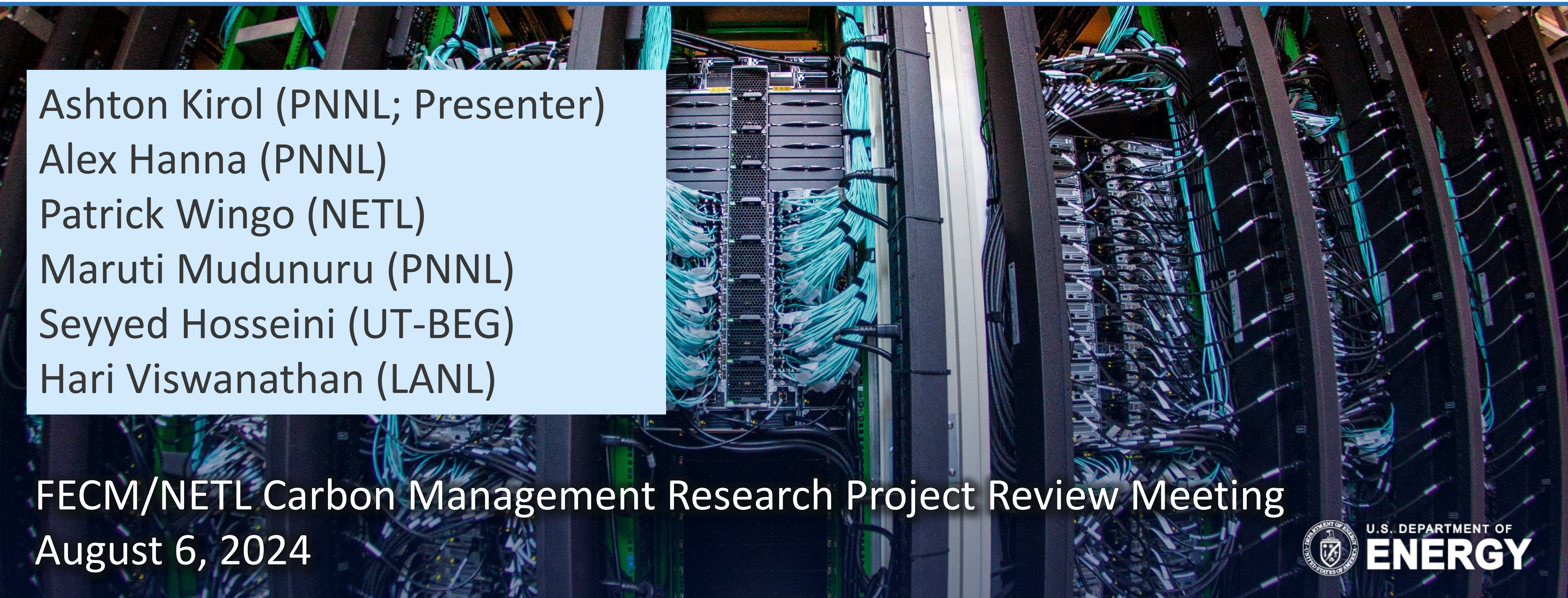
Model Explorer for Virtual Learning

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



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FECM/NETL Carbon Management Research Project Review Meeting
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U.S. DEPARTMENT OF ENERGY

SMART-Model Explorer Module

Outline – What to expect from this talk?

- Model Explorer development overview.
- Conceptual data processing workflow.
- Overview of Illinois Basin Decatur Project (IBDP) example field data and model output.
- Model Explorer Interface: IBDP data viewed in Model Explorer.
- Conclusion: How Model Explorer benefits commercial-scale carbon storage projects.

SMART-Model Explorer Module

Key Developers, Contributors, and Participants – PNNL, NETL, UT-BEG, and LANL

POCs and developers

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Introduction – Model Explorer Module

