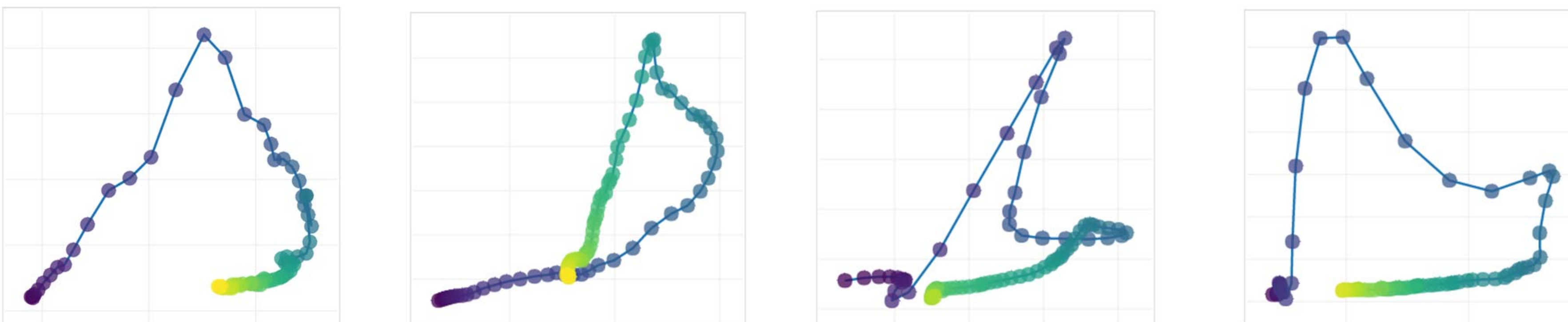
Applying Deep Learning to Hydrological Events for Watershed Modeling

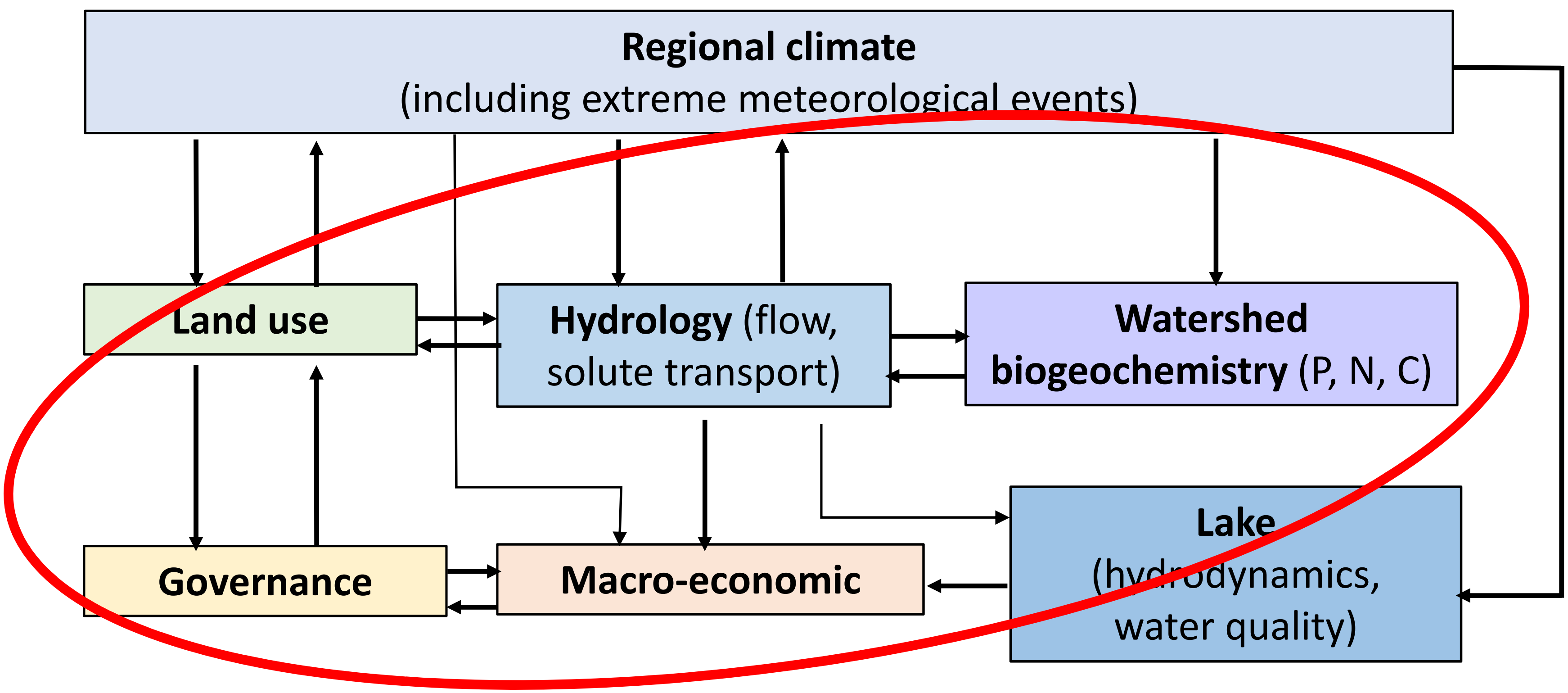


Scott Hamshaw, Donna Rizzo, Mandar Dewoolkar

Vermont EPSCoR | 06.04.2019

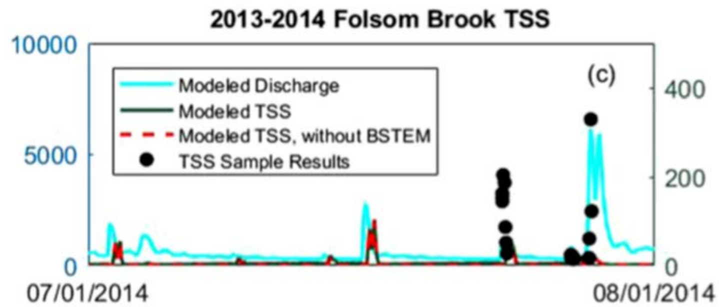
BREE
Basin Resilience to Extreme Events
in the Lake Champlain Basin

Major Features of the BREE Integrated Assessment Model



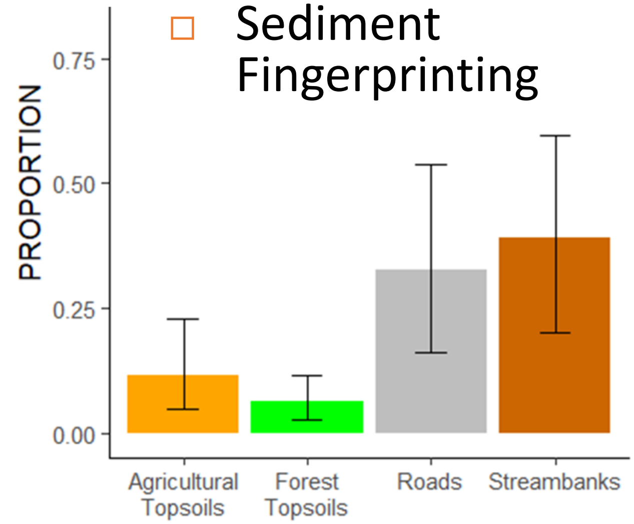
Identifying where riverine sediments originate

- Watershed Modeling



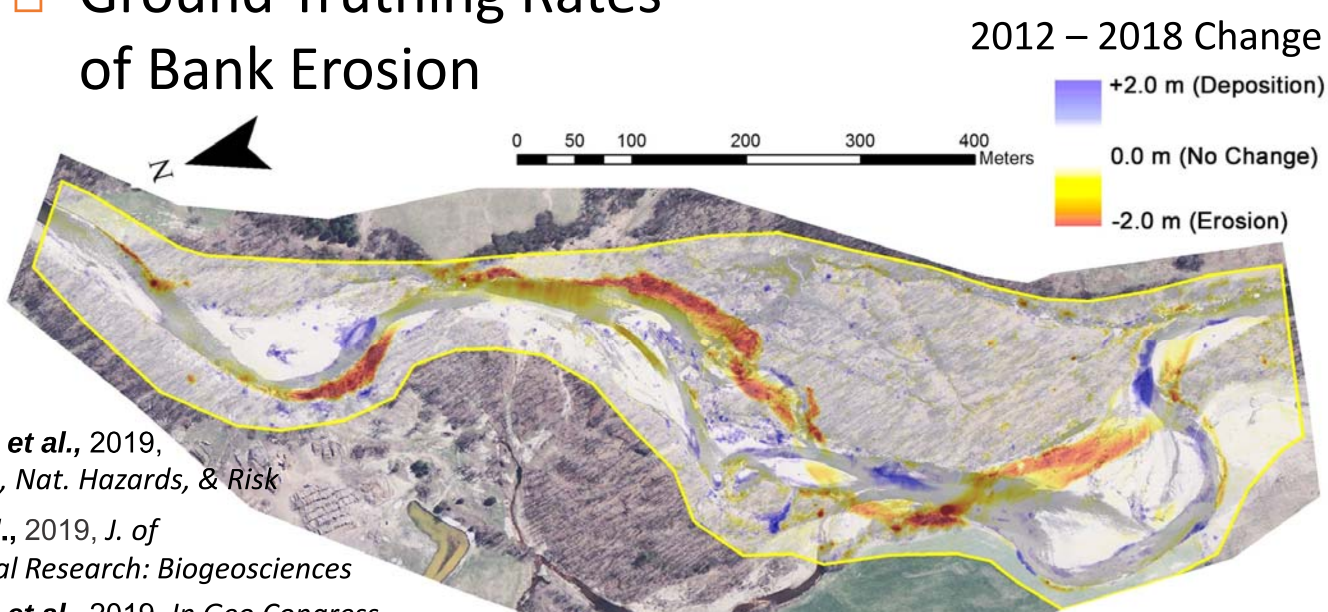
SOURCE: **Stryker, et al.,** 2018, *Journal of Hydrology: Regional Studies.*

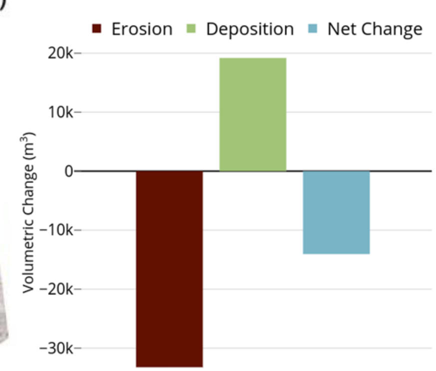
- Sediment Fingerprinting



SOURCE: **Underwood *et al.*, 2018**.

