NRCS CONSERVATION INNOVATION GRANT

Final Report

Grantee Entity Name
Project Title: Develop agronomic and irrigation strategies to manage drought conditions in irrigated agriculture
Agreement Number:69-3A75-13-83
Project Director: Kati Migliaccio
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Final Report: Sept 2017
Project End Date: 9/30/16; extension granted 9/30/2017

A. Project Status

1. Summary of progress, including the results to date and a comparison of actual accomplishments with proposed goals (milestones) for the period and, where project output can be quantified, a computation of the costs per unit of output.

2.

Activity	**Year 1 2013-14**				**Year 2 2014-15**				**Year 3 2015-16**			
Group meetings												
Drought innovation added to apps												
Rainfall integration with greater resolution to apps												
App continual improvement												
Purchase equipment for demonstrations												
Demonstrations												
Analyses of data collected												
Develop virtual field day												
Field days												
Workshops and in-service training												
Extension publications												
State and national conferences												
Semi-annual reports												
Quarterly financial reports												
Final project report												

Group meetings update

Project outputs:

Workshop events and in-service trainings (IST)

3. 2017 UF IFAS Weather and Climate Tools and Information for Florida Agriculture. Extension Symposium. Smartirrigation apps. Presenter. Gainesville, FL; 32 attendees
4. Spring Vegetable Field Day. May 5, 2016. Use of SmartIrrigation apps demonstration. SWFREC, Immokalee, FL, 83 growers
5. Citrus nutrient and irrigation management workshops.
6. March 2, 2016 Immokalee, FL 83 growers
7. March 9, 2016 Fort Pierce, FL 53 growers
8. March 15, 2016 Sebring, FL 45 growers
9. May 11, 2016 Arcadia, FL 32 growers
10. Strawberry Expo. Use of irrigation tools including SmartIrrigation Apps, March 29, 2016 132 growers
11. 2016 Regional Turf Seminars. Methods and Tools for Managing Irrigation, Mar 2. Venice, FL. Kati Migliaccio Presenter.
12. 2016 SFWMD and UF IFAS Water Conservation Expo. Feb 19, West Palm Beach, FL. Kati Migliaccio Presenter.
13. Advanced Irrigation Scheduling Techniques, TriState Climate Group, Mar 14, Headland, AL. Wesley Porter Presenter.
14. Irrigation Scheduling with the Cotton App, presentation by Wesley Porter at 16 county production meetings in Georgia between 15 January – 15 March, 2016.
15. Sensing Soil Moisture, Plant Stress, and Irrigation Scheduling, ANR County Agent Training, 03 December 2015, Statesboro, Georgia, 21 county agents.
16. Sensing Soil Moisture, Plant Stress, and Irrigation Scheduling, ANR County Agent Training, 01 December 2015, Tifton, Georgia, 28 county agents.
17. Smartphone App for Scheduling Irrigation in Cotton, EXTEND Leadership Program for Cooperative Extension, 17 November 2015, Tifton, Georgia, 23 participants.
18. Smartphone App for Scheduling Irrigation in Cotton, Georgia Congressional Delegation agricultural staff, 13 October 2015, University of Georgia Stripling Irrigation Research Park, Camilla, Georgia, 18 staff members.
19. Smartphone App for Scheduling Irrigation in Cotton, University of Georgia Cotton and Peanut Field Day, Tifton, Georgia, 09 September 2015, 100+ attendees.
20. Smartphone App for Scheduling Irrigation in Cotton, Georgia Senator Purdue's staff, 01 September 2015, University of Georgia Stripling Irrigation Research Park, Camilla, Georgia, 6 staff members.
21. Using the Cotton SmartIrrigation App for Variable Rate Irrigation, Southern States Precision Ag Field Day, Statesboro, Georgia, 23 July 2015, 33 attendees.
22. Smartphone App for Scheduling Irrigation in Cotton, University of Georgia Stripling Irrigation Research Park Field Day, Camilla, Georgia, Georgia, 08 July 2015, 200+ attendees.
23. Smartphone App for Scheduling Irrigation in Cotton, Cotton Commission Field Day, Tifton, Georgia, 24 June 2015, 100+ attendees.

24. Smartphone App for Scheduling Irrigation in Cotton, University of Georgia County Agent Training Field Day, Tifton, Georgia, 25 June 2015, 28 ANR county agents.
25. Citrus Irrigation Field Day, Orange County, Grower presentation on water scheduling and use of SmartIrrigaiton Apps. 24 growers, November 24, 2015.
26. FDACS Field Staff Train-the Trainer workshop on Advanced Ag. Technology, 26 staff, November 17, 2015.
27. CCA training on irrigation scheduling and app use. 38 CCAs, South Florida State College, Avon Park, FL, November 19, 2015.
28. Citrus Nutrition Workshop, presented relationship of irrigation and nutrient management with app use, Lake Alfred, FL, 94 growers, September 15, 2015.
29. Fruit and Vegetable modeling Workshop, Davis, Ca, August 30-31, 2015. 16 scientists.
30. 2015 UF IFAS CCA presentation. Irrigation and Evapotranspiration (including irrigation apps). Oct 14. Gainesville, Fl, presenter.
31. Smartphone App for Scheduling Irrigation in Cotton, Reidsville, Georgia, 21 January, 2015 (19 county agents)
32. Smartphone App for Scheduling Irrigation in Cotton, Tifton, Georgia, 22 January, 2015 (45 county agents)
33. Irrigation Scheduling Tools, Alabama Cooperative Extension System Irrigation Workshop, Opelika, Alabama, 20 March, 2015 (20 attendees)
34. Citrus nutrient and irrigation management workshops.
35. May 19, 2015 Immokalee, FL 73 growers
36. May 19, 2015 Sebring, FL 42 growers
37. May 20, 2015 Acadia, FL 26 growers
38. Agricultural BMPs for water quality – policy, challenges, and solutions. Irrigation apps presentation. April 29-30, 2015. Train-the-trainer, 24 agents; Gainesville, FL
39. Spring Vegetable Field Day. June 19, 2015. Irrigation apps presentation. SWFREC, Immokalee, FL, 67 growers
40. In-Service Training on SmartIrrigation apps and other irrigation tools. UF IFAS IST Irrigation technology: water conservation on-the-go; January 27, 2015 (Orange County, FL, 15 extension faculty/staff)
41. County Agent In-Service Trainings on the SmartIrrigation Cotton App
42. Reidsville, Georgia, 14 January 2014 (18 county agents)
43. Tifton, Georgia, 21 January 2014 (34 county agents) Advanced Irrigation Management Workshops – presentations on SmartIrrigation Cotton App
44. Stripling Irrigation Research Park, Camilla, Georgia, 19 February 2014 (55 attendees)
45. Hawkinsville, Georgia, 13 March 2014 (98 attendees)
46. TransAtlantic Precision Agriculture Consortium Workshops – presentations on SmartIrrigation Cotton App
47. Tifton, Georgia, 25 February 2014 (141 attendees)
48. Headland, Alabama, 27 February 2014, (74 attendees)
49. Shorter Alabama, 20 March 2014, (66 attendees)
50. Certified Crop Advisors Agronomic 2-Day Workshop, (32 crop advisors), Valdosta, 23 January 2014

