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Report on the Stream Two experimental design

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Abstract:
A document describing the design of the initialisation procedures to be applied by all partners for stream 2 decadal simulations has been compiled (Deliverable D2A.1.2). The present document will consider only the centennial simulations to be performed in WP2A.2 for the historical simulations over 1860-2000, and in WP2A.3 for the scenarios over 2000-2100. Improved versions of the coupled climate models, some including new components for the carbon cycle and aerosols, have been prepared for running a new set of simulations taking into account land-use changes, as observed or computed by a recent version of IMAGE integrated assessment model. In addition to an A1B scenario, a new stabilisation scenario to 450-ppm of CO2 equivalent (called E1), has been developed in collaboration with RT7, for use in the second stream of ENSEMBLES simulations.

Introduction

A growing community of researchers, policy-makers, businesses, and the general public are interested in the potential impacts of climate change and in the possible solutions for avoiding, or at least reducing, its undesirable consequences. This is however a particularly challenging task because projections of future natural climate variability and the human impact on climate have to rely on numerical simulations from models of different complexities that are still limited and highly uncertain.
The first phase of ENSEMBLES has provided an important contribution to the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4) (ref WG1) with climate model simulations corresponding to the IPCC SRES A1B, A2 and B1 emissions scenarios (Nakicenovic and Swart, 2000). The next phase ("Stream 2") of ENSEMBLES makes use of a different experimental design, and provides the first opportunity to test simulations and analysis being proposed for a possible future (5th) IPCC assessment of climate change (see Hibbard et al, 2007). Specifically, in ENSEMBLES a new set of climate models, including some with integrated carbon cycle (CC) components, will be used to simulate two future scenarios, specified in terms of global greenhouse gas (GHG) concentration pathways. All global climate models taking part in ENSEMBLES will simulate changes in climate for these pathways. Those models with CC components will also diagnose the implied carbon emissions that are consistent with the concentration pathways, which will likely differ between the models. While this has been explored mostly with integrated assessment models (IAMs), this will be the first multi-model intercomparison of implied emissions using complex GCMs including CC components. Two pathways are considered: a baseline without climate mitigation policy (SRES A1B), and an aggressive mitigation pathway which aims eventually to stabilise the additional anthropogenic radiative forcing to that equivalent to a carbon dioxide concentration (CO_2e) at around 450 ppm during the 22^{nd} Century (Figure 1). This second scenario was designed for attempting to match the European Union

target of keeping global anthropogenic warming below 2°C above pre-industrial levels.

This second phase of ENSEMBLES will provide a small but important step towards bridging the gaps between integrated assessment modelling (IAM), scenario development, global climate modelling efforts and impacts assessment. A summarized presentation of the Stream 2 methodology has recently been submitted for publication (Lowe et al., 2008). The present report aims at providing more detailed information by outlining the details of our scenario choices, experimental design and the opportunities for exploiting the simulations. Finally, we highlight similarities and differences between the ENSEMBLES simulations and the current IPCC proposals for a 5th assessment.

Choice of the scenarios

Objectives

The stated objectives of the second phase in RT2A are to use Earth system models of different complexity, to reproduce the evolution of the Earth system during the last 100 years, and for the next 100 years. It was decided that the new simulations will explore the impact of land-surface changes, which can be important particularly on regional climates. Since experiments initialised in the early 20th century are needed to avoid the “cold start problem” it was recommended to perform long control simulations with fixed preindustrial conditions (1860 conditions) to provide well balanced initial conditions for the coupled atmosphere-ocean models. For the simulations over the historical period, it has been agreed to perform a core simulation keeping essentially the same anthropogenic forcings (greenhouse gases, sulphate aerosols) as in stream 1, with the addition of the land use maps for crops and pasture fraction, without the natural forcings (solar and volcanic). A second, optional but strongly recommended, simulation should include in addition the same solar and volcanic forcings as specified in stream 1. This second simulation is intended for allowing a better comparison with observed changes for validation purposes. The dataset for the land use has been produced by Nathalie de Noblet over the period 1740-1992 for the Lucid project, based on crop dataset of Ramankutty and Foley (1999), and pasture from the HYDE dataset (Goldewijk, 2001) combined to give a fraction of grid-cell covered by crop and pasture on a 0.5x0.5° global grid for each year. The recommended methodology was that each model keeps its vegetation map as used in stream 1 simulations, and change only the crop and pasture fraction as provided in this dataset.

In the second stream, a coordinated effort towards a new quality of simulations is planned. To this purpose, all models have been improved compared to the stream 1 simulations that contributed to IPCC AR4 (inclusion or improvement of aerosol treatment, inclusion of carbon cycle models, inclusion of variable vegetation cover etc., cf. table 2). A multi-model ensemble of simulations with developed Earth System Models of different complexity will be performed using as input the atmospheric concentrations of chemical compounds and land-use changes produced by current integrated impact assessment models (scenarios). Since most models have now reached a level of complexity prohibiting a multitude of runs, a central scenario was agreed to be the common target in order to restrict the number of simulations. Priority was given to the estimates of future developments produced by the A1B SRES scenario of the IPCC, and on a new stabilization scenario, of particular interest to the EU, which was developed in collaboration with RT7.

