Project Number 282910

ÉCLAIRE

Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems

Seventh Framework Programme

Theme: Environment

9.3. Completed database and results of meta-analysis handed to WP12 and WP13

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Start Date of Project: **01/10/2011**

Duration: **48 months**

Organisation name of lead contractor for this deliverable :
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Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination Level		
PU	Public	☐
PP	Restricted to other programme participants (including the Commission Services)	x☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Executive Summary

The purpose of the literature-based data mining activities was to acquire response functions for the first stage improvement in the parameterisation of models used in C3 and C4 modelling. The focus was on the effects of ozone, alone and in combination with other pollutants and environmental stressors, on leaf-scale, season-long dynamic and ecosystem processes, particularly those associated with stomatal conductance, photosynthesis and carbon allocation. Data was collected using a standard template that facilitated cross-vegetation type analysis to look for commonalities in responses. Combined data were analysed to develop dose-response relationships for biomass effects and effects on leaf physiology, and meta-analyses were also conducted. The methods used for data compilation followed recommended procedure for quality assurance (Philibert et al., 2012). The focus of the work was on scientific papers on crops, grassland, heath and wetlands.

Over 1200 papers were considered for data mining and a sub-set of 216 papers with data that met the specific selection criteria were included in the data analysis. Statistical significance was greatest for effects on crops, reflecting in part the greater data availability for this vegetation type. Meta-analysis provided effect sizes as a percentage change per ppb of ozone. Across all vegetation types, significant effects were found for biomass (-0.48), A_{sat} (-0.33), Net photosynthetic rate (-0.36), V_{cmax} (-0.24) and stomatal conductance (-0.40). These effects parameters are for use in the further development of the photosynthesis-based DO_3SE model in WP12 and 13. In a further aspect of the data analysis, mined data has been used to develop biomass-response and leaf N resorption functions enabling ozone effects to be included for the first time in MADOC (WP13).

2. Objectives:

1. To conduct a meta-analysis on the compiled data to provide a priority analysis for the modellers of the most important effects and associated processes
2. To analyse the data to develop a database of response-relationships for key ecosystem processes, functions and services to air pollutants (singly, and where available, in combination) including the influence of climate change, for use in activities WP12 and WP13.

3. Activities:

Data compilation was conducted as part of deliverables 9.1 and 9.2. For this deliverable, we extracted data from the combined database for analysis using two approaches:

- Meta-analysis. Where sufficient data was available, meta-analysis was conducted using the software MetaWin (v2.1, Sinauer Associates, Inc., Sunderland, MA, USA). A mixed effects model was then used to calculate the response, which estimates the effect of ozone on the various parameters, relative to a set ozone concentration.

- Regression analysis to find significant linear (or non linear) relationships between ozone and plant process or ecosystem-relevant parameters. Where statistically relevant, data from as many species as possible were joined together in order to achieve broadly applicable response functions.

4. Results:

Meta-analysis A total of 216 peer-reviewed articles were included in the analysis. The mean values, standard deviations/standard errors, number of replicates and other information on the response variables (A_{sat}, V_{cmax}, etc) were taken from the figures, tables and text provided in published papers. The values were extracted from graphs using the *GetData Graph Digitizer* (http://getdata-graph-digitizer.com/, v2.26).

Table 1: The number of papers and species for which there was sufficient data for inclusion in the meta-analysis. Key: V_{cmax} (Maximum carboxylation velocity), J_{max} (maximum rate of electron transport), A_{sat} (the light saturated photosynthesis rate).

Crops

Process	***Papers***	***Species***
Biomass	7	10
A_{sat}	10	12
J_{max}	2	2
Net photosynthetic rate	14	17
V_{cmax}	7	5
Stomatal conductance	20	31
Senescence	1	1

Other vegetation

Process	***Papers***	***Species***
Biomass	7	35
A_{sat}	2	4
J_{max}	1	2
Net photosynthetic rate	2	4
V_{cmax}	2	4
Stomatal conductance	3	6
Senescence	3	15

As an example, the results of this analysis for crops and "other vegetation" (grassland, heathland and wetlands) are provided in Table 2. In most cases, the results for the two classes of vegetation were not significantly different from each other. Effects on biomass were significant for both crops and other vegetation, with crops being more sensitive. For photosynthetic parameters and stomatal conductance, effects were only significant for crops. The effect size was lower for V_{cmax} (Maximum carboxylation velocity) and J_{max} (maximum rate of electron transport) than for A_{sat} (the light saturated photosynthesis rate).

Table 2: The results of the meta-analysis conducted on the data from the Eclaire database. 9999 iterations were run to calculate the 95% bootstrap confidence interval. The "*" next to the effect size indicates at least a 95% confidence that the effect is not 0. The values from crops and other vegetation were significantly different from each other if their 95% bootstrap intervals did not overlap.

