1.6

COLLABORATIVE APPROACHES TO THE DEVELOPMENT OF CLIMATE-BASED DECISION SUPPORT SYSTEMS: WHAT ROLE FOR SOCIAL SCIENCES[*]?

TODD A. CRANE*, CARLA RONCOLI, NORMAN E. BREUER, KENNETH. BROAD, JOEL O. PAZ, CLYDE W. FRAISSE, KEITH T. INGRAM, DAVID F. ZIERDEN, GERRIT HOOGENBOOM, AND JAMES O'BRIEN

TODD A. CRANE*,
Wageningen University; Wageningen, Netherlands
and University of Georgia; Griffin, Georgia

CARLA RONCOLI, JOEL O. PAZ, GERRIT HOOGENBOOM
University of Georgia; Griffin, Georgia

NORMAN E. BREUER, KENNETH BROAD,
University of Miami; Miami, Florida

CLYDE W. FRAISSE, KEITH T. INGRAM,
University of Florida; Gainseville, Florida

DAVID F. ZIERDEN, JAMES O'BRIEN
Florida State University; Tallahassee, Florida

1. Introduction

The science of seasonal climate forecasting based on the El-Nino Southern Oscillation (ENSO) has made great strides in recent years. As such research examining the potentials for basing adaptive management upon that information has grown tremendously. Seasonal forecasts have shown promise as information inputs that can aid agricultural decision-making around planting dates, cropping systems, variety selection, irrigation needs, and input application (Hammer et al. 2001; Hansen 2002, 2006; Jones et al. 2000; Meinke; Stone 2005; Sivakumar 2006). Strategies for coping with market fluctuations, pests and disease outbreaks, and the crop insurance can also be affected by seasonal forecasts (Cabrera et al. 2006; Fraisse et al. 2006).

*Corresponding author address: Todd A. Crane, Univ. of Wageningen, Technology and Agrarian Development, Hollandseweg 1, 6706 KN , Wageningen, The Netherlands.
email: todd.crane@wur.nl

But doing good climate science does not necessarily ensure that its potential societal benefits will be fully realized (Broad et al. 2002; Ingram et al. 2002; Letson et al. 2001; Philips et al. 2001). End-users' decision-making processes are dynamic and multi-faceted, meaning that introduction of new information may not directly lead to changes in behavior. Analyzing how farmers' manage climate risk and understanding how climate forecasts may help them do so requires that climate scientists and social scientists work together closely (Roncoli 2006). Furthermore, understanding how end-users interact with information systems is also an important part of facilitating the development and adoption of useful forecasts (Pennesi 2007).

Given their widely divergent academic backgrounds, close cooperation of social and biophysical scientists does not necessarily come easily. It requires patience open-mindedness, mutual-respect, sustained efforts, and a shared sense of common purpose on the part of all parties. This paper explores some the ways in which social, agricultural and climate scientists have worked together within a single project aimed at delivering decision-support tools to the agricultural sector of the American Southeast. In particular, this paper explores ways in which social science research has contributed to the refinement of a climate-based decision-support system (DSS) for natural resource managers. By highlighting the interactions between social science research and technological development, we provide an example of how social sciences can be integrated into applied climate and meteorological research, and some of the challenges to that collaboration.

2. Background

The Southeast Climate Consortium (SECC)[*], a collaborative, interdisciplinary research project that includes six universities in Florida, Georgia and Alabama[†], is recognized as a successful case of integrating biophysical sciences, social sciences and the extension of climate-based decision-support systems to the agricultural[‡] community in the southeastern US. Incorporating climatologists, agronomists, anthropologists, crop modelers, hydrologists, economists, and agricultural extension specialists under the umbrella of one project, the SECC's overarching goal is to develop decision-support tools that are based on seasonal (90-day) climate forecasting.

The coastal plains region of the southeast has a strong ENSO signal, making probabilistic forecasting of seasonal temperature and rainfall trends scientifically viable. In addition to the forecasts, SECC member have also developed a wide variety of crop modeling tools that illustrate variability in agricultural production connected to the ENSO signal and other aspects of seasonal variation. These tools, distributed primarily through an interactive outreach website (*www.Agclimate.org*), are intended for agricultural and natural resource managers in the southeastern U.S. The premise of the SECC is that agricultural risk related to climate variability can be offset through various risk-management practices if farmers and agricultural extension agents have access to reliable seasonal forecasts and associated decision-support tools.

