Progress in Estimating Climate Change Impacts

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ABSTRACT

The assessment of potential impacts of climate change has progressed over time from taxonomies and enumeration of the magnitude of potential direct effects of climate change on individuals, societies, species, and ecosystems according to a limited number of metrics toward a more integrated approach that encompasses the vast range of human response to risk, perceived risk, and experience. Recent advances are both conceptual and methodological, and focus on analysis of some consequences of climate change that were viewed heretofore as intractable. This presentation will review a selection of these developments and represent them through a handful of illustrative cases. A key characteristic of the emerging areas of interest is a focus on understanding human responses to impacts and developing integrated approaches which assess impacts in an evolving socioeconomic and policy context.

1. Dynamic vulnerability

While climate impact analysis in some sectors, notably agriculture, has attempted to integrate human responses by accounting in part for the potential to adapt, such approaches have been marginal and particular, and unable to estimate the full interaction among humans, socioeconomic systems, and the climate. Ideally, impacts would be assessed in the context of development scenarios which capture vulnerability as an evolving feature rather than a static set of capacities and limits. Responses would also be dynamic, described as resulting from experienced-based perception of risk as well as "objective" risk. The latter is particularly important in situations where impacts are dominated by extreme and/or rare events, where uncertainty is large, and where learning is a critical determinant of response.

The SRES[1] represented a potential step in this direction. However, they were mainly used in impact analysis to determine a range of climate futures rather than the range of human responses. The emerging Shared Socioeconomic Pathways[2] may provide an improved basis for integrated analysis of impacts.

2. Mapping human responses and evaluating their indirect consequences

To date, impact studies have naturally tended to focus on the direct effect of changes in the physical climate system (including sea level). But some of the key impacts are indirect, arising from decisions stimulated by the initial physical changes, or expectation thereof. For example, it is well known that people migrate, sometimes temporarily, sometimes permanently, in response to unfavorable environmental changes, including climate.[3] These movements have the potential for large scale effects on natural resources, ecosystems services, and species. They are second order in the sense of being indirect but not necessarily in the sense of their magnitude[4].

For example, one recent study suggests that a potential relative shift in agricultural productivity in western South Africa compared to the eastern part of that country could encourage cultivation in regions now designated for protection for species conservation purposes[5]. Such indirect impacts may in some cases be larger than the direct consequences of the changing climate for the species at risk. While

ability to reliably quantify such responses runs into the limits imposed by regional modeling and downscaling, the same is true of the direct responses. On the other hand, modeling of some responses, like human migration[6] and the potential for large associated indirect impacts, is in its infancy, and this presents a key obstacle. But at the present time, it is at least possible to investigate which areas may become vulnerable because their relative attractiveness for cultivation or other economic activities is projected to increase. Other shifts in human settlement such as those driven by sea level rise could likewise bring about large scale indirect impacts.

Such impacts might fall under the category of action-at-a-distance, in the sense that a climate change in one region stimulates responses which have impacts on people and resources in another region(s). The potential number of such reverberations is large, including, for example via the interlinked global market system (discussed further in section 3, below).

3. Integration of impacts, adaptation, and mitigation (biofuels, geo-engineering)

It has long been known that adaptation actions bear consequences for mitigation strategies, e.g., projected increases in cooling and decreases in heating requirements bear implications for strategies to mitigated carbon dioxide emissions. A new focus is developing on the implications which mitigation actions bear for impacts and adaptation. For example, there is evidence that the conversation of unmanaged forest and cultivated land for the purposes of growing crops intended for bio-fuel feed stocks (encouraged in some instances by energy- and climate-related policy initiatives) could bring along substantial consequences for biodiversity and world grain prices, respectively[7]. A complex set of subsequent human responses would also result from the latter. These in turn would affect the initial mitigation actions by raising their cost and potentially undercutting political support for them.

A second emerging area of interest is geo-engineering, particularly short-wave radiation management, which is projected to produce significant, potentially harmful climate impacts far removed for the location of initiation of the mitigation actions[8]. Such impacts would not only result in various human impacts (via the water and agricultural sectors) and responses, but have the potential to feed back through the political system and affect judgments about the viability of this mitigation approach. Both of these examples illustrate the tightly couple nature of the mitigation-impact-adaptation system and the unavoidable necessity of understanding both political and economic consequences to adequately project future outcomes.

4. Interacting systems and stressors

Consideration of interacting stressors and systems[8] are not new to climate impact studies but just as with the topics above, a new emphasis is emerging which examines such interactions through the lens of human responses to general socioeconomic conditions as well as climate-related circumstances. Impacts of climate change evolve in the context of multiple additional environmental stressors including air pollution, water pollution, and the massive consequences resulting from urbanization and other concentrations of human population such as occur in deltaic and estuarine regions. In urban agglomerations, we see the potential increase in efficiency of use of some resources (energy), accompanied by the shifting of environmental natural resource exploitation to outlying regions (water withdrawal, food production). Interacting stresses include 1) the squeezing of an increasing population within a potentially shrinking land area (due to sea level rise), 2) the increasing health risk of a growing population subject to an increasing urban heat island effect, and 3) the increasing problems associated with water and solid waste disposal under conditions of increased heat and population density.

5. Extremes and disasters

Consideration of extremes and disasters provides an additional framework for understanding potential impacts, adaptation, and socioeconomic ripple effects. Much of the past climate change impacts research has focused on outcomes of changes in mean values of climate parameters. The difficulties entailed in attempting to account for changes in extremes include among others, the difficulty of projecting changes in many extremes, and the social and geographic specificity of conditions of vulnerability and exposure which combine with extreme physical events to produce extreme impacts and disasters.

The upcoming IPCC Special Report, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), is expected to provide new insights which should help define an emerging research agenda on such impacts. One noteworthy feature is the importance of the timing of events and their interactions, which can amplify the effects of both underlying trends in the mean climate as well as the effects of individual extreme events.

6. Methodological advances

As series of developments are gradually improving the ability to understand causation, to project future impacts and responses, and to permit a fuller risk management approach to impact assessment. Among these are advances in detection and attribution, further exploitation of methods commonly used in econometrics[9,10] , and probabilistic and multi-metric frameworks for evaluating risk.

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