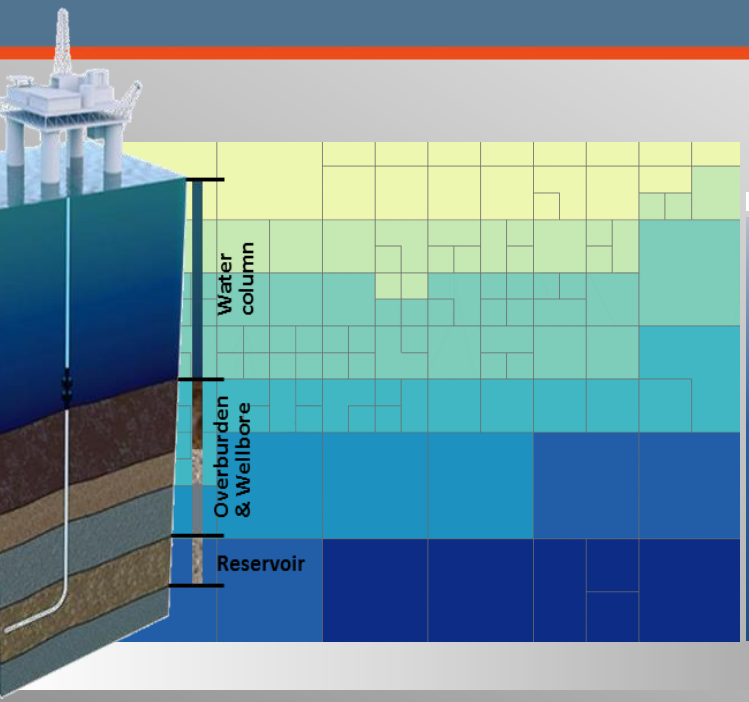


Spatial Decision Support Tools combining GIS for Oil Spill Preparedness & Marine Spatial Planning

Esri Ocean GIS Forum
Multi-Dimensional Data in the COP
November 6, 2015

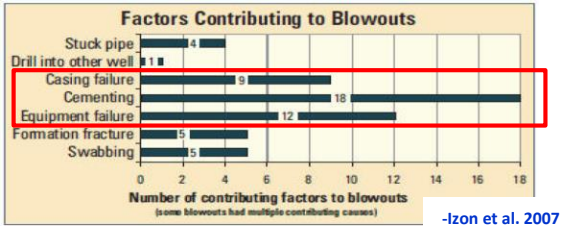
Jennifer Bauer[1,2] and Kelly Rose[1]

[1]U.S. DOE, National Energy Technology Laboratory, Office of Research and Development

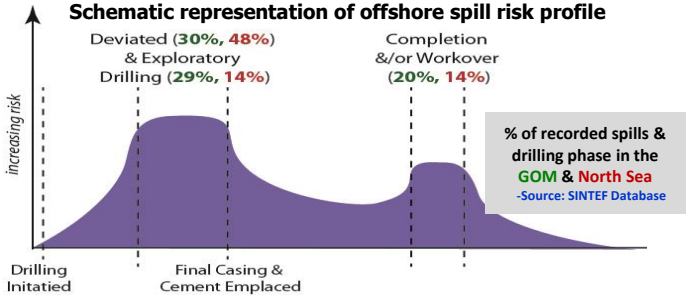
[2]AECOM

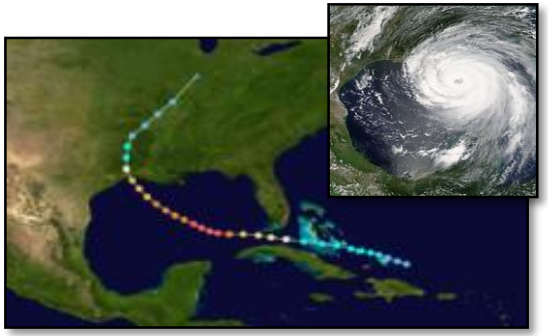
Increasing need for prevention of Offshore Spills

- Natural and Anthropogenic offshore events, such as Katrina/Rita (2005) & Deepwater Horizon spill (2010)
- 2010 Executive Order 13547, Interagency Ocean Policy Task Force
- 2012 Challenges Identified by DOI's OESAC Spill Prevention Subcommittee
  - Deep, ultra-deep water and other offshore frontier areas face production risks that are fundamentally distinct from onshore operations



