"Capacity Building and Strengthening Institutional Arrangement"

Analysis and sampling of air and air pollution

General principles on air quality monitoring equipment

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CONCENTRATION OF AIR POLLUTANTS

$$C_{(l)} = \frac{M}{V}$$

- C: concentration
- M: mass
- V: volume

FACTORS THAT AFFECT M

- Emissions
- Chemical-physical transformations
- Deposition

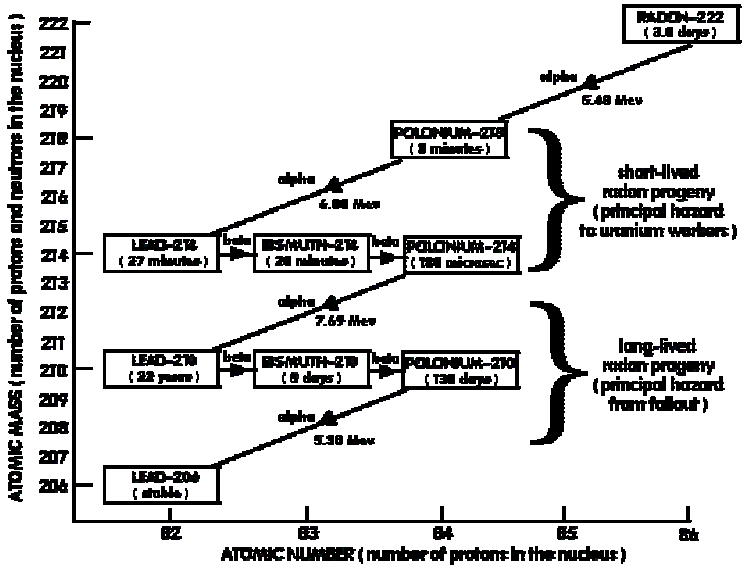
FACTORS THAT AFFECT V

- Air mass horizontal transport
- Air mass mixing

HOW CAN WE DETERMINE
WHICH VARIATIONS
IN POLLUTANTS CONCENTRATION
ARE DUE TO CHANGES
IN *EMISSION FLUXES*
OR IN *CHEMICAL REACTIONS*
AND WHICH OF THEM
ARE DUE TO *CHANGES*
IN THE AIR VOLUME
AVAILABLE FOR POLLUTANTS DISPERSION?

RADON PROGENY MEASUREMENTS FOR THE EVALUATION OF ATMOSPHERIC POLLUTION

RADON PROGENY



Decay products of radon gas (radon-222) in their order of appearance.

They are called the *radon progeny* (radon daughters).

Each radioactive element on the list gives off either *a* radiation or *b* radiation - and sometimes *g* radiation too - thereby transforming itself into the next element on the list.

$$\frac{\partial C_i}{\partial t} = \alpha[\phi_i(t)] - \beta\{C_i\} + Adv - L_s + \sum P_i - \sum L_i$$

Where:

$f_i(t)$	*emissive fluxes from sources*
L_s	*deposition on surfaces loss*
P_i	*formation processes*
L_i	*chemical removal processes*
a	*parameter that describes boundary layer stability*
$b\{C_i\}$	*parameter that describes mixing processes*
Adv	*parameter that describes transport processes*

Low-reactivity primary pollutants

$$\frac{\partial C}{\partial t} = \alpha[\phi(t)] - \beta\{C\} + Adv$$

$$L_S; \quad \sum P_i; \quad \sum L_i$$

are negligible

Radon

$$\frac{\partial C_R}{\partial t} = \alpha K - \beta\{C_R\} + Adv$$

$$[\phi(t)]$$

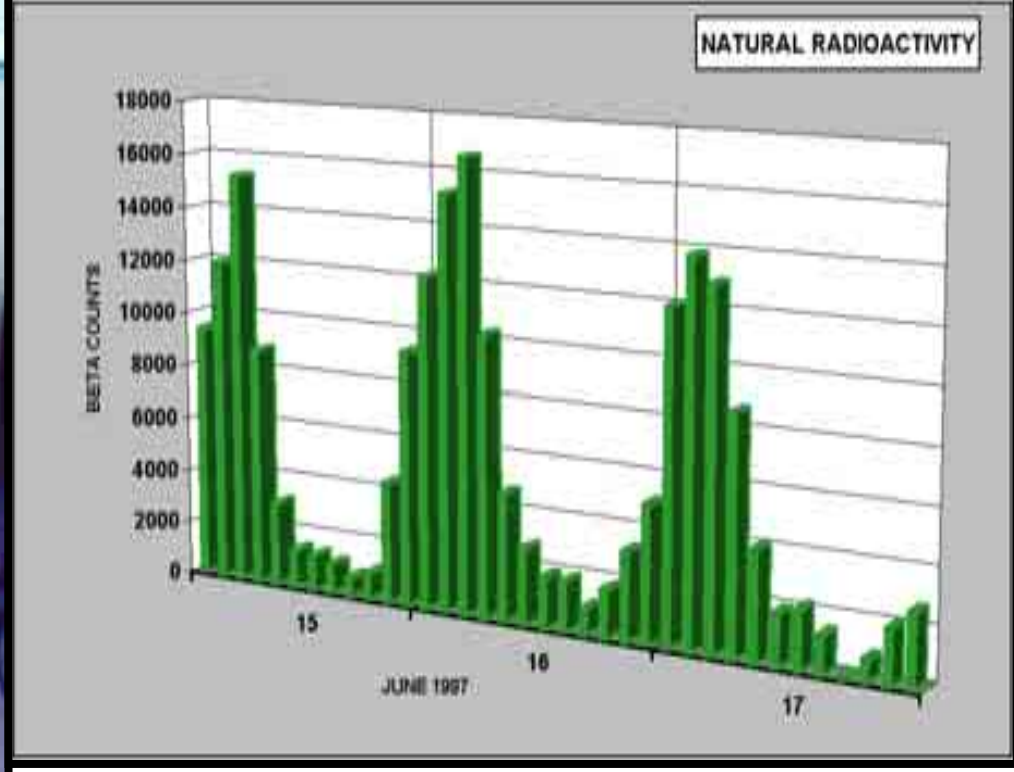
can be regarded as constant

Low-reactivity primary pollutants

$$\frac{\partial C}{\partial t} = \alpha[\phi(t)] - \beta\{C\} + Adv$$

Radon

$$\frac{\partial C_R}{\partial t} = \alpha K - \beta\{C_R\} + Adv$$



ATMOSPHERIC STABILITY MONITOR

Based on the measurement of Radon daughters

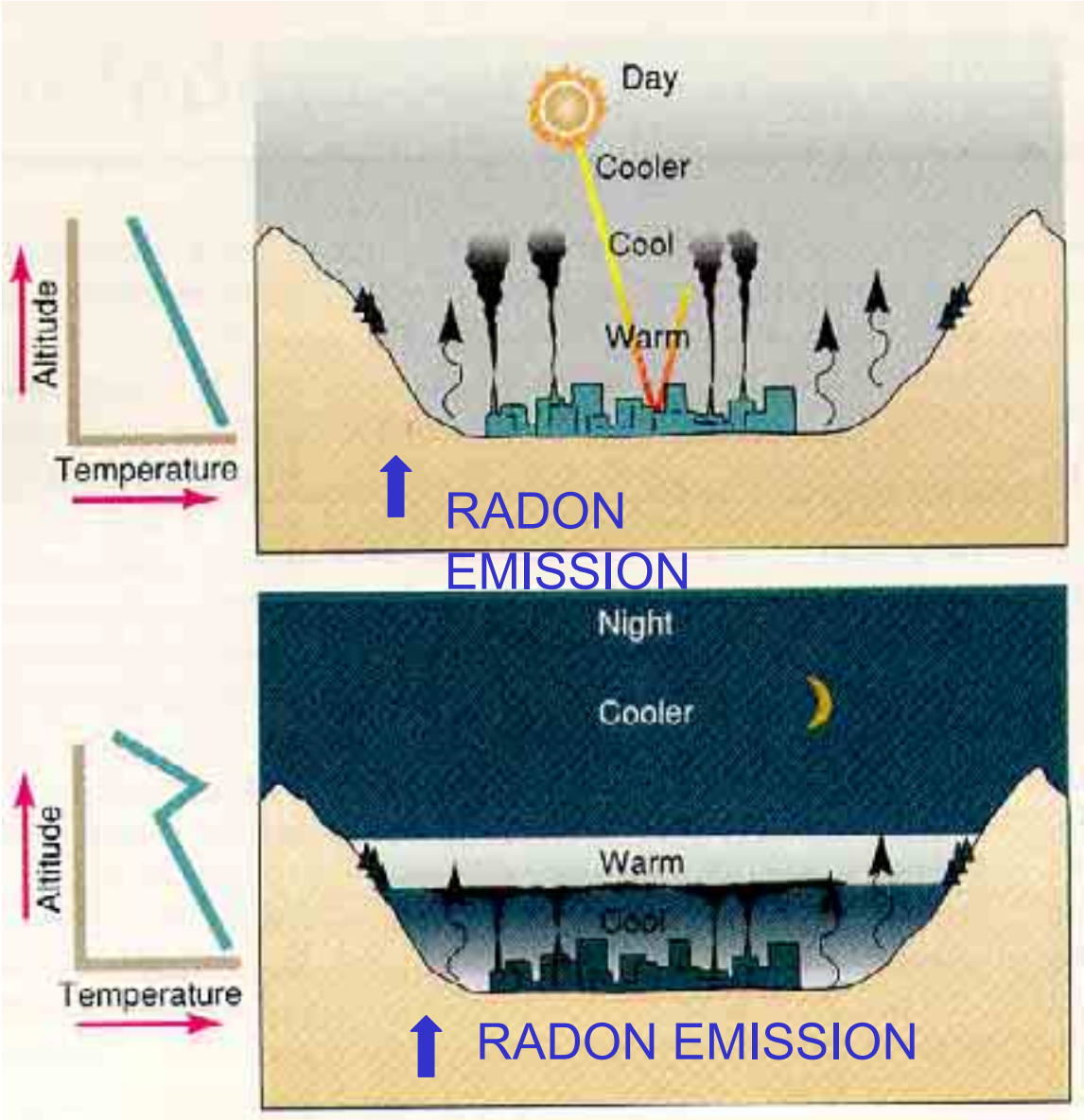
The instrument gives information about the mixing properties of the lower atmospheric layers