Where climatologists model and forecast climate trends, social scientists can provide a great deal of insight into the cultural and socioeconomic contexts into which climate models and forecasts are introduced. Since its onset, social scientists have been involved in the development of the SECC's overall program, contributing to the formulation and delivery of climate-based DSS's to the agricultural community in the Southeast. In particular, the involvement of agricultural anthropologists and other social scientists has been articulated around four themes, which were addressed progressively, as the project evolves: a) identifying end users, understanding decision processes, and the role of climate forecasts in their decision-making; b) assessing the accessibility, relevance, utility of *AgClimate* tools from end-users' point of view; c) evaluating *AgClimate* tools in terms of their actual use and impacts, d) eliciting programmatic lessons learned. These objectives have guided research activities and approaches, generating a considerably body of knowledge that has been integrated into the SECC research agenda and outreach efforts.

3. Social science research within the SECC

Since the beginning of the SECC[§] in 1997, rapid rural appraisals (RRA) have been conducted in 44 Florida counties in order to ascertain the kinds of climate and crop information would be most useful to farmers. Such RRA were

---

[*] The SECC is a Regional Integrated Science and Assessments program (RISA) funded by the National Oceanic and Atmospheric Administration (NOAA), by Risk Management Agency (RMA) and Cooperative State Research, Education, and Extension Services (CSREES) of the US Department of Agriculture (USDA).

[†] University of Florida-Gainesville, University of Miami, Florida State University, University of Georgia, University of Alabama-Huntsville, and Auburn University.

[‡] The SECC works with crop farmers, cattle ranchers, forest operators, and other natural resource managers. In this paper, we use "agriculture" and "farmer" to represent all of these production operations and decision makers.

[§] Originally, the SECC was the Florida Consortium, with only the three universities in Florida. In 2002, it expanded to a regional focus and changed its name accordingly.

conducted with different categories of farmers, including beef cattle and dairy producers, hay farmers, row crop, fruit, vegetable, organic produce, limited-resource, part time; and also with extension agents who serve these farmers. The rapid rural appraisal, also known as a *sondeo* (Hildebrand 1981), is a method of community-based interviews designed to elicit baseline knowledge on management practices and information needs. The *sondeos* focused on potential uses of climate forecast information with research questions such as 1) Are producers interested in climate information, especially climate forecasts? 2) What level of accuracy in forecasts do decision makers want before using them as decision aids? 3) What are the management options that producers can adopt in light of climate forecasts? 4) How should seasonal climate variability forecasts be presented and delivered? and 5) How do potential users evaluate the content and presentation available in *AgClimate*? In the rapid rural appraisals, farmers indicated ways that they might be able to use a 90-day forecast to their advantage, the times of year when they would need to make key management decisions, and in this way, social science research acted as an crucial bridge between climatologists' models, farmers' needs, and agronomists' development of tools for use by the farmers (Breuer et al. 2007).

Building on the rapid rural appraisals, in-depth ethnographic interviews were conducted with 47 farmers in south Georgia in 2006 and 2007. The sample included fruit and vegetable growers, row crop farmers and pine forest managers, along with county extension agents. The objective of these interviews was to refine our understanding of the decision-making environment into which climate-based decision support tools are to be introduced. The ethnographic interviews validated and elaborated on the *sondeo*'s findings about key management decisions and their calendars. The ethnographic interviews also elicited information about how farmers currently manage vulnerability to climate variability and how non-climate variables affect their risk-management decisions.

Finally, facilitated interactive sessions and focus groups with extension agents, farmers, and other relevant actors were conducted to elicit feedback on the information and tools presented on the AgClimate website. These preliminary sessions fed into the development of the AgClimate website and tools. Once the website was fully operational, it was again evaluated in the course of ten interactive sessions conducted with agricultural students, extension agents, and instructional technology experts. Participants provided feedback through guided discussions and questionnaires, which elicited ratings on web design, content, interface and navigability of AgClimate. Findings from these exercises and surveys were applied to efforts to improve the tools and the website. The quality of feedback with regard to presentation and interpretation as would be shown on an actual website was greatly improved by the first mock-up website developed in 2004 (Fraisse et al. 2006).

4. Integration of social and biophysical sciences in an applied context

4.1 *Farmer decision-making*

A key contribution of social science in the SECC has been the understanding of farmers' decision-making processes and identification of the potential roles of climate forecasts, and the obstacles and limitations to farmers' use of 90-day forecasts and other decision support tools. Findings from social science research have helped climate and agricultural scientists within the SECC to revise prevailing assumptions that did not always correspond to how farmers make decisions in real life. These include, for example, a) the criteria that guide risk management decisions and b) the role of climate considerations in decision making.

