Food security and climate change in North Africa - potential co-benefits of tackling ground-level ozone

Patrick Büker and Lisa Emberson
Stockholm Environment Institute, York, U.K.

Sub-regional workshop: Better air quality in North Africa
23 – 25 November 2009, Tunis

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Content

1. What is ozone?
2. Evidence of effects of ozone on agriculture
3. The North African perspective
4. Risk assessment methods
5. Potential co-benefits of tackling ozone pollution
6. Outlook

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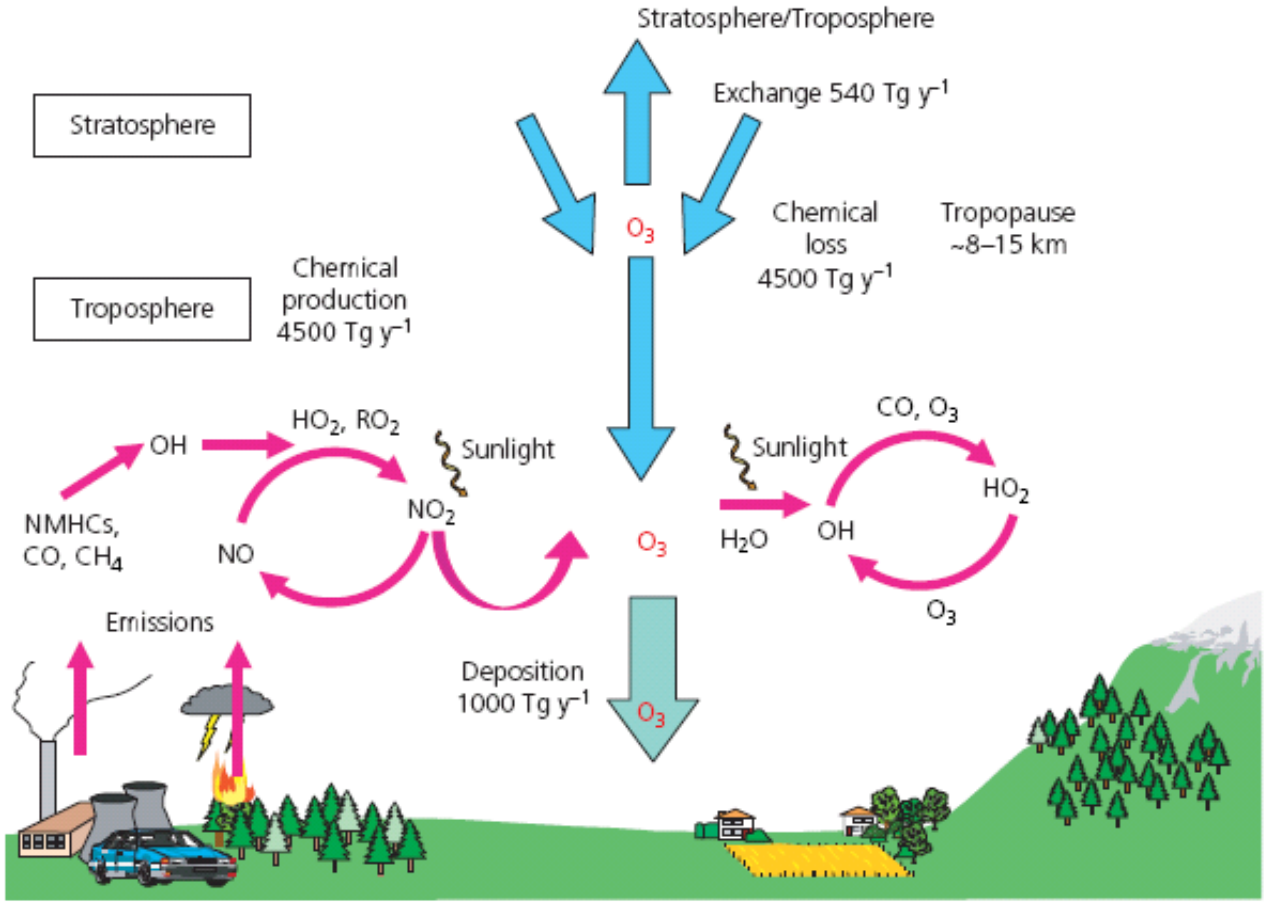
Ozone (O_3) is an important rural pollutant

O_3 Precursors

NOx, CO, CH_4, nmVOC



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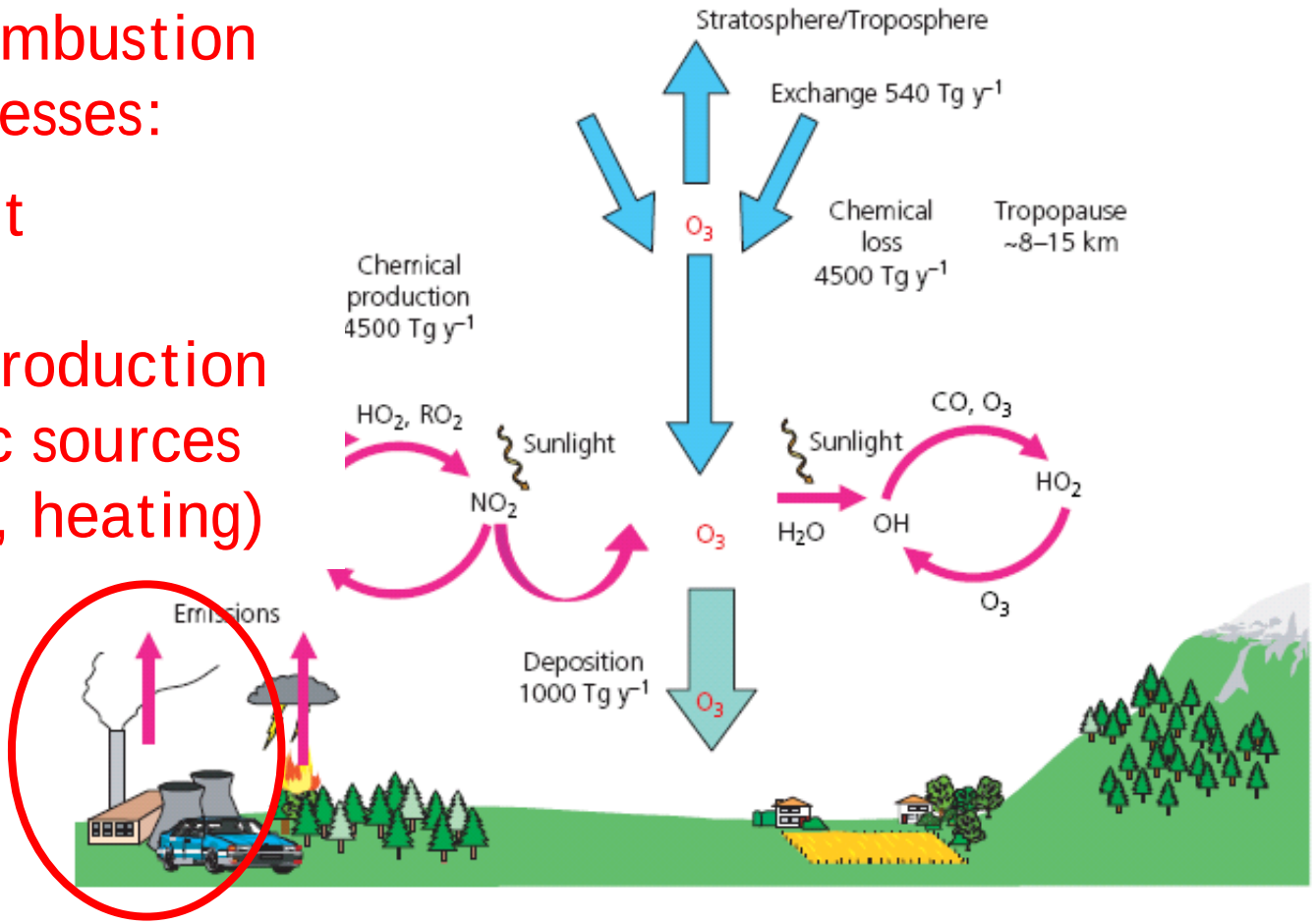
O_3 is an important rural pollutant

