Leveraging Earth Observations and Machine Learning for Sustainable Groundwater Management

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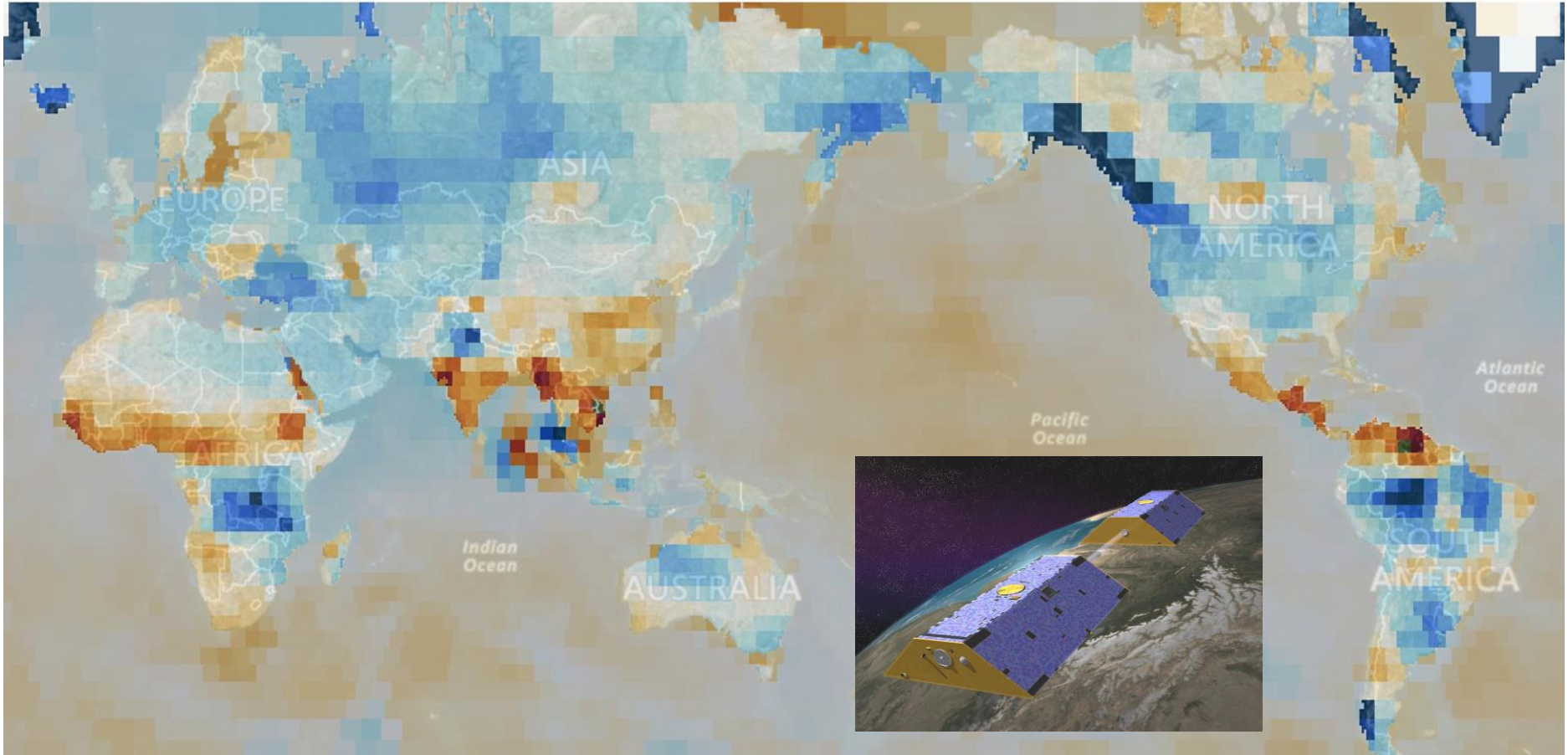
West Africa Project Objectives

Assist stakeholders and water managers in West Africa to assess, characterize, and sustainably manage **groundwater resources** for **economic development** and **drought resilience**.

Focus areas/deliverables:

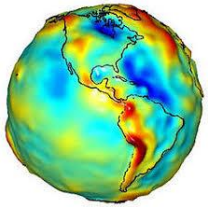
1) GRACE regional subsetting tool
2) Groundwater Data Mapping application
3) Regional groundwater model development

GRACE Water Storage Anomaly



Calculating Groundwater

GRACE
Total Water Storage Anom.



−

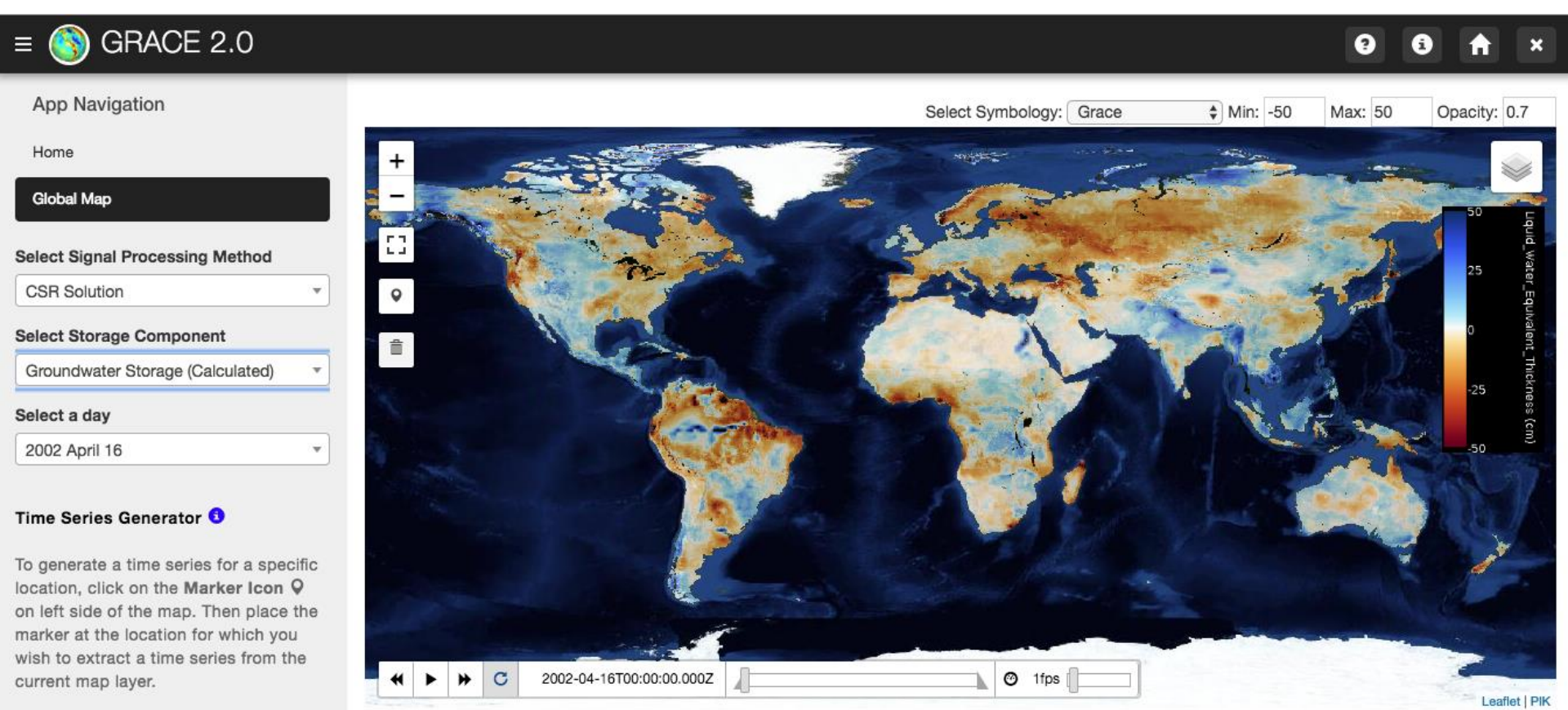
GLDAS
Total Surface Water Storage Anom.

