



Met Office
Hadley Centre

Do NO_x emissions cool or warm climate? Feedbacks via vegetation

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Introduction

Policy makers need to control NO_x for air quality legislation.

- Does this warm or cool climate (win-lose or win-win)?
- Emissions of precursors (NO_x , SO_2) form secondary products which have direct radiative impacts on climate (including cloud effects).
- Many constituents only have lifetimes of the order of a week or two → direct effects on temperature decrease rapidly with time.
- Impacts on vegetation perturb the carbon cycle. CO_2 has lifetime of decades-centuries → temperature impacts persist much longer.

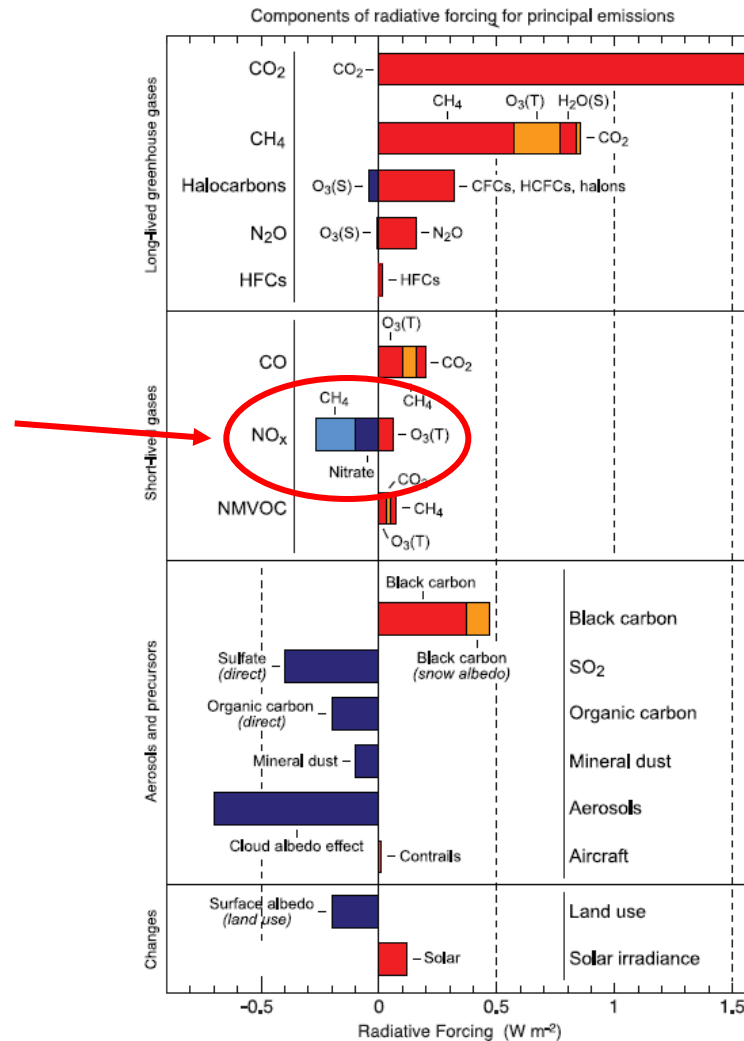


Vegetation impacts

- Ozone damages plants – focus of this talk
- Nitrate and ammonium deposition acts as fertiliser – not discussed
- Aerosols increase the diffuse light fraction – enhancing photosynthesis – discussed briefly

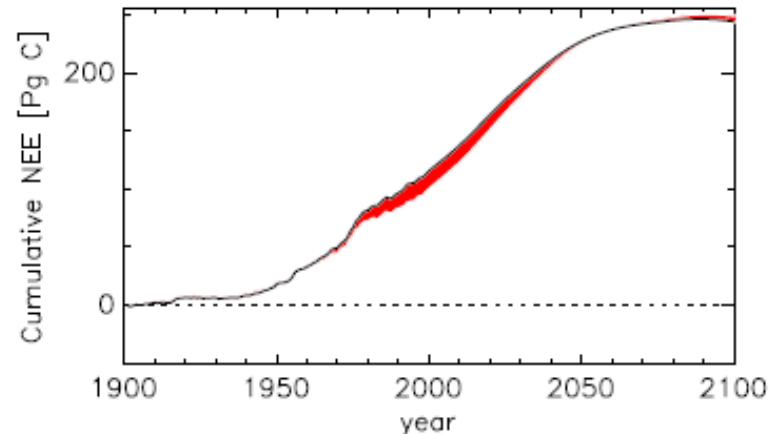
RFs of shortlived species

- According to AR4 NO_x emissions over 20th C have had cooling effect.
- Impact on methane and nitrate outweighs ozone increase
- Doesn't tell us about the climate impact of future emissions
- No account of carbon-cycle impact



