Hurricane Surge and Inland Flooding Impacts on Hazard Quantification and Mitigation along the Houston Ship Channel and Buffalo Bayou, Texas

James M. Kaihatu[1], Morgan Calvey[1], Alex Adame[2], Lauren Padilla[2], Galen Newman[1], and Cloelle Danforth[2]

NATIONAL ACADEMIES Sciences Engineering Medicine

[1]Texas A&M University

[2] Environmental Defense Fund

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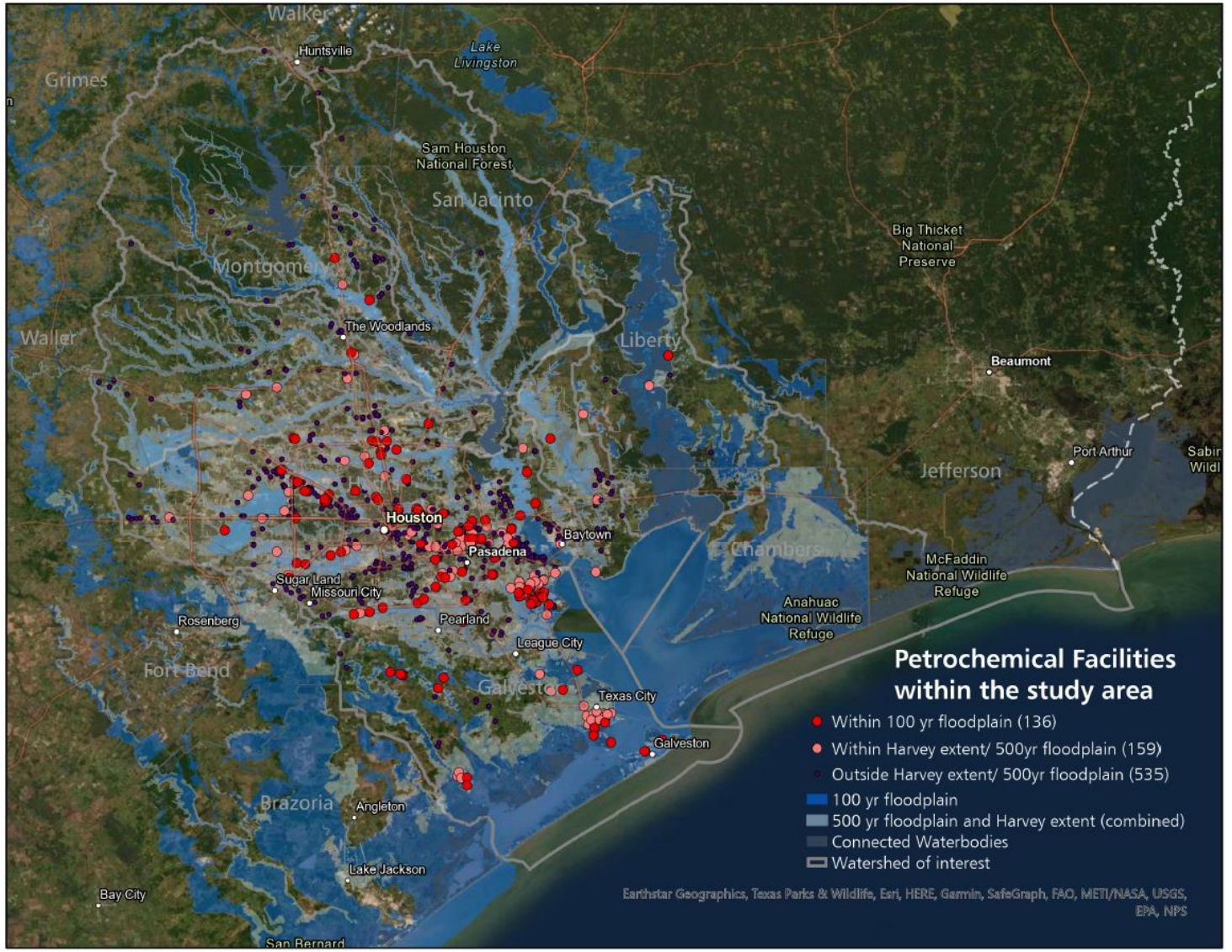
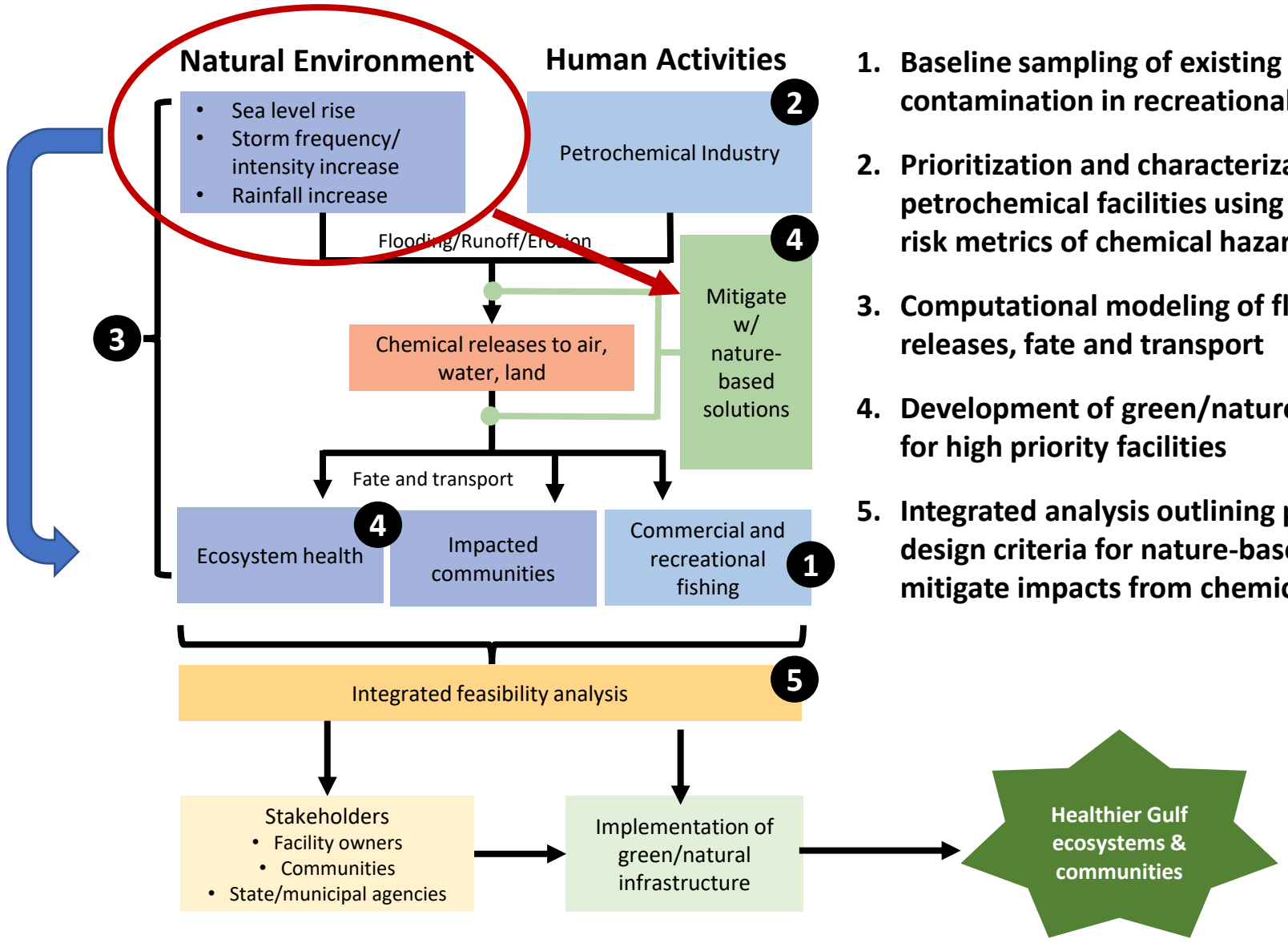
Overarching project goals/motivation

- Improve understanding of toxic releases due to flooding and sea-level rise in the Galveston Bay area
- Explore nature-based solutions that can mitigate risks and promote resilience of coastal communities and ecosystems.



Project aims and overview

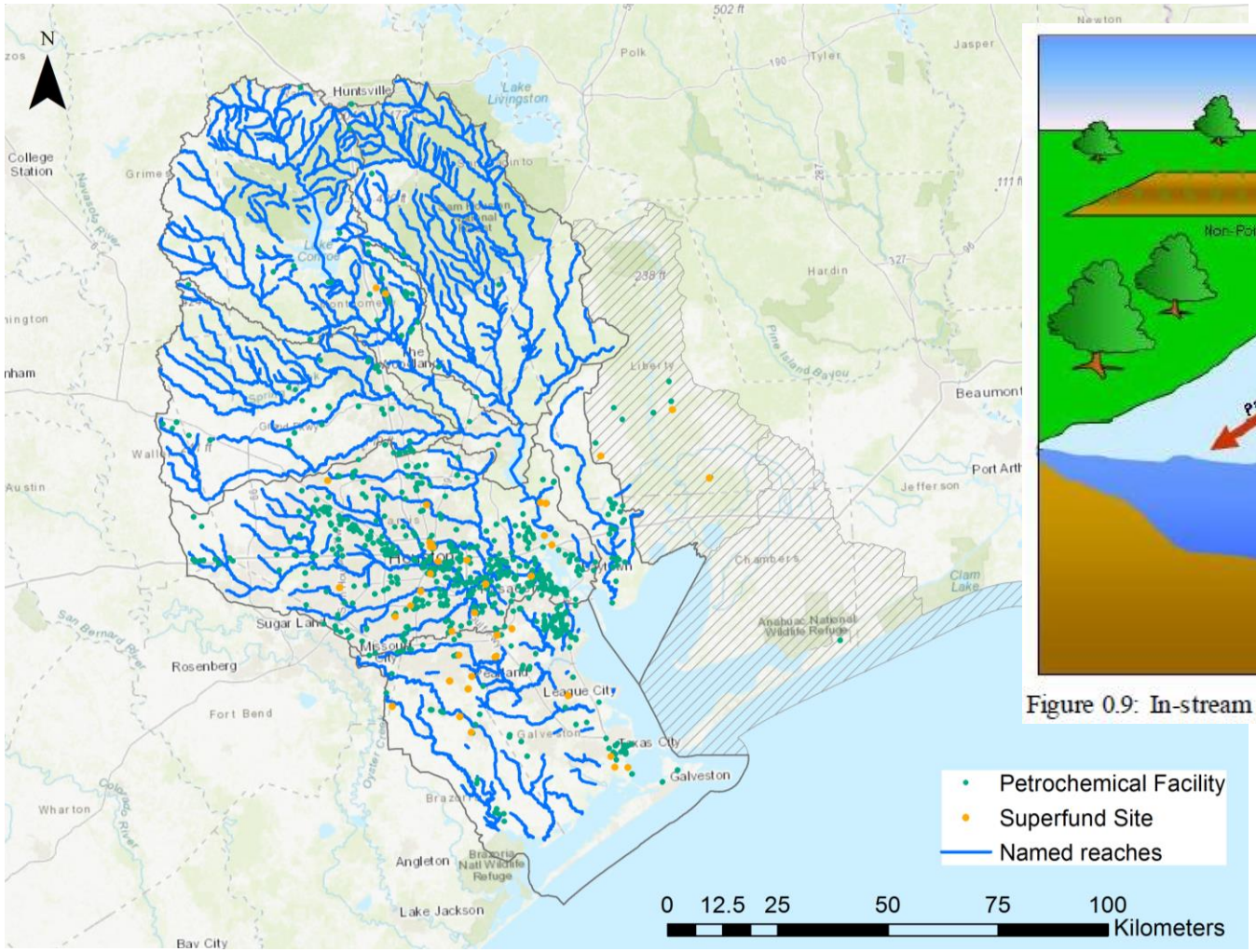


1. **Baseline sampling of existing chemical contamination in recreationally caught fish**
2. **Prioritization and characterization of petrochemical facilities using baseline data and risk metrics of chemical hazards**
3. **Computational modeling of flooding, chemical releases, fate and transport**
4. **Development of green/nature-based solutions for high priority facilities**
5. **Integrated analysis outlining planning and design criteria for nature-based solutions to mitigate impacts from chemical releases**

