Communicating the Needs of Climate Change Policy Makers to Scientists

Molly E. Brown, Vanessa M. Escobar and Heather Lovell

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/50607

1. Introduction

In the confusion of the national conversation on climate change issues, a clear and explicit narrative can help cut through the chatter. Science can provide information to improve societal outcomes by focusing debate and guiding policy in ways that are transformative. The science that is done to support climate change policy, however, must be focused and relevant. The purpose of this chapter is to suggest ways that policy and decision-maker needs can be communicated to scientists working to improve understanding of processes, relationships and products in climate change science. A partnership between science and policy must be forged at multiple levels and at many time scales in order to be effective. Many organizations are developing programs that seek to increase the relevance of its science and data products to decision makers grappling with science, influencing not only the scientific questions that are asked, but also the format, resolution and scale of the data output. It is only through two-way communication and relationship building can effective partnerships be built that will help policy makers have the scientific foundations they need.

This chapter will describe the challenges that earth scientists face in developing science data products relevant to decision maker and policy needs, and will describe strategies that can improve the two-way communication between the scientist and the policy maker. Climate change policy and decision making happens at a variety of scales – from local government implementing solar homes policies to international negotiations through the United Nations Framework Convention on Climate Change. Scientists can work to provide data at these different scales, but if they are not aware of the needs of decision makers or understand what challenges the policy maker is facing, they are likely to be less successful in influencing policy makers as they wished. This is because the science questions they are addressing may be compelling, but not relevant to the challenges that are at the forefront of policy concerns.

In this chapter we examine case studies of science-policy partnerships, and the strategies each partnership uses to engage the scientist at a variety of scales. We examine three case studies: the global Carbon Monitoring System pilot project developed by NASA, a forest biomass mapping effort for Silvacarbon project, and a forest canopy cover project being conducted for forest management in Maryland. In each of these case studies, relationships between scientists and policy makers were critical for ensuring the focus of the science as well as the success of the decision-making.

1.1. Background

Meeting the needs of decision makers requires a transformational change in how environmental research is organized and incorporated into public policy in the United States (NRC 2009). Although there has been much discussion in the literature on the need for scientists to clearly and accurately discuss their results (Pettricrew et al. 2004), little attention has been paid to how to communicate to scientists the needs of the policy community. The information needs of decision makers, and how they use scientific information needs to be clearly presented and communicated to scientists so that they can do the necessary research and focus on the processes that are truly important to society.

Increasing the usage of evidence in policy-making therefore requires that scientists increase their understanding and engagement with these organizations and individuals (Jones and Walsh 2008). By making explicit and testing the assumptions underlying the way a policy is supposed to work, researchers can identify additional questions for which existing empirical evidence can be sought. In this way, sequences of evidence can be gathered and accumulated to provide a rounded and appropriate evidence base for decision-making (Davies 2005).

As scientists we need to publish our results in multiple venues, including those where policy makers can find and understand our results. A researcher can greatly increase the likelihood that their results will be used and will influence climate change policy by documenting their research findings in clear, detailed and uncomplicated writing. Policy makers and other users of research evidence are usually quite aware that the scientific issues surrounding policies are complex (Davies 2005). However, the transformation of technical language used in scientific reports into user-friendly terms is worthwhile, but often requires a two-way conversation between the policy maker and the scientist to ensure the relevance of the science.

It has also been argued that researchers would help policy makers use research evidence more effectively if they could identify, report and present the key findings with greater clarity. Involving policy makers and other research users throughout the research process, and identifying the implications for policy and practice, might also enhance the utilization of research evidence in policy making (Davies 2005). In the end, in order to be relevant to policy and decision makers, scientific conclusions need to be important to the known users and relevant throughout the development process. The outcomes not only need to have a societal impact but in order to be relevant they must also be financially feasible

Scientific research, which is often not bound by time constraints, is difficult to integrate with the time sensitive demands of politicians who are compelled to work under tight deadlines to produce short- term, tangible policy results. However, policy-makers often struggle to stay apace of new scientific thinking, especially in terms of developing relevant policies and infrastructure to enable as well as regulate the implementation of scientific and technological advances (Alcock 2002). Fostering an ongoing, interactive relationship between the two communities, and clearly addressing each groups' sensitivity to implementation, quickly lessen these issues.

