

GRIME AI: Open-Source Software to Facilitate Ecohydrological Research and Education with Ground-Based Time-Lapse Imagery

Surface Water & Groundwater Monitoring Council Fall Meeting
October 21, 2025

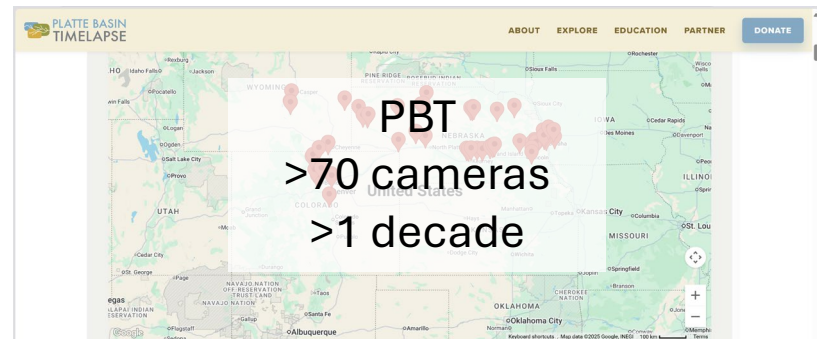
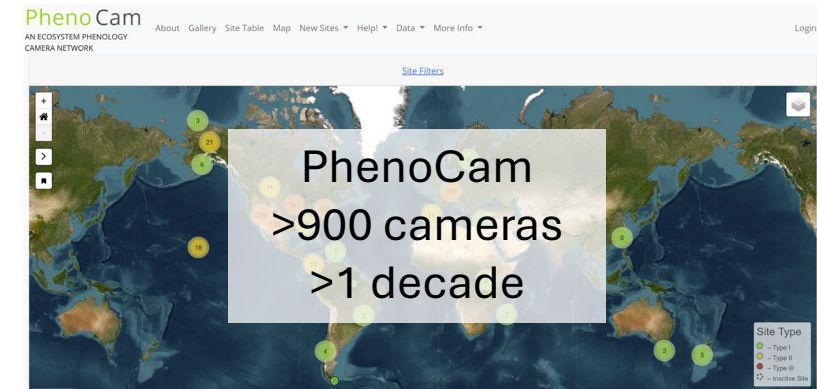
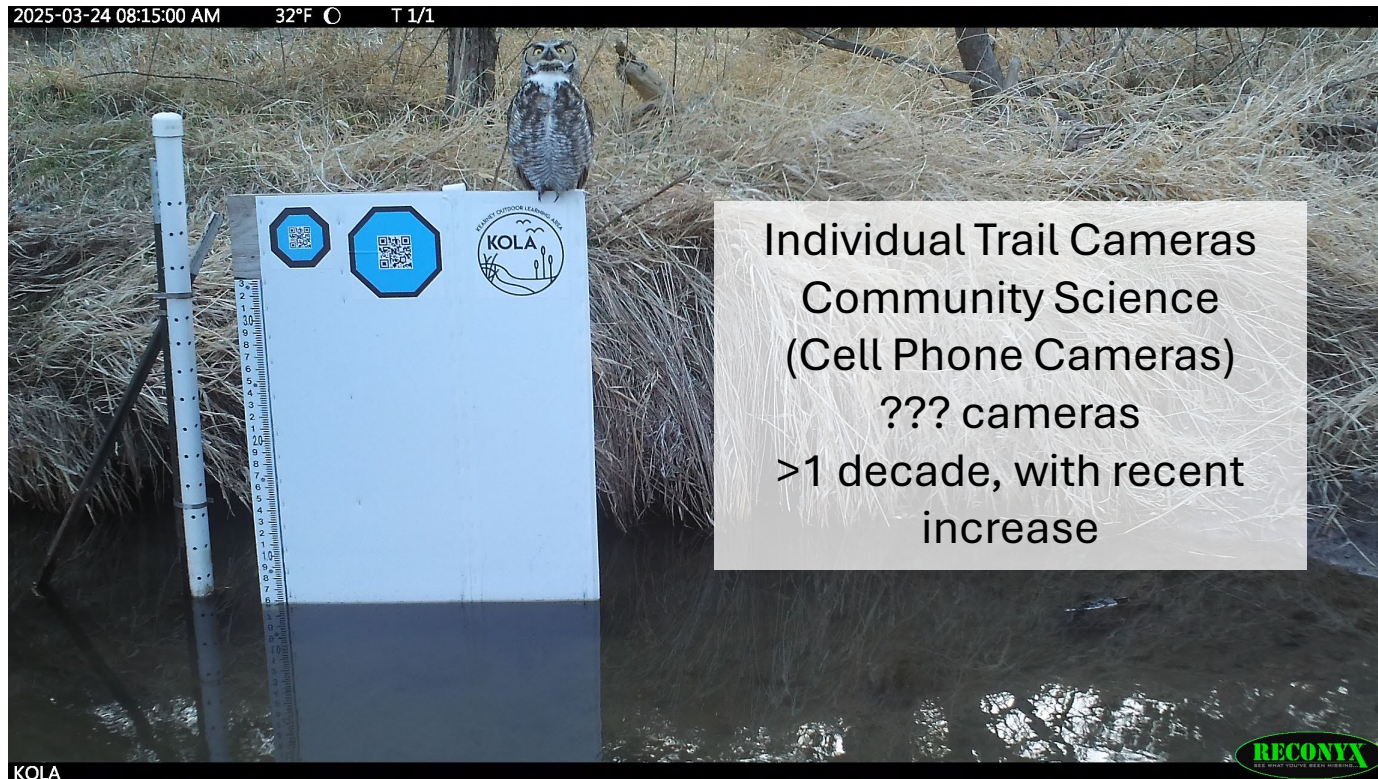
Troy Gilmore and GRIME Lab Team

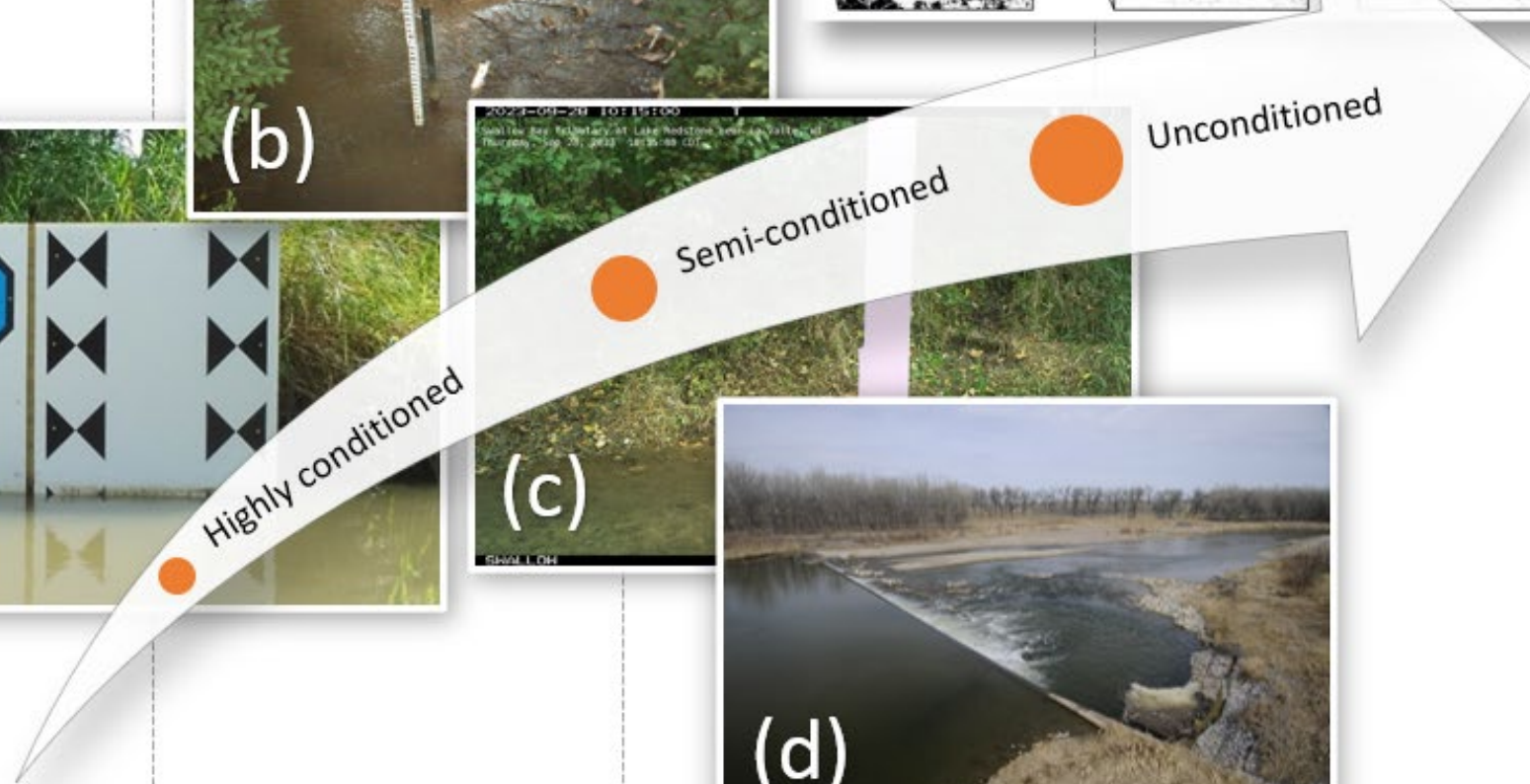
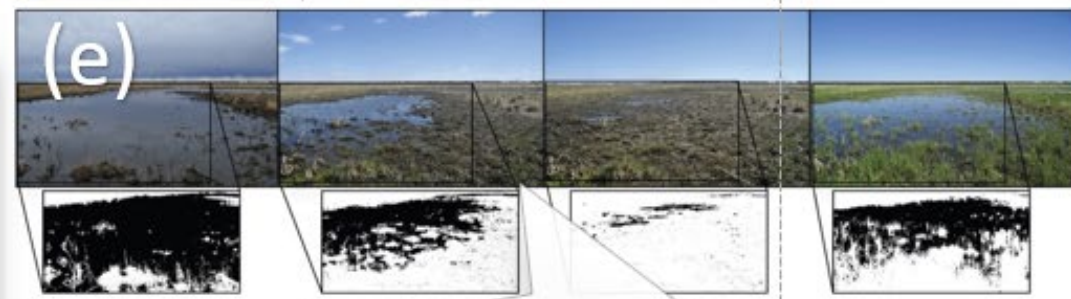
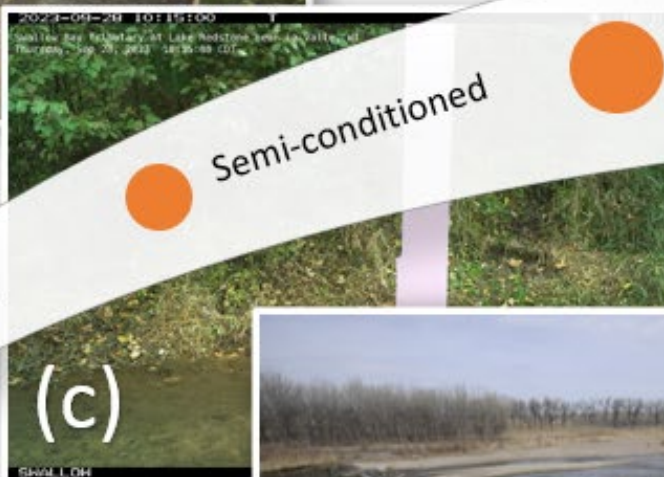