Future plans for the AR5 are currently being established, and new emission scenarios are discussed by the IPCC Task Group on New Emissions and at the IPCC Expert Meeting on New Scenarios. Among them the proposal of a type of experiment in which the carbon cycle responds to increasing CO2 was recommended by Hadley Centre as it would be perfectly relevant for Stream 2. This consists in imposing the CO2 concentrations to the coupled system and storing the carbon fluxes from the carbon model for validation of the carbon models, and for deriving mitigation policies aimed at achieving the desired emissions. This methodology would be very appropriate to Stream 2 as it would allow the RT2A models with and without a carbon cycle to use exactly the same concentration scenarios. In this way we could use for simulation A1B the same concentrations of CO2 and other GHG gases as used in stream 1, which would be very useful for comparisons with the former simulations. In addition the use of this AR5 methodology would lead the way in demonstrating the utility of this approach with GCMs in a major study, and this could feed this back into AR5 discussions.

The IPCC-SRES scenarios (Nakicenovic and Swart, 2000), which have been extensively used for climate and impact modelling, explore different possible pathways for GHG emissions. Since these do not explicitly include a climate mitigation policy, differences in the scenarios are resulting mainly from varying degrees of globalization, the role of environmental and social policy, economic and population growth and the rate of technology development. Within the SRES set, the A1B scenario forms a medium-high emission scenario driven by high economic growth, strong globalization and rapid technology development. The scenario also assumes material-intensive lifestyle so energy consumption grows rapidly, despite population growth being relatively low (the population peaks around 9 billion in 2050 and declines to around 7 billion in 2100). The A1B scenario has been chosen as the baseline scenario for the ENSEMBLES stream 2 simulations because the strong increase in emissions is consistent with real emissions growth (van Vuuren and O'Neill, 2006), and in order provide overlap with earlier climate modelling work. The use of A1B as the central scenario for simulations with regional models in research themes RT2B and RT3 was also an additional motivation for this choice.

To demonstrate the effect of significant mitigation actions, an emission reduction scenario (E1) will be run from all partners, based on the SRES A1B scenario. It was agreed to aim for a CO_2 stabilisation at 450 ppm. Stabilisation scenarios at higher targets will not be part of ENSEMBLES second stream, since it is agreed to rather use possibly available computing capacities for initial conditions ensembles in particular for the E1 scenario to increase the signal-to-noise ratio for this scenario.

In our analysis, the A1B baseline is thus contrasted with a corresponding aggressive mitigation scenario, designed in order to give a reasonable probability of meeting the EU target of avoiding more than 2 deg C of global average surface warming relative to pre industrial levels. Meinshausen et al. (2006) estimated that stabilisation of GHG concentrations at 450 ppm CO_2-eq would provide a 20 to 75 % probability of stabilising temperatures below a 2^oC target. Whilst many observers would prefer to approach such a concentration stabilisation level from below, socio-economic inertia might make this impossible. Therefore, starting from the A1B baseline, we have constructed a (so-called) peaking scenario which initially peaks at around 530 ppm CO2-eq and then decreases gradually to approach 450 ppm from above during the 22nd century. Den Elzen and van Vuuren (2007) recently showed, on the basis of cost considerations, that peaking scenarios may in fact be preferable to stabilisation scenarios for reaching long-term temperature targets.

