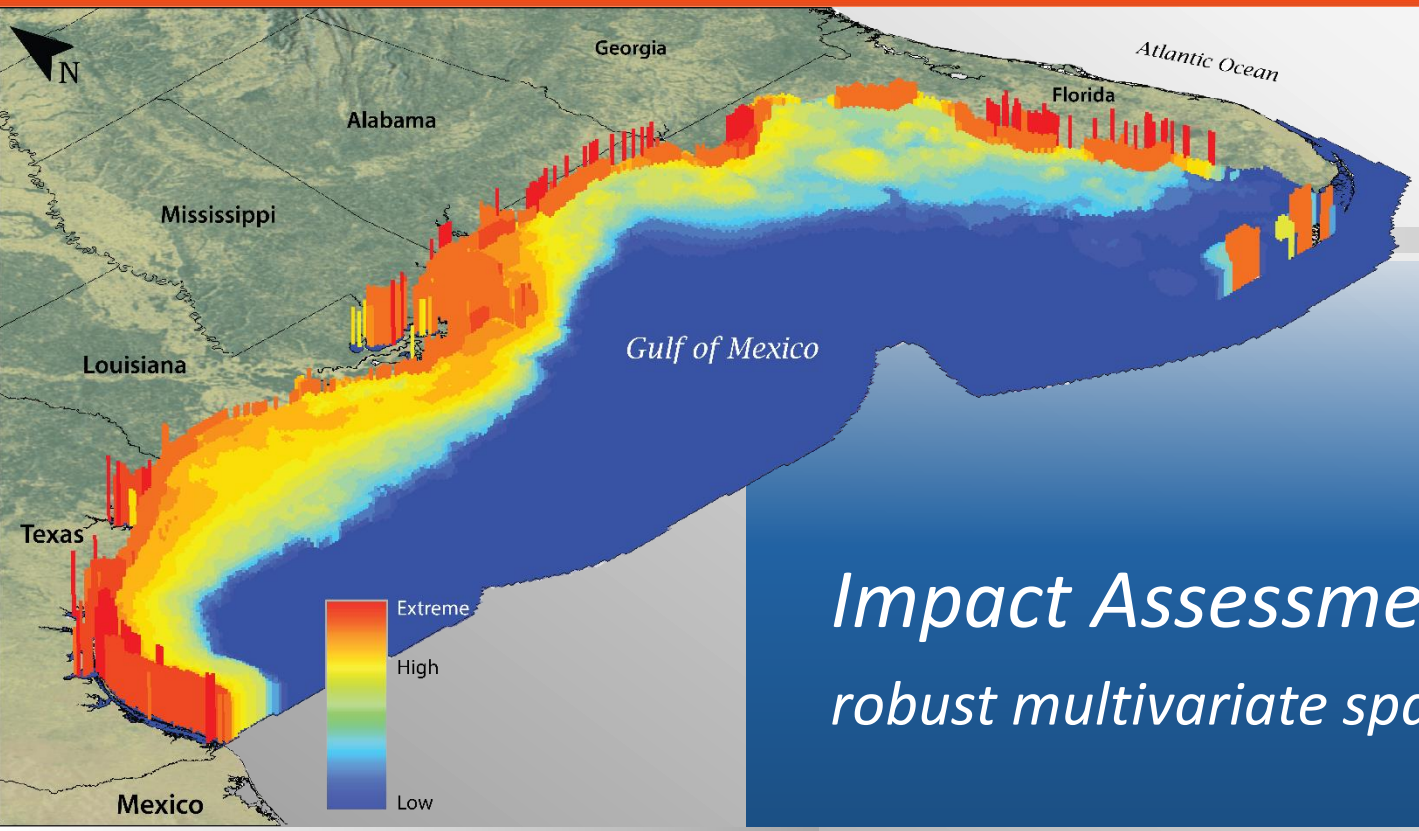
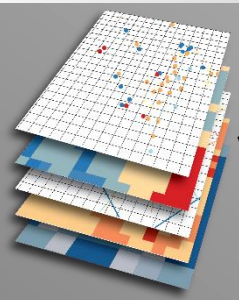


Impact Assessment Modeling:

robust multivariate spatial analysis tools



Cumulative Spatial Impact Layers

Lucy Romeo

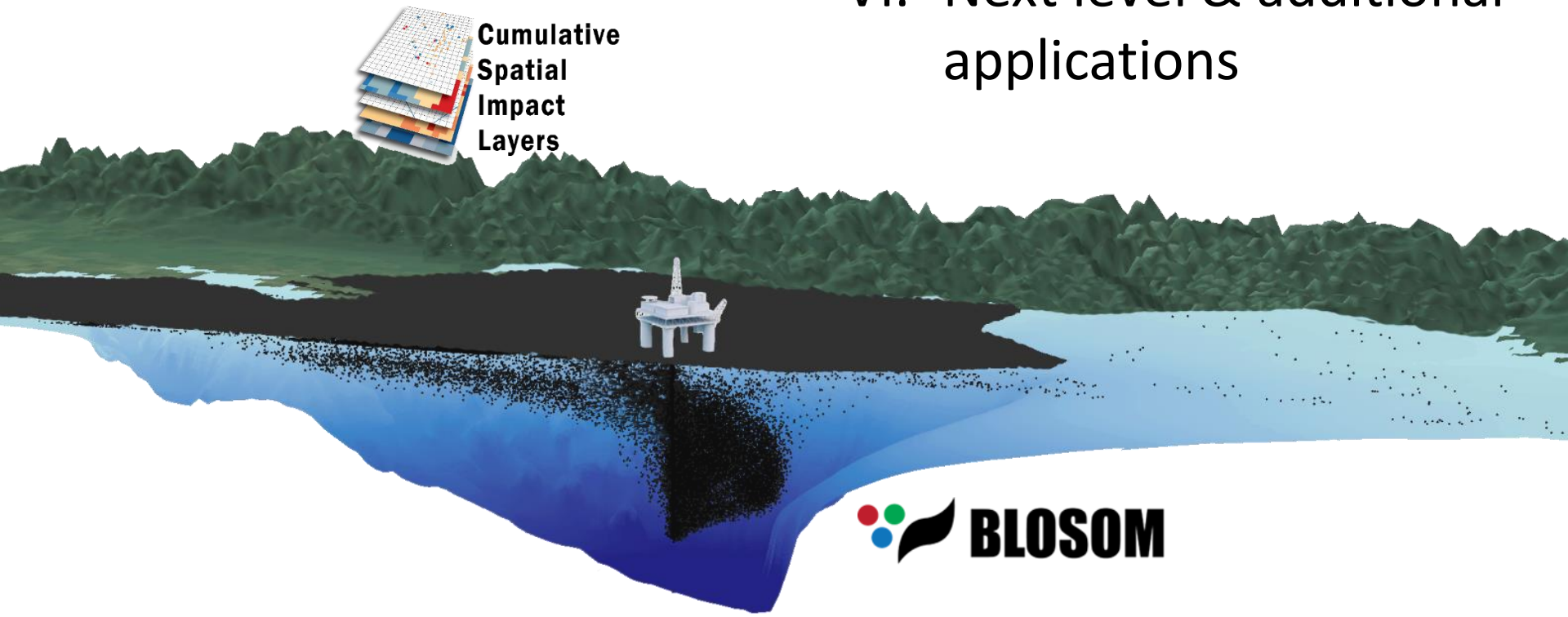
Jen Bauer, Jake Nelson, Dori Dick, Kelly Rose

ORISE Fellow & Geospatial Researcher

National Energy Technology Laboratory, DOE

Overview

I. Background
II. Measuring Impacts
III. Product Goals
IV. Cumulative Spatial Impact Layers (CSILs)
V. Design challenges
VI. Next level & additional applications



