

MODELLING THE TRANSFER OF ^{137}Cs ALONG A RIVER-SEA CONTINUUM AND APPLICATION TO ACCIDENTAL RELEASE SCENARIOS

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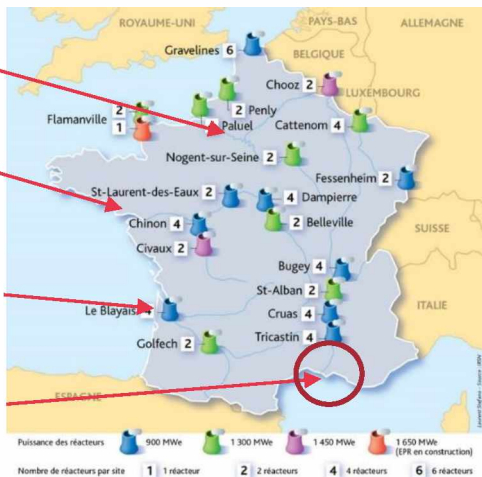
Estuaries are hot spot areas for the transfer of radionuclides

Seine 380 m³/s

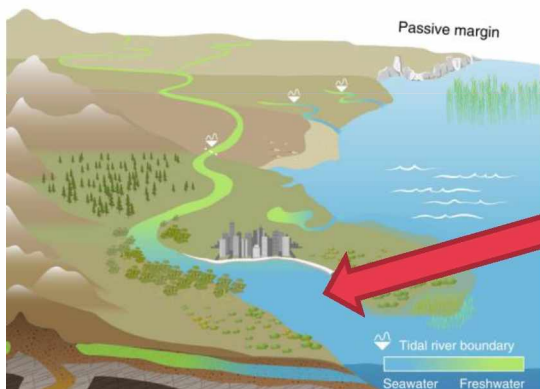
Loire 825 m³/s

Garonne 545 m³/s

Rhône, 1500 m³/s



- 13 nuclear plants are installed in France along four major rivers.
- Scenario of accidental releases of radionuclides (in the river or through atmospheric deposits) must take into account a potential contamination of the coastal areas.
- Estuaries are **hot spot areas** where specific physico-chemical processes must be correctly simulated for the evaluation of fluxes and activities transferred to the sea, and for the estimation of the potential impact on the ecosystems.



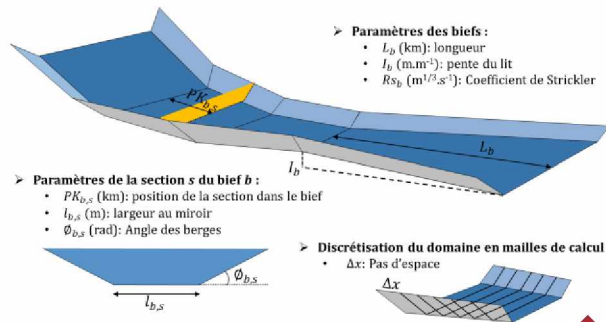
- Particles aggregation, deposit and resuspension
- Salinity changes
- Desorption from particles to dissolved phase
- Specific ecosystems
- Fisheries

IRSN Numerical models for radionuclide transfers in aquatic systems

CASTEAUR: 1D numerical model for radionuclides transfers in rivers

Inputs:

- Hydrographic parameters
- Chronics of :
 - water flows and suspended particles
 - Radionuclides by direct releases, atmospheric deposition and catchment erosion
- Sediments and radionuclides properties, ...



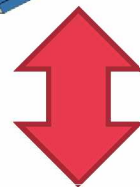
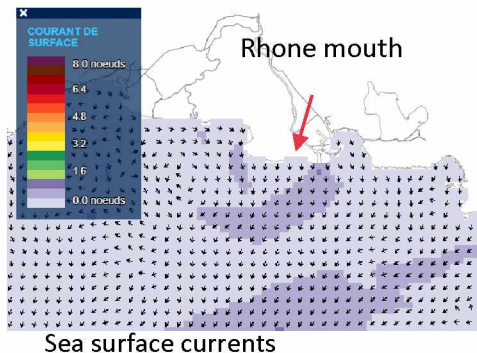
Outputs:

- Hydraulic variables : water flow, water height, ...
- Particulate matter content in water and sediment deposition
- **Radionuclides concentrations and fluxes** : dissolved (Bq/l) and particulate (Bq/kg) in water column and sediments

STERNE: 3D numerical model for radionuclides dispersion in the ocean

Inputs:

- Hydrodynamic data from oceanographic model
- Chronics of :
 - Radionuclides by direct releases **or atmospheric deposition**
 - Chemical and radioecological parameters (FC, Tp, Tb_{1/2}...)



