Project Number 282910

ÉCLAIRE

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

Seventh Framework Programme

Theme: Environment

D14.4 Model runs using ECLAIRE scenarios of future emissions and climate change

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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

In WP14 an ensemble of land surface models are used to simulate various scenarios of climate change, air quality (exposure to O_3 and CO_2) and deposition of nutrients on plant productivity and nutrient cycling of forests and semi-natural systems.

The specific objective of deliverable 14.4 is to describe the model runs of DGVMs and DSVMs in WP14 and in particular the following details of the modelling exercise are discussed in detail:

- Involved models
- Model initialization
- Forcing data for the period 1900-2050
- Model experiments
- Model Outputs

2. Objectives:

The main objective of deliverable 14.4 is to describe the details of the modelling exercise in WP14. All the details of the model runs, including the critical decision on the model initialization and the forcing data, have been discussed and a consensus solution found which was applied by all the modeling groups. This approach guarantees that the uncertainty in the model ensemble will be limited to the structural differences between models, while the uncertainty due to input drivers and model initialization will be minimized. This is an important achievement within ECLAIRE since it will give the opportunity to analyse outputs from a series of models applied with a common and consistent protocol.

3. Activities:

All the specific details of the protocol for the modelling exercise have been discussed and agreed during conference meeting and teleconferences of WP14. All modelling groups performed the planned simulations according to the protocol with the only exception of JULES that could not complete the runs S0 and S1 due to the lack of a fully coupled N module (more in Deviations).

4. Results:

4.1 Involved models

The DGVMs and DSVMs involved in the intercomparison and the responsible scientists are:

- CLM (Alessandro Cescatti; Iratxe Gonzalez-Aparicio)
- JULES (Lina Mercado/Rebecca Oliver)
- LPJ Guess (Almut Arneth)
- O-CN (Soenke Zaehle, Martina Franz)
- VSD+-Eugrow (Max Posch/Gert Jan Reinds/Wim de Vries)

4.2 Model initialization

Spin-up to equilibrium using

- 1960-1969 climate forcing (random series)
- 1901 Atmospheric CO_2 concentration
- 1901 Nitrogen deposition
- 1901 Ozone surface concentrations

4.3 Forcing data for the period 1900-2050

Climate data at hourly or daily resolution

- RCA forcing 1960-2050: data are from the original (non-bias-corrected) ECHAM5 A1B-r3 RCA3 simulation and cover the period 1960-2050.
- Bias correction is available only for daily temperature and precipitation, and it is recommended that some group test the effect of these corrections on model projections.
- To run models from 1901 onwards, climate data will be generated for the period 1901-1960 by random draws out of the climate data of 1961-1970.

• CO_2

- Atmospheric CO2 concentration 1900-2005 based on measured CO2 concentrations (air in Antarctic ice and firn for period 1900-1960; Etheridge et al., 1996 and Mount Loa for the period 1960-2005; Keeling and Whorf 2006). Predictions for the year 2050 based on the IPCC SRES A1B scenario for the period 2005-2050.

• Land-use

- Fixed cover fraction for the year 2000

• Nitrogen deposition

- Data on livestock numbers, N excretion rates and N fertilizer use are available at country data for the period 1960-2000 based on FAO (IMAGE) and for the future (2000-2050) from GAINS predictions (which are also used in the N emission estimates; see below).
- N Emissions: For the history (1900-2000), we make use of the Lamarque dataset and for the future (2000-2050), we use new GAINS emission scenarios, as improvement over RCPs. http://www.iiasa.ac.at/web/home/research/researchPrograms/Overview2.en.html
- Depositions, calculated with the EMEP model based on these emissions, will include annual and monthly N deposition data.

•Tropospheric Ozone Burden

- NOx and VOC emissions: see above for N deposition
- Ozone concentrations calculated with the EMEP model based on these emissions, include daily (needed in LPJ) and hourly (needed CLM, OCN) ozone concentration data at two heights (45m, 3m) for 2 land use types (forests and grasslands). NB this implies a 300 GB data file for hourly values.

- Grid Regular 0.5 by 0.5 degree grid with centre coordinates *.25 and *.75.

4.4 Model experiments

The four mandatory runs planned for all models are listed in Table 1, whereas Table 2 reports all the factorial runs (mandatory runs in bold). Non-mandatory runs are performed by modelling groups according to the availability of computing resources.

Table 1. Four mandatory runs foreseen for all models

Name	Climate	CO_2	N deposition	O_3
S0	1901-2050	1901-2050	1901-2050	1901-2050
S1	1901-2050	1901-2050	1901-2050	1901
S2	1901-2050	1901-2050	1901	1901-2050
S10	1901-2050	1901-2050	1901	1901

Table 2. All distinguished factorial runs (mandatory runs in bold) in the model protocol

Name	Climate	CO_2	N deposition	O_3
S0 (ref)	**1901-2050**	**1901-2050**	**1901-2050**	**1901-2050**
One driver constant				
S1	**1901-2050**	**1901-2050**	**1901-2050**	**1901**
S2	**1901-2050**	**1901-2050**	**1901**	**1901-2050**
S3	*1901-2050*	*1901*	*1901-2050*	*1901-2050*
S4	*1901*	*1901-2050*	*1901-2050*	*1901-2050*
Two drivers constant				
S5	1901	1901	1901-2050	1901-2050
S6	1901	1901-2050	1901	1901-2050
S7	1901	1901-2050	1901-2050	1901
S8	1901-2050	1901	1901	1901-2050
S9	1901-2050	1901	1901-2050	1901
S10	**1901-2050**	**1901-2050**	**1901**	**1901**
Three drivers constant				
S11	1901-2050	1901	1901	1901
S12	1901	1901-2050	1901	1901
S13	1901	1901	1901-2050	1901
S14	1901	1901	1901	1901-2050

4.4 Model outputs

The relevant model outputs are given in Table 3. Other aspects related to output are:

- Frequency: monthly (and aggregated to yearly)
- Two types of output are recommended:
  1) PFT level output (all per metre squared PFT), format: netcdf (longitude, latitude, pft, time)
  2) grid level average output (all per area weighted grid scale mean of PFTs) format: netcdf (longitude, latitude, time)

Table 3. Variable list. Variables in bold are mandatory for all groups. Unless otherwise stated, variables are per unit ground area.

