Building damage detection by fusing tsunami numerical modeling and remote sensing technology

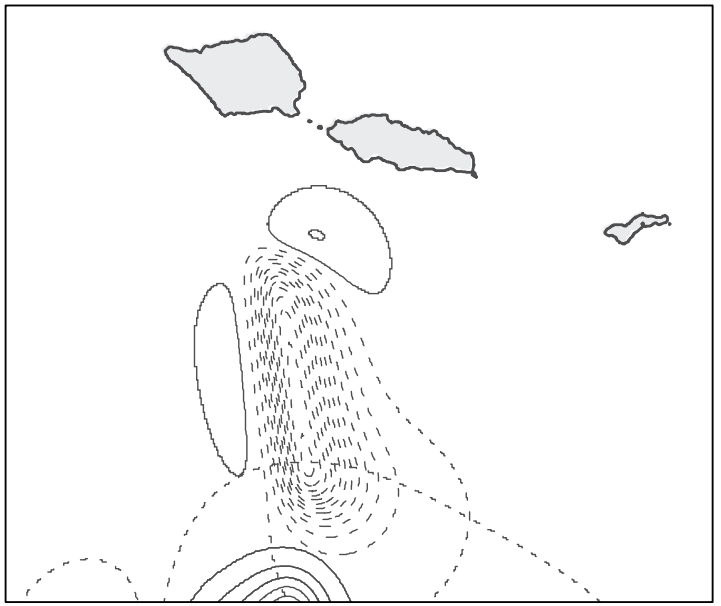
Hideomi Gokon, Satomi Hayashi, Shunichi Koshimura,
Masashi Matsuoka and Joachim Post

Research question

Which is the best approach to detect building damage in a tsunami affected area?

Remote sensing

Tsunami numerical modeling

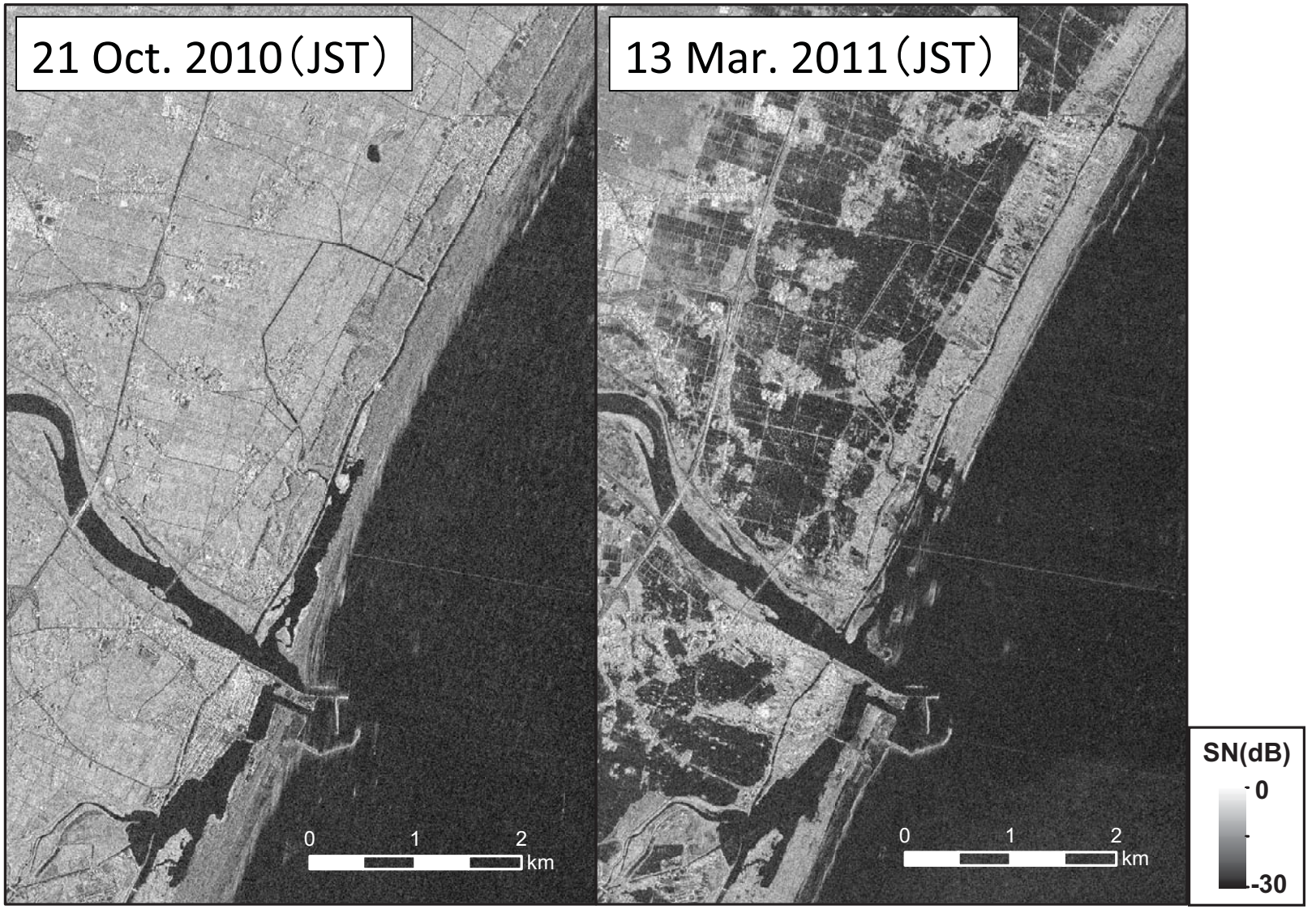


Or, should both approaches be integrated ?