- Ground Truthing Rates of Bank Erosion



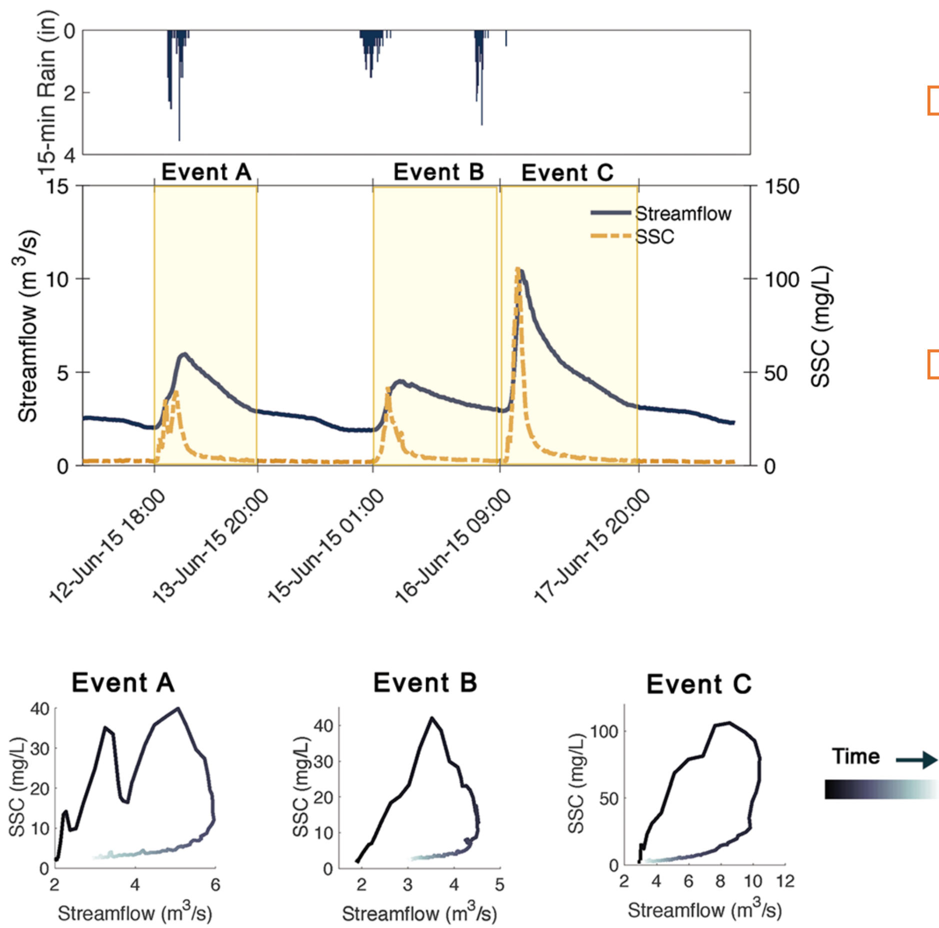


SOURCES:
Hamshaw *et al.*, 2019, *Geomatics, Nat. Hazards, & Risk*

Ross *et al.*, 2019, *J. of Geophysical Research: Biogeosciences*

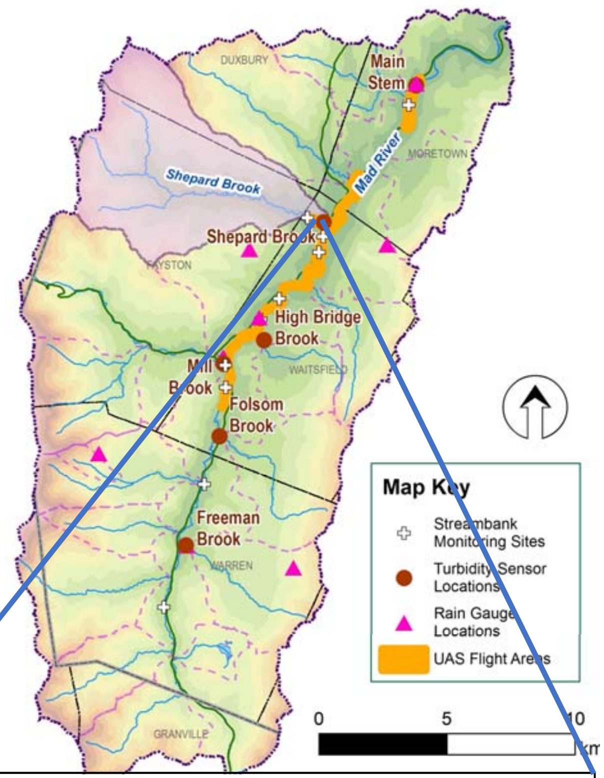
Hamshaw *et al.*, 2019, *In Geo Congress.*

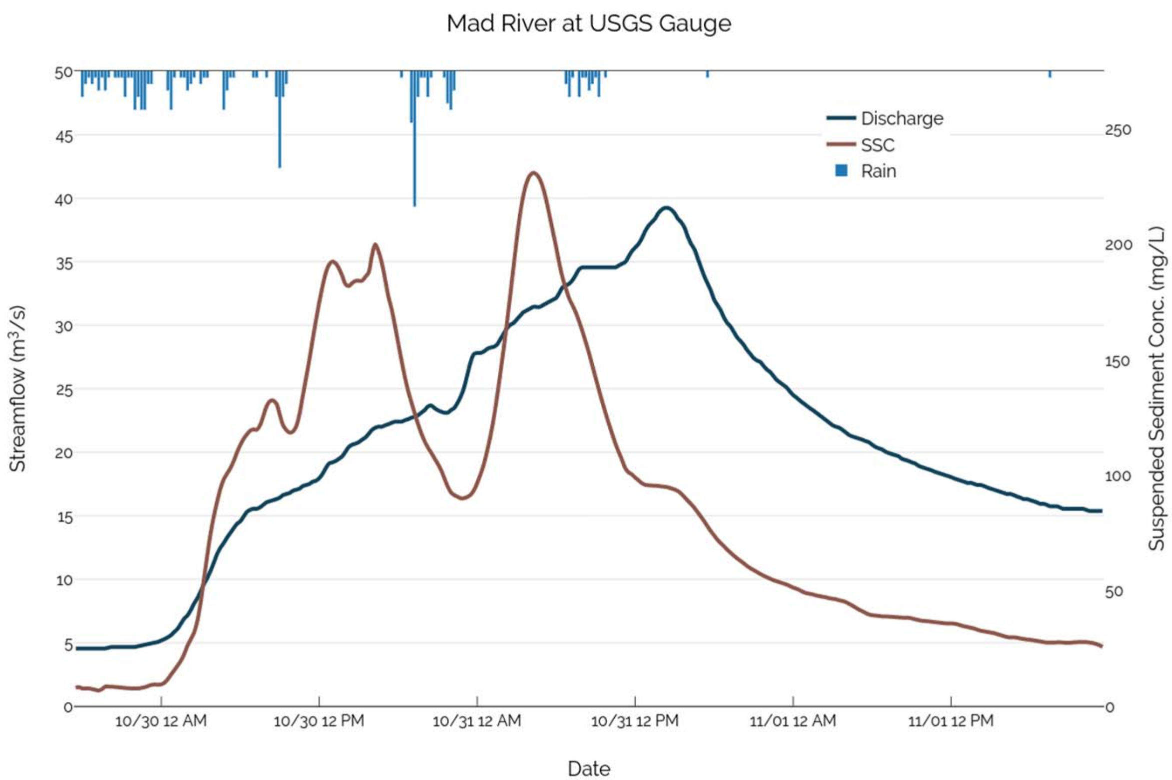
Another approach to understanding sediment dynamics in watersheds

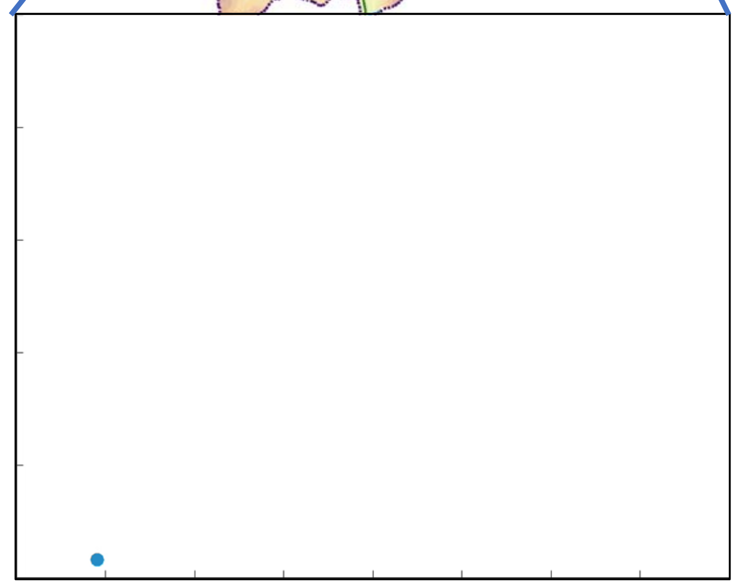


- Mine high-frequency water quality data
- Identify “types” of hydrological events

