Project Number 282910

ÉCLAIRE

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

Seventh Framework Programme

Theme: Environment

D21.2. ÉCLAIRE scenario reference

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Organisation name of lead contractor for this deliverable :
IIASA

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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)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Executive Summary

In order to guide ÉCLAIRE project participants on the selection of appropriate and, as much as possible, harmonized scenario data, a web page has been established operating within the ÉCLAIRE web site (http://www.eclaire-fp7.eu/scenario). This site hosts meta-information on scenarios considered most suitable for ÉCLAIRE, and detailed instructions on how to obtain the full information.

Access to these "recommended" scenario datasets is provided for anthropogenic emissions, meteorology, and for land use, respectively. Downscaling from global models will allow to arrive at a spatial resolution of at least 0.5°x0.5° for Europe. Results are available in time intervals of at least five years until 2050 and provide also information beyond – ideally data also for 2100 will be created for all datasets.

The ÉCLAIRE scenario team intends to trace further scientific developments throughout the project duration and provide ÉCLAIRE participants with up-to-date information on how to access scenario data. We will even provide the respective access protocol. Thus the document is meant to be continuously updated and in the original living as a web page. The current paper version just represents a link to that document.

Considering the data flows in ÉCLAIRE, recommendations at a certain time will be "frozen" – while further progress in science still will be documented on the web page such improvement will not anymore be regarded fit for ÉCLAIRE, as it would harm the potential for harmonized results. Ideally, all final scenario-based results of ÉCLAIRE would be derived from the identical set of "recommended" scenarios.

2. Objectives:

The purpose of this report is twofold: (i) it serves to inform ECLAIRE participants on the available meteorological, land-use and emission scenarios recommended for use within the project. While ideally a fully consistent project design would be based on the identical underlying assumptions, due to project duration and developments on other scientific endeavours some deviations to that concept were required. Thus this report (ii) allows to trace, to our understanding, what level of scenario data has been used in which parts of the project.

3. Activities:

The major tasks compiled in this deliverable consisted of opening up access to scenario information to ECLAIRE modellers, and to communicate consistent sets of data to them for further use. This was done at the occasion of several workshops, most of which were held in conjunction with the General Assemblies of ECLAIRE.

4. Results:

Climate-related projections have been constructed in support of the IPCC assessment reports, specifically AR5 published in 2013/14.

5. Milestones achieved:

MS99: Information exchange between internal users and scenario team established

6. Deviations and reasons:

No deviations, except for a moderate delay in compiling the final compilation. With the web interface in place, availability of updated information was safeguarded throughout the project

7. Publications:

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8. Meetings:

- Scenario workshop, ECLAIRE kickoff meeting, Brescia, Oct 26, 2011
- ECLAIRE modelling-protocol development Meeting, Laxenburg, AT, March 22-23, 2012
- Workshop on Global Nitrogen Scenarios in the 21st Century", Laxenburg, AT, October 11-12, 2012
- Scenario workshop, ECLAIRE 2nd GA, Edinburgh, Oct 18, 2012
- "Scenarios" plenary presentation, ECLAIRE 3rd GA, Zagreb, Oct 22, 2013
- Scenario utilization in GAINS (session CC2b), ECLAIRE 4th GA, Budapest, Sept 30, 2014

9. List of Documents/Annexes:

- ECLAIRE scenario web page
  [accessible at http://www.eclaire-fp7.eu/scenario after login as a user to the ÉCLAIRE homepage]
- ECLAIRE scenario documentation
  [attached]

ECLAIRE Scenario documentation

1. Introduction

The task "Scenarios" in the ECLAIRE project served to guide ECLAIRE researchers into working on a largely harmonized dataset on future data, in order to reduce result discrepancies to model differences and maximize data coherence. Instead of developing own sets of ECLAIRE scenarios, which would have consumed resources as well as time and hampered comparability of results achieved in other projects, we attempted to provide harmonization of approaches taken by guiding the respective ECLAIRE modelling teams towards recommended data sets. Such guidance included updates throughout the project duration, aiming for data consistency throughout.

The ECLAIRE geographic focus on Europe and temporal coverage of the time period to 2050 and possibly beyond provides an outline of requirements. Consistency with international research activities (other projects funded under FP7, science activities supporting the work of IPCC) and with scientific support to the European Commission also was strived for. Most importantly, all recommended scenarios needed to be accessible to the respective modelling teams, which was safeguarded by providing web-links or direct data access.

In defining the scenarios, also information on spatial resolution (0.5°x0.5° is like a standard provided for IPCC modelling work – but GAINS data mostly focusses on countries) and temporal resolution (often annual, but sometimes this is the consequence of interpolation: GAINS uses 5-year increments) is provided. Standard products may not come up to the requirements of specific models, in which case model developers needed to perform final adaptation steps.

Available scenarios are subdivided into "meteorology", "emissions" and "land cover/use". The respective sections provide information on (potentially different) datasets throughout the project duration, trying to capture in which parts of the project data has been used, and inform on upcoming improvements that may be relevant beyond the end of the project. Even between these divisions, we strived for compatibility of the background data between the respective scenarios.

