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

NSF

USGS
science for a changing world

CONSERVATION AND SURVEY DIVISION
School of Natural Resources

GRIME Lab

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE
at the University of Nebraska

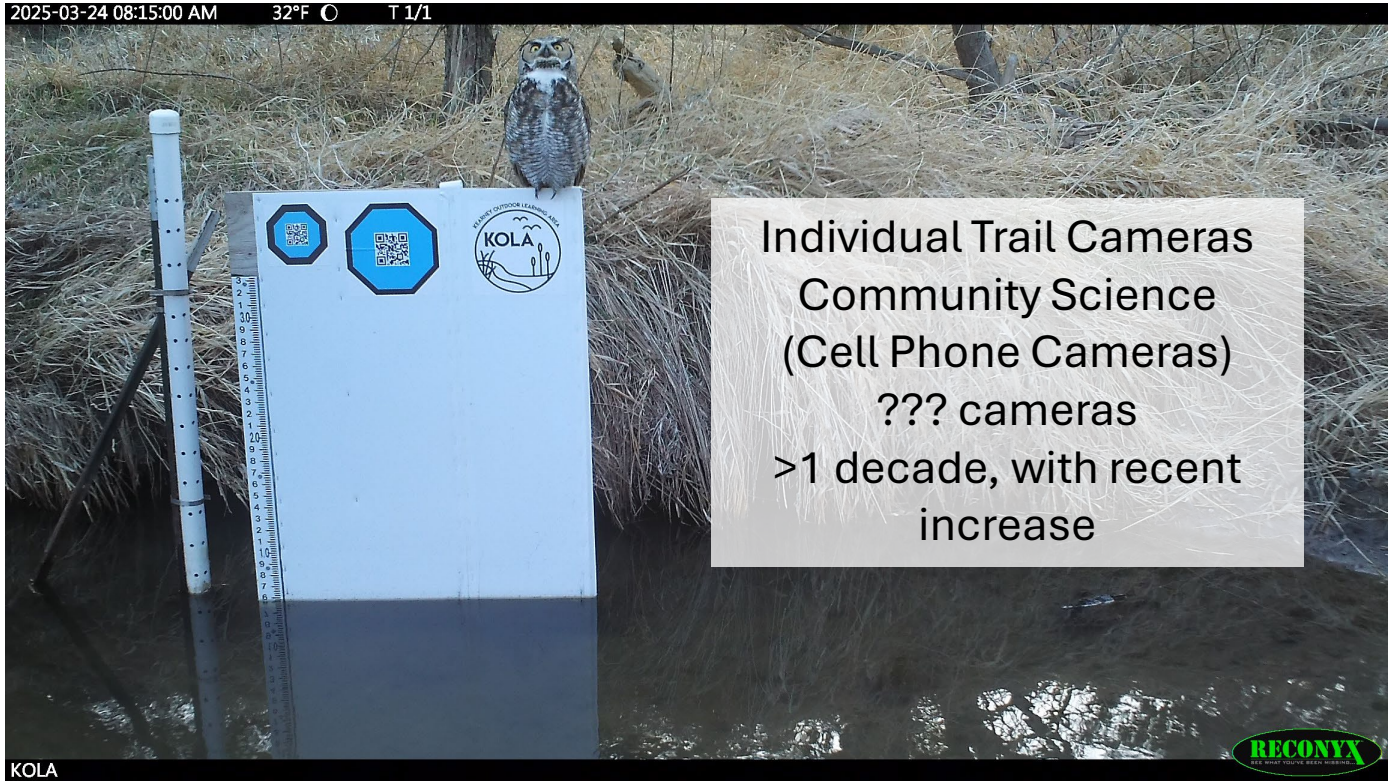
BIOLOGICAL SYSTEMS ENGINEERING
Institute of Agriculture and Natural Resources

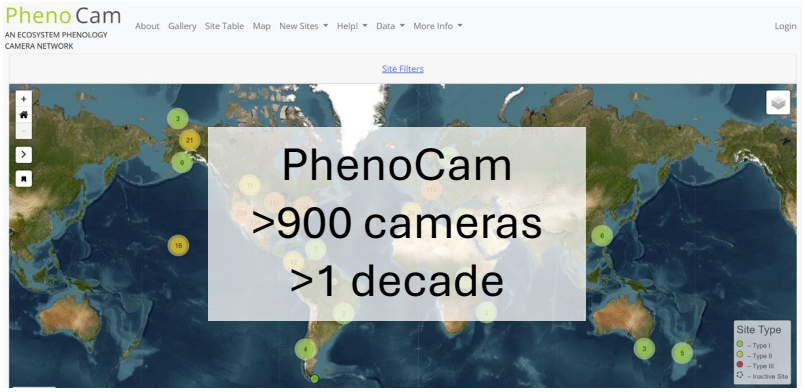
University of Nebraska Kearney

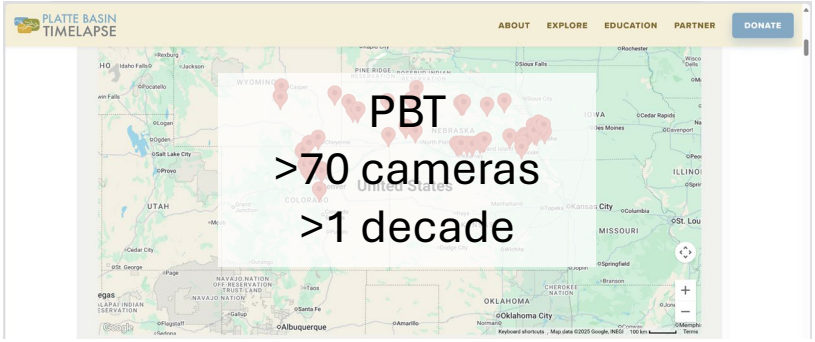
What?

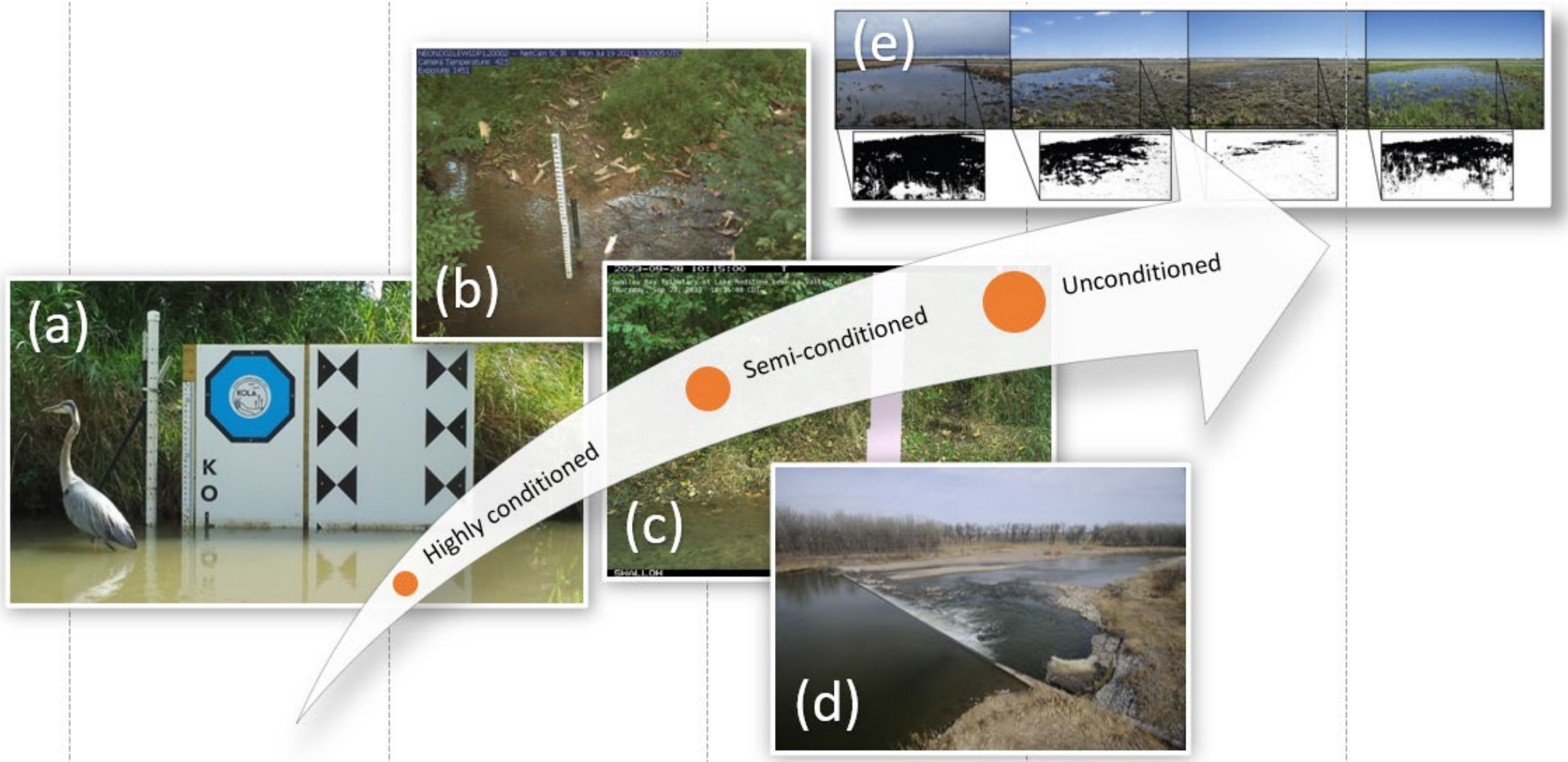
GaugeCam **R**emote **I**mage **M**anager **E**ducational **A**rtificial **I**ntelligence (GRIME AI) is an **open-source, commercial-friendly Windows application (Linux for HPC)** for science, education and communication using ground-based time-lapse imagery and other data.

