Artificial Intelligence Applications In Hydrogeology And Groundwater Management

Khalid ElHaj

Researcher

200734761@uaeu.ac.ae

Overview

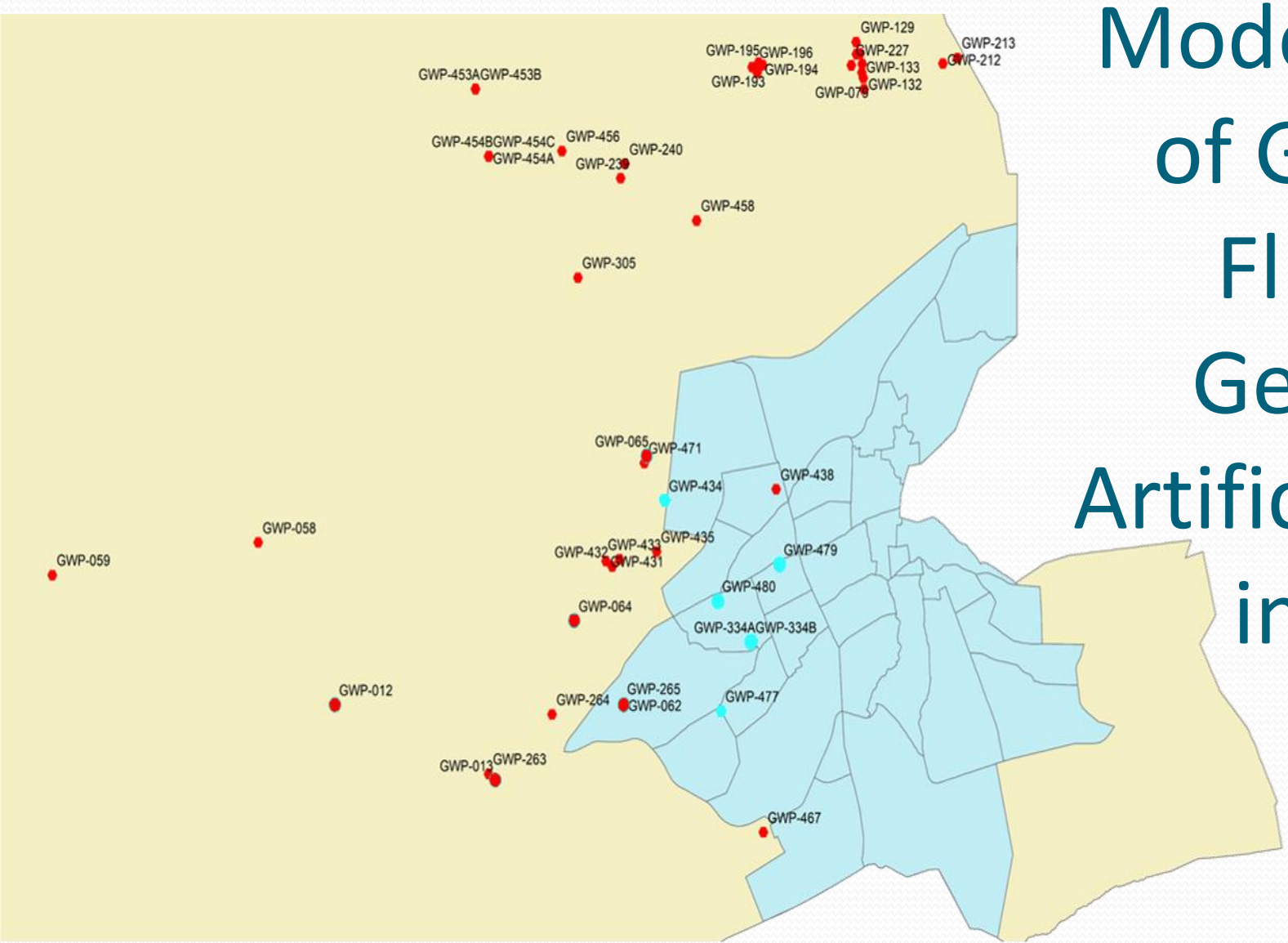
- Introduction
- **Modeling and Prediction of Groundwater Level Fluctuations** Using Geoinformatics and Artificial Neural Networks in Al Ain city, UAE
- **Adaptation To Climate Change Challenges In UAE**: An Artificial Intelligence (AI) Approach For The Prediction Of Groundwater Salinity Changes
- **Leveraging Machine Learning to Extract Insights and Spatial Patterns** from Hydrogeochemical Datasets for Three Major Regions in the UAE
- **Advancing Groundwater Management**: A Novel Machine Learning Approach to Aquifer Delineation
- Conclusion

Introduction

- More than two Billion people depend on groundwater as their Primary water source.
- More than half of the water used for irrigating the world's food supply comes from groundwater as well.
- Managing groundwater resources involves many aspects, including observing its usage and predicting its future utilization, In addition to aquifer delineation, pollution indicators, and any kind of relation the aquifers may maintain with each other.
- One of the key aspects of groundwater management is aquifer delineation. Accurately delineating aquifer boundaries provides numerous critical benefits that support sustainable groundwater management and utilization.

Modeling and Prediction of Groundwater Level Fluctuations Using Geoinformatics and Artificial Neural Networks in Al Ain city, UAE

Khalid ElHaj*, Salem Issa, Dalal Alshamsi, Biruk Cherkose



Modeling and Prediction of Groundwater Level Fluctuations Using Geoinformatics and Artificial Neural Networks in Al Ain city, UAE