−

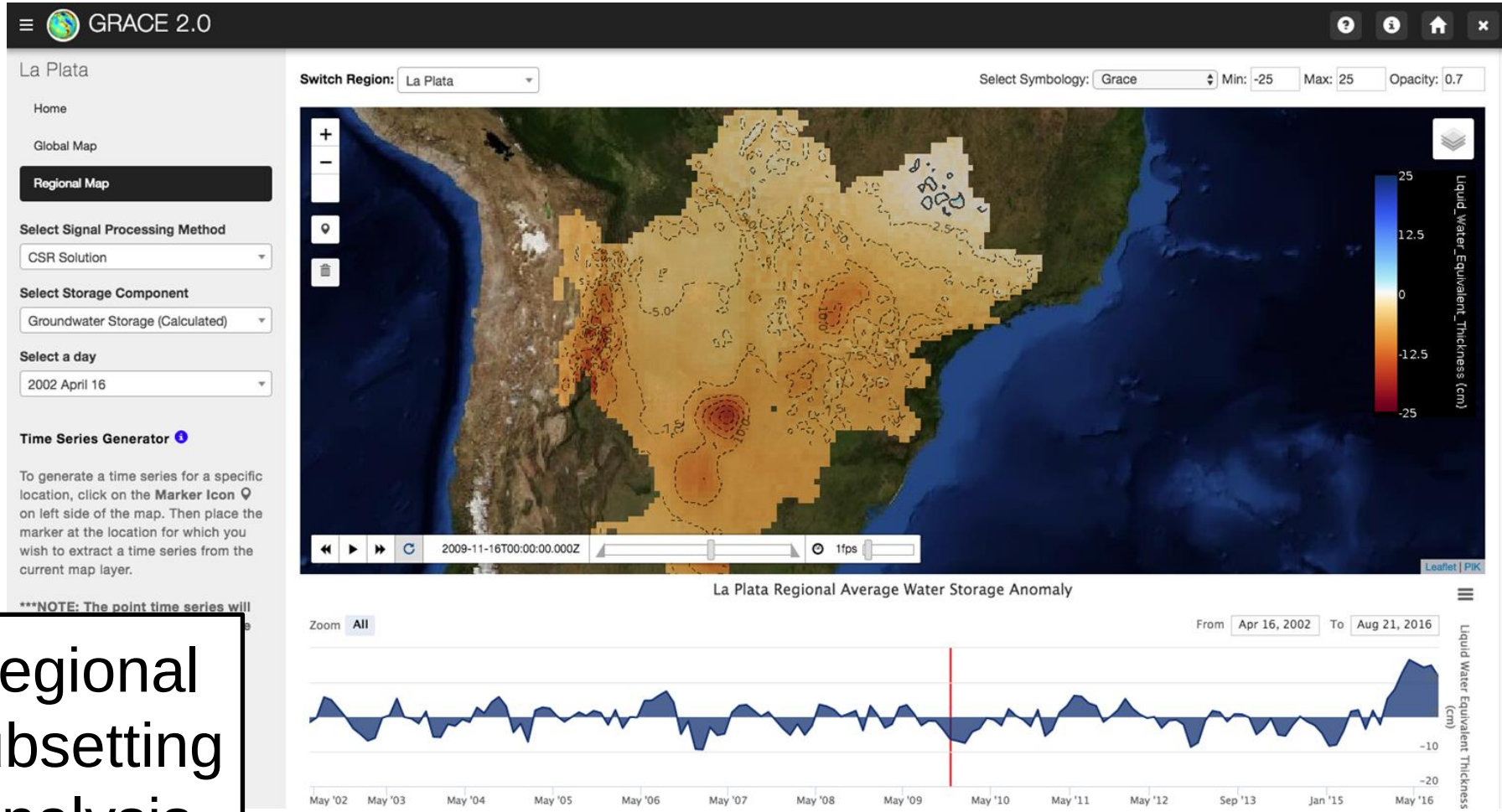
GLDAS
Total Soil Moisture Storage Anom

=

Total Groundwater Storage Anomaly



GRACE Data Visualization Application



Regional Subsetting Analysis

La Plata

- Home
- Global Map
- Regional Map

Select Signal Processing Method

CSR Solution

Select Storage Component

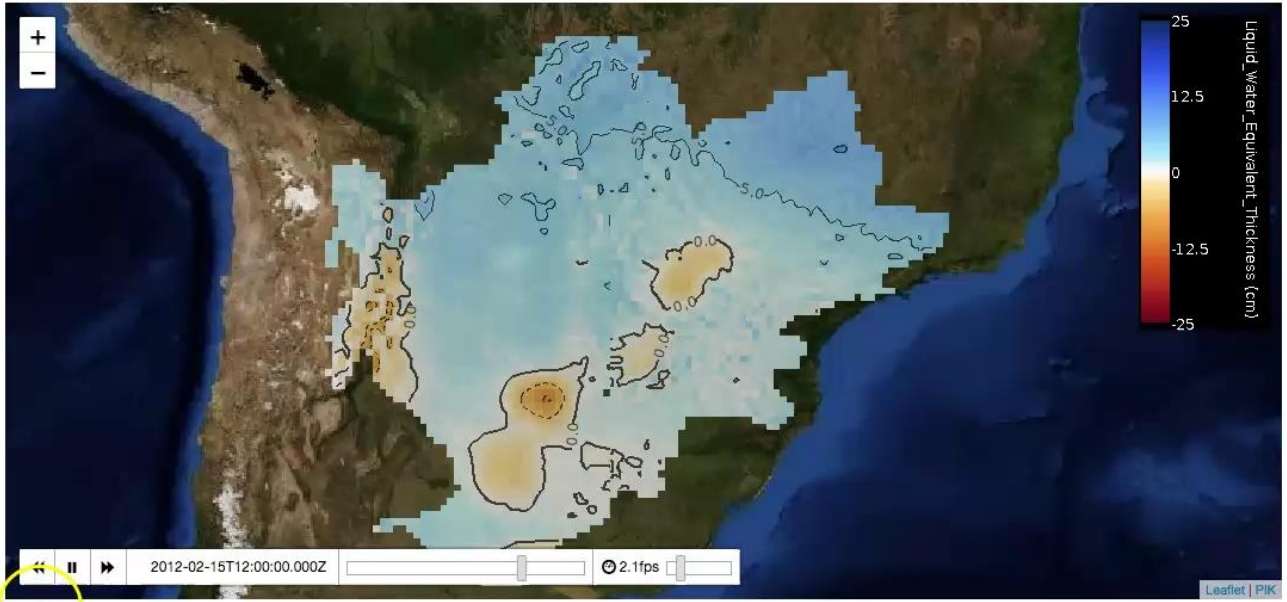
Groundwater Storage (Calculated)

