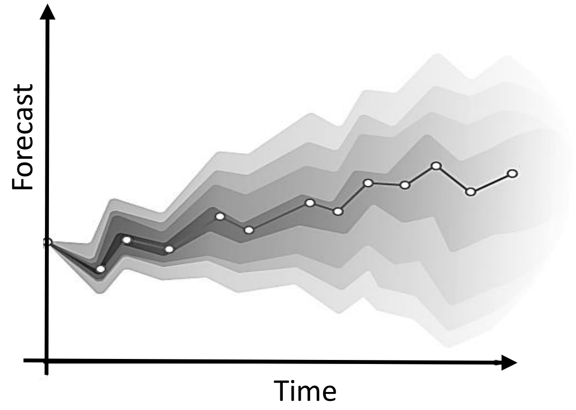
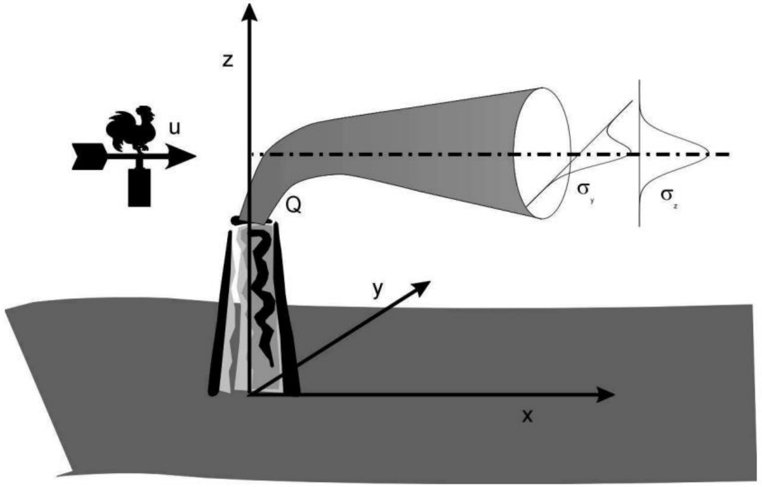
Towards the use of meteorological ensembles for short distance dispersion of radionuclides in case of an accidental release in the atmosphere

Youness El-Ouartassy[1,2], Irène Korsakissok[2], Matthieu Plu[1], Laurent Descamps[1], Olivier Connan[2] and Laure Raynaud[1]





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29 Oct. 2022

Context and motivations

Nuclear disasters (e.g. Fukushima 2011, Chernobyl 1986)

- Atmospheric dispersion models are used to predict the radiological consequences of the nuclear accidents.
- Crisis management: anticipate the countermeasures necessary for the protection of populations based on threshold exceedance.

Uncertainties →

The dispersion model simulations suffers from significant biases and uncertainties.

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Sources of uncertainty in atmospheric dispersion simulations

- **Source term**: evolution of the release rate over time.
- **Meteorology:** sensitivity to small variations in meteorological fields.

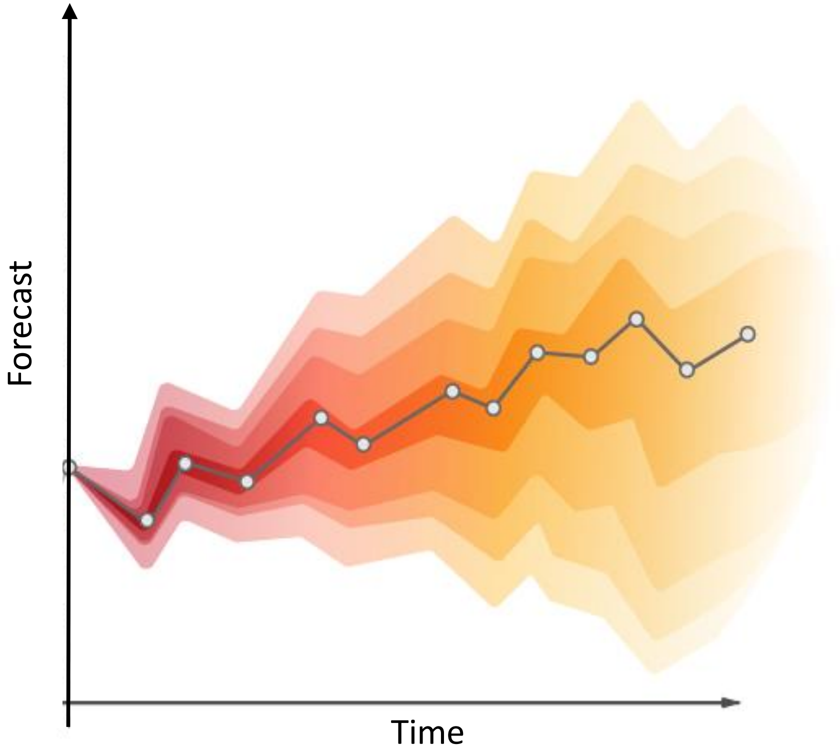
} **Input Data**

❖ **How can meteorological uncertainties be predicted and taken into account in order to improve the forecasts of radioactive pollutants transport during nuclear crisis situations ?**

