

Line 166: The authors have not explained how they constructed the network shown in figure 1. Is this network based on other references or did the authors construct it themselves? In the latter case, it will be helpful to include more information about the methodology for network construction.

Based on the networks, it appears that each edge has the same weight. However, not every earthquake is equal and not every earthquake will equally create a tsunami and not every tsunami would impact a populated area, and so on. So there is an inherent probabilistic causal component or in the network terminology, edge weights, that will define this network. Without considering this probability, I am unsure how the conclusions from this network can be supported. Can the authors please include more information about how they considered this probability in their networks?

Author response:

We thank the reviewer for the comments. The network formalisation follows Mignan and Wang (2020) and Helbing and Kuehnert (2003), while the hazard taxonomy is adapted from Mignan (2024). We acknowledge that real earthquakes vary in tsunami-generating potential, and not all tsunamis reach densely populated coasts. Our network is constructed using documented secondary hazard cases from dozens of major tsunami events. Limited by available records, the network describes observed hazard couplings instead of coupling occurrence probabilities. Below we explain the validity of our findings and the revisions made in the manuscript:

1. Our research questions and metrics are topological. Degree centrality, network density, centralisation, average path length and inter-layer net flow depend solely on edge existence, i.e. the support of the transition matrix, and do not rely on matrix entry values. Edge weights are unnecessary for all our conclusions; we do not report expected losses or frequency-based risk rankings. For instance, submarine and coastal earthquakes have zero in-degree since no other hazards trigger them, and this result holds under any weight configuration. Tsunami and critical-infrastructure-failure act as relay hubs because they both receive and re-propagate a large number of documented couplings (high in- and out-degree).
2. Mapping trigger relationships between hazards is a standard practice in multi-hazard interaction research (Gill & Malamud, 2014; Helbing & Kuehnert, 2003; Mignan & Wang, 2020). We adopt their framework conceptually, but, because the records do not provide transition probabilities, all our analyses are performed on its support, i.e. the binary adjacency matrix of documented couplings. Our novelty lies in the initial modelling of marine seismic hazard chains. Each edge in the network comes from at least one historically documented hazard coupling; no hypothetical couplings are added.
3. The cases noted by the reviewer relate to event probability and exposure, which change with site and event properties (magnitude, focal depth, bathymetry, coastal protection, population distribution). We intentionally separate the general hazard interaction structure from site conditions to enable cross-region transferability of the network. Probability and exposure parameters are only introduced when applying the model to a specific coastline, belonging to probabilistic tsunami hazard assessment and Bayesian network research. This network complements, and does not substitute, those assessment models.
4. The existing records do not support reliable assignment of uniform global probabilities to all 152 edges. Most hazard pairs are documented in only a handful of events; conditional frequencies estimated from sparse records have large uncertainties. Frequencies can act as a

simple filter to test result robustness but cannot provide accurate edge weights. We consider this edge-only representation more rigorous and objective than assigning weights lacking empirical support.

Line 16 - The paragraph can be expanded to further support the manuscript's motivations as it is missing the key definitions that the authors are emphasizing, like, adding some examples/definitions of secondary events, cascading behavior, indirect losses, cross-system chains, technological accident, influence, etc.

Author response:

We thank the reviewer for the comments. The original paragraph deployed multiple key terms in sequence without definitions, obscuring the study motivation for readers. We will revise the opening paragraph of the introduction and add sequential definitions and examples for these concepts.

Line 27 - Do the authors mean: the resulting inundation *can reach* coastlines *with concentrated*?

Author response:

We thank the reviewer for the comments. The reviewer's understanding matches our intended meaning. The original present-tense verb "reaches" gives the impression that tsunami inundation will always reach densely populated, infrastructure-heavy coastlines, which is not what we intended. This sentence describes a potential propagation pathway and does not guarantee realisation for every event. This aligns with our network definition: the network represents documented couplings, not their inevitability or probability of occurrence. We will revise this sentence following the reviewer's suggestion:

Original (Lines 26–28): A single submarine rupture can displace the seafloor, raise a tsunami, and destabilise submarine slopes, and the resulting inundation reaches coastlines that concentrate population, ports, energy supply, and communication networks.

