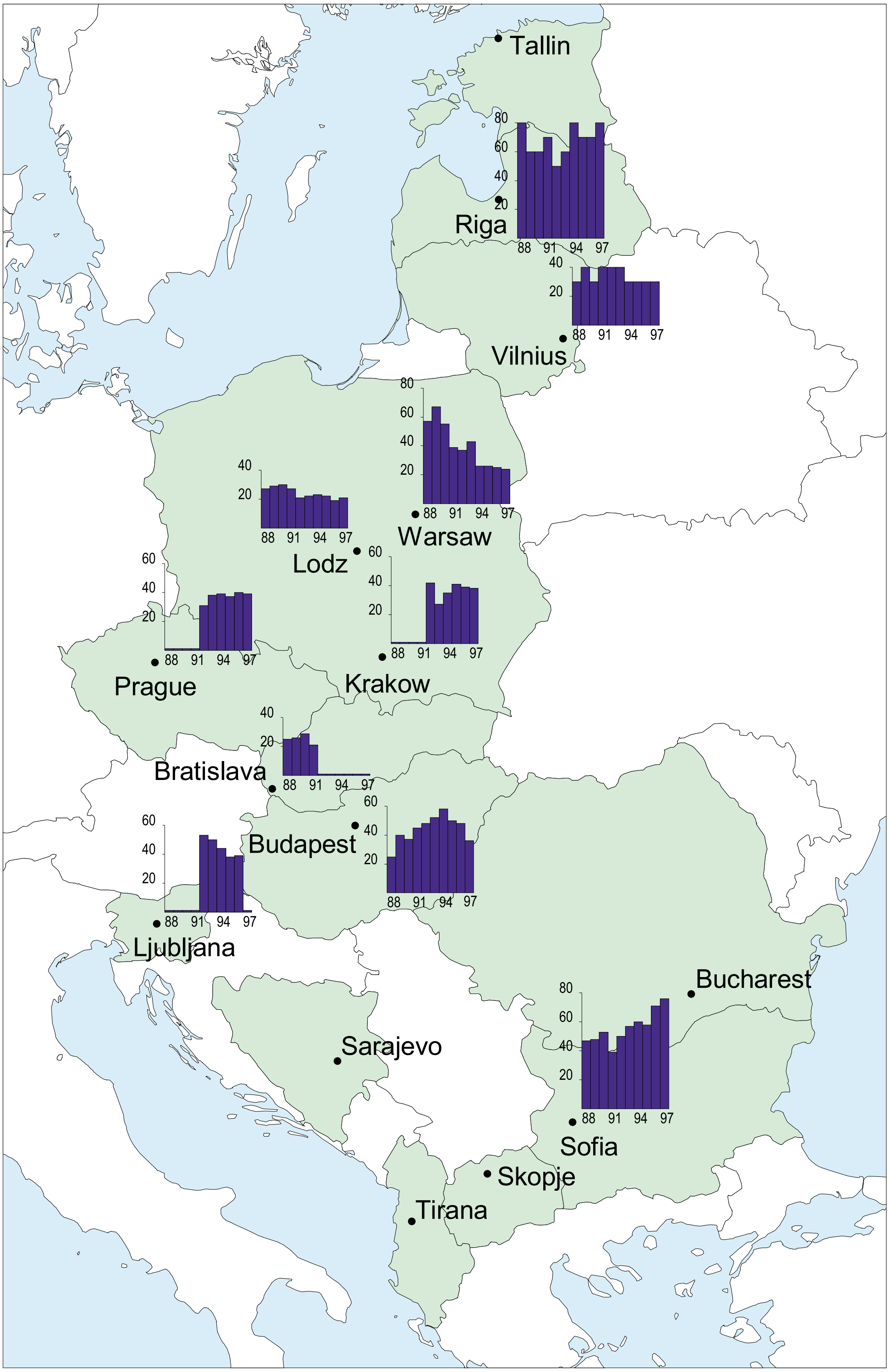
Figure 3.8 **Annual concentration trends in large cities, nitrogen dioxide, 1988–97 (µg/m³)**



Maximum hourly concentration trends in large cities, ozone, 1992–97 (µg/m³) Figure 3.9

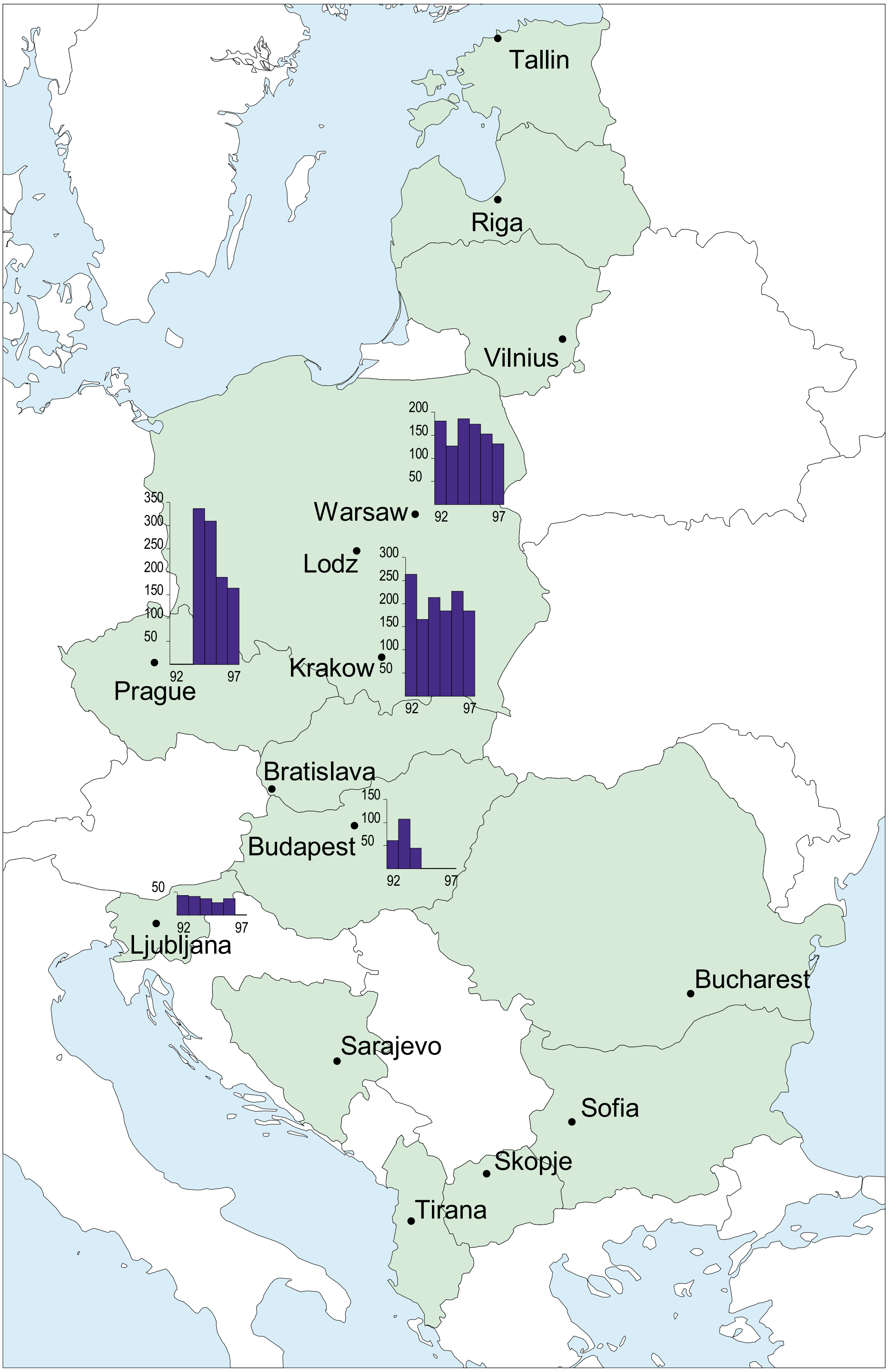
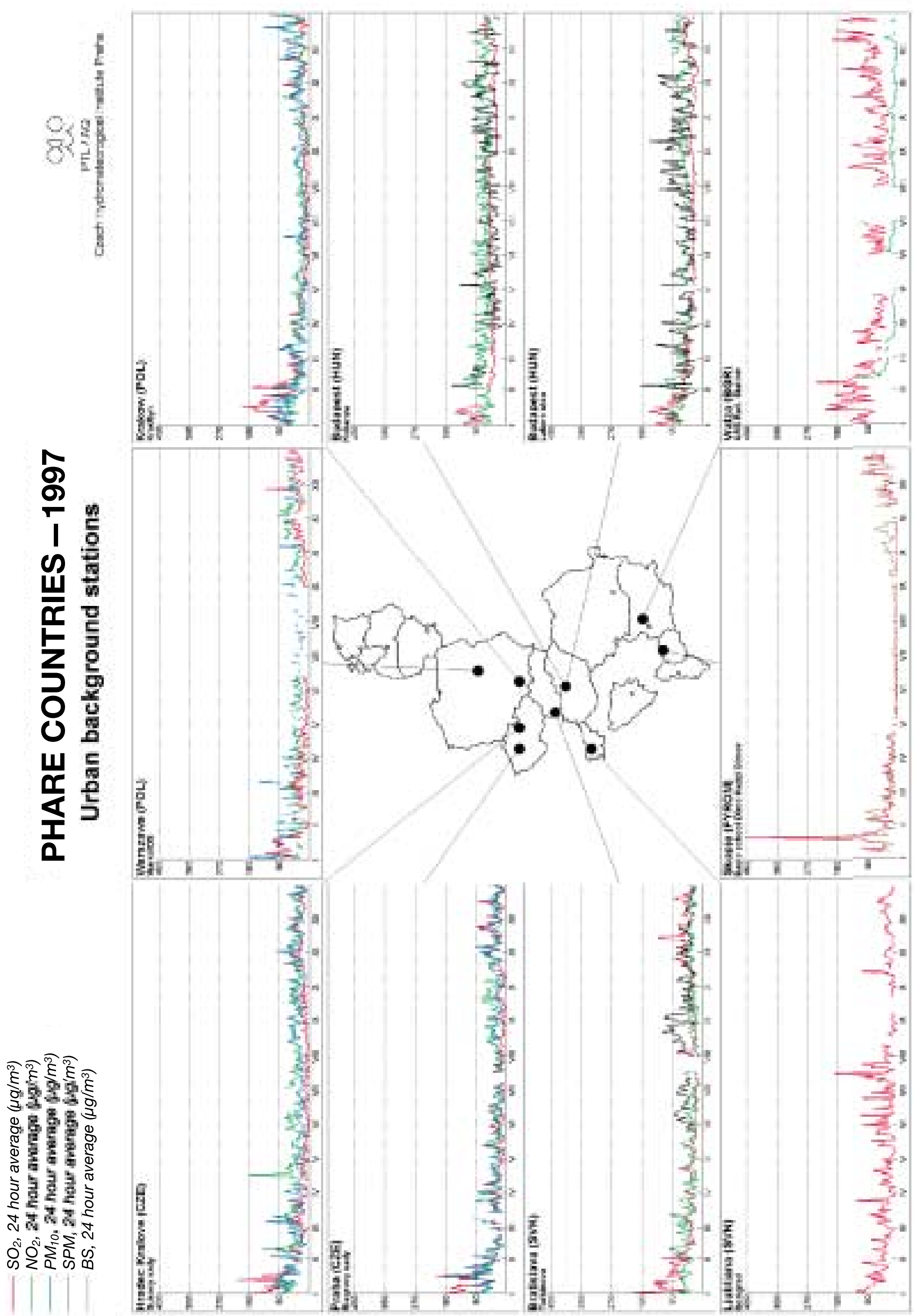


