Air Quality Network Design for Urban and Rural Model Validation

Las Quintas, Cuernavaca, Mexico
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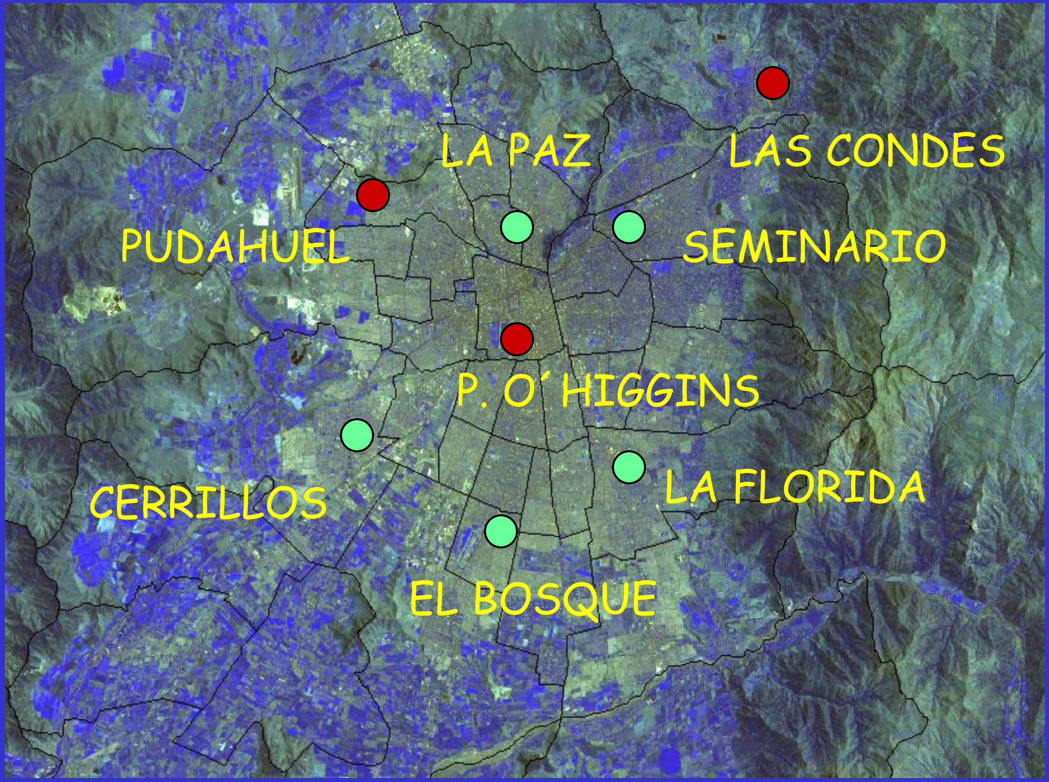
Introduction

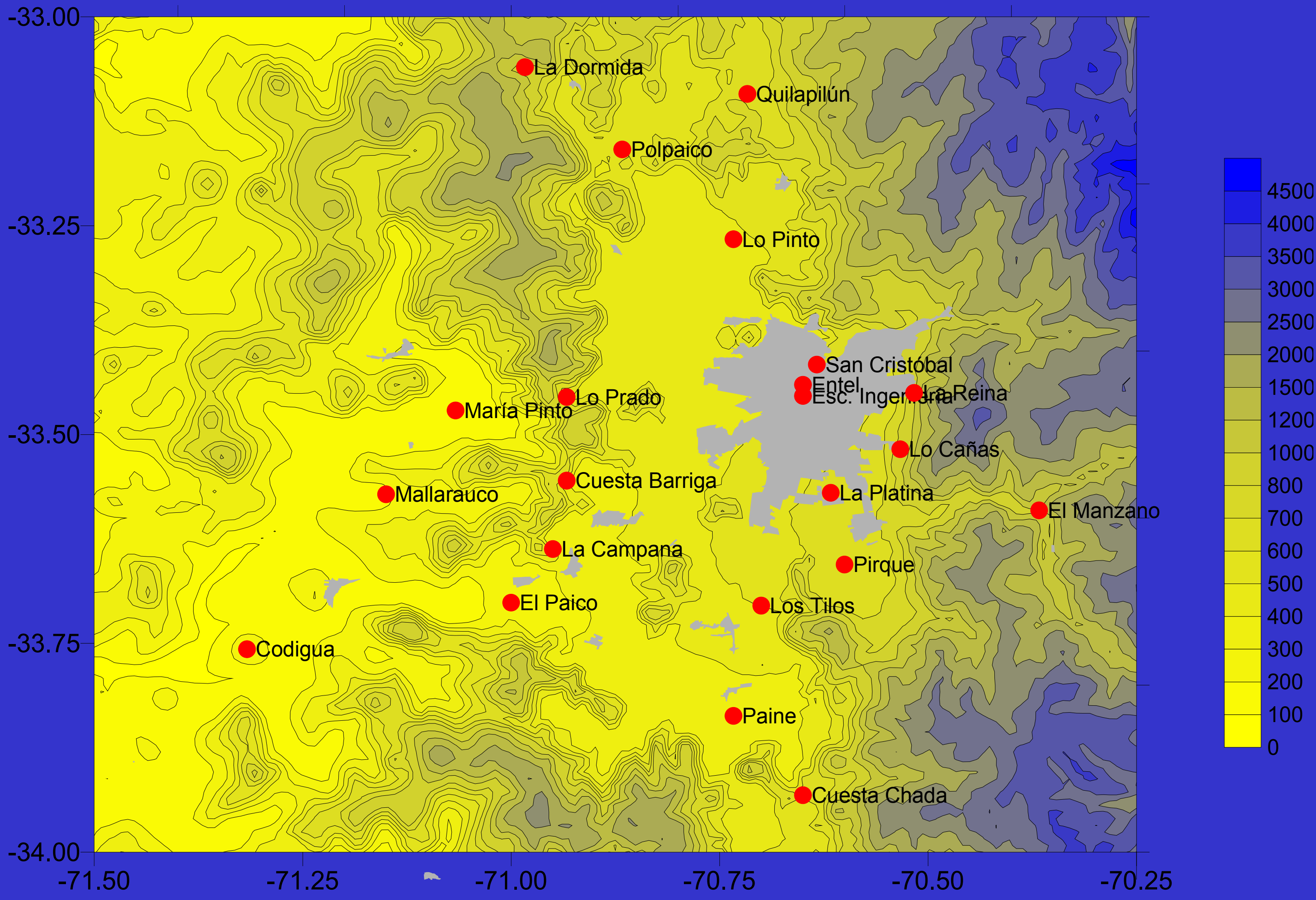
- In 1997 Santiago Metropolitan Region was declared saturated with TSP, PM_{10}, CO, O_3 and latent for NO_2.
- An Atmospheric Decontamination and Prevention Programme for the Metropolitan Region was initiated.
- An intensive program to reduce the impact from mobile sources, specially public transportation system was started.

Mapocho valley topographical characteristics

Santiago Metropolitan Region´s Air Quality Network



Metereological Network



Analytical Techniques

- **Particle Induced X-ray Emission - PIXE & XRF**

Detection limit 0.5 - 5 ng/m^3, accuracy and precision 5 - 10 %

> 20 elements (Cu, As, Mo, S, Se, Pb, Br, Cl, Ni, V, Cr, etc)

- **Ion & Gas Chromatography - IC &GC MS**

For cations and anions ($NH^+{}_4$, $SO^{-2}{}_4$, $NO^-{}_3$, Cl^-, etc) & N- alkanes and PAH

- **Reflectance and IR**

Black and Organic Carbon

- **Gravimetric analysis**

Aerosol mass concentration

Data Analysis

- Absolute Principal Factor Analysis
- Hierarchical Cluster Analysis
- Stepwise Multiple Linear Regression
- Molecular Diagnostic Ratios

Considerations in the design of ambient air monitoring networks

- Regulatory control
- Size of the city
- Density of Population
- Emission (stationary, mobile & diffuse sources)
- Meteorology
- Topography
- Effects (climate, health, materials,land-use)
- Air pollution forecasting

