DLR - IRIDeS - UN-SPIDER Joint Workshop on Remote Sensing and Multi-Risk Modeling for Disaster Management

- UN-SPIDER Bonn Office -

Extraction of building damage in tsunami affected areas using TerraSAR-X data

Bruno Adriano[1], Erick Mas[2], and Shunichi Koshimura[3]

[1]Graduate student, Graduate School of Engineering, Tohoku University, Japan
[2]Assistant professor International Institute of Disaster Science, Tohoku University, Japan
[3]Professor International Institute of Disaster Science, Tohoku University, Japan

September, 18-19

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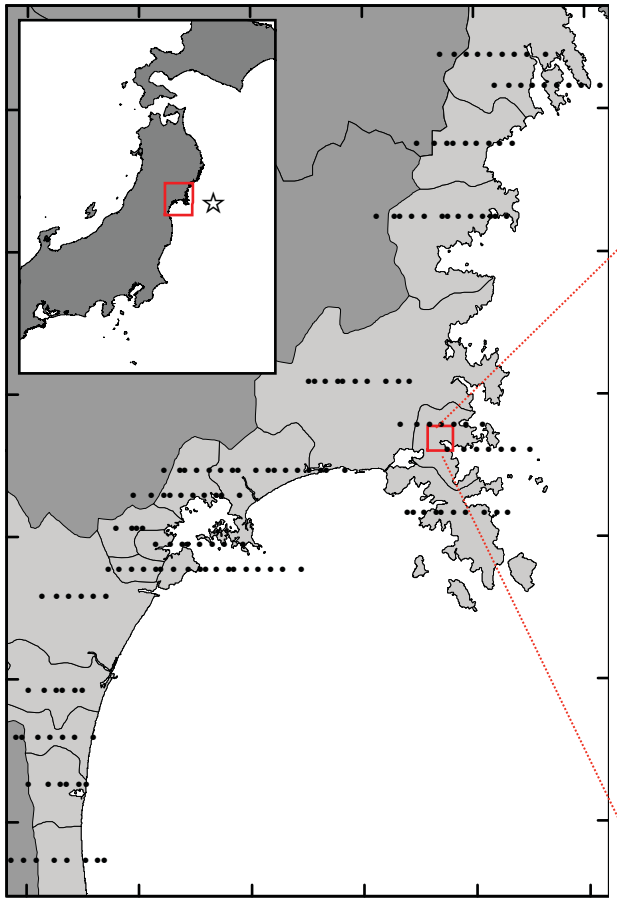
Introduction (Tohoku Tsunami 2011)

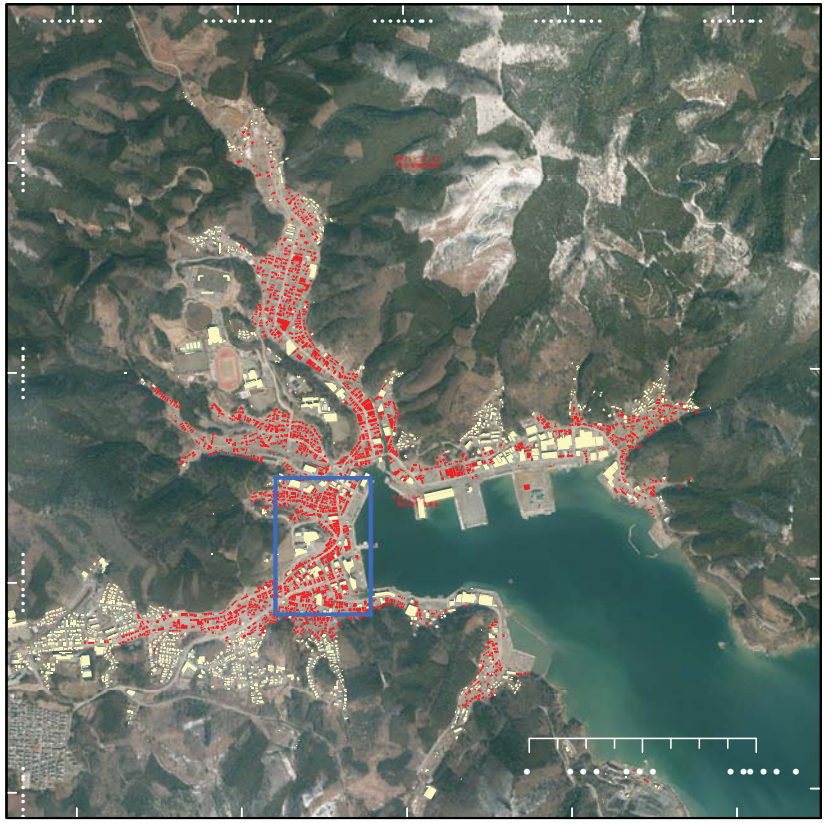


The tsunami attacked the town 35 minutes after the earthquake occurred causing 816 fatalities and 125 still missing.

Onagawa (post-event)

Source: The Geospatial Information Authority of Japan (GSI)

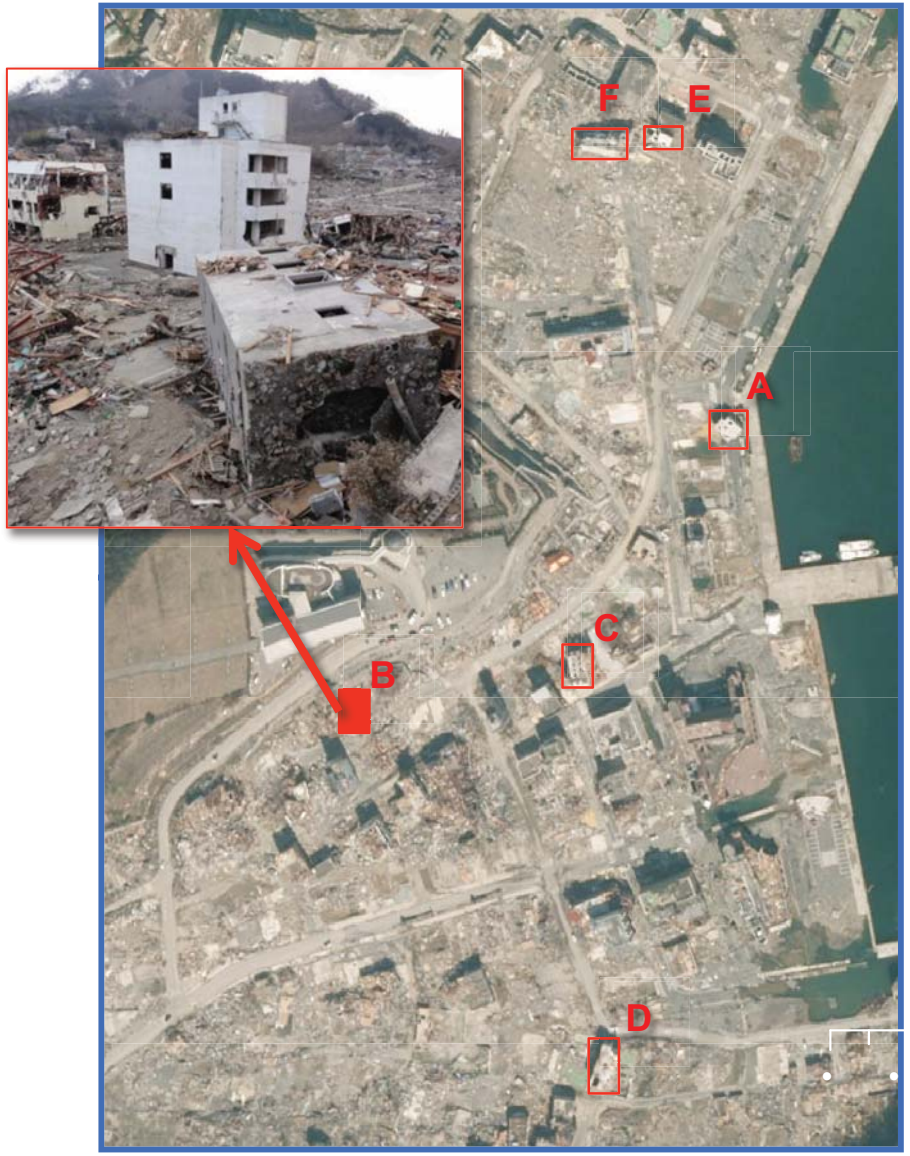
Introduction (Tohoku Tsunami 2011)



