Flood Inundation Mapping with FLDPLN

Xingong Li, Jude Kastens, David Weiss
University of Kansas

CIROH Developers CONFERENCE
May 27 - 29, 2026 | Salt Lake City, Utah

Flood Inundation Mapping with FLDPLN

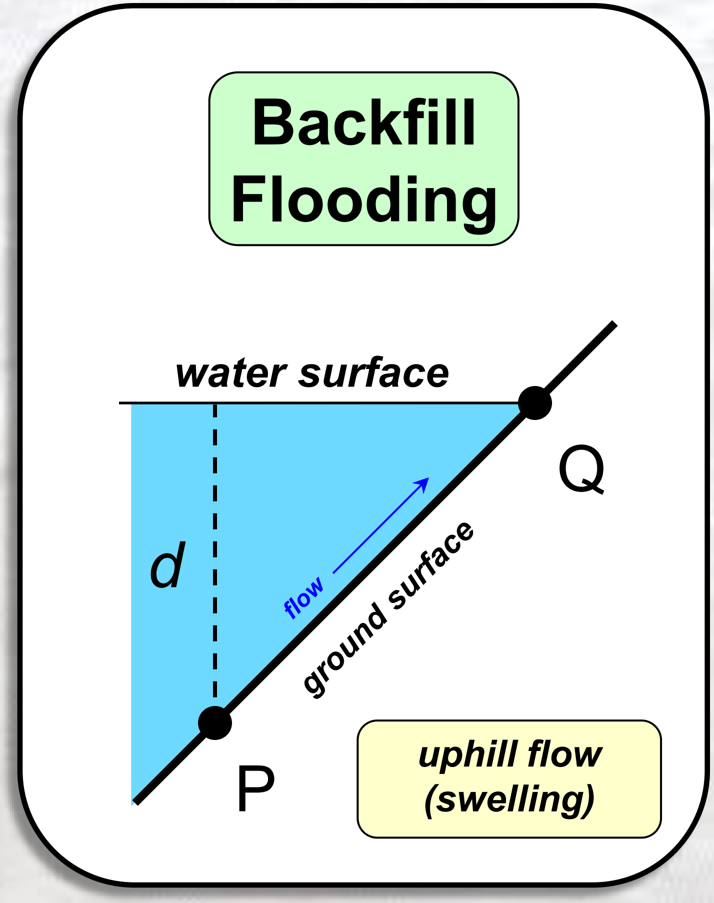
- Introduction to the FLDPLN FIM model
- Use Wildcat Creek, KS as an example
- Workshop materials
  - Notebooks, Python packages and tools are on GitHub
    - https://github.com/XingongLi/fldpln
    - MATLAB Runtime installer (without MATLAB Runtime), fldpln and ArcGIS toolbox
  - Wildcat Creek data is on a KU server
    - DEMs, segment shapefiles, gauge data and reference NOAA/NWS FIM map
  - Installers with MATLAB Runtime included are also on the KU server

Low Complexity FIM Model

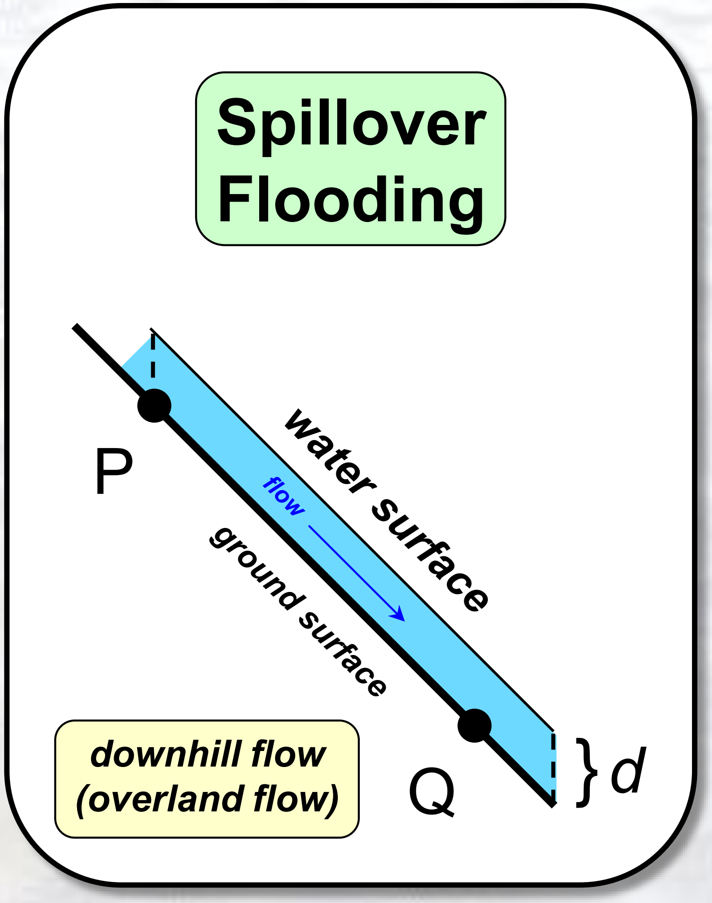
- Hydrodynamic models are more accurate but need more data and computational resources
- Low complexity models are faster and need few inputs
  - Faster at high resolution over large areas
  - Hydro-conditioned DEM as the primary input
- Especially useful in predicting inundation extent and depth that are likely to occur in the *immediate future* using observed or forecasted stream stage

