
StormSense Project
Forecasting Flooding from Storm Surge, Rain, and Tide
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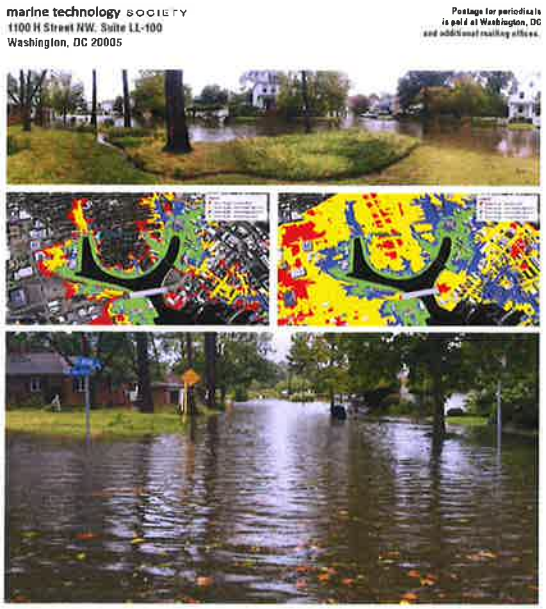
1940 - 2015
VIMS
75 years
VIRGINIA INSTITUTE OF MARINE SCIENCE
Presentation to Rappahannock River Basin Commission - 06/19/2019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StormSense Project

- 28 new Internet of Things (IoT) water level sensors installed in 2017-18 through NIST Smart Cities Award:
  - 10 installed in Newport News
  - 6 installed in Norfolk
  - 12 installed in Virginia Beach
- 6 more to be installed in Summer 2019 through Award from Natural Resources Defense Council, & more through city CIPs
- Harmonic Analysis for all sensors installed in tidal areas was completed in Spring 2018 for integration into CCRFR's Tidewatch service in Summer 2018

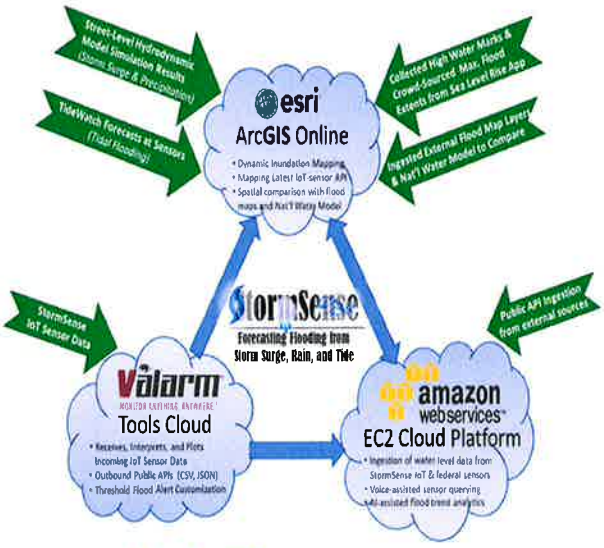


Figure 1 from Loftis *et al.*, 2018. *IEEE Smart Cities SCOPE Journal*

StormSense Budget Breakdown

List of Grants VIMS has written (or aided in writing) and City Expenditures on StormSense:

- $300,000, 2016-2018 Virginia Beach CIP
- $75,000, 2016-2017 NIST RSCT Grant
- $50,000, 2017 Amazon Web Services (City on a Cloud Innovation Challenge Winner, Best Practices)
- $30,000, 2017-2018 Newport News CIP
- $7,500, 2017-2018 Norfolk CIP
- $30,000, 2017-2018 VDEM (SLEMPG Grant)
- $26,000, 2018-2019 NRDC
- $109,000, 2019-2020 VDEM (HMGP Grant)
- $627,500 Total

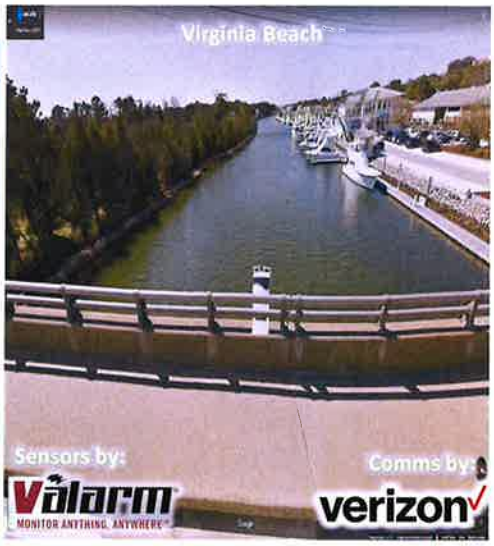
*Grants were mostly used to purchase sensors; city Capital Improvement Program (CIP) budgets paid to install and maintain them