ToxPi:

- Visualization tool
- Numerical score vulnerability ranking
- Consideration of EJ / SE factors in overall assessment

Soil and Water Assessment Tool (SWAT)



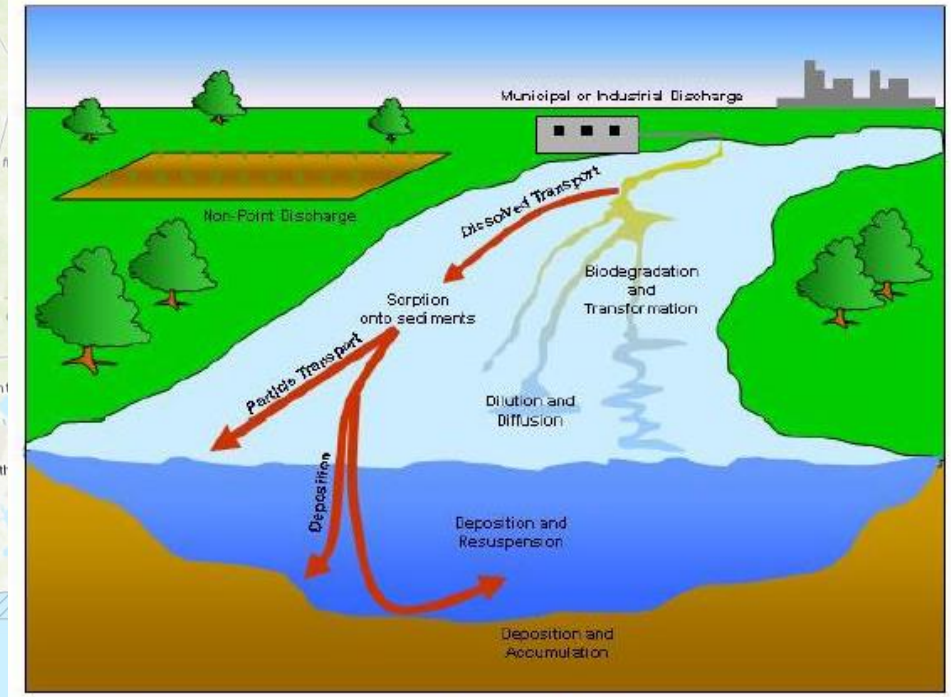


Figure 0.9: In-stream processes modeled by SWAT

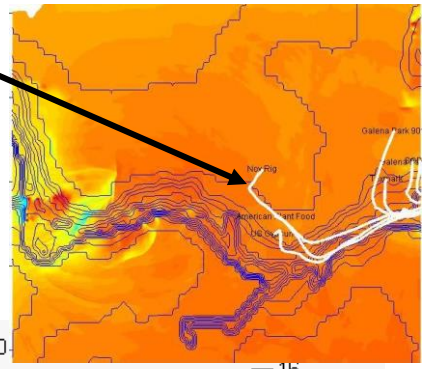
Obtain daily average flow rates at sub-basin outputs

- Cumulative for reach
- Yield at each sub-basin

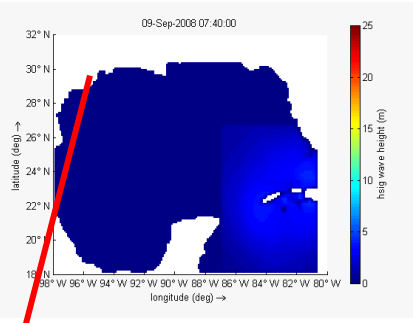
S.L. Neitsch et al., Soil and Water Assessment Tool Theoretical documentation version 2009 (2011). https://swat.tamu.edu/media/99192/swat2009-theory.pdf

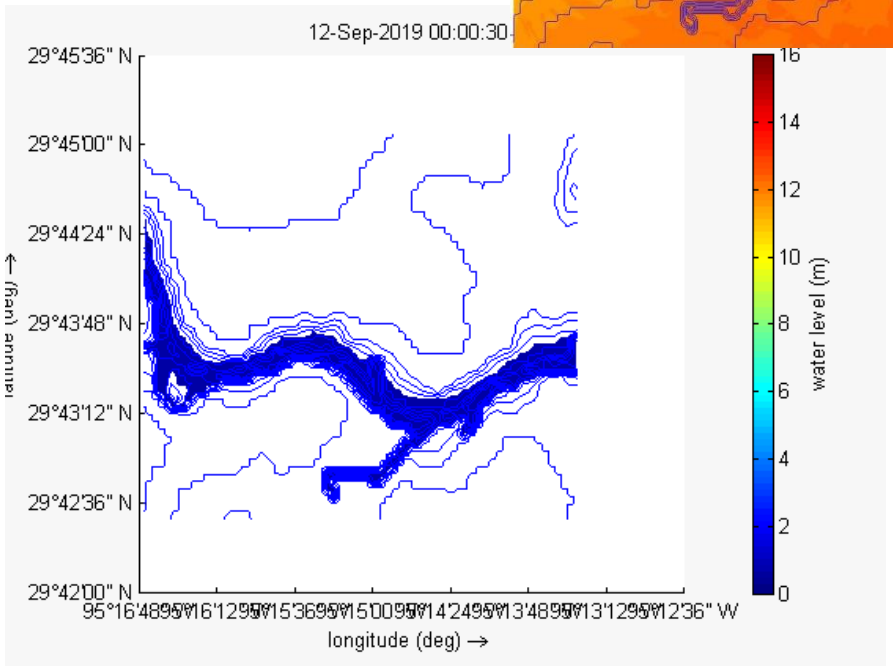
Delft3D - FLOW

Water transport paths during flooding from various industries in Galena Park

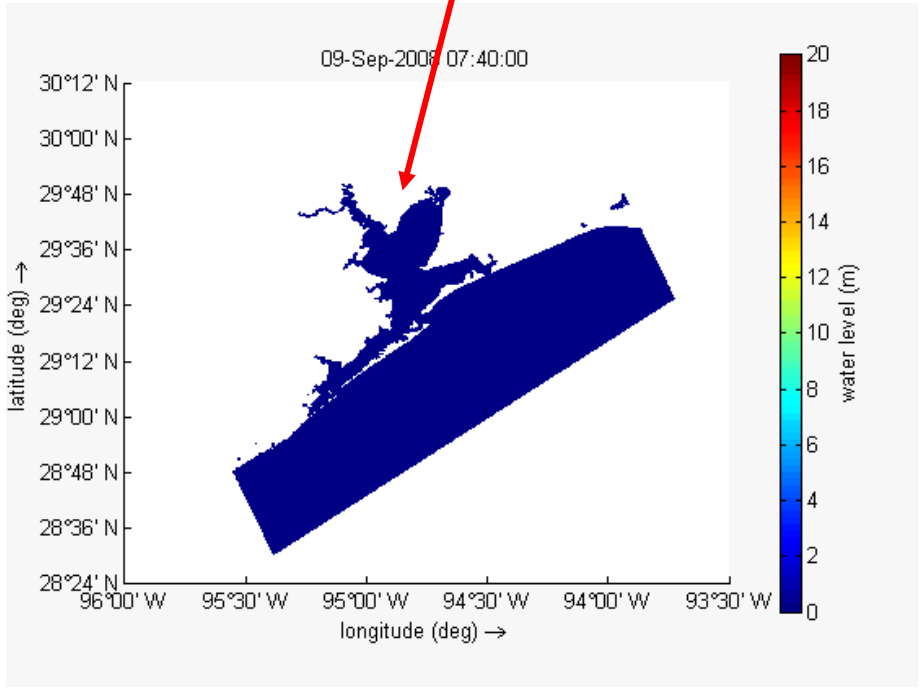


Wave heights from "Super" Ike

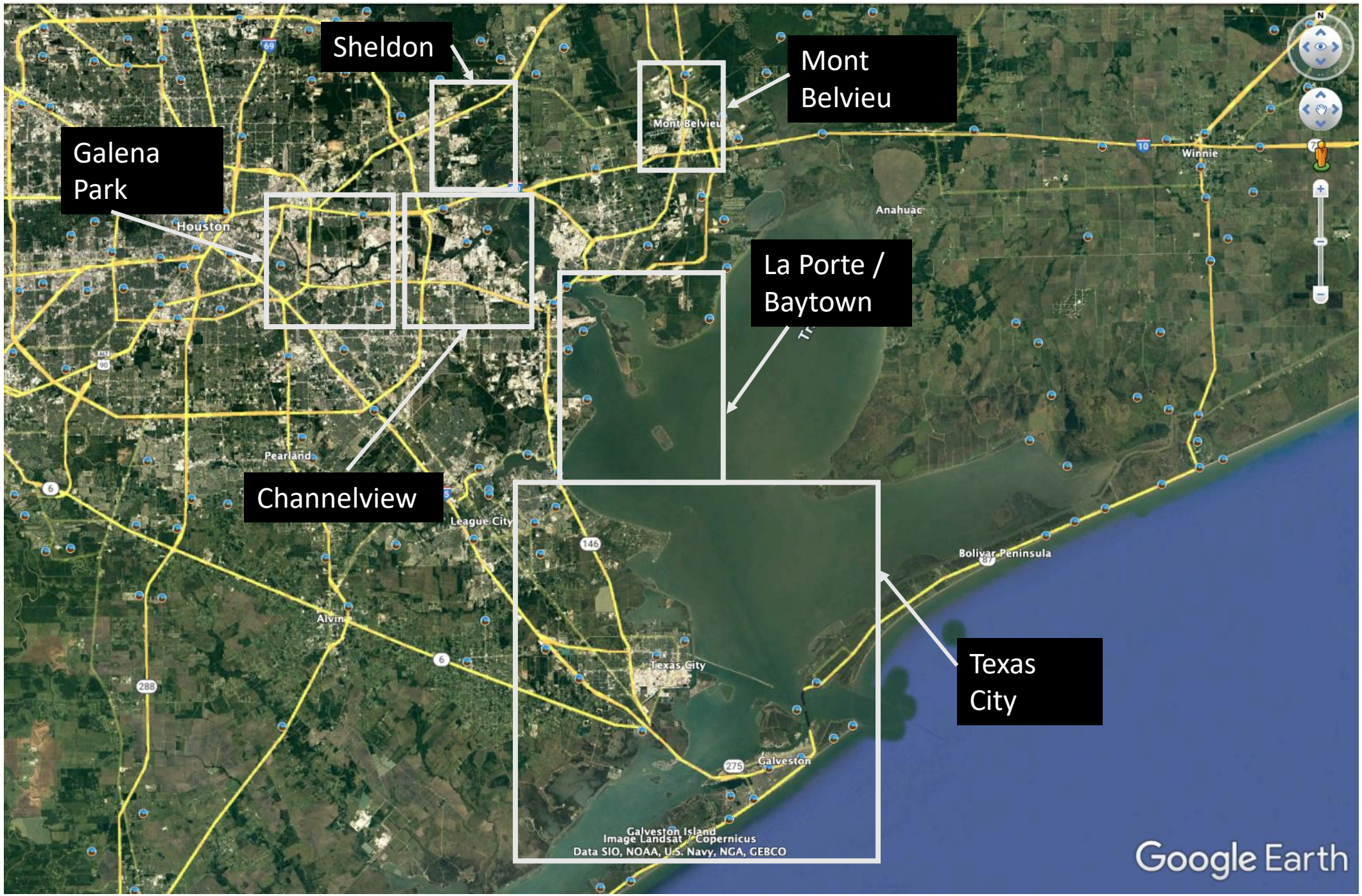




Flooding Simulation for Galena Park, TX
(Water level relative to sea level)