-Izon et al. 2007

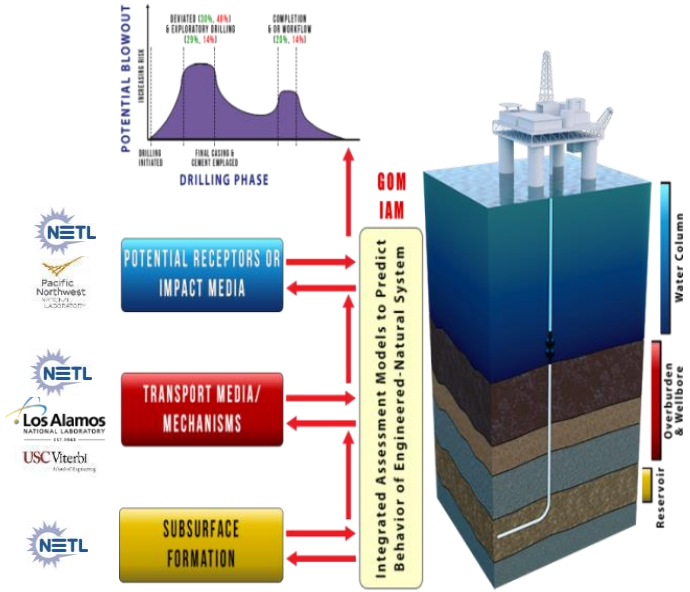


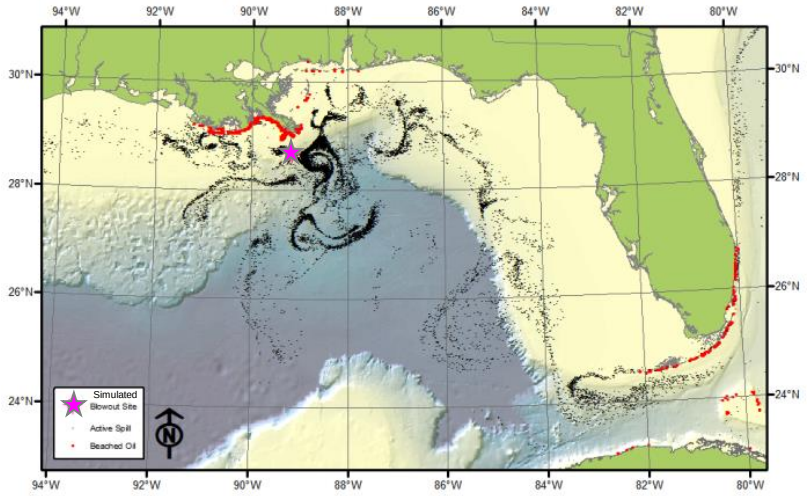


Focus on targeting the identification of knowledge & technology gaps in these most critical areas of operation to help reduce risks and improve resource, environmental, and safety evaluations

Offshore Integrated Risk Assessment Model

NETL's Offshore Integrated risk Assessment Model (IAM) is an integrated modeling and data system, from subsurface to the shore, developed to identify knowledge & technology gaps for spill prevention





IAM combines GIS and Marine Spatial Planning techniques for oil spill prevention, while also having enough flexibility to adapt to a range of stakeholder needs and questions

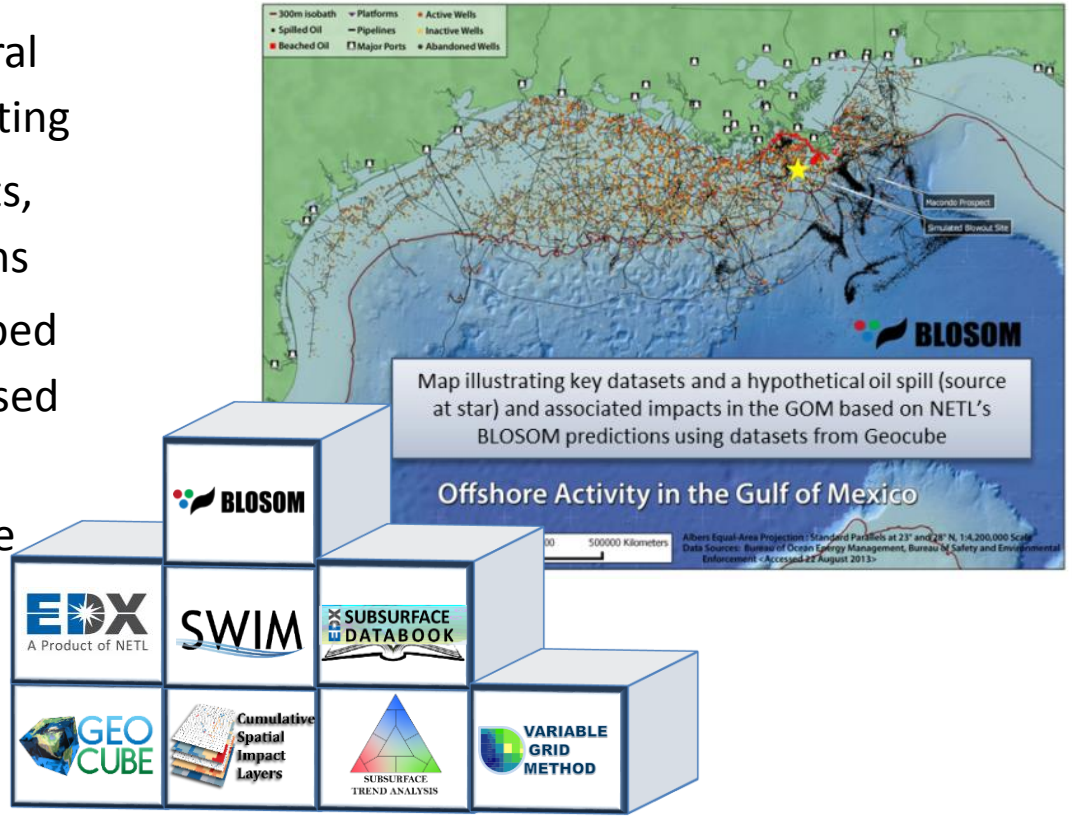
Offshore IAM Goals

Project aims to:

1. Provide a **"one-stop shop" for data** spanning the subsurface, through the water column to the coast
2. Create a **secure, coordinated system** for inter-agency/entity assessment and evaluation
3. Develop an **open-source, adaptable suite of models** for simulating processes in the full system
4. Innovate **spatio-temporal approaches & tools** for assessing risks and reducing uncertainty

Offshore IAM progress to date

- Several IAM models & spatio-temporal tools and approaches are in beta-testing
- Over 40 TB of data, in various formats, spatio-temporal extents & dimensions
- These tools & data are being developed into a COP that will leverage web-based tools and analytics
- The models, tools & approaches have generated additional interest from other stakeholders and helped expand their application