Each of the sections provides information (if applicable) on one or several scenario sets regarding

- name of the dataset discussed
- reference to scientific literature describing the dataset
- a web link (or other pointer to obtain data) to the respective dataset including a detailed description of the conditions and procedures to access data in the format that seems most appropriate to ECLAIRE use.
- an evaluation of the dataset limitations, and of the additional steps that may be needed to transfer data into a form adequate for ECLAIRE (if applicable)
- ECLAIRE modelling activities that actually have taken advantage of a given dataset

As ECLAIRE intends to cover climate change impacts, it seemed logical to look into offers available from the climate community and start out on products prepared under the IPCC umbrella.

2. Emission Scenarios

Representative Concentration Pathways (RCP) scenarios

Aimed at providing information to estimate greenhouse gas concentration to global circulation models, the RCP effort (van Vuuren et al., 2010a) see http://www.iiasa.ac.at/web-

apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome) has been devised to assess emissions globally till 2100. An unmitigated and several mitigation pathways are being investigated. While the focus is on CO_2 (half degree grid), information is provided for other greenhouse gases (CH_4, N_2O) and ozone precursors (NO_x, NMVOC, CO) as well as SO_2 and radiatively active PM (BC vs. OC). With a focus on climate effects, the depth of analysis for nitrogen compounds does not correspond to the needs for ECLAIRE. Moreover, as outlined in the "parallel process" devised for IPCC AR-5, the RCP's describe a certain atmospheric radiation behavior but are currently lacking of underlying storylines – i.e. any technical or behavioral mitigation efforts cannot be described (Moss et al., 2010).

Nevertheless, as this is currently the only existing consistent scenario for oxidized sulfur and nitrogen compounds extending to 2100, it constitutes an important input to WP5. Moreover, some deposition maps for that date based on RCP emissions (trends 2050 to 2100 only) have been produced under ECLAIRE (D20.7). Shortcomings regarding overly optimistic technological developments have been noted in that exercise.

ECLIPSE V4 scenario

Based on global energy scenarios (World Energy Outlook till 2035, POLES model thereafter) and FAO agricultural projections (Alexandratos and Bruinsma, 2012), a new GAINS scenario has been developed which projects emissions for all GAINS regions globally until 2050 (Klimont et al., 2012). For Europe, more detailed data from PRIMES and CAPRI, respectively, have been included. Using the new gridding algorithm of GAINS, emission data have been made available as global emission fields (0.5°x0.5°) in NetCDF format. The data set includes four years (2005, 2010, 2030 and 2050) for nine substances and a sector split following RCP. The same scenario has been prepared for use across a range of related EU projects (PEGASOS, ECLIPSE) thus allowing for comparability of results.

The underlying GAINS data (on a country resolution level, in 5-year time interval, allowing to choose from different sectoral attributions like the SNAP code or the NFR code) are accessible using the regular GAINS interface under the name "ECLIPSE_V4a_CLE_base" (internal ID: CP_WEO11_S10P50_v2). Access requires registration with the GAINS model.

Emission data from this scenario, which includes no further emission abatement beyond currently adopted legal requirements ("current legislation"), have been forwarded to EMEP for use in the EMEP model. Model results (including deposition numbers based on this scenario) have been provided to the vegetation models, the DGVMs and DSVMs developed in ECLAIRE WP6 and intercompared in WP14. Results from these activities thus derive from the scenario described here, which was available early in the project. Also, NH_3 projections from this scenario were provided to Task 6.3 (WP6).

ECLIPSE V5 scenario

Further developments in the GAINS model, which were i.a. based on consultations with countries during the TSAP process (Amann et al., 2014; 2015), lead to the implementation of revised parameters for abatement strategies and costs. While differences for a "current legislation" scenario are not important, abatement scenarios rely on these updates. Final assessments of the FP7 projects PEGASOS and ECLIPSE rely on these data (or on the V5a scenarios which cover further developments outside of Europe). The scenario is named "V5_ECLAIRE_CLE" and "V5_ECLAIRE_MFR" (for the maximum feasible reduction scenario) and is identical to "ECLIPSE_V5_CLE" and largely compatible with measures and costs reported to the Thematic Strategy on Air Pollution scenarios (Amann et al., 2015) and thus the European policy process.

This set of scenarios has been used in all exercises that considered emission abatement (WP18, WP19 and WP20). Some extensions were needed to cover decarbonization. These have been described in more detail in ECLAIRE D20.6.

Shared Socio-economic Pathways (SSPs)

Originally planned to provide storylines and harmonization to the "parallel process" to the RCP scenarios as input to IPCC's AR5, completion of SSP's took far longer time than expected. While results now are available for greenhouse gases (Nakicenovic et al., 2014), a consistent set of air pollution emissions that considers the range of possible future storylines is still in development (Shilpa Rao, personal information).

3. Meteorological Scenarios

GCM runs based on SRES emission data

Meteorological scenarios are generally prepared by downscaling from Global Circulation Model (GCM) results. One important input for GCMs is information on concentrations of radiatively active gases – based on GHG emission inventories. As downscaled GCM results were unavailable during the first phase of ECLAIRE, a set of older GCM data was applied. IPCC's Second Report on Emission Inventories (SRES) provides a set of "families" of scenarios, of which A1 (and even more A1B) reflects a business-as-usual notion related to RCP8.5.

