BMKG

Badan Meteorologi Klimatologi dan Geofisika

Indonesia's Tsunami Early Warning and Mitigation Efforts

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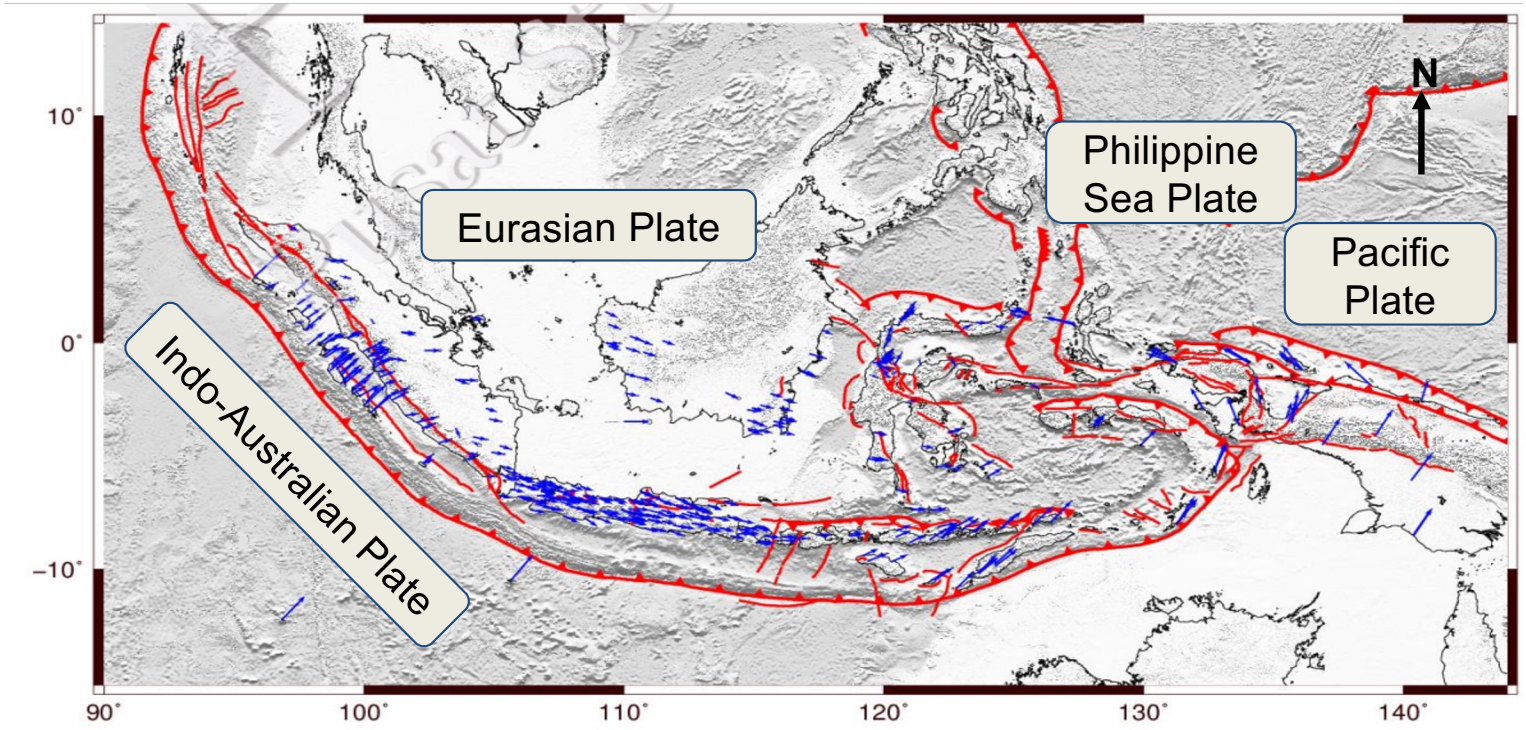
Geophysics Analyst

OUTLINE

1. Introduction
2. Overview of Indonesia's Tsunami Warning System
3. Mitigation Strategies
4. Standard Operating Procedures (SOPs)

INTRODUCTION



LEGEND:

: Direction of the subduction

: Vector movement of the plate tectonics

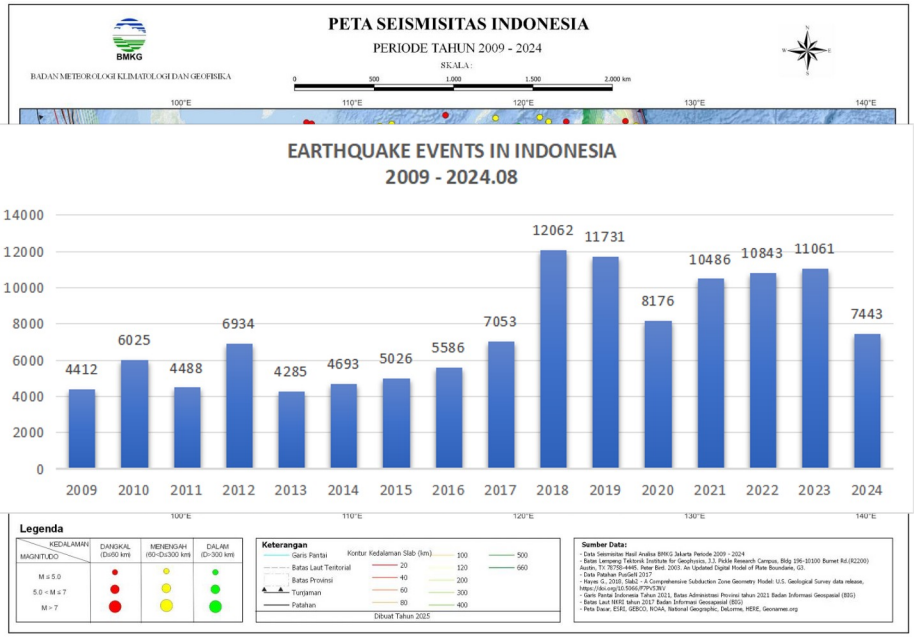
https://geology.com/world/indonesia-satellite-image.shtml

Tectonic setting of Indonesia (Modified from Irsyam et al., 2017)

INTRODUCTION

Seismicity of Indonesia

- Indonesia is one of the most seismically active areas.
- On average, about **7,524 earthquakes** occur annually.
- The number of earthquakes **drastically increased in 2018** due to the earthquake sequences in **Palu, Mamuju, and Lombok.**



(BMKG)

INTRODUCTION

Some notable destructive earthquakes and tsunamis are :

1. **2004 Aceh-Andaman (≥200,000 casualties)**
2. **2018 Palu (≥2,000 casualties)**
3. **2018 Sunda Strait (≥400 casualties)**

2004 Aceh
(DW, 2021)

2018 Sunda Strait
(Reuters, 2023)

2018 Palu
(Kompas, 2021)

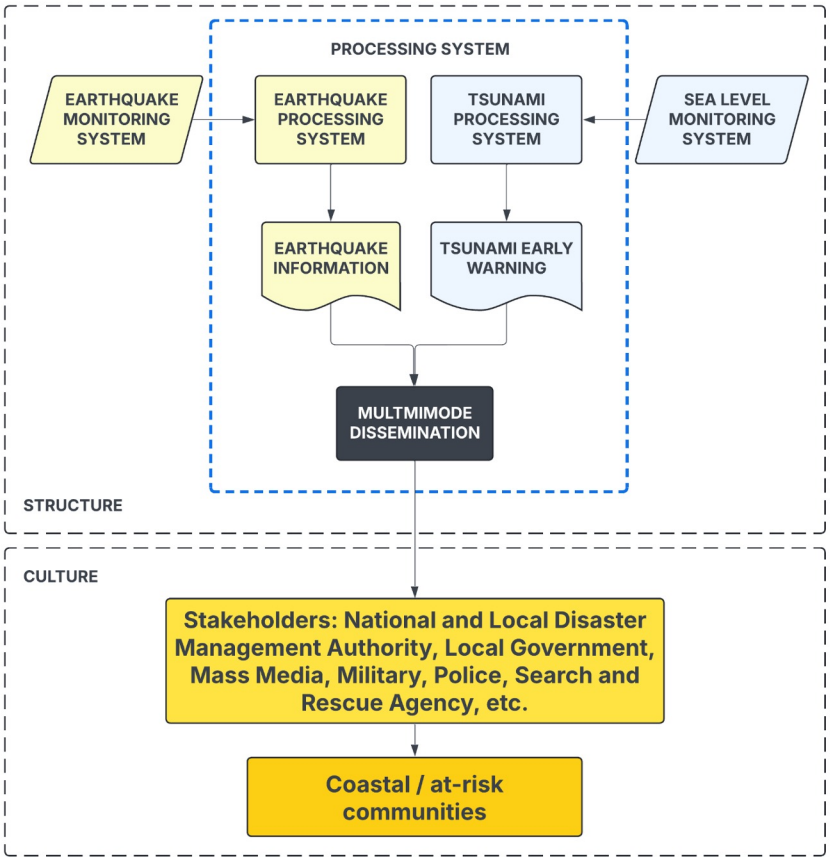
OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