Estuarine model

Outputs:

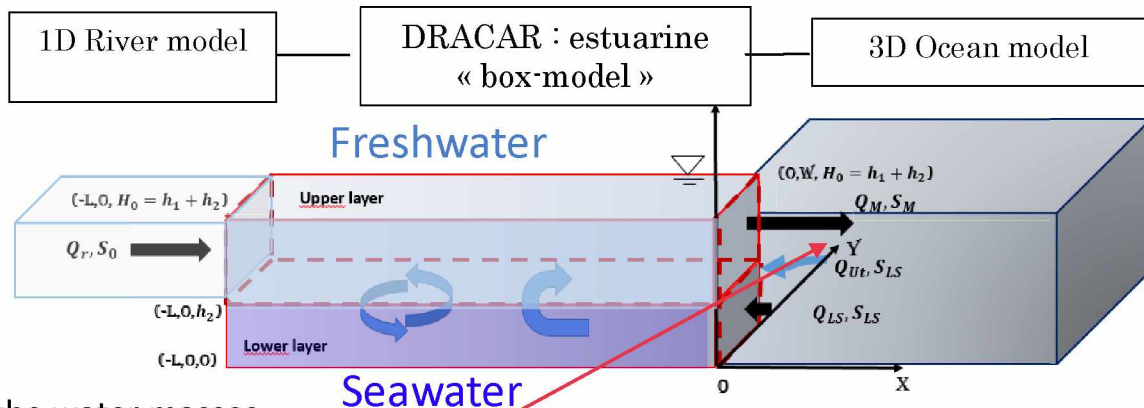
- **Radionuclides concentrations in water** (Bq/l) and biota (Bq/kg fresh)





DRACAR : Désorption des RADionuCléides à l'interfAce littoRale

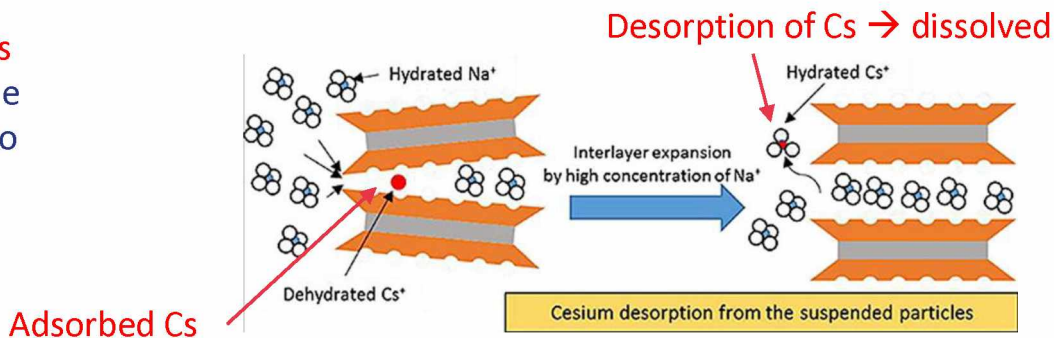
DRACAR: box-model able to simulate the freshwater-seawater mixing within an estuary and the physical structure of the water masses, in order to couple CASTEAUR and STERNE.



