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AgroClimate – Tools for managing climate risk in agriculture

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ABSTRACT

Agricultural production is always subjected to risk associated with climate variability. Producers are often at the mercy of natural forces, which they cannot control, especially changes in rainfall from season to season and year to year. Variations from the "normal" climate can set the stage for other kinds of production risks, such as pest and disease incidence. Climate information and forecasts can be used to reduce production risk, increase resource use efficiency and the profitability of agricultural operations. However, simply providing better climate forecasts to potential users is not enough. Climate information only has value when there is a clearly defined adaptive response and a benefit once the content of the information is considered in the decision making process. In an effort to integrate all aspects of applying climate information and forecasts in agriculture, climate scientists, agricultural engineers, agronomists, anthropologists, and extension specialists from the Southeast Climate Consortium (SECC) developed a web-based climate information system (http://agroclimate.org) to provide extension agents, producers, and natural resource managers with tools to aid their decision making processes in reducing risks associated with climate variability. *AgroClimate* tools are grouped in six categories: climate, crop yield, crop diseases, degree-days and chill hours, drought indices, and footprint calculators. Results from ongoing research at the University of Florida and other universities in the region are continuously incorporated into the system increasing its relevancy and contributing to a more sustainable and climate resilient agricultural industry in the Southeast U.S.A.

1. Introduction

Agricultural production is always subjected to risk associated with climate variability. Producers are often at the mercy of natural forces, which they cannot control, especially changes in rainfall from season to season and year to year. Variations from the "normal" climate can set the stage for other kinds of production risks, such as pest and disease incidence. Some weather patterns, such as high temperatures, high humidity, or higher than normal rainfall, can raise the chances of fungal diseases. They can also improve conditions for insects and other pests that spread disease among plants and fields (FRAISSE et al., 2006). Crop development and yield responds to both individual weather events as well as seasonal climate variation. The long-term sustainability of agricultural enterprises depends on raising productivity while protecting the environment and being climate resilient.

Producers can use weather and climate information to reduce production risk, increase resource use efficiency and the profitability of agricultural operations. Depending on the decision to be made, either short-term weather forecasts or seasonal climate outlooks can be incorporated into their decision-making process together with other important factors such as commodity prices, government programs, and individuals' preferences. Decisions such as which crop and variety to plant and whether to purchase or not crop insurance need to be made well ahead the planting date. The lead-time required for making a decision is an indicator of what sort of forecast is needed. It is well known that short-term weather forecasts are usually fairly accurate in terms of predicting the significant weather features for the coming 1 to 3 days. As lead times increase to 7 or 10 days the accuracy decreases significantly and needs to be revised as that day approaches. Seasonal climate forecasts or outlooks are probabilistic by nature and predict anomalies of the climate, i.e. the probabilities of seasonal precipitation amounts or air temperature being above, below or within the long-term climatological average. The total rainfall, for example, may be predicted to be higher than the climatological average due to a greater-than-normal expected frequency of a specific atmospheric circulation pattern such as an ENSO (El Niño Southern Oscillation) that is conducive to rainfall at the location in question. However, the specific timing of rainfall events or days with temperature above or below climatological averages remains unknown (IRI, Tutorial #2, 2015).

The potential for producers to benefit from seasonal forecasts depends on factors that include the flexibility and willingness to adapt farming operations to the forecast, the timing and accuracy of the forecast, and the effectiveness of the communication process. A common perception is that advances in seasonal climate prediction alone will be enough for societal benefits to accrue. However, simply documenting the effects of climate variability and providing better climate forecasts to potential users are not sufficient (JONES et al., 2000). Climate information only has value when there is a potential response and a clearly defined benefit, once the content of the information is applied.