Convective mixing of the lower atmosphere:

Radon dilutes into the whole mixing layer

Weak mixing of the lower atmosphere:

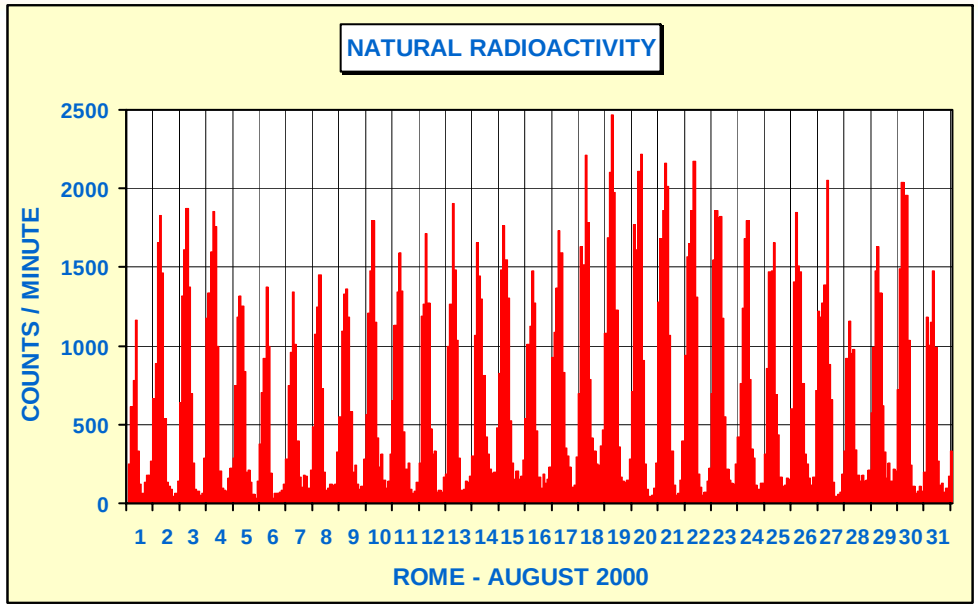
Radon is trapped in the lower layer and its air concentration increases

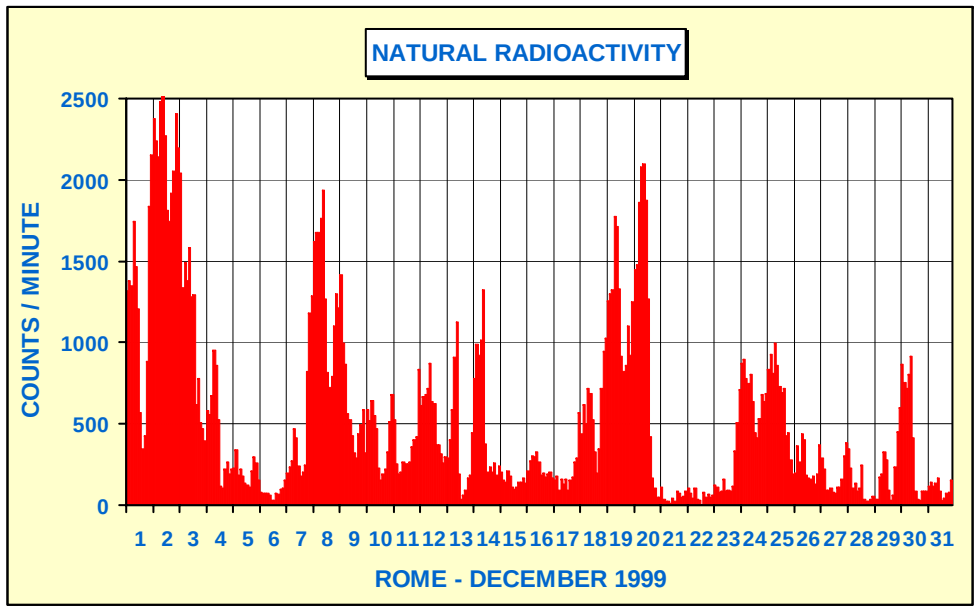


COMPARISON OF THE TEMPORAL TREND OF NATURAL RADIOACTIVITY DURING A SUMMER MONTH AND A WINTER MONTH

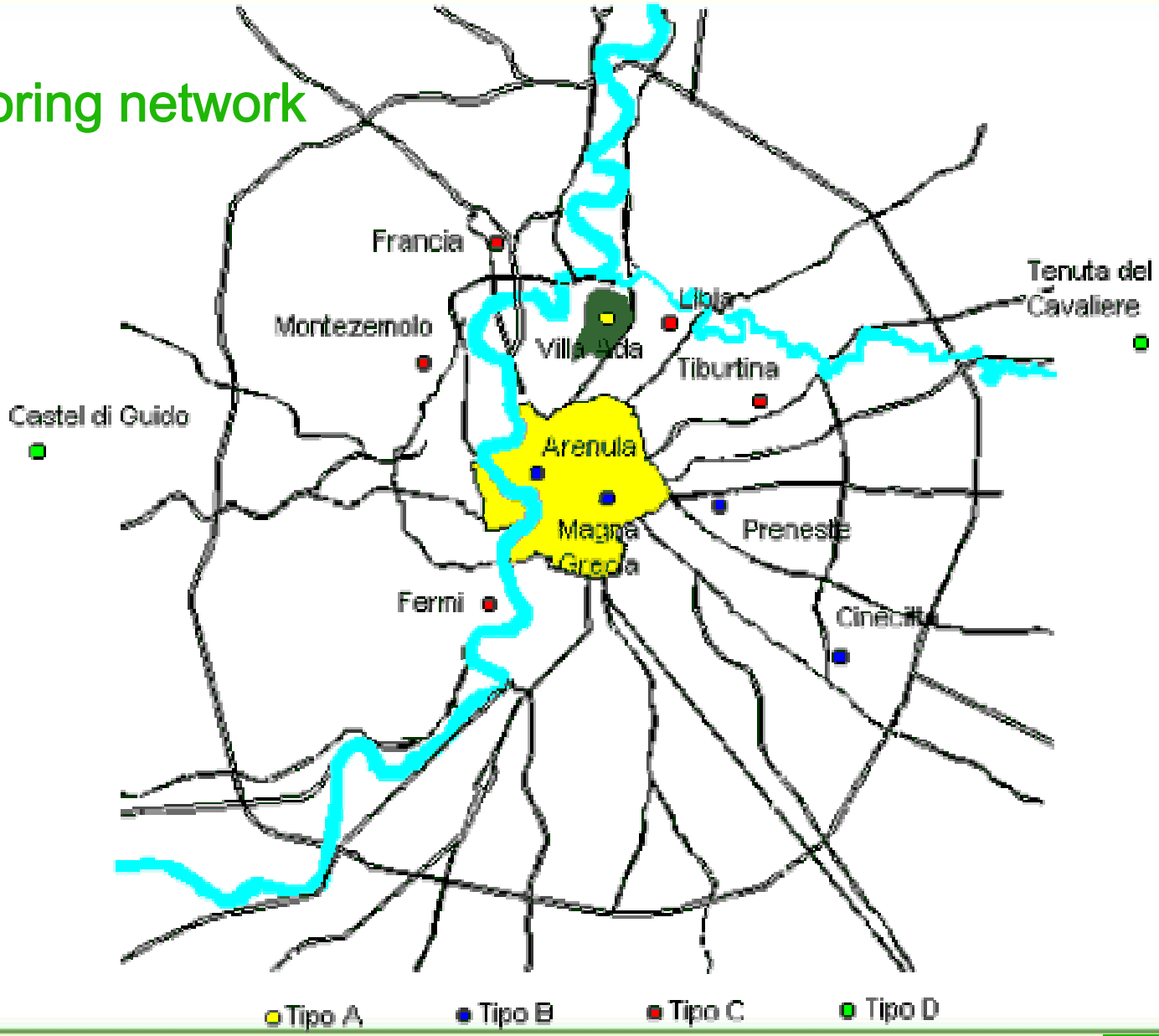
During **warm months** natural radioactivity shows a well-defined and modulated temporal pattern (all days are similar: nocturnal stability and convective mixing during the day)

During **cold months** high-pressure periods are sporadic and advection often occurs. Diurnal mixing is weak and of limited duration





