Modelling emission scenarios variations: an inert-mode CALGRID long-term application over the Florence metropolitan area to improve PM_{10}–related air quality standards

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Abstract: - The RAMS-CALMET-CALGRID modelling system developed by the LaMMA consortium has been used as a supporting tool in the framework of the "MODIVASET" project promoted by the Tuscan Regional Government with the aim of modelling emission scenarios variations. The system is based on the RAMS meteorological model forecasting and the CALGRID photochemical grid dispersion model, being suitably modified for the present work to be applied for inert pollutants. As a matter of fact, the attention was paid to particulate matter (PM_{10}) primary component, as well as Nitrogen Dioxides (NO_x), which is one of main precursors of PM_{10} secondary inorganic component. Both pollutants have been treated as inert ones.

A one-year long-term application of RAMS-CALMET-CALGRID has been carried out over the Florence metropolitan area, Italy. The study area is 49x40 Km^2 wide, featuring a 1-Km spaced 3-D computational grid.

The main project's aim is to assess possible air quality improvements after a number of interventions on emission scenarios have been planned by local authorities. Therefore, basing on IRSE regional emission inventory, two PM_{10} and NO_x emission scenarios have been set: a present one, updated to 2003, and a future one, projected to years 2010-2012, where "business as usual" emission variations are supposed to occur. All types of emission sources have been taken into account, i.e. point, line and area (split into 4 sub-categories) ones. This enabled single contributions brought by any to be assessed, as well as the overall one. Summarizing, a total of 28 run combinations (2 scenarios by 2 pollutants by 7 source categories) have been performed by the modelling system.

CALGRID-calculated PM_{10} and NO_x concentrations resulting from present and future emission scenarios have been compared, both in terms of spatial pattern over the study area and local one to a number of chemical stations. The final result was a general NO_x concentration reduction in the order of 10÷35%, particularly effective over the Florence and Prato urban areas. On the contrary, primary PM_{10} concentrations proved to decrease, about 15% over the Florence urban area, as well as increase, 10÷15% over the mountainous area Northwest to Pistoia.

Summarizing, the proper use of an integrated modelling system proved to be a fundamental tool for planning emission scenarios variations to improve air quality standards. Moreover, methodologies implemented and results achieved in the present paper are in agreement with other similar scenarios analysis works.

Key-Words: - Air quality planning, Emission scenarios, Dispersion models, PM_{10}, NO_x, CALGRID, RAMS, Florence.

1 Introduction

The Tuscan Regional Government launched the "MODIVASET" project with the aim of planning emission scenarios variations focused on air quality improvement policies. To achieve the project's main goals, the LaMMA consortium was involved through the application of a modelling system based on the CALMET [3] and CALGRID [4] models, starting from the RAMS [5] meteorological model forecasting. For the present work the CALGRID model has been suitably arranged to be used in an inert mode. As a matter of fact, the attention was generally paid to particulate matter (PM_{10}), and particularly to PM_{10} primary component, as well as Nitrogen Dioxides (NO_x), which proved to be one of main precursors of PM_{10} secondary inorganic component. Both pollutants have been treated as inert ones.

A long-term application of RAMS-CALMET-CALGRID has been carried out over the Florence metropolitan area, Italy, on a one-year time period.

Basing on IRSE regional emission inventory [2], two PM_{10} and NO_x emission scenarios have been planned by local authorities: a present one, updated to 2003, and a future one, projected to years 2010-2012, where "business as usual" emission variations are supposed to occur.

All types of emission source categories have been taken into account, i.e. point, line and area (split into 4 sub-categories) ones. This enabled single contributions brought by any to be assessed, as well as the overall one.

Thus, a total number of 28 run combinations have been performed by the modelling system: 2 scenarios by 2 pollutants by 7 source categories (where the 7th one is the "total" category).

2 Model description

The working scheme of the RAMS-CALMET-CALGRID modelling system applied in the present study is shown in Fig.1. It is made of a meteorological section, including the RAMS and CALMET models, the IRSE-based emission block, and the inert-mode CALGRID dispersion model, designed to calculate PM_{10} and NO_x concentrations.

CALGRID is an Eulerian transport and diffusion grid model specifically conceived to manage photochemical pollution, featuring a number of modules to fully reproduce all chemical and photochemical reactions involving the ozone precursor species. As a matter of fact, the RAMS-CALMET-CALGRID system has already been used for assessing ozone pollution over Tuscany region [1]. In the present work, on the contrary, a suitable modification has been made to CALGRID code in order to enable the model to be used in an inert mode, that is for NO_x and primary PM_{10}. Thereby, all CALGRID chemical modules have been disabled and the model applied as a mere Eulerian grid one.

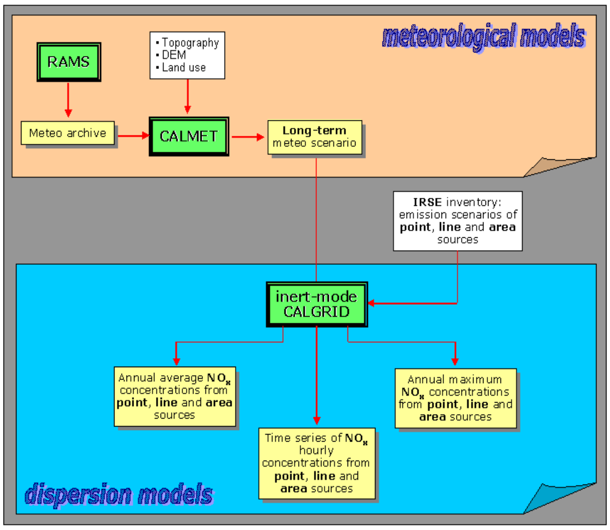

Fig.1: Architecture of the applied RAMS-CALMET-CALGRID modelling system.

3 System application features

3.1 Overview

Fig.2 shows the map of the study area, which is the Florence metropolitan one, located in Tuscany, Italy, and also including the cities of Prato and Pistoia. This is the most populated Tuscany area, affected by about 1,500,000 inhabitants (about the 42% of total in the region) and a number of different emission sources, such as both small and large industries, the Florence international airport, a crucial link of the motorway connecting Rome to Milan, and the motorway leading from Florence to the seaside. In addition, it also includes the Montelupo industrial district, near the town of Empoli.

As far as model application features are concerned, the study area is 49x40 Km^2 wide, made of a 1-Km spaced 49x40 computational grid with 12 terrain-following vertical levels ranging from 10 to 2860 m.

The long-term model application was carried out all over the year 2002 with a 1-hour time step.

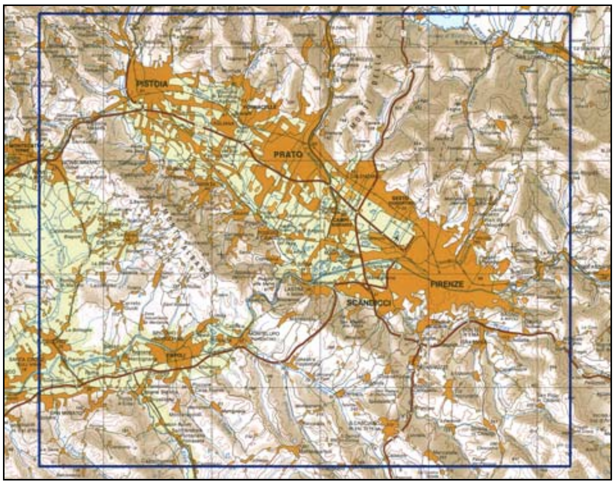

Fig.2: Topographic map of the study area.