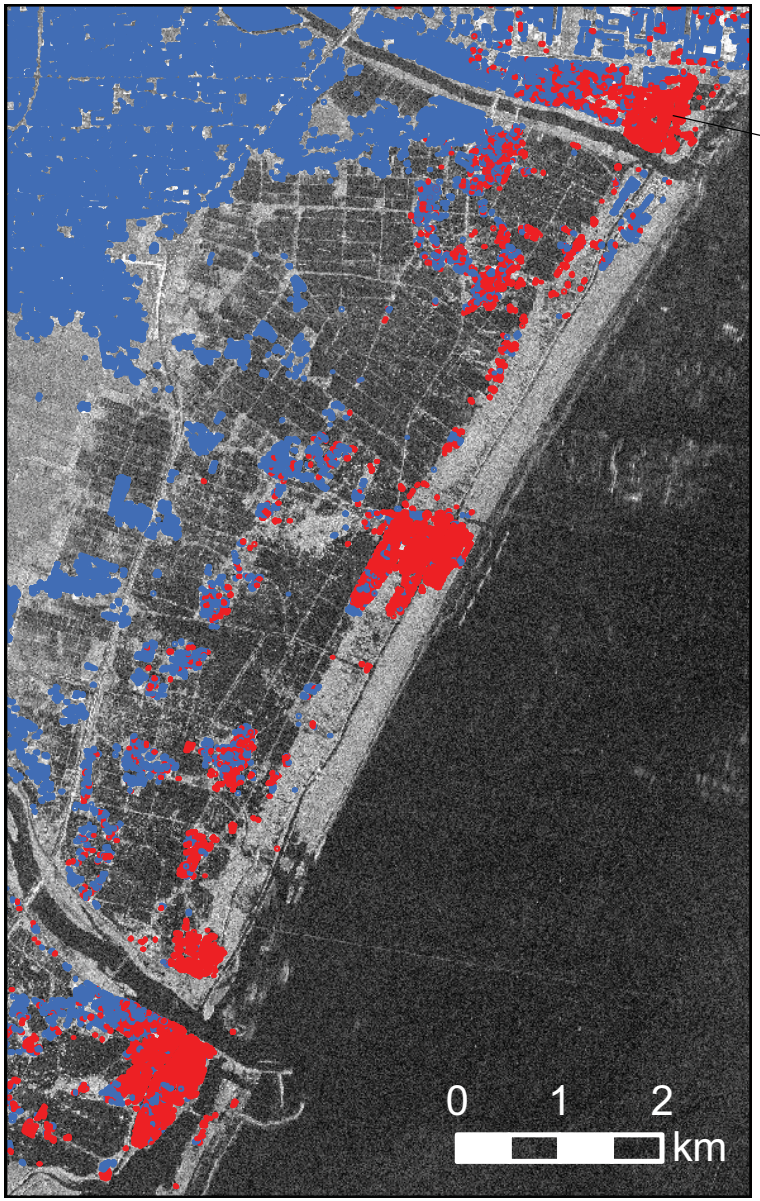
Remote sensing approach

- The 2011 Tohoku earthquake and tsunami
- TerraSAR-X data (Strip map mode)
- Change detection
- Damage ratio of washed-away buildings

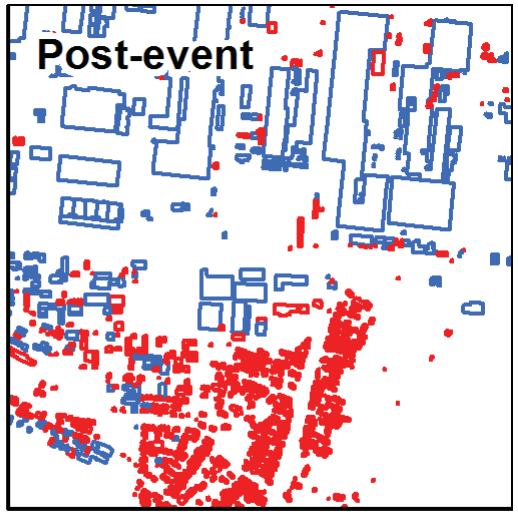
TerraSAR-X data (Sendai city in Japan)