- Indonesia Tsunami Early Warning System (InaTEWS) was inaugurated on **11 November 2008.**
- InaTEWS was developed with the **support of some countries**, such as Germany, Japan, China, etc.
- InaTEWS provides earthquake and tsunami information **not only for national areas but also for Southeast Asia and Indian Ocean countries.**

InaTEWS Command Center (2008)

InaTEWS Command Center (2025)

OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM



BMKG's Processing System Flowchart

Earthquake monitoring system includes:

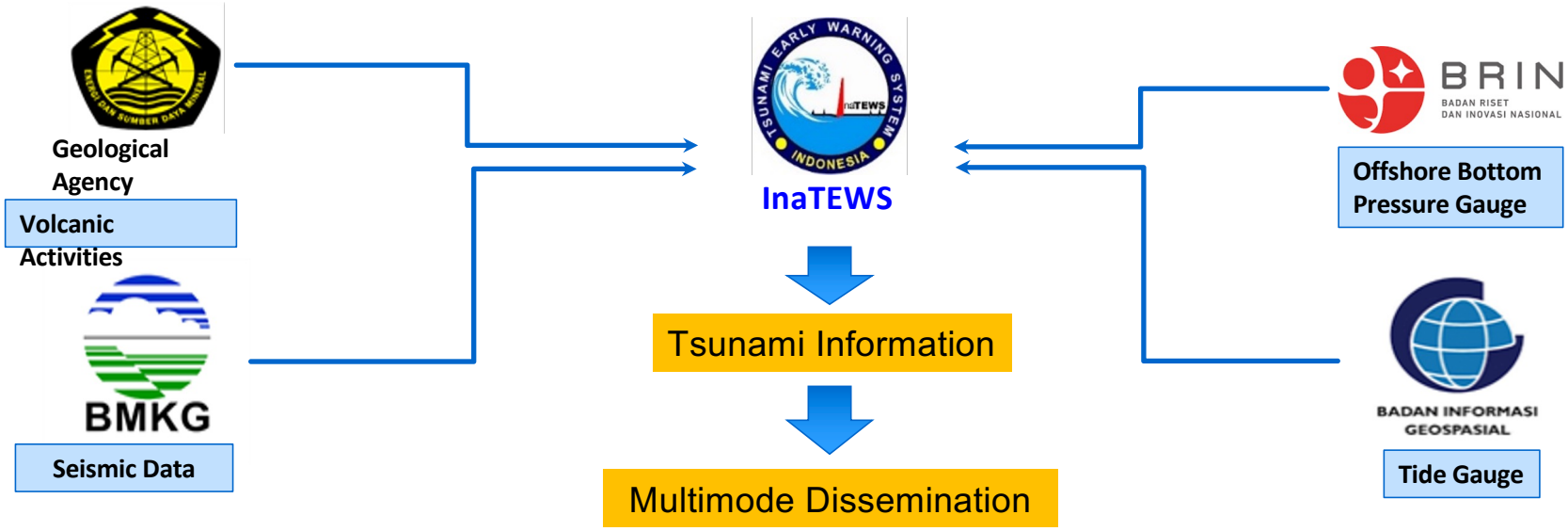
1. Seismometers
2. Accelerometers

Sea level monitoring system includes:

1. Tide gauges (radar, pressure, and encoder sensors)
2. Buoys

OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

Volcanic Tsunami Monitoring (Presidential Decree No. 93 Year 2019)



After the 2018 Sunda Strait volcanic tsunami event, the InaTEWS started to monitor the tsunami from the volcanic activities.

OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

Observation System

- **549 seismic stations** have been deployed in Indonesia.
- BMKG also operated **697 accelerometer** for strong motion monitoring
- Additionally, BMKG collects **real-time seismic data from other international networks** for earthquake monitoring.

OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

Observation System

- **416 sea level observations** are operated to support the InaTEWS.
- Type of sea level observation:

  1) Coastal tide gauge,

  2) Offshore bottom pressure gauge

  3) High Frequency Radar.

Sea Level Observations Distribution in Indonesia

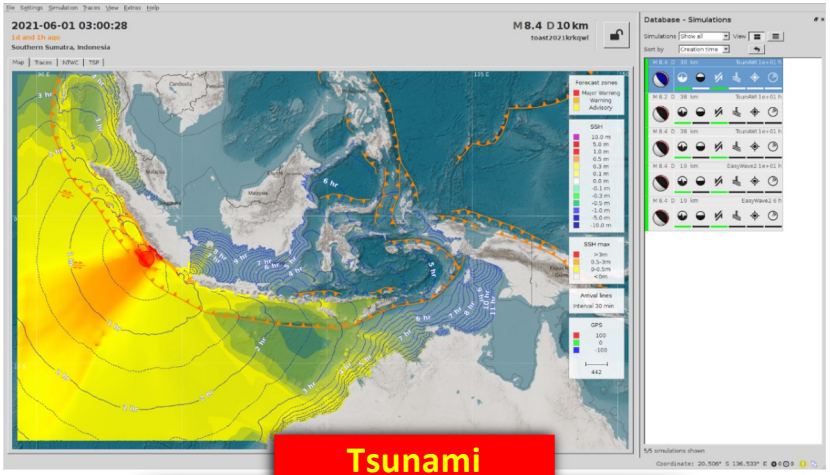
OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

PROCESSING SYSTEM

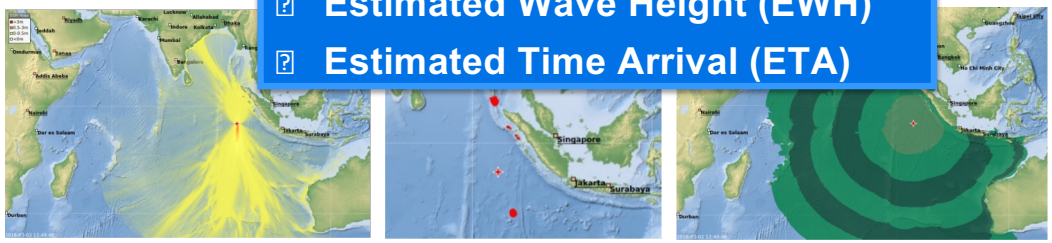
SeisComP – Earthquake Analysis

- Origin Time
- Magnitude
- Depth
- Epicenter

TOAST (Tsunami Observation And Simulation Terminal) -
real-time simulation and pre-calculated tsunami database (+ 22,000 scenarios)



- Estimated Wave Height (EWH)
- Estimated Time Arrival (ETA)



(Original slide from BMKG)

OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

Warning Level	Advice from BMKG to Local Government
MAJOR WARNING (AWAS)	Province/District/City government that are at "**Major Warning**" level are expected to pay attention to this warning and immediately guide their communities for **full evacuation.**
WARNING (SIAGA)	Province/District/City government that are at "**Warning**" level are expected to pay attention to this warning and immediately guide their communities for **evacuation.**
ADVISORY (WASPADA)	Province/District/City government that are at "**Advisory**" level are expected to pay attention to this warning and immediately guide their communities to **move away from the beach and river banks.**

