National Integrated Drought Information System NIDIS

A Pathway for National Resilience

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Coping with Drought: Research in Support of NIDIS

By Roger Pulwarty (National Oceanic and Atmospheric Administration)
Director of NIDIS

The National Integrated Drought Information System Act of 2006 was signed into law in December 2006 (Public Law 109-430). NIDIS consolidates physical/hydrological and socio-economic impacts data and information on an ongoing basis, develops a suite of usable drought decision support tools focused on critical management indicators, thresholds and triggers, and engages and enables proactive planning by those affected by drought across temporal and spatial scales. Developing and supporting a framework for collaboration between researchers and managers is important to the success of NIDIS.

NIDIS also conducts knowledge assessments to (i) determine where major drought-information gaps occur and where research improvements are needed and (ii) coordinate capabilities among those conducting research and research activities. A major goal of NIDIS is to foster and support a research environment that focuses on impact assessment and timely risk management. Through the NIDIS Coping With Drought research grants and contracts implemented under the NOAA Regional Integrated Sciences and Assessments (RISA), Sectoral Applications and Drought Early Warning Systems pilot programs, NIDIS supports and draws on research and research networks in academia and Federal agencies, the Regional Climate Centers, the University of Nebraska National Drought Mitigation Center, and State Climatologists among others.

Because of the inherent uncertainty associated with drought, researchers incorporate both biophysical and socioeconomic data and models into scenarios that allow managers to assess and mitigate their risks. NIDIS conducts and supports interdisciplinary research to develop (i) drought-sensitive socio-economic impacts assessments, indicators, and scenarios, (ii) reconcile various forecasts and predictions of drought variability and change, (iii) integrate information from various monitoring and forecasting networks into regional drought monitors and (iv) inform drought risk management decision making.

This NIDIS Newsletter Special Issue highlights NIDIS-supported work in diverse drought-sensitive areas such as water supply and demand, wildfire risk assessment and management, and agricultural production. The cases in this issue show that successful drought early warning information systems are reliant on a strong foundation of applied research on a collaborative basis among research and management professionals that (i) integrates indicators and threshold impacts with physical variables across timescales and (ii) supports a collaborative framework for early warning systems across temporal and spatial scales.

Implementation of a Climate-Vegetation Based Early Warning and Prediction System for Interagency Fuels Management

By: Timothy Brown
Research Team: Timothy Brown (Desert Research Institute (WRCC/CEFA/CNAP), Dominique Bachelet (Oregon State University), Jim Lenihan (US Forest Service Pacific Northwest Research Station) and Robert Webb (NOAA-Earth System Research Laboratory)

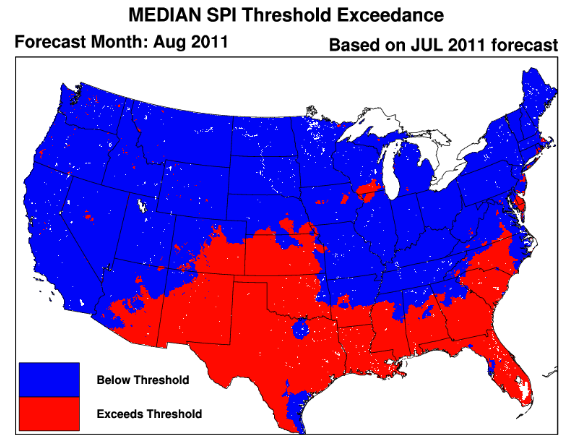

Figure: Example forecast showing SPI combined for all five GCM models.

The USDA Forest Service, Bureau of Land Management, National Park Service, US Fish and Wildlife Service and the Bureau of Indian Affairs as well as state and private forestry management utilize prescribed fire and other treatment methods to meet several primary land management objectives including hazardous fuel reduction, ecosystem and habitat restoration, forage for grazing and fuel breaks for wildland fire. Nearly two million acres are burned on average annually on federal land by prescribed fire, and it is desired to increase this amount to meet objectives outlined in federal fire policy. Meteorological prescription windows for prescribed burns are specific to fuel type and the management objective, and are defined in terms of temperature, humidity and wind (air quality regulatory guidelines increasingly are becoming a consideration). However, interannual climate variability impacts treatment implementation, both positively and negatively. For example, prescribed fire cannot be utilized on fuels that are too wet or dry because either they will insufficiently burn, or burn at an undesirable high intensity and risk escape from the control perimeter, respectively. In either case, the desired management objective will not be met. Successful fuel treatment implementation is dependent in part on climate.

