



Towards the forecast of false positives in nuclear network monitoring due to atmospheric radon.

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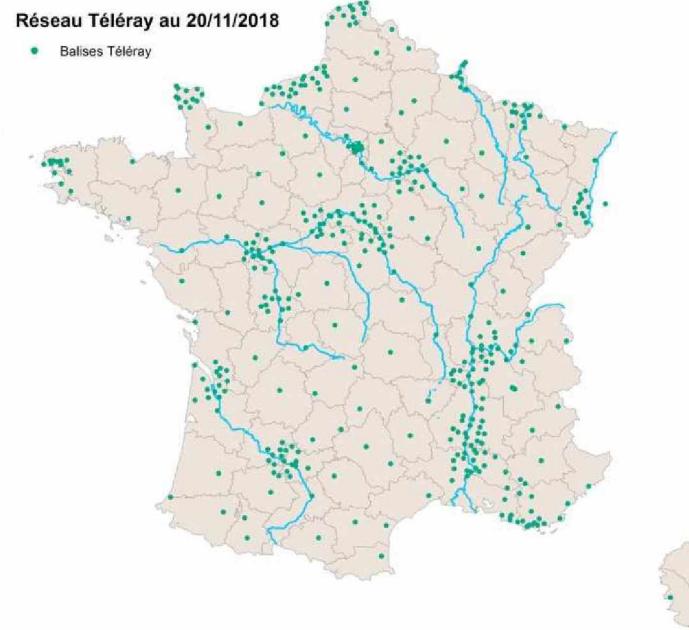
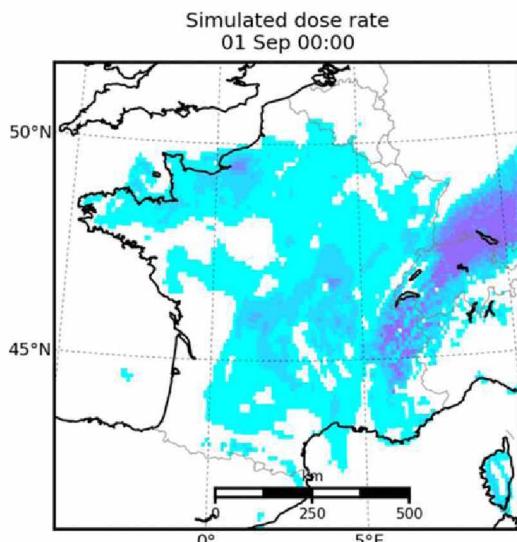


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INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire



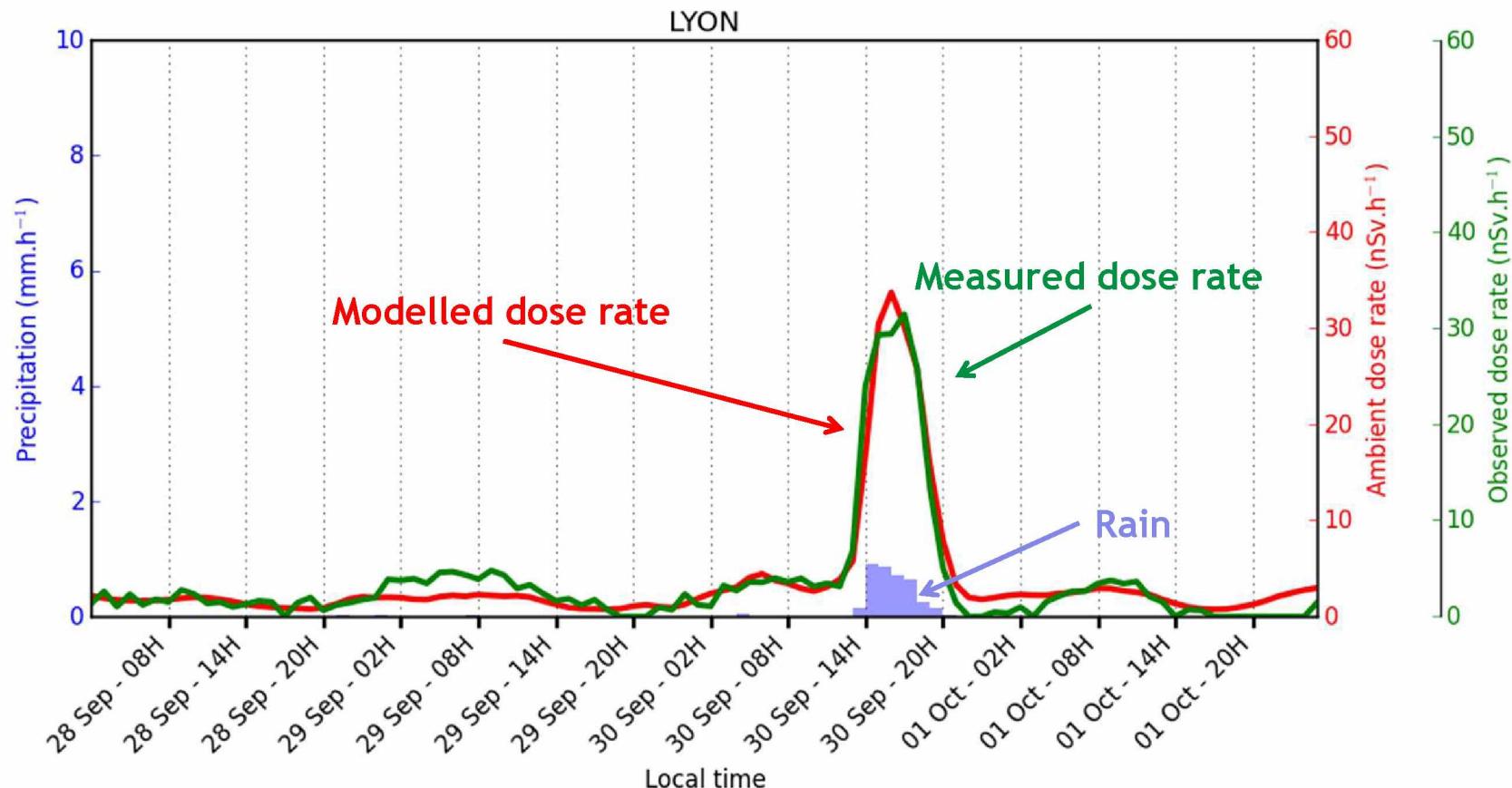
Towards the forecast of false positives in nuclear network monitoring due to atmospheric radon

EGU 2019 18762
April, 11th 2019

Arnaud QUÉREL
Denis QUÉLO
Thierry DOURSOUT

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A preliminary study showed encouraging results...



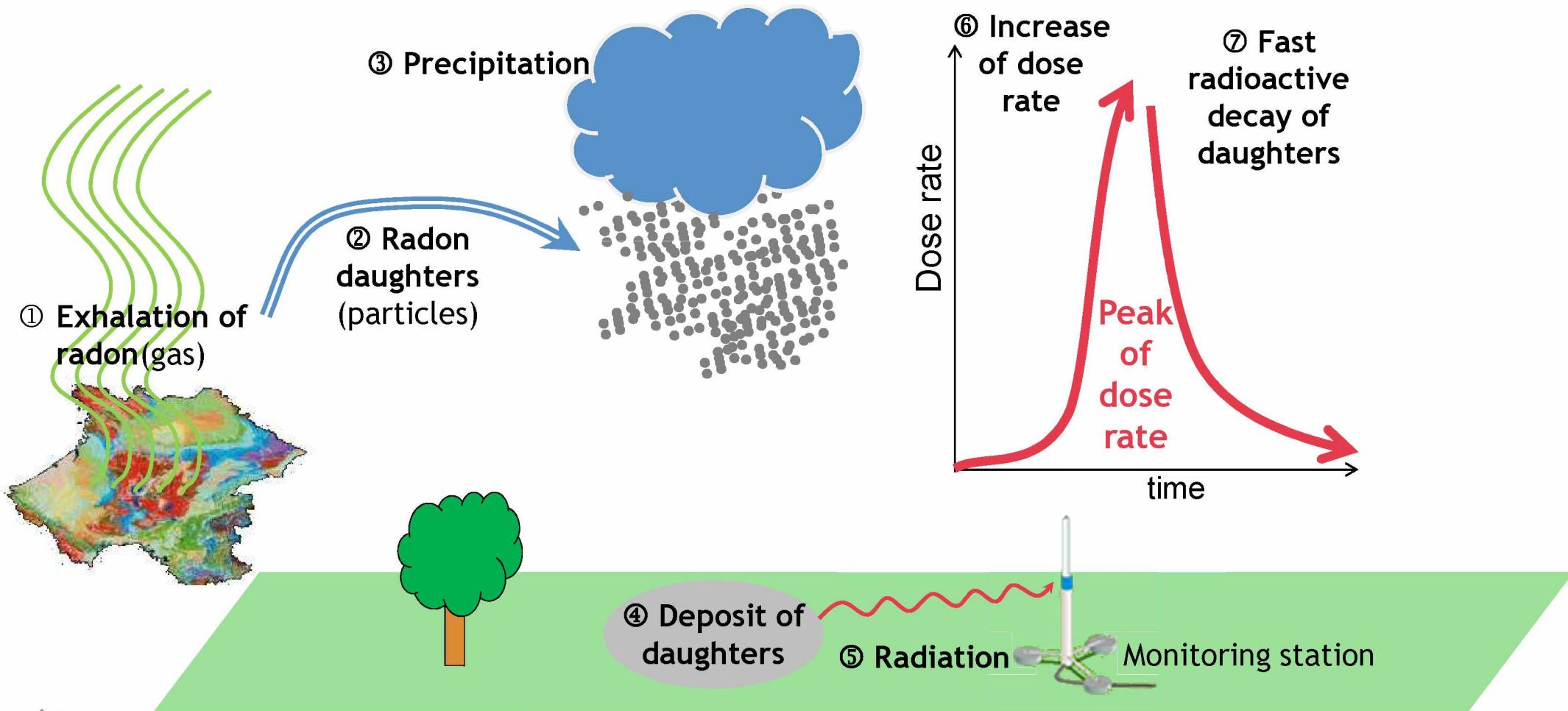
- In the event of an incident or accident involving radioactive materials, IRSN provides guidance to public authorities on the technical, public health and medical measures to be taken to protect the population and the environment.
- The monitoring network Teleray in France: Hundreds of gamma dose rate monitoring stations recording data each ten minutes all year round.
- Several times a year, alarms of this emergency monitoring network are triggered: these gamma dose rate peaks occurred during rainfall events because radon progenies concentrate in rain drops and fall down to the ground.
- Although these peaks do not present any risks to the population or environment, it is necessary to discriminate whether it comes from the natural radioactivity or if an accidental release of radioactive materials happened.



