Estimating stream flow from images: progress to date

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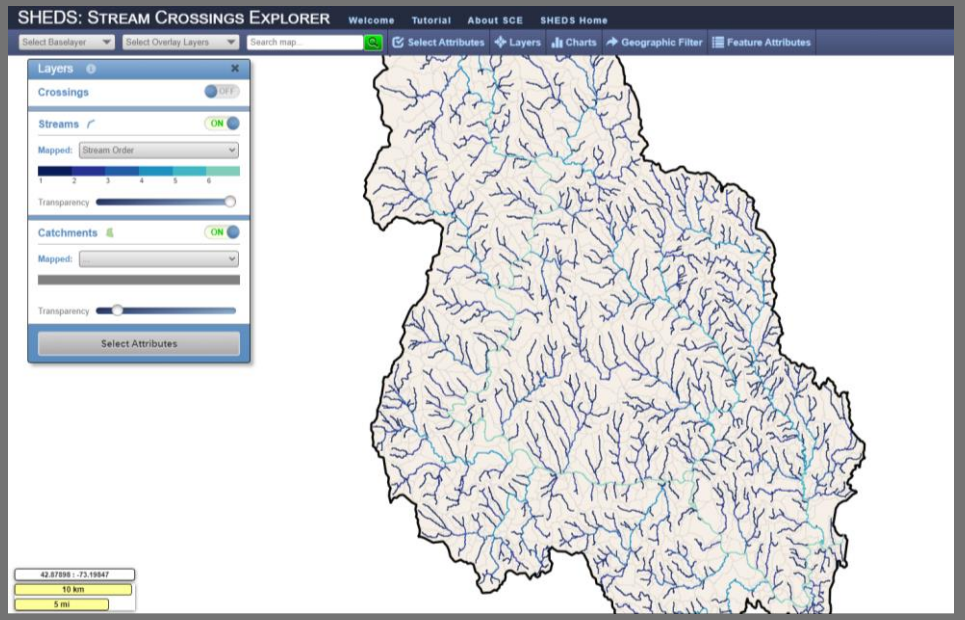
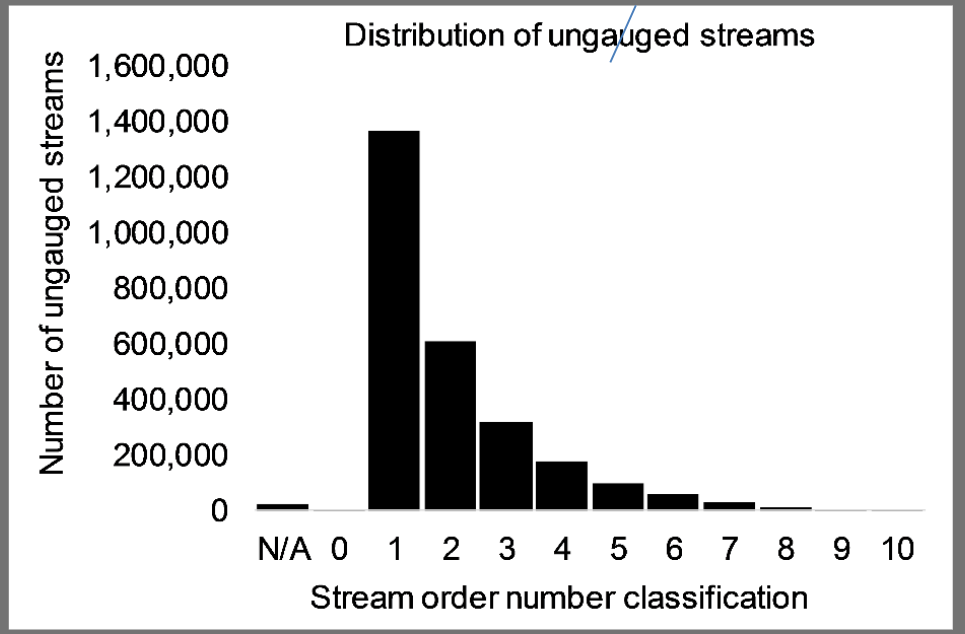
Headwaters

Small streams

- ~80% of flowing water
- Terrestrial/aquatic interface
- Critical habitat, many climate refugia (groundwater)
- Many protected waters, regulatory issues
- Nutrient, sediment and pollutant transport origin
- Climate squeeze (temperature below, flow variability above)





