Under the High Patronage of His Majesty King Mohammed VI

International Water Resources Association
IWRA

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

Kingdom of Morocco
Ministry of Equipment and Water

Advancing Groundwater Monitoring and Downscaling Using Open Datasets and Machine Learning in Mississippi River Basin

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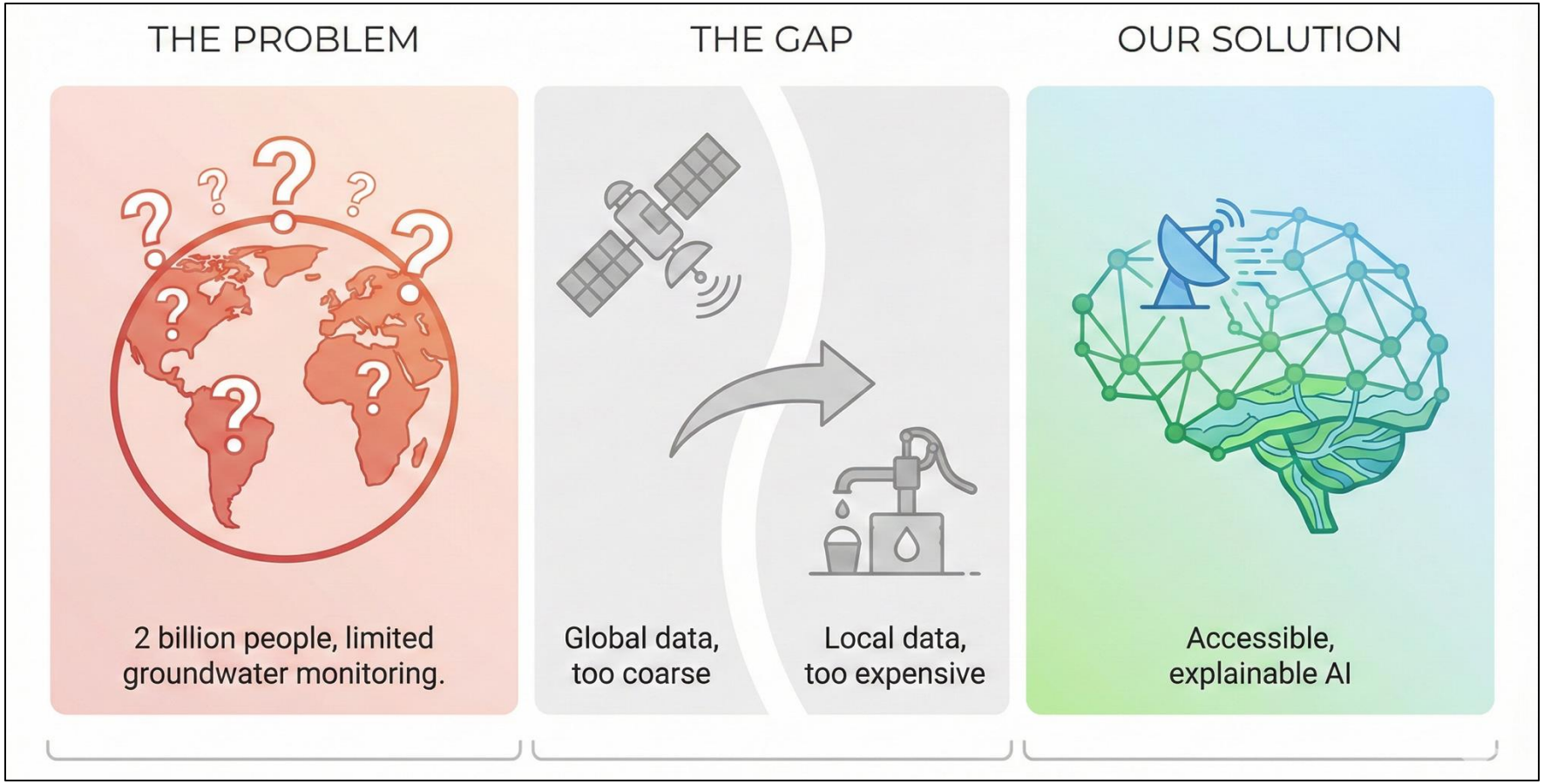
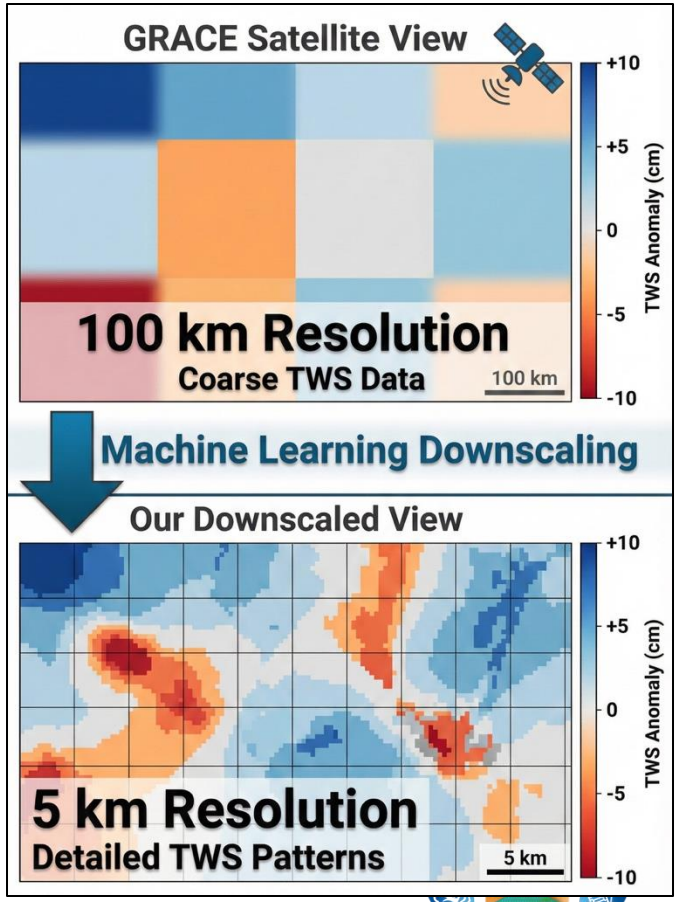
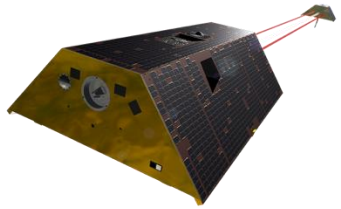
Jackson State University | Coastal and Hydraulics Laboratory, ERDC, USACE
December 1, 2025