Time-lapse Imagery for Environmental Monitoring








(a)
(b)
(c)
(d)
(e)
Highly conditioned
Semi-conditioned
Unconditioned
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.


USGS

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

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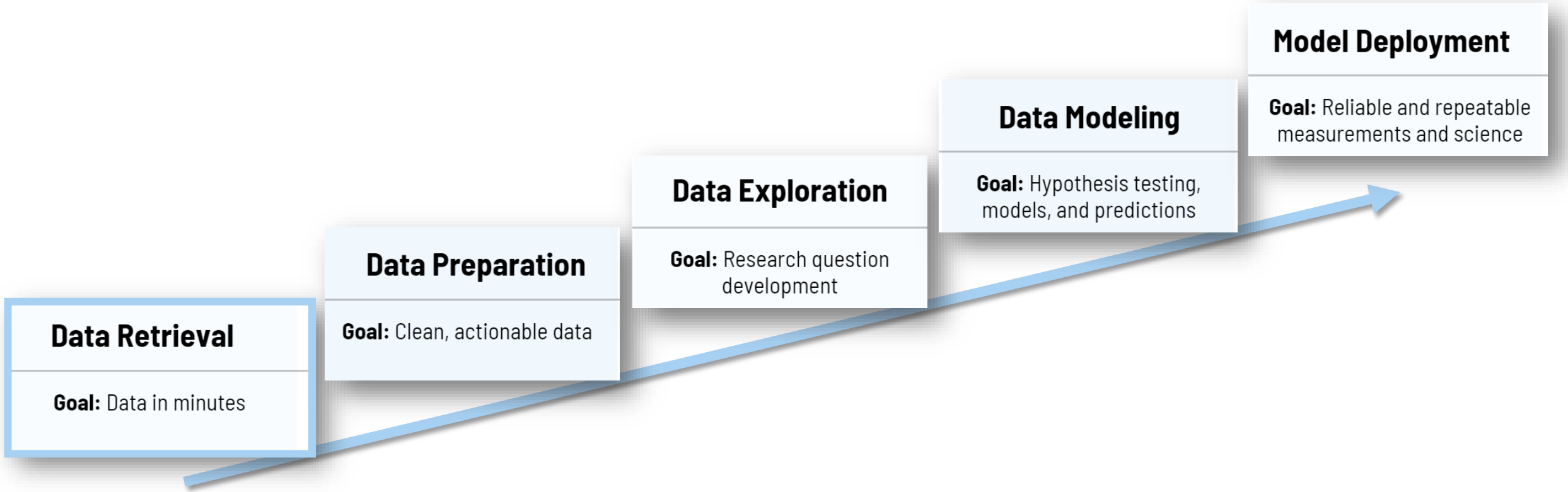
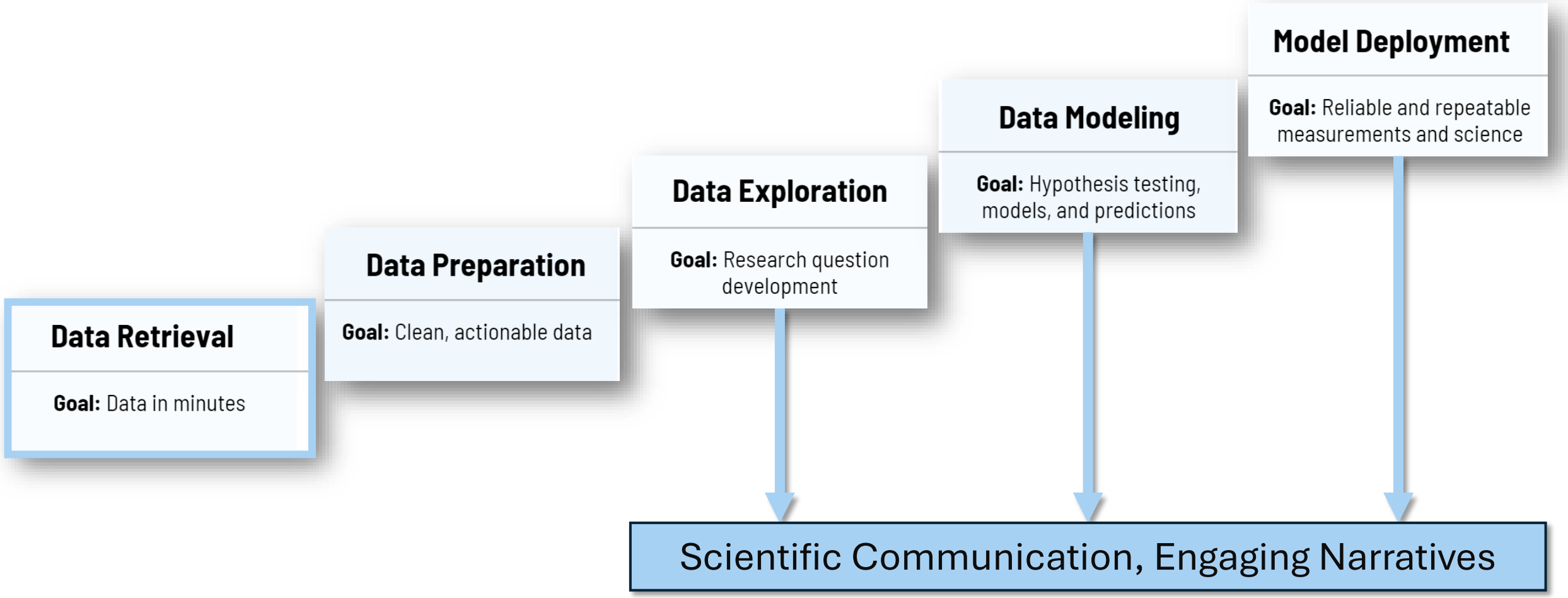
Workflow


Data Retrieval
Goal: Data in minutes
Data Preparation
Goal: Clean, actionable data
Data Exploration
Goal: Research question development
Data Modeling
Goal: Hypothesis testing, models, and predictions
Model Deployment
Goal: Reliable and repeatable measurements and science

Workflow



PLATTE BASIN TIMELAPSE

Data Retrieval

Goal: Data in minutes

USGS Imagery and Gauge Data

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_Asheville
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_Arkville
NY_East_Meadow_Brook_at_Freeport
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/
tlDir: https://usgs-nims-images.s3.amazonaws.com/timelapse/NE_Kearney_Outdoor_Learning_Area_RISE/
locus: aws
smallDir: https://usgs-nims-images.s3.amazonaws.com/720/NE_Kearney_Outdoor_Learning_Area_RISE/
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createdDate: 2023-09-14T17:53:02.458Z
lng: -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
stateAbrv: NE
newestImageDT: 2024-04-05T18:45:02.000Z
camId: NE_Kearney_Outdoor_Learning_Area_RISE
lat: 40.677026

Funding thanks to:
USGS science for a changing world

Data Retrieval

Goal: Data in minutes

PhenoCam Imagery

NEON Data Products

Image Analysis | Sensor Data Graphs | Google Maps (Provisional)

NEON Sites

ABBY - Abby Road NEON
ARIK - Arikaree River NEON
BARC - Lake Barco NEON
BARR - UtqiaÄ¡vik 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
deimsId: https://deims.org/fc3606ae-df89-4e21-96df-cc380bb0d89d
releases: [{'release': 'RELEASE-2021', 'generationDate': '2021-01-23T02:30:02Z', 'url': 'https://da
dataProducts: [{'dataProductCode': 'DP1.00001.001', 'dataProductTitle': '2D wind speed and di