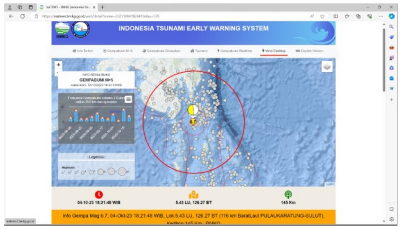
OVERVIEW OF INDONESIA'S TSUNAMI WARNING SYSTEM

Dissemination system

SMS

Fax

Email

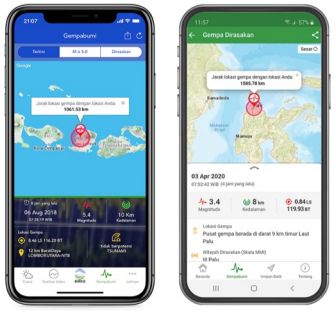


WEB

TV, Radio

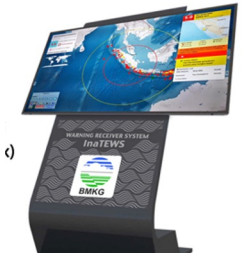
InfoBMKG

Smartphone Application



Info BMKG

WRS - BMKG



Warning Receiver System

MITIGATION STRATEGIES

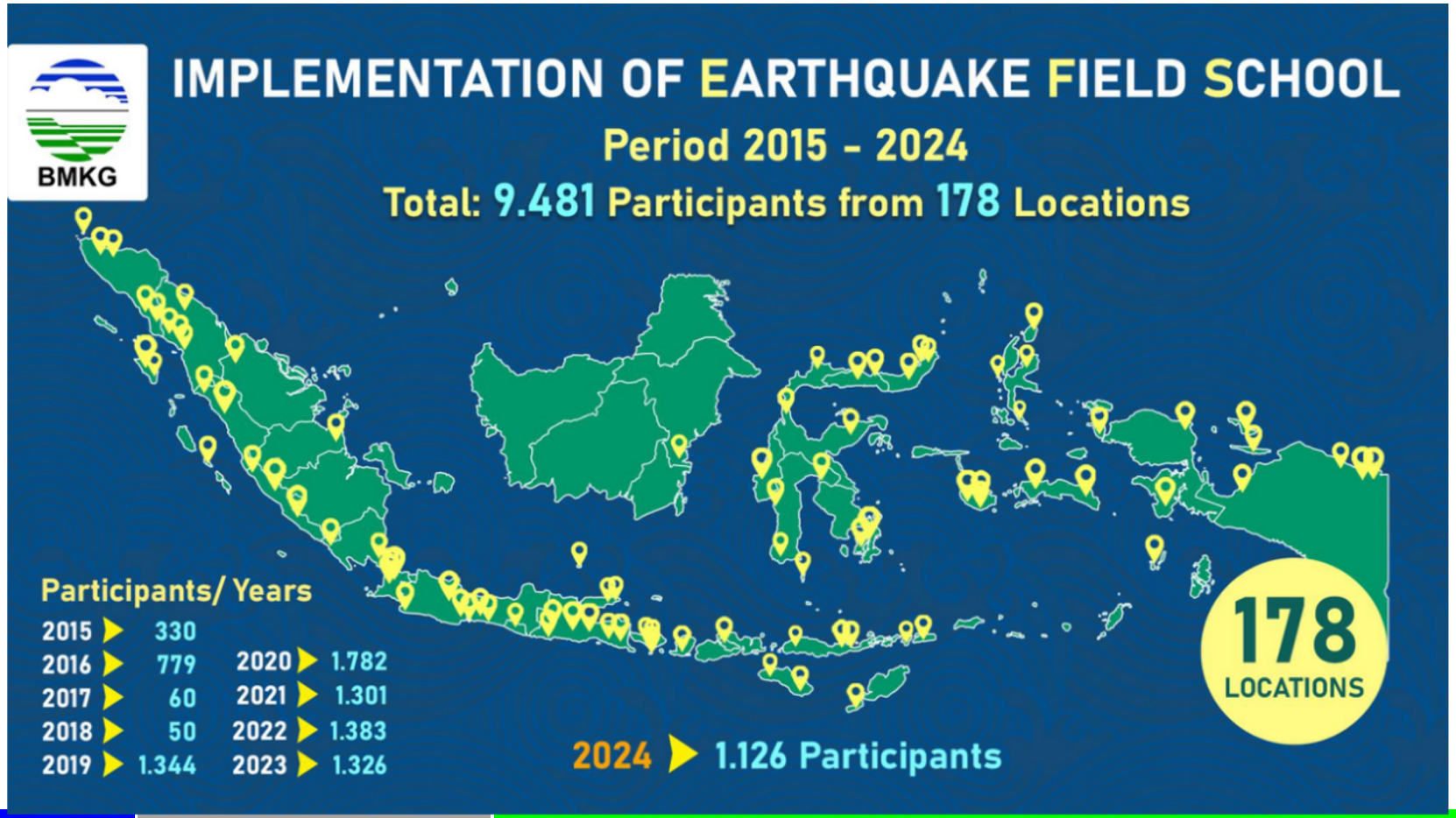
- BMKG conducts several **community capacity-building activities** to increase the awareness of the community :
  1. Earthquake Field Course (*Sekolah Lapang Gempabumi, SLG*)
  2. BMKG Goes to School
  3. Tsunami Ready Community
- The other institutions (i.e., **Disaster Management Agency, Universities, Research and Innovation Agency, and Non-Governmental Organizations**) are also involved in the capacity building activities.

Earthquake Field Course in North Sumatra, Sumatra (2021)

BMKG Goes to School in Manado, Sulawesi (2021)

Tsunami Ready Community in Tanjung Benoa, Bali (2025)