Towards the estimation of meteorological uncertainties

Ensemble Numerical Weather Predictions (NWP)

- Using **meteorological ensembles** instead of a single deterministic NWP



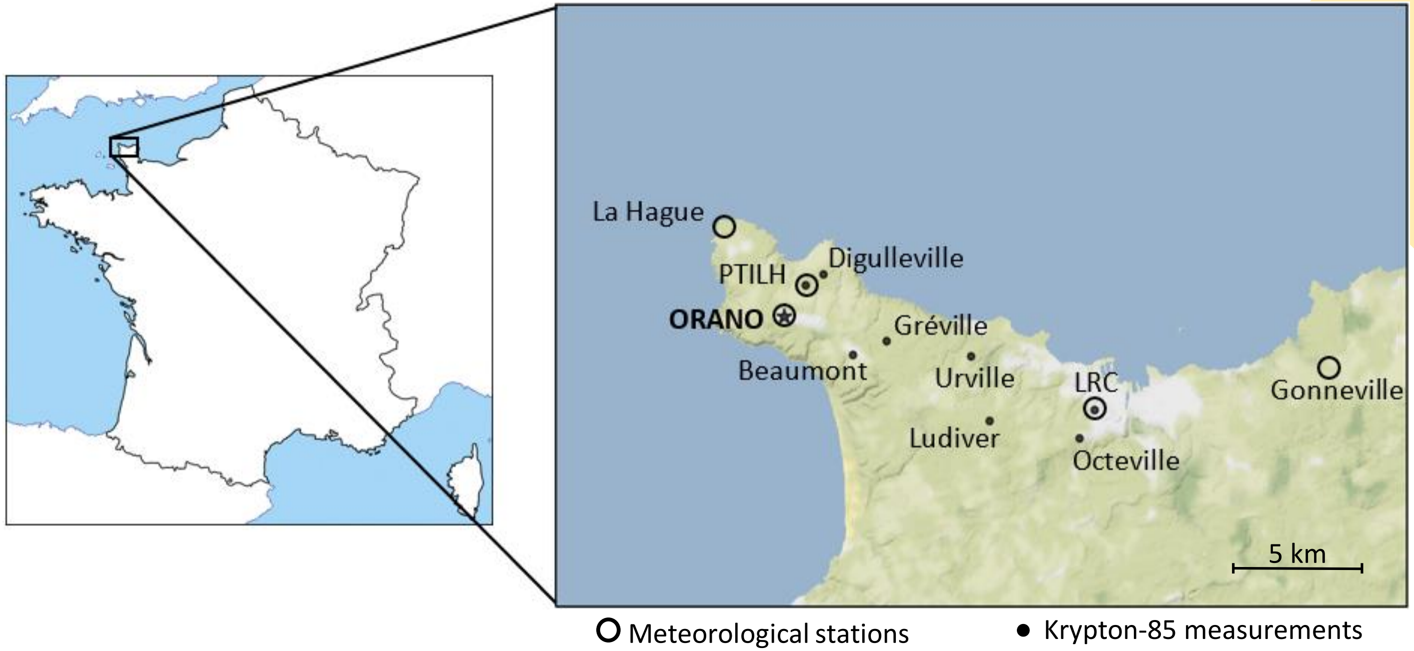
- An **Ensemble** allows to represent the probabilistic information and to represent the different possible scenarios of the evolution of the atmosphere.
- Each **Member** represents a scenario.

