DEVELOPMENT STATUS OF THE INTELLIGENT MONITORING SYSTEM (IMS) USING THE AQUISTORE CO_2 STORAGE PROJECT DATA

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INTRODUCTION

The Energy & Environmental Research Center (EERC) at the University of North Dakota is developing new, real-time data-capable workflows designed to automate the integration of carbon dioxide (CO_2) storage site-monitoring data within an intelligent monitoring system (IMS).

IMS is a next-generation system that will allow site operators to more effectively manage their CO_2 injection operations and integrate monitoring data more efficiently. In particular, the ability to rapidly process data, improve insight into the reservoir performance, expedite reservoir management decisions, and reconcile discrepancies between expected and observed reservoir performance, make IMS both unique and cutting-edge.

PROJECT OVERVIEW

Develop and demonstrate software and workflows capable of:

1. Improving short- and long-term prediction of the distribution of CO_2 saturations and reservoir pressure by using seismic and pressure data to reduce uncertainty of simulation predictions through iterative automated history matching.
2. Providing processing and integration of monitoring data and simulation results to allow the CO_2 storage site operator to more effectively monitor and manage operations and a site's evolving risk profile.
3. Providing decision support for improving storage performance and efficiency and/or reducing project risk through expedited response times and minimization of human error.

SPECIFIC OBJECTIVES

- Develop and demonstrate real-time data-capable workflows, algorithms, and a user interface which automate the integration of CO_2 storage site-monitoring and simulation data.
- Integrate continuous monitoring data, periodic monitoring data, and reservoir simulations with algorithms for visualization and real-time decision-making support.
- Develop and test an automated history-matching workflow to improve short- and long-term prediction of the distribution of CO_2 saturations and reservoir pressure.
- Develop and test a technical user graphical interface.

