Project Deliverables: D05.1

Mesoscale Meteo and Air Qualitiy Modelling (Addendum)

Programme name:	**Energy, Environment and Sustainable Development**
Research Programme:	**1.1.4. - 4.4.1, 4.1.1**
Project acronym:	**SUTRA**
Contract number:	**EVK4-CT-1999-00013**
Project title:	**Sustainable Urban Transportation**
Project Deliverable:	**D05.1: Addendum**
Related Work Package:	**WP 05 Mesoscale meteo and air quality modelling**
Type of Deliverable:	**RE Technical Report**
Dissemination level:	**RES Restricted**
Document Author:	**Ch. Naneris, K. Karatzas, and N. Moussiopoulos**
Edited by:	**Laboratory of Heat Transfer and Environmental Engineering**
Reviewed by:	
Document Version:	**1.0 (final draft)**
Revision history:	
First Availability:	**2003 04 09**
Final Due Date:	**2003 05 30**
Last Modification:	**2003 06 04**
Hardcopy delivered to:	**Eric Ponthieu** DG XII-DI.4 (SDME 4/73) Rue de la Loi, 200 B-1049 Brussels, Belgium

Executive Summary

The current document is the addendum of D5.1 and contains the OFIS calculation results for the updates of the reference scenarios per city and for the various city specific scenarios, on the basis of data that were made available from the city partners. Thus, the Geneva city scenario results and related indicators are not included as they were calculated with OFIS independently by the University of Geneva, and were included in the relevant city report, while no results are provided for Buenos Aires, due to lack of input data. The set of indicators calculated is defined at the beginning of the document, and the related results are provided for each city and scenario, together with the initial reference scenario from D5.1 for reasons of completeness. The validity of the emission calculations (and of the corresponding OFIS input data) was the responsibility of the city partners, while AUTh/LHTEE had the responsibility of performing the OFIS calculations and of estimating the relevant air quality indicators.

Keywords: air quality modelling, air pollution indicators

Contents

SUTRA: Sustainable Urban Transportation

1 Data availability

Table A.1 summarizes data availability and corresponding OFIS results for the various cities.

Table A.1. Emission Input data of each scenario for OFIS simulations provided by city partners

	Urban emissions	**Suburban emissions**	**Rural emissions**
GENOA	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4
GDANSK	S1, S2, S3, S4, S5	S1, S2, S3, S4, S5	S1, S2, S3, S4, S5
THESSALONIKI	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4
LISBON	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4	S0, S1, S2, S3, S4
GENEVA	Own calculations	Own calculations	Own calculations
TEL AVIV	S0	S0	S0
BUENOS AIRES	-	-	-

OFIS results are initially presented for each city and scenario in a twofold way:

a. as spatial graphs of days with 8hour running average ozone concentration exceeding 120μg/m^3 values (IND120) and
b. as AOT60 (in ppb x hours) and IND120 (in number of days) indicators according to Table A.2

Table A.2. OFIS indicators calculated per city scenario

AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
Maximum **ppb x hours** index within the computational domain	Average **ppb x hours** index within the computational domain	Average **ppb x hours** index within the suburban area	Average **ppb x hours** index within the town area
IND120(domain)	IND120(sub)	IND120(town)	
Number of days with exceedances of the 120 μg/m^3 value in the whole domain	Number of days with exceedances of the 120 μg/m^3 value in the suburban area	Number of days with exceedances of the 120 μg/m^3 value in the town area	

In addition, and in order to enrich the analysis, a “new statistics” table, containing “new” indicators, has been compiled, in the following way:

For each city, nine points are selected as explained in Figure A.1, one (number 5) at the centre of the urban domain, and the others in an array with a distance of 20km (horizontally and/or vertically). Ozone concentration values predicted at each one of these points are used for the calculation of the relevant “indicators”. It should be noted that the same layout of points is used in many air quality modelling exercises, like the city-delta activity

(http://europa.eu.int/comm/environment/air/cafe/pdf/steering_technical_group/item3_citydelta.pdf). Thus, for each one of these points, the average ozone concentration value (**ave_ofis**), and the AOT (**aot_ofis**) and IND (**ind_ofis**) values are calculated, for each one of the scenarios.

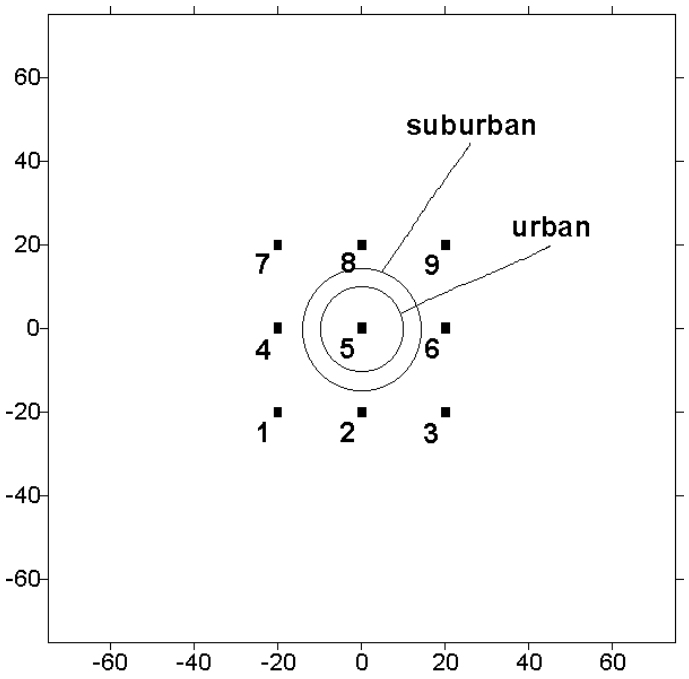

Figure A.1: The layout of the nine points selected per city and scenario for the calculation of the average ozone concentration value (ave_ofis), and the AOT (aot_ofis) and IND (ind_ofis) values. Distances are noted in km. The urban circle represents the urban area of each city (D=19 km), while the suburban ring the related suburban area of each city (D= 28 km).

2 Genoa

2.1 Initial reference scenario

The initial reference scenario results are copied here from D5.1, and are included in the current addendum in order to provide a complete picture of the work done for the reference scenario.

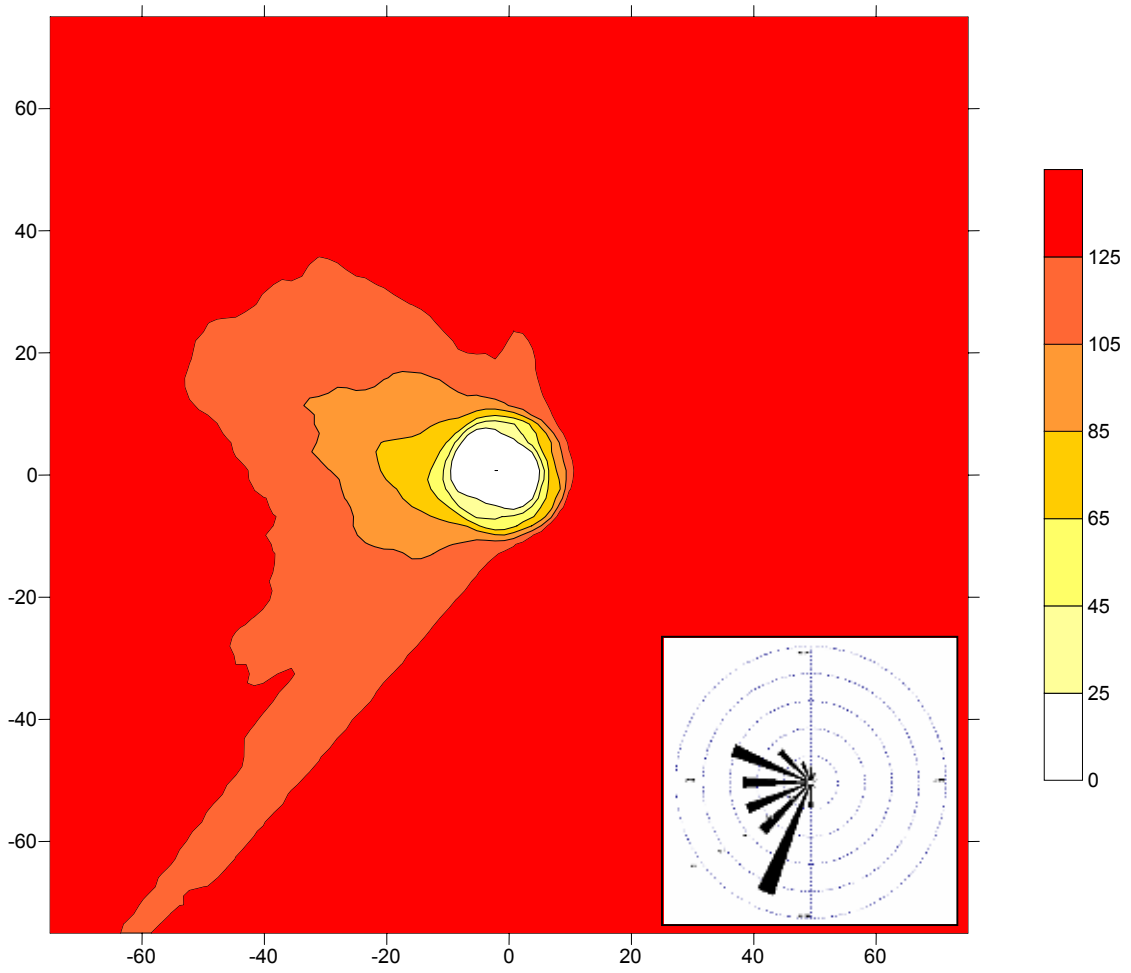

Figure A.2. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa, and wind rose of prevailing wind during the summer semester of 1999 (draft reference scenario).

Figure A.2 shows the initial estimation for the number of days exceeding 120μg/m^3 – as daily 8hour average – for the six months period studied and the wind rose[1] corresponding to this period. Instead of occurring in the urban ozone plume as expected, exceedances are observed away from the city and the area influenced by it; this unrealistic pattern is the consequence of air masses extremely rich in ozone and other pollutants entering in the area from the domain's boundaries. These boundary concentration values of main

[1] Wind speed and direction distribution for the period of interest

photochemical pollutants were supplied by the partners and although they should correspond to background levels, they were high enough to be observed in extremely polluted urban plumes. Lower ozone concentrations – and consequently fewer exceedances – are calculated in the urban area, as NO emissions consume ozone, and downwind, as “cleaner” air is advected from the city. Based on the above findings, a revised set of data was provided by the Genoa partners, resulting in the exceedances presented in Figure A.3.

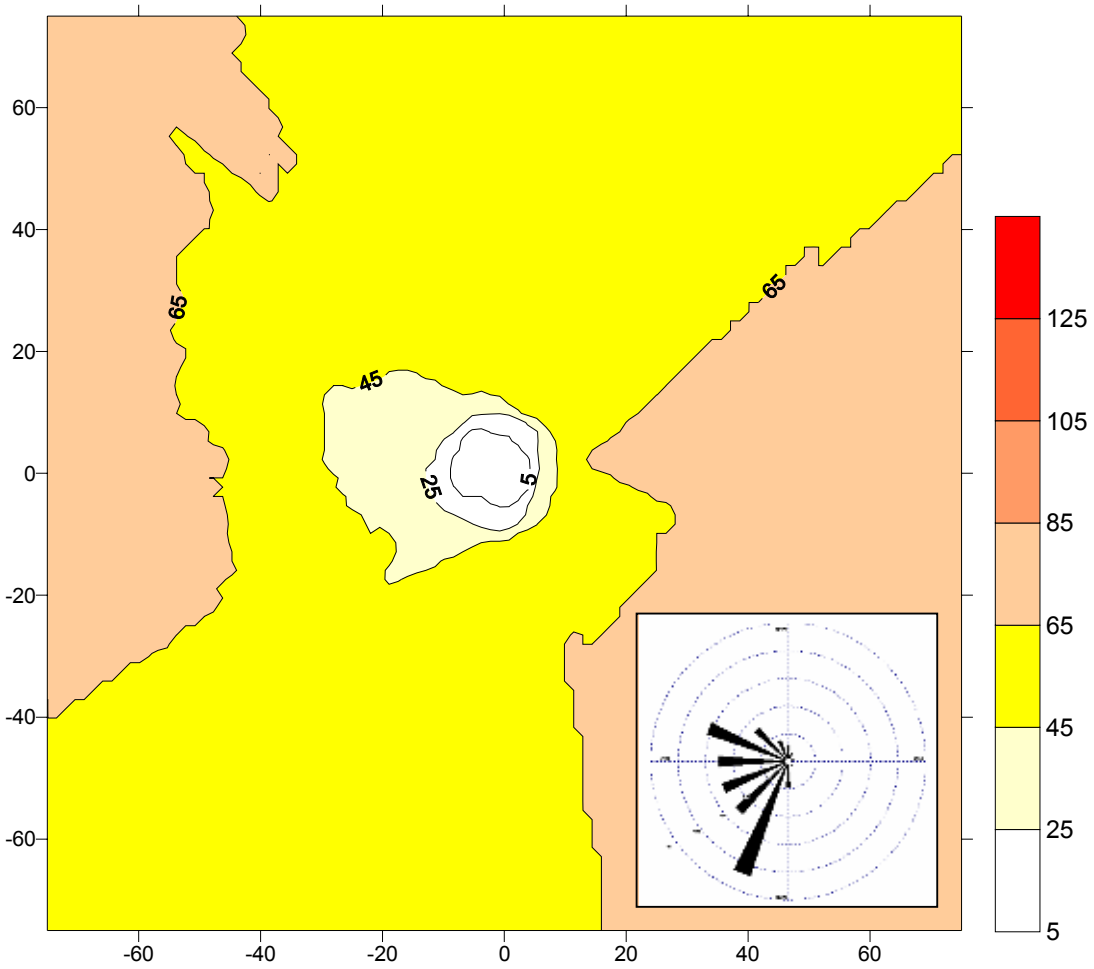

Figure A.3. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999 (final initial reference scenario).

Figure A.3.shows the final estimation for the number of days exceeding 120μg/m^3 – as daily 8hour average – for the six months period studied and the wind rose[2] corresponding to this period. Exceedances are observed in combination with the urban ozone plume, and the pattern is now more realistic, due to the refined boundary condition data. Lower ozone concentrations – and consequently fewer exceedances – are calculated in the urban area, as NO emissions consume ozone, and downwind, as “cleaner” air is advected from the

[2] Wind speed and direction distribution for the period of interest

city. As a final check, comparisons were made between the results presented here and the results that were made available from the GEA report (de Leeuw et. al., 2001). Thus, it should be noted that the exceedances calculated in the GEA report for Genoa were higher than the ones of the SUTRA reference scenario, the same standing for the emission data, thus verifying the importance of the emission related ozone production mechanisms in the area.

The indicators resulting for the Initial reference scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	144.11	19.12	3.81	1.79
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	28	12	

2.2 Final reference scenario

In continuation of the previous work, the Genoa city partners provided with updated input data for the final reference scenario. Calculation results are presented below.