51. Extension Professional Association of Florida Annual Conference; presentation on apps at IST, K.W. Migliaccio (June 3, 2014; Clearwater, FL)
52. Agronomic Crops Agent Training, Tifton, Georgia, 26 June 2014 (52 county agents)
53. Cotton Incorporated Crop Management Seminar, 12 November 2014 (140 crop consultants, cotton farmers, and county agents)
54. Georgia Cotton Commission Field Day, Tifton, Georgia, 27 June 2014 (100 attendees)
55. UGA Cotton and Peanut Research Field Day, Tifton, Georgia,10 September 2014 (200 attendees)
56. Presentations to visiting groups
57. Minister of Agriculture and 2 staff members, Republic of Senegal, 25 September 2014, Stripling Irrigation Research Park, Camilla, Georgia
58. 24 Argentine farmers, 07 October 2014, Stripling Irrigation Research Park, Camilla, Georgia
59. 32 Chinese, Taiwanese, and Japanese researchers, 14 October 2014, Tifton, Georgia
60. Presentation to the Georgia Commodity Commission on Peanuts Research Advisory Board (they are interested in a similar app for peanuts), 21 October 2014.
61. Migliaccio, K.W. 2014. Smart irrigation controllers – performance proven, app introduction. NatureScape Irrigation Services Smart Technology Workshop. Broward County, Plantation, Sept 12. Presentation.
62. 2014 UF IFAS IST at EPAF. IFAS supported app training. Organized and presented at EPAF IFAS sponsored apps. Aug 28. Panama City, FL. 34 attendees In-Service-Training Event
63. 2014 UF IFAS presentation for Manatee County. Smartirrigation Apps. Dec 8.
64. 2014 UF IFAS TREC avocado growers meeting on apps. Jan 21. Presentation.
65. 2014 UF IFAS Workshop: smart management of your farm, soil, and water for better yields and profits. Practical approaches and smart technologies. Sept 19. Presenter.
66. 2014 Managing Your Association's Utility Expenses. Sponsored by FirstService Management Company. Irrigation and water savings. Webinar Panelist and Speaker.
67. Migliaccio, K.W. 2014. Smart Irrigation controllers. NatureScape Irrigation Services Smart Technology Workshop. Sept. 12. Plantation, FL. Presentation.
68. Migliaccio, K.W. 2014. Water conservation and smartirrigation apps. Student Exchange hosted by the Caribbean Council of Higher Education (CACHE) and the University of Florida. July 21. Homestead, FL. Presentation.

Extension publications/newsletters

1. Migliaccio, K.W., M.D. Dukes, C. Fraisse. 2016. Water Management and Vegetables, What's New? The Vegetarian Newsletter. UF IFAS A Horticultural Sciences Department Extension Publication on Vegetable and Fruit Crops. Issue No. 611.
2. Dr. George Vellidis produced two different 1-minute radio spots on the Cotton App which were broadcast several times a day during the weeks of

March 28th and May 23rd, 2016, by 92.5 FM, a Tifton, Georgia based farm-oriented radio station.

3. UF IFAS publication highlighting smartirrigation turf app and research findings on water savings "UF/IFAS apps give irrigation, growing tips and more" (Fall 2015) https://news.ifas.ufl.edu/2015/08/ufifas-apps-give-irrigation-growing-tips-and-more/
4. Cotton App featured in the Spring 2015 issue of "Southscapes", the University of Georgia College of Agricultural & Environmental Sciences alumni magazine, p.29. http://www.caes.uga.edu/alumni/news/southscapes/spring15/
5. Dr. George Vellidis produced a 1-minute radio spot on the Cotton App which was broadcast several times a day during the week of March 30th by 92.5 FM, a Tifton, Georgia based farm-oriented radio station.
6. Georgia Faces – University of Georgia College of Agricultural and Environmental Sciences News to Use About Georgia Family, Agricultural, Consumer, & Environmental Sciences, 22 April 2014, http://georgiafaces.caes.uga.edu/?public=viewStory&pk_id=5116
7. Southeastern Farm Press – provides growers and agribusiness with in-depth coverage of the region's major crops plus the legislative, environmental and regulatory issues that affect their businesses, 25 April 2014, http://southeastfarmpress.com/cotton/cotton-irrigation-app-helps-manage-water-usage
8. Migliaccio, K.W., J.H. Debastiani Andreis, C. Fraisse, K.T. Morgan and G. Vellidis. 2013. Smartirrigation apps: urban turf. AE499 Agricultural and Biological Engineering Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/ae499, 5 pgs.
9. Migliaccio, K.W., C. Fraisse, K.T. Morgan, G. Vellidis and J. Andreis 2013. SmartIrrigation Apps: Citrus, Strawberry, and Turf. Miami-Dade County Extension Newsletter: Extension Connection. Winter 2013 Vol 4(4):4.
10. Migliaccio, K.W., C. Fraisse, G. Vellidis, K.T. Morgan, D. Rowland, L. Zotarelli. 2014. Smart Irrigation Apps. Envirocities. Dubai - United Arab Emirates Sustainable Smart Cities 8 (May): 11-14. Invited.
11. Migliaccio, K.W., K.T. Morgan and M.D. Dukes. 2013. Smartirrigation apps. Pipeline – Official Publication of the Florida Irrigation Society. December 2013

Conference presentation

69. Migliaccio, K.W., K.T. Morgan, G. Vellidis, L. Zotarelli, C. Fraisse, B.A. Zurweller, J.H. Andreis, J.H. Crane, D. Rowland. 2015. Smartphone Apps for Irrigation Scheduling. IA-ASABE Irrigation Symposium, Long Beach, CA. Nov. 9-12.
70. Liakos, V., G. Vellidis, W. Porter, A. Torre Neto, D. Pavlou, and A. Orfanou. 2016. A new simpler method to calculate evapotranspiration. In S. Boyd, M. Huffman and

B. Robertson (eds) Proceedings of the 2016 Beltwide Cotton Conference, New Orleans, LA, National Cotton Council, Memphis, TN, paper 16832, p.764-771.