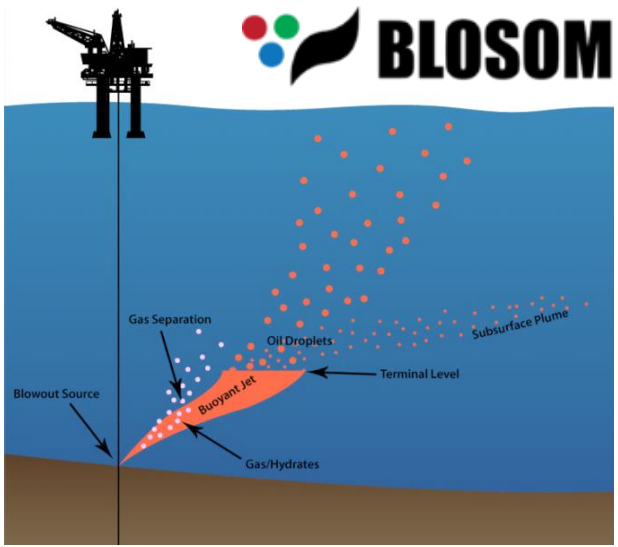


https://edx.netl.doe.gov/offshore

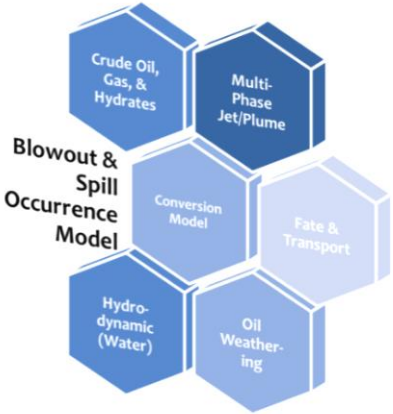
Blowout & Spill Occurrence Model (BLOSOM)

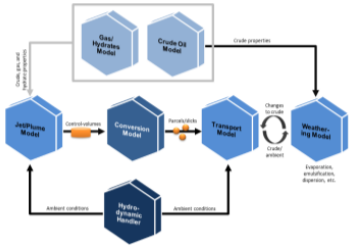
Office of Research and Development

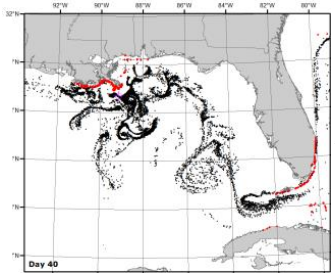
NETL

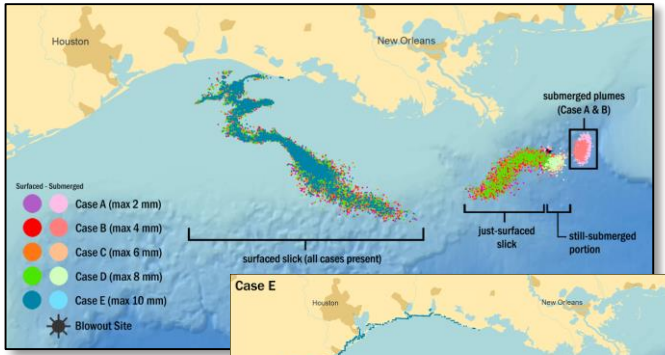


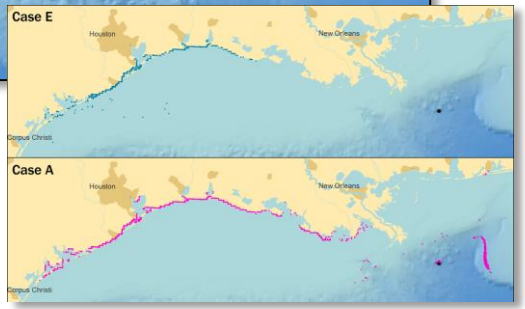
A comprehensive modeling suite for blowout & spill events, adapted for jet/plume behavior, high pressures, gas and hydrate dynamics, droplet-size distributions, and subsurface plume formation