Abbreviated history of domestic offshore spills

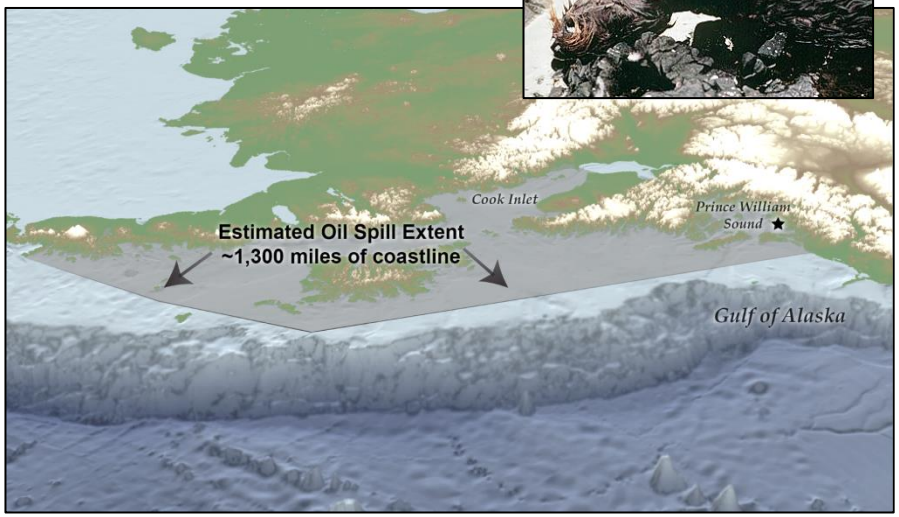
Santa Barbara Blowout
January 1969

- Over 72,000 bbl
- ~30 miles of coastline

Exxon Valdez Spill
March 1989

- ~240,000 bbl

response.restoration.noaa.gov



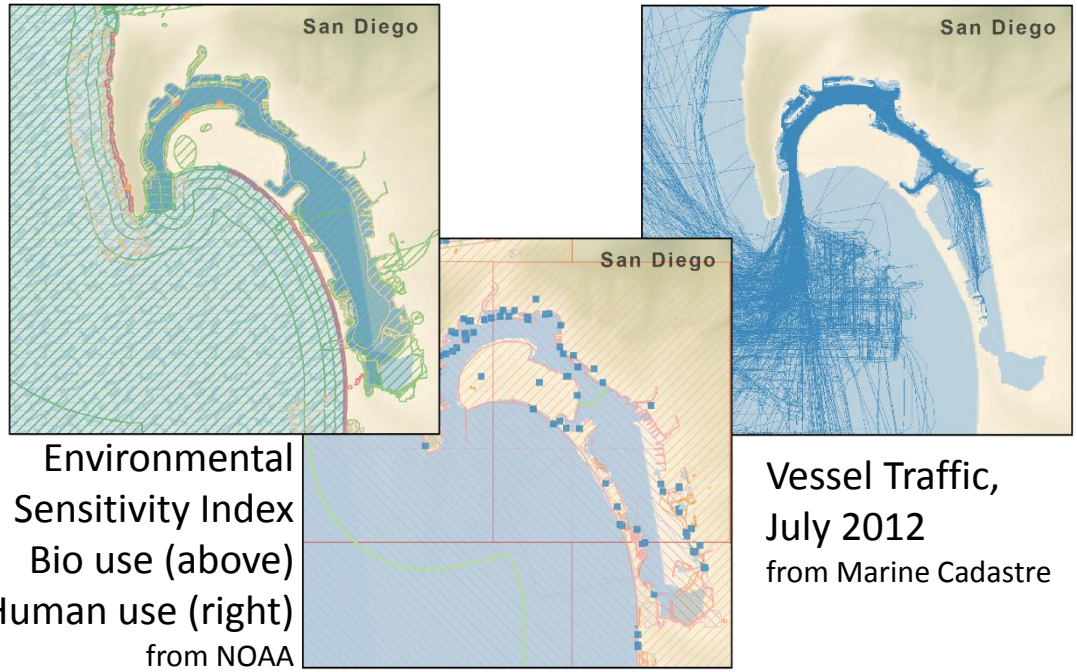
Deepwater Horizon Blowout
April 2010

- ~4.9 million bbl
- Over 1,000 miles of coastline

Barrels = bbl
1 barrel = 42 gallons

Past approaches for impact measurements

- Data collection
  - Observational, interviews, historical studies
- Measurements
  - Qualitative (historical studies, interviews)
  - Quantitative ($$$, sensitivity indexes)
- Current options for decision makers & stakeholders…
  - Data archives & a lot of **BIG DATA**…



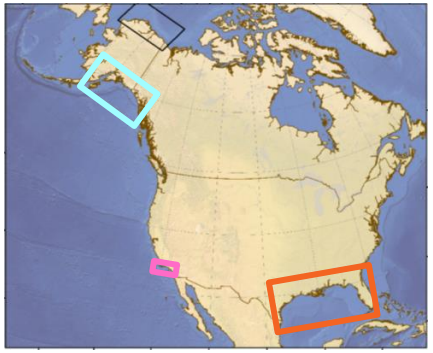
Environmental Sensitivity Index
Bio use (above)
Human use (right)
from NOAA

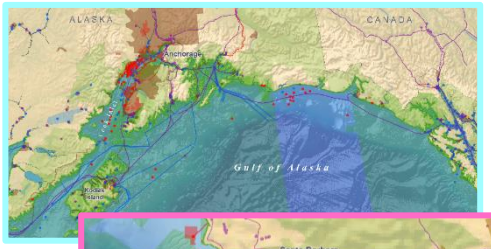
Vessel Traffic, July 2012
from Marine Cadastre

How to efficiently bring together ***disparate data*** from an ***array of sources*** to output a ***useful product*** for ***disaster management***?

Goals

1. Support spill prevention & response readiness through design of a spatio-temporal approach to analyze offshore spill risks & impacts
2. Automated approach through series of tools that are intuitive & robust
   - User-friendly, efficient, spatially & temporally robust
   - Handles diverse types of datasets
   - Different regions & applications
   - Works in conjunction with Offshore NETL tools & models

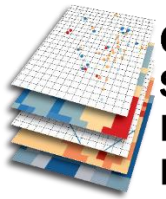




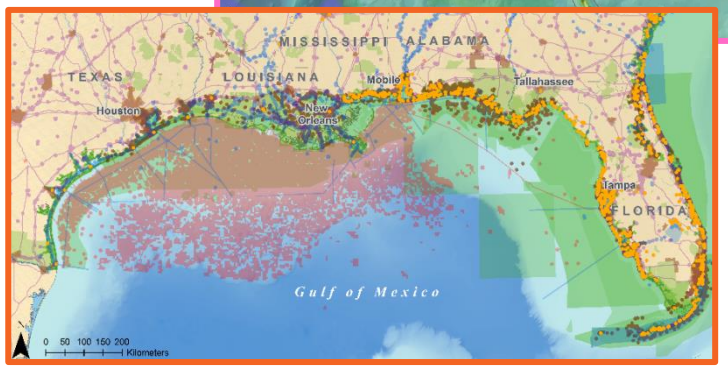
Gulf of Alaska

Offshore Santa Barbara, CA

Cumulative Spatial Impact Layers (CSILs) quickly measures the total ***number of activities*** OR ***estimated economic cost*** per area (cell)



