Flood inundation modeling in Schoharie Creek

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Aug 28, 2011 Hurrican Irene brought floods in Schoharie Creek Watershed…

Objectives

Event & post-event:

- Model flood extent & determine return period;
- Assist in the damage assessment and analysis;
- Pair flood gauge readings and FEMA flood scenarios.

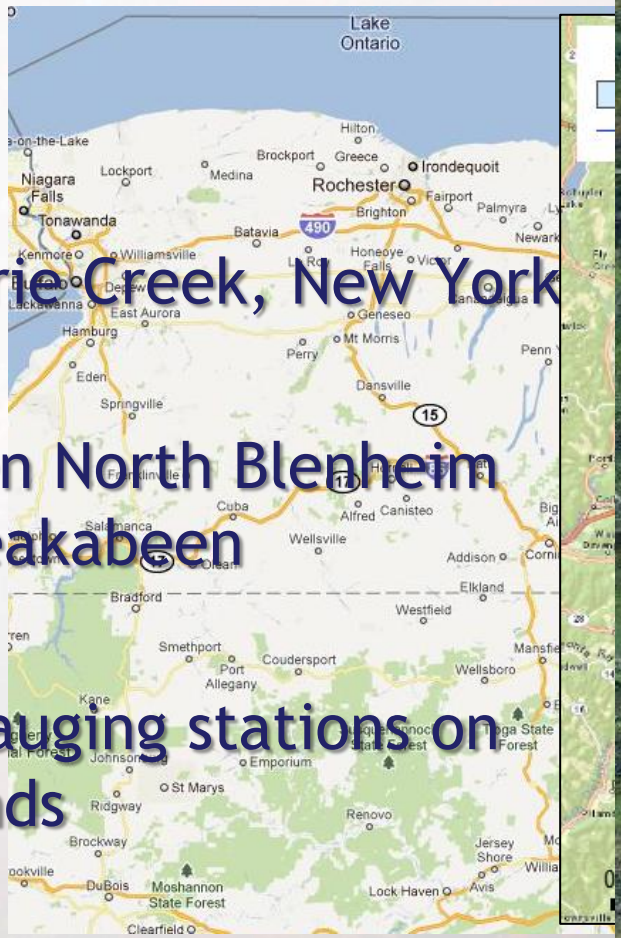
2yr, 5yr, 10yr…200yr, 500yr flood

Pre-event:

- Validate the framework for future quick responses;
- Set up a warning system for un-gauged areas

Study Area

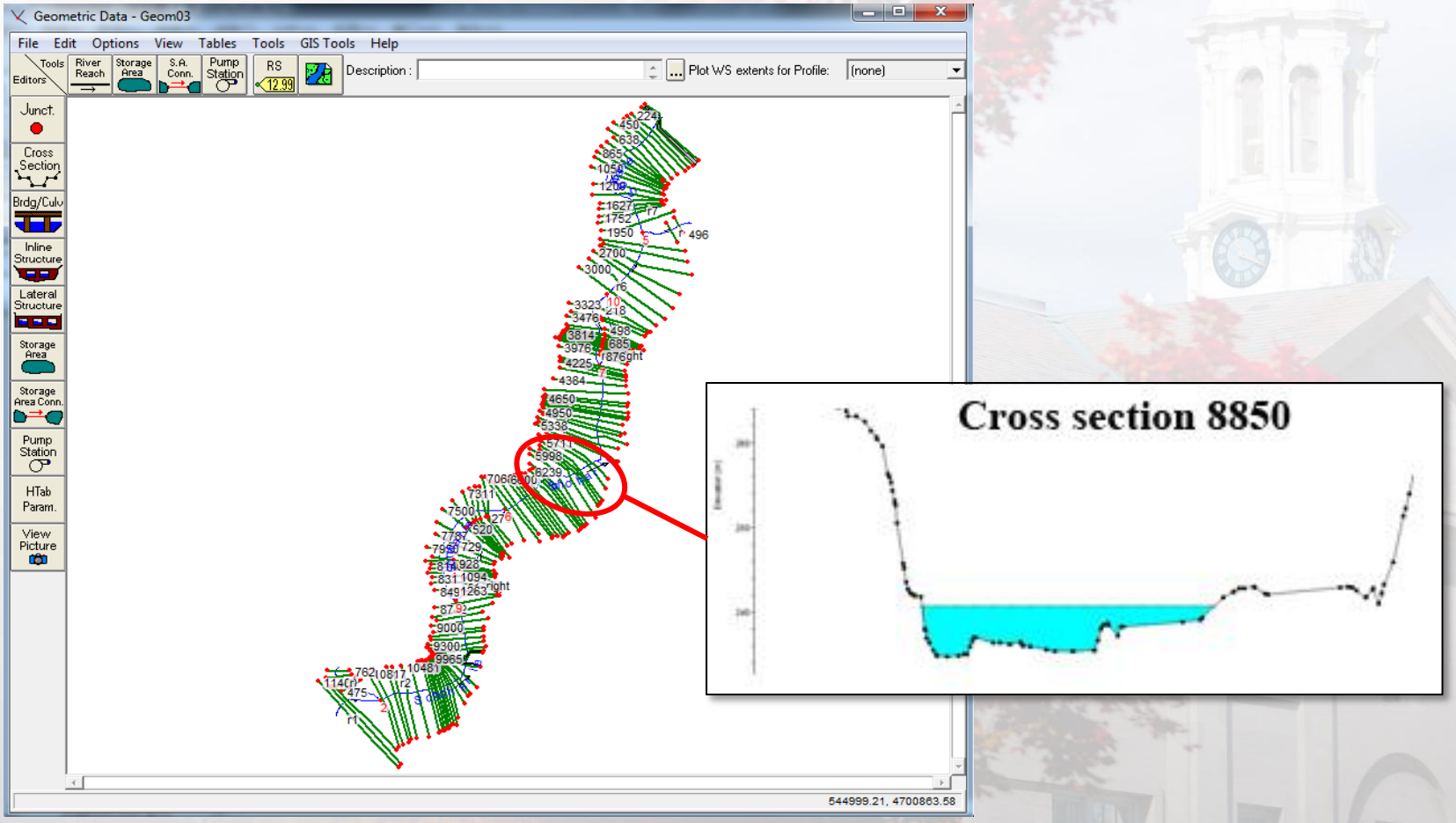
- Schoharie Creek, New York
- Between North Blenheim and Breakabeen
- USGS gauging stations on both ends

