GIS methodologies for local tsunami risk assessment: examples

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CONCERT-Japan Resilience Against Disasters

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NGI

ICG International Centre for Geohazards

EARTH SCIENCE & GEOGRAPHY Vassar College

Background and motivation

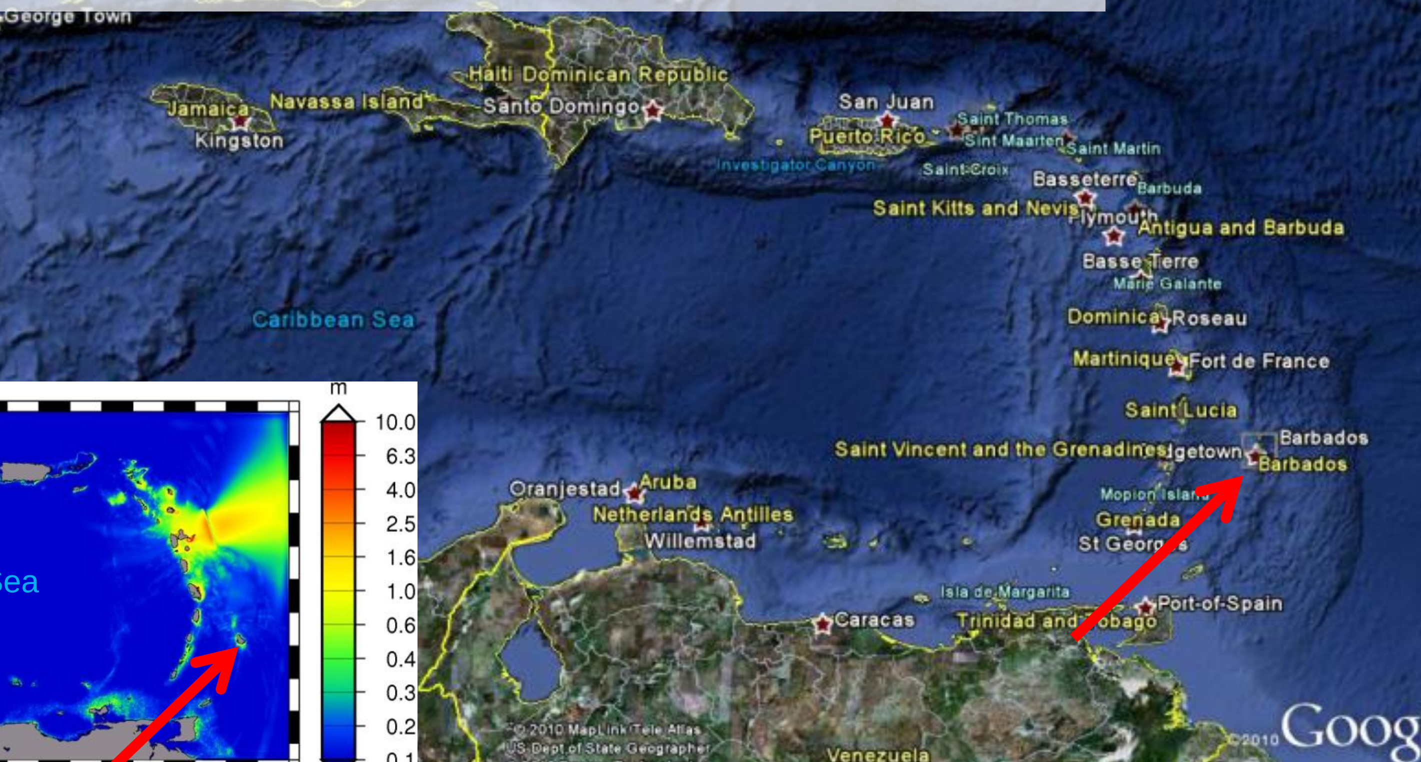
Three tsunami vulnerability and risk analyses performed. GIS model being adapted to the available information.

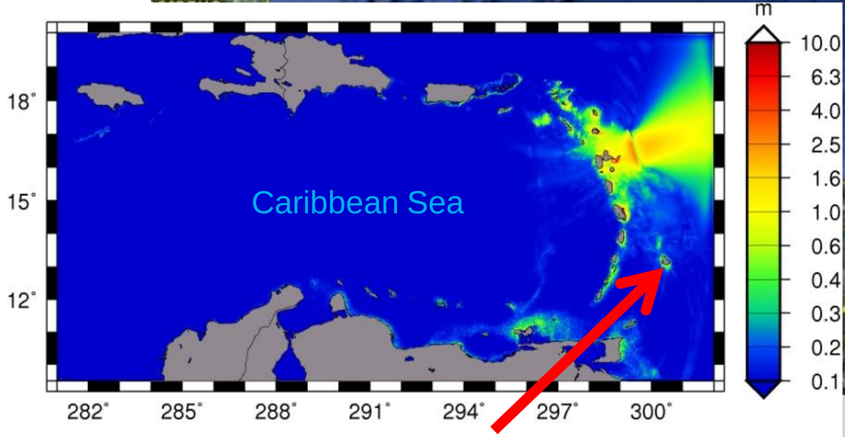
1. **Bridgetown, Barbados**: possible future tsunami scenario, *much information available*
   - Topography, population from local partners
   - Field survey for building use and vulnerability
2. **Batangas, The Philippines**: possible future scenario, *little information available*
   - Internet and other sources of information
3. **American Samoa**: *hindcast* of 2009 South Pacific tsunami *for validation* of the tsunami vulnerability and risk model

