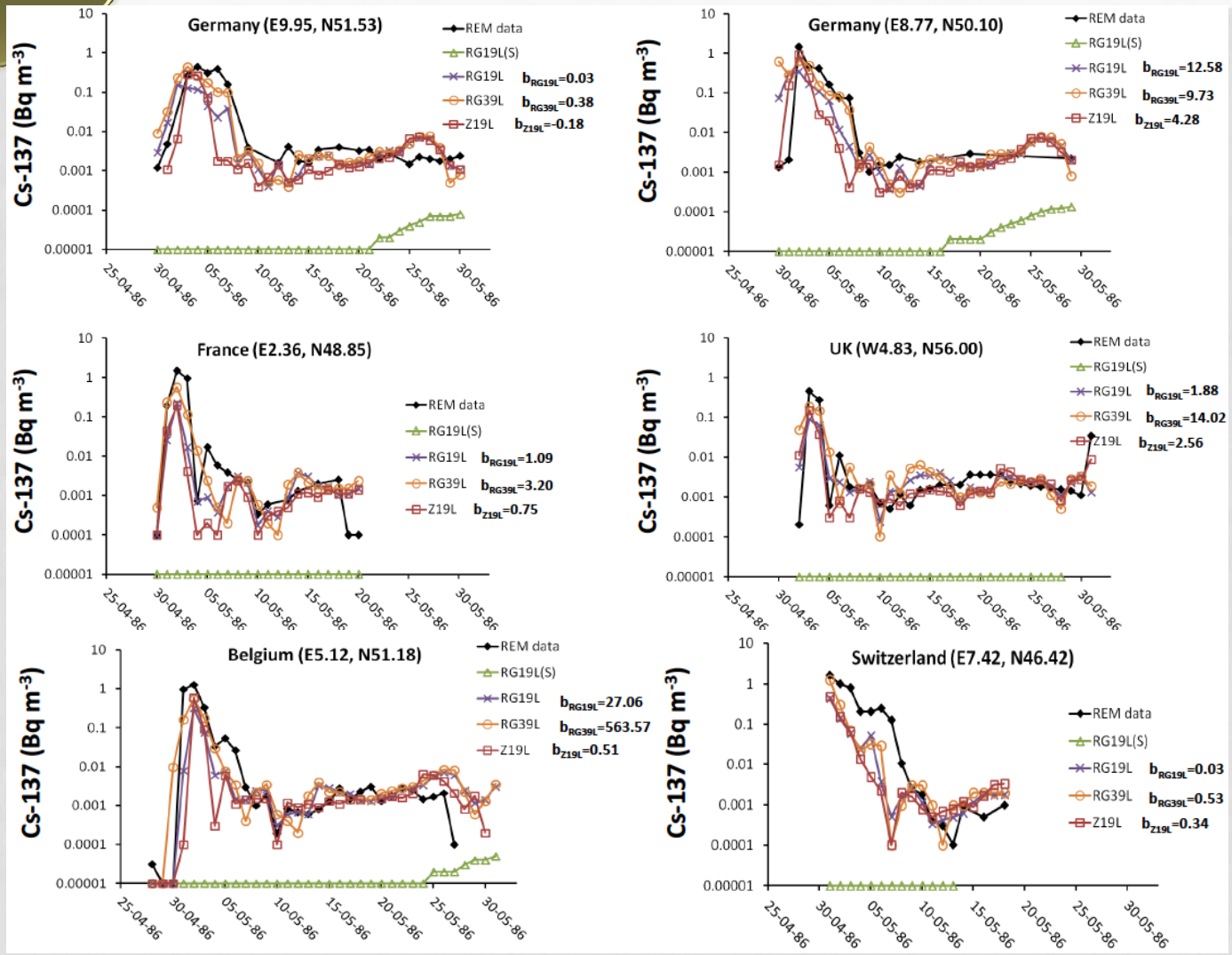
19 levels
or
39 levels

Vertical resolution



VALIDATION OF SURFACE ACTIVITY CONC.

Model vs Measurements



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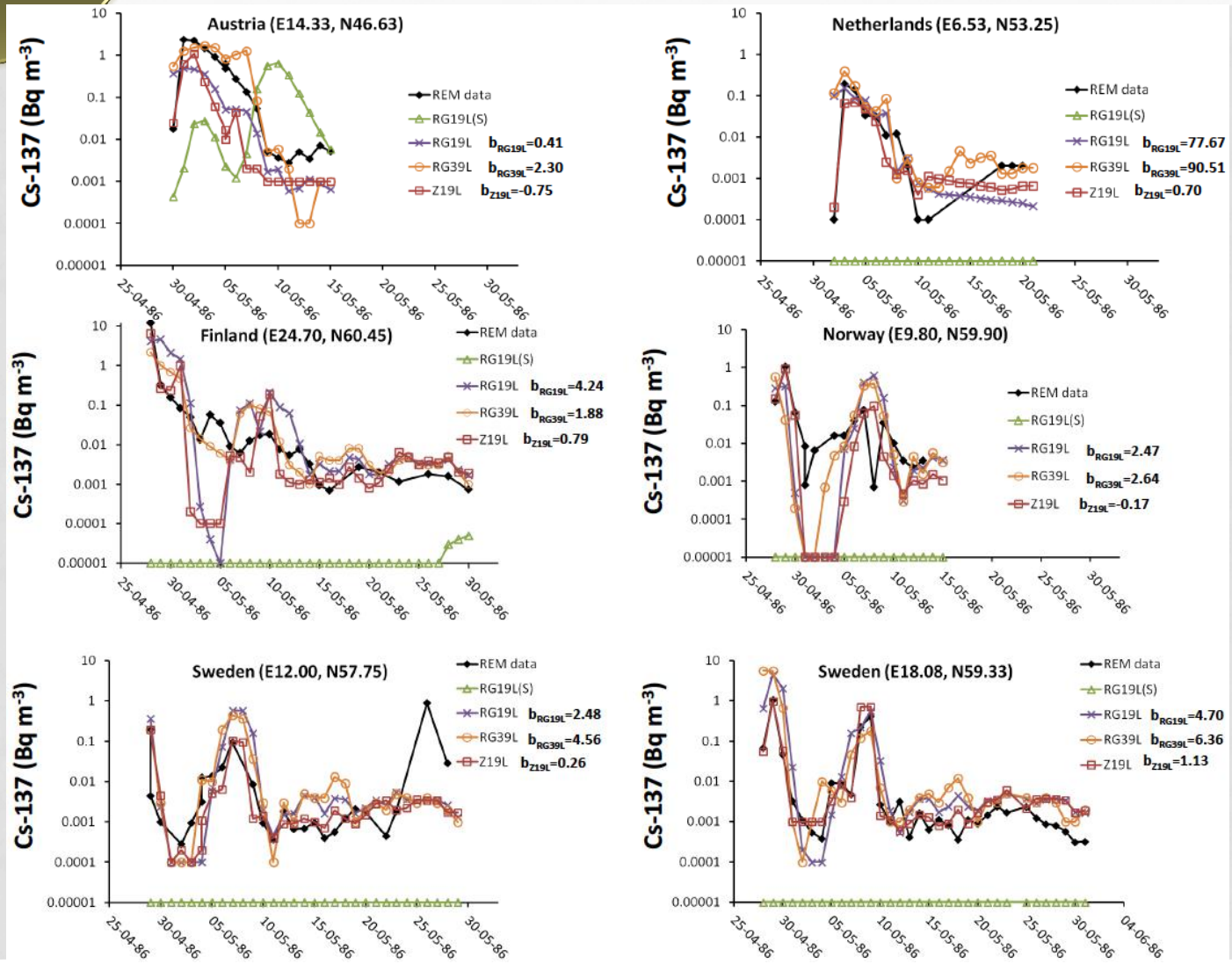