3.2 Meteorological input

The meteorological input of the application was given by the 4-Km spaced forecasting performed by the RAMS prognostic model. RAMS outputs are a number of vertical profiles, which later have been downscaled to 1 Km by the CALMET diagnostic model.

As an example, Fig.3 shows the wind rose spatial pattern at 10 m a.g.l. over the study area based on RAMS model outputs through the year 2002. Wind roses show NE and SW sectors to be the most frequent ones over the Florence metropolitan area, while winds basically bearing from ENE and WSW mostly occur over the Empoli and Montelupo area.

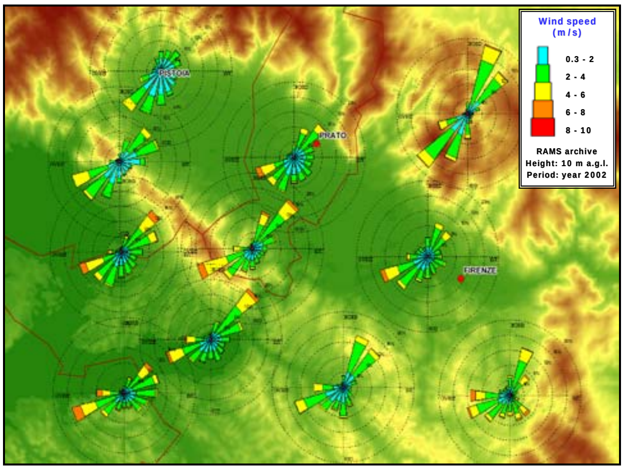

Fig.3: 10-m wind rose spatial representation based on RAMS model outputs (year 2002).

3.3 Emission scenarios setup

Basing on IRSE regional emission inventory [2], two PM_{10} and NO_x emission scenarios have been set: a base, present one, named "Scenario 0" and updated to 2003, and a future one, named "Scenario 1" and projected to years 2010-2012, where "business as usual" emission variations have been planned depending on social, economic, territorial and energetic indicators.

All types of emission source categories have been taken into account, as summarized in details in Table 1.

Table 1: Summary of PM_{10} and NO_x emission source categories taken into account (IRSE inventory).

No.	Code	Category	Sub-category	Description
1	PUNT	Point	-	Larger industries
2	LIN	Line	-	Major traffic routes (motorways)
3	DIFF_IND	Area	Industries	Smaller industries classified as area sources
4	DIFF_RIS	Area	Heating and cooling plants	Domestic heating and cooling classified as area sources
5	DIFF_MOB	Area	Local traffic routes	Local traffic routes classified as area sources
6	DIFF_ALT	Area	Other area sources	Other area sources
7	TOT	Total	-	All sources

In Fig. 4 the location of PM_{10} and NO_x point sources (No.1, coded as "PUNT") are plotted, including all the larger industries over the study area (15 in total). It is to be pointed out that no variation has been planned for point sources from present to future scenario.

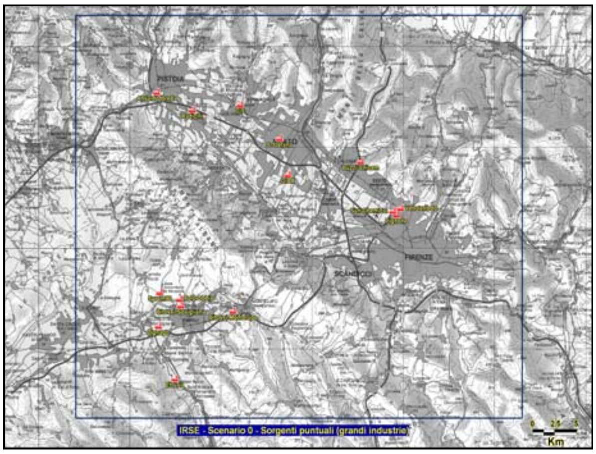

Fig.4: Location of "PUNT" PM_{10} and NO_x point emission sources: larger industries, scenarios 0 and 1 (IRSE inventory).

3.3.1 NO_x

Figs. 5 and 8 show the 1-Km gridded area sources of NO_x related to domestic heating and cooling (No.4, coded as "DIFF_RIS") as extracted by the IRSE inventory for scenarios 0 and 1, respectively. On the other hand, Figs. 6 and 9 show the gridded area sources of NO_x emissions resulting from local vehicular traffic (No.5, coded as "DIFF_MOB"). NO_x emission rates are plotted as well, showing for both types of sources a slight decrease when comparing scenario 1 to scenario 0.

As a summary, in Figs. 7 and 10 the aggregated "LIN" (No.2) and "DIFF" (Nos. 3-6) 1-Km gridded sources of NO_x are plotted for both scenarios. Actually, they include the overall emissions of line and area sources except for point sources. Thereby, since no emission variation is planned for the latter, the Fig.7 vs. Fig.10 comparison clearly highlights the related emission reduction.

3.3.2 PM_{10}

In Figs. 11 and 14 the gridded area sources of PM_{10} due to domestic heating and cooling (No.4, coded as "DIFF_RIS") are plotted as extracted for scenarios 0 and 1, respectively. In this case a general PM_{10} emissions increase occurs when considering the scenario 1 pattern against scenario 0. Figs. 12 and 15 show PM_{10} emission rates resulting from motorways (No.2, coded as "LIN") for both scenarios. The related PM_{10} emissions exhibit a general reduction once interventions planned for the future scenario would be effective.

Eventually, Figs. 13 and 16 show the aggregated "LIN" and "DIFF" 1-Km gridded emission sources of PM_{10} for both scenarios. Because of the above mentioned increase in "DIFF_RIS" emission sources, a decrease as well as an increase this time occur when comparing Fig.16 to Fig.13.

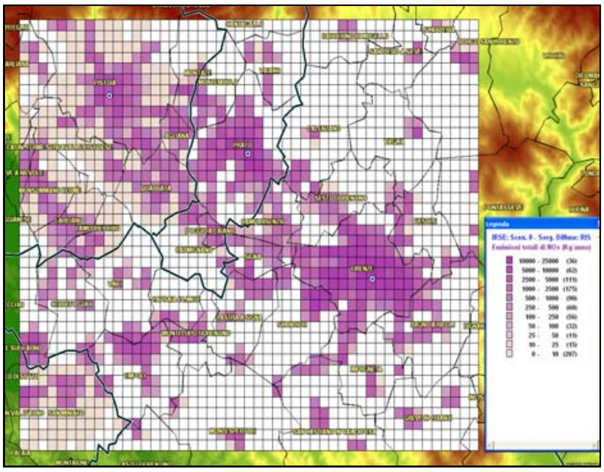

Fig.5: Location and rates of “DIFF_RIS” 1-Km gridded NO_x area emission sources: domestic heating/cooling, scenario 0 (IRSE inventory).

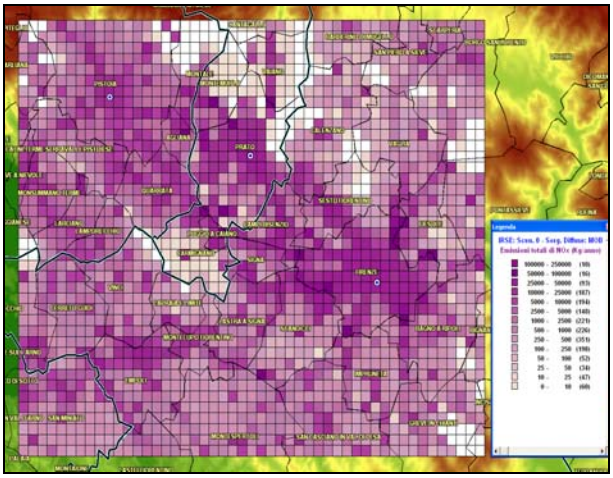

Fig.6: Location and rates of “DIFF_MOB” 1-Km gridded NO_x area emission sources: local vehicular traffic, scenario 0 (IRSE inventory).

