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. Lessons learned from the U.S. DOE and NETL involvement in Hurricanes Rita and Katrina and the 2010 Deepwater Horizon oil spill (Macondo blowout) in the Gulf of Mexico were also drivers 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

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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

Building on DOE's core competency of simulating and predicting the behavior of engineered-natural systems, NETL researchers developed the innovated multi-component Offshore Risk Modelling (ORM) suite of techniques, tools and models, which tie the data related to subsurface, wellbore and water column into an integrated assessment model. Using science-based and data-driven assessments, the ORM contains validated tools and models capable of evaluating potential risks and identifying possible knowledge and technology gaps in the offshore system. The tools and techniques involved leverage advanced big data science and computing to advance the understanding of spatial and temporal behaviors and relationships for engineered-natural, multi-variate systems. Products of the ORM can be used individually or combined to support the

R&D208, June 2019

analysis of subsurface, wellbore and water column to evaluate relationships, trends and risks of offshore spills, and uncertainty. ORM relies on the synthesis of data—from the subsurface to the shore—to develop innovative tools and approaches to drive analyses that effectively evaluates and reduces 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 six 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 six tools and models address concerns or needs from the subsurface, wellbore, and water column to evaluate relationships, trends, risks of offshore spills, and uncertainty.

The tools are: (1) Subsurface Trend Analysis™ (STA)—a data-driven approach and soon-to-be tool 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

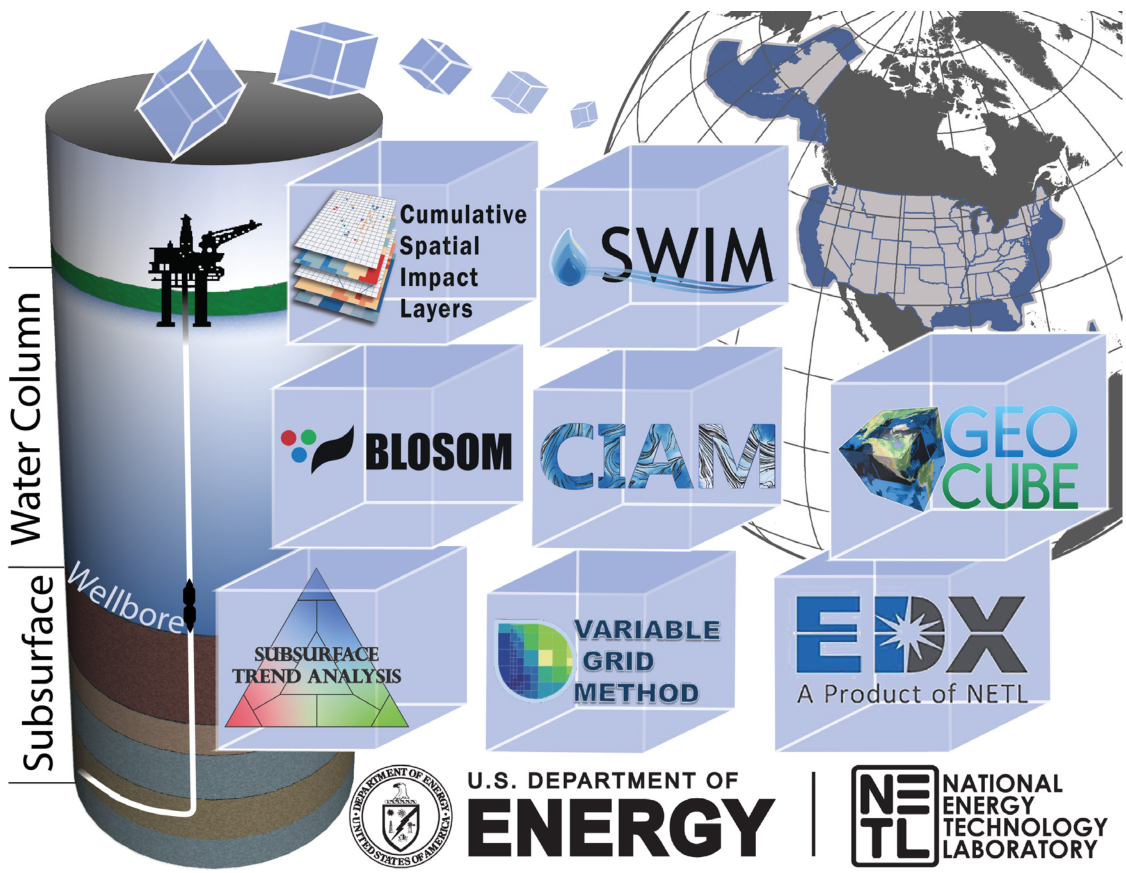

Figure 1. Schematic representation of the ORM components that can be configured to address a range of end-use, data-science driven questions and produce analyses to reduce uncertainty and assess the complex systems associated with offshore oil and gas operations. The ORM was developed to support data-science driven technology and knowledge assessments, identify gaps, assess trends and relationships, and drive efficiencies and breakthroughs to improve secure and reliable access to offshore resources.

