GeoThermalCloud

Fusion of Big Data and Multi-Physics Models

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Los Alamos NATIONAL LABORATORY EST.1943

Julia computing

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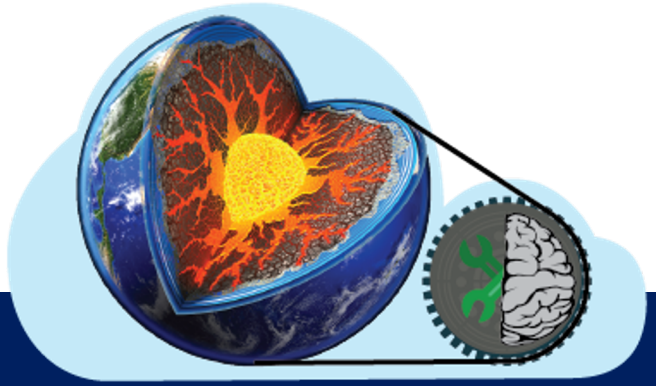
GeoThermalCloud



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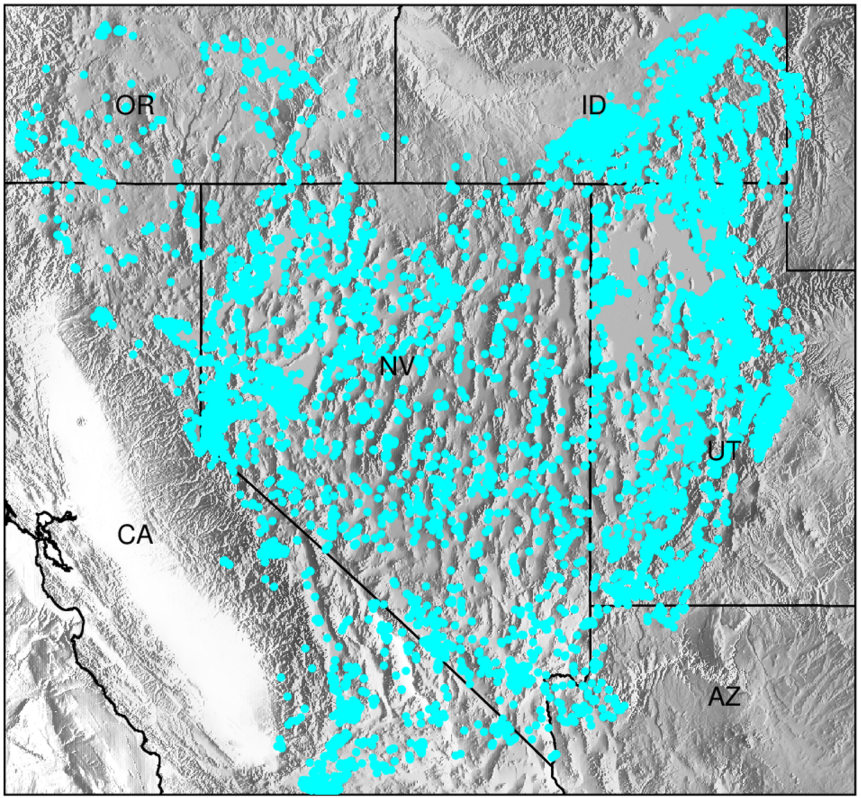
Motivation

- **Geothermal exploration and production are challenging, expensive and risky**
- **Diverse datasets available** (public and proprietary; satellite, airborne surveys, vegetation/water sampling, geological, geophysical, etc.)
- **How to utilize these datasets for geothermal exploration unknown due to imperfect understanding of how:**
  - **physical geothermal processes impact subsurface conditions**
  - **geothermal subsurface conditions are represented in observations**
- **ML is here to help …** (discover how geothermal conditions are represented in these datasets)

GeoThermalCloud

- GeoThermalCloud: a general (flexible) open-source cloud-based ML framework for geothermal exploration
- https://github.com/SmartTensors/GeoThermalCloud.jl: data, examples, jupyter notebooks, documentation
- GeoThermalCloud applied to:
  - discover and extract new (unknown/hidden) geothermal signatures in existing large datasets
  - categorize geothermal datasets and generate labels
  - fuse big data and multi-physics models
  - identify high-value data acquisition strategies
  - fill-in data gaps and perform transfer learning

