Response to Reviewer 1

Ms. No: Preprint nhess-2023-191

Title: **Shoreline and Land Use Land Cover Changes along the 2004 tsunami-affected South Andaman Coast: Understanding Changing Hazard Susceptibility. https://doi.org/10.5194/nhess-2023-191**

In this response file, the text in blue shows the comments from reviewers, while the text in black is our replies.

Reviewers comment

This paper addresses an important tsunami risk problem, which is aggravated by the increasing trend in population exposure, tourism etc. The analysis undertaken identifies a number of important tsunami risk issues, but falls short of what is required for a robust population tsunami safety study. To make the conclusions more robust, some additional scenario analyses would be insightful and instructive. First, all tsunami wave height outcomes are subject to a substantial degree of stochastic variability. Venturing beyond the actual 2004 tsunami wave height measurements, the implications for local upward variations in wave height should be considered by perturbing the tsunami source dynamics. Furthermore, other potentially dangerous earthquake-generated tsunamis merit attention, and an ensemble of some alternative potential tsunami scenarios should be considered, especially those which impact regions of recent economic development. This broadening of the basic tsunami modelling content of the paper would make the results more reliable for informing the practical risk management strategies and other conclusions listed at the end of the paper.

Reply

We appreciate the learned reviewer for his keen interest in reviewing our manuscript. His insightful comments and constructive feedback has been helpful in enhancing the quality of the manuscript.

As suggested by the reviewer we have considered a few more scenarios and also took into account the stochastic variability in the control source parameters. The results and findings are discussed and shall be added to the paper.

We have taken three distinct seismic scenarios: i) the Car Nicobar earthquake of 1881, ii) the North Andaman earthquake of 1941 (Table 1 a, b), and iii) the Andaman Sumatra Subduction Zone earthquake of 2004, with a particular focus on the 2004 Sumatra tsunami earthquake, extensively discussed within our paper. For each scenario, we have computed the arrival times (Minutes), maximum wave height (m), and inundation (m). Plots depicting these computations along the gauge locations in the southern Andaman region are provided: Fig 1a and b for the Car Nicobar earthquake of 1881, and Fig 1c and d for the North Andaman earthquake of 1941.

Table 1. Deformation parameters used to simulate different scenarios a) Car Nicobar, 1881 earthquake b) North Andaman, 1941 earthquake (Mishra et al. 2014)

Earthquake parameters and source location	**a) Car Nicobar, 1881**	**b) North Andaman, 1941**
Latitude (E)	8.52	12.1
Longitude (N)	92.43	92.5
Data of occurrence	31.12.1881	26.06.1941
EQ magnitude (Mw)	7.9	7.7
Fault Length (km)	200	200
Fault width (km)	80	80
Strike (deg)	350	20
Slip (m)	5	5
Dip (deg)	25	20
Rake (deg)	90	90
Depth (km)	15	30

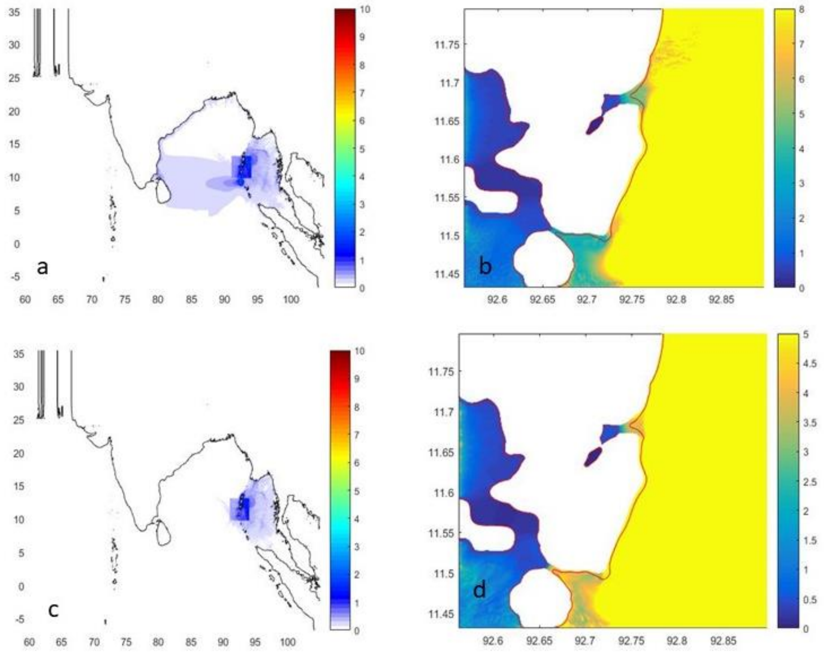

Fig 1a directivity and b wave run-up height for the Car Nicobar earthquake of 1881, and Fig 1c and d for the North Andaman earthquake of 1941. (Andaman-Sumatra 2004 earthquake added in Manuscript)

