# Knowledge from the 2011 Japan tsunami and tsunami disaster management perspectives under COVID-19 pandemic


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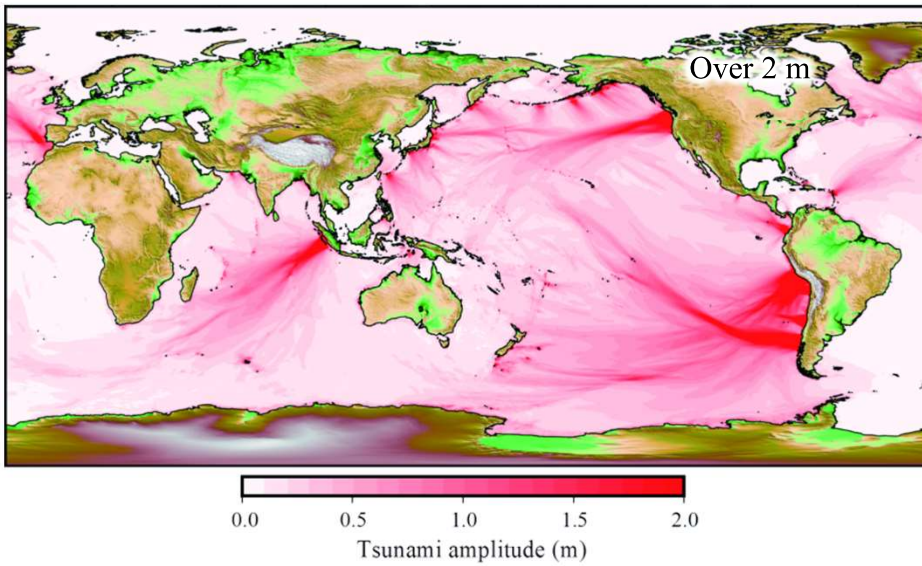
# Contents

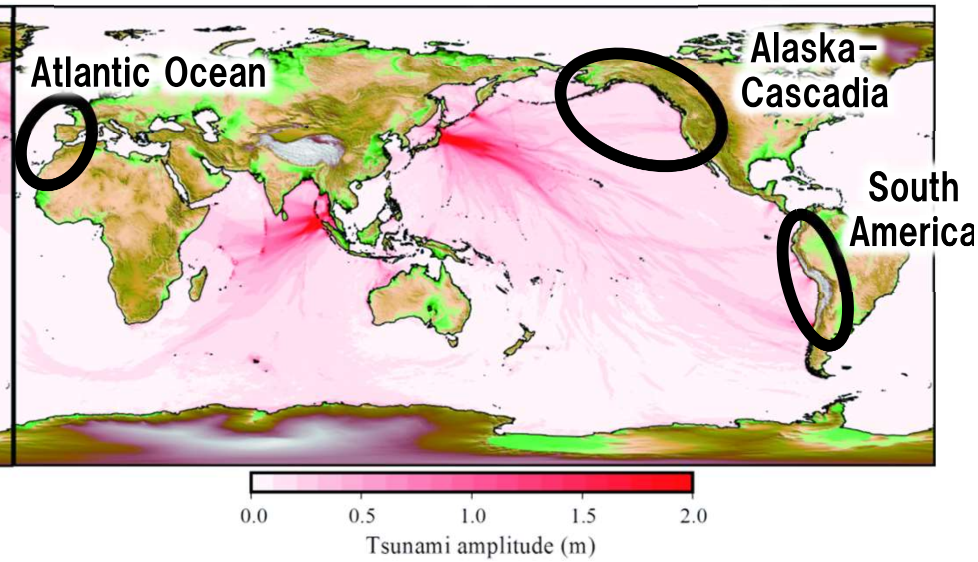
- Historical tsunamis in Japan
- The 2011 Japan tsunami:
  Knowledge and improvement
- Practical information based on recent tsunamis
- Tsunami evacuation during COVID-19

# Tsunami hazards from the last 400 years

1600-1969（64 events）




1970-2016（39 events）




Damaging tsunamis that exceeded 2 m can be seen virtually everywhere, especially along the Pacific Rim including 1700 Cascadia (M9.0), 1755 Lisbon (M8.5), 1833 SW Sumatra (M8.3), 1868 Peru (M8.3), 1906 Ecuador (M8.8) and 1960 Chile (M9.5).

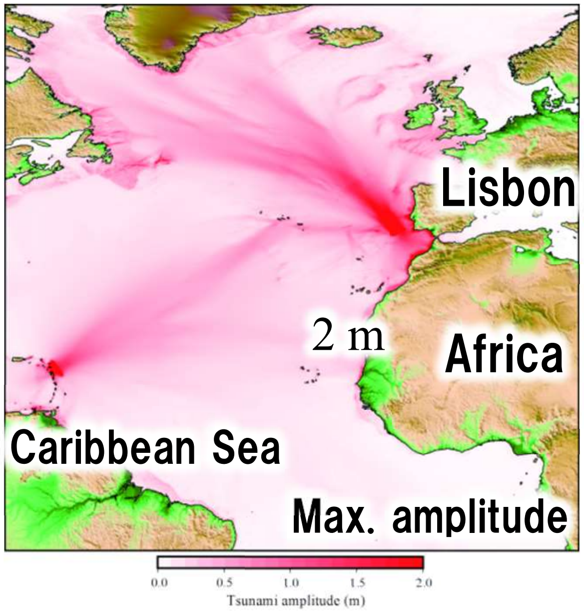
Only two major events, the 2004 Indian Ocean (M9.3) and Great East Japan (M9.0), classified as recent damaging tsunamis that exceeded 2 m and caused global impact meanwhile no major damaging tsunami in the east Pacific and Atlantic Ocean.

