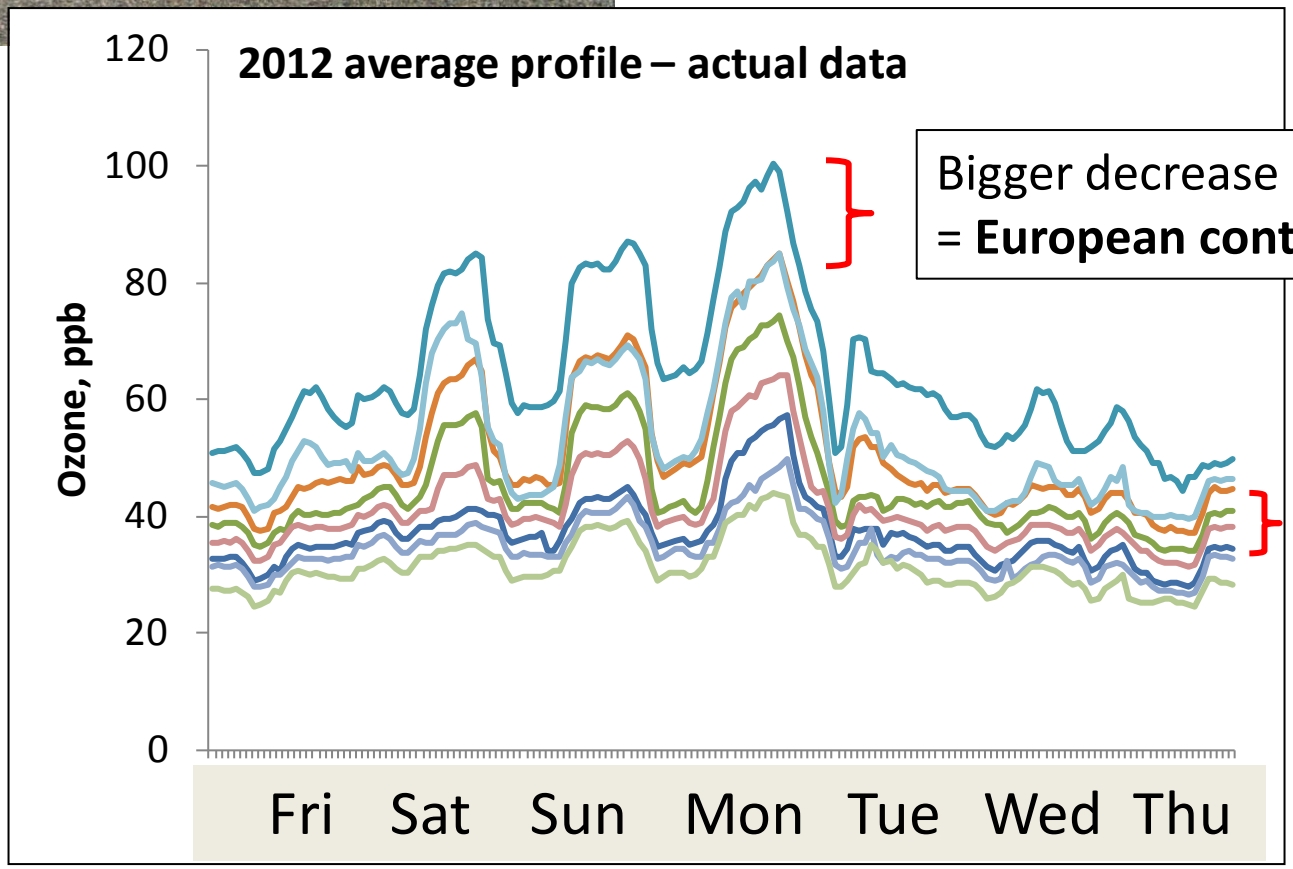
Ozone research at CEH

Tropospheric ozone

- Ozone climatology, concentrations, trends, spatial patterns (David Fowler Mhairi Coyle)
- Ozone Chemistry (Neil Cape)
- Effects of ozone on ecosystems (crops and semi-natural Gina Mills, Felicity Hayes, Harry Harman)
- Ozone deposition and flux measurement (Mhairi Coyle, David Fowler, Eiko Nemitz, Gina Mills, Felicity Hayes) Defra, UNECE, PEGASOS
- Global modelling and assessment (with Univ Edinburgh, Federico Centoni, David Fowler, Eiko Nemitz) PEGASOS, ACCENT+

