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Respiratory Effects of Ozone Exposure in children (RESPOZE): a panel study in Greece. Implementation of the field work and preliminary results

Celebrating the 21st Birthday of the Environmental Research group
Frontiers in Air Quality Science
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Background

- Studies on the effects of PM exposure clearly outnumber those on gaseous pollutants
- Ozone is a strong oxidant and there is evidence that ozone exposure affects respiratory health
- Children are a sensitive sub-population for ozone exposure
- Most studies on children have focused on asthmatic children
- As ozone is a secondary pollutant, formed in the presence of precursor pollutants and sunshine, inhabitants of Southern European cities are exposed to high ozone concentrations

Respiratory Effects of Ozone Exposure in children (RESPOZE): a panel study in Greece.

- The study I am going to present is a panel study focusing on the respiratory health effects of ozone exposure, in a sample of children living in two of the most polluted European cities in Europe, Athens and Thessaloniki, with a total population of about 4m.

Research Group

University of Athens epidemiology/pulmonology

- Klea Katsouyanni (PI)
- Anna Karakatsani
- Evangelia Samoli
- Konstantina Dimakopoulou
- Sofia Rodopoulou

University of Thessaloniki pulmonology

- Despoina Papakosta
- Dionysios Spyratos

Twelve field Workers

Modelling/ air quality groups:
University of Thessaloniki:

- Nikos Moussiopoulos,
- GeorgeTsiligiridis

University of Athens:

- Konstantinos Helmis
- Elena Floca
- Alexandros Gryparis

National Technical University of Athens: Ozone Measurements

- Georgios Grivas
- Douli Haloulakou

Advisors: Frank Kelly and Ian Mudway form King's College

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Main features of the study design

- Sponsored by the General Secretariat /for Science and Technology, Ministry of Education, through the EU structural funds
- Panel study in 10-11 year old students of state elementary schools
- Children have to live in the neigbourhood in order to attend the state school. (Inclusion ctiterion: they must have lived in the same area for 5 years)
- Total target 200 students; 100 in each city
- Duration 36 months (Oct 1, 2012-Sept 30, 2015). Field work during the academic year 2013-14 (just finished, on June 6).

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Sampling

- First, we selected schools. Then (after obtaining the right permissions) we visited them, presented the project, and students-parents volunteered participation.

- Schools were selected in high ozone areas (60%) and in low ozone areas (40%).

- Schools were selected to be near the fixed monitoring sites (to have measurements for PM, NO_2 and other pollutants and also fixed ozone measurements)

- **21** Schools in Athens, **13** in Thessaloniki. **1-19** students/school

What do outdoor ozone concentrations look like in these high/low ozone areas?

Site name	Mean ozone 8-hour concentration (µg/m3) 2013				% of days >100 µg/m3	Area Chracterisation
	J-F-M	A-M-J	J-A-S	O-N-D		
Pireaus (Ath)	33	43	29	27	0.8	Low ozone
Patission (Ath)	18	31	35	17	0.3	Low ozone
Marousi (Ath)	46	76	84	50	33.2	High ozone
Lykovrisi (Ath)	45	78	94	47	42.5	High ozone
Thrakom. (Ath)	80	110	111	75*	51.5	High ozone
Ag Paraskevi (Ath)	73	97	110	51	45.8	High ozone
Ag Sophia (Thes)	38	69	63	23	15.3	Low ozone
Panorama (Thes)	58	102	107	63	41.9	High ozone
*only October						

