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RiversEdge West

Using Time-series Satellite Vegetation Indices to Asses Fractional Plant Cover, Greenness and Evapotranspiration in Natural and Restored Western U.S. Riparian Sites

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2020 Riparian Restoration Conference
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Colorado Mesa University

THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
COLLEGE OF ENGINEERING
Biosystems Engineering

USGS

NASA

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Overview

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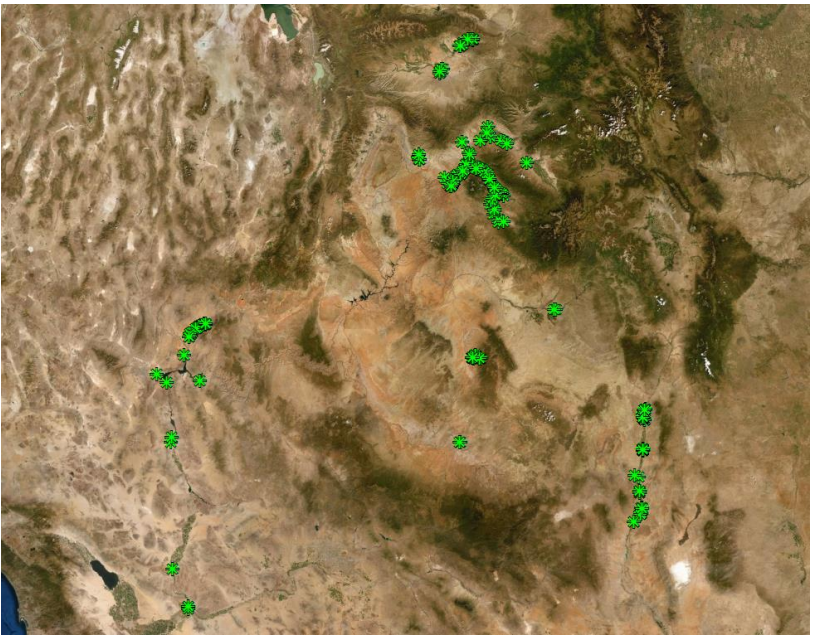
- Riparian zones provide critical habitat to 90% of wildlife species, are important breeding grounds and serve as avian flyways, while occupying less than 2% of the land area.
- Water is a primary environmental driver of plant productivity and an important metric of the efficiency of water use or ET.
- ET is a key component of the hydrological cycle and can indicate the resilience of vegetation under drought.

Overview (cont.)

Many places in the U.S. South West have undergone environmental changes that have led to myriad restoration techniques and a plethora of efforts over the last two decades aimed at restoring riparian vegetation across this dryland ecosystem.

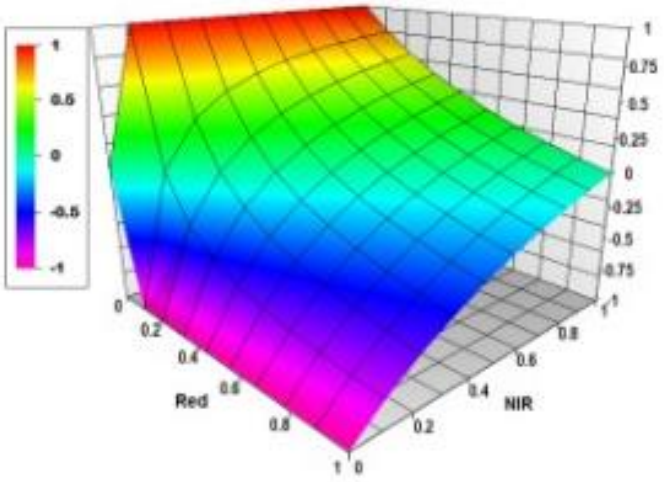
Remote Sensing observations provide an scale effective alternative to track vegetation changes and aid in the management of these riparian areas.



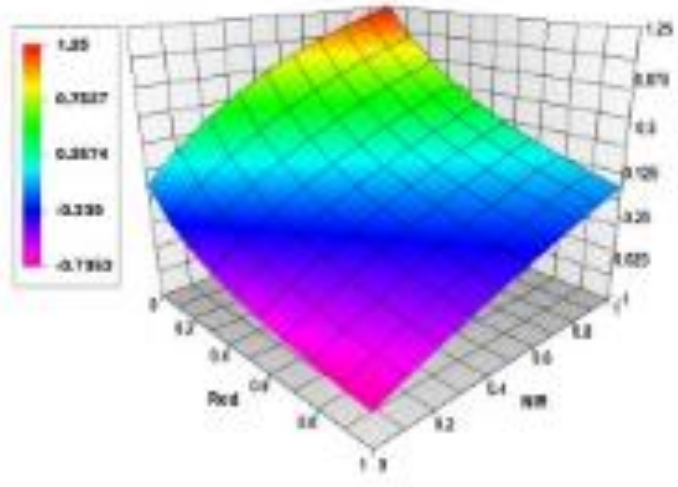
Overview (cont)

- Vegetation Indices (VI) remain one of the most widely used and accessible NASA Earth Science Data Records and Time Series supporting a variety of research topics
- The VI (& associated ancillary data) Time Series is now close to 40 yrs long albeit with different spatial, temporal, spectral, and radiometric characteristics (AVHRR, MODIS, VIIRS, Landsat, etc.)

NDVI



EVI2



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Objectives

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- Assess the greenup response of vegetation as captured by remote sensing time series for monitoring riparian areas vegetation health on the U.S. Southwest
- Measure changes in greenness in selected restoration plots using Vegetation Indices (NDVI, EVI,EVI2) from different sensors
- Characterize the VI and ET times series trends
- Develop a cloud based platform for the analysis of changes in landscape greenness and plant water
- Facilitate access to spatial data to assist informed decision about the status of vegetation and water in these corridors

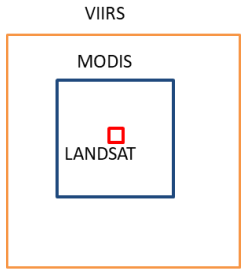




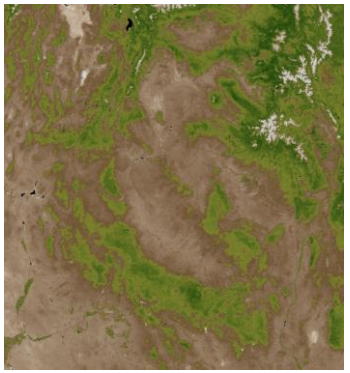
Datasets

- Landsat
  - TM (2000-2011), ETM (2008-2016), OLI (2013-2019)
    - ETM limited to bridging the gap (2012) between TM and OLI as it has serious issues
  - 30m spatial resolution, every 16days
  - UTM Projection
- MODIS
  - 250m spatial resolution, 16-day composite, daily*
  - Sinusoidal Projection
- VIIRS
  - 500m spatial resolution, 16-day composite
  - Sinusoidal Projection

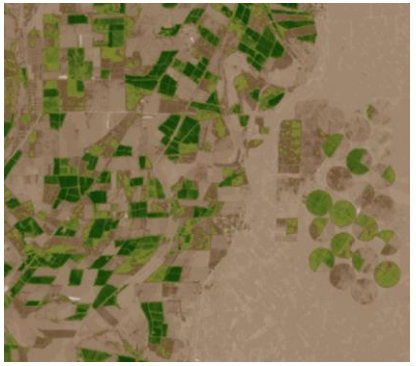
- Our cloud based platform updates these data records regularly



Pixel Size



MODIS/VIIRS resolution



TM resolution

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Standard Processing Pipeline

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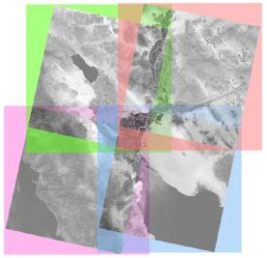
All data records are processed following this pipeline with potential to add other algorithms/methods



Data Acquisition

Subset/Mosaic

Landsat

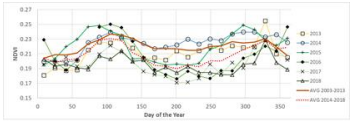
- QA standardization
- QA Filtering
- Long Term AVG
- Continuity Equations
- Continuity
- GAP Filling