Figure 4 from Loftis *et al.*, 2018. *Marine Tech. Soc. Journal.*

StormSense Sensor Deployment Workflow

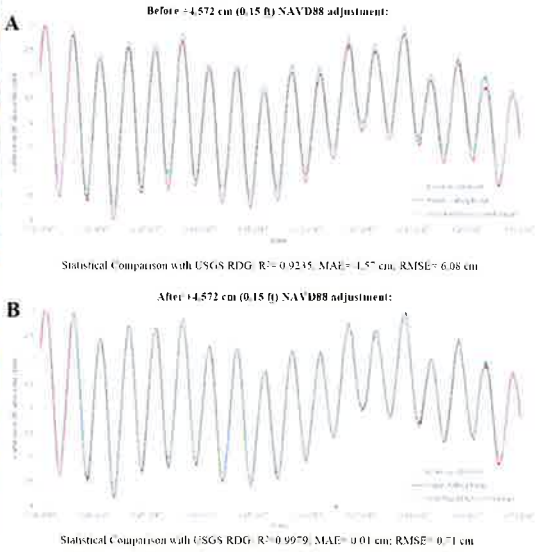
1. Apply for grants to defray sensor costs
2. Order the sensors
3. Receive the sensors:
   - Radar/Sonar Level Sensor
   - A Control Box
     - Data Logger
     - Transmission Hub
     - Solar Controller
     - Antenna
     - GPS
   - 30W Solar Panel

Installed Sensors & Virtual Tours



Road Inundation Sensors

- Green stream sensors deployed in frequently flooded intersections.
- Found to measure water level within ±4.5 cm during Hurricane Maria when compared with USGS RDG.
- After artificial adjustment, the sensor could measure as accurately as *RMSE* = ± 0.71 cm.

