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ASSESSING THE IMPACT OF PARTICULATE MATTER SOURCES IN THE MILAN URBAN AREA

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Source apportionment of PM10 and PM2.5

at a PUMI project (Particolato Urbano MIlanese – Urban Particulate in Milano) site: **Milano**

Using a receptor model:

- US-EPA CMB (Chemical Mass Balance) approach: a single-sample model
- More 'transparent' than multivariate models, where sources are estimated, not initially known

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Goals:

- Estimate the relative impact of different local emission sources on particulate concentrations

- Quantify the contribution of sources not included in emission inventories (e.g. re-suspension due to vehicular traffic, secondary particulate)

- Investigate the dependence of source contributions on particulate size

- Investigate the dependence of source contributions on meteorological conditions, such as rain and wind.

- Comparison and inter-validation with emissions inventories

- Useful information to evaluate control strategies

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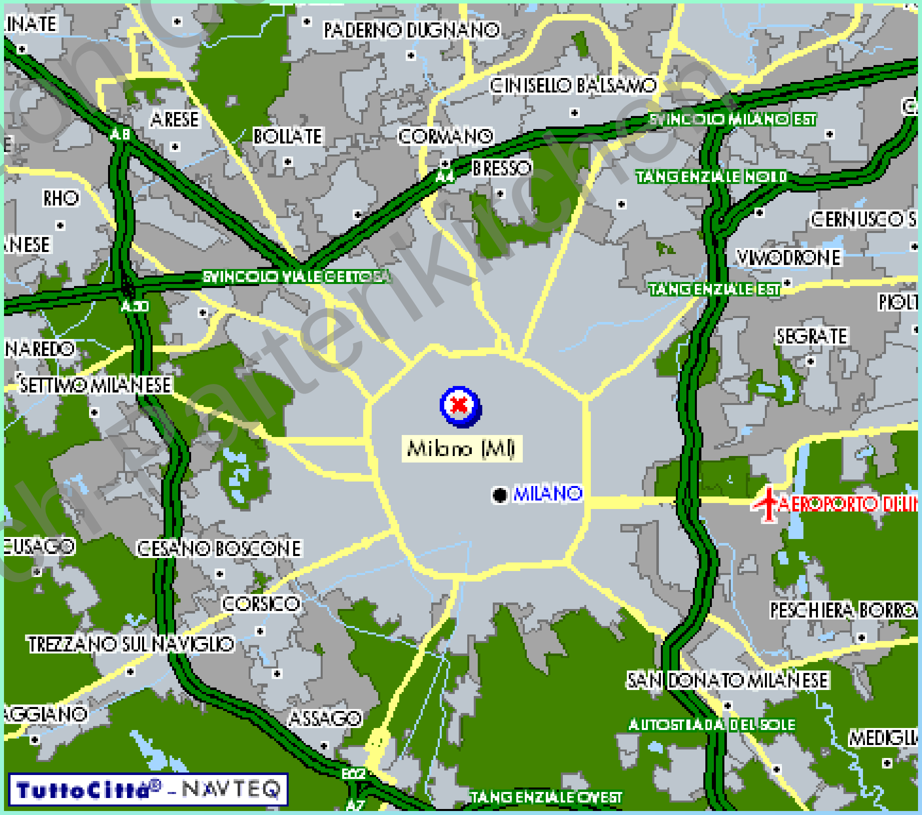
INPUT data → **Ambient data**

→ **Source data**

1- Ambient data

- **Receptor site:** via Messina

  Urban site, not directly influenced by local traffic



- **Available data:** daily average PM_{10} and $PM_{2.5}$ concentrations, element (Al, Si, S, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, Pb), nitrate (NO_3^-), sulphate (SO_4^{2-}), and ammonium ions (NH_4^+) concentrations

- **Sampling period:** April-July 2002 for PM10;
  April-May 2002 for PM2.5 (summer)

- **Number of samples**:

54 PM_{10} samples : 37 averaged for no-precipitation day, 15 for typical rainy conditions, 1 for heavy rain (43 mm of rain during 14 hours), 1 for strong wind.