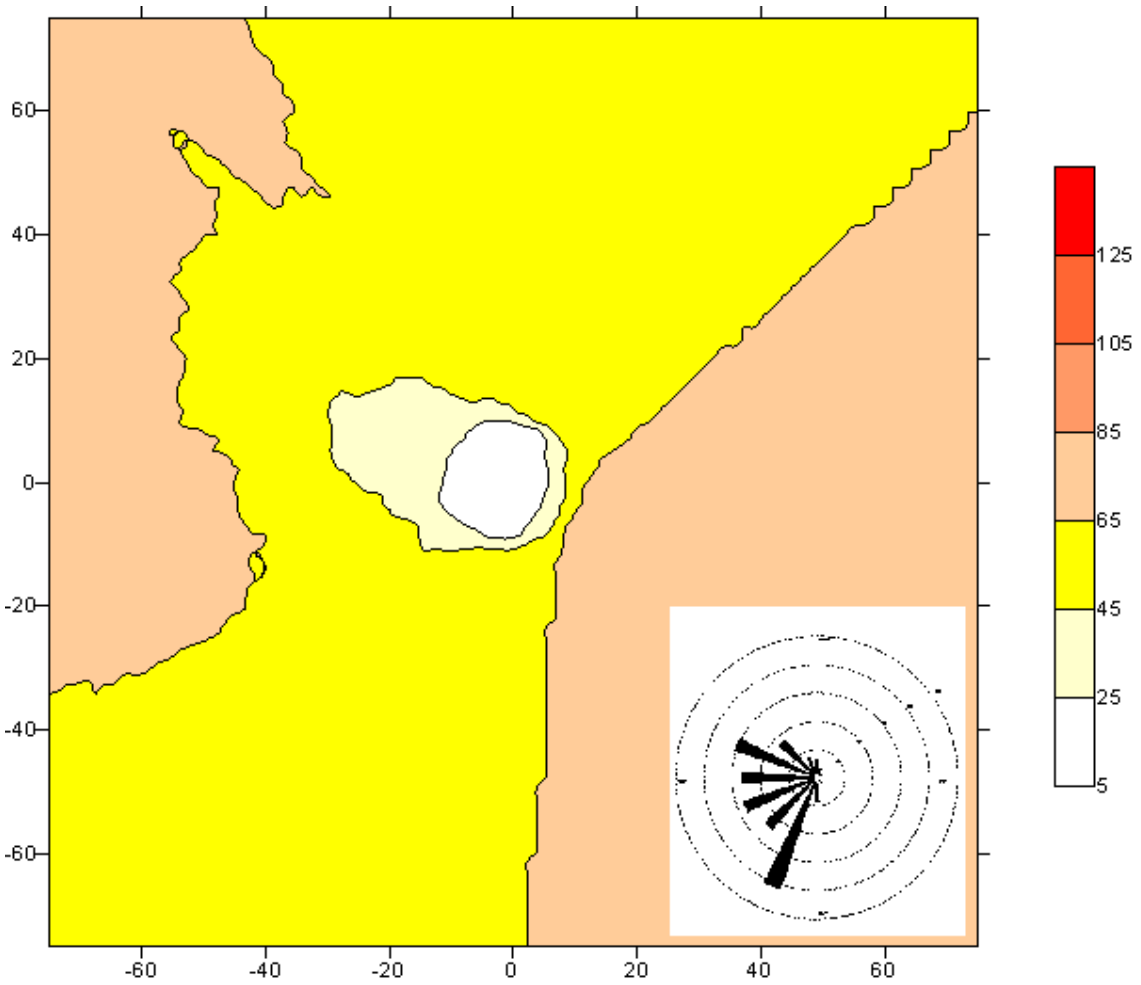

Figure A.4. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999 (final reference scenario).

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	144.26	19.13	4.11	2.18
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	31	16	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	42.41	9.69	70

2	35.84	8.07	59
3	43.13	10.39	67
4	33.14	5.8	46
5	11.46	0.57	9
6	33.54	5.87	46
7	43.18	10.5	67
8	36.11	8.07	59
9	41.96	8.82	65

2.3 Scenario S1

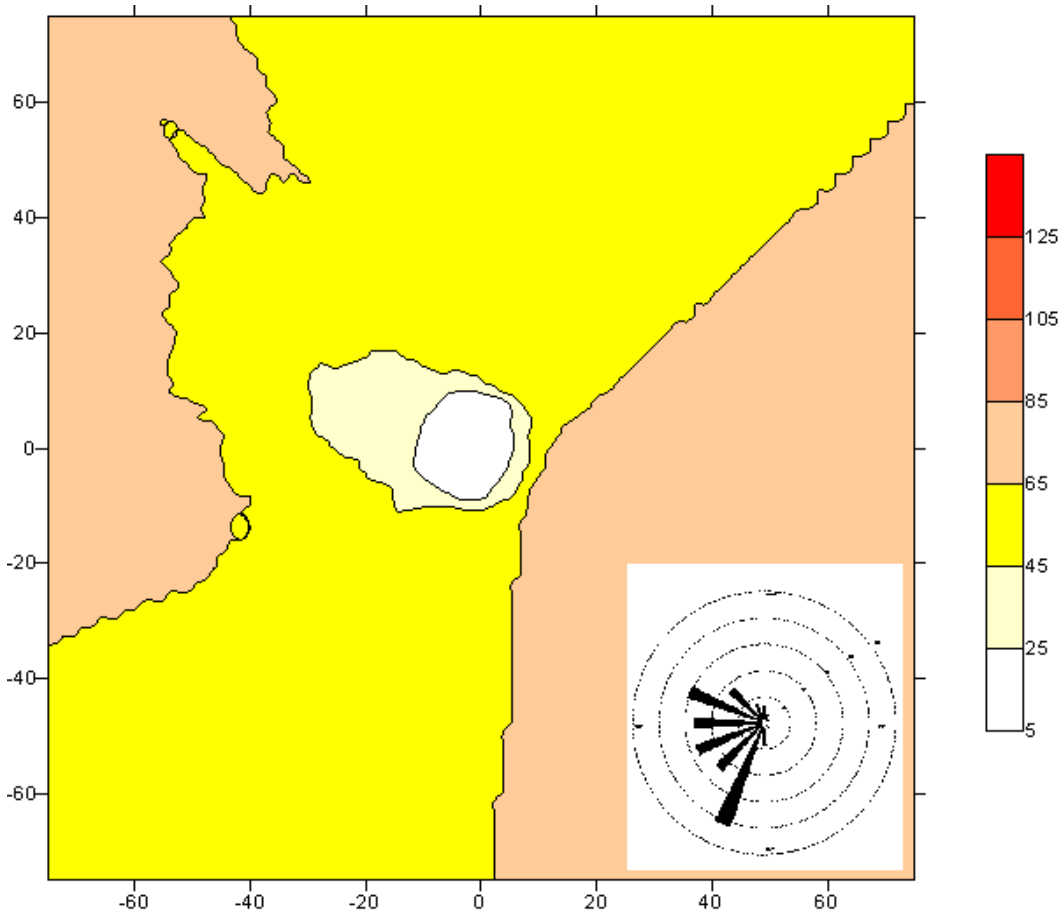

Figure A.5. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120) calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	144.02	19.12	4.17	2.26
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	31	17	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	42.51	9.69	70
2	35.88	8.07	59
3	43.17	10.39	67
4	33.17	5.84	46
5	12.07	0.71	11
6	33.55	5.89	46
7	43.21	10.5	67
8	36.15	8.07	59

9	42.2	8.93	66

2.4 Scenario S2

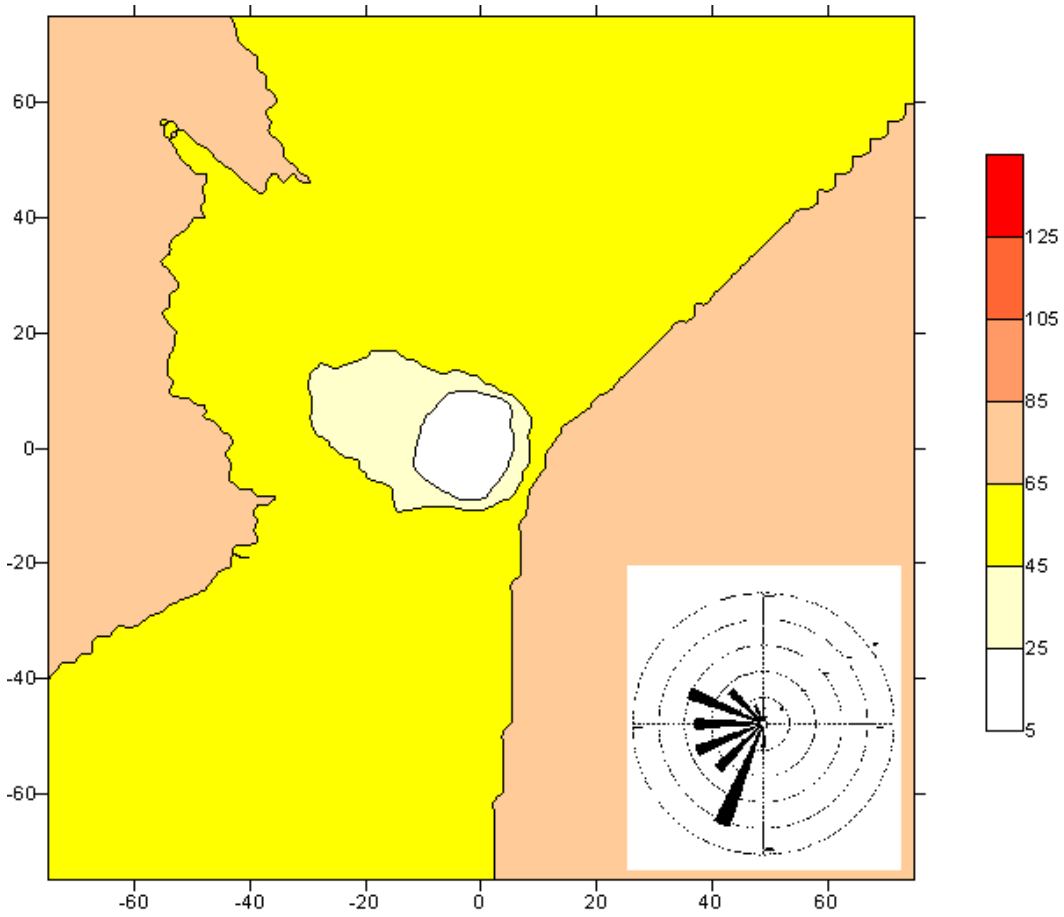

Figure A.6. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120) calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	143.98	19.13	4.19	2.28
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	31	17	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	42.51	9.78	70
2	35.88	8.07	59
3	43.16	10.39	67
4	33.17	5.85	46
5	11.92	0.71	10
6	33.56	5.94	46
7	43.21	10.5	67
8	36.14	8.07	59

9	42.14	8.92	65

2.5 Scenario S3

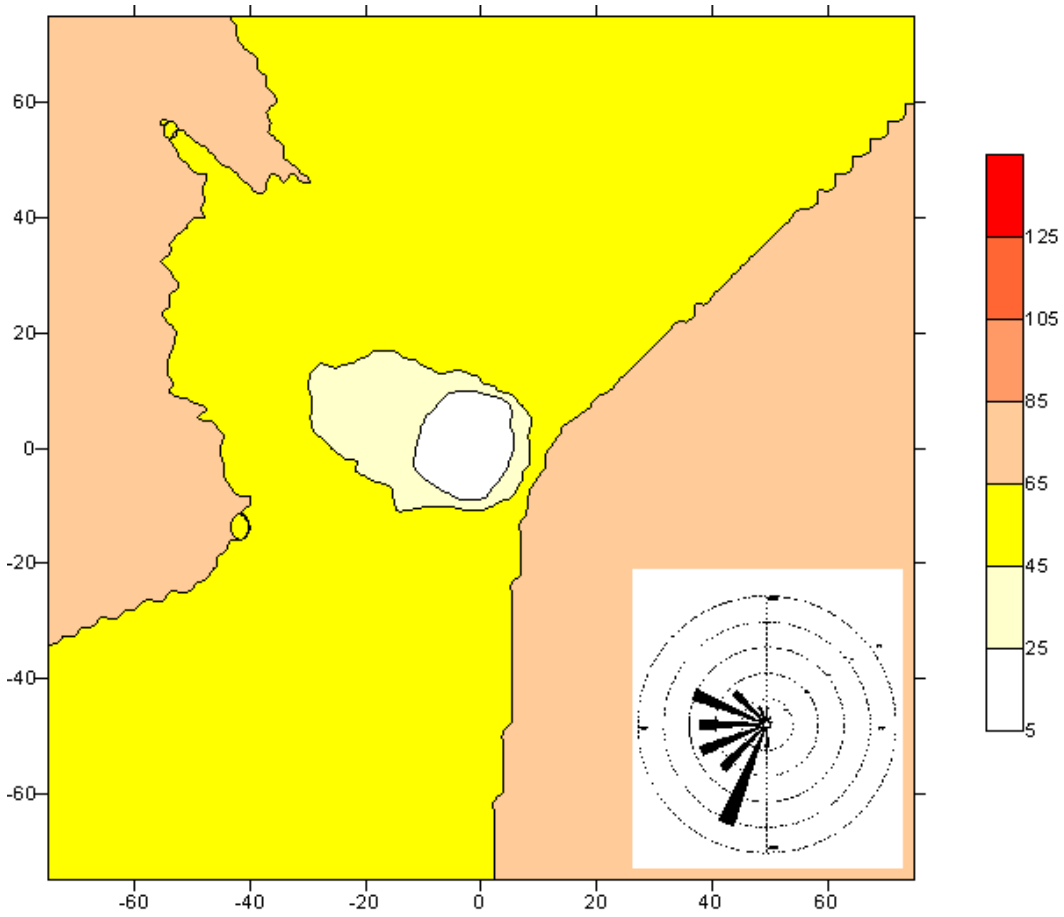

Figure A.7. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	144.05	19.11	4.14	2.23
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	31	17	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	42.48	9.61	69
2	35.87	8.07	59
3	43.17	10.39	67
4	33.17	5.82	46
5	12.07	0.68	11
6	33.54	5.85	46
7	43.21	10.5	67
8	36.14	8.07	59

