Present and Future of Modeling Global Environmental Change: Toward Integrated Modeling,
Eds., T. Matsuno and H. Kida, pp. 363–372.

Discussion on Strategy toward Modeling of the Integrated System

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FORWARD

In this session, a discussion was conducted for the integrated model. Before starting the discussion, Prof. Sumi explained the background for this purpose; "One big factor is a social demand. Maybe, all of you know that carbon sinks and carbon tax are critical issues. Regarding this aspect, Dr. Morita will later explain the demand of society and administration. They request scientists to answer this demand. There are the second and third factors. The TFLOPS computer will be available in a few years and too much data will be available in the next decades. These two factors are positive for the integrated (Earth) system model. The last factor is our knowledge about the Earth system." Then, he asked the following question, "the Earth System modelling, is it now or too early?" And "What is strategy for it?" and started discussion.

First of all, Dr. Morita presented his view on the request of policy makers.

THE POLICY MAKING PROCESS AND THE INTEGRATED ASSESSMENT MODEL (TSUNEYUKI MORITA)

The objective of my talk today is to outline the problems in the climate change issue from the policy maker's perspective. I am not a policy maker but a researcher. I was a Project Leader of the AIM Modeling Project, and for the last 3 years, I have been working on the interface between Japan's climate change policy making process and the related science field, so I worked to encourage communication between them. I am no longer a Project Leader and my current work is to direct a division on socio-environmental research, but I still encourage communication between the policy makers and scientists.

Using my previous and current work and experience, I'd like to talk about several questions related to the kind of knowledge and messages policy makers want in relation to the climate change issue.

The IPCC posed 10 TAR questions for the Lead Authors of the IPCC reports. These questions are based on the issues that policy makers consider important. For example, they include questions that require detailed considerations, such as:

"What factors contribute to the process of determining what constitutes dangerous anthropogenic interference with the global climate?"

"What is the evidence for, causes of, and consequences of changes in the Earth's climate since the pre-industrial era?"

"What is known about the potential for, and costs and benefits of, and timeframe for reducing GHGs emissions?

Also, the day before yesterday I received an e-mail from the IPCC technical support unit passing on a request from the EU government for the latest information on emission reduction scenarios from 2010 to 2020. This meant that we had to make the appropriate calculations in a very short time.

In order to respond confidently to such questions and requests, the Integrated Assessment (IA) model was developed. To understand the background of the IA model, the most important point to appreciate is that there are several epistemological gaps between the science and policy fields.

Policy makers are intelligent—and sometimes much more intelligent than the relevant scientists—but they often lack the scientific training necessary to accurately interpret and implement the scientific data supplied to them. On the other hand, scientists may have few incentives to either link their research results to the policy making process or integrate their own results with those from other fields.

In order to link policy makers to the science field, the IA model was introduced. There are a variety of such models operating at the interface of the policy making process and the academic process—the Japanese AIM model, the IMAGE model whose project leader is Dr. Leemans, the GCAM model developed by Dr. Edmonds, and the MIT model developed by Prof. Jacoby.

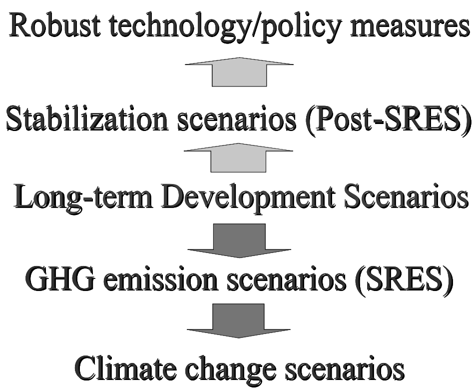
The IPCC 1995 Second Assessment Report defined IA as a framework for presenting the "best available synthesis of current scientific, technical, economic and socio-political knowledge". The first use of the IA process occurred in the early-1970s when the U.S. government was assessing the impact of supersonic aircraft on the stratosphere, and in the late-1970s, a computer model was developed to conduct a more formal simulation of the impacts. For example, Prof. Nordhous of Yale University introduced a simple but systematic model to analyze and integrate economic and physical phenomena.

