ASSESSING CONTRIBUTION OF AIR POLLUTANTS FROM LOCAL URBAN SOURCES DURING THE DAY OF ATONEMENT

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Previous reports

A Day Without Vehicular Pollution – Yom Kippur 1998
By Dr. Aryeh Wanger and Dr. Eliezer Ganor

Comparing the measurements obtained by transportation monitoring station on Yom Kippur 1998 with those obtained on the previous and following day.

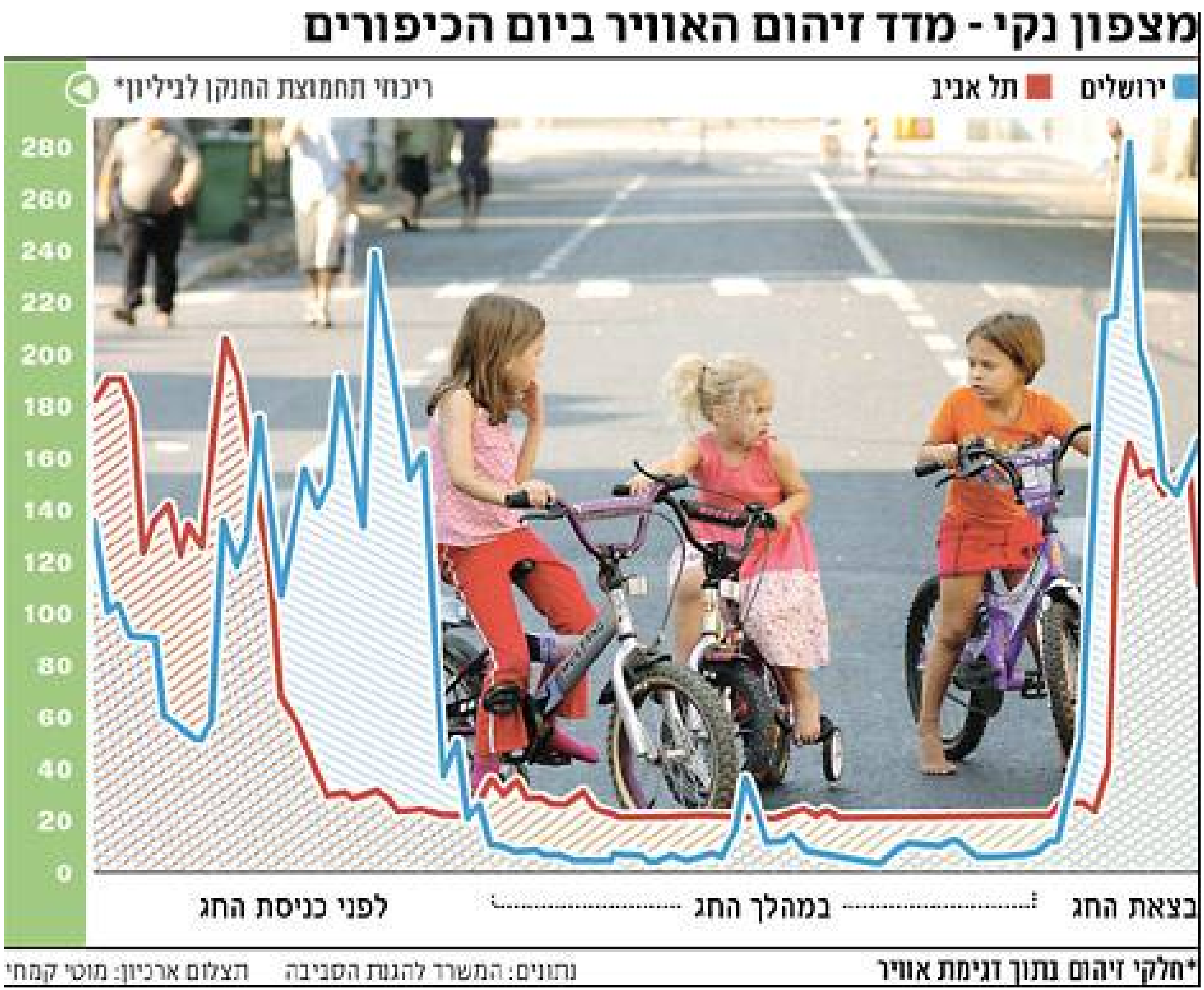
Pollution concentrations plummeted in all transportation monitoring stations in comparison to the previous and following day.

The decrease in average concentrations of **nitrogen dioxide** was more than **90%** and for **nitrogen oxide 95%.**

Decreases in the average concentration for carbon monoxide reached 50-75%.

Concentrations of respirable particles (PM10) decreased by 50%.

Previous reports



Related reports

The impact of a forced reduction in traffic volumes on urban air pollution

By: Yuval, B. Flicstein and D. M. Broday *(*October 6, 2007)

The Middle East **military conflict of summer 2006** resulted in a few weeks in which the city of Haifa, Israel, and its environs experienced very profound variations in the commercial and personal activities. Large industrial plants continued almost normal operations but activities of small scale industry, shopping, and personal commuting were drastically reduced, leading to a dramatic decrease in the commercial and personal traffic volumes.

The reduced traffic volumes resulted in lowered levels of **NO_2, hydrocarbons** and **particulate matter**. The **decrease** in these pollutants' mean **concentration** was significantly **larger** than the **reduction** in the mean **traffic volume**. Slightly **higher** mean O_3 concentrations were observed during the reduced traffic period.