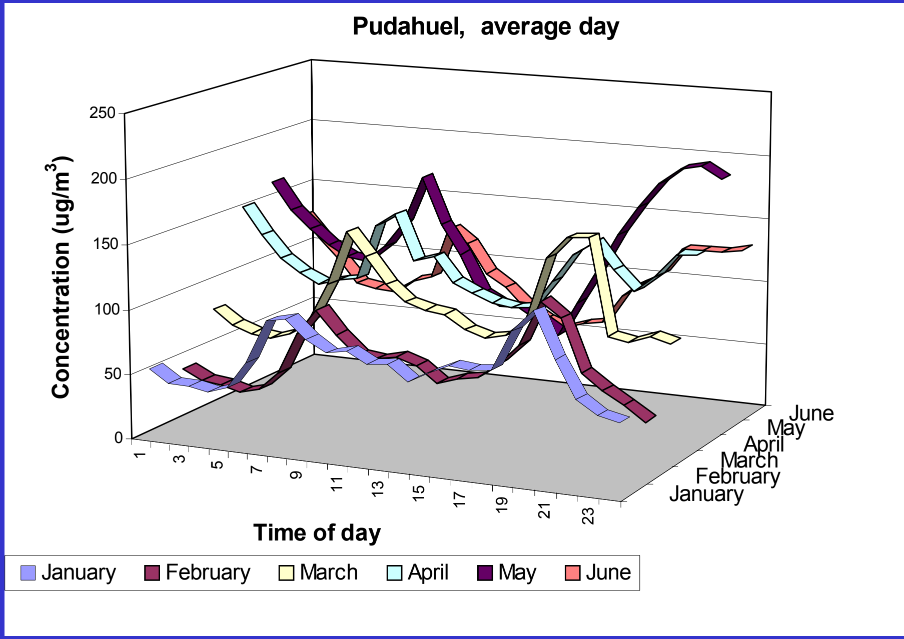
Emissions

- In large cities, vehicle emission are usually the most important
- In small cities, there may be sources specific (and limited) to the area that are significant (smelters, house heating, biomass burning, etc.)
- Fixed sources are easiest to control, moving sources are harder
- Local emissions may mislead the interpretation of the results.
- Monitoring site representativeness is needed

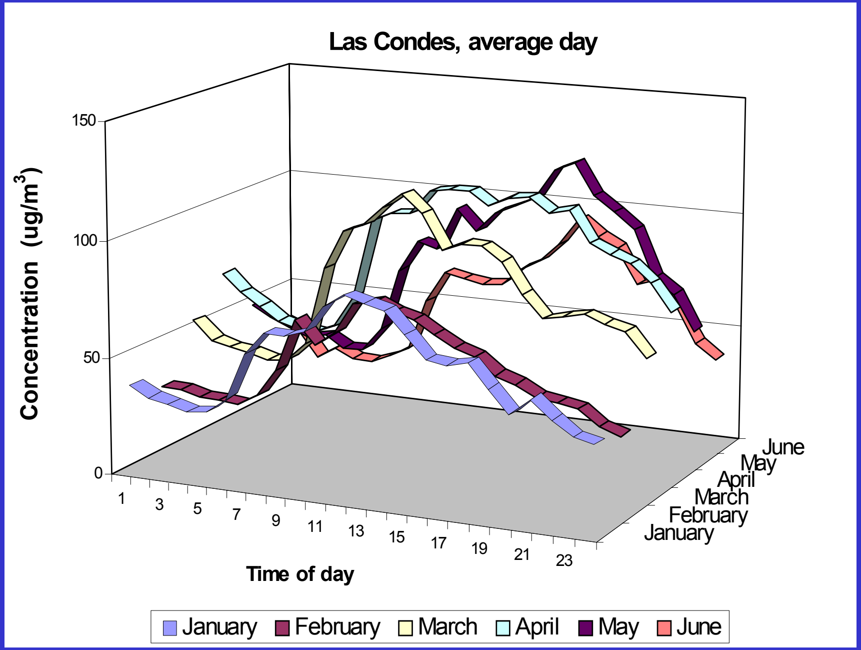
Monitoring site representativeness, PM-10

Data from a monitoring site should be representative of the community, independent of local sources.

Local traffic influence



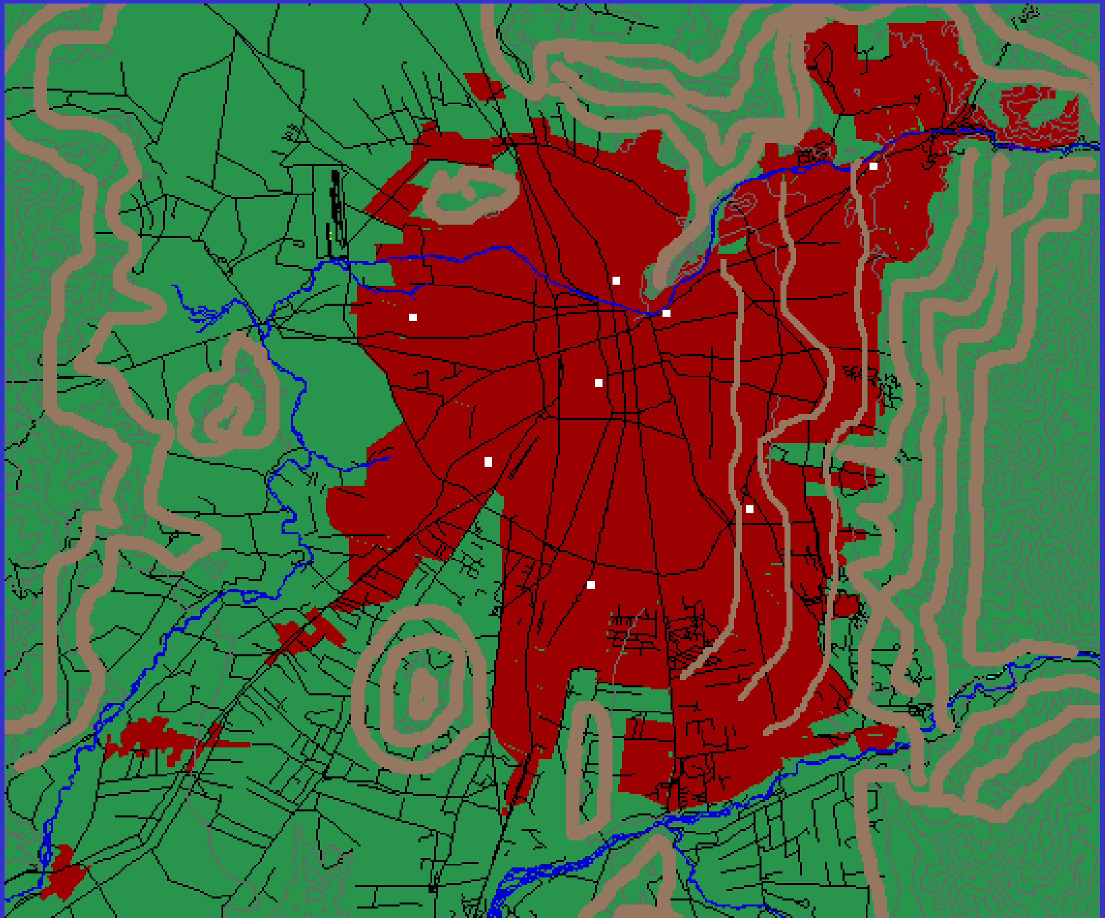
No local traffic influence



Topography

May determine the concentration of pollutants in certain areas

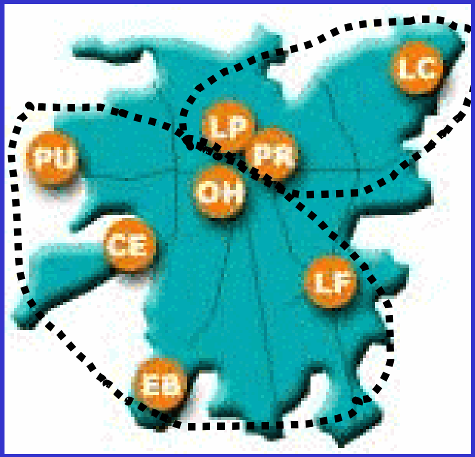
- Controls the local wind pattern
- Limits the spatial extent of pollutants



Environmental grouping

- Cluster analysis of the data among the stations is used to obtain groups with similar temporal behavior
- These groups are similar for PM10 and ozone
- The groups are independent of the season
- Topography of the city is probably responsible for the configuration of the groups