Select a day

2002 April 16

Switch Region: La Plata

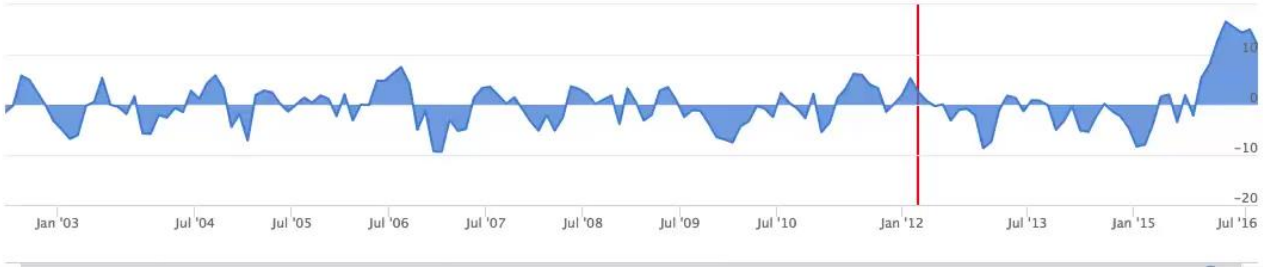
Select Symbology: Grace : -25 Max: 25 Opacity: 0.7



laplata Regional Average Liquid Water Equivalent Thickness (cm)

Zoom All

From Apr 16, 2002 To Aug 21, 2016

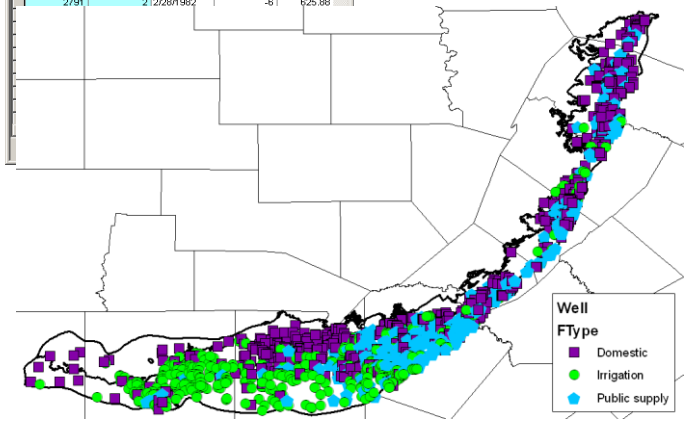


Groundwater Data Mapping App

Attributes of TimeSeries

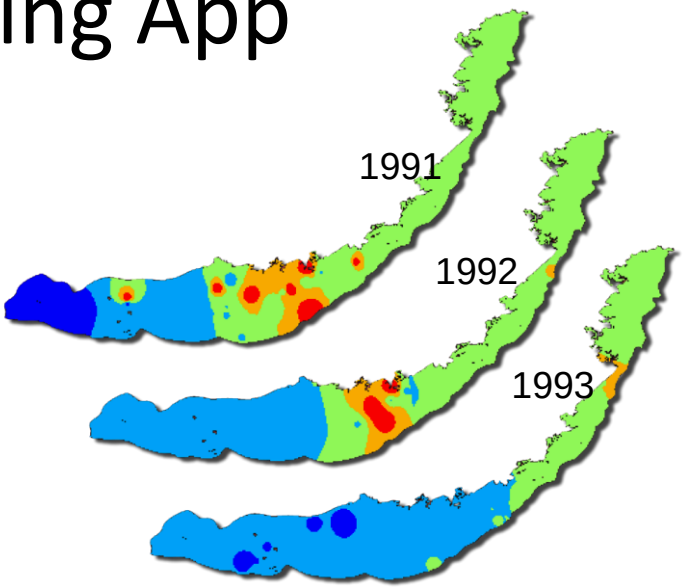
FeatureID *	VariableID *	TsTime	UTCOffset	TsValue
2791	2	3/30/1982	-6	625.75
2791	2	12/15/1981	-6	626.67
2791	2	12/30/1981	-6	626.57
2791	2	1/15/1982	-6	626.35
2791	2	1/30/1982	-6	626.27
2791	2	2/15/1982	-6	626.01
2791	2	7/30/1982	-6	623.7
2791	2	3/15/1982	-6	625.76
2791	2	7/15/1982	-6	624.37
2791	2	4/15/1982	-6	625.42
2791	2	4/30/1982	-6	625.34
2791	2	5/15/1982	-6	626.1
2791	2	5/30/1982	-6	626.35
2791	2	6/15/1982	-6	625.74
2791	2	4/15/1983	-6	624.63
2791	2	2/28/1982	-6	625.88