Is it possible to forecast peaks due to atmospheric radon?

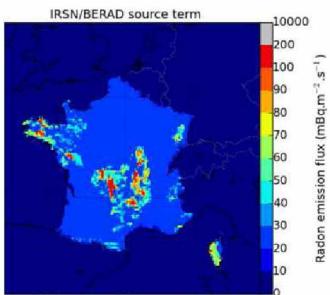


Atmospheric transport of radon



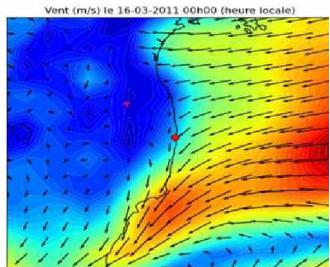
Modelling

① Exhalation of radon(gas)



② Atmospheric transport model IdX

① Meteorological data



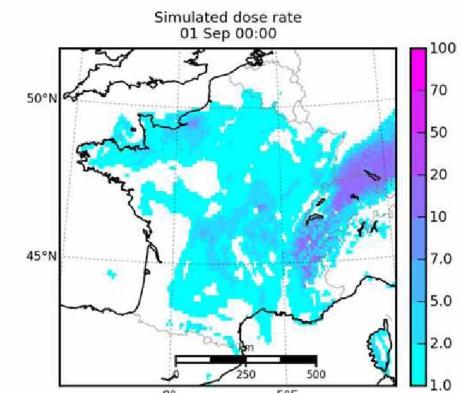
① Decay chain & Chem/phys form data

For each time step :
■ Dose rate at ground level (2D)

③ Dose rate computation

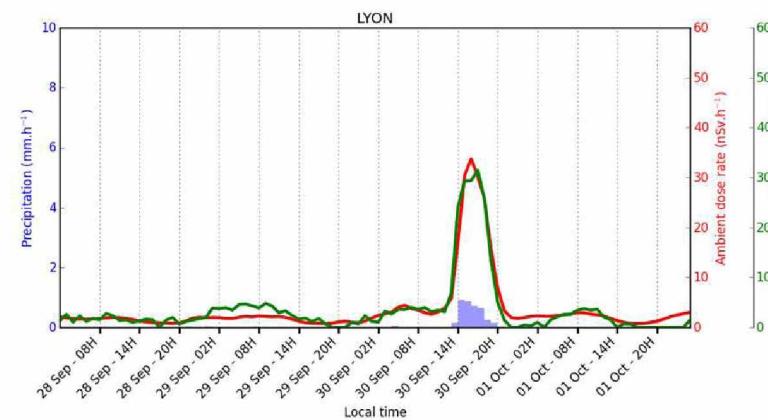
④ Outputs

■ Dose rate maps



■ Dose rate at a given location

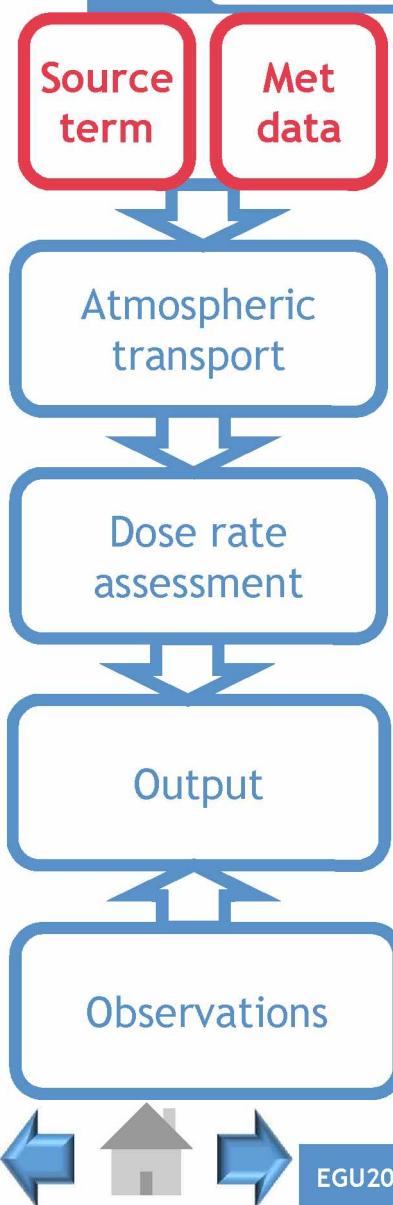
■ To be compared to the measurements



Teleray: the French monitoring network of gamma dose rate

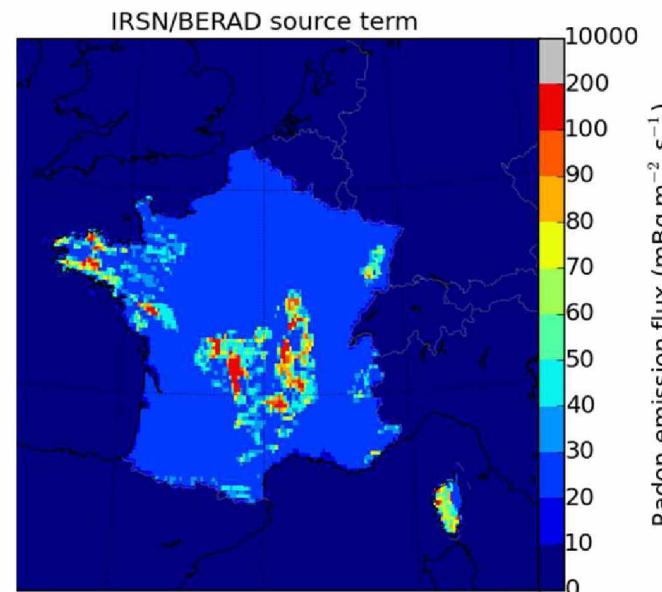
- Hundreds of stations (~420)
- Freq : 10 min





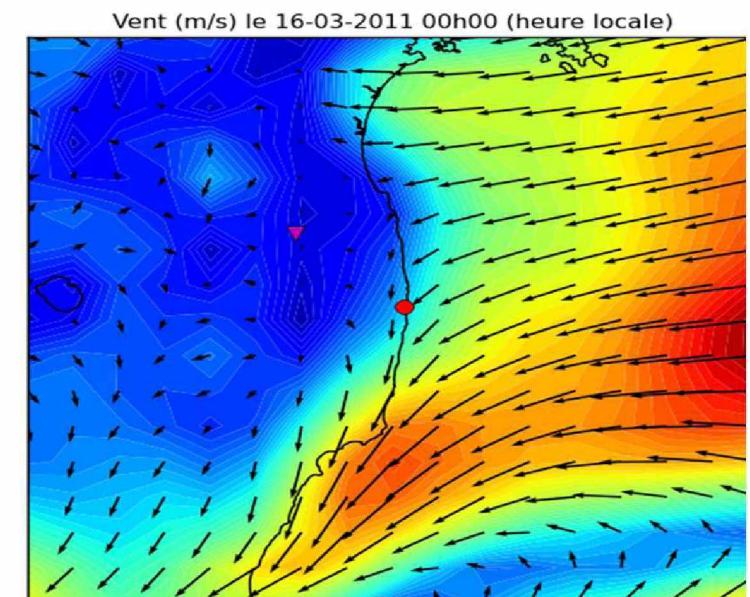
Source Term : Exhalation of radon(gas)