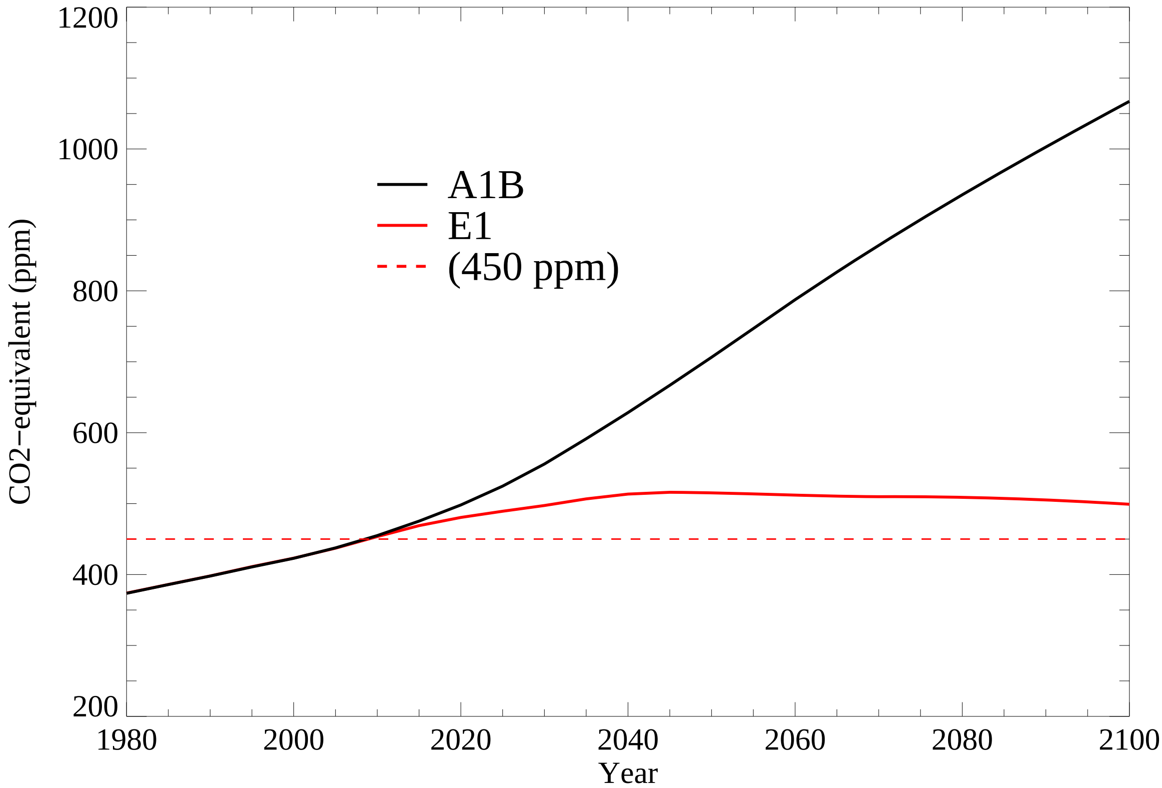

Figure 1: CO_2–equivalent concentrations for 1980 to 2100 for the ENSEMBLES stream two core experiments - consisting of A1B (black), and the updated E1 scenario (red) which overshoots beyond its long term 450 ppm target level. Note: A1B values differs slightly from the A1B-IPCC marker used in stream one; the A1B-IPCC marker will actually be used.

The new scenarios have been implemented at Netherlands Environmental Assessment Agency (MNP) by Detlef van Vuuren (Detlef.van.Vuuren@mnp.nl) and Elke Stehfest (Elke.Stehfest@mnp.nl) into the latest version of the IMAGE model, in which improvements have been made in the land use representation of the A1B scenario. The IMAGE 2.4 model was used to develop the 450 ppm stabilisation scenario from the A1B baseline, following a methodology used earlier to develop low stabilisation scenarios from B2 baseline (van Vuuren et al., 2007). This new scenario will be referred to as E1. IMAGE 2.4 is a complex Integrated Assessment Model with a detailed description of the energy system, land use and the carbon cycle. The latter are modelled at 0.5 x 0.5 degree. Abatement options that contribute to emission reduction include several reduction measures in the energy system, reduction of non-CO_2 gas emissions and carbon plantations. This latest version of IMAGE has an updated estimate of carbon fertilisation in natural ecosystems, and reforestation has been added as a means to reduce emissions in order to meet the target of 450-ppm of CO2-equivalent. This includes an increase in agricultural productivity, leading to a slow down in deforestation rates and allowing for more bio-energy production. Due to relatively low mitigation costs for non-CO_2 emissions from land use (including landfills and sewage), emissions from this sector are strongly reduced after 2010, and most of the maximum reduction potential is already reached in 2050, with most important reductions coming from animals, wetland rice, landfills and sewage (CH_4) and animal waste and fertilizer (N_2O). The increased agricultural productivity results in reduction in GHG concentration of 24 ppm CO_2 equivalents. The resulting concentration scenario for E1 is shown alongside the A1B baseline in Figure 1. One small inconsistency is that the E1 scenario was developed from an updated A1B rather than the original marker scenario. A notable difference is the sulphate aerosol emissions, which are substantially lower in the updated A1B case and are now considered more realistic.

A full description of the various components of IMAGE 2.4 is given in the MNP report by Bouwman et al (2006). Additional details on the IMAGE 2.4 model can be found on the MNP website: http://www.mnp.nl/image

As agreed upon, the global emissions and concentrations have been harmonized to 2000 values as they are available. For concentrations, the data that was provided on the RT2A site have been used. For emissions, all emissions have been harmonized to the mean of available inventories for 2000 emissions. A document indicates the values used in emission harmonisation (harmonization.doc). The numbers differ somewhat from SRES (that estimated in 1998 what 2000 emissions would be). Emission and concentration values were set to indicated values for 2000 using individual scaling factors. These scaling factors were assumed to linearly converge to 1 in 2100.
The results of the two new IMAGE simulations for global emissions and concentration have been provided as text files and in excel spreadsheets. The land cover maps are contained in two other zip files, with the land cover types indicated in an Excel file.
Crop fraction maps are also given for 19 crop types: A1B-450, A1B-baseline, crop types. Gridded emissions on a 0.5° x 0.5° grid for GHG and air pollutants have also been provided.

Additional modelling

Ozone concentrations

Ozone data have been computed at UiO (Björg Rognerud) from the Oslo-CTM2 model (Sovde et al, 2008) (horizontal resolution: T21, vertical resolution: L60, upper bound at 0.1 hPa) for the SRES A1B and the E1 scenarios as monthly mean global gridded 3-dimensional files for the years 1850, 1900, 1950, 1980, 2000, 2050 and 2100. Relative moisture content is assumed as constant for the simulations. The effect of future temperature change on ozone chemistry is included in the A1B scenario by using average monthly mean temperature anomalies for 2091-2100 with respect to 1991-2000, provided by the EGMAM model that has a detailed stratosphere. Bjorg Rognerud has generated with the chemistry transport model of the University of Oslo maps of ozone concentrations for the end of 21st century for the new IMAGE A1B-baseline and A1B-450 scenarios.

