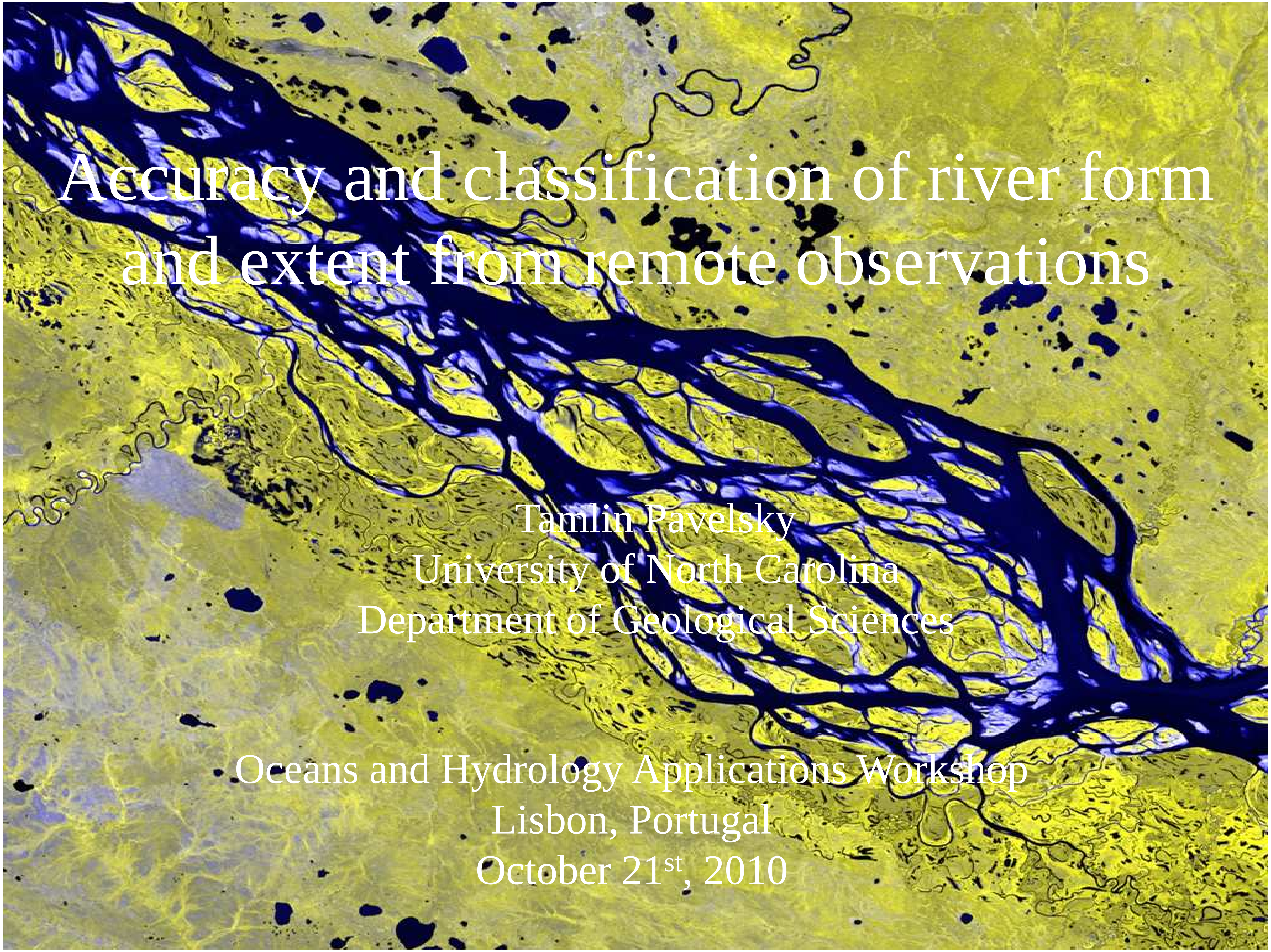

Accuracy and classification of river form and extent from remote observations

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University of North Carolina
Department of Geological Sciences

Oceans and Hydrology Applications Workshop
Lisbon, Portugal
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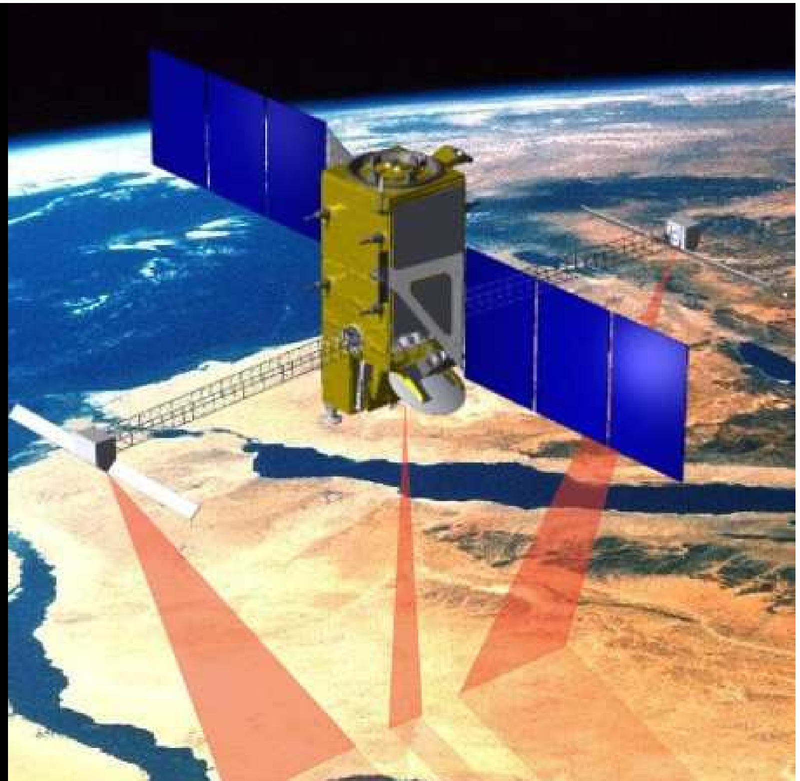
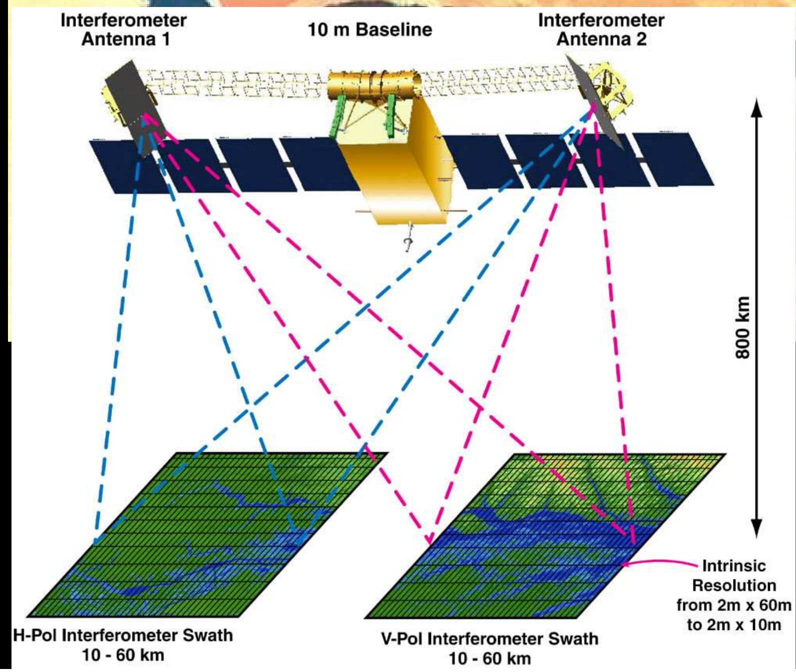
SWOT Measurements of Surface Water

SWOT will directly measure variations in inundated area and water surface elevation.