71. Vellidis, G., Liakos, V., C. Perry, W. Porter, and M. Tucker. 2016. Irrigation scheduling for cotton using soil moisture sensors, smartphone apps, and traditional methods. In S. Boyd, M. Huffman and B. Robertson (eds) Proceedings of the 2016 Beltwide Cotton Conference, New Orleans, LA, National Cotton Council, Memphis, TN, paper 16779, p.772-780.
72. Migliaccio, K.W., G. Vellidis, L. Zotarelli, C. Fraisse, J. Andreis, K.T. Morgan. 2016. Smartirrigation apps and their validation. Water & Climate Decision Tools for Farmers, Ranchers, & Land Managers Conference. Dec 5-7. Gainesville, FL.
73. Migliaccio, K.W. 2016. Landscape Apps and Agricultural Apps (2 presentations). North Carolina Irrigation Society Meeting. Nov. 2. Raleigh, NC.
74. Vellidis, G., K. Migliaccio, C. Fraisse, K. Morgan. 2015. SmartIrrigation Apps. Soil & Water Conservation Society 2015 Annual Conference - NIFA Project Directors' Meeting, 28 July, Greensboro, NC.
75. Vellidis, G., V. Liakos, M. Tucker, C. Perry, J. Andreis, C. Fraisse, K. Migliaccio. 2015. A smartphone app for precision irrigation scheduling in cotton. In: J.V. Stafford (Ed.), Precision Agriculture '15 - Papers Presented the 10th European Conference on Precision Agriculture (10ECPA), 15 July, Tel Aviv, Israel, p701-708, doi:10.3920/978-90-8686-814-8, 15.
76. Morgan, K.T., 2015. Demonstration of Improved Citrus Irrigation Using Soil Balance Model and Soil Moisture Sensors. Annual Meeting of the American Society of Horticulutral Sciences, New Orleans, LA, August 5, 2015.
77. Migliaccio, K.W., 2015. Smartirrigation apps for Irrigation Management. IA Conference Continuing Education Credits. IA-ASABE Irrigation Symposium, Long Beach, CA. Nov. 12.
78. Migliaccio, K.W., K.T. Morgan, G. Vellidis, L. Zotarelli, C. Fraisse, B.A. Zurweller, J.H. Andreis, J.H. Crane, D. Rowland. 2015. Smartphone Apps for Irrigation Scheduling. IA-ASABE Irrigation Symposium, Long Beach, CA. Nov. 9-12.
79. Vellidis, G., V. Liakos, C. Perry, P. Roberts, M. Tucker, and E. Barnes. 2015. Field evaluation of a smartphone app for scheduling irrigation in cotton. In S. Boyd, M. Huffman and B. Robertson (eds) Proceedings of the 2015 Beltwide Cotton Conference, San Antonio, TX, National Cotton Council, Memphis, TN (paper 15863).
80. Beltwide Cotton Conference, New Orleans, Louisiana, 08 January 2014; Vellidis, G., V. Liakos, C. Perry, M. Tucker, G. Collins, J. Snider, J. Andreis, K. Migliaccio, C. Fraisse, K. Morgan, D. Rowland, E. Barnes. 2014. A smartphone app for scheduling irrigation on cotton. In S. Boyd, M. Huffman and B. Robertson (eds) Proceedings of the 2014 Beltwide Cotton Conference, New Orleans, LA, National Cotton Council, Memphis, TN (paper 15551).
81. Georgia Cotton Conference, Tifton Georgia, 22 January 2014; Smartphone App for Scheduling Irrigation in Cotton – YouTube recording of the presentation available at https://www.youtube.com/watch?v=1gEtgQgN_R0
82. Southeast Climate Consortium Meeting. May 7-9, 2014; App poster presentation by J. Andreis, C. Fraisse, K.W. Migliaccio, K. Morgan, G. Vellidis (Tallahassee, FL)

83. Wagner, A., Fraisse, C. W., Migliaccio, K., Gelcer, E. Statistical Evaluation of NOAA's Real-Time Mesoscale Analysis (RTMA) Using Florida and Georgia Automated Weather Stations. ASA, CSSA and SSSA International Annual Meeting. November 2-5, 2014. Long Beach, CA. https://scisoc.confex.com/scisoc/2014am/webprogram/Paper89151.htm
84. Presentation at ASA-CSSA-SSSA Annual Meeting, 04 November 2014 (approximately 40 attendees during technical session).
85. Migliaccio, K.W. 2014. Irrigation apps. WERA meeting. Orlando, FL. Sept 17-18. Presentation. Invited.
86. Migliaccio, K.W., G. Vellidis, C.W. Fraisse, K.T. Morgan, L. Zotarelli, and D. Rowland. 2014. Smart irrigation apps. Florida Section 2014 ASABE Meeting. Jun 18-21. Naples, FL.