During the 1980s, IA was used in relation to a variety of environmental issues, including examination of the destruction of the ozone layer and the impact of acid rain. IIASA developed the RAINS model to help advance policy development on the acid rain issue and the climate change issue. Thus over the last 10 years or so, there has been both a rapid increase of interest in IA and great progress in computer simulation models as a core tool of IA. Governments have invested in the development of IA models and the IA research community had access to a great deal of funds through the 1990s which allowed them to advance their work considerably.

The other very important issue that needs to be considered in relation to IA is the gap that exists between the scientific uncertainties and the political decisions. Funtowicz and Ravtez published a very challenging paper entitled "Science for the Post-Normal Age" in a 1993 edition of the journal Future. They analyzed the current major social issues, including global environmental problems, and concluded that when uncertainties are very significant and when the stakes are high, applied science and even consulting activities are limited in their ability to support political decision-making. They decided that a new approach is needed to link the science and policy fields, especially for global environmental issues.

Funtowicz and Ravtez proposed some new methodologies, some of which are very unusual. These methodologies were given the name ‘POST-MODERN SCIENCE’ and are expected to be used to establish a new community of experts who could encourage communication between policy makers and scientists. Also, the ‘Multi-model Approach’ was strongly recommended when applying integrated assessment under the conditions of significant uncertainty. This approach requires a comparison of the relative consistencies of several models in an open process, and then a presentation to the policy makers of the most reliable model, model results and insights based on the most reliable model. This approach suggests two conclusions. The first was that the only way to assess the reliability of scientific knowledge is to compare the relative consistency of the models. The most reliable conclusions and insights at each time would then be passed to the policy makers. The second conclusion was that several model studies should be compared so different world views could be prepared—rather than just making an analysis of simple sensitivities using a single model.

The uncertainty in global environmental issues does not have a simple structure. Not only are there technical uncertainties, but there are ethical and ideological uncertainties as well as structural uncertainties. The only way to overcome this and provide a comprehensive perspective to policy makers is to compare several models.



An example using the IPCC process can be used to illustrate this issue as in the above figure. The IPCC began to establish new global climate change scenarios in 1996. First, the IPCC asked the project team to write long-term development scenarios, then use these to estimate the greenhouse gas emission scenarios (SRES scenarios) and transfer these SRES scenarios to the climate modeling community so it can develop climate change scenarios. The IPCC also requested the preparation of stabilization scenarios based on a wide range of development paths and identification of robust technology and policy measures.

A special report on these emission scenarios has already been published. This project was coordinated by Dr. Nakicenovic of IIASA. Four types of scenarios were prepared with different emphases on global governance, regional development and adaptation, economic growth and environmental conservation. These four scenarios are: ‘Tiger World’ with a very high growth scenario; ‘Cultural Pluralism’ with a world divided into regional blocks; ‘New Sustainability Paradigm’ and ‘Mixed Green Bag’ with more emphasis on environmental protection. The IA team was asked to quantify the scenarios, which was a very competitive process. For example, the AIM team collaborated with the Asian team to carefully examine in detail the consistency of the data on economic growth in the Asian region. As a result, our model was selected to represent the high growth scenario. The Dutch IMAGE model was selected as the marker for the sustainable development scenario. Each model was compared for reliability and consistency, and the competitive and open process that was used made an essential contribution to establishing the credibility of the models.

The emissions of SO_2 were also estimated and these data were then transferred to the climate modeling community who then adapted the multi-model approach to estimate the range in global temperature increases. This topic was discussed during the first day of this workshop.

Then we began to quantify the stabilization scenarios and find robust technology and policy measures. I have been the coordinator of this IPCC program, and first the IPCC technical support unit asked three questions based on requests from policy makers:

1. To what extent do the different SRES world views require different technology/policy measures and different costs of mitigation to stabilize the greenhouse gas emissions at the same level?
2. How does the stabilization level affect the technology/policy options and the cost of mitigation in each SRES world?
3. What packages of technology/policy measures are sufficiently robust to produce the desired result in the different world views?