Methodology Bridgetown, Barbados

Intentions:

- Develop methodology
- Demonstration study for local partners in a UWI/NGI capacity building programme





Tsunami risk assessment

GENERAL

Risk = Hazard * Consequence

Hazard = maximum tsunami flow depth related to a certain probability of occurrence

Consequence described by exposure and mortality

SITE DEPENDENT

Exposure; density of population

Mortality; function of flow depth and building vulnerability

→ 4 factors describing the buildings:

height – material – barrier – use

Structural building vulnerability

- Total structural building vulnerability was assessed using field survey data and their spatial extrapolation to bigger units

Height code	Height Vulnerability	Description
1	4	Only one floor
2	2	2 floors
3	1	3 or more floors

Material code	Material Vulnerability	Description
1	2	Stone
2	4	Wood or timber
3	3	Wood + concrete
4	1	Concrete
5	2	Metal
6	[illegible]	stone and wood
7		
8		

Use code	Use Vulnerability	Description
1	1	Residential/community service
2	3	Business/Commercial
3	4	Tourism
4	10	Government Services (Health, Education, Fisheries, transportation etc)
5	10	Emergency Services (Police, Fire, Coast Guard, EMS, medical etc)
6	5	Community facilities (e.g. churches, community centers, recreational areas)
	10	Utilities (water, electricity, sewage, telecommunications, fuel, gas stations)
	2	Heritage Sites
	5	Banking and finance
	0	Abandoned

Barrier code	Barrier Vulnerability	Description
1	4	No barrier
2	3	Low/narrow earth embankment
3	2	Low concrete wall
4	1	High concrete wall
5	2	Low stone wall
6	1	High stone wall

Credit: Nadia Gour, UWI

Total predicted mortality

Convert all building vulnerability scores to [0,1]

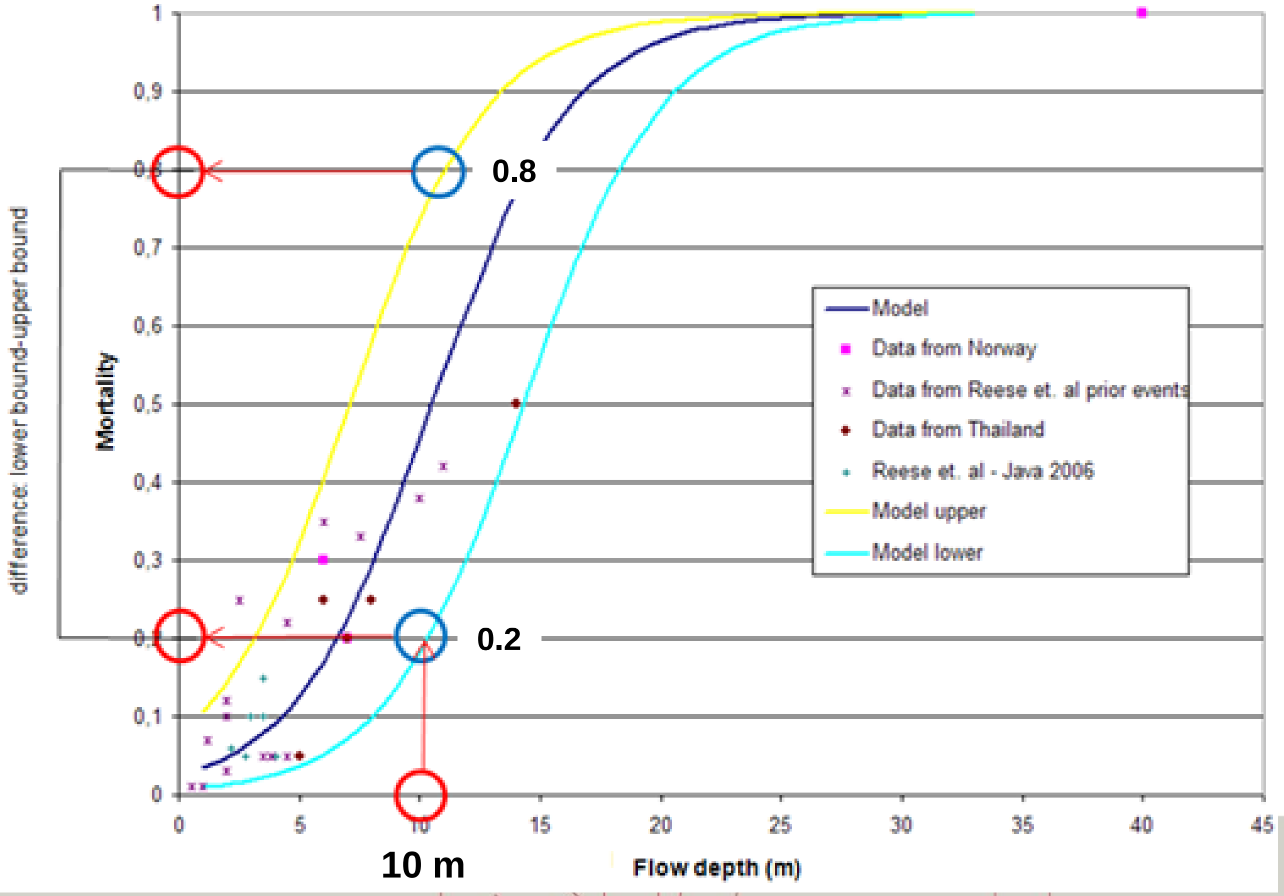
Use vulnerability score to pick the ”correct” S-curve.

