

2024 CWEMF ANNUAL MEETING  
SEPTEMBER 23-25, 2024 | LAKE FOLSOM, CA

# Developing Conceptual Models and Parameterizing Numerical Models using AEM and Other Hydrogeologic Data Types

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$\Sigma^2\Pi$



# Agenda

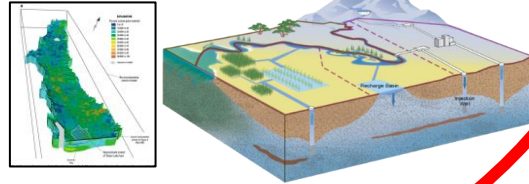
- Analysis Tools within DWR's Basin Characterization Program
- Data2HSM Suite – Hydrostratigraphic Model
- Data2Texture – Texture Model
- Texture2Par – Aquifer Parameter
- Tool Integration

# DWR's Basin Characterization Program

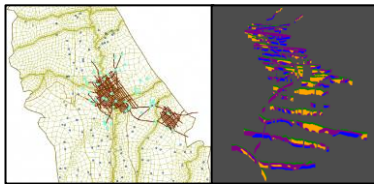
Collect & Compile Data



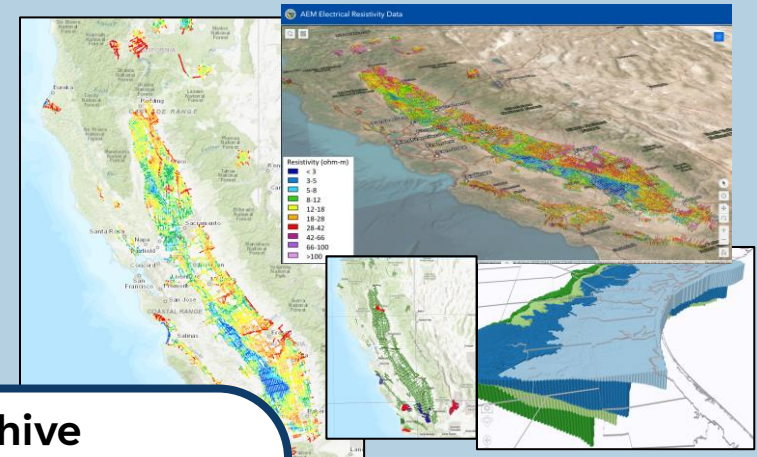
Texture Model & Hydrogeologic Conceptual Model



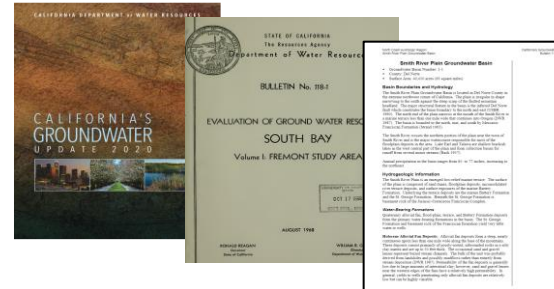
Integrated Analysis of All Subsurface Data