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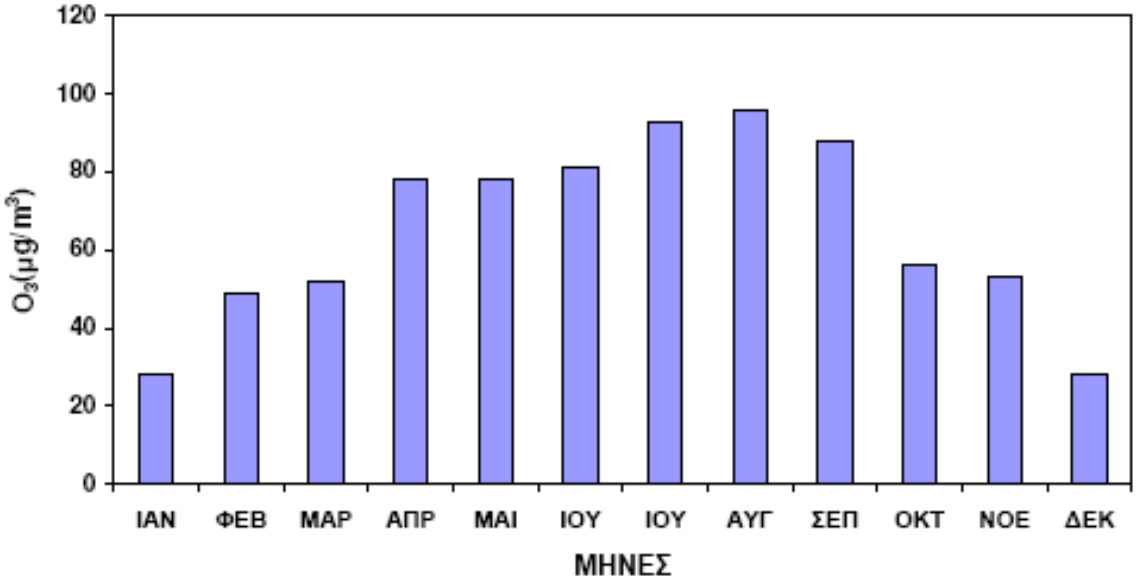