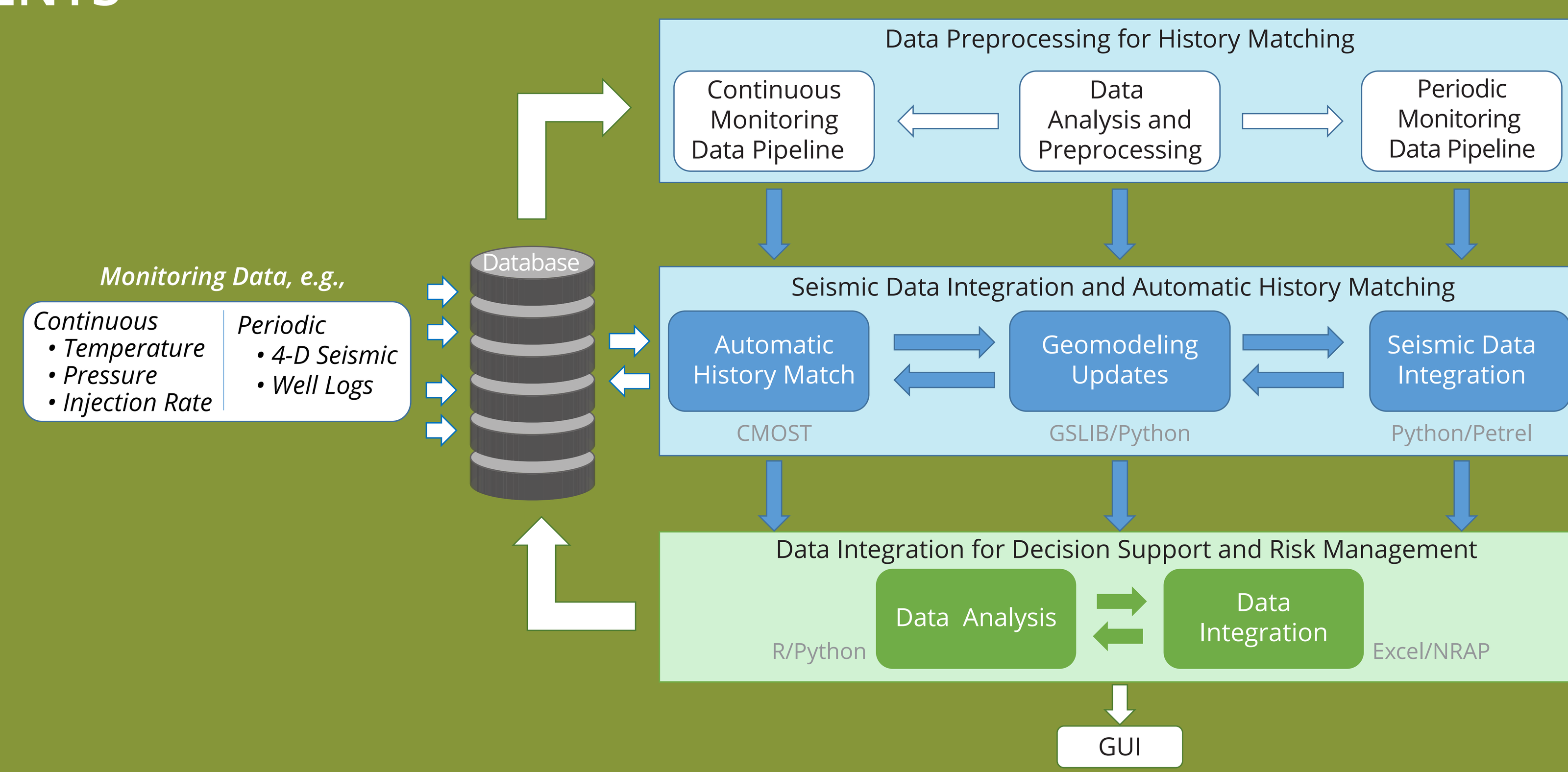
IMS TASKS AND COMPONENTS

IMS Module Development

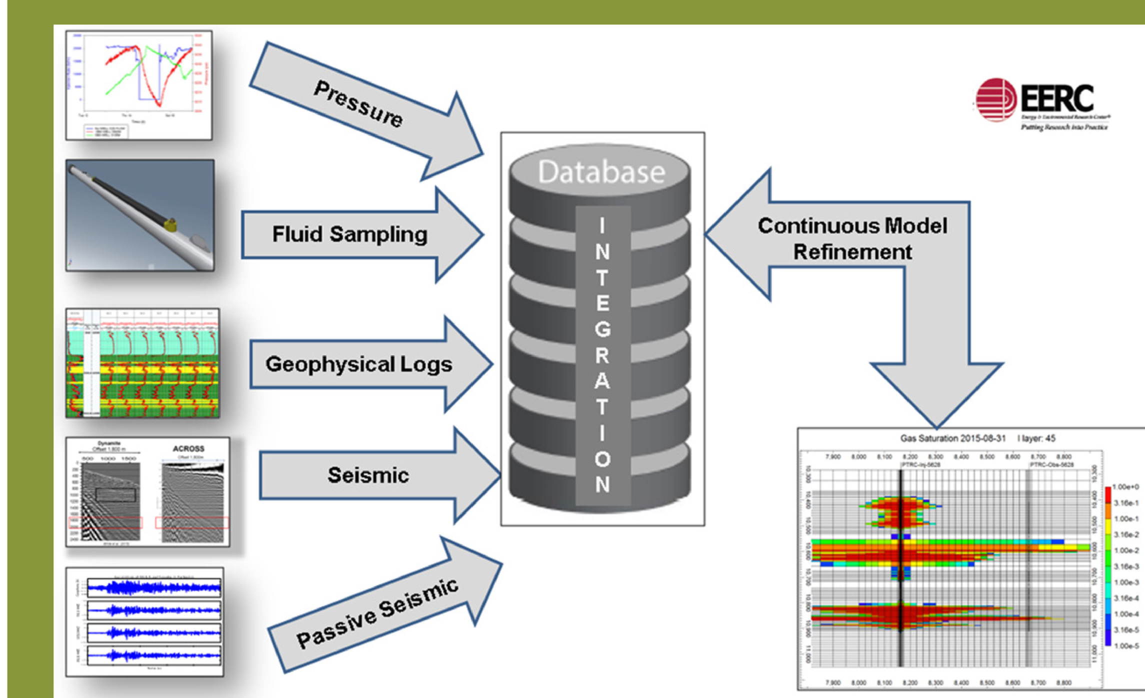
- Workflow Design
- Data-Preprocessing Design
- Seismic Data Integration
- History Match Automation
- Integration and Automation Testing

IMS Architecture Development

- Database Development
- Data Integration
- IMS Interface Development
- Process and System Testing



TECHNICAL STATUS



Flowchart illustrating the different data types being incorporated into the IMS modules.