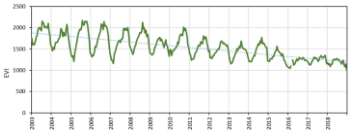
MODIS/VIIRS

- Reprojection
- Filtering
- Long Term Avg

High Fidelity Time Series

- VIS, ET clean dataset
- Time series
- Anomalies
- Trends

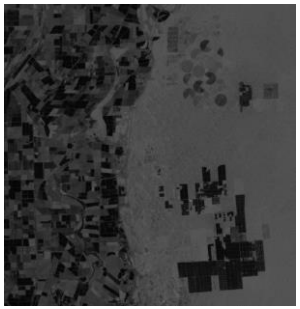




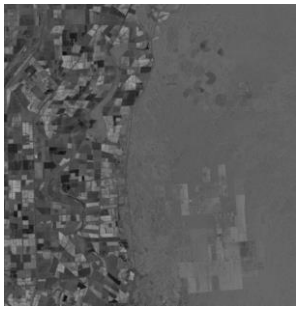
Datasets SDS

The following value added products are generated by the processing pipeline

RED

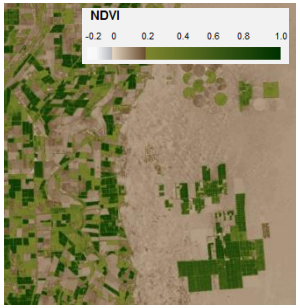


NIR

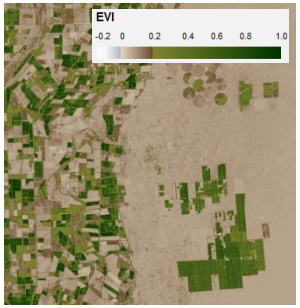


RGB

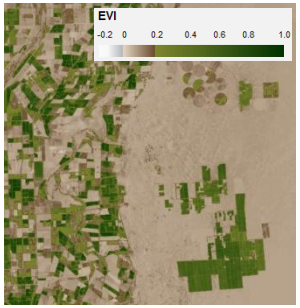
MNR



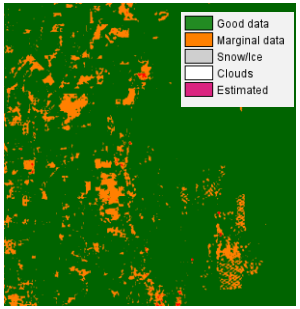
NDVI



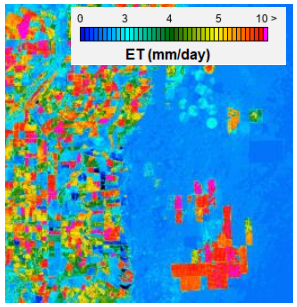
EVI



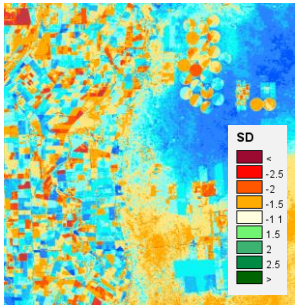
EVI2



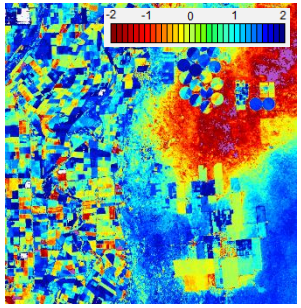
QA/Reliability



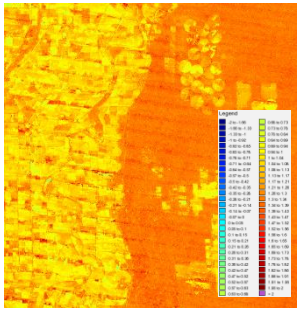
ET



Anomalies



Trends



Continuity

Case Study: Lower Colorado River

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Results

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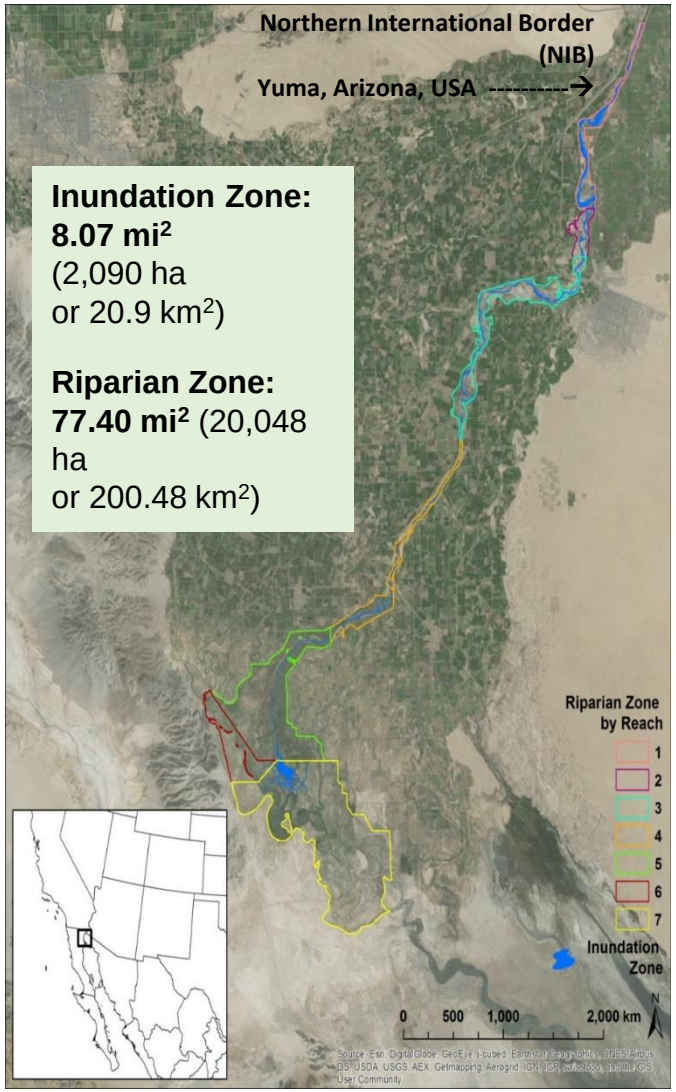

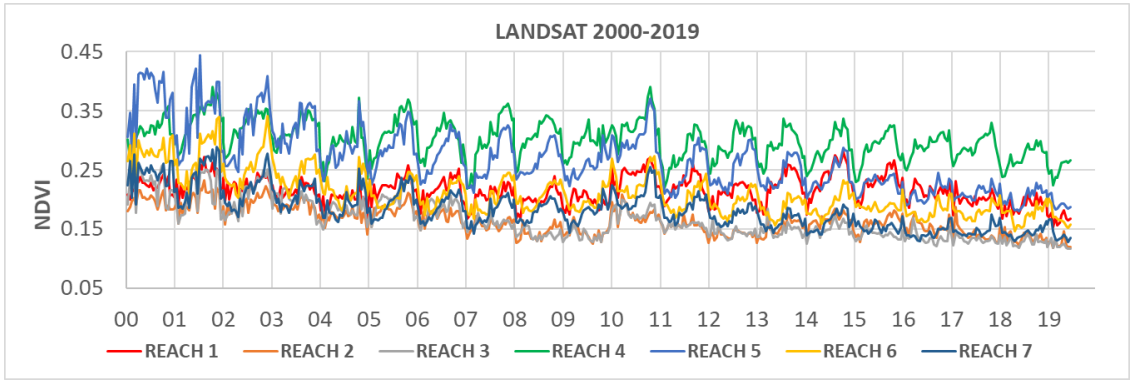

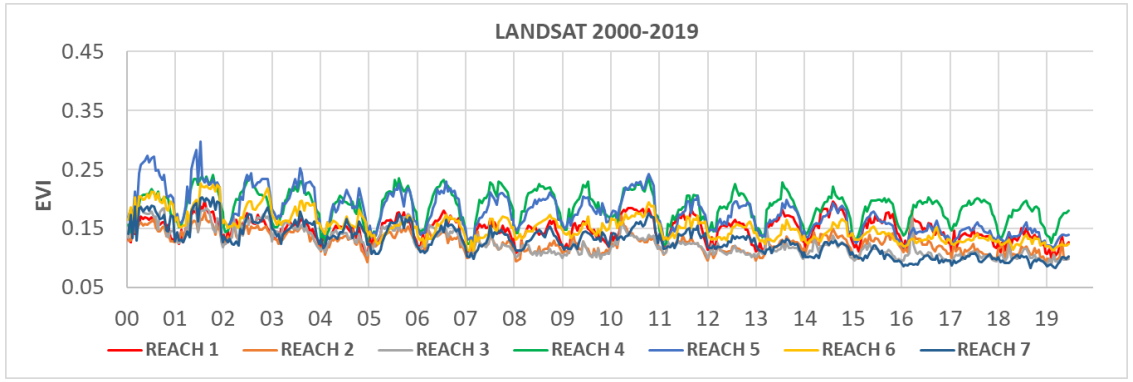

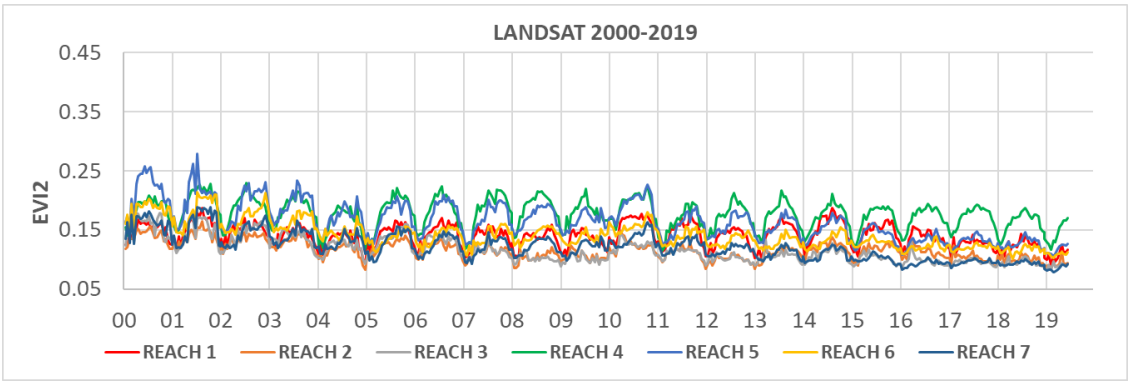

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Results (cont.)