Objective


THE PROBLEM
THE GAP
OUR SOLUTION
2 billion people, limited groundwater monitoring.
Global data, too coarse
Local data, too expensive
Accessible, explainable AI


GRACE Satellite View
100 km Resolution
Coarse TWS Data
100 km
+10
+5
0
-5
-10
TWS Anomaly (cm)
Machine Learning Downscaling
Our Downscaled View
5 km Resolution
Detailed TWS Patterns
5 km
+10
+5
0
-5
-10
TWS Anomaly (cm)

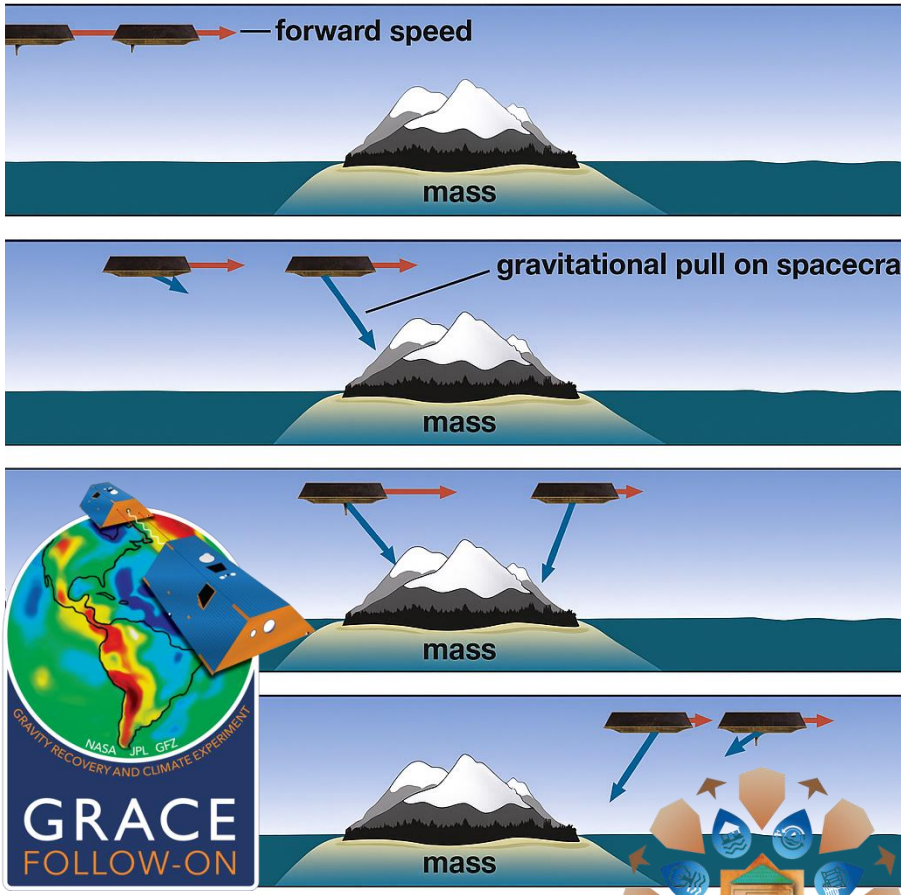


What is GRACE?

- GRACE (Gravity Recovery and Climate Experiment)
  – Joint NASA–DLR mission (2002–2017)
  – Measures inter-satellite separation using a microwave ranging system within 1μm

- GRACE-FO (Follow-On)
  – Launched in 2018; ensures mission continuity
  – GRACE-FO additionally onboarded an experimental instrument using lasers

- Key Product: Terrestrial Water Storage (TWS)
  – Captures total water variation (groundwater, soil, snow, surface)
  – Monthly, global coverage



Data

1. GRACE (Mascon Solutions)
- JPL RL06M, RL06.3M-CRI: 0.5° (~55 km grid)
- True resolving power ≈ 100–150 km
- Improved leakage correction and coastal recovery

2. CHIRPS (~5km)
- Precipitation

3. NASA SRTM Digital Elevation Module (~30m)

4. GLDAS (Global Land Data Assimilation System) (~27 km)
- Evapotranspiration (E_{vap})
- Soil Moisture (0-10cm, 10-40cm, 40-100cm, 100-200cm)
- Snow Water Equivalent (SWE)

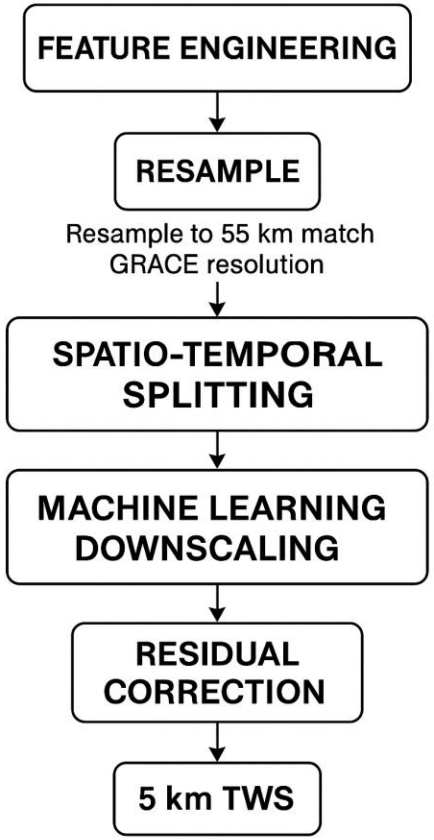
5. Landscan Annual Population (~1km)

