INTEGRATING COMPOUND FLOOD CONDITIONS THROUGH 2D HYDRAULIC MODELING FOR SIMULATING FLOOD RISK PROCESSES IN COASTAL CITIES

Francisco Peña Guerra[1,2,3,4], Fernando Nardi[125], Jayantha Obeysekera[4], Assefa Melesse[3]

[1]WARREDOC, University for Foreigners of Perugia – [2]DICEA, University of Florence – [3]Department of Earth & Environment, Florida International University
[4]Sea Level Solutions Center (SLSC), Florida International University – [5]UNESCO Chair on Sustainable Water Security, Institute of Water and Environment (InWE), FIU

AGU FALL MEETING San Francisco, CA | 7–11 December 2020

AGU Fall Meeting 2020
Poster: NH022-0001

INTRODUCTION

ISSUES

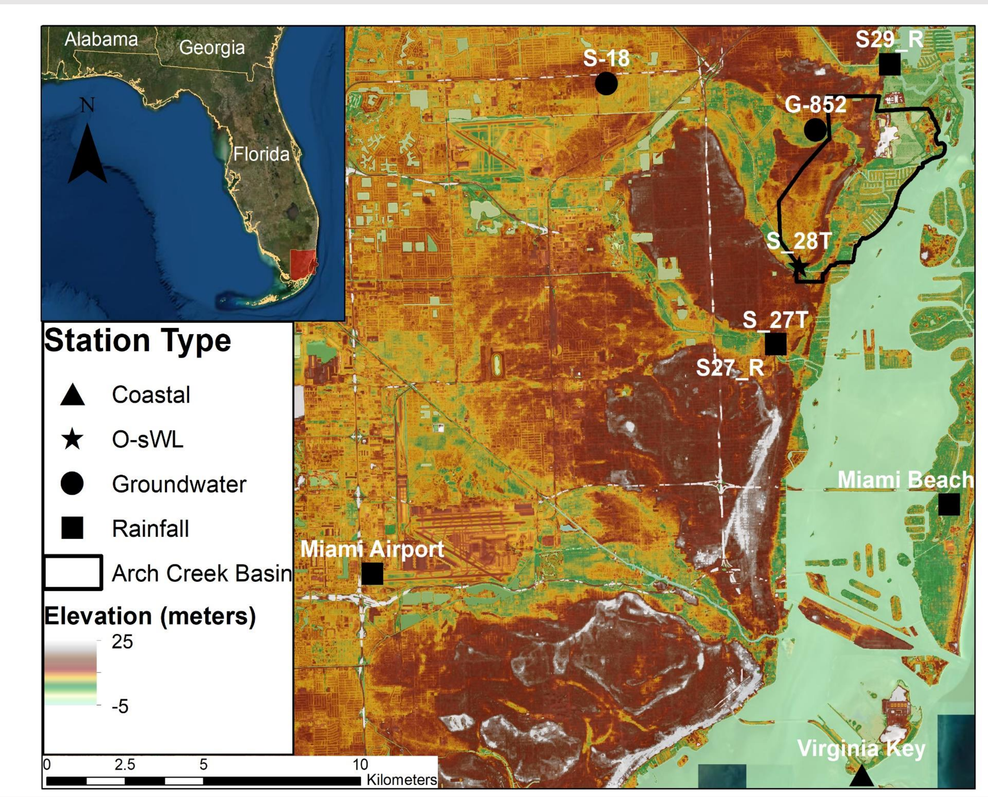
- Compound flooding hazards are increasing in coastal cities due to climate change
- Slow transition from traditional to compound flood models is challenging due to complexity, data needs, performance levels and code constraints issues
- Sea level rise and rising groundwater tables exacerbate flood risk conditions in karst environments
- Although significant scientific contributions in understanding groundwater flooding, relevant knowledge gaps on DRR and citizen awareness persist.