- **Ozone regimes simulated to +/- 1-2 ppb**
- **Allows for small changes in O_3 profile to be simulated**
- **2012/3 profile – highest treatment is Aston Hill episode repeated each week as a worst-case scenario**



Focus on Interactions – O3 + N, drought, flooding

➢8 ozone profiles - detailed dose-response relationships for impacts on: physiology, growth, C sequestration, biodiversity, water relations

Current experiments

➢ 7 x O_3 with 4 x N - effects on photosynthesis, stomatal conductance and growth

- results feed through to ecosystem and global climate modelling in EU-ECLAIRE project

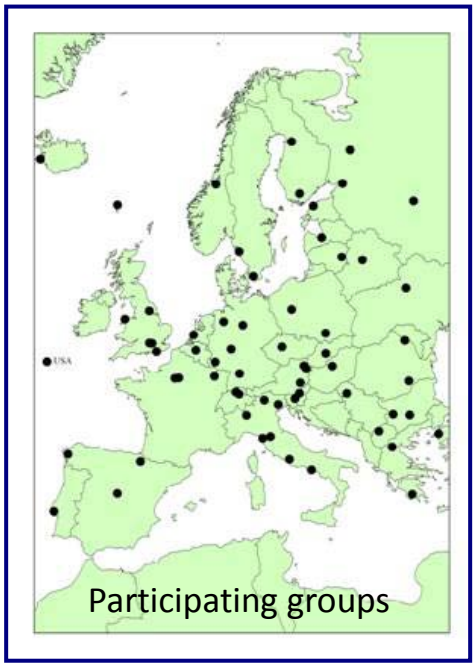
➢ 6 x O_3 with drought events

- simulated high-input pasture

Future work

➢Further experiments with vegetation, including cores from Whim bog

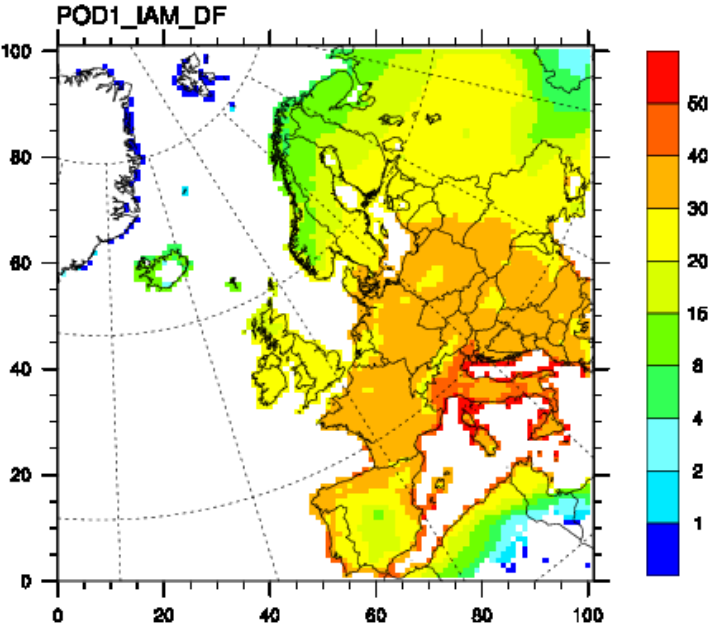
➢Potential addition of heating for simulating extreme events – heat, drought and ozone

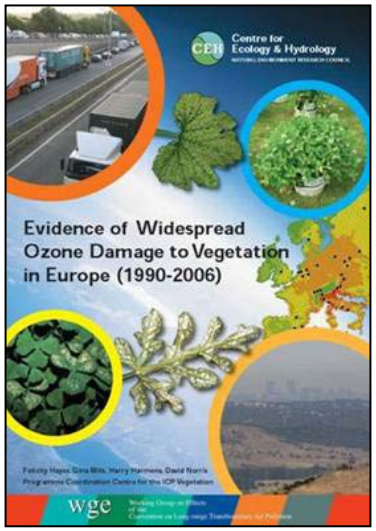


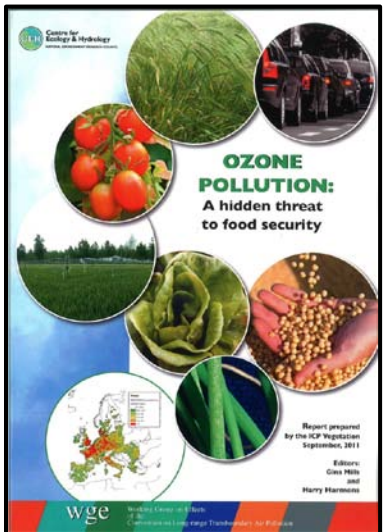
UNECE ICP Vegetation Coordination Centre at CEHBangor