Successfully developed new workflows designed to:

- Handle real-time monitoring data from the SaskPower database.
- Store and manage information in a secure database.
- Perform data preprocessing linked to an automated history match.
- Integrate periodic and continuous data into automated history match.

Significant progress toward:

- Utilizing the monitoring data to model and predict bottomhole conditions.
- Developing algorithms to establish decision criteria for real-time decision support.
- Developing associated risk management action levels.

Future plans:

- Integrate new seismic data into the modeling and simulation.
- Complete the programming and implementation of the GUI.

LESSONS LEARNED

Research difficulty: ***Time requirements for repeat logging or seismic methods:***

History Match Automation may still experience the associated time delay from the periodic data acquisition and interpretation.

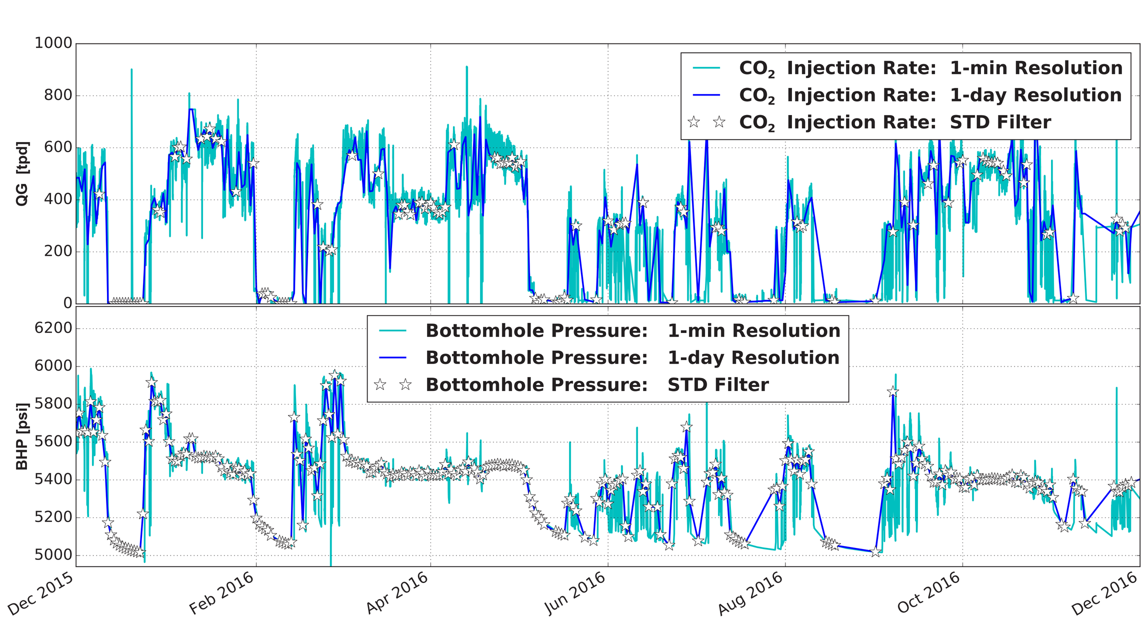
Research challenge: ***Data set incongruence:***

Scientific and engineering judgment needed to transform qualitative interpretations into quantitative changes to simulation input in order to improve the simulation output.