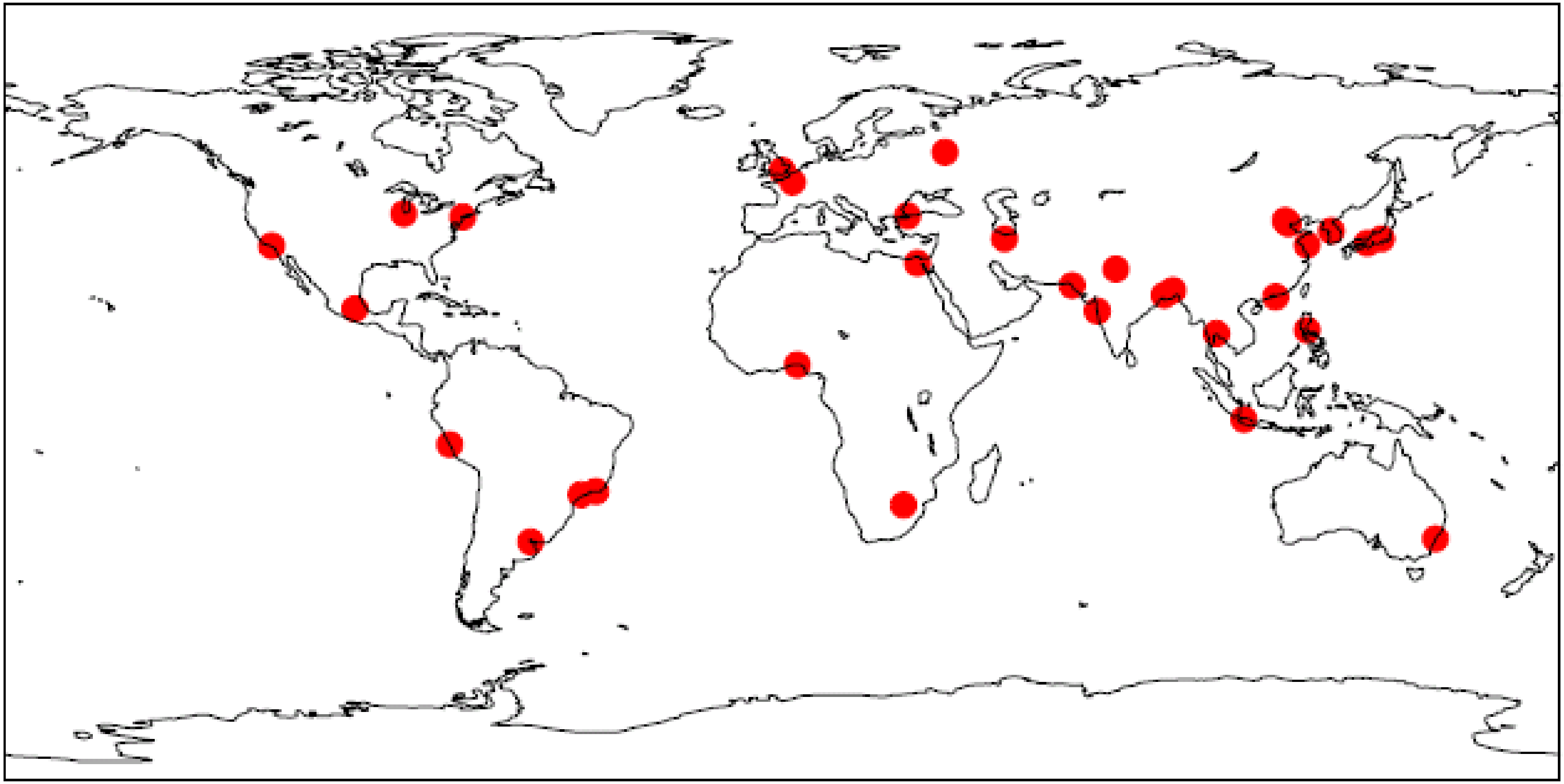


Fig. 1. Locations of the "megacities" considered in this study, shown in red.

$$\mathrm{MPI} = (1/n)\left[\sum\{(\mathrm{AC}_i - \mathrm{GC}_i)/\mathrm{GC}_i\}\right].$$

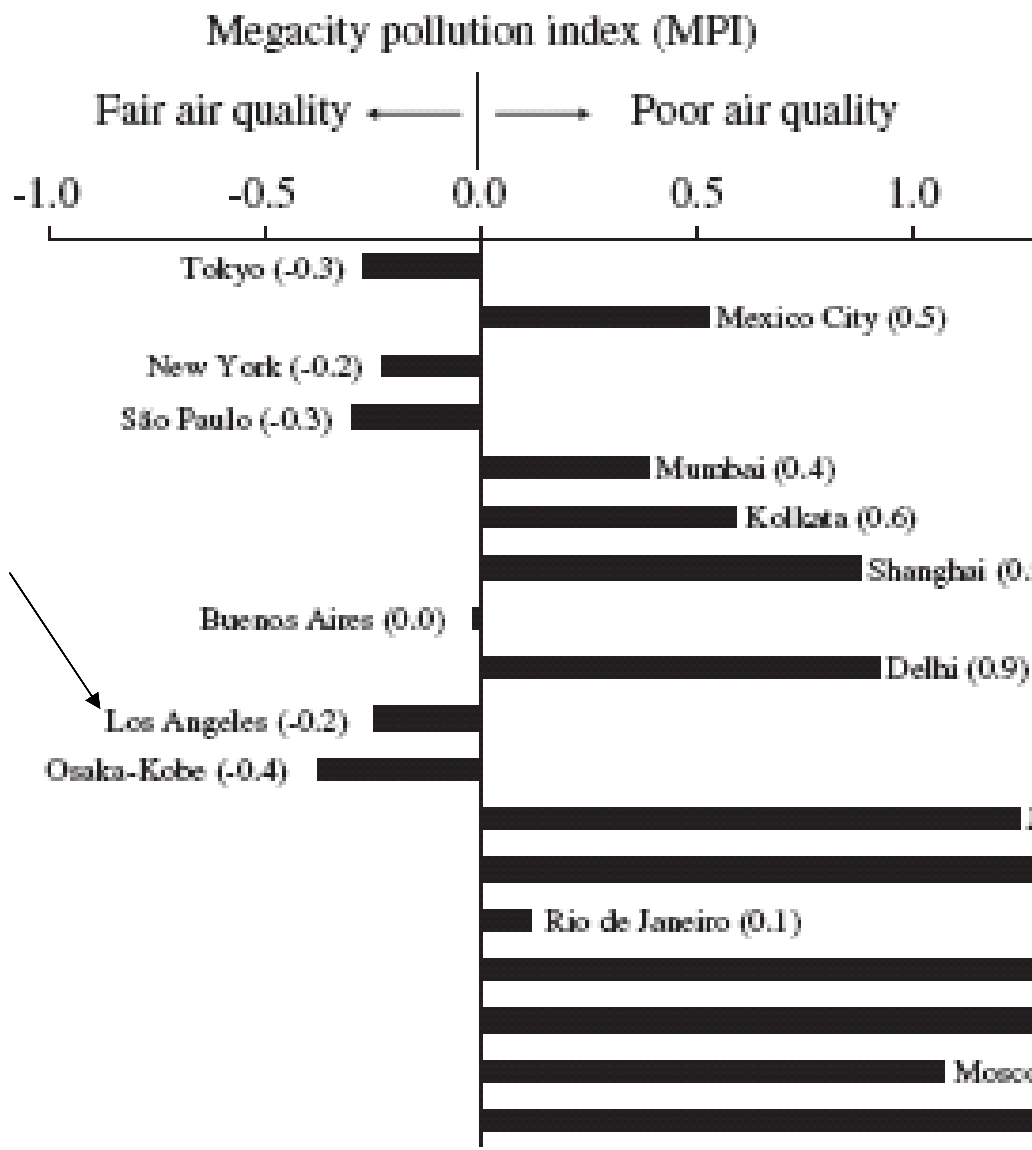


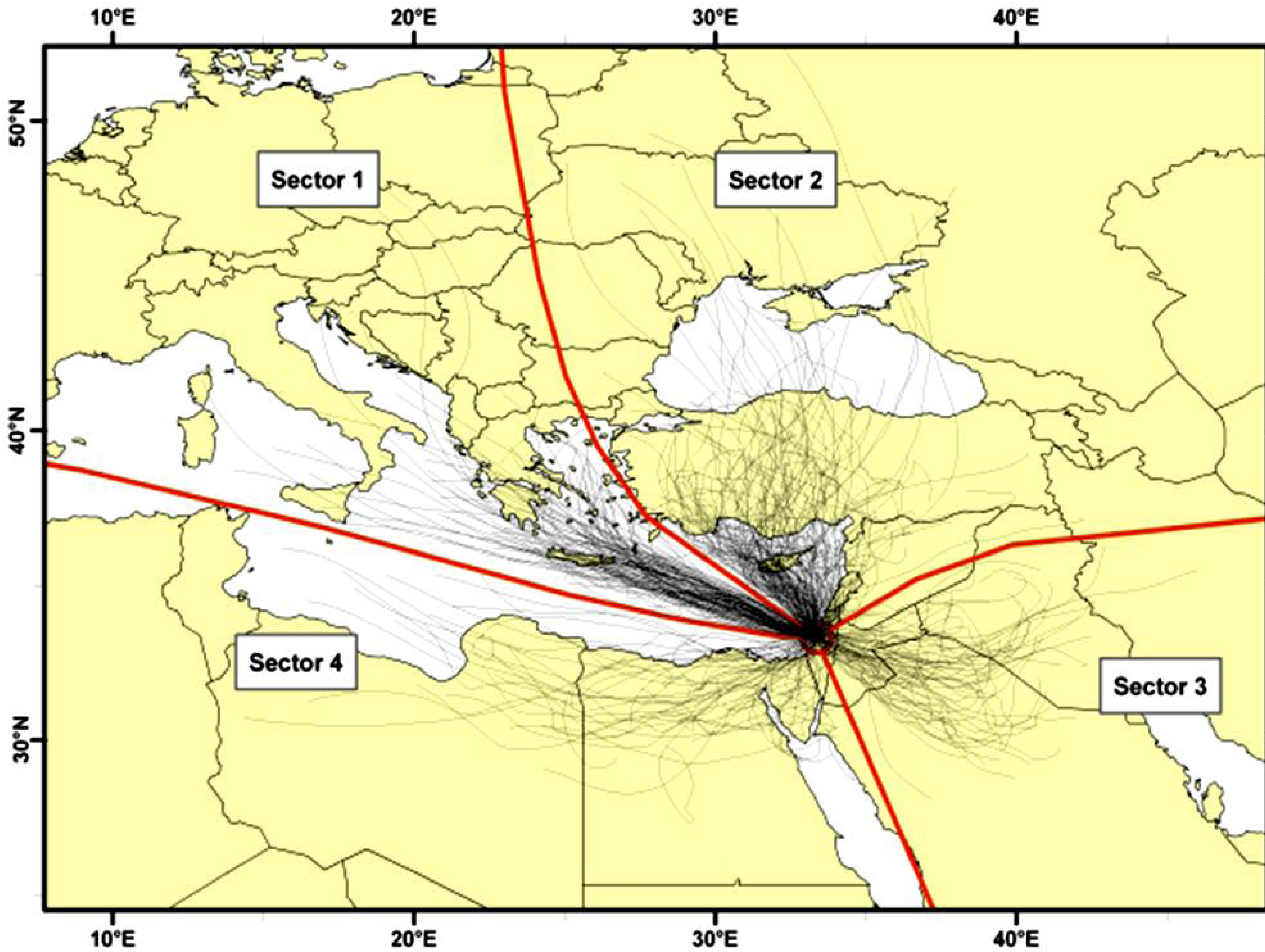
Fig. 6. MPI-based total pollution level in megacities.