Rome air monitoring network



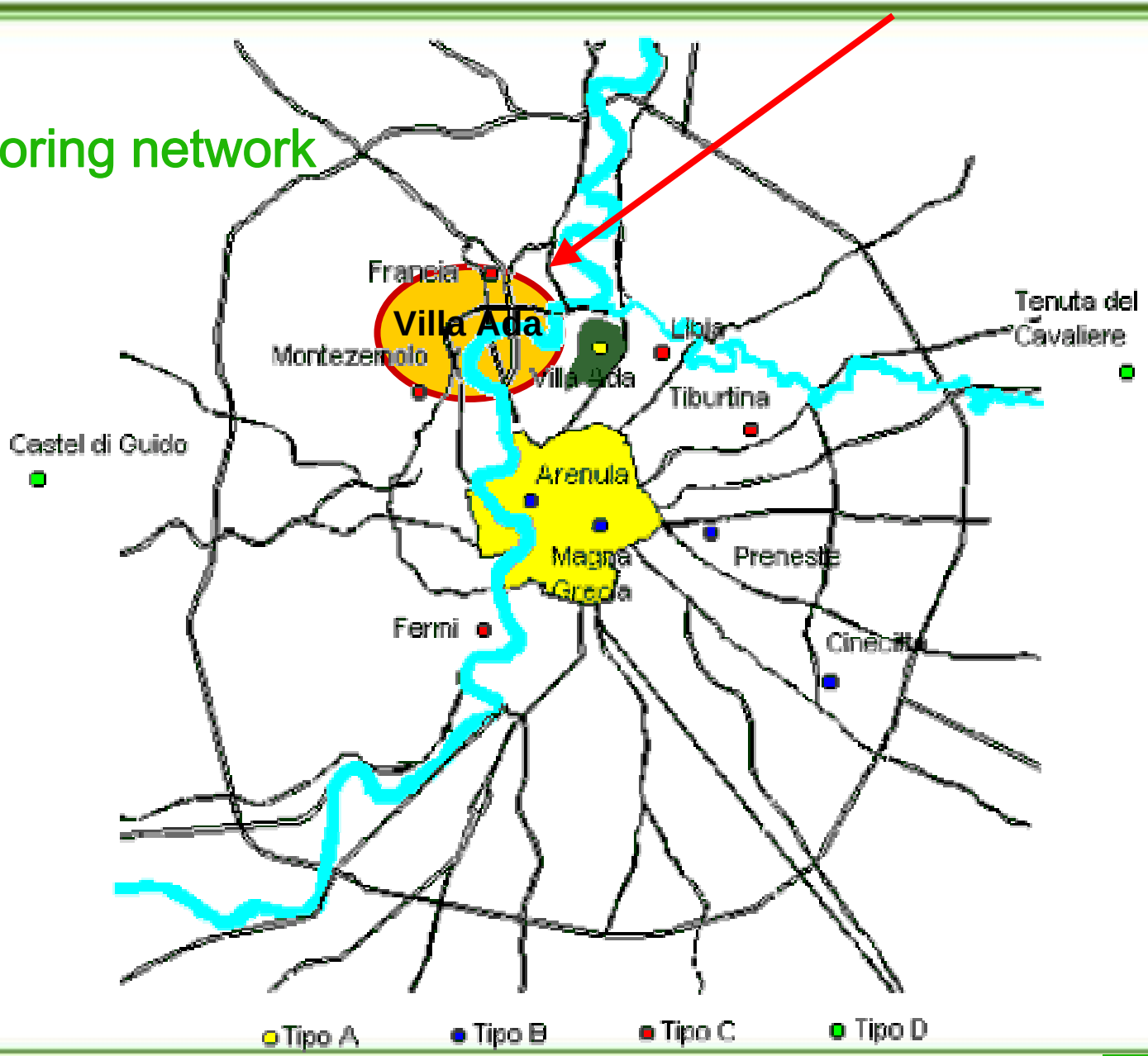
Rome air monitoring network

Station	Street	Street type	Traffic volume	Star date	End date	Station type (DM 20/5/91)	Station type (airbase)	Zone type (airbase)	Description
Ada	Villa Ada	Wide	Unknown	01/01/97		A	Background	Urban	Unknown
Arenula	L.go Arenula	Canyon	Low	01/01/93		B	Traffic	Urban	Commercial -residential zone. In the center of the city with traffic limitation. . Sited at 3 m to the vehicle emission
Cinecittà	Via Belloni	Wide	Low	01/01/98		B	Background	Urban	Residential-commercial zone. High population density. Main road at 15 m.
Magna Grecia	Via Magna Grecia	Canyon	High	01/01/93		B	Traffic	Urban	Residential-commercial zone. High population density. Sited at 4 m to vehicle emissions.
Preneste	Largo Perestrello	Wide	Low	01-01-98		B	Background	Urban	Residential-commercial zone. High population density. Main road at 20 m.
Preneste-Via Prenestina	Via Prenestina	Canyon	Medium	01-01-93	01-01-98	C	Traffic	Urban	Residential-commercial zone. High population density.
Fermi	P.za E. Fermi	Canyon	High	01/01/93		C	Traffic	Urban	Residential-commercial zone. Sited at 3 m to vehicle emissions
Francia	C.so Francia	Canyon	High	01/01/93		C	Traffic	Urban	Residential-commercial zone. Sited at 4 m to vehicle emissions
Gondar-Libia	Pza S.Emerenziana	Canyon	High	01/01/93		C	Traffic	Urban	Residential-commercial zone. High population density. Sited at 2 m to vehicle emissions
Montezemolo	L.go Montezemolo	Canyon	High	01/01/93		C	Traffic	Urban	Residential-commercial zone. High population density. Sited at 3 m to vehicle emissions
Tiburtina	Via Tiburtina	Canyon	High	01/01/93		C	Traffic	Urban	Residential-commercial zone. High population density.Sited at 2 m to vehicle emissions
Cavaliere				01/01/97		D	Background	Rural	Natural zone. Main road in radius 150 m
Guido				01/01/97		D	Background	Rural	Natural zone

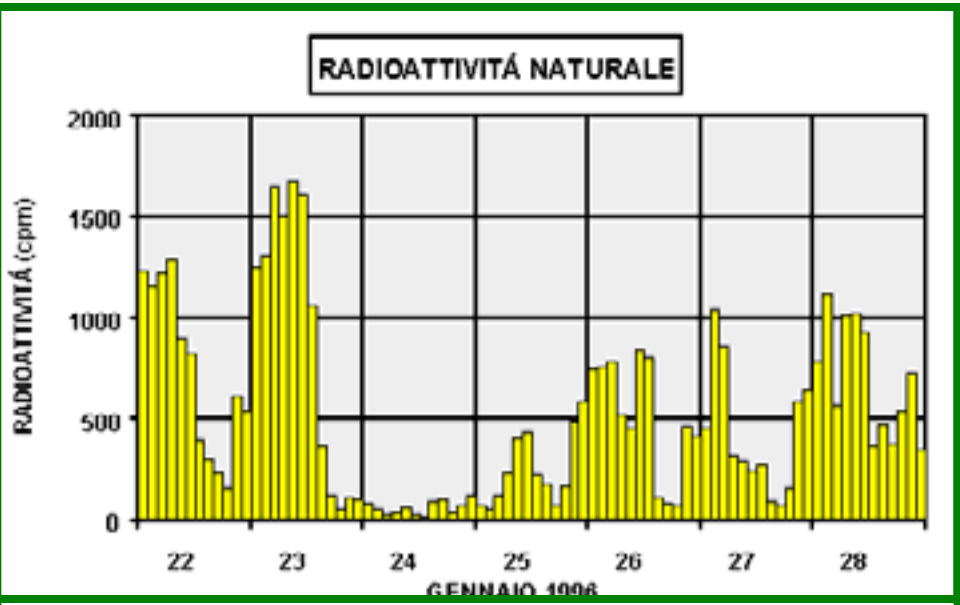
Rome air monitoring network

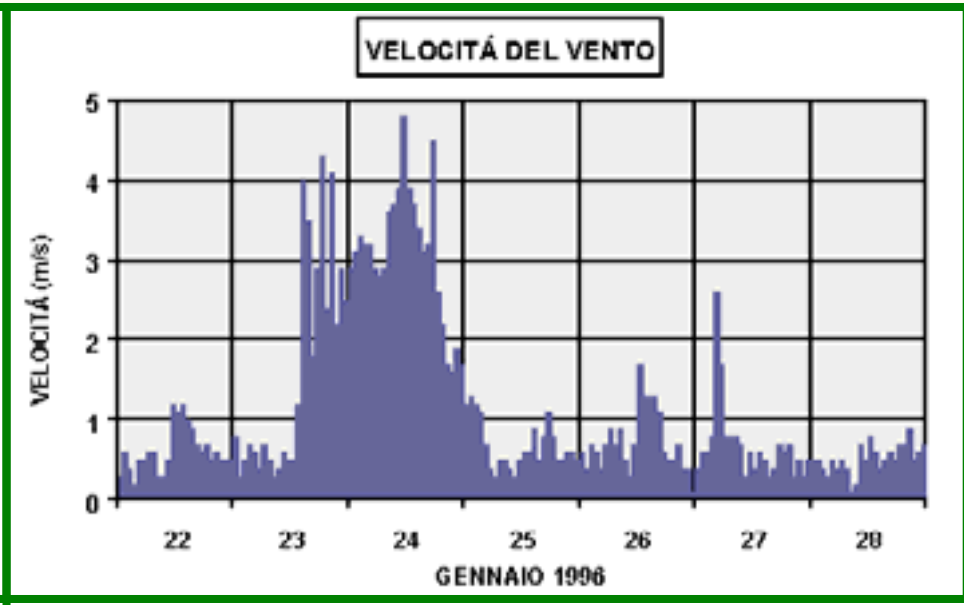
City	Station type	Station name	Period of activity	NO_2	SO_2	O_3	CO	Benzene	Particles	Others
ROMA	A	Villa Ada	1/1/97	**X**	**X**	**X**	**X**	**X**	**X**	Toluene, Xilene
	B	Arenula Cinecittà Mag. Grecia Preneste	1/1/93 1/1/98 1/1/93 1/1/98	**X**	**X**	**X**	**X**		**X**	
	C	Fermi Francia Gondar-Libia Montezemolo Tiburtina	1/1/93 1/1/93 1/1/93 1/1/93 1/1/93	**X**	**X**	**X**	**X**	**X**	**X**	Toluene, Xilene
	D	Cavaliere Guido	1/1/97 1/1/97			**X**				

