A TRAJECTORY STATISTICAL METHOD FOR THE IDENTIFICATION OF SOURCES ASSOCIATED WITH CONCENTRATION PEAK EVENTS

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INTRODUCTION

The analysis of source regions and their contributions to receptors is an important tool in the development of effective control strategies.
Receptor modelling techniques, based on Air Trajectories Analysis, indicate the linkages between sources and receptors and evaluate the probability of source location.
The results of the Trajectory Statistical Methods (TSMs) can be interpreted as spatial distributions of potential source.
We introduce a statistical methodology that, starting from the Concentration Field method, takes into account only the peak values in the concentration time series measured at multiple receptor sites.
We evaluate the performance of our approach using virtual simulations.

AIR TRAJECTORIES ANALYSIS – BRIEFLY REVIEW

•**Residence Time (RT) Analysis** (Ashbaugh L.L, 1983) is based on the estimation of the probability P[A] of finding a randomly selected air parcel in a given position during a given time period, along the pathway between source regions and receptor sites:

$$P[A_{ij}] \approx \frac{n_{ij}}{N}$$

where n_{ij} is the number of positions of the air parcels that, at each time increments, fell in the ij^{th} cell during a time interval T, and N is the total number of endpoints computed for the time interval. P [A_{ij}] represents the **residence time** of a randomly selected air parcel in the ij^{th} cell relative to the total time interval T.

• The **Potential Source Contribution Function (PSCF)** (Zeng and Hopke, 1989) calculates the conditional probability of the event B_{ij} (trajectories that arrived at the receptor site with pollutant concentration higher than a prescribed value) given that the event A_{ij} (randomly selected air parcel in the ij^{th} cell relative to time period T) occurs:

$$P[B_{ij} \mid A_{ij}] = \frac{P[B_{ij}]}{P[A_{ij}]} = \frac{m_{ij}}{n_{ij}} = \frac{\sum_{l=1}^{M_t} \tau_{ijl}}{\sum_{l=1}^{M} \tau_{ijl}}$$

where n_{ij} is the number of endpoints into the ij^{th} cell during the period T, m_{ij} are the endpoints corresponding to the trajectories that arrive at the receptor site with pollutant concentration higher than a prescribed value, M is the total number of trajectories, M_t is the total number of trajectories arriving to the receptor point when concentration is above the threshold value, and τ_{ijl} the time spent in grid cell *(i,j)* by trajectory *l*.

• The **Concentration Field method (CF)** (Siebert, P. et al., 1994) uses the pollutant concentration measured at receptor points to weight the residence time and computes the logarithmic mean concentration for each grid cell of the domain of trajectories simulation:

$$C_{ij} = \frac{1}{\sum_{l=1}^{M} \tau_{ijl}} \sum_{l=1}^{M} \log(c_l)\tau_{ijl}$$

where l is the index of trajectory, M the total number of trajectories, c_l the concentration observed on arrival of trajectory l and τ_{ijl} the time spent in grid cell *(i,j)* by trajectory *l*.

PROPOSED METHOD

To evaluate the relationship between peak events in the pollutant concentration, measured at the receptor sites, and source emission intensity, we propose the following modified CF method, herein called **Peak Events Concentration Field (PECF)**:

$$C_{ij} = \frac{1}{\sum_{l=1}^{M_t} \tau_{ijl}} \sum_{l=1}^{M_t} \log(c_l)\tau_{ijl}$$

where *(i,j)* are the indices of the horizontal grid, l the index of trajectory, M_t the total number of trajectories that arrive at the receptor site when pollutant concentration is higher than a prescribed value, c_l the concentration observed on arrival of trajectory l and τ_{ijl} the time spent in grid cell *(i,j)* by trajectory *l*.

- includes the residence times of trajectories only when the measured concentration field, at the receptor sites, is above a given threshold value;
- there is no need to compute all the trajectories for all time values of the concentration at the receptor sites.

NUMERICAL SIMULATIONS

simulation domain: (5°E to 42°30'E,41°N to 61°N)
simulation period: march 2006

1. Forward simulations (FLEXPART model, Stohl, A. et al., 2005):
Input: wind field from ECMWF: dx = dy = 0.25°, temporal resolution = 3 h,
source: areal (10^6 inert particles), height: 0-500 m, continuous release.
Output: hourly daily tracer concentrations.

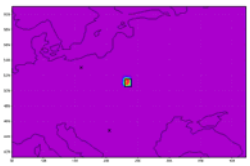

Fig. 1: Simulation domain used for backward and forward simulations. The square indicates the source region, crosses indicate the receptor points.

2. Five days backward simulations (FLEXPART model, Stohl, A. et al., 2005):
Input: wind field from ECMWF: dx = dy = 0.25° , temporal resolution = 3 h,
source: puntual (10^3 inert particles) in corresponding to receptor's position, duration of release = 30 min, height: 0-500 m.
Output: hourly residence time.

3. CF, PSCF, PECF postprocessing:
Input: hourly residence time,
daily concentration value integrated between 0-500 m.
Output: source spatial distribution.

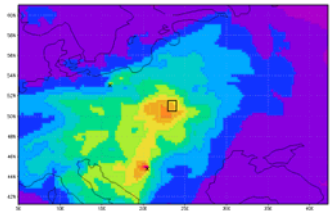

Fig. 2: Source spatial distribution from the CF method.

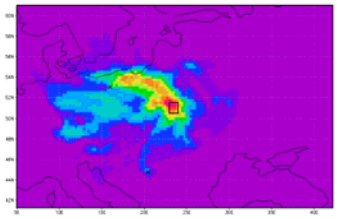

Fig. 3: Source spatial distribution from the PSCF method.

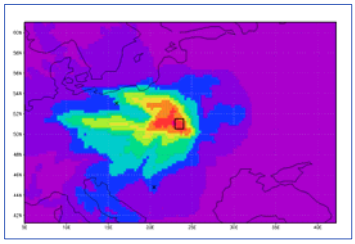

Fig. 4: Source spatial distribution from the PECF method.

CONCLUSIONS

- PECF method overcome the problem of ghost sources in the wake of the real emission source, at least for the used configuration of receptor points;
- much faster simulations with respect to the other approaches.

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