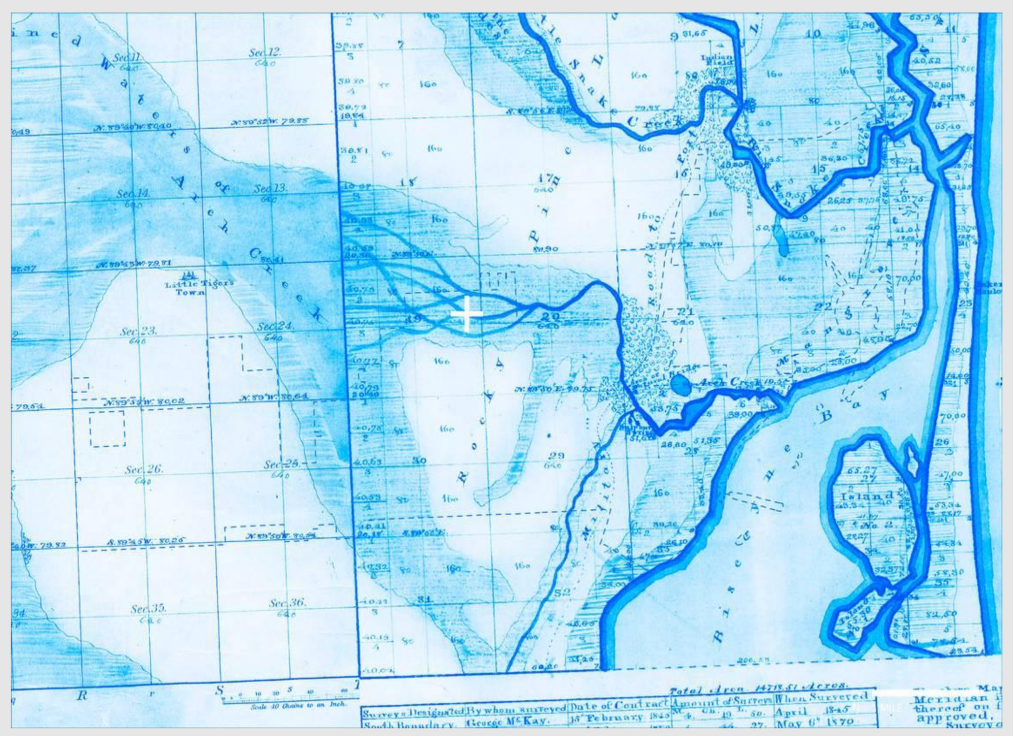
GOAL

- Development of a compound flooding model able to simulate pluvial, fluvial, coastal and groundwater flooding mechanisms simultaneously