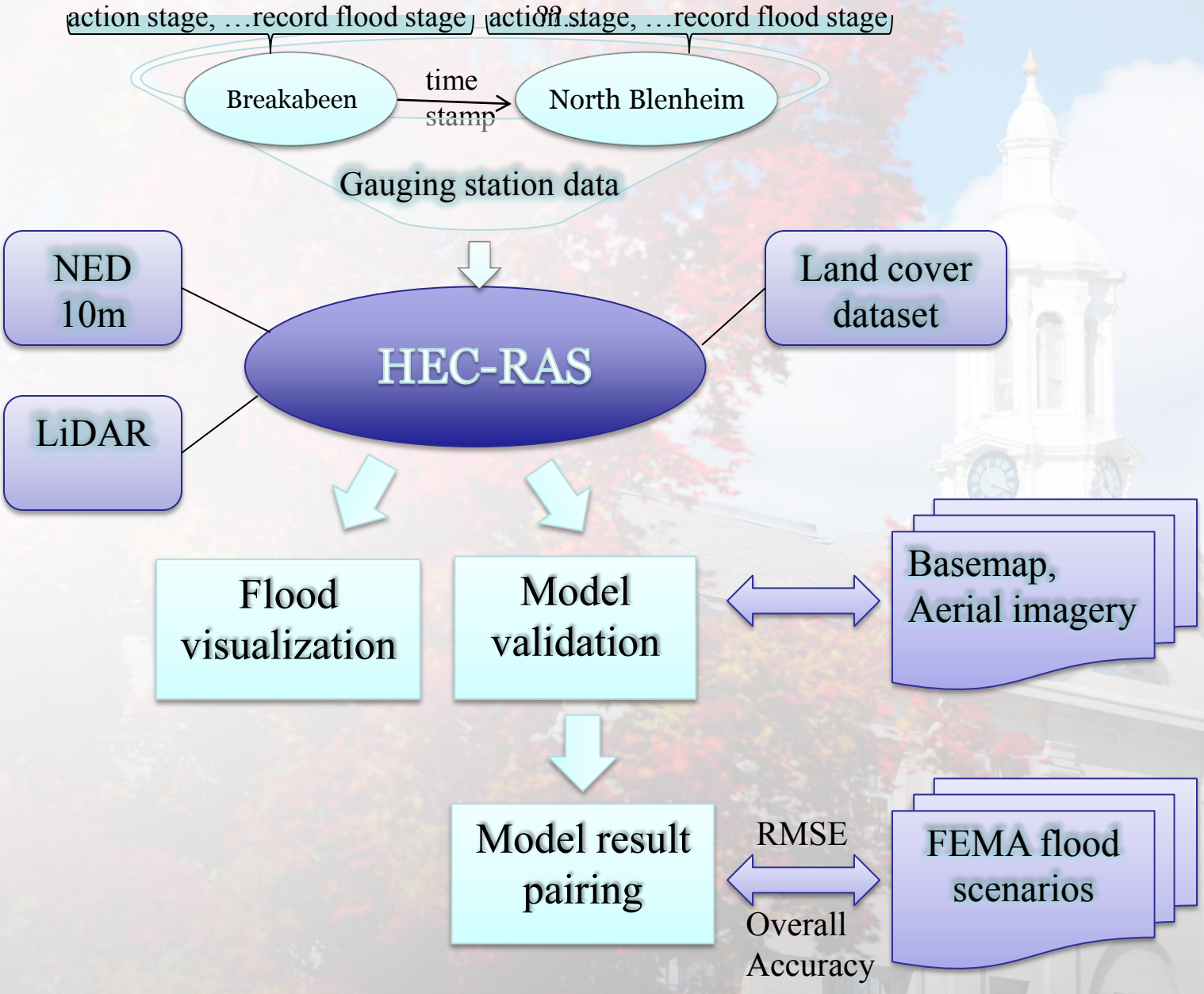


Data

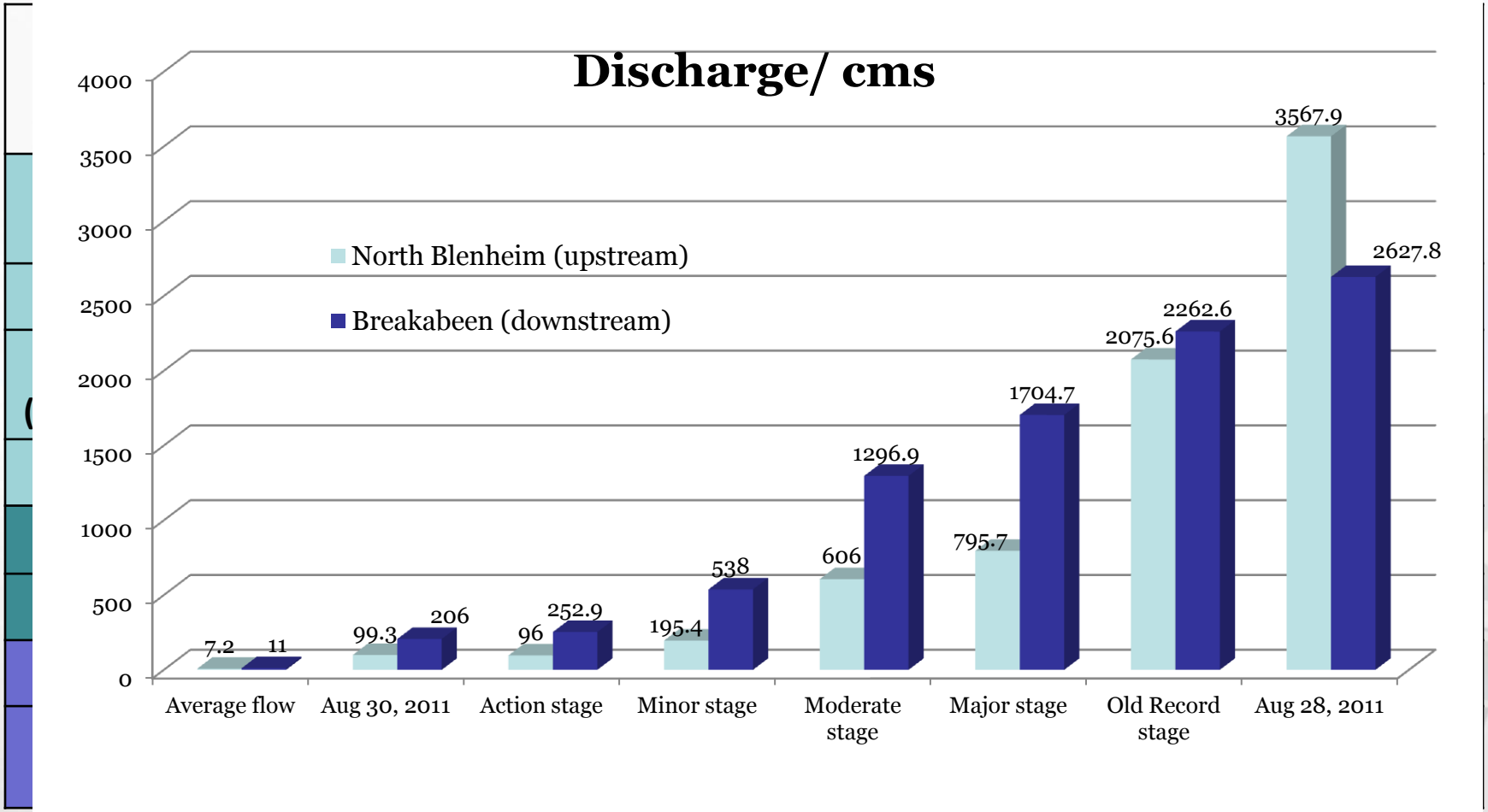
- Topographic data:
  - 1)National Elevation Dataset (NED) 10m DEM
  - 2) LiDAR data collected on Aug 30, 2011
- National Land Cover Dataset
- Ortho VNIR imagery collected on Aug 30, 2011
- USGS gauging station data
- NOAA flood stage categories (Action Stage, Minor Stage…Record Stage)
- FEMA Flood scenarios
- GIS world basemap from Esri

Hydraulic model: HEC-RAS

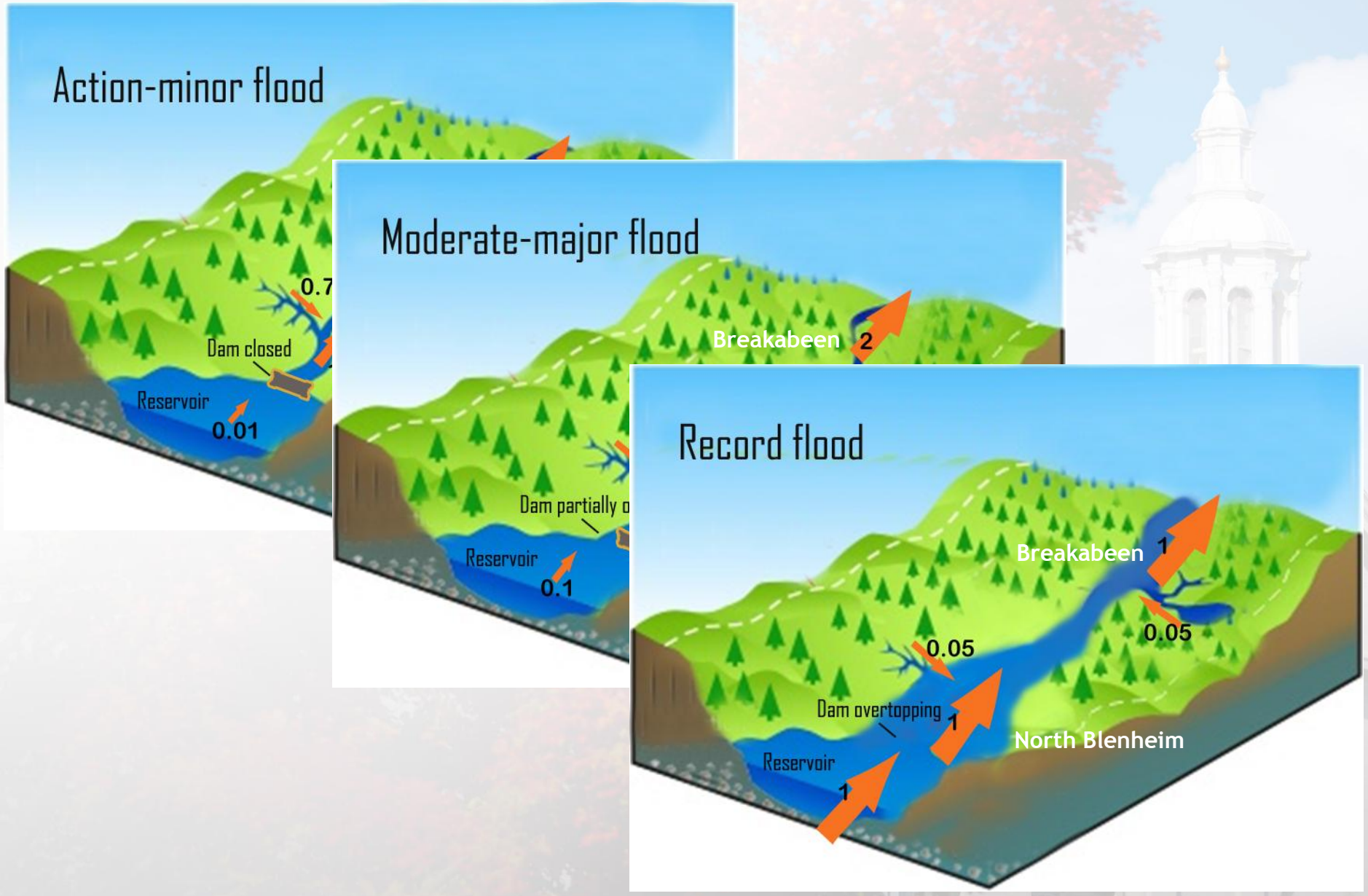



action stage, …record flood stage
action stage, …record flood stage
Breakabeen
time stamp
North Blenheim
Gauging station data
NED 10m
LiDAR
HEC-RAS
Land cover dataset
Flood visualization
Model validation
Basemap, Aerial imagery
Model result pairing
RMSE
Overall Accuracy
FEMA flood scenarios

Gauging station data



t refers to time stamp based.
r refers to calculated with the discharge-stage rating equation.


Action-minor flood
0.7
Dam closed
Reservoir
0.01
Moderate-major flood
Breakabeen
2
Dam partially
Reservoir
0.1
Record flood
Breakabeen
1
0.05
0.05
Dam overtopping
1
North Blenheim
Reservoir
1

Validation of HEC-RAS model

Model result ⟺ Observation

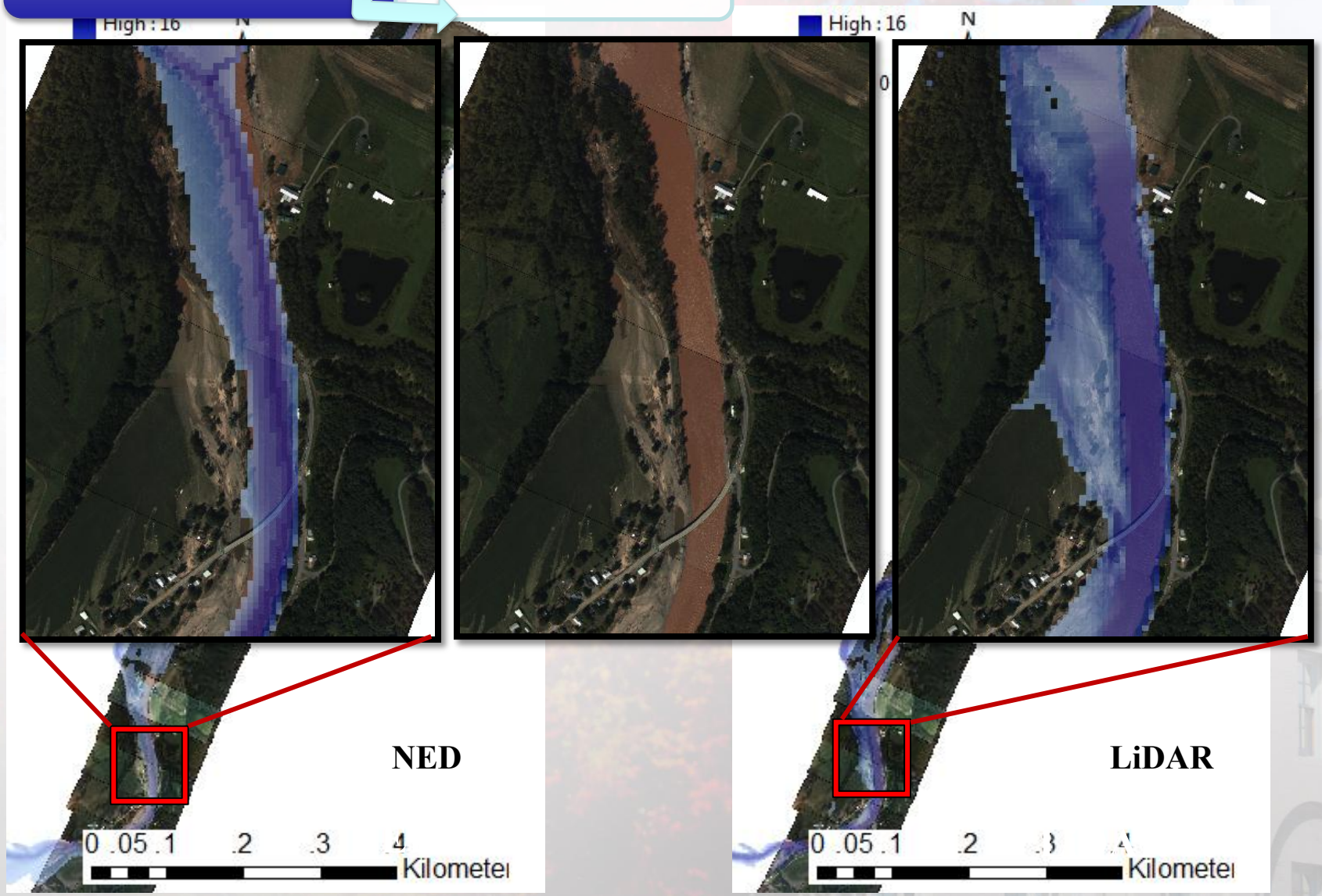
Average Flow[1]

