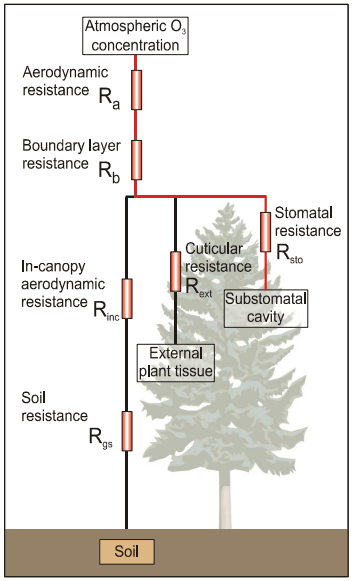
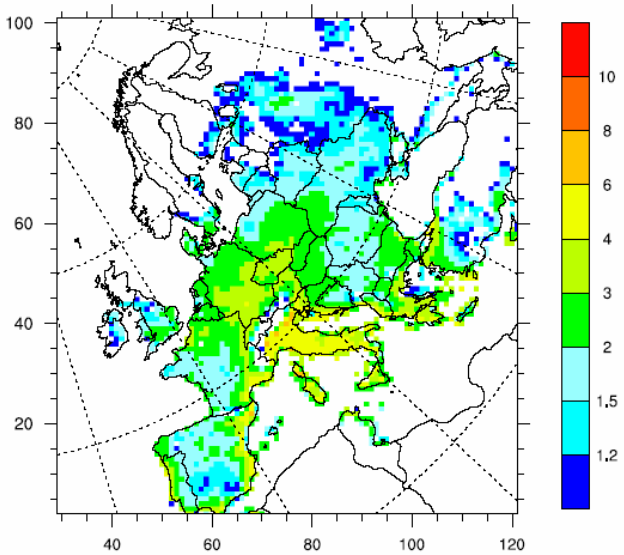
Assessing changes in ozone flux to vegetation





(f) $R_{CL}(AF_{st}6)$ - Crops

Lisa Emberson & Gina Mills

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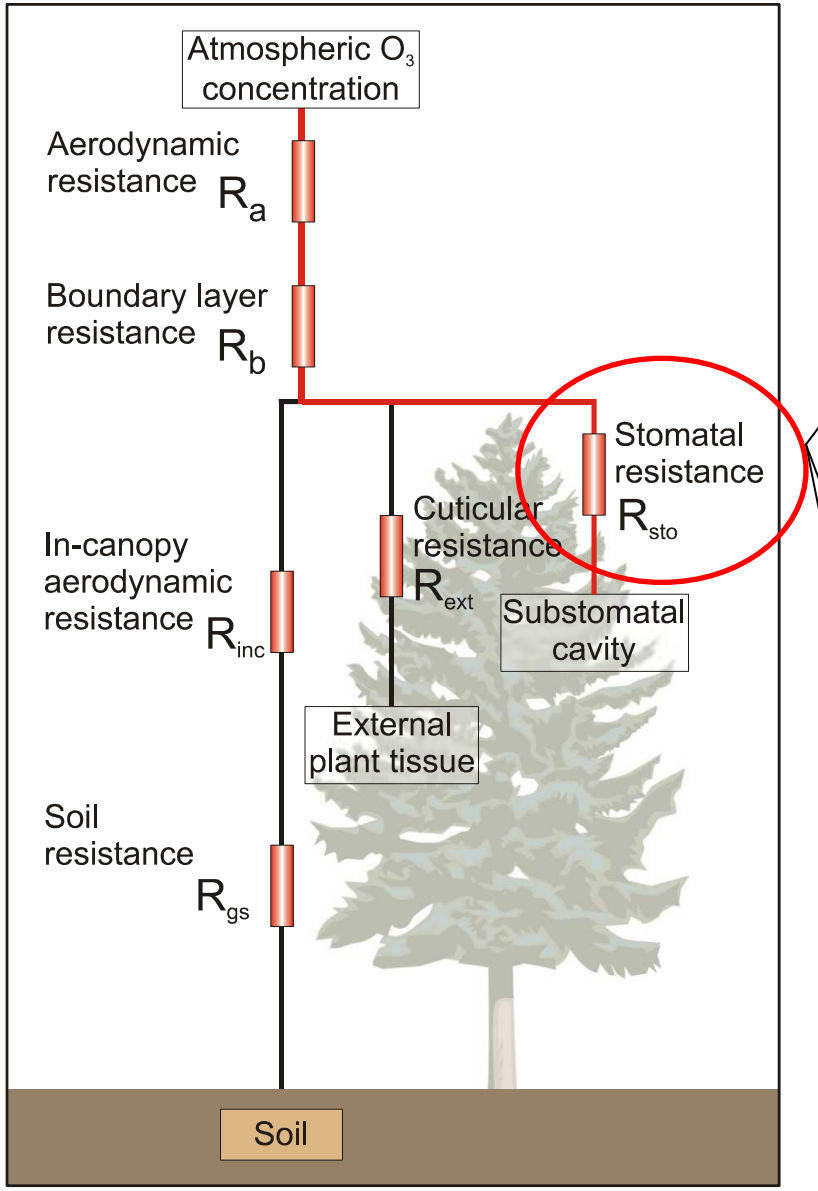
Flux modelling

The DO_3SE model (Deposition of Ozone and Stomtal Exchange)

Standard micrometeorological methods

Constant R values



Multiplicative g_s model

Species / cover type characteristics
- g_{max}

Phenology
- Timing + length of GS
- Leaf/Needle age

Canopy characteristics
- SAI + LAI; height

Environmental variables:
- Irradiance
- Temperature
- VPD
- SWP

> 10 cover types
> 20 species

Key Conclusions

1. Risk assessment methods based on stomatal flux rather than ambient concentration tend to give **different spatial assessments of risk**.

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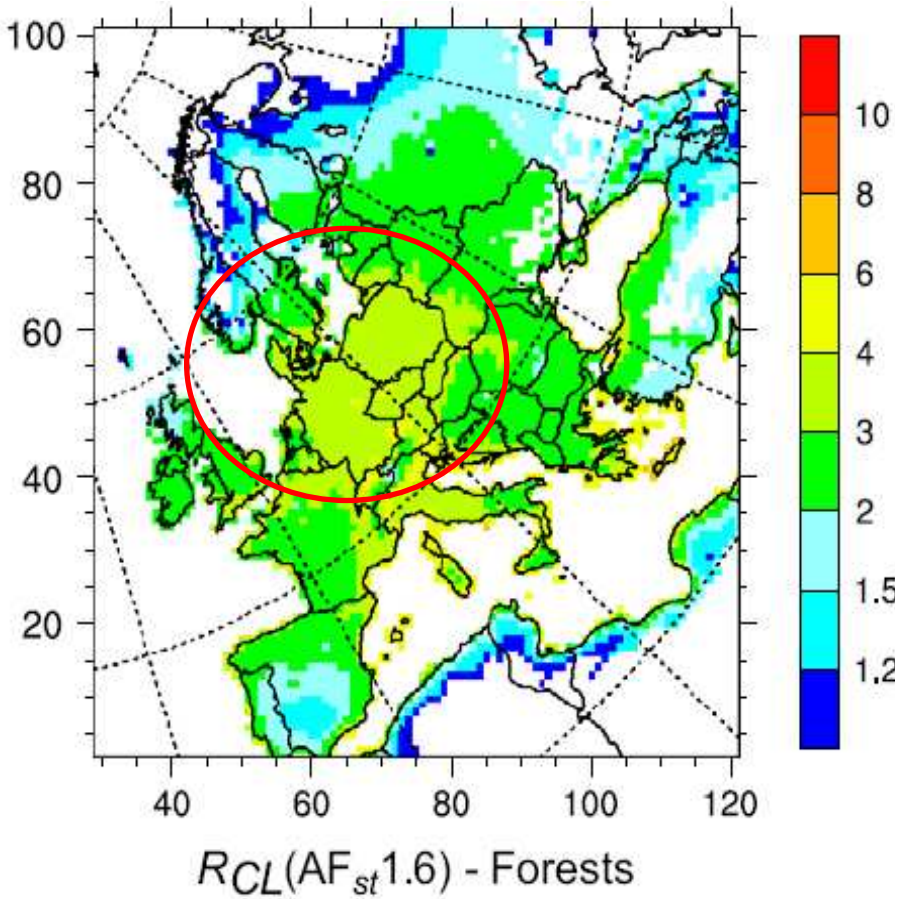
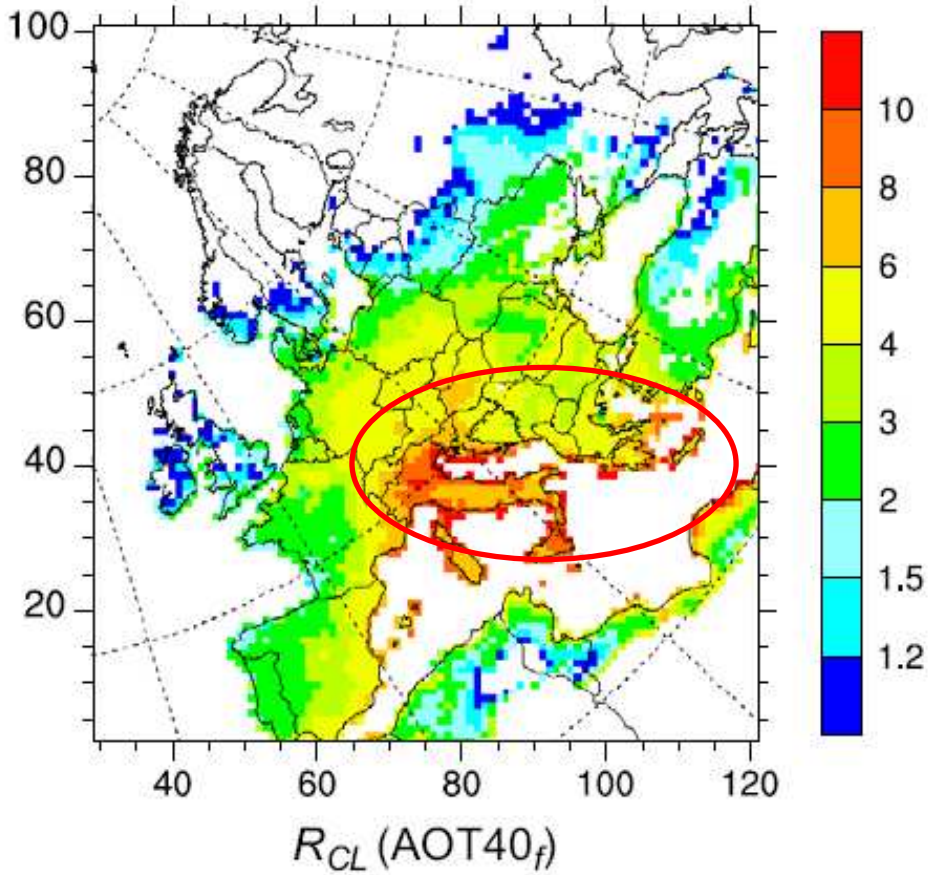
Concentration (AOT40) vs. stomatal flux (AFstY) risk assessments

