Modelling surface ozone during the 2003 heat wave in the UK

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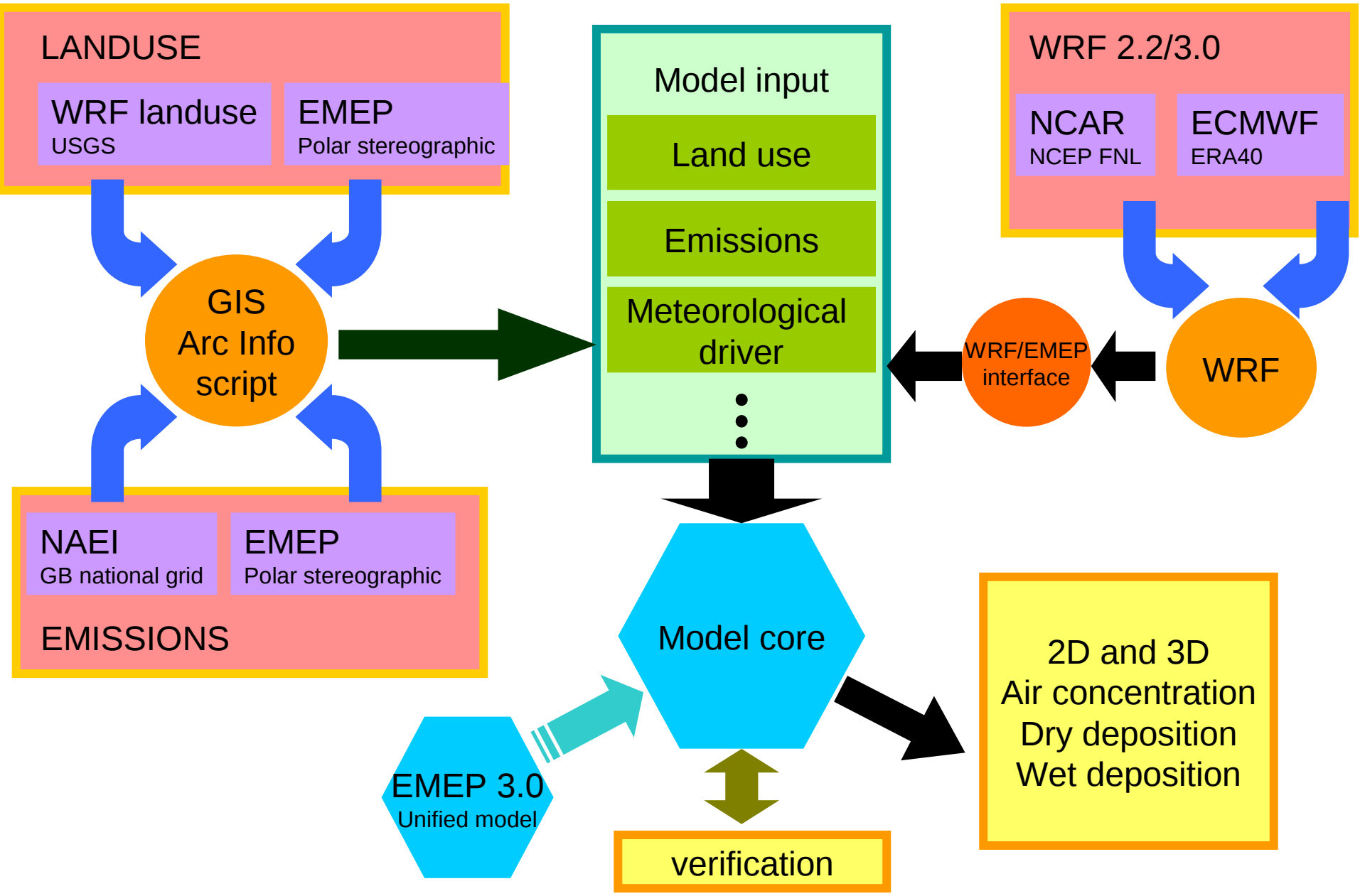
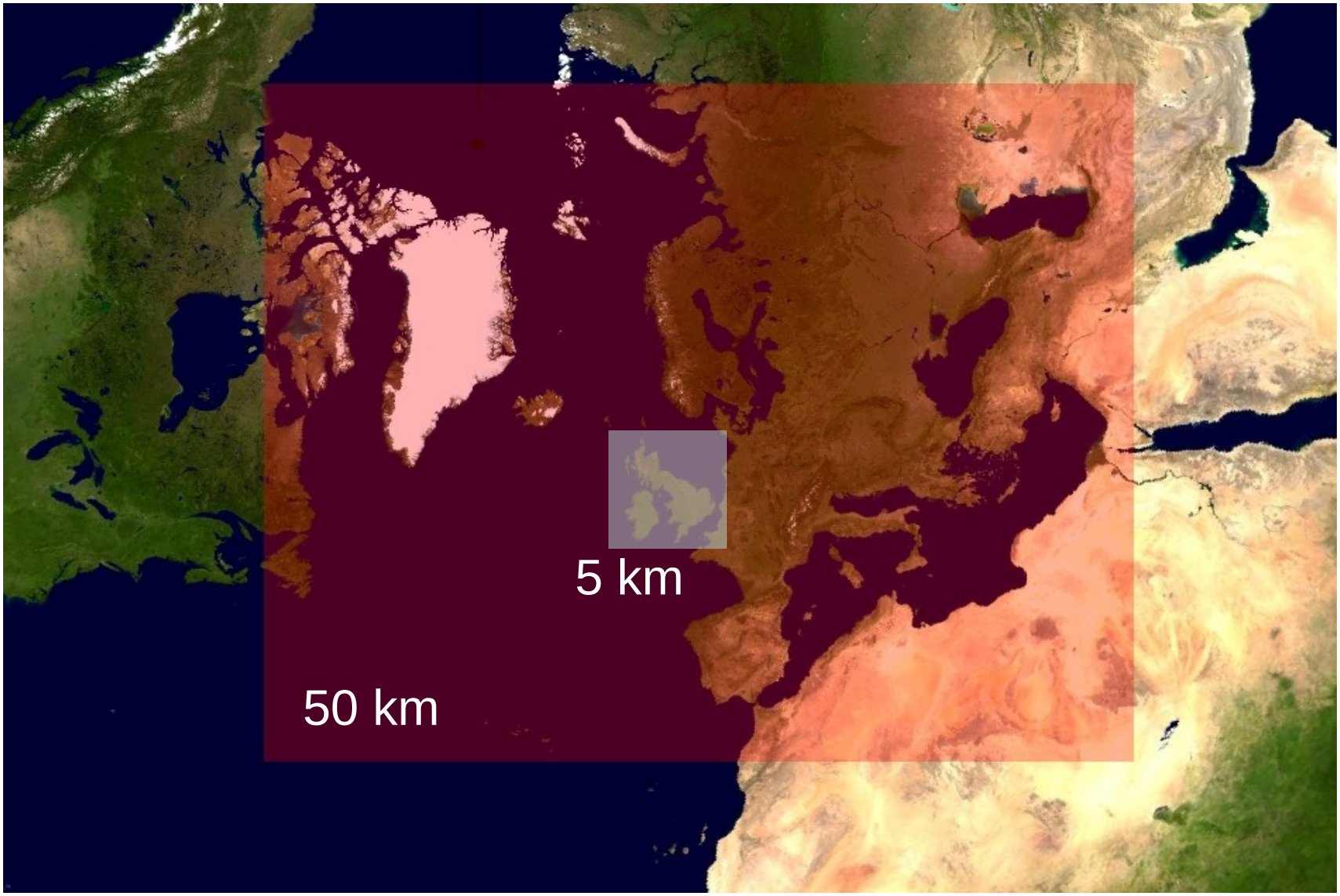
EMEP4UK framework



EMEP4UK Model stats

- Eulerian model
- Two nested domains on a polar stereographic projection.
  - Outer domain covers Europe 50 km
  - British Isles 5 km
- 20 vertical layers in sigma coordinates (terrain following)
  - centre of grid point for the surface layer ~45 m, and ~16 km top.
- Weather and Research Forecast model (WRF) is used as the meteorological driver
- Run time for EMEP4UK is ~1 day, and for WRF ~10 days.
  - Currently available years are 2003, 2006 and 2007(only January)

