OZONE TRENDS IN THE BRITISH ISLES AND THEIR EUROPEAN POLICY CONTEXT

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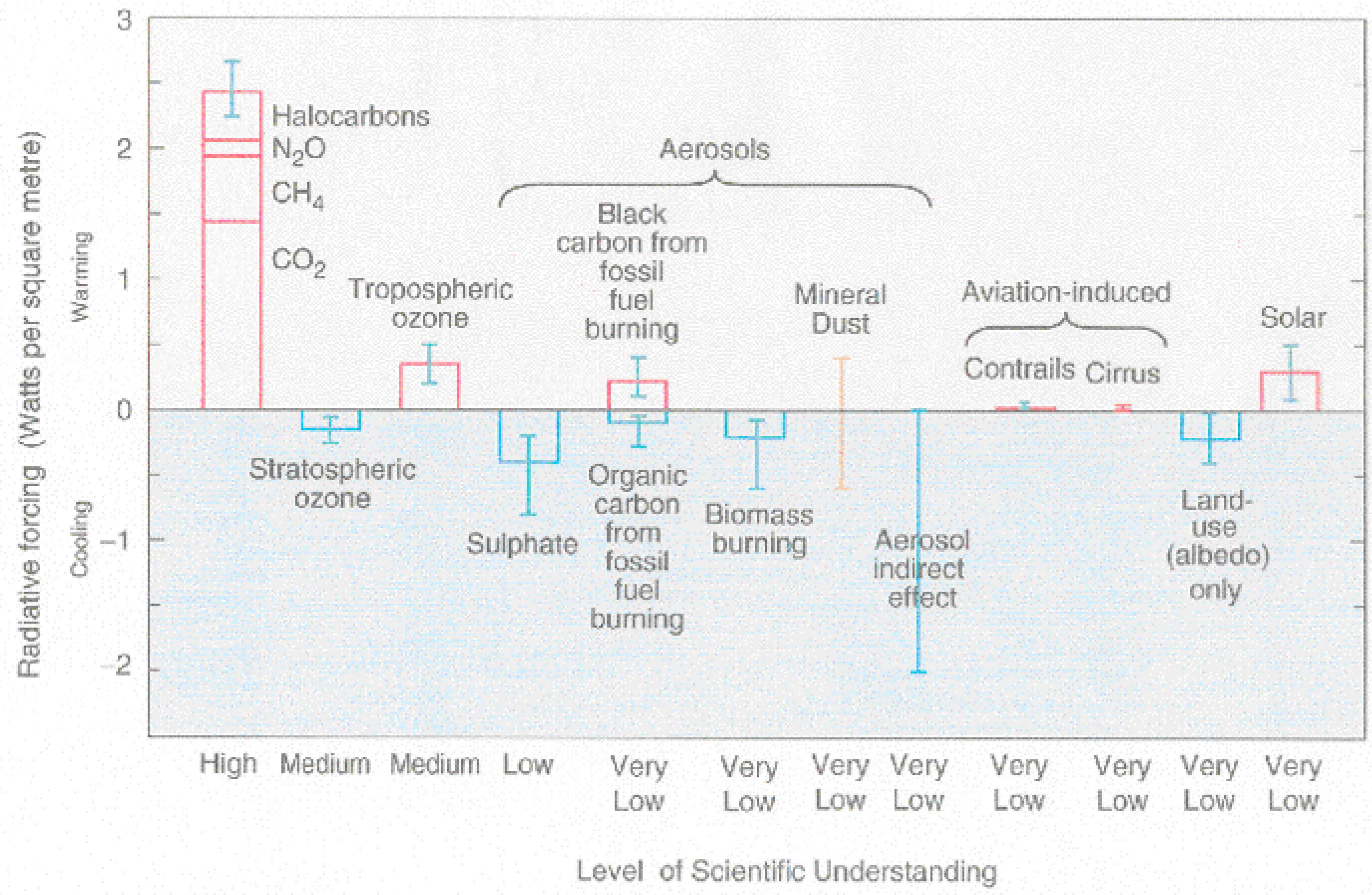
The recently published Third Assessment Report of the Intergovernmental Panel on Climate Change has pointed out that human activities have dramatically increased tropospheric ozone levels. This increase is such that ozone is now assessed as the third most important greenhouse gas.

This presentation addresses the policy issues surrounding the increase in global ozone levels and their imapct upon European ozone exposure levels.