90% the air trajectories within the atmospheric mixed layer reach Israel from : 1) North West Europe, crossing the Mediterranean Sea (36%); 2) Eastern Europe & Turkey (30%); 3) the Arabian Peninsula & Jordan (5%); 4) North African (19%) (After Dayan & Levy, 2005)

3, 4 can cause dust storms

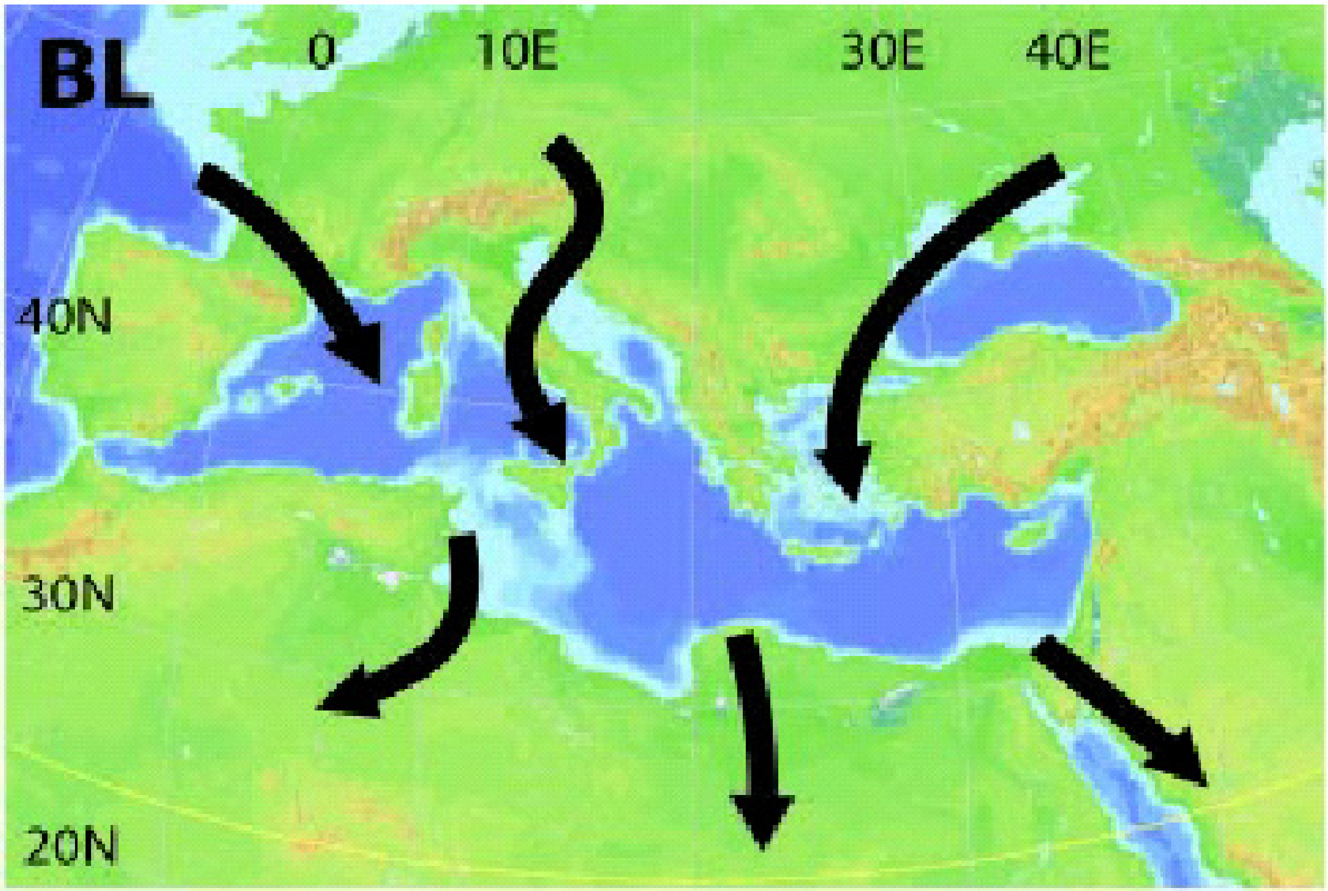
(4 also dust before rain)

2 prevails during the summer (PT)



Luria et al. (1996) Atmospheric sulfur over the east Mediterranean region.

Wanger et al. (2000) Some observational and modeling evidence of long range transport of air pollutants from Europe towards the Israeli coast



Lelieveld et al. (2002) Global Air Pollution Crossroads over the Mediterranean

Rudich, Kaufman and Dayan, 2008: Estimation of transboundary transport of pollution aerosols by remote sensing in the eastern Mediterranean

MODIS-derived sulfur fluxes (both Aqua and Terra) and estimates based on field measurements, for a 150 km line west of the Israeli coast agree reasonably well with GOCART model simulations of anthropogenic sulfate

