

**ESF-CIAMⁿ WORKSHOP ON
COMMUNITY INTEGRATED
ASSESSMENT MODELLING OF
CLIMATE POLICY
CLARE COLLEGE, CAMBRIDGE**

24-26 MARCH 2004

Convenor: Rachel Warren, Tyndall Centre

Appendixes

APPENDIX 1 *ABSTRACTS OF PRESENTATIONS*

Session 1 Policy Questions

RW introduced three sets of potential policy questions which are detailed here:

(i) The policy questions that the Tyndall centre plans to address with its prototype CIAMⁿ:

- a. Under baseline SRES scenarios in the absence of climate policy, what are the climate impacts?
- b. What global carbon taxes are required to achieve stabilisation at 450 or 500 ppmv of [CO₂] by 2100?
- c. Can we achieve this if US or China do not participate?
- d. What is the effect of introducing permit trading?
- e. How much would these policies cost?
- f. What are the benefits of these policies?

(ii) A list of policy questions which could be addressed with a more advanced version

- g. Repeat simple policy questions with more advanced climate models
- h. What is the robustness of our results to the use of different climate models?
- i. And different economic modules or carbon cycles?
- j. What is the robustness of our results to uncertainties?
- k. How does climate change affect probability of extreme events?
- l. What are the benefits of stabilisation as defined using an array of simple damage functions?

(iii) A list of policy questions arising from a brainstorming meeting held between DEFRA, Hadley Centre and Tyndall in the UK on the topic of climate stabilisation.

- m. How do different technological paths affect each other?
- n. What is the feasibility of different mitigation pathways
- o. What is the technical effectiveness of carbon sequestration?
- p. What are the limits to adaptation?
- q. Linking top-down/bottom-up impact/adaptation work to provide better estimates
- r. What are the effects of feedbacks on stabilisation scenarios
- s. What emission pathways avoid singularities in the climate system (THC, “surprise” events, geological disasters)?
- t. Derive an iterative solution to approaching stabilisation limits

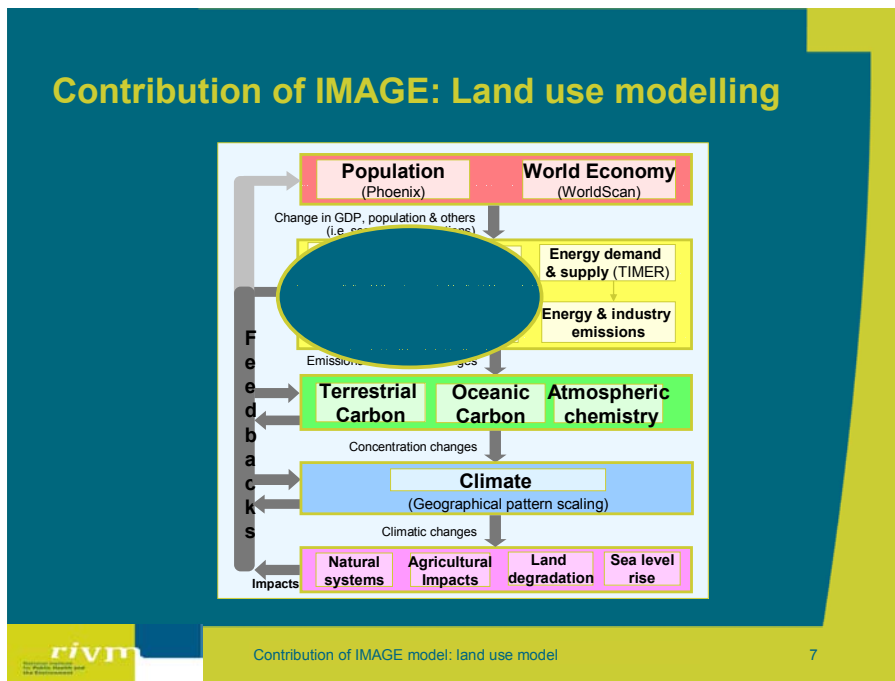
Session 2 Design of CIAMⁿ model experiments to address the policy questions.

