Virtual Learning Environment for Geological Storage Applications

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Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications

Abstract

The Science-informed Machine Learning for Accelerating Real-Time Decisions in Subsurface Applications (SMART) platform is a cutting-edge user interface designed to enhance decision-making processes in subsurface applications.

The SMART platform integrates various modules through the SMART Tools Rapid Visualization Environment (STRIVE) framework, offering a suite of advanced tools tailored for real-time data analysis and visualization.

The SMART platform provides a systematic method for assessing robust visualization, enabling users to interact with data through intuitive graphical interfaces, and a set of specialized tools designed for rapid data processing and interpretation.

Introduction

The SMART Initiative is a DOE-FECM funded project. The objective is to showcase how the utilization of Machine learning (ML) can significantly improve efficiency and effectiveness of field-scale commercial carbon storage operations in three main areas:

- ❑ Real-time visualization
- ❑ Virtual learning
- ❑ Real-time forecasting

This poster presents the status of SMART tools for demonstrating: (1) virtual learning during the pre-injection permitting phase, and (2) ML-assisted operational decision making and visualization.

The SMART tools and workflows will be made available as open-source packages and contribute to the deployment of commercial-scale geologic carbon storage projects along multiple fronts:

(a) Enabling dramatic improvements in the visualization of key subsurface features and flows,
(b) Creating a computer-based experiential learning environment to improve field development and monitoring strategies, and
(c) Transforming storage reservoir management by rapid analysis of real-time data and rapid forward prediction under uncertainty to inform operational decisions.

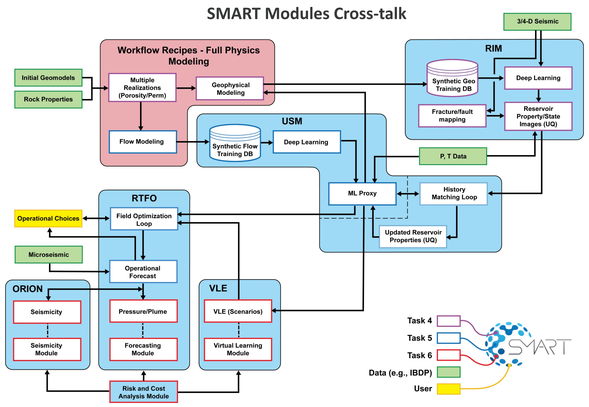
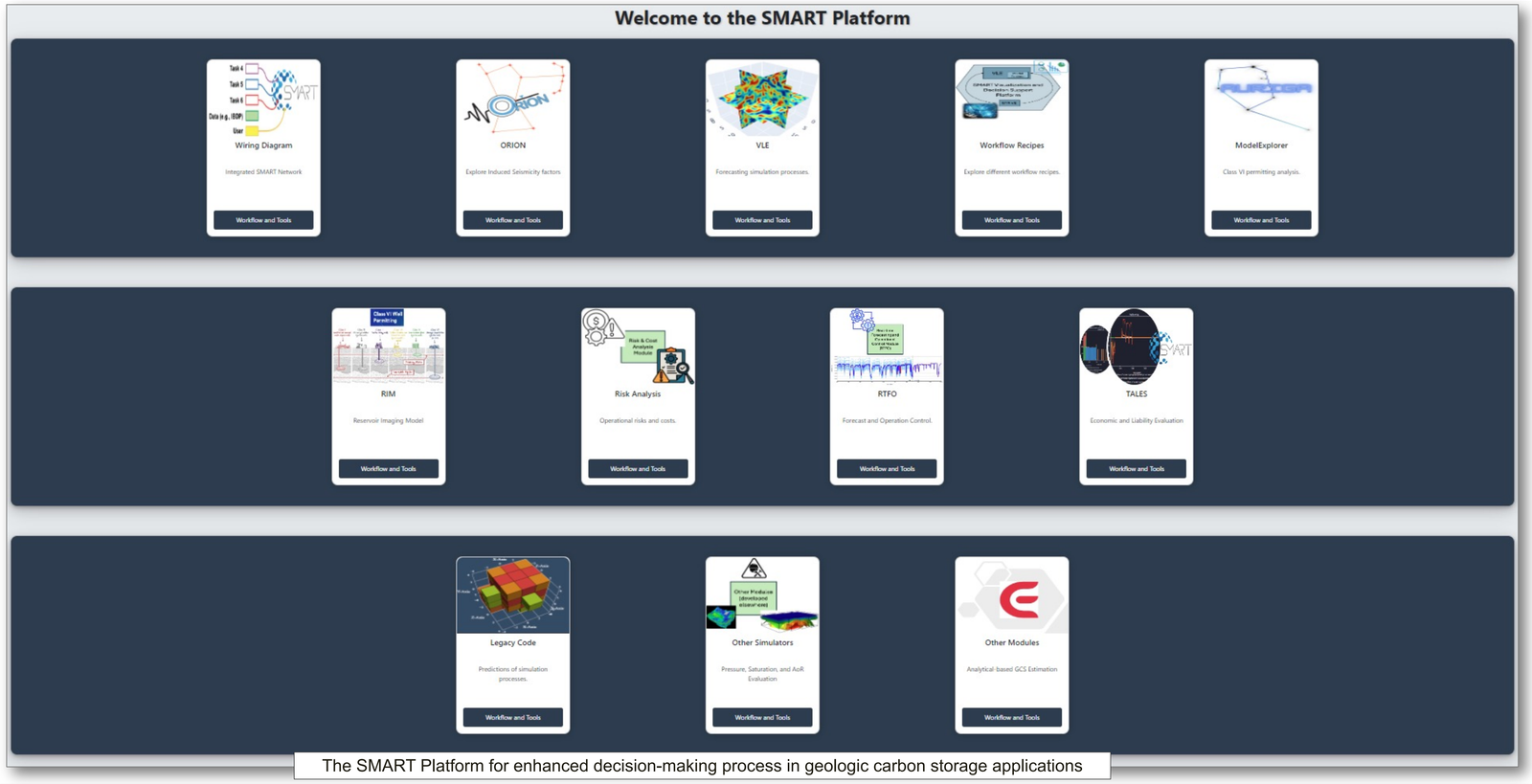


Figure 1: Workflow recipes of SMART modules and tools interaction

Conclusions

The SMART platform is a robust visualization environment, enabling users to interact with data through intuitive graphical interfaces, and a set of specialized tools designed for rapid data processing and interpretation.

