Integrated assessment models (IAM)

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Integrated models: Integrated assessment

Hermann Lotze−Campen (lotze−campen@pik−potsdam.de)

1 Introduction

Integrated assessment models try to link, within a single modelling framework, main features of society and economy with the biosphere and the atmosphere. Starting with a focus on the connection between anthropogenic greenhouse gas emissions and climate change, the agenda of Integrated Assessment Models (IAM) now includes aspects of land use, biogeochemistry, hydrology, demography and health. The goal is to make more and more parts of the "Earth system" endogenous to the modelling framework. This is an ongoing process, in which major methodological barriers between scientific disciplines have to be overcome. E.g. the optimisation mode of most economic models has to be linked with process−based time−step models in climate or biogeochemistry research. Integrated Assessment is a useful way of approaching highly complex issues like climate change, which involve a range of problems, disciplines, stakeholders and time and spatial scales. Climate change is very much a multi−actor problem: those involved include emitters of greenhouse gases, those who make climate change policy and those who will be affected directly and indirectly by climate change.

2 Methodology

The major building blocks of IAM are well−established models from specific disciplines, e.g. climate models, biogeochemistry models, general economy models, demographic models. These sub−models or modules communicate through the exchange of well−specified input and output data sets. Many feedback loops may be required to make outputs of two modules from different domains consistent. In some cases shortcuts and simplifications have to be made, often simplified versions of specific modules have to be developed. Earlier IAM were built as single entities with the different representations of the component parts of the problem interacting within one model. More recently, there has been a move towards a modular representation, in which the IAM is actually a grouping of a number of separate modules, each with a user interface, which can be added or removed as necessary to address different questions. The great advantage of this approach is its flexibility and greater transparency. This requires efforts in creating clear user interfaces.

3 Process

The process consists of the following steps:

- Define type of application and relevant end−users
- Select and modify original sub−models from relevant disciplines;
- Define appropriate input and output interfaces between sub−models;
- Design work flow for integrated modelling, including feedback mechanisms;
- Define joint scenarios;
- Run model simulations.

4 Review

4.1 Evaluation results

Integrated assessment models are still the most ambitious approaches to integrative modelling and assessment. They provide important examples of how model coupling and integration can work across very different disciplines. While many IAM still lack some detail in their separate parts, this will improve over time. So far, most IAM have been confined to studies on climate change, and to a lesser extent on air quality, water issues and biodiversity. This scope will be widened as the experience with model coupling continues to grow. But new challenges will also arise in this process. IA is still in an early stage, and many questions regarding interactions between different compartment of the Earth system are still unresolved. IAM provide the most promising approach to quantitative sustainability impact assessments.

4.2 Experiences

The first IAM have been developed for climate impact studies. The Special Report on Emission Scenarios (SRES) summarises the modelling results of a range of prominent IAM for global scenarios on future climate change due to anthropogenic greenhouse gas emissions. These provided the basis for the IPCC third assessment report. Applications in areas other than the economy/climate domain are still in an early stage. In the case of biofuel energy scenarios IAM will play an important role, as they provide a consistent link between social, economic and environmental processes and their feedbacks.

4.3 Combinations

Integrated Assessment models have been used in Scenarios, Vulnerability analysis, Cost−benefit analysis, Cost−effectiveness analysis, and in applications of the Guardrail approach (also known as "safe landing approach" or "tolerable windows approach"). IPCC and SRES reports on climate change, impacts and adaptations are the prime examples of these combinations.

IAM provide inputs for Scenario analysis; Cost−benefit analysis and Cost−effectiveness analysis; Vulnerability analysis

4.4 Strengths and weaknesses

Strenghts:

- Consistent integration between economy, climate and biosphere
- Ability to address trade−offs and synergies of policy strategies
- Operational modelling and model development in an interdisciplinary setting
- Ability to consider feedbacks between different domains
- Puts specific schools of thought and methods into a broader perspective
- Global coverage
- Long time scales

Weaknesses:

- Necessary trade−off between specialisation (depth of coverage) and integration (breadth of coverage)
- High complexity, which may cause low credibility by end−users
- Some models have a high demand for computer power, which limits their use for on−line applications
- Not appropriate for short−term forecasts
- Uncertainty analysis very difficult
- Problems of combining qualitative and quantitative research

4.5 Further work

The biggest challenge is still the linkage between economic modelling and biophysical modelling. This issue is currently addressed by many IAM.

4.6 References of the tool

Overview of IAM:

Schneider, S.H. (1997): Integrated assessment of global climate change: Transparent rational tool for policy making or opaque screen hiding value−laden assumptions? *Environmental Modelling and Assessment* 2, pp. 229−249.

IMAGE

http://www.mnp.nl/image

ICLIPS

Ferenc L. Toth, T. Bruckner, H.−M. Füssel, M. Leimbach, G. Petschel−Held (2003):
Integrated Assessment of Long−Term Climate Policies: Part I − Model Presentation,
Climatic Change 56, pp. 37−56.

FUND

http://www.uni−hamburg.de/Wiss/FB/15/Sustainability/fund.html

DEMETER

http://130.37.129.100/english/o_o/instituten/IVM/organisation/staff/papers/DEMETER1.zip

GENIE

http://www.genie.ac.uk

ICAM

http://sedac.ciesin.columbia.edu/mva/iamcc.tg/TGsec4−2−1.html

Dowlatabadi, H., and M. Granger Morgan. 1993a. "Integrated Assessment of Climate Change." Science 259 (26 March): 1813, 1932.

Dowlatabadi, H., and M. Granger Morgan. 1993b. "A Model Framework for Integrated Studies of the Climate Problem." Energy Policy 21 (March): 209−21.

Other IAM:

DICE/RICE (by W.D. Nordhaus)

MERGE (by A. Manne and R. Richels)

MESSAGE (by IIASA)

MiniCAM (by MIT)

AIM

Integrated models with a strong focus on energy sectors:

MIND

Edenhofer, O., Bauer, N., Kriegler, E. (2005): The Impact of Technological Change on Climate Protection and Welfare: Insights from the Model MIND. *Ecological Economics* 54, pp. 277−292.

FEEM−RICE

Carraro, C. and M. Galeotti (2003), "Does Endogenous Technical Change Make a Difference in Climate Change Policy Analysis? A Robustness Exercise with the FEEM−RICE Model", Fondazione Eni Enrico Mattei, October 2003.