The FLDPLN (floodplain) Model

Low-complexity flood inundation model based on backfill and spillover flooding mechanisms



"Water seeks its own level"

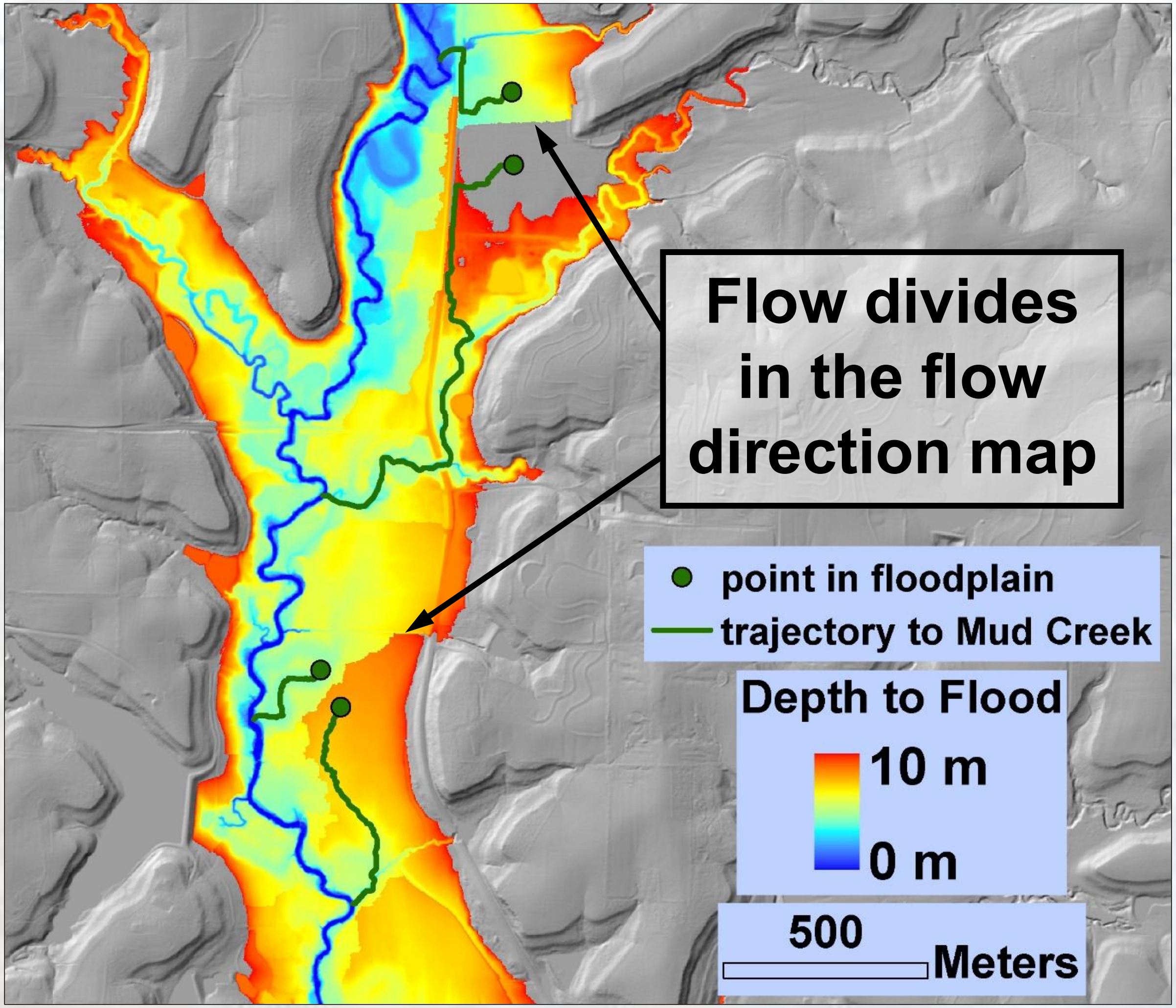


"Water flows downhill"

