Probabilistic Tsunami Hazard Assessment (PTHA) in Eastern Sicily (Italy) including sea level rise caused by climate change and local subduction effects

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EGU22 General Assembly, Vienna, Austria & Online NH5.1,**Wed, 25 May**

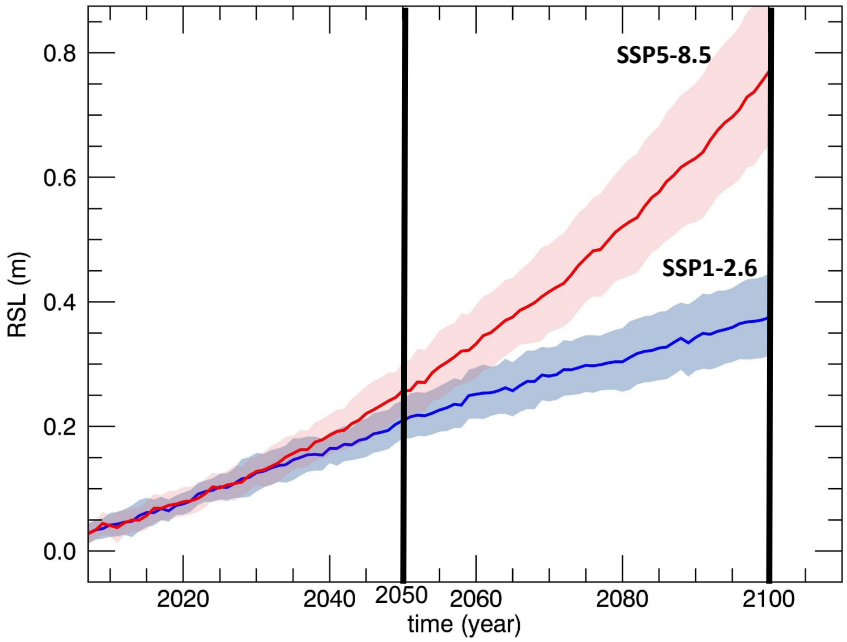
Overview

- PTHA
  - present coastlines www.tsumaps-neam.eu

- Sea Level Variations
  - Climate Change www.ipcc.ch

5 illustrative IPCC scenarios describe possible future anthropogenic emissions and consequent Relative Sea Level Rise (RSLR):

- **very low** GreenHouseGas (GHG) emissions and CO2 emissions scenario (**SSP1-2.6**) declining to net zero around or after 2050, followed by varying levels of net negative CO2 emissions by 2100
- **very high** GHG emissions and CO2 emissions scenario (**SSP5-8.5**) that roughly double from current levels by 2050



Anzidei et al. (2021)