Creating the Model

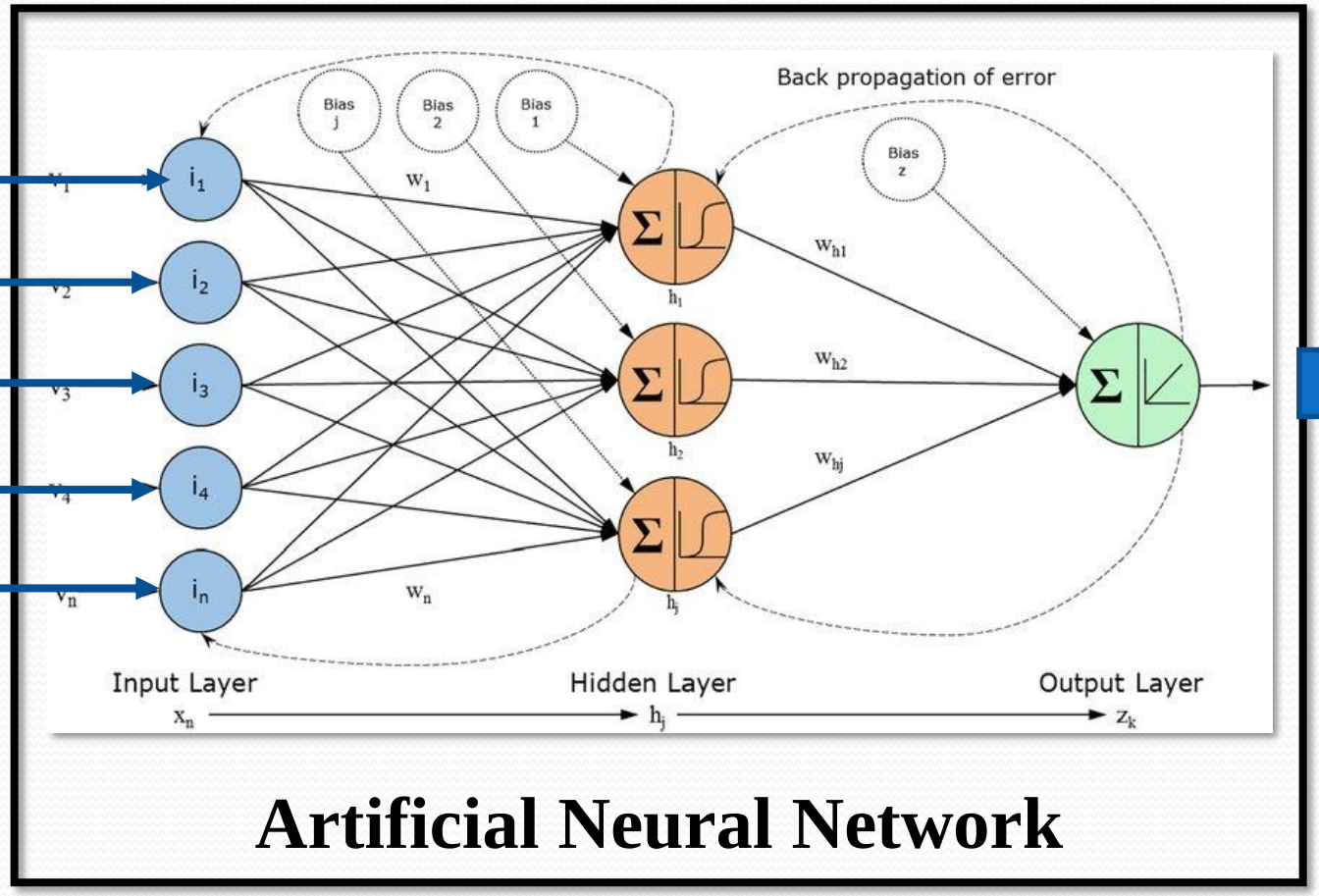
Rainfall

Humidity

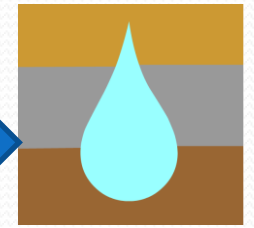
Evaporation

Temperature

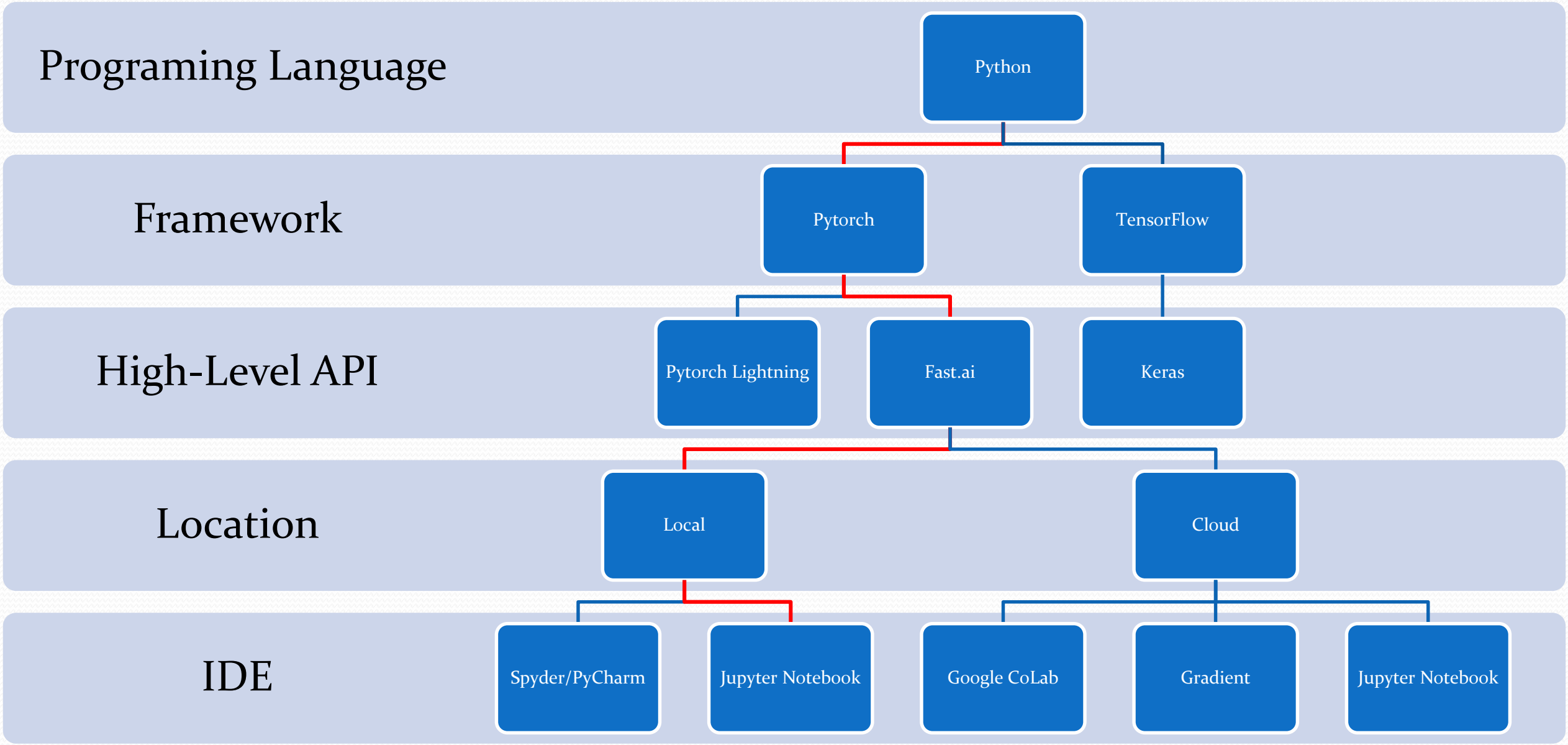
Date



Artificial Neural Network



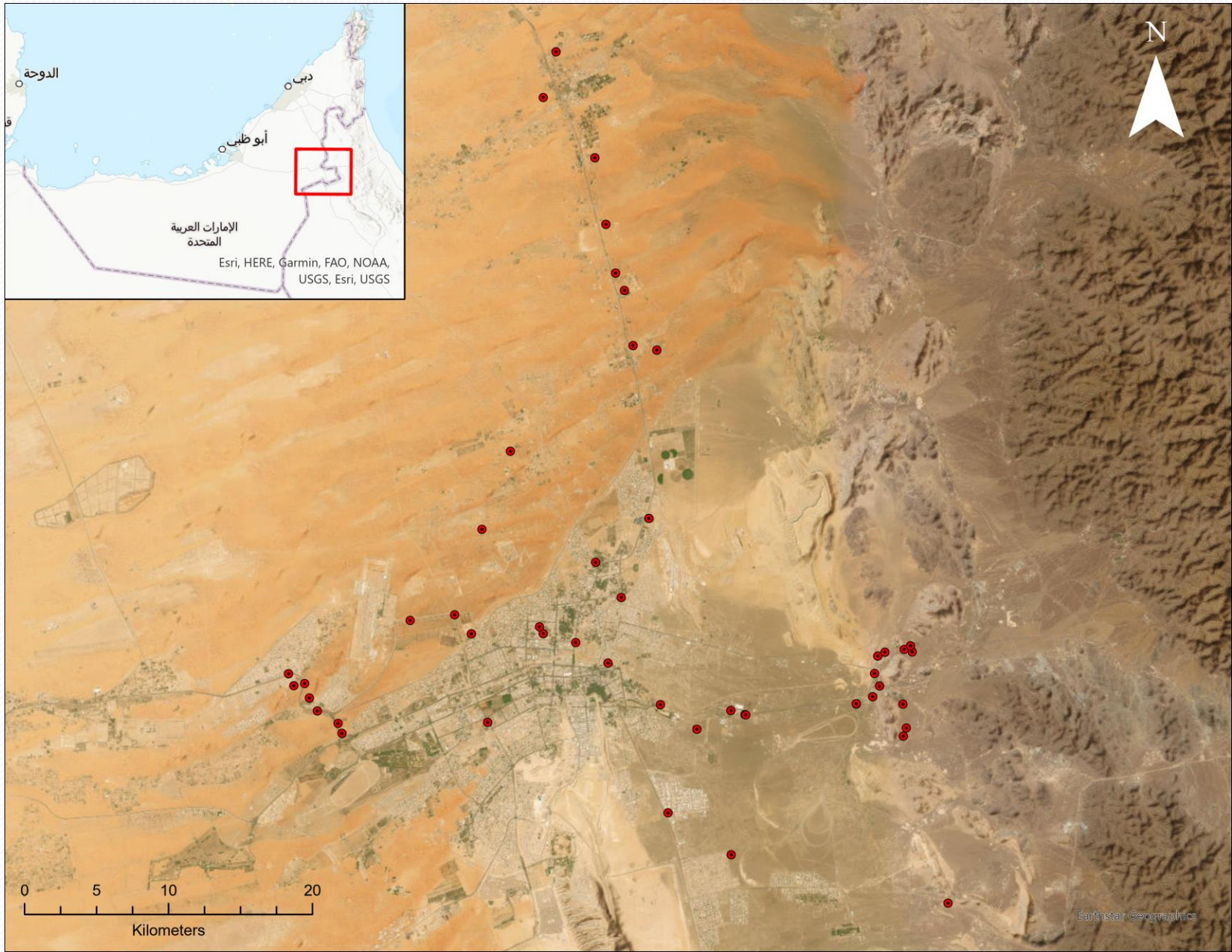
Groundwater Level


Programing Language
Framework
High-Level API
Location
IDE
Python
Pytorch
TensorFlow
Pytorch Lightning
Fast.ai
Keras
Local
Cloud
Spyder/PyCharm
Jupyter Notebook
Google CoLab
Gradient
Jupyter Notebook

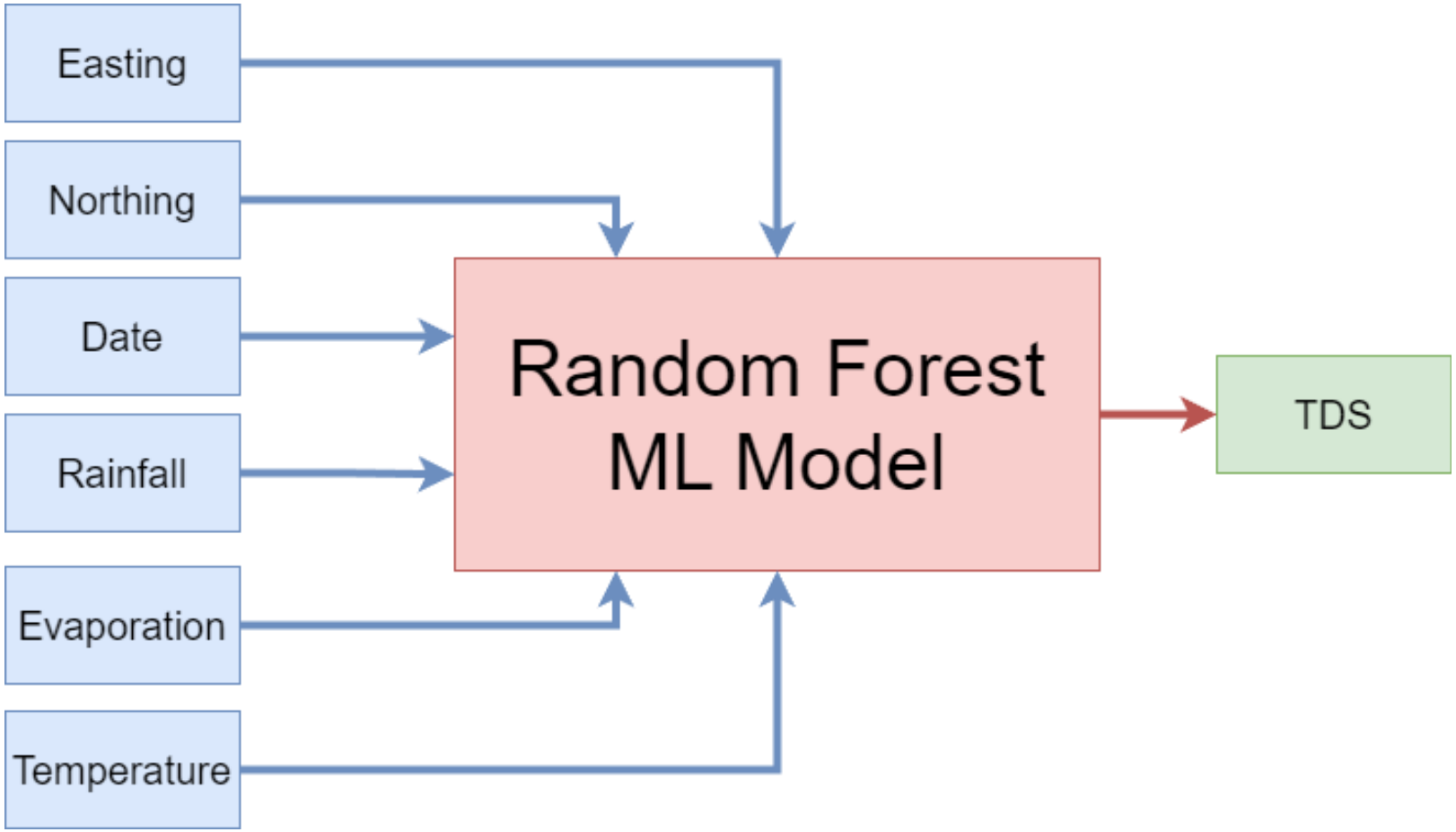
Adaptation to climate change challenges in UAE: an artificial intelligence (AI) approach for the prediction of groundwater salinity changes

Khalid ElHaj, Alaa Ahmed, Dalal Alshamsi, Ahmed Murad, Ali Al Ahbabi, Mohammed AlJanahi, Ala Aldahan

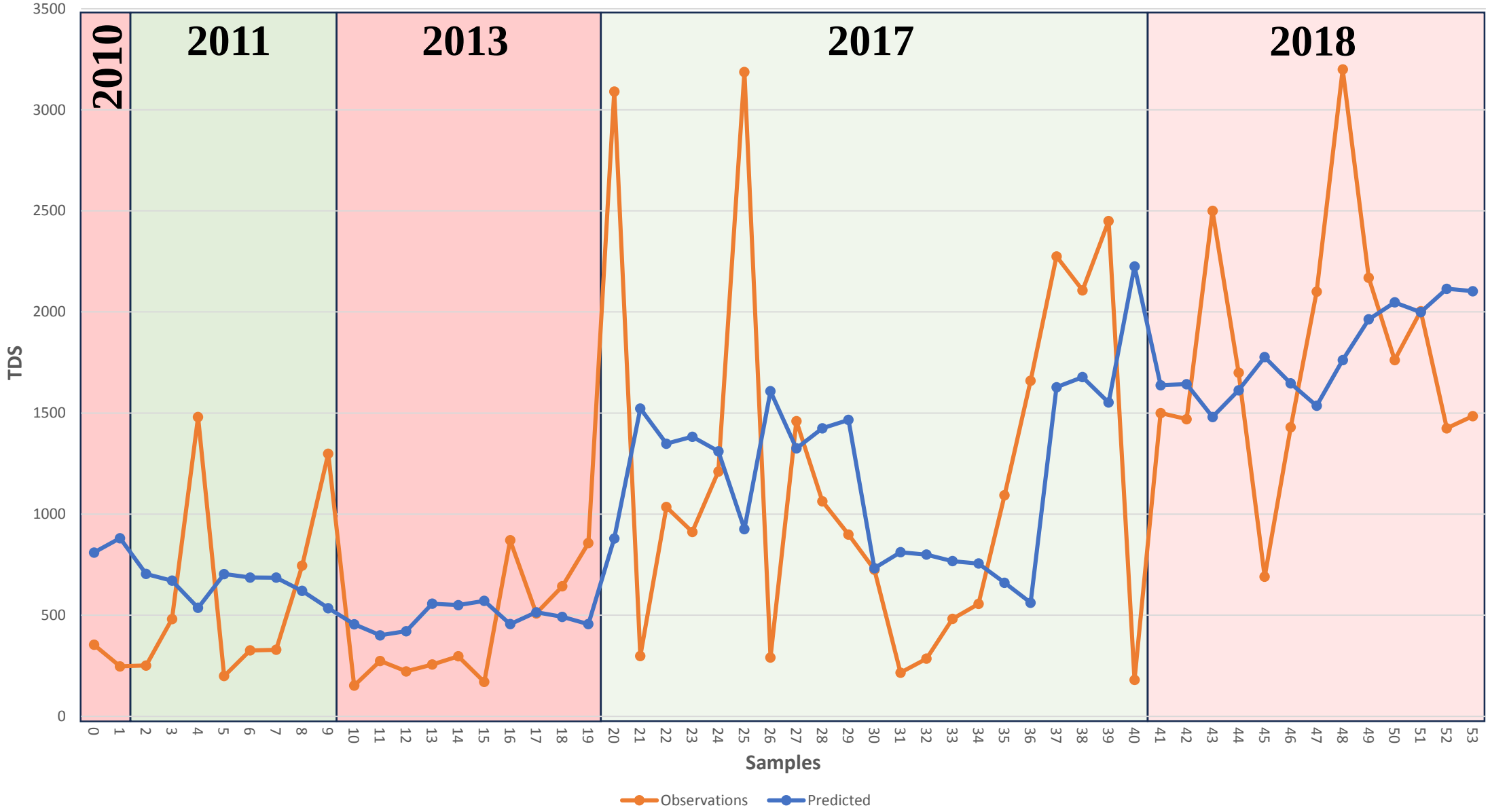
Study Area


الدوحة
دبي
أبو ظبي
الإمارات العربية
المتحدة
Esri, HERE, Garmin, FAO, NOAA,
USGS, Esri, USGS
N
0
5
10
20
Kilometers
Earthstar Geographics

