ESTIMATE OF POTENTIALLY HIGH OZONE CONCENTRATIONS AREAS IN THE CENTER OF THE IBERIAN PENINSULA

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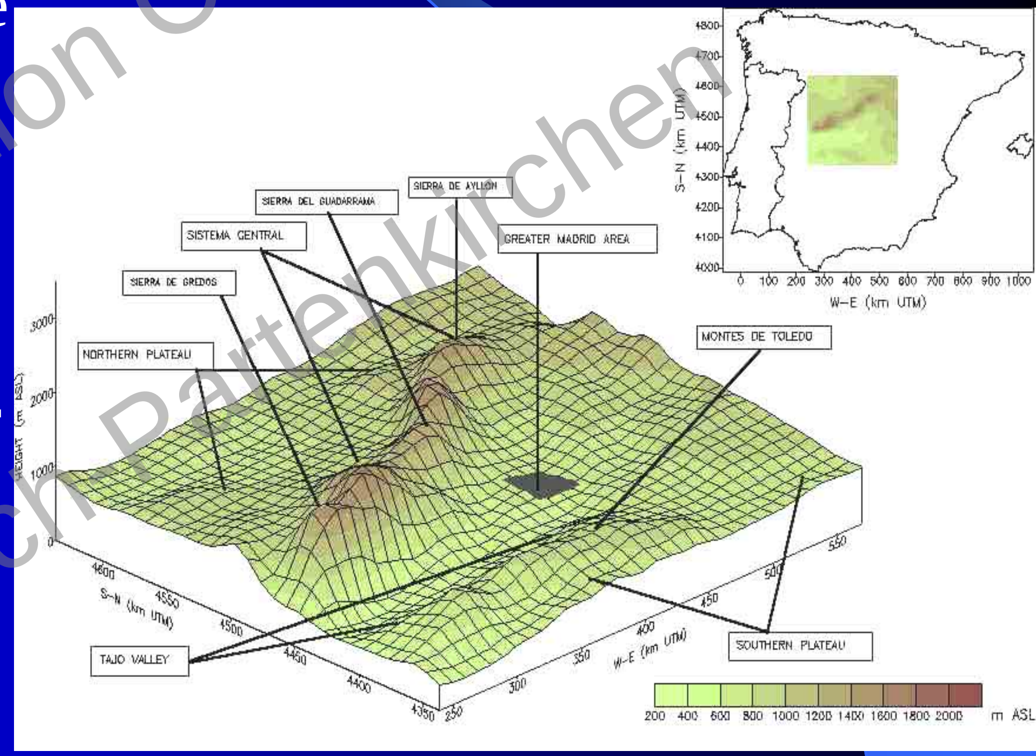
INTRODUCTION (1)

- The Greater Madrid Area (GMA) is located in the centre of the Iberian Peninsula
- Huge source of ozone precursors.
- Intense formation of tropospheric ozone in summer time, late spring and early autumn.



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INTRODUCTION (2)

- Recent European directives, air pollution modelling is a very important tool for many the air quality management:
  - air quality assessment,
  - design of plans and programs for air pollution abatement
  - design of networks for air quality monitoring. Furthermore,
- Development of ozone control strategies requires analysing ozone response to variations in precursors emissions considering a wide range of realistic meteorological conditions.

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INTRODUCTION (3)

- Previous simulations (TVM model coupled to transport/chemistry module) for two different summer ozone episodes in GMA:
  - High levels of ozone, above the population information threshold and close to the alert threshold areas 100 km far away from Madrid city
  - Confirmed by observations (validated model)
  - Need of forcing to the reduction of not only traffic road but also total anthropogenic emissions to comply with standard levels.

OBJECTIVE

- To study of which areas could be potentially affected by high ozone levels in the centre of the Iberian Peninsula by using an evaluated model.