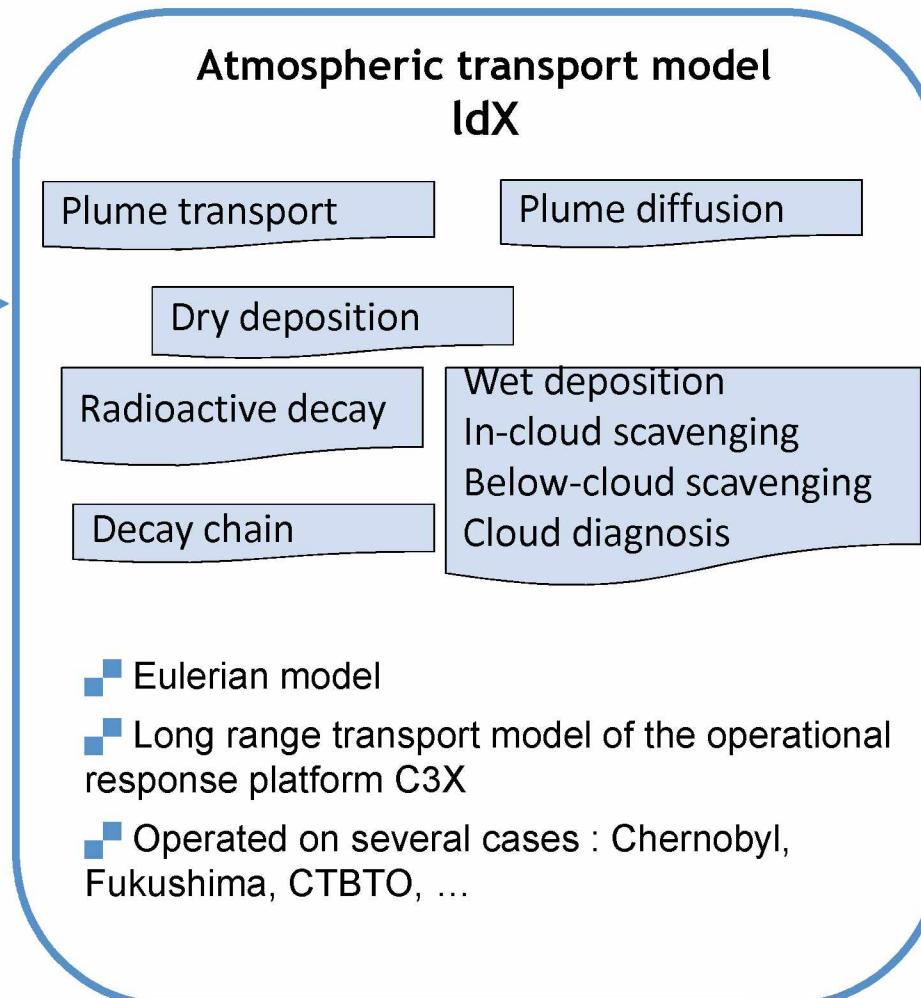
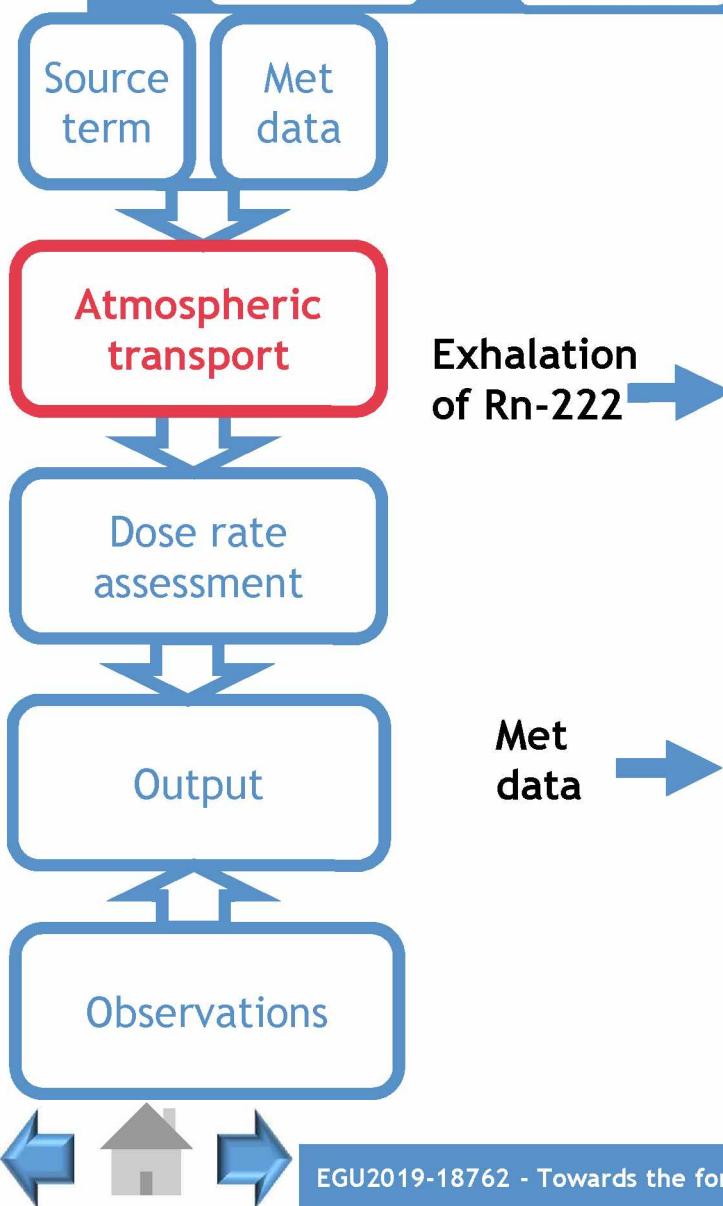
- Based on an exhalation flux of Rn-222 computed by the IRSN.
- In this study, considered constant in time



Meteorological data

- Météo-France meteorological data: ARPEGE
- $\Delta t: 1\text{h}$; $\Delta x = \Delta y = 0.1^\circ \approx 10\text{km}$





For each radionuclides at each time step :

- Air concentration (3D)
- Deposit (2D)

Eslinger, Paul W., Ted W. Bowyer, Pascal Achim, Tianfeng Chai, Benoit Deconninck, Katie Freeman, Sylvia Generoso, et al. 2016. « International Challenge to Predict the Impact of Radon Releases from Medical Isotope Production on a Comprehensive Nuclear Test-Ban Treaty Sampling Station ». *Journal of Environmental Radioactivity* 157 (juin): 41-51. <https://doi.org/10.1016/j.jenvrad.2016.03.001>.

Großl, Jérôme, Denis Quélé, et Anne Mathieu. 2014. « Sensitivity analysis of the modelled deposition of ¹³⁷Cs on the Japanese land following the Fukushima accident ». *International Journal of Environment and Pollution* 55 (1-4): 67-75. <https://doi.org/10.1504/IJEP.2014.065906>.

Kajino, Mizuo, Tsuyoshi Thomas Sekiyama, Anne Mathieu, Irène Korsakissok, Raphaël Perillat, Denis Quélé, Arnaud Quéré, et al. 2018. « Lessons Learned from Atmospheric Modeling Studies after the Fukushima Nuclear Accident: Ensemble Simulations, Data Assimilation, Elemental Process Modeling, and Inverse Modeling ». *Geochemical Journal* 52 (2): 85-101. <https://doi.org/10.2343/geochemj.2.0503>.

Kitayama, K., Y. Morino, M. Takigawa, T. Nakajima, H. Hayami, H. Nagai, H. Terada, et al. 2018. « Atmospheric Modeling of ¹³⁷Cs Plumes From the Fukushima Daiichi Nuclear Power Plant: Evaluation of the Model Intercomparison Data of the Science Council of Japan ». *Journal of Geophysical Research: Atmospheres*, juillet. <https://doi.org/10.1029/2017JD028290>.

