FRANZIUS-INSTITUT
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Leibniz
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Inundation modeling based on hypothetical tsunami scenarios for the city of Padang, West Sumatra within "Last-mile - Evacuation"

ANUGA - Present Applications and Future Potential
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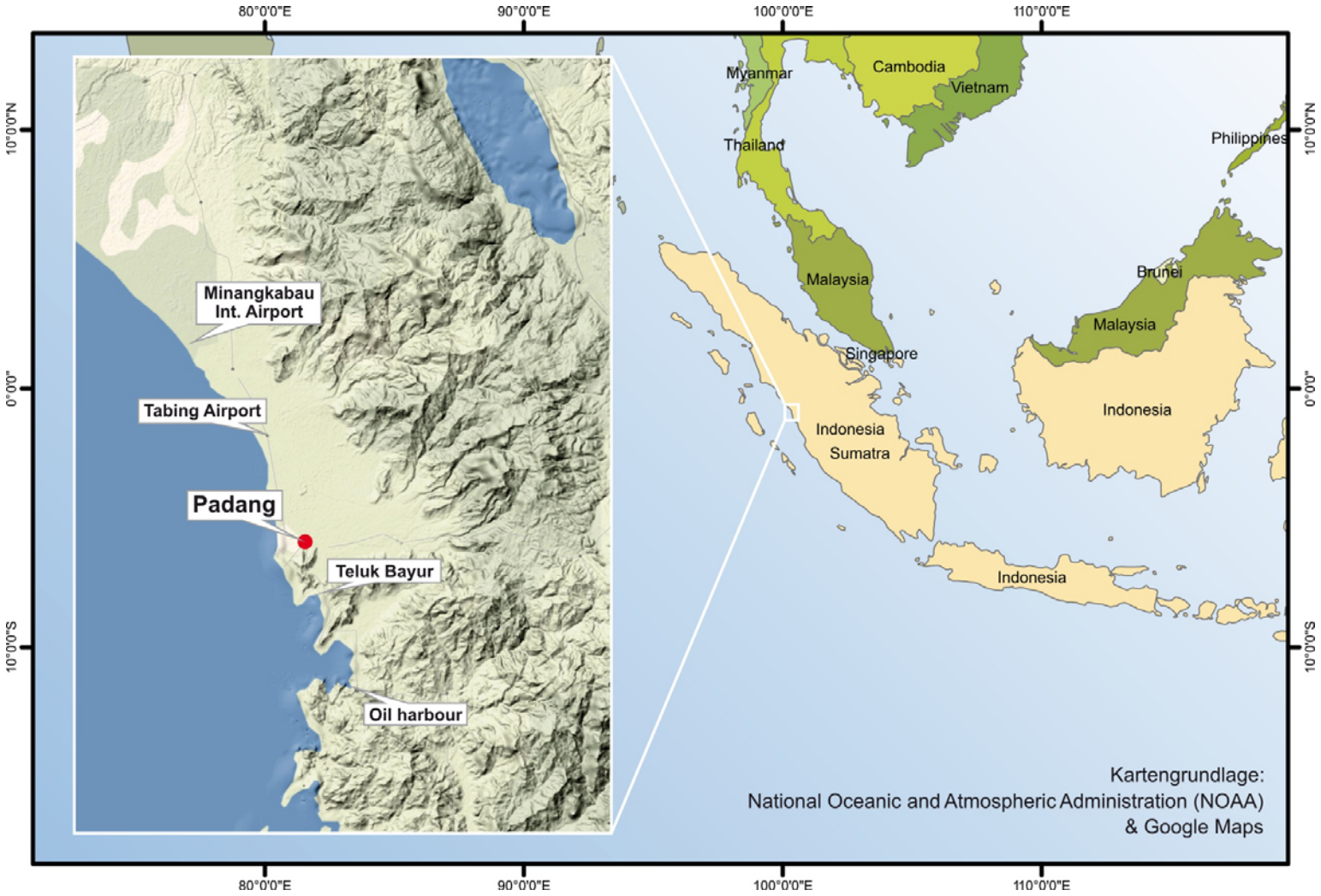
LAST-MILE - EVACUATION

Outline

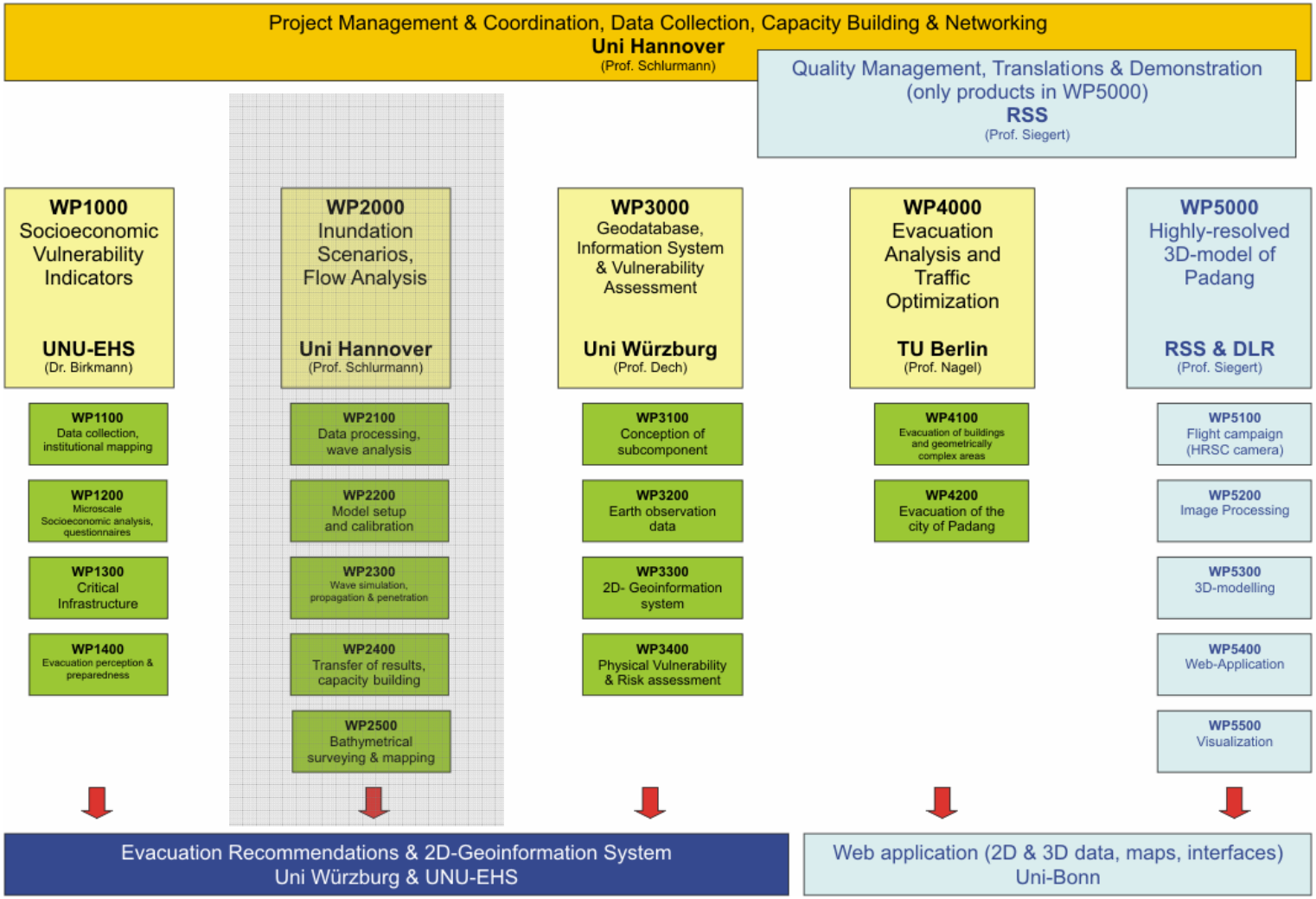
- Introduction and overview of joint project „Last-mile – Evacuation“
- Spatial database and finished surveys
- Methodology
- Inundation scenarios and hazard maps, evacuation planning
- Experiences and prospective development
- Discussion and outlook