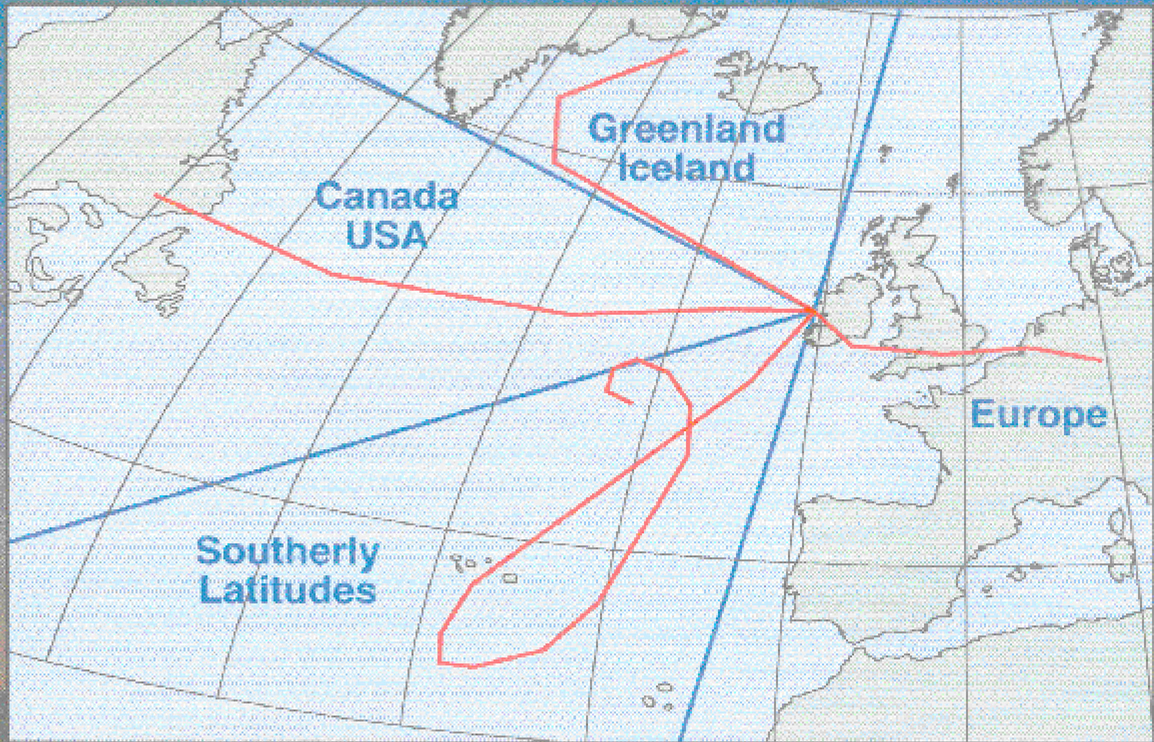
The global mean radiative forcing of the climate system for the year 2000, relative to 1750



Long-term measurements of radiatively-active trace gases have been made at mace Head on the Atlantic Ocean coast of Europe since 1987. These measurements have been carefully selected using meteorological data into two time series:

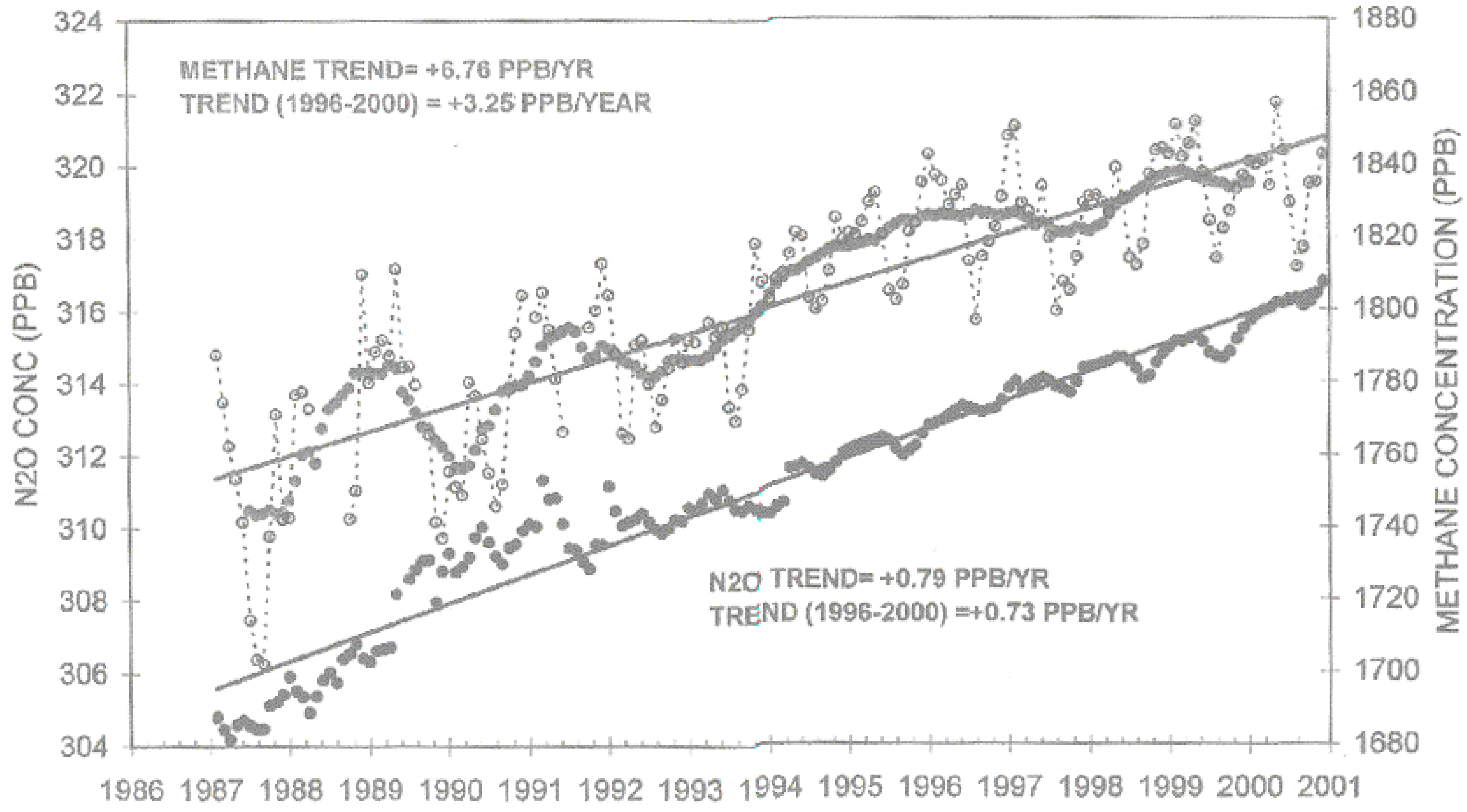
- unpolluted global baseline air masses
- regionally-polluted air masses for Europe