Brazil, I. (2018). CUAHSI Summer Institute Report 2018, HydroShare

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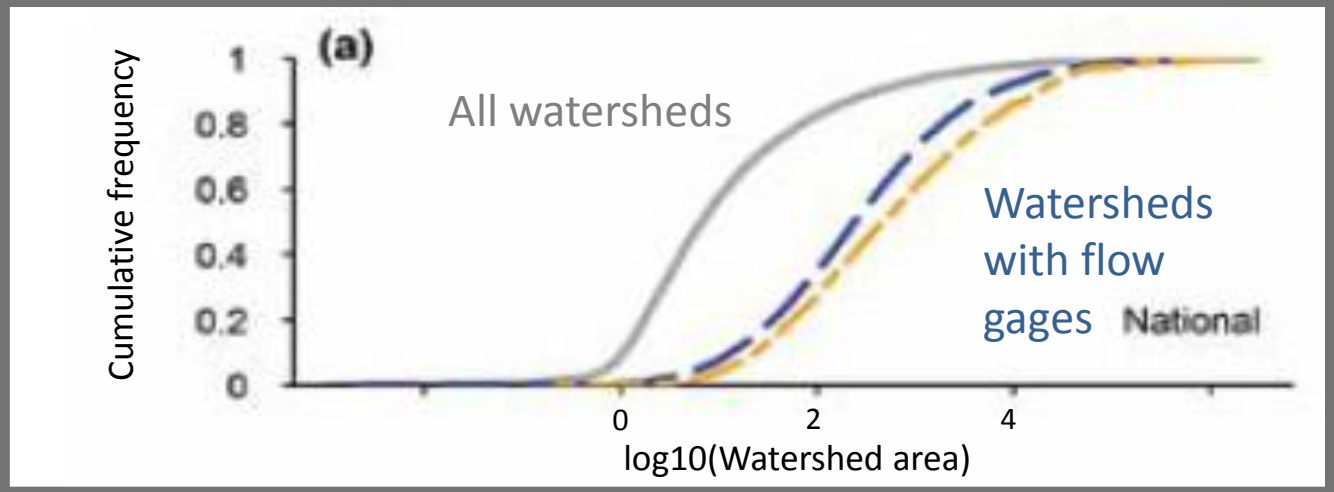
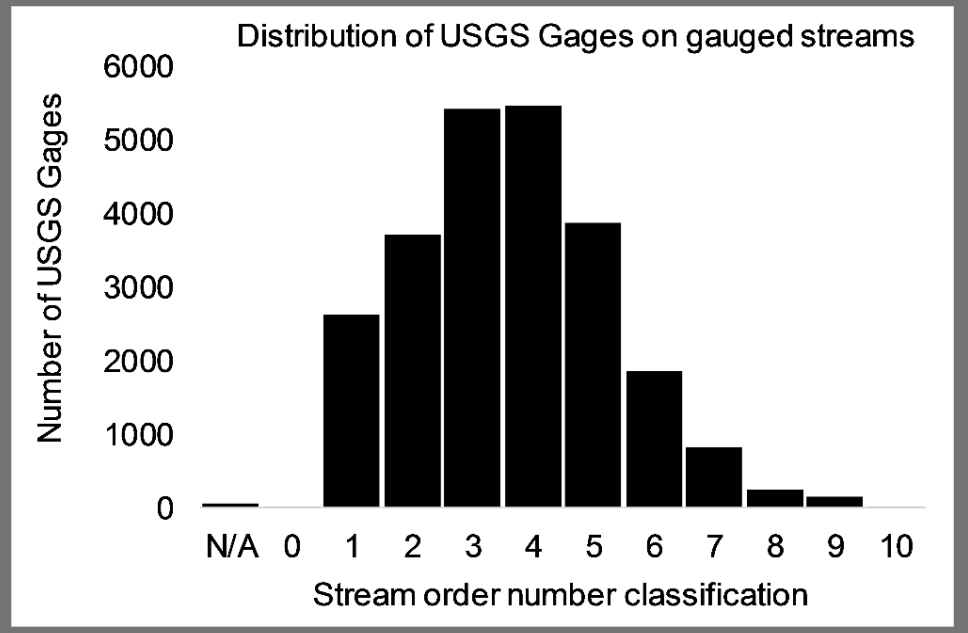
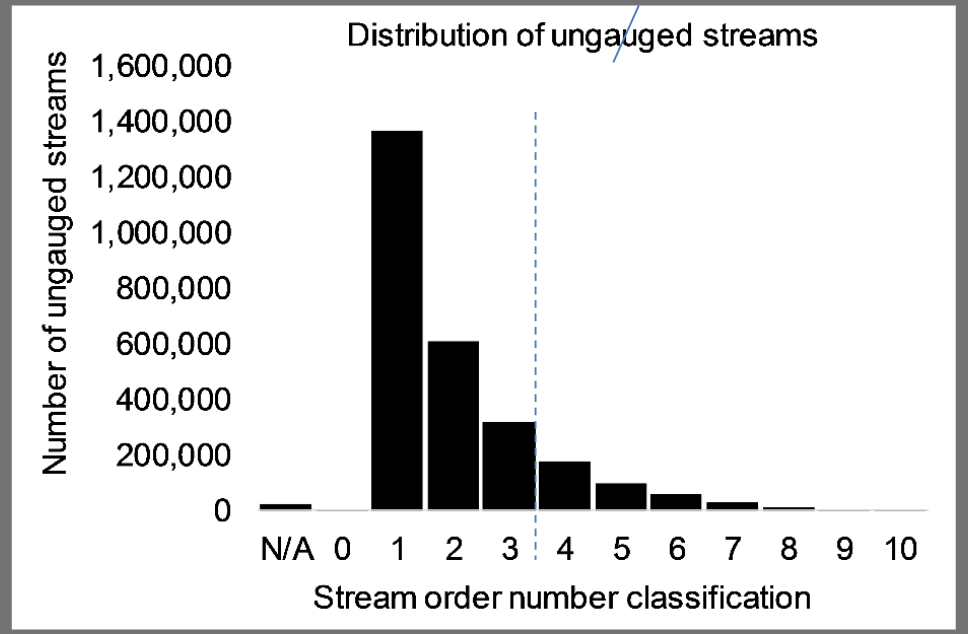
Fewer USGS gages in headwaters