2000

CL: AFstY Generic Deciduous



CL: AOT40 - Forests

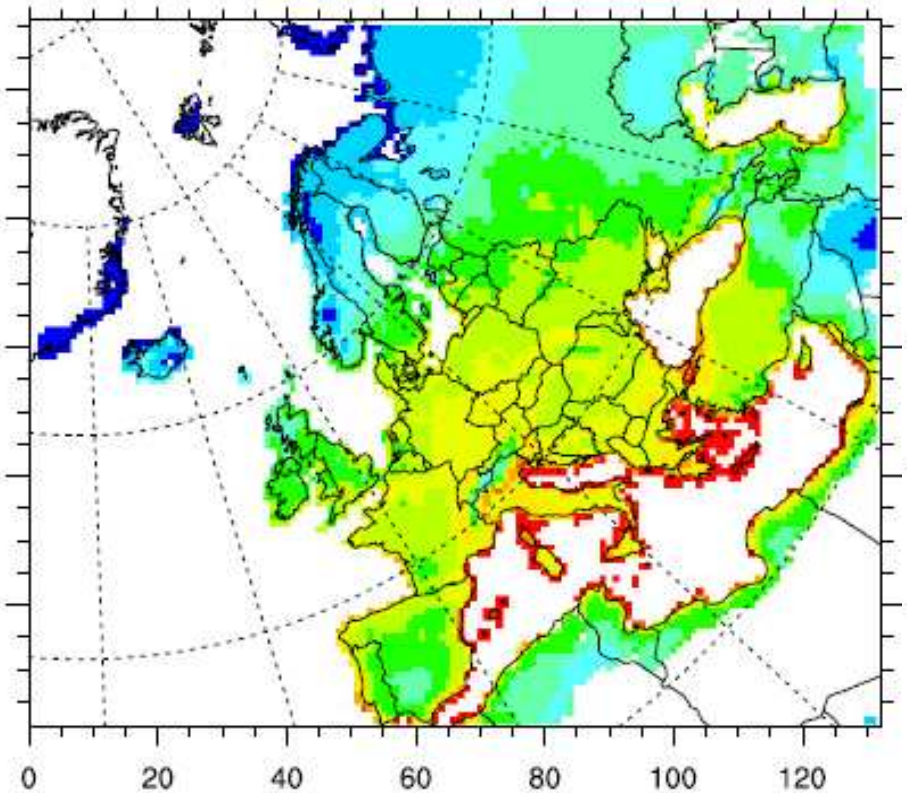


Simpson et al (2007)

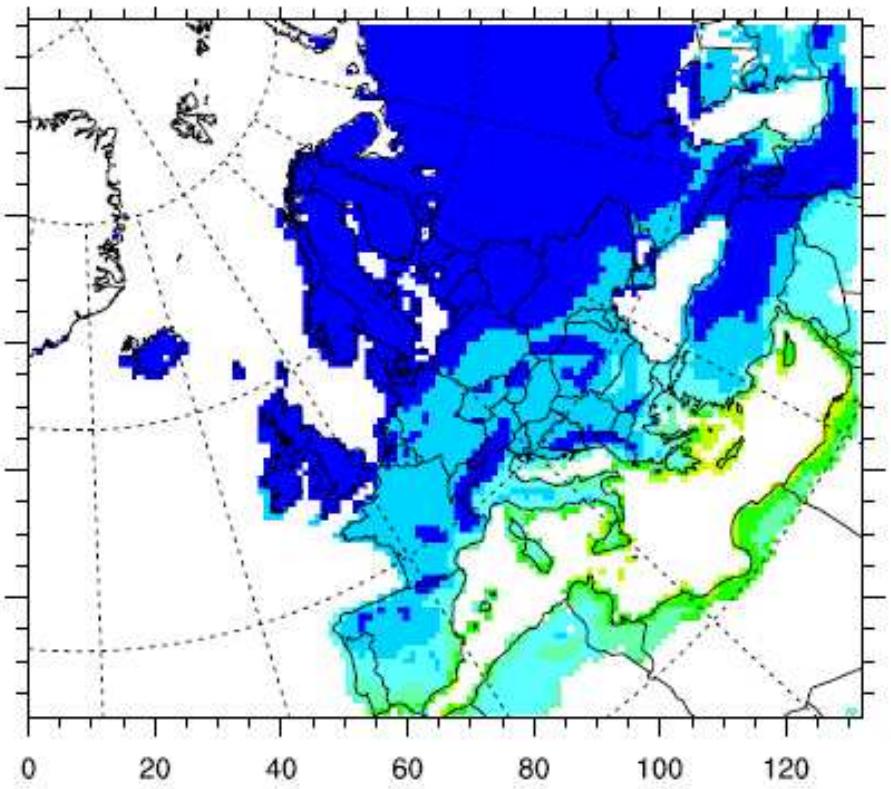
Concentration (AOT40) vs. stomatal flux (AFstY) risk assessments

2004

Generic Deciduous



Generic Mediterranean evergreen

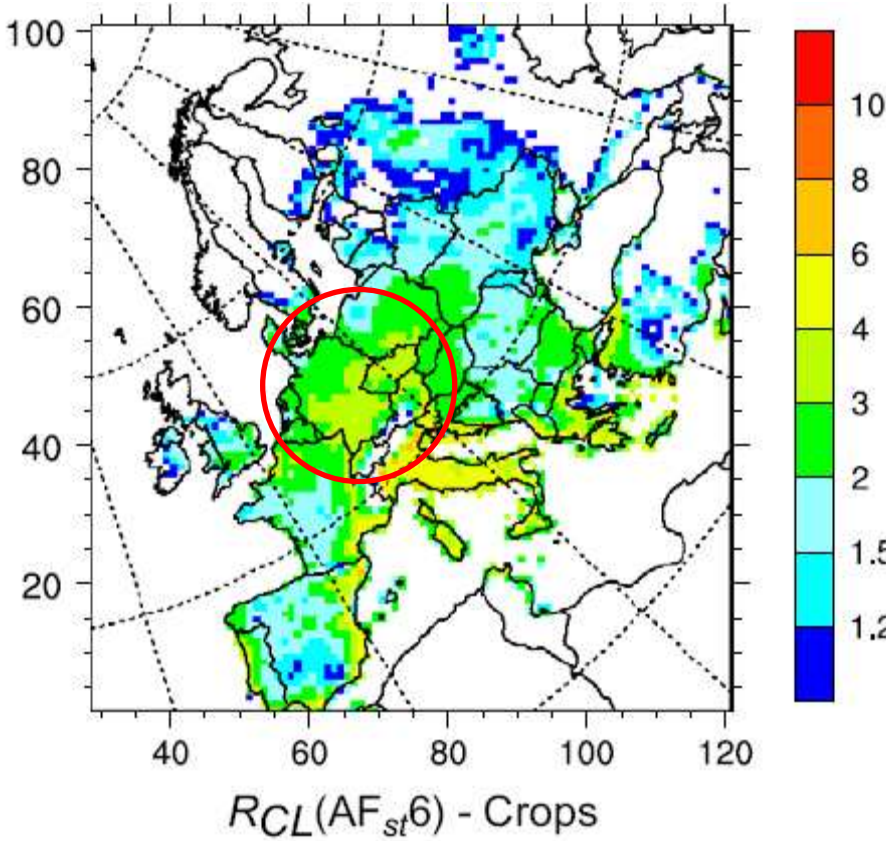


Simpson & Emberson (2006)