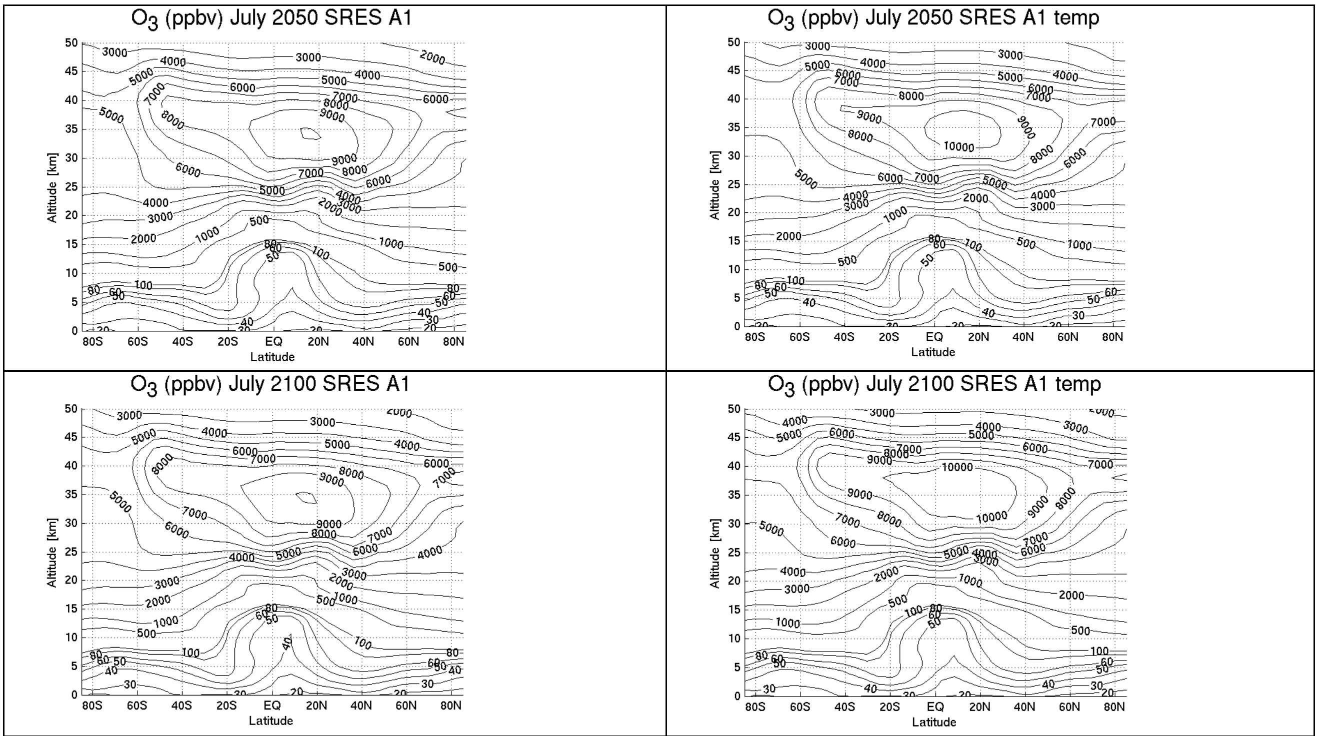

Figure 2: Calculated zonal mean ozone (ppbv) for July 2050 (upper panels) and 2100 (lower panels) forcing the model with the SRES A1 scenario. Panels to the right also include the temperature changes between 2000 and 2050 (upper panel) and 2000 and 2100 (lower panel) calculated by the EGMAM model.

The ozone fields for the stream 2 simulations for years 1850, 1900, 1950, 1980, 2000, 2050 and 2100 for scenarios A1B, are available as monthly mean NetCDF files on a server at UiO: http://folk.uio.no/bjoergr/ensembles

The resulting ozone zonal fields for July 2050 and 2100 in the A1B scenario are illustrated on figure 2. The figure shows that the correction for the temperature effect of greenhouse gas increases that leads to a cooling of the stratosphere, produces a small increase of the tropical ozone maximum.

Sulfate aerosols:

Using the gridded emissions of black carbon and precursors of sulfates from the IMAGE scenarios Olivier Boucher has used the same chemistry-transport model as used for IPCC (Boucher and Pham, 2002) to compute the 3-D sulphate aerosol concentration maps. Black carbon is not computed in IMAGE but has been scaled on sulphur emissions. 3-D sulfate (and other) aerosol concentrations for the A1B and E1 scenarios are available from the RT2A website.

The evolution of the total sulphate aerosol burden is illustrated in figure 3. Whereas in the IPCC SRES simulation the sulphate aerosol continue to increase in the first part of the 21st century to reach a peak in 2020 and decrease rapidly afterwards, the new IMAGE simulation of the A1B baseline scenario starts to decrease earlier to reach about the same levels at the end of the century. The stabilization scenario (A1B-450) produces a much more rapid decrease and return to near preindustrial levels by the end of the 21st century.