In addition to this valuable range of practical issues related to the climate change/science-policy interface, there are a number of academic studies that are useful to consider in terms of their insights into the relationship between science and policy (Jamison 2001; Jasanoff et al. 1995; Litfin 1994; Wynne and Irwin 1996), as well as the nature of the policy process (in particular how policy change takes place) (Kingdon 2003; Sabatier 1999; Smith 1997). One finding from these studies which is pertinent to the work of NASA and our specific case studies discussed below, is that the process of policy change, much like science, is uncertain and tends to be 'bumpy'; characterized by long periods of stability with little change or progress, interspersed with times of rapid innovation and upheaval of established ideas and ways of doing things (whether it be in the laboratory or in political debating chambers). In literatures on policy change and science innovation this pattern of change has been termed 'punctuated equilibrium' (John 2003; Phillimore 2001; True et al. 1999). The relevance of this insight for the role of NASA (and science more generally) is in conceptualizing what NASA and other science agencies do as *providing the science base for policy*. In other words, the science findings from NASA studies might well not provoke rapid immediate change in policy (sometimes this does happen, but it is rare), but rather that these findings will be there and available to policy makers as a 'solution' as and when a particular policy problem arises that demands them.

The work of the US political scientist John Kingdon (2003) eloquently explains this matching of policy problems and solutions in his book 'Agendas, Alternatives and Public Policies'. In his discussion of 'the policy primeval soup' – his metaphor for describing the chaotic nature of policy in which a messy mix of policy problems, politics and solutions floats around US government chambers and policy circles - Kingdon explains how a policy problem is much more likely to rise on the government agenda if a solution is already there and worked out, as he explains (2003: 142):

"It is not enough that there is a problem, even quite a pressing problem. There is also generally a solution ready to go, already softened up, already worked out."

Thus the role of climate change science is to engage with government, to be part of the 'policy primeval soup', but also to work to provide science-based solutions to current policy problems as well as emerging future problems, which are as yet only hazily defined. It is with this in mind that we turn to consider our case studies:

three different projects are examined that seek to bring together policy and decision makers with scientists working to do relevant science. In each project, the challenges scientists face are different, but the solution of increased interaction, product clarification and connection between the users of science and the producers, is the same.

2. Case study 1: NASA's Carbon Monitoring System

In 2007 the US National Research Council released the first earth science decadal survey report recommending “a suite of satellite missions and complementary activities that serve both scientific and applications objectives for the nation” (NRC 2007). The report presented a vision for developing new satellite data products that have specific user communities’ needs and requirements at the forefront of the mission development. Meeting this objective will require a transformation of the way that NASA traditionally does business. The NASA Carbon Monitoring Systems initiative is meeting this objective by re-evaluating priorities and integrating the local needs of society into the development of carbon science products. Two of the NRC report’s priorities over the next decade are (1) to develop the science base and infrastructure to support a new generation of coupled Earth system models to improve attribution and prediction of high-impact regional weather and climate; and (2) to strengthen research on adaptation, mitigation and vulnerability. The Carbon Monitoring System CMS project addresses both of these issues with a consortium of end users and policy decision makers.

2.1. NASA’s Carbon Monitoring System pilot project

The Carbon Monitoring System (CMS) is a NASA initiative designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks. The study uses satellite observations and model outputs to calculate human produced carbon dioxide (CO^2) while discussing effective delivery mechanisms with policy bodies such as the Environmental Protection Agency (EPA), the US State Department and others.

NASA CMS conducts pilot studies to provide information across a range of spatial scales that seeks to improve measures of the atmospheric distribution of carbon dioxide. NASA has initiated this work by building on its global measurement capability for carbon. Other agencies and organizations have ongoing activities that are related to CMS that support national carbon policy objectives and resource management, most notably the National Oceanic and Atmospheric Administration (NOAA)’s Carbon Tracker program and the US Geological Survey’s carbon sequestration efforts, and National Institute for Standards and Technology’s Greenhouse Gas Measurements and Climate Research Program. Thus coordination across these and other climate programs is critical to ensure long-term utility.

Emissions from vegetation disturbance and land-use and land-cover change are the most uncertain component of the global carbon cycle (Prentice et al. 2000). The CMS pilot project is designed to address the urgent need for geospatially explicit, observed (not modeled) carbon and biomass inventory information to inform national and international policy-making. The project addresses two objectives: 1) to develop prototype data products of national and global biomass (carbon storage and emissions) that can be assessed with respect to how they meet the nation's needs for Monitoring, Reporting, and Verification (MRV) of carbon inventories; and 2) to demonstrate our readiness to produce a consistent global biomass/carbon stock distribution using the existing in situ and satellite observations to meet the MRV requirements (Pawson and Gunson 2010).

