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Sensitivity analysis of radionuclides atmospheric dispersion following the Fukushima accident

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Atmospheric dispersion models are used in response to accidental releases with two purposes:
- minimising the population exposure during the accident;
- complementing field measurements for the assessment of short and long term environmental and sanitary impacts.
The predictions of these models are subject to considerable uncertainties of various origins.
Notably, input data, such as meteorological fields or estimations of emitted quantities as function of time, are highly uncertain.

The case studied here is the atmospheric release of radionuclides following the Fukushima Daiichi disaster.
The model used in this study is Polyphemus/Polair3D, from which derives IRSN's operational long distance atmospheric dispersion model ldX.
A sensitivity analysis was conducted in order to estimate the relative importance of a set of identified uncertainty sources.

The complexity of this task was increased by four characteristics shared by most environmental models:
- high dimensional inputs;
- correlated inputs or inputs with complex structures;
- high dimensional output;
- multiplicity of purposes that require sophisticated and non-systematic post-processing of the output.

The sensitivities of a set of outputs were estimated with the Morris screening method.
The input ranking was highly dependent on the considered output.
Yet, a few variables, such as horizontal diffusion coefficient or clouds thickness, were found to have a weak influence on most of them and could be discarded from further studies.

The sensitivity analysis procedure was also applied to indicators of the model performance computed on a set of gamma dose rates observations.
This original approach is of particular interest since observations could be used later to calibrate the input variables probability distributions.
Indeed, only the variables that are influential on performance scores are likely to allow for calibration.
An indicator based on emission peaks time matching was elaborated in order to complement classical statistical scores which were dominated by deposit dose rates and almost insensitive to lower atmosphere dose rates.
The substantial sensitivity of these performance indicators is auspicious for future calibration attempts and indicates that the simple perturbations used here may be sufficient to represent an essential part of the overall uncertainty.