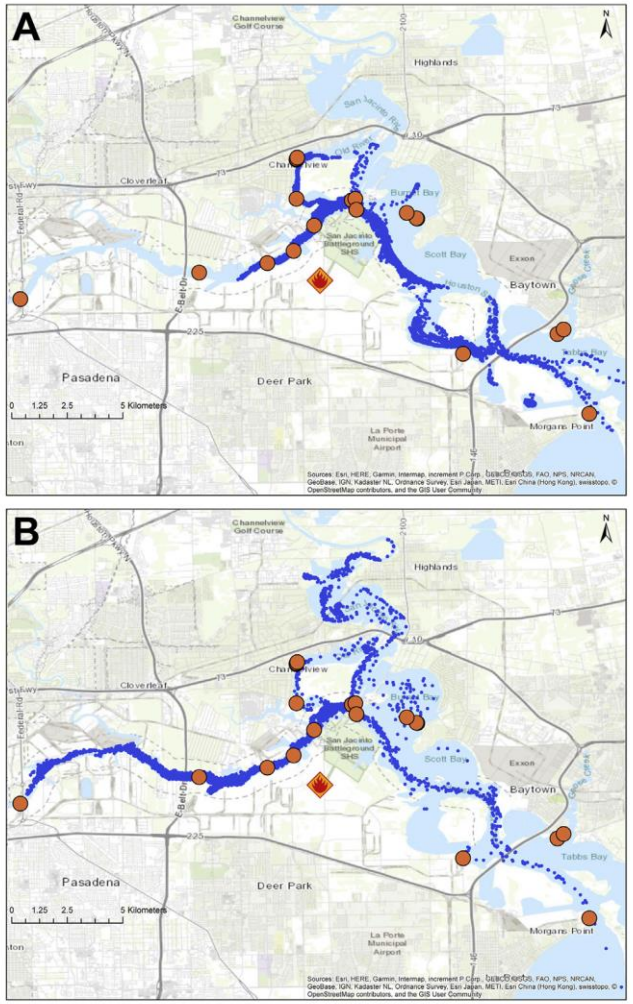


Surge in Galveston Bay from "Super" Ike
(Ike wind speeds doubled)
(Water level relative to sea level)

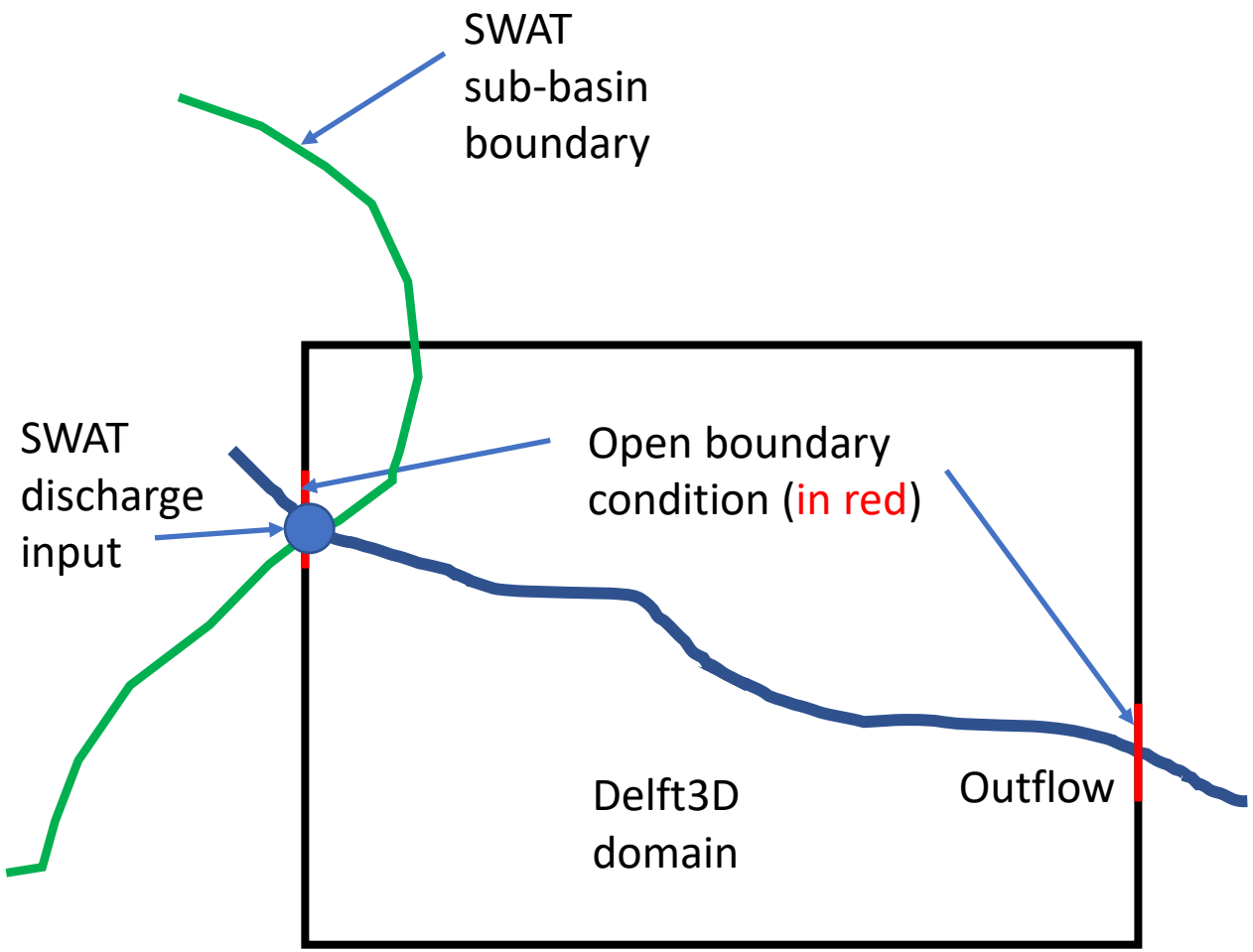

Sheldon
Mont Belvieu
Galena Park
La Porte / Baytown
Channelview
Texas City
Houston
Pearland
League City
Alvin
Anahuac
Winnie
Bolivar Peninsula
Texas City
Galveston
Galveston Island
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth

Why Delft3D-FLOW and not Delft3D-FM?

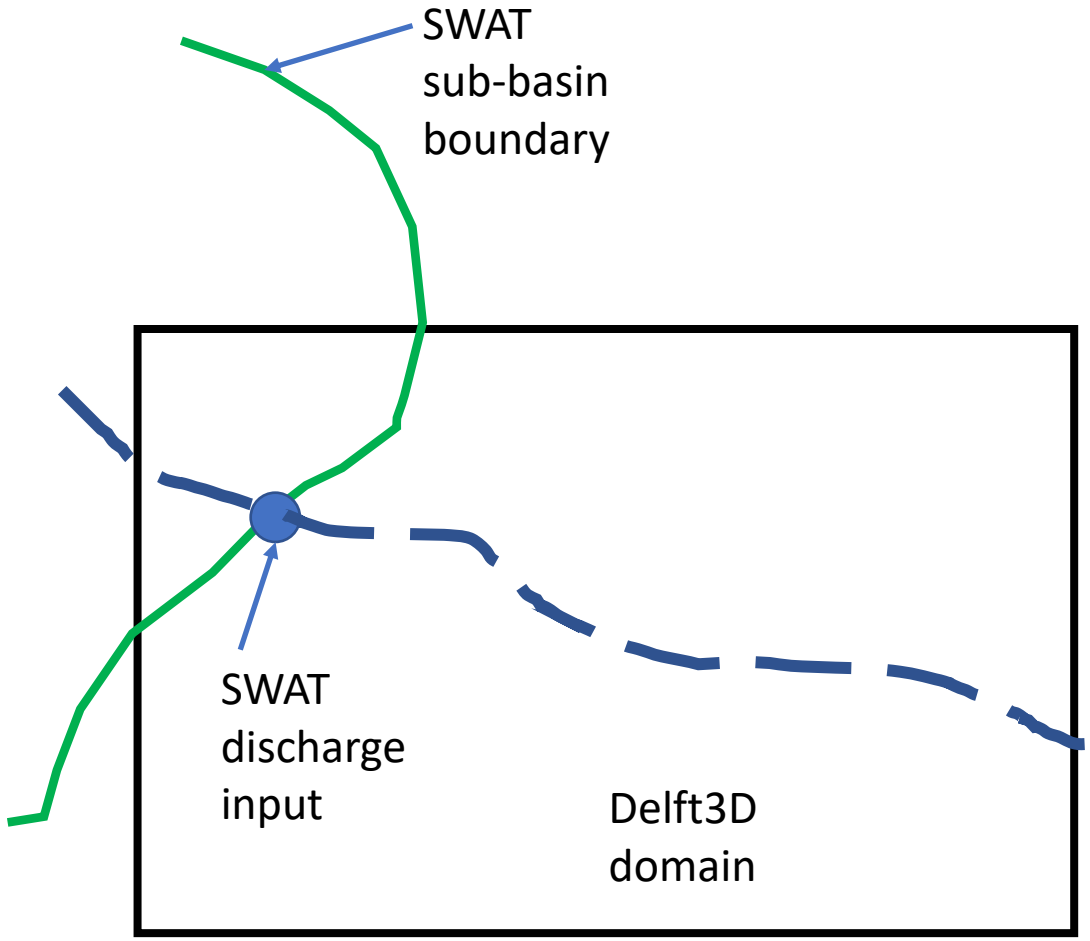
- Much previous experience with Delft3D-FLOW (since 2002)
- Delft3D-FLOW contains a numerical tracing algorithm (“drogues”)
- Use as a proxy for possible pollutant transport pathways



From Aly et al. (2020)