Research gap: ***Discontinuous injection cycles are the normal operating procedure:***

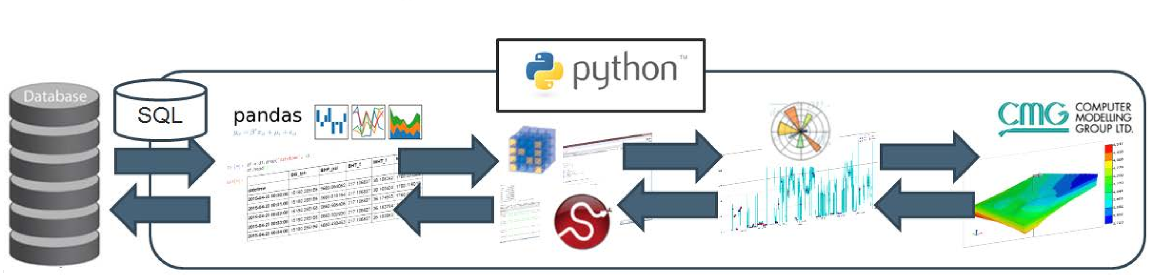
Need to adapt existing analytical and semianalytical models for utilizing continuous measurements to account for transient effects.

REAL-TIME DATA PREPROCESSING

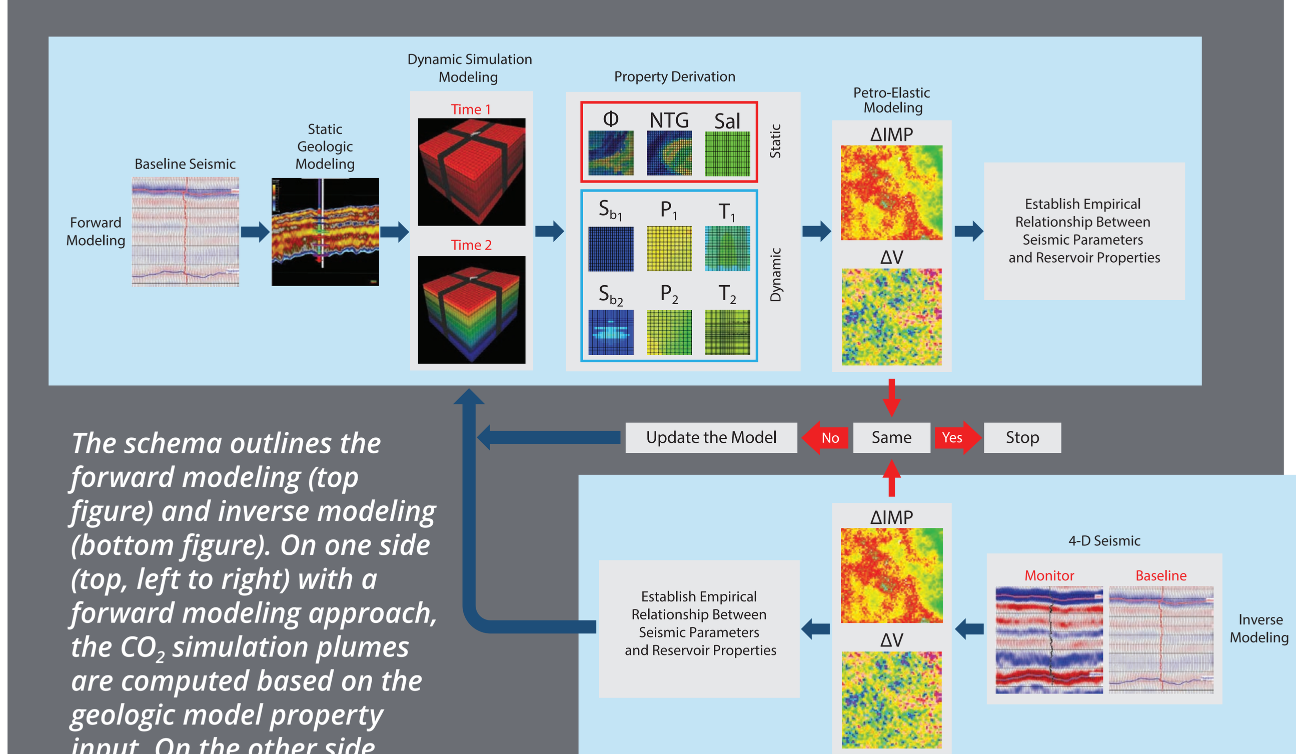


Example of the data cleaning, filtering, and resampling functionalities using Aquistore data from 2016.