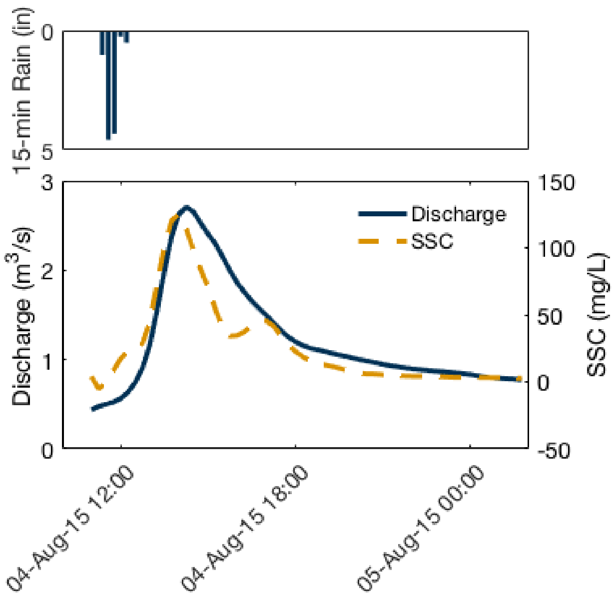
Smart Hydrological event analysis

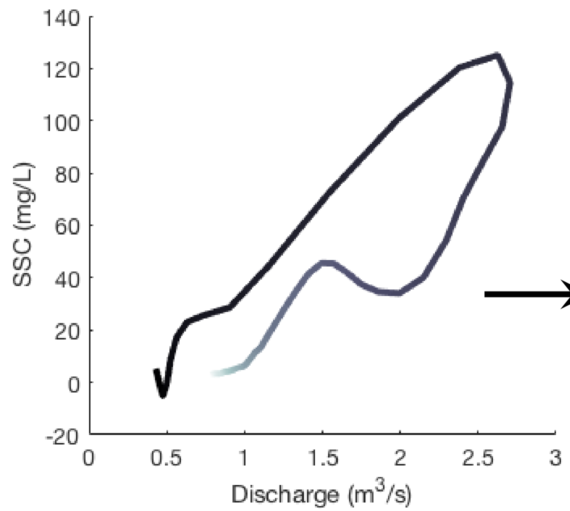




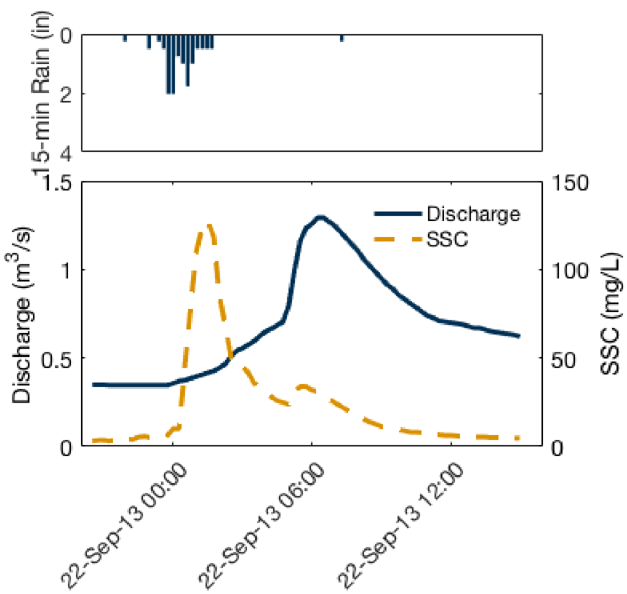


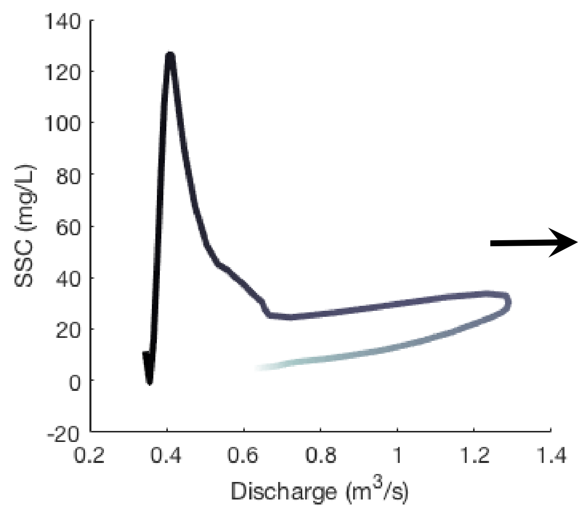
What if we let the watershed tell us what is going on?





Streamflow activated (channel network) sediment sources





Rainfall activated sediment sources

Methods of hysteresis (event) analysis

- **Garnett Williams, USGS, 1989**

Class I – Linear

Class II – Clockwise

Class III - Counterclockwise

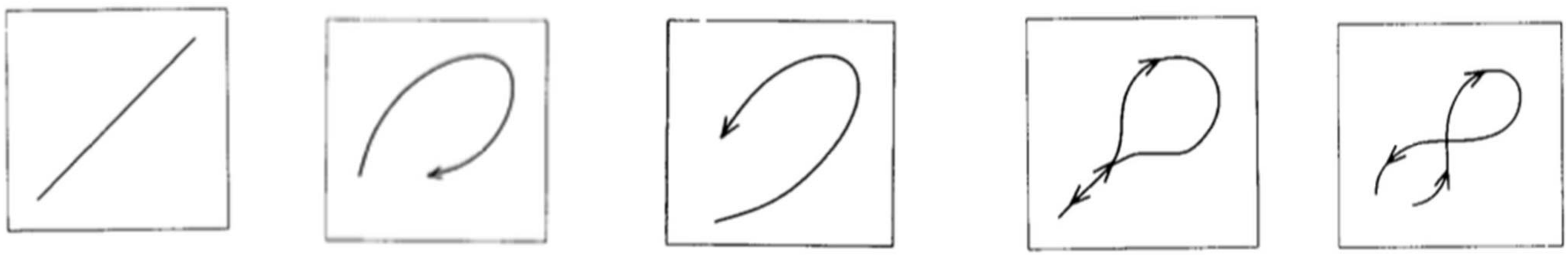
Class IV – Linear then Clockwise

Class V – Figure-Eight

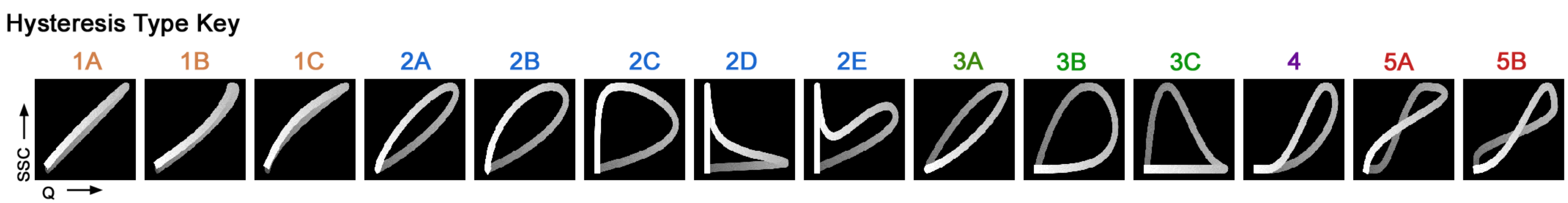
Methods of hysteresis (event) analysis

- **Garnett Williams, USGS, 1989**

Class I – Linear | Class II – Clockwise | Class III - Counterclockwise | Class IV – Linear then Clockwise | Class V – Figure-Eight



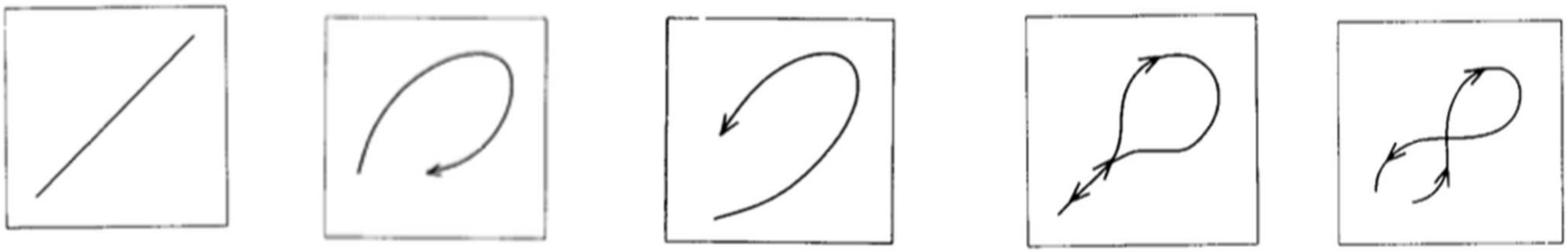
- **Expanded Hamshaw Classes/Patterns**



Methods of hysteresis (event) analysis

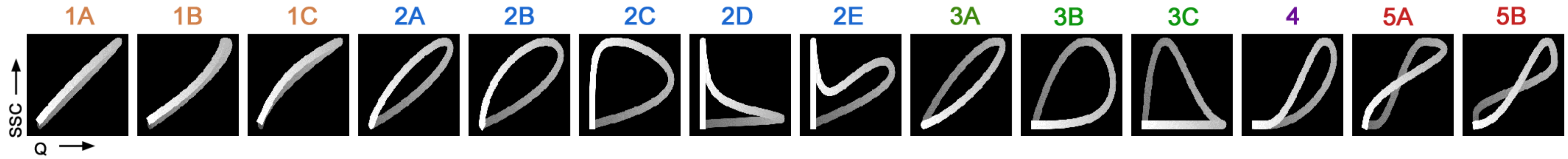
- **Garnett Williams, USGS, 1989**

Class I – Linear | Class II – Clockwise | Class III - Counterclockwise | Class IV – Linear then Clockwise | Class V – Figure-Eight



