

Emissions estimate from forest fires: methodology, software and European case studies

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topics

➤ Methodology

- Evaluation of the quantity of burnt biomass
- Evaluation of the quantity of emitted carbon, nitrogen and total particulate
- Calculation of carbon compounds, nitrogen compounds and Particulate Matter emissions

➤ Software

➤ Case studies

- National Case Study Results
- Regional Case Study Results

➤ Conclusions

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methodology

The emissions estimate follows the methodology developed by International Panel on Climate Change integrated with the methodology of the United States Environmental Protection Agency.

For this last pollutant a procedure consistent with the preceding ones has been introduced to the goal to furnish only one computational methodology.

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pollutants

- **Carbon Monoxide (CO)**
- **Carbon Dioxide (CO₂)**
- **Methane (CH₄)**
- **Nitrogen Oxides (NO_x)**
- **Nitrogen Protoxide (N₂O)**
- **Particulate Matter with diameter less than 10 micron (PM₁₀)**

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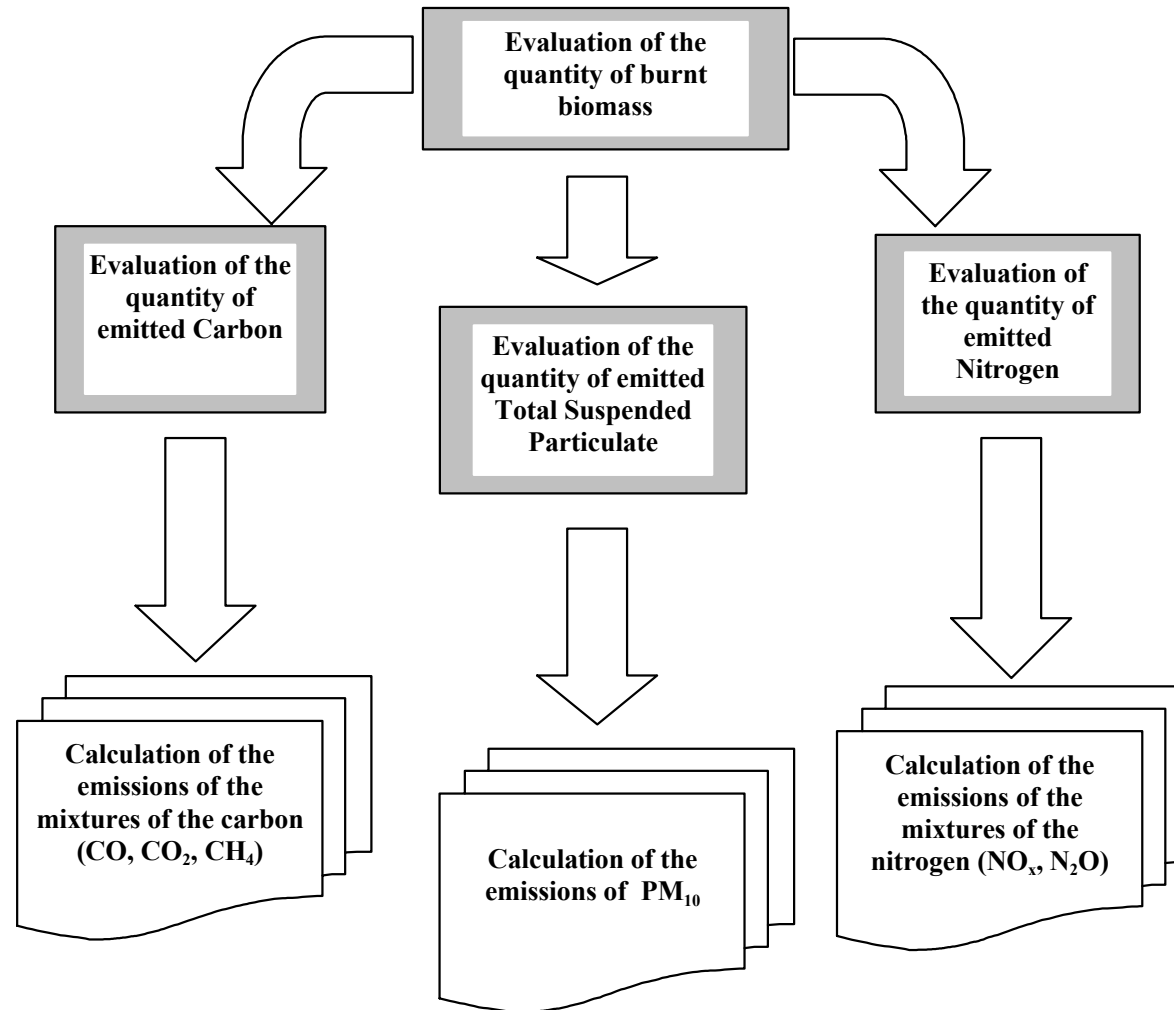
emissions estimate steps