This observation demonstrates the importance of assessing or recognizing the hazards based on historical events beyond recent experiences.

# Historical tsunamis in Atlantic Ocean

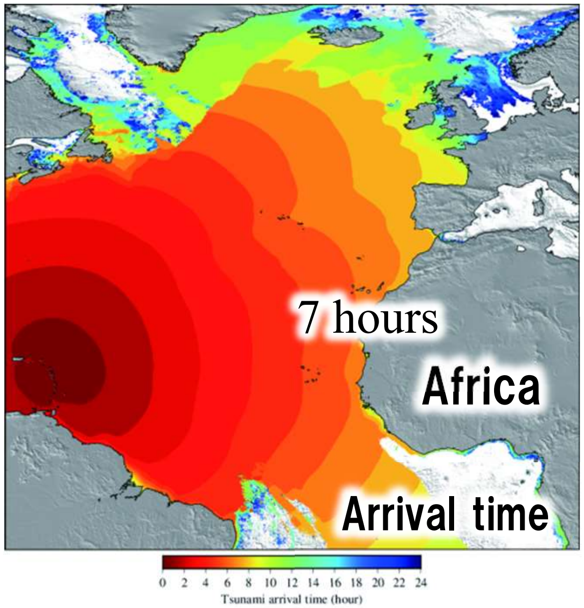
**A region having no major tsunami in this generation:**

**1755 Lisbon and 1843 Caribbean Sea tsunamis**




## Maximum tsunami amplitude

Tsunami from Lisbon could also arrive other parts of the region such as Caribbean Sea. This finding shows an importance in assessing both near-field as well as far-field tsunamis at the same time.

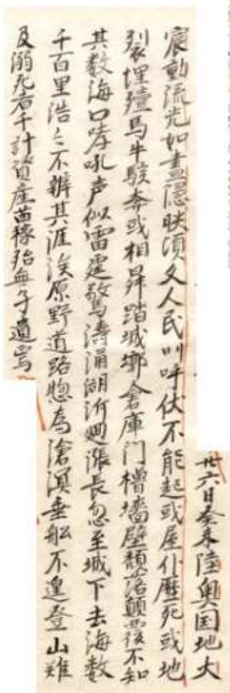



## Tsunami arrival time

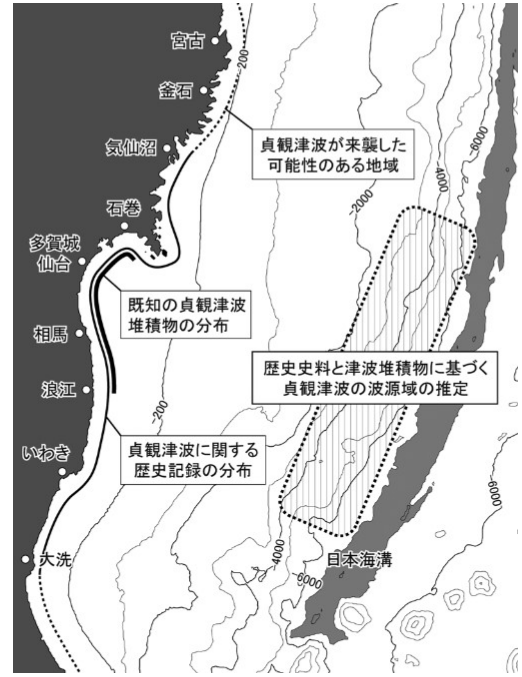
For the NW Africa, tsunami from Lisbon arrives after 1-2 hours but tsunami with the same size from Caribbean Sea arrives NW Africa after 7 hours. This finding shows an importance in assessing in global scale.

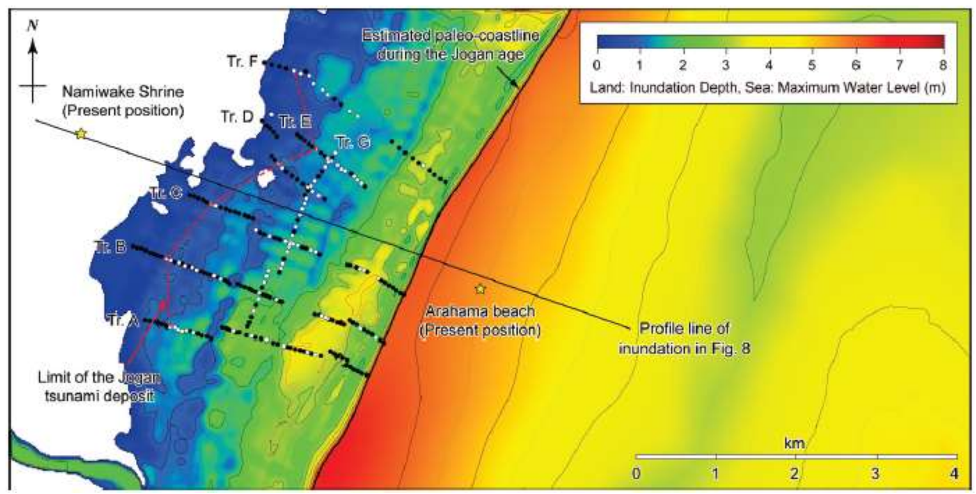
# 869 Jogan tsunami

Record of May 26, 869



廿六日癸未陸奥国地大
震動流光如晝隠映頃之人民叫呼伏不能起或屋仆壓死或地
裂埋殪馬牛駭奔或相昇踏城墎倉庫門櫓墻壁頽落顛覆不知
其數海口哮吼声似雷霆驚濤涌潮泝洄漲長忽至城下去海數
千百里浩々不辨其涯涘原野道路惣為滄溟乗船不遑登山難
及溺死者千許資産苗稼殆無孑遺焉

