Summary of the discussions on Stream 2 centennial simulations (RT1/RT2A meeting in Reading, 8-9 June 2006)

After a series of presentations of the new ESM model in working group C, a joint session of working group B and C was setup to discuss the different aspects relevant to stream 2 simulations (abbreviated as S2). The discussion was resumed on Friday morning after the RT7 presentation by R Tol. The different points relevant for the definition of the core simulations for the 20th century and 21st century simulation simulations were discussed:

- different versions of models,
- availability of computer resources,
- possible improvements of the forcings
- choice of initial conditions,
- size and generation of ensemble simulations,
- choice of the main simulations.

The main conclusions of these discussions have then presented by JF Royer in the session of the working group summaries and are summarized here

1) Different versions of models

Following presentation session of the new ESM models in RT1, a summary of the different categories of models that can be used for S2 simulations was prepared by M Giorgetta, who defined 3 categories of increasing complexity (and computer cost)

- physical models (coupled atmosphere+hydrology+Ocean+Sea ice models), which are improved versions of the models used in Stream one at DMI, CNRM, INGV?, MPIMET, FUB
- carbon cycle models (physical models with an additional carbon cycle components) at INGV, IPSL, METO-HC?, MPIMET
- aerosol (physical models with transport and chemistry for several aerosol species) at IPSL?, METO-HC, MPIMET, FUB?

(the question marks indicate the models for which one does know yet which version will be used in S2)

2) Availability of computer resources for the S2 simulations:

- Though some increase in computing power will be achieved in some centers due to changes in computer systems, on average the resources available for stream 2 will be about equivalent to those of stream one. In some centres it can be less since additional resources, or special priorities on computer, were made available in steam 1 as special allocations through National or institutional contributions to IPCC. As the complex ESM developed in RT1, particularly those with aerosol transport and chemistry, are much more expensive in computer time this will put a strong constraint in the number of simulations achievable by these models. For the physical models (Atmosphere-Ocean-Sea Ice) the use in stream 2 will be to make small ensembles of simulations (3 to 5) for each selected case. Consideration of these constraints on computer resources it was estimated that only about 4 or 5 different simulations for WP2A.2 and WP2A.3 together should be selected.

3) Possible improvements of the forcings:

Different possible improvements in the forcing fields were suggested

3A) Natural forcings:

the possibility of extending the natural forcing variability in the 21st simulations was considered to be a potentially important factor for the interannual climate variability with a possible impact on extremes, or for trend detection. As there is currently no way to predict deterministically the variation in the cycles of solar activity, or the date of major volcanic eruptions, the only possibility to include these sources of variability would be to use stochastic generators calibrated on the past behaviour in observed series over the few last centuries. However use of stochastic series of forcing will necessary imply to conduct and ensemble of simulations, with for example volcanic eruption at random dates, in order to sample the impact on simulated climate variability. This is considered not suitable for the core simulations, for which the expensive ESMs will be able to run only a single simulation, but could be attempted optionally by some of the OAGCM as part of their ensemble generation strategy.

3B) Anthropogenic forcings:

Land use change has been shown to be an important anthropogenic forcing that can have a local impact over the continents of about the same magnitude as that of aerosol forcings. This has been shown in published papers comparing preindustrial and current climate, and has been included in some coupled simulations at Hadley Centre, IPSL. It was considered that this forcing, which generally leads to a small cooling, should be included in the stream two simulations as it would increase the geographical realism of the 20th century simulations, and of 21st scenarios for which the land-use maps can be available.

Land use maps over the period 1700 to 1992 are being prepared as part of an intercomparison project (atmospheric GCMs forced by HadISST sea surface temperature over the 20th century, called C20C) by Dr Nathalie De Noblet at IPSL/LSCE. Use of this land-use database, which combines Ramankutty and Foley (1999) crop data and pasture data from the HYDE database, could be recommended as it would provide a useful interaction between ENSEMBLES and the C20C project (that also encourages ensemble simulations in forced mode).

For the future simulation land use changes can be available from scenarios from some impact assessment models (the IMAGE model from RIVM, and IAASA model).

So it was concluded that the introduction of land-use changes was feasible and should be made a priority in the S2 strategy.

Ozone changes will also be introduced in the simulations using the time-slice simulations performed by UiO

4) Choice of initial conditions

In order to avoid cold start problems it seems important to start the coupled simulations from a preindustrial control simulation that has been run long enough to stabilize (as was done in S1). It is encouraged to continue this preindustrial control simulation for 240 years in parallel with the 20th-21st simulations, in order to estimate (and correct if needed) a possible long-term drift. New problems could appear in the carbon cycle simulations, due to the long time constants of some carbon reservoirs.

The question of the possible choice of different initial states sampling different phases of the thermohaline (THC) circulation in the control simulation was discussed. This could be an interesting possibility to try to obtain a THC oscillation in better phase with the observations at the end of the 20th century, which could give a more realistic ocean initial state for starting the 21st century scenarios. However since the complex ESM will not be able to perform the multiple (about 3-4) simulations over the 1860-2000 period that would be needed, it was

considered that this could not be made part of the central simulations. This method is encouraged to be considered as an ensemble generation strategy for some of the AOGCM, but its implementation is left to the choice of each modelling group as all models do not represent similar long-term variability of the ocean circulation.

5) Size and generation of ensemble simulations

Due to their very high computational cost the more complex ESM with carbon cycle or aerosols will be able to run only a single realization of the chosen core simulations.
The physical AOGCM are expected to be able to run a small size ensemble (of the order of about 3 to 5) for each simulation using different initial conditions or forcing histories.