Physical Outputs:

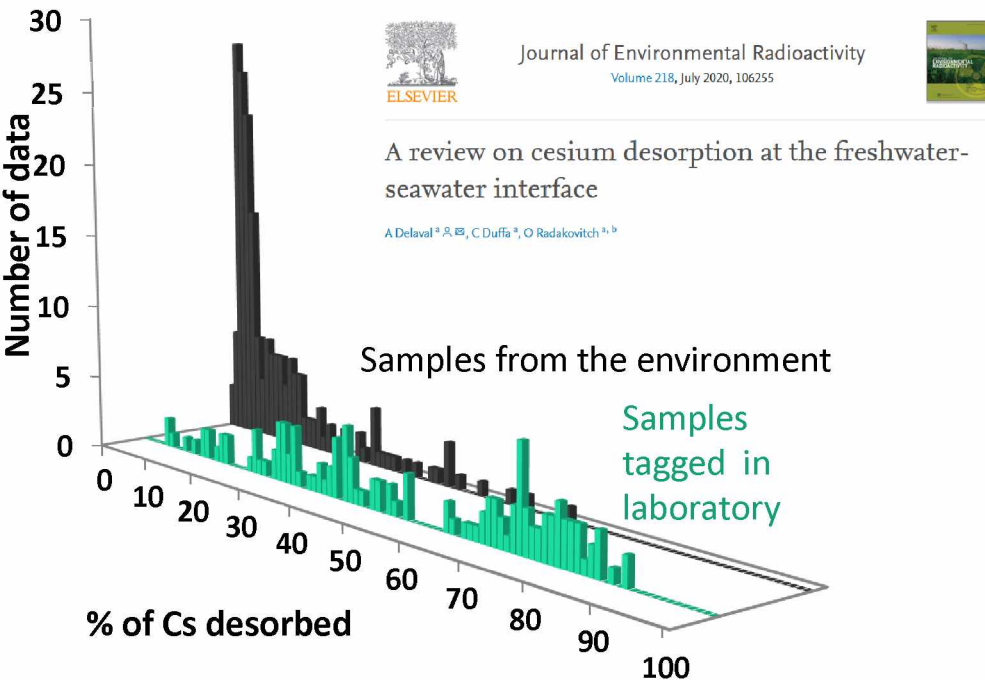
Physical structure of the water masses
Water residence time in the estuary
2D salinity, water and salinity fluxes at sea

Missing process: the intensity of ^{137}Cs desorption (particles \rightarrow dissolved) due to the exchange of radionuclides onto solid phase with dissolved seawater cations



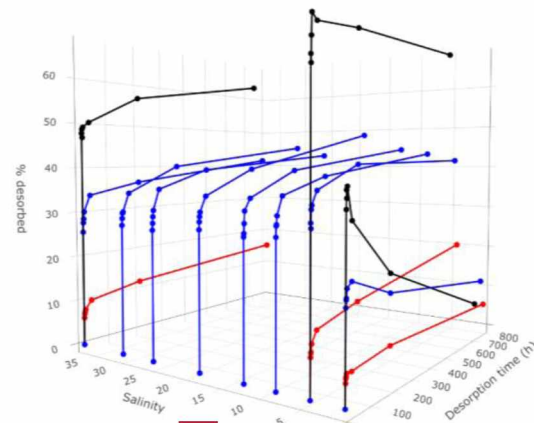
Desorption of ^{137}Cs at the fresh-seawater interface

Compilation of 32 studies from 1963 to 2017



- No clear trend with salinity
- Existence of an ageing effect

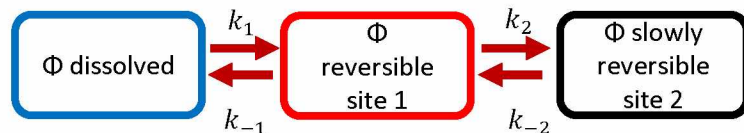
Experimental desorption in laboratory to test the influence of salinity and ageing effects



$T_{\text{sorption}} = 1 \text{ h}$
 $T_{\text{sorption}} = 3 \text{ j}$
 $T_{\text{sorption}} = 30 \text{ j}$



- Desorption initiates at 0,2-4 g/L salt
- Ageing effect influences desorption
- Two kinetics model simulates well the process