Presentation 2. Next steps for CIAMⁿ: Land Use Change

Bas Eickhout and Tom Kram, RIVM, NL

This presentation highlights an important contribution that the IMAGE model can make to CIAMⁿ, that of enabling the simulation of scenarios which simultaneously explore changes in climate and changes in land use, and the interaction between these two factors. The importance of understanding these interactions is highlighted through a number of examples of the use of the IMAGE land use/agricultural economy scheme. The first is the study of carbon cycle feedback, on which land use change obviously has a strong influence. For example, whilst climate change can convert land carbon sinks e.g. Amazonia into sources, if the area is largely deforested, then the picture looks rather different. The second is the political importance of land use change in mitigation options, for example to identify the geographical potential for growth of biofuels, which could result in very large areas being converted from natural ecosystems to cultivated areas (with obvious implications for biodiversity), or in the construction of non-CO₂ greenhouse gas control cost curves. The third area is the use of crop models to show how, under various SRES scenarios, new areas are brought under cultivation to satisfy the demand for food, whilst other areas of cropland are abandoned owing to unsuitable climatic conditions (typically desertification). Finally, plans for further development of IMAGE in the land use area are presented, aiming to enhance the representation of relevant interacting processes and broaden the scope to other environmental sustainable development issues. Submodels and modules are under development with partners in the Netherlands and abroad, asking for a more modular setup of future IMAGE versions that would improve opportunities for expanding CIAMⁿ to other sectors and concerns.

Figure 4 The IMAGE model, showing the potential contribution to CIAMⁿ



Presentation 3. Modelling divergent climate policy assessments with a multi-agent dynamic integrated assessment model MADIAM. Klaus Hasselmann

(with Michael Weber & Volker Barth) (MPI & University of Oldenburg, Germany)

A multi-actor dynamic model of the coupled climate-socioeconomic system is presented which is designed to bridge the gap between the two basic classes of growth models and computable general equilibrium (CGE) models used in current integrated assessment studies. Being formulated as a dynamic simulation model, the model also bridges the gap between short-to-medium and long-term processes, both of which are important when discussing the impacts of long-term climate policy on short-term policy concerns such as the employment rate, stable growth and business cycles, and competitiveness in a globalized economy. The climate module is based on a computationally highly efficient nonlinear impulse-response representation of the response of the climate system to greenhouse forcing, calibrated against a state-of-the-art three-dimensional model of the coupled ocean-atmosphere-carbon-cycle climate system. Although not yet implemented, the climate module can be readily generalized to include extreme events and instabilities such as the breakdown of the thermohaline ocean circulation. A number of multi-actor simulations with MADIAM are presented as examples.

Presentation 4. Bob Marsh, Tyndall Centre, UK

Grid ENabled Integrated Earth system model (GENIE):

A Grid-based, modular, distributed and scaleable Earth System Model for long-term and paleo-climate studies

Whole Earth System modelling requires the integration of a number of specialised components. Current computing technologies are not well suited for constructing, executing and effectively utilising such a model. However, the Grid and associated component-based application construction techniques should provide a natural solution. To achieve this, a structured, multi-disciplinary and multi-institutional collaboration is needed for model development and use, and to share the large volumes of output data from integrated simulation runs. We propose to challenge use of the Grid to unify widely distributed UK expertise, and generate a new kind of Earth System Model (ESM). Our scientific focus is on long-term and paleo-climate change, especially through the last glacial maximum (~20kyr BP) to the present interglacial, and the future long-term response of the Earth system to human activities. A realistic ESM for this purpose must include models of the atmosphere, ocean, sea-ice, marine sediments, land surface, vegetation and soil, ice sheets and the energy, biogeochemical and hydrological cycling within and between components.

In the GENIE project we are developing, integrating and deploying a Grid-based system which allows us: (i) to flexibly couple together state-of-the-art components to form a unified ESM, (ii) to execute the resulting ESM on the Grid, (iii) share the distributed data produced by simulation runs, and (iv) to provide high-level open access to the system, creating and supporting virtual organisations of Earth System modellers. The project will deliver both a flexible Grid-based architecture, which will provide substantial long-term benefits to the Earth system modelling community (and others who need to combine disparate models into a coupled whole), and also new scientific understanding from versions of the ESM generated and applied in the project. The component models are supplied by recognised centres of excellence at Reading, SOC, UEA, CEH and Bristol. The Grid-based architecture leverages significant ongoing activity and experience in the e-Science centres at Southampton and Imperial College. The project fills important gaps in an emerging spectrum of Earth System Models, and represents a rare example of using the Grid for a truly multi-disciplinary modelling activity.