Videos

1. Additional videos in development for cotton and strawberry.
2. Videos developed and posted on youtube: links to all currently posted can be found at http://www.abe.ufl.edu/faculty/kwm/apps.html and http://smartirrigationapps.org/
3. Smartirrigation app cotton video:
4. https://www.youtube.com/watch?feature=player_embedded&v=MpDVj1Z4bJo
5. https://www.youtube.com/watch?v=c8H4yTusffU
6. https://www.youtube.com/watch?v=1gEtgQgN_R0

1. Current problems or unusual developments or delays. Turf plots in Gainesville have been established and are being tested with app treatments, soil water sensor treatments, and ET controller treatments. Thus far, app and other smart technology is showing lower rates than a set irrigation schedule not based on site specific parameters. Homestead turf demonstration on-going. Work is continuing on the app videos and to conduct a strawberry demonstration in the fall 2016.
2. Reasons why goals and objectives were not met, if appropriate. Not applicable.
3. Additional pertinent information including, where appropriate, analysis and explanation of cost overruns or high unit cost. Nothing to report.
4. Any funded or unfunded time extensions. None.
5. Any changes to the project's original objectives, methods, or timeline with a summary of the justification for the changes. No changes.
6. Lessons learned that inform future project activities or broader efforts in the project's topic area. Nothing to report.
7. Work to be performed during the next six month period. Over the next 6 months, demonstration sites and data collection will continue for citrus, cotton, strawberry, and turf. Training events will be held and rainfall data will be assessed. Additional videos will be completed.

B. Project Results

1. There are no preliminary results that can be used by NRCS for practice standard revisions, new practice standard adoption, policy changes, program revisions and training opportunities.
2. Software updates. We currently have four apps developed and released in the app stores (Android and iOS). The drought strategy or water conservation component was added to the turf app; addition of this concept to other apps is still in development.

   The turf options for drought are identified in the app using the terms water conservation options with a 'seasonal option' and a 'year-round option'. The seasonal option reduces the irrigation schedule when rainfall exceeds evapotranspiration by 25%. The year-round option reduces irrigation schedules by 25% at all times. This is based on research published in Florida suggesting this stress level was appropriate for warm season turf.

3. Software updates in progress.
   A regular frustration of the SmartIrrigation Apps users has been that the individual weather stations closest to them occasionally fail and may not be made operational for several days. This causes the Apps which rely on the station to provide inaccurate information. To address this issue, we have been evaluating using national gridded meteorological data sets instead of weather station networks. We have just released a beta version of the SmartIrrigation Cotton App which uses NOAA data products instead of weather stations. ET is provided by NOAA's FRET (Forecast Reference ET) product and precipitation, minimum daily temperature and maximum daily temperature are provided by the National Weather Service's RTMA (Real Time Mesoscale Analysis) data. The resolution of the data are on a 4km grid. The performance of the beta version of the SmartIrrigation Cotton App (SmartIrrigation Cotton NWS) is being compared to the original version of the App.

   The SmartIrrigaiton Cotton App was modified based on user input and a new release made available in the app stores on 01 May 2016. Among other improvements, the new version provides more irrigation system and soil type options and improves the crop coefficient curve.

   Six irrigation have been released. As of January 2018, SI Avocado has had 1.4K downloads, SI Citrus has had 1.8 downloads, SI Cotton has had 1.7K downloads, SI Strawberry has had 1.9K downloads, SI Turf has had 2.9K downloads, SI Vegetable has had 1.6 downloads.

B. Summary of the rainfall

Primed acclimation has been incorporated into the spreadsheet form of the SmartIrrigation Cotton App. The app with primed acclimation will be evaluated in

replicated plot trials at the Stripling Irrigation Research Park near Camilla, Georgia and at the Plant Science Research Education Unit at Citra, Florida during the 2014 growing season. This concept will be integrated into the app.

The SmartIrrigaiton Cotton App was modified based on user input and a new release made available in the app stores on 01 May 2015. Among other improvements, the new version provides user notifications when rain is recorded at the weather station.

A summary of the rainfall data investigation follows:

- RTMA data (rainfall, wind speed, maximum and minimum temperatures, and hourly air and dew point temperatures)
- The Real-Time Mesoscale Analysis (RTMA) was implemented by the NOAA National Centers for Environmental Prediction (NCEP) as a component of the Reanalysis of Record program to help satisfy the demand for high-resolution meteorological analysis at the National Weather Service (NWS) and in the environmental community. This study compares hourly 5 km resolution 2-m temperature, 2-m dew point, wind speed, and rainfall RTMA data with observed data from the Florida Automated Weather Network (FAWN) and Georgia Automated Environmental Monitoring Network (AEMN) from 2011 to 2014. We analyzed rainfall occurrence and compared total daily rainfall amounts with observations at Florida and Georgia stations. Daily average wind speed, maximum and minimum temperatures, and hourly air and dew point temperatures were only compared to observations at Florida stations. Overall, the results indicate a good agreement between observed and RTMA, especially for daily air temperatures and rainfall, followed by hourly dew point temperature. Using all weather stations, the analysis indicated an accuracy of 81.3% to detect rainfall occurrence, and a small bias (0.81mm). For maximum temperature, RTMA showed high correlation with observed values (RMSE=1.4ºC and EF=0.97) and a small underestimation (bias=0.31ºC), while for minimum temperature the correlation was also high (RMSE=1.48ºC and EF=0.96) but RTMA overestimated the values (bias=-0.22ºC). Evaluation of hourly temperature indicated that 95% of the temperature error are within -1.87 and 2.07 °C (Figure 2). Although these results indicate an overall good agreement between observed and RTMA, the agreement varies depending on weather station location and season of the year. We observed better agreement in Georgia than in Florida and a decrease in data quality for rainfall during summer, for minimum temperature during winter, and for dew point temperature during daytime. Overall, the level of agreement seems to be suitable for evapotranspiration calculation, irrigation scheduling and for other agricultural applications
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- Rain Wave data (rainfall)
- The analysis indicated a general accuracy of 83.6% to detect rainfall occurrence and similar results for the entire points. The Rain Wave showed high correlation with observed values (R~0.8), an error deviation of the RMSE~10mm; MAE~3mm and a small overestimation (bias~2mm). However, the agreement varies depending on

weather station location and season of the year with a decrease in data quality for rainfall during summer. Overall, the Rain Wave seems to be suitable for irrigation scheduling and for other agricultural applications.