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 GIS-based tool 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, (5) Variable Grid Method© (VGM)—an approach for quantifying and visualizing uncertainty associated with spatial data, and (6) Climatological Isolation and Attraction Model (CIAM)–a data-driven, rapid response tool that applies mathematical theories of dynamic systems with metocean data to predict where oil (or debris, hazardous waste, etc) is likely to go.

These tools and models can be used individually or together to contribute to DOE's integrated risk assessment modeling effort for offshore hydrocarbon systems 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, more than six terabytes of authoritative data have been collected and incorporated into EDX and GeoCube. BLOSOM, VGM and CSIL have been released via EDX. The remaining tools and models are under final testing and will undergo external reviews before they are released. Four of the tools (BLOSOM, CSIL, SWIM and STA) have trademarks and VGM has a copyright. In addition, journal publications and technical reports on BLOSOM, VGM, STA, CIAM and CSIL have been published, with links to manuscripts located here: https://edx.netl.doe.gov/offshore/research-products/.

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

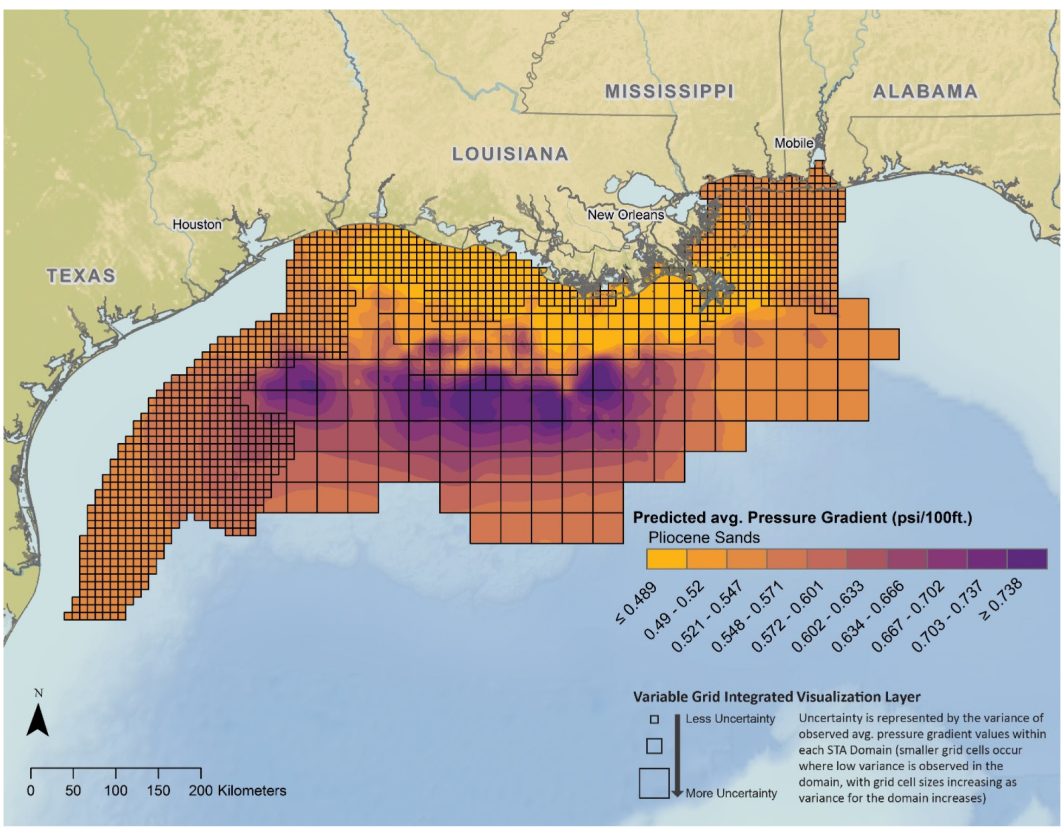

Figure 2. Example of an ORM analysis to reduce subsurface uncertainty. In this analysis, ORM tools and data were used to predict the subsurface pressure gradient (psi/100 ft) within Pliocene sands in the Gulf of Mexico (color scale). In addition, the variability of those predicted pressure gradient values (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.

