

**FLOOD EARLY WARNING
PROJECT ID: CEEN_2018CPST-DR-003**

by

**WEL Water
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A Capstone Project 30% Completion Report

Submitted to

**Fidel Pérez
Instituto Nacional de Recursos Hidráulicos (INDRHI)**

**Department of Civil and Environmental Engineering
Brigham Young University**

December 12, 2018

Executive Summary

PROJECT TITLE: EARY FLOOD WARNING
PROJECT ID: CEE_n_2018CPST-DR_003
PROJECT SPONSOR: INDRHI
TEAM NAME: WEL Water

The goal of this capstone project is to create a GIS database that can be used to predict floods in the Dominican Republic. The database will not be the primary prediction tool, but an additional tool to utilize in predicting floods. This will allow INDRHI officials to send timely warnings to citizens living in affected areas. The database will not be expected to create warnings on its own; rather, it should be easily integrated into existing online dashboards, and assist in data consolidation. In an effort to achieve this goal, team members will spend weekly meetings familiarizing themselves with datasets, such as National Oceanic and Atmospheric Administration (NOAA) precipitation and runoff forecasts, and programs, such as ArcGIS Pro, in order to create said database. Once accurate, high resolution data sets have been found, the database will automatically pull the datasets into the database and create an interactive map showing the forecasted precipitation and runoff in various watersheds.

Team members will meet with INDRHI officials in November to better understand the project requirements. Weekly reports will be taken to measure team progress throughout the semester. Team members will travel to the Dominican Republic in January/February 2019 in order to receive direct feedback and specific desired deliverables from INDRHI officials. The team will then spend February through April designing and testing the deliverables. The finished product will be presented on April 15, 2019. It is expected that teams will spend October to December of 2018 learning the tools necessary for the project.

Table of Contents – Hunter

List of Figures.....4

List of Tables.....5

Introduction.....6

Schedule.....7

Assumptions & Limitations.....8

Design, Analysis, & Results.....9

Lessons Learned.....12

Conclusions.....13

Recommendations.....14

Appendix A.....15

List of Figures

Figure 1: Example NAM Caribbean precipitation forecast.9
Figure 2: Example GFS precipitation forecast.10
Figure 3: Example of GFS forecast averaged across Provinces.11

List of Tables

Table 1: NASA Forecast Model Summary – NOMADS Database9

Introduction

As part of a capstone project last year, a web application called Hydroviewer Hispaniola was created. The app helps INDRHI prepare for flood events by displaying information from the Flashflood Guidance System and streamflow forecasts. The purpose of this capstone project was to expand the functionality of this application through additional data including precipitation and runoff forecasts. Additionally, the team will continue to investigate data about floods from social media platforms including Twitter to determine usability.

A GIS model will be created to obtain and process precipitation and runoff forecasts. Precipitation forecasts were taken from the National Operational Model Archive and Distribution System (NOMADS), produced by NOAA. Specific models used were the Global Forecast System (GFS) 0.25 degree and the North American Mesoscale Forecast System (NAM) Caribbean/Central America. GFS runoff forecasts were also used. Each forecast was processed in ArcGIS to show forecast averages over different watershed boundaries.

This process will be compiled into a script that will download the correct data, combine the forecast time-steps for each day, and average them out over a given polygon boundary. These boundaries could be watersheds, provinces, or the Flash Flood Guidance catchments. INDRHI can then use this workflow to analyze any forecast and apply it to any boundaries.

Finally, the potential for social media use was investigated. There is an enterprise called FloodTags that searches social media posts, particularly Twitter, to find updates on floods. This particular organization has not reviewed much information in Dominican Republic. More research will be done to determine the availability of needed data.

Schedule

- 09/10/18 – WEL Water formed and assigned the flood early warning project.
- 09/17/18 – Principal goals created for the team.
- 10/04/18 – Team meeting with Dr. Nelson to clarify project scope.
- 10/08/18 – Statement of Work finalized.
- 11/06/18 – Meeting with Dr. Hughes to discuss social media possibilities.
- 11/06/18 – Meeting with Fidel Perez to discuss scope.
- 12/10/18 – 30% Report completed.
- 01/25/19 – Leave for the Dominican Republic.
- 02/03/19 – Return from the Dominican Republic.
- 04/17/19 – Final Project completion date.