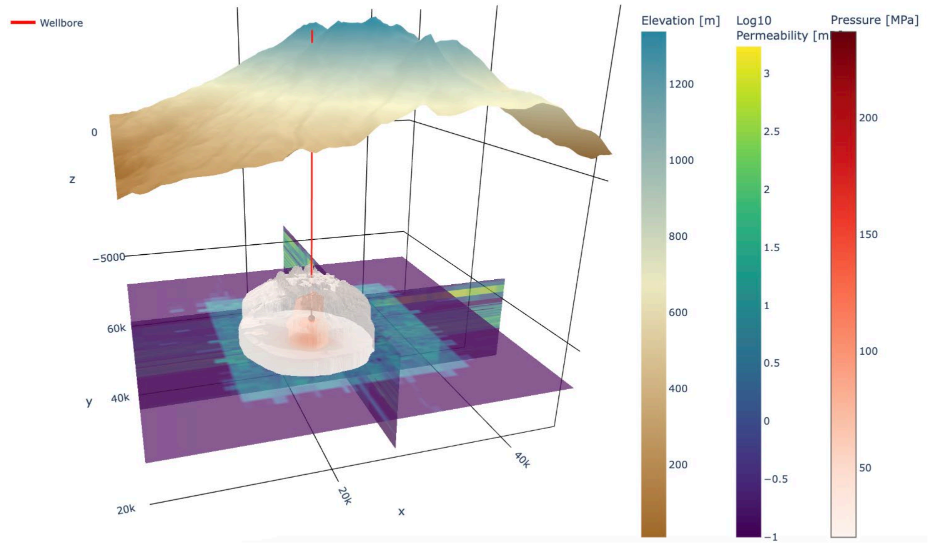
Why is Model Explorer important, and how can it accelerate the Class-VI permitting process?

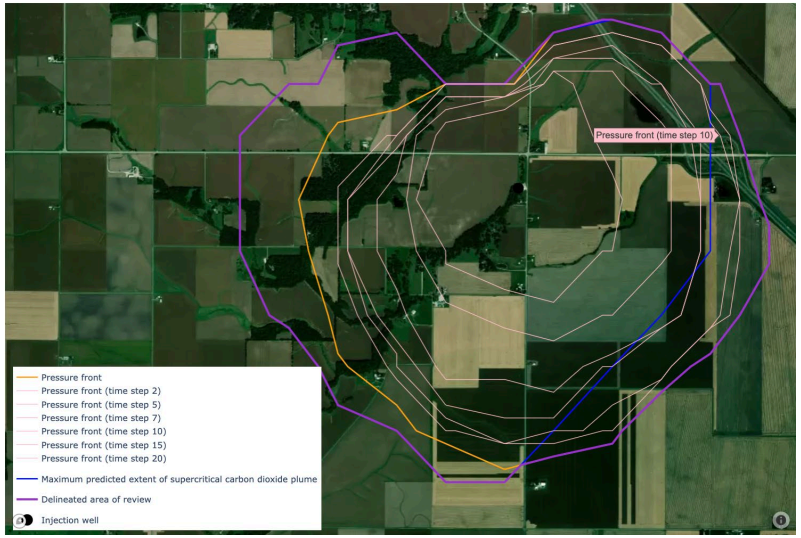
•Allows for quick visualization of the model inputs, output, and other types of data integration, where multiple sets of technical information (e.g., site characterization data and modeling input) can be visualized and evaluated in an integrated fashion.

•Calculates and maps Area of Review (AoR) in real-time in response to model inputs.

•Displays the evolution and maximum predicted extent of the supercritical CO_2 plume, pressure front, and the combined AoR.

•AoR calculation is based on a pressure-front that can be user defined or determined using the suggested EPA methods.





SMART-Model Explorer

Status – Module's Workflow – Data Transformation

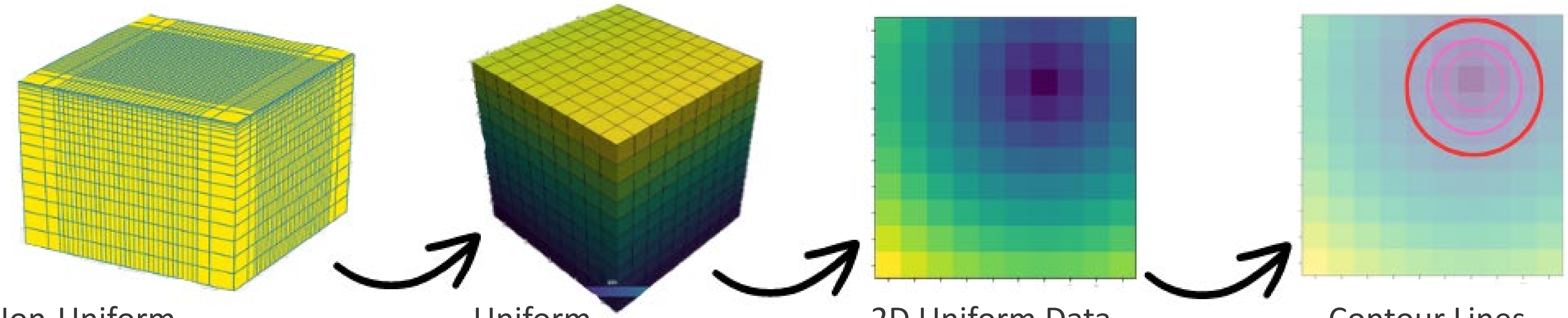
Inputs from model files or SMART-USM output

