PIXELS FOR PUBLIC HEALTH:

A Digital Twin for Coastal Flood Hazards Using Earth Observations, Sensors, and Models

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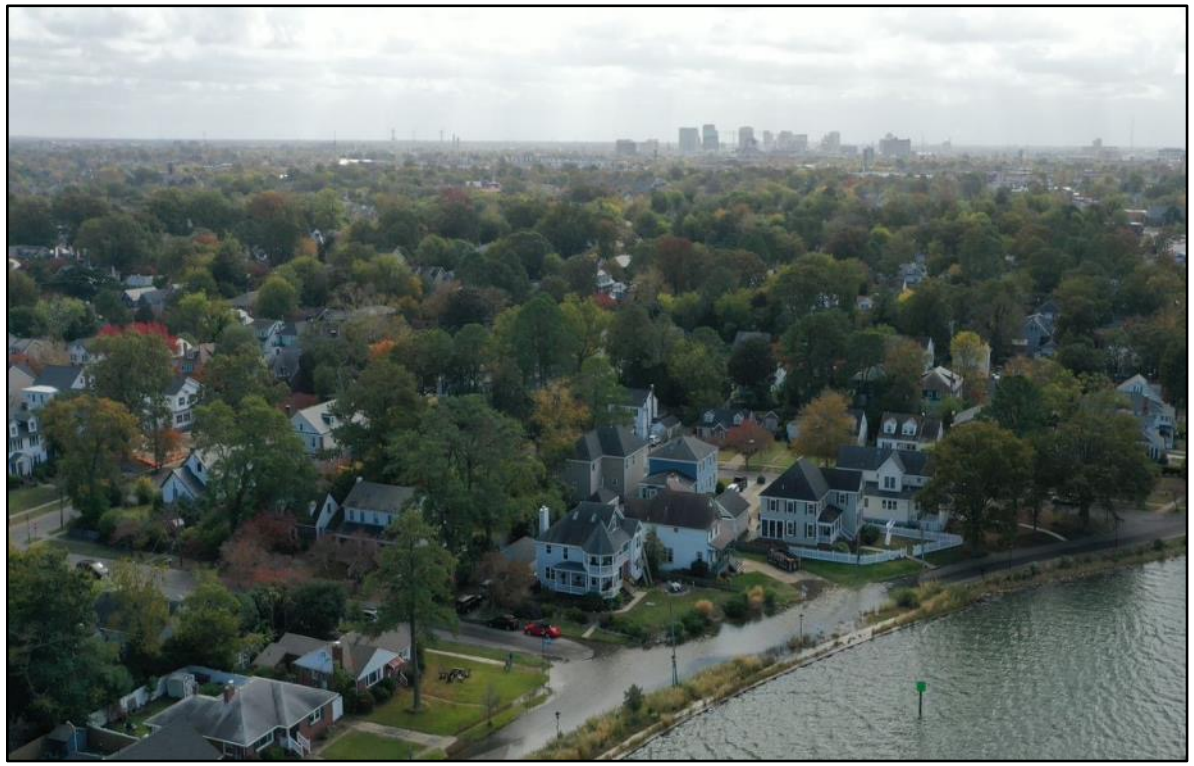
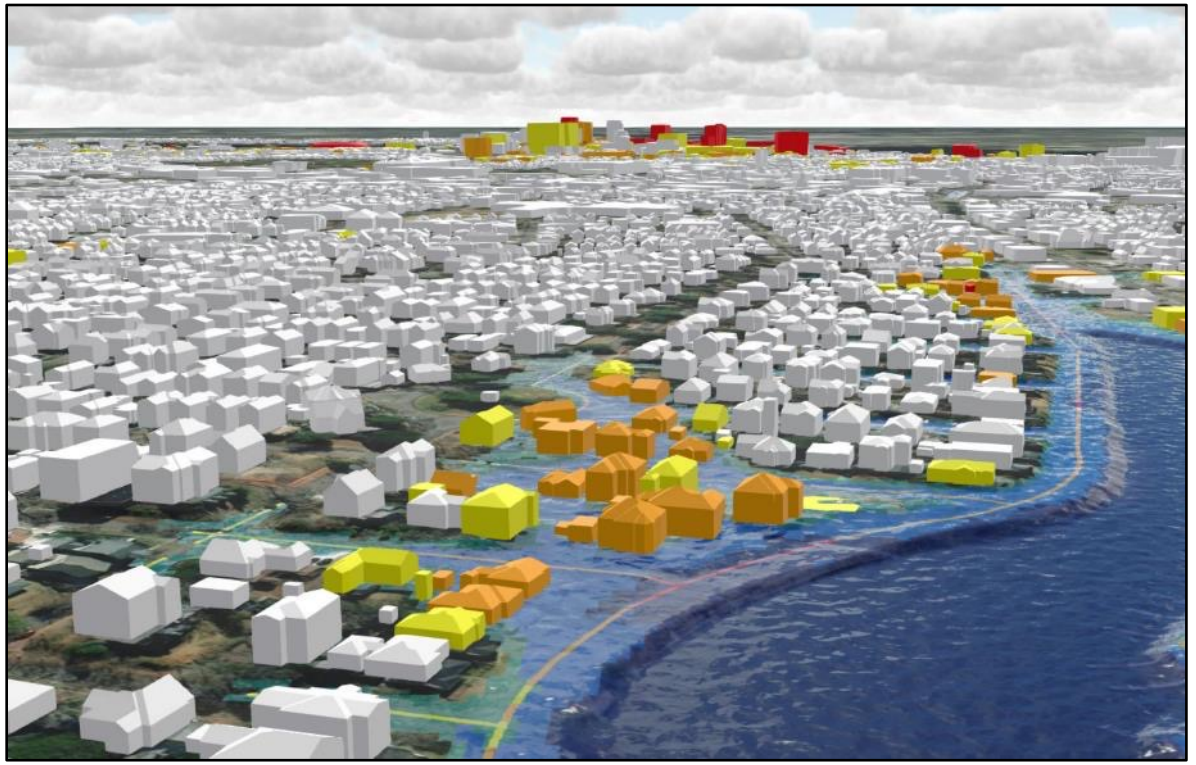
OLD DOMINION UNIVERSITY

The Science Use Case

How can a Digital Twin (DT) analyze future sea-level change, flooding, land use, and population vulnerability?

