Project Number 282910

ÉCLAIRE

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

Seventh Framework Programme

Theme: Environment

D14.2
Updated versions of DGVMs and DSVMs that include O3 uptake model and N deposition on carbon uptake

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Organisation name of lead contractor for this deliverable :
JRC

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	☐
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 objective of D14.2 was to further develop dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) by including interacting effects of air pollutants on ecosystem productivity. This goal was achieved by developing new routines and modules within each model to account for the effect of O3 and N depositions on the photosynthetic capacity and stomatal conductance of plants. The development of the models has been kept independent among groups/models in order to avoid contamination and, therefore, to allow a better estimation of the structural uncertainty of models.
In summary, the DGVMs, i.e. LPJ-Guess, JULES, CLM, O-CN and ORCHIDEE, and DSVMs, i.e. VSD+-Forspace and MADOC, were expanded by including process descriptions for the impact of ozone exposure and/or nitrogen deposition on the carbon and water balance of plants. A separate simple empirical forest growth and management model, GrowUp, was developed for rapid assessment of the interacting impacts of air quality and climate change making use of (meta-analysis of) literature information and published data.

2. Objectives:

The objective of D14.2 was to further develop dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) by including interacting effects of nitrogen, ozone and climate on modelled ecosystem productivity. DGVMs and DSVMs have been developed to use large scale European databases on meteorology, deposition, air quality, soils and vegetation and in order to assess the effects of combined air pollution and climate change scenarios on productivity and ecosystem C/GHG balance for forests, semi-natural and agricultural systems.

3. Activities:

The activity has focused on the improvement of process descriptions in dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) to be applied within Eclaire. The activity include the development of new routines and module to account for the effect of O3 deposition on the photosynthetic capacity and stomatal conductance of plants. The development of the models has been kept independent among groups in order to avoid contamination of modelling strategies and solution and therefore to allow a better estimate of the structural uncertainty of models.
In summary, the DGVMs, i.e. LPJ-Guess, JULES, CLM, O-CN and ORCHIDEE, and DSVMs, i.e. VSD+-Forspace and MADOC, were developed by including process descriptions for the impact of ozone exposure and/or nitrogen deposition on productivity. A separate simple empirical forest growth and management model, GrowUp, was developed for rapid assessment of the interacting impacts of air quality and climate change making use of (meta-analysis of) literature information and published data.

4. Results:

As a result of the activity all models involved in WP14 have been improved and preliminary tested as follows:

Dynamic global vegetation models (DGVMs)

- **LPJ-GUESS**: Algorithms to model the effects of O_3 on C uptake and assimilation have been implemented in the model. Preliminary model evaluation against previous LPJ output and other model results has been performed, and the final evaluation against data from specific sites and from leaf-level measurements is underway. Parameterisation of the effects of N deposition on C uptake and assimilation have been incorporated in the model. These algorithms have been fully evaluated against previous model output and site specific data from the FLUXNET and FACE sites.
- **JULES**: A comprehensive dataset of experimental observations has been collected to improve the existing leaf level O_3 uptake model in JULES by: (i) updating the existing O_3 formulation with parameters derived from updated data sets and (ii) implement an updated stomatal conductance formulation. Although progress has been made on the stomatal conductance representation (close to completion), the O_3 effects on photosynthesis for European vegetation types still need to be re-parameterised with the latest data sets. When this is done, it will be linked with soil N and vegetation N uptake models within JULES.
- **O-CN**: A flux scheme has been implemented into O-CN, to estimate surface ozone concentration and stomatal ozone uptake. Modules for calculating the differing impacts of ozone uptake on net assimilation and stomatal closure have been developed and the marginal effects of the two factors on plant production assessed. Generally, decoupling stomatal closure from productivity is most important in seasonally dry regions. A close collaboration with SEI in York is foreseen to evaluate the fully

developed model. The ozone impact work links directly to the coupled carbon-nitrogen cycle parameterisation of O-CN to calculate the joint impacts of ozone and nitrogen deposition on the terrestrial C and N budgets.

- **CLM**: A new routine for the assessment of the impacts of ozone on vegetation functioning has been recently introduced within CLM4 and applied at global scale. The new model is under testing at European scale forced by the meteorological drivers selected for the ECLAIRE project. CLM4 model developments include new routines for: (1) the computation of the cumulative O_3 uptake dependent by the O_3 concentration and leaf area index; 2) the simulation of the O_3 phytotoxic effects on photosynthesis and transpiration. The typical description of the O_3 effects on vegetation simulated by the state of the art terrestrial biosphere models couples the processes of photosynthesis and transpiration. The new routine implemented in CLM4 allows for decoupling the effects of O_3 on the two processes.

Dynamic soil vegetation models (DSVMs)

- **Forspace**: the effects of O_3 uptake, base cations availability and soil pH on the photosynthetic machinery and plant growth were included and tested in terms of sensitivity analysis. The improved model was coupled to VSD+ as input for simulations of soil carbon sequestration while VSD+ output on base cations availability and soil pH is used by FORSPACE
- ***GrowUp****:* An empirical model *GrowUp* has been developed, based on results of meta-analysis of literature data on the single and combined effects of changes in climate (temperature and water availability), nitrogen availability, carbon dioxide (CO_2) exposure and ozone (O_3) exposure in forests and forest soils.
- **MADOC**: Ozone effects have been incorporated using simple functions derived from experiments and published literature. Two effects have been incorporated, both functions of mean ambient ozone concentration: limitation to plant production, parameterised initially using results from the Bangor solardomes experiment; and a reduction in the proportion of N translocated out of leaves before senescence, parameterised using data from Uddling et al. (2006; Tree Physiology 26: 113-20). These response functions will be adapted and refined as results from data mining become available. Other mechanisms (e.g. effects on root vs. shoot allocation) may also be included if warranted by the results of the data mining exercise.

5. Milestones achieved:

M61: Upgraded version of DGVMs and DSVMs operational.

6. Deviations and reasons:

No deviations form plan

7. Publications:

None

8. Meetings:

None

9. List of Documents/Annexes:

None