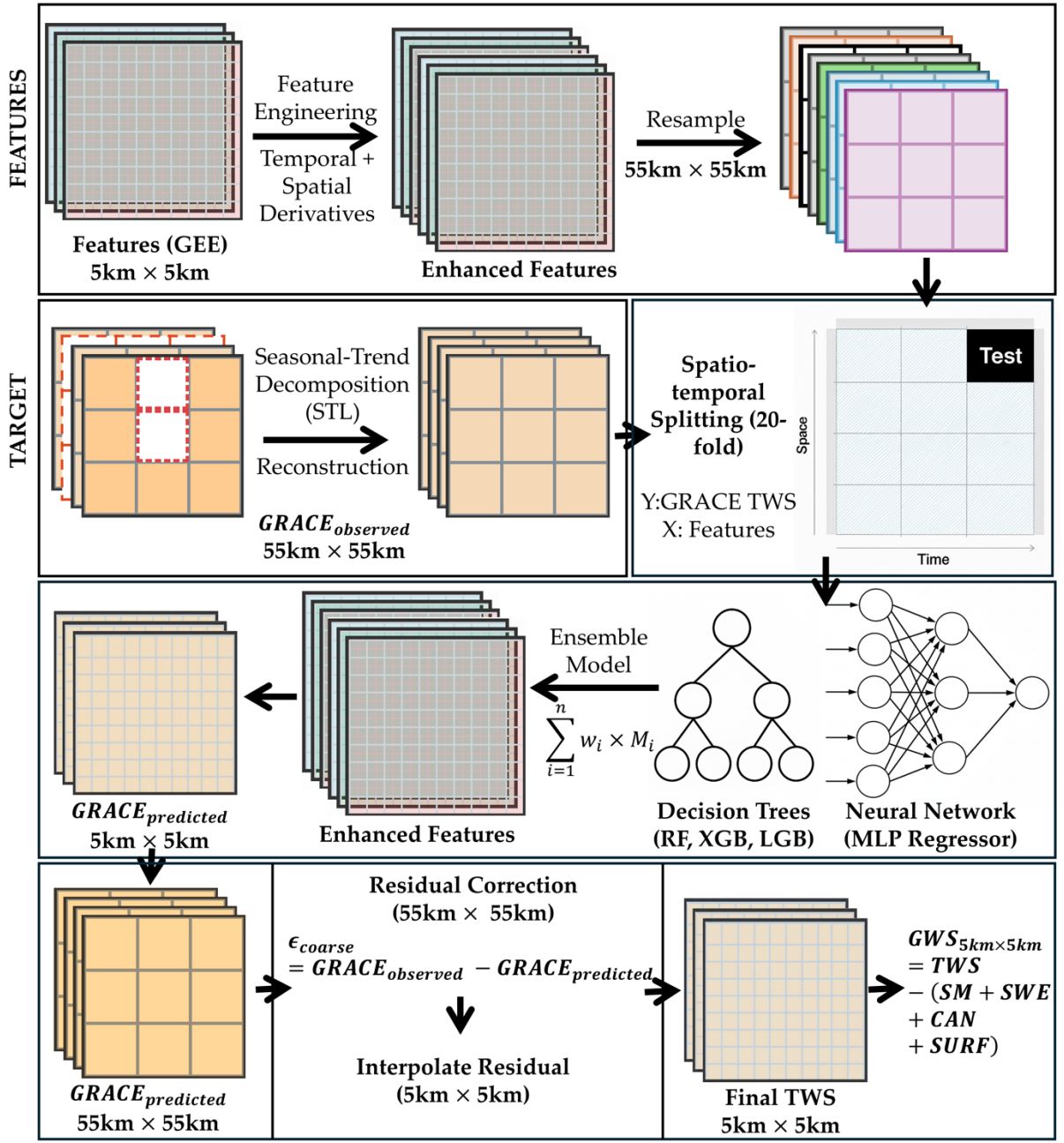
6. TerraClimate (~5km)
- Actual Evapotranspiration (aet)
- Potential Evapotranspiration (pet)
- Precipitation (pr)
- Monthly Maximum Temperature (tmmx)
- Monthly Minimum Temperature (tmmn)

7. Openlandmap (~250m)
- Percentage of Clay(0-10cm, 10-30cm, 30-60cm, 60-100cm, 100-200cm)
- Percentage of Sand(0-10cm, 10-30cm, 30-60cm, 60-100cm, 100-200cm)

8. MODIS Land Cover (~500m)

Method


FEATURE ENGINEERING
RESAMPLE
Resample to 55 km match GRACE resolution
SPATIO-TEMPORAL SPLITTING
MACHINE LEARNING DOWNSCALING
RESIDUAL CORRECTION
5 km TWS


FEATURES
Features (GEE)
5km × 5km
Feature Engineering
Temporal + Spatial Derivatives
Enhanced Features
Resample
55km × 55km
TARGET
Seasonal-Trend Decomposition (STL)
Reconstruction
GRACE observed
55km × 55km
Spatio-temporal Splitting (20-fold)
Y:GRACE TWS
X: Features
Test
Space
Time
GRACE predicted
5km × 5km
Enhanced Features
Ensemble Model
Decision Trees (RF, XGB, LGB)
Neural Network (MLP Regressor)
GRACE predicted
55km × 55km
Residual Correction (55km × 55km)
Interpolate Residual (5km × 5km)
Final TWS
5km × 5km

Results: STL Reconstruction

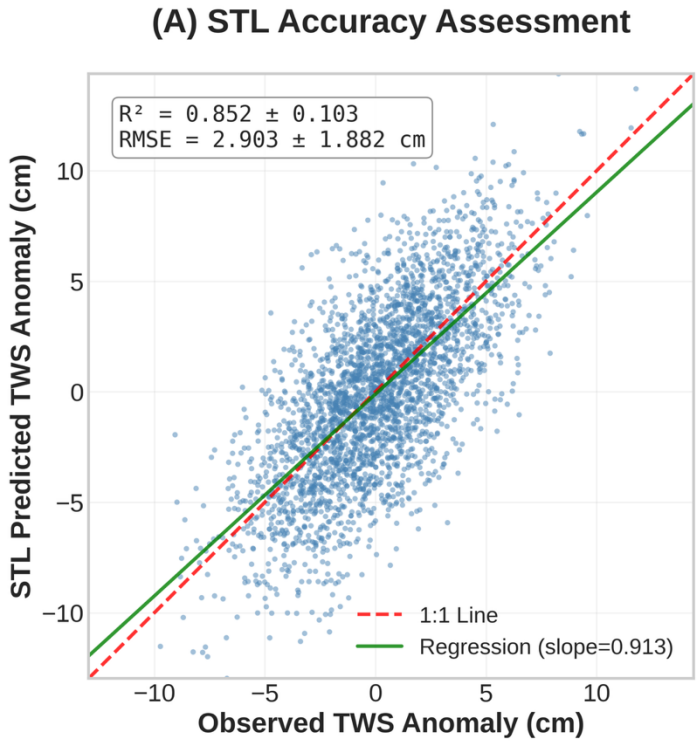
Time Period:
(2003-01 to 2024-12)

