Project Number 282910

ÉCLAIRE

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

Seventh Framework Programme

Theme: Environment

D14.5 Dataset of model runs to assess the impact of combined air pollution and climate change scenarios

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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 Component 4, 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 14.5 is to illustrate the ensemble dataset of model runs performed in WP14 and describe the structure of the data archive. As examples, some of the results obtained by the CLM model are reported. A full analysis of the multi-model dataset and the ensemble statistics will be summarized in Deliverable 14.8.

2. Objectives:

The main objective of deliverable 14.5 is to describe the ensemble dataset derived from the modelling exercise in WP14 in the temporal and spatial domains. The outputs of one land surface model, i.e. CLM is presented as an example to illustrate the results.

3. Activities:

Modelling groups involved in WP 14 have been running upgraded versions of DGVMs and DSVMs with the forcing data (climate, air quality and depositions) made available by other groups of the ECLAIRE consortium. This includes the models CLM, OCN, JULES, LPJ-Guess and VSD+-EUgrow. Model outputs have been stored in a common, self-documenting portable format (NetCDF) and will be further analysed to derive ensemble statistics of the combined effect of environmental drivers (climate, CO_2, O_3, N deposition) on plant productivity.

4. Results:

Input data

DGVMs and DSVMs have been driven with external forcing generated by different groups within the ECLAIRE consortium. All environmental drivers are consistent with the IPCC SRES A1B scenario. In particular, the meteorological forcing was generated with the RCA3 regional climate model (RCM) forced by the ECHAM5 global climate model. As chemical drivers, the series of atmospheric CO_2 concentrations is based on measurements for the period 1900 to 2005 and on CO_2 predictions (A1B scenario) for 2005-2050. The hourly O_3 concentrations at 45 m height and monthly nitrogen depositions have been obtained using the European Monitoring and Evaluation Programme (EMEP) model. As an example, the EMEP simulated O_3 concentration and N depositions used in the model simulations are presented in Figure 1 with maps for 4 different time intervals and time series for the whole temporal domain.

As an example of the data contained in the ensemble dataset Figure 2 reports the time series of the gross primary productivity (GPP) as predicted by the CLM model under different scenarios of exposure to transient N deposition and O_3 concentration. Similar data are available from the different models and will be analysed thoroughly in deliverable 14.7.