Example:
10 m flow depth-
S-curve returns M∈[0.2,0.8]

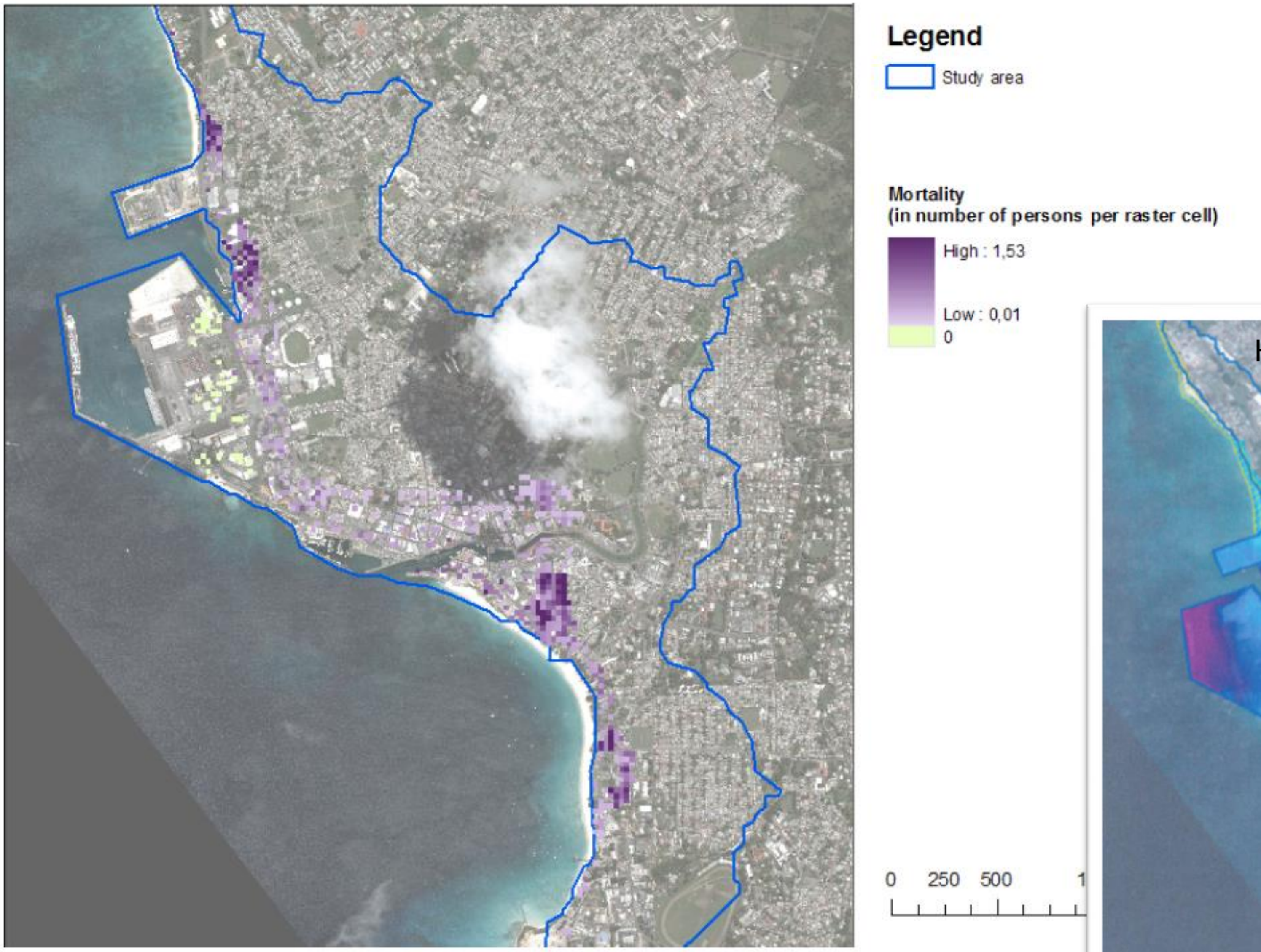
Norm. build. vuln. score = 0.4

Mortality =
0.2 + 0.4 x (0.8-0.2) = 0.44

Number of deaths =
0.44 x (population in cell)