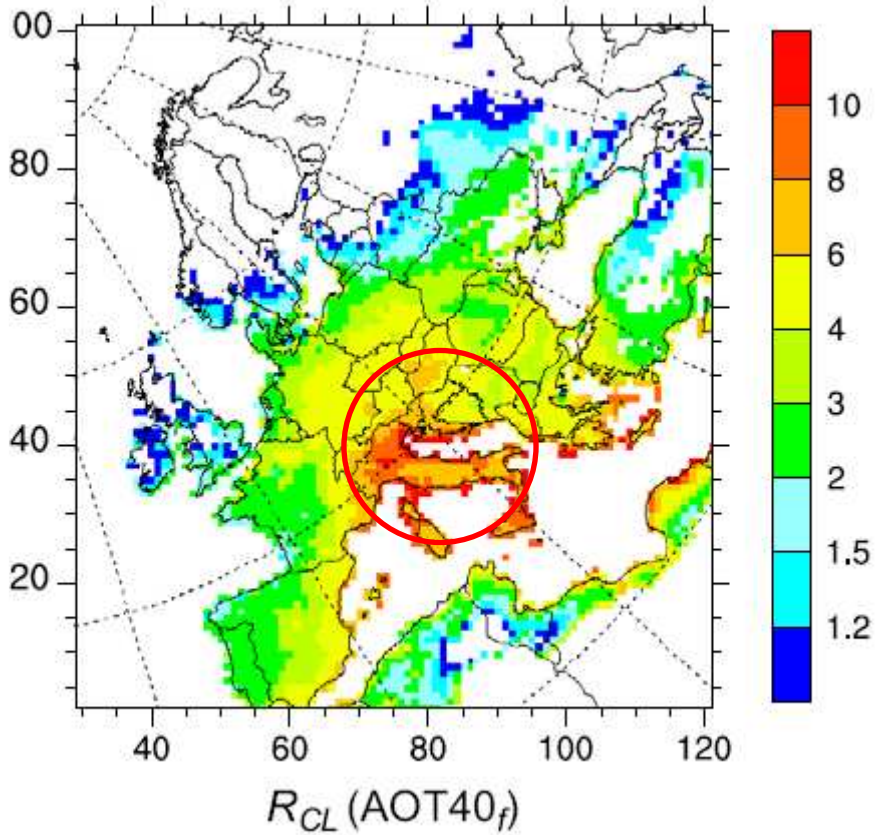
Concentration (AOT40) vs. stomatal flux (AFstY) risk assessments

2000

CL: AFstY Generic wheat



CL: AOT40 - Crops



Simpson et al (2007)

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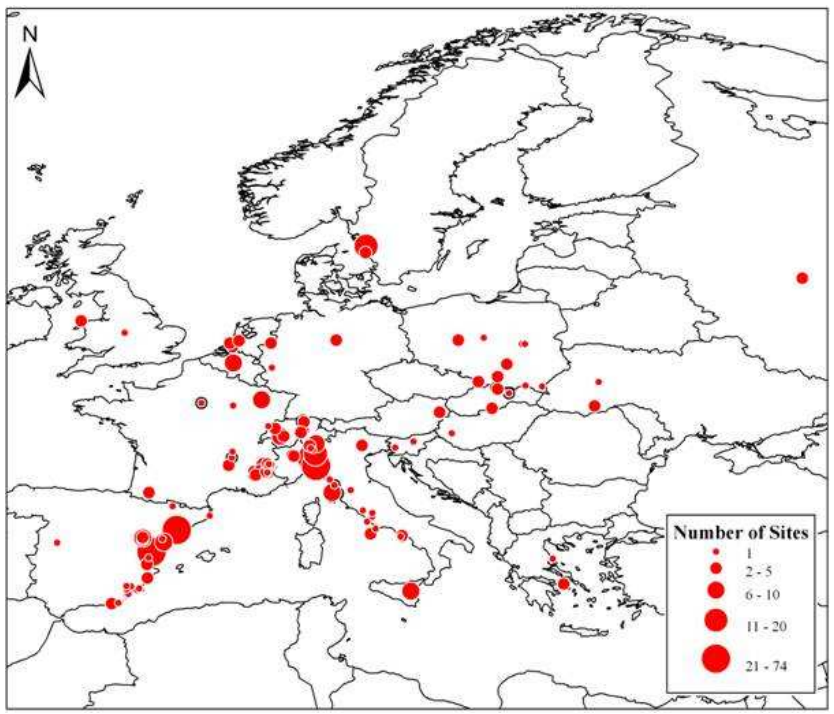
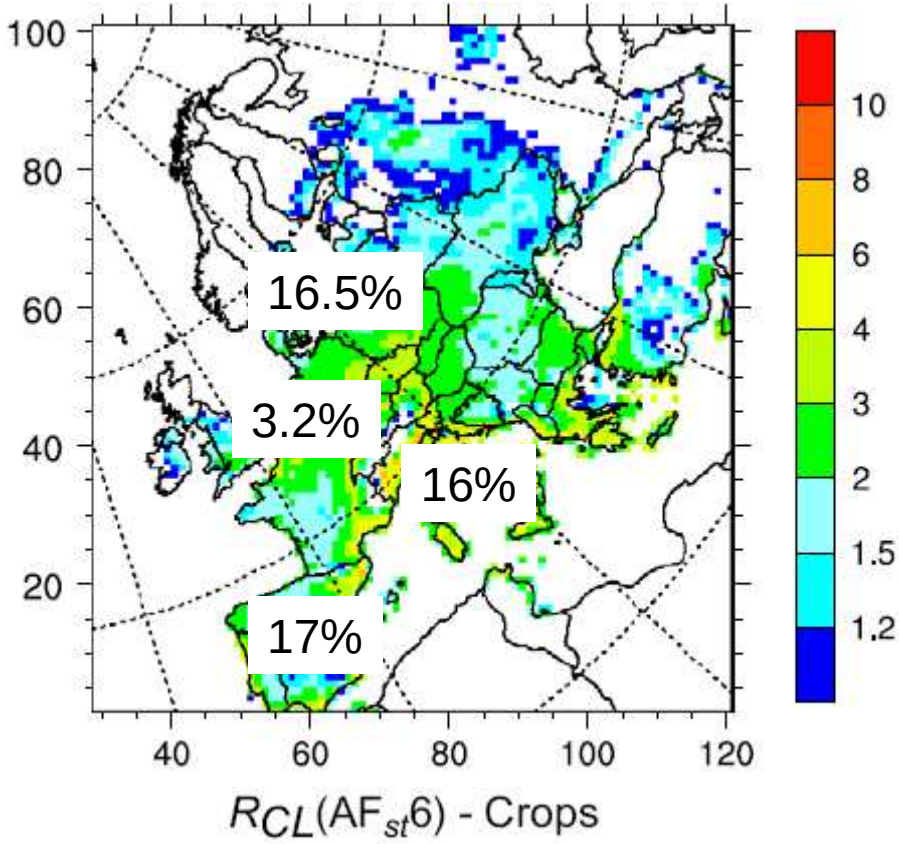
Flux modelling

Evidence for stomatal flux based impacts



Records of visible injury (ICP Vegetation evidence report. In prep.)