Backfill Flooding Is Not Sufficient

A depth-to-flood (DTF) map determined using only backfill flooding

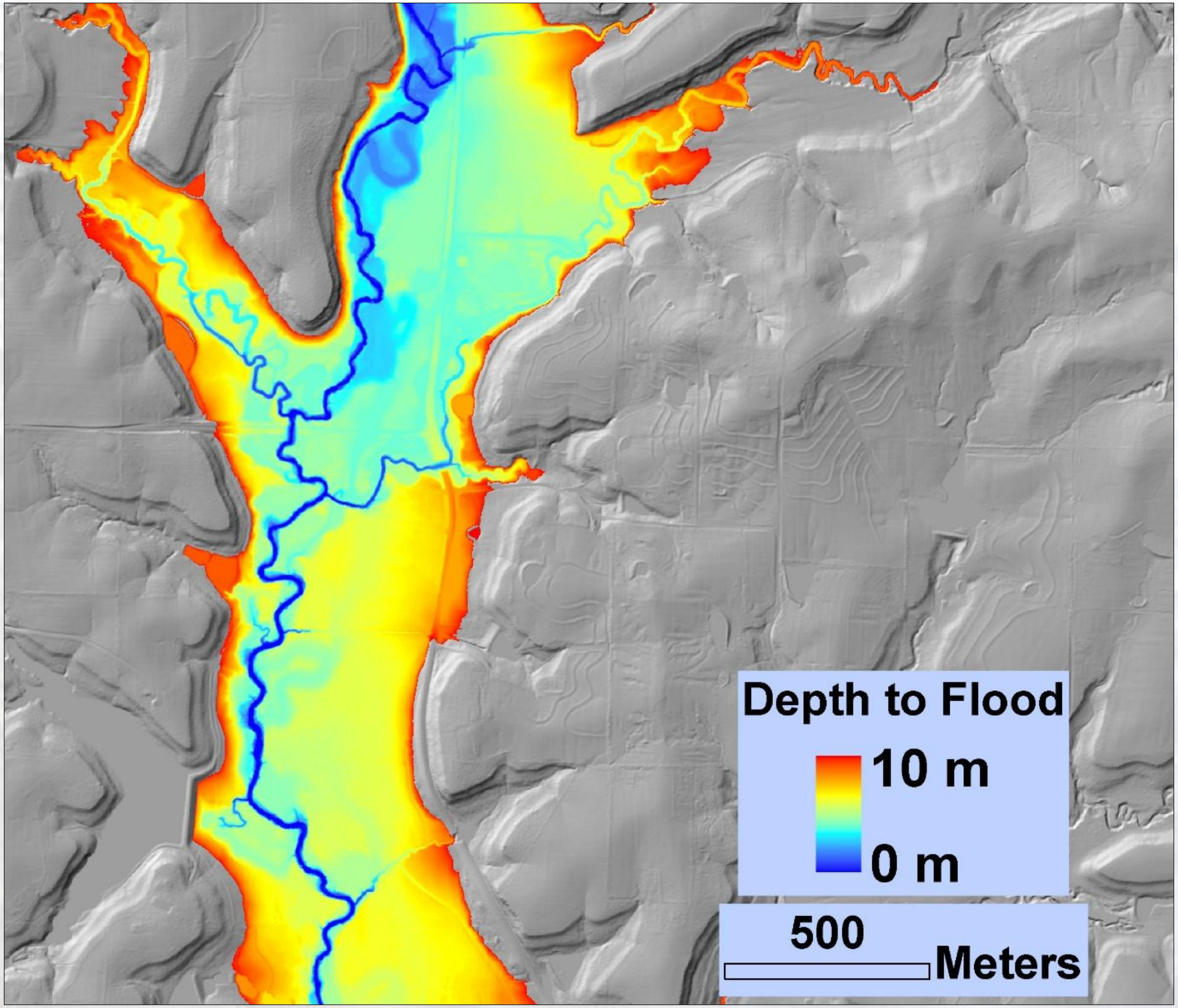
Note the erroneous discontinuities caused by ridgelines in the DEM.



Backfill + Spillover Flooding

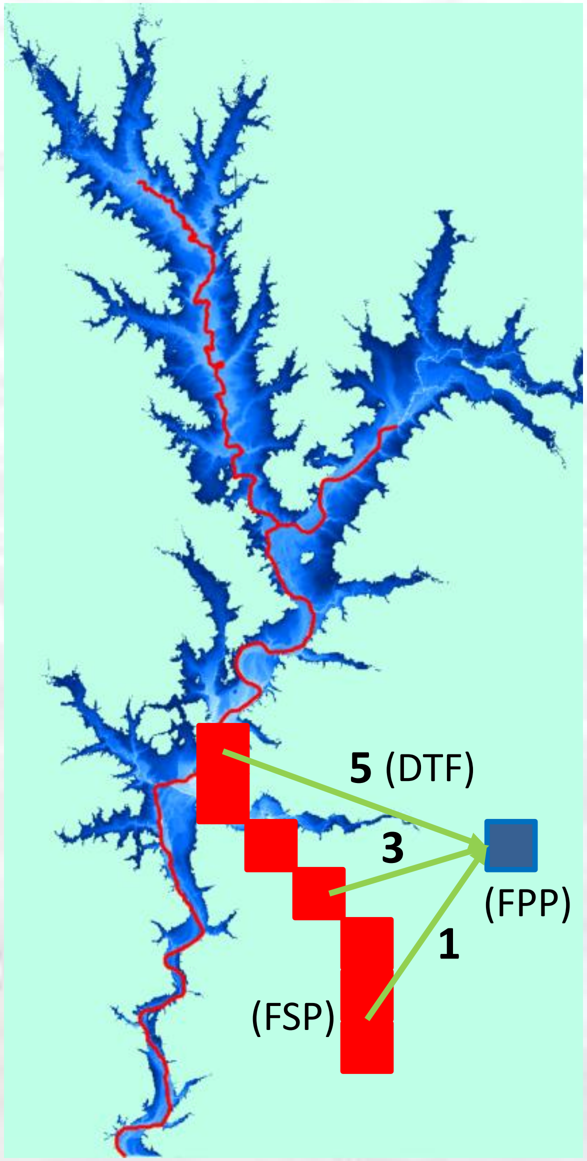
By backfill flooding using small flood depth increments and allowing spillover flooding to occur on the floodplain boundary between iterations, the DTF discontinuity problem is mostly resolved.