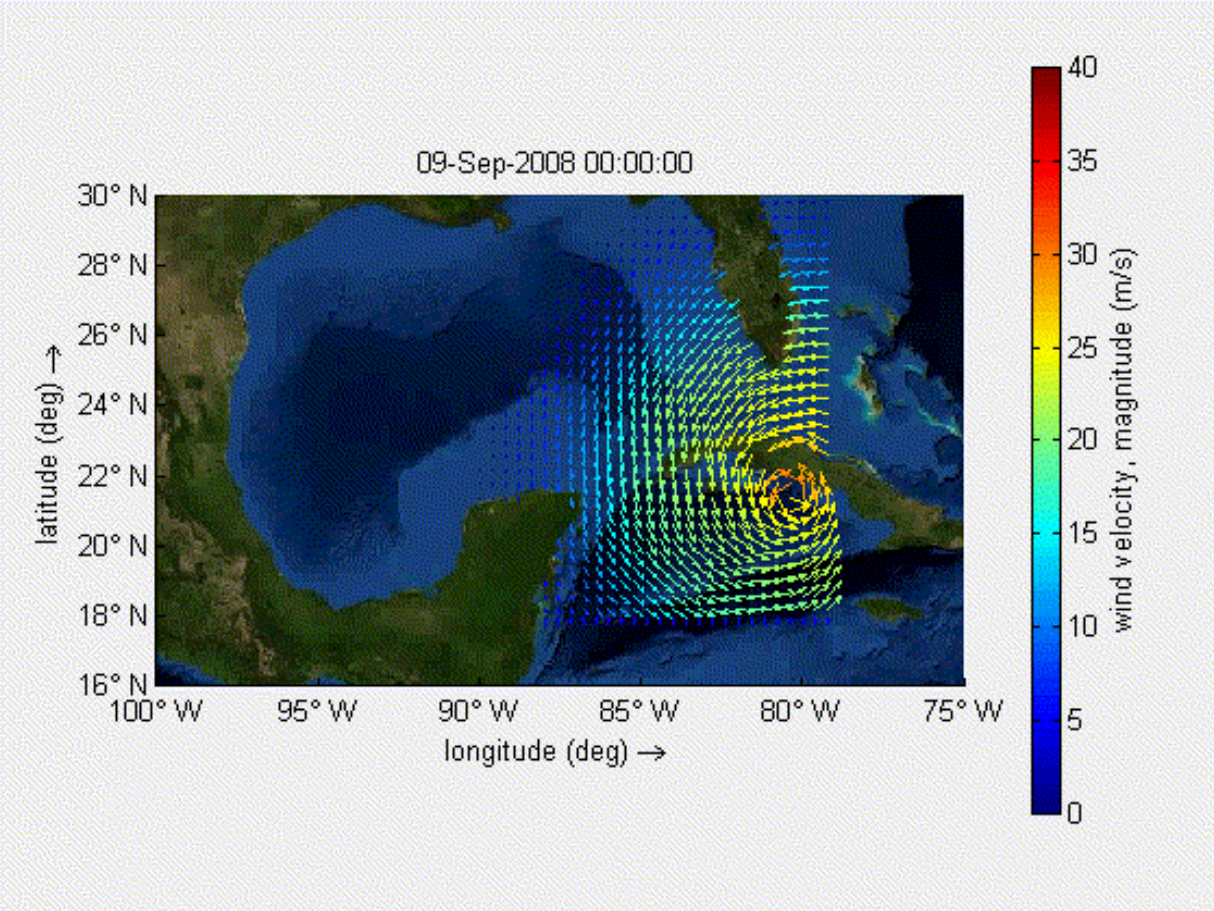


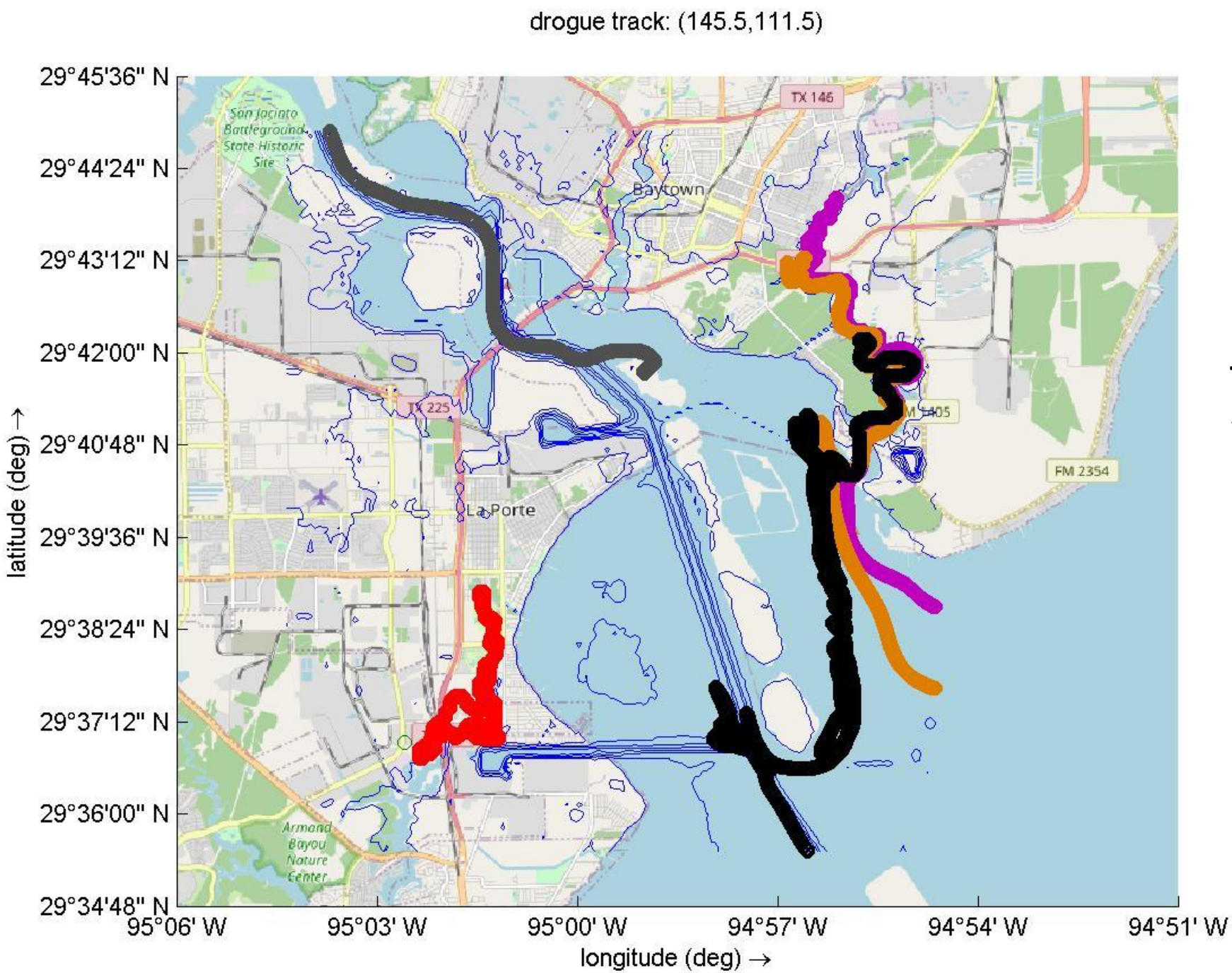
Ideal Setup



Workaround

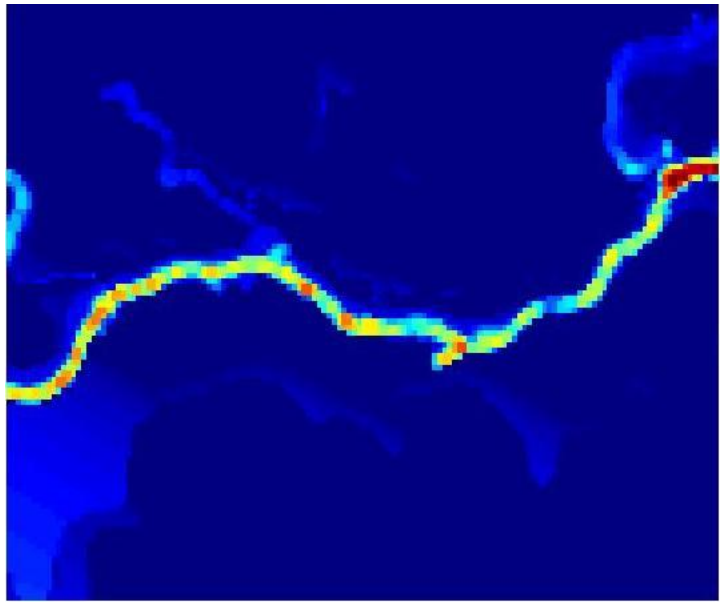
Hurricane Ike





Numerical Drogue Motion for Hurricane Ike – with and without SWAT discharge

Processing for Evaluation of Surge / Flooding Impact – Hurricane Ike



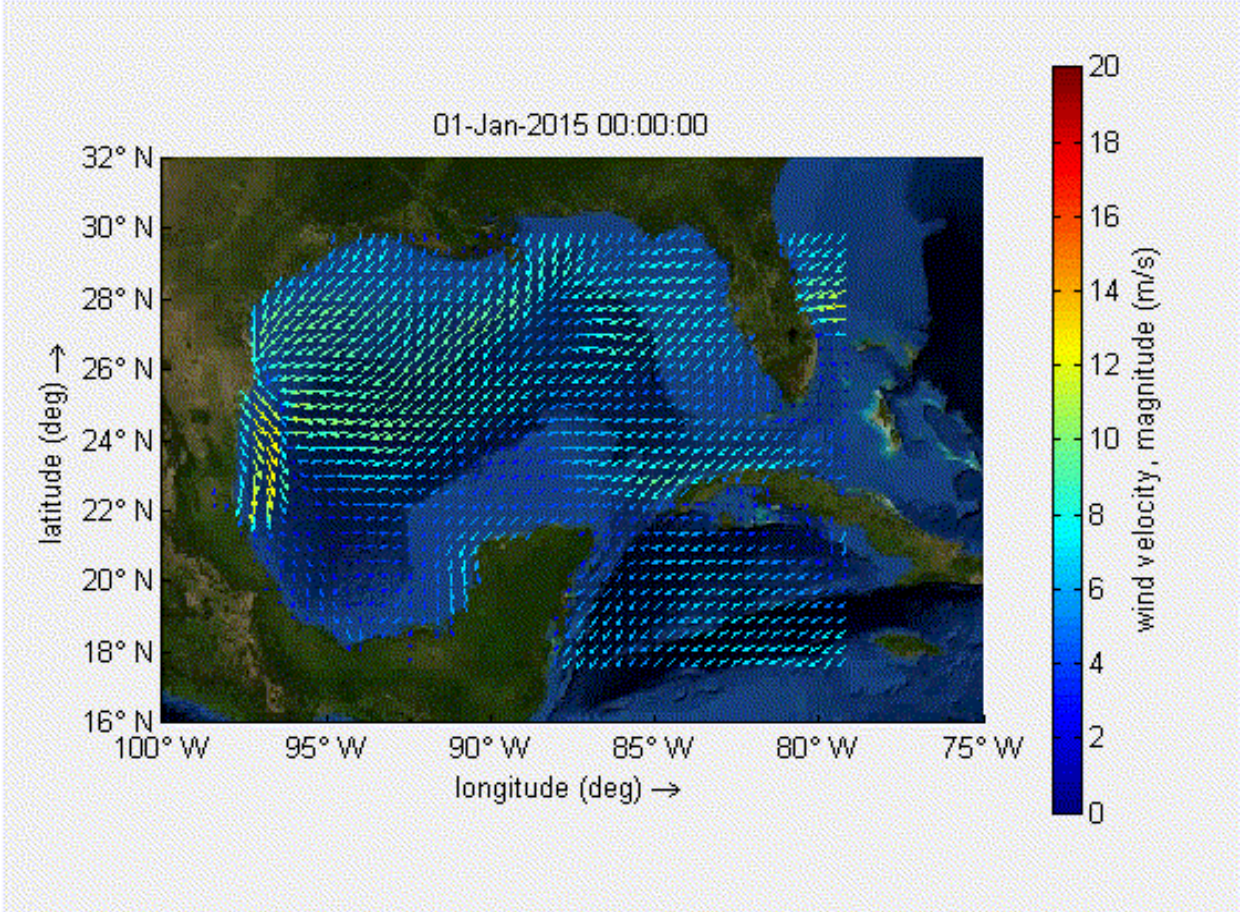
Delft3D Output of Maximum Water Level from Ike in Channelview

