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

Focus sites

Sendai and Ishinomaki
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/

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

\[
\frac{1}{1+150\times e^{-0.3\times \text{Flowdepth}}} \\
\frac{1}{1+12\times e^{-0.3\times \text{Flowdepth}}} \\
(\text{lowerbound} + (\text{vulnerability} \times (\text{upperbound} - \text{lowerbound})))
\]
Flow depth in m (23 x 23 m cells)
Possible extension: introduction of urban roughness

http://hdl.handle.net/1957/20794

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


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

- No mitigation, no roughness
- No mitigation, incl. roughness
- Incl. mitigation, incl. roughness
- Coastline
- Mitigation structure
Vulnerability (200 x 200 m) → resampled to 23 x 23 m

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

Population density

Possible extension: refining exposure

Possible extension: refining exposure

No. of males/females

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

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)
Verification data
Verification data: building damage data set I

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

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

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

http://worldmap.harvard.edu/japanmap/
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?) into flow 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!

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