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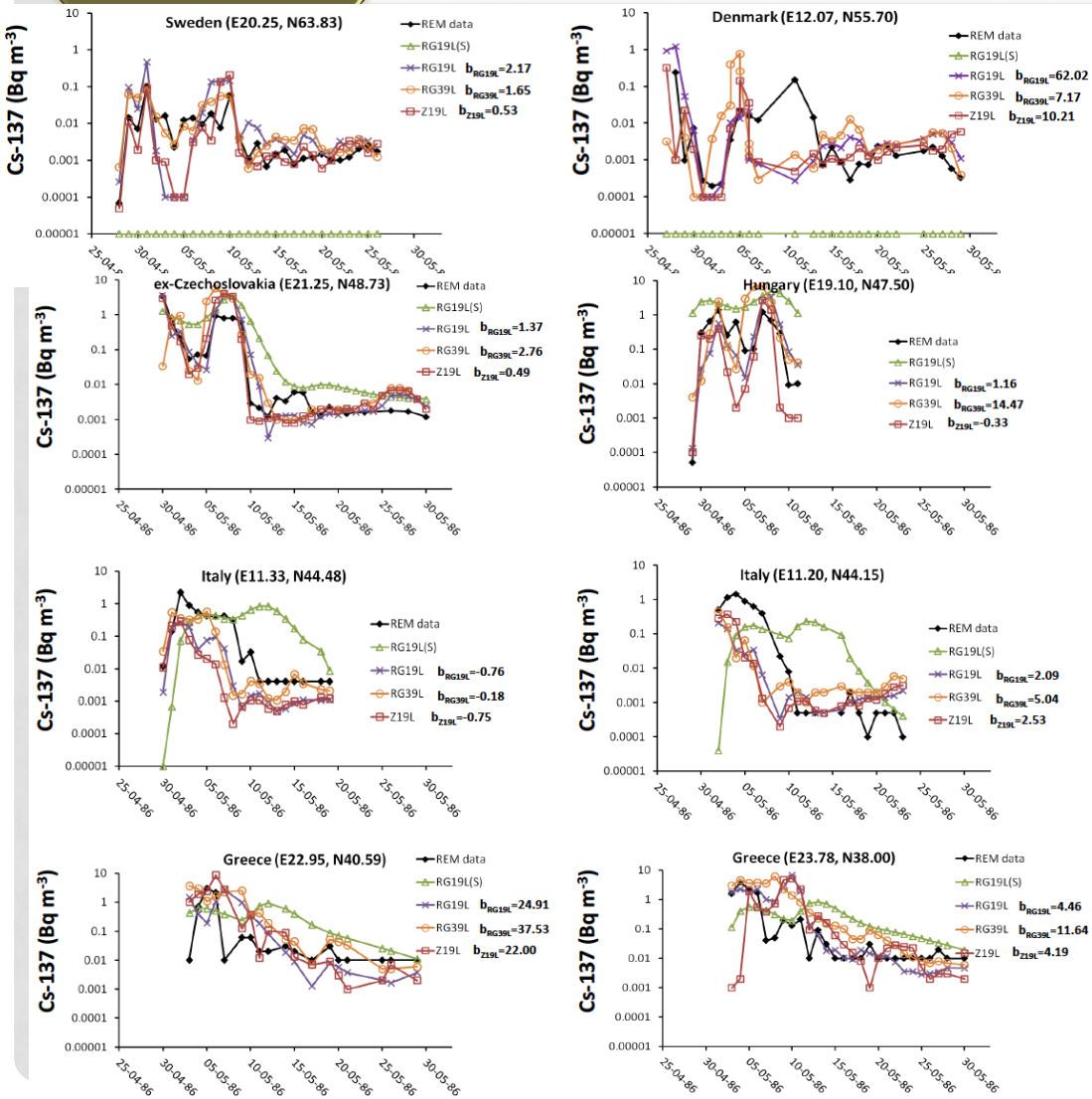