- Reservoir static properties
- ML-model predicted dynamic data
- Injection well data
- Site topography
- Injection zone and USDW parameters

Model Explorer outputs

- Interactive 3d rendering of reservoir and site data
- Pressure and CO_2 saturation time series
- Site maps with pressure front, plume extent, and AoR contours
- AoR shapefile

Generalized workflow:



Non-Uniform, Unstructured Data → Uniform, Structured Data → 2D Uniform Data → Contour Lines

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Status - Module Workflow – Area of Review Calculation

1. Pressure Front

- User defined threshold.
- EPA Method 1. Under-pressurized injection zone. Pressure front based on bringing injection zone and USDW to equivalent hydraulic heads.

$$P_{i,f} = P_u + \rho_i g \cdot (z_u - z_i)$$

- EPA Method 2. Hydrostatic injection zone. Pressure front based on displacing fluid initially present in the borehole.

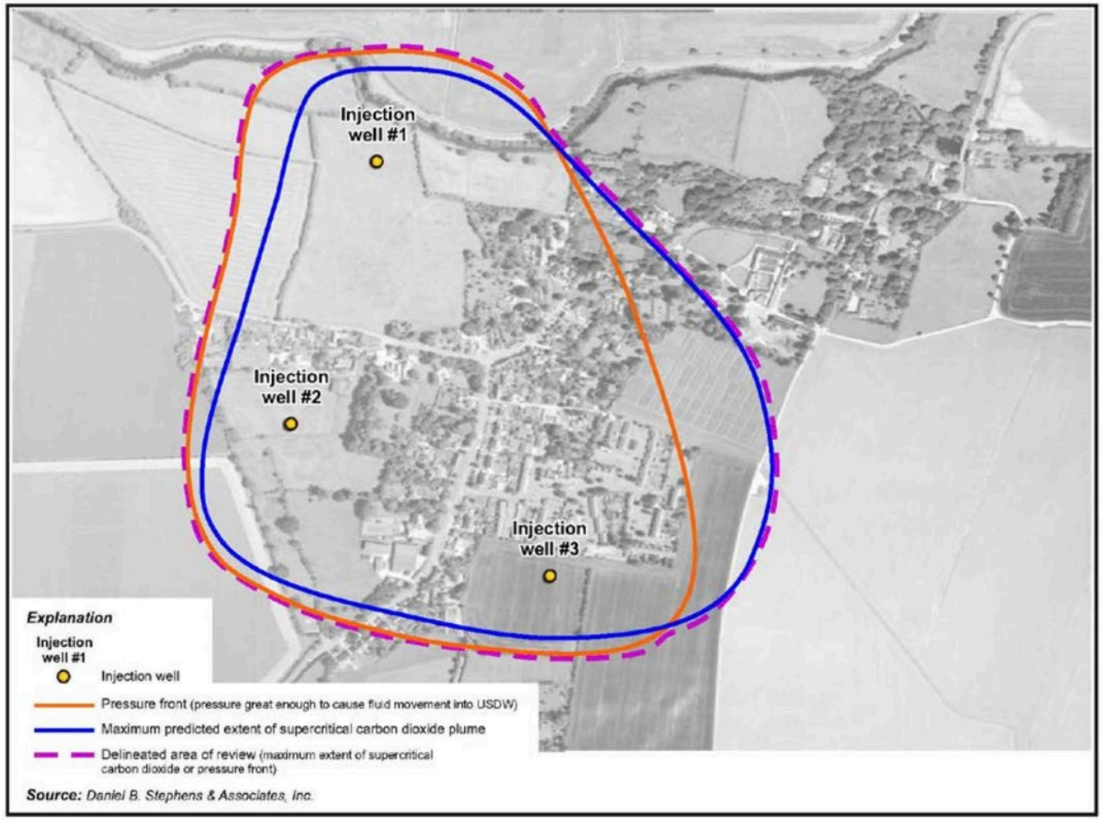
$$\Delta P_c = \frac{1}{2} \cdot g \cdot \xi \cdot (z_u - z_i)^2$$

2. Supercritical CO_2 Plume

- Maximum predicted extent of the separate-phase plume.

3. Area of Review

- Combined maximum extent of pressure front and supercritical CO_2 plume.