A large amount of climate information is potentially available for input into prescribed fire decisions, though this information is largely under-utilized (Kolden and Brown 2010). Raw climate data (such as precipitation anomalies or drought indices), and even many value-added products, do not provide a maximum benefit to decision-makers because this information is not directly linked with on-the-ground decisions. For example, a standardized precipitation index number of -1 is only a relative number to a land manager unless it is associated with a specific impact or activity. For this project, we examined over 37,000 prescribed fires and wildland use fires for the period 1980-2008 in relation to a number of climate and fire indices. Specifically, index values were matched to days that a burn event was initiated, and examined the index frequency counts to determine if there were obvious thresholds. Generally, the 75th percentile seemed to serve as a good indicator for three indices – the standardized precipitation index (SPI), fire line intensity (FLI; energy at the flame front) and rate of spread (ROS; fire spread per unit of time). Each index was examined separately for 10 geographic areas across the US that serves as interagency management boundaries. FLI and ROS indices varied by geographic area, but the SPI was fairly consistent across the country; 75% of all managed fires took place when the SPI was on average across the geographic areas -0.60 or greater (normal to wet conditions). The SPI values, along with those found for FLI and ROS, then provide a specific link of each index to a management action (i.e., prescribed burning).

Monthly forecasts of the three indices have been produced by incorporating output from five operational GCMs into the MC1 dynamic vegetation model (www.fsl.orst.edu/dgvm). MC1 is a dynamic general vegetation model (DGVM) that simulates life-form mixtures and vegetation types, ecosystem fluxes of carbon, nitrogen, water and fire disturbance. Forecasts are being made available for each individual model, but are also combined as mean and median ensembles, as are all three indices for all three models. The forecasts, along with interpretative information, are made available for management use at http://cefa.dri.edu/mc1 (see the accompanying figure for an example). Currently, members of the interagency Fuels Management Committee are exploring how best to utilize this product for national budget and strategic use planning.

This project was supported by the NOAA TRACS program and the interagency Fuels Management Committee.

Reference:

Kolden, C., and T. Brown, 2010: Beyond wildfire: Understanding climate impacts on managed fire in the U.S.A. International Journal Wildland Fire, 19, 364-373.

Evaluation of Climate Forecast Products to Enhance Wildfire Preparedness and Response

By Gigi Owen
Research team: Gigi Owen, Jonathan McLeod and Daniel Ferguson (Climate Assessment for the Southwest, University of Arizona), Crystal Kolden (Department of Geography, University of Idaho), and Timothy Brown (Desert Research Institute)

Wildfires raged across the U.S. Southwest this year. Dry conditions heading into the 2011 fire season ripened the landscape for disaster. Moisture levels in soils and vegetation were extremely low due to extended periods of severe drought, scant rainfall, above-average temperatures, and high winds. These conditions helped small sparks turn into large-scale blazes across the region. Since January, almost 2 million acres have burned, making this season the worst in the written record in Arizona and New Mexico. The previous record was set in 2002, when 1.05 million acres burned in these two states. That year, the Southwest was plagued by similar conditions – little rainfall, high temperatures, and extended periods of severe drought.

Since the early 2000s, climatologists have worked with fire management professionals to apply climate information to forecasting seasonal wildfire potential. These days fire managers have access to multiple types of climate information through a wide range of sources. However it is not well understood how these different types and sources of information influence fire management since few evaluations have been conducted. In our study, we surveyed a population of fire management professionals in the Southwest to understand how climate-related products are perceived and used in fire management practices and how these relate to other types of commonly used information. Through a social network analysis these preferences were explored in the context of personal, professional, and institutional ties that affect the distribution and acceptance of new forms of information.

Data were collected from November 2009 to June 2010 via 37 semi-structured phone interviews lasting approximately 45 minutes each and 40 online surveys. We gathered quantitative and qualitative data about preferences for forecast information in the pre-fire and peak fire seasons, uses and perceptions of fire potential outlooks, and the social network of fire management professionals through which information is created and circulated.

We found that climate-based forecasts were the most important type of information in the months preceding the Southwest's fire season as they allowed managers to proactively plan for the upcoming fire season, whereas the suppression process during the peak fire season was primarily reactive and based on short-term weather forecasts and current fuel conditions. We also found that the acceptance and integration of climate-based information on the part of fire management professionals was largely due to person-to-person communication patterns.