METHODOLOGY

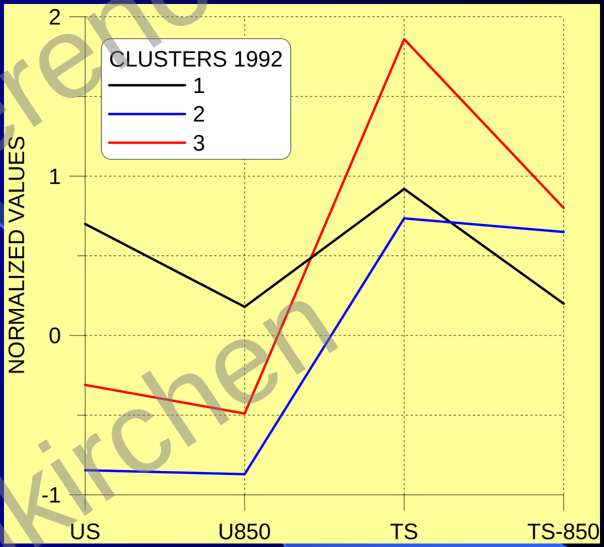
1. Set up of meteorological scenarios.
2. Simulations of the photochemical air pollution for the meteorological scenarios.
3. Analysis of the simulated spatial patterns of ozone concentration distribution.

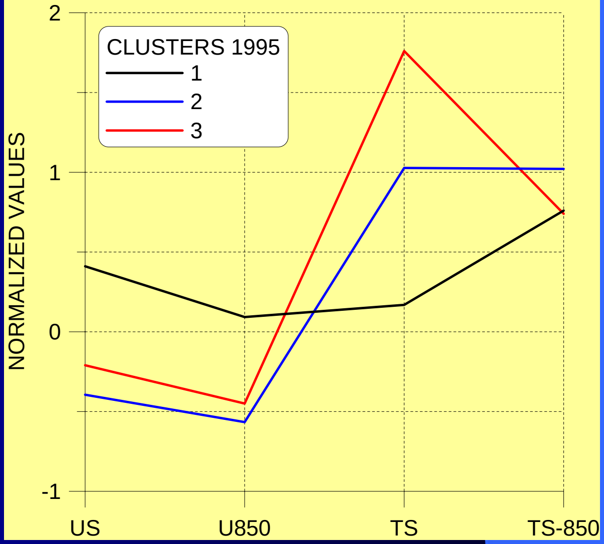
Meteorological scenarios (1)

- Period for selecting meteorological scenarios from mid April to mid October.
- 1992 and 1995 (each year treated separately).
- Days with rain or overcast was removed.
- Selected variables representing the atmosphere state every day:
  - Surface and 850-HPa-level wind speed (ventilation).
  - Surface air temperature (important for ozone formation).
  - Temperature gradient between 850 HPa level and surface (atmospheric stability).
- Cluster analysis (k-means technique) was used in order to group days with similar meteorological state.
- All data were previously normalised.

Meteorological scenarios (2)

- 3 significant cluster resulted from every year
  - Custer 1 (3% and 4% of the studied days in 1992 and 1995).
    - higher-than-average winds,
    - high temperatures (less high in 1995)
    - little atmospheric unstability
  - Cluster 2 (63% -1992-, 77% -1995-)
    - very weak winds,
    - high temperatures
    - higher atmospheric unstability,
  - Cluster 3 (34% -1992-, 19% -1995-)
    - weak winds
    - temperatures are even higher than former cases.





Meteorological scenarios (3)

- Wind direction (850 HPa) was not used in cluster analysis because of its circular features.
- For setting up the meteorological scenarios representing every cluster, a sub classification was done based on wind direction (analysis of frequency - histograms).
- The selected meteorological scenarios were determined as the day being closest to the mean state of every sub cluster.
- 9 representative days (scenarios) for every reference year were used in simulations (65% correspond to summer time).
- TVM models was used for air flows simulations.