During the discussion it was noted that the GENIE project will produce a hierarchy of EMICS (intermediate complexity modules), of which BC-GOLDSTEIN, an ocean/biogeochemistry

module, is the most relevant for CIAM-n owing to its centennial or so timescale (other EMICS are used to address longer timescales). Such EMICS enable study sensitivity of model outputs such as THC collapse to model parameterisations in a very thorough manner, which is not possible with a GCM owing to cpu-time limitations. As shown above, BC-GOLDSTEIN is currently being connected to the CIAMⁿ prototype at the Tyndall Centre.

The use of EMICS raised the question of the degree of complexity necessary to accurately represent a process. The necessity of complementing the process of increasing model complexity with a rigorous uncertainty analysis was highlighted.

Presentation 5. Experiences from module coupling experiments: new insights from the CIAMn approach.

Marian Leimbach, Ottmar Edenhofer, PIK, Germany

This presentation relates to the CIAMⁿ pilot system at PIK. This consists of a number of independently running modules of three basic types:

(1) domain knowledge modules (data modules or functional modules (which may be optimisation or simulation modules)), (2) numerical coupling modules, which capture feedbacks between domain modules and represent the mathematical relations of the coupled system by an iterative numerical algorithm (3) job control modules. (Figure 5). The numerical coupling approach is unusual in that it describes a method of optimisation which can work in the absence of the knowledge of the gradient of the climate model. It has been demonstrated to converge in a meaningful manner.

The features of numerical coupling modules are studied in two module coupling experiments. In the first experiment (Figure 6) an economic module (optimisation module) and a climate module (simulation module) are coupled in order to find that emission reduction policy that meets a normatively given climate guard-rail (i.e. maximum temperature increase) with lowest macroeconomic costs. The second experiment aims at reconciling the economic activities of decentralized economic agents (i.e. world regions). The numerical coupling modules represent numerical algorithms which operate by means of a barrier approach, make use of shadow price information, and capture particular kinds of feedbacks.

Alternative climate modules are used within the first experiment. It can be demonstrated that by means of the numerical coupling modules results of the traditionally coupled models can be reproduced.

Figure 5

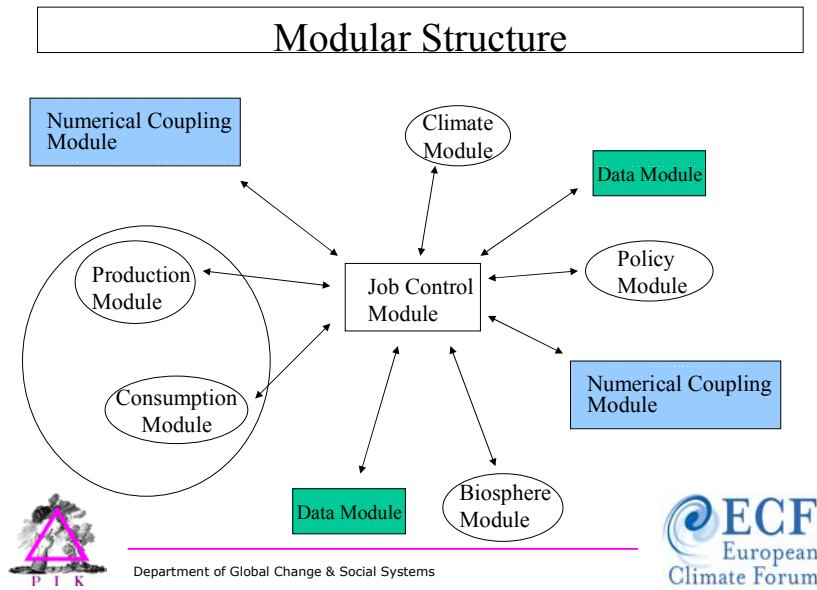
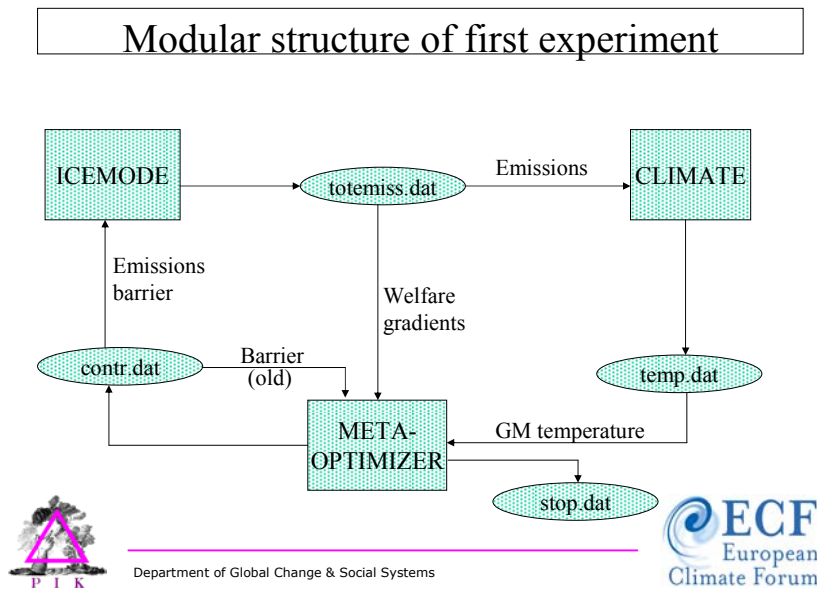