Local mortality risk – Bridgetown, Barbados



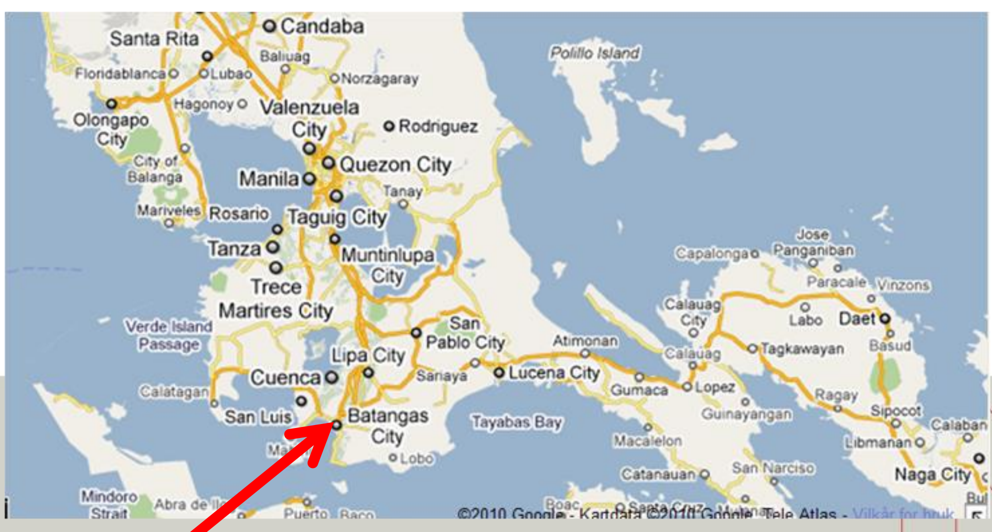
Methodology Batangas City, The Philippines

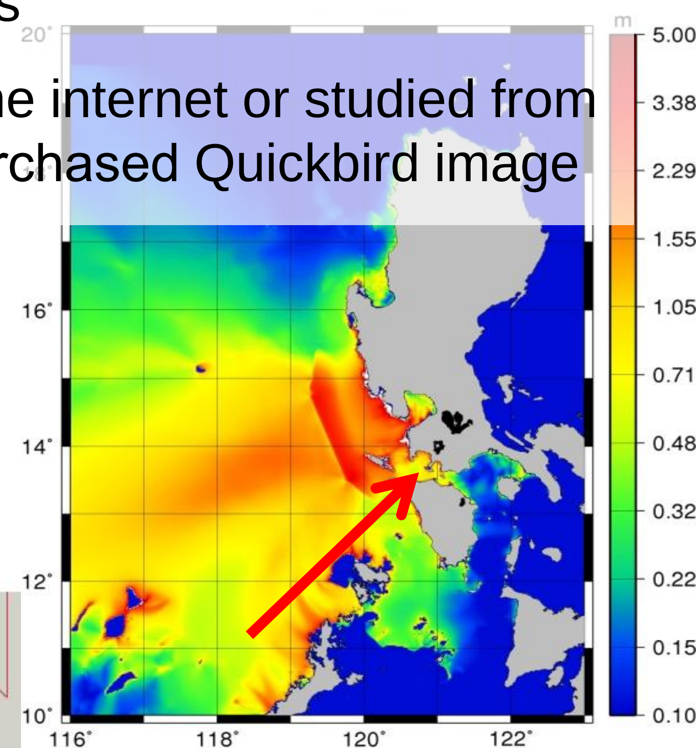
Intentions:

- Apply “Bridgetown” methodology in different study area
- Local demonstration project

Challenge:

- Limited amount of data from local partners
- Therefore, everything was searched on the internet or studied from “the sky”, i.e. from google maps and a purchased Quickbird image





Structural building vulnerability

- Total structural building vulnerability was assessed using publicly available photographic imagery available on GE