AROME-EPS = 16 possibles scenarios

Case study

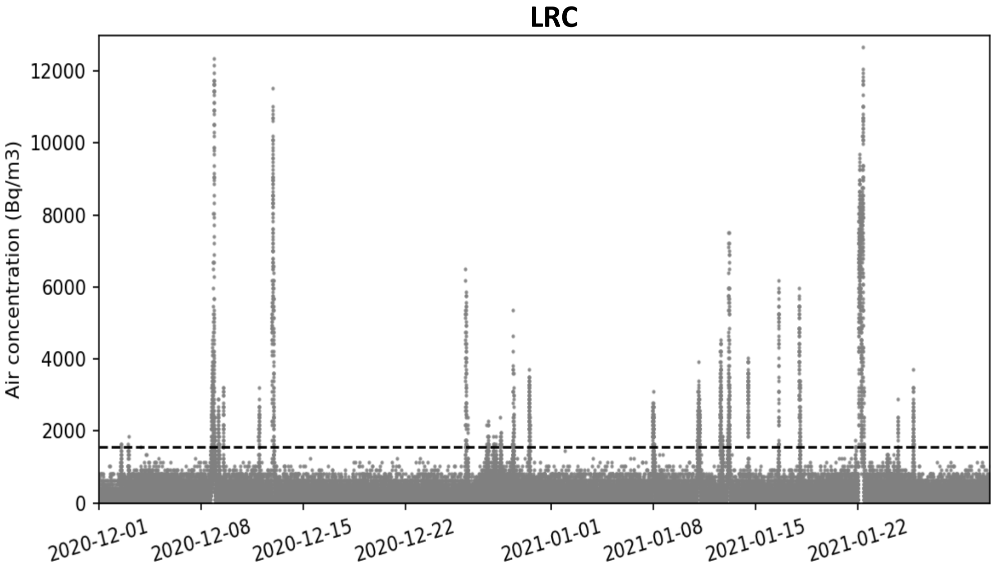
Why the La Hague site ?

1. Regular discharge of ^{85}Kr which is a good tracer of atmospheric dispersion (no deposition, $\tau_{1/2}$=10.7 y)
2. Well-known source term data.
3. Sufficient density of meteorological measurement sites (Météo-France/ IRSN).
4. Sufficient density of radiological measurement sites (continuous measurement campaign of ^{85}Kr air concentration, IRSN-LRC/BMCA).



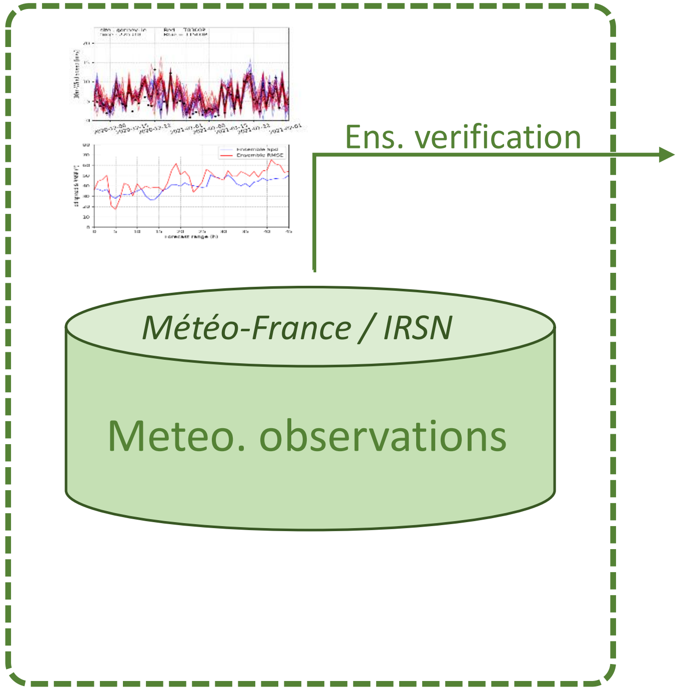
Krypton-85 field campaign around Orano RP: DISKRYNOC project

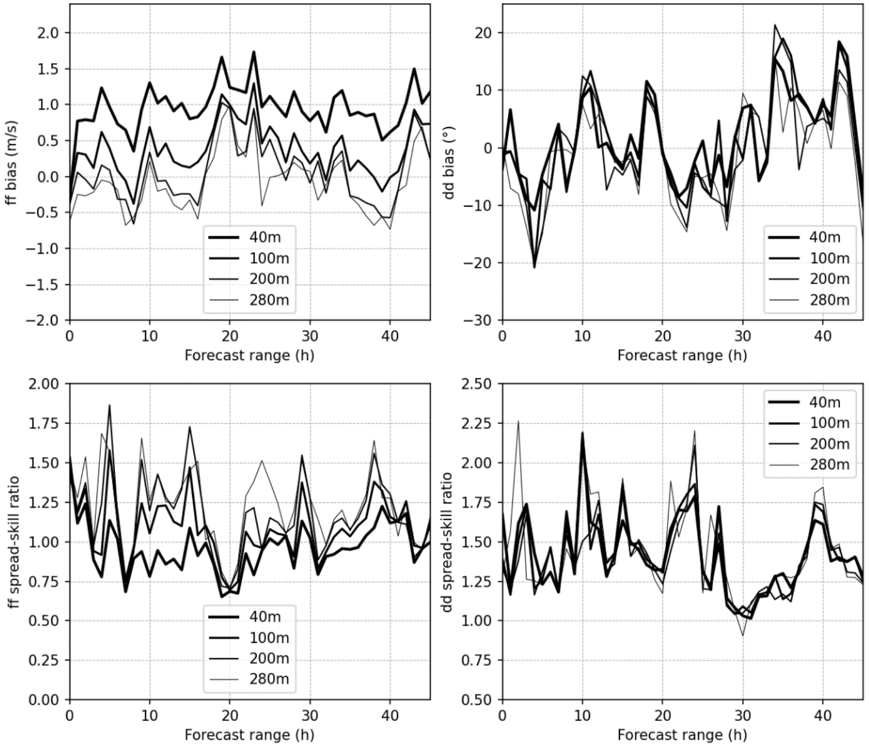
- Experimental measurements around Orano at 8 fixed points: continuous measurements of the ^{85}Kr air concentration since Nov. 2020 (Δt={1s, 10min}).
- Provision of the ^{85}Kr release data (since Nov. 2020) with a good accuracy (Δt ≈ 10min).



