Spatial Modelling Approach for Oil Spill Impact Calculations

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Overview

Introduction

Motivation and Objectives

Spill Model

Impact Modelling Approach

Application

Conclusions

Introduction

- History of U.S. oil spills
  - The three most recent events – Exxon Valdez, Deepwater Horizon, Refugio
- 100’s of millions to over a billion dollars worth of damage
- Diverse range of spill and impact models
  - Large increase in research following Deepwater Horizon
- Most common way to model spills is through simulation.
  - Varied approaches
  - Oil “plume” is modeled as a set of individual points
  - Undergo separate environmental processes – unique characteristics.

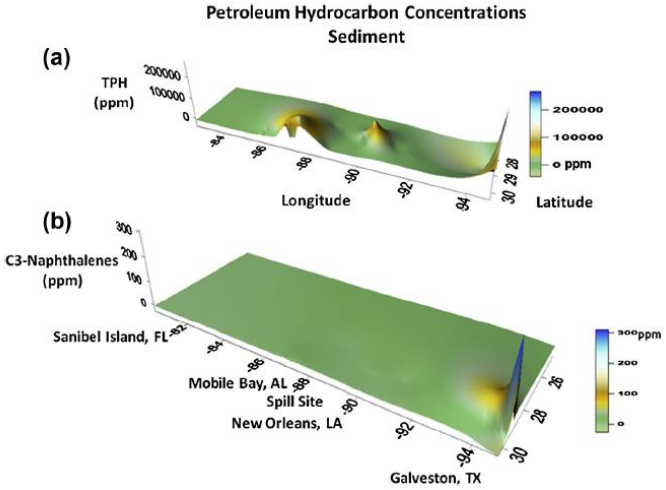
Motivation/Objectives

- Plumes, in reality, aren't discrete points travelling through the water column.
  - Coalesce and form long tails, coagulate across the surface.

- Distribution has shown autocorrelative behavior.

- Representation of plume as points
  - Points cannot be treated as if they effect only the discrete locations estimated by the models.

- Uncertainty built into models
  - Results change from simulation to simulation.



-Sammarco, et al. (2013)

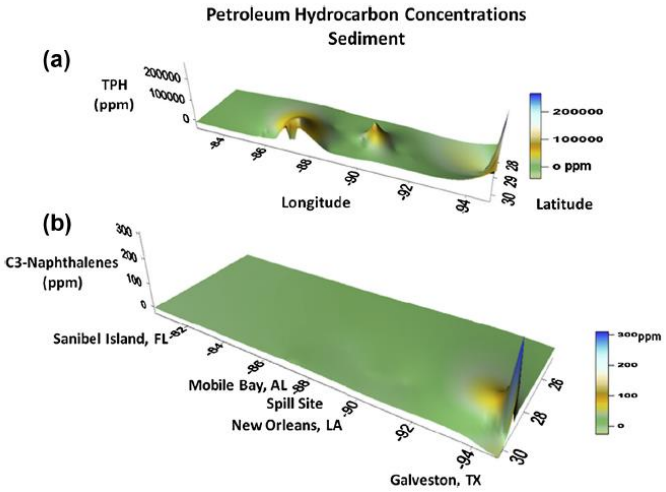
Motivation/Objectives

- Impact models draw hard-lines in areas of impact.

- County boarders, census blocks, or grids divide oiled area up into separate and distinct areas.

- Useful for reporting total oil within an area, but limits the impact assessment at finer scales.

*This study employs interpolation methods to communicate oil impact for a more realistic estimate of a spills effect and minimizes uncertainty through a simulation approach.



