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Supporting Community Responses to Non-Seismic and Complex Source Tsunamis

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Indian Ocean Tsunami Warning & Mitigation System

Recent Tsunami Event Motivation

- **Palu** non-subduction zone earthquake, submarine landslides, and tsunami, **Indonesia 2018**
- **Sunda Strait Ana Krakatoa** flank collapse and tsunami, **Indonesia 2018**
- **Tonga** volcano eruption and tsunami, **Tonga 2022**

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Challenges for monitoring and timely warning for tsunamis generated by non-seismic and complex sources:

- Dynamic and relatively more difficult to quickly and accurately characterise sources
- Requirements for bespoke and flexible monitoring systems
- Mostly local impacts, with very short warning lead times
- Coordinating global efforts to optimise response efforts
- Further community education on natural warning signs required

PALU AND SUNDA STRAIT TSUNAMIS

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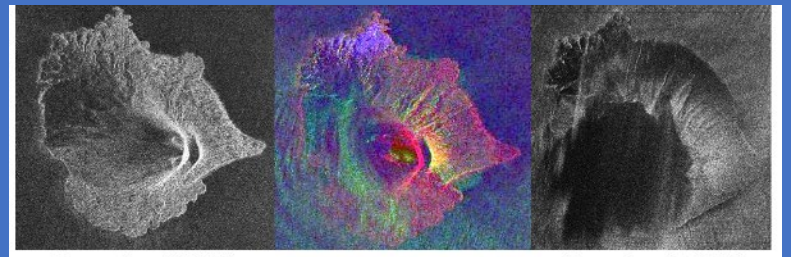
Palu Tsunami, 28 Sep 2018

- Deaths - 2,100; Missing 680; Injured 4,612; and Displaced 78,994
- Complex Event – Strike Slip Earthquake, Extensive Liquefaction, Coastal / Submarine Landslides, Bay
- Tsunami Warning issued by BMKG in 5 Minutes
- Tsunami Waves of Several Metres arrived within 2 – 4 minutes
- No time for communities to receive official warning
- IOC-UNESCO International Tsunami Survey Teams

Sunda Strait Tsunami, 22 Dec 2018

- Deaths - 430; Missing 128; Injured 1,459; and Displaced 5,695
- Caused by flank collapse due to eruption of Anak Krakatau volcano
- No Tsunami Early Warning issued
- Tsunami waves arrived in succession following the eruptions patterns, and avalanches.
- Tsunami confirmed only by recognizing wave anomaly at near-by tide-gauges



December 11, 2018 At 17:28 WIB | December 23, 2018 | December 27, 2018 At 17:28 WIB

Lessons Learnt in the Downstream

- False sense of security in the community
- Sustained preparedness, awareness, and education in local context
- Importance of evacuation plans, routes and shelters
- Importance of internalizing past experience
- Self-Evacuation is the key to safety - “near field”

Challenges in the Upstream

- Gaps in Hazard Assessment
- “Uncertainties” in tsunami early warning
- Warning systems not suited for “near-field”, “nonseismic” sources
- Failure of tsunami early warning chain

HUNGA-TONGA HUNGA-HA'APAI SUBMARINE VOLCANIC ERUPTION & TSUNAMI (Observations)