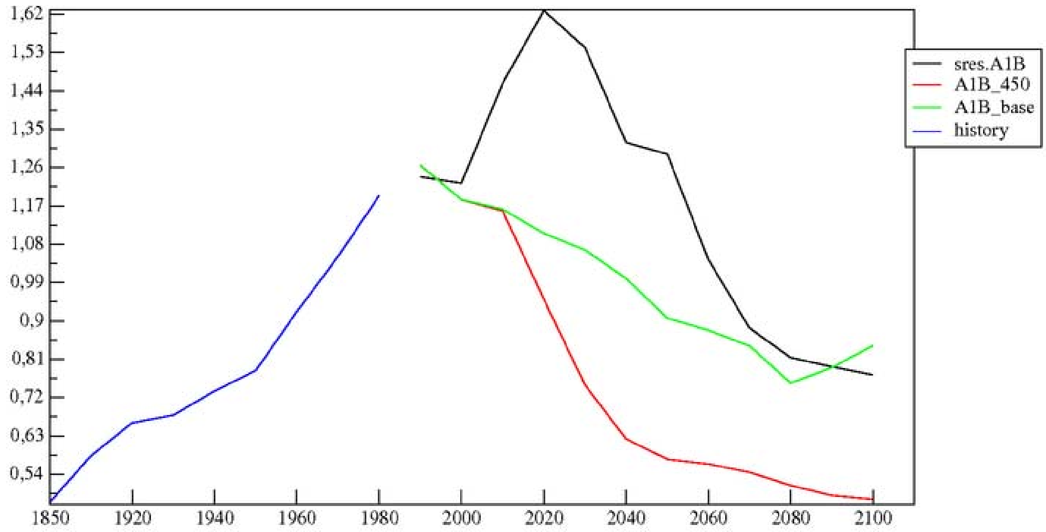

Figure 3: Time evolution of the total aerosol burden simulated by the chemistry-transport model, based on historical emissions up to 1980, and then according to IPCC SRES marker scenario (sres-A1B), and the new IMAGE scenarios for A1B baseline (A1B-base) and E1 (A1B_450).

Land use changes:

Historical reconstructions for cropland (in percentage of each grid cell yearly from 1700 to 1992, Ramankutty and Foley, 1999) and pasture from the HYDE dataset (in absence or presence, i.e. 0% or 100% per grid cell 1700 to 1990, every 50 years from 1700 till 1950, and every 20 years afterwards; Klein Goldewijk, 2001) are used by Nathalie de Noblet (IPSL/LSCE) to produce a fraction of grid-cell covered by crop and pasture on a 0.5x0.5° global grid for each year from 1700 to 1992.

To produce the future land-use maps contact was established between Detlef van Vuuren and Nathalie de Noblet in order to apply on the mitigation scenario the same adjustment method as for scenario A1B, taking into account only changes in land-use computed by the IMAGE scenario, in order to interpolate smoothly to the observed land-use maps in 1992.

Extrapolation of the data set for the future is obtained using the new A1B-450 and A1B baseline IMAGE2.4 scenarios, producing maps of absence or presence of either cropland or pasture per grid cell. The sum of crop and pasture define, per year and per grid-cell, the amount of natural vegetation cover that can exist. The methodology for the use of the crop&pasture data in the second stream simulations is that in each model the vegetation map as used in stream 1 simulations (IPCC AR4) is kept, and only changes of the crop and pasture fraction as provided in this dataset are applied, as described in the report: " Designing historical and future land-cover maps at the global scale for climate studies", by Nathalie de Noblet-Ducoudré and Jean-Yves Peterschmitt (2007). Changes in future crop and pasture extent is derived from the IMAGE 2.4 scenarios using an anomaly procedure to ensure consistency between past and future changes. Every 10 years, starting year 2000, the changes predicted by IMAGE between the specific decade under consideration and the previous one are examined. Since the IMAGE scenarios only give the presence or absence of a given vegetation type, the increase in either crop or pasture is always done at the expense of natural vegetation that disappears completely from the grid cell (i.e. crop + pasture extent = 100%). If no change is found, then the extent of crop and/or pasture of the decade is set equal to the extent of the previous decade (i.e. the one derived from the historical databases for 1990 if year 2000 is under consideration). If either crop or pasture increases, then its spatial extent is either increased to the amount needed for the sum (crop+pasture) to be equal to 1, or unchanged. Conversely, if a decrease in either crop or pasture extent is found, then its spatial extent is set to zero, and natural vegetation can occupy the part of the cell that just became vacant. If they both increase, then their extent is increased by 50% of the part of the grid-cell that was natural the previous decade.