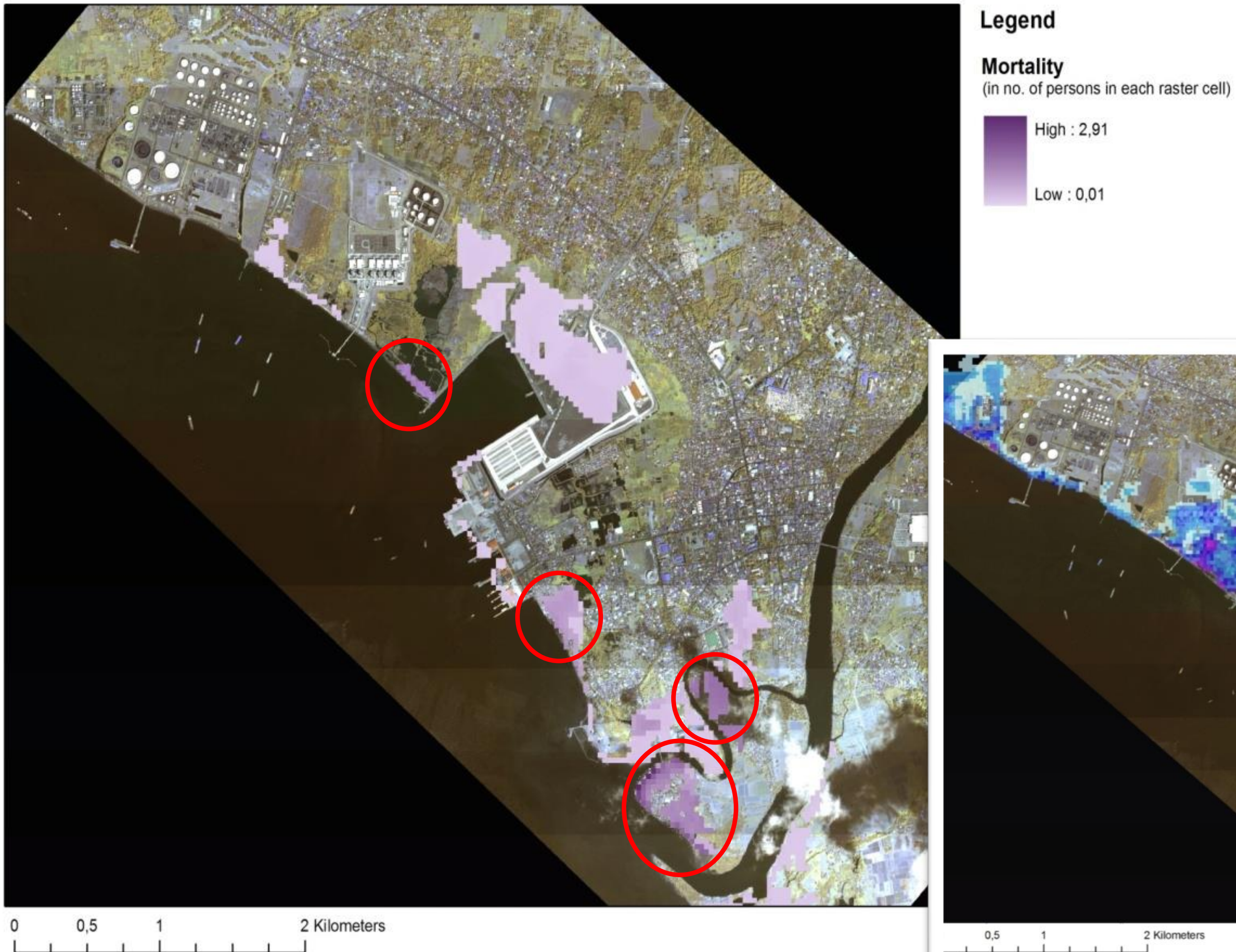
ID	Assigned Vulnerability	Description
1	0,25	concrete-stone, several floors
2	0,5	concrete-stone-wood, one or two floors
3	0,75	stone-wood, one or two floors
4	1	wood-corrugated iron, one floor
5	0,25	Large industrial plants

