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SPECIAL FEATURE: EDITORIAL

Integrated Climate Assessment: Risks, Uncertainties, and Society (ICA-RUS)

Integrated climate assessment: risks, uncertainties, and society

Seita Emori[1] · **Kiyoshi Takahashi**[1]

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Climate change caused by human activities mainly through increasing concentrations of atmospheric greenhouse gases (GHGs) is one of the major threats to the current civilization of humankind. Since the United Nations Framework Convention on Climate Change (UNFCCC) aiming at "preventing dangerous anthropogenic interference with the climate system" was established in 1992 (United Nations 1992), long-term goals of climate change mitigation in more concrete terms have long been discussed both scientifically and politically (Randalls 2010; UNFCCC 2015a). As the culmination of such discussions, a set of statements on long-term climate goals were included in the Paris Agreement which was agreed by the international community under UNFCCC in 2015 and came into force in the following year (UNFCCC 2015b). Namely, "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" was agreed. To be roughly consistent with this, to "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" is also stated in the agreement, which essentially means reducing net global anthropogenic GHG emissions to zero sometime between 2051 and 2100.

The ICA-RUS project ("Integrated Climate Assessment—Risks, Uncertainties and Society") was commenced in 2012 as a "Comprehensive Research on the Development of Global Climate Change Risk Management Strategies" S-10 Strategic Research Project supported by the Environmental Research and Technology Development Fund of the Ministry of the Environment of Japan, and finished its 5-year plan in March, 2017. It was an inter-disciplinary research project pulling together experts of climate science, impact assessment, energy economics, and studies on science and technology from various institutes and universities in Japan, aiming at assessing climate risks and ways to manage them in a systematic manner. Motivated partly by a reflection on the Fukushima nuclear crisis that Japanese society had experienced in 2011, just before we started the project, we framed the climate issue as a risk management problem at a global scale. From a risk management perspective, incorporation of a full range of uncertainties into decision making is required, which has not been successfully done in most of the discussions on climate goals so far (Mabey et al. 2011).

Research in the ICA-RUS project was undertaken in the following five themes: (1) synthesis of global climate risk management strategies; (2) optimization of land, water, and ecosystem uses for climate risk management; (3) identification and analysis of critical climate risks; (4) evaluation of climate risk management options under technological, social, and economic uncertainties; and (5) interactions between scientific and social rationalities in climate risk management.

This special feature is a collection of articles that present major outcomes from different themes of the ICA-RUS project. These articles, together with articles that were already published elsewhere, which are cited in the articles here, enable readers to explore a wide range of scientific findings and discussions developed in the inter-disciplinary research of ICA-RUS.

As an overview of the whole project, Emori et al. (2018) presents the overall conclusions from the discussion in ICA-RUS invoked by its inter-disciplinary research, following brief descriptions of the design and results of the essential parts of the assessment done in the project, in their article "Risk implications of long-term global climate goals —Overall conclusions of the ICA-RUS project—". They have concluded that, given the uncertainties in climate sensitivity, "net zero emissions of anthropogenic greenhouse gases in

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Handled by Dr. Osamu Saito, United Nations University Institute for the Advanced Study of Sustainability, Japan.

✉ Seita Emori
emori@nies.go.jp

[1] National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, Japan

the second half of this century" (the Paris emission goal) is a more actionable goal for society than the 2 or 1.5 °C temperature goals themselves. If the climate sensitivity is proven to be relatively high and the temperature goals are not met even when the net zero emission goal is achieved, the options left are: (A) accepting/adapting to a warmer world, (B) boosting mitigation, and (C) climate geoengineering, or any combination of these. They have claimed that this decision should be made based on a deeper discussion of risks associated with each option.

As a contribution form theme 1 (synthesis), Su et al. (2018) explores uncertainties involved in the assessment of emission pathways needed for achieving long-term global temperature goals through a set of systematic sensitivity experiments with the simple climate model SCM4OPT, which was used in the ICA-RUS project to synthesize emission and temperature scenarios. In their article "How do climate-related uncertainties influence 2 and 1.5 °C pathways?", they have evaluated emission pathways that are consistent with the Paris 2 and 1.5 °C goals while considering uncertainties in the carbon cycle and the climate system, and explored how such uncertainties will influence socioeconomic outcomes. Their results generally illustrate the significance of climate-related uncertainties in socioeconomic assessments of climate policies. For example, the climate-related uncertainties are expected to lead to a difference (17–83% uncertainty range) in the 2100 CO_2 emission levels of 20.5 $GtCO_2$ (− 1.2 $GtCO_2$ to 19.4 $GtCO_2$) for the 2 °C goal, whereas this difference is 12.0 $GtCO_2$ (− 6.9 $GtCO_2$ to 5.1 $GtCO_2$) for the 1.5 °C goal.