MITIGATION STRATEGIES

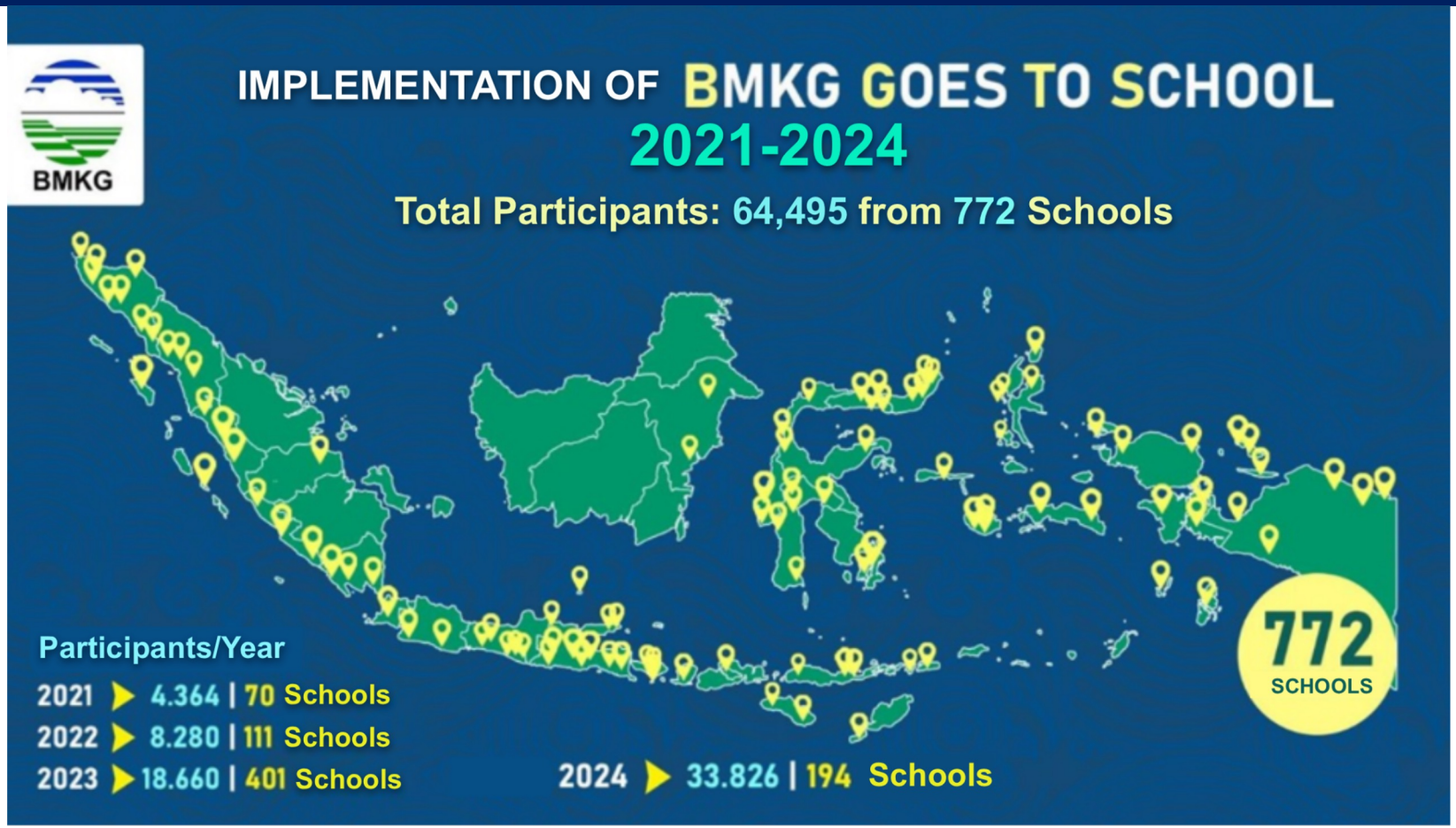


MITIGATION STRATEGIES

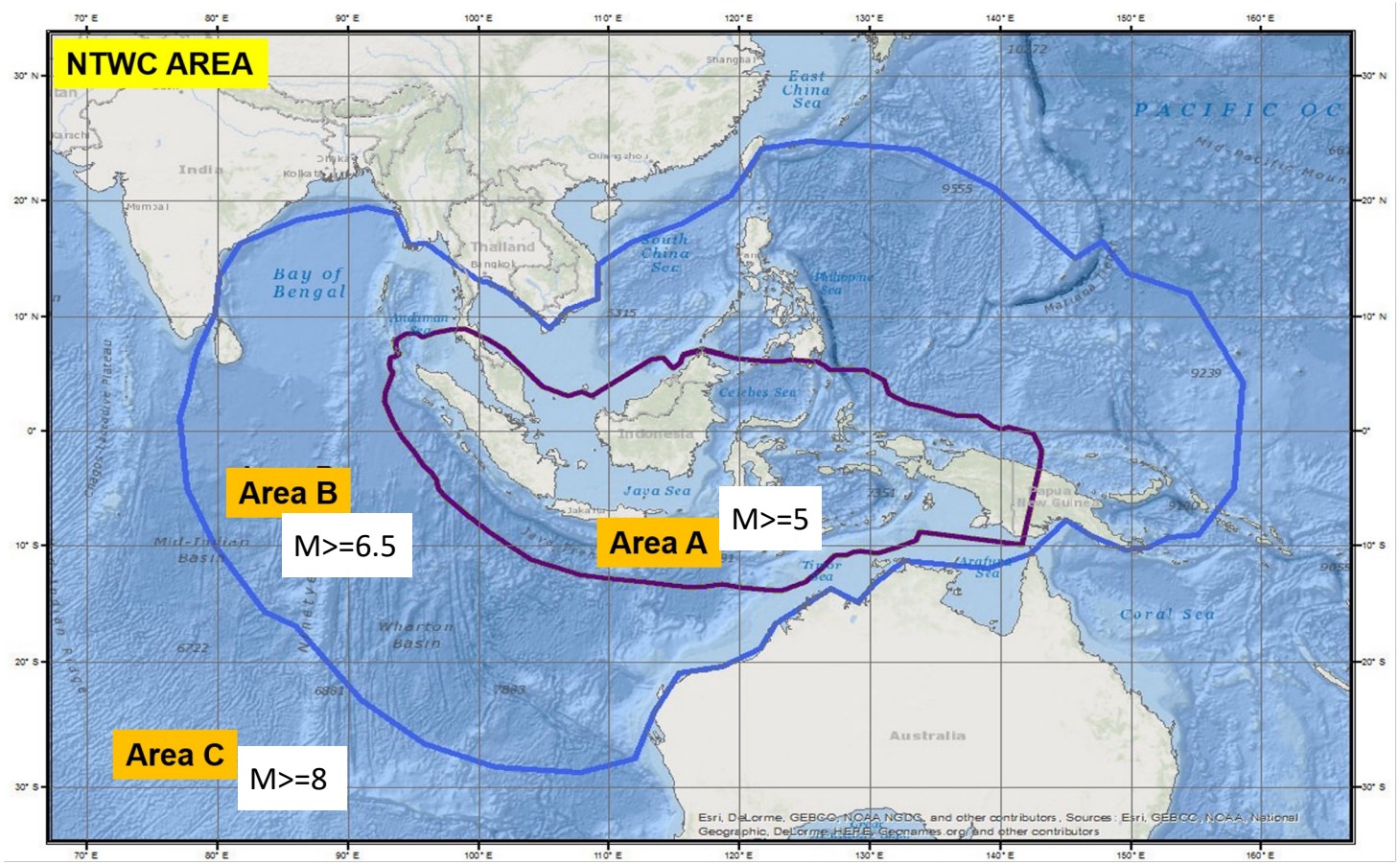
MITIGATION STRATEGIES

	TSUNAMI READY INDICATORS
I	**ASSESSMENT (ASSESS)**
1	**ASSESS-1**. Tsunami hazard zones are mapped and designated.
2	**ASSESS-2**. The number of people at risk in the tsunami hazard zone is estimated.
3	**ASSESS-3**. Economic, infrastructural, political, and social resources are identified.
II	**PREPAREDNESS (PREP)**
4	**PREP-1**. Easily understood tsunami evacuation maps are approved.
5	**PREP-2**. Tsunami information including signage is publicly displayed.
6	**PREP-3**. Outreach and public awareness and education resources are available and distributed.
7	**PREP-4**. Outreach or educational activities are held at least 3 times a year.
8	**PREP-5**: A community tsunami exercise is conducted at least every two years.
III	**RESPONSE (RESP)**
9	**RESP-1**. A community tsunami emergency response plan is approved.
10	**RESP-2**. The capacity to manage emergency response operations during a tsunami is in place.
11	**RESP-3**. Redundant and reliable means to timely receive 24-hour official tsunami alerts are in place.
12	**RESP-4**. Redundant and reliable means to timely disseminate 24-hour official tsunami alerts to the public are in place.