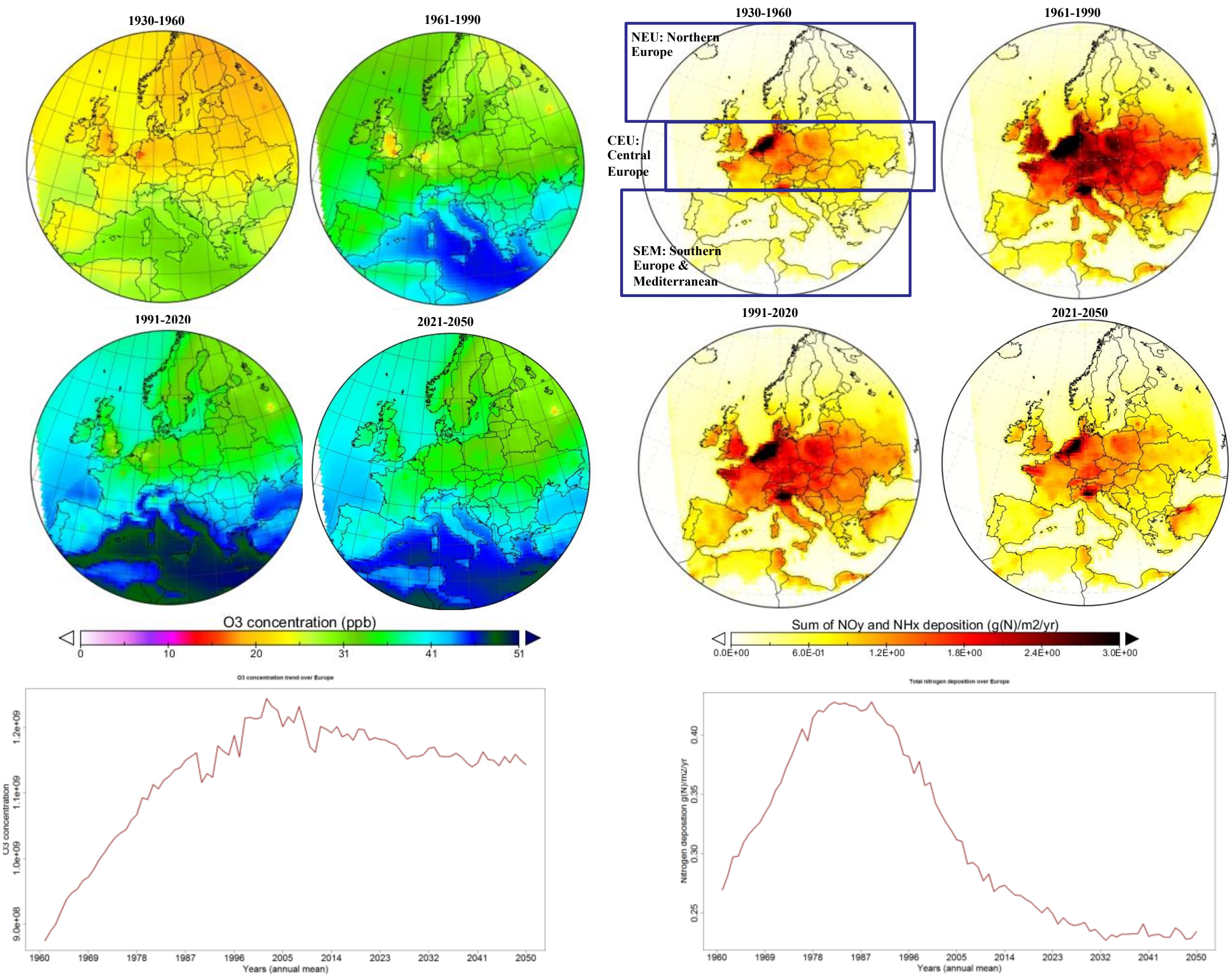

Figure 1: Maps and time series of the N deposition and O3 concentration fields produced with the EMEP model and used as drivers of the land models.

Figure 3 shows the magnitude of the stimulating effect of N depositions in all European sub-domains (difference between red and blue bars) and in particular in Central Europe. In parallel, ozone depresses growth (difference between green and blue bar) more markedly in Central and Southern Europe. The net combined effect of N, ozone and climate varies in the different sub-domains, with apparently strong negative interactions between pollutants in both northern and Southern Europe.

Model outputs for the different variables are available on a regular 0.5° grid over the European domain with a yearly resolution. Figure 4 reports an example of these maps for GPP in two different temporal intervals: near future (1991-2020) and far future (2021-2050).

Data fields shown in Figures 2-4 for GPP are available for all the variables listed in Table 1 over the European domain for the period 1960-2050. A systematic inter-comparison of models outputs will be reported in deliverable 14.8.

