Zentralanstalt für Meteorologie und Geodynamik

Operational ozone forecasts for Austria

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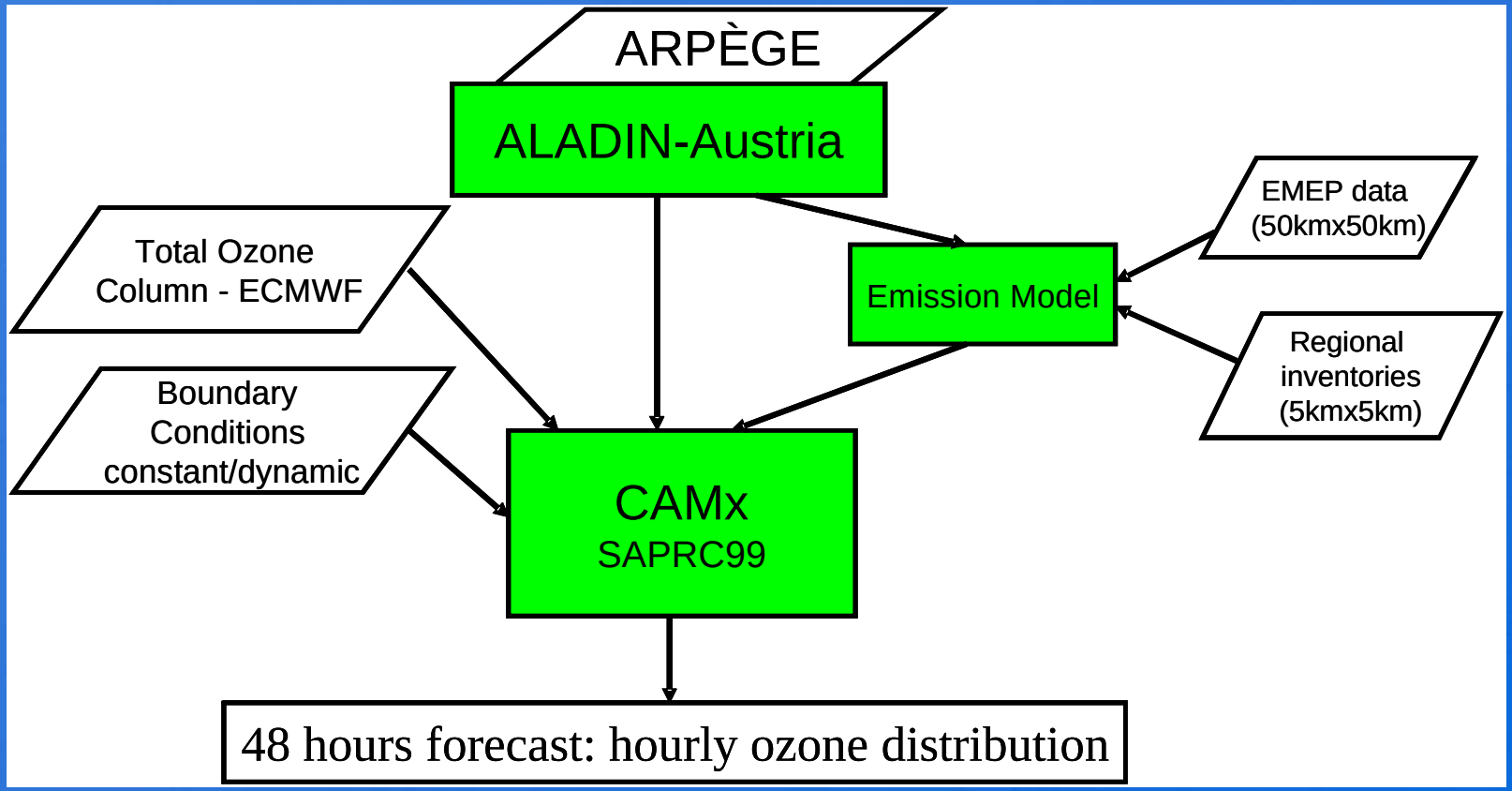
Overview

- Model set-up
- Evaluation
  - Ozone episode 2003
  - Operational test-run in summer 2005 and 2006
- Outlook

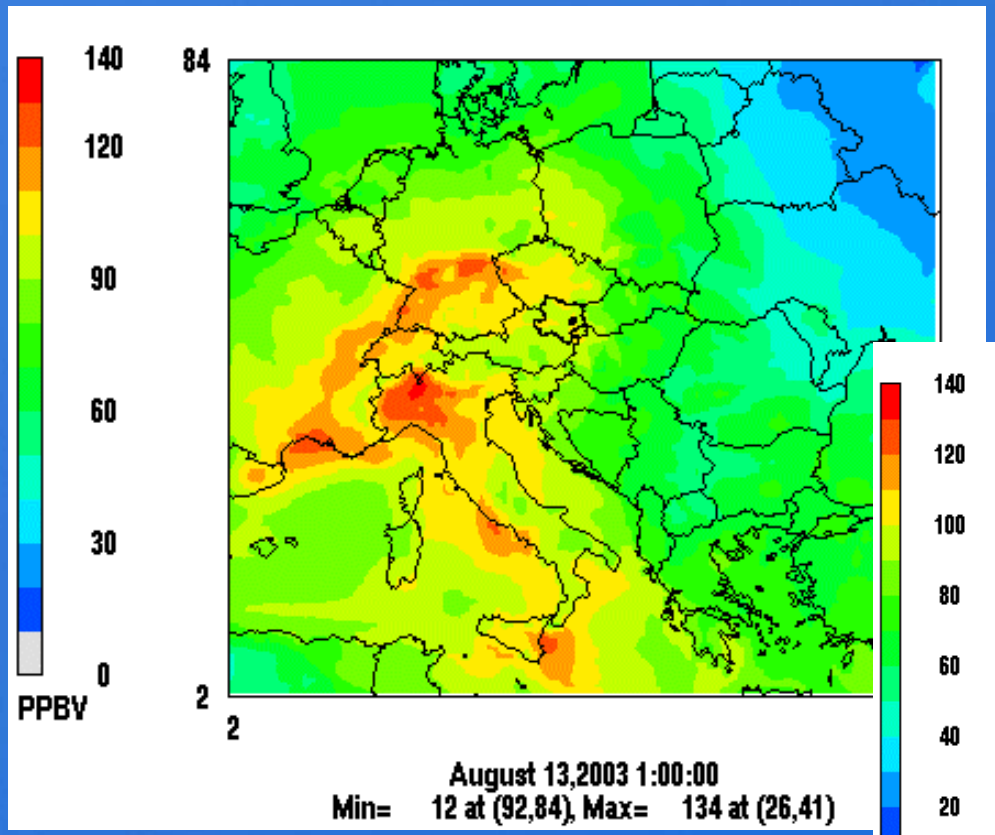
The Austrian Ozone Forecast Model System



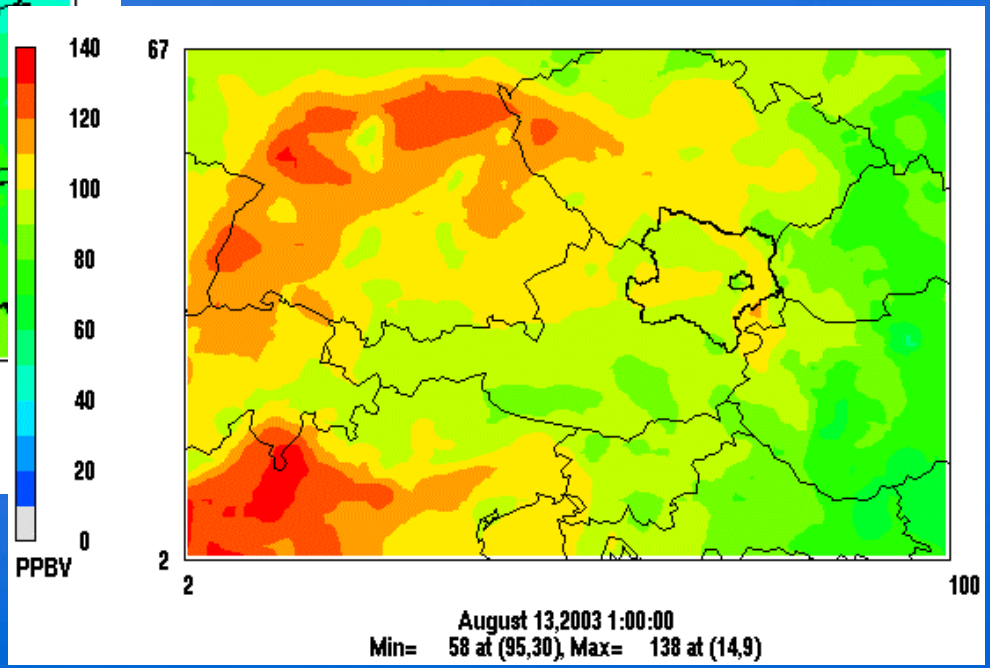
Modelling domain

Horizontal resolution: 2 nested grids

Δx = 27 km



Δx = 9,6 km



Modelling domain

Vertical grid

ALADIN	CAMx	
30+31+32+33	15	11000 m
26+27+28+29	14	8500 m
22+23+24+45	13	6200 m
19+20+21	12	4500 m
16+17+18	11	3400 m
14+15	10	2500 m
13+12	9	1900 m
10+11	8	1400 m
8+9	7	950 m
6+7	6	600 m
5	5	350 m
4	4	250 m
3	3	150 m
2	2	80 m
1	1	30 m