Meteorological scenarios and daily flow evolution in GMA (1992)

1992

Cluster	Julian day	%	Wind Speed (m/s)	Wind Direction (°)	Night	Morning	Noon	Afternoon	Evening
1	133	3	7.4	151					
2	112	13	2.5	140					
	118	19	1.4	107					
	276	4	3.1	318					
	177	23	4.2	211					
	253	4	2.6	92					
3	195	9	4.7	160					
	197	9	3.8	144					
	213	16	5.2	134					

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Meteorological scenarios and daily flow evolution in GMA (1995)

1995

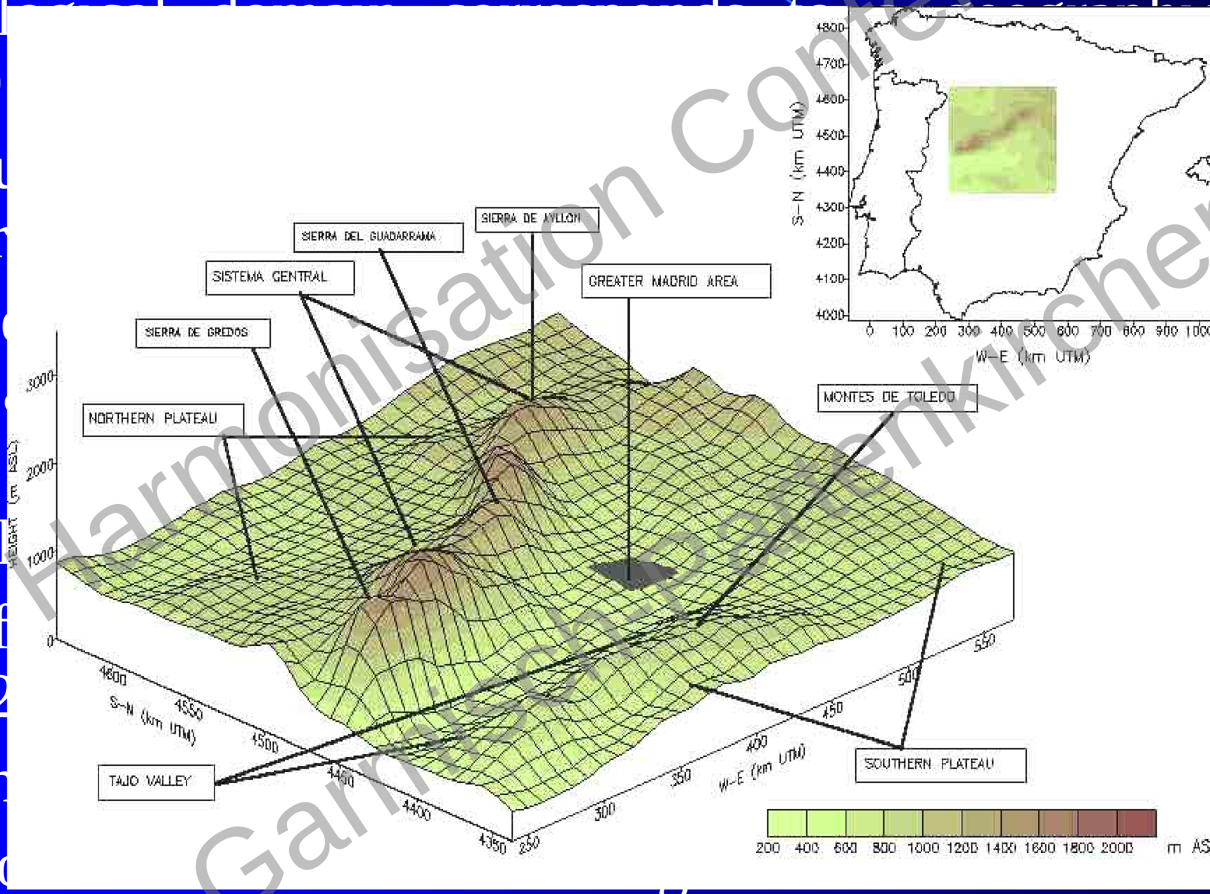
Cluster	Julian day	%	Wind Speed (m/s)	Wind Direction (º)	Night	Morning	Noon	Afternoon	Evening
1	256	4	7.2	333	○				
2	192	13	3.3	281					
	186	9	4.7	159	○	○	○		○
	158	12	5.3	114					○
	173	13	5.7	135					○
	215	22	3.4	217					
	153	7	2.8	98					
3	188	12	5.1	143					○
	209	7	4.6	176	○				