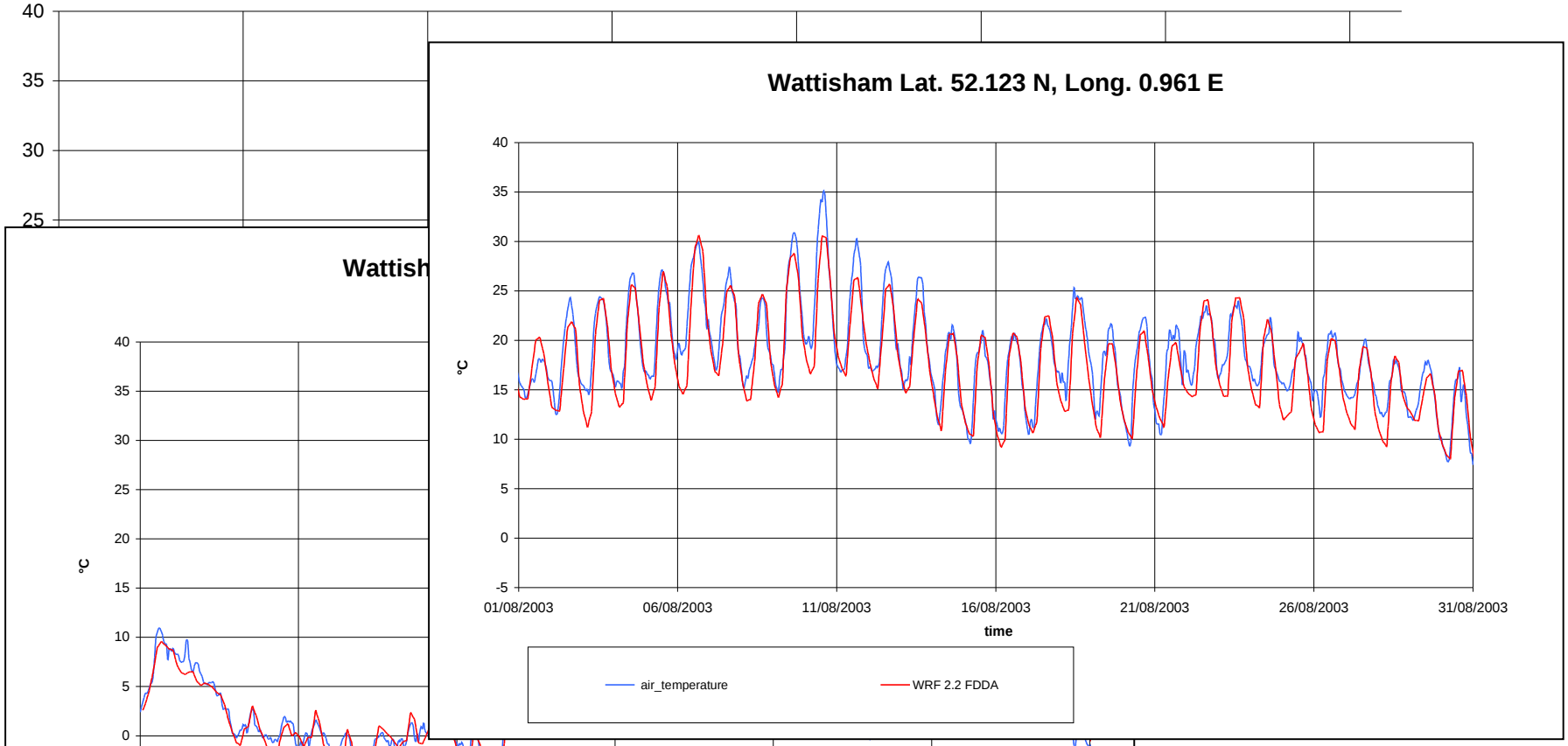
EMEP4UK domain



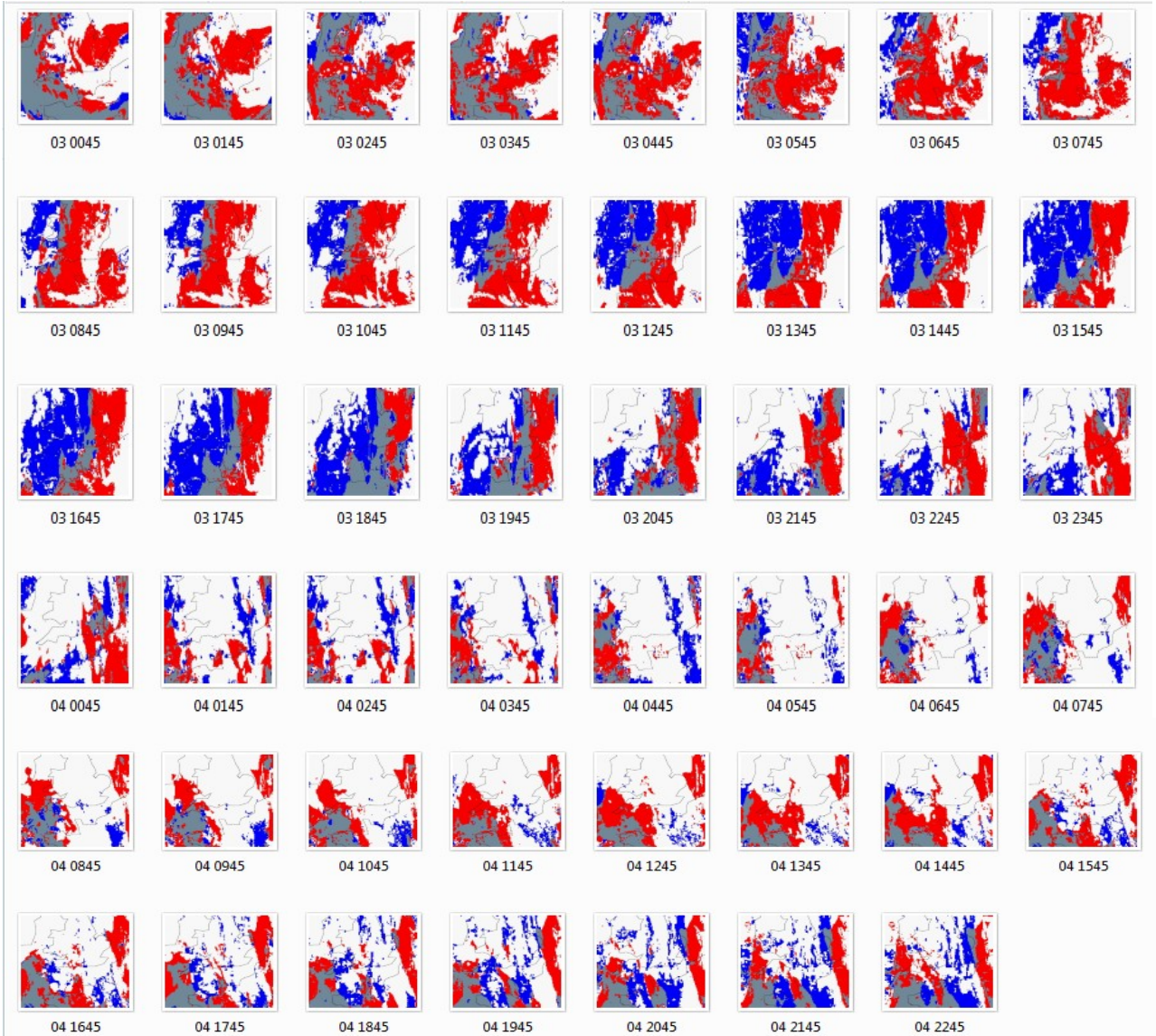
WRF met driver

WRF driver results example:

Wattisham Lat. 52.123 N, Long. 0.961 E



WRF 2.1 no FDDA using the ETA microphysics predicted cloud and SEVERI satellite observations