16 $PM_{2.5}$ samples

2- Source identification and fingerprints

Correlation matrix between species concentrations

	AL	SI	S	K	CA	TI	V	CR	MN	FE	NI	CU	ZN	BR	PB
AL	1.00														
SI	0.98	1.00													
S	0.28	0.22	1.00												
K	0.86	0.85	0.41	1.00											
CA	0.94	0.97	0.13	0.84	1.00										
TI	0.86	0.84	0.48	0.94	0.82	1.00									
V	0.41	0.41	0.66	0.71	0.39	0.78	1.00								
CR	0.59	0.61	0.45	0.84	0.61	0.88	0.93	1.00							
MN	0.70	0.71	0.46	0.89	0.72	0.92	0.87	0.95	1.00						
FE	0.78	0.83	0.29	0.86	0.81	0.81	0.62	0.78	0.85	1.00					
NI	0.33	0.34	0.59	0.65	0.34	0.73	0.98	0.93	0.85	0.57	1.00				
CU	0.57	0.58	0.40	0.81	0.59	0.83	0.84	0.91	0.92	0.84	0.83	1.00			
ZN	0.45	0.46	0.39	0.69	0.48	0.64	0.68	0.70	0.72	0.68	0.65	0.76	1.00		
BR	0.24	0.25	0.56	0.59	0.25	0.64	0.95	0.87	0.79	0.50	0.96	0.80	0.72	1.00	
PB	0.37	0.37	0.55	0.72	0.37	0.72	0.89	0.86	0.81	0.68	0.88	0.87	0.72	0.89	1.00

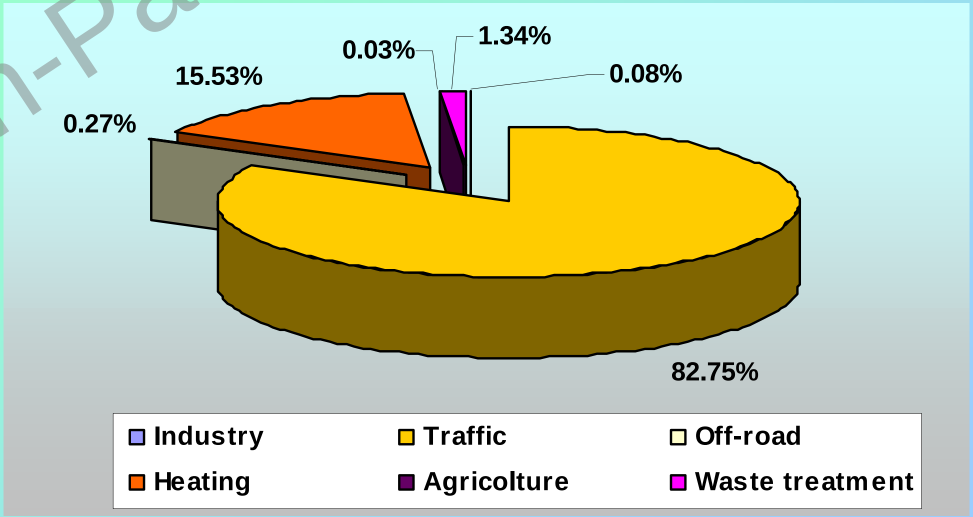
Soil dust and crustal material (Al, Si, Ca, Ti, K);

Traffic (Fe, Cu ...)

Stacks, industrial (Zn, Mn)

Secondary (S)

Emission sources of PM10 in Milano (Provincial emissions inventory, 1998)



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Source speciation

Source	Reference
Soil dust	Speciate 3.2 US-EPA
Industry	Speciate 3.2 US-EPA
Secondary	Watson e al., 1994
Traffic	This work

Traffic speciation: from local tunnel data

- Includes exhaust emissions, brake, tyre, asphalt wear, re-suspension
- **Secondary**: NO_3^- SO_4^{2-} source profiles consisting only of ammonium sulfate (SO_4^{2-}, NH_4^+, S) and ammonium nitrate (NO_3^-, NH_4^+)
- Traffic source in more detail

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Results

Model results verified against statistical validation targets (EPA)

$R^2 > 0.8$

$\chi^2 < 4$

80% < % total mass < 120 %

DoF > 5

Calculated PM10 and PM2.5 concentrations reproduce the measured values within ± 18%

Statistical uncertainties are associated to mass contributions of each source.