9	42.2	8.91	66

2.6 Scenario S4

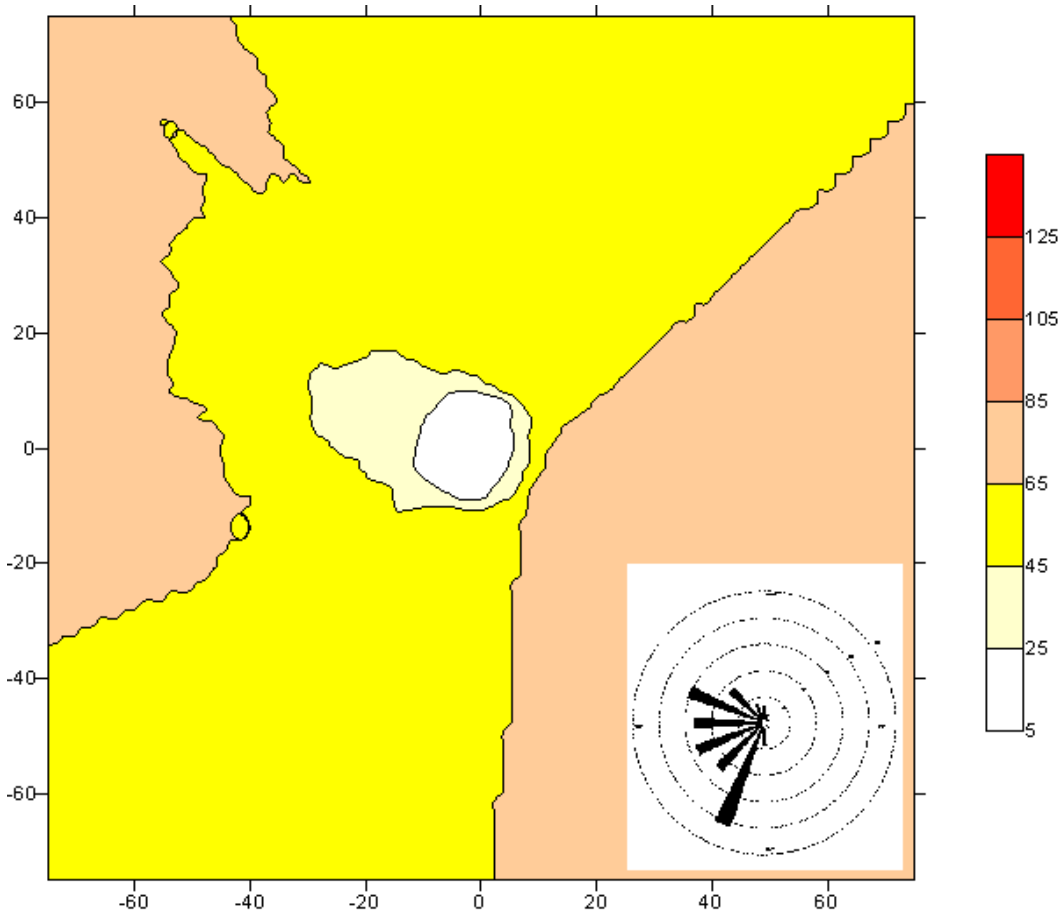

Figure A.8. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Genoa and wind rose of prevailing wind during the summer semester of 1999.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	143.99	19.12	4.17	2.27
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	61	31	17	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	42.51	9.7	70
2	35.88	8.07	59
3	43.17	10.39	67
4	33.17	5.84	46
5	12.05	0.71	11
6	33.55	5.9	46
7	43.21	10.5	67
8	36.14	8.07	59

9	42.19	8.93	66

2.7 Scenario summary

The next figure provides with an overall summary of the indicators vs scenarios for Genoa, indicating that the scenario performance is identical, with the slight exception of IND120.

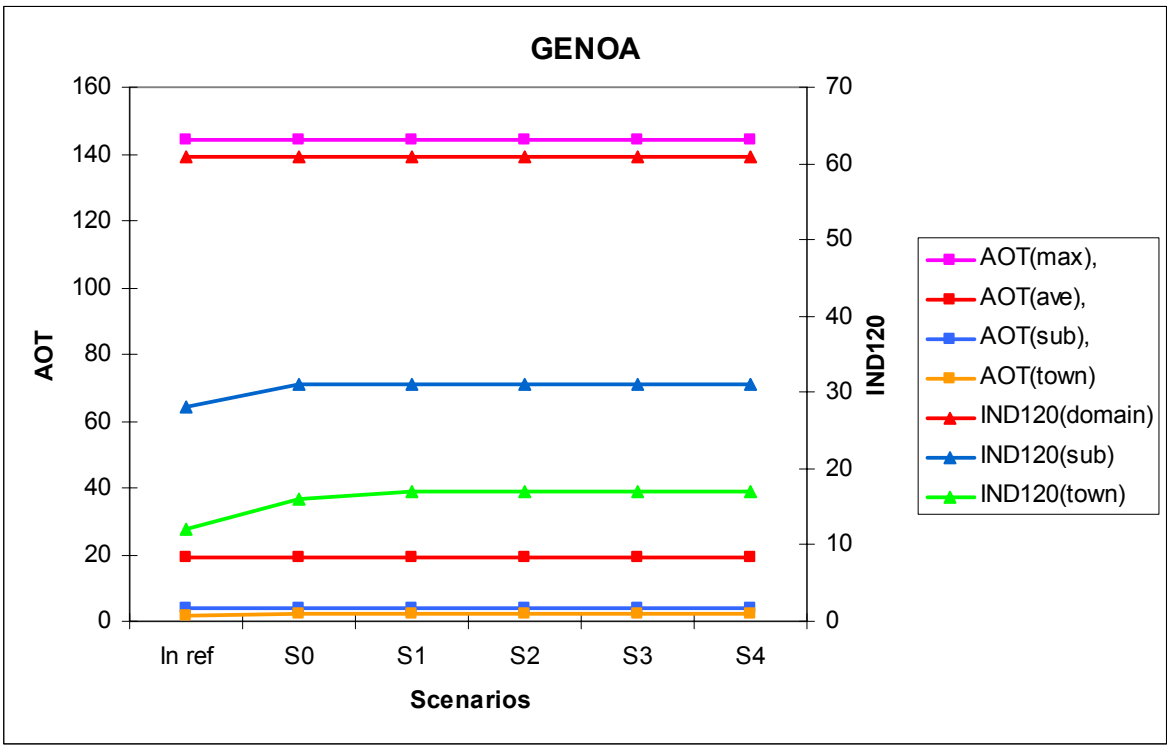

Figure A.9. Overall summary of the indicators vs scenarios for Genoa.

The same conclusion is supported by the next three diagrams (Figure A.10) concerning the “new statistics” introduced. A slight difference at the city centre is attributed to the urban NO emissions influencing the Ozone concentrations.

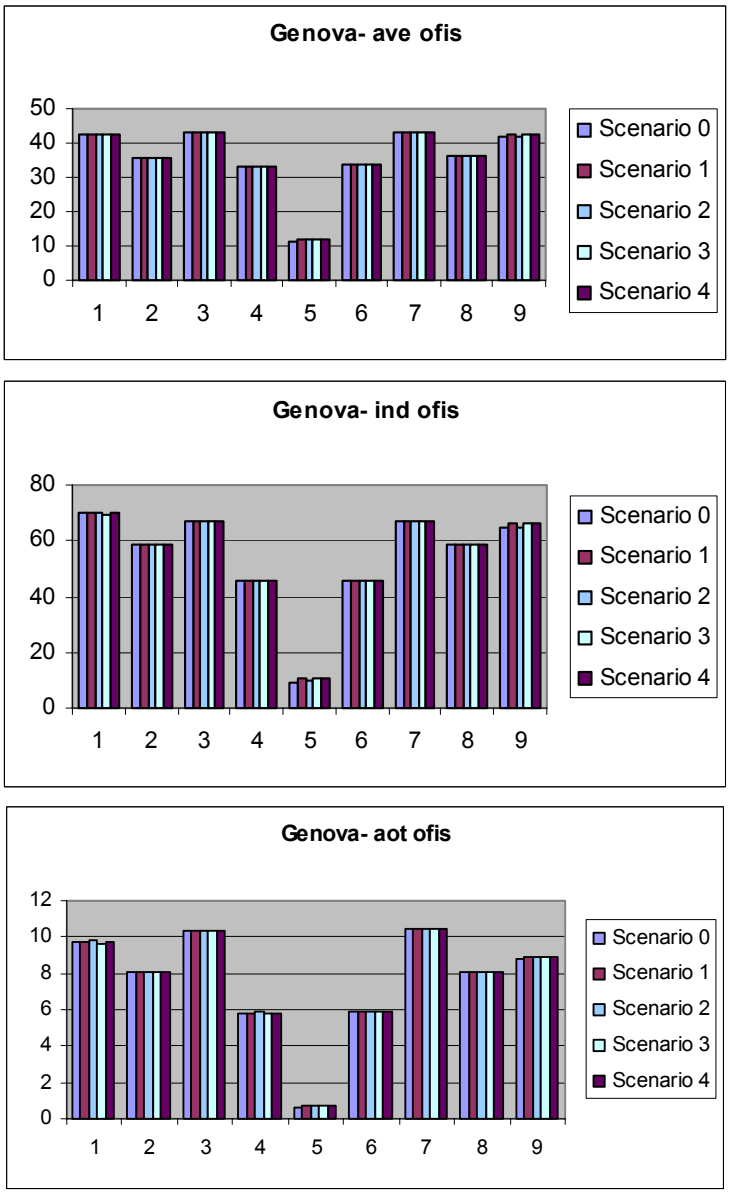

Figure A.10. Receptors (x axis) and indicator values (y axis) for the Genoa scenarios.

3 Gdansk

3.1 Initial reference scenario

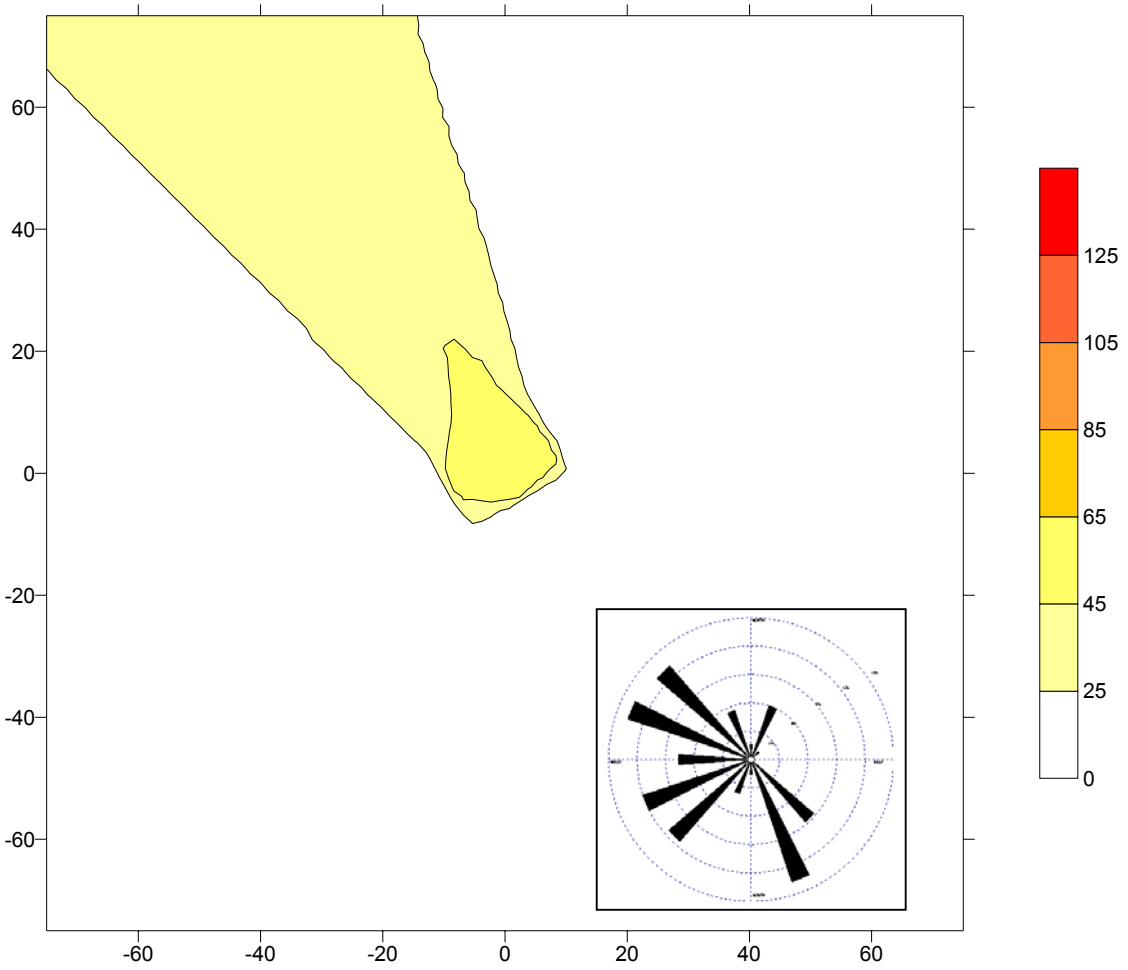

Figure A.11. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk, and wind rose of prevailing wind during the summer semester of 1999 (final reference scenario).

Few days of exceedances were observed for the area of Gdansk. As shown in Fig. A11, these days are characterized by SE winds and high ozone concentrations mainly above the urban area. Although there is a considerable occurrence of NW winds and SW winds, no ozone plume is formed downwind of the city during the corresponding days. Very low emission estimations for urban NO_x and no emissions for VOC at all, combined with zero boundary concentrations for ozone and VOC, resulted in limited production of radicals which would interfere to the NO-NO_2-O_3 reaction chain to favour ozone production. The small number of exceedances for most of the area is due to the absence of VOC in the studied area. The high urban ozone levels occur in the days of SE winds, as the pollution of air masses moving downwind of the city indicate in Fig. 2. This happens also due to the scarcity of the emission data available; there are no NO ground emissions for the urban area or the SE neighbouring cities of Elblag and Tczew to “consume” ozone that NO_2 – emitted in considerable amounts from these two cities – photolysis produces. NW to

Gdansk, in Gdynia and Sopot, comparable amounts of NO_2 are emitted, but ozone production is counterbalanced by NO emissions, which, for these two cities, are available. As a final check, comparisons were made between the results presented here and the results that were made available from the GEA report (de Leeuw et al., 2001). Thus, it should be noted that the exceedances calculated in the GEA report for Gdansk, and the relevant emissions, were the same with the ones of the SUTRA reference scenario.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	176.04	26.55	76.35	105.78
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

3.2 Final reference scenario

The final reference scenario is the same with the initial one, as no updated emission or meteorology data were provided for the latter.