- evaluation of effective fired biomass through:
 - evaluation of fired forest area
 - evaluation of above surface biomass factor
 - evaluation of forest fire efficiency
- evaluation of total Carbon, total Nitrogen and total Particulate Matter emitted,
- carbon compounds, nitrogen compounds and PM10 emissions evaluation.

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burnt biomass estimates

The quantity of dry biomass of given vegetation specie burnt is given from:

$$M_i = a A_i B_i$$

where:

- i vegetation specie (different crops as defined by forest statistics)
- A_i area (in hectares) of fired surface covered by the i specie
- B_i middle quantity of dry biomass (in tons for hectare) emerged by the ground for i specie
- a efficiency of the fire or fraction of definitely destroyed biomass (in case of complete fire must be sets equal to 1 while in case of partial fire it will have to express the evaluation of the quantity of biomass burnt)

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crops list and biomass

<i>Crops</i>	<i>Biomass (t/ha)</i>
Resinous tall stem	295
Deciduous tall stem	250
Mixed tall stem	225
Simplex coppice	175
Mixed coppice	185
Mediterranean bush	50

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quantity of emitted carbon

The quantity of emitted carbon (in tons) is given from:

$$C = b M$$

where

M biomass

b carbon's quantity contained in the biomass (can be set equal to 0.45)

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quantity of emitted nitrogen

The quantity of emitted nitrogen (in tons) is given from:

$$N = \gamma' C = \gamma M$$

where:

- γ' proportion among carbon C and nitrogen N (can be set equal to 0.01)
- γ nitrogen quantity contained in biomass (can be set equal to 0.0045).

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quantity of emitted particulate

The quantity of emitted total particulate (in tons) is given from:

$$P = \delta M$$

where:

δ quantity of total particulate emitted for unity of biomass (in g of total particulate emitted for g of burnt biomass)

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carbon compounds emissions

Emissions of carbon compounds j are
obtained as:

$$E_j = \varepsilon_j \delta_j \text{CC}$$

where:

ε_j fraction of total carbon emitted as
compound j

δ_j factor of passage from the emissions
in tons of Carbon to the emissions in
tons of the specific compound

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Compound	Fraction of total carbon emitted as	Mass conversion factor from C to compound
Carbon Dioxide	0,888	44/12
Methane	0,012	16/12
Carbon Monoxide	0,1	28/12

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nitrogen compounds emissions

Emissions of nitrogen compounds j are obtained as:

$$E_j = \varepsilon_j \delta_j \text{CC}$$

where:

ε_j fraction of total nitrogen emitted as compound j

δ_j factor of passage from the emissions in tons of nitrogen to the emissions in tons of the specific compound

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Compound	Fraction of total nitrogen emitted as	Mass conversion factor from N to compound
Nitrogen Oxides	0,007	44/28
Nitrogen Protoxide	0.012	30/14

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PM10 emissions

Emissions of PM10 are obtained as:

$$E_{PM10} = \varepsilon_{PM10} N$$

where:

ε_{PM10} fraction of total suspended particulate emitted as PM10 (0,73 according AP 42)

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Air Fire Model

Air Fire allows the estimate of the emissions produced by Forest Fire

The model is developed in Visual Basic Windows environment language with an ACCESS database

The model is part of a complete system for air pollution evaluation (Air Suite)

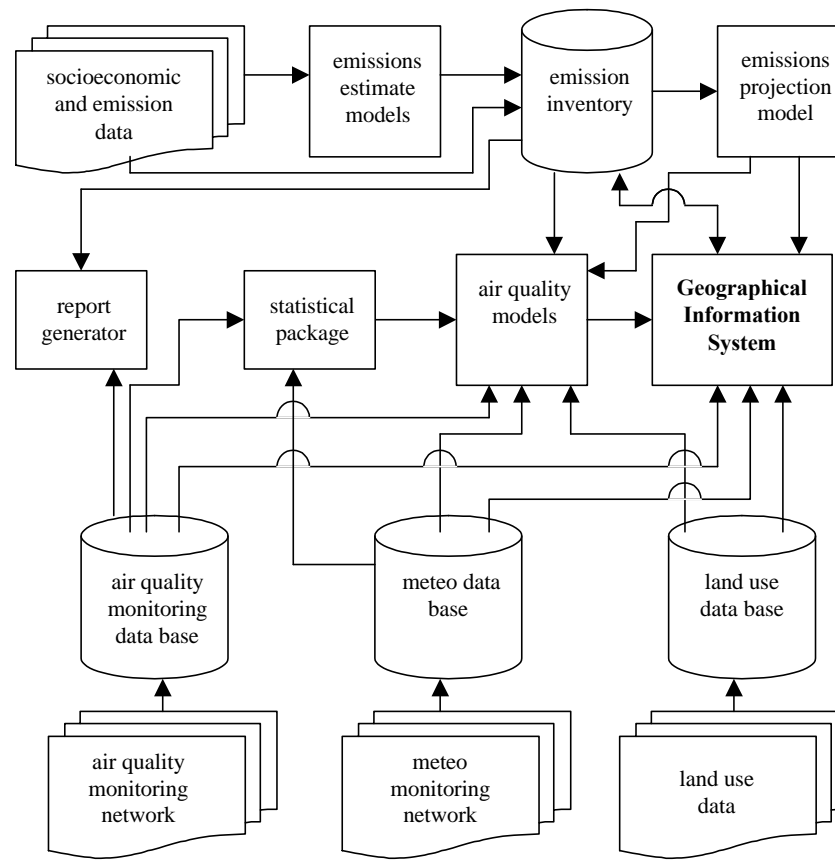
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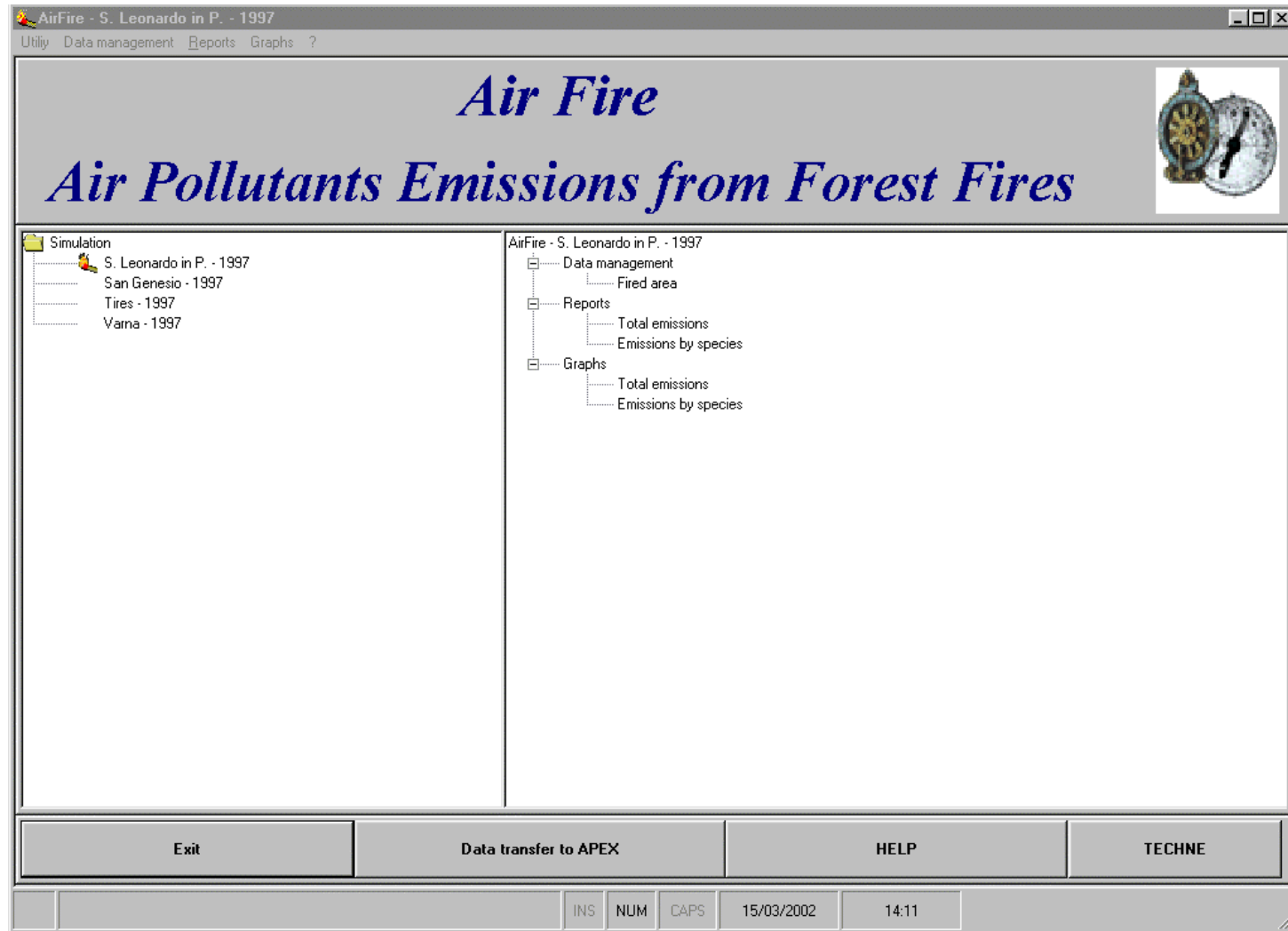
Air Suite