Methodology

Coupling of the Météo-France fine-scale meteorological ensembles (**AROME-EPS**, 2.5km) to the IRSN Gaussian dispersion model **pX**





Meteorological ensembles validation

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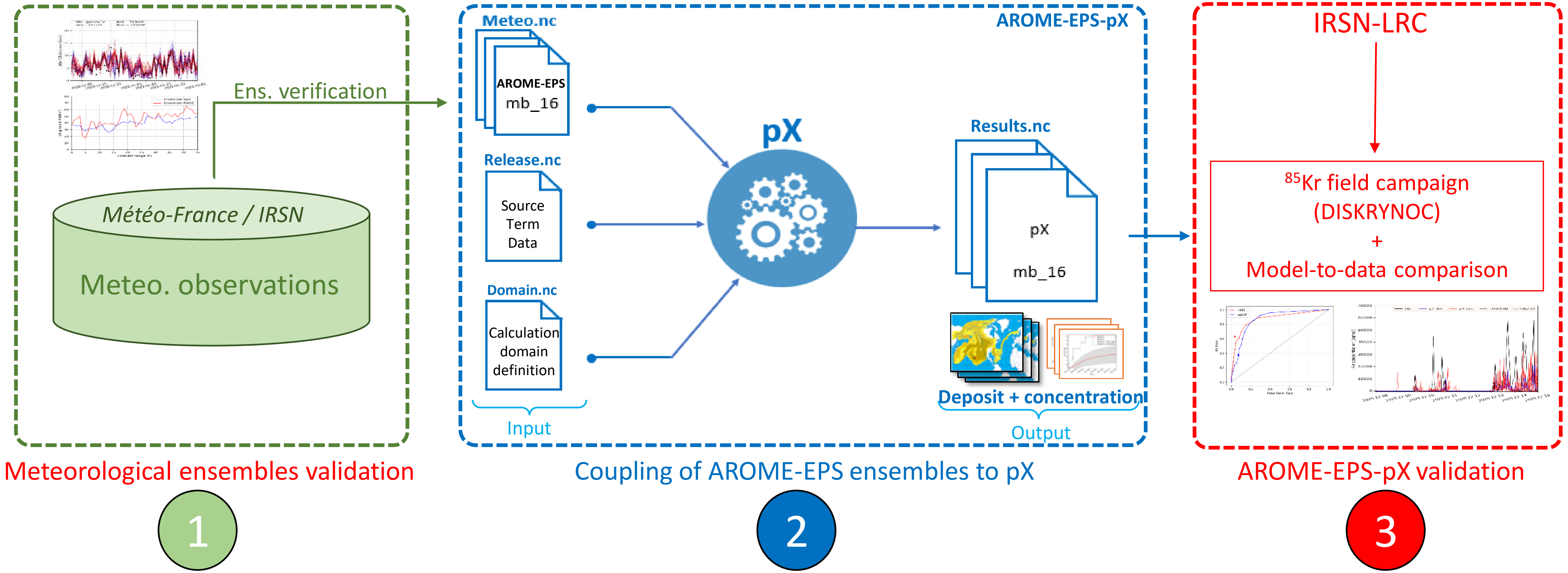
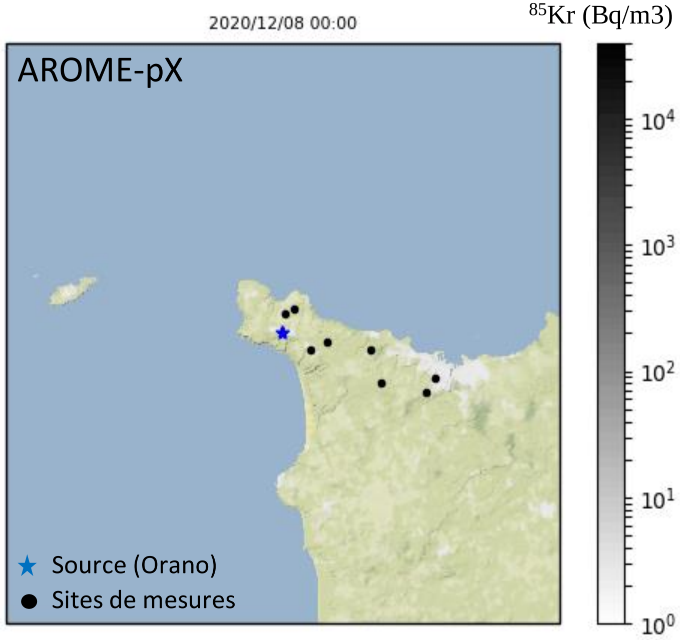
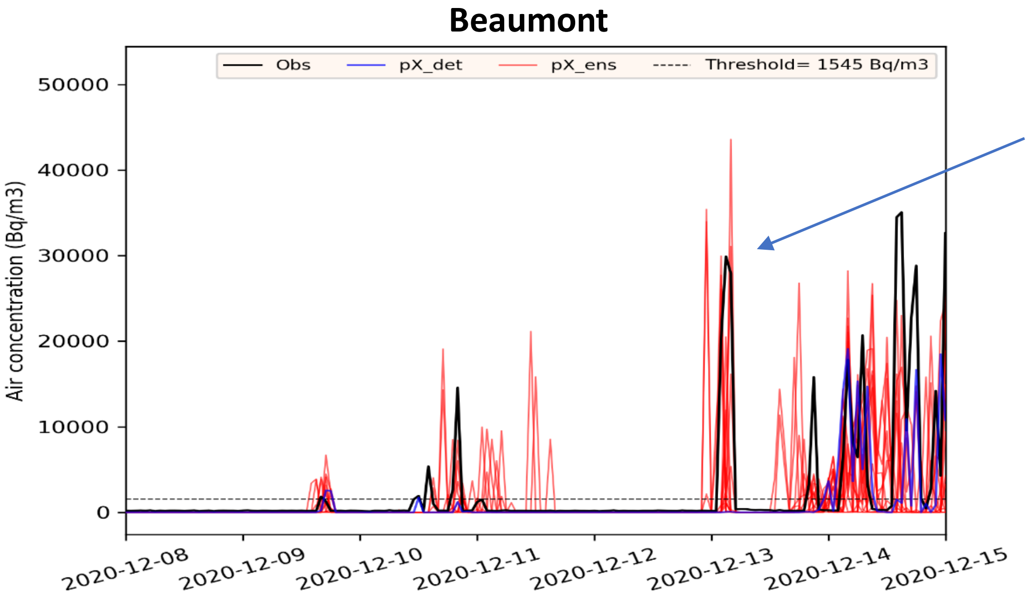