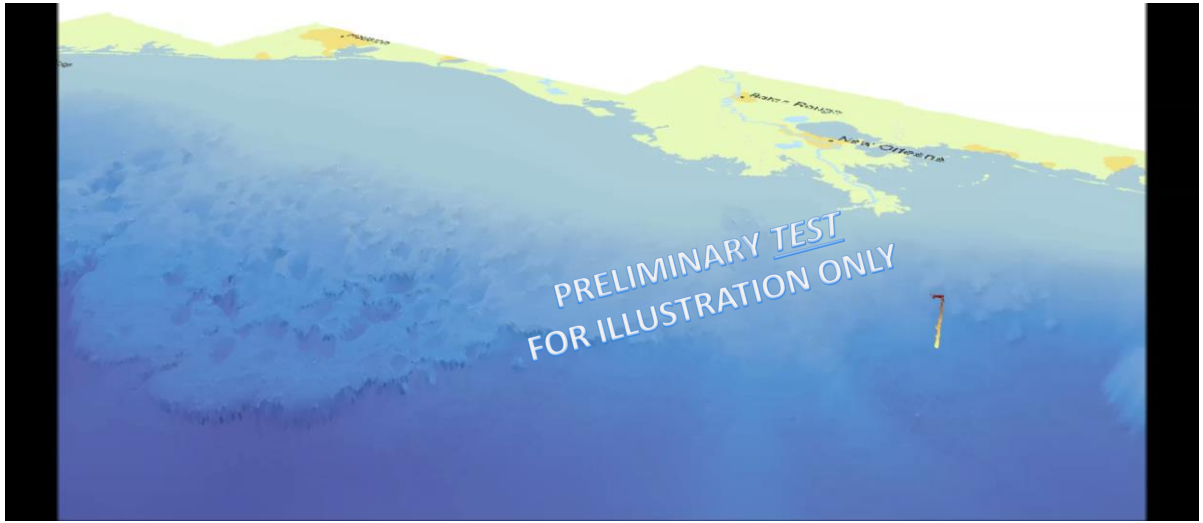


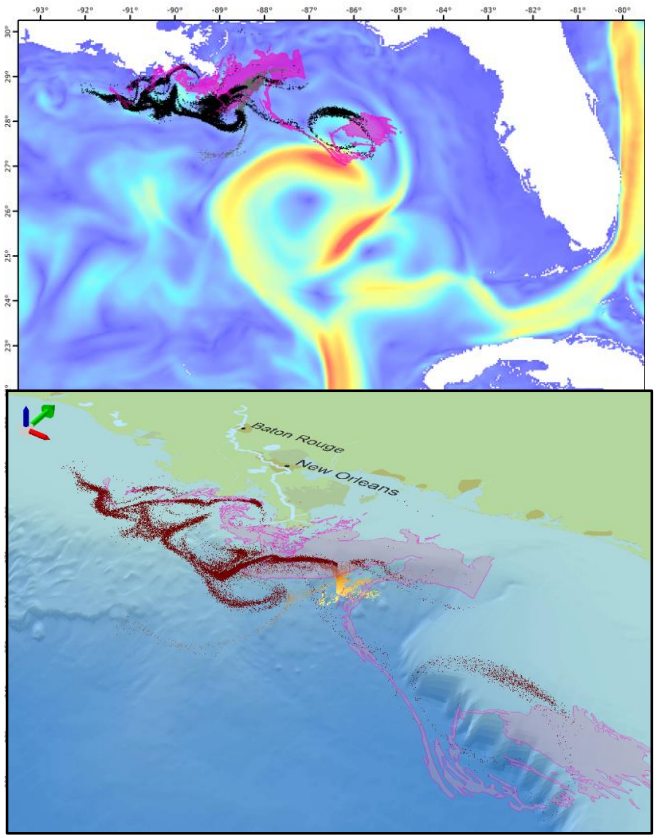




Sim, L.; Graham, J.; Rose, K.; Duran, R.; Nelson, J.; Umhoefer, J.; Vielma, J. ***Developing a Comprehensive Deepwater Blowout and Spill Model***; NETL-TRS-9-2015; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2015; p 44.

BLOSOM Capabilities

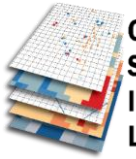


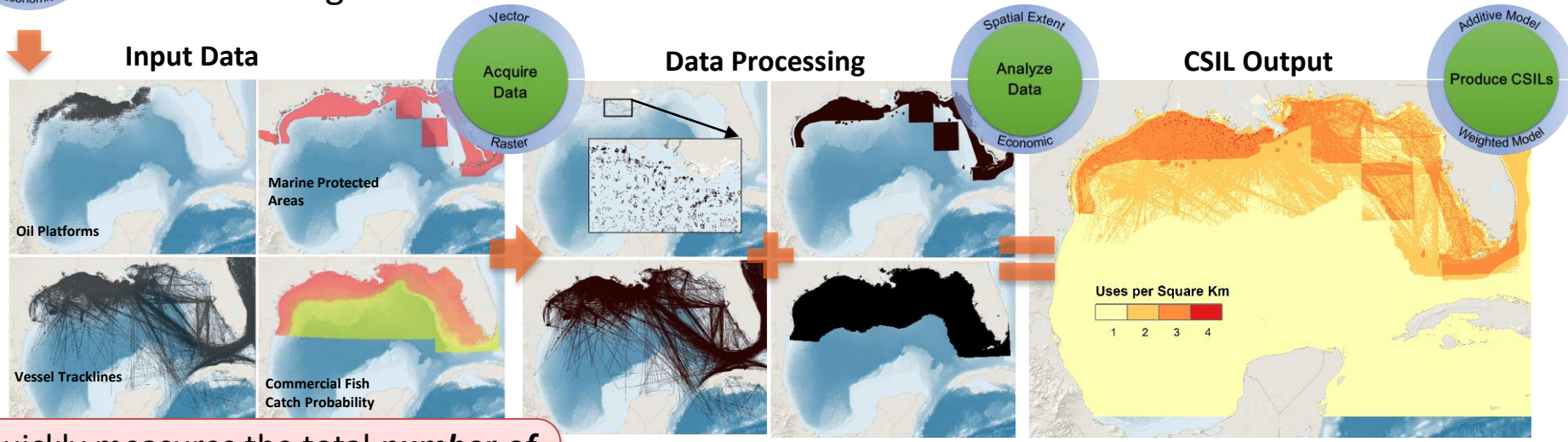


- Ultra-deepwater physics and methodologies
- Advanced modeling of long-lived submerged plumes
- Heavily utilizes task-parallelization for computational efficiency
- Part of international spill model comparison study led by API

Cumulative Spatial Impact Layers (CSILs)

CSILs are a spatio-temporal approach that identifies potential impacts to various socio-economic and environmental actives within a region





Quickly measures the total ***number of activities*** OR the ***estimated value*** (economic, etc.) per unit area (cell)

- Additive or Weighted design
- User-friendly tool
- Works with large volumes of data
- Measures a variety of potential impacts
- Geographically robust

Spatially Weighted Impact Model (SWIM)