Ozone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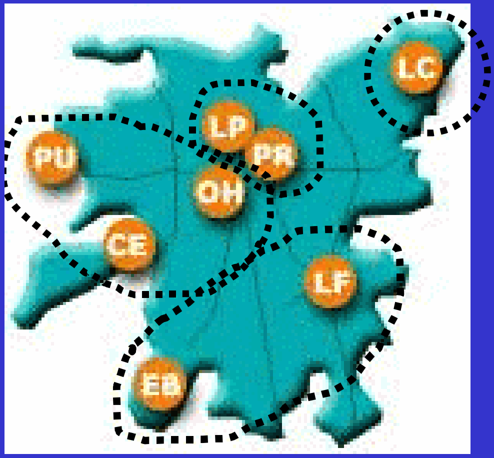
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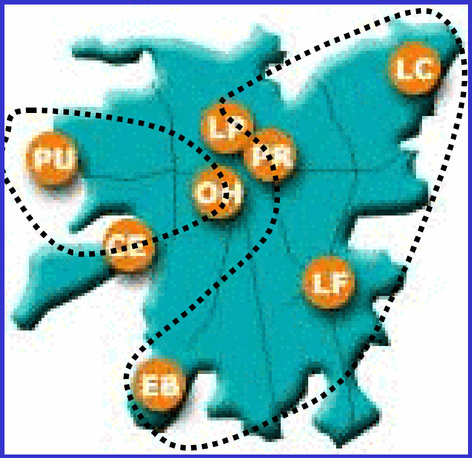
PM10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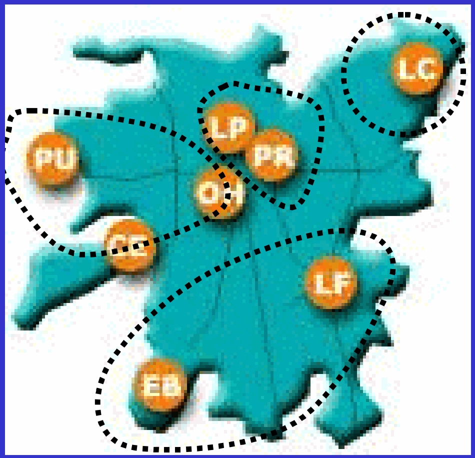
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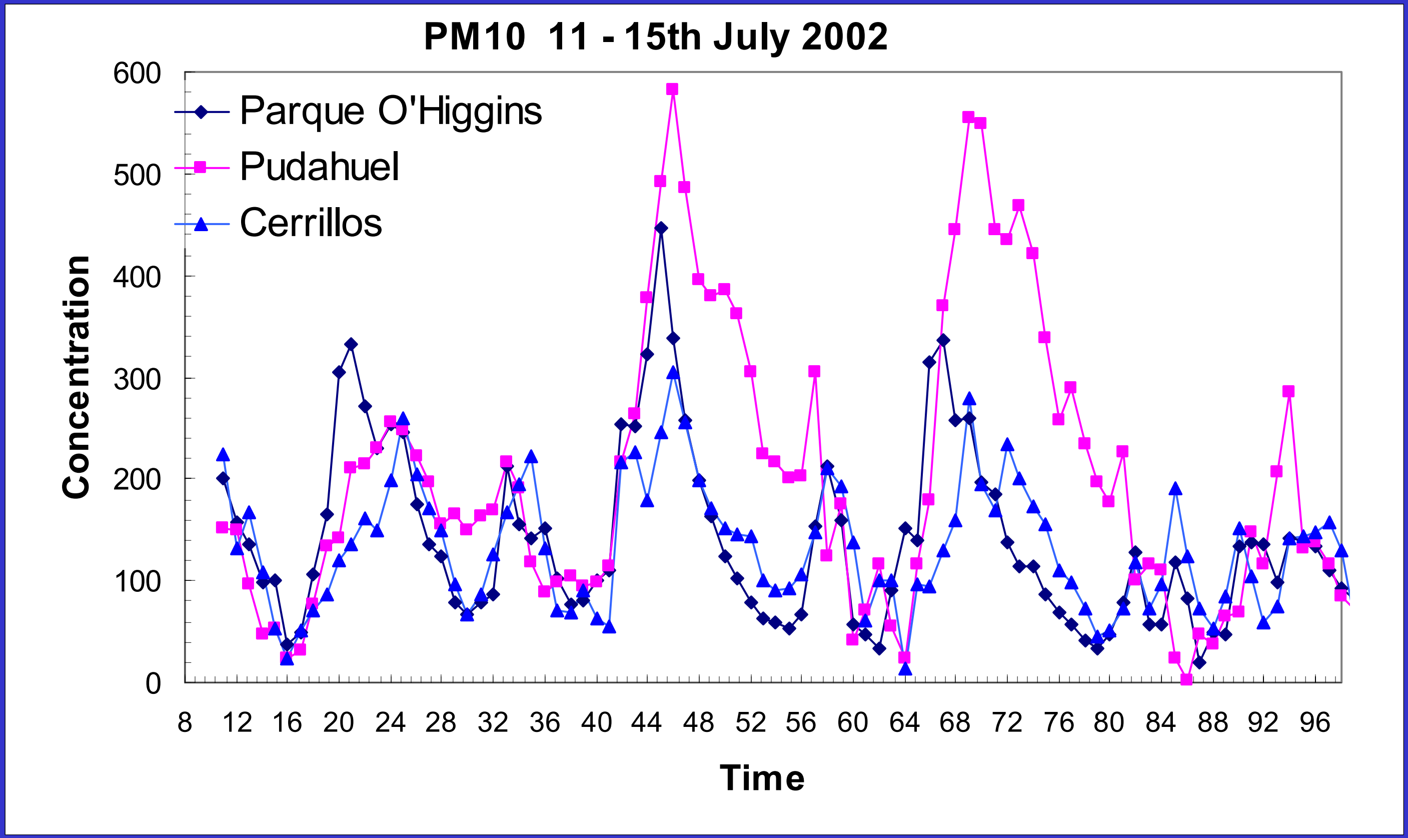
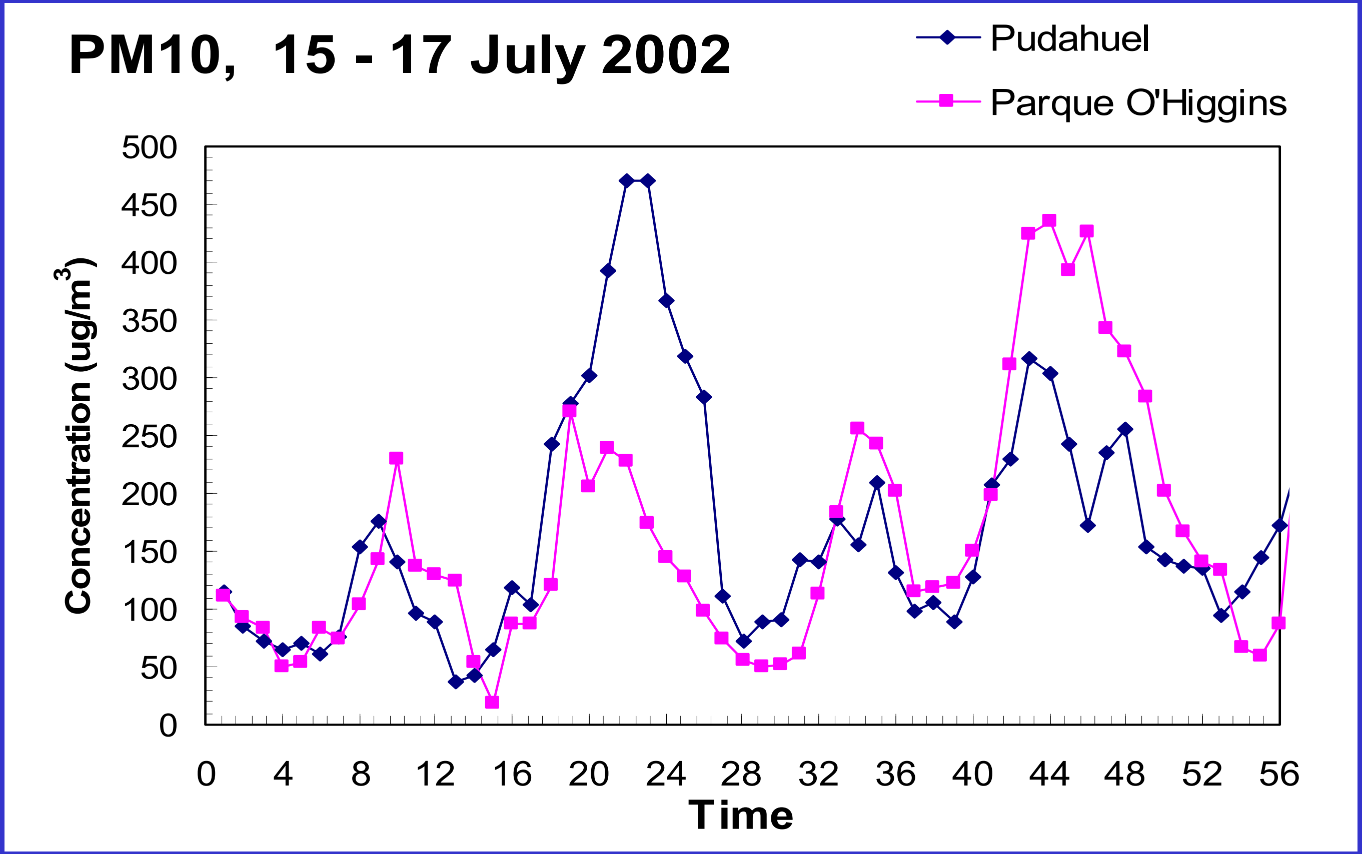
Meteorology

- Determine the concentration levels of pollutants in a city
- Determines the time variation of pollutants
- Wind and mixing layer height are probably the most important meteorological parameters
- Has hourly, daily and seasonal variation very hard to predict.