Source: 'Nihon Sandai-Jitsuroku'
(One of Six Official Chronologies of Ancient Japan)
Imperial Household Agency


http://www.kunaicho.go.jp/e-okotoba/02/address/koen-h24az-mizuforum6th.html

# Learning step by step from historical tsunamis in Japan

- Early period:
  → Felt a shake = tsunami is coming & No tsunami in Japan Sea side
- 1896 Meiji Sanriku tsunami: tsunami-earthquake type
  → Small shake but large tsunami (38.2 m / 22,000 deaths)
- 1933 Showa Sanriku tsunami: Outer-rise earthquake
  → Large shake and large tsunami (28.7 m / 3,000 deaths)
- 1960 Chile tsunami: Far-field tsunami from M9.5 earthquake
  → No shake but large tsunami (10.7 m / 142 deaths)
- 1983 Japan Sea tsunami: The first recent tsunami in Japan Sea
  → Warning after 14 mins but tsunami arrived after 12 mins (14.9 m / 104 deaths)
- 1993 Okushiri tsunami: Just 10 years after the 1983 event
  → Waning after 5 mins but tsunami arrived after 2-7 mins (32.0 m / 230 deaths)
- 2011 Tohoku tsunami: M9.0 never record in Japan
  → Large shake and large tsunami (40.5 m / 19,000 deaths)

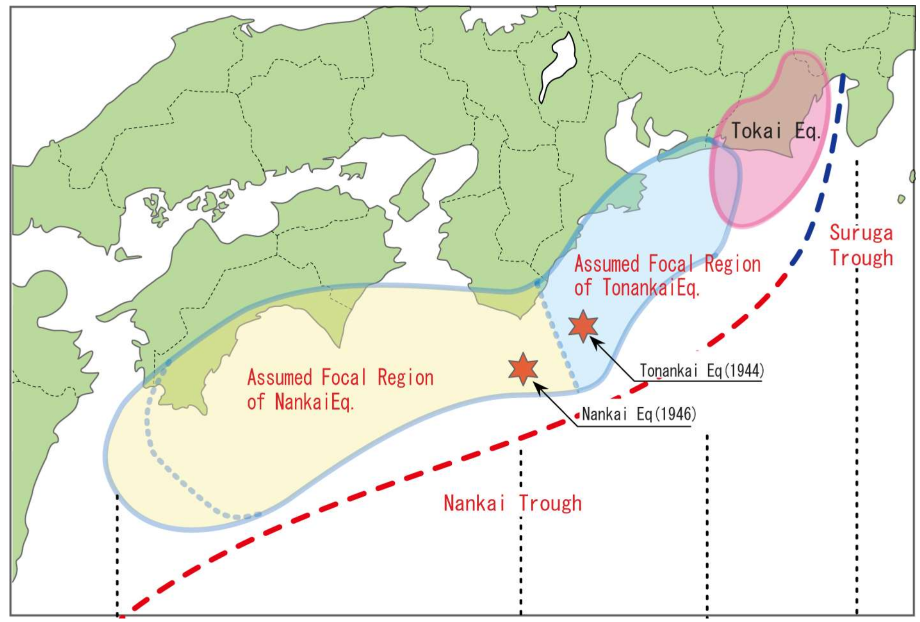
| | **1923 Great Kanto** | **1995 Great Hanshin** | **2011 Great East Japan** |
|---|---|---|---|
| $M_w$ | 7.9 | 6.8 | 9.0 |
| Time | 11:58 | 05:46 | 14:46 |
| Casualty | 105,385 | 6,434 | 18,579 |
| | Fire = 87.1% | Shake = 83.3 % | Tsunami = 92.4 % |
| | Shake = 10.5 % | Fire = 12.8 % | Shake = 4.4 % |