Data Access & Visualization

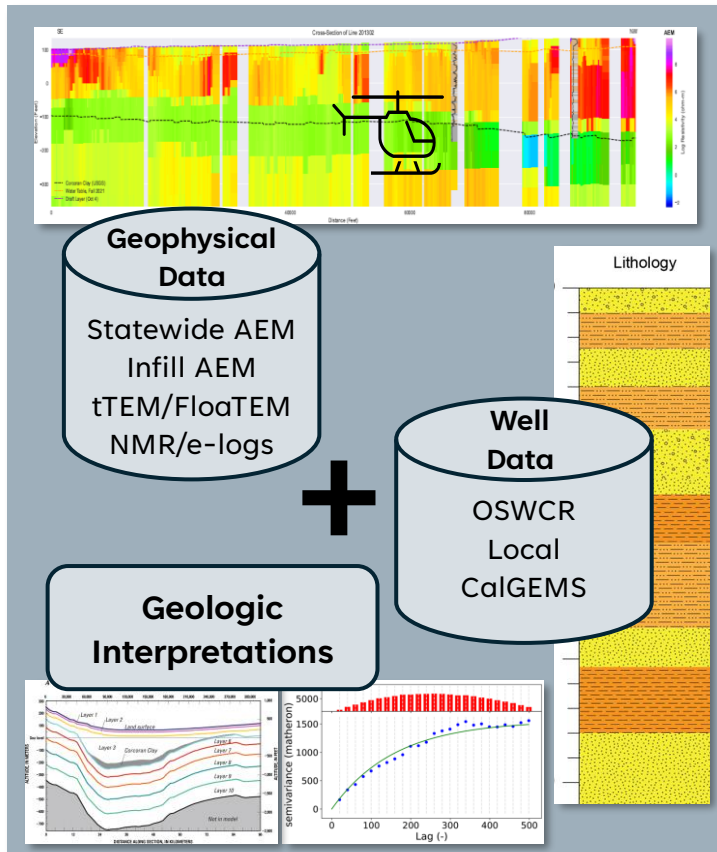


Data Archive  
*California's Groundwater*

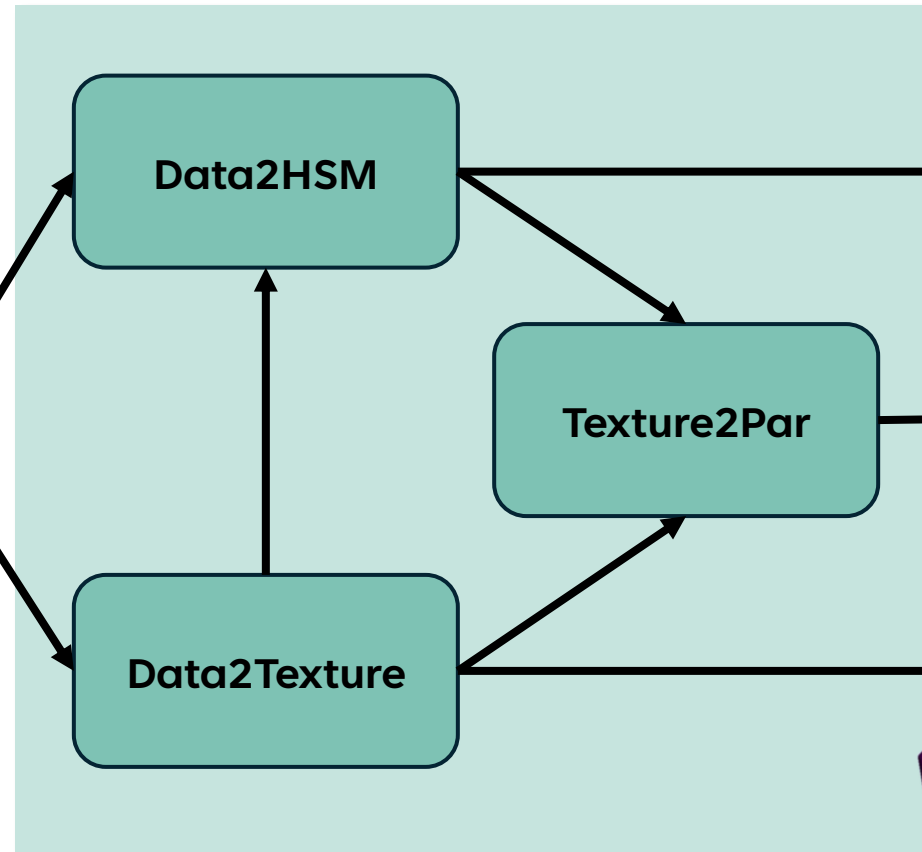


# Analysis Tools Overview

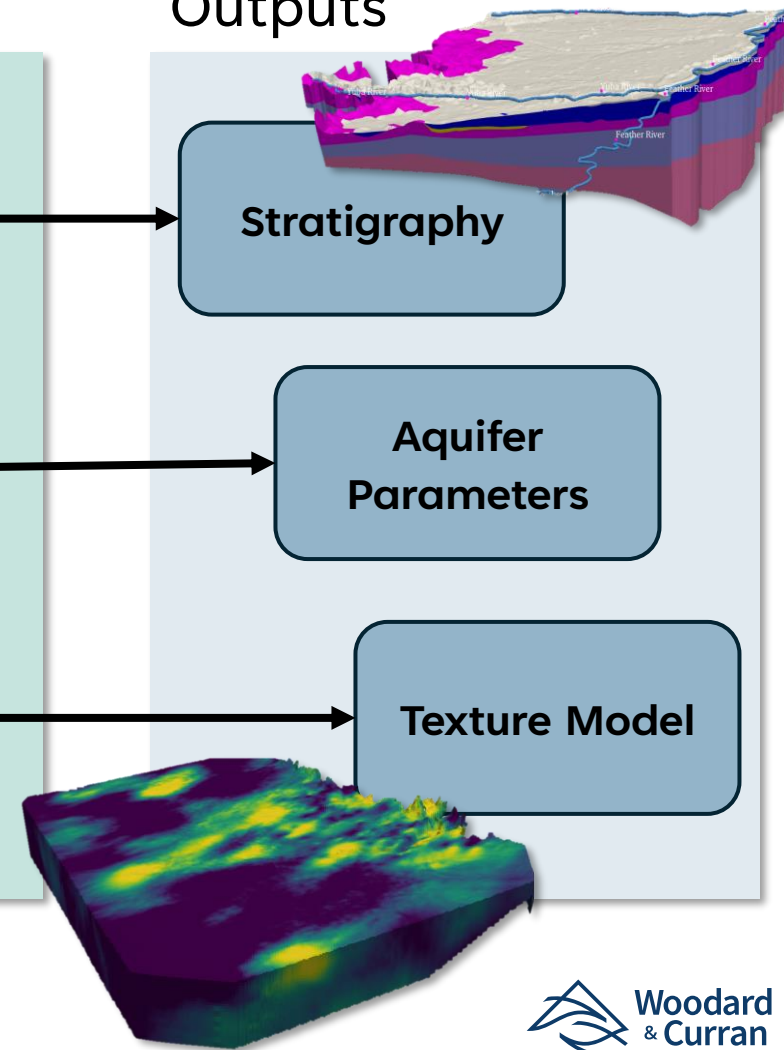
Inputs



Tools

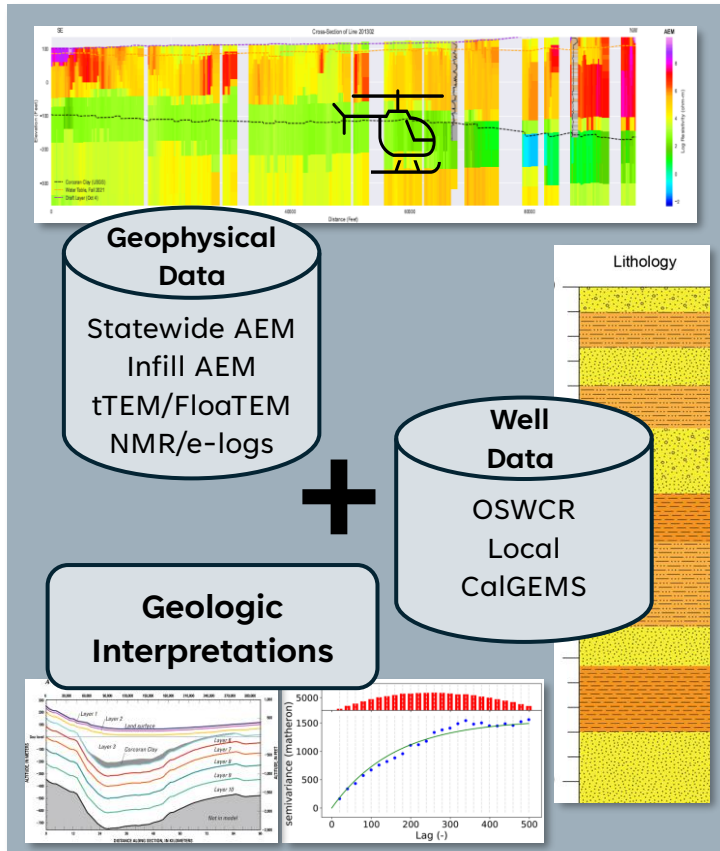


Outputs

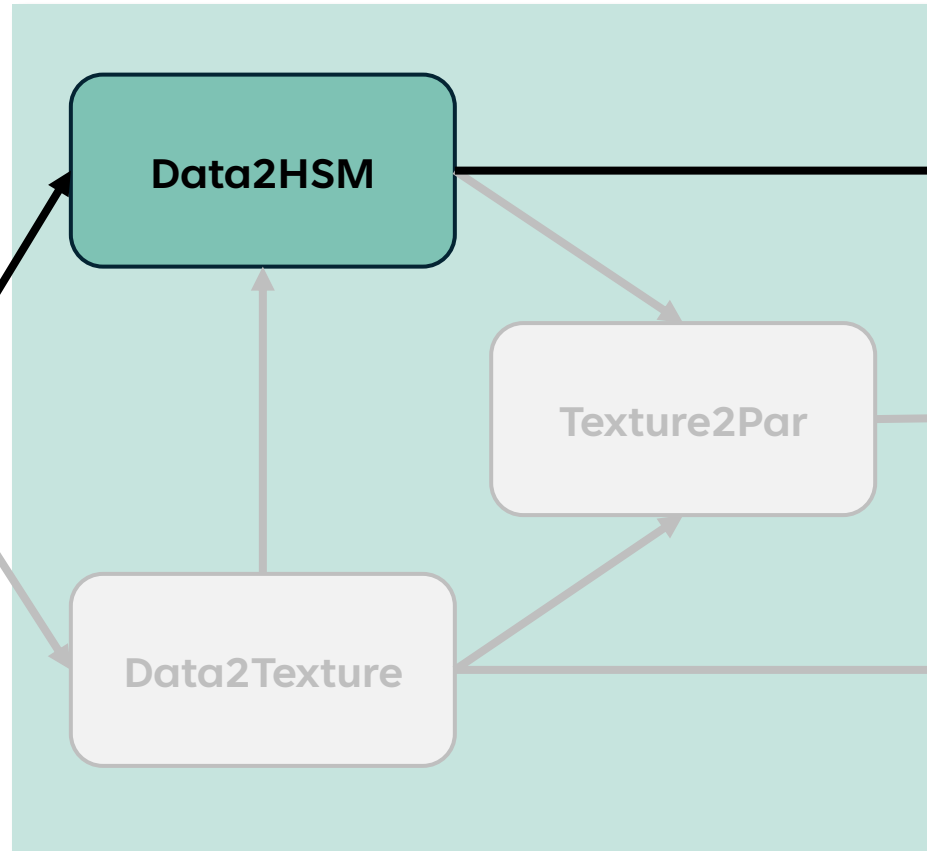


# Generate Stratigraphy on X-Sections

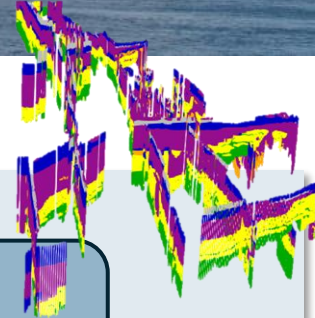
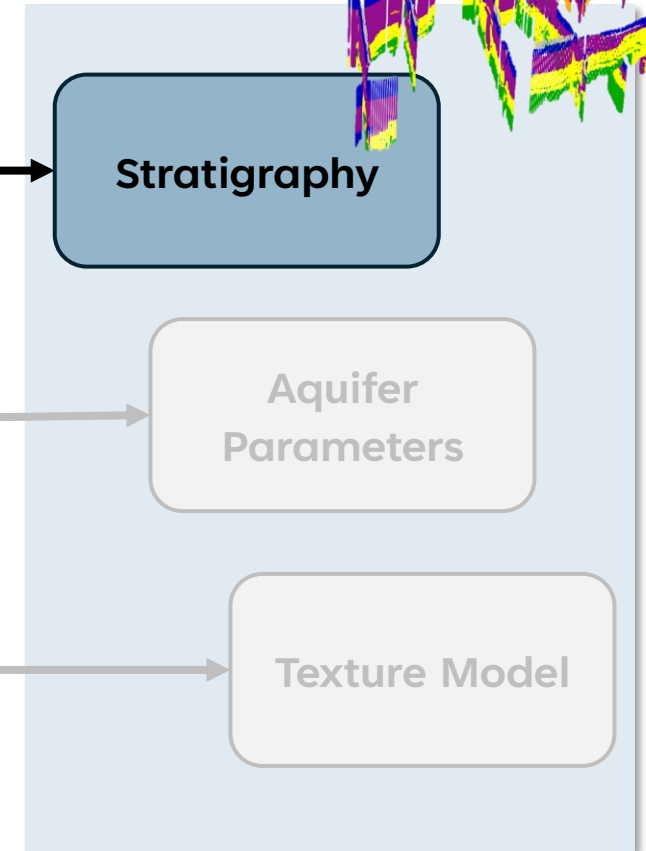
Inputs