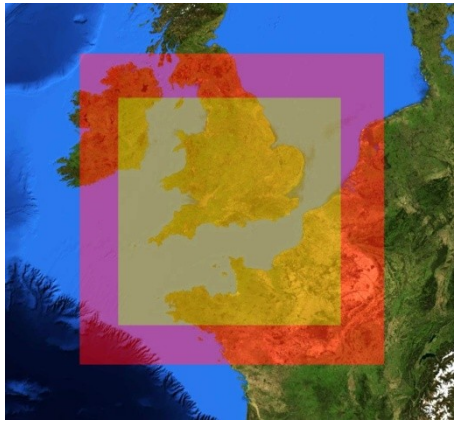
SEVERI cloud WRF no-cloud

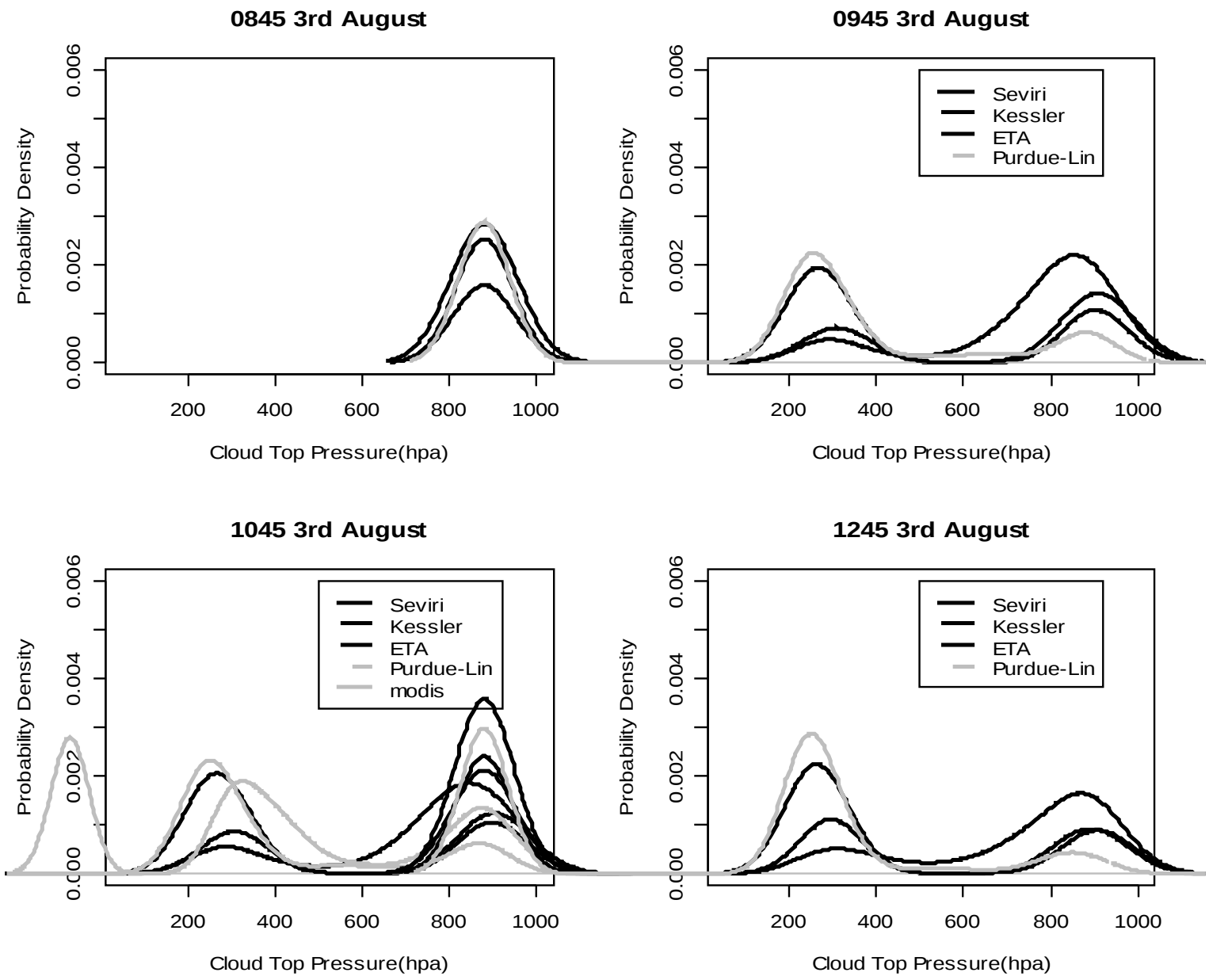
SEVERI no-cloud WRF cloud

SEVERI no-cloud WRF no-cloud

SEVERI cloud WRF cloud

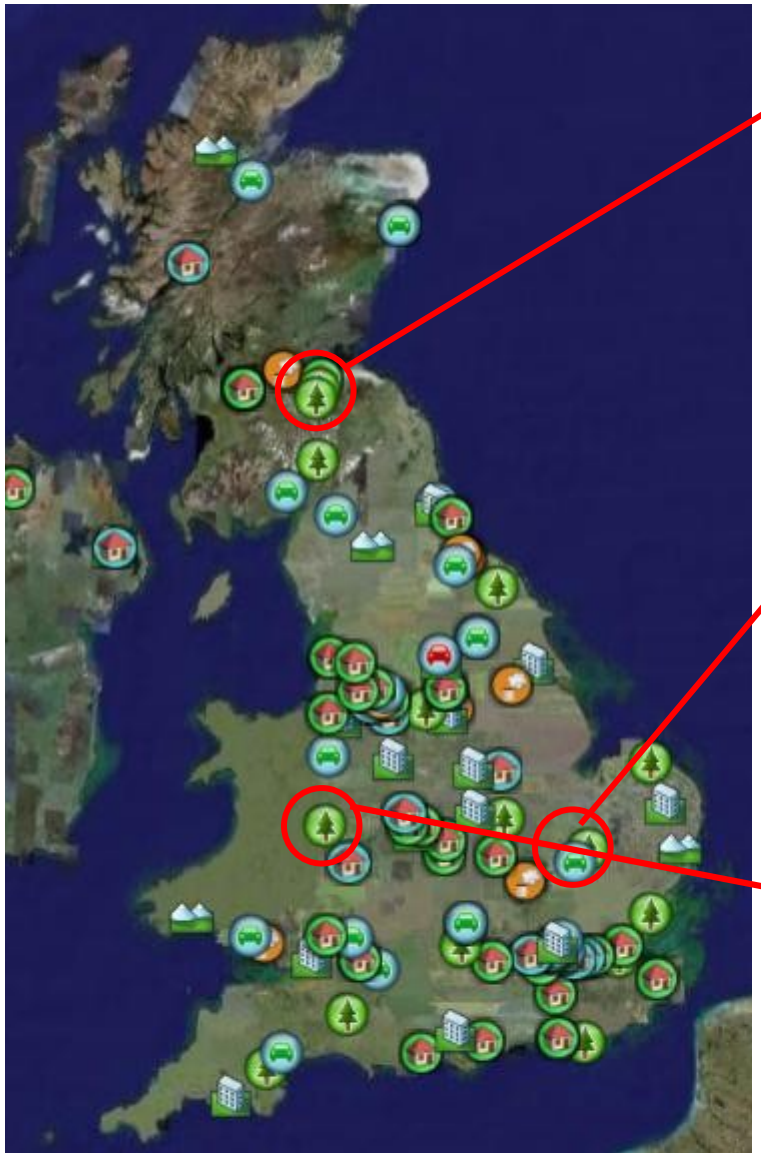
Simulation domain for 03-04 of August 2006

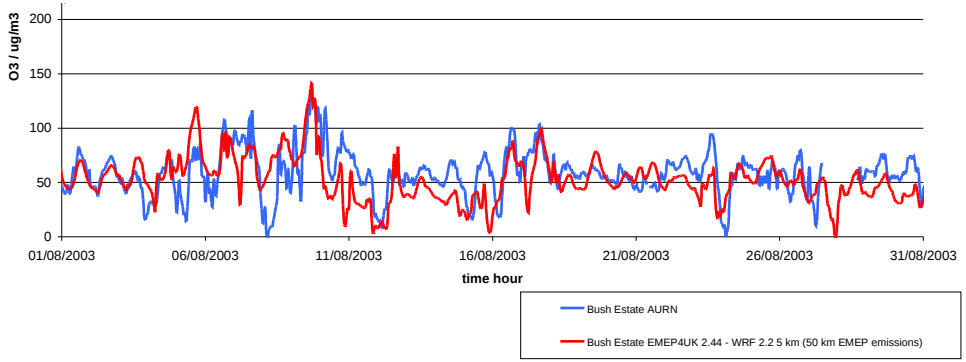


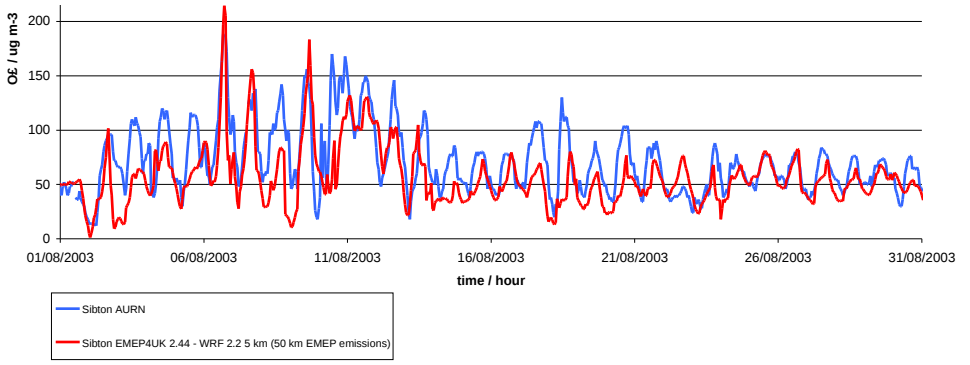

0845 3rd August
0945 3rd August
1045 3rd August
1245 3rd August
Probability Density
Cloud Top Pressure(hpa)
0.000
0.002
0.004
0.006
200
400
600
800
1000
Seviri
Kessler
ETA
Purdue-Lin
modis

