In the wake of Paris Agreement, scientists must embrace new directions for climate change research

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At each Conference of Parties (COP), scientists hand over the climate change problem to diplomats and policymakers. A COP also offers scientists a chance to take stock of their research, confront emerging policy questions, identify research gaps, and update their research agendas. We, as an interdisciplinary group of academic experts who have been providing independent insights to the COP21 French presidency and negotiation team (1), have seen not only the importance of science in policymaking but also its limitations and sometimes its lack of alignment with the complex environmental and societal issues addressed in the negotiations. Here we analyze research gaps and identify new directions of research in relation to a number of facets of the Paris Agreement, including the new 1.5 °C objective, the articulation between near-term and long-term mitigation pathways, negative emissions, verification, climate finance, non-Parties stakeholders, and adaptation.

The Paris Agreement has sealed several concrete achievements, in particular the introduction of a five-year submission cycle for nationally determined contributions (NDC), which spells out voluntary short-term domestic climate policies and the generalization of a measurement, verification, and monitoring (MRV) system to all parties. Another objective is to increase finance flows "towards low greenhouse gas emissions development" (2). These and other measures aim to encourage "holding the increase in the global average temperature to well below 2 °C" and call for "pursuing efforts to limit the temperature increase to 1.5 °C above preindustrial levels" (2). Furthermore, the agreement invites the Intergovernmental Panel on Climate Change (IPCC) to provide a special report in 2018 on the impacts of a global temperature rise of 1.5 °C above preindustrial levels and global greenhouse gas emission pathways leading to this new objective.

A Controversial 1.5 °C Objective

However, the agreement has left in its wake numerous complex issues with which scientists and policymakers must wrestle. For example, the 1.5 °C objective offers contradictory perspectives that may be difficult to reconcile, and hence may divide the scientific community. Diverging short-term interests among signatory countries, socio-economic barriers to changes, and technological lock-ins in energy systems question the feasibility of such a goal. Furthermore, this 1.5 °C objective may distract the community from focusing research efforts on

The Paris Agreement is an admirable first step, but scientists must come to terms with its research and policy implications. Image courtesy of Flickr/jmdigne.

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the risks and impacts of more severe warming scenarios between 2 °C and 4 °C. These scenarios are more likely to happen than the 1.5 °C, and require adaptation measures planned well in advance. Focusing on a 1.5 °C scenario also constitutes, some argue, a form of hypocrisy, sustaining false hope from the public and most vulnerable countries.

Although achieving a 1.5 °C objective may appear as a lost cause, it can nevertheless be seen as a necessary baseline for climate negotiations (3). There is also an ethical issue in play: it is certainly too early in climate negotiations to accept the destruction of low-lying islands and other regions that may not be capable of adapting to warmer conditions. Finally, we must acknowledge that technological progress, together with efforts from all stakeholders and widespread changes to individual behaviors, could bring enough mitigation to effectively bridge the gap to the 2 °C—if not the new 1.5 °C—objective.

Indeed, the Paris Agreement does not specify a date for the long-term goal, opening the possibility for overshoot scenarios, whereby global warming would exceed 1.5 °C or 2 °C before being driven down via negative-emission technologies. In this view, there is a real risk that such technologies will meet constraints that strongly limit their large-scale deployment (4, 5); as a result, they would not deliver the hypothesized greenhouse gas mitigation in the second half of the century. The continued development and effective deployment of these technologies cannot occur without a strong political drive, as well as sustained research and development efforts.

What synergies and trade-offs exist with other policy goals (including development, poverty alleviation, air quality, energy security, and employment)? Such analyses are necessary to understand how ambitious climate policies can strive to be.

To gain credibility, scenarios compatible with the 1.5 °C or 2 °C objectives will have to identify all potential innovations—whether incremental or disruptive, social or technical—and consider the many barriers involved in curbing emissions. Achieving such pathways will require transformational changes in human behavior and economic production, arguably carrying profound geopolitical implications. A massive reliance on bioenergy, for example, could have important consequences on water resources and food security. Such pathways will have to be considered in a systemic way, beyond the usual model assumptions of rapid and optimal deployment of solutions for greenhouse gas emissions reductions.

In any case, the research effort to reduce uncertainties on the magnitude of the response of the climate system to greenhouse gases should not be diminished, as possible 21st century greenhouse gas emissions pathways depend strongly on it.

Reconciling Short- and Long-Term Visions

A number of analyses, including that of the United Nations Framework Convention on Climate Change secretariat (6) and the United Nations Environment Programme Gap Report (7), have estimated that current intended NDCs will place 2030 global emissions well above emissions trajectories compatible with the 2 °C objective. This estimate is acknowledged in the COP decision, which notes "with concern" that "much greater emission efforts will be required than those associated with the intended NDCs in order to hold the increase in global temperature to below 2 °C" (2). There is, therefore, a pressing need to reconcile the long-term global 2 °C objective with the short-term national objectives. The Paris Agreement therefore calls for a dual articulation of efforts across the space and time dimensions.