Tools

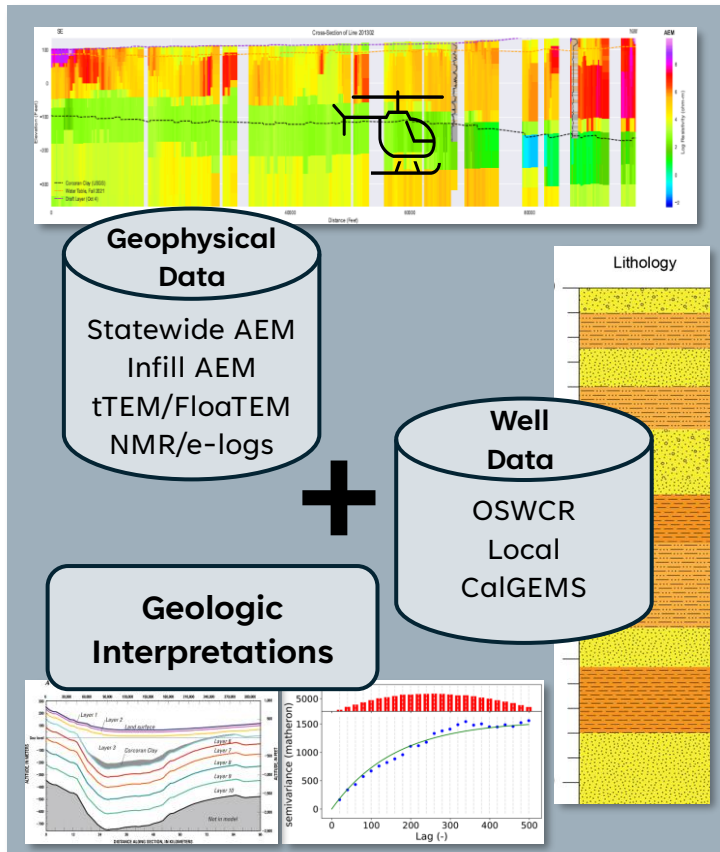


Outputs

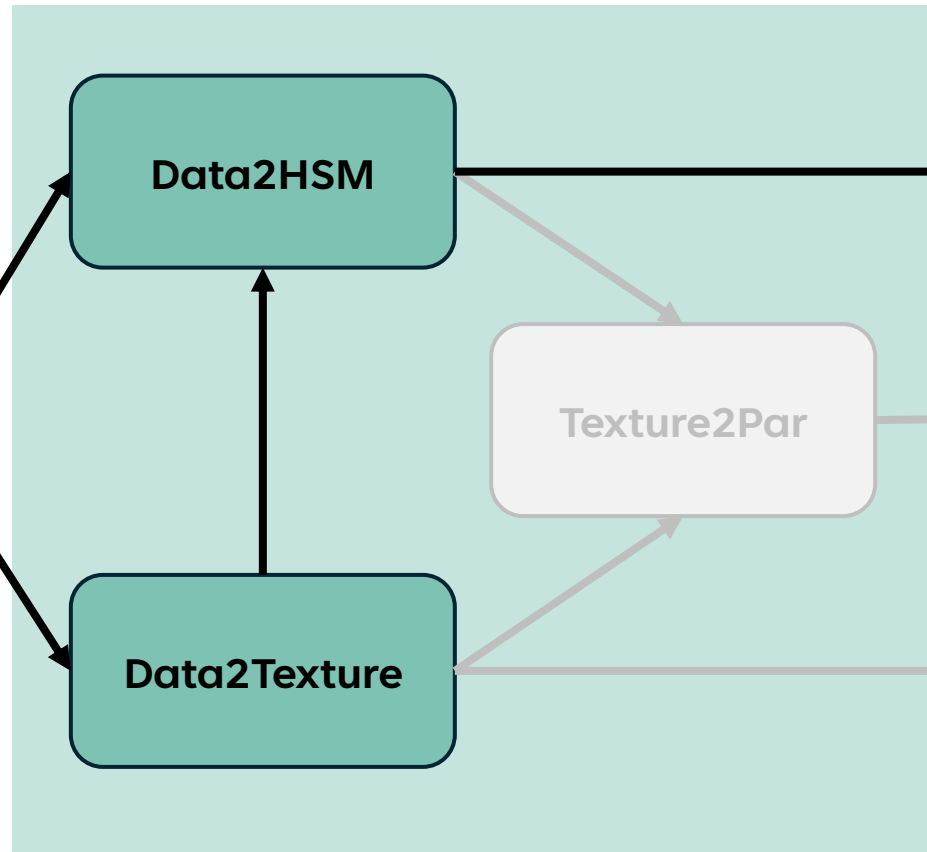


# Generate 3D Continuous Stratigraphy

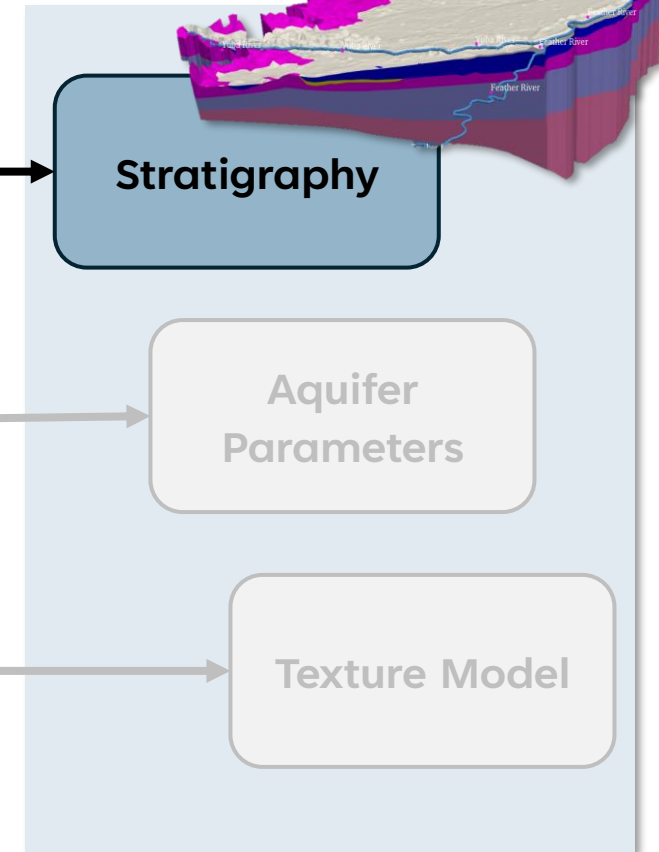
Inputs



Tools

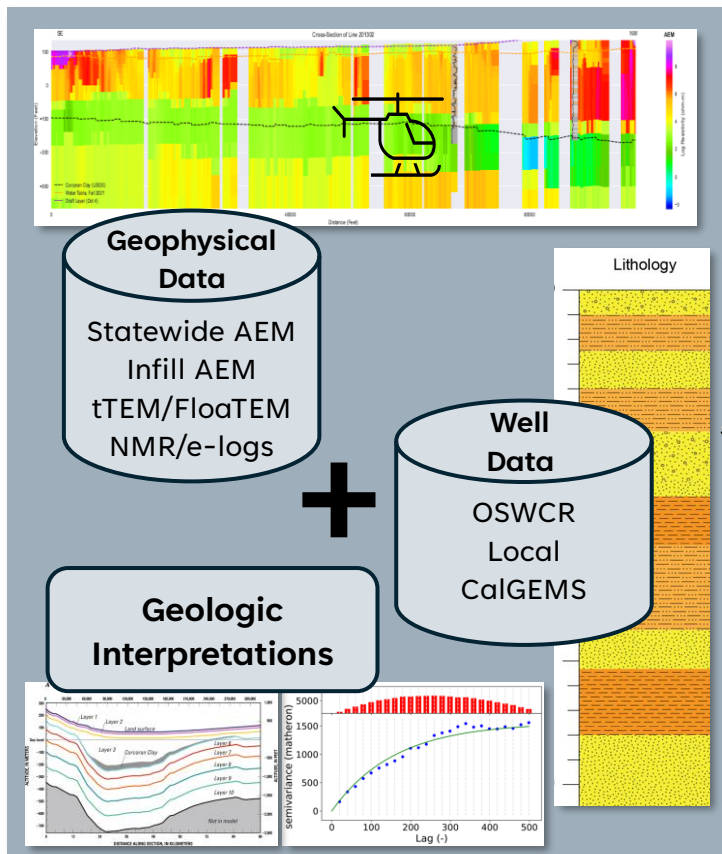


Outputs

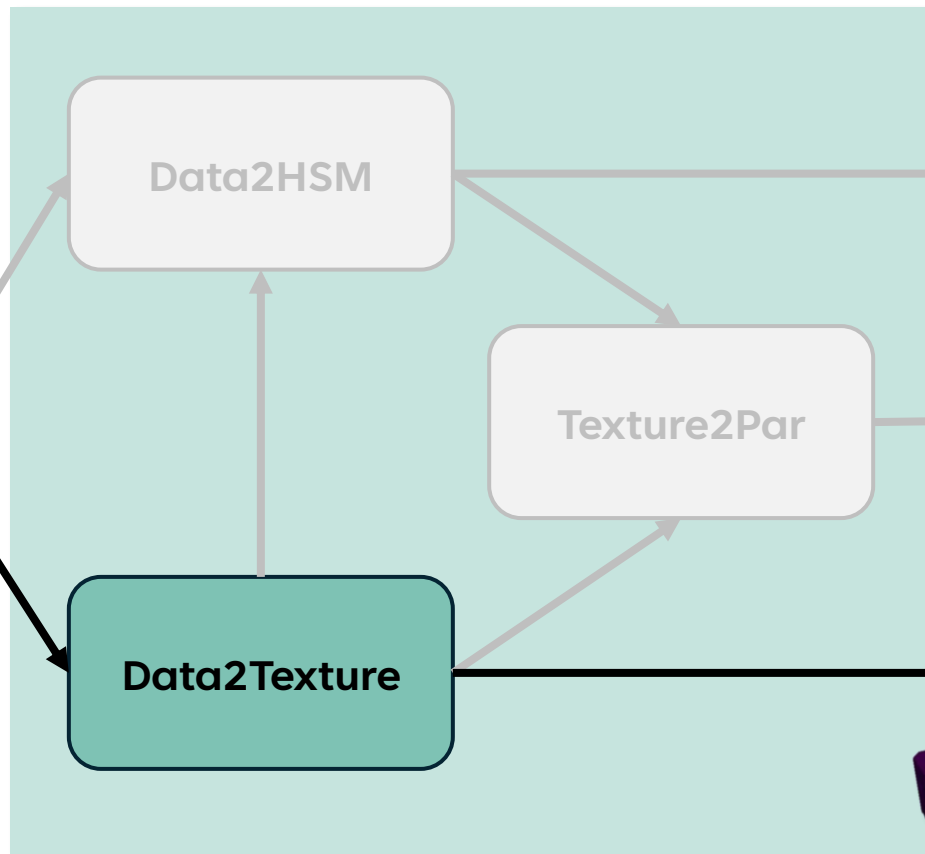


# Generate 3D Texture Model

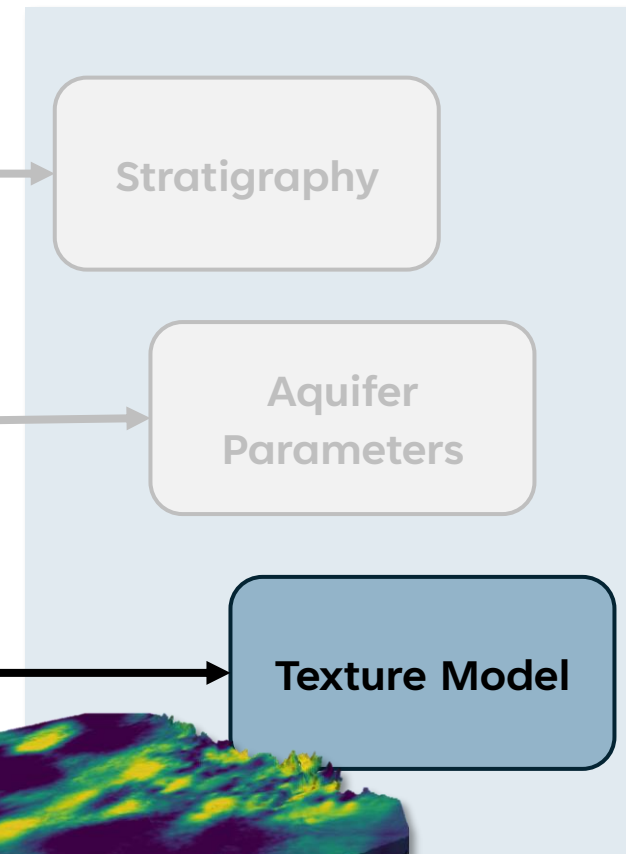
Inputs



Tools

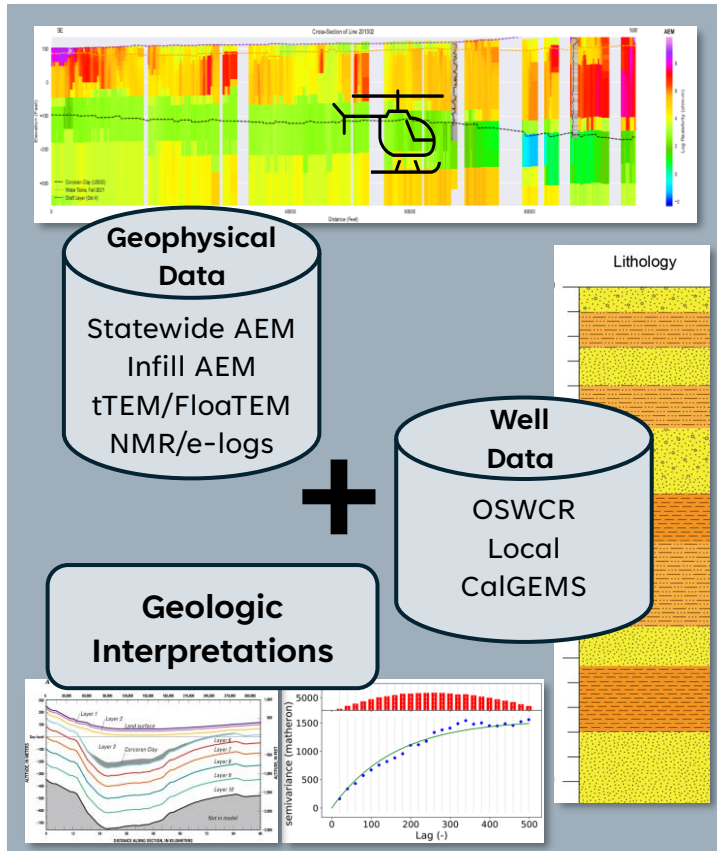


Outputs

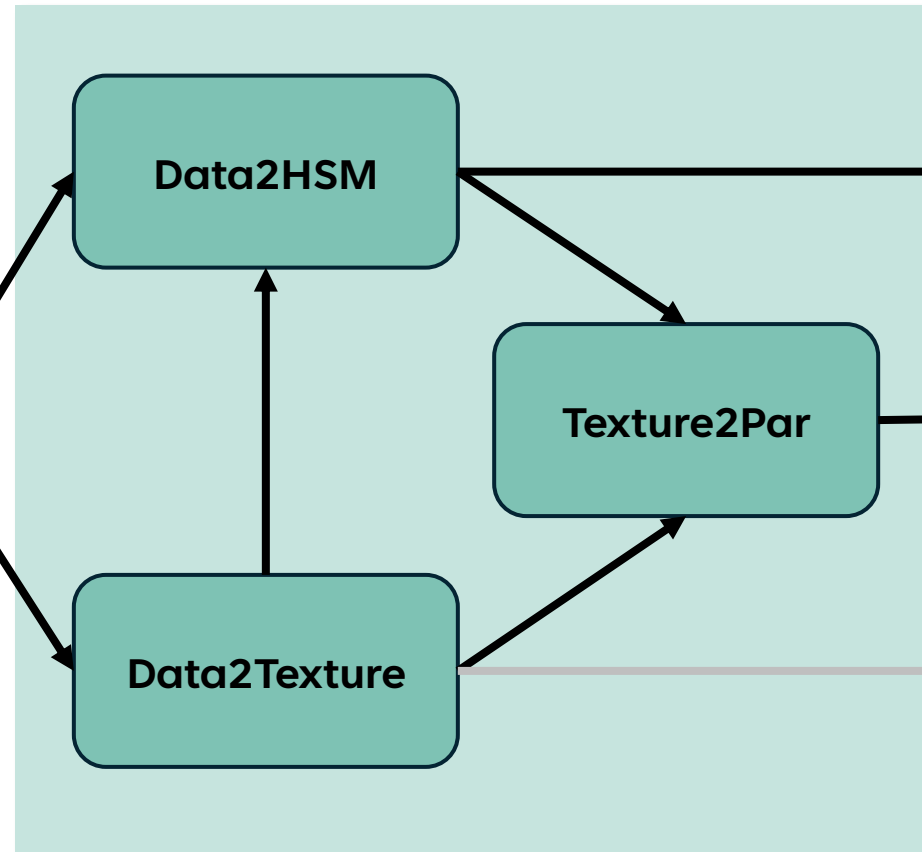


# Generate Aquifer Parameters and Stratigraphy for GWM Development

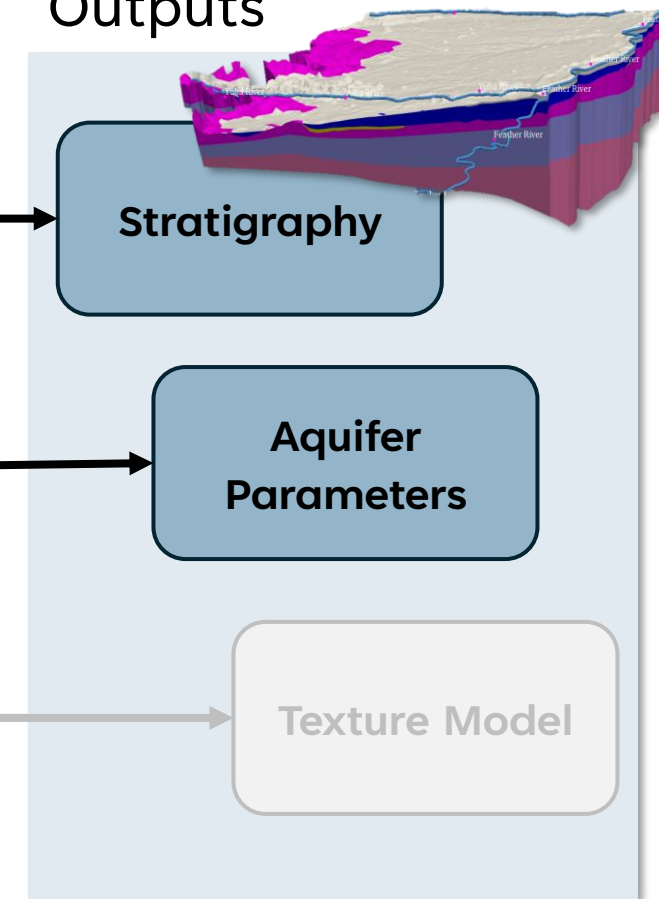
Inputs



Tools



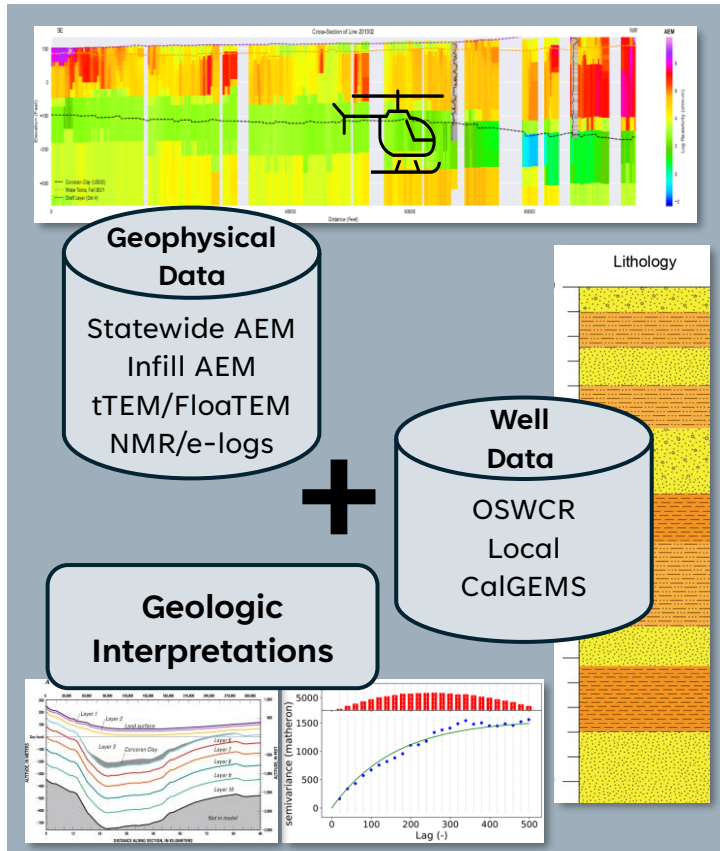
Outputs