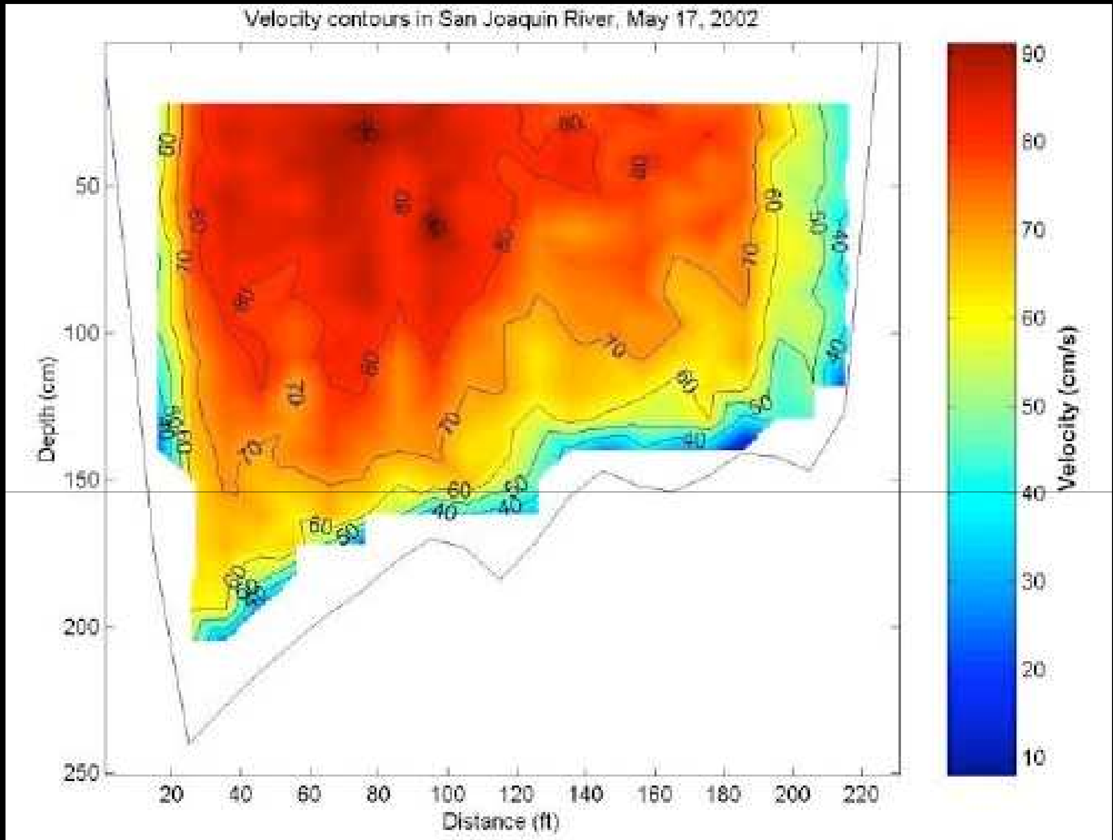
From these quantities, we will be able to estimate both river discharge and change in water storage.

Before launch, we need to understand and quantify the sources of uncertainty in SWOT observations.





Source of Error in SWOT Discharge Measurements



Q=wdv

All three dimensions must be measured or estimated. Errors in all three will contribute to discharge error.

Algorithms to estimate depth and velocity are currently under development (Durand, Smith, Andreadis, etc).

Focus of this Presentation:

How will errors in measurement of river width affect discharge retrievals in different kinds of rivers?