Location of interest



Stahlmann, 2007

“Last-mile - Evacuation” – short summary



Characteristics for Padang region

- Motivation for scientific tsunami research and joint efforts
  - Current dormant period for western Sumatra section in order of recurrence interval
  - Topography partly beneath mean sea level
  - Drained by various channels and rivers
- Research effort must definitely lead to improvement in evacuation procedure
  - Level of detail
  - Credible information about safe/unsafe regions, degree of protection

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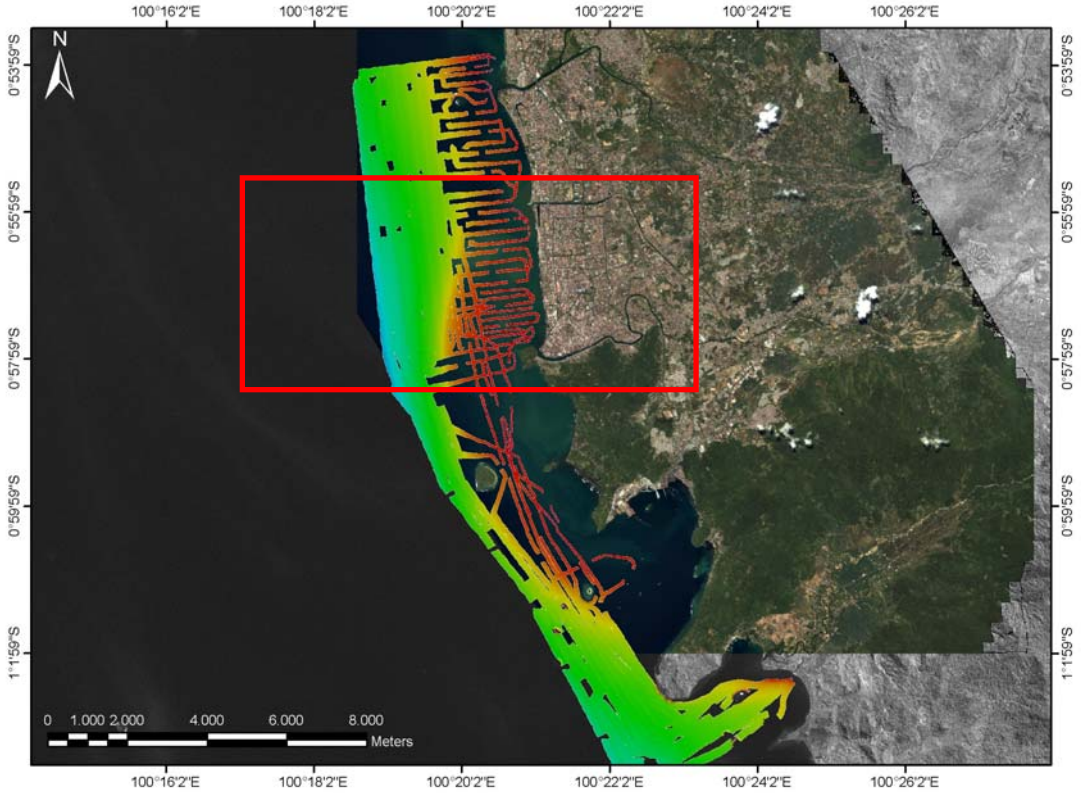
Spatial database

- Bathymetry
  - Digitized nautical and local charts on the basis of echo soundings
  - Constructional drawings „Padang Area Flood Control Project“
  - GEBCO (1-min-grid)
  - Multibeam echo soundings, 2007, Franzius-Institute
- Topography, satellite images
  - Shuttle Radar Topography Mission (SRTM), 2000
  - DGPS measurements in Padang, 2007, Franzius-Institute
  - Ikonos and Landsat7 images
  - Datasets from flight campaign with HRSC-camera, 2008, RSS GmbH