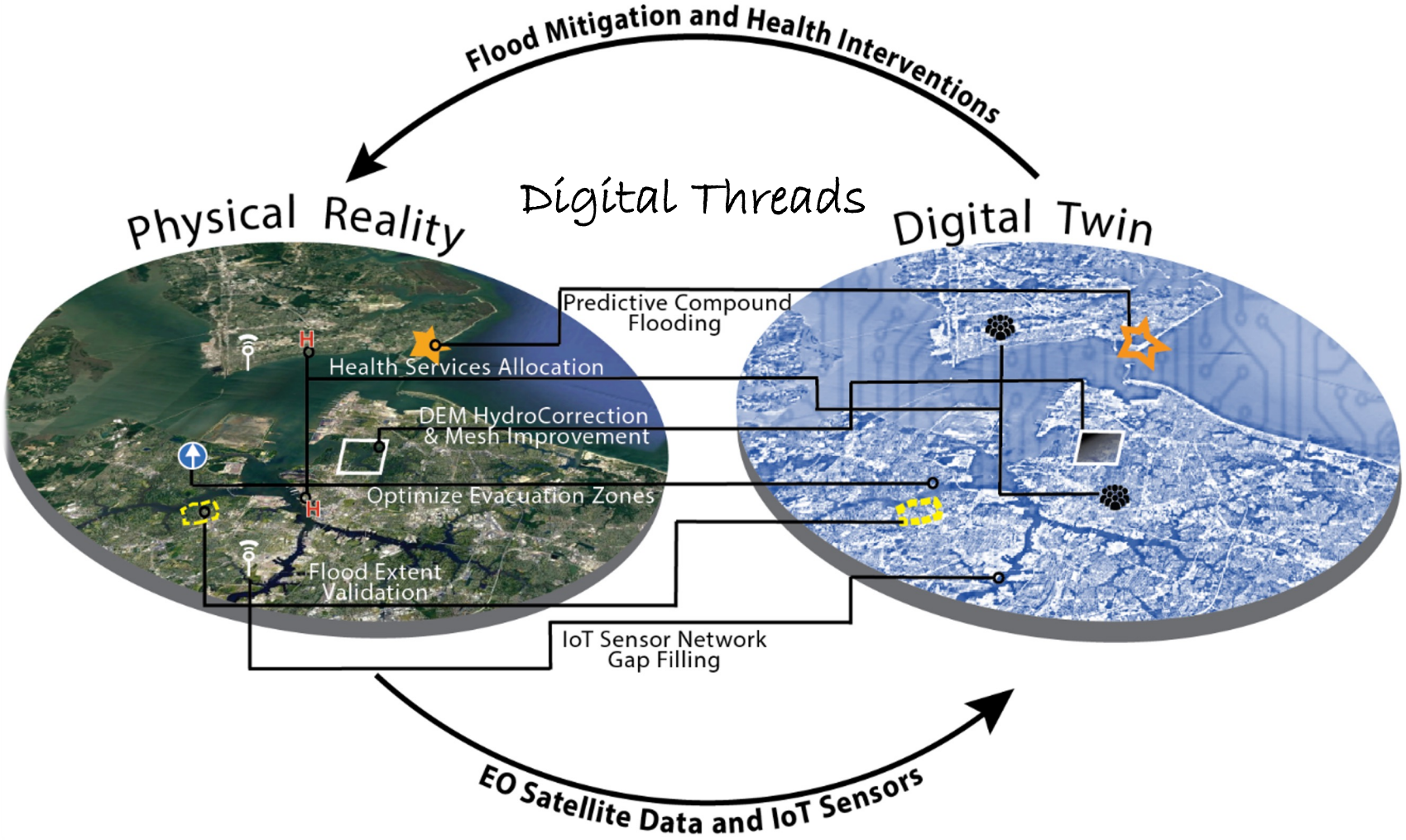




King Tide Flooding Today and the Future: Norfolk, Virginia, USA

Digital Twin Vision for Tackling Combined Flooding and Risk

- Mainstream the data models, access and application
- Apply Machine Learning with imagery of flooding, rainfall, flood sensors and flood models

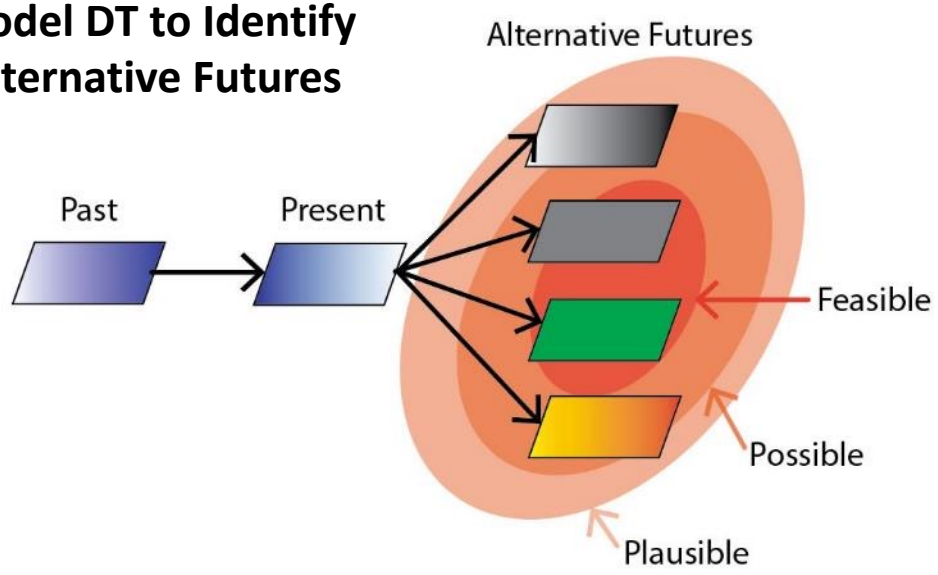


Benefits

An Earth System Digital Twin of sea-level, coastal storms and hydrologic extremes to understand compound flooding and its impacts on urban coastal communities (population, industry, and infrastructure.)

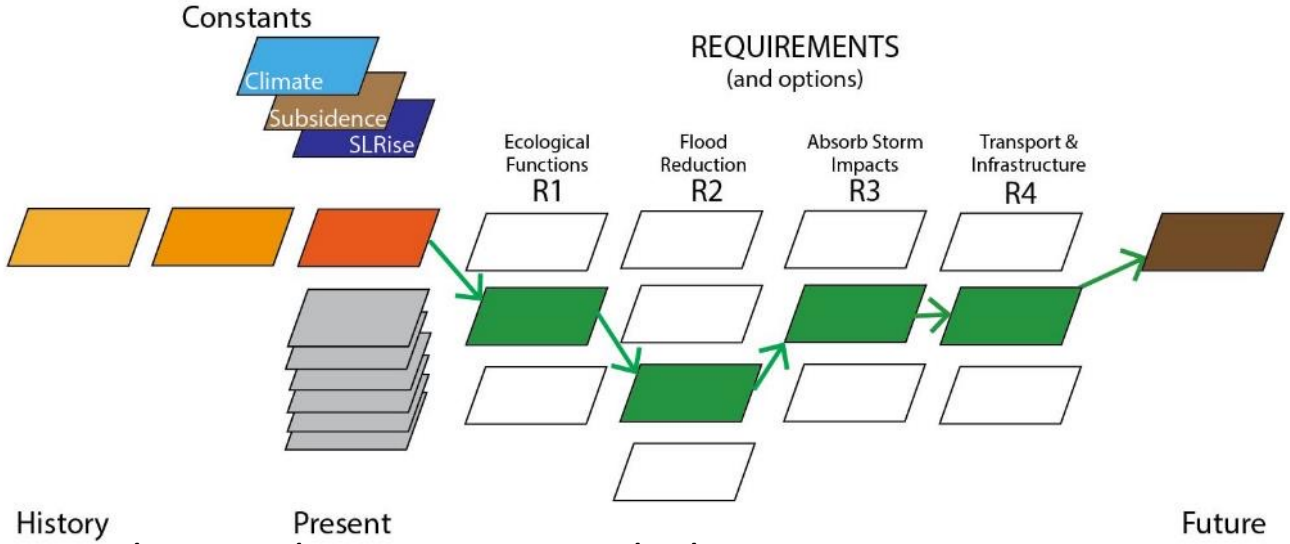
The DT enables foresight of future coastal risks and selection of preferred alternative multidimensional conditions for urban planning and design.

