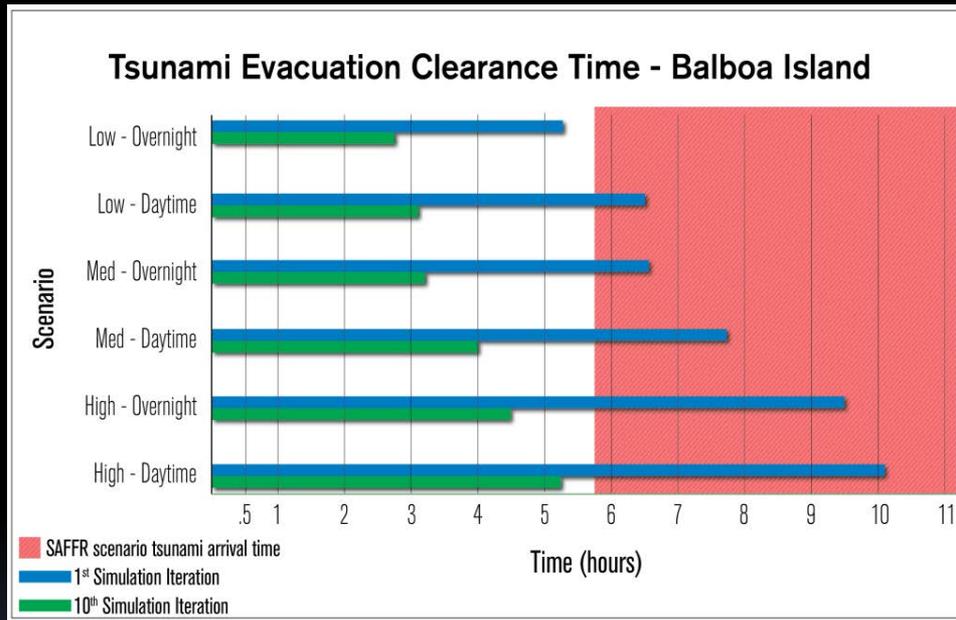


Modeling pedestrian evacuations



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U.S. Geological Survey

Categories of evacuation studies

Agent-based model

- To track individual movement along road network to safe point
- Focus on individuals or cars
- Good for specific scenario and likely congestion



Least-cost-distance model

- To map travel times to safe zone by calculating “costs” due to varying land
- Focus on evacuation landscape
- Good for overall insight, mixed populations, and varied landscape



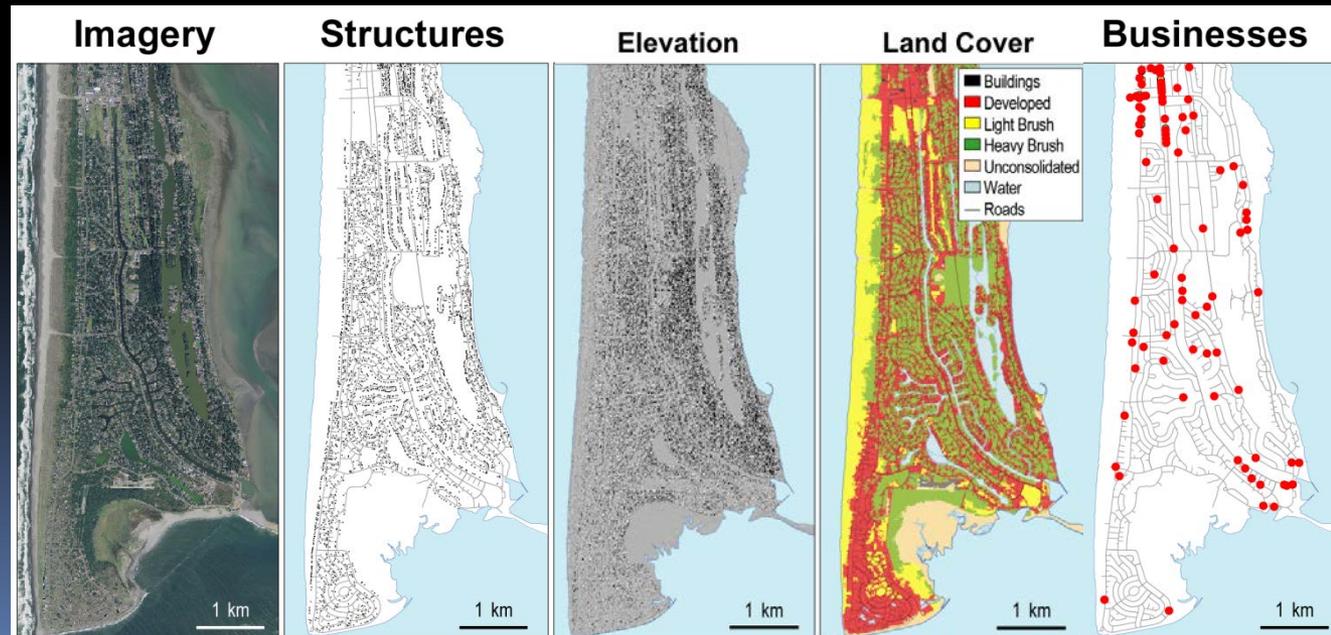
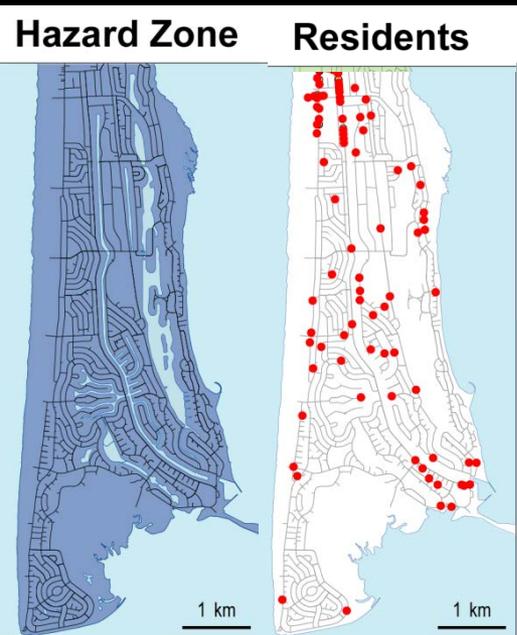
Data input

