ROLE OF EDUCATION AND TRAINING IN AGRICULTURAL METEOROLOGY TO REDUCE VULNERABILITY TO CLIMATE VARIABILITY

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Abstract. Agricultural meteorologists are concerned with many operational aspects of the effects of climate on crop production, livestock, and natural resource management. For them to continue to make a contribution to the economy of a country they must continually sharpen their skills and remain updated on the latest available information. Training should include a variety of skills, including transferable skills (e.g. communication, numeracy), professional skills (including cognitive skills) and information technology skills. Problem-based learning can be used to promote critical thinking, decision making and analytical skills. More use should be made of computer-aided learning for agricultural meteorologists' in-service training. In particular, the Internet or CDs could be used to disseminate specific recently developed techniques and applications to improve the understanding of the variability in climate and its effect on agricultural production and natural resource management. Examples that can address the vulnerability of farmers include crop–climate matching, the use of indices, crop modelling and risk assessment together with seasonal outlooks. A strategy needs to be formulated to address these needs and implement changes in the education and training of agricultural meteorologists. These training needs must be constantly updated to meet the changing demands of new technology to cope with climate change and climate variability.

1. Introduction

Agricultural meteorology is an applied science that brings together the effects of the climate and weather on the production of crops, livestock and forests. Our lives are closely affected by daily and annual variability in climate. The agricultural community is no exception. Farmers are affected by the extremes in climate and its variability that often lead to wide interannual fluctuations in yields and productivity. In many parts of the world climatic variability is large, creating potentially severe problems for farm managers to solve. If the agricultural meteorologists are to help the farmer, they need to remain up-to-date on advancing knowledge of forecasting, climatic change, and the tools being developed to address these issues. But, most importantly, they must find ways to adapt local farming systems in a practical manner to predicted near-term forecastable events and to long-term climatic change.

For this to happen agricultural meteorologists must receive in-service training and be able to attend short courses to sharpen their skills and learn new techniques. A common basis for success is competence in numeracy, communication and general

Climatic Change (2005) 70: 311–318

computer skills and these skills should be strengthened where necessary. However, agricultural meteorologists also need many specific scientific skills in highly specialised areas of meteorology, climate analysis, and the agricultural sciences and these too must be provided.

2. Basic Education

Advances in the fields of weather analysis and prediction, and climate change and climate variability have been rapid. Thus, it is necessary that agricultural meteorologists have full understanding of the scientific background relating to these areas in order to effectively service the agricultural community. This means that agricultural meteorologists themselves need to attend frequent update sessions where they are continually challenged to refresh their understanding and skills based on the latest knowledge.

As long as agricultural meteorologists have a firm science background, they will be able to maintain a current state of awareness in developments related to impacts, adaptation, vulnerability, and mitigation resulting from trends in climate change and climate variability. The undergraduate education of agricultural meteorologists needs to be diverse and broad so as to ensure that they have a firm scientific and technical base on which to build for the future. In their undergraduate studies, students need to prepare for professional careers that focus on advances in operational agrometeorological services and developing new, innovative techniques for improving services to their local communities. Furthermore, students must be equipped to keep abreast of possible future developments in the science of agricultural meteorology, including rapid changes in climate that may alter land-use planning or force significant changes in agricultural practices.

Training requirements should not only focus on those who have received formal degrees in agricultural meteorology but also on those now working in the field who were trained in related disciplines. Meteorology is based on sound physical, mathematical, biological and statistical principles (Lomas et al., 2000). If any of this background is lacking, then those from other disciplines may be in need of special training to catch-up and understand the science at a more advanced level. Training tools should be developed for use at the secondary school, technical, undergraduate, and graduate levels.

Another matter that should receive attention is the best ways to convey agrometeorological information to the lay groups that have a vested interest in the interpretation of climate science and its application to their specific needs. In order to promote the use of climatic data in agricultural applications, agricultural meteorologists should have a wide range of knowledge and experience of the kind that makes them respected in their users communities. This will enable them to interpret complicated scientific issues for their clients, few of whom will have a science background. In many countries successful efforts of this kind can bring much goodwill among communities of farmers/pastoralists/foresters and strengthen support for the continuation of local and national weather services.

The aim of this paper is to address some of the options available to educators in preparing agricultural meteorologists to address climate variability and change and their possible impacts on agricultural production systems. The first part of the paper will focus on the basic professional skills essential for agricultural meteorology training. The second part will address how these skills relate to the application of agriculture as a sensitive indicator to climate change and climate variability.