Water Level Measurements



Well Locations

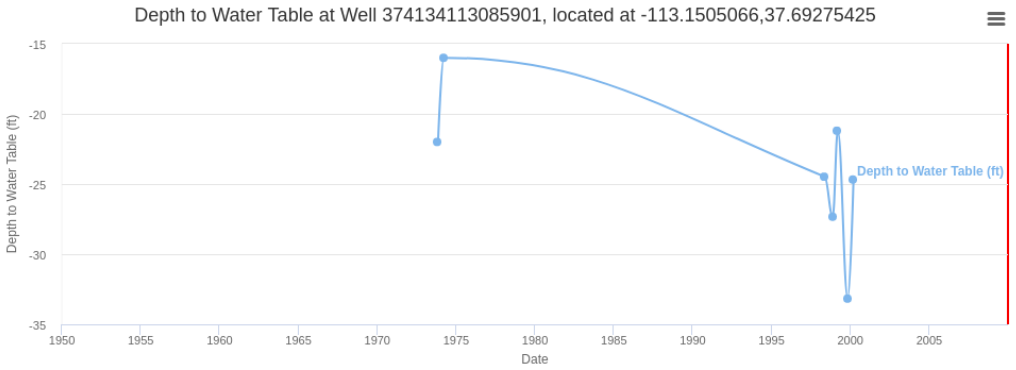
Time and Space Interpolation Algorithms



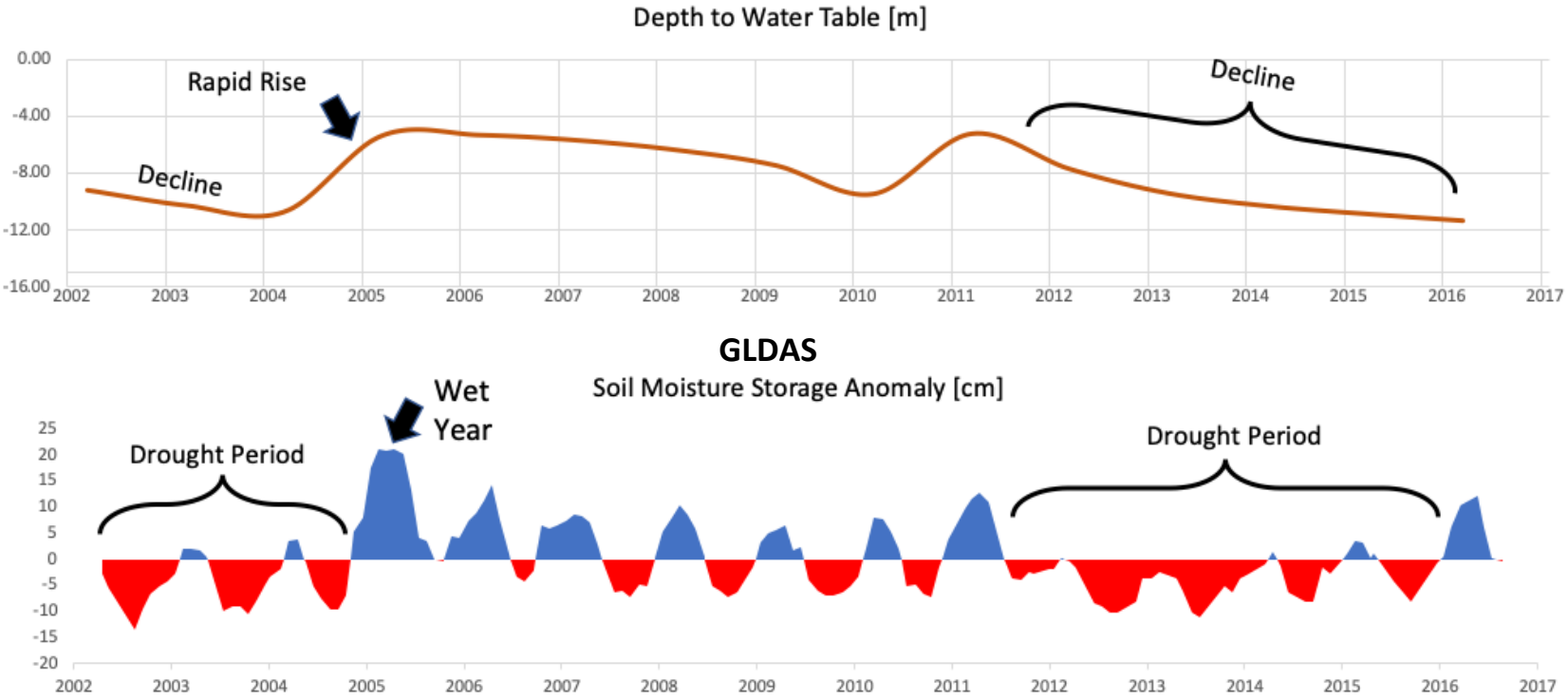
Earth Observations

Temporally Sporadic Data

- Well Time series often include large gaps in collected data
- Some wells may only have data for one or two years



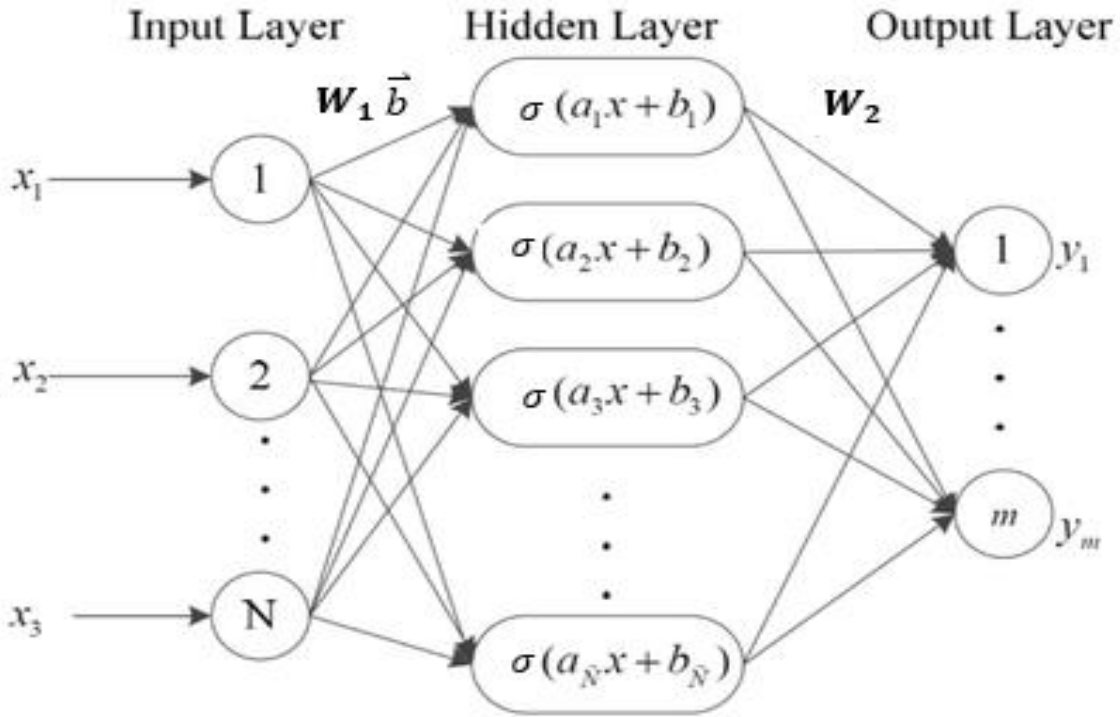
Correlation with Earth Observations



Earth Observations

- Palmer Drought Severity Index (PDSI)
- Global Land Data Assimilation (GLDAS) Root Zone Soil Moisture
- Climate Prediction Center (CPC) Soil Moisture
- Gravity Recovery and Climate Experiment (GRACE) Total Water Storage