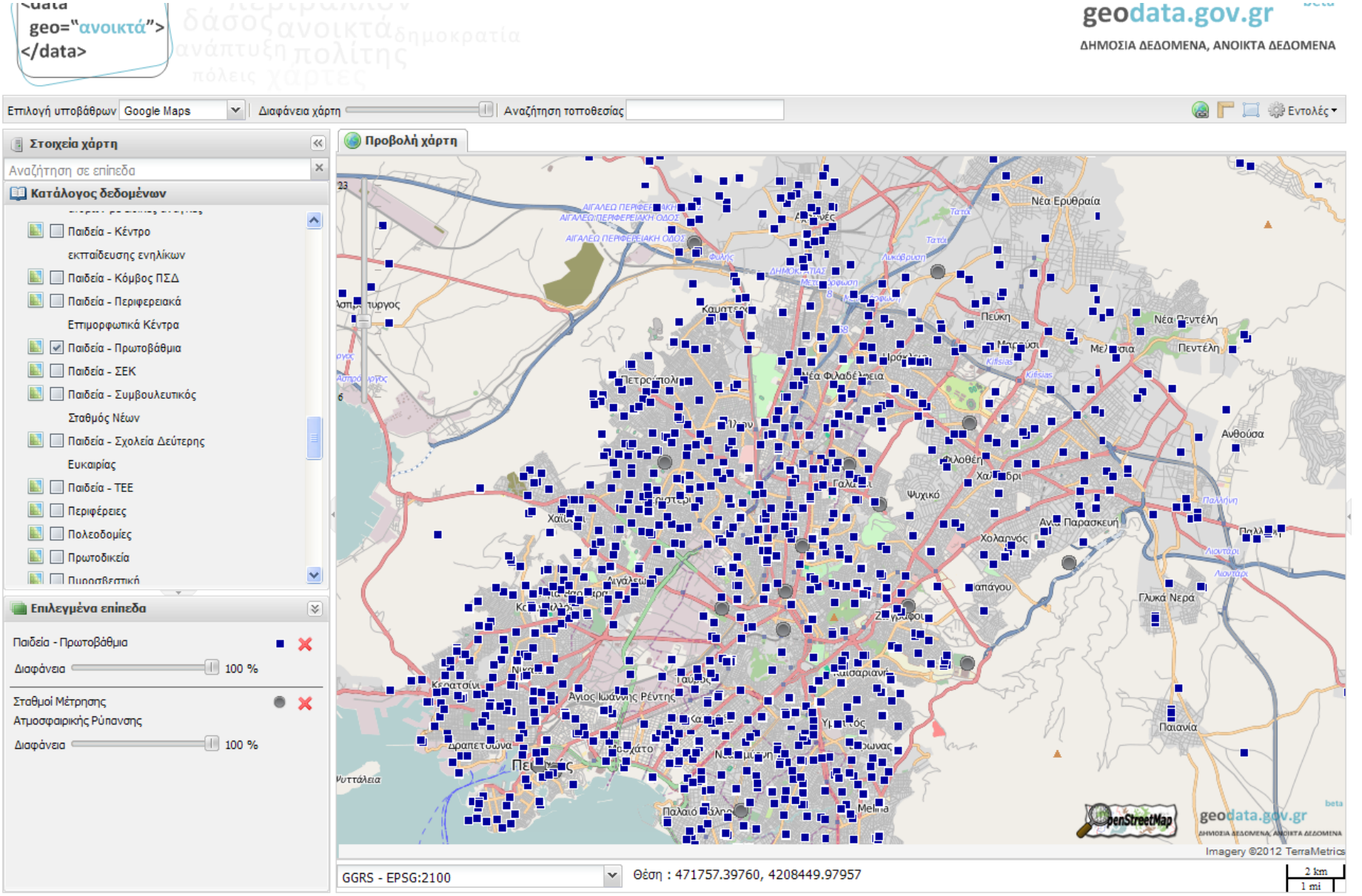
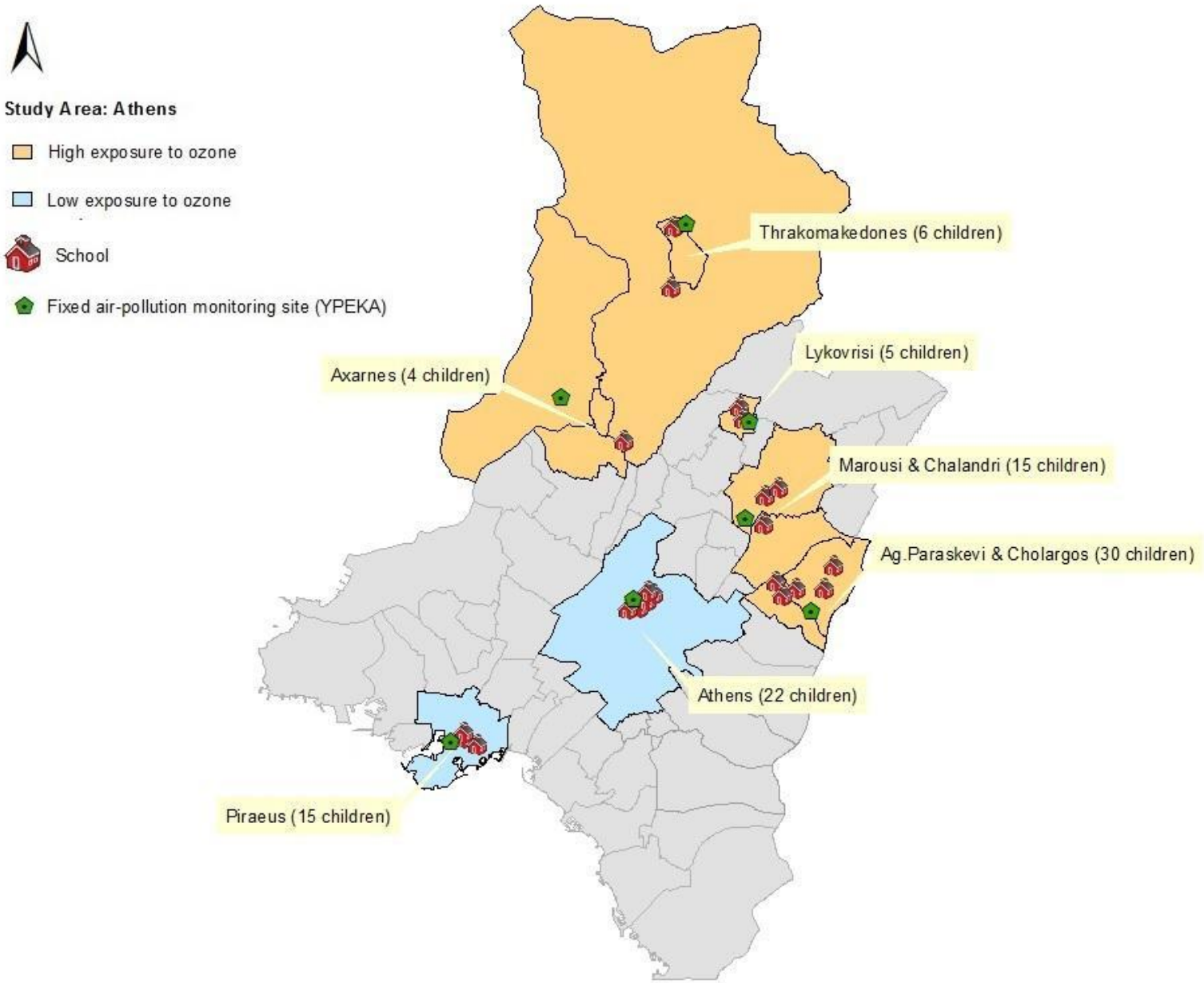