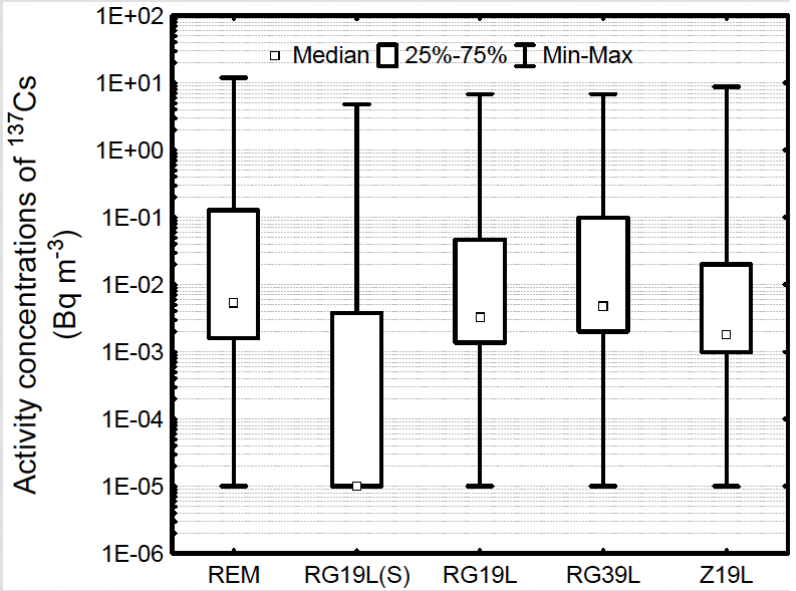

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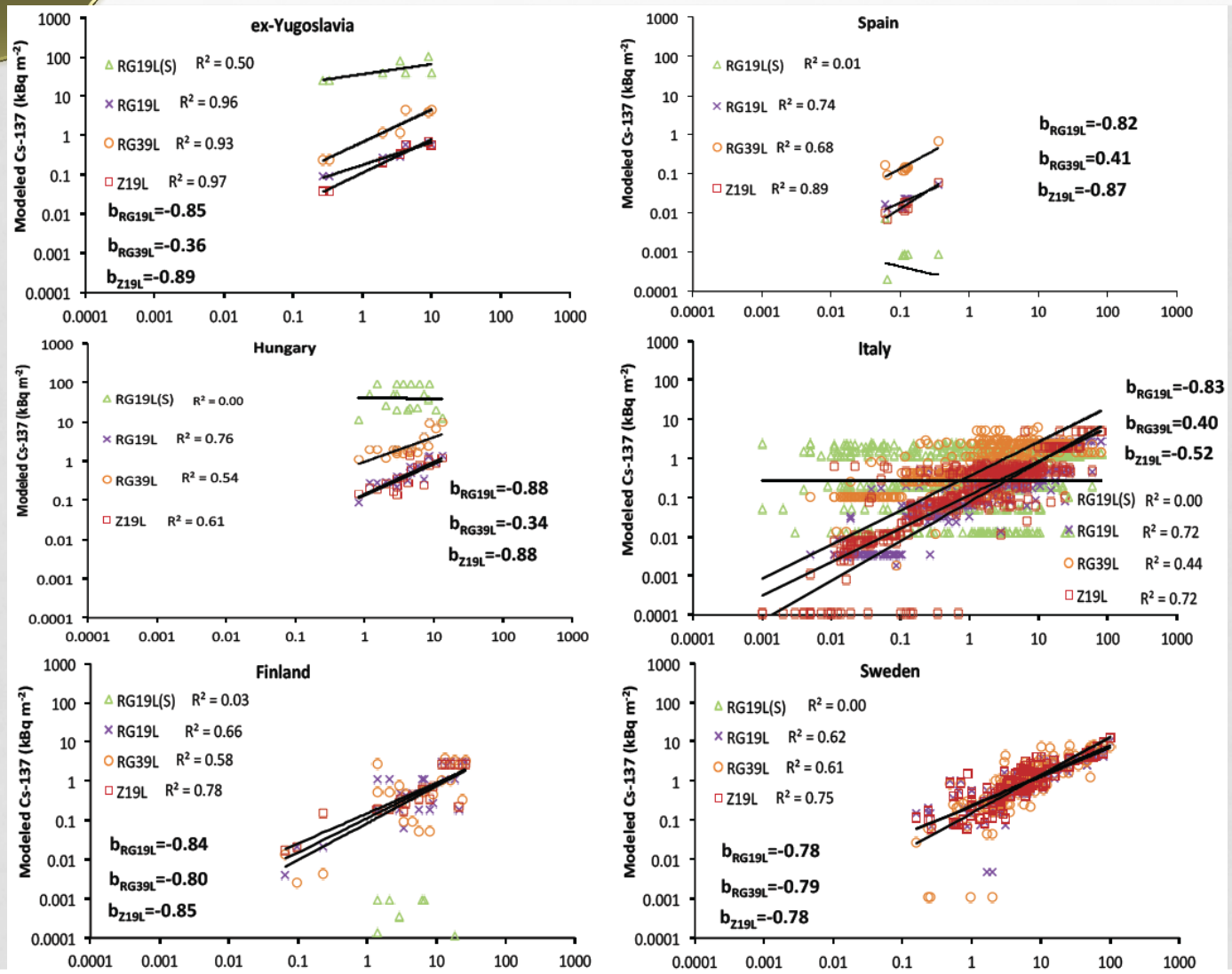