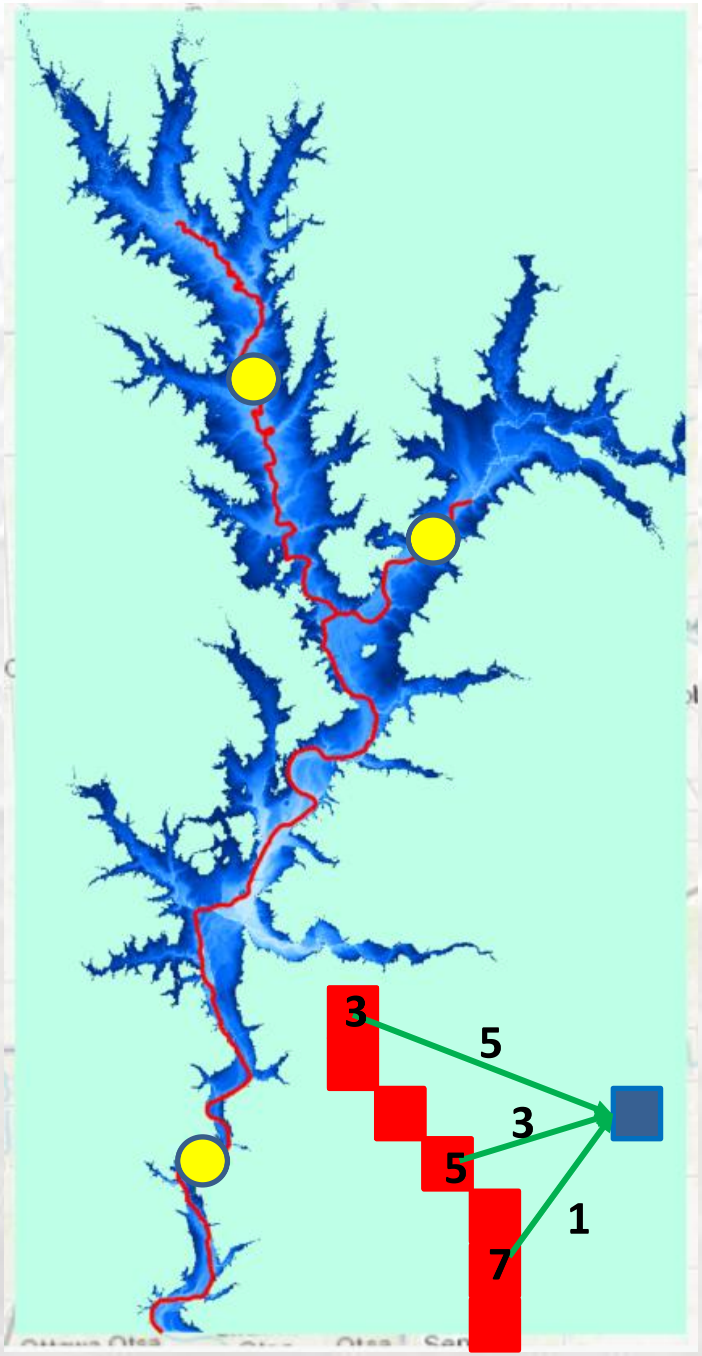
The 10-m steady state floodplain is shown, computed using the FLDPLN model and 0.5 m increments.



FLDPLN Library

- Flood stream pixel (FSP)
- Floodplain pixel (FPP)
- FLDPLN model identifies the **flood inundation relationship** between FSP and FPP through an iterative process segment by segment
- Depth to flood (DTF) is the minimum depth needed to flood a FPP from a FSP
- Many-to-many FSP-FPP-DTF relationship
  - 1 FSP → n FPPs
  - 1 FPP ← n FSPs