> We found that climate-based forecasts were the most important type of information in the months preceding the Southwest's fire season

Though the current impacts of forecasting tools are difficult to measure, our results indicate the strengthening of person-to-person relationships may be an unforeseen but valuable outcome of incorporating long-term predictive forecasting into fire management. Through frequent communication, fire managers begin to strategize where fires are most likely to occur and how resources may be allocated to where they are needed most. This capability opens up new possibilities for fire managers during the pre-season, when activities were previously limited to activities such as training, budgeting, equipment maintenance, or furloughs. However, because of current institutional limits on how much pre-season resource allocation is based on forecasting, fire managers are restricted in their direct application of seasonal forecasts to management decisions. One exception is that fire managers use these forecasts to request severity dollars. When there is high potential for severe fire behavior or fires starting outside the usual fire season, requests for severity dollars can be made for additional suppression resources beyond what is locally and regionally available. Examples include increased firefighting staff, funding for use of aircrafts, and increased fire prevention activities.

There are many benefits to proactive, long-term wildfire management. Preventative measures go a long way to protect environments, human lives, and economies. Weather information provides short-term forecasts that are useful for short-term planning; climate information provides longer-term outlooks that can be useful for long-term planning. Due to the probabilities and uncertainty inherent in climate outlooks, it has taken time to translate these outlooks into useful tools for fire management. The complex and probabilistic nature of climate-based forecasting becomes more accessible to users when delivered by trusted experts who can explain and interpret forecasts.

Despite all the current knowledge regarding climate forecasting and its applications to wildfire management, large record-setting fires will still occur. The successful implementation of a forecast may largely be invisible, which increases levels of uncertainty on how to best apply fire potential outlooks. Despite these unknowns, our research shows it is beneficial to continue exploration of translating climate forecasts into direct and measurable benefits for fire management.

This work was supported by the National Oceanic and Atmospheric Administration's Climate Program Office with the Climate Assessment for the Southwest program at the University of Arizona.

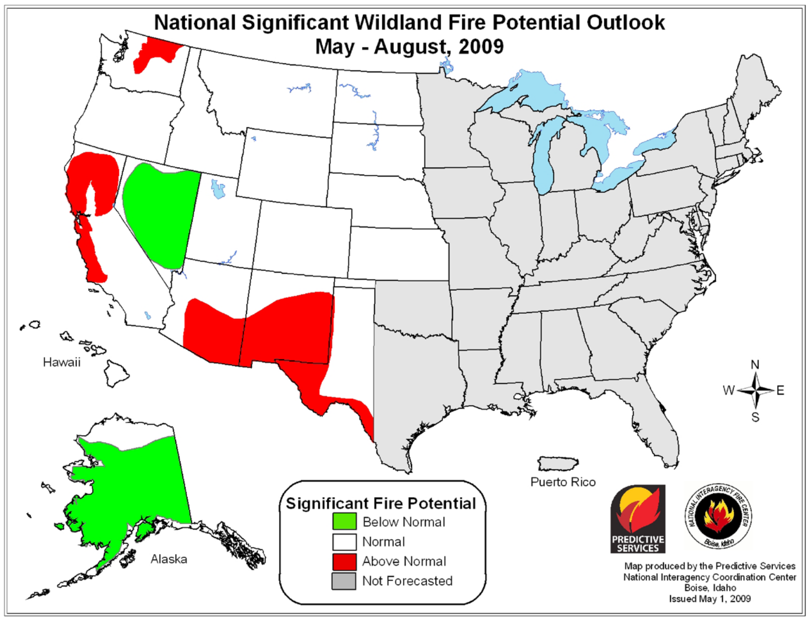

Figure: National Significant Wildland Fire Potential Outlook for May – August, 2009. This is an example of the type of product evaluated during the project. This product was produced by fire managers, climatologists, meteorologists, and fire behavior analysts from across the western states at a workshop in 2009. The workshops to create the seasonal outlook still occur once a year, before the wildfires start. The outlooks are then updated monthly throughout the fire season via conference calls. The current product is available here: http://www.nifc.gov/nicc/predictive/outlooks/monthly_seasonal_outlook.pdf.