Reports to the LRTAP Convention on effects of air pollutants on vegetation, including:

- State of knowledge reports
- Impacts of future scenarios (food security, C sequestration, biodiversity)
- Standardised methodology for international application (DO3SE, critical levels etc)
- Evidence of effects in field





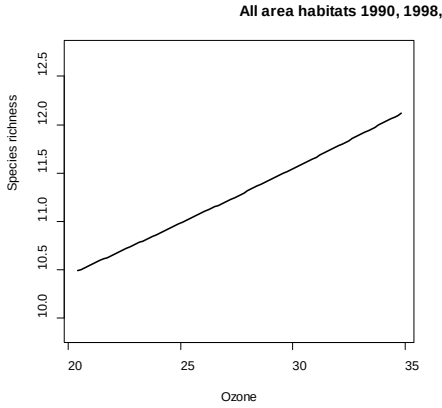


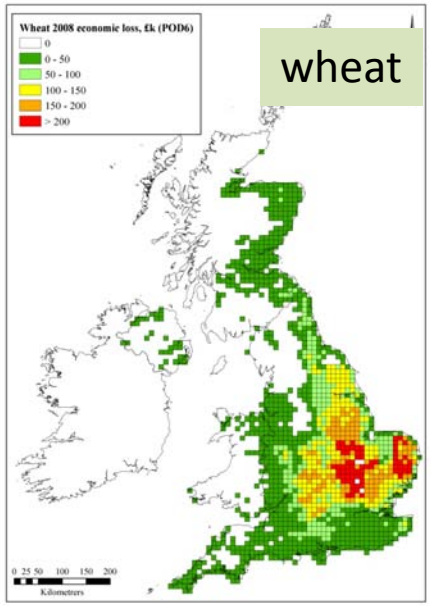
For Defra:

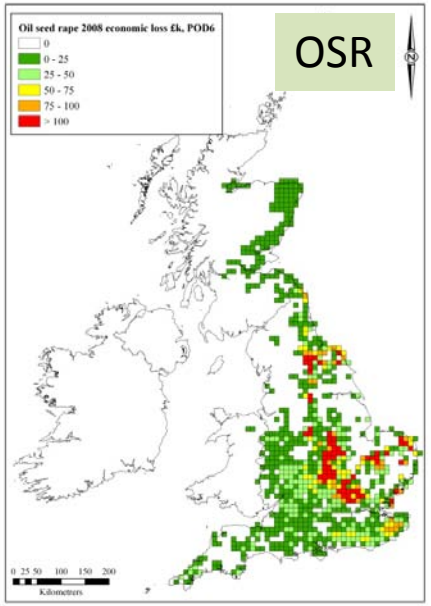
Spatial analysis, and where possible monetising of ozone impacts on:

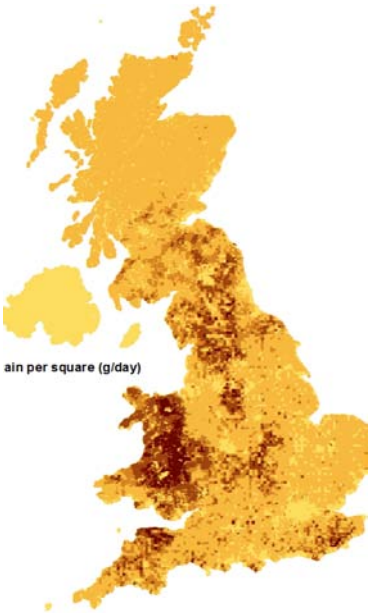
- Crop yield (2005 and 2008 comparison)
- Pasture quality – impacts on lamb production
- C sequestration – grass and trees
- Biodiversity – CS data

Future work – expansion of services quantified









Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

PEGASOS
Pan-European Gas-AeroSOls-climate interaction Study

Global scale modelling of atmosphere-biosphere exchange and interactions between air quality and climate change

Supervisors:

- **Prof. David Fowler**
- **Dr. David Stevenson**
- **Dr. Eiko Nemitz**
- **Dr. Richard Essery**