What?

GaugeCam **R**emote **I**mage **M**anager **E**ducational **A**rtificial
Intelligence (GRIME AI) is an **open-source, commercial-friendly**
Windows application (Linux for HPC) for science, education and
communication using ground-based time-lapse imagery and other
data.

Time-lapse Imagery for Environmental Monitoring





less flexible imagery, high precision, low multi-disciplinary expertise and/or computational requirements

flexible imagery, lower precision, high multi-disciplinary expertise and/or computational requirements

Why?

The unrealized potential of ground-based imagery is gaining recognition in ecohydrological research.

Major challenges exist in efficiently advancing scientific knowledge, science communication, and education using imagery.

Our goal is to encompass a diverse spectrum of users: researchers, educators, communicators.

How?

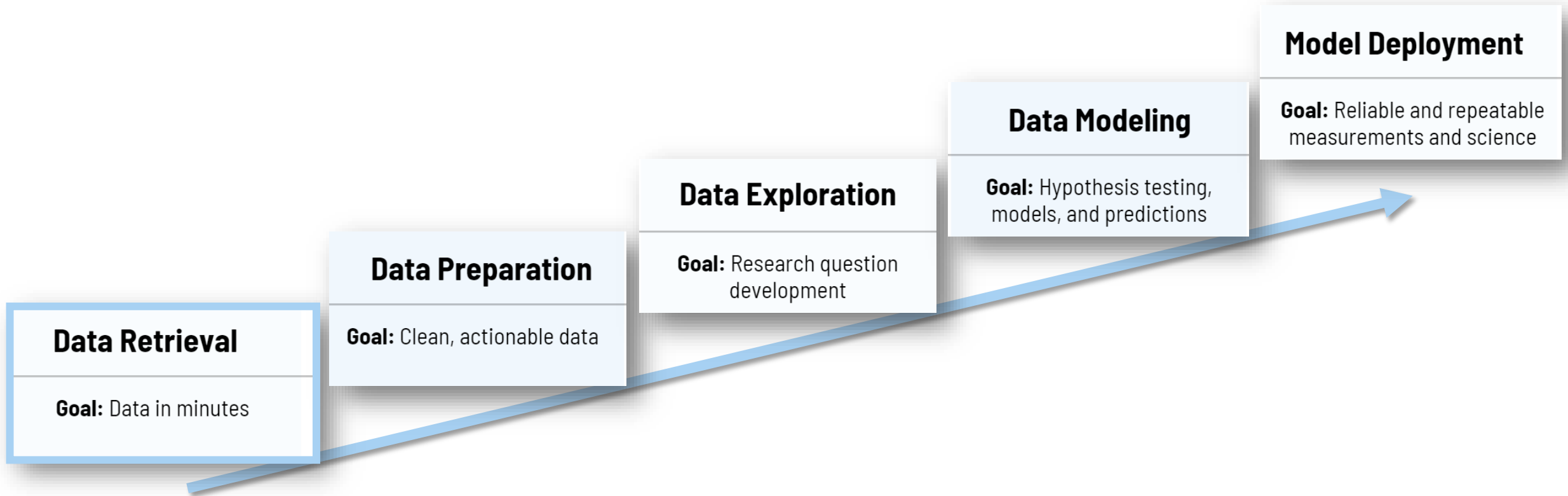
GRIME AI aims to **streamline workflows**,
from data retrieval to visualization and model deployment,
to empower scientists, educators in discovery and
to amplify creative ideas from multiple disciplines.



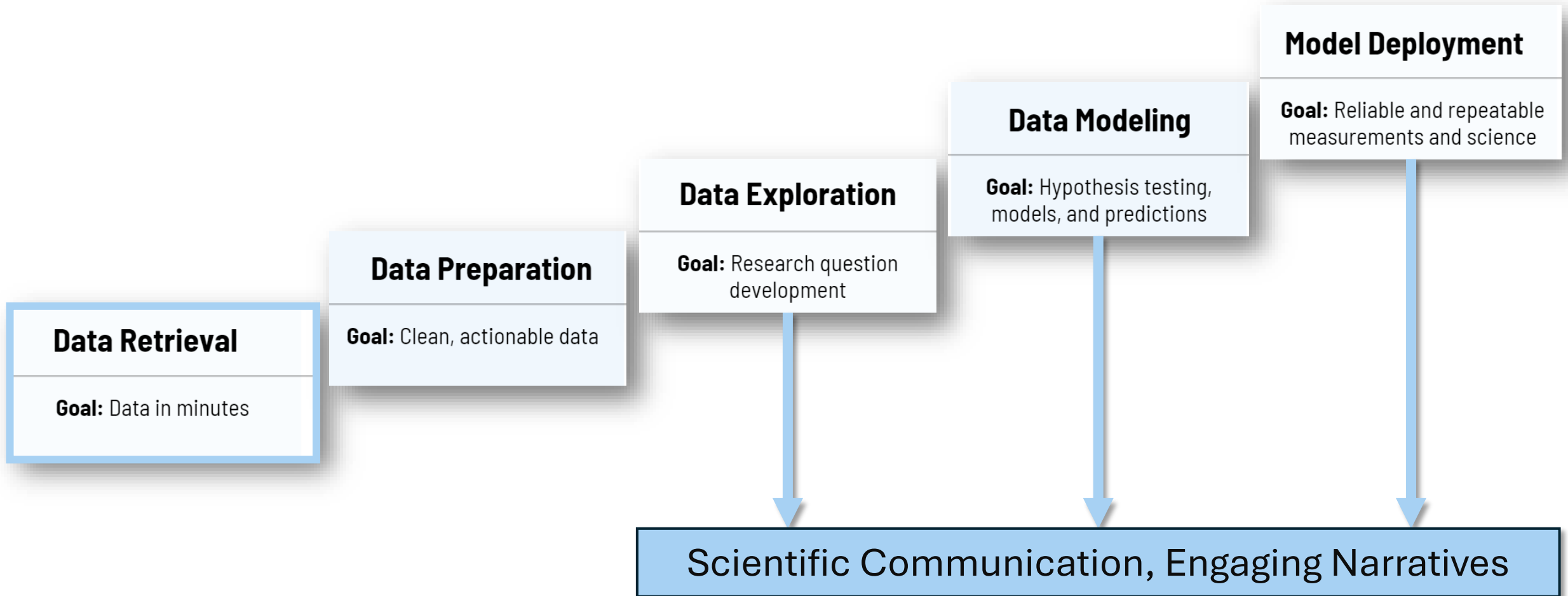
Conceptualization, Development, and Testing Team

- Jamila Bajelan – UNK – Communication
- Kenneth Chapman – UNL – Natural Resources/Industrial Machine Vision & Software Development
- Pavan Guggilla – UNL – Computer Science
- Jahir Udin – UNL – Computer Science
- Troy Gilmore – UNL – Engineering/Natural Resources
- Mary Harner – UNK – Biology/Communication
- Razin Issa – UNL – Computer Science/Natural Resources
- Keegan Johnson – USGS – Hydrology/Natural Resources
- Dawson Kosmicki – UNK – Biology
- Aaron Mittelstet – UNL – Engineering
- Mackenzie Smith – UNK – Biology
- John Stranzl – UNL – Natural Resources/Industrial Machine Vision & Software Development
- Chris Terry – UNK – Communication
- Maggie Wells – UNK – Communication

Workflow



Workflow



Data Retrieval

Goal: Data in minutes



GRIME-AI: John E. Stranzl Jr.