Deweber, et al. 2014. Fisheries





Brazil, l. (2018). CUAHSI Summer Institute Report 2018, HydroShare

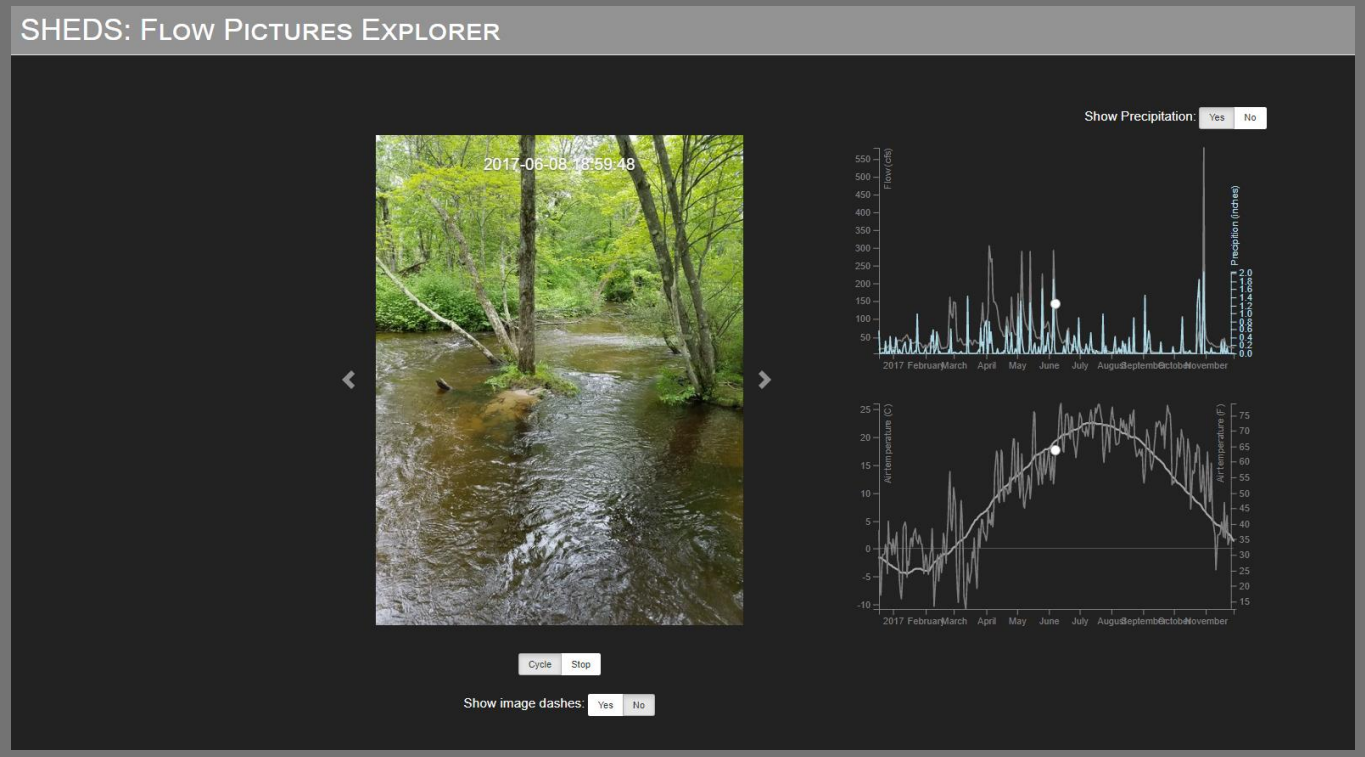
Project goal