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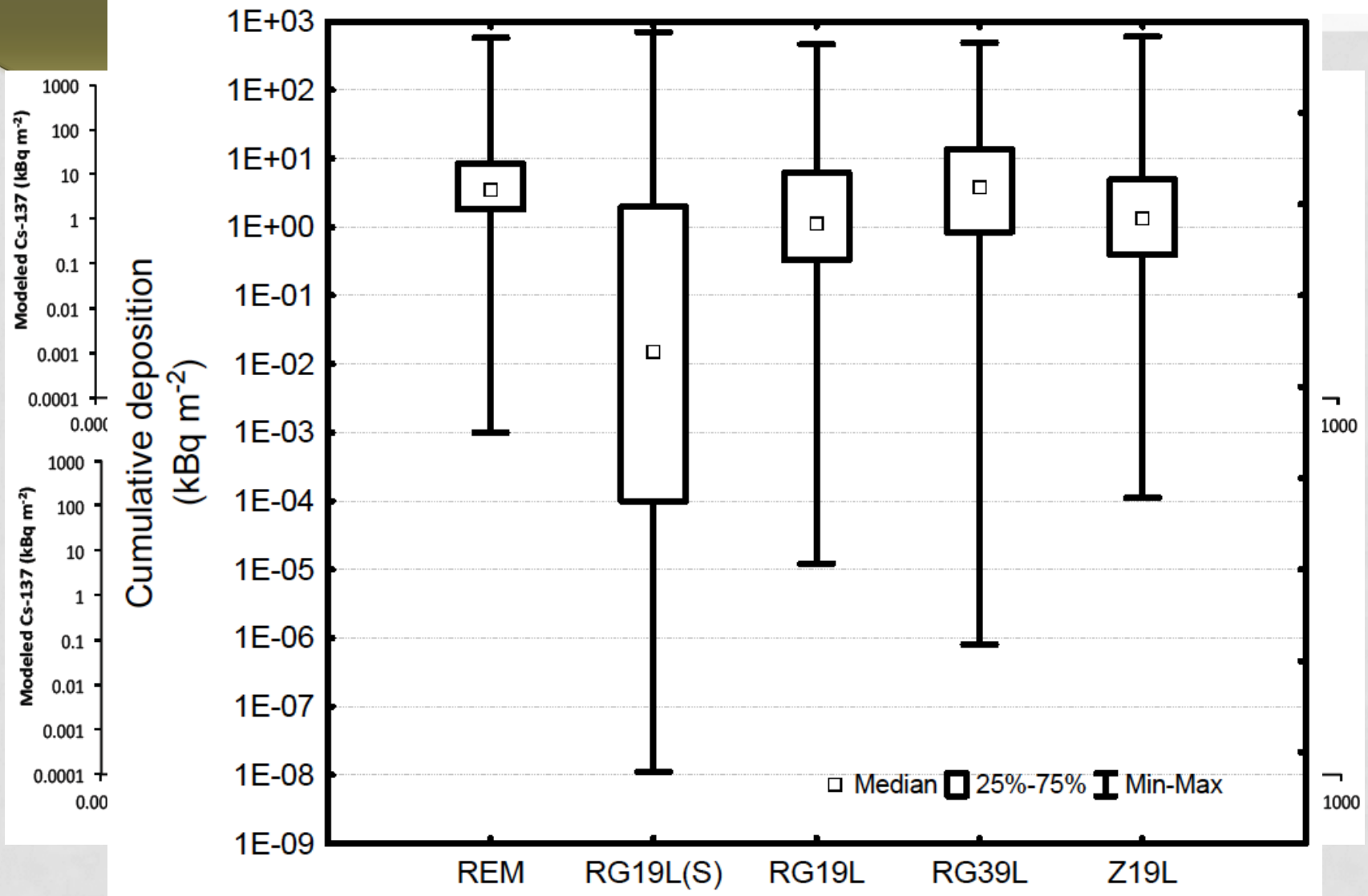
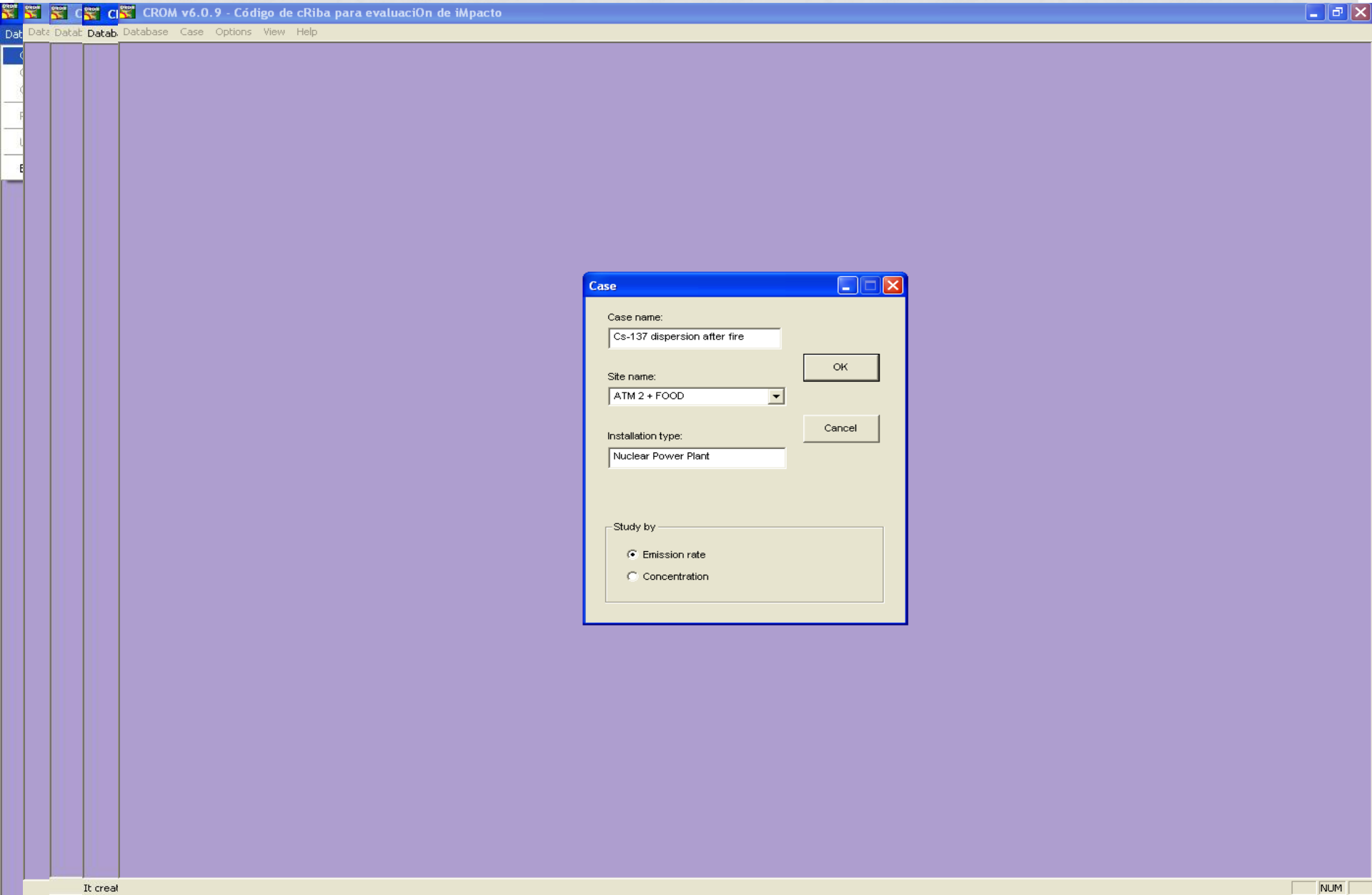


Assessment of the radiological risk to the population in nearby areas



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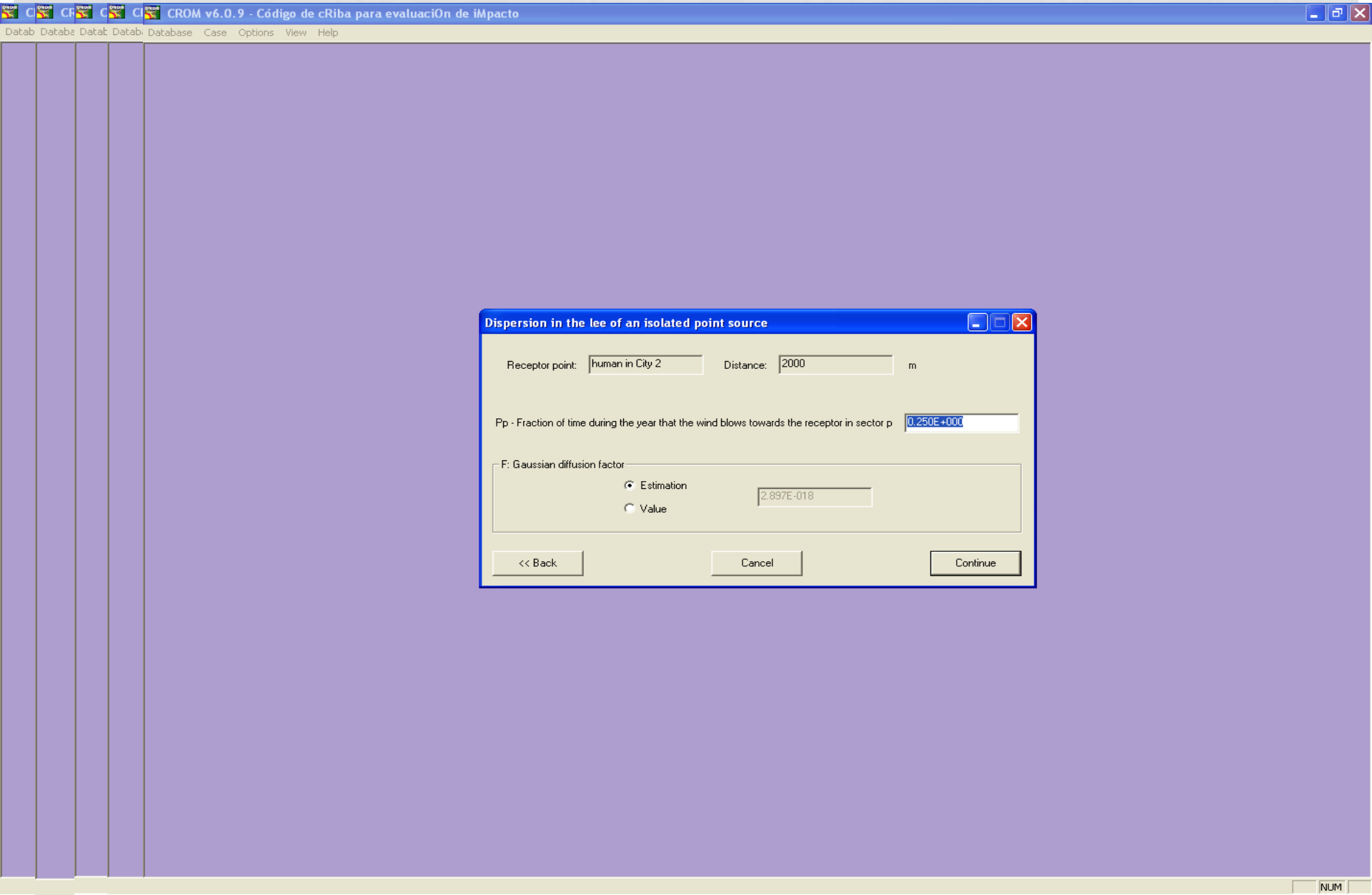