Great Basin

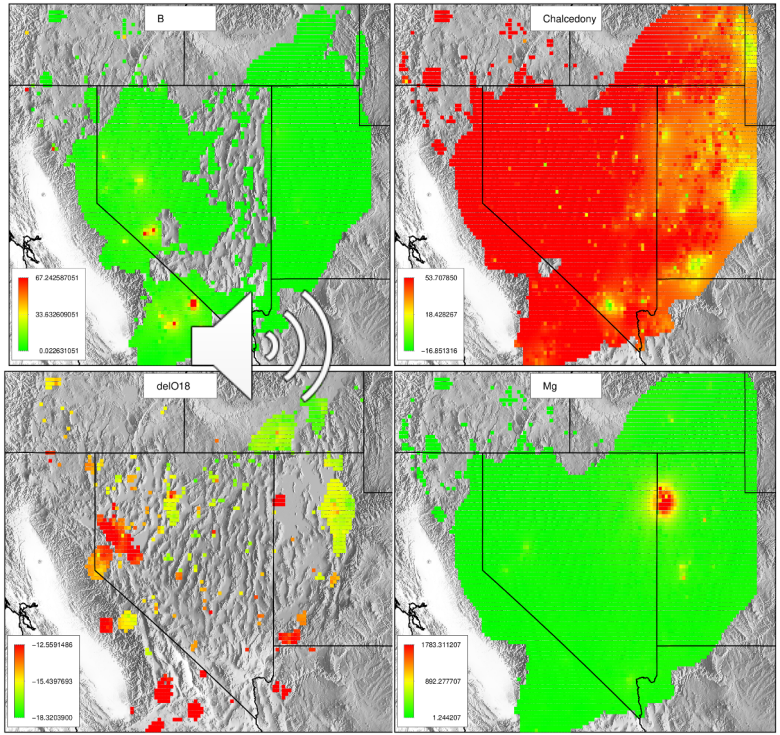


Study area with 14,341 data points

- Great Basin includes multiple geothermal reservoirs
- Great Basin has huge geothermal potential
- Better understanding of the available geothermal data collected throughout the Great Basin region is needed
- > 14,000 locations at which geothermal-related data are available
- 18 geothermal data attributes observed (with data gaps)