- Constrained to the channel

1: Average flow of January, 2009

Aug 30, 2011
(imagery collecting day)

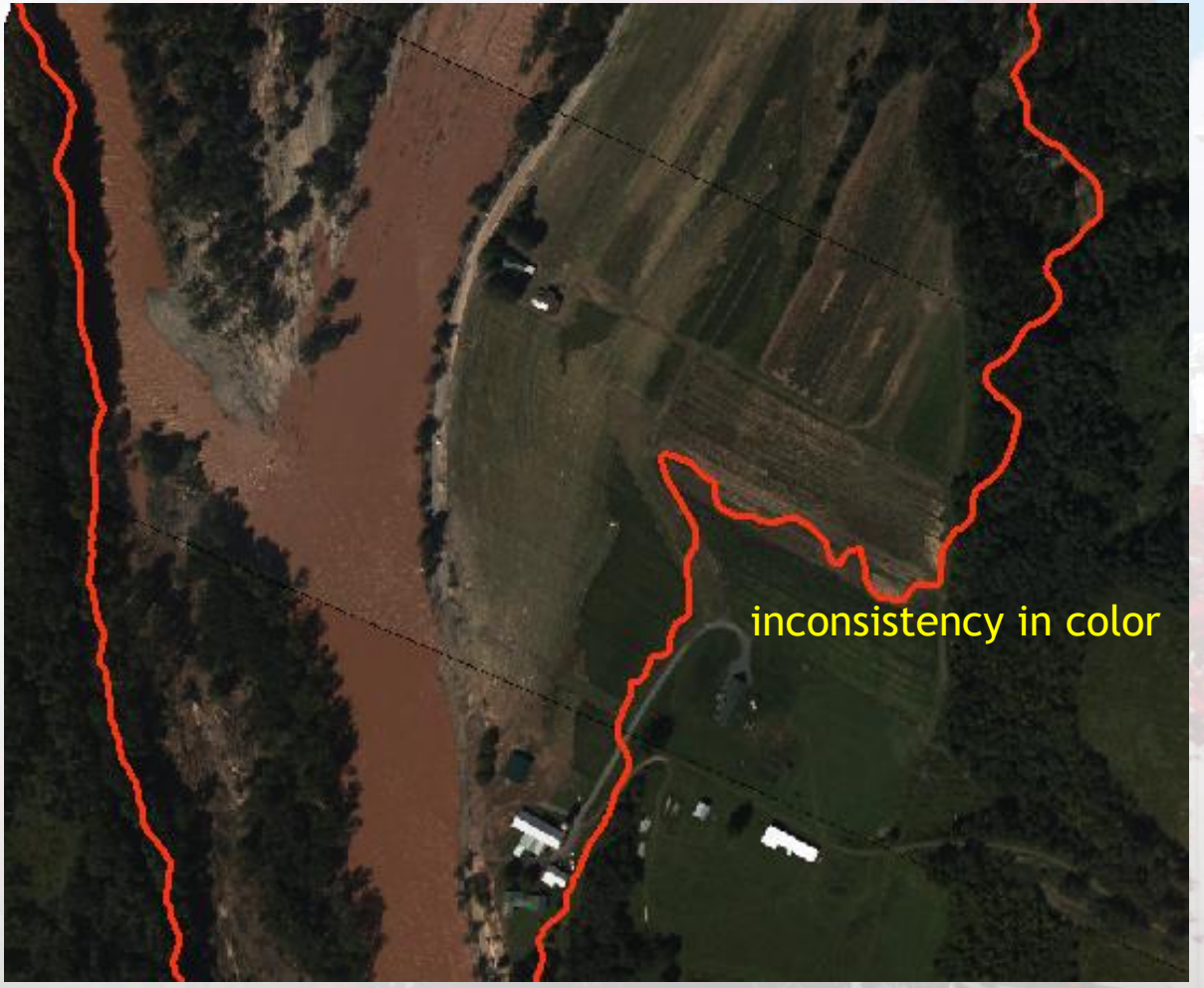
- Ortho imagery (water line)



Aug 28, 2011
(event day)

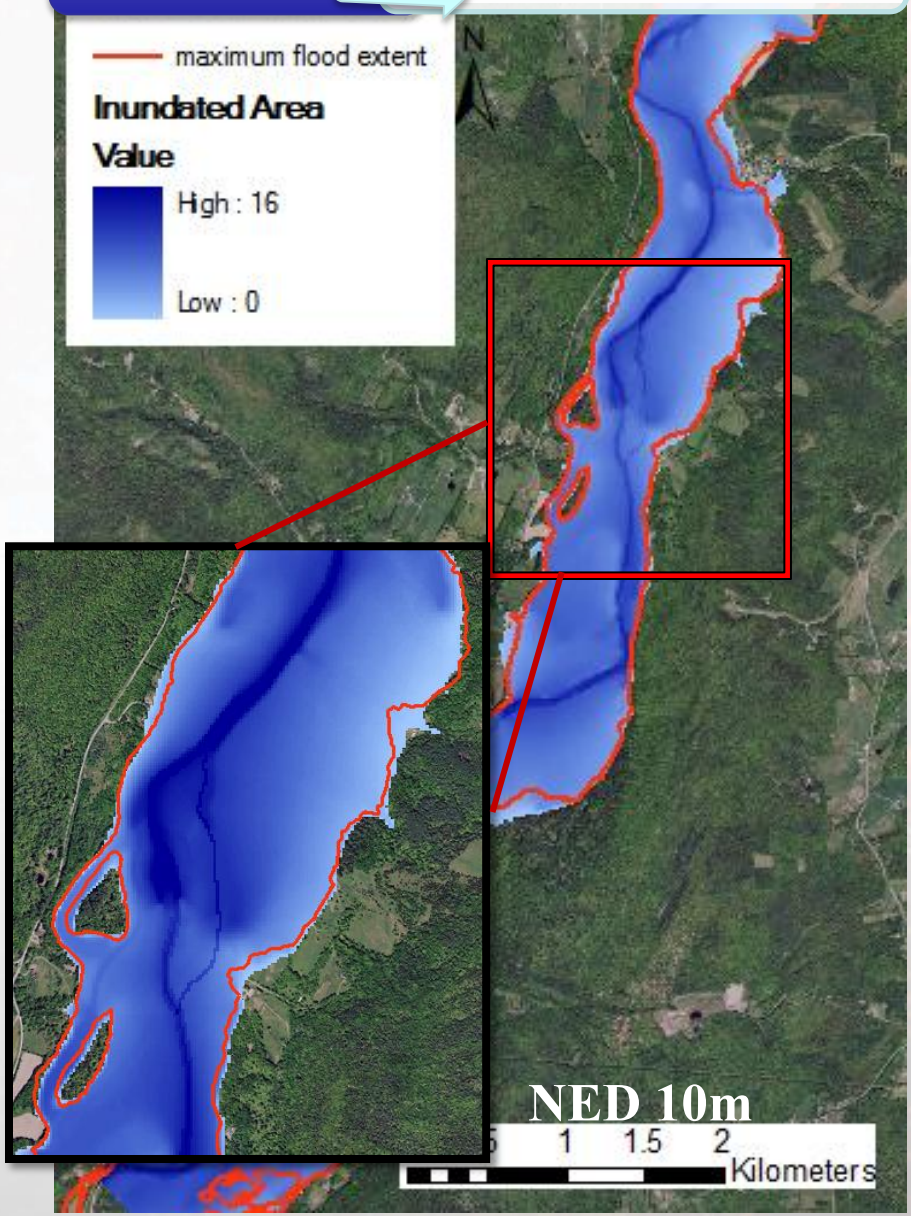
- Ortho imagery
(max flood extent)

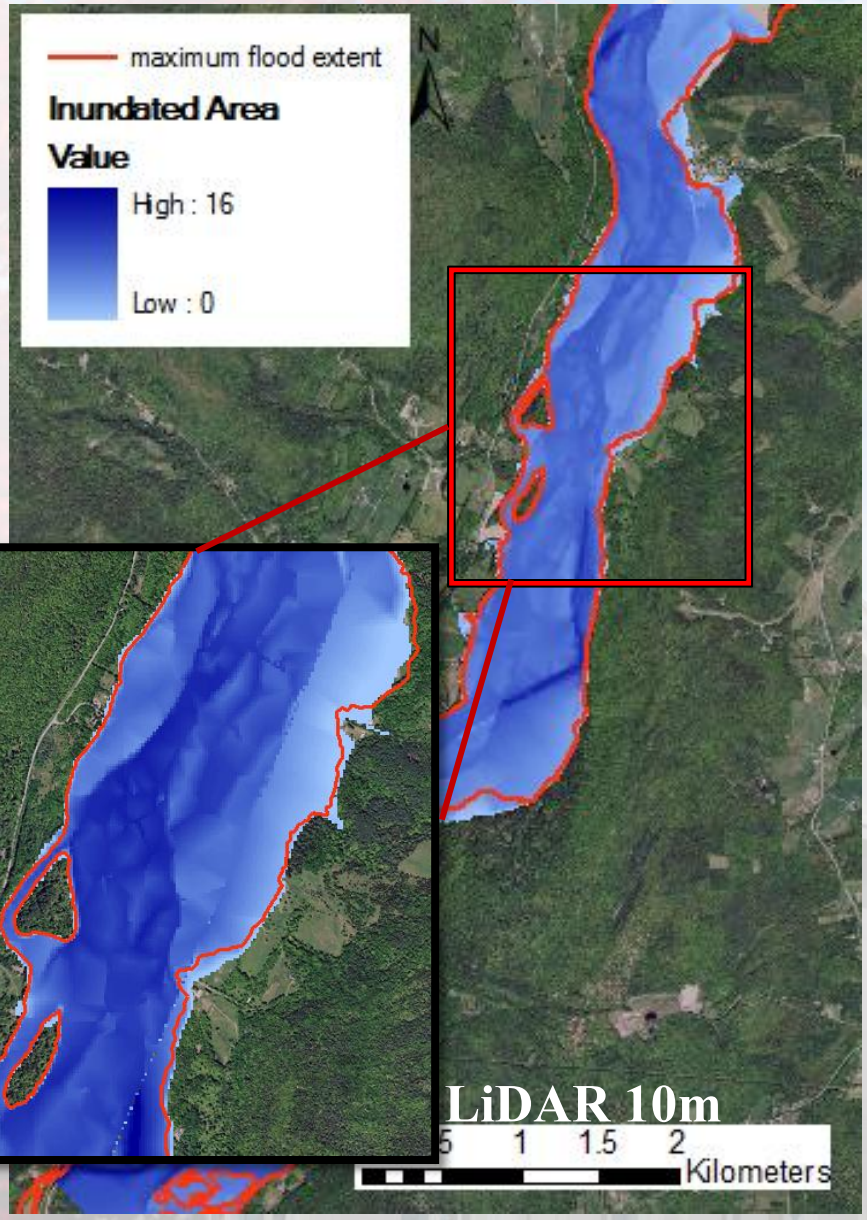
Maximum flood extent indicated on the imagery by:
physical flood evidence
inconsistency in the ground color