Generic crops

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Flux modelling

Evidence for stomatal flux based impacts

	N	AFst6*	% reduction
Sweden	3	1.2	16.5
The Netherlands	5	2	3.2
Spain	19	3.5	17.6
Italy	3	5	16

**** Generic crop, mean from map***

Published effects of ambient air, compared to filtered air, in open-top chambers, compared with mapped AFstY for 2000

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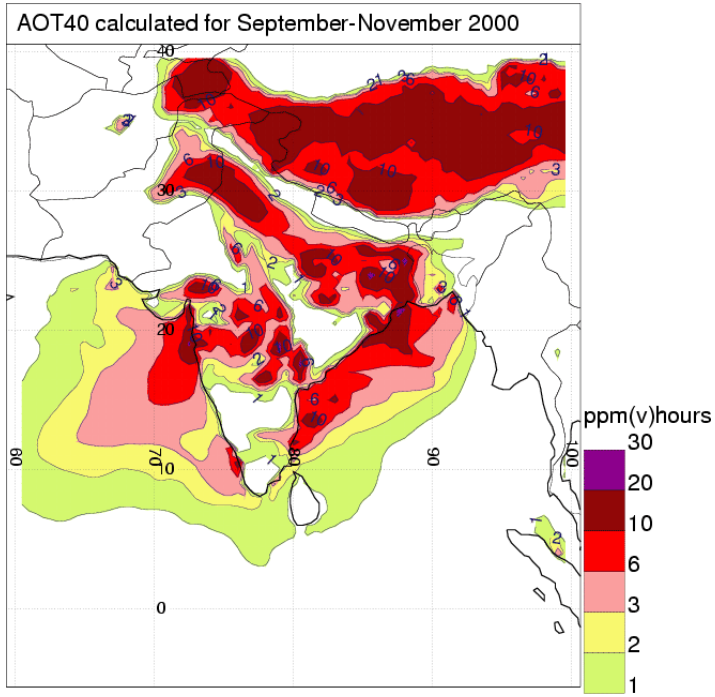
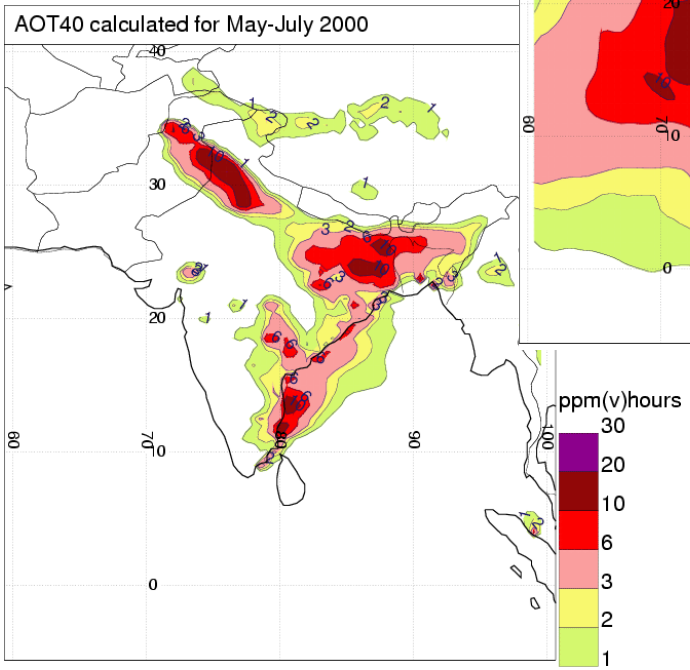
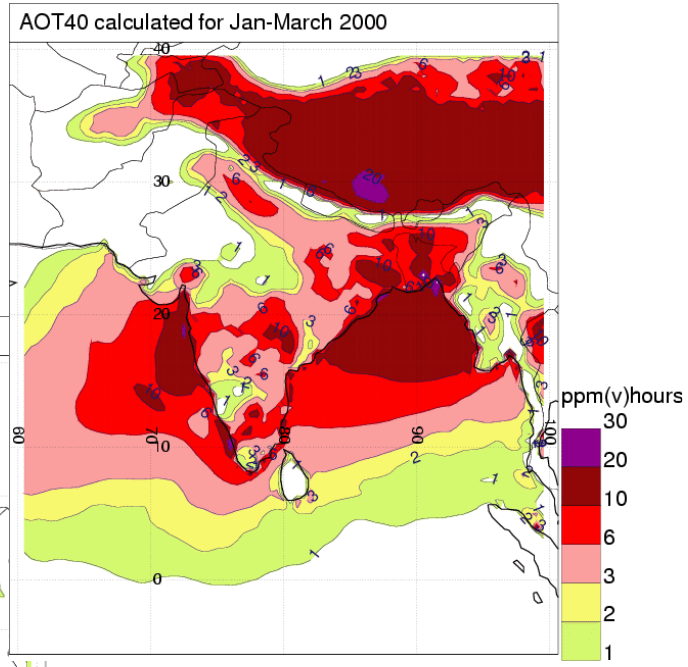
Flux modelling

Transferable to other regions







3 month AOT40 simulations calculated with the MATCH model

Engardt pers. comm., Emberson et al. in press

Flux modelling

Transferable to other regions

- Species type / cultivar

Climate

Precipitation patterns
Sunshine hours
Higher temperatures
Atmospheric humidity
Soil Moisture deficit

Vegetation sensitivity
Cropping patterns (growing season)
Pollutant dispersion
O_3 formation

- Agronomic practices

Irrigation
Fertilizer
Breeding programmes (selecting increased / reduced crop sensitivity)

Dose modifiers

Flux

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Flux modelling under climate change

Winter wheat case study

Model runs: Performed using EMEP/MSC-W for the year 1997 (Current)
Annual hourly O_3 concentrations and surface meteorological data were provided by

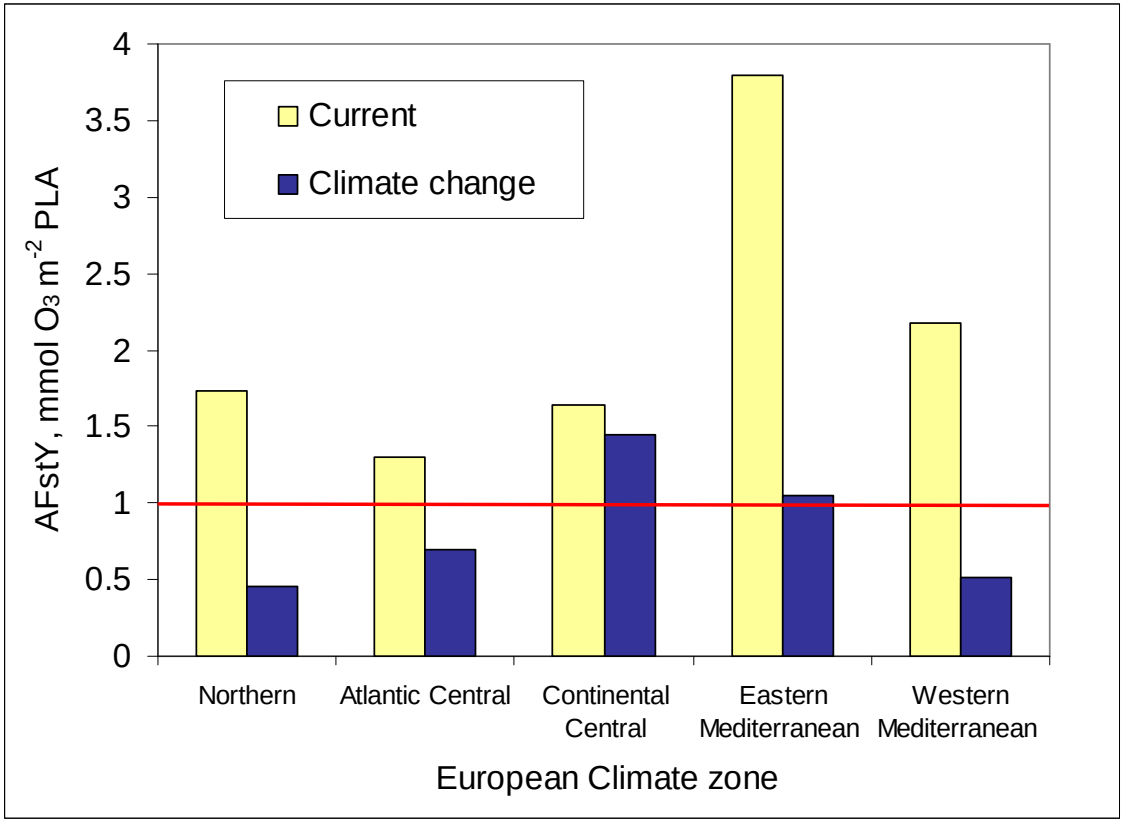
Parameter	Climate change (2100)
$[O_3]$ (ppb)	Increase $[O_3]$ by 5 ppb
Temperature	+ 3 ^oC
CO_2 effect on g_s	g_{max} * 0.65 (Garcia et al., 1998)
Precipitation (P) (mm)	If P > 0, increase P by 10% in northern and central Europe
VPD (kPa)	Assume absolute humidity remains constant, calculate VPD according to + 3^oC

Harmens et al. (2007)

Flux modelling under climate change

Winter wheat case study

Modelling performed for 5 selected grid squares representing different climates across Europe

