Integrated source apportionment in support of Aosta Valley and Piemonte air quality plans

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Introduction

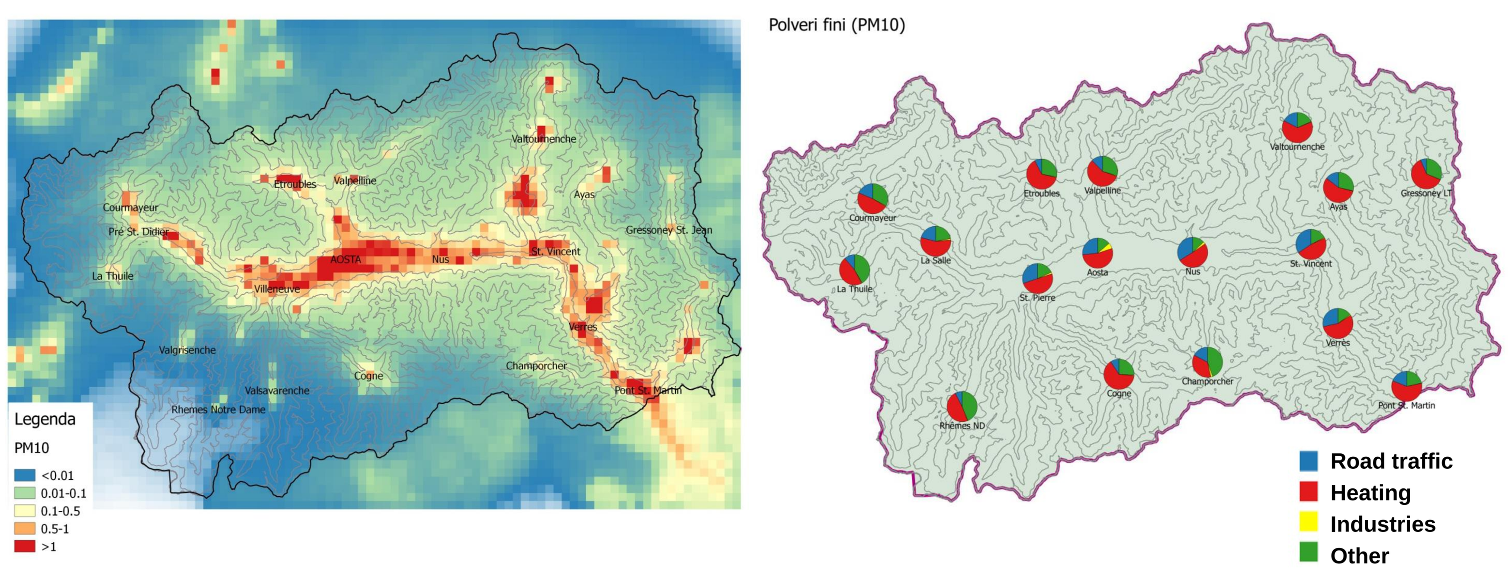
The knowledge of the origin of the main contributions to ambient concentrations is a key precondition for the elaboration of a coherent and effective air quality plan, to focus control actions on emission sources most affecting the pollutant levels, especially in areas where ambient air quality standards are not respected. The attribution of contributions given by multiple emission sources to air concentrations can be achieved by using different methodologies, either receptor-oriented or source-oriented. In the case of Aosta Valley and Piemonte regions, the need of covering different part of the territory, together with the existence of well-established regional modelling systems fed by regularly updated emission inventories, both routinely used for yearly assessments and daily forecasts (see references at bottom), has determined their use also to apportion sources contributions to ambient concentrations.

Methodology

The two regional modelling systems are based on FARM chemical-transport model (Mircea *et al.*, 2014), that has been recently equipped with the BFM integrated facility, allowing to apportion sources contributions on ambient concentrations of any target pollutant using the so called "brute force method", also known as "3D sensitivity runs" (Burr and Zhang, 2011). According to it, multiple simulations with the air quality model are performed, each one of them made using the same input data, except for the emissions from the sets of sources of interest (any desired combinations of sectors and geographic areas), that are cyclically perturbed by a fixed percentage (e.g. -20%). The resulting ambient concentrations from the perturbed runs are then compared against the ones from the reference run, made with unperturbed emissions, leading to concentrations variations. The first-order estimate of the contribution from each set of sources is finally computed as the ratio between the variation obtained for that set and the sum of variations from all sets. To allow such a normalization, the sources sets to be altered have a "completeness" constraint: taken as a whole they must cover all the sources of the area that need to be investigated; when the chosen sets do not meet the constraint, FARM/BFM computes the "remainder set" of emission sources, allowing to complete the needed set of runs. The apportioning facility of the system starts from a formal description of the desired emissions sets, eventually complete them through a scan of the input emission inventory, perform the sensitivity runs with altered emissions and post-process the results to obtain the contributions estimates.