Agent-based model

- Roads (typically)
- Flat surface area
- Population points (parcels)
- Census block resident/car #
- Agent “behavior”

Least-cost-distance model

- Landscape - roads, landcover, etc.
- Elevation (slope, directionality)
- Population points (parcels, user)
- Census, businesses, user supplied



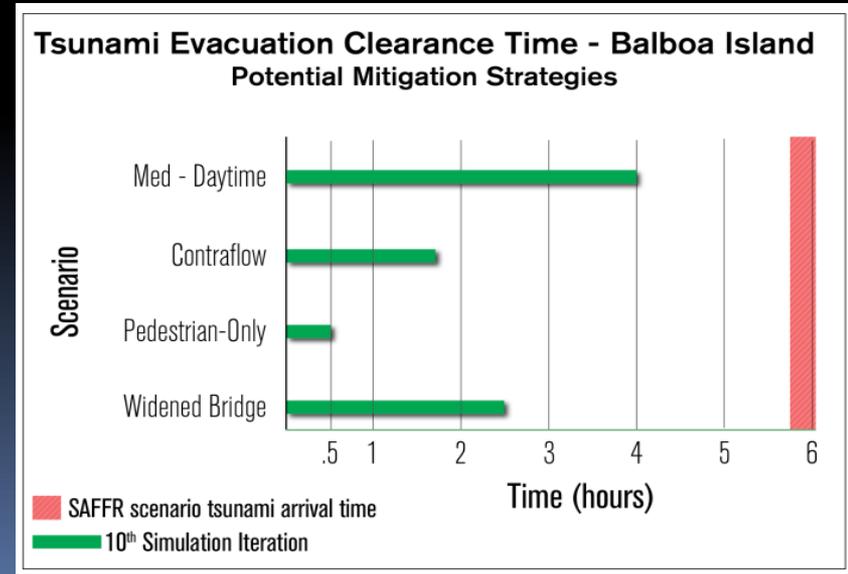
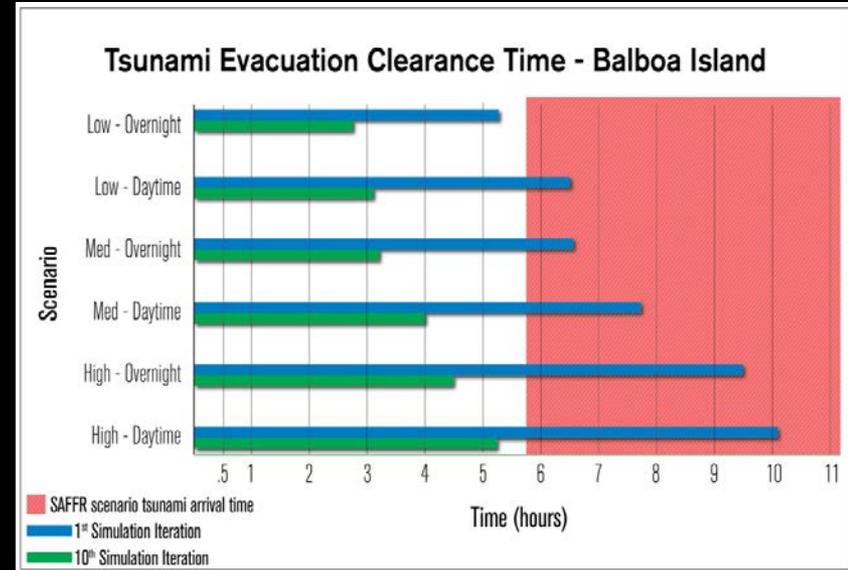
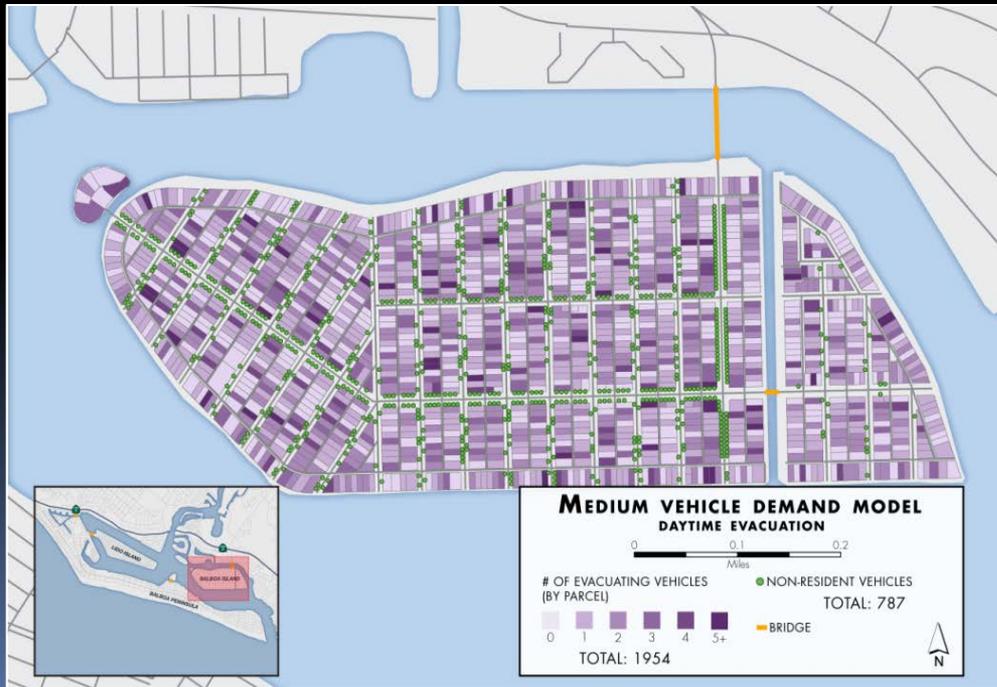
Agent-based modeling

Software platforms

- Many proprietary software
- Open source – e.g., MATSim

Outputs:

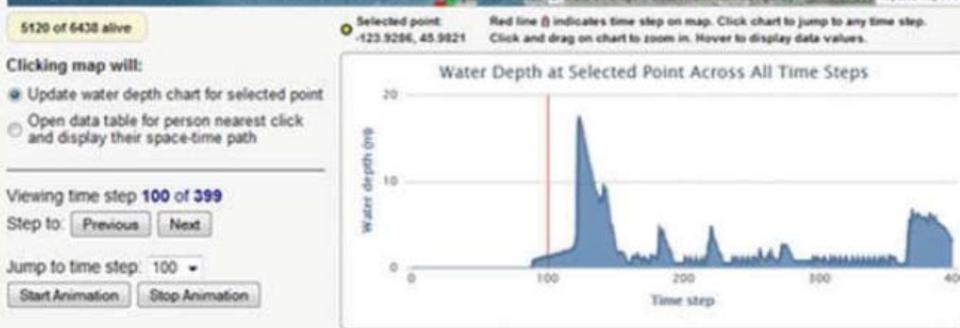
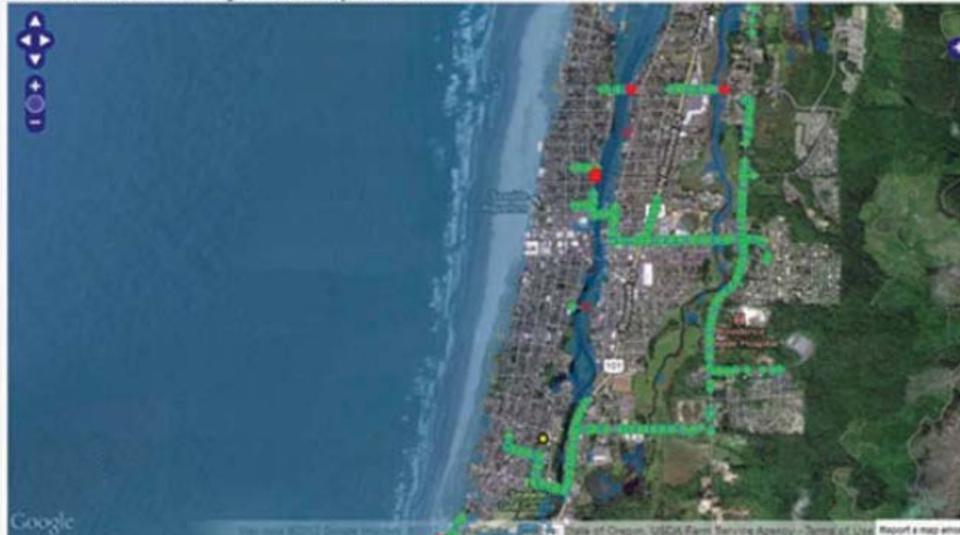
- Mortality estimates for specific scenarios
- Animations of movement
- Time-based snapshots



Agent-based modeling

Tsunami Inundation and Evacuation Simulation

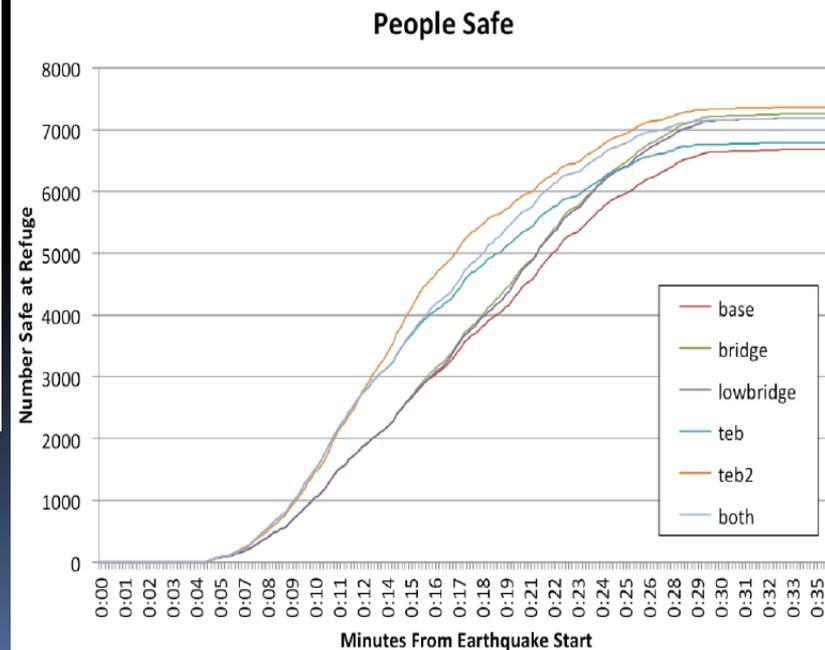
Simulation Results - Dynamic Map and Chart



Keon et al., 2014

Table 1. Summary of simulations (casualties and survivors).

Refuge Sites	1	2	3	4	5	6	7	8	9	TEB	TOTAL
(a) Base Case											
Saved	1015	357	2282	1794	357	549	180	186	9	0	6729
Killed	45	42	150	768	0	30	0	0	21	0	1056 (*)
(b) TEB											
Saved	1015	357	2276	156	357	549	180	186	9	1761	6846
Killed	45	42	150	0	0	30	0	0	21	651	939 (- 11 %)
(c) Bridge											
Saved	1015	936	2282	1794	357	549	180	186	9	0	7308
Killed	45	123	150	108	0	30	0	0	21	0	477 (- 55 %)
(d) TEB + Bridge											
Saved	1015	750	2276	156	357	549	180	186	9	1761	7239
Killed	45	48	150	0	0	30	0	0	21	252	546 (- 48 %)
(e) Low Bridge											
Saved	1015	864	2282	1794	357	549	180	186	9	0	7236
Killed	45	105	150	198	0	30	0	0	21	0	549 (- 48 %)
(f) TEB (Alt.)											
Saved	1015	357	2282	663	357	549	180	186	9	1818	7416
Killed	45	42	150	3	0	30	0	0	21	78	369 (- 65 %)