Filtering and QGIS

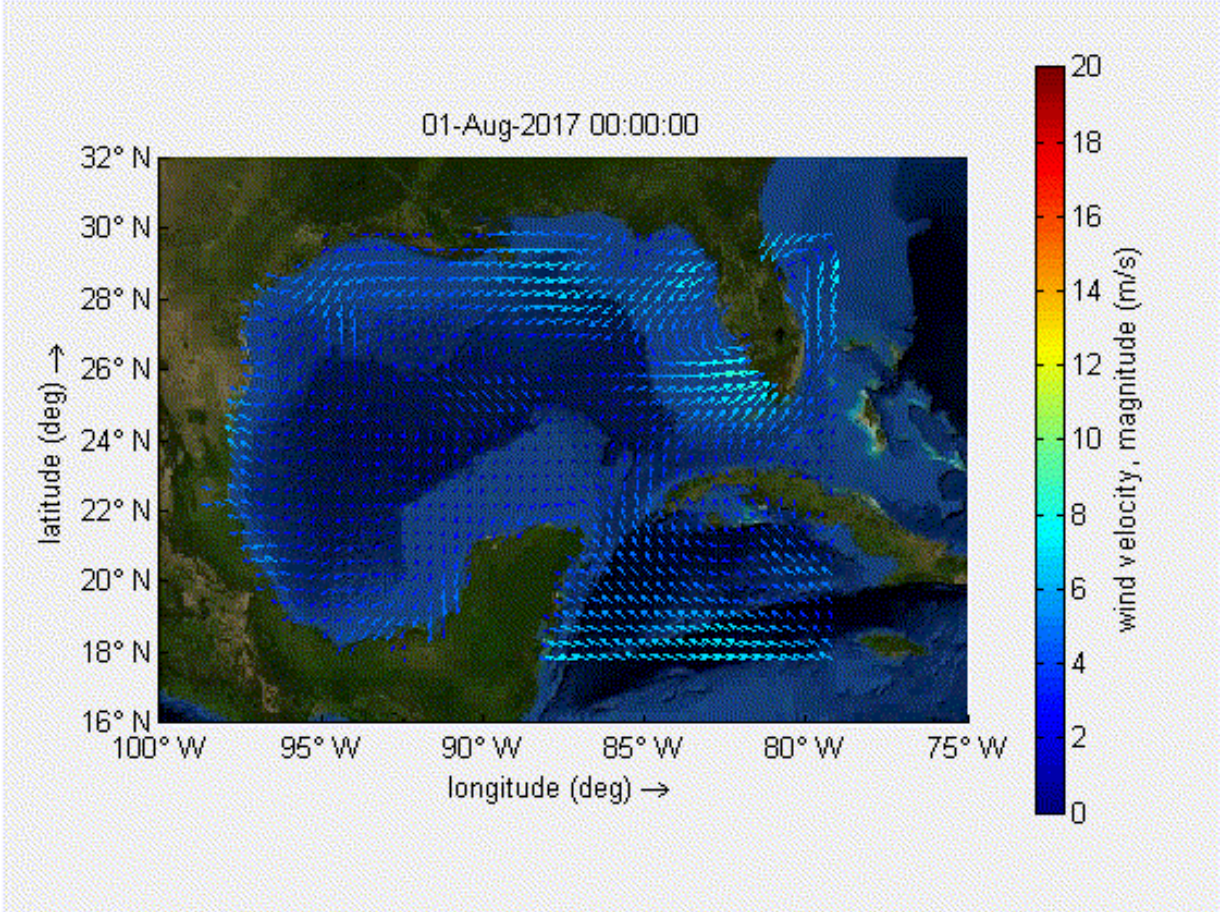
GeoTIFF image with necessary metadata

ToxPi Analysis

Longer Time Series – 2015 and 2017

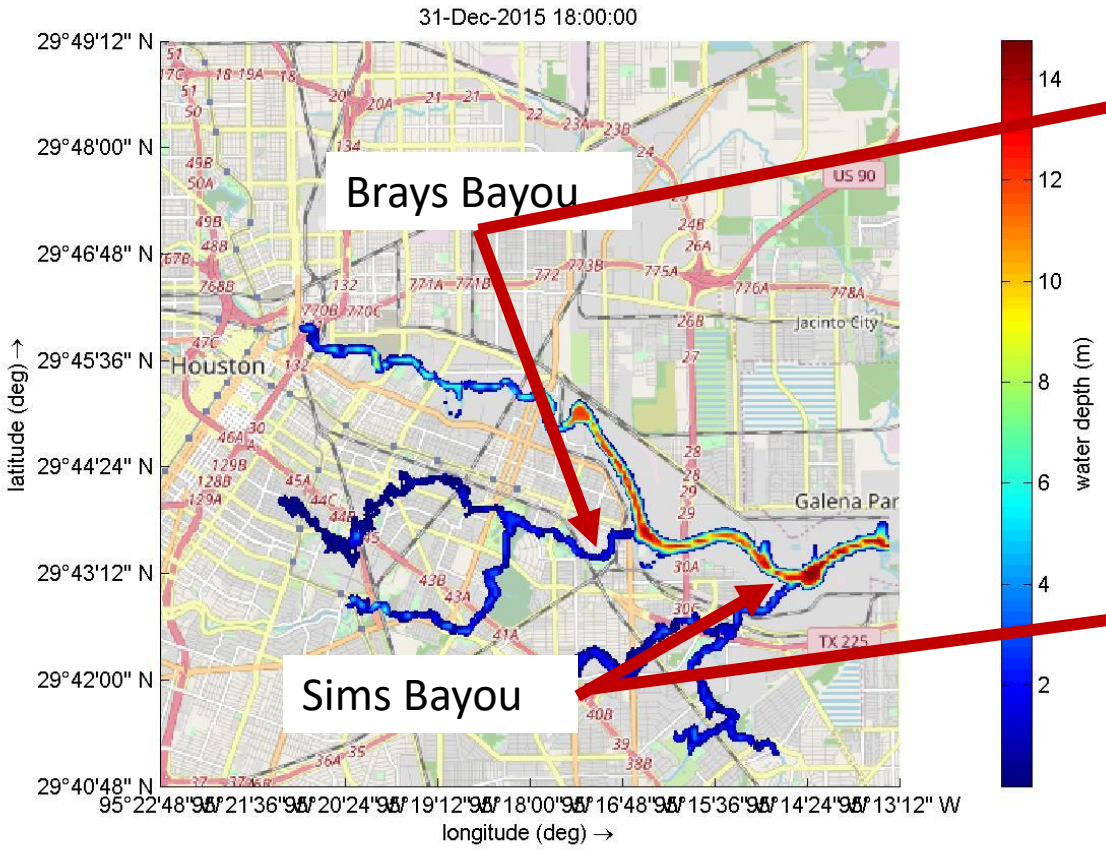


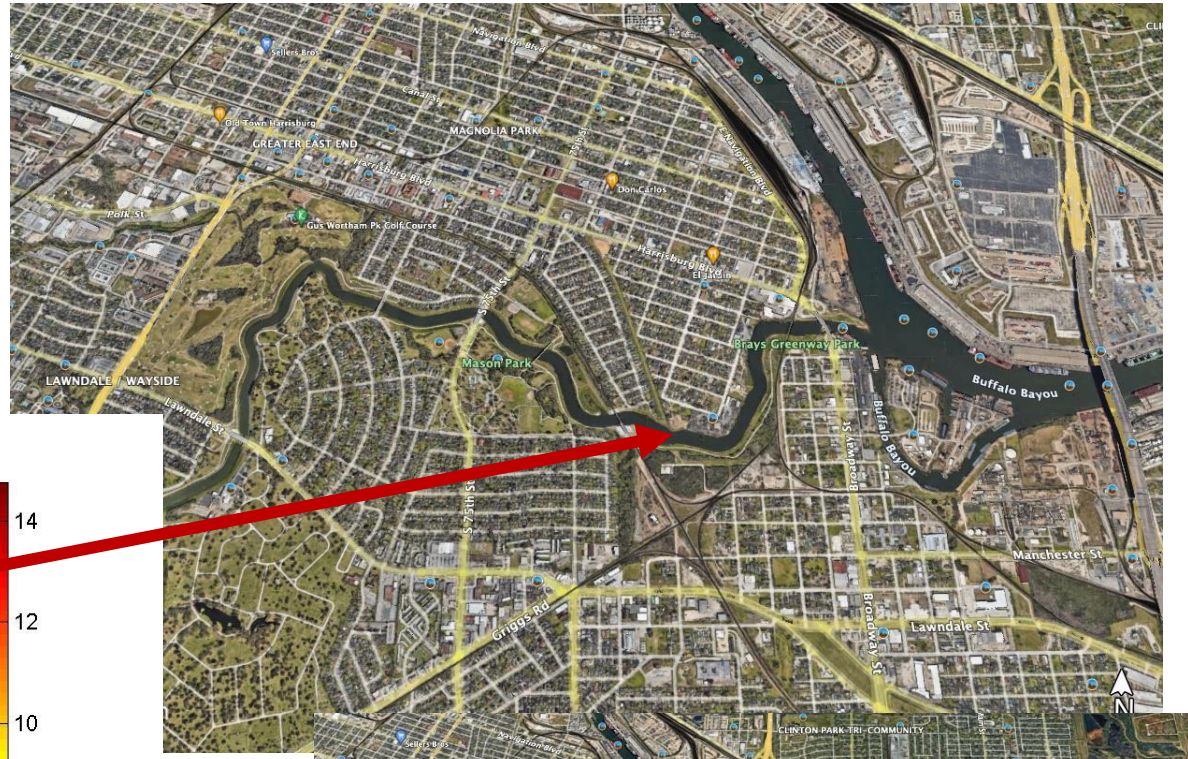
NCEP Wind Fields: Jan-Apr 2015

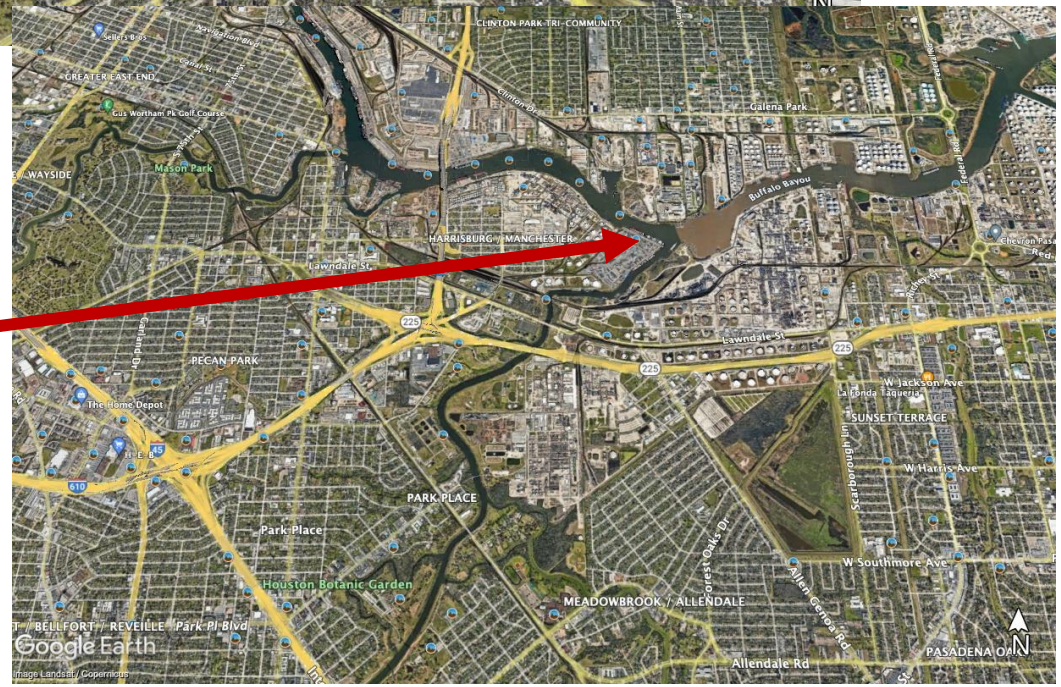