Monthly mean values of O3-1h in Lykovrisi - 2011

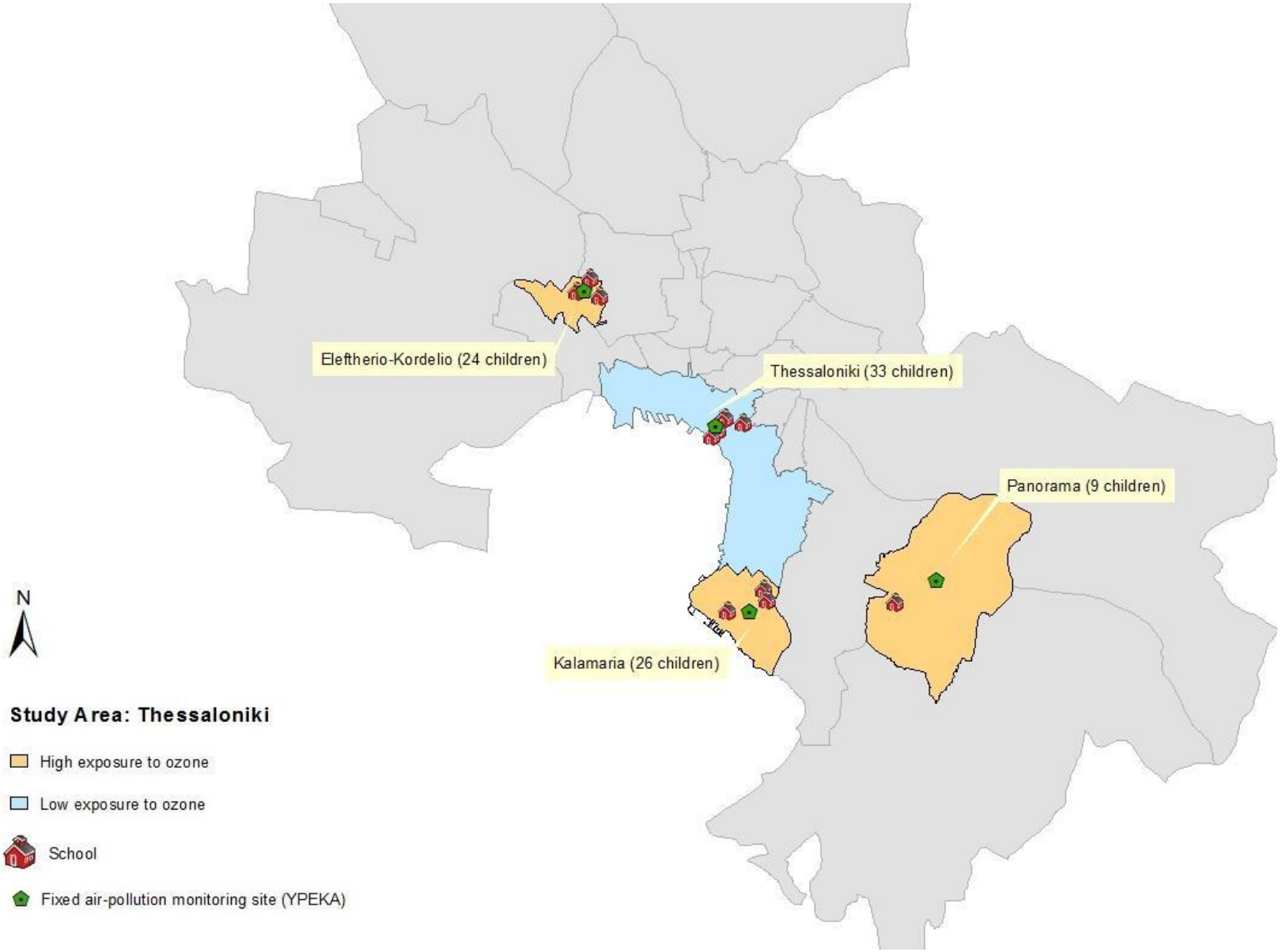
Geodata: ■ Primary schools ● Monitoring site