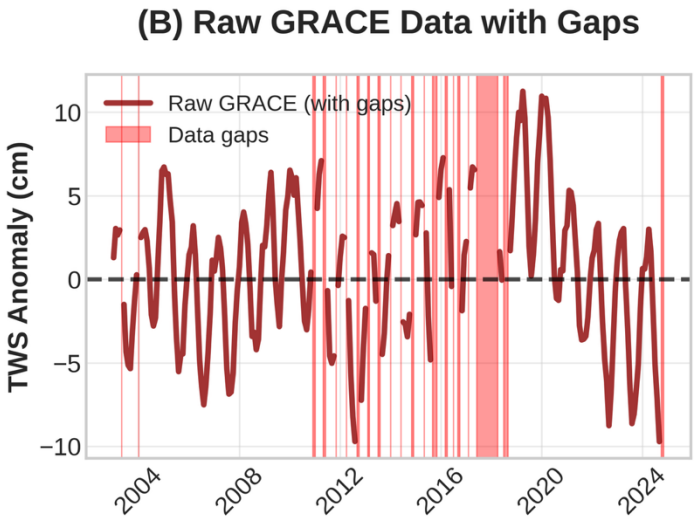
Gaps Identified:
(34 months)

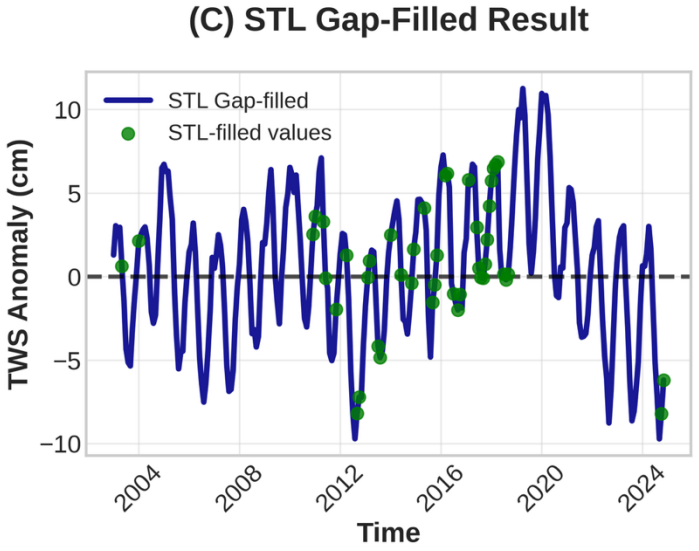
Scaling Factor Applied:
(CRI Source)