DATA PIPELINES



SEISMIC HISTORY-MATCHING CONCEPT

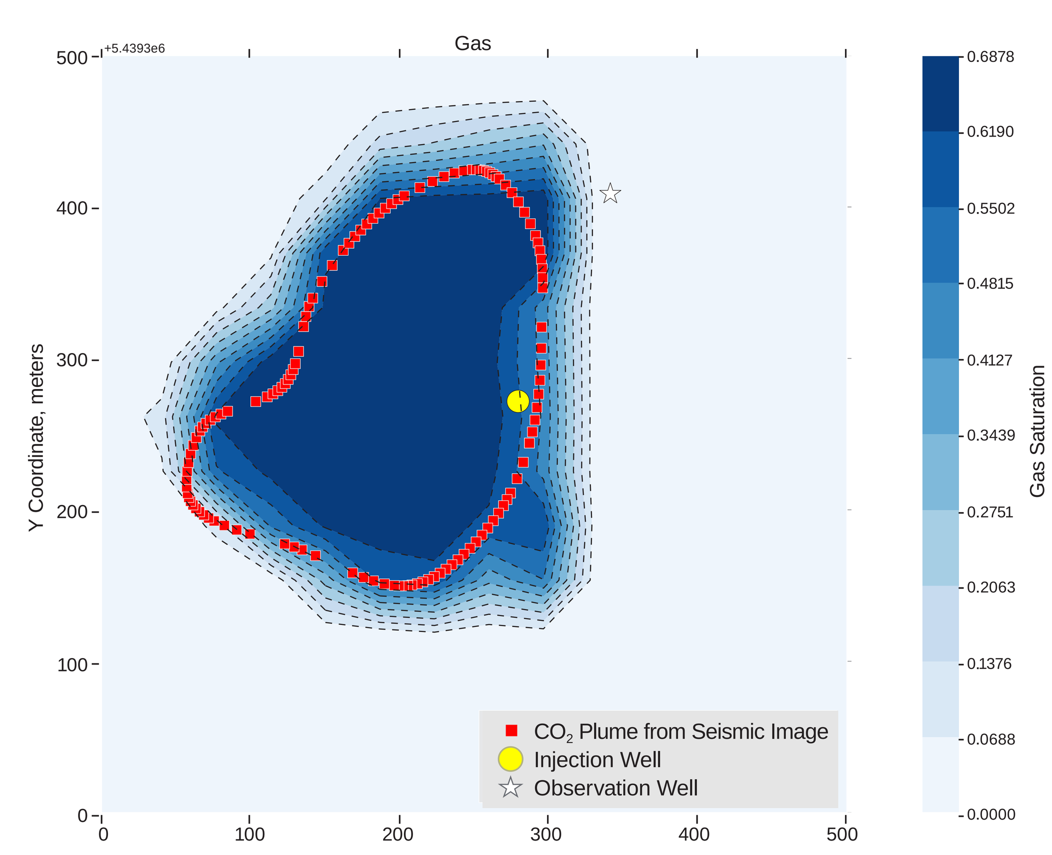


The schema outlines the forward modeling (top figure) and inverse modeling (bottom figure). On one side (top, left to right) with a forward modeling approach, the CO_2 simulation plumes are computed based on the geologic model property input. On the other side (bottom, right to left) with an inverse modeling approach, the CO_2 plume actual shapes and locations are measured with 4-D seismic.

Main steps

- Measure CO_2 plume actual shapes and locations with 4-D seismic.
- Compare simulation plumes based on geologic model properties input.
- Compare predicted to observed plumes and calculate goodness-of-fit.
- Make adjustments to the geologic model and recompute the simulation.
- Iterate until misfit threshold is met.

HISTORY MATCH EXAMPLE*



Map view of the CO_2 plume spatial distribution from simulation results (blue-filled contour) and observed plume shape (after the seismic data interpretation).

*Test case for demonstration purposes only. It does not represent the location of the actual CO_2 plume.

ACKNOWLEDGMENTS

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