Priority	Shortname	Longname	Unit
		Model Inputs	
1	atm_o3	tropospheric ozone concentration corresponding to the lowest level of the CTM atmosphere	ppb
1	surf_o3_forest	leaf surface ozone concentrations in forests	ppb
1	surf_o3_grass	leaf surface ozone concentrations in grasslands	ppb
1	surf_o3_crop	leaf surface ozone concentrations in croplands	ppb
1	POD	Phytotoxic ozone dose (POD)	mmol m^{-2}
1	nDep	nitrogen deposition, divided over NH3 and NOx	g N m-2 day-1
1	SDep	Sulphur deposition	g N m-2 day-1
		Physical variables	
1	Gs	canopy conductance	m s-1
1	**evapotrans**	**total evapotranspiration**	**g H_2O m-1 s-1**
2	sh	sensible heat flux	W m-2
2	Ts	surface temperature	K
2	fAPAR (or LAI)	Fraction of absorbed photosynthetically active radiation	[-] [m2m-2] in case of LAI
		Land Pools	
1	**cVeg**	**carbon in vegetation**	**kg C m^{-2}**
2	**cLitter**	**carbon in litter pool**	**kg C m^{-2}**
2	**cSoil**	**carbon in soil organic pools**	**kg C m^{-2}**
3	**nVeg**	**nitrogen in vegetation**	**kg N m^{-2}**
3	**nLitter**	**nitrogen in litter pool**	**kg N m^{-2}**
3	**nSoil**	**nitrogen in soil organic pools**	**kg N m^{-2}**
		Land C fluxes	
1	**Gpp**	**gross primary production**	**g C m-2 $month^{-1}$**
1	**Npp**	**net primary production**	**g C m-2 $month^{-1}$**
2	Ter	Total ecosystem respiration	g C m-2 $month^{-1}$
2	Rh	heterotrophic respiration	g C m-2 $month^{-1}$
3	fFire	CO2 emission from fire & disturbance (if used)	g C m-2 $month^{-1}$
3	fLuc	CO2 emission from land-use change (if used)	g C m-2 $month^{-1}$
1	Nbp	net biome production (positive is flux into land!)	g C m-2 $month^{-1}$
		Land N fluxes	
2	N_2Oem	N_2O emissions	g N m-2 $month^{-1}$
2	Nupt	N uptake	g N m-2 $month^{-1}$
2	nleach	N losses due to leaching	g N m-2 $month^{-1}$
2	Nvol	N losses due to volatilisation	g N m-2 $month^{-1}$

Priority	Shortname	Longname	Unit
		Land O_3 flux	
1	**fo3veg**	**stomatal ozone flux**	**nmol m^{-2} $month^{-1}$**
1	fo3surf	total surface ozone flux	nmol m^{-2} $month^{-1}$

5. Milestones achieved:

Milestone	Milestone Title	Month
MS62	ÉCLAIRE modelling platform linking DGVMs, DSVMs, climate and air pollution fields operational	24
MS63	Database with ensemble runs of DGVM on common climate and air pollution scenarios released, improved understanding of where models provide robust projections and where largest uncertainties lie.	36

MS62: The upgraded DGVMs, i.e. LPJ-Guess, JULES, CLM and O-CN and VSD+-EUgrow have been linked to relevant climate scenario data, that have become available both and with scenarios for N deposition and O3 exposure derived by the EMEP model (see WP6).

MS63*:* The database of DGVMs outputs related to the modelling experiments in WP14 is completed. The four mandatory scenarios (S1-S4) are now available in a common file format (monthly data, netcdf files) to perform ensemble statistics of the combined impacts of air pollutants on the C budget of terrestrial ecosystems and to assess the structural model uncertainty.

6. Deviations and reasons:

Delay in D14.4

Deliverable 14.4 was completed with a delay of about six months. The main reason was a delay in the further development of the models including the combined interaction of both N and ozone deposition that appeared to be more demanding than originally foreseen.

JULES development

The JULES modeling group used an improved stomatal conductance model and respective parameterization derived from observations from Europe. At present the group has been unable to run simulations with a fully coupled N cycle. This is because the soil N model (ECOSSE) and the vegetation N model (FUN) have led to conceptual issues when coupling the models into JULES, e.g. FUN has an annual time step and calculates N retranslation and its cost on an annual basis, whereas JULES works on a sub-diurnal time resolution; this is particularly difficult to solve for temperate deciduous vegetation with distinct periods of leaf-on and -off. Coupling these models and then testing and evaluating has taken a lot more time and people's resource than initially planned, especially as this N -cycle development was not funded through ECLAIRE.

7. Publications:

None

8. Meetings:

ECLAIRE plenary meetings.

9. List of Documents/Annexes:

None.