Model DT to Identify Alternative Futures



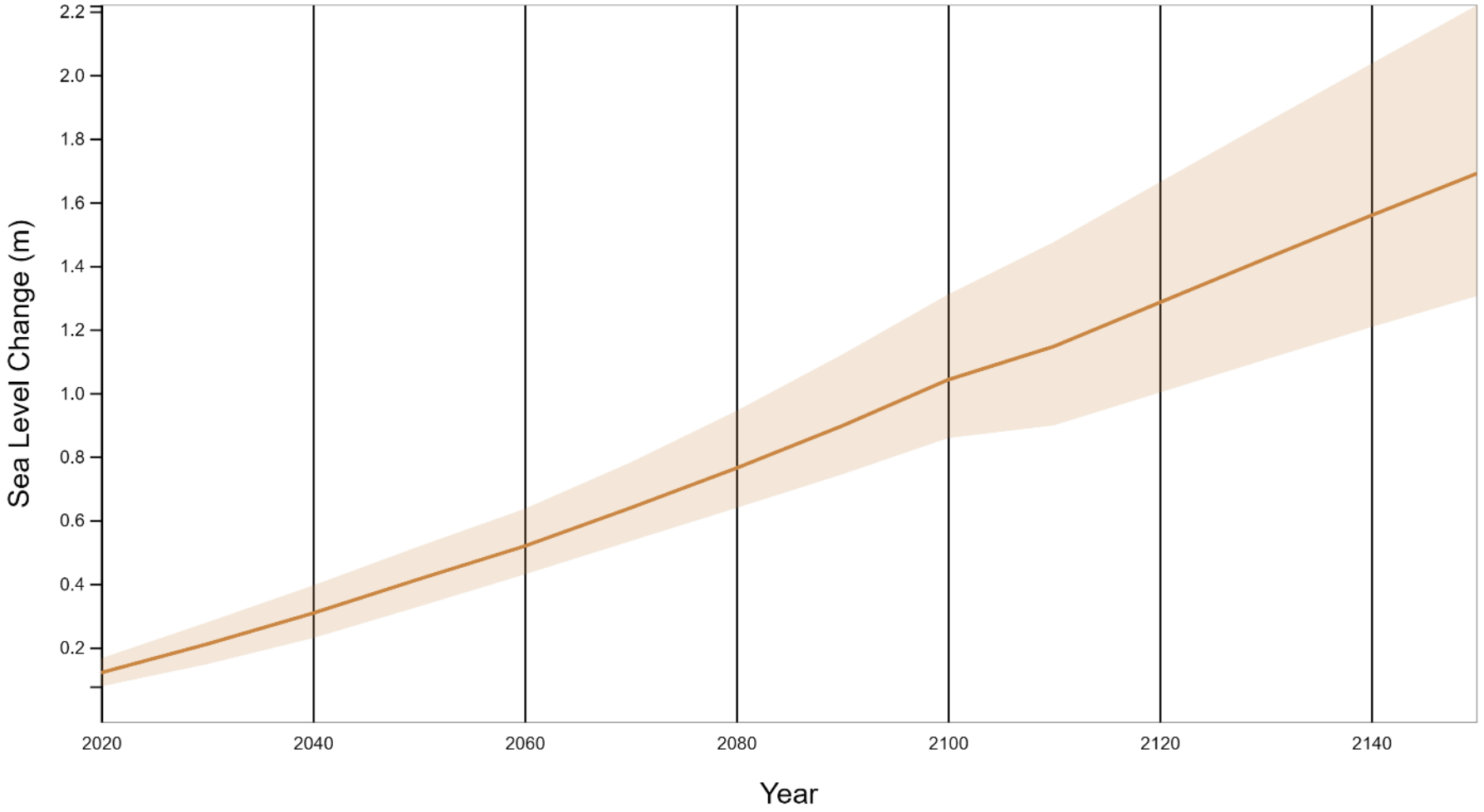
What-Ifs?

Enable Stakeholders to Design the Future



After Steinitz (2012) *A Framework for Geodesign: Changing Geography by Design*

Projected Sea Level Rise at Sewells Point, Norfolk, Virginia

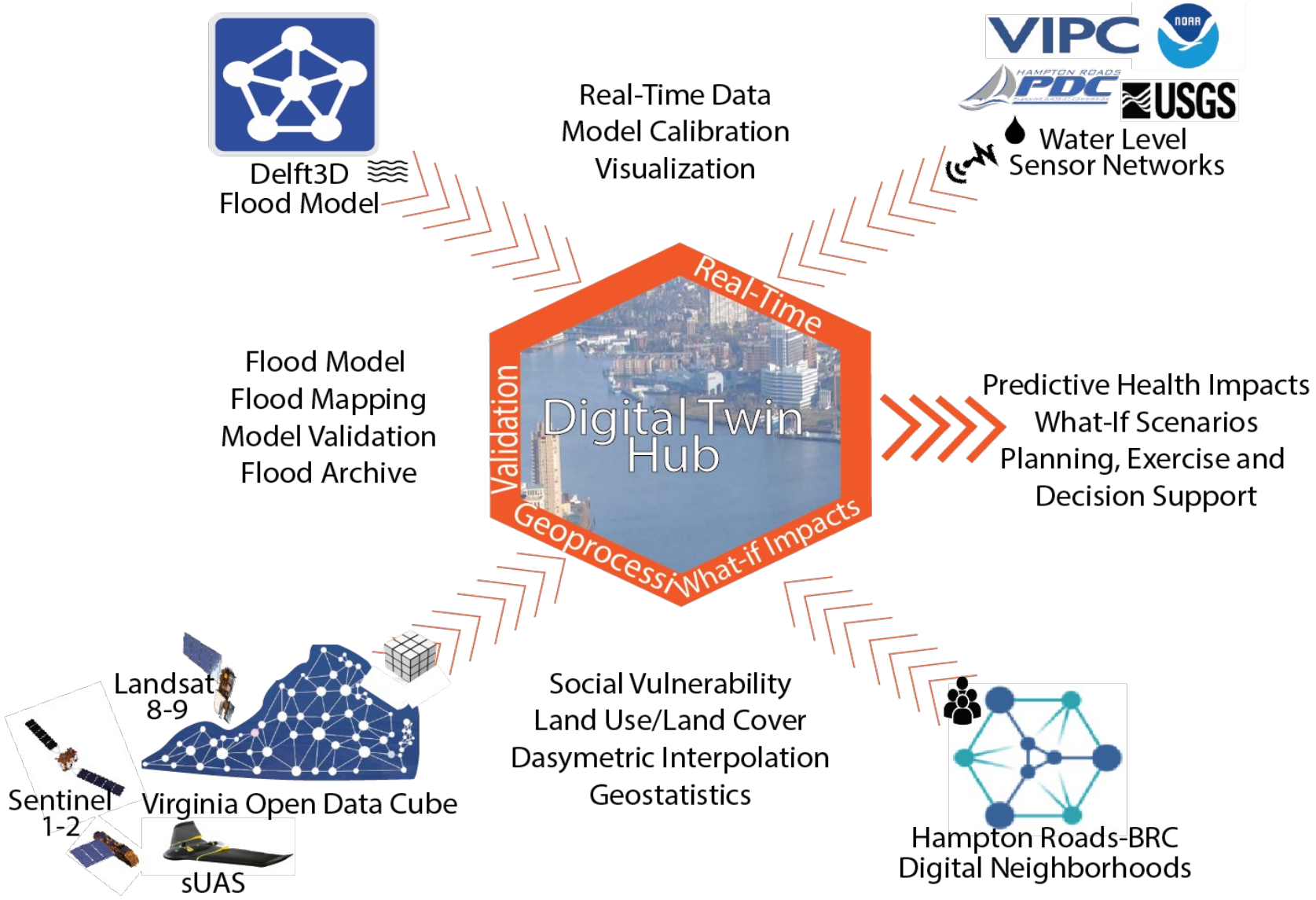


A medium-high scenario of no new major climate policy will realize 1m of relative sea level in Hampton Roads likely before 2100

SSP3-7.0 scenario with 1994-2014 baseline

NASA Sea Level Projection Tool
https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?psmsl_id=299&data_layer=scenario

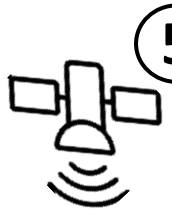
Pixels for Public Health: **Preliminary Digital Twin Concept**



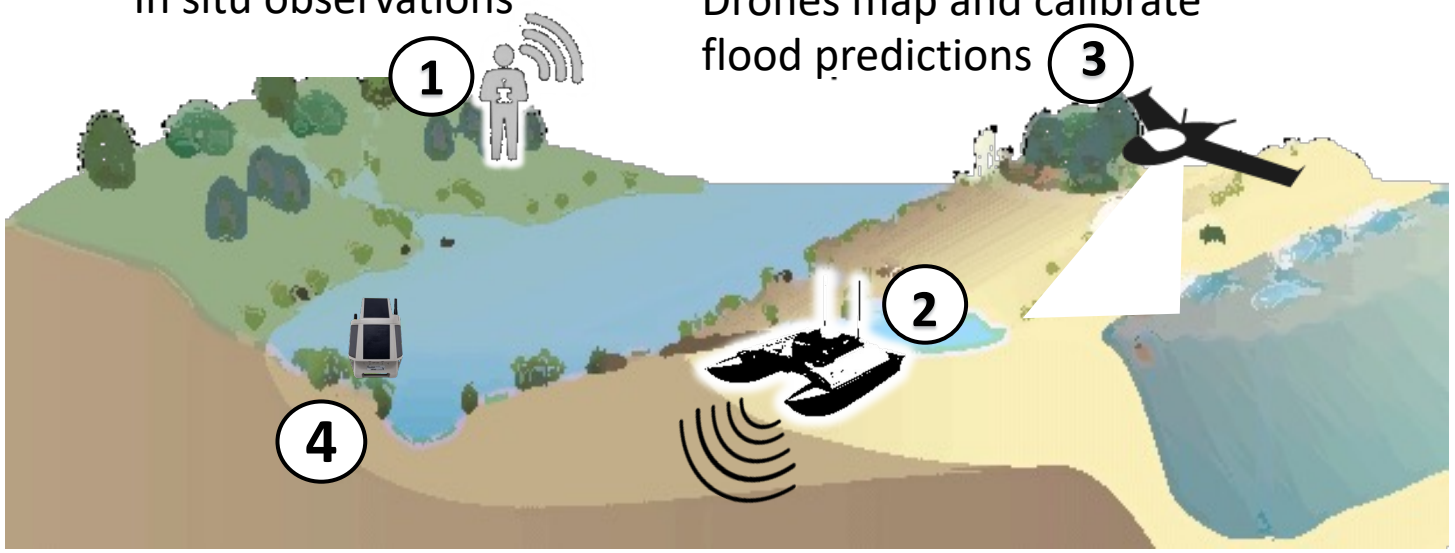
NASA AIST

Inventorying the Technology:

A variety of observing systems are being combined in the digital twin



5 EO Satellites scale-up the extent of the digital twin

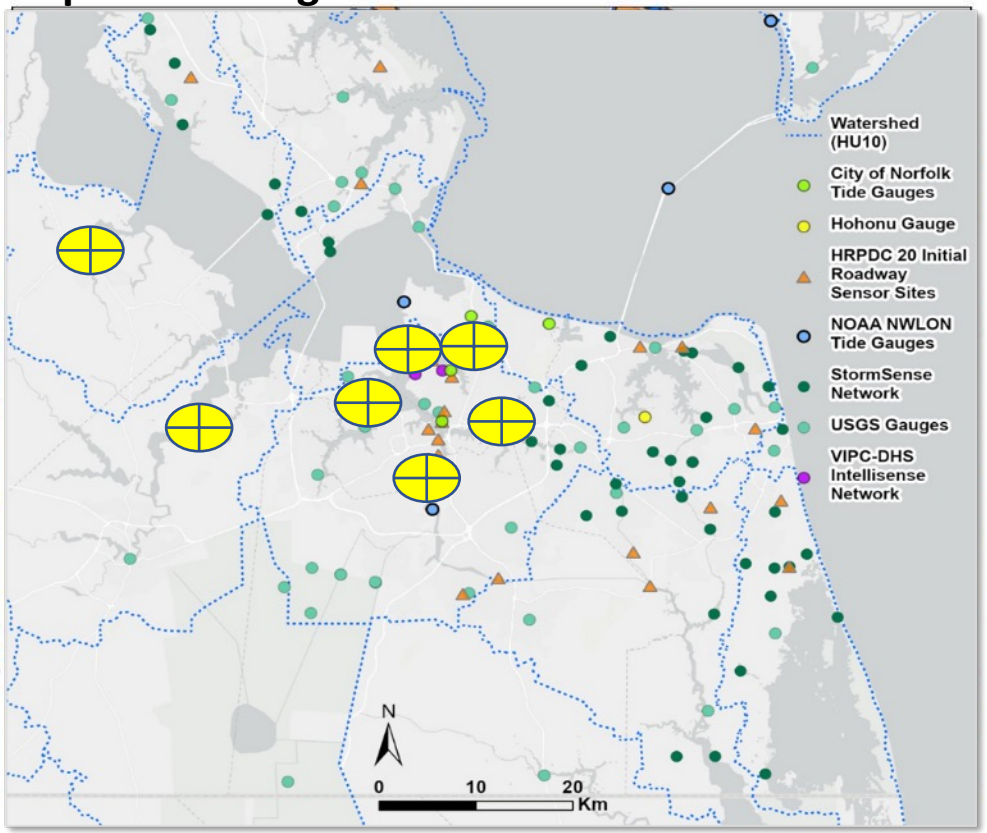


IoT flood sensors parameterize and validate predictions

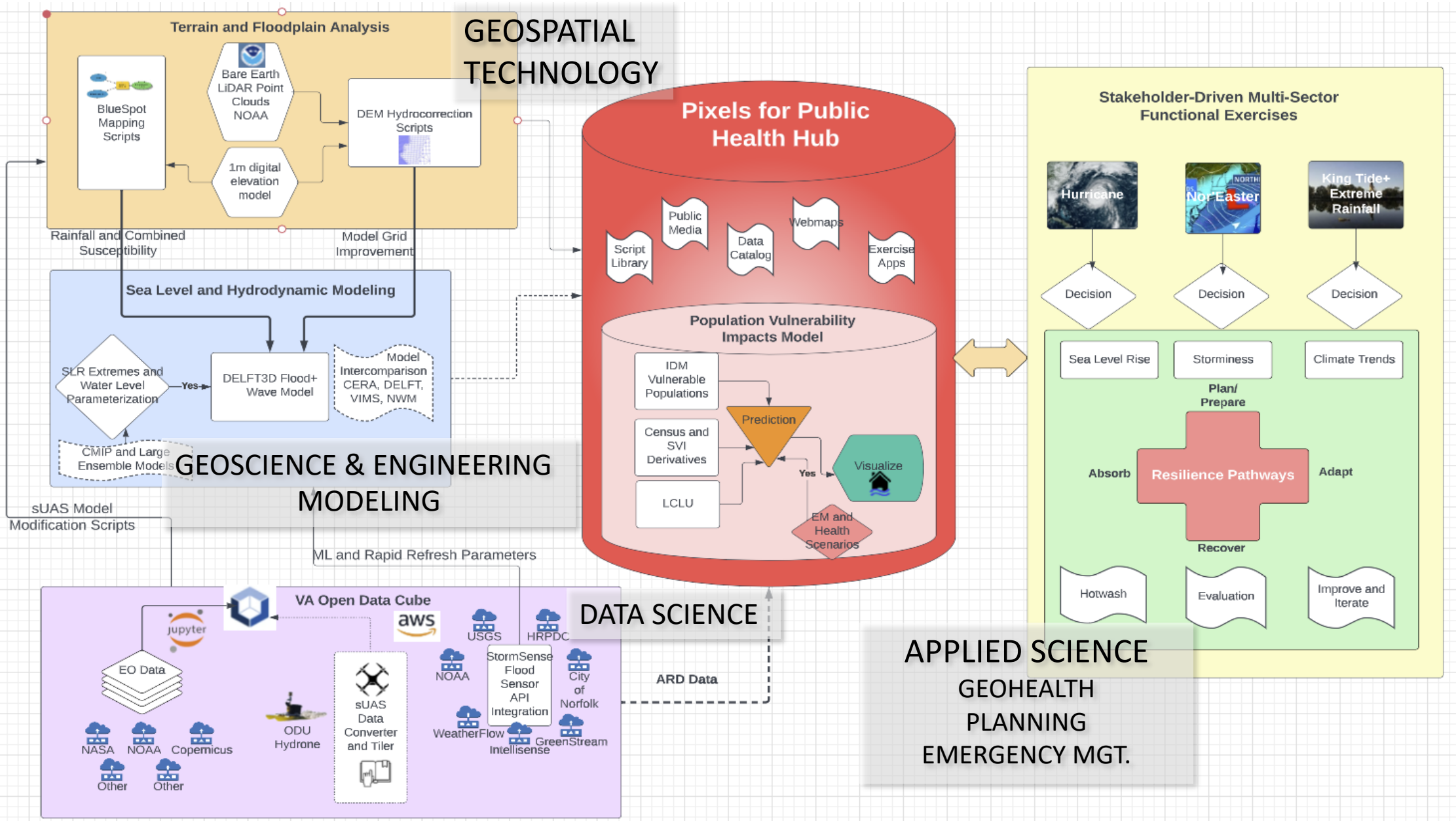
Autonomous Surface Vessels Improve bathymetry for flood models


Webcam at Smithfield, Virginia

Disparate flood sensors need to be combined.
Gaps in coverage need to be filled.