-Sammarco, et al. (2013)

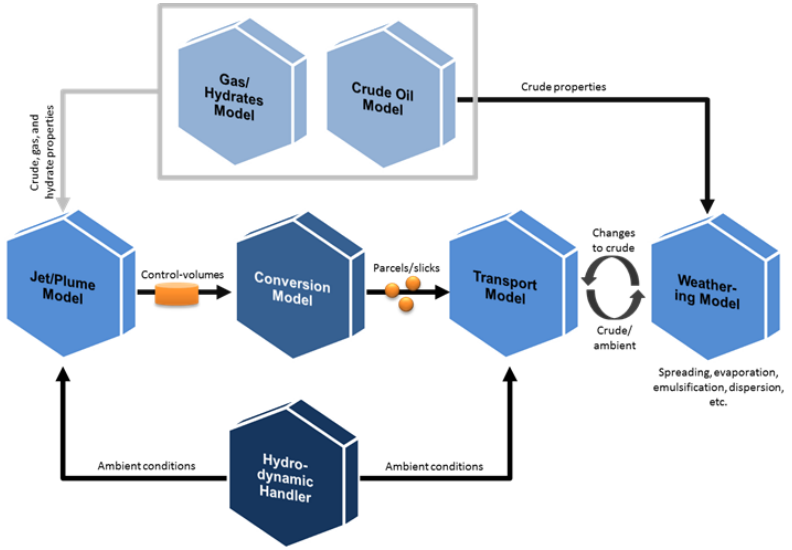
Spill Modelling

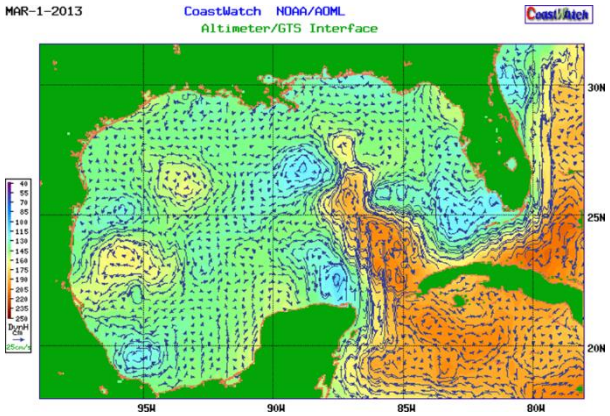
- Using the Blowout and Spill Occurrence Model (BLOSOM) – new model developed by the National Energy Technology Lab

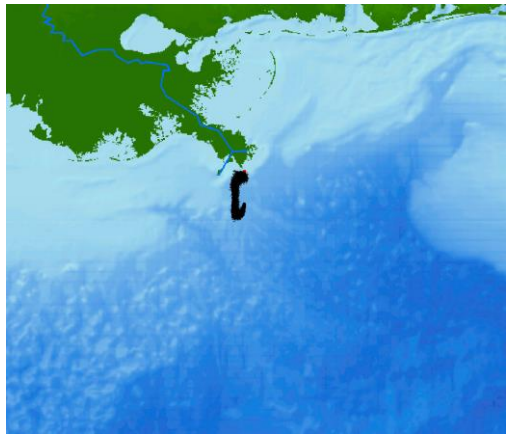
- Multi-component deterministic model, 3D spatially explicit

- Advection by wind, wave, and currents
  - Movement using random walk/flight with diffusion (function of diffusion coefficient) and deflection by wind velocity and direction

- Stochasticity built in which changes the final fate of plume given subsequent simulations in the same location.