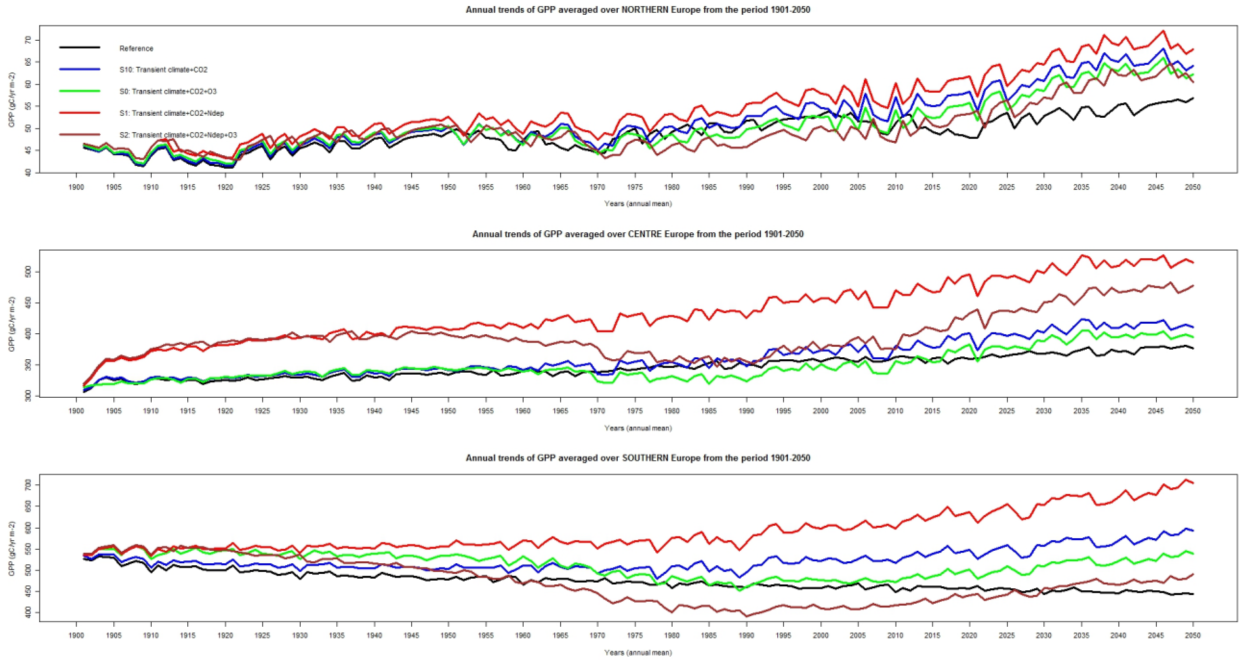

Figure 2: Time series of the gross primary productivity (GPP) under different scenario of N deposition and O_3 concentration as predicted by the model CLM.