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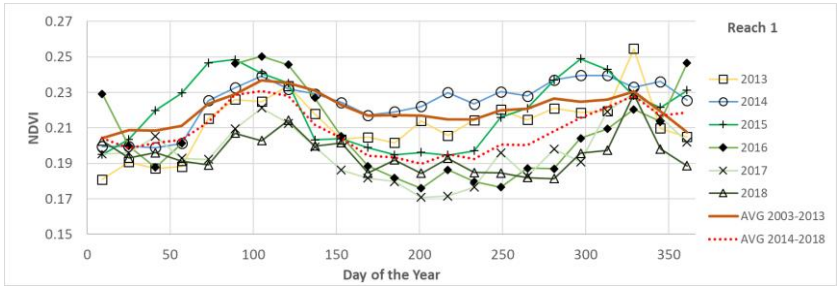
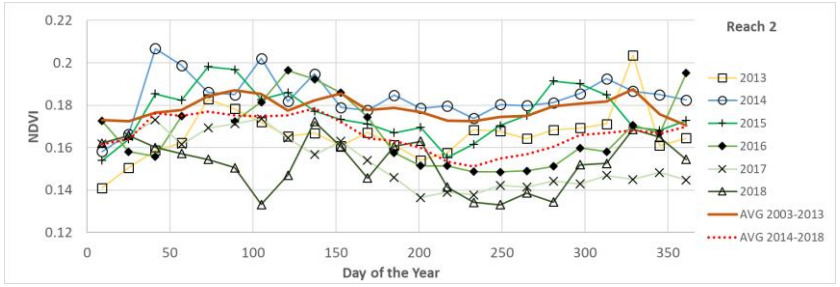
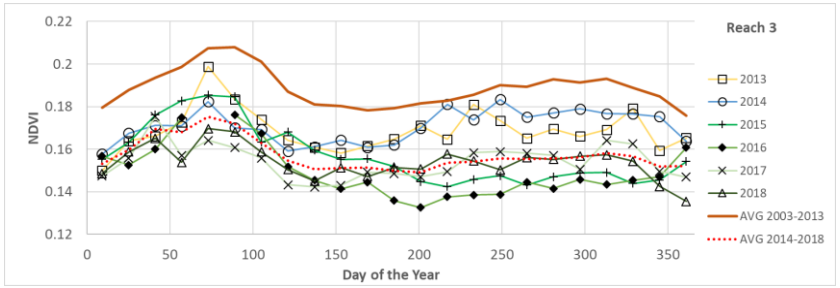
MODIS AQUA (250m): Decomposition of VI Signal post-flow compared to Average of Years 2003-2018

Reaches 1, 2, 3

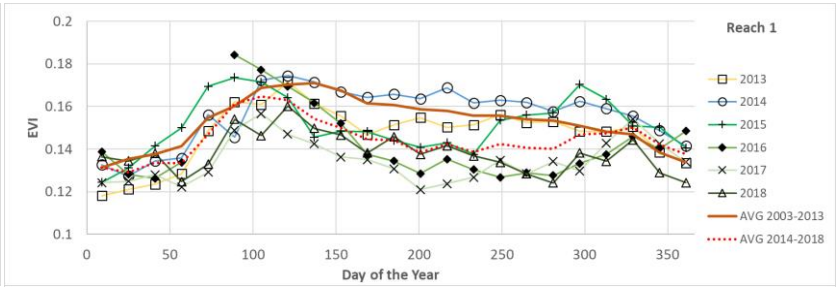
NDVI

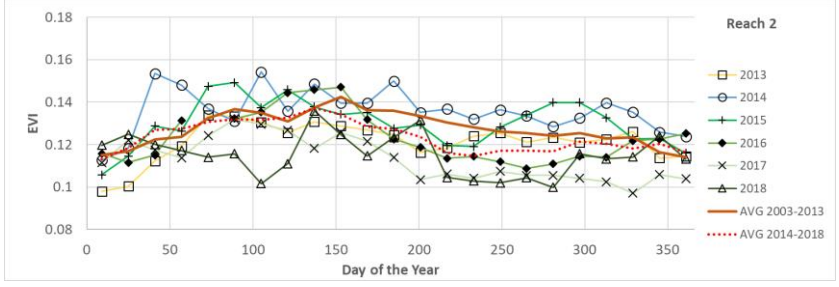


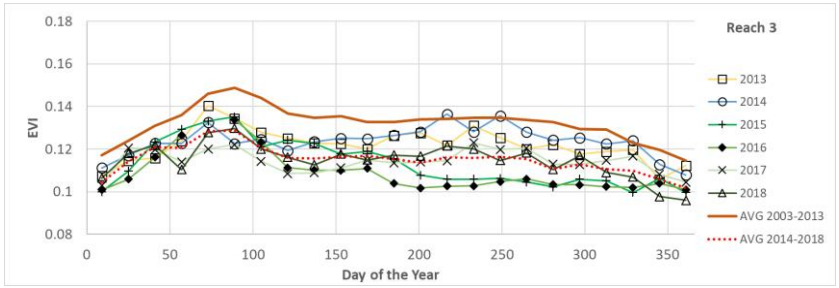




EVI







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Results (cont.)

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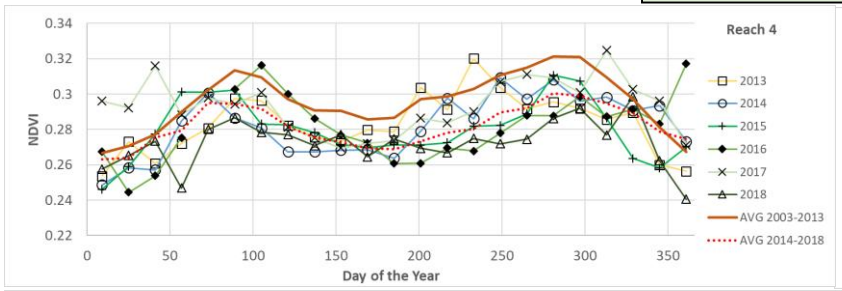
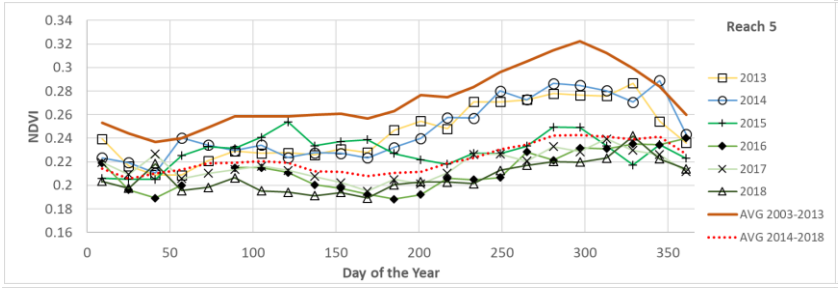
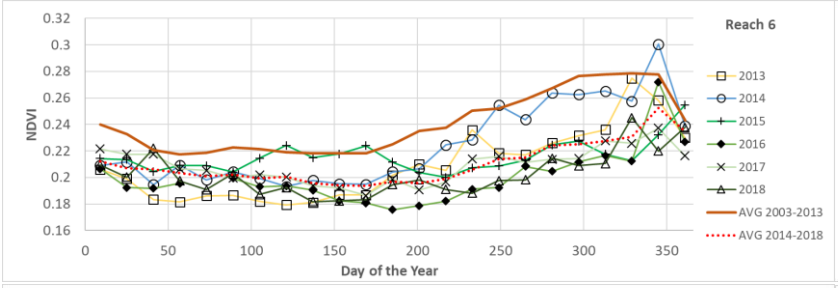
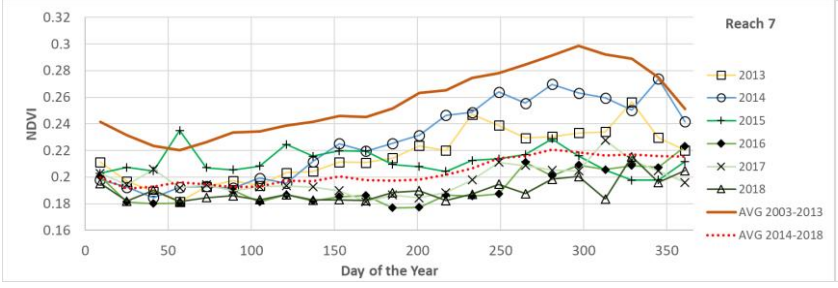
Reaches 4, 5, 6, 7

NDVI









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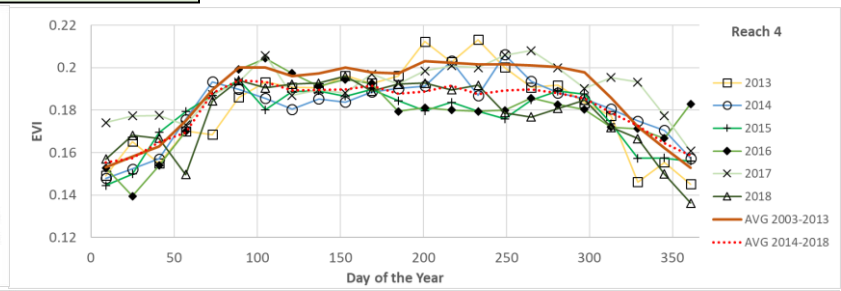

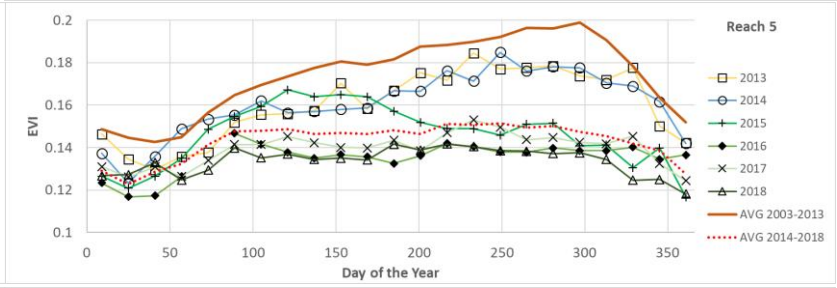

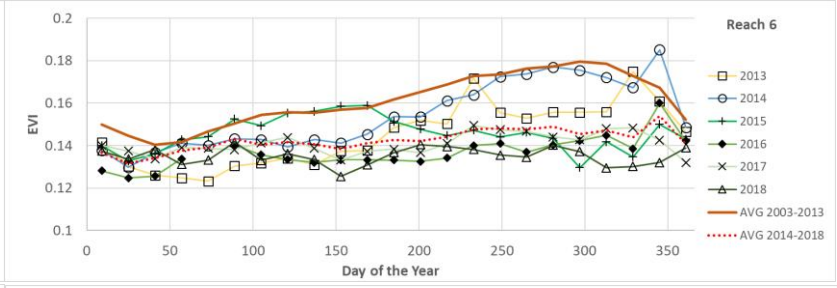

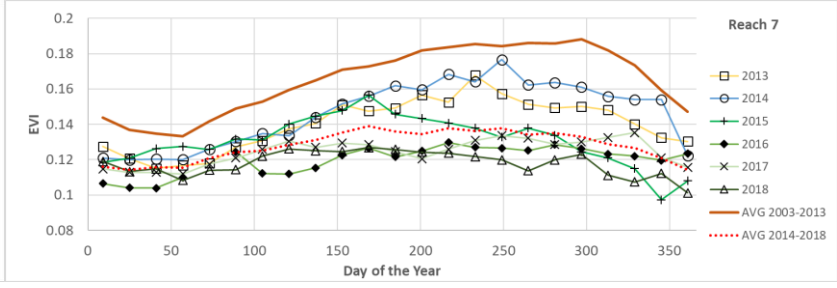

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Results (cont.)