Ohio
Wide, Single Channel

Widths: 300-1000 m
Mean Discharge: 8000 m^3/s
Principal Adjustment:
Depth

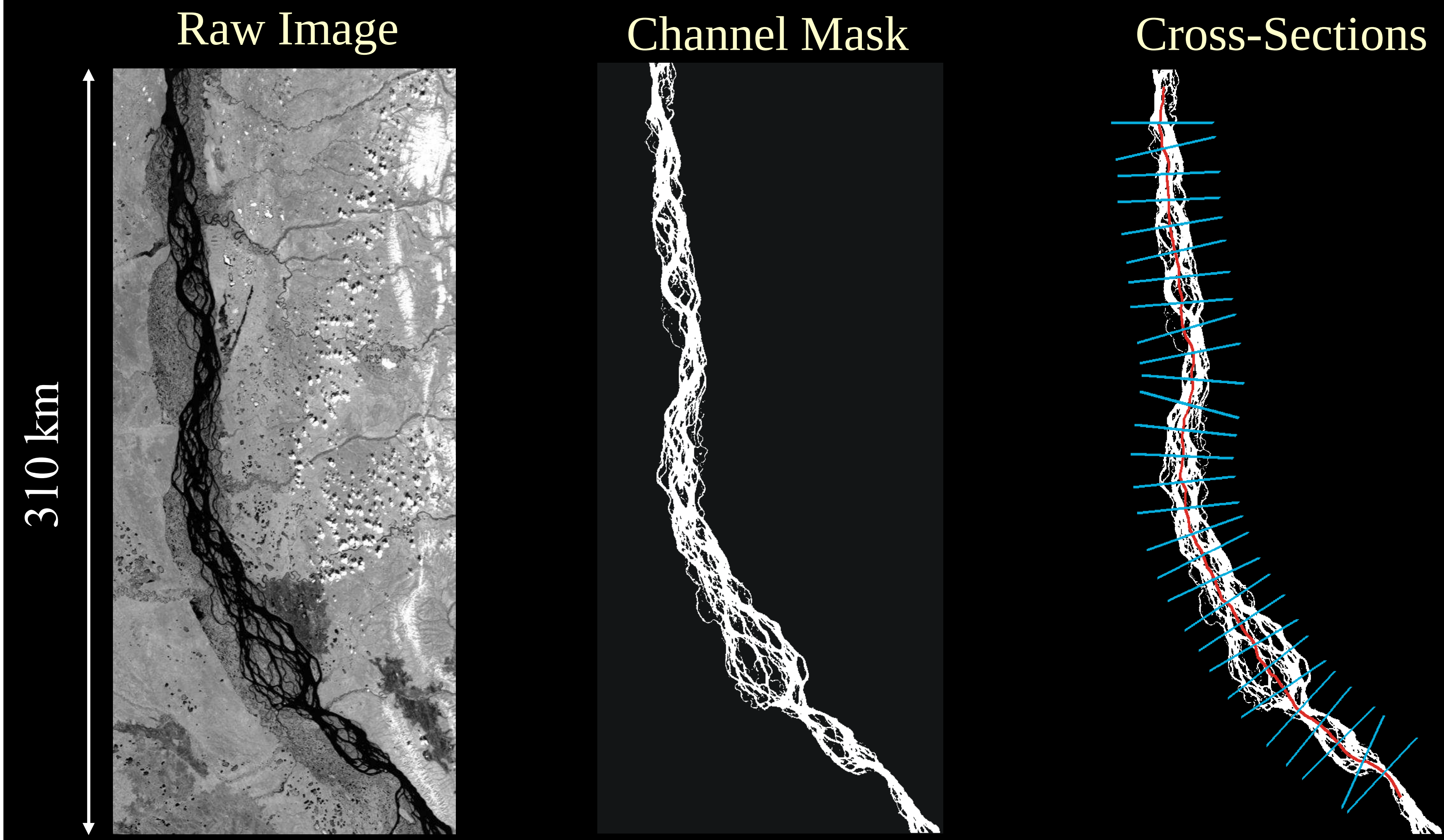
Tanana
Wide, Braided

Widths: 300-1500 m
Mean Discharge: 1200 m^3/s
Principal Adjustment:
Width

Kentucky
Narrow, Single Channel

Widths: 50-200 m
Mean Discharge: 285 m^3/s
Principal Adjustment:
Depth

RivWidth: Automatic River Flow Width Monitoring



Pavelsky and Smith (2008), *IEEE GRSL*

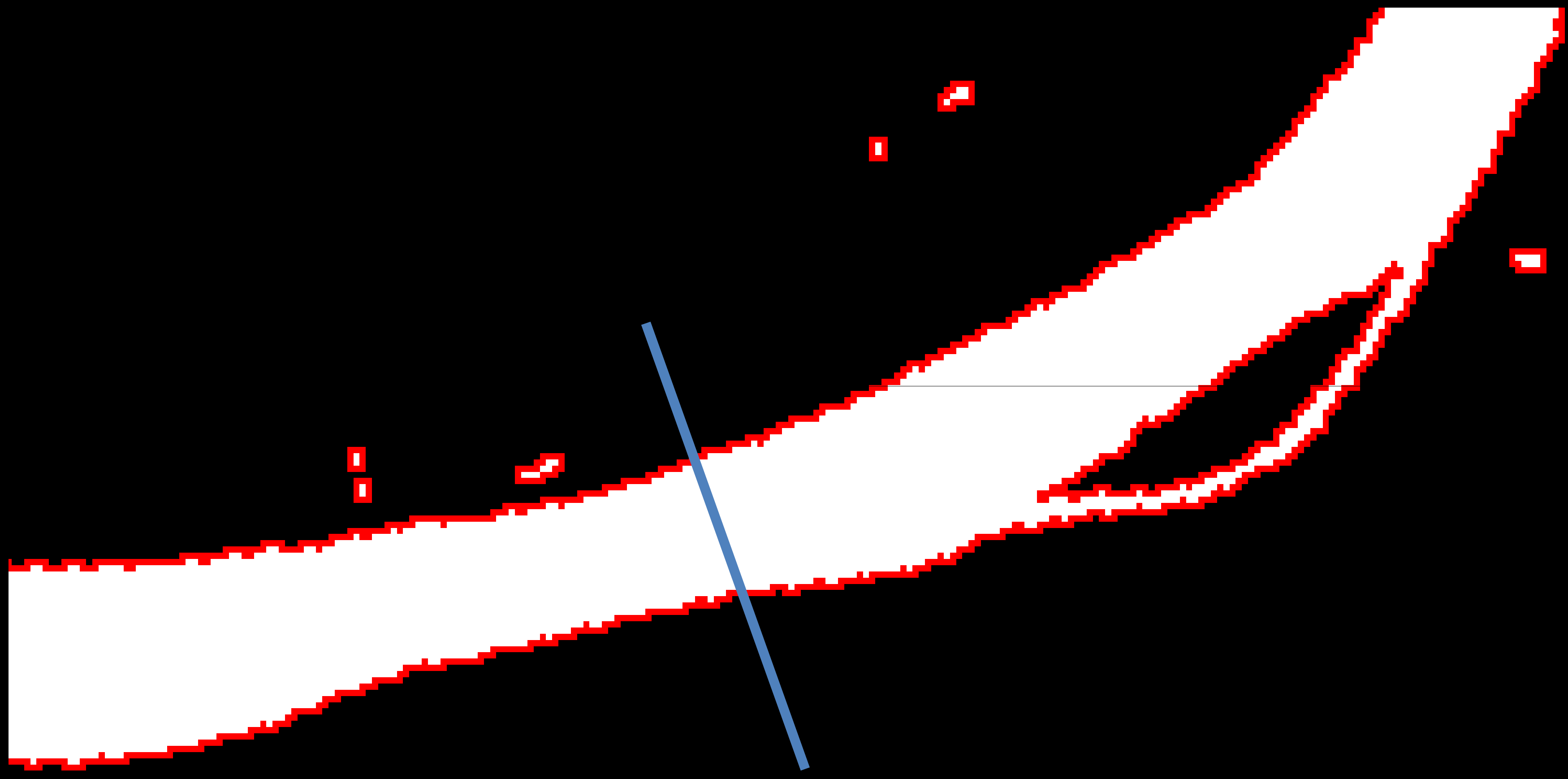
Sources of Error in Width Classification

- Misclassification of pixels as water/nonwater
  - Sources: Emergent vegetation, wet sediment
- Error in cross-section calculation
  - Source: Complex river planforms
- Boundary/edge effect errors
  - Source: Inherent in calculation of river width from binary inundation masks
  - Defined by the number of channels in a river:

$$E = \frac{1}{2}RC$$

E: edge effect error R: pixel resolution C: channel crossings

Error in Cross-Section Calculation

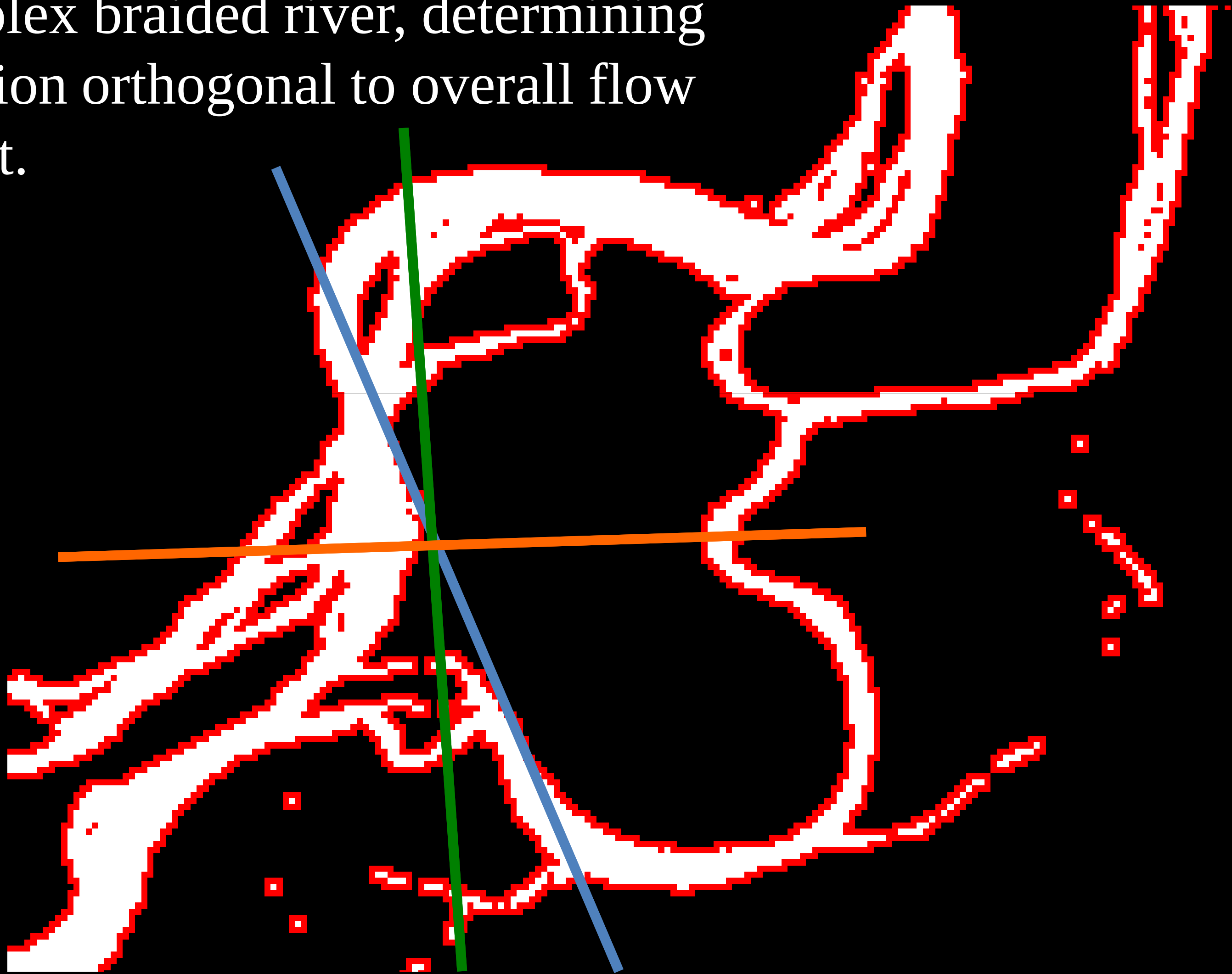


Deriving an accurate cross-section is simple in a single-channel river.

Ohio River

Error in Cross-Section Calculation

In a complex braided river, determining the direction orthogonal to overall flow is difficult.