Assumptions & Limitations

Assumptions:

- GIS model we created would be added to Hydroviewer Hispaniola Web application.
- When averaging out the forecasted precipitation in a catchment or other polygon boundary, we assume that the rainfall will be the same throughout that catchment.

Limitations:

- The NOMADS database was difficult to navigate.
- Global forecasts have lower spatial resolutions.
- NOAA forecasts come in small time-steps (6 hours) and needed to be combined to create a long term forecast. Each time-step had to be downloaded separately.
- ONAMET does not provide its own forecast
- We have a limited understanding of how to access useful data from social media platforms.
- FloodTags has not processed much data from the Dominican Republic.

Design, Analysis & Results

The precipitation and runoff forecasts used come from the NOAA-NOMADS database. A global and local model were used. Table 1 below summarizes each model and corresponding variables.

Table 1: NASA Forecast Model Summary – NOMADS Database

Model	Resolution	Frequency	Variable	Units
NAM Caribbean/Central America	12 km	6 hrs	Total Precipitation (APCP)	Kg/m ² (mm depth)
GFS 0.25 degree	~26 km	6 hrs	Total Precipitation (APCP)	Kg/m ² (mm depth)
GFS 0.25 degree	~26 km	6 hrs	Water Runoff (WATR)	Kg/m ² (mm depth)

The NAM forecast has a higher resolution than GFS. Figures 1 and 2 show an example of each gridded precipitation forecast over the Dominican Republic. Each figure only shows 1 time-step, the first 6 hours.