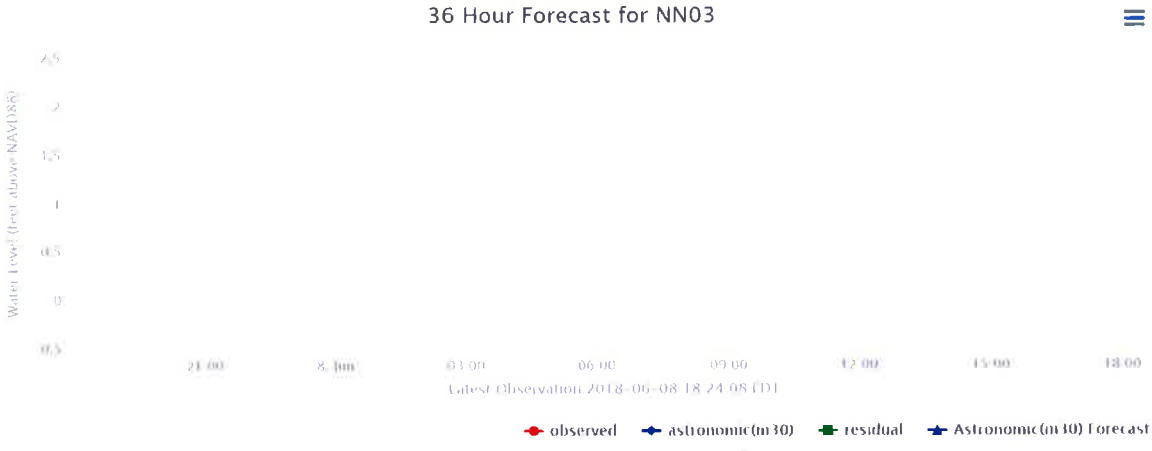


StormSense Accuracy

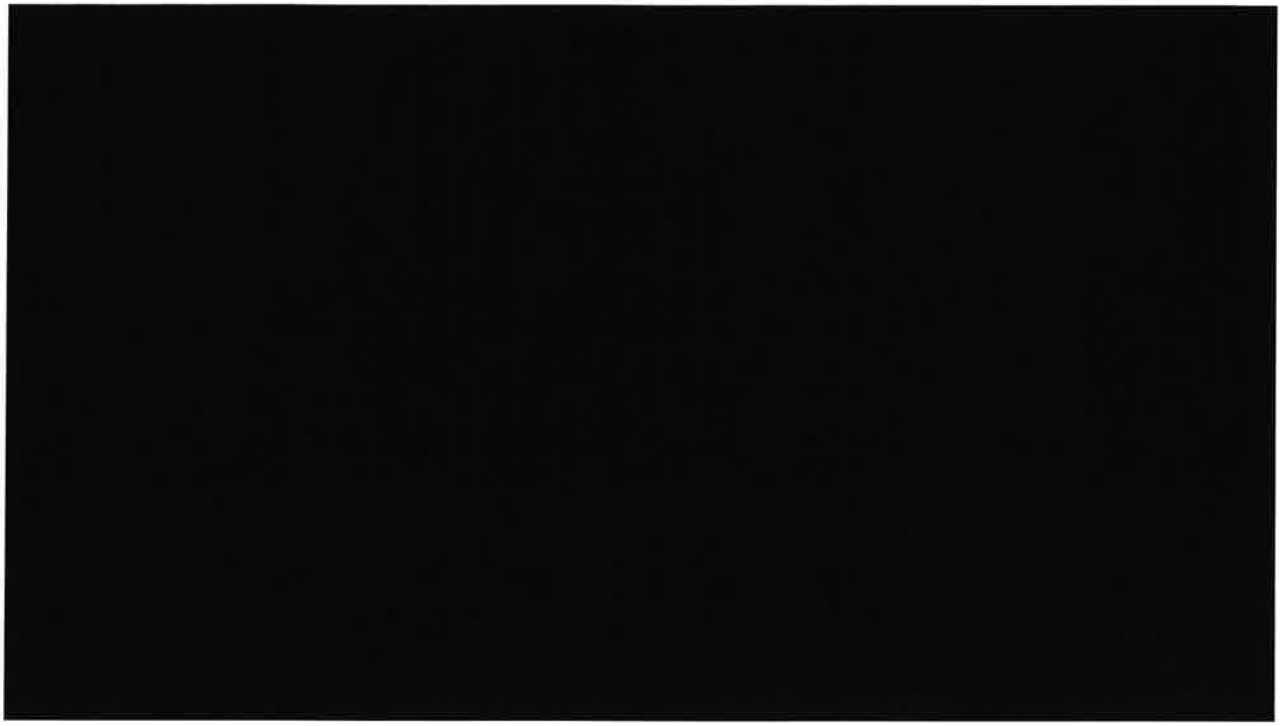
- Some sensors were temporarily co-located on the same bridges in Virginia Beach to test StormSense's low-cost (≈$3,000) ultrasonic sensor accuracy compared to USGS' radar sensors (≈$30,000).
  - Over a 4-month period (Nov. 2017 - Mar. 2018) an aggregate RMSE of ±1.18 cm (n=4) were observed.
  - During this time, a king tide (Nov.), and 4 relatively minor nor'easters (Mar.) occurred
- These sensors will be relocated in Fall 2018 after collecting 12 months of data
- Knowing this preliminary comparison, Virginia Beach has submitted a PO for 13 more water level sensors through a CIP.