Aug 28, 2011
(event day)

- Ortho imagery
(max flood extent)

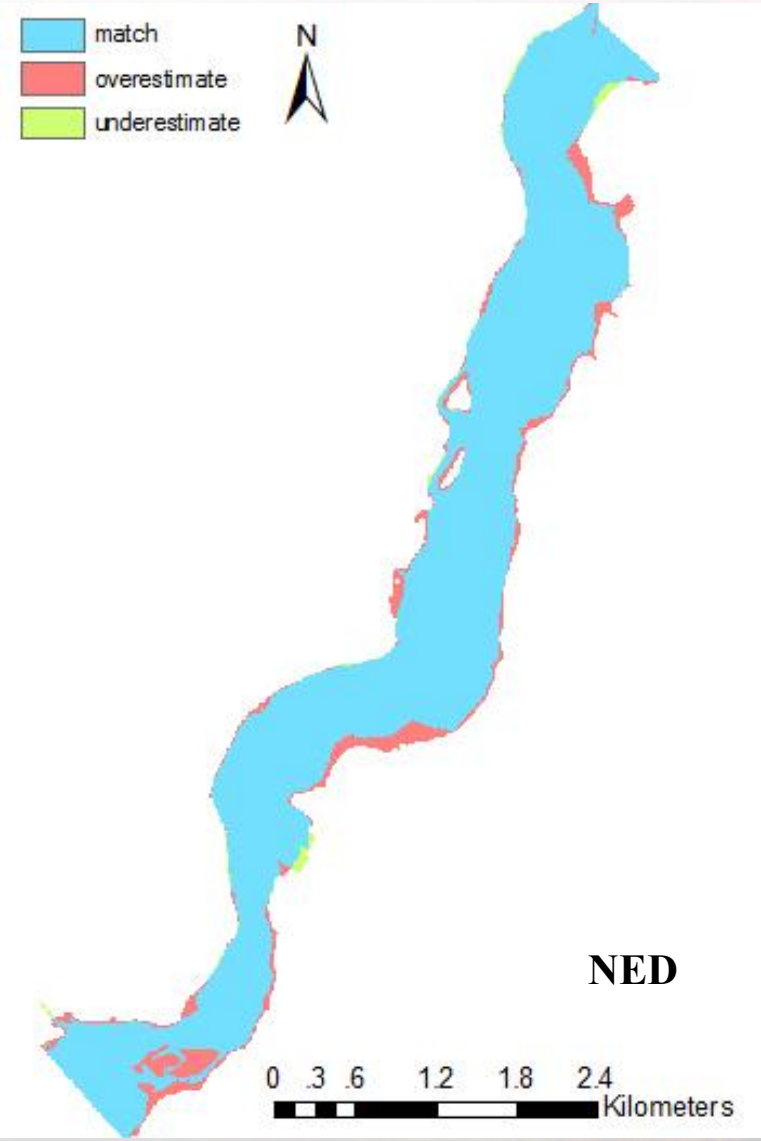


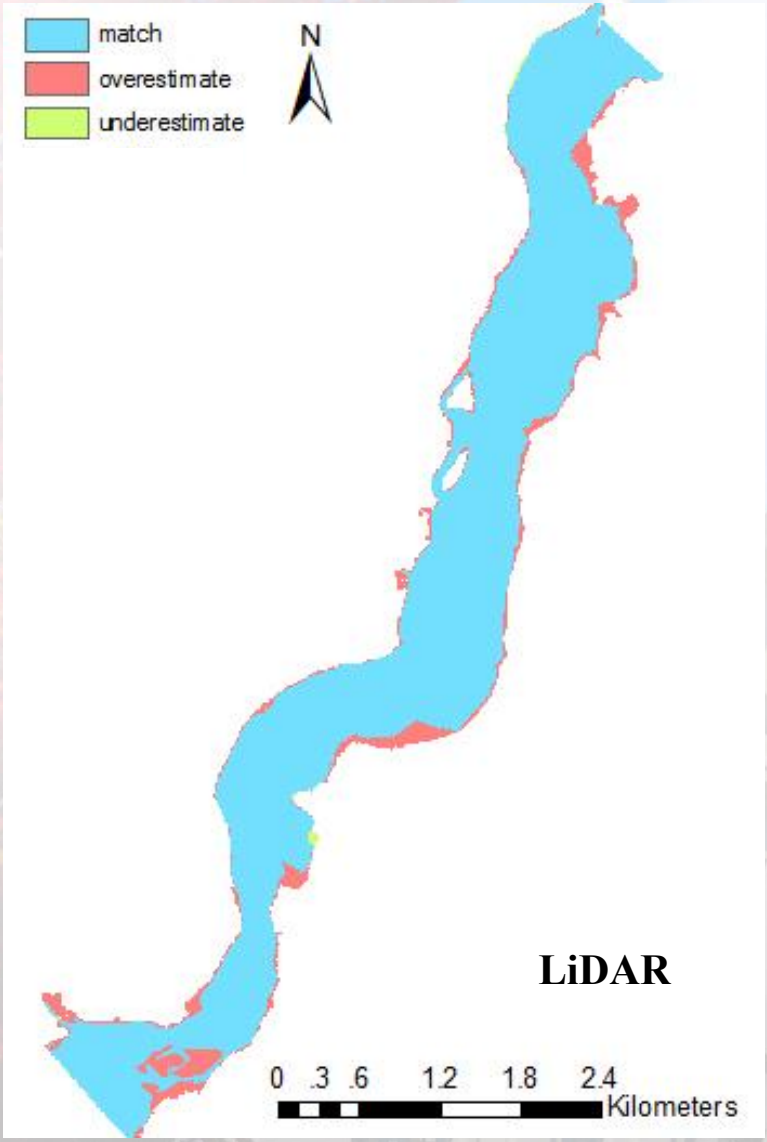


Aug 28, 2011 (event day)

- Ortho imagery (max flood extent)

Difference map





Two indexes to compare the inundated areas:

Overall Accuracy:

(most agree) 1 ~ 0 (most disagree)

Observation / Model Prediction	Flooded	Not Flooded
Flooded	N_1	N_2
Not Flooded	N_3	N_4

$$\text{Overall Accuracy} = \frac{N_1}{N_1 + N_2 + N_3} \times 100\%$$

Root-mean-square error (RMSE):

(most agree) 0 ~ $+\infty$ (most disagree)

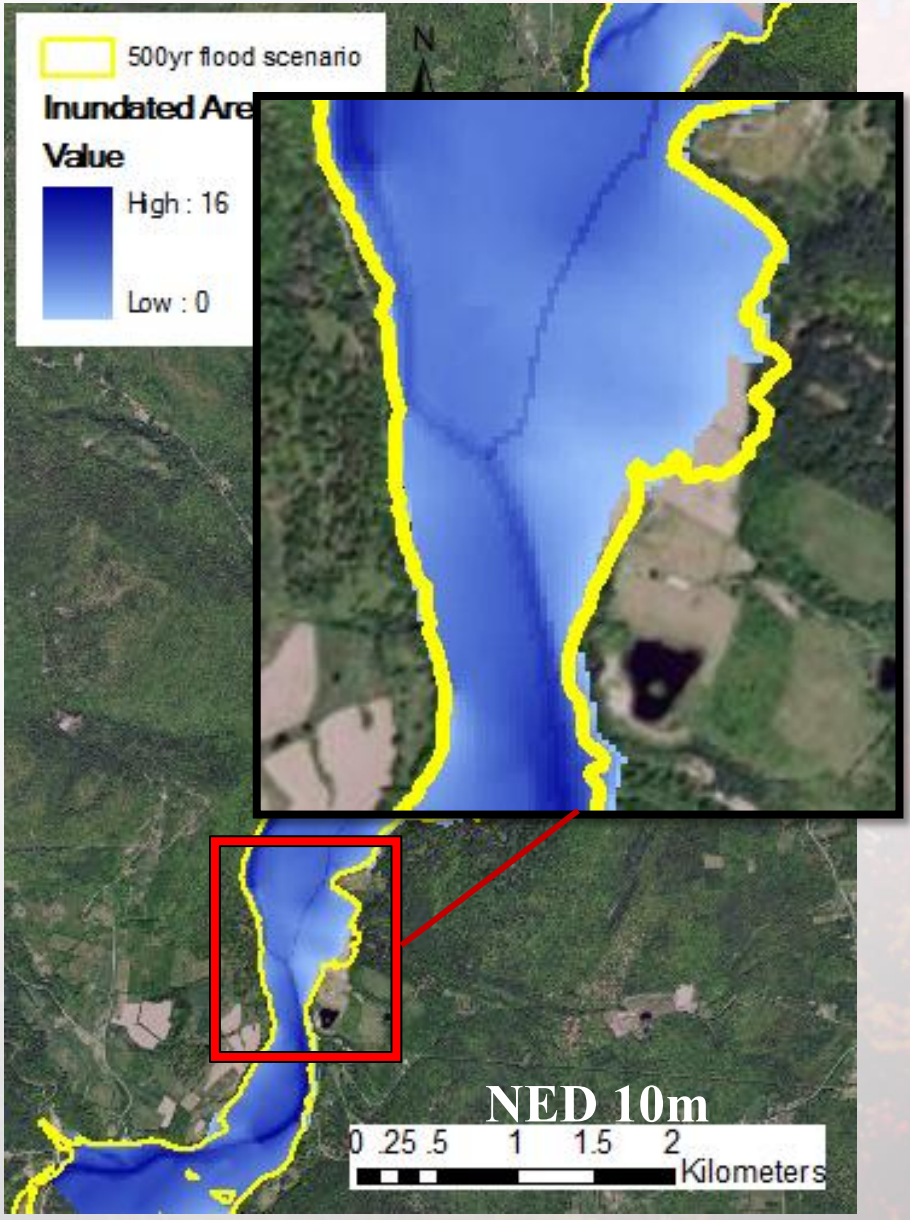
$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (P_i - O_i)^2}{N}}$$