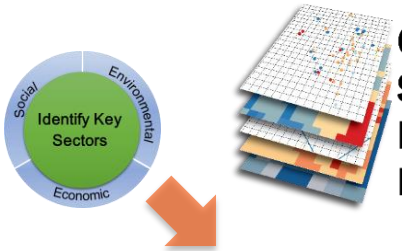
Cumulative Spatial Impact Layers



Gulf of Mexico

See **Bauer et al. 2015** for more information

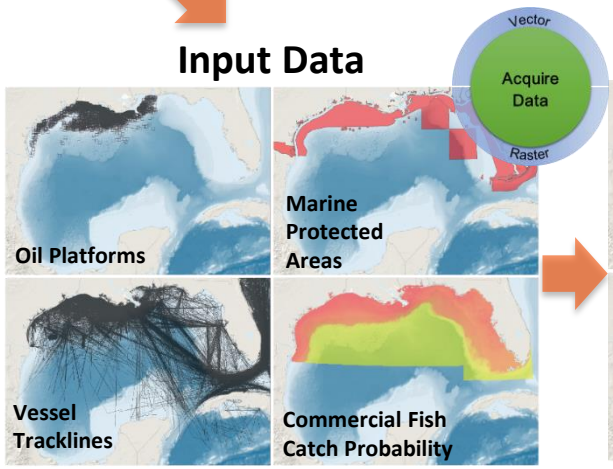
Introducing CSILs



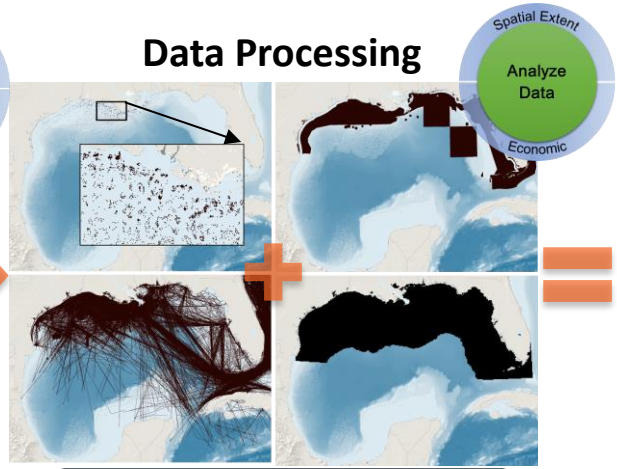
Cumulative Spatial Impact Layers

- Written in Python 2.7
- Simple additive design
- Data-driven
- Can measure variety of impacts
- Geographically robust