NCEP Wind Fields: Aug-Nov 2017

Validate flow paths with Google Earth

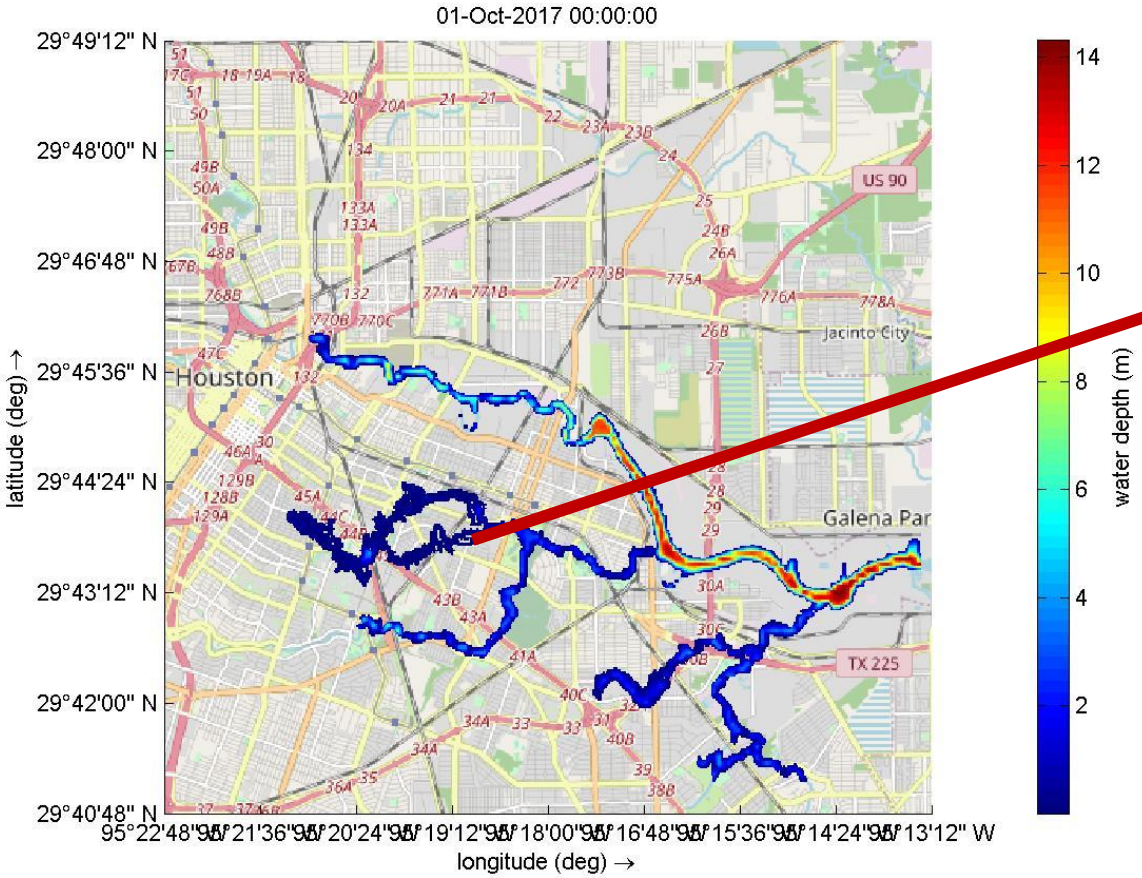


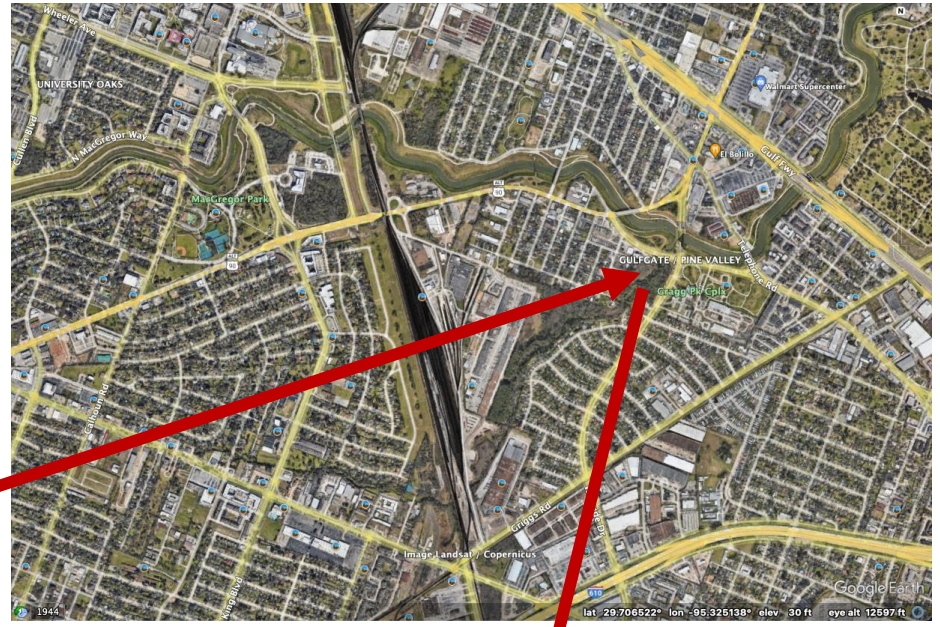


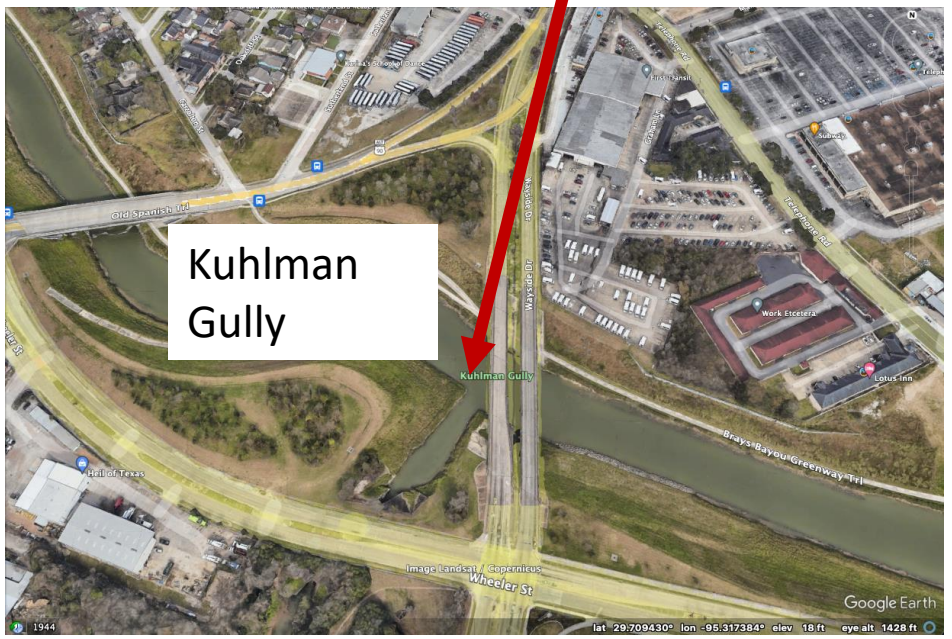


Delft3D result for 31 Dec 2015 1800

Validate flow paths with Google Earth

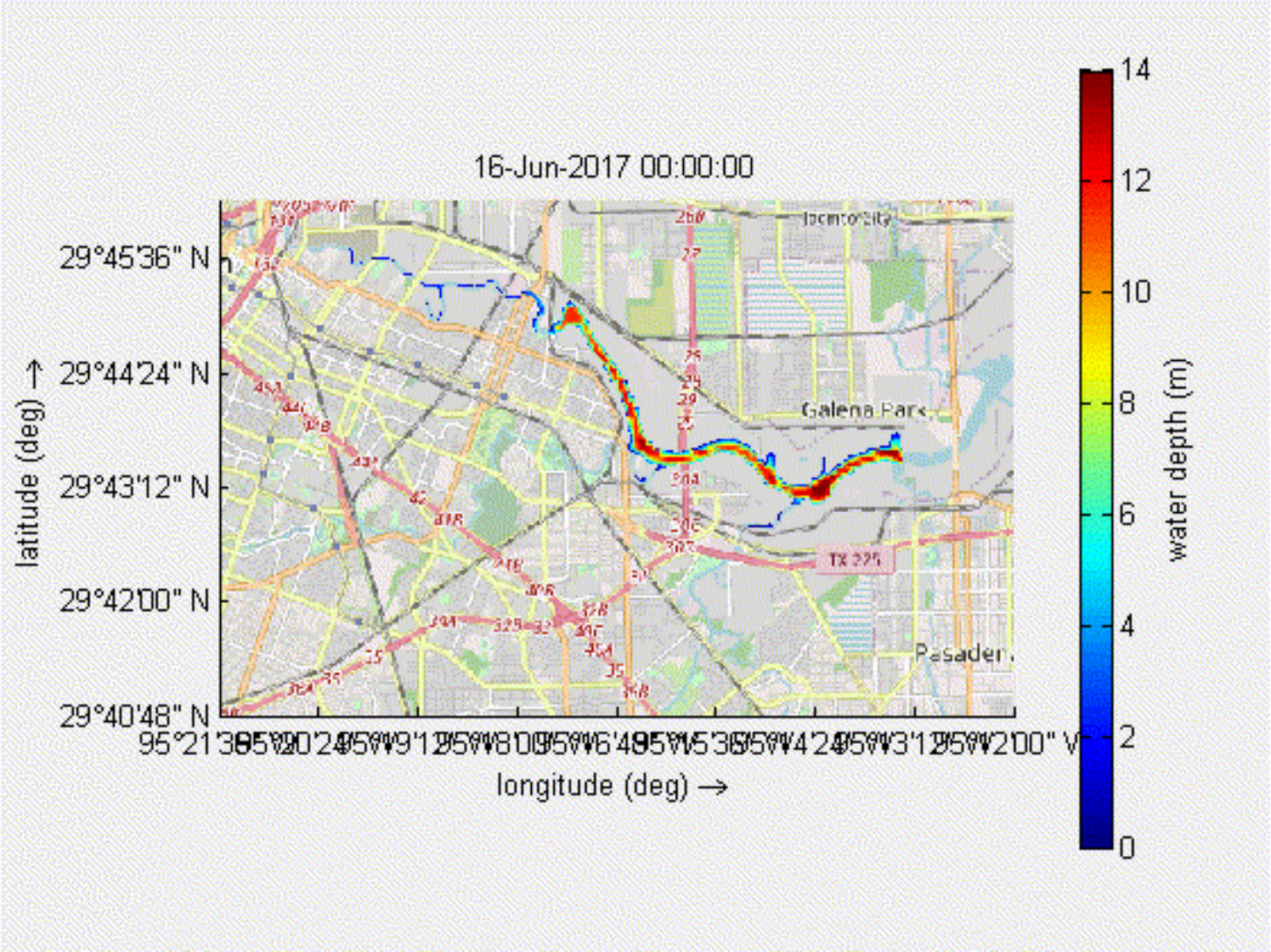