ML Model Description

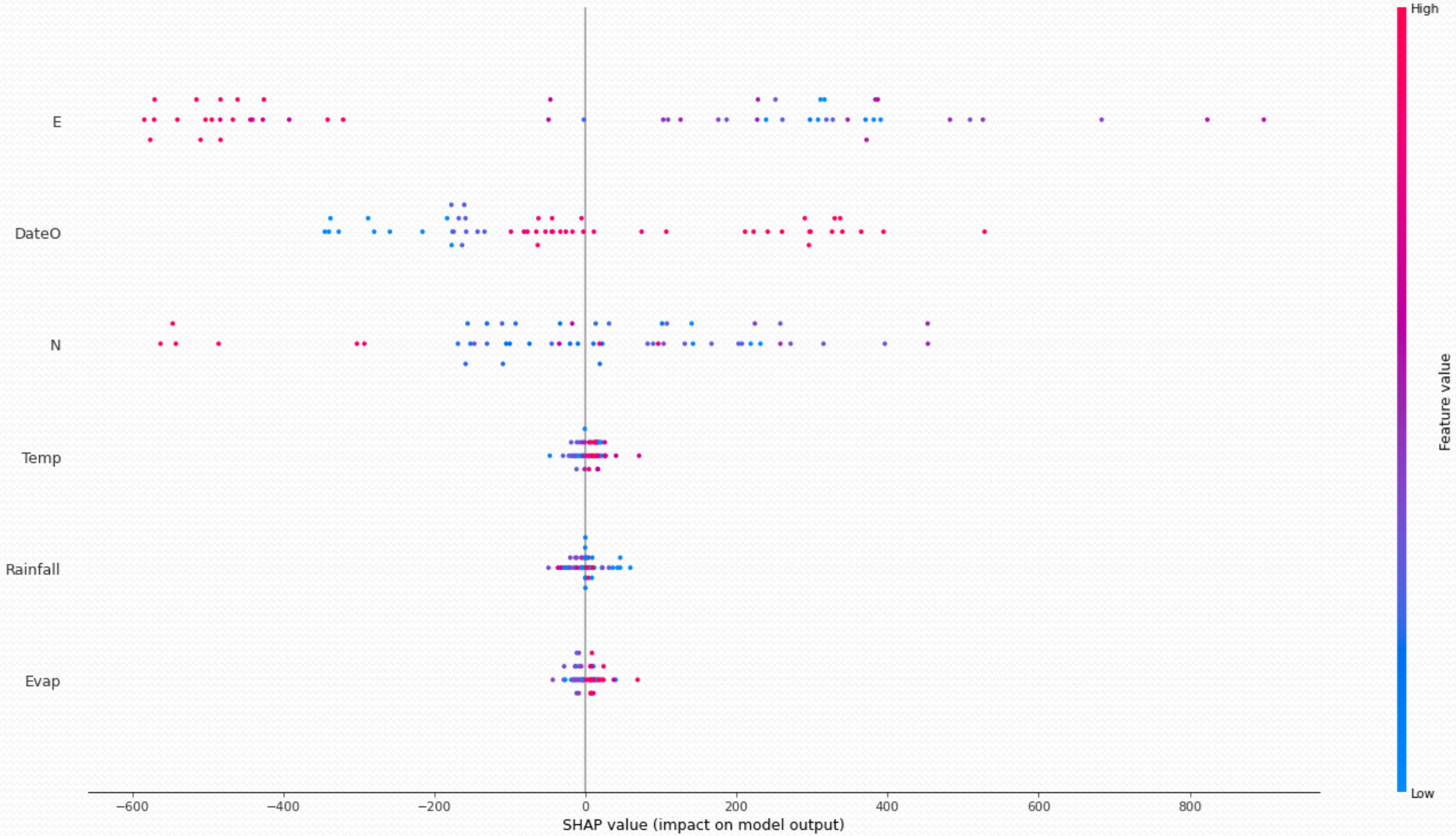


Observations vs Predictions



Factors Affecting Salinity in Al Ain

Feature	Importance
Easting	48.62%
Date	23.77%
Northing	22.08%
Temperature	1.88%
Rainfall	1.84%
Evaporation	1.81%



Leveraging Machine Learning to Extract Insights and Spatial Patterns from Hydrogeochemical Datasets for Three Major Regions in the UAE

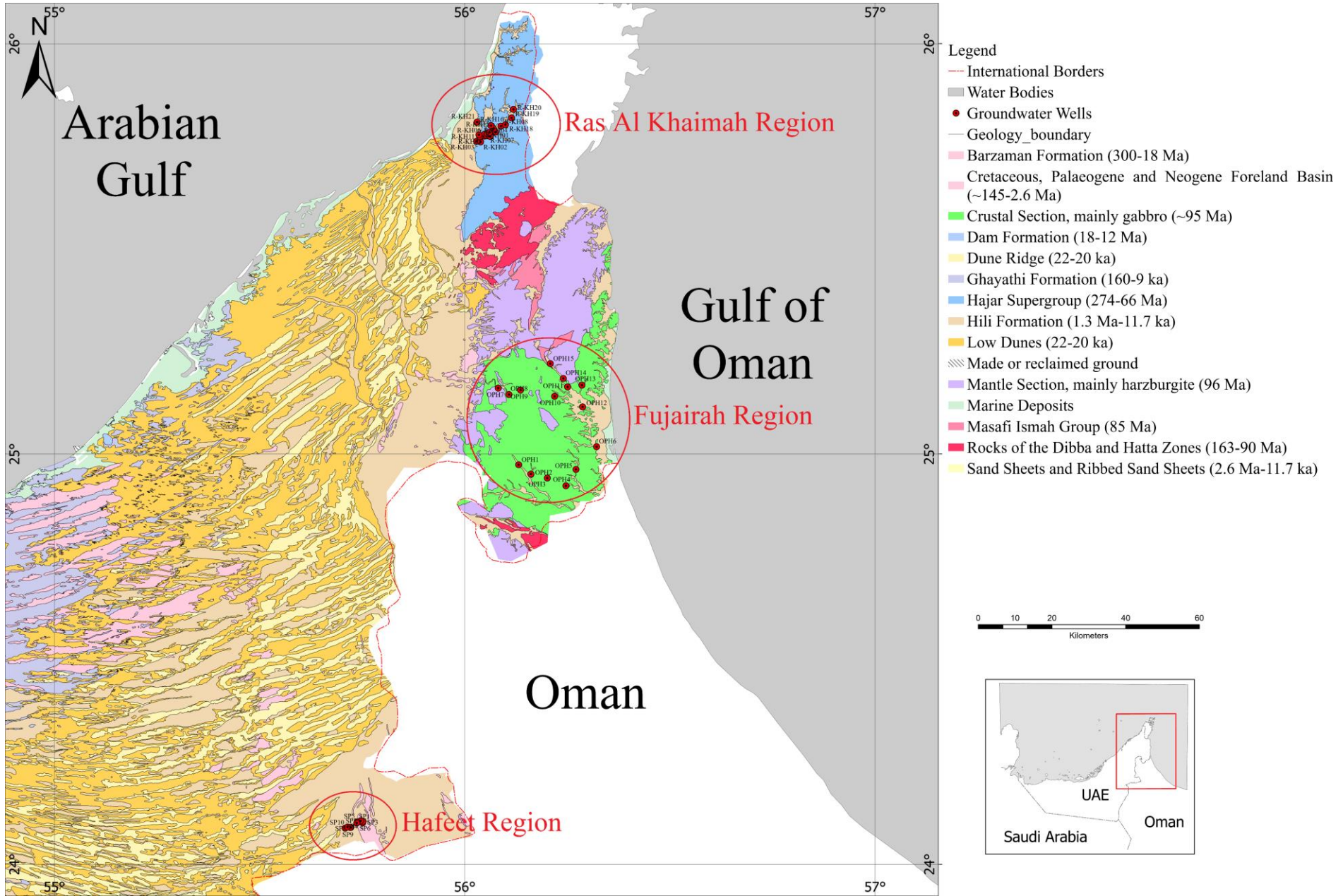
Khalid ElHaj*, Dalal Alshamsi, Balqees Alblooshi, Fatima Haile, Shamma AlRashdi, Basant Elabyad

Geological Setting

Jabel Hafeet

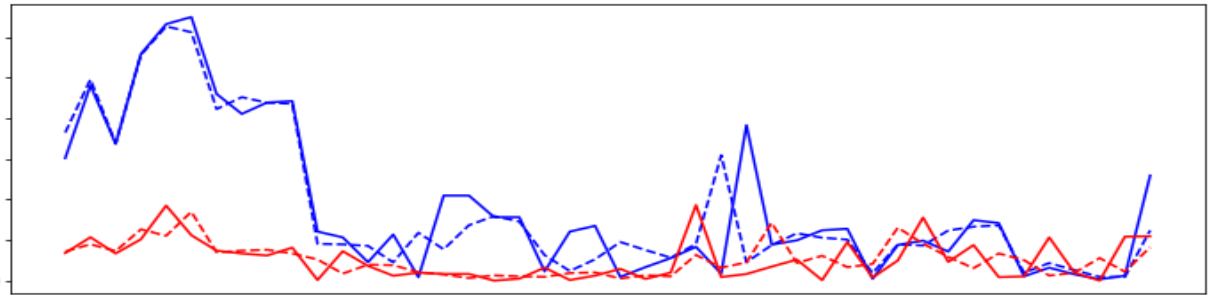
Fujairah

Ras Al Khaimah

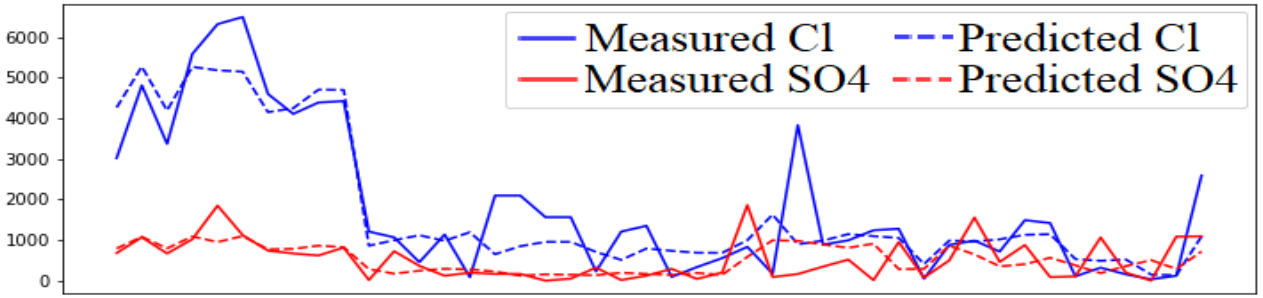


Imputation Models

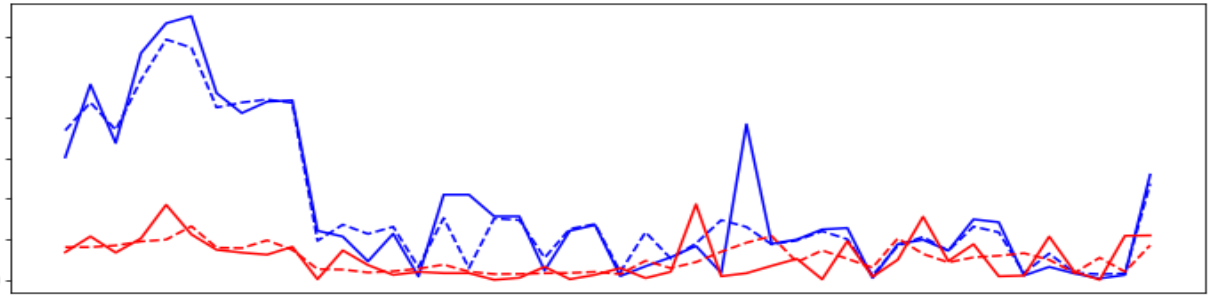
K-Nearest Neighbors [Nnumber of Neighbors=3, Weights=Distance]



