River bathymetry analysis in the presence of large woody debris

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Outline

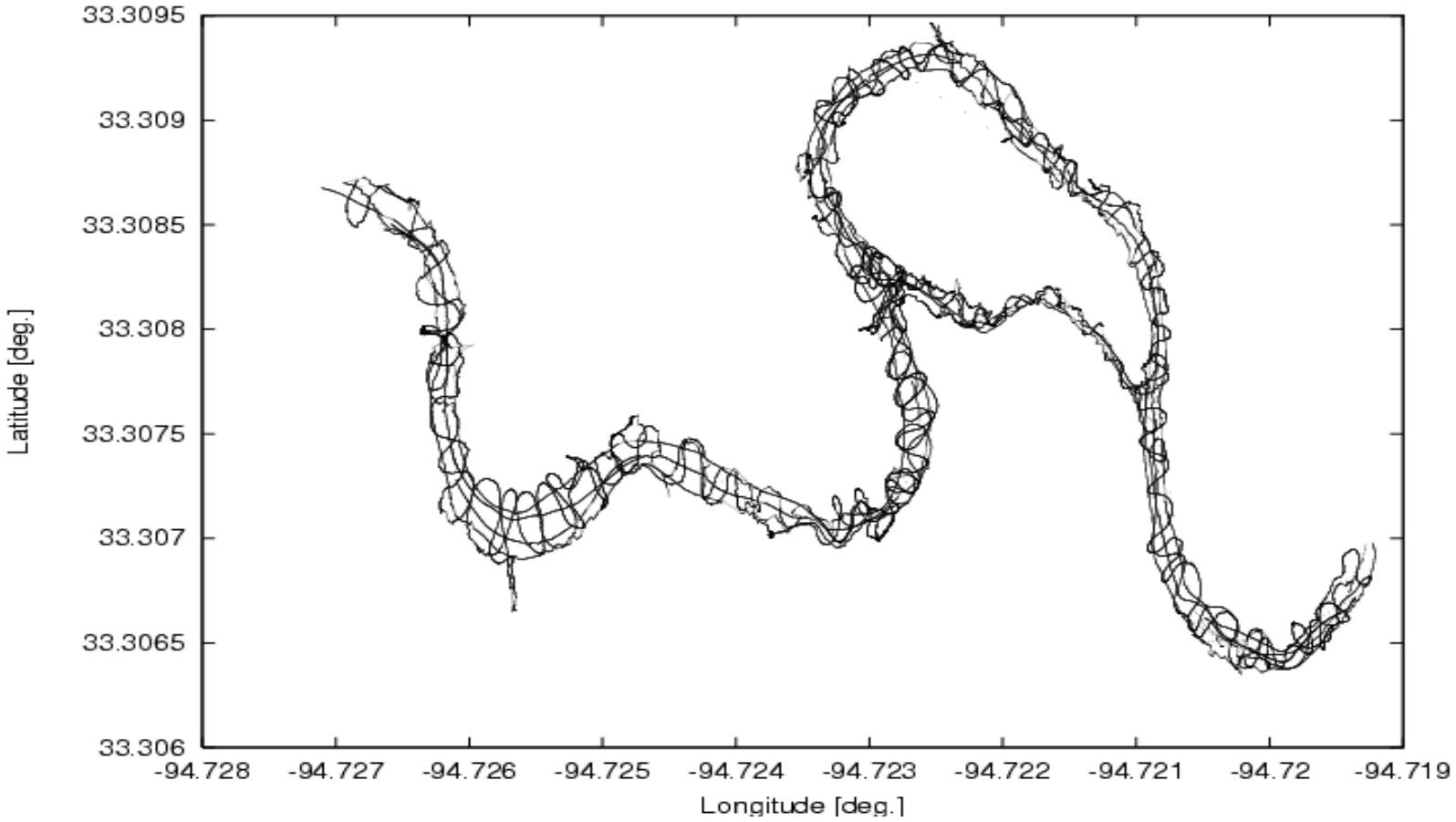
- Introduction
- What is the problem ?
- Hypothesis and objective
- Filtering techniques
  - Linear filters
  - Nonlinear filters
- Conclusion

Introduction (1/2)

- Submerged large woody debris (LWD) in the Sulphur River (Northeast Texas)