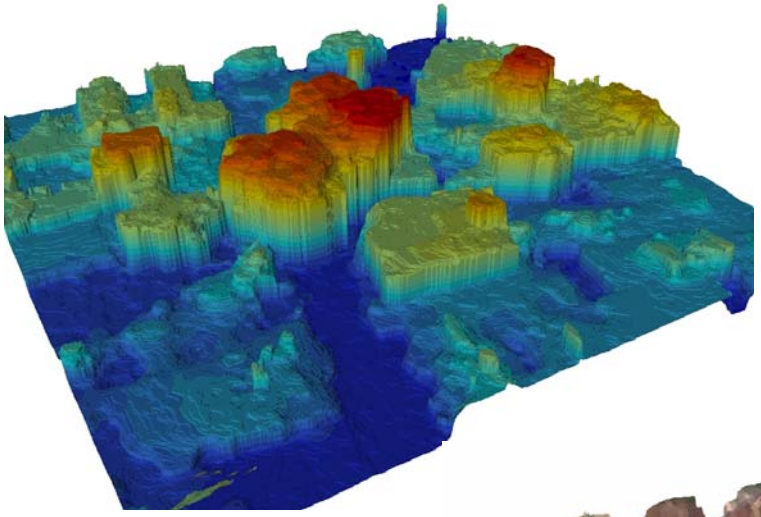
Coverage plot hydrographical measurements Aug. and Nov. 2007

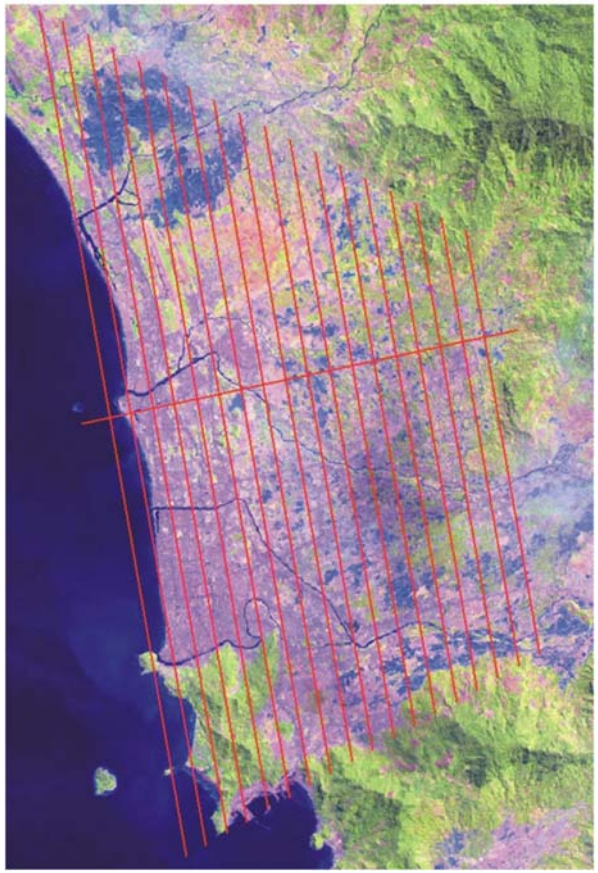
- Shallow water depths for 42 km² on a 3m-grid available



Flight campaign in Padang (RSS GmbH + DLR)

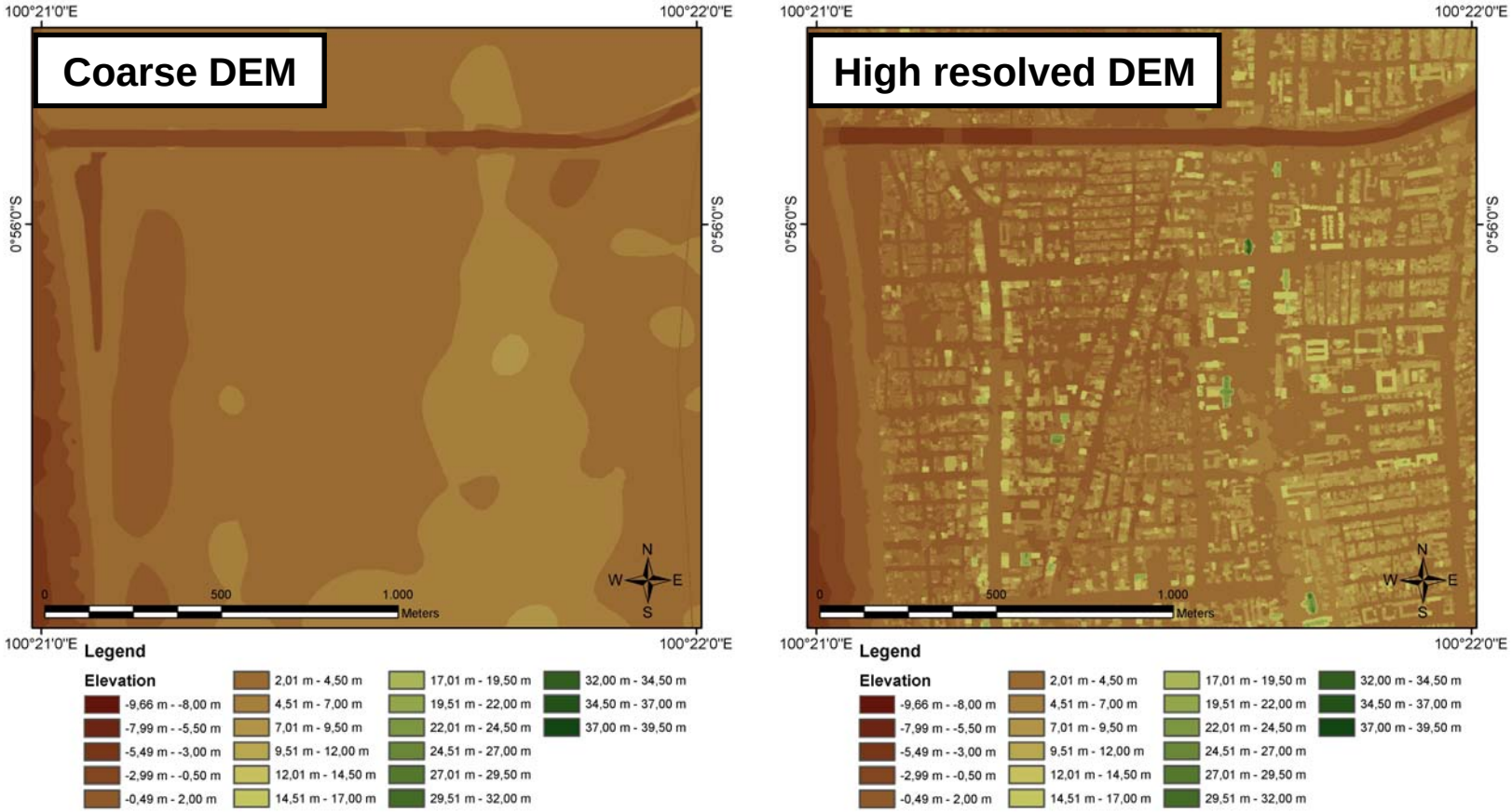
- 3D-clipping of DSM (vegetation influence) and coverage plot