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The screenshot shows the 'Air Fire' software interface. The title bar reads 'AirFire - S. Leonardo in P. - 1997'. The menu bar includes 'Utility', 'Data management', 'Reports', and 'Graphs'. The main window title is 'Air Fire' and the subtitle is 'Air Pollutants Emissions from Forest Fires'. A small icon of a pocket watch is visible in the top right corner. The main content area lists utility function options:

- **utility function options:**
 - **simulation management (identification and efficiency of the forest fire)**
 - **make an existing simulation on line**
 - **create a new simulation**
 - **modify an existing simulation**
 - **deleting an existing simulation**
 - **export of simulation data to APEX**

The bottom of the window features a control panel with buttons for 'Exit', 'Data transfer to APEX', 'HELP', and 'TECHNE'. The status bar at the very bottom shows 'INS NUM CAPS', the date '15/03/2002', and the time '14:11'.

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- **data management function options:**
 - **manage of fired area (allows to insert or modify fired area for each vegetation specie)**

At the bottom of the window, there is a toolbar with buttons for 'Exit', 'Data transfer to APEX', 'HELP', and 'TECHNE'. The status bar at the very bottom shows 'INS NUM CAPS', the date '15/03/2002', and the time '14:11'.

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The screenshot shows the 'Air Fire' software interface. The title bar reads 'AirFire - S. Leonardo in P. - 1997'. The menu bar includes 'Utility', 'Data management', 'Reports', 'Graphs', and '?'. The main window title is 'Air Fire' and the subtitle is 'Air Pollutants Emissions from Forest Fires'. A small icon of a pocket watch is visible in the top right corner. The main content area contains a list of report options:

- **reports function options:**
 - **report of total emissions (produce the report of the total emissions for all pollutants)**
 - **report of emissions by species (produce the report of the total emissions for all pollutants and each crop species)**

The bottom of the interface features a toolbar with buttons for 'Exit', 'Data transfer to APEX', 'HELP', and 'TECHNE'. At the very bottom, there is a status bar with fields for 'INS', 'NUM', 'CAPS', '15/03/2002', and '14:11'.

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AirFire - S. Leonardo in P. - 1997
Utility Data management Reports Graphs ?

Air Fire

Air Pollutants Emissions from Forest Fires



- **graph function options:**
 - **graph of total emissions (produce the graph of the total emissions for all pollutants)**
 - **graph of emissions by species (produce the graph of the total emissions for all pollutants and each crop species)**

Exit Data transfer to APEX HELP TECHNE

INS NUM CAPS 15/03/2002 14:11

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case studies

➤ national level

the methodology and the computer model was used for the realization of national emissions inventory

➤ regional level

the methodology and the computer model were used in the realization of several regional air quality management plans in Italy (Trento, Toscana, Bolzano, Liguria, Friuli Venezia Giulia and Umbria regions) and several emissions inventories (Firenze, L'Aquila, Roma)

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national level

- the emissions estimate uses the official statistical data available from Forest Body of the State
- the Forest Body of the State, since the years 70, picks up and elaborates the information and the data on the forest fires that occur during the year
- recently has been activated an informative system that allows the networking among the peripheral offices of the Forest Body of the State, in charge to collect and elaborate data, the Service "Forest Fire Struggle" of General Direction and the Office of Statistic
- this allows to update a real time data base and to have univocal data on the forest fires to central level

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national estimate 1998

Species	CH ₄	CO	CO ₂	N ₂ O	NO _x	PM ₁₀
1 - Resinous	5772.9	84187.6	1174778.3	92.8	39.7	4975.1
2 - Deciduous	3054.0	44537.3	621485.8	49.1	21.0	2631.9
3 - Mixed Resinous/Deciduous	4134.5	60294.1	841361.4	66.4	28.4	3563.1
4 - Simplex coppice	4457.0	64997.3	906990.9	71.6	30.6	3841.0
5 - Mixed coppice	325.2	4742.9	66183.6	5.2	2.2	280.3
6 - Coppice deteriorate	874.9	12758.3	178033.2	14.1	6.0	754.0
7 - Mediterranean bush	1096.3	15987.8	223098.4	17.6	7.5	944.8
TOTAL	19714.8	287505.3	4011931.6	316.8	135.5	16990.2

tons

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contribution on total

- the contribution of emissions from forest fires on total national emissions can be obtained using the national official total emissions estimates by the Italy Environmental Protection Agency (ANPA)
- from these data it is obtained that the forest fires contribute for about:
 - 4.5% to the national Carbon Monoxide emissions
 - 1% to the national Nitrogen Oxides and Methane emissions
 - 0,9% to the national Carbon Dioxide (CO₂) emissions
 - 0,2% to the national Nitrogen Protoxide emissions