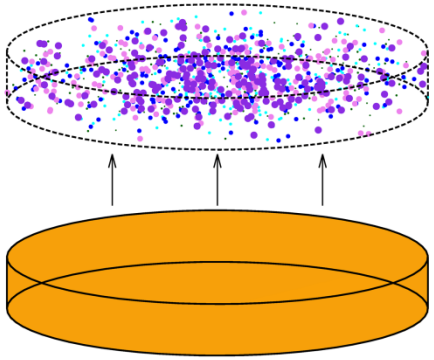






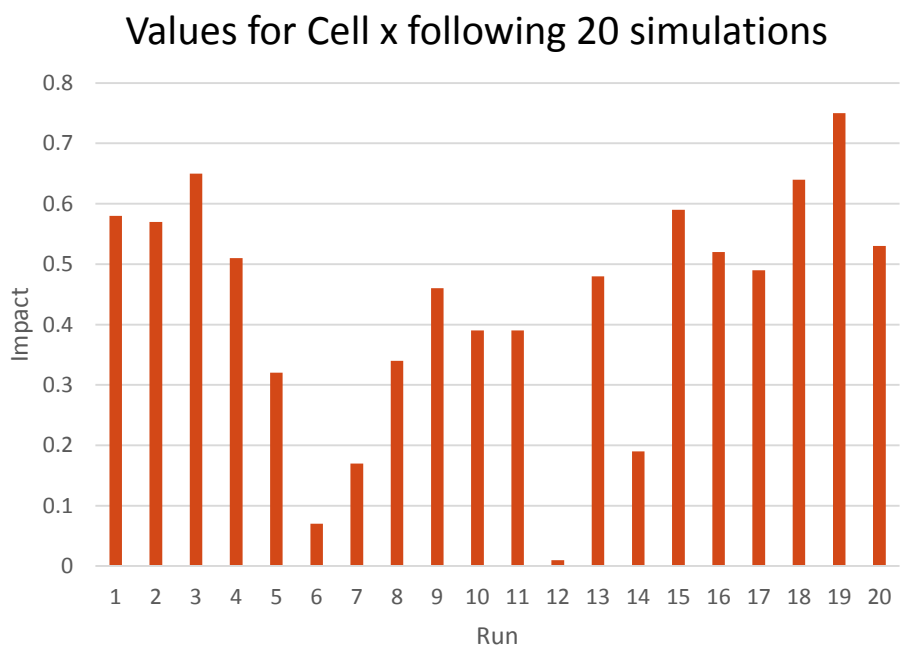
Droplet Distribution

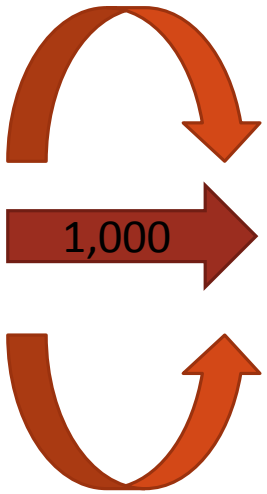
Control Volume

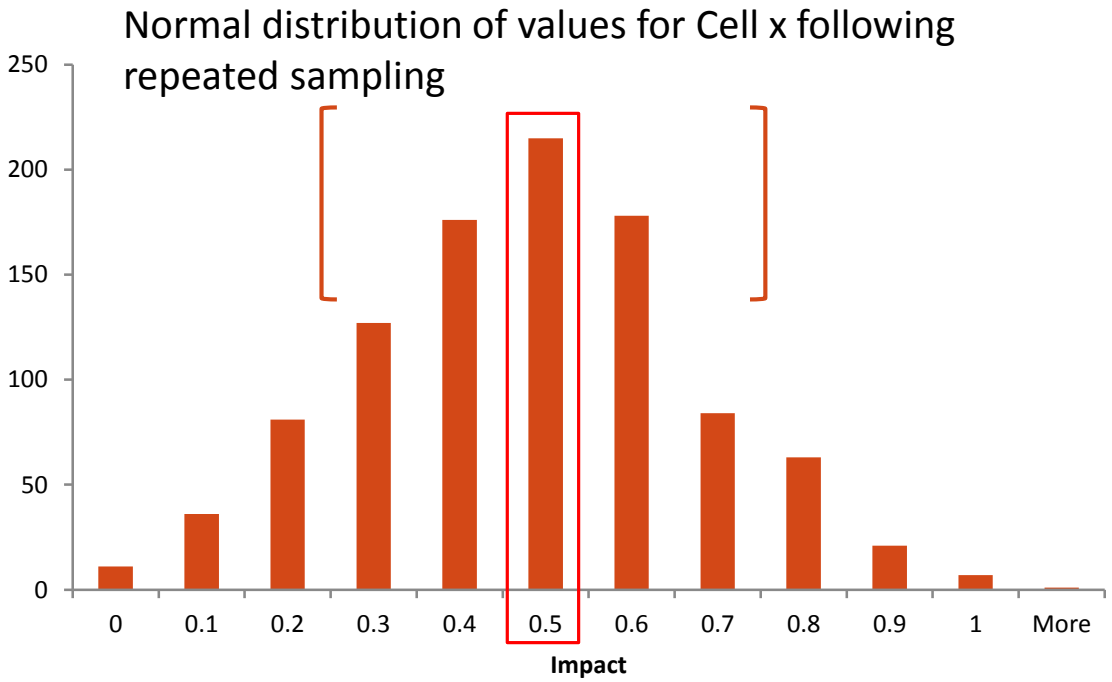


Spill Impact Approach

- Monte Carlo approach of repeated sampling of a sample
- Mean value assigned to impact area, 95% confidence interval generation