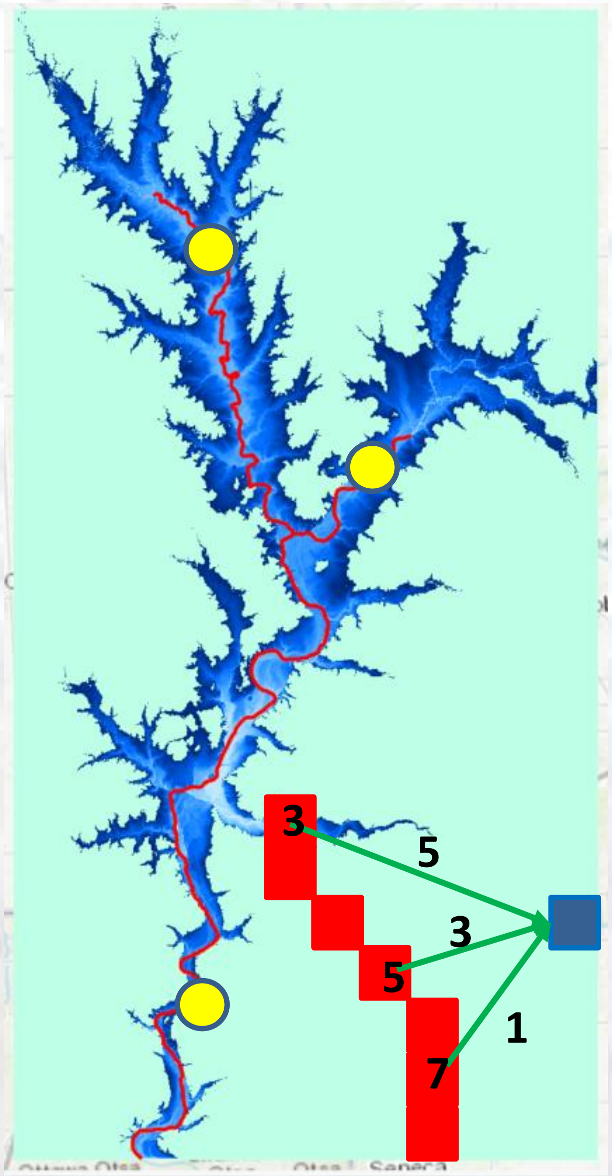


Flood Inundation Mapping

- With depth of flow (DOF) (or stage) at FSPs estimated
- A FPP is flooded by a FSP if its DOF > DTF
  - $FloodDepth_{FSP(i)} = DOF_{FSP(i)} - DTF_{FSP(i)}$
- Flood depth at a FPP
  - $max(FloodDepth_{FSP(1)}, \ldots, FloodDepth_{FSP(n)})$
  - N is the number of FSPs that can flood the FPP
- Example
  - Flood depth = max((5-3), (7-1)) = 6

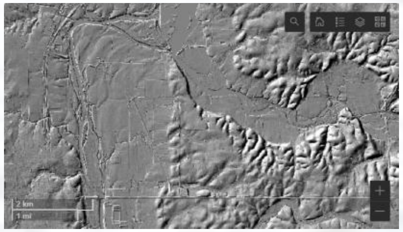
Interpolate Stream/FSP Stage (DOF)

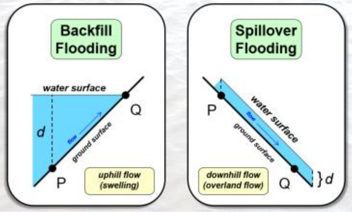
- Linear interpolation between gauges
  - Horizontal distance
  - Vertical elevation
  - Assume smooth DOF change
  - Based on steam orders
    - From low (mainstem) to high (tributary)
    - Confluences are used as gauges for higher order streams
- Volume-based interpolation
  - Each segment has a stage-volume rating curve
  - Stages observed at gauges are converted to volumes
  - Volume is linearly interpolated between gauges
  - Interpolated volume converted to stage for each segment



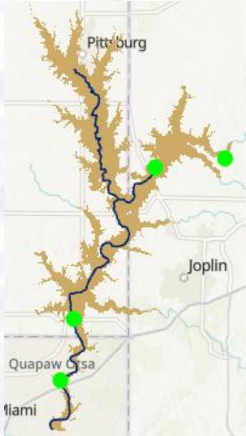
Kansas FIM Workflow

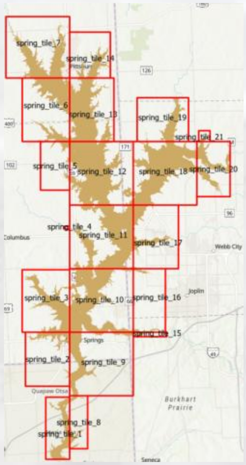
- Hydro-conditioning DEM
- Generate FLDPLN segment-based library
- Tile segment to tiled library
- Inundation mapping (real-time or forecast)
- Serving flood depth map

