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A Geospatial Decision Support System for Drought Risk Management

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Introduction

Drought affects virtually all regions of the world and results in significant economic, social, and environmental impacts. The Federal Emergency Management Agency estimates annual drought-related losses in the United States at $6-8 billion, which is more than any other natural hazard. Congress enacted the Agricultural Risk Protection Act of 2000 to encourage the United States Department of Agriculture (USDA) Risk Management Agency (RMA) and farmers to be more proactive in managing drought risk.

Through the National Science Foundation (NSF) Digital Government program, the USDA RMA is working with the University of Nebraska–Lincoln Computer Science and Engineering (CSE) Department, National Drought Mitigation Center (NDMC), and High Plains Regional Climate Center (HPRCC) to develop new geospatial decision support tools to address agricultural drought hazards and identify regions of vulnerability in the management of drought risk. The goal of this research project is to develop a support system of geospatial analyses that will enhance drought risk assessment and exposure analysis. The tools and technologies developed have been integrated into the National Agricultural Decision Support System (NADSS), http://nadss.unl.edu/ .

Collaboration

Research and tool development was guided by advice and feedback from an advisory panel that consists of members from the University of Nebraska (Lincoln, Omaha, and Kearney), Industry, USDA RMA, and the USDA Natural Resources Conservation Service. Individual members included government and university experts in climatology, agronomy, GIS and computer science. The advantage of including members with such varied backgrounds is that they brought different interpretations of the problem and visions for future solutions. Of course, this also created a challenge when the group first started to work together. Weekly meetings with the group of researchers and quarterly meetings with the advisory panel helped members to learn to communicate with each other and to earn mutual respect. The result has been a very productive interdisciplinary collaboration.

Scientific and Application Research Objectives

The proposal, of course, detailed a list of scientific research objectives, which were split into computer science research and application research objectives. These objectives were reviewed and discussed during the first advisory panel meeting. The combined objectives set by that meeting were as follows:

- Develop an extensible distributed computing architecture that addresses data interoperability problems and provides better support for geospatial decision support systems.
- Improve the spatial and temporal resolution of drought index computations and maps.
- Develop new time series data mining algorithms that are able to identify relationships between antecedent and consequent events with varying time lags.

- Develop new interpolation methods that use only linear constraints that are fast, and suitable for the internal representation of the MLPQ/GIS system.
- Speed RMA's risk assessment with automation, so that information can be used interactively and to trigger emergency actions.
- Enhance risk assessment with increased spatial and temporal resolution and additional biophysical variables characterizing climate, natural resources, land management and infrastructure.
- Extend risk assessment to vulnerability mapping, forecasting, and economic and environmental impact assessment.
- Improve the ability of RMA to understand risks across agricultural landscapes and communicate these risks to producers, crop insurers and other government agencies.

The first four research objectives have been accomplished. The remaining four application objectives are partially completed. We are continuing to work on these objectives with a new cooperative research agreement from our government partner, USDA RMA.

Broader Impact

The tools and technology developed have enabled scientists and government personnel to ask new (research) questions that were unimaginable four years ago! The web site http://nadss.unl.edu/ is used daily by producers throughout the U.S., research scientists throughout the world, government scientists and risk assessment personnel. Workshops have increased awareness of individual producers, extension education and rural communities as to the importance of drought mitigation and the tools available to assist them. The project has provided educational and research experiences for undergraduate and graduate students in computer science, agronomy and geography (four PhD dissertations, ten masters projects/theses, two undergraduate honors theses, and a summer internship for a minority student participating in the UNL Summer Research Program).

Success Stories

- The USDA RMA and UNL have entered a Cooperative Agreement to transition research prototype models and tools from the lab to sponsored tools used by producers and the agency. The initial agreement provides $1.3 million over 2.5 years, and a $2.5 million follow-on agreement (over 5 years) is pending.
- Technologies and research models developed by this project have led to partnerships and other research projects with approximately $500,000 in new research funds from NSF, USGS, NOAA, and USDA.
- The distributed architecture and some of the tools developed by this project are being reused in new projects proposed by other researchers in food science, agronomy, climatology, and geosciences.
- The results from our web-based tools have been used by state government agencies to evaluate the need for disaster relief associated with the effects of drought.
- GIS Workshop, Inc. has emerged as an industry partner that is providing assistance with technology transfer for NSF and USDA funded research to industry. GIS Workshop has a full-time employee working with the UNL Computer Scientists on the project to learn the technology being developed and deployed. Moreover, GIS Workshop has adopted the distributed computing architecture for all of its current and future Web-based applications.
- An undergraduate student for this project developed the Self-Calibrating Palmer Drought Severity Index (SC-PDSI) at UNL, which represents the first major change to the Palmer Drought Severity Index since its creation in 1965. A paper presenting and evaluating the SC-PDSI will appear in the Journal of Climate in 2004. Researchers in the U.S., South Africa, Italy, and the Czech Republic are already using the SC-PDSI to evaluate and monitor climate change in addition to drought.
- UNL has emerged as the leading institution in the development of new automated Quality Assurance and Control algorithms for climate data. This project is a collaborative effort between NOAA's National Climate Data Center and the regional climate centers.