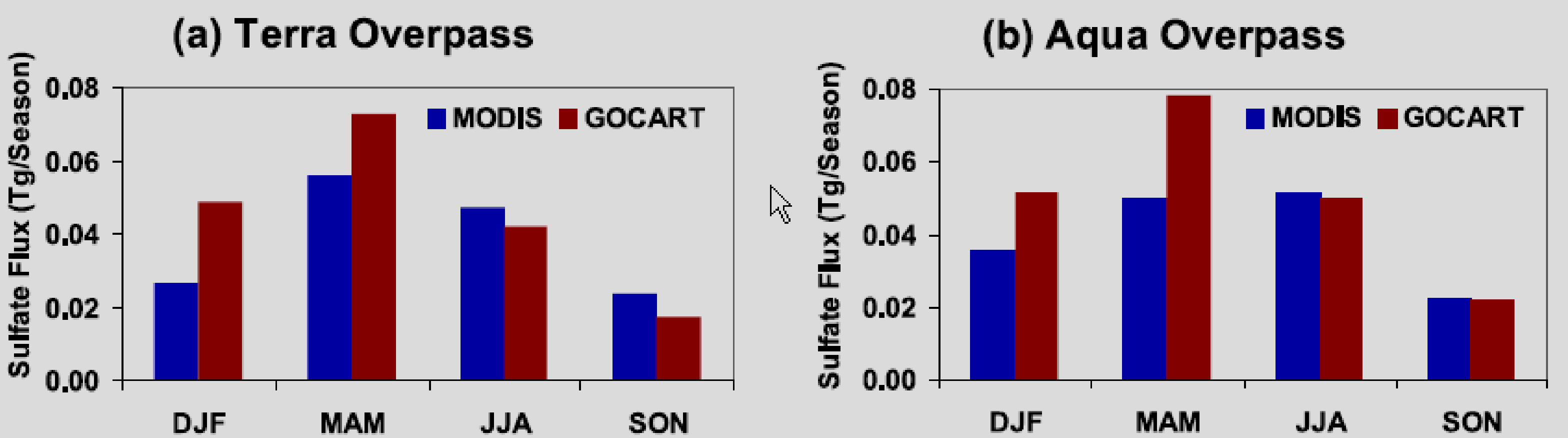
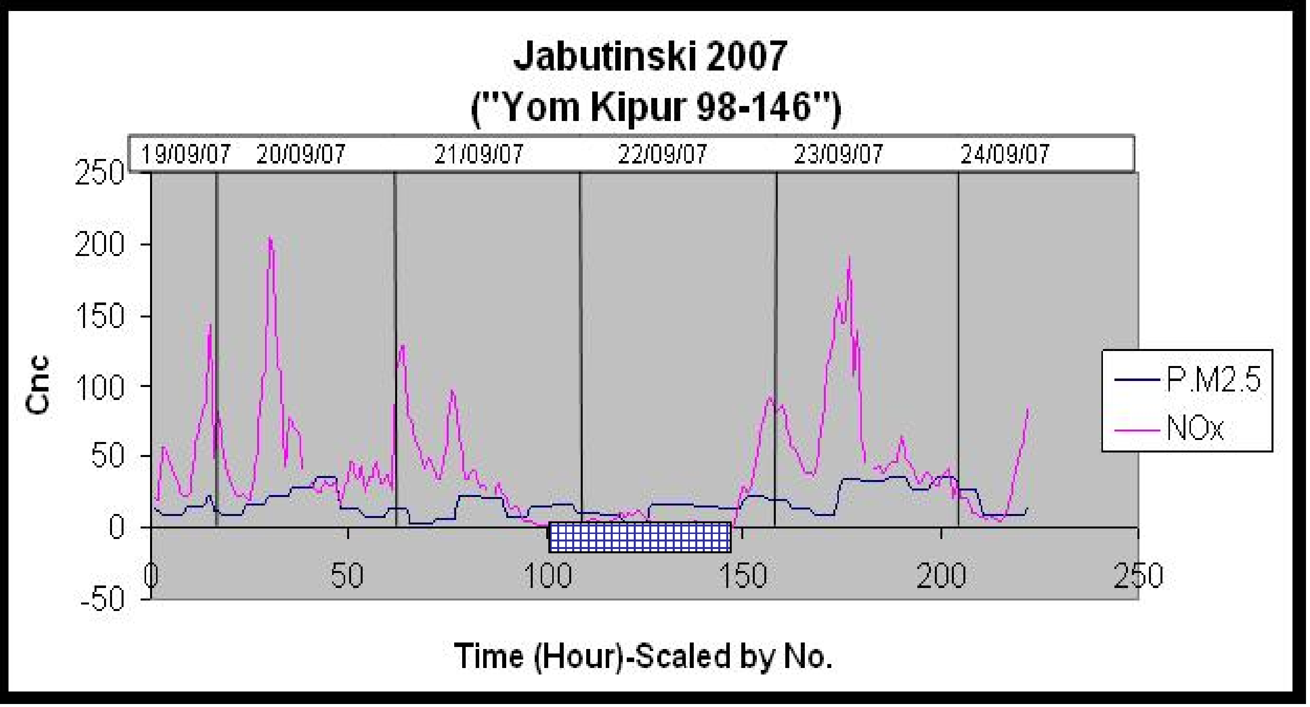


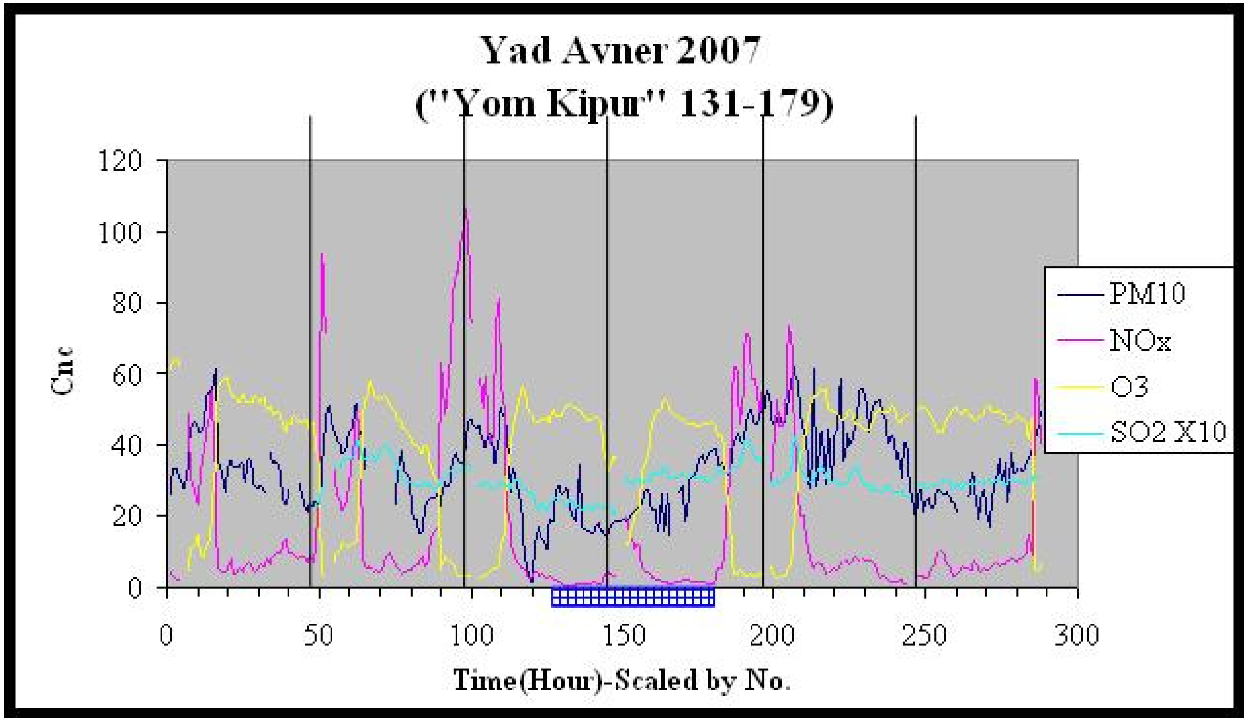
Figure 2. Comparison of MODIS and GOCART estimates of seasonal flux (Tg/season) of dry sulfate to the EM along the 150 km coastline for (a) the Terra overpass and (b) the Aqua overpass.