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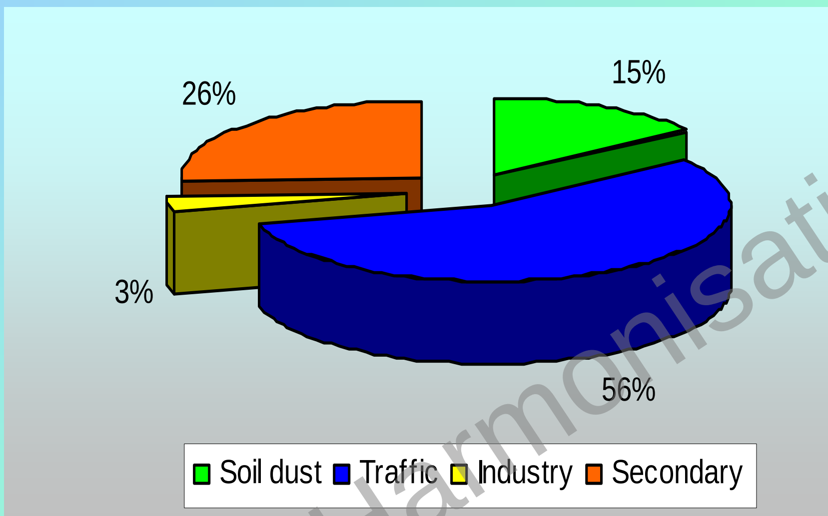
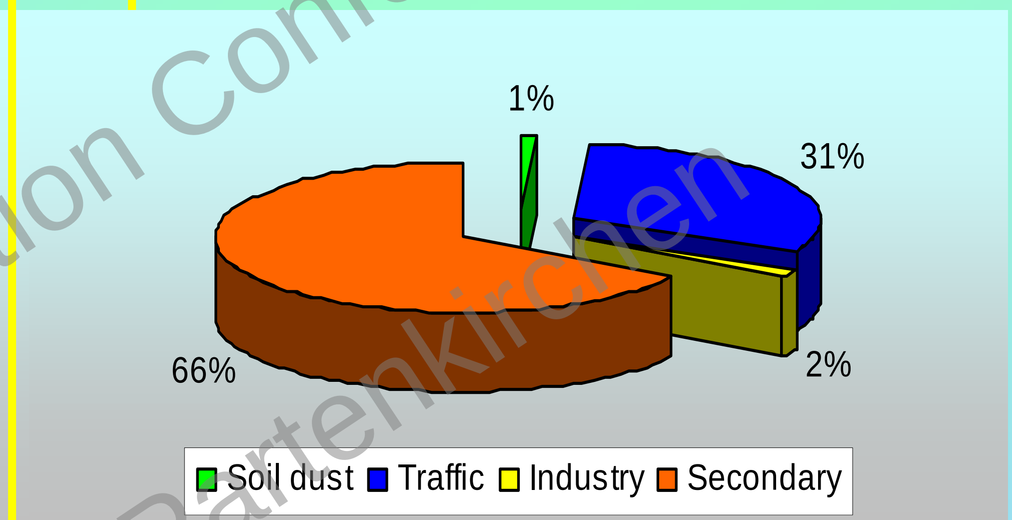
PM10 and PM2.5 Source apportionment (summer)

PM10



PM2.5



Source	Mass (µg/m³)	Uncertainty (µg/m³)
Traffic	33.1	± 5.8
Soil dust	9.3	± 1.0
Industry	2.3	± 0.7
Secondary	16.0	± 2.8

Source	Mass (µg/m³)	Uncertainty (µg/m³)
Traffic	11.1	± 1.7
Soil dust	0.4	± 1.8
Industry	0.9	± 1.9
Secondary	23.3	± 1.10