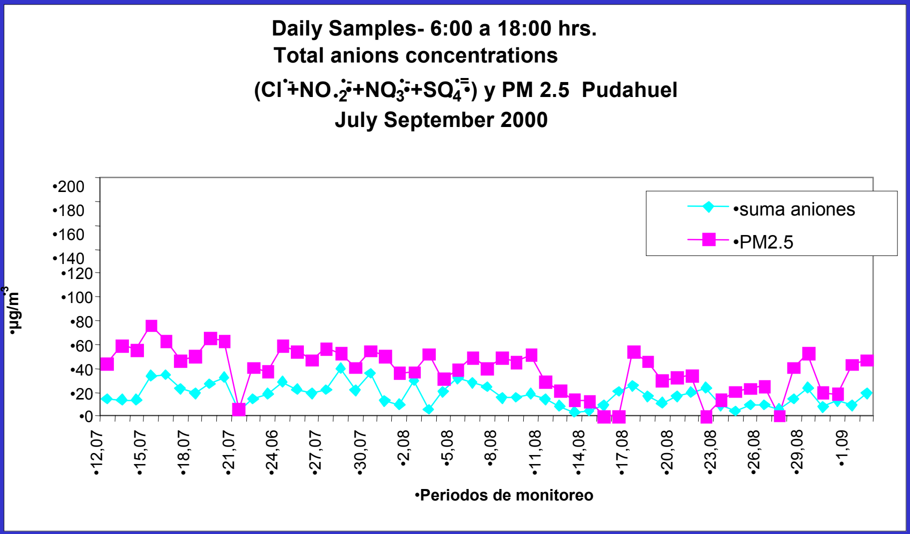
Episode situation at Pudahuel

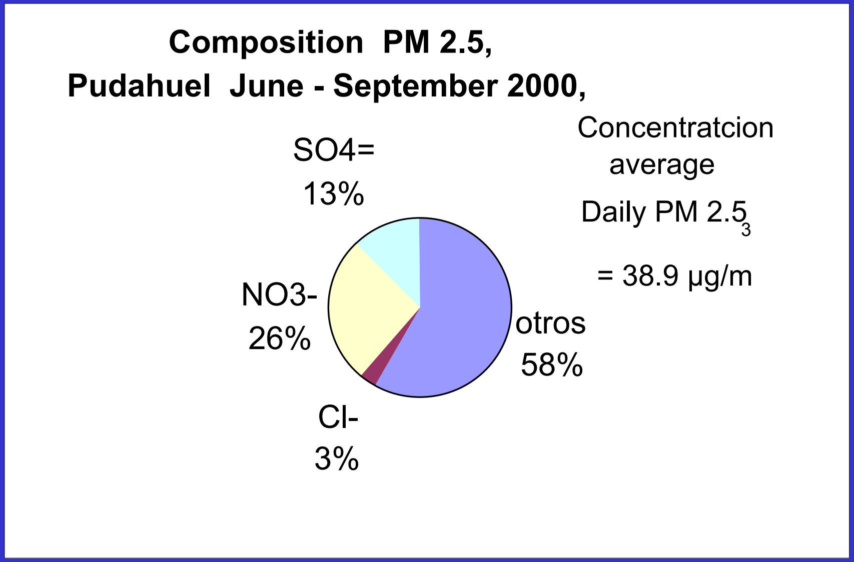


A cloud with high PM_{10} levels is transported to Parque from Pudahuel area by low level winds