Purpose and underlying datasets

- Run-up and inundation scenarios based on DEM with different accuracy and resolution for recommendations on evacuation routes



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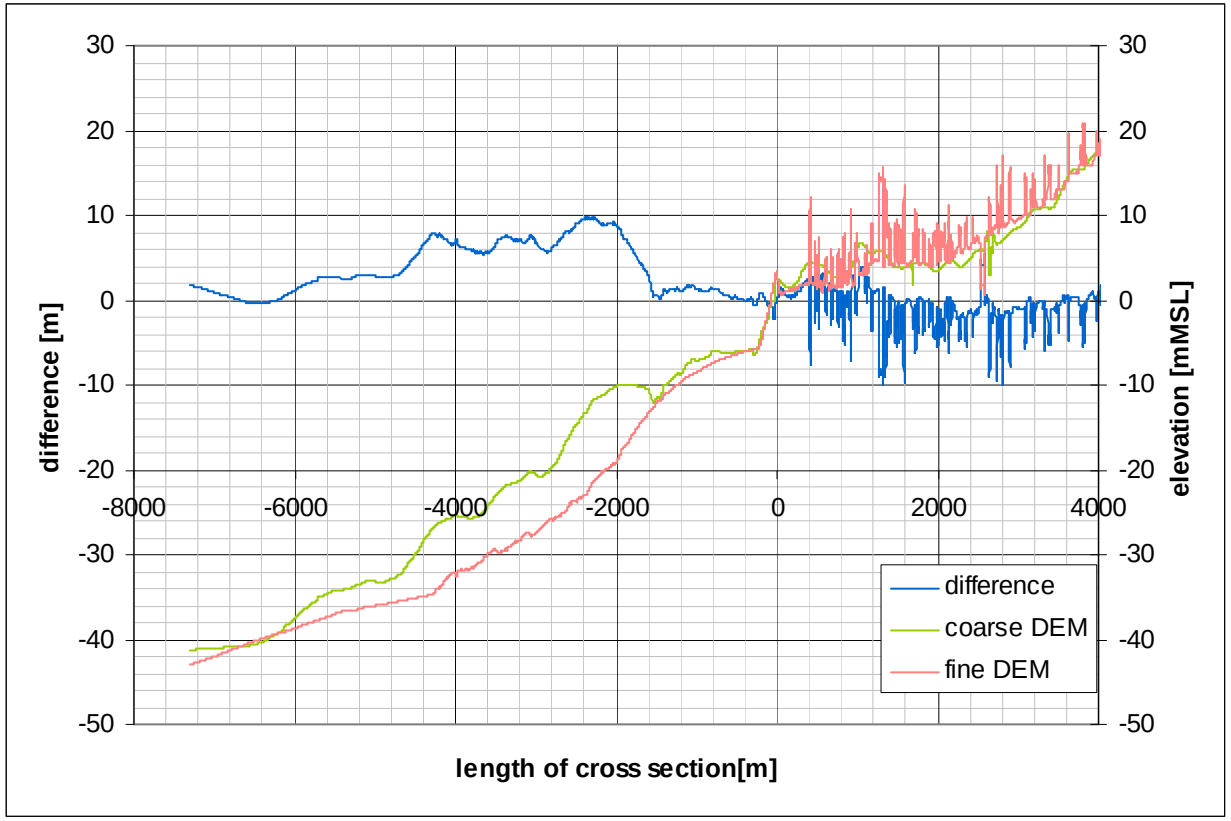

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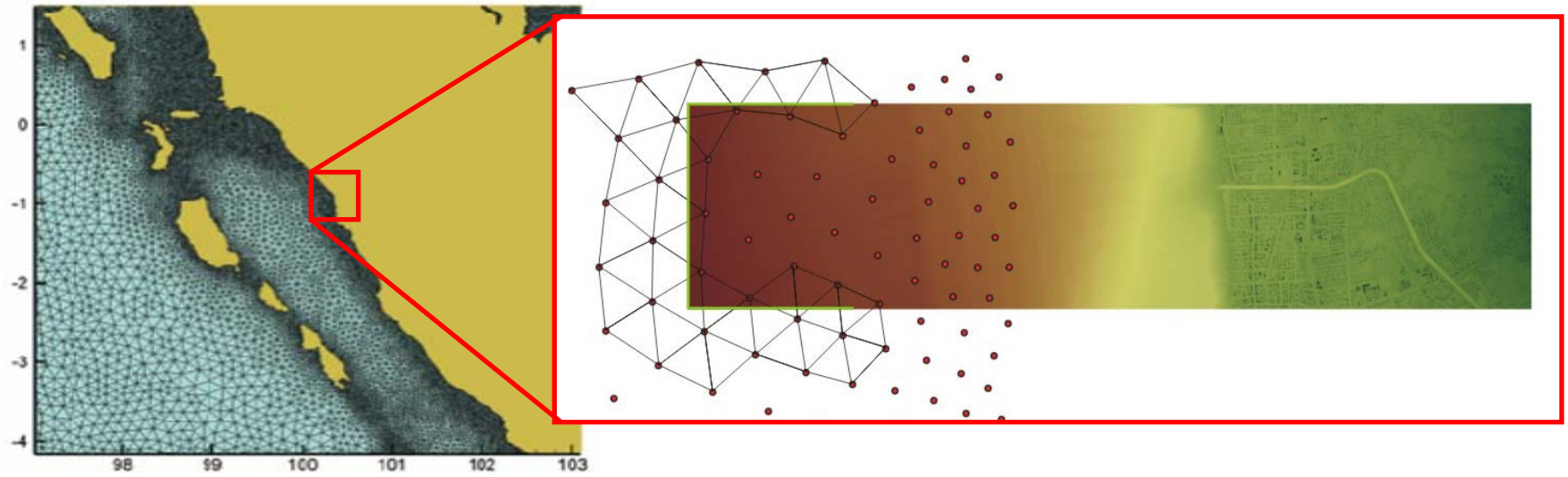
Numerical models using ANUGA 1.0beta_4824 and 1.0beta_5638