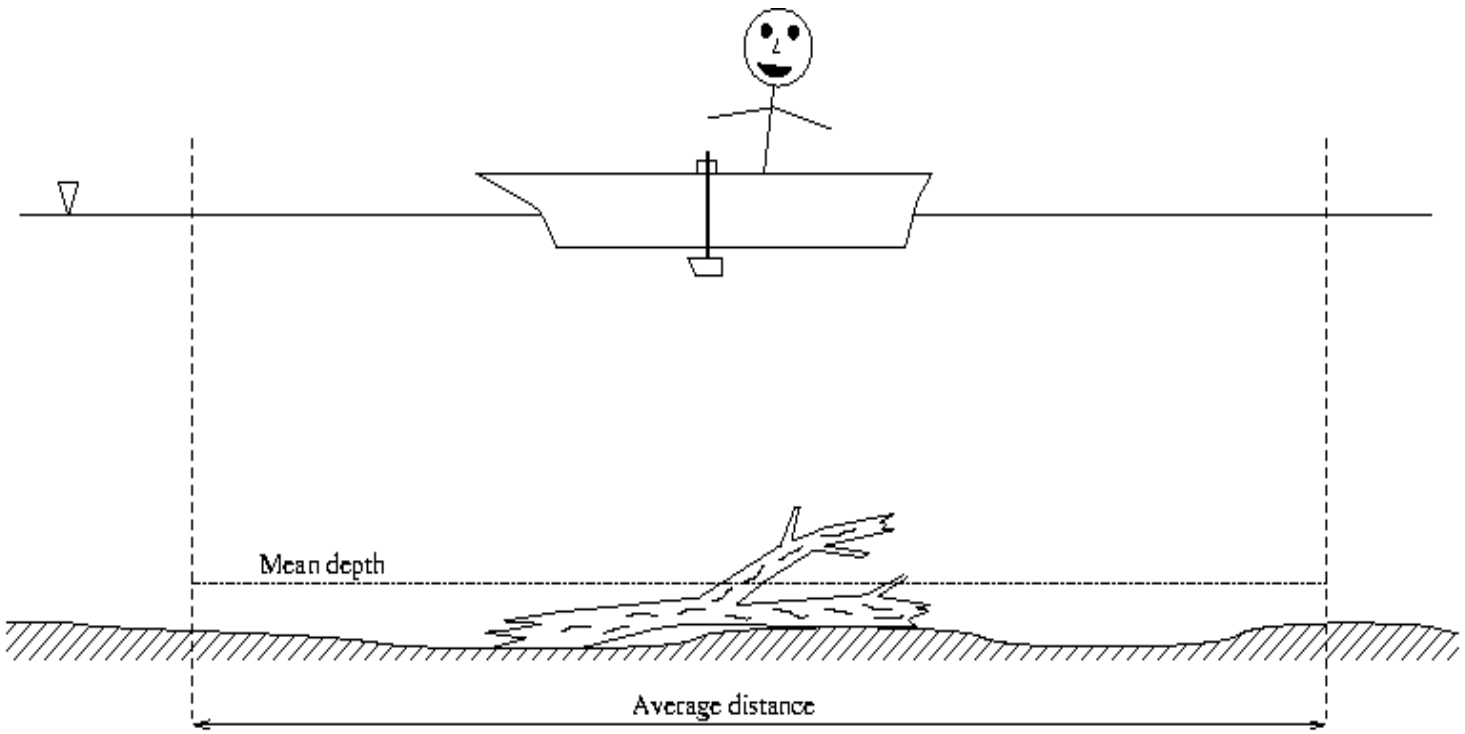
Introduction (2/2)

- Survey site: boat tracks



What is the problem ? (1/2)

- In the presence of LWD, averaging and/or interpolation may lead to bathymetry distortion:

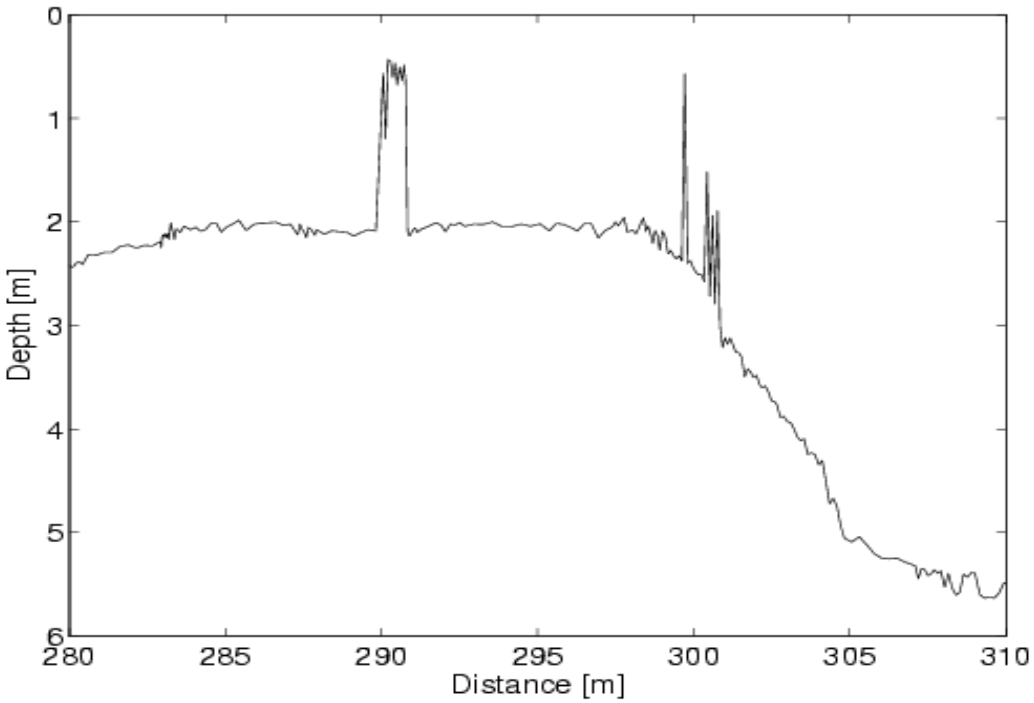


What is the problem ? (2/2)

- Example of bathymetry distortion for real data:

Hypothesis (1/2)