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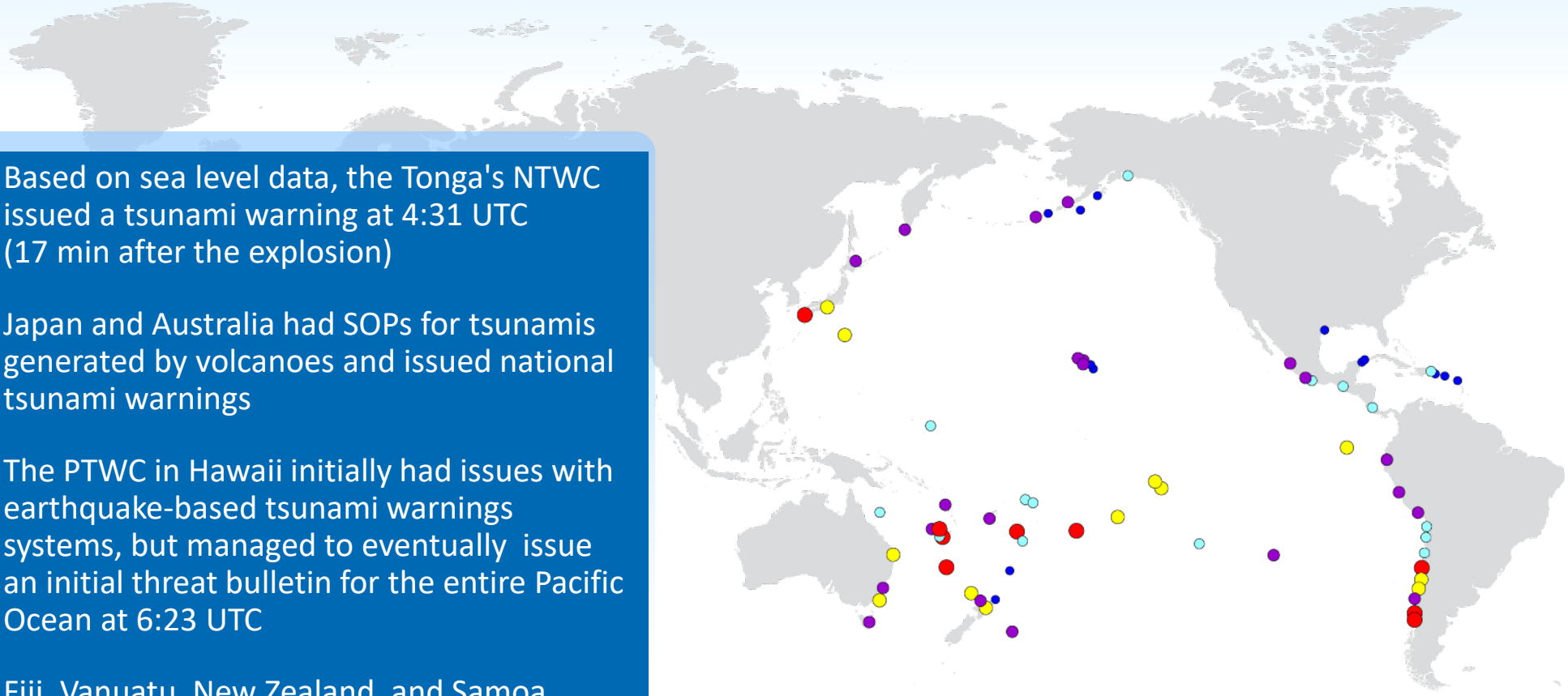
- Based on sea level data, the Tonga's NTWC issued a tsunami warning at 4:31 UTC (17 min after the explosion)
- Japan and Australia had SOPs for tsunamis generated by volcanoes and issued national tsunami warnings
- The PTWC in Hawaii initially had issues with earthquake-based tsunami warnings systems, but managed to eventually issue an initial threat bulletin for the entire Pacific Ocean at 6:23 UTC
- Fiji, Vanuatu, New Zealand, and Samoa NTWCs issued tsunami warnings at 6:35, 7:35, 7:41 and 8:45 UTC, respectively
- ITIC organized 3 post-event briefings and Member State survey of responses



MAXIMUM TSUNAMI AMPLITUDES REPORTED by PTWC on 15 January 2022

Interim Responses and other Global Activities

- Ongoing work undertaken globally and by the four Intergovernmental Coordination Groups (ICGs) of the UNESCO-IOC Tsunami Programme
  - IOC-UNESCO TOWS-WG ad hoc teams: 1) Atypical Tsunamis; 2) Tsunamis Generated by Volcanoes; and 3) Meteotsunamis
  - Indonesian operational monitoring and warning response to Palu and Sunda Strait tsunamis in 2018
  - ICG/PTWS operational response to Hunga Tonga – Hunga Ha'apai (HTHH) volcano eruption and tsunami 15 January 2022:
  - JRC/DG-ECHO/UNESCO-IOC Joint Hybrid-Workshop on Local Tsunami Warning in the context of Multi-Hazard Disaster Risk Mitigation in the NEAM region - Requirements, Challenges, Opportunities October 2022
  - ICG/IOTWMS SOP Workshops in 2023 incorporating outcomes Working Group for Tsunami & Other sea level related Warning & mitigation Systems (TOWS-WG) Task Teams and Ad Hoc Teams
  - ……
- Kyoto Landslide Commitment 2020 (2020+)
- Germany-Indonesia Tsunami Risk Project (2021+)
- ……