Example area of review contour epa.gov

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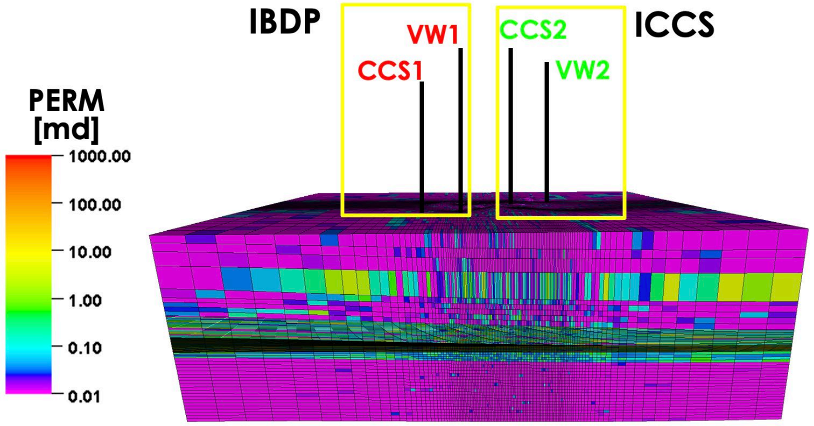
Example Usage – IBDP Data

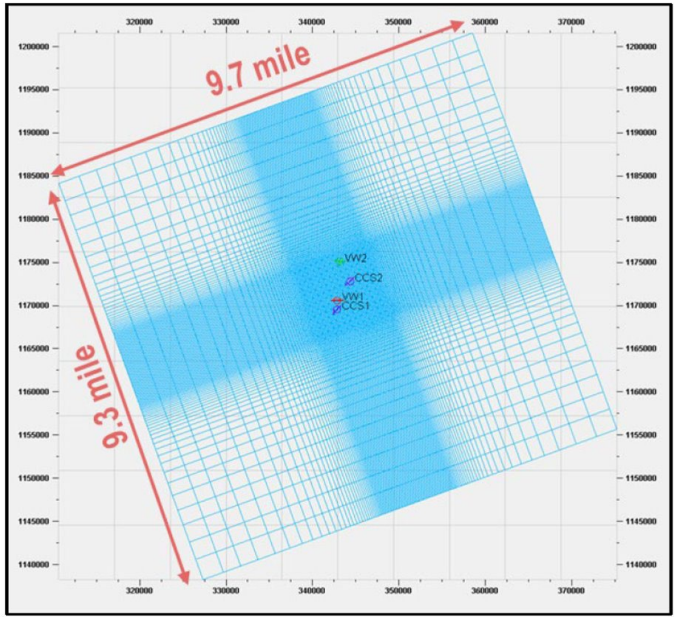


Static Reservoir Property Data [126 x 125 x 110]

- Grid points
- Permeability
- Porosity

Dynamic ML-Model Output [126 x 125 x 110 x 50 time points]