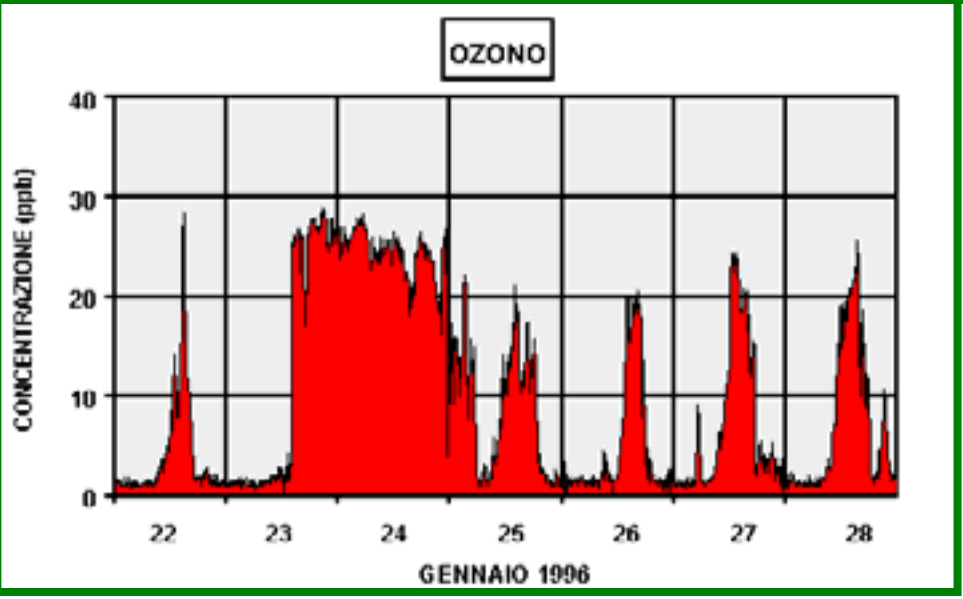
Rome air monitoring network



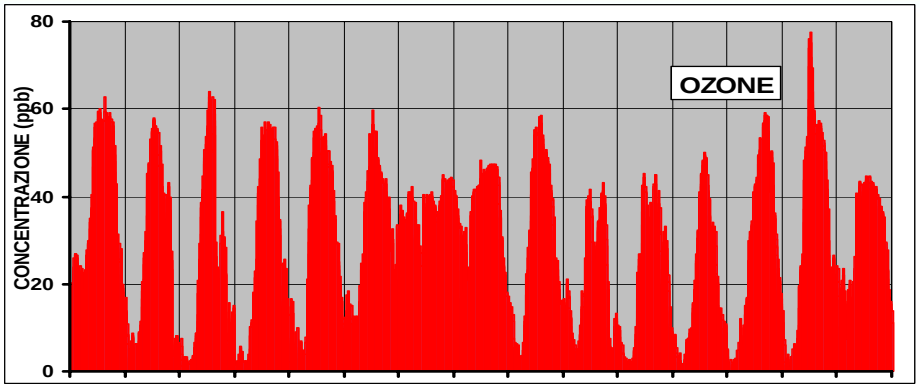
Measuring station in Villa Ada

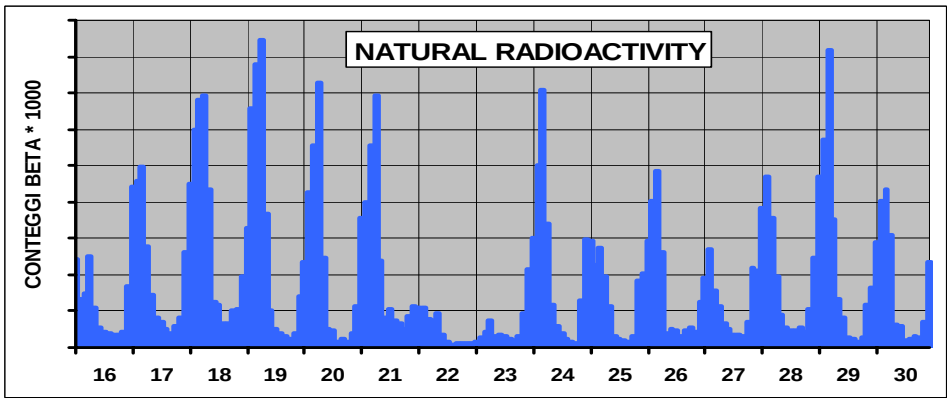


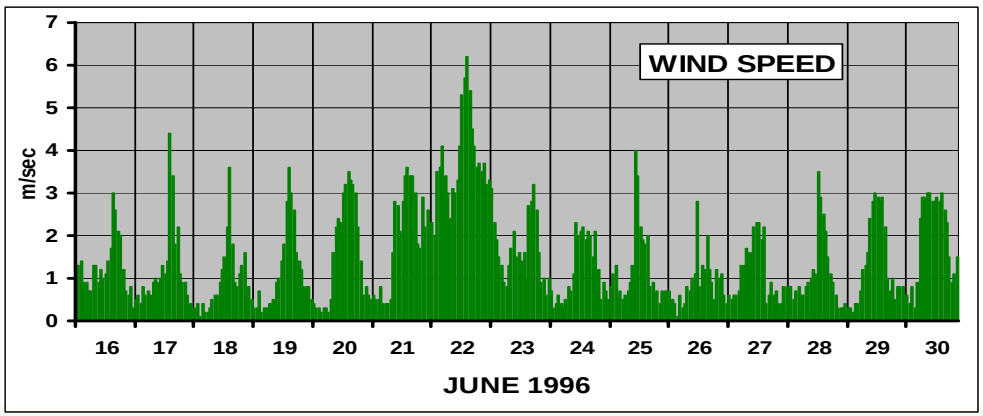




Interpretation
of ozone temporal trend on
the basis
of natural radioactivity:
a wintertime event