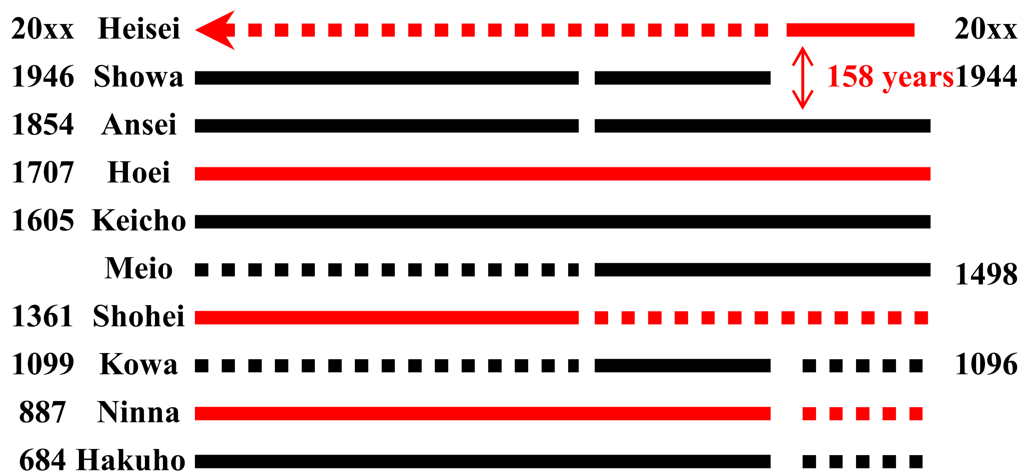
# Condition before March 2011

## Earthquake possibility in Japan


http://www.jishin.go.jp/main/chousa/07_yosokuchizu/img/f1-3-2.jpg

## Tokai-Tonankai-Nankai earthquake

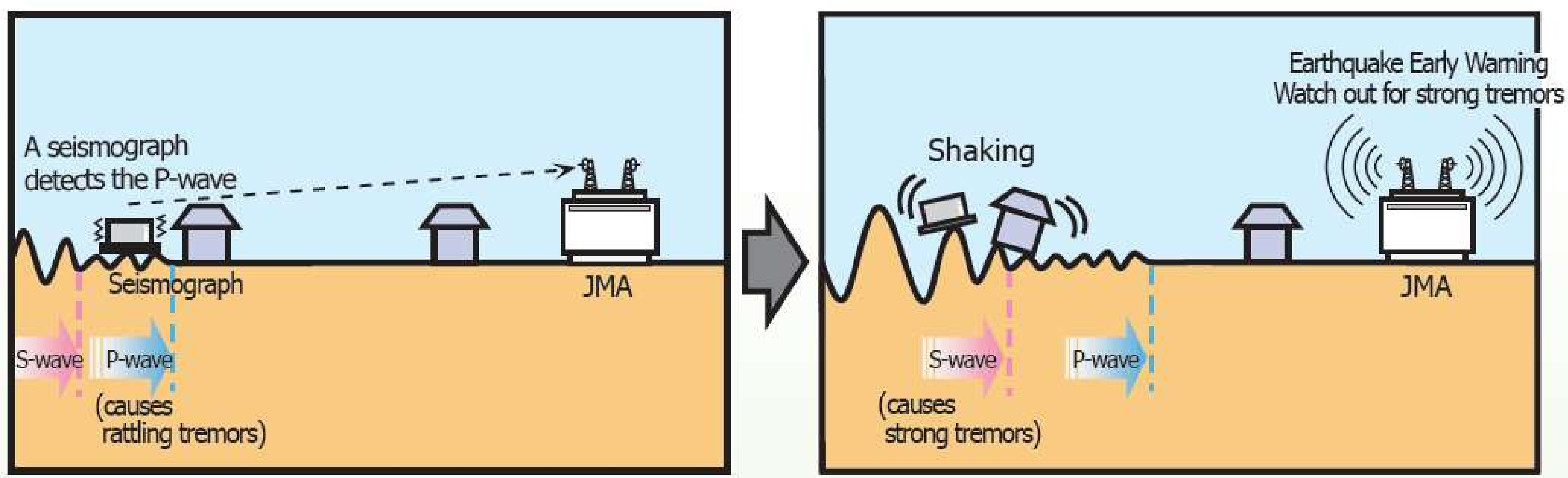



http://www.jma.go.jp/jma/en/Activities/earthquake.html

# Earthquake early warning system in Japan

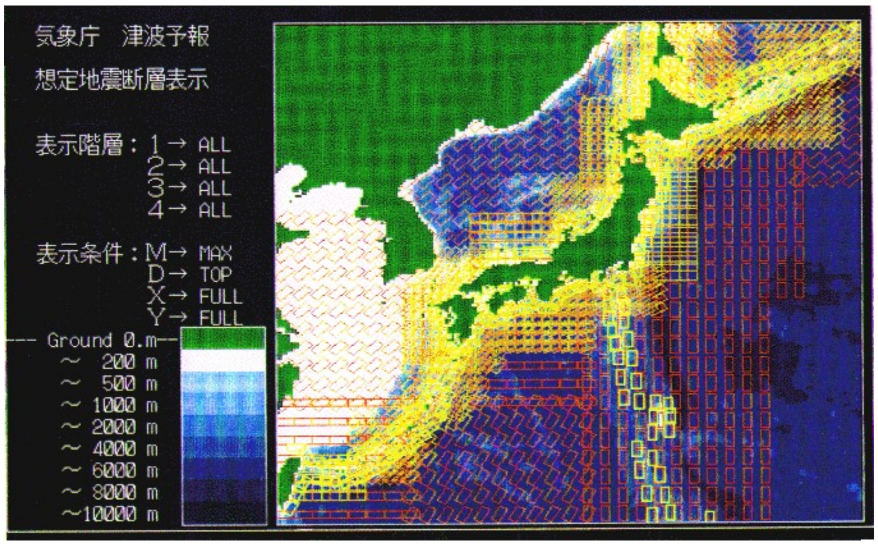
- ❖ Quick estimation of Hypocenter, Magnitude and depth
- ❖ Seismic Intensity at a few stations around the source
- ❖ Broadcasting the information before ground shaking
- ❖ JMA starts this service in October 2007