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).

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

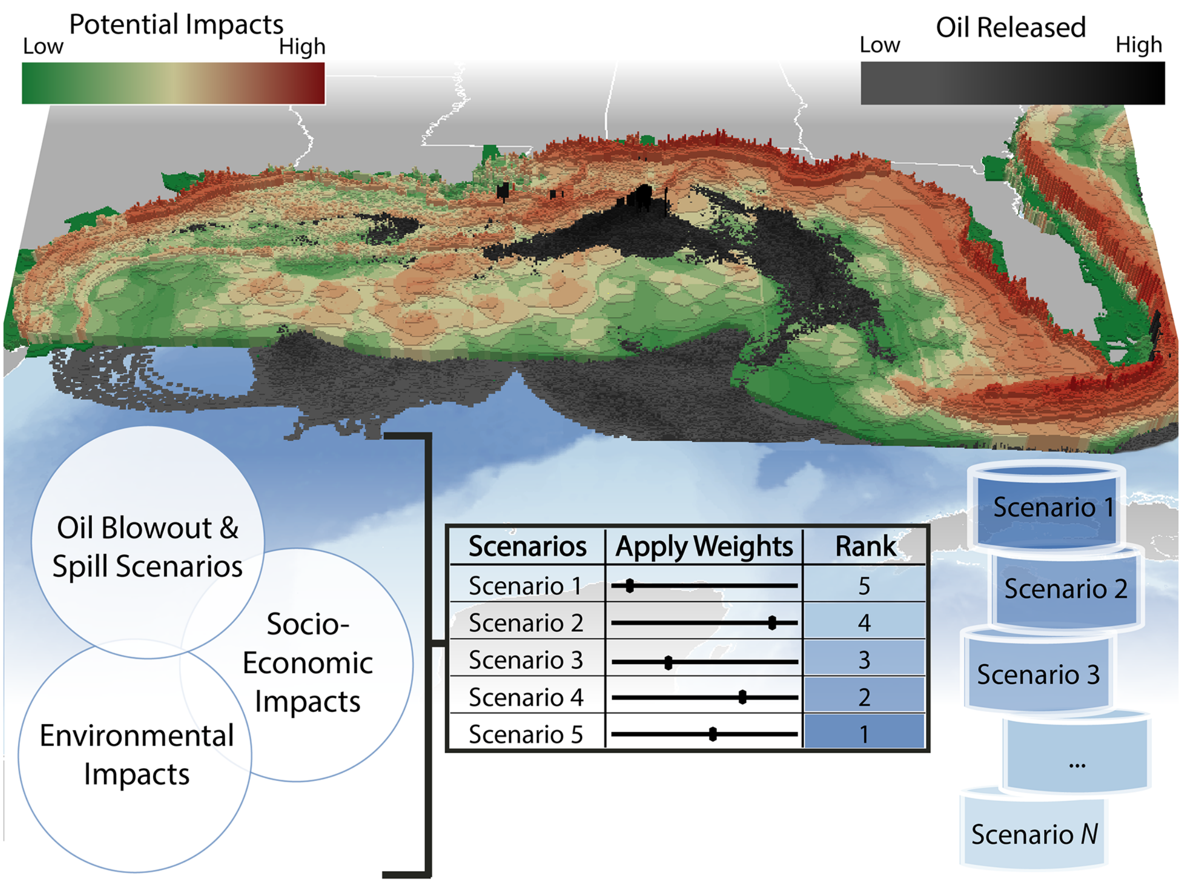

Figure 3. Example of worst case discharge analysis using a combination of the ORM capabilities. Hypothetical oil spills are simulated with BLOSOM (grey bars) and validated using CIAM forecasts. Resources potentially impacted by the hypothetical spill event and any available response can be spatially evaluated with CSIL, the resulting summarized spill, impact (green to red gradient bars), and response information can be compared and ranked against other scenarios using SWIM. All of the data and tools throughout the processes are served up by EDX and visualized via Geocube. The ORM capabilities helps assess vulnerabilities to environment, transportation, tourism and other factors as well as risks and costs to operations.

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