The CMS flux pilot involved multiple institutions (four NASA centers as well as several universities) and over 20 scientists in their development. This pilot study strives to use complimentary models to transform satellite-derived observations into quantities that are both meaningful and useful for carbon cycle science and policy. The CMS pilot will generate CO^2 flux maps for two years using observational constraints in NASA's models. Bottom-up estimates (the movement of carbon dioxide from the land surface to the atmosphere) of the CO^2 flux will be computed using data-constrained land and ocean models; comparison of the different techniques will provide some knowledge of uncertainty in these estimates. Ensembles of atmospheric carbon distributions will be computed using an atmospheric general circulation model (GEOS-5), with perturbations to the surface fluxes and to transport. Top-down flux estimates (absorption of carbon dioxide by plants on the land from the atmosphere) will be computed from observed atmospheric CO^2 distributions and model retrievals alongside the forward-model fields, in conjunction with an inverse approach based on the CO^2 model (Figure 1). The forward model ensembles will be used to build understanding of relationships among surface flux perturbations, transport uncertainty and atmospheric carbon concentration. This will help construct uncertainty estimates and information on the true spatial resolution of the top-down flux calculations. The relationship between the top-down and bottom-up flux distributions will be documented (Pawson and Gunson 2010).

Because the goal of NASA CMS is to be policy relevant, the scientists involved in CO2 flux modeling pilot need to understand and be focused on the needs of the climate policy community. How should the data be presented? What analysis of the data would be most useful for policy makers? What is the time scale of the information needed by decision makers (daily fluxes, annual, 5-year)? What is the optimal spatial resolution of these products? What is the needed accuracy of the information? If the answers to these questions are communicated to scientists working on the pilot study, it is more likely that the project will be relevant and produce the answers that are needed by policy and society.

2.2. Policy and NASA's CMS System

Because of its ambitious goal to produce products relevant to policy, NASA has organized meetings between policy makers, decision makers and CMS scientists to ensure that the data products being developed are relevant and responsive to the needs of policy makers. In September 2011, a meeting between in Washington D.C. NASA CMS flux scientists and local DC policy decision makers provided an overview of the status of the NASA CMS flux pilot and data products under development, and provided a forum to discuss how to better characterize uncertainty in CO2 measurements. The focus of the meeting was to ensure that the data is able to meet the needs of other agencies and organizations engaged in flux measurement and monitoring. Early product development conversations such as this will enable NASA to generate better overall products in support of agency needs. Much of the discussion during the CMS flux meeting focused on how the CMS pilot products could contribute to US carbon policy and decision making.