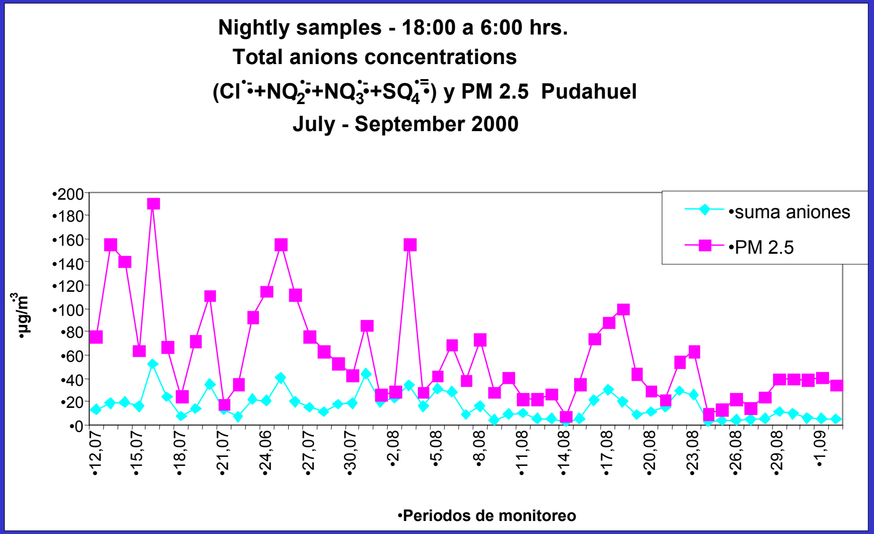


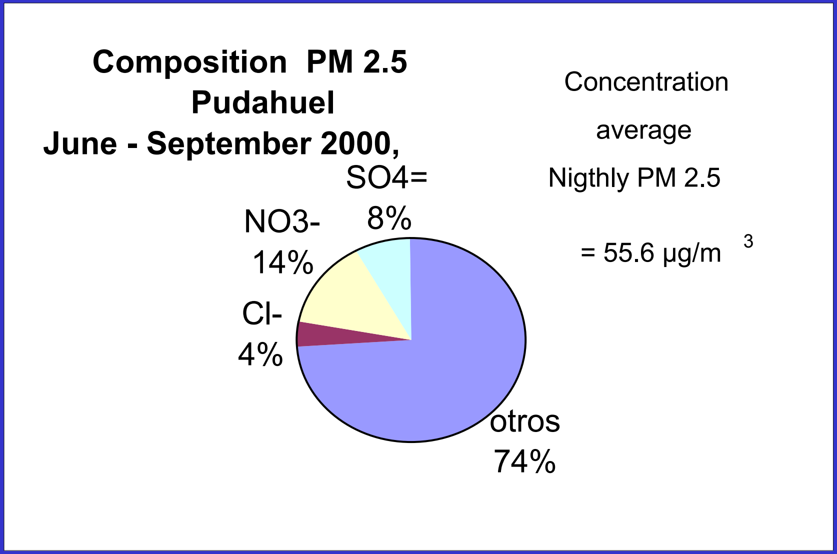
Daily samples





Nightly samples





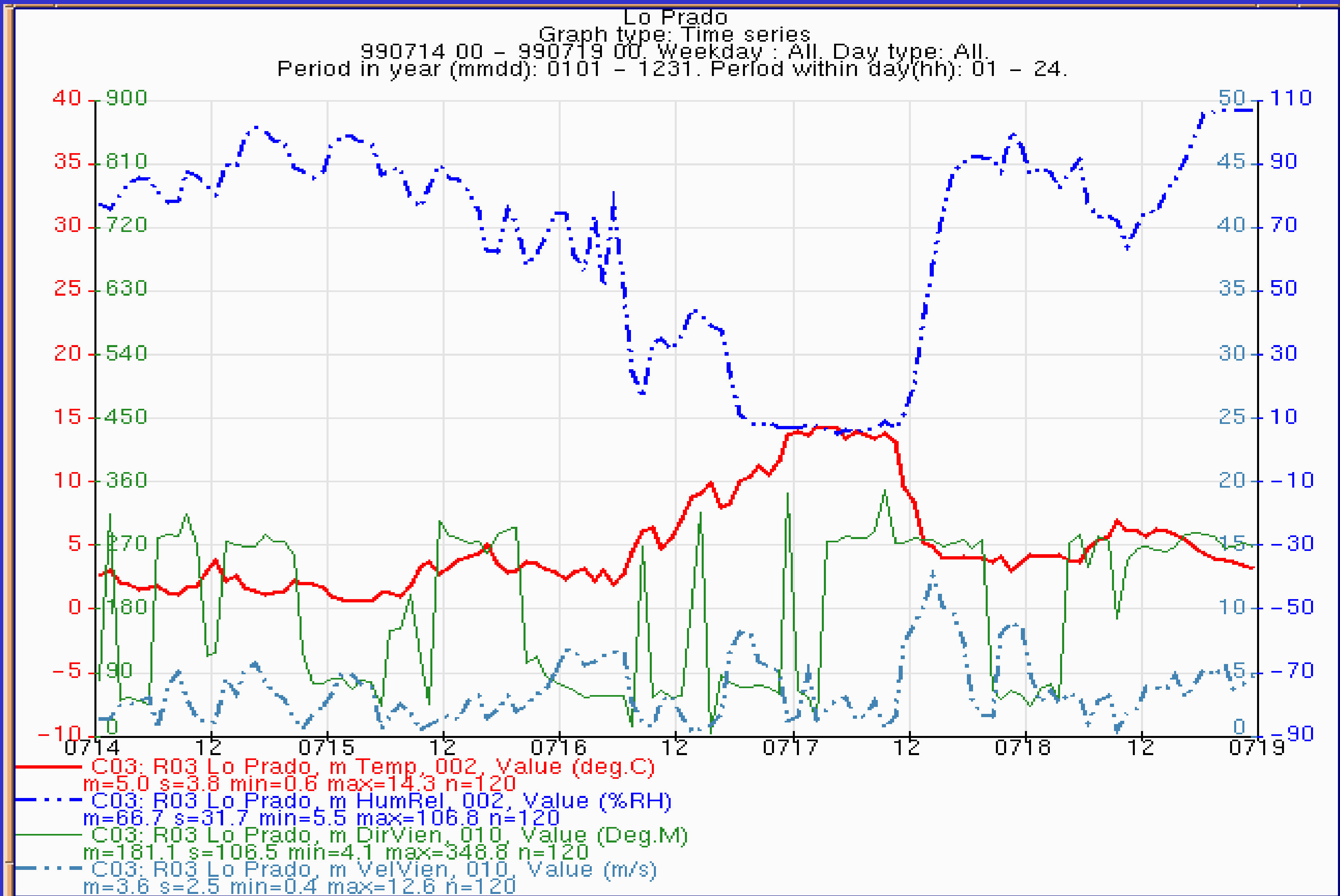
Episode Type "A"

(J. Rutllant 1994)

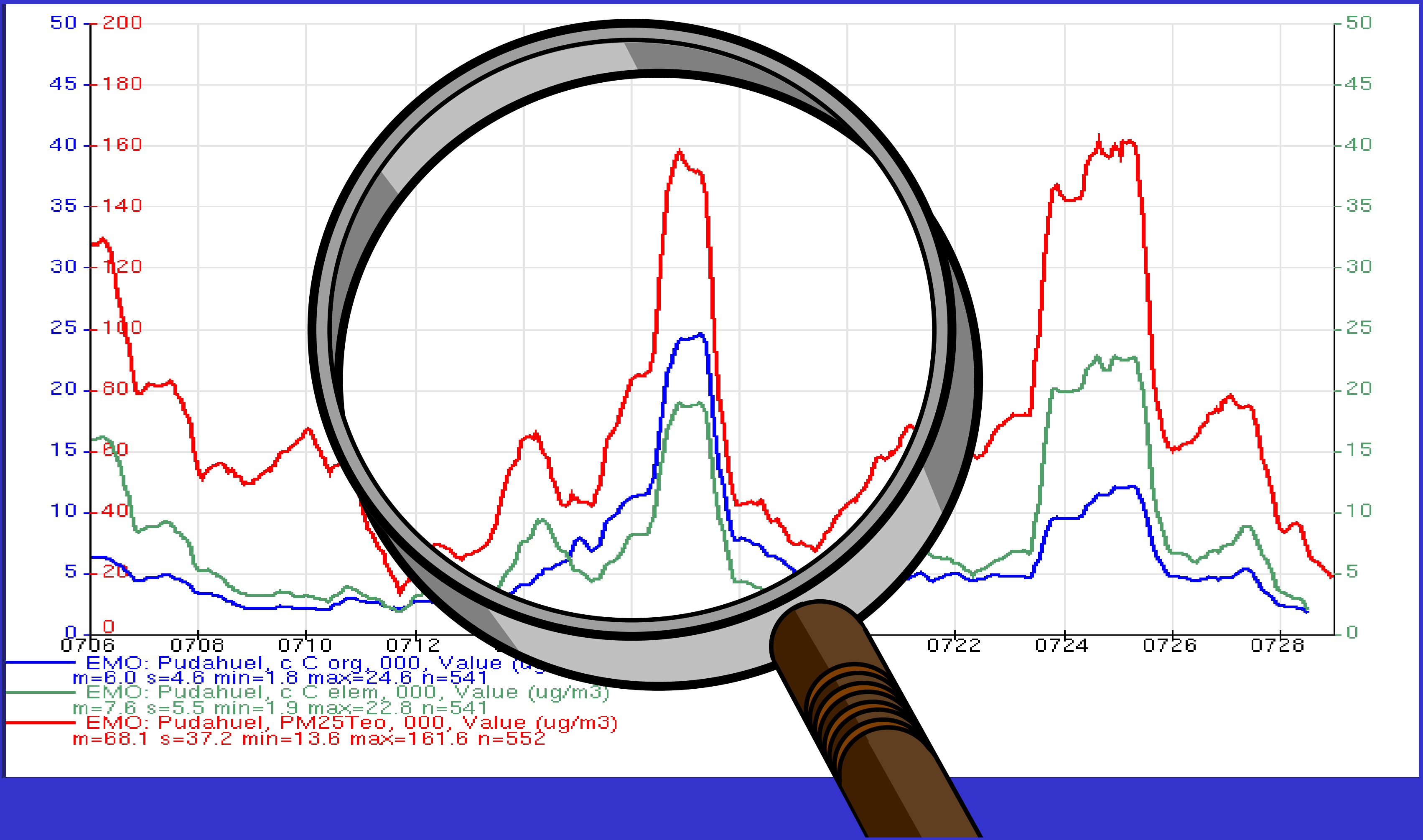
Meteorology, Episode type "A"
(after J. Rutllant, 1994)

- Formation of a Coastal Low between two high preassure systems: the Semipermanet Pacific and migratory cold high located at Central-North Argentina
- Irruption of a mid troposphere Warm Ridge above Central Chile.
- Post frontal conditions
- East wind component and warming at low levels. Marked stability conditions. Reduction of the mixing layer and ventilation factor.
- Zonal circulation index (at 500 hpascal): regular to high synoptic patterns will move eastward relatively fast.
- Frequency : 70 % of total number of episodes (Autumn-Winter time).

Meteorological Parameters at Lo Prado



Elemental and Organic Carbon and $PM_{2.5}$ 24 hrs runing averages, at Pudahuel, July 15 - 19th, 1999. Episode type "A"