Farmers' management systems have long been predicated on treating climate variability as an unknown. They tend to hedge their decision-making to guard against risk, sometimes at the cost of capitalizing on ideal conditions. Many of the row-crop farmers interviewed said that they anticipate having bad years, even losing money, three out of every ten years, due to poor climate conditions. Therefore, contrary to common assumption, many family farmers are guided by decision criteria that go beyond maximizing yields and profits. Rather they seek to avoid avoiding catastrophic losses and forced disinvestment; to attain consistent production levels and maintain viable market linkages, to meeting living expenses and to repay debt.

Farmers' decisions are driven by a host of variables other than climate, including commodity prices, agricultural policies, input prices, crop insurance coverage, agro-ecological considerations, and even maintaining social relations within agricultural commodity chains. Farmers' agricultural strategies are also significantly influenced by economic circumstances, such as degree of infrastructural investment, debt load and terms set in their agricultural loans, and the availability of off-farm income. The effect of climate and climate information on decision-making is conditioned by this framework of external factors, many of which have greater relative certainty compared to climate forecasts. These non-climatic factors were not necessarily taken into account in climate-based decision support tools.

In highlighting the complexity of farmers' systems of decision-making, and their tendency to conservatively manage risk rather than seek to maximize yields and profits, social scientists have encouraged a different understanding of technological adoption. In a research project that is focused on climate forecasts and related tools as technologies that can transform farmers' relationship with the uncertainty of weather, social science research has fostered an understanding that farmers' response to climate forecasts is likely to be a gradual and partial process rather than a clear-cut case of acceptance or rejection. In other words, farmers will respond to forecasts by the same cautious experimental process whereby they incorporate innovations into their production systems. Therefore, assessment of forecast uptake and impacts must be structured by approaches that can capture the iterative, incremental nature of farmers' learning processes.

4.2 *Farmers' information environment*

To facilitate farmers' incorporation of climate forecasts into decision-making, it is necessary to understand how they acquire, process and use weather and climate information systems. SECC social scientists found that farmers are accustomed to using several sources of weather and climate information, often triangulating among them and against their observations of their immediate environment. Significantly, social scientists found that the way farmers respond to any particular piece of information is influenced by the overall information environment and the performance of other predictive systems. For example, although the SECC forecast for a drier-than-average spring/summer 2006 was generally accurate, farmers interviewed expressed skepticism about medium-range forecasts because other sources' predictions for an intense hurricane season did not come true. This led to the realization that the SECC needs to develop a well defined "brand name" identity to avoid confusion between its mandate and products and those of other public and private sector agencies.

By examining farmers' information management systems, social scientists arrived at important insights that guided efforts to improve the accessibility of SECC tools and information. For example, the realization that farmers' time is already stretched very thin encouraged efforts to simplify the format and eliminate unnecessary information. Furthermore, while the website is developed on high-end computers with broadband internet access, farmers are more likely to use old and slow computers on dial up connections. Many farmers said that if something takes too long to access, they will lose patience and give up. Therefore, efforts were made to keep the file size of graphics and interactive tools to a minimum, as well as to streamline the navigation, to make the tools more intuitive and interactive, to simplify the technical language, and to provide users with instructions.

Interviews with farmers highlighted how information is processed in a social context, and how farmers access and manage information through interactions with other people. In the case of older farmers, who are often unfamiliar with the internet, wives and children often do all farm-related computer work. This pointed to the need to broaden outreach activities to reach these groups (e.g. Young Farmers, Crop Advisors, etc.) which are being actively pursued by the SECC extension team. Being particularly attuned to the social implications of knowledge and technology, social scientists also spearheaded efforts within the SECC to include underrepresented groups that are not often reached by agricultural cooperative extension services, such as minority and organic farmers.

4.3 *Integrating end-user perspectives*

Social science research helped integrate end-users' perspectives into programmatic decisions about when and how climate forecasts are disseminated. For example, 90-day forecasts were originally published quarterly, but by elucidating the calendar of key management decisions in the main production systems of the region, social scientists showed that the forecasts were needed more frequently. Therefore, the SECC now publishes the 90-day forecast on a monthly basis. Likewise, the first Climate Outlooks were produced in academic language and logically organized in terms of deductive reasoning that is common in scientific circles. This meant that the actual forecast was only published at the end of the documents, after presenting and analyzing a great deal of information. These Outlooks provided methodological clarification and background information deemed necessary by the climate scientists, but not directly relevant for end-users, most of whom lack the technical expertise to critically evaluate the data and simply wanted to know the "useful information". Even though simplifying the language and eliminating technical detail went against their scientific training, SECC climate scientists have worked closely with social scientists to formulate the Climate Outlooks in ways that make them accessible to end-users.