Estimate stream flow in headwaters using images

Cheap

Broad coverage

Possible?



fpe.ecosheds.org

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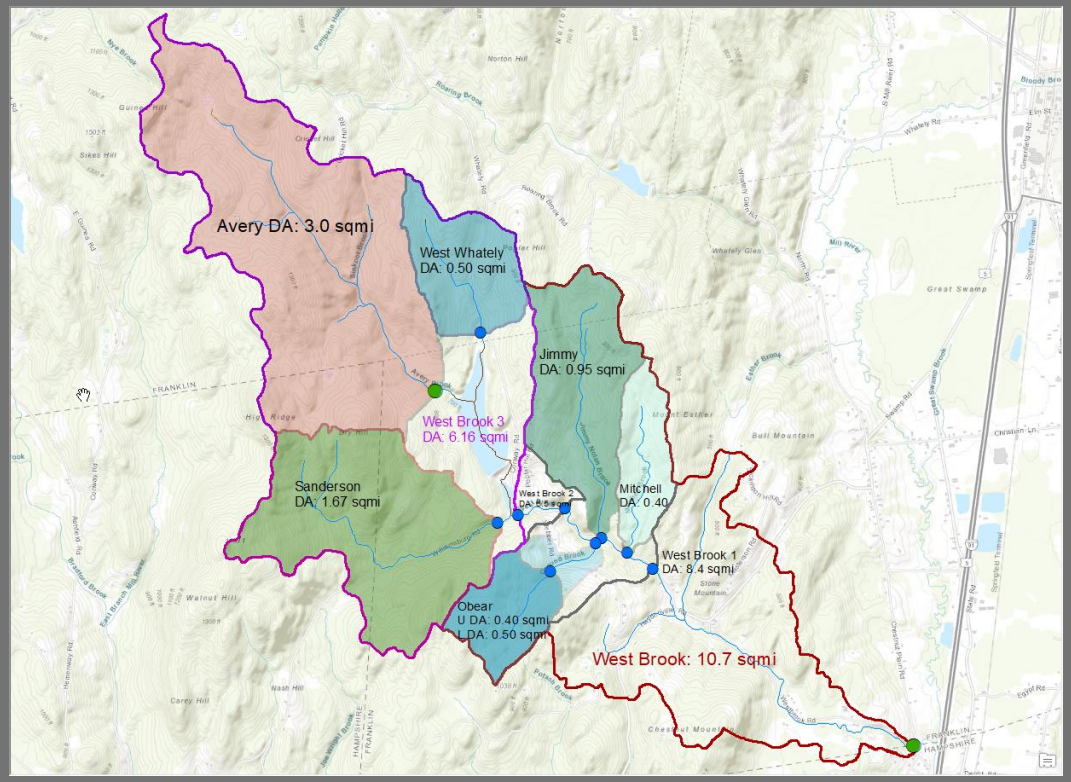
Possible?