Gokon and Koshimura, 2012

Building exposed	4,607
Washed-away	3,459

6 RC and Steel construction buildings were overturned or washed away.

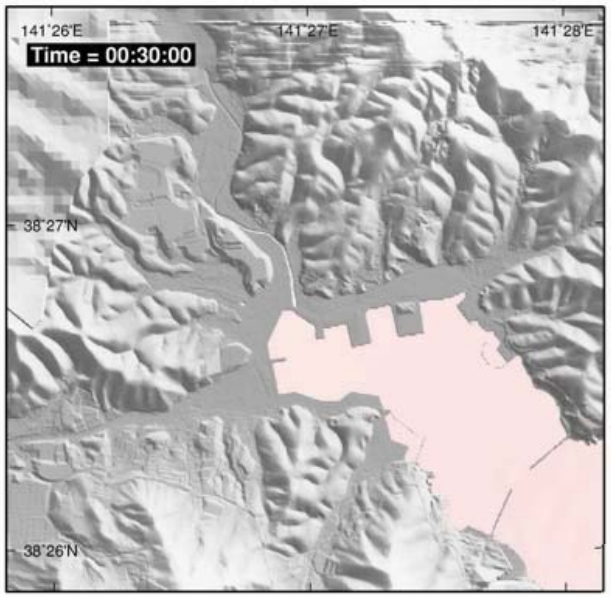


Numerical modeling (building destruction)