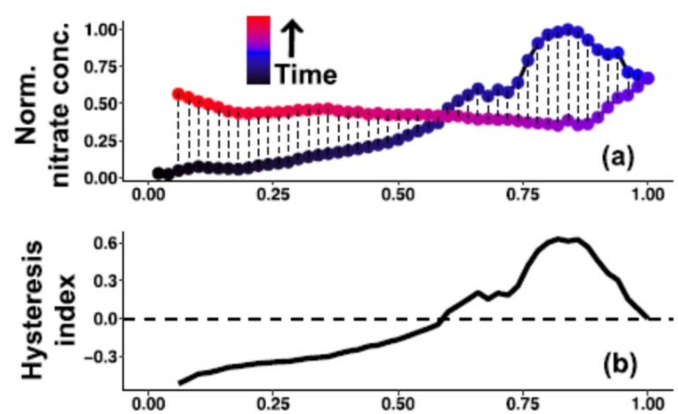
- **Expanded Hamshaw Classes/Patterns**

Hysteresis Type Key



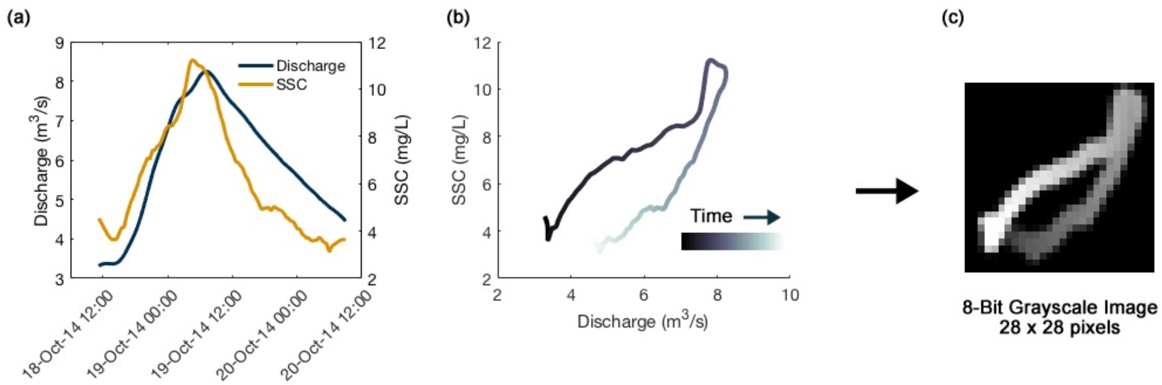
- **Hysteresis Index (non categorical)**

HI



SOURCE: **Vaughan, et al.,** 2017 *Water Resources Research.*

Automated event classification system

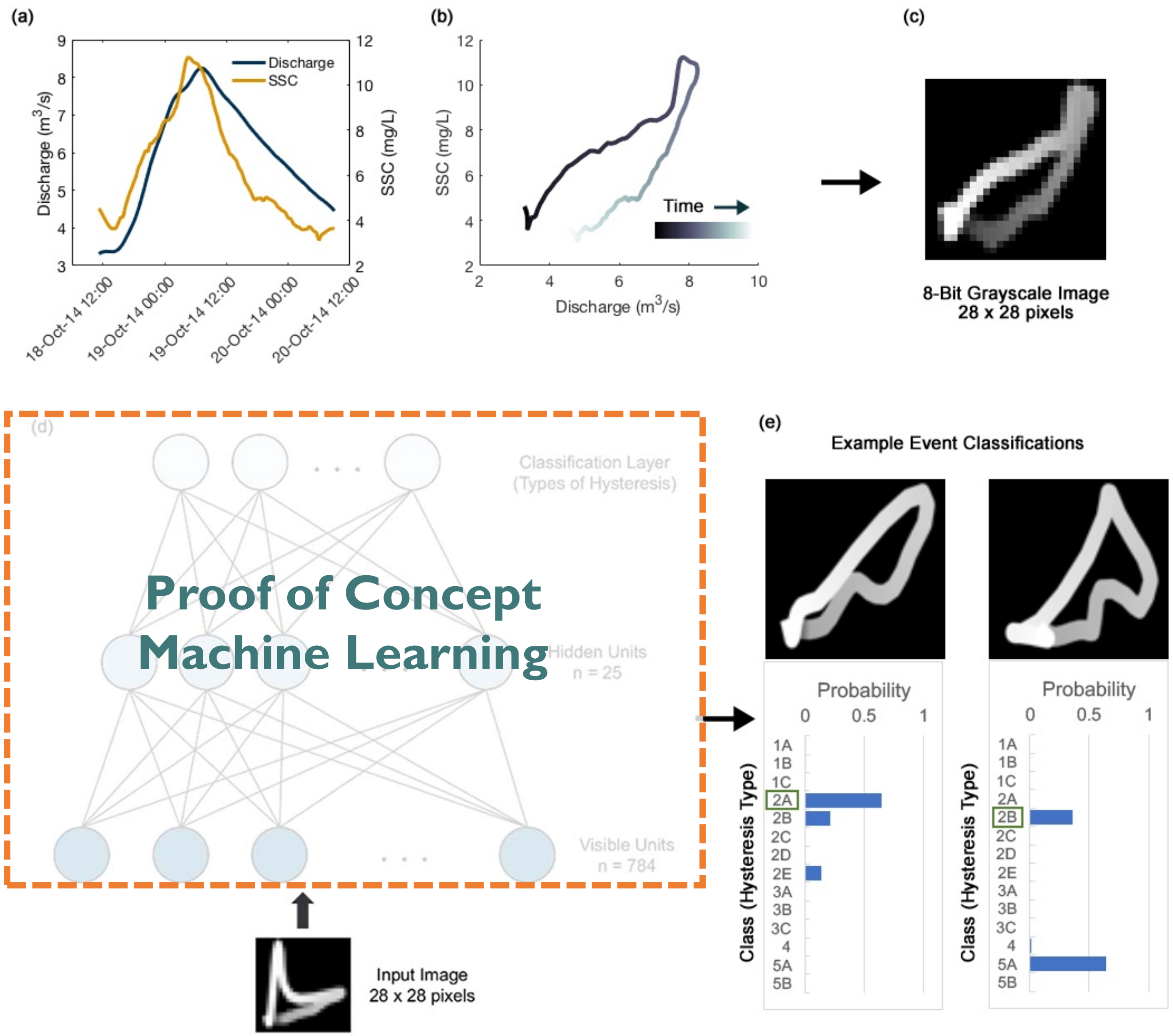


Hamshaw et al. (2018). "A new machine learning approach for
classifying hysteresis in suspended sediment-discharge relationships using high- frequency monitoring data", ***Water Resources Research***

Hamshaw & Rizzo. (2019). "Using Machine Learning to Leverage the Value of Big Data and High-Frequency Monitoring in Characterizing Watershed Sediment Dynamics" *in **DOE Open Watershed Science Report** (Invited)*

Automated event classification system

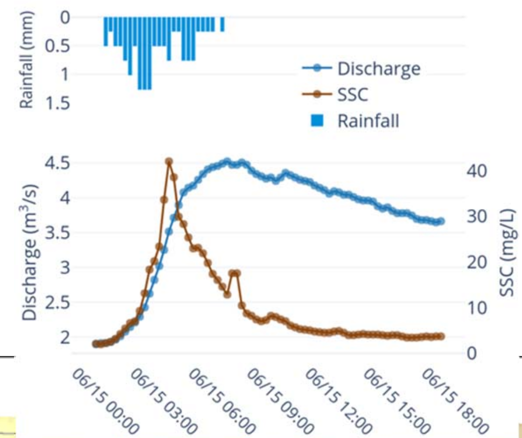
- 53% – 72% Accuracy
- Need for larger storm event data set

