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Applying the GIS methodology for local tsunami risk assessment to the 2011 Tohoku event

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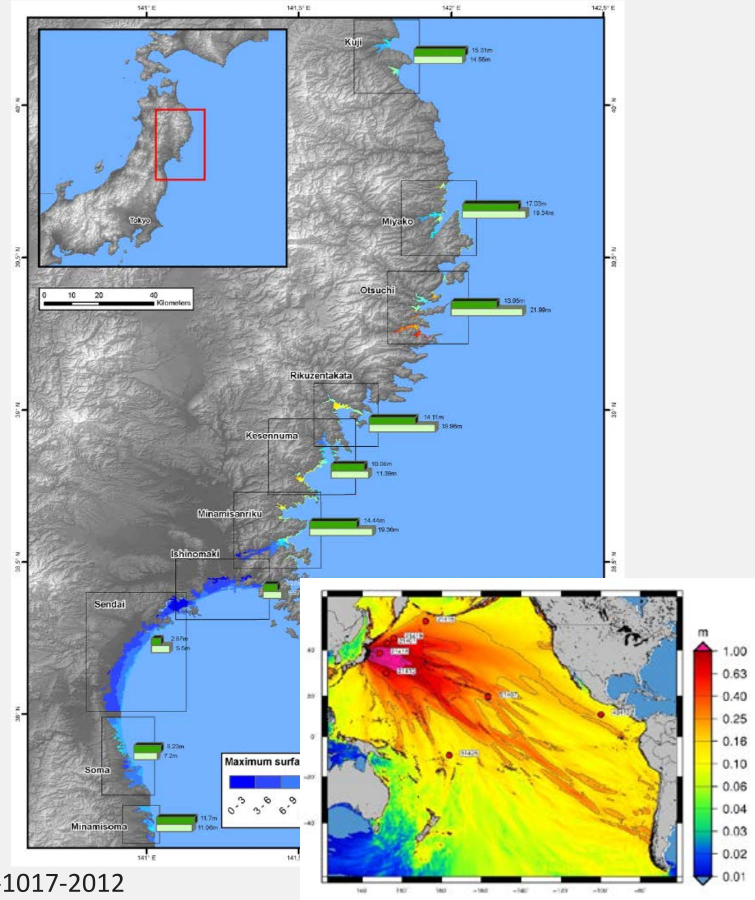
Motivation, sites, and data

Motivation

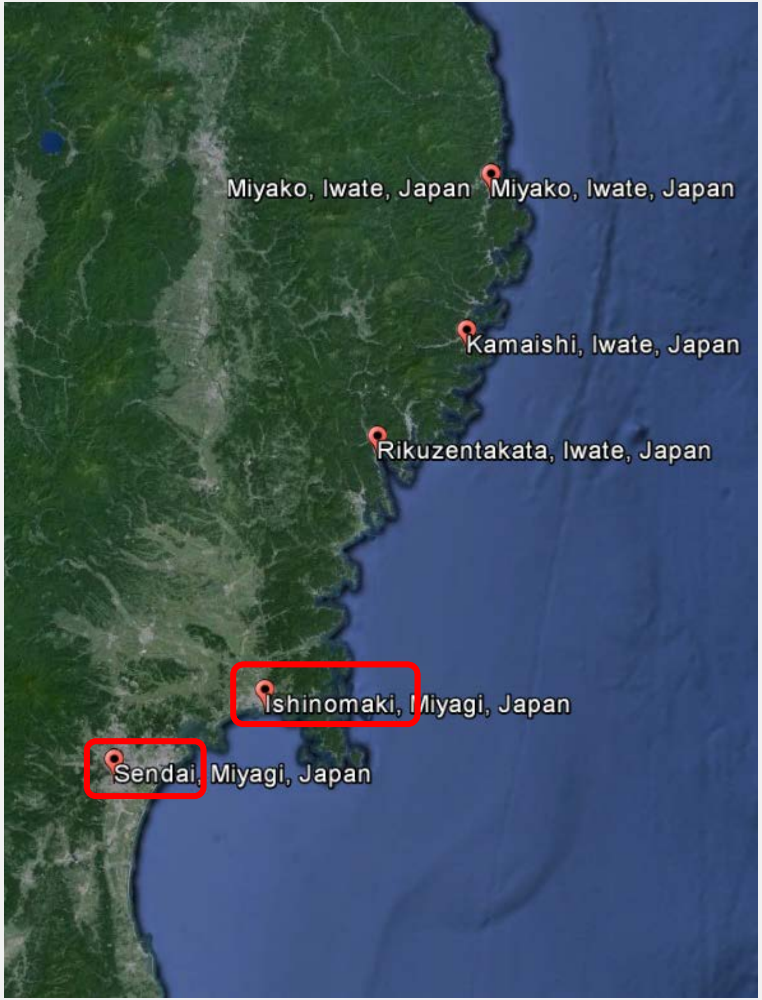
- Validating the GIS model approach for building vulnerability and mortality by hind-casting the event
- Maximum flow depth was obtained by back calculating the 2011 Tohoku earthquake and tsunami
- Potentially a lot of data available on population, building types, infrastructure, inundation, flow depth, damages, and death toll



Løvholt et al. 2012.
doi:10.5194/nhess-12-1017-2012

Focus sites

- Sendai and Ishinomaki



GoogleEarth

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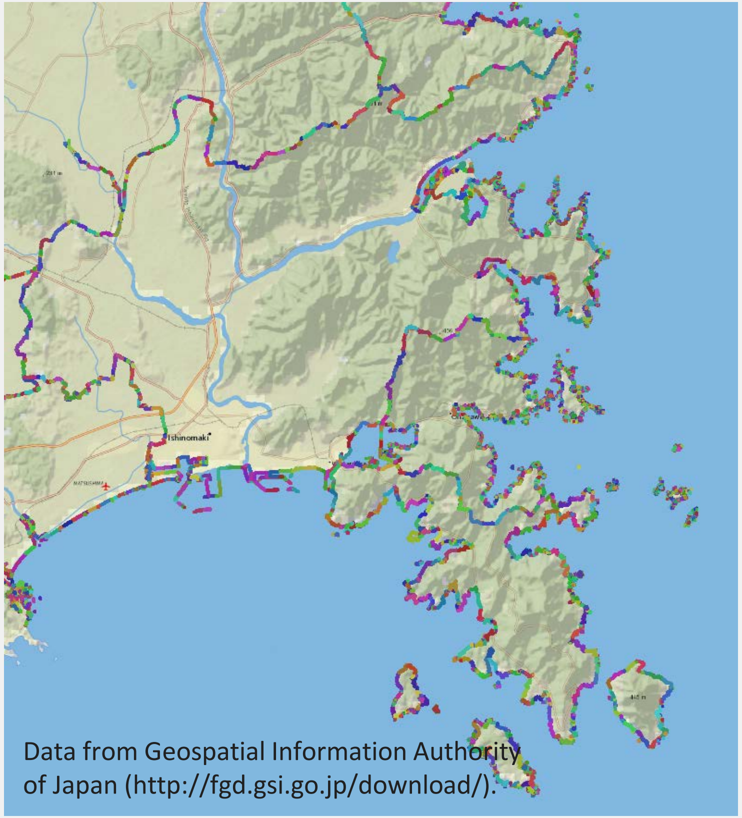
Available data by autumn 2014