Accuracy:
0.852 ± 0.103

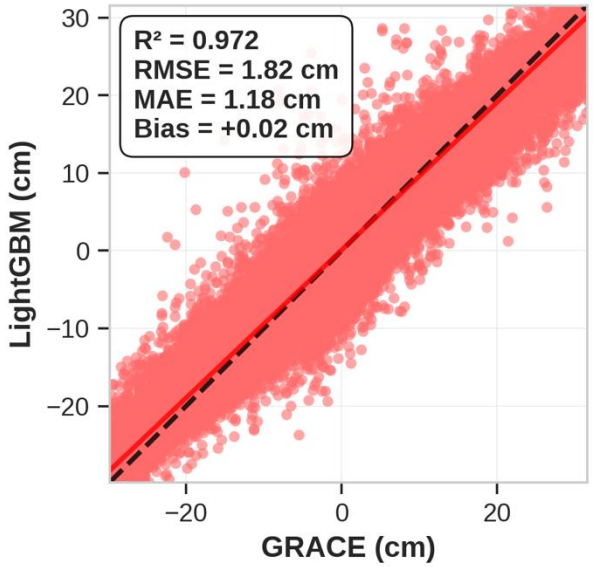
Final Availability:
100%

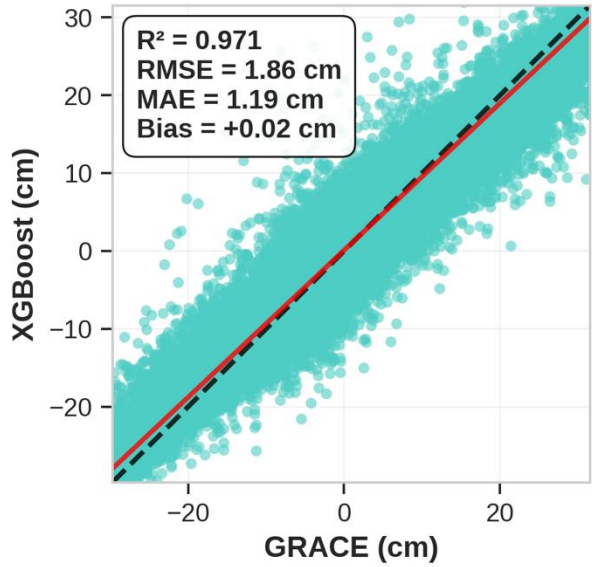


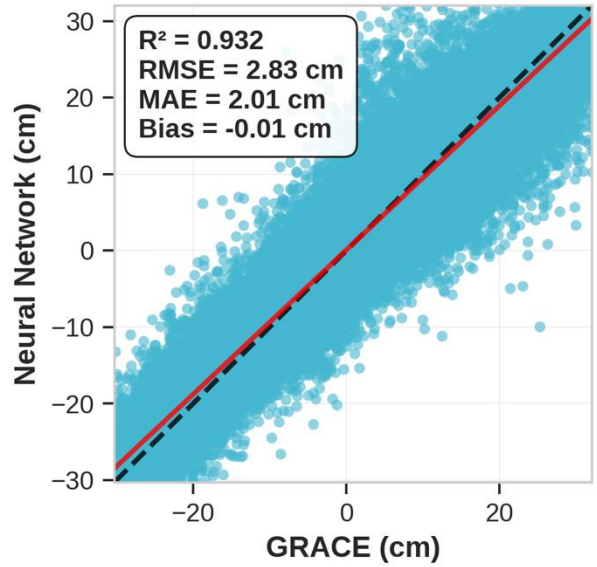


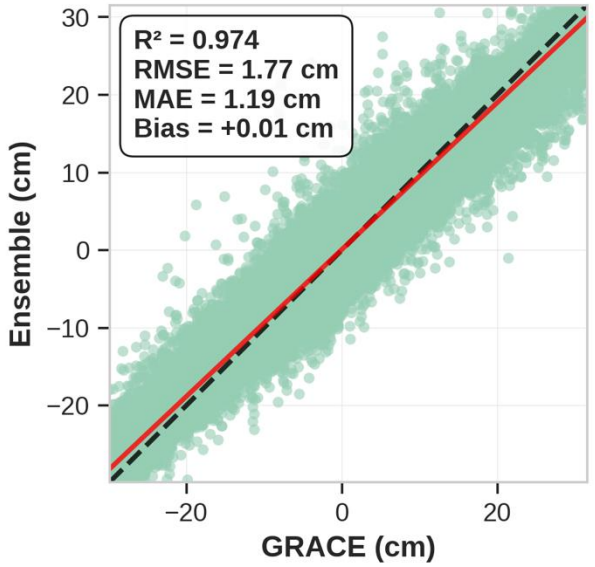


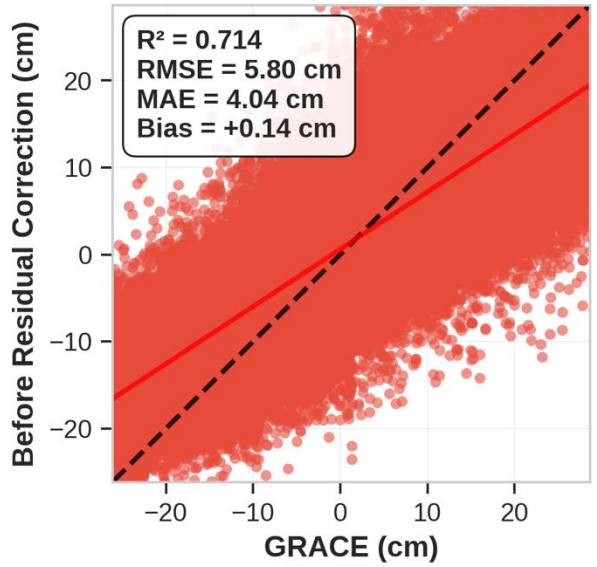
Result

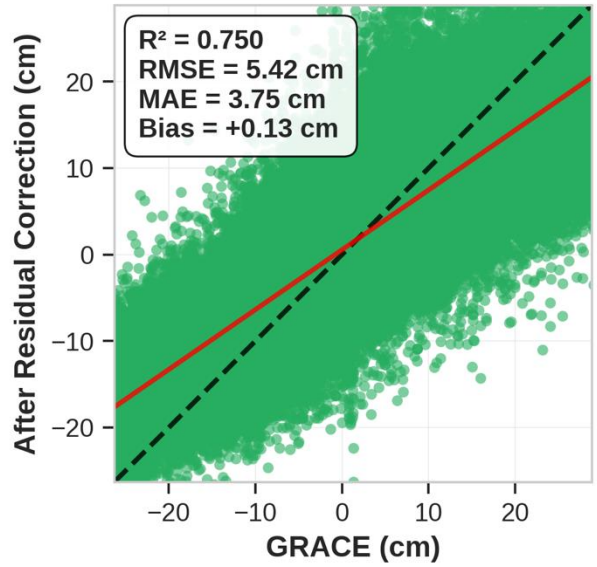

R² = 0.972
RMSE = 1.82 cm
MAE = 1.18 cm
Bias = +0.02 cm
LightGBM (cm)
GRACE (cm)


R² = 0.971
RMSE = 1.86 cm
MAE = 1.19 cm
Bias = +0.02 cm
XGBoost (cm)
GRACE (cm)

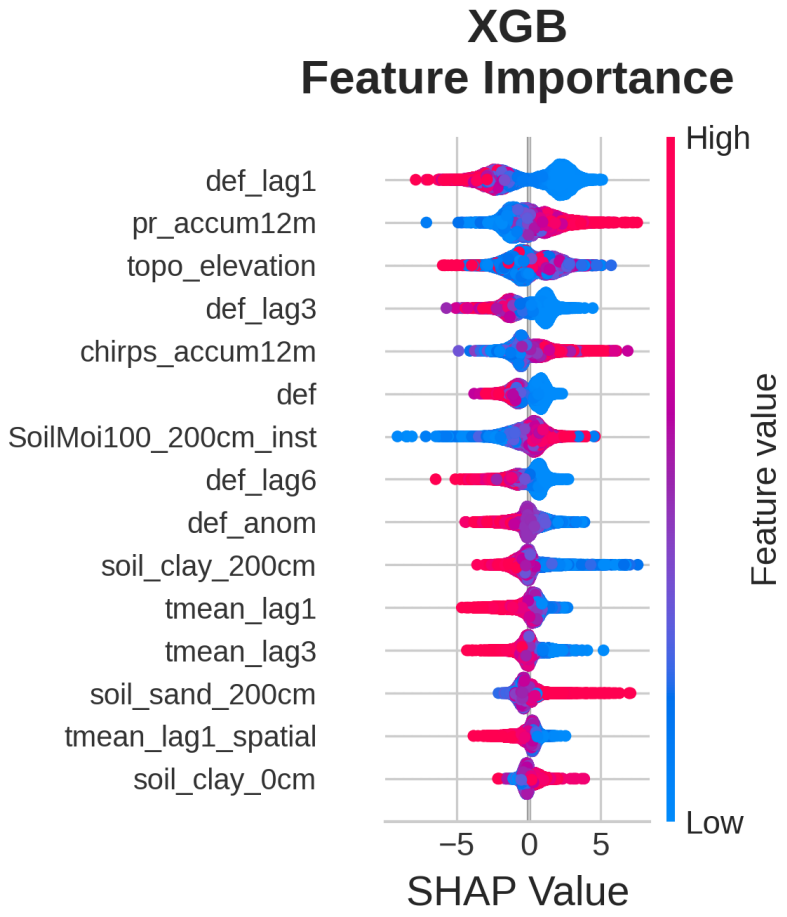

R² = 0.932
RMSE = 2.83 cm
MAE = 2.01 cm
Bias = -0.01 cm
Neural Network (cm)
GRACE (cm)