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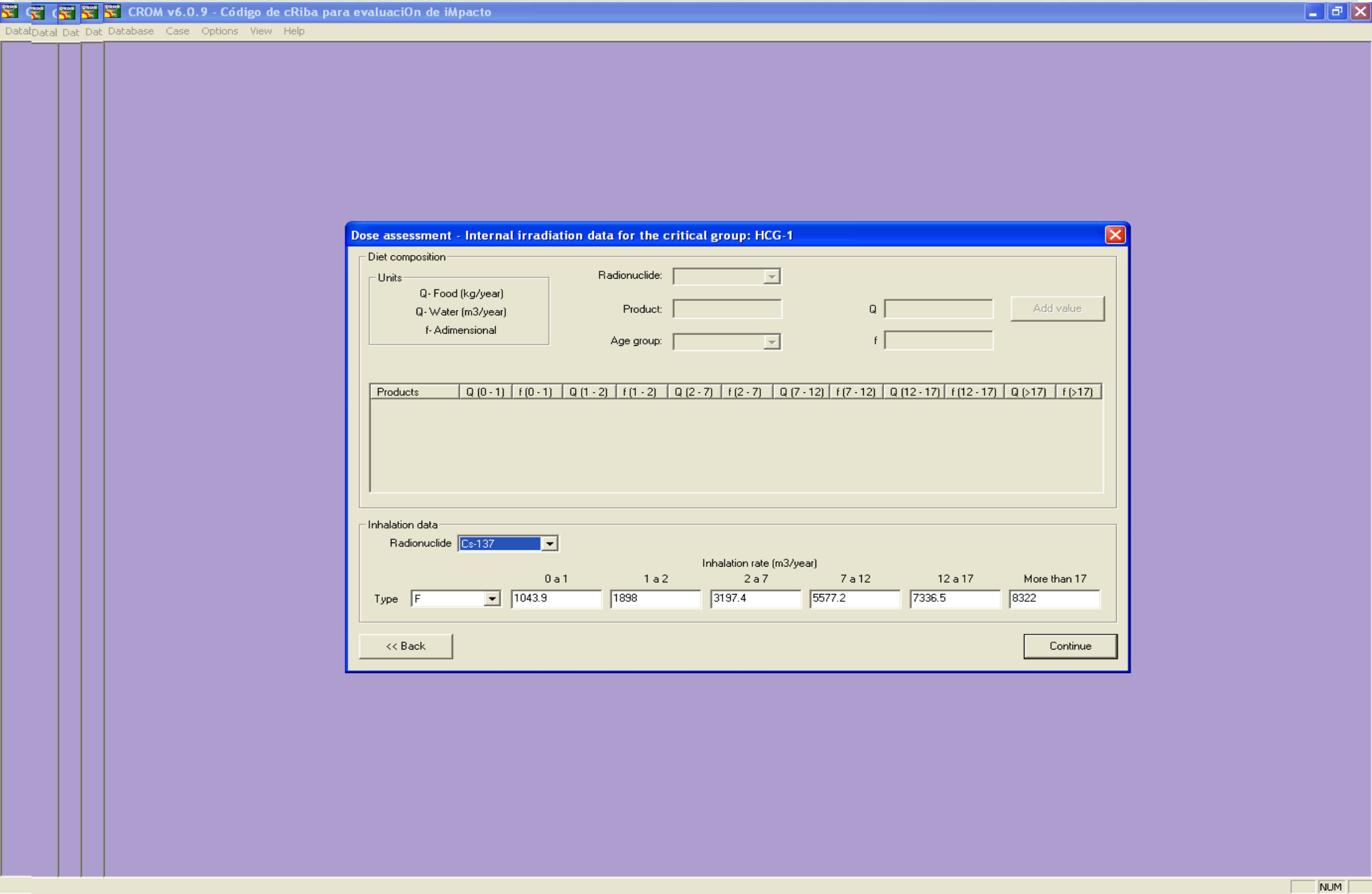