3. Skills Training

The ultimate goal of the agricultural meteorologist is to make a positive impact, in the face of the variability of weather and climate, on the livelihood of the agricultural community. To accomplish this they need basic skills and more refined professional skills to deliver the correct message in a timely and appropriate manner. There are several different types of skills that should be included in continuing education programmes for agricultural meteorologists. These include the basic skills of communication and numeracy, professional skills (including cognitive skills) and information technology skills (e.g. retrieval and analysis of weather datasets). If agricultural meteorologists are to succeed in their jobs and remain abreast of current developments, then all of these skills are necessary.

The training of agricultural meteorologists must address information gathering skills, as this will enable them to retrieve the latest information from various sources and include evaluating the sources and interpretation of the data (Gibbs, undated). These skills should include traditional library as well as networking skills and the ability to use contemporary technology. However, it is essential, with the availability of modern electronic technology, that agricultural meteorologists have computer skills at a level sufficient to allow them to search the Internet and download relevant information and data. At a minimum, basic computer literacy, spreadsheet and word processing skills are essential. In addition, they should also develop the necessary ability to "surf the web" and be able to discern the difference between information that is scientifically sound and correct and that which is poorly grounded. At least some agricultural meteorologist should acquire skills in Geographic Information Systems (GIS), statistical packages and international databases. Finally, but very importantly, once the agricultural meteorologist has acquired the appropriate information or data, they must know how to transform it into forms or products useful to the end user.

4. Agriculture as a Sensitive Indicator to Climate Change and Climate Variability

The agricultural sector is probably the most sensitive indicator of changes in general climatic conditions and in climatic variability. Agriculture can be particularly sensitive to climate anomalies. For example, crops typically grown under certain agroclimatic conditions may face large increases in yield variability due to weather extremes during the growing season. Persistent extremes, such as drought, excessively hot summers, and excessively cold winters may alter the growing season, cause soil erosion, and land degradation. Other factors such as crop diseases and crop pests may be influenced by variable climatic conditions in a specific growing area.

The two primary portions of the training program for an agricultural meteorologist focus on operational services and developing new techniques to support these services for farmers, extension service personnel, and the agricultural community, in general. However, an essential training component must also be devoted to the current awareness of agriculture's keen sensitivity to climate change and climate vulnerability. Further, given the vulnerability to agricultural losses that occur in many local communities caused by weather extremes, it is essential that agricultural meteorologists take a proactive role in understanding local adaptation and mitigation measures that farmers may apply to reduce the negative impact of weather and climate extremes on their farm productivity.

The type of professional skills needed to assess the vulnerability of a community to climate variability will be those of integration and simulation where different scenarios will be evaluated and contrasted in a logical manner and then explanations or causes can be related to a meaningful impact on agriculture. So, care must be taken to expose students to appropriate information and tools so they can extrapolate it to their own situations. They need to be taught to reflect on and apply theories to specific problems. If they can take the theoretical information and argue its relevance to the problem, then they may be able to deduce a logical solution or a number of options available to address the problem. One would also need to learn how to evaluate the various options available and to follow through to predict the consequences of the various options.

These skills are not usually acquired under the normal teaching approach that often focuses on memorisation, identification and description of the situations or superficial conditions (Biggs, 1999). This type of superficial learning needs to be supplemented with in-depth learning that will stimulate the adoption of the required skills. One of the methods of stimulating this learning is problem-based learning (Boud and Feletti, 1999). In a typical problem-based learning situation the student will be faced with a typical problem and then guided through the necessary steps to acquire the skills needed to solve the problem (Walker, 2002). The students need to begin to pull together isolated knowledge, skills and experience into a holistic in-depth understanding of the conditions and situation. This will enable them to develop a strategy for a structured approach to problem solving. This problem-based learning makes active use of the students' existing knowledge (Boud and Feletti, 1999) that in turn encourages the student to gain confidence and therefore be able to succeed sooner.

Although specific technical meteorological skills are needed, sometimes the general professional, information and transferable skills are in need of further development as well. If these skills can be improved and applied to the variability of the climate in a certain area so as to address the specific needs and requirements of the clients, then agricultural meteorologists will be able to consider the problems and provide some solutions for their clients. These skills and techniques are invaluable to students in training in agricultural meteorology. The subject of climate change and climate variability is complex in itself. The impacts on agriculture are enormous. How farmers and the agricultural community respond to potential adaptation and mitigation measures to cope with variable climatic conditions will likely depend upon the ability of agricultural meteorologists to successfully communicate with their clients.