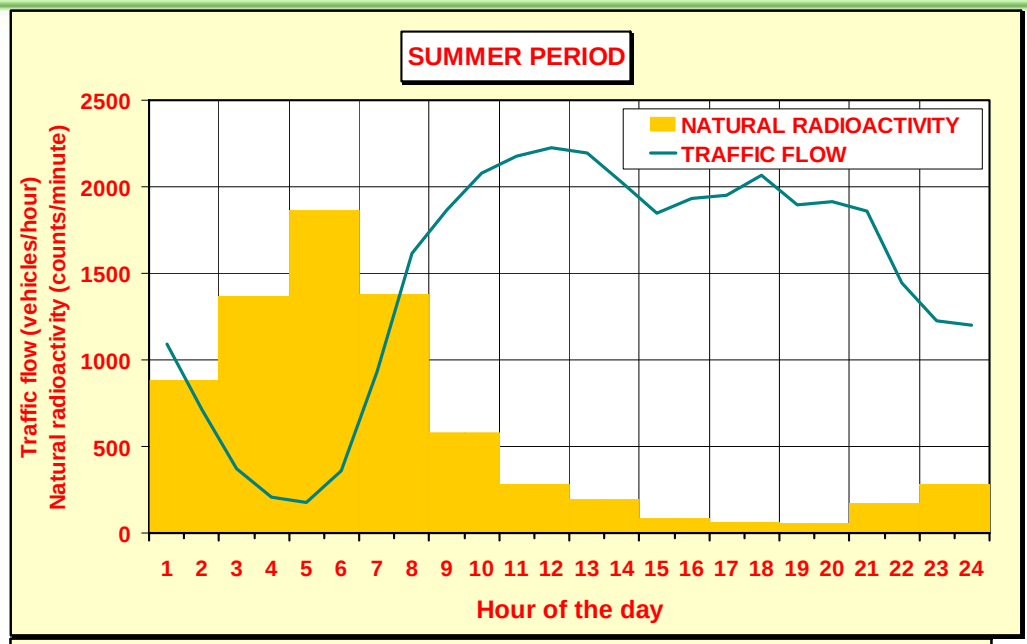


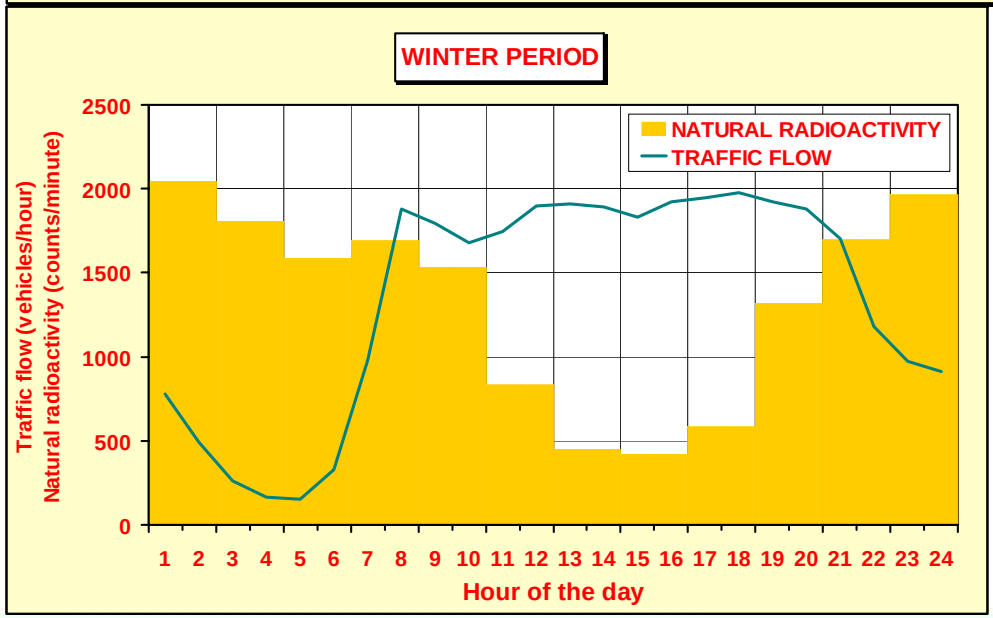




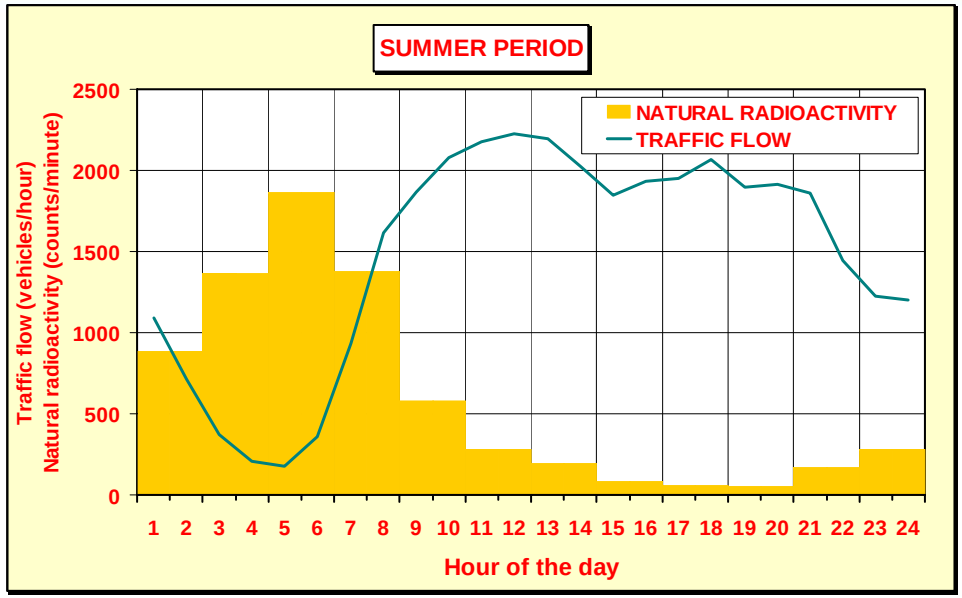
Interpretation
of ozone temporal trend on
the basis
of natural radioactivity:
a summertime event

OVERLAPPING
OF TRAFFIC FLOW
AND
ATMOSPHERIC MIXING
DURING A TYPICAL
SUMMER DAY
AND
WINTER DAY

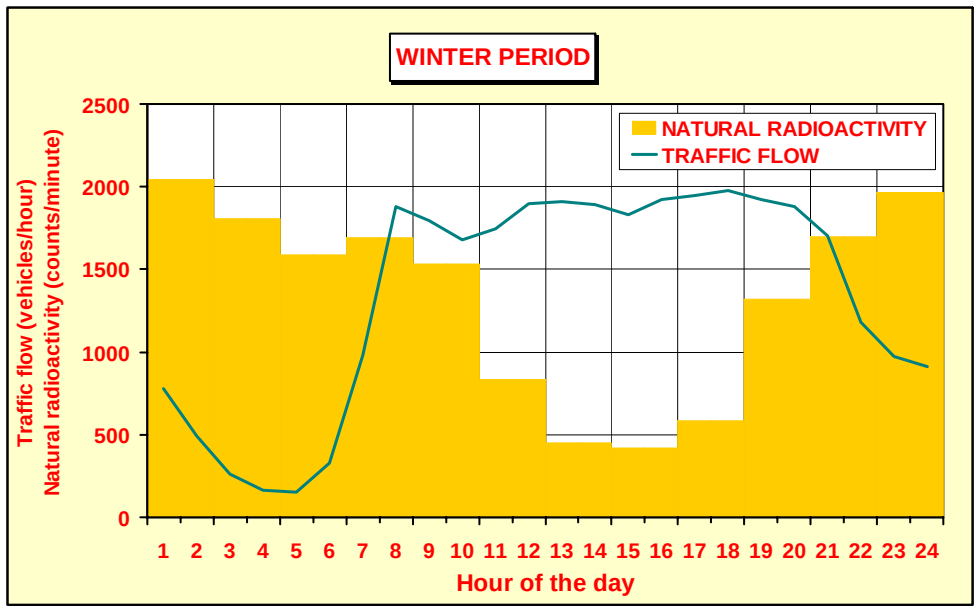




SUMMER: when the morning traffic increases the lower atmosphere is already well-mixed; night time stability occurs when the traffic has already decreased.

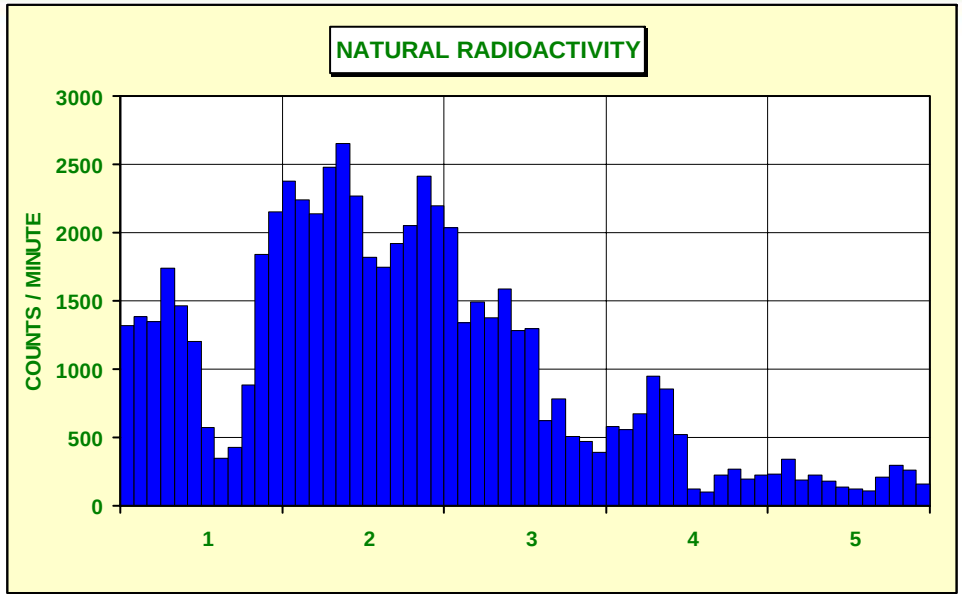


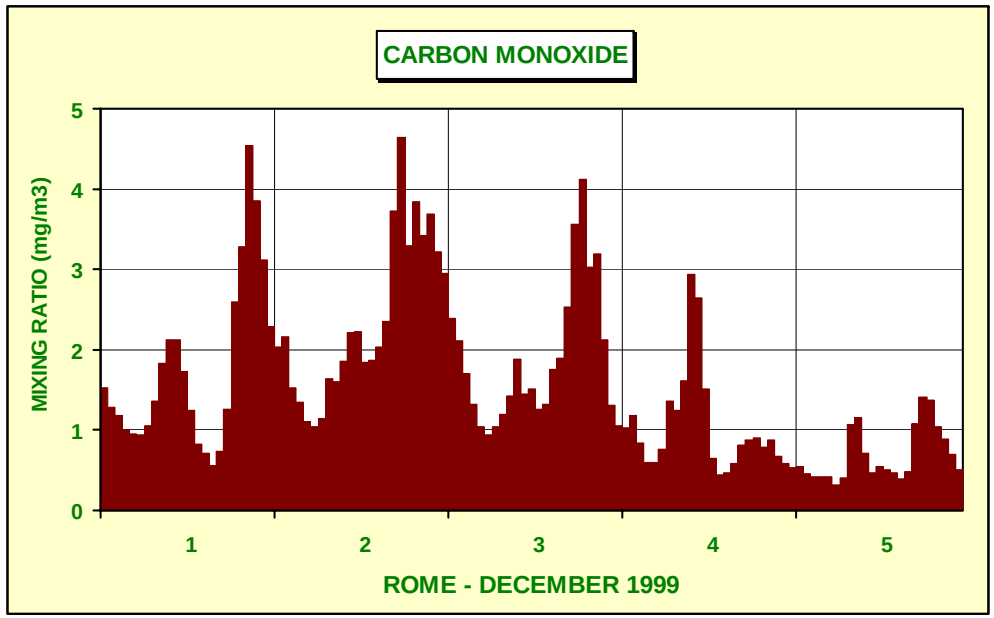
WINTER: when the morning traffic increases the mixing layer is still undeveloped; evening stability occurs when the traffic flow is still high.