Simulations of photochemical air pollution Model description

- Meteorological model used was the Topographic Vorticiy Mesoscale (**TVM**) model (Thunis and Clappier, 2000).
- Evaluated for the same domain (Martín *et al*., 2001a, 2001b).
- Meteorological model is coupled to **a transport/chemistry module** based on the CIT model (McRae *et al*.,1983) and updated by Harley *et al*. (1993).
- Operator splitting technique by which advection is integrated separately from the diffusion/chemistry.
- Highly accurate and computational efficient hybrid scheme Gong and Cho (1993) for solving the chemical system of **RACM mechanism** (Stockwell *et al*., 1997).
- TVM+RACM has simulated satisfactory ozone pollution episodes taking place in this region (Palacios, 2001; Palacios *et al*., 2002b).

Simulations of photochemical air pollution
Meteorological model setup

- Meteorol[...] al area of 360x300
- Non-regu[...] considering 64x54 gr
- Spatial r[...] coinciding with the
- Capture [...] the main mesoscal
- Terrain f[...] e lowest of them at 2[...] m.
- Top of th
- Simulatio



Simulations of photochemical air pollution
Photochemical model setup

- A different grid than that for meteorology was used to run the transport/chemical module.
- Photochemical modeling domain is 270x200 km^2
- Regular resolution of 5x5 km^2 coinciding with the area of maximum resolution of the TVM model.
- 54x40 grid points in horizontal
- 8 in the vertical up to 4400 m above the ground.
- Simulations cover 37 hours starting at 1200 UTC.
- Emission data resulted from a Top-Down methodolgy (Palacios and Martín, 2002):
  - Spatial disaggregation to 5x5 Km cells.
  - Time disaggregation → hourly.
  - VOC speciation (18 species) by Loibl et al. (1993)

RESULTS
Analysis of simulated flow patterns.

1992

1995

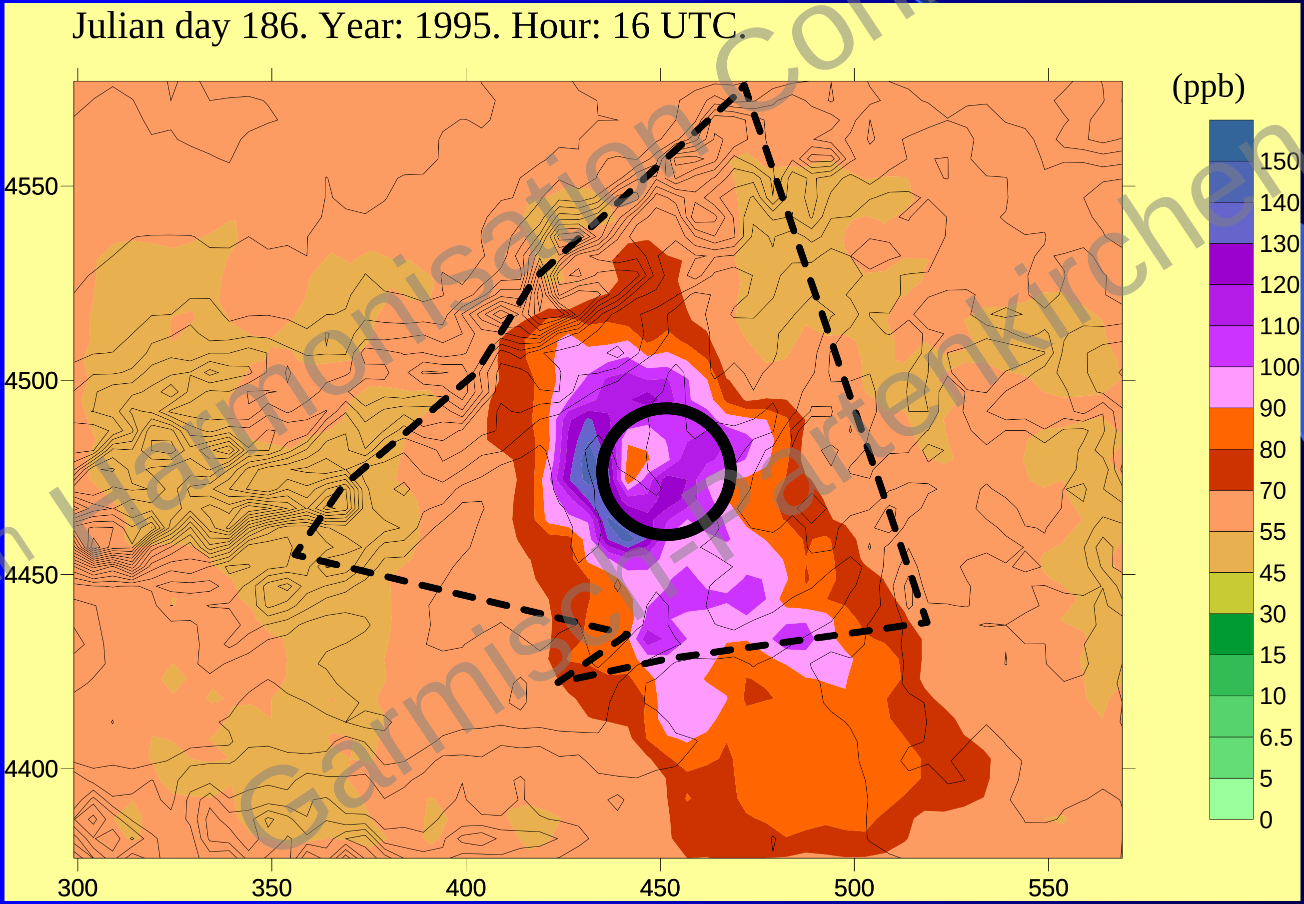
- Very notable air flow cycles.
- Mesoscale wind flows are strongly driving by the synoptic forcing.
- In many cases, surface winds have the same direction than those of synoptic.