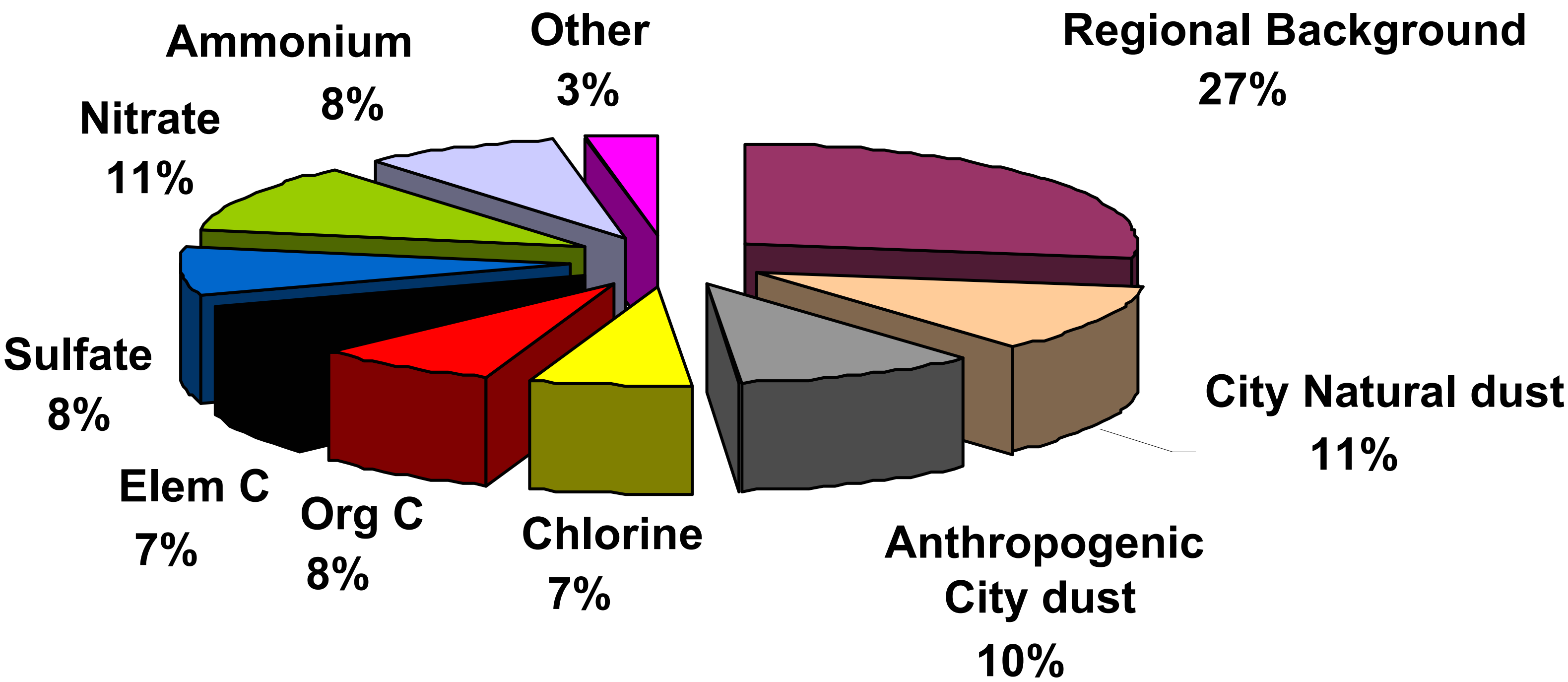
Air mass trajectory simulations

- A meteorological network (16 with sensors at 10 m, 24 m profiling tower and a LAP RASS)
- 56x56 km model domain
- Hourly windfields with a resolution of 1x1 km, modeled with a diagnostic one layer model.
- Sensible heat flux and friction velocity has been determined from profile measurements (24 m profiling tower) at one suburban station
- Of interest is to quantify:
  - The frequency with which the air mass passes specific parts of the city.
  - The total time the air mass has been within the Metropolitan Area

Trajectory

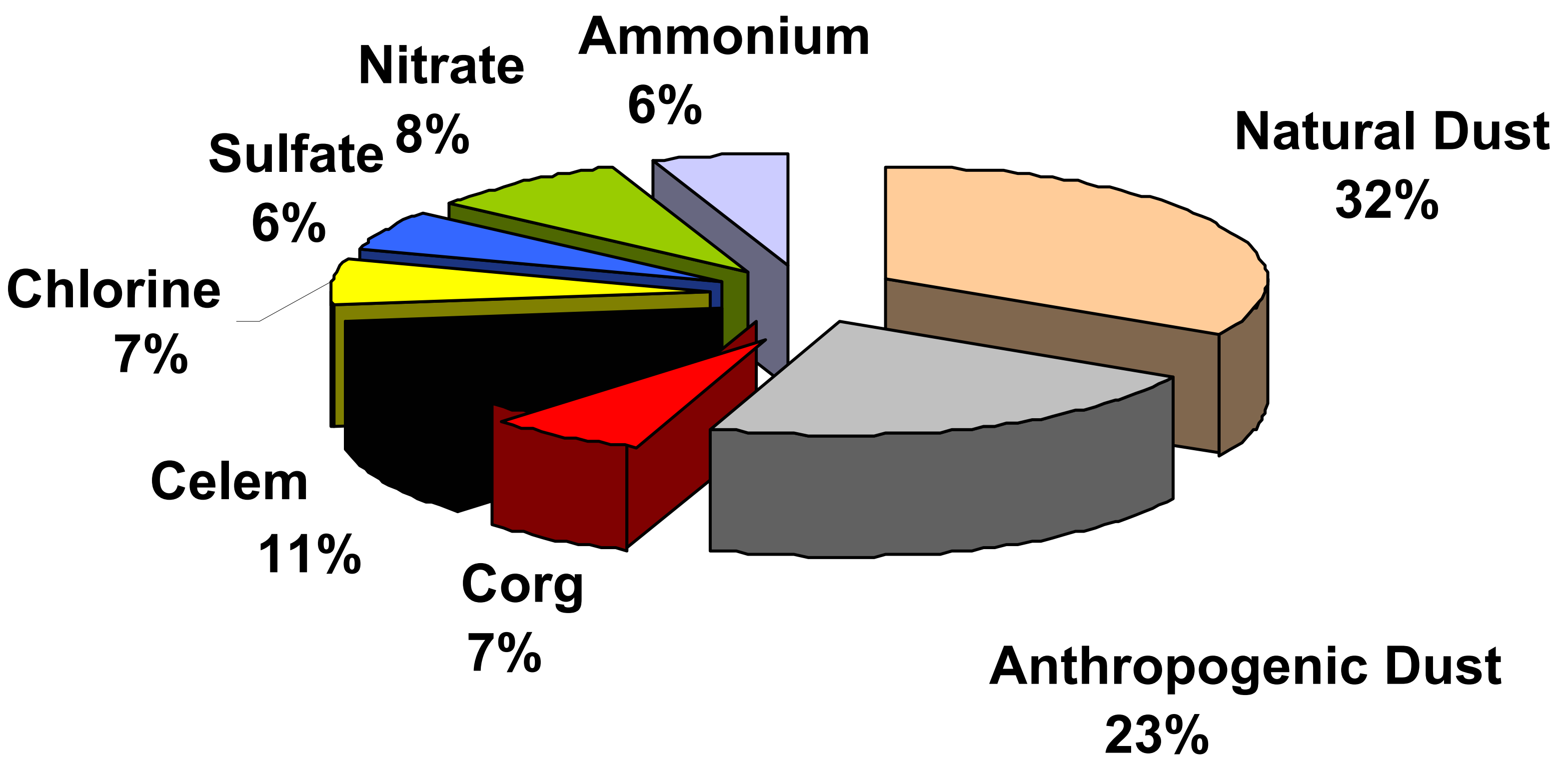
Concentration (µg/m3) PM10
Santiago - Winter 1999

Average concentration 118,42 µg/m3



Concentration (µg/m³) PM_{10}
Parque O`Higgins (Episode July 29th- 1 August 1st 1999)

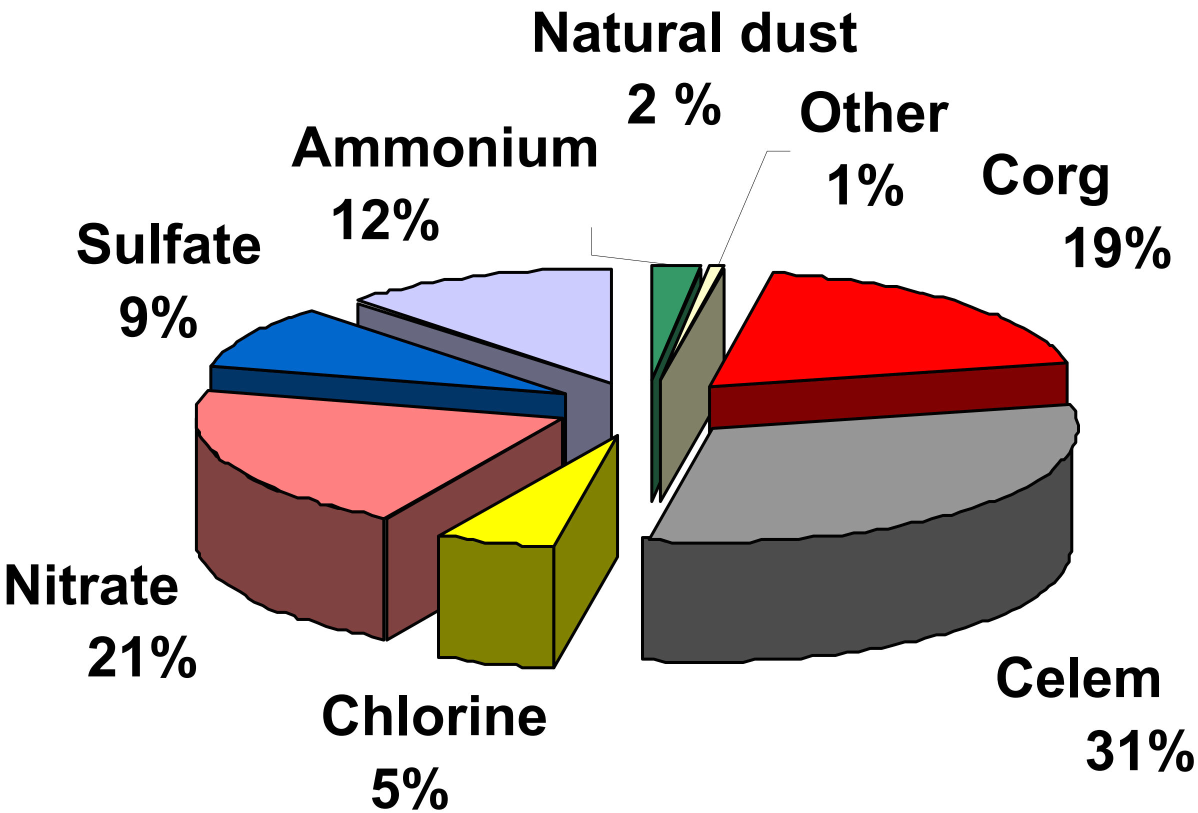
Total Concentration = 166,01 µg/m3



Concentration (μg/m^3) Fine Fraction

Parque O`Higgins (Episode 29 Jul 29th - Aug 1st 1999)