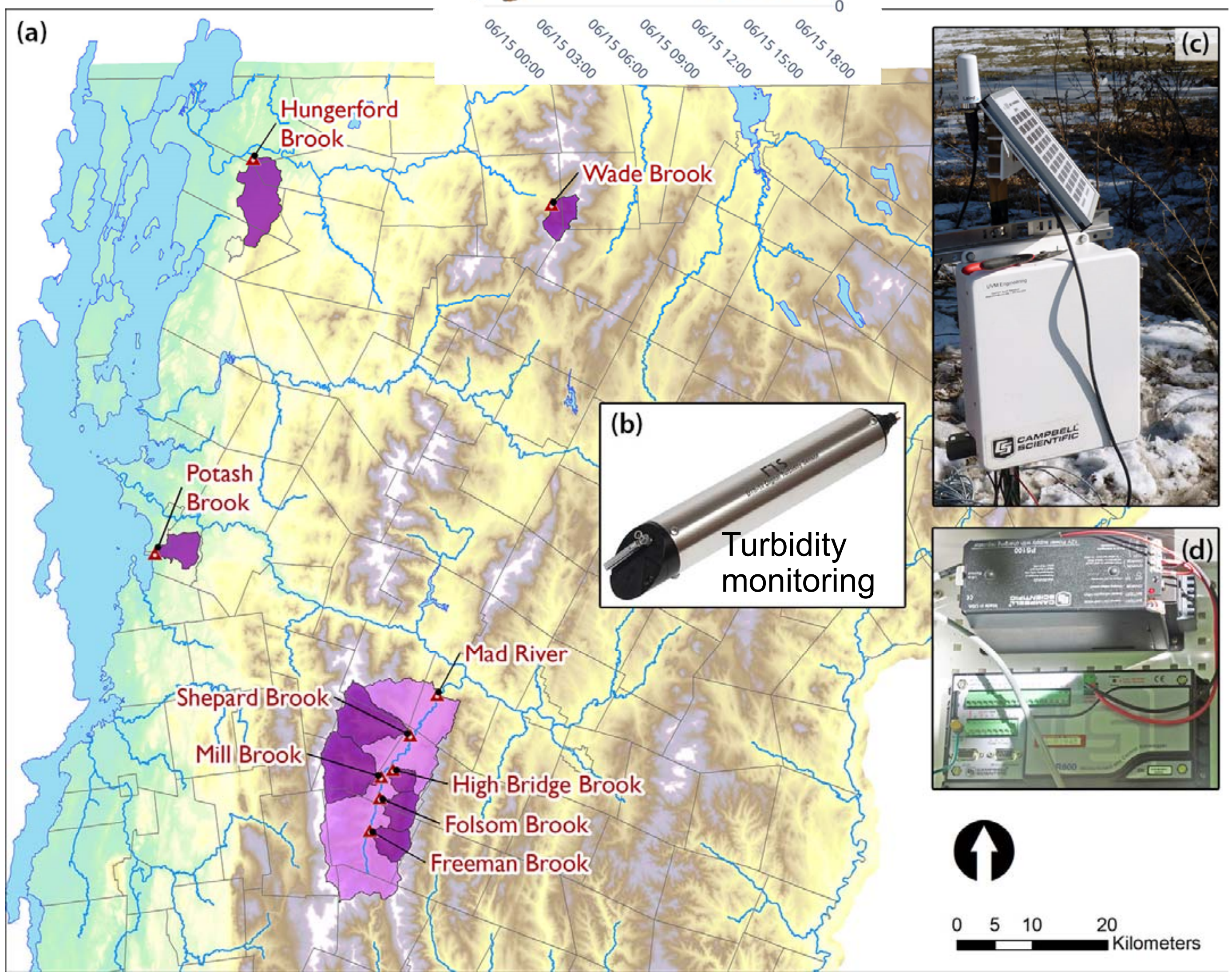


Hamshaw et al. (2018). "A new machine learning approach for classifying hysteresis in suspended sediment-discharge relationships using high- frequency monitoring data", ***Water Resources Research***

Hamshaw & Rizzo. (2019). "Using Machine Learning to Leverage the Value of Big Data and High-Frequency Monitoring in Characterizing Watershed Sediment Dynamics" *in **DOE Open Watershed Science Report** (Invited)*

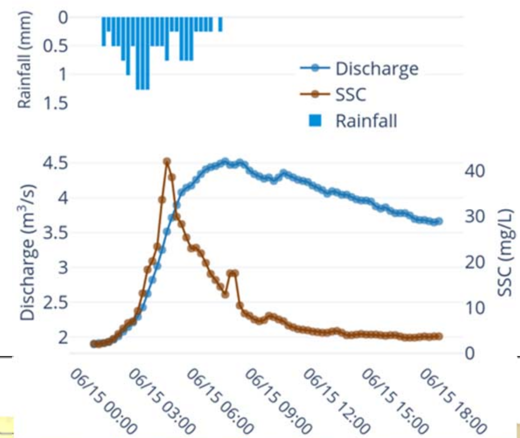
Leveraging EPSCoR in-stream water quality sensors