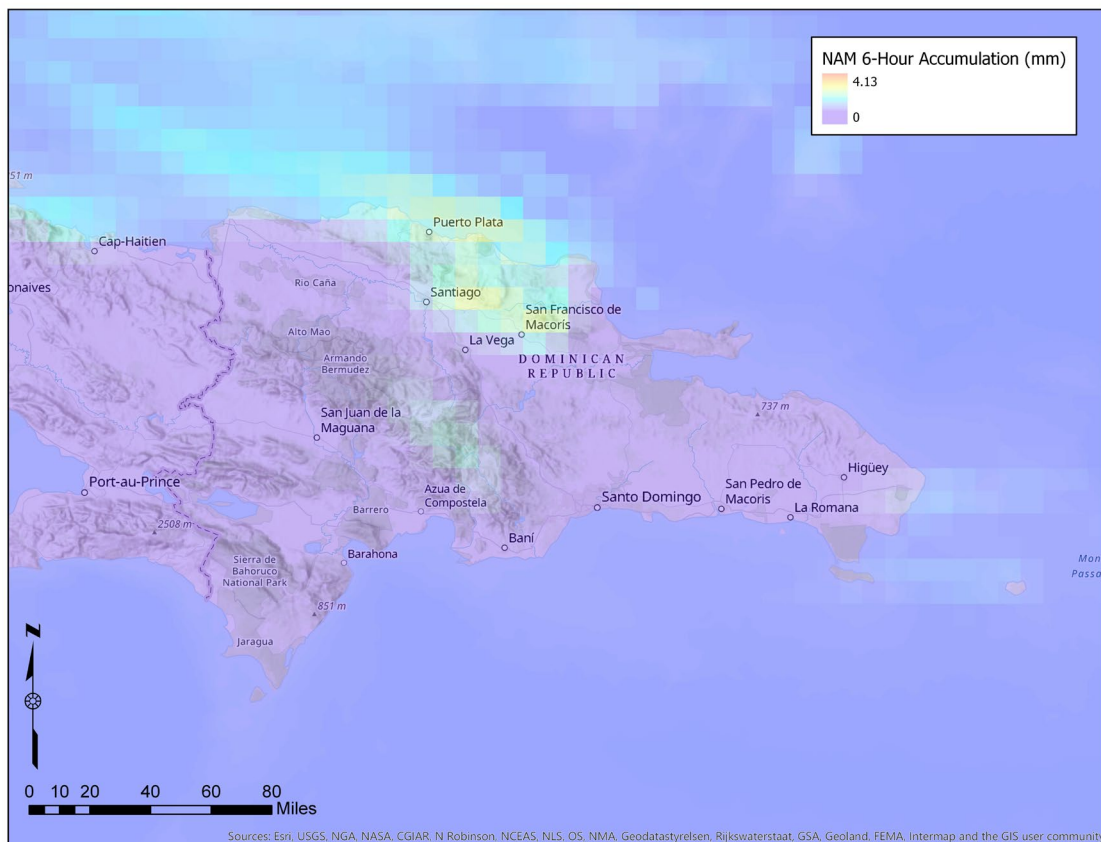


Figure 1: Example NAM Caribbean precipitation forecast.

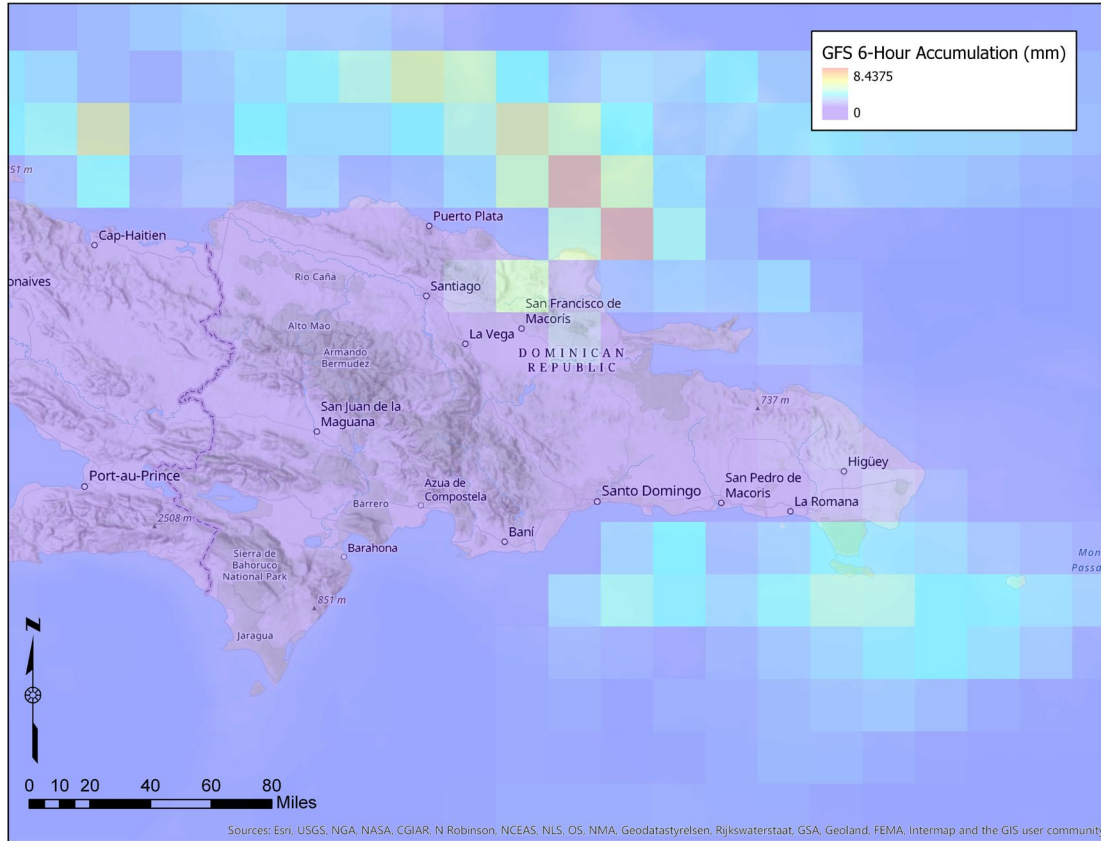


Figure 2: Example GFS precipitation forecast.