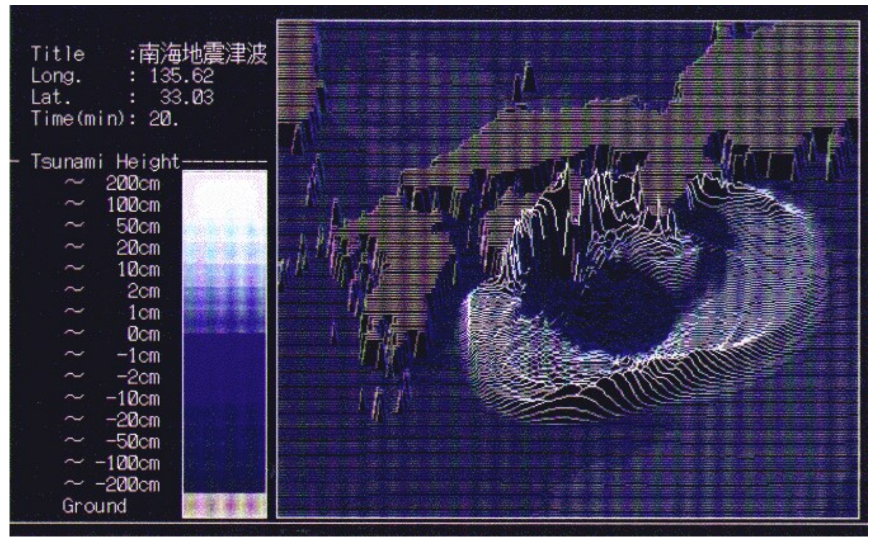

Source: JMA http://www.jma.go.jp/jma/en/Activities/earthquake.html

# Tsunami warning systems in Japan

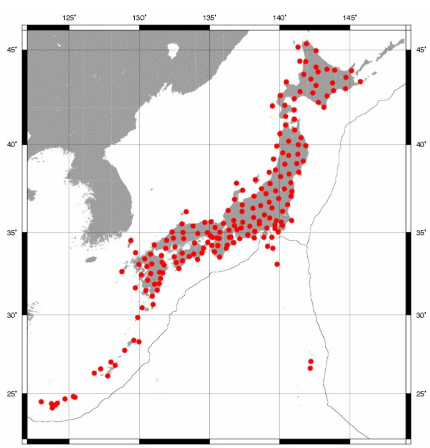
Assumed faults around Japan
(100,000 cases)