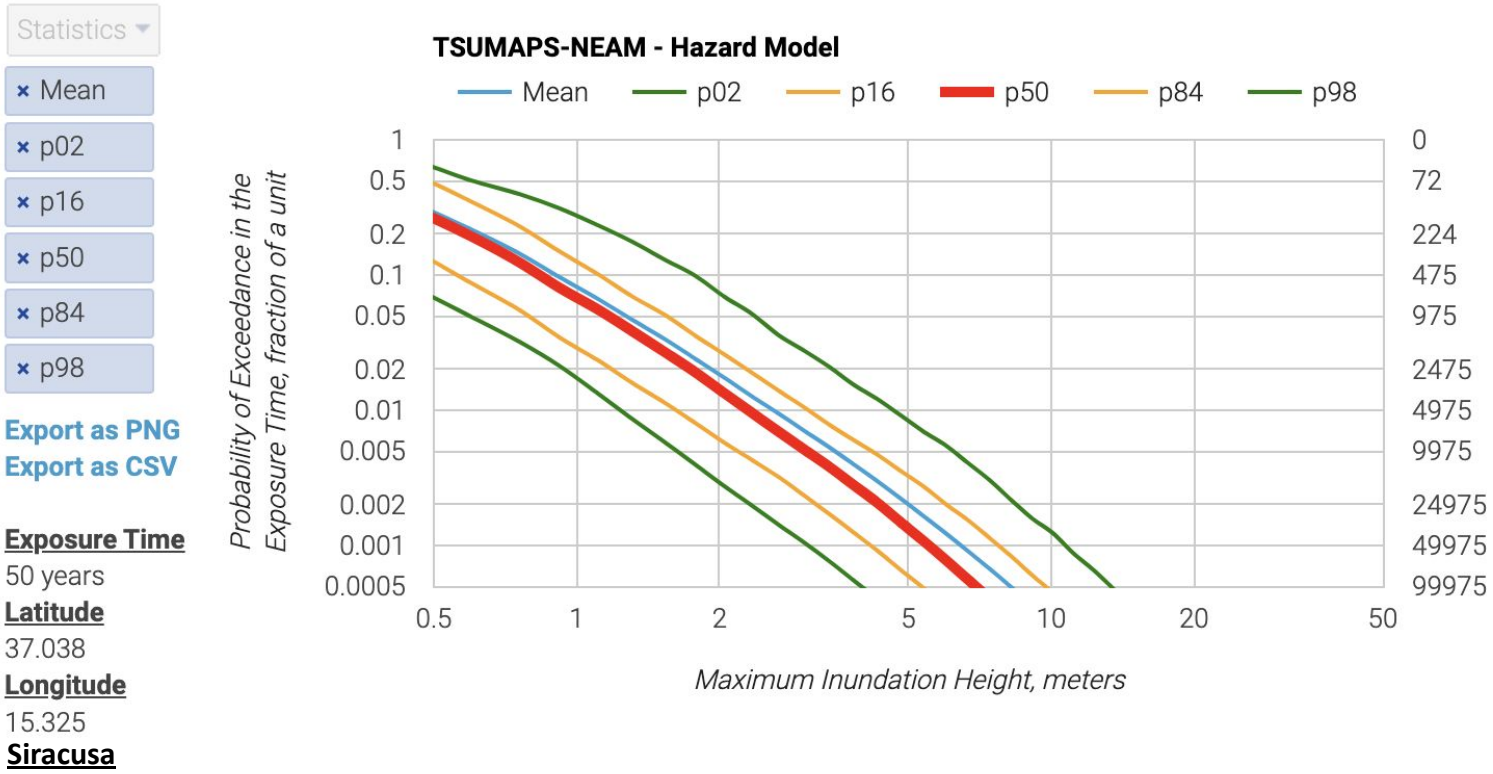
  - Local geological factors www.savemedcoasts.eu
    - subsidence

PTHA ⇨ $p(Z \geq z, \Delta t)$

➢ Hazard Curves

Probability that a selected value *z* of a chosen tsunami intensity parameter *Z* is overcame in a certain exposure time Δt in a given coastal location, where

- ➢ *Z* represents runup, velocity, energy, moment flux, wave height, max. inundation height, … any parameter required by the hazard assessment
- ➢ *z* are threshold levels for each given location consider the <u>present coastline</u>