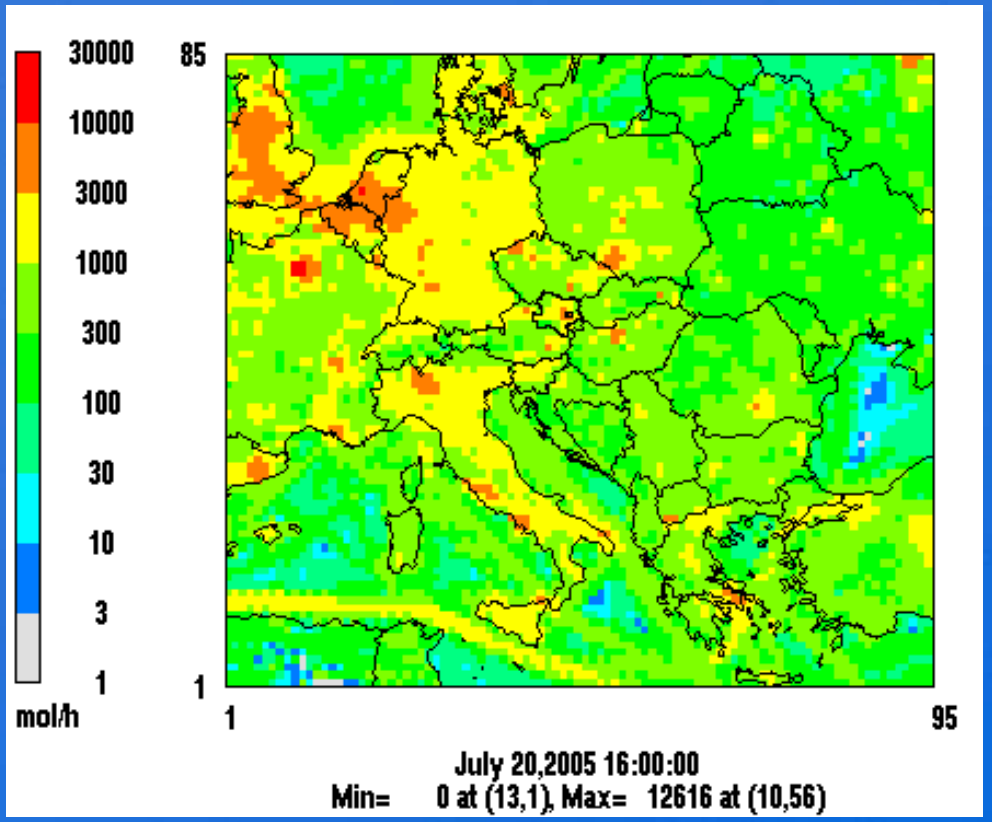
best possible vertical resolution

Emissions

EMEP (1999/2003) emissions are used for Europe.

For Austria, Czech Republic, Slovakia, and Hungary the original 50 km x 50 km data are downscaled to 5 km x 5 km based on an inventory from 1995 (Winiwarter and Zueger, 1996).

In addition, a new highly resolved (up to 100 m x 100m) emission inventory for the City of Vienna (Orthofer et al., 2005) is used for this area.

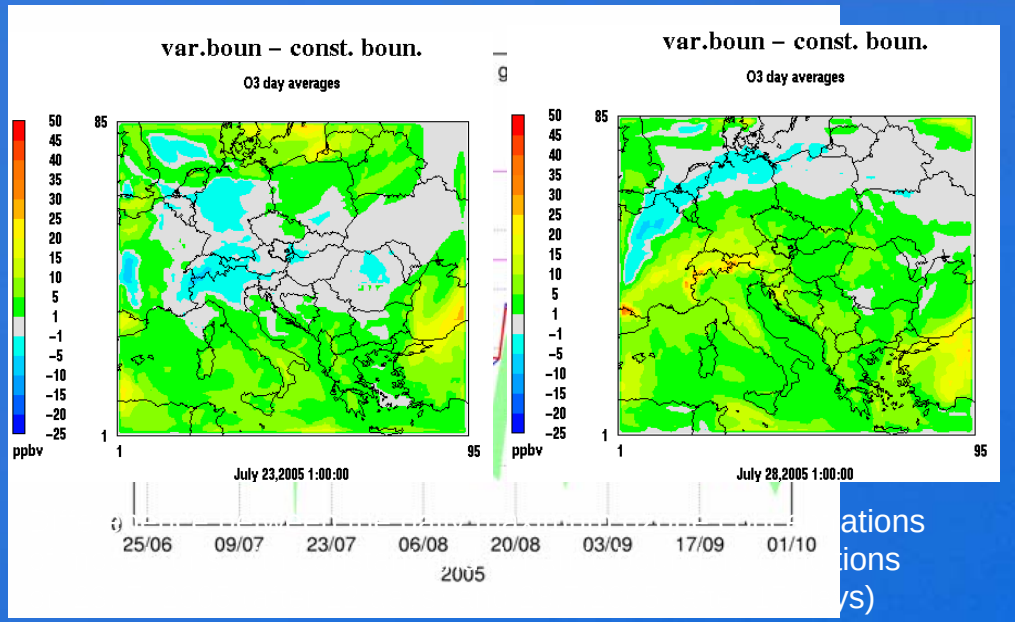


NO2 emissions in the coarse grid (27 km), Wednesday, July 20, 2005, 16:00, unit: mole/gridcell h, base: EMEP 2003.

Boundary conditions

Calculation of the outer boundary conditions

- 2005 constant values (11.7.2003)
  - The main problem in the forecast calculations of 2005 occurred in September, when ozone concentrations were calculated too high.
- 2006 dynamic boundary conditions
  - concentrations calculated for the second grid row/column of the previous day at the same hour by the model CAMx



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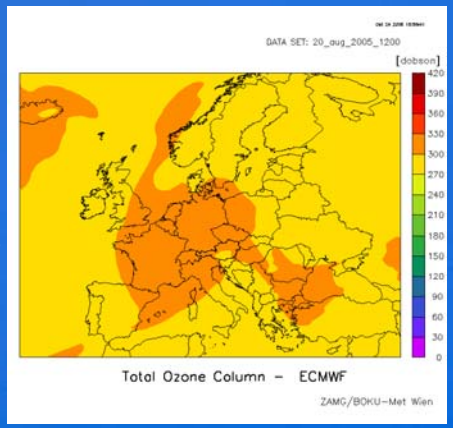
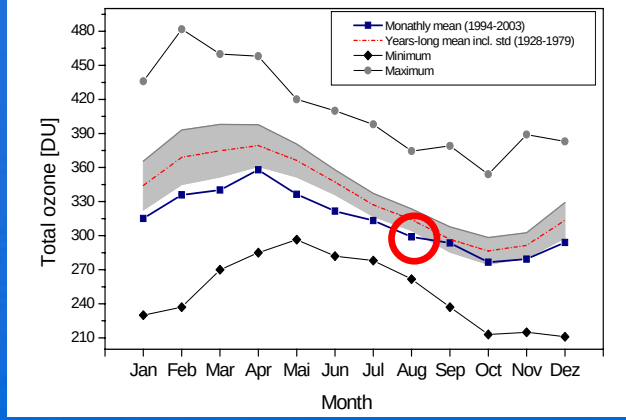
Total ozone column