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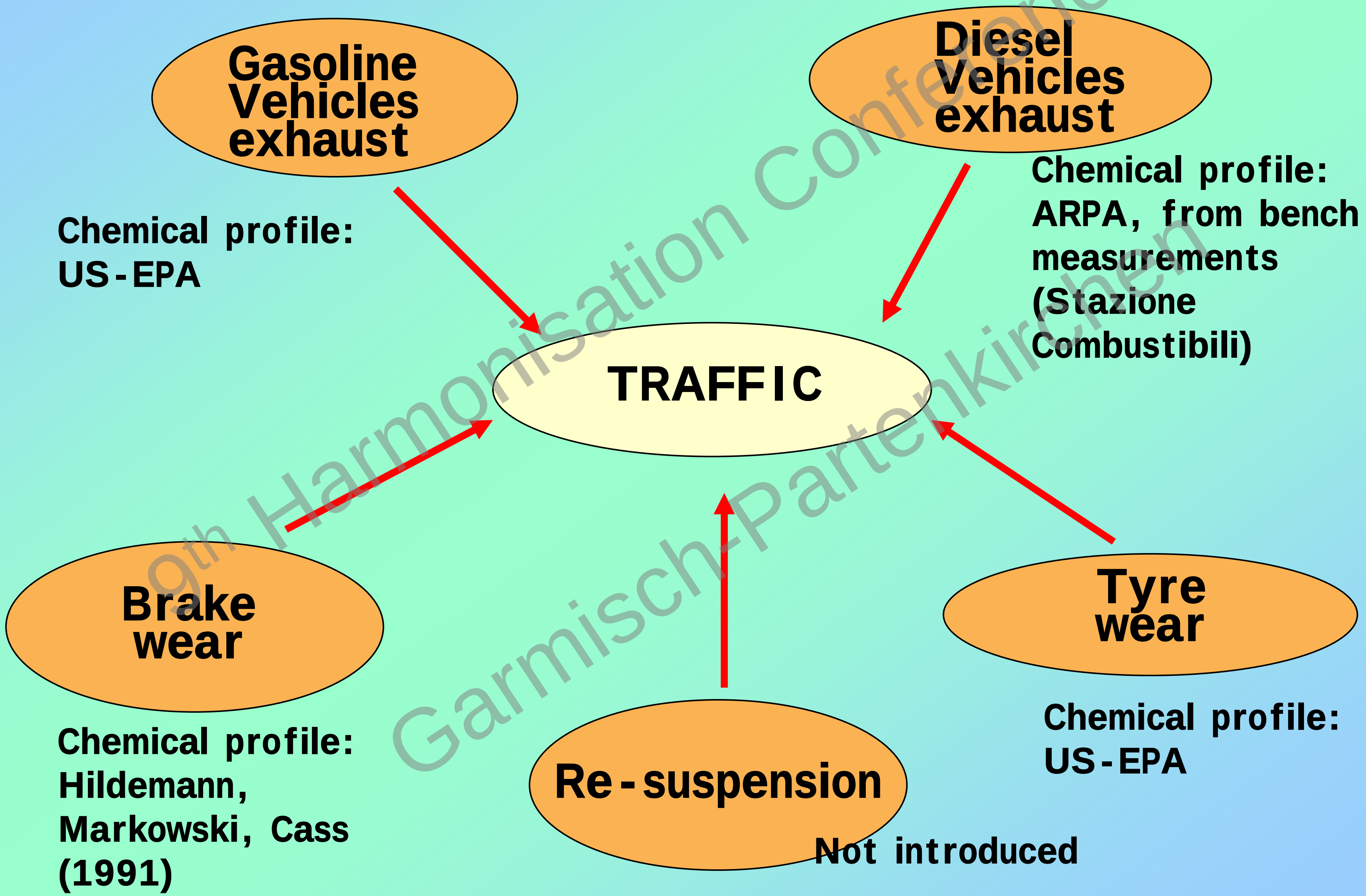
Traffic source in more detail



