ADVANCED RISK AND IMPACT MODELS FOR OFFSHORE SYSTEMS

BACKGROUND

Motivation for this project stems from the advancement of offshore oil and gas operations into extreme offshore environments that are often remote, environmentally sensitive, and economically challenging. The lessons learned from the Department of Energy (DOE) and National Energy Technology (NETL) involvement in Hurricanes Rita and Katrina and the 2010 Deepwater Horizon oil spill (Macondo blowout) in the Gulf of Mexico were also impetuses for the development of the project. These events highlighted the need for improved models, data, and tools to identify knowledge and technology gaps with offshore hydrocarbon exploration and production (E&P) systems to help prevent future spills and provide predictions for a range of end-users.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

PROJECT GOAL AND OBJECTIVES

The goal of this project is to develop an integrated modeling and data system from the subsurface to the shore. The objectives are to evaluate potential risks and identify knowledge and technology gaps to improve offshore spill prevention efforts.

PROJECT DESCRIPTION

This project will provide data, tools, and techniques to help evaluate potential risks and identify possible knowledge and technology gaps in the offshore system using science-based, data-driven assessments. The tools and techniques involved leverage advanced big data science and computing to innovate and advance the understanding of spatial and temporal behaviors and relationships for engineered-natural, multi-variate systems. These products can be used individually or in combination to support the analysis of subsurface, wellbore, and water column to evaluate relationships, trends, and risks of offshore spills, and uncertainty.

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Building on DOE's core competency of simulating and predicting the behavior of engineered-natural systems, NETL researchers developed a new multi-component Offshore Risk Model (ORM), which ties the data related to subsurface, wellbore, and water column into an integrated assessment model. ORM relies on the synthesis of data—from the subsurface to the shore—to develop innovative tools and approaches to drive analyses that effectively evaluate and reduce risks associated with extreme offshore hydrocarbon development.

The data has been collected and integrated into NETL's Energy Data eXchange (EDX), providing a single point of discovery and access. Details on these datasets are discussed in the document "Integration of Spatial Data to Support Risk and Impact Assessments for Deep and Ultra-deepwater Hydrocarbon Activities in the Gulf of Mexico."

Along with discovery and access to data via EDX, users can visualize data using NETL's GeoCube, a custom web-based mapping application. GeoCube supports basic spatial and temporal analysis, allowing users to quickly identify overall trends and patterns in the data, as well as share these discoveries with others using various export functions (print, snapshot, and extract data).

In addition, data has been used to develop five science-based, data-driven tools and models for the ORM to support the evaluation and reduction of risks and uncertainty associated with extreme offshore hydrocarbon development (Figure 1). These five tools and models address concerns or needs from the subsurface, wellbore, and water column to evaluate relationships, trends, risks of offshore spills, and uncertainty.