State Drought Planning in the Western U.S.: A Multi-RISA–Agency–NIDIS Collaboration

By: Anne Steinemann
Research Team: Anne Steinemann (CIG, CNAP)
Dan Cayan (CNAP),
Melissa Finucane (Pacific RISA),
Gregg Garfin (CLIMAS),
Mike Hayes (NDMC),
Ed Miles (CIG),
Kelly Redmond (WRCC, CNAP),
Brad Udall (WWA),
Dan White (ACCAP)

This project examines ways that drought information provided by the National Integrated Drought Information System (NIDIS) can be useful for state drought planning in the 19 Western Governors Association states. The first phase of this study found that nearly all states have drought plans, and use a range of drought information from individual indicators to integrated products (such as the U.S. Drought Monitor). But state officials also expressed a need for more customized types of drought resources that NIDIS could provide, such as more regionally specific, clear, and relevant drought indicators for both monitoring and forecasting. The second phase of this study, to be conducted in Fall 2011, will examine in greater detail the types of drought decisions made by state officials, the drought information needed for those decisions, the most useful formats and means of communicating that information, and the value of a drought early warning information system. An overall goal of this work is to identify and demonstrate ways that drought resources offered by NIDIS, as well as the western Regional Integrated Sciences & Assessments (RISAs), Regional Climate Centers (RCCs), the National Drought Mitigation Center (NDMC), and others, can be useful and valuable to state drought planning and, ultimately, can improve drought decision-making and reduce drought impacts.

City Uses Climate Information for Drought Preparedness

By: Puneet Srivastava
Research Team: Puneet Srivastava and Latif Kalin (Auburn University)
Keith Ingram (University of Florida)
David E. Stooksbury (University of Georgia)
Muthuvel Chilliah (Climate Prediction Center)
Matthew Dunn (City of Auburn, AL)
Richard R. Marcus (California State University)

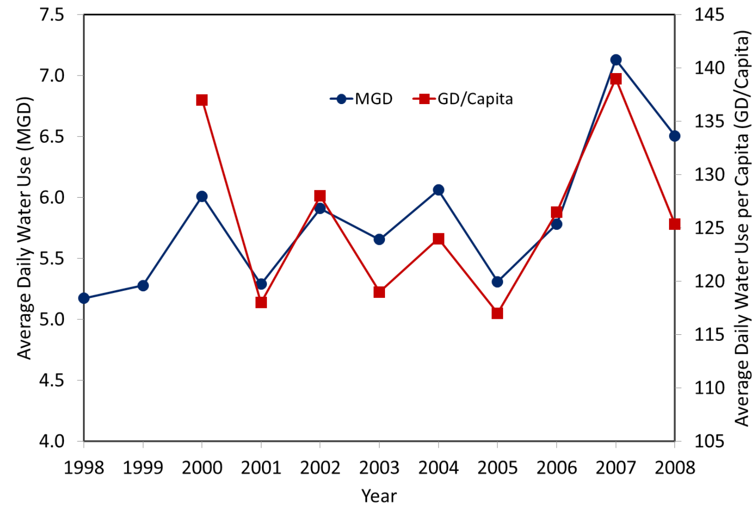

Figure: Average daily water use in (a) million gallons per day (blue line) and (b) per capita (red line), in Auburn.

As part of a Southeast Climate Consortium (SECC) initiative and as a result of a 2007-2008 drought in the Southeast US, we started working with the City of Auburn, AL to see how the city was dealing with the water supply and demand issues during drought. As with many southeastern cities, Auburn is experiencing significant population growth and urbanization. The population of the city jumped from 33,830 in 1990 to currently over 50,000, which is expected to grow to 66,000 by 2025. There has been an apparent trend of increasing water demand in the city, which has often been exacerbated by drought. For example, the impacts of the 2000 and the recent 2007 droughts on water use are evident as seen the accompanying figure.

The population of Auburn, AL jumped from 33,830 in 1990 to currently over 50,000, increasing demands on the water supply

In the Southeast, seasonal to inter-annual (SI) climate variability and, hence, occurrence of drought is greatly influenced by El Niño Southern Oscillation (ENSO). El Niño years tend to be cool and wet, while La Niña years tend to be warm and dry, between October and April. Drier conditions in winter have an enormous impact on southeastern states because these states depend on water recharge during the cool season. A drier winter also increases the odds of going into a multi-year drought. Since La Niña typically returns every two to seven years, drought is a recurring phenomenon in the Southeast.