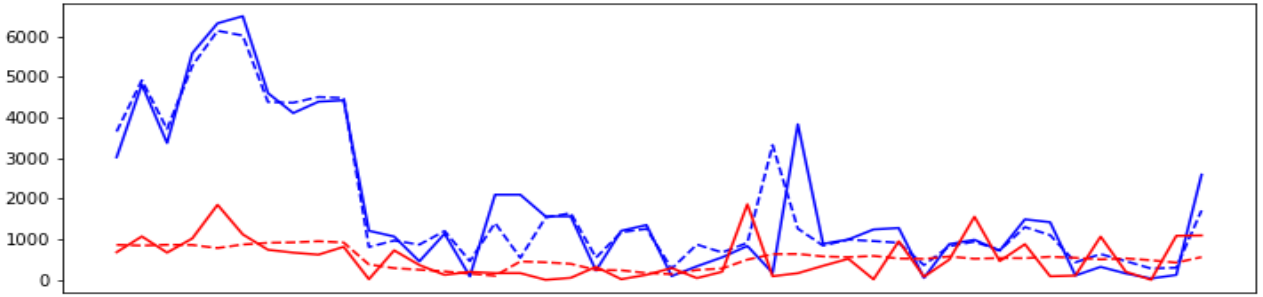
K-Nearest Neighbors [Nnumber of Neighbors=5, Weights=Uniform]



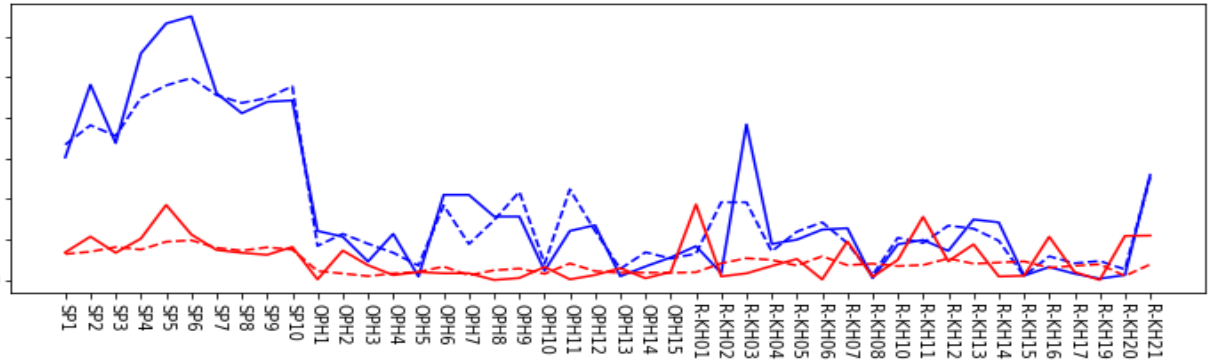
Random Forrest [Esitmators=200, Max Depth=6]



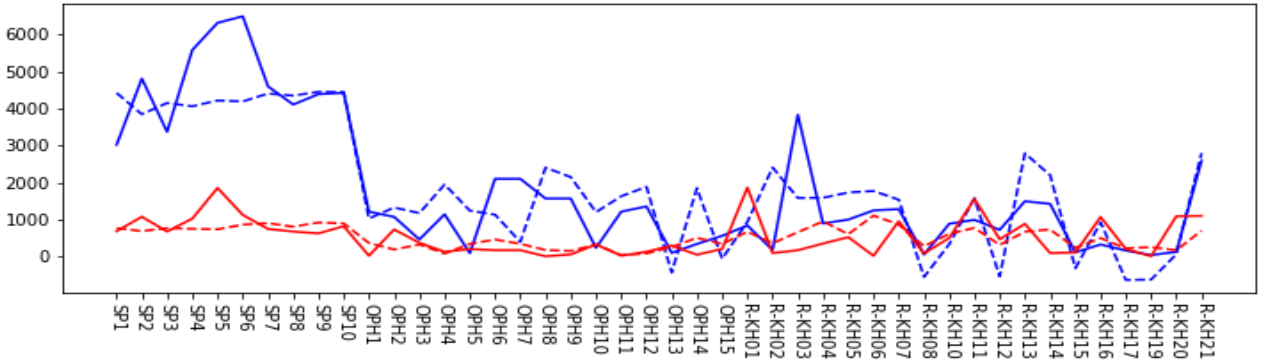
Bayesian Ridge



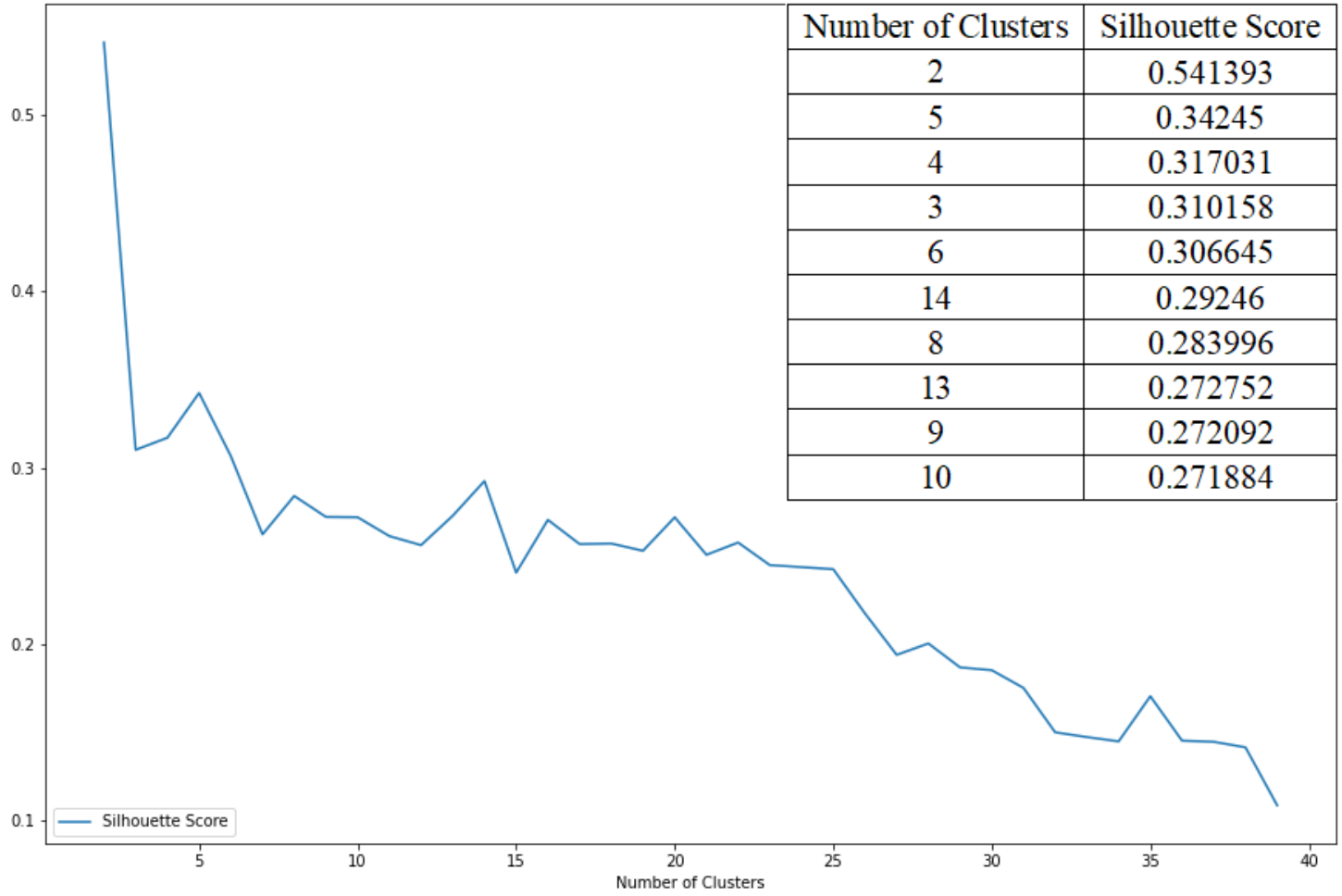
Support Vector Machines



GradientBoosting [Learning Rate=0.1, Max Iteration=100]