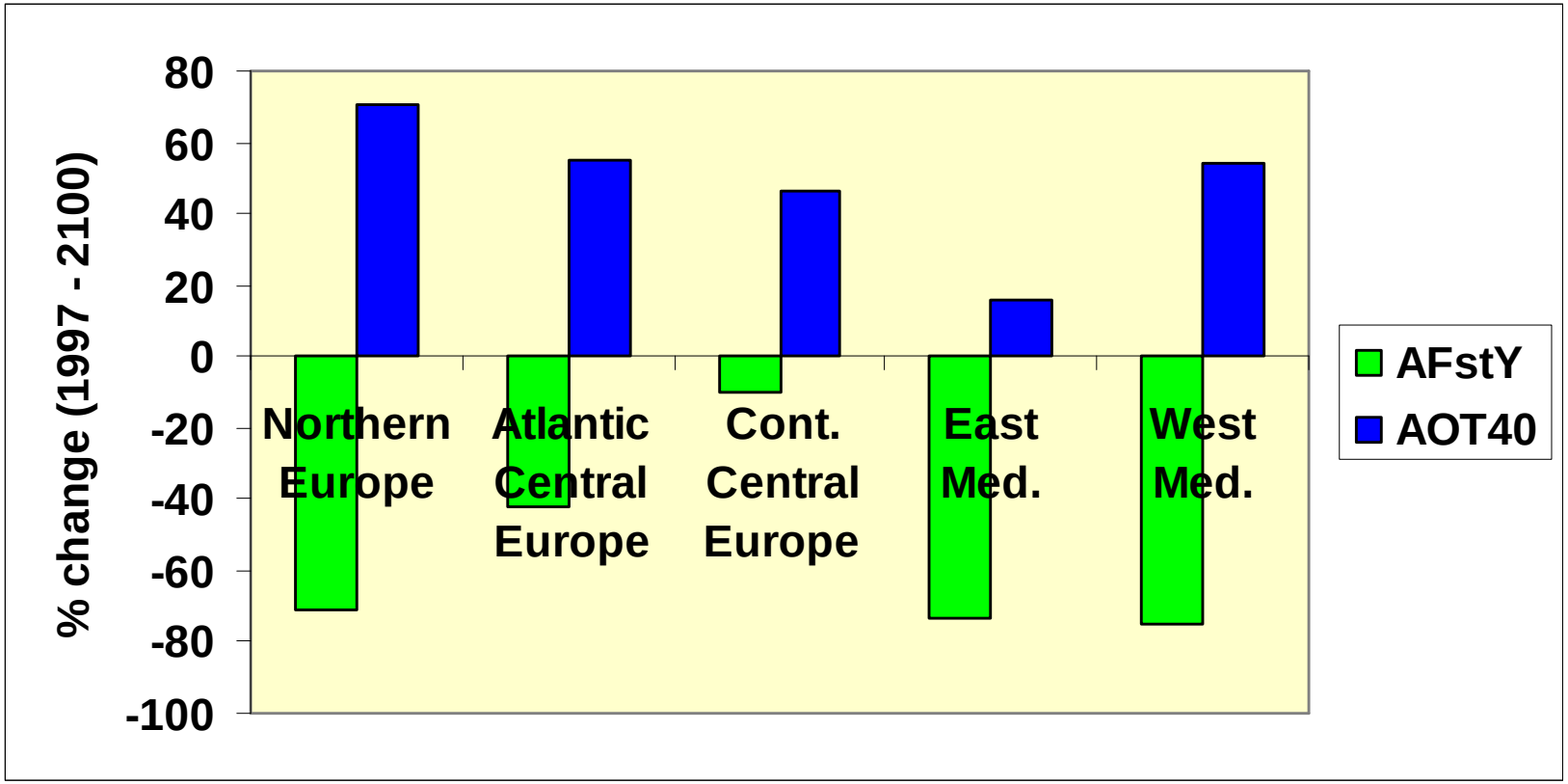


adapted from Harmens et al. (2007)

Flux modelling under climate change

Winter wheat case study

Projected AOT40 vs flux in a 2100 climate



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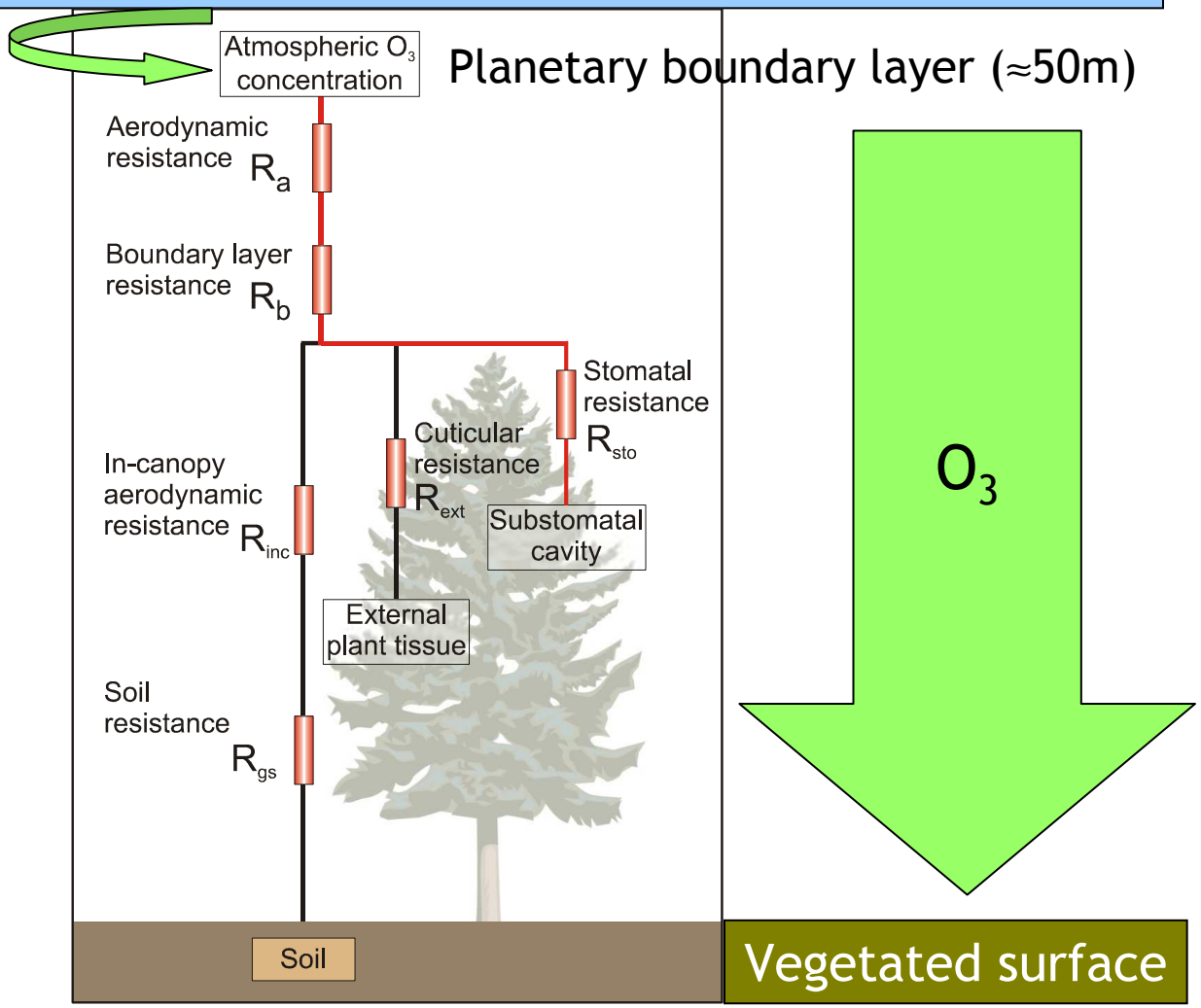
Flux modelling for ozone deposition

Estimate vegetation sink strength

Regional scale photo-oxidant model (EMEP model)



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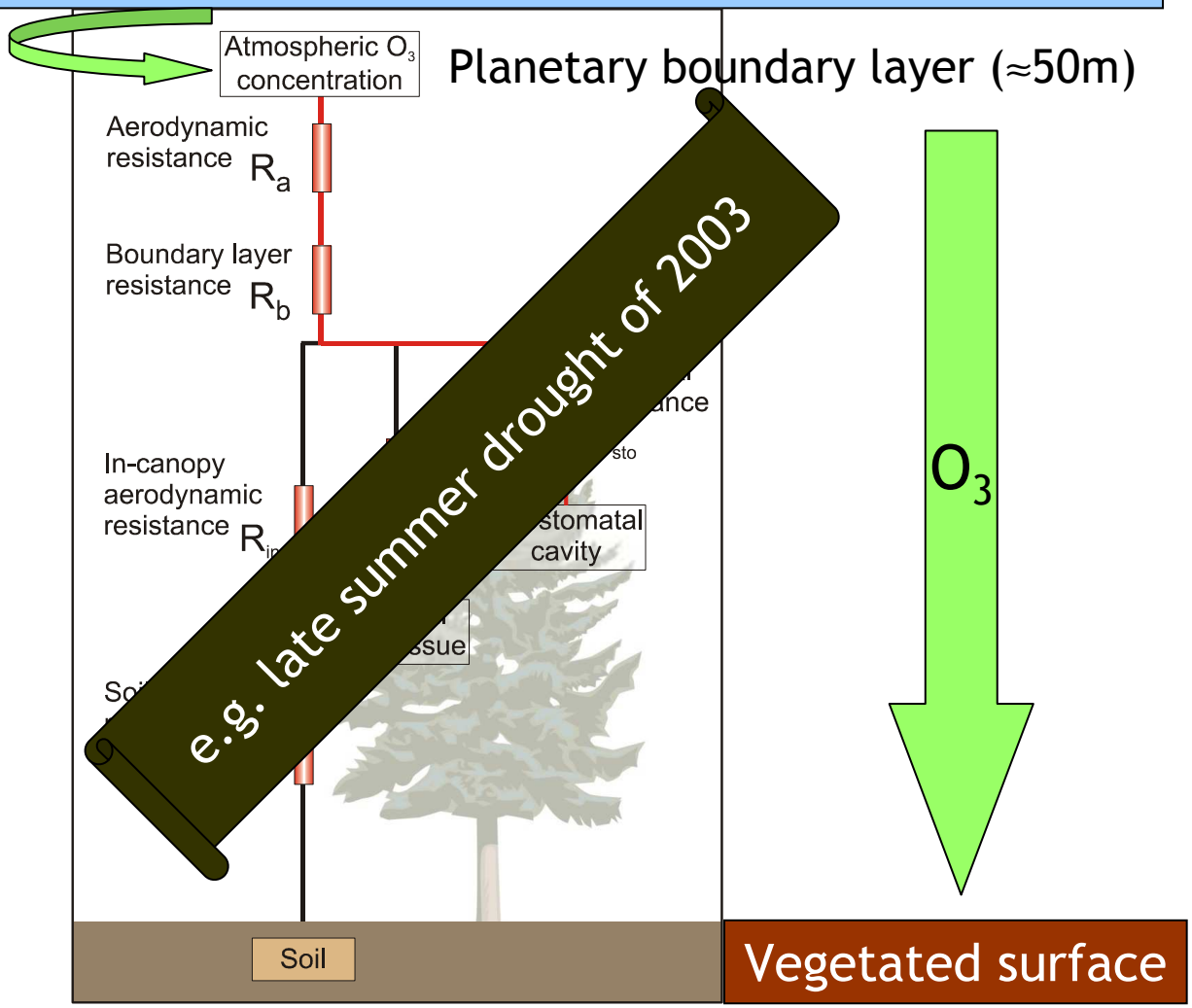