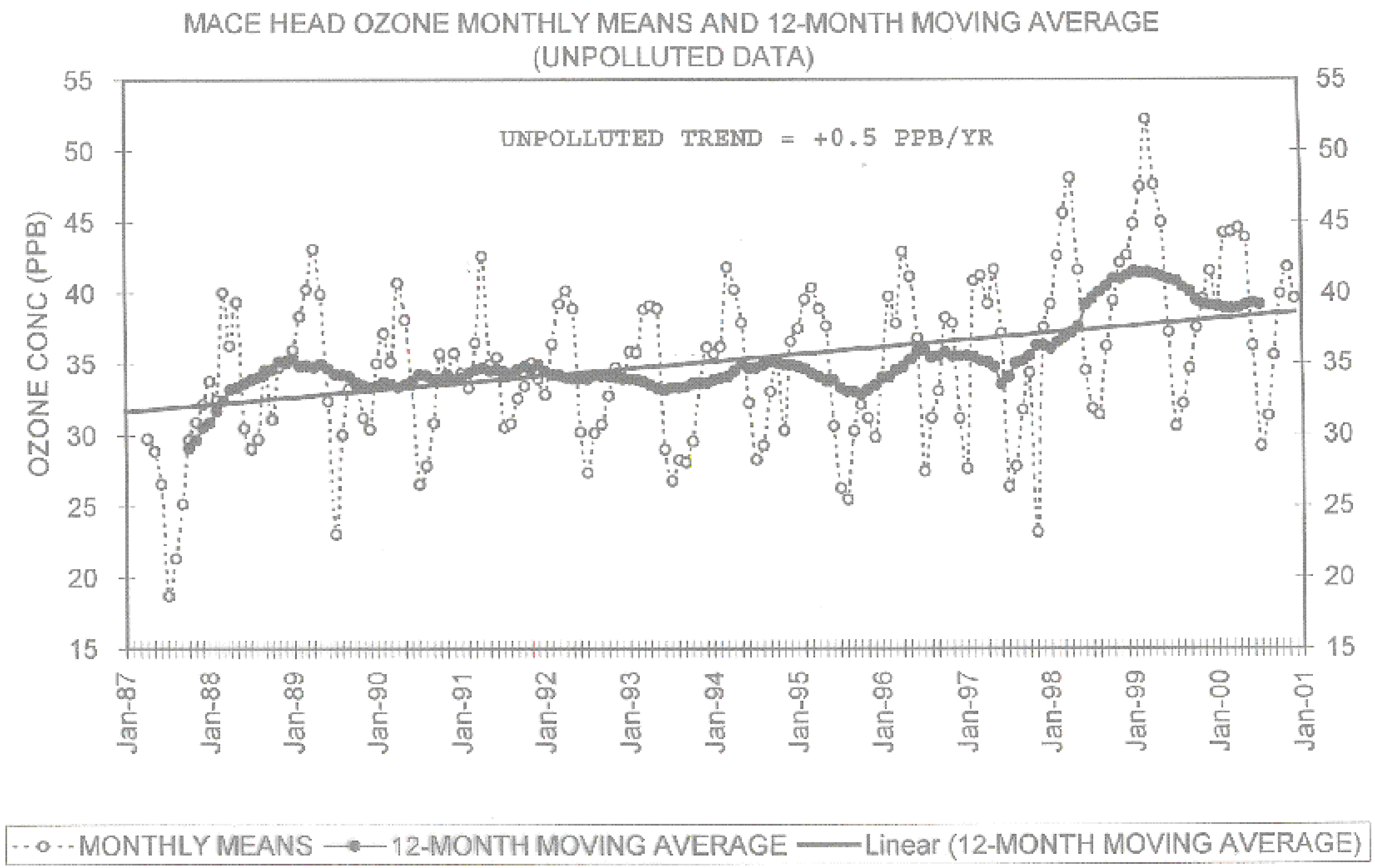
REGIONAL SEPARATION OF THE AIR MASSES ARRIVING AT MACE HEAD, IRELAND



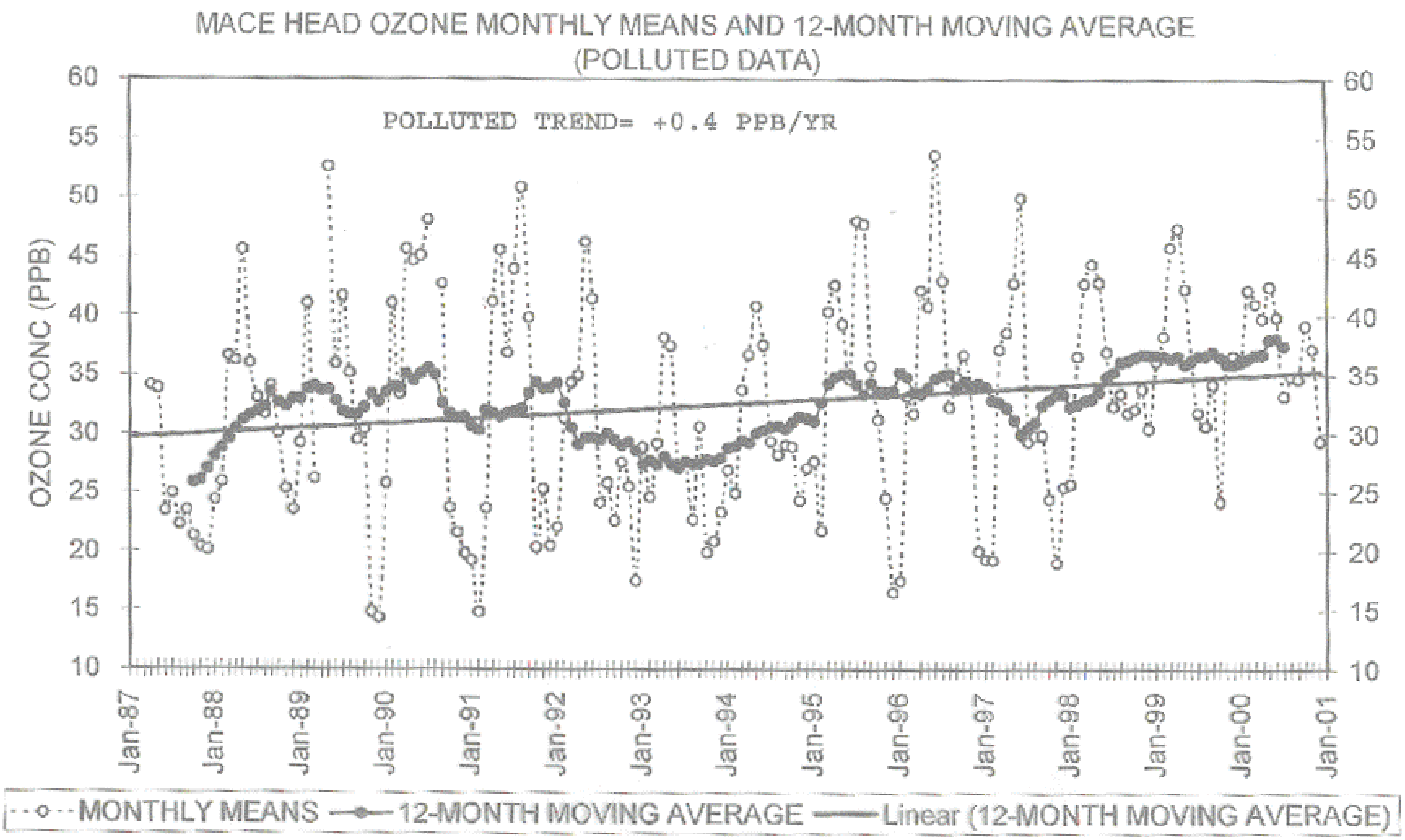
The Met.Office

Trends in the monthly means of methane and nitrous oxide.





MACE HEAD OZONE MONTHLY MEANS AND 12-MONTH MOVING AVERAGE
(UNPOLLUTED DATA)
UNPOLLUTED TREND = +0.5 PPB/YR
OZONE CONC (PPB)
55
50
45
40
35
30
25
20
15
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
MONTHLY MEANS
12-MONTH MOVING AVERAGE
Linear (12-MONTH MOVING AVERAGE)



MACE HEAD OZONE MONTHLY MEANS AND 12-MONTH MOVING AVERAGE
(POLLUTED DATA)
POLLUTED TREND= +0.4 PPB/YR
OZONE CONC (PPB)
10
15
20
25
30
35
40
45
50
55
60
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
MONTHLY MEANS
12-MONTH MOVING AVERAGE
Linear (12-MONTH MOVING AVERAGE)

Methane concentrations are projected to increase in the future following the IPCC scenarios. This methane increase will drive up tropospheric ozone levels also.

STOCHEM

- global 3-D chemistry-transport model
- Lagrangian transport scheme
- 6-hourly meteorological fields from operational archive at 0.833^{o} x 1.25^{o}
- 50,000 air parcels to give 5^{o} x 5^{o} x monthly output
- 5-minute chemistry and 3-hour advection timesteps
- air parcels carry mixing ratios of 70 chemical species which take part in 160 chemical reactions
- upper boundary at 100 mb
- photolysis rates are fully time-dependent
- dry and wet removal treated for all air parcels in the boundary layer