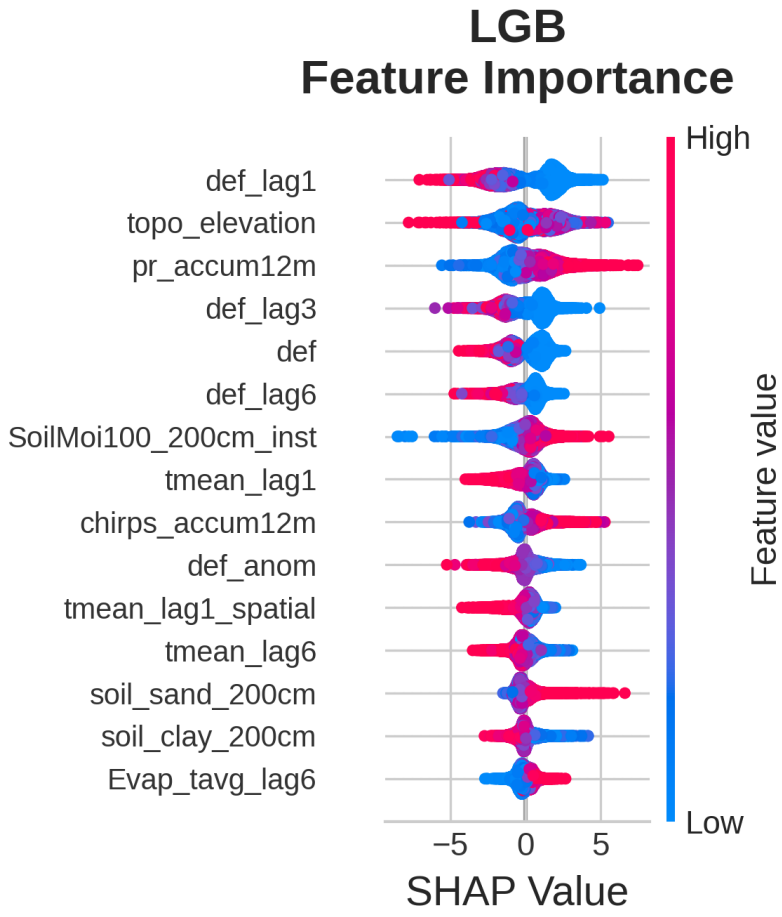

R² = 0.974
RMSE = 1.77 cm
MAE = 1.19 cm
Bias = +0.01 cm
Ensemble (cm)
GRACE (cm)

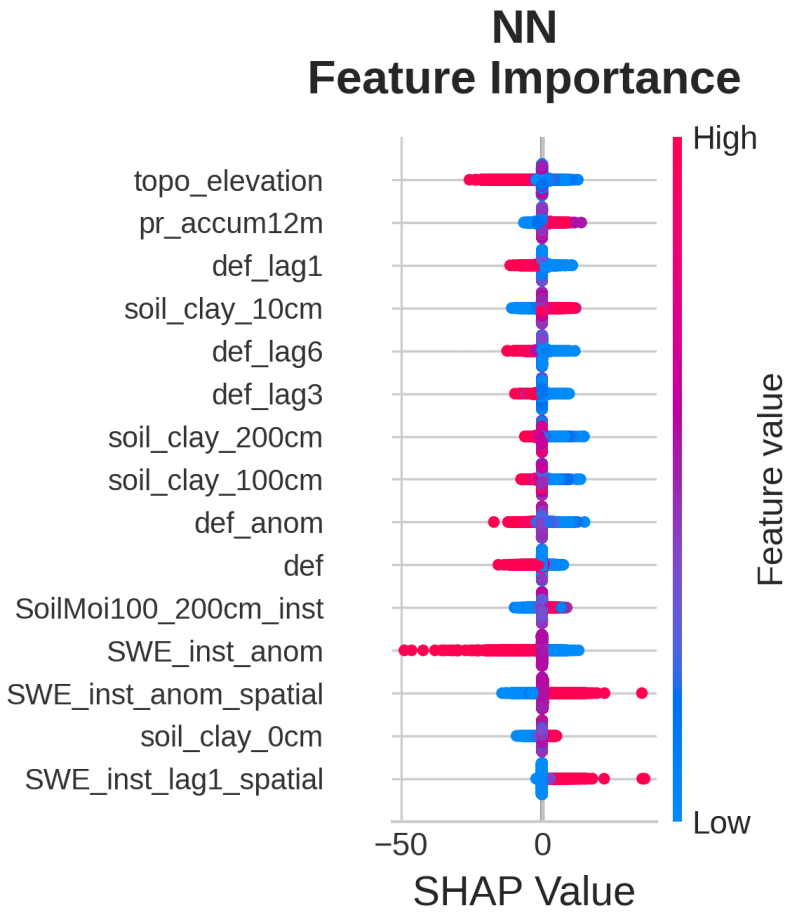

R² = 0.714
RMSE = 5.80 cm
MAE = 4.04 cm
Bias = +0.14 cm
Before Residual Correction (cm)
GRACE (cm)


R² = 0.750
RMSE = 5.42 cm
MAE = 3.75 cm
Bias = +0.13 cm
After Residual Correction (cm)
GRACE (cm)