Anthropogenic precursor sources from combustion processes:

- Transport
- Industry
- Energy production
- Domestic sources (cooking, heating)

O_3 Precursors
NOx, CO, CH_4, nmVOC



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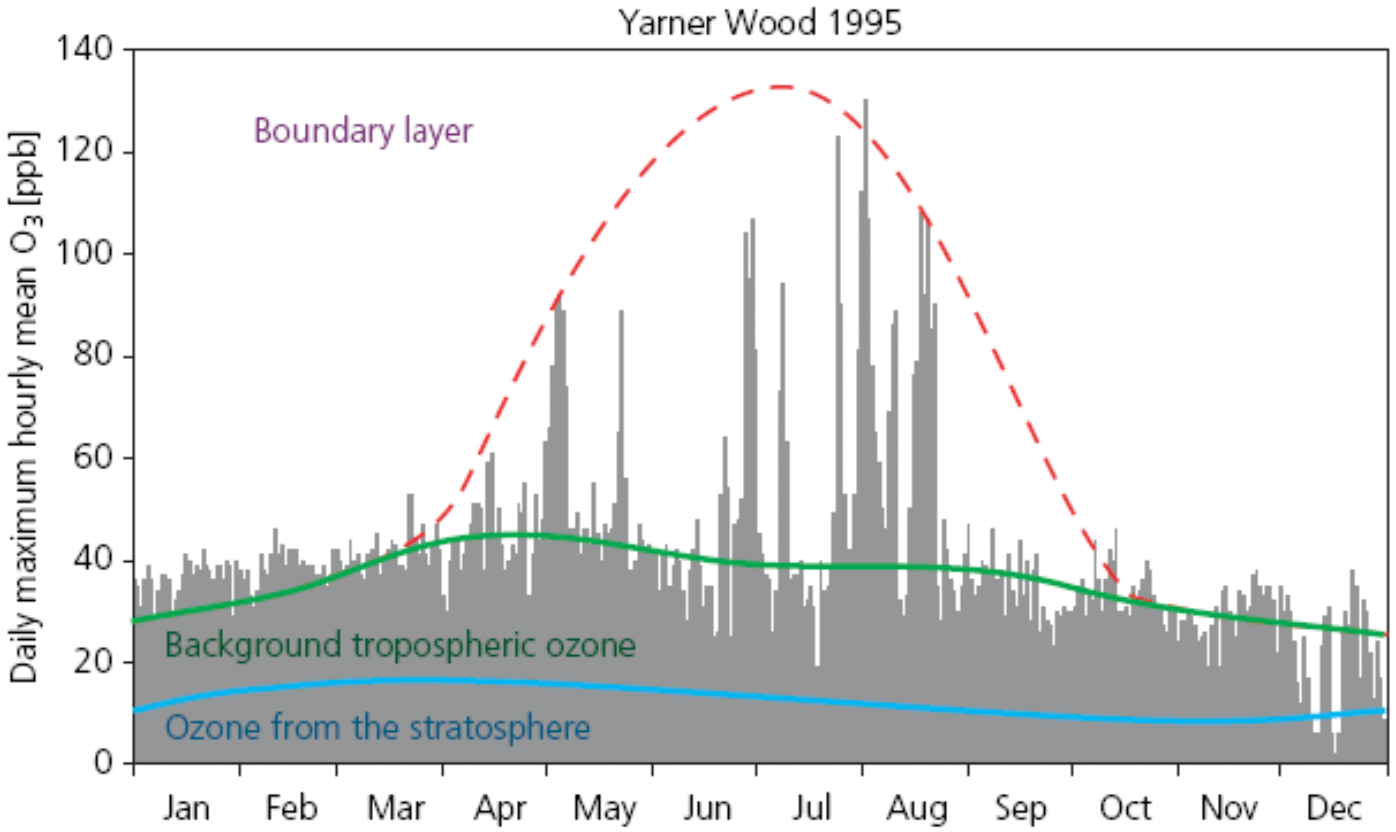
O_3 concentrations vary seasonally



Royal Society, 2008

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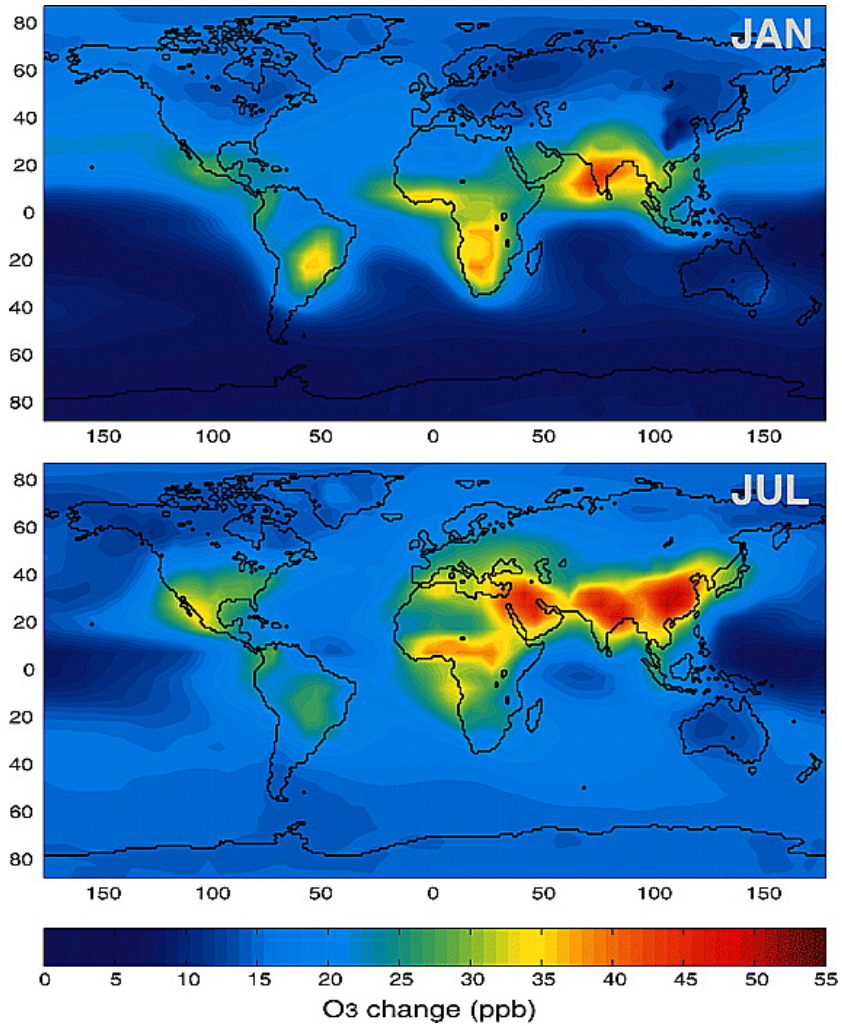
Surface O_3 predictions