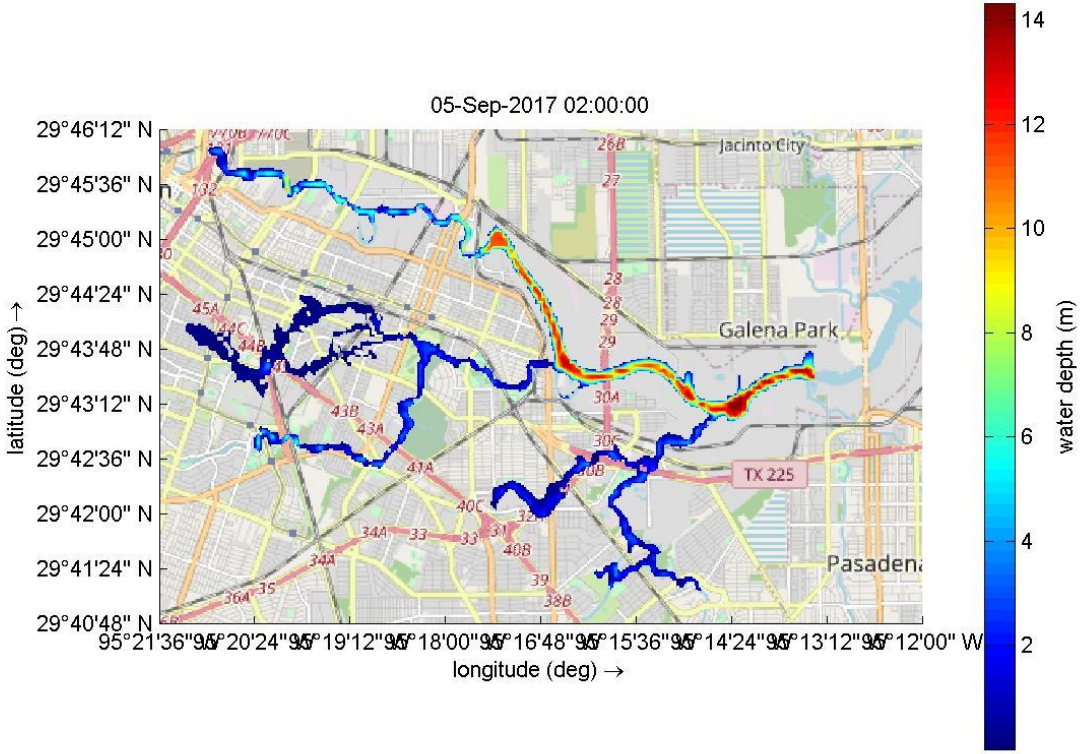


After Harvey near Galena Park

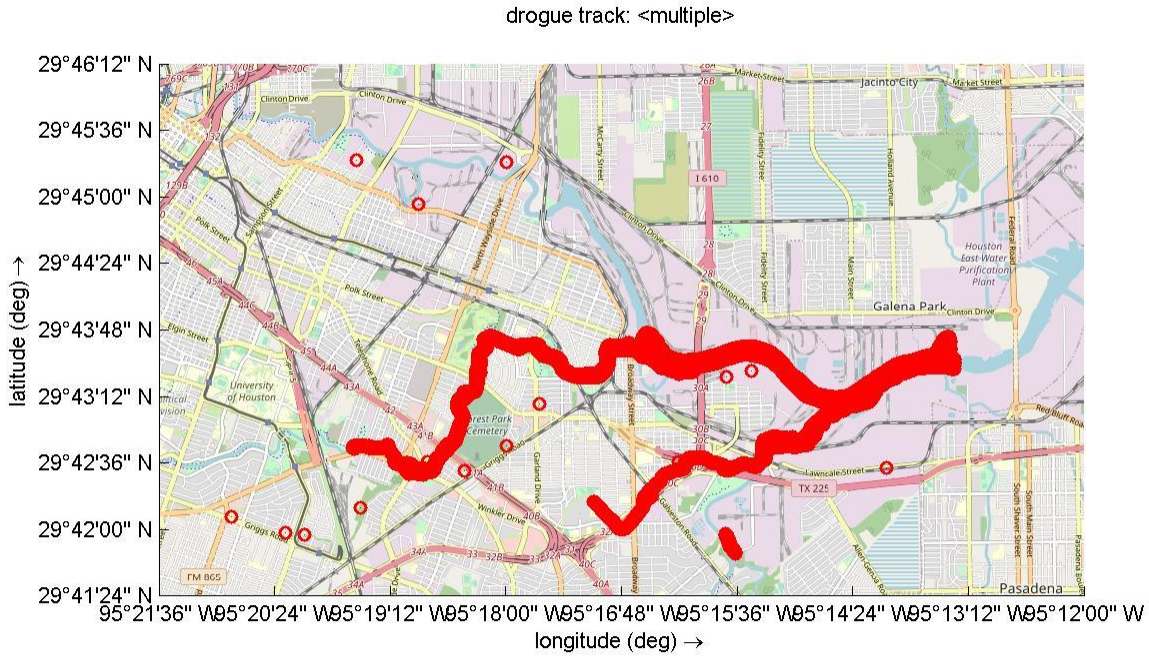
Water Depth During Harvey near Galena Park



Water Depth and Drogue Tracks post-Harvey

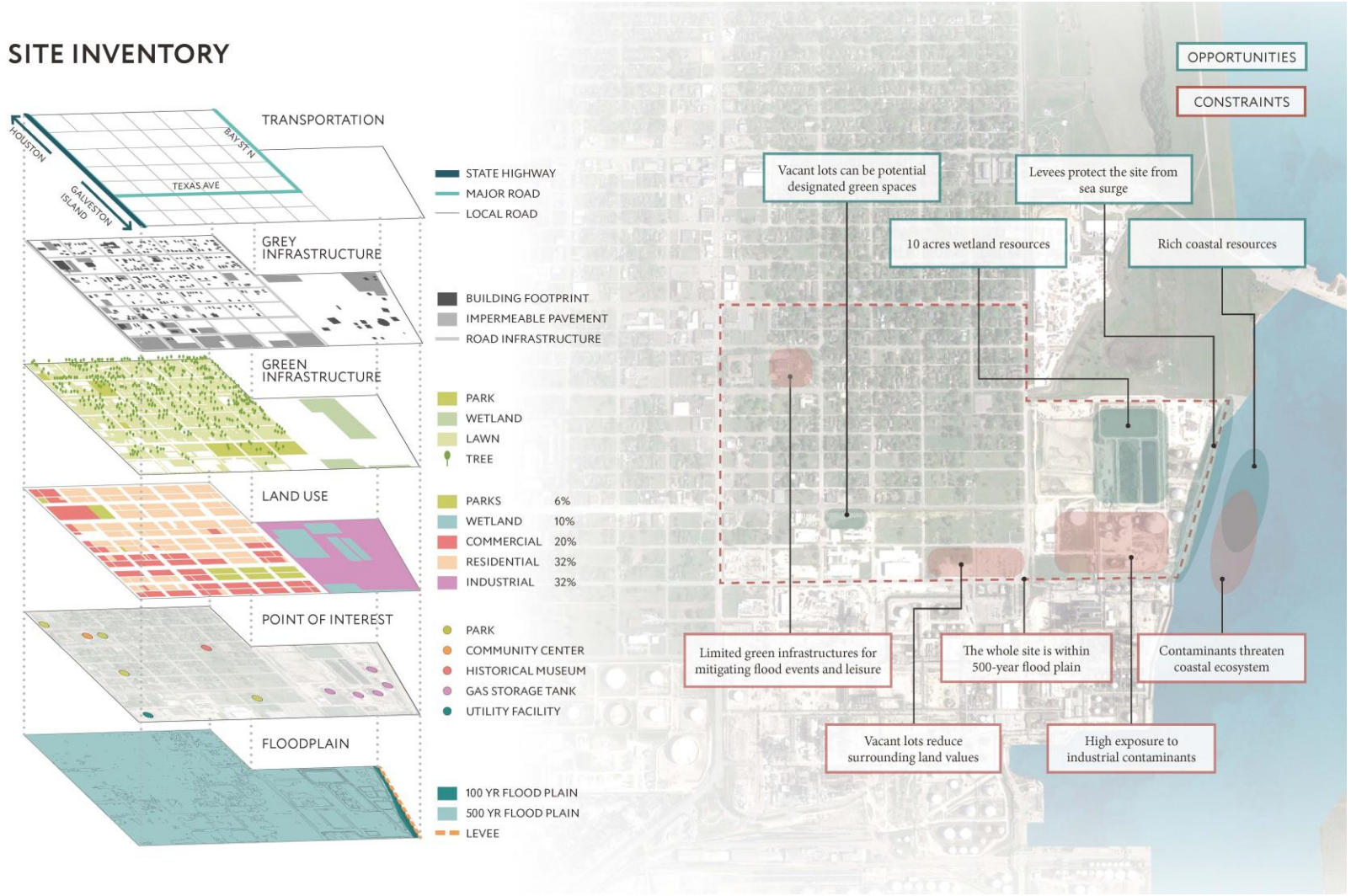


Depth in water courses near Galena Park from SWAT predicted discharge during Hurricane Harvey