Extreme Learning Machine

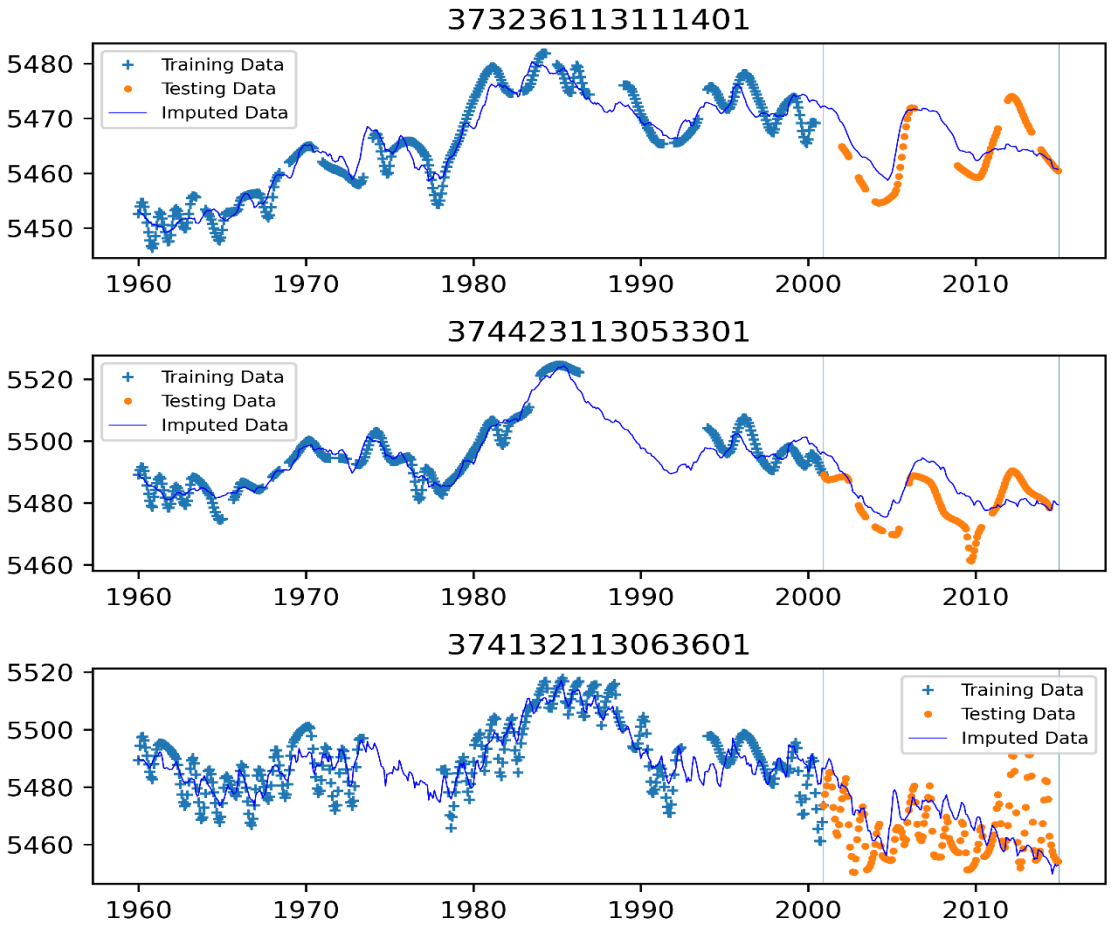


$$\vec{Y} = \boldsymbol{W}_2 * \sigma(\boldsymbol{W}_1\boldsymbol{X} + \vec{b})$$