Δ in surface O_3 from 2000 to 2100



Prather et al. (2003)

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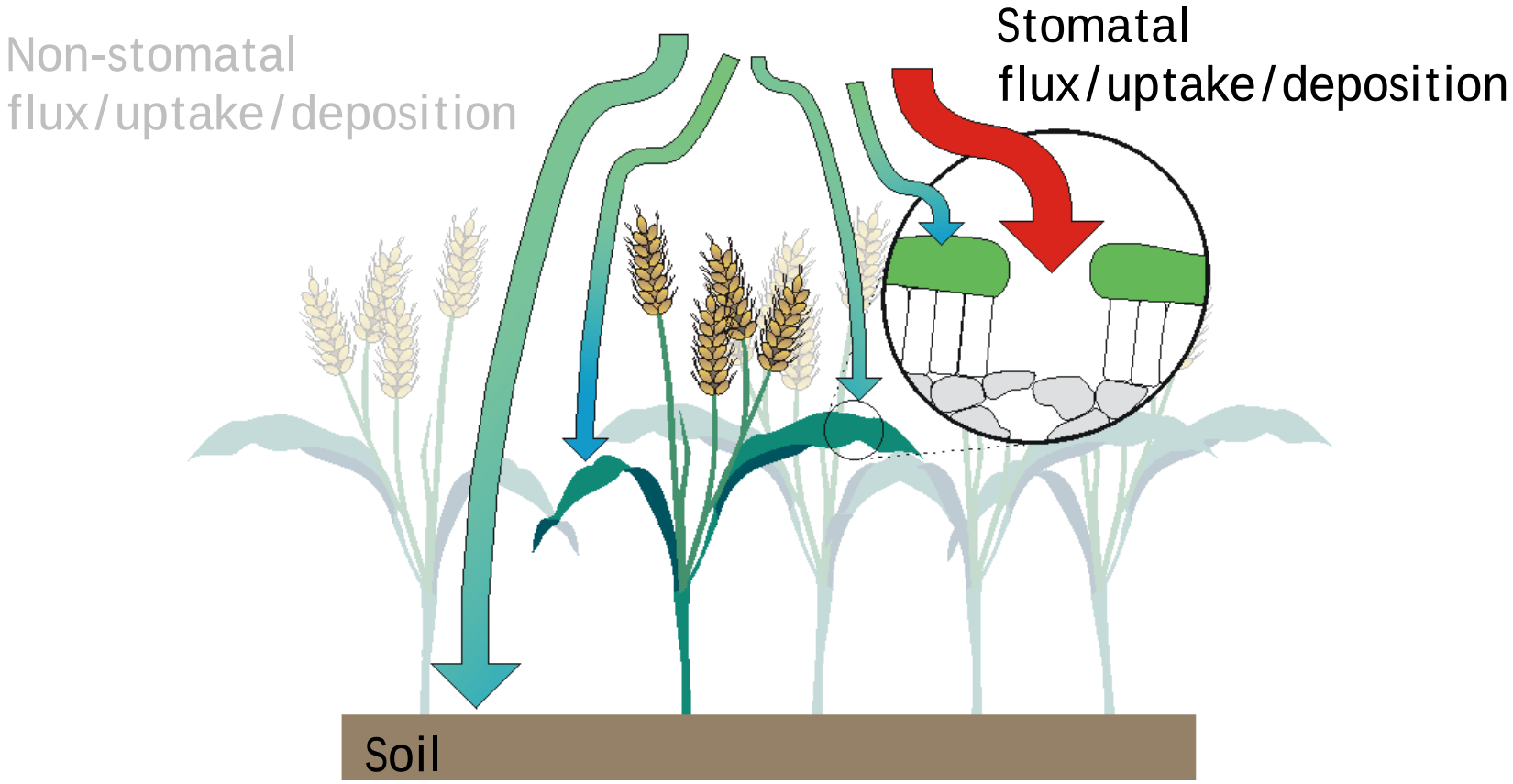
Uptake of O_3 by plants

Ambient O_3 concentration



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Evidence of effects of O_3 on agriculture

Reported effects of ozone on agriculture:

- Visible leaf injury
- Reduced growth
- Yield loss
- Premature senescence
- Increased attacks by pests

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Evidence of effects of O_3 on agriculture

Crops that have shown some effect after exposure to ozone

- Wheat
- Rice
- Maize
- Potato
- Legumes (beans, pea etc.)
- Tomato
- Leafy vegetables (spinach, lettuce etc.)
- Melon
- Tobacco