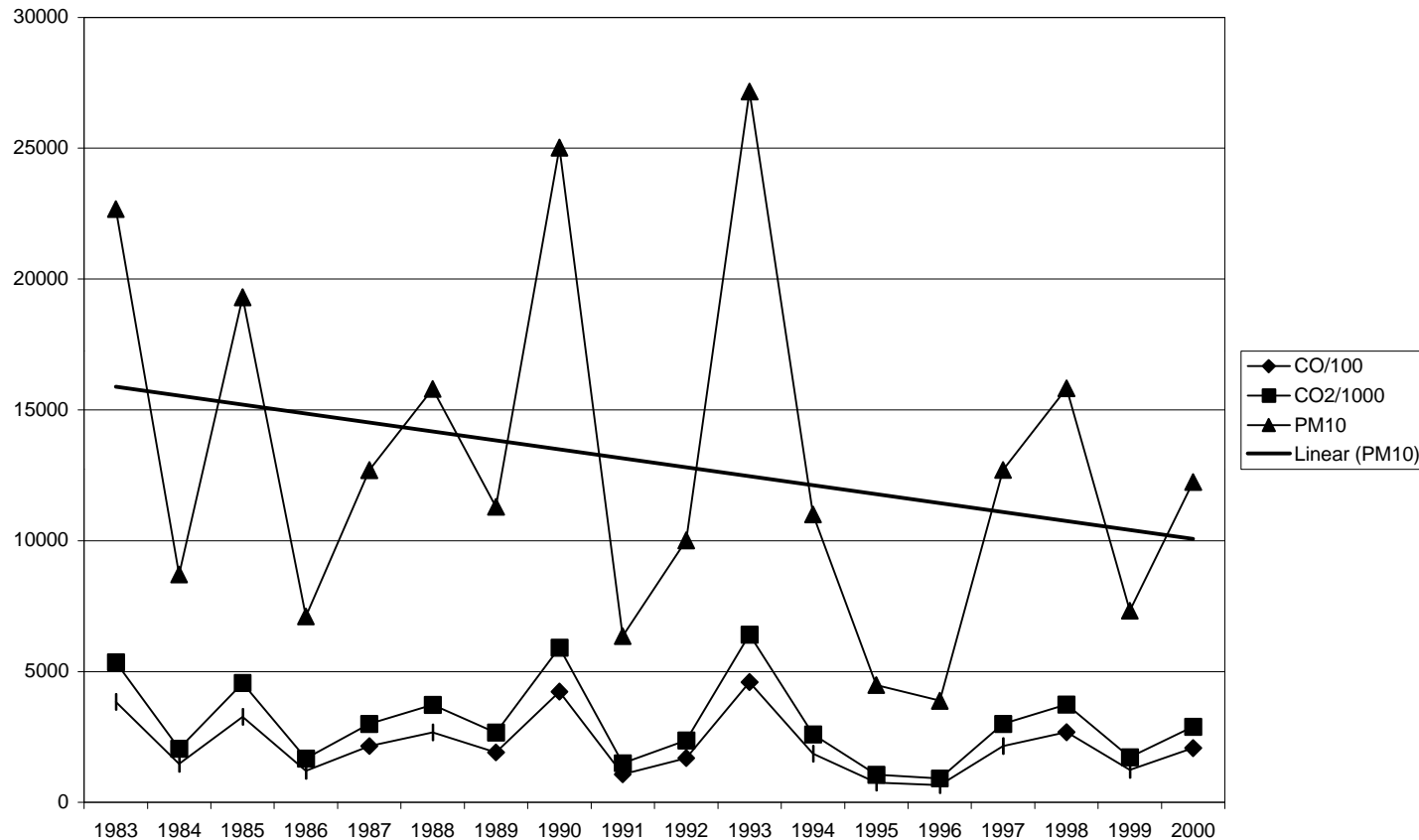
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national estimate 1983-2000