3.3 Scenario S1

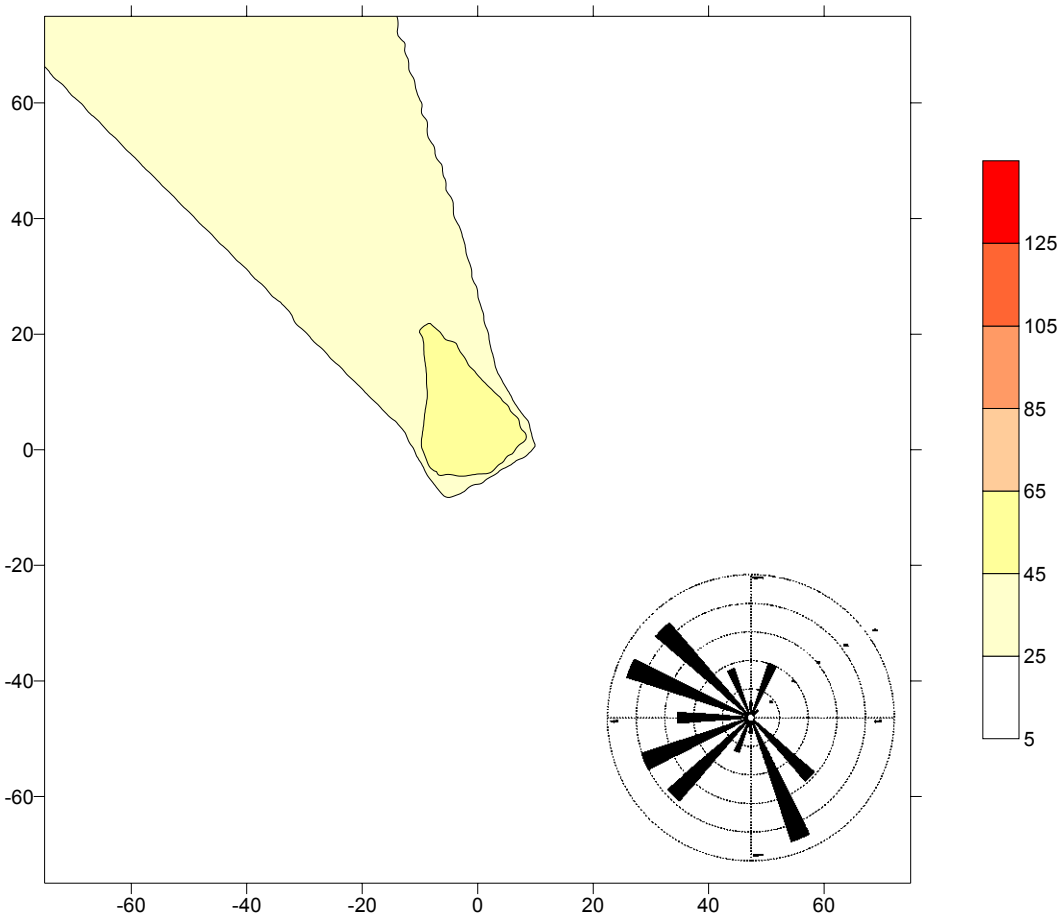

Figure A.12. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	175.39	26.45	76.09	105.42
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	10.64	0.11	2
2	18.73	24.04	9
3	47.33	107.61	36
4	18.63	25.2	10
5	68.61	146.96	48
6	16.78	18.69	10
7	61.53	156.23	36
8	20.18	30.1	9

9	10.75	0.11	2

3.4 Scenario S2

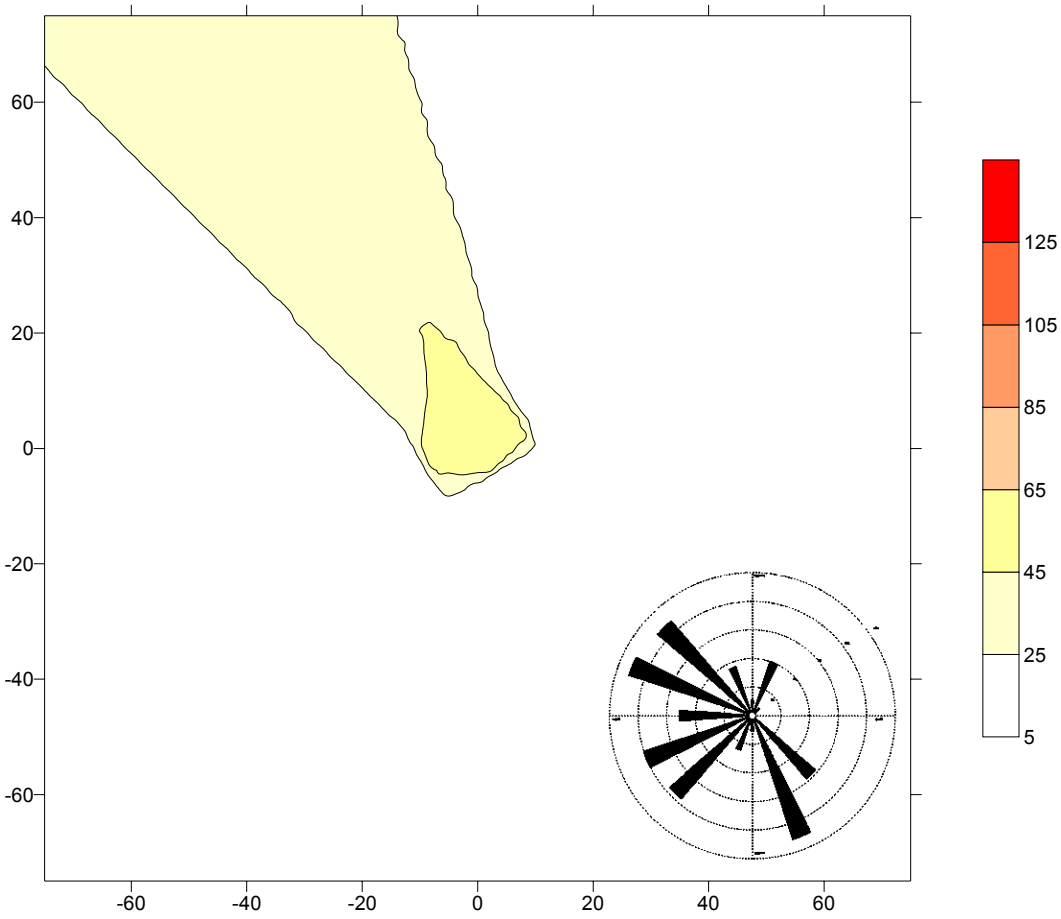

Figure A.13. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	175.36	26.45	76.09	105.43
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	10.47	0.11	2
2	18.64	24.09	9
3	47.3	107.55	36
4	18.58	25.2	10
5	68.78	146.97	48
6	16.72	18.69	10
7	61.5	156.18	36
8	20.11	30.18	9
9	10.66	0.11	2

.

3.5 Scenario S3

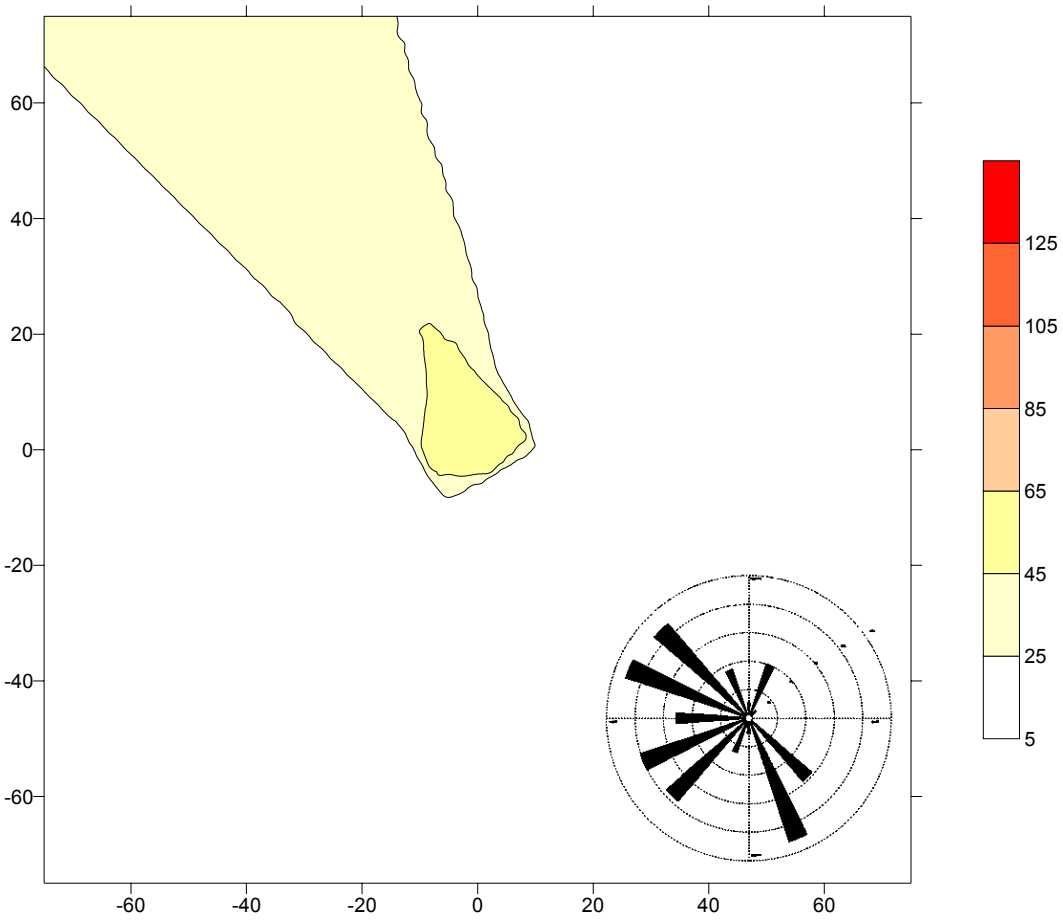

Figure A.14. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	175.29	26.43	76.03	105.34
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	10.28	0.12	2
2	18.56	24.03	9
3	47.24	107.5	36
4	18.5	25.2	10
5	69.82	146.86	48
6	16.64	18.69	10
7	61.46	156.14	36
8	20.09	30.1	9

9	10.48	0.12	2

3.6 Scenario S4

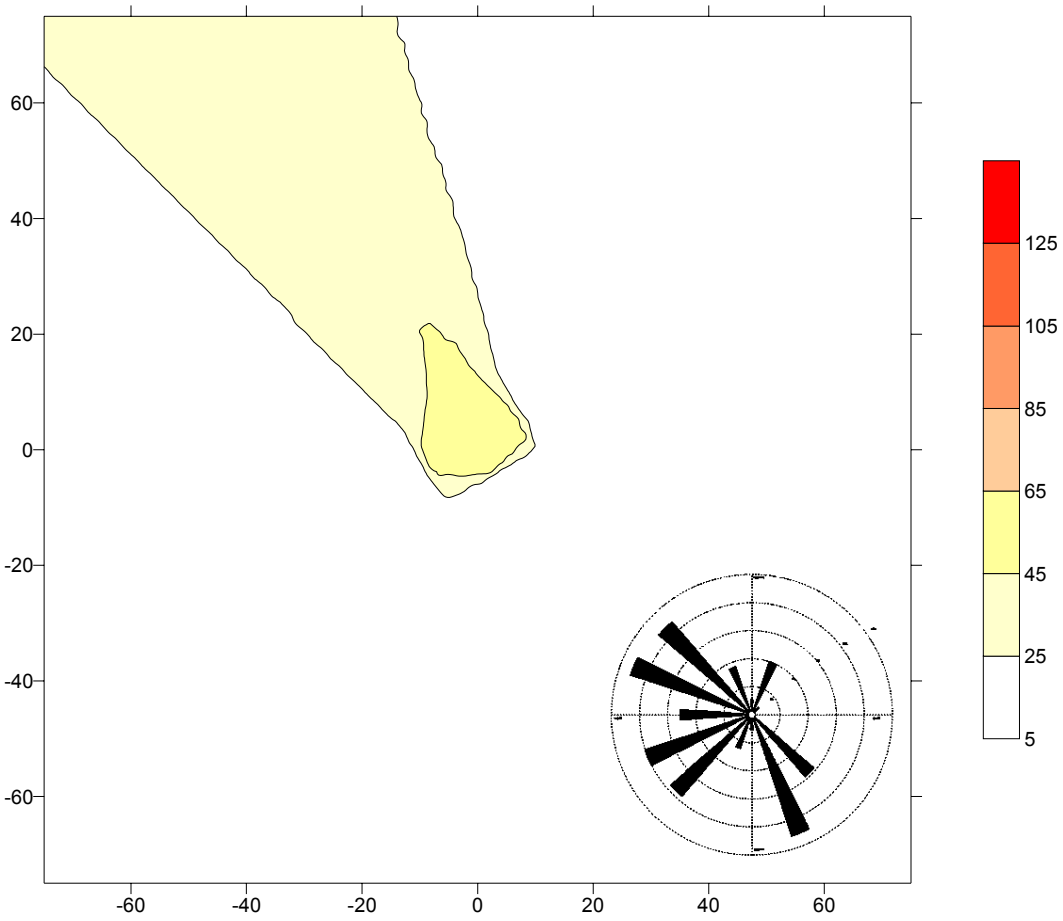

Figure A.15. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	175.27	26.42	76.04	105.35
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	10.18	0.12	2
2	18.5	24.05	9
3	47.23	107.47	36
4	18.45	25.16	10
5	70.27	146.85	48
6	16.56	18.65	10
7	61.53	156.1	36
8	20.03	30.12	9

9	10.38	0.12	2

3.7 Scenario S5

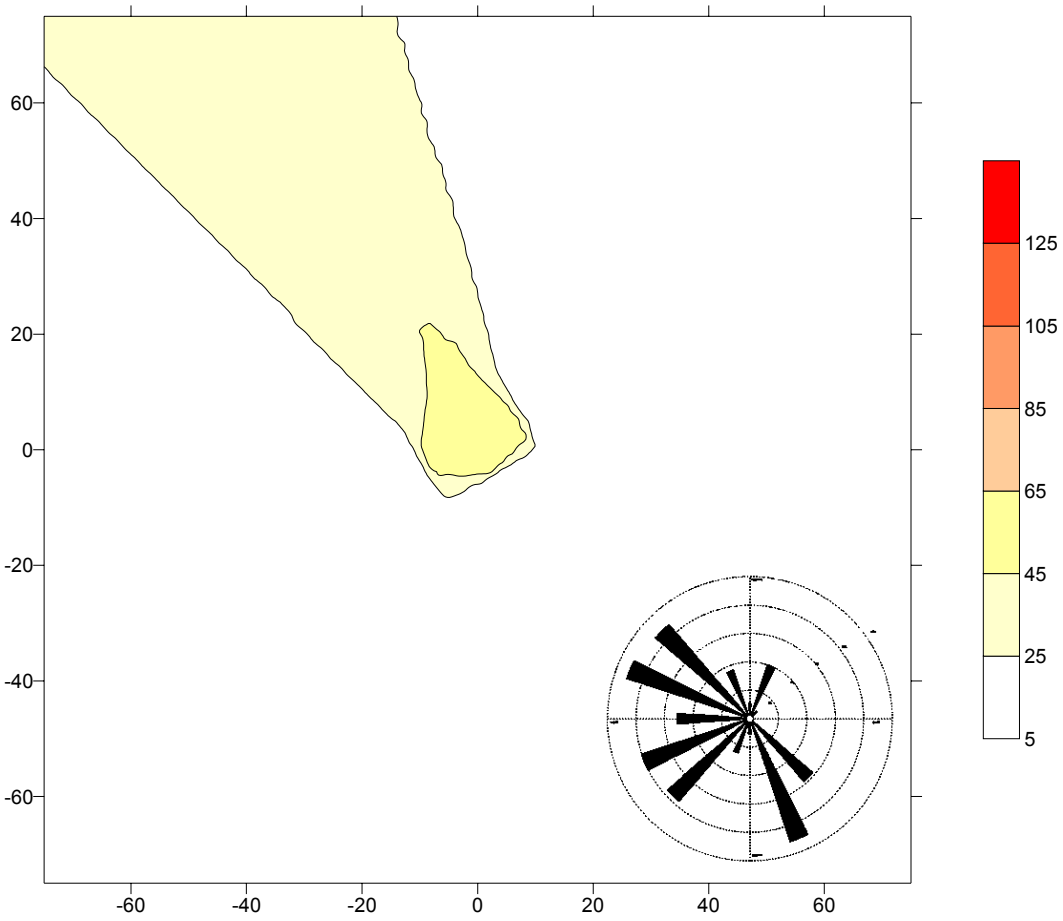

Figure A.16. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Gdansk.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	175.34	26.43	76.07	105.41
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	9	28	39	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	10.13	0.12	2
2	18.47	24.06	9
3	47.33	107.58	36
4	18.43	25.16	10
5	70.92	146.99	48
6	16.54	18.66	10
7	61.68	156.23	36
8	19.99	30.13	9

9	10.34	0.12	2

3.8 Scenario summary

The next figure provides with an overall summary of the indicators vs scenarios for Gdansk, indicating that the scenario performance is identical.