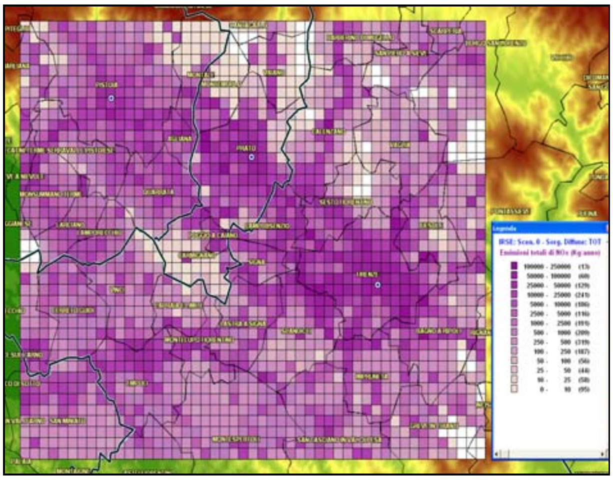

Fig.7: Location and rates of aggregated “LIN” and “DIFF” 1-Km gridded NO_x emission sources: line and area sources, scenario 0 (IRSE inventory).

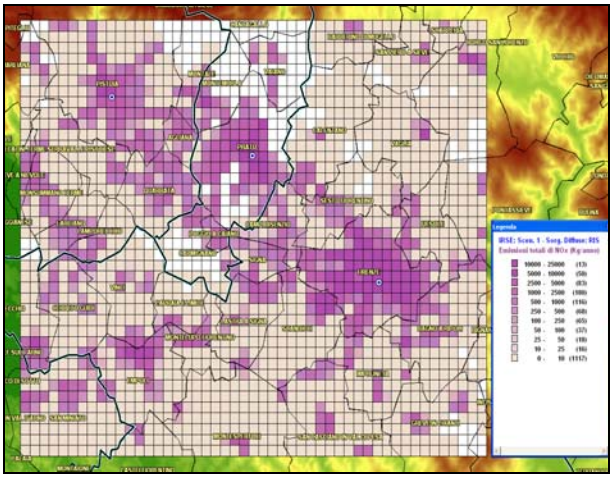

Fig.8: Location and rates of “DIFF_RIS” 1-Km gridded NO_x area emission sources: domestic heating/cooling, scenario 1 (IRSE inventory).

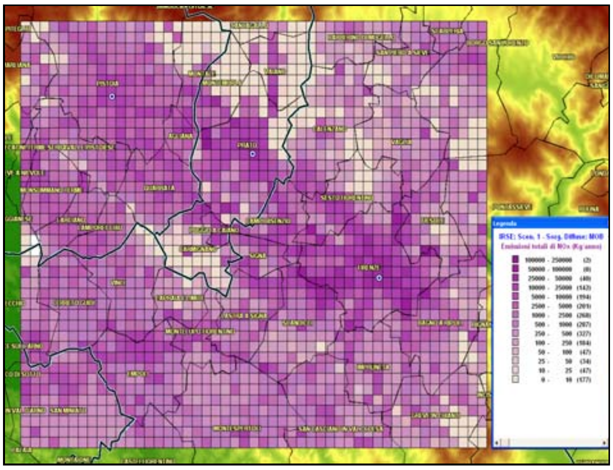

Fig.9: Location and rates of “DIFF_MOB” 1-Km gridded NO_x area emission sources: local vehicular traffic, scenario 1 (IRSE inventory).

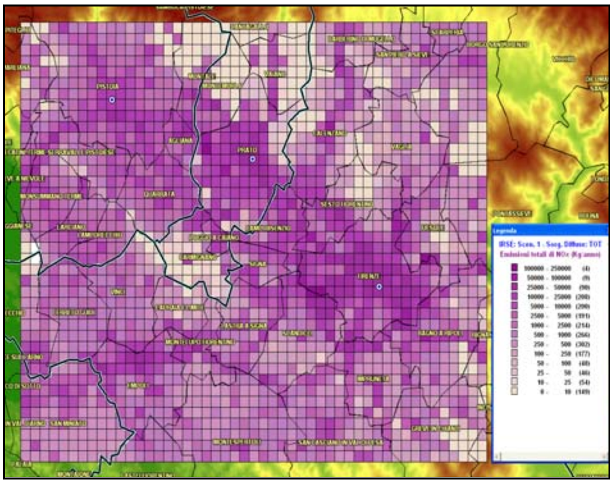

Fig.10: Location and rates of aggregated “LIN” and “DIFF” 1-Km gridded NO_x emission sources: line and area sources, scenario 1 (IRSE inventory).

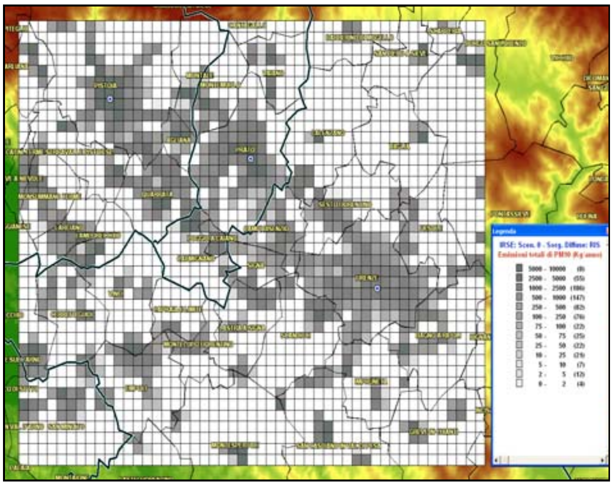

Fig.11: Location and rates of “DIFF_RIS” 1-Km gridded PM_{10} area emission sources: domestic heating/cooling, scenario 0 (IRSE inventory).

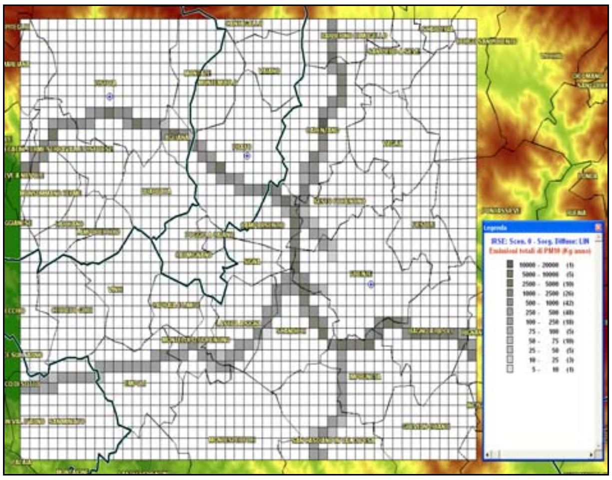

Fig.12: Location and rates of “LIN” 1-Km gridded PM_{10} line emission sources: motorways, scenario 0 (IRSE inventory).