File Image Set Help

NEON Sites

NEON Download Manager

MT_East_Poplar_River_at_International_Boundary

MT_Yellowstone_River_at_Miles_City

NC_Briar_Creek_at_Providence_Road_at_Charlotte

NC_Briar_Creek_near_Charlotte

NC_French_Broad_River_at_Ashville

NC_French_Broad_River_near_Bent_Creek

NC_Lake_Johnson_above_Dam_at_Raleigh

NC_Little_Hope_Creek_at_Seneca_Place_at_Charlo

NC_Little_Sugar_Creek_at_Medical_Center_Dr_at_C

NC_McMullen_Creek_at_Lincrest_Place_at_Charlot

NC_PIGEON_R_BL_POWER_PLANT_NR_WATERVILL

NC_South_Buffalo_Creek_near_Pomona

NC_Walnut_Creek_at_South_State_Street_at_Raleig

ND_Missouri_River_at_Bismarck

NE_Elkhorn_River_at_Waterloo

NE_Elkhorn_River_at_West_Point

NE_Elkhorn_River_near_Winslow

NE_Kearney_Outdoor_Learning_Area

NE_Kearney_Outdoor_Learning_Area_RISE

NE_Platte_River_above_Loup_Power_Canal_near_C

NE_Platte_River_at_North_Bend

NE_Platte_River_near_Ashland

NE_Platte_River_near_Duncan

NE_Platte_River_near_Fremont

NE_Platte_River_near_Grand_Island

NE_Platte_River_near_Leshara

NE_Platte_River_near_Overton

NE_Platte_River_near_Schuyler

NJ_Delaware_River_at_Trenton

NJ_Spruce_Run_Res_3075_ft_NW_of_dam_at_Clint

NM_Gavilan_Canyon_at_Skunk_Canyon_near_Holl

NM_Pecos_River_near_Acme

NM_Pecos_Web_Camera_near_Roswell

NM_Rio_Grande_below_Elephant_Butte_Dam

NM_Storrie_Lake_Diversion_near_Montezuma

NY_Callicoon_Creek_at_Callicoon

NY_Diversion_From_Schoharie_Reservoir

NY_Dry_Brook_at_Arkwille

NY_East_Meadow_Brook_at_Freepo

NY_Keshequa_Creek_UPSTREAM_WEIR

NY_Keshequa_Creek_at_Craig_Colony_at_Sonyea

overlayDir: https://usgs-nims-images.s3.amazonaws.com/overlay/NE_Kearney_Outdoor_Learning_Area_RISE/

thumbDir: https://usgs-nims-images.s3.amazonaws.com/thumbnail/NE_Kearney_Outdoor_Learning_Area_RISE/

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locus: aws

smallDir: https://usgs-nims-images.s3.amazonaws.com/720/NE_Kearney_Outdoor_Learning_Area_RISE/

FRP: UMid

createdDate: 2023-09-14T17:53:02.458Z

Ing: -99.119951

tz: US/Central

modifiedDate: 2023-09-14T17:53:02.458Z

camName: Kearney Outdoor Learning Area RISE

camDesc: Kearney Outdoor Learning Area (KOLA) in Kearney NE - RISE camera with Raspberry Pi.

nwisId: 44444444

stateAbvr: NE

newestImagedT: 2024-04-05T18:45:02.000Z

camId: NE_Kearney_Outdoor_Learning_Area_RISE

lat: 40.677026

USGS science for a changing world

Data Retrieval

Goal: Data in minutes

PhenoCam Imagery

NEON Sites

- ABBY - Abby Road NEON
- ARIK - Arikaree River NEON
- BARC - Lake Barco NEON
- BARR - UtqiaĀvik NEON
- BART - Bartlett Experimental Forest NEON
- BIGC - Upper Big Creek NEON
- BLAN - Blandy Experimental Farm NEON
- BLDE - Blacktail Deer Creek NEON
- BLUE - Blue River NEON
- BLWA - Black Warrior River NEON
- BONA - Caribou-Poker Creeks Research Watershed NEON
- CARI - Caribou Creek NEON
- CLBJ - Lyndon B. Johnson National Grassland NEON
- COMO - Como Creek NEON
- CPER - Central Plains Experimental Range NEON
- CRAM - Crampton Lake NEON
- CUPE - Rio Cupeyes NEON
- DCFS - Dakota Coteau Field Site NEON
- DEJU - Delta Junction NEON
- DELA - Dead Lake NEON
- DSNY - Disney Wilderness Preserve NEON
- FLNT - Flint River NEON
- GRSM - Great Smoky Mountains National Park NEON
- GUAN - Guanica Forest NEON
- GUIL - Rio Yahuecas NEON
- HARV - Harvard Forest & Quabbin Watershed NEON
- HEAL - Healy NEON
- HOPB - Lower Hop Brook NEON
- JERC - The Jones Center At Ichauway NEON
- JORN - Jornada Experimental Range NEON
- KING - Kings Creek NEON
- KONA - Konza Prairie Agroecosystem NEON
- KONZ - Konza Prairie Biological Station NEON
- LAJA - Lajas Experimental Station NEON
- LECO - LeConte Creek NEON
- LENO - Lenoir Landing NEON
- LEWI - Lewis Run NEON
- LIRO - Little Rock Lake NEON
- MART - Martha Creek NEON
- MAYF - Mayfield Creek NEON

BARC

siteCode: BARC
siteName: Lake Barco NEON
siteDescription: Lake Barco NEON
siteType: CORE
siteLatitude: 29.675982
siteLongitude: -82.008414
stateCode: FL
stateName: Florida
domainCode: D03
domainName: Southeast
deimslid: https://deims.org/fc3606ae-df89-4e21-96df-cc380bb0d89d
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Latest Site Image



NEON Data Products

NEON Site Products

- DP1.00001.001: 2D wind speed and direction
- DP1.00002.001: Single aspirated air temperature
- DP1.00004.001: Barometric pressure
- DP1.00023.001: Shortwave and longwave radiation (net radiometer)
- DP1.00024.001: Photosynthetically active radiation (PAR)
- DP1.00098.001: Relative humidity
- DP1.10111.001: Site management and event reporting
- DP1.20002.001: Land-water interface images
- DP1.20004.001: Barometric pressure above water on-buoy
- DP1.20015.001: Specific conductivity in groundwater
- DP1.20016.001: Elevation of surface water
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- DP1.20046.001: Air temperature above water on-buoy
- DP1.20059.001: Windspeed and direction above water on-buoy
- DP1.20063.001: Aquatic plant bryophyte chemical properties
- DP1.20066.001: Aquatic plant bryophyte macroalgae clip harvest
- DP1.20092.001: Chemical properties of groundwater
- DP1.20093.001: Chemical properties of surface water
- DP1.20097.001: Dissolved gases in surface water
- DP1.20100.001: Elevation of groundwater
- DP1.20120.001: Macroinvertebrate collection
- DP1.20126.001: Macroinvertebrate metabarcoding
- DP1.20138.001: Surface water microbe cell count
- DP1.20141.001: Surface water microbe community composition
- DP1.20163.001: Periphyton, seston, and phytoplankton chemical properties
- DP1.20166.001: Periphyton, seston, and phytoplankton collection
- DP1.20194.001: Sediment chemical and physical properties
- DP1.20206.001: Stable isotopes in surface water
- DP1.20217.001: Temperature of groundwater
- DP1.20219.001: Zooplankton collection
- DP1.20221.001: Zooplankton metabarcoding
- DP1.20252.001: Secchi depth
- DP1.20254.001: Depth profile at specific depths
- DP1.20261.001: Photosynthetically active radiation below water surface
- DP1.20264.001: Temperature at specific depth in surface water
- DP1.20267.001: Gauge height
- DP1.20271.001: Relative humidity above water on-buoy
- DP1.20275.001: Riparian composition and structure

Data Retrieval

Goal: Data in minutes

Time Period Selection and Download

GRIMe-AI: John E. Stranzl Jr.