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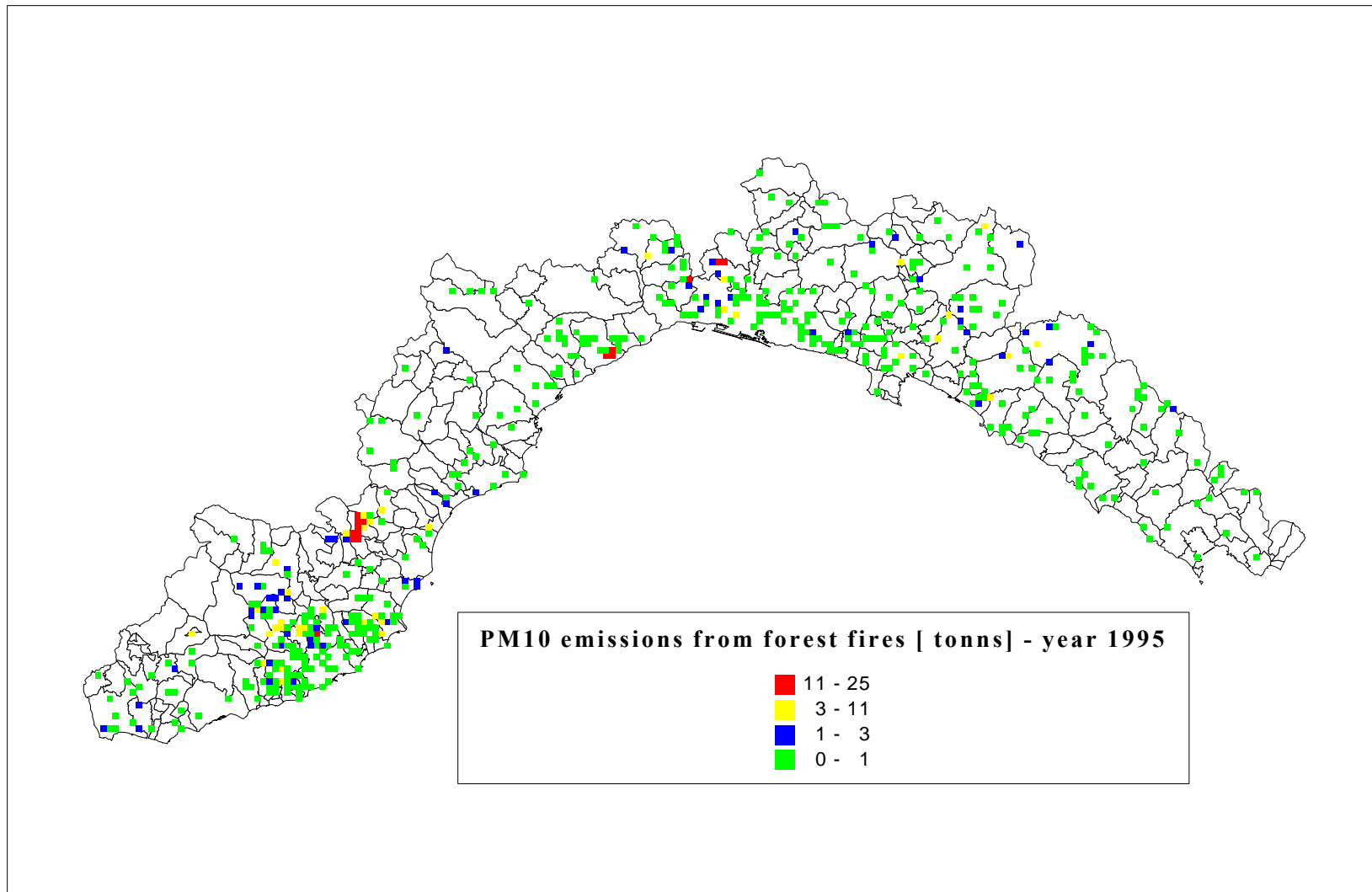
regional level

- nomenclature used in the emissions inventories, at the local level in Italy, follows the European Commission CORINAIR working group guidelines
- for forest fires the data from Forest Body of the State are used
- at regional level, for example in Liguria in the year 1995, forest fires emissions were 5% of total CO emissions and 8% of total PM10 emissions

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conclusion

- in the presentation methodology and software for forest fires emissions estimate are presented
- the methodology and the software can be usefully applied to national and local emissions estimates.