e.g. late summer drought of 2003

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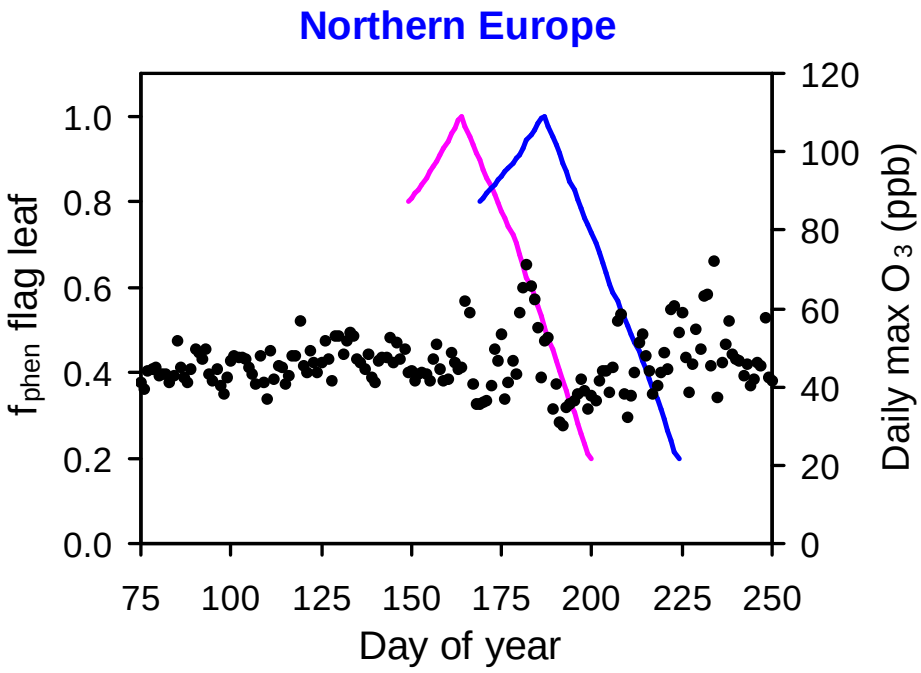
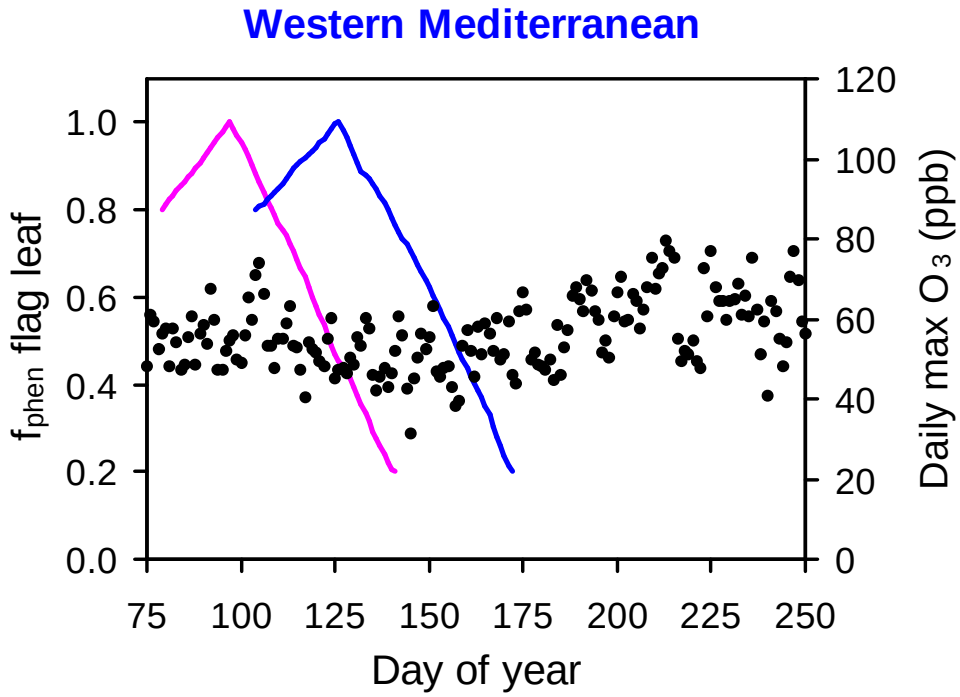
Flux modelling under climate change

Phenology considerations

Under climate change the growth and accumulation period starts and ends earlier





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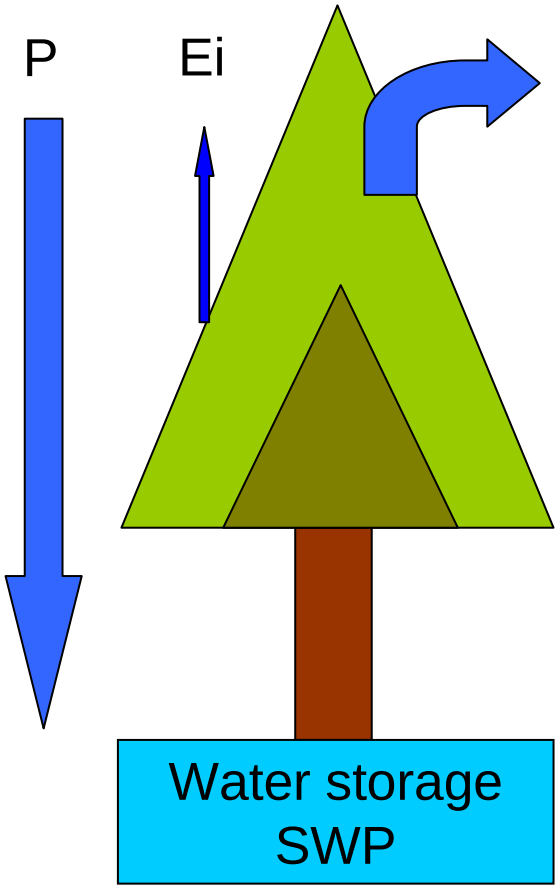
Flux modelling under climate change