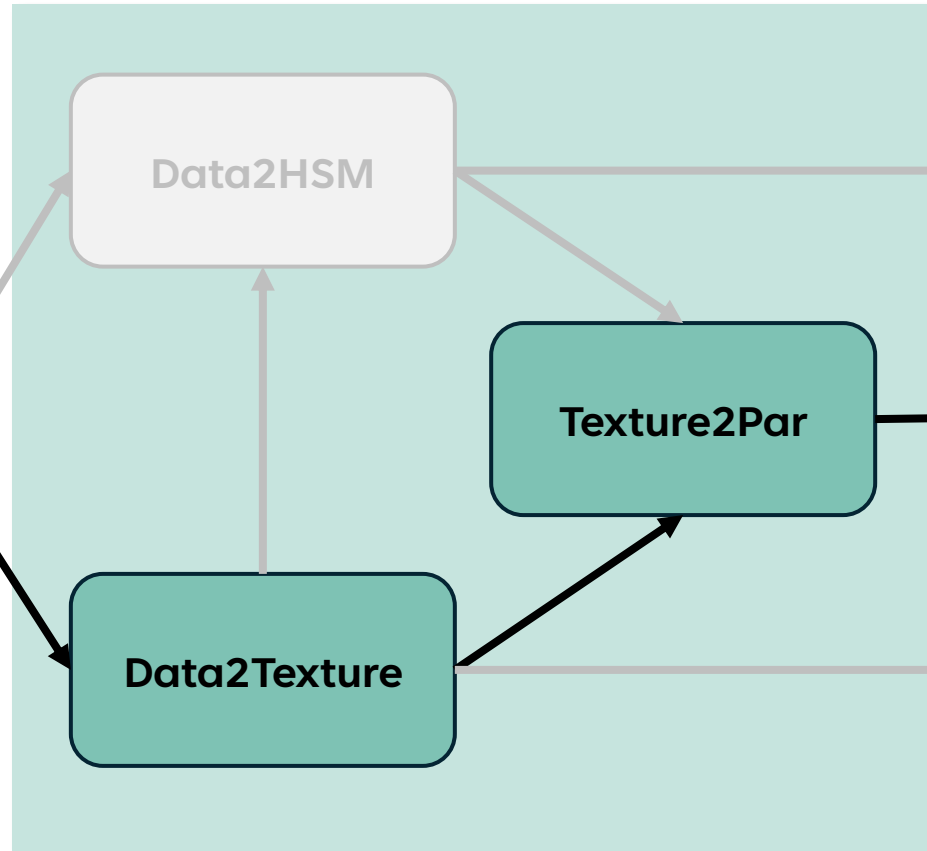


# Generate Aquifer Parameters for GWM Calibration

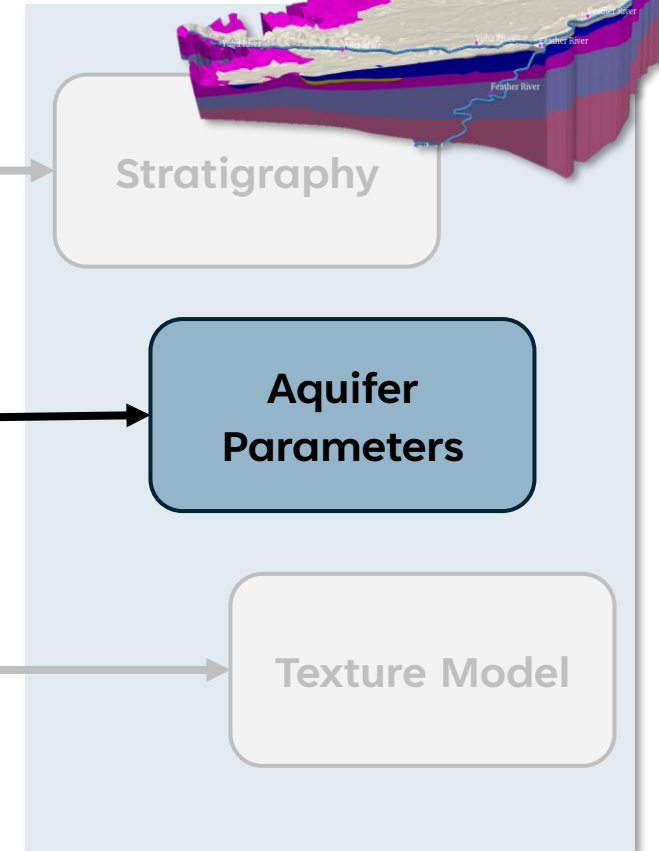
Inputs



Tools



Outputs

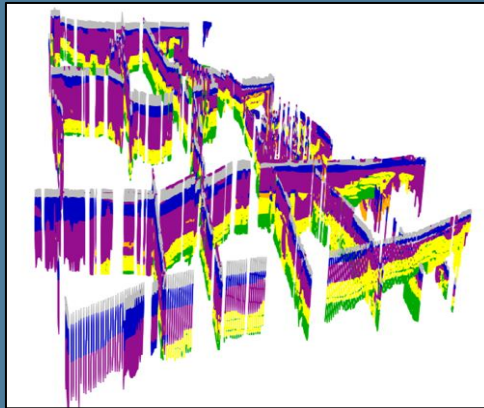




# Data2HSM

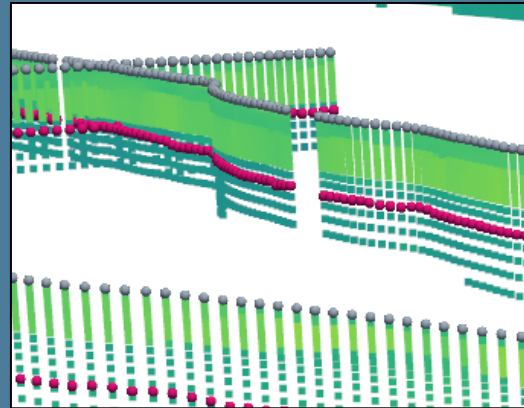
# Data2HSM Suite

## Gaussian Mixture Model



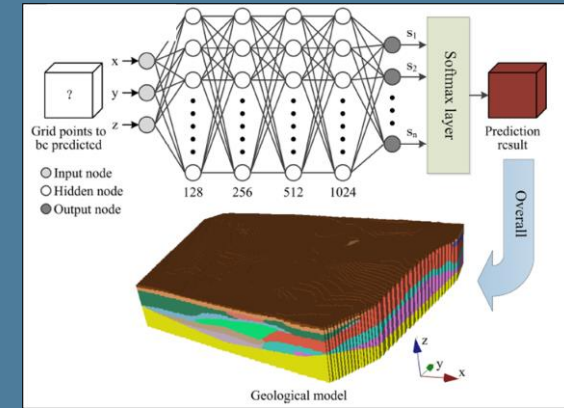
Clustering

## Smart Interpretation



Surface Identification

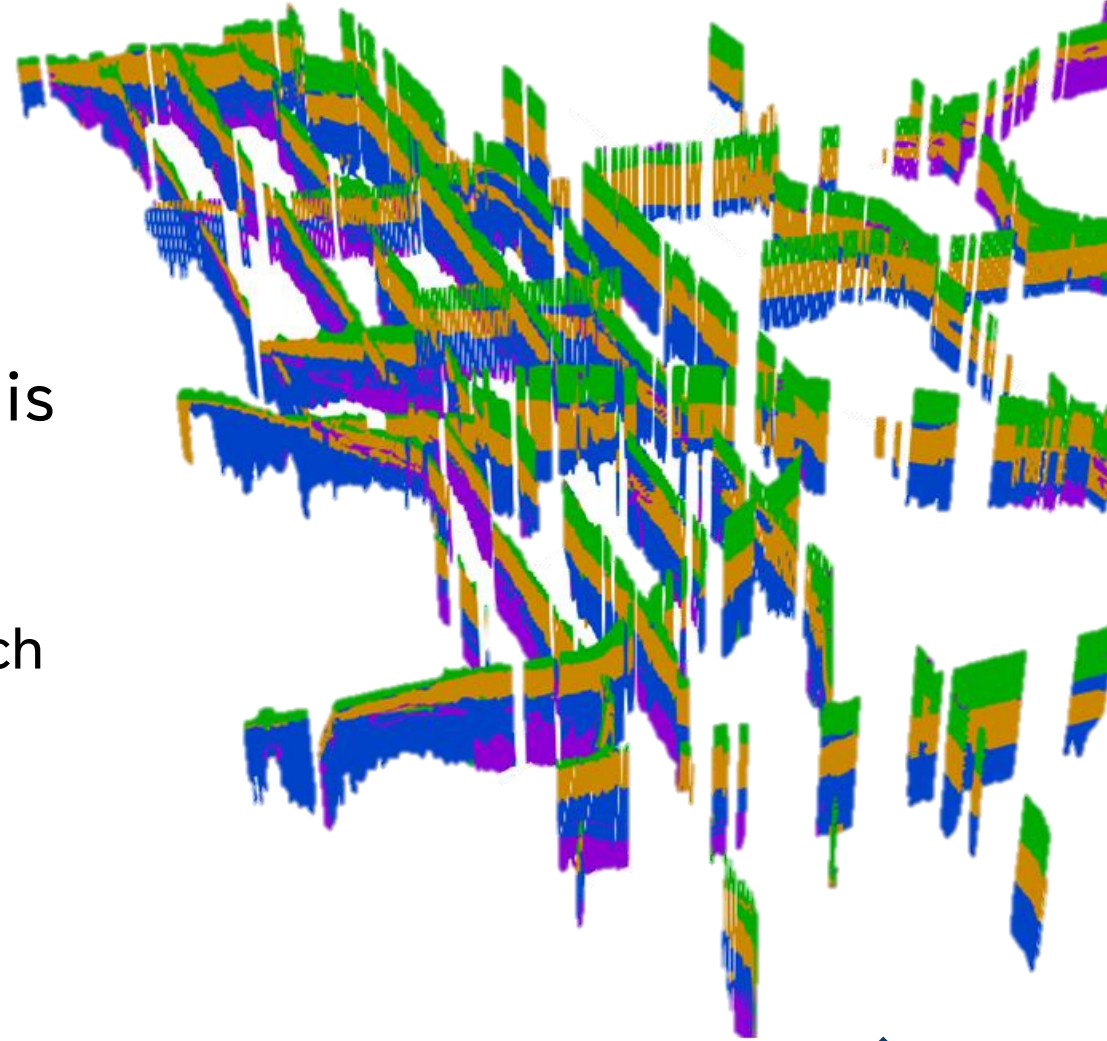
## GeoPDNN



Neural Network based prediction

# Data2HSM: Gaussian Mixture Model

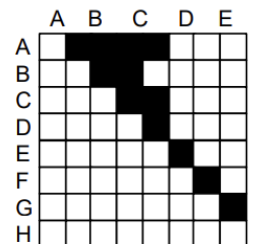
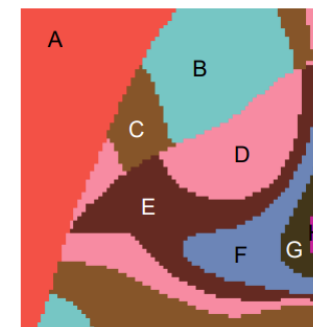
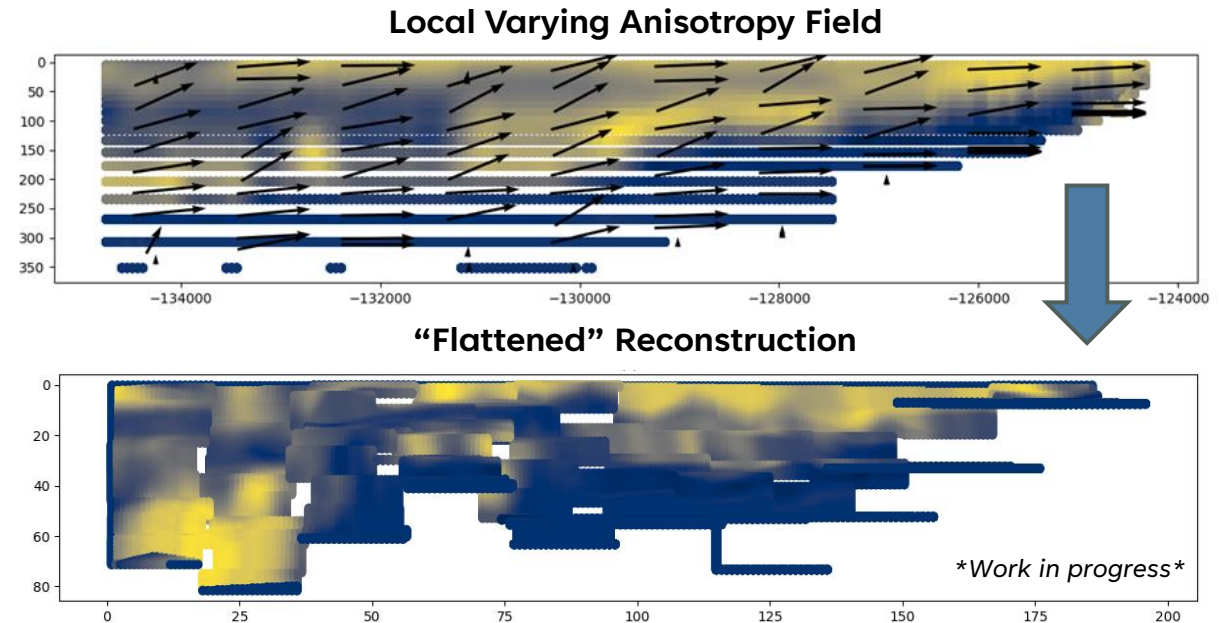