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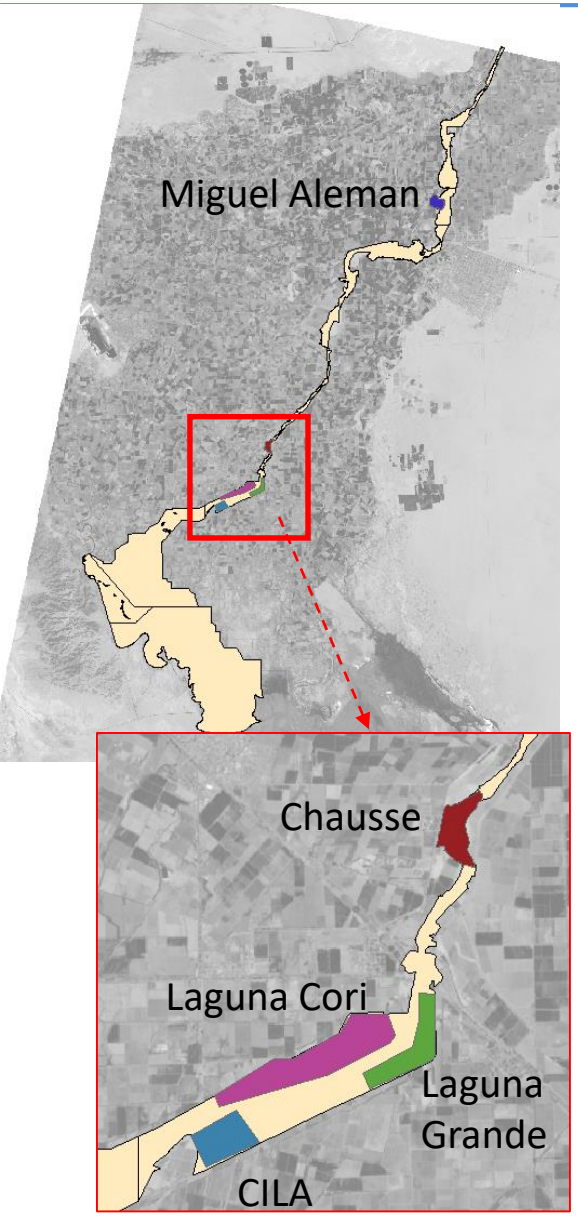
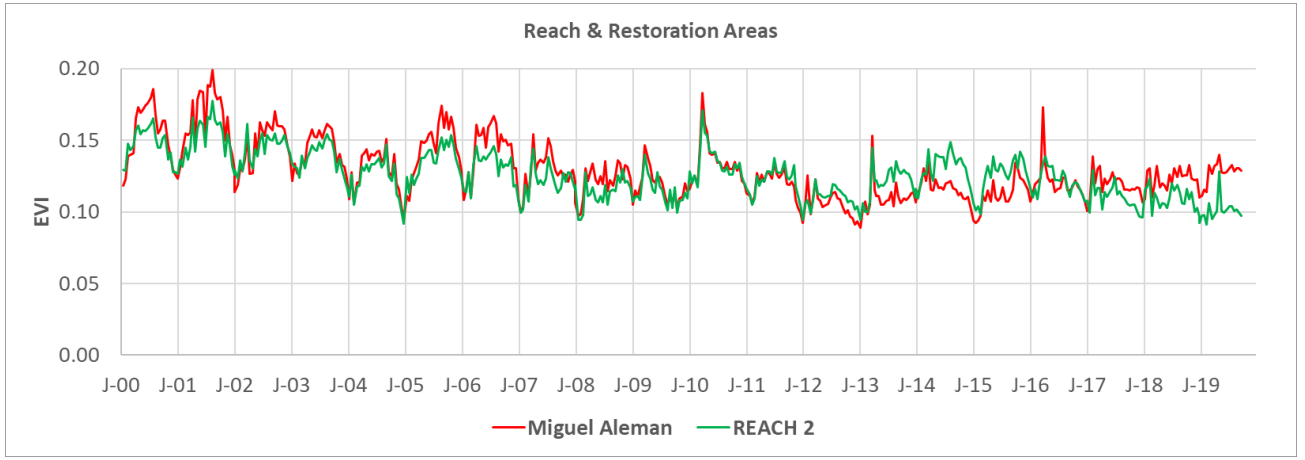
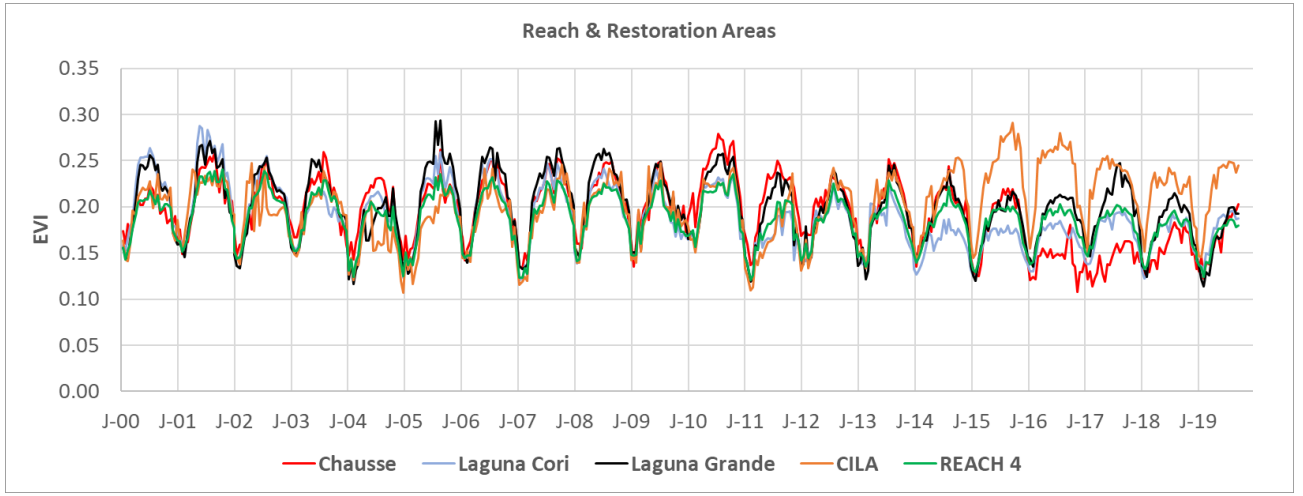


Active Restoration Areas along the Reaches





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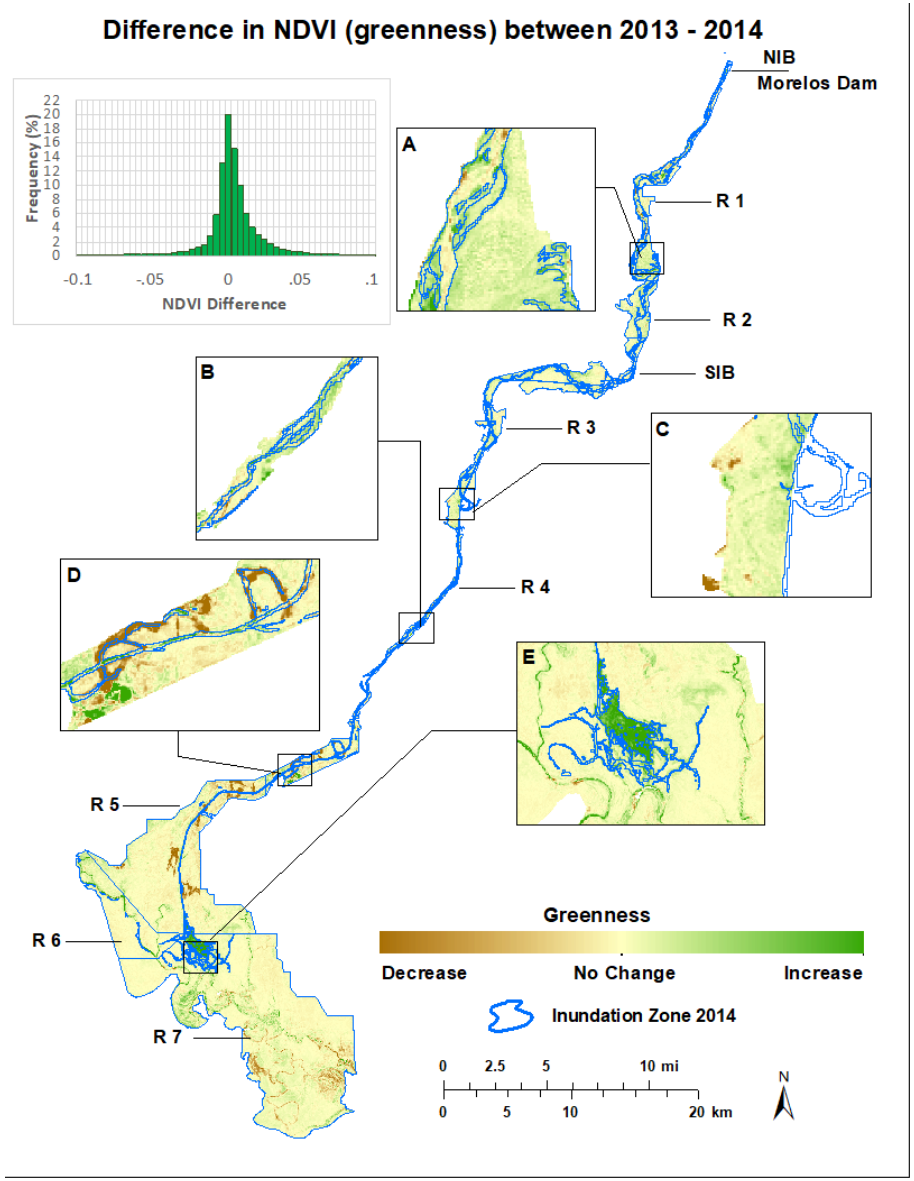