Cannon Beach Evacuation simulator, Karon and Yeh, 2011

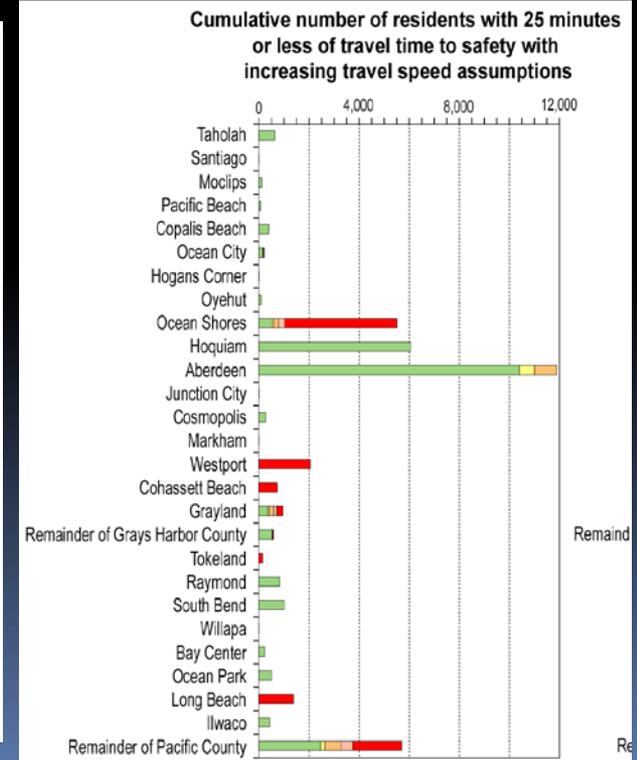