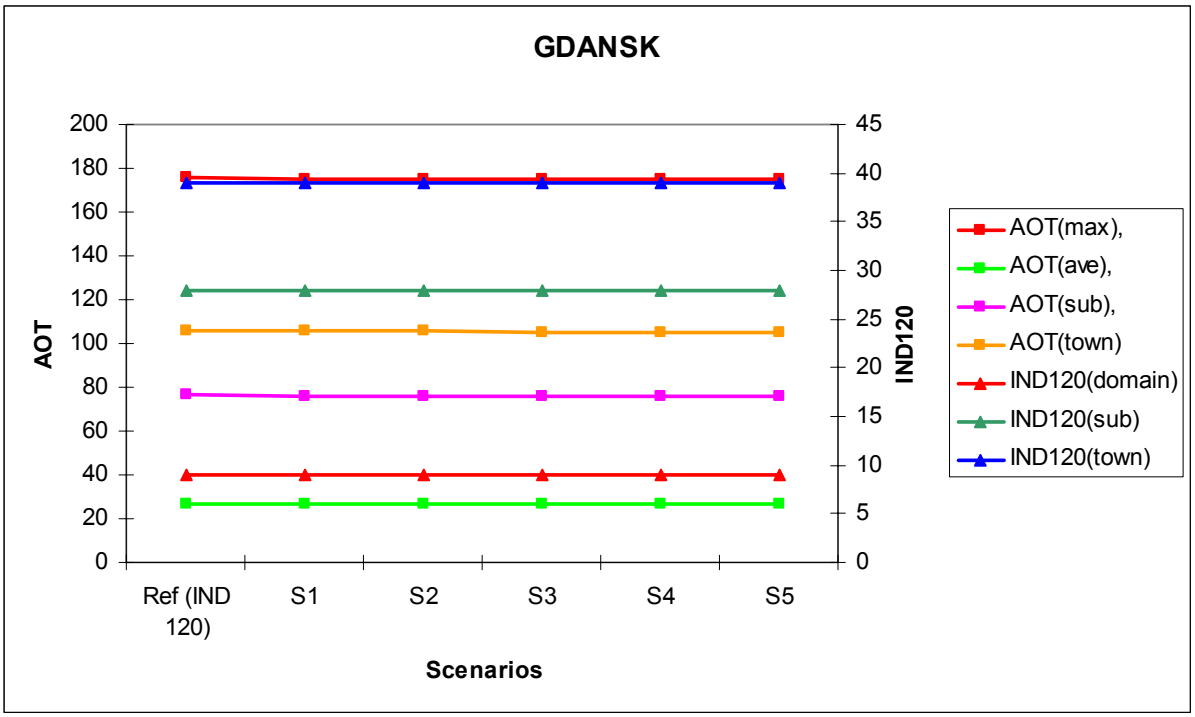

Figure A.17. Overall summary of the indicators vs scenarios for Gdansk.

The same conclusion is supported by the next three diagrams (Figure A.18) concerning the "new statistics" introduced. A slight difference at the city centre is attributed to the urban NO emissions influencing the Ozone concentrations.

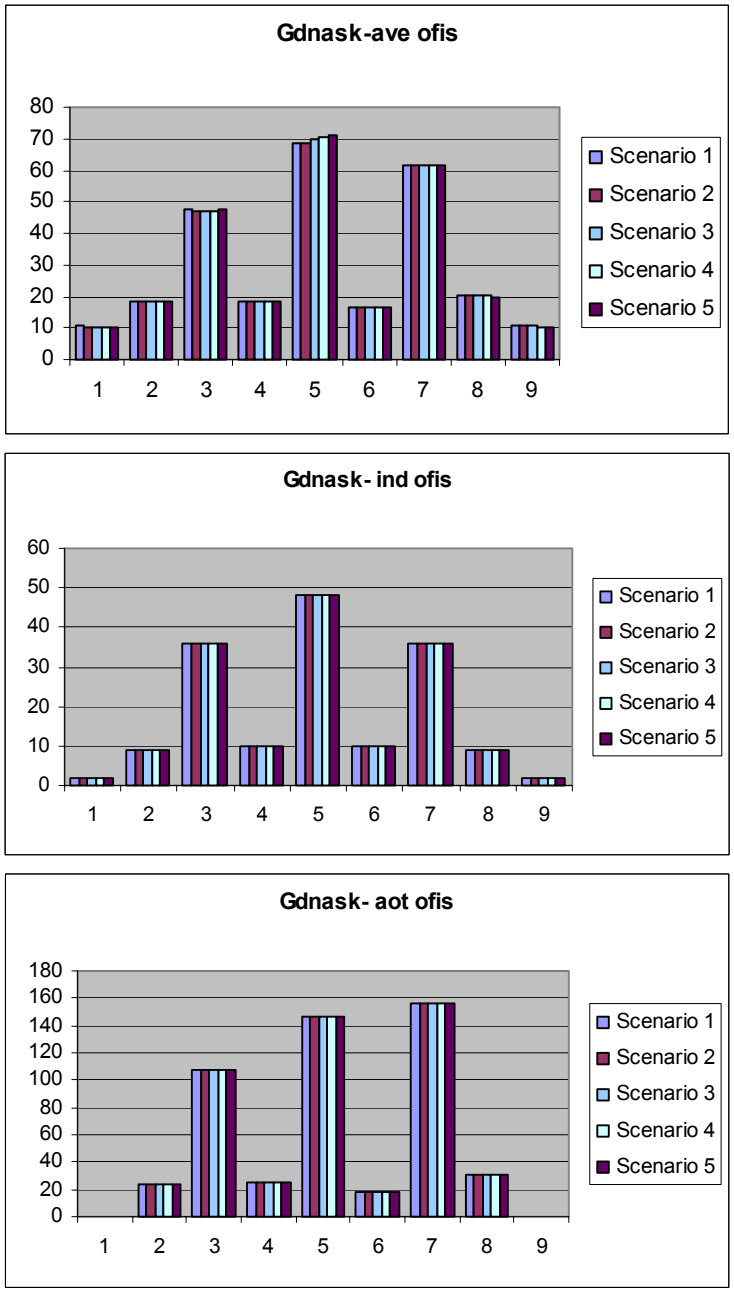

Figure A.18 Receptors (x axis) and indicator values (y axis) for the Gdansk scenarios.

4 Thessaloniki

4.1 Initial reference scenario

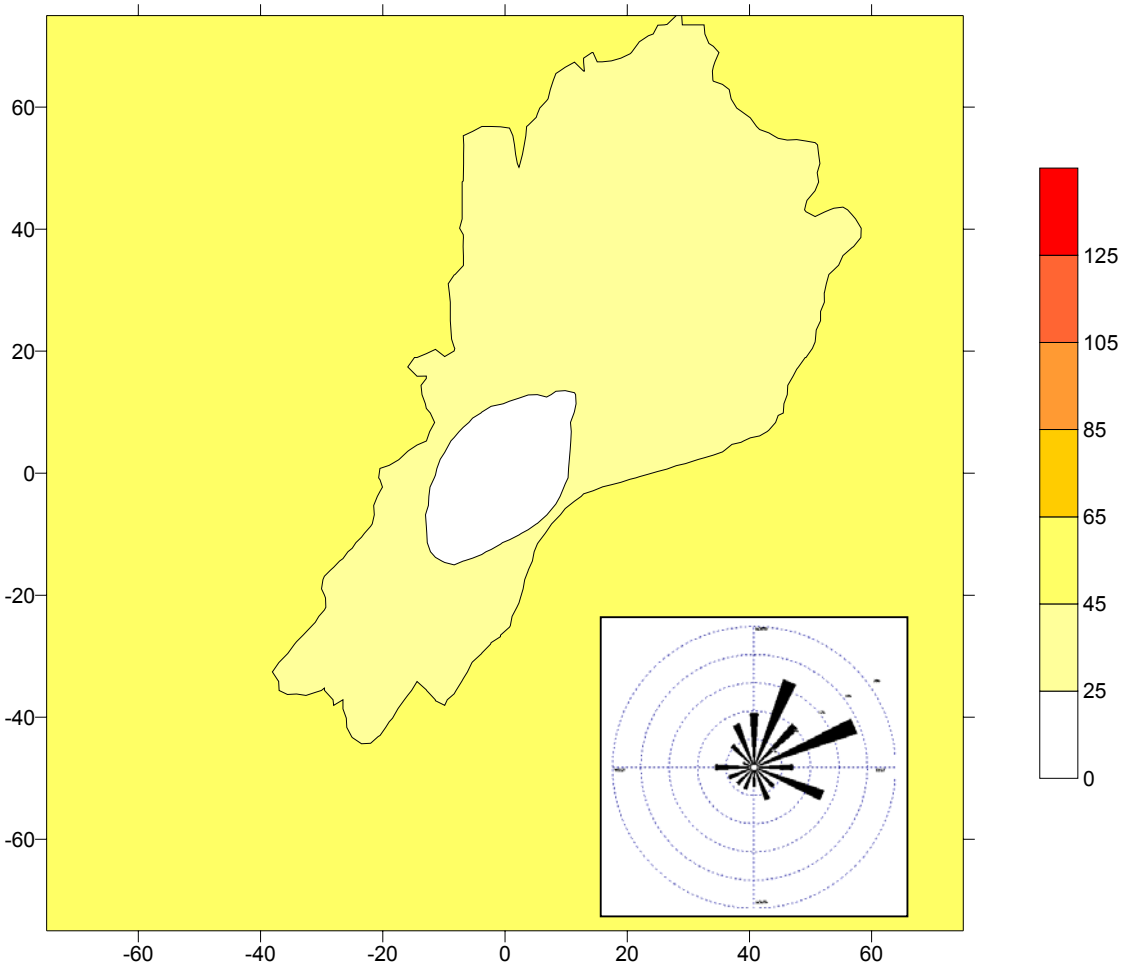

Figure A.19. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki and wind rose of prevailing wind during the summer semester of 1995 (draft reference scenario).

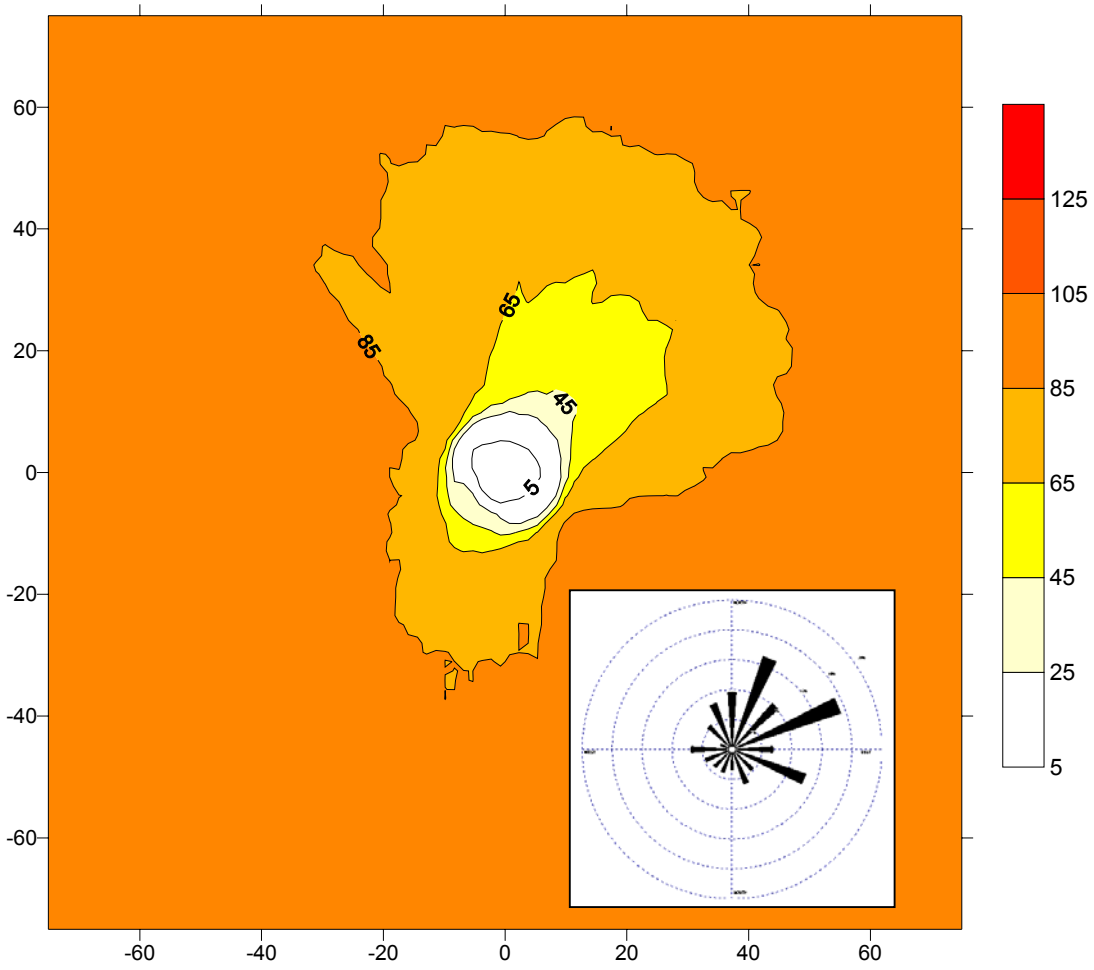

Figure A.20. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki and wind rose of prevailing wind during the summer semester of 1995 (final initial reference scenario).