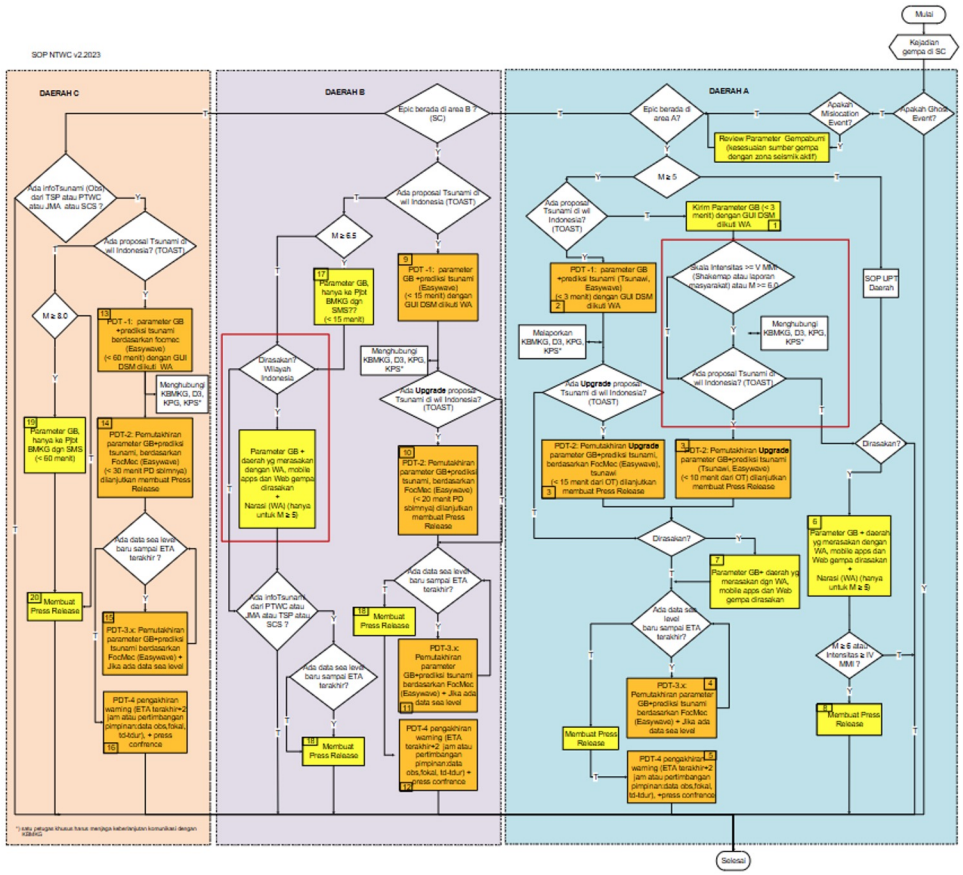
MITIGATION STRATEGIES



STANDARD OPERATING PROCEDURE (SOP)



STANDARD OPERATING PROCEDURE (SOP)



SOP of National Tsunami Warning Center (NTWC)

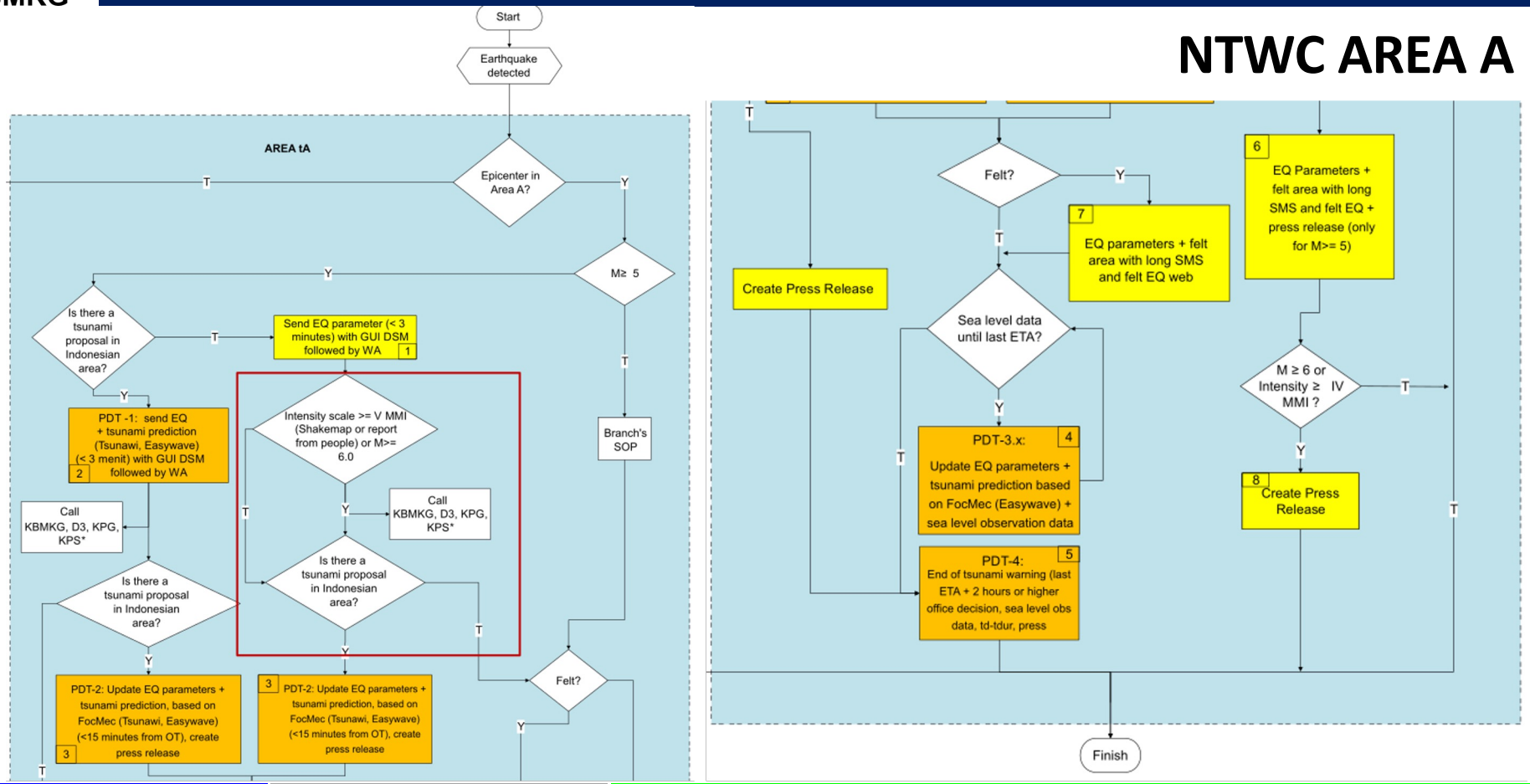
Area A: M≥5

Area B: M≥6.5

Area C: M≥8

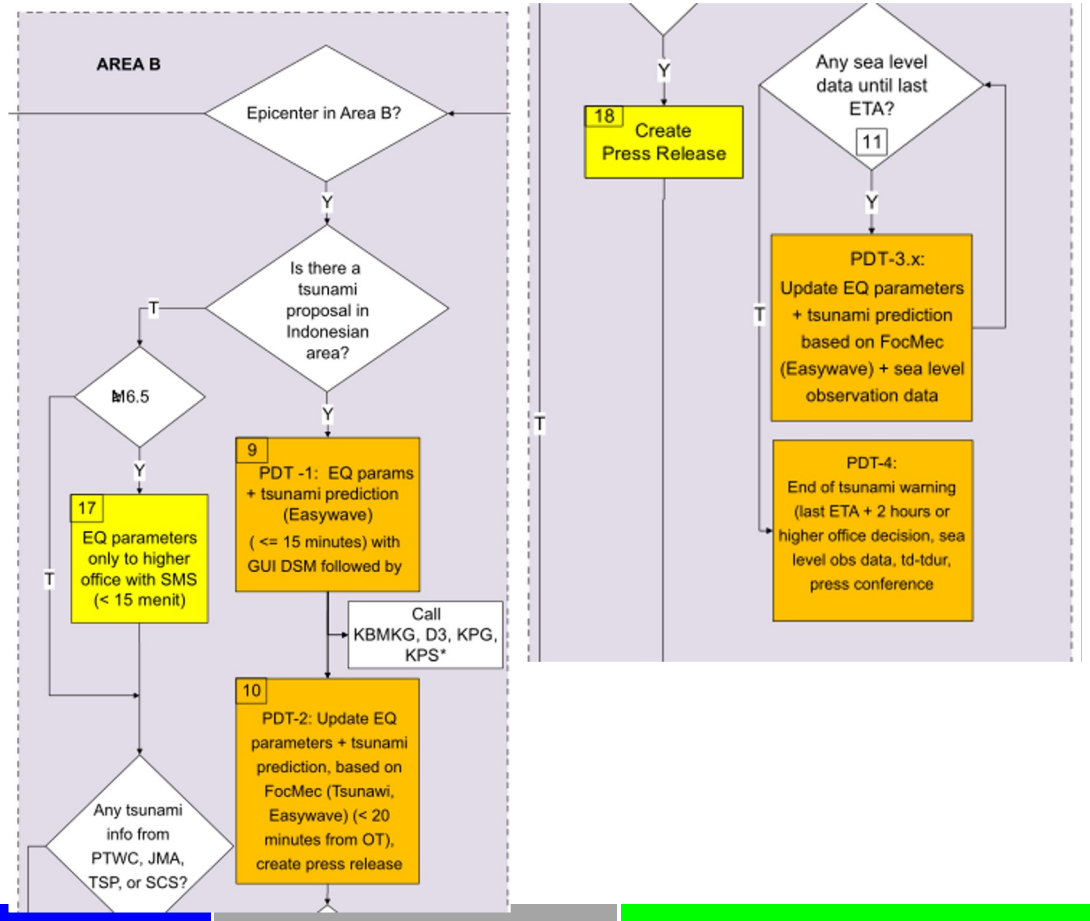
STANDARD OPERATING PROCEDURE (SOP)