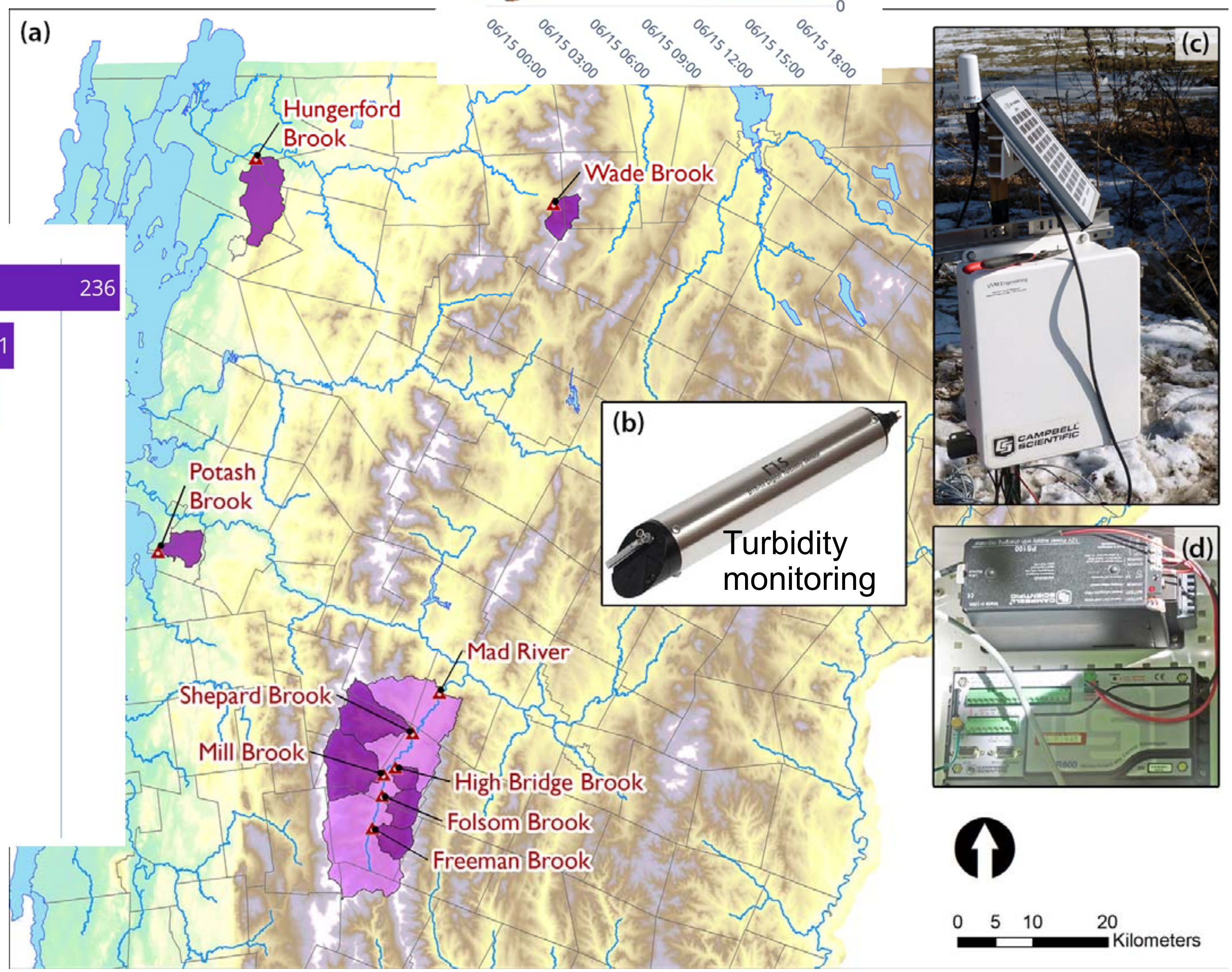


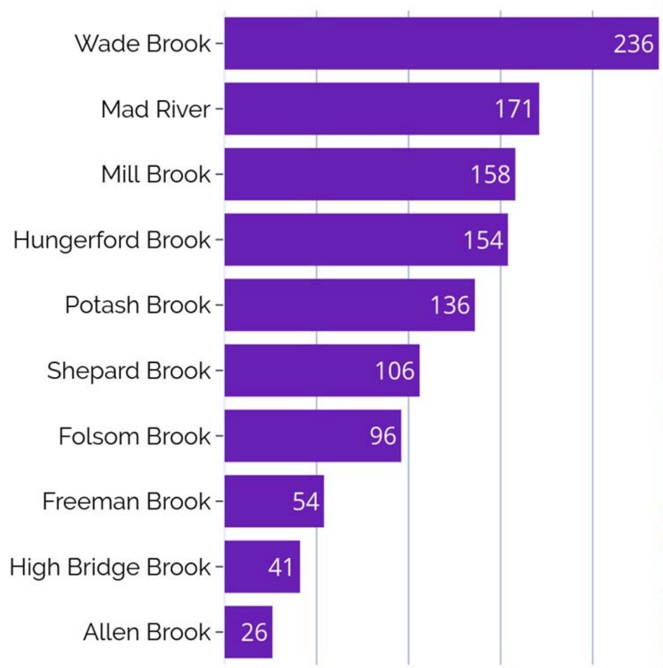


Leveraging EPSCoR in-stream water quality sensors

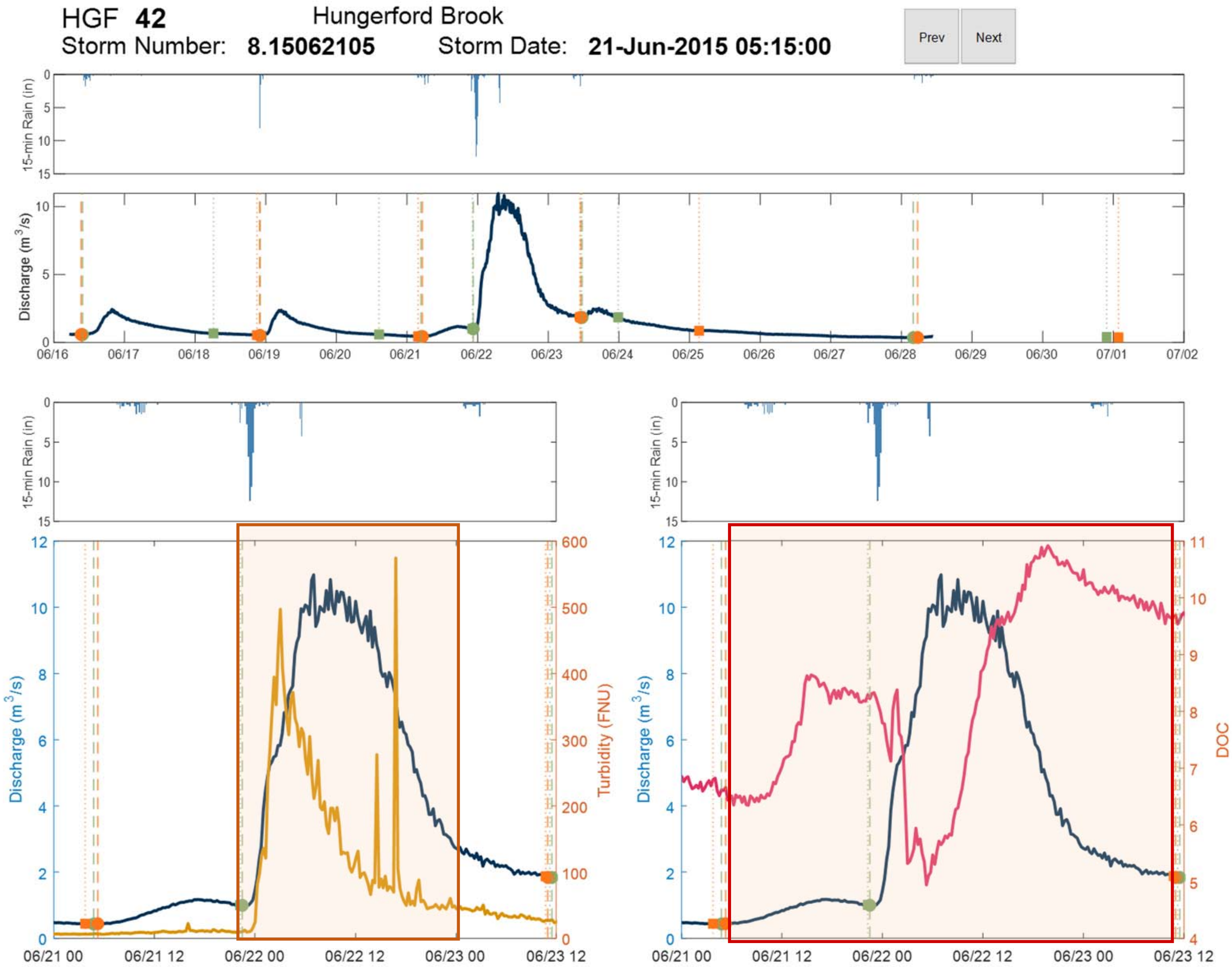
- 2012 - 2018
- **1,178 Events**







Automated, supervised event extraction

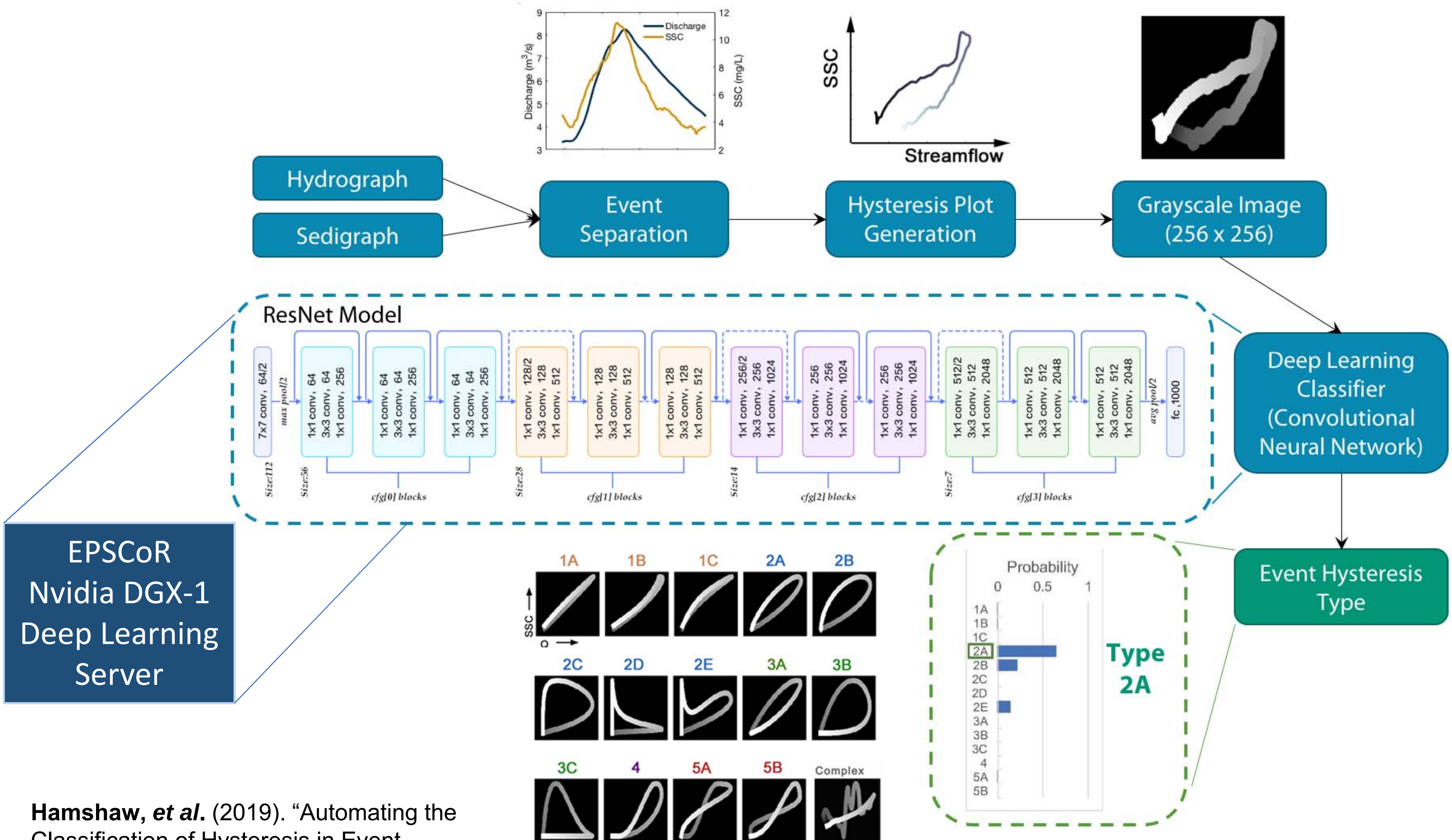


Simultaneous water quality (turbidity, DOC) and streamflow event analysis

Hamshaw & Javed, 2019. Improvements to Event-based Analysis of High-Frequency Turbidity and Suspended Sediment Monitoring Data.

CUAHSI Hydroinformatics Innovation Fellowship

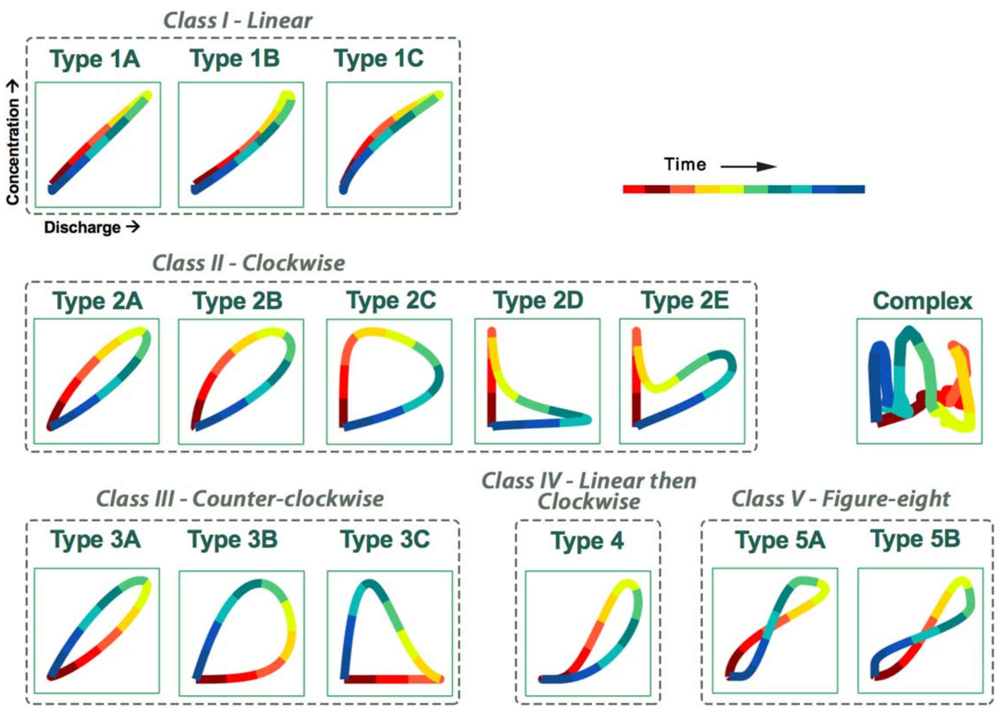
Expansion of event classification to state of the art deep learning algorithms



Hamshaw, *et al*. (2019). “Automating the Classification of Hysteresis in Event Concentration-Discharge Relationships.” *In **Proceedings of SedHyd 2019 Conference***

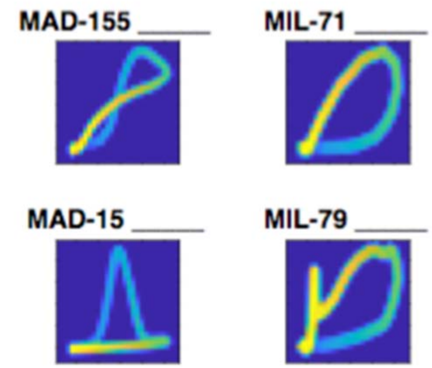
Visual representation of hydrological event data

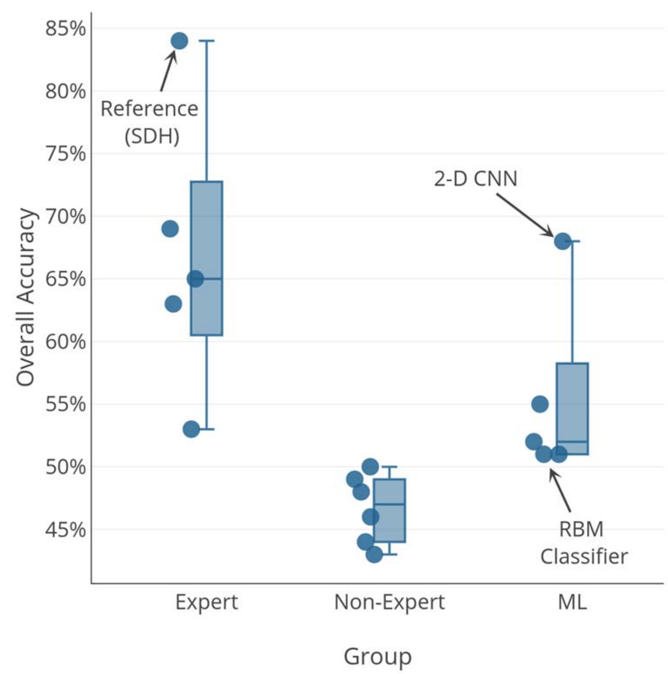
- Color as Time

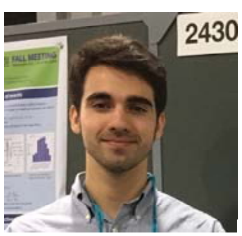


- Evaluation of human visual interpretation

Can You Identify the Hysteresis Pattern?