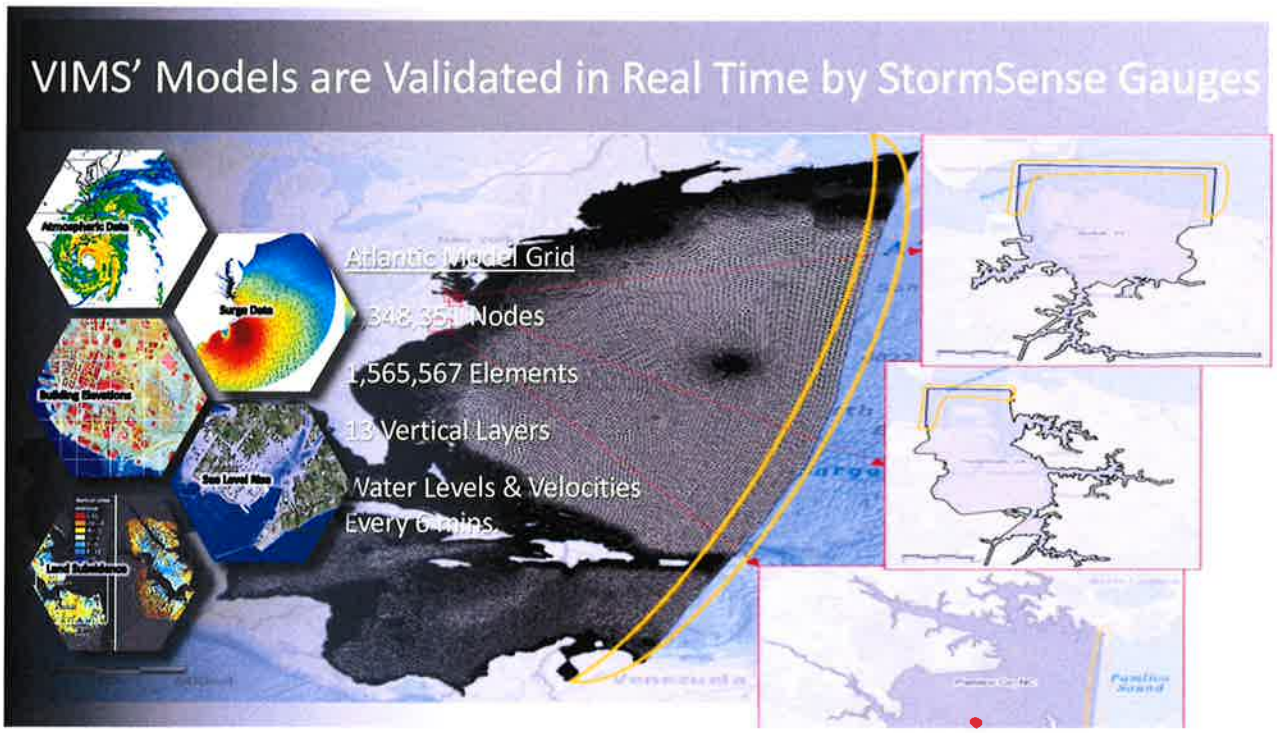
Figure 5 from Loftis *et al.*, 2018. *Marine Tech. Soc. Journal.*

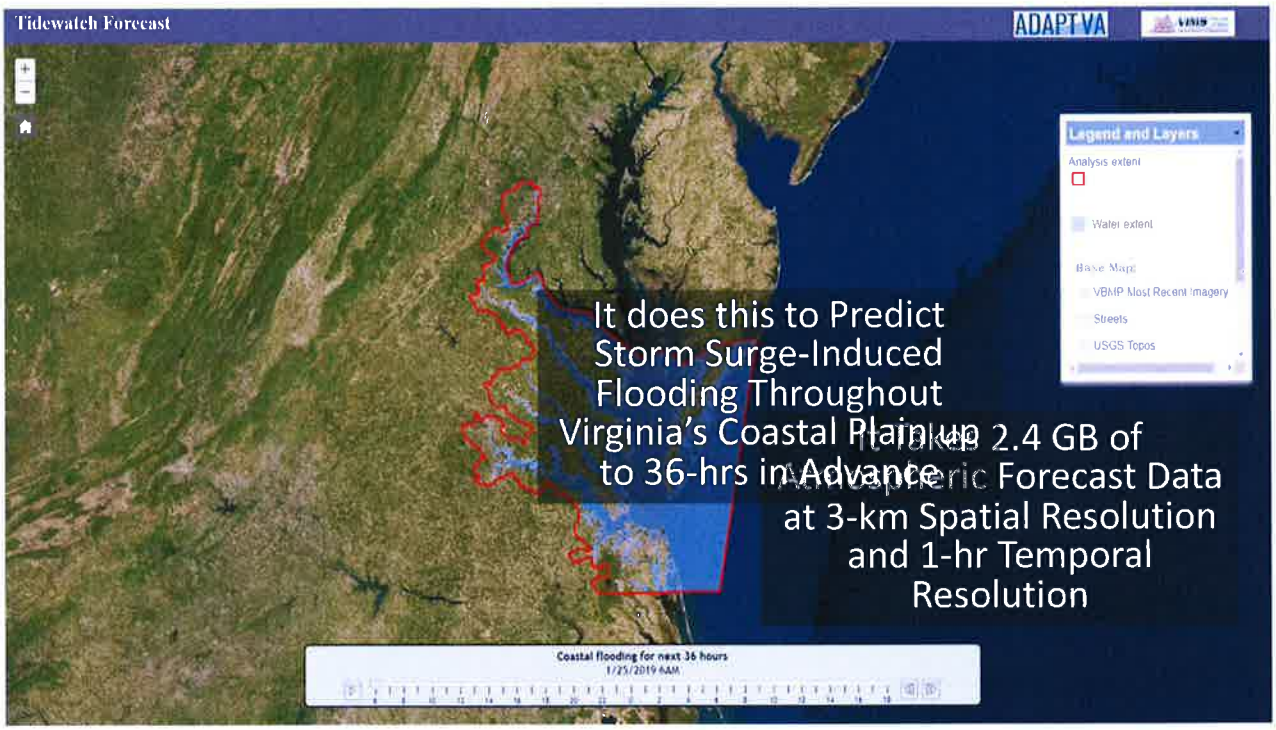
StormSense Sensor Tidal Forecasts via Tidewatch