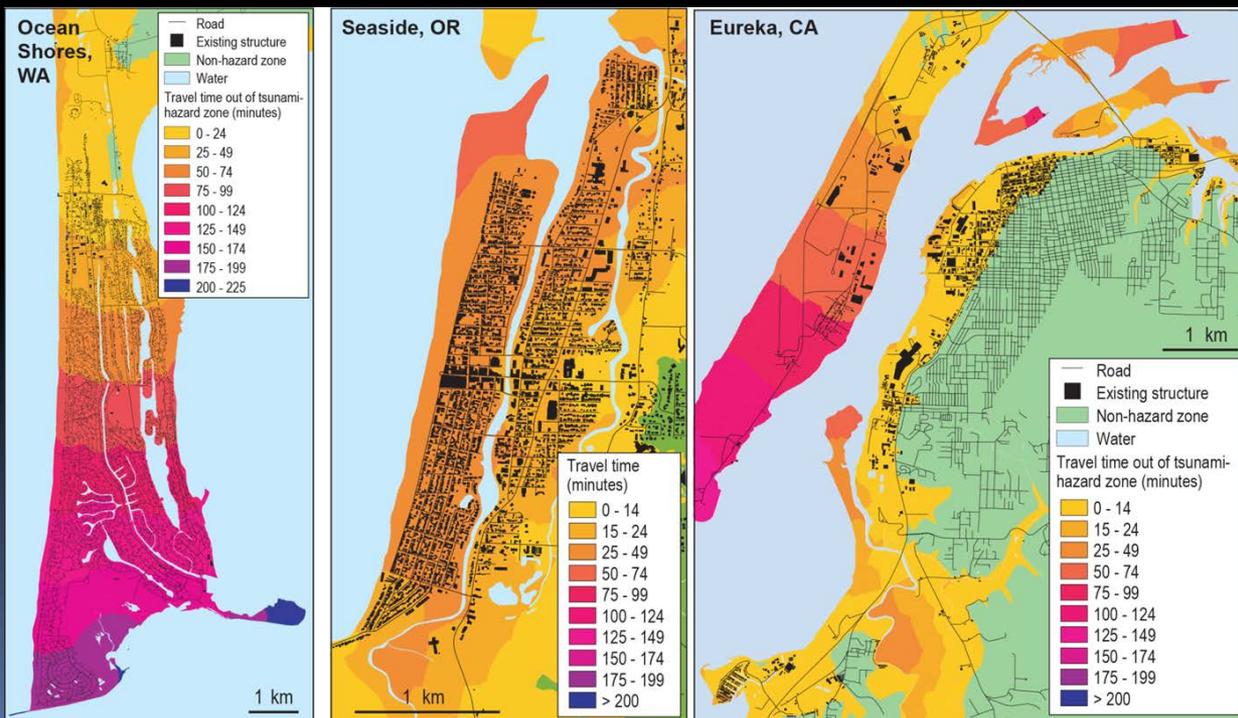
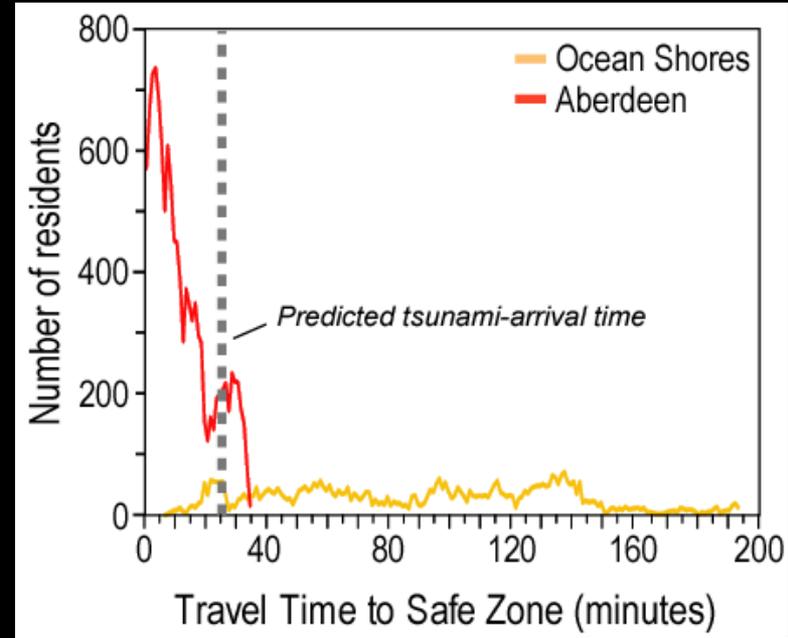
Least-cost-distance modeling