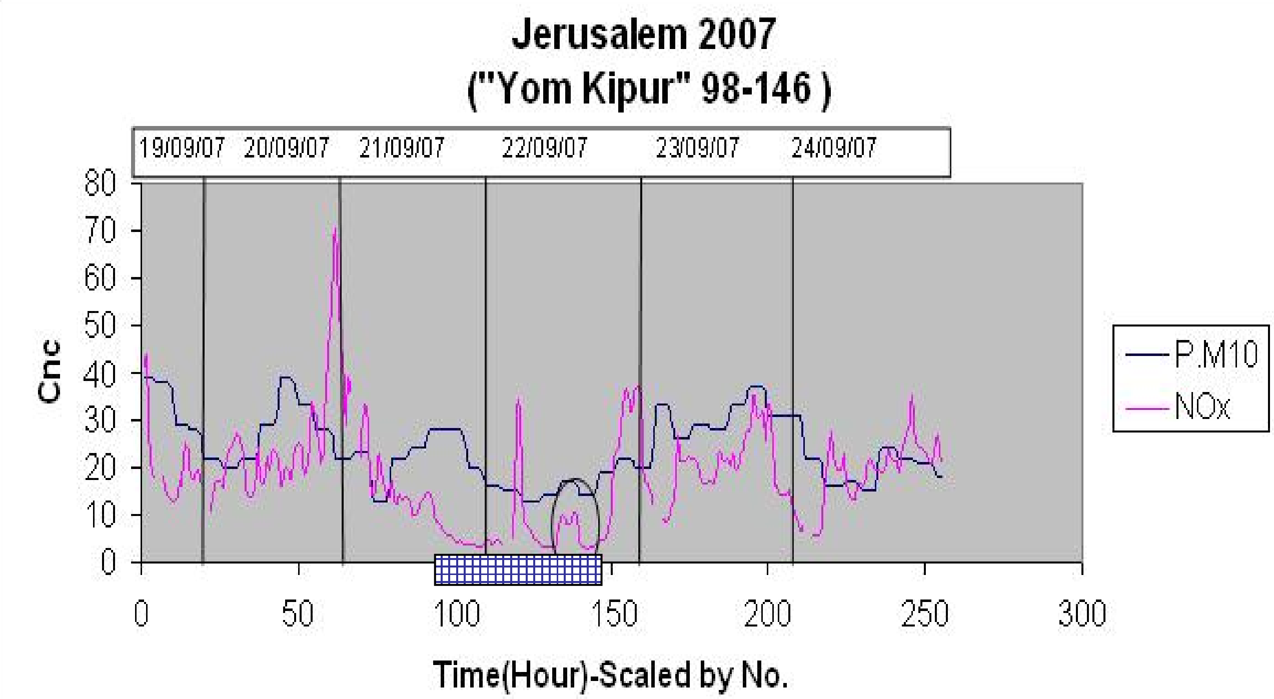
Methodology

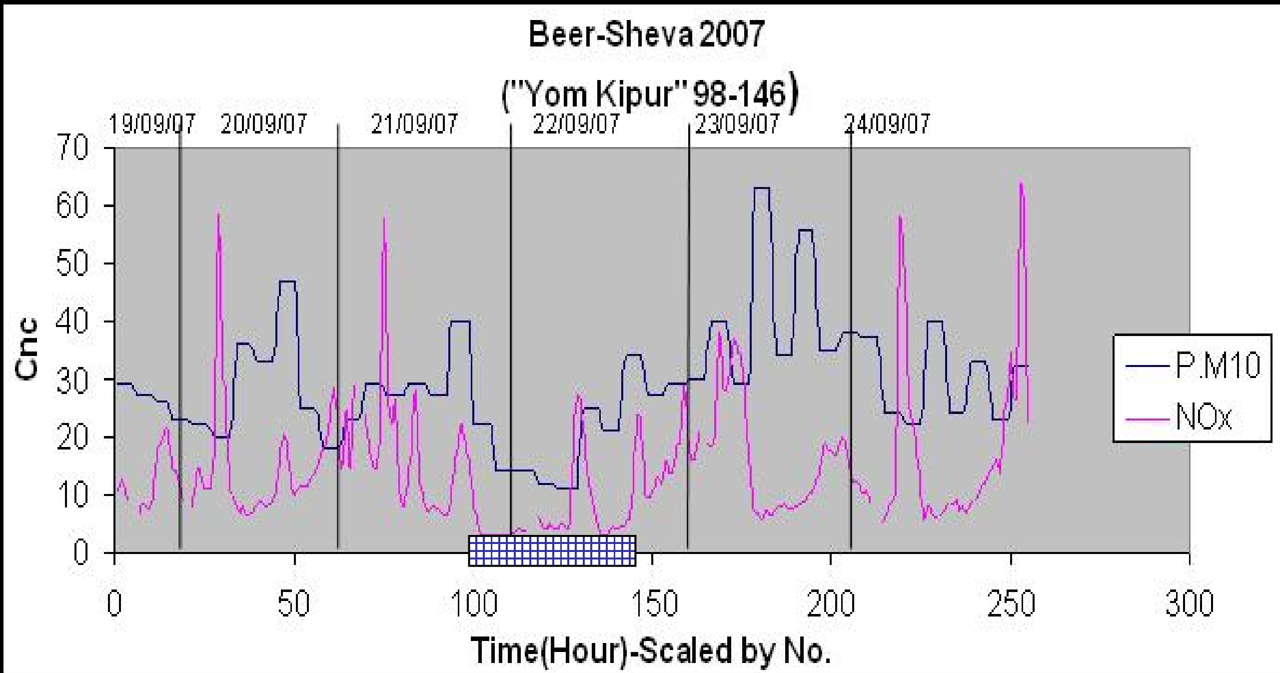
- Compare NO_x and PM_{10} ($PM_{2.5}$) concentrations during Yom Kippur with the day before and after (24-hour averages, 10 lowest values,10 highest values)
- Do that for the last nine years
- Do that in three urban centers
- Compare transportation station with residential station
- Verify data quality by comparing NO_x levels with O_3 levels



Air sampled before, during and after Yom Kippur 2007.
Left: NO_x and $PM_{2.5}$ in a transportation sampling station near Tel Aviv. **Below**: NO_x, PM_{10}, O_3 and SO_2 in air sampled in a residential sampling station near Tel Aviv.







NO_x and $PM_{2.5}$ in air sampled before, during and after Yom Kippur 2007

Left: Jerusalem.

Below: Beer Sheva

Concentrations of NOx (ppb) and PM (mg/m3) of the 24-average, lowest, and highest values (ten for NOx, and three for PM) during the Day of Atonement (DA) and the day before or after.

	Remez						Yad Avner						Jerusalem					
average	N0x			P.M2.5			N0x			P.M2.5			N0x			P.M2.5		
	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after
2008	40	5.6		10	5.2		26	6.1	23	30	14	21	19	7.0	13	23	12	15
2007	43	3.8	66	12	12	23	33	3.6	28	29	23	44	23	6.2	20	24	17	27
2006	25	3.1	53	32	15	31	6.6		18	25	21	37	13	4.5	23	36	18	28
2005	61	12	40	12	17	24	32	3.9	12	48	49	42	28	18	14	32	42	48
2004	64	5.4	61				22	6.3	27	26	18	35	15	7.7	21	26	21	27
2003				16	16	17	22	6.9	24	43	45	50	22	12	34	43	61	83
2002	56	9.2	140	21	26	24	15	5.4	51	38	57	70	13	7.9	36	35	86	85
2001	70	11	62	46	44	33	22	5.4	11	59	55	53	19	5.9	14	76	74	62
2000	71		72	22	16	15	27	4.5	16	43	45	37	12	7.3	24	57	50	58

	Remez						Yad Avner						Jerusalem					
lowest	N0x			P.M2.5			N0x			P.M2.5			N0x			P.M2.5		
Year / Day	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after
2008	8.1	0.39		14	2.7		4.8	1.02	3.0	16	13	14						
2007	12	1.09	22	5.3	4.1	11	2.5	0.81	4.0	3.6	15	29	11	7.6	13	17	14	20
2006	8.9	0.87	15	5.7	1.8	6.0				9.1	13	21	7.4	3.1	8.5	20	13	17
2005	19	2.7	12	3.3	10	15	4.2	1.9	2.9	22	4.4	14	11	4.0	6.2	17	31	31
2004	12	0.75	17				6.4	4.4	7.1	6.5	1.4	22	8.4	4.0	7.8	13	11	15
2003				10	6.1	12	4.2	2.3	4.7	21	20	27	11	4.9	11	26	31	51
2002	21	2.5	30	10	10	15	2.9	2.4	7.0	19	34	26	7.4	4.1	7.2	26	64	36
2001	21	1.2	23	21	27	24	5.8	3.9	6.1	48	47	20	12	2.9	3.8	55	61	43
2000				9.1	3.7	3.9	4.3	1.7	3.8	25	9.3	13	6	4.5	10	26	28	42

