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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Report on import/export budgets from the Po-Valley area at the regional and global scales

Introduction

The purpose of this report is the evaluation of the import/export budget of the Po Valley hot spot.

This exercise is performed using the regional model BOLCHEM, for a 1 year period run.

The influence of pollutants released in the Po Valley on the air quality of the surrounding area due to transport is quantified selecting emissions inside and switching off the emissions outside. The reverse (switching off emissions inside and keeping active the ones outside) is made to evaluate the import of pollutants from the surrounding region, identified as the European area.

The model used forces the evaluation to be made at the regional scale. Thus the long range transport from remote areas (for instance Saharan dust) cannot be evaluated with this approach and is deferred to a future work, in which a global model or boundary conditions supplied by a global model will be needed.

The tracer used in the numerical experiment does not react and is not removed by dry or wet deposition. Moreover, it is assumed to have the same emission pattern as CO. Carbon monoxide is representative of vehicular traffic, which is a major pollution source in the Po Valley hot spot, so that our idealized tracer can be assumed to represent broadly the import/export budget of the slowly reacting species associated with transportation pollution.

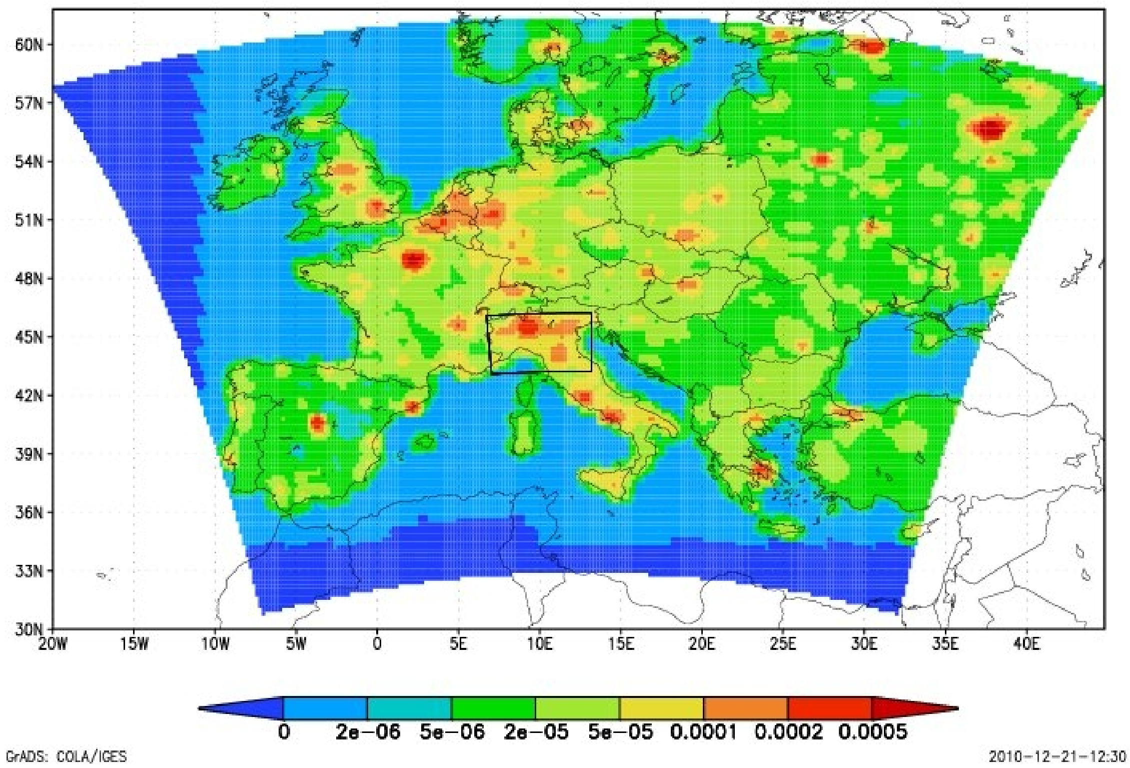

Fig. 1: Emission pattern, averaged for the entire one year period of integration. The large Po Valley area is evidenced. Units are in µg/m^2/h. The box over the Po Valley indicates the geographical boundaries of this region.