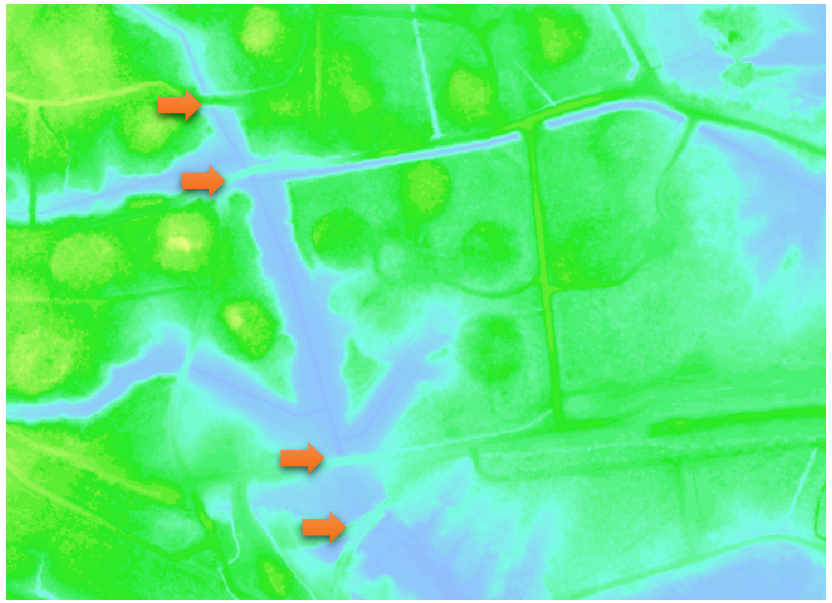
Current Development: Combine Diverse High Velocity Data



With a Digital Twin, we can experiment and assess the uncertainties and impacts of decisions, rather than await an actual event and suffer hard lessons learned.

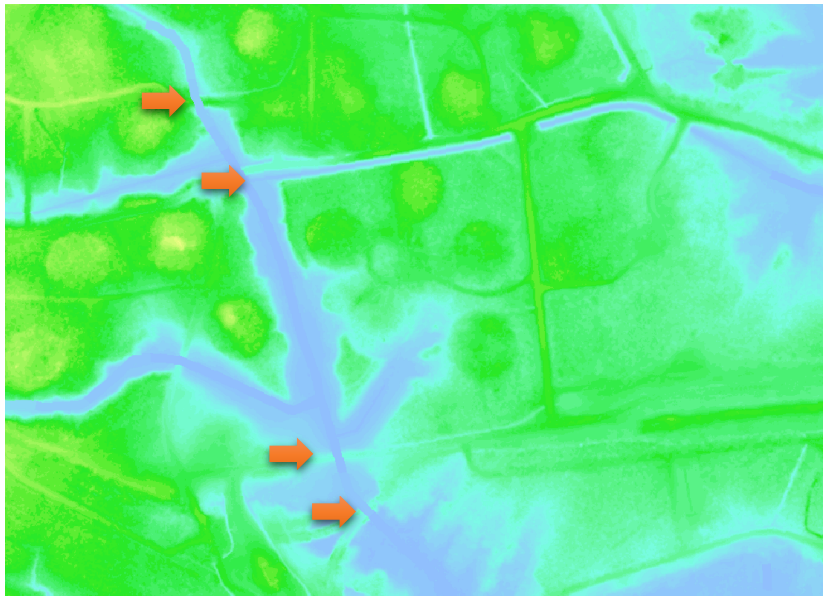
In this example, flooding is simulated with *vs.* without improved representation of topography.