- Predicted pressure
- Predicted CO_2 saturation



Site Characteristics

- Topography
- Well locations

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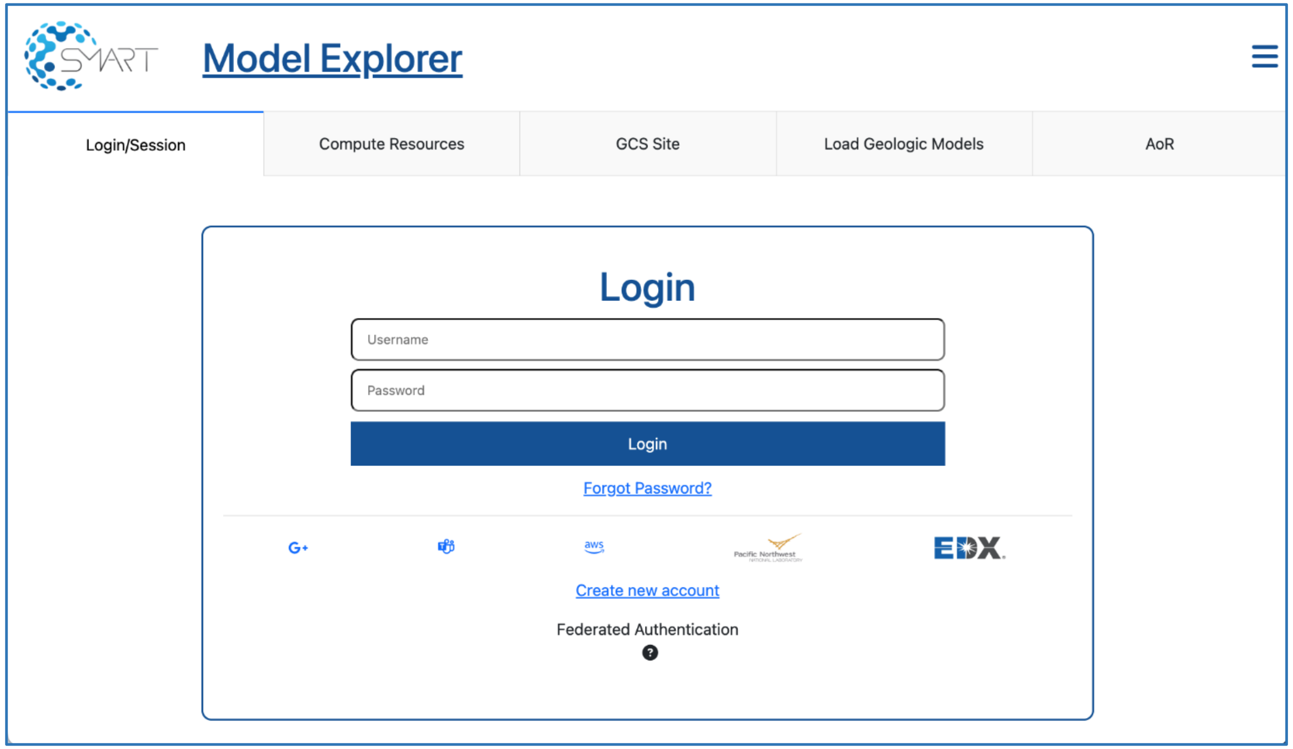
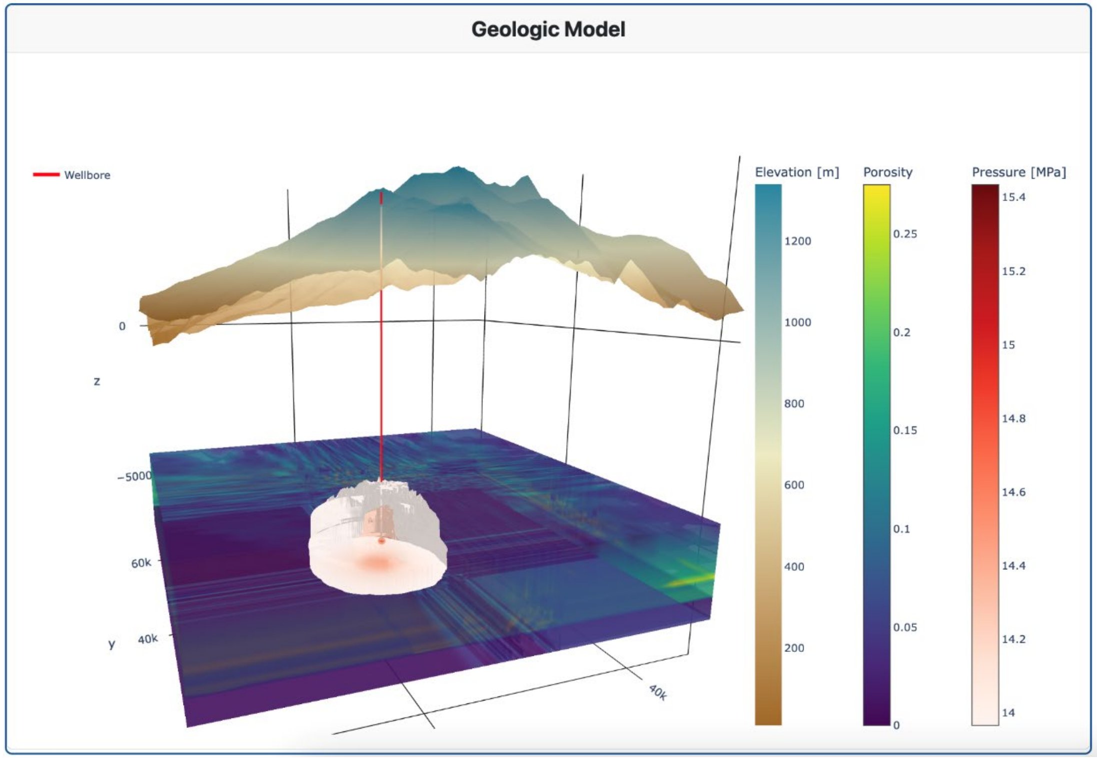
Example Usage – User Interface Demonstration

Model Explorer Interface

Live demonstration and poster presentation August-6-2024 (Tuesday) 5:45 – 7:45 p.m