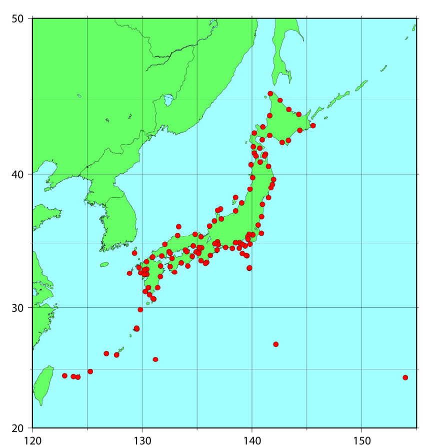

Numerical simulation results stored in database



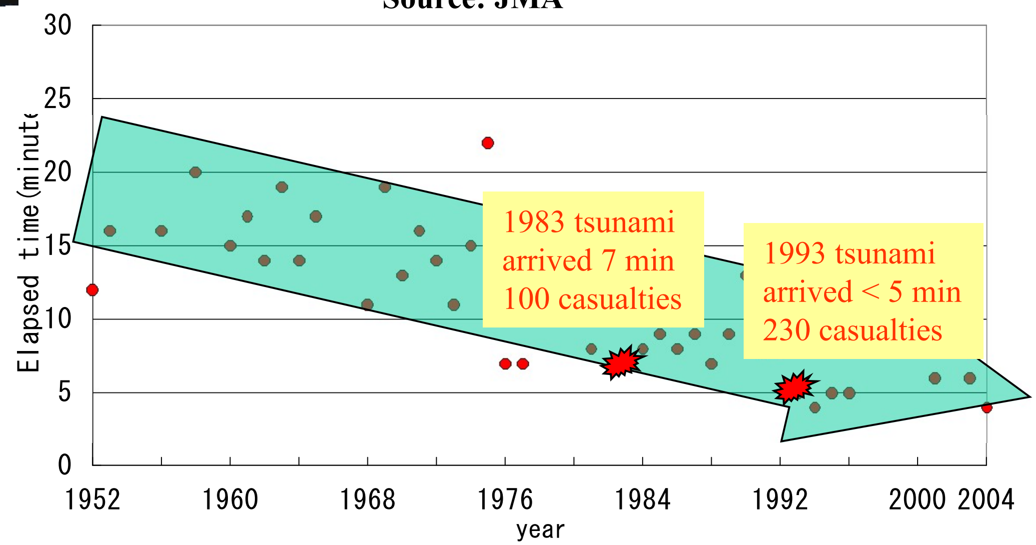

Seismic Network



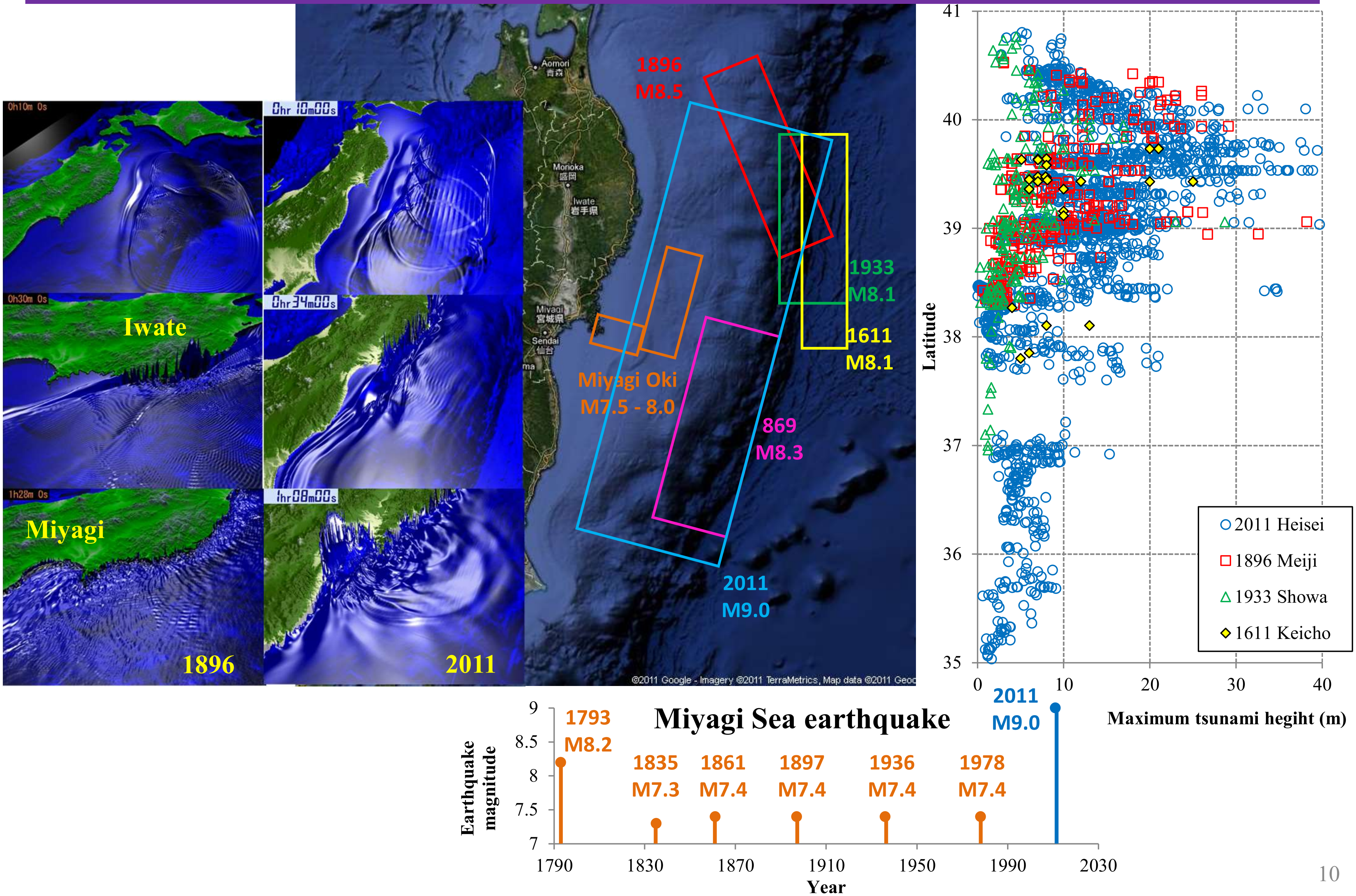
Sea Level Network




**Source: JMA**

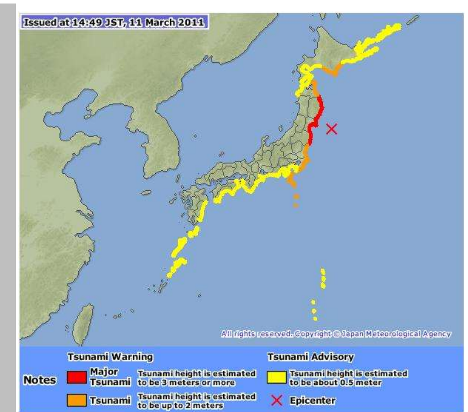


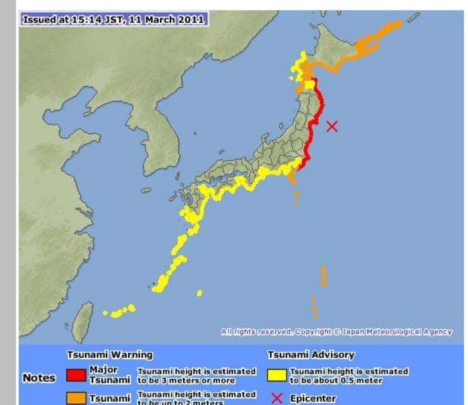
# Sanriku tsunamis and Miyagi Sea tsunamis

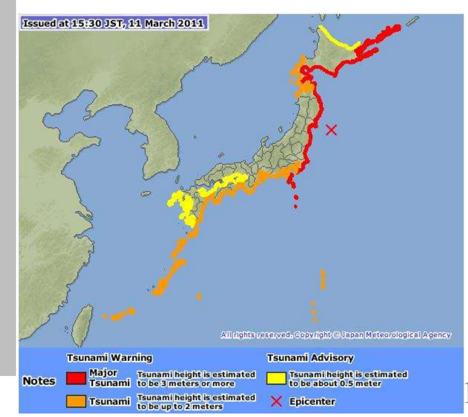


# Tsunami warnings during the 2011 tsunami

| Local | Event | Information |
|---|---|---|
| 14:46 | Earthquake | |
| 14:49 | Mjma = 7.9 Major | Tsunami Warning - Iwate, Miyagi and Fukushima |
| 14:50 | | Tsunami Information - Iwate: 3m, Miyagi: 6m, Fukushima: 3m, etc. |
| | | Only up to M8.0 in the database |
| 15:10 | GPS buoys > 3m | |
| 15:14 | | Tsunami Warnings/Advisories extended |
| 15:14 | | Tsunami Information - Iwate: 6m, Miyagi: over 10m, Fukushima: 6m, etc. |
| | Tsunami hit the nearest coast | |
| 15:21 | Tide gauges at Kamaishi (Iwate) > 4.1m (scale out) | |
| 15:30 | | Tsunami Warning extended |
| 15:31 | | Tsunami Information- Iwate, Miyagi, Fukushima: over 10m, etc. |
| 16:00 | Mjma = 8.4 | |
| 17:30 | Mw = 8.8 | |
| 13th May | Mw = 9.0 | |