The gridded precipitation forecast was then averaged across polygon boundaries. This was done by first resampling the forecast raster to a smaller cell size. Then, the Zonal Statistics tool in ArcGIS Pro calculated the average rainfall depth in each of the boundaries. Figure 3 shows this result using GFS as the forecast and Provinces as the boundaries. This averaging can be done for any set of boundaries.

The next step will be to generate a 15-day precipitation forecast by combining all of the different time-steps found in the NOMADS database. The entire process will then be combined into a script. The user will be able to select the model, date, and boundaries to use. The correct data will be automatically downloaded, combined into a full forecast, and averaged into the selected watershed or political boundaries.

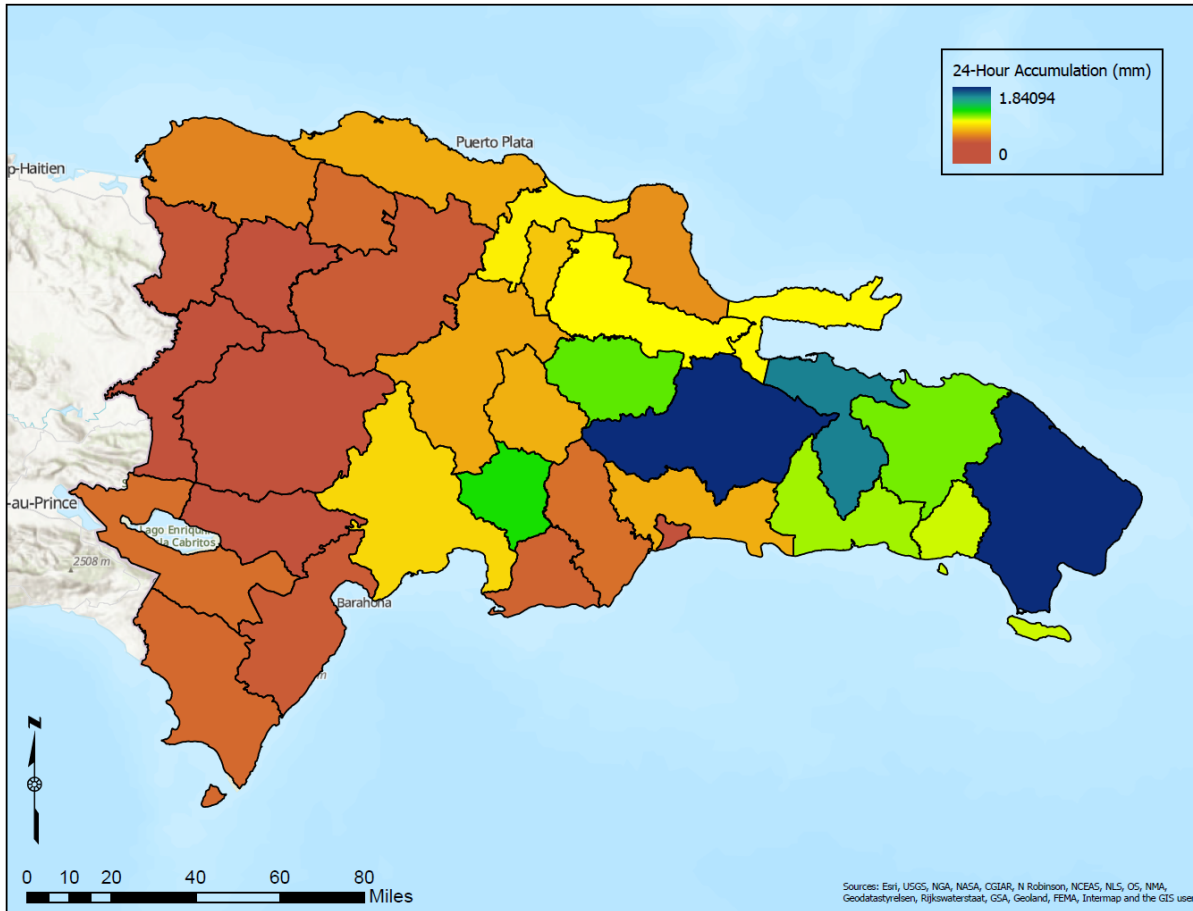


Figure 3: Example of GFS forecast averaged across Provinces.