Effects have also been reported on grassland and forest species

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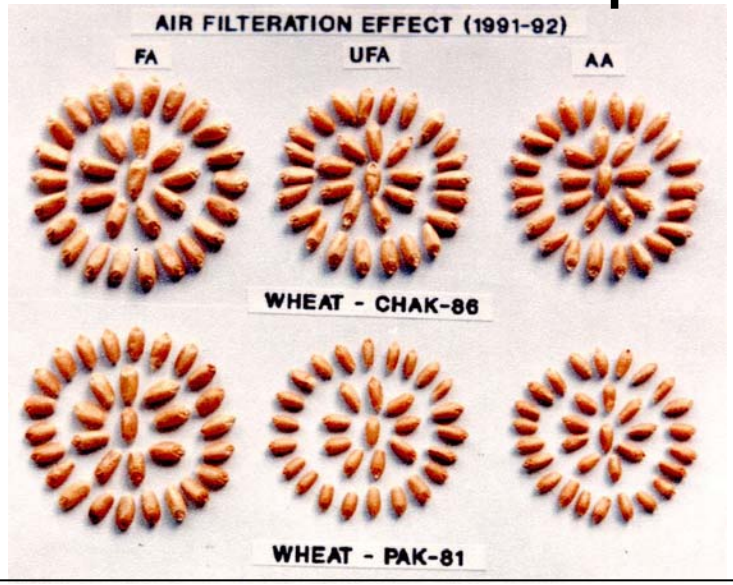
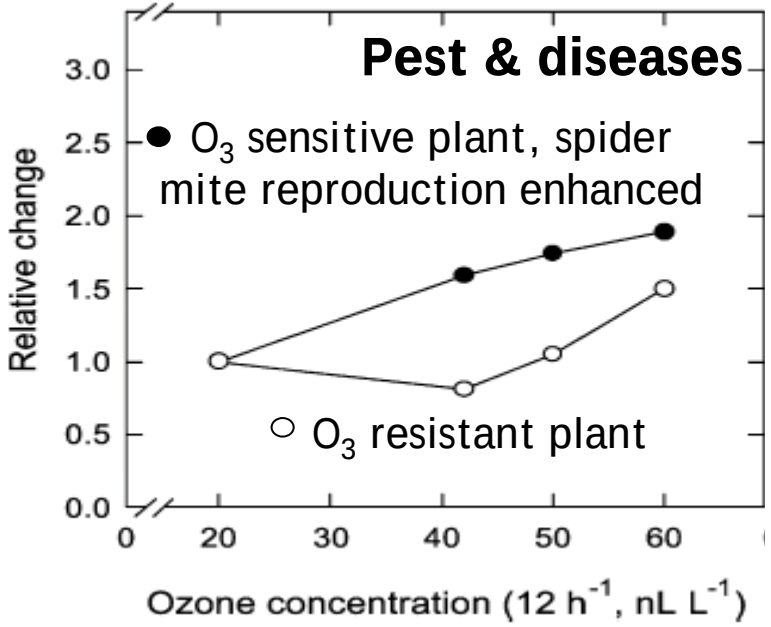
Effects of O_3 on agriculture: wheat

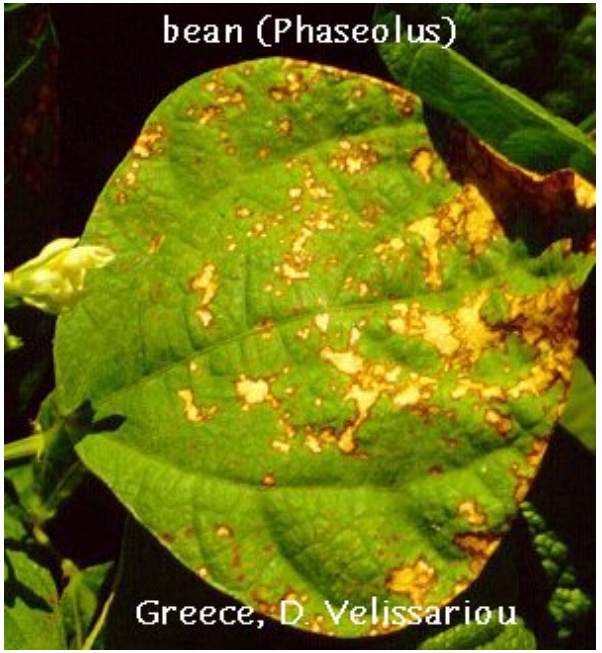
Yield loss and effects on quality





Evidence of effects of O_3 on agriculture

Leaf injury



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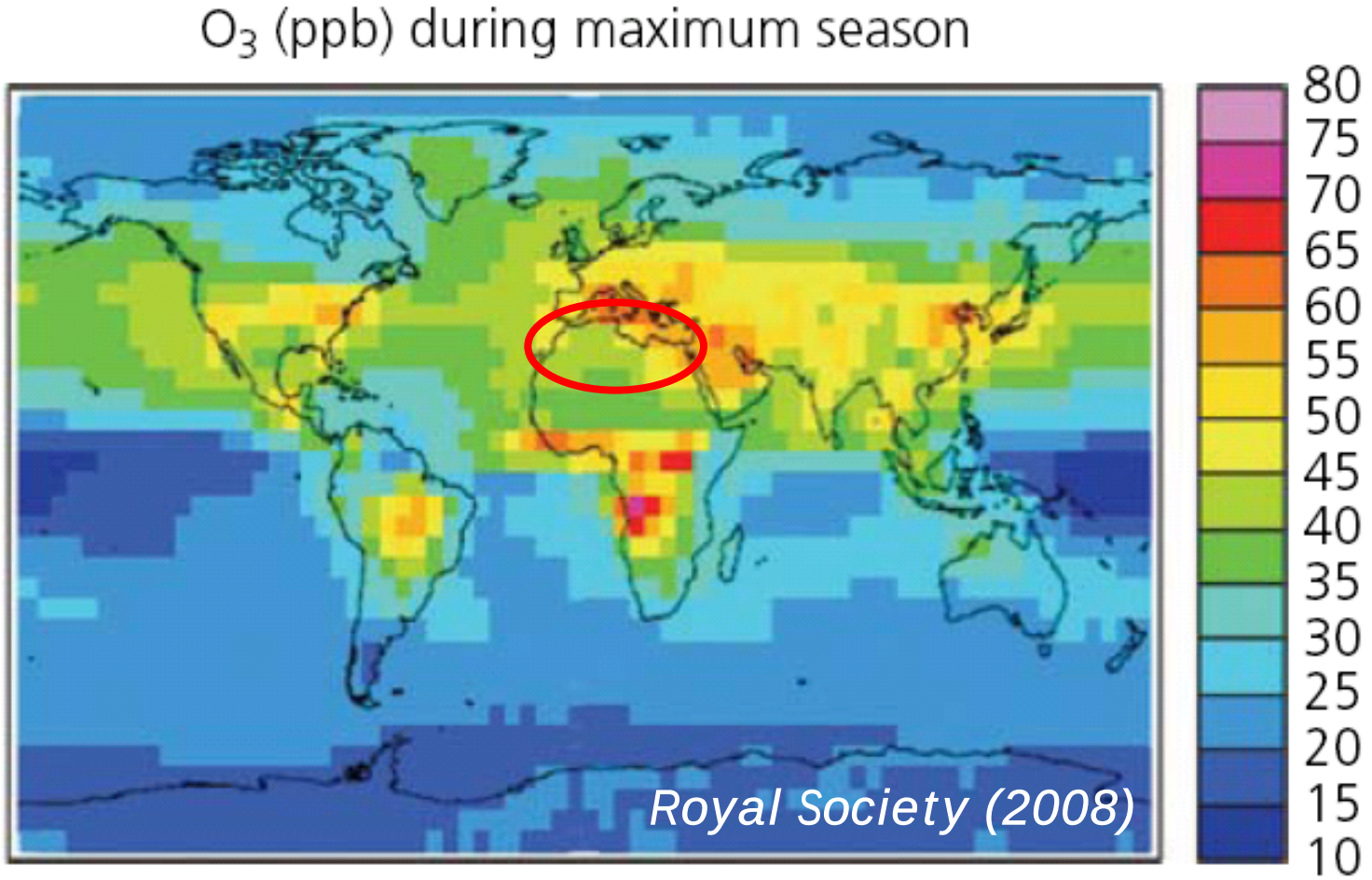
Maximum surface O_3 in 2000