NTWC AREA A



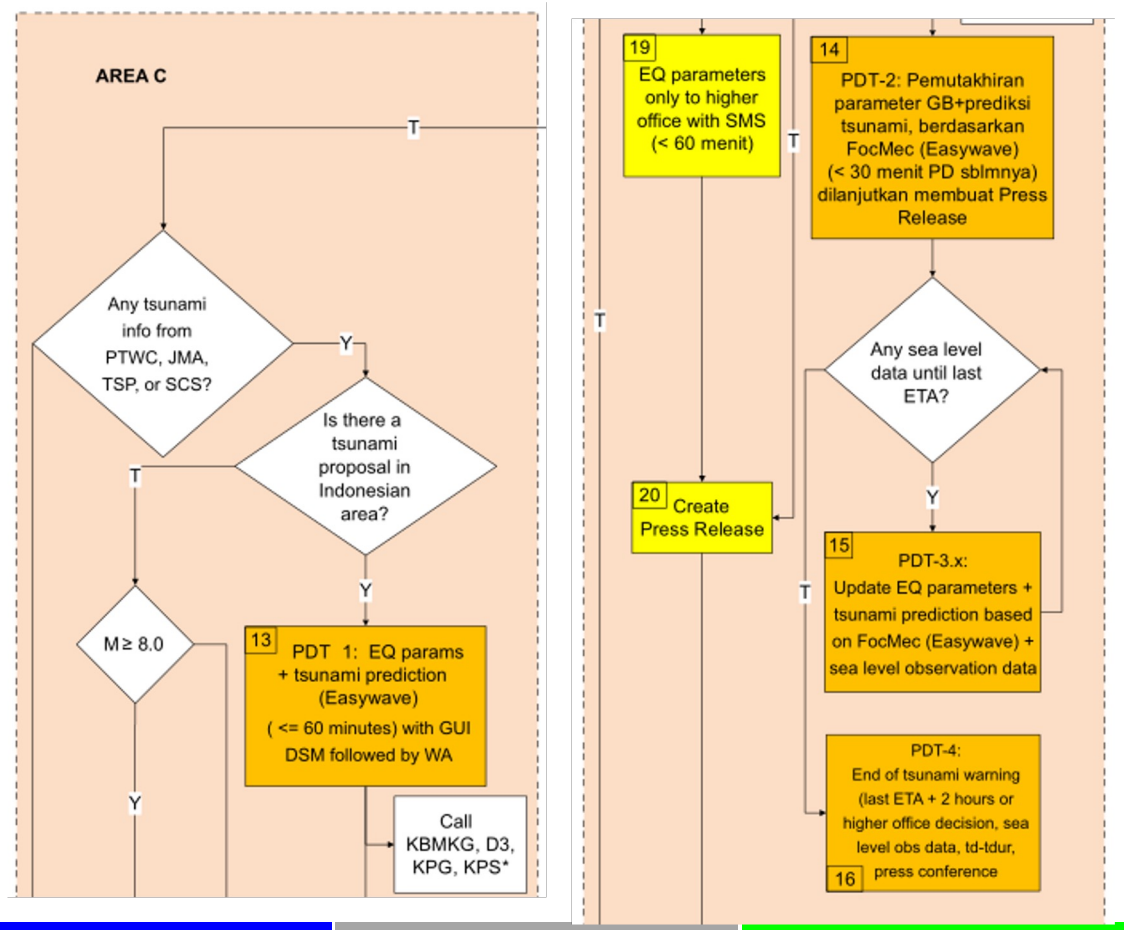
STANDARD OPERATING PROCEDURE (SOP)

NTWC AREA B

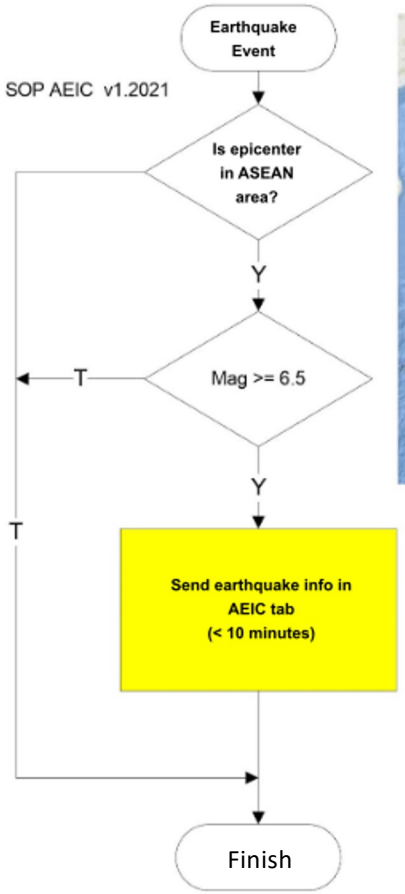


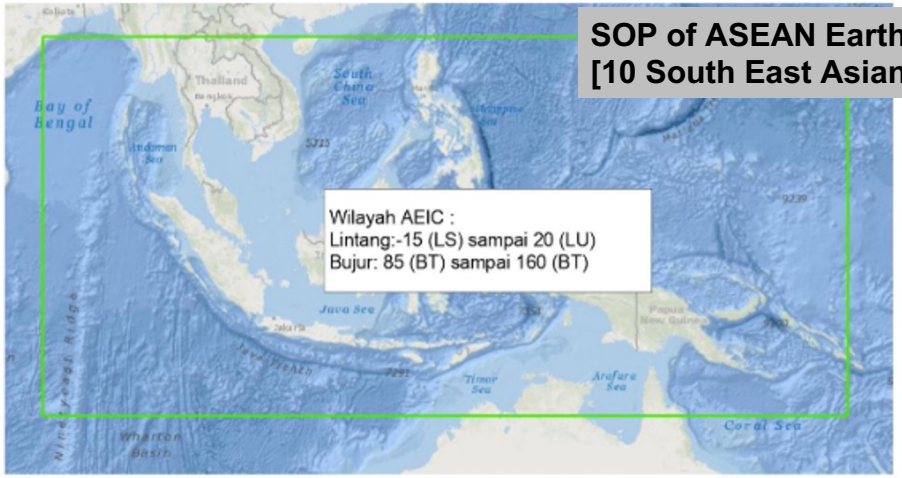
STANDARD OPERATING PROCEDURE (SOP)