Figure 3.10 **Urban background stations, the Phare countries, 1997**



Traffic stations, the Phare countries, 1997 — Figure 3.11

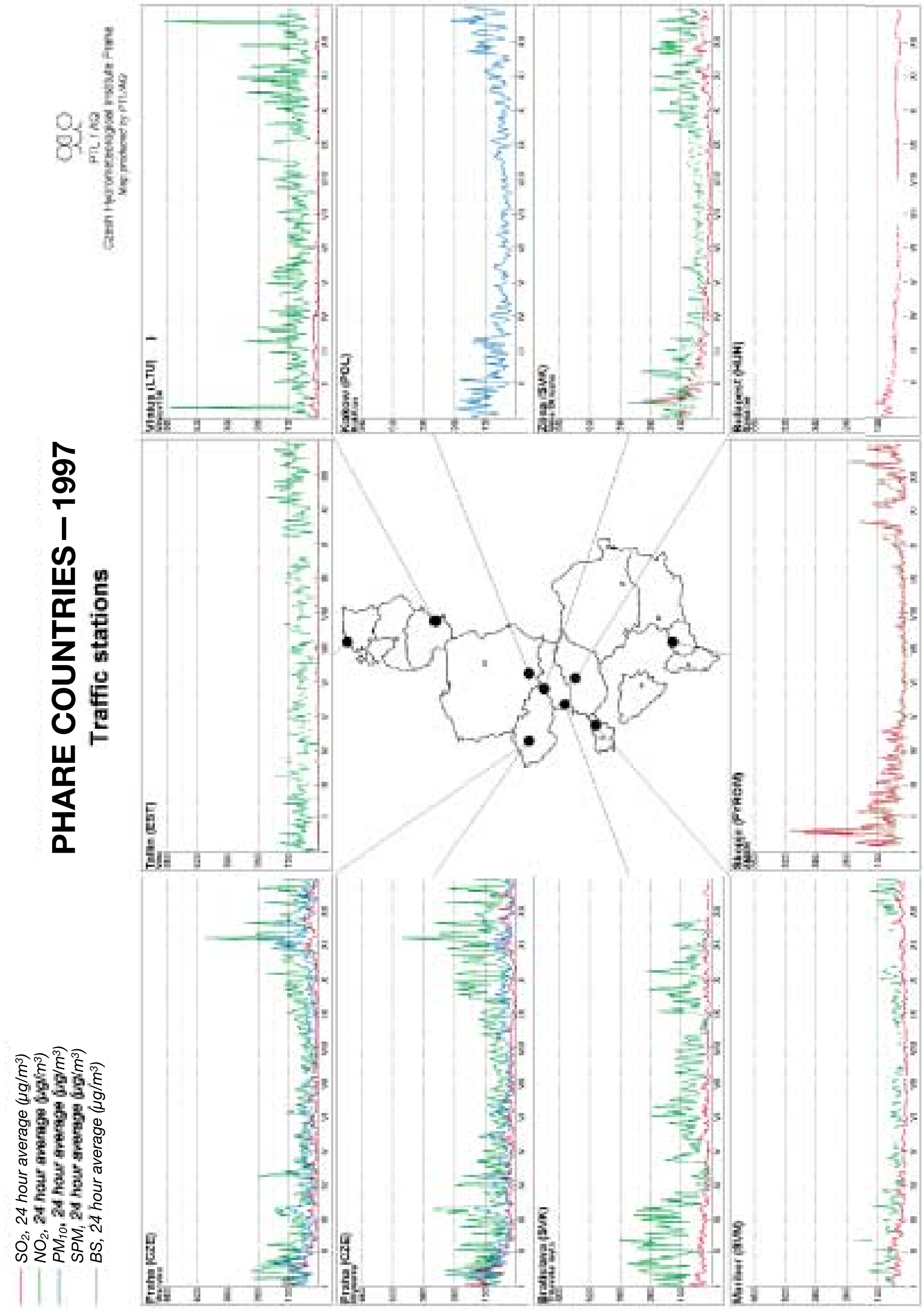
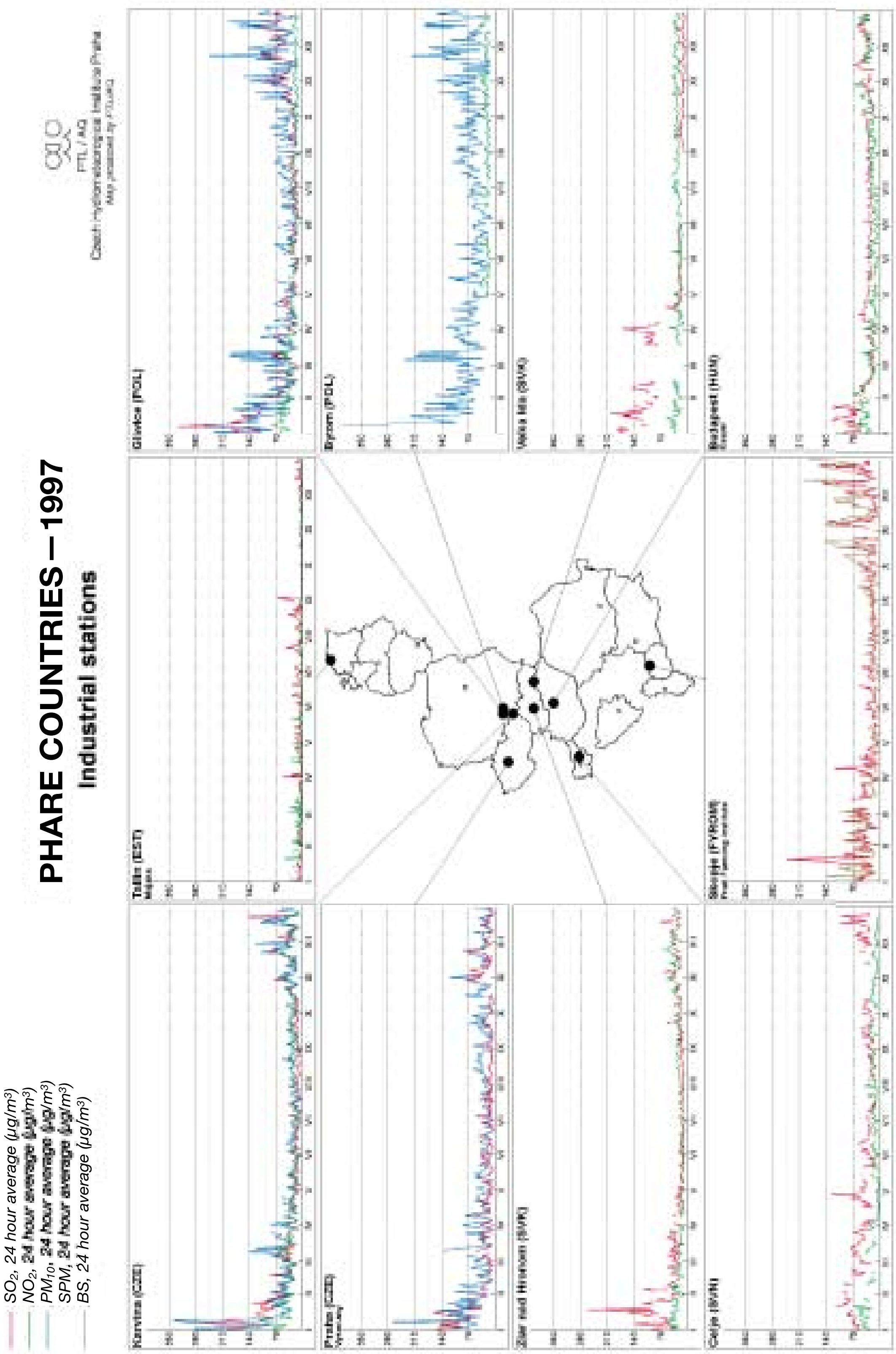