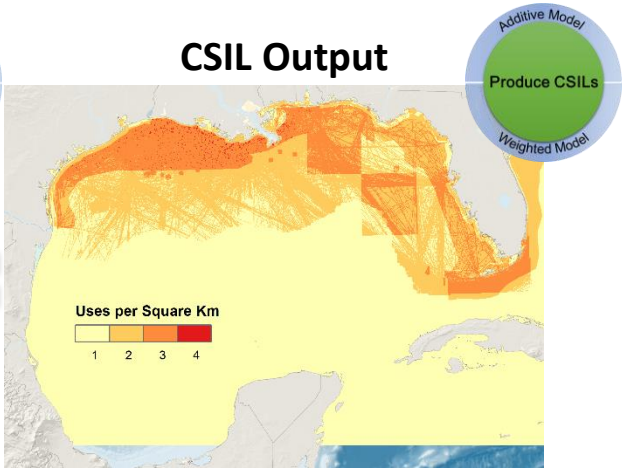
Input Data



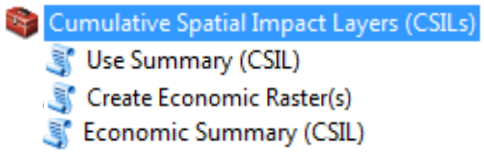
Data Processing

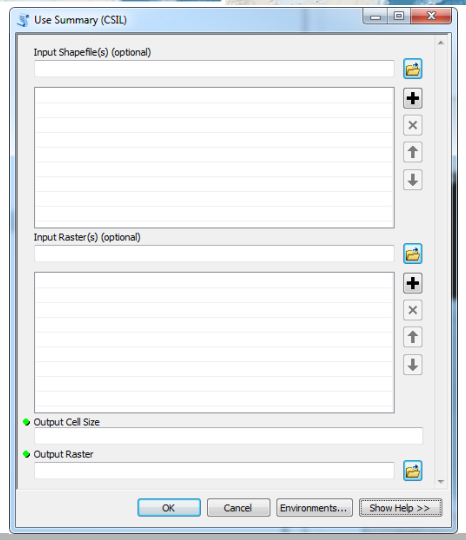


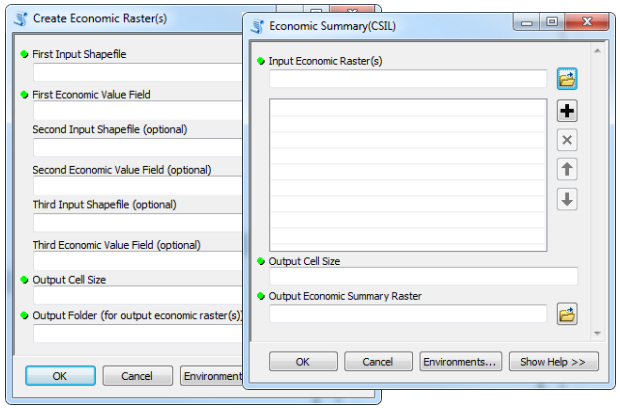
CSIL Output



ArcToolbox contains tools to rapidly output **Use** & **Economic Summary Layers**, as well as **Create Economic Raster(s)**

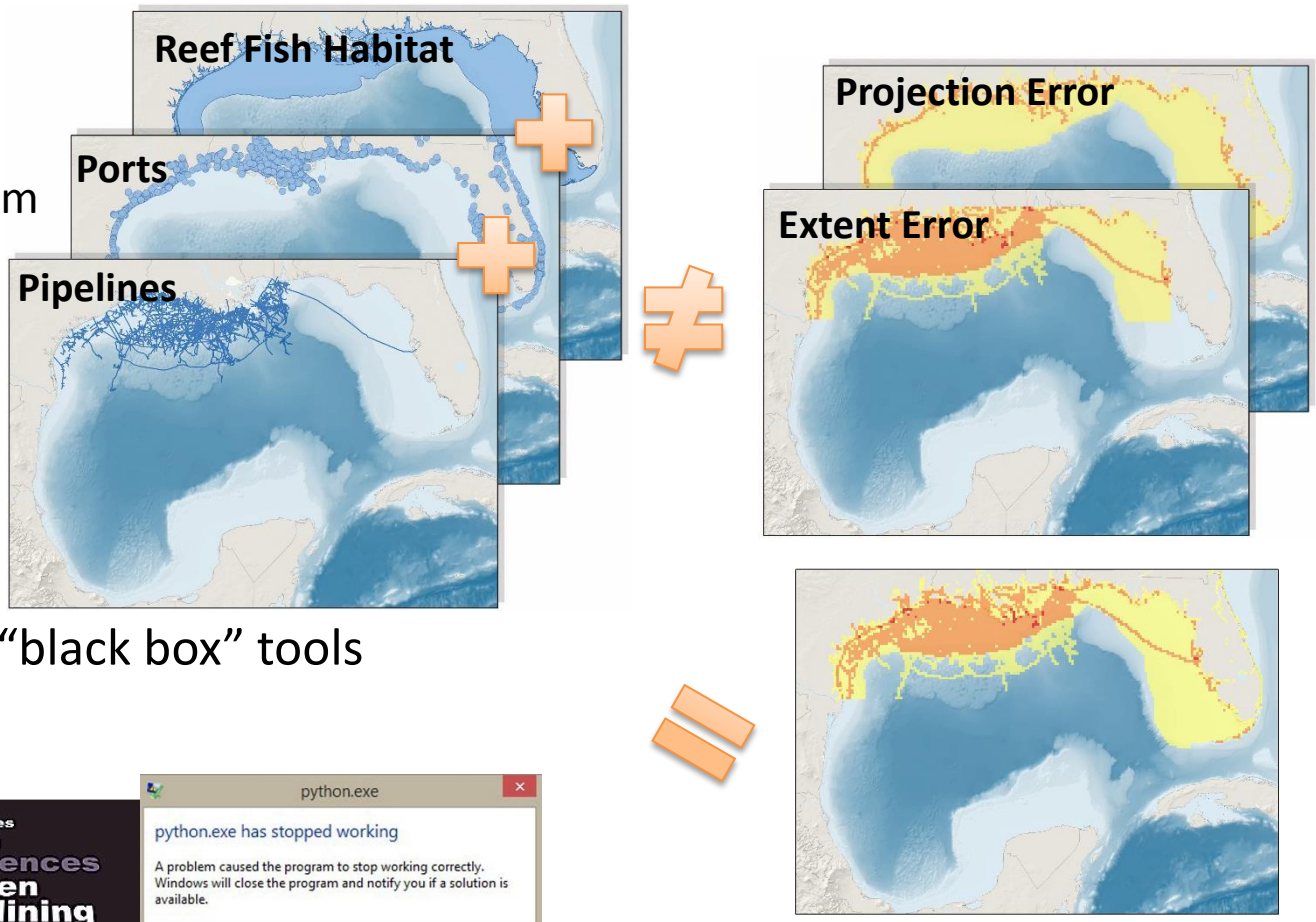






Tool construction challenges

- Big data
- Spatial accuracy
  - Spatial reference system
  - Output extent errors
- Processing data
- Data & tool storage
- Avoidance of creating “black box” tools
- Data-driven