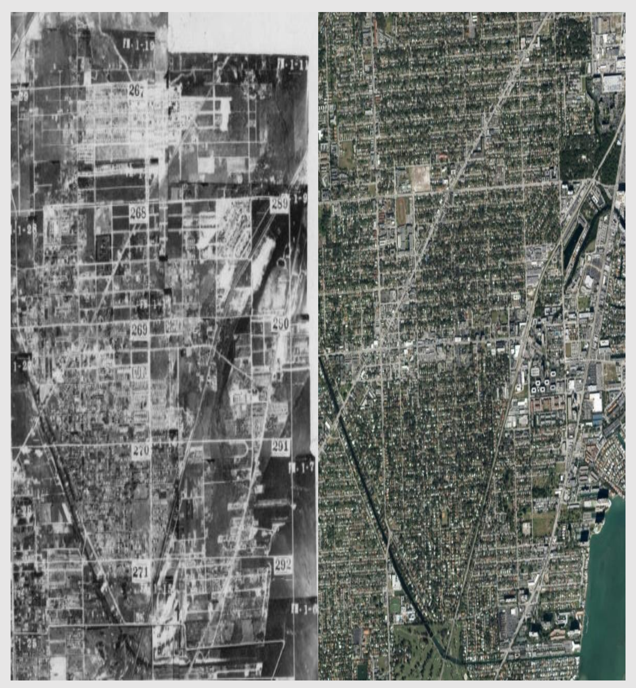
CASE STUDY

The Arch Creek Basin located in North Miami





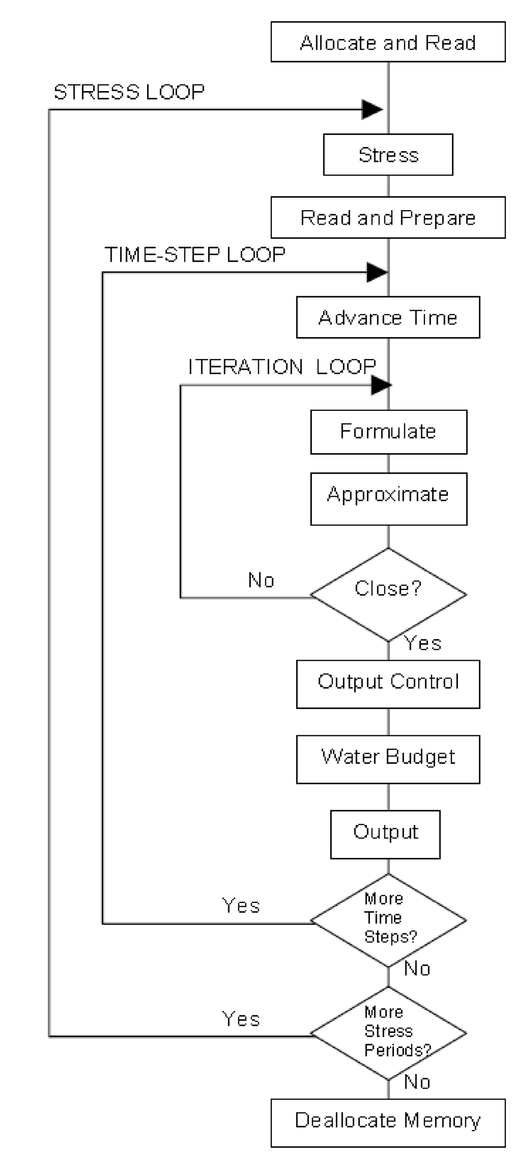
1948 2020



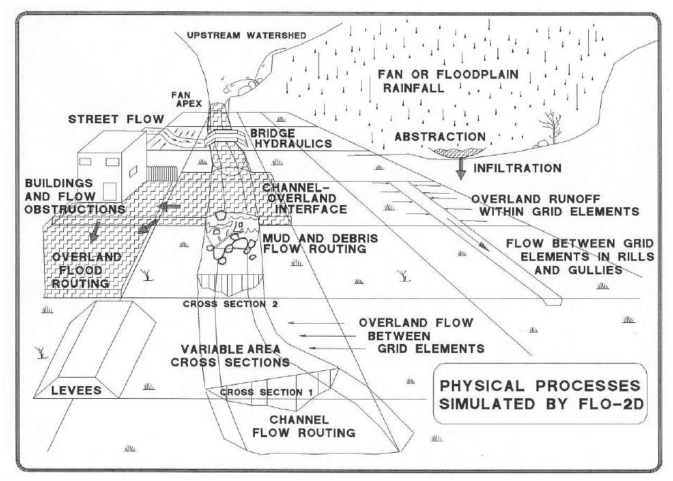
The Arch Creek river served as an important flow corridor that connected the Everglades to the Biscayne Bay