THE UNIVERSITY of EDINBURGH
School of GeoSciences

Atmosphere-biosphere exchange

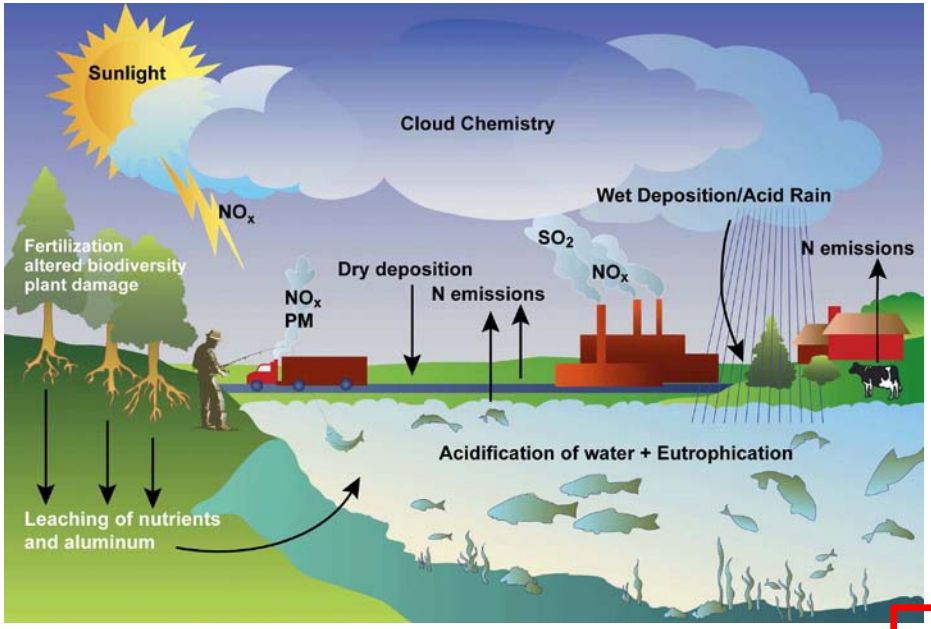
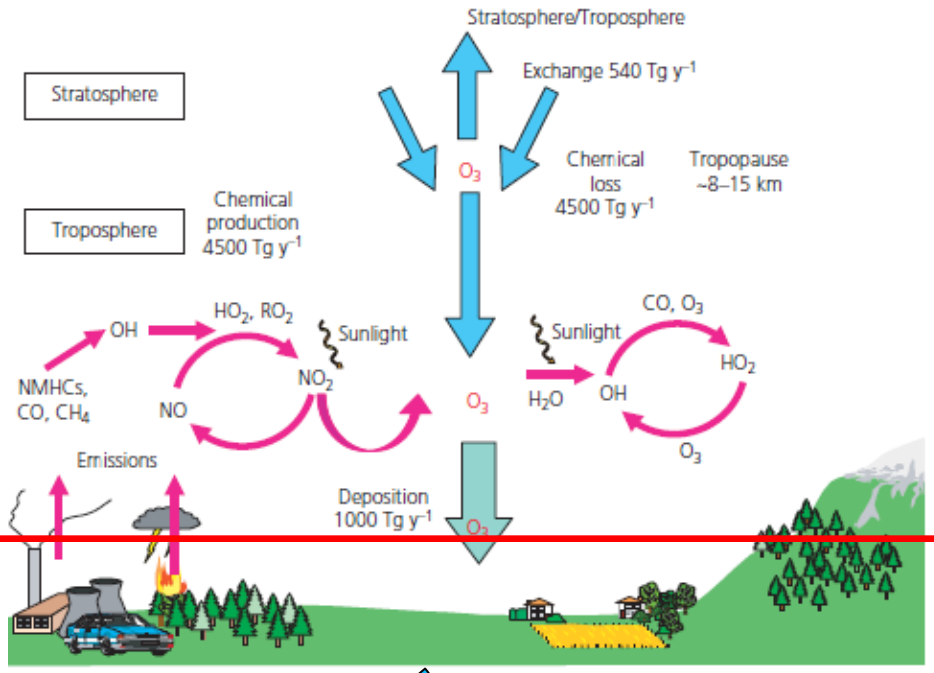
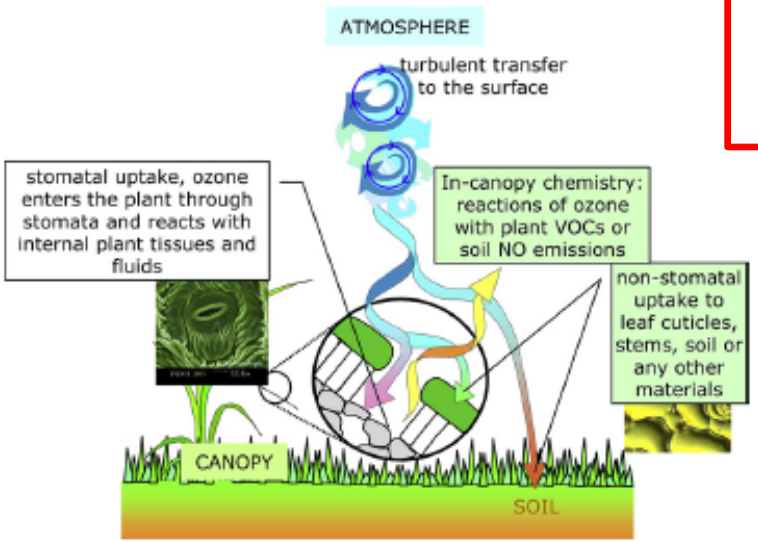