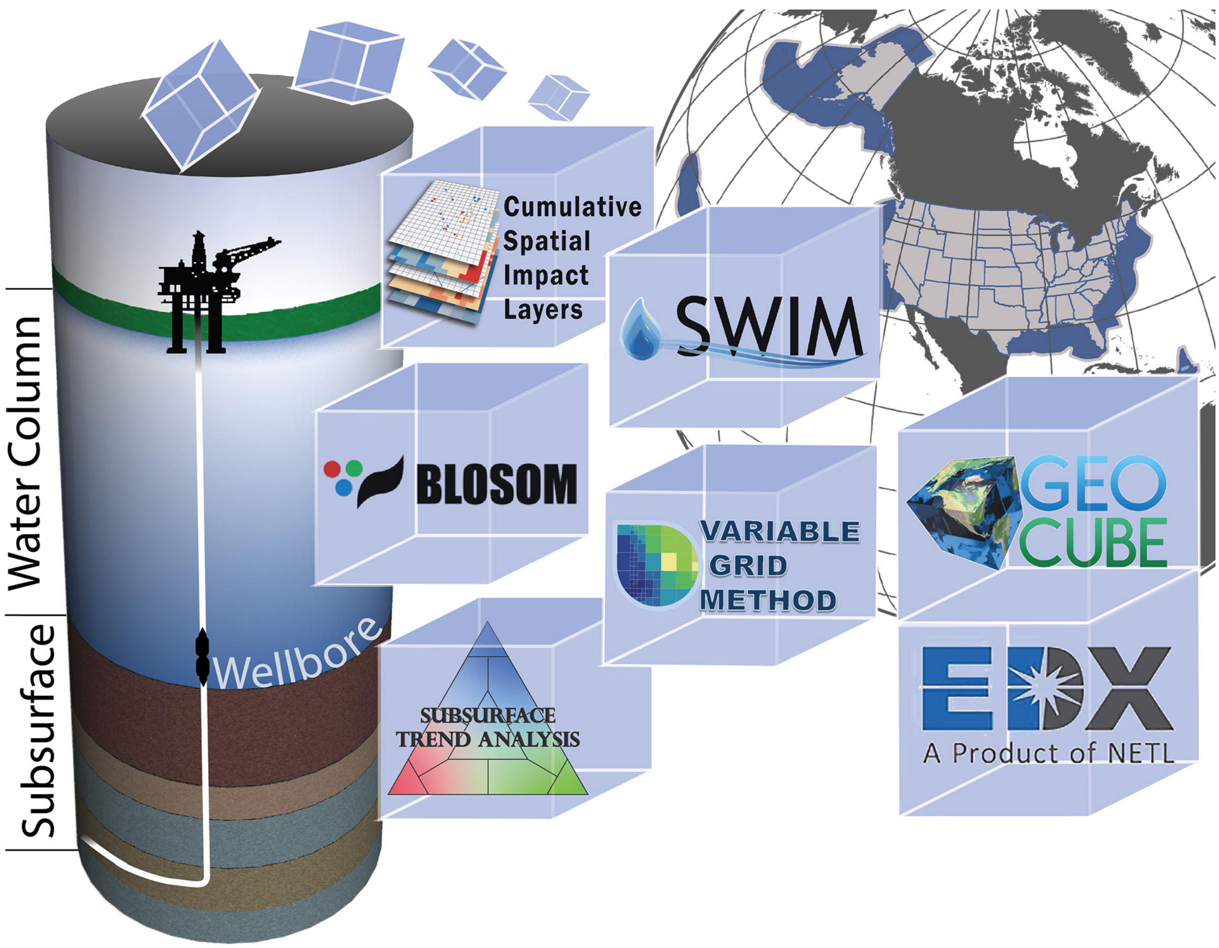

Figure 1. Example worst case discharge analysis using a combination of the Offshore Risk Model capabilities. Forecast and analysis using hypothetical spill simulated using BLOSOM (gray scale) and potentially impacted resources assessed and analyzed using CSIL, SWIM, EDX and Geocube served information. Helps assess vulnerabilities to environment, transportation, tourism, and other factors as well as risks and costs to operations.

The tools are: (1) Subsurface Trend Analysis (STA)—a data-driven approach for improving geologic knowledge and reducing subsurface uncertainty; (2) BLOwout and Spill Occurrence Model (BLOSOM)—a 4D fate and transport model for simulating oil spills to support spill prevention and provide a greater understanding of how hydrocarbon leaks from all sources are transported throughout offshore systems; (3) Cumulative Spatial Impact Layers (CSIL)—a spatial-temporal approach for rapidly quantifying potential impacts; (4) Spatially Weighted Impact Model (SWIM)—a decision support tool driven by multi-variate relationship models and user-defined weights; and (5) Variable Grid Method (VGM)—an approach for quantifying and visualizing uncertainty associated with spatial data.

The five tools and models can be used individually or together to contribute to DOE's integrated risk assessment modeling effort for offshore hydrocarbon systems, which aims to reduce uncertainty and improve science-based decision-making for stakeholders involved in supplying safe and reliable domestic energy.

ACCOMPLISHMENTS

The suite of data and tools from the ORM have been applied to a range of research problems and decision scenarios. Since the start of this project, over 6 terabytes of authoritative data have been collected and incorporated into EDX. Several of the ORM tools and models are under final testing and will undergo external reviews before they are released on EDX. A patent application has been made as the result of these tools, models, and products.