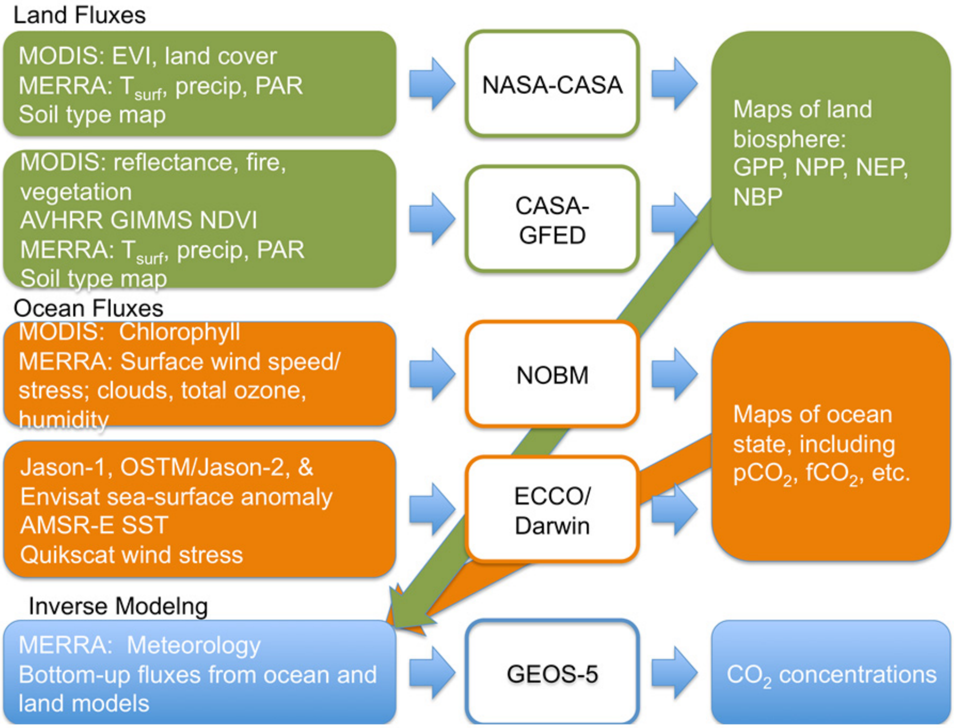

Figure 1. NASA Carbon Monitoring System Flux project data inputs, outputs and connections.

The CMS flux products are based on satellite observations of land, ocean, and atmosphere, as well as CO2 concentrations. The CO2 flux estimation that can be attributed to a specific location on the ground and could complement Global Climate Models and direct CO2 atmospheric observations. Were a mitigation policy be put into place, decision makers would need a mechanism to know if the policy was making an impact.. The CMS effort will be able to provide information on the underlying emissions irrespective of whether a policy intervention requires voluntary or mandatory actions. NASA can work to ensure that CO2 models are used with observations from satellite observatories to provide information on the success of mitigation efforts.

In order to make a difference with climate policies, we need to know CO^2 trends through time. Sustained observational monitoring is necessary for carbon management. NASA is well positioned to do this task and no one else has this job in the federal government. There is a significant need for scientific infrastructure to determine if regulations and policies put in place (on the local, state and federal levels) are making a difference. This need for scientific infrastructure is usually forgotten. It is difficult to fund because it is perceived as unimportant and requires continuous support, despite it being at the center of effective programs and policies. However the NASA's engagement between scientists and end users is designed to remind society of the relevance of scientific structure. NASA CMS will provide a key to better understanding what such a system will looks like. CMS will enable us to estimate the impacts of our policies through the use of satellite observations. We need to ensure that the resolution, time step and uncertainty of the CMS CO^2 flux product are adequate for these needs-keeping an open line of communication with the scientist will be necessary for a developing a successful product.

Through briefings and presentations at meetings, scientists involved with CMS have learned about policy maker needs. This knowledge will affect how the CMS project moves forward. Questions regarding next steps in the project, such as working to improve the spatial resolution or to improve the fidelity of ocean models, for example, can be decided with policy objectives in mind. This is important, as the group working on CMS flux models is large, interdisciplinary, and is fundamentally interested in producing an output relevant to policy makers.

3. Case study 2: Mapping the forests for REDD

In 2010, the United Nations climate negotiations launched the Reducing Emissions from Deforestation and Forest Degradation (REDD) program. REDD is an effort to create a financial value as an incentive for the carbon stored in forests, offering developing countries environmental and financial benefits to reducing emissions from forested lands and invest in low-carbon paths to sustainable development. The REDD program goes beyond deforestation and forest degradation and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Silva Carbon is the United States Government's contribution to the REDD methods through the GEO Forest Carbon Tracking task, a component of the Global Earth Observation System of Systems (GEOSS), which provides data and information about a variety of Earth observations to users around the world. The program is designed to strengthen global capacity to understand changes in land cover and monitor and manage forest and terrestrial carbon.

The United Nations is setting up systems of Measurement, Reporting and Verification (MRV) of forests in order for countries to benefit from the United Nations treaty. Thus countries will need to develop cost-effective, robust and compatible national monitoring systems. The REDD agreement defines MRV as:

- Measurement – The process of data collection over time, providing basic datasets, including associated accuracy and precision, for the range of relevant variables. Possible data sources are field measurements, field observations, detection through remote sensing and interviews with stakeholders.
- Reporting – The process of formal reporting of assessment results to the United Nations Framework Convention on Climate Change (UNFCCC), according to predetermined formats and according to established standards.
- Verification – The process of formal verification of reports, for example, the established approach to verify national communications and national inventory reports to the UNFCCC.

Understanding of how ground information can be used in conjunction with aerial measurements of forest height and canopy, together with satellite remote sensing data, is central to REDD and will influence the research that scientists are doing. It is no longer enough to be developing new models or to do novel, publishable research. REDD set a standard to be 'cost effective, robust and compatible'. Knowing this, how do scientists working on methodological approaches to map biomass engage with the REDD countries and process to ensure that they can meet this standard? How do they simultaneously engage with REDD, progress in their own careers and publish the work that they do?

