QUALIFICATION OF A LONG-RANGE TRANSPORT MODEL OF RADIONUCLIDES IN AN EMERGENCY CONTEXT

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The objective of this study is to investigate the validity of a long-range transport model to be used in a nuclear accidental context. First, it appears to be more important to know where the plume is moving and where the material is deposited than to evaluate precisely the concentration levels. Then, for communication issues, it is important to not reconsider any estimation upward. It is then preferable that the model overestimates the doses. Finally, anticipation is a key factor for the crisis management. The prediction of the time of arrival of the plume is therefore crucial. The level of reliability of our model ldX is reported using specific indicators related to this emergency context. Some new indicators concerning the plume location and the dose are introduced. Model-to-data comparisons are presented using the ETEX-I measurements campaign.

THE EMERGENCY CONTEXT

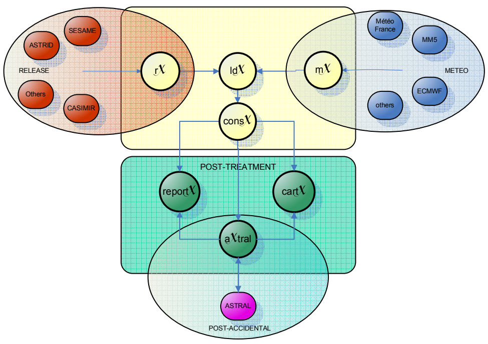
In case of an accidental situation involving radioactive material, the Institute for Radiological Protection and Nuclear Safety (IRSN) has to provide the decision makers with fast, reliable, consistent and comprehensive information. Decision making relies on a scientific estimation of the consequences for human health and environment. The emergency centre of the IRSN operates a complete model chain in order to compute the technical elements necessary to define the appropriate emergency actions to protect the population and the agricultural countermeasures. Depending on the severity of the accident, it could be necessary to address the problem of the dispersion of radionuclides at a large scale and in particular transboundary dispersion.

In an emergency context, decision makers have to deal with the following constraints:

- to anticipate since countermeasures may take time to initiate;
- to deal with other expertises overestimating their own assessment;
- to communicate as soon as possible.

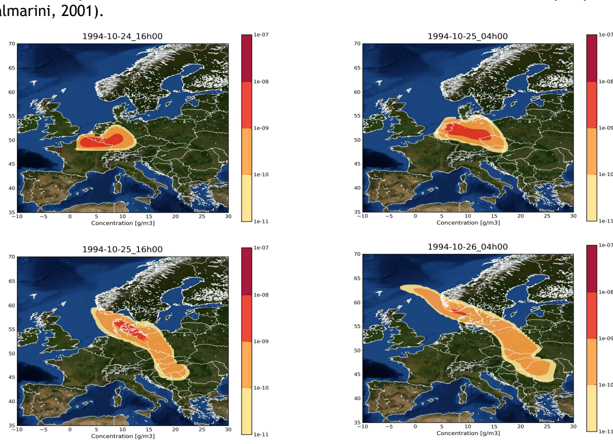
THE LARGE-SCALE MODEL: LDX

ldX is part of a modelling platform operated to help the crisis centre of the IRSN to estimate the consequences for human health and environment. ldX comes from the chemistry transport model Polair3D (Boutahar, et al. 2004) which is part of the Polyphemus system (Mallet, V., D. Quélo, et al., 2007). It uses the same numerical solvers and parameterizations but differs by its comprehensive mechanism for radioactive filiation and decay. A previous work (Quélo, et al. 2007) indicates a good behaviour of ldX compared to other state-of-the art models on some case studies: the ETEX-I campaign, the Chernobyl accident and the Algeciras release.



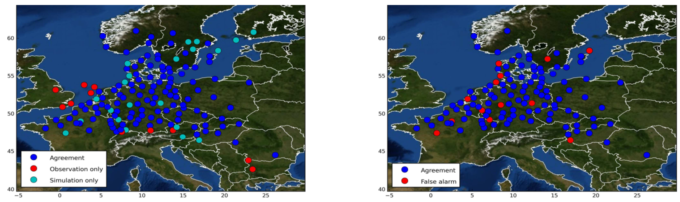
THE ETEX-I CAMPAIGN

The ETEX campaign consists in the release of an inert tracer in the western part of Europe and its following over Europe with numerous observational stations (168 in total). ETEX-I constitutes a suitable playground since its framework have been used for model intercomparison exercises. For instance, one may refer to the ATMES-II exercise or to the multi-model ensemble analysis performed in (Galmarini, 2001).



ldX simulation : evolution of the plume over Europe at T0+24h, T0+36h, T0+48h and T0+60h.

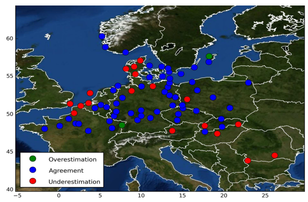
Agreement on location and false alarms



Agreement on location (left) and false alarms (right).

- **Agreement on location**: Both model and measurements agree that the plume pass through the station (i.e. at least one value above the detection threshold (0.01 ng/m^3)).
- **False alarm**: The model predicts the passing of the plume with a value ten times above the detection threshold whereas nothing is measured.
  - Missed stations are localised on the border of the plume (England).
  - 13 false alarms which are difficult to interpret since they are located close to stations where positive measurements were made (measurement problems and local phenomena not taken into account in long-range transport models).

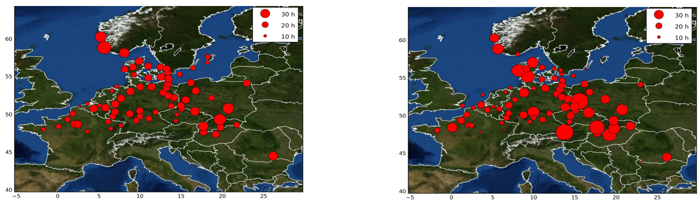
Dose agreement



Dose agreement.

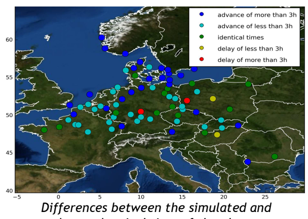
The **dose agreement** indicates if the model reasonably overestimates the doses. The indicator is positive if the simulated dose is comprised between the measured dose and ten times this value.

- Many stations are subjected to underestimation of doses in particular on the border of the plume.
- The stations where the predicted dose is underestimated correspond often to an underestimated duration (e.g. Denmark).



Duration of the plume for the simulation (left) and the observations (right).

Arrival time



Differences between the simulated and observed arrival time of the plume.

The **arrival time** is the first time the concentration exceeds the detection threshold (0.01 ng/m^3).

- The arrival time simulated by ldX is mostly in advance compared with observations (dilution of the tracer in the first cell of the grid at the beginning of the release).
- This indicator is hard to interpret (close stations give very different values of arrival time).

This study introduces new indicators more appropriate to the emergency context. In general, the model shows a good behaviour which is satisfactory for crisis management. Nevertheless, ETEX-I is an ideal case since the release and the meteorology are well known. It might be different in a real emergency situation. Some stations appear to be more difficult to predict all the more so very close stations may have different scores. This may be due to local phenomena not taken into account in our large scale model.

To go further in the qualification process, comparison to other models may be useful as well and has been initiated in the ENSEMBLE framework (Galmarini, 2001). The opportunity of using data assimilation and ensemble modelling seems to be promising as well in order to improve the technical assessment of a crisis.

References

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