Workshop Report

Expert Workshop on Epidemiological Analysis of Air Pollution Effects on Vegetation

Ozone related activity under the ICP Vegetation (UNECE CLRTAP)

Basel, 16-17 September 2014

1. Introduction

The Expert Workshop on Epidemiological Analysis of Air Pollution Effects on Vegetation, organized by the Institute of Applied Plant Biology[1] in cooperation with the Swiss Federal Office for the Environment[2], was held in Basel (Switzerland) from 16-17 September 2014.

The workshop was attended by experts from Italy, Sweden, Switzerland and the United Kingdom, all involved in applying epidemiological methodologies to analyse air pollution effects, especially ozone effects on growth of mature trees, by considering simultaneously modifying factors such as climate and nitrogen.

The workshop was offered by Switzerland on the basis of the following general recommendations from the 27th meeting of ICP Vegetation, held in Paris, 28-30 January 2014:

- Further epidemiological studies should be conducted to validate critical levels. The methodology to separate climate and direct ozone effects should be discussed amongst experts;
- Develop flux-effect relationships and associated critical levels for vegetation, taking into account modifying factors such as other pollutants (specifically nitrogen) and climate change.

2. Topics and questions addressed

During the workshop the following topics and questions were addressed in form of presentations and during the discussions:

Statistical methods

- Model selection: selection of predicting variables, confounding factors;
- Regression methods: mixed linear regression, logistic regression;
- Model validation and residual analysis;
- Derivation of safety thresholds;
- Interpretation and representation of regression results (e.g. covariate-adjusted means and functional relationships.

Mapping

- Mapping of air pollutant concentrations, fluxes and deposition
- Mapping of meteorological parameters;
- Comparison of results with various spatial resolution.

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[2] Federal Office for the Environment (FOEN), CH-3003 Bern

Predictors

- Drought: comparison of various drought predictors.

Datasets

- Steps to prepare a dataset before carrying out an epidemiological analysis.

3. Presentations and discussion

Mr Beat Rihm presented the procedures applied in Switzerland to map environmental factors that are required as predicting variables at high spatial resolution (see attachment I). Examples were given for ammonia concentration, nitrogen deposition and ozone flux. In the case of gradient studies with nitrogen deposition, significance was lost at spatial resolutions above 5 km (see presentation B. Rihm). For ozone flux a description of the mapping procedure can be found in Braun et al. (2014).

Ms Sabine Braun presented the epidemiological methodology applied to derive exposure-response relationships between ozone-flux and growth of mature beech and Norway spruce (see attachment II). Results of this work are published in Braun et al. (2014).

Mr Christian Schindler gave an overview of important epidemiological concepts and of statistical methods used for epidemiological analysis (see attachment III).

Mr P.E. Karlsson presented results from an epidemiological study analysing the relative stem basal area increment of 5 Norway spruce trees on each of ten plots situated around the Asa Experimental Forest in southern Sweden (Karlsson et al. 2006, attachment IV). The explanatory variables tested were stand basal area, temperature sum (>5 °C), drought days, AOT40, VPD, precipitation and radiation. The negative impacts of AOT40 were statistically significant. A conservative estimate was that the relative stem basal area increment was reduced 5 % at 5 ppm h AOT40 over the growing season. A new study was described that will make use of the relative stem basal area increment over >20 years from 25 plots in managed forests in southern and mid Sweden, derived from dendrochronological analysis (attachment V).

Ms Alessandra de Marco presented data from a field survey of ozone-induced symptoms (ICP-Forests protocol) in 54 plots in South-eastern France and North-western Italy (attachment VI). Stomatal ozone fluxes were modelled and correlated to visible injury (stippling/mottling, crown discoloration and leaf loss) in 2012 and 2013. The indicators POD0 and POD1 were calculated using the DO_3SE model with parameterization for Mediterranean and continental deciduous broadleaf forests and conifers. The dataset was explored using the Spearman rank test. POD0 was a better indicator for visible injury than POD1, while AOT40 was the best predictor for discoloration or defoliation.