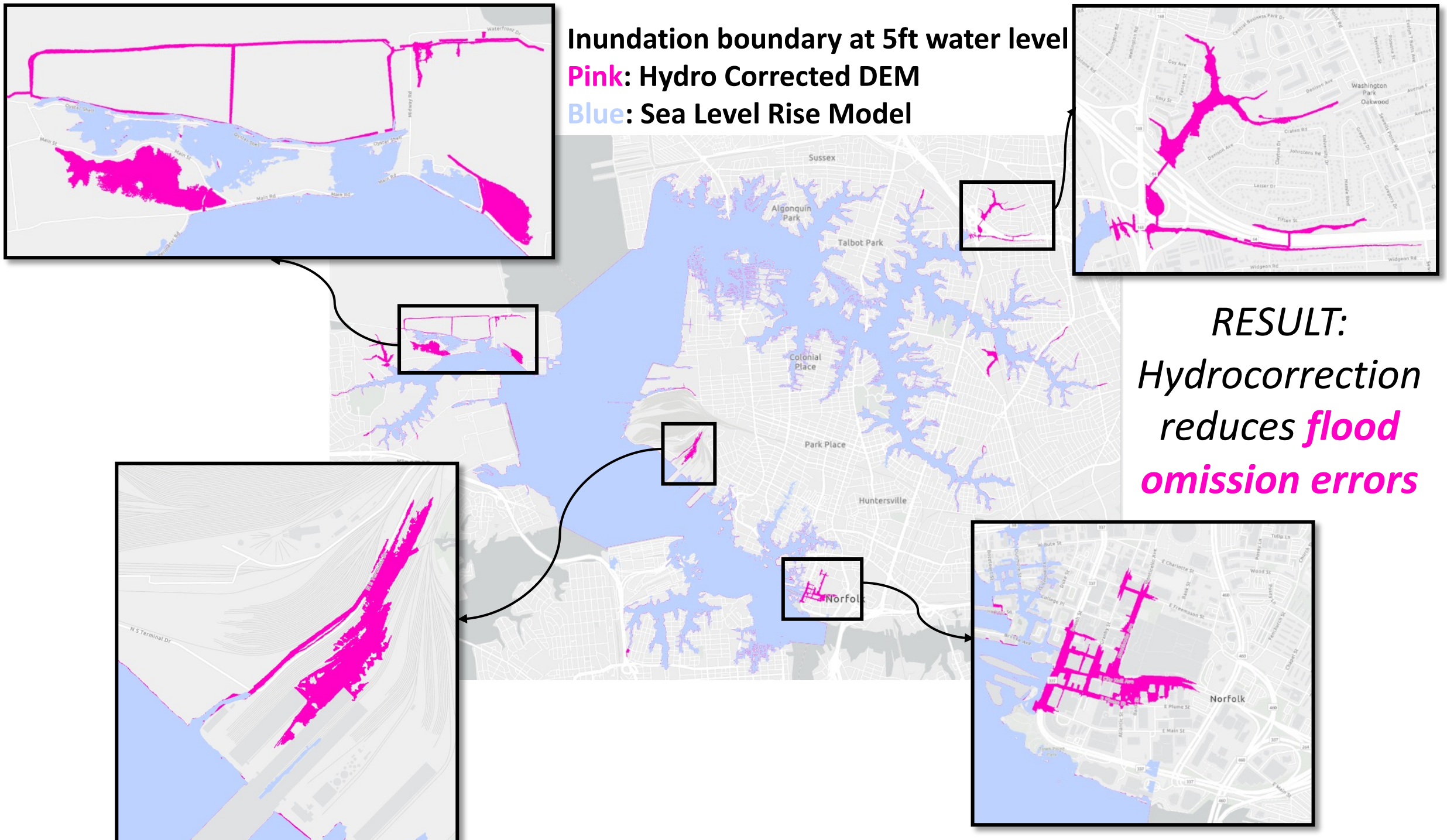
Original



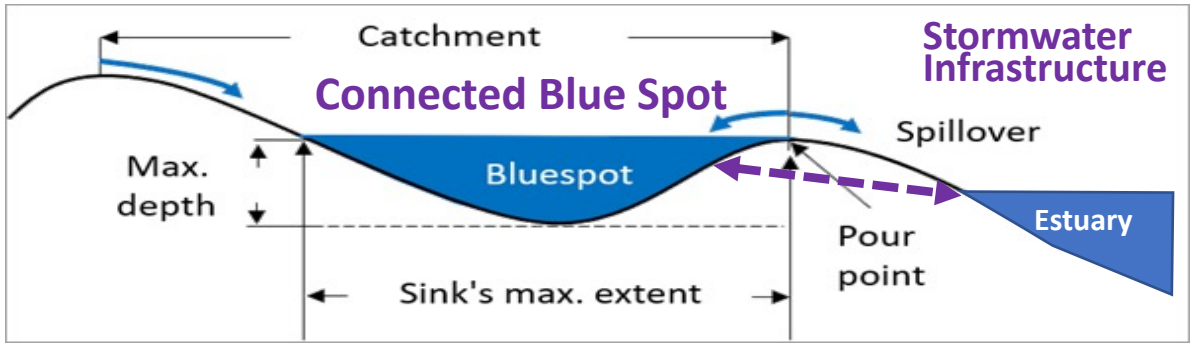
Real World

Corrected

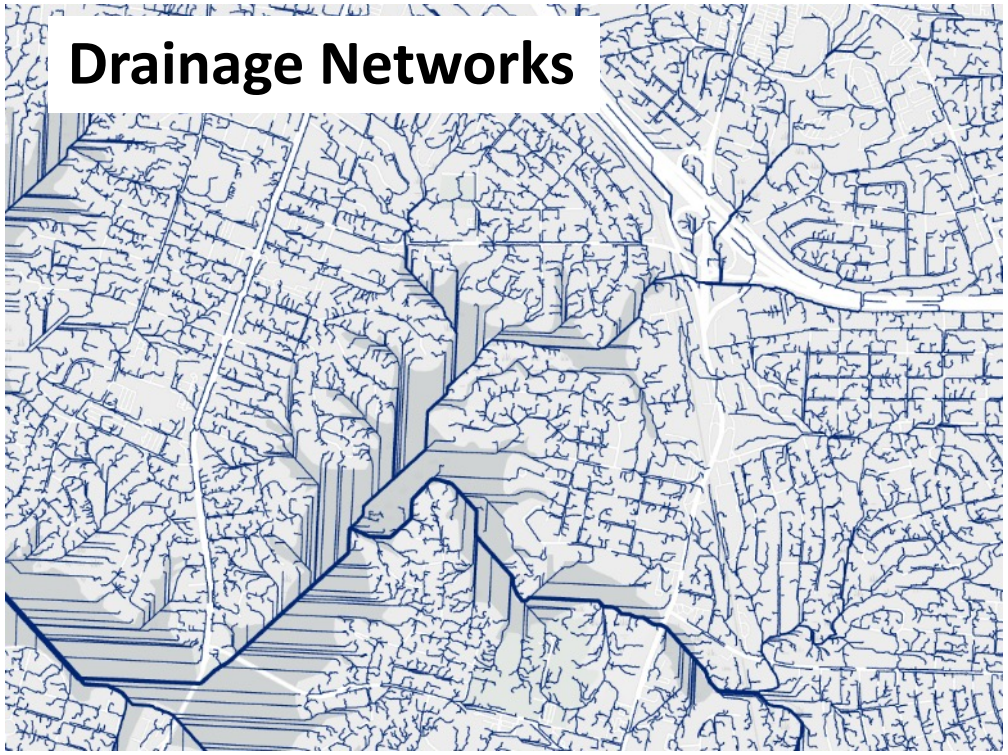


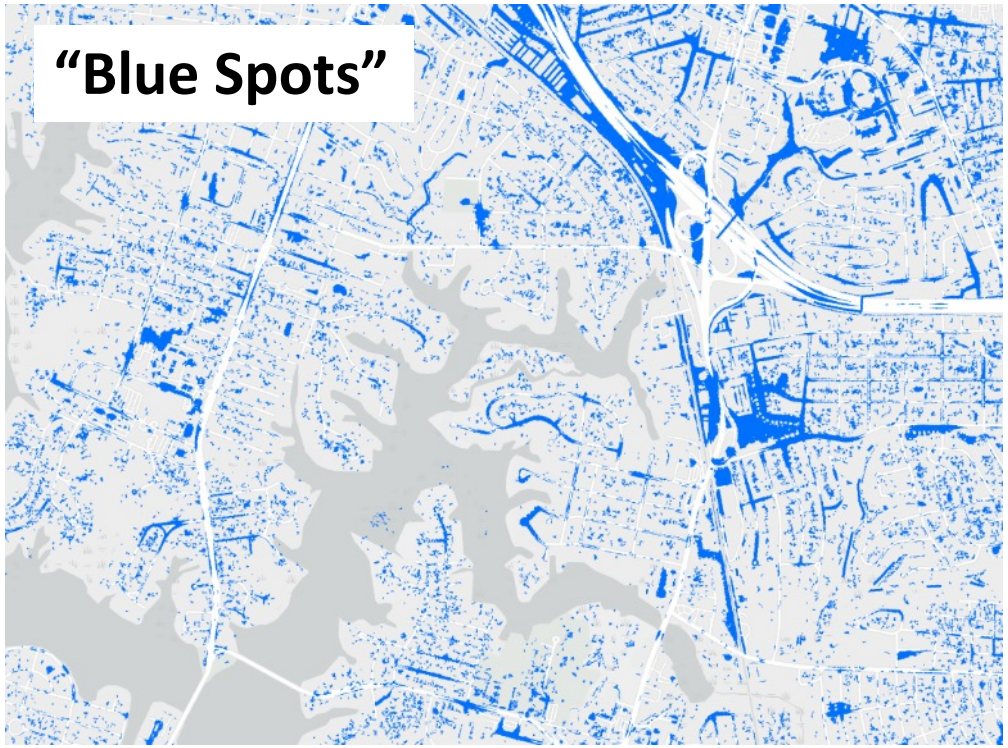

Inundation boundary at 5ft water level
Pink: Hydro Corrected DEM
Blue: Sea Level Rise Model
RESULT:
Hydrocorrection
reduces flood
omission errors
Sussex
Algonquin
Park
Talbot Park
Colonial
Place
Park Place
Huntersville
Norfolk
Washington
Park
Oakwood
Norfolk

*DT lets us simulate multiple hazards, such as depressions that are filled by extreme rainfall and tidal backflow filling in storm drains (“**combined flooding**”)*



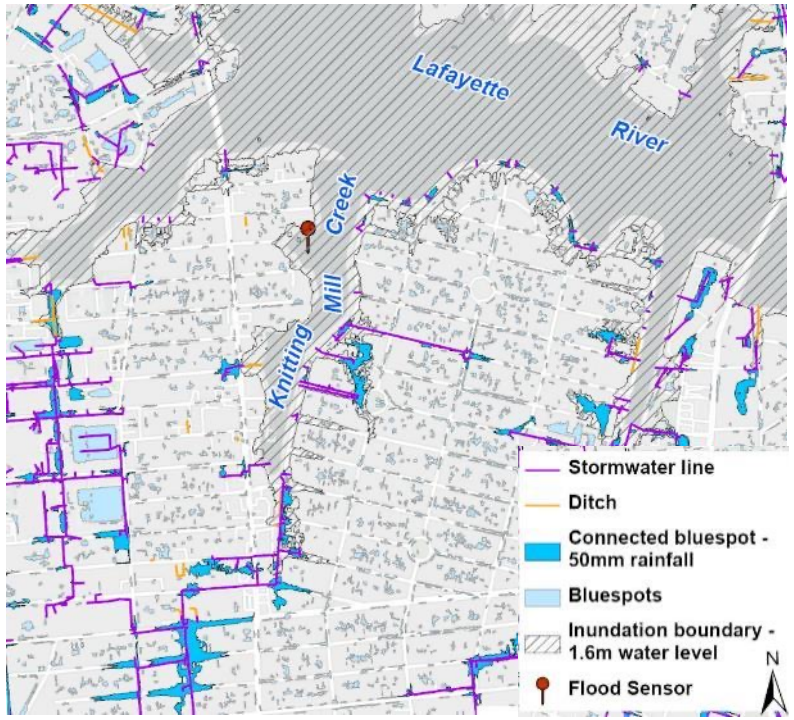
Stormwater infrastructure connections and processes are typically not represented in watershed and sea-level risk assessments (e.g., tidal backflow)