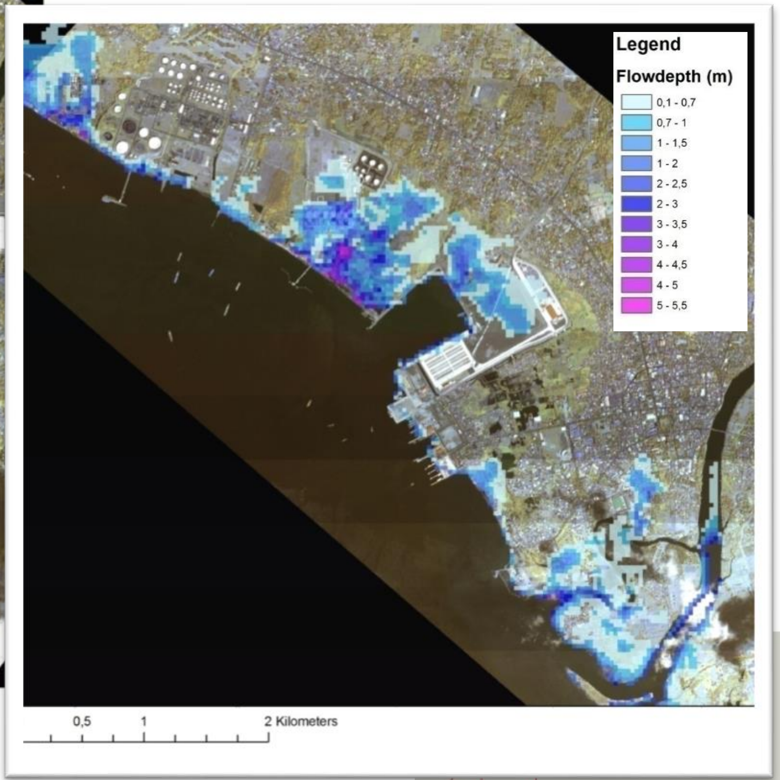





Image credit: GoogleEarth, users: batangas, Romeo E. Barcena, samuel006, Teban

Local mortality risk – Batangas

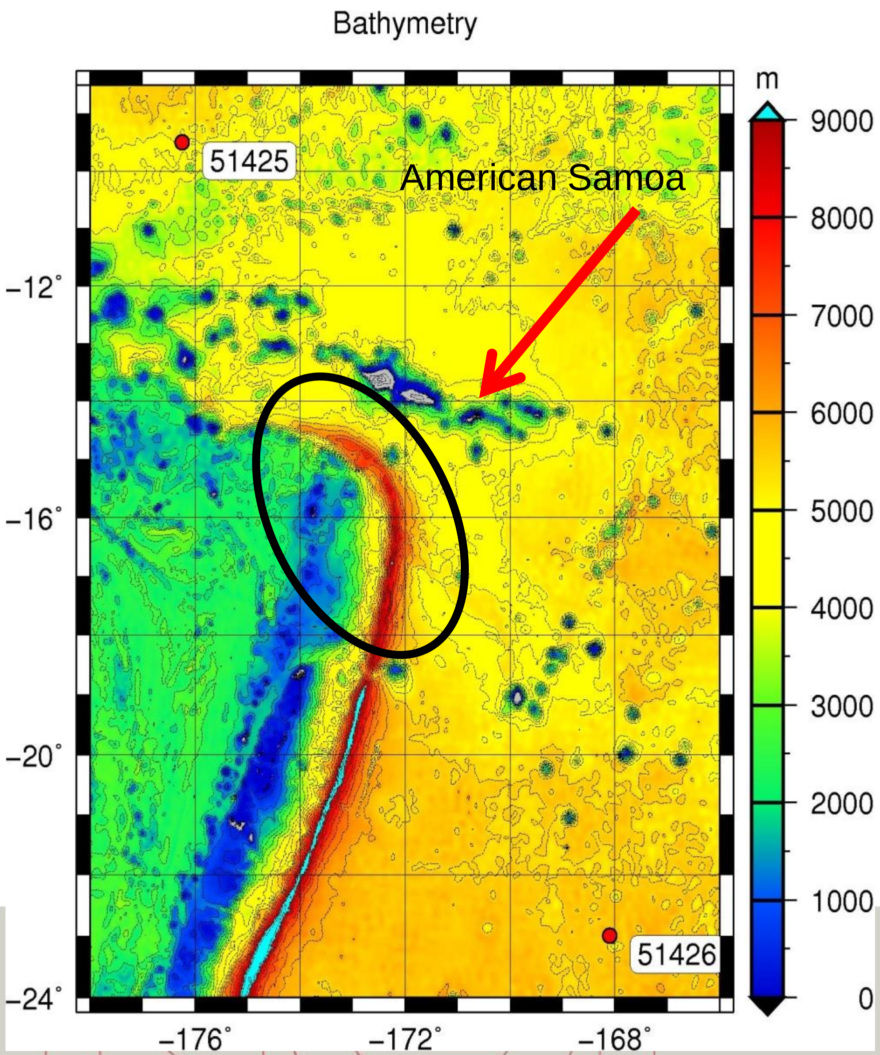




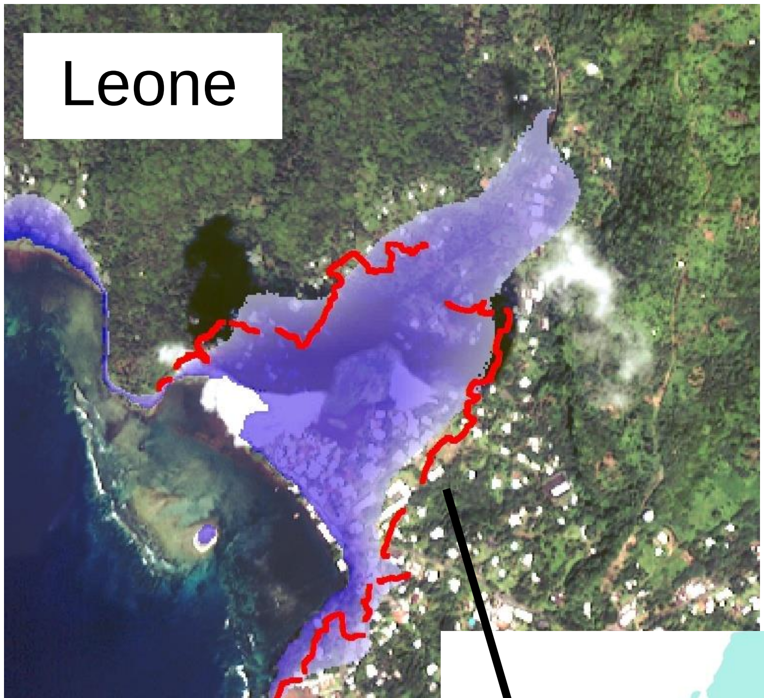
Hindcast of 2009 South Pacific tsunami for American Samoa