Imagery is available for testing

- State agencies (CT, MA, etc)
- USGS ecoDrought project
- NSF NEON

AI/ML

- Modeling with deep learning



Project components:

Flow/image data

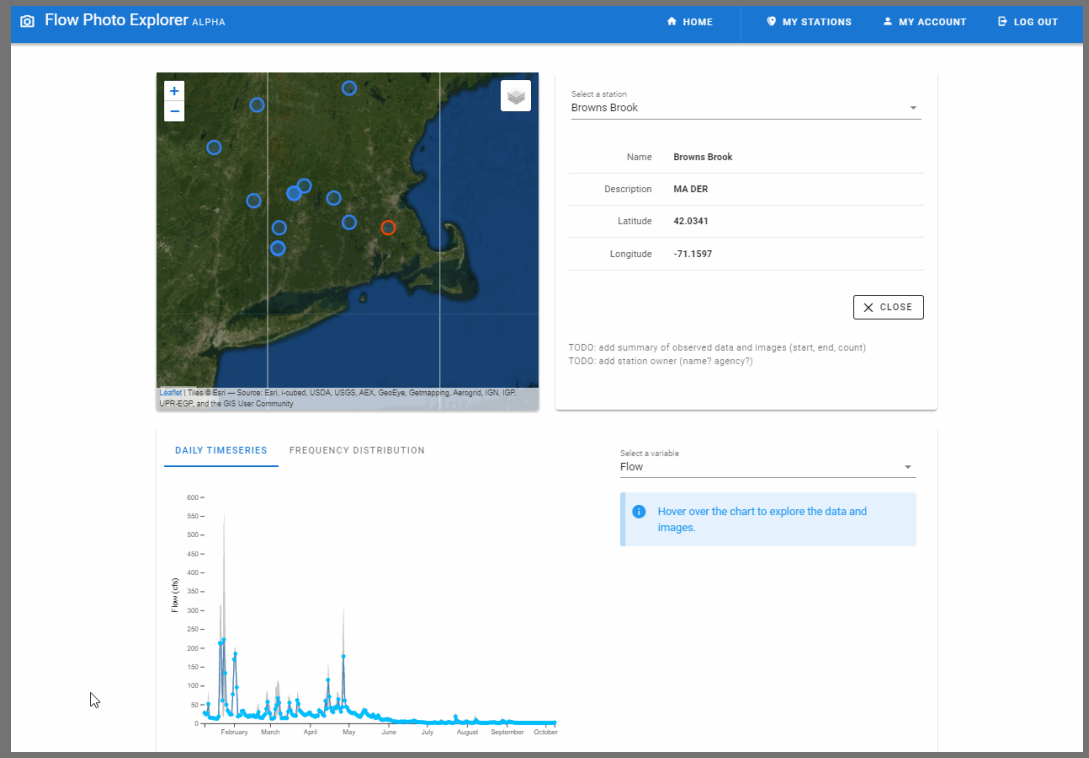
- New database for easy upload

AI/ML models

- Under development
- Will be integrated into database

Share predictions

- Development of web app (proposed)