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- NLDAS data (rainfall, temperature, wind speed, specific humidity, pressure, u-v-component of wind, convective available potential energy, potential evaporation, downward long wave/shortwave radiation flux)
- The North American Land Data Assimilation System (NLDAS) is a collaboration project among several groups: NOAA/NCEP's Environmental Modeling Center (EMC), NASA's Goddard Space Flight Center (GSFC), Princeton University, the University of Washington, the NOAA/NWS Office of Hydrological Development (OHD), and the NOAA/NCEP Climate Prediction Center (CPC). NLDAS is currently running in near real-time on a 0.125 degree grid ~ 5km over central North America; retrospective NLDAS datasets and simulations also extend back to January 1979. NLDAS constructs a forcing dataset from gauge-based observed precipitation data (temporally disaggregated using Stage II radar data), bias-correcting shortwave radiation, and surface meteorology reanalyzes to drive several different Land Surface Models (LSMs) to produce model outputs of surface fluxes, soil moisture, and snow cover.
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- The NLDAS is a potential suitable data source to uses in evapotranspiration calculation, irrigation scheduling and for other agricultural applications. Currently, we are in the initial stage for evaluating it working on procedures to: a) understand the product; and b) preprocessing at a sample data.
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- The other interest we have as a group besides precipitation is evapotranspiration (ET). If a data source of precipitation data is selected, we may also want to use the same source of data for ET estimations. Thus, PRISM data has been evaluated in regards to ET by Dr. Fraisse's group.
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- The main goal of our ongoing study is to determine the adequate methodologies to estimate evapotranspiration (ETo) in the Southeast USA using gridded weather data. Specific objectives include the evaluation of PRISM (Parameter-elevation Relationships on Independent Slopes Model)1 data and the calibration of several empiric equations to reduce the error.
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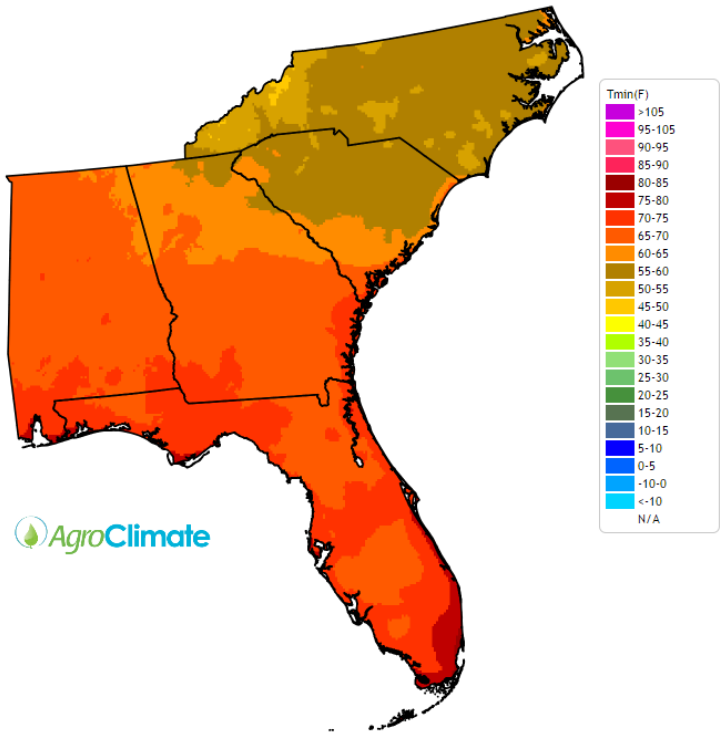
- Daily ETo calculated from 2008 and to 2013 by FAO Penman-Monteith (FAO-56 PM; Allen et al., 1998) was compared with ETo estimated by seven empiric equations: Priestley and Taylor (Priestley and Taylor, 1972), Turc, Makkink, Stephens-Stewart, Blaney-Criddle (McGuinness and Bordne, 1972), Jensen-Haise (Jensen and Haise, 1965), and Hargreaves (Hargreaves and Samani, 1985) using temperature and rainfall from PRISM. Temperature, solar radiation, wind speed and relative humidity data from 44 automated weather stations in Florida (FAWN2),

[1] http://prism.oregonstate.edu/
[2] http://fawn.ifas.ufl.edu/

Georgia (GAEMN3) and North Caroline (EcoNET4) were used to calculate FAO-56 PM. PRISM data for the locations of each weather station were extracted from the whole PRISM dataset and used to estimate ETo. Five out of the seven empiric equations tested (Priestley and Taylor, Turc, Makkink, Stephens-Stewart, Jensen-Haise) are based on solar radiation. For these equations, the Bristow and Campbell (Bristow and Campbell, 1984) methodology was used to estimate solar radiation. All empirical methods will be calibrated for the study area and the results compared with the original equations.

- Preliminary results indicate that ETo estimates using Priestley and Taylor and Hagreaves equations may be an suitable alternative for daily ETo estimations, even before calibration (Figure 2). We expect calibration to improve our current results leading to with higher correlation and lower error. We also expect improved results for aggregated ETo to 5, 10 and 30 day periods.



[3] http://weather.uga.edu/aemn/cgi-bin/AEMN.pl?site=GADX

[4] http://www.nc-climate.ncsu.edu/econet

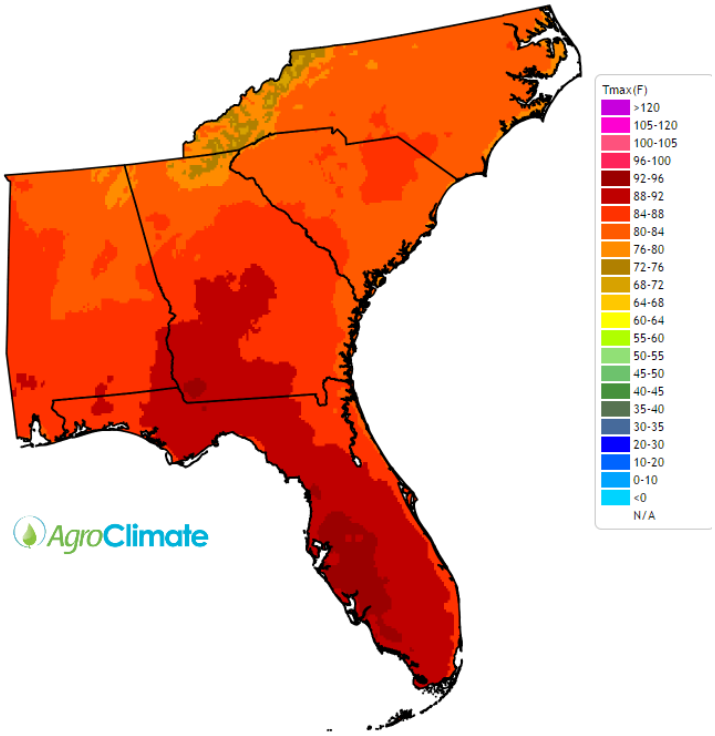


Figure 1. Example of minimum and maximum temperature from PRISM.