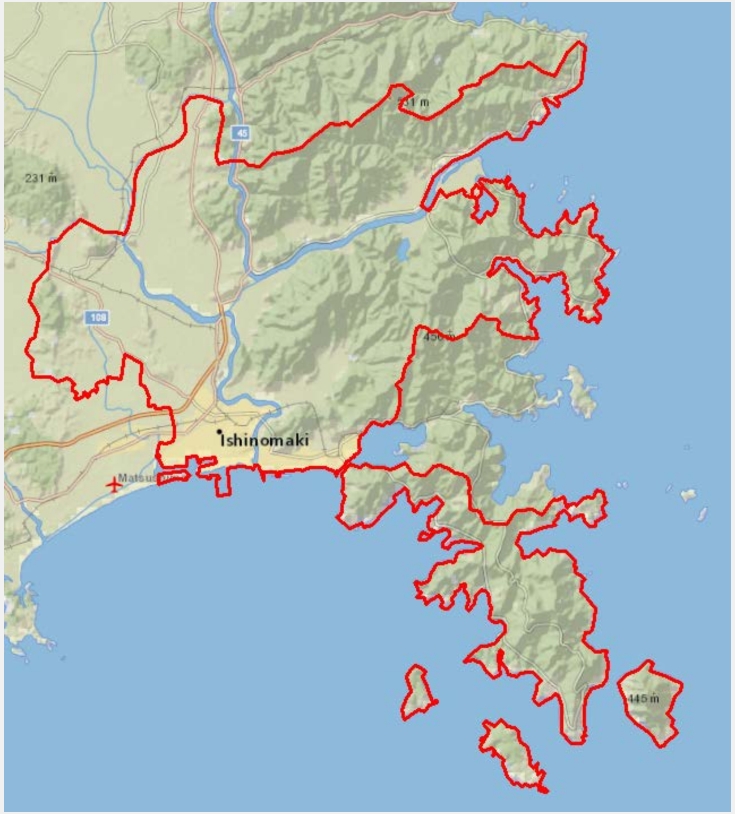
- Very high resolution digital elevation model – VHR DEM, pre-tsunami and post-tsunami data (provided by Dr. Arikawa)
- Post-tsunami field data (water mark measurements, data on structural building vulnerability, etc.) downloaded from http://fukkou.csis.u-tokyo.ac.jp/
- Census data aggregated by geographical units from the Portal Site of Official Statistics of Japan: http://www.e-stat.go.jp/SG1/estat/eStatTopPortal.do (courtesy of Prof Maruyama, Chiba University)

Maruyama, Y., Tanaka, H., 2014. Evaluation of building damage and human casuality after the 2011 off the Pacific coast of Tohoku earthquake based on the population exposure. International Conference on Urban Disaster Reduction, Sept. 28.-Oct.1, 2014, Boulder, Colorado, US.

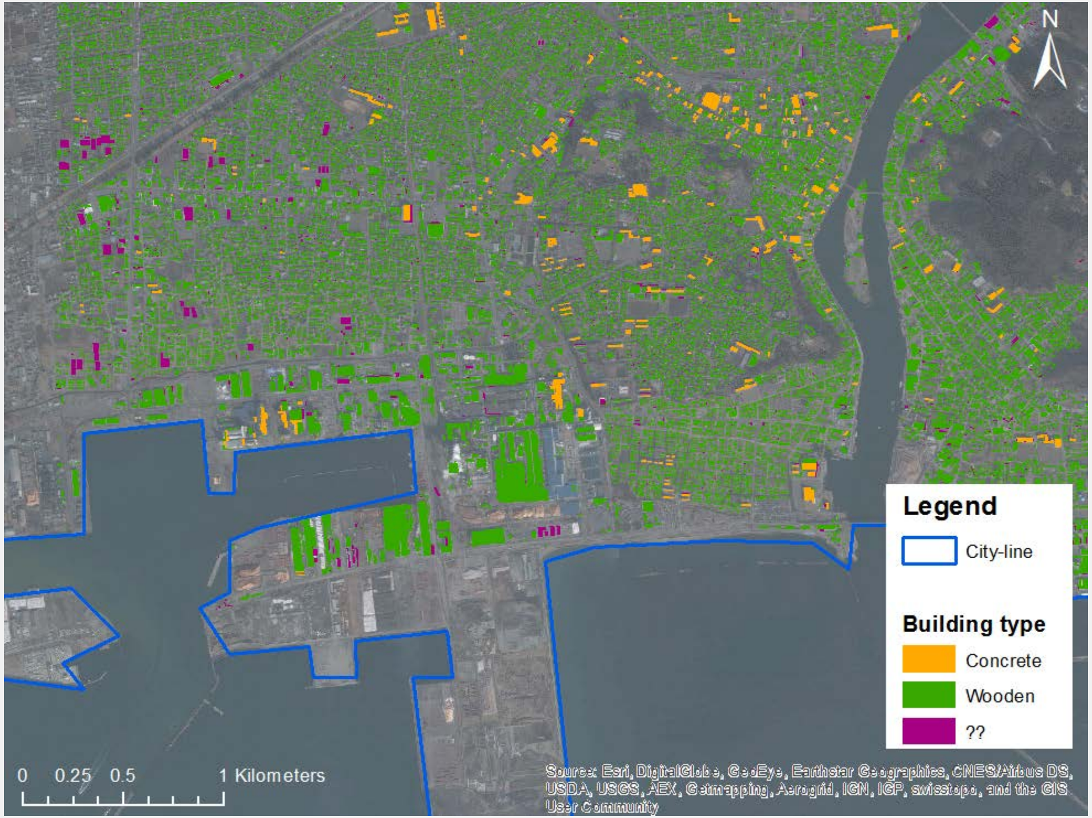
New data February 2015: city boundaries



Data from Geospatial Information Authority of Japan (http://fgd.gsi.go.jp/download/).



New data February 2015: building types

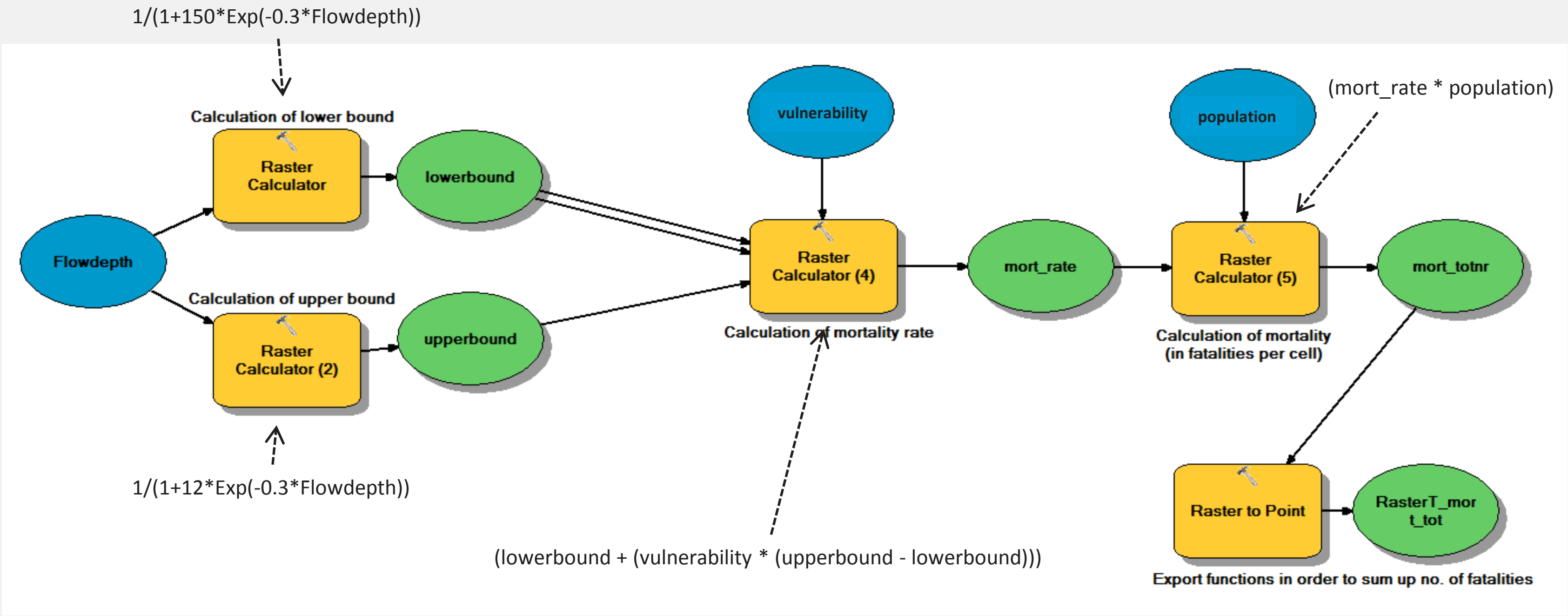


- Possibility to assign three different vulnerability classes
- Data can also be used to introduce urban roughness into flow depth modelling

Data from Geospatial Information Authority of Japan (http://fgd.gsi.go.jp/download/).