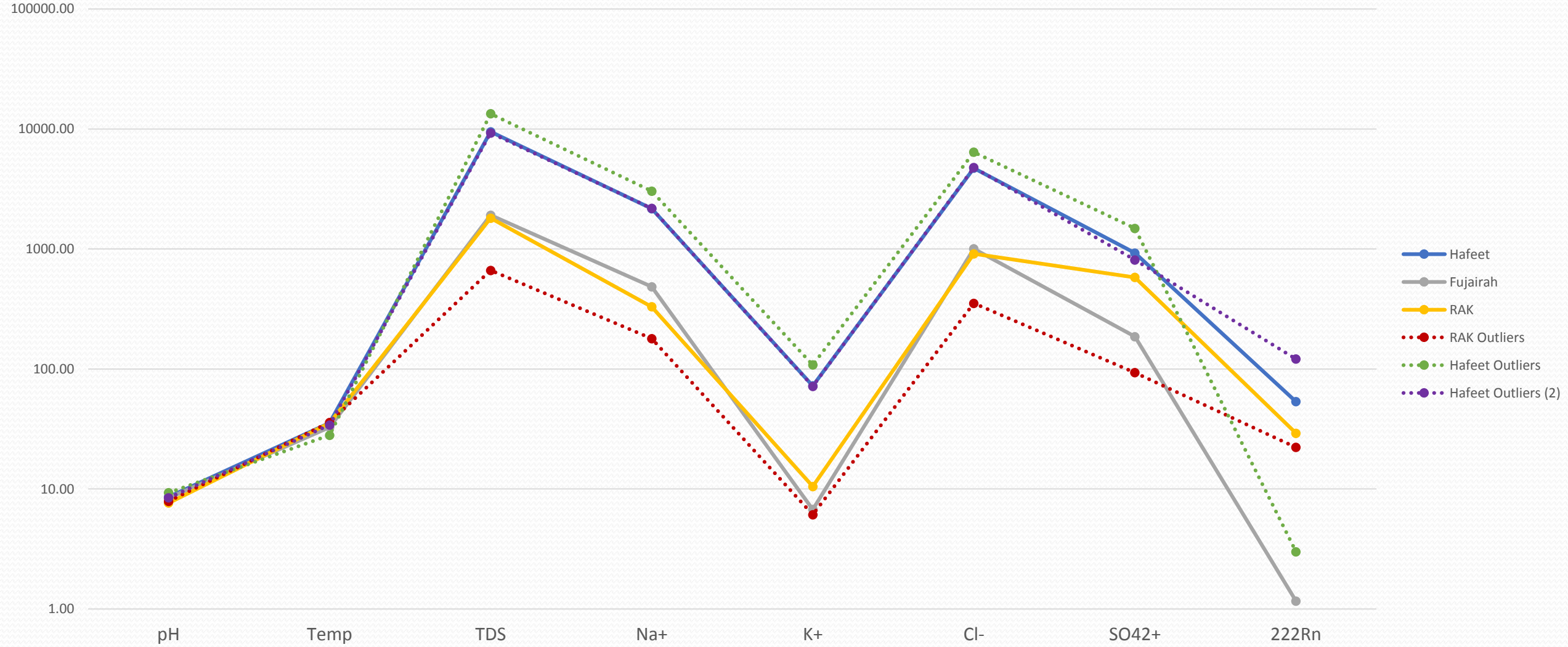


Optimum Number of Clusters



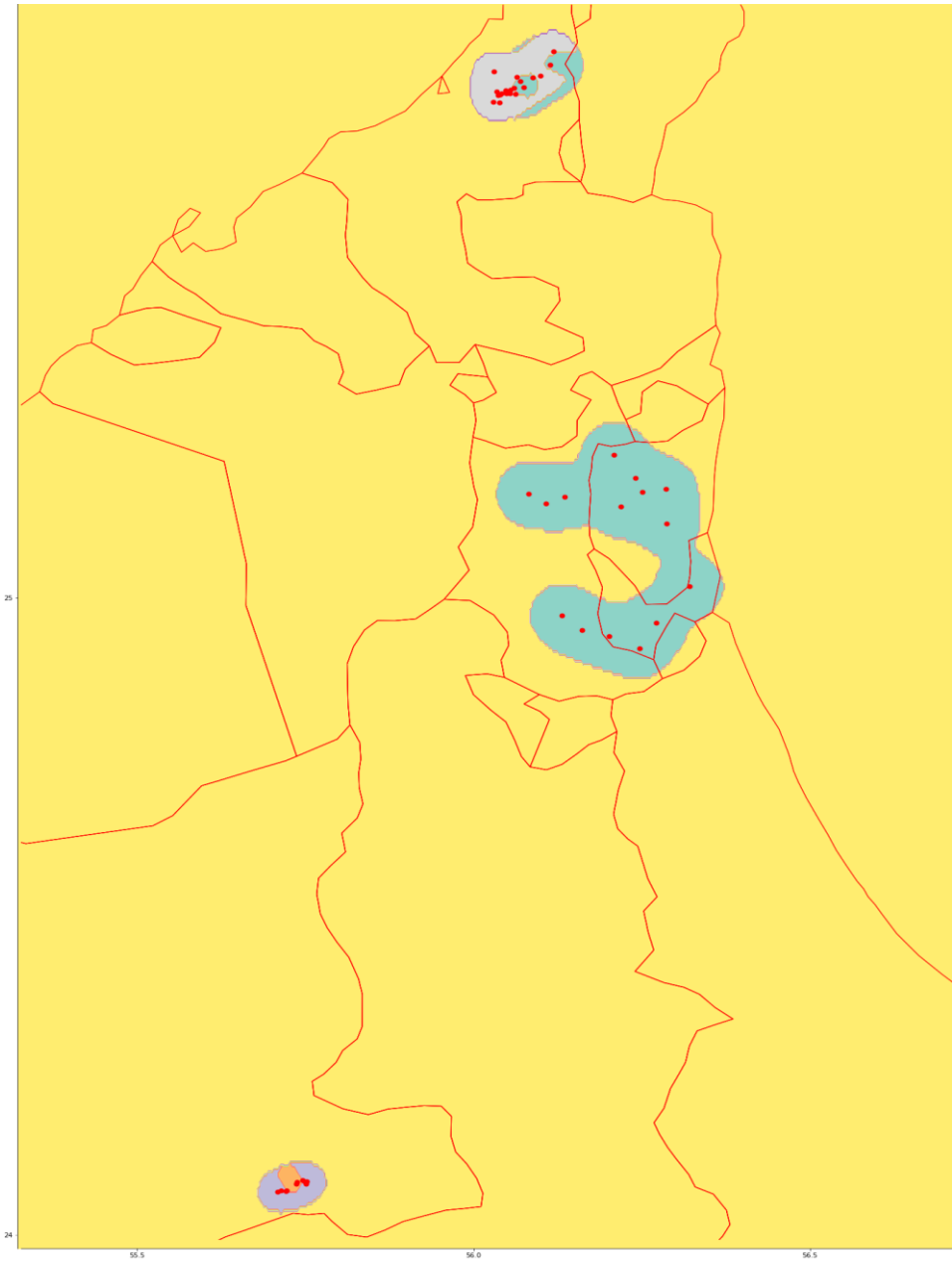
Number of Clusters	Silhouette Score
2	0.541393
5	0.34245
4	0.317031
3	0.310158
6	0.306645
14	0.29246
8	0.283996
13	0.272752
9	0.272092
10	0.271884

Sensitivity



Clustering Map and Conclusions

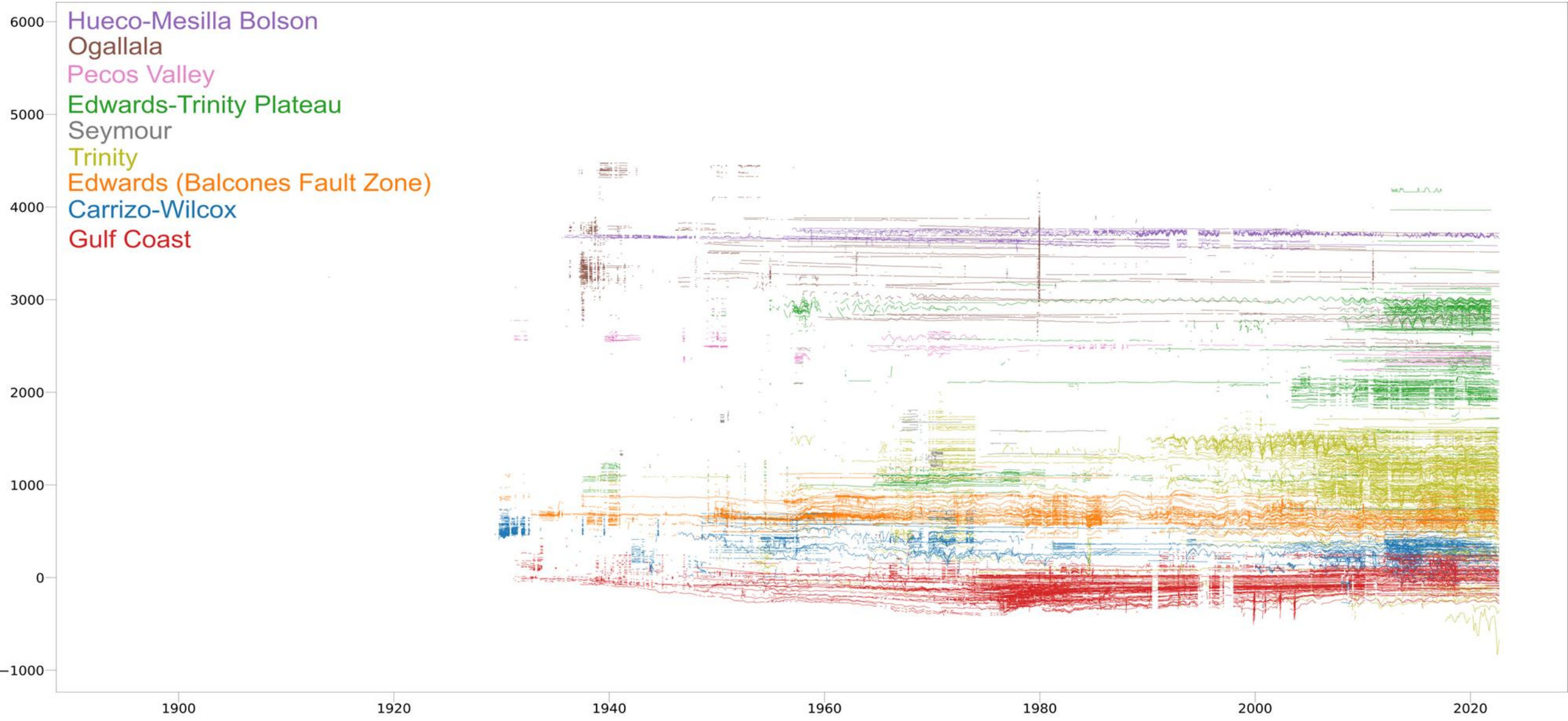
- First, the samples collected in the Fujairah region were always classified as one cluster, never subdivided into smaller clusters even when the number of clusters was raised into five.
- Five wells in Ras Al Khaimah were classified into the same cluster as the Fujairah wells, which indicate their abnormality compared to the region and their close resemblance to the Fujairah region wells
- The model classified two samples as a different group compared to the rest of the samples collected in the Hafeet region. Both samples were collected from surface water (Green Mubazzarah Lake) as opposed to the other samples being from groundwater sources



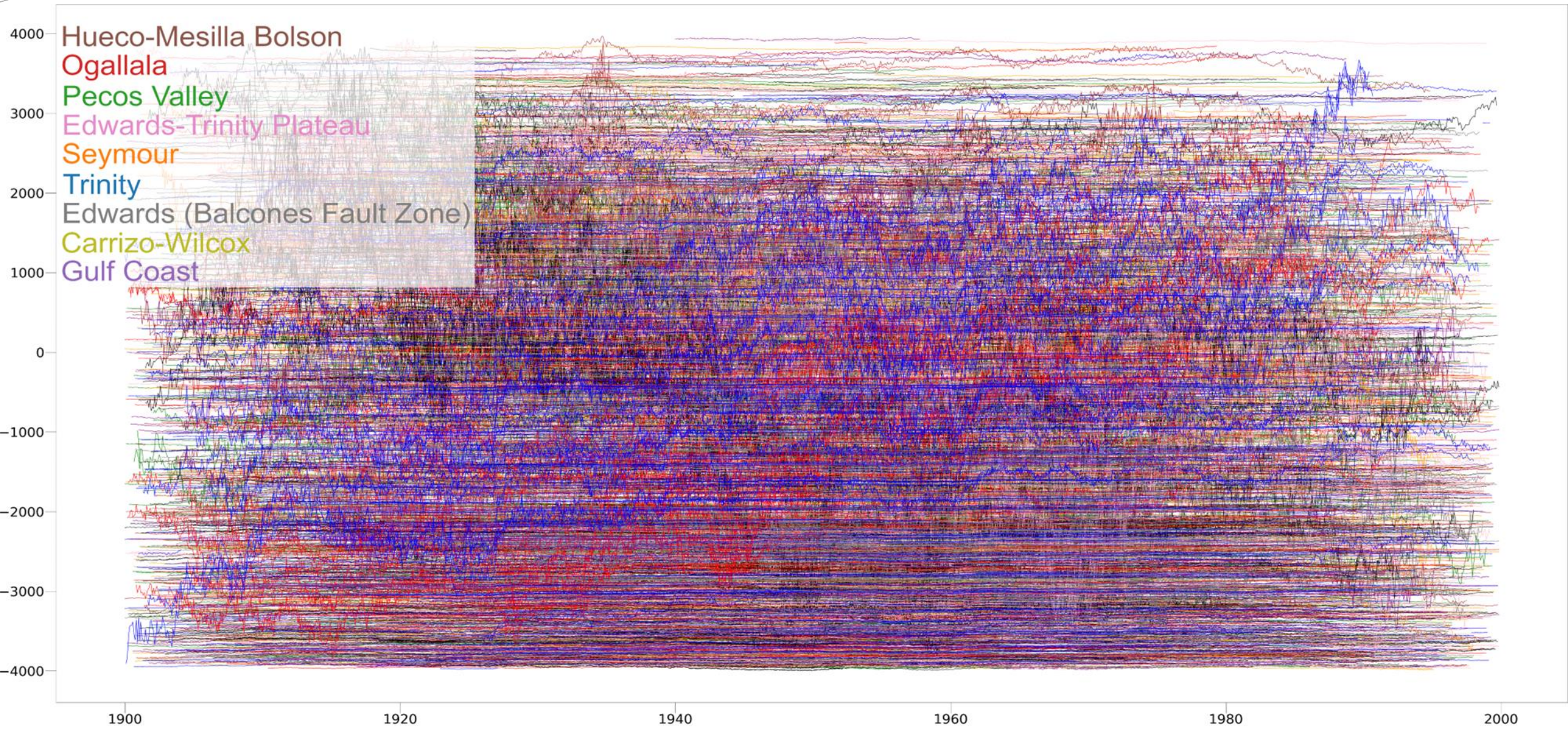
Advancing Groundwater Management: A Novel Machine Learning Approach to Aquifer Delineation