6) choice of the main S2 simulations.

After examining the possibilities and constraints it was attempted to define a coherent strategy for the S2 simulations. It was also considered that the methodology should remain as close a possible as the one that proved successful for the S1 simulations.

- a small number of well defined core experiments that could be done with all the participating models (single simulation for ESMs, small ensemble of simulations for AOGCMs)
- simulations that could be sufficiently similar to the S1 simulations so that some of the S1 and S2 simulations could be pooled together so as to increase the multimodel ensemble size

In order to keep compatibility with S1 it was decided that the only new forcing to be introduced will be land-use, which is an anthropogenic forcing not considered in S1.

6A) WP2.2 historical simulations:

For the 1860-2000 simulations the choice was made for two simulations comparable to those in S1:

- anthropogenic only: the GHG concentrations will be as in S1, but in addition the land-use changes will be included in the S2 simulations. The motivation of making this simulation, without natural forcings, is to be able to extend without any discontinuity over the 21st century in which the natural forcings are not known.
- Anthropogenic + natural: GHG + solar and volcanic forcing as in S1, with the addition of land-use. The rationale of this experiment is to obtain a more realistic simulation including all known forcings for the purpose of validation by comparison of the observed climate variations over the 20th century.

6B) WP2.3 scenarios

The strategy was to chose a core simulation according to one of the IPCC SRES scenarios used in S1, and a new simulation according to the recommendations put forward by RT7.

The choice of the IPCC scenario converged rapidly to the A1B scenario for the following reasons:

- it is the scenario chosen by RT2B, so new S2 simulations could optionally be proposed to RT2B if they wished to extend their regional multimodel simulations.
- A1B could be close enough to the most likely scenario of future GHG changes in the absence of climate negotiations.

The choice was then made of performing a scenario that could best illustrate the climate impact of international negociations for the reduction of GHG emissions. We followed the

recommendation made by R. Tol, of using one of the stabilisation scenarios, as these are part of an international effort of scenario development, and are likely to be used by other modelling groups as well. After discussion on the level of stabilisation that would be best the choice was made of the stabilisation at 450 ppm for the following reasons:

- it gives a very different path of CO2 concentration than in the IPCC scenarios with a slight overshoot of the concentration near the end of the 21st century, which can be of interest for the carbon cycle models
- With a low level of concentration it should be able to best illustrate the limitation of climate impact that can be reached by climate oriented policies
- it is expected to corresponds to some European policies for GHG reductions, and thus the associated climate impact should be of major interest

The stabilisation scenarios have been run by several impact assessment model among which the IMAGE model is able to provide most of the needed forcings, except for black carbon emissions.

It was recognized that it might be interesting to perform another stabilisation scenario at 650 ppm as this seems to corresponds to some US policies, and to extend some of the simulations into the 22-nd century, but this was left optional for individual modelling groups to decide if they would have the interest and resources to do this.

The question was raised of whether at this point we should commit RT2A to perform another core simulation based on the new scenarios developed in RT7. In view of the appreciations given by R Tol on their scenario model, which needs some further developments in order to provide satisfactory and credible results, it seems premature to decide to chose one of the current RT7 scenario for performing a core simulation in our next 18-months plans. Furthermore the new RT7 scenarios do not yet provide the land use changes which are an essential element in the S2 strategy. This question should be re-examined again in one years time, if RT7 can then recommend a scenario that could be included in the RT2A plans for months 36-54.

It was suggested that the new RT7 scenarios should be perhaps be first tested in simplified climate models in order to evaluate first their likely climate impact, before deciding which one to use in the RT2A simulations. It remains to be explored whether this could be made in some RT1 WP exploring ensemble generation strategies, as this was not part of the initial plans. This would probably be a sensible alternative to evaluate how far the new scenarios will provide a different climatic response than the chosen stabilisation scenarios, and help decide whether it is scientifically worthwhile to invest the huge computational resources (and manpower!) needed to perform a multimodel simulation with all the set of complex models used in RT2A.

In summary the currently chosen core scenario chosen for S2 are

- a control simulation with preindustrial (1860) forcing to specify the initial conditions, and then extended over a 240 year period corresponding to other simulations (1860-2100) for estimating model drift
- anthropic forcings only including land use changes for 1860-2000
- anthropic and natural forcings with land use changes for 1860-2000
- SRES A1B with land use changes for 2000-2100
- Stabilisation scenario to 450 ppm CO2 equivalent with land use changes for 2000-2100

With the above strategy it seems possible to store the same list of results as in Stream One in the DKRZ archive for at least one of the above simulations for each model. For the models that will produce ensembles of several members it may be necessary to define a reduced list of stored fields.

It has been suggested to initiate a discussion on the web based forum corresponding to RT2A at http://www.ensembles-eu.net/index.php to discuss further this strategy and the other specific implementation details of S2 simulations. The discussion will be initiated by a post by R. Tol. Participation to the discussion is encouraged to help improve the strategy for the centennial stream two simulations.

A meeting of RT2A will be organized at the General assembly in Lund in order to finalize the technical details for the full specification of the land use datasets and other forcings needed for these simulations.

The workpackage leaders of WP2A.2 (E Kaas) and WP2A.3 (U Cubasch or F Niehörster) will contact the RT2A partners to discuss some of the remaining issues for the elaboration of a detailed implementation plan of the S2 simulations for the next 18 months. Response from the partners will be needed by 1 July, so that the WP leaders can provide a first draft by 15 July.