When SECC started working with Auburn, the city was not using SI climate forecasts for their water supply and demand management. We worked with the city's Watershed Division Manager, Matthew Dunn, and discussed with him how to use SI climate forecasts to reduce the impact of drought on water supply and demand. As a result of the SECC's interactions with Matthew Dunn, using the SI climate forecasts issued by the National Oceanic and Atmospheric Agency's (NOAA) Climate Prediction Center, the city issued a drought update to its customers in March 2011 in an effort to curb water demand during the 2011 lawn-watering season. The update was issued well in advance to make sure that it was effective in reducing water demand. The city experienced severe drought until middle of June 2011. However, because of its proactive response to the impending drought, the city's water supply was not greatly affected.

The city now actively uses climate information for managing water supply and demand. The drought briefings conducted by the National Integrated Drought Information System (NIDIS) in the Apalachicola-Chattahoochee-Flint (ACF) river basin provides a good source of climate information to the city (visit http://www.drought.gov/portal/server.pt/community/acfrb for access to the latest drought briefing slides).

SECC's Collaboration with the city also led to a proposal to develop a municipal water deficit index for small municipalities in the Southeast that depend on surface water sources for their municipal water supply.

This proposal received funding from the National Integrated Drought Information System's (NIDIS) Coping with Drought initiative through the NOAA Sectoral Applications Research Program (SARP). The project is expected to engage a large group of small municipalities in the Southeast and, just like the City of Auburn, would help them use SI climate forecasts to effectively deal with drought.

Dynamic Drought Index Tool and ACIS: Implementation of a Drought Mapping Tool in the Eastern United States

By: Greg Carbone
Research Team: Greg Carbone, Kirstin Dow and Jinyoung Rhee (University of South Carolina)
Arthur DeGaetano (Northeast Regional Climate Center)
Hope Mizzell (South Carolina State Climatology Office)
Richard R. Marcus (California State University)

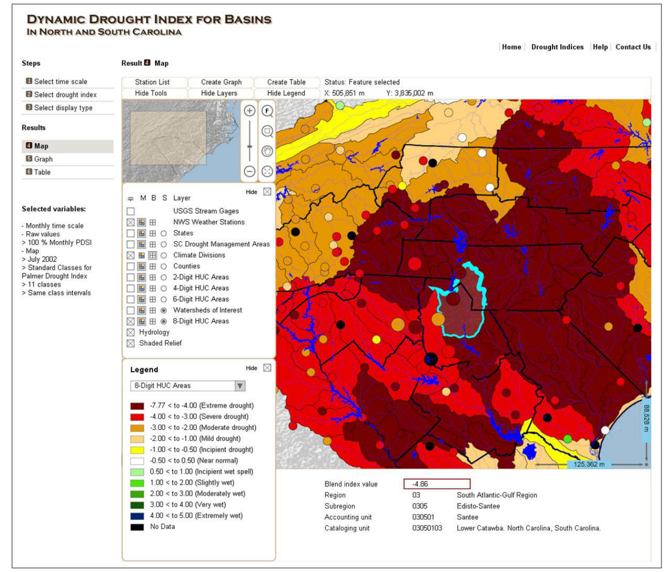

Figure 1: Computed monthly PDSI for the Lower Cawtawba Basin in July 2002, as computed and displayed by the Dynamic Drought Index Tool.

Drought mitigation and planning require a monitoring system that considers a range of spatial and temporal scales, and includes indices that relate to specific impacts to meet the diverse needs of decision makers. While the United States Drought Monitor (http://droughtmonitor.unl.edu/monitor.html) will continue to provide comprehensive and timely national drought information, the goals of the National Integrated Drought Information System (NIDIS) will require supplemental regional and local tools. The Carolinas Regional Integrated Sciences and Assessments (RISA) group developed the Dynamic Drought Index Tool (DDIT) – a web-based application for creating drought maps – in response to a four-year drought in the Carolinas and to water management negotiations associated with dam relicensing in large river basins. This regional drought monitoring system accommodates decision makers, such as those at the South Carolina Department of Natural Resources, who must consider drought across different physical and political units and in the context of state and local ordinances. Its flexible, open-architecture design meets these needs as well as the reality of wide-ranging definitions of and sensitivity to drought. Its graphical user interface provides options for drought indices and blends, classification methods, time scales, and user-specified regions (Fig. 1). The tool allows comparison of different regions or times, and combinations of maps, graphs, and tables.