Truth data



Visual inspection



Surviving

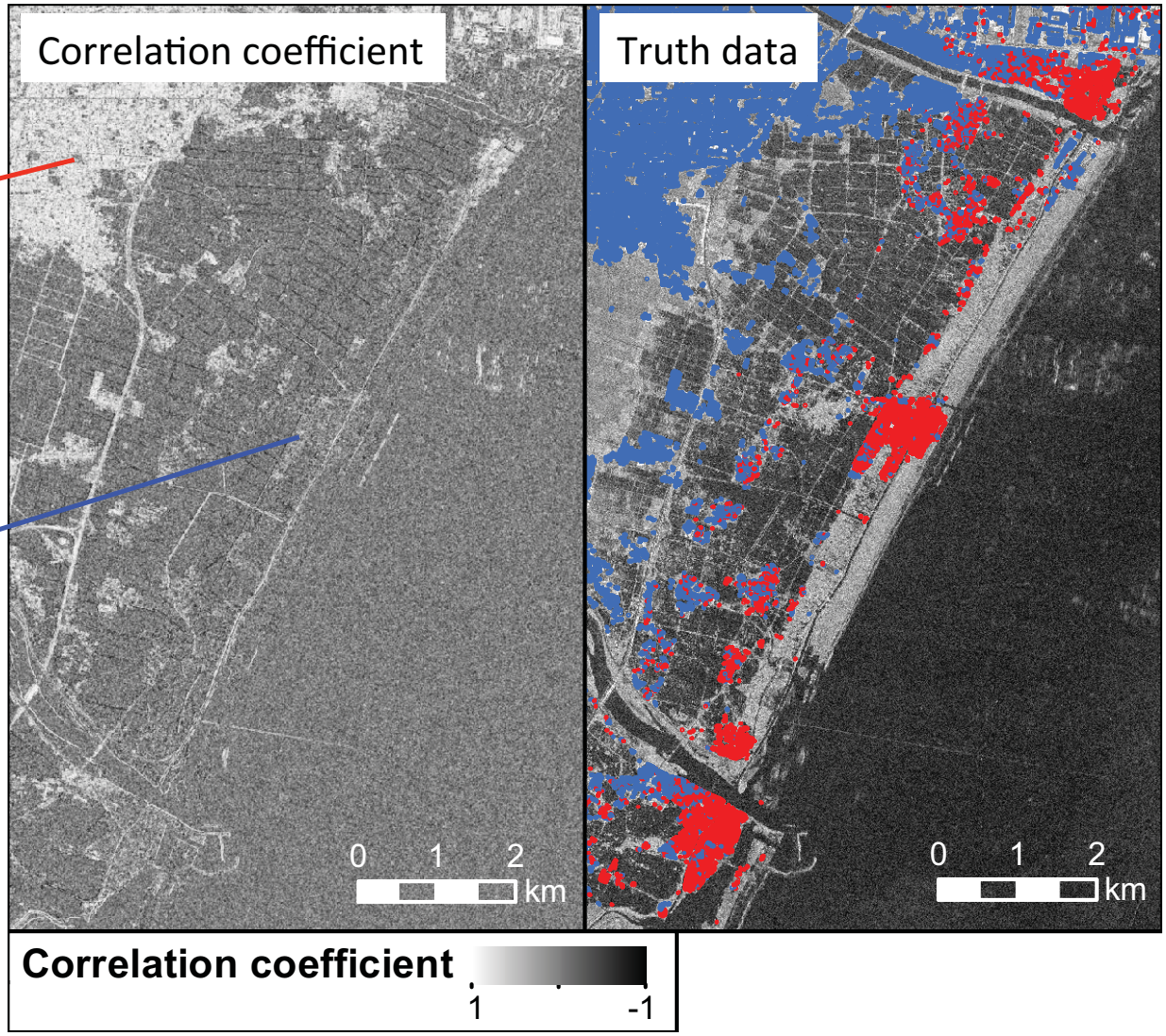
Washed away

Change detection

Correlation coefficient

Non-damaged areas
→ Higher values

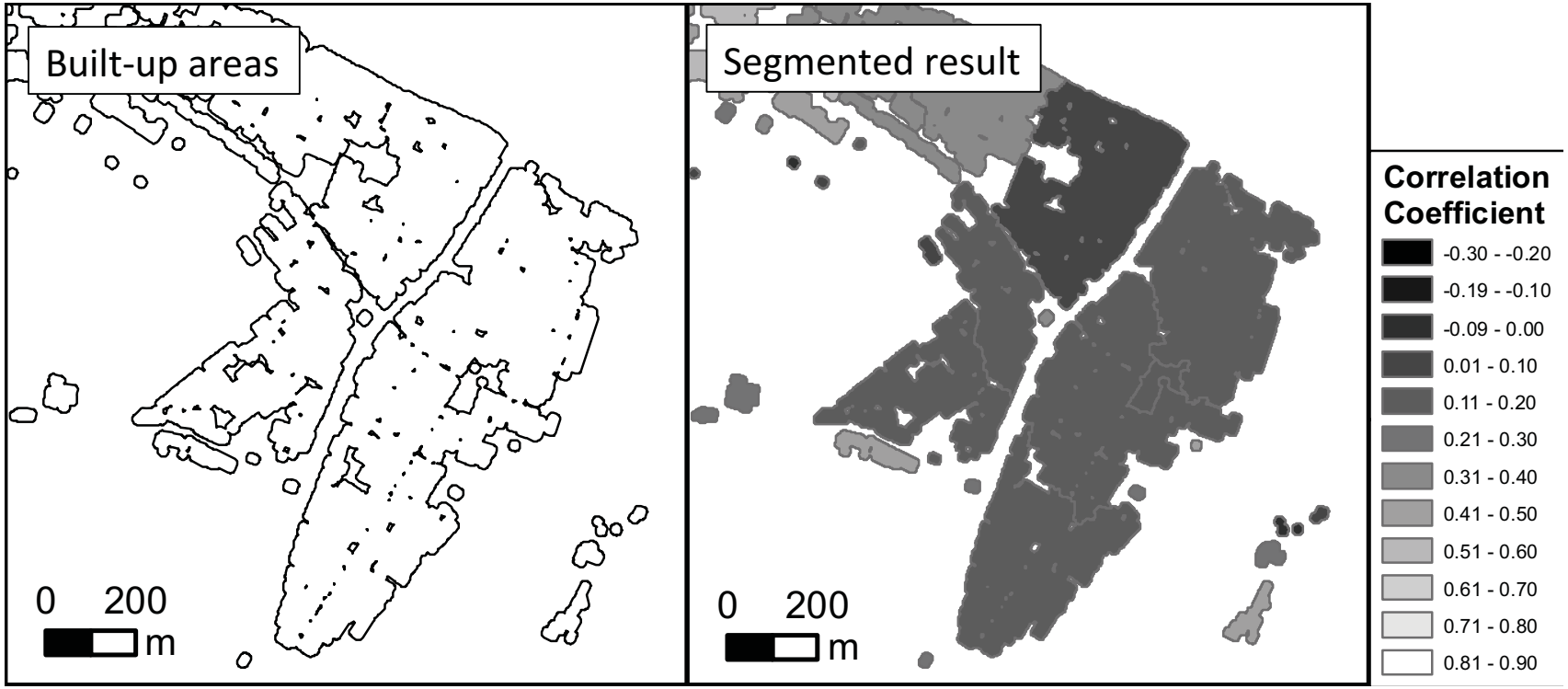
Devastated areas
→ Lower values



Segmentation

Assumption

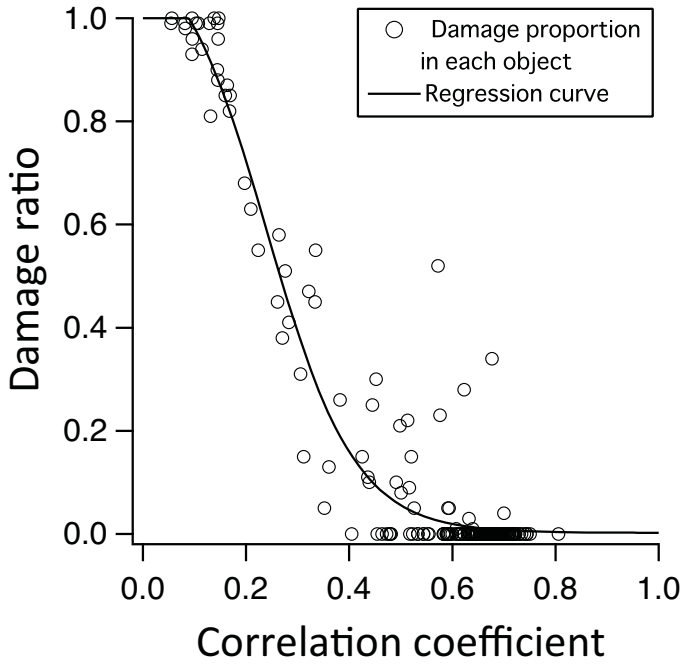
Similar damage situation→ Similar correlation coefficient