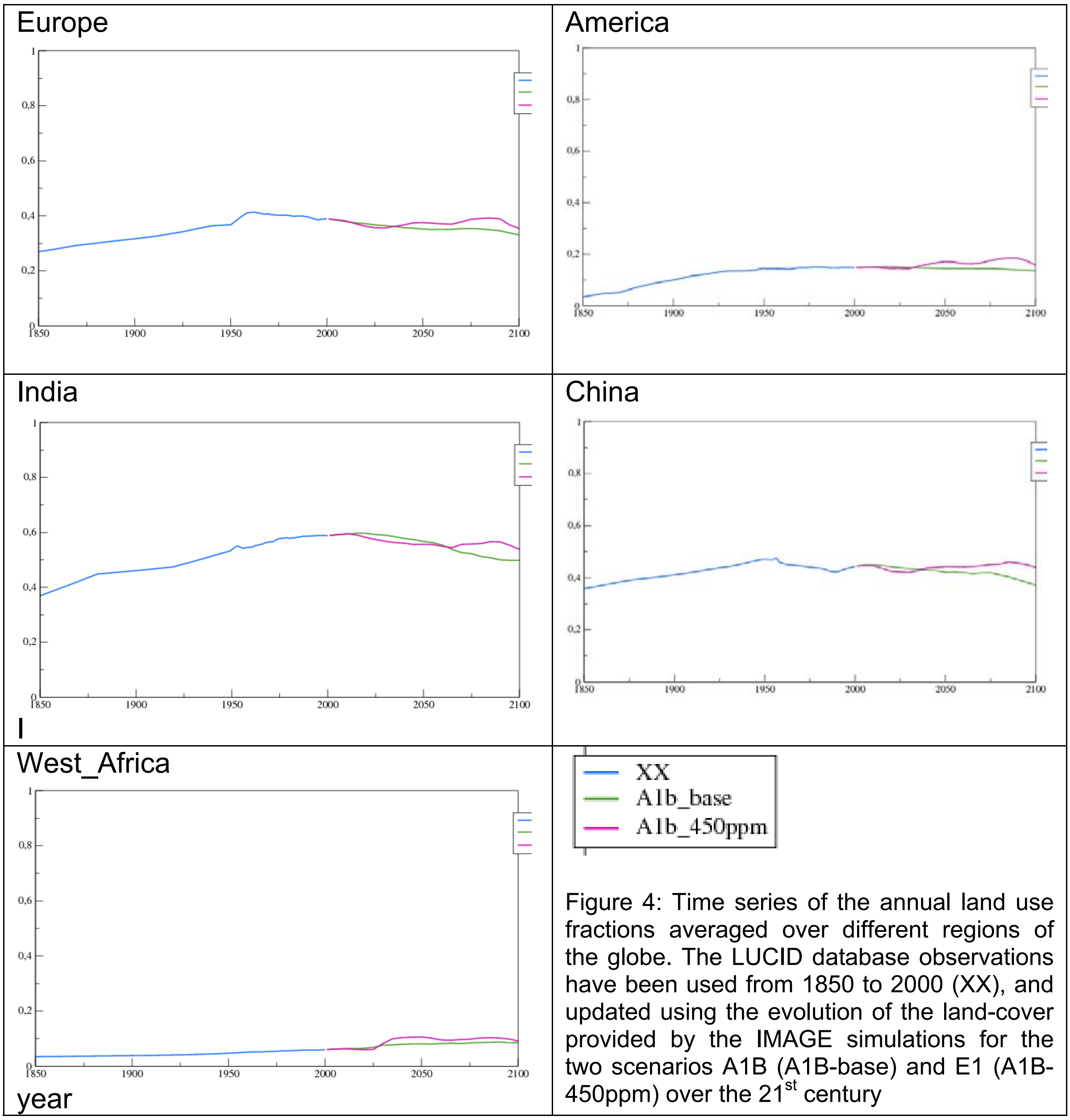

Figure 4: Time series of the annual land use fractions averaged over different regions of the globe. The LUCID database observations have been used from 1850 to 2000 (XX), and updated using the evolution of the land-cover provided by the IMAGE simulations for the two scenarios A1B (A1B-base) and E1 (A1B-450ppm) over the 21st century

The land-use maps for cropland and pasture fractions are available as NetCDF files at 0.5° resolution from Nathalie de Noblet's DODS server at LSCE: http://dods.extra.cea.fr/data/p25nath/DIVA/ForcingData/Vegetation/

An illustration of the evolution of the land-use fraction on different continents is given in figure 4. The observed historical trend toward an increase of the land use fraction over most continents, is stopped and reversed in the 21st century, except for West Africa where deforestation keeps progressing due to population increase. However in scenario E1 land-use start to increase again during the 21st century due to the needs of new agricultural land for biofuels production.

Greenhouse gas concentrations:

The greenhouse gas (GHG) and aerosol data are produced by RIVM (Detlef van Vuuren) using the IMAGE model (FAIR-SiMCaP) and are available as emission data (on a 0.5° Lat/Lon grid) and as concentrations as required for the structure proposed by Hibbard et al. (2007) for the A1B and the E1 scenario. They include the major GHG and air pollutants from energy, industry and land use (change) as vertical integrated values from 1970 to 2100 in time steps of 5 years. To maximise the consistency of the forcings used, all partners use temporal linear interpolation of the emissions which are available every five years.

The series of CO2, CH4, N2O and CFC12 from the Excel files have been interpolated at annual resolution. The radiative forcing resulting from all the halogenated species except CFC12 has been converted into the CFC11 concentration giving the same radiative forcing. This has been done from the A1450.xls and baseline.xls files by adding the radiative forcings of “chloride”, “HFC”, “PFC&SF6” and “Halon” (columns E-H in sheet "forcing"), substracting the radiative forcing of CFC12 (computed from CFC12 concentrations from column C in sheet "Conc_clor" with a radiative forcing of 0.32 W/m2/ppb, a value taken from WMO/UNEP Scientific Assessment for Ozone Depletion 2002). The resulting forcing has then be reconverted back into CFC11 equivalent concentration called CFC11* using a radiative forcing coefficient of 0.25 W/m2/ppb. The annual series are contained in ascii files :A1B-450 and A1B-IMAGE on the RT2A website. The other forcing data for running the stabilisation scenario have been made available on the RT2A website as time series of concentrations of the main greenhouse gases using the spreadsheets and format applied for stream one.

As an illustration the resulting series of GHG concentrations of the new scenarios produced by the IMAGE model and interpolated at annual resolution are displayed in figure 5 an compared with the former Stream One scenarios based on the IPCC SRES marker scenarios. It can be noticed that the concentrations in the A1B-Image scenario are slightly higher than those from the A1B SRES scenario, due to the use of a different integrated assessment model for the production of the IPCC marker scenario. The GHG concentrations resulting from the new stabilisation scenario (A1B-450 = E1) are smaller than those in the B1 scenario, except for CH4 where they are similar.