Several tools and models from the ORM have been applied at NETL to evaluate and reduce risks associated with extreme offshore hydrocarbon development. Analyses are being performed to predict subsurface geologic properties, such as pressure, temperature, porosity, and permeability in offshore regions for which there is little or no data. Using data from EDX and GeoCube coupled with the STA and VGM, these predictions will help fill knowledge gaps, reduce geologic uncertainty, and support decision-making needs for a range of industry, regulatory, and research stakeholders (Figure 2).

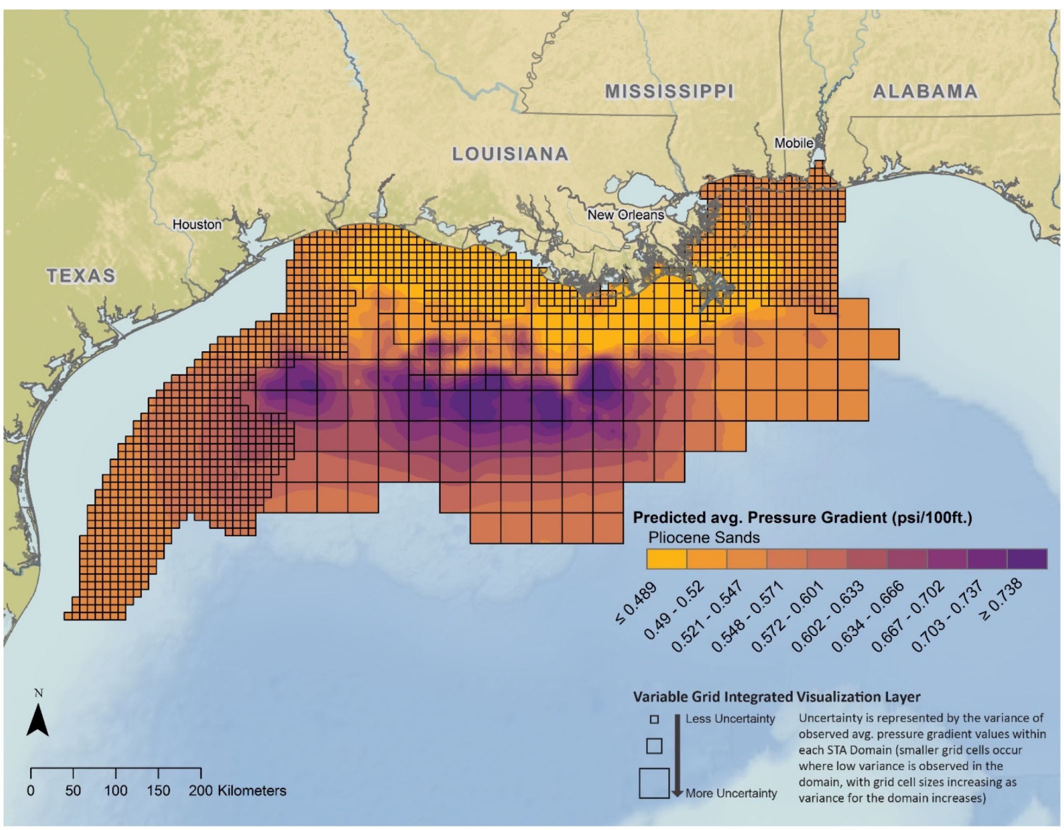

Figure 2. Example of an Offshore Risk Model analysis to reduce subsurface uncertainty. In this analysis ORM tools and data were used to predict the subsurface pressure gradient (psi/100 ft) within Pliocene sands in the Gulf of Mexico (color scale). In addition, the variability of those predicted pressure gradient values (grid cell sizes) are shown simultaneously to help constrain uncertainty about the system. This analysis used a combination of EDX, GeoCube, STA, and VGM components of the ORM.