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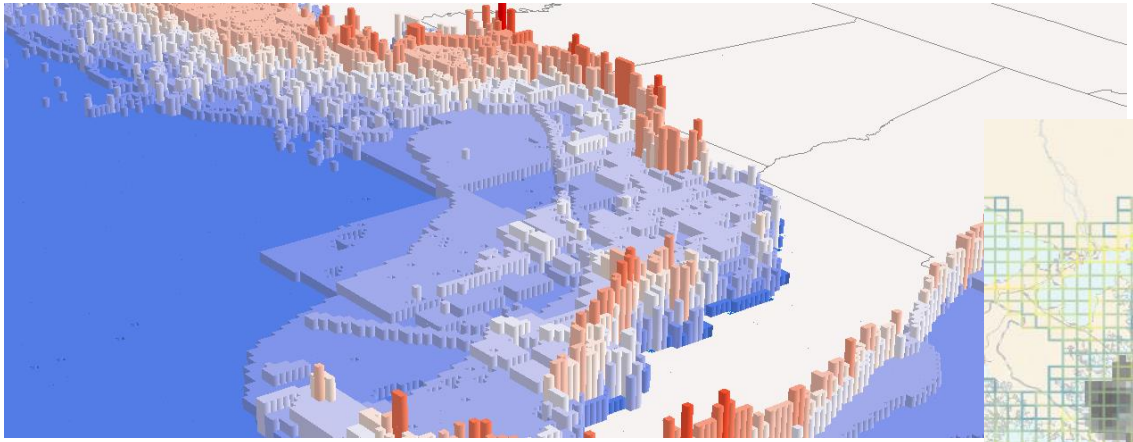
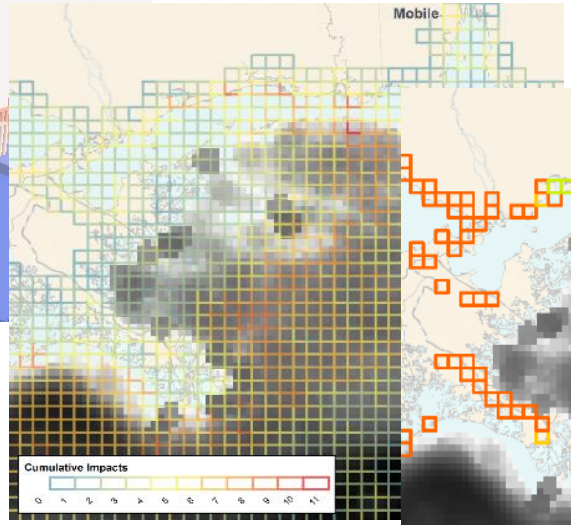
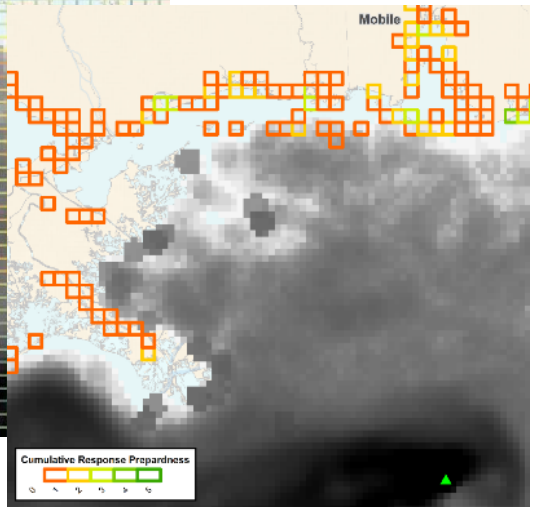
SWIM builds off of the CSIL approach, so that it not only evaluates potential impacts to key socio-economic and environmental activities in an area, but also allows users to rank and compare scenarios



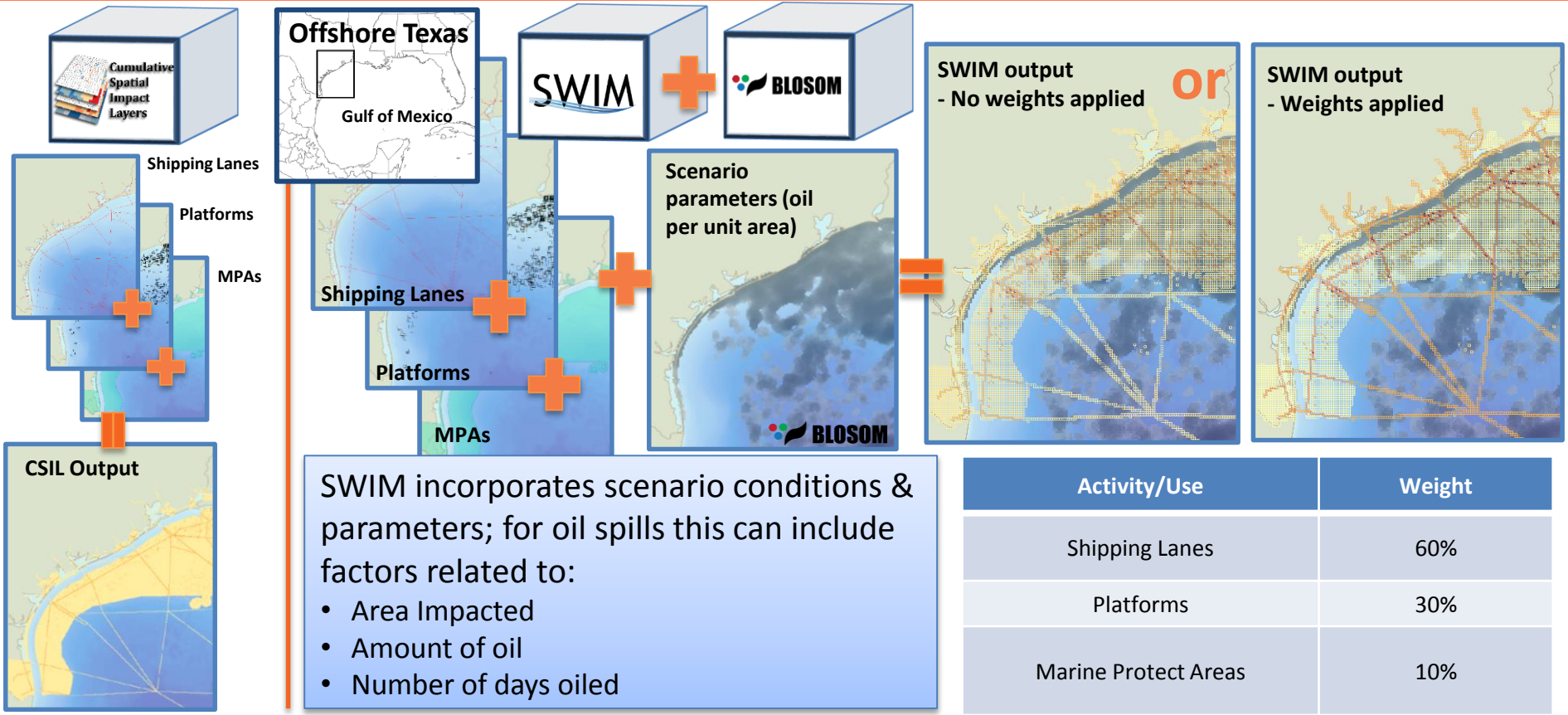




- Applies user-defined weights to impacts to evaluate scenario outcomes
- Utilizes spatial and temporal analyses used to more accurately evaluate interactions and assess potential impacts