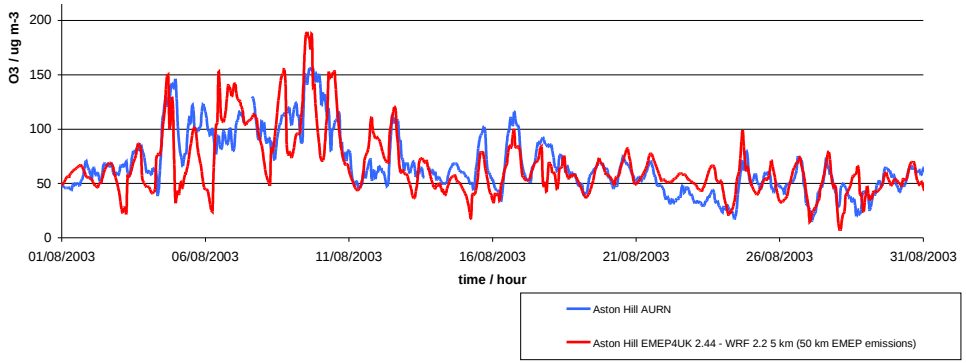
EMEP4UK 2003 results

2003 surface Ozone – EMEP4UK vs. Rural site of the AURN

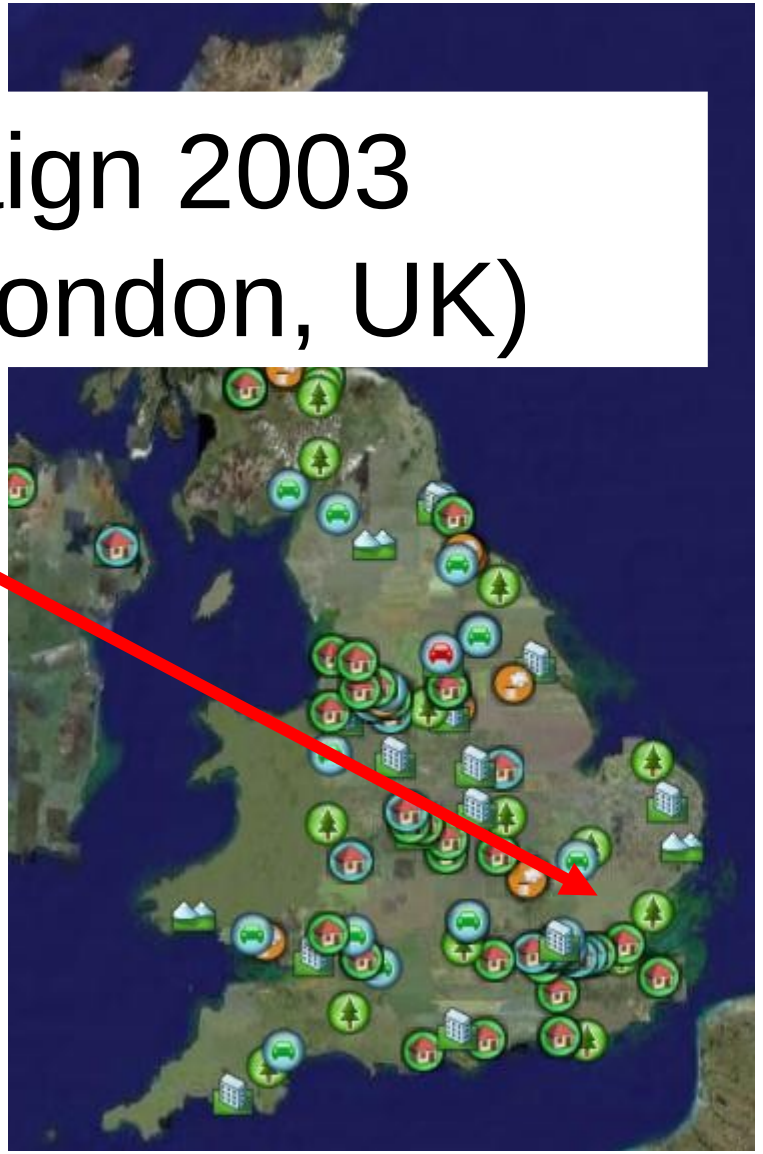




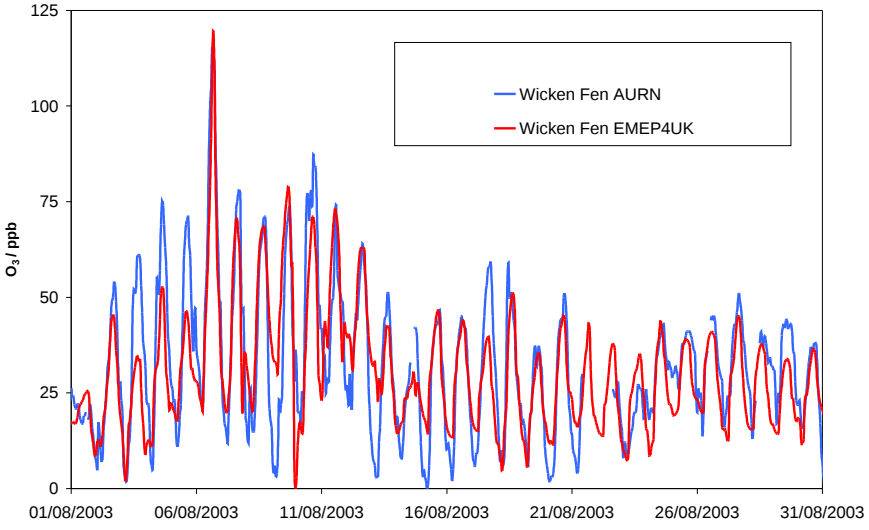




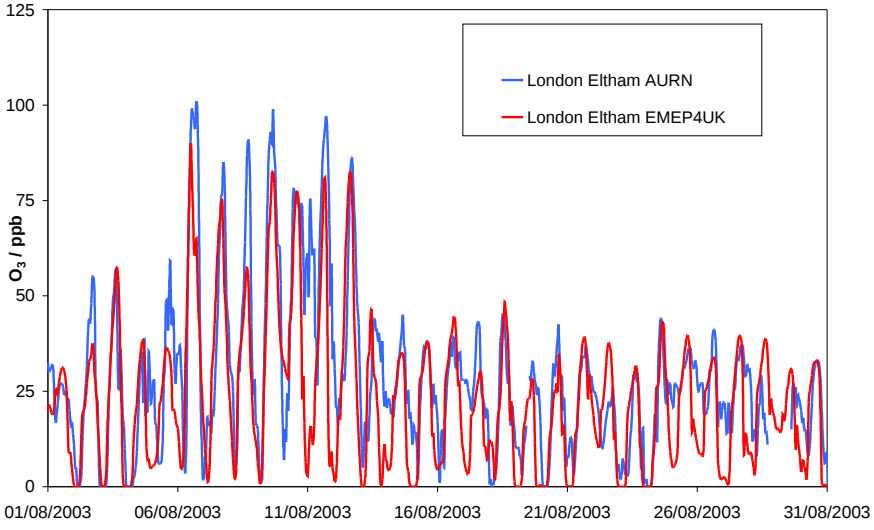
TORCH campaign 2003
Writtle (North of London, UK)



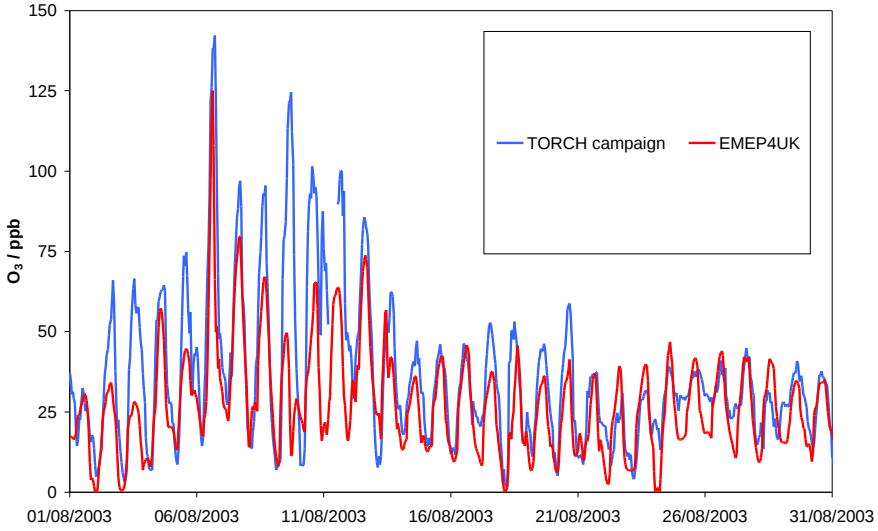
a)



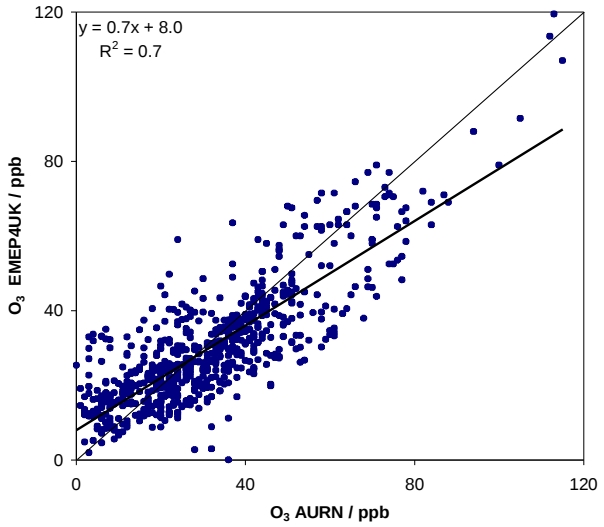
b)



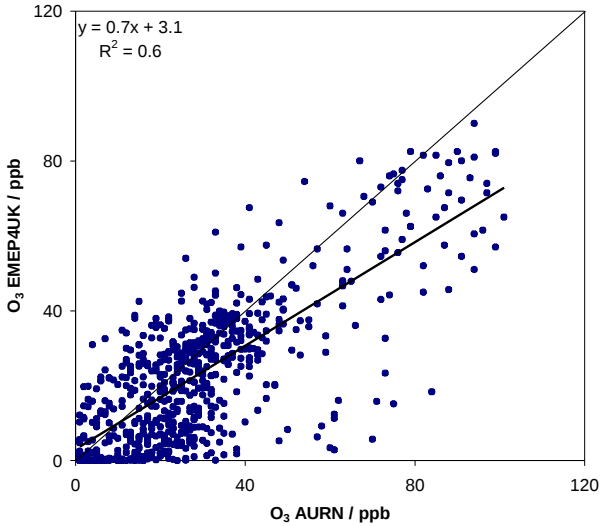
c)



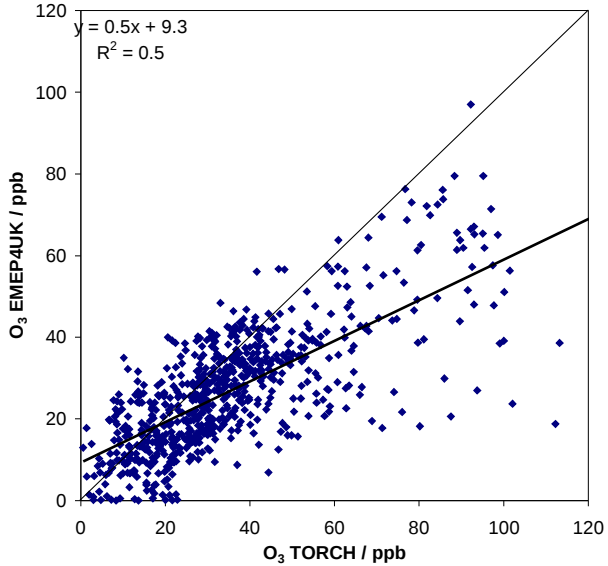
a) Wicken Fen (AURN)
b) London Eltham (AURN)
c) Writtle (TORCH)



a)



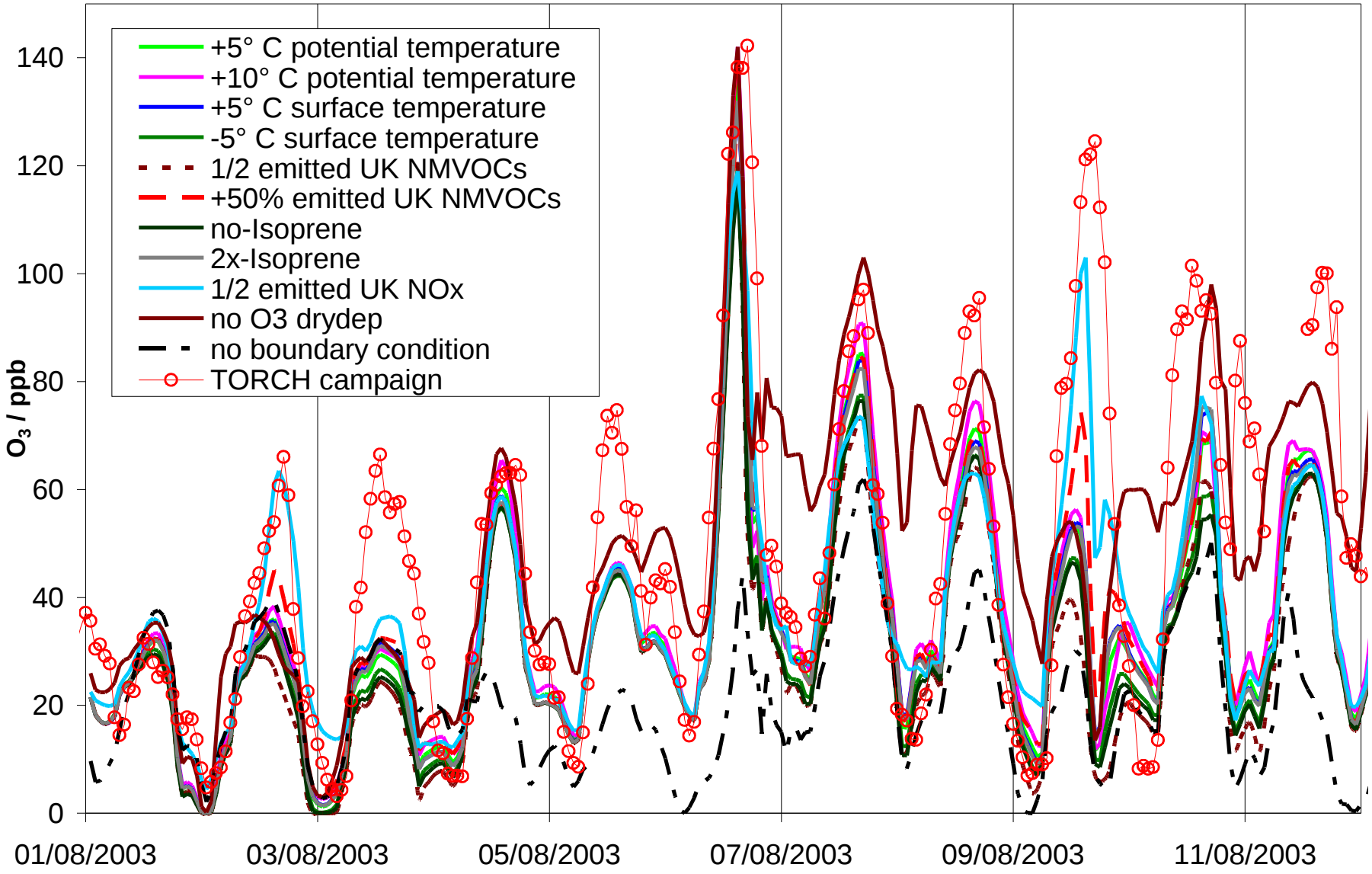
b)