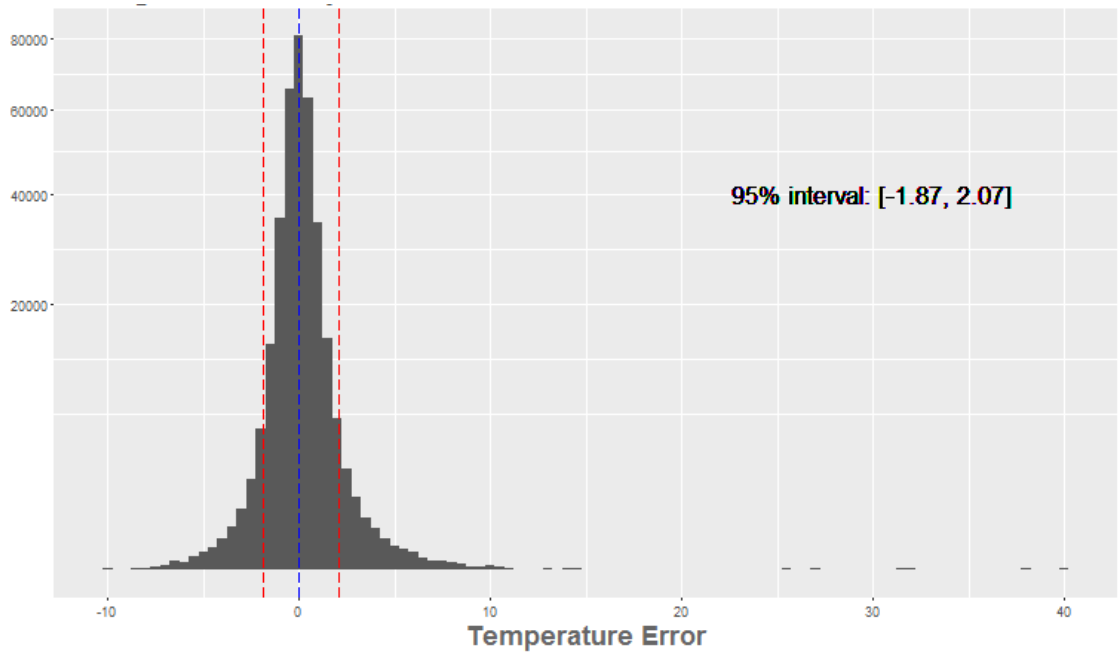


Figure 2. Histogram of RTMA hourly air temperature error, 95% between -1.87 and 2.07 °C.

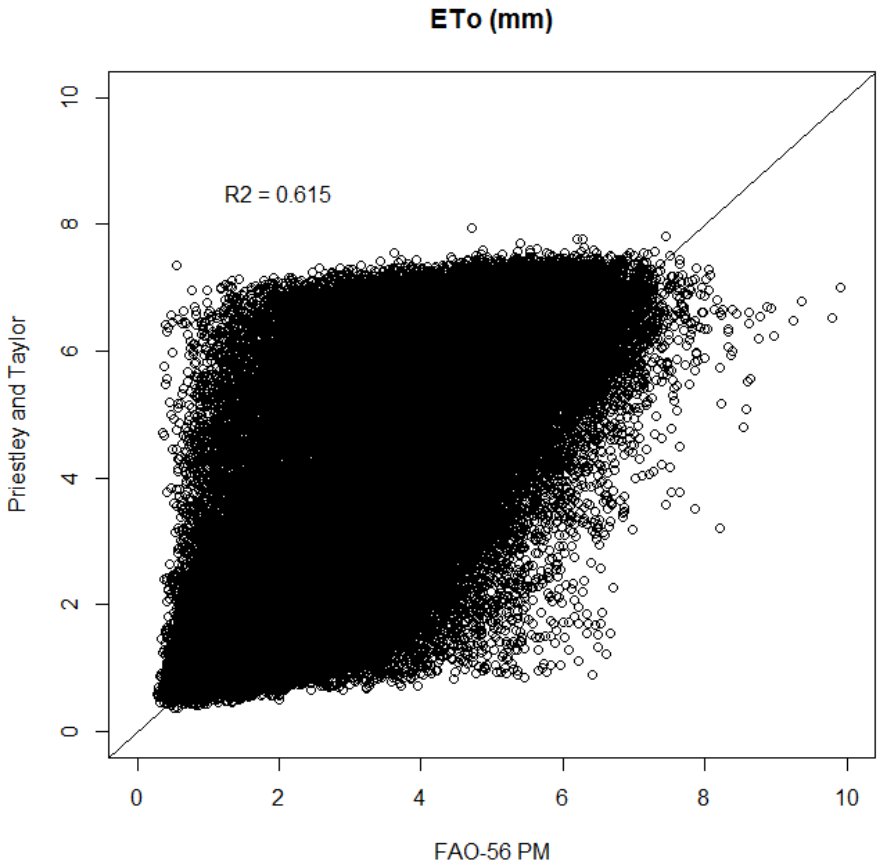


Figure 3. Example of scatterplot for ETo calculated using FAO-56 PM and Priestly and Taylor.

Since the last report, RTMA data have been further evaluated using ST4 (approximately 5 km resolution) database of the precipitation grid. RTMA daily precipitation data were compared to FAWN weather station daily precipitation data. Results show relatively good agreement considering the comparison between is between a point and a spatial area (Figure 3).

Precipitation data were further evaluated considering if rainfall occurred or did not occur and different thresholds for minimum rainfall were considered. This evaluation is on-going.