JJA

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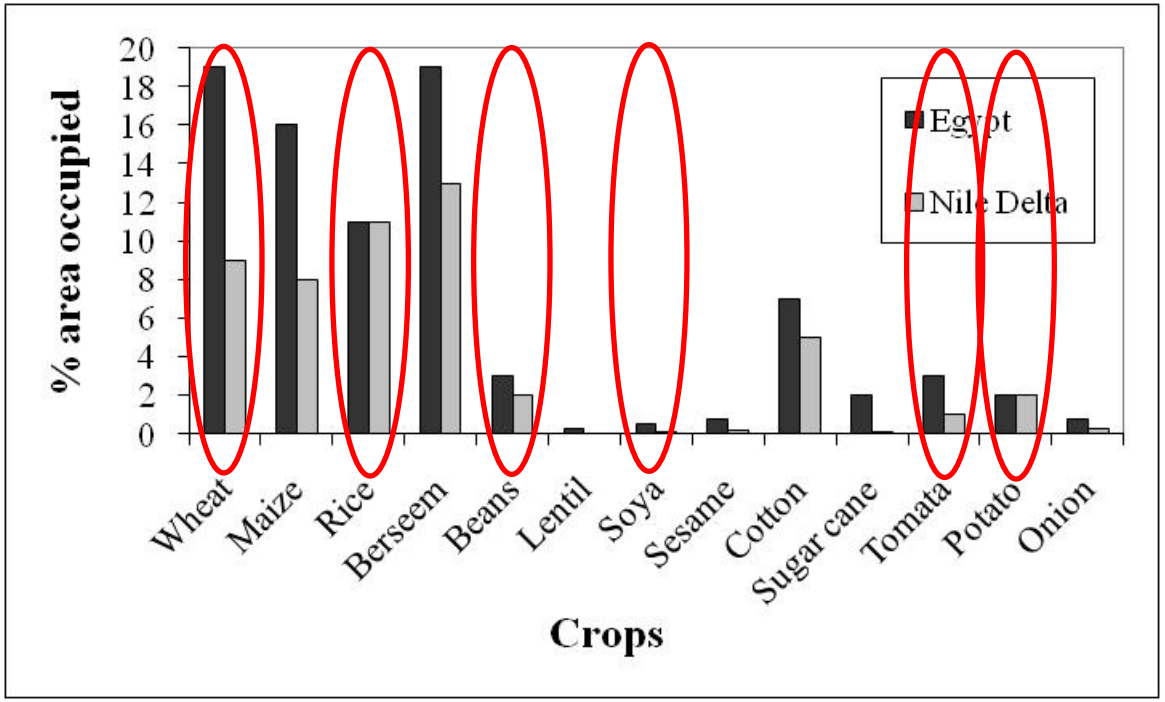
Cultivated crops in North Africa (example Egypt)



The percentage land area occupied by important crops in the Delta region as compared to Egypt as a whole for the year 1996 (Source: MALR, 1996)

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Evidence of ozone effects on crops in North Africa

- visible injury symptoms on radish and turnip in Egypt (Hassan et al., 1995)
- yield reduction in radish and turnip up to 30 and 17 %, respect. in Egypt (Hassan et al., 1995)
- yield reduction in broad bean and corn reduced significantly in Egypt (Ali, 2008)
- yield reduction in potato tubers up to 30 % in Egypt (Hassan, 2006)

Various studies available from European Mediterranean countries (Italy, Greece, Spain etc.)

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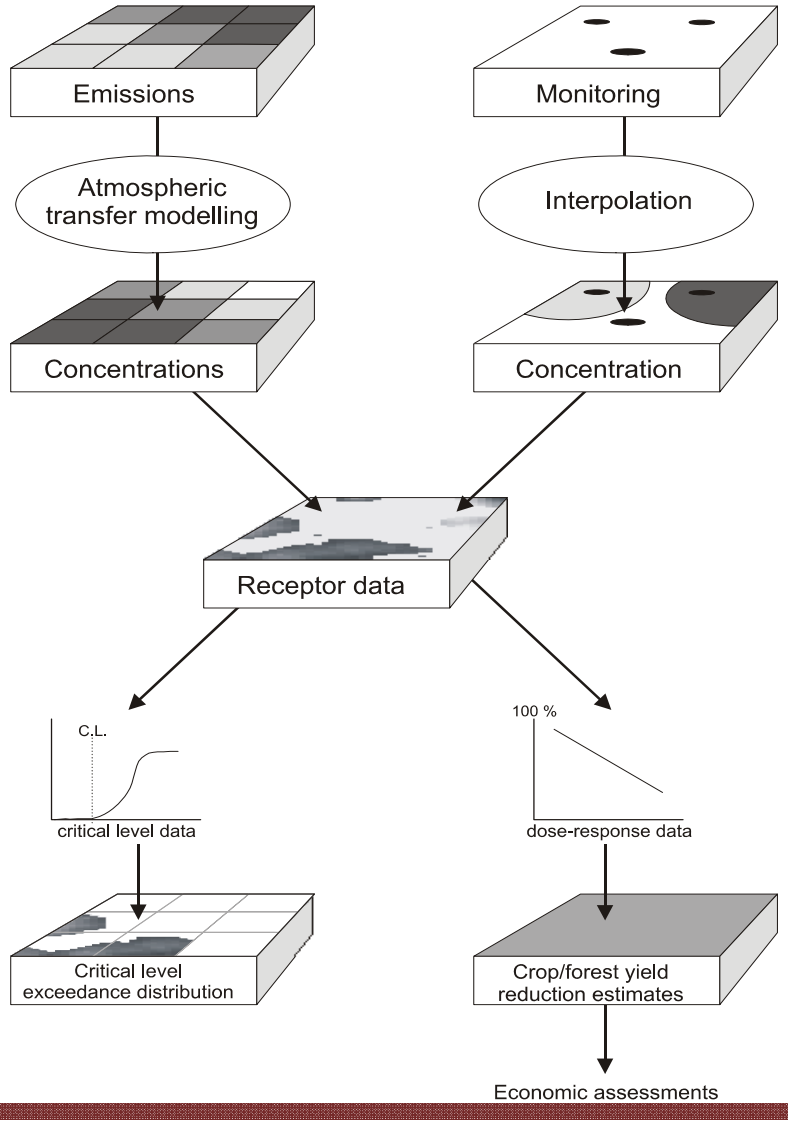
Risk assessment methods