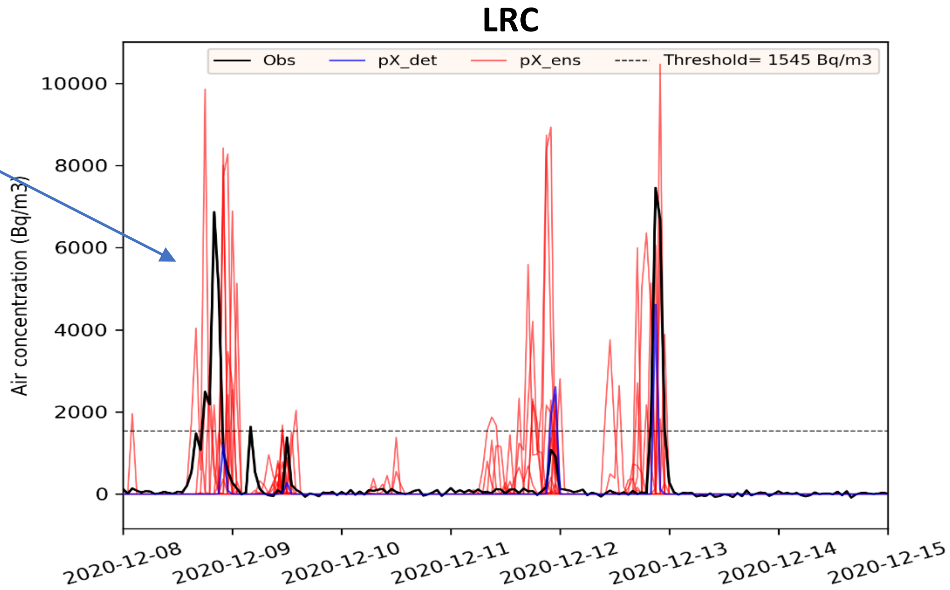
AROME-EPS-pX - Results

Model-to-data comparison





The value of the use of the ensemble rather than a single deterministic forecast.