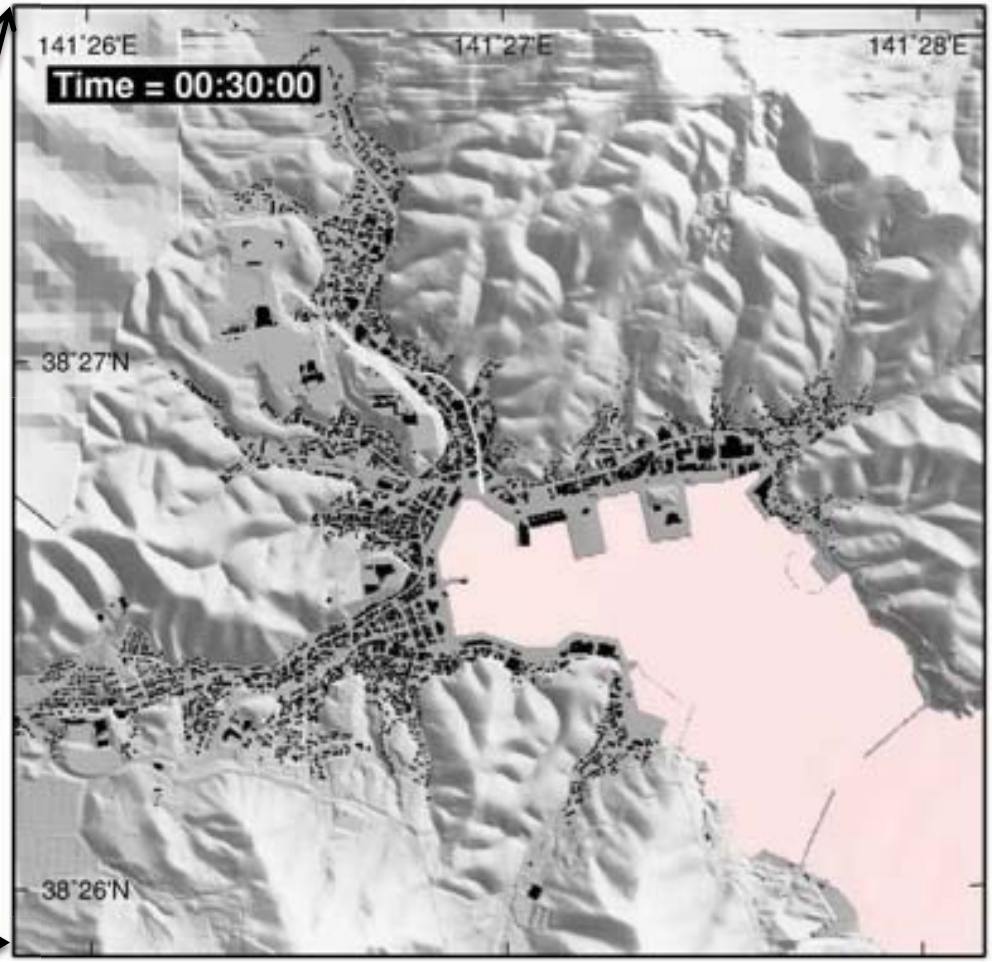
Animation result

- Analysis interval = 0.5 m
- Inundation time = 60 min

Tsunami Inundation



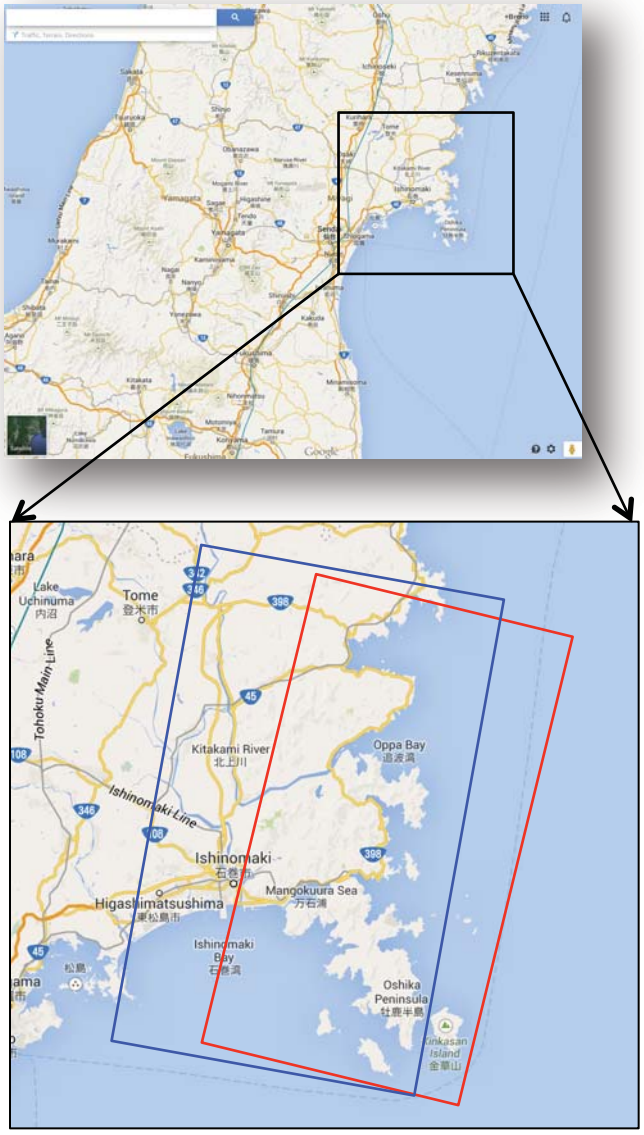
Building damage

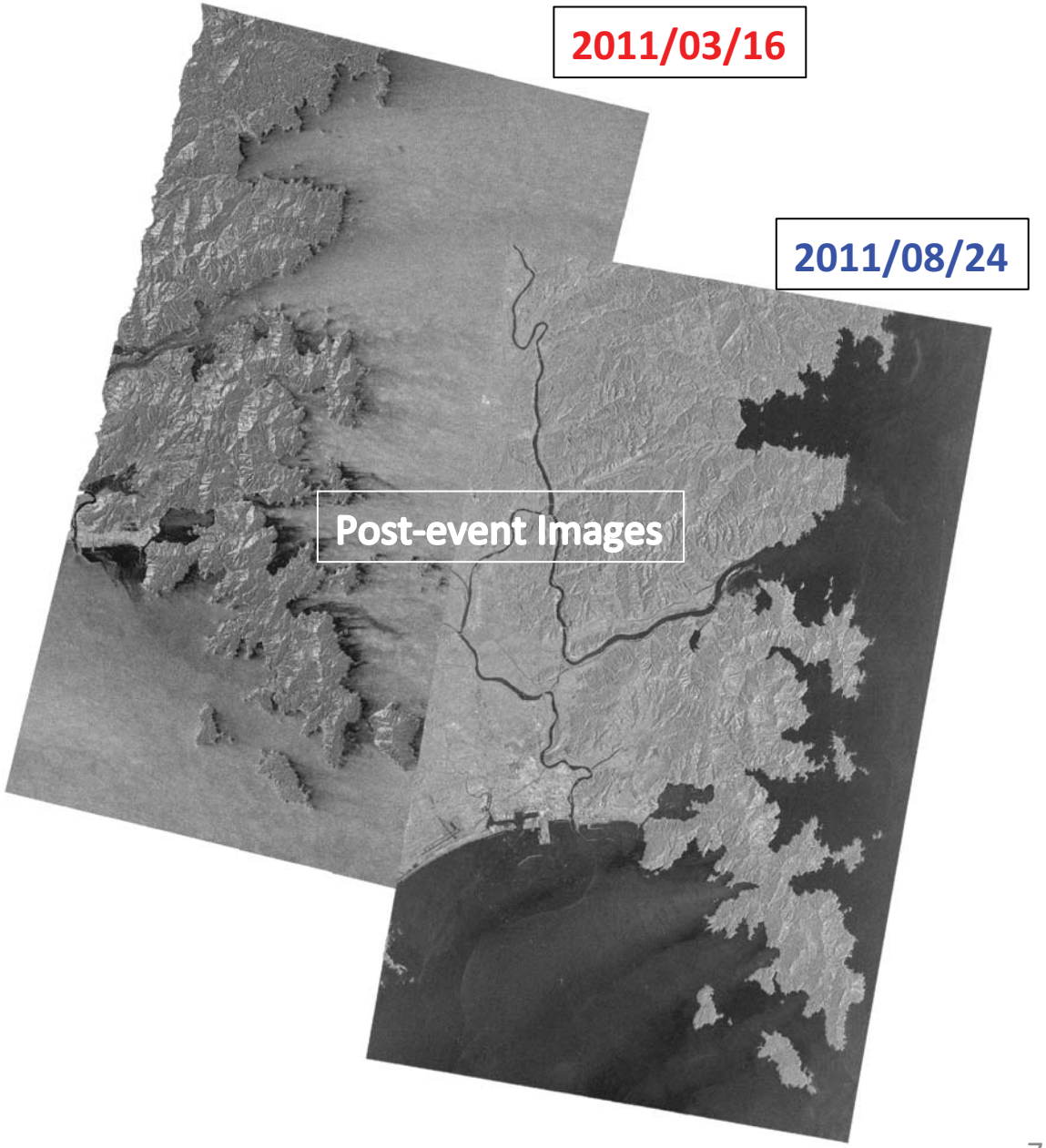


Objective

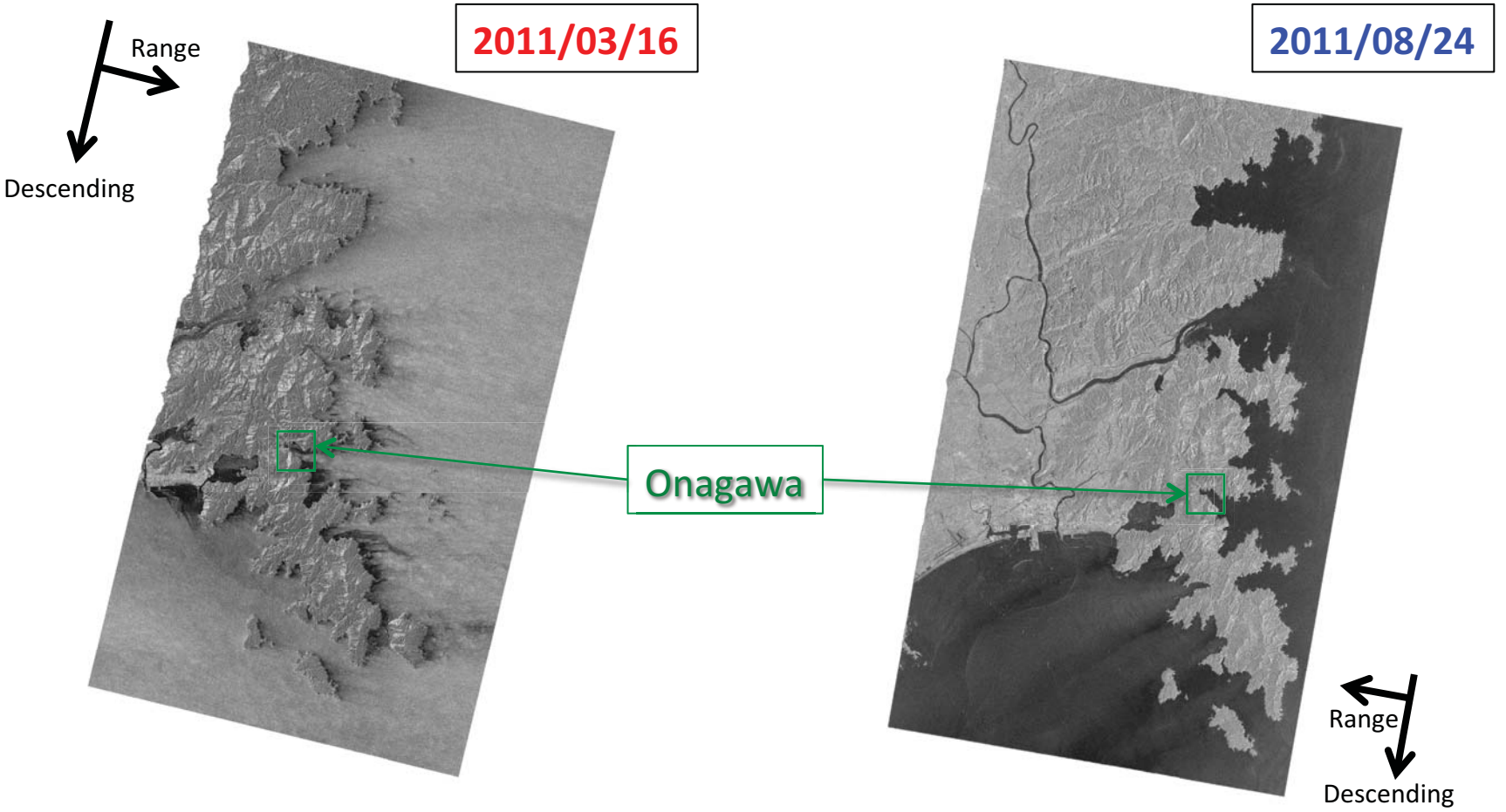
To develop a method to detect buildings in tsunami affected areas using post-event TerraSAR-X data with support of pre-event optical images.