A grant from NOAA's Transition of Research Applications to Climate Services (TRACS) program supports collaboration between the Carolinas RISA and the Northeast Regional Climate Center (NRCC) to expand the DDIT to the states served by the Northeast and Southeast Regional Climate Centers (SERCC). The tool will be integrated with the near-real time Applied Climate Information System (ACIS). Specifically, it will use a 5-km gridded database designed to support new products and research at the NRCC. Gridded daily precipitation and temperature data will be available on the server and provide inputs to spatially-aggregated drought index values that are calculated through web services. Intermediate gridded drought index values may be calculated for some drought indices with recursive characteristics such as Palmer Drought Index (e.g., January values for every ten years for monthly time scale) and saved for later use to reduce calculation time. The DDIT will maintain metadata for spatial features (drought management areas, specific to each state) and climate data directly through web services. The new version will allow SVG map export to JPEG format, ESRI Shapefiles, and as overlay maps in KML format for Google Map compatibility. A preliminary version of this expanded tool will be available in fall 2011.

The project also explores measurement and display of uncertainty associated with drought mapping. Interpolation and aggregation errors are being investigated with a variety of techniques. A series of cognitive mapping experiments have gathered feedback from users on the visual display of uncertainty on drought maps. The results of these studies will be incorporated into some sample products. Development of the expanded DDIT will involve interaction with climate service providers in the 18 eastern states served by the NRCC and SERCC in order to incorporate user suggestions for improving the interface and functionality of the tool. Workshops with other user groups, planned for spring 2012, will help to evaluate the tool's effectiveness in decision making.

The Dynamic Drought Index Tool can be found at https://www.dnr.sc.gov/drought/.

Open AgroClimate: An Open Source Toolkit for Managing Climate Risk

By Christopher Villalobos
Research Team: Keith Ingram, Clyde Fraisse, Howard Hu, James Jones, Oxana Uryasev and Christopher Vallalobos (University of Florida)
Gerrit Hoogenboom (Washington State University)
David Zierden (Florida State University)
Holly Hartmann and Ellen Lay (Climate Assessment for the Southwest)
Michael Brewer (NOAA/National Data Climatic Center)
Willingthon Pavan (Universidade de Passo Fundo, Brazil)
Gail Wilkerson (North Carolina State University)

To understand Open AgroClimate and how it has evolved, we must start at the root project, an SECC initiative called AgroClimate. AgroClimate is an interactive website with climate, agriculture, and forestry information that allows users to assess resource management options with respect to their probable outcomes under forecast climate conditions. AgroClimate uses crop simulation models along with historic and forecast climate data to allow decision makers to compare changes in probable outcomes under different climate conditions.

Why Go Open Source?
Open AgroClimate is an open source implementation of the SECC's AgroClimate initiative. The goal is to ensure that the climate-based crop and risk management tools of AgroClimate can continue to evolve and be portable enough to deploy anywhere in the world at a reduced cost.

By going open source, we hope to also receive greater exposure in both the private and public sectors. Any private company or public municipality could deploy this code either in a public site, or on a secure intranet, and have full access to the information provided by the tools.

Currently, all the tools are being developed as WordPress plug-ins, which will allow the tools to be deployed alongside a Content Management System. This also simplifies the packaging of specific tools, because the WordPress API allows for developers to leverage WordPress for database management, information gathering, and formatting for various languages. As the project progresses, Open AgroClimate can be ported to other development platforms and programming languages, such as Django and Ruby on Rails.

Bumps on the Open Road
Going open source on a project like this is not an easy task. Figuring out the best license for software distribution was one of the more difficult challenges, especially because there are several large groups of people who contribute to Open AgroClimate and we need to assure recognition for their past and future contributions. Another challenge was to replace the proprietary code base that runs AgroClimate with open source alternatives that meet the needs of the stakeholders. (e.g., farmers and crop reinsurers).

Moving Forward
The Open AgroClimate project is in the process of converting most of the tools from the AgroClimate site into a portable format. The conversion is anticipated to be complete in the next year or so. Also, the project is building frameworks to interact with various web services, such as NDFD and CRONOS, as well as acquiring more tools from other universities who would like to contribute to this project. If you are interesting in contributing, or learning more about Open AgroClimate, please visit the links below for more information.

Links

Agroclimate – http://agroclimate.org/

Open AgroClimate – http://open.agroclimate.org/

Open AgroClimate Forum – http://open.agroclimate.org/bb/

Figure 1: An example of AgroClimate implemented in Brazil through Open AgroClimate.