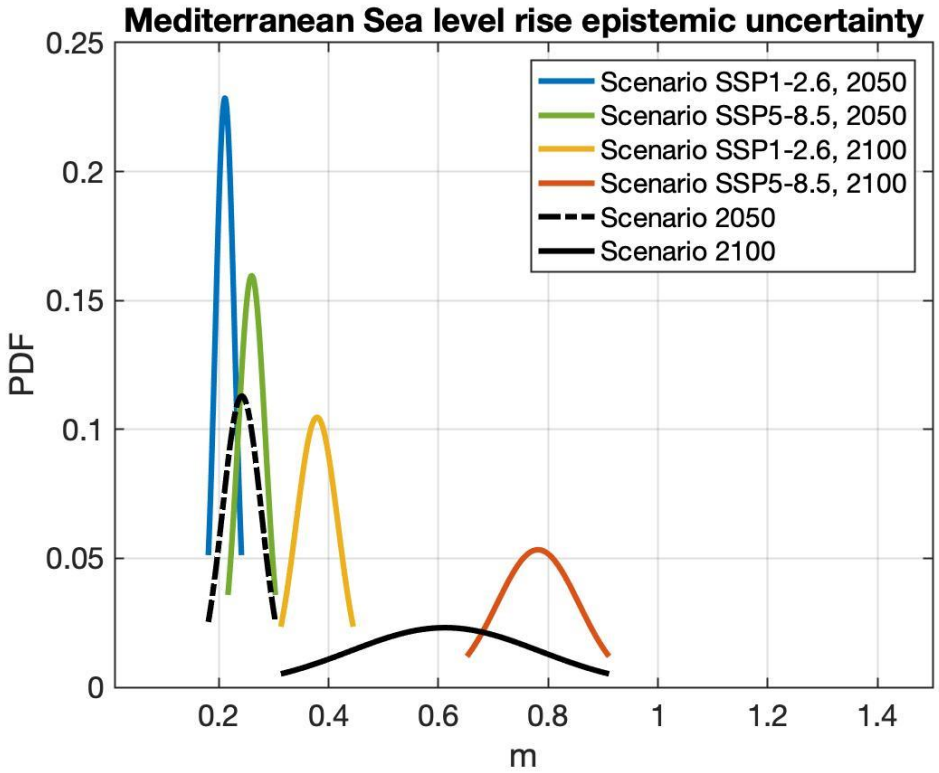


IPCC AR5 ⇨ $RSLR \pm \Delta_{ErrorRSLR}$

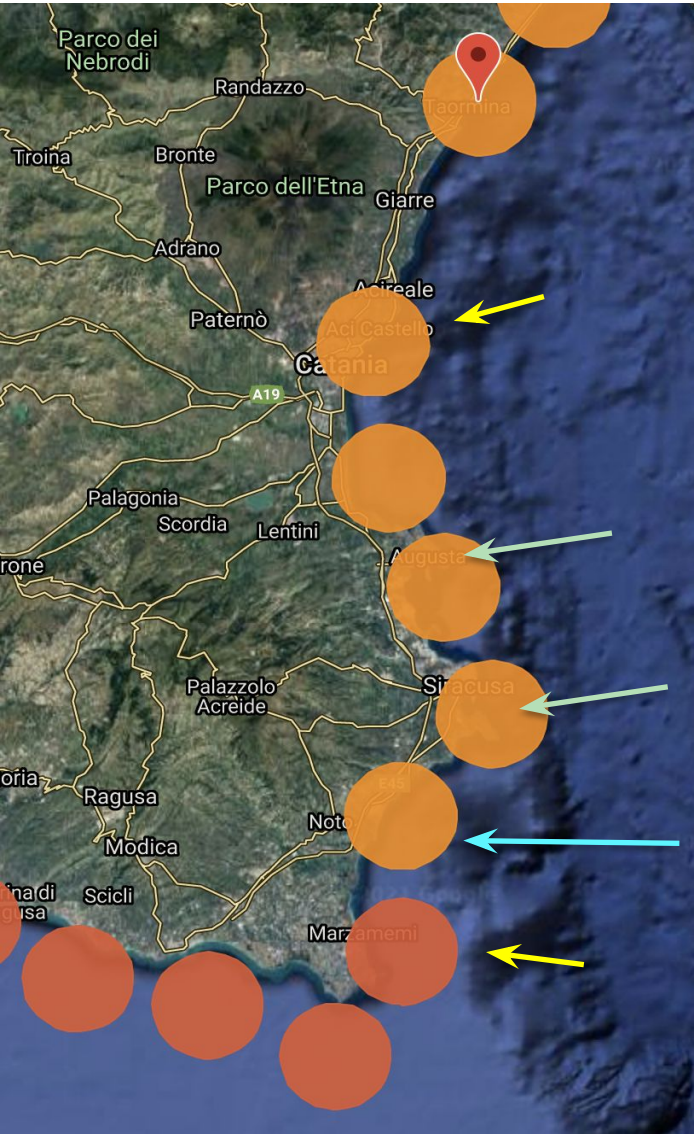
➢ Epistemic Uncertainty

IPCC scenarios (SSP1-2.6 - SSP5-8.5) of future anthropogenic emissions indicate a **general RSLR** for the Mediterranean Sea in the range **0.20 ± 0.03 ÷ 0.25 ± 0.04 m** by 2050 and **0.37 ± 0.06 ÷ 0.77 ± 0.14 m** by 2100. In a probabilistic framework