- 2005 constant values of 300 DU
- 2006 integration of operational ECMWF data



ECMWF forecast for total ozone column



1994-2003: Sonnblick
1928-1979: Arosa

Meteorological input data from ALADIN-Austria

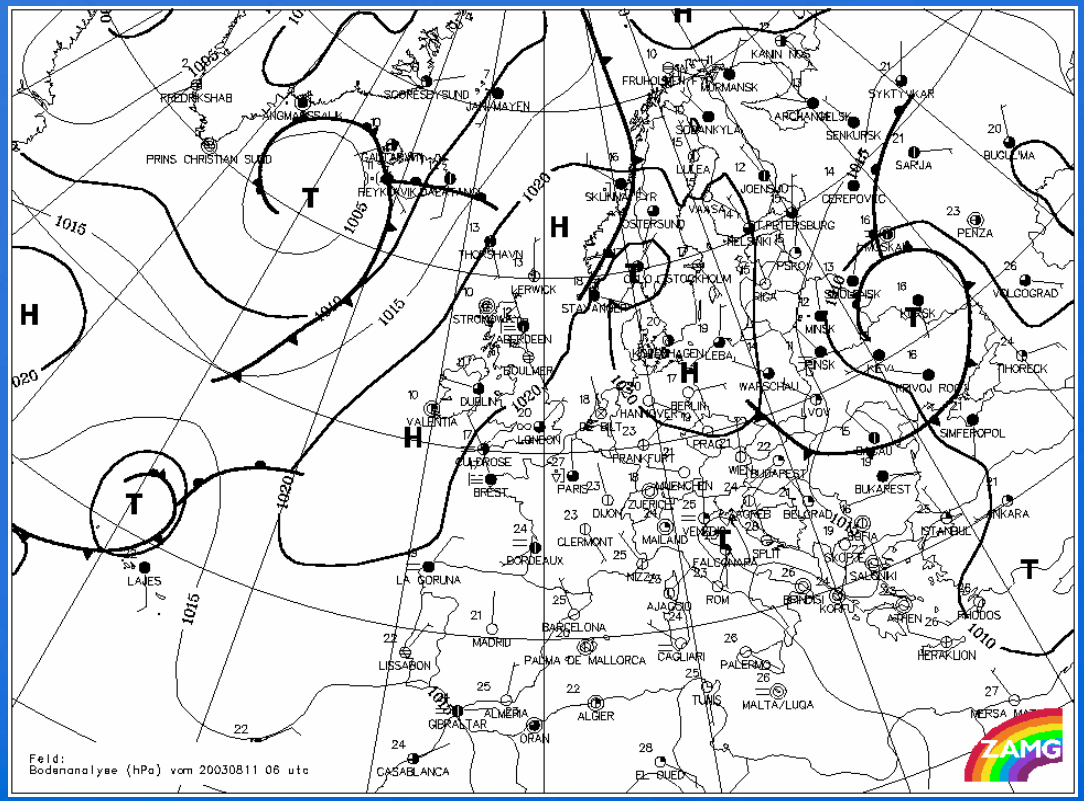
- Air pressure
- Horizontal wind
- Temperature
- Humidity
- Rainrate (convective,large scale)

- Cloud water content ← Convective rainrate (Scott, 1978)
  Nonconvective cases: from optical depth
- Rain water content ← Large scale and convective rain
- Optical depth ← Humidity and layer thickness (CHIMERE)
- Vertical diffusion coefficient ← Wind shear, stability (Ri-number)
  Louis (1979)

Evaluation (ozone episode in August 2003)

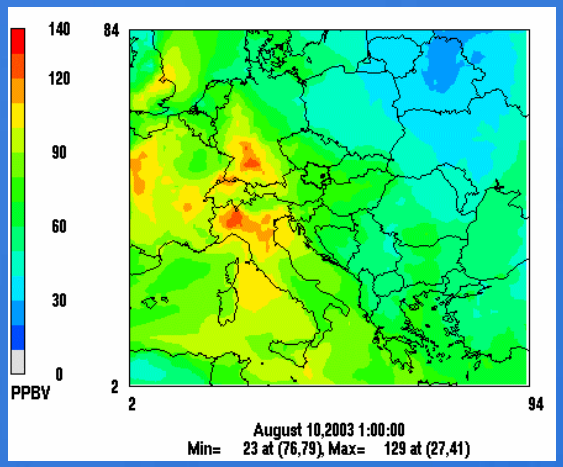
8. – 14. August 2003

- high pressure
- dry and hot air masses
- stable conditions

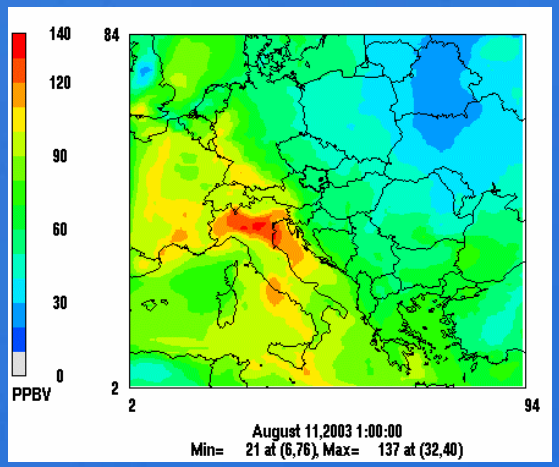


Evaluation (ozone episode in August 2003)

ALADIN/CAMx – SAPRC99 Layer 1 (daily maximum ozone)



10.8.2003



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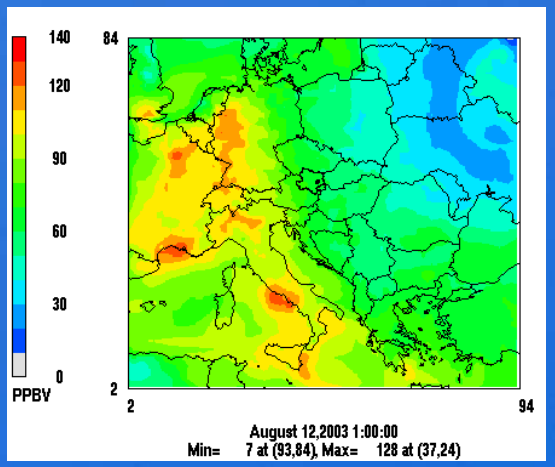
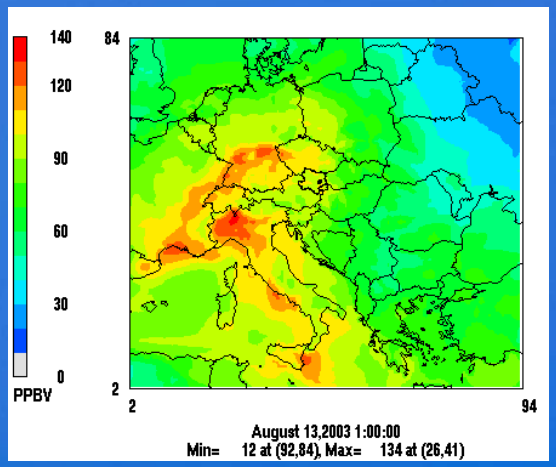
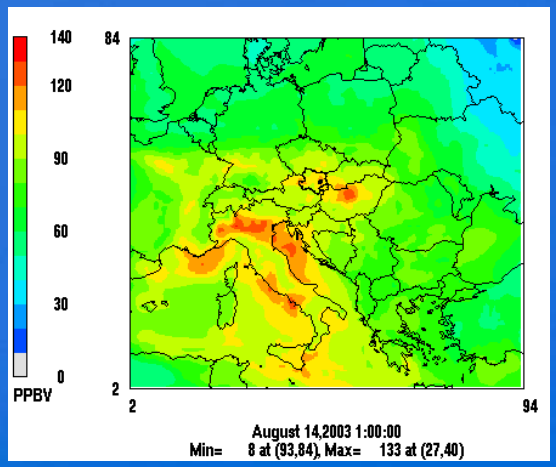