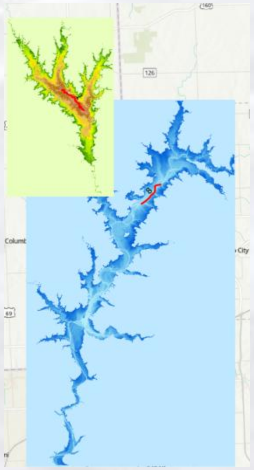


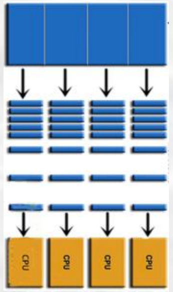


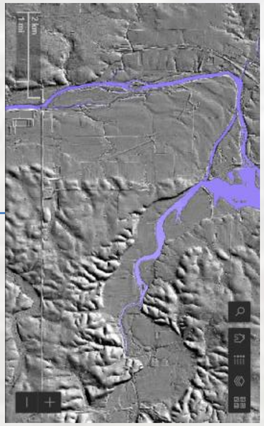
FLDPLN

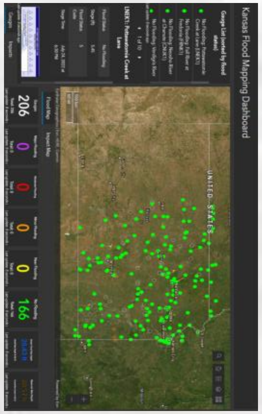




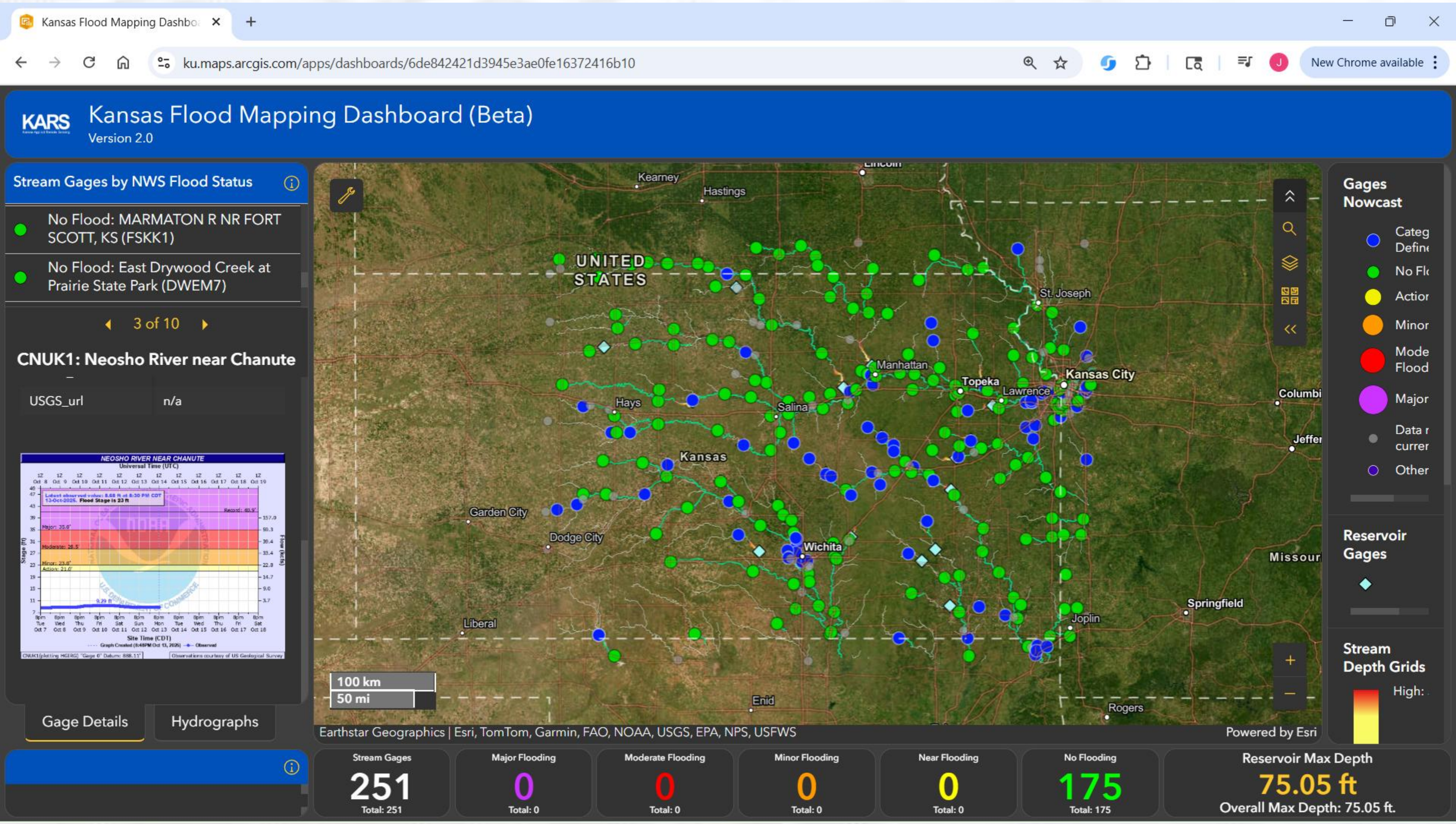




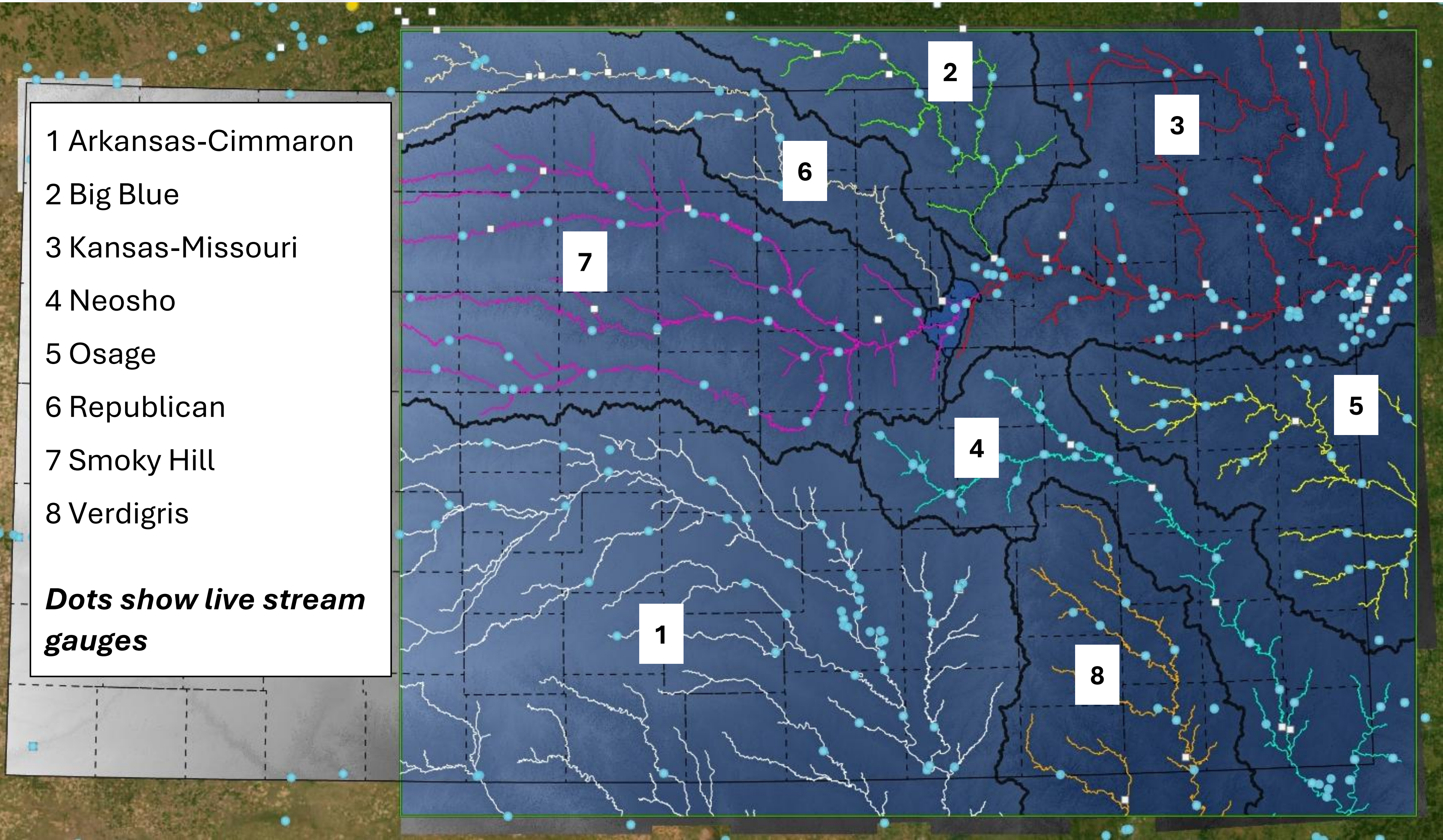




Kansas Flood Mapping Dashboard



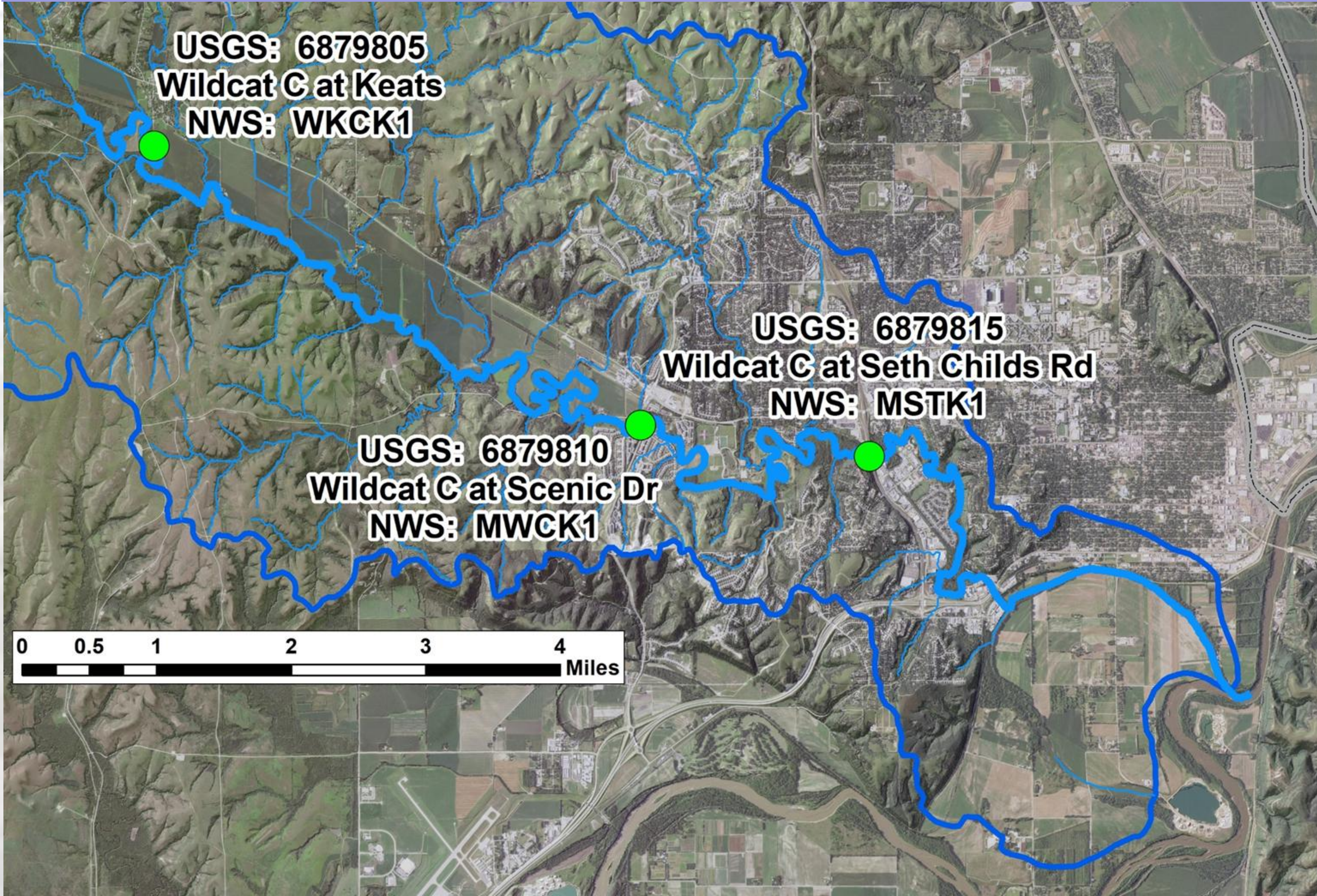
Kansas FLDPLN Libraries



Mapping Wildcat Creek 2018 Labor Day Flood

- Wildcat Creek data is on KU KBS-KARS server
  - DEM (GeoTIFF and BIL)
  - Gauge data
  - Reference inundation map
  - Segment shapefiles (not necessary but just in case)
- Notebooks, Python packages and tools are on GitHub
- Installer with MATLAB Runtime included is on a KU server

Mapping Sep. 3, 2018 Wildcat Creek Flood



Prepare DEM

- Hydro-condition DEM
  - No conditioning for the Wildcat DEM 10-m DEM
  - Larger than the Wildcat Creek
- Convert hydro-conditioned DEM (in GeoTIFF) into BILs
  - ArcGIS toolbox fldpln preprocess model.atbx
