

Unified Simulation Module (USM): A Data Handling Framework for Field and ML-based Data in Geologic Carbon Storage Applications



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

Executive Summary

USM offers a standardized workflow for data handling and surrogate ML model executions related to carbon storage applications. This tool forms the backbone of visualization tools in SMART.

Tool Features

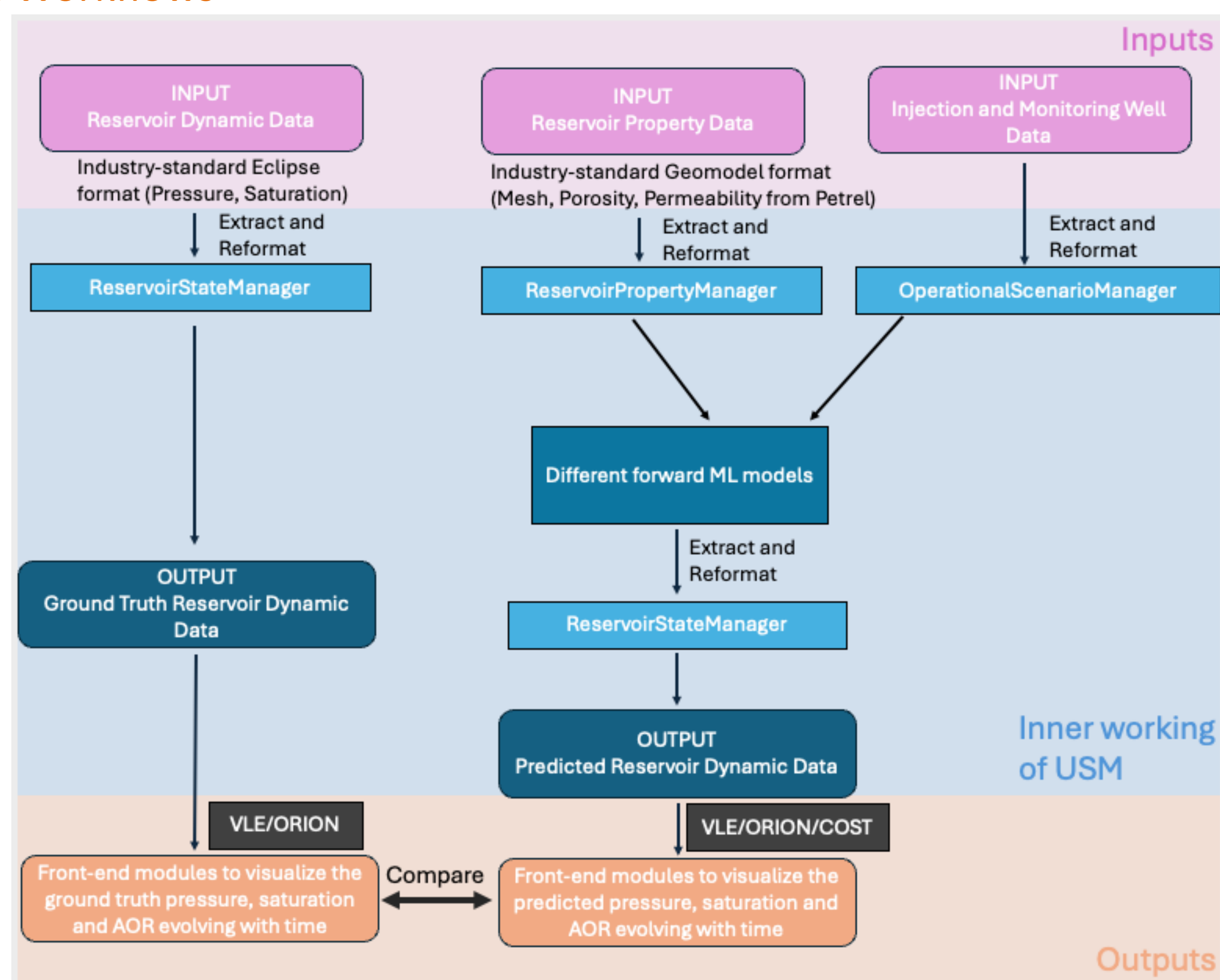
Data Managers – data extraction and management from industry-standard geologic and reservoir model data formats