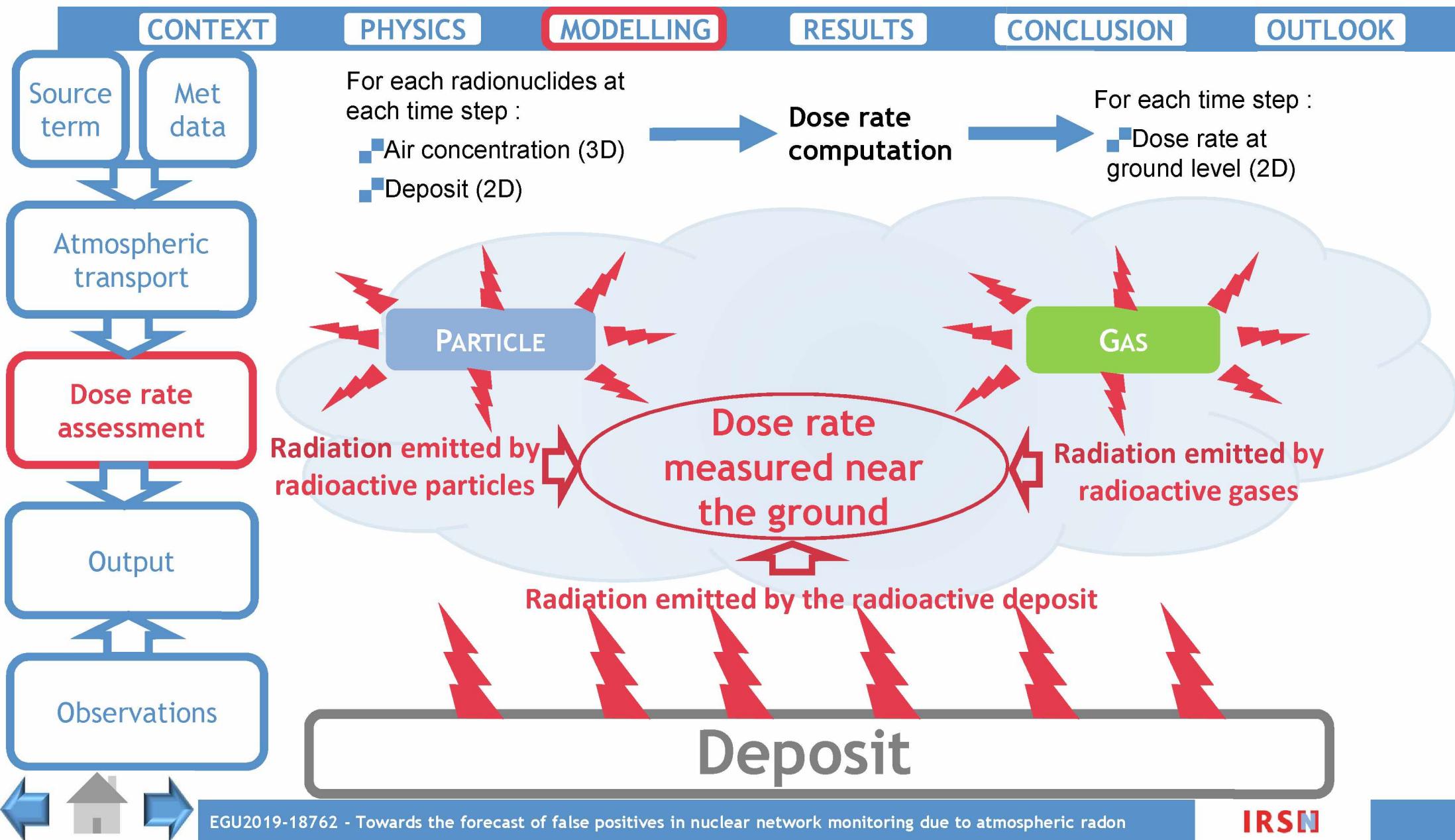
Mathieu, Anne, Irène Korsakissok, Denis Quélé, Jérôme Großl, Marlyne Tombette, Damien Didier, Emmanuel Quentrec, Olivier Saunier, Jean-Pierre Benoit, et Olivier Isnard. 2012. « Fukushima Daiichi: Atmospheric Dispersion and Deposition of Radionuclides from the Fukushima Daiichi Nuclear Power Plant Accident ». *Elements* 8 (3): 195-200. <https://doi.org/10.2113/elements.8.3.195>.

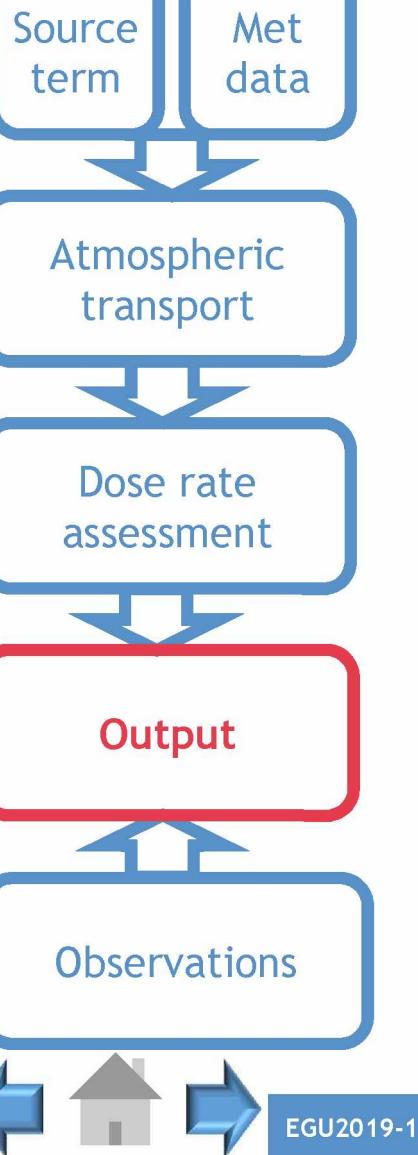
Maurer, Christian, Jonathan Baré, Jolanta Kusmierszky-Michalec, Alice Crawford, Paul W. Eslinger, Petra Selbert, Blake Orr, et al. 2018. « International Challenge to Model the Long-Range Transport of Radon Releases from Medical Isotope Production to Six Comprehensive Nuclear-Test-Ban Treaty Monitoring Stations ». *Journal of Environmental Radioactivity* 192 (décembre): 667-68. <https://doi.org/10.1016/j.jenvrad.2018.09.030>.

Quéré, Arnaud, Yelva Roustan, Denis Quélé, et Jean-Pierre Benoit. 2015. « Hints to Discriminate the Choice of Wet Deposition Models Applied to an Accidental Radionuclide Release ». *International Journal of Environment and Pollution* 59 (4): 269-79. <https://doi.org/10.1504/IJEP.2015.077457>.

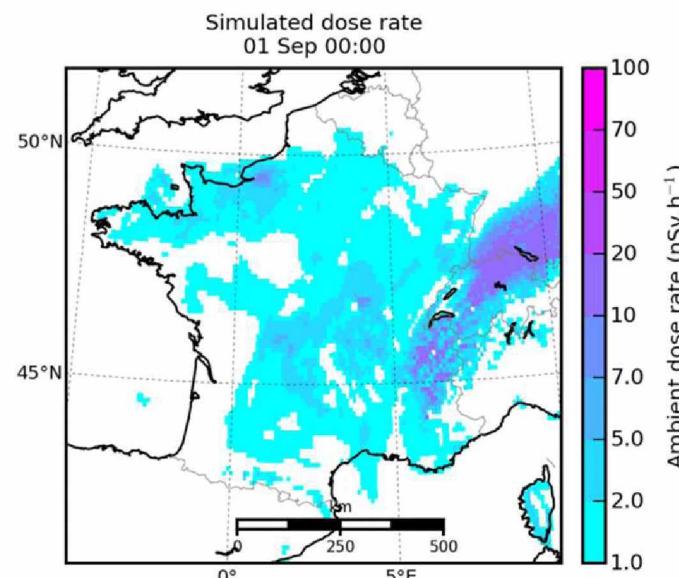
Sato, Yousuke, Masayuki Takigawa, Tsuyoshi Thomas Sekiyama, Mizu Kajino, Hiroaki Terada, Haruyasu Nagai, Hiroaki Kondo, et al. 2018. « Modis Intercomparison of Atmospheric ¹³⁷Cs from the Fukushima Daiichi Nuclear Power Plant Accident: Simulations Based on Identical Input Data ». *Journal of Geophysical Research: Atmospheres*, octobre. <https://doi.org/10.1029/2018JD029144>.

Saunier, Olivier, Anne Mathieu, Damien Didier, Marlyne Tombette, Denis Quélé, Victor Winiarek, et Marc Bocquet. 2013. « An inverse modelling method to assess the source term of the Fukushima Nuclear Power Plant accident using gamma dose rate observations ». *Atmospheric Chemistry and Physics* 13: 11403-21. <https://doi.org/10.5194/acp-13-11403-2013>.