Spill modeled by BLOSOM

CSIL Approach versus SWIM



SWIM incorporates scenario conditions & parameters; for oil spills this can include factors related to:

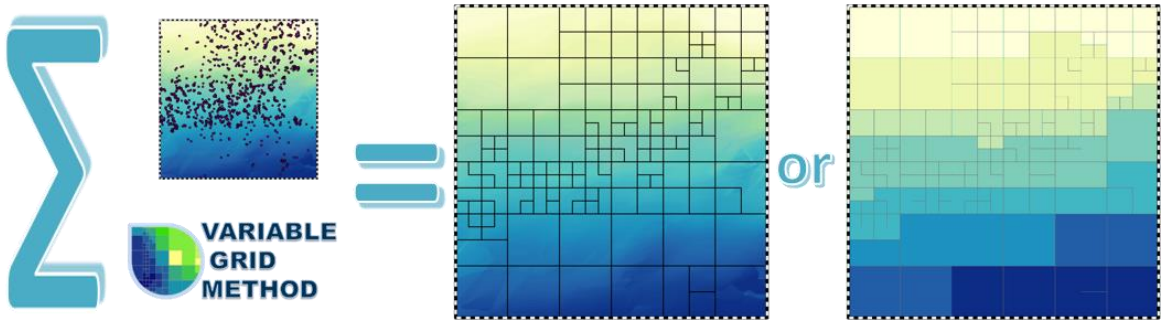
- Area Impacted
- Amount of oil
- Number of days oiled

Activity/Use	Weight
Shipping Lanes	60%
Platforms	30%
Marine Protect Areas	10%

Variable Grid Method (VGM)

Office of Research and Development

Research surrounding offshore and subsurface systems are often plagued with uncertainty. The VGM was designed to better communicate uncertainty by presenting spatial data and uncertainty simultaneously…



Communicates data (via colors) and uncertainty (via grid cell size)

…whilst:

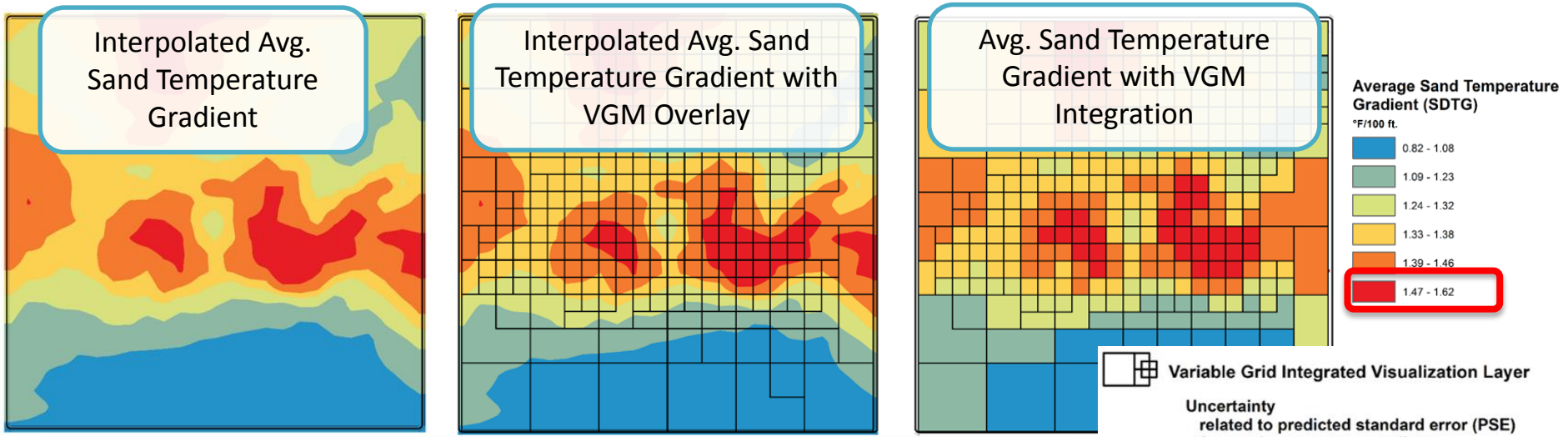
- allowing the ***flexibility*** to use different data types and uncertainty quantifications
- preserving ***overall spatial trends and patterns*** observed within the data, and
- enabling users to ***customize*** the final product to meet their needs and best communicate results in an ***intuitive manner***

Bauer, J.; Rose, K. Variable Grid Method: an Intuitive Approach for Simultaneously Quantifying and Visualizing Spatial Data and Uncertainty. *Transactions in GIS* **2015,** *19*, 377–397.

