TIME PERIOD ADDRESSED BY REPORT: 10/01/2012 – 6/30/2013

SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP) –
PROJECT ANNUAL REPORT

PROJECT TITLE: Use of seasonal climate forecasts to minimize short-term operational risks for water supply and ecosystem restoration

INVESTIGATORS:

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PROJECT YEARS (Award Period): October 2012- September 2014

TIME PERIOD ADDRESSED BY REPORT: *October 1, 2012 – June 30, 2013 – YEAR 1*

I. PRELIMINARY MATERIALS

A. Research project objective.

The overall goal of this project is to improve the regional relevance of seasonal climate forecasts and increase their usability for multiple water managers in Florida to minimize short-term operational risks for water supply as well as ecosystem restoration. This project is integrated with the Florida Water and Climate Alliance, a stakeholder-scientist partnership focused on increasing the relevance of climate science data and tools for water resource planning and supply operations in Florida (*partially funded under NOAA-SARP Grant NA11-OAR4310110*).

The specific objectives of this project are to:

1. Evaluate the skill of the National Multi-Model Ensemble (NMME) seasonal climate predictions (temperature and precipitation) over all seasons and over a common grid across the Southeast US.

2. Statistically downscale the NMME forecasts to the watershed scale and evaluate the skill of these seasonal predictions over three specific domains: Peace River Manasota Regional Water Supply Authority, Tampa Bay Water and the South Florida Water Management District.

3. Conduct a comparative study across three organizations of the benefits and limitations of using seasonal climate forecasts for their operational needs.

B. Stakeholders and decision makers

- Alison Adams and Tirusew Asefa, Tampa Bay Water
- Kevin Morris, Peace River Manasota Regional Water Supply Authority
- Jayantha Obeysekera, South Florida Water Management District

C. Approach

The approaches being used in the project are described below by objective.

Objective 1: Robustly evaluate the skill of the NMME seasonal climate predictions (ENSO (i.e. SST in the Niño3.4 region), temperature, precipitation, and solar radiation, humidity, wind speed where available) on a monthly basis over all seasons and over a common grid (12km NLDAS grid) across the Southeast US. Forecast skill will be evaluated as function of lead time, season, and geographical location. Both probabilistic (Briar Skill Score) and deterministic (Mean Square Error Skill Score) skill will be evaluated. We will use the NMME set of seasonal hindcasts (http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/), which are from seven different global coupled ocean-atmosphere models. Forecast skill will be evaluated as function of lead time, season, and geographical location. Additional variables will be evaluated from the Climate Forecast System version 2 (CFSv2).

Objective 2: Statistically downscale and bias correct the NMME forecasts to the watershed scale and disaggregate to the space and time scales needed for application over three specific domains: Peace River Manasota Regional Water Supply Authority, Tampa Bay Water and the South Florida Water Management District. After the skill of the NMME forecasts has been evaluated at the watershed-scale, translate the downscaled NMME forecasts into formats that fit each of the user's decision making contexts for planning, modeling, and risk assessment. We will work with each of the three users to incorporate the forecasts in their operational models (Tampa Bay Water and SFWMD) and decision support systems (Peace River Manasota Water Supply Authority). Exercises will be conducted jointly with the users to determine whether different operational decisions would have been made in the past to improve operations over the hindcast period, were these downscaled forecasts available. The risks and benefits of using probabilistic forecasts to make operational decisions will be explored.

Objective 3: Carry out a comparative study across three organizations of the benefits and limitations of using seasonal climate forecasts for their operational needs. Activities will include: 1) Interviews to gain an understanding of the organizational culture and current use of climate information; 2) Qualitative focus groups with representative groups of managers, scientists and stakeholders to gain insight and in-depth understanding about the potential for integration of climate forecasts into planning; 3) Cross organizational comparisons and analysis to document the opportunities and barriers of each organization in integrating climate-related information in their decision making process.