Study area and Dataset (TerraSAR-X)



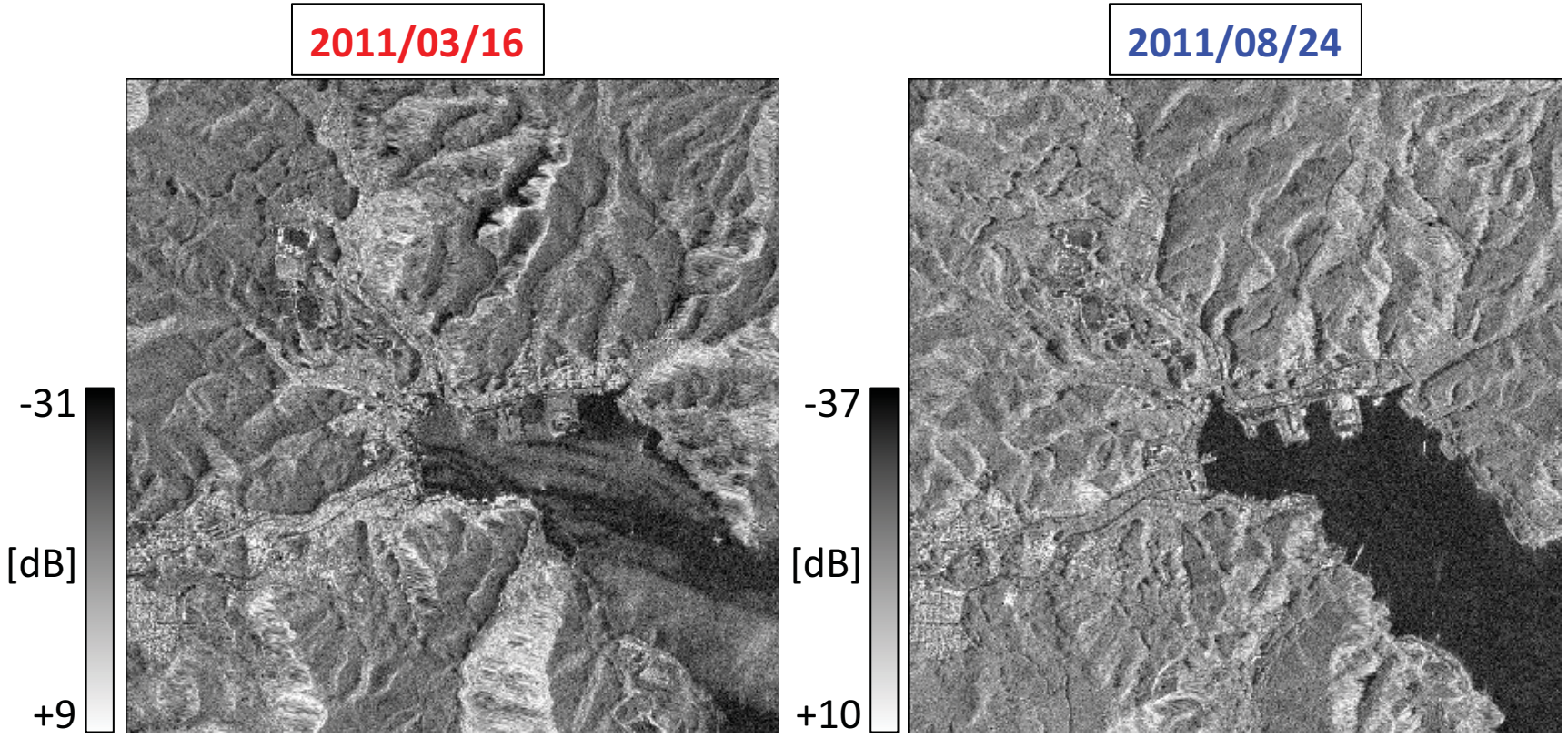


Dataset



	Heading angle	Beam config.	Inc. angle	HS	Orbit direction
2011/03/16	193.9	StripMap	26.29	EEC	Descending
2011/08/24	190.2		35.29	EEC	

Dataset (Calibrated data)



Data pre-processing:

- Radiometric calibration, Digital Number ➔ Sigma Naught [dB]
- Speckle filter, Gamma Map filter (3 x 3 pixels)
- Resampling, Cell size 1.25m