I invited 9 modeling teams—3 from Japan (including the AIM team), 3 from the United States and 3 from Europe—to quantify the stabilization scenarios based on the new IPCC emission scenarios. Each modeling team then conducted many trials to determine how to stabilize and reduce the greenhouse gas emissions and atmospheric concentrations. The ‘generator’ for this stabilization scenario was prepared by Prof. Matsuoka. Each team quantified the 450 ppm stabilization scenario, the 550 ppm stabilization scenario, and the 670 and 750 ppm stabilizations.

These scenarios were then compared. The preliminary conclusions are that the wide range of future development paths require different technology/policy measures and that afforestation and improvements in energy efficiency are very robust policies across the different development paths. Other robust features are the introduction of low-carbon sources of energy, especially biomass energy and natural gas. In a world of high greenhouse gas emissions, the use of nuclear energy and carbon sequestration would have a more important role. Solar energy and carbon sequestration would then act as insurance for climate stabilization in the latter part of the 21st century. The scenarios also indicated that the higher the level of future emissions, the more severe the technology/policy measures that will need to be introduced over the next 20 years to prevent the next human generation having to deal with greater impacts from climate changes.

However, probably the most important conclusion and recommendation for policy makers is that the most effective and efficient method for reducing greenhouse gases is to integrate the climate change policy with general socio-economic policies. In turn, this suggests that more attention needs to be paid to the linkages between policies on climate change and policies on sustainable development. This is an example of the multi-model approach and the IPCC process.

Finally, I would like to make four points.

First, the Integrated Assessment modeling should be introduced to international research programs and domestic policy making processes to assist in global environmental conservation.

Second, there is both a practical political necessity and a moral obligation for developed countries to support integrated assessment research activities in developing countries because the developing countries are faced with much more serious situations in relation to environmental protection. Such work is being done by Japan’s AIM team through assistance to researchers in China and Asia.

Third, it is important for researchers to maintain an appropriate distance from the political processes so as to protect their academic independence. For example, before COP3, our AIM team was directly attacked by the Ministry for International Trade and Industry. It was one of our worst nightmares in terms of protecting our apolitical academic position. Also, the AIM modeling team developed and designed our model, but then sub-contracted it out to individual users, such as governments, private companies and international organizations who were then able to change input assumptions to suit specific situations. Academic independence is needed to operate this kind of system.

Fourth, I strongly recommend that competition in the academic field be used to supply policy makers with the most reliable insights at appropriate times. My recent work has been to provide funds to domestic and international scientific research competitors, so that, for example, when the Japanese government wants to estimate a suitable carbon tax rate or the impact of a carbon tax on the macro-economy, it can invite three or four modeling teams to make estimates. It is then able to compare the reliability or consistency of their work. I would like to stress the importance of this last point.

SUMMARY OF DISCUSSION

Following Dr. Morita’s presentation, we discussed the following three points; (1) how to answer the social demand?, (2) how to produce an integrated model?, and (3) where we should go?

How to answer the social demand?

About this topic, the necessity of an integral assessment model and uncertainty of models were mainly discussed. The major comments from participants are listed below;

"A premise of an integrated assessment is used in order to start with a general circulation model. And carbon-dioxide and maybe a greenhouse gas derive a climate system and everything follows this. So I would like to offer this framework for prediction. You can really think of predictions in different categories.

You can guess what the future is going to be if you have perfect knowledge, but we can exclude this possibility. What you really want to have is the future climate, and to define how the regional climate would be. To take term of the regional climate, you need to do something in terms of an impact. The question is how to estimate the future climate change? What has been done up to present by the IPCC is a sensitivity experiment.

In the sensitivity experiments, you look at running different GCMs and you actually get different results. And you give the results to the assessment people. They work for it. We can think this is one realization. And you need an ensemble and try to use an envelope for what the future climate would be.

So what I would like to propose as an approach to the assessments is to use the Earth system concept and start from the impact model and exercise these models to understand where the sensitivities of these models are and to determine what the threshold and where the vulnerability are, and then go back to the models to estimate whether it is possible or not. You can also provide some kind of confidence and probability to the policy-makers. because the natural fluctuations may in fact provide more threat to the future than the GCM sensitivity experiments and we should protect them."