GIS-model

Recapitulation of model



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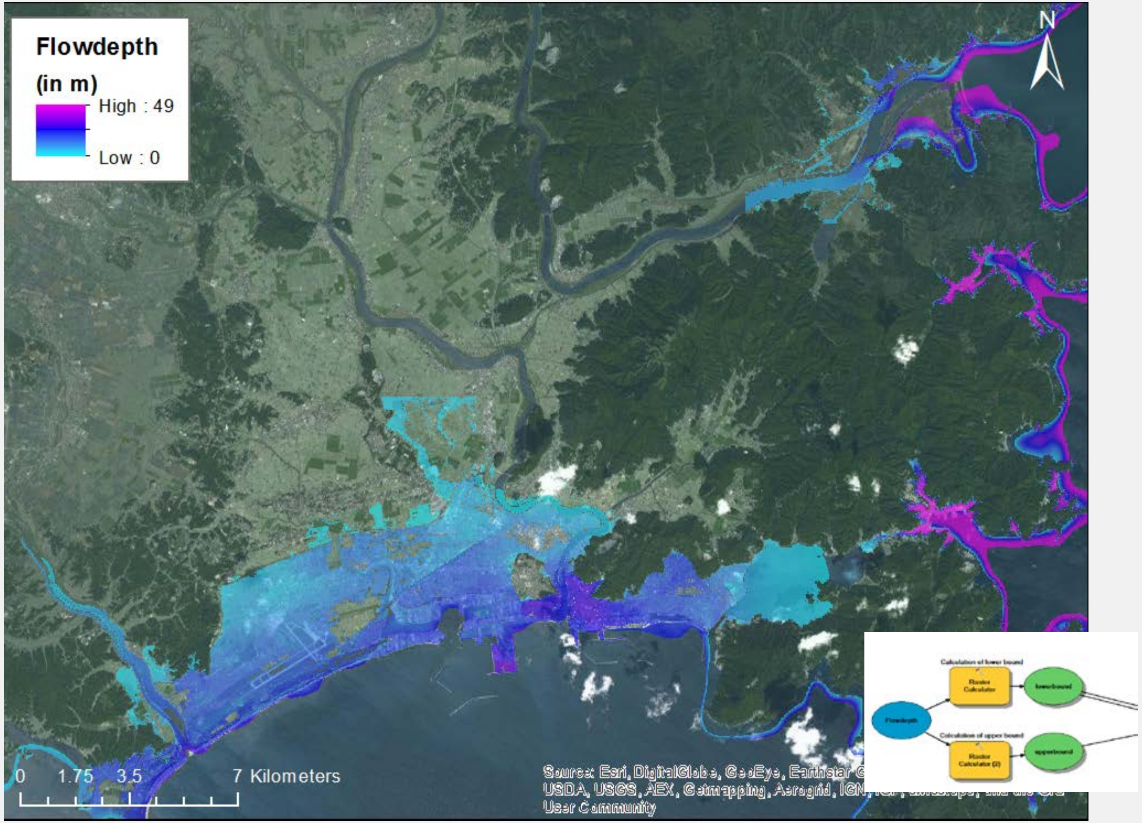
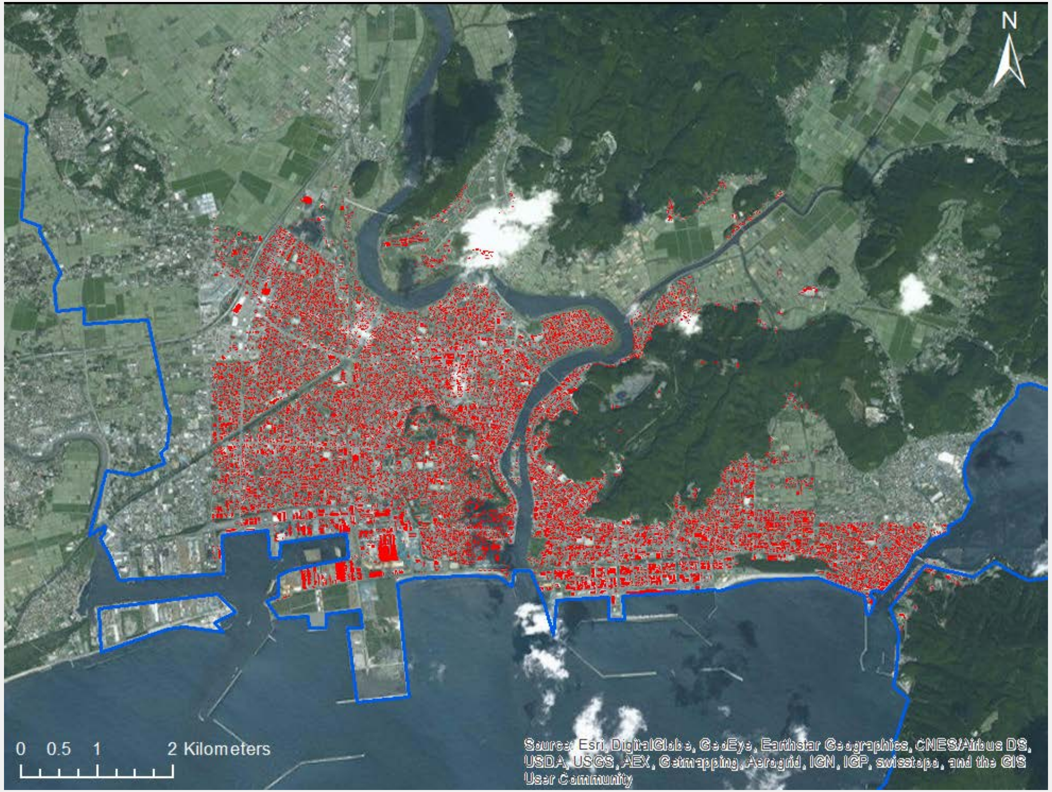
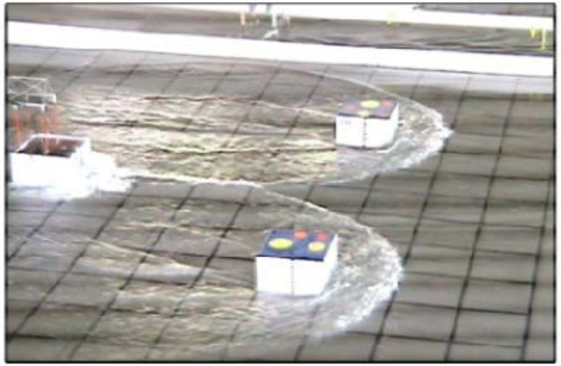
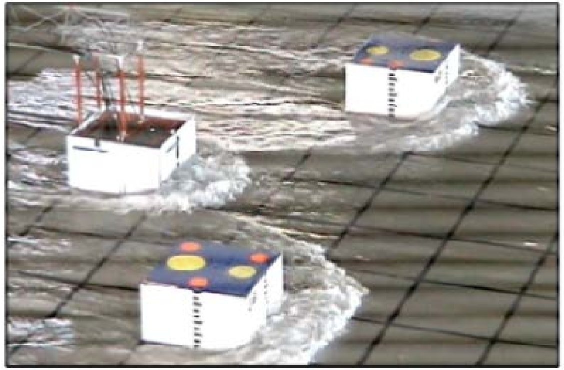
Flow depth in m (23 x 23 m cells)



Possible extension: introduction of urban roughness







Bridges, Kerri-Jane. 2011. Influence of macro-roughness on tsunami runup & forces. http://hdl.handle.net/1957/20794

Data from Geospatial Information Authority of Japan (http://fgd.gsi.go.jp/download/).

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Influence of roughness

Kaiser, G., Scheele, L., Kortenhaus, A., Løvholt, F., Römer, H., Leschka, S. 2011. The influence of land cover roughness on the results of high resolution tsunami inundation modeling. Nat. Hazards Earth Syst. Sci., 11, 2521-2540. doi:10.5194/nhess-11-2521-2011

