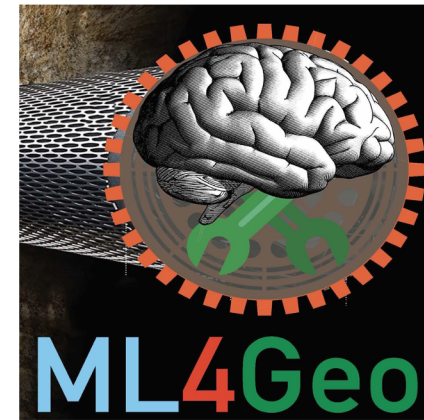


ML4Geo

Machine Learning for Geosciences

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ML4Geo motivation

- **Subsurface (geologic) systems are represented by complex coupled multi-physics/multi-phase dynamics**
- **Building models simulating these systems from first principles is challenging**
- **Models need to be adjusted (calibrated) to match observed system behavior**
- **However, data representing subsurface dynamics and properties are sparse and uncertain**
- **To perform model analyses, we need:**
 - **rigorous data assimilation methods**
 - **fast and accurate models**
- **Physics-informed ML methods address these challenges**



ML4Geo Capabilities

- **ML4Geo** is capable to execute various ML analyses:
 - Unsupervised (NMFk, NTFk, SVR, SVD, HO-SVD, etc.) methods
 - Supervised (CNN, GAN, etc.) methods
 - Physics-Informed ML (PINN, regularizations, penalties) methods
- **ML4Geo** is designed to be deployable on diverse platforms (cloud, servers, laptops, handhelds)
- **ML4Geo** funded by ARPA E
- **ML4Geo** uses SmartTensors
- **SmartTensors** has been nominated for R&D 100 award
- **SmartTensors** video: <https://youtu.be/ni3EgQVypbQ>



ML4Geo Applications

- **ML4Geo is applicable to various geo problems:**
 - Oil/gas production
 - Geothermal energy extraction
 - Geo cooling
 - Geologic carbon storage
 - Waste storage
 - Energy storage
 - Induced seismicity
 - Contaminant flow and transport
 - Groundwater supply
 - In-situ mining



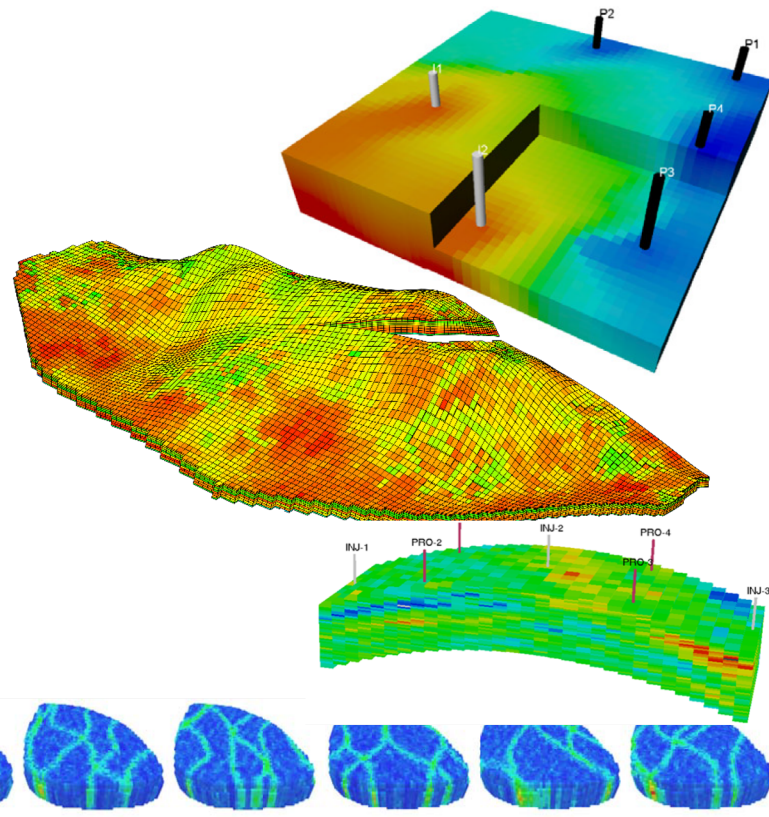
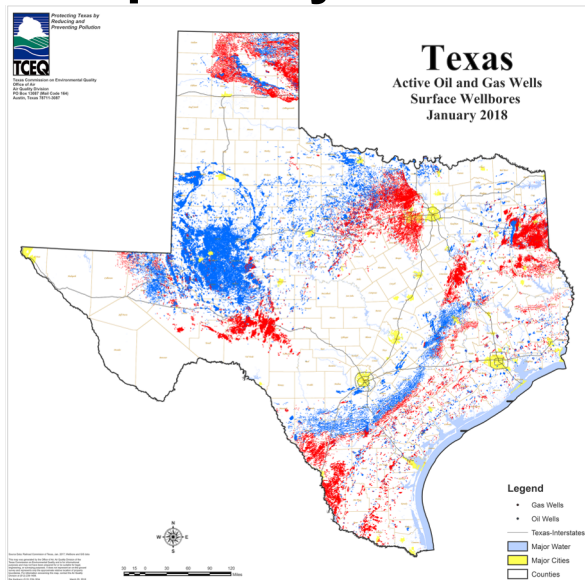
SmartTensors

- **SmartTensors** have been already applied to perform ML analyses related to:
 - **2020 California wildfires**
 - **COVID-19**
 - **Neutron accelerator**
 - **Geothermal**
 - **Carbon storage**
 - **Watersheds**
 - **Contamination**
 - **Seismicity**
 - **Climate**
 - **Spectroscopy**
 - **Microbial population**
 - **Isotope fractionation**
 - **Reactive mixing**
 - **Protein molecular dynamics**
 - **Human cancer genome**



ML4Geo manages various existing datasets

- Real-world public datasets
- Representative synthetic datasets
- Proprietary datasets



ML4Geo Results

- Develop DP (automatic differentiation) on multi-physics model
- Perform history matching of oil/gas production data
- Blind predictions of future oil/gas extraction rates
- Quantify posterior predictive uncertainties
- Estimate model input sensitivities