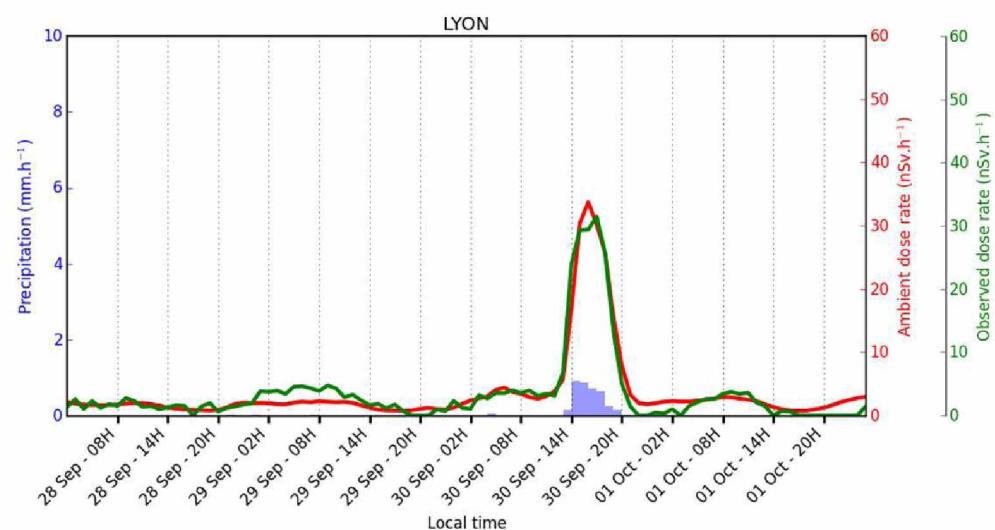


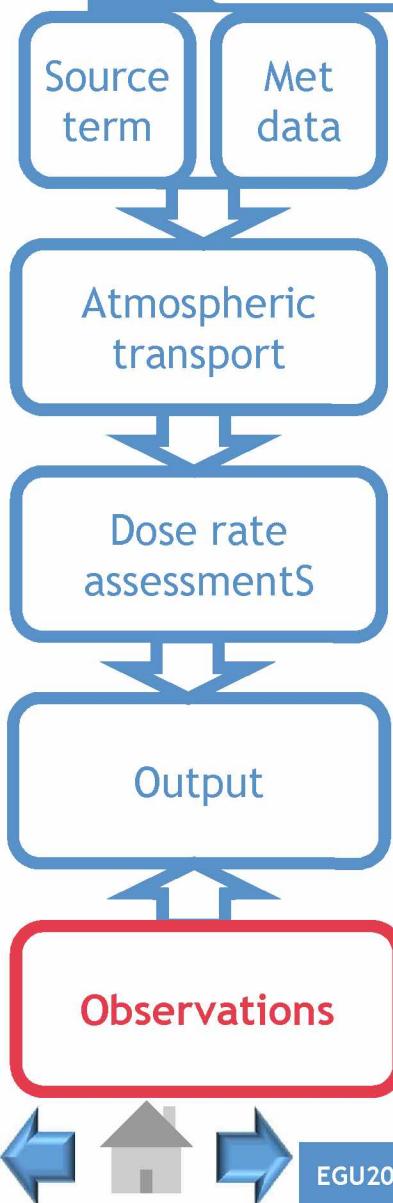


Dose rate maps



- Dose rate at a given location
- Compared to the local observation





Teleray : the French monitoring network of gamma dose rate

- Hundreds of stations (~420)
- Freq : 10 min

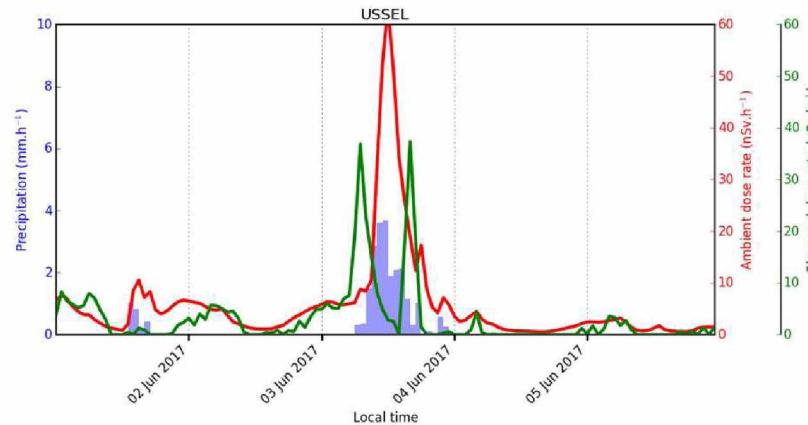
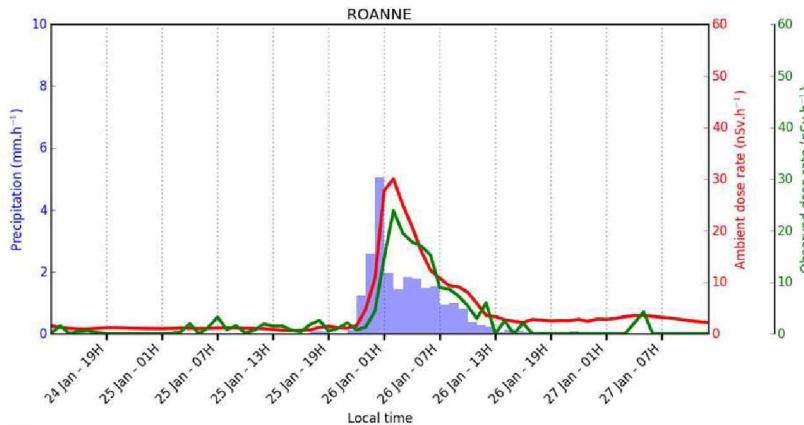
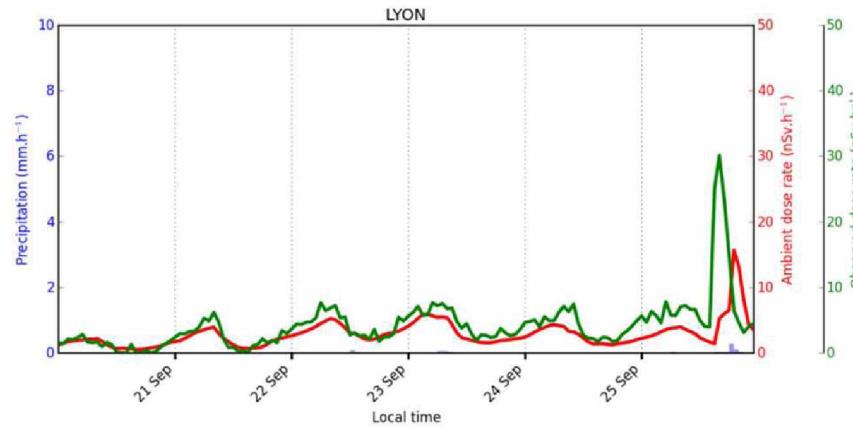
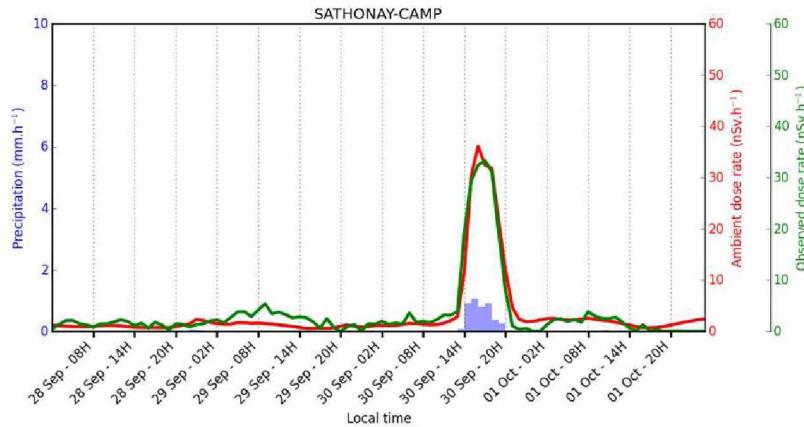
Réseau Téléray au 20/11/2018



Model-to-data comparison...

Some comparisons of dose rate : **model** vs **measurements**

Some peaks are very well modelled in time and intensity



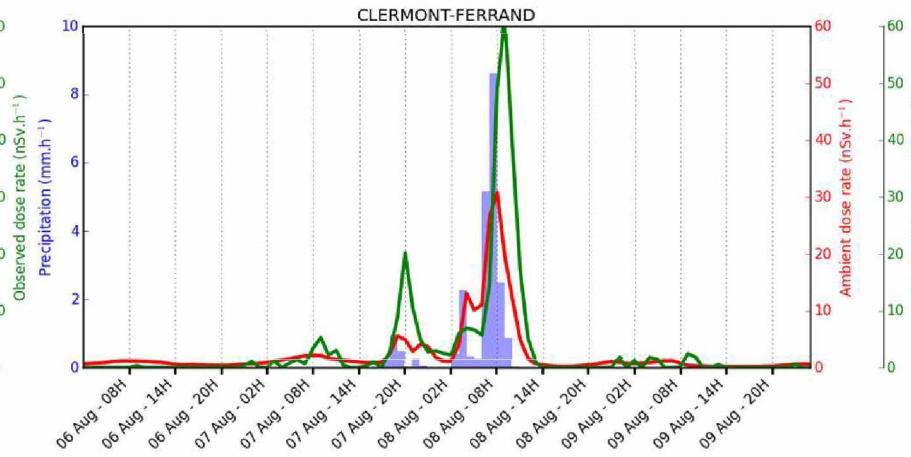
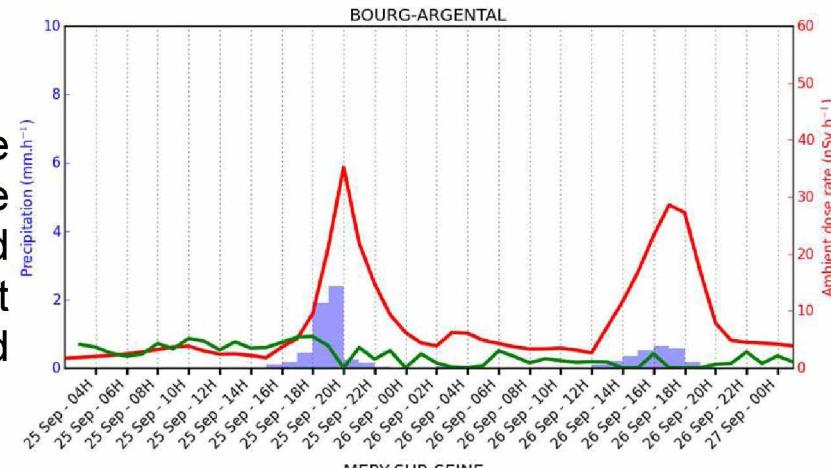
Day/night cyclic variation is correctly reproduced