Correlation coefficient image was divided into segment with homogeneous changes

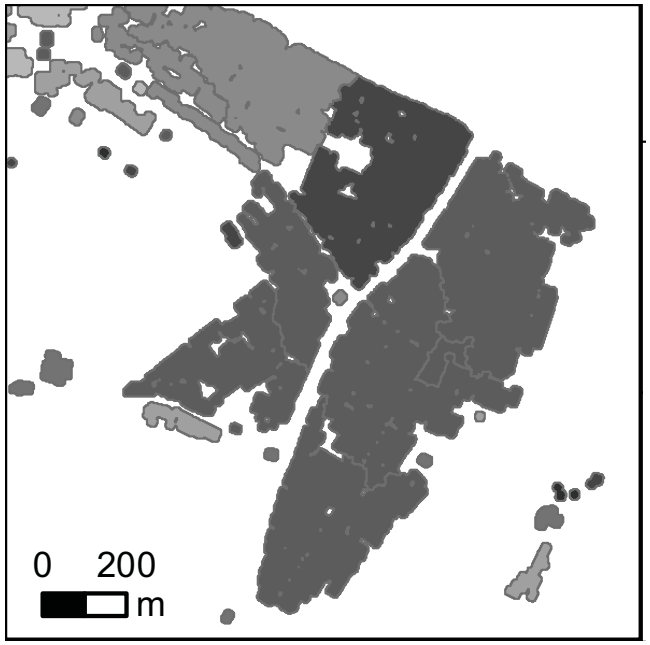
Damage estimation

Damage function



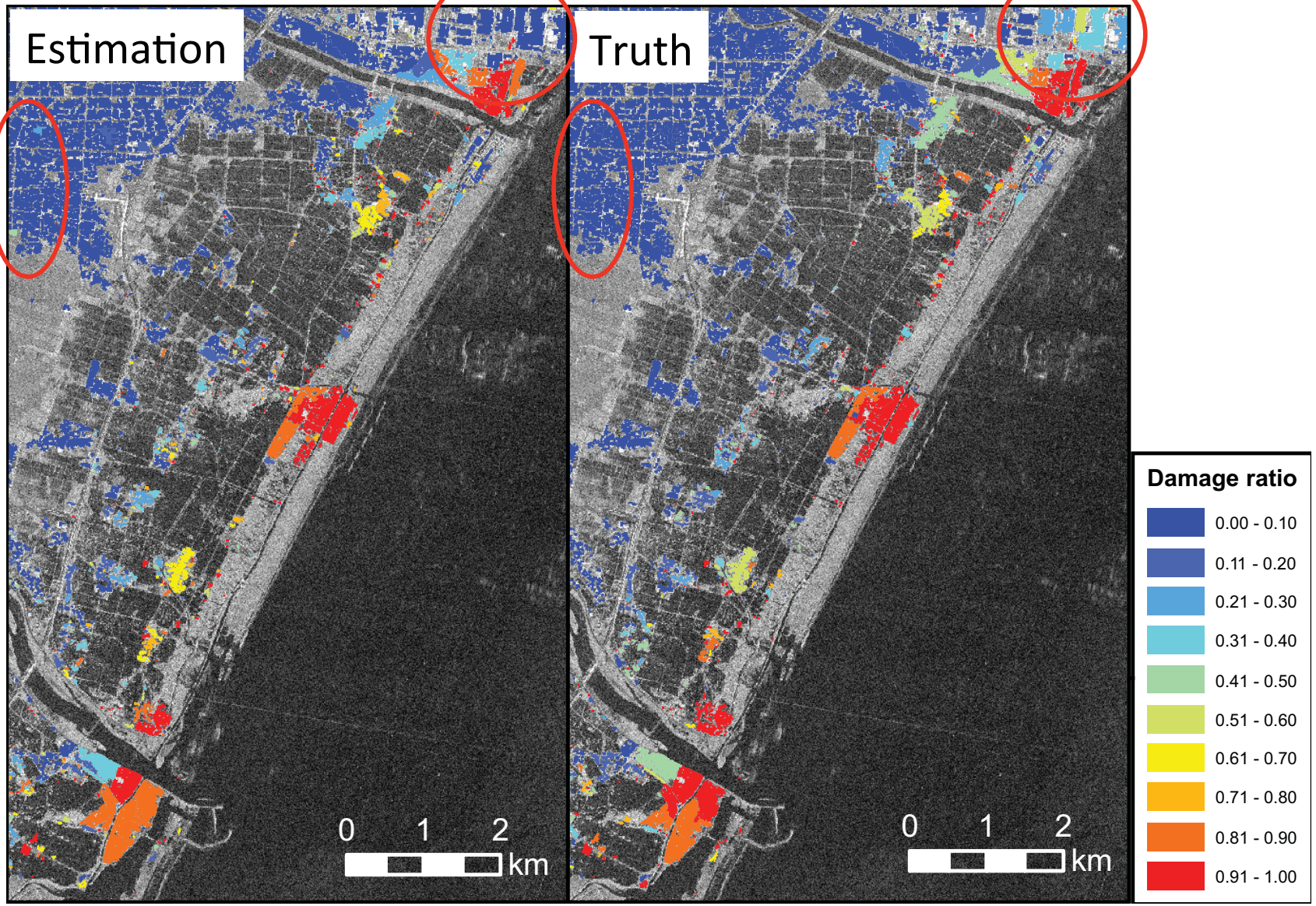
×

Correlation coefficient



Estimate damage ratio

Result (Remote sensing)