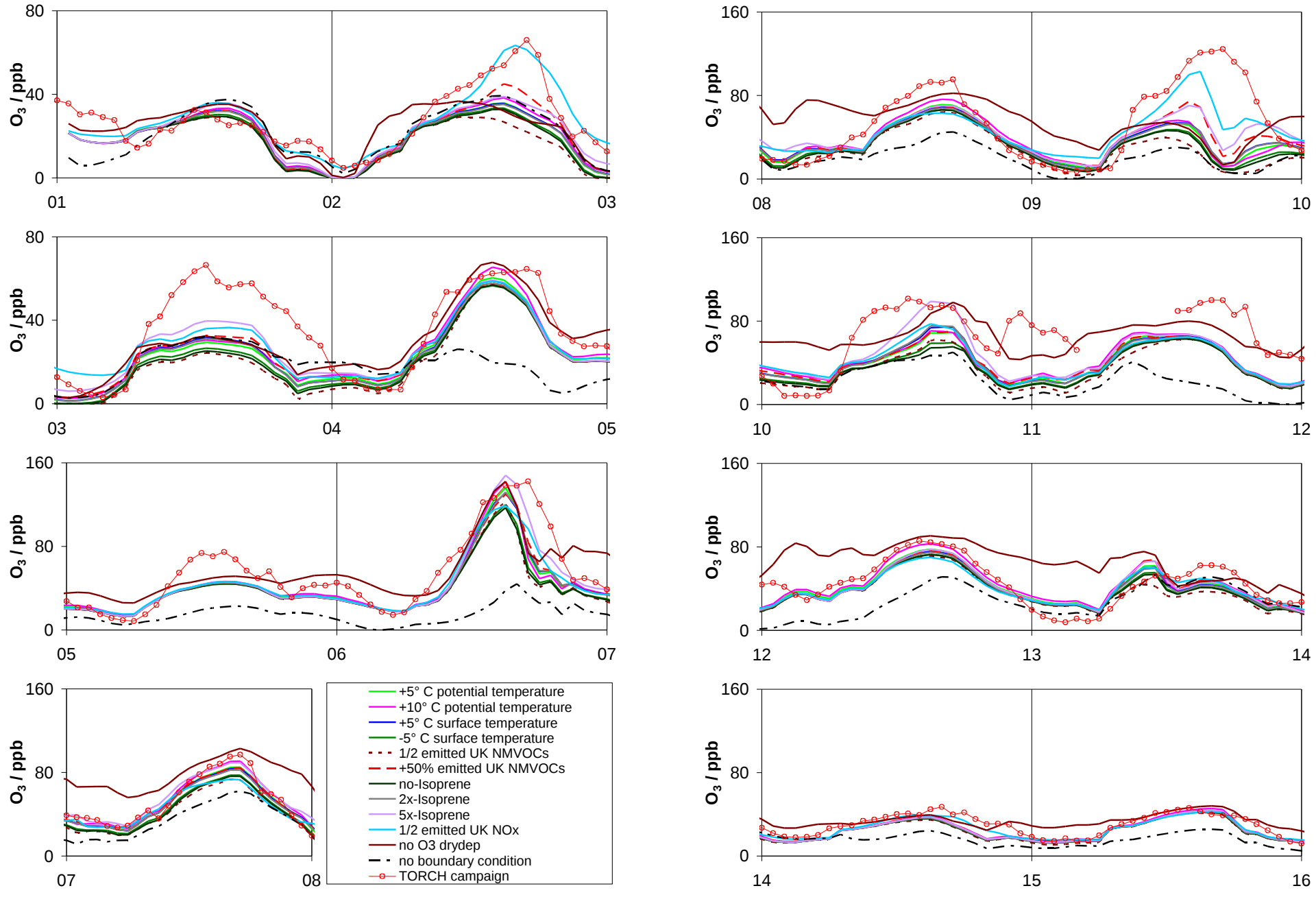


c)

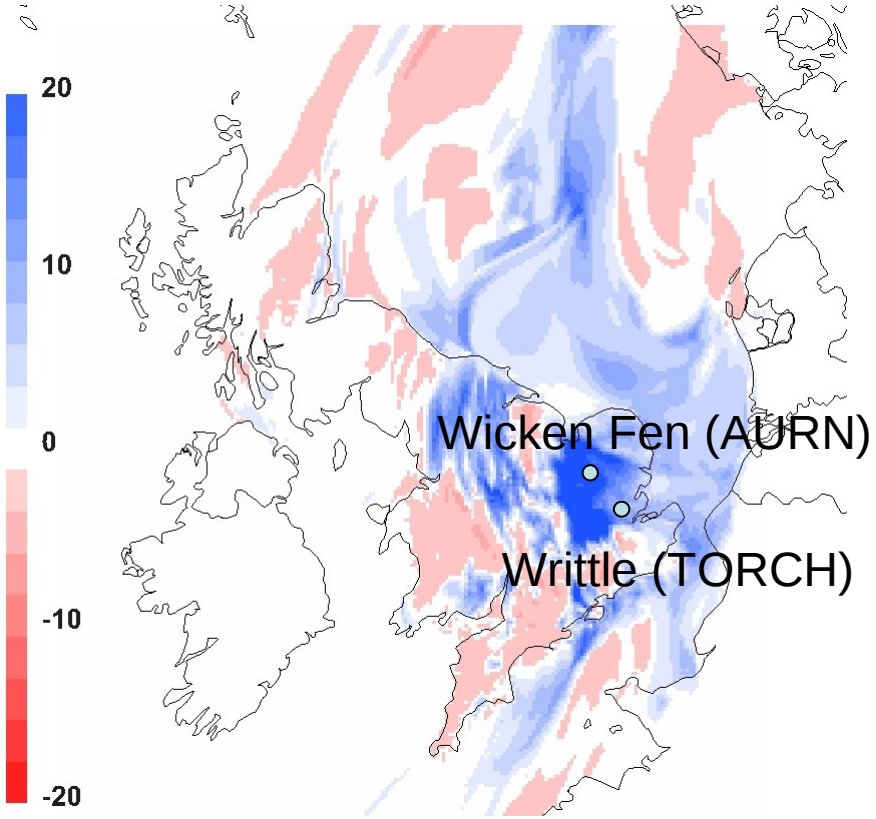
a) Wicken Fen (AURN)
b) London Eltham (AURN)
c) Writtle (TORCH)

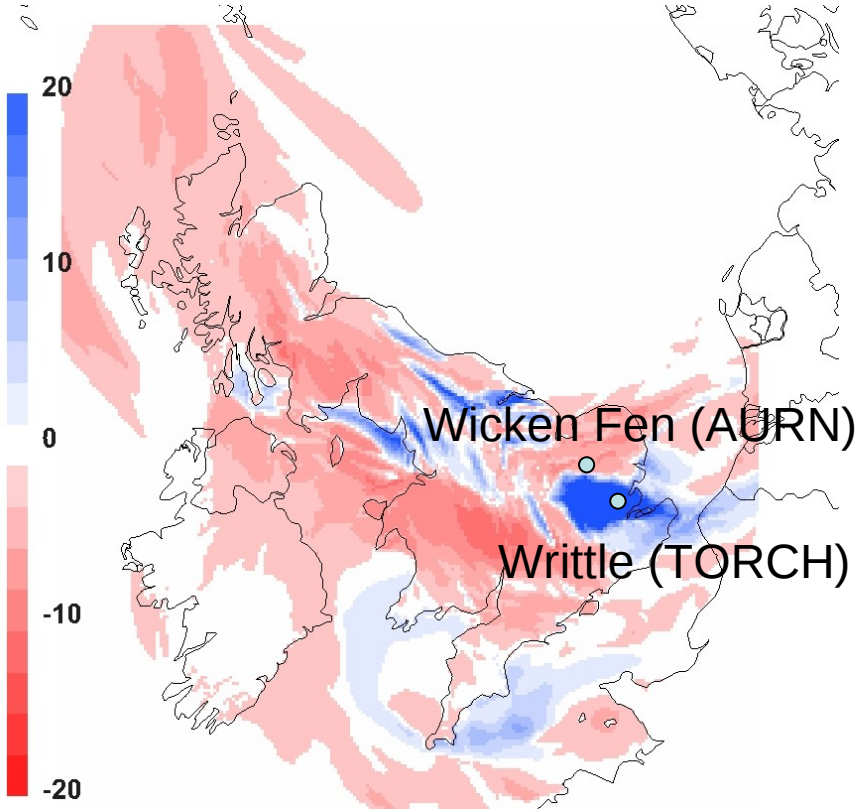
1) Reduced surface temperatures by -5° C (with unchanged vertical potential temperature);
2) Increased surface temperatures by +5° C (with unchanged vertical potential temperature);
3) Increase the potential temperature of +5 degree (for the full 3D domain);
4) Increase the potential temperature of +10 degree (for the full 3D domain);
5) Halved anthropogenic UK NMVOC NAEI emissions;
6) Increase by 50% the anthropogenic UK NMVOC NAEI emissions;
7) Switched off UK biogenic isoprene emissions;
8) Doubled UK biogenic isoprene emissions;
9) 5x UK biogenic isoprene emissions;
10) Halved anthropogenic UK NOx NAEI emissions;
11) Switched off dry deposition of ozone (both stomatal and non stomatal deposition)
12) Zero boundary condition


+5° C potential temperature
+10° C potential temperature
+5° C surface temperature
-5° C surface temperature
1/2 emitted UK NMVOCs
+50% emitted UK NMVOCs
no-Isoprene
2x-Isoprene
1/2 emitted UK NOx
no O3 drydep
no boundary condition
TORCH campaign
O3 / ppb
0
20
40
60
80
100
120
140
01/08/2003
03/08/2003
05/08/2003
07/08/2003
09/08/2003
11/08/2003