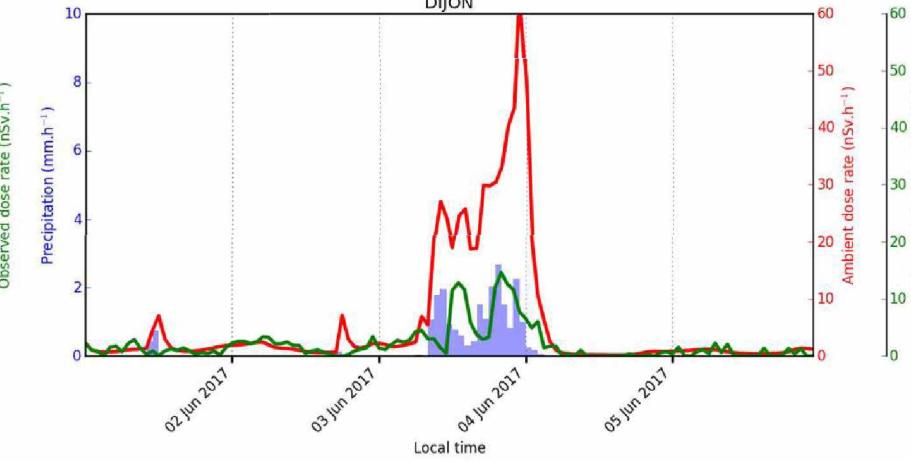
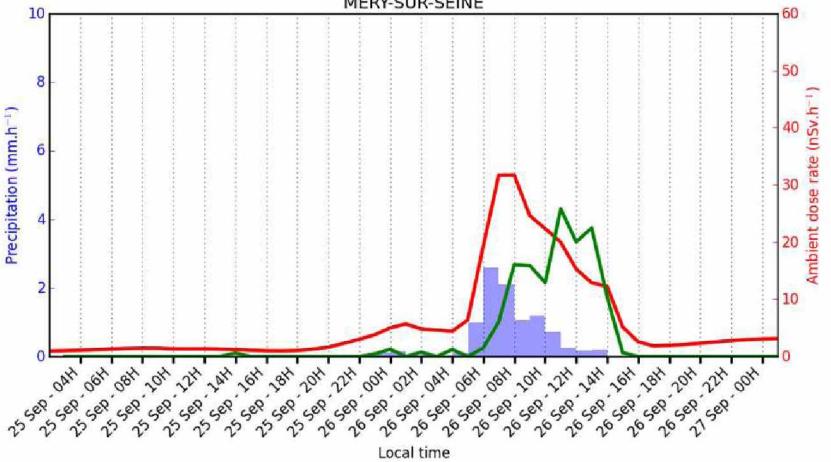
Model-to-data comparison...

Some comparisons of dose rate : **model** vs **measurements**

Some peaks are modelled but not observed



Time shifting

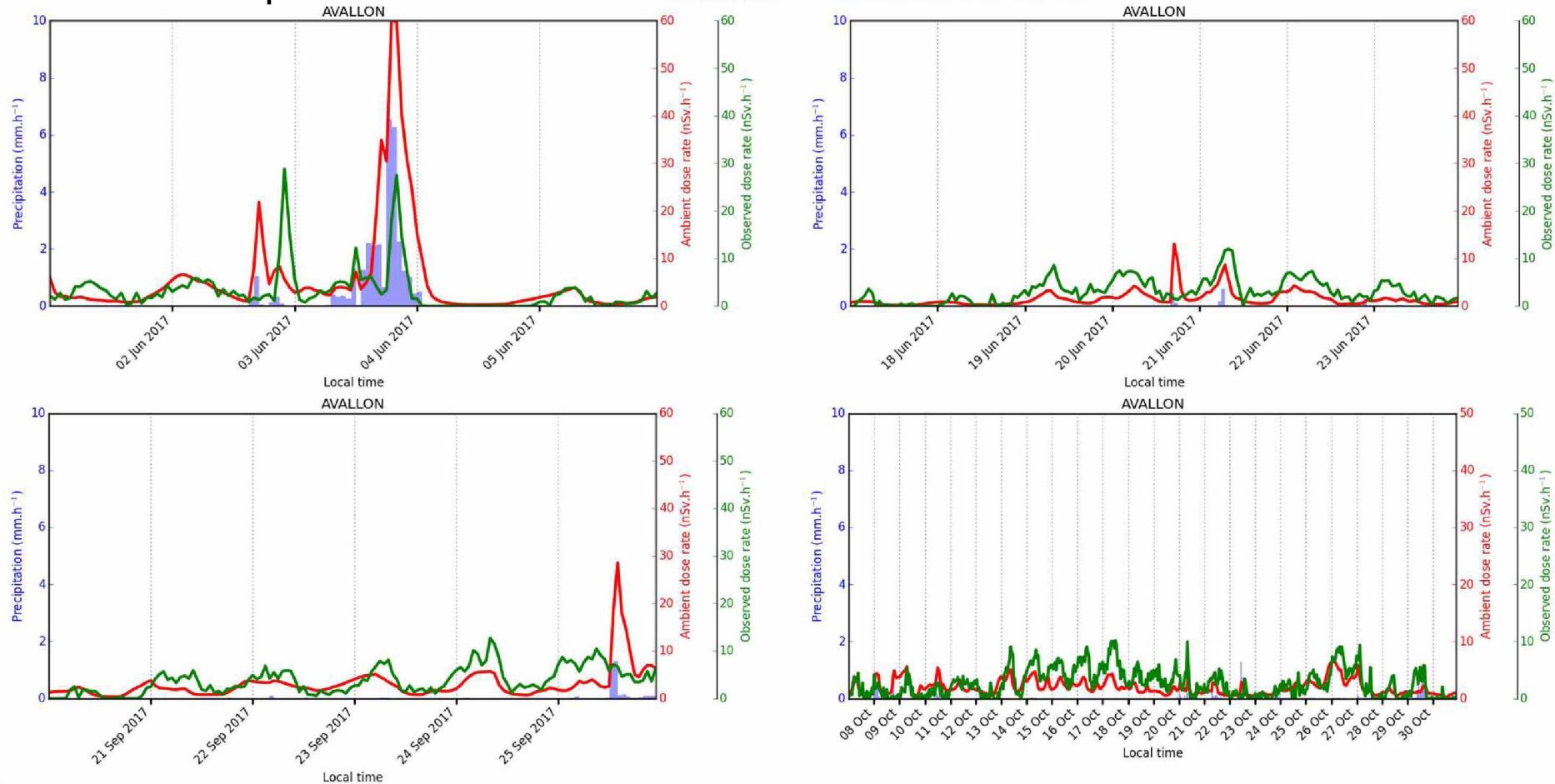


The height of the peaks can also be challenging to model



Model-to-data comparison...

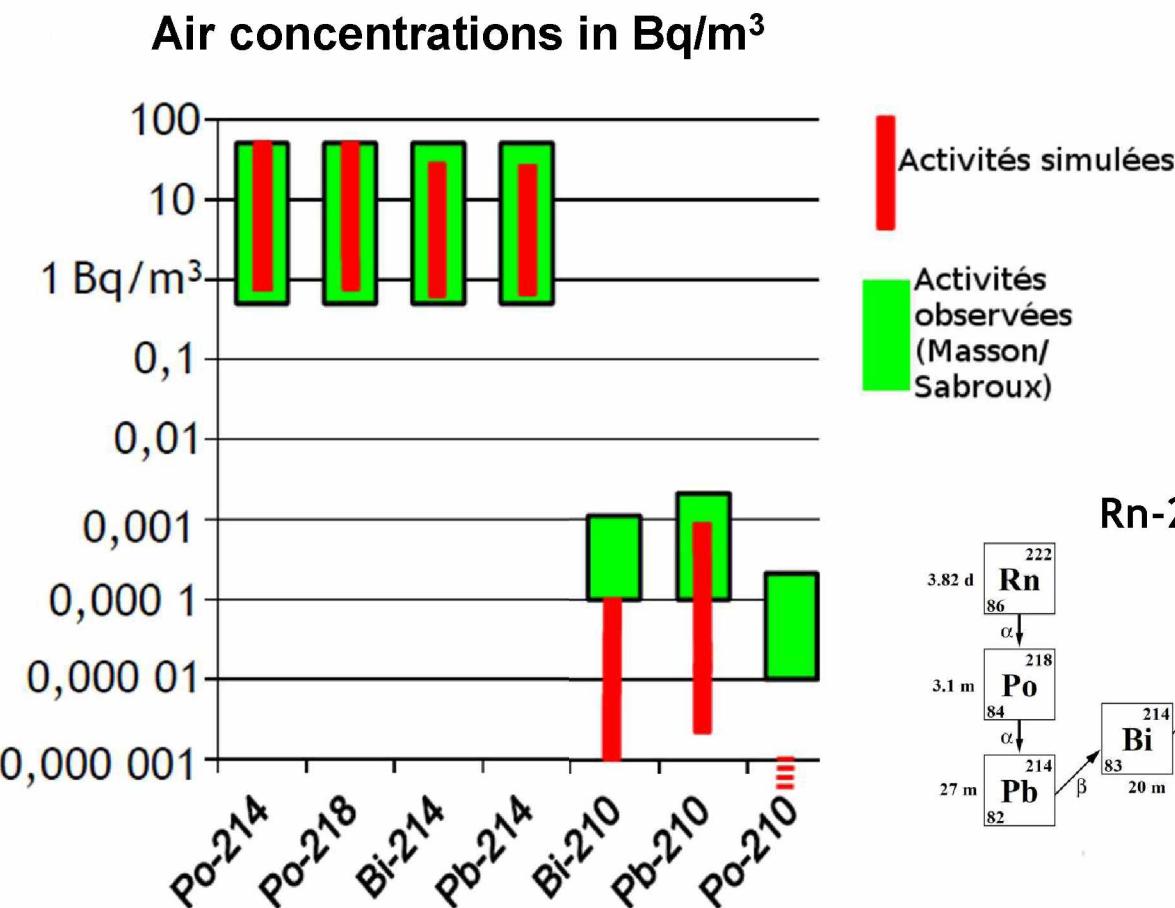
Some comparisons of dose rate : model vs measurements