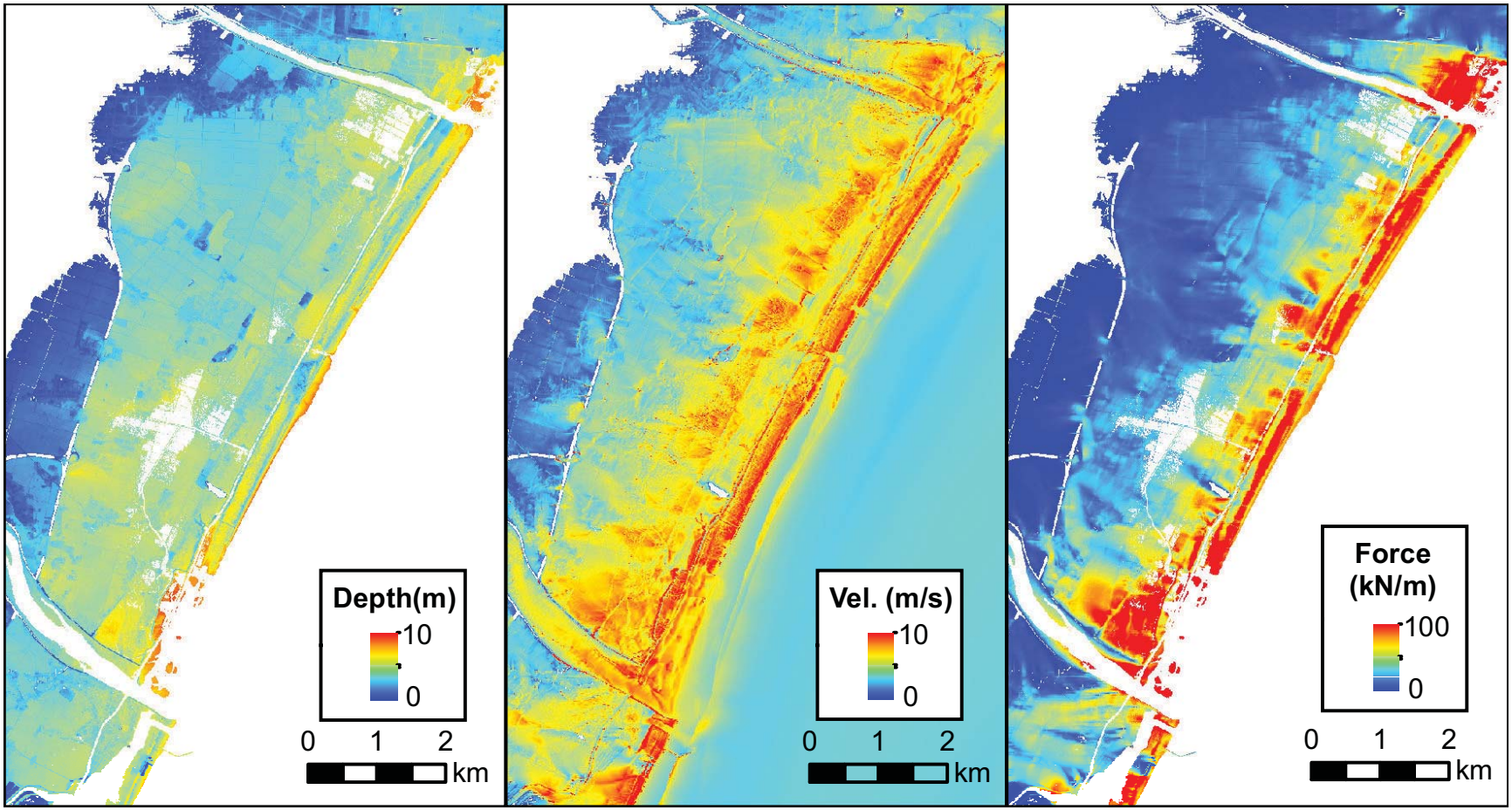
Numerical modeling approach

- Tsunami numerical modeling
  - Flow depth, Current velocity, Hydrodynamic force
- Fragility function
- Damage ratio of washed-away buildings

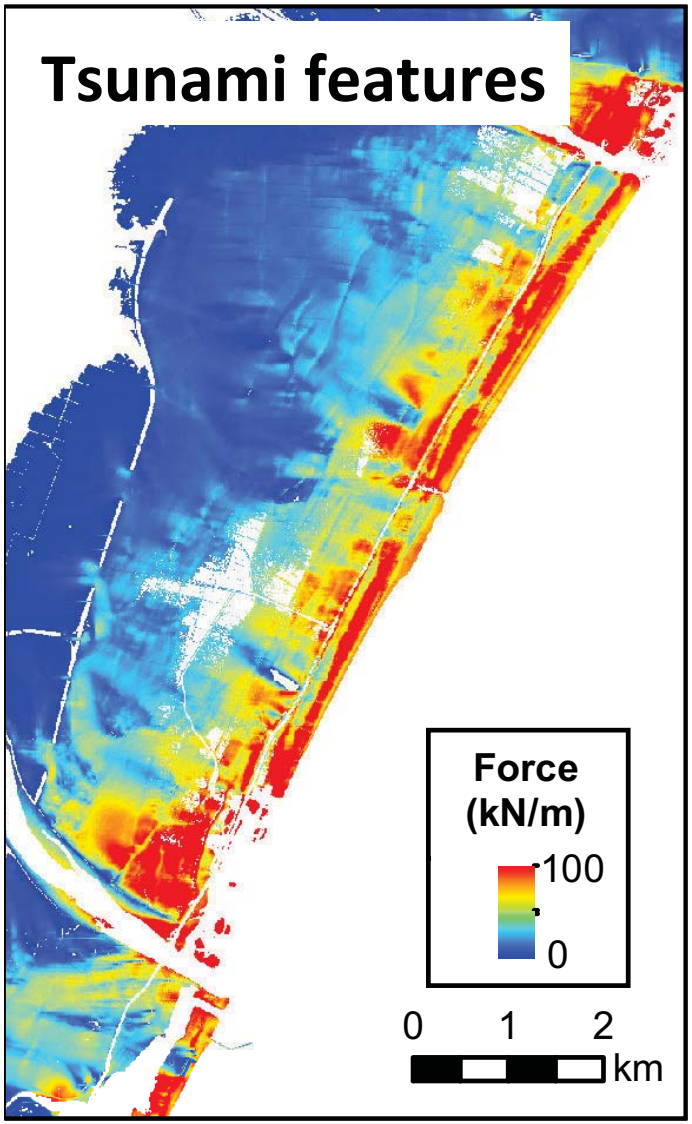
Tsunami numerical modeling

(Hayashi et al., 2013)