Using the VGM to Communicate Uncertainty

Office of Research and Development

Let's look at an example, evaluating sand temperature gradients in a region of the Gulf of Mexico without the VGM and with the VGM…



VGM presents uncertainty with spatial data in an ***intuitive manner*** so it can be ***effectively used*** to support various decision-making needs

NETL's Energy Data eXchange (EDX)

The **Energy Data eXchange (EDX)** was developed for NETL/DOE R&D as an ***innovative*** solution to these challenges by offering:

- A secure, online ***coordination and collaboration platform*** supports energy research, knowledge transfer and data needs
- Enduring and reliable ***access*** to historic and current R&D ***data, data driven products, and tools***
- Both ***public*** and ***secure, private*** functionalities

Public Access
Enable knowledge transfer, data reuse & discovery

Secure/Private Access
Support research development, collaboration, & online analytics

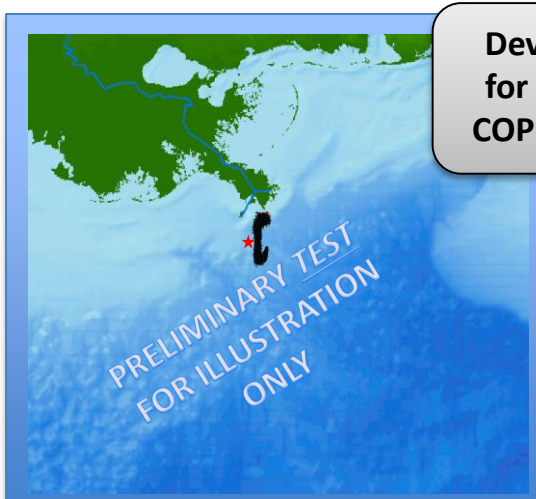
EDX
A Product of NETL

Built by researchers for research

Accessing data and tools online

Geocube integrates key datasets through EDX or allows users to add their own, provides access to built-in geoprocessing, and provides quick tools to share products

Numerous developed datasets, models, and tools are available online, through EDX. In addition to the data, the IAM leverages NETL's **Geocube,** a flexible, customizable Web Mapping Application



Test scenario run to evaluate both BLOSOM and the integrated spatial assessment approach

Development plans aim for Geocube to host the COP for the Offshore IAM

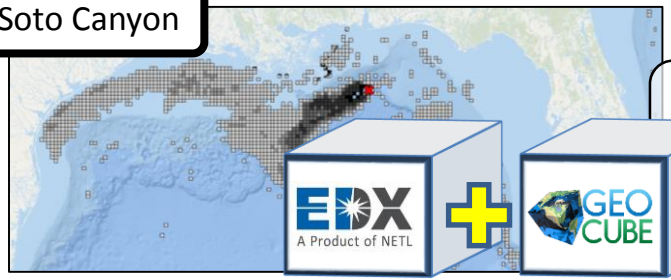
https://edx.netl.doe.gov/offshore

Putting it All Together – Data, Tools & Models

Office of Research and Development

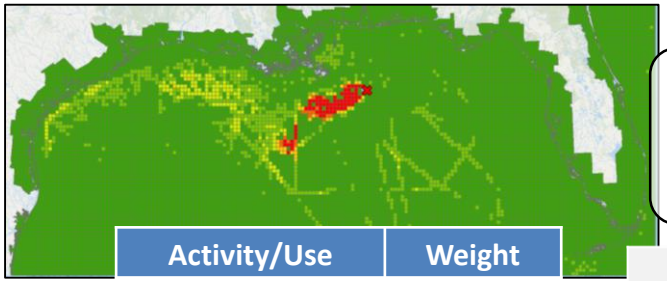
NETL

De Soto Canyon



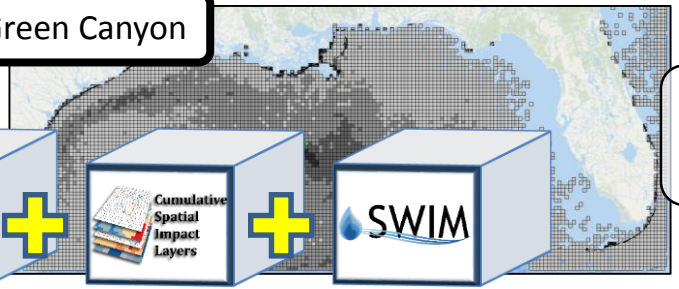
Oil Released (bbl)

EDX A Product of NETL + GEO CUBE + BLOSOM



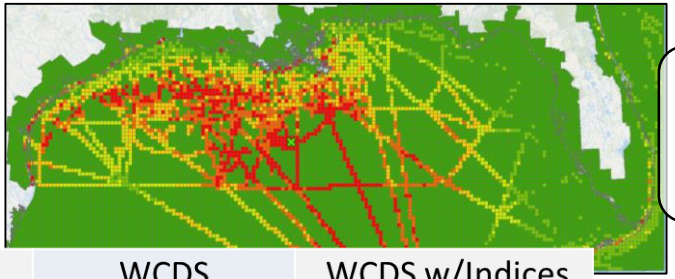
Sum Sectors Impact Value

Green Canyon



Oil Released (bbl)