D. Matching funds/activities

- Funds from Tampa Bay Water are being used to fund an additional Ph. D. student who is supporting this project.
- In addition, significant in-kind contribution of partners' (TBW, SFWMD and PRMRWA) time and effort for project planning, research and specific testing and application efforts at their sites is recognized.

- This project is integrated with the Florida Water and Climate Alliance, a stakeholder-scientist partnership focused on increasing the relevance of climate science data and tools for water resource planning and supply operations in Florida (*partially funded under NOAA-SARP Grant NA11-OAR4310110*). Workshops provide venues for project activity and broader stakeholder feedback. All working group members from the Public Water Supply Utilities, Water Management Districts and local governments provide in-kind support through paying their own travel costs to quarterly project meetings and staff time to attend the meetings and conduct project specific activities between quarterly meetings.

E. Partners

- Southeast Climate Consortium (SECC)
- Florida Water and Climate Alliance (FloridaWCA)
- Tampa Bay Water
- Peace River Manasota Regional Water Supply Authority
- South Florida Water Management District

II. ACCOMPLISHMENTS - Project timeline and tasks accomplished (Year 1)

A. Project timeline and tasks accomplished

Project accomplishments are reported here by objectives and tasks in the work plan for YEAR 1.

Objective 1: Robustly evaluate the skill of the NMME seasonal climate predictions

1. **Task 1:** Evaluate the skill of the National Multi-Model Ensemble (NMME) seasonal climate predictions (temperature and precipitation), using probabilistic and determinstic skill measures, over all seasons and over a common grid across the Southeast US.

Results: Four approaches were used to downscale seasonal precipitation (P) and 2 meter air temperature (T2M) forecasts from NMME seasonal climate predictions the over the states of Alabama, Georgia, and Florida in the southeastern United States (SEUS). The downscaled P and T2M forecasts from 0- to 7-month lead were produced from individual model forecasts and multi-model ensemble (MME) forecasts of the NMME system. Two MME schemes were tested by combining all forecast members (SuperEns) or assigning equal weights to each model (MeanEns). Two of the downscaling approaches were model output statistics (MOS) methods, which are based on spatial disaggregation and bias correction of the NMME P and T2M forecasts using climatology (SD) or using the quantile mapping technique (SDBC). The other two approaches were perfect prognosis (PP) linear regression (LR) and nonparametric locally weighted polynomial regression (LWPR) models, which used the NMME forecasts of Niño3.4 sea surface temperatures (SSTs) to forecast local-scale P and T2M. Both the deterministic forecasts and probabilistic forecasts in terciles were evaluated for all leads and all forecast target seasons over the SEUS. The downscaled P and T2M forecasts showed considerable improvement of forecasting skill compared to direct interpolation of the raw model output. In particular, the LWPR method generally showed the highest forecast skill with the highest occurring in cold seasons. While the SuperEns mostly showed higher skill than the MeanEns and most of the single models, its skill did not outperform the best single model. The results of this work are being submitted to the Journal of Climate.

Task 2: Evaluate the skill of additional variables from the CFSv2 model.

