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Emergence of a tracer source from air concentration measurements, a new strategy for linear assimilation

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Abstract. The measurement of atmospheric concentrations by a monitoring network is a promising tool for the identification of the widespread sources of trace species. The paper addresses the case of the species scattered linearly by a known meteorology. The question is classical: what can be said about the source from a set of measurements? Is it possible to guess from the values observed by the measurements that the source is spread close to the detectors, or that the tracer comes from a remote region? And, if the source was a point source, would it be possible to understand it by just considering these values? A part of the answers is a matter of practical sense: the resolution with which an emission can be retrieved will always be limited and probably lower for a remote region, even if the detectors and dispersion model are error free. The paper proposes a linear strategy of inference: to any set of values taken by the observed concentrations is associated linearly an estimate of the source. Doubled values lead to a doubled estimate. The method, based on adjoint techniques, is intended to optimise the resolution by quantifying, with the concept of illumination, which regions are well, poorly or not seen at all. The illumination tied to ordinary adjoint functions becomes excessive close to the detectors thus leading to inversion artefacts. This may be corrected by attributing each point of the space time domain a geometric and statistical weight. The adjoint functions are transformed. The choice of this renormalising function is constrained by an unambiguous entropic criterion preventing any overestimation of the available information that would lead to artefacts. It amounts to evenly distribute the information between the points organised with their weights as a "known domain". The theory is illustrated by calculations performed with the experimental source ETEX1.

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