In the case of Thessaloniki, exceedances are observed, as in the Genoa case, away from the city influence and due to high ozone background concentrations exceeding in some days the target value of 120μg/m^3. After the fist test run (Figure A.19), emission information vere revisited and refined, resulting in the final reference scenario (Figure A.20). NO emissions limit ozone production in the urban area as expected, but low VOC emissions prohibit ozone formation downwind, similarly to the Gdansk case. The exceedance frequency increases with the distance from the city centre, obviously in conjunction with the transition from VOC to NO_x limitation Although detailed and comprehensive emission data were available for this case, the lumping of VOC from the original speciation to the one used by the model was inadequate. NE of the city, the sea breeze effect is evident, as SW winds, occurring in 40% of the studied summer days, advect poor in ozone air from the city. As a general remark, it should be noted that wind statistics in a city appear to drastically affect the spatial pattern of the ozone exceedance frequency: In cases like Thessaloniki, where the statistical predominance of certain winds is evident, OFIS results reveal the anisotropy in ozone exceedance frequencies around the city centre. Finally, and in comparison to the GEA results, emissions considered for the

GEA report were higher than the ones considered in the frame of the SUTRA scenario, yet the latter exhibits higher exceedances, thus revealing the non-linear relationship of ozone levels and emissions, in the cases of high photochemical sensitivity in a studied area (VOS vs NOx sensitivity), and the overall photochemistry dominance in Ozone formation for the Thessaloniki area (as also suggested by Güsten et al., 1997 and Zanis et. al., 2001)

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	8.13	7.18	3.45	1.62
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	88	37	14	

4.2 Final reference Scenario

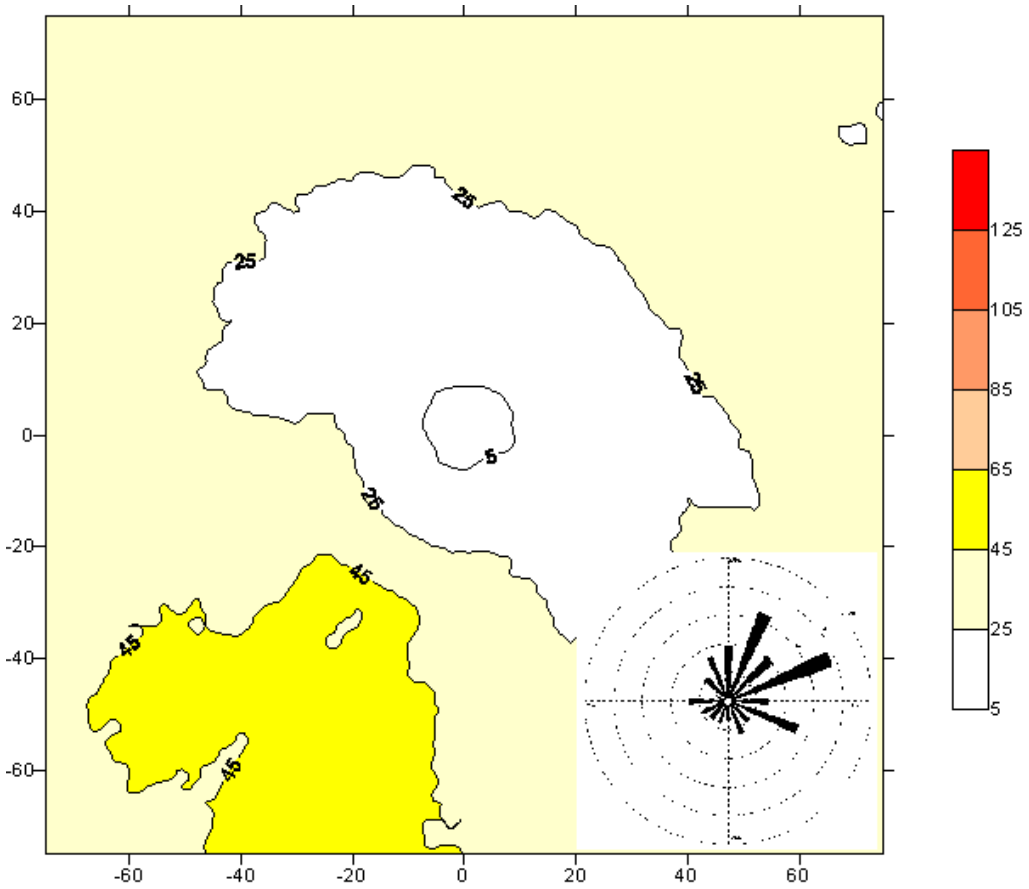

Figure A.21. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki, and wind rose of prevailing wind during the summer semester of 1995 (final reference scenario).

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	3.21	1.95	0.62	0.29
	E120(domain)	E120(sub)	E120(town)	
DAYS	31	10	4	

"New Statistics" for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	39	2.04	37
2	31.01	0.81	24
3	42.82	1.09	45
4	42.51	1.18	46
5	8.13	0	0
6	42.48	1.18	46
7	42.65	1.09	45

8	31.43	0.81	24
9	38.89	1.11	37

4.3 Scenario S1

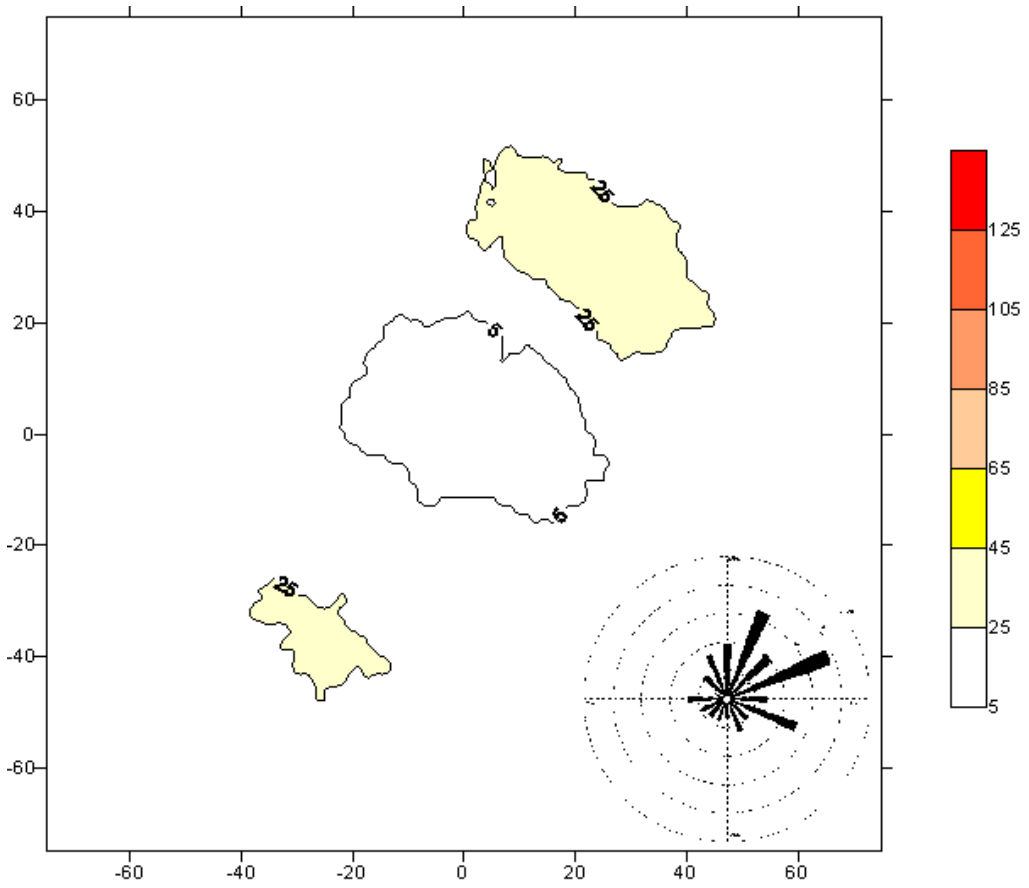

Figure A.22. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	3.20	1.37	0.12	0.08
	E120(domain)	E120(sub)	E120(town)	
DAYS	14	2	1	

"New Statistics" for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	41.85	1.12	12
2	35.9	0.45	8
3	42.97	0.41	10
4	42.42	0.16	8
5	20.55	0.05	0
6	42.32	0.16	8
7	43.35	0.77	15

8	35.52	0.23	8
9	40.94	1.15	21

4.4 Scenario S2

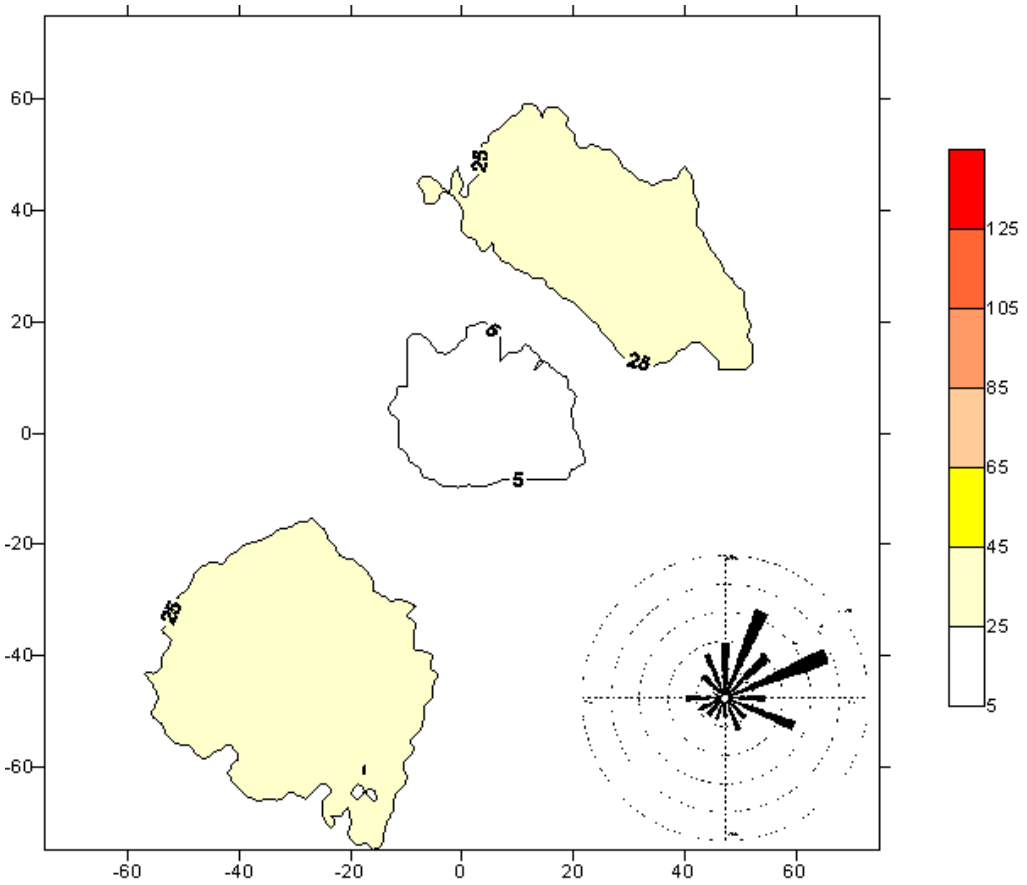

Figure A.23. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	3.56	1.60	0.15	0.08
	E120(domain)	E120(sub)	E120(town)	
DAYS	17	3	1	

"New Statistics" for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	41.32	1.32	13
2	34.6	0.49	10
3	42.86	0.45	11
4	42.29	0.23	11
5	17	0.01	0
6	42.19	0.23	11
7	43.2	0.78	15
8	34.25	0.28	10
9	40.37	1.08	21

SUTRA: Sustainable Urban Transportation

4.5 Scenario S3

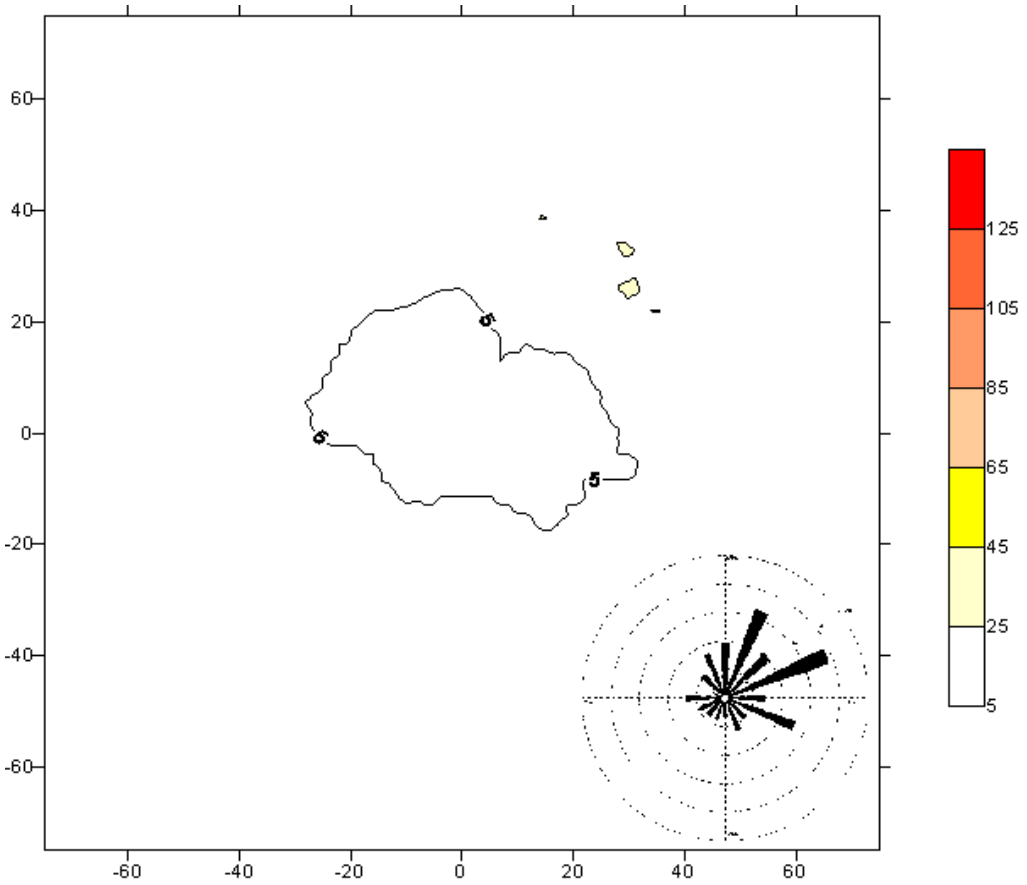

Figure A.24. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	2.38	1.03	0.10	0.05
	E120(domain)	E120(sub)	E120(town)	
DAYS	12	2	1	