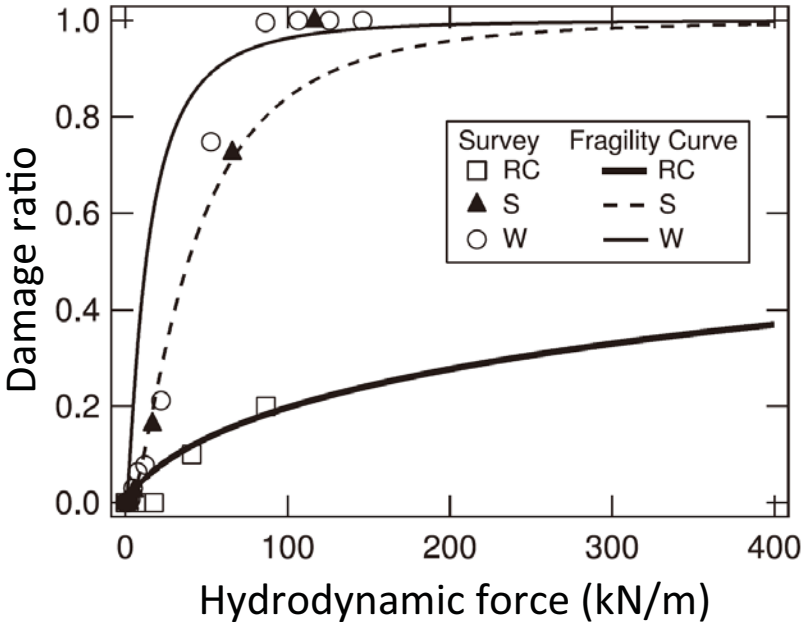
Flow depth | Current velocity | Hydrodynamic force