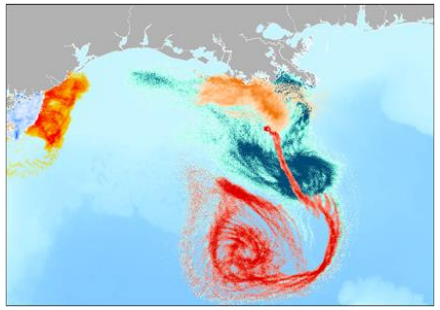


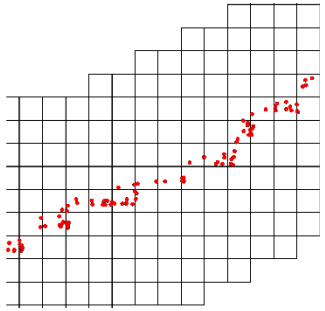


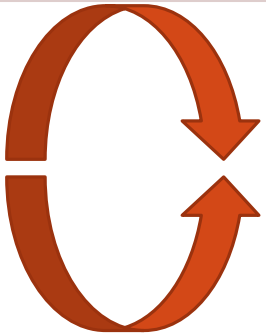


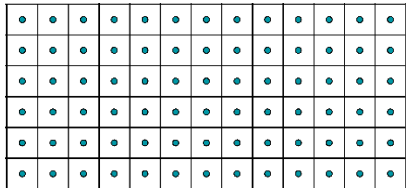
Spill Impact Approach

Simulate spill → Capture quantities → Simulate distribution → Apply simulated values → Interpolation