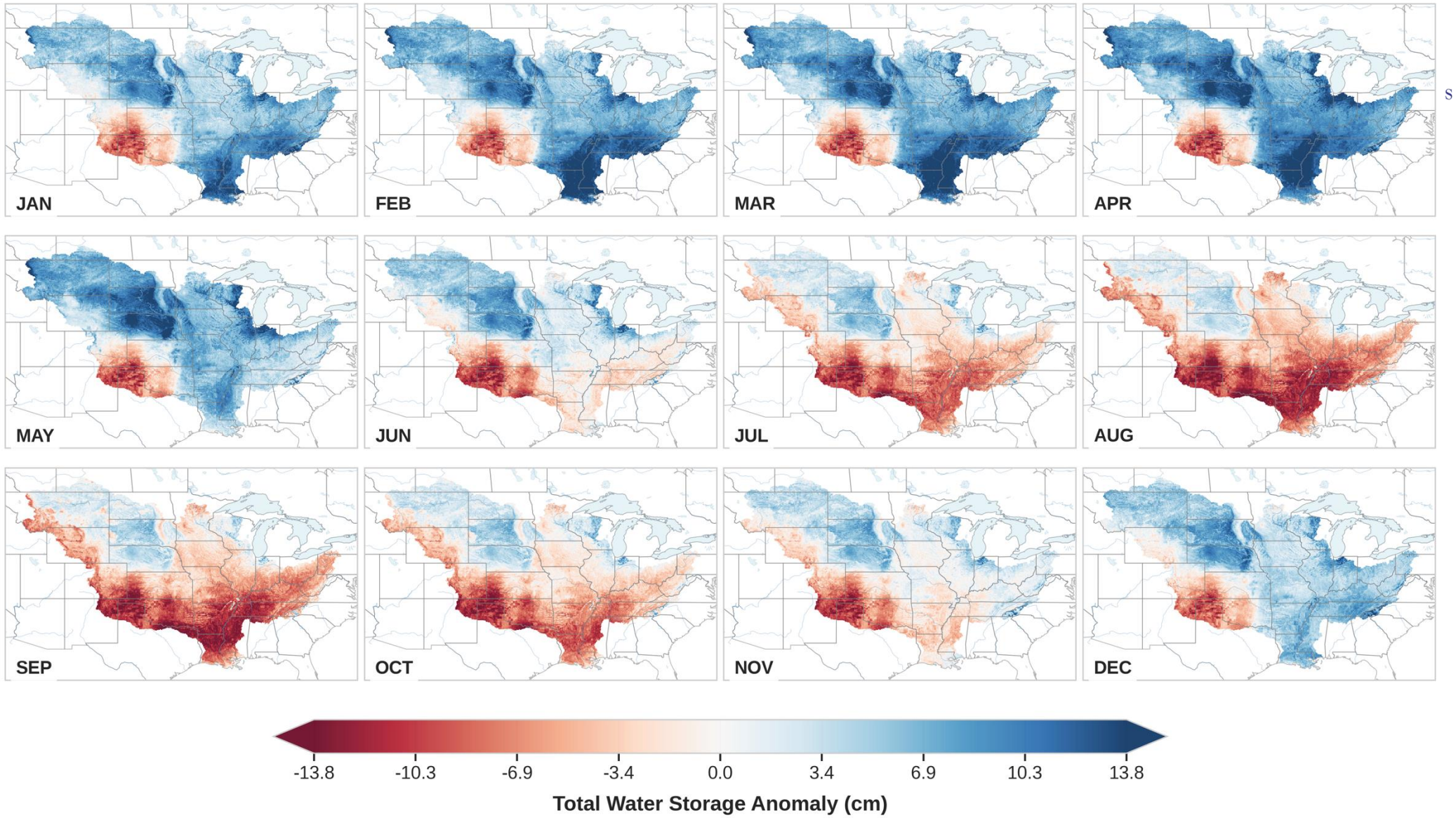
Result


XGB
Feature Importance
def_lag1
pr_accum12m
topo_elevation
def_lag3
chirps_accum12m
def
SoilMoi100_200cm_inst
def_lag6
def_anom
soil_clay_200cm
tmean_lag1
tmean_lag3
soil_sand_200cm
tmean_lag1_spatial
soil_clay_0cm
−5
0
5
SHAP Value
High
Low
Feature value


LGB
Feature Importance
def_lag1
topo_elevation
pr_accum12m
def_lag3
def
def_lag6
SoilMoi100_200cm_inst
tmean_lag1
chirps_accum12m
def_anom
tmean_lag1_spatial
tmean_lag6
soil_sand_200cm
soil_clay_200cm
Evap_tavg_lag6
−5
0
5
SHAP Value
High
Low
Feature value


NN
Feature Importance
topo_elevation
pr_accum12m
def_lag1
soil_clay_10cm
def_lag6
def_lag3
soil_clay_200cm
soil_clay_100cm
def_anom
def
SoilMoi100_200cm_inst
SWE_inst_anom
SWE_inst_anom_spatial
soil_clay_0cm
SWE_inst_lag1_spatial
−50
0
SHAP Value
High
Low
Feature value

Result


JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
-13.8
-10.3
-6.9
-3.4
0.0
3.4
6.9
10.3
13.8
Total Water Storage Anomaly (cm)