"New Statistics" for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	41.47	0.82	7
2	35.47	0.32	7
3	42.83	0.29	8
4	42.32	0.14	6
5	20.28	0	0
6	42.27	0.15	6
7	43.15	0.39	11
8	35.14	0.21	7
9	40.55	0.45	10

SUTRA: Sustainable Urban Transportation

4.6 Scenario S4

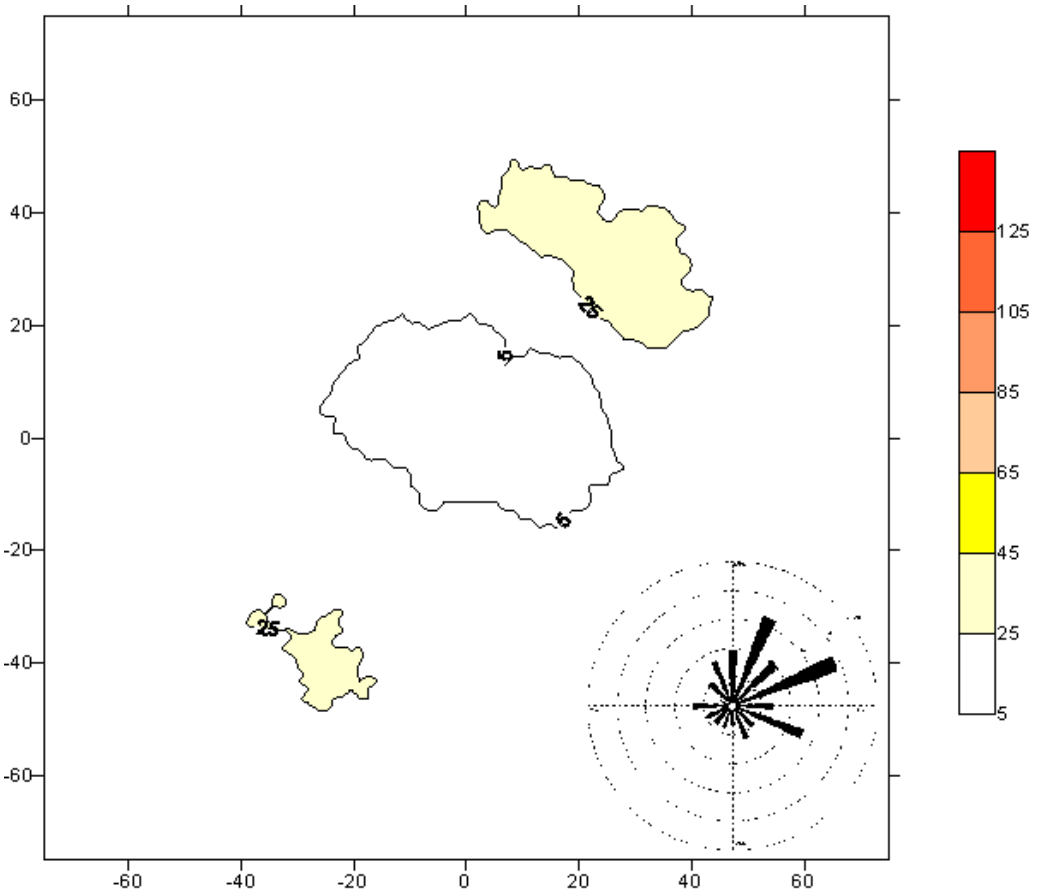

Figure A.25. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Thessaloniki.

The indicators resulting for this scenario are as follows:

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	3.00	1.31	0.12	0.06
	E120(domain)	E120(sub)	E120(town)	
DAYS	13	2	1	

"New Statistics" for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	41.54	1.06	10
2	35.3	0.4	8
3	42.88	0.38	10
4	42.33	0.18	8
5	19.28	0.01	0
6	42.25	0.18	8
7	43.22	0.61	14
8	34.95	0.24	8

9	40.61	0.83	16

4.7 Scenario summary

The next figure provides with an overall summary of the indicators vs scenarios for Thessaloniki. The overall differences between the various scenarios are well demonstrated, while it is easily shown that the update of the reference scenario corresponds to lower indicator values compared to the old one.

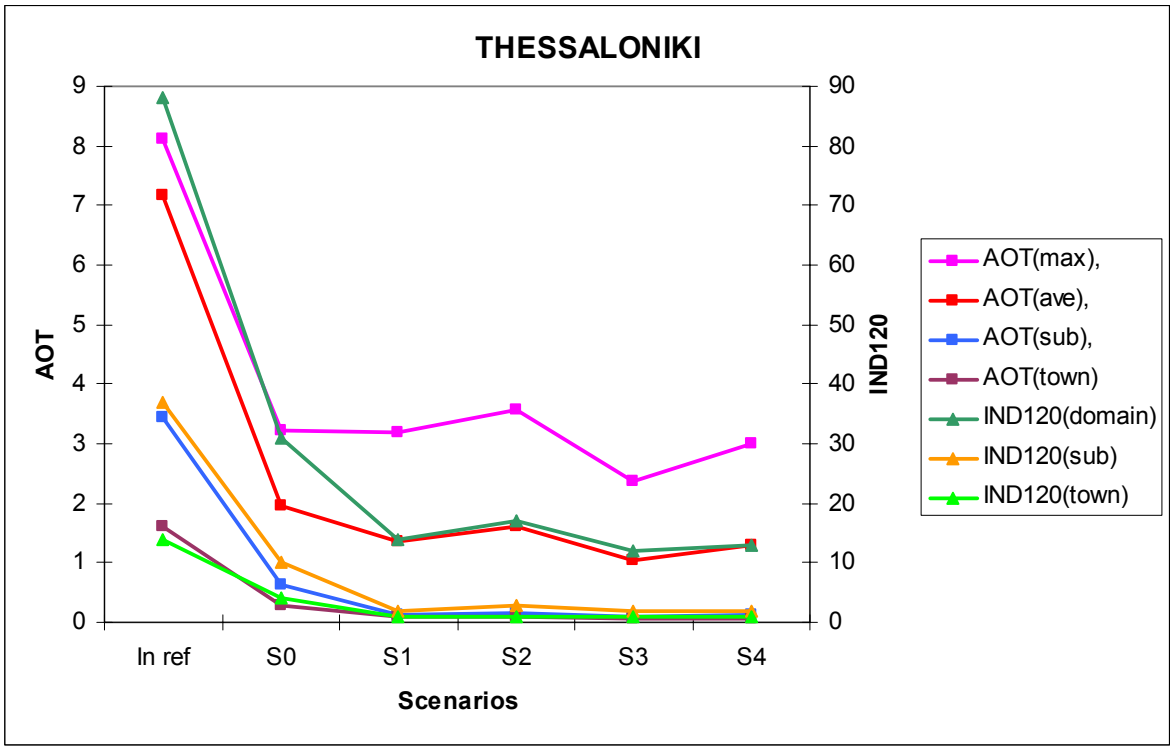

Figure A.26. Overall summary of the indicators vs scenarios for Thessaloniki.

The same conclusion is supported by the next three diagrams (Figure A.27) concerning the “new statistics” introduced. The influence of complex meteorology and topography, in association with the emission variation per scenario and the NO emissions at the city centre (receptor “5”) justify the variation of results.

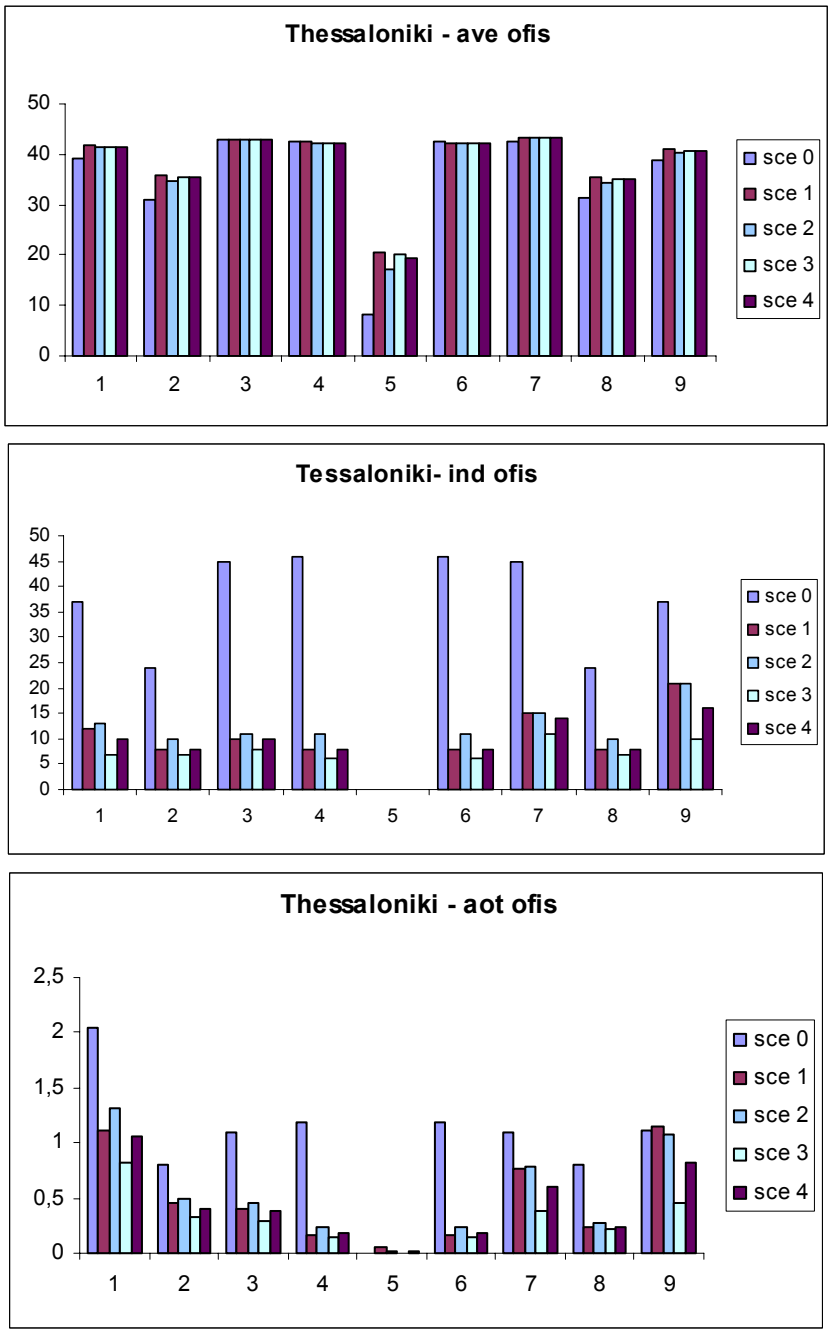

Figure A.27. Receptors (x axis) and indicator values (y axis) for the Thessaloniki scenarios.

5 Lisbon

5.1 Initial reference scenario

The analysis of the input data for Lisbon reveals that there are some basic background concentrations missing. In comparison to the GEA results, emissions are lower. Overall, no exceedances are observed and therefore the final reference scenario for Lisbon should be considered as one with zero exceedances (this is why no Figure is provided here). This results supports previous findings (Calheiros and Casimiro, 2001), that state that for the year 1999, available ozone concentration level information suggest no exceedances above the EU 1-hour threshold and no 8-hour exceedances of the WHO guideline and EU thresholds. Nevertheless, the same reference also stated that "preliminary analysis indicates that daily exposures in 1999 may have contributed up to 1.6% of all deaths (± 350 cases) and 1.9% of respiratory hospital admissions in Lisbon", thus revealing the complex rela.tionship between exposure limit values and actual health related impacts.

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

5.2 Final reference scenario

The final reference scenario demonstrates zero exceedances, as the initial one.

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	5.03	0	0
2	4.55	0	0
3	5.12	0	0
4	4.8	0	0
5	1.45	0	0
6	4.81	0	0
7	5.11	0	0
8	4.54	0	0
9	5.04	0	0

5.3 Scenario S1

The indicators resulting for this scenario are as follows (due to the zero IND120 values, no figure is provided).

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	1.01	0.11	0.14	0.18
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	4.16	0.01	0
2	3.89	0	0
3	4.28	0.11	1
4	4.28	0.09	1
5	2.88	0.22	1
6	4.49	0.43	1
7	4.24	0	0
8	3.9	0	0
9	4.37	0.13	1

5.4 Scenario S2

The indicators resulting for this scenario are as follows (due to the zero IND120 values, no figure is provided).

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	5.67	0	0
2	5.07	0	0
3	5.77	0	0
4	5.41	0	0
5	1.56	0	0
6	5.41	0	0
7	5.78	0	0
8	5.06	0	0
9	5.69	0	0

5.5 Scenario S3

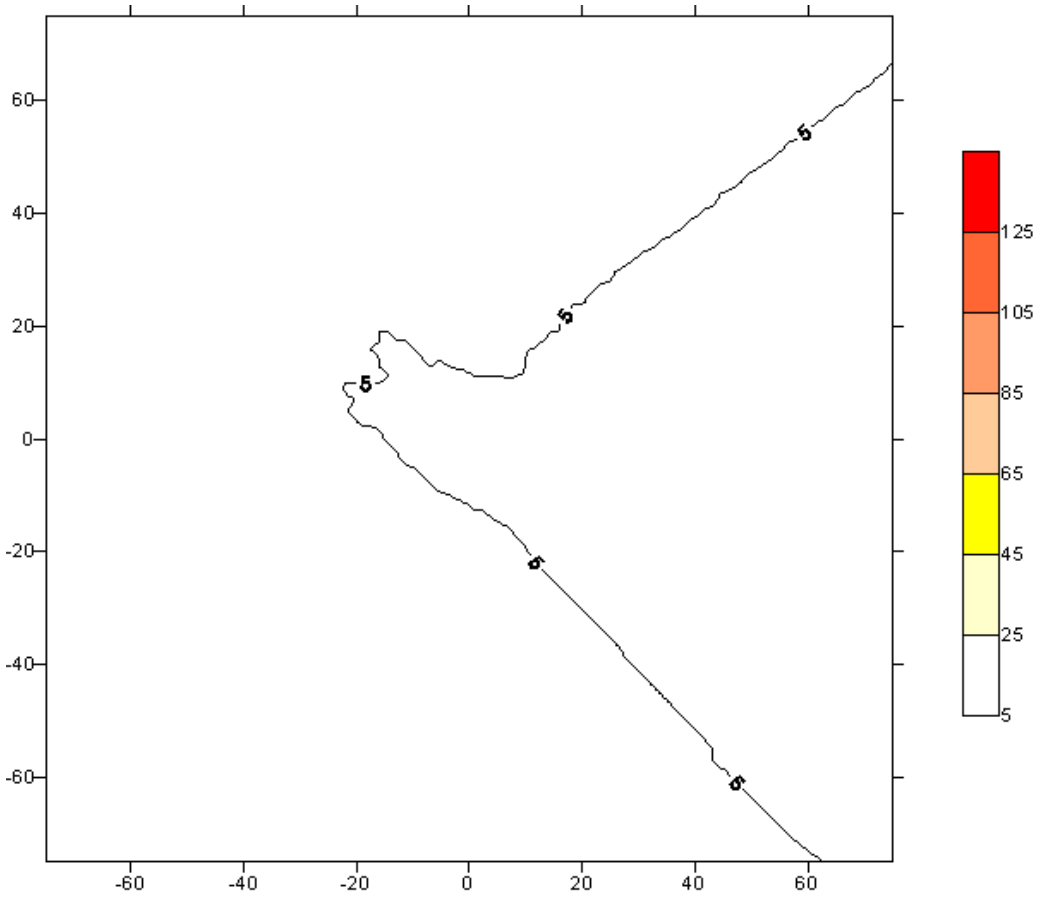

Figure A.28. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Lisbon.