Research should focus on both the short-term effects of planned policies centered on greenhouse gases emissions abatement, as well as their long-term implications. Emissions reductions imply socio-economic transformations that need to be made explicit (8): What might be the role of different mitigation wedges, including those that have been understudied such as improved urban planning or behavioral changes? What socio-technical challenges will come about because of the high rate of changes (e.g., on stranded assets in the energy sector) and how can they be addressed? How should the needed policies and measures be financed and by whom?

Managing terrestrial carbon sinks, as put forward in the intended NDC of some countries, is another way to achieve mitigation. The rate of carbon uptake by vegetation and soils varies between regions, fluctuates over years in response to climate variations, and may have slightly weakened over the last 50 years (9). The short- to long-term potential for carbon sequestration in (natural and managed) ecosystems remains uncertain, and models currently fail to produce a consistent story about the future efficiency of carbon sinks as climate change proceeds (10). This calls for a better description of land-use management in Earth system models and further improvement in their explanatory and predictive capability of the carbon cycle.

From Global to Local and Back

Research efforts must decipher to what extent national scenarios build on plausible future international contexts and whether global scenarios are integrating realistic national priorities (11). Hence, national and global models and scenarios have to be made consistent with one another. Doing so would allow policymakers to check the consistency of NDCs, understand their interlinkages (through explicit dependencies in national or regional policies, such as emission trading schemes, technology transfers, trade, and capital flows), and potentially identify levers to raise their collective ambition. This analysis is particularly important for energy-exporting nations in the context of a transition to a low-carbon world economy.

An innovative feature of the Paris Agreement is that it recognizes the crucial role of "non-Parties stakeholders," including the private sector and subnational authorities. This feature drastically widens the scope of relevant research for social and economic sciences. First, studies on development strategies could analyze the macroeconomic implications (in terms of, for example, growth and employment) of a "New Climate Economy" that achieves prosperity while also addressing climate change (12). Second, research on the role of low-carbon technologies could help identify new innovation strategies for companies of all sizes (13).

Furthermore, the role of local, state, and regional governments should be taken into consideration. In many cases, managing low-carbon solutions depends on local authorities' abilities to design appropriate systemic solutions, such as in urban planning and public transportation. Mitigation actions at the local level may also trigger important cobenefits in terms of adaptation, as well as specific capacities to limit climate risks and other social and environmental risks.

Transparency and Verification

Comparing the intended NDCs from countries to emission inventories and pathways available in academic studies leads to more questions than answers regarding data sources, quality, and accounting methods. Extending to non-Annex 1 countries the obligation to submit appropriate national greenhouse gas inventories in line with IPCC guidelines will generate a more transparent and accurate emission dataset at the national scale. However, transparency should not be seen merely as a technical issue, but also as a full-fledged research topic both in natural and social sciences.

In the social sciences, the cost/benefit of an increased effort to strengthen MRV needs to be carefully assessed: higher MRV stringency can be detrimental if they hamper possible mitigation actions (14). In practice, MRV rules adopted in actual climate-mitigation mechanisms strongly influence the cost efficiency of MRV (15). Designing rules that optimize resource allocation in MRV is therefore paramount.

In the natural sciences, reducing uncertainties in greenhouse gases sources and sinks—especially for non-CO_2 gases and soil carbon in the sector of agriculture, forestry and other land use (16)—should be a high priority. In particular, estimates of soil carbon content and its variations are very uncertain. New and future CO_2 measurements offer opportunities for source and sink inversion methods combining bottom-up (statistical data) and top-down (atmospheric) approaches (17).

Beyond Emissions

Reduction in greenhouse gas emissions is the final outcome of a mitigation policy, which takes time to achieve. The urgency of climate action calls for verification procedures to be broadened to structural changes and other early indicators of climate policies (such as investment and financing). This verification would allow checking that the Paris Agreement measures, with regard to finance flows, effectively contribute toward low greenhouse gas emissions development. More regular and intercomparable ex post assessments of climate policies will be needed to provide critical information on which policy is more effective, so that countries can learn from each other on how to best implement and monitor their climate policies.

Finally, the Paris Agreement underscores the importance of climate change adaptation policies with substantial funding mechanisms. Approving and prioritizing such adaptation undertakings will require robust climate science on regional climate change and impact assessment, with improved global climate simulations and downscaling techniques. This will involve a better understanding of regional climate variability, and disentangling the role of climate change and other drivers for changes. It also requires assessing synergies between adaptation to climate change and increased resilience to natural climate variability and other stresses.

In conclusion, the Paris Agreement not only calls for further disciplinary research but also for an increased capacity of the scientific community for interdisciplinary work on multiple scales. The need to better estimate the magnitude of the climate response to greenhouse gases, and its regional aspects in relation to adaptation strategies, cannot be overstated. Research in social and economic sciences rely on three paradigms: the use of Integrated Assessment Models, the development of national de-carbonization scenarios, and the production of sectoral or community level "innovation-for-transition" studies that are applied jointly to climate governance at international, regional, national, and subnational levels. Finally, the need for transparency and verification will require research to improve regulatory design.

The Paris Agreement is an admirable first step. But in order for the deal to have a long-term impact, scientists must come to terms with its research and policy implications, and pursue all aspects of this massive challenge.

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