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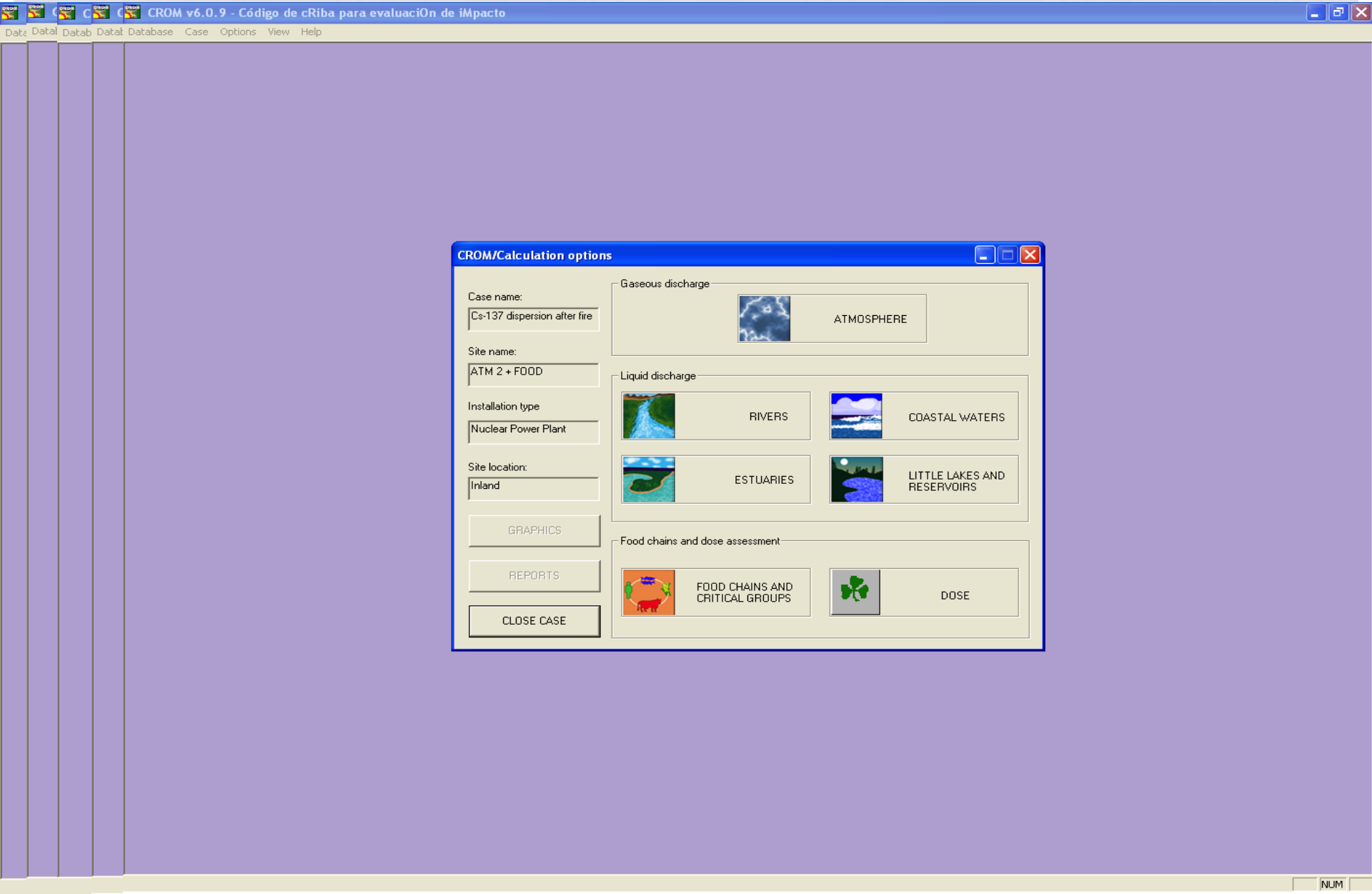


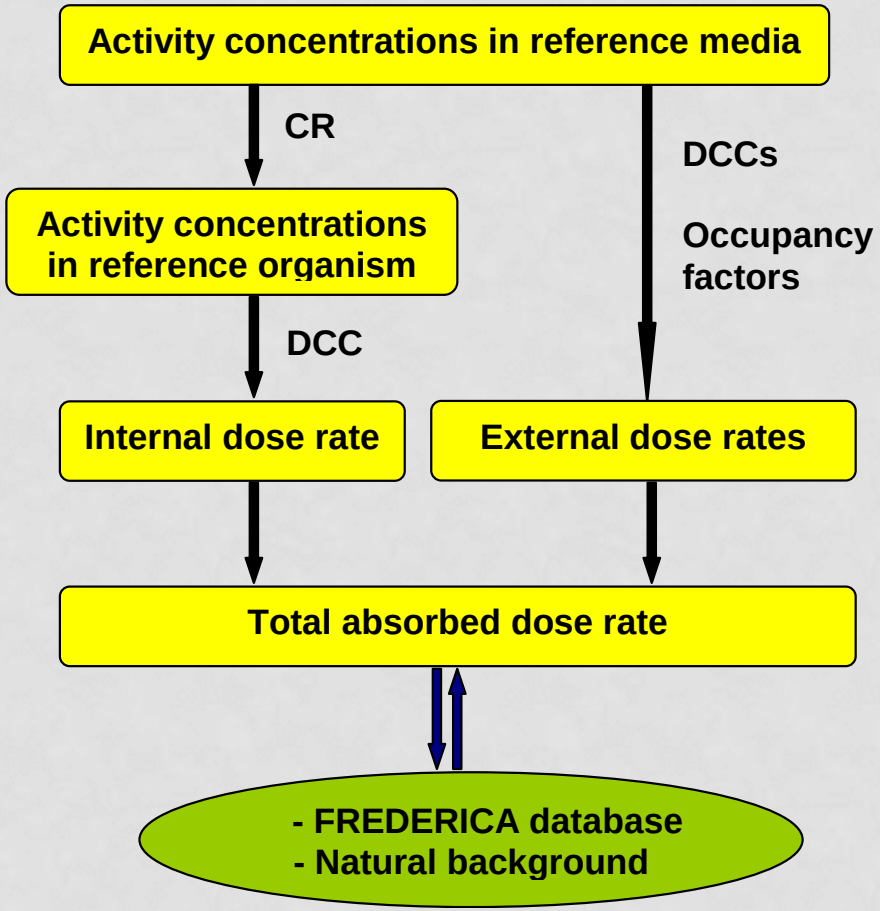
Dosimetric modeling of the ecosystem (ERICA example)

ERICA approach

- Transfer to the environment

- Estimates of dose to biota from internal and external distributions of radionuclide

- Establish the significance of the dose rates the organisms are exposed to



Info: www.erica-project.org

Dosimetric modeling of the ecosystem (ERICA example)

Reference organisms in ERICA

Terrestrial
Soil Invertebrate (worm)
Detritivorous invertebrate
Flying insects
Gastropod
Lichen & bryophytes
Grasses & Herbs
Shrub
Tree
Mammal
Bird
Bird egg
Reptile
Amphibian

Marine
Phytoplankton
Macroalgae
Vascular plant
Zooplankton
Polychaete worm
Bivalve mollusc
Crustacean
Benthic fish
Pelagic fish
(Wading) bird
Mammal
Reptile
Sea anemones/true corals

Freshwater
Phytoplankton
Vascular plant
Zooplankton
Insect larvae
Bi-valve mollusc
Gastropod
Crustacean
Benthic fish
Pelagic fish
Bird
Mammal
Amphibian