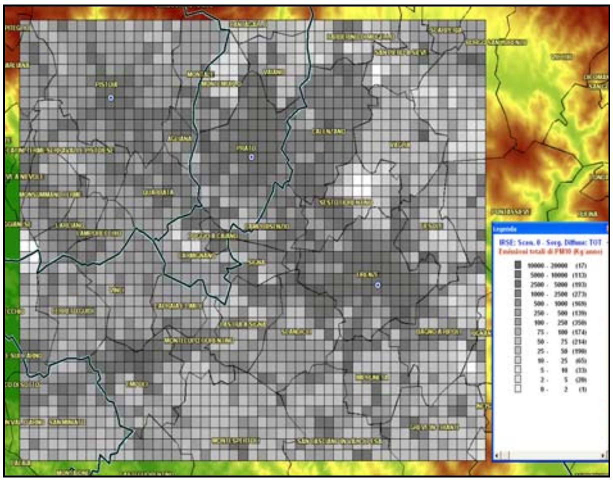

Fig.13: Location and rates of aggregated “LIN” and “DIFF” 1-Km gridded PM_{10} emission sources: line and area sources, scenario 0 (IRSE inventory).

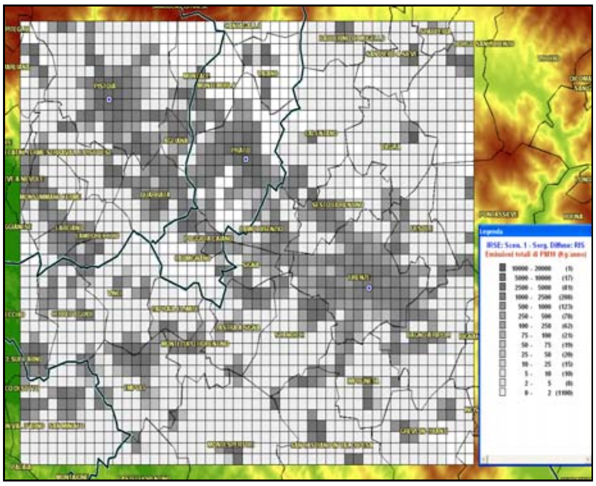

Fig.14: Location and rates of “DIFF_RIS” 1-Km gridded PM_{10} area emission sources: domestic heating/cooling, scenario 1 (IRSE inventory).

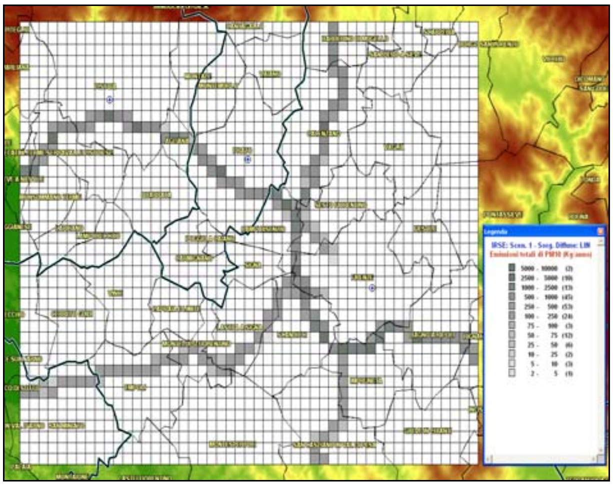

Fig.15: Location and rates of “LIN” 1-Km gridded PM_{10} line emission sources: motorways, scenario 1 (IRSE inventory).

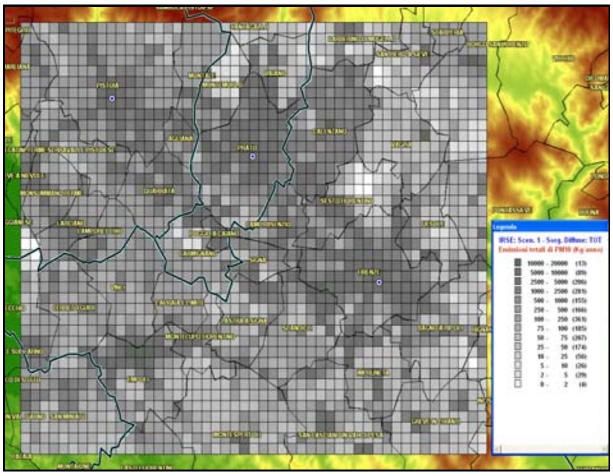

Fig.16: Location and rates of aggregated “LIN” and “DIFF” 1-Km gridded PM_{10} emission sources: line and area sources, scenario 1 (IRSE inventory).

4 Analysis of results

4.1 Spatial pattern of calculated concentrations

A detailed analysis of results performed by inert-mode CALGRID model was made in terms of spatial contributions to annual mean and maximum concentrations of NO_x and primary PM_{10} resulting from any single emission source (see Table 1).

4.1.1 NO_x

Figs. 17 and 18 show the calculated NO_x annual mean concentrations as disaggregated by source category resulting from scenarios 0 and 1, respectively.

Focusing on Fig.17, point sources proved to play the major role to NO_x concentrations, particularly over the Montelupo industrial district (Fig.17-1). Another remarkable contribution is the one due to local vehicular traffic (Fig.17-5), which involves the whole study area. On the contrary, contributions resulting from other sources can be reckoned as negligible, apart from a slight one from line sources (Fig.17-2).

The scenario 0 vs. scenario 1 comparison shows a general NO_x concentration decrease when considering the latter (Fig.18). Despite no emission variation was planned for point sources (Figs. 17-1 and 18-1), the contributions from all other sources proved to decrease, both in peak values and spatial extent.

A global comparison overview can be achieved by means of Figs. 21 and 22, where NO_x annual mean concentrations are plotted due to all emission sources as far as scenarios 0 and 1 are concerned, respectively. Eventually, Fig.23 gives a spatial summary of relative difference between NO_x concentrations resulting from the two considered scenarios. The map, actually resulting from a point-by-point difference between Figs. 21 and 22, shows the present-to-future emission scenarios variation leading to a general NO_x concentration reduction in the order of 10÷35%, which is particularly effective over the Florence and Prato urban areas.

In Figs. 27 and 28 the maps of calculated NO_x annual maximum concentrations are plotted due to all emission sources as far as scenarios 0 and 1 are concerned, respectively. NO_x concentrations resulting from the future scenario proved to decrease also when considering the top values through the application year.

4.1.2 PM_{10}

Figs. 19 and 20 show the calculated primary PM_{10} annual mean concentrations as disaggregated by source resulting from scenarios 0 and 1, respectively.

Focusing on Fig.19, as well as NO_x point sources play the most relevant role to primary PM_{10} concentrations, particularly over the Montelupo industrial district (Fig.19-1). Remarkable contributions result from local vehicular traffic too (Fig.19-5), as well as domestic heating and cooling (Fig.19-4). On the contrary, contributions resulting from other sources appear to be negligible.

The scenario 0 vs. scenario 1 comparison shows a general PM_{10} concentration decrease when considering the latter, both in peak values and spatial extent (Fig.20). However, this is not the case for emissions due to domestic heating and cooling (Fig.19-4), which increase instead.

Figs. 24 and 25 show the comparison of annual mean concentrations of PM_{10} primary component due to all emission sources as far as scenarios 0 and 1 are concerned, respectively. The derived concentration spatial relative difference resulting from the two considered scenarios (Fig.26) exhibits a different pattern from the NO_x one (Fig.23). As a matter of fact, the present-to-future emission scenarios variation leads to a concentration pattern not of a monotonic kind such as NO_x, as PM_{10} concentrations proved to increase as well as decrease. In particular, the highest reduction in the order of 15% occur over the Florence urban area, whereas PM_{10} concentrations even increase (10÷15%) in the mountainous area Northwest to Pistoia and (about 5%) Southeast of it (Monsummano Terme).