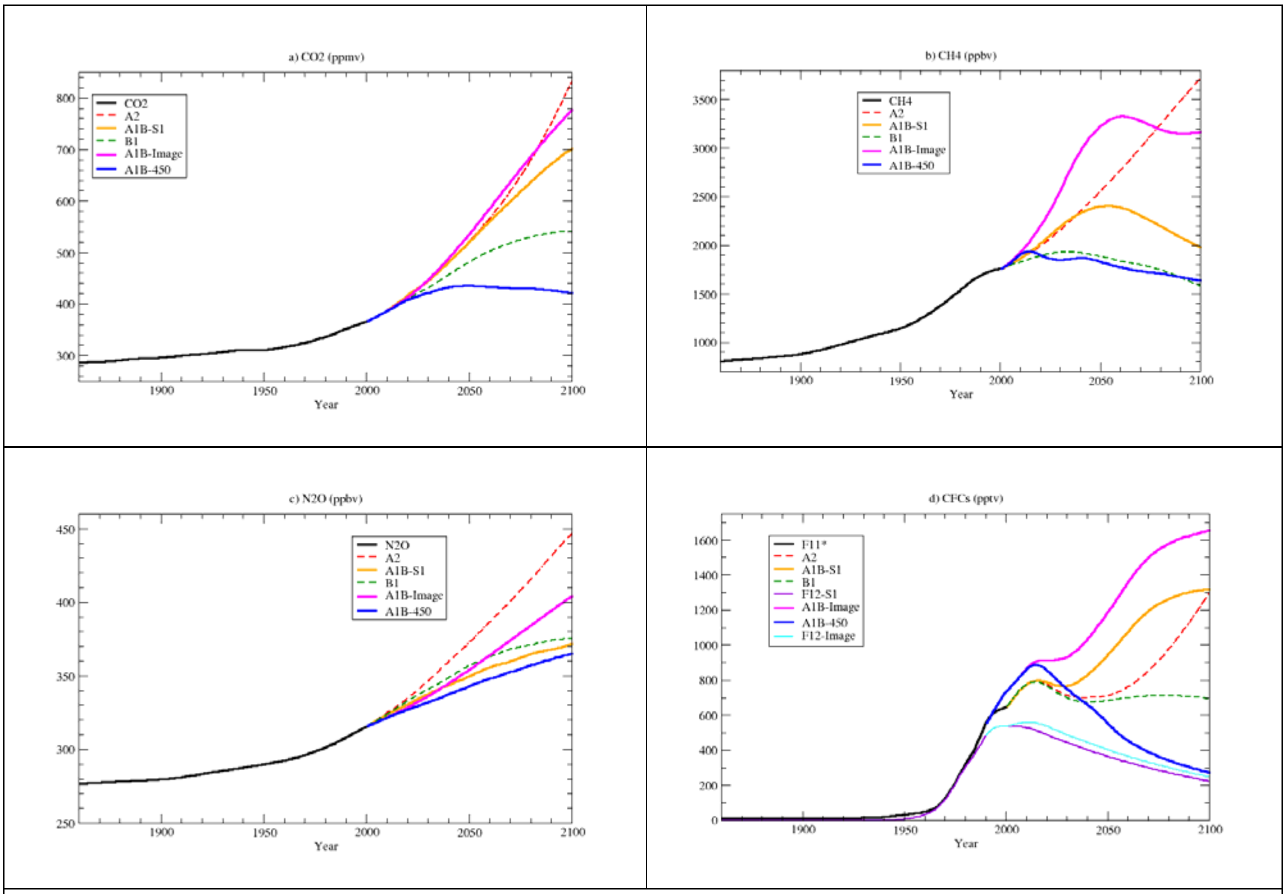

Figure 5: Evolution of the greenhouse gas concentrations for the historical period 1860-2000 and for the different scenarios: A2, A1B-S1 and B1 are the IPCC SRES marker scenarios used in Stream One, A1B-Image and A1B-450 (E1) are the new Stream 2 scenarios produced with the IMAGE model

Participating models

The stream 2 consists in a multiple GCM experiment similar to that suggested by Hibbard et al. (2007). All GCMs in the study, initialised for pre-industrial conditions (c. 1860), are simulating climate change driven up to present day with 19th and 20th Century reconstructed climate forcings and 21st century forcings extending up to at least 2100 for two core scenarios A1B and E1. In many models, land use change due to human activity is included, though this could not be done however with every model due to the technical challenge of representing it in GCMs that include CC components. Some simulations will additionally include natural (solar and volcanic) forcings as previously modelled in stream 1.

Considerable efforts have been made to implement the forcings in a similar way across the various models. The implementation is based largely on the IMAGE model outputs harmonised with reconstructed 19th/20th Century forcing datasets previously adopted in the first phase of ENSEMBLES. For ozone and aerosol concentrations (as opposed to precursor emissions) some additional off-line chemical-transport modelling work has been required to generate the forcing datasets, via the University of Oslo-CTM2 troposphere-stratosphere GCM to derive ozone, and O. Boucher's

transport model to derive the aerosol concentrations, both being driven by the necessary emissions (and climate) for given time slices, with interpolation between the time slices. The global land use/land cover change dataset (for crops and pasture) with 0.5°x0.5° resolution from 1700 to 2100 has been constructed and extrapolated for the scenarios taking into account historical reconstruction sources and the IMAGE model outputs. However, some extra model-specific processing has been required to blend this with the assumed undisturbed vegetation map, which differs between models.
In total 8 ENSEMBLES groups will use 9 models to make simulations of climate given GHG concentrations as input, which essentially mimics Figure 3 (bottom panels) of the Hibbard et al. (2007) proposal. The participating models are generally improved or extended versions of models contributing to IPCC AR4 (through improvements to core physical schemes, inclusion or improvement of aerosol, CC and variable vegetation cover components). The key features of the different models and the simulations to be performed are listed in Table 1.