  - fldpln_pre_process_tool tool

Build the fldpln_fim Python Environment

- 00_build_fldpln_python_environment.md
- Major steps
  - Install miniconda to access conda
  - Create the fldpln_fim environment using fldpln_fim.yaml
  - Install MATLAB runtime and the fldpln_model package for running FLDPLN model
  - Install fldpln package for tiling and mapping

Build Segment-Based Library

- 01_build_segment_library.ipynb
- Major steps
  - Identify stream networks and generate segments
  - Select segments and prepare spatial mask
    - Wildcat Creek segments are already selected in a shapefile
  - Create raw segment-based library
  - Generate stage-volume tables
  - Reformat segment-based library
  - Generate stream order

Tile Segment-Based Library

- 02_build_tiled_library.ipynb
- Major steps
  - Tile segment-based library
  - Calculate FSP and segment downstream distance
  - Move stage-volume into tiled library
  - Assign stream order to FSPs and segments

Map Flood Events

- 03_mapping_event.ipynb
- Major steps
  - Prepare gauge stage elevation
  - Snap gauge to FSPs
  - Interpolate FSP stage
  - Generate inundation depth map
  - Compare with NOAA/NWS FIM library maps

Create Special Maps

- 04_mapping_special.ipynb
- Four special maps
  - Minimum depth to flood map
  - Number of FSP map
  - Depression depth map
  - Constant FSP stage map (all the FSP has the same stage)

FIM Team @ KU

KARS
Kansas Applied Remote Sensing

Jude Kastens

Xingong Li

David Weiss

Abu Mahdi

Jack Edwards

KU KANSAS BIOLOGICAL SURVEY & CENTER FOR ECOLOGICAL RESEARCH
The University of Kansas

KU DEPARTMENT OF GEOGRAPHY & ATMOSPHERIC SCIENCE
The University of Kansas
College of Liberal Arts & Sciences

CIROH

THE UNIVERSITY OF ALABAMA

James Halgren

Junho Song

Brodie Alexander

Acknowledgements

- Funding
  - Kansas Water Office (KWO) / KDEM
  - CIROH and CIROH Visiting Scholar program (2025)

- Contact
  - Xingong Li (lixi@ku.edu)