$$\sigma(x) = \max(0, x)$$

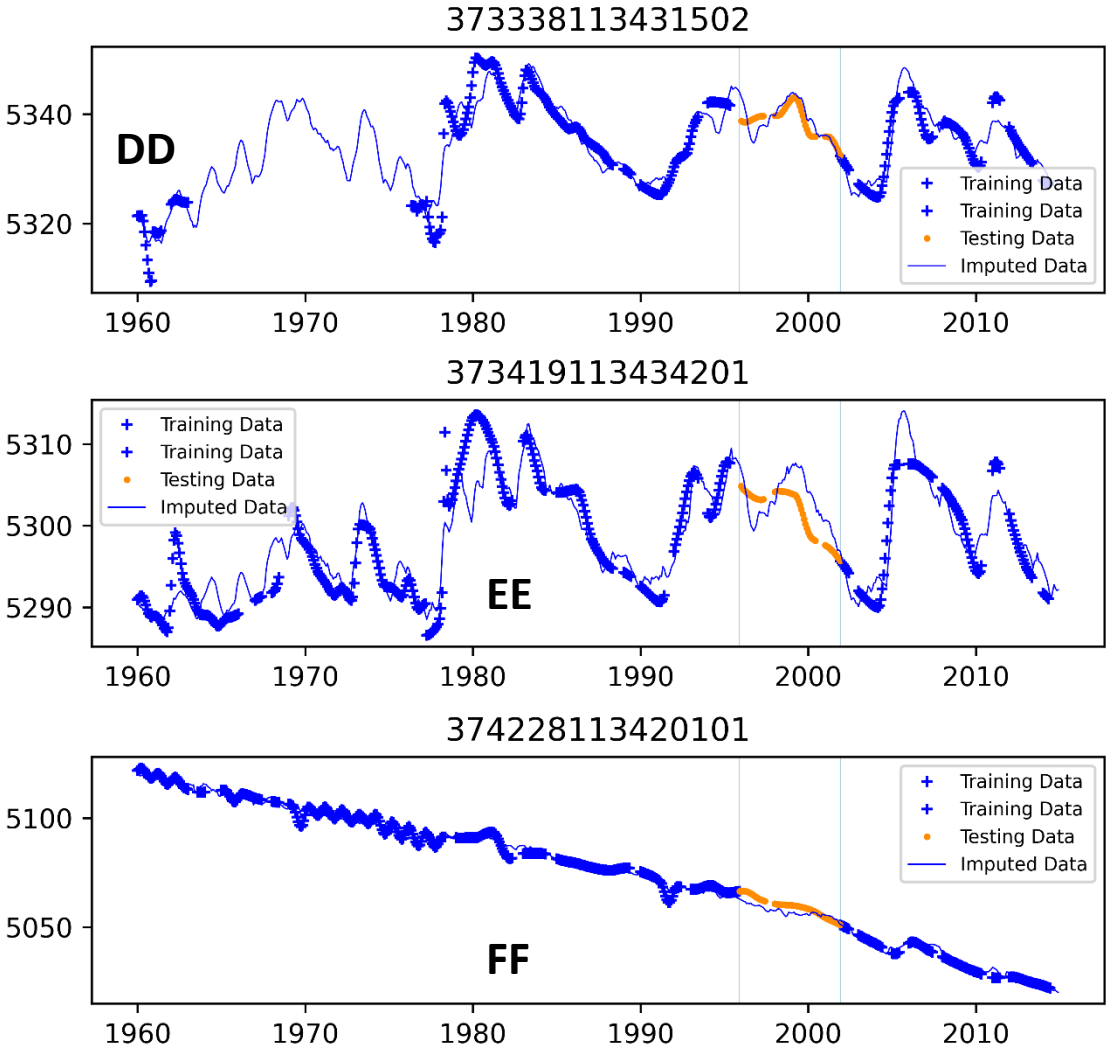
Extrapolation

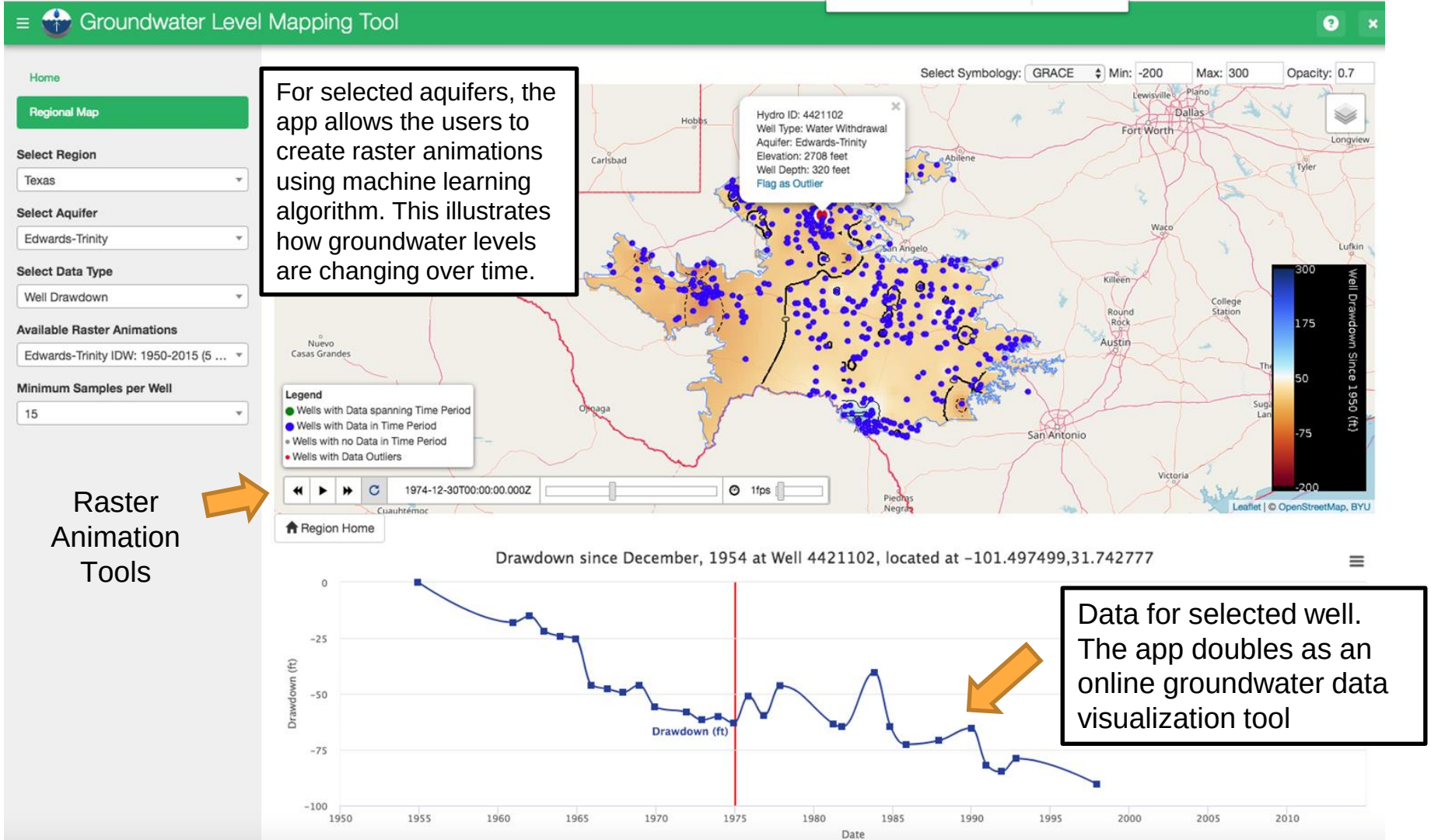
Cedar Valley Aquifer
Utah, USA



Imputation

Cedar Valley Aquifer
Utah, USA




Groundwater Level Mapping Tool
Home
Regional Map
Select Region
Texas
Select Aquifer
Edwards-Trinity
Select Data Type
Well Drawdown
Available Raster Animations
Edwards-Trinity IDW: 1950-2015 (5 ...
Minimum Samples per Well
15
For selected aquifers, the app allows the users to create raster animations using machine learning algorithm. This illustrates how groundwater levels are changing over time.
Select Symbology: GRACE
Min: -200
Max: 300
Opacity: 0.7
Hydro ID: 4421102
Well Type: Water Withdrawal
Aquifer: Edwards-Trinity
Elevation: 2708 feet
Well Depth: 320 feet
Flag as Outlier
Legend
Wells with Data spanning Time Period
Wells with Data in Time Period
Wells with no Data in Time Period
Wells with Data Outliers
1974-12-30T00:00:00.000Z
1fps
Well Drawdown Since 1950 (ft)
Region Home
Raster Animation Tools
Drawdown since December, 1954 at Well 4421102, located at -101.497499,31.742777
Drawdown (ft)
Date
Data for selected well. The app doubles as an online groundwater data visualization tool