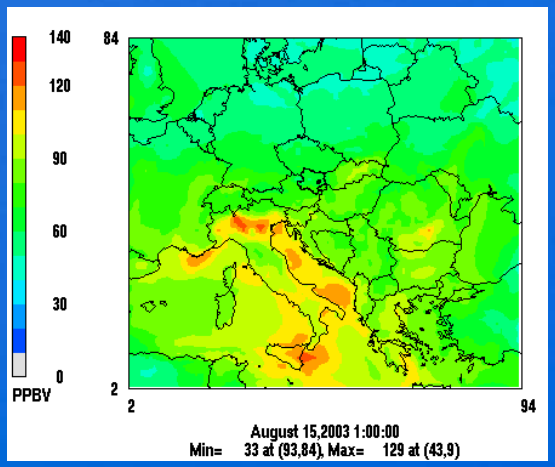
12.8.2003



13.8.2003



14.8.2003

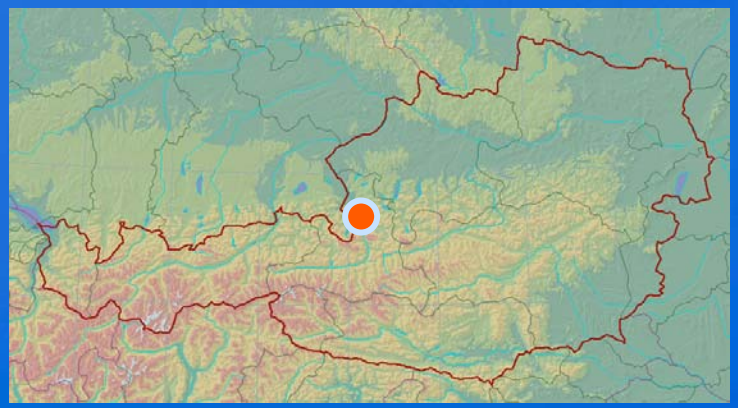


15.8.2003

Evaluation (ozone episode in August 2003)

Measurem.

Measurements/ppbv



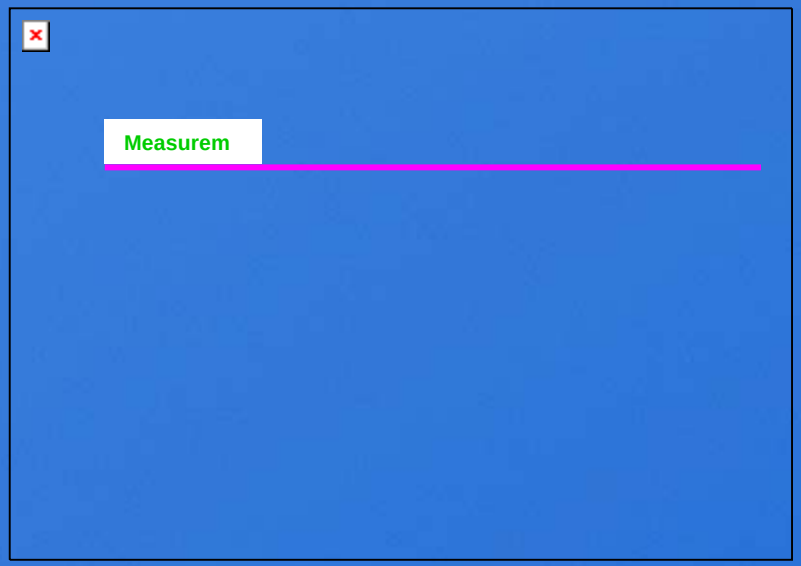
Ozone:

Information – 90 ppbv

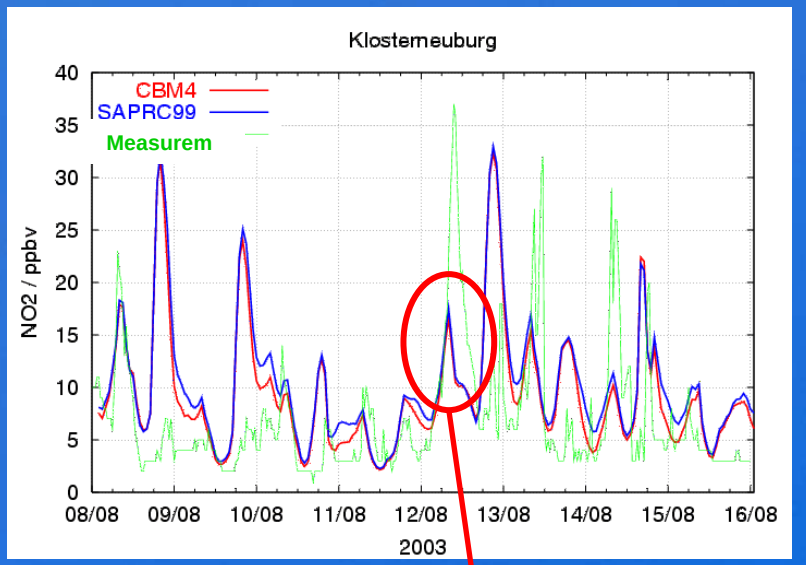
Alarm – 120 ppbv

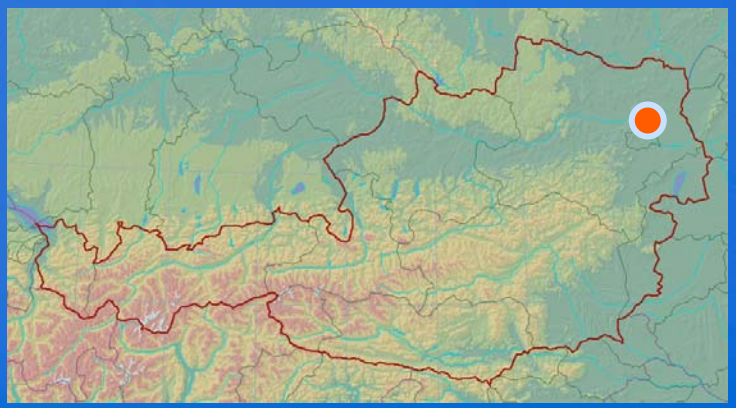
Evaluation (ozone episode in August 2003)

O3



NO_2



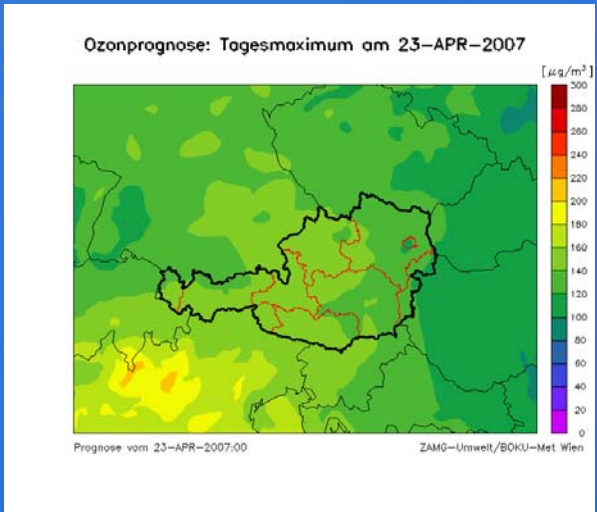


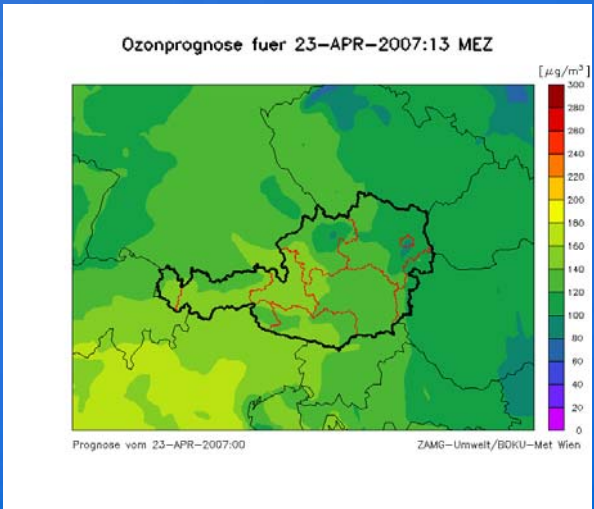
Temperature reduction in the previous night -> inversion