- ➢ the choice of RSLR representative scenarios for tsunami hazard analysis is source of epistemic uncertainty
- ➢ range of RSLR scenarios ($\in RSLR \pm \Delta_{ErrorRSLR}$) are estimated by a normal Probability Density Function (PDF)
  - ⇨ a wider range of possible RSLR respect to the IPCC scenarios



Eastern Sicily: Relative Sea Level Rise

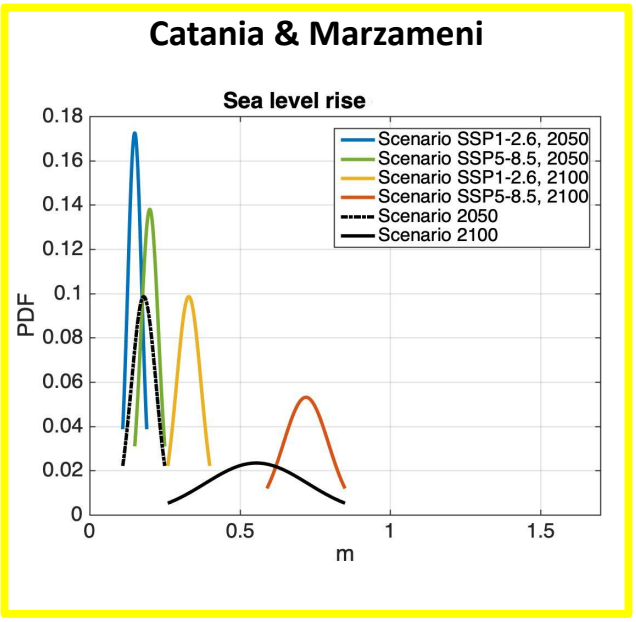


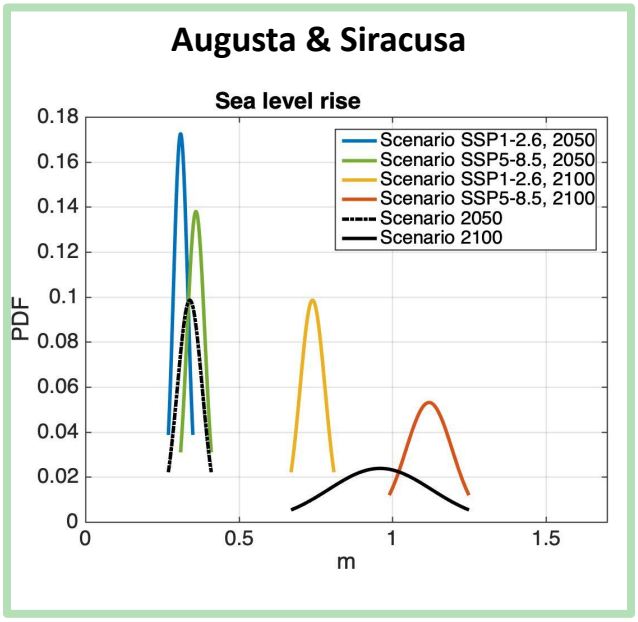
Relative Sea Level Rise
=
Climate Change + Local Subduction