3.1. Biomass mapping and REDD

Accurate and precise quantification of the amount of biomass in forests has become a key issue for policy makers as it is a key requirement of REDD for climate mitigation strategy. Active aerial instruments measuring the height and structure of vegetation (using lidar and radar observations) will quantify carbon stock and changes, improve our knowledge of the geographic distribution of carbon sources and sinks, and help us understand where carbon is being sequestered in the landscape. The distribution of biomass and carbon storage produced from the existing remote sensing and in situ measurements will provide sub-optimum, but necessary information to develop national and international scale REDD policies and MRV frameworks (Goetz et al. 2009).

The NASA contribution to Silvacarbon and REDD is a biomass mapping project designed to address the urgent need for geospatially explicit, consistent carbon and biomass inventory information to inform national and international policy. The project will address two objectives: 1) To develop prototype data products of national and global biomass (and carbon storage/emissions) that can be assessed with respect to how they meet the nation's needs for MRV of carbon inventories; and 2) to demonstrate our readiness to produce a consistent global biomass/carbon stock distribution using the existing in situ and satellite observations to meet the REDD monitoring, reporting and verification requirements (USAID 2011).

Biomass mapping can be the basis of a tool that could be used by investors to target REDD projects. Land cover and carbon density maps can be used together with information on agriculture and opportunity costs of land. This is especially relevant in addressing the needs of developing countries who have tropical forests and would like to have an MRV capacity, thus capturing REDD funding. This has resulted in the US government's development of the SilvaCarbon program. This program focuses on enhancing the scientific capacity of countries worldwide to map and monitor biomass in forests. SilvaCarbon will draw on the scientific expertise of the U.S. scientific and technical community including experts from government, academia, non-governmental organizations, and industry (USAID 2011). Working with developing countries and international institutions, SilvaCarbon works to enhance scientific capacity by identifying, testing, and disseminating good practices and cost-effective, accurate technologies for monitoring and managing forest and terrestrial carbon.

3.2. Communication challenges between scientists and decision makers

Organizations and government agencies are actively working to adjust to conservation in the context of REDD standards, which may take five to ten years to implement. Bilateral and multilateral agreements are now in place and currently giving developing countries money to be part of REDD. The question is how to make biomass-mapping part of the policy discussion here in the United States. Research, communication and relationships must be forged in a way that provides a metric for producing affordable, repeatable measurements that are spatially explicit.

We need large-scale datasets that have some defensibility, with clear estimation of the uncertainty of the data both in space and in time. For Silvacarbon, the social and economic factors that affect the success of a REDD program are uncertain, so improved ways of calculating biomass as well as better data acquisition methods are important. Each country will need to be able to implement the methodology for biomass monitoring at the country scale

In order to connect policy makers to scientists, the U. S. Geological Survey (USGS) and REDD hosted international scientists at a SilvaCarbon Workshop in September 2011. Scientists received satellite data and training for the data, which applied to their areas of study, while policy makers had the opportunity to explain the challenges they face in implementing REDD globally. A big part of this challenge was the spatial uncertainty that is due to different land histories and species contribution. Many biomass mapping methodologies do a poor job of estimating uncertainty, which affects the broader policy and program implementation. Thus new science that is done, seeking to be REDD relevant must use older technologies that are inexpensive and develop models that are rigorously tested, but simple to implement. The workshop provided improved communication on the technological and scientific needs, and ensure that they were relevant to the MRV requirements of countries involved in REDD. Linking satellite observations to measurements taken from the ground and from independent instruments on airplanes is another strategy that can lead to new, inexpensive but highly accurate estimates of forest biomass that meet the needs both of scientists and of the community.

The SilvaCarbon Workshops are designed to coordinate with project partners in distribution of products to organizations in need and to help address issues of deforestation and carbon reduction. Each workshop has participants sharing discourse on projects and accomplishments in their regions, accessing and downloading datasets pertinent to their studies, and meeting with leading scientists working on biomass. Two additional workshops are planned in 2012. As the science of using satellite remote sensing to estimate biomass evolves, understanding the challenges of local, regional and international actors working to implement REDD will affect the way this science is focused.