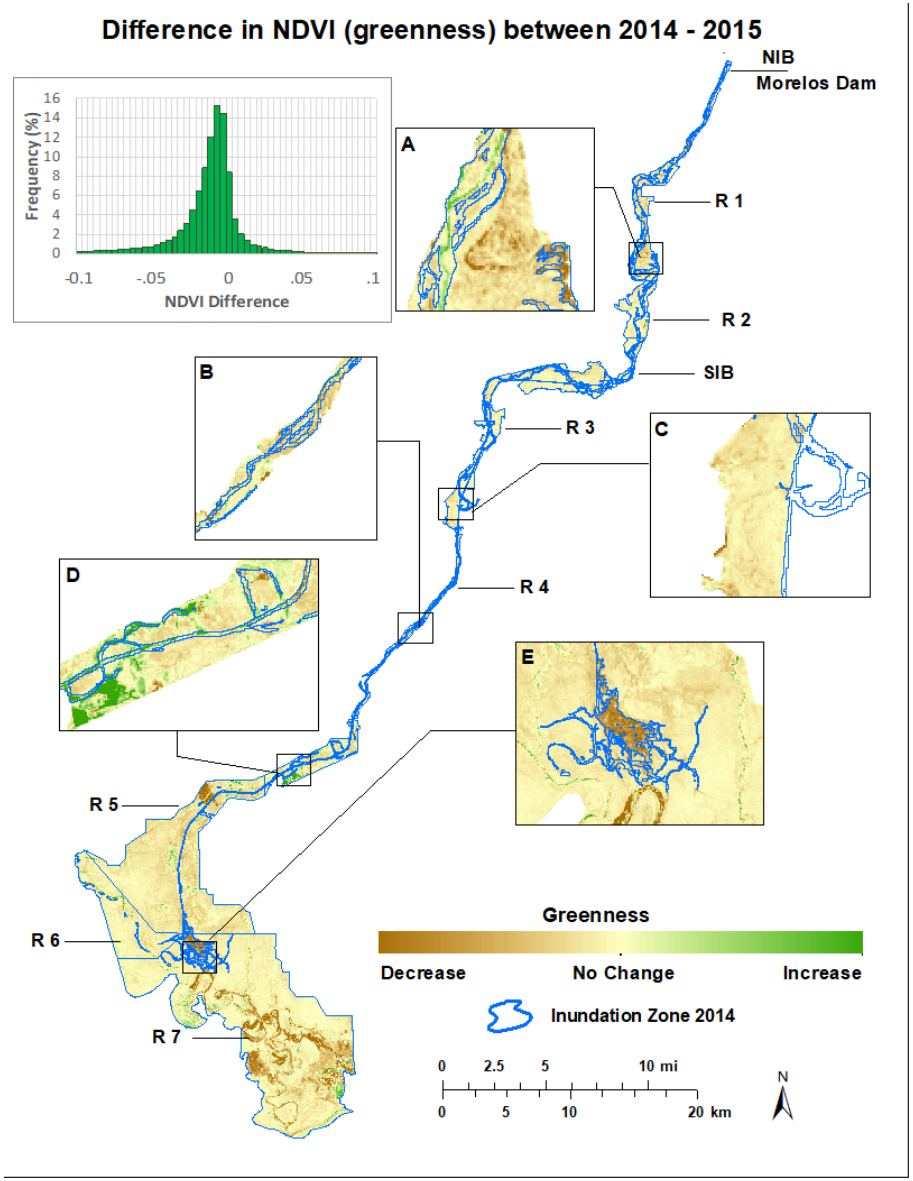

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Results (cont.)

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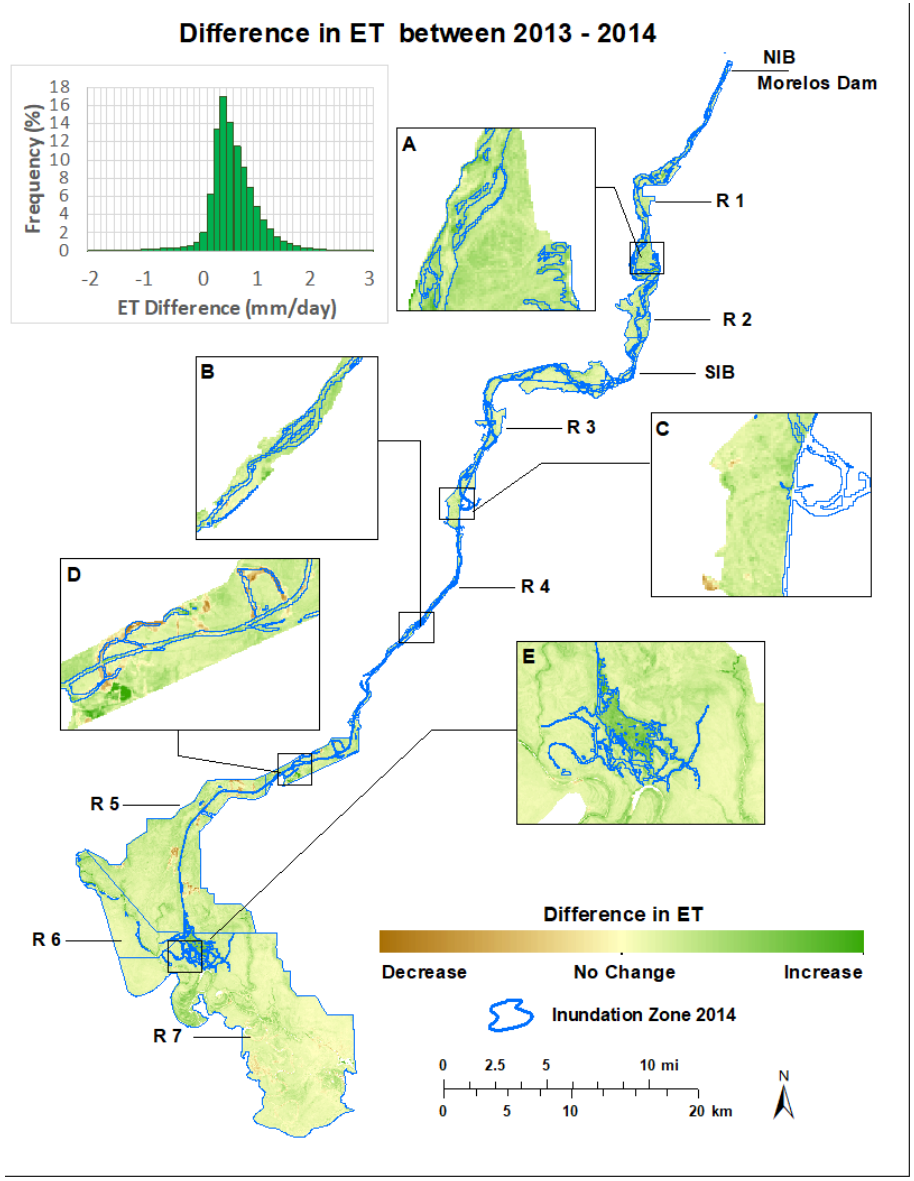