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ORM tools and models are also being used to assess large scale spatial and temporal trends associated with simulated oil spills and the potential social, economic, and environment impacts each simulation could pose (Figure 3).

For additional information, we invite you to visit
https://edx.netl.doe.gov/offshore

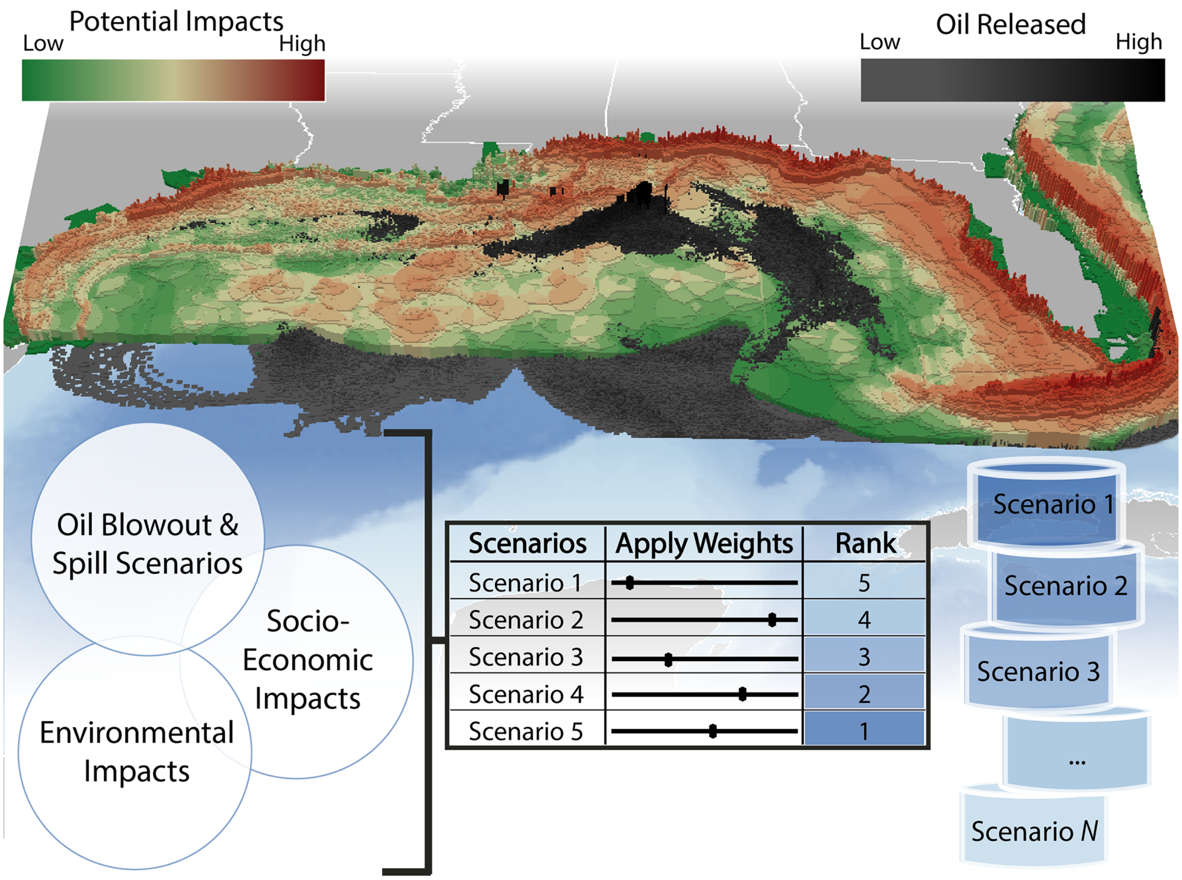

Figure 3. Schematic representation of the Offshore Risk Modeling components that can be configured to address a range of end-use, data-science driven questions and produce analyses to reduce uncertainty and assess the complex systems associated with offshore oil and gas operations. The ORM was developed to support data-science driven technology and knowledge assessments, identify gaps, assess trends and relationships, and drive efficiencies and break throughs to improve secure and reliable access to offshore resources.

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