ICP Vegetation
Scientific Contribution to review of the Gothenburg Protocol

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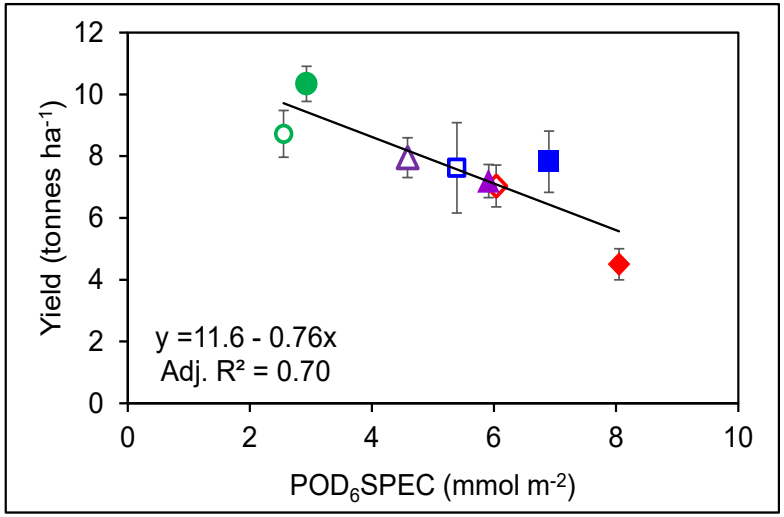
** Financial support provided by Defra (UK) and UNECE*

Question 2.3b – observed and predicted trends in risk to vegetation

Preferred metric: Ozone fluxes
Confounding factor: Change in ozone profile (lower peaks, higher background)

Impacts of ozone are also observed when low to moderate ozone concentrations coincide with conditions favouring uptake



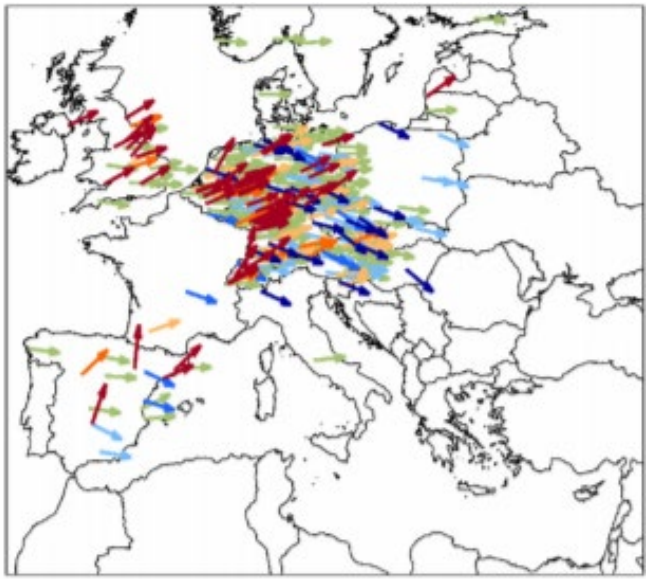
Wheat yield is predicted by total ozone flux, and this is not dependant on whether the ozone regime is episodic (peaks) (solid symbols), or based on increasing background concentrations (open symbols). Harmens et al., 2018.

Question 2.3b – observed and predicted trends in risk to vegetation

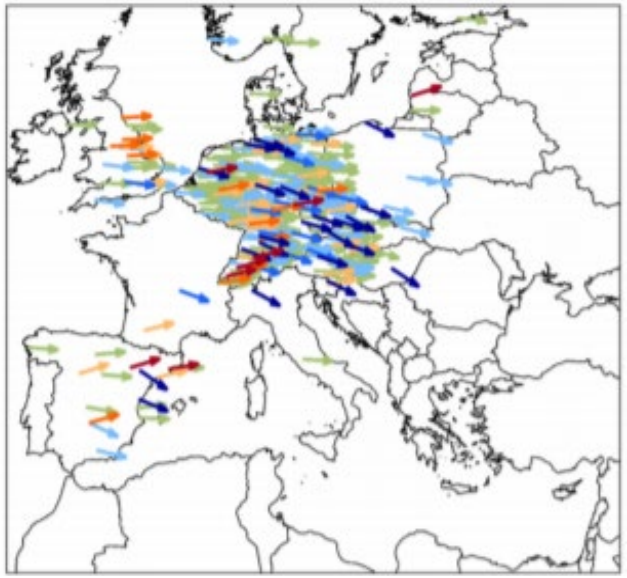
Vegetation impacts trends: TOAR report
Timescale: 1995-2014
Vegetation types: wheat and perennial vegetation
Metrics: includes M12, W126 and AOT40

In Europe a decreasing trend for:

6% of sites (M12)



12% of sites (AOT40)