Fig.1



FFig. 2



FFig. 3

Fig.1 www.epa.gov
Fig.2 Fowler et al. ,Royal Society,2011
Fig.3 Fowler et., Atm Envir.,2009

Research questions

- Quantifying interactions between air quality and climate change?

- How do policies aimed at controlling air quality influence climate forcing?

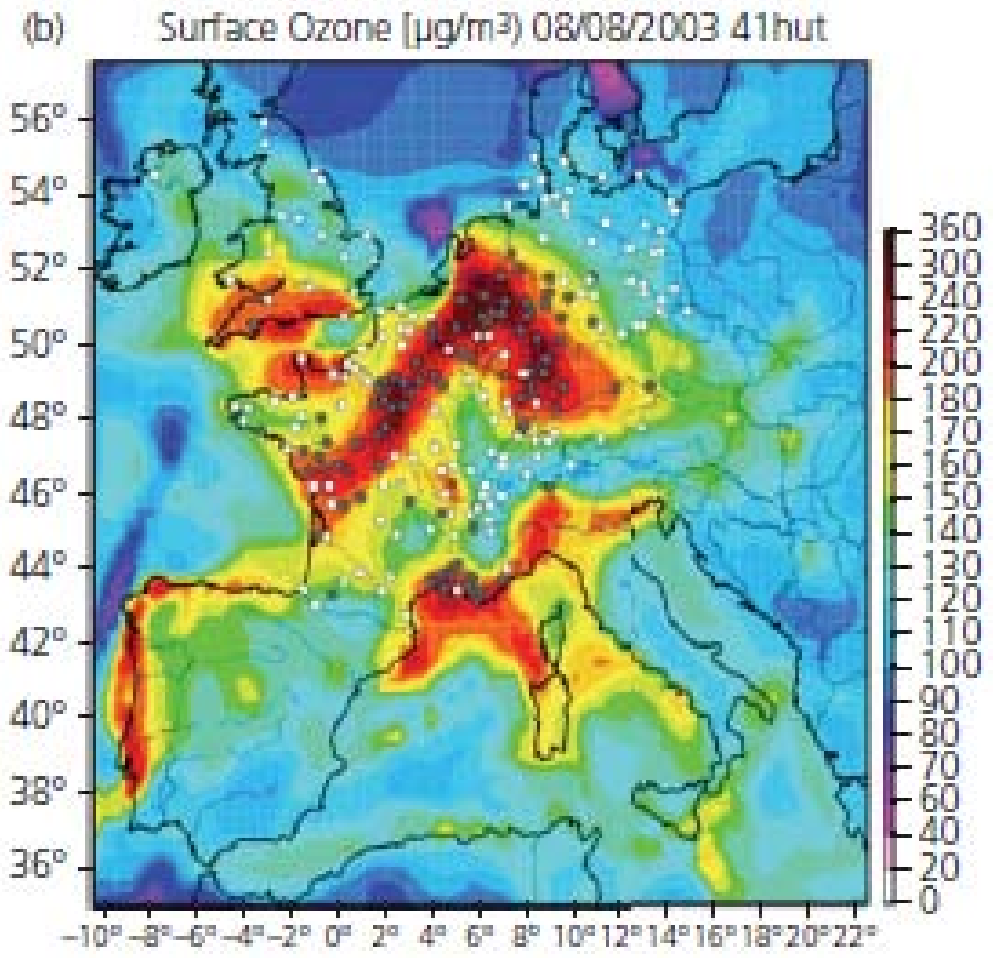
How climate change may affect Dry Deposition processes?