FileImage SetHelp

NEON Sites

NEON Download Manager

USGS Sites

USGS Download Manager

Image Analysis

Sensor Data Graphs

Google Maps (Provisional)

UniquImages are not filtered by tim

	Site	Image Count	min Date	max Date	Start Date	End Date	Start Time	End Time
1	DP1.20002.001: Land-water interface images		1/1/1970	1/1/1970	4/18/2024	4/18/2024	00:00	00:00
2	DP1.20033.001: Nitrate in surface water		1/1/1970	1/1/1970	4/18/2024	4/18/2024	00:00	00:00
3	DP1.20100.001: Elevation of groundwater		1/1/1970	1/1/1970	4/18/2024	4/18/2024	00:00	00:00

Output Folders

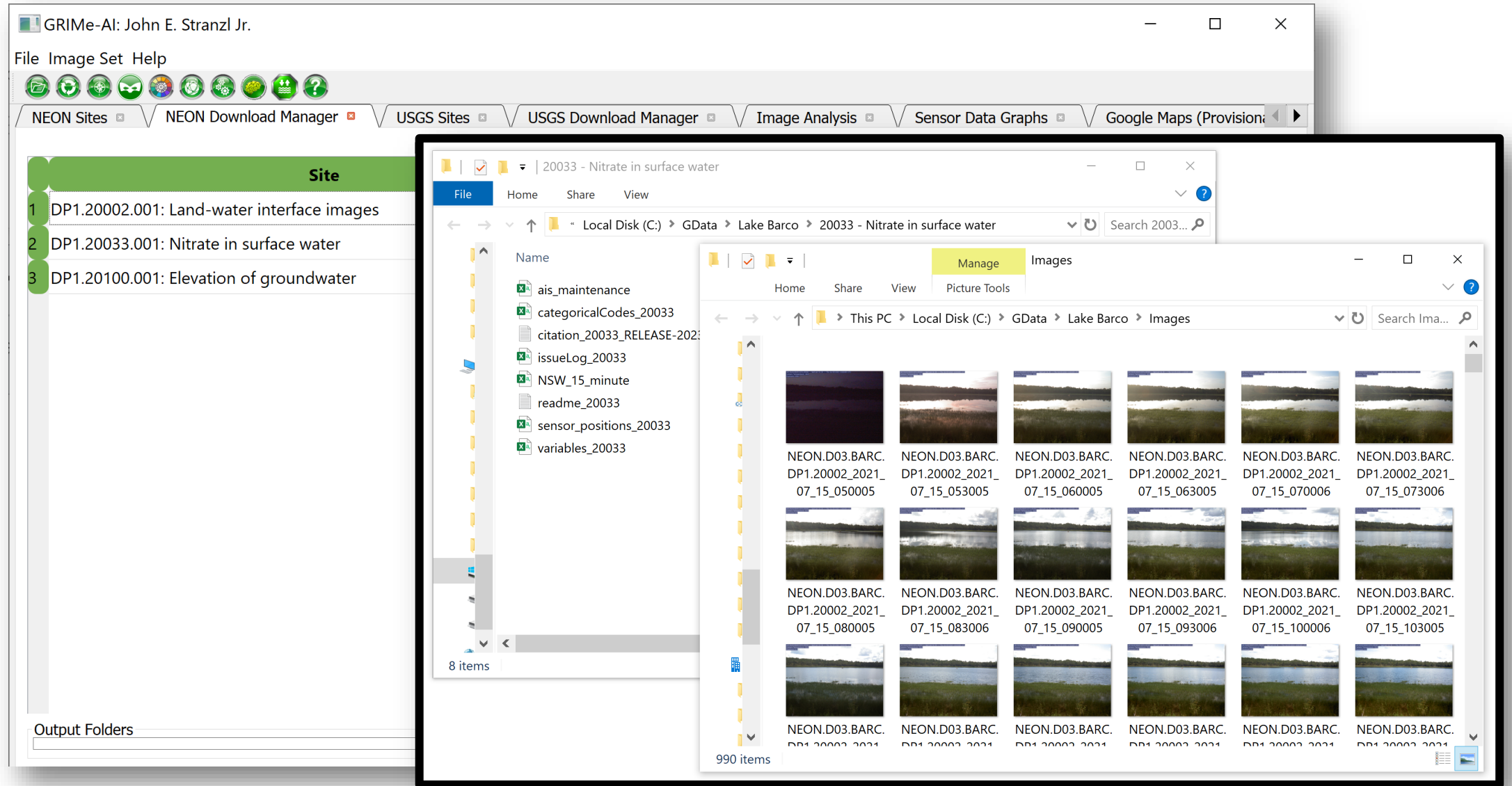
Browse

Download

Data Retrieval

Goal: Data in minutes

Select time period and download



Workflow



Data Preparation

Goal: Clean, actionable data

Triage imagery datasets

The image shows a software dialog box titled 'Triage Options' with a dotted grid background. It contains several sections for configuring image triage:

- Triage Options:** A list of four checkboxes:
 - ☒ Generate Report
 - ☐ Move Bad Images
 - ☐ Save Polyline
 - ☐ Affine Transformation
- Image Transformation:** A section containing a button labeled 'Select Reference Image' and a 'Rotation Threshold' set to 0.25 with a spinner control.
- Blur:** A section with two settings:
 - 'Threshold' set to 17.50 with a spinner control.
 - 'Shift Size' set to 60 with a spinner control.
- Brightness:** A section with two settings:
 - 'min' set to 65.00 with a spinner control.
 - 'MAX' set to 180.00 with a spinner control.

At the bottom of the dialog are two buttons: 'OK' and 'Cancel'.

Data Preparation

Goal: Clean, actionable data

Data Preparation

Goal: Clean, actionable data

The image displays a file explorer window titled "GData > Walker Branch > DEMO". It shows a grid of 100 small image thumbnails arranged in 10 rows and 10 columns. Each thumbnail is labeled with a file name, such as "NEON.D07.WALK.DP1.20002_2022_11_19_063006". A red dashed arrow originates from the top-left corner of the grid and points towards the bottom-right corner, indicating the movement of low-information images. The bottom-right corner of the grid shows a smaller grid of images, labeled "NEON.D07.WALK.DP1.20002_2022_11_19_063006".

GData > Walker Branch > MovedImages

NEON.D07.WALK
_DP1.20002_2022
_11_19_063006

NEON.D07.WALK
_DP1.20002_2022
_11_19_070006

NEON.D07.WALK
_DP1.20002_2022
_11_19_180005

NEON.D07.WALK
_DP1.20002_2022
_11_20_063006

NEON.D07.WALK
_DP1.20002_2022
_11_20_070005

NEON.D07.WALK
_DP1.20002_2022
_11_20_180006

NEON.D07.WALK
_DP1.20002_2022
_11_21_063006

NEON.D07.WALK
_DP1.20002_2022
_11_21_070005

GData > Walker Branch > MovedImages

NEON.D07.WALK
_DP1.20002_2022
_11_19_063006

NEON.D07.WALK
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_11_19_070006

NEON.D07.WALK
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GData > Walker Branch > MovedImages

NEON.D07.WALK
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NEON.D07.WALK
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NEON.D07.WALK
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_11_21_070005

Workflow



Image feature extraction

GRIMe-AI: John E. Stranzl Jr.

File Image Set Help

NEON Sites NEON Download Manager USGS Sites USGS Download Manager Image Analysis Sensor Data Graphs Google Maps (Provisional)

*Double click to enlarge

Pecos River near Acme, NM
Sunday, Oct 9, 2022 12:38:02 MDT

sky1

veg2

water1

veg1

water2

Select Features

Define ROI

Name: veg2 Color Clusters: 4 Add

Shape: ☐ Rectangle ☐ Ellipse

☒ Display ROIs ☒ Display ROI Colors

Delete All ROIs

Feature Calculations

Region Select

☐ Whole Image ☒ ROI

Feature Select

☒ Shannon Entropy ☒ Intensity ☒ Color (HSV) ☐ Texture

Greenness

☒ GCC (Greenness Index) ☐ GLI (Green Leaf Index) ☐ ExG (Excess Green Index) ☐ RGI (Red-Green Index) ☐ NDVI (Norm. Dif. Veg. Index)

Build Feature File

ROI Name Ref. Image Cur. Image Greenness Intensity Entr

Whole Image			---	---	---
water1			0.3080	138.8904	
water2			0.3042	100.7123	
sky1			0.3171	197.8404	
veg1			0.3335	69.0366	
veg2			0.3404	65.1201	