Figs. 29 and 30 show the maps of calculated primary PM_{10} annual maximum concentrations due to all emission sources as far as both scenarios are concerned. Again such as for mean concentrations (Fig.26), also when considering annual top values primary PM_{10} concentrations proved to decrease as well as increase once interventions planned for the future scenario would be effective. Moreover, by analyzing Figs. 29 and 30, top values increase both in ammount and number of occurencies just over the Pistoia area.

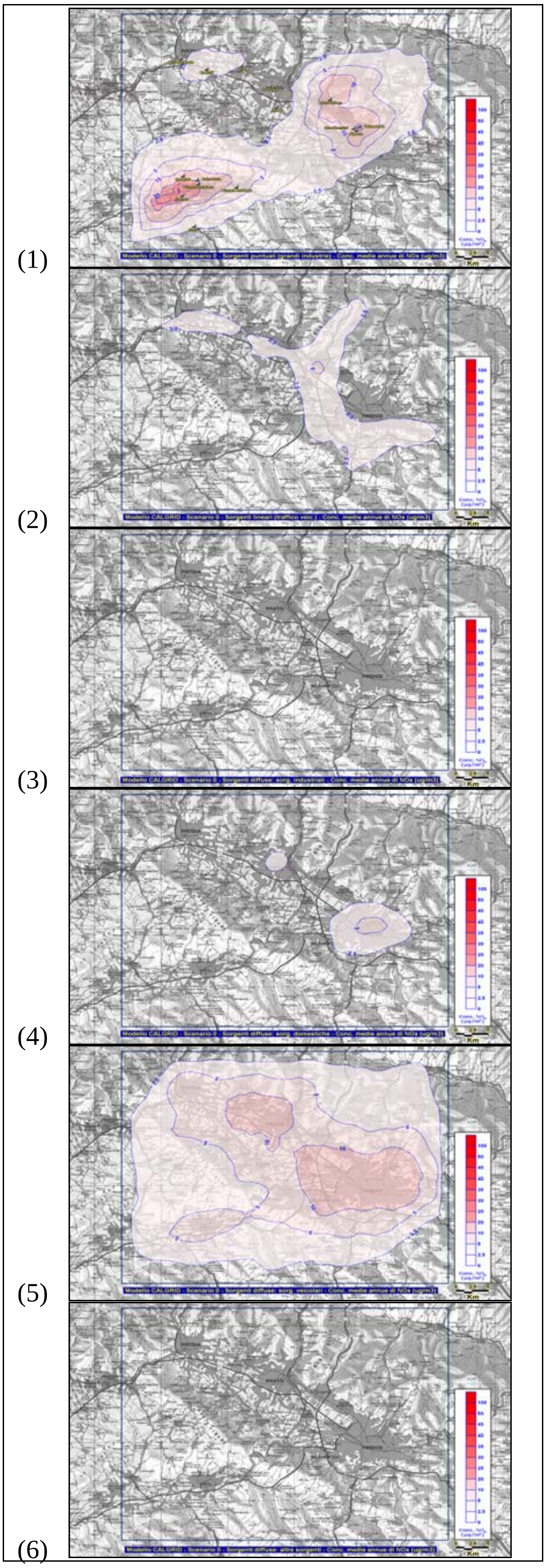

Fig.17: Map of disaggregated emission source contributions to NO_x annual mean concentrations calculated by CALGRID over the Florence metropolitan area for emission scenario 0.

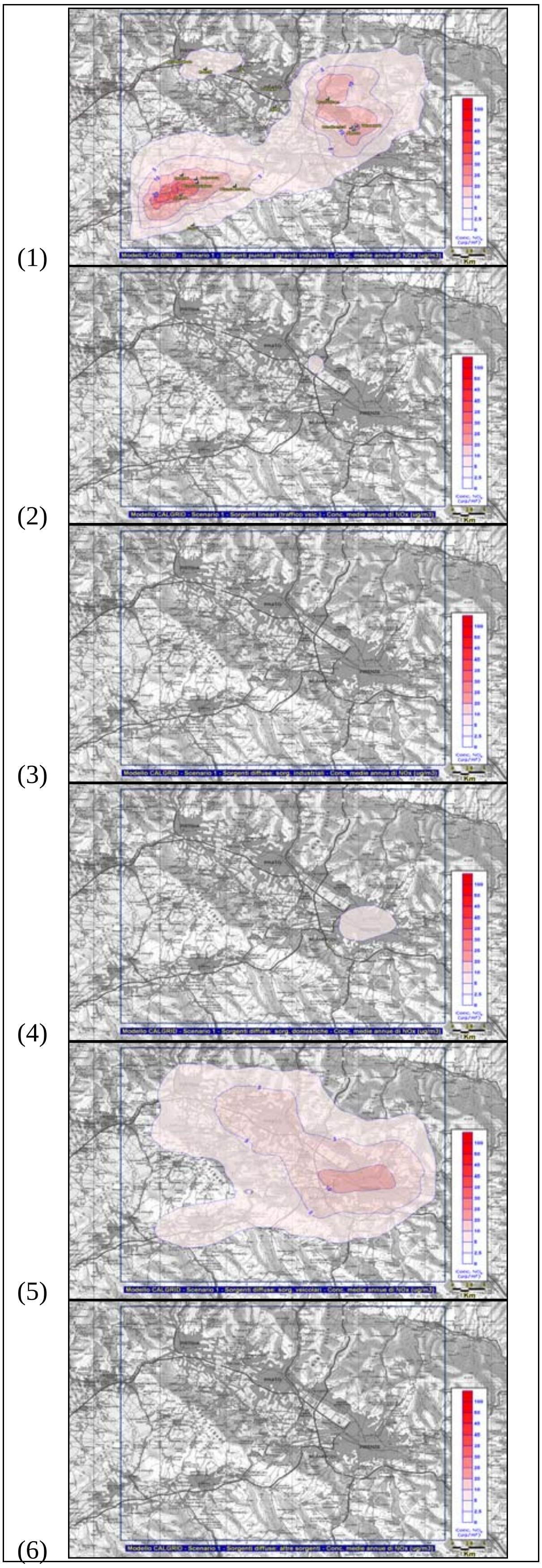

Fig.18: Map of disaggregated emission source contributions to NO_x annual mean concentrations calculated by CALGRID over the Florence metropolitan area for emission scenario 1.