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Outcomes following TOWS-WG 2021

Task Team on Tsunami Watch Operations

- **Ad Hoc Team "Atypical" Tsunamis**
  - Chair Francois Schindele (France)
  - Draft report completed and to be published
  - Examined tsunamis generated by non-subduction zones earthquakes, volcano flank collapses, and meteo-tsunamis
  - Considered processes involved, monitoring and warning requirements

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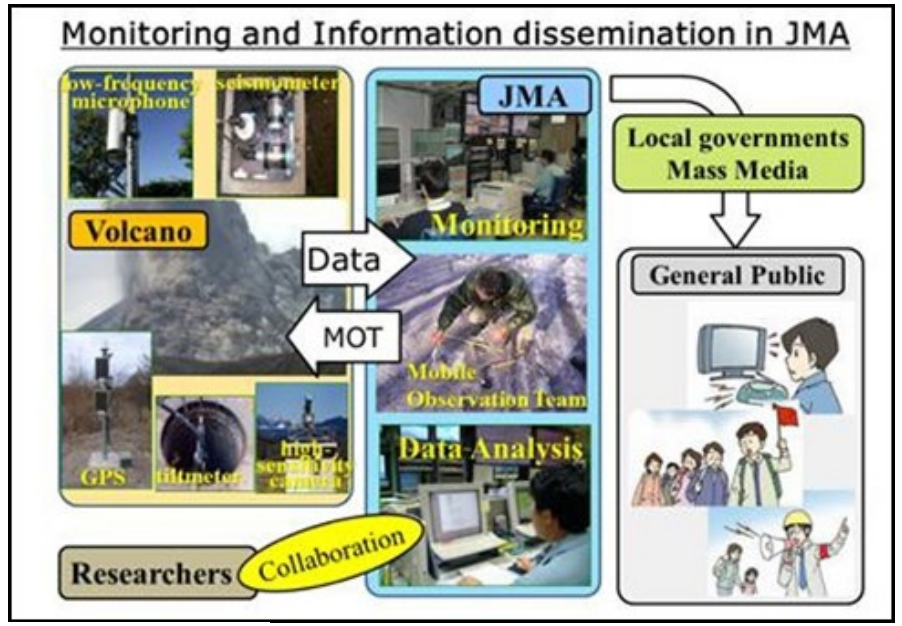