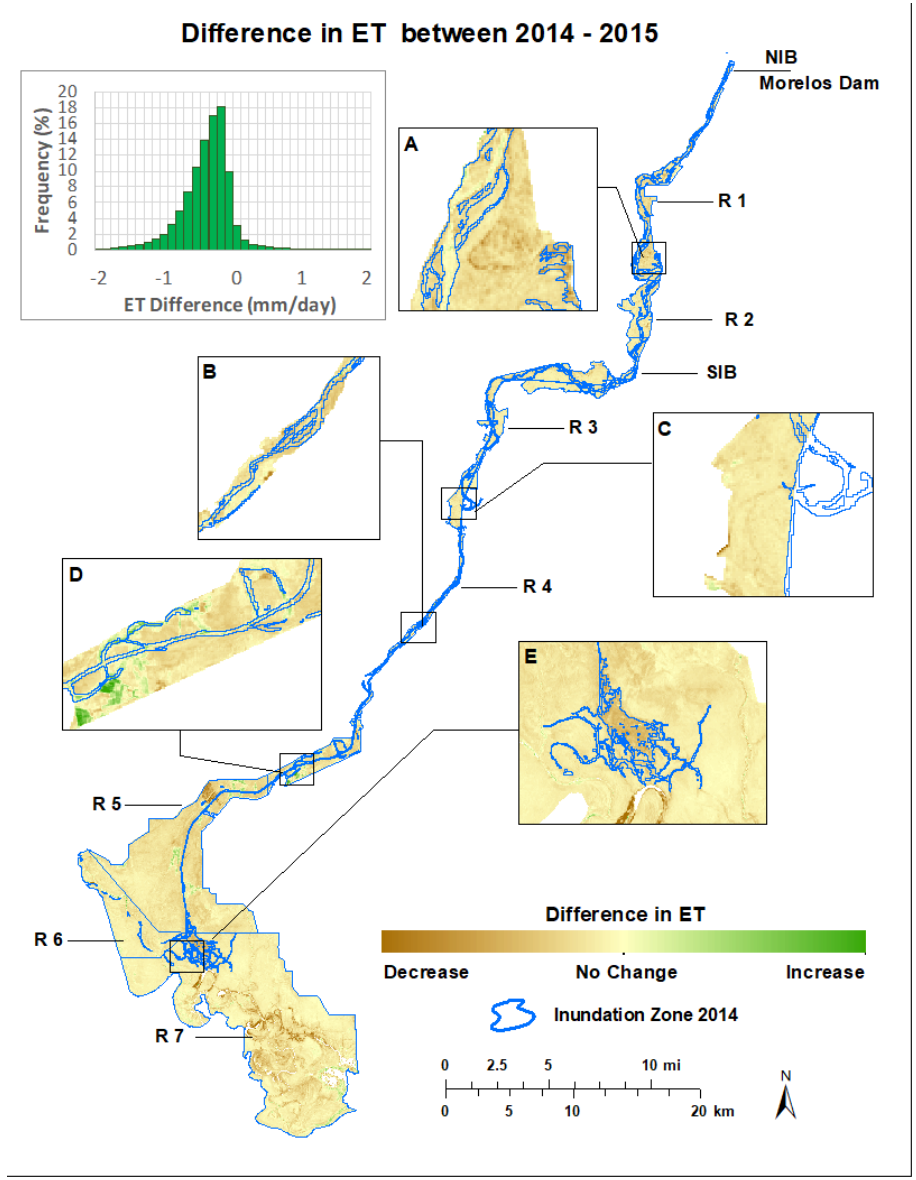

Platform Prototype

Design Considerations:

- RS data is demanding in terms of storage, specialized processing tools, and computing resources.
- At the VIPLab we have invested in developing a variety of online visualization and processing tools built around specific land cover and vegetation health change monitoring and analysis objectives (vip.arizona.edu)
- The goal is to free 'most' data users from the repetitive tasks of data preprocessing and basic manipulation, so they can focus on the science and analysis
  - The online system provides easy access to project specific data and tools and are modular enough to provide for improvement and repurposing and reuse
  - Most data used for these projects has undergone standard pre-processing
    - Time series
    - Spatial/Temporal resampling
    - QA filtering and required gap filling or continuity transformation
    - Value addition via Project specific Science Algorithms (like ET, Anomalies, Trends, etc.)

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Platform Architecture

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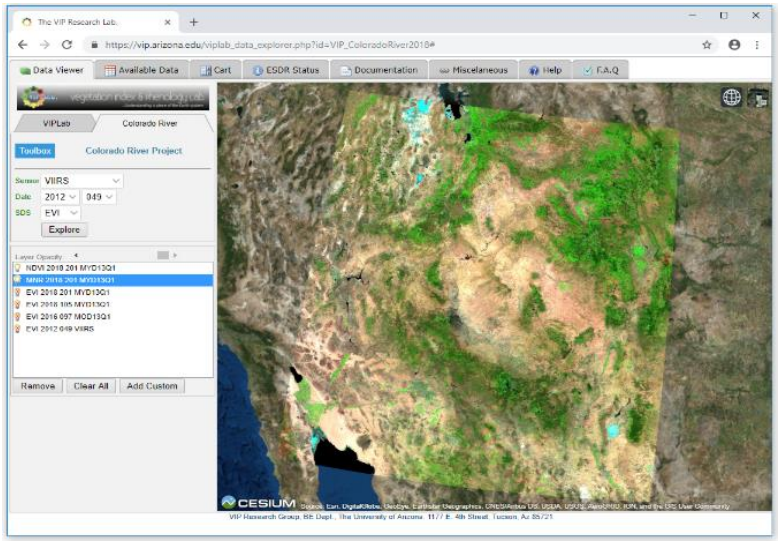
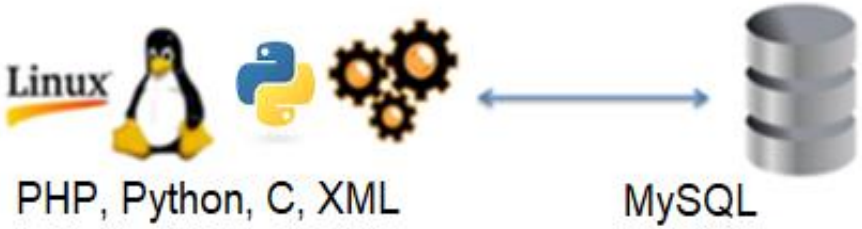
Client Side



A client side browser based application written in HTML, CSS and JavaScript

Server Side



These technologies provide the APIs to handle the user requests

- A client/server architecture provides an efficient design for accessibility and versatility through any device with a browser
- Heavy processing takes place at the server side
- Users do not need specialized software or high computing resources