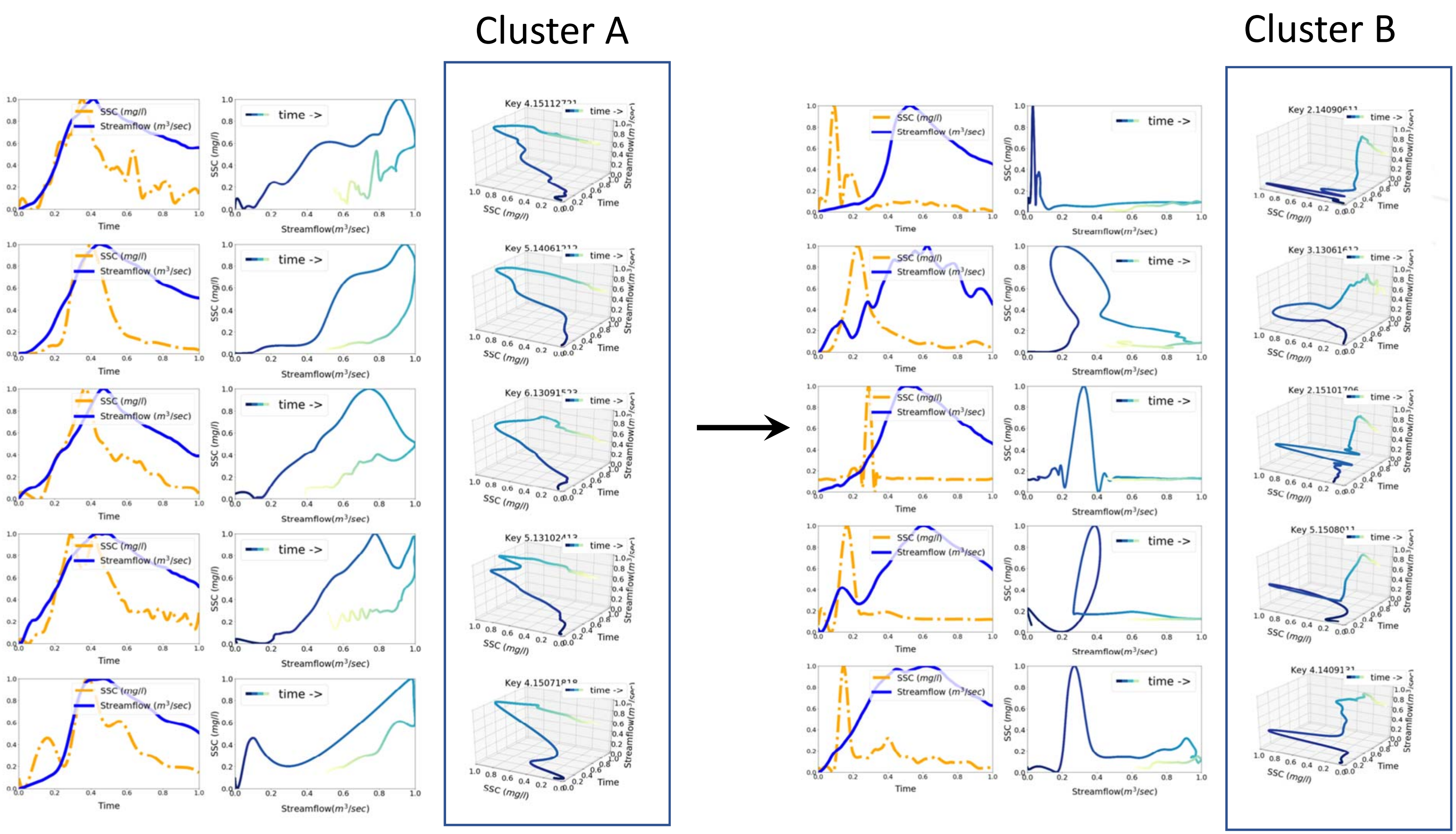


BREE Undergrad Interns **Eric Romero** & **Nicole Dávila**

Romero, *et al*. (2018). "Automating the Classification of Hysteresis in Event Concentration-Discharge Relationships." *In **AGU Fall Meeting 2018***

Data-driven identification of new categories of events

- Leverage temporal information in sensor signal “3-D trajectories”

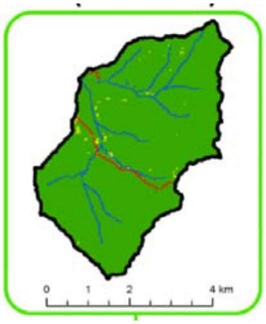


Javed et al. (2019) In preparation.

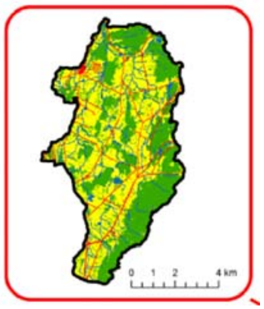
Connection to LULC/BMP

- Watersheds have existing characteristic distribution of event types
  - Affected by changes in
    - Climate & extreme events
    - LULC & BMP adoption