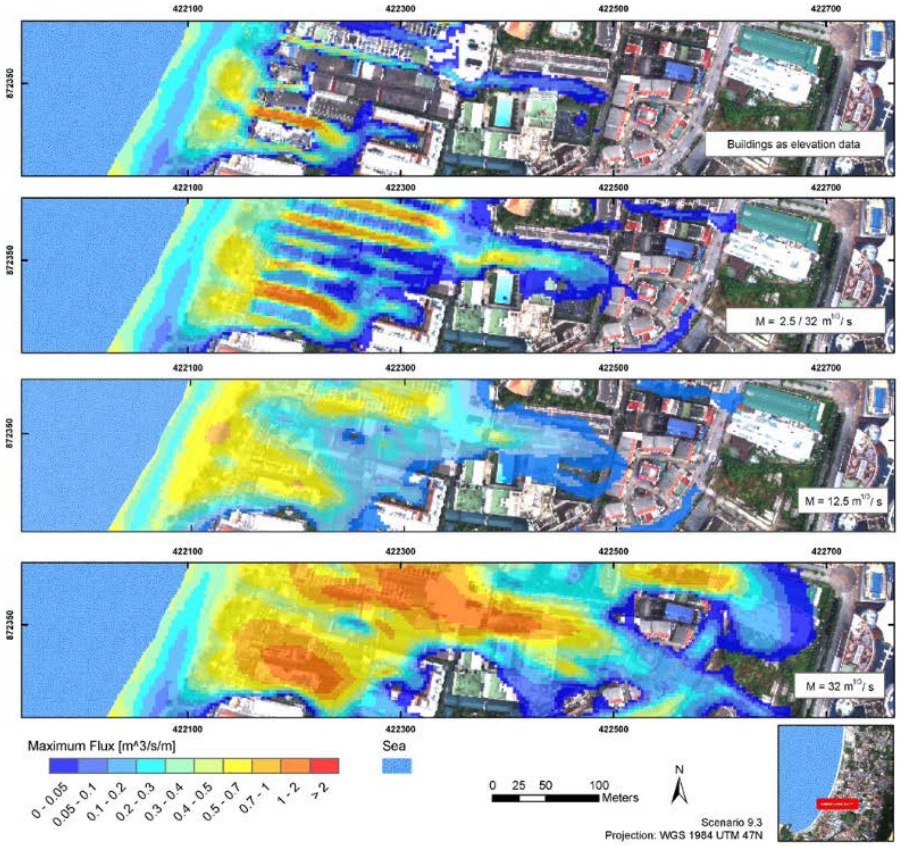
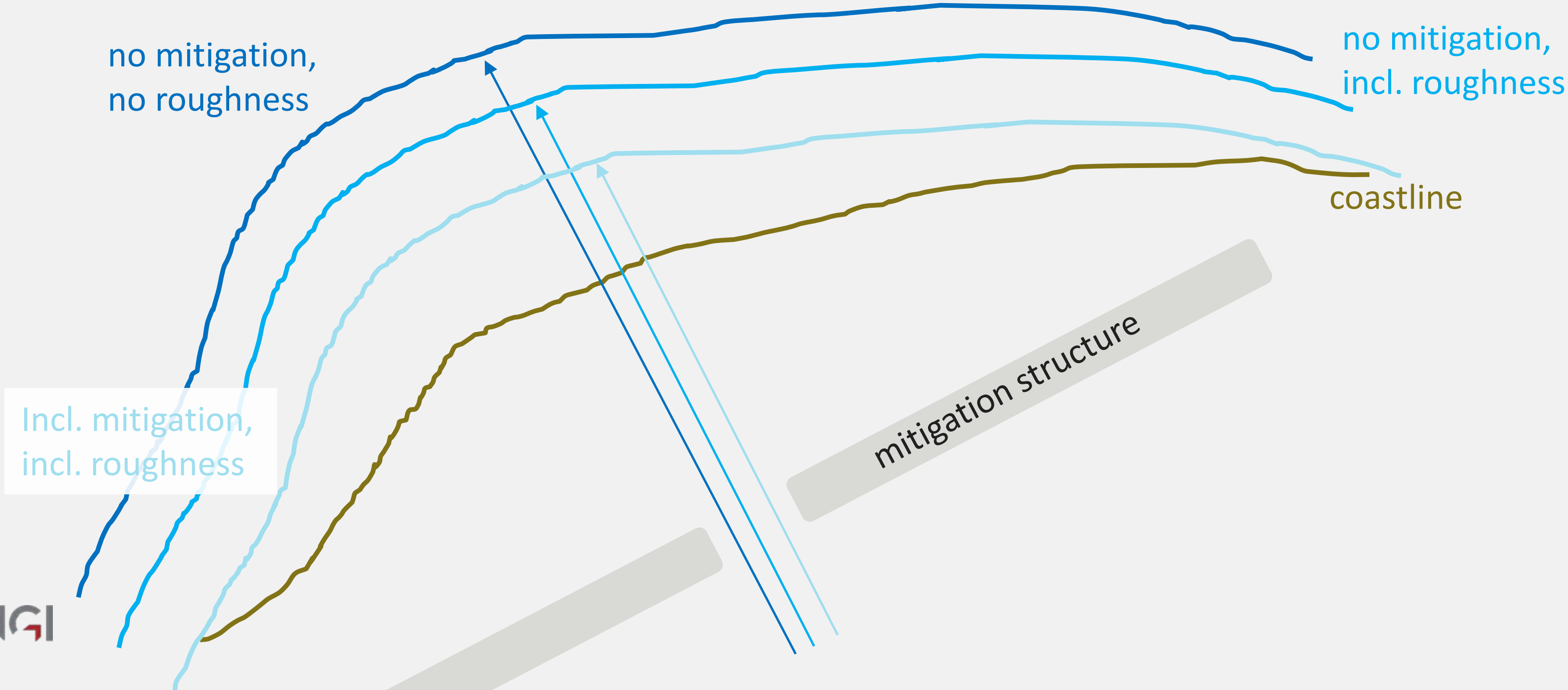


Fig. 15. Maximum flux in Patong Beach, including four different scenarios to represent buildings (top to bottom: buildings as elevation data; $M = 2.5\,\mathrm{m}^{1/3}\,\mathrm{s}^{-1}$; urban area roughness: $M = 12.5\,\mathrm{m}^{1/3}\,\mathrm{s}^{-1}$; and $M = 32\,\mathrm{m}^{1/3}\,\mathrm{s}^{-1}$ uniform values.

Possible extension: inclusion of mitigation structure



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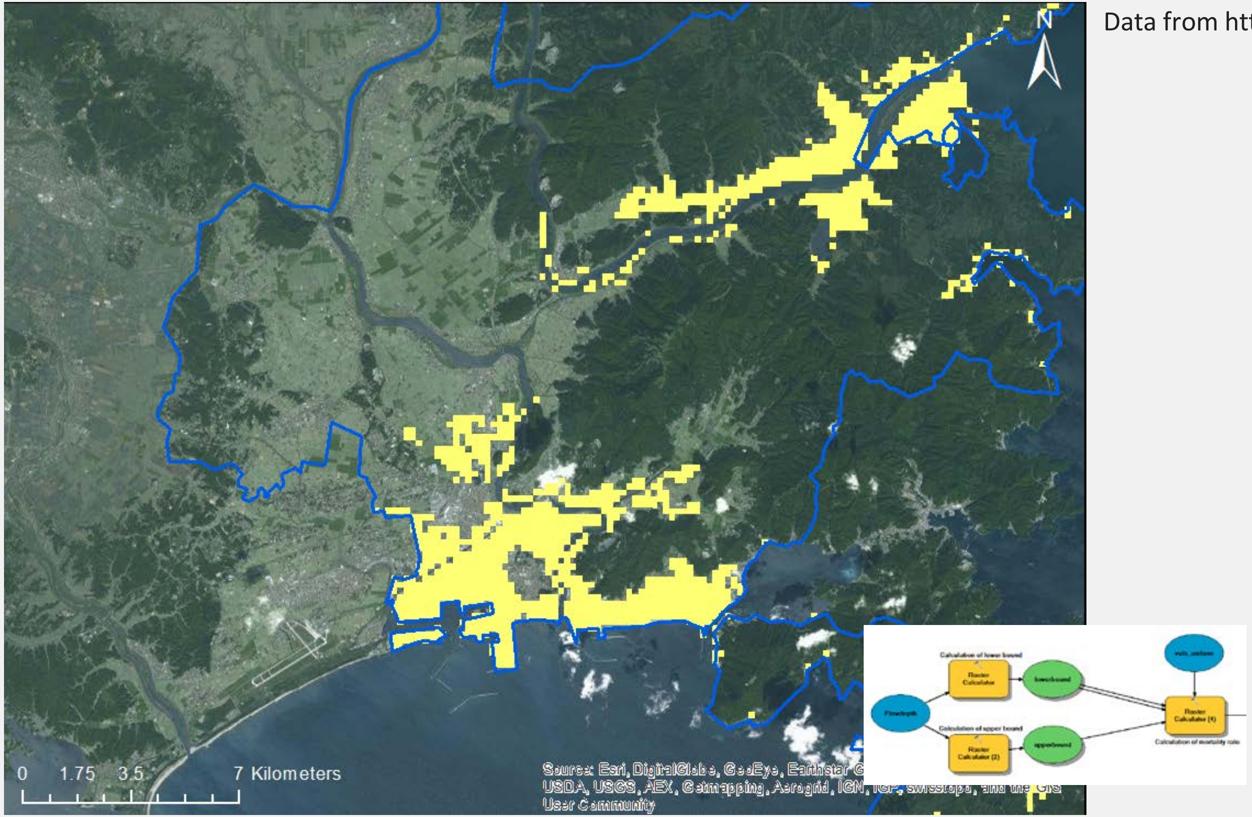
Vulnerability (200 x 200 m) → resampled to 23 x 23 m