E.g. to identify ozone hot-spots across the region using:-

- modelled ozone concentration data.
- agricultural distribution data
- Air Quality Guidelines (e.g. AOT40, Flux)

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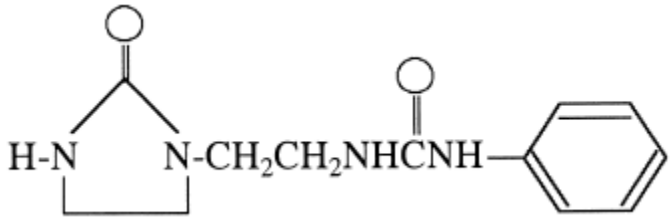
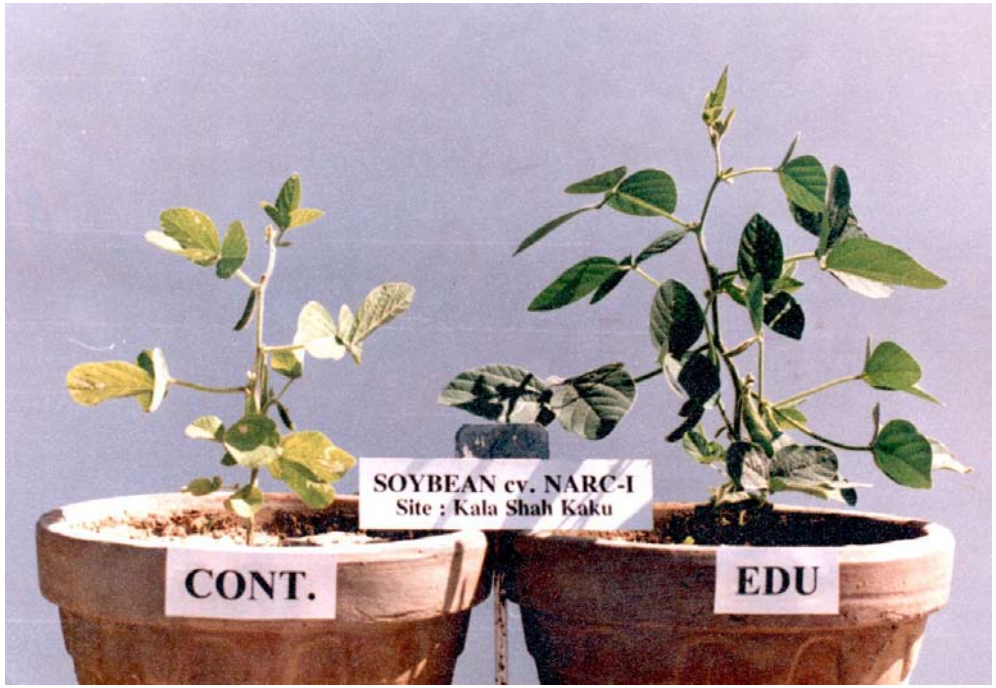
Bio-monitoring

Chemical Protectant Studies



Structural formula for N-(2-(2-oxo-1-imadazolidinyl)ethyl)-N'-phenylurea

abbreviated as EDU for ethylenediurea



Pakistan soybean cv. NARC-1 showing protective effect of EDU at a roadside rural site in Lahore, Pakistan (photo courtesy of A. Wahid)

EDU suppresses acute and chronic ozone injury on a variety of plants under ambient O_3 conditions (Godzik & Manning, 1998)

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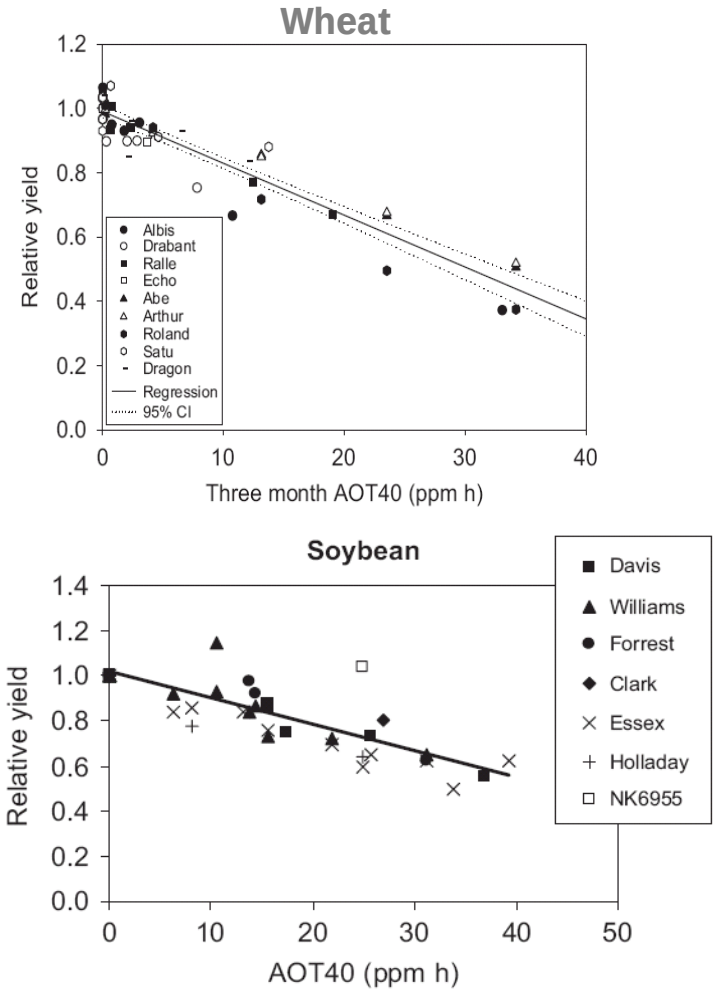
Open Top Chambers allow controlled O_3 fumigation and filtration