4. Case study 3: Developing forest canopy change maps for forest managers

The Baltimore Washington Partners for Forest Stewardship (BWPFS) was formed in 2006 and is a coalition of federal landowners who have joined with leaders from the Maryland Department of Natural Resources and the Center for Chesapeake Communities to promote collaborative strategies for the restoration, conservation and stewardship of shared forested ecosystems and managed lands in the Baltimore Washington corridor. Current BWPFS partner agencies include the U.S. Department of Agriculture Beltsville Agricultural Research Center, U.S. Fish and Wildlife Service Patuxent Research Refuge, NASA/Goddard Space Flight Center, U.S. Army Fort George G. Meade, Cities of Greenbelt and Bowie and Town of Cheverly, Maryland-National Capital Park and Planning Commission, University of Maryland, U.S. Secret Service, U.S. Forest Service, U.S. Geological Survey. The 2011 partners' semi-contiguous boundaries have an area totaling over 69,000 acres, 38.3% of which is forested. This region is critical for ensuring that the Baltimore-Washington’s water resources, air quality and other basic ecosystem services (Costanza 1996).

One of the issues that BWPFS community forest managers are coping with is a significant new reporting requirement under a Chesapeake Bay federal mandate. In 2011, the Chesapeake Bay was placed on the *Federal Impaired Waters List for Nutrients and Sediment* as a result of a successful 2008 lawsuit against the EPA by Chesapeake Bay watermen in two states and the Chesapeake Bay Foundation. The resulting watershed implementation plan resulted in significant reporting requirements as well as strict new storm water runoff and regulatory requirements that apply to federal, state and local jurisdictions. Forest cover is a critical input to these requirements, as they serve as a buffer around streams and tributaries that filters storm water, reducing sediment and pollutants before they reach the Bay. Climate change policy is a second important input for these communities, with the State of Maryland implementing new programs relevant to climate change that implicate forest management. Thus the BWPFS partners use satellite and other environmental data, but have needs that are not met by the current suite of products, particularly those that describe change through time at a sufficiently high resolution for community-based forest management. These needs include repeatable, quantitative and high-resolution tree canopy cover percentages and change through time, maps of impervious surfaces, and integration of forest information into storm water hydrological models for estimation of pollutants and sediment contribution to the Chesapeake Bay.

4.1. Science and decision makers working together

The BWPFS aims to promote forest stewardship through best management practices for contiguous forest in the Baltimore/Washington corridor. To encourage communication between scientists and decision makers, a meeting was held in September 2011 that focused on identifying areas where NASA data and applications can be utilized by partners to improve forest management or to promote forest stewardship. In turn, the forest managers had the opportunity to identify needs that cannot be met by currently available data and systems. The meeting was attended by 25 people from 20 different entities.

A consensus was reached that the science community needs to improve their ability to produce temporally comparable products that can be used by decision makers at multiple agencies and incorporated into policy. Current systems for valuing ecosystem services are insufficient in determining the value of a given plot of forest. For example, a 1-acre plot of forest that is between a shopping mall and a stream may have greater ecosystem value than a 1 acre plot in a rural setting. This is because the forest near a stream in an urban setting absorbs runoff water coming from parking lots and buildings, catches and retains sediment and absorbs nutrients and keeps them from entering the water system. Being able to map the location and health of these urban tree plots is a critical part of the forest management in the Baltimore-Washington region. Scientific, remotely sensed data, can contribute to the monitoring and evaluating of forest health critical for environmental management in the region. Regional and national datasets can help bridge the needs for continuous and independent information for reporting to the Federal and State governments, though local information will be needed to supplement.

By improving relationships, we can develop approaches that provide data and information needed to ensure that the products developed by scientists are both regulation compliant as well as scientifically robust and repeatable into the future. Although forest mapping is on the agenda for many agencies and individuals, few products provide the information needed by decision makers (to include forest canopy percentage) that can be repeatedly measured through time. By bringing out the needs of these local decision makers, scientists can report this secondary product from models used to estimate biomass to address local environmental challenges.

5. Conclusions

In order to produce scientific data that is readily useful, it is important for scientists and potential end-users to exchange information and ideas early and often in a science product development process. Scientists and policy makers need to work together as much as possible within the chaotic 'policy primeval soup' (after Kingdon, 2003) to use science to identify policy problems as well as provide solutions. Many research organizations have as their goal to make the products useful to a wide community of scientists, managers and policy makers. The voice of the user (ie not only those working directly in government, but also decision makers from business, local communities, charities etc) is helpful not just to these scientific programs, but to the entire community working on related activities. As decisions are made throughout the research development process, scientists need the voice of the user to specify resolution needs, site details, etc. so that policy relevant science is delivered.