Software platforms

- GIS – e.g., ArcMap
- USGS Evacuation Analyst – built on ArcMap

Outputs:

- Maps of travel time
- Exposure numbers and profiles as a function of travel time





Pedestrian Evacuation Analyst

The Pedestrian Evacuation Analyst—Geographic Information Systems Software for Modeling Hazard Evacuation Potential

Chapter 9 of Section C, Geographic Information Systems Tools and Applications
Book 11, Collection and Delineation of Spatial Data

DOWNLOAD
TOOL

DOWNLOAD
USER'S GUIDE

Pedestrian Evacuation Analyst Workflow

1 Create a portfolio for the study area

2 Preprocess input data

Digital elevation model
Land use/land cover
Hazard zone
Safe zone

3 Create evacuation surfaces and maps

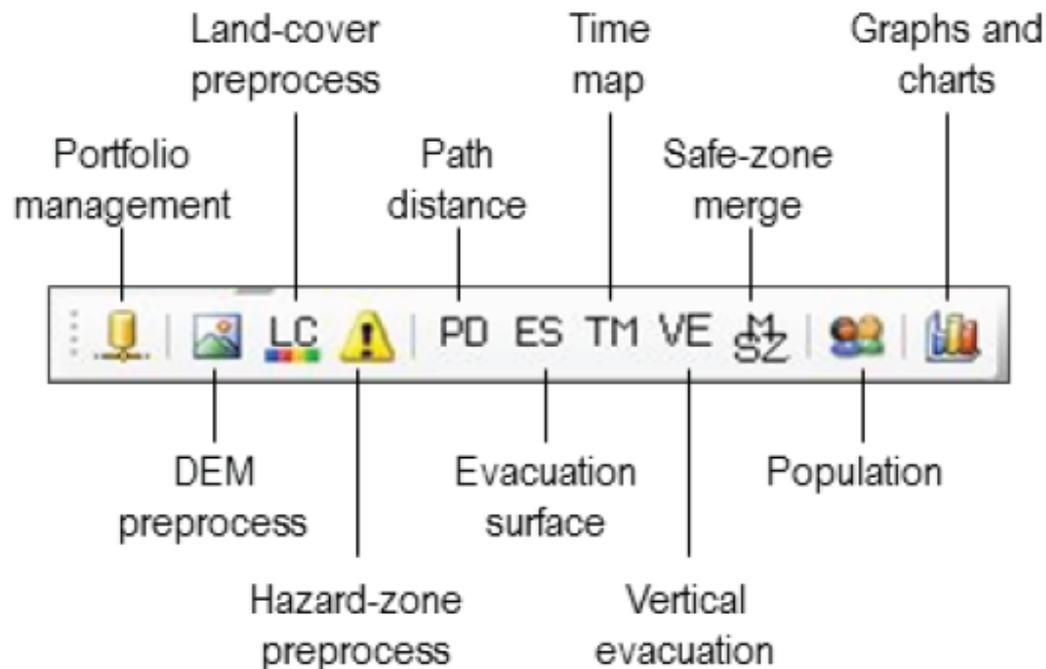
Calculate path distance
Create evacuation surface
Determine maximum time value
Create time map