More frequently occuring hot summers (heat waves)

Summer 2003

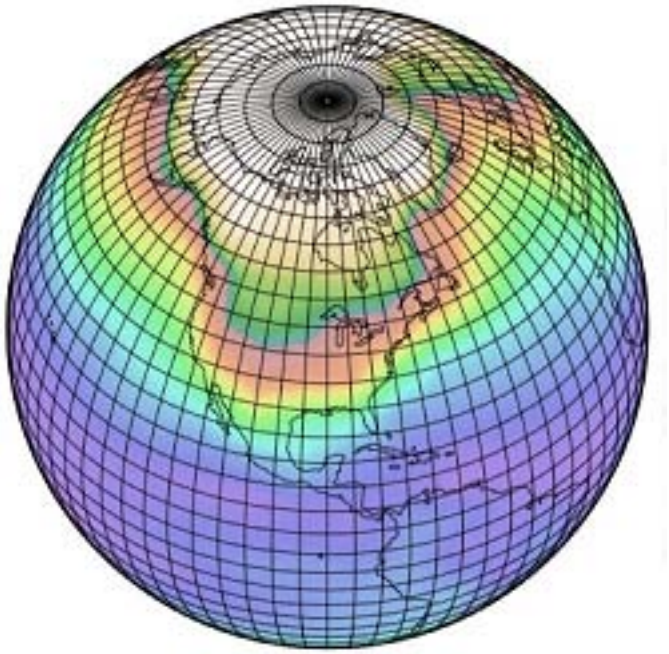
Daily Dose ≤ 100 µg m^{-3}

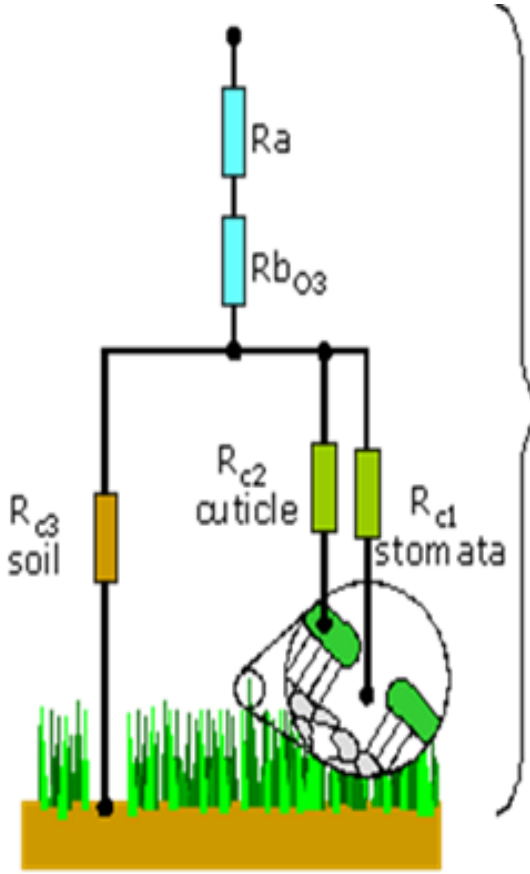
World Health Organization



Surface Ozone concentrations (summer 2003)
EU Envir. Agency,2007

UK Chemistry-Aerosol Model (UKCA) Dry Deposition Scheme





Wesely, 1989

$$R_t = R_a + R_b + R_c$$

$$R_c = \left(\frac{1}{\frac{1}{R_{c1}} + \frac{1}{R_{c2}} + \frac{1}{R_{c3}}} \right)$$

Surface Tile Scheme (9 type)