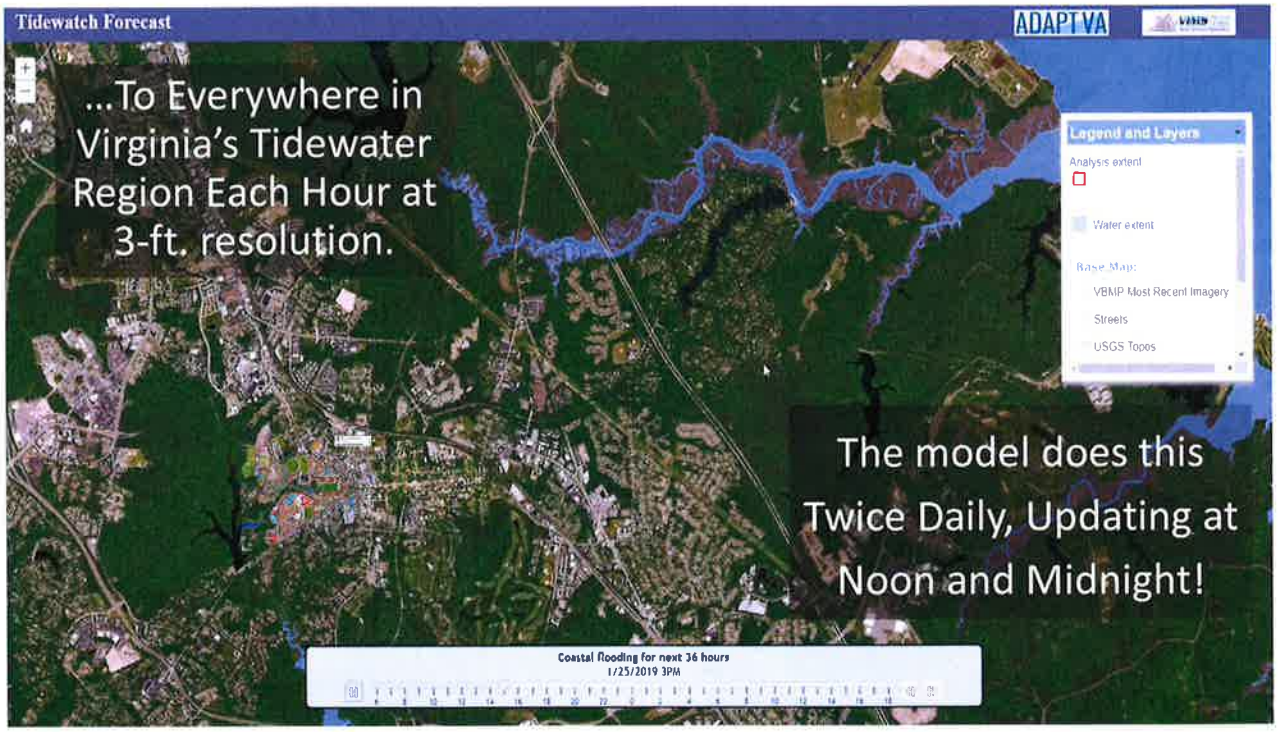


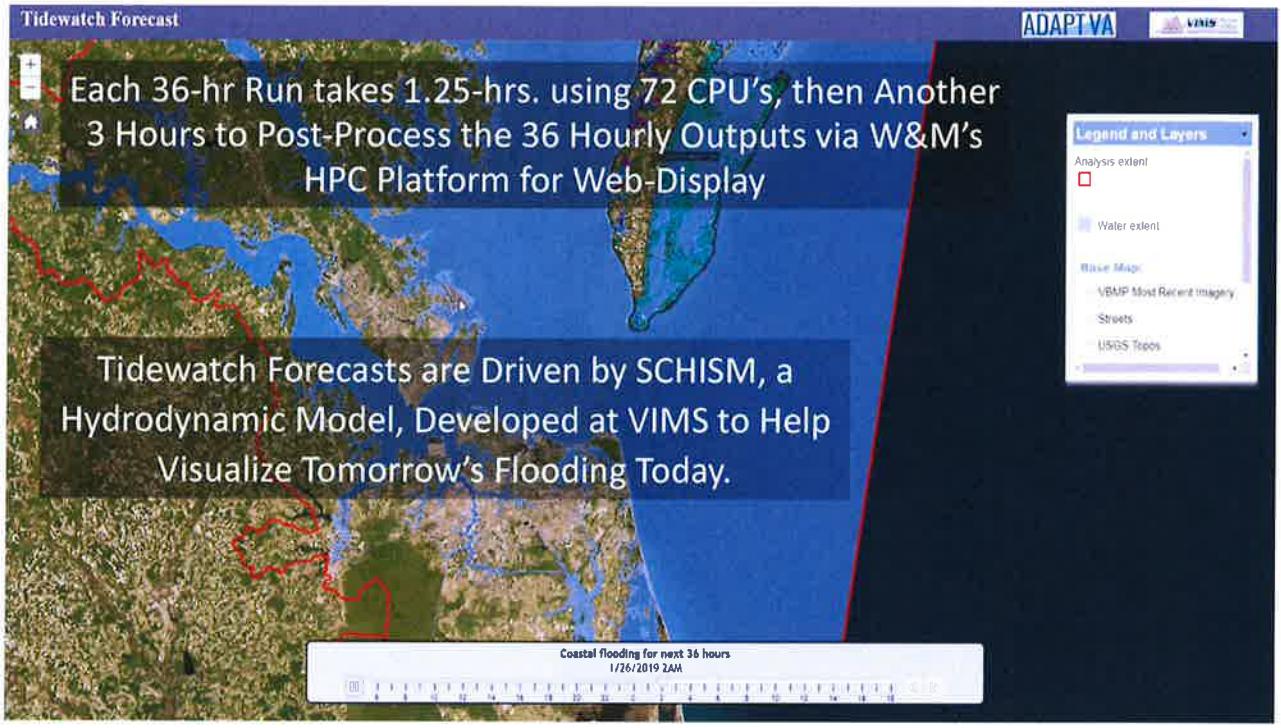
Sensor Data API URLs: http://www.vims.edu/people/loftis_jd/HRVASensorAssets/index.php
Sensor Data Tidewatch Pages: http://www.vims.edu/bayinfo/tidewatch/stations/cbbt/index.php
Aggregated Recurrent Flooding Data: http://www.vims.edu/people/loftis_jd/HRVASensorAssets/hrva-persistent-flood-data.php