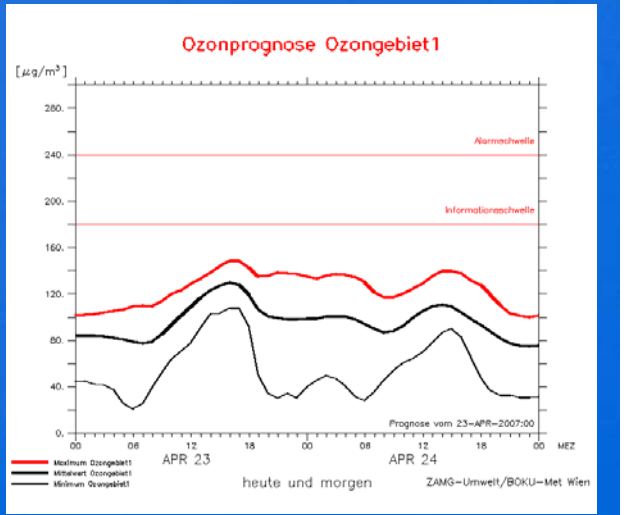
not resolved by meteorological model

Operational Test-run (Summer 2005 and 2006)

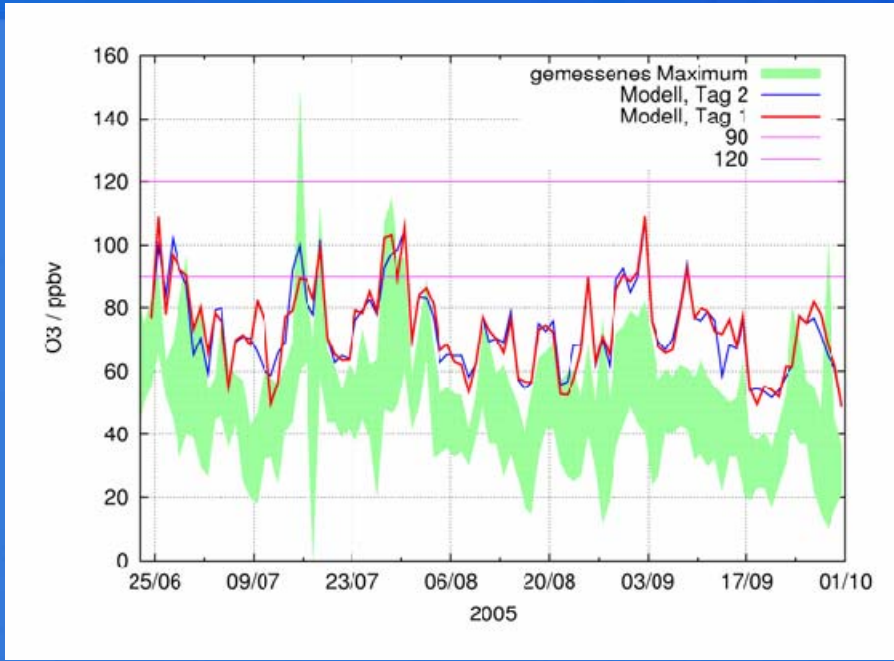
- Automatic model start as soon as ALADIN-Austria fields available
- 48 hours ozone forecasts available at ~7:30 am local time
  - performance for a workstation with 4-Dual Core Opteron processors ~8min for 24h (using pgf90 compiler with OMP and the SAPRC99 mechanism)
- Fields of the previous run are used as input
- Automatic distribution of results (Email and internal homepage)





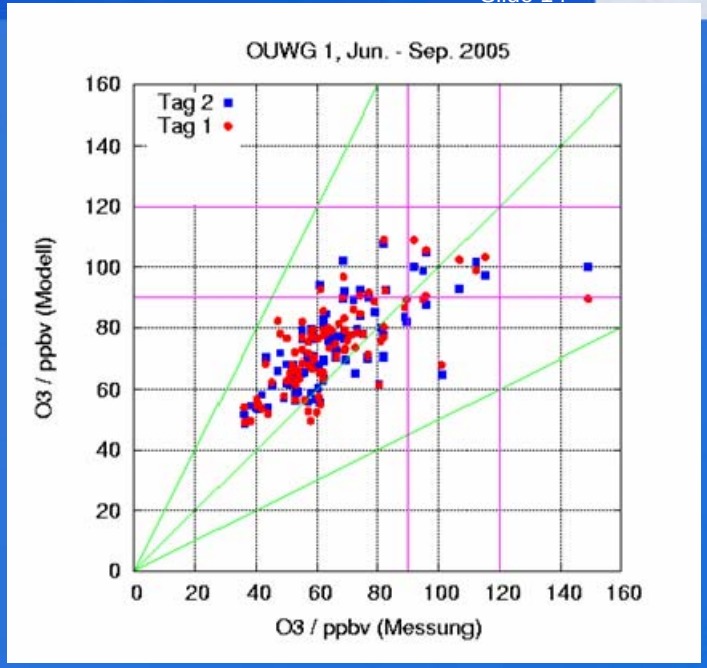


Evaluation of ozone warnings summer 2005



Daily ozone maxima in the Austrian ozone region 1

Green area: range between highest and lowest maximum observations (hourly average) at stations within the region
Blue line: maximum predicted on previous day
Red line: maximum predicted on same day
Magenta lines: information and alert threshold (Directive 2002/3/EC)

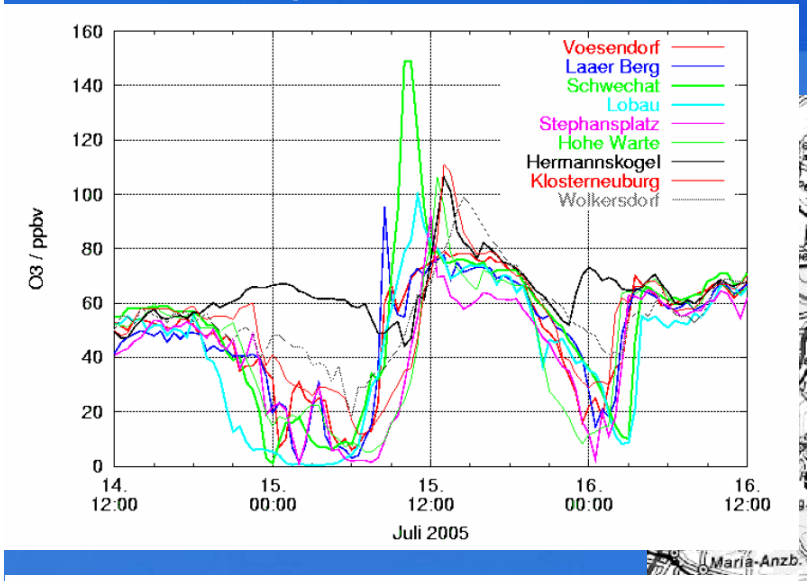


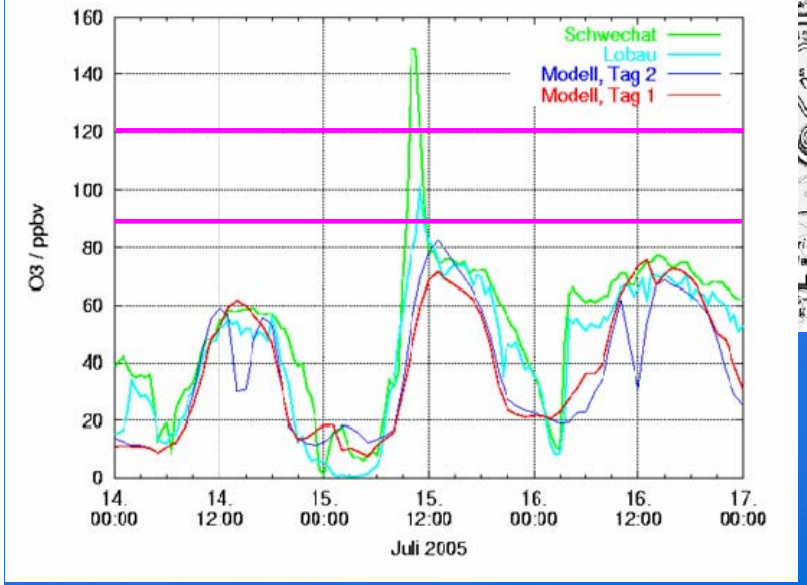
Scatter-diagram of daily ozone maxima predicted versus observed in ozone region 1

Blue: maximum predicted on previous day
Red : maximum predicted on same day
Magenta lines: information and alert threshold (Directive 2002/3/EC)

- The simulated maximum ozone values were close to the observed values in July and August and tended to overestimate the measurements in September.
- The excess of the 90 ppbv threshold were correctly predicted on 6 days out of 9 in summer 2005. On 6 days, values above the threshold were predicted but not observed.