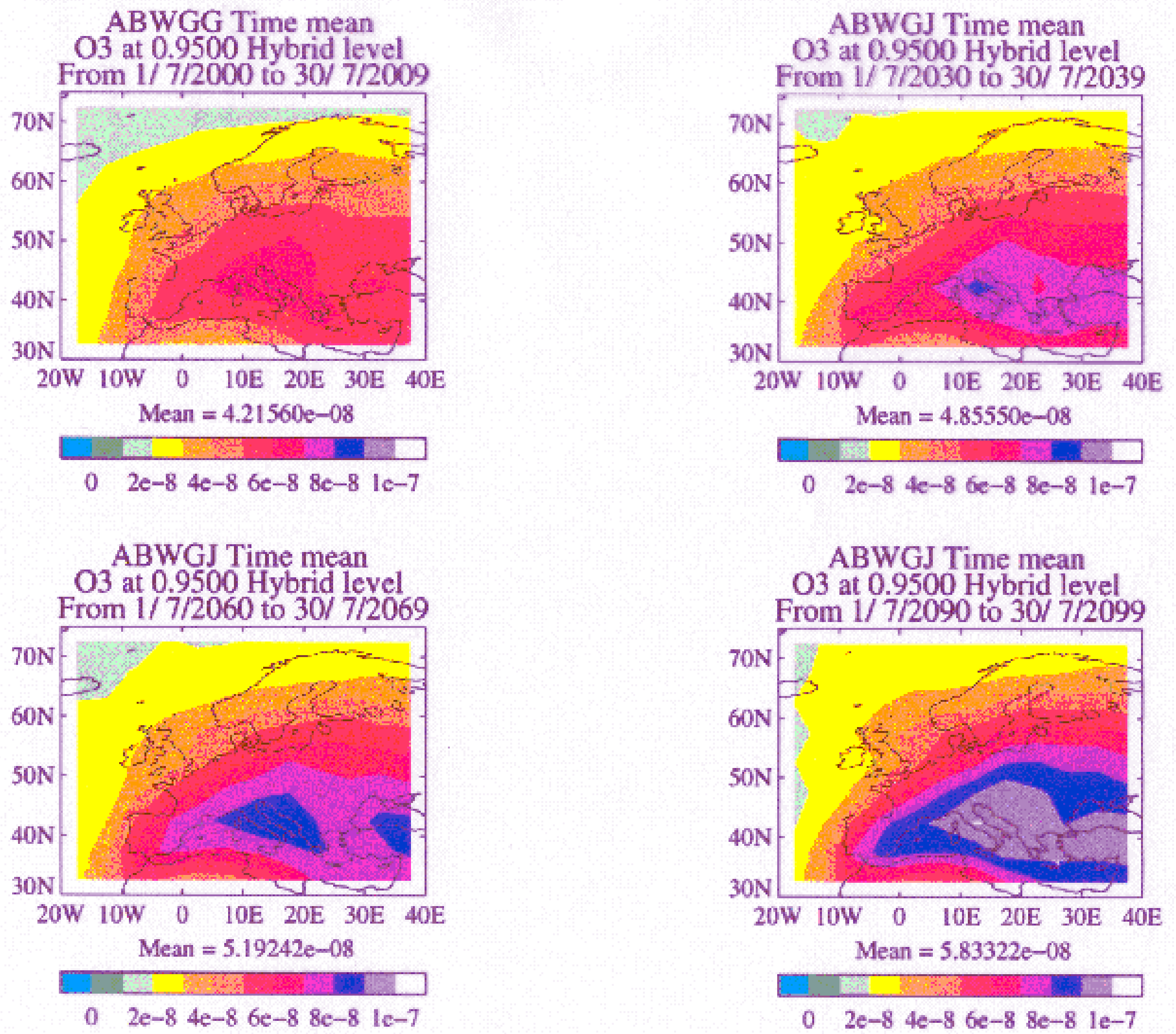
EMISSIONS

SO_2
DMS
NO_x
NH_3
terpenes
isoprene
VOCs

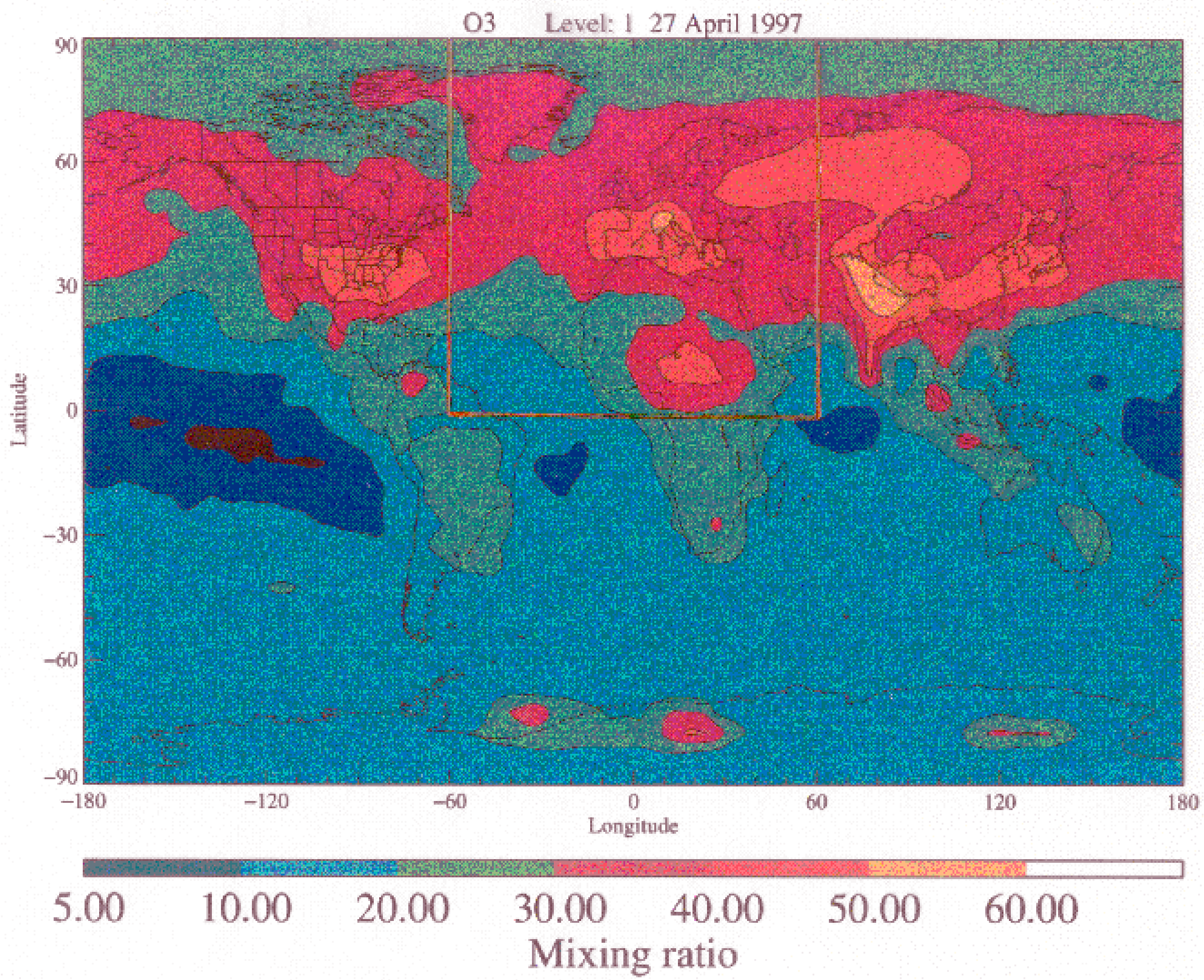
combustion
biomass burning
soils
oceans
vegetation
lightning
aircraft
animals