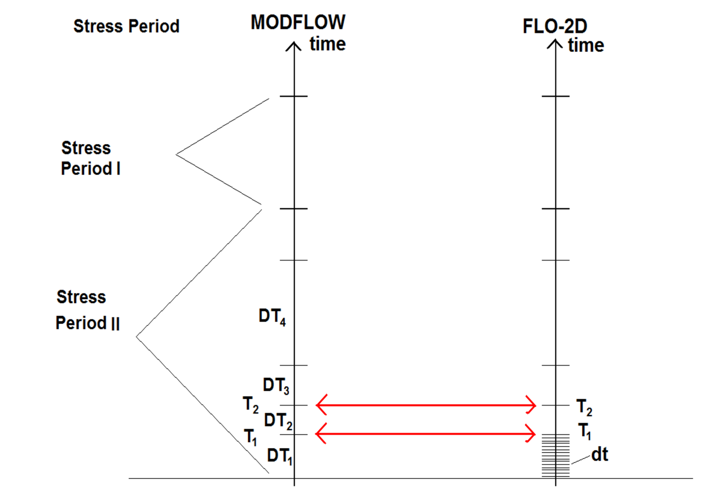
METHODOLOGY

Loosely-coupled modeling framework

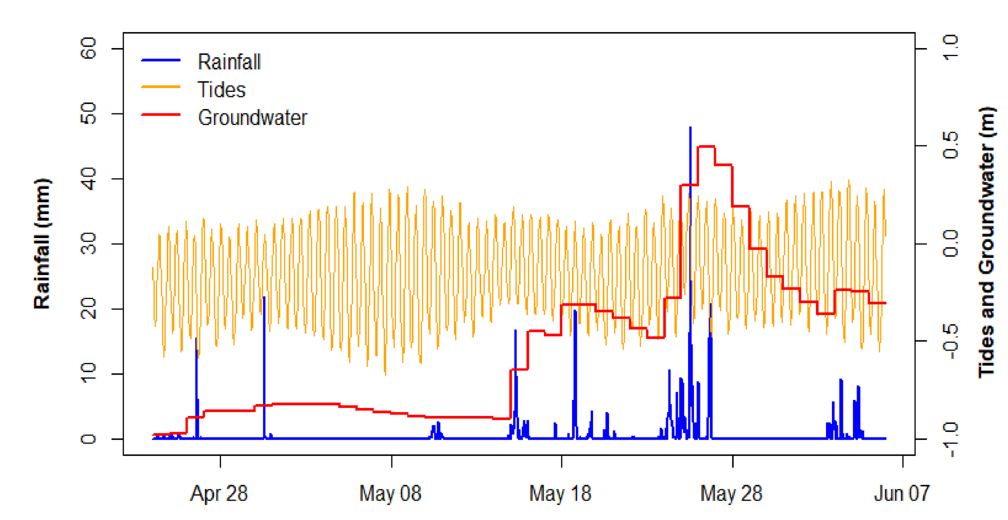


- Surface hydrology: FLO-2D hydraulic model (O'Brien, 1993).
- Groundwater: MODFLOW-2005 (Harbaugh, 2005)
- Forcing inputs: Rainfall + coastal surge + water table
- Components: Channels + buildings + land use
- Mathematical + spatiotemporal compatibility
- Infiltration process critical for coupling
- Soil infiltration capacity can result in flow recharge or flow emergence processes
- MODFLOW-2005 intermediate loop applies time-synchronization scheme transfer output between models