In an effort to integrate all aspects of applying climate information and forecasts in agriculture, climate scientists, agricultural engineers, agronomists, anthropologists, and extension specialists from the Southeast Climate Consortium (SECC) developed a web-based climate information system (http://agroclimate.org) to provide extension agents, producers, and natural resource managers with tools to aid their decision making processes in reducing risks associated with climate variability. The SECC is a consortium of eight universities in the states Alabama, Florida, Georgia, North Carolina and South Carolina. The mission of the SECC is to provide scientifically based climate, climate impact, and response option knowledge for decision makers in agriculture, water resources, and forest management.

2. AgroClimate.org

AgroClimate (Figure 1) is a web-based climate information and decision support system. The website includes seasonal forecasts, expected impacts of management options for different crops and climate scenarios, and a wide variety of interactive tools that help producers monitor current conditions and plan for the season ahead. *AgroClimate* has been developed to serve agricultural stakeholders in the Southeastern states of Florida, Georgia, Alabama, South Carolina, and North Carolina (BREUER et al., 2009). Users can monitor variables of interest such as growing degree-days, chill hours, disease risks for selected crops, and current and projected drought conditions. Users can also learn about the forecast of climate cycles affecting the Southeastern United States, such as the ENSO phenomenon. Water and carbon footprint calculators can provide estimates of how efficiently water and energy are being used. *AgroClimate* can help producers develop a strategy for the coming season and track current climate conditions affecting crop development and yield.

Using the climate information, producers can evaluate management practices to reduce risks from climate. Based on the expected seasonal climate outlook or other climate information, producers could change crop selection, planting dates, plant population, cover crop management, input purchasing, nutrient management, and others. The following list highlights the main ways that the information and tools available in AgroClimate can help agricultural producers reduce production risks associated with climate variability:

- Keep track of what climatologists are saying about the expected climate for the season;
- Understand how expected climate conditions may affect crops commonly grown in the Southeastern U.S.A.;
- Explore how El Niño and La Niña phases have historically affected crop production in the Southeastern U.S.A.;
- Learn how El Niño and La Niña events affect the climate in the region and in individual counties;
- Explore the best planting dates for selected crops according to the expected climate forecast;
- Monitor disease risks for selected crops;
- Monitor soil moisture conditions using different drought indices;
- Receive alerts by e-mail or mobile phone.