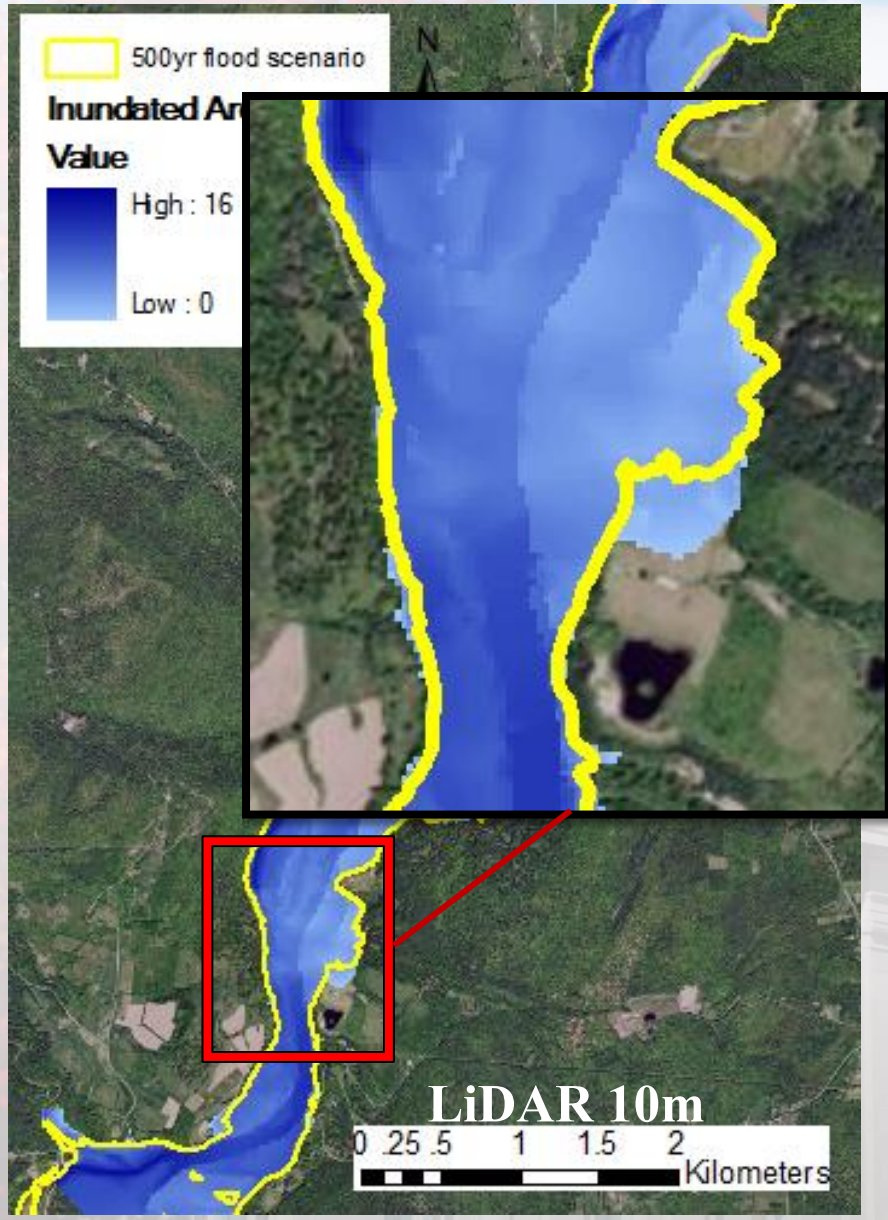
	Overall Accuracy	RMSE/m
NED result vs. maximum flood extent	89.80%	0.319
LiDAR result vs. maximum flood extent	89.77%	0.320

Pairing model results

Aug 28, 2011
(event day)

- 500yr flood

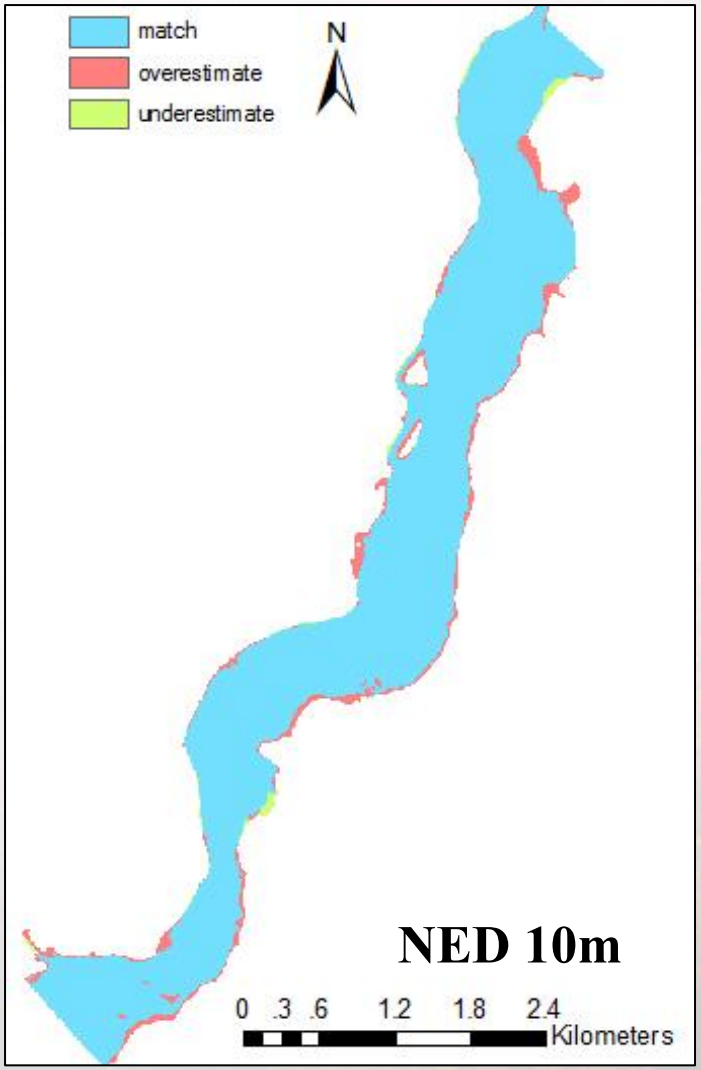


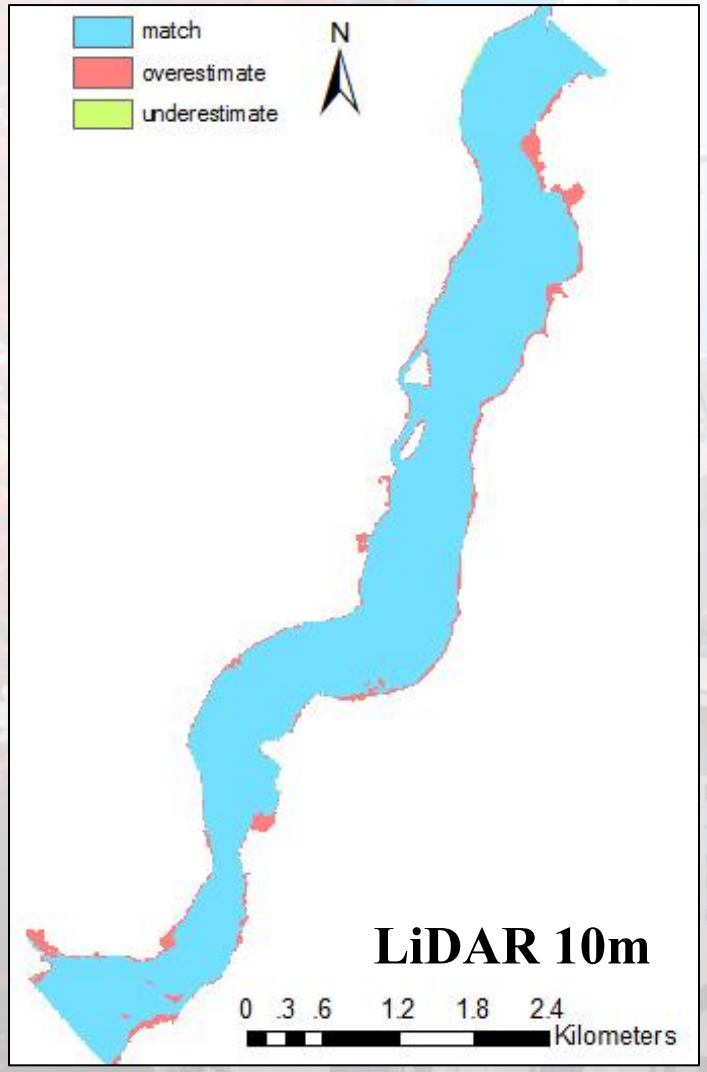


Aug 28, 2011 (event day)

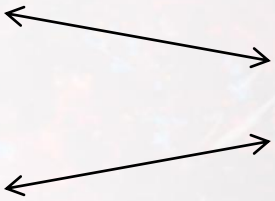
- 500yr flood

Difference map





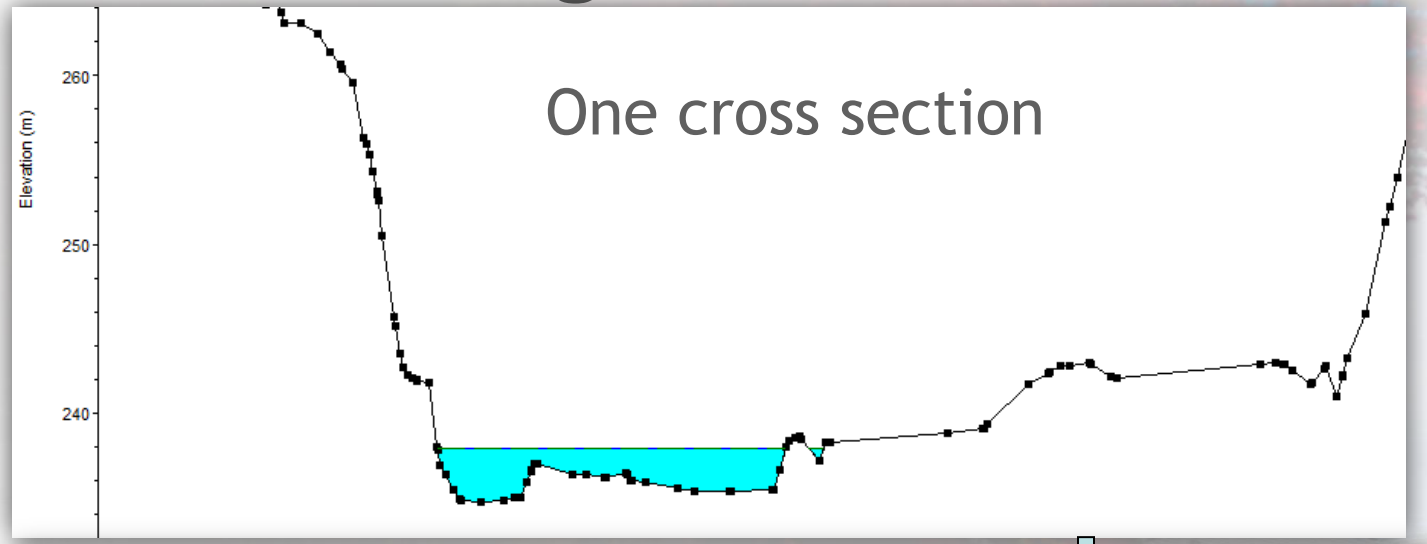
	Overall Accuracy	RMSE/m
NED result vs. 500yr	92.25%	0.278
LiDAR result vs.500yr	92.36%	0.276