Experimental setup

The model BOLCHEM (Mircea et al.,2008), an atmospheric dynamic and composition model in which meteorology and chemistry are coupled online, has been run at a resolution of about 50x50 km^2 with 33 vertical levels (for meteorology) and 16 vertical levels (for chemistry, up to ~500hPa) over the European area (see the domain in Fig.1) for the year 2007.

Two tracer, TR1 and TR2, has been emitted. We will label TR1 the tracer emitted in the Po Valley area and TR2 the one emitted outside. The sum of the two is the emission of CO according to the INERIS inventory, shown in Fig.1. In Fig.2 the average surface concentration of TR1 and TR2 over the year 2007 are shown.

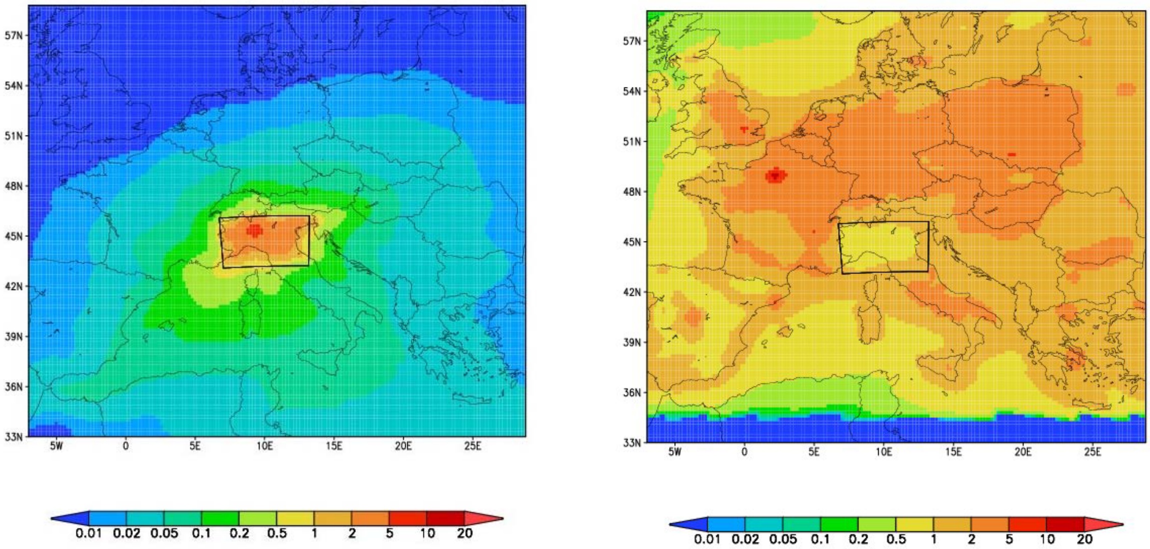

Fig. 2. Year averaged surface concentration of TR1 (left) and of TR2 (right). Units are in μg/m^3.

Results

To evaluate the import/export budgets at regional and global scales we analized the behaviour of the two tracers inside and outside the Po Valley.

Fig.3 reports the total emissions for TR1 and TR2, as well as the total over the entire domain, as function of the day of the year. The amount emitted in the hot spot area is one order of magnitude smaller that the tracer outside, which has obviously an impact on the evaluation of the results. The cumulated amount of emission, corresponding to the one shown in Fig.3, is reported in Fig.4.