Groundwater Level Mapping Tool

Select Region

Texas

Select Aquifer

Edwards-Trinity

Select Data Type

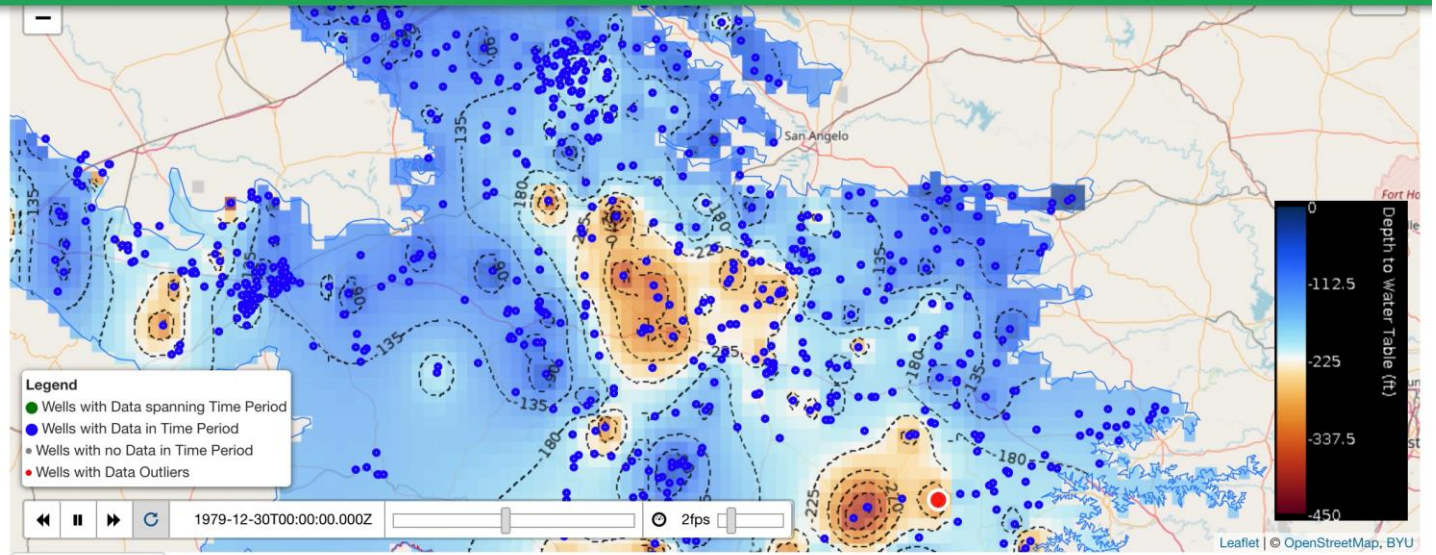
Depth to Groundwater

Available Raster Animations

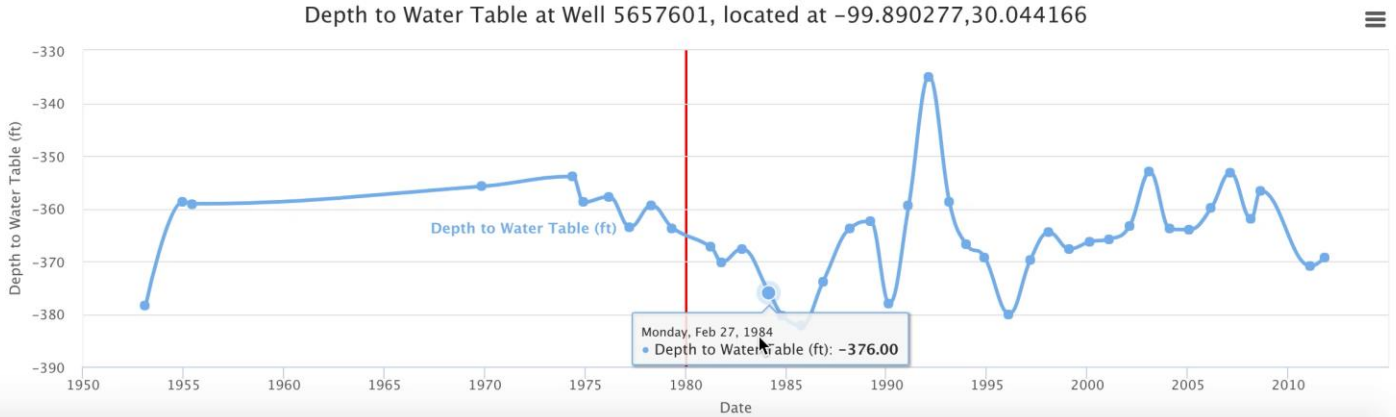
Edwards-Trinity IDW: 1950-2015 (5 …

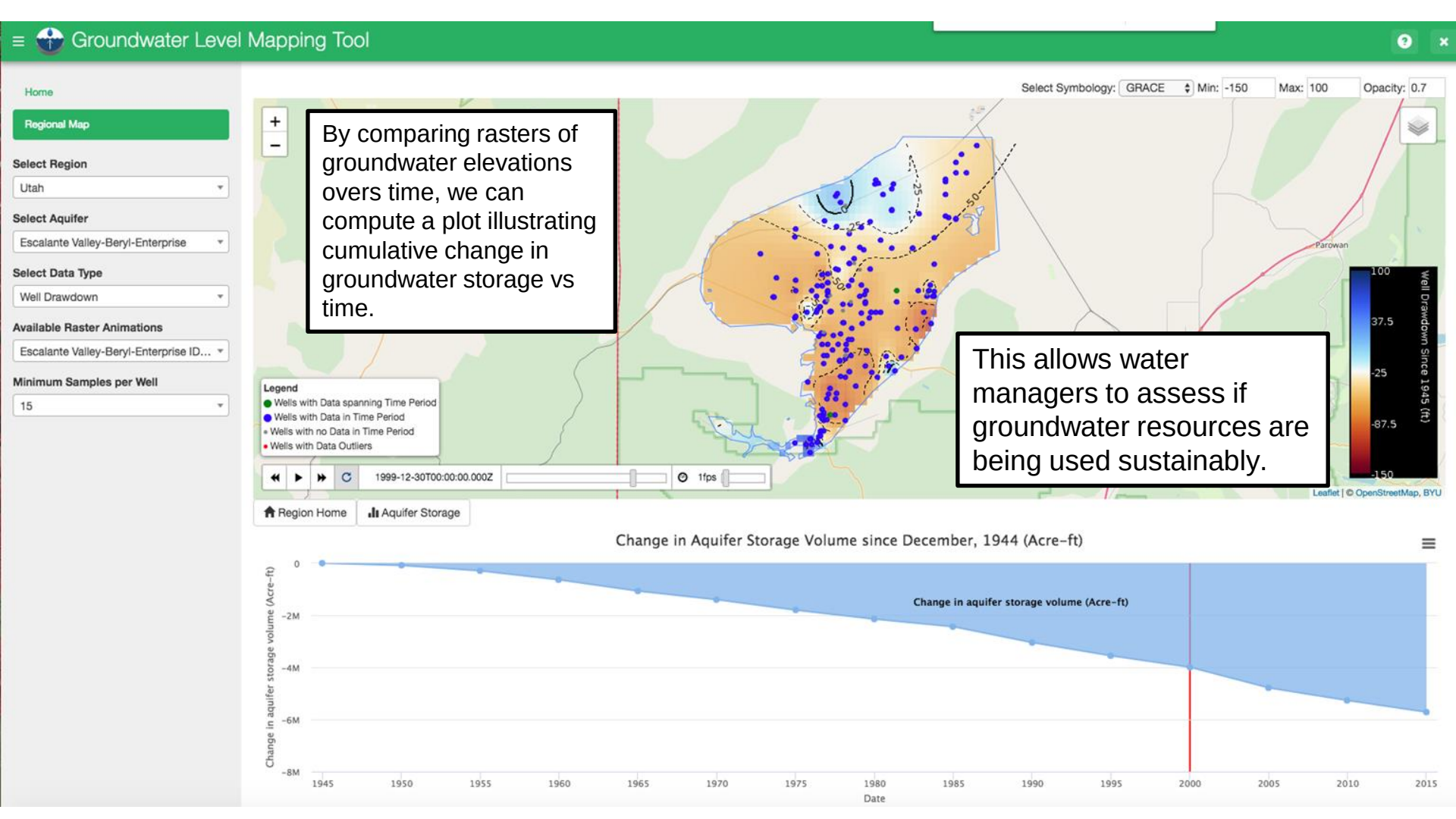
Minimum Samples per Well

5



Region Home




Groundwater Level Mapping Tool
Home
Regional Map
Select Region
Utah
Select Aquifer
Escalante Valley-Beryl-Enterprise
Select Data Type
Well Drawdown
Available Raster Animations
Escalante Valley-Beryl-Enterprise ID...
Minimum Samples per Well
15
Select Symbology: GRACE Min: -150 Max: 100 Opacity: 0.7
By comparing rasters of groundwater elevations overs time, we can compute a plot illustrating cumulative change in groundwater storage vs time.
This allows water managers to assess if groundwater resources are being used sustainably.
Legend
Wells with Data spanning Time Period
Wells with Data in Time Period
Wells with no Data in Time Period
Wells with Data Outliers
1999-12-30T00:00:00.000Z
1fps
Parowan
Well Drawdown Since 1945 (ft)
100
37.5
-25
-87.5
-150
Leaflet | © OpenStreetMap, BYU
Region Home
Aquifer Storage
Change in Aquifer Storage Volume since December, 1944 (Acre-ft)
Change in aquifer storage volume (Acre-ft)
Change in aquifer storage volume (Acre-ft)
0
-2M
-4M
-6M
-8M
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Date