Figure 3.12 **Industrial stations, the Phare countries, 1997**



Annual average and 98th percentile pollutant concentrations at urban background sites 1997 — Figure 3.13

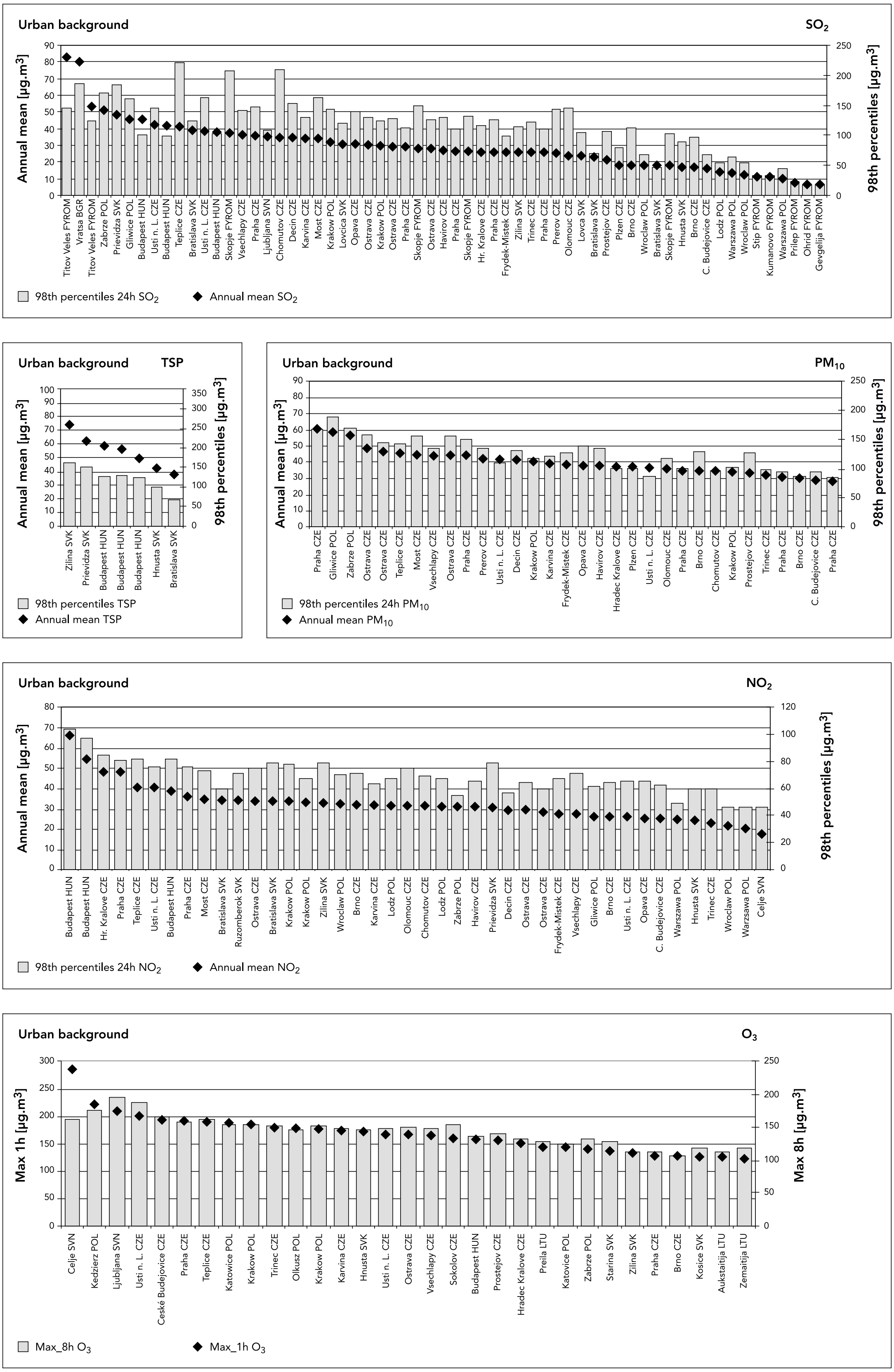
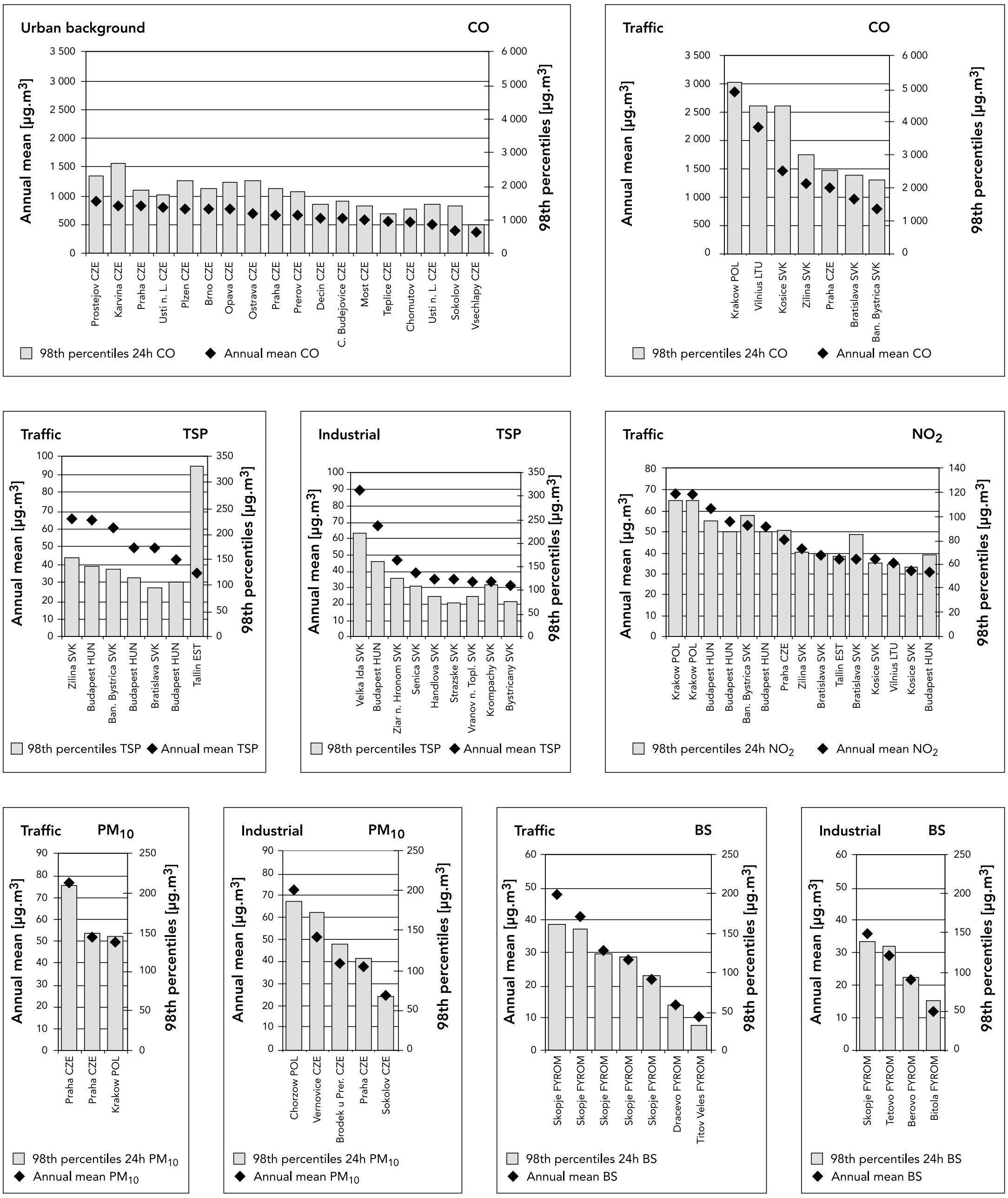


