Spatiotemporal assessment of tsunami vertical evacuation: A case study of the Shizuoka Metropolitan Area

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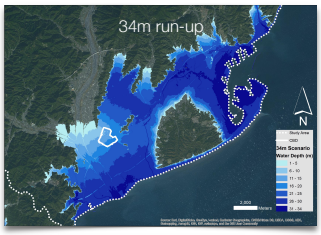
Purpose and study area

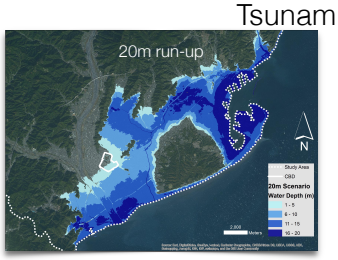
To apply GIS methods in the current building stock of the city of Shizuoka in order to identify potential vertical evacuation sites within the flood zones of variable tsunami scenarios and estimate their capacity to accept tsunami evacuees during different time zones of the day providing multiple spatiotemporal vertical evacuation options that aim in saving lives during a tsunami event.

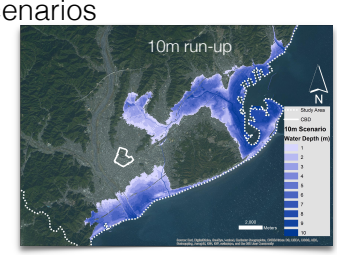
Research Objectives:

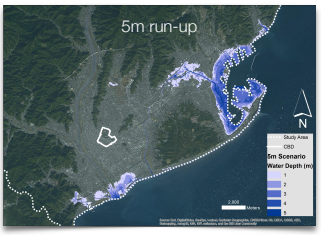
- Establish and visualise variable tsunami inundation scenarios in the study area
- Estimate the inundation ratio of buildings and their available for evacuation volume in each scenario
- Estimate building population over 24 hours of a day
- Combine building and volume estimations with vertical evacuation criteria, identifying potential sites per hour of the day, their potential capacity and location

Tsunami scenarios









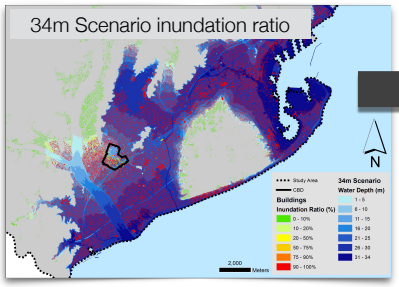
Inundation ratio and building volume loss

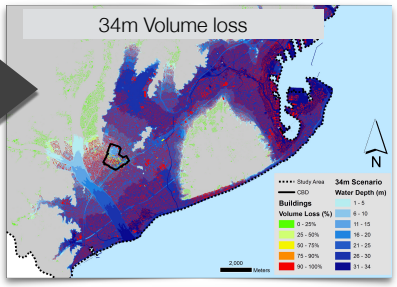
- The inundation ratio shows the extent that a building becomes flooded in the form of percentage

Inundation = (Exposure / Building Height) x100

- Subtracting the inundation ratio from the volume of each building results in the estimation of its volume loss
- The volume loss estimation shows how much volume is available for each building after a tsunami. The volume that is left can be used to evacuate locals vertically

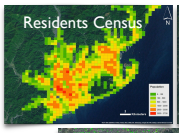
Available volume= Building Volume - Inundated volume

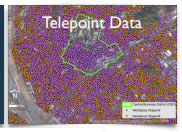


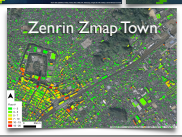


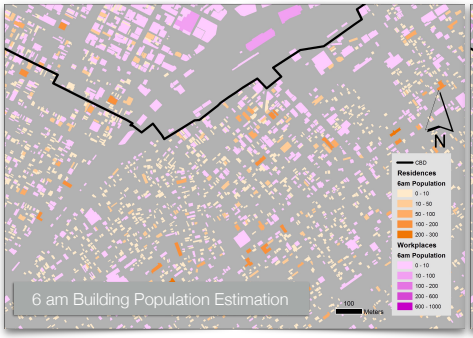
24h building population estimation

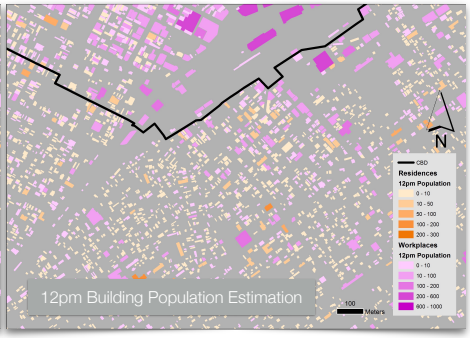
- Method by Greger (2015), that provides temporal building population estimation, adjusted to Shizuoka data availability
- Utilisation of census tracts, building footprints and person trip data in order estimate building population over 24h of the day
- Applied using the 2010 census meshes, the Zenrin Zmap Town II 2008/2009 datasets, and the 2001 Shizuoka Person Trip Data