RESULTS
Analysis of the simulated patterns of ozone concentration (1)

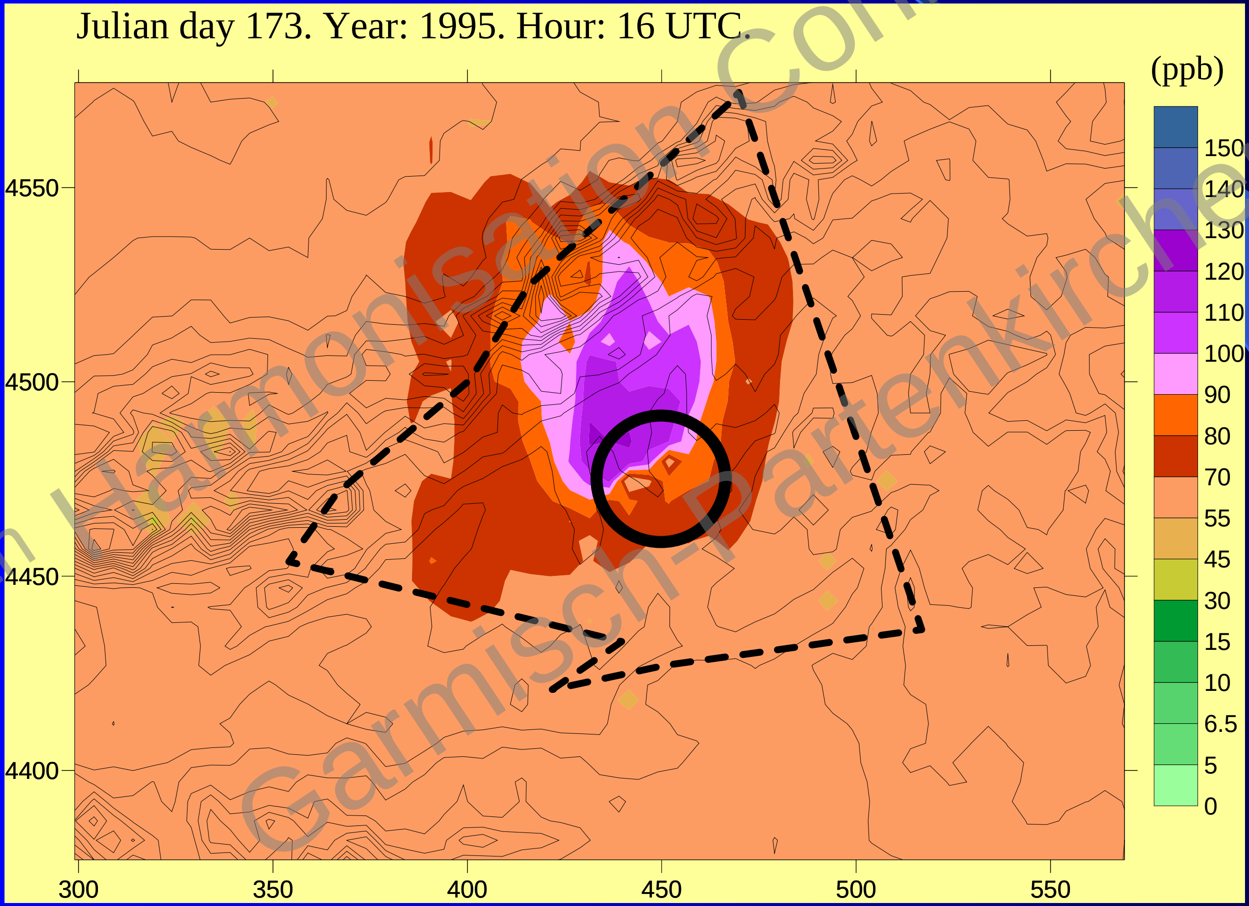
Four Ozone concentration patterns:

- Type A : The whole Community of Madrid
- Type G: Sierra del Guadarrama (Northwest)
- Type N: Sierra de Ayllón (North)
- Type E: East from Madrid metropolitan area.

Type A

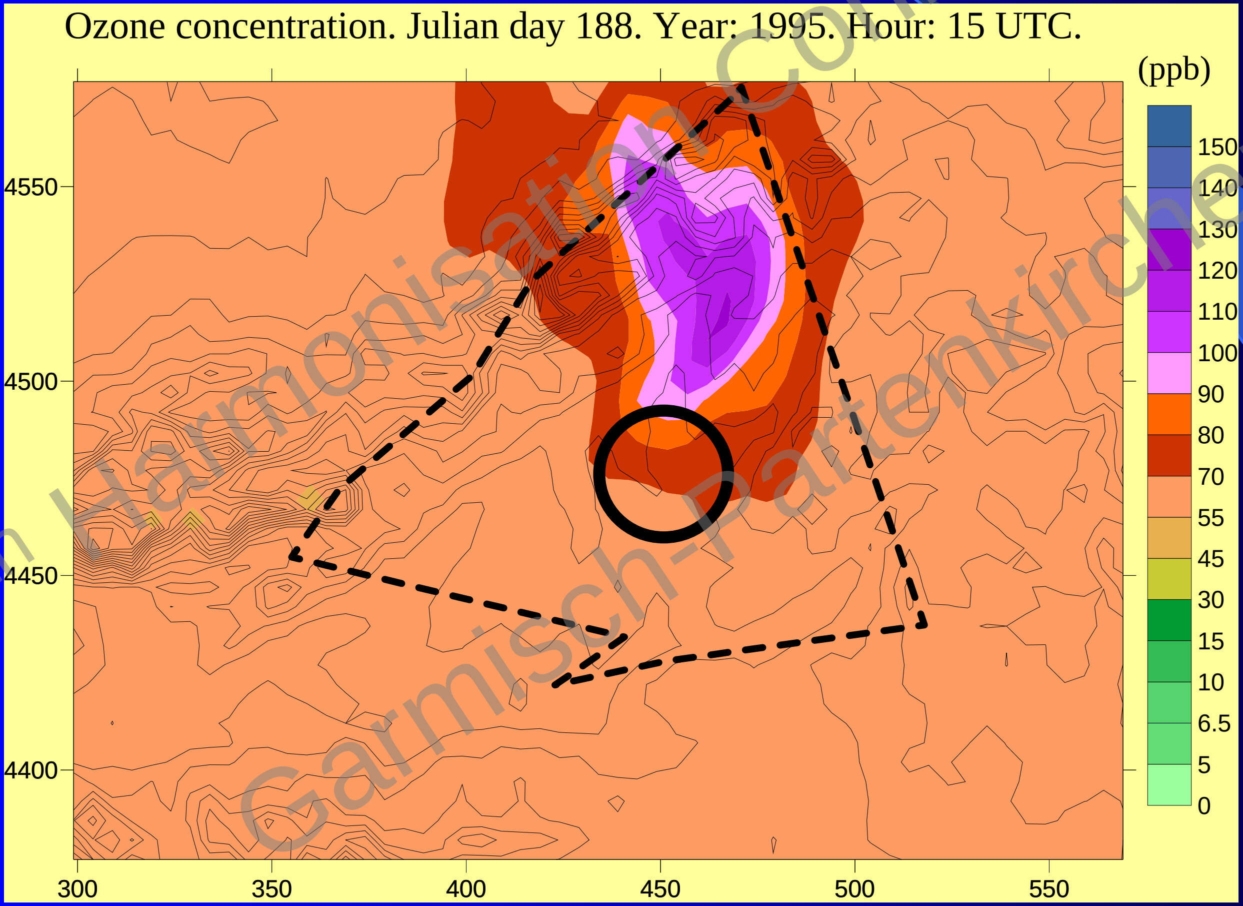

Julian day 186. Year: 1995. Hour: 16 UTC.
(ppb)
150
140
130
120