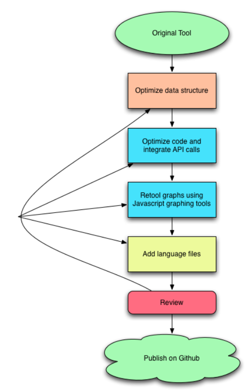

Figure 2: Flow diagram showing process for converting AgroClimate to an open source software system.

Reducing Forage Producers' Drought Vulnerability in the Southeastern USA

By: Clyde Fraisse
Research Team: Clyde Fraisse, Yoana Newman, Lincoln Zotarelli (University of Florida)
Norman Breuer (University of Miami)
Dennis Hancock, Mark Boudreau (University of Georgia)
Gerrit Hoogenboom (Washington State University)

Drought conditions are a frequent occurrence in the Southeast and generally create a pasture and hay shortage throughout the region, greatly impacting farm finances and profit. When pasture conditions are poor most cattlemen need to feed supplemental hay and grain to maintain the herd, increasing costs and decreasing profitability. A severe and sustained drought is stressful to the grazing herd, forage crops, and herd manager. Forage-based livestock producers are faced with the difficult decision of either (i) purchase feed and/or hay or (ii) sell their animals. Purchasing feed or hay is a reasonable strategy for what is expected to be a short-term drought. However, a prolonged drought may be much more disastrous if the producer continues to invest in feedstocks with little or no likelihood of a return.

The overall goal of this research project was to reduce the vulnerability of forage producers to drought in the southeastern U.S. To reach this goal, we have outlined four objectives that progress from our research base to climate information products tailored to meet producer's needs: (i) Understand forage producer perceptions of climate and weather, and potential application of drought monitoring and forecasting systems to forage production in the region; (ii) Develop a drought index to help quantify drought impacts on forage production; (iii) Develop a web-based drought decision support tool on AgroClimate.org (http://agroclimate.org/, the web site for the Southeast Climate Consortium); (iv) Deliver training workshops and outreach events in Florida and Georgia. In this article we address objectives (ii), (iii) and (iv).

Develop a drought index to help quantify drought impacts on forage production

Forage producers are primarily interested in forecasting the impact of rainfall anomalies on biomass production to better plan stocking rates, feed purchase, and fertilization management. Although a drought index such as the Agricultural Reference Index for Drought (ARID) (Figure 1, http://www.agroclimate.org/tools/drought/) developed in this project helps to quantify a drought, the real benefit comes from associating ARID with biomass production. To establish this association, in March of 2009 a field experiment was established at the University of Florida, Plant Science Research and Education Unit, near Citra, FL. This area has been monitored since that time under rain fed and irrigated conditions. Two irrigation treatments (irrigated and non-irrigated) and two fertilizer treatments (fertilized and non-fertilized) were established in a split plot design.

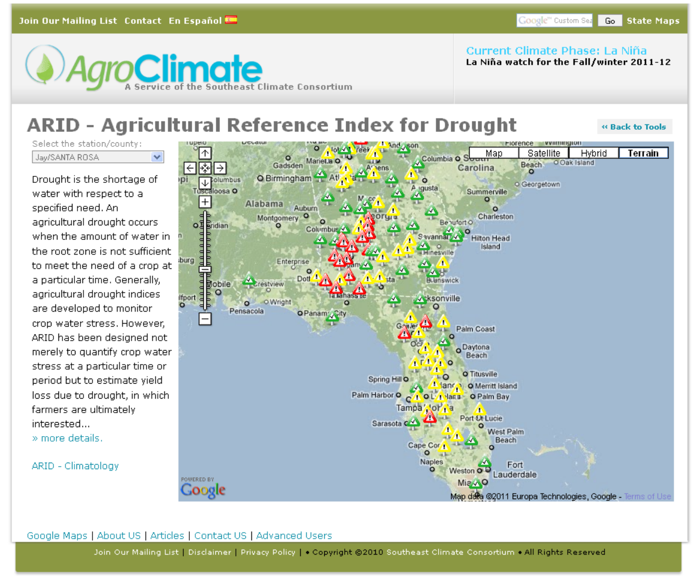

Figure 1: Agricultural Reference Index for Drought (ARID) main page (http://www.agroclimate.org/tools/drought/)

We found that the irrigated and fertilized plot had the greatest biomass production, with the main effect of water stress happening in the spring (Fig. 2). In the case of non-fertilized plots water was not a limiting factor. Data collected in this experiment are being used to validate a simple grass growth model that correlates ARID values with biomass production to help estimate the amount of biomass a rancher can expect to have under different climate scenarios and fertilization practices.