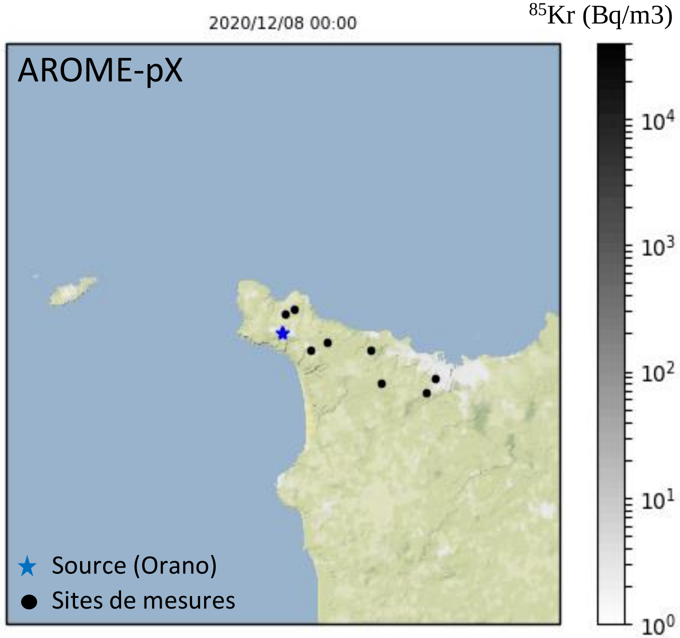


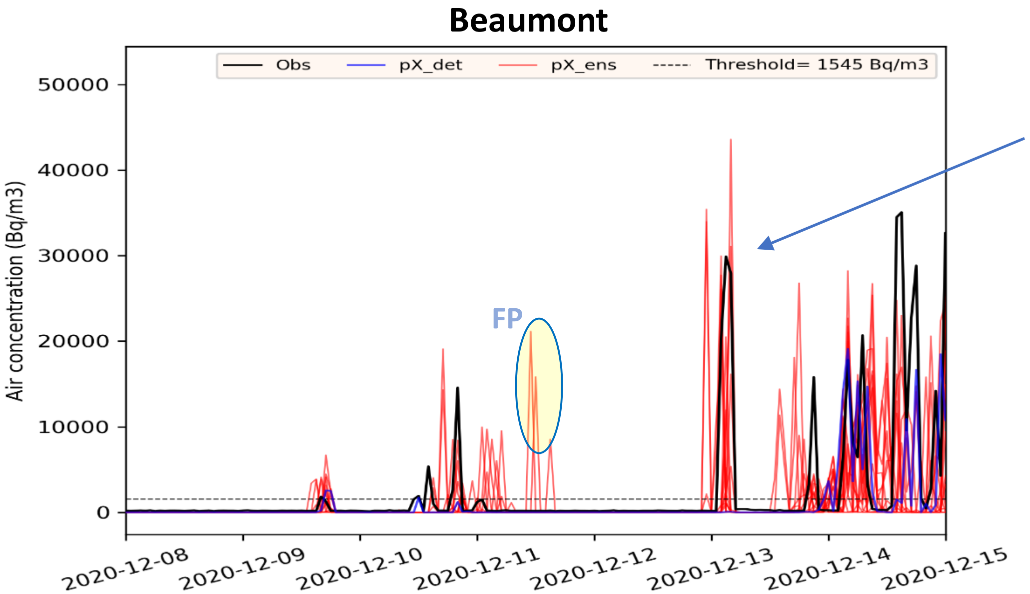
AROME-EPS-pX - Results

Model-to-data comparison

		Observation	
		Yes	No
Simulation	Yes	TP	FP
	No	FN	TN

TP : True Positive
FP : False Positive
FN : False Negative
TN : True Negative





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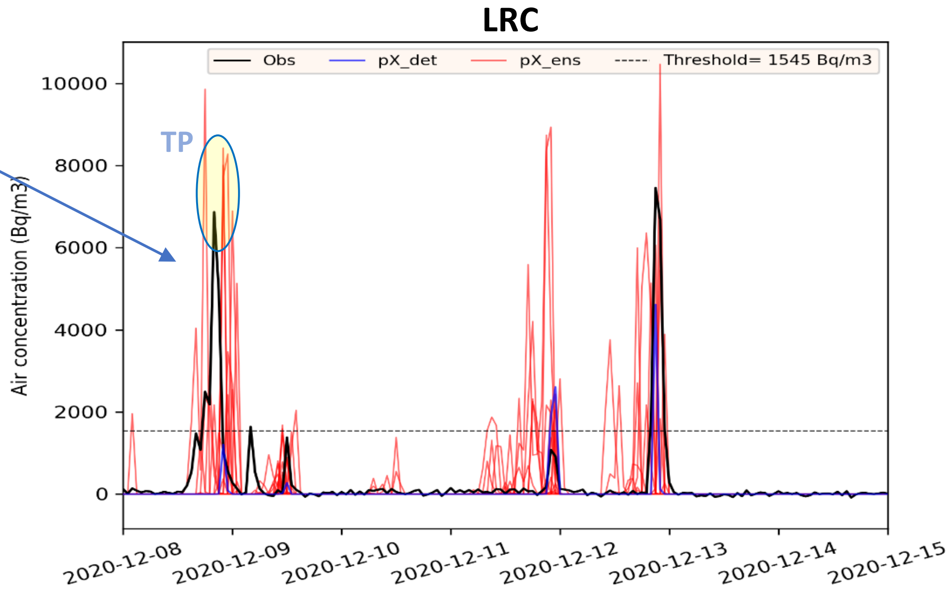

Probabilistic indicators and evaluation

Questions : 1- What are the decision thresholds from which the ensemble performs better than the deterministic ?

2- What is the optimal number of members for the prediction of threshold exceedances ?

AROME-EPS-pX - Evaluation

Probabilistic indicators and evaluation

