Protocol for an ensemble model assessment of CTMs, DGVMs and DSVMs in scenario analysis in ECLAIRE

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This document is based on discussions and decisions at a meeting in February 2012 at IIASA. However, it is a life document and may change depending on simulation results and/or problems encountered.

Background and aim.

The primary objective of the European scale model exercise within Eclaire is to evaluate the impacts of various scenarios affecting climate, land cover/use and energy use, including a historical reconstruction (the period 1900-2100) on

- Biogenic and anthropogenic (industrial, agricultural and natural) N and S emissions (emission models)
- Atmospheric concentrations and deposition fluxes of nitrogen, ozone and CO_2 (Chemical transport models or CTMs)
- The exchange of greenhouse gases (specifically CO_2 but also N_2O, CH_4 and O_3) from/to terrestrial ecosystems (Response models, i.e. dynamic global vegetation models, DGVMs, and dynamic soil vegetation models, DSVMs)

This protocol is related to the ensemble model application of Eclaire models (CTMs, DGVMs and DSVMs) and includes the following aspects:

- Which models are involved in the ensemble model application and inter comparison
- What are characteristics of CTMs and DGVMs/DSVMs in terms of outputs (CTMs) and needed inputs (DGVMs/DSVMs) at which spatial and temporal extent and resolution and in what units.
- Which databases for land cover/land use are used to produce the results and how to harmonize their use. What is the geographic extent of the application.
- Which meteorological data and emission input/output data are used to produce the 20th and 21st century runs: how to assure comparable model inputs at the same spatial resolution.
- What format to produce the output files in so that they can be swapped between the CTMs and DGVMs and DSVMs.
- Which scenarios do we evaluate, for which time period do we make the comparison and what type of comparisons do we make.

A related question that will be dealt with is: Which datasets do we use for independent regional model validation.

Models involved in the ensemble application and intercomparison

The currently participating models within Eclaire (with the contact persons in brackets) are:

CTMs
Regional models (Dave Simpson is coordinator)

- EMEP (Dave Simpson)
- Eurad - Hendrik Elbern
- LOTOS - Martijn Schaap

- MATCH - Magnuz Engardt

Global models (Frank Dentener is coordinator)
- TM5 (Frank Dentener)
- LMD-INCA Orchidee (Didier Hauglustaine)

Involved in ensemble application, model intercomparison and validation
- EMEP (Dave Simpson)
- TM5 (Frank Dentener)
- LMD-INCA- Orchidee (Didier Hauglustaine)

Involved in CTM model intercomparison and validation only
- Eurad (Hendrik Elbern)
- LOTOS (Martijn Schaap/ Roy Wichink Kruit)
- MATCH (Magnuz Engardt)
- DEHM model (Camilla Geels/Carsten Skoth)

The DGVMs and DSVMs thus get results form 3 CTMs only. The DGVMs and DSVMs involved in the intercomparison are (Alessandro Cescatti is coordinator)
- CLM (Alessandro Cescatti)
- Jules (Lina Mercado)
- LPJ Guess (Almut Arneth)
- O-CN (Soenke Zaehle)
- ORCHIDEE (offline; Didier Hauglustaine.)
- VSD+-FORSPACE (Gert Jan Reinds/Koen Kramer)

Model characteristics in terms of outputs (CTMs) and needed inputs (DGVMs/ DSVMs), spatial and temporal extent and resolution and units in view of linkage

Characteristics of CTMs

Models used for ensemble applications

Model	**Outputs**	**Extent Europe**	**Spatial resolution**
EMEP	N, S, AOT40, POD	All options possible	50 x 50 km to 7 x7 km
TM5	N,S, AOT40	All options possible	0.50°x0.50° (ca. 50km x 50 km)
LMD	N,S, AOT40	All options possible	2.00° x 2.00°

Models used for intercomparisons

LOTOS	N,S, AOT40,(POD)	Defined domain	50 x 50 km to 7 x 7 km
MATCH	N,S, AOT40	All options possible	50 x 50 km to 7 x 7 km
DEHM	N,S, AOT40	Northern hemisphere/Europe	150 x 150 km/50 x 50 km

All CTMs run on a sub-daily basis (often 20 minutes) and results can be aggregated at any temporal resolution from hourly to daily and higher resolutions.