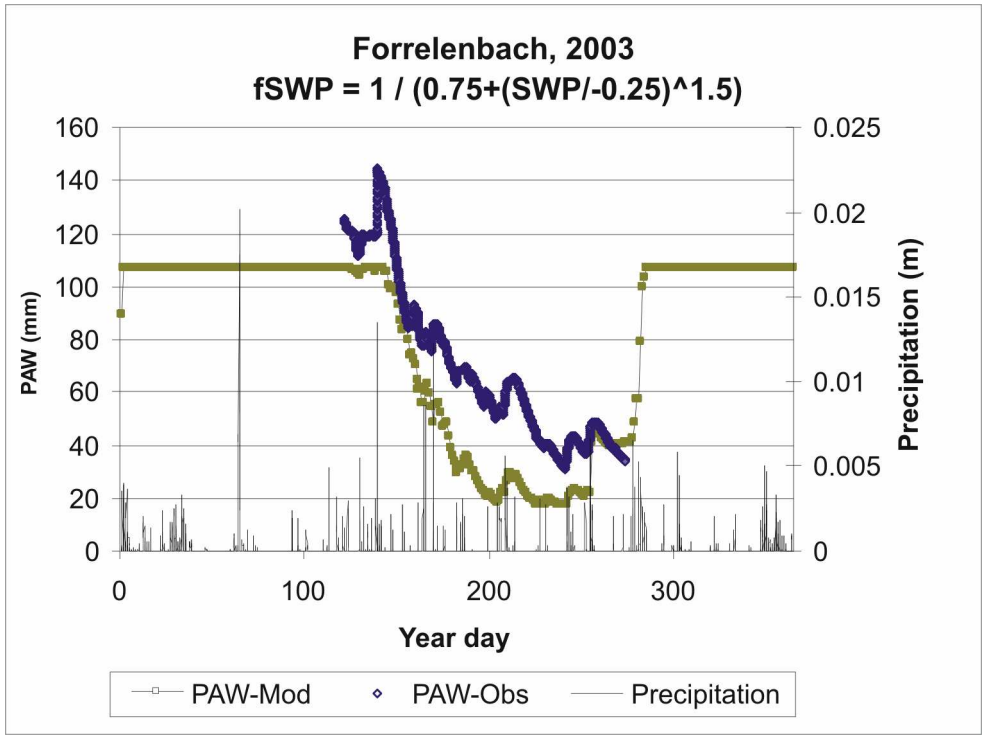
Drought considerations

Based on Penman-Monteith model



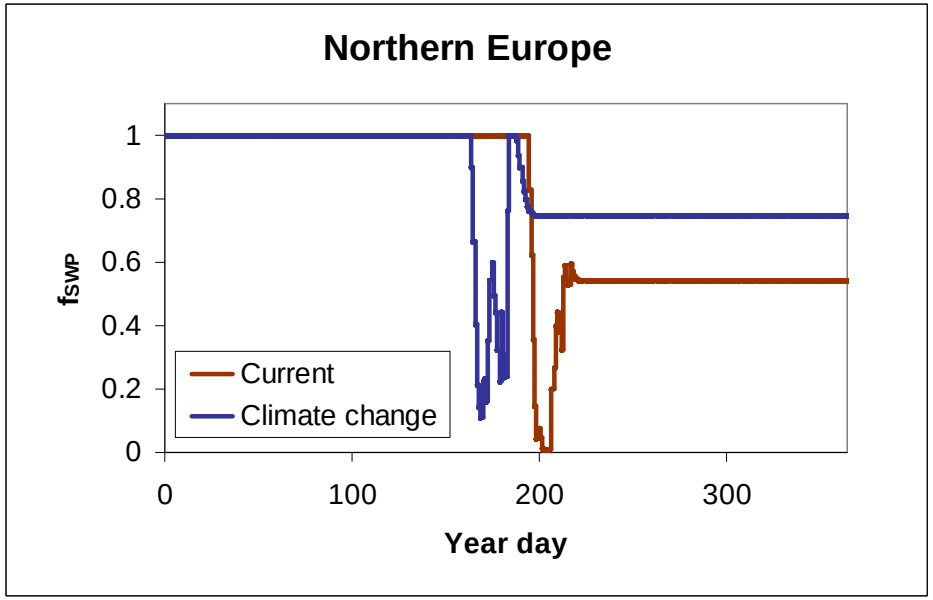
AEt

f(Ra, Rb, Rsto) & VPD & Net radiation

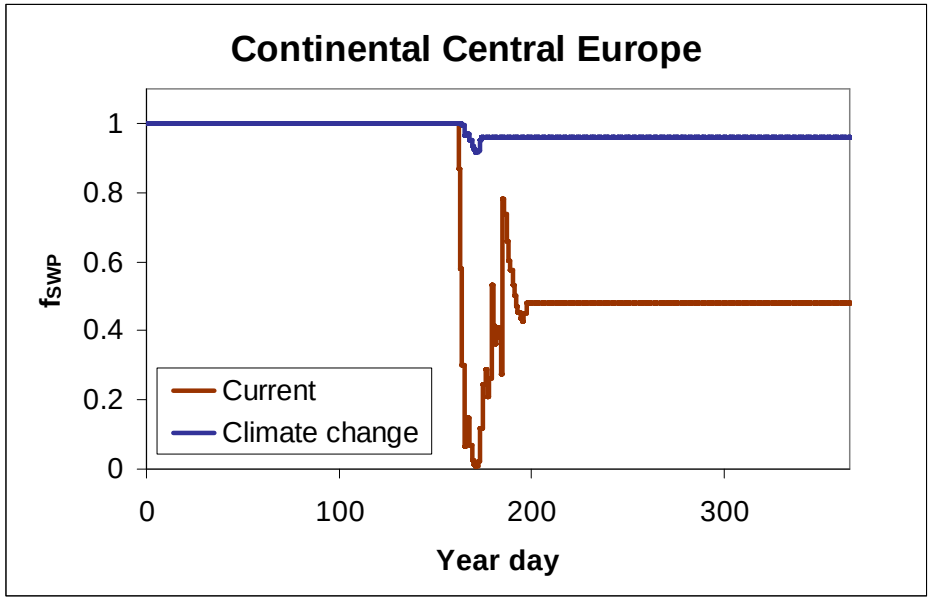


Flux modelling under climate change

Drought considerations



ToC & VPD driven



Phenology & P driven

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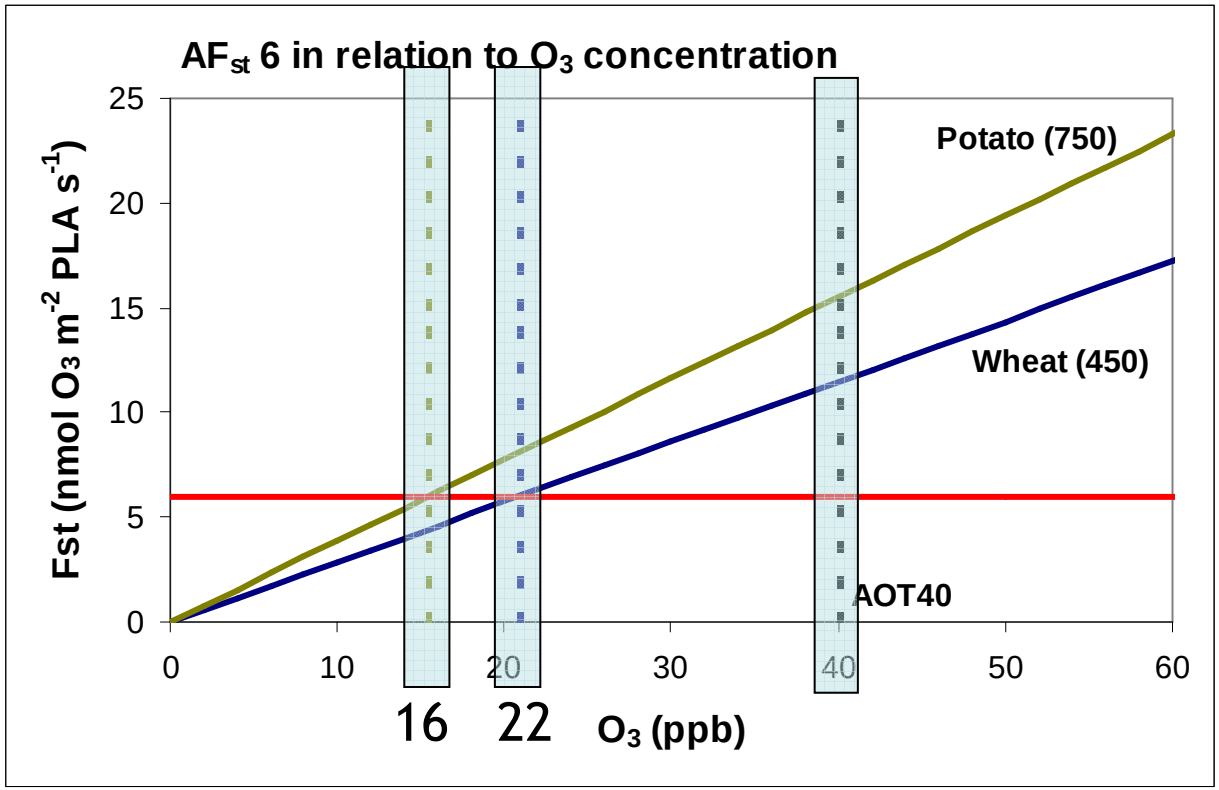
Flux modelling under climate change

Rising background concentrations

Assuming g_{max} and rb = 50 s/m



AOT40 – only able to incorporate effect of rising global background concentration above 40ppb

AFstY – able to differentiate species sensitivity to rising background concentration