Emissions are divided equally between air parcels within each emission grid square in the model atmospheric boundary layer

Emissions grid is 5^o x 5^o and most are described with monthly time resolution


ABWGG Time mean
O3 at 0.9500 Hybrid level
From 1/ 7/2000 to 30/ 7/2009
70N 60N 50N 40N 30N
20W 10W 0 10E 20E 30E 40E
Mean = 4.21560e-08
0 2e-8 4e-8 6e-8 8e-8 1e-7
ABWGJ Time mean
O3 at 0.9500 Hybrid level
From 1/ 7/2030 to 30/ 7/2039
70N 60N 50N 40N 30N
20W 10W 0 10E 20E 30E 40E
Mean = 4.85550e-08
0 2e-8 4e-8 6e-8 8e-8 1e-7
ABWGJ Time mean
O3 at 0.9500 Hybrid level
From 1/ 7/2060 to 30/ 7/2069
70N 60N 50N 40N 30N
20W 10W 0 10E 20E 30E 40E
Mean = 5.19242e-08
0 2e-8 4e-8 6e-8 8e-8 1e-7
ABWGJ Time mean
O3 at 0.9500 Hybrid level
From 1/ 7/2090 to 30/ 7/2099
70N 60N 50N 40N 30N
20W 10W 0 10E 20E 30E 40E
Mean = 5.83322e-08
0 2e-8 4e-8 6e-8 8e-8 1e-7

To follow the impact of the global ozone increase on European ozone levels, a nesting approach has been adopted to increase the spatial resolution in the Lagrangian chemistry modelling.


O3 Level: 1 27 April 1997
90
60
30
0
−30
−60
−90
Latitude
−180
−120
−60
0
60
120
180
Longitude
5.00
10.00
20.00
30.00
40.00
50.00
60.00
Mixing ratio

EURO-STOCHEM

- fully nested within global STOCHEM
- identical meteorology, chemistry and emissions
- 500,000 air parcels released over one sixth of the area of the global model domain
- treats atmosphere from Equator to North Pole and from 60^oW to 60^oE

AIMS OF NESTED MODEL APPROACH

- address ozone across Europe with 3-hour time resolution

- feed in global ozone baseline for 1990s and 2030 in IPCC A2 scenario

EURO-STOCHEM EXPERIMENTS

- BASE CASE WITH 1990s EMISSIONS
- 30% NO_x emission reduction
- 30% VOC emission reduction
- global ozone for 2030 in IPCC A2 emission scenario