Tanana River

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  - Sources: Emergent vegetation, wet sediment
- Error in cross-section calculation
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- Boundary/edge effect errors
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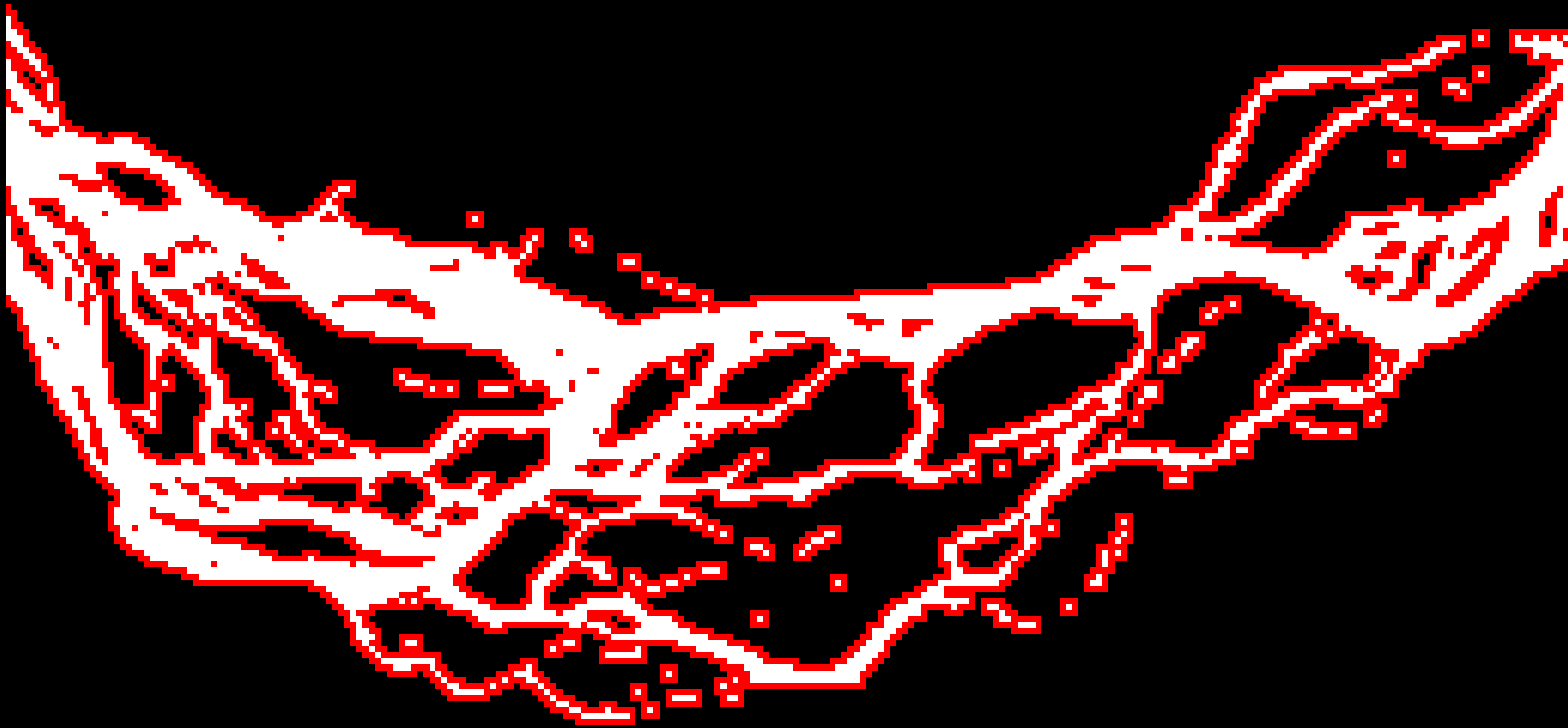
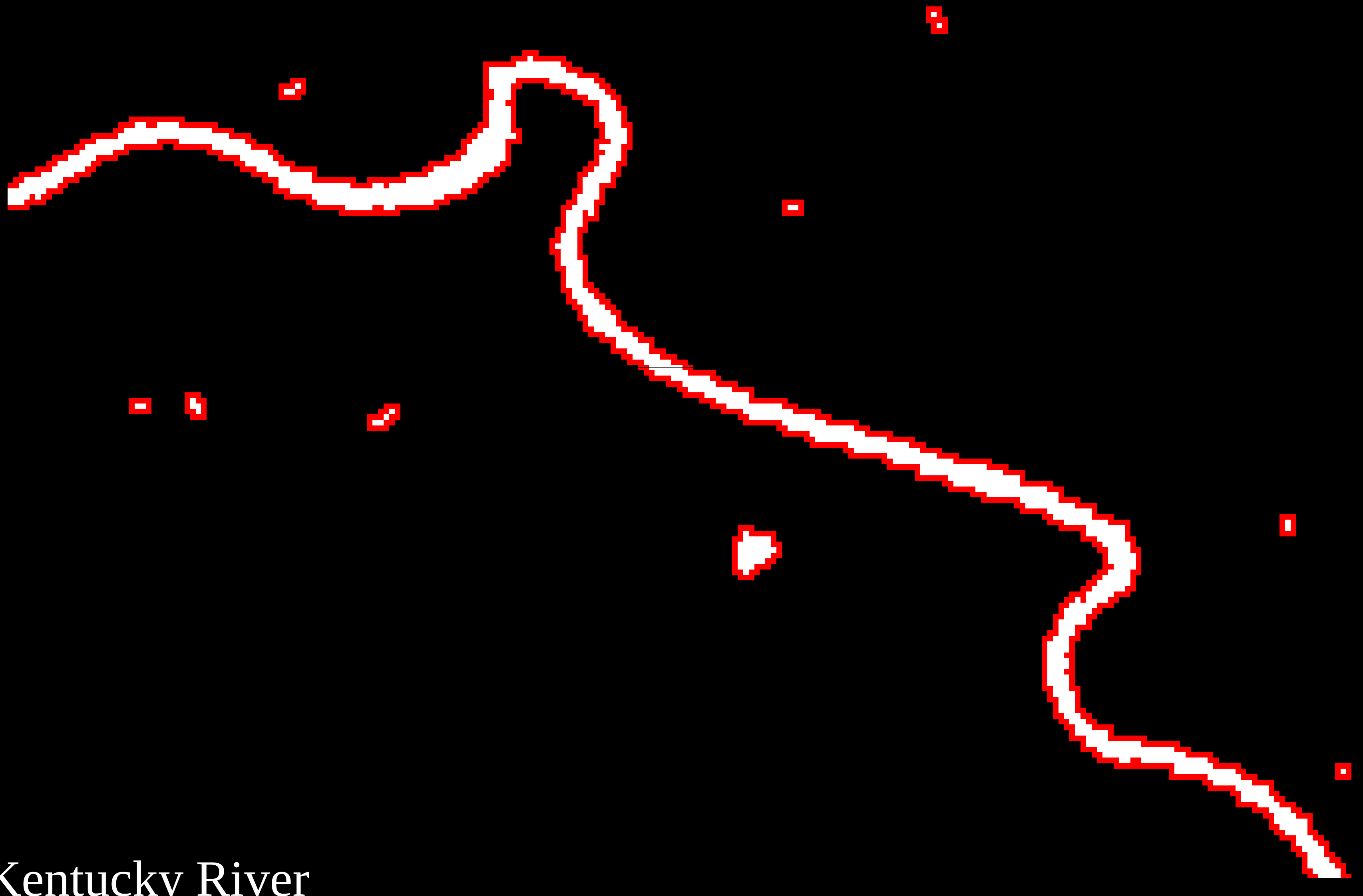
Boundary/Edge Effect Error