Study Area: Athens



Study Area: Thessaloniki



Design of the field work

- **Three** intensive field work periods (fall, winter, spring) (within 2013-14), **five** weeks per student: two in fall period; one winter period; two spring period.

- Fall period: 2 weeks per student during Oct-Nov-Dec.
- In Thessaloniki 11-24/10 & 19/11-2/12 & in Athens 25/10-21/11.

- Winter period: 1 week per student in February.
- In Athens 3-14/2 & in Thessaloniki 17-28/2.

- Spring period: 2 weeks per student during April-May-June.
- In Thessaloniki 31/3- 11/4 & 26/5-6/6 & in Athens 28/4-22/5.

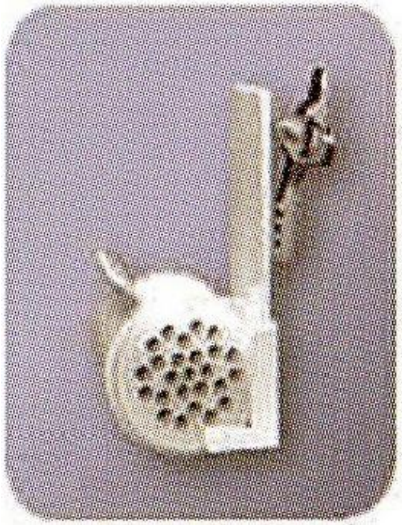
Field work stages: 1. Visit at home

- During the week prior to the intensive measurements period
  - Inform and explain the objectives
  - Explain the procedures
  - Administer questionnaire by interview to the parent (demographic variables; behavioral aspects e.g. smoking, heating, cooking, way of going to school; medical history; residential history with addresses)
  - Give a mini-Wright portable spirometer and instructions to use it twice a day, during the periods of intensive field work.

Field work stages: 2. Visits at schools

- Each school was visited twice for each intensive field work week, by a team of three researchers (at least one MD) on the same weekday.

- At the first visit students were handed out the ozone passive samplers (ogawa samplers) and the Time Activity Symptom Diary (TASD).



- At the second visit the ozone sampler and the TASD were collected, spirometry performed, fractional exhaled nitric oxide FE_{NO} was measured, Exhaled Breath Condensate (EBC) was collected in Athens and rhinomanometry performed in Thessaloniki. A 24-hour dietary recall questionnaire was completed.

- One saliva sample at the very last visit.