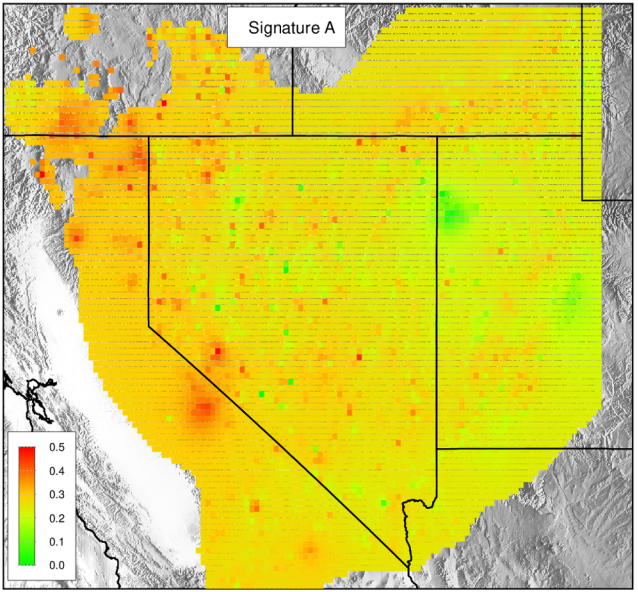
Great Basin: Data Attributes

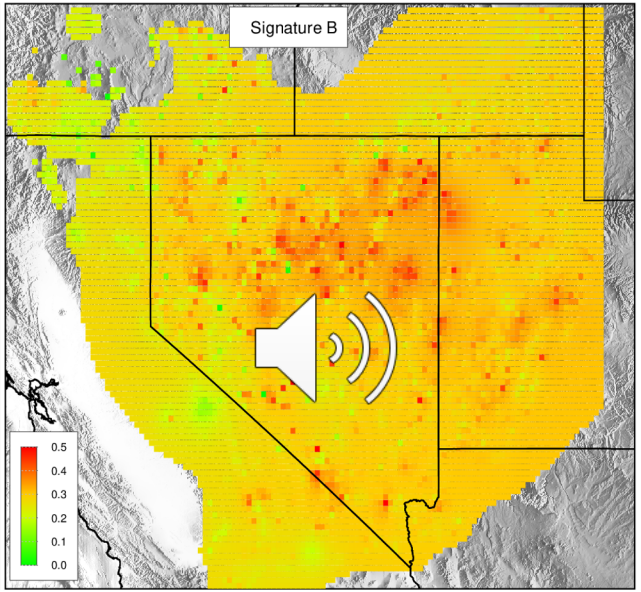
Attribute	Missing (%)
Groundwater temperature (℃)	2.6
Quartz geothermometer (℃)	39.1
Chalcedony geothermometer (℃)	39.1
pH	35.0
TDS (total dissolved solids) (PPM)	87.8
Al^{3+} (PPM)	90.5
B^{+} (PPM)	61.7
Ba^{2+} (PPM)	82.4
Be^{2+} (PPM)	88.5
Br^{-} (PPM)	86.4
Ca^{2+} (PPM)	33.6
Cl^{-} (PPM)	29.2
HCO_3^{-} (PPM)	76.1
K^{+} (PPM)	40.8
Li^{+} (PPM)	80.3
Mg^{2+} (PPM)	34.8
Na^{+} (PPM)	38.2
$\delta^{18}O$ (‰)	89.7