Tanana River

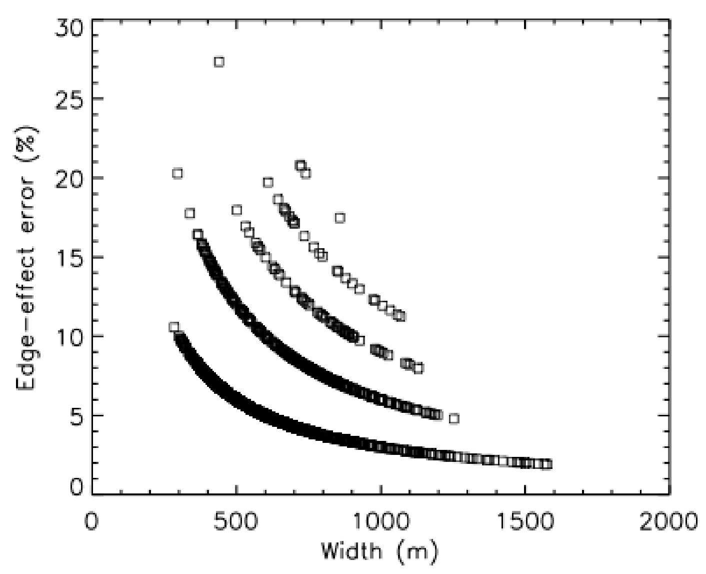
Boundary/Edge Effect Error

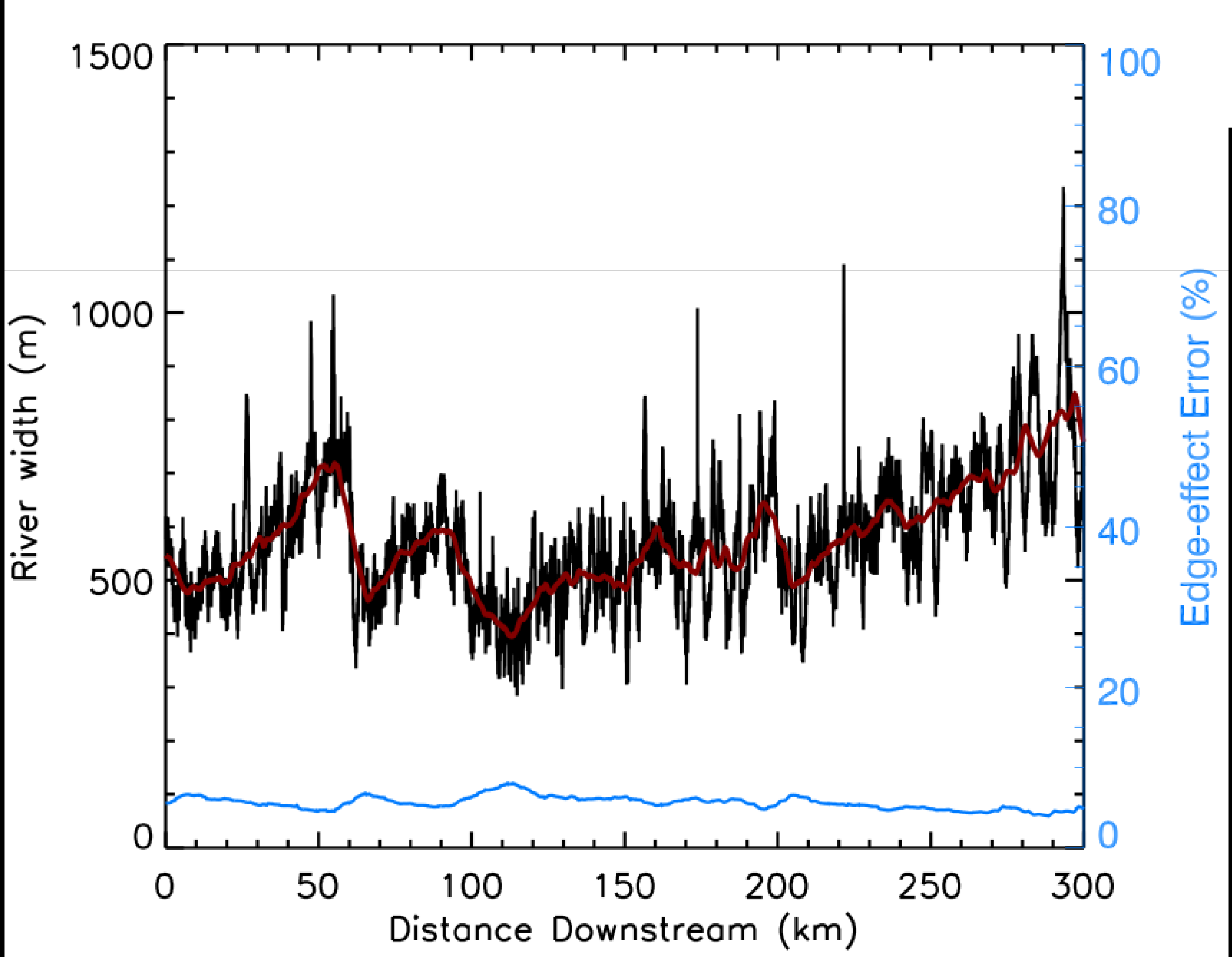


Kentucky River

Ohio River

On large, single channel rivers like the Ohio, edge-effect error is relatively small.



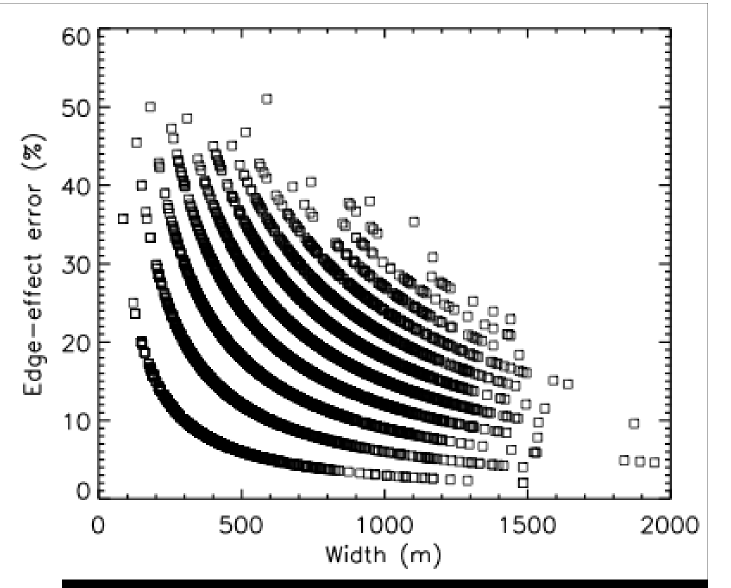


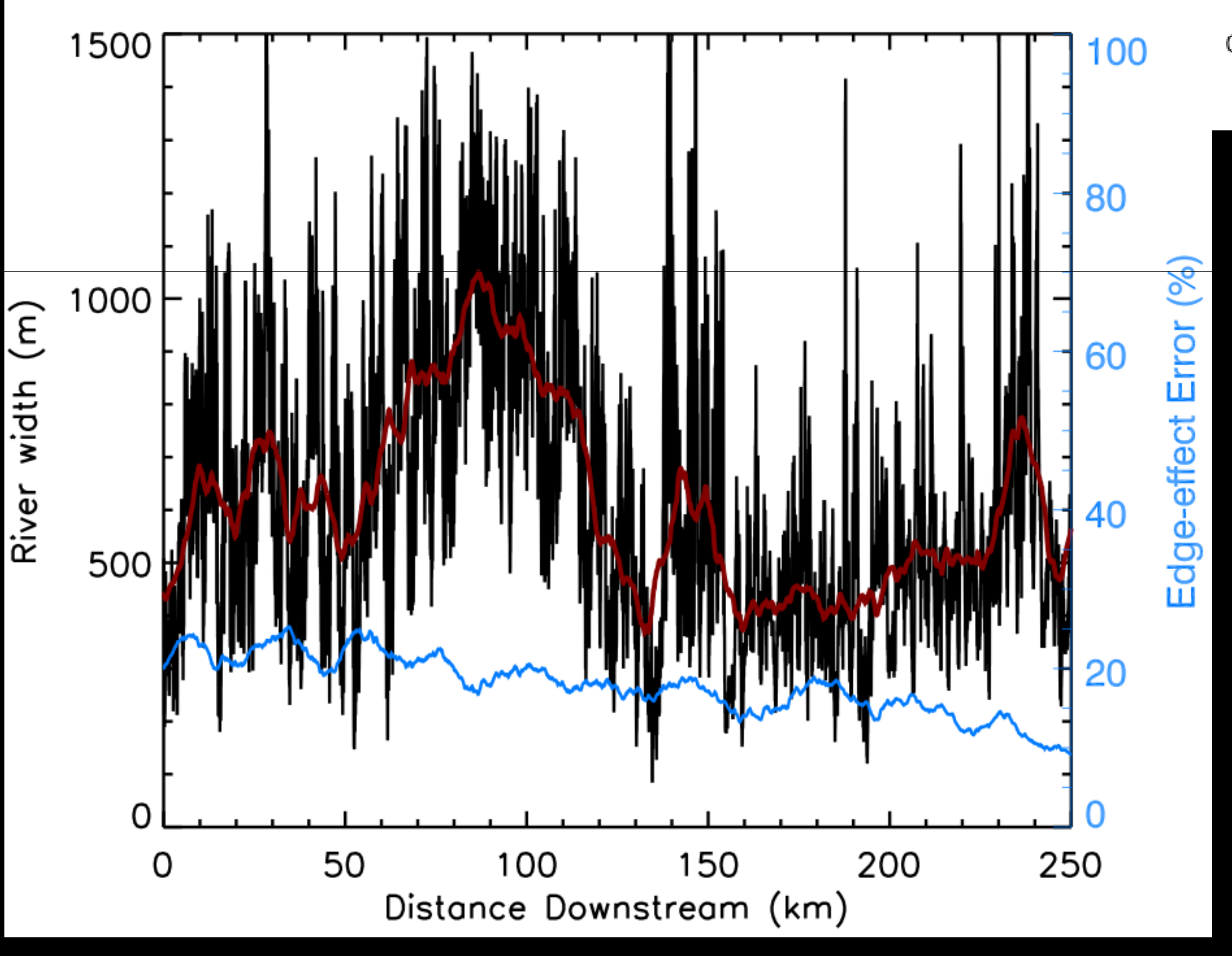
Mean Width: 585 m
Max Width: 1575 m
Min Width: 284 m

Mean Error: 6%
Max Error: 27%
Min Error: 2%

Tanana River

Increased braiding substantially increases edge-effect errors when width is constant.