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Data base

Once	Five weekly	Thirty five daily
Demographic (from General Questionnaire GQ)	Personal ozone	Pollutant measurement from nearby monitor (PM_{10}, NO_2, O_3)
Life style (GQ)	Spirometry	Time activity
Housing conditions/indoor sources (GQ)	FE_{NO}	Symptoms, absenteism
Medical history (GQ)	pH EBC	PEF from the portable spirometer
Saliva sample	Rhinomanometry	
(Estimates of air pollution at residence from models)	24-hour dietary recall	

Hypotheses – Questions to be investigated (1)

- Are the main and secondary short-term (daily and weekly) exposures associated with acute outcomes?
  1. Main exposure: weekly personal ozone for 5 weeks
  2. Secondary exposures: daily ozone from nearest fixed monitor ; PM_{10} (maybe $PM_{2.5}$), NO_2 from nearest fixed monitor; Ambient temperature
  3. Acute outcomes: Lung function daily PEF; weekly spirometry: FEV; weekly and daily symptoms; absenteism; weekly FE_{NO}; weekly EBC pH
  4. Confounders: data from TASD

Hypotheses – Questions to be investigated (2)

- Are the main and secondary long-term (life-long) exposures associated with chronic outcomes?
  - Main long-term exposure: life long ozone exposure based on residential history provided by dispersion and LUR models
  - Secondary long-term exposures: life long ozone and other pollutants exposures estimated from nearest fixed site monitor
  - Long-term outcomes: average of spirometry indices; average of daily PEF; prevalence of symptoms over whole period; average of FE_{NO}; of EBC pH;
  - Confounders: data from questionnaire; indices derived from TASD e.g. average time outdoors; average time exercising; passive smoking exposure.

Hypotheses – Questions to be investigated (3)

- Are the main and secondary medium or intermediate -term (annual) exposures associated with chronic outcomes?
  - Main medium-term exposure: annual study year ozone exposure based on measurements on all 5 weeks and on dispersion and LUR models
  - Secondary medium-term exposures: study year ozone and other pollutants estimated from nearest fixed site monitor.
  - Medium-term outcomes and confounders: same as for chronic effects

Hypotheses – Questions to be investigated (4)

- Exposure assessment issues:
  - –Validation of dispersion models (using measurements)
  - –Validation of LUR models
  - –Comparison of ozone exposure assessment using different methods (Dispersion, LUR, fixed site monitors of the permanent network, fixed school monitors, personal measurement)
  - –Report on ozone exposure of schoolchildren in Athens and Thessaloniki- between person variability and exposure determinants (using personal measurements)

- Other descriptive data
  - Dietary habits of Greek schoolchildren
  - Time activity of Greek school children

Some preliminary results

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Descriptive statistics for demographic, somatometric and SES characteristics of 96 children in Athens & 92 in Thessaloniki, by exposure to ozone (as defined by the school's location).

	Exposure to ozone			
	Athens		Thessaloniki	
Demographic characteristics	**Low (n=37)**	**High (n=59)**	**Low (n=33)**	**High (n=59)**
Boys (n; %)	22 (59.5)	27 (45.8)	14 (42.4)	30 (50.9)
Age (yrs; mean, SD)	10.3 (0.3)	10.3 (0,3)	10.4 (0.4)	10.4 (0.3)
Height (cm;mean, SD)	147.2 (6.7)	143.7 (7.5)	145.9 (9.5)	144.4 (7.3)
Weight (kg;mean, SD)	39.5 (7.7)	38.0 (7.8)	38.6 (9.7)	37.7 (7.5)
BMI (kg/m2; mean,SD)	18.2 (2.8)	18.4 (3.5)	18.0 (3.4)	18.0 (2.8)
Mother's education (yrs; mean, SD)	13.5 (3.0)	15.9 (3.3)	15.4 (3.4)	14.7 (3.2)
Working mother (yes; n,%)	22 (59.5)	47 (79.7)	26 (78.8)	37 (62.7)
Working father (yes; n, %)	29 (78.4)	54 (91.5)	27 (81.8)	53 (89.8)

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Home characteristics of 96 children in Athens & 92 in Thessaloniki, by exposure to ozone (as defined by the school's location).