NTWC AREA C

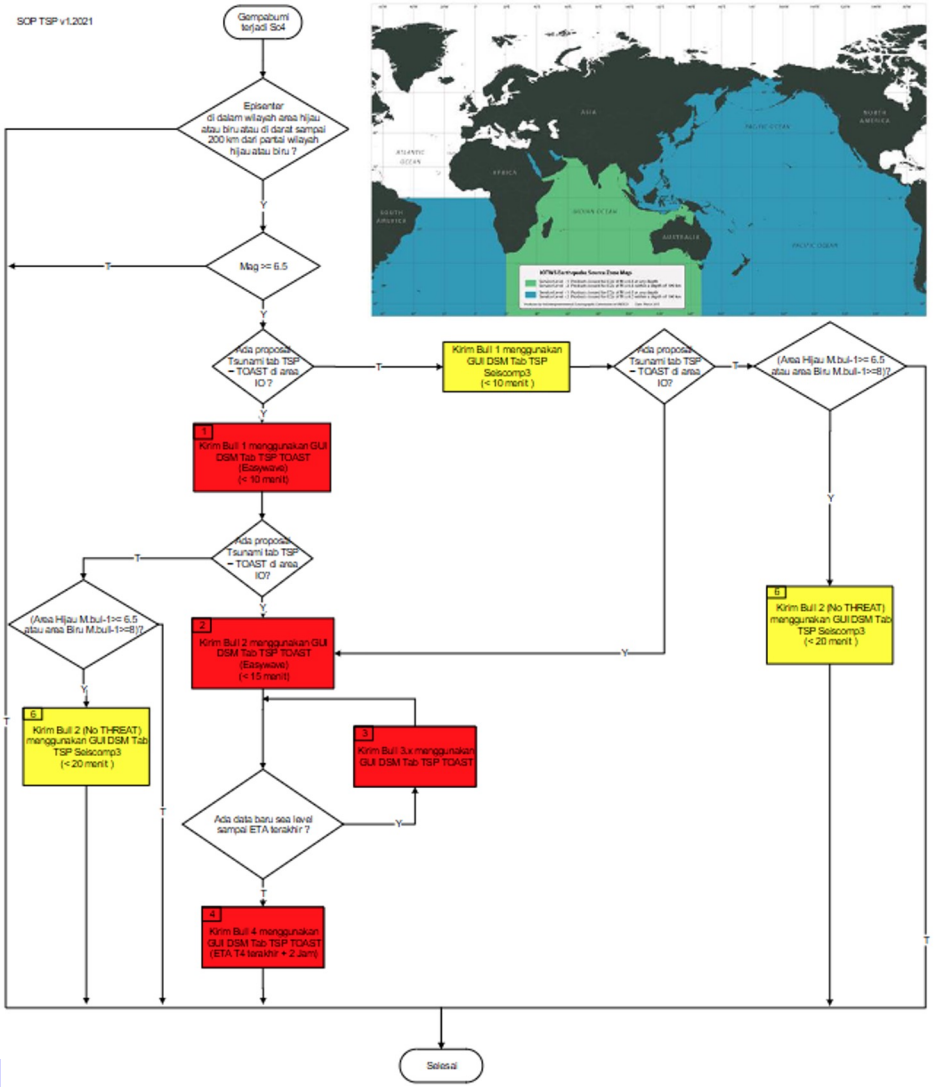


STANDARD OPERATING PROCEDURE (SOP)





SOP of ASEAN Earthquake Information Center (AEIC) [10 South East Asian Countries]

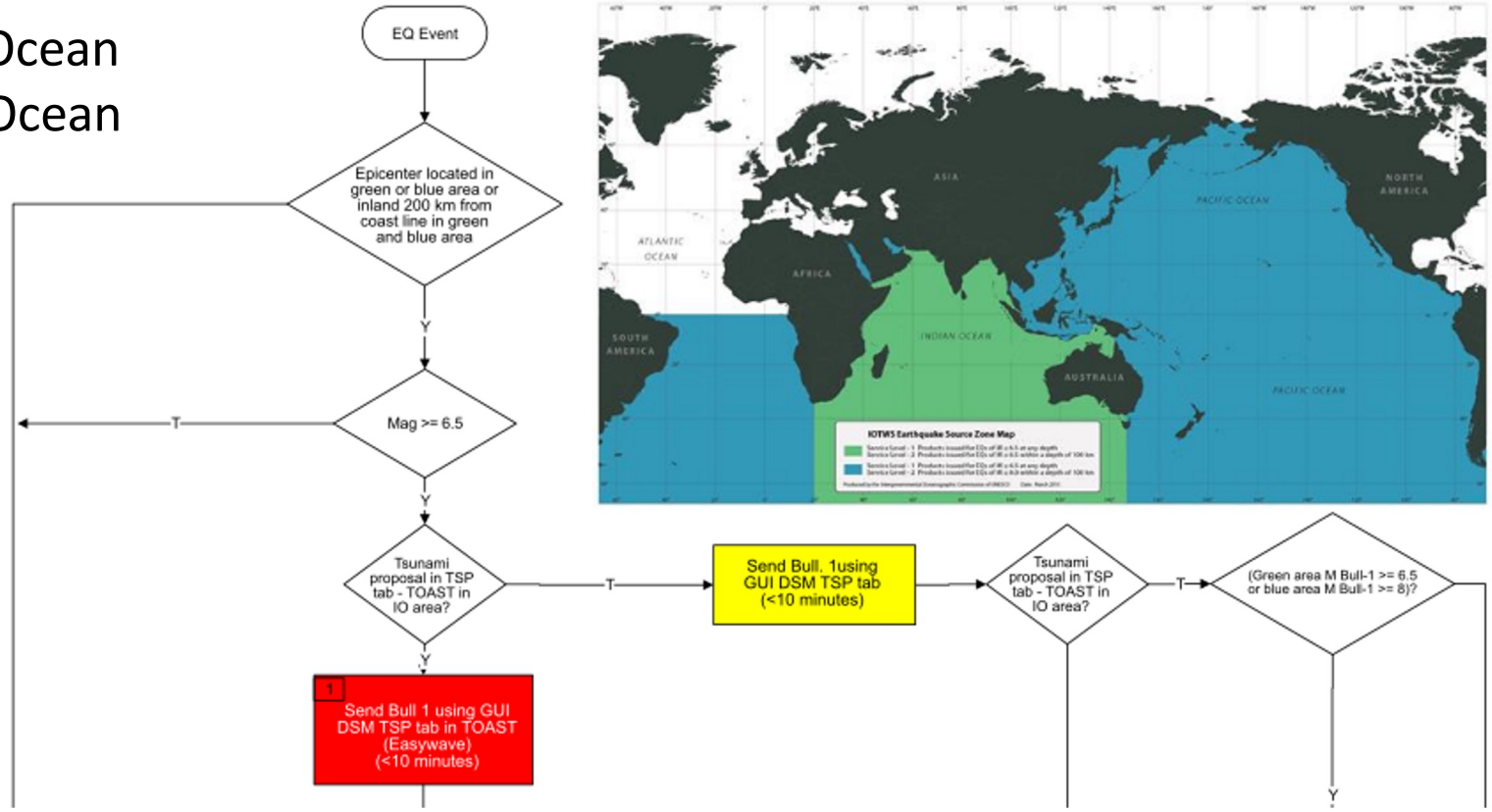


SOP of Tsunami Service Provider (TSP) [24 Indian Ocean Countries]