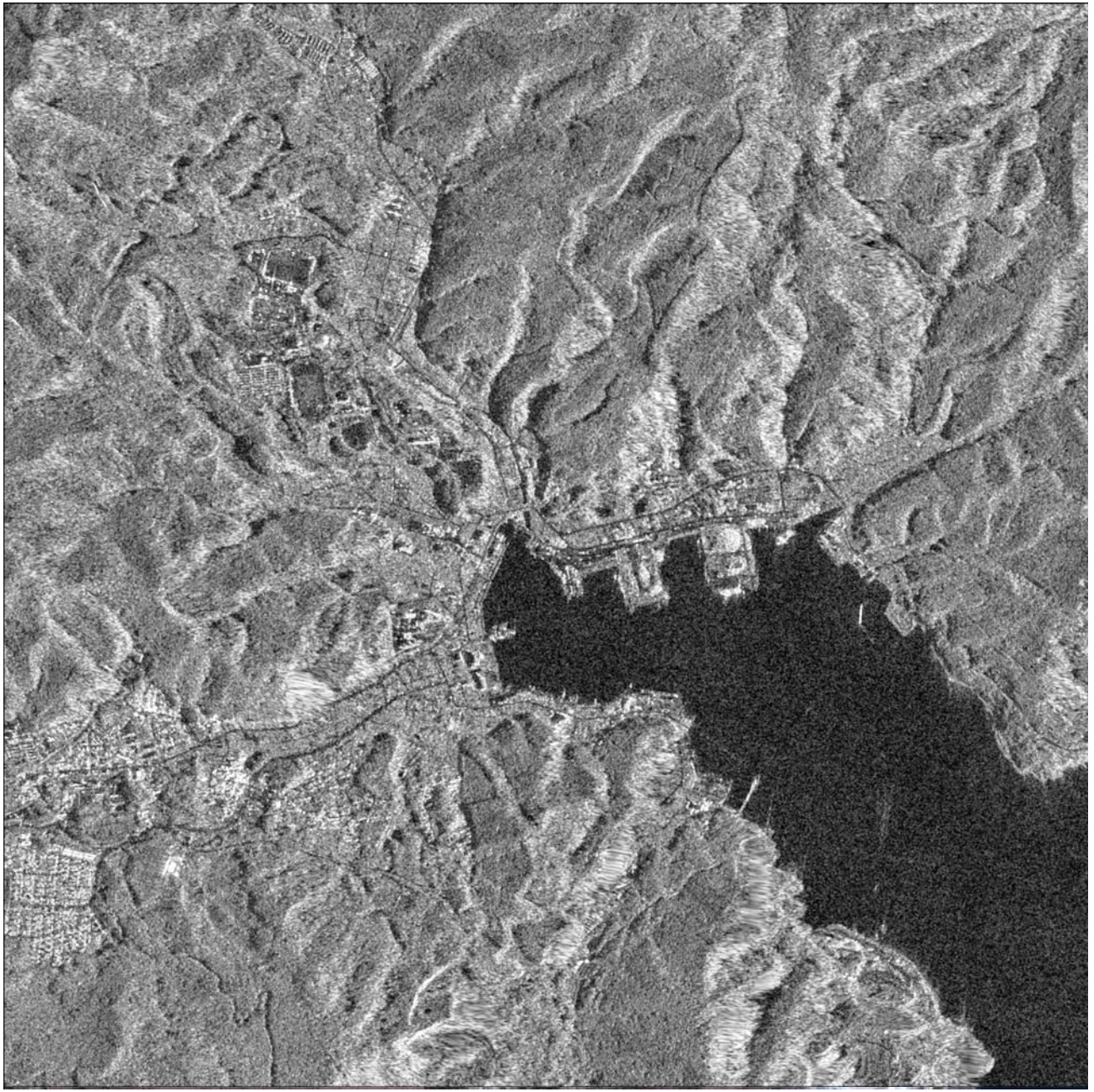
Dataset

QB: 2009/05/13

TSX: 2011/03/16

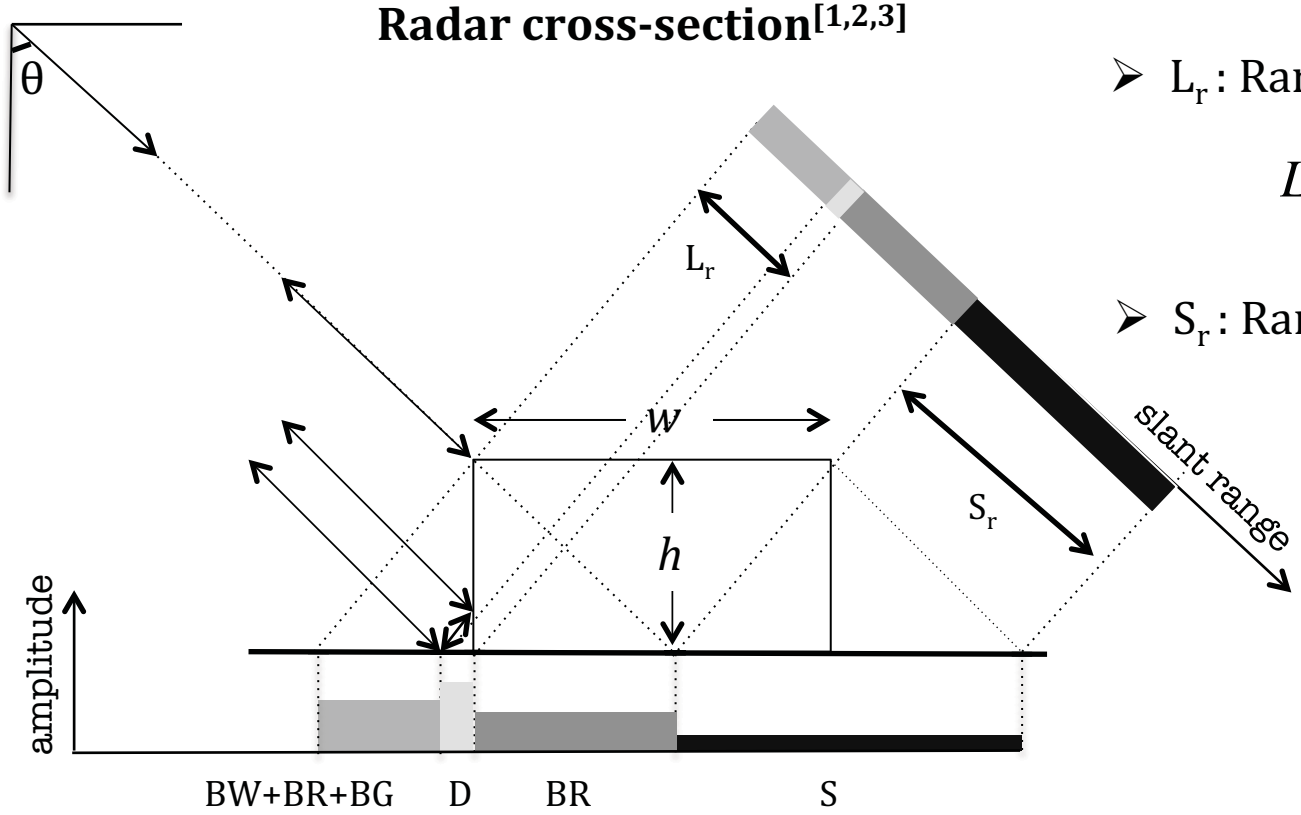
WV2: 2011/04/06

TSX: 2011/08/24



Methodology

Radar cross-section[1,2,3]



- L_r : Range of size of layover

$$L_r = h \times \cos\theta \quad \text{.....} \quad (1)$$

- S_r : Range of size of shadow

$$S_r = \frac{h}{\cos\theta} \quad \text{.....} \quad (2)$$

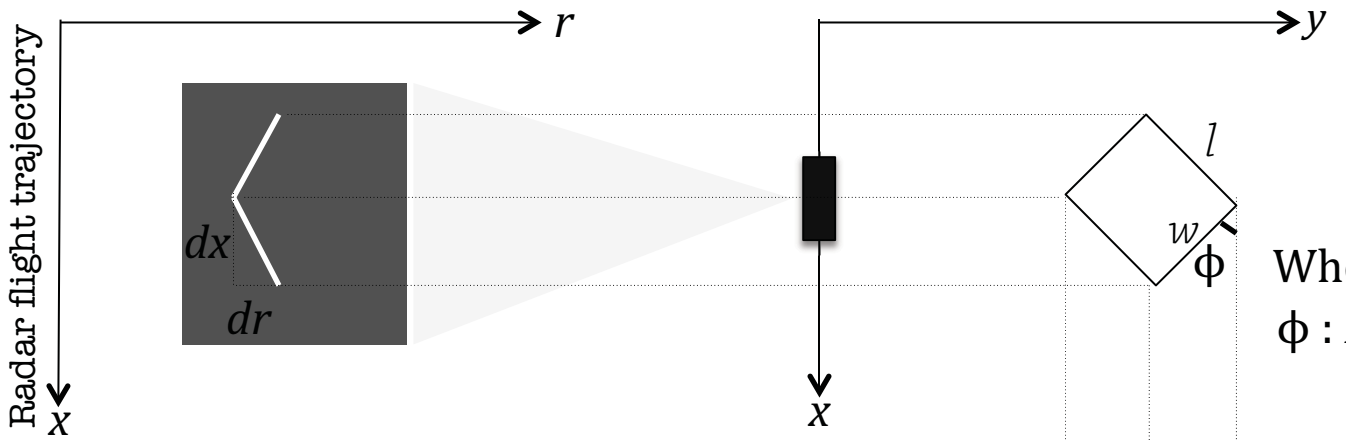
where:

- BW : Backscattering from wall
- BR : Backscattering from roof
- BG : Backscattering from ground
- D : Double scattering
- S : Shadow
- w: width
- l : length

[1] Brunner et al., [2010]
[2] Guida et al., [2010]
[3] Mason et al., [2014]

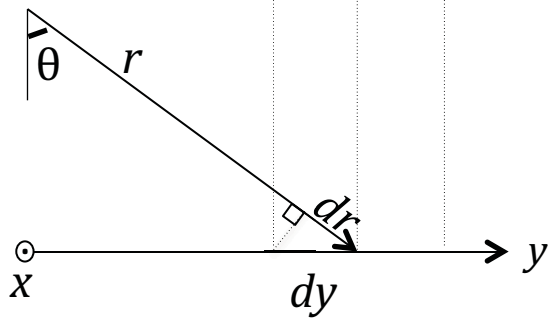
Methodology

Top view of an urban scene[1]



Where:
ϕ : Aspect angle

Ground-slant-range projection[1,2]



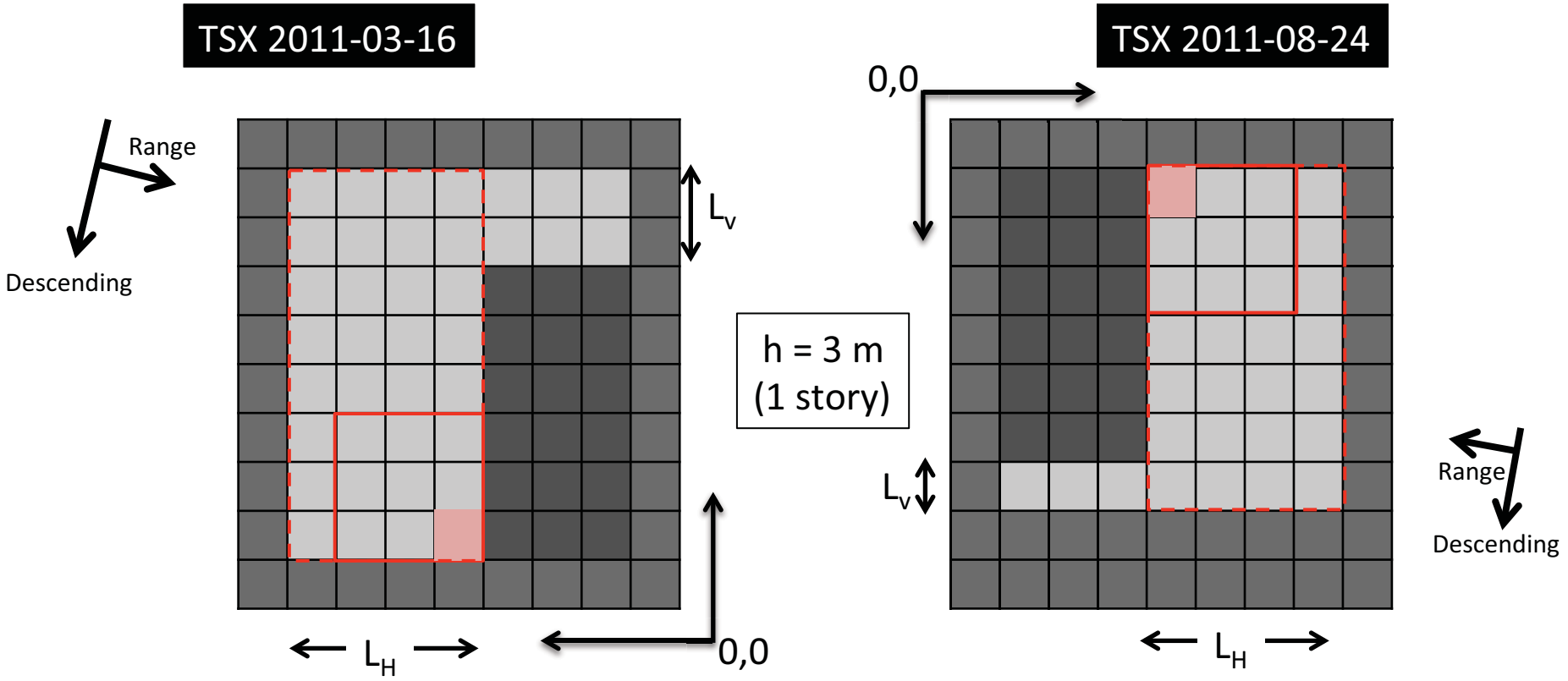
Geometric relations:

$$l = \sqrt{dx^2 + dy^2}, \quad dy = \frac{dr}{\sin\theta} \qquad \text{(3)}$$

$$w = \frac{S_r}{\sin\theta}\cos\phi \qquad \text{(4)}$$

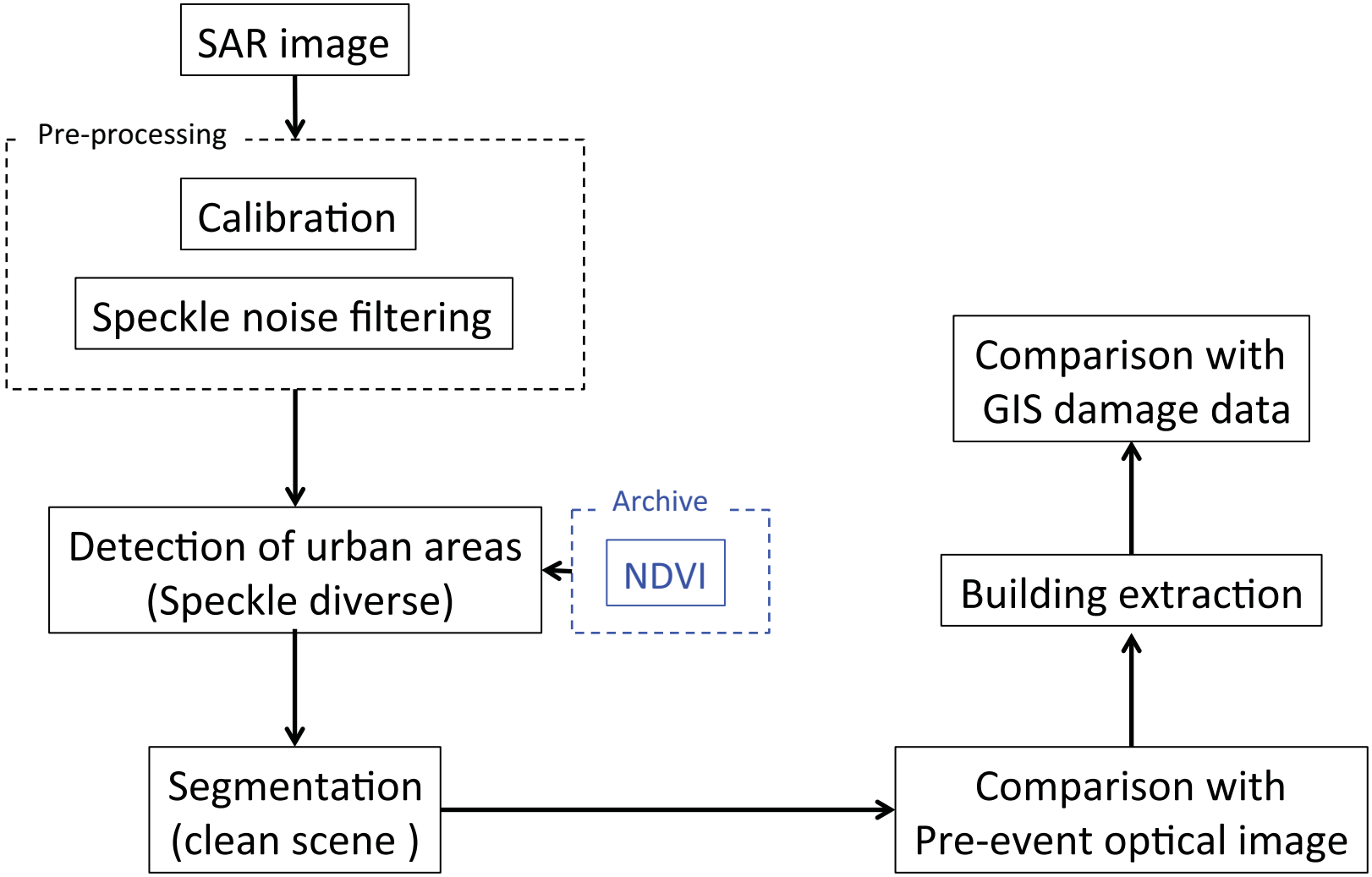
[1]Guida et al., [2010]
[2]Bennett and Blacknell, [2003]