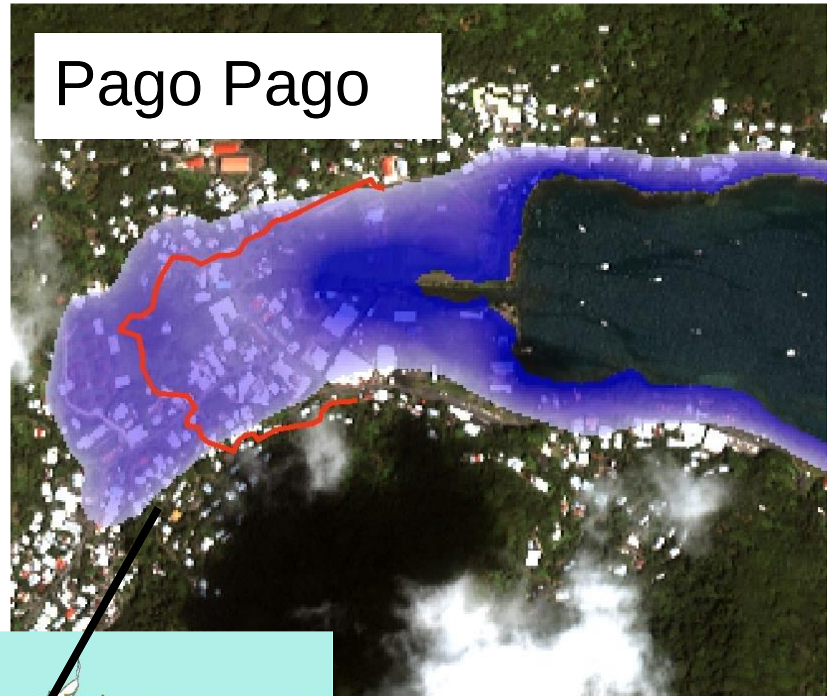
Intentions:

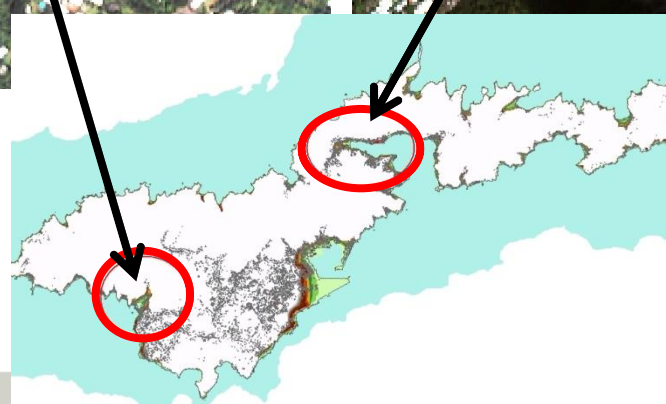
- Validating the GIS model approach for building vulnerability and mortality
- Maximum flow depth was obtained by back calculating the 2009 South Pacific earthquake and tsunami,
- A lot of data on population, building types, infrastructure, inundation, flow depth, damages, and death tolls
- The GIS model was adapted for optimal use of the available data



Comparison to trimlines (“v7”)







Buildings and infrastructure not included in the simulations (may reduce the run-up)

Concluding remarks

- Method for quantitative tsunami risk assessment developed
- Flexibility with regard to amount and type of data at hand
- Two assessments + 1 validation successfully performed
- Potential for further development (distribution of people night/day, indoors/streets/public areas, importance of TEWS…)

First deliverable to Rapsodi

Publication in peer-reviewed journal about the three studies in Bridgetown, Batangas and Samoa, comparison of similarities and differences (WP1, D.1)

Further work within Rapsodi

Apply modified tsunami risk assessment for 2011 Tohoku event (WP4, D.8)

- Collaboration with PARI necessary
- Data, location, focus?