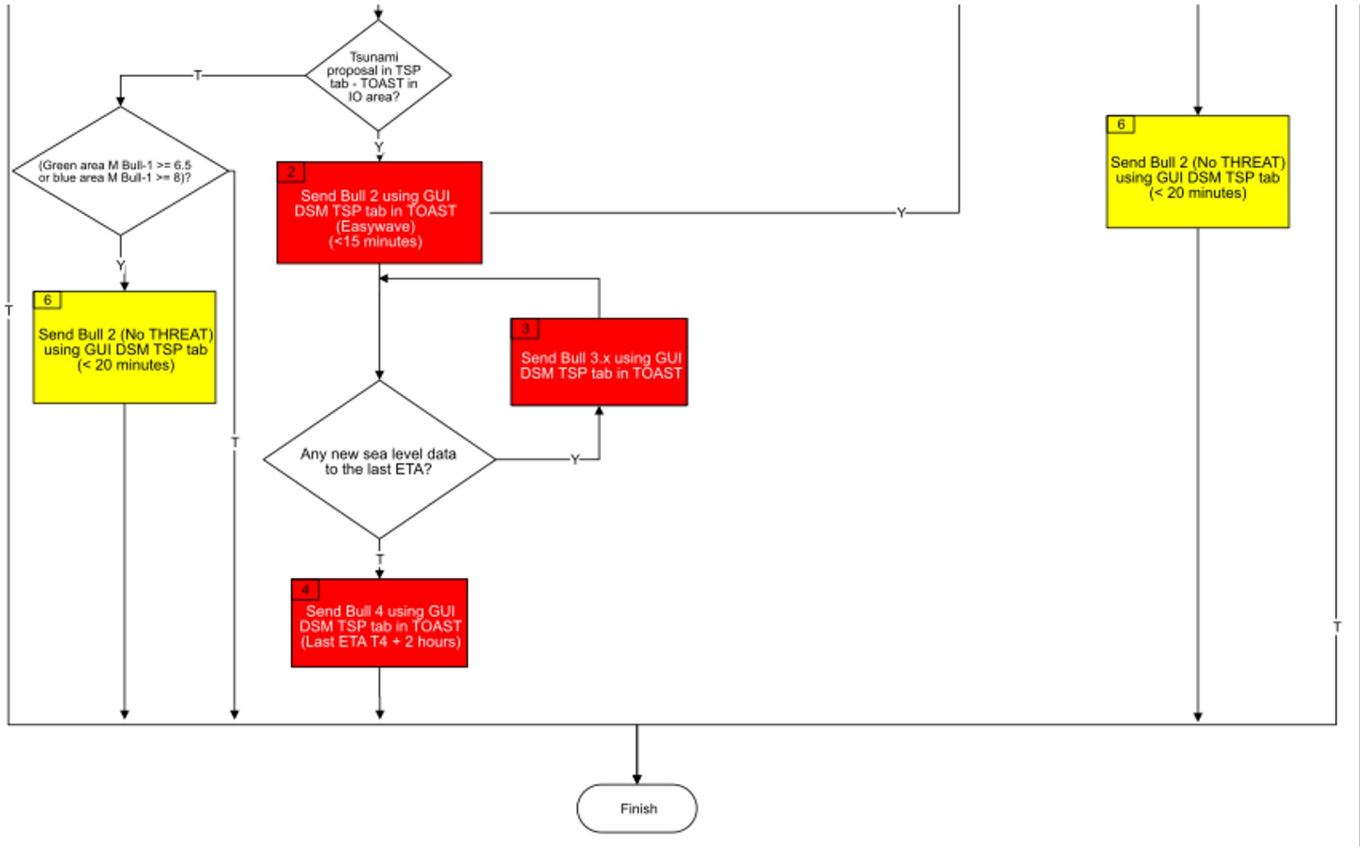
- Indian Ocean
- Pasific Ocean

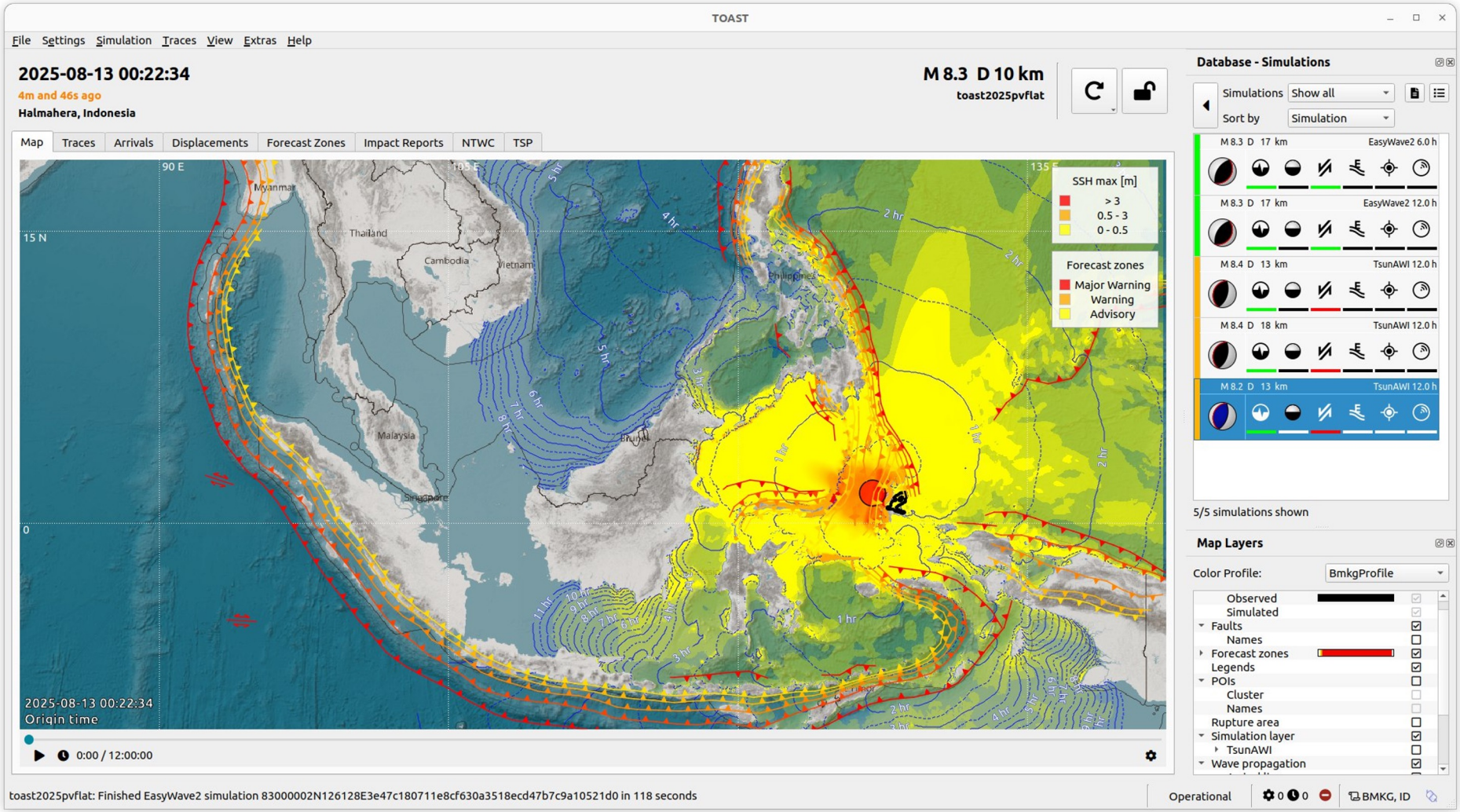
STANDARD OPERATING PROCEDURE (SOP)

- Indian Ocean
- Pasific Ocean



STANDARD OPERATING PROCEDURE (SOP)




TOAST
File Settings Simulation Traces View Extras Help
2025-08-13 00:22:34
4m and 46s ago
Halmahera, Indonesia
M 8.3 D 10 km
toast2025pvflat
Map Traces Arrivals Displacements Forecast Zones Impact Reports NTWC TSP
SSH max [m]
> 3
0.5 - 3
0 - 0.5
Forecast zones
Major Warning
Warning
Advisory
Myanmar
Thailand
Cambodia
Vietnam
Philippines
Malaysia
Brunei
Singapore
90 E
135 E
15 N
0
2025-08-13 00:22:34
Origin time
0:00 / 12:00:00
Database - Simulations
Simulations Show all
Sort by Simulation
M 8.3 D 17 km EasyWave2 6.0 h
M 8.3 D 17 km EasyWave2 12.0 h
M 8.4 D 13 km TsunAWI 12.0 h
M 8.4 D 18 km TsunAWI 12.0 h
M 8.2 D 13 km TsunAWI 12.0 h
5/5 simulations shown
Map Layers
Color Profile: BmkgProfile
Observed
Simulated
Faults
Names
Forecast zones
Legends
POIs
Cluster
Names
Rupture area
Simulation layer
TsunAWI
Wave propagation
toast2025pvflat: Finished EasyWave2 simulation 83000002N126128E3e47c180711e8cf630a3518ecd47b7c9a10521d0 in 118 seconds
Operational
BMKG, ID


D1 SEISMIC PROCESSING SYSTEM (SEISCOMP3)
Latitude: 0.09 °S
Longitude: 126.61 °E
Depth: 30 km
Phase Count: 22
MS Residual: 0.6
2024-10-05 04:51:39 UTC
44 minutes and 52 seconds ago


InaTNT (D3)
QC(D5)
TOAST (D2)
SeisComP (D1)
Diseminasi (D4)

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Terima Kasih

Thank You

Mahalo