- (1) Reservoir Property Manager
 - Holds static reservoir property data: e.g., porosity and permeability
- (2) Reservoir State Manager
 - Holds dynamic reservoir data: e.g., pressure and CO₂ saturation
- (3) Operational Scenario Manager
 - Holds data from injection and monitoring wells: e.g., injection rate and bottomhole pressure

ML-based surrogated models

- (1) Reservoir simulator for rapid prediction of reservoir responses

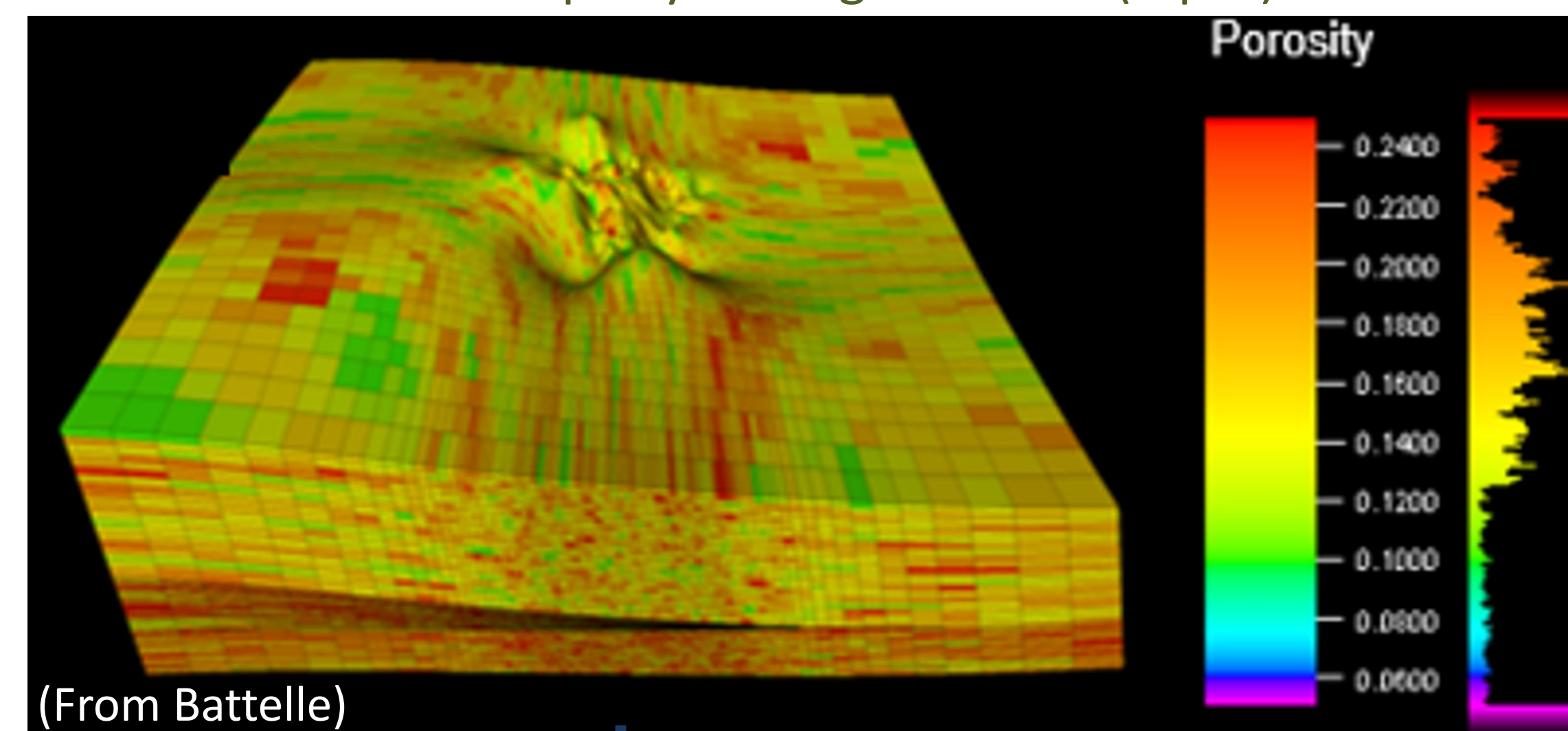
Tool Workflows



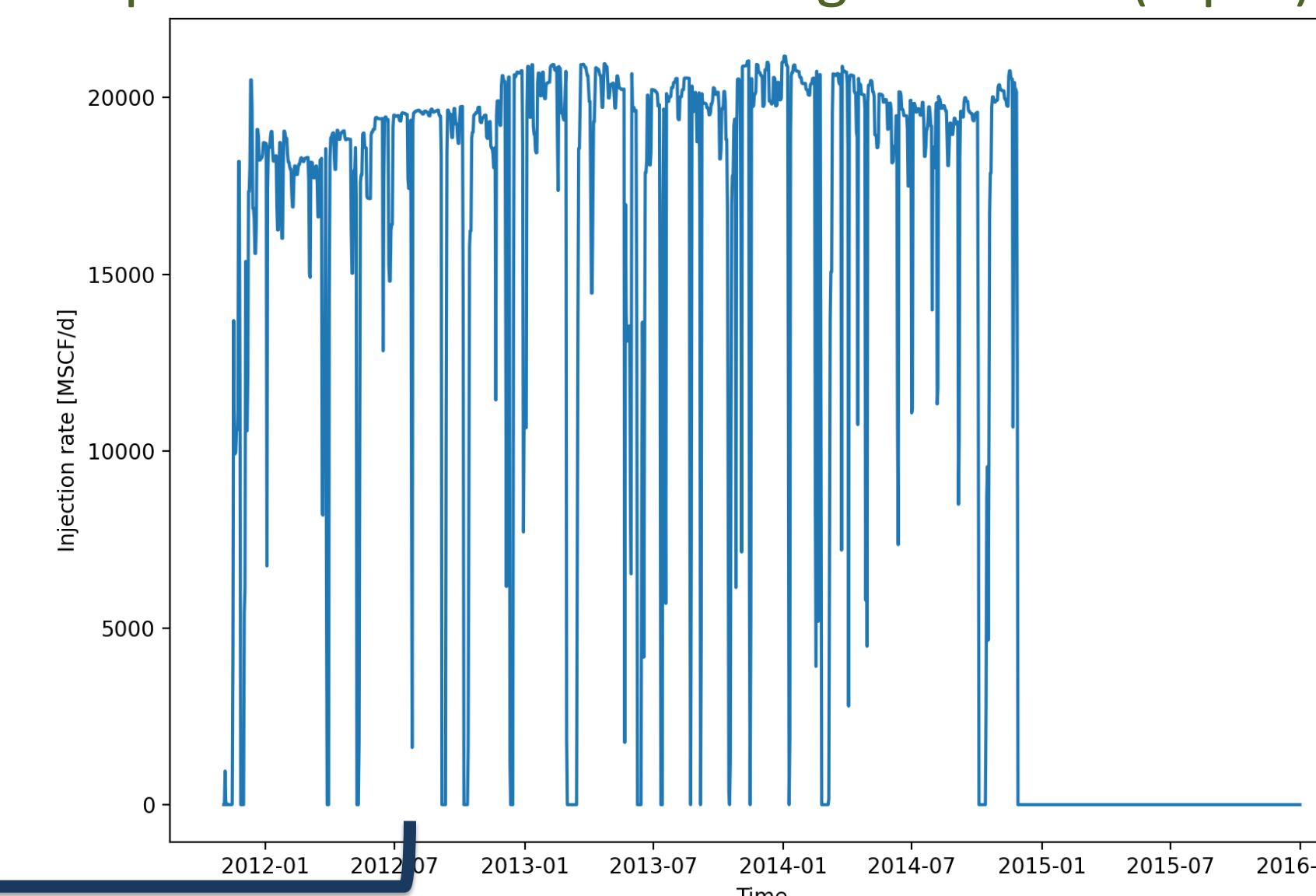
Example Usage - Illinois Basin Decatur Project (IBDP)

- Static geomodel dimension: 126 X 125 X 110 (x, y, z)
- Dynamic model dimension: 126 X 125 X 110 X 50 (x, y, z, t)
- Injection started on Nov 17th, 2011 and was completed successfully on Nov 26th, 2014 with a total volume of 999,231 tons.