- Using two different geometries – a coarse and a high resolved DEM
- Area of interest: ~12.5 x 4.5 km
- 400.000 – 600.000 cells, area in range of 15 to 1250 m²
- Manning's roughness: 10 to 40 $m^{1/3}/s$
- Source generation and wave propagation → TsunAwi
- Boundary conditions:
  - Combination of File_boundary and Transmissive_momentum_set_stage_boundary for introducing wave height
  - Dirichlet_boundary wetting/drying region
  - Transmissive_boundary/Reflective boundary elsewhere
- Models with and without masking houses
- Future: extent the model to account for bay effects

Coupling ANUGA with TsunAWI

- TsunAWI
  - Nonlinear shallow water wave equation, source generation
  - Finite-element method on an unstructured mesh
  - Wetting and drying, time stepping with filtered leap-frog scheme
- Coupling ANUGA and TsunAWI – two step hybrid approach



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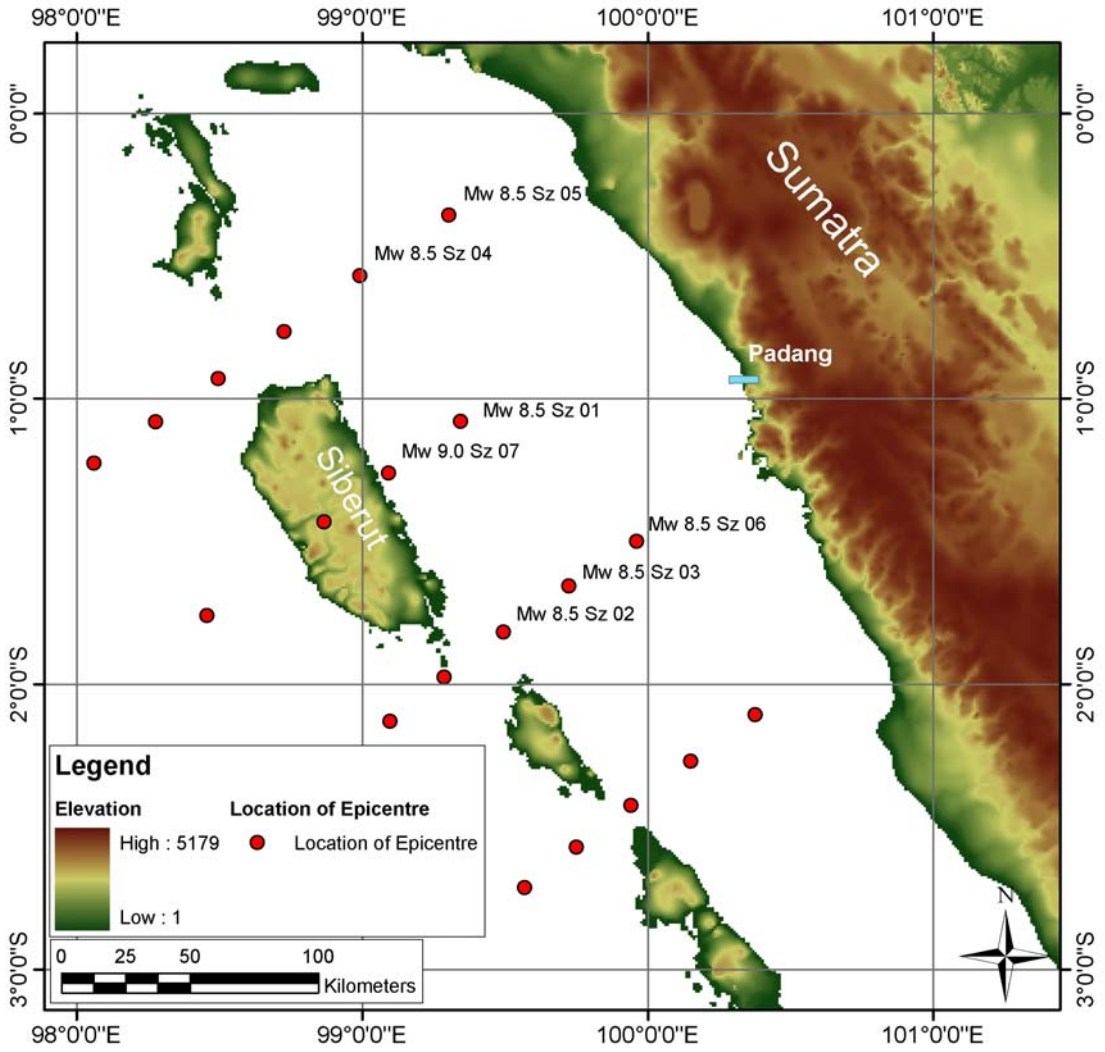
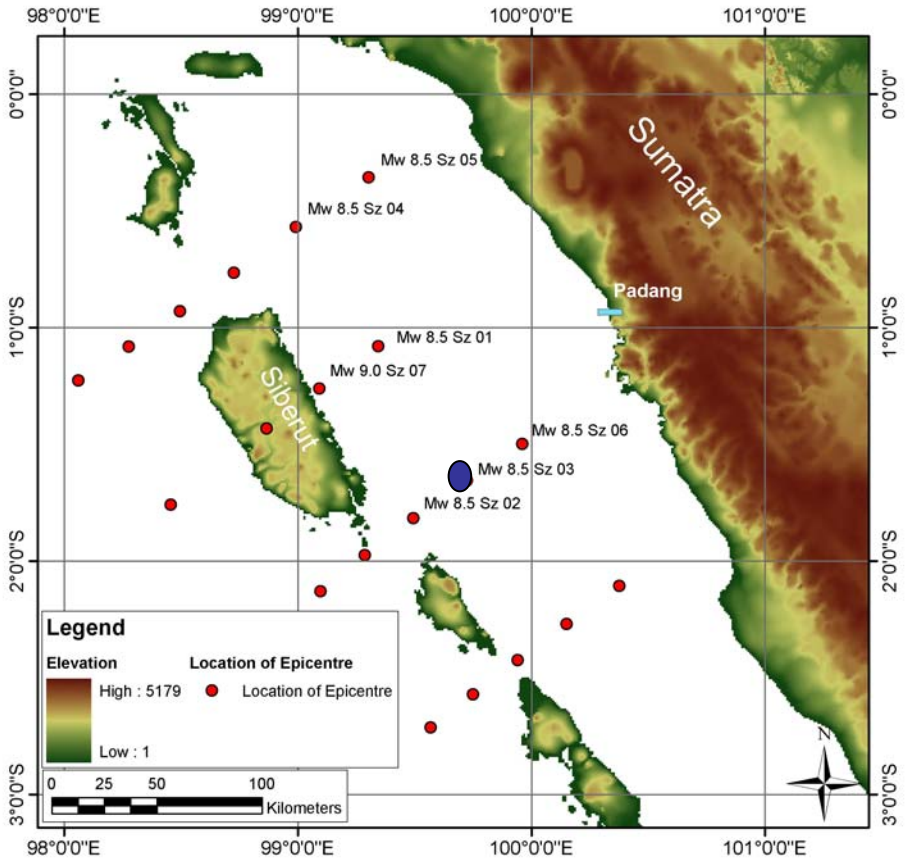
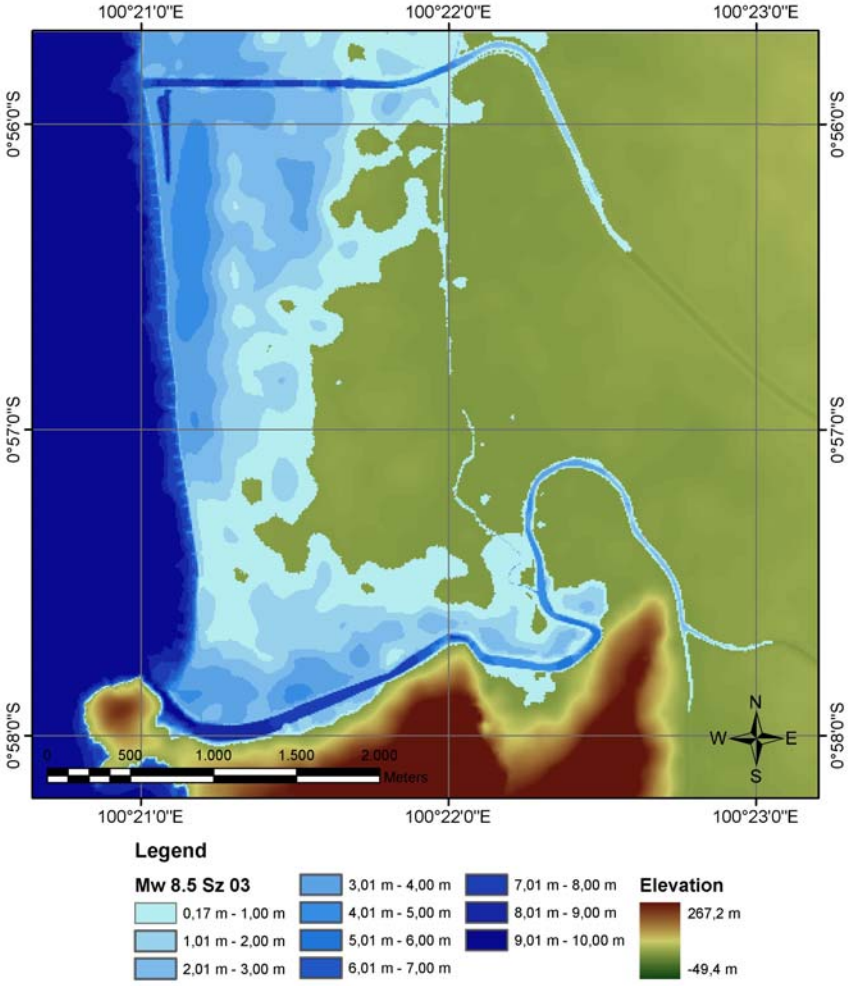
Scenarios based on TsunAWI modelling