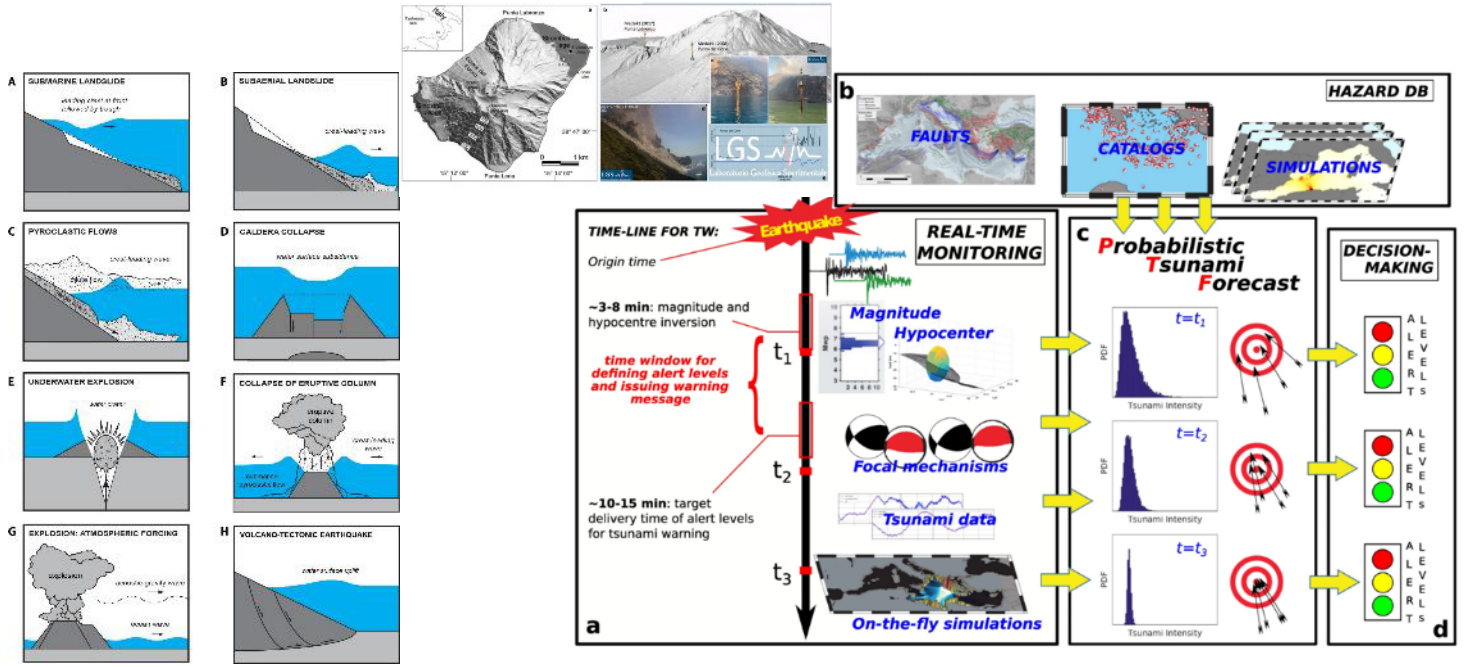

Outcomes following TOWS-WG 2022

- **Definition of "Atypical" tsunamis can be very confusing.**
- Decided better terminology to be adopted and used is:

  "Tsunamis generated by non-seismic and complex sources"

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Established two new Ad Hoc Teams under the Task Team for Tsunami Watch Operations:

- ***Ad Hoc Team on Tsunamis Generated by Volcanoes***
  chaired by Dr Francois Schindele

- ***Ad Hoc Team on Meteo-tsunamis***
  chaired by Mr Mike Angove

ToRs Ad Hoc Team on Tsunamis Generated by Volcanoes

1. Confirm the list of tsunami sources related to volcanoes and volcanic eruptions
2. Complete the list of potential threat volcanoes (referred to in annex to ATS Report)
3. Identify methodologies to monitor and detect volcanic sources of tsunami
4. Review relationship required between TSPs/NTWCs and Volcanic Ash Advisory Centres (VAACs) and other relevant agencies to monitor and warn for volcano generated tsunamis
5. Develop guidelines on SOPs to monitor, detect and warn for any the induced tsunami waves
6. Write a report to submit to the TT TWO for its next session in February 2023

Members: Francois Schindele (chair), Laura Kong, Emily Lane, Raphael Paris, Maurizio Ripepe, Vasily Titov

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ToRs Ad Hoc Team on Meteo-tsunamis

1. Review and advise on gaps related to meteo-tsunami monitoring and warning systems.
2. Develop guidelines on SOPs to monitor and warn for meteo-tsunamis.
3. Review relationship required between TSPs/NTWCs and Regional/National Met Services to monitor and warn for meteo-tsunamis
4. Write a report to submit to the TT TWO for its next session in February 2023

Members: Mike Angove (chair), Philip Chu, Sebastian Monserrat, Alexander Rabinovich, Vasily Titov, Ivica Vilibic

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Germany-Indonesia Tsunami Risk Project (2021+)