The components of the SMART platform work synergistically to support a range of subsurface carbon storage scenarios and monitoring.



The SMART Platform for enhanced decision-making process in geologic carbon storage applications

Figure 2: Interface of ORION SMART Tool

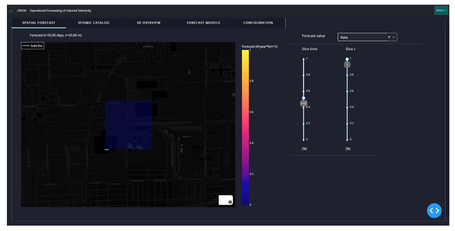
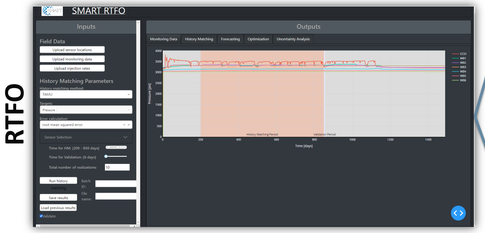
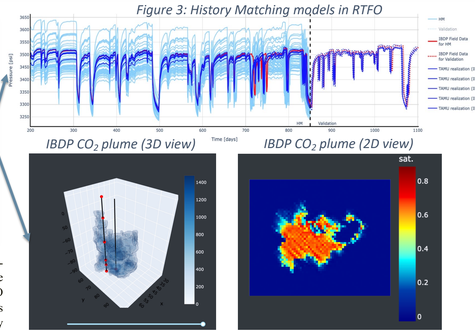


Figure 2: Interface of RTFO SMART Tool



RTFO: The RTFO is a cutting-edge software tool designed to enhance real-time decision-making in geologic carbon storage projects. RTFO is integrated with advanced machine learning models, optimization algorithms, and interactive data visualization tools. RTFO provides a robust platform for managing and analyzing reservoir data. The tool supports both browser-based and virtual reality interfaces, enabling users to interact seamlessly with machine-learning accelerated reservoir simulators.

Figure 3: History Matching models in RTFO



VLE

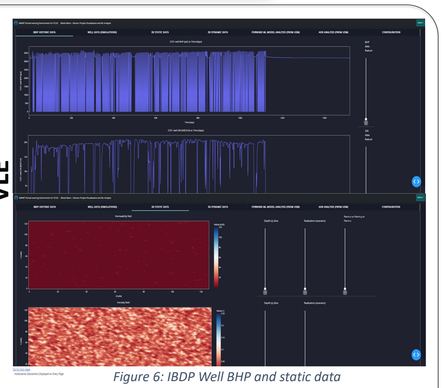


Figure 6: IBDP Well BHP and static data

VLE (Virtual learning environment module) translates technical results from numerical simulations and machine learning (ML) models into actionable decision support for developers, operators, regulators, and stakeholders. VLE addresses critical questions about CO_2 storage, including current CO_2 locations, strategies for handling CO_2 migration, and plume evolution.

VLE enables users to explore what-if scenarios and understand the impacts of altered inputs on reservoir simulations and ML models. Tested with data from the Illinois Basin – Decatur Project (IBDP), VLE aids users in exploring changes in pressure and saturation over time based on injection rates and permeability profiles, integrating data from unified simulation modules-based ML models.

Model Explorer

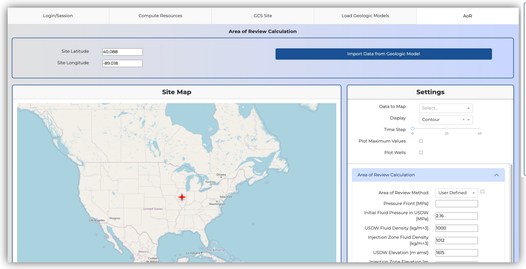


Figure 4: Interface of Model Explorer SMART Tool

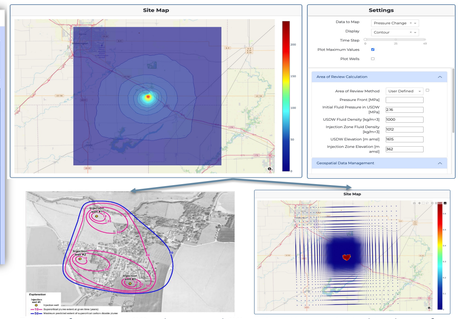


Figure 5: AoR of pressure, CO_2 plume, and CO_2 saturation projected to the surface

Model Explorer is to assist the CCS Class VI well permit process. It is a tool that leverage machine learning, surpassing the existing standards by accurately characterizing critical parameters like faults, fractures, injection zones, and confining system. Accessible through the SMART platform interface, users are able to perform real-time scenario analysis of the Area of Review.

The Model Explorer addresses key aspects of the Class VI well review process, including Site Characterization, Area of Review (AoR), Corrective Action, Testing and Monitoring, and Post-Injection Site Care (PISC) and Closure.

The image shows preloaded data from the IBDP site.

Acknowledgement

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