Case study of the Aosta Valley

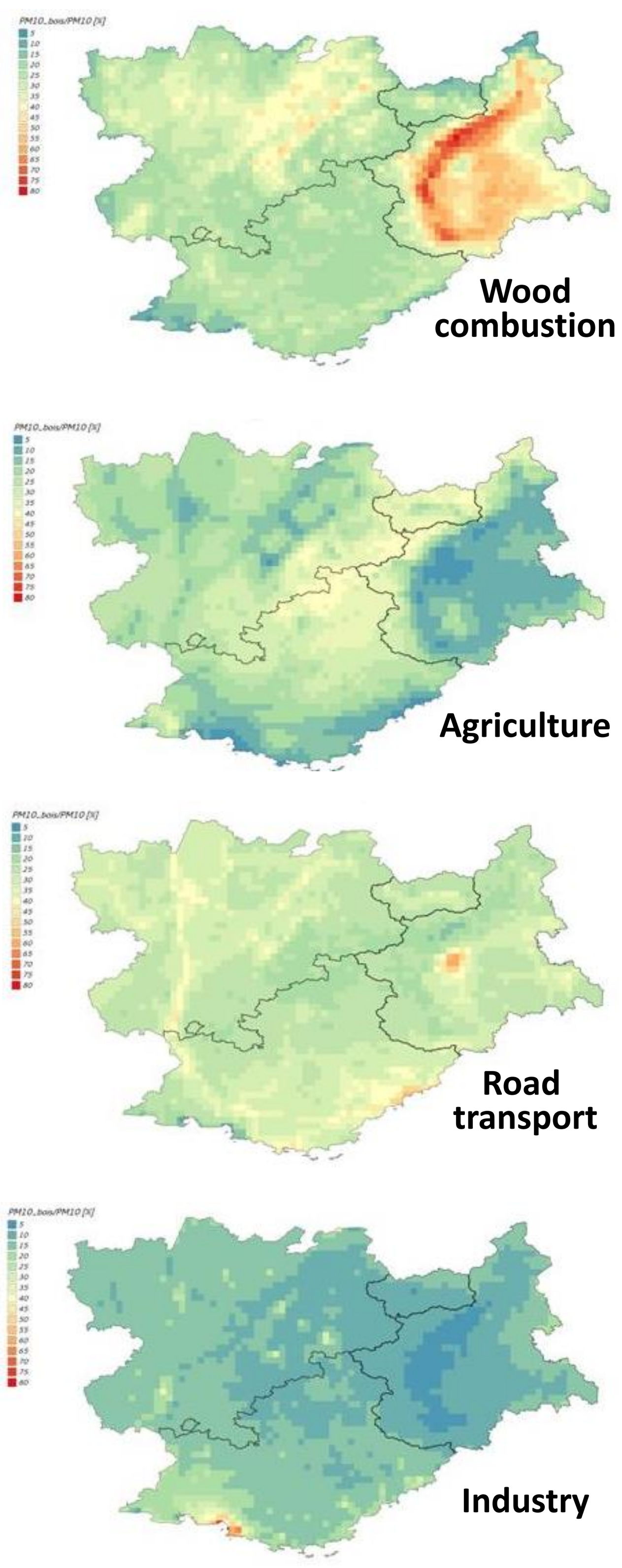
This approach was applied to the modelling domain of Aosta Valley Region, 90*60 km wide with 1 km resolution, covering the adjacent parts of Italy, France and Switzerland. The first map shows as an example the variation of PM10 yearly concentrations over Aosta Valley resulting from the sensitivity run for domestic heating emissions, evidencing the role played by the built-up areas in the central valley but as well the smaller centers in the lateral valleys, as a result of region morphology and meteorology, population distribution and related heating emissions.



Variation of PM_{10} concentrations produced by sensitivity run on domestic heating sector (left) and PM_{10} main sources contributions at selected locations in Aosta Valley Region (right).