Biospheric impacts: Aerosols

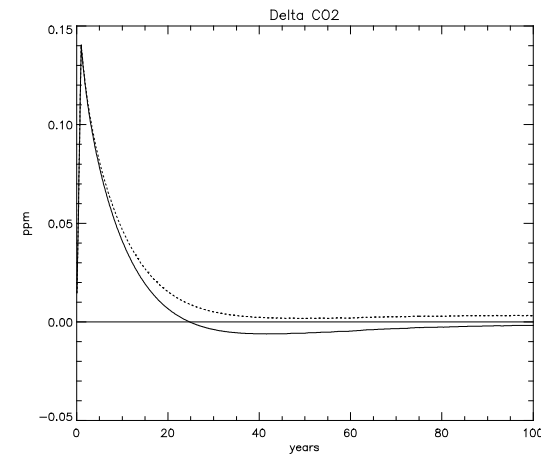
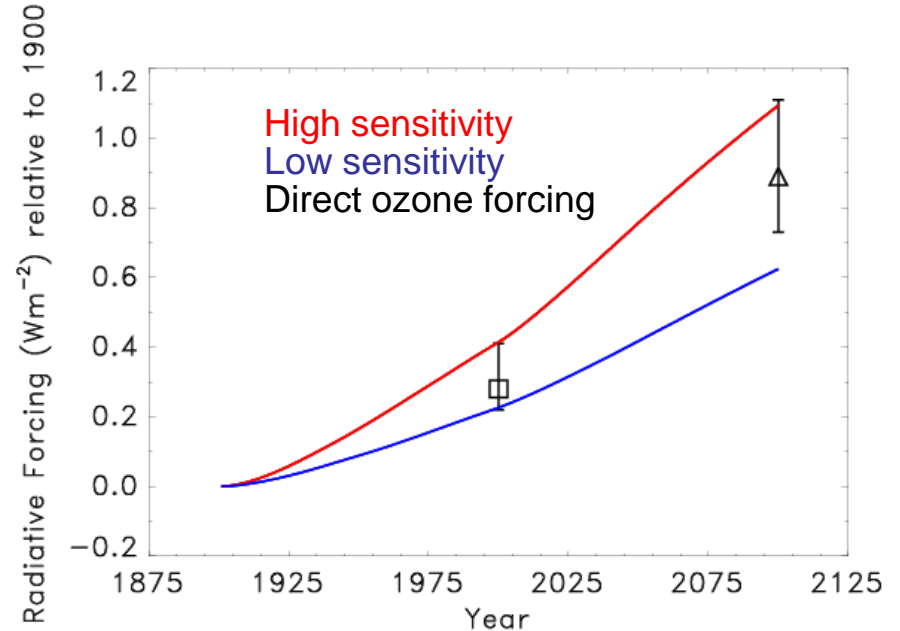
- Aerosol scattering:
 - Decreases total Photosynthetically Active Radiation (PAR)
 - Increases diffuse fraction of PAR
- Diffuse radiation penetrates better into canopy → more photosynthesis and carbon uptake
- Enhanced the land carbon sink Contribution of diffuse fraction to land carbon sink by ~25% 1960-1999 (Mercado et al. Nature 2009)



Mercado et al. Nature
(2009)