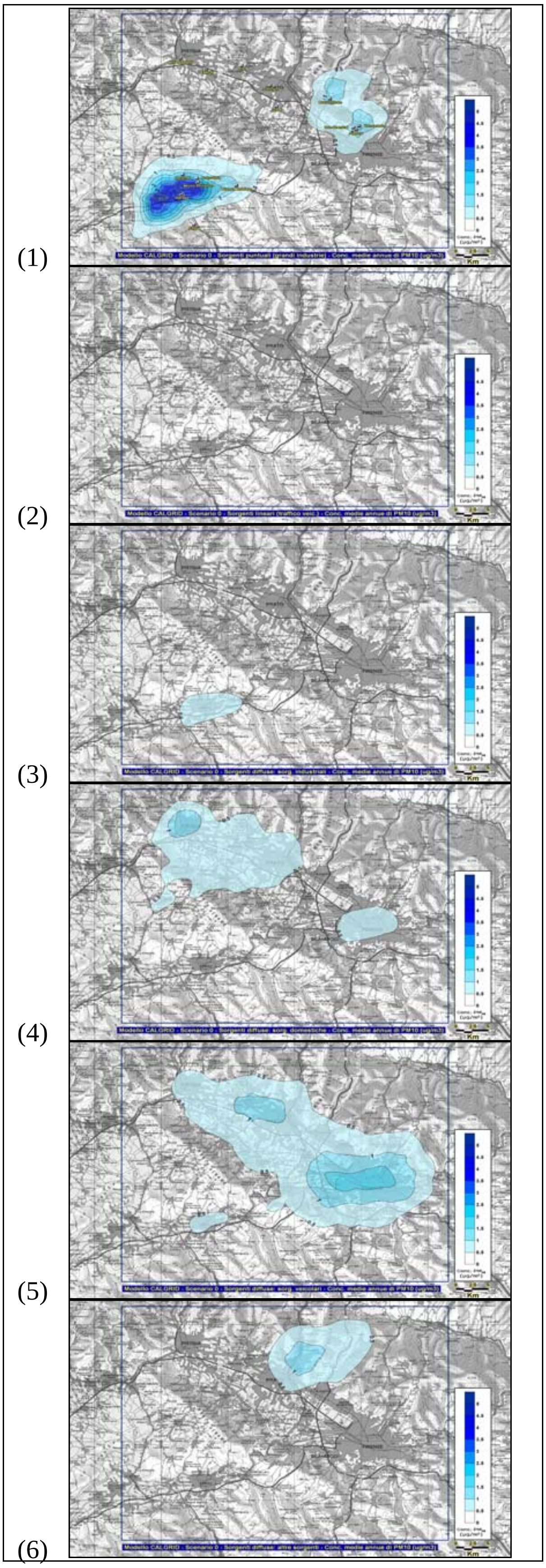

Fig.19: Map of disaggregated emission source contributions to primary PM_{10} annual mean concentrations calculated by CALGRID over the Florence metropolitan area for emission scenario 0.

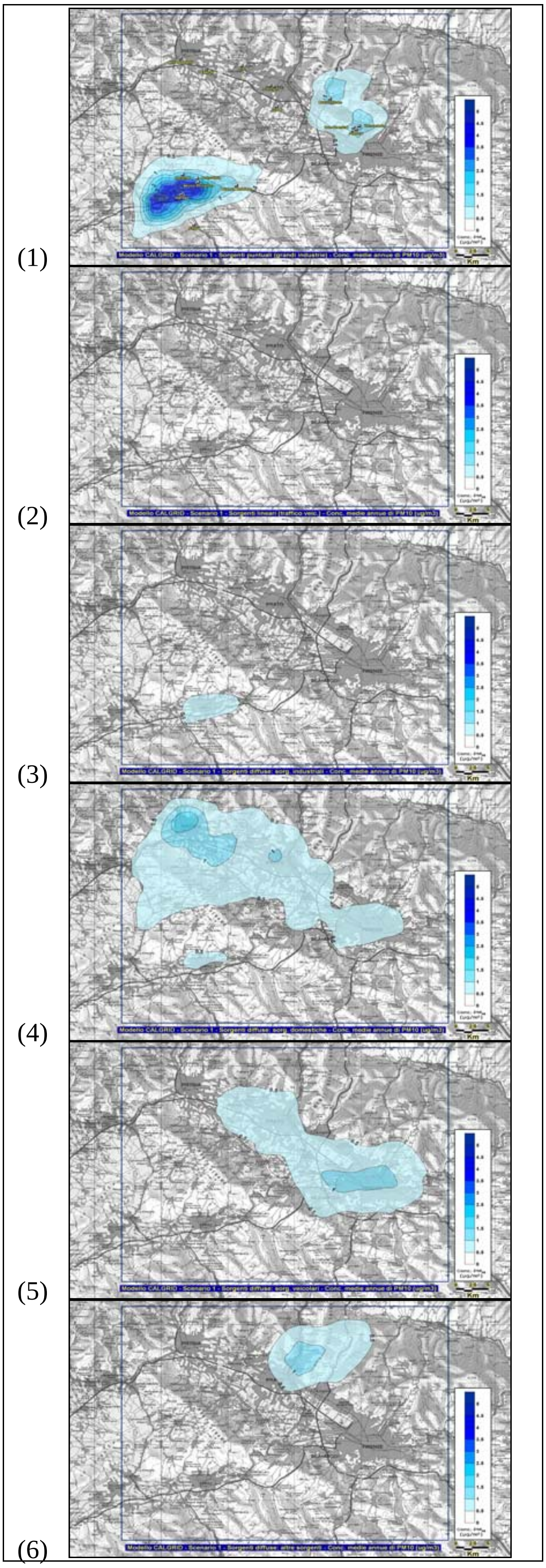

Fig.20: Map of disaggregated emission source contributions to primary PM_{10} annual mean concentrations calculated by CALGRID over the Florence metropolitan area for emission scenario 1.

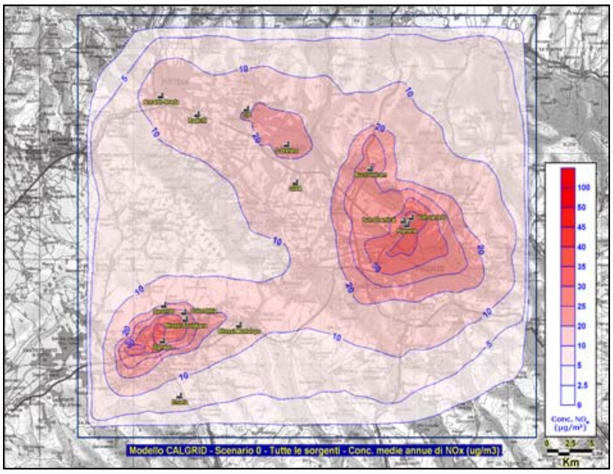

Fig.21: Map of total emission source contribution to NO_x annual mean concentrations calculated by CALGRID over the study area for scenario 0.

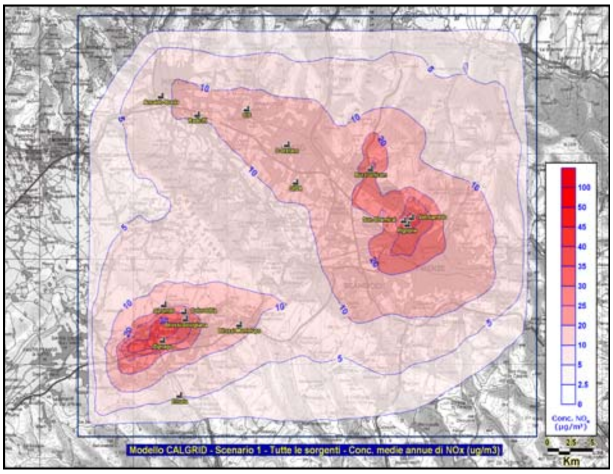

Fig.22: Map of total emission source contribution to NO_x annual mean concentrations calculated by CALGRID over the study area for scenario 1.

Fig.23: NO_x annual mean concentrations due to all emission sources calculated by CALGRID over the study area: spatial pattern of scenario 0 vs. scenario 1 relative difference.

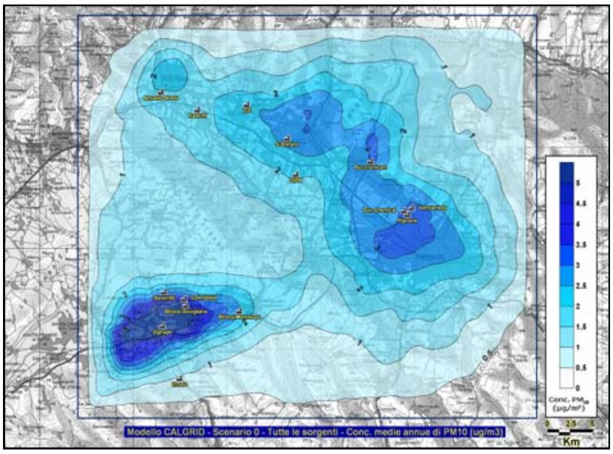

Fig.24: Map of total emission source contribution to primary PM_{10} annual mean concentrations calculated by CALGRID over the study area for scenario 0.