Image Navigation

Image Index: 1201 Reset Index

Play STOP

Images Retrieved: 12766 Close

GRIMe-AI

0.7%

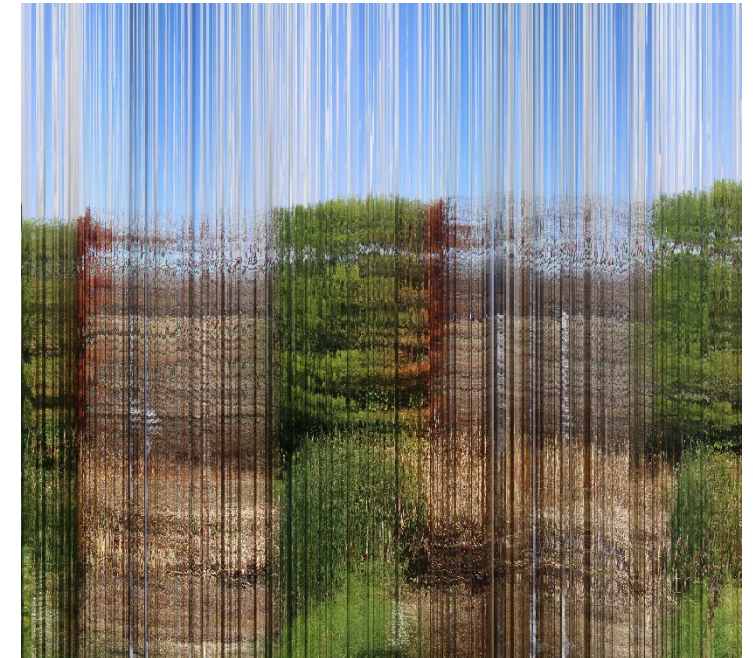
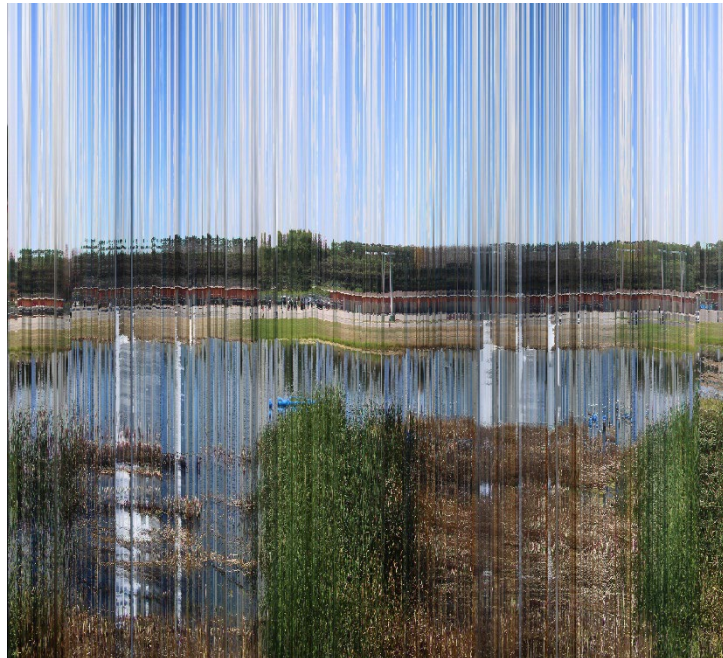
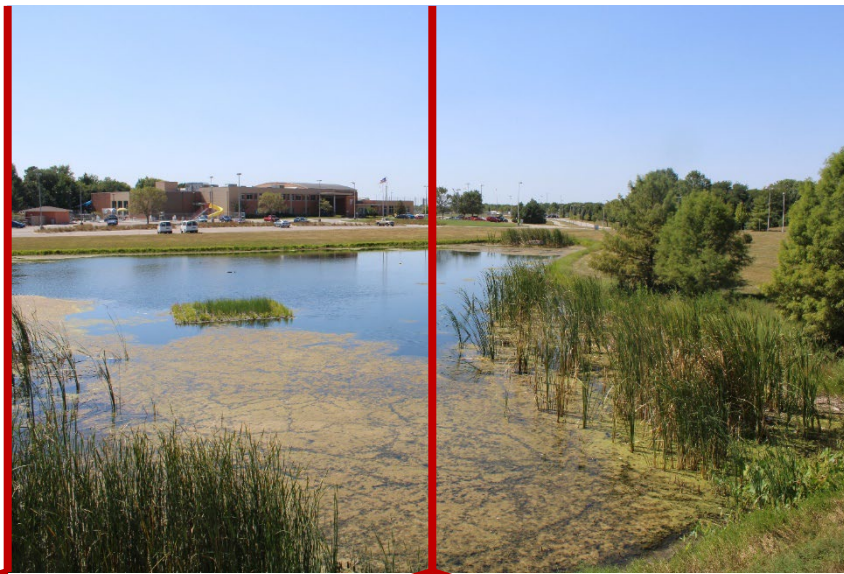
Imagery source:

USGS
science for a changing world

Data Exploration

Goal: Research question development

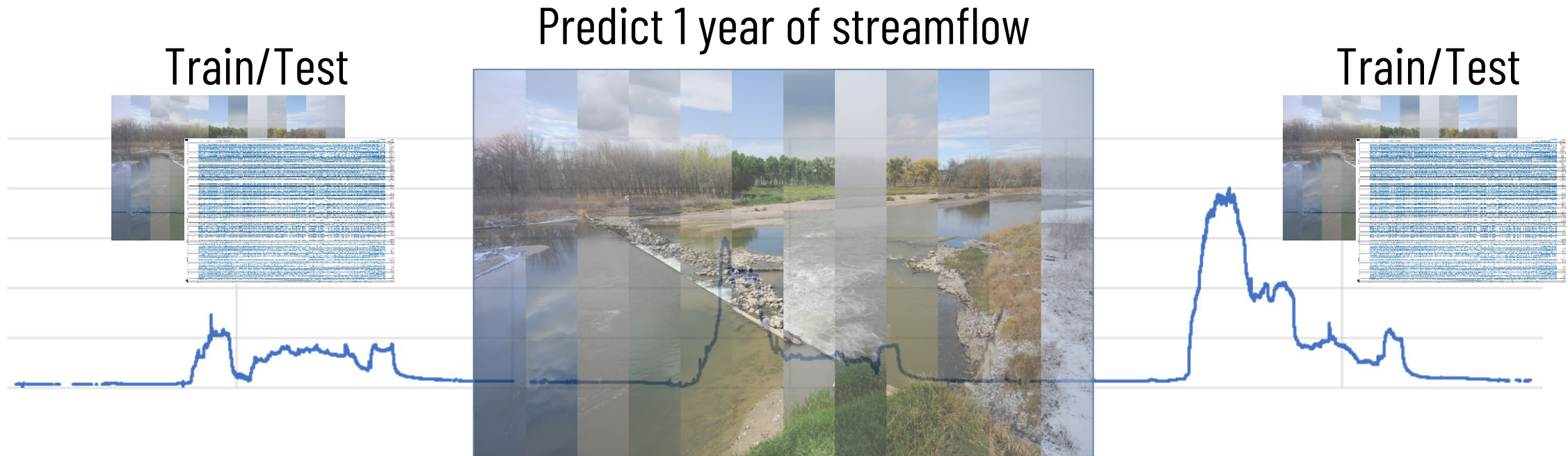
Imagery source:



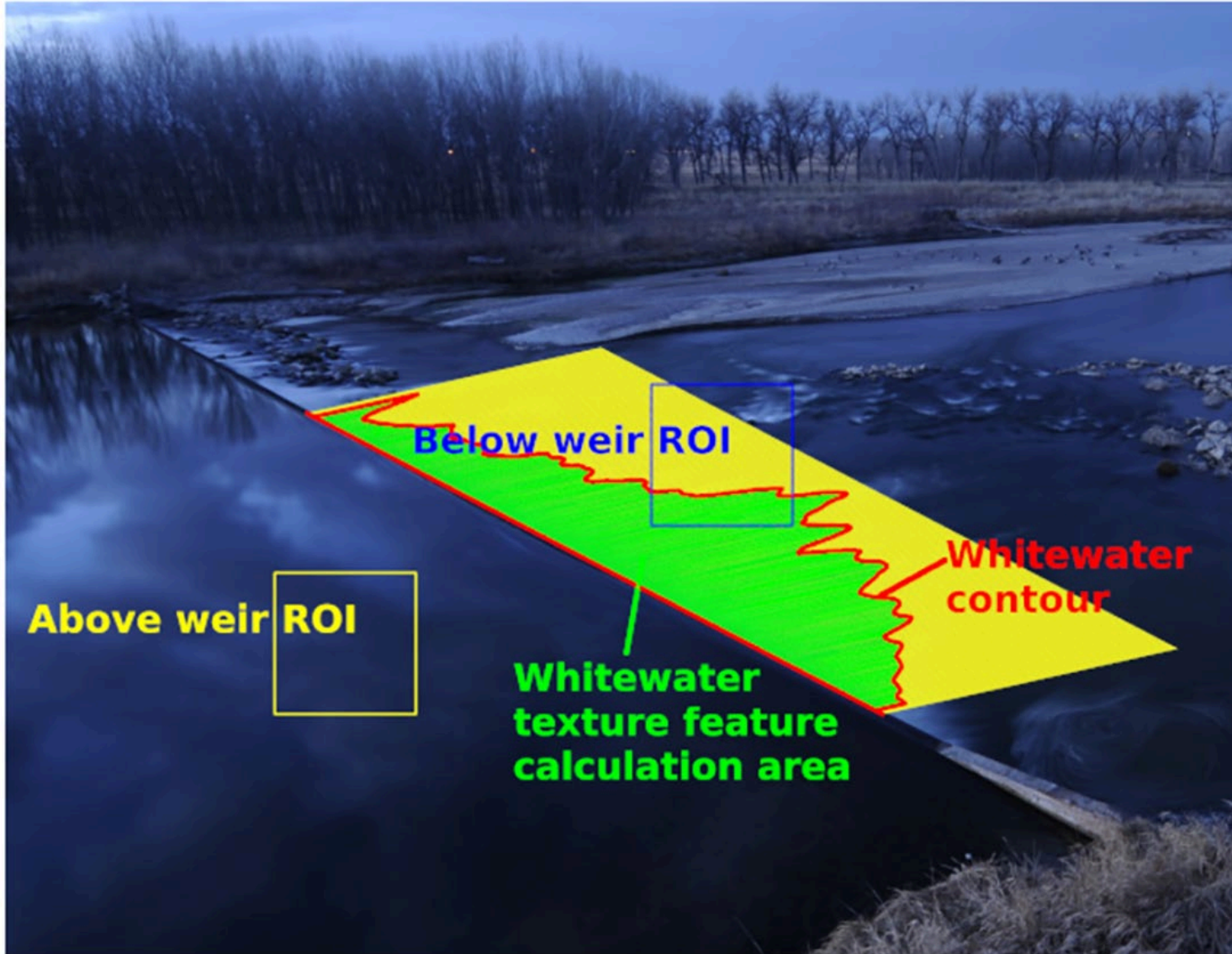
Workflow



Data gap filling using imagery from a watershed documentary project



Example image features



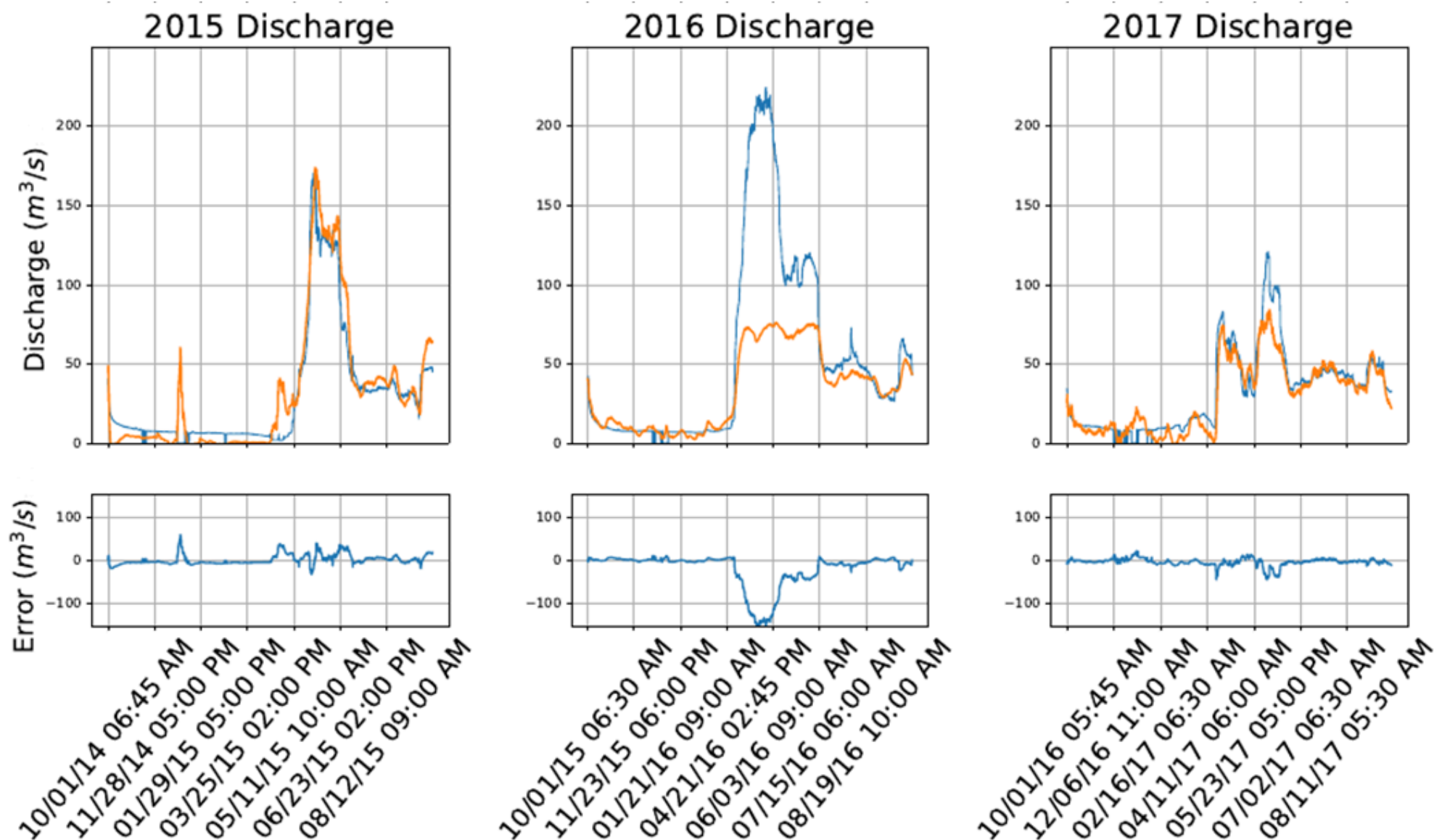
Features

- Intensity
- Entropy
- HSV
- Dimensions*

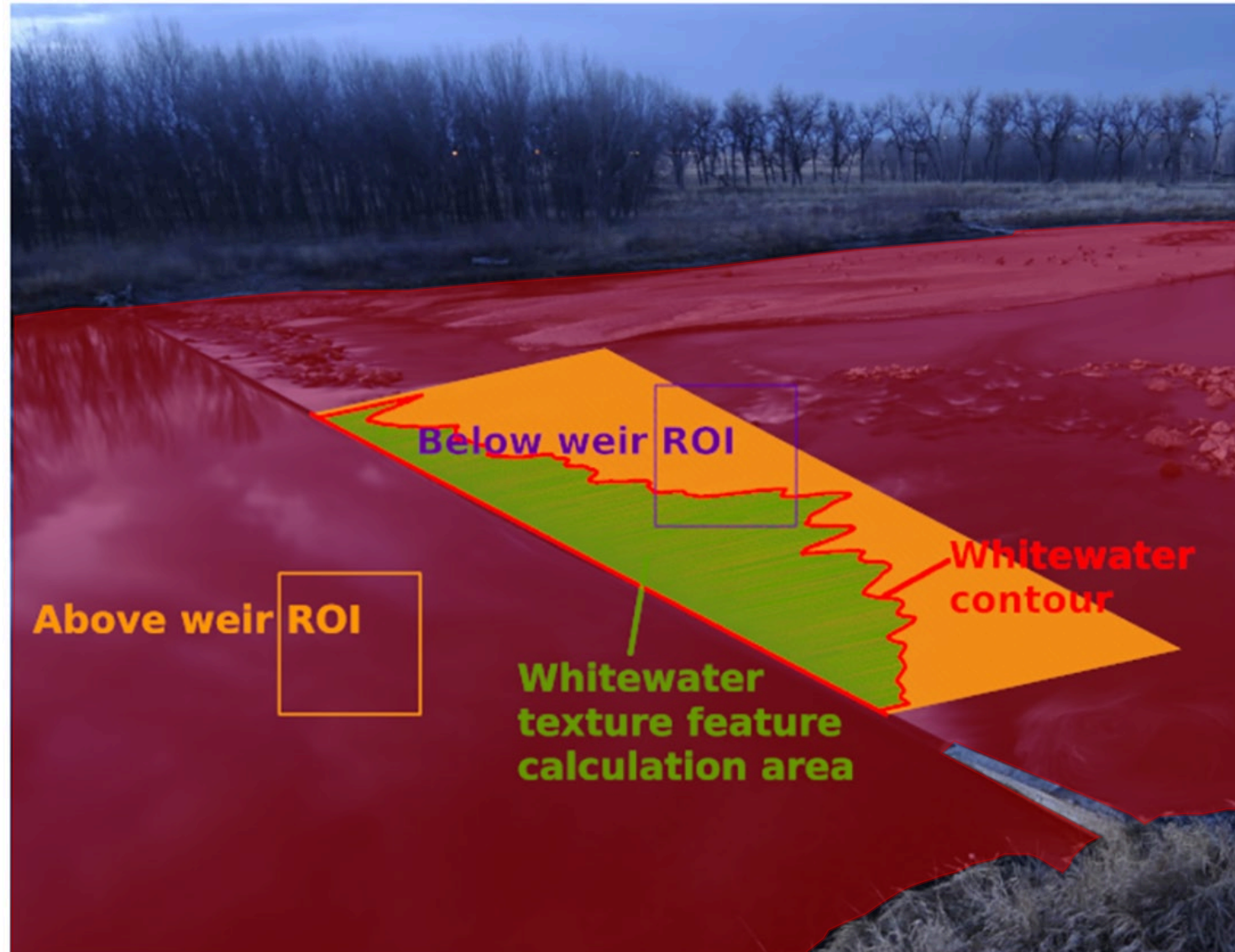
Calculated for

- Whole image
- ROIs
- Segmented turbulent area*

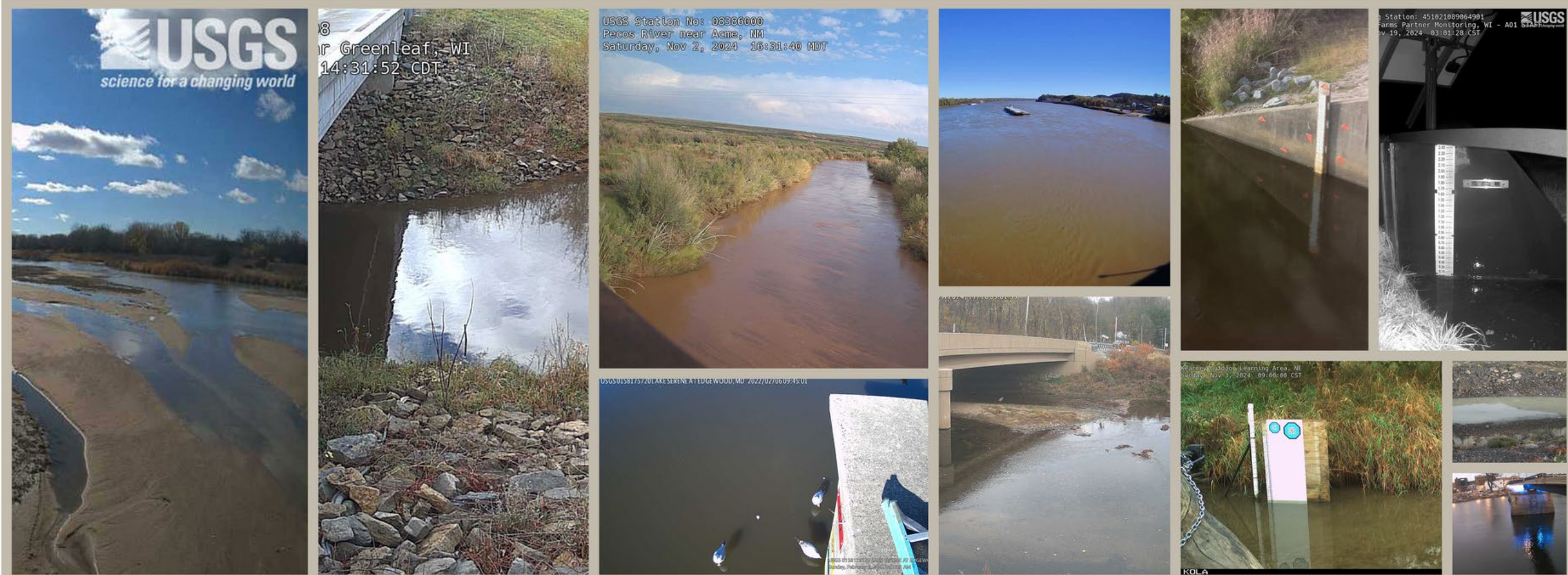
Data Modeling



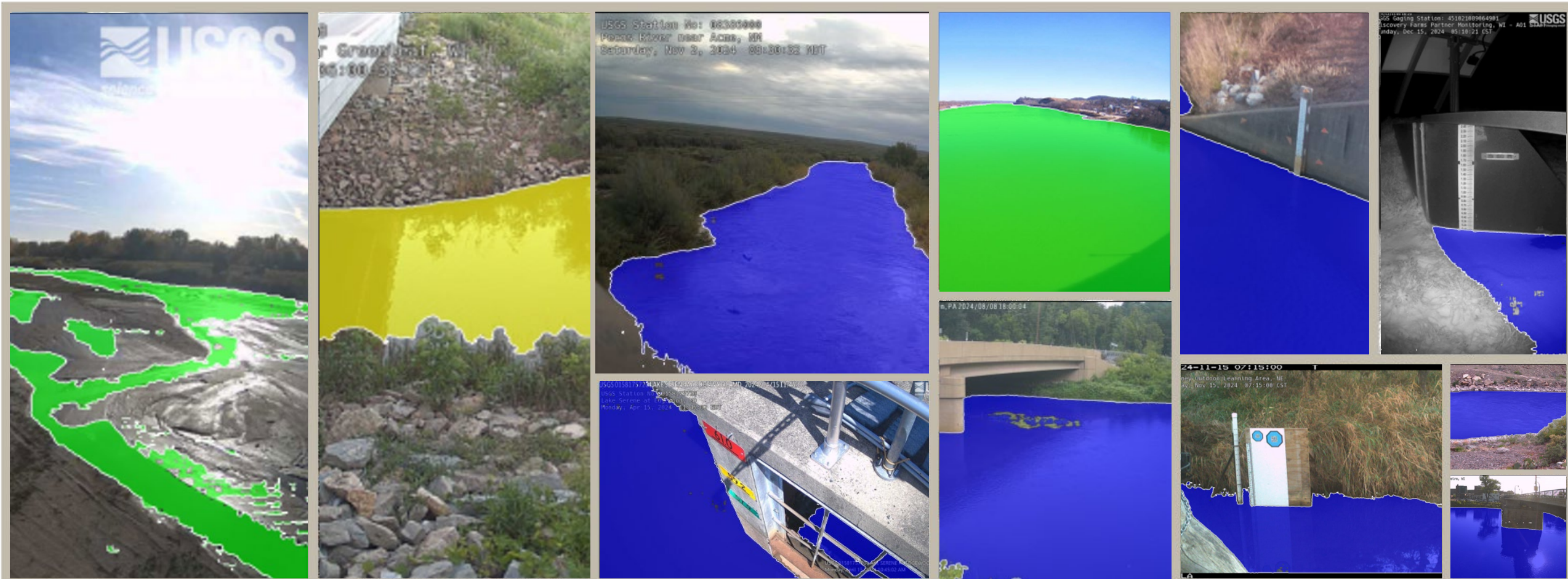
Can we automatically extract more information?



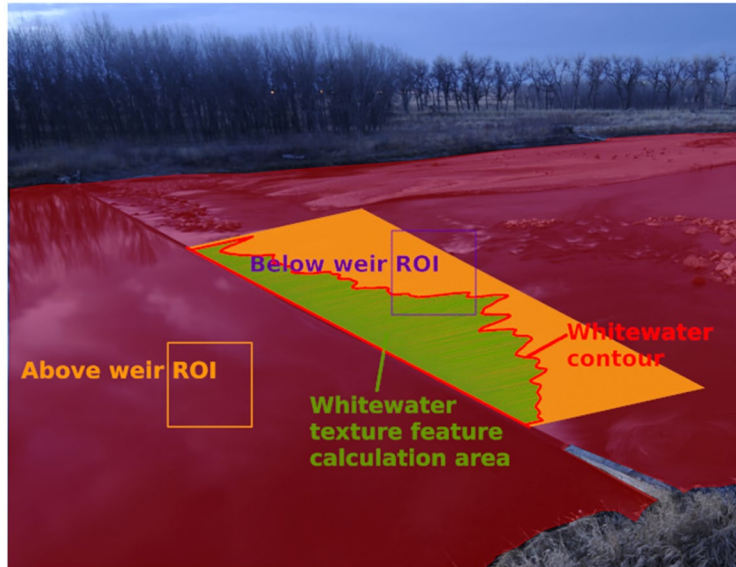
Training Data from Diverse USGS Sites



Test Data from Segmentation Models



A multi-step process to predict environmental variables from imagery



1. Train/test a model delineate specific regions in images (segmentation)*
2. Build a second model that predicts a variable of interest based on information in the segmented areas.



USGS Collaborator
Keegan Johnson

go.unl.edu/kdata



KOLA Data Dashboard C

Data and Imagery from the Kearney Outdoor Learning Area (KOLA)

Select Time Period

7/14/2022 - 6/8/2025



Data Description

KOLA is equipped with several sensors and ground-based time-lapse cameras. The data shown here is from our stream monitoring site.

Water level detection:

The image below show water level detected by GRIME2 software.