- Available scenarios with epicentres within range of Padang
- Variety of magnitudes (Mw 8.0, 8.5 and 9.0)
- Sensitivity of inundation to location of epicentre
- Ongoing production of additional scenarios



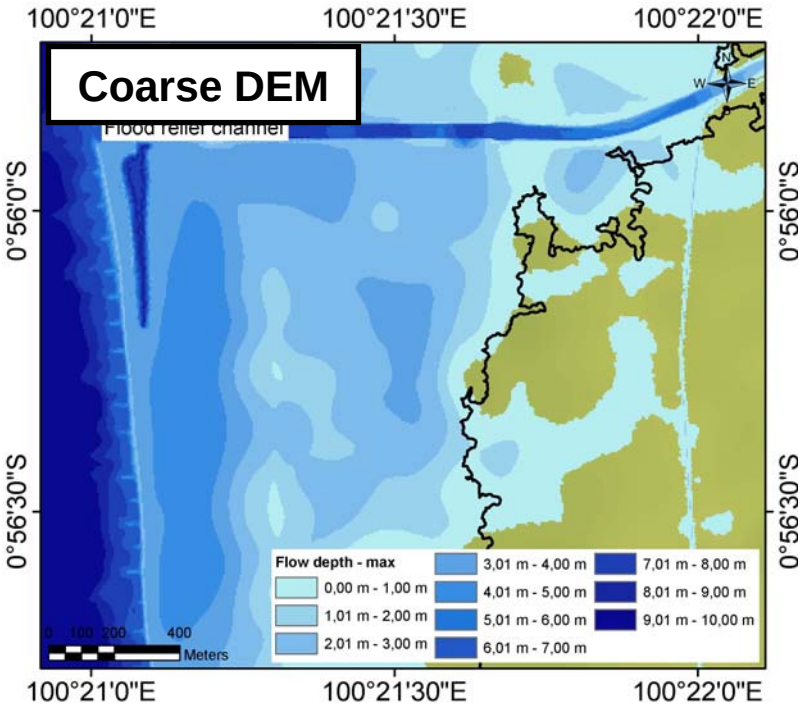
Maximum inundation scenario Mw 8.5 Sz 03