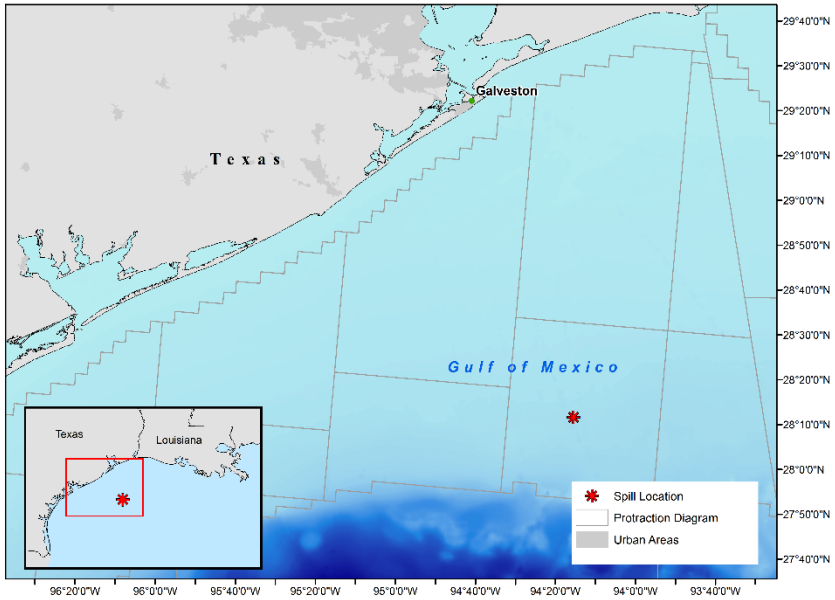




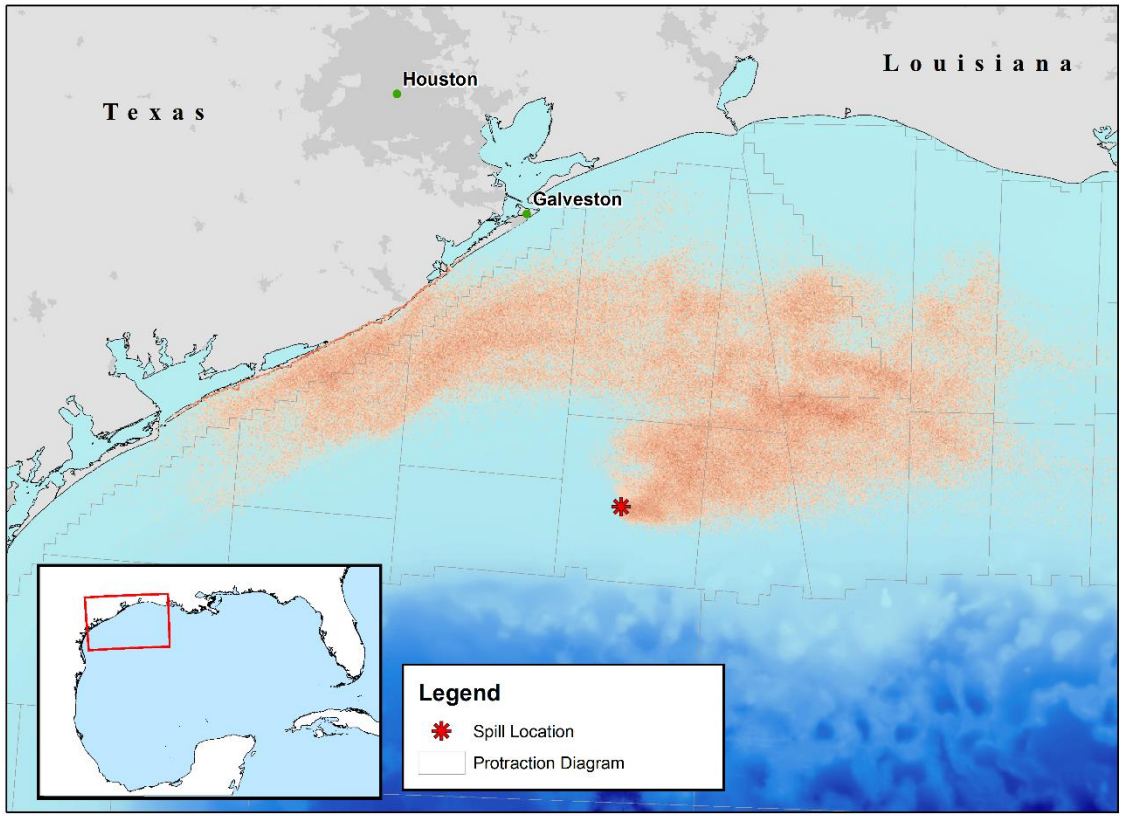


$$\bar{Z}(S_o) = \sum_{i=1}^{N} \lambda_i Z(S_i)$$

Application in the Gulf of Mexico