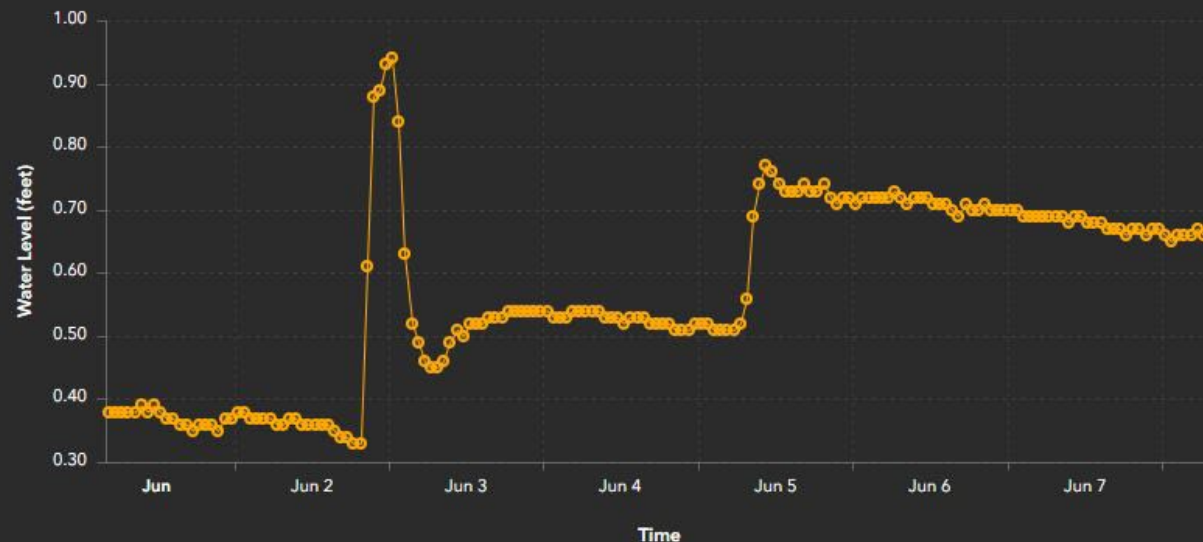
Time-lapse imagery:

The image to the right shows slices of noon and midnight imagery for the last week.

Water level records:

The top graph shows one week of hourly data from a water level sensor. This graph pairs with the one-week time-lapse imagery shown above.

Stream Water Levels for the Past Week



About

Download Other Data

Hourly Data (Past Week)

Long-term Data (Maximum Daily)

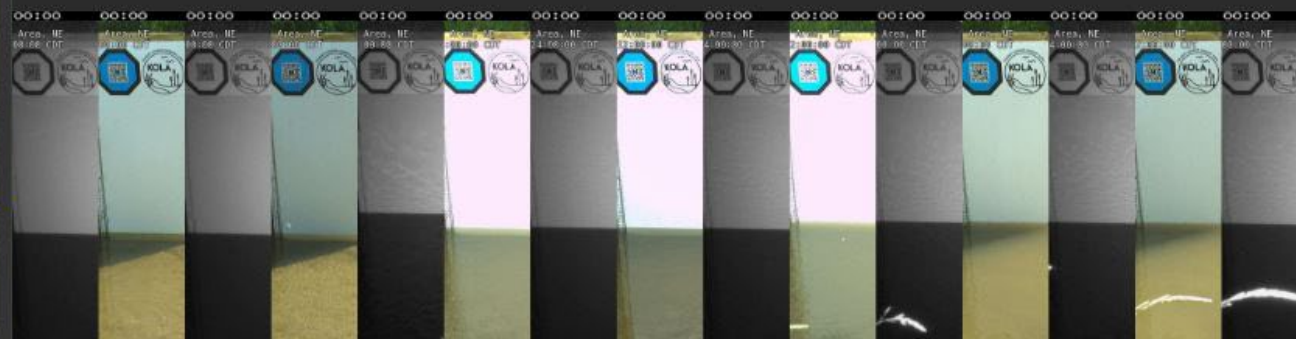
Long-term Data (Average Daily)

Latest Image-base Water Level Detected by GRIME2



Yellow text shows water level detected by image analysis. A blue line indicates the detected water line. Red lines across the image indicate a failed measurement. Created with [GRIME2](#).

Day and Night Image Slices from the Last Week



Each image slice is from either noon or midnight over the last seven days. The slice on the right-hand side is the most recent. Created with [GRIME AI](#).

Sign up for regular updates



*Some of this material is
based upon work
supported by the
National Science
Foundation under
Grant No. 2411065.*

*Some of this material is based upon
work supported by the U.S.
Geological Survey under
Grant/Cooperative Agreement No.
G23AC00141-00*



Data Preparation

Goal: Clean, actionable data

Detect and adjust for rotation and translation



*Human-derived training data

NEON Sites ☐ NEON Download Manager ☐ USGS Sites ☐ USGS Download Manager ☐ Image Analysis ☒ Sensor Data Graphs ☐ Google Maps (Provisional) ☐

Lake Barco NEON *Double click to enlarge

07-31-2023 Mon 13:00:39
05429500 YAHARA RIVER AT MC

USGS
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Mask Editor

ADD Mask

GENERATE Mask

☐ Auto-save

RESET Mask

Drawing

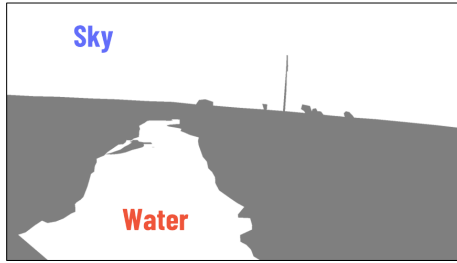
Line Color

☐ Red ☐ Green
☐ Orange ☐ Blue
☐ Yellow ☐ Purple

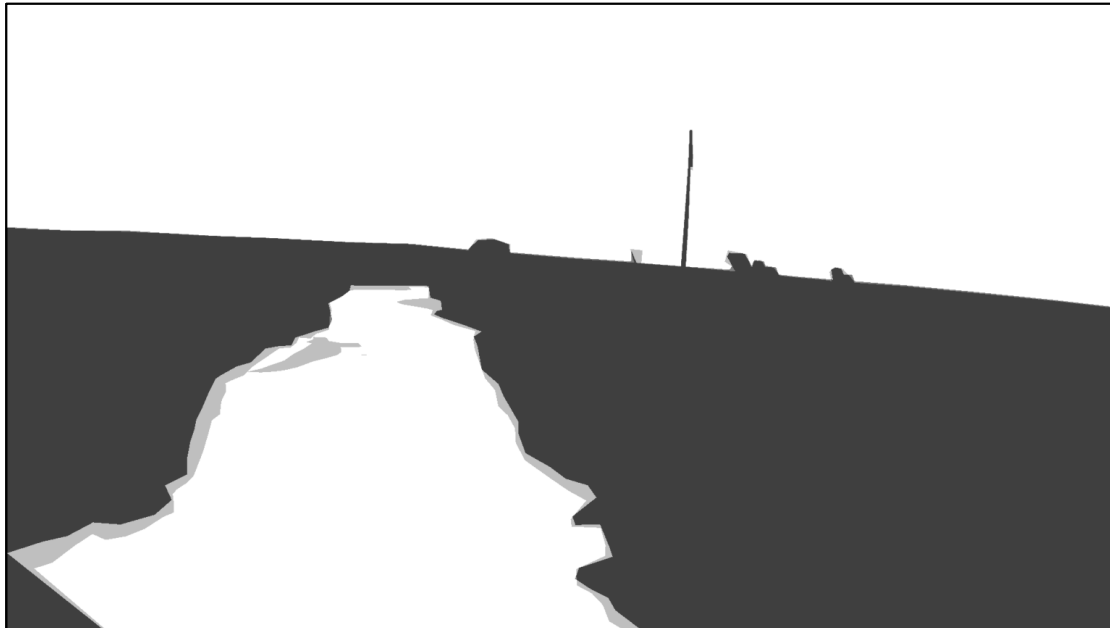
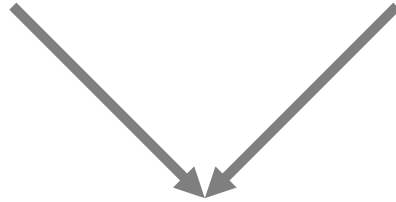
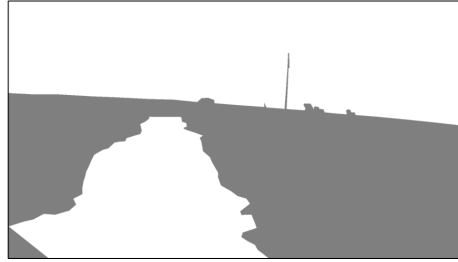
☐ Fill Polygon

Masks

Human A

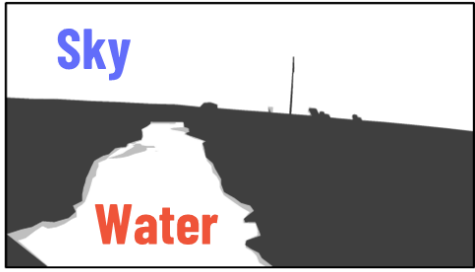


Human B



**Intersection
Over Union**

$$\text{IoU} = \frac{\text{White}}{\text{White} + \text{Grey}}$$



IoU values indicate high quality labeling