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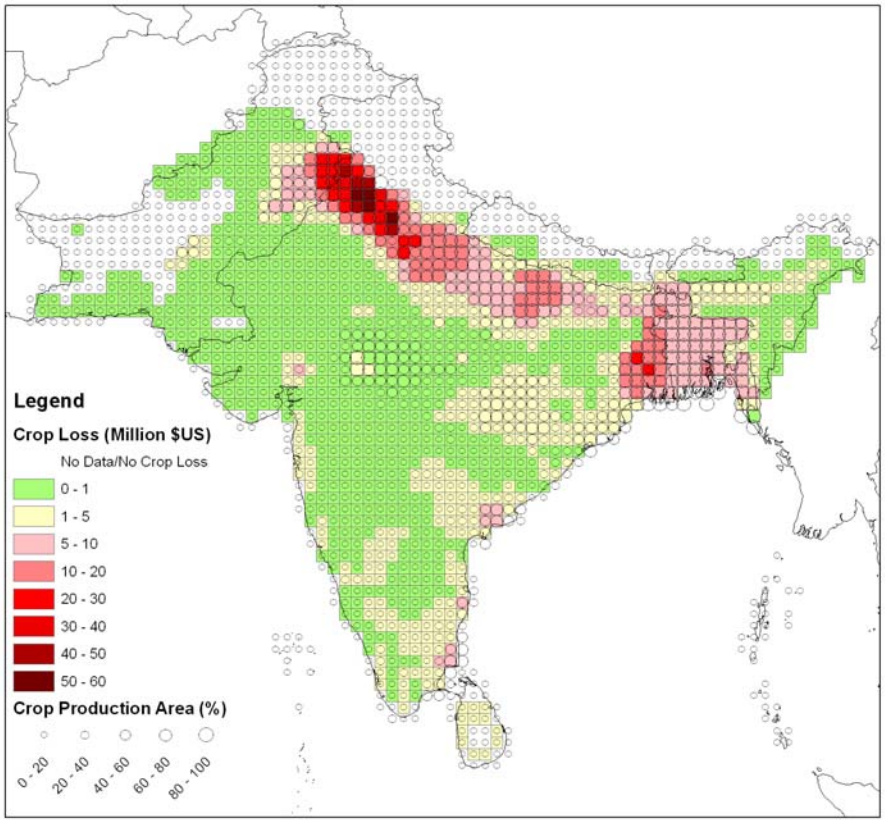
Provisional economic loss estimates for South Asia



Wheat, Rice, Soybean, Potato

European AOT40 dose-response relationships

FAO crop production, distribution and producer price data for 2000

MATCH modelled O_3 concentrations for 2000

Loss estimated at US$ 3.9 Billion

India (US$ 3.1), Pakistan (US$ 0.35) and Bangladesh (US$ 0.4)

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Key regional / global economic loss estimates

Reference	O_3 index	Geographical Region	Crops	Yield / economic crop losses
Europe & US				
Adams et al. (1988)	7- & 12- hr seasonal means	US	9 crops arable	**US $ 3 x 10^9**
Holland et al. (2002)	AOT40	Europe	> 20 arable crops	**US $ 8 x 10^9**
Asia				
Wang & Mauzerall (2004)	7- & 12- hr seasonal means	East Asia (China, Japan, S. Korea)	wheat, rice, corn soybean	**US $ 5 x 10^9**
Jamir et al (pers comm)	AOT40	South Asia	Wheat, rice, soybean and potato	**US $ 3.9 x 10^9**
The globe				
Van Dingenen et al . (2009)	7- & 12- hr seasonal means and AOT40	World	wheat, rice, corn soybean	3 to 10 % **US $ 16 to 30 x 10^9**

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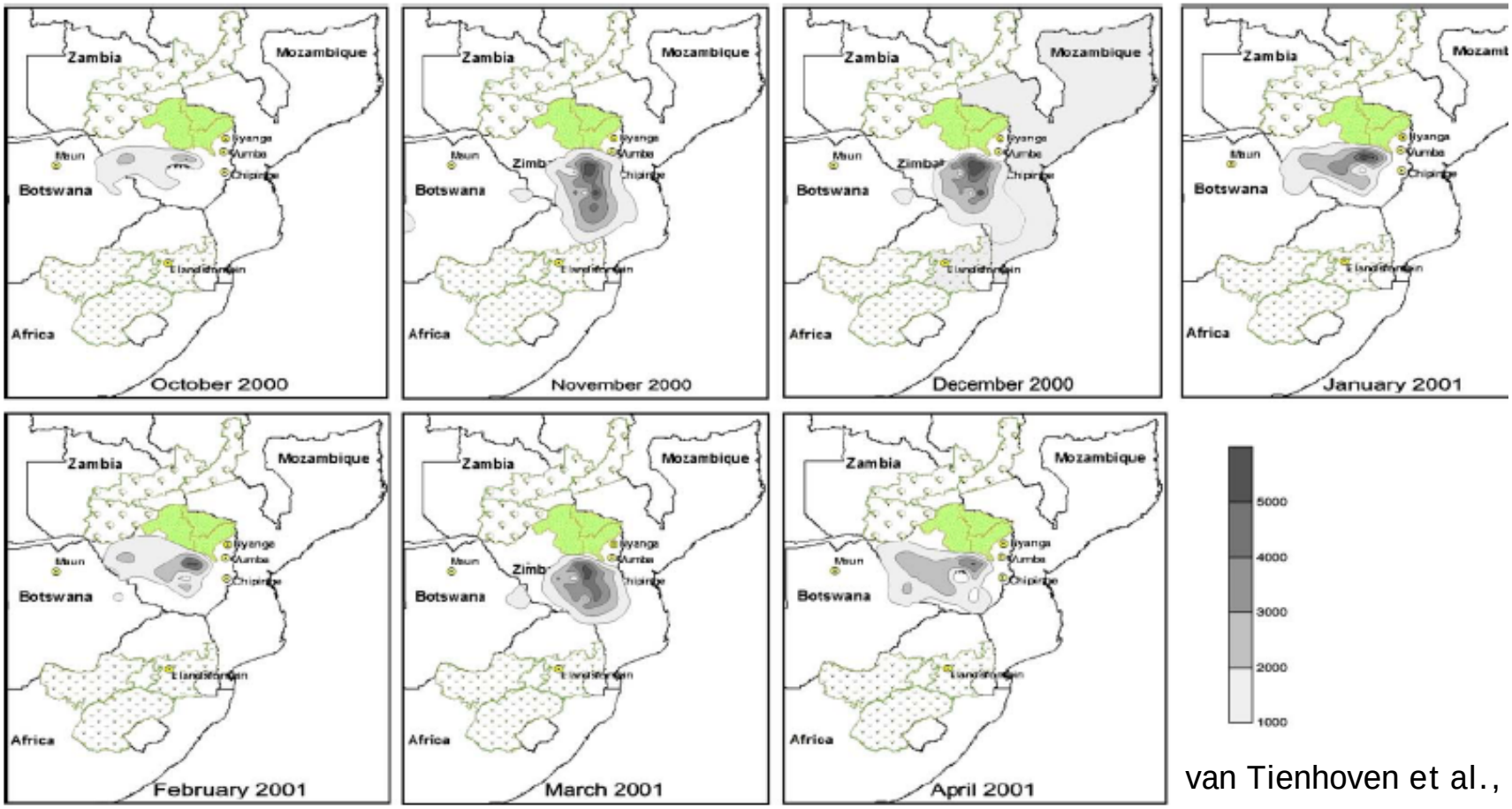
Provisional Risk Assessment (Southern Africa)