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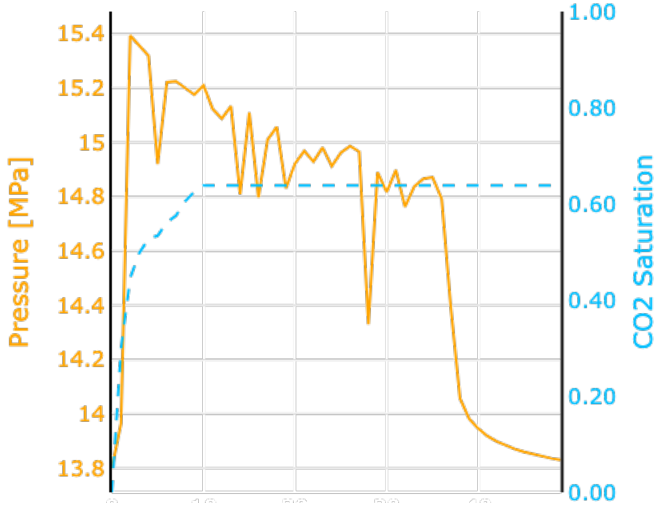
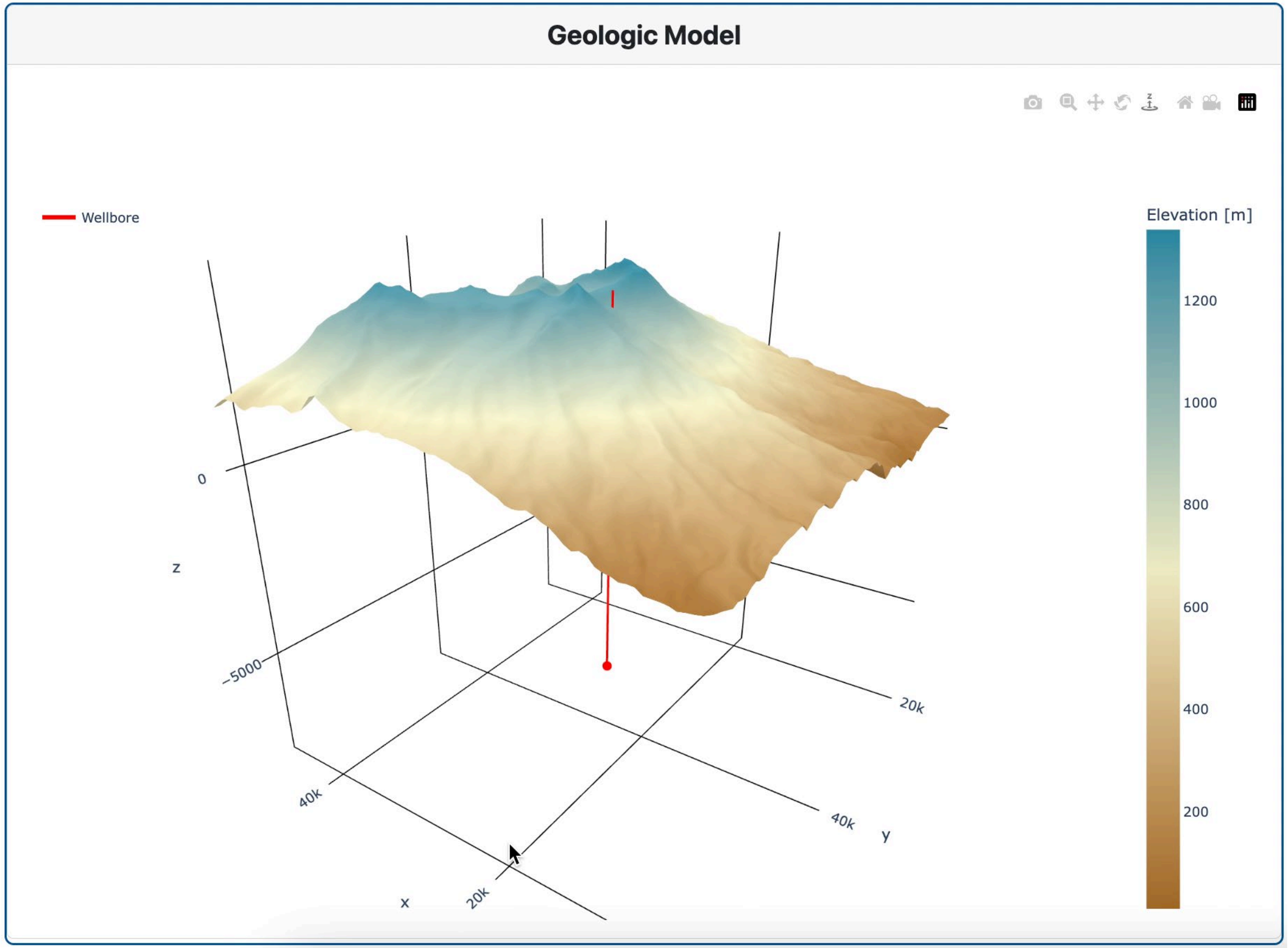
Example Usage – IBDP Model