Another area where end-users and scientists' perspectives diverge is the understanding of the probabilistic nature of forecasts. SECC forecasts have been delivered in terms of terciles of probability. Scientists understand that the low probability scenario can occur and, even in such case, the forecast is technically "accurate". For farmers, on the other hand, who need information to guide economic decisions, such occurrence means that a forecast is "inaccurate", or at least "not useful". During interviews, farmers frequently wanted to know the track record of the SECC forecasts so that they could assess the SECC forecasts in their own terms. Likewise, the AgClimate evaluations conducted with extension agents and agricultural students suggested that the SECC publish historical data on the forecasts' past performance, including good and poor performance.

The idea of a published track record is currently under evaluation. The current SECC approach is to forecast the upcoming ENSO phase and then provide probabilistic forecasting of temperature and precipitation based on long term historical records. Under this approach the forecast of the ENSO phase has been consistently correct. However, typical weather patterns associated with a given ENSO phase have not always materialized. This question underscores the tension between meeting end-users suggestions and the state of the science. Yet farmers do not require perfect knowledge or absolute accuracy, but the ability to assess for themselves the extent to which they want to trust the information, expressed in terms of empirical experiences rather than in terms of statistical testing.

Significantly, during discussions surrounding the accuracy, reliability, and credibility of the SECC predictive information, end-users (farmers and agents alike) stressed the need to highlight the social and institutional context in which such information is produced. This translated into the suggestion of providing contact and even biographical, information for the scientists who produce the forecasts ("the people behind the website") as well as more opportunities for asking questions and providing feedback. Emphasizing the SECC association with land-grant universities, which farmers and agents have close personal and professional ties with and experience in collaborating with, was also recommended as a way of promoting trust and making AgClimate a habitual resource in farmers' experience.

5. Challenges

The process of successfully integrating social and biophysical sciences within the SECC also highlights some of the challenges that this effort entails. These challenges pertain to three main issues: language, methodologies, and broader philosophy of science.

5.1 *Linguistic barriers*

Inter-interdisciplinary collaboration requires that scientists relinquish use of their own discipline-specific jargon as well as learn the essential concepts and terminologies of other disciplines. This need is reinforced by the social scientists' direct interactions with farmers in the field, as they are sometimes called to explain those concepts and terminologies, such as the forecast skill or the El Nino-La Nina phases. Being able to address those questions is important to establishing rapport and credibility vis-à-vis research participants. In addition, some level of familiarity with the basics of climate and agricultural science is required by the fact that findings from the SECC social science research are often presented in inter-disciplinary conferences and journals.

5.2 *Methodological challenges*

Beyond the cross-fertilization of concepts and harmonization or terminologies, the integration of biophysical and social scientists requires an appreciation for the diverse methodological approaches that different disciplines bring. Scientists who work in highly quantitative disciplines sometime overvalue survey-based research because it lends itself to quantification, but overlook more qualitative research. In the SECC's case, while climatic and agricultural modeling relies on processing vast quantities of statistical data, field-based social sciences, such as anthropology and rural sociology, often utilize qualitative methods and small sample sizes. These approaches enable social scientists to elicit concerns and categories that are salient and meaningful to research participants, thereby minimizing biases that may be introduced into structured survey questions formulated by scientists. Open-ended, in-depth interviews with individuals and groups are effective tools for exploring the complex interaction of multiple factors that shape real life decisions (Bernard 1995; Holstein; Gubrium 1995; Kohler Riessman 1993; Stewart 1998). While ethnographic research may not easily lend itself to replication and statistical analysis, this does not mean it cannot render strong conclusions through systematic textual analysis. Recent advances in qualitative analysis software have made organizing and coding field notes and interview transcripts easier. Open-mindedness to these approaches has allowed SECC biophysical scientists to use findings from ethnographic interviews to inform and refine their own work.