Other examples



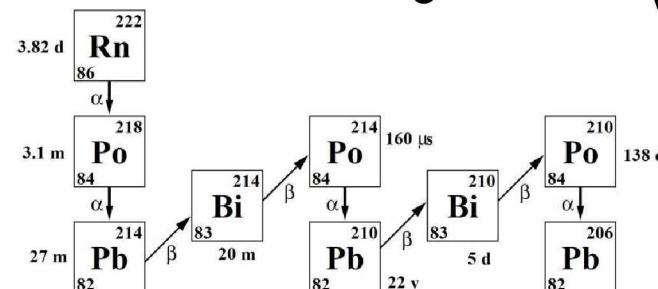
Air concentrations: order of magnitude



Modelling : Lyon
from may 2017 to
may 2018

Bi-210 is created
very slowly and
comes in a large
part from
volcanoes

Rn-222 daughters

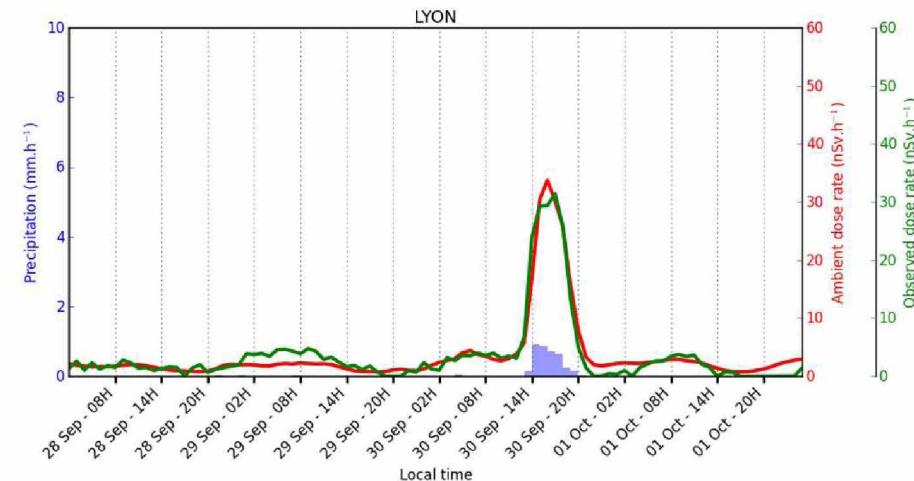


Conclusion

- This preliminary study shows encouraging results for the feasibility of atmospheric radon modelling at regional scale
- To be done...
 - more realistic source term
 - take into account radar measurements for rain events

Outputs for IRSN

- Forecast of dose rate peaks
- Improve the atmospheric transport model (wet deposition modelling)
- Atmospheric radon exposure



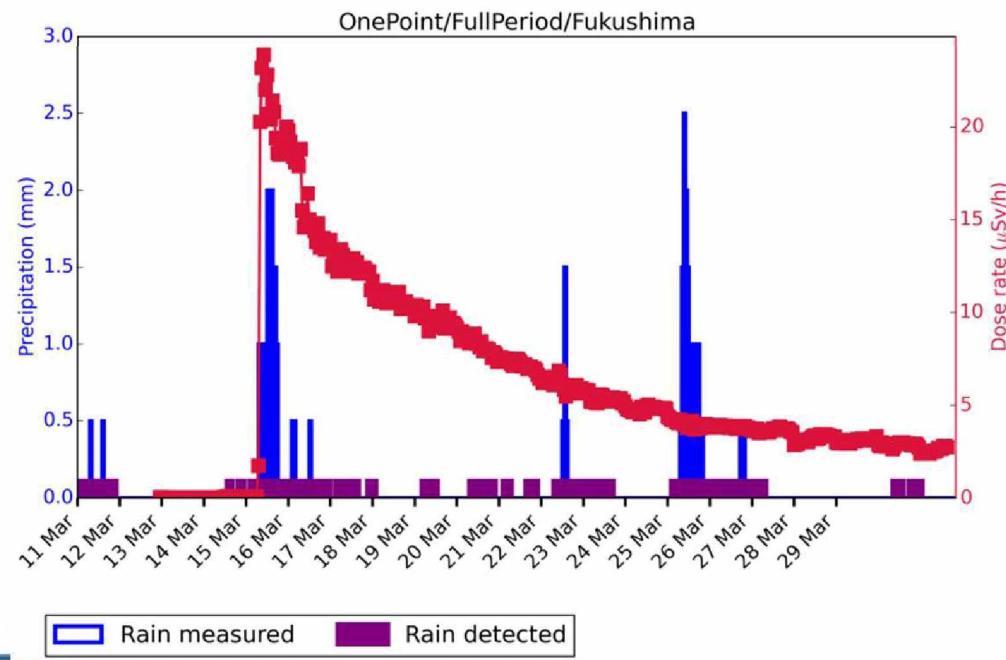
...perspectives

- | Studying a large period in the past (5 years) :
statistical analysis on French monitoring network
 - Where and when is the model able to reproduce the measurements?
- | Analysing of specific events
 - Case studies to fully understand recent peaks for which additional information are easy to gather (meteorological observations).
- | Daily learning
 - To experience routinely the operational product chain
 - To forecast potential risk of dose rate peaks for monitoring purpose



Improve the atmospheric transport model (wet deposition modelling)

- The Fukushima accident was a privileged case study for verification of the model capability to simulate accidental releases.
- The newly available emission inventories of Radon-222, joined with a network of gamma dose rate stations, can be used as a suitable radiological case study for model validation and improvement.

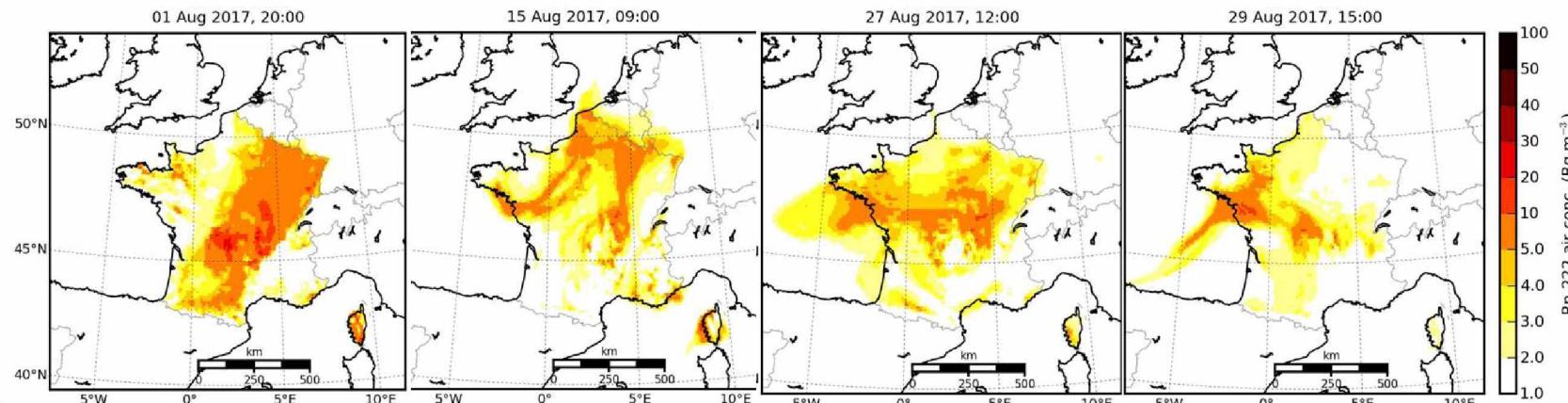


■ Dose rate increase triggered by a rainfall = similarity between dose rate peaks observed during the plume passing of Fukushima and those attributed to radon daughters

Outdoor exposure to radon: the role of long-range atmospheric transport?

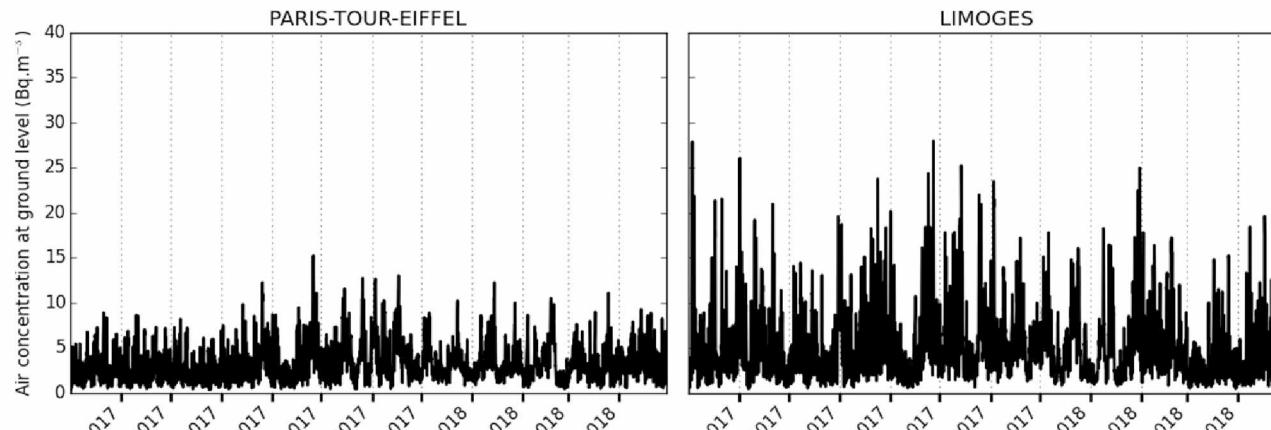
- When breathed, the radon-222 disintegrated inside the lung can damage the cells, increasing the risk of cancer.
- Radon-222 air concentration at one location is the combination of a potentially high local source - within few kilometres - and probably a long-distance origin - dozens or hundreds of kilometres.

