

Localization of sources for events detected during the noble gas equipment test

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1. Introduction

Recent developments in meteorological data processing enable to manage in a quantitative manner the unavoidable ambiguity of atmospheric phenomena. When several measurements are available the ambiguity is reduced significantly. Signal dynamics observed in successive measurements at a single station are combined into distance information. The ideal situation is when an event has been observed by different stations, including possibly zero valued measurements. Sources to be investigated may be underground tests, underwater tests or industrial releases. The diagnostics below are therefore adapted to the search of spot sources at sea or ground level with an undetermined duration.

2. Context

An analysis is proposed here for the detection of the 100 mBq/m³ peak concentration of ¹³³Xe in Freiburg last February the 3d. This analysis is completed with the previous and second following measurements performed at Freiburg. No other station was active by that time. The potential contribution of the station in Stockholm was nevertheless investigated through virtual measurements. So far it has not been possible to confirm any source for this episode. As a validation of the proposed analysis, similar calculations have been performed using data from ETEX.

3. Diagnostic proposed

Let's first analyze the single 100mBq/m³ peak measurement. The history of air in the sample is investigated in terms of a concentration propagated back in the time, just like a cloud spreading into the past from the detector. This approach is called adjoint. The source lies somewhere in the cloud called "retroplume". It is not possible to determine exactly the position, but position and intensity are correlated as follows. The intensity should be inversely proportional to the retroplume concentration for a given date, and it should be at least equal to a minimum related to the maximum concentration. The latter minimum depends only on the position, it is independent of the date or duration of the release. The further the source, the bigger its expectable intensity.

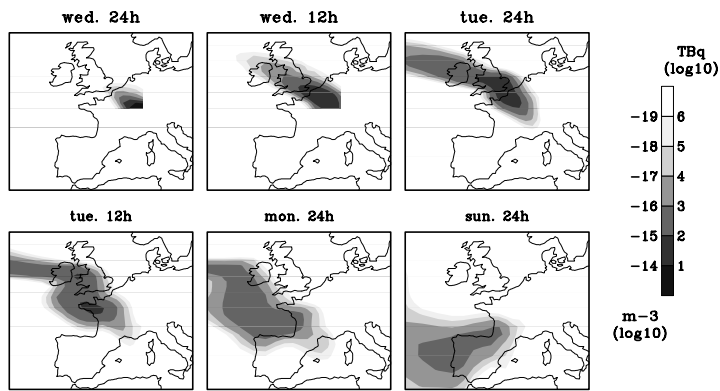


Figure 1: Retroplume $r_1(\vec{x}, t)$ at ground or sea level from the 100 mBq/m³ peak in Freiburg on 2000/02/03. The air sampled between 10 and 2 UT is spread back in time. The intensity q of a point source in $(\vec{x}, t)$ is inversely proportional to the corresponding concentration of this air according to the relation : $100 \text{ mBq/m}^3 = qr_1(\vec{x}, t)$. Analyzed wind fields from ECMWF.

In the situation of interest, the retroplume first goes northwest where moderate sources could be proposed. When it turns southwest on Tuesday and Monday, it is already so diluted that only unrealistic sources could be expected from southwest Europe. As might be expected, additional measurements become additional

constraints leading through adequate mathematics to a more restrictive, larger value of the above minimum. This diagnostic clearly excludes all sources outside an axis northwest from Freiburg.