Ozone episode summer 2005





- exceedance of alarm threshold at Schwechat (airport and industrial area) on 15th july.
- local peak emissions ?

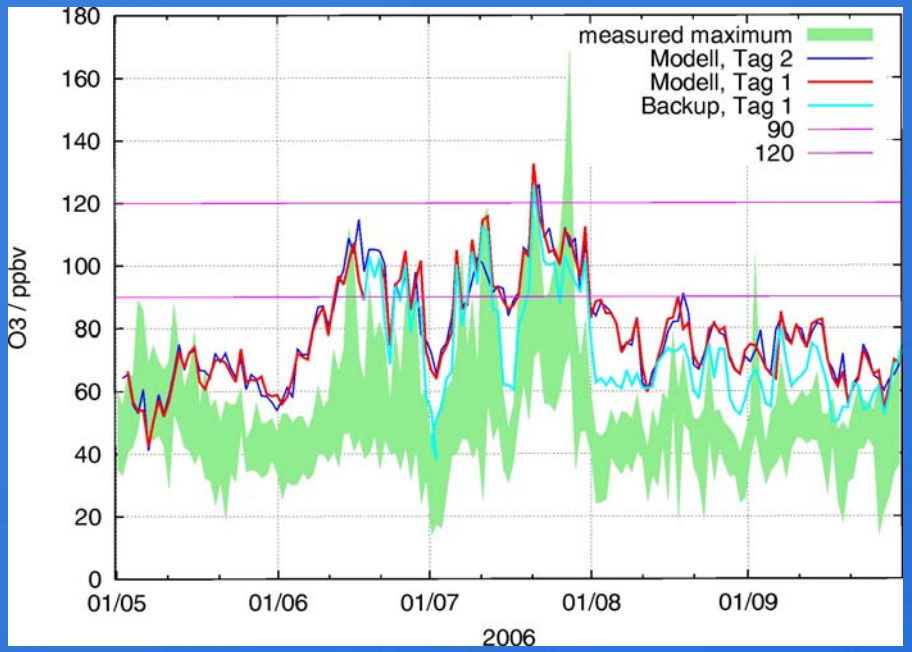
Statistics 2005

	Day 1		Day 2		July		9-18 h	
	r	$s_{y,z}$	r	$s_{y,z}$	r	$s_{y,z}$	r	$s_{y,z}$
Amstetten	0.63	11.4	0.66	10.7	0.63	11.2	0.72	10.5
Annaberg	0.33	10.0	0.37	9.1	0.48	8.3	0.57	8.3
Bad Vöslau	0.56	10.3	0.58	9.7	0.64	8.3	0.64	9.9
Dunkelsteiner W.	0.66	9.8	0.68	9.4	0.70	9.8	0.73	9.3
Eisenstadt	0.58	10.6	0.60	10.0	0.60	9.6	0.68	9.5
Forsthof	0.61	9.1	0.62	8.6	0.66	8.0	0.70	8.3
Gänserndorf	0.71	10.2	0.74	9.8	0.73	9.9	0.76	9.4
Großenzersdorf	0.73	11.3	0.75	11.0	0.76	9.7	0.75	10.7
Hainburg	0.73	10.6	0.76	10.1	0.76	9.3	0.76	9.5
Heidenreichstein	0.64	9.0	0.67	8.3	0.69	8.2	0.72	8.0
Hermannskogel	0.54	13.8	0.56	13.7	0.61	12.3	0.70	12.3
Himberg	0.69	12.1	0.71	11.6	0.74	10.5	0.76	10.5
Hohe Warte	0.69	11.9	0.71	11.7	0.70	11.0	0.74	11.7
Illmitz	0.67	10.3	0.69	9.8	0.71	9.0	0.75	8.7
Stephansplatz	0.62	13.0	0.63	12.9	0.61	12.2	0.70	12.4
Irnfritz	0.70	8.8	0.72	8.6	0.72	8.7	0.74	8.6
Kittsee	0.67	11.8	0.72	11.3	0.73	9.9	0.77	9.5
Klosterneuburg	0.71	10.6	0.74	10.3	0.73	10.3	0.77	9.9
Kollmitzberg	0.70	10.7	0.71	10.2	0.76	9.4	0.73	10.5
Krems	0.63	9.8	0.64	9.6	0.62	9.7	0.66	9.9
Laaer Berg	0.66	12.5	0.68	12.2	0.71	10.7	0.73	11.8
Lobau	0.77	12.0	0.79	11.8	0.77	11.3	0.73	12.3
Mistelbach	0.70	10.0	0.72	9.7	0.70	10.3	0.74	9.3
Mödling	0.61	10.2	0.63	9.6	0.65	8.8	0.73	9.2
Oberwart	0.48	8.7	0.51	8.3	0.61	7.4	0.62	8.2
Pillerdorf	0.72	9.2	0.73	8.8	0.74	8.8	0.75	8.6
Pöchlarn	0.62	10.6	0.65	9.9	0.66	10.5	0.69	10.0
Purkersdorf	0.57	10.7	0.60	10.2	0.64	9.5	0.71	9.5
Payerbach	0.51	7.4	0.49	7.3	0.57	6.6	0.52	7.5
Schwechat	0.74	12.8	0.76	12.3	0.74	12.1	0.74	12.0
Stixneusiedl	0.73	11.1	0.75	10.6	0.76	10.0	0.77	10.1
Stockerau	0.73	10.1	0.75	9.7	0.75	9.9	0.75	10.0
St. Pölten	0.67	10.2	0.71	9.6	0.72	9.8	0.77	9.3
Streithofen	0.63	11.0	0.64	10.8	0.62	11.1	0.71	10.4
St. Valentin	0.66	12.4	0.69	11.7	0.67	12.3	0.71	12.1
Ternitz	0.56	8.2	0.58	7.9	0.64	7.0	0.68	7.8
Tulln	0.61	11.3	0.64	11.0	0.64	11.5	0.64	11.4
Waidhofen / Y.	0.54	10.4	0.58	9.7	0.57	9.5	0.63	10.2
Wiesmath	0.63	7.5	0.60	7.5	0.67	6.7	0.69	7.5
Wiener Neustadt	0.60	9.0	0.62	8.5	0.67	7.7	0.74	7.9
Wolkersdorf	0.71	10.0	0.73	9.7	0.73	9.9	0.75	9.5
Average	**0.64**	**10.50**	**0.66**	**10.07**	**0.68**	**9.68**	**0.71**	**9.81**

r ... correlation
s ... standard deviation

- Day 1: forecast for the first day
- Day 2: forecast for the second day
- July: only forecasts of July
(no exceedances during other months)
- 9-18h: only hours between 9 a.m. and 6 p.m. are considered

Evaluation of ozone warnings summer 2006



Daily ozone maxima in the Austrian ozone region 1

Green area: range between highest and lowest maximum observations (hourly average) at stations within the region
Red line: maximum predicted on previous day
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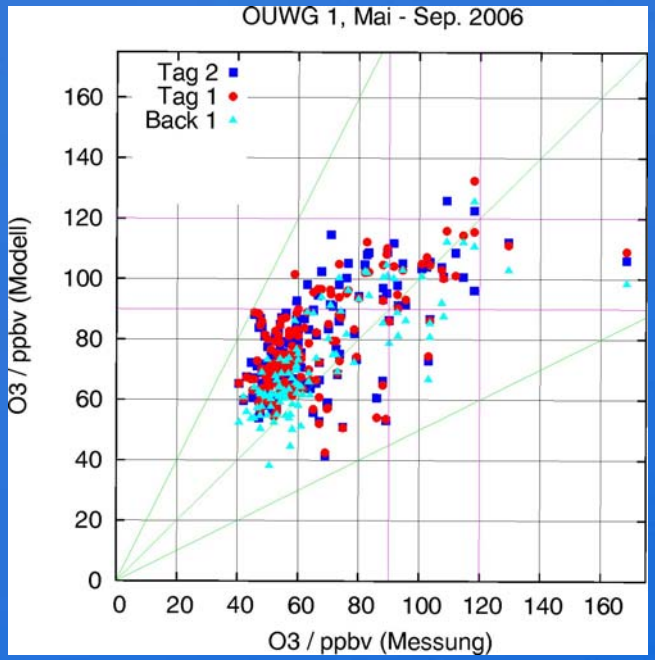
Magenta lines: information and alert threshold (Directive 2002/3/EC)