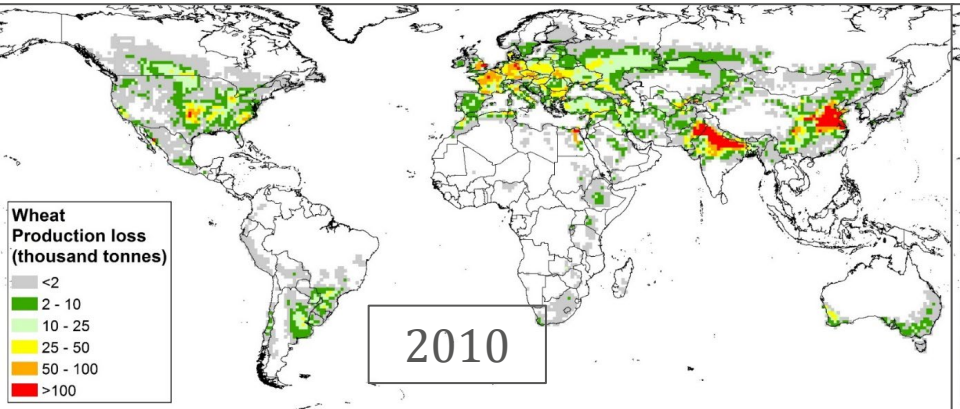
Question 2.3b – observed and predicted trends in risk to vegetation

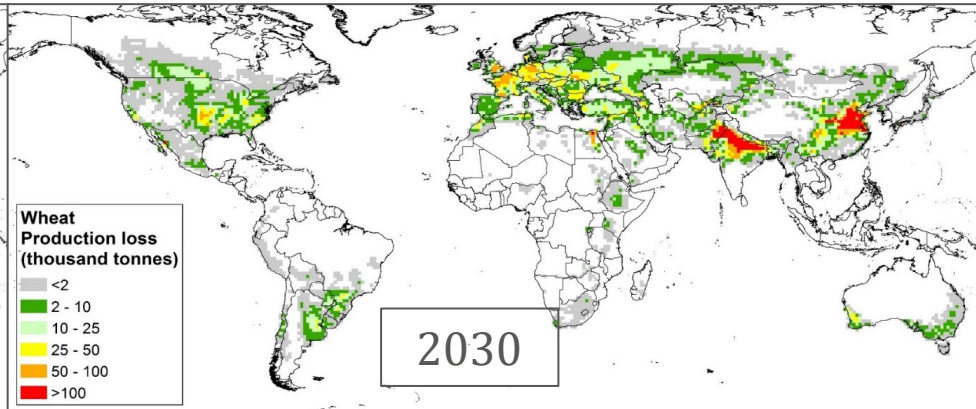
Predictions of trends:

Estimate (pending further analysis) that ozone will still cause impacts on vegetation by 2030. There might be some small improvements in some locations. Anticipate that the impacts will be broadly similar to now.

Supporting evidence / existing analysis:

- Ozone risks to **biodiversity** will still occur by 2050, as ozone exposure will remain similar using RCP4.5 compared to that experienced in 2000 (Fuhrer et al., 2016).
- Significant effects of ozone on the **biomass increment of trees** will remain (de Vries et al., 2017).
- Estimates of **wheat yield** based on ozone fluxes predict yield losses in 2030 of 5.8%, 6.8 % and 7.6% in North America, Europe and the EECCA countries respectively. (using ECLIPSE V5a emissions)





Question 2.3b – observed and predicted trends in risk to vegetation

Field Evidence:

No evidence for a change in impacts (but evidence is very limited) based on:

- Comparisons of impacts in filtered vs non-filtered air
- Visible injury on vegetation in ambient air
- Biomonitoring (1998-2006)

Confounded by differences in intensity of effort between years, and between locations

Question 2.7: Is the monitoring and modelling system of the Convention sufficient?

Emissions inside and outside UNECE area:

Benefit from some more detailed analysis on the influence of emissions (and emissions controls) within the ECE region compared to the influence of emissions outside the ECE region. GP does not cover all countries contributing to precursors

Lack of field evidence / ground truthing of impact predictions:

- Comparatively little work (compared to 1990's)
- Visible injury might not be best with lower ozone peaks, but filtered air chambers (good for other impacts e.g. flowering) are expensive

Improvements to risk assessments are needed:

- Dose-response relationships and parameterisations for more species
- Wider breadth of ecologically relevant impacts (e.g. pollinators, C-sequestration in soils, water and nutrient cycling)
- Local application / testing can indicate where improvements are needed

Question 2.8: What are the expected impacts of new scientific findings ?

Risk assessment should be based on ozone fluxes:

Climate change can alter exposure of vegetation to ozone:

- Earlier bud-break with increasing temperature – shift time-window
- Altered fluxes via stomatal opening
- 'non-stomatal' physiological interactions affecting crop yield (not currently accounted for in models)
- Ozone can modify responses to environmental stress (sluggish stomata)

Ozone and nitrogen interactions:

- Ozone can reduce N-use efficiency – N 'leaking' from the system
- No clear relationships between ozone sensitivity and N application rate for individual species – but this inconsistency could change vegetation species communities
- Changes in species community composition due to N can alter community sensitivity to ozone.

Thank you

Remaining Work:

ICP Vegetation will calculate crop losses per country, risk to biodiversity, and impacts on trees using ozone fluxes (POD) from EMEP when available (Spring 2022?).