Needs of DGVMs and DSVMs from CTMs

Model	**Outputs**	**Extent**	**Spatial resolution**	**Temp**
CLM	[O3], total Ndep	Global	25x25 km	hourly
Jules	[O3], total Ndep	Global	any resolution	hourly
LPJ-G	[O3], total Ndep	Global or Europe	0.50^0 x0.50^0 (world)	daily/
			10 x10 min(Europe)	month
O-CN	[O3], wet/dry NH_x/NO_x	Global.	0.25^0 x 0.25^0	daily
VSD$^+$FS	[O3], wet/dry NH_x+NO_x	Europe	Any resolution	daily
VSD$^+$	POD, wet/dry NH_x+NO_x, SO_2	Europe	Any resolution	month

Conclusion is that

- Only EMEP delivers POD and only VSD+ needs POD.
- All other models calculate O3 exchange themselves on the basis of the hourly or daily O3 concentration data. The hourly or daily concentration data for ozone needed to assess the stomatal exchange by the DGVMs can be delivered by the CTMs
- The surface ozone concentration data from CTMs is, however, calculated using a concentration gradient that assumes a stomatal conductance which can be meaning that the ozone is being passed through the stomata twice (once in the CTMs and once in the DGVMs). David suggested that DGVMs should use a concentration from higher in the atmosphere and calculate the surface concentration on the basis of their own stomatal conductance.
- The resolution of the CTMs (mostly 50 km x 50 km) is coarser than the DGVMs, that can mostly run at any resolution. For DGVMs, the resolution of climate data is generally determining the spatial resolution plus the computing time, In general a resolution near 20km x 20 km seems the maximum for most DGVMs in view of computing time.

The following agreements are made

Spatial resolution
The suggested spatial resolution is 50 km x 50 km in line with the climate data used. The regional climate data from EMEP are running for the same 50 km x 50 km resolution grid cells as those climate data, but there is possibly a need for remapping from 0.5 x 0.5 degrees or 1 x 1 degrees for other models

Temporal extent and resolution
The period will be 1960-2050 and hourly resolution, but it may be extended in past and future

Harmonization of used databases to assure comparable model inputs

There is a need for harmonization of databases with respect to:

- Land cover/land use to produce the results and how to harmonize their use.
- Meteorological data and emission input/output data for the simulation period

Attached excel files give a specification of databases used in CTMs , DGVMs and DSVMs with respect to

- CTMs wrt Land Cover, Climate/meteo and Emissions
- DGVMS and DSVMs wrt Land Cover, Climate/meteo, air quality/deposition and soil

Which scenarios do we evaluate and for which time period

The results will be compared in *a scenario analysis*, using three major scenarios, including past reconstructions, for the period 1960-2050. The number of scenarios to be evaluated is limited in view of the time involved in their evaluation by the various models and the fact that the DGVMs and DSVMs use results of the outcomes of various CTMs. In ECLAIRE, a scenario group has been formed to support harmonization and improve consistency of scenario data used in the project. Details on data and access are available at at http://www.eclaire-fp7.eu/scenario (note that the link will become available only after you login to the ECLAIRE web site). Topics and participants are

- Climate scenarios (Magnuz Engard)
- Land cover/Land use scenarios (Adrian Leip)

- Emission scenarios (Wilfried Winiwarter)
- Integration (Clare Howard)

Climate datasets and climate scenarios (responsible Magnuz Engard)
Multi-layered climate datasets are needed for CTMs, while climate data near the land surface are needed for DGVMs. For the period1960-2000 detailed multi layered (ECMWF based) data on temperature and precipitation (most likely bias corrected near the land surface: Magnuz will check), wind speed, radiation (relative humidity where we will use an approach suggested by Dave for bias correction) are available at 50 km x 50 km based on measurements for use by both CTMs and DGVMs. Future predictions are also available up to 2100 based on predictions by global circulation models (GCMs). The DGVMs only need the so-called bias corrected surface fields (lowest layer).