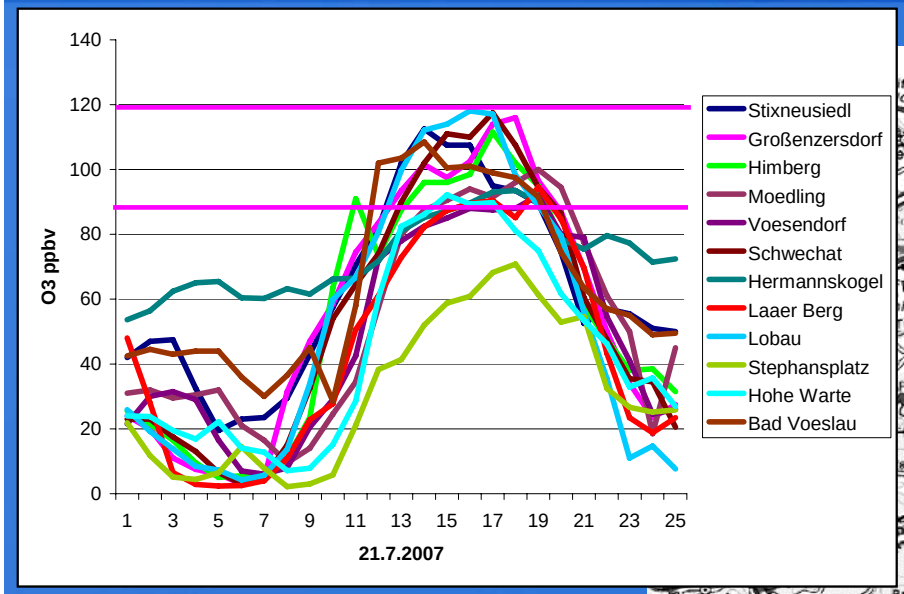


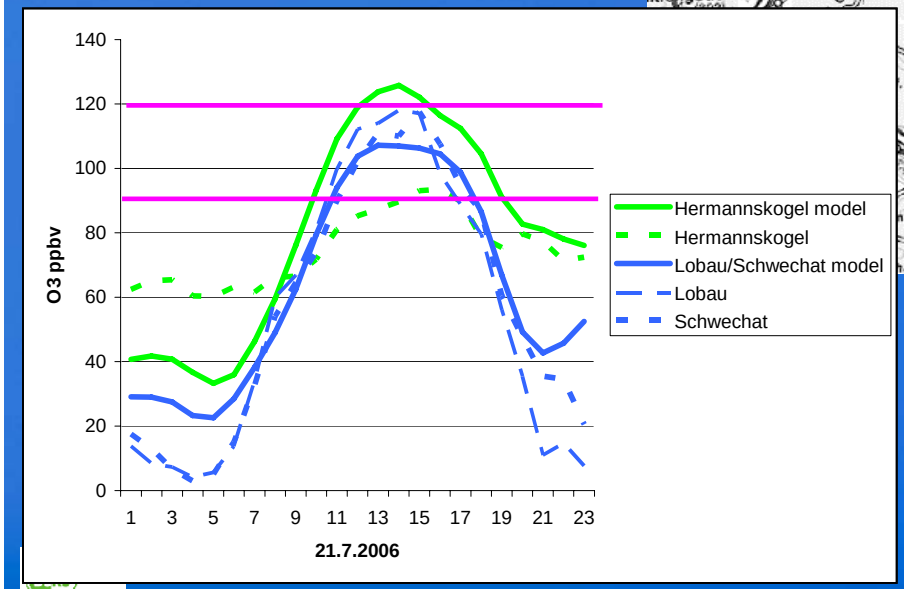
Scatter-diagram of daily ozone maxima predicted versus observed in ozone region 1

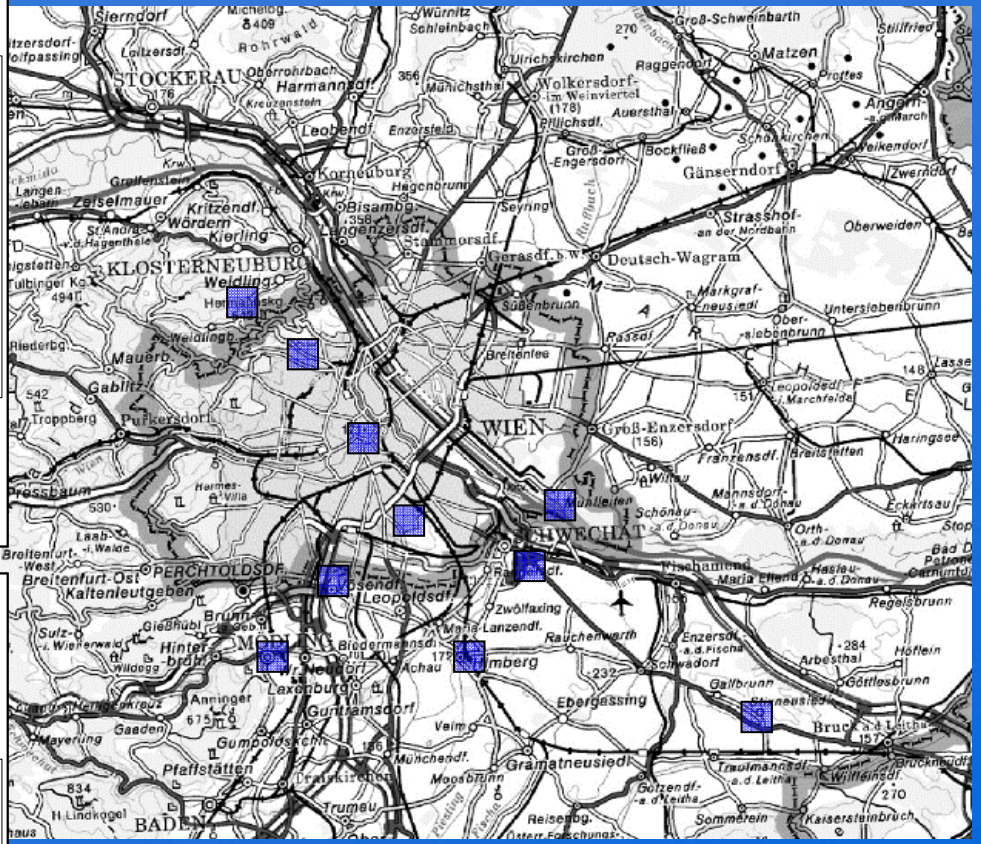
Blue: maximum predicted on previous day
Red : maximum predicted on same day
Magenta lines: information and alert threshold (Directive 2002/3/EC)

According to the station measurements, the information threshold has been exceeded on 16 days in the period. 10 of these exceedances were forecasted correctly. The model gave a warning on 11 days when the measurements remained below the information threshold. The alert exceedance predicted for July 21 was not observed but the measured values were just below the threshold value.