Khalid ElHaj, Dalal Alshamsi

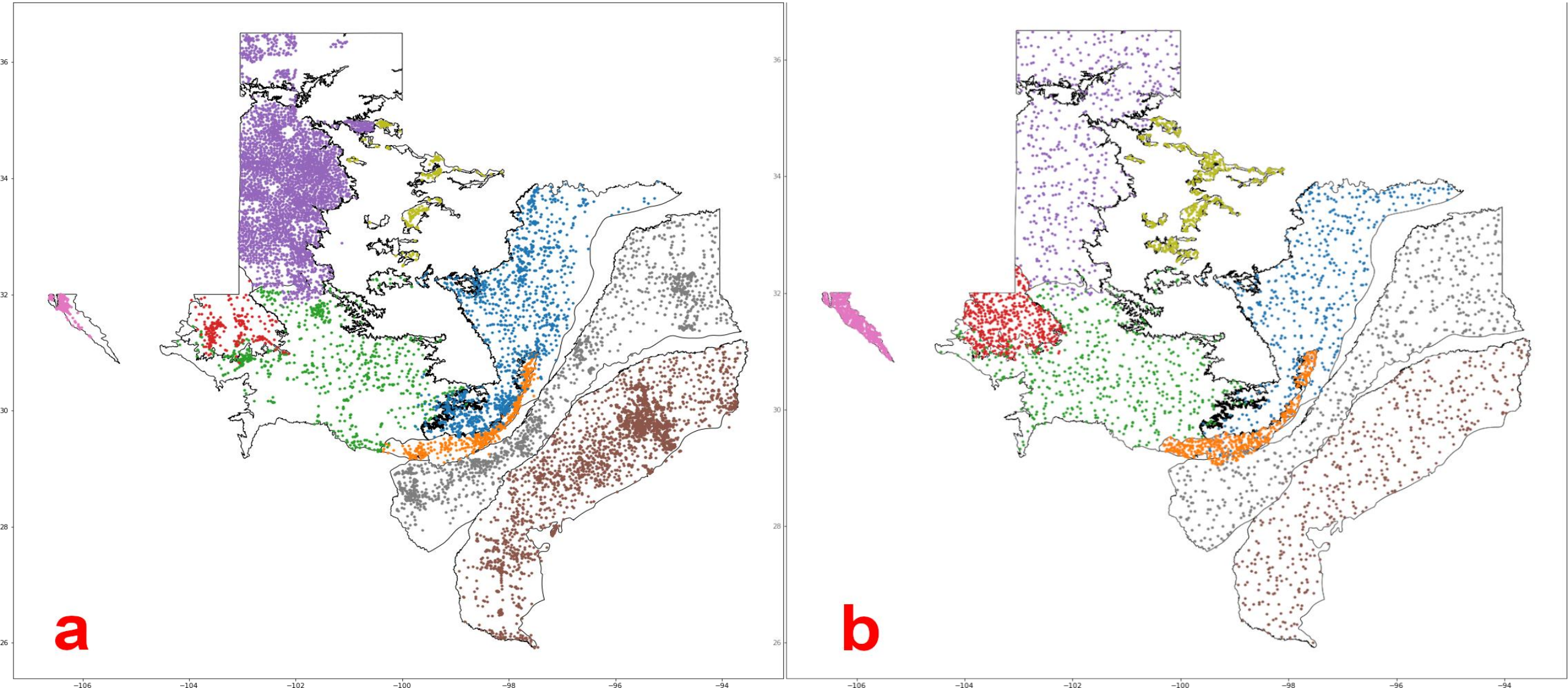
Datasets (Real)



Datasets (Synthetic)

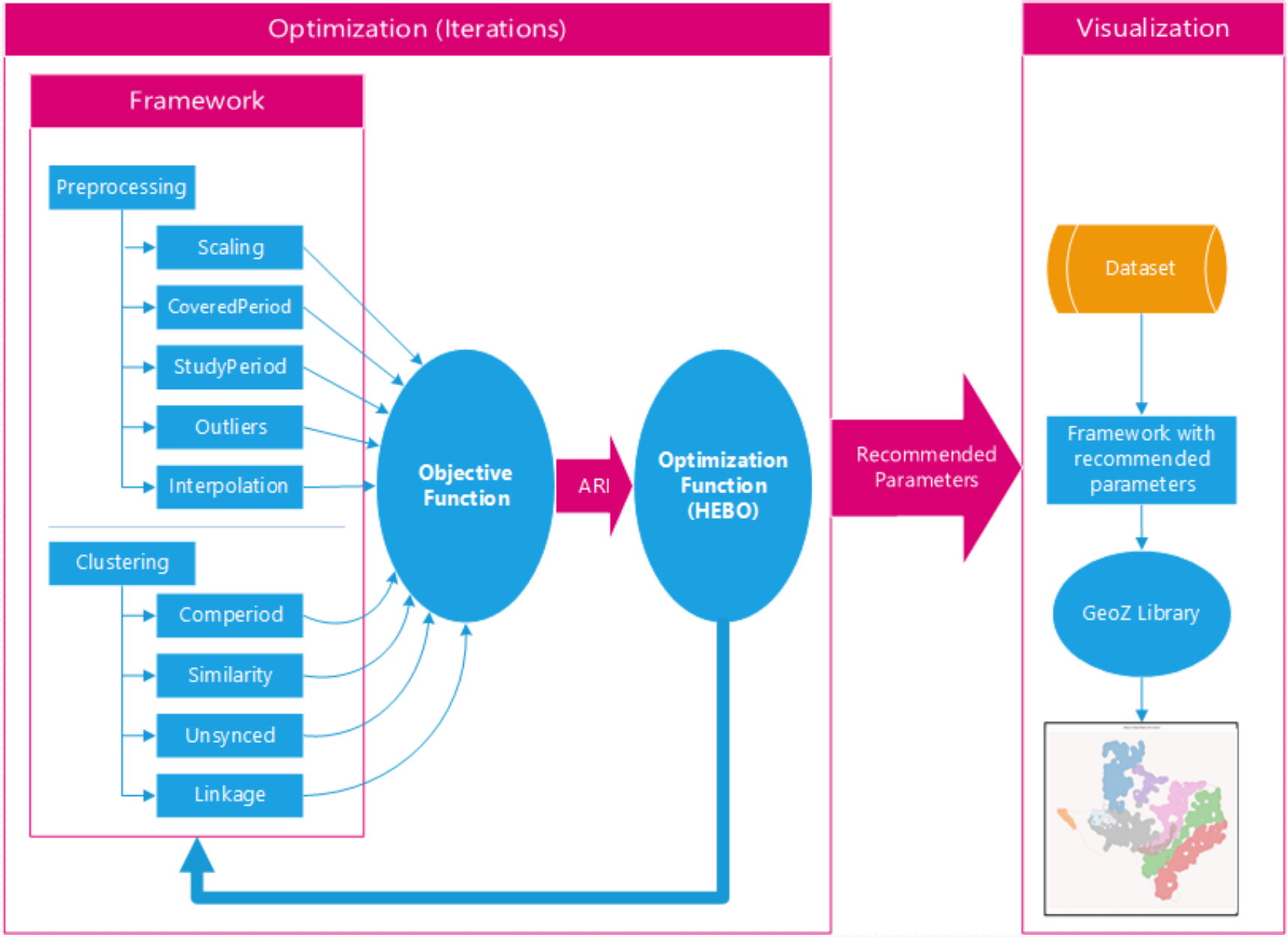


Datasets (Spatial Distribution)

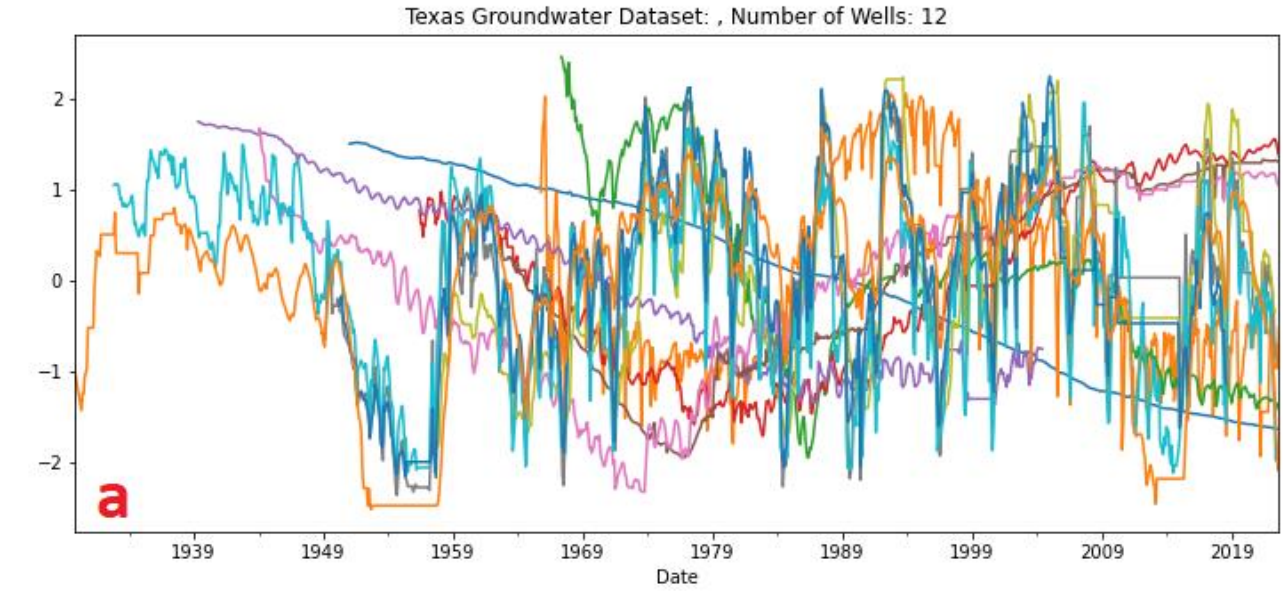


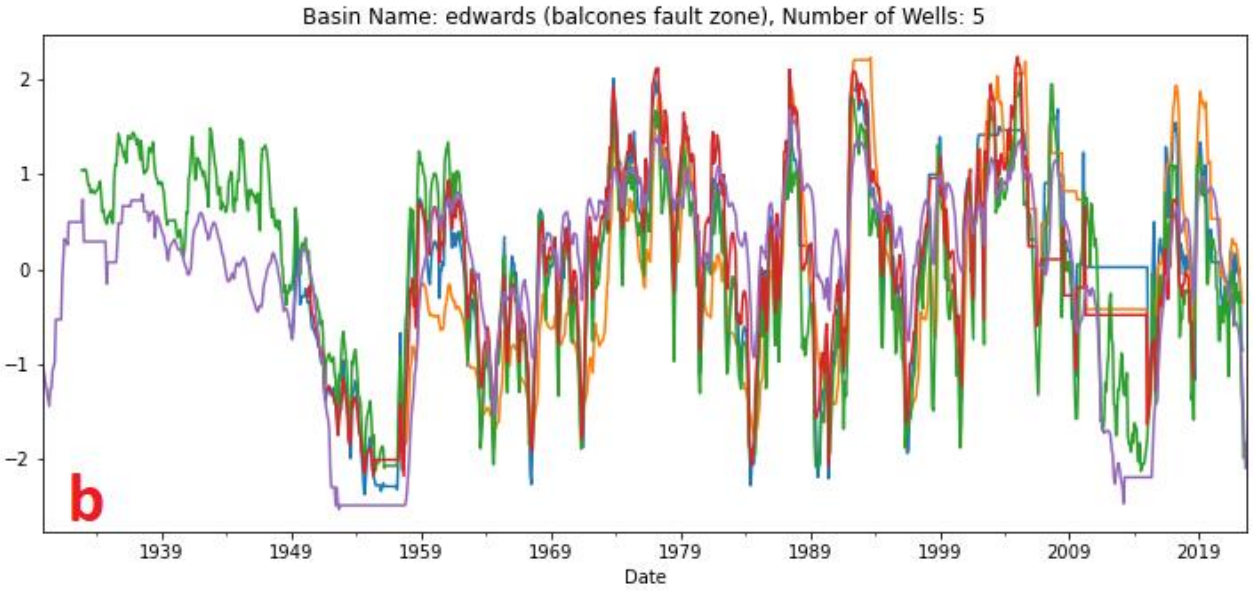
Methodology

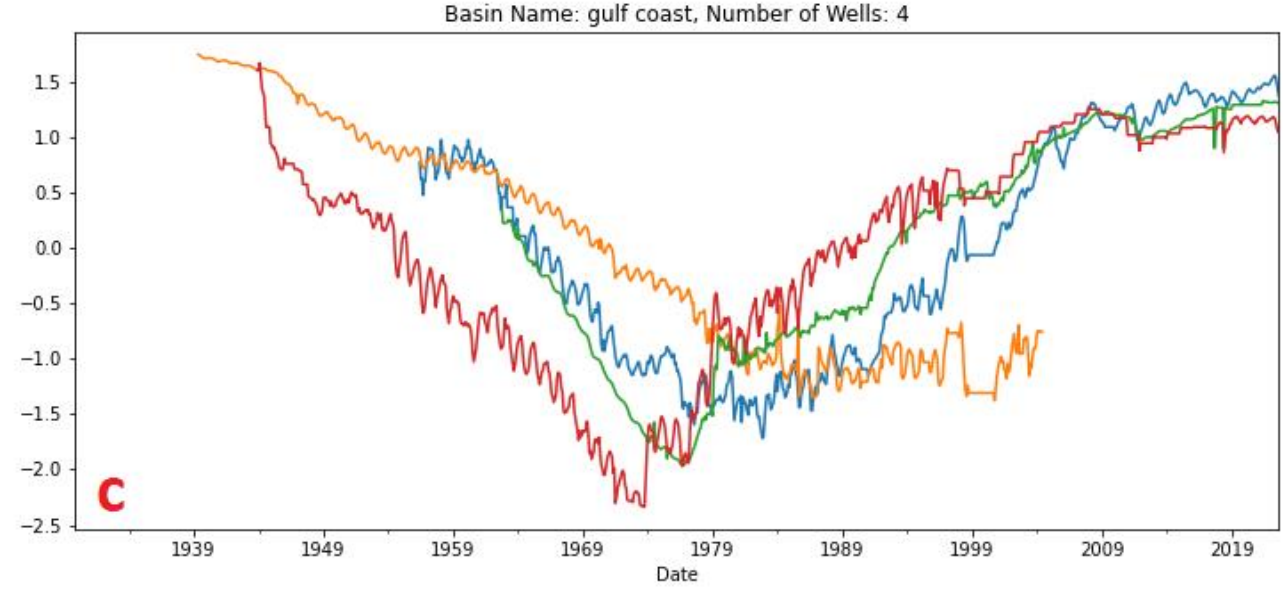
1. Framework
    - Preprocessing
    - Clustering Model
      a) Custom Distance Function
      b) Prediction
    - Framework Parameter
2. Optimization Via Simulation (OVS)
3. Visualization