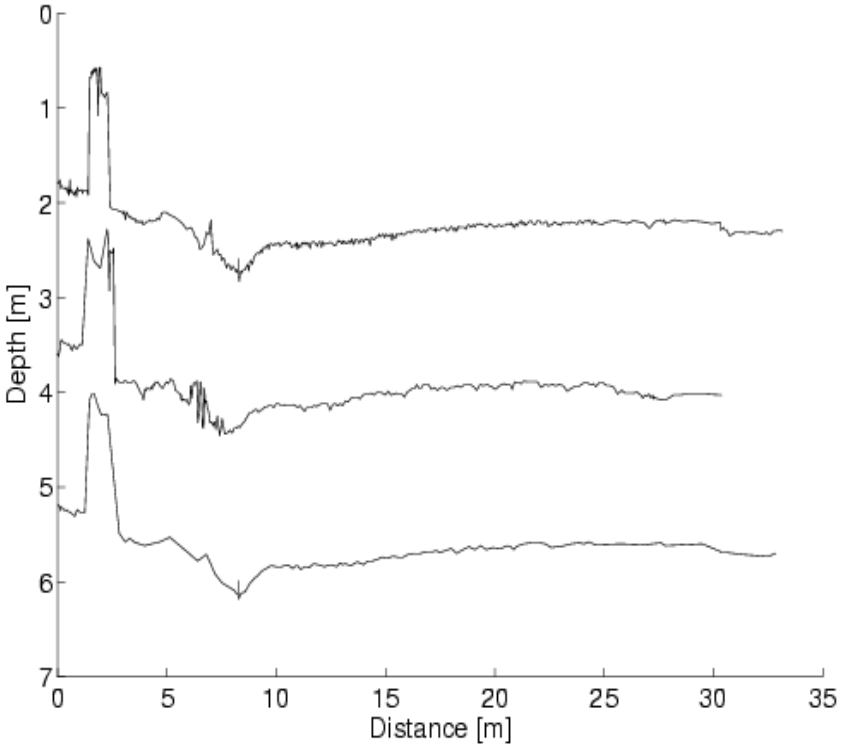
- Typical signal in Sulphur River:



Spike in data set = signature of LWD

Hypothesis (2/2)

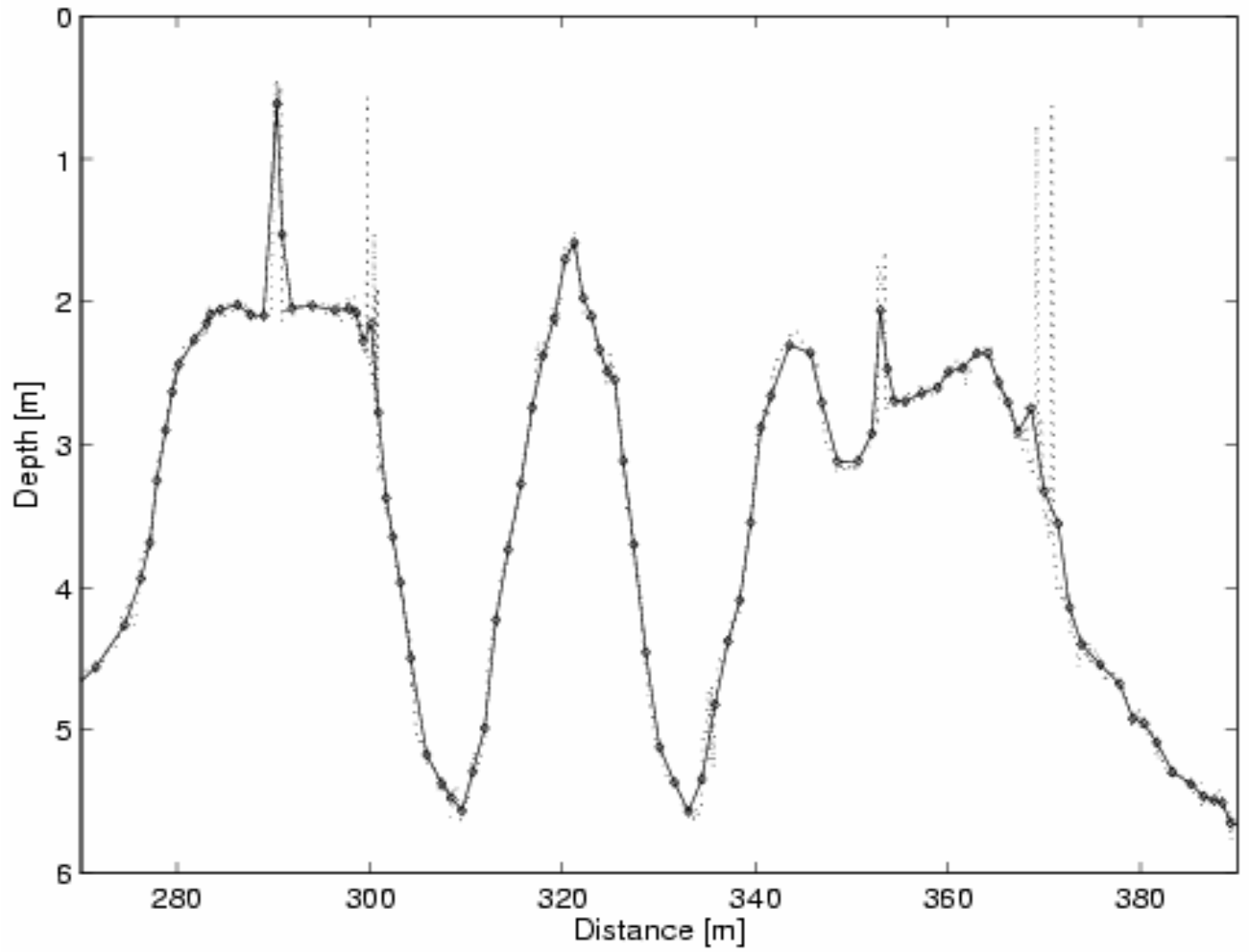
- To improve confidence: field experiment in Guadalupe River