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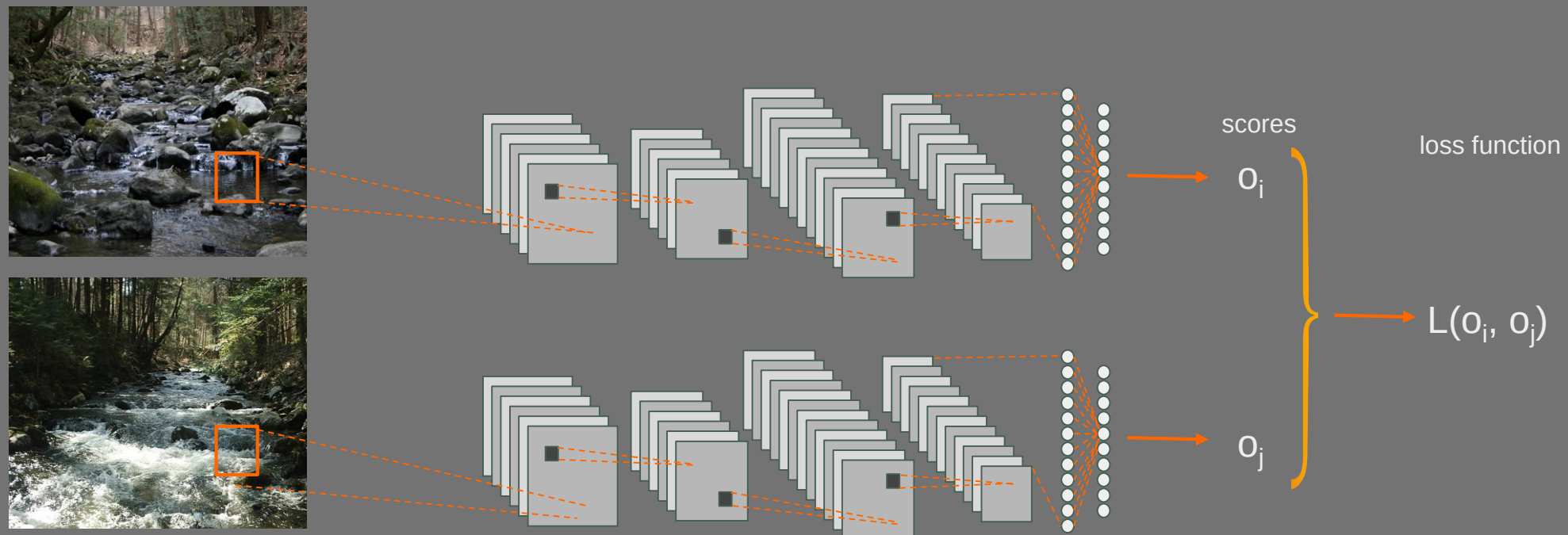
AI/ML models

Deep convolutional neural network

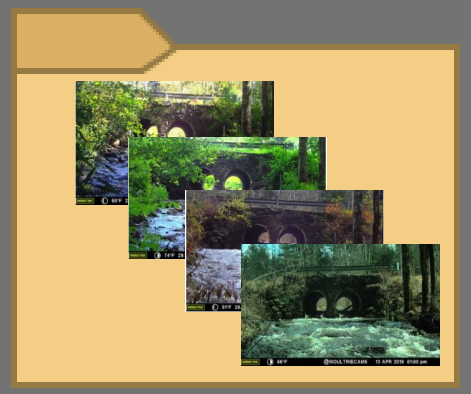
Structure: Siamese neural network with ResNet-50 feature extractor plus a few fully-connected layers