Biospheric impacts: Ozone

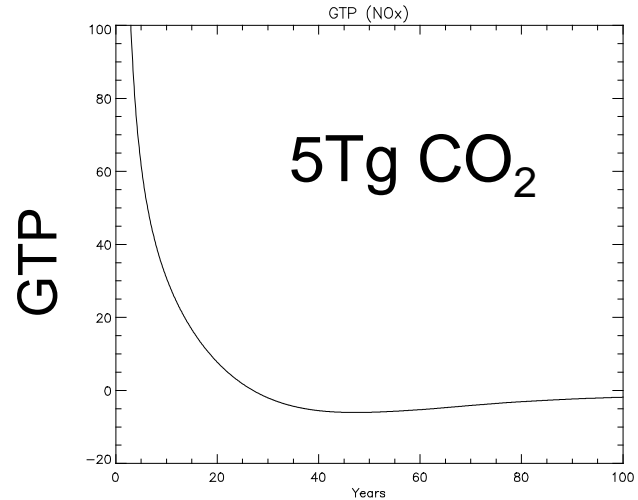
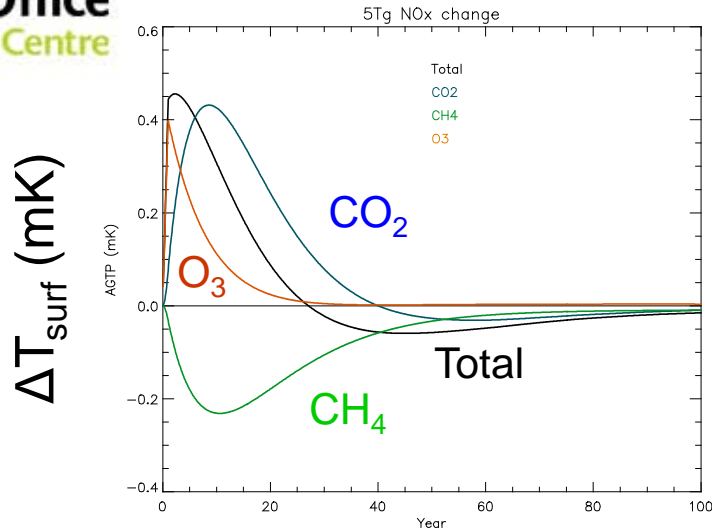
- Ozone damage reduces the amount of carbon removed from the atmosphere by plants
- Sitch et al. Nature 2007 looked at RF over 20th & 21st Centuries
- New work looks at GTPs (Shine et al. 2007) from pulse emissions of precursors



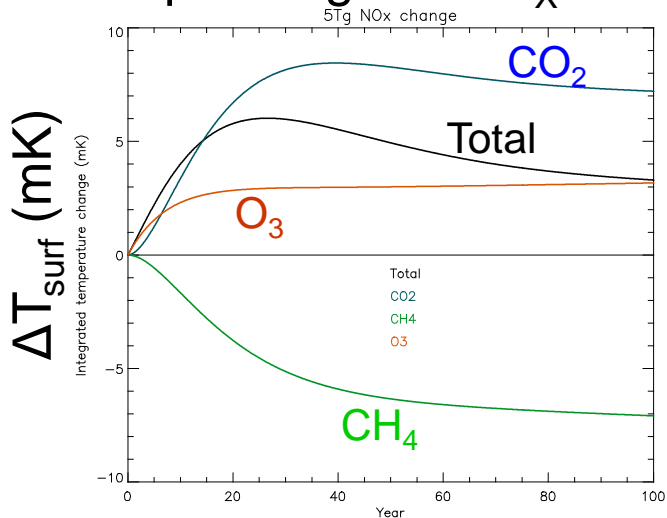
CO₂ change from a 1yr 20% NO_x pulse

Calculation of GTPs

1 year 20% (~5Tg) NO_x pulse (N. Am., Eur. S. Asia, E. Asia)



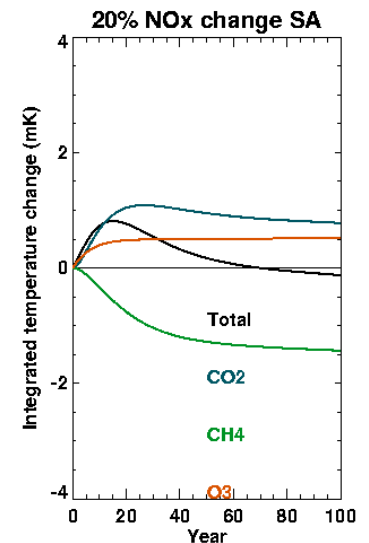
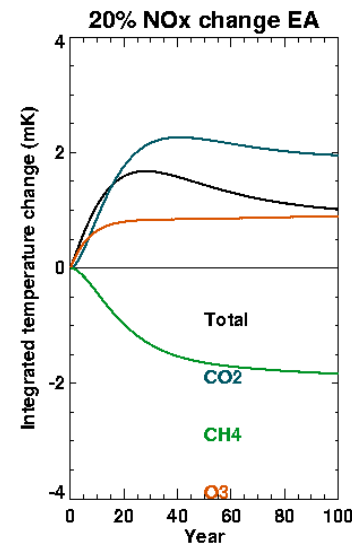
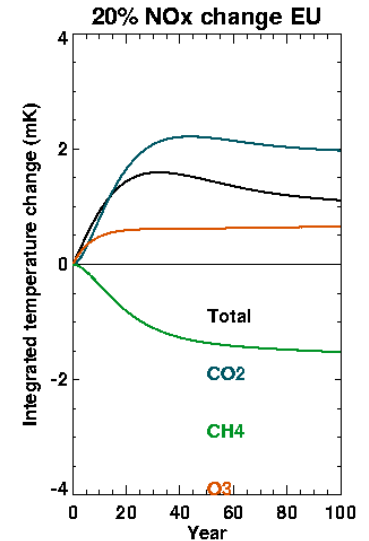
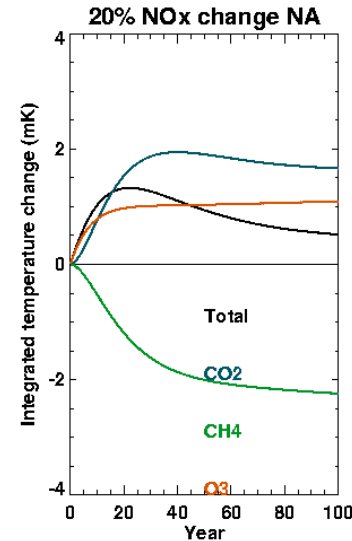
Step change in NO_x