Temperature data were also compared for RTMA ST4 and FAWN stations (Figure 4). The higher correlation found in temperature data as compared to precipitation data was expected due to the variability in the parameters. Temperature is typically less variable across space as compared to precipitation.

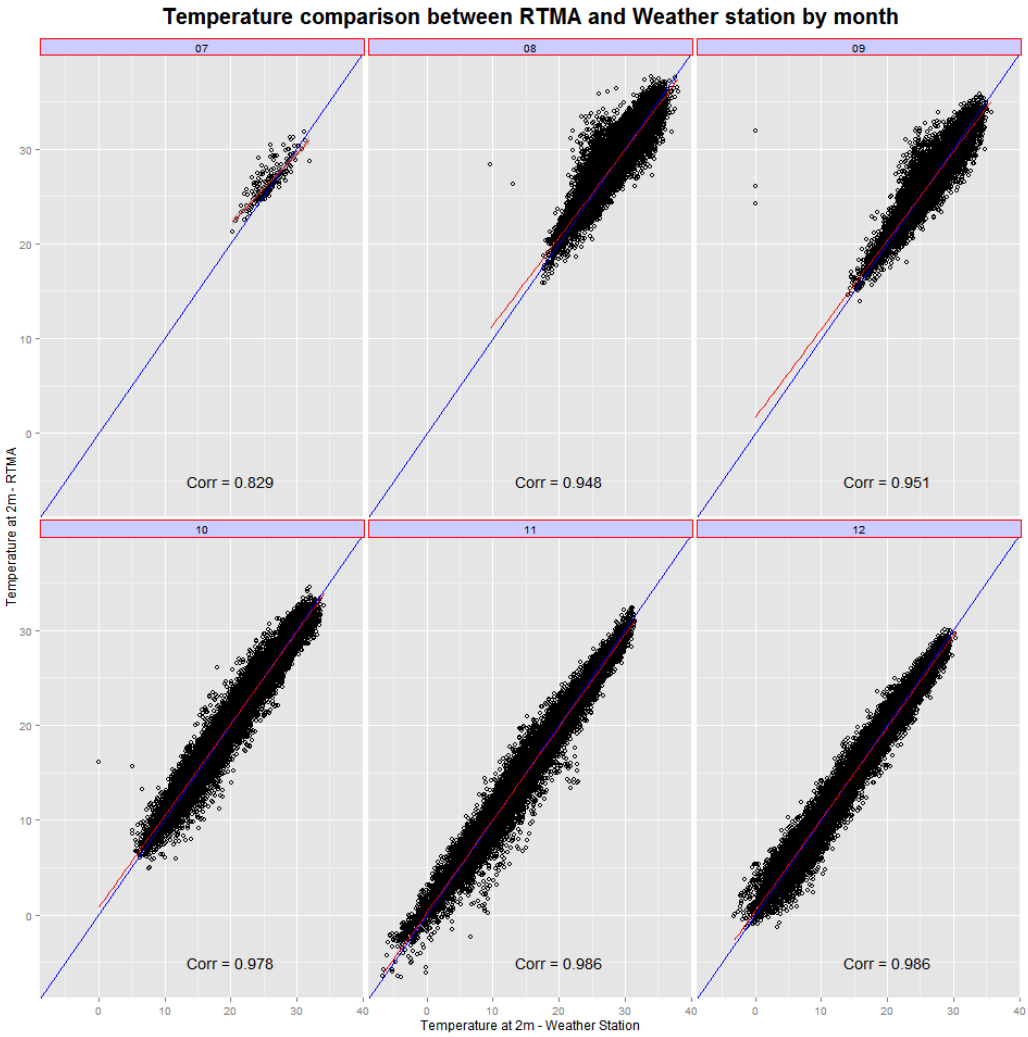


Figure 4. Example of temperature comparisons between RTMA data and FAWN weather stations.

References

Allen, R.G., Pereira, L.S., Raes, D., Smith, M., 1998. Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrig. Drain. Pap. 56. FAO, Rome. 174.

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4. There are no new data or research needs to inform broader efforts in the project's topic area.
5. Project activities and products are showcased on our website, smartirrigationapps.org. We currently do not have success stories but should have examples as data collection continues. We have developed a statistic web tool for accessing user information (released in the spring 2015). The tool was developed by Dr. Fraisse's Agroclimate group and can be accessed at: http://agroclimate.org/tools/App-Statistic/

Current data summary for cotton

The SmartIrrigation Cotton App was demonstrated at two locations in Georgia during the 2014 growing season – at UGA's Stripling Irrigation Research Park (SIRP Plots) and at UGA's Tifton Campus.

At UGA's Tifton Campus, we compared irrigation scheduling between the SmartIrrigation Cotton App and the UGA Extension-recommended Checkbook Method. The demonstration was done in two fields within a mile of each other (NESPAL field and RDC Pivot field). At each field, four varieties were planted. At the NESPAL field, irrigation was scheduled using the SmartIrrigation Cotton App while at the RDC Pivot field, irrigation was scheduled using the UGA Extension Checkbook. Table 1 presents the average yield across varieties. Precipitation at the NESPAL field between planting and 31 August when irrigation ceased was 11.1 in. Precipitation at the RDC Pivot field between planting and 31 August was 14.5 in. Irrigation at the NESPAL field was 10.05 in while at the RDC Pivot field it was 16.8 in. Yields were approximately the same.

At SIRP, five cotton irrigation scheduling treatments were demonstrated including the SmartIrrigation Cotton App and the SmartIrrigation Cotton App with Primed Acclimation (PA). All treatments were evaluated in conservation and conventional tillage plots. Each plot had three replicates for a total of 30 plots. Each plot was 8 rows wide and 50 ft long. Four cotton varieties were planted in each plot (DP1252, FM1944, PHY333, PHY499) with each variety occupying 2 of the 8 rows. However, PHY499 was not considered in the results because problems during planting resulted in a poor stand. Table 1 presents the average yield across varieties. The UGA Extension-recommended checkbook method was used as the benchmark against which yields and irrigation water use were compared. The SmartIrrigation App PA out-yielded all other irrigation scheduling methods and used 9.1 in of supplemental irrigation – about 60% of the irrigation used by

the Checkbook Method. Primed acclimation was implemented by applying 60% of the normal irrigation amount during irrigation events occurring during the first 60 days of the growing season. Because of regular rainfall events during the first 60 days, PA was implemented for one irrigation event only. Although the SmartIrrigation Cotton App used about the same amount of supplemental irrigation water as the App with PA, yields were lower. Precipitation at SIRP between planting and 31 August when irrigation ceased was 11.2 in.