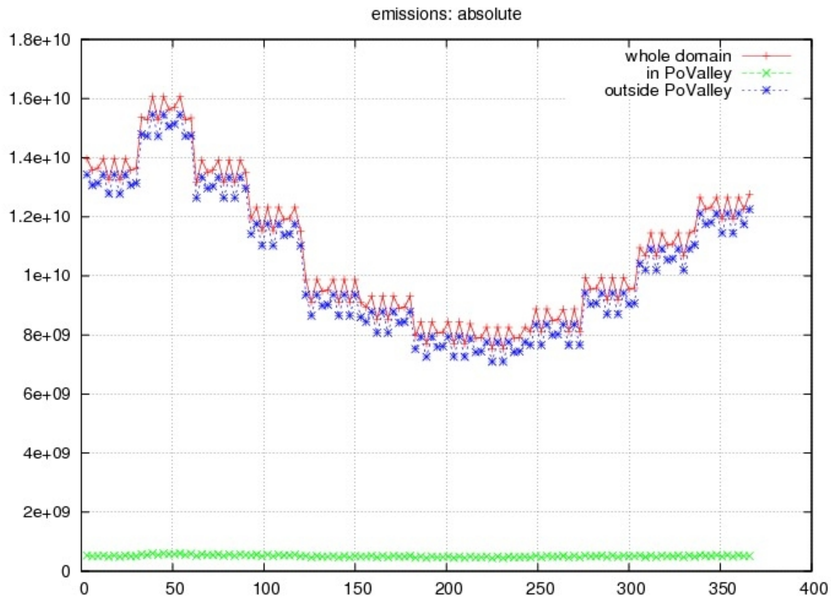

Fig. 3: Total mass emitted per unit day for the tracer TR1 (green), TR2 (blue) and the sum of the two (red) integrated on the whole domain and as a function of the day of the year. Units are μg/day.

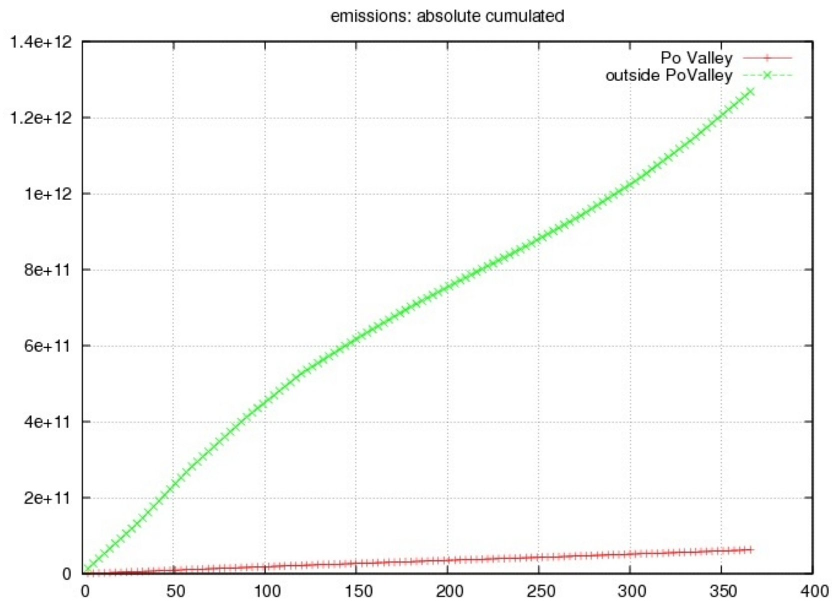

Fig. 4: Cumulated mass emitted for the tracers TR1 (red) and TR2 (green) integrated on the whole domain. Units are in μg.

Fig.5 shows the total mass integrated over the Po Valley, outside it and the total mass in the model volume. Note that the height considered for determining the volume is the total chemical model domain, which is about the middle of the troposphere . The mass inside the hot spot volume reaches in less than 10 days a steady value, which is about 0.15 of the total (see Fig.6). No seasonal trend appears, but some typical transport patterns can be recognized (a few examples are reported in

Fig.9) Note also that the mass exported (outside the Po Valley) overcomes in a few (3) days the mass still present inside, highlighting the effect of transport. In summary, the exported tracer mass is much larger than the the mass remaining inside the Po Valley.