The indicators resulting for this scenario are as follows

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	371.64	51.88	92.18	128.83
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	5	9	11	

«New Statistics» for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	5.61	5.58	3
2	8.11	17.7	2
3	11.75	31.82	2
4	25.93	83.87	5
5	55.25	162.07	10
6	37.87	127.81	13
7	4.83	3.76	2
8	9.31	22.42	2
9	32.43	115.37	11

5.6 Scenario S4

The indicators resulting for this scenario are as follows (due to the zero values, no figure is provided).

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0.01	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

«New Statistics»for Ozone

ST	ave_ofis	aot_ofis	ind_ofis
1	4.32	0	0
2	3.99	0	0
3	4.4	0	0
4	4.3	0	0
5	2.42	0	0
6	4.4	0	0
7	4.41	0	0
8	3.99	0	0
9	4.45	0	0

5.7 Scenario summary

The next figure provides with an overall summary of the indicators vs scenarios for Lisbon, indicating that the scenario performance is identical, with the pronounced exception of scenario S3.

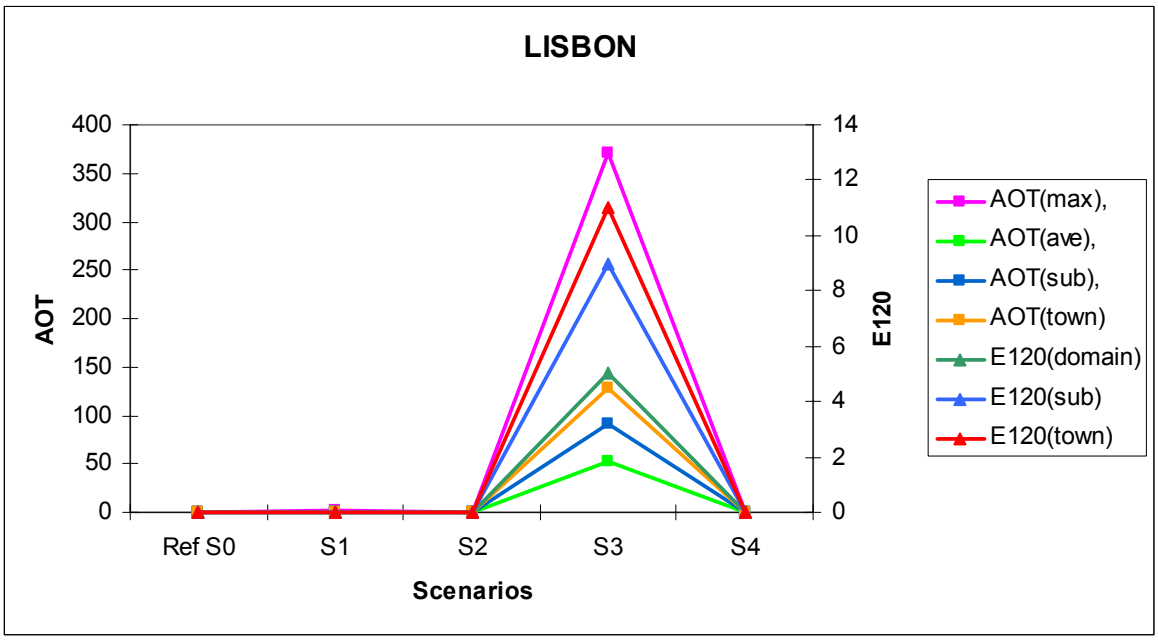

Figure A.29. Overall summary of the indicators vs scenarios for Lisbon.

The same conclusion is supported by the next three diagrams (Figure A.30) concerning the "new statistics" introduced. Scenario 3 produces the most interesting (non zero) results, as it correlated to the lower ozone consumption pollutants, accompanied by scenario 1. It should be notes that the two scenarios result in similar indicators for some of the receptors (like int_ofis for receptor 3), while they correspond to very different indicator values for other receptors, thus pronouncing the influence of the meteorology over emission and concentration patterns.

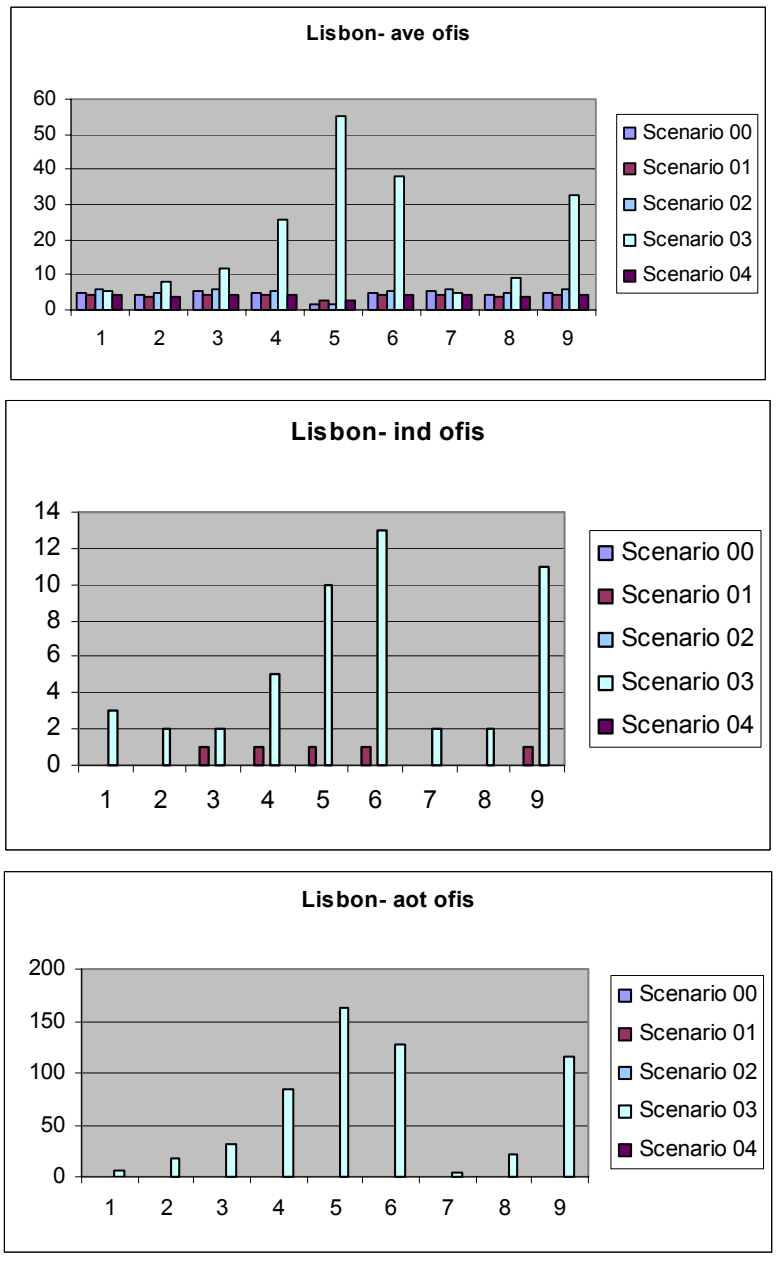

Figure A.30. Receptors (x axis) and indicator values (y axis) for the Lisbon scenarios.

6 Geneva

6.1 Initial reference scenario

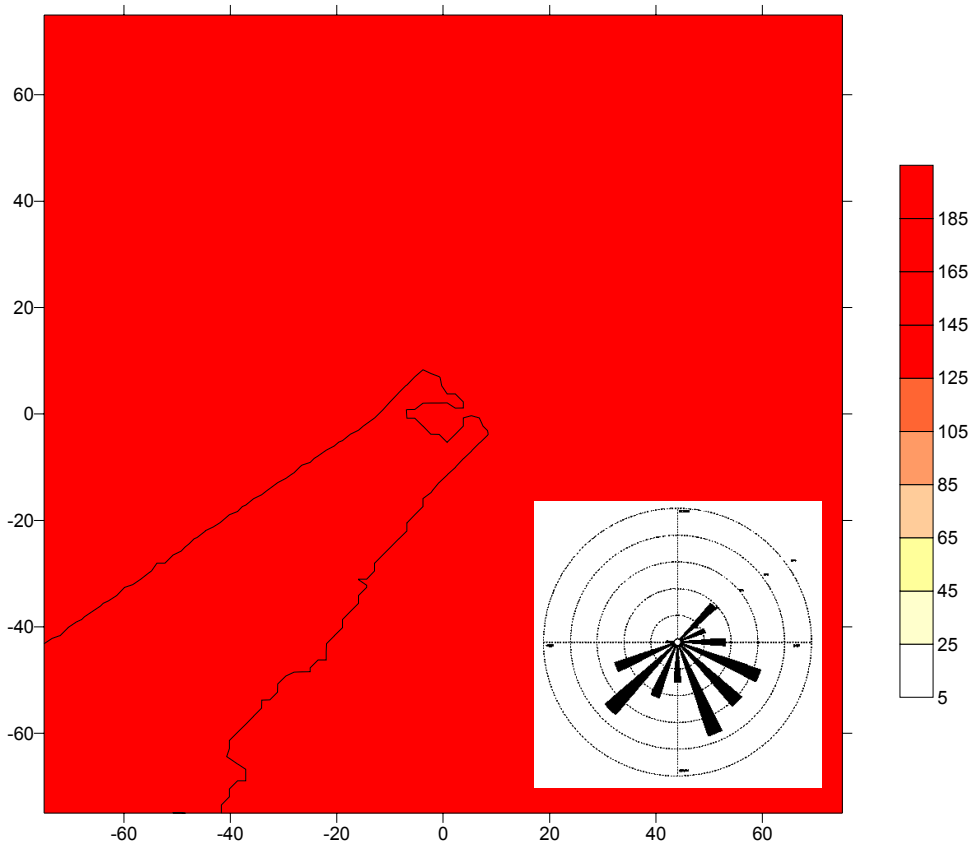

Figure A.31. Number of days with 8hour running average ozone concentration exceeding 120μg/m^3 (IND120), calculated by the OFIS model, for a 150x150km^2 area surrounding Geneva, and wind rose of prevailing wind during the summer semester of 1995 (final reference scenario).

In the case of Geneva, the combination of low wind speeds and high emissions resulted in high ozone exceedances (170 days for IND120). This is attributed also to the sensitivity of ozone formation in correlation to VOC and NOx emissions, as discussed in detail for Switzerland in Andreani-Aksoyoglou et. al., 2001. Last but not least, it should be noted that high ozone concentration have already been reported for Geneva in literature, without sufficient explanation on the cause-effect chain. (Neininger, 1997).

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	44.72	31.81	37.81	40.31
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	173	169	167	

6.2 Final reference scenario

No updates were made available

6.3 City related scenarios

No data were made available. Calculations were performed by the University of Geneva, and the corresponding results are made available under http://ecolu-info.unige.ch/recherche/sutra/Results/

7 Tel Aviv

7.1 Initial reference scenario

In the case of Tel Aviv, input data were supplied by the city partner with delay due to problems in collecting and compiling necessary information. Although ground level emission information was not made available, the assumption that the elevated emission data provided are identical with the (missing) ground level ones was used. The corresponding results (representing vague input data), do not suggest any INT120 exceedances. These results correspond to OFIS model input data quality and availability and their use in the frame of the SUTRA project should be considered as problematic.

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

7.2 Final reference scenario

An update of the reference scenario was made available at late May 2003. Results demonstrate zero exceedances, as reported by the Table below.

	AOT(max),	AOT(ave),	AOT(sub),	AOT(town)
AOT60	0	0	0	0
	IND120(domain)	IND120(sub)	IND120(town)	
DAYS	0	0	0	

7.3 City scenarios

No data were currently made available.

8 Conclusions

Contemporary Urban Air Quality Management calls for a new approach in the environmental management methods and tools that should be used. The EU Air Quality Framework Directive (96/62/EC) and the Daughter Directives stress out the need of model application as a supplementary assessment method to reporting of monitoring data. The directions within the Directives raise a twofold challenge for the modelling research community;

1. estimating spatial distributions of pollutant concentrations and
2. doing so for at least one year

The challenge can be met by using

- Eulerian Chemical Transport Models (computationally expensive and rather impractical approach considering CPU-time and disk-space requirements) or.
- simpler approaches like OFIS.

Based on the results of various OFIS applications (GEA report and CITY-DELTA model intercomparison exercise), OFIS leads to realistic estimates regarding the long term air pollution exposure in urban areas and can actually allow authorities assess urban air quality in a fast, simple and reliable way. Overall, OFIS may well be applied for addressing the issues raised by the EU Air Quality Framework Directive.

References

Andreani-Aksoyoglou S., Lu C.H., Keller J., Prevot A.S.H. and Chang J.S. (2001), Variability of indicator values for ozone production sensitivity: a model study for Switzerland and San Joaquin Valley (California), *Atmospheric Environment* **35**, 5593-5604.

Bowman F.M. and Seinfeld J. H. (1996), Atmospheric chemistry of alternate fuels and reformulated gasoline components, *Fuel and Energy Abstracts* **37**, Page 134.

Calheiros J.and Casimiro E. (2001), http://www.siam.fc.ul.pt/health/health05_01.ppt

de Leeuw F., Moussiopoulos N., Bartonova A., Sahm P, Pulles T., Visschedijk A. (2001), Air quality in larger cities in the European Union, A contribution to the Auto-Oil II programme (GEA report), European Environment Agency, Topic report 3/2001, http://reports.eea.eu.int/Topic_report_No_032001/en/toprep03_2001.pdf

Güsten H., Heinrich G., Monnich E. and Weppner J., Cvitas T. and Klasinc L., Varotsos C. A. and Asimakopoulos D. N. (1997), Thessaloniki '91 field measurement campaign--II. ozone formation in the greater Thessaloniki area, *Atmospheric Environment* **31** 1115-1126.

Neininger B. (1997), http://www.bbw.admin.ch/abstracts/abstr2000/abstracts/cost/c97.0044.html.

Zanis P., Zerefos C. S., Gilge S., Melas D., Balis D., Ziomas I., Gerasopoulos E., Tzoumaka P., Kaminski U. and Fricke W. (2001), Comparison of measured and modelled surface ozone concentrations at two different sites in Europe during the solar eclipse on August 11, 1999, *Atmospheric Environment* **35**, 4663-4673.