Variability of Rn-222 air concentration at the ground-level for several times during August, 2017

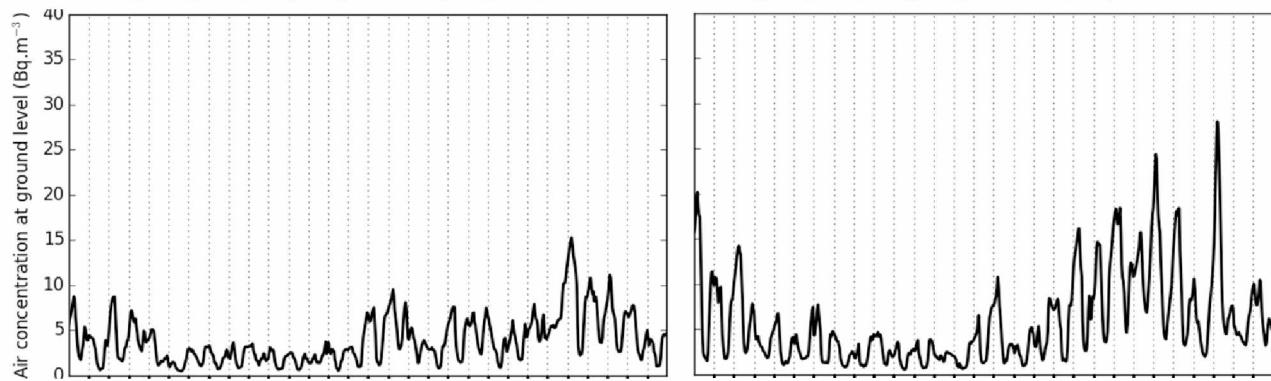


Air concentrations of Rn-222

1 year



1 month
September

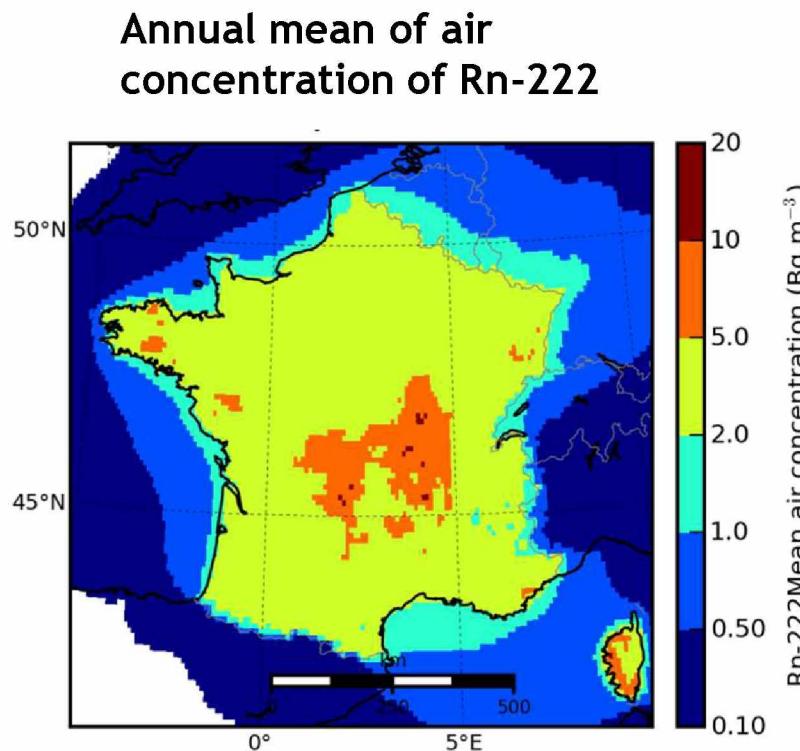


...a site with a local radon exhalation VS a remote one

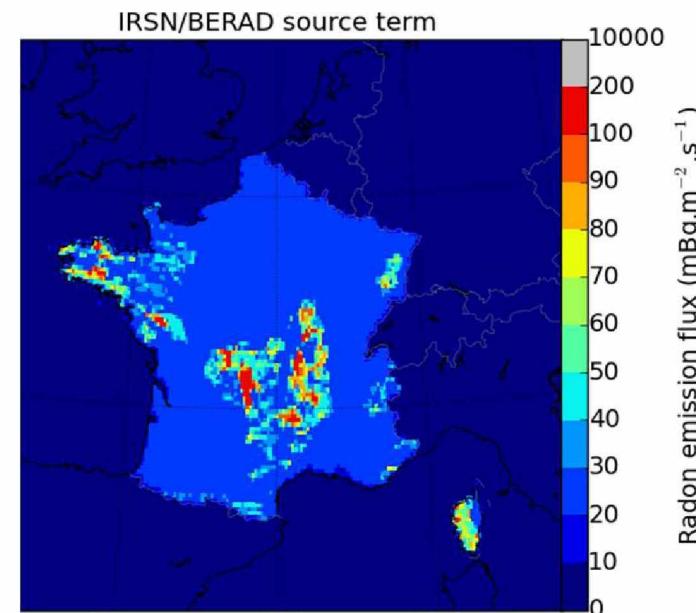


Outdoor exposure to radon: annual mean

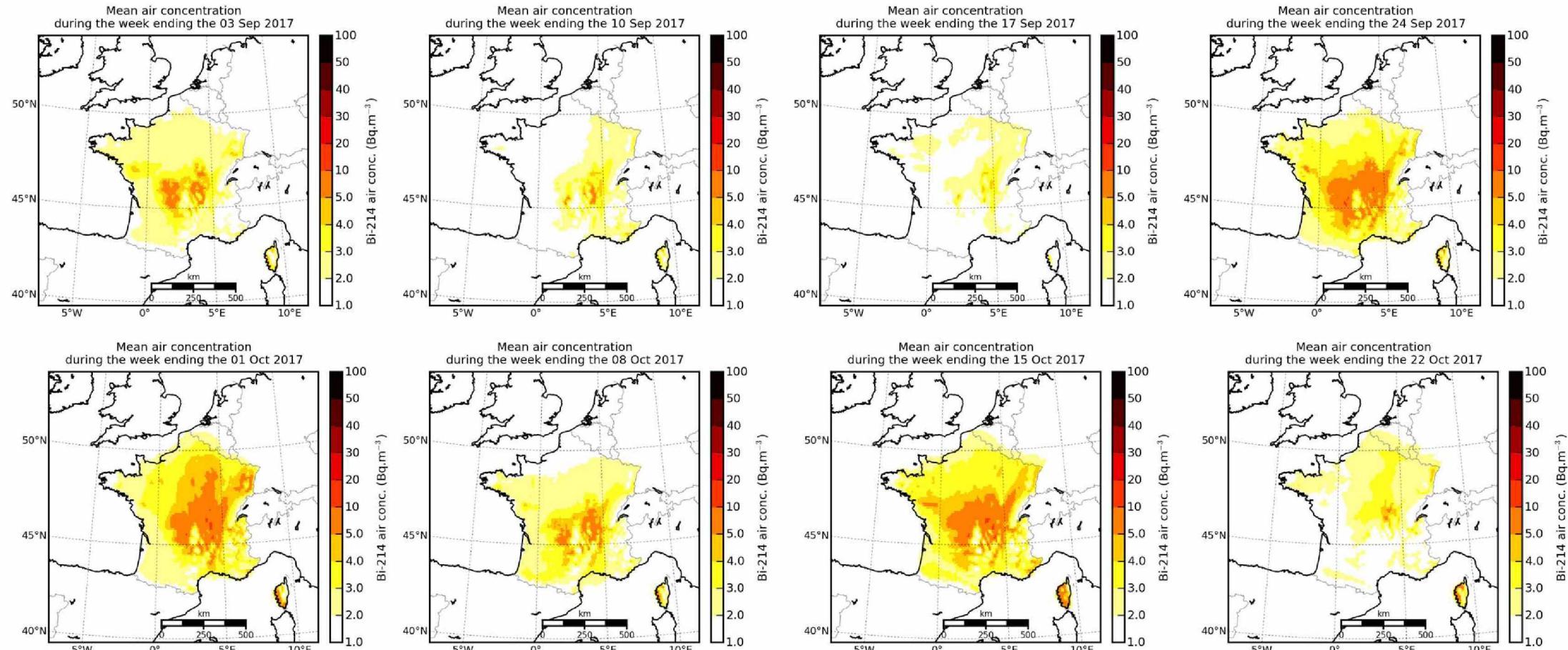
...similar patterns



Exhalation rate of Rn-222



Air concentrations of Bi-214



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