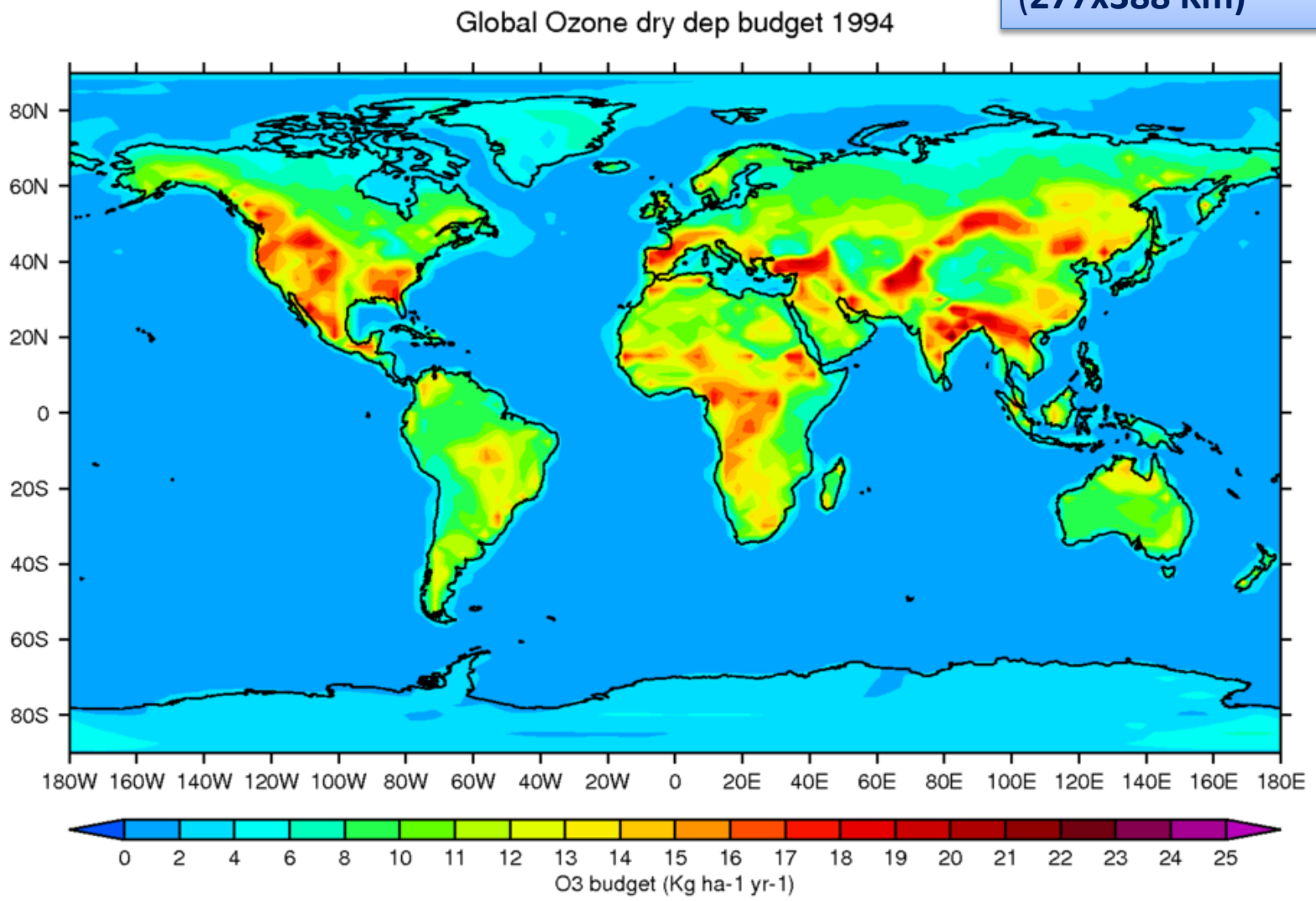
Broadleaved trees, Needle leaf trees, C3 (temperate) Grass, C4 (tropical), Grass, Shrub, Urban, Water, Bare Soil, and Ice