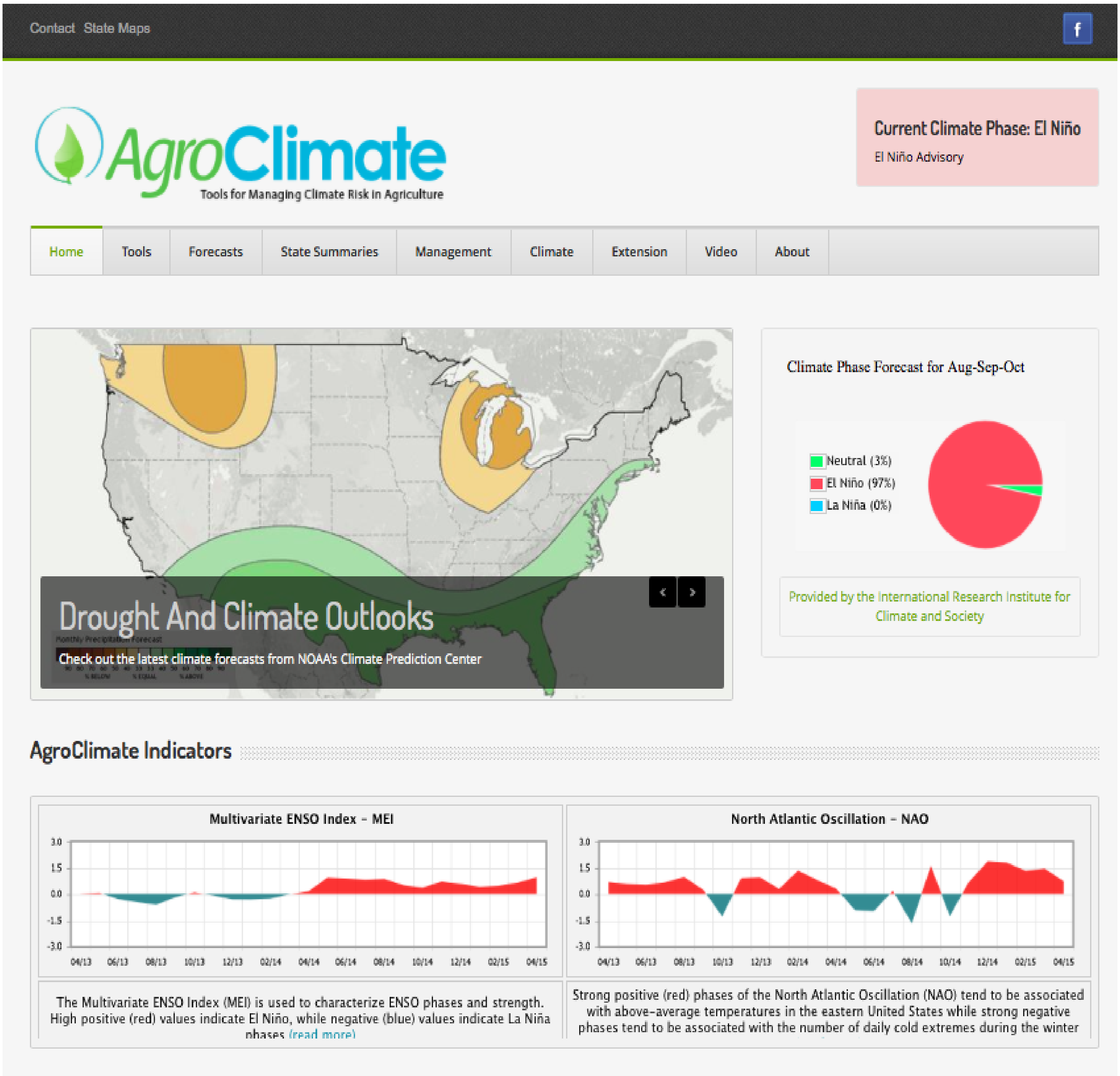

Figure 1. The main *AgroClimate* page displays links to tools, forecasts, factsheets, El Niño Southern Oscillation (ENSO) phase forecast, and indicators for ENSO and North Atlantic Oscillation (NAO) cycles.

The first step for implementing the *AgroClimate* information system was the development of a climate database for the region. Weather observations were compiled from the National Weather Service's Cooperative Observer network (NCDC TD 3200), which contains daily values for maximum temperature, minimum temperature, and precipitation for a period of record of at least 50 years. This database is updated annually with current records extending through 2014. The stations were selected based on (1) length of record, (2) data completeness, (3) homogeneity, and (4) representativeness of surrounding agricultural areas. Since then new sources of climate information such as gridded datasets of precipitation and temperature have been incorporated in the database and used to generate additional information.

Several indirect agronomic benefits can be achieved as a result of using the information provided by *AgroClimate*. For example, the Planting Date Planner tool (http://agroclimate.org/tools/Planting-Date- Planner/; FRAISSE et al., 2007) can help producers explore the likelihood of low, average, or high yield depending on a range of planting date options for a variety of crops growing under neutral, El Niño, or La Niña phases. Impacts of El Niño and La Niña on county-average crop yields throughout the Southeast are displayed by the Regional Yield maps on *AgroClimate*; these can be helpful for determining which ENSO phase results in the highest likelihood for top yields of a crop in a specific location.

Any management modifications based on ENSO phase or seasonal climate outlooks are typically location-specific

Table 1. Gives management options that could be adjusted in fall and spring based on the expected seasonal climate outlook.