Data from http://fukkou.csis.u-tokyo.ac.jp/

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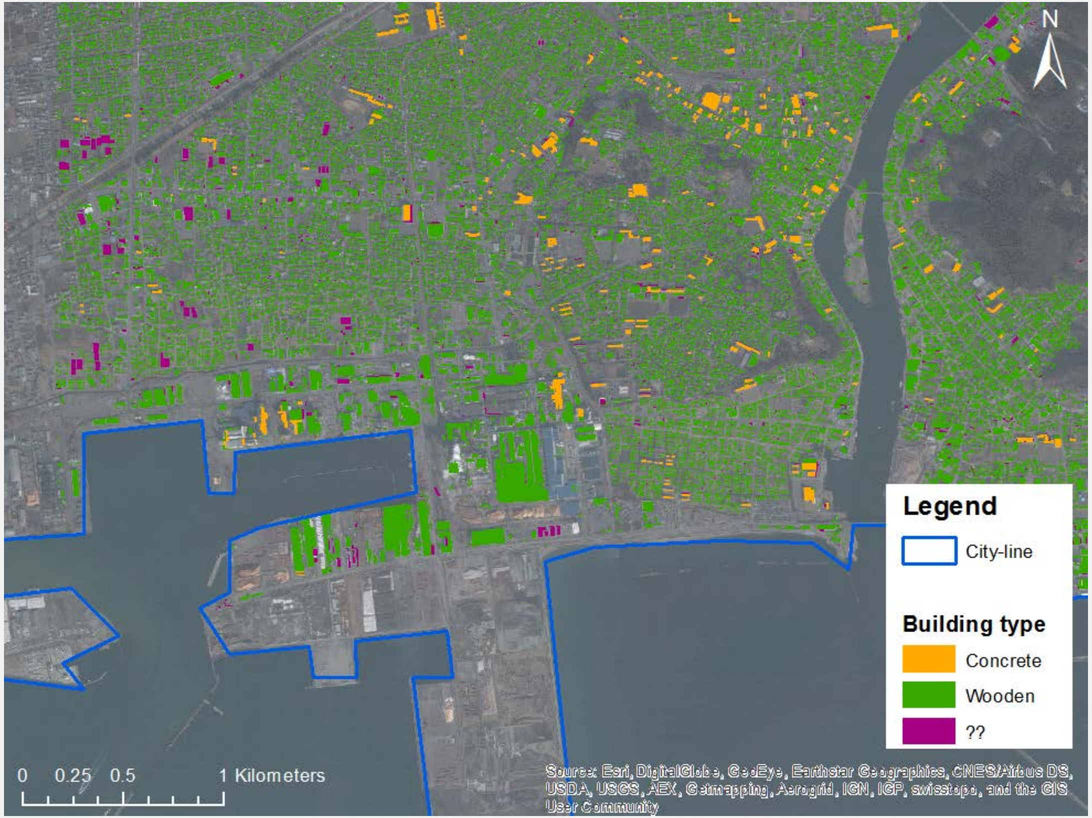
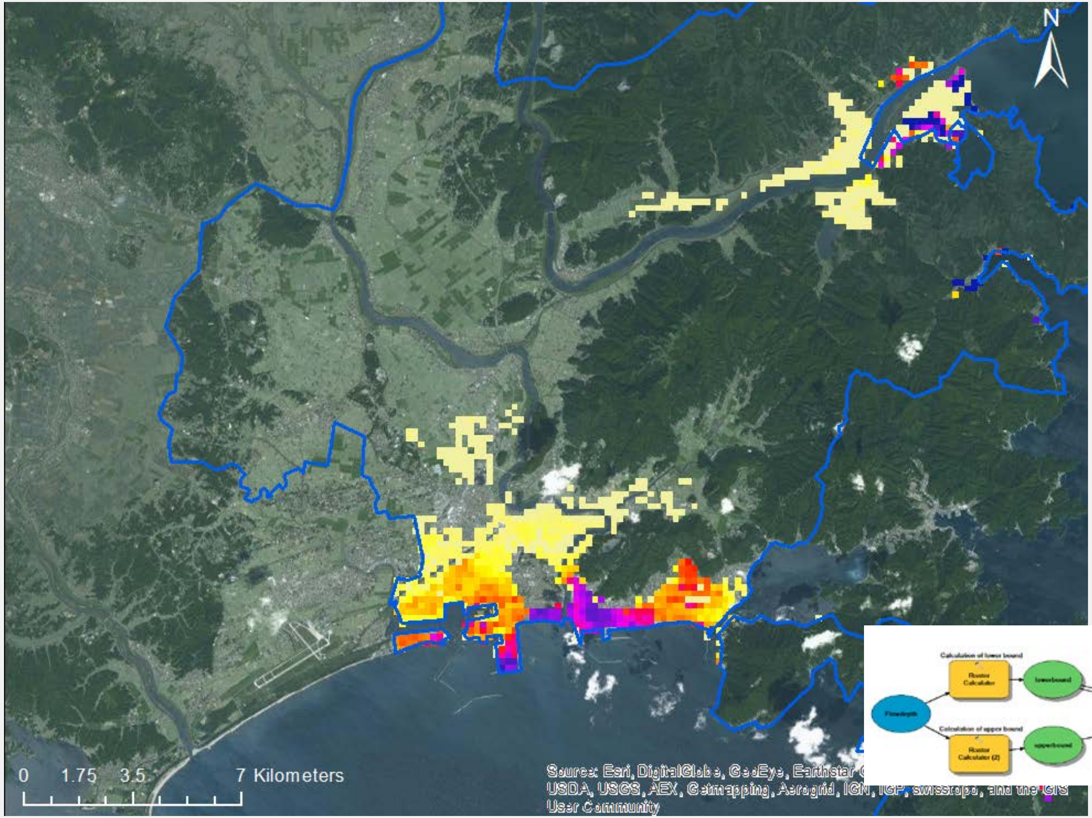
Possible extension: refining vulnerability

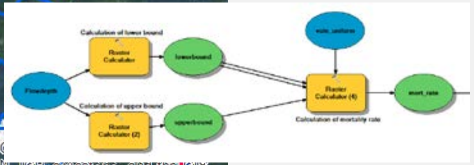


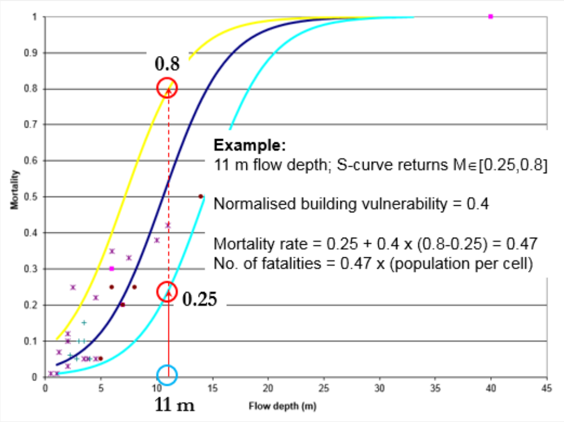
- Possibility to assign three different vulnerability classes to three different building type categories
- Directly calculate raster with 23 x 23 m resolution (no resampling) from vector data

Data from Geospatial Information Authority of Japan (http://fgd.gsi.go.jp/download/).

Mortality rate







After Eidsvig, U. M. K., Medina-Cetina, Z, Kveldsvik, V., Glimsdal, S., Harbitz, C. B., Sandersen, F.(2009) ”Risk assessment of a tsunamigenic rockslide at Åknes”, Natural Hazards, DOI 10.1007/s11069-009-9460-6.