Objective

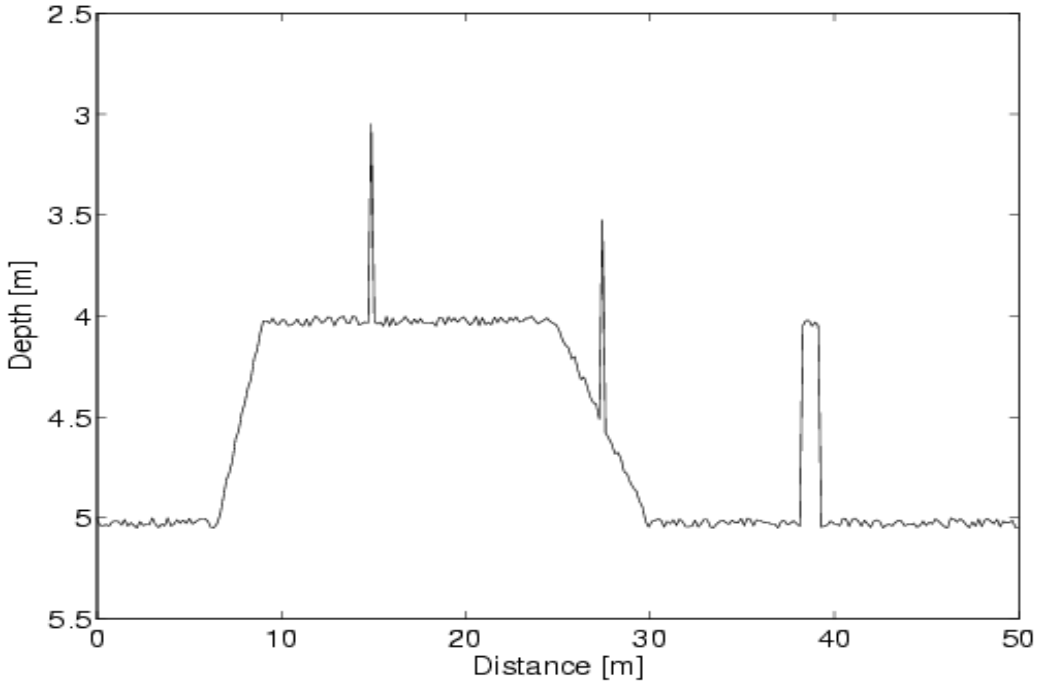
- Eradicate spikes in the signal to
  1. Obtain a smooth, ready-to-use, bathymetry
  2. Obtain all spike locations (e.g., for aquatic habitat analysis)

More spikes examples



Filtering techniques

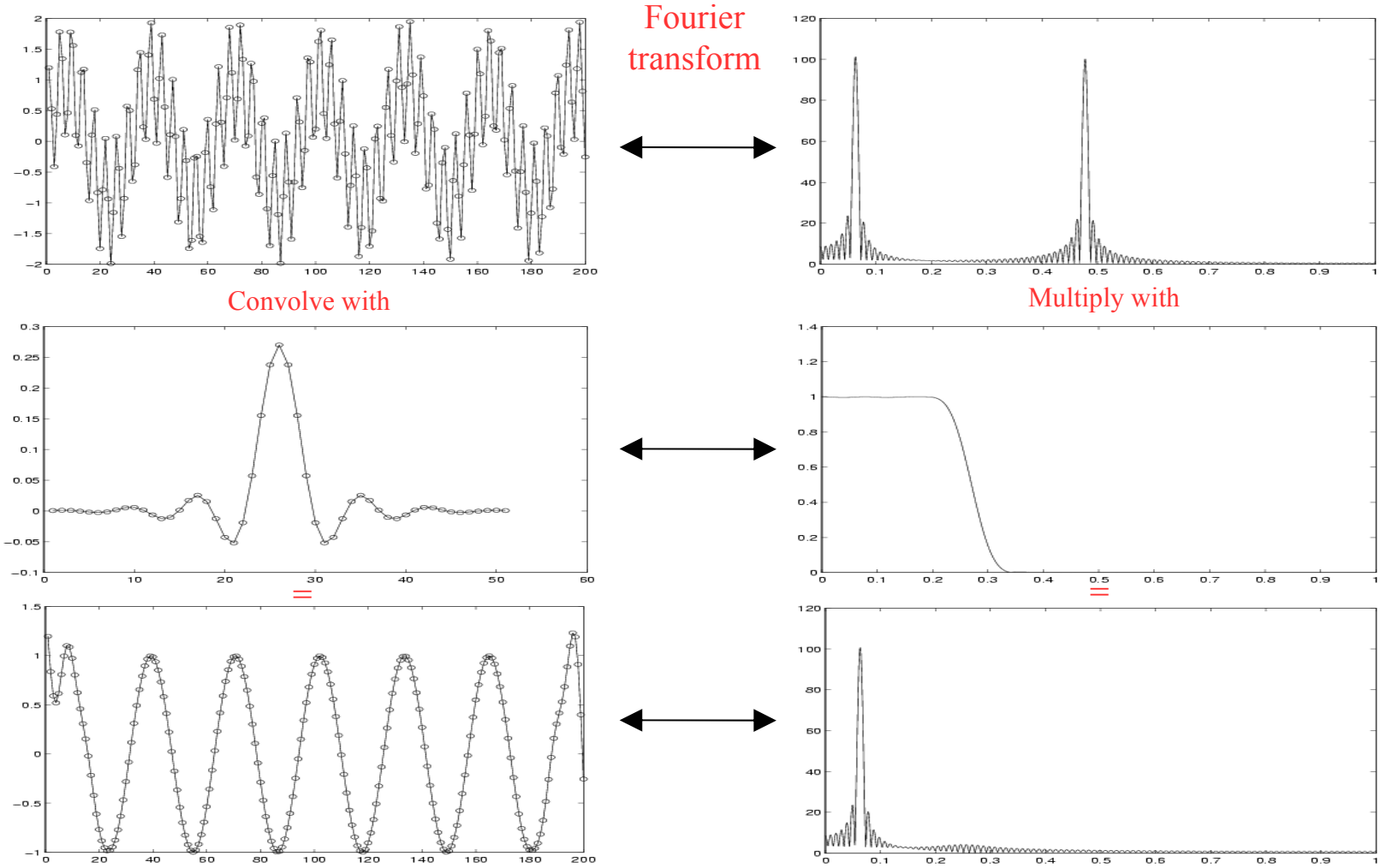
- Linear filtering
- Nonlinear filtering
- Benchmark to evaluate effectiveness of methods:



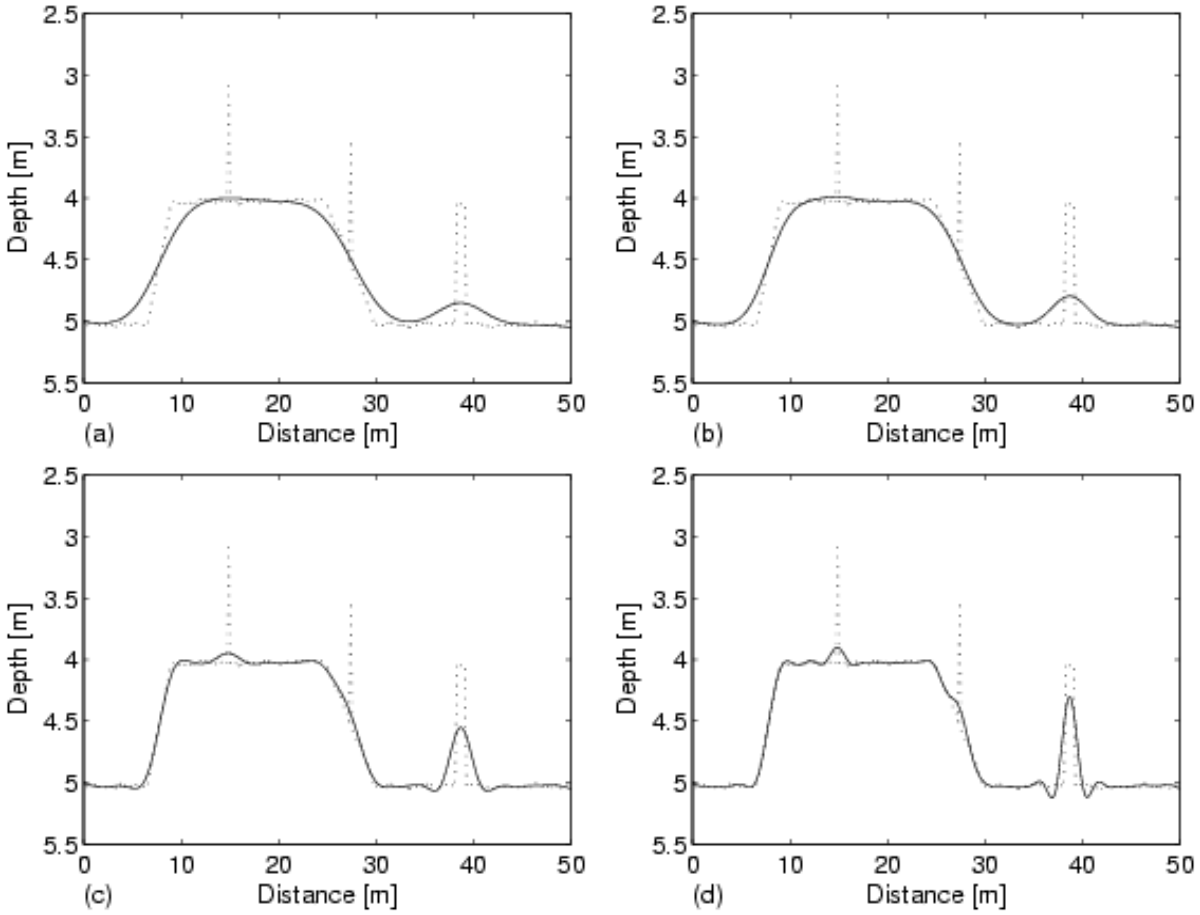
Lowpass linear filtering (1/4)

- Why linear ?
  - Computationally very efficient
  - Easy mathematical analysis
- Why lowpass filtering ?
  - Lowpass filters remove high-frequency components
  - High-frequency components are associated with sharp spikes

Lowpass linear filtering (2/4): (Very) brief overview



Lowpass linear filering (3/4)
Evaluation



Increasing cutoff frequencies:

a. 0.025

b. 0.05

c. 0.1

d. 0.15

Lowpass linear filtering (4/4)
Comments

- Difficulty in selecting adequate cutoff frequency
- Trade-off between edge retention and spike rejection

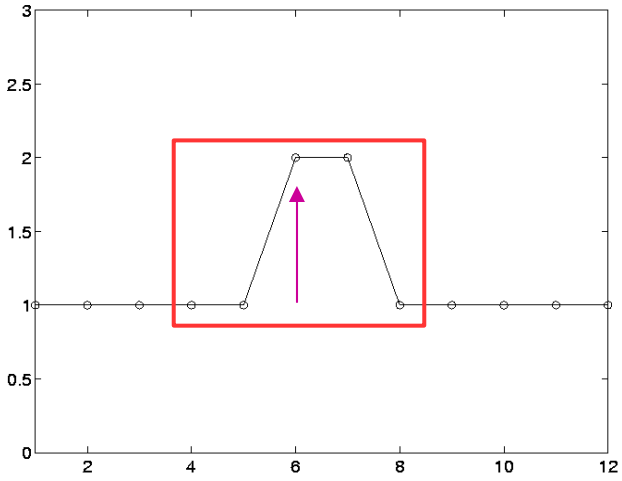
=> New technique is required

Nonlinear filtering

- Advantages:
  - Specifically designed to eradicate spikes and leave edges undisturbed
  - No need to select cutoff frequency
- Drawbacks:
  - Mathematical analysis is not straightforward
  - Not computationally efficient

Median filtering (1/4)
How does it work ?