Season	Management options for the Southeast U.S.A.
Fall	Harvest planning: Schedule labor and equipment to adjust timing of harvest in order to avoid damage/losses from excess rainfall.
	Choice of winter cover crop.
	Cover crop establishment: Hasten the establishment of cover crop in seasons when it is expected that cover crop growth will be reduced because of lower than average rainfall.
	Fertilization of cover crop.
	Winter pasture: invest on winter pasture when climate conditions are expected to be favorable, otherwise plan ahead for feed purchase.
Spring	Insurance coverage adjustments.
	Termination of cover crop: Could be early or late depending on recent and expected rainfall.
	Crop/variety selection: Decide which cash crop(s) to plant and to what extent.
	Planting dates of cash crops.
	Plant population: Adjust seeding rates based on expected seasonal rainfall, for example, lower than average rainfall, lower plant population.
	Fertilization: Adjust fertilization strategy based on expected rainfall.

and season-specific; therefore, no general "best practices" for modifying agricultural management are available. However, producers can make some management changes when lower-than-average rainfall and higher-than-average temperatures (or higher-than-average rainfall and lower-than-average temperatures) are expected. The nature of the management adjustments will depend on a producer's system and on the direction and probability of rainfall and temperature departures from average.

3. AgroClimate tools

Tools can be map-based, weather station-based, based on different temporal resolutions (15-minute, hourly, daily), require real time monitoring and/or historical datasets, based on process-based mechanistic models, regression models, or simple statistics. They are grouped in six categories: climate, crop yield, crop diseases, degree-days and chill hours, drought indices, and footprint calculators. A few of these tools are briefly described below.

The Planting Date Planner tool (crop yield group) is based on historical daily weather station records and local soils information. It helps producers decide on best planting dates for selected crops based on the expected climate. The Decision Support System for Agrotechnology Transfer-Cropping System Model (DSSAT-CSM) suite of crop models (JONES et al., 2003) was used for this effort. Crop models were used to simulate crop yield under different management scenarios using weather data from 1950 to 2004 for several counties in Georgia, Florida, and Alabama. Figure 2 shows the results of selecting four planting date options for dryland peanut production in Jackson County, FL. In this example, the May 22 gives the greatest likelihood for high yields in La Niña years. This tool allows for selection of different soils, irrigation management, crops and varieties, and ENSO phase for a numerous counties in Florida, Georgia, and Alabama.

The Climate Risk tool (http://agroclimate.org/tools/climate-risk/) provides detailed information about the ENSO effects on local climate by displaying station-based monthly statistics of temperature and rainfall for neutral, El Niño, and La Niña phases. Each month for the period of study was categorized as El Niño, La Niña or neutral using the Multivariate ENSO Index (MEI; WOLTER & TIMLIN, 1993) and later the monthly average for each phase as well as for all years were calculated. A map-based interface allows selection of weather stations in Florida, Georgia, Alabama, South Carolina, and North Carolina. For Florida and Georgia, current year conditions are also shown for comparison to historical climatology. Data presentation options include average and deviation, probability distribution and exceedance, and five-year monthly data.

Diverse diseases commonly affect crop fields due the interaction between the three components of the disease triangle—host (plant), pathogen (disease-causing agents, such as fungus, bacteria, virus) and environment. Disease