- **Real-time 3D rendering of reservoir properties and ML-model output.**
- **Time series of pressure and CO_2 saturation at any point within the model domain**

Wellbore pressure and CO_2 saturation





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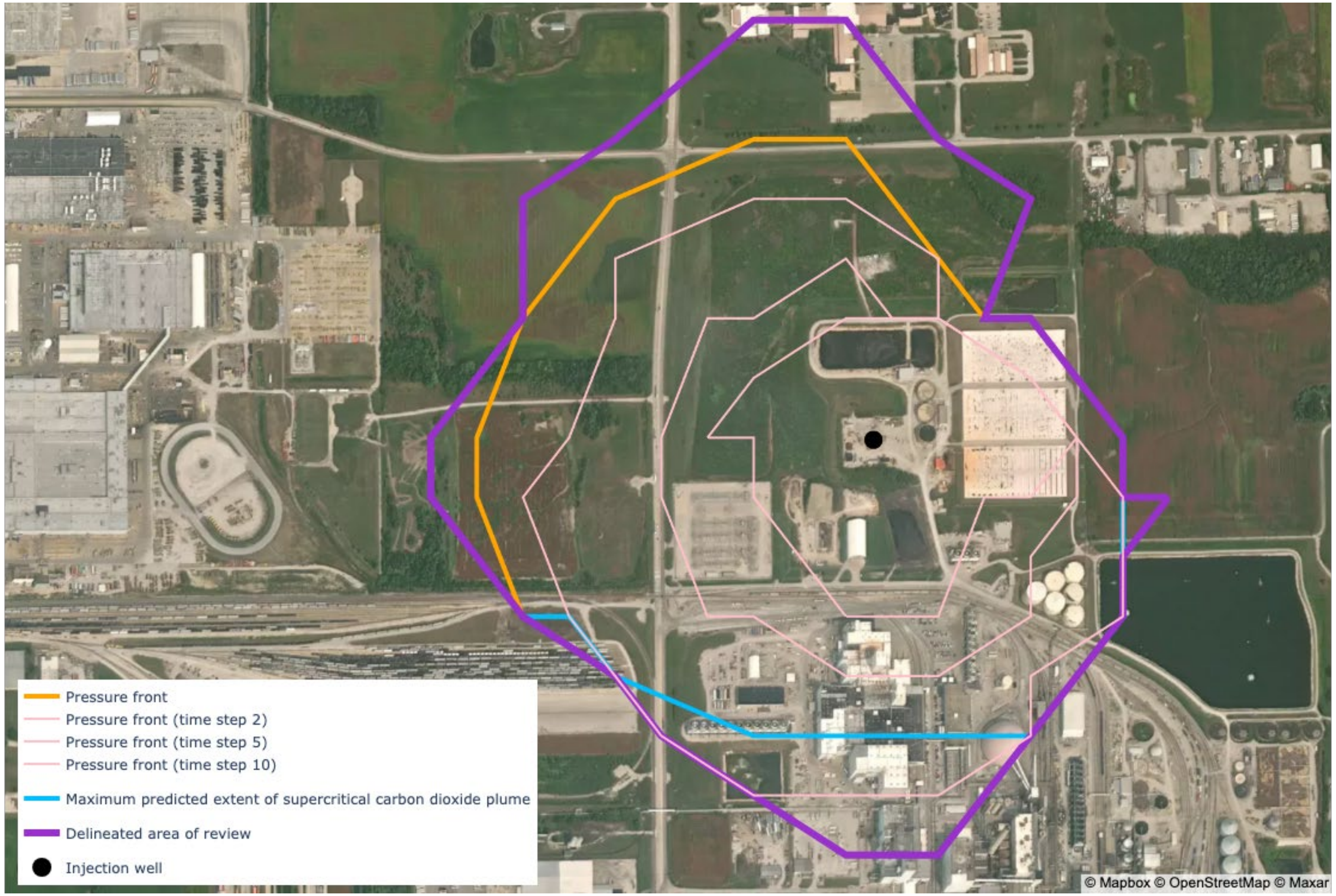
Example Usage – IBDP Example AoR

- **Maximum extent of supercritical CO_2 plume updates with ML-model output.**
- **Example pressure front evolution updates with ML-model output and injection zone parameters.**
- **Combined AoR contour is updated and mapped dynamically.**
- **Area calculations for each contour level.**