In this chapter we have provided examples from three research programs where scientists and decision and policy makers have been brought together to increase communication and understanding of each group. Ensuring strong relationships and knowledge of the problems policy makers have in their efforts to address climate and environmental change at a variety of scales is critical to ensuring relevance. Our need for policy relevant scientific data products will continue to grow, with the demand of managing climate change impacts at local, regional and national levels, Only through improved relationships and effective communication forums will we ensure that these needs are met and delivered to society.

Author details

Molly E. Brown
NASA Goddard Space Flight Center, Greenbelt MD, USA

Vanessa M. Escobar
Sigma Space/NASA Goddard Space Flight Center, Lanham, Maryland, USA

Heather Lovell
The University of Edinburgh, UK

6. References

Alcock, F. (2002). Mobilizing Science and Technology for Sustainable Development. In. Cambridge, MA: Forum on Science and Technology for Sustainability

Costanza, R. (1996). Ecological Economics: Reintegrating the Study of Humans and Nature. *Ecological Applications*, *6*, 978-990

Davies, P. (2005). What is Needed From Research Synthesis From a Policy Making Perspective? . In J. Popay (Ed.), *Putting Effectiveness Into Context*. London: Prime Minister's Strategy Unit, Cabinet Office, United Kingdom

Goetz, S.J., Baccini, A., Laporte, N., Johns, T., Walker, W.S., Kellndorfer, J.M., Houghton, R.A., & Sun, M. (2009). Mapping & monitoring carbon stocks with satellite observations:a comparison of methods. *Carbon Balance and Management*, 4

Jamison, A. (2001). Science, technology and the Quest for Sustainable Development. *Technology Analysis and Strategic Management, 13*, 9-22

Jasanoff, S., Markle, G.E., Petersen, J.C., & Pinch, T.J. (Eds.) (1995). *Handbook of Science and Technology Studies*. London: Sage

John, P. (2003). Is There Life After Policy Streams, Advocacy Coalitions, and Punctuations: Using Evolutionary Theory to Explain Policy Change? *Policy Studies Journal, 31*, 481-498(418)

Jones, N., & Walsh, C. (2008). Policy Briefs as a communication tool for development research. In, *Background Note*. Overseas Development Institute

Kingdon, J.W. (2003). *Agendas, alternatives and public policies*. New York: Harper Collins College Publishers

Litfin, K.T. (1994). *Ozone discourses: science and politics in global environmental cooperation*. New York: Columbia University Press

NRC (2007). Earth Science and Applications from Space: National Priorities for the Next Decade and Beyond. In. Washington DC: National Research Council

NRC (2009). Restructuring Federal Climate Research to Meet the Challenges of Climate Change. In. Washington DC: National Research Council of the National Academy of Science

Pawson, S., & Gunson, M. (2010). NASA CMS 2010, Pilot Study: Surface Carbon Fluxes. In. Greenbelt, MD: NASA

Pettricrew, M., Whitehead, M., Macintyre, S., Graham, H., & Egan, M. (2004). Evidence for public health on inequalities: 1: The reality according to policymakers. *Journal of Epidemiology and Community Health, 58*, 811-816

Phillimore, J. (2001). Schumpeter, Schumacher and the Greening of Technology. *Technology Analysis and Strategic Management, 13*, 23-37

Prentice, I.C., Heimann, M., & Sitch, S. (2000). The carbon balance of the terrestrial biosphere: Ecosystem models and atmospheric observations. *Ecological Applications, 10*, 1553-1573

Sabatier, P.A. (1999). *Theories of the Policy Process: theoretical lenses on public policy*. Boulder: Westview Press

Smith, A. (1997). Policy networks and advocacy coalitions: explaining policy change and stability in United Kingdom industrial pollution policy? *Environment and Planning C, 18*, 95-114

True, J., Jones, B.D., & Baumgartner, F.R. (1999). Punctuated-Equilibrium Theory: Explaining Stability and Change in American Policy making. In P.A. Sabatier (Ed.), *Theories of the Policy Process* (pp. 97-115). Boulder: Westview Press

USAID (2011). USAID Silvacarbon Fact Sheet. In. Washington DC: US Agency for International Development

Wynne, B., & Irwin, A. (Eds.) (1996). *Misunderstanding science? The public reconstruction of science and technology*. Cambridge: Cambridge University Press