	Remez						Yad Avner						Jerusalem					
higest	N0x			P.M2.5			N0x			P.M2.5			N0x			P.M2.5		
Year / Day	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after	before	AD	after
2008	77	14		6.9	9.4		56	16	60	38	12	32						
2007	89	9.4	136	19	16	34	84	11	63	48	38	62	46		29	31	24	35
2006	48	6.6	101	82	33	66				48	30	54	18	6.0	35	57	26	37
2005	119	29	88	23	29	49	67	6.4	40	88	132	79	51	45	26	57	53	73
2004	131	16	129				61	11	53	56	40	53	21	16	37	45	33	37
2003				24	29	24	44	15	69	72	73	74	34	30	75	61	111	124
2002	101	22	364	33	56	35	37	10	135	86	97	128	23	13	95	52	120	174
2001	130	24	117	130	75	46	45	8.2	31	75	69	81	26	11	29	100	99	87
2000				42	36	25	58	7.7	43	72	120	73	21	11	37	95	76	87

Qualitative observations

- There is a large difference in NO_x values during Yom Kippur relative to the days before and after
- PM_{10} ($PM_{2.5}$) changes much less
- NO_x and O_3 (as expected) display mirror-like behavior

Quantitative analysis: Comparing 24 hour averages, 10 (3) lowest, and 10 (3) highest values in Tel Aviv area. Transportation (Remez) and Residential (Yad Avner) as well as in Jerusalem and Beer Sheva stations

	Remez				Yad Avner				Jerusalem				Beer Sheva			
average	N0x		P.M2.5		N0x		P.M2.5		N0x		P.M2.5		N0x		P.M2.5	
	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after
2008	0.14		0.51		0.23	0.27	0.46	0.64	0.36	0.56	0.52	0.80	0.36	0.42	0.40	0.61
2007	0.09	0.06	1.07	0.54	0.11	0.13	0.79	0.52	0.27	0.31	0.71	0.64	0.44	0.46	0.71	0.52
2006	0.12	0.06	0.45	0.47			0.82	0.56	0.34	0.19	0.49	0.63	0.60	0.40	0.61	0.57
2005	0.19	0.29	1.38	0.71	0.12	0.34	1.03	1.16	0.66	1.30	1.32	0.86	0.53	0.73	1.05	0.97
2004	0.08	0.09			0.29	0.23	0.71	0.52	0.51	0.37	0.80	0.77	0.40	0.37	0.65	0.72
2003			1.03	0.93	0.31	0.29	1.05	0.89	0.53	0.34	1.43	0.74	0.29	0.35	0.96	0.96
2002	0.16	0.07	1.26	1.09	0.35	0.11	1.51	0.80	0.61	0.22	2.45	1.01	0.47	0.31	1.76	0.67
2001	0.15	0.17	0.96	1.34	0.25	0.51	0.93	1.04	0.32	0.41	0.97	1.18	0.31	0.56	1.03	0.96
2000			0.74	1.11	0.16	0.28	1.05	1.21	0.59	0.31	0.88	0.87	0.34	0.57	0.76	1.07
average	0.13	0.12	0.93	0.89	0.23	0.27	0.93	0.82	0.47	0.44	1.06	0.83	0.42	0.46	0.88	0.78
stdev	0.04	0.07	0.33	0.32	0.09	0.13	0.29	0.27	0.14	0.34	0.61	0.17	0.10	0.13	0.39	0.21

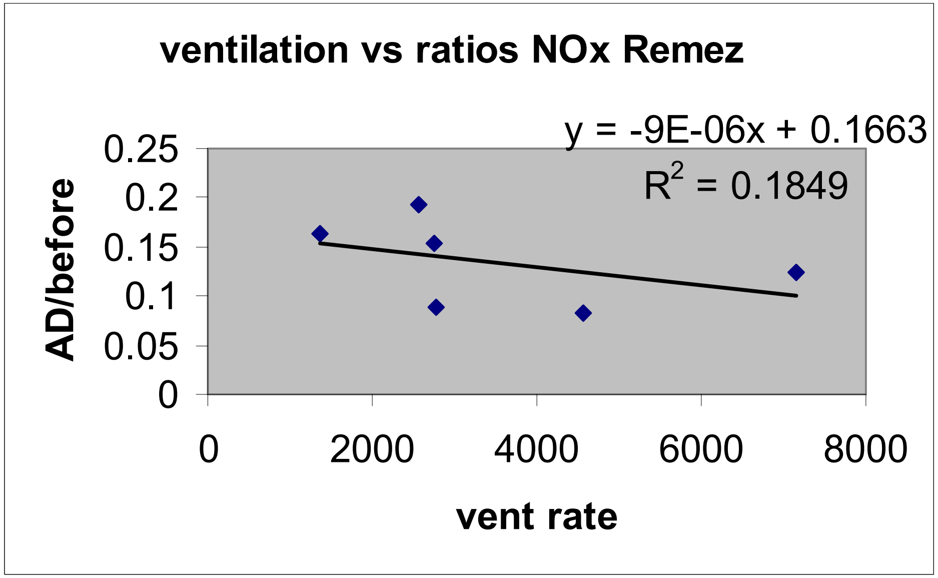
	Remez				Yad Avner				Jerusalem				Beer Sheva			
lowest	N0x		P.M2.5		N0x		P.M10		N0x		P.M10		N0x		PM10	
	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after
2008	0.05		0.19		0.21	0.34	0.79	0.91								
2007	0.09	0.05	0.77	0.37	0.33	0.20	4.02	0.51	0.67	0.58	0.84	0.70	0.40	0.42	0.57	0.40
2006	0.10	0.06	0.31	0.30			1.47	0.65	0.42	0.37	0.67	0.77	0.64	0.65	0.99	0.67
2005	0.14	0.22	3.00	0.67	0.44	0.64	0.20	0.32	0.35	0.64	1.82	0.99	0.68	0.78	1.18	1.00
2004	0.06	0.04			0.70	0.62	0.21	0.06	0.48	0.52	0.82	0.70	0.55	0.54	0.51	0.60
2003			0.60	0.53	0.55	0.49	0.95	0.73	0.44	0.43	1.22	0.61	0.30	0.61	0.87	0.82
2002	0.12	0.09	1.00	0.67	0.82	0.34	1.79	1.33	0.56	0.57	2.42	1.77	0.49	0.39	2.36	0.70
2001	0.06	0.05	1.34	1.15	0.68	0.65	0.97	2.29	0.24	0.76	1.12	1.42	0.43	0.74	1.12	1.26
2000			0.40	0.94	0.39	0.44	0.37	0.72					0.34	0.64	0.50	0.77
average	0.09	0.08	0.95	0.66	0.56	0.48	1.25	0.83	0.45	0.55	1.27	0.99	0.48	0.60	1.01	0.78
stdev	0.03	0.07	0.91	0.31	0.18	0.17	1.26	0.70	0.14	0.13	0.63	0.44	0.14	0.14	0.61	0.26