GW Data Mapper | GRACE GW Subsetting Tool | MODFLOW Model

Geospatial Information Tools for Sustainable Groundwater Management in West Africa

NASA SERVIR Applied Science Team

Brigham Young University, Provo Utah, USA

The project is funded by the NASA SERVIR program. The objective of the SERVIR program is to assist developing countries in using Earth Observations to assess, analyze, and sustainably manage natural resources and to improve lives. SERVIR works with a set of regional "hubs" serving more than 30 countries. These hubs are located in Amazonia, West Africa, East and Southern Africa, Hindu Kush Himalaya, and Mekong. Every three years NASA s
form an Applied Science Team that works with the regional hub to deliver science, data, trainin
Our project was funded in October, 2019 and will continue through October, 2022. We are work
Ghana, and Senegal. The hub is headquartered in an orgnanization called AGRHYMET, located
funded by USAID.

http://hydroinf.groups.et.byu.net/servir-wa/

The objective is this website is to provide a repository of information, links, training materials and other resources related to this project.

CILSS AGRHYMET

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SERVIR

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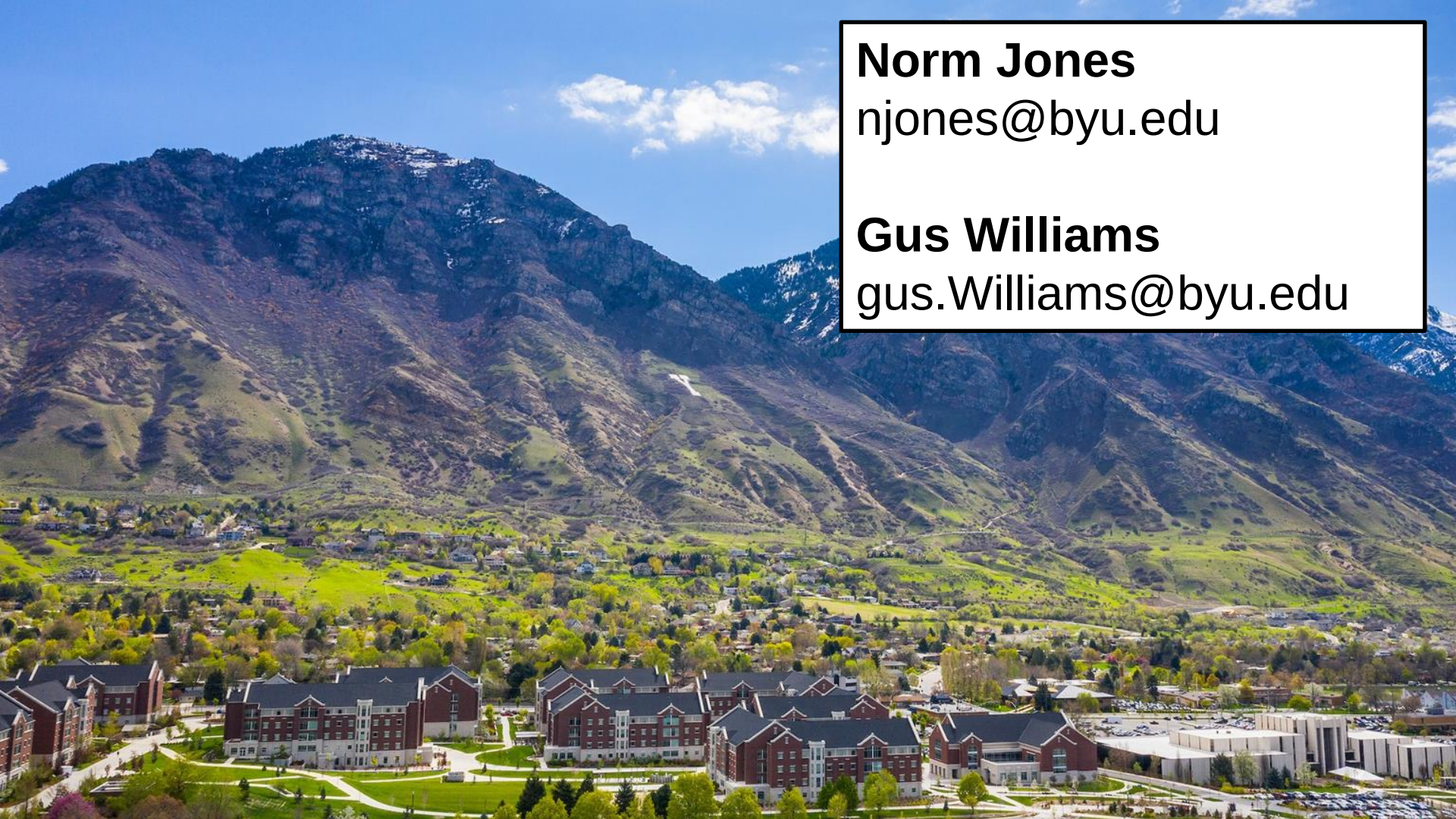

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