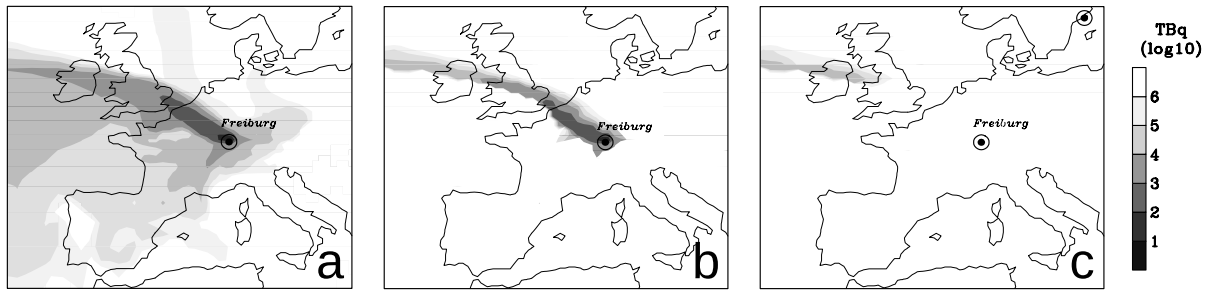


Figure 2: A point source in $\vec{x}$ at ground or sea level may be represented by a rate of release $s(t)$ in such a way that $s(t) \geq 0$ $100 \text{ mBq/m}^3 = \int s(t)r_1(\vec{x}, t)dt$. A: The minimum for the total release $\int s(t)dt$ from a point source in $\vec{x}$ is merely determined by the maximum value of $r_1(\vec{x}, t)$. B: The minimum intensity for a release in $\vec{x}$ compatible with the three measurements performed in Freiburg between 18-2 and 18-2 UT (respectively labelled 0, 1, 3) is determined using the simplex algorithm with the following constraints: $s(t) \geq 0$; $\int s(t)r_0(\vec{x}, t)dt \approx 5 \text{ mBq/m}^3$; $\int s(t)r_1(\vec{x}, t)dt \approx 100 \text{ mBq/m}^3$; $\int s(t)r_3(\vec{x}, t)dt \approx 10 \text{ mBq/m}^3$. C: An imaginary 100 mBq/m^3 measurement performed in Stockholm the 2000/02/05 would eliminate the eventuality of a weak source near Freiburg.

4. Conclusion

One should notice that successive measurements in Freiburg could be explained by a source composed of successive little releases in the neighborhood. It will be so whenever all measurements are from a single station. The local or remote character of the source, and accordingly its intensity, can be decided only with relevant measurements from another station or other independent information.

When several stations will simultaneously detect abnormal concentrations the question will arise whether this set of data corresponds to several local events or to a single important one. In the first case the data will hardly be all compatible with any single point source, the thresholds calculated will be infinite or undetermined. In the second case the coherence in the data will be emphasized, the intensity and area to be investigated will be restricted appropriately.

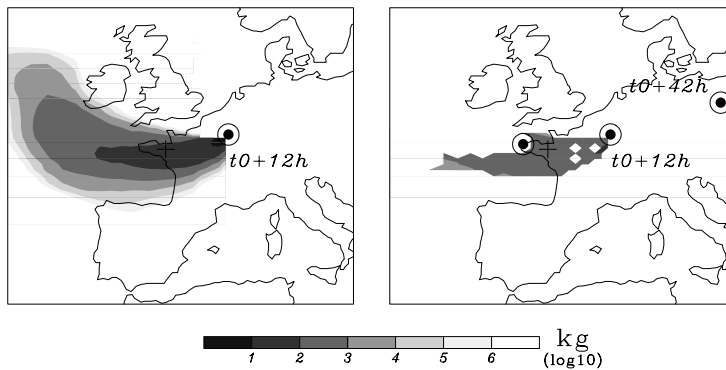


Figure 3: Validation of the method with data from ETEX. The source, 340 kg of inert pmch, was released on 1994/10/23 in Monterfil (cross on the maps) during twelve hours after $t_0 = 16$ UT. The position and date of the measurements taken into account are described on the figures. The thresholds obtained for sources in Monterfil are correct : 90 kg for the left figure, 240 kg for the right figure. Observe on the right figure that the sequence of zero measurements in Brest eliminate most possible sources westward.

References

- Hourdin, F. and Issartel, J.-P., 2000: Sub-surface nuclear tests monitoring through the CTBT xenon network. *Geo. Res. Letter*, **27**(15), 2245–2248.
- Pudykiewicz, J. A. 1998: Application of adjoint tracer transport equations for evaluating source parameters. *Atmos. Env.*, **32**(17), 3039–3050.