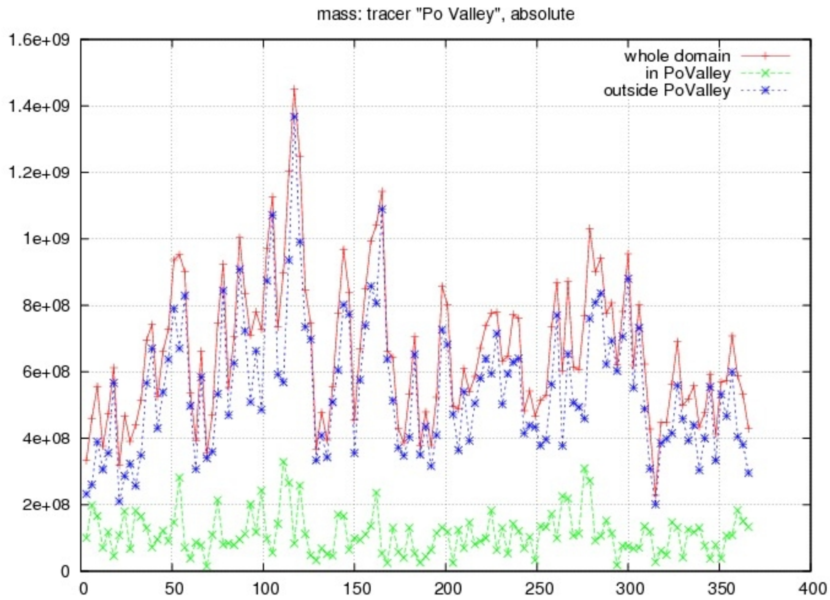

Fig 5: Total mass of TR1 integrated in a volume over the Po Valley (green), outside the Po Valley (blue) and over the whole simulation domain (red). Units are in µg.

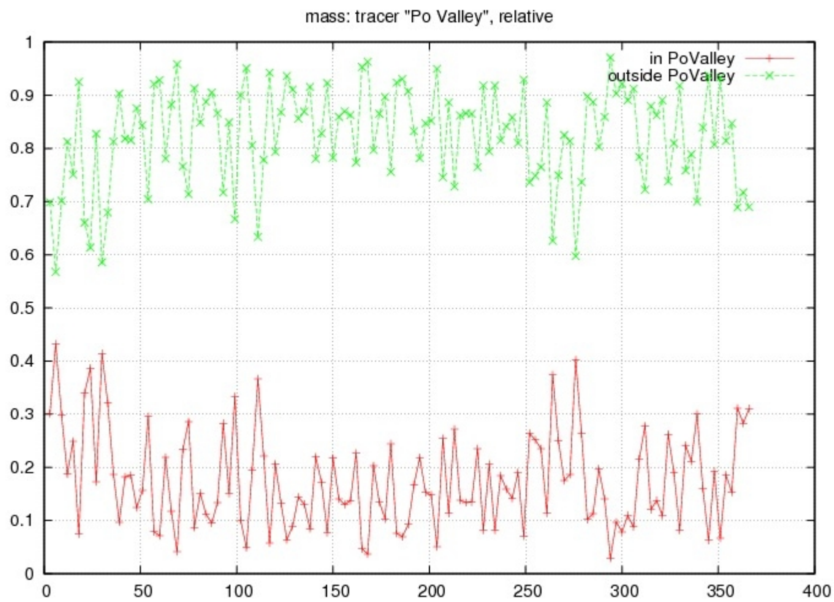

Fig 6: Fractional amount of mass of TR1 in a volume over the Po Valley (red) and outside the Po Valley (green). The sum of the two quantities displayed is normalized to 1.

Since the cumulated emissions increase with time, the substantial steadiness of the total mass means that there is loss of mass at the boundaries.