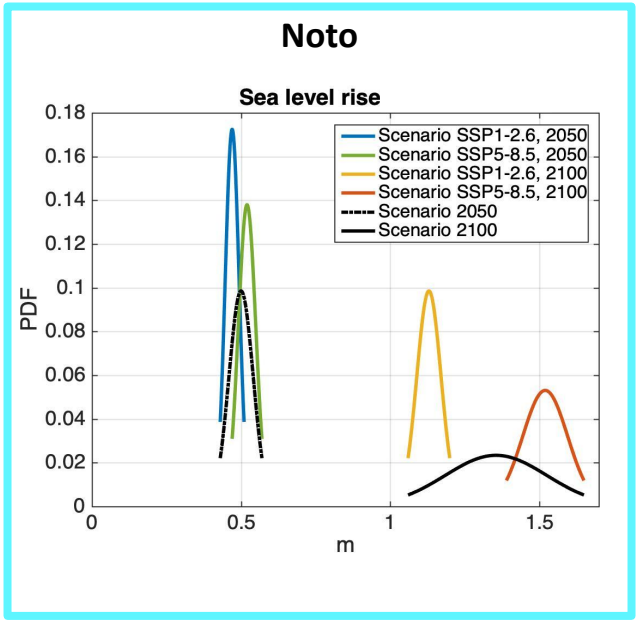
	***Catania Marzameni* (m)**	***Augusta Siracusa* (m)**	***Noto* (m)**
2050 SSP1-2.6	**0.15** ± 0.04	**0.31** ± 0.04	**0.47** ± 0.04
SSP5-8.5	**0.20** ± 0.05	**0.36** ± 0.05	**0.52** ± 0.05
2100 SSP1-2.6	**0.33** ± 0.07	**0.74** ± 0.07	**1.13** ± 0.07
SSP5-8.5	**0.72** ± 0.13	**1.12** ± 0.13	**1.52** ± 0.13

Anzidei et al. (2021)