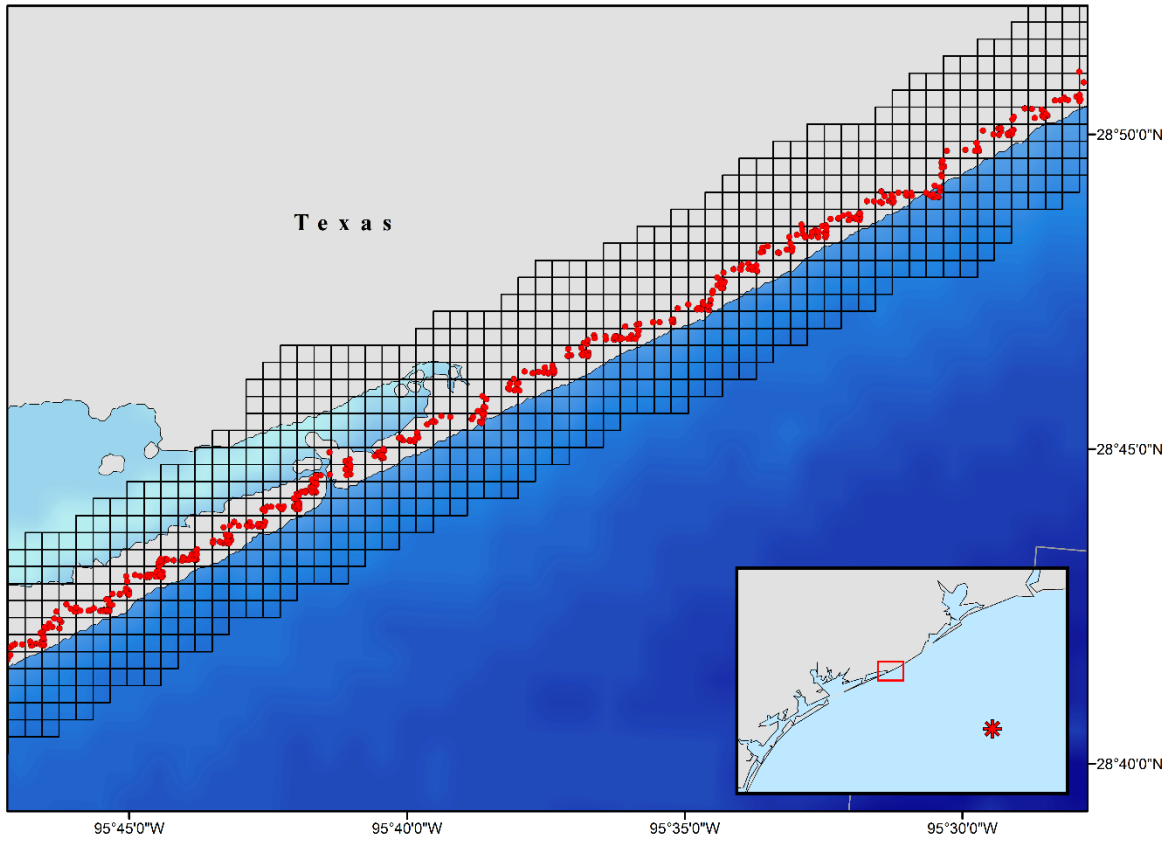


- 28.14°N, 94.29° W
- Western Gulf of Mexico
- 82 miles off the coast
- 25 active well platforms in the area
- 196ft water depth
- 1 week blowout, 2 month duration

