CLIMATOLOGY BETWEEN SCIENCE AND POLITICS

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As pollution increases, it becomes more and more important to assess its impact on climate, in order to cope with the geopolitical consequences of large-scale environmental modifications. The need of a new scientific approach. Global warming is just a part of the story.

1. It has become widely appreciated that humans have an influence on the climate system. As a consequence scientists, political advocates, and policy makers are debating what sorts of policies make sense to implement related to climate change. The timing for such debates have been motivated by the disappointing results of the Kyoto Protocol process, which in any case, is focused only on the period leading to 2012 and was not designed to serve as a comprehensive solution.

But as debate on climate policies takes place, what has not been well appreciated is that decisions related to complex scientific issues often must be based on oversimplifications of the relevant science. Such oversimplifications are of course acceptable if the scientific shorthand nonetheless manifests itself in actions that lead to desirable societal outcomes. Climate science is incredibly complex, yet is at risk of being over-simplified in policy proposals in ways that creates risks for achieving desirable societal outcomes.

Under the Framework Convention on Climate Change the term ‘‘climate change’’ is defined as ‘‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability over comparable time periods.’’ This narrow definition stands in stark contrast to the broader definition used by the Intergovernmental Panel on Climate Change (IPCC), the United Nations group tasked with assessing climate science for policy makers, which states that climate change is “any change in climate over time whether due to natural variability or as a result of human activity.“

A narrow view of climate change may have been appropriate when the science was less well understood and greenhouse gases were thought to be the primary (and perhaps only) significant human forcing of the climate system. However, in recent decade there has been increasing recognition among many in the scientific community that the components of the Earth System are intimately connected, and that interactions extend from local to global scales. The recognition of the multiple interactions across space and time scales has led to a new interdisciplinary perspective, which promises to be an effective means to advance our understanding of the Earth System, and its human-caused and natural dynamics.

A consequence of a narrow view of climate science means that important scientific considerations – such as the role of land use effects on climate – may be overlooked in policy discussions. A narrow view may also distract attention from the need to improve adaptation to climate, particularly in developing countries.

2. Multi-decadal climate projections from global atmospheric-ocean circulation models have been the tools used by the International Panel on Climate Change (IPCC) to communicate expected weather conditions in the upcoming decades. Climate models are comprised of approximations of physical, biological, and chemical components of the climate system, expressed as mathematical formulations, and then averaged over grid volumes. These approximations are then converted to a programming language so that they can be solved on a computer and integrated forward in discrete time steps over the chosen model domain. To fully represent the earth system, a global climate model needs to include component models to represent the oceans, atmosphere, land, and continental ice and the interfacial fluxes between each other.

There are three types of applications of these models: for sensitivity studies, for diagnosis and for forecasting.

The application of climate models to improve our understanding of how the system works is a valuable application of these tools. In a sensitivity study, a subset of the forcings and/or feedbacks of the climate system may be altered to examine its response. Such a model of the climate system might be incomplete and not include each of the important feedbacks and forcings. Sensitivity studies can add significant value to scientific understandings, but because they are incomplete, they are not predictions or projections of the climate future. Most climate model studies are of this type, and their results are frequently mistaken as forecasts of the future.

In the second application of climate models, observed data is fed into the model, to produce a real-world constraint on climate data. The model is used to interpolate climate data at locations which do not have observed data.

Finally, the application of climate models to predict the future state of the climate system. Forecasts can be made from a single run of the model, or from an large number of runs which are produced by slightly perturbing the initial conditions and/or other aspects of the model. A set of model runs performed in this manner provides a sense of the confidence in the prediction from a single model run.

With these definitions, how should we think of today’s generation of leading climate models, such as those used by the IPCC? Since the global atmospheric-ocean circulation models do not contain all of the important climate forcings and feedbacks, the models results must not be interpreted as forecasts. Since they have been applied to project the decadal-averaged weather conditions in the next 50-100 years and more, they cannot be considered as diagnostic models since we do not yet have the observed data to insert into the models. Therefore, such climate models are more appropriately described as sensitivity studies. Too often climate models are described as predictions or projections of the future, which can be misleading. Such models can provide important information about how the climate system works, but should not be expected to accurately predict the climate in the coming decades.

Indeed, with respect to multi-decadal climate projections, as we increasingly recognise the diverse, multiple types of influences on the global climate system, accurate forecasts of future global and regional climate become increasingly more challenging. No climate change model even includes all of the important forcings and feedbacks.