Methodology



- The method exclude the isolated pixels.
- A changed pixel-window is used to extract the layover areas, minimum building height is 3 m (1 story) and maximum is 15 m (5 stories).
- This method should improve the normal segmentation by focusing on bigger objects in the SAR scene.

Methodology



Application (urban areas)

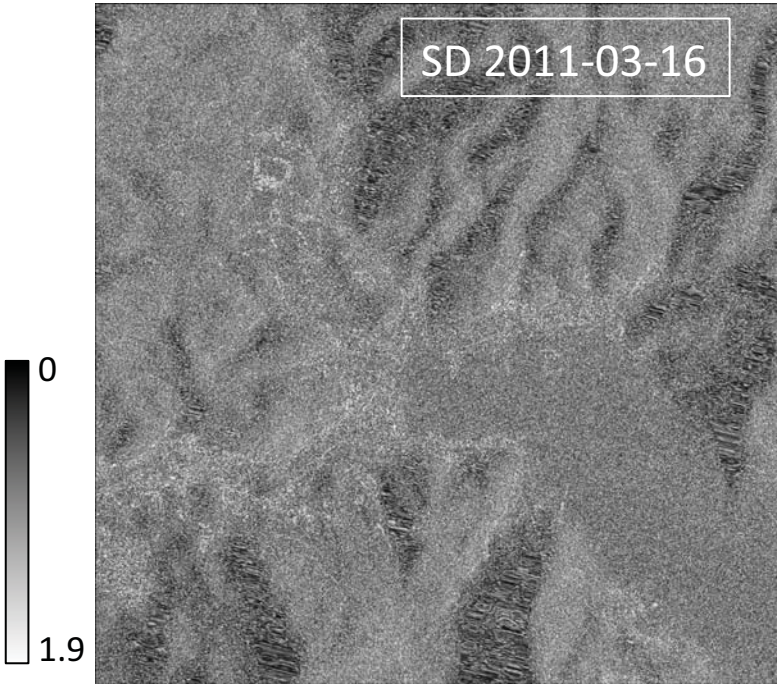
Speckle divergence (SD)

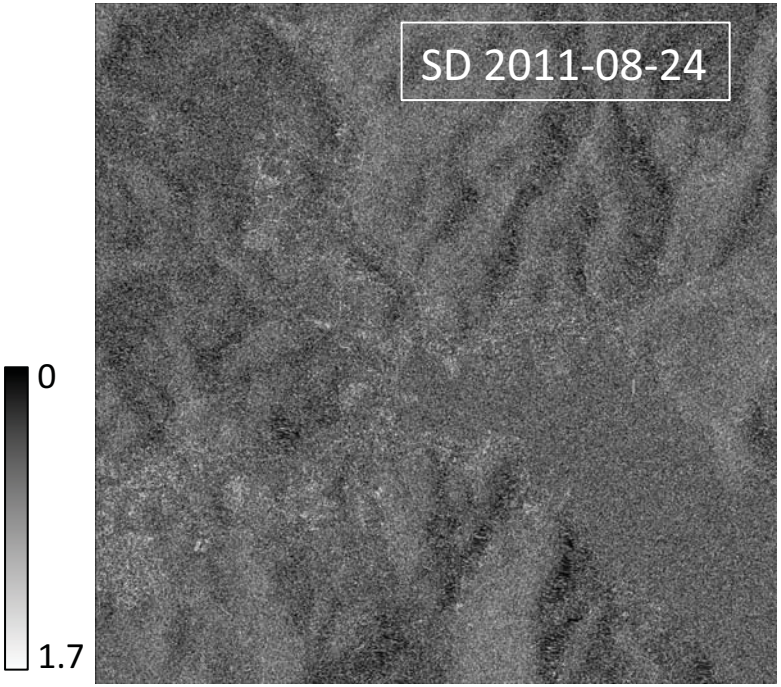
Esch et al., 2010

$$SD_{x,y} = \frac{\sigma_{x,y}}{\mu_{x,y}} - \frac{1}{L_a + L_r}$$

- $\sigma_{x,y}$ = local standard deviation.
- $\mu_{x,y}$ = local mean value.
- L_a and L_r = La and Lr defining the effective number of looks in the azimuth and range.

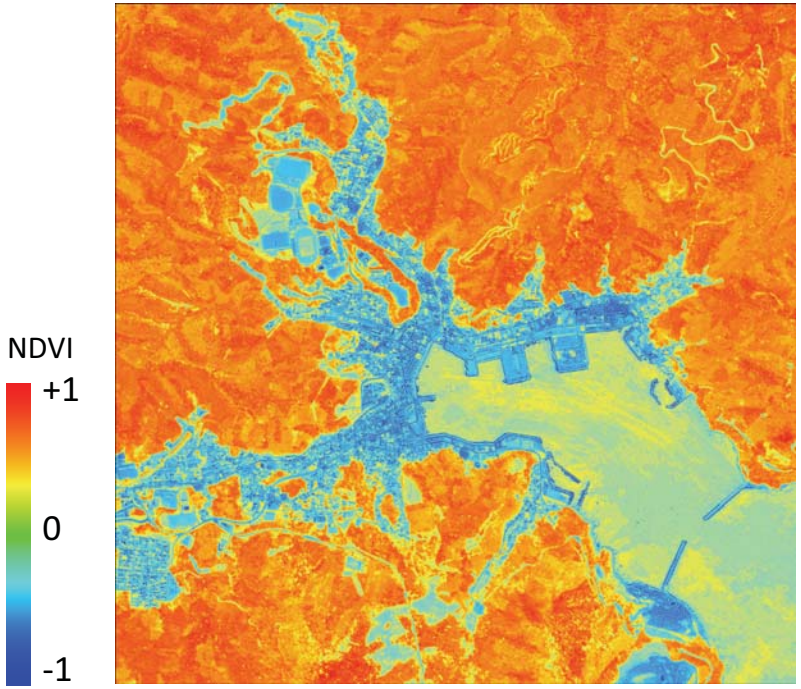
Due to the complexity of the topography the SD can not describe the built-up areas.