Latest Site Image

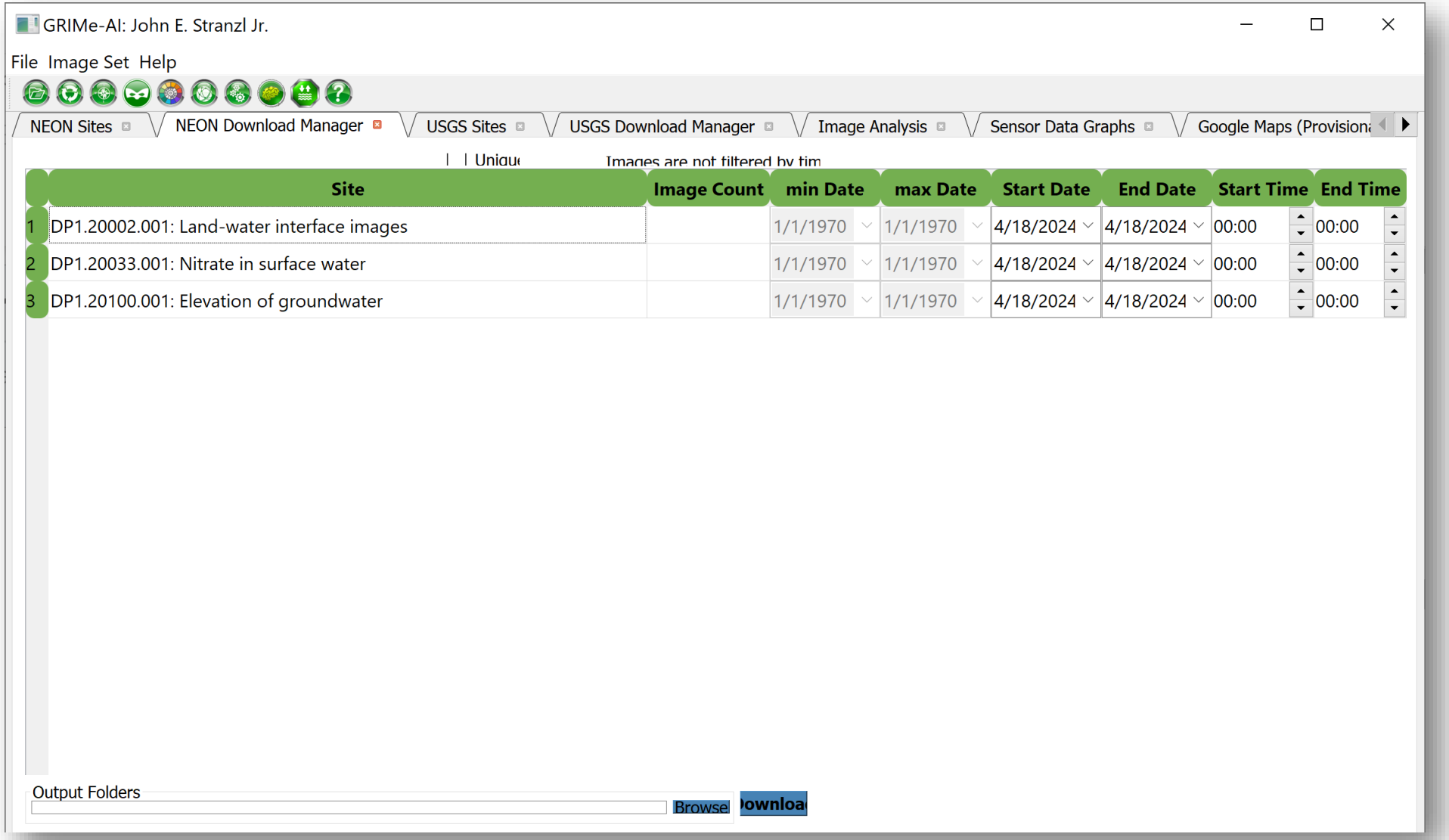
NEON Site Products

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
DP1.20032.001: Shortwave and longwave radiation above water on-buoy (net radiometer)
DP1.20033.001: Nitrate in surface water
DP1.20042.001: Photosynthetically active radiation at water surface
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



Data Retrieval

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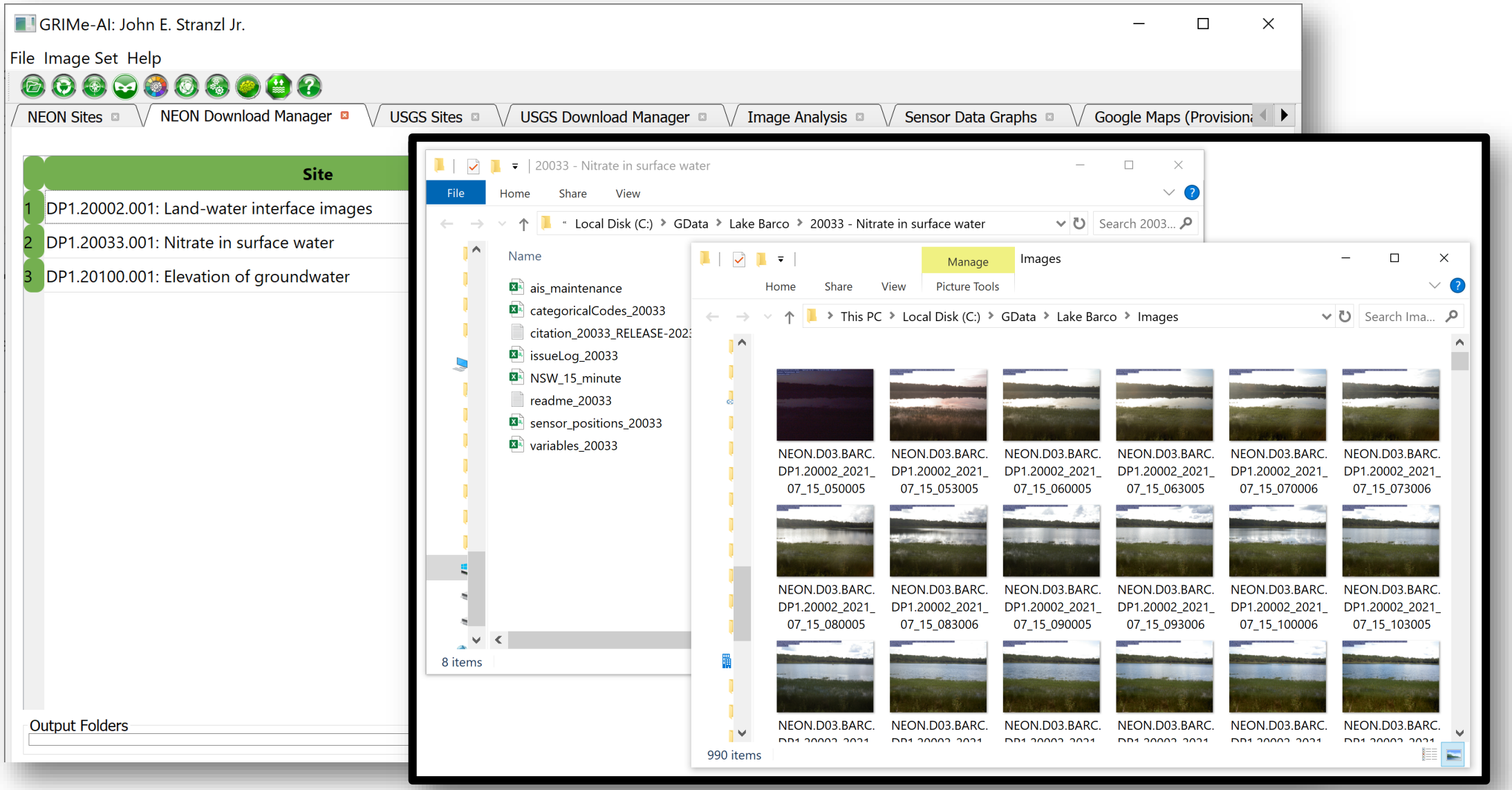
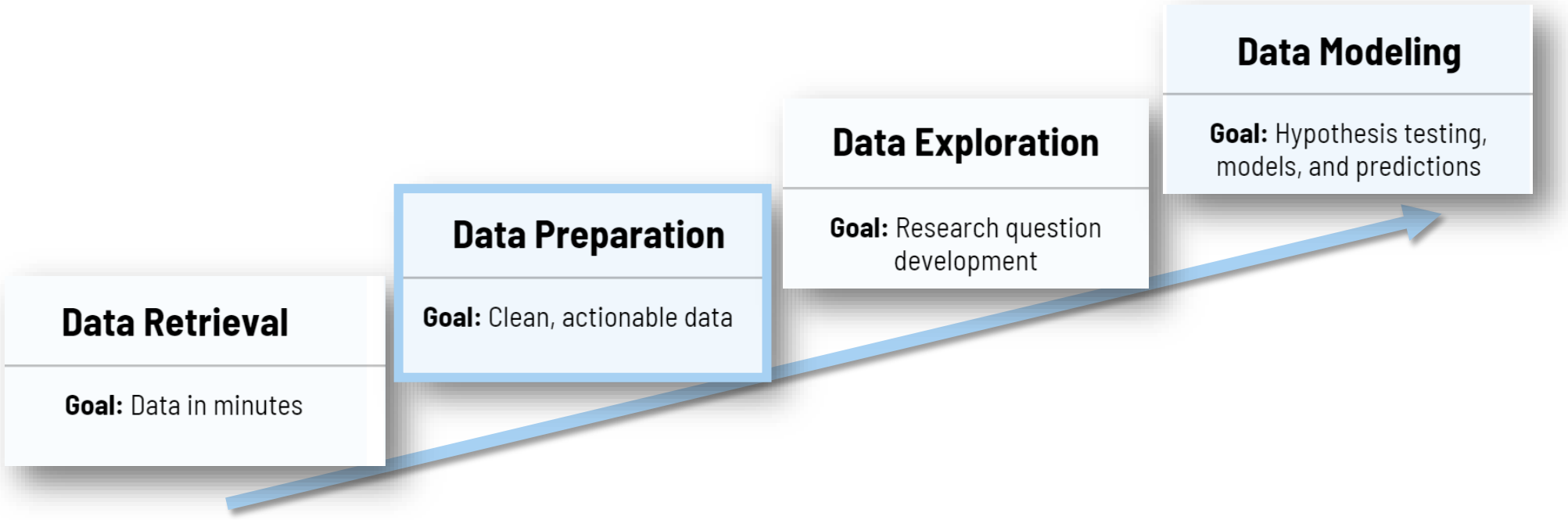
Select time period and download