4 Model potential vertical-evacuation sites

Process vertical evacuation sites
Merge safe zones

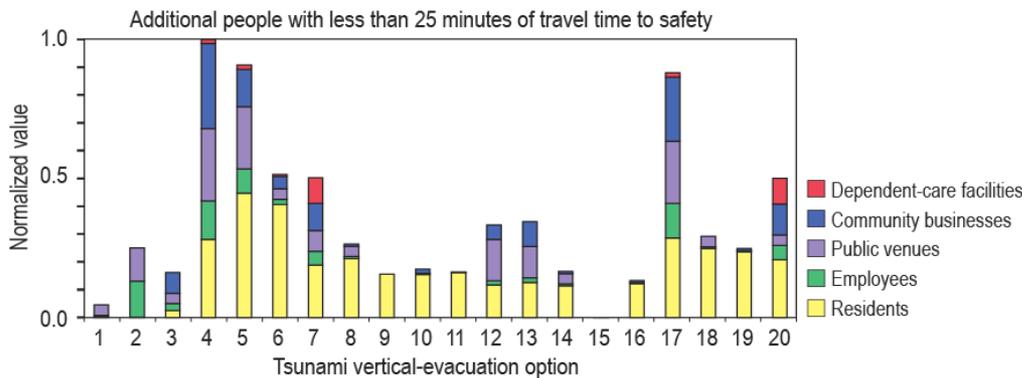
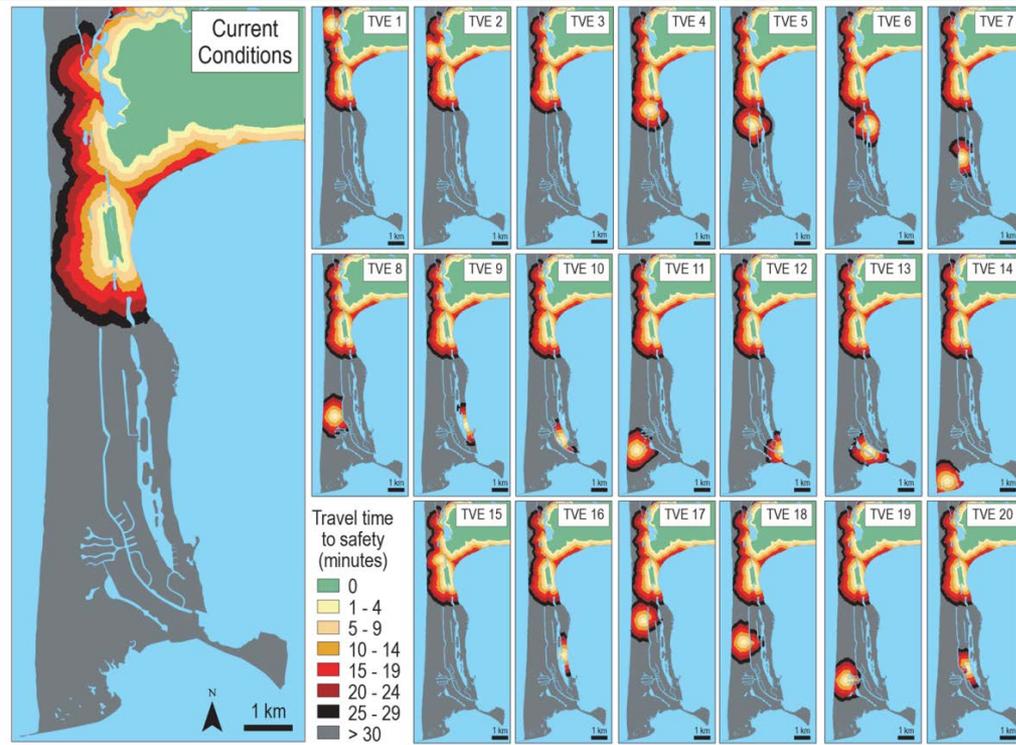
5 Incorporate population data