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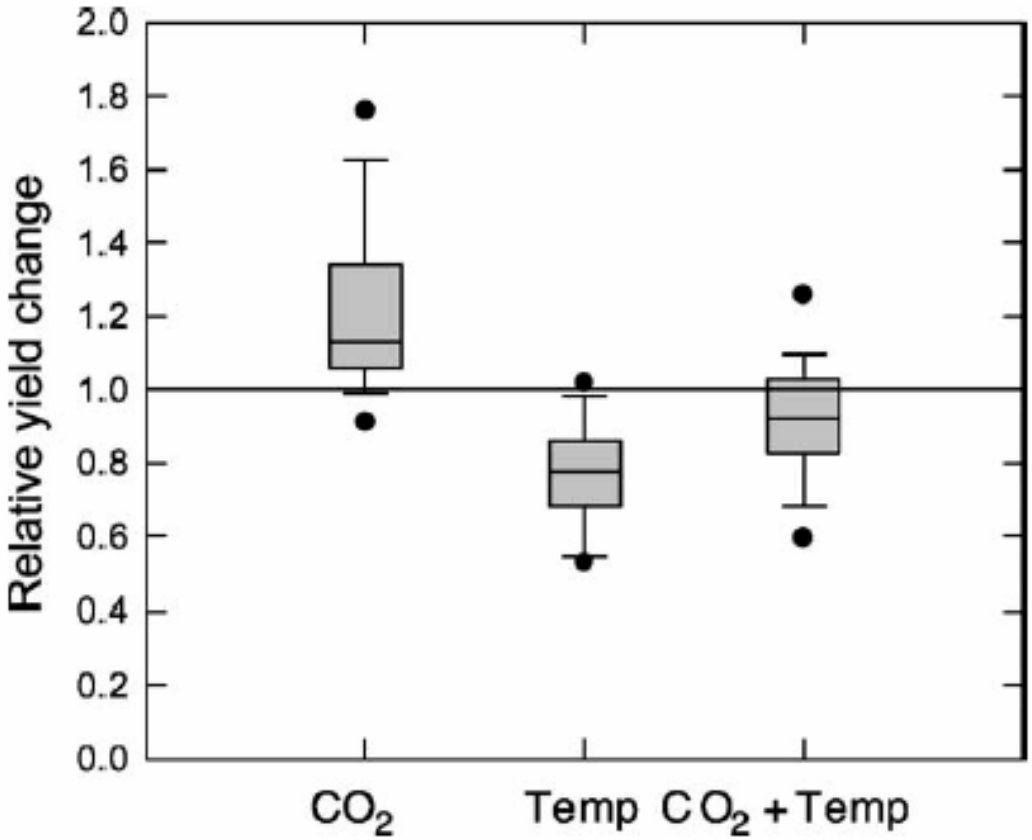
Flux modelling under climate change

Response considerations



Effects of elevated CO_2 and increased temperature, singly and in combination, on yield of wheat.

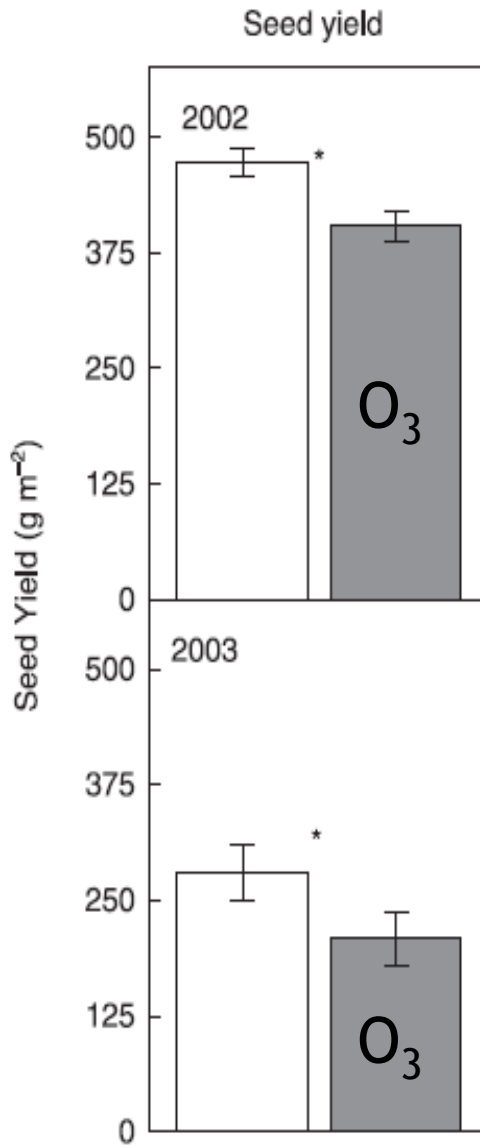
Fuhrer 2003

Flux modelling under climate change

Response considerations

- FACE soybean (*glycine max*) experiment
- Increased O_3 concentrations over two growing seasons by 23 % - mimicking projections for 2050
- Resulted in 20% loss in seed yield
- Results suggest even greater losses than those previously predicted by closed chamber studies
- "Direct effects of O_3 on food crops could offset any positive response to rising CO_2"

Morgan et al. 2006



Flux modelling under climate change

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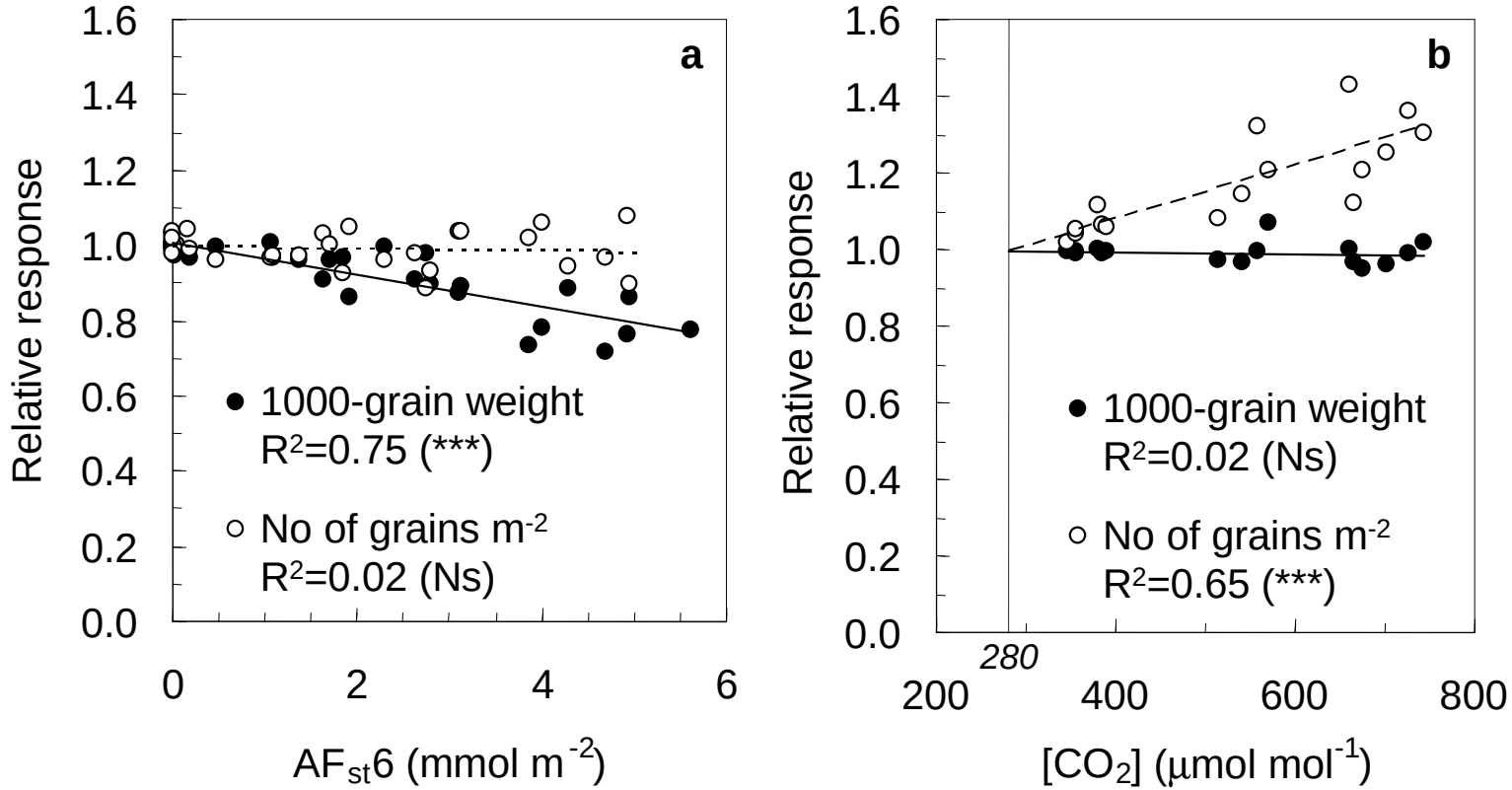

Comparison of O_3 and CO_2 effects on wheat **grain number** and **grain size**

Pleijel et al, submitted

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Uncertainties and gaps in knowledge

1. Impacts of climate change on vegetation distribution
2. Flux modelling: Uncertainties associated with stomatal flux estimates
3. Consideration of rising CO_2 concentrations
4. Experimental evidence: limited for O_3 under climate change conditions
5. Change in agricultural and forestry practices e.g. no flux models available for energy crops
6. Uncertainties in defining detoxification thresholds