Process	***Vegetation type***	***Effect size***	***Bootstrap CI***	***Significantly different***
Biomass	Crops	-0.34*	-0.45 to -0.26	No
	Other vegetation	-0.70*	-1.04 to -0.28	
Asat	Crops	-0.41*	-0.61 to -0.23	No
	Other vegetation	-0.20	-0.44 to 0.01	
Jmax	Crops	-0.20*	-0.55 to -0.19	No
	Other vegetation	-0.08	-0.35 to 0.27	
Net photosynthetic rate	Crops	-0.41*	-0.56 to -0.28	Yes
	Other vegetation	-0.02	-0.22 to 0.09	
Vcmax	Crops	-0.22*	-0.38 to -0.07	No
	Other vegetation	-0.02	-0.38 to 0.58	
Stomatal conductance	Crops	-0.41*	-0.54 to -0.28	No
	Other vegetation	-0.39	-0.61 to 0.11	

Dose-response functions for use in MADOC modelling Relative biomass was determined for three categories of vegetation: trees, wet grassland and bog, and dry and mesic grassland. Data sources for this analysis included published data, data from experiments conducted as part of ECLAIRE WP10 and unpublished data from experiments conducted in the CEH solardome facility. The daylight mean ozone concentration was used as the ozone parameter as it was the most commonly reported in papers and is independent of effects of time period for accumulation or a threshold such as 40 ppb in AOT40. There was insufficient data available to use accumulated ozone flux (e.g. POD_1) as the ozone parameter. Different species and vegetation type combinations were compared, with the distinct functions provided in Figure 1 being of most practical use within MADOC. Dry and mesic grassland species are clearly more sensitive than wet grassland, bog or tree species, with a response function slope nearly three times that of the other vegetation types.

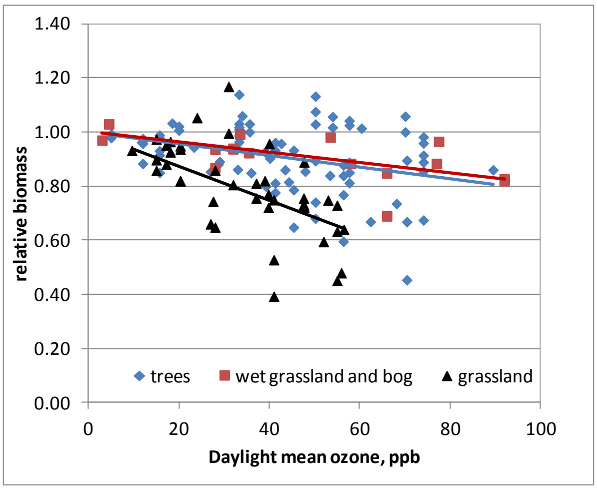

Figure 1: Biomass response functions derived from the scientific literature, ECLAIRE experiments and unpublished data for use in MADOC modelling. Note: “Grassland” refers to dry and mesic grasslands.

Also for use in MADOC modelling, the effect of ozone on the percentage resorption of N from senescing leaves was calculated as an input into the soil N and C cycling component of the model. Much less has been published on this subject, with data from two papers and the ECLAIRE experiments for _Betula_ spp (birch) being used to form a function suitable for modelling (Figure 2). Combining these three data sources showed a strong relationship between ozone and N resorption (r^2 = 0.87), indicating that increasing ozone decreases N resorption, with significant consequences for soil litter decomposition processes and GHG production from soils.

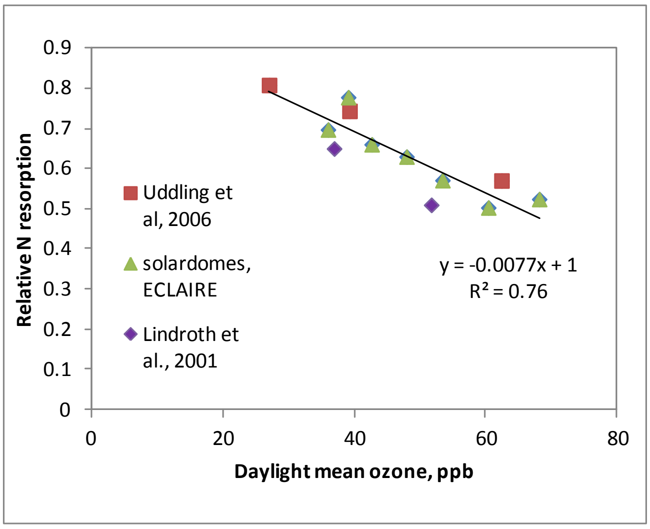

Figure 2: Effects of season long ozone exposure on the resorption of N by senescing leaves of birch species (*Betula pendula* for Uddling et al., 2006 and solardome experiments as part of ECLAIRE WP10, and *Betula payrifera* for Lindroth et al., 2001).

5. Milestones achieved:

MS41: Completion of meta-analysis and handing over of data for use in WP12 and WP13.

6. Deviations and reasons:

Analysis was delayed for this deliverable because it took longer to compile the databases than originally anticipated.

7. Publications:

None as yet, papers are in the planning stage

8. Meetings:

Meetings were held at the GA in Zagreb (October, 2013) and prior to the ICP Vegetation meeting in Paris (January, 2014). In addition, there have been numerous telecoms between the various contributors to this deliverable.

9. List of Documents/Annexes:

10. Papers cited

Lindroth, R. L., B. J. Kopper, et al. (2001). "Consequences of elevated carbon dioxide and ozone for foliar chemical composition and dynamics in trembling aspen (Populus tremuloides) and paper birch (Betula papyrifera)." Environmental Pollution 115(3): 395-404.

Philibert, A., C. Loyce, et al. (2012). "Assessment of the quality of meta-analysis in agronomy." Agriculture Ecosystems & Environment 148: 72-82.

Uddling, J., P. E. Karlsson, et al. (2006). "Ozone impairs autumnal resorption of nitrogen from birch (Betula pendula) leaves, causing an increase in whole-tree nitrogen loss through litter fall." Tree Physiology 26(1): 113-120.