In the ensuing discussion several methodological aspects of the chosen approaches were addressed including advantages and disadvantages of different models, priorities to be set in addressing modifying factors, possible ways for model validation, protection thresholds and uncertainty analysis.

4. Conclusions and recommendations

On the basis of the presentations and discussions, the following conclusions and recommendations were made:

4.1. General conclusions and recommendations

- Epidemiological analysis of air pollution effects on trees requires a sufficiently large number of observations at large spatial and/or temporal scale, along with a sufficiently pronounced gradient of impacts of air pollutants and modifying factors.
- According to a rule of thumb, in epidemiological analyses of numerical outcome variables, the number of covariates at each cluster level should not exceed 10% of the number of clusters at the respective level. For instance, if the main cluster level is plot, then the number of covariates defined at the level of plots (i.e., not varying within plots) should not exceed 10% of the number of plots. However, if there are variables defined at the level of trees, their number should not exceed 10% of the total number of trees. If the outcome considered is binary, the total number of covariates should not exceed 10% of the minimum of the number of cases (i.e., units with the value 1) and the number of non-cases (i.e., units with the value 0).
- Process-oriented information on dose-response-relationships can also be obtained at single sites where many explanatory variables are measured over a long time period.
- Epidemiological analysis needs quality controlled data for both dependent and independent variables. Information on validation and quality control should be included in the reporting of the study.
- Epidemiological approaches can disentangle and quantify the contributions of different predictor variables to an overall effect e.g. growth.
- Epidemiological analysis cannot prove causality but can provide strong indications for causality. Plausibility and causality of exposure-response relationships have to be established with experimental studies.
- Epidemiological findings can generate hypotheses deserving further study in experiments.
- The results from epidemiology are the best approach for modelling dependent variables under different regional/global climate change and air pollution scenarios. Useful dependent variables are growth, visible injury, crown transparency, mortality and species richness. Also remote-sensing variables can be considered.
- Analysis of datasets which already exist (e.g. historical data, ICP Forests, NFI) is encouraged.
- Results from epidemiological studies in different countries may be combined by using meta-analysis. A prerequisite is to carefully take into account heterogeneity.

4.2. Methodological recommendations

- The exposure assigned to an observation unit should be representative for the average exposure at this point.
- It is important to determine whether sites are influenced by local air pollutant emission sources. If this is the case (often in the case of agricultural sources), the spatial resolution should depict the horizontal gradients around those sources (cell-size 0.1 - 0.5 km).
- If the topography around sites is complex (e.g. in mountainous areas), meteorological parameters show strong gradients. In such cases the spatial resolution needs to be adapted accordingly (cell-size < 0.5 – 2 km).
- If the spatial resolution for modeled environmental data is too low, the effects of impacts can loose significance.
- Resolution in time should be as high as possible without increasing too much complexity (annual is considered as an optimum if growth is the dependent variable).
- If process based numerical atmospheric models cannot be applied (costs, complexity, spatial resolution), geo-statistical interpolation and statistical dispersion models are useful.

- The ozone Critical Levels Workshop planned for 2016 should address statistical and toxicological evidence for setting different threshold values in exposure indices like flux, AOT and concentration.
- The possibility of a follow-up epidemiological workshop in autumn 2015 in Sweden will be explored.

It was suggested that the recommendations for epidemiological studies should be compiled to a background paper to be submitted to the journal “Environmental Pollution”. This background paper should address the following issues:
Statistical model approaches
- End points to be addressed
- Exposure modelling and mapping
- Confounding factors
- Data quality aspects
- Examples of successful studies

5. List of participants

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6. Attachments

I Presentation Beat Rihm
II Presentation Sabine Braun
III Presentation Christian Schindler
IV Presentation 1 Per-Erik Karlsson
V Presentation 2 Per-Erik Karlsson
VI Presentation Alessandro de Marco