Reservoir Property Manager in USM (Input)

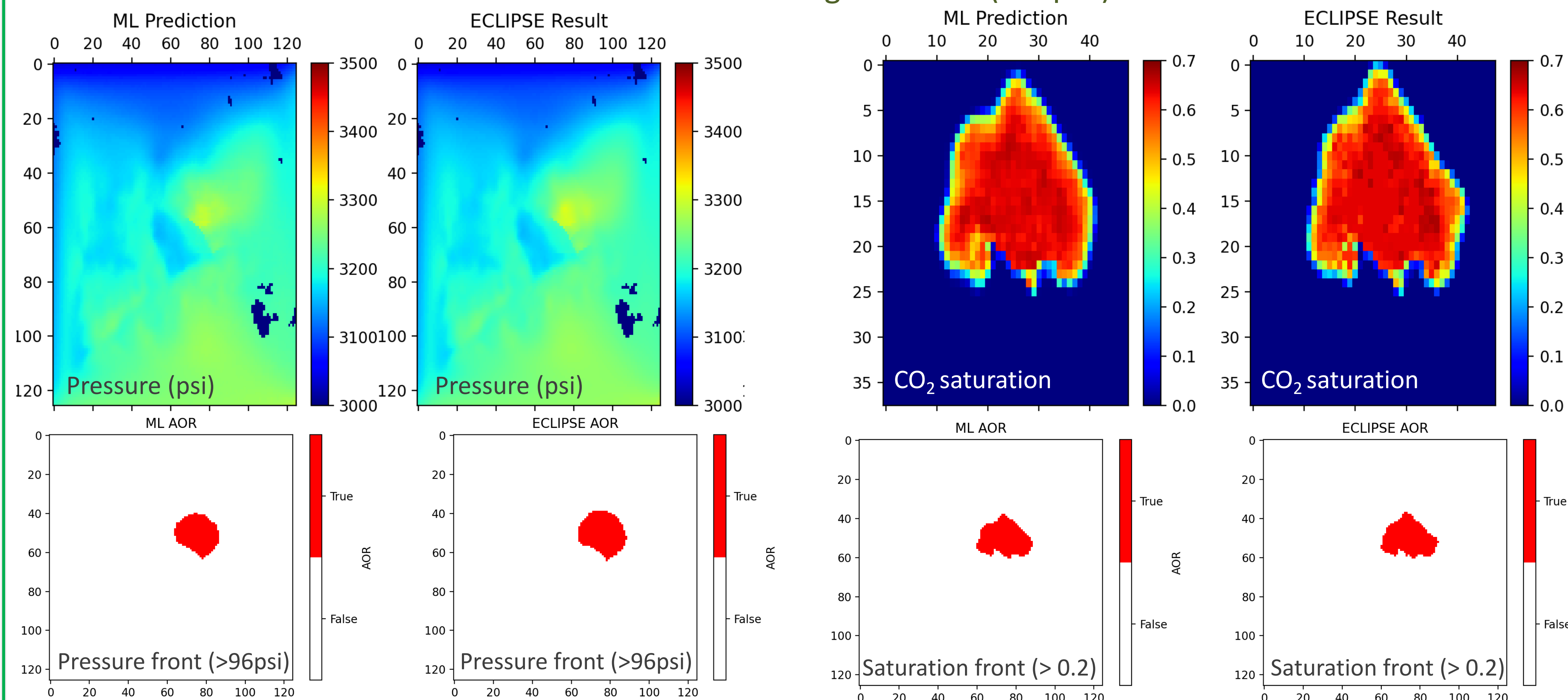


Operational Scenario Manager in USM (Input)



ML models in USM:
 (1) UNet-MLP (developed by UTBEG)
 (2) DeepONet, CNN-LSTM (developed by SNL)

Predicted Reservoir State Manager in USM (Output)



Impact of USM on CCS industry

- Data handling for exported industrial geomodel files to integrate seamlessly with other SMART visualization tools
- ML-based reservoir simulators for fast prediction of pressure and saturation fields after injection over time and space
- Calculations of pressure and saturation front based on user-specified threshold

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