Revised: A single submarine rupture can displace the seafloor, raise a tsunami, and destabilise submarine slopes, and the resulting inundation can reach coastlines with concentrated population, ports, energy supply, and communication networks.

Line 28: Suggest defining the concept of a chain prior to its use here.

Author response:

Thanks for the comments. We will provide the definition of hazard chains prior to the first use of this term.

Line 32: Is the Palu catastrophe an example of a sub-marine seismic hazard?

Author response:

Thanks for the comments. The 2018 Palu event, a coastal strike-slip earthquake with its main rupture on land, showed that coseismic submarine and coastal landslides, rather than seafloor displacement by the rupture itself, can dominate tsunami generation in a confined bay (Somphong et al. 2022).

Line 30: Suggest adding numeric figures about the losses for the listed disasters to further support the manuscript's motivation.

Author response:

We thank the reviewer for the comments. We agree with this comment. Quantitative characterization of triggering events can better support our arguments compared with the qualitative descriptions in the original manuscript. Following your suggestion, we will add numeric figures for the cited hazard events in the revised text.

Line 55: Do the authors intend to make a distinction between islands and mainland?

Author response:

We thank the reviewer for the comments. We thank the reviewer for pointing out this ambiguity in wording. This study does not aim to distinguish between “islands” and “continents”. The term “mainland” in our text refers to onshore (inland) earthquakes, in contrast to “marine” (offshore) earthquakes. The classification is based on the environment where the earthquake source lies and the cascade pathways activated accordingly, rather than whether the exposed landmass belongs to an island or a continent.

Marine seismic hazard chains are triggered by submarine earthquakes (SEQ) and near-coast earthquakes (EQ) — earthquakes that may drive marine hydrodynamic processes including tsunamis, submarine landslides and coastal flooding. The impacted regions recorded within the network cover many islands and archipelagos.

Onshore seismic hazard chains originate from inland earthquakes. Their secondary hazards are mainly terrestrial processes such as coseismic landslides, rockfalls and barrier lakes, without marine processes.

We acknowledge that “mainland” is prone to being read as “continent, contrasted with islands”. In revision, we will change “mainland earthquake chain” to “onshore (inland) earthquake chain”. An explicit definition will be added at the first mention in the introduction: “onshore earthquake chains, i.e. cascades initiated by inland earthquakes with no marine components involved, as opposed to marine chains initiated by submarine or coastal earthquakes”.

Line 75: Suggest adding a citation for this formulation or further explanation for the assumptions if this is the authors’ original formulation.

Author response:

We thank the reviewer for the suggestion. The equation on Line 75 is not our original derivation. It is the Kolmogorov forward equation for continuous-time Markov processes, a standard result within Markov process theory. We adopt it to describe hazard cascade propagation following the catastrophe-dynamics framework Mignan and Wang (2020). In the revised manuscript, this derivation is condensed: Eqs. (1)–(6) are removed from the main text and replaced by a brief statement of the framework with the appropriate citations (Mignan and Wang, 2020), because, as also noted by the other reviewer, no transition rates are estimated in this study and all results are computed on the binary network.

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- Mignan, A., Wang, Z.: Exploring the Space of Possibilities in Cascading Disasters with Catastrophe Dynamics. *International Journal of Environmental Research and Public Health*, 17, <https://doi.org/10.3390/ijerph17197317>, 2020.
- Somphong, C., Suppasri, A., Pakoksung, K., Nagasawa, T., Narita, Y., Tawatari, R., Iwai, S., Mabuchi, Y., Fujita, S., Moriguchi, S., Terada, K., Athanasius, C., Imamura, F.: Submarine landslide source modeling using the 3D slope stability analysis method for the 2018 Palu, Sulawesi, tsunami. *Nat Hazards Earth Syst Sci*, 22, 891–907, <https://doi.org/10.5194/nhess-22-891-2022>, 2022.
- Mignan, A. (2024). *Introduction to Catastrophe Risk Modelling: A Physics-based Approach*. Cambridge University Press. <https://doi.org/10.1017/9781009437370>