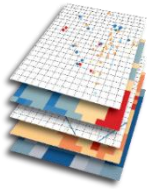


python

Java

hadoop

CSILs in today's world



Cumulative Spatial Impact Layers

Intuitive tools for prevention and response readiness that…

- Combines disparate data
- Quantifies use or cost
- Rapid output

Current events

washingtonpost.com

usnews.com

- 'Plains All American Pipeline' in Santa Barbara
- 2,500 barrels released, 500 bbl entered Pacific Ocean, spread across 9 miles of coastline

royaldutchshellplc.com

response.restoration.noaa.gov

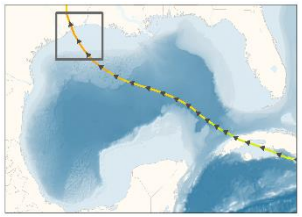
- Shell approved for drilling in Chukchi & Beaufort Seas off Alaska's North Slope
- Potential impacts on indigenous groups who subsist on marine life

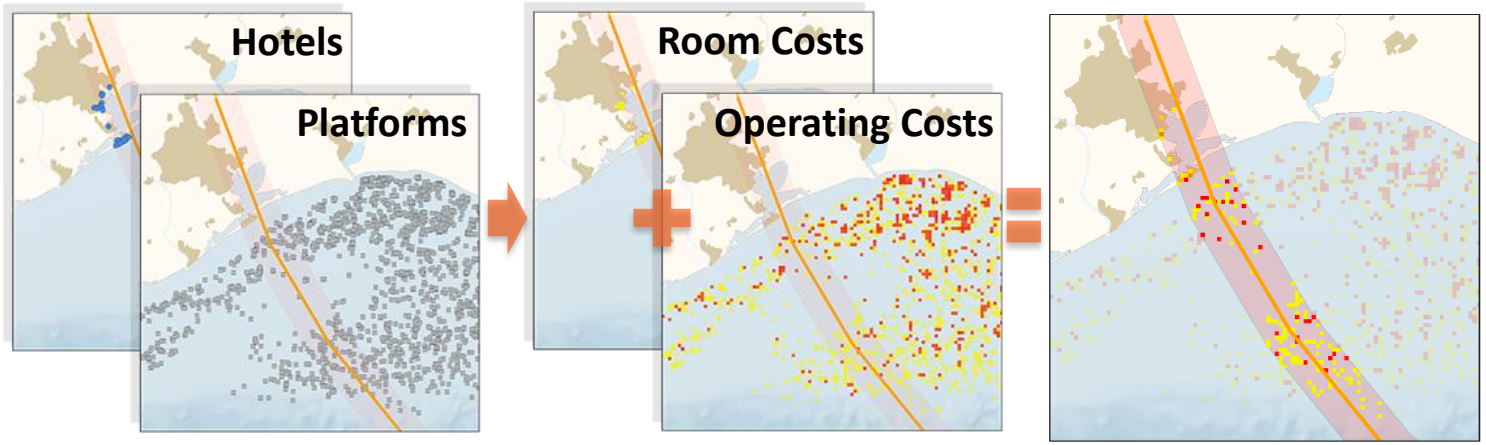
Broader applications

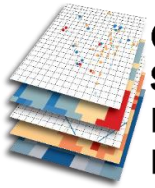
CSILs approach and tools measure impacts for a variety of disasters:

- Earthquakes
- Floods
- Fires
- Landslides
- **Hurricanes**

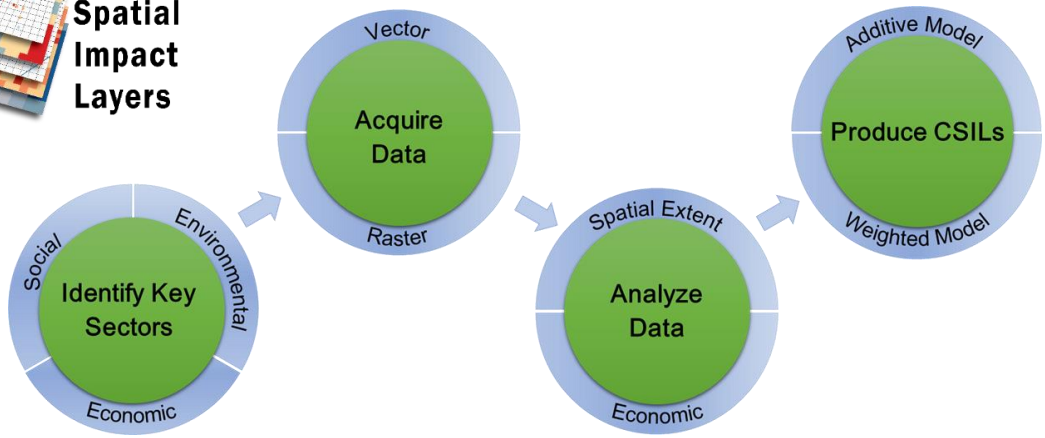
If Hurricane Ike (2008) Happened Today







Cumulative Spatial Impact Layers



- Result map shows economic costs within 20km of Hurricane Ike
- Measures potential economic loss due to disasters

Hurricane data from the National Weather Service

Taking it to the next level!