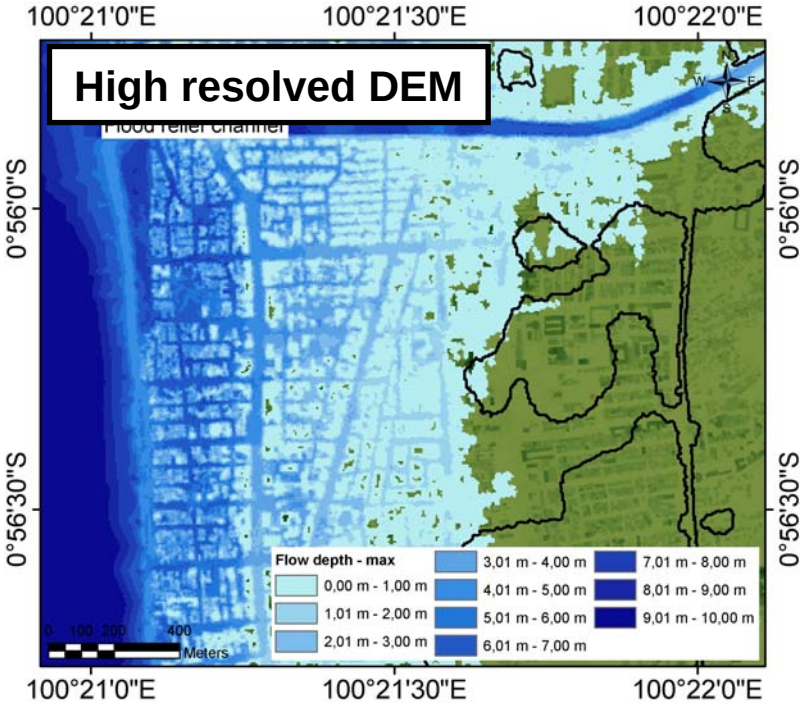




Comparison of DEM with different resolution and accuracy

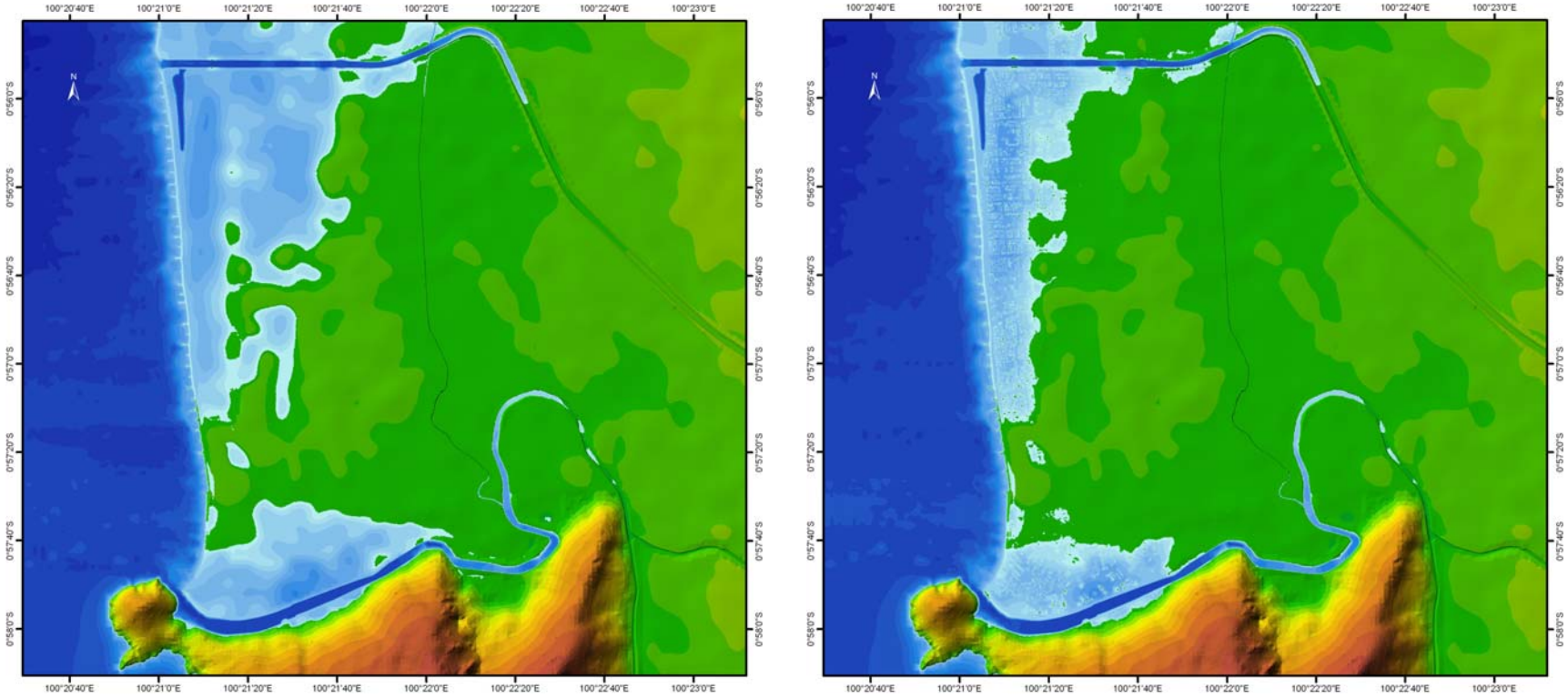
- Maximum inundation as comparison of coarse and high resolved DEM
  - Significant run-up differences and time shift