Eastern Sicily: Max. Inundation Heights

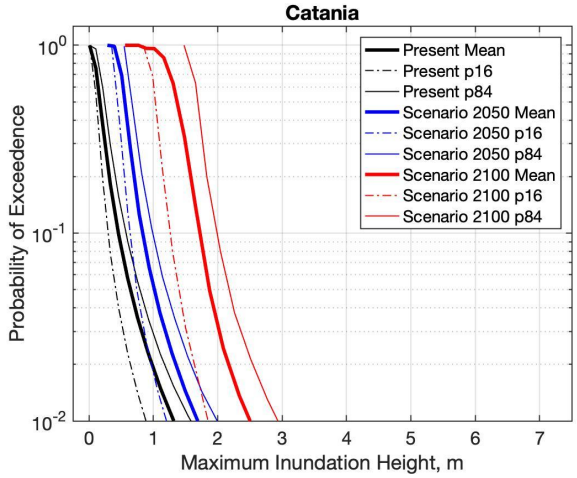


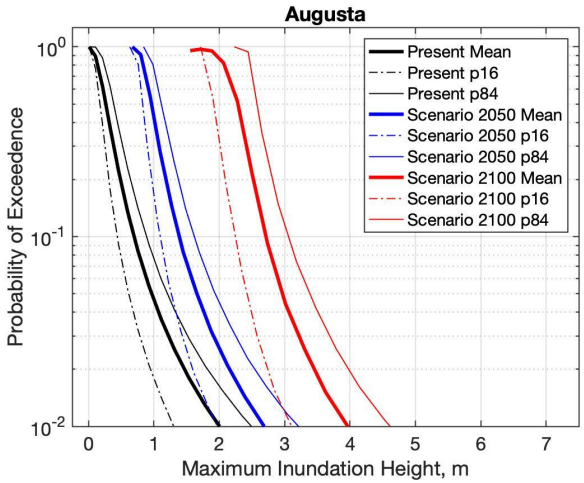


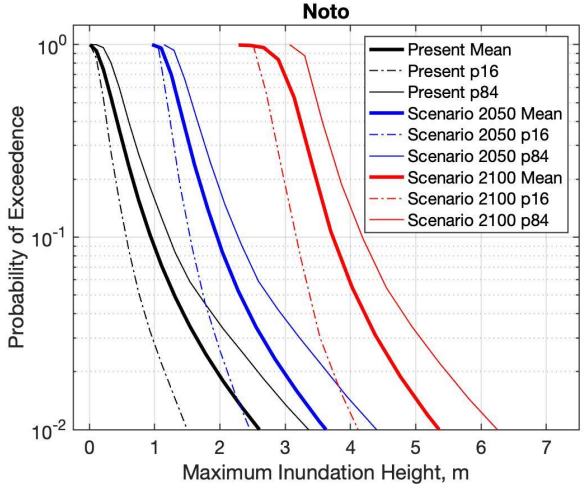


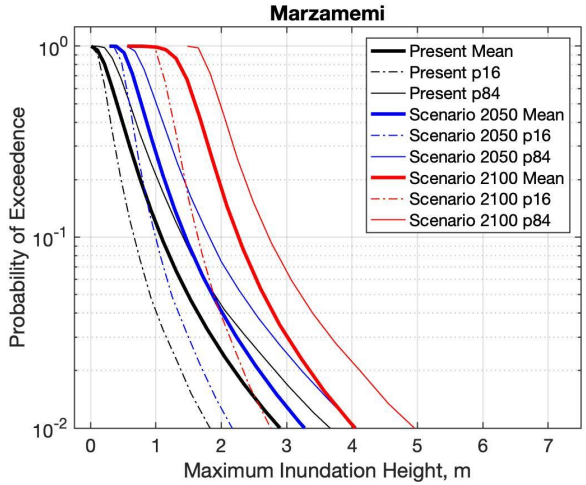
- In each site thousands scenarios of Updated Max. Inundation Heights are computed from the normal PDFs
- Epistemic Uncertainty for Max. Inundation Height in scenario by 2100 is higher than scenario by 2050
- Probabilities of Exceedence the Updated Max. Inundation Height thresholds in 50 years are computed providing Updated Hazard Curves