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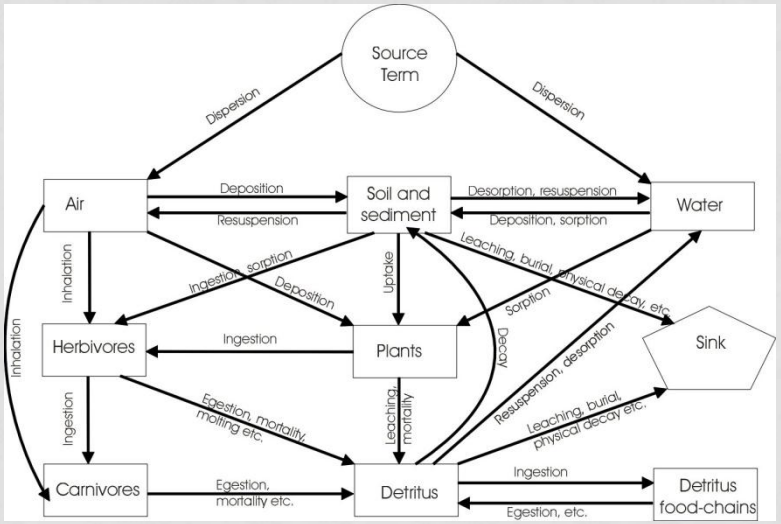
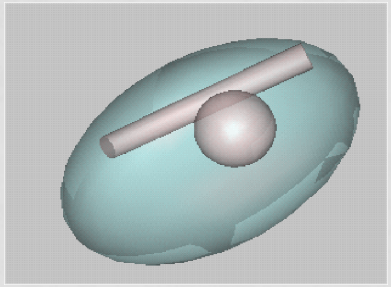
Dosimetric modeling of the ecosystem (ERICA example)