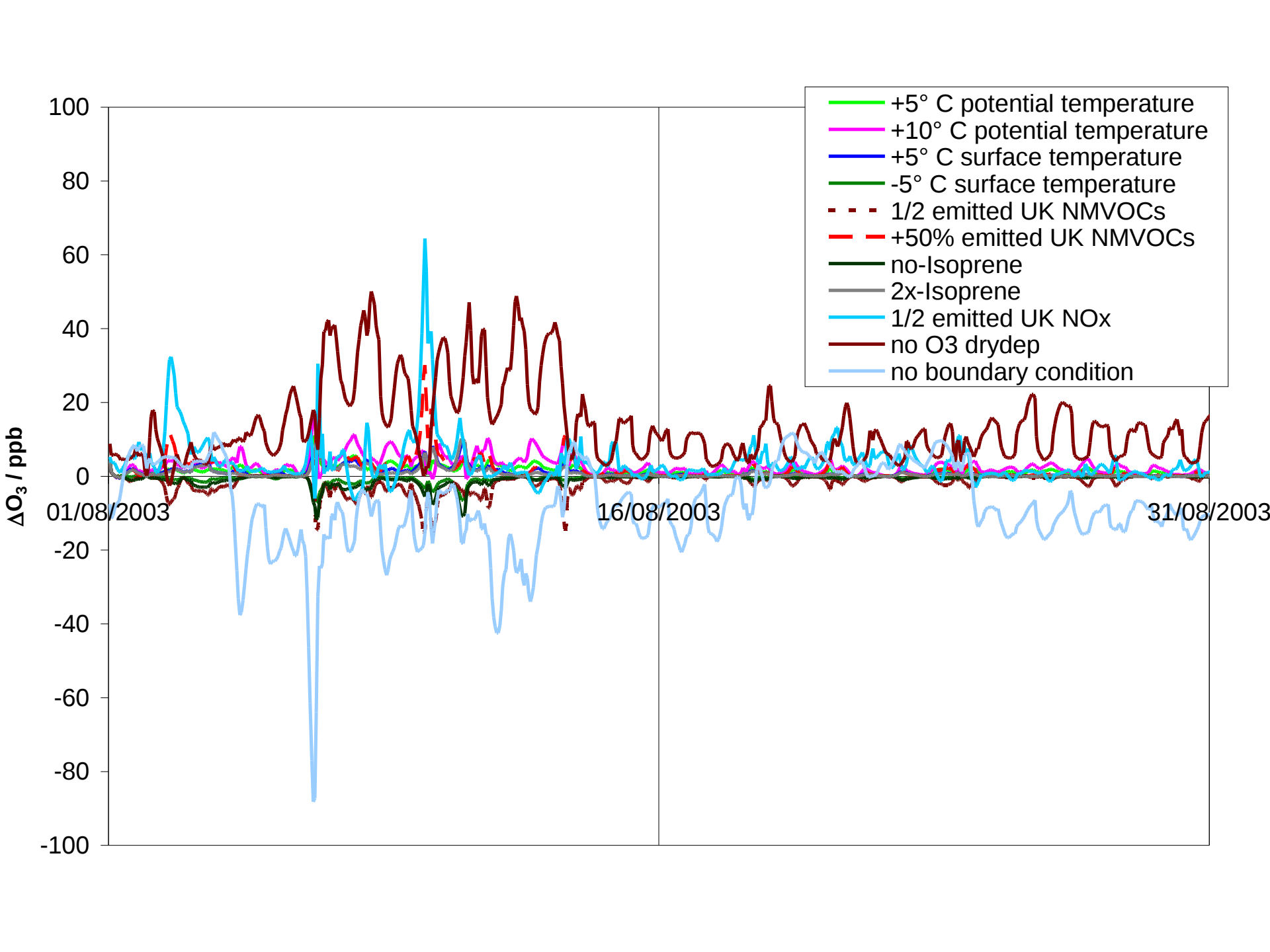

O3 / ppb
01
02
03
08
09
10
03
04
05
10
11
12
05
06
07
12
13
14
07
08
14
15
16
+5° C potential temperature
+10° C potential temperature
+5° C surface temperature
-5° C surface temperature
1/2 emitted UK NMVOCs
+50% emitted UK NMVOCs
no-Isoprene
2x-Isoprene
5x-Isoprene
1/2 emitted UK NOx
no O3 drydep
no boundary condition
TORCH campaign

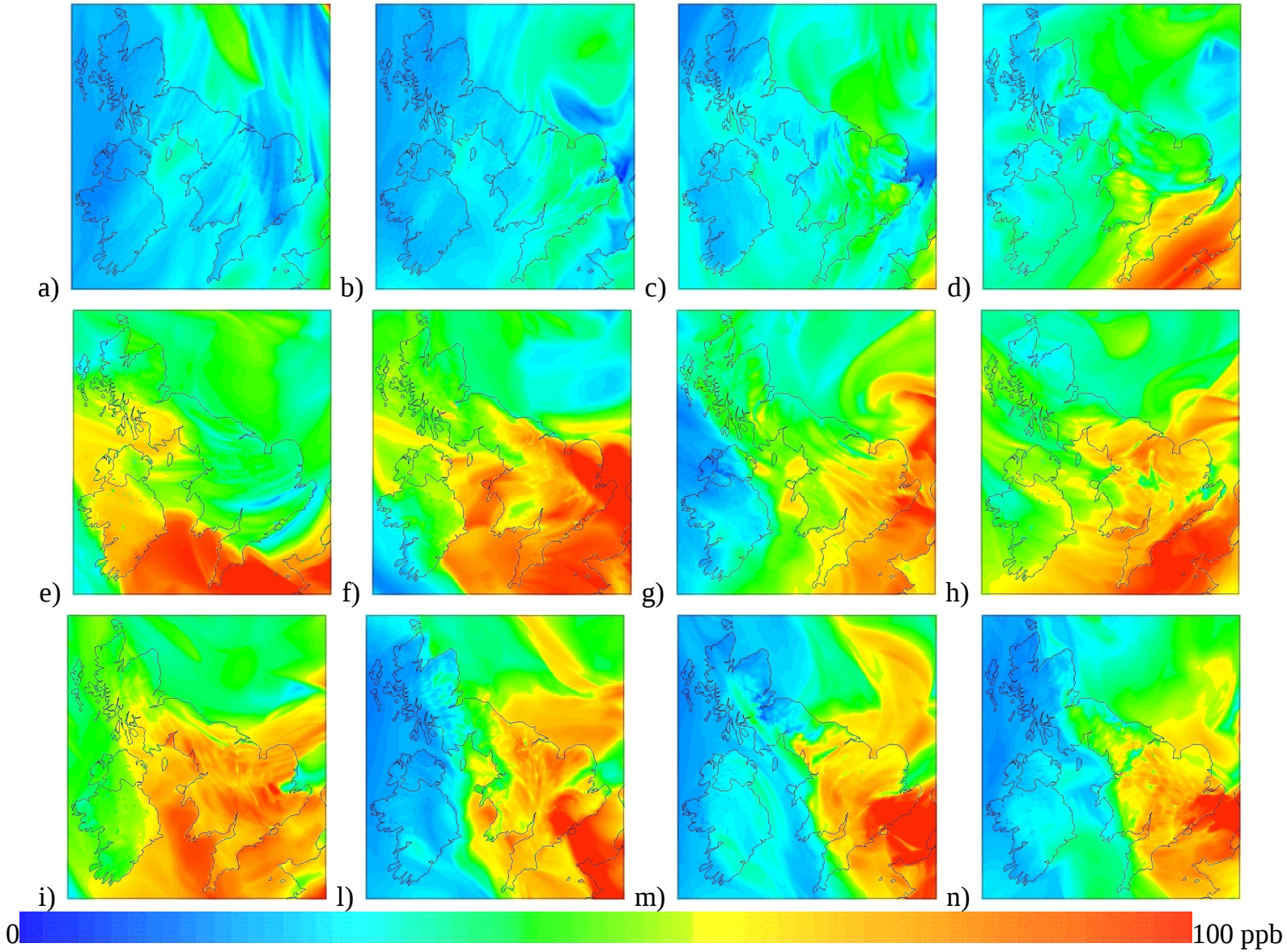
½ UK NOx emissions – Base Run for the 3rd and 9th of August 2003





Writtle – Wicken Fen ~ 70 km apart


100
80
60
40
20
0
-20
-40
-60
-80
-100
ΔO3 / ppb
01/08/2003
16/08/2003
31/08/2003
+5° C potential temperature
+10° C potential temperature
+5° C surface temperature
-5° C surface temperature
1/2 emitted UK NMVOCs
+50% emitted UK NMVOCs
no-Isoprene
2x-Isoprene
1/2 emitted UK NOx
no O3 drydep
no boundary condition