"Modeling will provide the best answer but just one answer. We have to have an uncertainty range and so we used various ways to look at the uncertainty, but it is at a very primitive stage. So we came up with the statement that the by doubling CO_2 you have 1.5 to 4.5 degree warming. Now nobody has developed since then the methodology to prove the number because nobody is focussed on trying to look at uncertain ranges. What happened is that people go to meeting and quickly try to come up with some number saying that I can do any better than that number. So it is a research programme to focus on the range of uncertainty in a model and to make it much more useful for policy issues."

"I will discuss the issues regarding greenhouse gas warming, We need a prediction in the century if a scenario is given. That is the request from the policy-makers. That is one way we can contribute to society. On the other hand, no matter what policy is made and anyhow greenhouse gas emissions are continued and land use and cover change are made by human activity, we can make a kind of very long-range prediction for the global environment, say 30 years or so, considering and including the inertia of the climate system, which may be very useful not only for policy decisions but also for many industry sections or people. This is considered to be a sort of forecast and this is another way to provide scientific results to society. For the first part, it is not easy. We have to consider the integration of the policy, society and the feedback, but, in the second part, extension of our research effort is easy."

"Uncertainty is an important issue with regard to the integrated assessment, because when we integrate more elements, uncertainty will become larger. And sometimes if you put a very unreliable component, then the uncertainty becomes infinity. So, it would be never intended to be a prediction of future change. An assessment model should be used for vulnerability assessment. Integrated assessment is useful not for prediction purposes but for people to think through all the factors which may come in the decision making. When we just vaguely think about it, we usually miss many important factors, but when we to try to create an integral model, that forced people to think through end to end. For that reason, integral assessment is a useful exercise, but it should be never intended to prediction of future change."

"In the case of water resource management, there are key issues in the politics. If you are in the water management agency, they do plan in time horizon, 30–40 years, in the future; you have to have a water supply design to provide it with a certain reliability. If there are failures, for example, a drought may happen, somebody will lose a job, that is, politicians lose elections. And then, the question is what they can do.

In an engineering area, the standard way that you can deal with climate effect on some systems is to use historical observations. You use them, and can run some kinds of models, which say how much water is available each year and you design a system so that supply has certain reliability for a given demand. These demands somewhat get projected for future population change, that is, a major stress to most system.

Question is a sensitivity analysis. What is the design for the new sequence? What we can do for the actual design?"

"I would like to suggest a perturbation method. All perturbation is provided to historical records and you can develop a robust system.

"However, GCM has shifted mean and probability. That is a big issue."

"If you can use 25 percentile, all occurrence effectively change mean."

"That is expensive."

"It is an insurance issue. How much insurance do you want to pay? When we need to think system, we need define what level is the failure and what level is the problem."

"My comment is about engineering design. When you design a dam in which many people are living downstream, you have to take a very low risk factor; for example, a chance of million. There are potential catastrophic consequences of climate change we haven't got through yet. The best way of our research is to look at the low probability or catastrophic possibility. If we rule them out, so all problem becomes less problem. From a viewpoint of mankind, the expected value of the climate change in 50 years has a much smaller impact than future catastrophy."

"About the uncertainty of GCM, what is the priority in terms of society? For example, we have to balance cloud effects and land surface processes. But how? Prioritizing is very difficult.

"We have to support decision-makers and contribute to the society, but the answer is not the same. Politicians would like to pick up what they like. Decision maker's attitude is not beneficial to society as a whole. Politicians and society, including us, may not behave rationally. Even though catastrophic future is waiting, we may go for that direction.

In that case, if we really want to direct the society to certain direction, we have to very much concentrate on how to direct the society. We may be able to stimulate people to organize certain direction; this is beyond modeller's ability to direct society in a certain direction.

"What kind of data is our model based on? We have two types of data, small-scale data and large-scale data. They provide a contradictory basis for parameterization in a model. And, if you use a different scale parameterization, you obtain different results. And you obtain a definite policy oriented recommendation.

Then, our discussion was criticized by Dr. Morita;

"This kind of discussion was done 30 years ago. If we clarify the issues for environment and social requirements, we can reduce it to structure. It is not necessary to work in a precise model. Assessment of values shifts global modelling to a local integration model. We need to establish not only a global model but also be beneficial to regional climate.