From CASTEAUR to STERNE

Rhône flood 17/06/10

Q = 2300 m³/s

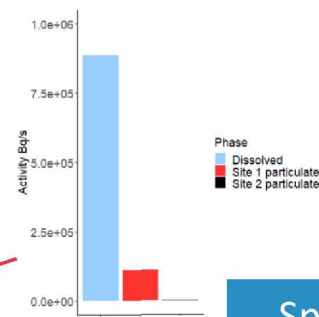
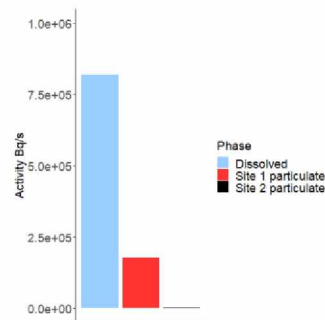
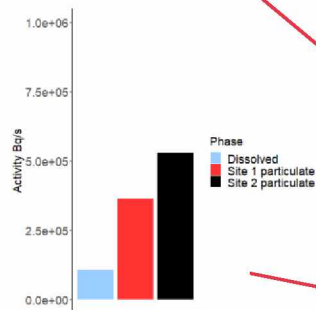
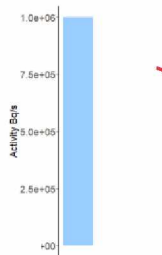
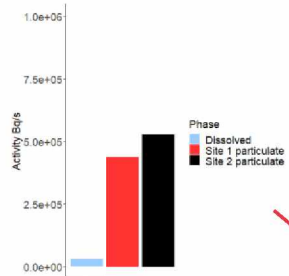
SPM = 1g/L



Rhône low flow 25/07/10

Q = 700 m³/s

SPM = 0,016 g/L



Settling of particulate ¹³⁷Cs

Spreading of dissolved ¹³⁷Cs

Evaluation of the main hydrodynamic scenarios allowing the dispersion of Rhone freshwater surface plume at sea



Survey Buoy

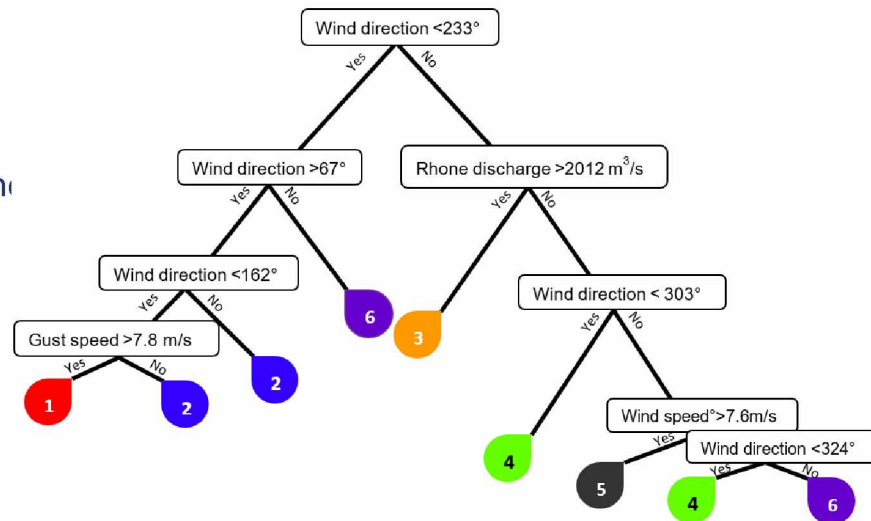
Freshwater and turbid Surface plume

- Fuzzy clustering classification applied to liquid discharges of the Rhone, wind direction and intensity (Mesurho buoy)
- 10 years of surveys at time step of ½ h : 120,000 observations
- 6 main scenario** of hydrodynamic conditions evidenced. They can be **anticipated** using a classification tree and online data from river and meteorological surveys