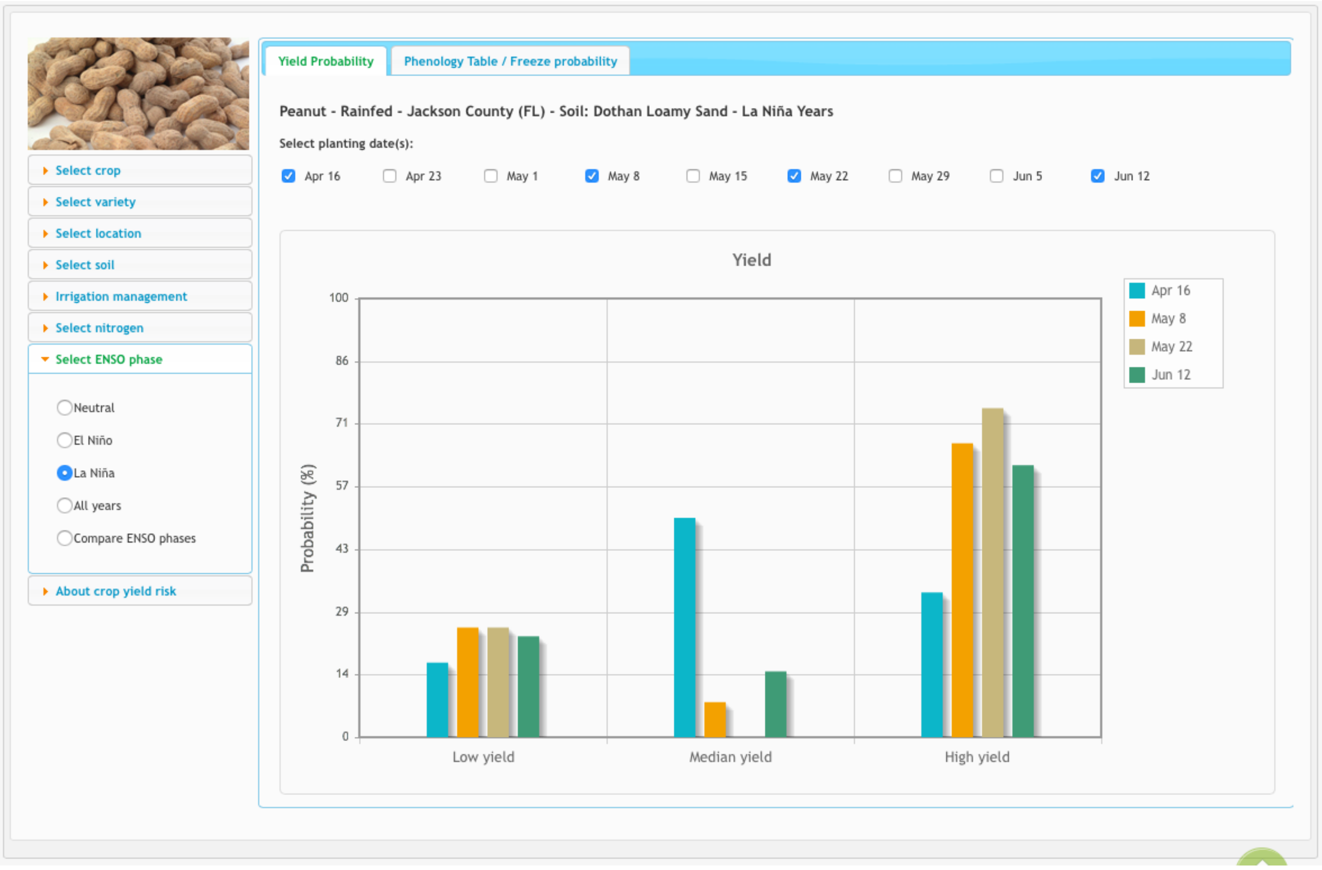

Figure 2. Planting date options for peanut production in Jackson County, FL. In this example, planting around May 22 gives the greatest likelihood for high yields in La Niña years.