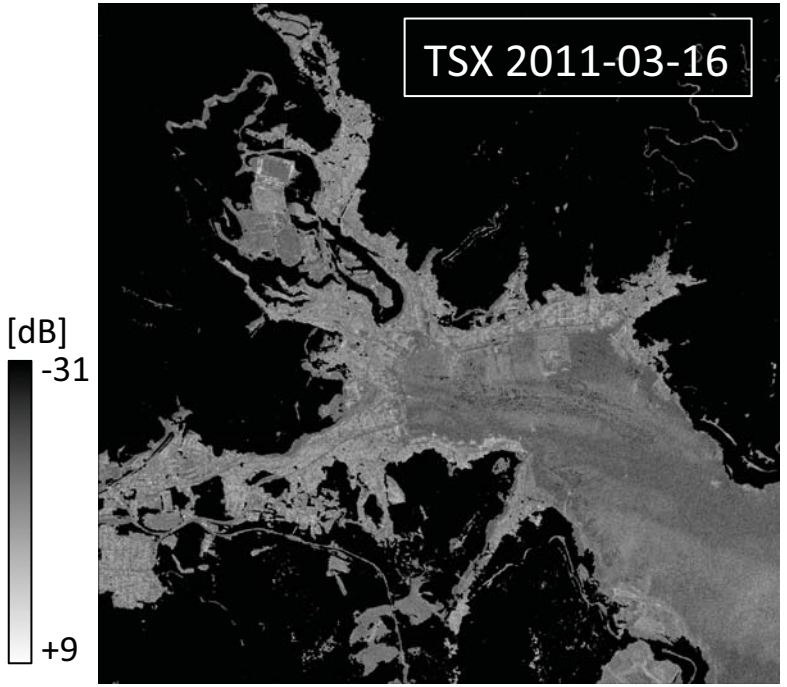


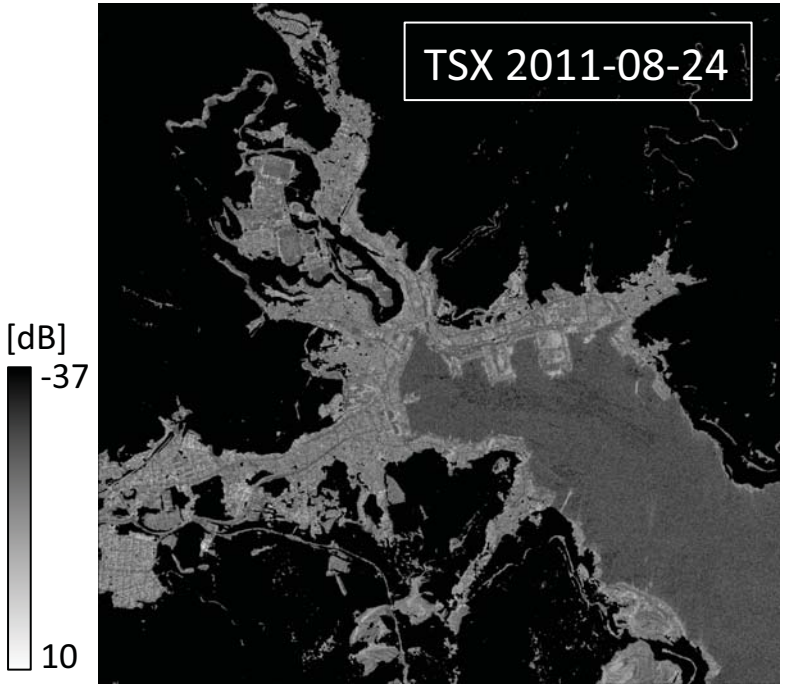
Application (Urban areas)

NDVI (QuickBird 2009/05/12)

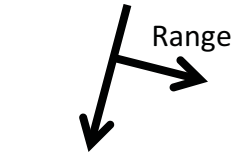


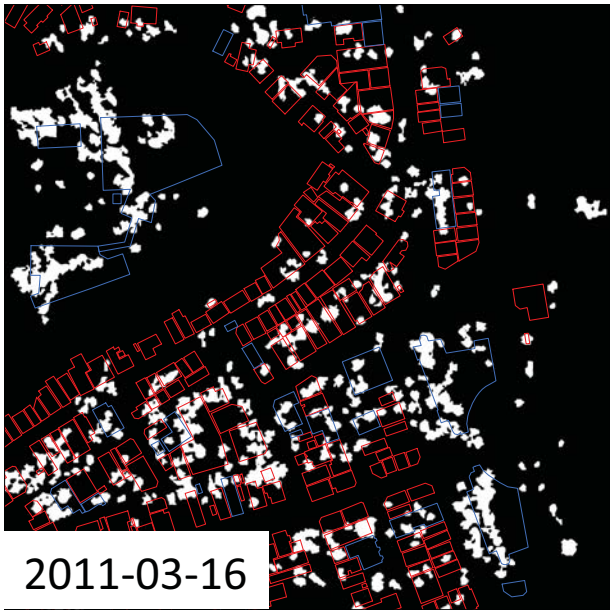
In order to concentrate the analysis on built-up areas, we use the NDVI image as a base template to classify the TSX images.

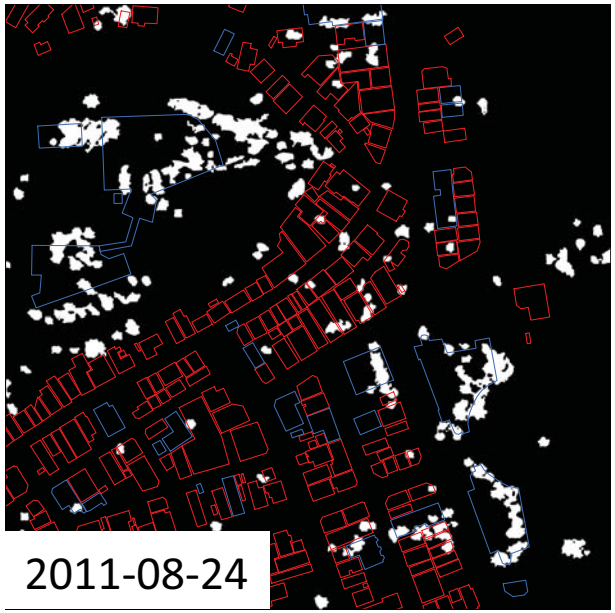




Application (Segmentation)







- In the case of the left-looking image, the segmentation gives more white spots (layover), which are considered “false alarm” by comparing with the GIS-data.
- In case of the right-looking image, the segmentation is more cleaner. However, this may be due to the fact that some debris were removed.

Summary

- Due to the complexity of the topography in the study area, the speckle diverge image does not, adequately, detect the urban areas.
- The extraction of urban areas on TerraSAR-X data was conducted with the support of optical images (NDVI).
- A simple segmentation method, based on the TSX acquisition's parameter was presented.
- The segmentation of the right-looking image gives better results than the left-looking. However, this result may be related to the removal of some debris in the tsunami affected area. Finally, based on the segmented layover areas, the damage building (washed-away) were detected.
- As a future work should be improve for automatic building detection by using a pre- and post- SAR data.