PRIMARY POLLUTION EPISODES

TEMPORAL TREND OF NATURAL RADIOACTIVITY AND OF CARBON MONOXIDE CONCENTRATION



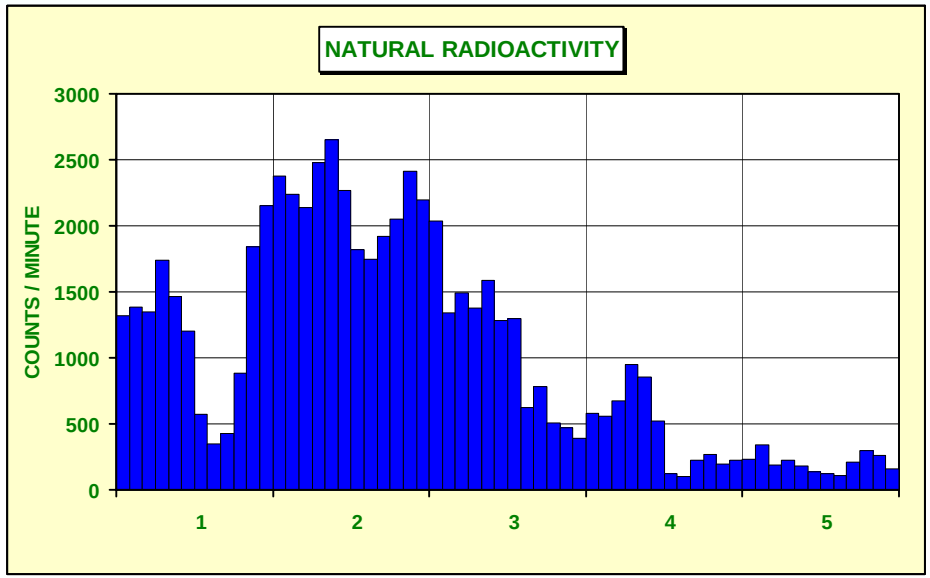


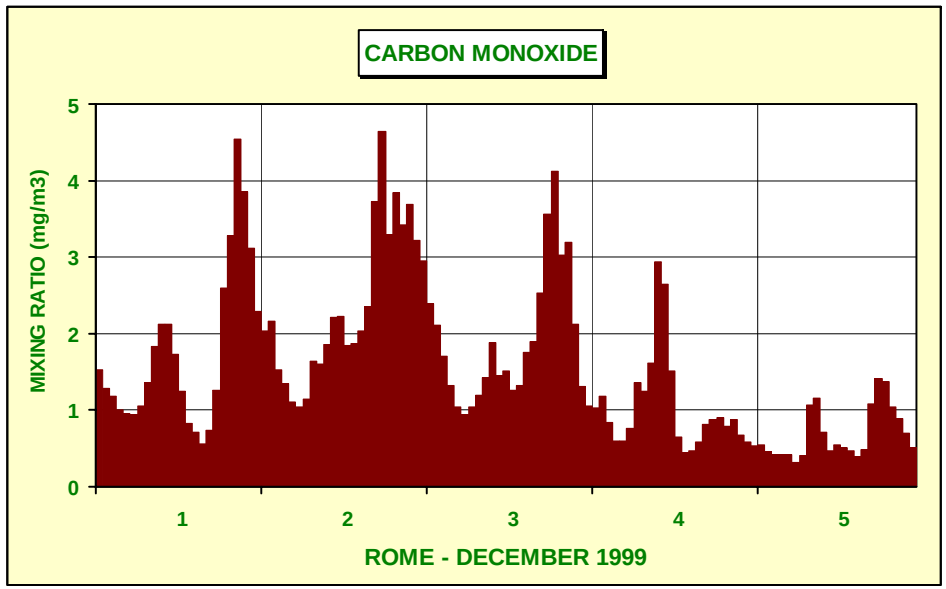
December 1st: nocturnal stability and daytime mixing - CO shows a distinct 2-peak shape

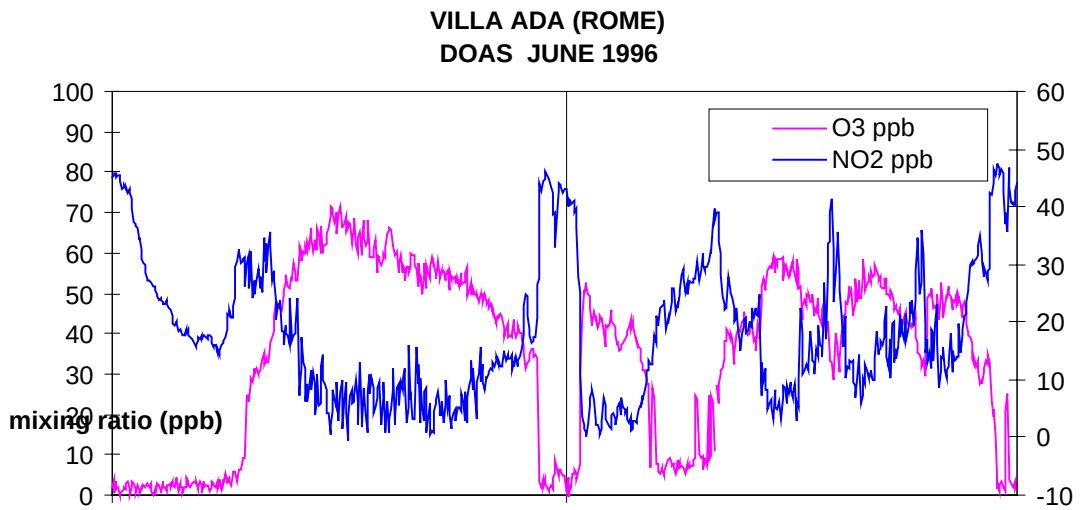
December 2nd: weak daytime mixing – CO keeps high values during the whole day

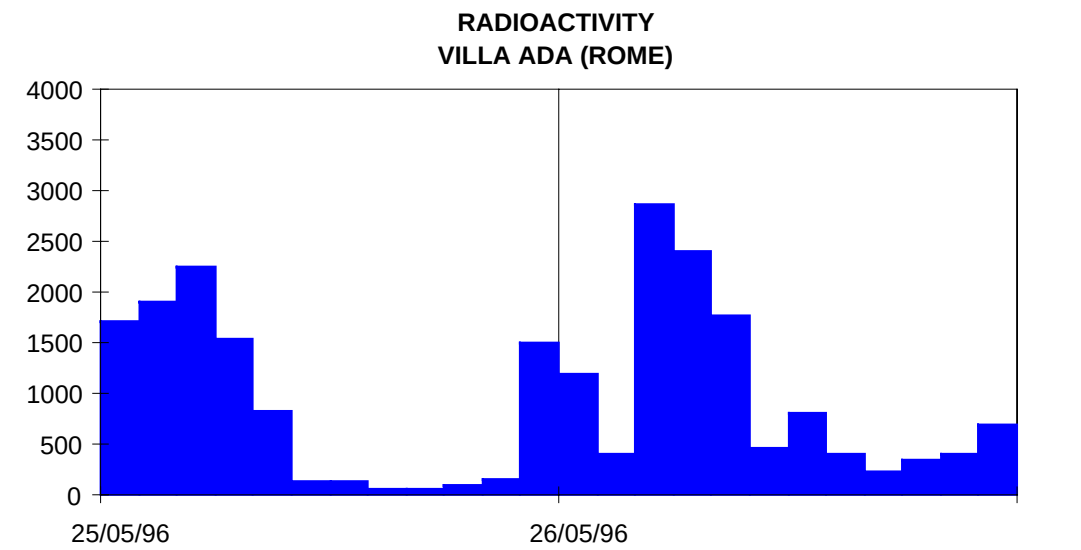
December 3rd: intermediate conditions

December 4th (from noon) and 5th: advection – CO keeps low values during the whole day