- Unsupervised ML algorithm trained on resistivity and texture data to cluster distinct hydrostratigraphic units
- Stratigraphic coordinate transformation is performed
  - Geologically informed anisotropy removal
  - Informed via user-provided information, such as existing cross sections, or model layers



# Data2HSM: Gaussian Mixture Model

## Plans for Future

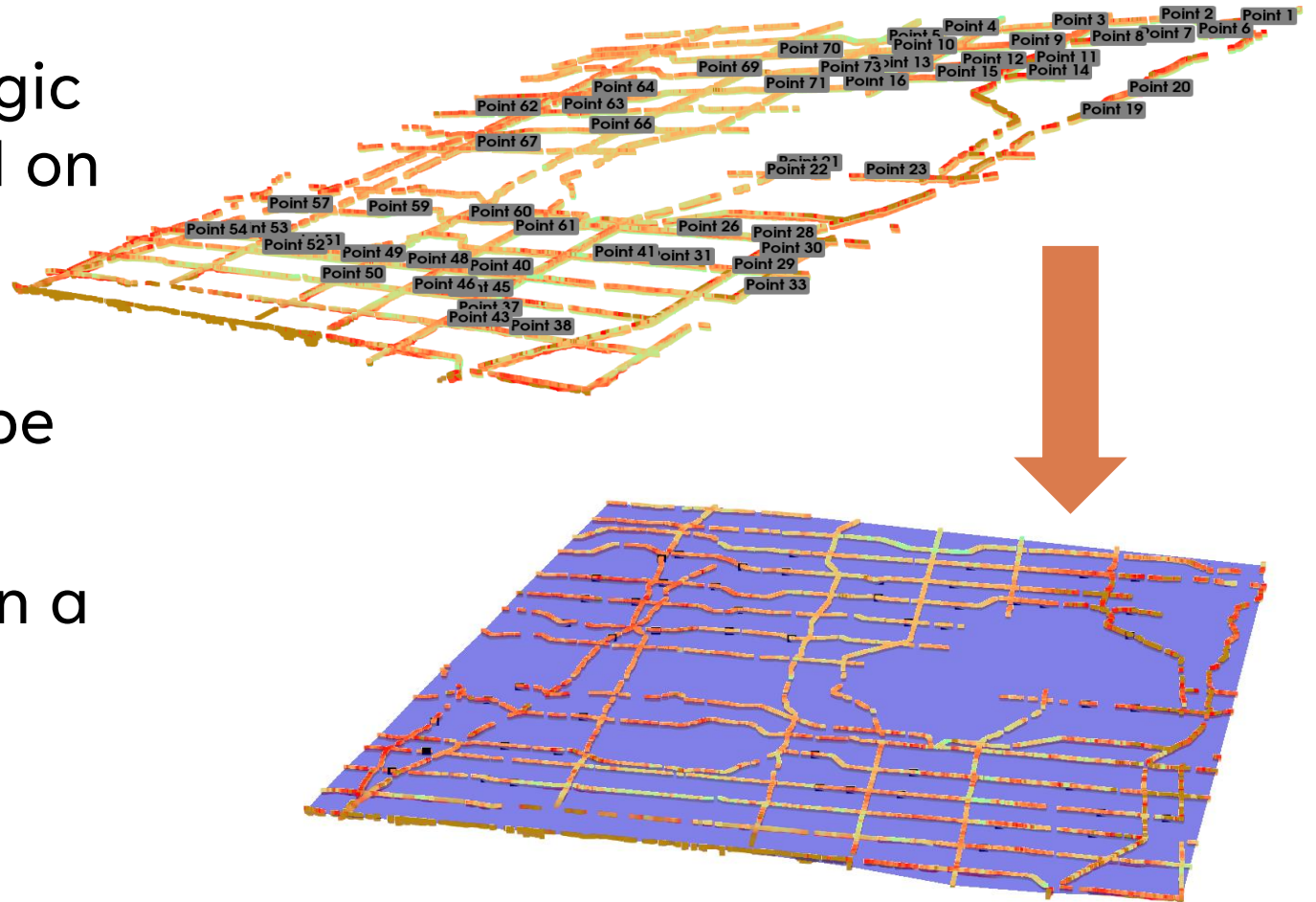
- Removing need for user to input existing information
  - Local Varying Anisotropy field
  - Field is then flattened to mimic the stratigraphic coordinate transform
- Post-processing of clusters using topological analysis and adjacency matrix to clean layers