Table 2. Estimated Run-up heights, Arrival Times, and inundations at the study region from i) Car Nicobar, 1881 earthquake ii) North Andaman, 1941 earthquake, and iii) Andaman Sumatra Subduction Zone, 2004 earthquake

Location	Parameters	Earthquake Events		
		Carnicobar, 1881	North Andaman, 1941	Andaman Sumatra, 2004
Rutland Island	Arrival Time (Min)	26.55	25.9	27
	Run up height (m)	1.44	1.01	6
	Inundation (m)	50-380	10-220	700
Wandoor	Arrival Time (Min)	42.80	22.5	36.5
	Run up height (m)	2.21	1.25	3.5
	Inundation (m)	20-200	10-180	450
Tirupati Temple, Port Blair	Arrival Time (Min)	46.5	21.75	38
	Run up height (m)	1.65	1.42	1
	Inundation (m)	20-400	10-360	200
Wimberlygunj	Arrival Time (Min)	32.95	25.6	58
	Run up height (m)	1.40	1.12	12.5
	Inundation (m)	10-250	10-180	210
Shoal Bay	Arrival Time (Min)	42.5	34.8	56
	Run up height (m)	1.45	1.77	13
	Inundation (m)	20-220	10-180	950
Chidiyatopu	Arrival Time (Min)	26.5	21.75	36
	Run up height (m)	2.05	1.79	3.9
	Inundation (m)	20-500	20-300	585
South Point, Port Blair	Arrival Time (Min)	28.4	22	31.5
	Run up height (m)	2.31	2.12	9.6
	Inundation (m)	20-500	20-280	550
	Arrival Time (Min)	28.8	22.3	33

Corbyns Cove Beach	Run up height (m)	2.3	2.1	12.7
	Inundation (m)	20-580	10-320	900
Bombooflat	Arrival Time (Min)	31.2	24.55	42
	Run up height (m)	2.35	2.23	5.5
	Inundation (m)	20-650	20-350	90

Comparing three different scenarios, it is observed that the run-up height along the Eastern coast of South Andaman is greater than the Western coast (Fig. 1 c and d). This difference is due to the wider continental shelf on the Western coast of the south Andaman region and shallow water depths. In case of a higher magnitude of tsunamigenic earthquakes in the Car Nicobar or the North Andaman region, we would get higher run-ups along the gauge locations.

The arrival times of tsunamis varied across all locations, with each earthquake event exhibiting a range from approximately 21.75 minutes to 58 minutes (Table 2). The Car Nicobar, 1881 earthquake generally resulted in shorter arrival times compared to the other two events. Run-up heights ranged from approximately 1 meter to as high as 13 meters. Particularly, the Andaman Sumatra, 2004 earthquake tended to generate the highest run-up heights, in locations like Shoal Bay and Corbyns Cove Beach. The extent of inundation, representing the area covered by the tsunami, exhibited wide variation across locations and earthquake events, with depths ranging from 10 meters to a maximum of 950 meters. The Andaman Sumatra, 2004 earthquake led to the most extensive inundations, especially notable at locations like Shoal Bay and Corbyns Cove Beach. Comparing the three earthquake events, the Andaman Sumatra, 2004 earthquake generally resulted in higher run-up heights and more extensive inundations compared to the Car Nicobar, 1881, and North Andaman, 1941 earthquakes. The observed run-up heights and inundations were influenced by various factors, including the magnitude of the earthquake, the proximity of the source to observation locations, and the local coastal topography. Shoal Bay and Corbyns Cove Beach experienced significant inundations during the Andaman Sumatra, 2004 earthquake, highlighting the urgent need for robust mitigation and preparedness measures in these vulnerable coastal regions.

We acknowledge the importance of robust population tsunami safety studies and have taken steps to enhance our analysis accordingly. In addition to evaluating historical tsunami events, we have incorporated additional scenario analyses to capture the stochastic variability of tsunami wave heights and consider local upward variations. By expanding our study to include an ensemble of alternative tsunami scenarios, particularly those impacting regions of recent economic development, we aim to provide more reliable insights for practical risk management strategies. This involves engaging with local communities, optimizing evacuation planning, enhancing early warning systems, fortifying infrastructure resilience, and adopting a multi-hazard risk assessment approach (National Research Council, 2011). Our study contributes to this broader goal by providing essential data and insights to support evidence-based decision-making and mitigate the adverse impacts of tsunamis on coastal population.

References

Mishra, P., Usha, T., & Ramanamurthy, M. V. (2014). Evaluation of tsunami vulnerability along northeast coast of India. Continental Shelf Research, 79, 16-22.

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