5. Computer Aided Learning (CALMet)

There is considerable expertise available throughout the world on the study of climate change and climate variability and its impact on regional agriculture communities. However, the results of scenario analyses and scientific evaluations are often not effectively communicated widely to the appropriate user community. As electronic communication technology improves, it is possible to share information, experiences, and data more efficiently with many other people around the world. Computer-aided learning provides an opportunity to use CDs or the Internet to develop self-paced modules on any topic of interest. The use of computer-aided learning in meteorology has mainly been confined to the synoptic weather patterns and daily weather predictions (Floor, 2001). As the various systems become more widely used, modules will be developed and this method of learning will be expanded into other areas including agricultural meteorology (Spangler and Fulker, 2001). This could become a highly efficient method of teaching the agricultural meteorologists many of the skills and techniques necessary to assess the impact of climate change and climate variability on agriculture. Using such computer-aided learning tools, agricultural meteorologists could study various scenarios based on unique climate and agronomic features within their regions. Using these scenario analyses, the agricultural meteorologists could then become more aware of potential future conditions. These scientific results can form the basis of advisories issued to farmers and decision-makers on adaptation and mitigation measures to reduce the vulnerability to climate variability.

6. Examples of Professional Expertise Training

To show the application of the above logic some specific examples will be given of the types of applications that could be taught to agricultural meteorologists to empower them to make a contribution to decreasing the vulnerability of the community.

6.1. CROP – CLIMATE MATCHING

Crop–climate matching can be used to select the most suitable crop for specific climatic conditions. All the aspects of the situation need to be considered including the socio-economic acceptability of the alternatives to the community (FAO, 1990). An approach that can be taken is to characterise the specific crop requirements from the perspective of the climate (Doorenbos and Kasaam, 1979; Doorenbos and Pruit, 1992). The ecotope must also be described and defined in similar terms (Sys et al., 1991) so as to determine the potential of the environment for crop production. It is important at this stage to identify the limitations of both the cropping systems and the environmental conditions and also to clarify the predicted changes. The logic is then followed whereby the most limiting factor must be satisfied first and then the others can be considered. For example, in many climates the length of the growing season is a limiting factor for crop selection. A suitable crop or cultivar can be selected using the length of the frost-free season. With changes in the growing season due to climate variability, or trends over decades, it may be necessary to alter cropping patterns, crop types, and crop cycles to adjust to the climate extremes.

6.2. USE OF INDICES AND CROP MODELS

In operational agricultural meteorology much use has been made of climate based indices to assess and integrate the effect of the environment. Many indices have been developed from an empirical perspective and do not really represent the cause and effect relationships. Under these circumstances they will inevitability fail under some conditions so that the boundary conditions should be careful defined (Rosenberg et al., 1983). Among the most common is the use of thermal time calculations for prediction of flowering and maturity dates of crops (McMaster and Wilhelm, 1997). Such an index can be used with the long-term climate data to make recommendations for cultivar choice and select planting dates. However, it is difficult to include climate variability into such calculations and still make it easily understood at the farmers' level. This can be addressed by the use of deterministic crop models together with the long-term data to provide improved cropping recommendations (Singels and de Jager, 1991).

6.3. RISK ASSESSMENT AND SEASONAL OUTLOOKS

Risk can be defined in various ways and should be considered from the communities' perspective using the available long-term weather data. Communities face different circumstances and have different historical experiences so they can be classified as risk averse or risk susceptible (Anderson and Dilion, 1992). The climate data can be used together with modelling techniques to develop cumulative distribution curves of probabilities for obtaining a certain yield under certain conditions (Muchow et al., 1991). These curves have been used to advise farmers on selection of cropping systems or choice of crops or tillage practices or the management of natural resources. As seasonal outlooks improve (Mason et al., 1996), and become more readily available, they can make a contribution to reducing the vulnerability of the communities to extreme weather events (Walker et al., 2001). If these probabilities can be used in conjunction with seasonal outlooks (Hammer and Nichols, 1996), then it is possible to take into consideration some degree of climate variability in a specific place and to make a recommendation to the producers in that area.

7. Conclusions

There should be no question that education and training must be used to empower and equip the agricultural meteorologist to address the issue of climate change and climate variability and their effects on agricultural communities around the world. At the present time there is a large gap between the state of the art in the world as a whole and the information and knowledge that is available and used at an operational level, particularly in developing countries. Strategies need to be developed to formulate plans of action to rectify this serious lack of adequate proactive planning. One of the most promising methods to address this need would be to introduce a problem-based curriculum into the formal education system for both undergraduate and graduate studies. The use of computer-aided learning modules made available on CD or the Internet would be a good approach to distribute the information, thereby allowing agricultural meteorologists in the work place to access the latest technologies and information. There are various methods available that can be used to classify the variability in the climate and its effect on vulnerable communities and they need to be made available to all national meteorological services. The agricultural meteorologists can then adapt the methods and utilise their own local datasets to develop recommendations for the areas that they serve.

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(Received 15 December 2003; in revised form 22 July 2004)