a) 01/08/2003 – n) 12/08/2003 Ozone maximum daily surface concnetration

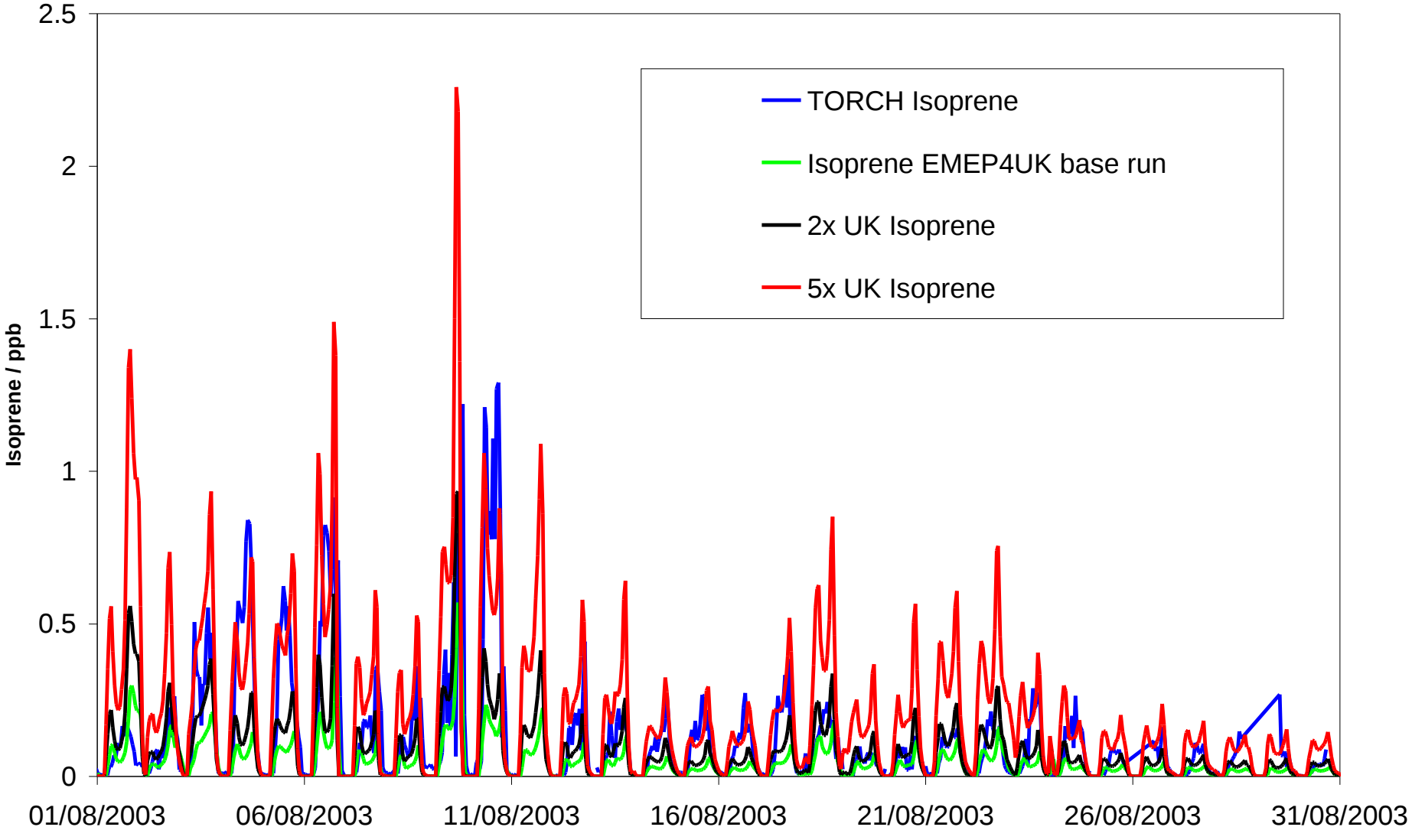
Conclusions

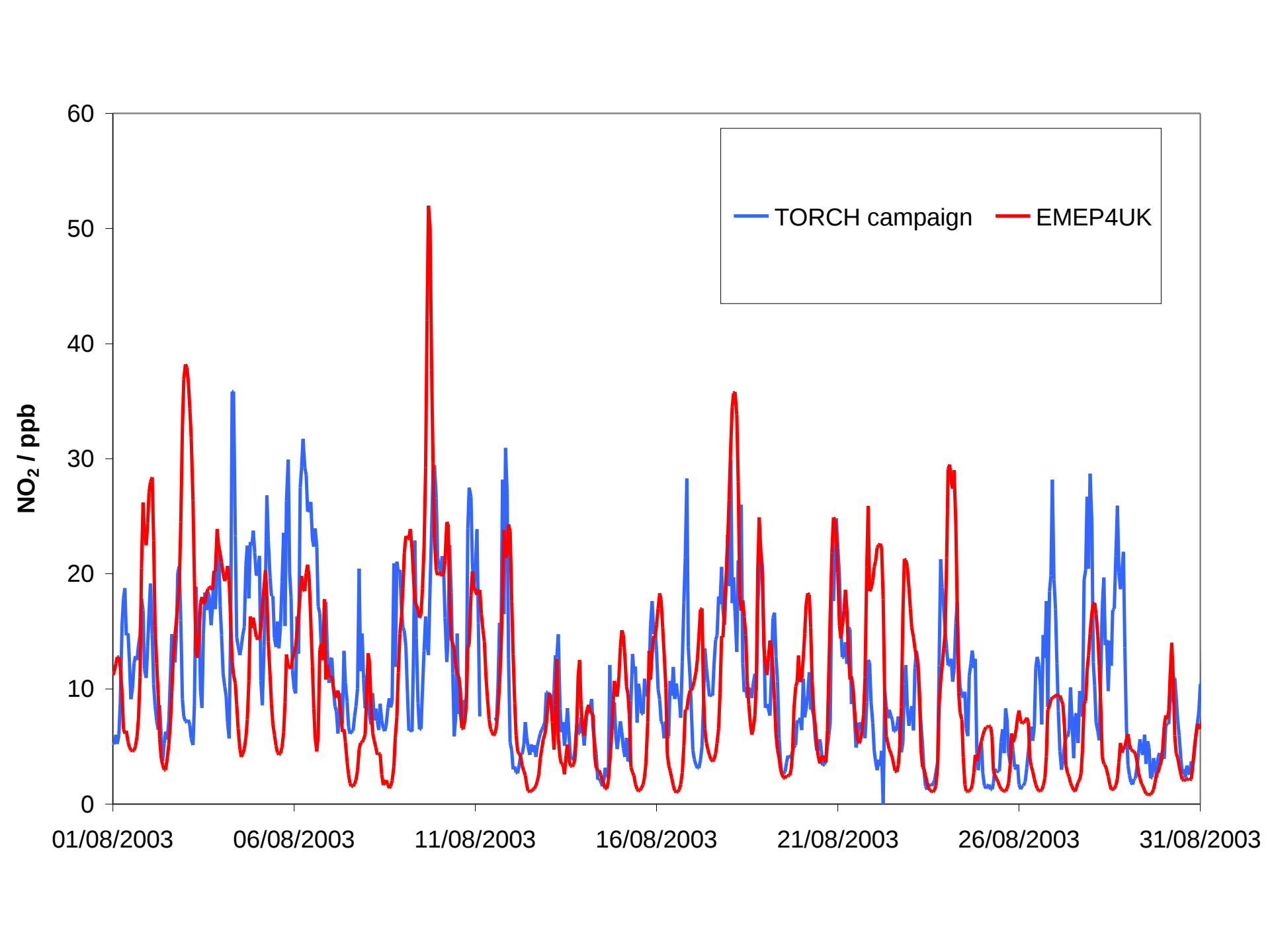
Sensitivity test	+ (ppb)	- (ppb)	Effect on:
½ UK NO_x emissions	70	10	Chemistry
No Dry deposition of O_3	50	2	Dry deposition
+50% UK NMVOCs emissions	30	0	Chemistry
5x UK Isoprene emissions	30	0	Chemistry
No import form EMEP 50 km	10	80	All
+5 C Temperature (2 m)	10	0	Biogenic emission and dry deposition
+ 10 C Potential temperature	10	0	Chemistry conversion rate
2x UK Isoprene emissions	10	0	Chemistry
+ 5 C Potential temperature	5	0	Chemistry conversion rate
½ UK NMVOCs emissions	0	15	Chemistry
-5 C Temperature (2 m)	0	10	Biogenic emission and dry deposition
No Isoprene emissions	0	10	Chemistry

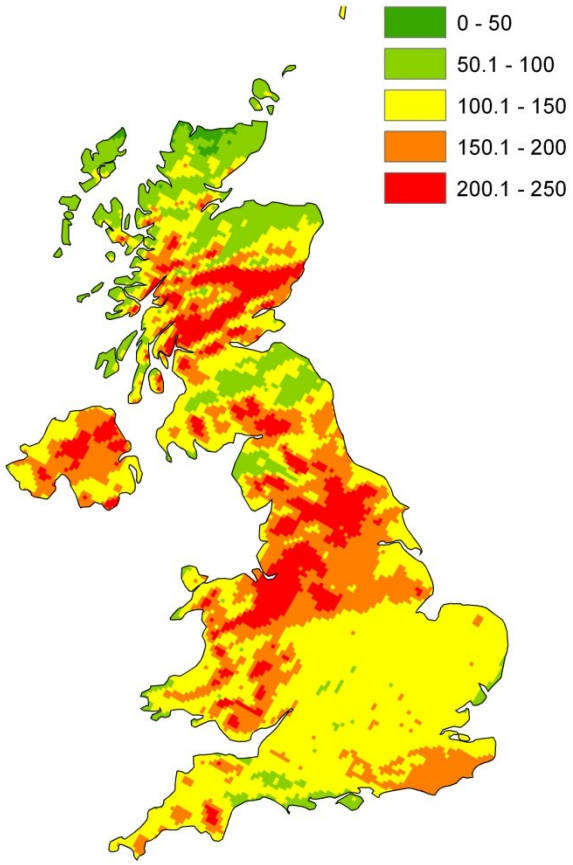
Conclusions

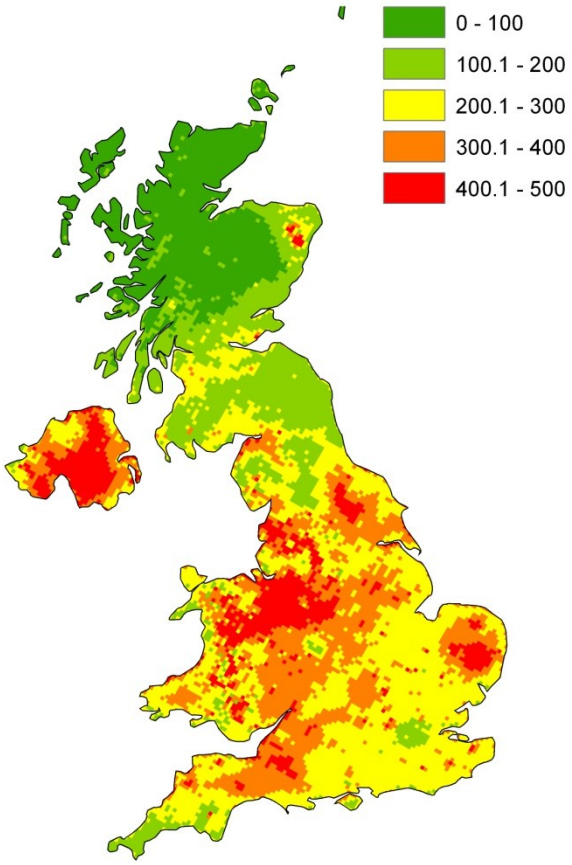
- Different causes of high level of ozone
- Dry deposition and NO_x largely control surface ozone
- Import (outer domain) control few episodes (6^{th} of August!)
- Local condition also affect ozone concentration

Not only ozone what about N and S


2.5
2
1.5
1
0.5
0
Isoprene / ppb
TORCH Isoprene
Isoprene EMEP4UK base run
2x UK Isoprene
5x UK Isoprene
01/08/2003
06/08/2003
11/08/2003
16/08/2003
21/08/2003
26/08/2003
31/08/2003