Figure 3.14 **Annual average and 98th percentile pollutant concentrations at urban, traffic and industrial sites, 1997**



Exceedances of limit values Figure 3.15

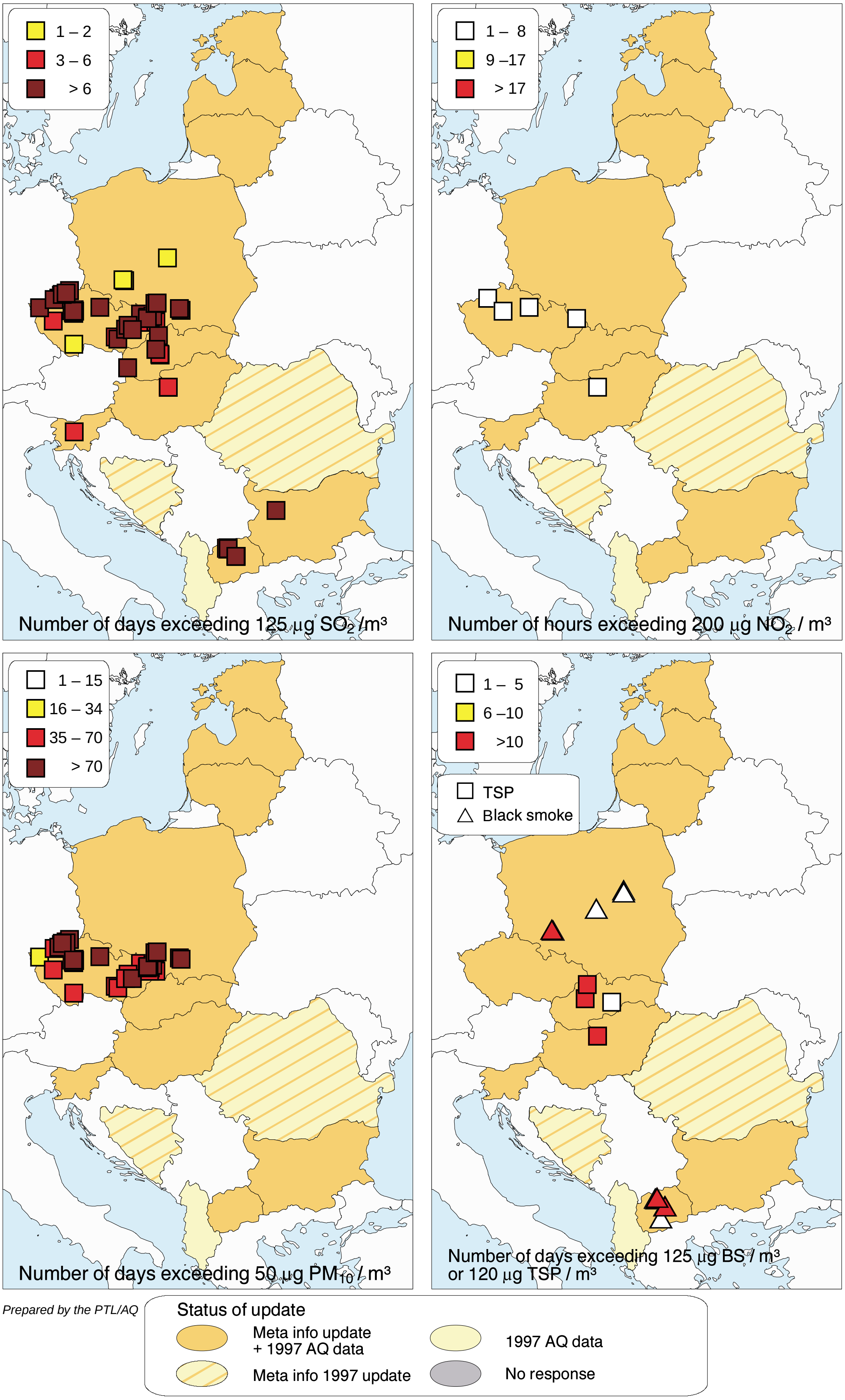


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Table 3.8 **Exceedance of WHO (WHO, 1997) and EU limit values (Directive 99/30/EC)**