Vertical evacuation site criteria and results

- Strict criteria for the less severe scenarios (5m and 10m), selecting buildings with inundation ratio of 25% or less
- Less strict criteria for severe scenarios (34m and 20m) selecting buildings with inundation ratio of 75% or less
- Assign volume of 3, 6 and 9 cubic meters per person to estimate capacity to accept people for vertical evacuation

20m Scenario - 10426 potential sites

Population already in buildings

Time	5am	6am	7am	8am	9am	10am	11am	12pm	13pm	14pm	15pm	16pm	17pm	18pm	19pm	20pm	21pm
	115280	114322	107974	94934	91080	59797	60718	89265	58830	85967	88313	93733	99499	107632	111339	113758	114931

Potential for additional population

Total

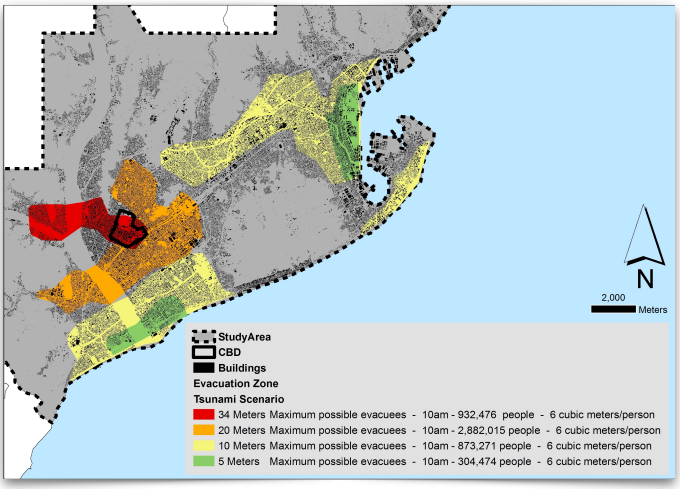
Time	5am	6am	7am	8am	9am	10am	11am	12pm	13pm	14pm	15pm	16pm	17pm	18pm	19pm	20pm	21pm
3m³ per person	5587754	5589666	5602380	5628454	5636164	5764030	5765984	5639800	5700666	5646396	5641706	5630852	5619320	5603058	5595638	5590794	5588454
6m³ per person	2793877	2794833	2801190	2814227	2818082	2882015	2882992	2819900	2850333	2823198	2820853	2815426	2809660	2801529	2797819	2795397	2794227
9m³ per person	1862584	1863222	1867460	1876151	1878721	1921343	1921994	1879933	1900222	1882132	1880568	1876950	1873106	1867686	1865212	1863598	1862818

Residences - 7969 potential sites

3m³ per person	3240792	3243964	3273092	3339272	3360892	3416078	3418032	3368452	3431862	3378938	3367750	3344222	3315658	3279216	3259582	3245092	3240502
6m³ per person	1620396	1621982	1636546	1669636	1680446	1708039	1709016	1684226	1715931	1689469	1683875	1672111	1657829	1639608	1629791	1622546	1620251
9m³ per person	1080264	1081321	1091030	1113090	1120297	1138692	1139344	1122817	1143954	1126312	1122583	1114740	1105219	1093072	1086527	1081697	1080167

Workplaces - 2455 potential sites

3m³ per person	2346962	2345702	2329288	2289182	2275272	2347952	2347952	2271348	2268804	2267458	2273956	2286630	2303662	2323842	2336056	2345702	2347952
6m³ per person	1173481	1172851	1164644	1144591	1137636	1173976	1173976	1135674	1134402	1133729	1136978	1143315	1151831	1161921	1168028	1172851	1173976
9m³ per person	782320	781900	776429	763060	758424	782650	782650	757116	756268	755819	757985	762210	767887	774614	778685	781900	782650



Conclusions

- Temporal dimension in vertical evacuation
- Morning hours offer more capacity to accept people for vertical evacuation
- High volume availability for vertical evacuation in all tsunami scenarios
- Spatial distribution of potential vertical evacuation sites is good in the 5m and 10m scenarios but poor in the severe 20m and 34m scenarios

Homepage: http://giswin.geo.tsukuba.ac.jp/
Person trips browser and analyzer: http://land.geo.tsukuba.ac.jp/persontrips/

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