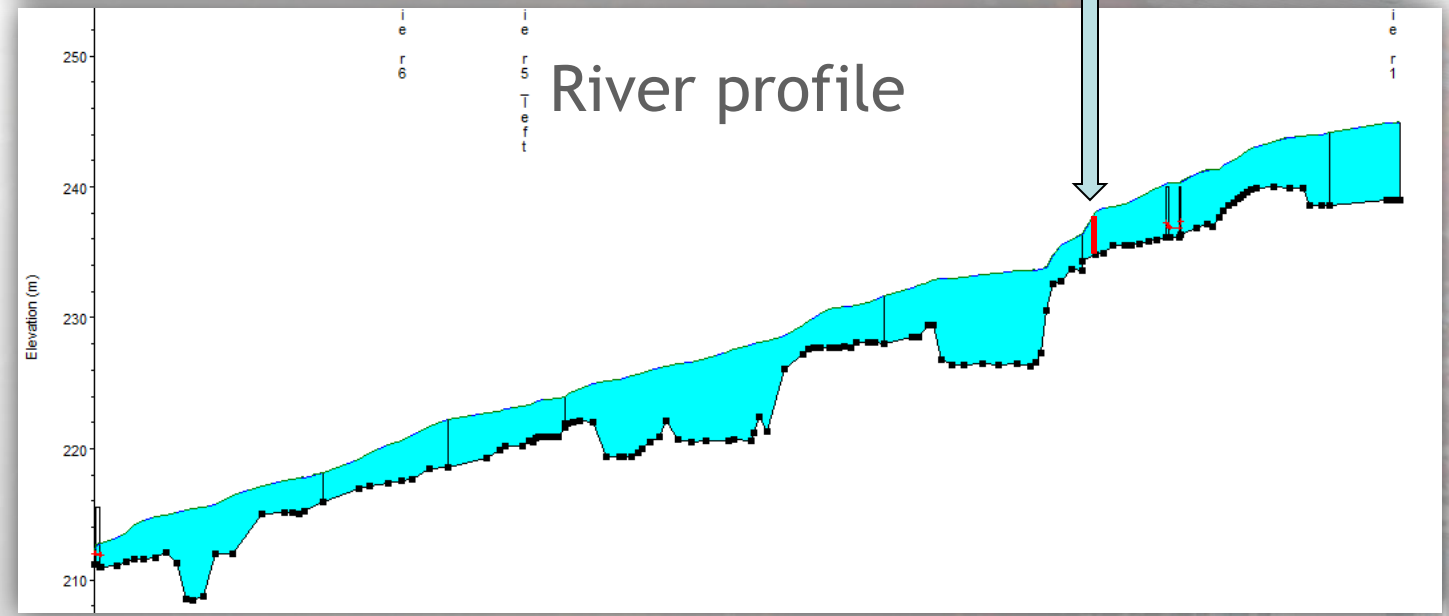


Action stage	2yr flood
Minor stage	5yr flood
…	…
Record stage	500yr flood

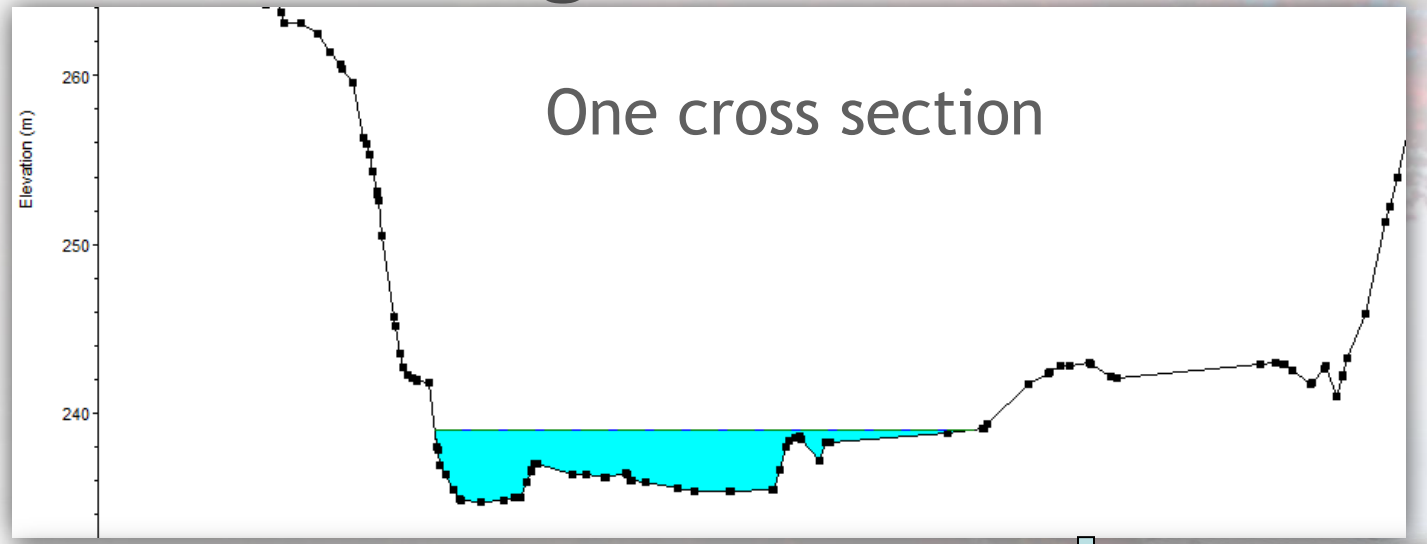
Pairing principle:
find the pair with the largest Overall Accuracy & smallest RMSE.