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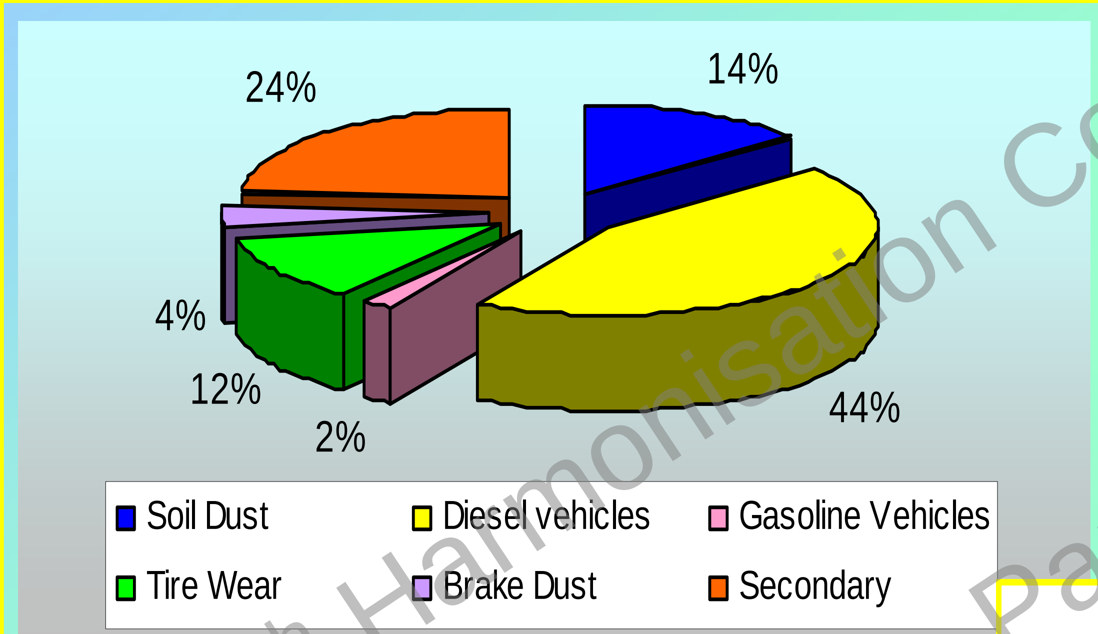
PM10 Source apportionment with traffic in detail

Preliminary results



Source	*Mass (µg/m³)*	*Uncertainty (µg/m³)*
Soil dust	9.0	± 0.8
Diesel vehicles exhaust	27.2	± 2.7
Gasoline vehicles exhaust	1.5	± 0.9
Tyre wear	7.2	± 1.9
Brake wear	2.3	± 0.3
Secondary	14.8	± 1.2

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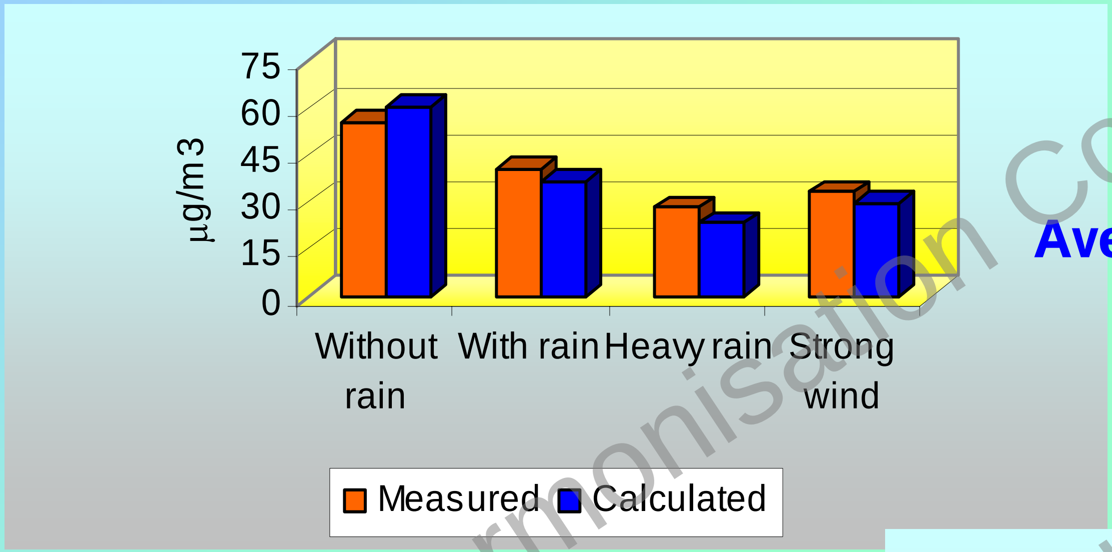
Effects of meteorology