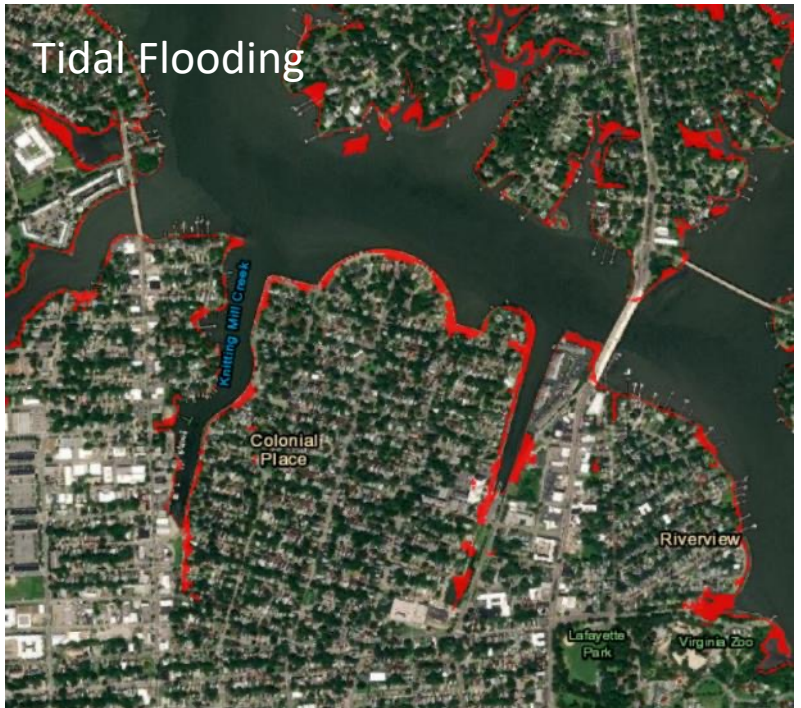


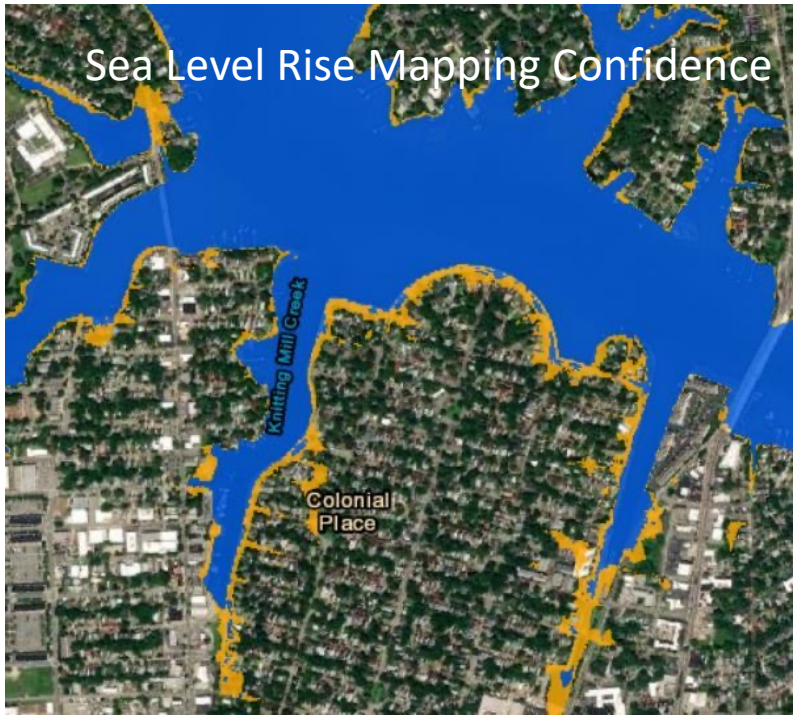


Digital Twin allows rigorous testing of multiple flood models and future sea level

- ***What if*** we had a high tide combined during a 50mm rainfall event?
- ***What if*** this occurs in 40yrs with +0.5m of sea level rise?







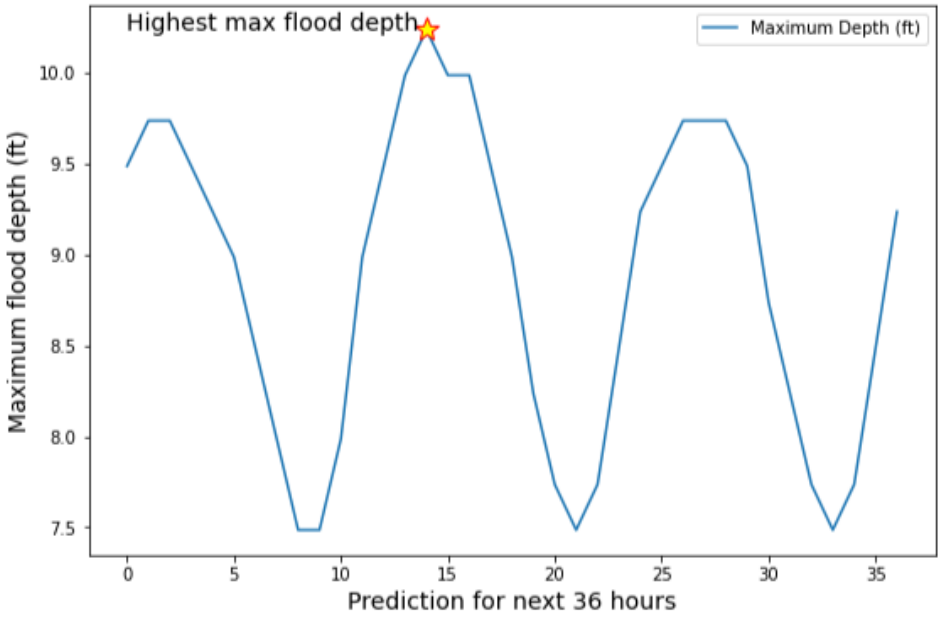
Example:

VIMS TideWatch Inundation Model is read by our DataCube daily to map and analyze flood impacts.

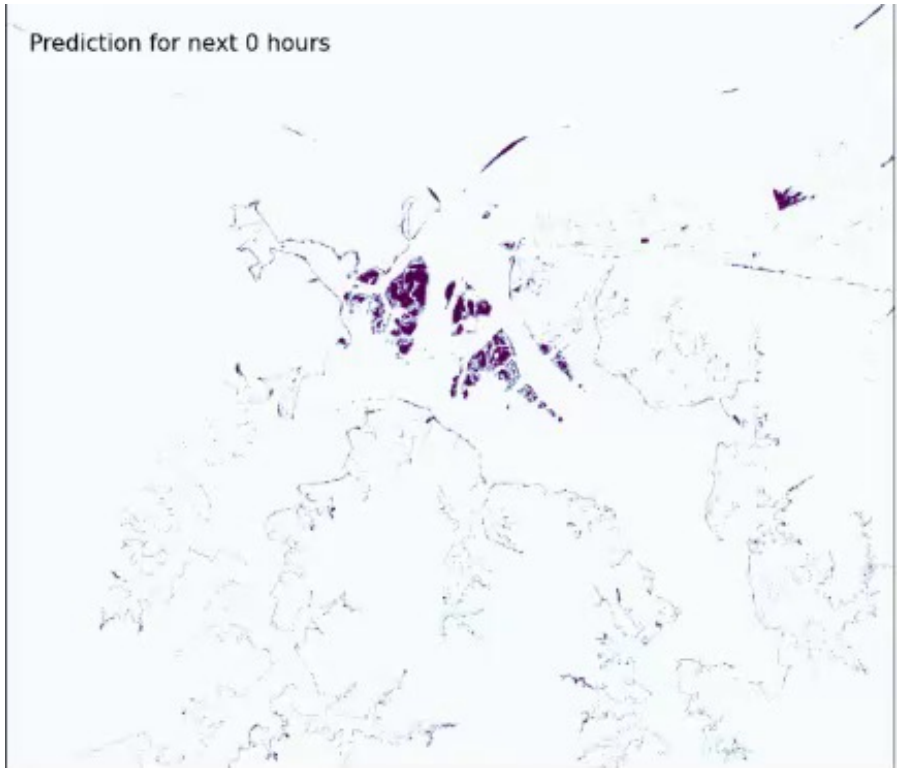
Raw time series hydrology data

	Prediction hour	Minimum Depth (ft)	Mean Depth (ft)	Maximum Depth (ft)
0	0	0.000108	0.816269	9.485605
1	1	0.000065	0.897950	9.735605
2	2	0.000065	0.894644	9.735605