Workflow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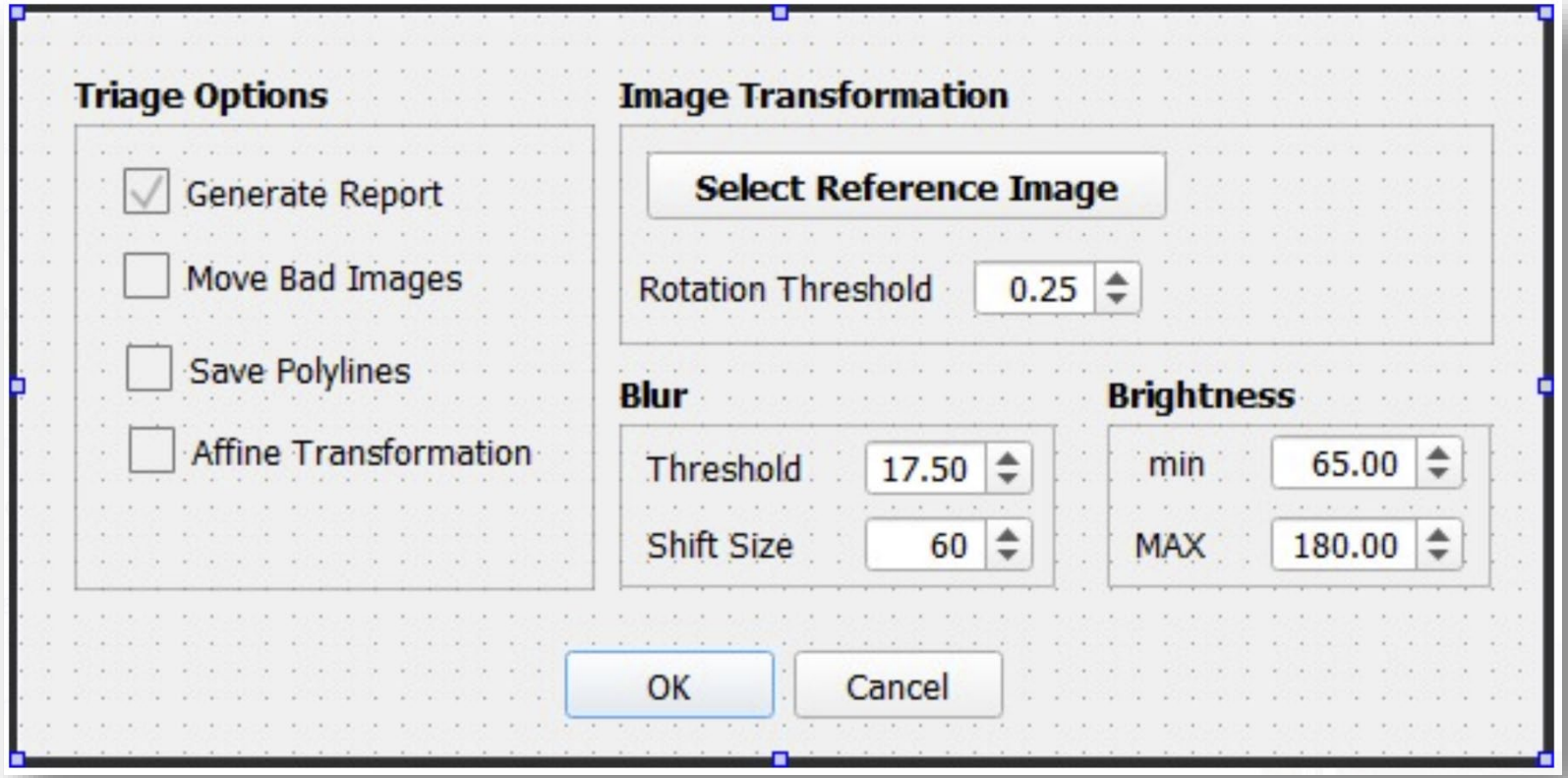
Data Preparation

Goal: Clean, actionable data

Triage imagery datasets



Data Preparation

Goal: Clean, actionable data

Identify and move low-information Images

Workflow

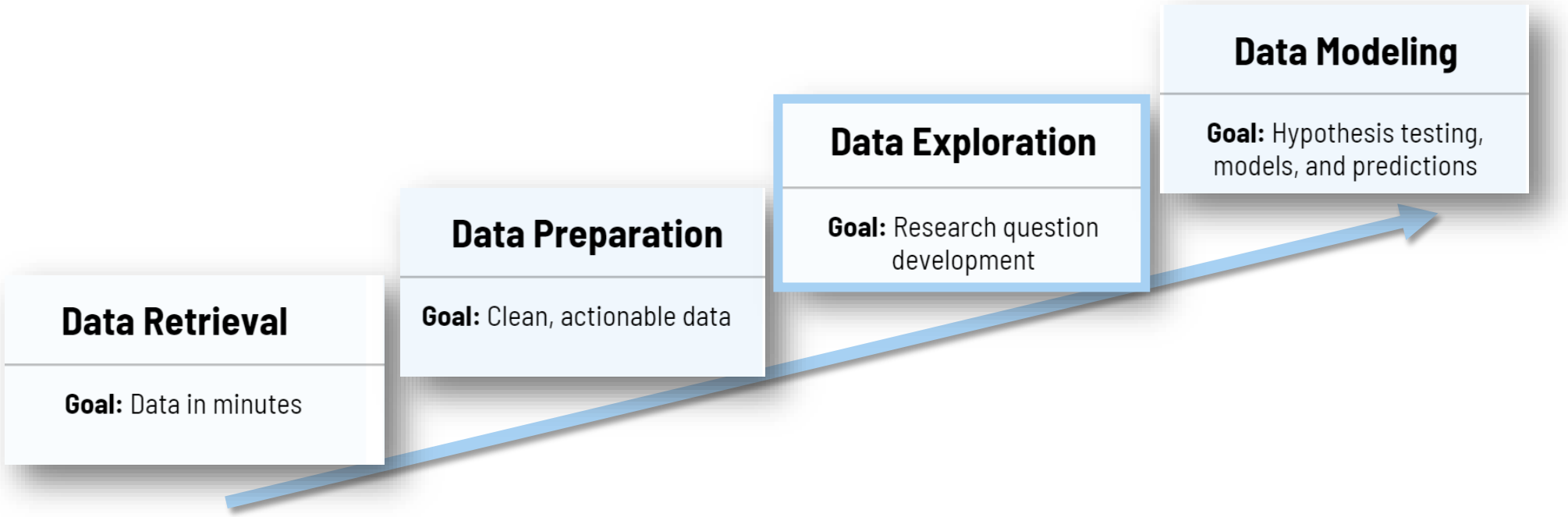

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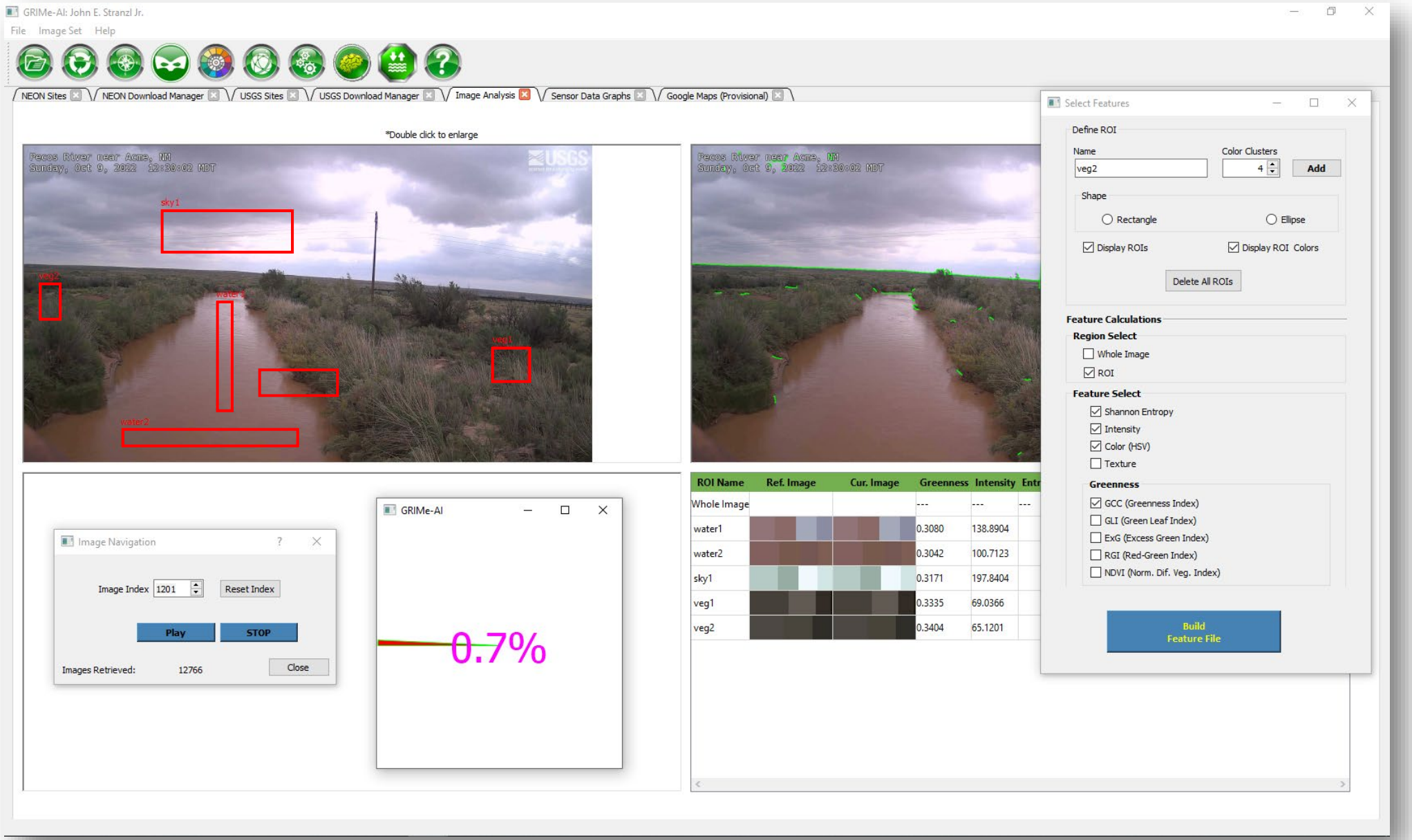
Image feature extraction