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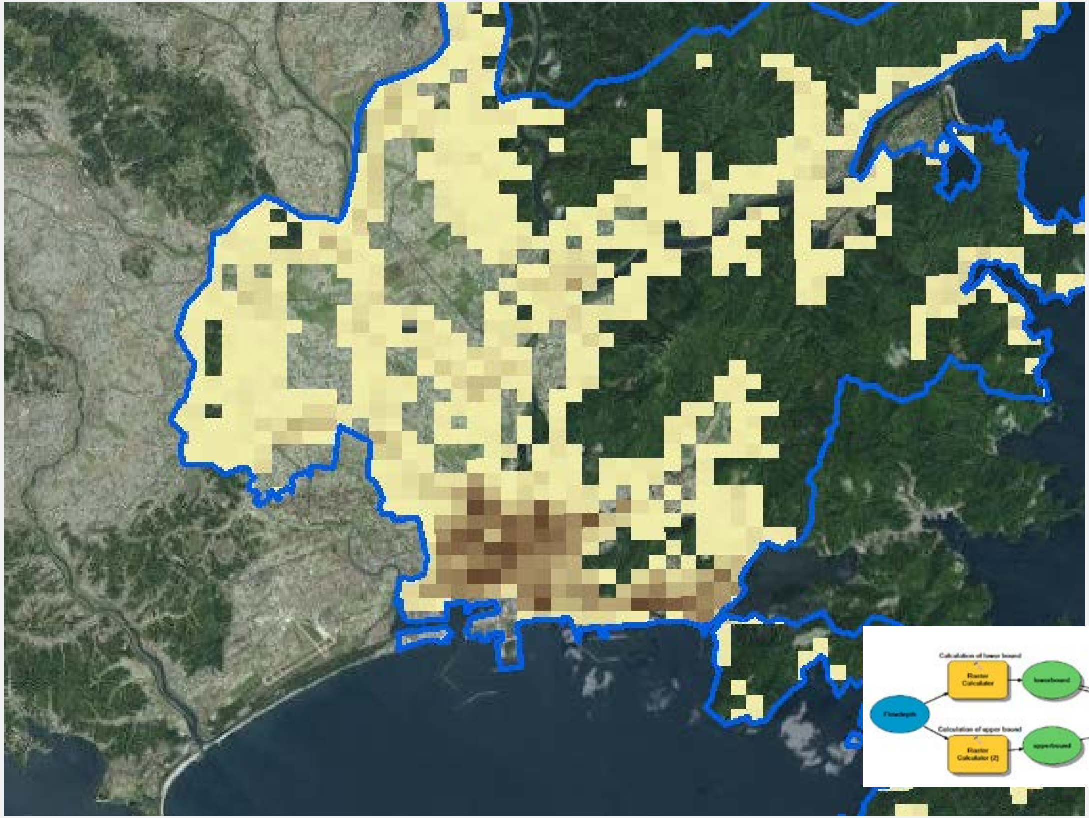
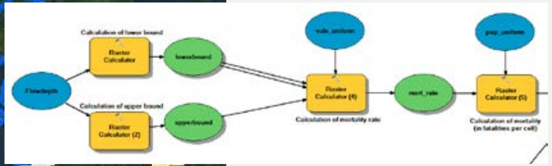
Population density





Population data by courtesy of Assoc. Prof. Y. Maruyama, Chiba University (Maruyama, Y., Tanaka, H., 2014. Evaluation of building damage and human casuality after the 2011 off the Pacific coast of Tohoku earthquake based on the population exposure. International Conference on Urban Disaster Reduction, Sept. 28.-Oct.1, 2014, Boulder, Colorado, US.)

Possible extension: refining exposure

Nakanishi et al., 2013. Transportation planning methodologies for post-disaster recovery in regional communities: the East Japan Earthquake and tsunami 2011. Journal of Transport Geography 31: 181–191.

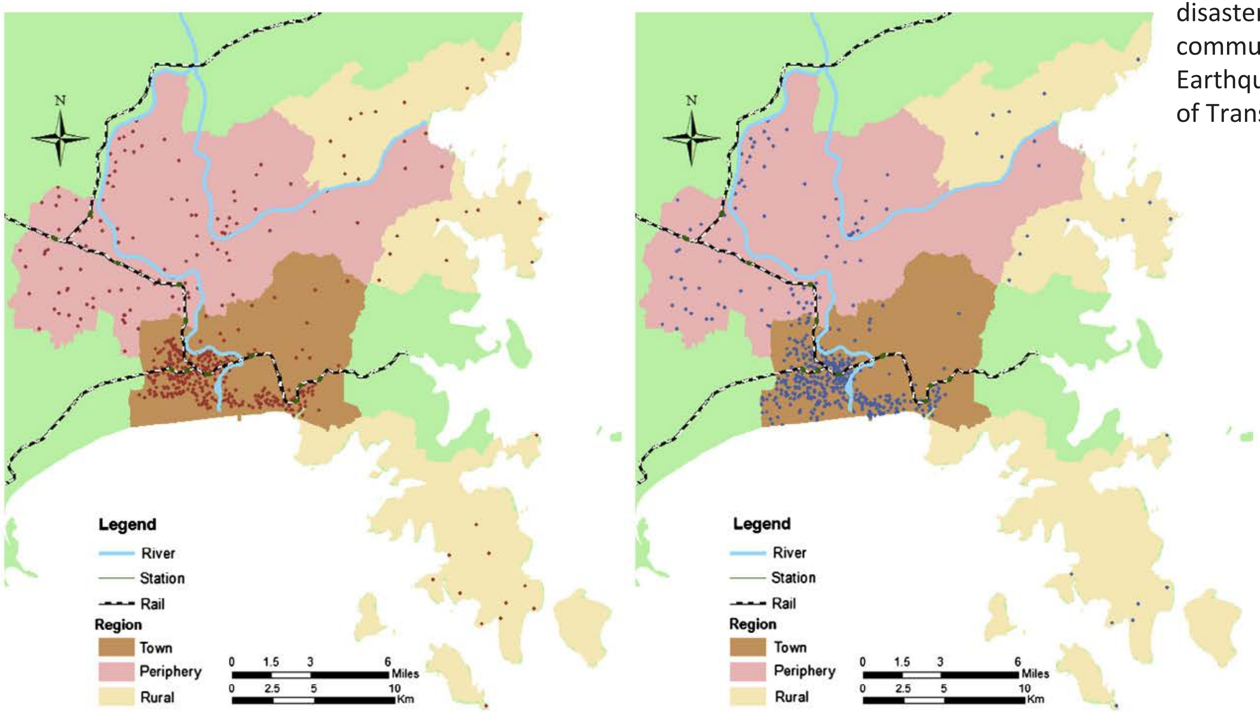
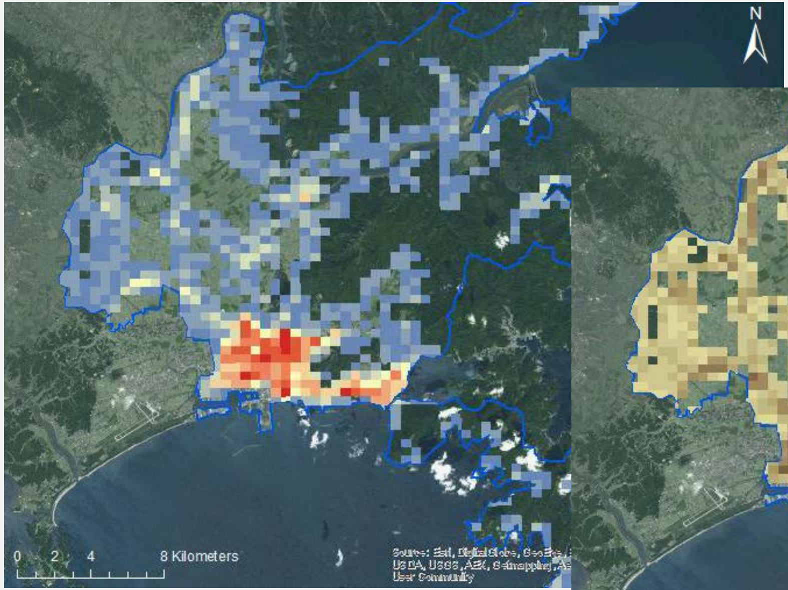
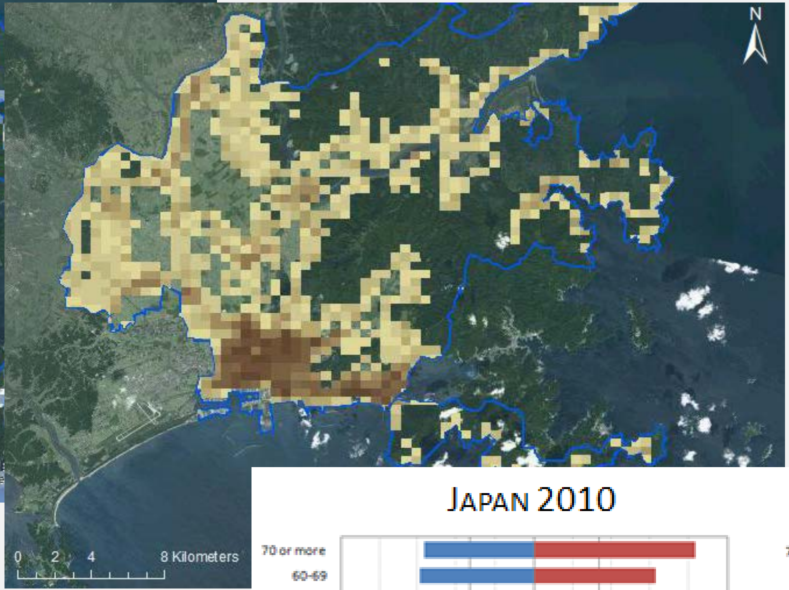