Characterization of the threat

Earthquake

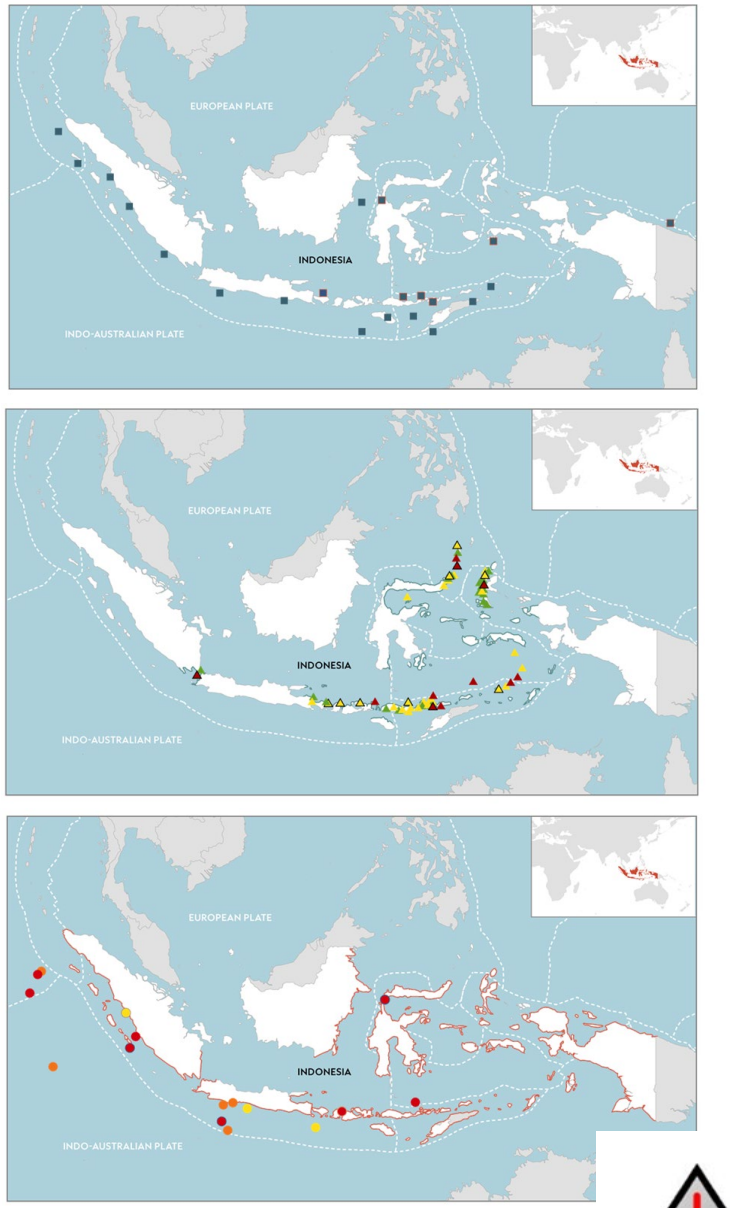
Characteristics and impacts of recent earthquake-tsunami related events (2006-2022) in Indonesia

Landslide

Locations of historical landslide tsunamis in Indonesia and places of geophysical evidence for submarine landslides. Assumptions on characteristics of landslide induced tsunamis