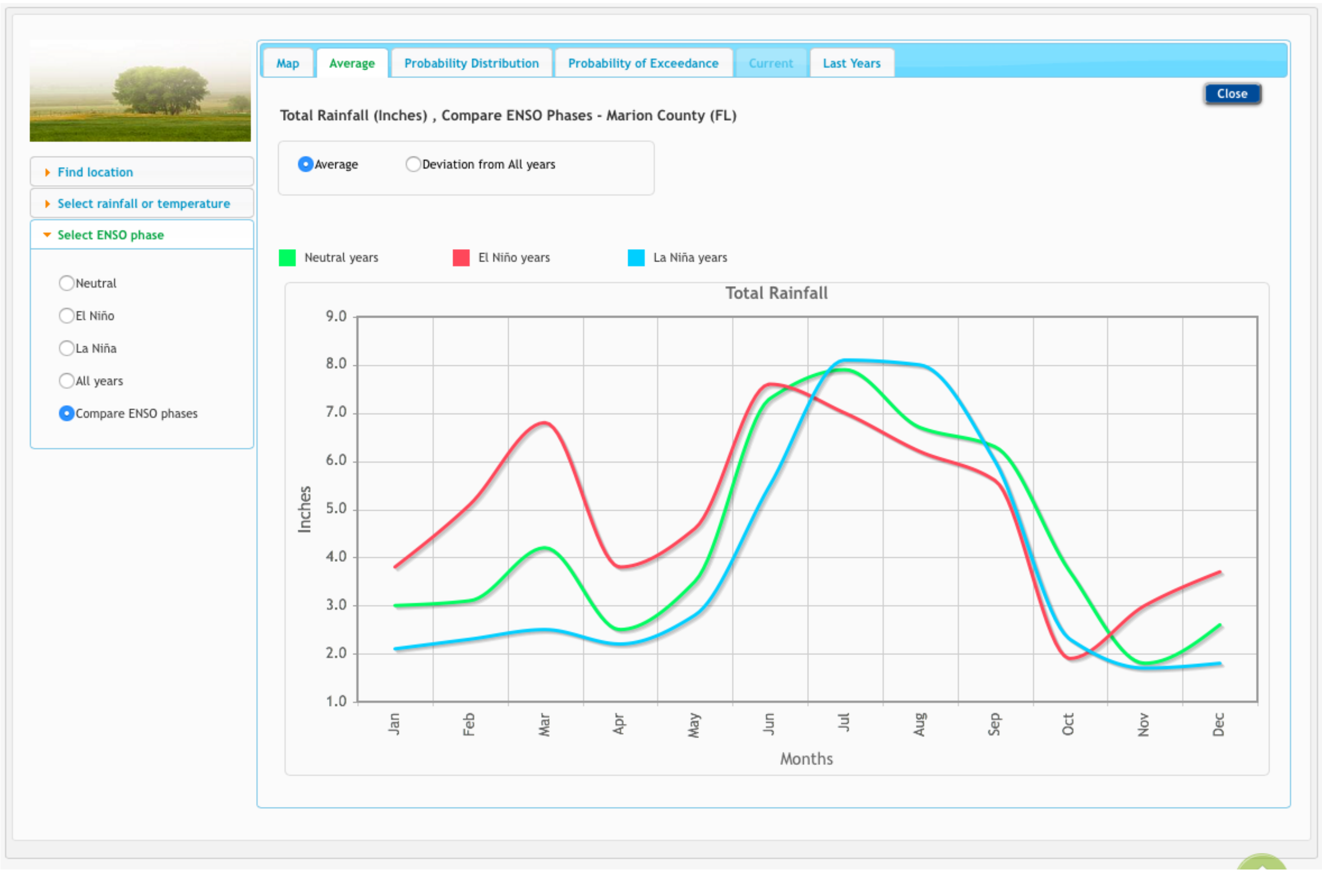

Figure 3. The climate risk tool displays information about basic climatology. In this example it shows average monthly rainfall for Marion County, FL during the El Niño, La Niña e neutral phases.