Damage estimation



Fragility function

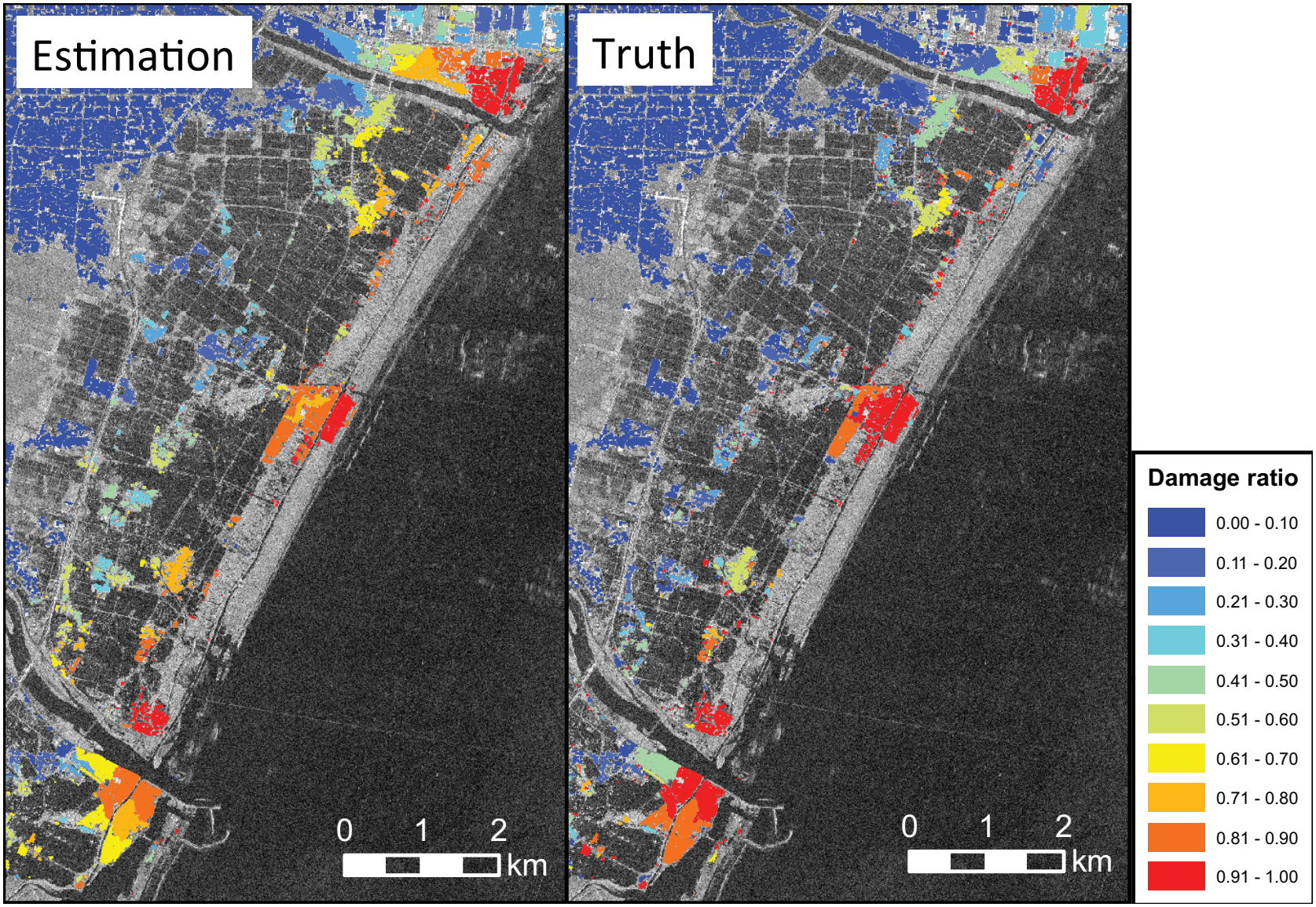


×

Estimate damage ratio

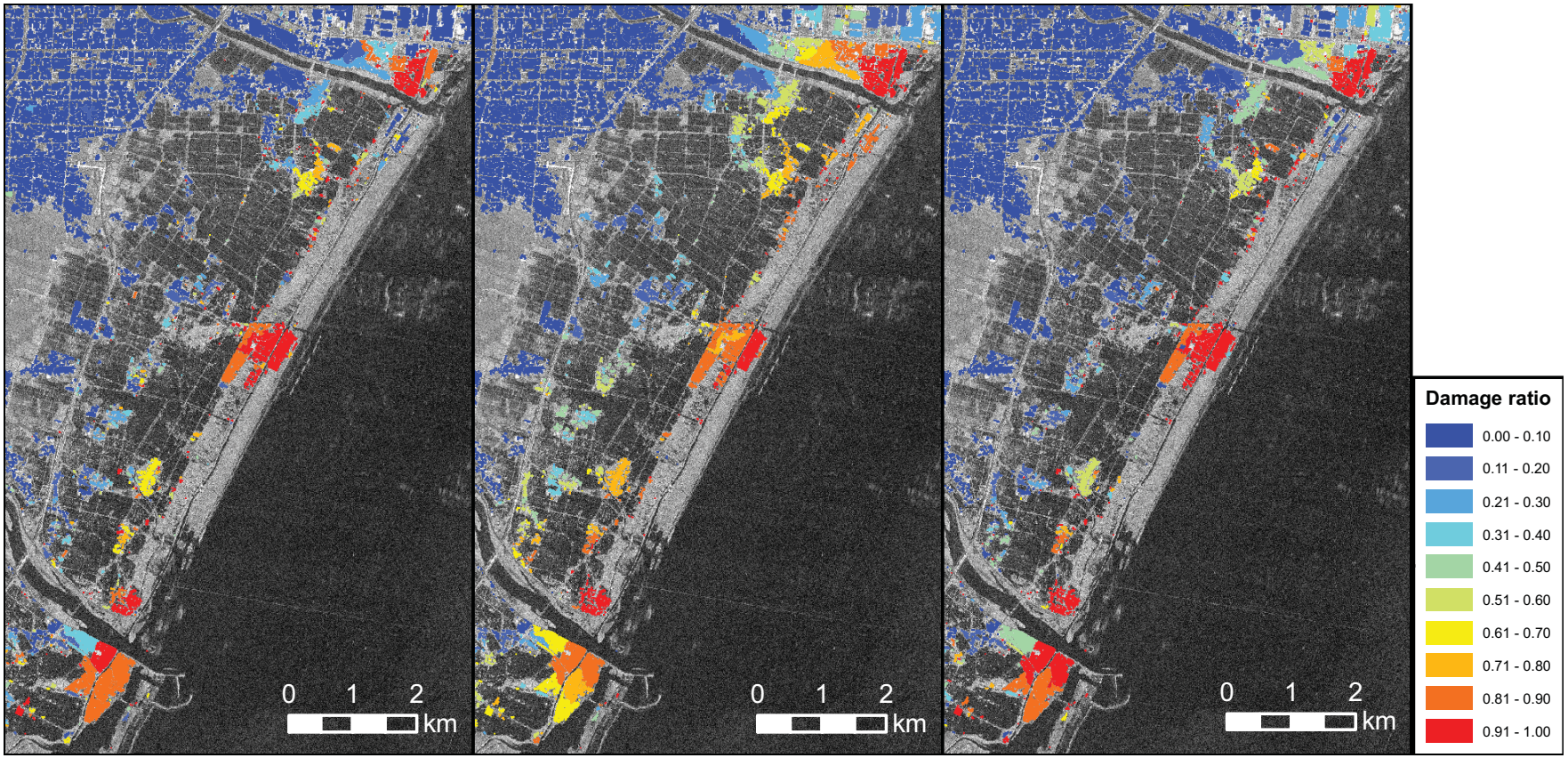
Fragility curve : Hayashi et al.(2013)

Result (Numerical modeling)



Comparison

Remote sensing | Numerical modeling | Truth



- On the whole, remote sensing approach shows higher performance
- In some parts, numerical modeling approach is better

  → large scale buildings, outside of tsunami flooded areas

Integration of these approaches

The advantage of each approach should be utilized.

Two approaches were integrated based on the following rule.