Total concentration = 58,08 μg/m3



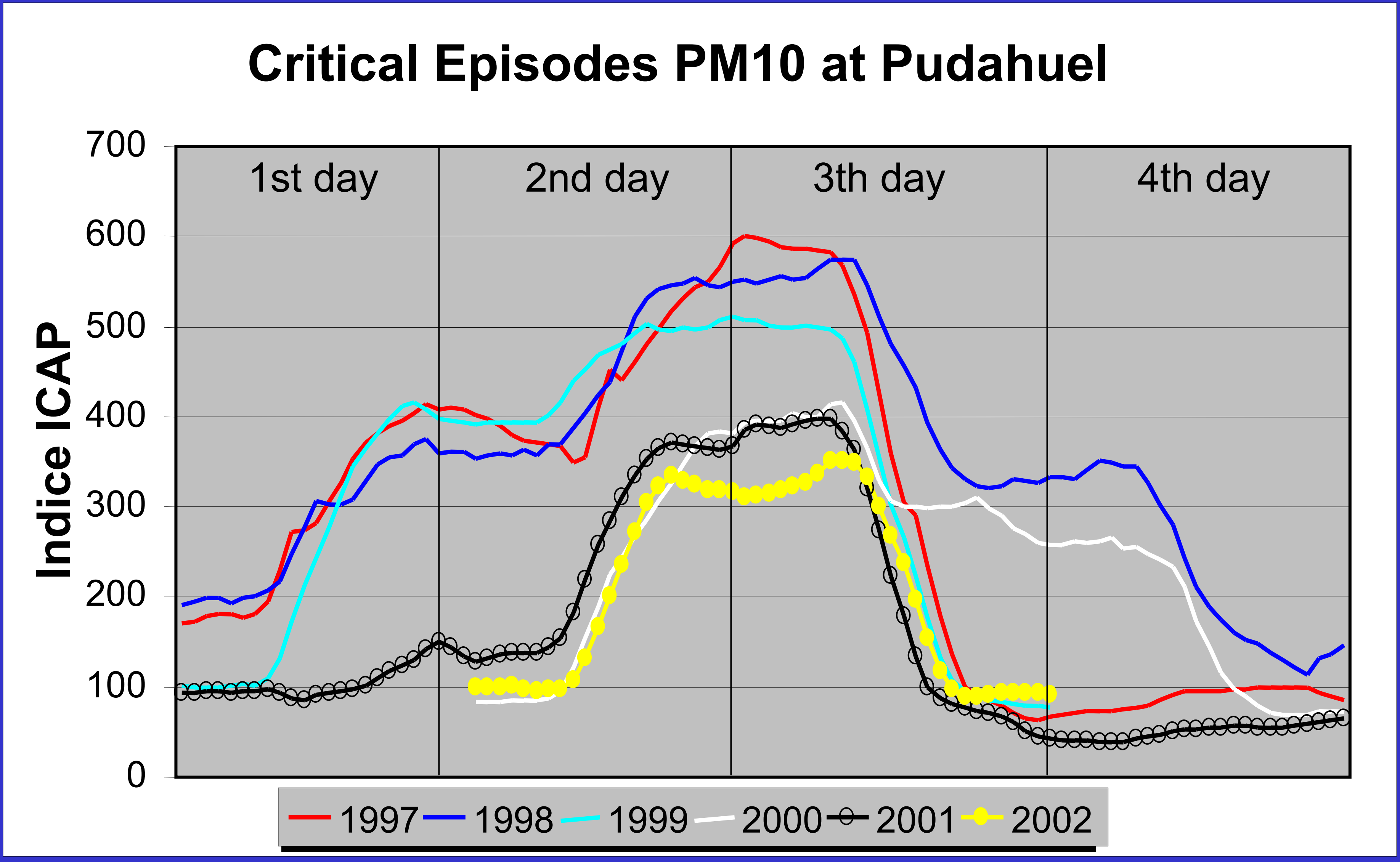
Meteorological Conditions

Air Pollution = Emission + Ventilation

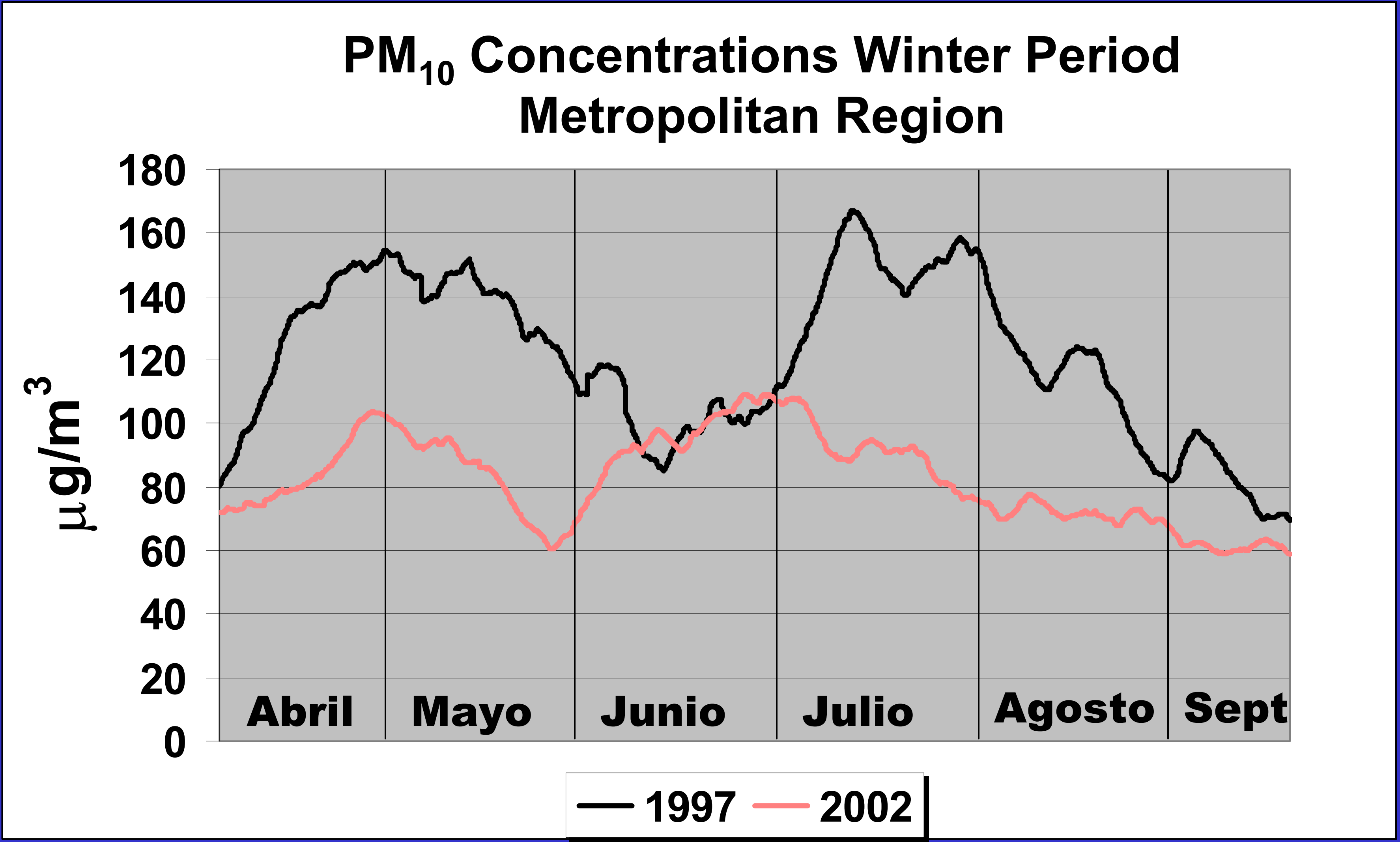
The ventilation indicators for Santiago are