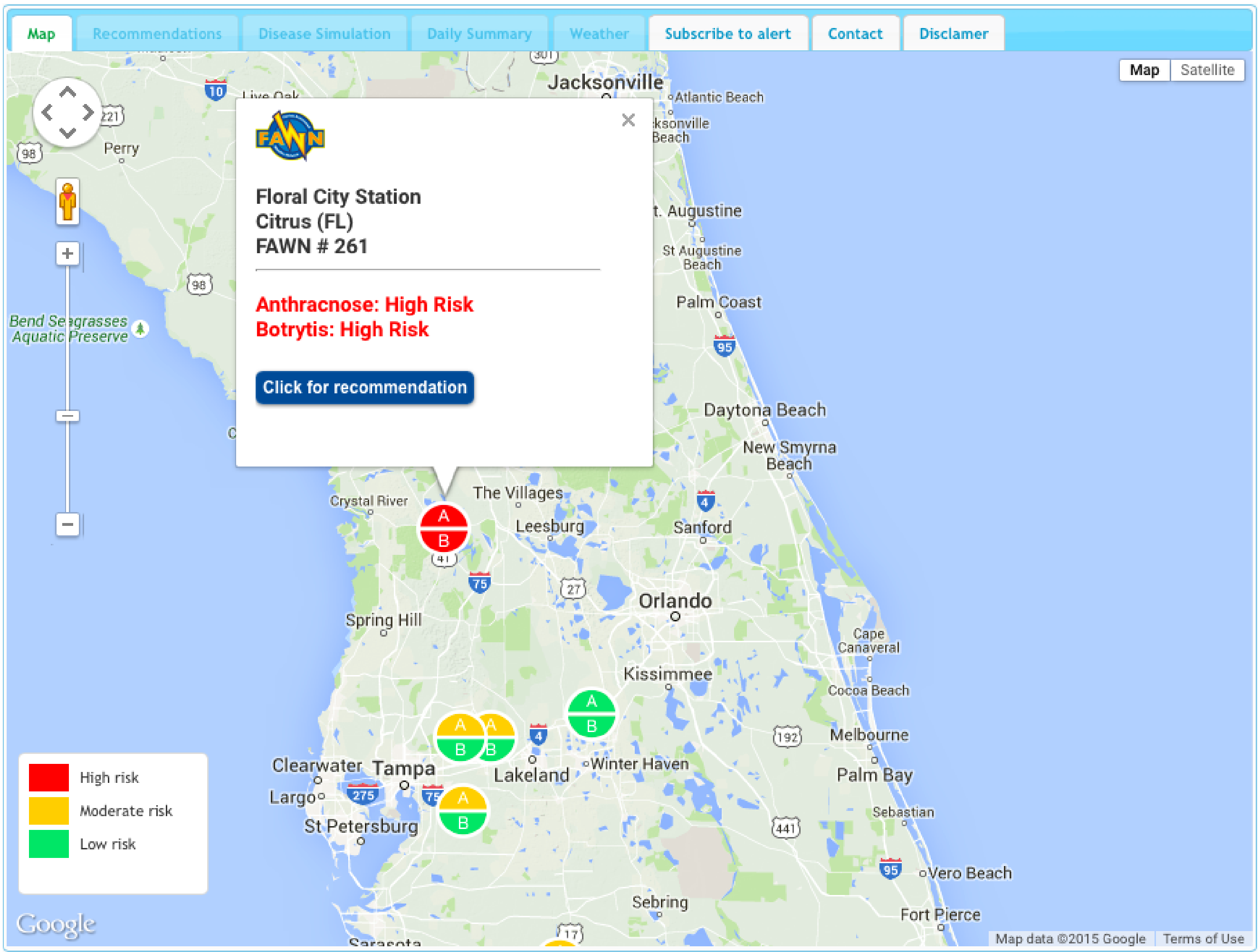

Figure 4. The Strawberry Advisory System (SAS) helps growers decide when to apply fungicide to control Botrytis (gray mold) and anthracnose fruit rots in Florida.

occurs when the pathogen is virulent i.e., can cause damage to a susceptible host and the environment is favorable. The Strawberry Advisory System (SAS: http://agroclimate.org/tools/strawberry/; PAVAN et al., 2011) monitors real-time and forecasted weather conditions that increase the risk for Botrytis (gray mold) and anthracnose fruit rots, providing risk-level information for these important diseases affecting strawberry production in Florida. The tool provides easy access to the information growers need to make spraying decisions in the field, saving them time, helping to improve disease control, and avoiding unnecessary fungicide applications.