Mw 8.5 Sz 03 - inundated areas, model time t = 2580s

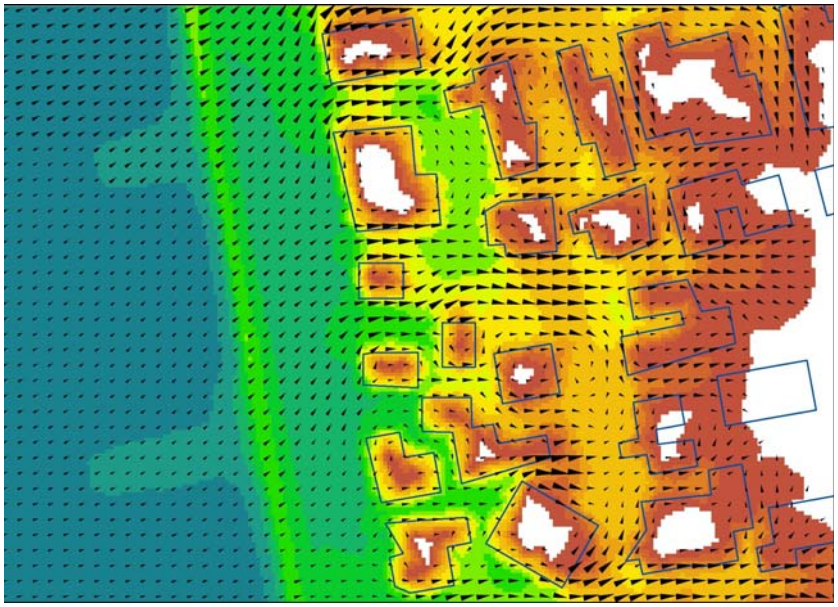
- Model result with and without taking buildings into account
- Inundation extent is reduced, flow velocities are increased



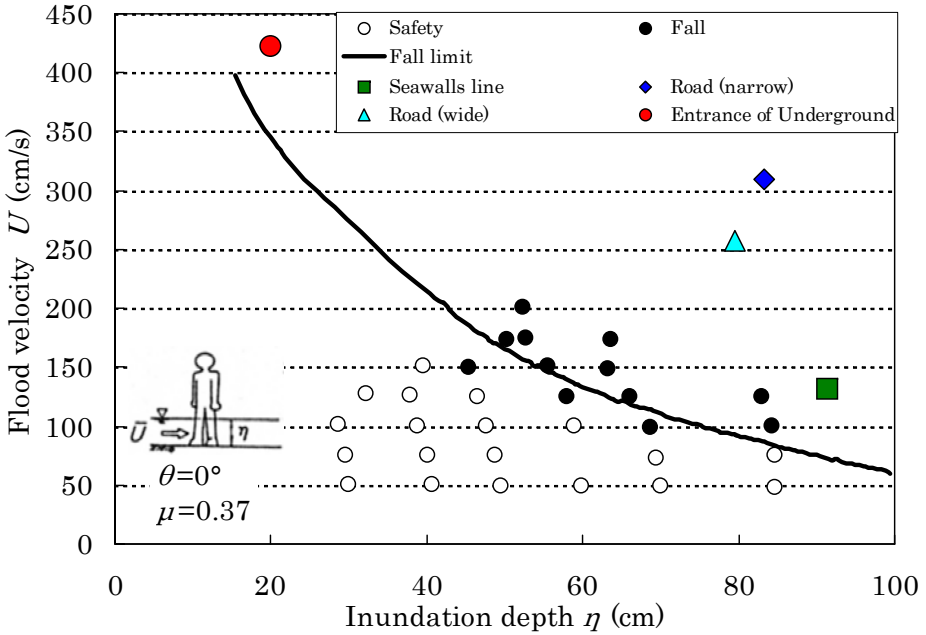
- Stahlmann, 2007

Tsunami scenario Mw = 8.5 – inundation dynamics

Flow velocities and fall limit conditions



- Stahlmann, 2007



- Takahashi et al., 1992

Coupling with simulation of pedestrian evacuation – animation

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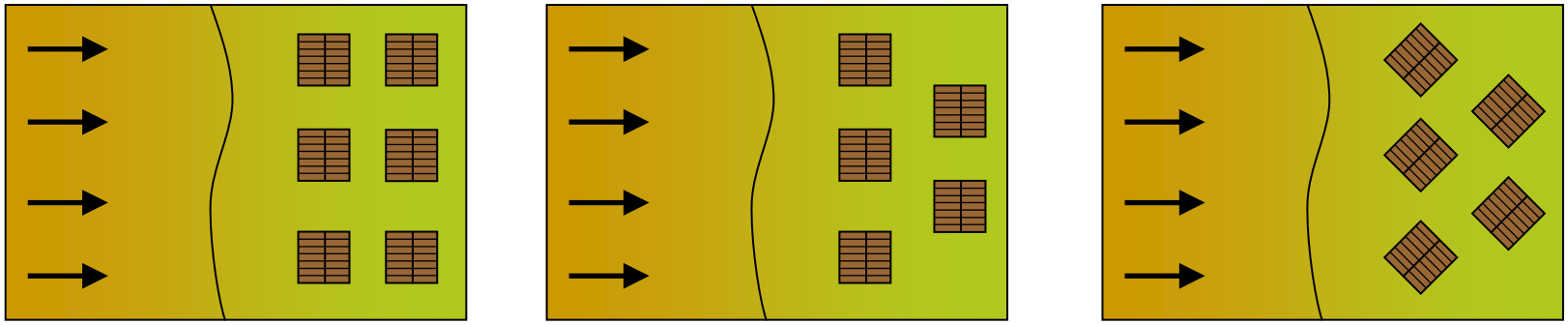
Experiences …

- Code suitable for scale corresponding to our project domain, but single CPU computations for domain are time consuming
- First facing many problems with installation routines under Fedora, but changing to Ubuntu brought much improvement
- Using parallel version is still tricky → maybe more documentation available?
- Using house masks: add_hole_from_polygon don't work for us
- Sometimes too small triangles (degenerate triangle) → method to get rid of them beforehand?
- Sometimes we observed a strange loss of the complete water in domain ??

Prospective development – suggestions / ideas

- Implementation of weirs (Sharp/broad crested weir, undershot sluice gates, etc.)
- Representation of houses and infrastructure:
  - House mask → time consuming
  - Manning's roughness not capable to represent influence of structures
  - Deduction of macro-roughness law from 3D hydrodynamic simulations investigating general parameters such as street width/house width ratio, different configurations of houses, angle with respect to flow direction, etc.
  - Implementation as additional negative force term in Anuga



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Discussion

- Inundation scenarios are extremely sensitive to location of epicentre – multi scenario approach might be useful
- Level of resolution for simulations and spatial database is essential for evacuation planning
- New approaches to account for roughness induced by buildings and structures

Outlook – work-in-progress

- Additional scenarios are being simulated
- Evacuation planning and pedestrian simulation
- Documentation of results as hazard and evacuation maps

Acknowledgement

- Bundesministerium für Bildung und Forschung (BMBF), Germany
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