In 2014, the Cotton App was used in 237 different fields by 71 users in Georgia and Florida.

Method	Conservation Tillage		Conventional Tillage	
	Lint Yield (lb/ac)	Water Use (in)	Lint Yield (lb/ac)	Water Use (in)
Tifton Campus				
Checkbook	-	-	1596	16.8
Cotton App	-	-	1573	10.1
Stripling Irrigation Research Park (SIRP)				
Checkbook	1660	15.3	1709	15.3
Cotton App	1597	9.4	1440	9.4
Cotton App PA	1741	9.1	1844	9.1

Table 1. Results from the 2014 irrigation scheduling plots studies.

Current data summary for turf

A plot study/demonstration is currently underway to evaluate the app using St. Augustine grass in Homestead, FL. A secondary site is being developed in Gainesville, FL. The app irrigation schedules are being compared to the UF IFAS recommended rate and Evapotranspiration controllers (real-time ET controllers) at both sites. Each plot is monitored using water meters and soil water sensors. Rainfall and other weather parameters are recorded by the on-station Florida Automated Weather Network system.

Cumulative water volumes applied were similar for the app and ET controllers ranging from 35 to 47 inches for the year (Dec 2013 – Nov 2014). The set schedule of 0.75 inches twice a week resulted in a total of 82 inches being applied (Table 2).

Table 2. Irrigation depths (inches) applied in demonstrating the utility of the turf app.

	Control	ET controller 1	ET controller 2	App
Dry season	41.5	18.5	28.2	19.9
Wet season	40.2	16.1	18.7	22.3
Total	81.7	34.6	46.9	42.2

Dry season includes data from Dec 2013 to May 2014; wet season includes data from Jun 2014 to Nov 2014.

Additional demonstrations are being conducted in Homestead and Gainesville, FL. A website has been created to help assist app usage and potential water savings (this if for all smartirrigatino apps).

The turf app has also been modified to include not only turf but other landscape plants. This revised app was released in app stores in the spring of 2015.

Current summary for citrus

The demonstrations are being conducted Near Ave Maria (South of Immokalee, lat. 26°16’ N, long. 81°25’ W) in the southwest Florida flatwoods (Collier county), Arcadia (lat. 27°13’ N, long. 81°39’ W) in the south-central flatwoods (Desoto County), and Avon Park (lat. 27°36’ N, long. 81°31’ W) in the central ridge (Highlands county). The demonstrations consisted of the following irrigation scheduling treatments for conventional micro-sprinkler irrigation: 1) standard grower irrigation (Grower), 2) Citrus SmartIrrigation smart phone app. The trees at all sites were Hamlin orange spaced at 15 x 25-ft. Water volumes applied and fruit yields were measured.

Fruit drop was determined in October 2013 six months after irrigation treatment began and November 2014 eighteen months into the demonstration. The number of dropped fruit ranged from 10.3 to 19.1 fruit per tree for all treatments in 2013. Fruit drop in 2014 was lower because of an extended rainy season, resulting in a range of 3.1 to 6.2 fruit per tree. No significant differences were noted among irrigation treatment in 2013 but the grower treatments were significantly greater than the app scheduled irrigation at Ave Maria and Avon Park in 2014. Yields were similar with for all treatments with a range of

2.1 to 3.7 90-pound boxes of fruit per tree in 2013 with no significant difference among irrigation treatments.

Average water use among irrigation treatments were significantly different at the P≤ 0.10 level for all three demonstration sites (Table 4). The range of annual water use was 19,895 to 23,543 gallons per grove acre for the groves scheduled with the Citrus app and 22,986 to 28,554 gallons per grove acre for the grower scheduled blocks. These numbers indicate a significant (P≤ 0.10) water savings of 11.1 to 23.5 percent annually. The smartIrrigation app managed irrigation schedule had greater sap flow (P<0.05) than the grower scheduled irrigation at both the Ave Maria site and Avon Park sites. Stem water potential was greater for SmartIrrigation managed irrigation trees than the grower scheduled irrigation plots at Avon Park and Arcadia suggesting higher water use by the Smartirrigation scheduled trees. These results indicate that the trees irrigated using schedules determined by the citrus app were better hydrated than trees receiving irrigation following the grower schedule.

Table 3. Fruit drop in 2013 and 2014 and 2013 yield for two irrigation scheduling treatments at three commercial citrus groves.

	Ave Maria	Arcadia	Avon Park	Ave Maria	Arcadia	Avon Park	Ave Maria	Arcadia	Avon Park
Grower Schedule	14.4	15.2	12.4	6.2	4.6	5.8	2.6	3.5	3.4
Citrus App	10.3	19.1	11.4	4.3	3.1	3.6	2.1	3.7	2.9
Statistics (P<0.05)	NS	NS	0.034	0.048	NS	0.032	NS	NS	NS

Table 4. Water applied for period October 1, 2013 to September 1, 2014.

Irrigation Treatment	Ave Maria Water applied (gal per grove acre)	Arcadia Water applied (gal per grove acre)	Avon Park Water applied (gal per grove acre)
Grower Schedule	22,986	26,512	28,554
Citrus App	19,895	23,543	21,851
Statistics (p value)	0.055	0.068	0.046

Current summary for strawberry

Plans are in place to test the strawberry app in Balm, FL in 2015. We have growers using the app but have not completed a review of their comments.

C. EQIP Requirements

We have no Environmental Quality Incentives Program (EQIP) associated with this CIG grant.

Other publications

Mbabazi, D., K.W. Migliaccio, J.H. Crane, C. Fraisse, L. Zotarelli, K.T. Morgan, N. Kiggundu. 2017. An irrigation schedule testing model for optimization of the Smartirrigation avocado app. Agricultural Water Management 179:390-400. http://dx.doi.org/10.1016/j.agwat.2016.09.006

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