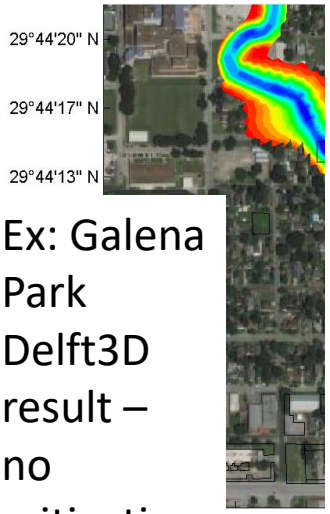


Drogue travel paths near Galena Park from SWAT predicted discharge during Hurricane Harvey

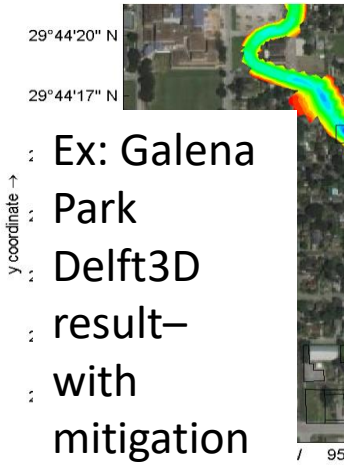
Nature-Based Features and Impact on Flooding



Nature



Ex: Galena Park Delft3D result – no mitigation



Ex: Galena Park Delft3D result– with mitigation

https://doi.org/10.15302/J-LAF-1-040031

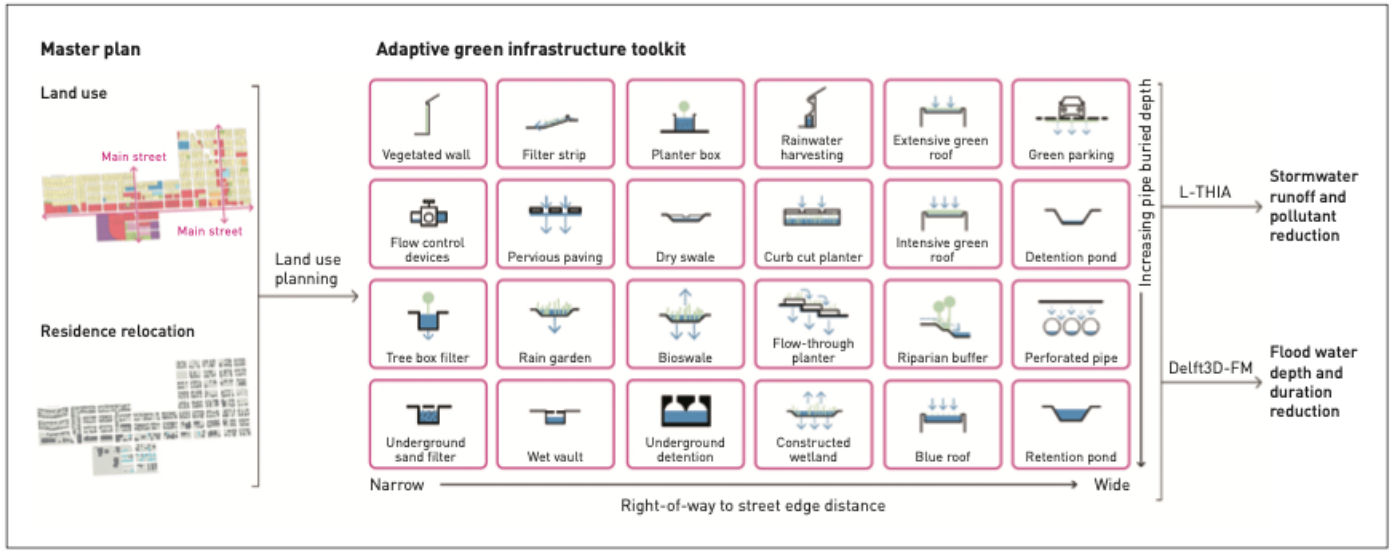
An Adaptive Toolkit for Projecting the Impact of Green Infrastructure Provisions on Stormwater Runoff and Pollutant Load —A Case Study on the City of Galena Park, Texas, USA

Rui ZHU*, Galen NEWMAN, Sunghoon HAN, James KAIHATU, Tianyi WANG

Department of Landscape Architecture and Urban Planning, Texas A&M University, College Station, TX 77843, USA

*CORRESPONDING AUTHOR
Address: Texas A&M University, 3137 TAMU, College Station, TX 77843, USA
Email: zr1991@tamu.edu

GRAPHICAL ABSTRACT



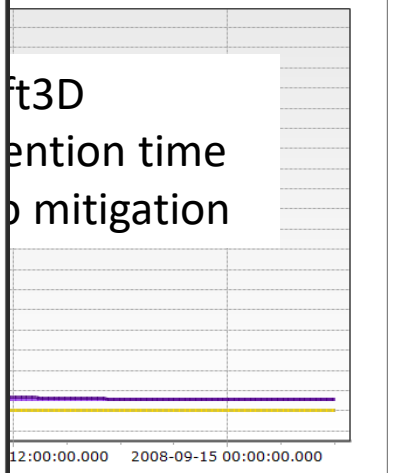
HIGHLIGHTS

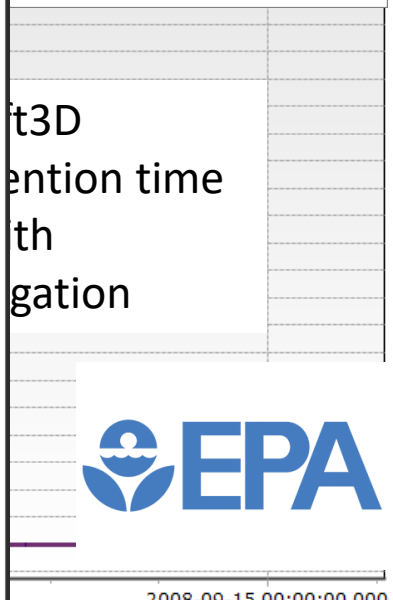
- The adaptive green infrastructure toolkit can help reduce flood vulnerability and exposure to industrial contaminants in urban areas
- Integration of the L-THIA and Delft3D-FM models provides a dynamic assessment of stormwater runoff reduction and pollutant mitigation
- The toolkit can be tailored by both on-ground spatial size and underground depth of obstruction
- The toolkit can assist master planning to significantly reduce stormwater runoff and non-point source pollutants

KEYWORDS

Stormwater Runoff;
Pollutant Load;
Public Health;
Adaptive Green Infrastructure Toolkit;
Delft3D-FM;
L-THIA Model

oding

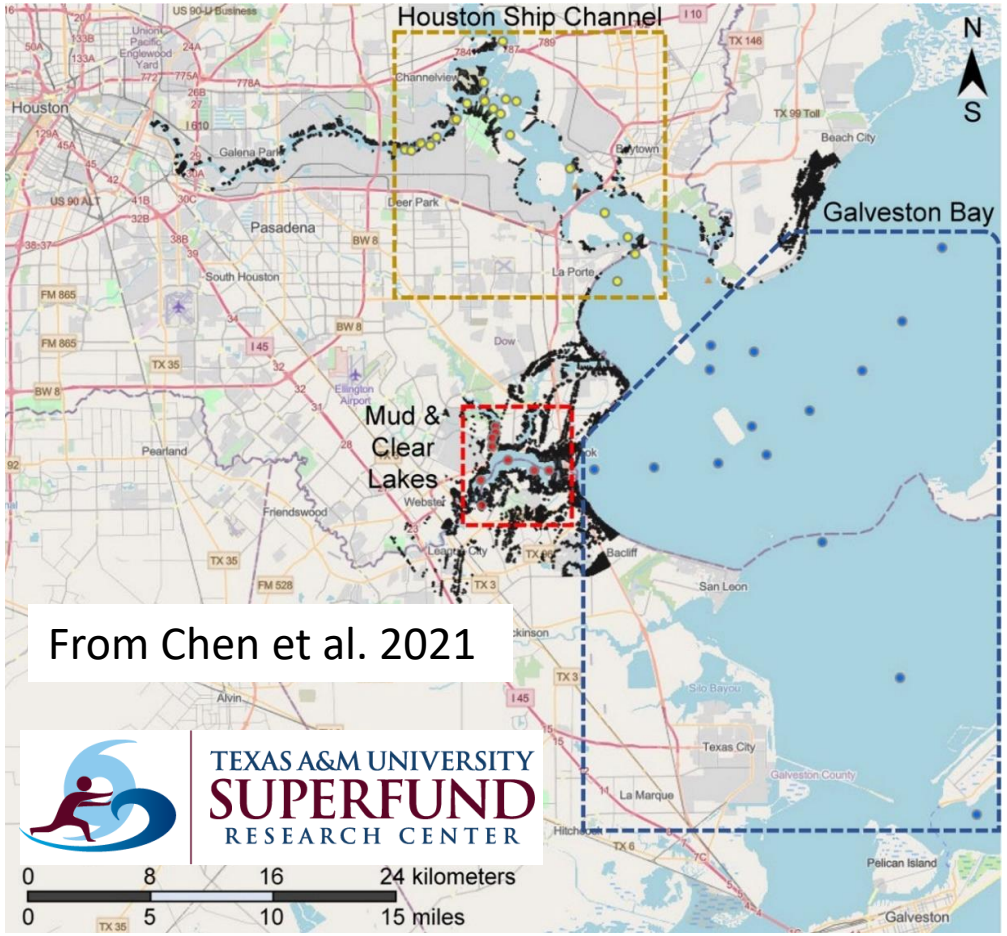




EPA

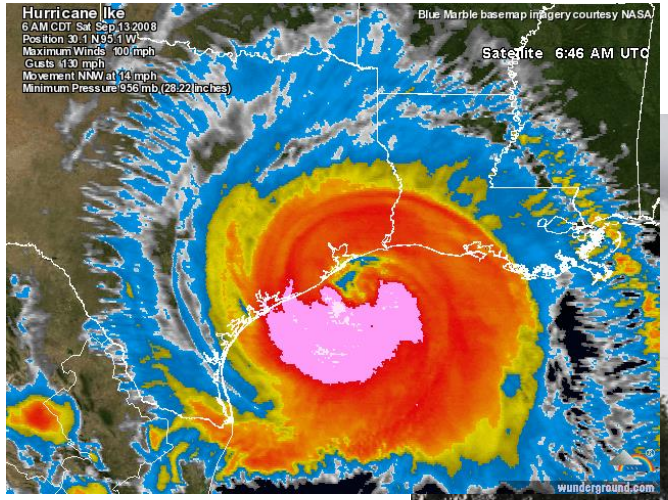
Future Work

- Couple SWAT sediment loading with Delft3D-FLOW
  - Sediment transport under surge – flooding events
- Long-term simulation with coupled system (~ 10 years)
- Future effects:
  - Amplify historical storms (Super Ike, Ultra Harvey)
  - Future climate scenarios (USACE Design Storms, RCP 8.5, etc.)
- Incorporate nature-based features
  - Evaluate impacts
- Fold into ToxPi analysis



Delft3D prediction of on-land deposition of Galveston Bay sediment from Hurricane Ike

Thanks…


Hurricane Ike
6 AM CDT Sat Sep 13 2008
Position 30.1 N 95.1 W
Maximum Winds 100 mph
Gusts 120 mph
Movement NNW at 14 mph
Minimum Pressure 956 mb (28.22 inches)
Blue Marble basemap imagery courtesy NASA
Satellite 6:46 AM UTC
wunderground.com


URTESY
HARRIS COUNTY CONSTABLE PCT 5
IOLD HINOJOSA