Extensive work has been performed on SRES GCM runs, which is also well documented (e.g. Kjellström et al., 2011 - http://onlinelibrary.wiley.com/doi/10.1111/tea.2011.63.issue-1/issuetoc). The runs based on SRES scenarios also available from different GCM's (in order to make results more robust) have been made available both to EMEP and directly to the vegetation models. Data files needed by DGVMs are potentially huge (hourly resolution for 140 years), so way to transfer was data physically via shipping of a hard disk. Some bias correction was performed (on a daily basis: temperature, precipitation, relative humidity – the latter according to Andersson-Sköld et al., 2008) to make up for the most critical issues in DGVMs.

In case hourly resolution is indeed needed, bias correction needs to be reconsidered. The following possibilities exist (but were not further explored in detail):

1) Run all models (including the Chemistry&Transport Models, CTMs) on the same non-corrected data.
2) Run all models on the same data, but employ own bias correction to certain parameters (possibly starting from the bias-corrected diurnal mean values and adding daily cycles to the temperatures). Someone has to volunteer for doing this, if bias correction should be harmonized.
3) Run the CTMs on the meteorology available without correction, but run the DGVMs on other meteorology which is bias-corrected and available on sub-daily resolution. Possibly such data exist, (available in e.g. the ENSEMBLES data-base), which will of course induce inconsistencies.

Specifically, daily meteorological data from RCA3 - ECHAM5_A1B-r3 have been made available for download daily data via the internet. Due to huge file sizes, the links that have been provided to the ECLAIRE community could not be maintained for an extended period of time. The filenames provided with the dataset indicate the respective parameters reported:

SWMEAN_xxxx.txt.gz - daily average shortwave radiation [W/m2]
TMIN_xxxx.txt.gz - daily minimum temperature [K]
TMAX_xxxx.txt.gz - daily maximum temperature [K]
TMEAN_xxxx.txt.gz daily average temperature [K]

All files had been individually compressed with gzip -9 (no tar balls!), and were extracted from the raw, non bias-corrected, meteorology from the RCA3 downscaling of the ECHAM5 A1B-r3 simulation (that the CTMs used for air quality modelling). Daily average temperature was also provided as a courtesy in order to compare with the bias-corrected values provided earlier.

The files had been organised slightly differently compared to the earlier, bias-corrected, data. Each year came in a separate file. There were no headers etc.

Each yearly file consisted of 365 or 366 rows (depending on the length of the year), each row containing the daily value in the respective grid cell of RCA3. The first row stands for 1 Jan, second row is 2 Jan, etc.

There are (85x95; nx*ny) columns in each file. The first column is lower left of the RCA3-domain, column 85 is lower right of model domain, column 7991 is top left of domain, 8075 is top right of model domain, etc. (same order of data as in the bias-corrected data).

Requests for data on subdaily resolution for: (1) near-surface temperature; (2) precipitation; (3) near-surface humidity of air; (4) shortwave radiation; (5) near-surface windspeed have been accounted for, too.

SRES A1B-based meteorological scenario data have been used not only by DGVMs and DSVMs (WP6 and 14), but included also in CTMs and in the assessment of climate-dependent biodiversity sensitivity factors (WP19 and 20, see D20.7). Even extended ECLAIRE scenarios in WP5 (see D5.2) the same SRES-based scenarios were made use of (while referring to RCP in some of the emission data).

GCM runs based on RCP emission data

Using RCP obviously is more consistent with the emission database used. Due to time delays in producing downscaled data on GCM results derived from the RCP process, that information did not make it into meteorological data disseminated during the lifetime of ECLAIRE.

4. Land Use Scenarios

Land use scenarios prepared for RCP

Land use information (fractional shares in 0.5° x 0.5° resolution) is available annually for the time period 1500-2100 according to Hurtt et al (2011). Their land use harmonization database can be accessed at http://luh.umd.edu. Just follow the “data - download” links to the respective FTP site. A detailed description is presented in the README files, e.g. (http://luh.umd.edu/~luh_data/LUHa.v1_future.v1.1/readme.txt) Note that “future” refers to data / changes after 2005, and “v1.1” is only available for IMAGE and AIM, while MESSAGE and MiniCAM can be downloaded as v1 only, for the time being.

The methodology adopted to implement the Hurtt scenarios in CLM (e.g. conversion of broad land categories to plant functional types, PFTs) is reported in the following document at page 224: http://www.cesm.ucar.edu/models/cesm1.0/clm/CLM4_Tech_Note.pdf

The Hurtt et al. database is, to our knowledge, still the most up-to-date global land use information. The extent of its use in ECLAIRE is not fully clear, as many models use embedded land use information which is not so easy to trace

Land use scenarios under CMIP6

New activities of the Coupled Model Intercomparison Project have started (Meehl et al., 2014) which will also include updated land use scenarios, again coordinated by G. Hurtt. At this time, no new results are available

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