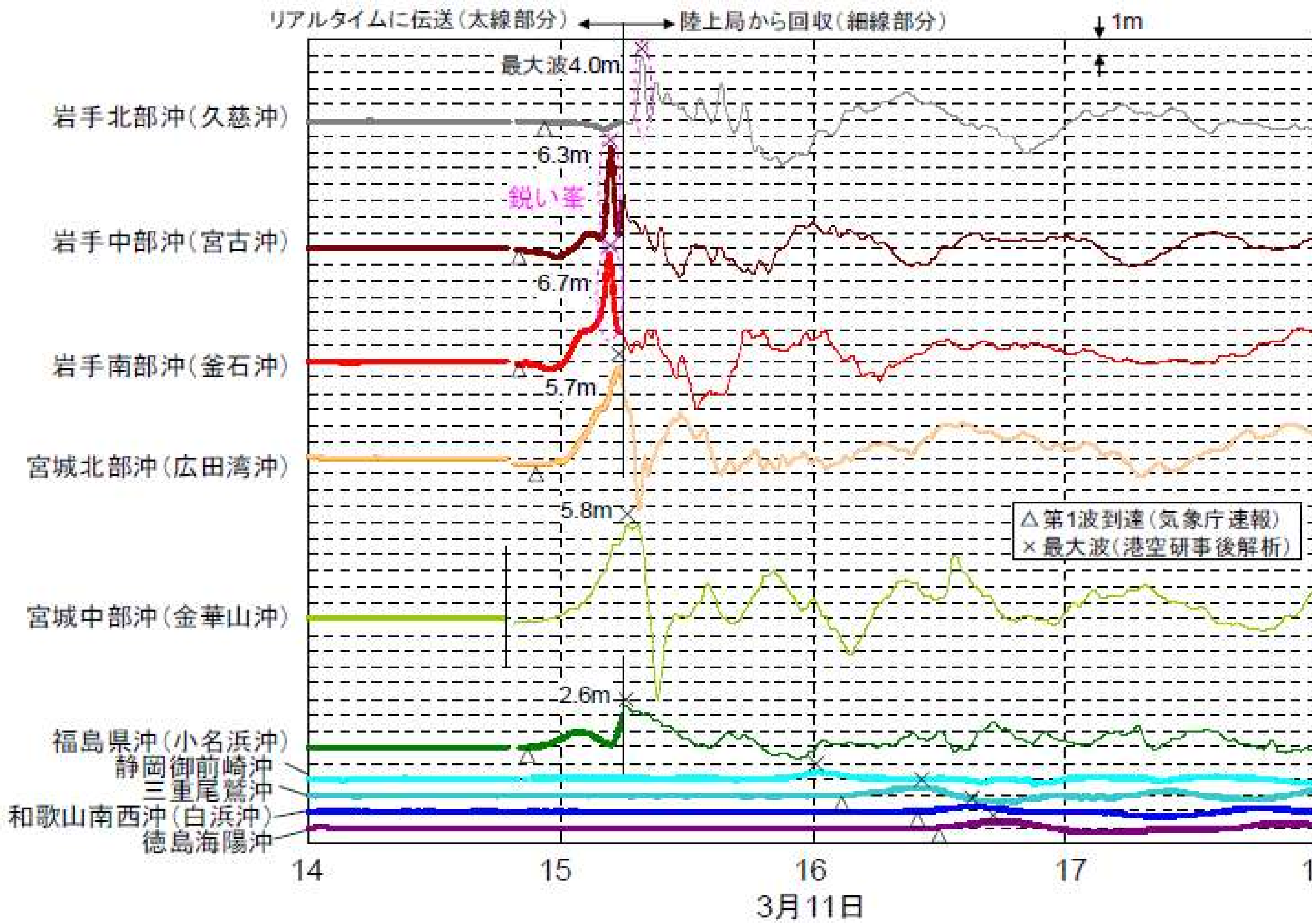


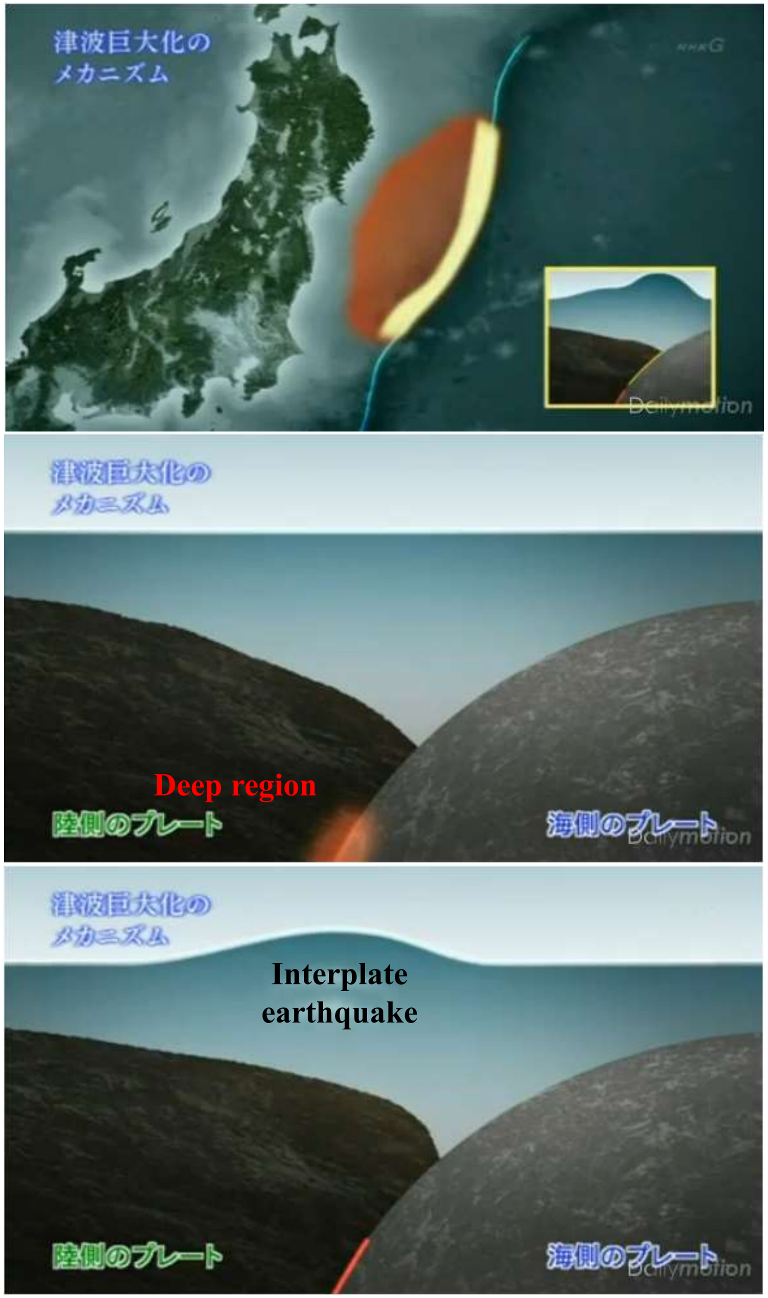

Hayashi et al (2011) and http://www.jma.go.jp/jma/en/2011_Earthquake.html