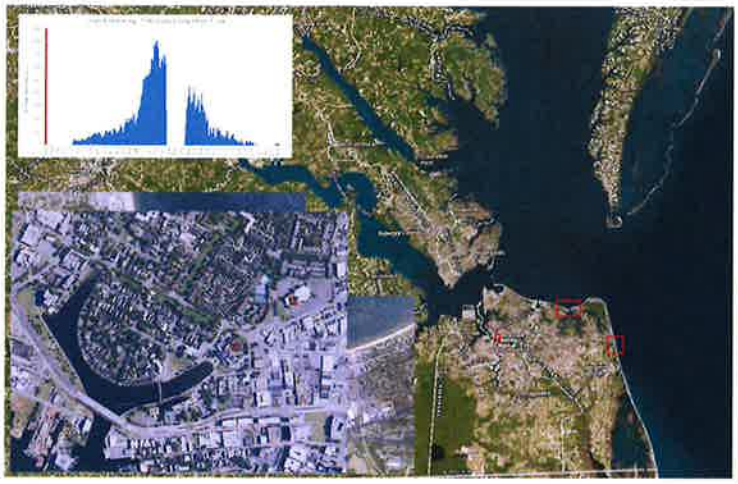

VIMS' Models are Validated in Real Time by StormSense Gauges
Atmospheric Data
Surge Data
Building Elevations
Sea Level Rise
Land Subsidence
Atlantic Model Grid
348,357 Nodes
1,565,567 Elements
13 Vertical Layers
Water Levels & Velocities
Every 6 mins.


Tidewatch Forecast
ADAPT VA
Legend and Layers
Analysis extent
Water extent
Base Map:
VBMP Most Recent Imagery
Streets
USGS Topos
It does this to Predict Storm Surge-Induced Flooding Throughout Virginia's Coastal Plain up to 36-hrs in Advance
It takes 2.4 GB of Atmospheric Forecast Data at 3-km Spatial Resolution and 1-hr Temporal Resolution
Coastal flooding for next 36 hours
1/25/2019 6AM

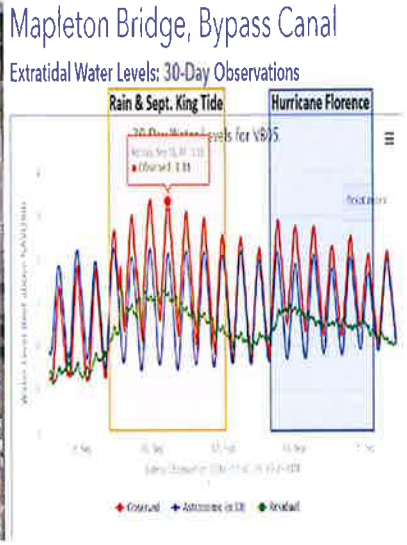

Tidewatch Forecast
ADAPT VA
...To Everywhere in Virginia's Tidewater Region Each Hour at 3-ft. resolution.
Legend and Layers
Analysis extent
Water extent
Base Map:
VBMP Most Recent Imagery
Streets
USGS Topos
The model does this Twice Daily, Updating at Noon and Midnight!
Coastal flooding for next 36 hours
1/25/2019 3PM