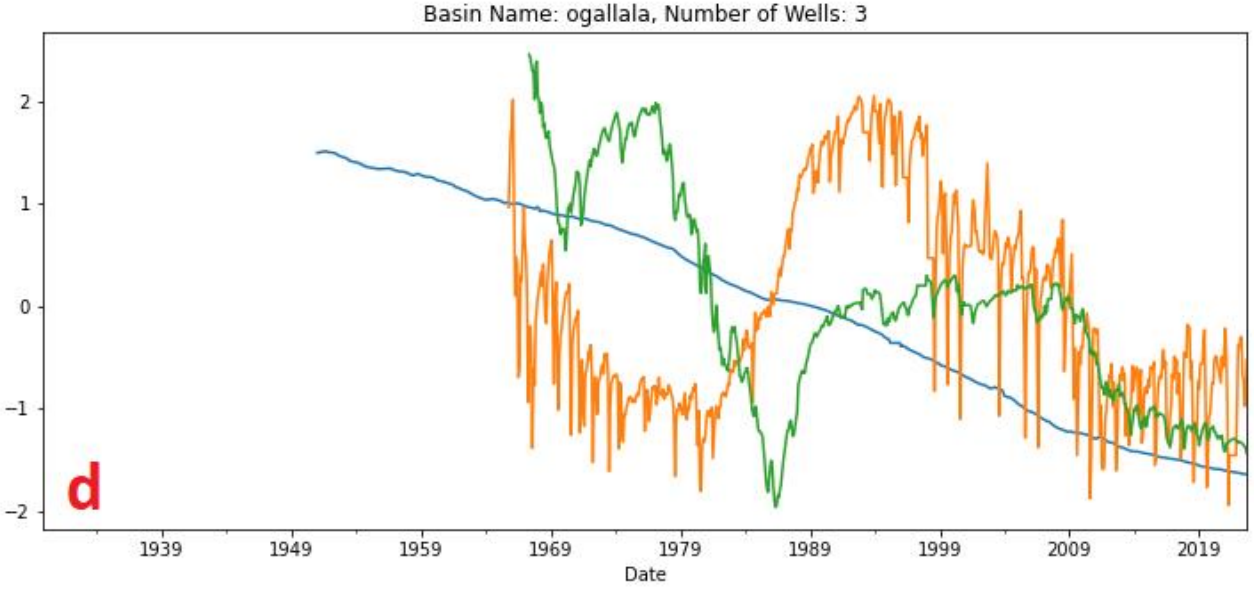


Results - Profiles

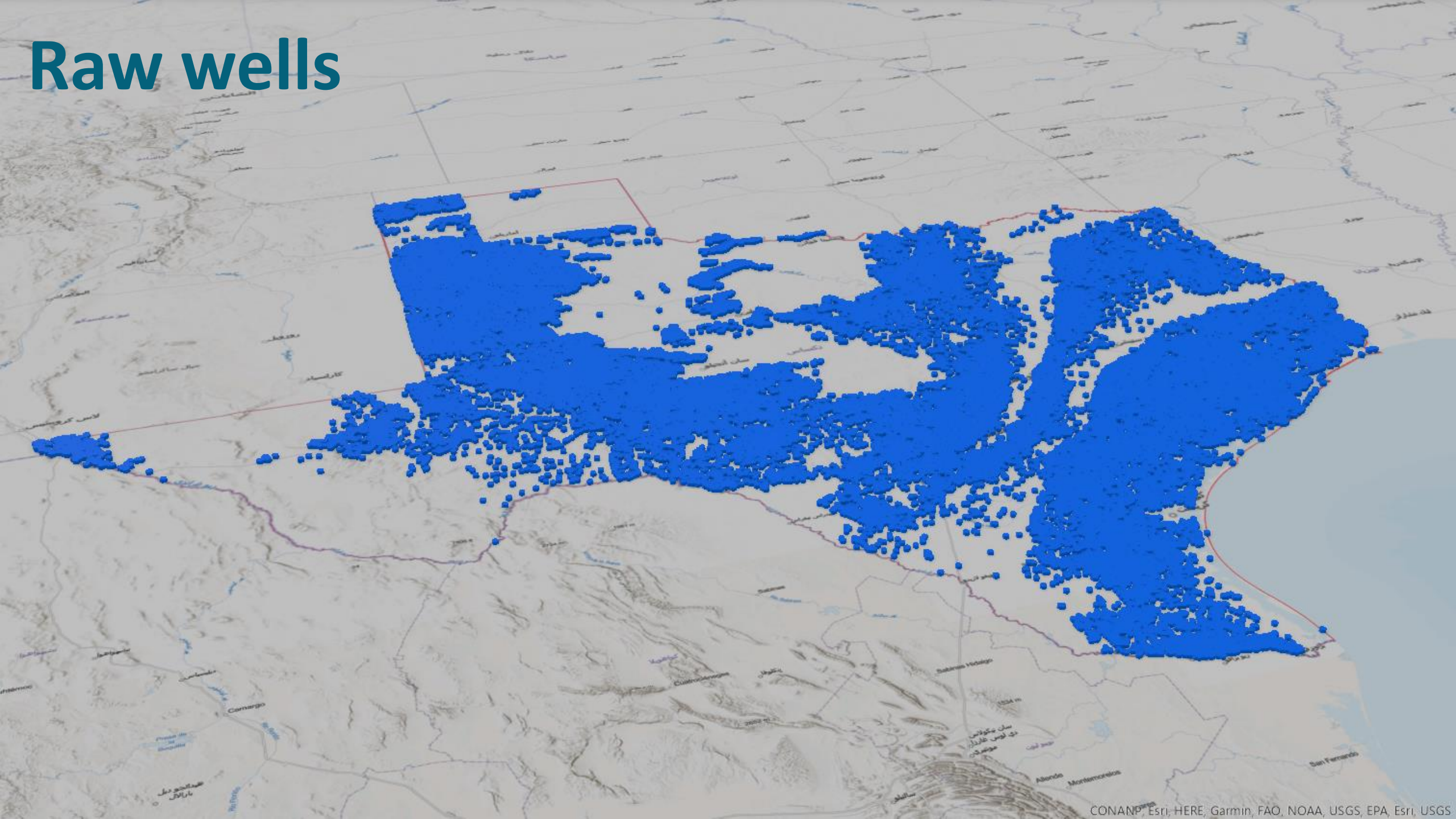




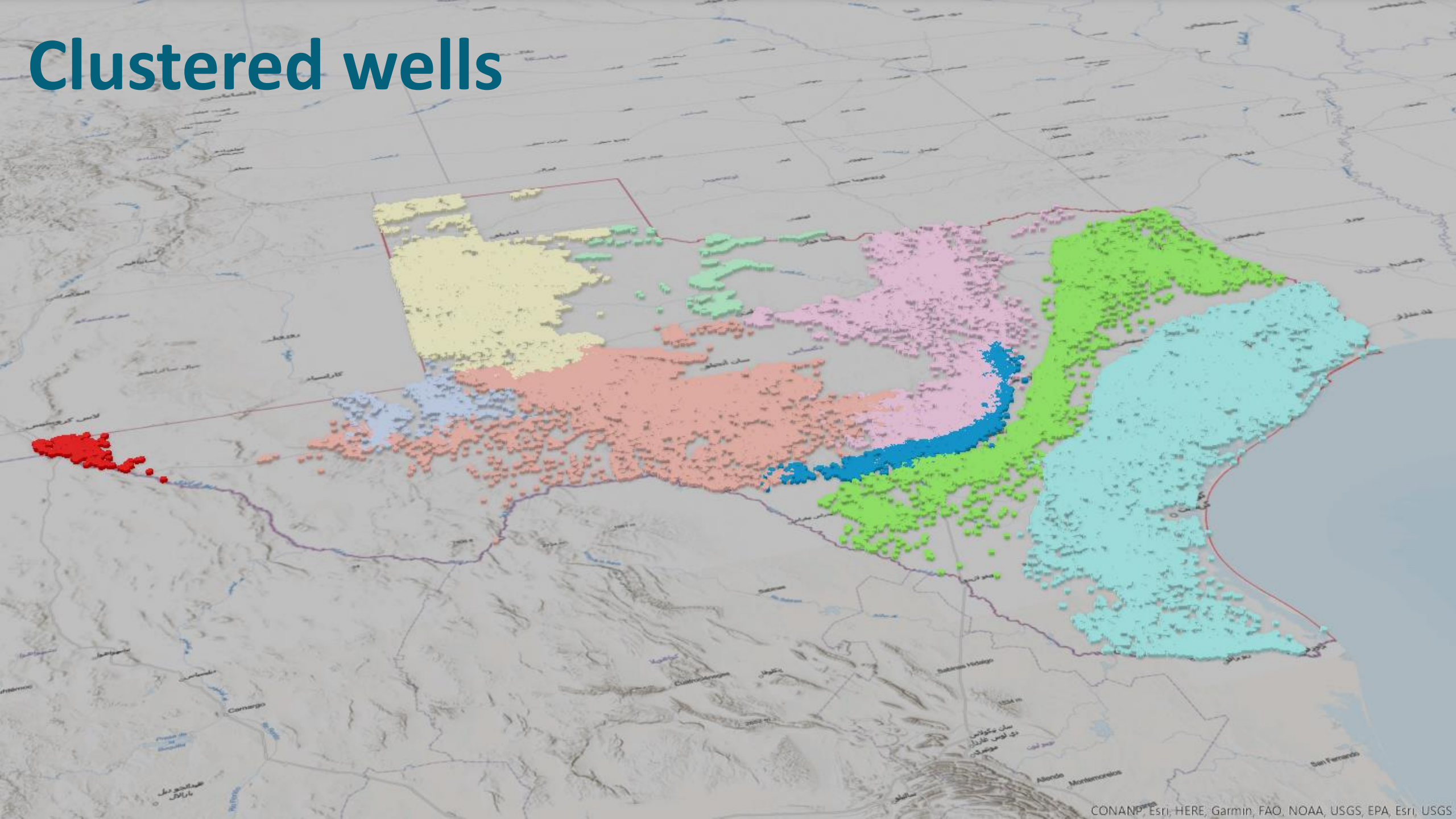




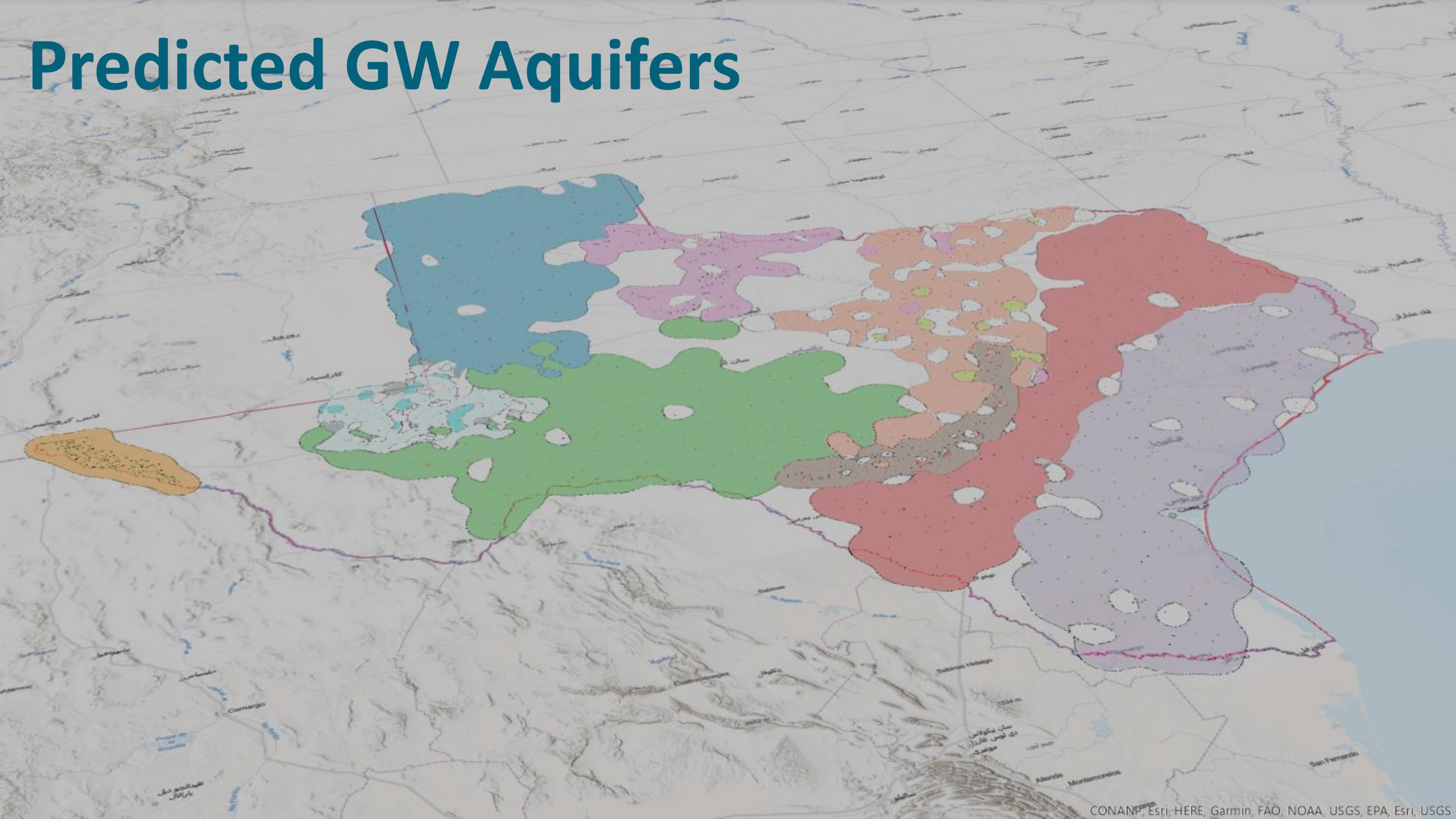
Raw wells


Camargo
Monterrey
Allende
San Fernando
CONANP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, Esri, USGS

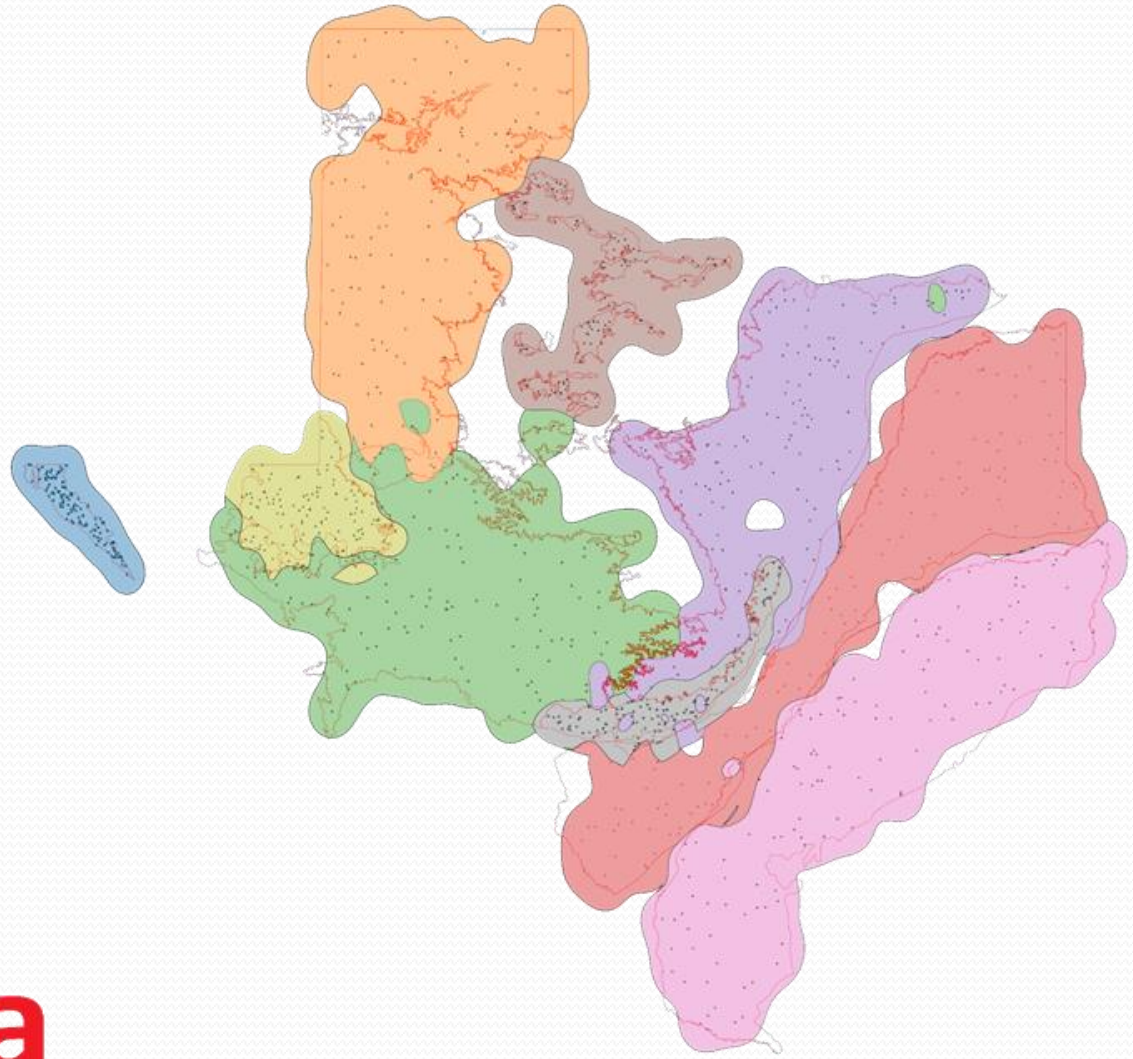
Clustered wells



Predicted GW Aquifers



Results - Spatial



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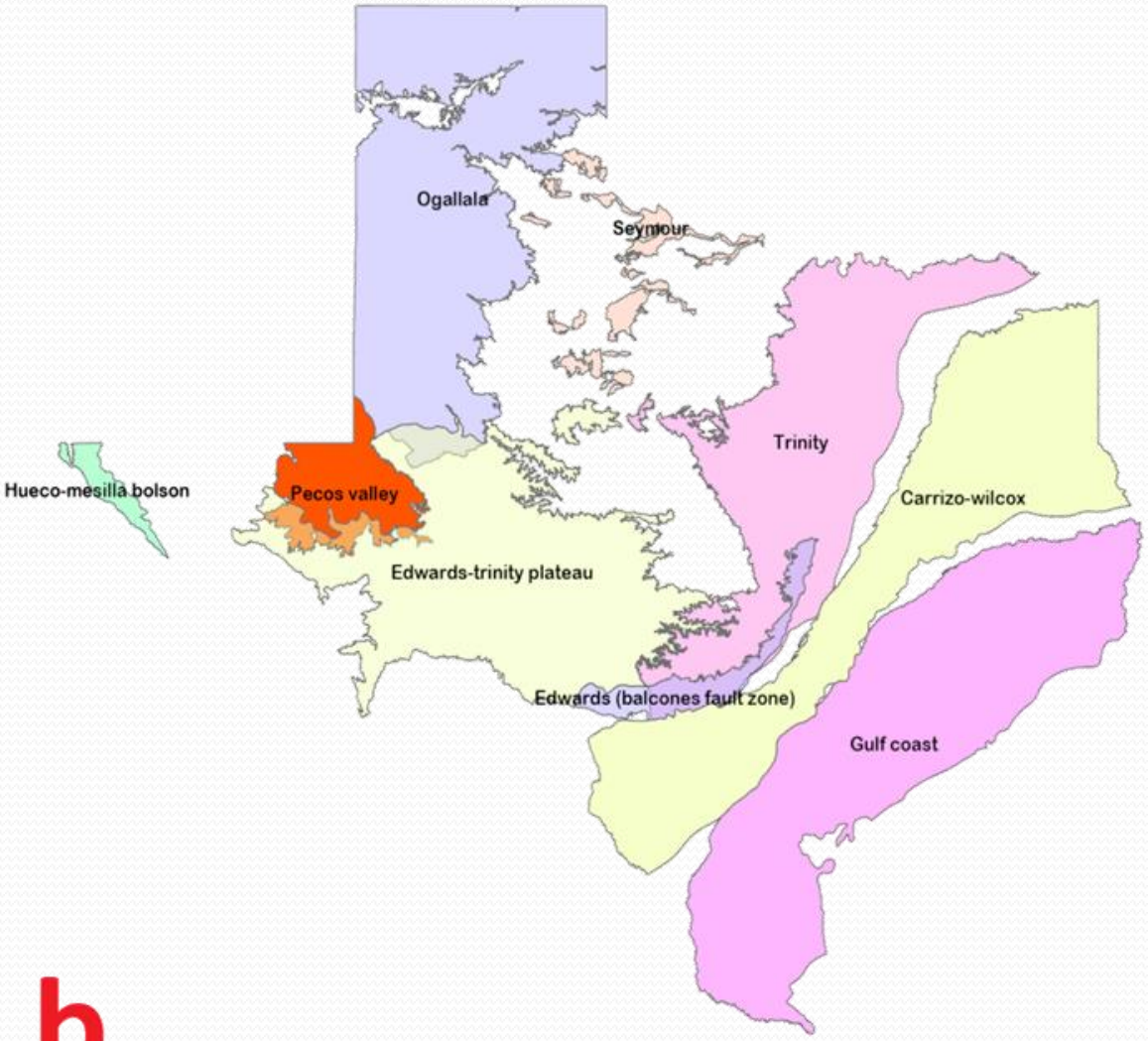

b

Conclusion and Recommendations

- Artificial Intelligence (AI) utilization in hydrology is expanding exponentially. Yet awareness of its benefits and advantages are quite lacking.
- Data is the backbone of AI, yet protocols and policies that encourage sharing is almost none existent in the GCC.
- Collaboration and knowledge sharing has always been of incredible importance to Science in general, and to AI research in particular.
- Platforms and standardization of hydrology data would allow scientists to benefit immensely from the AI revolution and would allow the GCC countries to reap the benefits of advanced modeling and prediction techniques.
- We believe its imperative to have an initiative on the GCC level similar to the G20 Data Gaps Initiative (DGI) to organize, follow, and implement policies and solutions for Data sharing, utilization, and dissemination to prepare for the advent of AI.

Credits and Acknowledgements

- I would like to extend my thanks to the Gulf Water Science and Technology Association for their kind invitation to the 15th Gulf Water Conference.
- We acknowledge with appreciation the financial support provided by the research affairs office of UAE University and the NWEC through the funds (Fund No. 416 31S445), and (Fund No. G00004039), respectively.
- We also extend our appreciation to the Geoscience Department and the National Water and Energy Center (NWEC) for their continuous support and advice during and after the aforementioned projects.
- We would like to extend our thanks to UAE University for providing the facilities, Labs, and the High-Performance Computing (HPC) systems to conduct our research and achieve our objectives.
- Finally, I would like to extend my thanks and heartfelt appreciation to my main collaborator and PhD Supervisor, Dr. Dalal Alshamsi for her endless support, kindness and consideration.