Ozone episode summer 2006

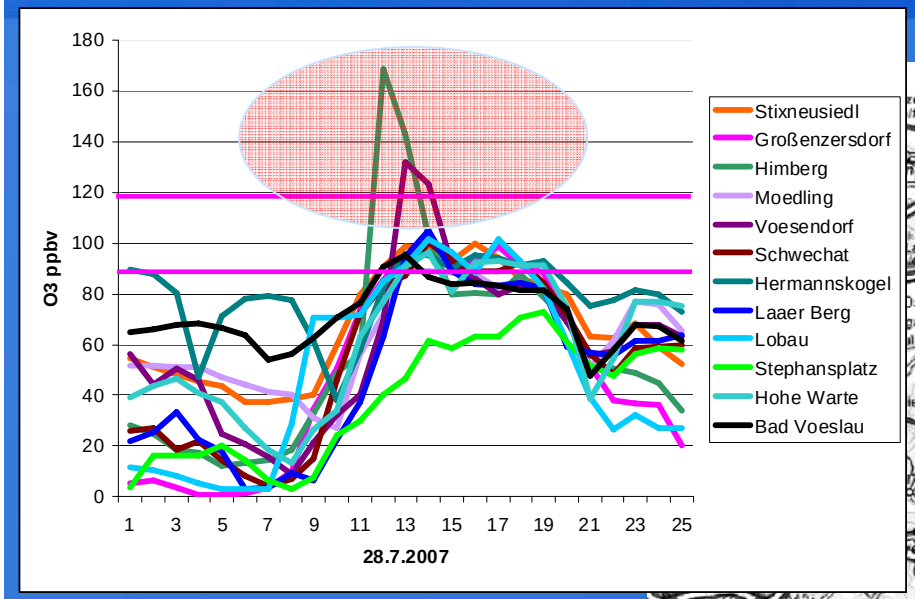


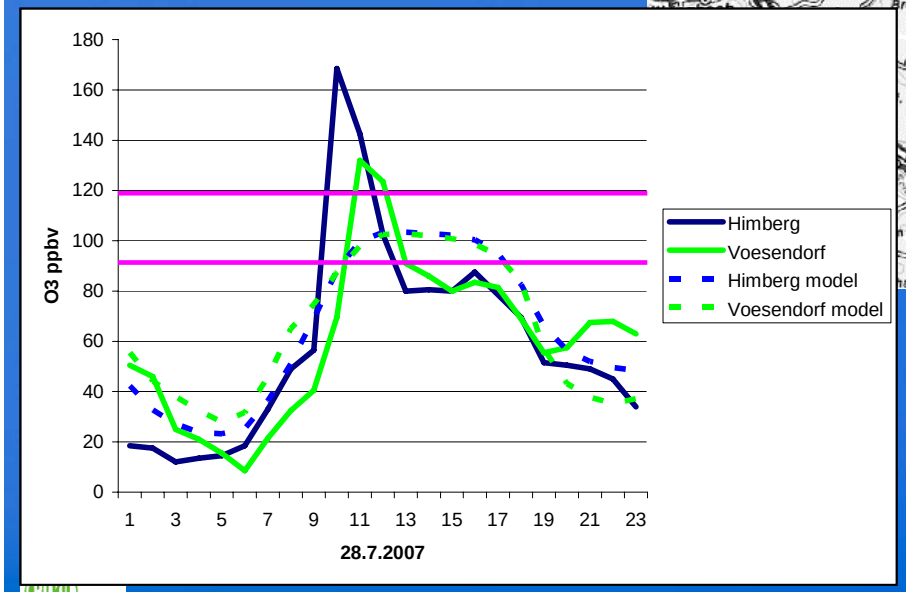


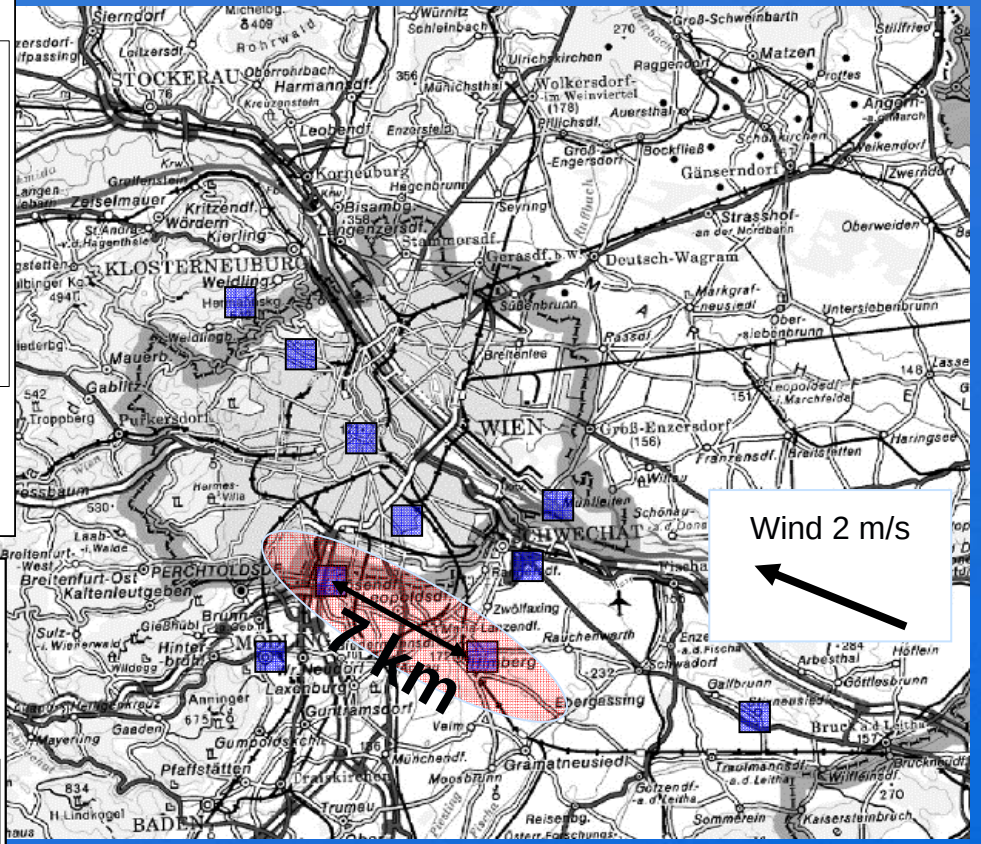


- model predicted an exceedance of the alarm threshold
- observation were close below 120 ppbv

Ozone episode summer 2006







• It is supposed that power plants emitted peak emissions due to maximum electricity required for cooling etc. during this heat wave episode. The model forecast - which is based on average emission data (with seasonal variations) – does not reproduce these singular events.

Statistics 2006

r ... correlation
s ... standard deviation

	forecast day 1		forecast day 2		Backup day 1	
	r	s	r	s	r	s
Eisenstadt	0.62	12.16	0.61	12.54	0.73	10.26
Kittsee	0.63	13.47	0.64	13.15	0.72	11.75
Himberg	0.69	13.10	0.69	13.29	0.76	11.51
Schwechat	0.71	13.85	0.71	13.99	0.78	12.10
Tulln	0.65	14.27	0.65	13.84	0.70	12.49
Wiener Neustadt	0.54	12.23	0.55	12.27	0.64	10.48
Hohe Warte	0.68	13.33	0.68	13.53	0.75	11.56
Lobau	0.71	13.71	0.71	13.99	0.78	12.03
Average	**0.59**	**13.03**	**0.59**	**13.00**	**0.70**	**10.93**

- Day 1: forecast for the first day
- Day 2: forecast for the second day
- Backup Day 1: constant boundary conditions

Hit-rate

- **the highest value of the observations as well as the model forecasts are bellow the information threshold (90 ppbv) in ozone region 1**
- **observation and model lie above the threshold**
- **the observations lie below the threshold, the model above it**
- **the observations lie above the threshold, the model below it**

Obs.	*Mod.*	*May*	*June*	*July*	*Aug.*	*Sep.*	*Total*	*%*
Forecast 2006, day 1								
<90	<90	28	16	11	31	30	116	88.0
>90	>90	0	3	13	0	0	16	
<90	>90	0	11	6	0	0	17	12.0
>90	<90	0	0	1	0	0	1	
Total		**28**	**30**	**31**	**31**	**30**	**150**	
Backup-run 2006, day 1								
<90	<90	-	7	10	31	30	78	84.8
>90	>90	-	1	10	0	0	11	
<90	>90	-	4	7	0	0	11	15.2
>90	<90	-	1	4	0	0	5	
total		-	**13**	**31**	**31**	**30**	**105**	
Forecast 2005, day 1								
<90	<90	-	3	25	30	27	84	90.9
>90	>90	-	2	4	0	0	6	
<90	>90	-	2	0	1	2	6	9.1
>90	<90	-	0	2	0	1	3	
Total		-	**7**	**31**	**31**	**30**	**99**	

Conclusions

- Prediction of threshold exceedances:
  - Information threshold: days with exceedances of the information threshold could be predicted by the model with a probability of 88% during the summer period in 2006.
  - Alarm threshold:
    - current resolution to coarse to resolve local peaks
    - exceedances due to local peak emissions can not be modelled
- Necessary: sensitivity studies with different boundary conditions

Outlook

- Finer horizontal resolution with the model package WRF/SMOKE/CMAQ based on operational ECMWF data: 3 km for eastern Austria
- Assimilation of satellite data (GOME2) and measurements of air quality stations
- Assimilation of the boundary concentrations from a global tropospheric model (CHIMERE)