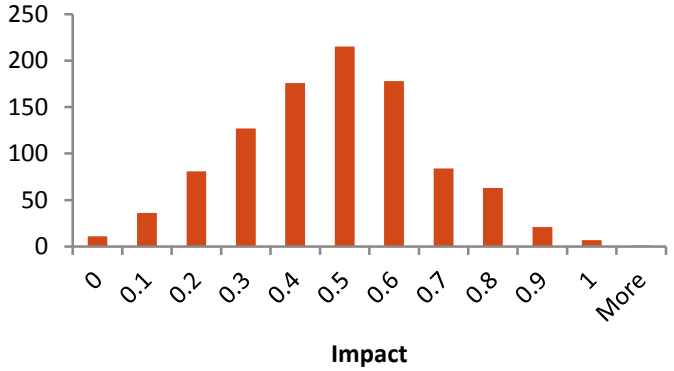


**20 simulations

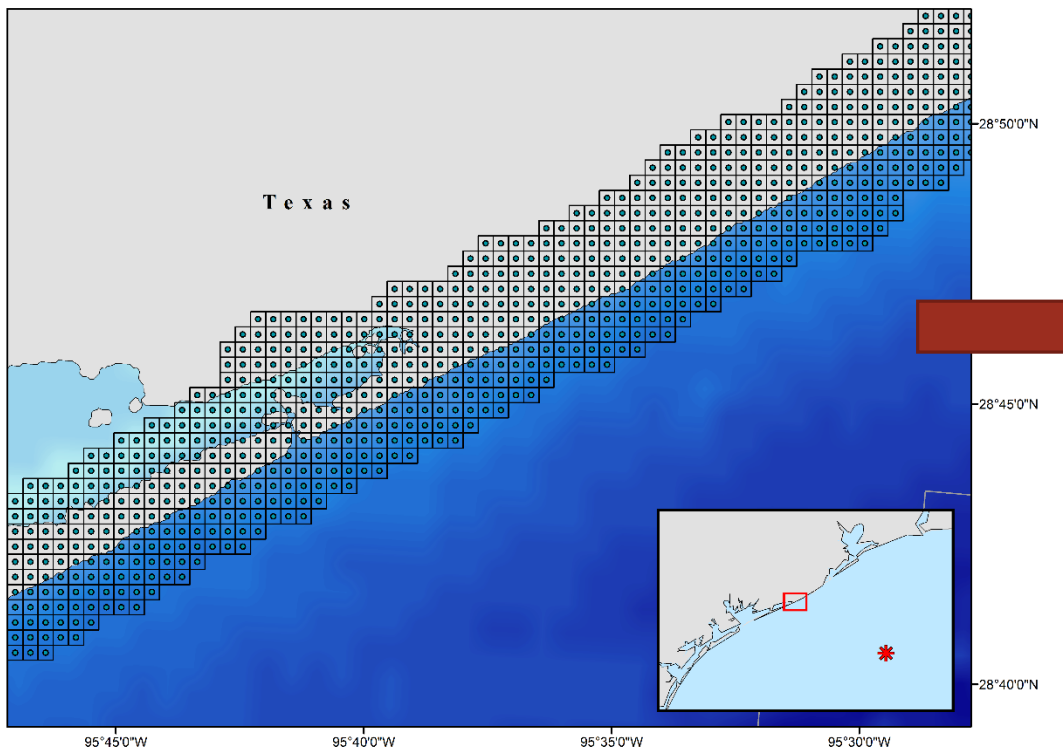
Application in the Gulf of Mexico

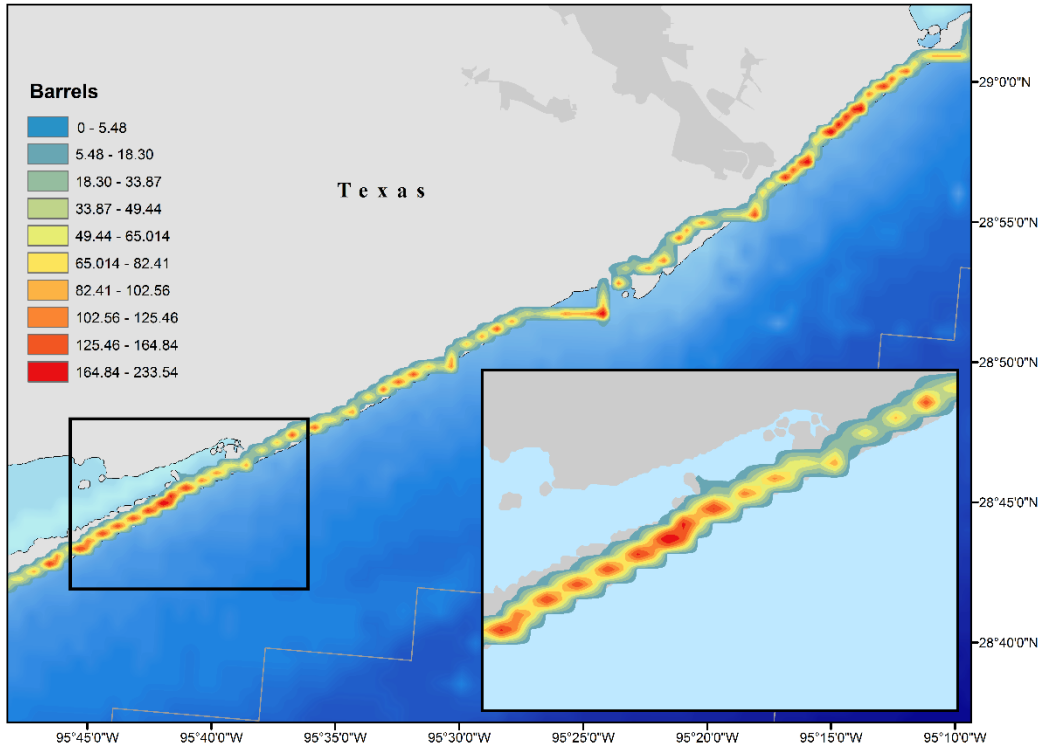


- Recorded the total amount of oil for each cell following the 20 simulations.
- Exported to CSV.
- 10/20 values extracted and used to calculate a mean. Repeated 1000 times/cell
- Mean value from the 1000 simulations assigned to the cell.



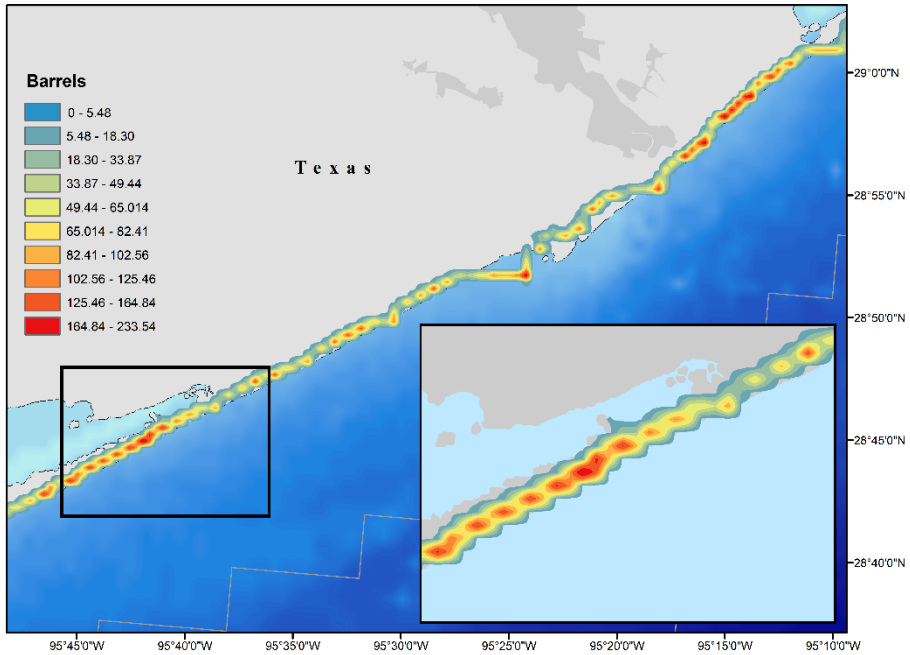
Application in the Gulf of Mexico





Assigned values to centroid of cell. Generated interpolated surfaces using the Kriging method

Application in the Gulf of Mexico



	RMSE					
	MC Surface	Run 2 Surface	Run 6 surface	Run 10 surface	Run 15 surface	Run 18 surface
Sample 1	11.96703806	16.74544714	17.86952713	17.44591643	17.11987149	17.15517415
Sample 2	12.51159462	16.39786571	17.41292623	17.80870574	16.35359288	16.75678967
Sample 3	11.91595569	15.45930141	16.64632091	16.89704116	15.69554077	15.58300356
Sample 4	11.17989266	15.77117624	16.59518002	16.68412419	15.99468662	15.67705329
Sample 5	11.8	15.16673993	16.84784853	16.07731321	15.8757677	16.19012044

Generated 5 additional simulation for comparison

- Created interpolated surface from 5 separate runs
- RMSE calculation for each surface
- Smaller RMSE for MC surface.

Concluding Remarks

- Interpolated surfaces generated from one simulation may misrepresent actual spill amounts

- Monte Carlo simulations can more accurately illustrate the level of oiling along a shoreline
  - Generation of confidence intervals for each reported value

- In a timely uncertain situation, Monte Carlo can offer decision makers and responders a way to quickly address uncertainty in spill models.

- Additional work is needed to determine “best” interpolation method.