Output: 1-dimensional score output for each image



AI/ML models

Images from new site



Streamflow measurements available

Only images available

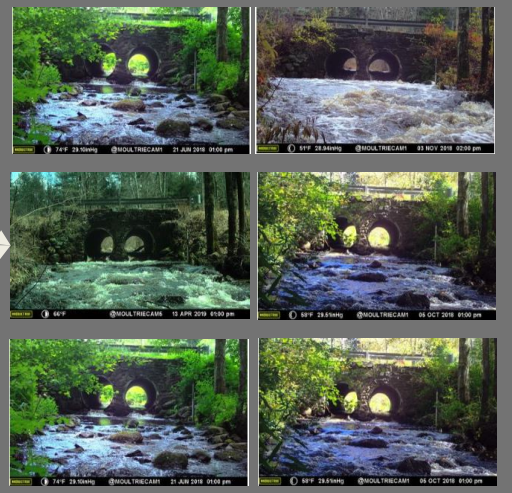
Input data

1. Stream flow data to generate ordered image pairs

2. Human annotator to order image pairs

~ 1000 = 1/2 hr

Training data for model



left lower

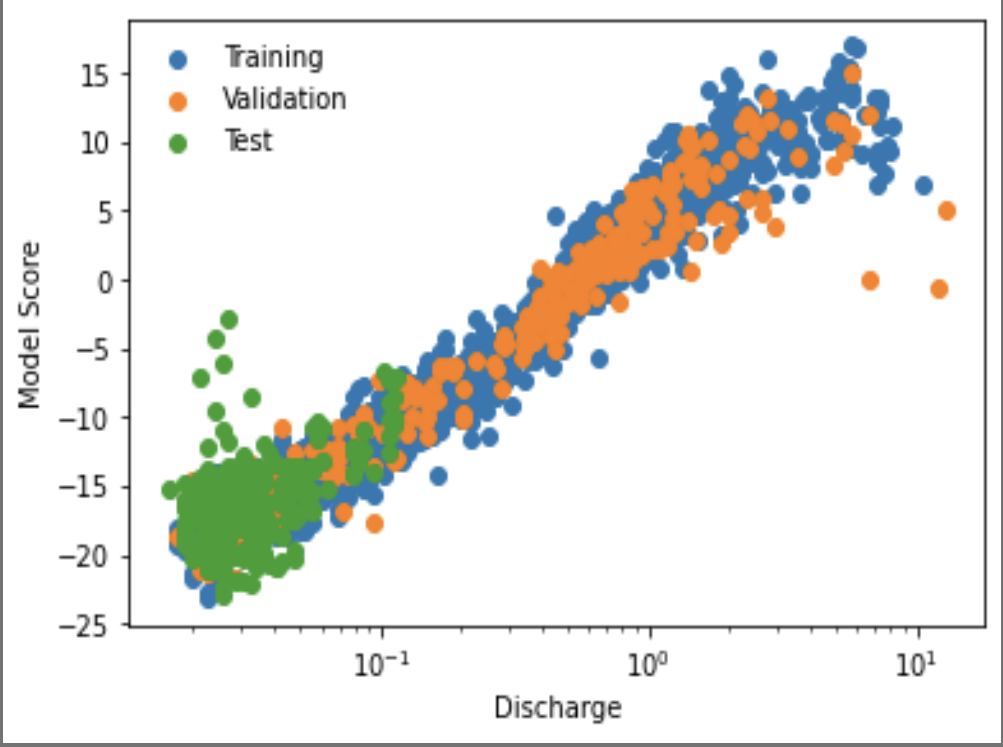
left higher

same

Current results – with flow data

10,000 images from one site

Model learns scores that are highly correlated with discharge



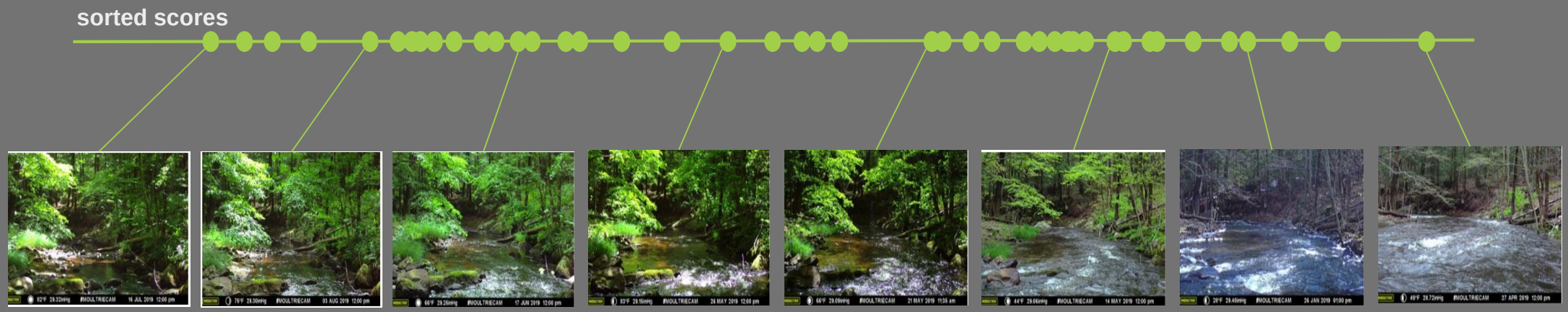
Dataset Split	Tau	P-value
Training	0.90	< 0.00001
Validation	0.86	< 0.00001
Test	0.28	< 0.00001

Kendall-Tau Rank Correlation between True Discharge and Predicted Score

Current results – without flow data

Model can be used to rank images by score, producing an ordering similar to ranking by flow

For any new image, we can compare it to previously collected images to estimate the flow percentile captured in the image



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Future

Next steps

- Release image database
  - Encourage image uploads
  - Flow image ranking for sites without flow data
- Continue model development
  - ‘Feature extraction’, isolate the stream in the image
  - Pair images, [low, high] → [much lower, slightly lower, same, slightly higher, much higher]
  - Understand transferability of model to sites with limited data
  - Integrate flow estimates with Process-Guided Deep Learning models of flow and temperature
- Develop web app for dissemination of results

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BIG picture

Possible gaging system for headwaters to complement USGS gages

- Drought and flood monitoring
- Flow permanence
- Expand possible locations for water quality
- LTERs that require flow data
- Sediment transport (turbidity)

Thanks to everyone from EPA and the RMN partners