110
100
90
80
70
55
45
30
15
10
6.5
5
0
4550
4500
4450
4400
300
350
400
450
500
550

Type G



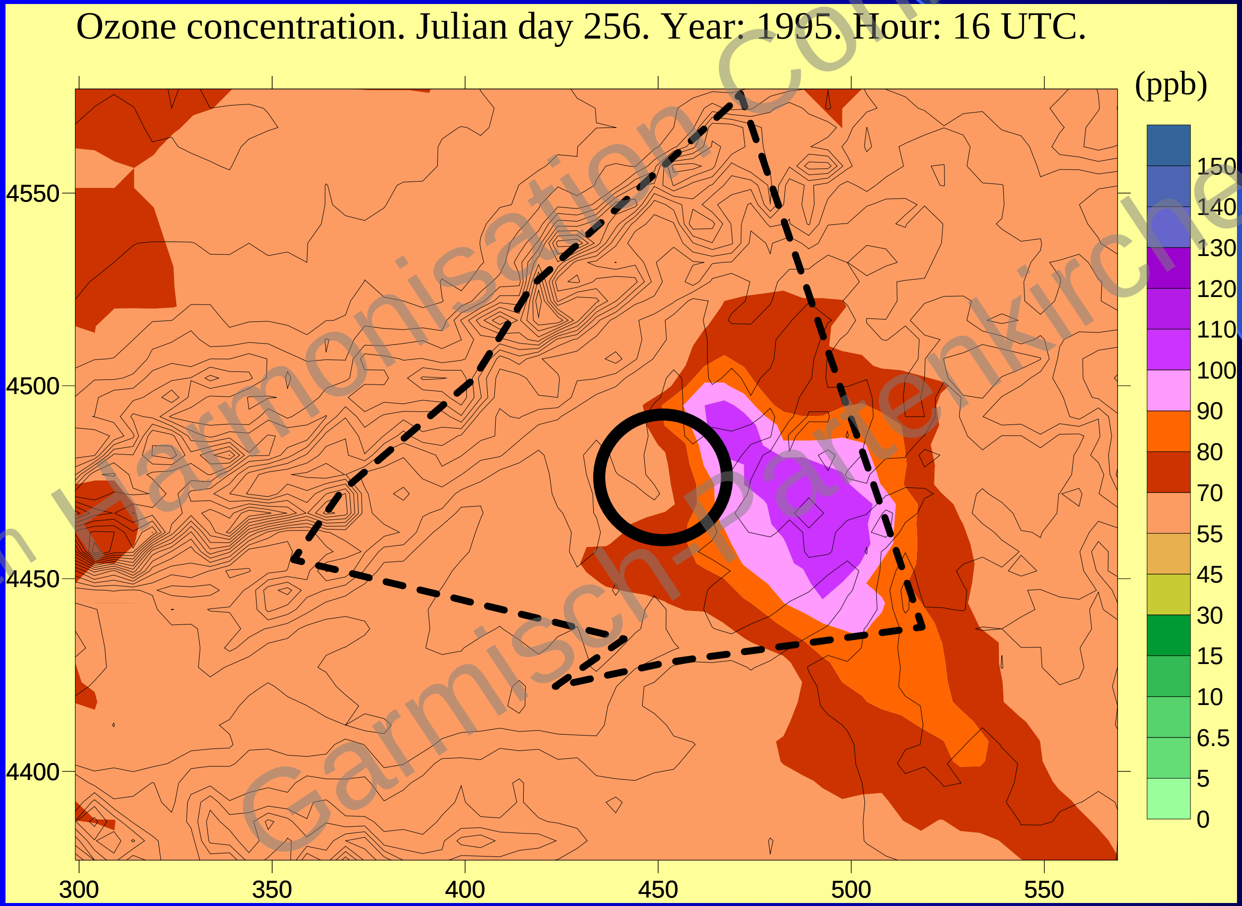
Julian day 173. Year: 1995. Hour: 16 UTC.
(ppb)
150
140
130
120
110
100
90
80
70
55
45
30
15
10
6.5
5
0
4550
4500
4450
4400
300
350
400
450
500
550