Ogarko, et al., 2018

# Data2HSM: Smart Interpretation

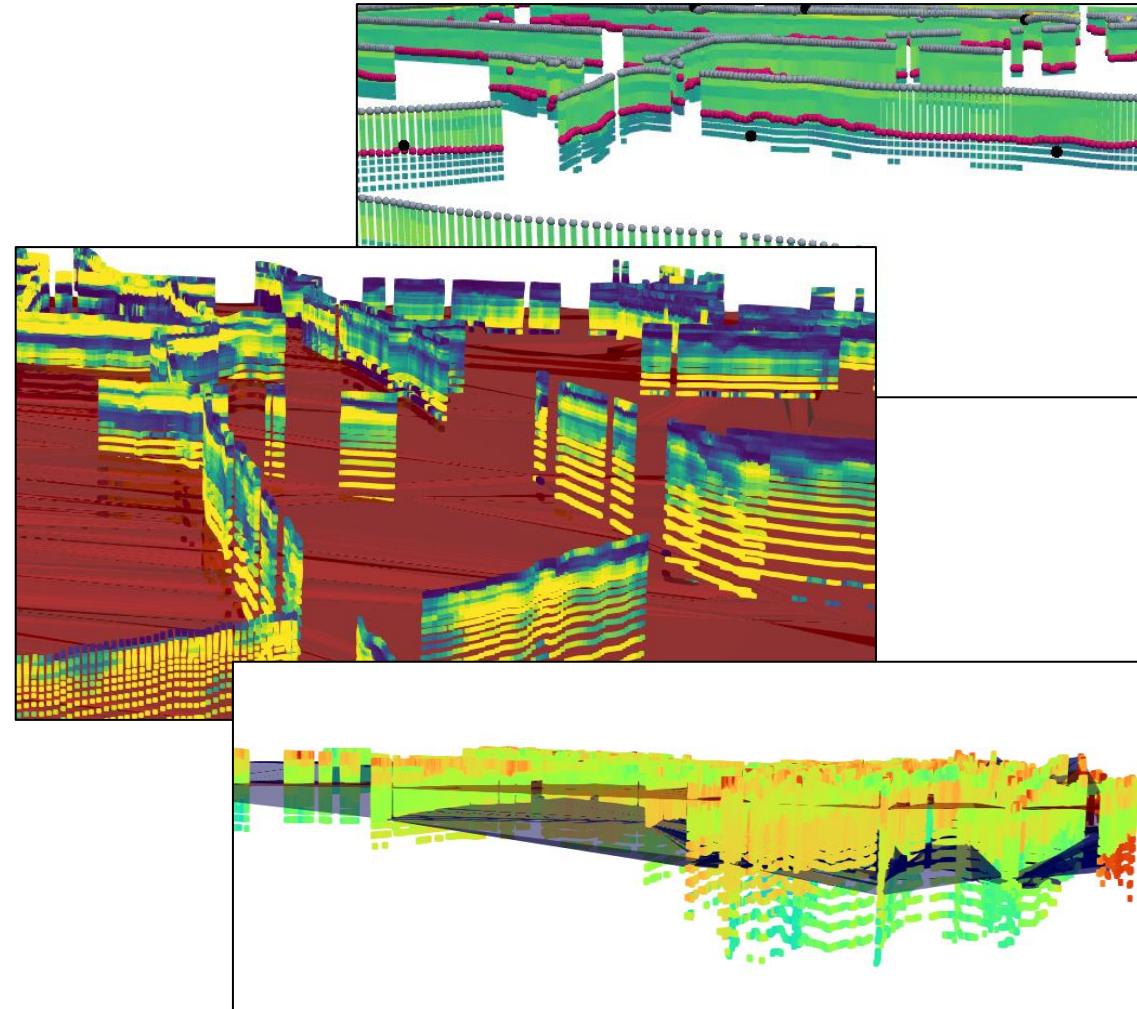
- Automatically interprets geologic contacts from XYZ data, based on user-selected training points
- Works on Resistivity or Texture datasets, and can potentially be used on other datasets
- Can delineate multiple layers in a single run



# Data2HSM: Smart Interpretation

## Plans for Future

- Internal testing of alpha version is underway
- Performance improvements for optimization algorithm
- Use of non-collocated point datasets as training datasets
  - Water Table Data
  - Formation picks from boring logs
  - Picks from E-logs

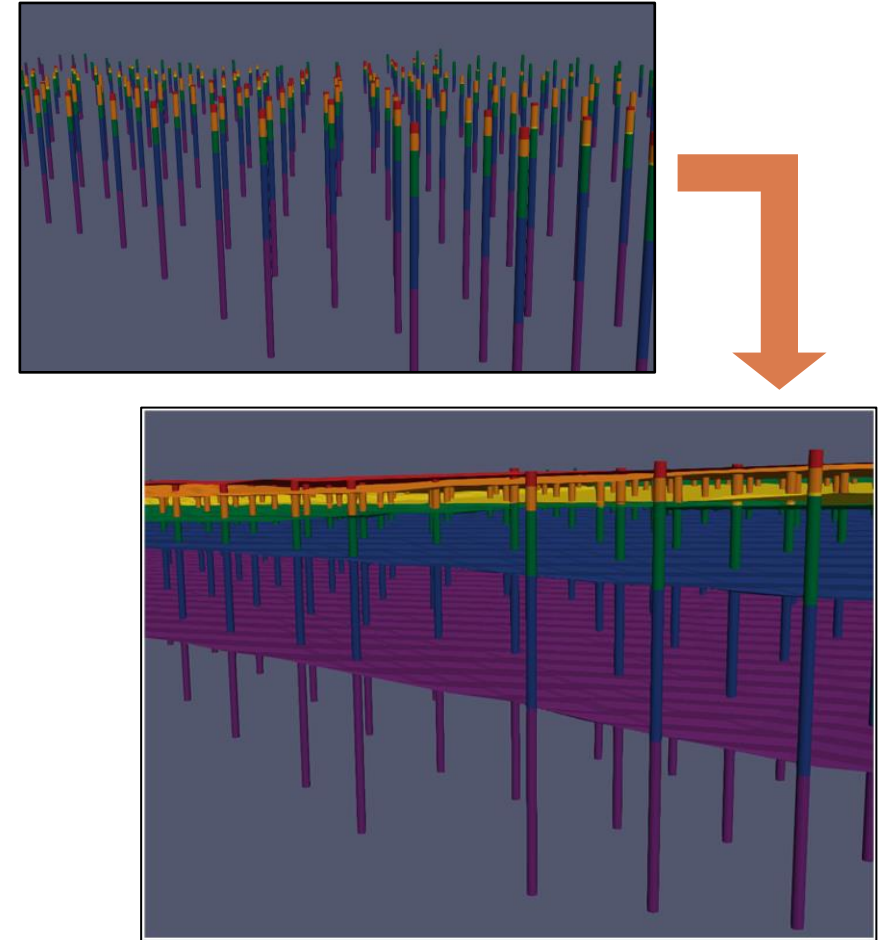


# Data2HSM: GeoPDNN

- Based on Guo et. Al (2024) approach
- Uses point-based datasets (ex: boring logs) to model stratigraphic surfaces
  - A way for the user to incorporate different types of datasets

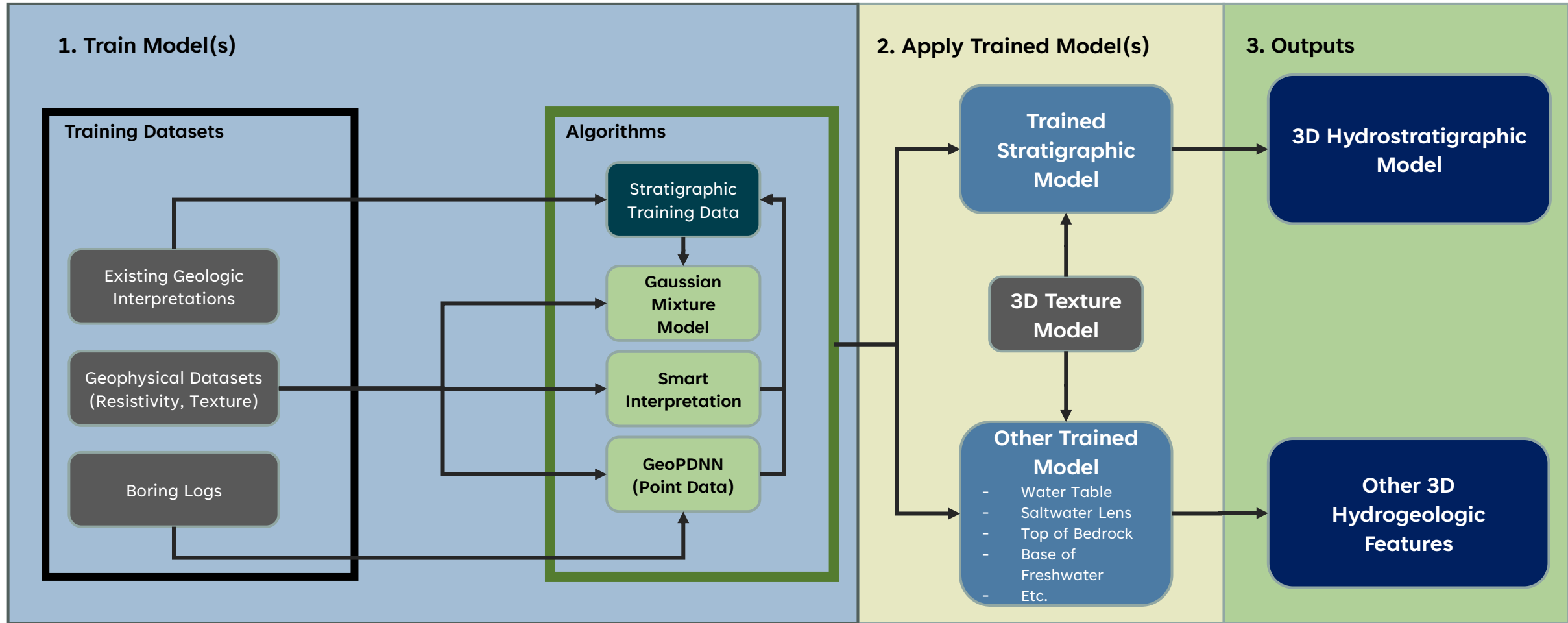
## Plans for Future

- Testing ways to improve model runtime, while still maintaining accuracy
- Integration with other datasets:
  - AEM Data
  - Picks from e-logs