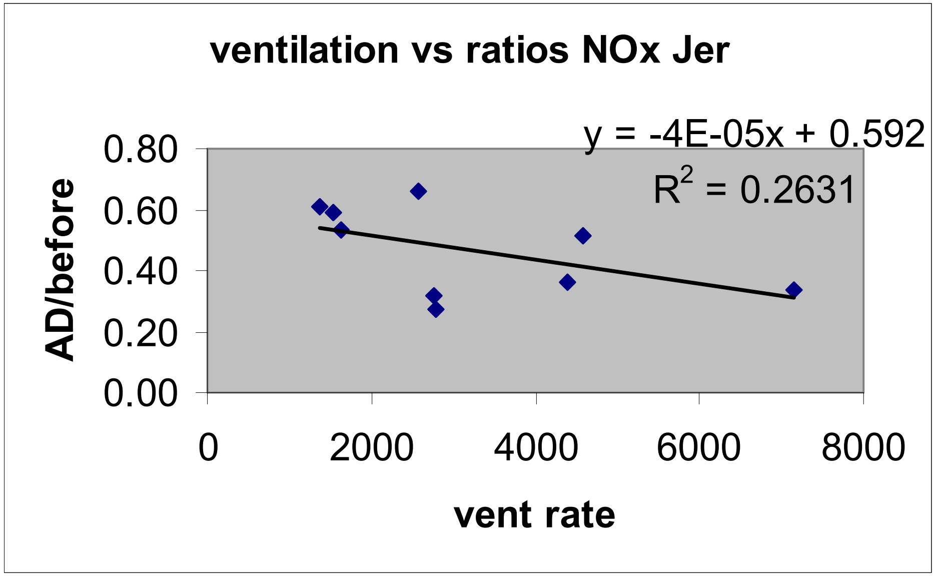
	Remez				Yad Avner				Jerusalem				Beer Sheva			
highest	N0x		P.M2.5		N0x		P.M10		N0x		P.M10		N0x		PM10	
	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after	DA/before	DA/after
2008	0.19		1.36		0.28	0.26	0.31	0.37								
2007	0.10	0.07	0.84	0.47	0.13	0.17	0.79	0.61			0.79	0.70	0.64	0.61	0.81	0.62
2006	0.14	0.07	0.41	0.50			0.62	0.55	0.33	0.17	0.46	0.71	0.63	0.32	0.48	0.63
2005	0.24	0.33	1.27	0.59	0.10	0.16	1.51	1.67	0.89	1.73	0.93	0.72	0.45	0.74	0.97	1.08
2004	0.12	0.13			0.19	0.21	0.70	0.75	0.75	0.43	0.73	0.88	0.32	0.33	0.79	0.72
2003			1.23	1.23	0.33	0.21	1.02	0.99	0.88	0.40	1.81	0.89	0.67	0.29	0.98	1.12
2002	0.21	0.06	1.70	1.60	0.28	0.08	1.12	0.75	0.56	0.14	2.29	0.69	0.37	0.24	1.29	0.73
2001	0.18	0.20	0.58	1.63	0.18	0.27	0.92	0.86	0.44	0.40	0.99	1.14	0.35	0.69	1.15	1.10
2000			0.85	1.44	0.13	0.18	1.67	1.63					0.41	0.70	0.74	1.33
average	0.17	0.14	1.03	1.07	0.19	0.18	1.04	0.98	0.64	0.55	1.14	0.82	0.48	0.49	0.90	0.92
stdev	0.05	0.11	0.43	0.53	0.09	0.06	0.38	0.44	0.23	0.59	0.66	0.16	0.14	0.21	0.25	0.27

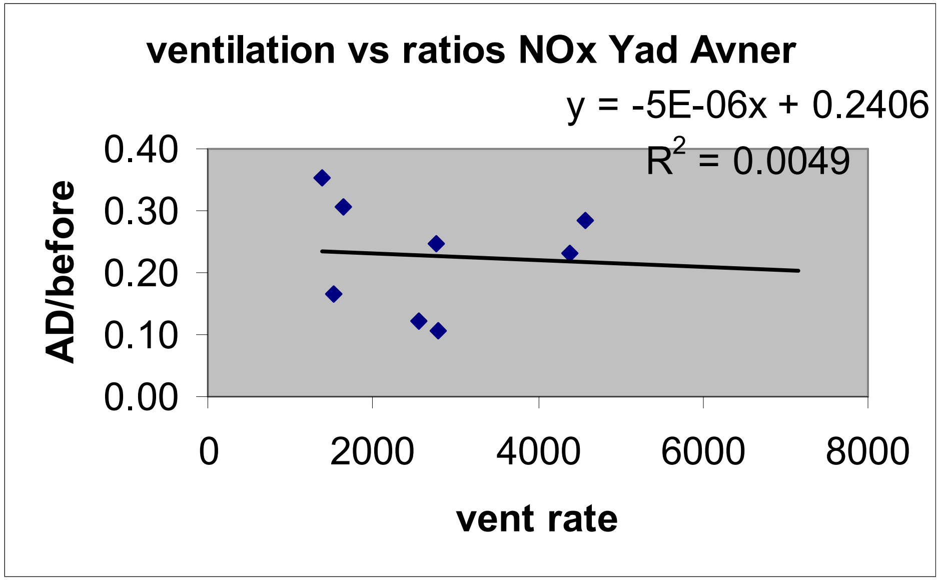
Correlations between 24-average values in the different stations (2000 – 2008)

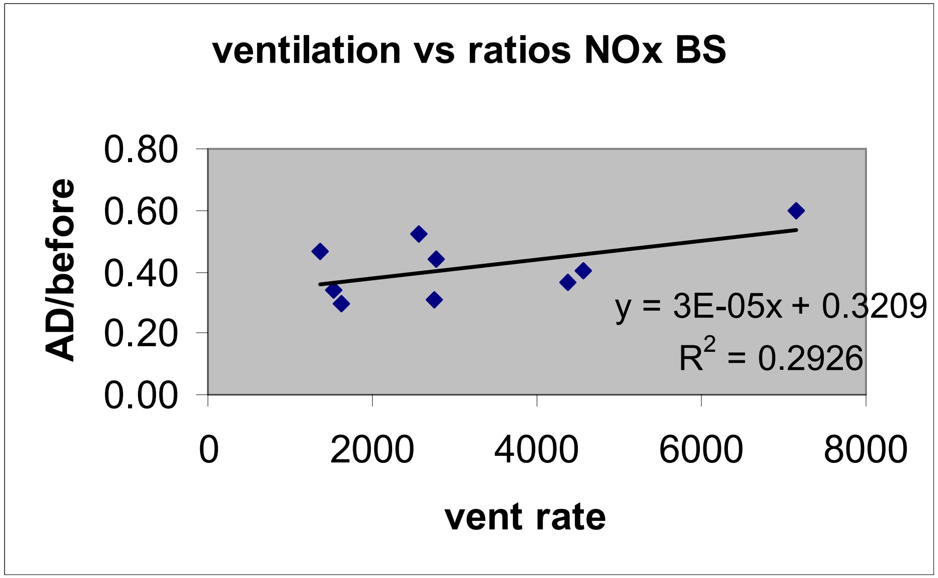
	N bef R	*N af R*	*P bef R*	*P af R*	*N bef Y*	*N af Y*	*P bef Y*	*P af Y*	*N bef J*	*N af J*	*P bef J*	*P at J*	*N bef B*	*N af B*	*P bef B*	*P af B*
N bef R	1.00															
N af R	0.72	1.00														
P bef R	0.53	0.52	1.00													
P af R	0.45	0.20	0.18	1.00												
N bef Y	0.01	-0.43	0.06	0.60	1.00											
N af Y	0.38	0.66	-0.25	0.53	-0.10	1.00										
P bef Y	0.66	0.06	0.49	0.49	0.47	-0.26	1.00									
P af Y	0.91	0.88	0.28	0.64	-0.20	0.60	0.42	1.00								
N bef J	0.57	0.47	0.47	0.26	0.22	-0.14	0.58	0.54	1.00							
N af J	0.62	0.94	0.59	-0.13	-0.49	0.35	-0.01	0.50	0.45	1.00						
P bef J	0.58	0.09	0.67	0.43	0.62	-0.34	0.93	0.27	0.60	0.07	1.00					
P at J	0.58	0.39	0.35	0.89	0.34	0.59	0.49	0.60	0.19	0.13	0.47	1.00				
N bef B	0.16	-0.05	-0.11	-0.73	-0.32	-0.47	-0.02	-0.35	-0.02	0.22	-0.08	-0.42	1.00			
N af B	0.56	0.93	0.23	0.04	-0.77	0.57	-0.16	0.69	0.17	0.79	-0.25	0.26	0.05	1.00		
P bef B	0.65	0.11	0.65	0.50	0.54	-0.20	0.93	0.30	0.46	0.07	0.96	0.62	-0.02	-0.16	1.00	
P af B	0.69	0.88	0.16	0.64	-0.05	0.73	0.20	0.91	0.53	0.42	0.13	0.52	-0.58	0.56	0.09	1.00