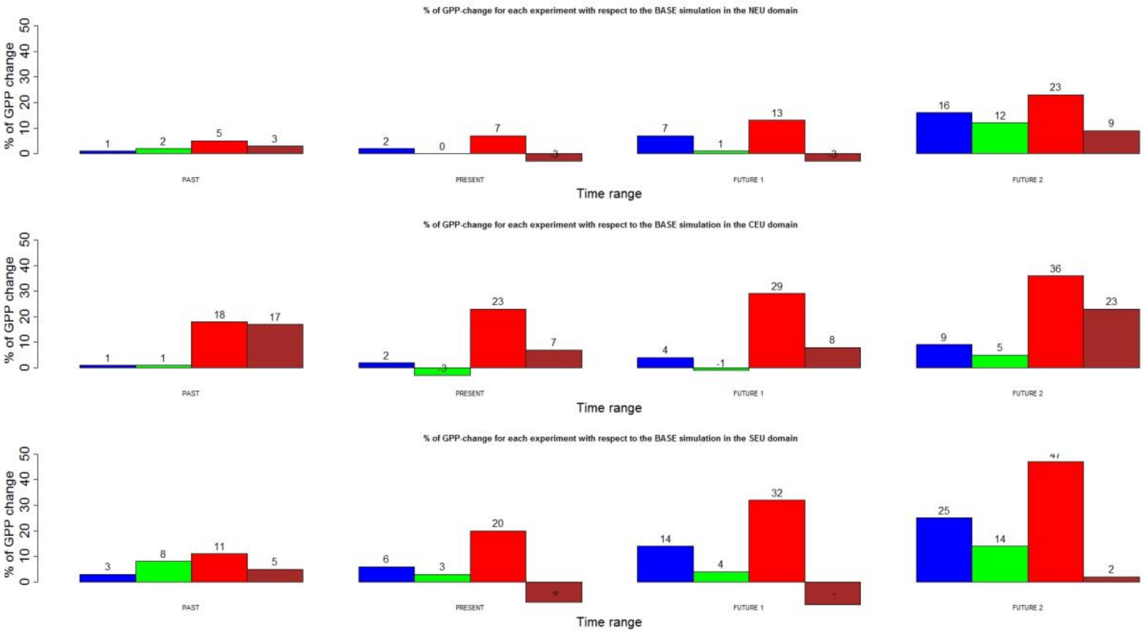

Figure 3: Predicted relative changes in GPP compared to 1900 for the past (1930-1960), present (1961-1990), near future (1991-2020) and far future (2021-2050) for model runs with a changing climate in which both N and O_3 are fixed (S10), N is fixed and O_3 is transient (S0), O_3 is fixed and N is transient (S1) and both N and O_3 are transient.

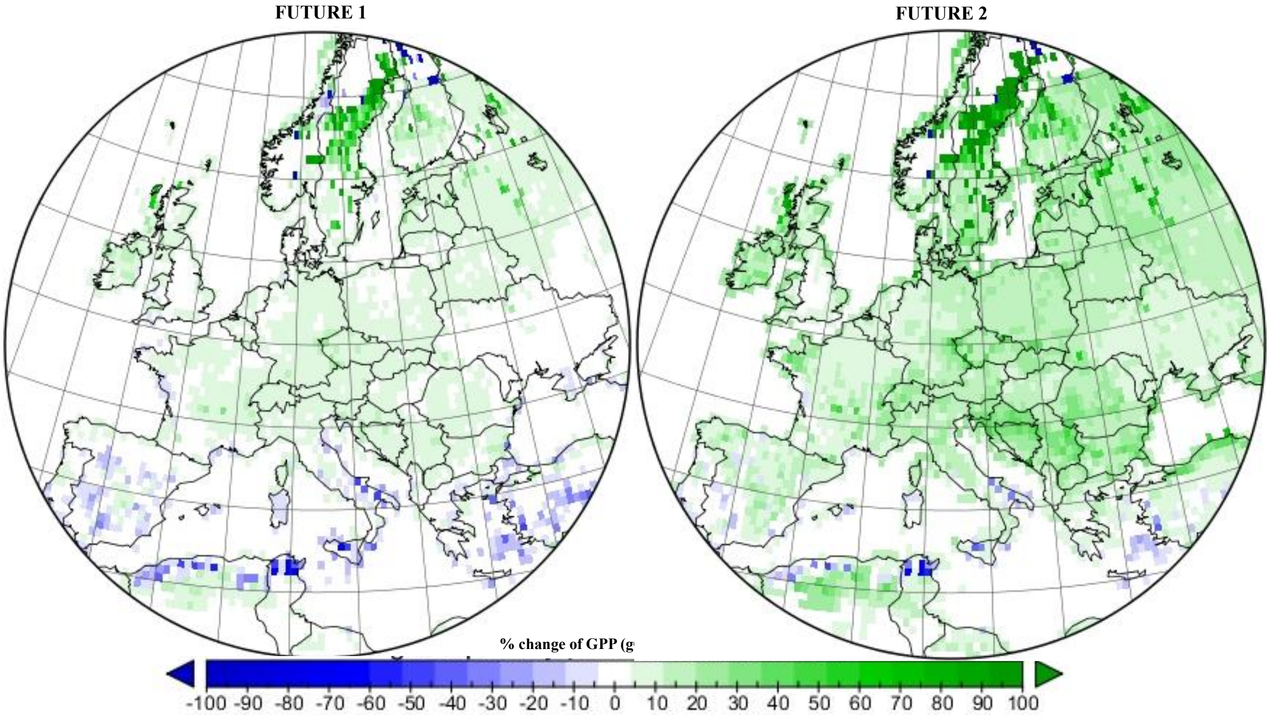

Figure 4: Maps of relative changes in GPP as predicted by CLM for the near future (1991-2020) and far future (2021-2050) for model runs with a changing climate CO_2 and O_3.

Table 1: List of variables stored in the ECLAIRE WP14 modelling dataset.

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

Priority	Shortname	Longname	Unit
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}
		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 O_3 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:

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.