Country	City	No of days with SO_2 24-hour conc. >=125 μg.m^{-3}	No of days with NO_2 1-hour conc. >=200 μg.m^{-3}	No of days with PM_{10} 24-hour conc. >=50 μg.m^{-3}	No of days with TSP. BS* 24-hour conc. >=125(120*) μg.m^{-3}	Population
Bulgaria	Vratza	36				82 000
Czech Republic	Brno	4–8 (2)		42–47(2)		388 296
	C. Budejovice	1		35		97 243
	Decin	14		85		54 341
	Frydek-Mistek	6		66		63 808
	Havirov	8		59		86 297
	Hradec Kralove	7	6	73		99 917
	Chomutov	13		69		53 107
	Karvina	9		71		68 405
	Most	12	1	110		70 670
	Olomouc	8		54		102 786
	Opava	8		54		62 815
	Ostrava	8–9 (3)	3	87–95 (3)		327 371
	Plzen	3		60		173 008
	Praha	2–12 (9)	1	38–173 (9)		1 214 174
	Prerov	10		81		51 300
	Prostejov	8		56		50 074
	Sokolov	8		25		25 210
	Teplice	15		118		53 004
	Trinec	6		40		41 620
	Usti n.L.	12–16 (2)		67–99 (2)		98 178
Hungaria	Budapest	2–4 (3)			8–13 (3)	1 909 000
FYROM	Prilep				1*	71 899
	Skopje	2–12 (4)			2–24 (7)*	550 000
	Titov Veles	7–33 (2)			1–13 (2)*	50 000
Poland	Krakow	8–13 (2)		66–81 (2)		741 100
	Lodz	1			1*	833 700
	Warszawa				1–2 (2)*	1 642 700
	Wroclaw	1–2 (2)			4–12 (2)*	642 300
	Silesia conurbation	20–30 (2)		152–153 (2)		2 100 000
Slovak Republic	Bratislava	7				445 000
	Prievidza	18			29	53 393
	Ruzomberok					29 403
	Zilina	7			43	98 000
Slovenia	Celje					50 648
	Ljubljana	3				264 200
Total						**12 744 967**

3.3. Air quality in rural areas

Air quality data for 1997 were delivered from more than 30 rural sites in the Phare countries. The main objective of rural stations is to monitor air pollution for population and ecosystem exposure assessment. As mentioned in the previous chapter, in rural areas the spatial coverage is not well represented and needs further improvement. Some improvement is expected by incorporating all of the EMEP stations and inclusion of further rural stations. The present selection includes 43 monitoring stations selected in 31 rural areas of seven Phare countries.

The annual average time series of 24-hour concentrations of SO_2, NO_2, PM_{10}, SPM, BS and O_3 in selected rural sites are shown in Figure 3.16. Some of the sites (Košetice — the Czech Republic; Stará Lesná — the Slovak Republic; Krvavec — Slovenia; K-puszta — Hungary; Rucava — Latvia; and Zoseni — Latvia) are included in the EMEP programme.

Graphs of ordered 98th percentiles and annual mean concentration of NO_2 SO_2 PM_{10} and for O_3 maximum 8-hour and 1-hour concentrations are shown in (Figure 3.17). This figure shows the highest pollutant concentrations and their range at rural sites.

Decreasing emissions of lead due to the increasing use of unleaded petrol are well reflected in ambient lead concentrations at the K-puszta rural monitoring station (Figure 3.18).

3.4. Estimating pollutant concentrations using empirical models

Empirical models have been developed to estimate annual average pollutant concentrations on national and regional scale (Stedman, 1998). These models have made use of a combination of emissions estimates and measurement data to identify simple relationships between ambient concentrations and pollutant emissions. The application of similar techniques have been investigated for estimating pollutant concentrations in the Phare countries in order to generate territory-covering maps of estimated concentrations.

3.4.1. General approach to modelling

The approach used to model pollutant concentrations within the Phare countries has been based upon the identification of simple relationships between measured pollutant concentrations and surrogate data available over a much larger geographical area than measurements data themselves (e.g. emissions estimates per unit area or land cover statistics).

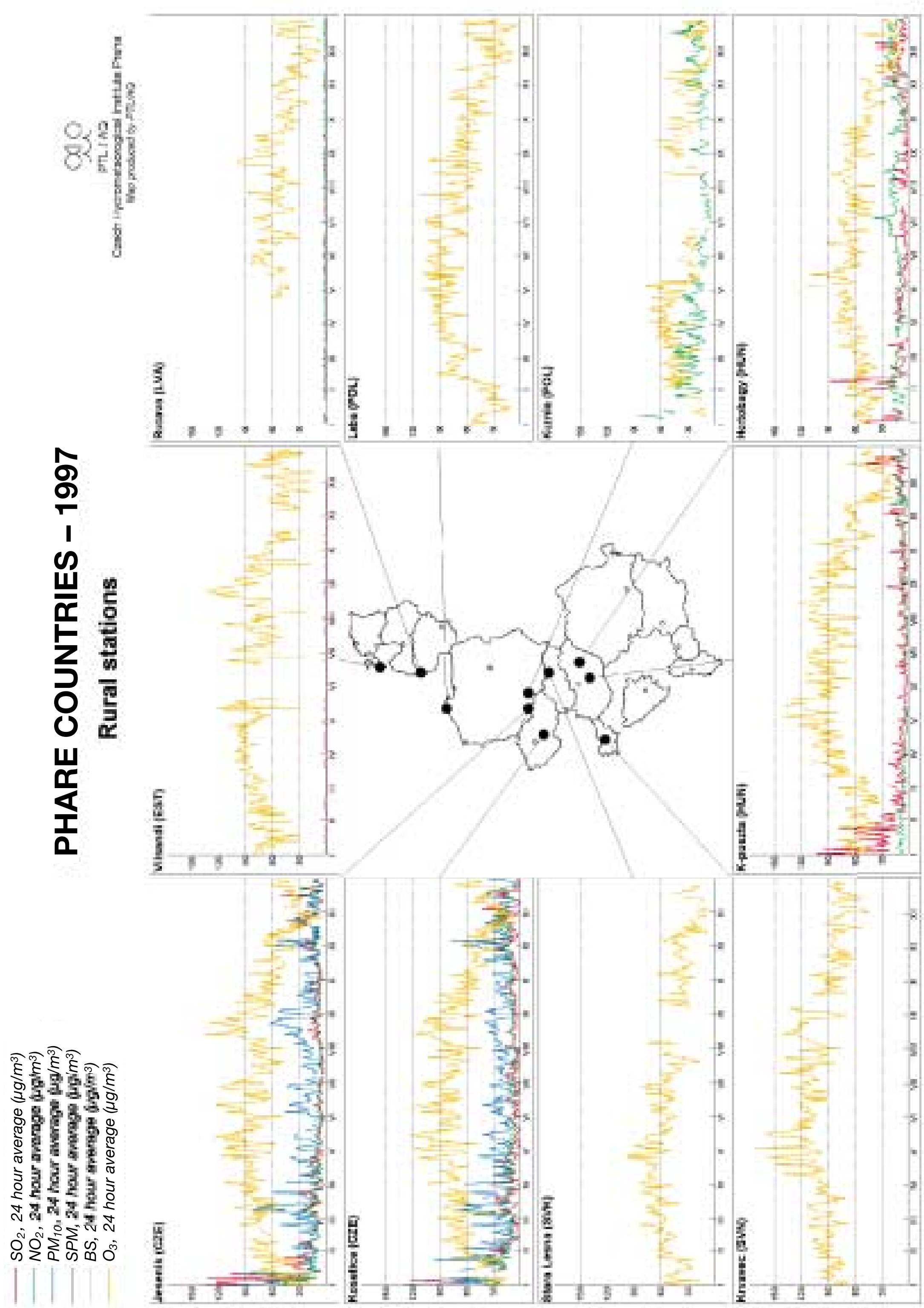
Annual average measurement data for the 1997 calendar year were available within the following countries: Bulgaria, the Czech Republic, FYROM, Hungary, Latvia, Lithuania, Poland, the Slovak Republic and Slovenia. Measurement data for the following pollutants were provided:

- nitrogen dioxide (NO_2)
- sulphur dioxide (SO_2)
- carbon monoxide (CO)
- PM_{10}
- black smoke (BS)
- suspended particulate matter (SPM)