6 Develop charts and graphs

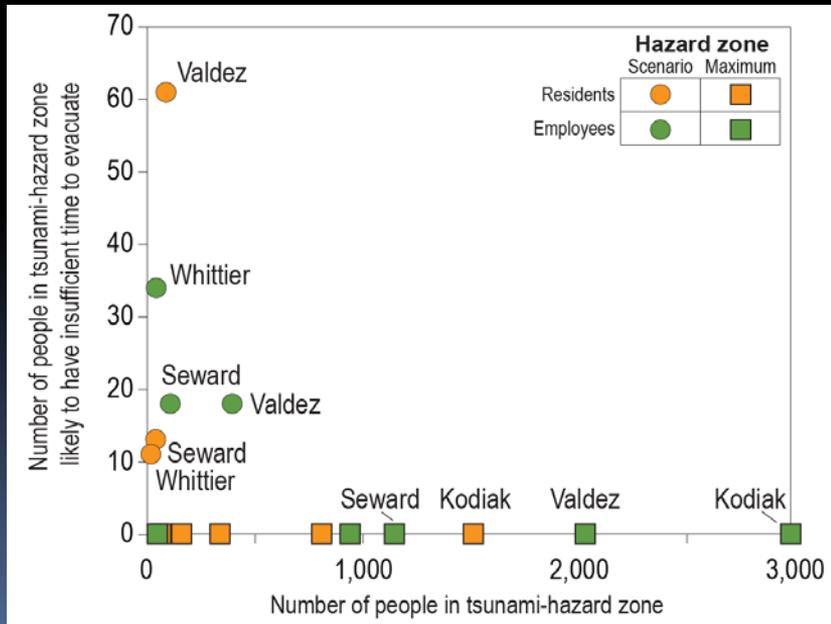
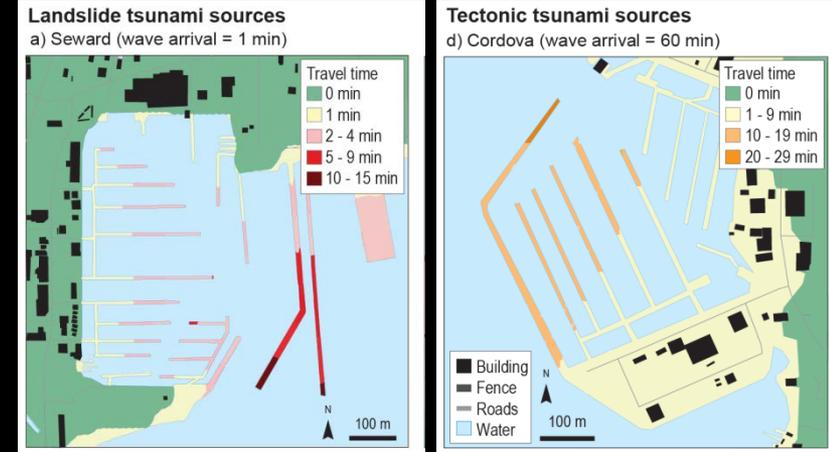


Least-cost-distance modeling

Implications of vertical-evacuating siting



Modeling for areas with variable hazards



Comparison of approaches

Both approaches are useful for evacuation modeling but in different ways

Agent-based

- Population #'s & sites well constrained
- Focus on population movement
- Focus on specific scenario
- Loss estimation and clearance times
- Decision support for scenario

LCD-based

- Desire for flexibility in population
- Focus on evacuation landscapes
- Focus on worst case @ site
- Maps and graphs
- Outreach product for public

Use of tools for emergency management

	Agent-based	LCD-based
• Ease of use	✗	✓
• Assess population composition/distribution	✓	✓
• Attention for vulnerable populations	✓	✗
• Scenario-specific loss estimation	✓	✗
• Establishment of evacuation routes, assembly areas, evacuation areas	✗	✓
• Incorporation into emergency response plans and better planning	✓	✓
• Dissemination of information and better response by the public	✗	✓