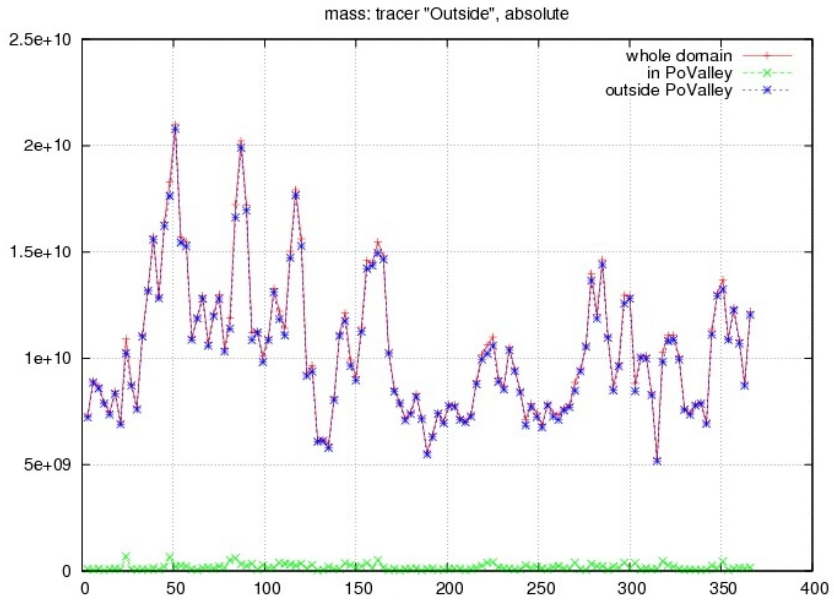

Fig 7: Total mass of TR2 integrated in a volume over the Po Valley (green), outside the Po Valley (blue) and over the whole simulation domain (red). Units are in µg.

The import from the emissions outside is quantified in Fig.7. From this figure clearly results that the imported amount is a small fraction of the total (a few %), but now is relevant the observation made looking at Fig.3. In fact, in the balance in the Po Valley area, as shown in Fig.8, the contribution from outside (the import term) is systematically larger the the contribution from sources present inside, a part of few cases, normally characterised by relatively low values. As a general observation, the peaks of mass in the hot spot (integrated over the entire volume) are due to import from outside emissions.

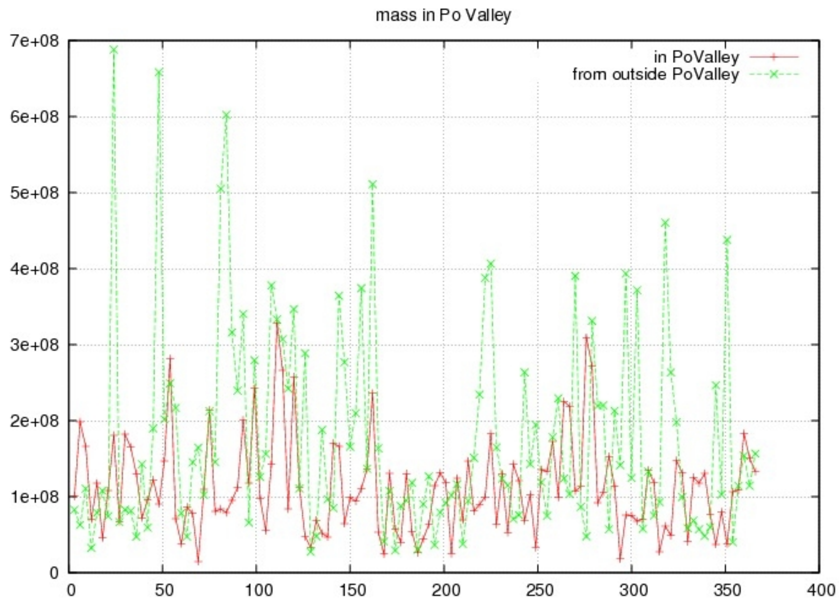

Fig 8: Import term in the Po Valley. The total mass of TR1 in the Po Valley is indicated in red while the total mass of TR2 in the Po Valley is indicated in green. Units are in µg.