$$CR_{b,i}\ (dimensionless) = C_{b,i}/C_{soil,I}$$

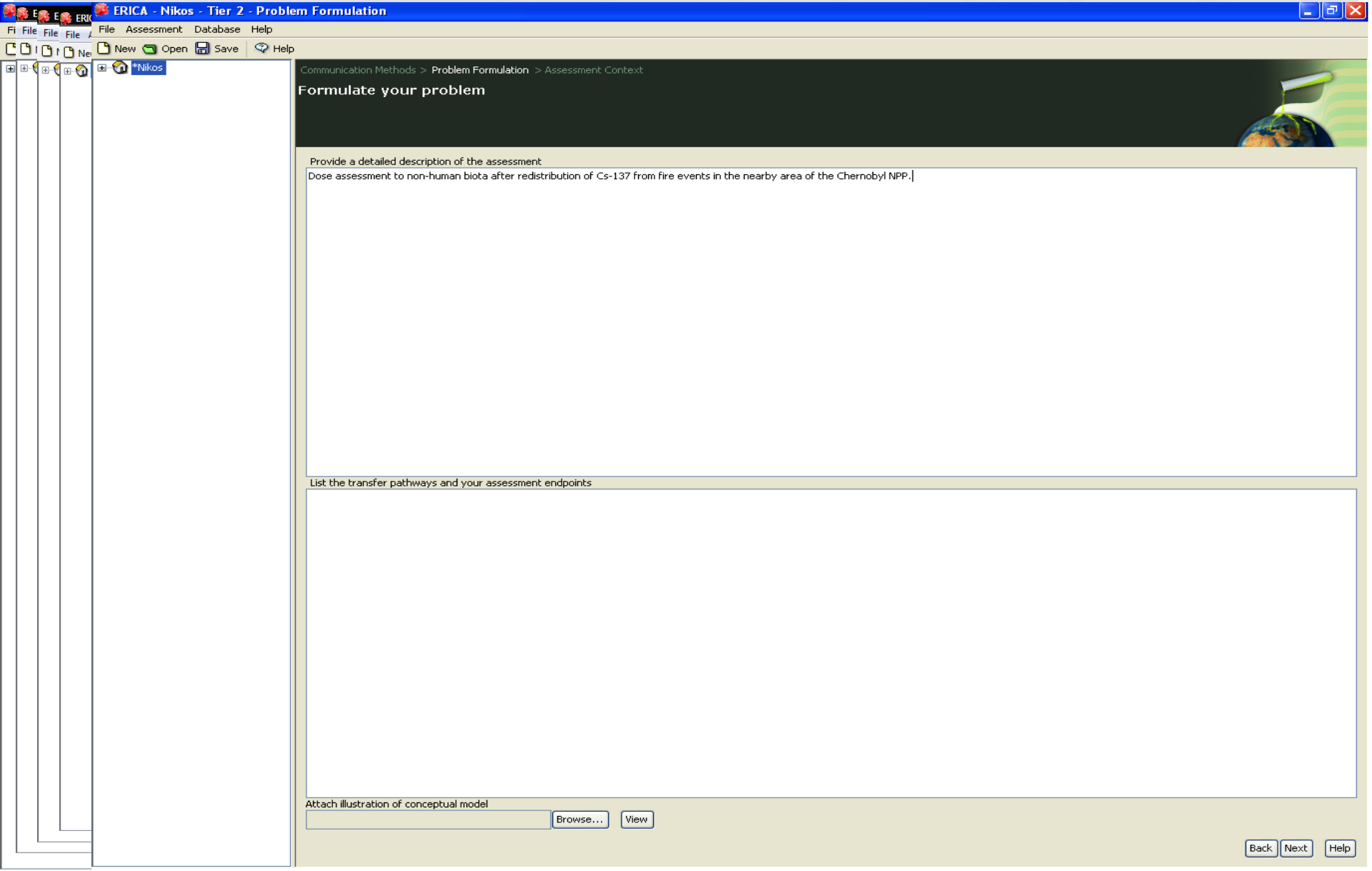


$$DCC = \dot{D}/A$$

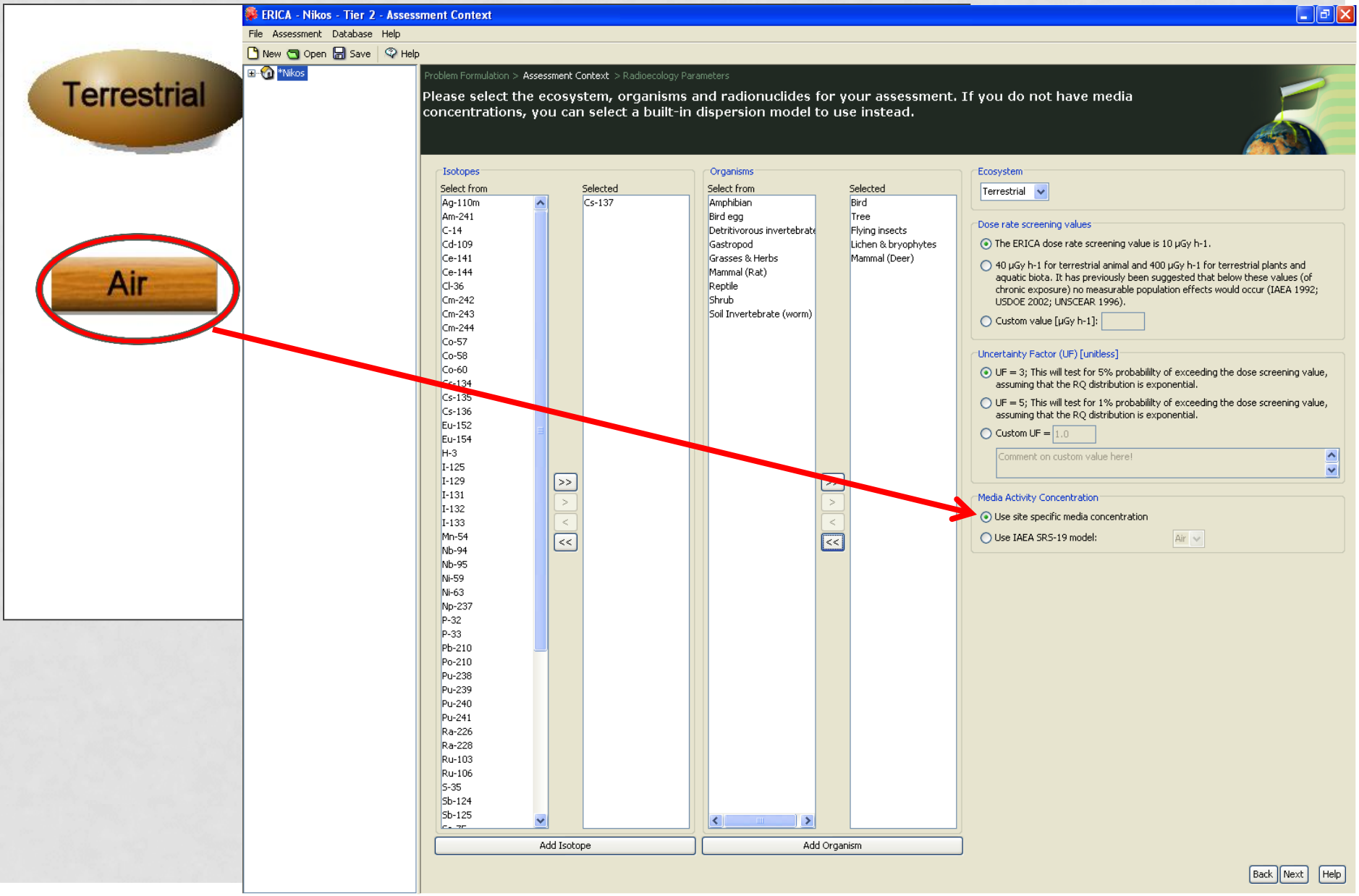
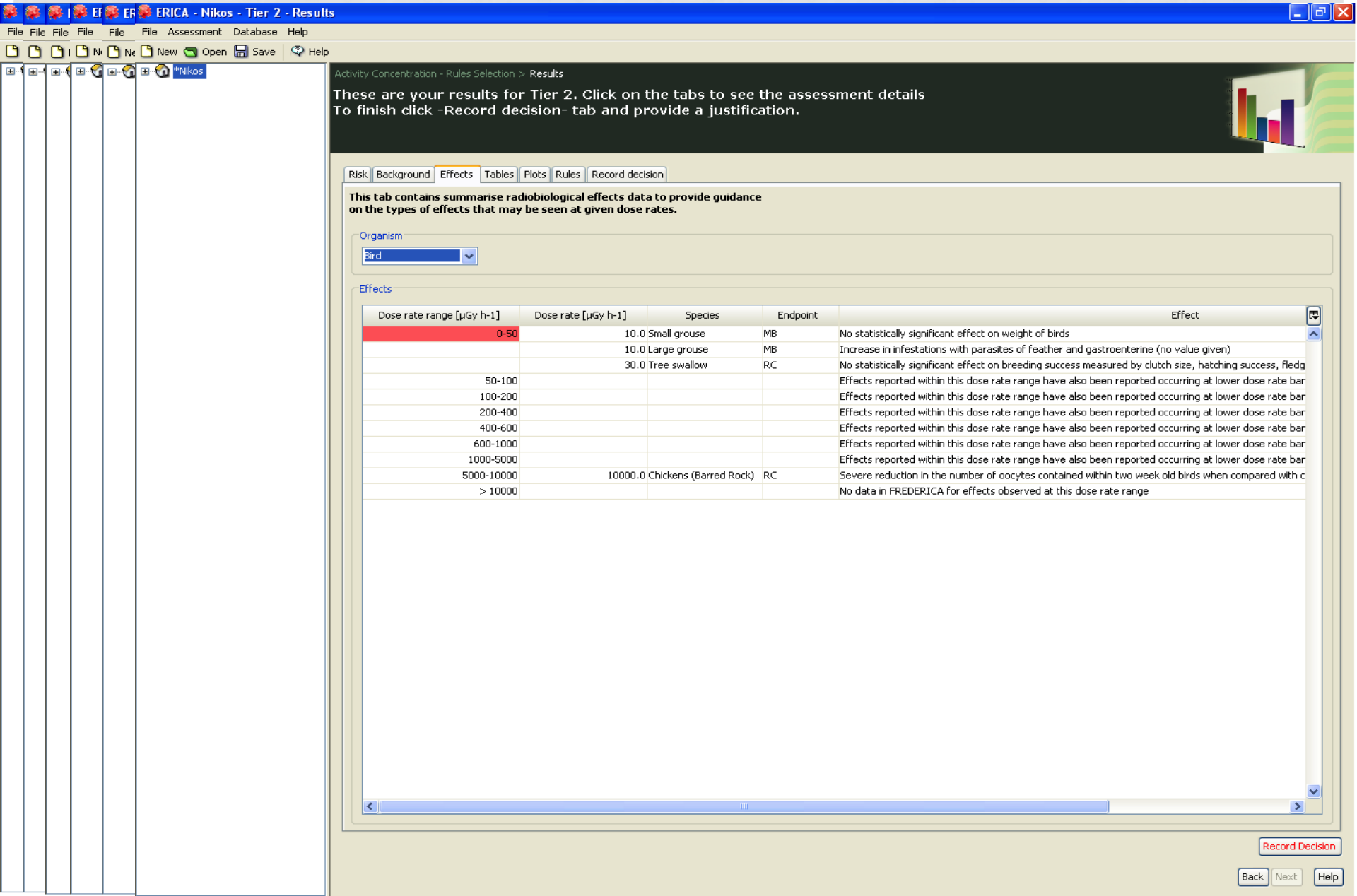
Dose rate µGy/h per unit activity Bq/kg f.w.

Info: www.erica-project.org

Dosimetric modeling of the ecosystem (ERICA example)



Dosimetric modeling of the ecosystem (ERICA example)



Dosimetric modeling of the ecosystem (ERICA example)