Results: This task explored the potential of using the Climate Forecast System version 2 (CFSv2) for seasonal predictions of ETo over the states of Alabama, Georgia, and Florida. The fine resolution (12 km) ETo forecasts were produced by downscaling coarse-scale (1.0^{o}) ETo forecasts from the CFSv2 retrospective forecast (reforecast) archive and by downscaling CFSv2 maximum temperature (Tmax), minimum temperature (Tmin), mean temperature (Tmean), solar radiation (Rs), and wind speed (Wind) individually and calculating fine-scale ETo using those downscaled variables. All the ETo forecasts were calculated by the Penman-Monteith equation. Two statistical downscaling methods were tested: 1) spatial disaggregation (SD); and 2) spatial disaggregation with bias correction using the quantile mapping technique (SDBC). The forcing dataset of Phase 2 of the North American Land Data Assimilation System was employed for both verification and bias correction. Deterministic forecasts and probabilistic forecasts in terciles were evaluated using the mean square error skill score and the Brier skill score, respectively. The downscaled ETo from the coarse-scale ETo showed similar skill to those by downscaling individual variables first and then calculating ETo. Among the downscaled CFSv2 variables, Tmax showed highest predictability, followed by Tmean, Tmin, Rs, and Wind. SDBC had slightly better performance than SD for both probabilistic and deterministic forecasts due to the quantile mapping bias-correction procedure. The skill is regionally and seasonally dependent. The CFSv2-based ETo forecasts showed higher predictability in cold seasons than in warm seasons. The CFSv2 model could better predict the ETo in cold seasons during the El Nino Southern Oscillation (ENSO) only when the forecast initial months are in ENSO. The results of this work have been submitted to the Journal of Hydrometeorology.

Objective 2: Statistically downscale and bias correct the NMME forecasts to the watershed scale.

Task 1: Garner feedback from project participants on relevant space-time resolution needed for forecasts

Results: This and other tasks in this objective are on-going. In discussion with project participants an interest was expressed to evaluate the skill of the NMME first. The results of this skill would then determine whether they would be used in other models or simply to define the forecasted "state" of the climate. In addition, participants were interested in knowing whether or not the NMME performs better or worse compared to practices currently used. Work is in progress to provide access to stakeholders to the historical forecasts of the NMME. These forecasts will include forecasts of the Niño3.4 region in the tropical Pacific Ocean and precipitation and temperature from select NMME models.

Task 2: Translate downscaled monthly forecasts to space and time scales needed

Results: On-going.

Task 3: Downscale daily climate model output if/when it is available.

Results: To date, only daily values for the CFSv2 model are available. Current discussions among the group are debating whether it is better do downscale daily values from seasonal forecasts or to downscale seasonal values and then disaggregate as appropriate.

Objective 3: Comparative study across three organizations of the benefits and limitations of using seasonal climate forecasts

Task 1: Complete background research, designed interview questions, and carried out interviews of three organizations.

Results: Initial interviews focused on informational needs, use of climate data at seasonal scale, and institutional constraints. The initial findings were shared with the Project Team, and discussions took place regarding potential next steps for moving forward on the study. Kevin Morris, Peace River Manasota Regional Water Authority, agreed to develop an outline of the decision making process they currently use as a start to begin to understand smaller utilities. This moved forward significantly as an additional exercise complementing the study (see more detail below in B.2.)

B. Application of your findings to inform decision making

1. Provide access to seasonal forecast data evaluated in the project

Tampa Bay Water and South Florida Water Management District partners have expressed interest in having access to forecast data. A question has arisen as to what downscaled data would be made available. We are currently exploring avenues to host the data produced in this project. The data likely to be made available will include forecasts of the Niño 3.4 index and seasonal precipitation and temperature using the downscaling methods and models which exhibit the highest skill.

Discussions among the project participants that are interested in incorporating NMME seasonal forecasts into their own models have focused on the skill of the forecasts and how they compare to the skill of methods currently used. The evaluation of seasonal skill of the NMME has not yet been finalized since additional statistical methods (in addition to those initially proposed) are currently being evaluated. We expect that, once completed, the skill found from the NMME will determine how and in what way the forecasts will be used.