BLOSOM + Cumulative Spatial Impact Layers + SWIM



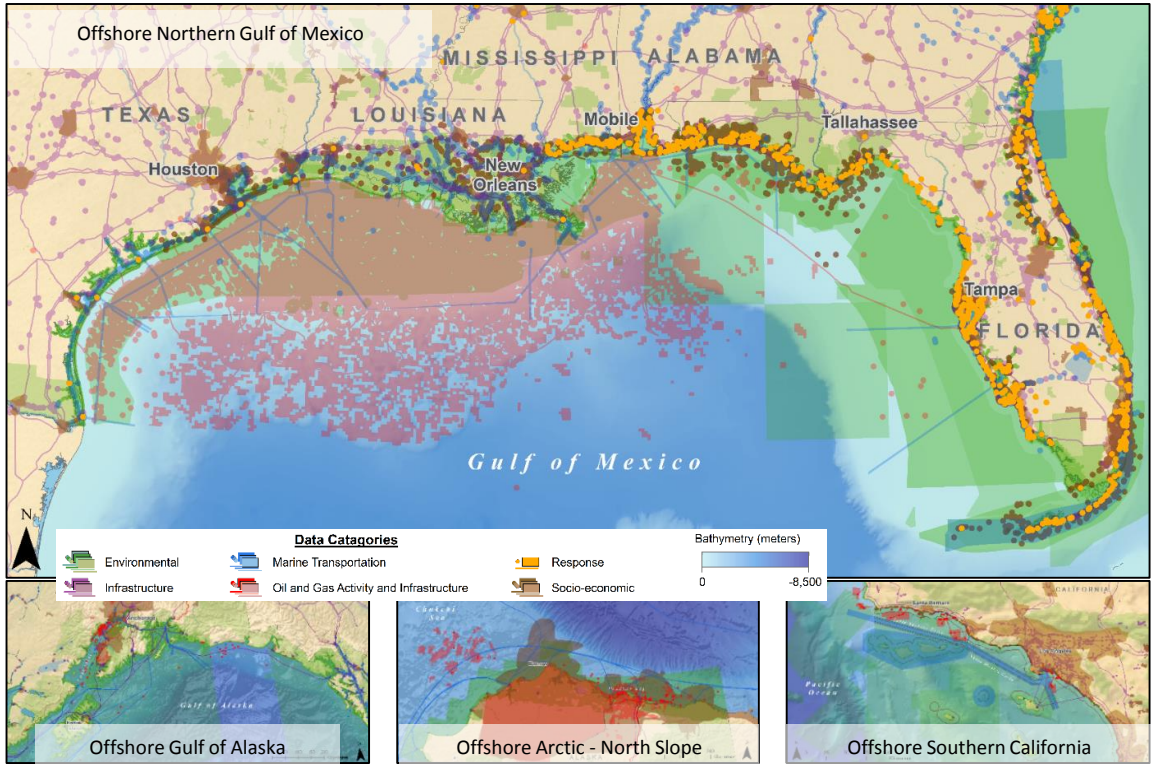
Sum Sectors Impact Value

Activity/Use	Weight
Commercial Transportation	60%
Tourism	30%
Response	10%

	WCDS	WCDS w/Indices
	Final Rank Value	Final Rank Value
De Soto Canyon	5	4
Green Canyon	3	2

Working with Complex, Big Data

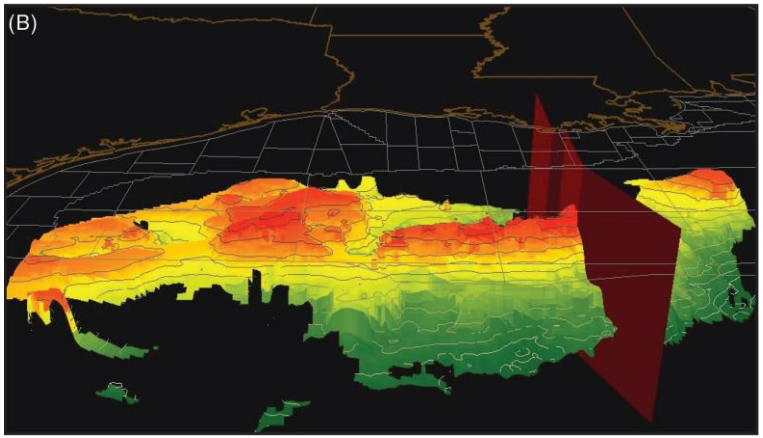
- Accumulated almost 500,000 authoritative datasets for multiple offshore regions in the U.S., covering the subsurface, water column, and coastal regions
- Data are in numerous formats, dimensions & spatio-temporal extents
- These data drive the models, tools & approaches



https://edx.netl.doe.gov/offshore

Next steps – Advanced Geoscience Computing

As studies evolve from macroscale to exascale, the need to efficiently & effectively incorporate, analyze & visualize multi-dimensional data becomes even more important



Our next steps focus on integrating advanced computational approaches, and pushing the boundaries of existing 3D/4D analytical techniques to address questions within engineered-natural systems

Thank you!

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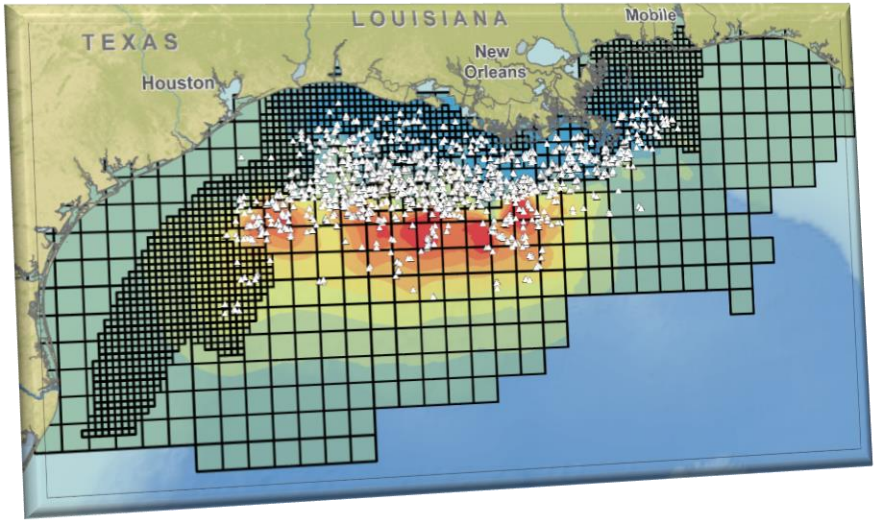
For more information on our research, tools, and models in the offshore portfolio:
https://edx.netl.doe.gov/offshore/



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AECOM ORISE OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION Mid-Atlantic Technology, Research & Innovation Center MATRIC

Outreach & Additional Resources

Bauer, J. R., and Rose, K., 2015, **Variable Grid Method: an Intuitive Approach for Simultaneously Quantifying and Visualizing Spatial Data and Uncertainty**, *Transactions in GIS*. 19(3), p. 377-397

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

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

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)

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

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

Sim, L.; Graham, J.; Rose, K.; Duran, R.; Nelson, J.; Umhoefer, J.; Vielma, J. ***Developing a Comprehensive Deepwater Blowout and Spill Model***; NETL-TRS-9-2015; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Albany, OR, 2015; p 44.

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