Multi-model ensemble members		**Model components**			**Generic resolution**		**Planned simulations**				
								1860-2000		2000-2100	
Group	**Model name(s)**	CC	AT	LU	Atmos	Ocean	CTL	GA	GA+SV	A1B	E1
METO-HC	HadGEM2-AO		●	●	N96L38	1º L40	●	●		●	●
	HadCM3C	●	●		N48L38	1.25º L20	●			●	●
IPSL	IPSL-CM4			●	N48L19	2º L31	●		●	●	●
	IPSL-LOOP	●			N48L19	2º L31	●			●	●
MPI(+DMI)	ECHAM5-C	●		●	T31L19	3º L40	●	●	●	●	●
FUB	EGMAM+		●	●	T30L39	T42 L20	●	●	●	●	●
INGV	ECHAM5-OPA-C	●			T31L19	2° L31	●	●	?	●	●
CNRM	CNRM-CM3.3			●	T63L31	2º L31	●	●	●	●	●
DMI	CNRM-CM3.3			●	T63L31	2º L31		●			●
NERSC	BCM S1	●		●	T63L31	1.5º L35	●		●	●	●
	BCM S2			●			●	●		●	

Table 1: ENSEMBLES Stream 2 multi-model ensemble summary (CC=carbon cycle component; AT=aerosol transport/chemistry component; LU=transient land use change component) and core simulations planned (CTL=pre-industrial forcing control; GA=historical forcing by GHGs and aerosols, plus land use changes if represented; +SV=plus solar and volcanic forcing; A1B and E1=future forcing scenarios for SRES A1B baseline and ENSEMBLES low stabilisation cases). ● = model component included / simulation (or multiple simulations) planned.

The second key part of the experimental design is that the subset of models that include the CC will diagnose the net flux of carbon into the atmosphere needed to achieve the prescribed target concentration profiles. In turn, this will yield allowable carbon emissions, with an ensemble spread as the results from any given model will depend on its carbon cycle formulation plus the feedback processes that govern the regional transient climate change for a given applied climate forcing.

The groups with CC components in their models also intend to run another experiment in which increases in carbon dioxide concentration are prevented from causing climate change by their radiative effects but are still allowed to affect the carbon cycle and climate through, for instance, their role in photosynthesis. This third set of ensemble simulations characterises the strength of the carbon cycle feedback in the model ensemble (as in Freidlingstein et al. (2006) for the SRES A2 scenario

The historical simulations (20C) use starting conditions from pre-industrial equilibrium runs (representing 1860 conditions) and are subsequently forced by the 20th century anthropogenic green house gas emissions until reaching present day concentrations. The simulations are continued for the planned scenarios for the 21st century. All partners will run at least one realization of the A1B scenario and the GHG and aerosol forcings as in stream one, but with the improved model versions.

4. Conclusions and perspectives

The new ENSEMBLES experiments provide a number of exciting opportunities. For the first time we will be able to compare the link between carbon emissions and atmospheric concentrations in a set of GCMs for an aggressive mitigation scenario. As in the C4MIP study (Friedlingstein et al., 2006) we will attempt to understand the regional differences in behaviour between the models. We will also examine the relative contributions of fast climate feedbacks and carbon cycle responses to the spread in derived carbon fluxes

GCM climate modellers have, in the past, often preferred to study future scenarios with large increases in forcing in order to achieve a favourable signal-to-noise ratio. This allows the extraction of climate change signals on smaller spatial scales than would otherwise be possible and is consistent with policy maker’s requirement for climate change information on the scales in which people live and work. In the fourth IPCC assessment some modelling groups ran simulations in which forcing was stabilised at near present day levels. This was a very implausible scenario and, furthermore, regional analysis of these simulations was very limited. With the ENSEMBLES experiments we will have the challenge of examining many aspects of climate change and climate impacts for a plausible scenario with a small signal-to-noise ratio. Unless we can afford to run a large initial condition ensemble, which is currently unlikely, we will need to develop new techniques to extract the fine scale climate change information. In some instances our results might be a statement of the smallest scale at which we can detect future changes reliably without more initial ensemble members.

The choice of the low stabilization E1 scenario will make our results particularly relevant in the mitigation debate from the EU’s perspective, since we can examine the modelled probability of exceeding a 2°C global warming target alongside the reduction of allowable emissions relative to the baseline.

As some other modelling groups have already expressed their interest in performing the ENSEMBLES RT2A Stream Two simulations, the forcing fields necessary for running the scenarios have been put on the RT2A web server in a directory that is publicly accessible:

- http://www.cnrm.meteo.fr/ensembles/public/model_simulation.html

It is hoped that the paper submitted to EOS (Lowe et al, 2008) will further encourage other groups to also run these simulations, so that they might contribute to the AR5 evaluation.

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