2. Using probabilistic seasonal forecasts in operations planning.

Recognizing that our partners differ in size and use of modeling, we were interested in considering usefulness from both extremes. Tampa Bay and SFWMD have similar expertise and both organizations use predictive models for operational decisions. Peace River is a smaller utility, and currently is not using predictive models for operational decisions

Tampa Bay Water and South Florida Water Management District partners, who are currently working with their own models, are interested in applying the local forecast data and using it with their own models, applications. Over the next year we will work with Tampa Bay Water and SFWMD to incorporate these space-time scale forecasts in their operational models.Peace River Manasota Regional Water Authority (PRMRWA) is not currently using modeling as part of their decision making process. During a project meeting, a suggestion was made that, to better understand the organizational opportunities of and constraints to incorporating probabilistic seasonal forecasts, it would be helpful to develop an outline of the decision process currently being used. Our PRMRWA partner, Kevin Morris, agreed that from their perspective, it would be helpful to "map" their decision process to help better see

the risks and benefits of using probabilistic forecasts in their operations planning. There was general agreement that many other smaller utilities could benefit from the exploration of Peace River Manasota as a "case."

As a result, Kevin Science and Technology Officer, Peace River Manasota Regional Water Supply Authority), developed a draft document "Peace River Manasota Regional Water Supply Authority Decision Processes Related to Water Supply Management Choices. This DRAFT was developed as an exercise to explore and demonstrate application of Decision Science Methods to framing and articulating utility management decisions employing a widely varied pool of historic data observations coupled with scientific forecast products. Kevin worked with Jessica Bolson and Lisette Staal to engage the Florida Water and Climate Alliance for discussion and feedback. He developed a presentation for the Florida Water and Climate Alliance workshop held on June 26th, 2013, Decision Tool Development Exerciser: When to Start ASR Recovery?" and shared both his learning experience, the tool developed, and the need for future refinement and data access. FloridaWCA participants provided comments during the workshop and have been in contact with Kevin following the workshop.

C. Planned methods to transfer the information and lessons learned from this project

The project is fully integrated into the Florida Water and Climate Alliance workshops and website, providing broad access to both FloridaWCA participants and the public. In the June 26th Florida WCA workshop three presentations were provided that covered the results of the evaluation of skill of forecast data, as well as specific efforts on using seasonal data in the operations planning at Tampa Bay Water and Peace River Manasota Regional Water Authority. In particular, the development of the PRMRWA case study provided excellent example for discussion, and stimulated ideas similar types of activities from other stakeholders in future workshops.

D. Significant deviations from proposed work plan

Since daily data is currently only available for one model in the NMME, our work has focused on downscaling and evaluating seasonal variables.

E. Completed publications, white papers, or reports (with internet links if possible

1. Tian, D., Martinez, C.J., Graham, W.D. and S. Hwang. Statistical downscaling multi-model forecasts for seasonal precipitation and temperature over southeastern USA. To be submitted to Journal of Climate .
2. Tian, D., Martinez, C.J., and W.D. Graham. Seasonal predictions of regional reference evapotranspiration (ETo) based on Climate Forecast System version 2 (CFSv2). Submitted to Journal of Hydrometeorology.
3. Tian Di, and C. Martinez, Seasonal forecasting skill of the National multimodel Ensemble (NMME) over southeastern Unitized States, Presentation at Florida Water and Climate Alliance Workshop 9, June 26, 2013
4. Asefa, Tirusew, How we use seasonal forecasts at Tampa Bay Water, presentation at Florida Water and Climate Alliance Workshop 9, June 26, 2013
5. Morris, Kevin, "Peace River Manasota Regional Water Supply Authority Decision Processes Related to Water Supply Management Choices," case study shared at the Florida Water and Climate alliance Workshop 9, June 26, 2013
6. Morris, Kevin, PRMRWA Deciscion Tool Case Study- When to start ASR? presentation at Florida Water and Climate Alliance Workshop 9, June 26, 2013

III. GRAPHICS: JPEG document included as a separate attachment.

IV. WEBSITE ADDRESS FOR FURTHER INFORMATION

- http://waterinstitute.ufl.edu/research/projects_detail.asp?TA=Water+and+Climate&Contract=86885
- http://FloridaWCA.org

V. ADDITIONAL RELEVANT INFORMATION NOT COVERED UNDER THE ABOVE CATEGORIES

NA

VI. REFERENCES