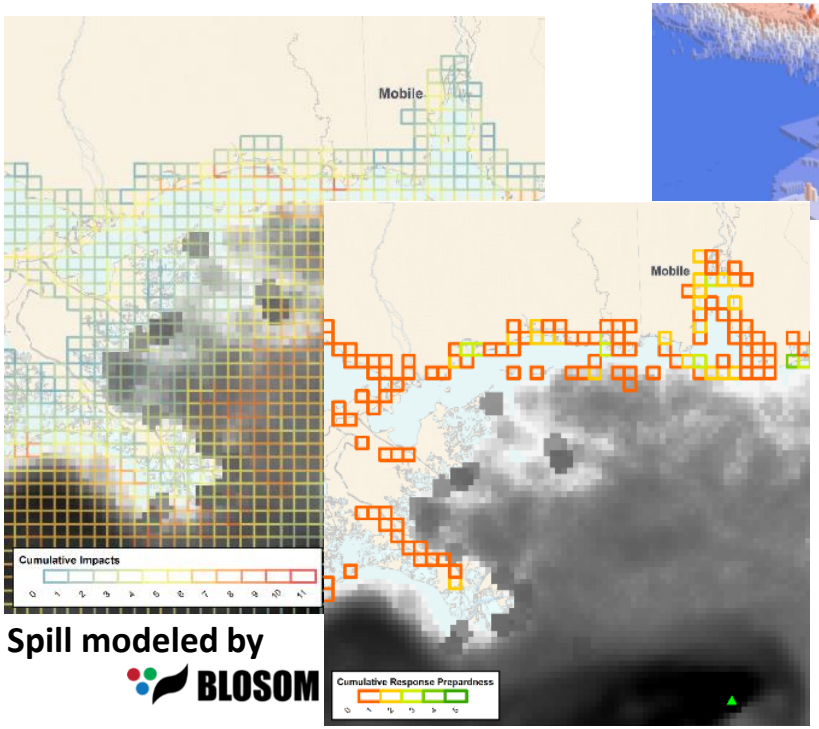
Office of Research and Development

NETL

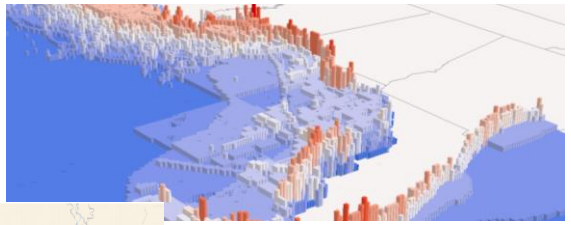
SWIM

Take impact modeling to the next level with the **Spatially Weighted Impact Model**

(in development!)

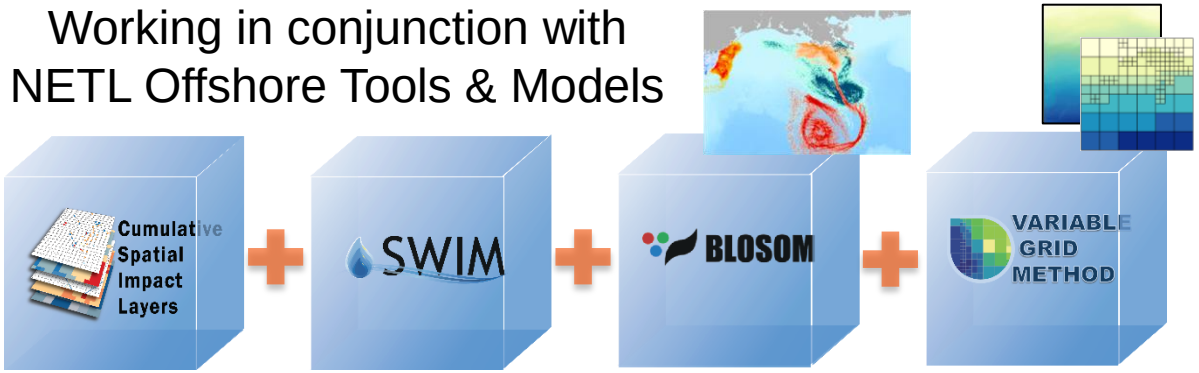


Spill modeled by BLOSOM



- Applies user-defined weights to impacts
- Density and distance analysis used to accurately measure impacts
- Identifies response resources

Working in conjunction with NETL Offshore Tools & Models



- Apply validated BLOwout & Spill Occurrence Model outputs for multiple regions
- Implement spatial uncertainty analysis with Variable Grid Method

Relevant Publications

Bauer, J. R.; Nelson, J.; Romeo, L.; Eynard, J.; Sim, L.; Halama, J.; Rose, K.; Graham, J. *A Spatio-Temporal Approach to Analyze Broad Risks and Potential Impacts Associated with Uncontrolled Hydrocarbon Release Events in the Offshore Gulf of Mexico*; NETL-TRS-2-2015; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Morgantown, WV, 2015; p 60.