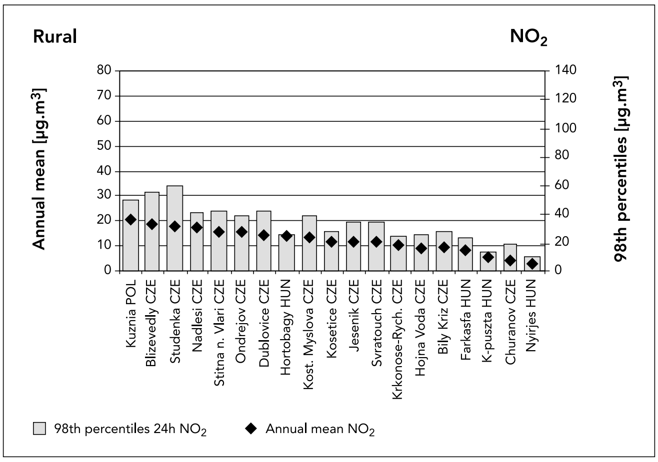
The relationships between measured annual average concentrations for these pollutants at background locations and surrogate information were investigated. The following surrogate information was available for comparison:

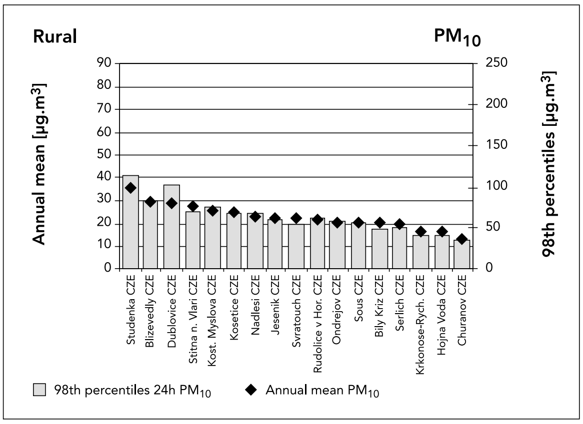
- emissions estimates per unit area (km^2) derived from the NUTS administrative regions database
- population per NUTS administrative region
- population density per NUTS administrative region
- urban/suburban land cover at a 10 × 10 km resolution derived from Corine 250 m resolution land cover data (available for Bulgaria the Czech Republic Hungary Poland Romania and the Slovak Republic).

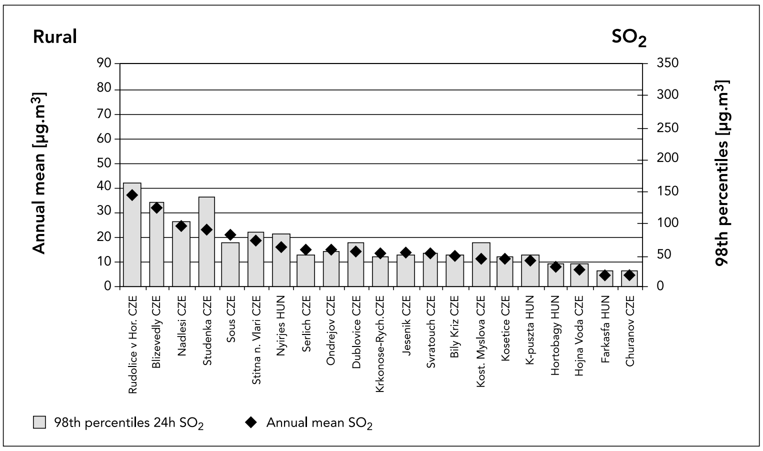
Figure 3.16 **Rural stations, the Phare countries, 1997**



Annual average and 98th percentile pollutant concentrations at rural sites, 1997 Figure 3.17







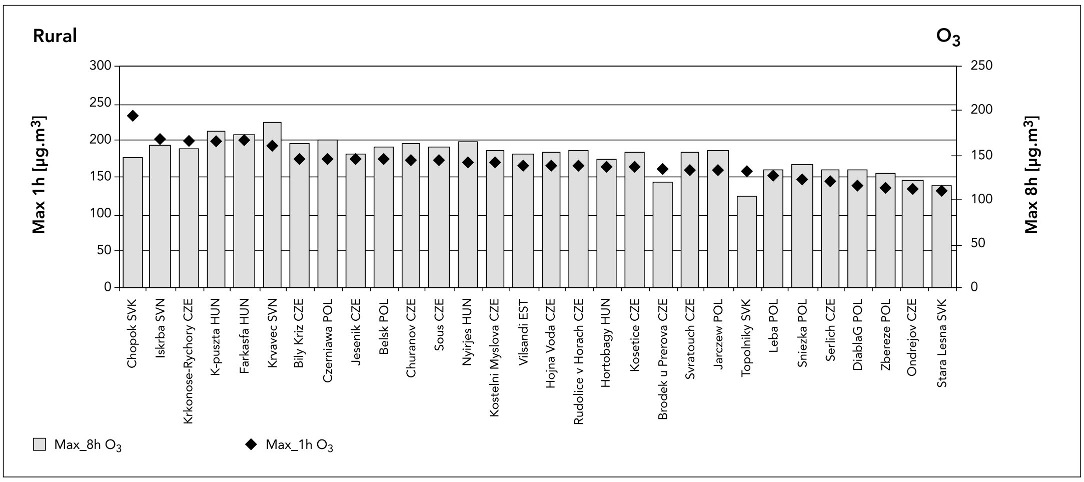
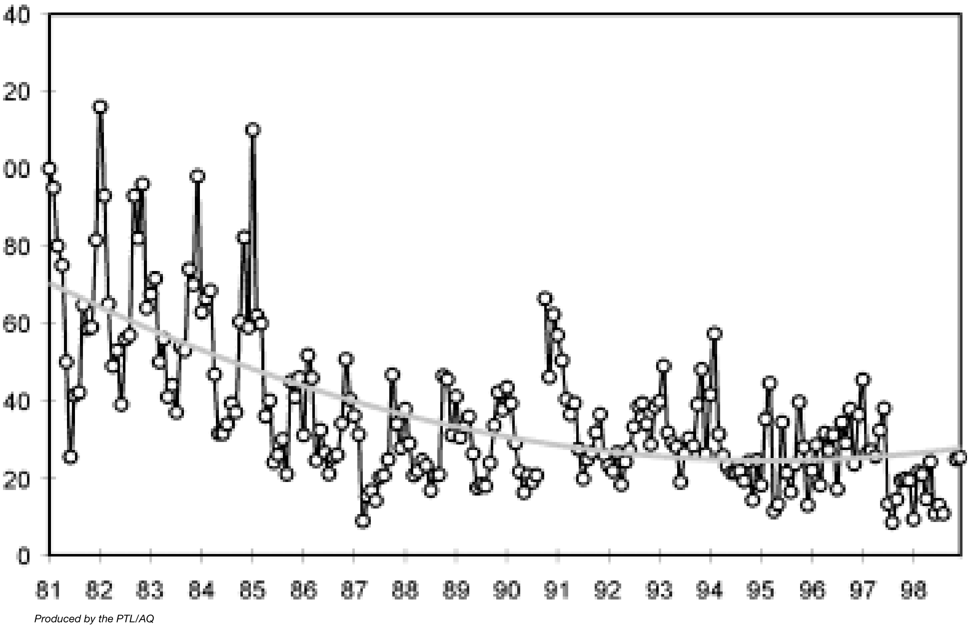


Figure 3.18

Monthly average lead concentrations (ng.m-3) with second order polynomial trendline at K-puszta rural background station in central Hungary