Atmospheric stability and Oxidants

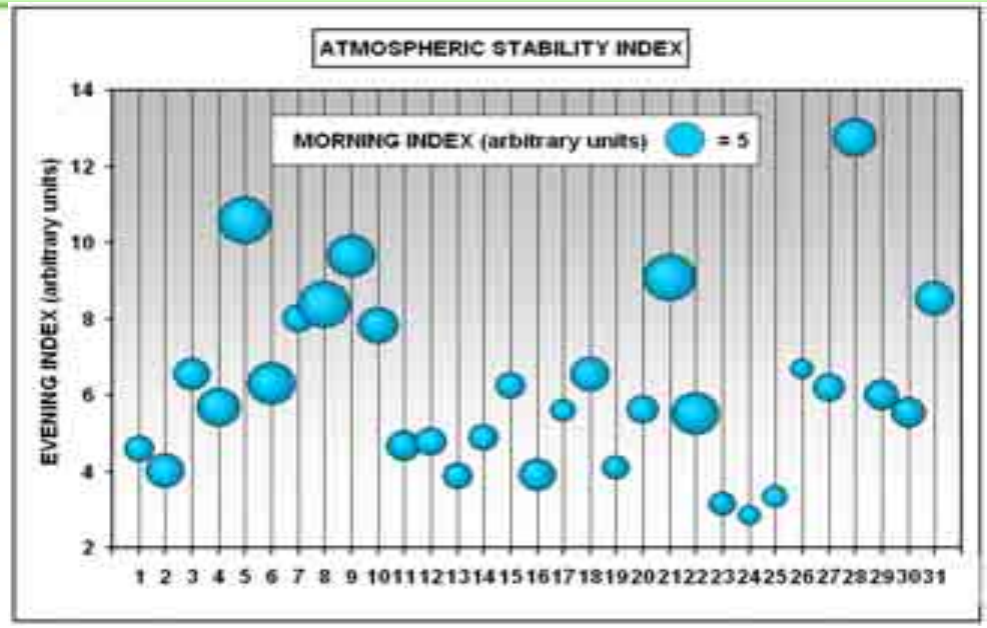
$$NO + O_3 \rightarrow NO_2$$

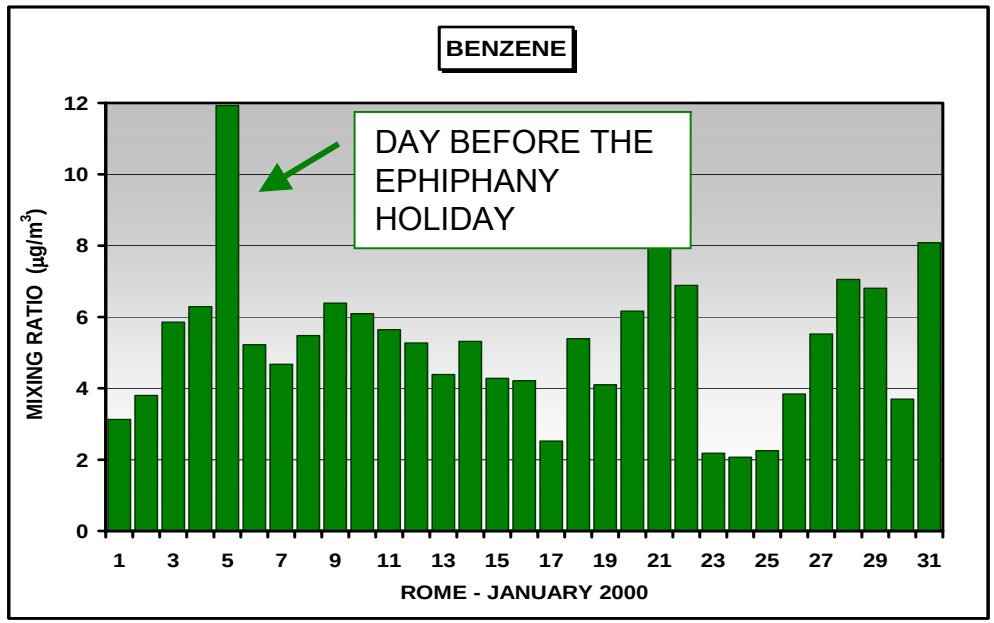
Tot. Ox = Constant

Ox

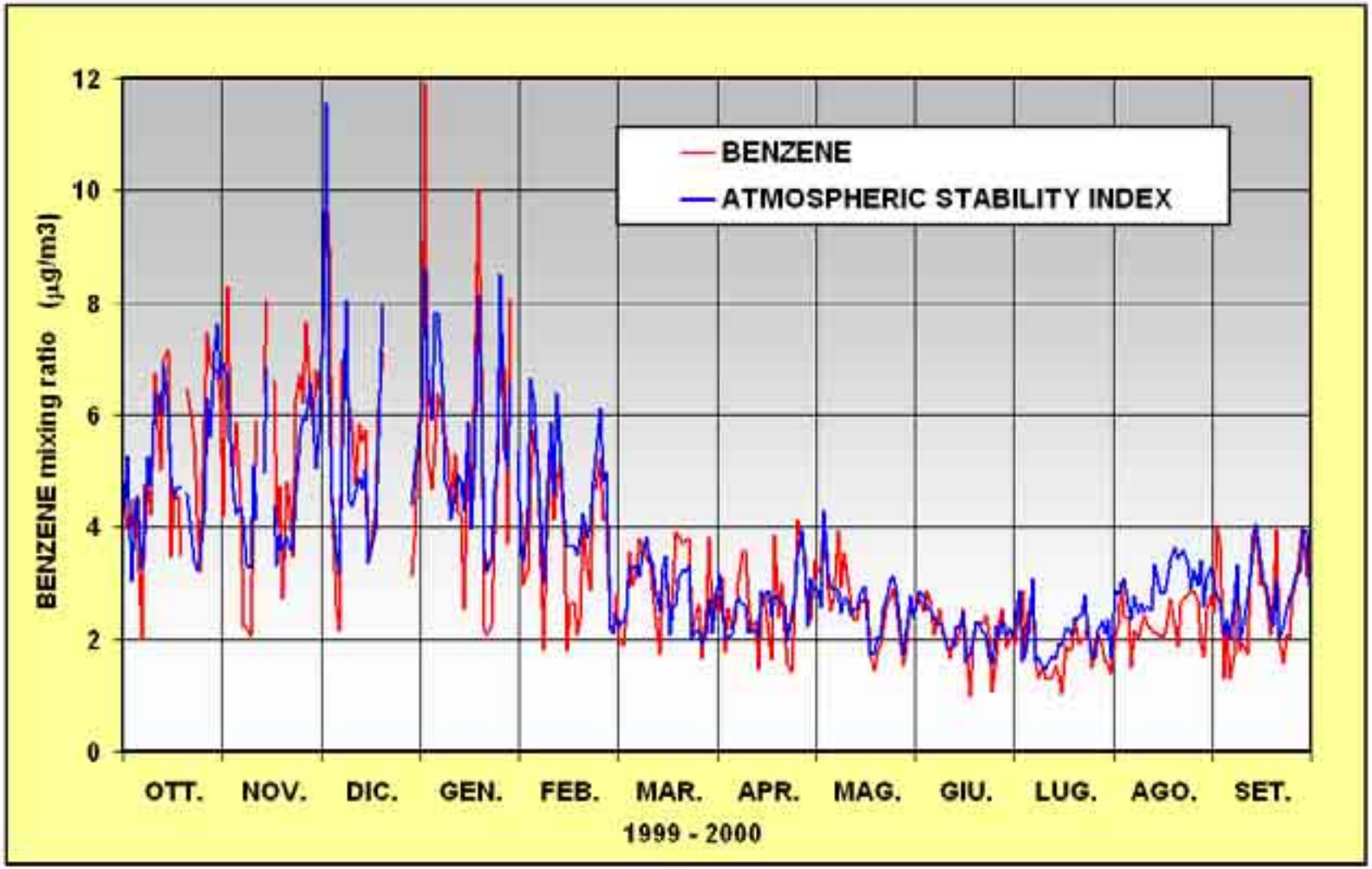
The Atmospheric Stability Index (two scalars referring to morning and to evening hours) is calculated on the basis of natural radioactivity values and of their time derivatives during significant periods of the day.

Primary pollution events are closely dependent on the mixing conditions of the lower atmopsheric layers, well described by the ASI