5.3 *Philosophical differences*

However, adjusting language and methods and embracing collaborative research as a professional priority does not guarantee communication and consensus across disciplines. Despite good intentions and joint effort, social scientists and biophysical scientists may still hold different understandings of the very nature of science and technology *vis a vis* society. Biophysical scientists tend to view science and technology, as objective and value-free dimensions that are ideologically and politically neutral. On the other hand, social scientists, and particularly anthropologists, sociologists, and political scientists, view science and technology as socially constituted processes (Demeritt 2001; Lahsen 2005; Shackley; Wynne 1995). This means looking at science as a process that reflect the prevailing values and assumptions of dominant society and that may be engaged in by different actors in pursuit of specific interests. Consequently, where biophysical scientists may consider the development of effective technologies or sound knowledge as an end in itself, social scientists are more likely to raise questions about its effects on society, such as equity in the relative distribution of costs and benefits. Within the SECC, this translates into concerns about whether the climate information it produces and disseminates may differentially benefit large-scale or small scale operators, or give insurance agencies and lending institutions over farmers.

Consequently, SECC social scientists have been instrumental in pushing for greater inclusion of research and extension among populations who have traditionally been underserved by agricultural extension, such as African-Americans, Hispanics and organic farmers.

Finally, because specialized language and methods are used in scientific circles to establish affiliation and good standing within one's discipline, the collaborative process confronts the scientist with dilemmas beyond the need to make oneself understood and taken seriously beyond one's peers. Rather, it may challenge scientists to embrace a broader, more composite or hybrid intellectual identity, which includes their identification with the collaborative process as well as with their own disciplinary specialization. This may complicate how one relates back to one's own discipline, given that many disciplines (in biophysical and social sciences alike) are still characterized by a rift between basic science and applied practice. That is changing, however, on both sides. Members of both the climate and meteorology communities have recently established seen interdisciplinary workshops designed to facilitate collaborative work. Climate sciences has the *DISsertation initiative for the advancement of Climate Change ReSearch* (DISCCRS) Workshop (Weiler 2007), while meteorology has the *Weather and Society*Integrated Studies* (WAS*IS) Workshop (Demuth et al. 2007), both of which include participants from biophysical and social sciences with the goal of developing the knowledge and skills necessary for collaborative research. In addition to individual social scientists' participation in both of the abovementioned workshops, the social science disciplines themselves are starting to call for greater engagement. Despite the fact that anthropologists' involvement in climate research has thus far occurred largely outside the boundaries of "official" anthropology, there has recently been a call for mainstream anthropology to embrace climate application research as a priority for the discipline (Finan 2007; Lahsen 2007).

6. Conclusion

The SECC experience exemplifies the advantages of cross-disciplinary collaboration. This paper focuses on the contribution of social science research to improving the relevance and accessibility of the SECC climate forecasts and decision support tools products. Within the project, social science research has applied a multi-layered, iterative approach to address several goals. It has used a combination of participatory techniques, qualitative methods, and interactive exercises to elicit end-users' perspectives and feedback. It has aimed to produce methodological rigorous and relevant research, while at the same time also deriving insight from informal interaction with farmers and agents in the field, on their farms, at trade shows, or over a meal. This has resulted in a deeper understanding of the complexities of farmers' decision making processes and the role of climate information plays in them, in the development of more relevant and responsive decision support systems, and in efforts to communicate SECC forecasts in ways that are more accessible and more inclusive.

These insights have been generally welcomed by the SECC climate and agricultural scientists and incorporated into the SECC research agenda and outreach efforts. Yet, even in a context such as the SECC, characterized by openness to cross-disciplinary collaboration and appreciation for the role of social science, the process of interdisciplinary integration does not unfold automatically and unproblematically from social scientists' involvement in a project. To be successful in responding to programmatic needs and in affecting programmatic decisions, social sciences cannot just be "added to the mix" into climate research projects but left to run parallel to other research tracks. Rather, integrating social sciences requires that all collaborators understand how the findings of social and biophysical researchers complement and inform the others' work, which in turn entails planning, negotiation and adjustments on the parts of both social and biophysical scientists. There are differences in linguistic terminologies, semantic content, relevance of parameters, standards of rigor, and criteria for establishing credibility and accuracy of information. Integrating these different perspectives requires time and effort, willingness to compromise, and commitment to common goals. Social scientists and their biophysical colleagues all want to do good research by the standards of their own discipline, but being focused on developing the information delivery system that is most useful to end users can provide an important shared objective to unite the different perspectives on research.

7. Works Cited

Bernard, R., 1995: *Research methods in anthropology: Qualitative and quantitative approaches.* Altamira, 585 pp.