The growing degree-days tool is available both in map and weather station formats, allowing users to map recent accumulation or evaluate the accumulation based on a specific weather station. Footprint calculators include tools to help the evaluation of carbon and water footprints of selected crops and management practices. Estimating GHG production from different production systems is important to pinpoint possible strategies to mitigate emissions, improve energy use efficiency (Lash and Wellington, 2007). It can also be used as a tool to set economic values in ecosystem services that result from some of the mitigation strategies used (MULKEY et al., 2008). The carbon footprint tool on *AgroClimate* (http://agroclimate.org/tools/Carbon-Footprint/) (TORRES et al., 2015; JONES et al., 2012) can be used to estimate the estimate the carbon footprint of selected cereal crops and strawberry production systems in the Southeast U.S. The Water Footprint tool (http://agroclimate.org/tools/Water-Footprint/) is a user-friendly web-resource capable of simulating the system-specific green and blue water footprints for crop production in the United States.

4. Factsheets

AgroClimate also provides a number of factsheets on management practices or technologies that can help produce reduce risk and improve resource use efficiency. Several management practices discussed in a way that highlights not only their agronomic benefits but also the opportunities they provide to increase the climate resiliency of crop production systems to long-term climate change and enhanced climate variability such as extreme

Table 2 lists the current factsheets currently available in the system.

Topic	Factsheet
Management options for climate variability and change	AgroClimate
	High-residue cover crops
	Sod-based rotation
	Conservation tillage
	Sensor-based Nitrogen application
	Irrigation and climate risks
	Microirrigation
	Sub-surface drip irrigation
	Variable rate irrigation
	Soil moisture monitoring
	Irrigation extension personnel in the Southeast
	Corn and climate variability
	Wheat and climate variability
	Crop insurance: Basics
	Crop insurance: Individual yield policies
	Crop insurance: Individual revenue policies
Weather and climate	Is it weather or climate?
	Climate impacts of ENSO
	Agricultural impacts of ENSO
	ENSO, climate and agriculture
	Drought basics
	Climate trends in the Southeast: Temperature
	Climate trends in the Southeast: Precipitation
	Rainfall intensity

rainfall events (FRAISSE et al., 2009; DOURTE et al., 2015). *AgroClimate* also includes factsheets discussing the basics of climate science.

5. Summary and conclusions

AgroClimate is a web-based climate information and decision support system that includes seasonal forecasts, expected impacts of management options for different crops and climate scenarios, and a wide variety of interactive tools that help producers monitor current conditions and plan for the season ahead. It was designed with the participation of potential end users, including agricultural producers and extension agents from its inception. It is intended to be a user-friendly and interactive decision support system that translates seasonal climate forecasts into information that can help users make decisions in their operations in the face of uncertainty. Results from ongoing research at the University of Florida and other universities in the region are continuously incorporated into the system increasing its relevancy and contributing to a more sustainable and climate resilient agricultural industry in the Southeast U.S.A.

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AgroClimate – Ferramentas para gestão de riscos climáticos em agricultura

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RESUMO

O risco climático é um fator importante a ser considerado na produção agrícola. Produtores rurais estão sempre expostos a ocorrência de anomalias do clima, principalmente anomalias dos níveis de precipitação durante a safra. A informação climática, juntamente com previsões do tempo e do clima, pode ser usadas para reduzir riscos, aumentar a eficiência no uso de insumos e a rentabilidade da atividade agrícola. Todavia, o simples fato de fornecer previsões climáticas não é suficiente, produtores precisam incorporar a informação climática no processo de tomada de decisões. O sistema *AgroClimate* (http://agroclimate.org) foi desenvolvido por pesquisadores e extensionistas de um consórcio de universidades no sudeste dos Estados Unidos com o objetivo de fornecer informações climáticas de forma integrada com os seus efeitos na agricultura no sentido de facilitar o uso deste tipo de informação por produtores rurais da região. As ferramentas incluídas no sistema *AgroClimate* estão classificadas em seis categorias: clima, rendimento de culturas, manejo de pragas e doenças, calculadores de graus dia e horas de frio, e pegadas de carbono e hídrica. Resultados de pesquisas conduzidas na Universidade da Florida pelo grupo *AgroClimate* são constantemente incorporados no sistema melhorando as informações fornecidas e contribuindo para aumentar a resiliência da atividade agrícola na região a variabilidade e mudanças climáticas.

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