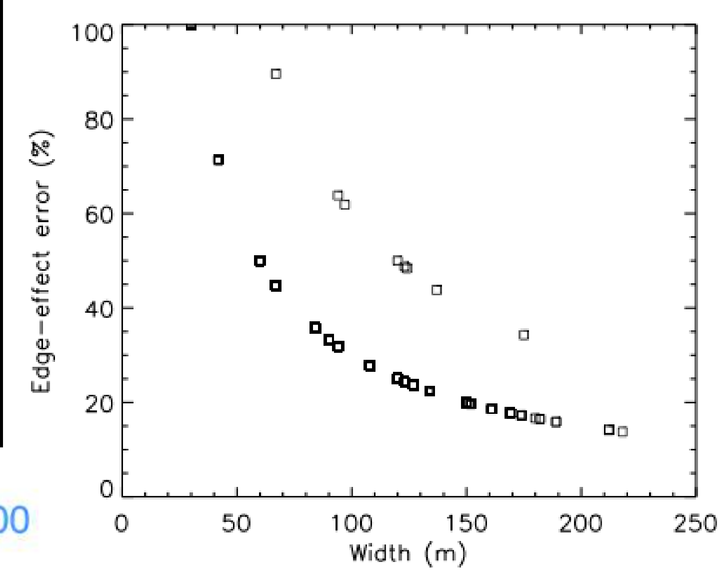


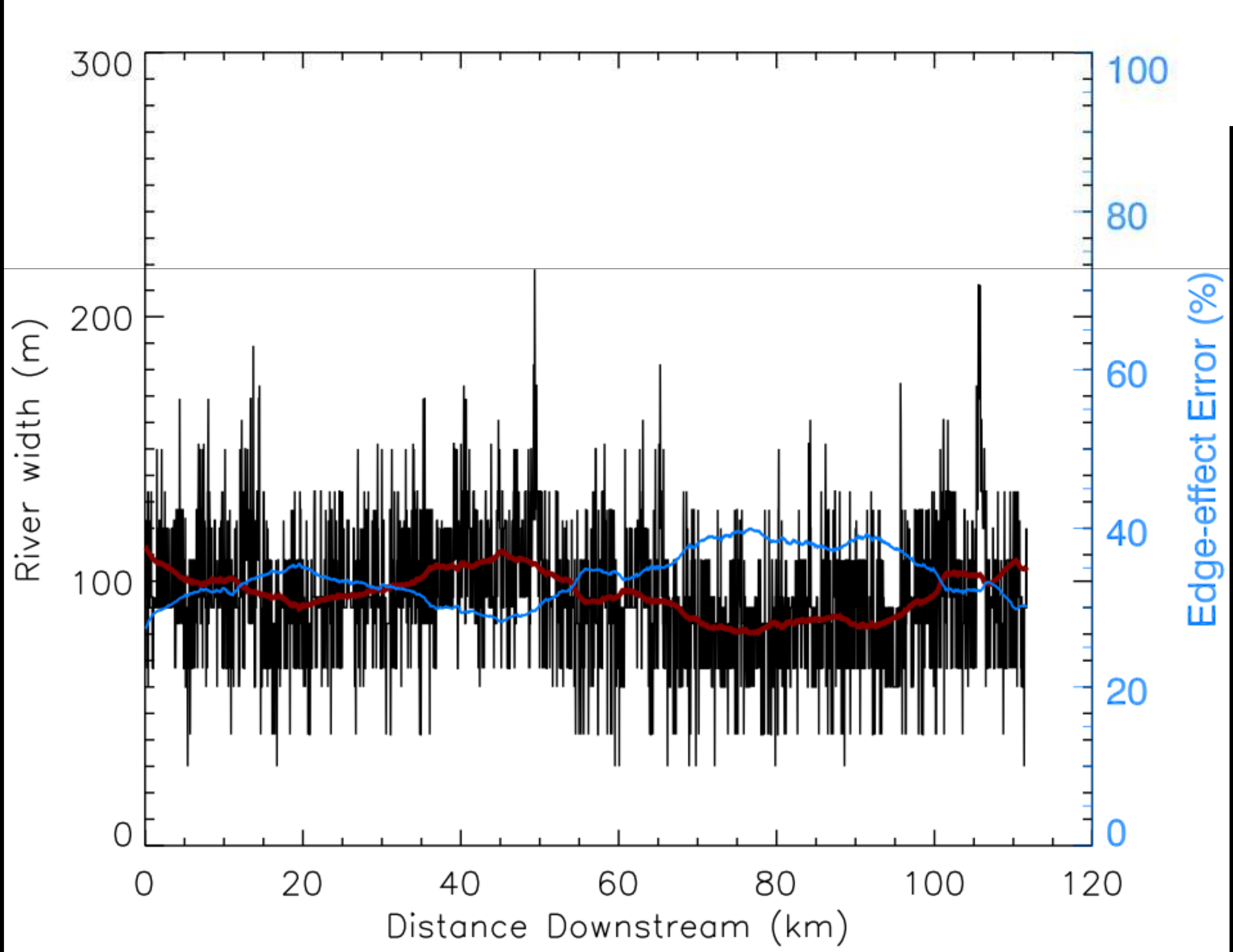
Mean Width: 611 m
Max Width: 1944 m
Min Width: 84 m

Mean Error: 17%
Max Error: 51%
Min Error: 2%

Kentucky River

As a river narrows, edge-related uncertainty becomes increasingly important.

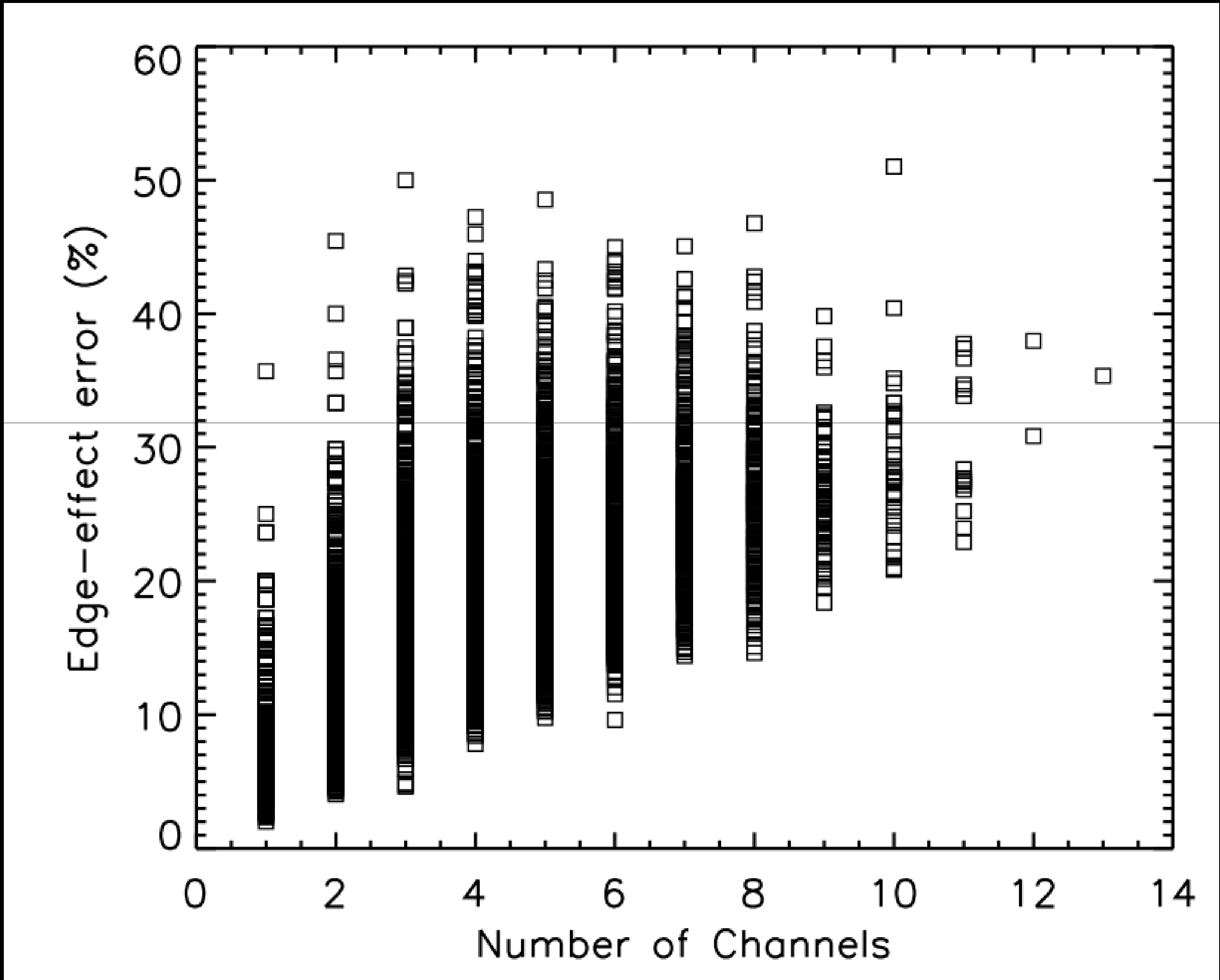




Mean Width: 95 m
Max Width: 218 m
Min Width: 30 m

Mean Error: 35%
Max Error: 100%
Min Error: 13%

Edge-Effect Error vs. Number of Channels, Tanana River



Examples of Discharge Errors

Assuming constant width and depth, how will width errors affect discharge calculations?

Ohio	Tanana	Kentucky
Mean width/error:	Mean width/error:	Mean width/error:
4413-4946 m^3/s	1004-1442 m^3/s	125-254 m^3/s
Maximum error:	Maximum error:	Maximum error:
2563-4460 m^3/s	576-1775 m^3/s	0-300 m^3/s
Minimum error:	Minimum error:	Minimum error:
6176-6418 m^3/s	1454-1513 m^3/s	210-270 m^3/s

Ways to Minimize Width Error

- Limit cross-sections used to those below a given error threshold.

- Develop a method to reliably extract subpixel inundation information

- Average widths across multiple adjacent cross-sections or switch from width to area.