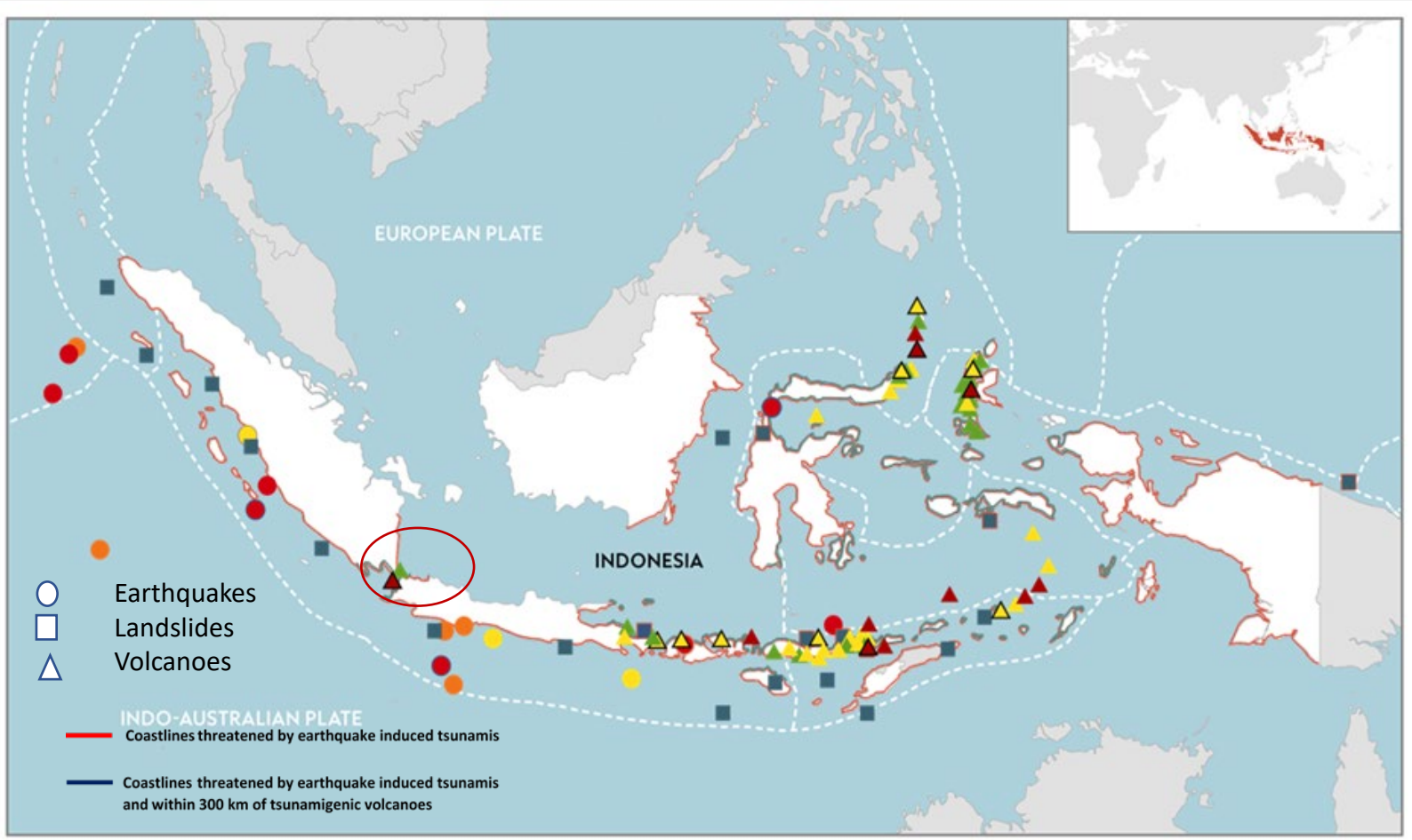
Volcano

Location and categorization of tsunamigenic volcanoes and outline of regional impact zone (300 km). Characteristics of volcanic tsunamis generated by different source mechanism.



Germany-Indonesia Tsunami Risk Project (2021+)

The spatial distribution of the tsunami threat in Indonesia



Germany-Indonesia Tsunami Risk Project (2021+)

DISASTER RISK MANAGEMENT STRATEGIES

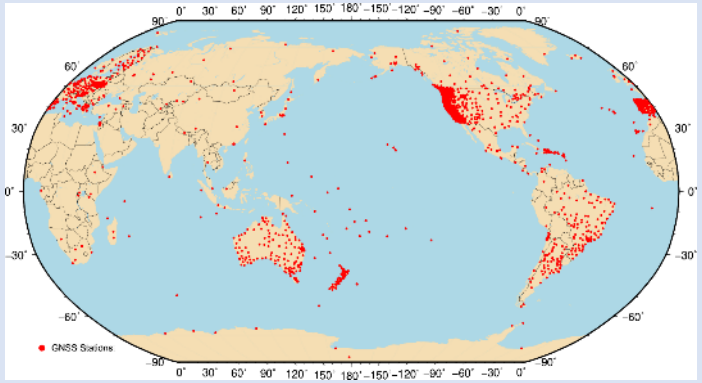
- In addition to knowledge of the different tsunami source areas, information about the coastal areas at risk is particularly relevant. In this regard, **it is essential that communities understand which sections of the coast are at risk from which types of tsunami**.
- The spatial distribution of the different types of tsunami threat to coastal areas in Indonesia reveals quite clear patterns. From this pattern, **three basic types of tsunami threat scenarios for communities** can be deducted:

Scenario	EQ Near-field	EQ Far-field	Land-slide	Volcanic < 300 km	Volcanic > 300 km	Provinces
1						Aceh, North Sumatra, West Sumatra, Bengkulu, West-Java, Central Java, Yogyakarta,
2		Minor threat				Lampung, Banten, East-Java, Bali, West Nusa Tenggara, East Nus Tenggara, West Papua, Maluku, North Maluku, North Sulawesi, Gorontalo, Central Sulawesi, South East Sulawesi, South Sulawesi
3		Minor threat			Minor threat	Papua, West Sulawesi, North Kalimantan, East Kalimantan, South Kalimantan

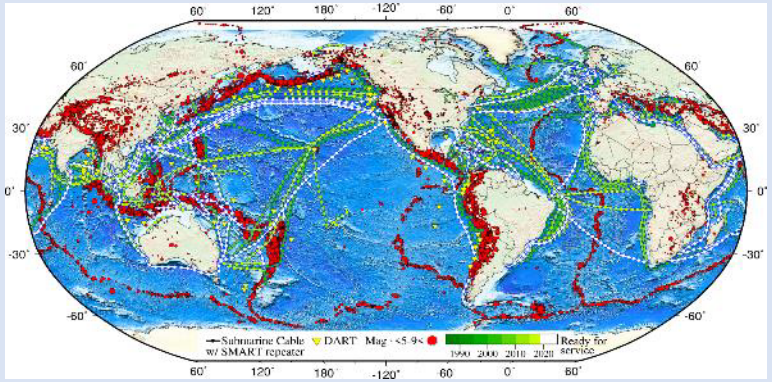
UN Ocean Decade Tsunami Programme

Includes a **Science Plan** being developed for tsunami warning & mitigation system development.
The **Vision** is based on two over-arching aspects:

1. Explore technological and observational advances to **lower uncertainties and improve timeliness of tsunami detection and warnings.**
2. Match these capability advancements with improved community preparedness efforts, including striving for **100% Tsunami Ready or comparable recognition of all at-risk coastlines.**



Eg use of Global Navigation Satellite System (**GNSS**)



Eg instrumentation of sub-sea communication (**SMART**) cables

Tsunami **Ready**

Establish Tsunami Ready Coalition

UN OCEAN DECADE TSUNAMI PROGRAMME
Draft Science Plan

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Table 1, Specific **aspirational** targets of the UNODTP related to tsunami detection, analysis and forecasting are as follows:

Tsunami Source	**Initial indicators** (time after origin)	**Source partially constrained** (time after origin)	**Source fully constrained** (time after origin)
Earthquake	3min	10min	45 mins
Non-EQ (known)	10mins	45mins	1hr
Non-EQ (unknown)	45 mins	1hr	90mins

Achieving the aspirational goals in Table 1 will require investigation of four focus areas including:

(1) Maximizing current capabilities and instrumentation;
(2) expanding current instrumentation grid;
(3) Identify capabilities that exist but are not currently applied to tsunami and
(4) Identifying new capabilities that require development.

For each focus area it will be necessary to estimate the quantitative improved accuracy and timeliness in relation to the aspirational targets to justify implementation.


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2021 2030 United Nations Decade of Ocean Science for Sustainable Development
Safe Ocean Laboratory Satellite Activity:
FURTHER CHALLENGES FOR WARNINGS OF TSUNAMIS
6 - 7 April 2022

Non-seismic and complex source generated tsunamis and Tsunami Ready Recognition Programme

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- Hazard assessment… identify areas where volcanoes, submarine sediment, and meteorological conditions may also lead to tsunamis being generated (usually local tsunamis) **(ASSESS-1)**
- Need consider multi-hazard cascading risk **(ASSESS-1)**
- As mostly only local tsunamis generated, need further educate communities about natural warning signs associated with tsunamis generated by non-seismic and complex sources and do exercises to test **(PREP-2, -3, -5)**
- In warnings don't confuse communities by differentiating and providing scientific explanation about what generated the tsunami…. All they need/want to know is a tsunami is coming and what to do **RESP-3, -4)**

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THANK YOU