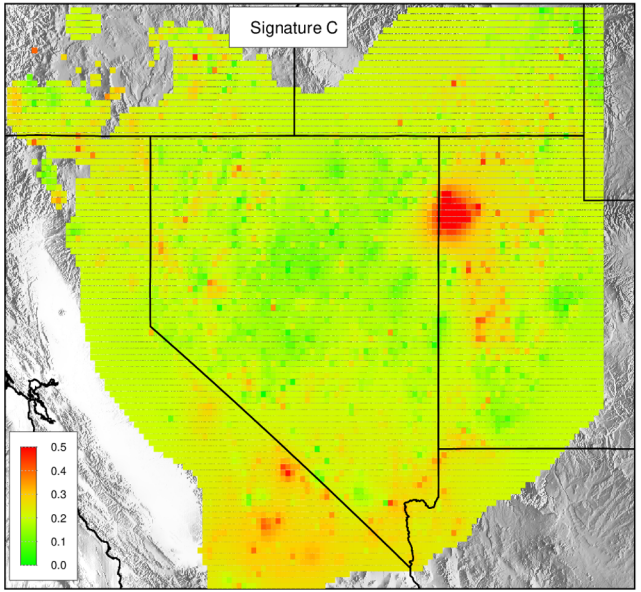


ML extracted geothermal Signatures

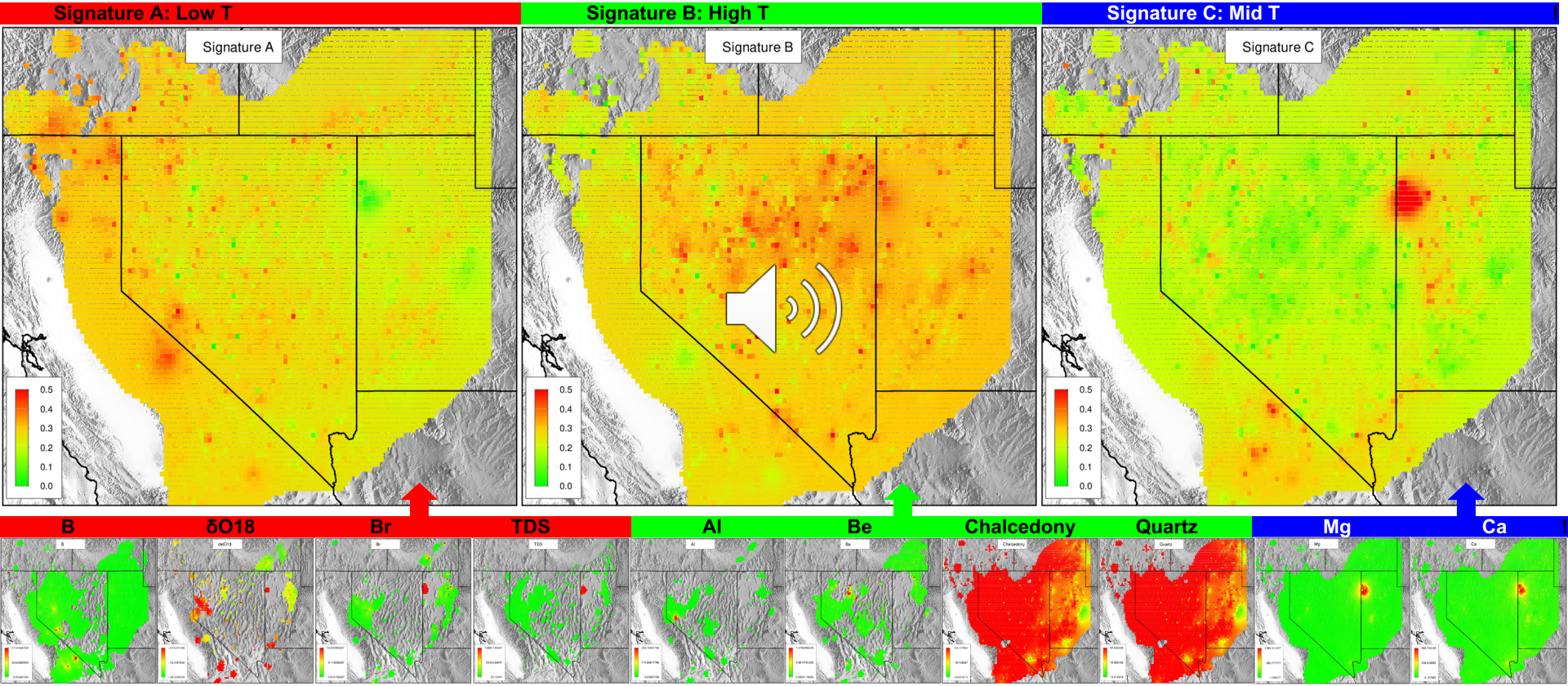
Signature A: Low T | **Signature B: High T** | **Signature C: Mid T**





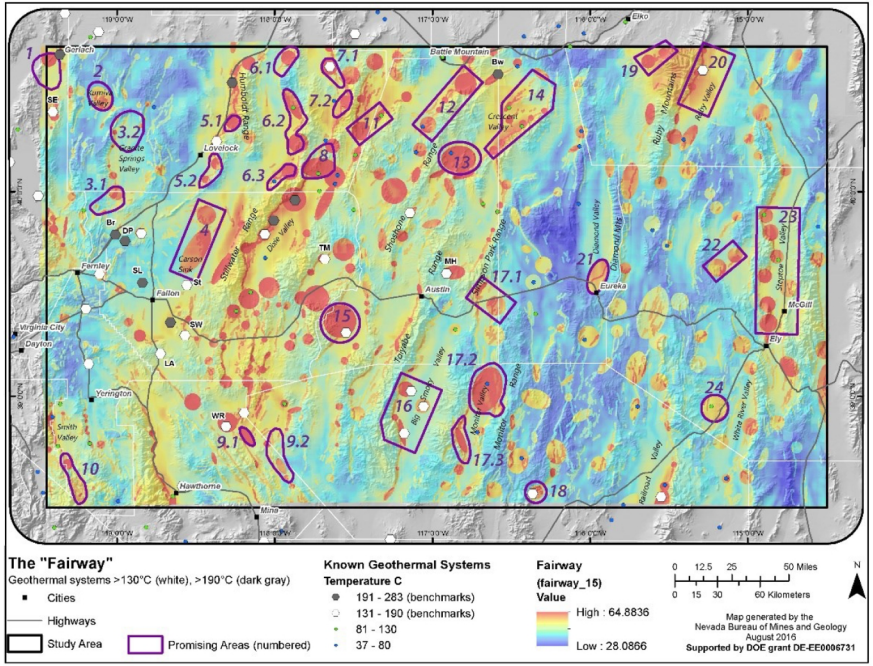


Great Basin: Geothermal Signatures



Comparison of prospectivity maps

Prospectivity estimated based on subject-matter expertise (Faulds et al. 2017)



Source: https://gbcge.org/recent-projects/nevada-play-fairway-phase-2/

Prospectivity estimated using GeoThermalCloud (unsupervised ML with no subject-matter expertise required!)