Negative emission technologies such as bioenergy with carbon capture and storage (BECCS) are regarded as an option to achieve the Paris goals. In their article "Estimating water–food–ecosystem trade-offs for the global negative emission scenario (IPCC-RCP2.6)", Yamagata et al. (2018) have assessed the impact of BECCS deployment scenarios on the land systems including land use, water resources, and ecosystem services, as a contribution from theme 2 (land–water–ecosystem nexus). They have shown that (1) a vast conversion of food cropland into rainfed bio-crop cultivation yields a considerable loss of food production; (2) when irrigation is applied to bio-crop production, the bioenergy crop productivity is enhanced, however, water consumption is doubled and this may exacerbate global water stress; and (3) if conversion of forest land for bioenergy crop cultivation is allowed without protecting the natural forests, large areas of tropical forest could be used for bioenergy crop production.

Evidence suggests that several elements (i.e., subsystems) of the Earth's climate system could tip into a qualitatively different state due to on-going and future anthropogenically-induced climate change. As a contribution from theme 3 (risk assessment), Iseri et al. (2018) have attempted to address the lack of scientific knowledge on such tipping elements by conducting several calculations under various policy choices based on target temperatures, in their article "Toward the incorporation of tipping elements in global climate risk management: probability and potential impacts of passing a threshold". Using two major tipping elements (Arctic summer sea-ice loss and Greenland ice-sheet melting) as examples, they have suggested that the probability of exceeding the threshold within this century is 24.8% for Greenland ice sheet and 2.7% for Arctic summer sea ice under the 1.5 °C temperature goal. They have also shown that the estimation of the potential global coastal exposure exhibited a large gap between the scenarios not exceeding the threshold (1.5 °C target) and those exceeding it.

As a contribution from theme 4 (response option assessment), Mori et al. (2018) have provided a quantitative assessment of technology options and policy measures by integrated assessment model simulations, in their article "Assessment of mitigation strategies as tools for risk management under future uncertainties: a multi-model approach". They have employed the multi-model approach to deal with the complex relationships among various fields such as technology, economics, and land-use changes. The models have contributed to the ICA-RUS by providing two information categories. First, the models have provided common simulation results based on shared socioeconomic pathway scenarios and shared climate policy cases to see the ranges of the evaluation. Second, each model has also provided model-specific outcomes to answer special topics, e.g., geoengineering, sectoral trade, adaptation, and decision making under uncertainties. In their article, they have also introduced a statistical meta-analysis of the multi-model simulation results to see whether the differently structured models provide inter-consistent findings.

As a cross-cutting topic across climate science and economics, Mori and Shiogama (2018) have discussed approaches to reduce uncertainties in global climate risk management in their article "The value of knowledge accumulation on climate sensitivity uncertainty—comparison between perfect information, single stage and act–then–learn decisions". Shiogama et al. (2016) have applied the Allen–Stott–Kettleborough (ASK) method (Allen et al. 2000; Stott and Kettleborough 2002) to estimate how quickly and in what way the uncertainties in future global mean temperature changes can decline when the current observation network of surface air temperature is maintained. Based on this expected reduction in uncertainties, Mori and Shiogama (2018) have revealed how accumulating observations helps to mitigate economic losses by expanding the existing Act–Then–Learn method to deal with the uncertainty eliminating process by ASK. They have found that (1) the value of information largely increases as the climate target policy is more stringent, and (2) even if the uncertainties in the equilibrium climate sensitivity are not fully resolved, scientific knowledge is still valuable.

In the last article, as a contribution from theme 5 (science and technology studies), "Interactions between scientific and social rationality: recommendation of an intermediate layer for transdisciplinary sustainable science", Fujigaki (2018) has analyzed how two different kinds of rationality—scientific and social—interact with each other with respect to the management of global climate change risks. It is easy to criticize dichotomy between facts and values and linear models in which the interaction between science and policy is conceived of as unidimensional, linear, and one-way: from science to policy. However, in actual interaction in transdisciplinary practice, these kinds of dichotomy and linear models still underlie the base of experts' thinking. To overcome these kinds of gaps between experts and citizens as well as between natural scientists and social scientists, she has recommended a discussion space as an intermediate layer between government, experts, and the public.

As widely recognized, the adoption and entry into force of the Paris Agreement are great achievements of humankind. However, we believe that they do not bring an end to the discussion of long-term climate goals. Even if the goals of different countries are summed up, the globally agreed reduction target remains unachievable; moreover, these individual country goals require further investigation. In addition, the rise of national particularism in some countries poses additional uncertainties to the Paris Agreement framework because it assumes international cooperation. This situation requires a continuous review of the long-term goals and risk decisions associated with them. We hope that the results from the ICA-RUS project presented here and from other similar research projects will provide a direction for continuing discussion.

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