	Exposure to ozone			
	Athens		Thessaloniki	
Home characteristics	**Low (n=37)**	**High (n=59)**	**Low (n=33)**	**High (n=59)**
Type of residence:				
Apartment (n; %)	35 (94.6)	39 (66.1)	32 (96.7)	48 (81.4)
Detached House (n; %)	2 (5.4)	20 (33.9)	1 (3.0)	11 (18.6)
Area of the home (m^2; mean, SD)	90 (28.7)	126 (51.2)	98 (36.4)	105 (51.6)
Frequency of heavy traffic within 100m				
Continuous (n; %)	16 (43.2)	14 (23.7)	24 (72.7)	21 (35.6)
Often (n; %)	20 (54.1)	15 (25.4)	6 (18.2)	15 (25.4)
Seldom (n; %)	1 (2.7)	17 (28.8)	1 (3.0)	13 (22.0)
Never (n; %)	0 (0.0)	13 (22.0)	2 (6.1)	10 (17.0)
Distance of residence from nearest street (m; mean, SD)	4.6 (8.4)	13.2 (9.2)	5.2 (6.4)	12.6 (14.1)

Life style characteristics of 96 children in Athens & 92 in Thessaloniki, by exposure to ozone (as defined by the school's location).

	Exposure to ozone			
	Athens		Thessaloniki	
	Low (n=37)	**High (n=59)**	**Low (n=33)**	**High (n=59)**
Smoking indoors (n;%)	11 (38.9)	14 (23.7)	7 (21.2)	13 (22.0)
Air conditioning yes (n; %)	28 (75.7)	44 (74.6)	25 (75.8)	49 (83.1)
Cooking with*				
Electricity (n; %)	33 (89.2)	59 (100.0)	31 (93.9)	58 (100.0)
Gas (n; %)	4 (10.8)	2 (3.4)	1 (5.0)	2 (8.0)
Other (n; %)	0	4 (6.8)	0	0
Heating with*				
Central diesel or gas (n;%)	25 (67.6)	56 (94.9)	28 (84.8)	48 (81.4)
Fireplace/wood stove (n;%)	3 (8.1)	30 (50.8)	7 (21.2)	12 (20.3)
Electric (n;%)	21 (56.7)	23 (39.0)	4 (12.1)	17 (28.8)
Open windows yes (hours/day)				
Summer (mean, SD)	18.4 (6.2)	20.4 (6.8)	20.2 (7.0)	20.1 (7.1)
Winter (mean, SD)	3.5 (2.1)	3.1 (3.0)	3.8 (5.8)	2.6 (3.2)

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Medical history as reported by parents of 96 children in Athens & 92 in Thessaloniki, by exposure to ozone (as defined by the school's location).

	Exposure to ozone			
	Athens		Thessaloniki	
	Low (n=37)	**High (n=59)**	**Low (n=33)**	**High (n=59)**
Asthma (n;%)	2 (5.4)	5 (8.5)	4 (12.1)	10 (17.0)
Ever wheezing (n; %)	8 (21.6)	9 (15.3)	4 (12.1)	14 (23.7)
Cough outside infection (n; %)	0 (0)	6 (10.1)	2 (6.1)	7 (11.9)
Sneezing/stuffed nose outside infection (n;%)	11 (29.7)	11 (18.6)	10 (30.3)	20 (33.9)
Allergic rhinitis (n; %)	5 (13.5)	5 (8.5)	7 (21.2)	12 (20.7)

Summary statistics for various outcomes, by exposure to ozone (as defined by the school's location) for all 189 children in both cities.

	Exposure to ozone		
Outcomes	**Low (n=70)**	**High (n=119)**	**Total**
[1]$FEF_{25-75\%}$	2.57 (0.648)	2.38 (0.482)	2.45 (0.553)
[2]FE_{NO} value (ppb)	12.2 (11.8 , 16.5)	12.4 (11.0 , 13.9)	12.3 (11.3 , 13.4)
	Low (n=20)	**High (n=31)**	
[1]EBC pH	8.113 (0.2585)	8.095 (0.2015)	8.101 (0.2216)

[1]Mean (SD)
[2] Geometric mean (95% C.I.)

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Association of $FEF_{25-75\%}$ (average value of 1st & 2nd measurement performed in October-November 2013) with long-term exposure to ozone (according to the school location) in 189 children from Athens & Thessaloniki.