- Strong wind (daily average wind speed > 5 m/s, Foehn episode)
- Rain
- Hard and prolonged rain (precipitation =43 mm duration 14 hours)

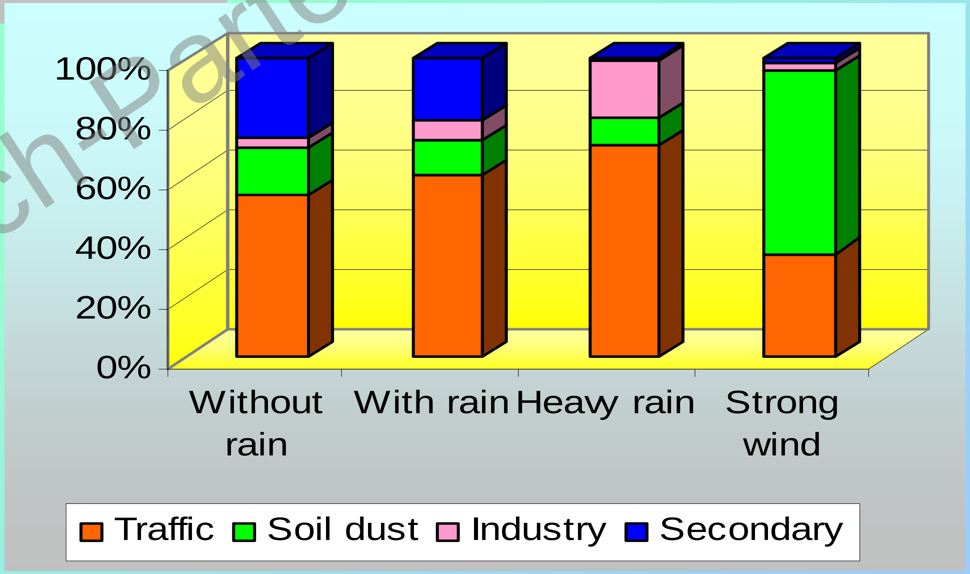
Source	Without rain		With rain		Heavy rain		Strong wind	
	Mass (µg/m3)	Unc. (µg/m3)	Mass (µg/m3)	Unc. (µg/m3)	Mass (µg/m3)	Unc. (µg/m3)	Mass (µg/m3)	Unc. (µg/m3)
Traffic	33.058	± 5.757	22.420	± 3.952	16.307	± 3.659	10.189	± 3.464
Soil dust	9.265	± 0.973	4.341	± 0.624	2.143	± 0.742	18.032	± 1.363
Industry	2.329	± 0.691	2.557	± 0.683	4.514	± 1.001	0.860	± 0.264
Secondary	15.954	± 2.792	7.549	± 1.445	0.144	± 0.037	0.429	± 0.166

Effects of rain and wind on PM_{10} source apportionment



Average PM10 concentrations

% Source contributions



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Conclusions

- Contribution of traffic source: mainly diesel
- Brake and tyre wear not negligible
- Secondary source dominant in PM2.5 – important also when deciding limits on PM2.5
- Important to consider dominant meteorological conditions when evaluating main emission sources

Needed:

- Extend model application to winter season (heating source fingerprint)
- Some source profiles must be improved (gasoline vehicles, re-suspension)
- Better description of secondary particulate (OC-EC)
- Focus investigation on PM2.5 as more data become available
- Extension of application to several other urban, extra-urban, rural sites in Lombardy (different emission sources: wood burning, cattle/swine/poultry)