One-year Postdoctoral Research Position

Institutions: CEA / DAM & Univ. Bretagne Sud, Lab-STICC UMR CNRS 6285
Location: Campus Tohanic, Vannes, France
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Subject

The threat of Chemical, Biological, Radiological and Nuclear (CBRN) attack is a frequent feature of the modern battlefield. Indeed, many rogue nations and terror groups seek to employ asymmetric warfare and some groups will be attracted by the use of chemical weapons to achieve major impact. As a consequence, rapid detection and early response to a release of a CBRN agent could dramatically reduce the extent of human exposure and minimize the cost of the subsequent clean up.

In the event of a CBRN incident, the assessment of the damage likely to be caused by the release is a problem of great importance. This assessment is usually undertaken using a predictive model for the mean transport and turbulent diffusion of the contaminant through the atmosphere, which in turn provides the information required to determine the temporal window and geographical extent of the hazard zone required in the formulation of an effective response. Unfortunately, an array of CBRN sensors by itself is not sufficient for this task, owing to the fact that detection of a toxic agent plume by the sensor array only indicates that a release has occurred, but without knowing the characteristics of the source (source location, mass, time release, agent type, etc.), the prediction of the dispersion of the contaminant in the atmosphere cannot be made.

The “reverse” estimation of source characteristics using a finite number of noisy concentration data obtained from an array of sensors has received quite a lot of attention in recent years since the importance of the solution of this problem for a number of practical applications is obvious. Nevertheless, there are still some issues for obtaining satisfactory results when the aim is to have a complete identification of the sources in urban scenarios where the presence of obstacles and the non-stationary meteorology have to be taken into account.

Most of the existing work is based on non-statistical methods, especially on direct-inversion procedures [1–3], where an inverse solution is obtained using an adjoint advection-diffusion equation [4]. Recently in [5, 6], we propose a novel statistical method based on adaptive importance sampling. This technique has shown promising results to solve this complex Bayesian inference problem by providing accurately and efficiently the posterior distribution of the source’s characteristics.

In this project, we will study and propose advanced Monte-Carlo methods in order to facilitate the applicability of such statistical tools in practice. First, the aim will be to design methods which are able to estimate not only the main characteristics of the sources but also the parameters of the considered probabilistic model. Secondly, we want to propose an on-line version of the algorithm in order to sequentially process the sensor measurements as they arrive. Finally, an optimization procedure combined with such Monte-Carlo based inference algorithms in order to find “optimal” locations of the sensors in a given surveillance area will be studied. Implementing these techniques in Python (or R) will be required.

Candidate profile

We are looking for a motivated and talented researcher, **holding nationality from a European Union nation**, with:

- a PhD in a relevant subject (engineering science, applied mathematics, computer science or physics)
- experience in several of the following areas: statistical inference, inverse methods, numerical analysis, programming, atmospheric dispersion, meteorological flow, fluid dynamics, etc
- good mathematical and computer skills
- experience in programming, preferably in Python and/or Fortran
- team spirit, determination and curiosity

Details

A one-year contract with the CEA (French Alternative Energies and Atomic Energy Commission [link]) is available, starting as soon as possible. The selected candidate will be working at the Université of Bretagne Sud located at Campus Tohannic in Vannes with François SEPTIER [link] (francois.septier@univ-ubs.fr) and also with Patrick ARMAND (patrick.armand@cea.fr) from the CEA in Arpajon near Paris.

Applicants should submit a letter of application explaining their suitability for the position and how they meet the selection criteria, a full curriculum vitae, list of publications, a statement of research interests and the names and contact details of two referees. Applications should be sent both to François Septier (francois.septier@univ-ubs.fr) and to Patrick Armand (patrick.armand@cea.fr).

References

[1] J. Pudykiewicz, "Application of adjoint tracer transport equations for evaluating source parameters," *Atmospheric Environment*, vol. 32, pp. 3039–3050, 1998.

[2] J.-P. Issartel and J. Baverel, "Inverse transport for the verification of the Comprehensive Nuclear Test Ban Treaty," *Atmospheric Chemistry and Physics*, no. 3, pp. 475–486, 2003.

[3] R. Brown, D. Dussault, R. Miake-Lye, and P. Heimback, "SCIPUFF Adjoint model for atmospheric transport and dispersion optimization," Aerodyne Research, Report RR-1392, Tech. Rep., Billerica, MA 2005, 24pp.

[4] R. Errico, "What is an adjoint model?" *Bulletin of the American Meteorological Society*, vol. 78, no. 11, pp. 2577–2591, 1997.

[5] H. Rajaona, F. Septier, P. Armand, Y. Delignon, C. Olry, A. Albergel, and J. Moussafir, "An adaptive Bayesian inference algorithm to estimate the parameters of a hazardous atmospheric release," *Atmospheric Environment*, vol. 122, pp. 748–762, Dec. 2015.

[6] H. Rajaona, "Inférence bayésienne adaptative pour la reconstruction de source en dispersion atmosphérique," University of Lille1, Nov. 2016.