Quantitative tsunami risk assessment

Our suggestion:

- to use extended tsunami risk model used at NGI
- extension could include:
  - Specification of people exposure according to different scenarios
  - Inclusion of economical values of private building and companies
  - Accounting for environmental impacts and socio-economical interrelations (e.g. loss of ecosystem services)
  - Inclusion of risk to lifelines (such as railway networks or social facilities)

General data interests

- High resolution (better than SRTM) digital elevation model
- Alternatively, digital contour line maps
- Census data aggregated by geographical units (enumeration districts, city quarters, etc.), the smaller the aggregation units, the better
- Data on structural building vulnerability (material, height, barriers)

General data interests

- Information on:
  - Location of shelters
  - Location of mitigation measures (evacuation plans and routes, safe elevated areas, barriers, etc.)
  - Age of population (distribution)
  - Differences in seasonal (residents?, seasonal workers?, tourism?) and/or night and day use of specific buildings, traffic routes, etc. -> Scenario-based distribution of people

Specific data interests (depending on final focus)

Ecological focus:

- Land use/land cover map
- Value of ecosystems – services/functions
- Location of industrial sites with potential for harm

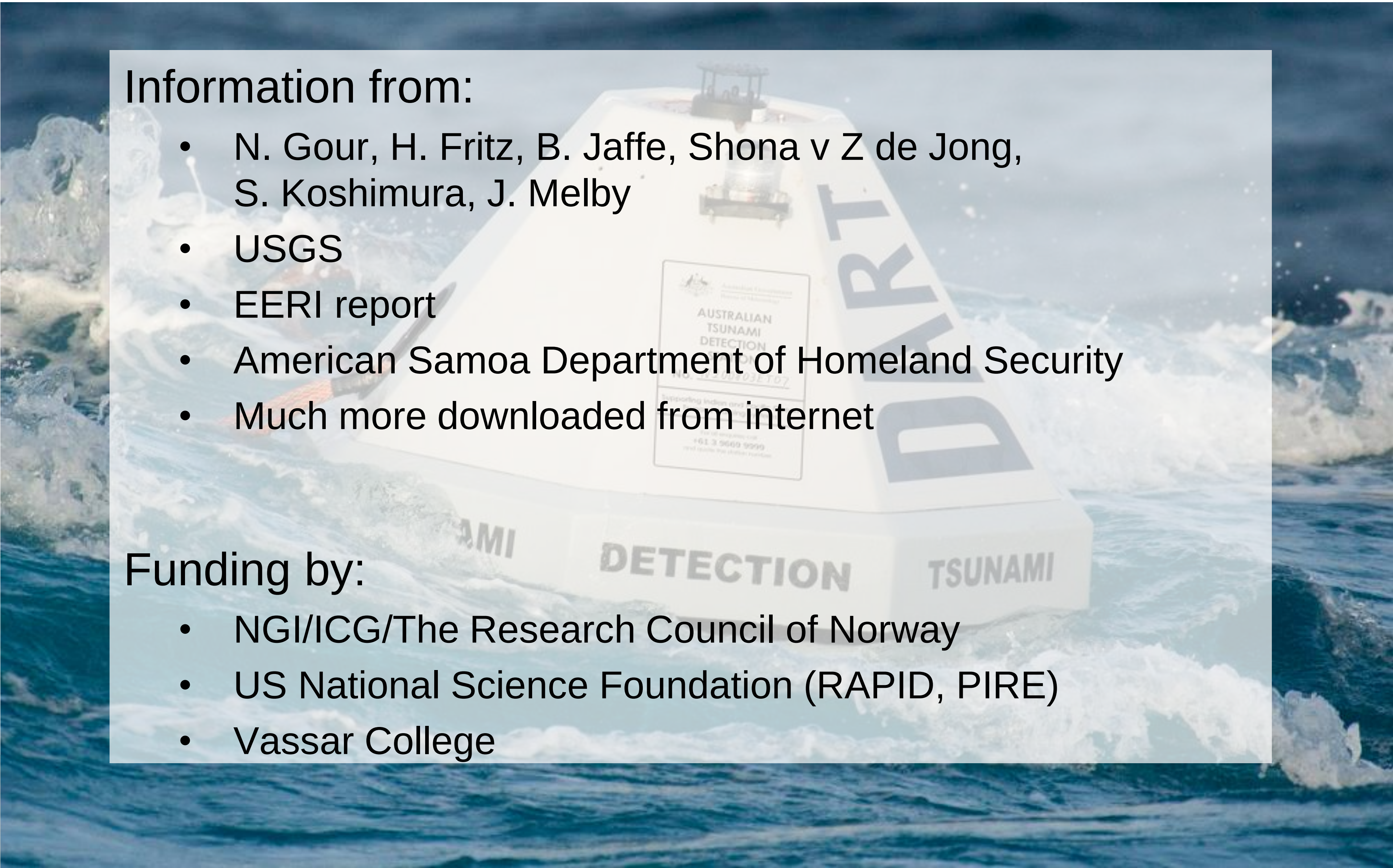
Economical focus:

- Property values (from statistics, GDP, number of employees, etc.)

Critical infrastructure focus:

- Location of critical infrastructure, shelters, lifelines, …

Thank you for your attention!



Information from:

- N. Gour, H. Fritz, B. Jaffe, Shona v Z de Jong, S. Koshimura, J. Melby
- USGS
- EERI report
- American Samoa Department of Homeland Security
- Much more downloaded from internet

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