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- ROC curves (Receiver Operating Characteristic) : presentation of the Hit Rate (H) as a function of the False Alarm Rate (F) for each decision threshold :

$$\mathrm{H} = \frac{TP}{TP+FN} \quad \text{and} \quad \mathrm{F} = \frac{FP}{FP+TN}$$

- Peirce Skill Score (PSS): the difference between the Hite Rate and the False Alarm Rate. $(\mathrm{H} - \mathrm{F})$. A perfect PSS is equal to 1 $(\mathrm{H} = 1 \text{ et } F = 0)$:

$$\mathrm{PSS} = \frac{TP \text{ x } \mathrm{TN} - \mathrm{FP} \text{ x } \mathrm{FN}}{(TP + FN)\ (FP + TN)}$$

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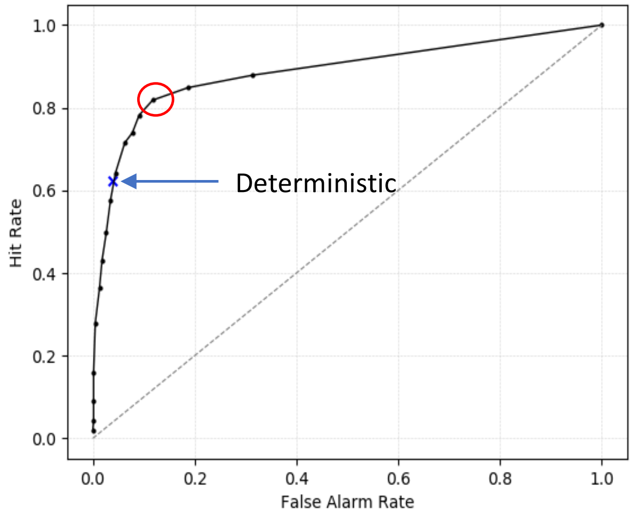
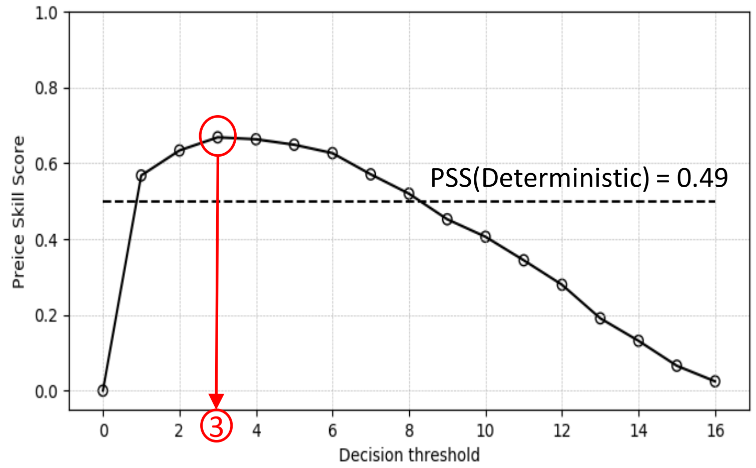
➢ **Configuration 1: Global performance**





An event is likely to happen since it have predicted by at least 3 members.