Develop a web-based drought decision support tool on AgroClimate.org

Information available on AgroClimate is used by Extension agents in Florida and Georgia working with forage and livestock for closely tracking the El Niño Southern Oscillation (ENSO) phase forecast. The interest of agents in ENSO is related to the fact that La Niña

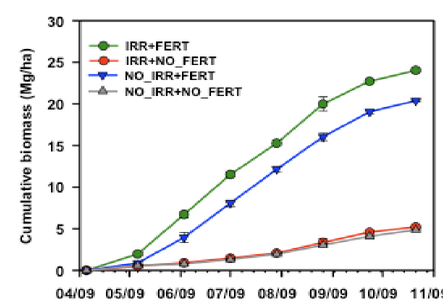

Figure 2: Biomass production in Citra, FL as affected by irrigation and fertilizer management.

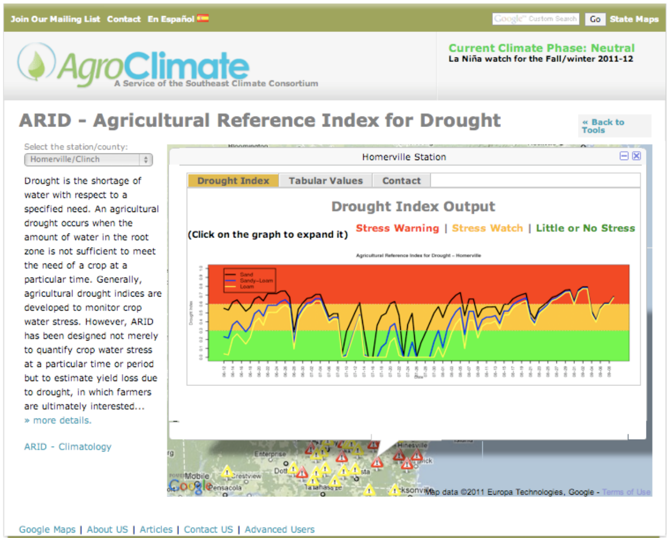

Figure 3: Agricultural Reference Index for Drought (ARID) monitoring tool on Agro-Climate.org, showing results for the Homerville Station

generally brings drier conditions during the winter and spring, negatively affecting the development of winter forage. We developed a comprehensive discussion of management options based on the impacts of ENSO on forage and livestock production in the southeastern U.S. (http://www.agroclimate.org/forage_livestock/pasture_hay.php). Topics include the establishment of warm and cool season grasses, fertilization, and grazing and stocking rates, among others.

The ARID monitoring system, mentioned above, is also part of the AgroClimate decision support tool. ARID is primarily used to track soil moisture conditions based on data collected at the automated weather stations operated by the Florida Automated Weather Network (FAWN) and the Georgia Automated Environmental Monitoring Network (AEMN). County Extension Agents are the main users of the system and the ones conveying the information to ranchers. An example of a time series from the ARID page is shown in Figure. 3.

Deliver training workshops and outreach events in Florida and Georgia

During our workshops and meetings with agents and ranchers we learned that their main interest during the warm season is on 30-day forecasts that would help them fine tune their fertilization management, avoiding the use of expensive inputs when below average rainfall is expected to limit biomass growth and make sure that fertilizer will not be the limiting factor when good moisture conditions are forecasted. We continue to work with extension agents and ranchers to improve and expand the system based on their feedback and needs.

This project was supported by the NOAA Sectoral Applications Research Program (SARP).

NIDIS Program Office

Roger Pulwarty, Director (Roger.Pulwarty@noaa.gov)

Jim Verdin, Deputy Director (Verdin@usgs.gov)

Chad McNutt (Chad.McNutt@noaa.gov)

Robert Webb (Robert.S.Webb@noaa.gov)

Lisa Darby (Lisa.Darby@noaa.gov)
Newsletter designer and editor

Carsen Ott (Carsen.Ott@noaa.gov)

Drought Portal

Mike Brewer (Michael.J.Brewer@noaa.gov)

Jason Symonds (Jason.Symonds@noaa.gov)