Type N



Ozone concentration. Julian day 188. Year: 1995. Hour: 15 UTC.
(ppb)
150
140
130
120
110
100
90
80
70
55
45
30
15
10
6.5
5
0
4550
4500
4450
4400
300
350
400
450
500
550

Type E



Ozone concentration. Julian day 256. Year: 1995. Hour: 16 UTC.
(ppb)
150
140
130
120
110
100
90
80
70
55
45
30
15
10
6.5
5
0
4550
4500
4450
4400
300
350
400
450
500
550

RESULTS
Analysis of the simulated patterns of ozone concentration (2)

1992

Cluster	Julian day	%	Night	Morning	Noon	Afternoon	Evening	Ozone maxima location	Ozone maxima (ppb)
1	133	3	↗	¬	↘	↘	o	G	104
2	112	13	↗	¬	✓	└	o	A	115
	118	19	↗	↘	✓	✓	└	N	103
	276	4	o	o	✓	└	↖	E	91
	177	23	o	✓	✓	✓	└	N	114
	253	4	o	⌋	✓	✓	└	N	92
3	195	9	o	✓	└	└	└	E	112
	197	9	↗	¬	↘	↘	o	G	110
	213	16	¬	↘	›	›	↘	N	88

RESULTS
Analysis of the simulated patterns of ozone concentration (3)

1995

Cluster	Julian day	%	Night	Morning	Noon	Afternoon	Evening	Ozone maxima location	Ozone maxima (ppb)
1	256	4	○					E	110
2	192	13						N	117
	186	9	○	○	○		○	A	149
	158	12					○	G	117
	173	13					○	G	126
	215	22						N	81
	153	7						N	103
3	188	12					○	N	121
	209	7	○					N	82

RESULTS

Analysis of the simulated patterns of ozone concentration (4)

- Not very high ozone levels → strong winds and low isolation
- Very high ozone levels → weak winds and high isolation.
- High concentrations areas related to the synoptic wind forcing on the diurnal wind flow cycle.
- Frequently, high concentrations areas are 100 Km away from city.
  - Type N (affecting North area) → 61%
    - Maximum average (104 ppb) but large variability in ozone levels (81-121 ppb).
  - Type G (affecting Northwest area) → 18%
    - Maximum average (117 ppb), variability (104-126 ppb)
  - Type A (affecting almost all Community of Madrid) → 12%
    - Maximum average (129 ppb) with a record of 149 ppb.
  - Type E (affecting East area) → 9%
    - Maximum average (107 ppb), variability (91-112 ppb)