Graham, J., Rose, K., Bauer, J., Disenhof, C., Jenkins, C., Nelson, J., Ringo, C., Sim, L., and K. VanAckeren. 2012. *Integration of Spatial data to Support Risk and Impact Assessments for Deep and Ultra-deepwater Hydrocarbon Activities in the Gulf of Mexico*. NETL-TRS-4-2012; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Morgantown, WV; p 36.

Nelson, J. R., Bauer, J. R., and K. Rose. 2014. Assessment of Geographic Setting on Oil Spill Impact Severity in the United States - Insights from Two Key Spill Events in Support of Risk Assessment for Science-Based Decision Making. *Journal of Sustainable Energy Engineering,* 2 (2), pg. 152-165.

Nelson, J. R., Grubesic, T., Sim, L., Rose, K., and Graham, J., 2015, Approach for Assessing Coastal Vulnerability to Oil Spills for Prevention and Readiness Using GIS and the Blowout and Spill Occurrence Model (BLOSOM), *Journal of Ocean and Coastal Management.*

Romeo, L.; Bauer, J. R.; Rose, K.; Disenhof, C.; Sim, L.; Nelson, J.; Thimmisetty, C.; Mark-Moser, M.; Barkhurst, A. Adapting the National Energy Technology Laboratory's Offshore Hydrocarbon Integrated Risk Assessment Modeling Approach for the Offshore Arctic; NETL-TRS-X-2015; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Morgantown, WV, 2015; p 40.

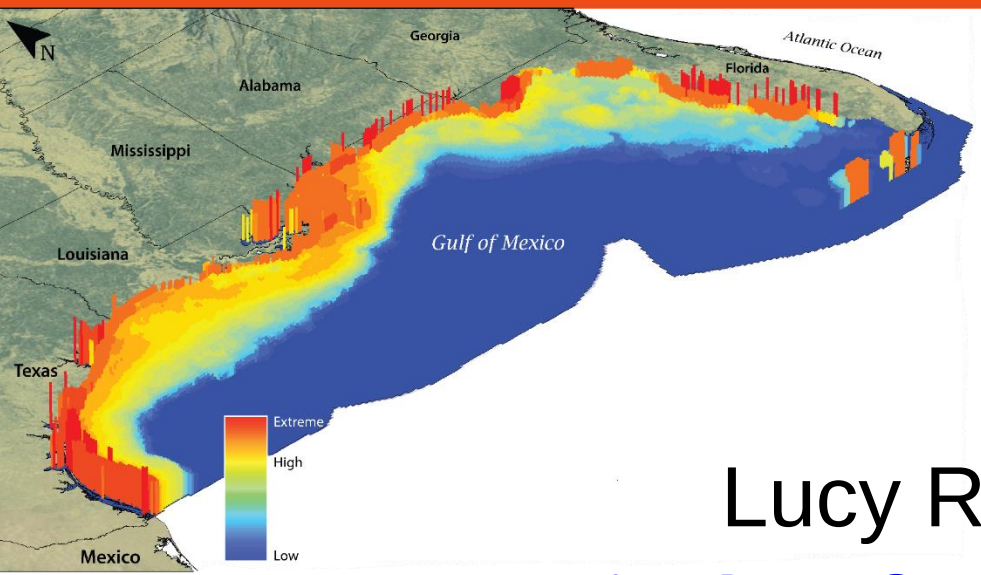
Rose, K., Aminzadeh, F., Sim, L., Ghanem, R. G., Disenhof, C., Bauer, J., Mark-Moser, M., Thimmisetty, C., Jabbari, N., and A. Khodabakhshnejad. 2014. Risks and Impact Assessment for Deepwater and Ultra-Deepwater Gulf of Mexico Resources. Offshore Technology Conference. doi:10.4043/25364-MS 17 pgs.

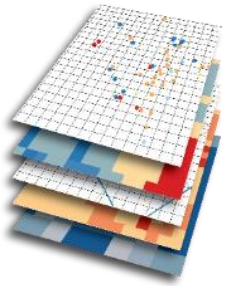
Sim, L., Graham, J., Rose, K., Duran, R., Nelson, J., Umhoefer, J., and J. Vielma. in review. Developing a Comprehensive Deepwater Blowout and Spill Model, *Environmental Modelling and Software*

EDX
A Product of NETL

For more information on our research, CSILs, and other tools and models in the offshore portfolio:
https://edx.netl.doe.gov/offshore/

Thank you!





Cumulative Spatial Impact Layers

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Geospatial Researcher, Geology & Geospatial Team

Department of Energy

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