Fig. R. Fowler et al. 2009

Fig. L. Henderson-Sellers, 1985

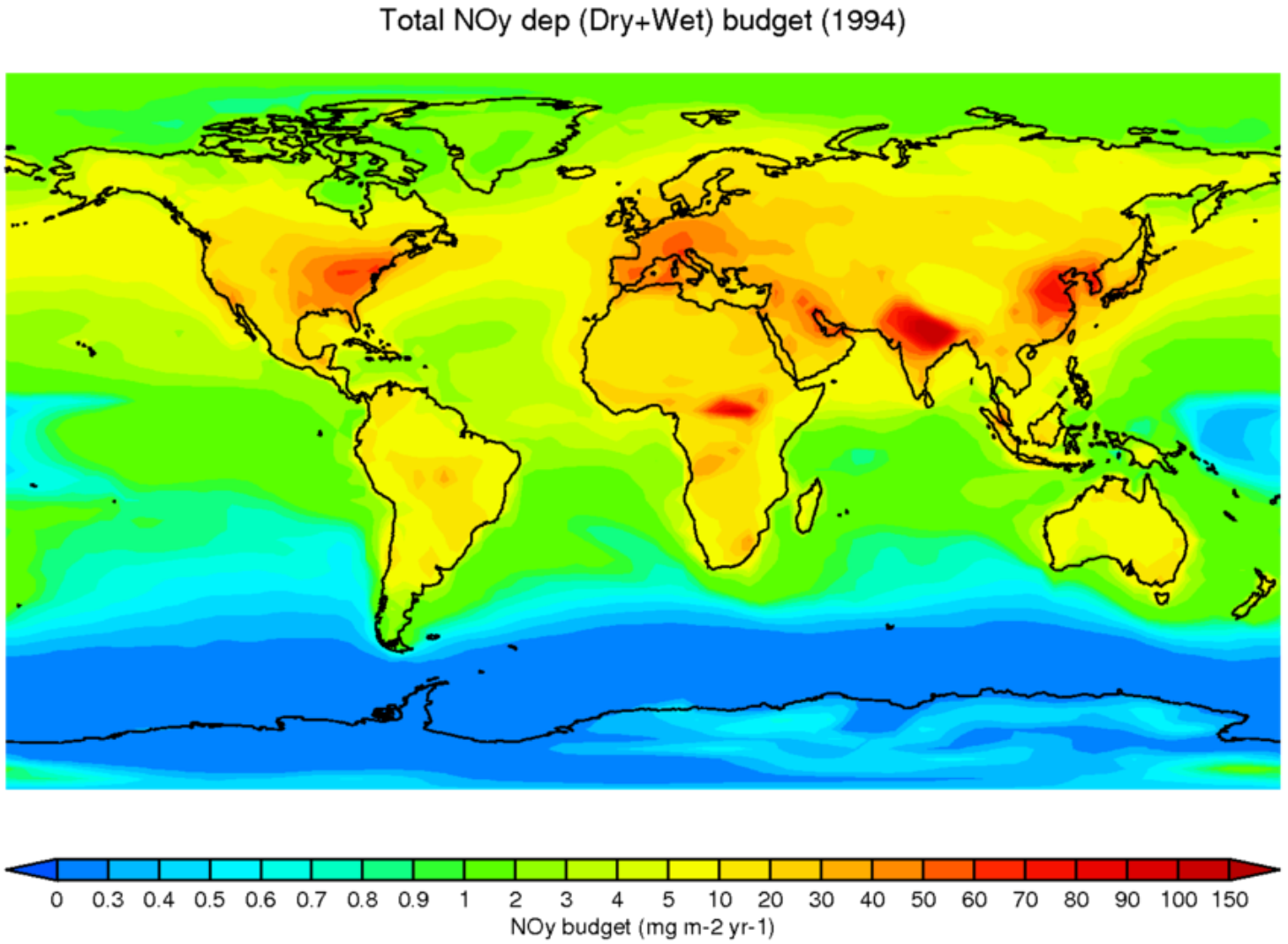
Quantifyng the global O_3 dry dep budget: 1990-2000 Base run UKCA model (v7.3)

Resolution : 2.5° x 3.75° (277x388 Km)



Quantifyng the global NO_y (dry+wet) dep budget: 1990-2000
Base run UKCA model (v7.3)

$NO_y = NO + NO_2 + NO_3 + 2N_2O_5 + HNO_3 + PAN + RNO_3^-$



Some numbers...O_3 and NO_y total annual budgets

Model	Flux terms/Tg ozone a^{-1}				τ/days
	P	L	D	S	
CESM-CAM-superfast	3877	3638	687	448	25.5
GEOSCCM	4692	3853*	1240	401	24.8
GFDL-AM3	5853	5089	1240	476	21.8
NCAR-CAM3.5	4494	4112	842	460	24.8
STOC-HadAM3	5989	5050	1350	411	19.9
UM-CAM	4358	3816	1205	663	23.4
ACCENT mean (±sdev)	5110 ± 606	4668 ± 727	1003 ± 200	552 ± 168	22.3 ± 2.0
UKCA			**1120**	**Tg (O_3) yr^{-1}**	

yYoung et al. 2013

Model	Dry	Wet	Total dep.	eminox	emilnox Tg(N) yr^{-1}	Total emi.
CESM-CAM-superfast	17	29	46	42	4	46
CMAM	27	23	50	47	4	51
GEOSCCM	12	33	45	40	5	45
GISS-E2-R	14	39	53	41	8	49
GISS-E2-TOMAS	17	37	54	41	8	49
MOCAGE	20	27	47	43	5	48
NCAR-CAM3.5	20	29	49	43	4	47
STOC-HadAM3	26	27	52	45	7	52
UM-CAM	31	26	56	49	5	54
Multi-model mean	20	30	50	47	6	49
PhotoComp			51			
UKCA				**52**	**Tg (N) yr^{-1}**	

yLamarque et al. 2013

East Asia seasonal O_3 dry deposition