Imagery source:

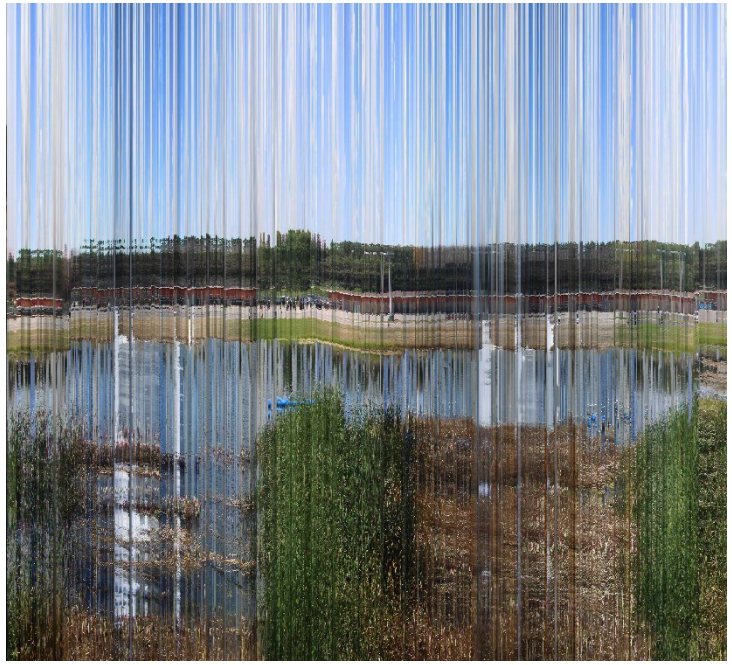
USGS science for a changing world

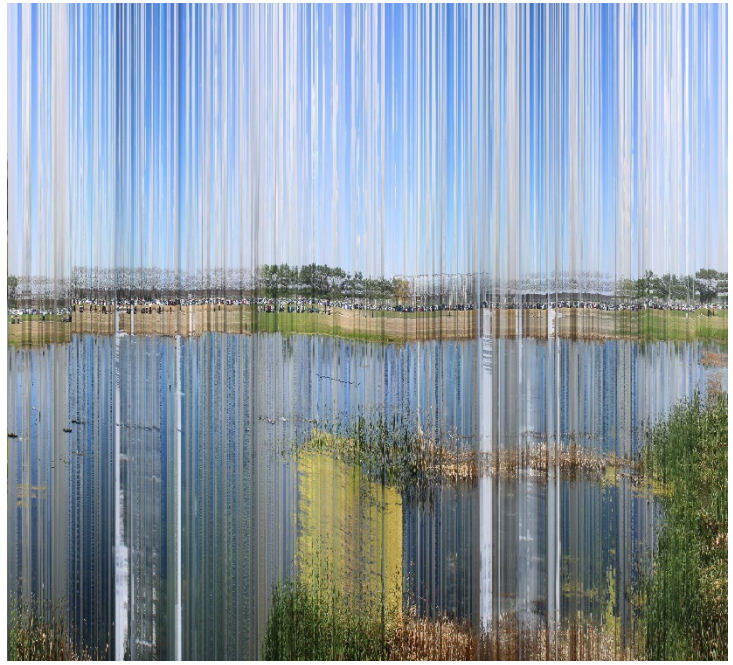
Data Exploration

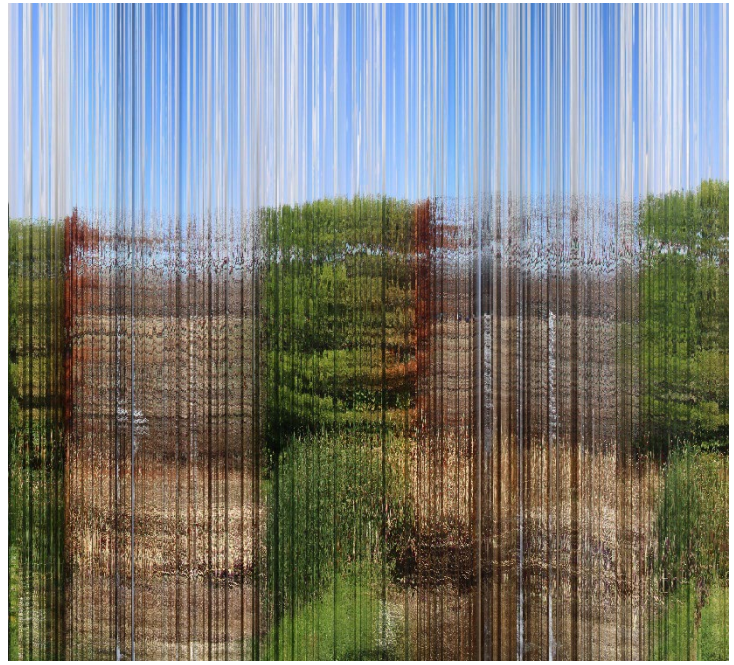
Goal: Research question development

Imagery source:

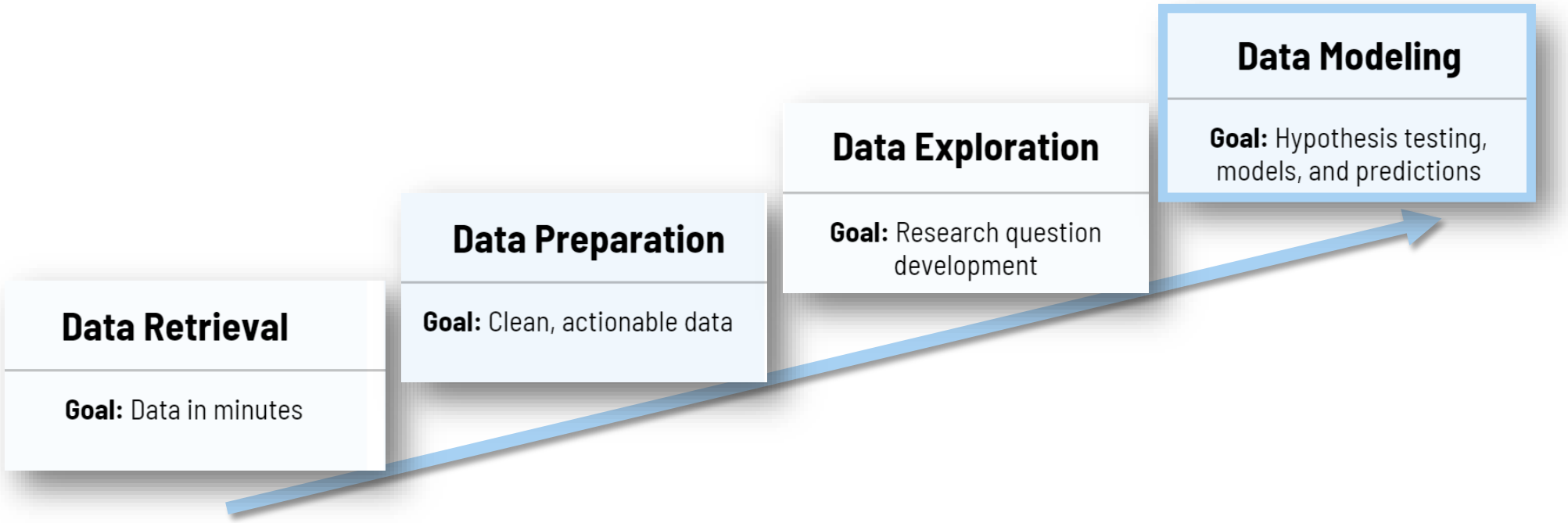
PLATTE BASIN TIMELAPSE







Workflow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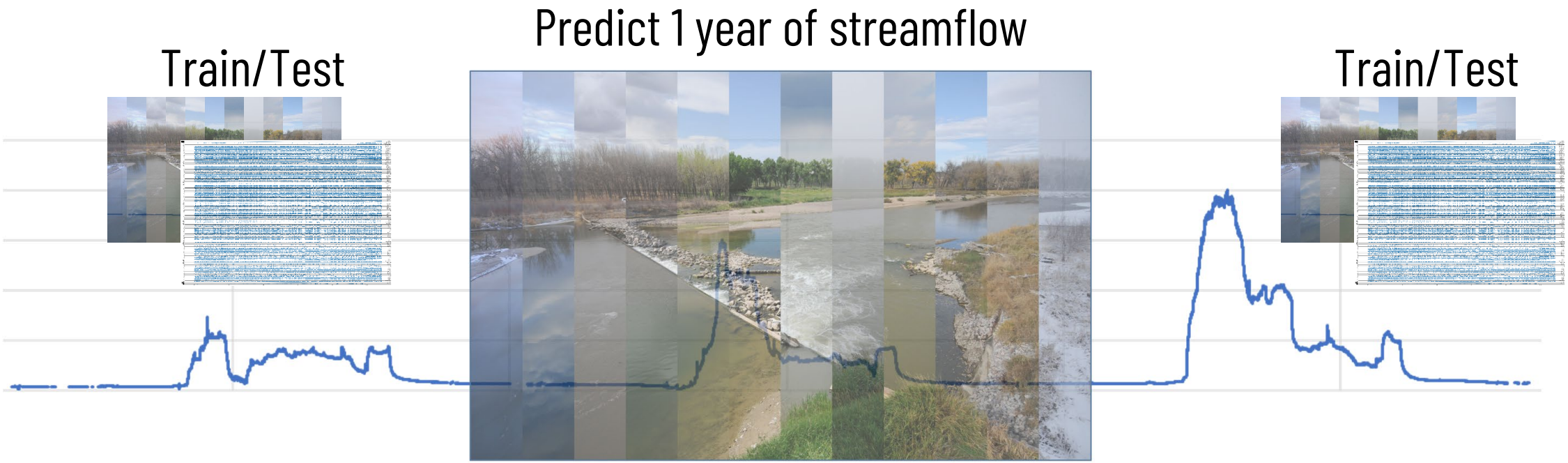
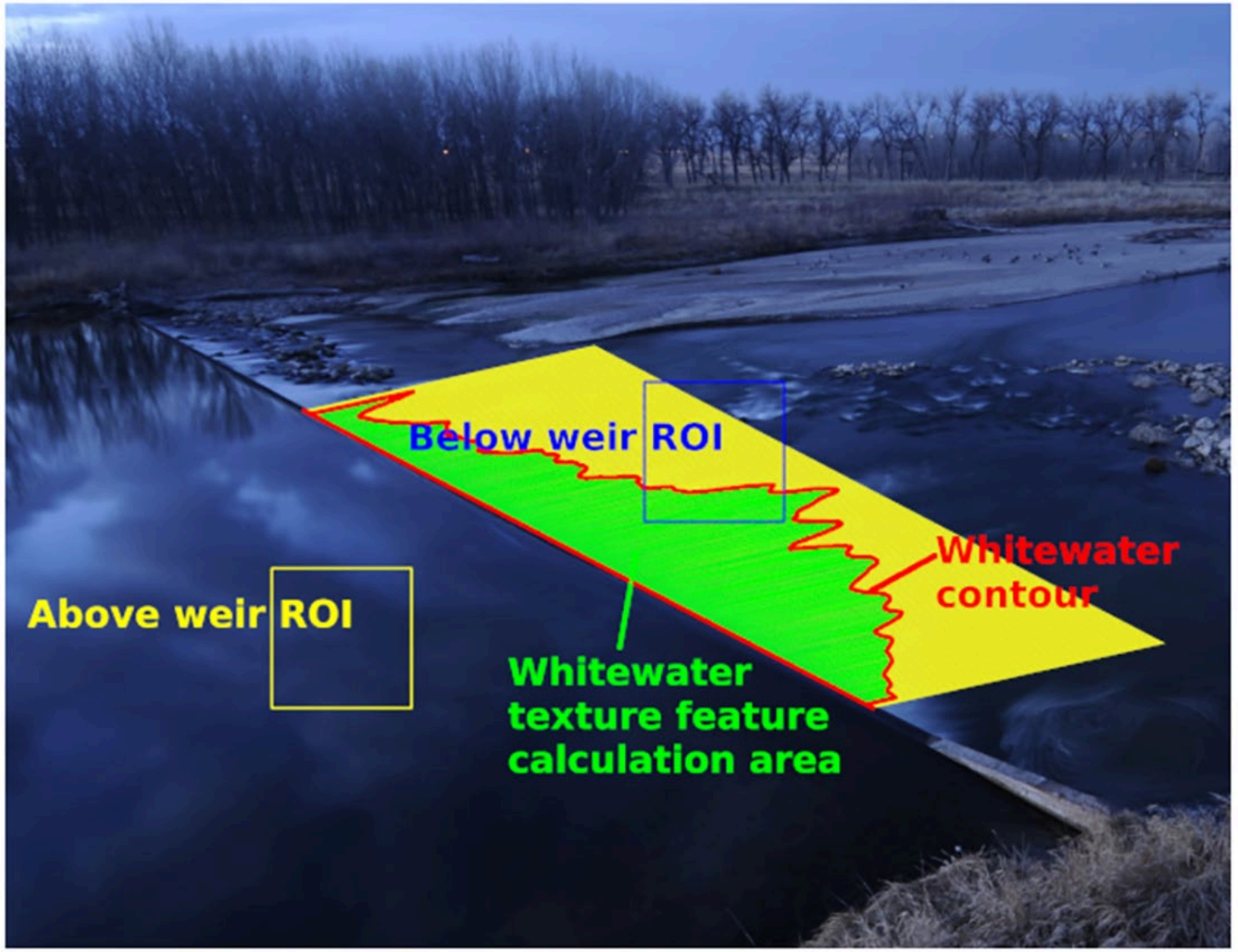
PLATTE BASIN TIMELAPSE

Data gap filling using imagery from a watershed documentary project



Chapman et al., 2024; PLOS Water; https://doi.org/10.1371/journal.pwat.0000106
Chavez-Jimenez et al., 2023; Feature Analysis and Selection for Water Stream Modeling; https://doi.org/10.1007/978-3-031-33783-3_1

Example image features



Features

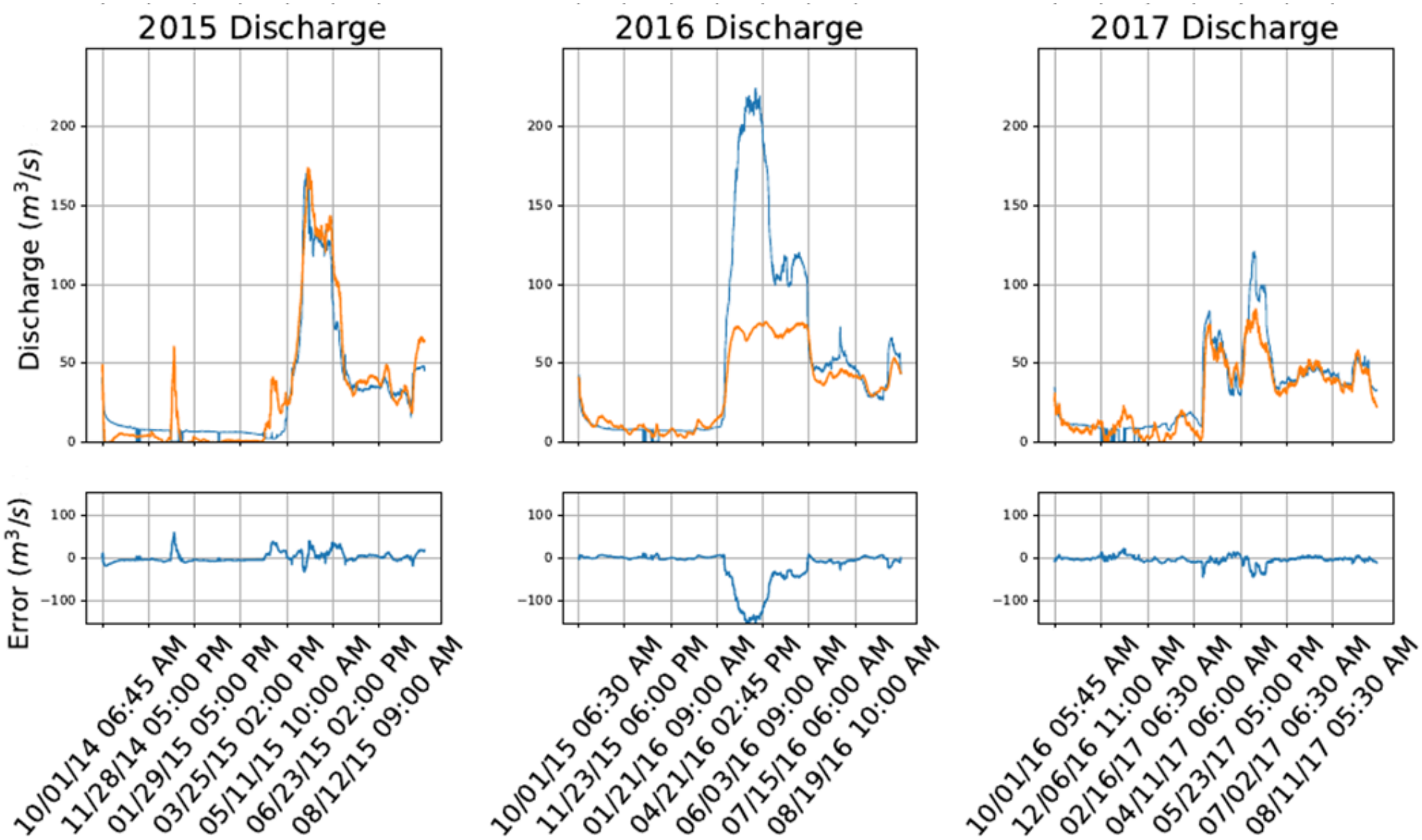
- Intensity
- Entropy
- HSV
- Dimensions*

