Project Number 282910

ÉCLAIRE

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

Seventh Framework Programme

Theme: Environment

D11.2

Predictive modelling of GHG fluxes, especially CO_2 under different N deposition regimes

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Dissemination Level		
PU	Public	☐
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	X
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

Executive Summary

To start with, the location of deliverable 11.2 was a typographical error, since WP11, entitled "Investigation of novel ecosystem – air pollution –climate interactions" is an experimental WP, not including any modelling. In reality it was part of W13 entitled "Modelling of carbon stocks, greenhouse gas and vegetation change". The objective of D11.2 was to further develop and test process based and empirical dynamic models simulating the interactive effects of climate, CO_2, O_3 and N on GHG exchange, with a special focus on plant C assimilation and CO_2 exchange/ C sequestration

The process based models LPJ-GUESS and DNDC-MOBILE model have been further developed and evaluated against previous model output and site specific data from FLUXNET and FACE sites (LPJ-GUESS) and used to assess the uncertainty of key parameters using Bayesian calibration methods (DNDC-MOBILE). The empirical model EUgrow has been developed and applied to assess C-N responses for representative boreal, temperate and tropical forests, respectively. CO_2 exchange (C sequestration) under different N deposition regimes is predicted using a typical global average N deposition levels on the various forest types.

1. Objectives:

The objective of D11.2 was to further develop and test process based and empirical dynamic models simulating the interactive effects of climate, CO_2, O_3 and N on GHG exchange, with a special focus on plant C assimilation and CO_2 exchange/ C sequestration. The location of deliverable 11.2 was a typographical error, since WP11, entitled “Investigation of novel ecosystem – air pollution –climate interactions” is an experimental WP, not including any modelling. In reality it was part of W13 entitled “Modelling of carbon stocks, greenhouse gas and vegetation change”.

2. Activities:

The LPJ-GUESS model has been further developed by incorporating and parameterizing the effects of N deposition on C uptake and to simulate the interactive effects of climate, CO_2, O_3 and N on plant C assimilation and C sequestration. The model has been evaluated against previous model output and site specific data from FLUXNET and FACE sites. Furthermore, the Landscape DNDC (or Mobile-DNDC as it was named earlier) model has been improved in process parameterization with regard to ecosystem GHG exchange, including an assessment of the uncertainty of key parameters using Bayesian calibration methods. The model performance was evaluated with regard to GHG emissions (agriculture/grassland/ forest), but also specifically into the simulation of NO emissions from soils. Finally, an empirical model (EUgrow) has been developed, making use of (meta-analysis of) literature information and published data, that enables a fast assessment of the effects of N deposition on plant (tree) and soil C sequestration in interaction with climate, CO_2, and O_3. The EUgrow model has been used to assess CO_2 exchange (C sequestration) under different N deposition regimes using typical global average N deposition levels on various forest types (see results).

3. Results:

The EUgrow model has been used to assess ranges in C responses to N deposition for needle-leaved forests, deciduous broadleaved forests and evergreen broadleaved forests, mainly representative for boreal, temperate and tropical regions, respectively (De Vries et al., 2014). Results thus obtained for different forest compartments (woody parts with long turnover times, distinguished in stems, coarse-roots and non- woody parts with short turnover times, distinguished in leaves and fine roots, are given in Table 1.

Table 1 Calculated C to N responses of different forest vegetation pools and soil of boreal, temperate and tropical forests with the EUgrow model

Compartment	C to N response (kgC kgN^{-1})		
	Boreal forests Needle leaf	Temperate forests Deciduous broadleaf	Tropical forests Evergreen broadleaf
Stems	21.3 (17 - 25.5)	14.4 (11.6 - 17.3)	5 (3.3 - 6.6)
Coarse-roots	5.0 (4.0 – 6.0)	3.1 (2.5 - 3.7)	1.1 (0.8 - 1.5)
Woody parts	26.3 (21.0 - 31.5)	17.5 (14.0 – 21.0)	6.1 (4.1 - 8.1)
Leaves	4.7 (3.8 - 5.7)	2.5 (2 - 2.9)	1.7 (1.1 - 2.2)
Fine-roots	2.4 (1.9 - 2.9)	1.1 (0.9 - 1.3)	1.7 (1.1 - 2.2)
Non woody parts	7.1 (5.7 - 8.6)	3.6 (2.8 - 4.3)	3.3 (2.2 - 4.5)
Total vegetation (NPP)	33.4 (26.7 - 40.1)	21.1 (16.8 - 25.3)	9.4 (6.3 - 12.6)
Soil	13.5 (10.7 -18.1)	13.7 (10.8 -18.3)	5.4 (4.4 - 7.1)
Wood and soil (NEP)	39.8 (31.7- 49.6)	31.2 (24.8 – 39.3)	11.5 (8.5 – 15.2)

Results illustrate that in forests, the response of C in woody parts, i.e. stems and coarse roots, to external N inputs is much larger (varying from 4.1-31.5 kg C/kg N) than the response of C in non-woody parts, i.e. leaves and fine roots (varying from 2.2-8.6 kg C/kg N), due to the higher C:N ratios of the woody parts. Furthermore, the response of tropical forests is much lower than of boreal and temperate forests, reflecting the more severe N limitation of the latter forests. The calculated range in soil C sequestration is approximately half of the woody parts in boreal forests and equal to it in tropical forests (Table 1). The model predicted range in C-N responses presented in Table 1 is comparable to experimental N addition studies and monitoring based field studies along N deposition gradients.

CO_2 exchange (C sequestration) under different N deposition regimes has been predicted using typical global average N deposition levels on the various forest types and their area. By doing so, a preliminary estimate was made of the contribution of N deposition to the current global forest C sink. Results obtained vary between 276-448 TgC yr^{-1}, with approximately 60% retained in tree wood and 40% in soil (De Vries et al., 2014). This range is comparable with recent results from global scale coupled C–N cycle models (200–400 TgC yr^{-1}), considering the interactive impacts of climate change, CO_2 fertilization and N deposition

4. Milestones achieved:

No milestones related to this deliverable

5. Deviations and reasons:

No deviations from plan

6. Publications:

De Vries, W, E. Du and K. Butterbach-Bahl, 2014. Short and long-term impacts of nitrogen deposition on carbon sequestration by forest ecosystems. Current Opinion in Environmental Sustainability (Accepted)

7. Meetings:

None

8. List of Documents/Annexes:

None