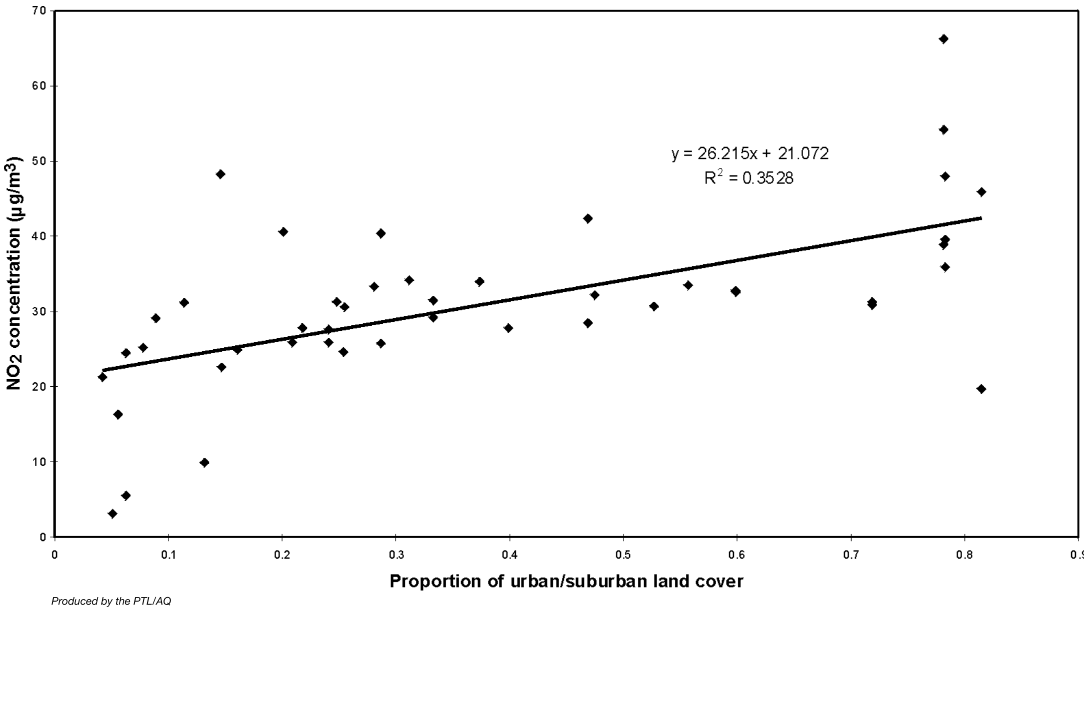


3.4.2. Relationships between measured data and surrogate information

In order to identify robust relationships between pollutant concentrations and the various surrogate statistics, comparisons were only performed at monitoring locations where greater than 50 % data capture (as hourly averages) was achieved. Regression analyses for each pollutant against the surrogate statistics detailed above were performed. It soon became evident that a reasonable correlation was only obtained between NO_2 and land cover; all other pollutants showed very poor correlations with any of the surrogate information available. Figure 3.19 presents the best overall correlation obtained for nitrogen dioxide and the surrogate statistics.

Figure 3.19

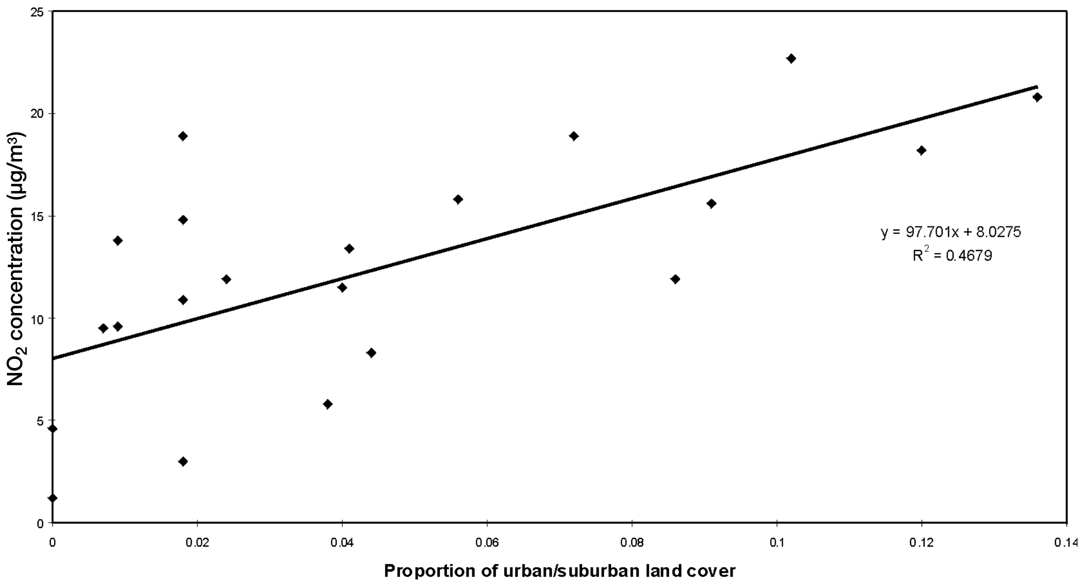
Relationship between annual average nitrogen dioxide concentrations at urban background locations and urban/suburban land cover in the Phare countries, 1997



3.4.3. Further investigation of relationships with nitrogen dioxide

In order to better identify the relationship between annual average NO_2 concentrations and suburban and urban land cover the measurement data and land cover data were scrutinised for outliers. Data points which obviously did not fit the general trend were removed from the data set. In addition, the relationship between measurement data at rural monitoring sites and urban and suburban land cover was investigated using regression analysis and found to be reasonable. Figure 3.20 presents this relationship.

Relationship between annual nitrogen dioxide concentrations at rural background locations and urban/suburban land cover in the Phare countries, 1997 Figure 3.20

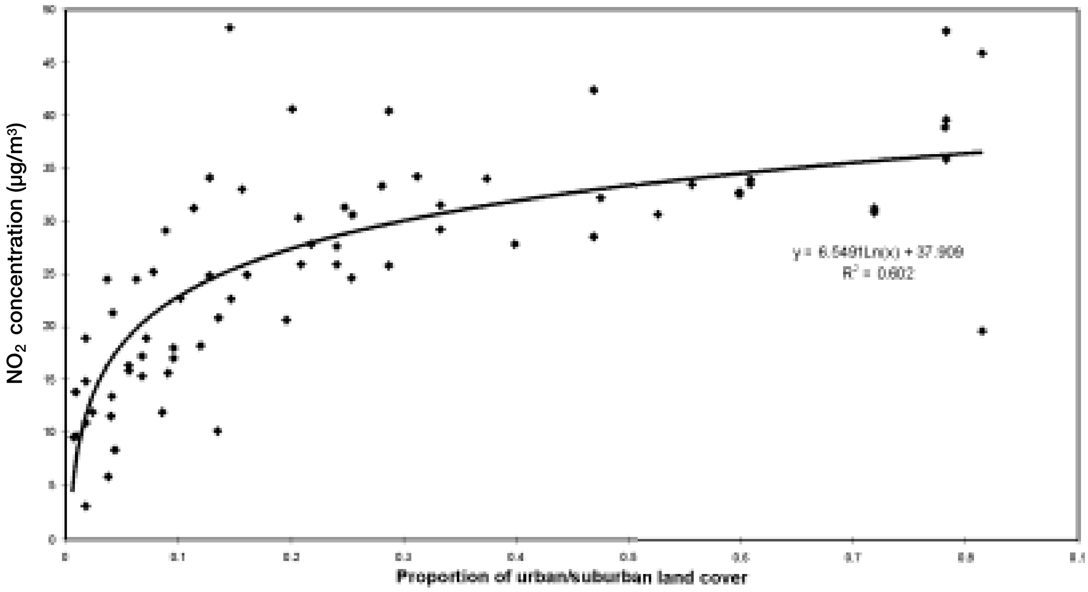


Produced by the PTL/AQ

The overall relationship between both rural and urban background NO_2 concentrations and urban and suburban land cover were then investigated by plotting both data sets on the same axes against suburban and urban land cover. The data were again scrutinised and data points that were found to be significant outliers were removed.

Figure 3.21 presents these data. A logarithmic regression model has been fitted to indicate the best fit relationship between annual average NO_2 concentrations at rural and urban background monitoring locations and the percentage of urban land cover in the 10 ¥ 10 km gridcell within which these monitoring stations are located. Clearly, the correlation between data using the logarithmic regression model is good and therefore the regression model itself presents an acceptable method for estimating annual average NO_2 concentrations from percentage urban and suburban land cover.