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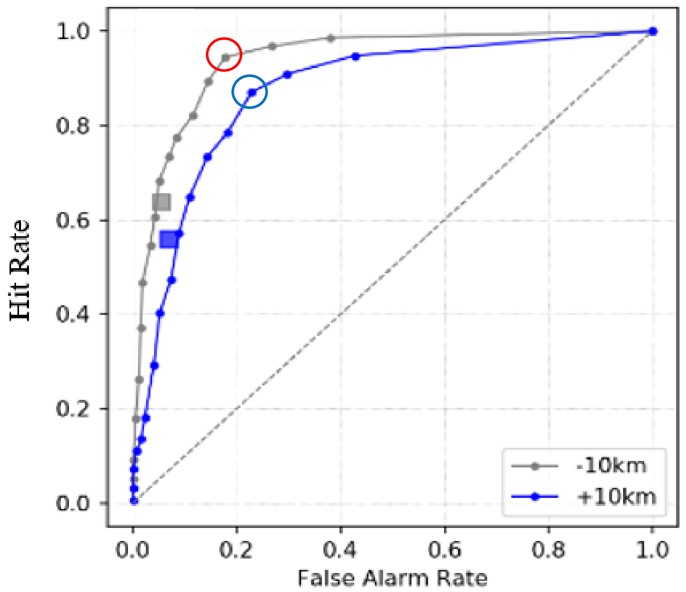
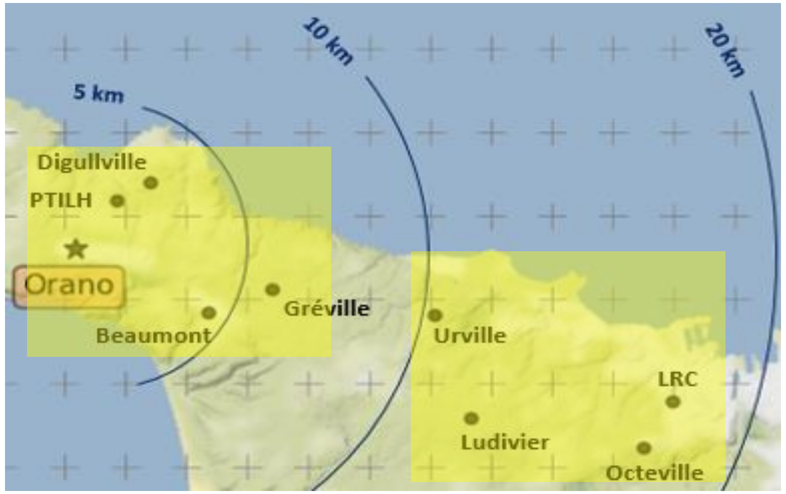
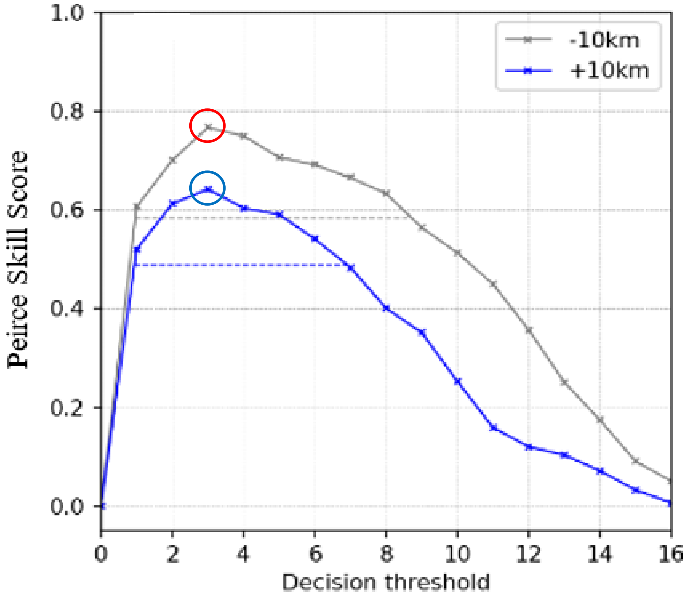
➢ **Configuration 2: Impact of the distance from the source**







The model performs better in the near-field stations.

Probabilistic indicators and evaluation

For more details on this study : ***El-Ouartassy et al. (2022)***

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Combining short-range dispersion simulations with fine-scale meteorological ensembles: probabilistic indicators and evaluation during a ^{85}Kr field campaign

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Conclusions & perspectives :

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1. The use of fine-scale meteorological ensembles (AROME-EPS) allows to perform satisfactory dispersion simulations.
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Perspectives

1. Study the contribution of the resolution of the meteorological ensemble in the atmospheric dispersion simulations: AROME-EPS-pX vs ARPEGE-EPS-pX.
2. Develop complementary indicators to evaluate the consistency of dispersion simulations in term of intensity between simulated and observed peaks.
3. Work on the clustering of the meteorological ensembles in order to reduce their size while keeping their consistency.

Thank You !

Questions ?

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