Fig. 3. Current population (left) and employment (right) distribution (2010) (one red dot (left) = 300 persons, one blue (right) dot = 150 employments). (For interpretation of

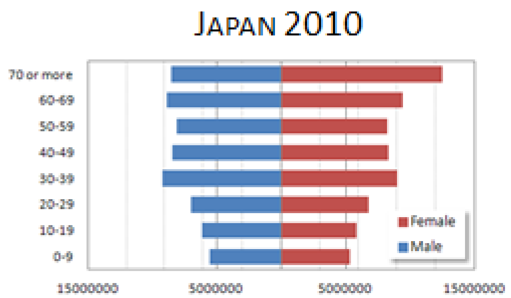
Possible extension: refining exposure

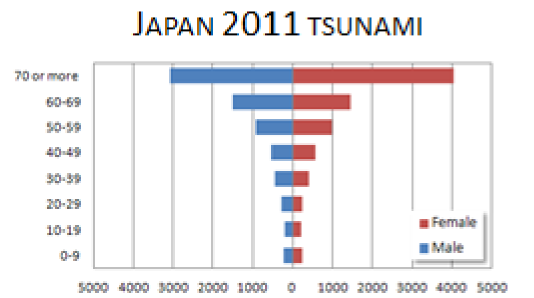


No. of males/females



Population data by courtesy of Assoc. Prof. Y. Maruyama, Chiba University





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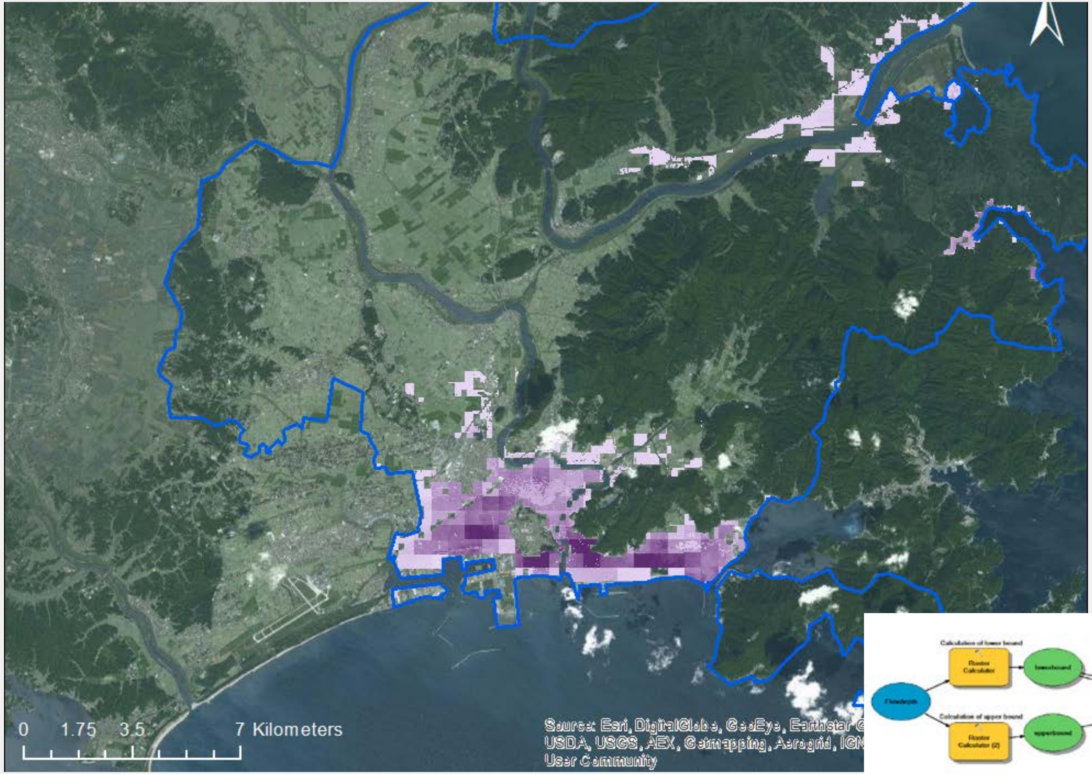
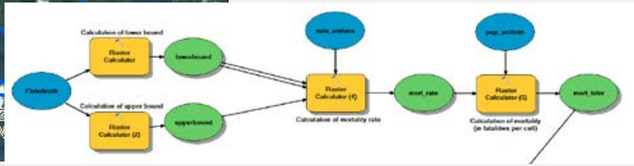
From Pino Gonzalez-Riancho Calzada

No. of fatalities





- Identification of most prone areas
- Estimate of no. of fatalities (oops, depends on quality of input data)

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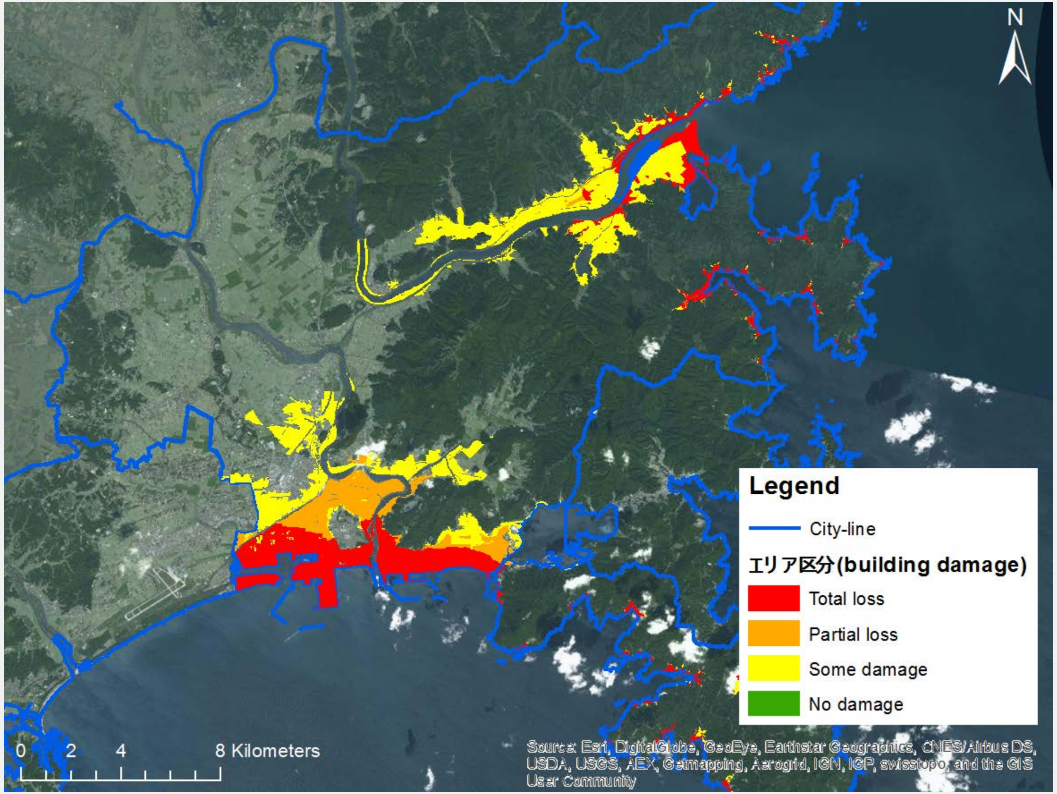
Verification data

Verification data: building damage data set I



Data from http://fukkou.csis.u-tokyo.ac.jp/

- In addition, data on inundation area, indundation height and water mark height (all from http://fukkou.csis.u-tokyo.ac.jp/).