Ways to Minimize Width Error

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- Develop a method to reliably extract subpixel inundation information

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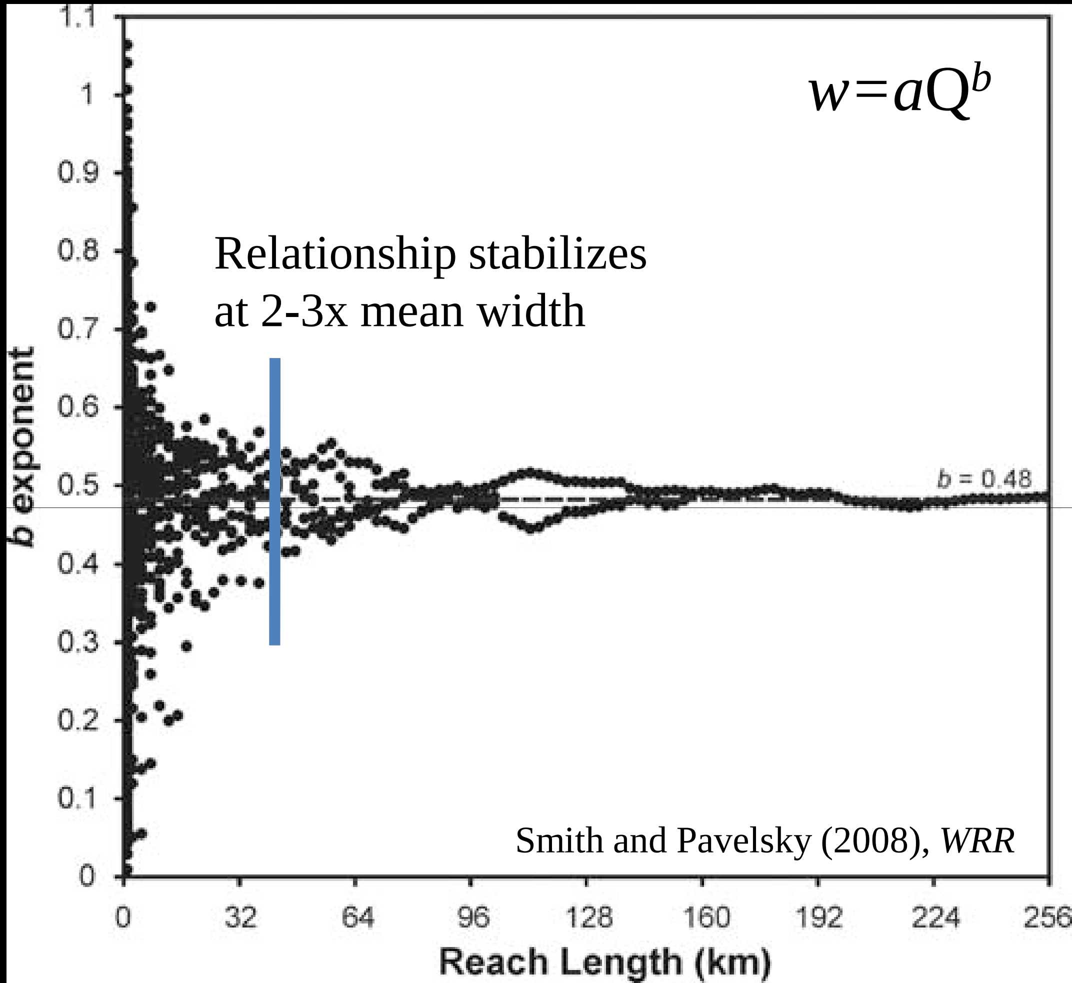
Most methods for extracting subpixel information on inundation use either multiple optical bands or a combination of optical and microwave sensors. Can a method be developed to extract subpixel inundation information from SWOT-like data alone?

Ways to Minimize Width Error

- Limit reaches used to those below a given error threshold.

- Develop a method to reliably extract subpixel inundation information

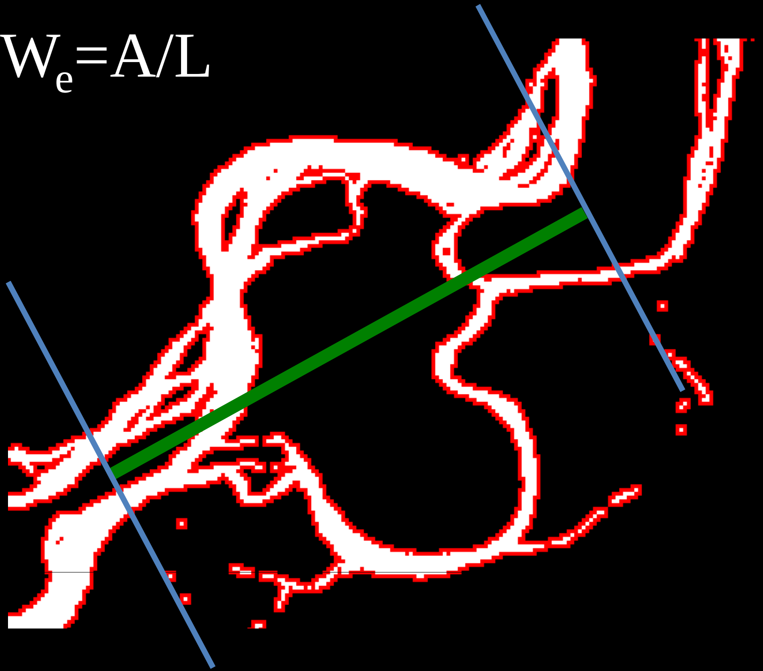
- Average widths across multiple adjacent cross-sections or switch from width to area.



Relationship between reach length and the coefficient in the width-discharge power law equation for the Lena River, Siberia.

Effective width vs. Averaged width

$W_e = A/L$

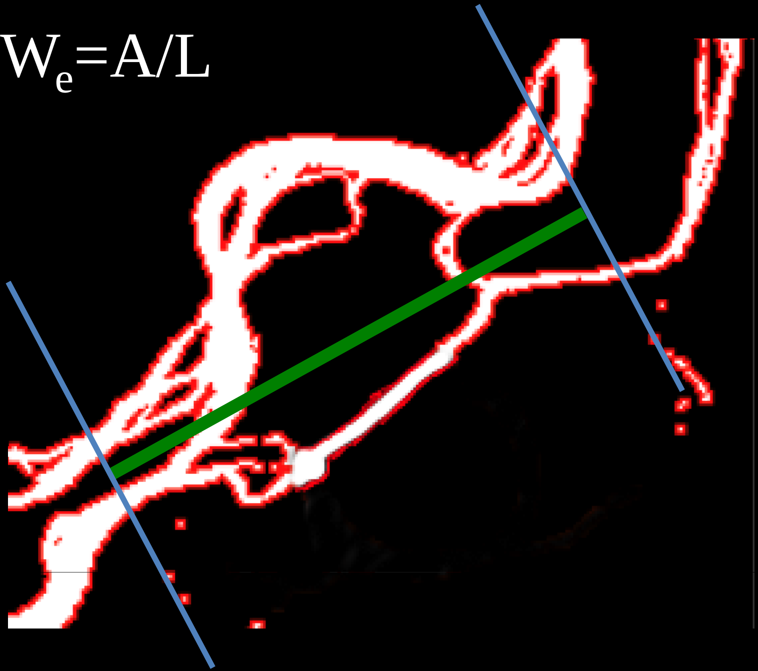


Advantages:
Fast, easy to compute

Disadvantages:
Varies depending on the sinuosity of channels within reach

Effective width vs. Averaged width

$W_e = A/L$



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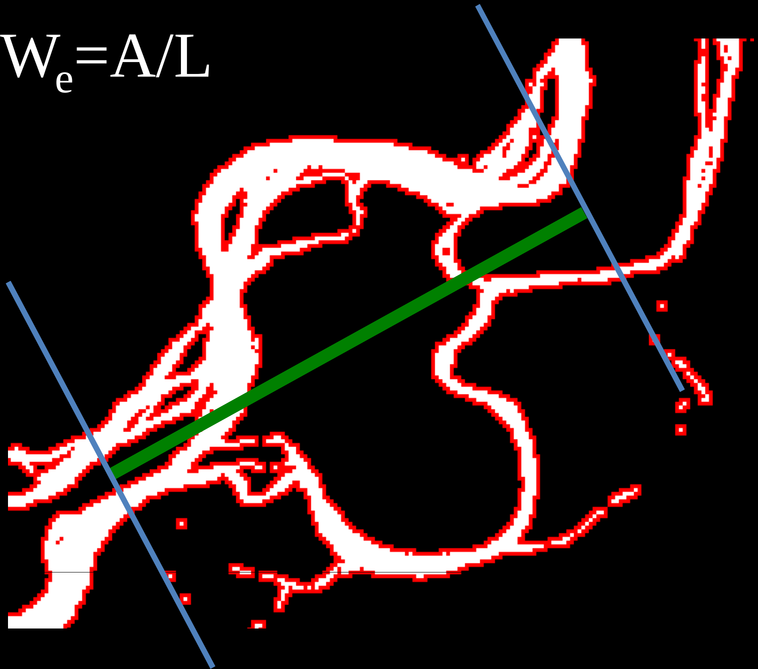
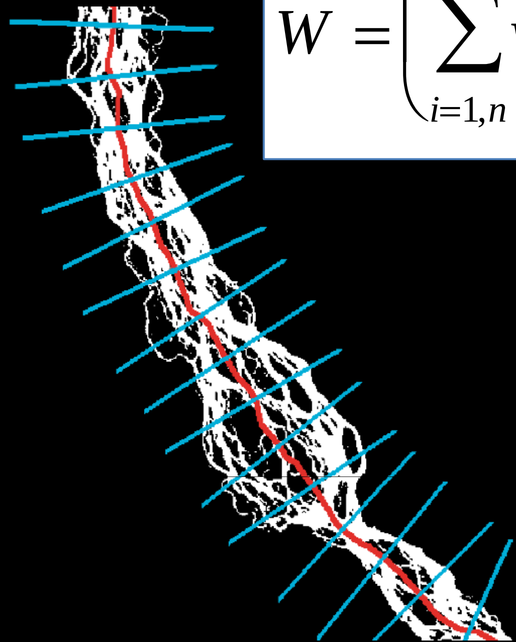