# Data2HSM Detailed Workflow

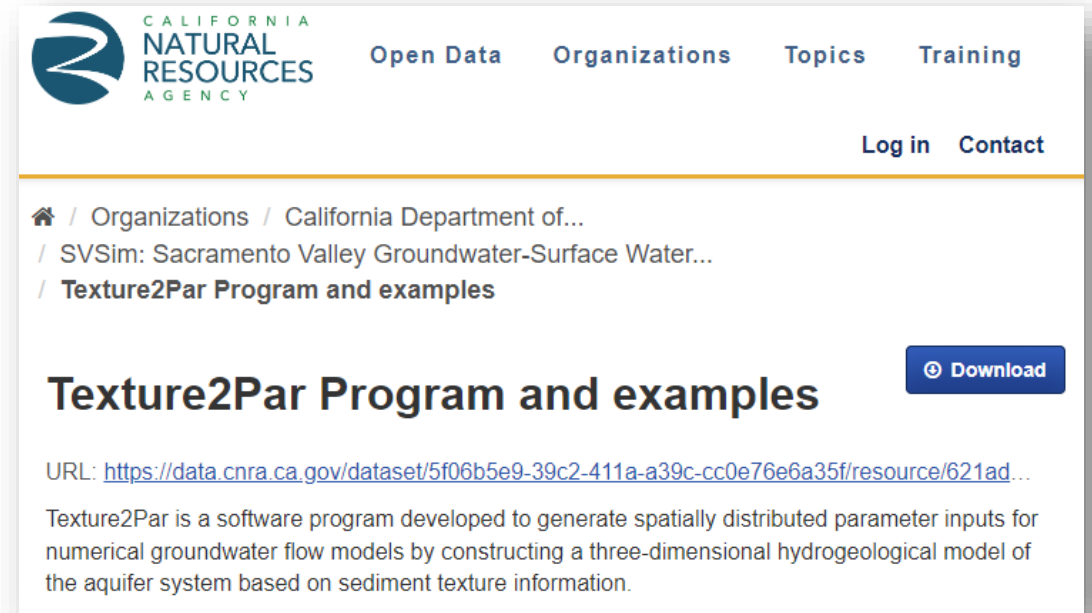




# Data2Texture and Texture2Par

# Texture2Par Version 1

- Available on DWR's website
  - Reads texture data from well logs
  - Interpolates percent coarse to model grids
  - Reads user-specified texture properties
  - Computes aquifer parameters for IWFM and MODFLOW models
- Applied on several real-world applications

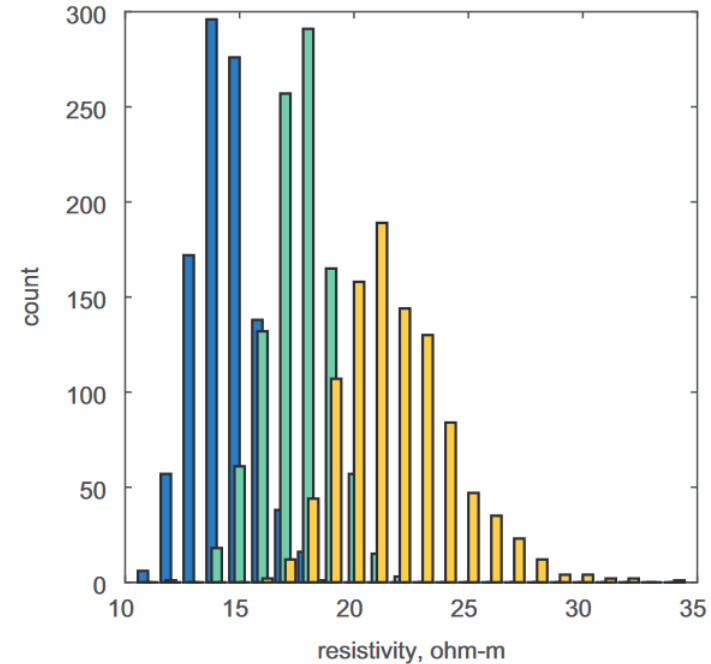


The screenshot shows the California Natural Resources Agency website. The header includes the agency logo and navigation links for Open Data, Organizations, Topics, and Training. A 'Log in' and 'Contact' link is also present. The main content area shows a breadcrumb trail: Home / Organizations / California Department of... / SVSim: Sacramento Valley Groundwater-Surface Water... / Texture2Par Program and examples. Below this is the title 'Texture2Par Program and examples' with a 'Download' button. The URL is provided as <https://data.cnra.ca.gov/dataset/5f06b5e9-39c2-411a-a39c-cc0e76e6a35f/resource/621ad...>. A descriptive paragraph follows: 'Texture2Par is a software program developed to generate spatially distributed parameter inputs for numerical groundwater flow models by constructing a three-dimensional hydrogeological model of the aquifer system based on sediment texture information.'

# Texture2Par Version 2

## Completed Work

- Incorporate AEM data
- Multiple texture classes
- Multiple interpolation options
  - Simple Kriging
  - Ordinary Kriging
  - Co-Kriging



Probabilistic Texture  
EM Classification

# Texture2Par Version 2

## Completed Work

- Revised input structure for flexibility
  - Provision for accommodating a variety of data in the future

```
*=====
* Texture2Par Main Input File
*=====

BEGIN OPTIONS
  MAX_VSTRUCT      1
  DATA_CLASSES    2
  INFER_LAST_CLASS
END OPTIONS

BEGIN FLOW_MODEL
  TYPE IWFM
  SIM_FILE          SVSim.in
  PREPROC_FILE      ../Preprocessor/SVSim_Preprocessor.in
  TEMPLATE_FILE     Groundwater/SVSim_Groundwater19730rig.dat
  PP_ZONE_FILE      zones.txt
END FLOW_MODEL

BEGIN CLASSES
  # Primary, Secondary
  Coarse Rho
  Fine
END CLASSES

BEGIN DATASET
  FILE wells_wAEM.dat
END DATASET

BEGIN VARIOGRAMS
# Structure Vtype Nugget Sill Range_min Range_max ang1 nnear
CLASS Coarse
  1 Sph 0.00 1.0 1.5E4 1.5E4 0.0 32
CLASS Rho
  1 Sph 0.00 1.0 1.5E4 1.5E4 0.0 200
CLASS Coarse:Rho
  1 Sph 0.00 1.0 1.5E4 1.5E4 0.0
CLASS PilotPoints
  1 Sph 0.00 1.0 1.5E5 1.5E5 0.0 25
END VARIOGRAMS
```

# Texture2Par Version 2

## Modes of operation

- Data2Texture
- Texture2Par

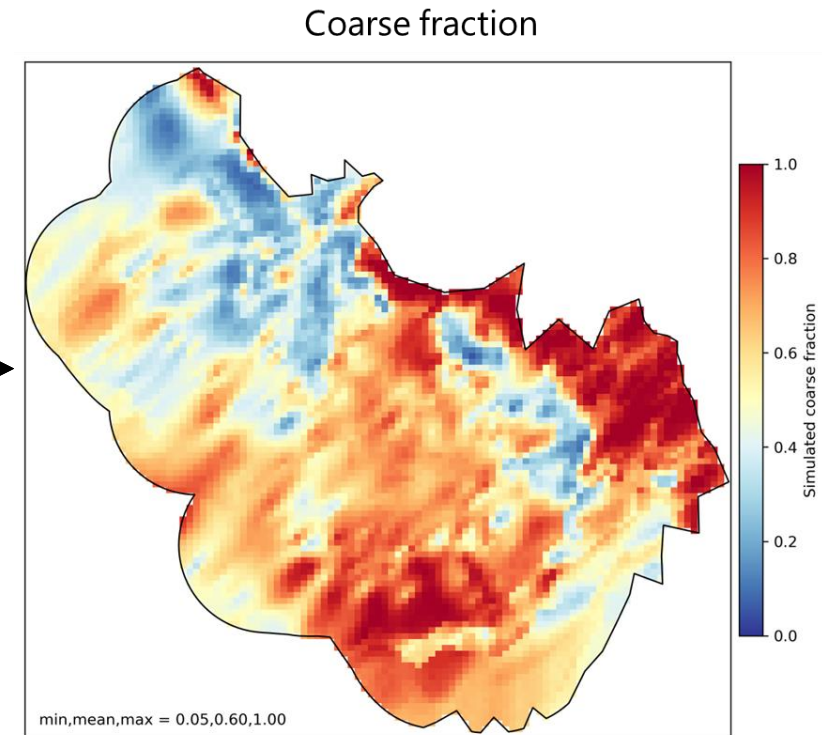
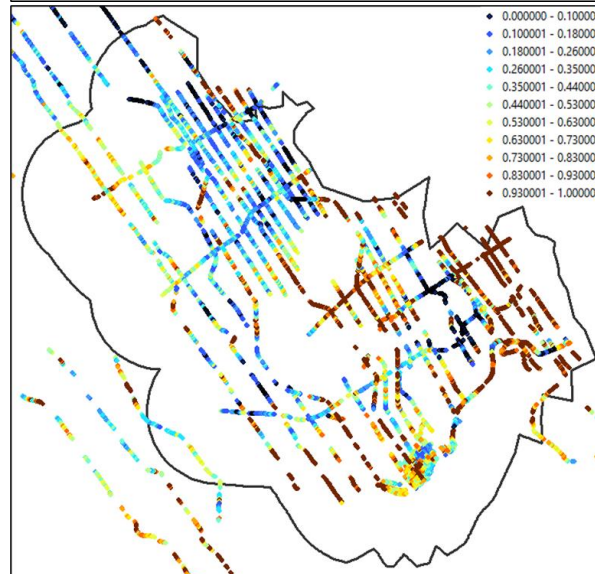
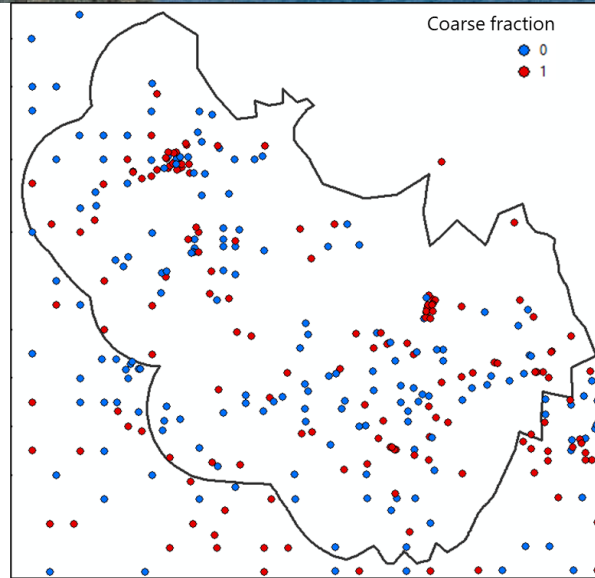
Data2Texture