AOT40 values for southern Africa for October 2000 to April 2001, based on projection of 5-day modelled concentrations



van Tienhoven et al., 2006

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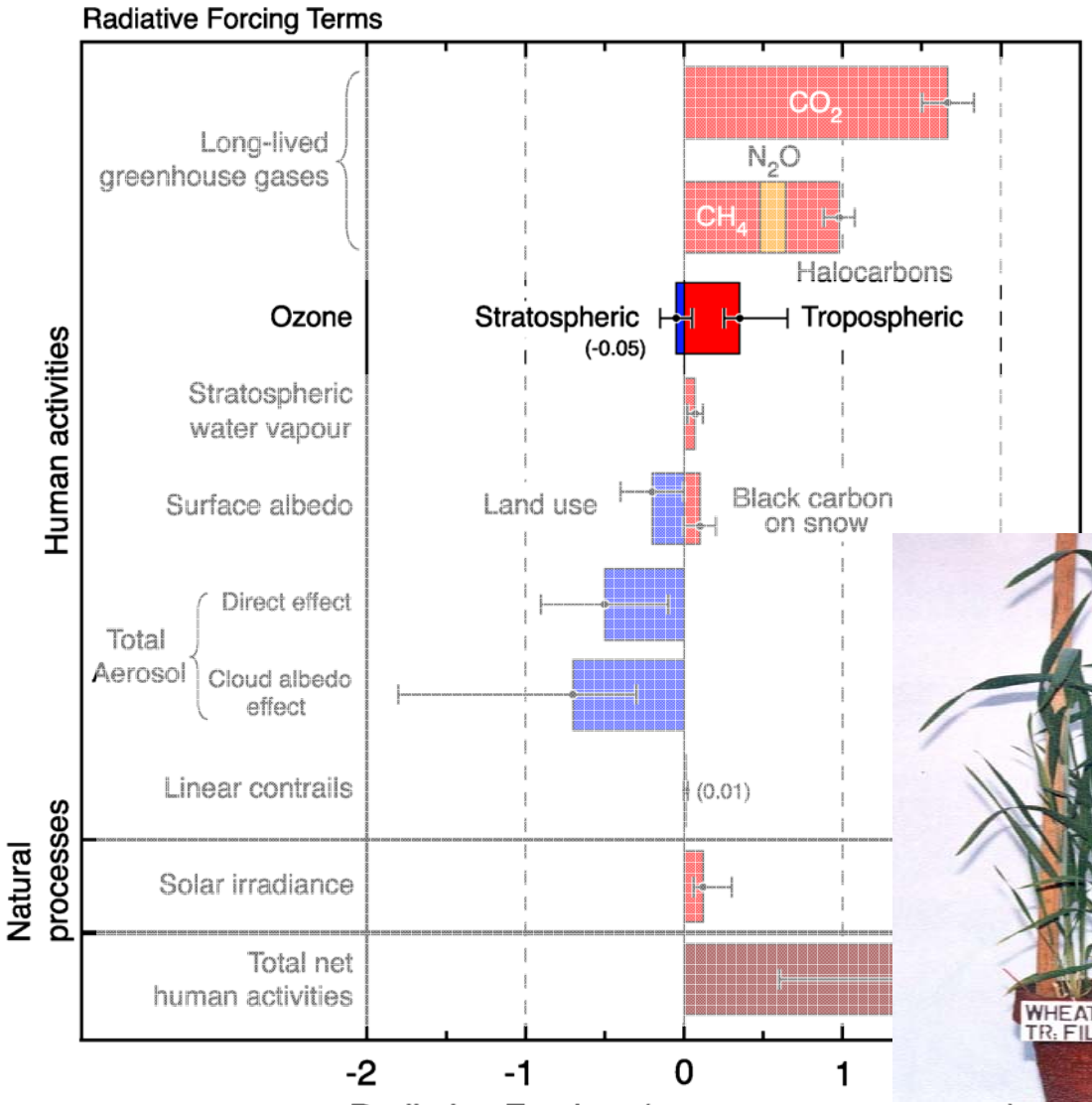
Multiple benefit of reducing ground-level/tropospheric ozone



Source: IPCC 2007

i. Ozone – an important GHG; short residence time – immediate climate benefits from reductions

ii. Ozone – reduces crop yields by up to 40%

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Climate change will affect surface temperature and hence water availability for agriculture

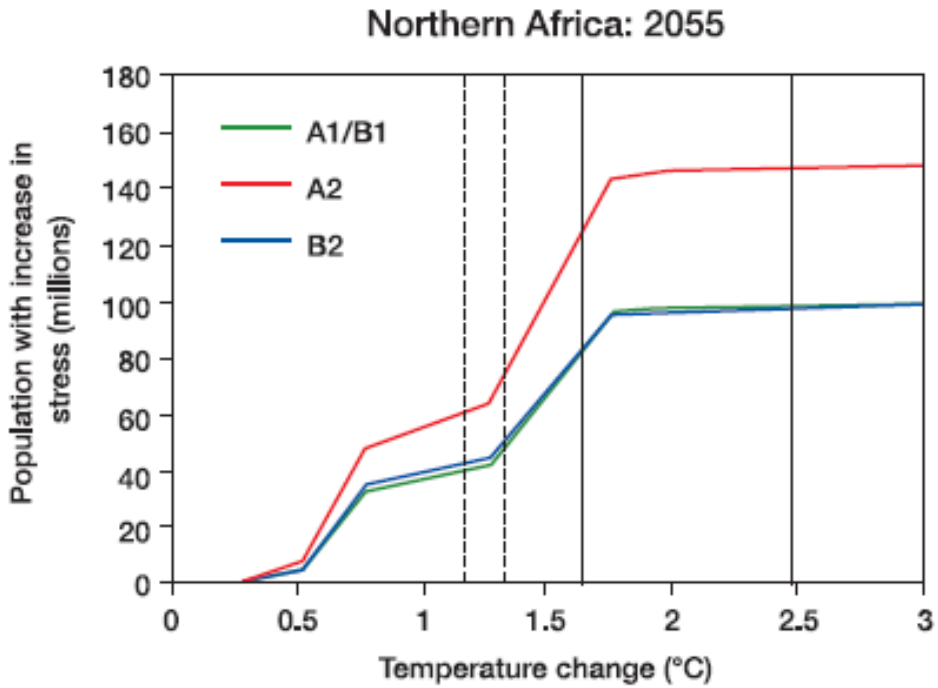

Figure 9.3. *Number of people (millions) with an increase in water stress (Arnell, 2006b). Scenarios are all derived from HadCM3 and the red, green and blue lines relate to different population projections.*

Boko et al., 2007; Fourth Assessment Report of the IPCC

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Co-benefits

Reducing ozone concentrations through control of precursors such as NOx, methane etc. will not only directly (short-term) improve crop growth and crop yields due to a reduction of phytotoxic effects, but also indirectly (long-term) due to the abatement of climate change (e.g. drought) effects

Additional positive effects are on human health

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Outlook

- Pan North African & Middle East crop impact risk assessment (Funding sources : e.g. European Union? ADB?)
  - Emission monitoring network
  - Modelling of ozone concentrations
  - Ground-truth model studies with application of bio-monitoring techniques
  - Assessment of climate change impacts by variation of water availability in bio-monitoring techniques
- Link with other air pollution networks (e.g. APINA) via GAP Forum
- Close collaboration with climate change research community

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