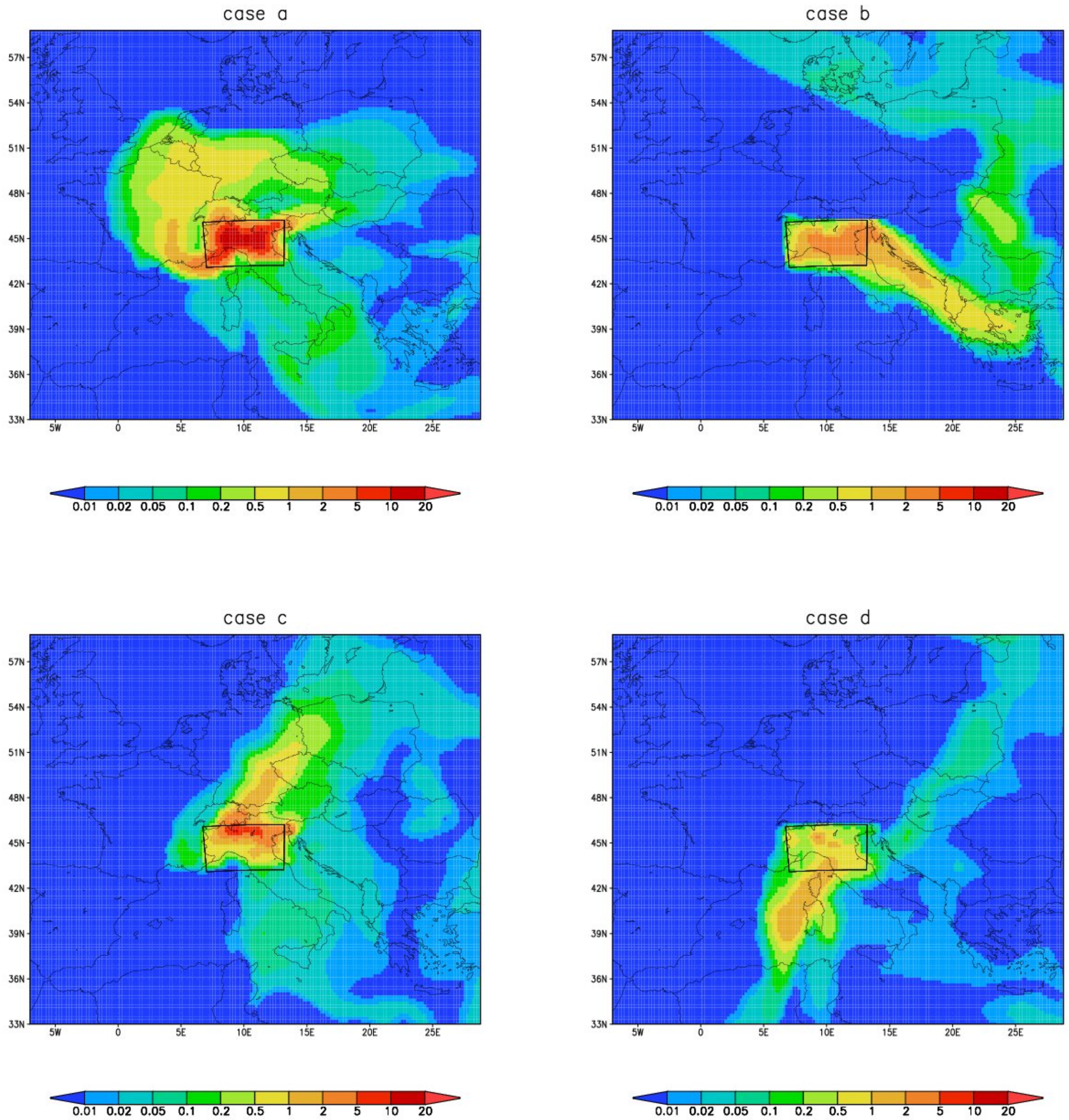

Fig.9: surface concentration (μg/m^3) of TR1 for some cases of transport.

Fig.9 reports four examples of transport (export) of tracer from the Po Valley area. Case a shows intense transport of the tracer TR1 from the Po Valley towards northern Europe along a cyclonic pattern surrounding the Alps. Case b shows an example of transport towards Greece along the Adriatic sea. Case c shown a case of transport over northern Europe with the traces passing directly over the Alps. Case d shows an example of transport from the Po Valley towards the Tyrrhenian sea. It is therefore evident that depending on meteorological factors the patterns are different, but the general observation that can be made is the possibility of intense contamination of the surrounding regions. In particular for cases like Case b and d, when the transport is towards regions where the pollutant is not emitted, the contribution of the Po Valley to the local abundance of the pollutant can become significant.

Conclusions

The budget study shows that the contribution from outside of passive non reacting species can be often larger than the contribution from the inner sources, for the Po Valley hot spot. For the specific year studied here, most peaks are due to the import of tracer.

A second observation is the occurrence of cases characterised by intense transport from the Po Valley area These cases can lead to the presence of pollutants over the Adriatic or Tyrrhenian Sea, and could be detected in Central Europe.