Finally, FloodTags has been contacted and has expressed interest in working with us. They have not done a lot of work in Latin America, and they would like us to help improve their analysis in Spanish. We will research news articles and social media to find key words that are used to report flooding. This will help us understand whether or not there is sufficient data to help report floods.

Lessons Learned

Communication: This project has been fluid. After initial team assignments were made by Dr. Nelson, it was still unclear what direction our team should go. Through email, we were able to communicate with Fidel, the INDHRI representative, as well as other concerned parties. The email chains were helpful, but the most effective communication occurred during a face-to-face meeting with Fidel and Dr. Nelson. The face-to-face interaction allowed us to communicate clearly and directly and achieve the most with our time.

Leveraging skills: Both Jacob and Chris are more familiar with ArcGIS and other software the team has been using. They have performed a bulk of the data research for the project and helped Hunter understand how to use the respective software.

Questions: The more questions the team has asked, the more answers we have found. As we have utilized our resources, especially highly skilled professors and mentors, we have been able to turn our confusion into a plan with tangible deliverables. If we had not reached out, we would be stuck floundering in the brainstorming stage of our project.

Conclusions

As the team has worked on this capstone project, we have learned the importance of focused goal-setting and scheduling. Because the team's sponsors live in the Dominican Republic, only one face-to-face meeting could be arranged during the first semester. Because of this, it was important to ensure that the meeting with Fidel Perez was effective. By setting focused goals and a detailed schedule, the team was able to monitor the project's progression to ensure that proper materials were prepared for said meeting. Similarly, the team was able to prepare for the trip to the Dominican Republic next January.

The team was also able find and interpret the necessary precipitation and surface runoff models from the NOAA NOMAD system. After discovering how the files were organized, the team hopes that these models can be used within a GIS database to assist in the prediction of floods within the Dominican Republic. These models will be presented to INDRHI in January.

Recommendations

The team's current recommendation is that INDRHI review the work completed this semester. The team will then discuss the project during its visit to the Dominican Republic in 2019. The recommendations made by INDRHI will then be implemented in the Winter 2019 semester.

Appendix A

Internet Sources

- <http://nomads.ncep.noaa.gov/>
- http://nomads.ncep.noaa.gov/cgi-bin/filter_gfs_0p25.pl
- http://nomads.ncep.noaa.gov/cgi-bin/filter_nam_crb.pl
- <https://www.floodtags.com/>

Christopher Edwards

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Education

CIVIL ENGINEERING | BRIGHAM YOUNG UNIVERSITY | APRIL 2019

- Current GPA: 3.99
- Minor: Business Management

Work Experience

HYDROINFORMATICS RESEARCH ASSISTANT | BYU | MAY 2018 – PRESENT

- Delineated watersheds using ArcGIS Software to simulate streamflow in specific areas
- Analyzed historical streamflow simulations using Python to validate forecasting model

CIVIL ENGINEERING INTERN | BYU PHYSICAL FACILITIES | APRIL 2016 – APRIL 2018

- Produced plans for a \$100,000 house demolition and parking lot construction project
- Updated campus maps in AutoCAD to provide accurate reference for future projects
- Standardized construction details in AutoCAD to ensure uniform work across campus
- Aided in the design of campus construction projects not outsourced to a contractor

OFFICE ASSISTANT | BYU CENTER FOR SERVICE AND LEARNING | JANUARY – APRIL 2016

- Verified the completion of student leadership training programs to uphold club standards
- Managed legal agreements between BYU and external organizations to protect student liability

CREW SUPERVISOR | BYU CAMPUS CHICK-FIL-A | JULY – DECEMBER 2015

- Directed and trained a team of 12 employees to sell over \$500 of food per hour
- Ensured prompt service and conducted quality control to enhance customer satisfaction