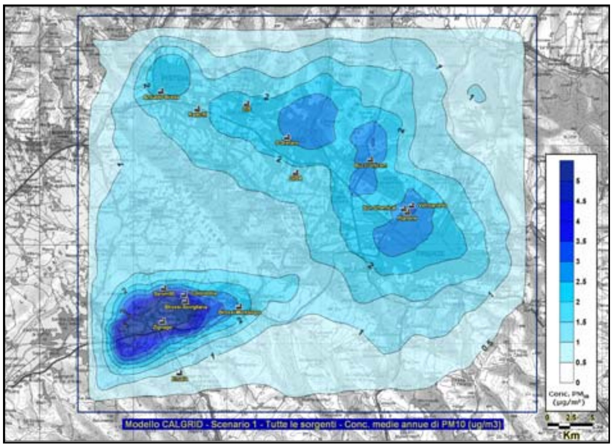

Fig.25: Map of total emission source contribution to primary PM_{10} annual mean concentrations calculated by CALGRID over the study area for scenario 1.

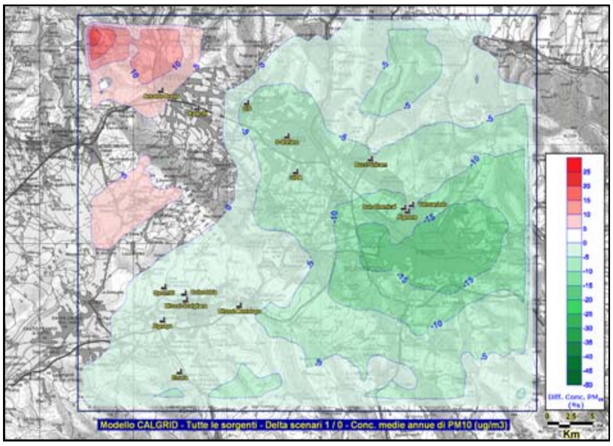

Fig.26: Primary PM_{10} annual mean concentrations due to all emission sources calculated by CALGRID over the study area: spatial pattern of scenario 0 vs. scenario 1 relative difference.

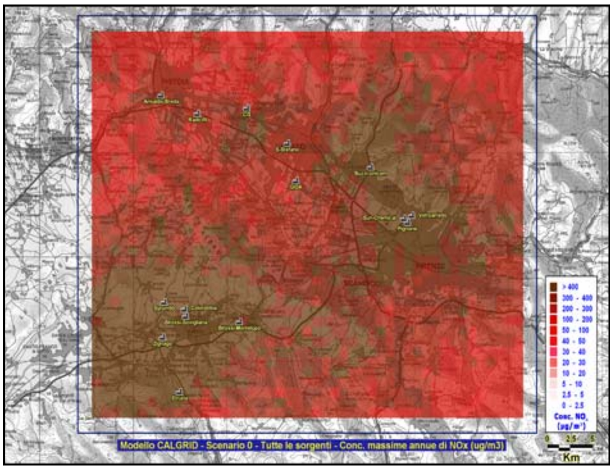

Fig.27: Map of total emission source contribution to NO_x annual maximum concentrations calculated by CALGRID over the study area for scenario 0.

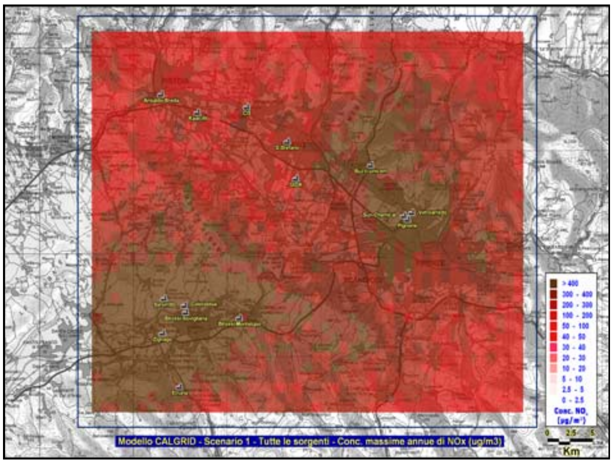

Fig.28: Map of total emission source contribution to NO_x annual maximum concentrations calculated by CALGRID over the study area for scenario 1.

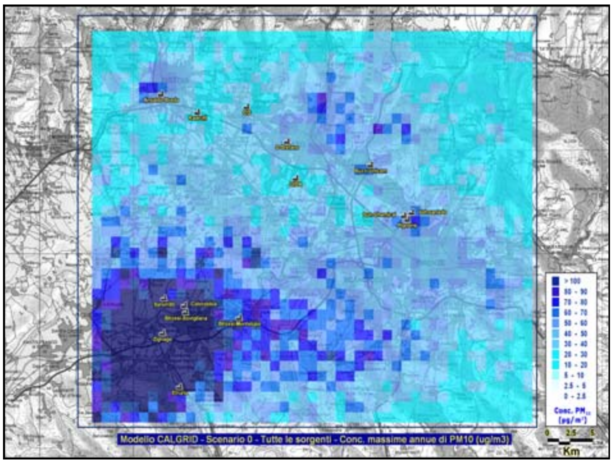

Fig.29: Map of total emission source contribution to primary PM_{10} annual maximum concentrations calculated by CALGRID over the study area for scenario 0.

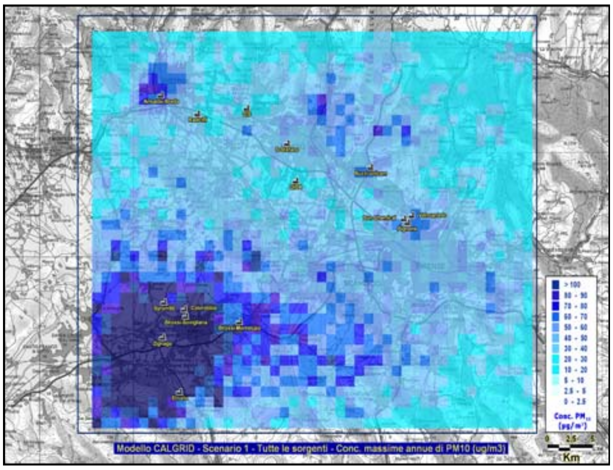

Fig.30: Map of total emission source contribution to primary PM_{10} annual maximum concentrations calculated by CALGRID over the study area for scenario 1.

4.2 Local pattern of concentrations calculated on chemical stations

All PM_{10} and NO_x chemical stations of the regional monitoring network over the study area have been taken into account to perform an analysis of local CALGRID estimations. In particular, 15 stations were considered, whose features are listed in Table 2 and spatial location plotted in Fig.31.

Incidentally, it is to be noted that PM_{10} and NO_x concentrations are measured at 3 m a.g.l. by the chemical stations, whereas CALGRID estimations are vertically averaged from 0 to 20 m a.g.l. This accounts for the substantial low values performed by the model. Moreover, while PM_{10} estimations refer to the primary component only, measurements concern the overall PM_{10} instead.

Table 2: List of chemical stations selected for CALGRID estimations local analysis.