APRIL 1997	O_3 mean ppb	AOT_{40} ppm hrs	>60 ppb
Mace Head	41.8	2.8	12
Harwell	43.5	3.4	18
Monte Vehlo	41.6	3.6	28
Tustervatn	39.7	1.4	2
Aspreveten	44.0	3.0	16
Virolahti	35.5	1.1	3
Shepeljovo	36.3	1.3	5
Lahemaa	35.5	1.1	13
Preila	41.4	2.0	9
Illmitz	46.8	4.2	25
Taenikon	48.8	5.2	31
Kosetice	45.7	3.7	26
Waldhof	45.8	4.0	25
Frederiksborg	42.2	2.2	5
K-puszta	46.3	4.3	23
Kollumerwaard	38.7	2.2	9
Jarczew	42.7	3.1	19
Starina	43.4	3.2	18
Roquetas	45.6	2.7	13
Revin	46.5	4.7	30
Aliartos	48.3	4.4	19
Montelibretti	51.4	4.7	31
Iskrba	48.0	4.4	24

OZONE-PRECURSOR SENSITIVITY

Ozone responses to precursor emission controls - 30% NO_x and 30% VOC reduction

$\delta O_3/\delta NO_x$ > $\delta O_3/\delta VOC$ NO_x sensitive

$\delta O_3/\delta NO_x$ < $\delta O_3/\delta VOC$ VOC sensitive

Quantitative relationship between the oxidation of NO_2 to NO_z and photochemical ozone formation from Sillman et al.

$[O_3]/[NO_z]$ > 10 NOx sensitive

$[O_3]/[NO_z]$ < 10 VOC sensitive

where $[NO_z] = [HNO_3] + [PAN] + [\text{nitrate aerosol}]$

APRIL 1997	Changes in occurrences of $O3$ >60 ppb	
Controls :	30% NO_x	30% VOC
Mace Head	-2	-2
Harwell	+4	-3
Monte Vehlo	-4	-2
Tustervatn	0	0
Aspreveten	-1	0
Virolahti	0	-1
Shepeljovo	-2	-1
Lahemaa	-8	-4
Preila	+1	-2
Illmitz	-4	-6
Taenikon	-7	-2
Kosetice	-5	-7
Waldhof	-1	-11
Frederiksborg	+1	0
K-puszta	-4	-6
Kollumerwaard	+3	-1
Jarczew	-2	-2
Starina	-1	-2
Roquetas	-3	-2
Revin	0	-6
Aliartos	-6	-4
Montelibretti	-5	-2
Iskrba	-8	-8

APRIL 1997 Changes in AOT_{40} in ppm hrs

Controls :	30% NO_x	30% VOC
Mace Head	-0.4	-0.4
Harwell	+0.1	-0.7
Monte Vehlo	-0.5	-0.2
Tustervatn	-0.06	0
Aspreveten	-0.3	-0.2
Virolahti	-0.1	-0.1
Shepeljovo	-0.1	-0.2
Lahemaa	-0.2	-0.2
Preila	0	-0.4
Illmitz	-0.2	-0.8
Taenikon	-0.6	-0.5
Kosetice	-0.2	-0.5
Waldhof	+0.3	-0.7
Frederiksborg	+0.1	-0.3
K-puszta	-0.4	-0.5
Kollumerwaard	+0.2	-0.3
Jarczew	-0.3	-0.3
Starina	-0.4	-0.4
Roquetas	-0.6	-0.4
Revin	0	-0.9
Aliartos	-0.6	-0.1
Montelibretti	-0.7	-0.4
Iskrba	-0.7	-0.5

APRIL 1997 Changes in AOT_{40} in ppm hrs

Influence of Climate Change by 2030 A2

Mace Head	+1.2
Harwell	+0.9
Monte Vehlo	+0.4
Tustervatn	+1.5
Aspreveten	+1.3
Virolahti	+0.7
Shepeljovo	+0.6
Lahemaa	+0.8
Preila	+1.3
Illmitz	+1.2
Taenikon	+1.1
Kosetice	+1.0
Waldhof	+1.1
Frederiksborg	+1.3
K-puszta	+1.1
Kollumerwaard	+1.1
Jarczew	+0.9
Starina	+0.9
Roquetas	+0.4
Revin	+1.0
Aliartos	+1.4
Montelibretti	+0.8
Iskrba	+0.9

CONCLUSIONS

European ozone exposure level	=	Baseline contribution	+	Internal European Production

Efforts to reduce the potential for ozone formation inside Europe may be partially offset in the future by the global ozone build-up.

This offsetting may be more severe for mean ozone and AOT40 exposures compared with 60 ppb exceedances.

The future global ozone build-up is driven by emissions both inside and outside of Europe in Asia and North America.

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