Volunteer Experience

ASCE CLUB OFFICER | BYU STUDENT CHAPTER | JANUARY 2018 – PRESENT

- Organized bimonthly STEM program for kids through United Way at a local community center
- Constructed steel footbridge in Saratoga Springs to give children access to a new playground

MISSIONARY | THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS | MAY 2013 – 2015

- Learned to speak conversational Spanish fluently in Asuncion, Paraguay
- Managed visas and return travel for more than 200 missionaries

Jacob Lewis

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EDUCATION

Brigham Young University (BYU) **Provo, UT**
Bachelor of Science in Civil Engineering April 2019

- Member of the BYU ASCE Networking Committee

WORK EXPERIENCE

BYU Physical Facilities **Provo, UT**
Civil Engineering Intern August 2016 – Present

- Created drawing sets in AutoCAD Civil 3D for campus projects costing more than \$100,000
- Maintained drawings of campus utilities through daily surveys with GPS and Total Station equipment
- Trained new interns in surveying and AutoCAD

BYU Physical Facilities **Provo, UT**
Hardscape Construction Worker April 2016 – August 2016

- Constructed heavy landscape projects such as retaining walls and planter beds on BYU campus
- Worked with a team to meet deadlines and effectively use construction materials

BYU Police Department **Provo, UT**
Senior Building Security Student Officer August 2014 – April 2016

- Patrolled campus nightly to ensure security of campus buildings and equipment
- Entrusted with access to multi-million-dollar campus laboratories and equipment
- Organized trainings and scheduling for 20 student officers

Barrick Gold Corporation **Carlin, NV**
Student Surveyor May 2011 – August 2011 and May 2014 – August 2014

- Completed daily surveys of active mining areas, and drew daily dig plans for mining shovels
- Performed 2 to 3 daily stakeouts of gold ore deposits using GPS surveying equipment

OTHER RELEVANT EXPERIENCE

Volunteer Service Representative **San Pedro Sula, Honduras**
The Church of Jesus Christ of Latter-day Saints February 2012 – March 2014

- Worked 10-12 hours daily speaking with others in Spanish
- Developed leadership, managerial, and interpersonal relations skills
- Collaborated with other volunteers to present trainings on goal-setting, problem-solving, etc.

SKILLS

Technical Skills: Microsoft VBA programming, AutoCAD Civil 3D, Bluebeam Revu

Languages: Spanish

Hunter Williams

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Provo, Utah

Work Experience

AutoCAD Designer, *R.B. Williams & Associates, Inc.* | *Phoenix, AZ* Feb 2016-Present

- Designed over 50 grading plans for commercial developments
- Completed earthwork assessments and drainage calculations for development projects
- Prepared complete plan sets for submittal to clients and municipalities
- Addressed technical problems noted by clients and municipalities
- Communicated effectively with clients, design professionals, and municipal authorities
- Trained co-workers to use AutoCAD to create effective project designs and plan sets

Backroom Associate/Shift Lead, *DownEast Outfitters* | *Orem, UT* Feb 2015-Jan 2016

- Processed and organized furniture inventory for in store use and deliveries
- Planned delivery routes and scheduled delivery dates and times
- Analyzed daily cash flow including sales, refunds, credits, and mischarges
- Trained co-workers to perform cash flow analyses

Sales Consultant, *Pane Frei Window Cleaning* | *Gilbert, AZ* Feb 2015-Jun 2015

- Advertised products to over 500 potential clients
- Prepared service cost estimates for clients
- Scheduled appointments for two technician teams

Education

Bachelor of Science, *Brigham Young University (BYU)* | *Provo, UT* Dec 2019

- Major: Civil and Environmental Engineering
- Passed Fundamentals of Engineering Exam (FE) Mar 2018

Volunteer Experience

Service Mission Feb 2013-Feb 2015

- Planned and lead multiple training conferences for 250 volunteers (age range: 18-75)
- Coordinated housing, transportation, and material needs for 250 volunteers
- Communicated daily with people of varying backgrounds, social positions, and economic statuses