No.	Station name	City	UTM-32 WGS84	
			X (m)	Y (m)
1	BASSI	Florence	683990	4850606
2	BOBOLI	Florence	680952	4848140
3	GRAMSCI	Florence	682787	4849063
4	MOSSE	Florence	679472	4850389
5	ROSSELLI	Florence	680037	4849530
6	BUOZZI	Scandicci	676454	4847103
7	BOCCACCIO	Calenzano	674931	4857407
8	RIDOLFI	Empoli	656912	4842395
9	PRATELLE	Montelupo F.	666827	4843365
10	MILANI	Montelupo F.	662698	4843776
11	FERRUCCI	Prato	669078	4860017
12	FONTANELLE	Prato	667061	4857199
13	STROZZI	Prato	668127	4861058
14	ZAMENHOF	Pistoia	653571	4865830
15	MONTALE	Montale	661057	4864403

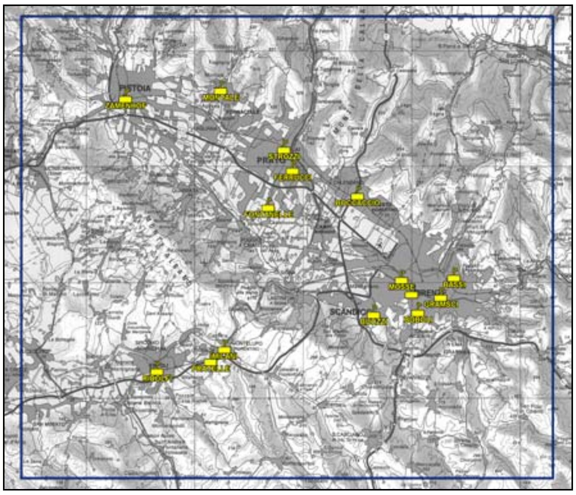

Fig.31: Location of chemical stations selected for CALGRID estimations local analysis.

4.2.1 NO_x

Table 3 gives a summary of NO_x annual mean concentrations calculated by the model against emission scenarios 0 and 1, as well as their relative difference.

Table 3: NO_x annual mean concentrations calculated by CALGRID on selected stations for emission scenarios 0 and 1 and relative difference.

No.	Station name	NO_x annual mean conc. ($\mu g/m^3$)		NO_x conc. relative diff. (%)
		Scen. 0	Scen. 1	Scen. 1 vs. Scen. 0
1	BASSI	30.08	19.68	-34.6
2	BOBOLI	24.09	15.79	-34.5
3	GRAMSCI	25.74	16.76	-34.9
4	MOSSE	35.04	25.31	-27.8
5	ROSSELLI	27.95	18.86	-32.5
6	BUOZZI	25.64	17.02	-33.6
7	BOCCACCIO	26.01	20.10	-22.7
8	RIDOLFI	24.34	21.07	-13.4
9	PRATELLE	15.05	12.16	-19.2
10	MILANI	14.07	11.28	-19.8
11	FERRUCCI	19.43	13.01	-33.0
12	FONTANELLE	16.48	10.95	-33.5
13	STROZZI	20.35	13.77	-32.4
14	ZAMENHOF	13.65	9.38	-31.3
15	MONTALE	13.09	8.92	-31.8

NO_x concentrations of Table 3 give a local confirmation of general conclusions drawn as far as the spatial analysis is concerned (§ 4.1.1). The present-to-future emission scenarios variation results in an overall NO_x concentration decrease on all chemical stations. In particular, the highest reductions, in the order of 34÷35%, occur on Florence stations of Bassi, Boboli and Gramsci, and secondly on Prato (32÷33%) and Pistoia (31÷32%) stations. On the contrary, the lowest concentration reductions occur on those stations located over Empoli urban area (about 13%) and Montelupo industrial area (19÷20%). Of course, this is due to the fact that no emission variation was planned for point sources, i.e. major industries, which are particularly effective over such areas (Fig. 4).

4.2.2 PM_{10}

In table 4 a summary is given of PM_{10} primary component annual mean concentrations calculated by the model against emission scenarios 0 and 1, as well as their relative difference. Differently from NO_x concentrations, the PM_{10} present-to-future emission scenarios variation results both in a concentration reduction and an increase on chemical stations. In particular, the highest reductions, in the order of 15÷18%, occur on those stations of Florence urban area, while elsewhere reductions range to lower values (3÷7%). On the contrary, over the Pistoia stations PM_{10} concentrations remain substantially unchanged (Montale), whereas they even increase (Zamenhof) by an amount of about 7%.

Table 4: primary PM_{10} annual mean concentrations calculated by CALGRID on selected stations for emission scenarios 0 and 1 and relative difference.

No.	Station name	Primary PM_{10} annual mean conc. ($\mu g/m^3$)		Primary PM_{10} conc. relative diff. (%)
		Scen. 0	Scen. 1	Scen. 1 vs. Scen. 0
1	BASSI	2.89	2.37	-18.0
2	BOBOLI	2.42	2.02	-16.5
3	GRAMSCI	2.54	2.11	-16.9
4	MOSSE	3.24	2.76	-14.8
5	ROSSELLI	2.72	2.28	-16.2
6	BUOZZI	2.48	2.10	-15.3
7	BOCCACCIO	2.74	2.54	-7.3
8	RIDOLFI	4.53	4.40	-2.9
9	PRATELLE	2.41	2.31	-4.1
10	MILANI	2.04	1.96	-3.9
11	FERRUCCI	2.67	2.48	-7.1
12	FONTANELLE	1.95	1.81	-7.2
13	STROZZI	3.01	2.82	-6.3
14	ZAMENHOF	1.98	2.12	+7.1
15	MONTALE	1.68	1.67	-0.6

4 Conclusions

The RAMS-CALMET-CALGRID modelling system developed by the LaMMA consortium has been used as a supporting tool within the framework of the "MODIVASET" project promoted by the Tuscan Regional Government with the aim of modelling emission scenarios variations.

For the application purposes, the CALGRID photochemical grid dispersion model has been suitably modified to be applied for inert pollutants. In other words, all CALGRID chemical transformation modules have been disabled and the model applied as a mere Eulerian grid one. As a matter of fact, the attention was paid to particulate matter (PM_{10}) primary component, as well as Nitrogen Dioxides (NO_x), which proved to be one of main precursors of PM_{10} secondary inorganic component. Both pollutants have been treated as inert ones.

A one-year long-term application has been carried out over the Florence metropolitan area, Italy.

Aiming at assessing possible air quality improvements once interventions on emission scenarios have been planned by local authorities, two PM_{10} and NO_x scenarios have been set: a present one, updated to 2003, and a future one, projected to years 2010-2012, where "business as usual" emission variations are supposed to occur. All types of emission source categories have been taken into account, i.e. point, line and area (split into 4 sub-categories) ones. This enabled single contributions brought by any to be assessed, as well as the overall one.

Calculated PM_{10} and NO_x concentrations resulting from present and future emission scenarios have been compared, both in terms of spatial pattern over the study area and local one to chemical stations. The final result was a general NO_x concentration reduction in the order of 10÷35%, particularly effective over the Florence and Prato urban areas. On the contrary, primary PM_{10} concentrations proved to decrease, about 15% over the Florence urban area, as well as increase, 10÷15% over the mountainous area Northwest to Pistoia.

However, it is to be stressed that methodologies implemented and results achieved in the present paper are definitely in agreement with other similar scenarios analysis works carried out on Italy, such as [6] and [7], for instance. Summarizing, the proper use of a comprehensive and flexible modelling system proved to be a fundamental tool for planning emission scenarios variations to improve air quality standards.

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