- Good
- Good to Regular
- Regular
- Bad
- Critical

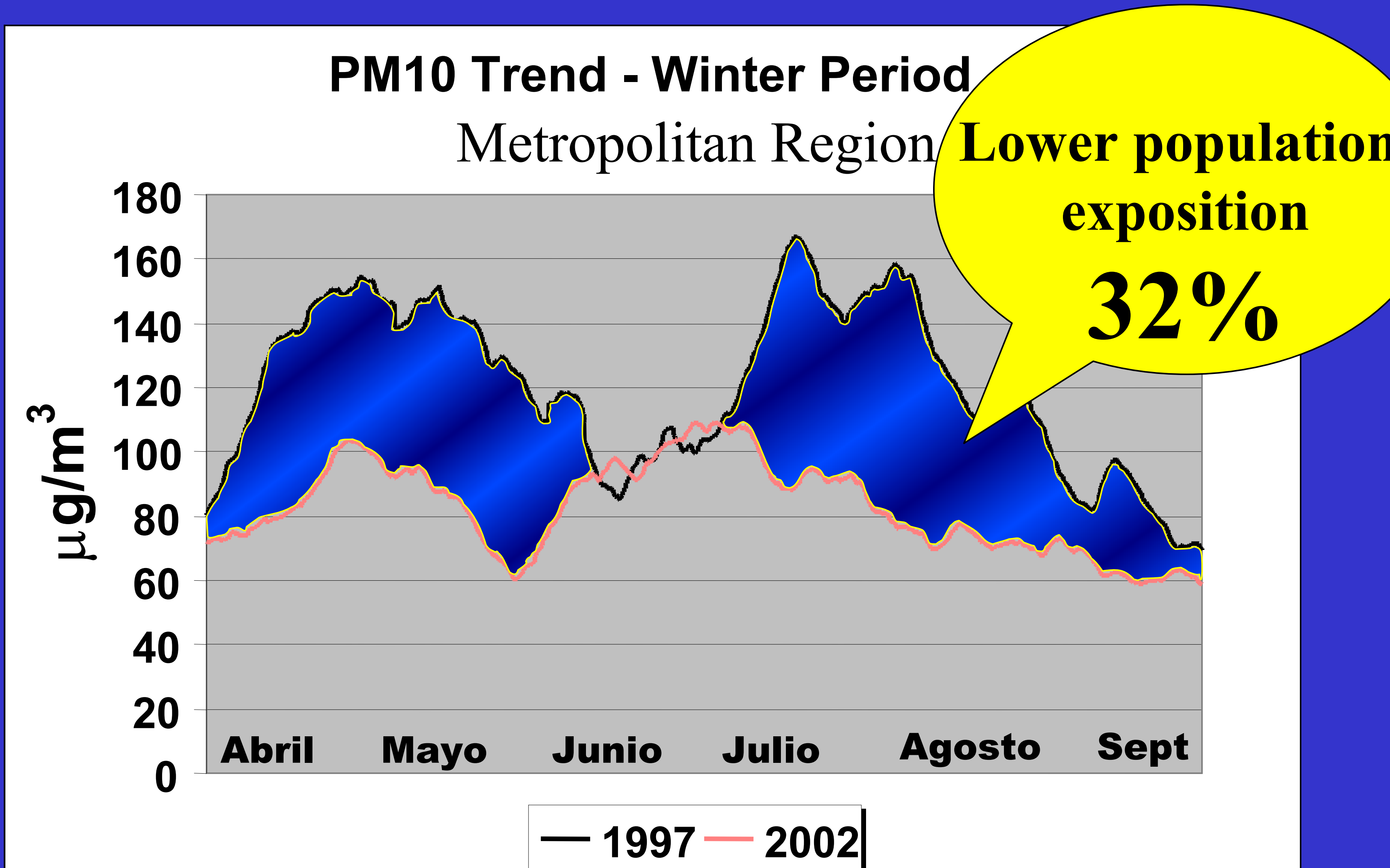
Lower population exposition



Lower population exposition



Environmental gain



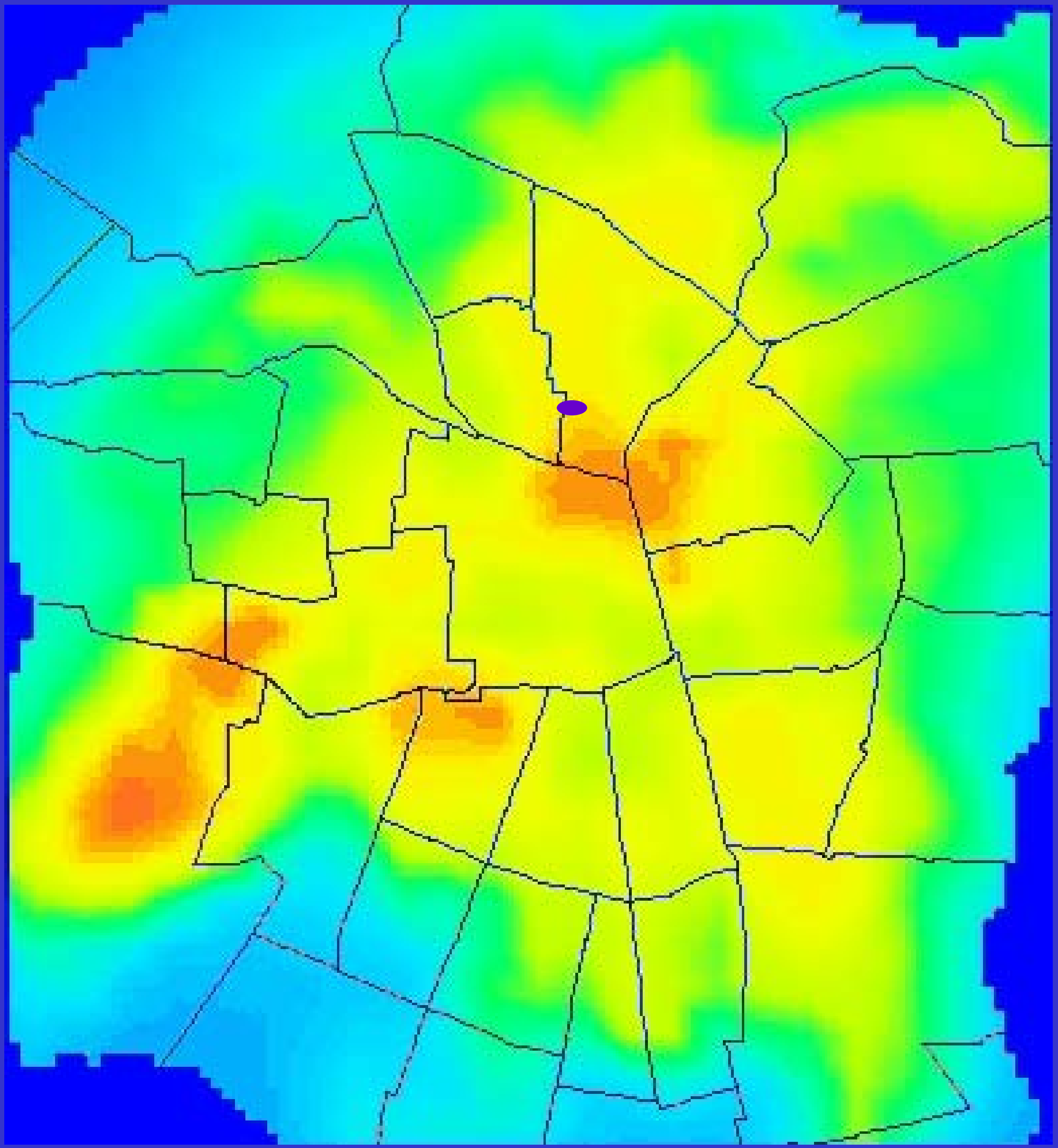
Health effects due a lower population exposition - Winter 2002

PM_{10} releated health outcomes	**Avoided cases**	**Monetized benefit (US$)**
Premature mortality	322	115.018.987
AH RSP	226	632.386
AH COPD	713	2.566.532
AH Cardiovascular	244	926.796
AHCardio Ischemic	139	657.091
AH Pnemony	191	697.385
Asthma attacks	206.637	1.446.460
Acute bronchitis	45.896	458.962
Emergency room visits	19.660	1.041.972
Days with respiratory difficulties	2.611.714	2.611.714
Work loss days	294.880	5.602.725
Minor restricted activity days	902.561	8.123.047
MRADs days	1.089.086	8.712.685
Lower respiratory symptoms	25.332	75.995
Upper respiratory symptoms	14.771	51.698
Respiratory illness	1.332.033	5.328.131
Total		153.952.565

Georeferential Model

PM10 Dispersion Model

May-June 2000



Acknowledgements

http://fisica.usach.cl/uv/archivos
http://www.conama.cl/rm/realtime

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