For the years 2012/2013, we will use an available dataset (contact person Magnuz) based on
- 1 Climate scenario A1B (or A2)
- 1 Global model: there are 3 models ECHAM, CNRM, HADCM3 but we use 1.
- Downscaling by 1 regional model

So, for climate, we use the 140 year simulation data and the idea is to have later on a consistent set of e.g. 2 climate scenarios related to the RCP work. The results will be given on a yearly basis. This approach implies consistency between meteorology and air concentrations to be used in the DGVMs.

Land cover and land use data sets and scenarios
All DGVMs use global land cover datasets (GLC2000), while the European based CTMs (e.g. LOTOS Euros) and DSVMs (VSD+) use Corine based datasets and Alterra has also a tree species specific dataset over Europe. Since the DGVMs use a limited set of plant functional types and only need the fraction of these types for a large grid cell size (suggestion is 50 x50 km since this is the spatial resolution of the climate data), most likely there is not a large difference when using CORINE or GLC . This will be checked

Land cover scenarios
We will base scenarios as described in Hurtt et al, which gives land cover changes related to the RCP calculations (paper in special issue of RCPs will be send). The data are available for the period 1500-2100 (history up to 2005 and then different scenarios for 2005-2100) on a repository and Mirco Migliavacca will send them. The past is based on the Hyde database. For the future we will now first use RCP 8.5 which is conceptually closest to A1B. The spatial resolution is 0.5 x0.5 degree up to 2005 and then 0.5 x0.5 degree or 1 degree x 1 degree after 2005.

Land use scenarios
For land use, we will focus on changes in livestock numbers, N excretion rates and N fertilizer use. A group around Wilfried (IIASA) /Adrian (JRC) and Alterra (Wim/Gert Jan) will come up with a proposal to make use of livestock predictions in GAINS from 1960 up to 2050 (country level data).

Emission scenarios
Wilfried will provide new GAINS emission scenarios, developed as an improvement over the RCPs as these emission scenarios have their focus on future climate and do not sufficiently address air pollutant facts. By May 31 the information is on the shelf for predictions from 2000-2050, based on GAINS and the dataset is disseminated to Dave to

make a spatial resolution to a grid and then those data are disseminated to the other CTM modellers. For the history, we will make use of the Lamarque dataset.

Outputs and their spatial and temporal resolution used in the inter-comparison of DGVMs and DSVMs

As a first approach, the idea is to make an intercomparison of results at a spatial resolution of 50 km x 50km and temporal resolution of one year for the period 1960-2100. A very basic suggested output is given in Table 2, including the units used. For some of these a sub-annual output period could be useful for comparison. For CO_2, it is also normally helpful to diagnose not only net fluxes but GPP and R separately (also: LAI).

Table 2. Suggested model outputs used for comparing Eclaire models. Exchange are all related to terrestrial ecosystems

Flux	Unit (per ha)	Unit (per area)
N_2O exchange	kgN_2O-N/ha/year	kton N_2O-N/year
CO_2 exchange	$kgCO_2$-C /ha/year	kton CO_2-C /year
Change in C pool	kgC/ha/year	kton C/year
- Vegetation (trees)		
- Soil		
- Total		
N budget, i.e	kgN/ha/year	kton N/year
- N uptake		
- N denitrification		
- N accumulation		
- N leaching/runoff		

Possible comparisons for each of the given model outputs:

- Graphs showing the temporal evolution for the period 1950-2100 at a yearly time scale for Europe. The graph includes the results from the various models (see Table 2 for each output) for 2-3 scenarios and different model inputs (ensemble application).
- Maps for the year 1950, 2000, 2050 and 2100 for the scenarios (4 maps per output).