Calculated for

- Whole image
- ROIs
- Segmented turbulent area*

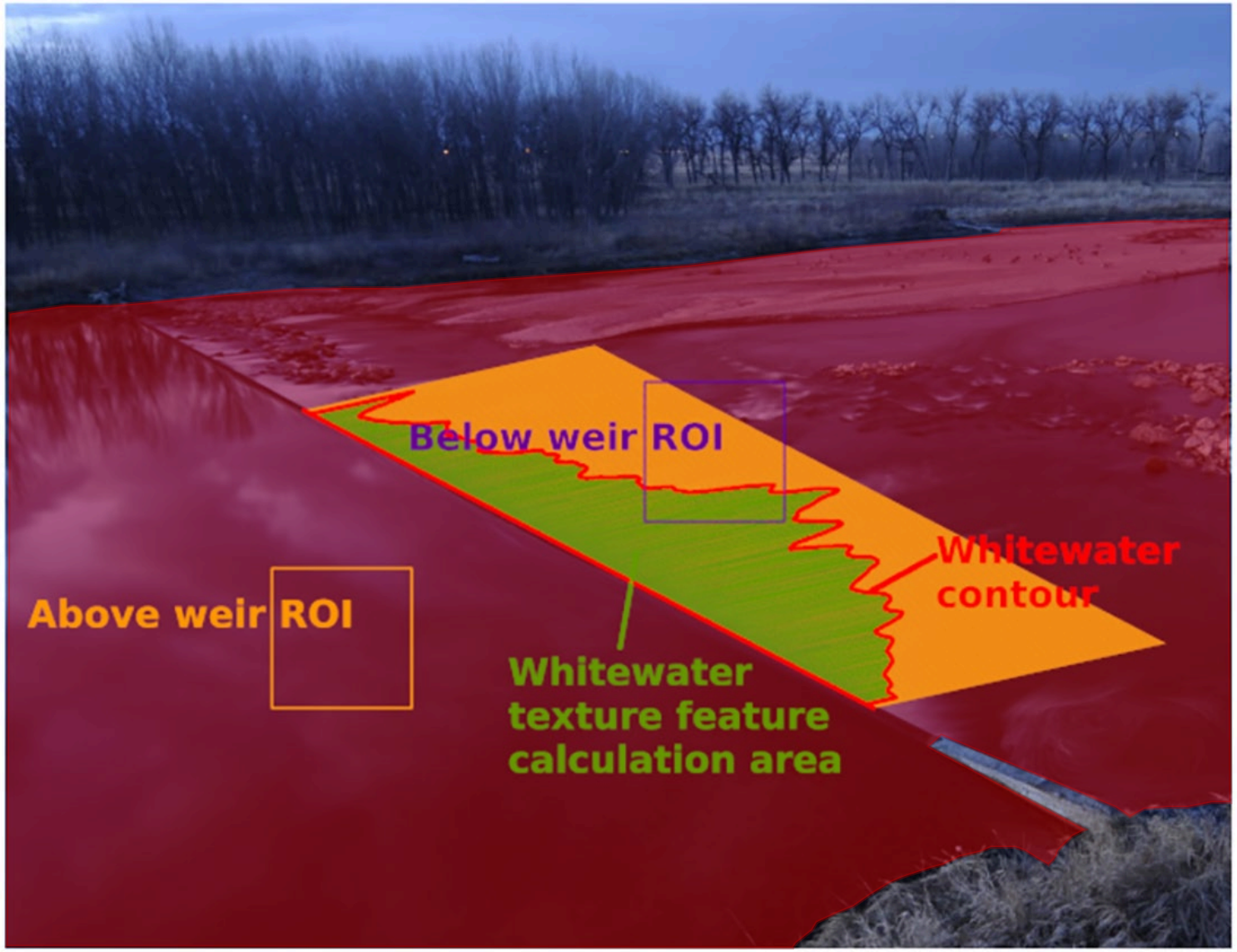
Chapman et al., 2024; PLOS Water; https://doi.org/10.1371/journal.pwat.0000106
Chavez-Jimenez et al., 2023; Feature Analysis and Selection for Water Stream Modeling; https://doi.org/10.1007/978-3-031-33783-3_1

Data Modeling



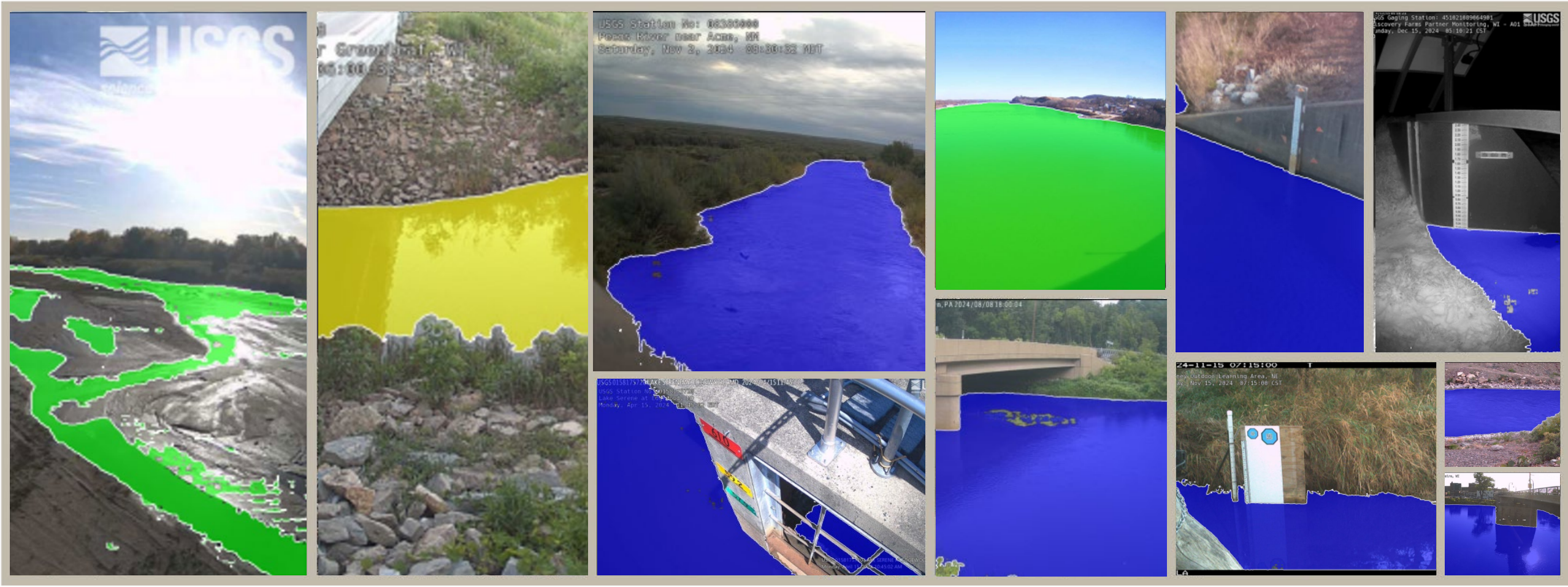
Chapman et al., 2024
Chavez-Jimenez et al., 2023

Can we automatically extract more information?

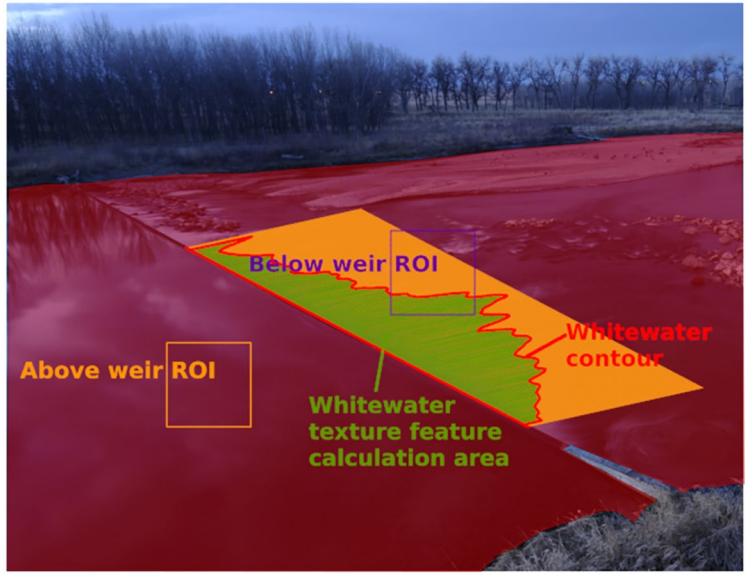


Training Data from Diverse USGS Sites

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

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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.

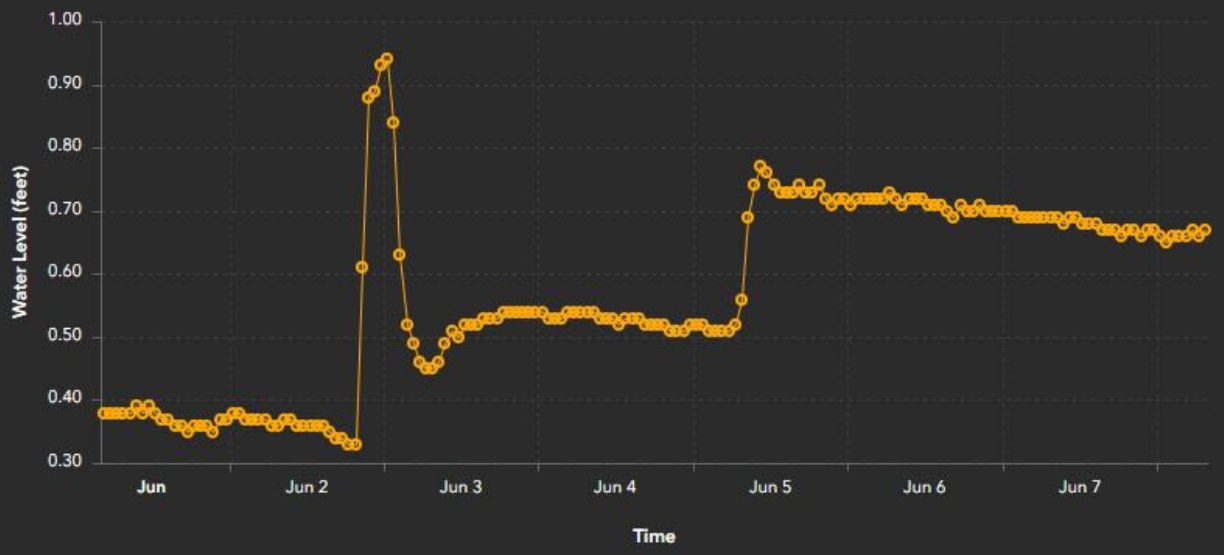
Time-lapse imagery:

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

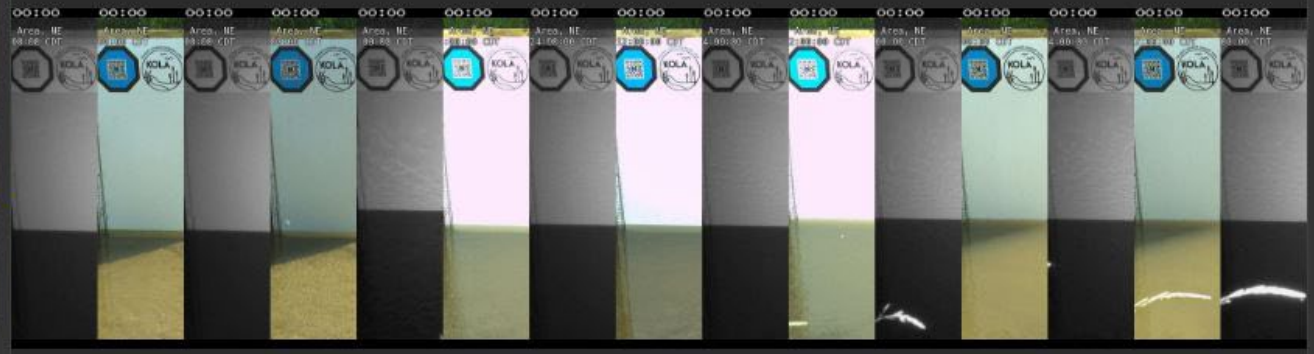


About | Download Other Data | Hourly Data (Past Week) | Long-term Data (Maximum Daily) | Long-term Data (Average Daily)

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

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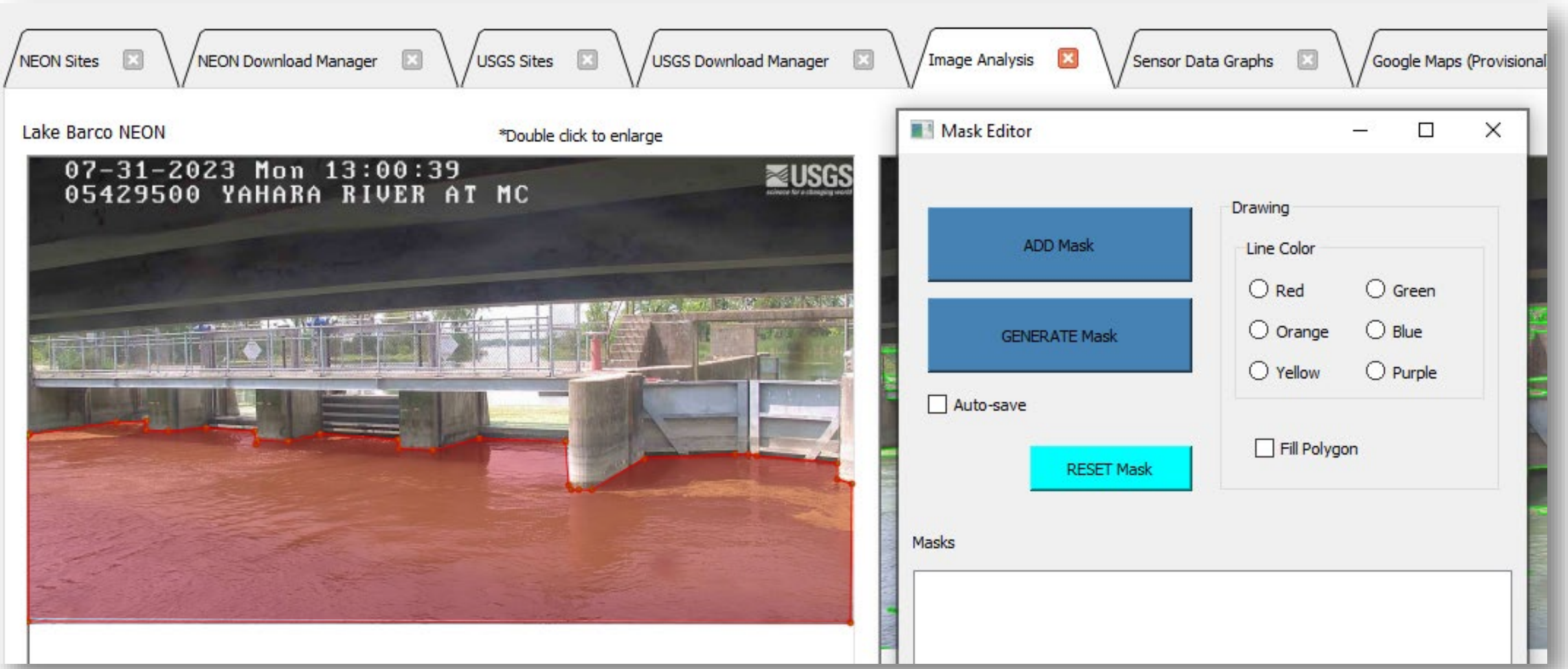
BIOLOGICAL SYSTEMS ENGINEERING
Institute of Agriculture and Natural Resources

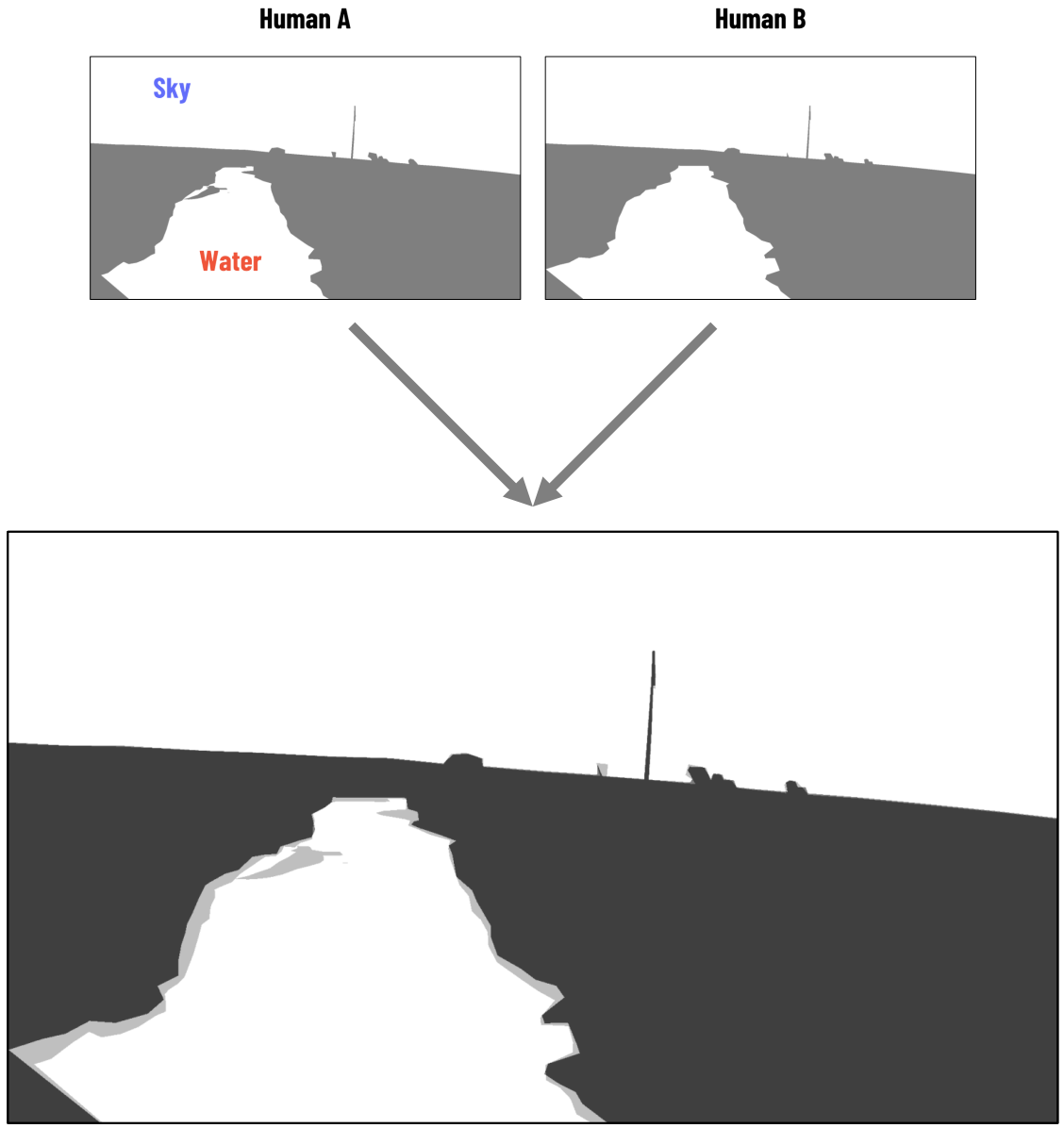
Data Preparation

Goal: Clean, actionable data

Detect and adjust for rotation and translation

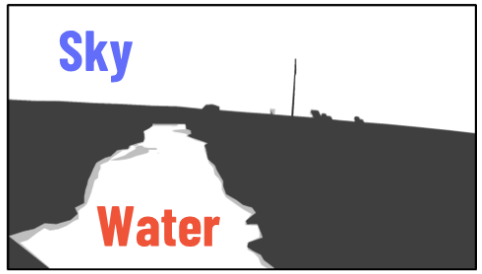
*Human-derived training data





Intersection Over Union

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



IoU values indicate high quality labeling