In short, our climate model cannot be free from errors. So, it is very much important to find a way where we can abstract useful information from our models with limited certainty and add vales to them, which will be transferred to policy-makers. Finally, I will close this discussion by quoting Dr. Morita's comments;

"We strongly expect your progress. Especially, we strongly expect a reduction of climate model's error. But we have been waiting for last 10 years. We recognize it is difficult to reduce drastically model's uncertainty. So, our frontier of assessment is shifting from climate to regional assessment. If you provide more reliable information, our frontier will come back.

How to couple the heterogeneous sphere?

In order to make an Earth System Model, we have to couple many models in different spheres and different natures. How to do is a big and challenging issue. Complication is not the only way. Many people expressed their concern about losing our way in a "forest of complicated model". Several comments by the participants are listed below:

"We used to start from climate modelling. Now we include chemistry and start to include biology. My impression now is that we are ready to go. Land surface and its interaction with climate is non-linear interaction and it causes different results. So, how to parameterize this interaction?

"Vegetation is not a more complicated process than clouds. It can be treated statistically and parameterized.

“There exists a value of simple models. I think a simple model with a first order physics is essential.”

“What parameter or process is necessary depends on people to people.”

“I have a comment about an integrated model. Let’s think about one tree. When we start from a molecular biology, it becomes a huge model. Then, when we think about a forest, a huge and huge integrated model becomes necessary. Obviously, if you include everything, your model becomes too complicated. It is too complicated to understand and it is too complicated to calibrate. Try to look for the most important factor.”

“About simplicity and complexity, a more precise model can be applied to many fields. But, a realistic and precise model can be applied everything? A simplified model that abstracts the essential part is enough for 90% of the issues? Which should be combined to the integrated assessment?

“When we do coupling, something happens even though each model is working well. So be careful when we start coupling. We have to make a tactical decision, and we really ask ourselves, “Do we really need coupling?” We have to work to maximize productivity with minimum cost. Often people work to maximize cost with minimum productivity.”

Toward the future

Finally, the future way was discussed. Although many participants consider that the way toward the integral model is not easy, they agree that we should go toward that objective carefully;

“There are two types of integrated models; one is the interface between scientists and policy makers. This is important for society. It is a model to predict GDP and even though it is correct, it is necessary for policy. The other model is the integration of a heterogeneous sphere, meteorology, ocean and so on. This is the right way to science. Without biology, it is not the Earth. Chemistry is the interface between biology and physics, and integration of the sciences is the right way.”

“Integration of modelling is the right way but in the right fashion.”

“With respect to the limits of our brain, when we want to integrate components, we have to collaborate. Then, uncertainty becomes an issue. Politician needs a clear answer. The same thing happens between scientists in different fields. Clear answer from ecology is welcome and we may be attempted to give a clear answer, but we should be honest to give the right answer.

“For the last 5 years, the most significant change in the academic society to introduce an integrated assessment model is to encourage competition. Sometimes biological scientists criticize climate scientists, “You should work harder in order to reduce an uncertainty.”

“I would like to discuss the interaction with policy makers. They blame us for not reducing the uncertainty, but when science becomes advanced, it will becomes clearer who benefits and who loses. Once a better prediction becomes realized, politicians makes it impossible to reach an agreement. We should put emphasis on how to adapt a change and how to develop a technology.”

Finally, we have to recognize our responsibility to the society. One student pointed out;

“Scientists should teach people through conferences like this or publications. Even before reaching your conclusion or results, showing the way of your thinking helps us very much.

CLOSING

Prof. Matsuno closed this symposium by saying that “Now is the time for closing conference on how to integrate many aspects of the Earth environments and the Earth sciences. This is the first time to make this kind of symposium of many different fields of sciences. I was afraid that we could not exchange information, but now I am confident that people from different fields can communicate with each other and we can understand what is the present status of modelling and research in the Earth system sciences.

Finally, as many participants made an effort to provide a clear presentation, I would like to thank all participants, and also the members of the organizing committee. Lastly, I would like to thank the Toyota Motor Corporation for giving us this nice opportunity.”

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