$$\overline{W} = \left(\sum_{i=1,n} w_i \right) / n$$

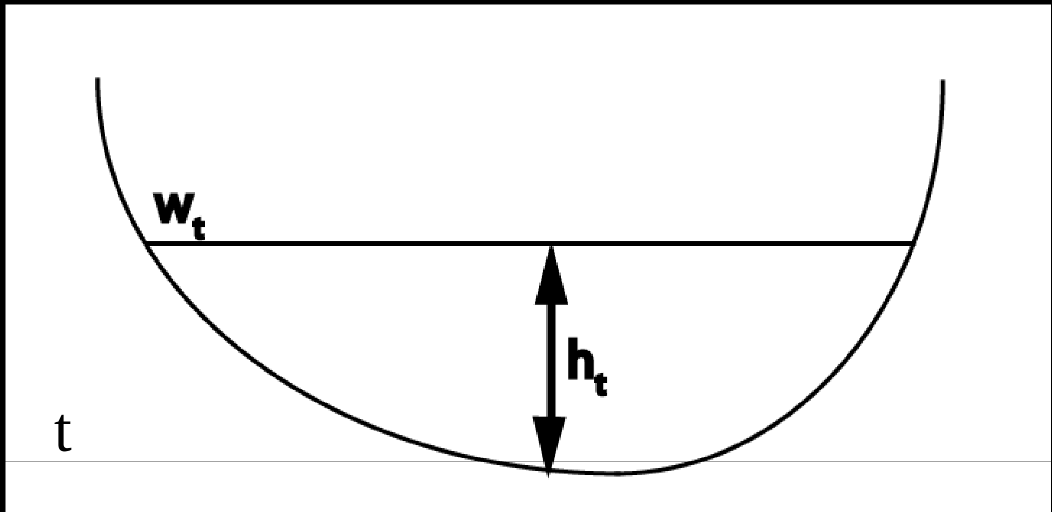
Advantages:
Fast, easy to compute

Disadvantages:
Varies depending on the sinuosity of channels within reach

Advantages:
More precise widths, easier to compare to gauge data

Disadvantages:
More difficult to calculate, problems with orthogonals.

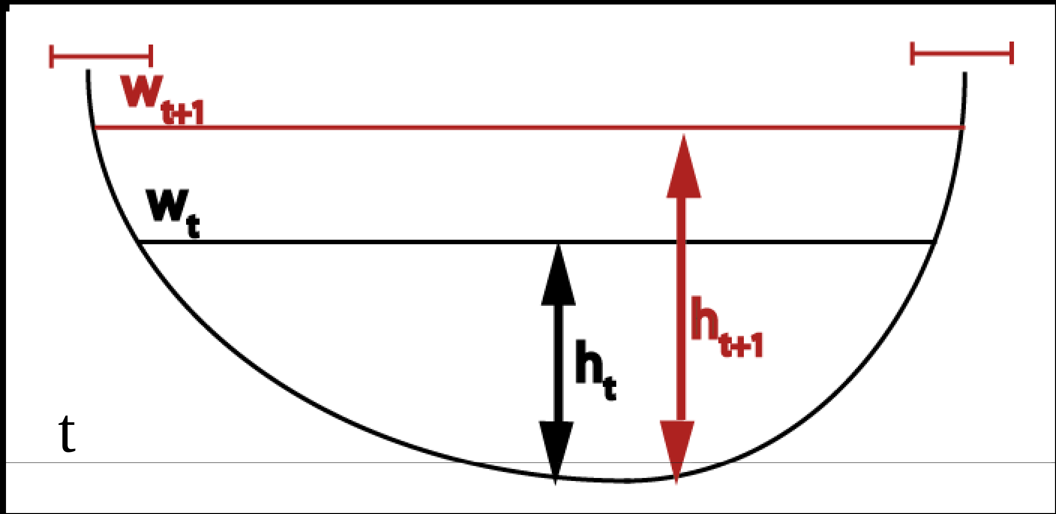
Constraining Widths with Multitemporal Data



Multitemporal SWOT data will allow us to constrain width errors further.

Given two overpasses at times t and t+1, if $h_{t+1} > h_t$ then w_{t+1} also must be greater than w_t.

Constraining Widths with Multitemporal Data



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This method will be particularly useful because high-resolution overpasses can be used to constrain low-resolution overpass widths.

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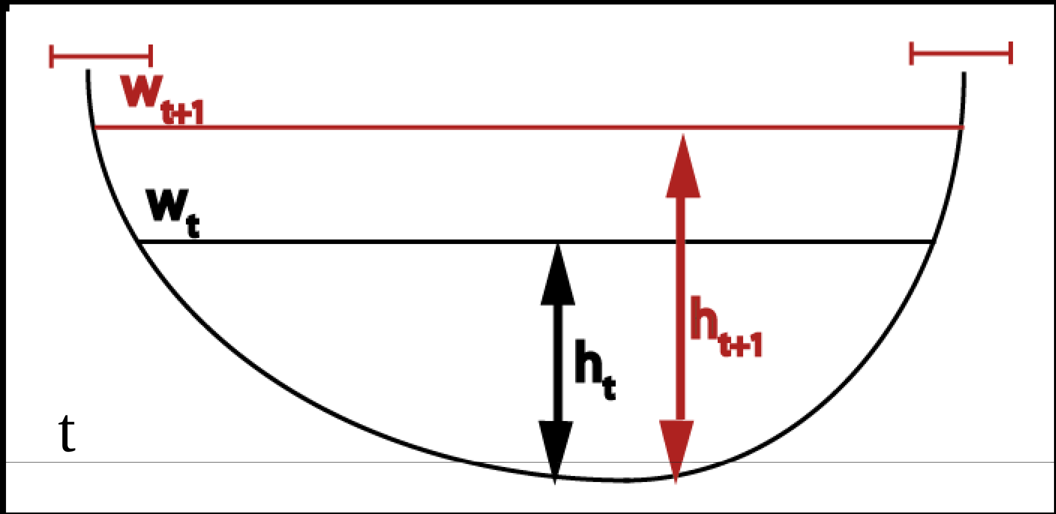

Multitemporal SWOT data will allow us to constrain width errors further.

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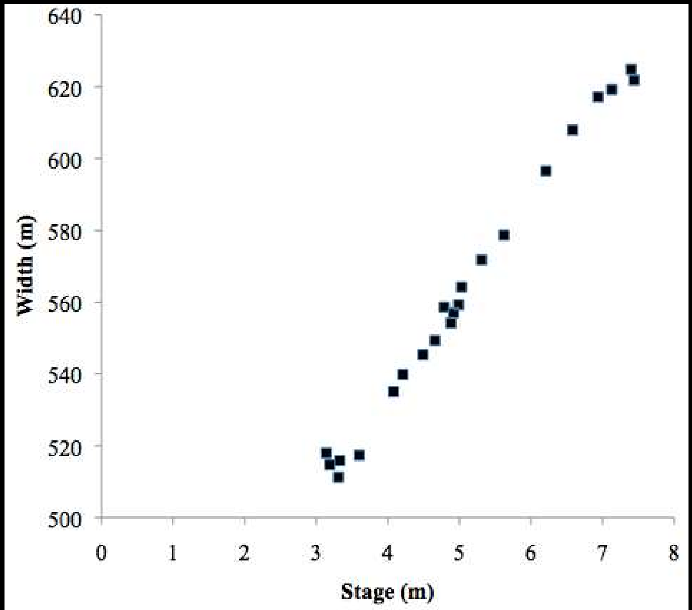
Using many time steps, we can build up SWOT-based width-depth rating curves



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Next Steps

- Use AirSWOT to validate and calibrate inundation retrievals
- Develop a system for classification of river reaches for SWOT discharge retrieval
  - Map likely sources of uncertainty
  - Adjustment based on Width vs. Depth
- Release an improved version of RivWidth