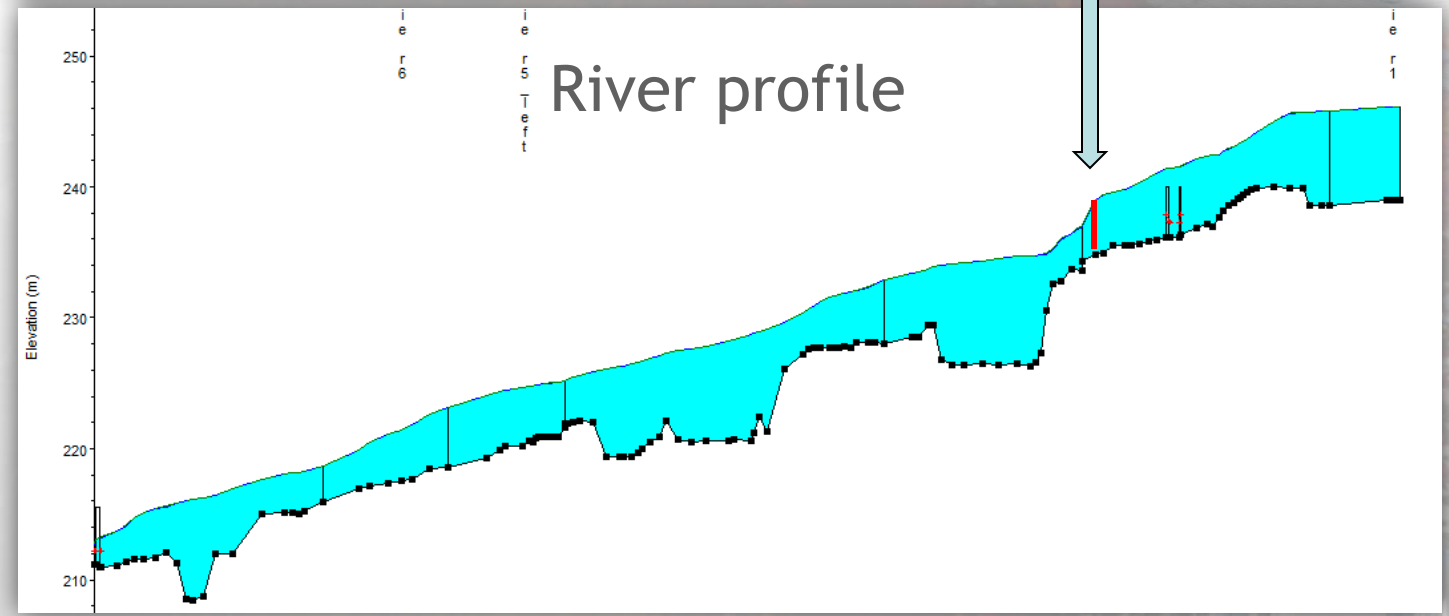
Action stage



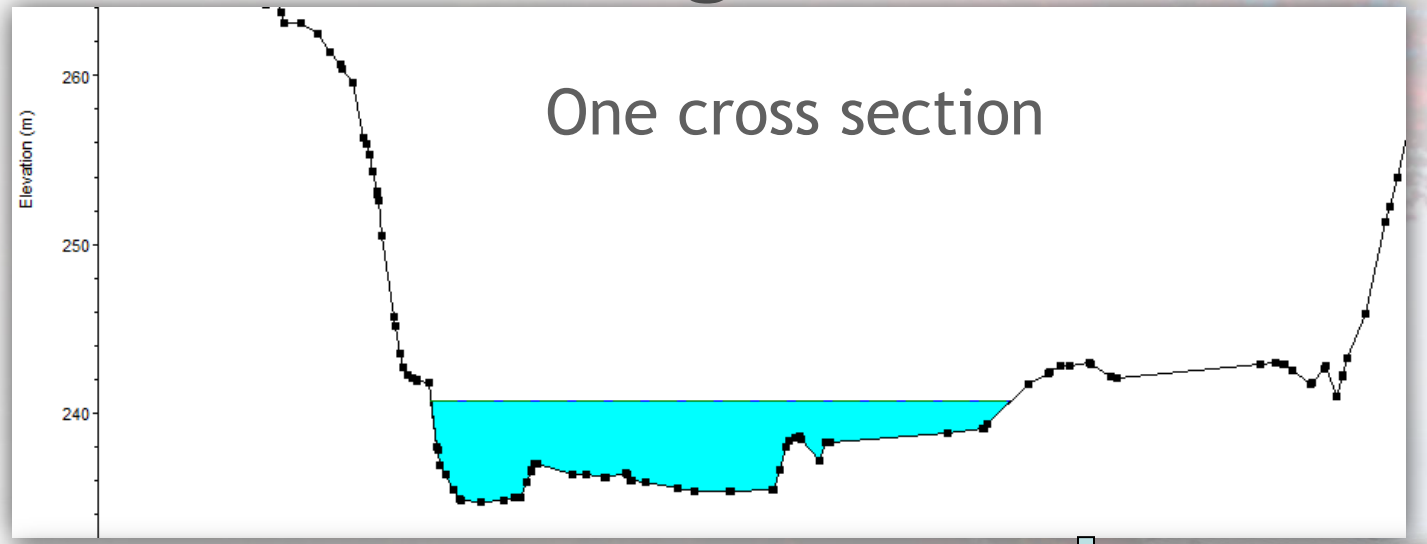


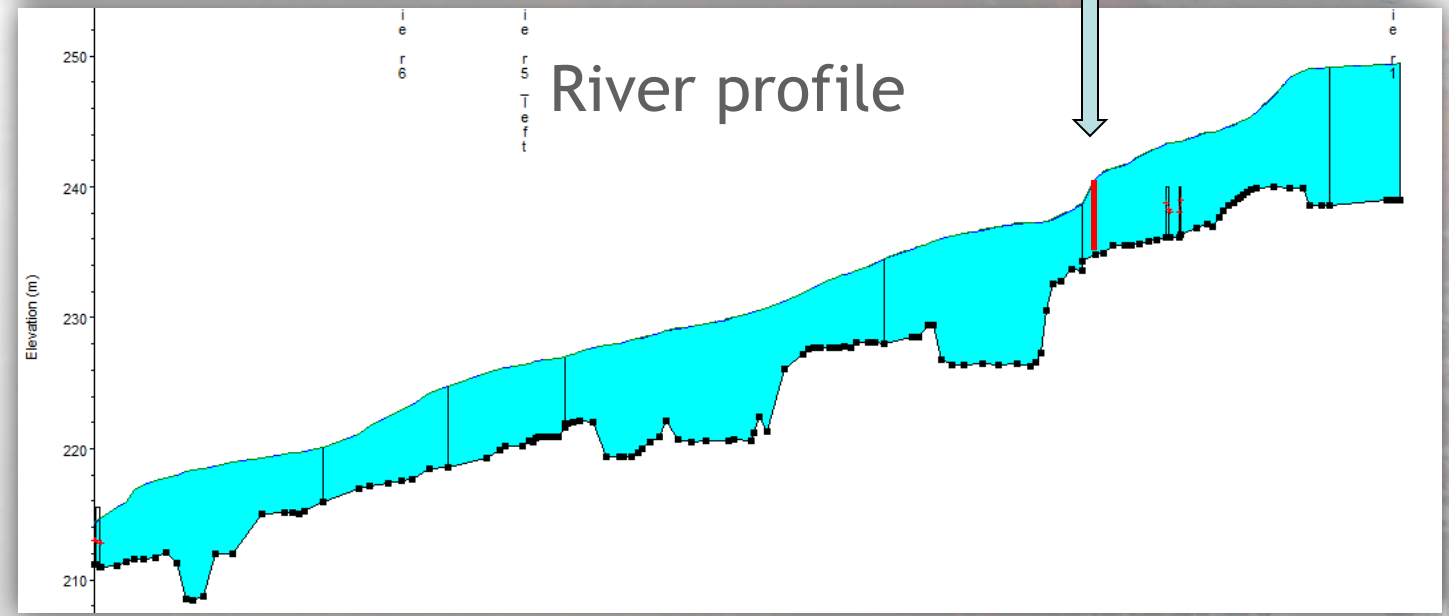
Minor stage


One cross section
Elevation (m)
260
250
240

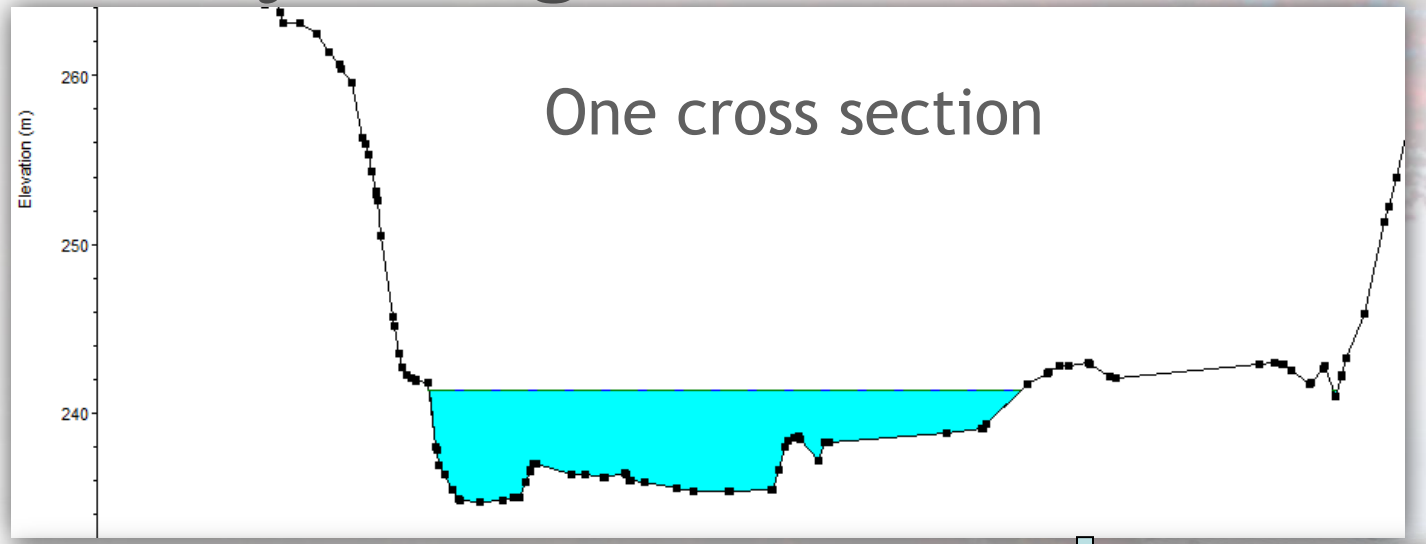

River profile
Elevation (m)
250
240
230
220
210

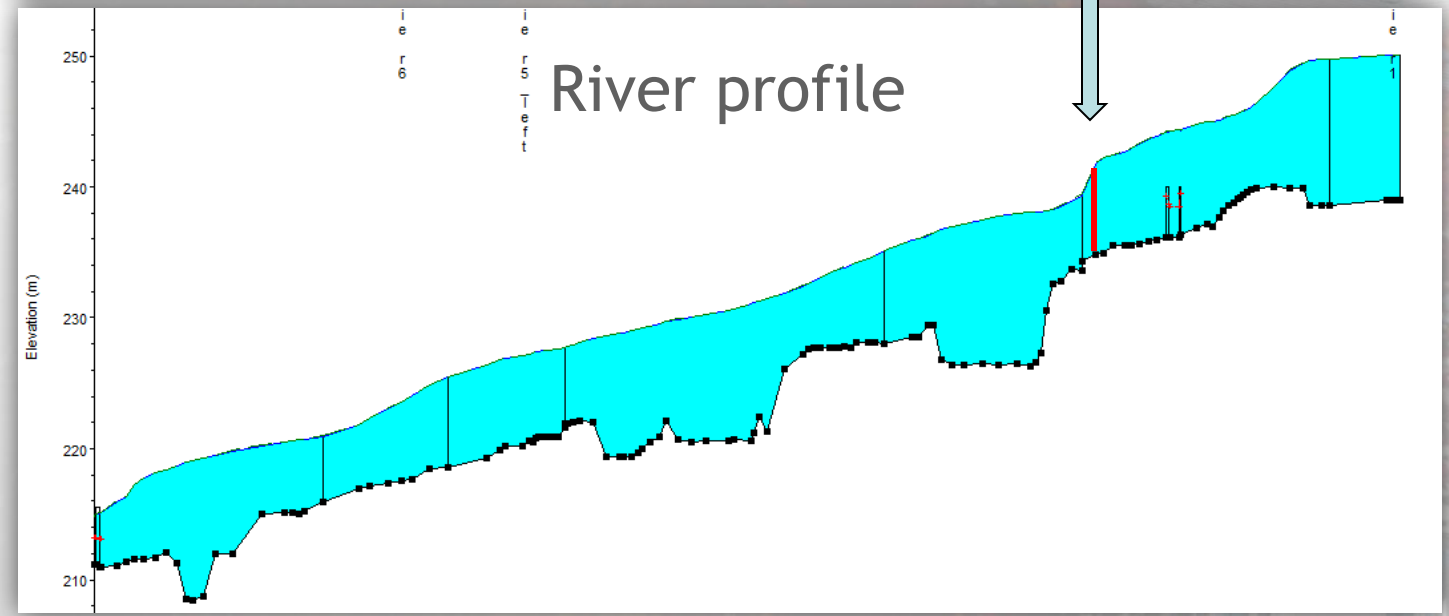
Moderate stage



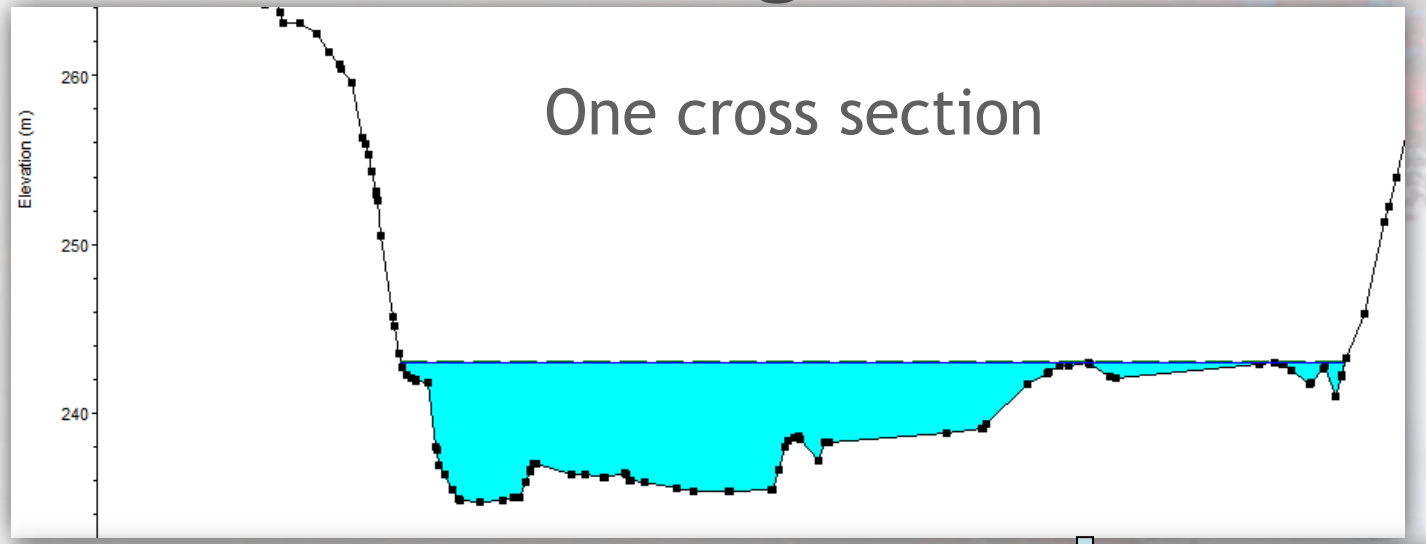


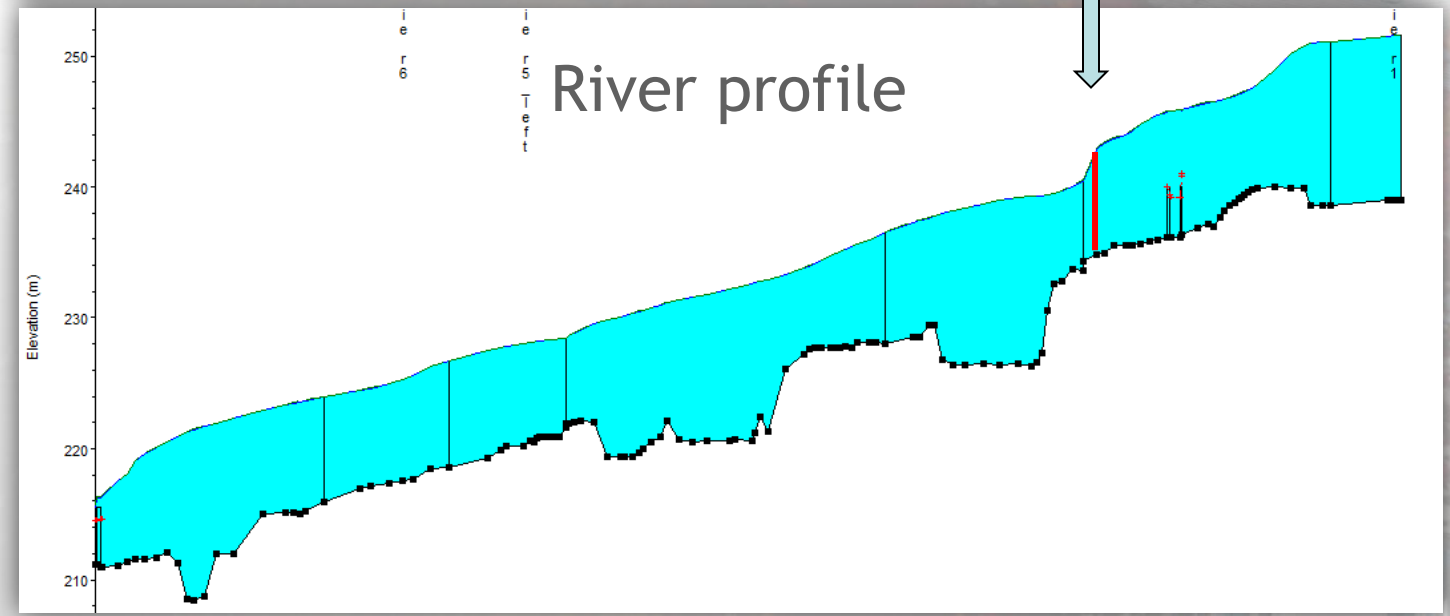
Major stage


One cross section
Elevation (m)
260
250
240

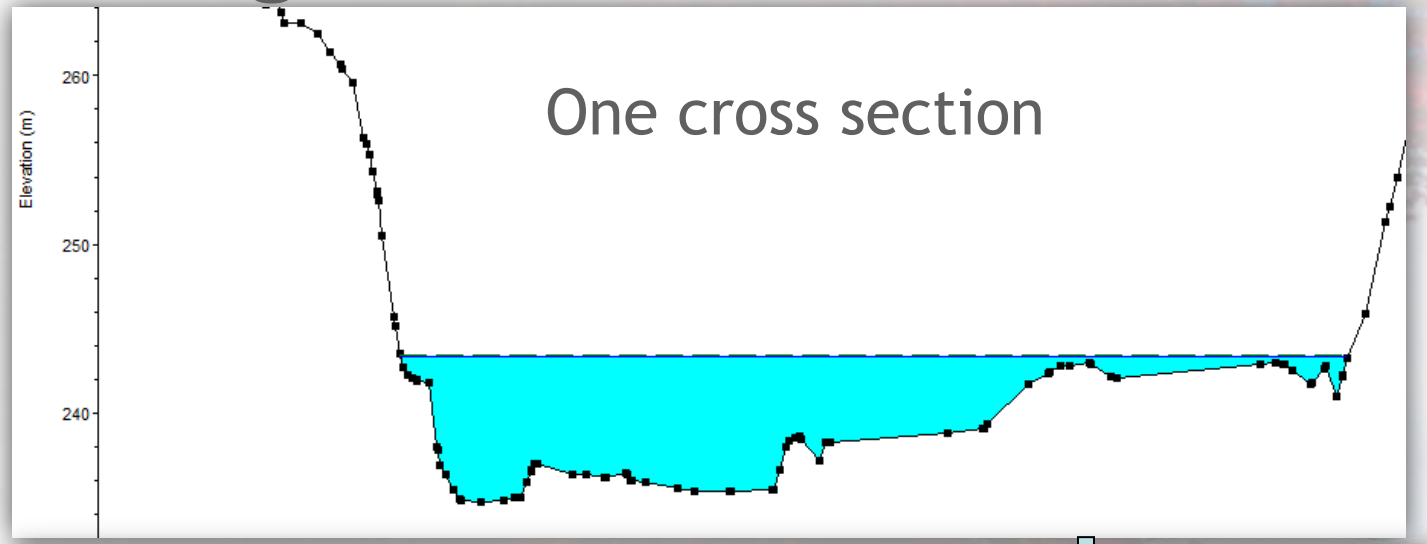

River profile
Elevation (m)
250
240
230
220
210

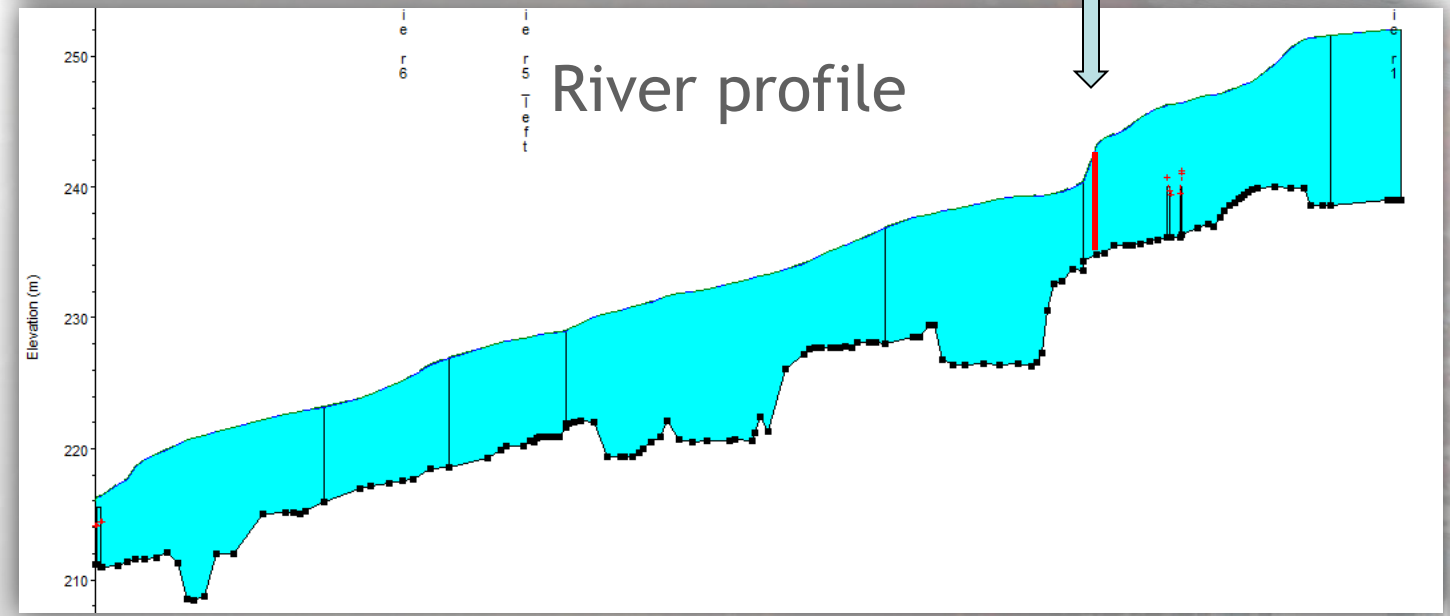
Old Record stage





Aug28, 2011 Event





Overall accuracy of inundated areas of NED results vs. FEMA flood scenarios

FEMA scenarios Model result	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
Aug 30, 2011	63.48%	62.77%	61.12%	/	/	/	/	/
Action stage	64.79%	65.62%	64.33%	/	/	/	/	/
Minor stage	/	73.96%	74.53%	74.41%	/	/	/	/
Moderate stage	/	/	/	/	/	87.15%	88.45%	88.65%
Major stage	/	/	/	/	/	89.02%	91.07%	91.84%
Old Record stage	/	/	/	/	/	/	91.66%	93.43%

RMSE (m) of inundated areas of NED results vs. FEMA flood scenarios

FEMA scenarios Model result	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
Aug 30, 2011	0.604	0.610	0.624	/	/	/	/	/
Action stage	0.593	0.586	0.597	/	/	/	/	/
Minor stage	/	0.510	0.505	0.506	/	/	/	/
Moderate stage	/	/	/	/	/	0.358	0.340	0.337
Major stage	/	/	/	/	/	0.331	0.299	0.286
Old Record stage	/	/	/	/	/	/	0.289	0.257

Overall Accuracy of inundated areas of LiDAR results vs. FEMA flood scenarios