The relationships between NOx ratios and ventilation rates

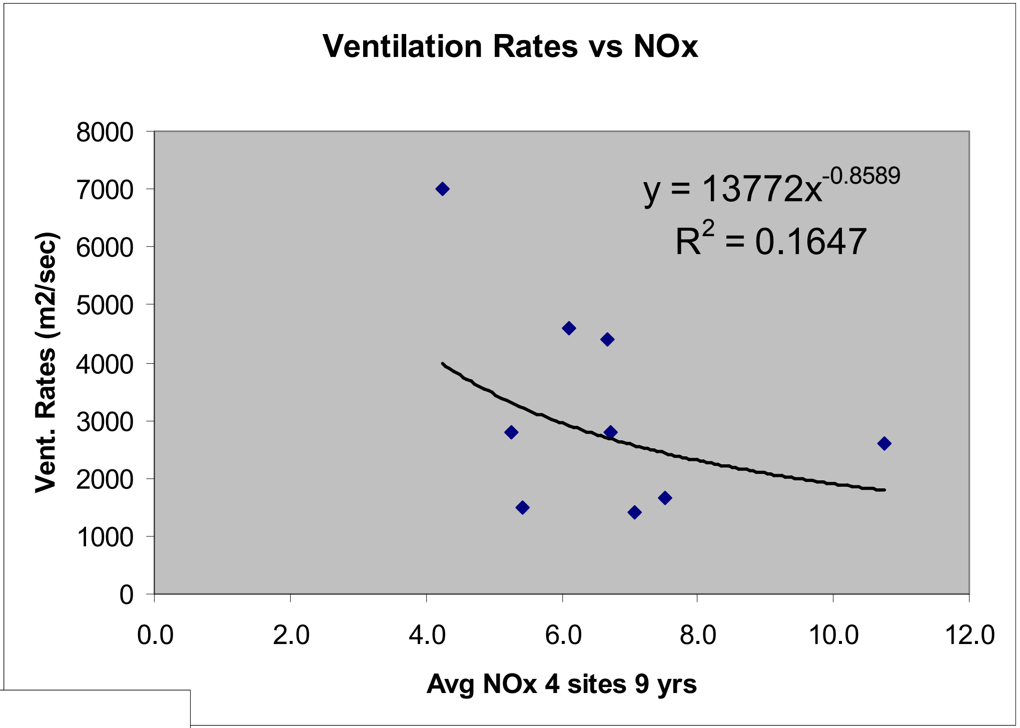


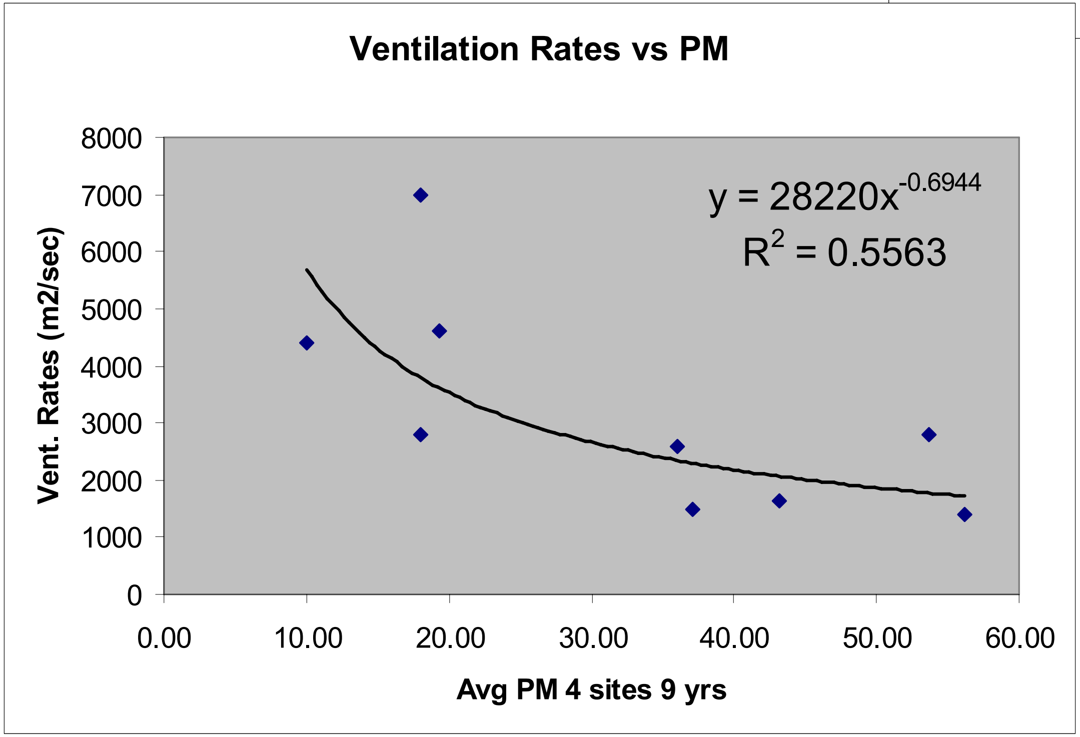






Ventilation rate's influence on NOx (right) and PM (below)





Classification of nine Days of Atonement along synoptic categorization and local potential conditions for dispersion

Date	Inv. Base BD 12Z Height (m)	Wind Speed BD 12Z (m/s)	Vent. Rates WS BD (m^2/s)	Synoptic Cat
Thursday: 9-10/10/08	**1460**	3.0	**4380**	Red Sea Trough
Saturday : 21-22/09/07	**766**	3.63	**2781**	Persian Trough (Modal)
Monday : 01-02/10/06	**1768**	4.05	**7160**	Persian Trough (Deep)
Thursday : 12-13/10/05	**476**	5.38	**2561**	Red Sea Trough
Saturday : 24-25/09/04	**1276**	3.58	**4568**	Persian Trough (Deep)
Monday: 05-06/10/03	**466**	3.5	**1631**	Red Sea Trough
Monday : 15-16/09/02	**323**	4.25	**1373**	Cole
Thursday : 26-27/09/01	**614**	4.5	**2763**	Persian Trough (Modal)
Monday : 08-09/10/00	**284**	5.38	**1528**	Red Sea Trough

Sources of data: Inversion base, wind speed and ventilation rates are from:
http://weather.uwyo.edu/upperair/sounding.html
Synoptic Categories from : http://www.cdc.noaa.gov/cgi-bin/db_search/DBSearch.pl

Conclusions

- NO_x is reduced to 10% (transportation), 25% (Tel Aviv), 50% (Jerusalem, Beer Sheva) of normal value
- PM_{10}, $PM_{2.5}$ – no effect (not from transportation, not local)
- 10 – 50% of NO_x and most of PM from outside the metropolitan area – long range transport
- Still, majority of air pollution in metropolitan areas is from local emissions.
- PM - long residence time. NOx - short residence time.
- Observations can be explained by combination of synoptic – scale atmospheric conditions and ventilation ratio: Ability of the atmosphere to transport contaminants away from a source region.