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DataExplorer Interface

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Project tab

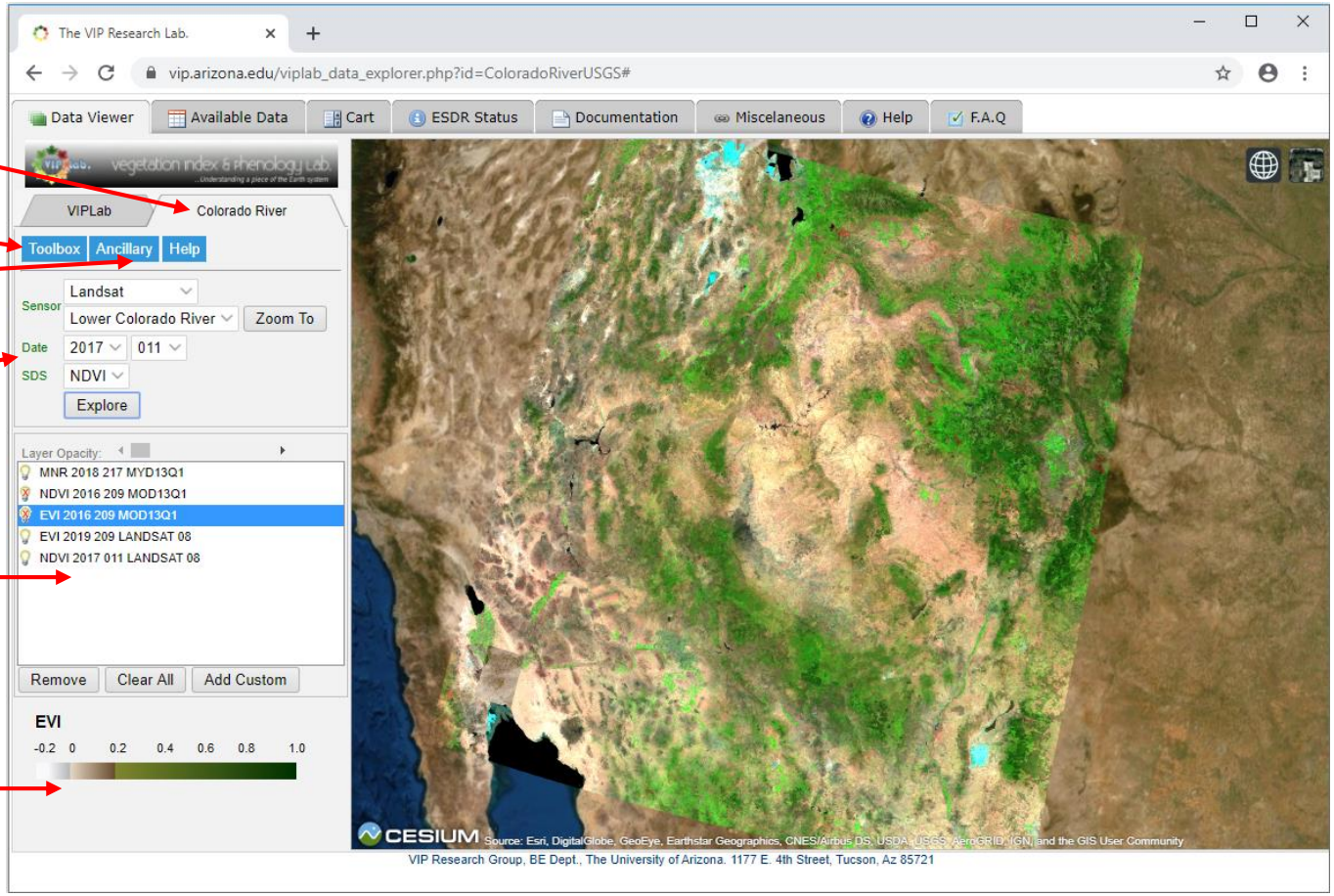
Toolbox

Ancillary

Dataset/Date selection

Layers manager

Legend

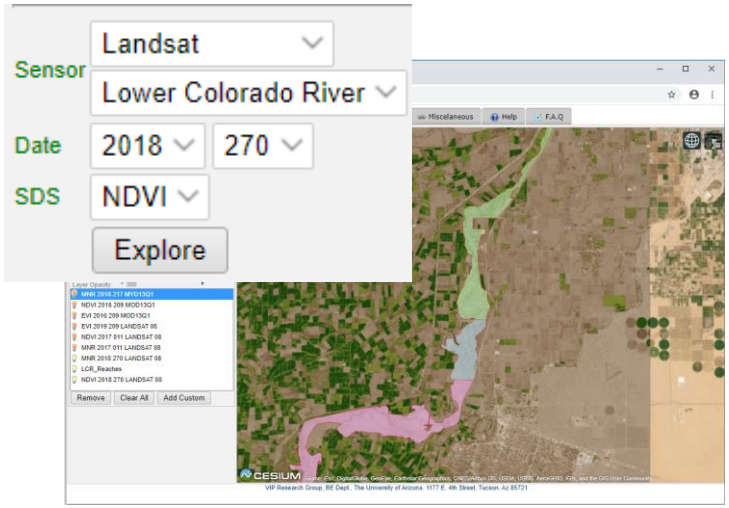


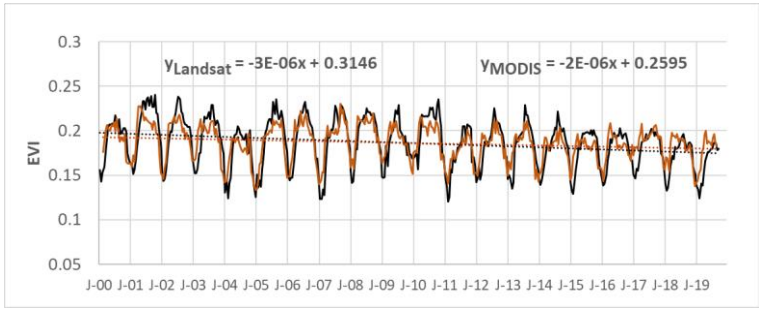
The main interface provides for the quick visualizing of any data in any of the areas of interest with additional controls for advanced and refined manipulation

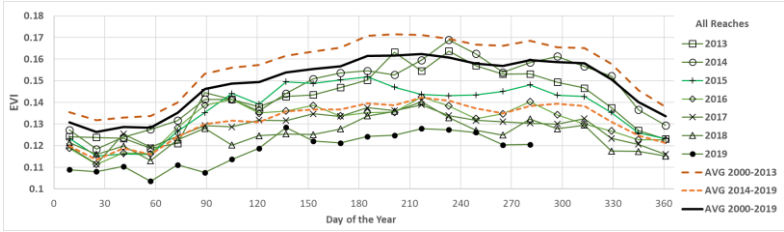
Visualization

There are two types of results

- **Spatial**
  - The dataset selector allows for a Sensor, Date and dataset to be displayed
  - Datasets can be overlapped (with transparency) to allow for refined interpretation of change and visual spatial correlation
  - Can display ET maps and the associated spatial anomalies
- **Time Series**:
  - The Database can be queried and can plot site specific time series
  - Timeseries can be generated for a point location (pixel), box of pixels, user defined mask (reaches, conservation plots).
  - The Time series output can further be processed into anomalies, trends, and yearly summary plots.
  - These functionalities are accessible via the Toolbox tab







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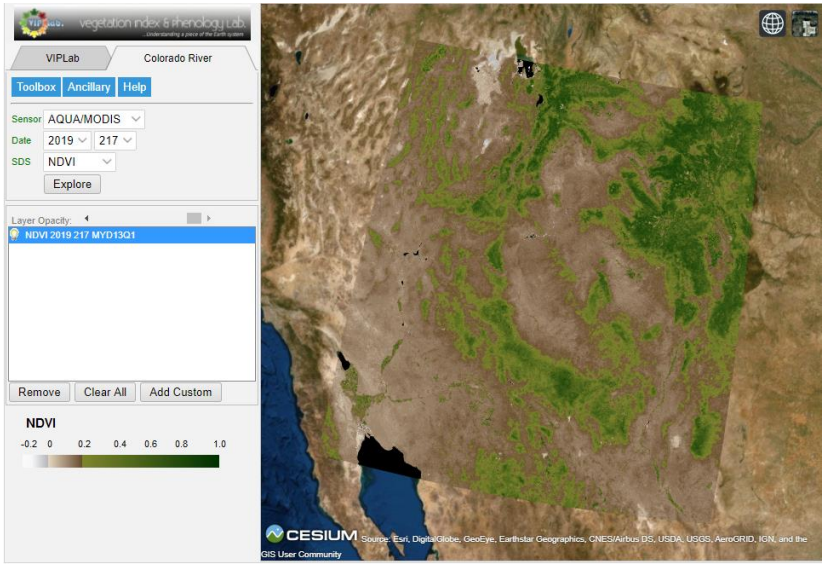
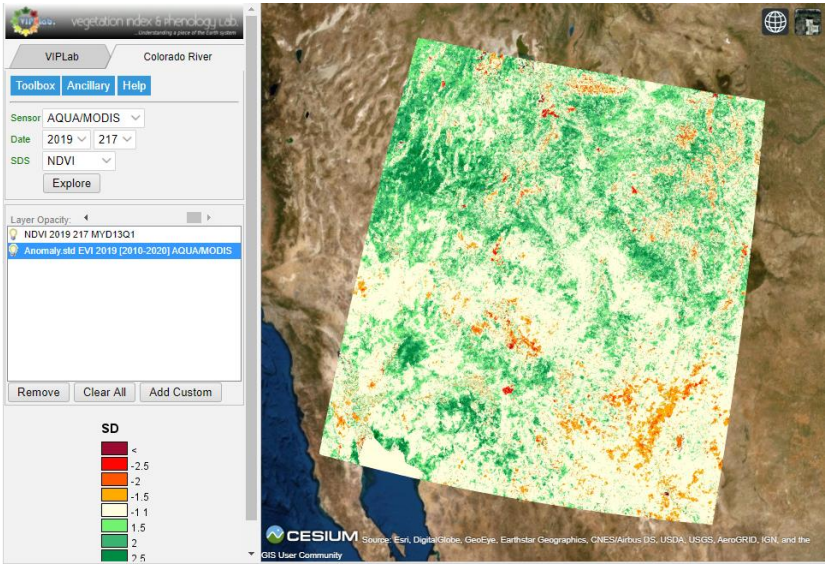
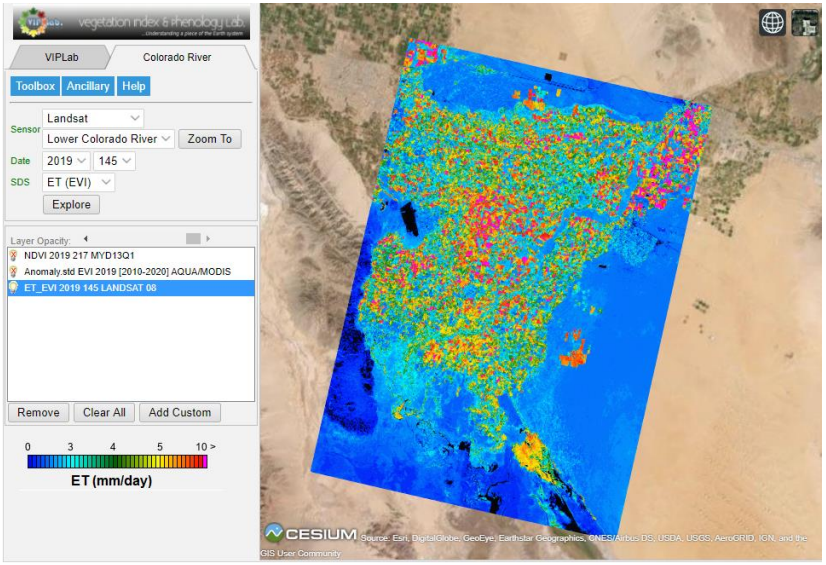
...Understanding a piece of the Earth system

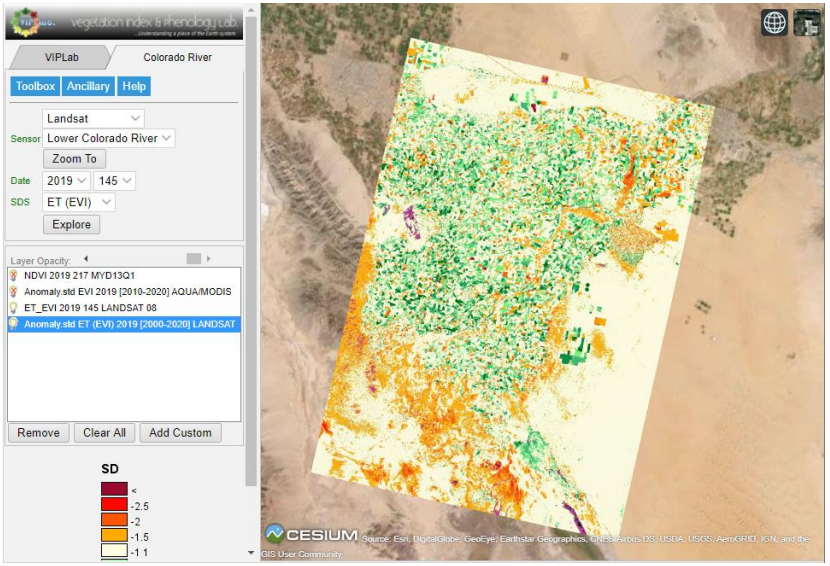
DataExplorer Spatial Visualization

RiversEdge West









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ToolBox

RiversEdge West

VIPLab | Colorado River

Toolbox | Ancillary | Help

- Anomalies
- TimeSeries by Reach
- TimeSeries by Pixel
- TimeSeries by Region
- TimeSeries Manager