Texture2Par

# Data2Texture

## How it works

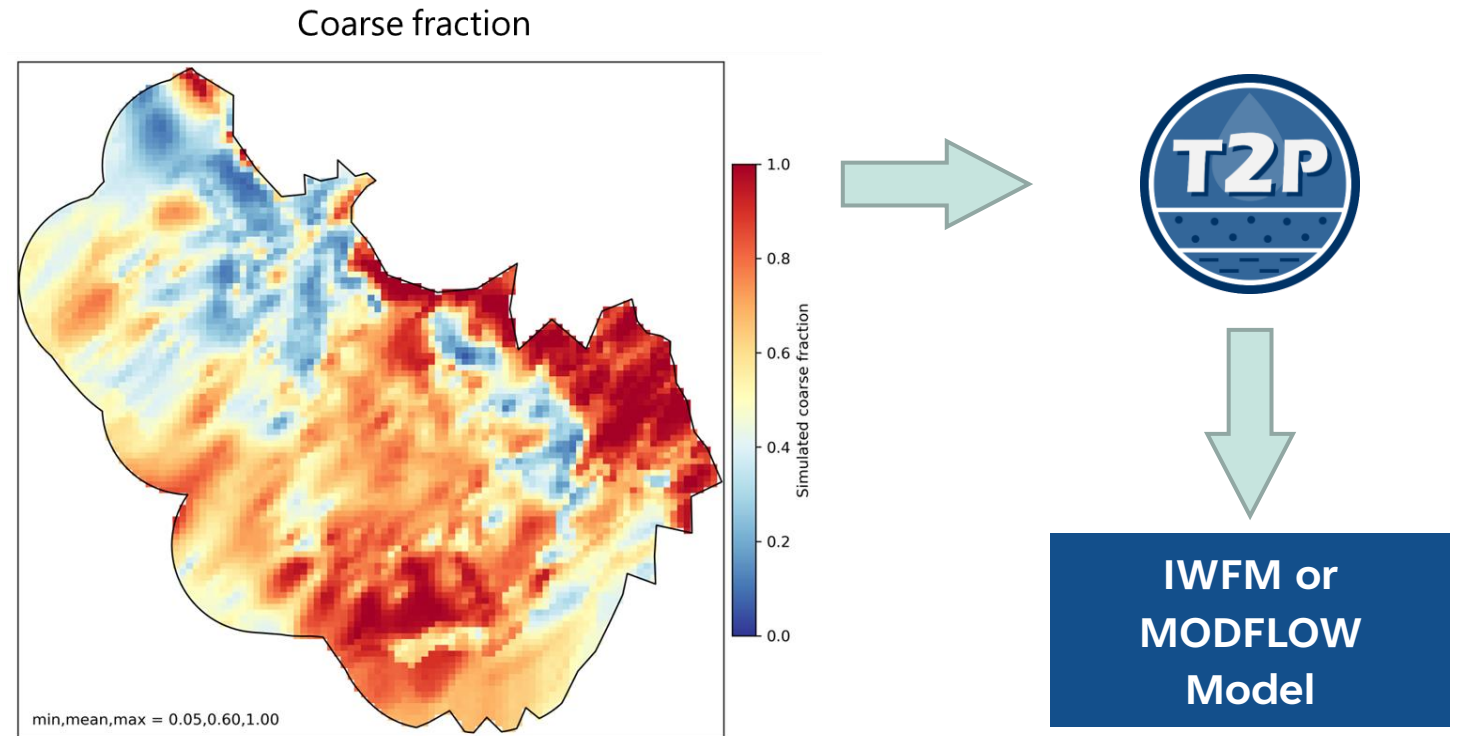
- Read well logs
- Read AEM data
- Read variogram, grid, and other settings
- Generate 3D Texture Models
- Development is ongoing



# Texture2Par

## How it works

- Read texture-scale properties
- Apply power-law averaging
- Calculate and write aquifer parameter files for IWFM and MODFLOW
- Development/testing is ongoing

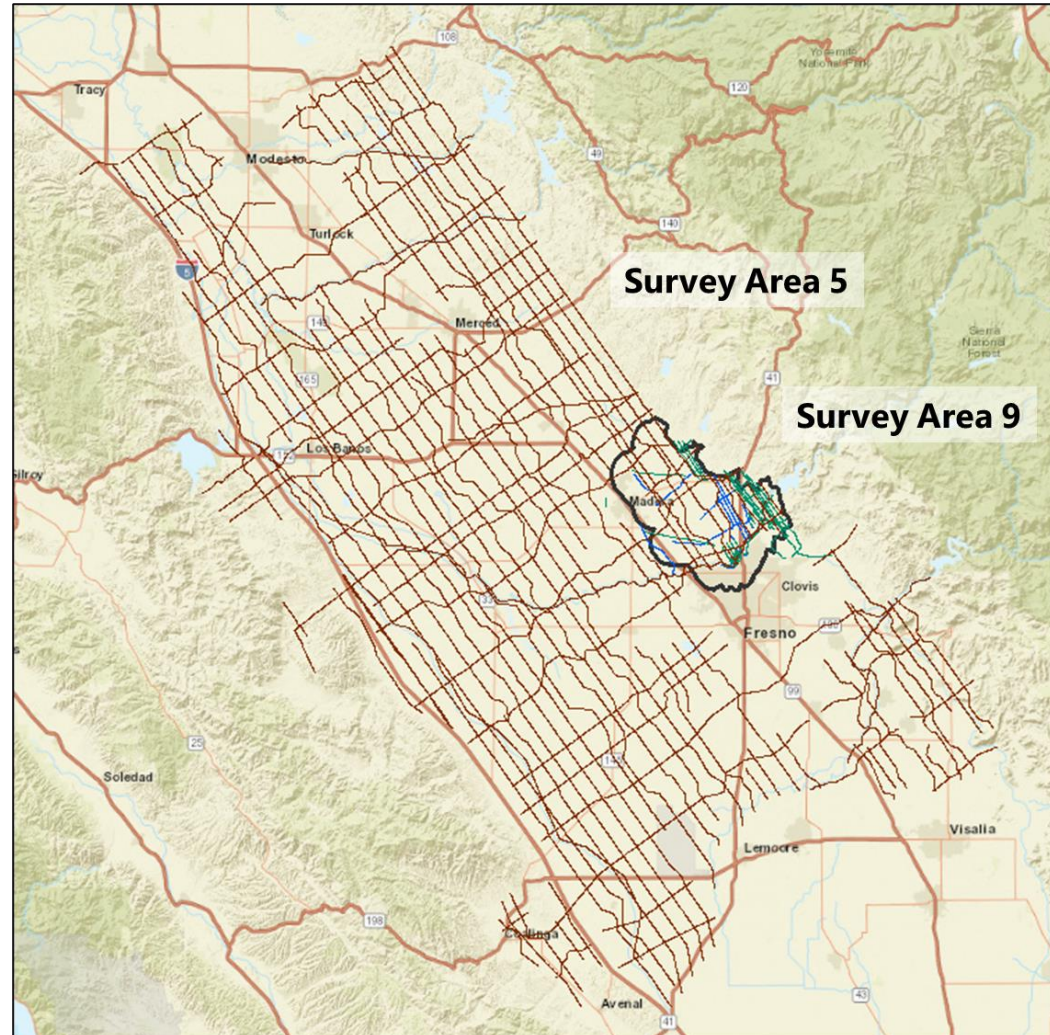




# Texture2Par Version 2

## Ongoing Work

- Add more capabilities
  - Block Kriging
- Uncertainty estimation
  - Testing phase
- Add support to MODFLOW-USG
- Test implementation within local and regional models



# Texture2Par Version 2

## Future Work

- Add support for MODFLOW 6
- Add non-stationary 3D kriging option
  - Varying angle of horizontal anisotropy
- Quantify uncertainty with Sequential Gaussian Simulation

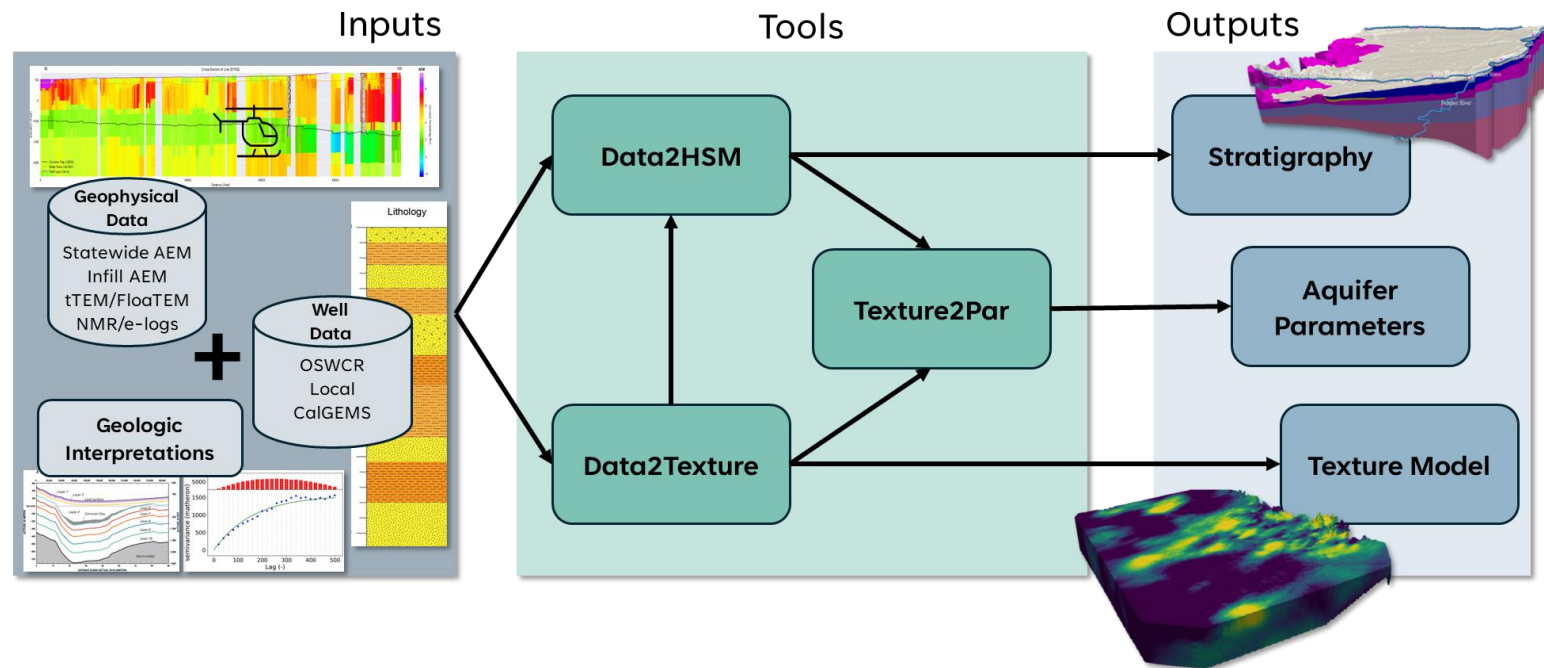


# Tool Integration

# Tool Integration

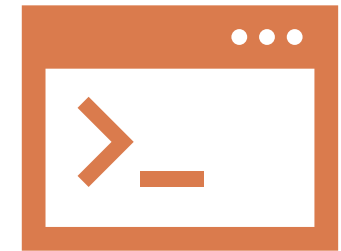
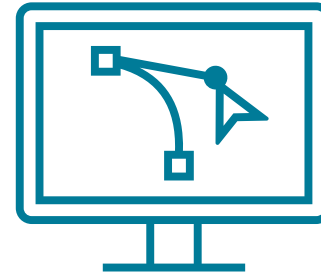
## Ongoing Work

- Integrate to work as a single program:
  - Data2HSM
  - Data2Texture
  - Texture2Par
- Design the graphical user interface / command line interface focusing on the desired outputs and available inputs



# Future Work

- Complete testing in different basins and with different models
- Develop integrated tool and user interface
- Create distribution tests for version control
- Prepare tool documentation, guidance, and training documents



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# Thank you

## Project Team

### CA DWR

Steven Springhorn  
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Ben Brezing  
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### SSPA

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Vivek Bedekar  
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### Woodard & Curran

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Tori Ward  
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Sercan Ceyhan  
Mesut Cayar  
Saquib Najmus

## Technical Feedback & Support

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Paul Thorn

### USGS

Claudia Faunt  
Lyndsay Ball  
Geoffrey Cromwell