Flood event May 25, 2020

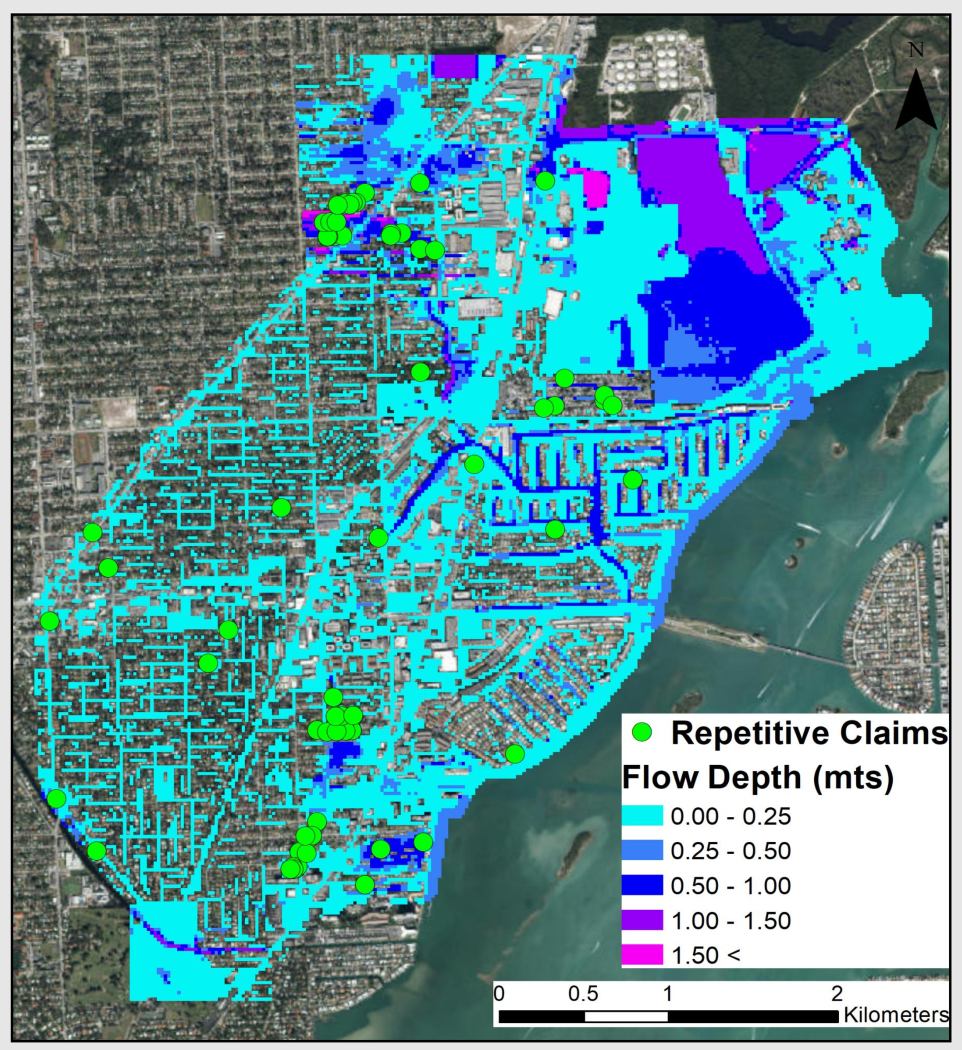


Continuous precipitation from May 15 resulted in an increased of the water table by 50cm.

A 25-year storm exceeded the basin level of service leading to a compound flooding scenario from pluvial and groundwater sources

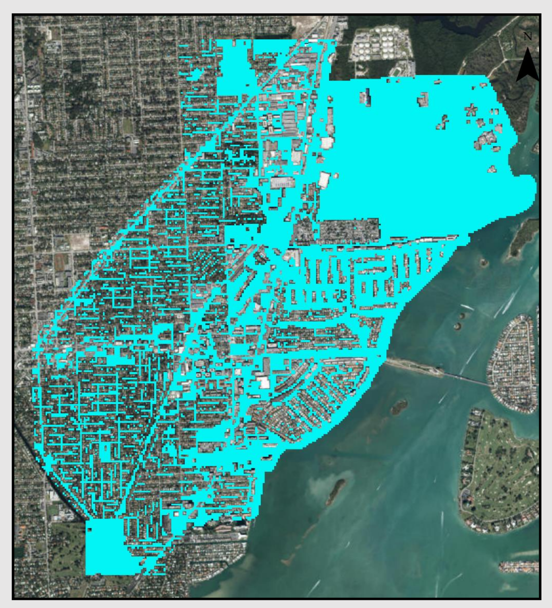
RESULTS

Compound flood model



VS

Rainfall + Tides model



- Better understanding of compound flood hazard interactions in LECZ
- Furthers knowledge in the compound flood modeling field
- Serve as a tool to identify flooding drivers thresholds for current and climate change scenarios

REFERENCES

Harbaugh, A.W. 2005. MODFLOW-2005, The U.S. Geological Survey modular ground-water model—the Ground-Water Flow Process. USGS Techniques and Methods 6-A16. Reston, Virginia: U.S. Geological Survey.

Macdonald, D. & Dixon, A. & Newell, Andrew & Hallaways, A.. (2012). Groundwater flooding within an urbanised flood plain. Journal of Flood Risk Management. 5. 10.1111/j.1753-318X.2011.01127.x.

O'Brien, J. S., Julien, P. Y., and Fullerton, W. T., 1993. Two-dimensional water flood and mudflow simulation. Journal of hydraulic engineering, 119(2), 244-261.

Santiago-Collazo, Felix & Bilskie, Matthew & Hagen, Scott. (2019). A comprehensive review of compound inundation models in low-gradient coastal watersheds. Environmental Modelling & Software. 119. 10.1016/j.envsoft.2019.06.002.

Sea Level Solutions Center (SLSC), Florida International University (FIU) (2019), Potential Implications of Sea-Level Rise and Changing Rainfall for Communities in Florida using MDC as a Case Study

Sukop, Michael & Rogers, Martina & Guannel, Greg & Infanti, Johnna & Hagemann, Katherine. (2017). High temporal resolution modeling of the impact of rain, tides, and sea level rise on water table flooding in the Arch Creek basin, Miami-Dade County Florida USA. Science of The Total Environment. 616-617. 10.1016/j.scitotenv.2017.10.170.

Zscheischler, J., Westra, S., van den Hurk, B. J. J. M., Seneviratne, S. I., Ward, P. J., Pitman, A., AghaKouchak, A., Bresch, D. N., Leonard, M., Wahl, T., and Zhang, X.: Future climate risk from compound events, Nat. Clim. Change, 8, 469–477, https://doi.org/10.1038/s41558-018-0156-3, 2018.