Catch the King Tide

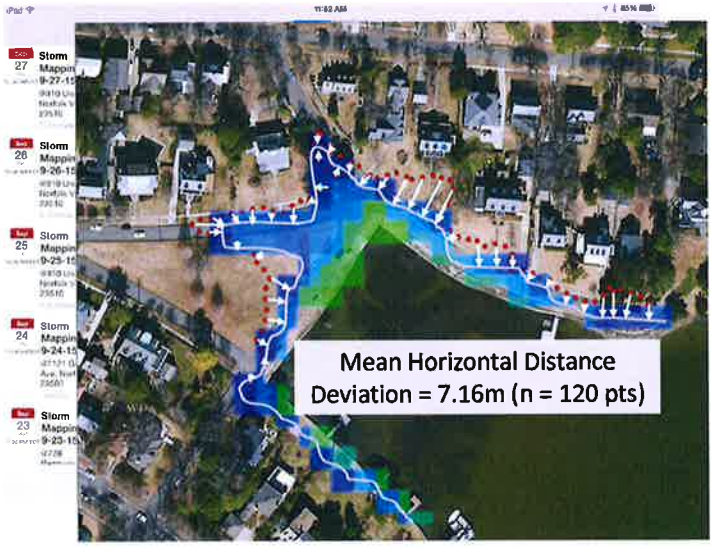


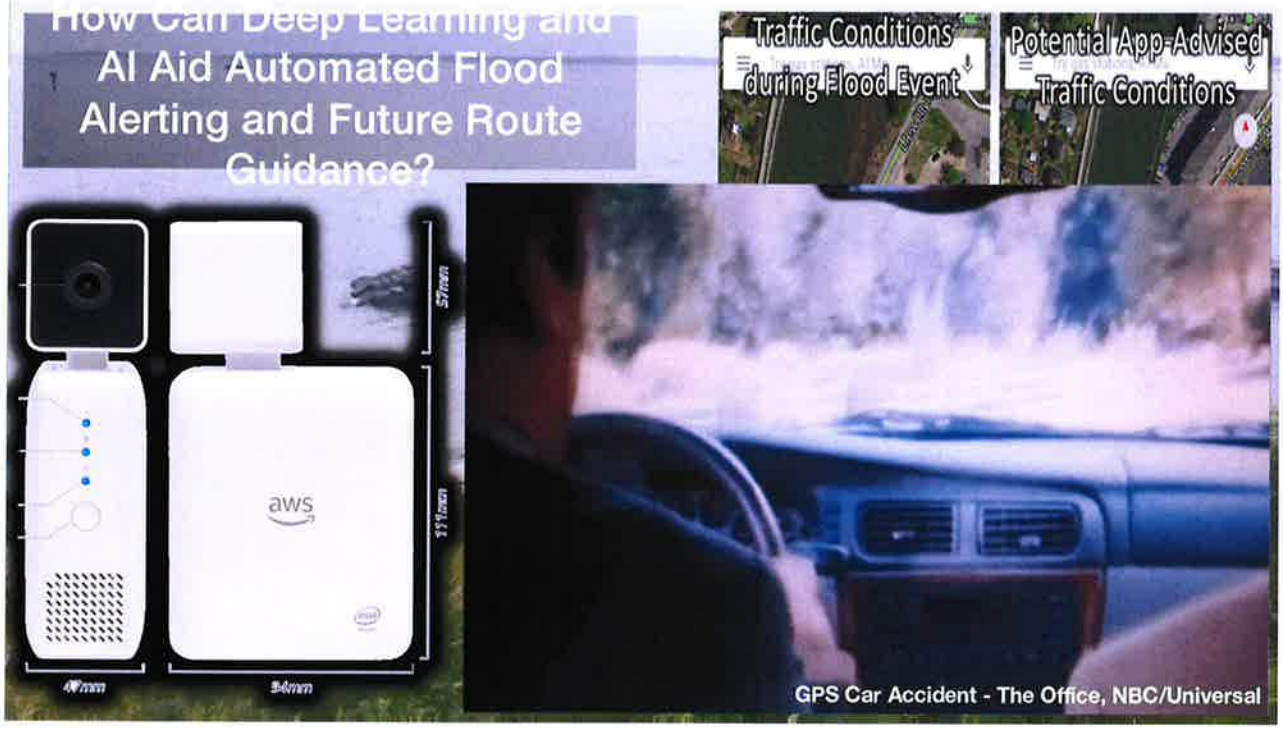
Catch the King Tide Data Collection



Collected via Sea Level Rise Mobile Application.

Catch the King Model Data Comparison




How Can Deep Learning and AI Aid Automated Flood Alerting and Future Route Guidance?
Traffic Conditions during Flood Event
Potential App-Advised Traffic Conditions
aws
GPS Car Accident - The Office, NBC/Universal

StormSense Recognitions

1. NIST/US Ignite Global City Teams Challenge Winners
2. AWS City on a Cloud 2017
3. GovLoop Top 30 Govt. Innovations of 2017
4. Smart 50 Awards '18 Recipient
5. Alliance for Innovation – Transforming Local Govt. 2018 Featured Case Study & Innovation Award Winner
6. Internat'l Data Group's 2018 CIO 100 Award Winner
7. Gov't Innovation Awards 2018 Public Sector Winner
8. 2019 Esri Special Achievement in GIS Award

Thank You!

- **Hampton Roads Planning District Commission** for providing an opportunity to initially present StormSense in 2016
- **Funding**
  - National Institute of Standards and Technology (Repl. Smart City Tech. Grant)
  - Commonwealth of Virginia (Commonwealth Ctr. for Recur. Flooding Resiliency)
- **Newport News**
  - Information Technology
    - Andy Stein, Eric Beach, and Tammie Organski
  - Public Works
    - Mike Ashe, Wade Gerze, and Frank James
  - Emergency Management
    - Jay Bowden, George Glazner, and Chief R.B. Alley
- **Norfolk**
  - Office of Resilience
    - Christine Morris and Kyle Spencer
- **Virginia Beach**
  - Comm. and Information Tech.
    - Robert Jessen and Sridhar Katragadda
    - Natasha Singh-Miller and Mike Zecca