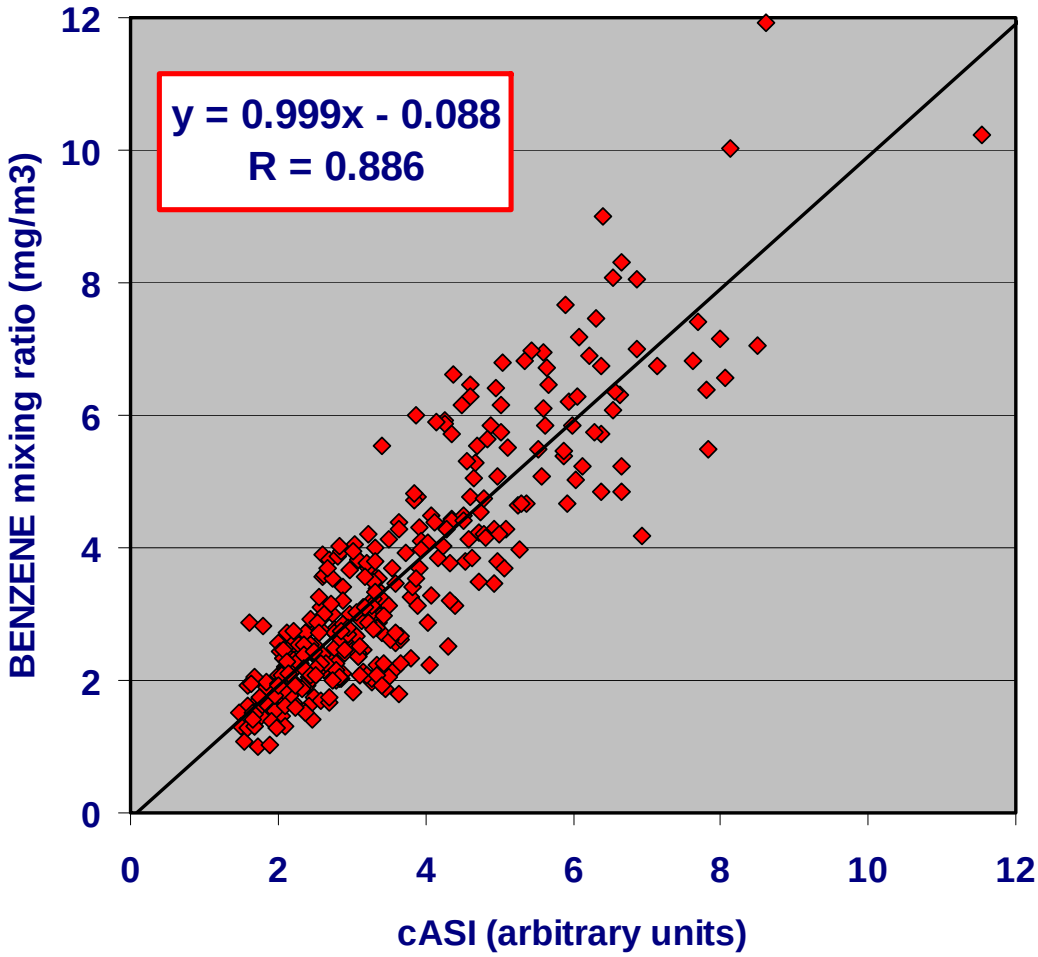




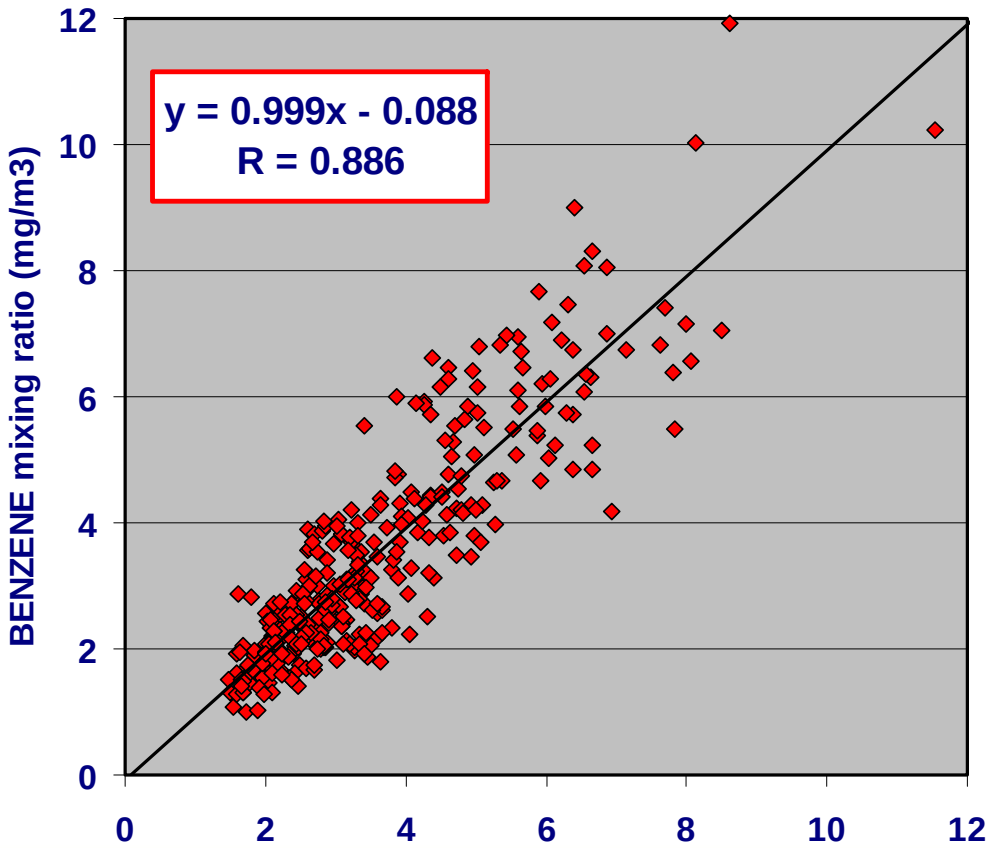
COMBINED ATMOSPHERIC STABILITY INDEX: 1-YEAR RESULTS



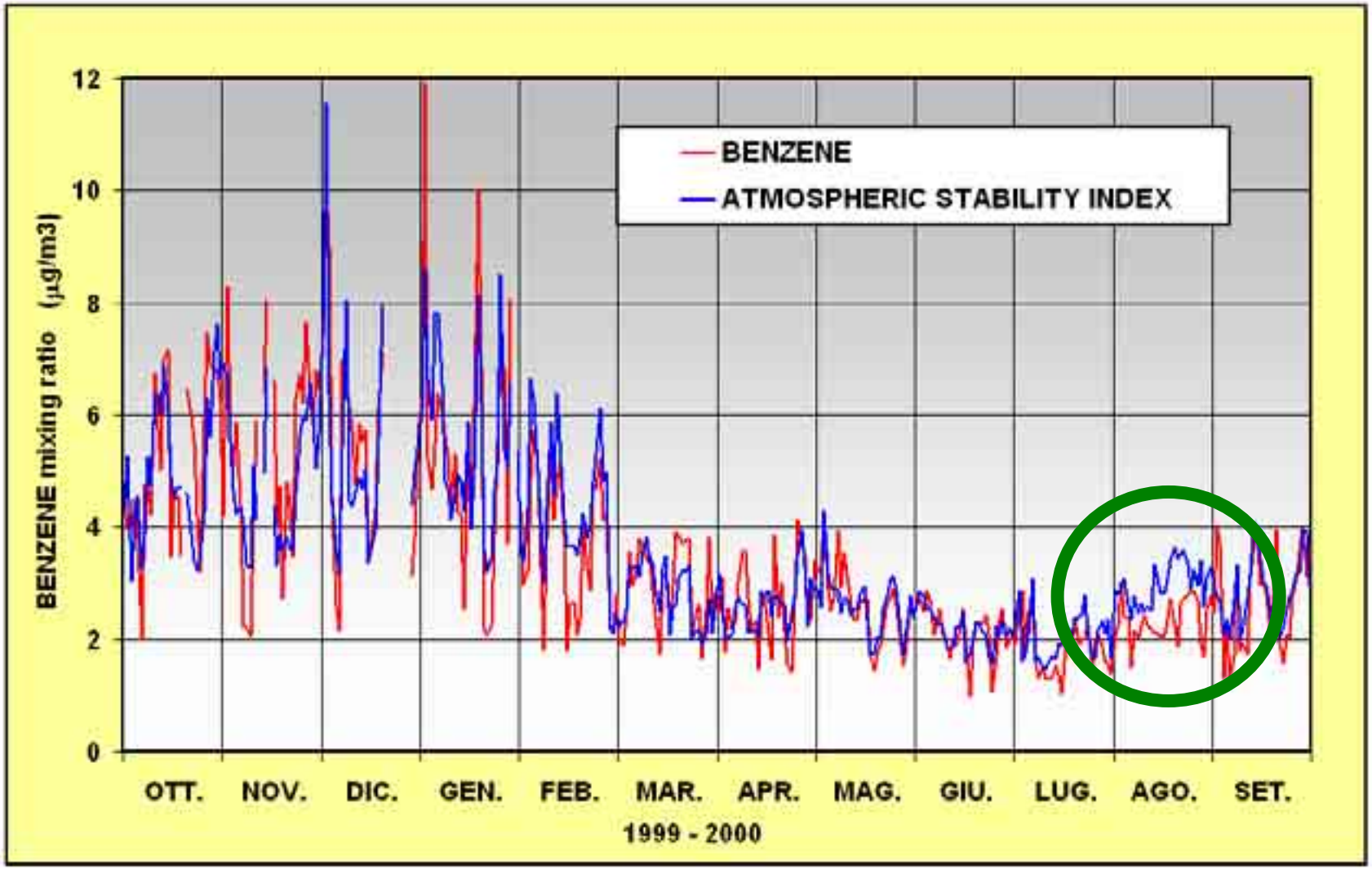
SCATTER PLOT OF THE COMBINED ATMOSPHERIC STABILITY INDEX AND THE AVERAGE BENZENE CONCENTRATION



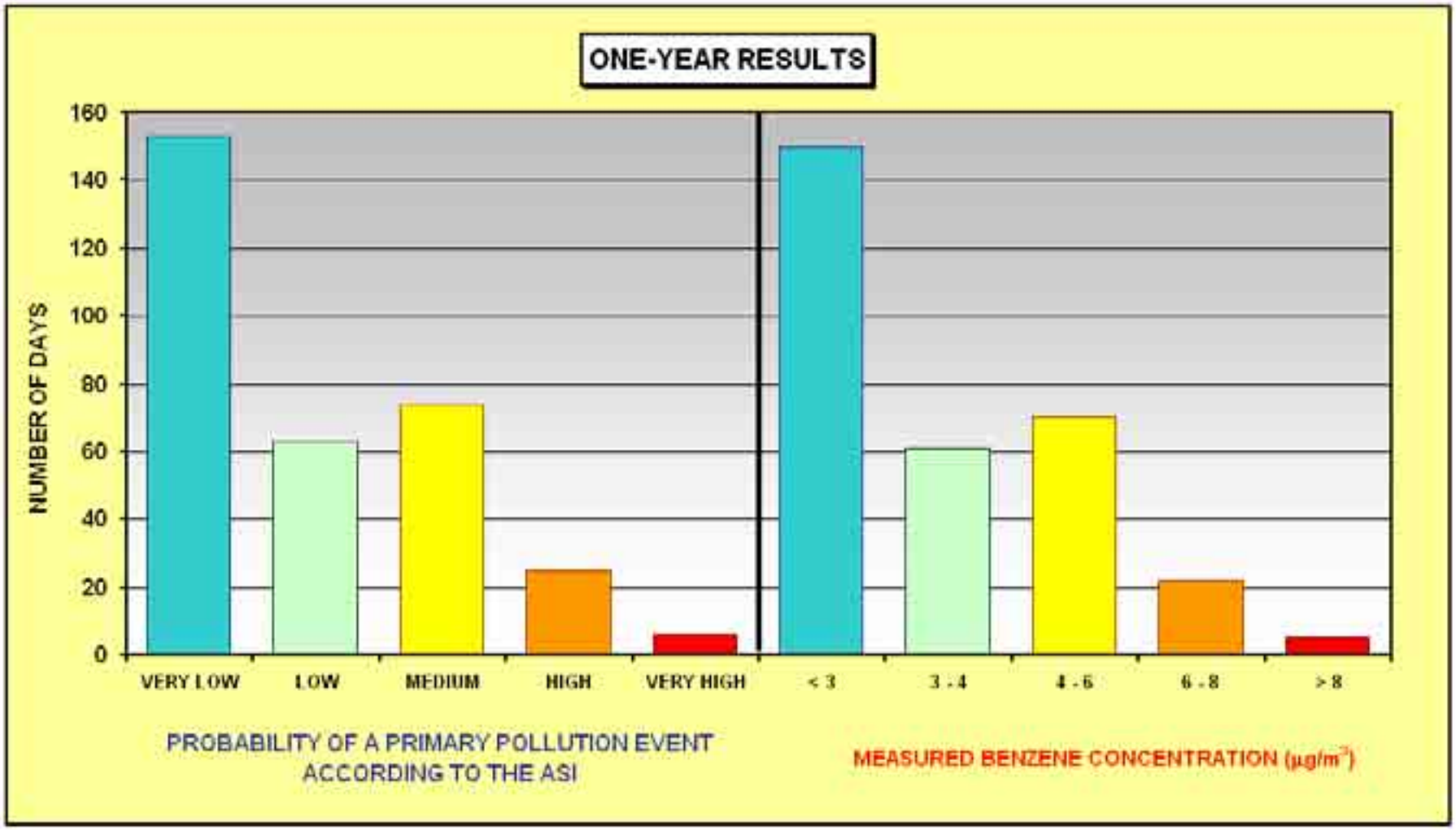
A one-to-one correlation is not expected since the ASI takes into account only one of the two driving forces determining pollutant concentrations, that is the meteorological factor.
The two data sets should coincide only
if the emission flux of benzene were constant in time



On **August**, the benzene air concentration was lower than predictable on the only basis of the mixing properties of the atmopshere because the emission flux was distinctly lower than during the rest of the year.



Classification of the days of one year according to the ASI
(probability of a primary pollution event)
and according to the real benzene concentration.



CONCLUSIONS

✓ Natural radioactivity is a valuable tool for the interpretation of atmospheric pollution.

✓ The Atmospheric Stability Indexes allow the characterisation of the period under study in terms of meteorological predisposition to a primary pollution event.

✓ The ASI allow public Authorities to evaluate, on a scientific basis, the results of possible strategies or actions undertaken to reduce urban pollution.

✓The ASI make it possible to carry our a sound comparison of pollutant concentration trend over the years.