Zoom To

Colorado River

Yearly Growing Season Anomalies

SDS NDVI | Year 2008 | From 2000-2010

LANDSAT | Lower Colorado River

Standardized Anomaly | Process | Close

Processing takes approximately 2 minutes to complete

2000-2020
- 2000-2020
- 2000-2010
- 2010-2020
- 2000-2005
- 2005-2010
- 2010-2015
- 2015-2020
- 2000-2013
- 2013-2020

Colorado River

Timeseries Extraction by Predefined Regions

Subset Lower Colorado River

Mask Riparian (Reaches)

Sensor LANDSAT | SDS ET (EVI)

Process | Close

Processing may take a few minutes to complete

Colorado River

Timeseries

Sensor LANDSAT | SDS NDVI | Pixel box 3x3

QA Filtering Remove Clouds and High Aerosols

Lat 32.569205 | Lon -114.865839

Back to Results | Process | Close | Test

1x1
- 1x1
- 3x3
- 5x5
- 7x7
- 9x9
- 11x11

All pixels / No filtering
- All pixels / No filtering
- Remove Clouds
- Remove Clouds and High Aerosols
- Remove Clouds, High and Average Aerosol
- Keep only Snow/Ice Pixels

Terra MODIS
- Terra MODIS
- Aqua MODIS
- VIIRS
- LANDSAT

NDVI
- NDVI
- EVI
- RED
- NIR
- BLUE
- MIR

TimeSeries VI

Add New TimeSeries Location:

- Click the Globe to add a Location

Cancel | Help

Colorado River

Timeseries by Region

Sensor LANDSAT | SDS EVI

QA Filtering Remove Clouds and High Aerosols

Region (lat,lon list) | Clear | Example | Get/View

32.38980988963613,-114.97446638649411
32.38881331953851,-114.97156960075803
32.388396568782554,-114.97135502403684
32.387200664633276,-114.97148377006955
32.38593226414277,-114.97313601082273
32.38643962647623,-114.97487408226438

TXT | KML | TIF Mask | Process

Processing may take a few minutes to complete (avg 6 mins)

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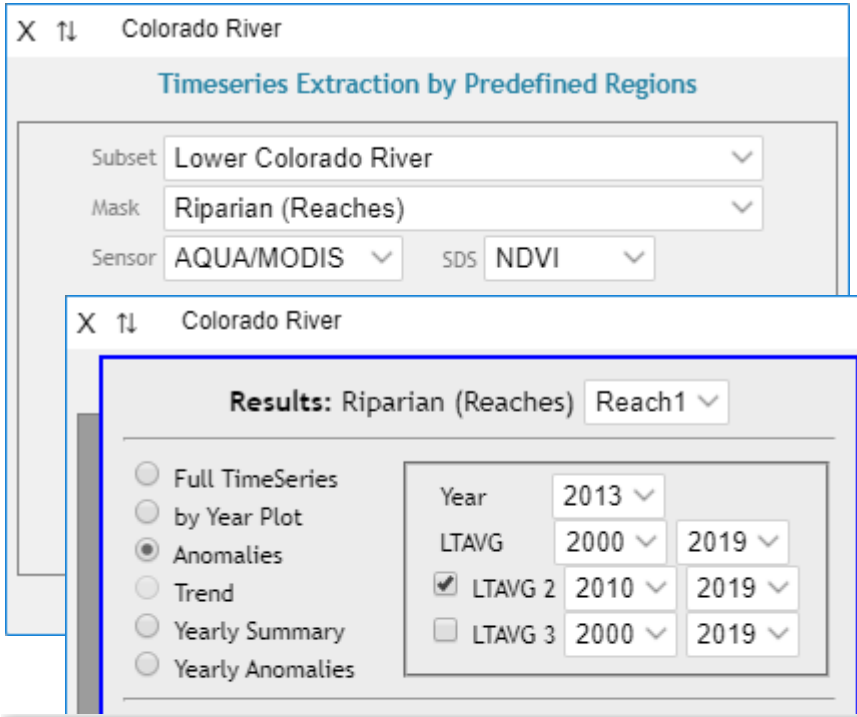
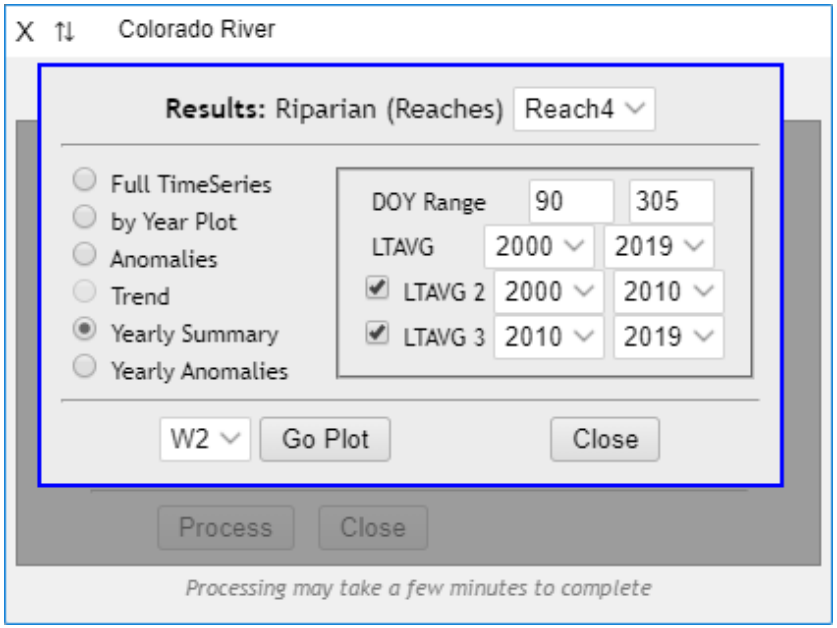
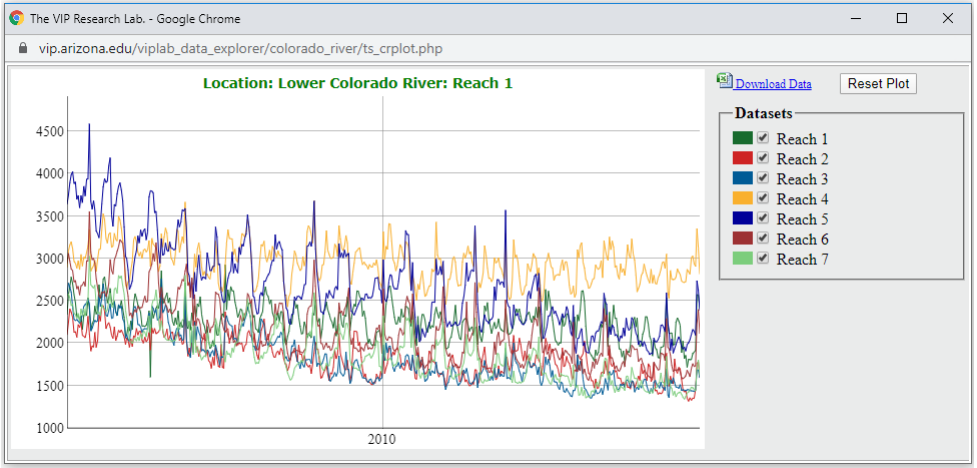
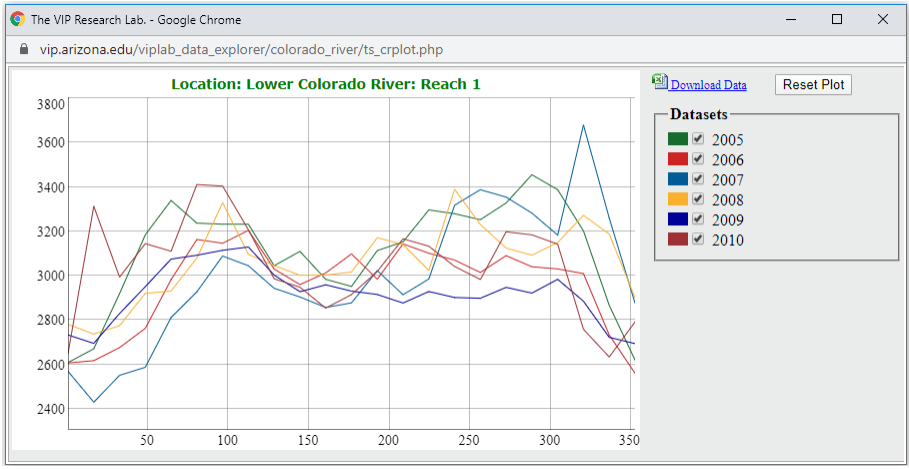
ToolBox

RiversEdge West









Future Enhancements

- The system is being expanded to cover all riparian corridors of the four corner states with focus on the lower Colorado river network
  - Including all restoration sites
- We are exploring the addition of high resolution sensors like:
  - Sentinel (10m)
  - World View (3m)
  - And opportunistic UAS/Drone and field data
- The system will be integrated with
  - Other open access online databases and ancillary data servers (USGS, US-NPN, etc.)
- Additional functionalities are planned
  - On demand user defined algorithms (simple equations and models)
  - Addition of ancillary Ecosystem related data

Conclusions

- Vegetation Indices are effective monitoring tools for restoration and can provide immediate proxies for many ecosystem data
- Data fusion from TM/OLI (fine resolution) and MODIS/VIIRS (more frequent observations) can provide an effective and scale dependent approach when addressing narrow riparian corridors like the river network of the US southwest.
- The presented cloud based prototype platform (DataExplorer) is designed to support easy access to data while providing a basic pre-preprocessing pipelines capable of provisioning data to most ecosystem researchers and minimizing resources and time investments.
- The system can visualize and run basic analysis which are meant to free users from the resource intensive tasks

Acknowledgements

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