Variable	Beta coefficient (95% C.I.)	p-value
Exposure to ozone		
Low	Reference Category	
High	-0.119 (-0.273 , 0.036)	0.131
Gender		
Boy	Reference Category	
Girl	0.011 (-0.136 , 0.159)	0.878
Height (cm)	0.019 (0.007 , 0.031)	0.002
Weight (kg)	0.013 (0.002 , 0.025)	0.023

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Association of ln(FE_{NO}) (average value of 1st & 2nd measurement performed in October-November 2013) with exposure to ozone (according to the school location) in 189 children from Athens & Thessaloniki.

Variable	Beta coefficient (95% C.I.)	p-value
Exposure to ozone		
Low	Reference Category	
High	0.016 (-0.155 , 0.187)	0.854
Gender		
Boy	Reference Category	
Girl	-0.058 (-0.223 , 0.106)	0.485
Height (cm)	0.003 (-0.010, 0.017)	0.605
Weight (kg)	0.012 (-0.000 , 0.025)	0.055

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Association of pH (average value of all study periods in 2013-2014) with exposure to ozone (according to the school location) in 51 children living in Athens.

Variable	Beta coefficient (95% C.I.)	p-value
Exposure to ozone		
Low	Reference Category	
High	-0.029 (-0.126 , 0.068)	0.555
Gender		
Boy	Reference Category	
Girl	-0.018 (-0.113 , 0.076)	0.700
Height (cm)	0.004 (-0.004, 0.013)	0.294
Weight (kg)	-0.001 (-0.008 , 0.007)	0.891

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Personal ozone measurements (mean value of the measurements performed during the 1st & 2nd week of the 1st study period: October-November 2013) for 92 Athens children by ozone level as defined by the school's location.

	Ozone level in relation to school location			
	Low (n=34)	High (n=58)	Total	p-value[2]
Ozone Personal Measurement ($\mu g/m^3$) mean (SD)	6.16 (2.64)	8.11 (4.37)	7.39 (3.92)	0.02*

[2] Independent samples t-test

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Comments: comparison of fixed site outdoor and personal ozone measurements (all during October-November 2013)

	Ozone level in relation to school location	
	Low	**High**
Ozone Personal Measurement (µg/m³) Mean (number of children)	6.16 (n=34)	8.11 (n=58)
Ozone concentrations from fixed site measurements (µg/m³) mean (SD) [2] Independent samples t-test	22.00 (2 monitors, mean Oct-Nov-Dec)	49.33 (4 monitors, mean Oct-Nov-Dec)

Comparison of personal to ambient O_3 exposures in the Boston area (from Ward Brown et al, 2009, Sci Tot Environ 407: 3754)

	Winter	Summer
Ozone Personal Measurement ($\mu g/m^3$) mean (SD)	1.6 (6.8)	13.2 (14.0)
Ozone concentrations from fixed site measurements ($\mu g/m^3$) mean (SD)	23.6 (9.6)	50.4 (19.6)

[2] Independent samples t-test

Association of the weekly $FEF_{25-75\%}$ with personal exposure to ozone (2 weeks in October-November 2013). Results from random effects models in 92 children from Athens

Variable	Beta coefficient (95% C.I.)	p-value
Ozone ($\mu g/m^3$)*	**-0.004 (-0.015 , 0.008)**	**0.528**
Sex		
Boy	Reference Category	
Girl	0.024 (-0.169 , 0.218)	0.805
Height (cm)	0.016 (0.001 , 0.032)	0.040
Weight (kg)	0.018 (0.003 , 0.032)	0.020
Order of measurement	-0.140 (-0.216 , -0.065)	<0.001

*Mean 7-day personal exposure

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Conclusions – Discussion points

- The need to implement field work for data collection is highlighted
- There are important characteristics that differentiate local situations
- Ozone must be assessed through personal measurements!
- Ozone exposure may affect children's health in various ways
- Need to study acute and long-term effects
- More discussion and better understanding of the mechanisms
- Public health policy issues: Protection of children's health ⇨ are specific activities and/or life style factors (e.g. diet), exposure or effect modifiers?

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Thank you!

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