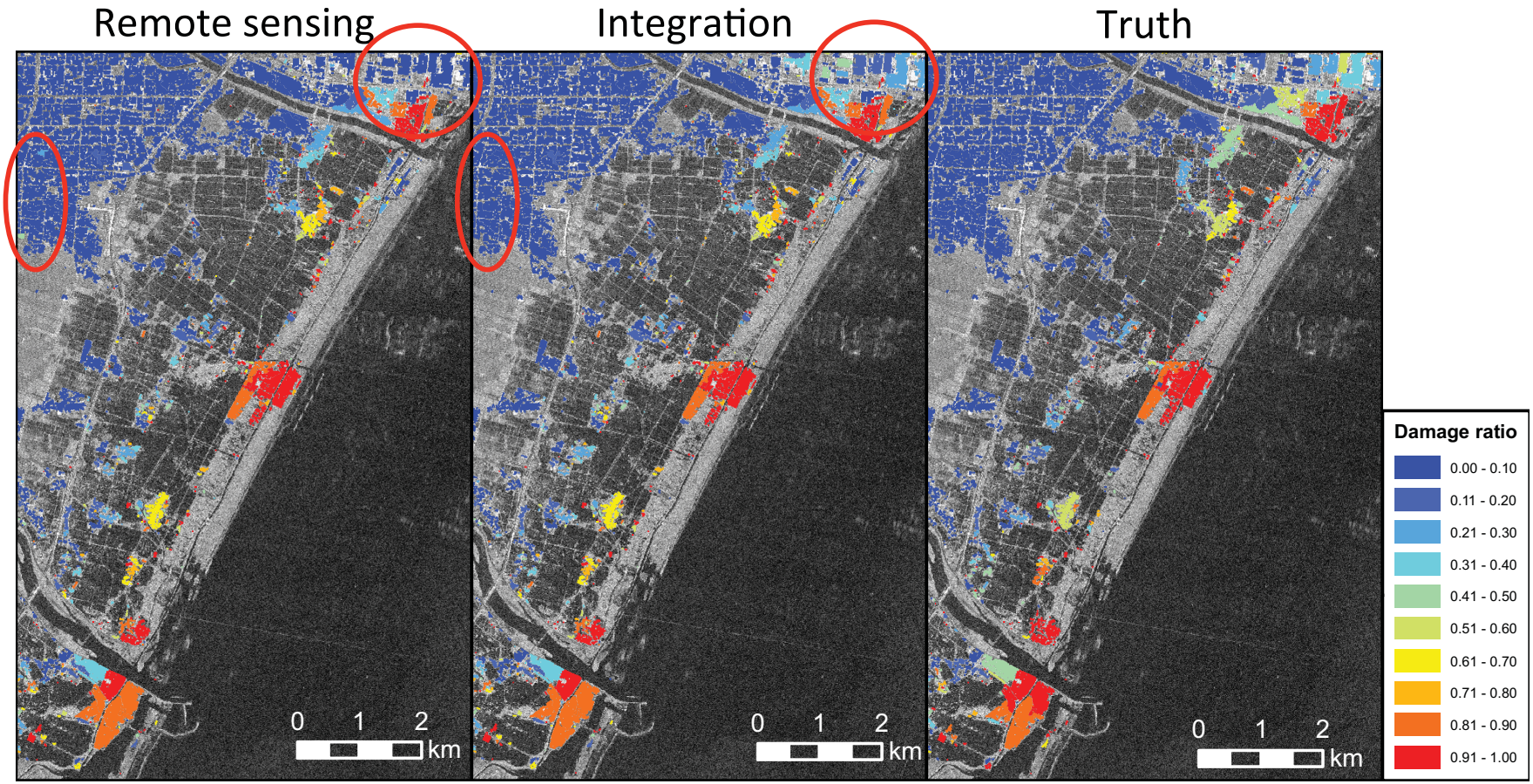
On the whole, → **Remote sensing approach**

Outside of tsunami flooded areas,

Areas with large scale buildings (> 10000 m^2),

→ **Numerical modeling approach**

Result (Integration)

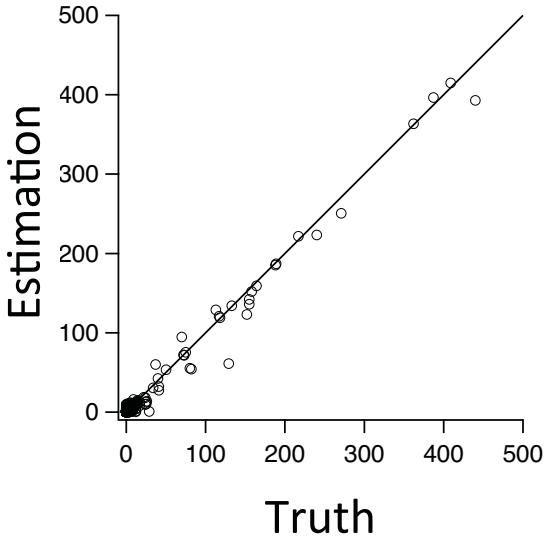


- Improvements could be confirmed in some parts

Accuracy assessment

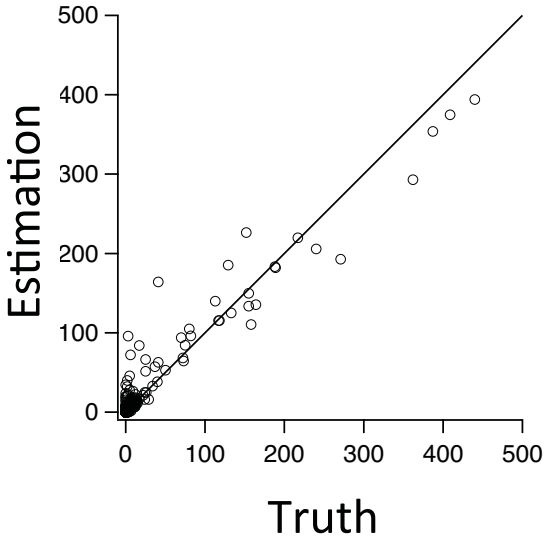
(Damage ratio × the number of buildings in a object)

Remote sensing



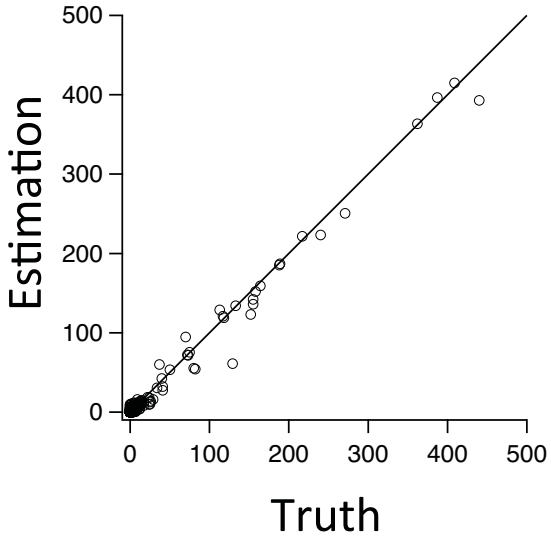
R=0.9931

Numerical modeling



R=0.9645

Integration



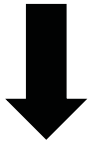
R=0.9935

Integrated approach shows best performance

Summary

Building damages were estimated by these approaches.

- Remote sensing approach
- Numerical modeling approach
- Integrated approach



As a result of the comparison,

Integrated approach shows best performance for damage estimation in a tsunami affected area.