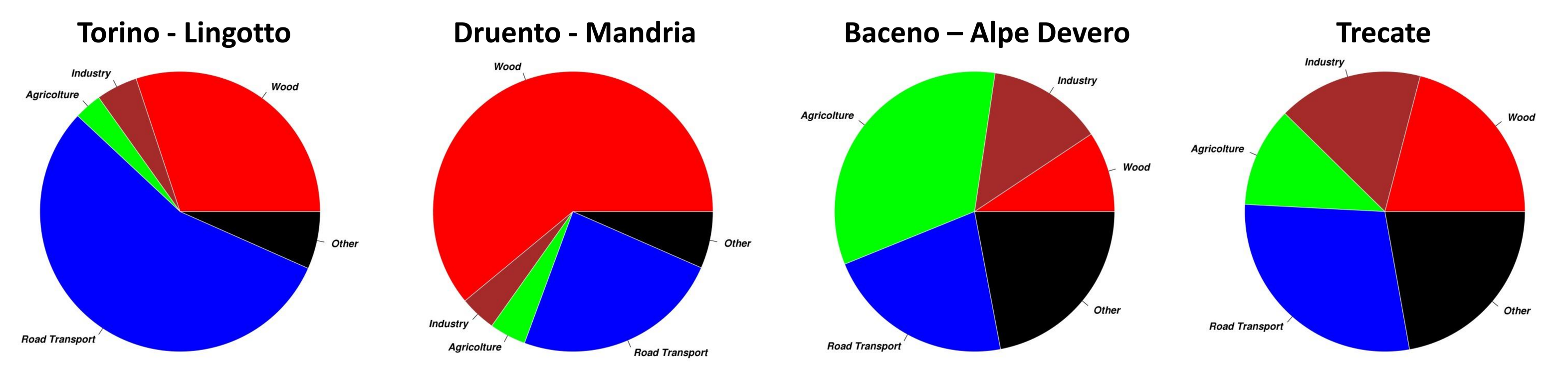
The combination of similar runs for the other sectors allowed to estimate their relative contributions to ambient concentrations, as shown in the next map for PM10 at different locations in the region.
Peculiarities were evidenced for the different pollutants and areas: the heating sector is the dominant sector for PM_{10} concentrations over most of the region (also due to the use of biomasses, as you see in the second map) and for NO_2 concentrations in the lateral valleys; road traffic otherwise plays the dominant role for NO_2 in the main valley (also linked to the presence of a major highway connecting Italy and France), and is by far the main contributor to benzene concentrations; the few industrial activities in the region give limited contributions to NO_2, PM_{10} and SO_2 concentrations in parts of the main valley; other sectors (painting activities, off-road transport, animal husbandry) play local roles for specific pollutants.

Case study of Piemonte Region in the SH'AIR Project



In the SH'AIR Project (ALCOTRA Program) the BFM method was applied to assess the contribution of different sources in a transboundary French-Italian domain - covering Piemonte, Aosta Valley, PACA and Rhône-Alpes regions – with 6 km resolution. The emission sources have been grouped in 5 activity sectors: wood combustion (both residential and industrial), agriculture (animal breeding included), road transport, industry (except wood combustion) and the rest of sectors. The main contribution to concentrations of particulate matter in ALCOTRA domain is due to biomass combustion in winter, especially in Alpine and Prealpine areas. During winter vehicular traffic contribution is also important in the urban areas and near main road axes (see maps at left). During summer, road transport is the most significant source, reaching up to 70% contribution in the major cities.

The sectorial source apportionment results for the Piemonte Region highlights that regional air quality plans must consider different measures in different areas and take into account of local peculiarities (examples in pie charts below): traffic in urban centers (Torino), wood residential heating in suburban areas (Druento – Mandria), farming in remote territories (Baceno – Alpe Devero), and a mix of measures in industrial districts (Trecate).



Conclusion

Source apportionment based on 3D chemical-transport models and emission inventory currently in use allowed to obtain a clearer picture of contributions from main emissions sectors to ambient concentrations in different parts of the territory. Specificities found by area and pollutant will help the regional stakeholders in focusing the actions of their plans aimed at improving the air quality levels of the territories of competence, as also requested by EC. Further comparison with receptor models on speciated PM at selected points is on course.

References & links

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SH'AIR Project: http://www.shair-alcotra.eu