Collated to allow machine learning prediction



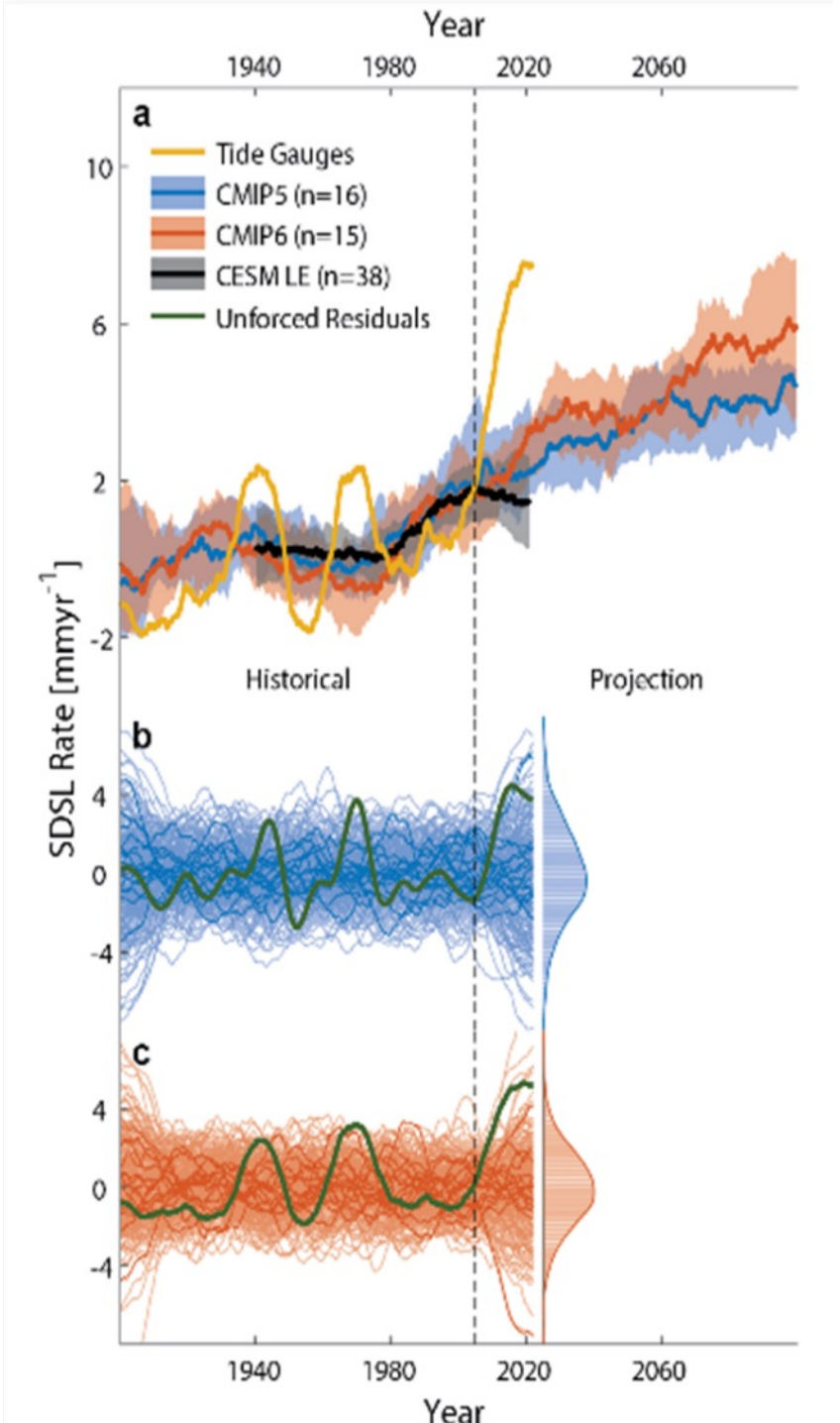
Mapped with GIS and interactive dashboards



Used for spatial impact analysis (homes, roads, infrastructure, vulnerable populations)

Sea-Level Science Advances

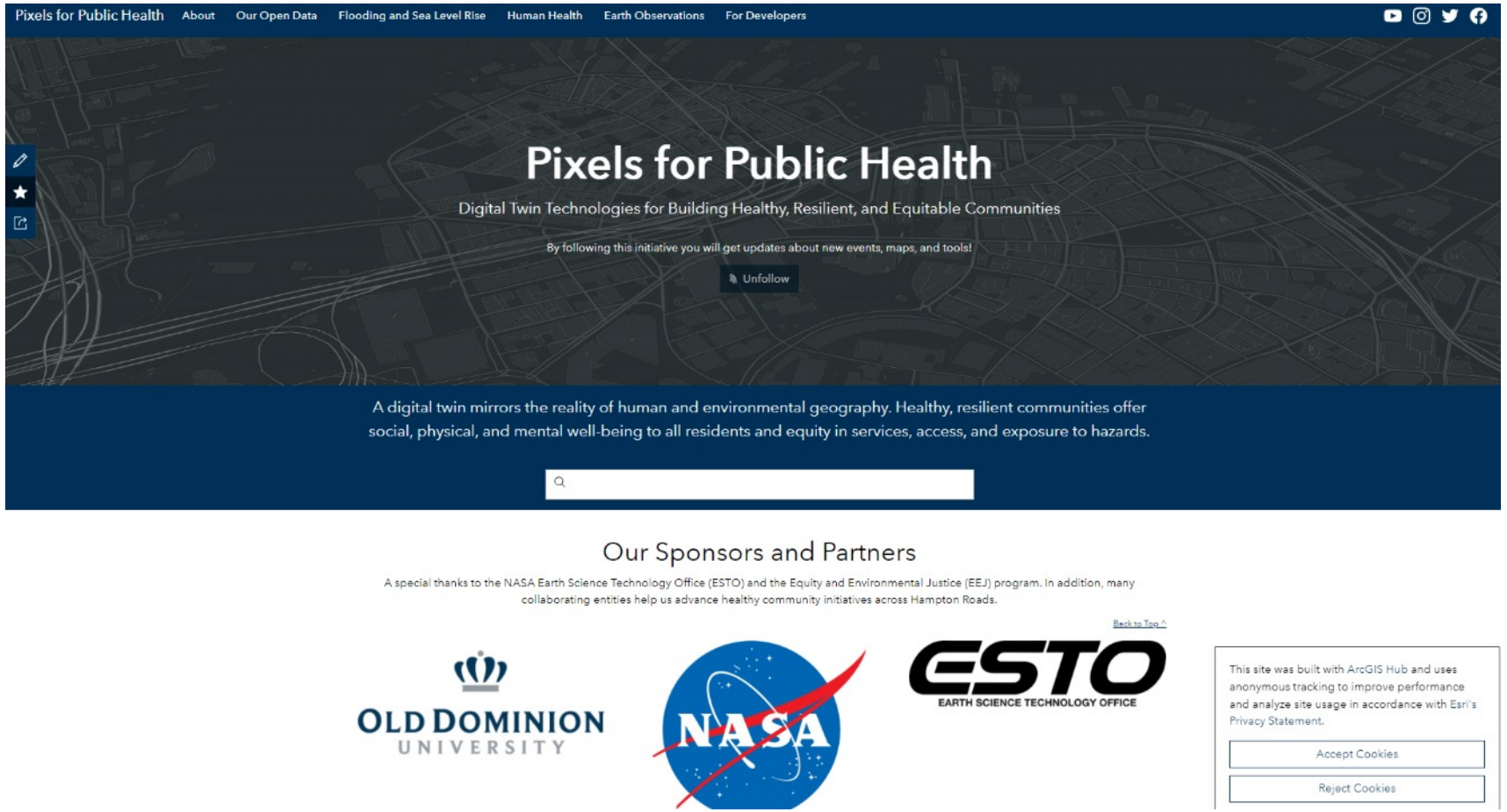
- Accelerating sea-level along the U.S. East Coast has been detected.
- Large uncertainty owing to future emissions and ice-sheet sensitivity must be reduced.
- We identify accelerations differentiating forced sea level versus natural variability in Hampton Roads.
- We approach this using CMIP5, CMIP6, and large ensemble models, attributing observed changes to different earth processes.
- Results improve modeling future scenarios for emergency management exercises and coastal resilience planning.



A Geospatial Hub for Scientific and Community End-Users

tinyurl.com/pixels4health

https://pixels-for-public-health-digital-twin-odu-gis.hub.arcgis.com/



Thank You and Welcome Questions

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