Breuer, N. E., V. E. Cabrera, K. T. Ingram, K. Broad, and P. E. Hildebrand, 2007: AgClimate: A case study in participatory decision support system development. *Climatic Change*.

Broad, K., A. P. Pfaff, and M. H. Glantz, 2002: Effective and equitable dissemination of seasona-to-interannual climate forecasts: Policy implications for the Peruvian Fishery during El Nino 1997-98. *Climatic Change*, 54, 415-438.

Cabrera, V. E., N. E. Breuer, and P. E. Hildebrand, 2006: North Florida dairy farmer perceptions toward the use of seasonal climate forecast technology. *Climatic Change*.

Demeritt, D., 2001: Social studies, climate change and the prospects for a constructivist critique. *Economy and Society*, 35.

Demuth, J. L., E. V. E. Gruntfest, R. E. Morss, S. Drobot, and J. K. Lazo, 2007: Building a Community for Integrating Meteorology and Social Science. *Bulletin of the American Meteorological Society*, 88, 1729-1737.

Finan, T., 2007: Is "official" anthropology ready for climate change? *Anthropology News*, 48, 10-11.

Fraisse, C. W., and Coauthors, 2006: AgClimate: A climate forecast information system for agricultural risk management in the southeastern USA. *Computers and Electronics in Agriculture*, 53, 13-27.

Hammer, G. L., J. W. Hansen, J. G. Philips, J. W. Mjelde, H. Hill, and A. Love, 2001: Advances in application of climate prediction in agriculture. *Agricultural Systems*, 70, 515-553.

Hansen, J. W., 2002: Realizing the potential benefits of climate prediction to agriculture: Issues, approaches, challenges. *Agricultural Systems*, 74, 309-330.

——, 2006: Translating climate forecasts into agricultural terms: Advances and challenges. *Climate Research*, 33, 27-41.

Hildebrand, P. E., 1981: Combining disciplines in rapid appraisal: The Sondeo approach. *Agricultural Administration*, 8, 423-432.

Holstein, J. A., and J. F. Gubrium, 1995: *The active interview.* Vol. 37, Sage Publications, 85 pp.

Ingram, K. T., C. Roncoli, and P. Kirschen, 2002: Opportunities and constraints for farmer of West Africa to use seasonal precipitation forecasts with Burkina Faso as a case study. *Agricultural Systems*, 74, 331-349.

Jones, J. W., J. W. Hansen, F. S. Royce, and C. D. Messina, 2000: Potential benfits of climate forecasting to agriculture. *Agriculture, Ecosystems and Environment*, 82, 169-184.

Kohler Riessman, C., 1993: *Narrative analysis.* Vol. 30, Sage Publications, 78 pp.

Lahsen, M., 2005: Seductive simulations: Uncertainty distribution around climate models. *Social Studies of Science*, 35, 895-922.

——, 2007: Anthropology and the trouble of risk society. *Anthropology News*, 48, 9-10.

Letson, D., I. Llovet, G. Podesta, F. Royce, V. Brescia, D. Lema, and G. Parellada, 2001: User perspectives of climate forecasts: Crop producers in Pergamino, Argentina. *Climate Research*, 19, 57-67.

Meinke, H., and R. C. Stone, 2005: Seasonal and inter-annual climate forecasting: The new tool for increasing preparedness to climate variability and change in agricultural planning and operations. *Climatic Change*, 70, 221-253.

Pennesi, K., 2007: Improving forecast communication: Linguistic and cultural considerations. *Bulletin of the American Meteorological Society*, 88, 1033-1044.

Philips, J. G., L. Unganai, and E. Madaudze, 2001: Current and potential use of seasonal climate forecasts for resource-poor farmers in Zimbabwe. *Impacts of El Niño and climate variability on agriculture*, C. Rosenzweig, Ed., American Society of Agronomy, 87-100.

Roncoli, C., 2006: Ethnographic and participatory approaches to research on farmers' responses to climate predictions. *Climate Research*, 33, 81-99.

Shackley, S., and B. Wynne, 1995: Integrating knowledges for climate change: Pyramids, nets and uncertainty. *Global Environmental Change*, 52, 113-126.
Sivakumar, M. V. K., 2006: Climate prediction and agriculture: Current status and future challenges. *Climate Research*, 33, 3-17.
Stewart, A., 1998: *The ethnographer's method.* Vol. 46, Sage Publications, 97 pp.
Weiler, S., 2007: Meeting PhD graduates' needs in a changing global environment. *Eos*, 88, 149-151.