60
50
40
30
20
10
0
NO2 / ppb
TORCH campaign
EMEP4UK
01/08/2003
06/08/2003
11/08/2003
16/08/2003
21/08/2003
26/08/2003
31/08/2003

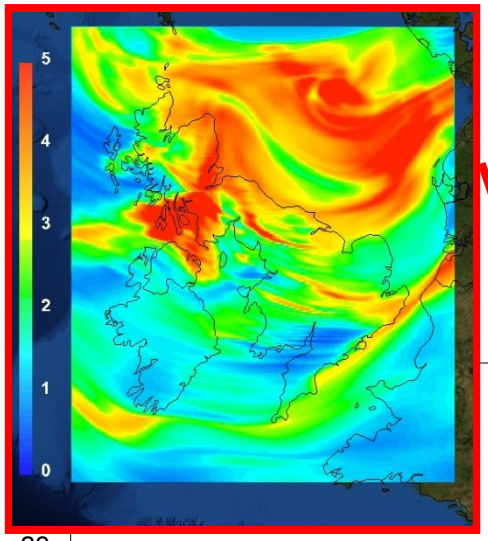


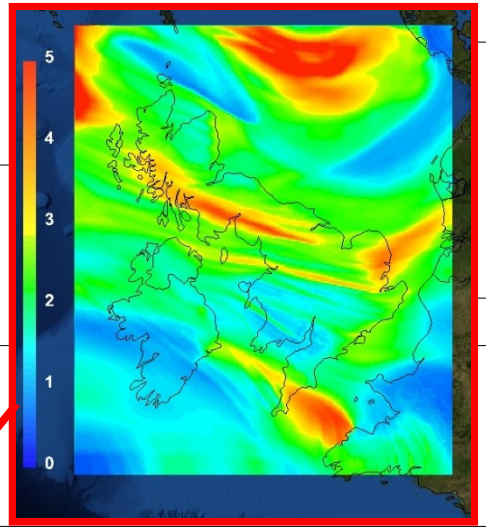


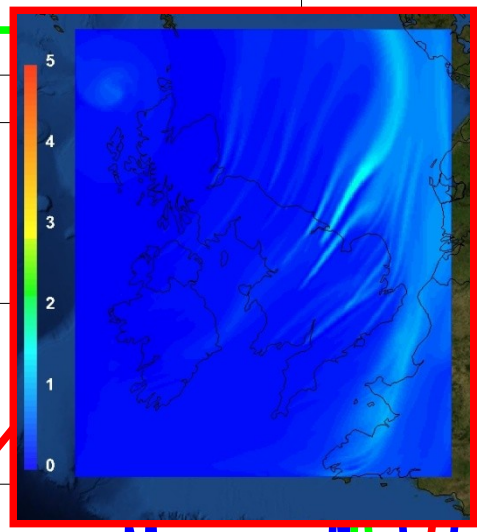
- Wet deposition capture the rainfall pattern over mountain terrain (LEFT)
- Dry deposition follow the ammonia emissions hot spot

Units are mg(N) m^{-2}

EMEP4UK
Auchencorth







Auchencorth SO4
June 2006 (hourly)

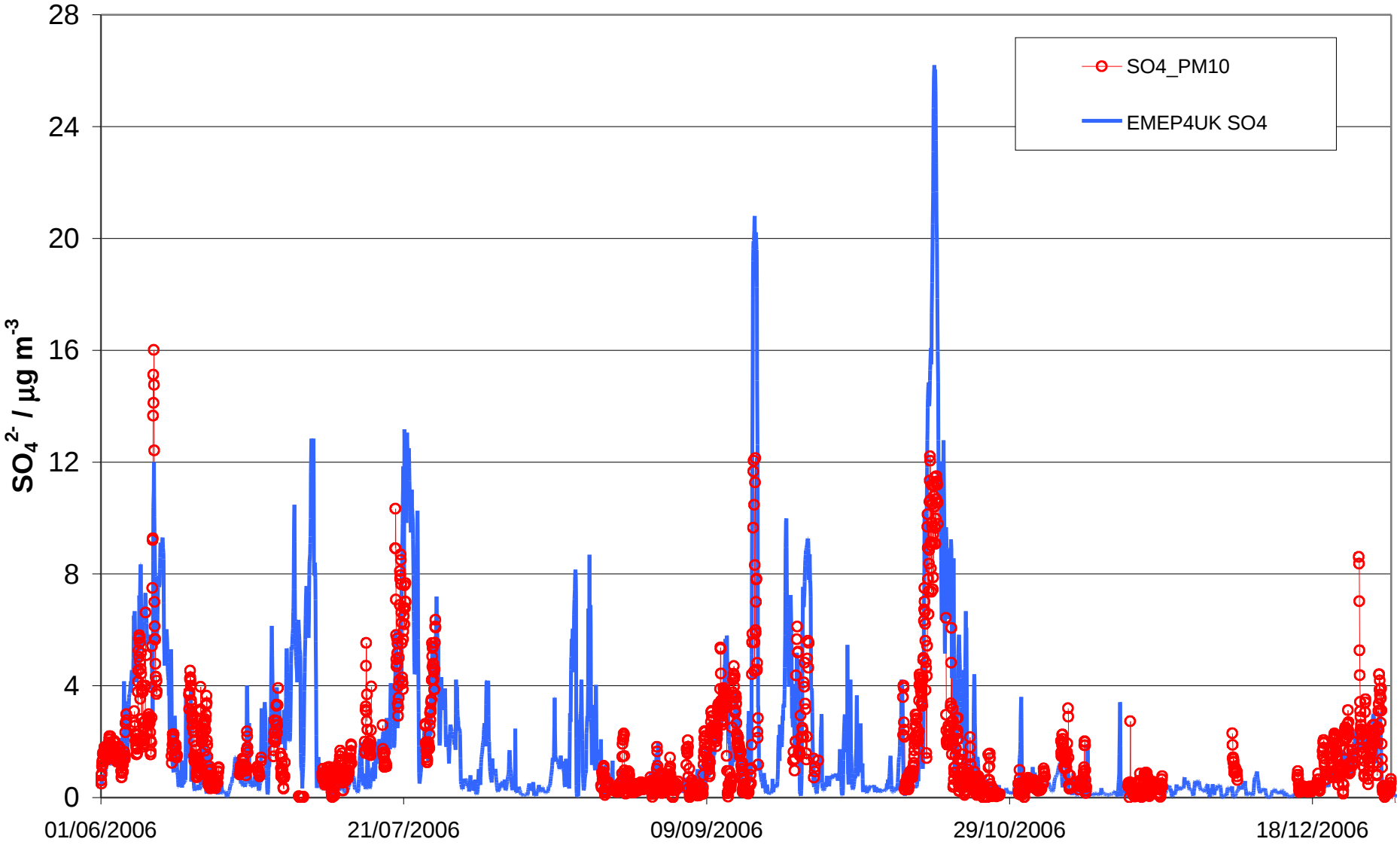
EMEP4UK (Auch)
MARGA (Auch)

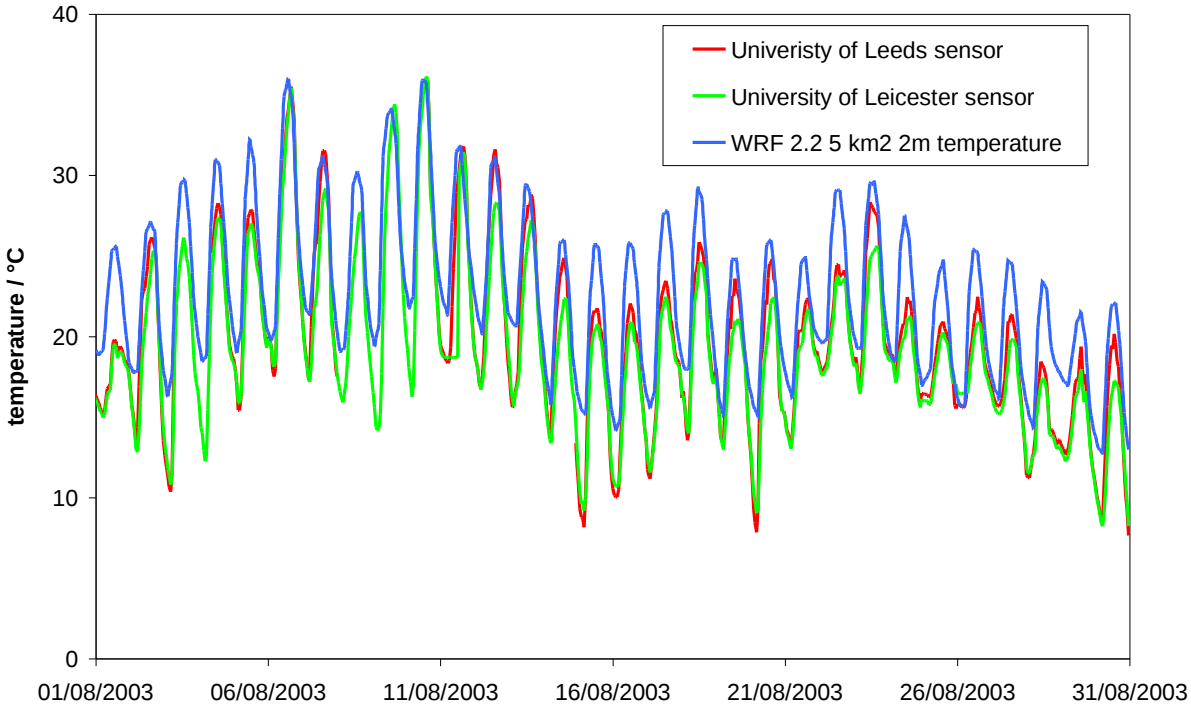
concentration / ug m-3

20
15
10
5
0

01/06/2006
06/06/2006
11/06/2006
16/06/2006
21/06/2006
26/06/2006

time / hours


28
24
20
16
12
8
4
0
SO_4^{2-} / µg m^{-3}
01/06/2006
21/07/2006
09/09/2006
29/10/2006
18/12/2006
SO4_PM10
EMEP4UK SO4


Univeristy of Leeds sensor
University of Leicester sensor
WRF 2.2 5 km2 2m temperature
temperature / °C
40
30
20
10
0
01/08/2003
06/08/2003
11/08/2003
16/08/2003
21/08/2003
26/08/2003
31/08/2003

Conclusions

- The WRF model is well suited as driver for ACTM.

- The EMEP4UK perform well for Ozone in the 2003 and during the heat-wave