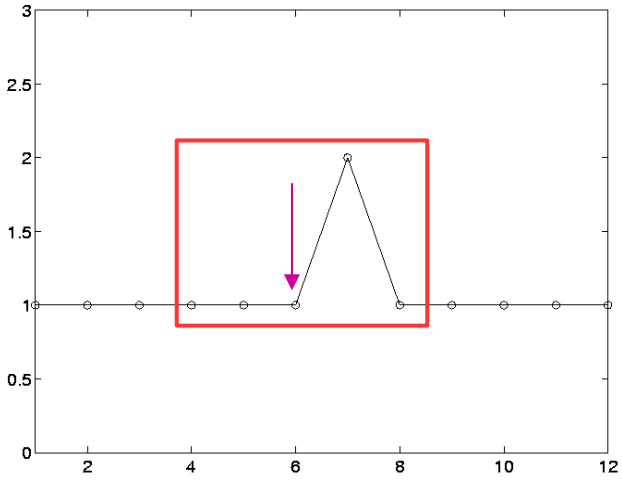
- Example of a length-5 filter



Order the windowed set

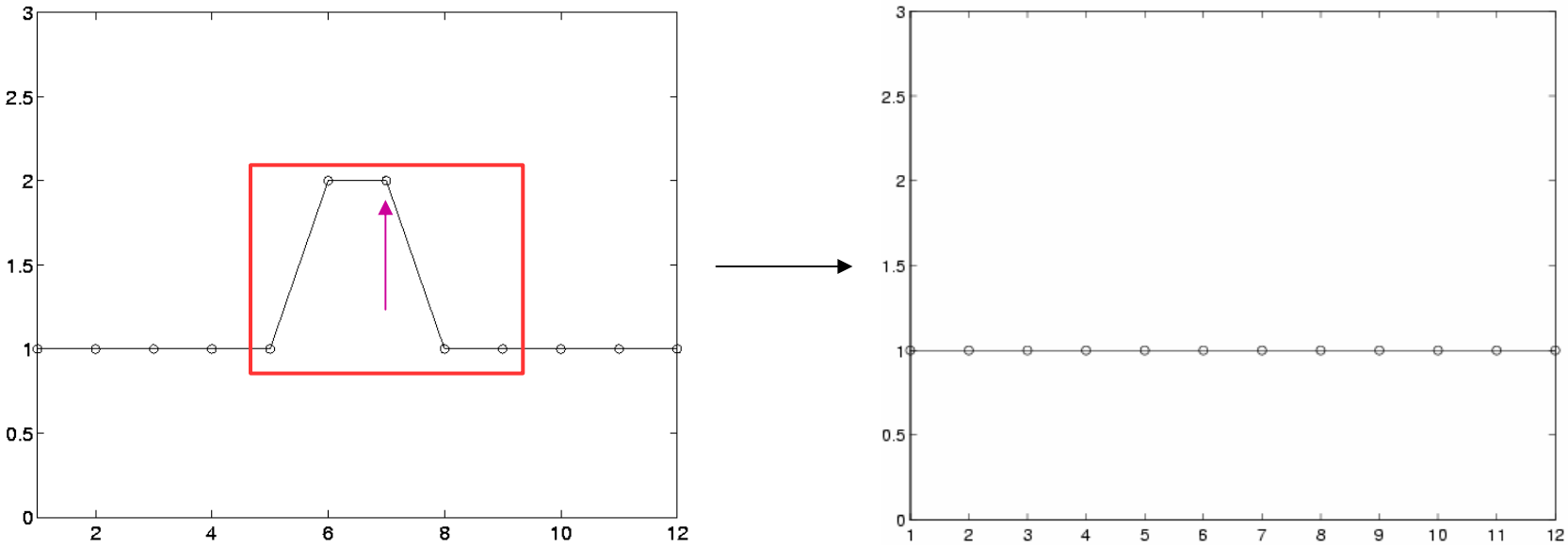
{1 1 1 2 2}

Take the median: 1

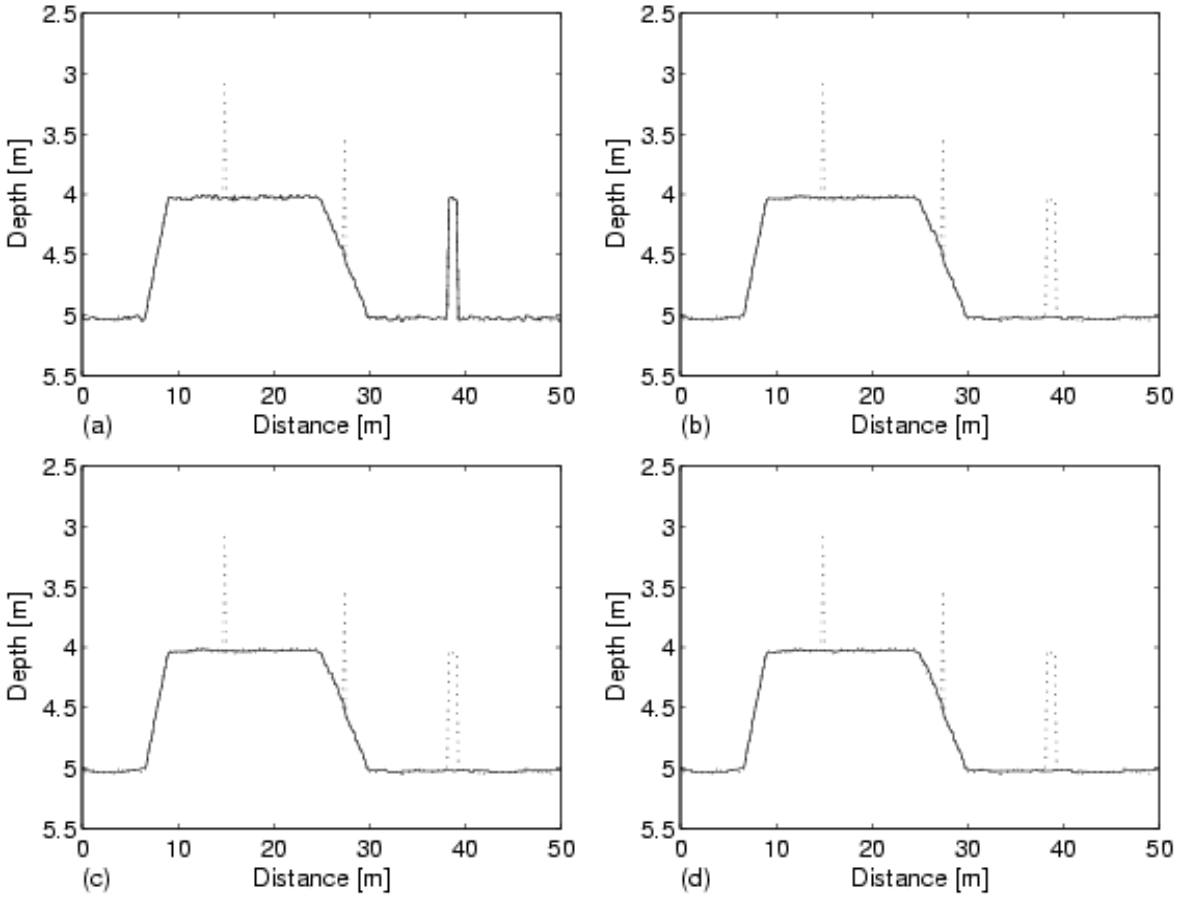


Replace the center sample by the median

Median filtering (1/4)
How does it work ?



Median filtering (2/4)
Evaluation



Increasing filter length:

a. 3

b. 13

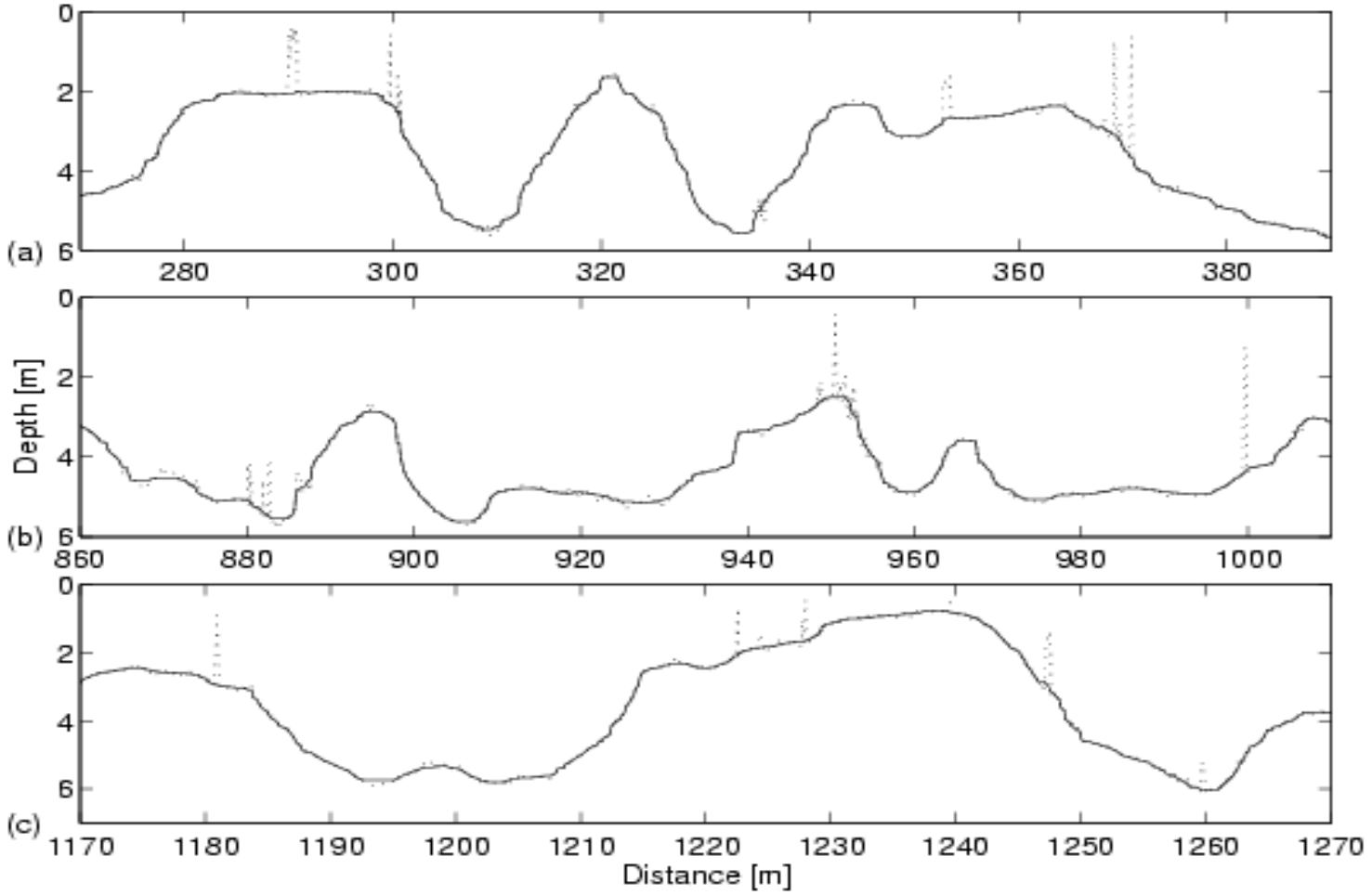
c. 17

d. 25

Median filtering (3/4)
Comments

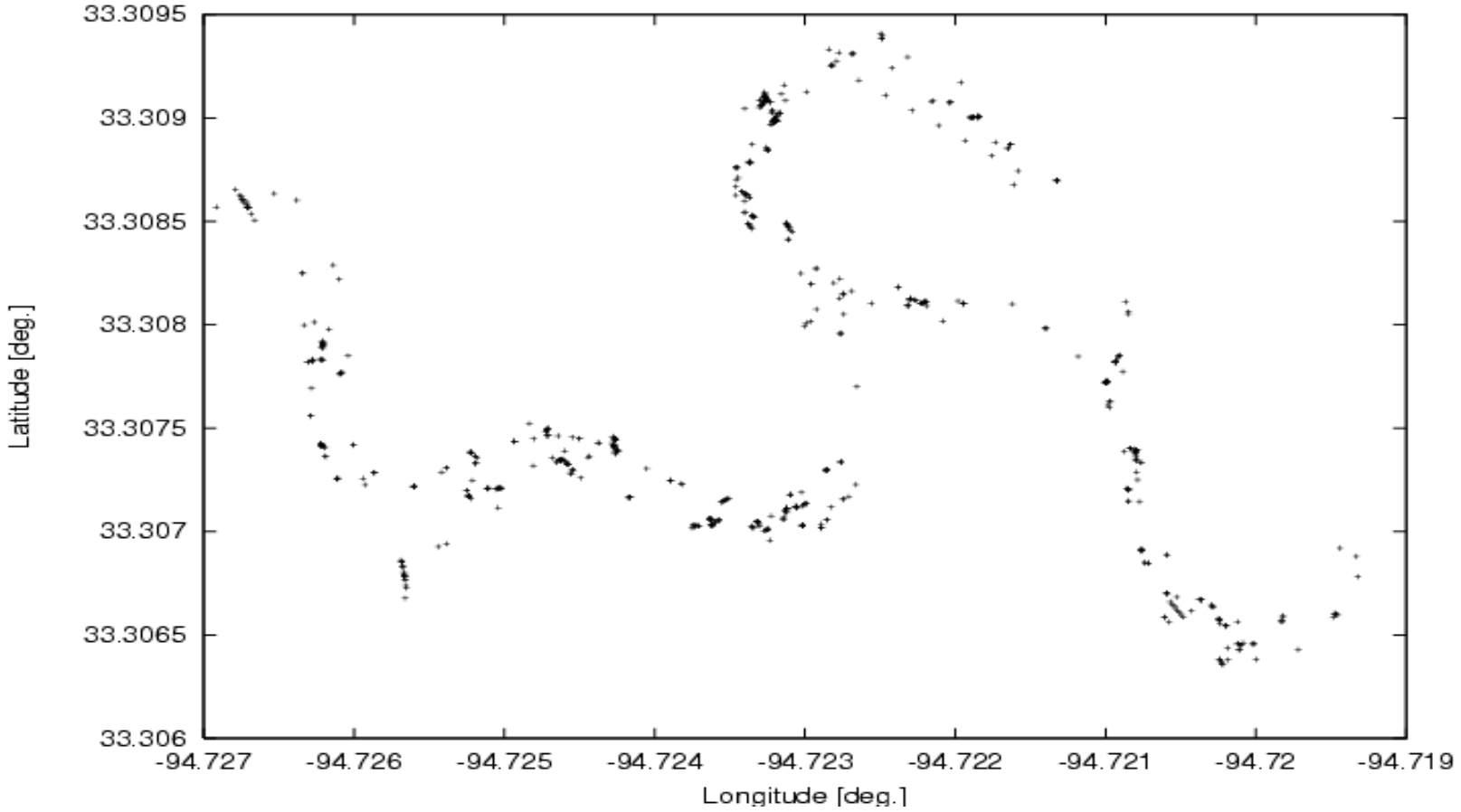
- No trade-off between edge retention and spike rejection
- Use of higher order filter does not distort large-scale bathymetric features
- Robust and easy to implement

Median filtering (4/4)
Practical use: length-23 filter



Mapping of LWD

- By comparison between original and filtered bathymetries



Conclusion

- Median filtering is a very effective way of filtering out spikes caused by LWD
- It yields a smoothened bathymetry and LWD locations

Acknoledgements

- Dr Hodges
- Texas Water Development Board
- Tim Osting

Questions ?