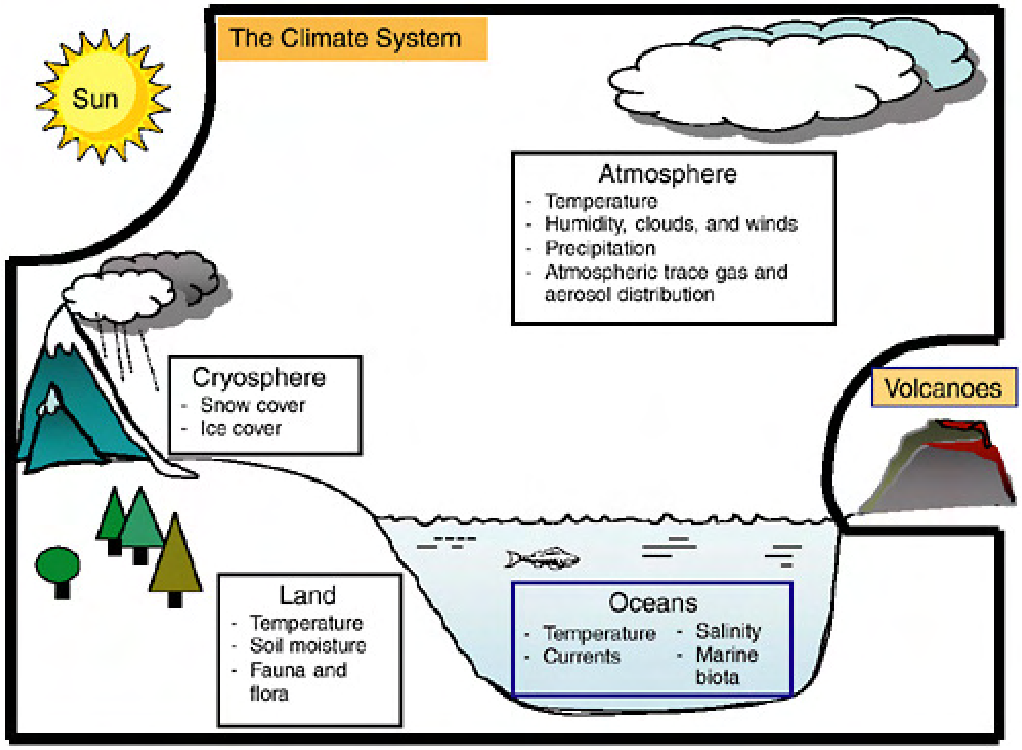
A 2005 National Research Council Report entitled “Radiative forcing of climate change: Expanding the concept and addressing uncertainties” identified important human climate forcings that have been ignored so far or are very poorly understood. These include the effects on the climate system of land use/land cover change, the biogeochemical effect of the human input of carbon dioxide and nitrogen compounds, and the effect of aerosol clouds from vehicular, industrial and agricultural activity. These climate forcings can significantly alter the regional structure of spatial heating and cooling, even in the absence of a global warming effect.

A recent study by J. Feddema and colleagues entitled “The Importance of Land-Cover Change in Simulating Future Climates“ found, for example, that global modeled regional temperature and precipitation patterns in the coming decades were substantially different depending on the human management of the landscape in the coming decades. Similarly, the effect of the human emissions of non-greenhouse gases and aerosols will also have a major effect on regional temperature and precipitation patterns. These effects are in addition to the effects of carbon dioxide emissions.

3. Significant weather events occur on the regional scale and are not evident in a global average surface temperature. Droughts occur in one region, while floods could occur just a few hundred kilometers away. Important influences on regional climate can originate in human activity.
For example, changes to the land surface, such as from urbanization or deforestation, can change patterns of atmospheric heating over these landscapes. This necessarily alters the regional pressure fields and thus the wind pattern. This pressure and wind pattern then affects the pressure and wind patterns at large distances from the region of the heating. Thus regional climate forcings can affect weather not only where the forcing occurs but at long distances from the source of the climate distrubance.

The use of a global average surface temperature trend to assess global warming is an incomplete climate metric. Around 90% of the heat changes in the climate system occur in the oceans. The surface temperature is a poor measure of the accumulation of heat in the oceans. Indeed, over the last decade or so, most of global warming has occurred through depth in the mid latitude oceans of the Southern Hemisphere, for reasons that have not been replicated by the global climate change models. In addition, methane, carbon aerosols and other climate effects play a more important role in global warming than previously thought.

To complicate the issue even further, global warming is only one component of climate change. It is the alteration of atmospheric and ocean circulations as a result of the diversity of climate forcings which have a larger impact on the climate that we experience. The climate forcing of land-use/land-cover change is just one example of such a climate forcing. With regional climate forcings, there are large regional changes which determines whether a region warms or cools, and becomes wetter or drier over time. This can occur even with little or no global average heat changes. We can see the importance of atmospheric circulation changes, for instance, in hurricane tracks. Whether the USA is pummeled by landfalling hurricanes such as Katrina or recurves offshore depends on the regional tropospheric wind field not a global average surface temperature trend. Global warming is just one aspect of a much more complicated environmental issue.



The climate system, consisting of the atmosphere, oceans, land, and cryosphere. (From National Research Council, 2005: Radiative forcing of climate change: Expanding the concept and addressing uncertainties.)

4. To accommodate the large uncertainty in accurately predicting the climate in the coming decades, a focus on global climate models should be complemented with an approach focused on first assessing key societal and environmental vulnerabilities. An example of such an approach is in understanding how population growth and climate change predicted by multi-decadal global climate prediction models combine to pose threats to water resources in semi-arid and arid regions. Charles Vorosmarty and colleagues found that future population growth creating additional demands for water is more important than changes in precipitation as projected under a range of climate

scenarios.

Efforts to modulate the future climate via greenhouse emission reductions can only address a portion of the expected future risks to water resources and escalating tropical cyclone damage. These comparisons, of course, do not mean that human-caused climate change is not a risk, but that responses to climate-related impacts necessarily must focus on a broader range of policy options than only greenhouse gas emissions.

To accommodate the perspective that the Earth System, including the climate, involves complex forcings and interactions across space and time scales requires us to be more inclusive in the involvement of the diverse communities performing climate and environmental change research, and to elevate interdisciplinary scientists to leadership roles in these communities.