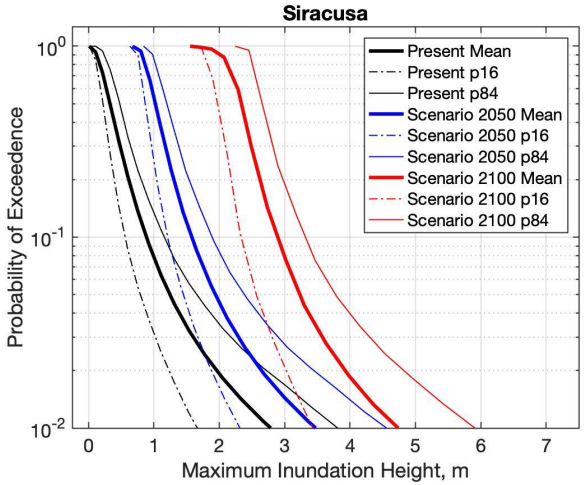
Eastern Sicily: Updated Hazard Curves









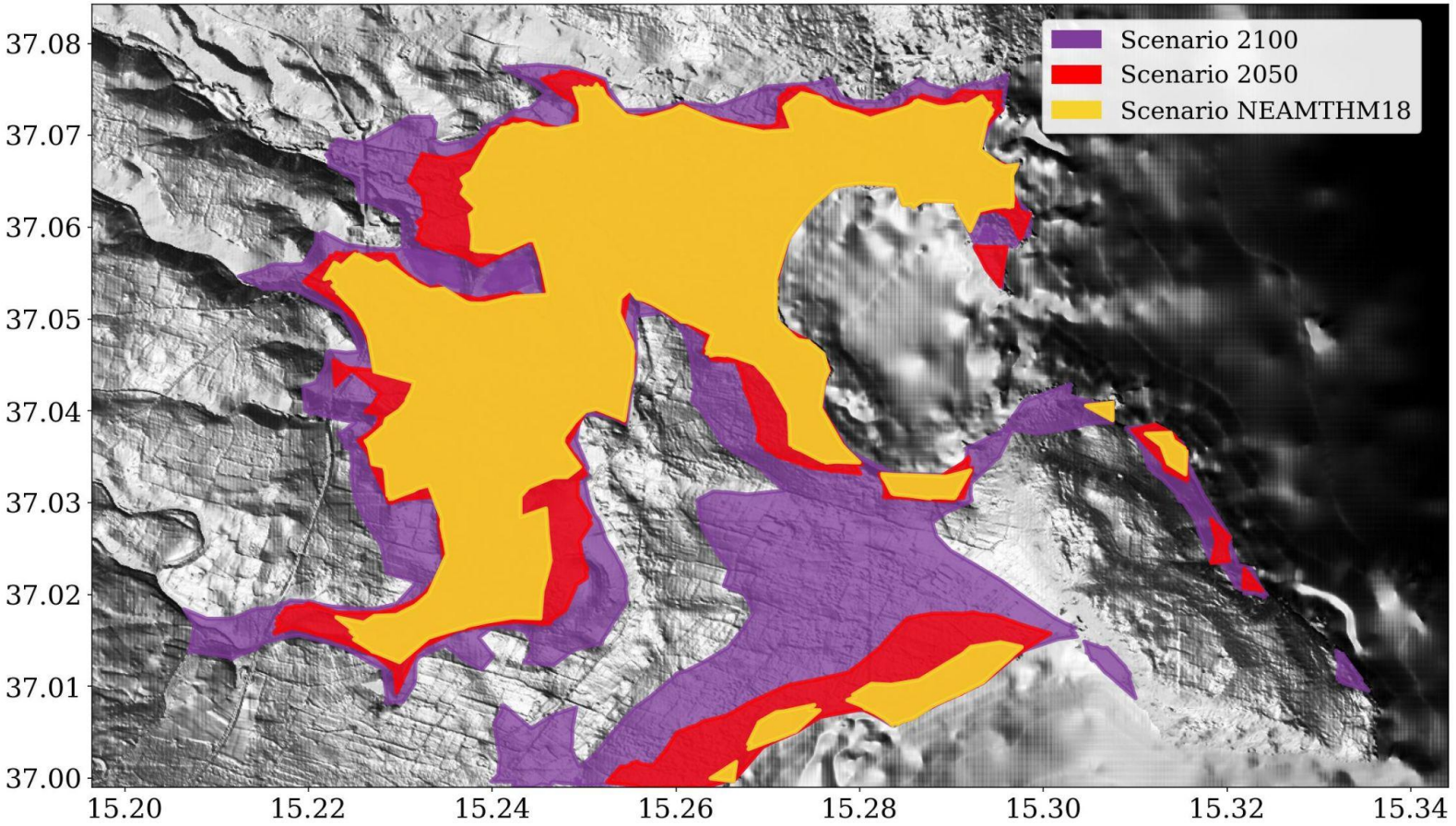


> 3 m	Present	2050	2100
Catania	0.0012	0.0015	0.022
Augusta	0.0039	0.0052	0.098
Siracusa	0.0085	0.0108	0.0188
Noto	0.0068	0.0111	0.0311
Marzamemi	0.0089	0.0107	0.0157

In the Updated Hazard Curves the Probability of Exceedence the Max. Inundation Height thresholds in 50 years and relative uncertainties increase in all sites, with local variations:

- higher probabilities respect present may occur in different sites where not expected
- similar RSLR ⇏ similar probabilities in Updated Hazard Curves due to complexity

Siracusa: Inundation Map



Max. Inundation Heights with the 2,500 years Averaged Return Period at the 84th percentile of the epistemic uncertainty distribution are converted into design maximum run-up values:

9.2 m Present Scenario NEAMTHM18 *Tonini et al. (2021)*

11.3 m Scenario 2050

15.0 m Scenario 2100

Conclusions

- PTHA
  - present coastlines

- updating PTHA
  - Global Climate Changes + Local geological factors ⇨ RSLR
  - Epistemic Uncertainty is higher due to the anthropogenic activities (different IPCC Scenarios)
  - Probability of Exceedence the Maximum Inundation Height thresholds in 50 years generally increases
  - Hazard curves and Hazard Maps are complex products and PTHA needs to be recomputed locally to include the effects of sea level rise and vertical land movements