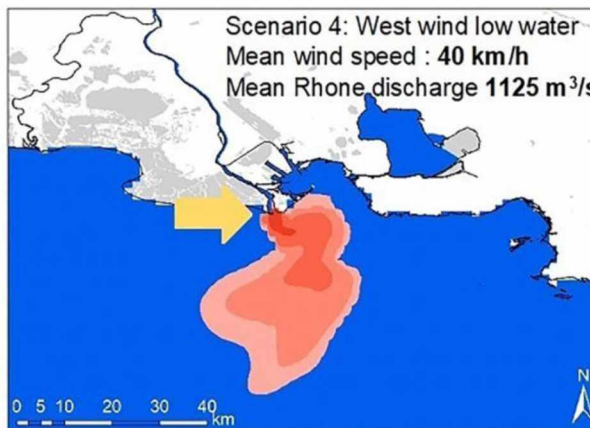
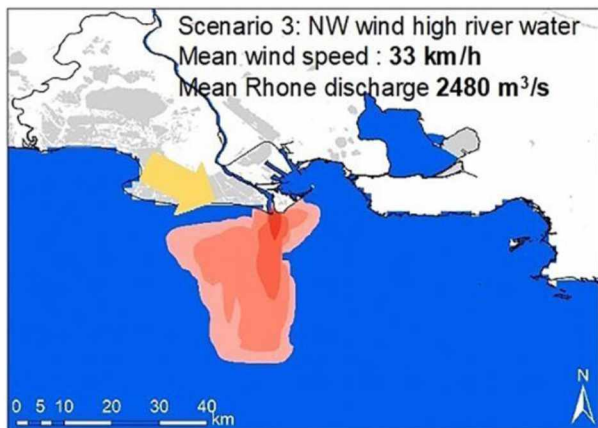
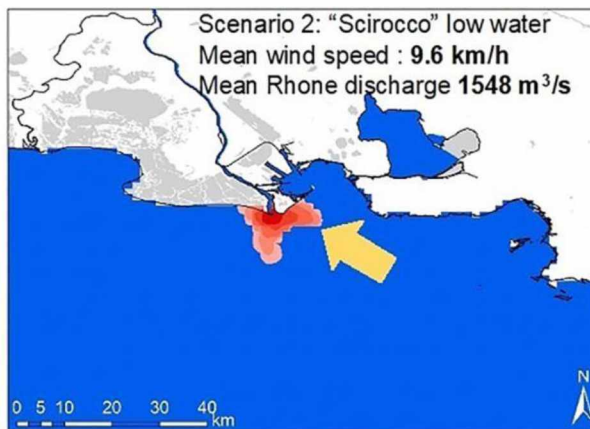
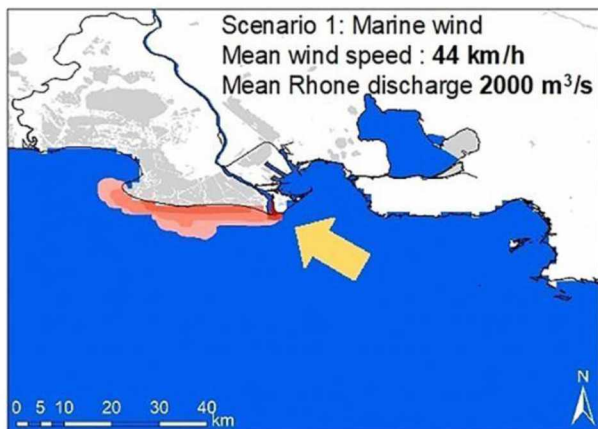


A fuzzy classification of the hydrodynamic forcings of the Rhone River plume: An application in case of accidental release of radionuclides

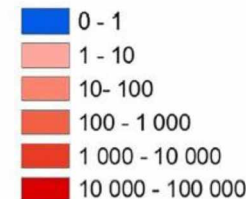
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Scenarios of dispersion of a ^{137}Cs release at the Rhone estuary (1TBq, 48h)



Activity in seawater (Bq/m³)



The impacted areas depends on hydrodynamic scenarios and coastal areas can be directly affected

How to evaluate the coastal vulnerability for a radionuclide release ?



Socio-economic, sedimentological and ecological parameters compiled onto GIS database with weighting factors

Simulation of ^{137}Cs dissolved activities after an accidental release weighted by seawater-fish transfer factor

Combination of both maps to determine a final risk index

Rhone mouths