Figure 6



This presentation also highlighted the following common deficiencies in integrated models for climate policy and this helped shape later group discussion:

- Concerns of South (e.g., intra- and intergenerational equity and responsibility) are neglected
- Policy instruments are treated exogenously
- Biomass energy and carbon capturing and sequestration gain importance – respective modules needed
- Dynamic foreign investments (e.g. into the energy sector) neglected in IA models
- Spillovers beyond substitution and leakage effects are missed

Presentation 6. The biosphere and human activity in biogeochemical modelling.

Wolfgang Lucht, PIK, Germany

This presentation considered the role of biogeochemistry in integrated assessment.

In particular the BIOS-X scenarios simulated at PIK were highlighted, which link biomes (using the LPJ model), agricultural practices (from LPJ agriculture module and Land Use Manager), and a general trade model. This approach puts climate change in the context of other global changes. The following BIOS X projects were considered potentially relevant :

- Comparative studies of climatic and non-climatic land use effects on
 - Coupling of LPJ, Land Use and Economic Model
 - Scalable “lean” biosphere model
 - Coupling into CIAMⁿ modelling network
 - Biospheric sensitivity functions for IA
 - Integrated Assessment of biosphere-climate-economy

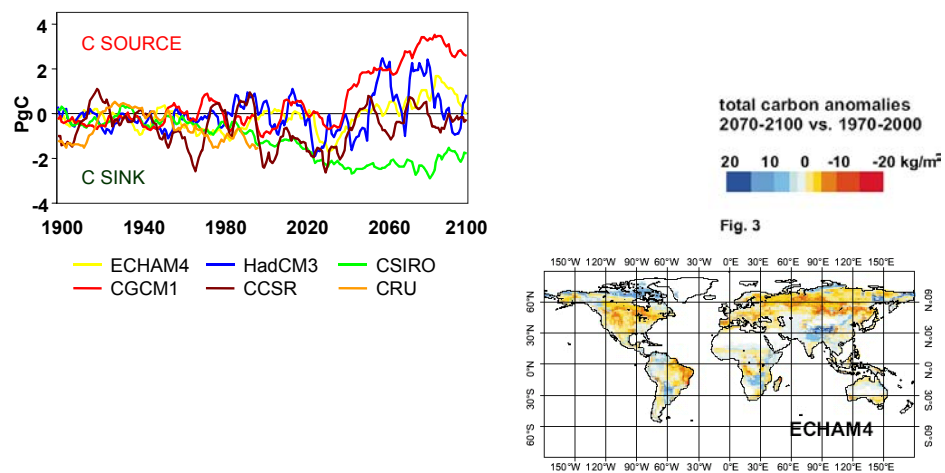
After considering the huge range of scales one could potentially study in biogeochemistry which might be relevant to integrated assessment, illustrative results from the LPJ biome model were produced, focusing on (i) natural vegetation distribution and soil carbon at equilibrium (ii) the carbon balance to 2100, showing the slow evolution of the biosphere from sink to source of CO₂ (Figure 7) and (iii) the impact of agriculture on carbon and water, using the new implementation of agriculture in the LPJ-DGVM (Figure 8) which considers a co-existence of natural vegetation and crops within each land surface grid cell. “Mind-game” scenarios of land use, carbon and water may then be produced. An account of the land use manager MagPIE under development was also given. The role of soil carbon was emphasised.

RW asked if the turning points where C sinks become sources can be used as thresholds for dangerous climate change. WL explained that the transition point would vary not only between regions, but according to which GCM was referred to.

This approach would therefore be difficult, unless a regional set of probability distributions for the risk of such transitions could be produced.

Figure 7

LPJ-Simulations Biospheric Carbon Balance 1900 – 2100



Schaphoff et al., in prep

Figure 8