FEMA scenarios Model result	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
Aug 30, 2011	71.12%	73.40%	71.45%	/	/	/	/	/
Action stage	71.21%	75.75%	74.20%	/	/	/	/	/
Minor stage	/	/	/	80.81%	82.16%	81.45%	/	/
Moderate stage	/	/	/	/	/	89.43%	91.64%	92.42%
Major stage	/	/	/	/	/	90.00%	92.79%	94.37%
Old Record stage	/	/	/	/	/	/	91.96%	94.24%

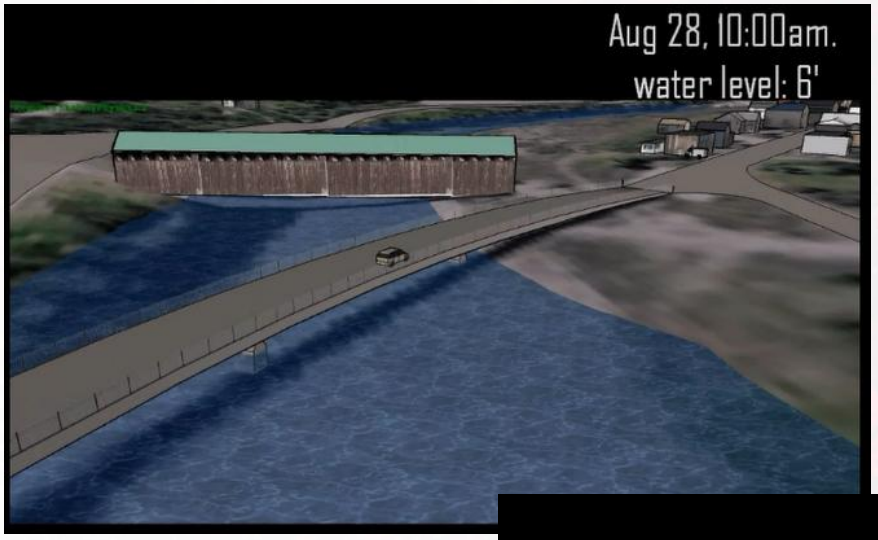
RMSE (m) of inundated areas of LiDAR results vs. FEMA flood scenarios

FEMA scenarios Model result	2yr	5yr	10yr	25yr	50yr	100yr	200yr	500yr
Aug 30, 2011	0.537	0.516	0.534	/	/	/	/	/
Action stage	0.537	0.492	0.508	/	/	/	/	/
Minor stage	/	0.501	0.477	0.438	0.422	0.431	/	/
Moderate stage	/	/	/	/	/	0.325	0.289	0.275
Major stage	/	/	/	/	/	0.316	0.268	0.237
Old Record stage	/	/	/	/	/	/	0.284	0.240

Pairing results

Gauging station data	FEMA flood scenarios
Action stage	5yr flood
Minor stage	25yr flood
Moderate stage	200yr flood
Major stage	500yr flood
Record stage	500yr flood

3D Flood Visualization Model



http://lesami.geog.buffalo.edu/projects/initiatives/flood-modeling-of-schoharie-creek/

Conclusion

- Aug 28, 2011 event at Schoharie Watershed was a 500yr flood.
- HEC-RAS model has a better performance with high flow.
- A devastating flood will make the target area more vulnerable.

Future work

- Integrate social media information
- Set up a warning system for un-gauged areas

Acknowledgement

Sincere thanks to:

- All coworkers in the LESAM lab;
- Wenjie Ji

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Questions?