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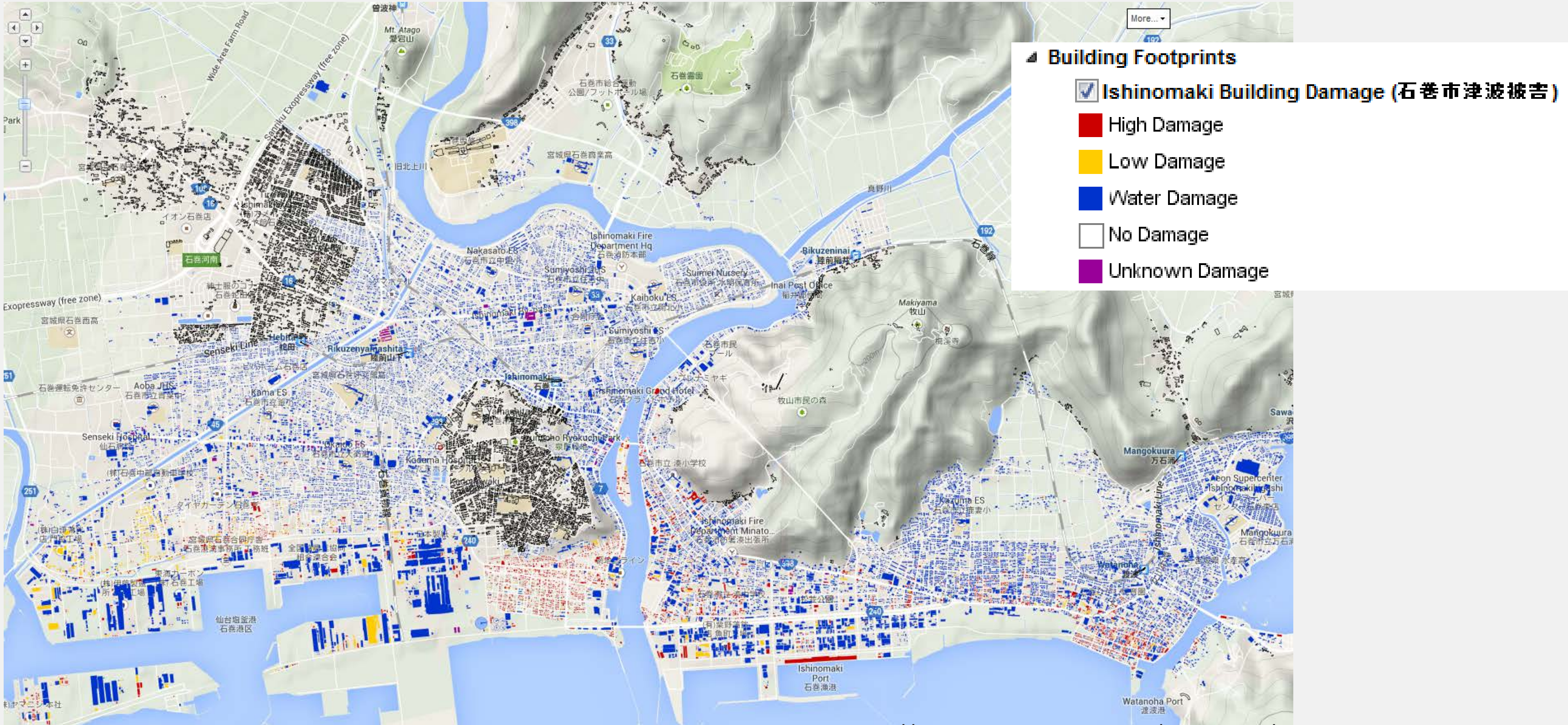
Verification data: building damage data set II



http://worldmap.harvard.edu/japanmap/

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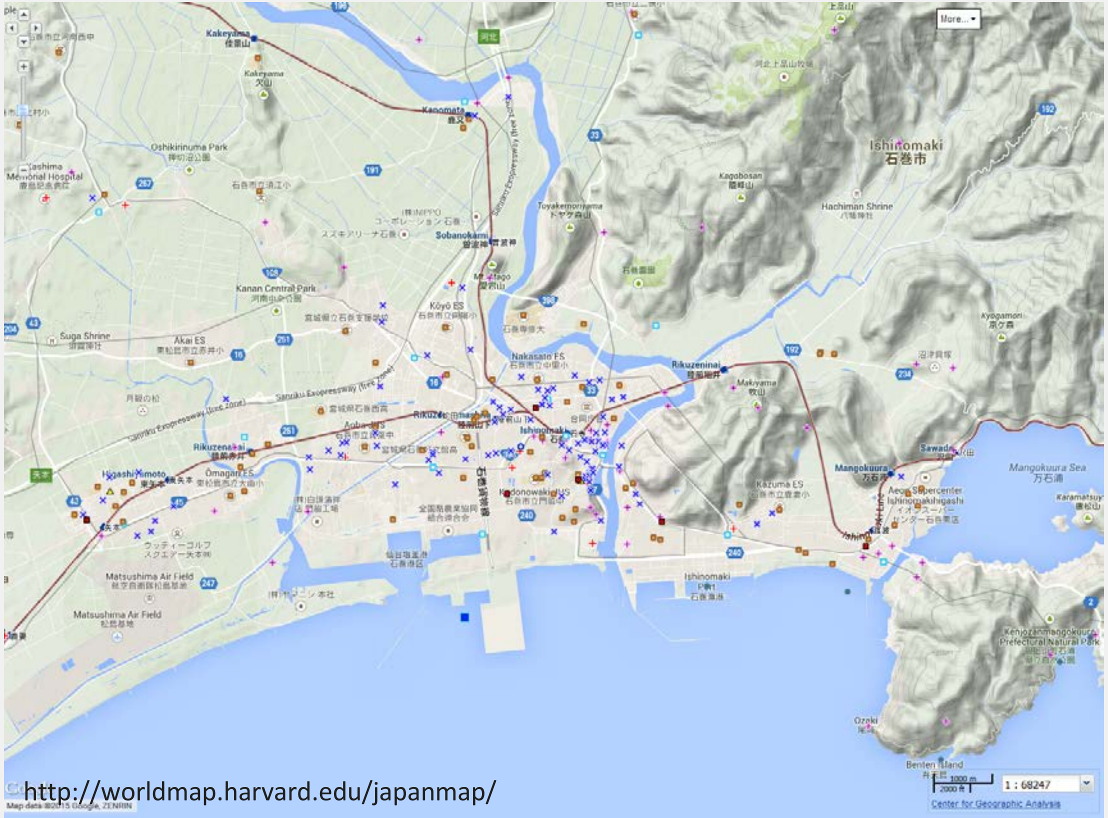
Critical facilities



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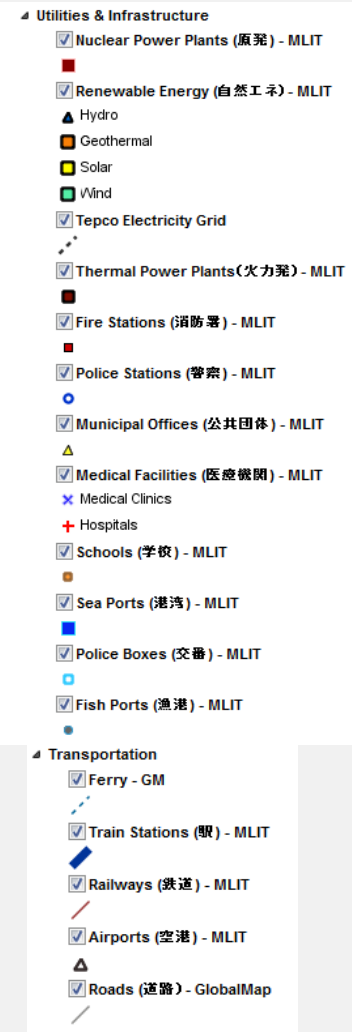

Conclusions and questions

Concluding remarks

- Maximum flow depth was obtained by back-calculating the 2011 Tohoku earthquake and tsunami using very high resolution digital elevation data
- First and second runs for validation of GIS tsunami risk model
  - Using gridded population data from Portal Site of Official Statistics of Japan
  - Using uniformly distributed building vulnerability
- Next and last steps *(tentative)*
  - *Incorporation of urban roughness into flow depth modelling?*
  - Incorporation of mitigation structure (sea dike, sea wall?) intoflow depth modelling?
  - Improvement of building vulnerability layer
  - Refinement of population exposure

Questions

- Which type of mitigation structure to use in simulation?
- Availability of «Daytime population»?
- Third class of «building type» data set (slide7). We have «wooden» and «concrete», what is the third class?

Thank you for your attention!

- We acknowledge the help from:
  - T. Arikawa, Y. Nakamura
  - Y. Mayurama
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  - NGI/ICG/The Research Council of Norway

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