Dissemination and Accessibility

Open-Source Development

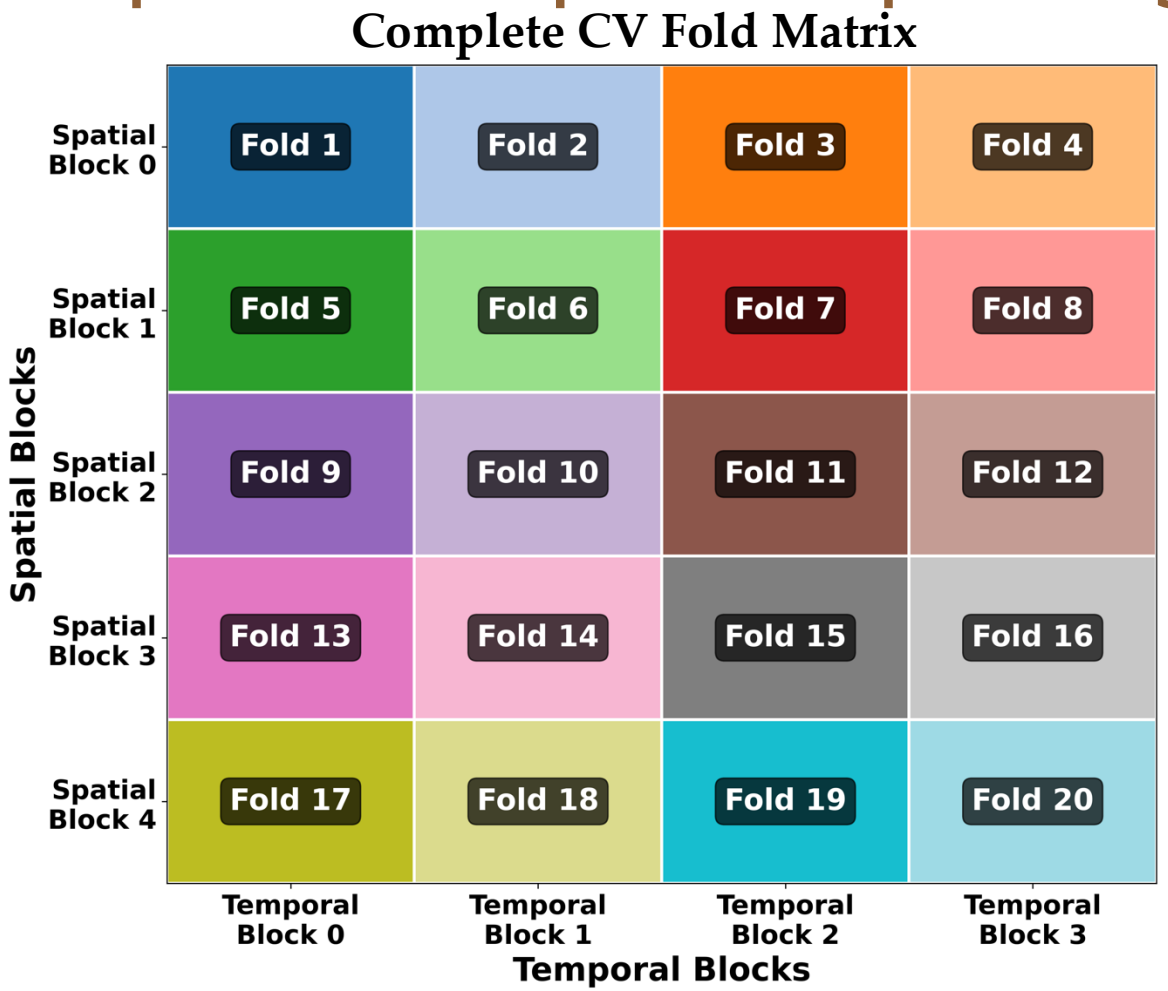
Complete codebase available on **Github** for transparency and collaboration

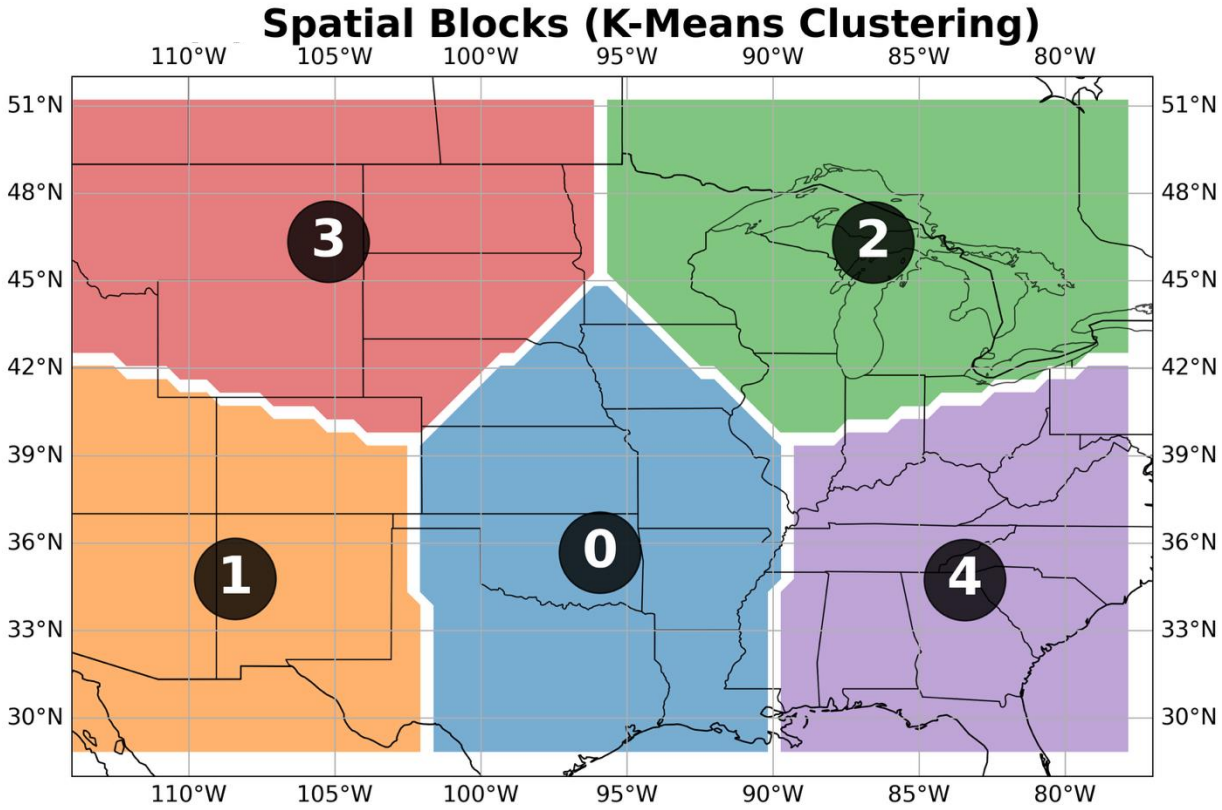
Users only need to provide **latitude and longitude** coordinates — the framework handles all processing with a Google Earth Engine account

Interactive Web Application

Results hosted on Streamlit for interactive area selection and analysis of groundwater data

Spatiotemporal Splitting





Temporal Blocks

T0: 200301-200804 T2: 201312-201902

T1: 200807-201309 T3: 101905-202410

Acknowledgements

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Thank you!

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