- N.B. We do not account for nitrate aerosol formation
- This could flip the sign negative again

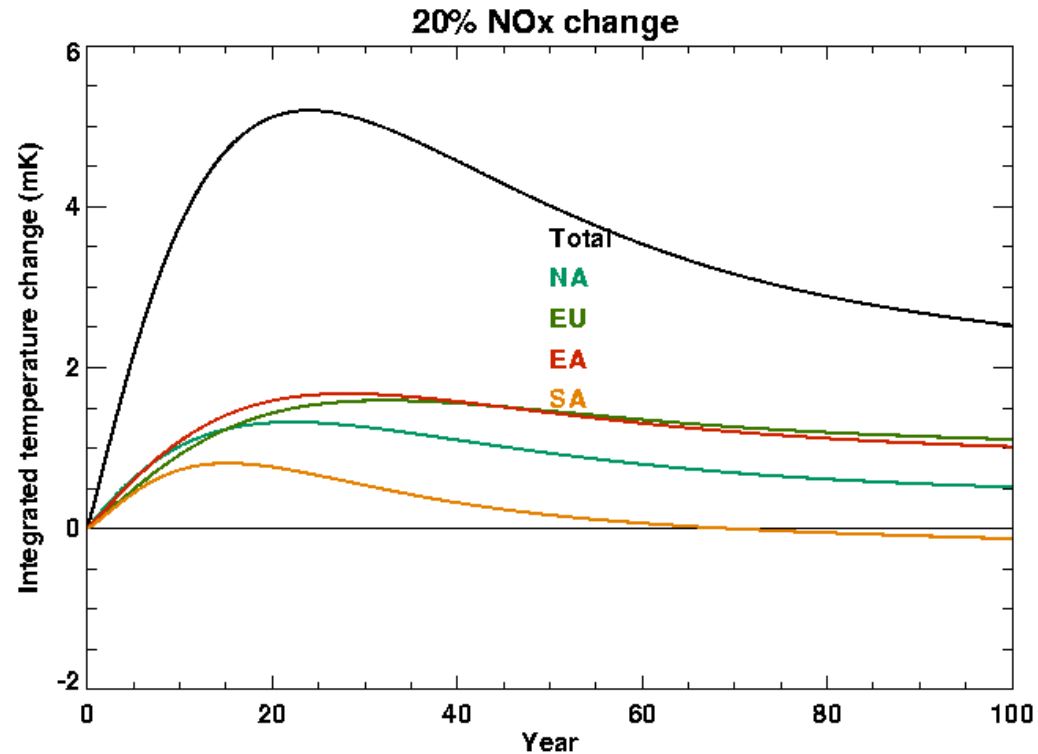
Regional effects

- Balance between different forcing agents depends on emission region
- EU has least impact on methane => most positive temperature perturbation
- SA has largest (relative) impact on methane, and least affect on CO₂
 - Quicker recovery of tropical vegetation(?)



Total temperature change

- All regions show NO_x emissions lead to a temperature rise (ignoring nitrate)
- Maximum after ~20 years
- SA has a negative temperature impact after 70 years
- Only small numbers (mK)





Summary

- GTP for NO_x changes dramatically when impact of ozone on C-cycle is included.
 - Haven't included nitrate aerosol change, or N-fertilisation
 - These may be large enough to turn the sign negative again
- Large regional variations in this effect (as for direct ozone and methane impacts)
- Very large uncertainties
 - neglecting C-cycle effects introduces systematic bias

- Responses to 1-year pulses