Example area of review for IBDP site

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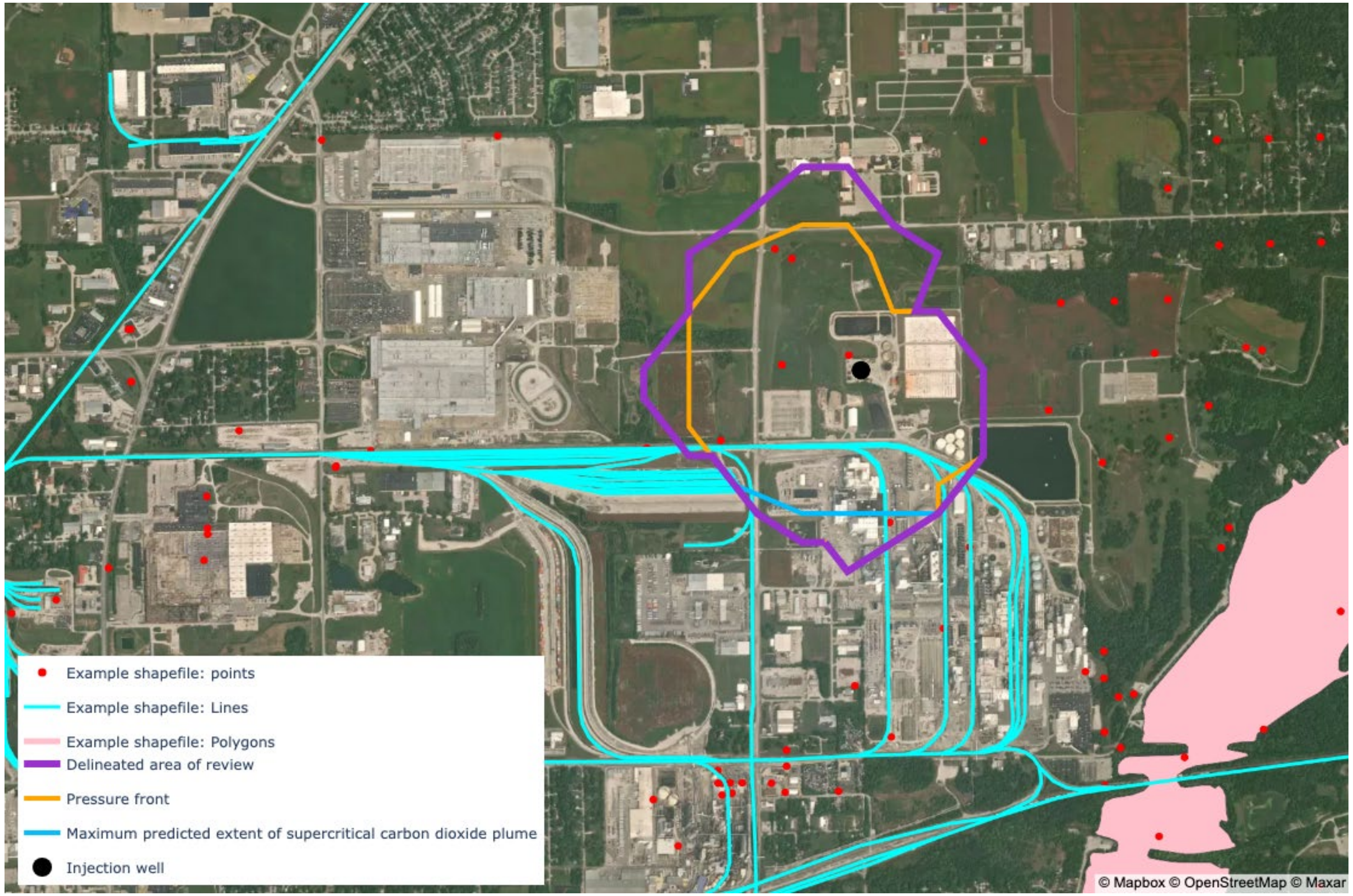
Example Usage – Geospatial File Management

- **Upload and customize additional geospatial data layers.**
- **Model Explorer supports shapefile, GeoJSON, and csv file formats to plot point, line, and polygon objects.**
- **Export AoR boundary shapefile compatible with other GIS software.**



Example IBDP site map

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Conclusion: Contributions to commercial-scale CCS deployment

Data Integration

- Combine various data sources into a cohesive model, offering a holistic view of subsurface conditions.

Improved Communication

- Facilitates effective communication with stakeholders through dynamic and clear data visualization.

Enhanced Decision Making

- Provide detailed visualizations, enabling stakeholders to make informed decisions about site selection and storage management.
- Enhance planning and execution of injection strategies through accurate subsurface mapping and real-time data analysis.

Regulatory Compliance

- Assist in meeting regulatory requirements through detailed and reliable reporting of model results and storage performance.

Thank you!

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Acknowledgement

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