Figure 3.21 **Relationship between annual average nitrogen dioxide concentrations at urban background and rural locations and urban/suburban land cover in the Phare countries, 1997**



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3.4.4. Modelling nitrogen dioxide concentrations in the Phare countries

The relationship identified in Figure 3.21 has been used to map annual average NO_2 concentrations at urban and rural background locations in the Phare countries. Mapping has been performed at a 10 km^2 resolution using urban and suburban land cover statistics derived from the Corine land cover data set. Therefore:

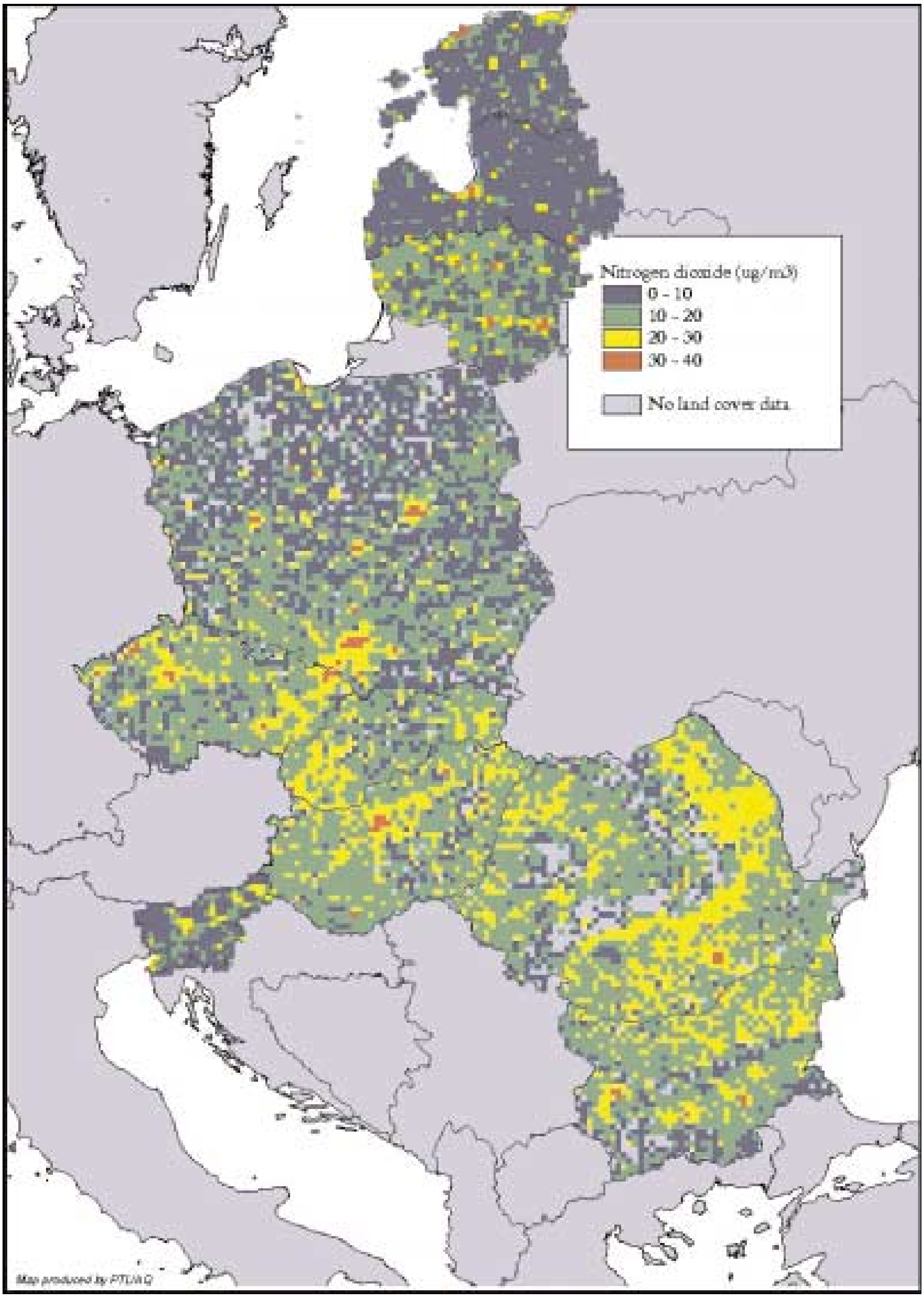
$$\textit{Annual average urban/rural background } NO_2\ (\mu g.m^{-3}) = 6.549 * \text{Ln}(usublcov) + 37.9$$

where:

usublcov is the proportion of urban and suburban land cover at a 10 km^2 resolution.

Figure 3.22 presents the map of estimated annual average background NO_2 concentrations for the Phare countries during 1997.

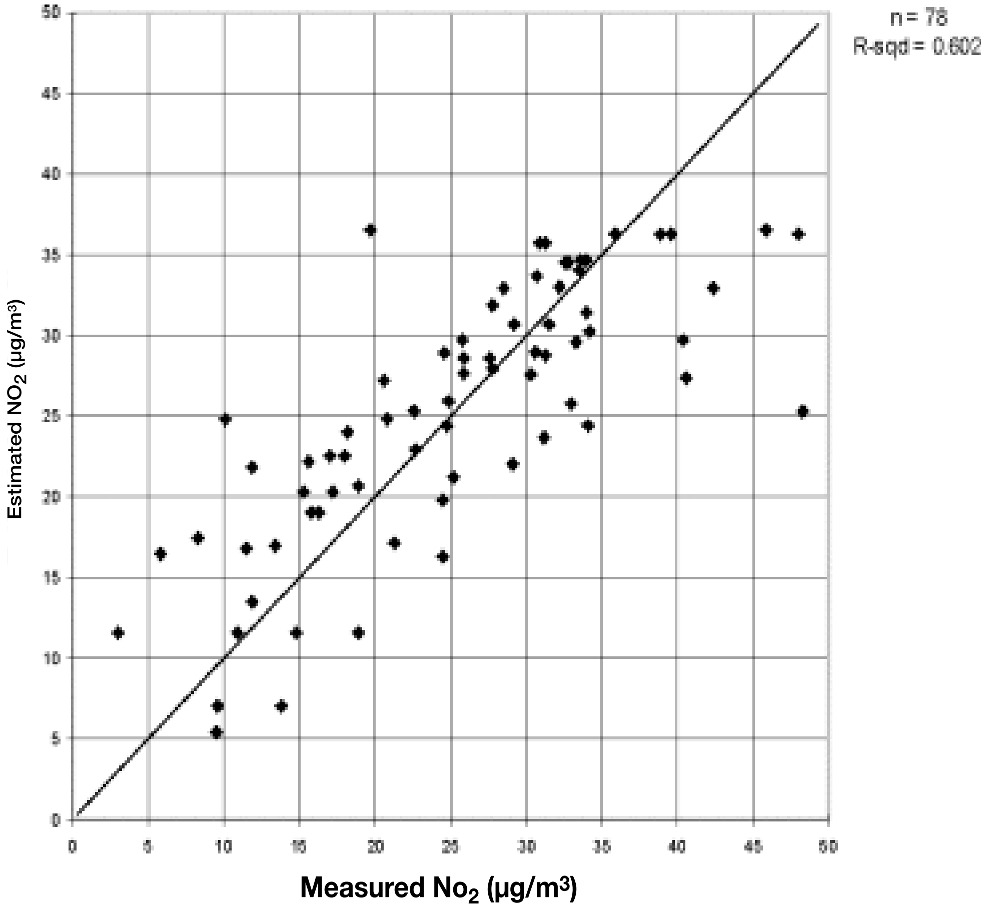
Estimated annual average nitrogen oxide concentrations at background locations in the Phare countries, 1997 Figure 3.22



3.4.5. Reliability of the model

In order to provide some means of assessing the reliability of the model, estimated NO_2 concentrations have been plotted against measured concentrations. These data are presented in Figure 3.23 and show that relationship between estimated and measured annual average NO_2 is approximately 1:1. Some scatter is evident although 95 % of modelled concentrations are within 14 µg.m^{-3} of the measured value.

Figure 3.23 **Comparison of measured and estimated annual average nitrogen dioxide concentrations in the Phare countries, 1997**



Produced by the PTL/AQ