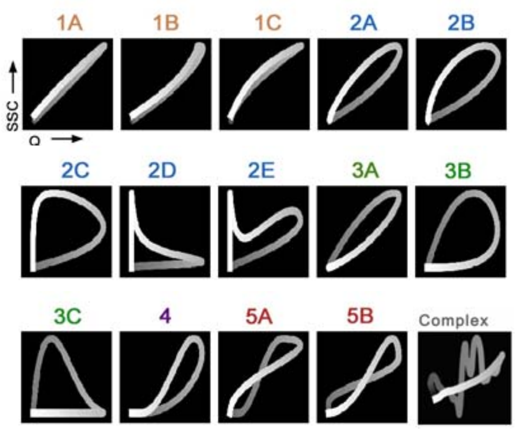
Wade Brook

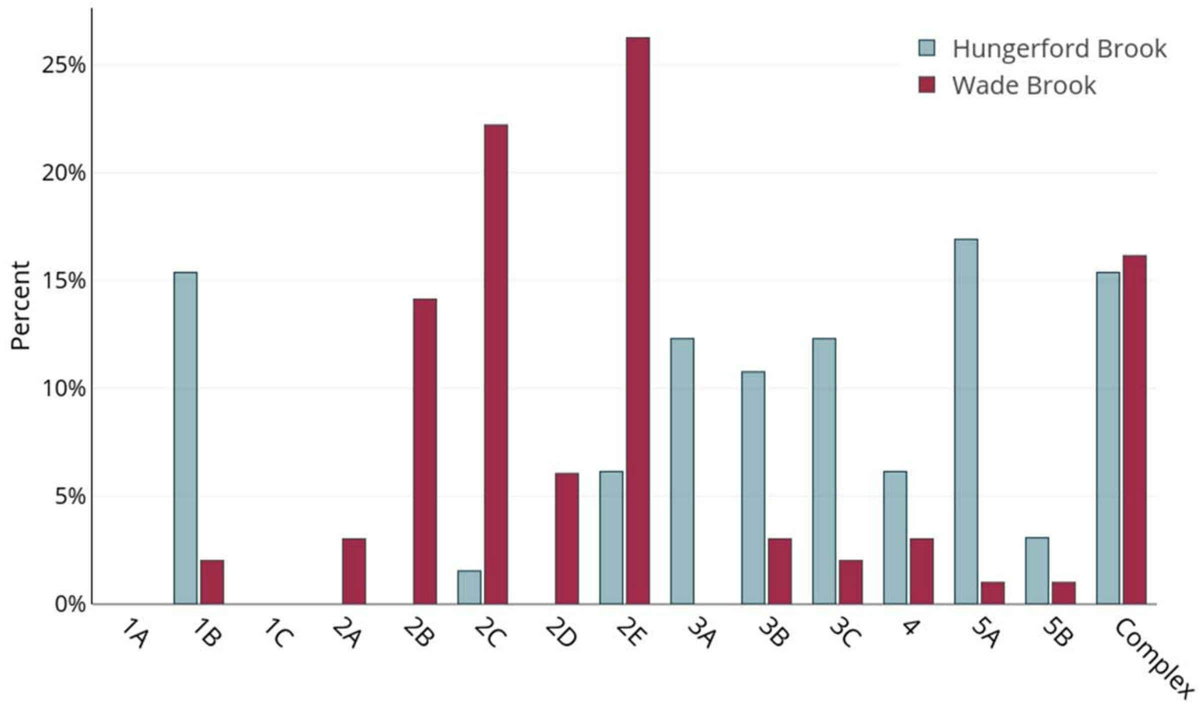


Hungerford Brook



Event Types



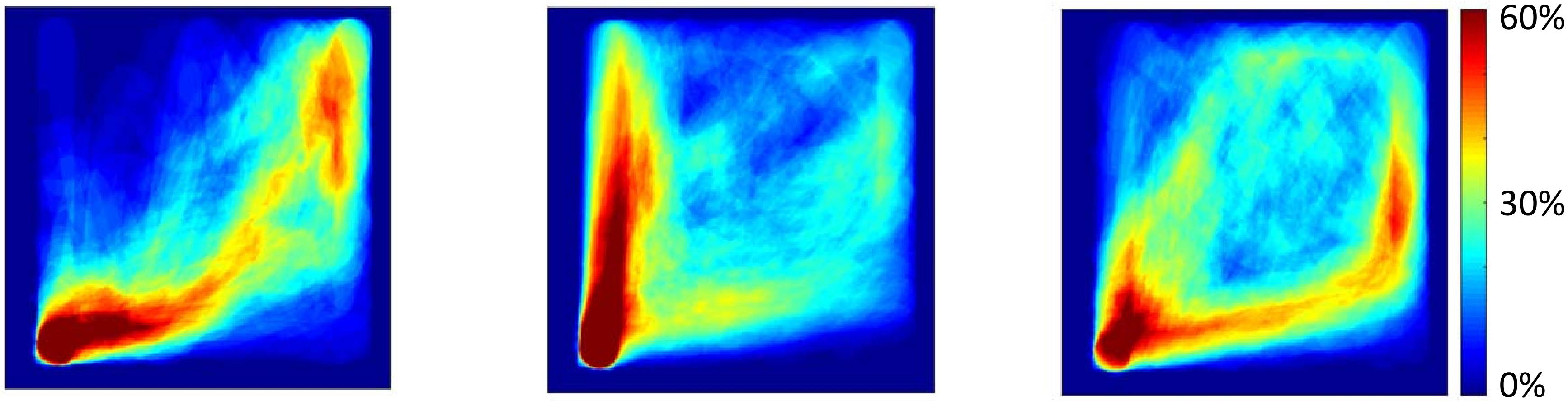


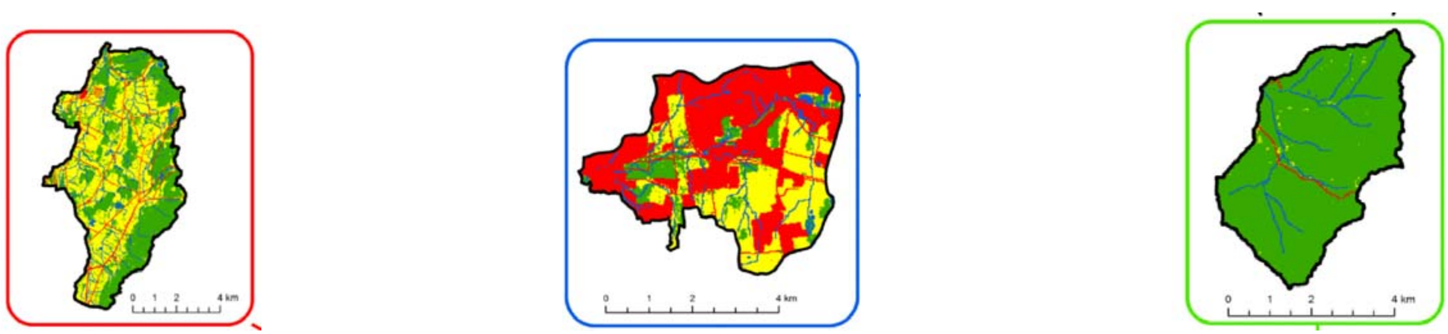
Smart detection of shifts in storm event behavior

Watershed 3:
Hungerford Brook

Watershed 2:
Potash Brook

Watershed 1:
Wade Brook

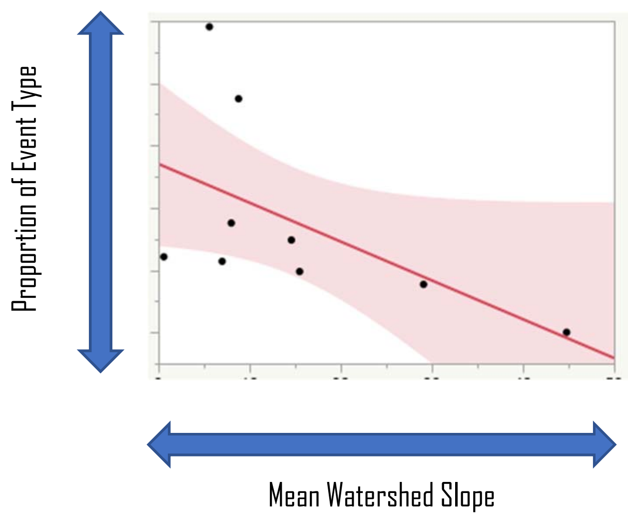


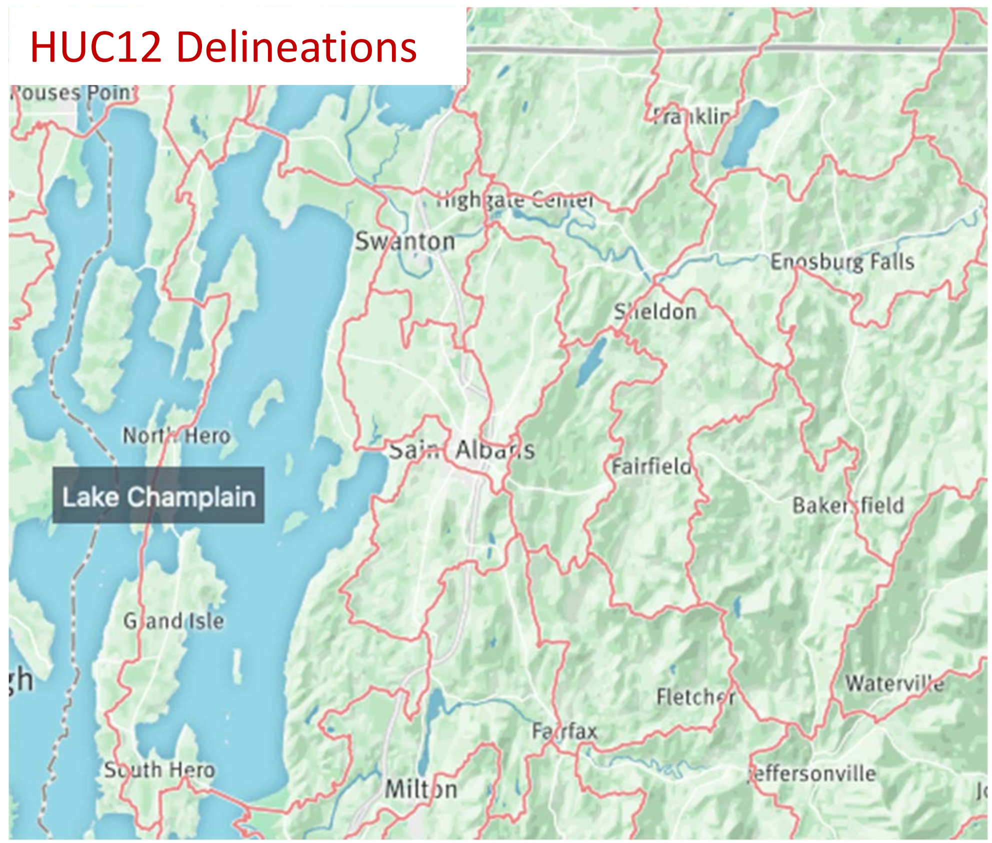


Maps courtesy
Matt Vaughan

Scaling event analysis to additional watersheds in the IAM

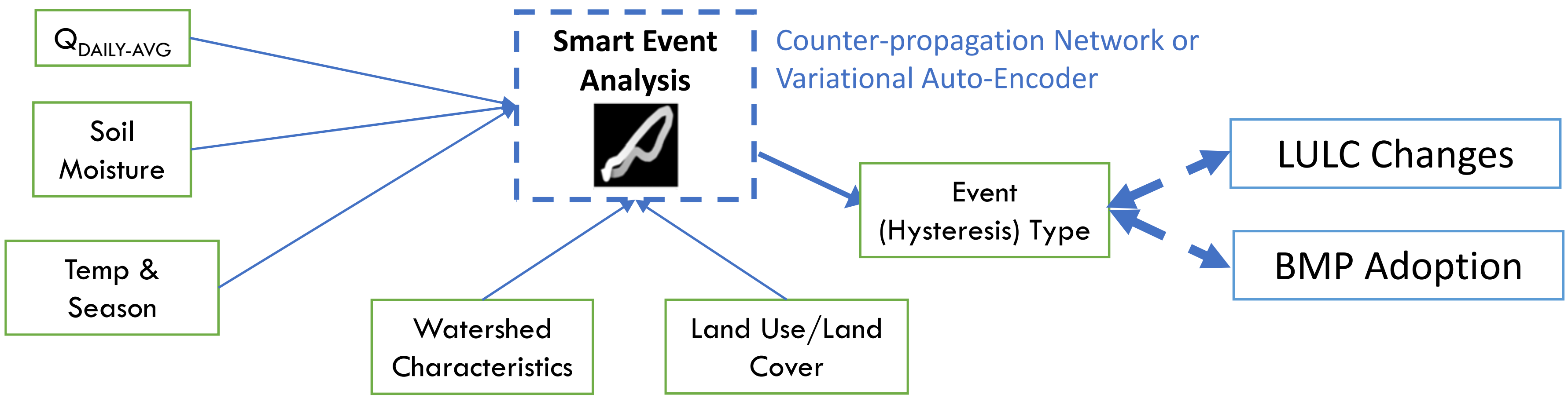
- Regionalization approach





Scaling event analysis to additional watersheds in the IAM

- Predict hysteresis type occurring at subwatershed outlet



Output → Informs BMP Implementation and Adoption:

- RHESSys (e.g., alter manure application at subwatershed level)
- ABM (e.g., alter intent to adopt)