FIU Sea Level Solutions Center
FLORIDA INTERNATIONAL UNIVERSITY

Interim Report (March 3, 2019)

Potential Implications of Sea-Level Rise and Changing Rainfall for Communities in Florida using Miami-Dade County as a Case Study

Florida Department of Business and Professional Regulation
Florida Building Commission

And

Sea Level Solutions Center (SLSC), Florida International University (FIU)

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Introduction

The Florida Building Code (FBC) is one of the strongest in the nation for protection from coastal hazards including wind and storm surge. Coastal communities are at risk of increased flooding due to variations in rainfall extremes, sea-level rise, and a rising water table exacerbating potential for flood damage to buildings. The Florida Building Commission awarded a contract to the Sea Level Solutions Center (SLSC), Institute of Water and Environment (InWE), Florida International University (FIU) to assess whether new flood elevations would increase flood risk due to increasing sea levels and changes in rainfall extremes. The overall effort to assess flood risk may be accomplished by comparing existing flood elevations with new elevations based on updated rainfall data and sea-level rise projections. The initial effort will be focused on Miami-Dade County to establish an applicable model that can be applied for other areas across the State. For the current contract, SLSC will evaluate groundwater level due to sea-level rise and changes in extreme rainfall in Miami-Dade County and potential implications for the current Florida Building Code (FBC). The scope the current efforts includes the following tasks:

Task 1. Development of average May-October groundwater level maps (used for evaluating flood risks) through groundwater modeling under future sea level rise scenarios.

Task 2. Updating Existing Rainfall Maps

Task 3. Evaluation of the FBC-related requirements.

This Interim Report provides the progress to date on all three tasks above. The work associated with this project was accomplished by the following investigators at FIU:

- Dr. Jayantha Obeysekera, P.E. (Director, SLSC, and Principal Investigator)
- Dr. Michael Sukop, P.G., C.Hg (Professor, Co-PI)
- Dr. Tiffany Troxler, (Director of Science, SLSC, and Co-PI)
- Michelle Irizarry, P.E. (SLSC Research Affiliate, Owner, Continuity, H2O)
- Martina Rogers (Ph.D. student)

Modeling was shared among the project personnel. The primary scenario runs and the rainfall data analysis tasks were sub-awarded to SLSC Research Affiliate and the principal at Continuity H2O, Michelle Irizarry, P.E.

Task 1. Development of average May-October groundwater level maps under future sea level rise scenarios.

This task requires the following subtasks:

- FIU SLSC shall review and apply the existing Miami-Dade groundwater model (MODFLOW based but with improved surface water routing capabilities) developed by the United States Geological Survey (USGS) for Miami-Dade Water and Sewer Department (WASD) to create wet-season (May through October) water-table maps. The maps will be produced using ArcGIS software to allow determination of water-table elevation for any location within the county.

- The Miami Dade groundwater model developed by the WASD shall be executed for a future condition (approximately 2060-2069 to capture a condition approximately 50 years from now) using existing and future rainfall scenarios. This particular future condition is the same as what has been used in Broward County and by using the same period, consistency between the two counties will be ensured. Future ocean boundary conditions reflecting sea level rise for modeling shall be obtained from the Unified Sea Level Rise Projections developed by the Southeast Florida Regional Climate Change Compact.

- FIU SLSC shall evaluate various climate model outputs to determine potential changes in rainfall under future conditions. Other input parameters shall remain the same as in the calibrated model to be provided by WASD. Once the modeling scenarios (sea level rise and rainfall) are completed, the simulated water table data shall be analyzed for the months of May through October to develop the spatial maps of water table elevation for the entire modeling domain.

Groundwater Model

The Urban Miami-Dade Model was produced through a cooperative partnership between Miami-Dade County and the United States Geological Survey (USGS, Hughes and White, 2016). It serves a de-facto role as the County's groundwater model-of-record.

It the most comprehensive model known to exist at the whole-county scale and includes many processes. Perhaps most important of these is its linkage to a surface water routing model (SRW1, Hughes, et al., 2012) designed to simulate the region's extensive canal system and its water level control structures. The canals exert a controlling influence on the water table position and are operated with the dual purposes of flood control and to protect well fields from saltwater intrusion.

The model was designed to operate into a 30-year future. Many of the processes it simulates need to be partially and/or wholly re-worked to properly simulate more distant futures when infrastructure – particularly canal water control structures and in some instances, canals themselves – may be inundated.

The SLSC team used the aforementioned groundwater model developed by USGS for the Miami-Dade Water and Sewer Department (Hughes and White, 2016). A decision was made to begin the model development starting from the peer-reviewed and published version of the code and associated datasets made available by USGS. A review of the model and the data sets revealed that significant numbers of datasets needed updates. The effort to date included:

- Implementing the model code, pre- and post-processing software written primarily in Python language in the computers at FIU.
- Development of future land use and groundwater properties. The details of this subtask are found in Appendix I
- Development of future rainfall conditions. This required a considerable effort to review future climate model data, assess the models' skills for Miami-Dade region, bias correction, and selection of rainfall input for groundwater modeling. The details of this work are shown in Appendix II.
- Development of future ocean boundary condition (2060-2069). Details of this subtask are shown in Appendix III. The original model used actual water levels at the ocean boundary that included, astronomical tides, storm surge, waves, and sea level rise at the time of its development. However, for the update, it is not possible to project total water levels (including storm surge and waves) for 2060-2069 and a decision was made to use only the astronomical tide predicted for that period. Since the final product of this project is to produce and average of groundwater levels over the wet season months, the use of only the future astronomical tides (including the projected sea level rise) was deemed appropriate. A sensitivity analysis to demonstrate that the use of astronomical tides alone is adequate is being conducted (see Appendix V)

Task 2. Updating Existing Rainfall Maps

- FIU SLSC shall evaluate the most recent rainfall data and the studies available from South Florida Water Management District (SFWMD), National Oceanographic and Atmospheric Administration (NOAA), and other agencies (eg., Miami-Dade County) to develop 100-year, rainfall for durations of 1hour up to 3 days. Based on this analysis, spatial maps of rainfall will be produced.

- FIU SLSC shall assemble a database of rainfall data up to Year 2017 and develop a time series of annual extremes for various durations of 1 hour up to 3 days.

- FIU SLSC shall use the extreme value analysis methods using the statistical software packages in R (popular statistical software package that is free) to determine the design rainfall magnitudes for 100-year return period for various durations. The resulting values shall be mapped across Miami-Dade County using appropriate spatial interpolation methods to produce the rainfall loading maps. For further validation of the maps, the rainfall loading maps shall be compared with the published data available from SFWMD and NOAA.

FIU team has acquired the following data sets for this purpose:
1. Daily rainfall data from the South Florida Water Management District (SFWMD)
2. Daily rainfall data from the Center for Ocean-Atmospheric Prediction Studies (COAPS) at Florida State University
3. Annual maximum series of precipitation from NOAA Atlas 14 for durations from 5 minutes to 60 days.

4. Projected future daily precipitation from the University of California (San Diego)'s Localized Constructed Analogs (LOCA) product, which employed statistical downscaling techniques to spatially downscale and bias-correct CMIP5 global climate model output.

FIU team is in the process of evaluating changes in precipitation extremes for durations of interest from 1 hour up to 3 days based on data from NOAA Atlas 14, SFWMD and COAPS. In addition, future projected changes in precipitation extremes are being evaluated based on the LOCA dataset. Additional bias-correction is being performed to match the distribution of extremes in the historical period and applying this correction to the predicted future distribution of extremes from LOCA.

Task 3. Evaluation of the FBC-related requirements.

- FIU SLSC shall evaluate the current Florida Building Code requirements to recommend what additional steps will be necessary to incorporate results of the proposed study into the sections of the Codes mentioned above. Specifically, the changes to the rain loads and their implications for rain loads as applied to figure 1611.1 and figure 1106.1 of the FBC, Plumbing, shall be recommended.

- FIU SLSC shall evaluate how the groundwater table maps and the revised rainfall maps should be used to update the flood loads as applied to Chapters 16 and 31 of the 6th Edition, Florida Building Code (2017), Building. The groundwater table maps and the revised rainfall maps shall also be reviewed to determine if an update to Chapter 3 of the 6th Edition, Florida Building Code (2017), Residential, is necessary.

- FIU SLSC shall provide specific recommendations for modifications to the Florida Building Code that are necessary to incorporate the updated information on groundwater elevation due to sea level rise and rainfall.

To evaluate potential implications of sea-level rise and changing rainfall in the Florida Building Code for communities in Florida using Miami-Dade County as a case study, we are evaluating the current Florida Building Code requirements to recommend what additional steps will be necessary to incorporate results of the proposed study into the sections of the Codes mentioned above. Specifically, we are evaluating 1) how the changes to the rain loads and their implications for Rain Loads as applied to Figure 1611.1 and figure 1106.1 of the FBC, Plumbing, are being evaluated, 2) how the groundwater table maps and the revised rainfall maps should be used to update the Flood loads as applied to (Chapter 16), Flood Resistant Construction (Chapter 3, Section R322), and the structures seaward of the coastal construction line (Chapter 31, Section 3109) of the FBC, and 3) specific recommendations for Code modifications to incorporate the updated information on groundwater elevation due to sea level rise and rainfall. Individual sections are being reviewed and a set of preliminary considerations are being put forth, that, when evaluated along with new flood and rain data, recommendations, will be drawn. Preliminary considerations include defining a "coastal zone", similar to a "coastal A zone" for floodplain management, with implications for building, plumbing, and residential sections of the code.

In summary, FIU team has significant progress on model and data updates and is beginning to make scenario runs which will feed into recommendations for FBC modifications.

References

Hughes, J.D., Langevin, C.D., Chartier, K.L., and White, J.T., 2012, Documentation of the Surface-Water Routing (SWR1) Process for modeling surface-water flow with the U.S. Geological Survey Modular Ground-Water Model (MODFLOW–2005): U.S. Geological Survey Techniques and Methods, book 6, chap. A40 (Version 1.0), 113 p. https://doi.org/10.3133/tm6A40.

Hughes, J.D., and White, J.T., 2016, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow (ver. 1.2, July 2016): U.S. Geological Survey Scientific Investigations Report 2014–5162, 175 p., http://dx.doi.org/10.3133/sir20145162.