# Recorded wave amplitudes

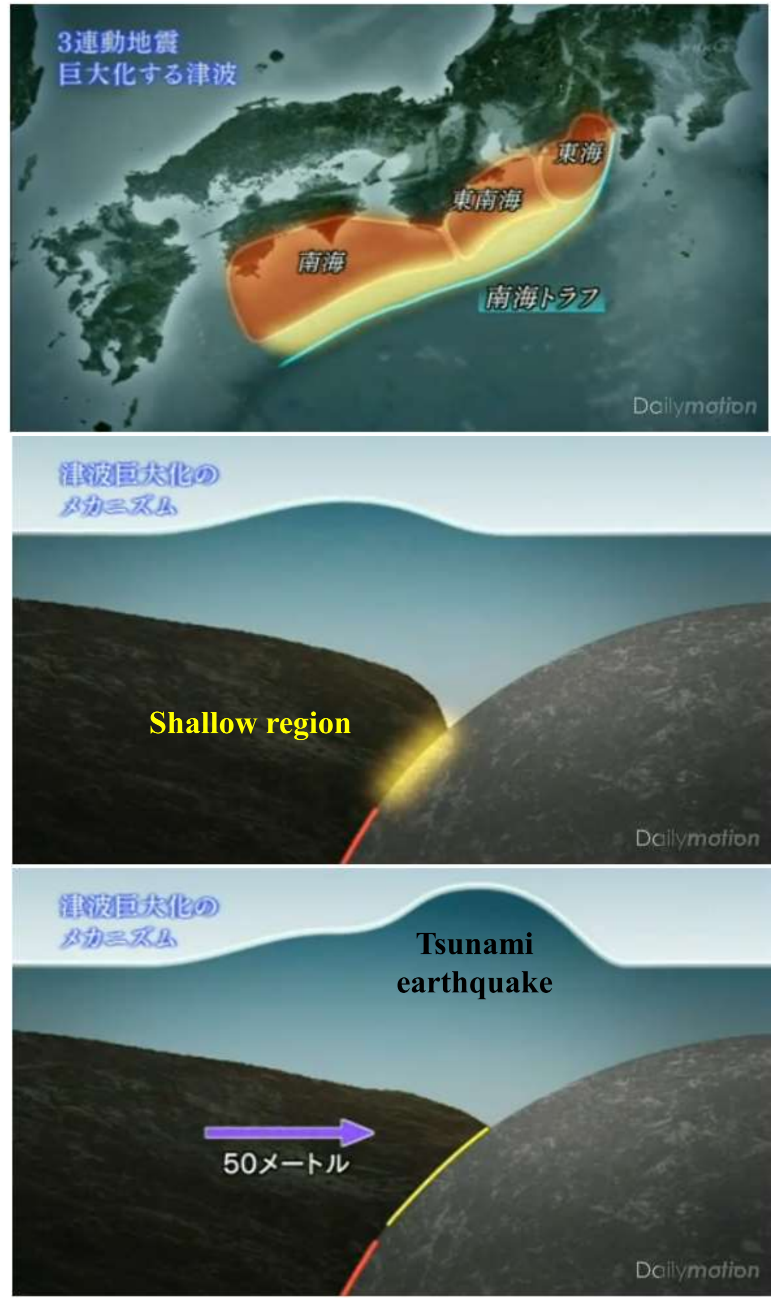



http://www.pari.go.jp/info/tohoku-eq/

## 2011 Tohoku earthquake



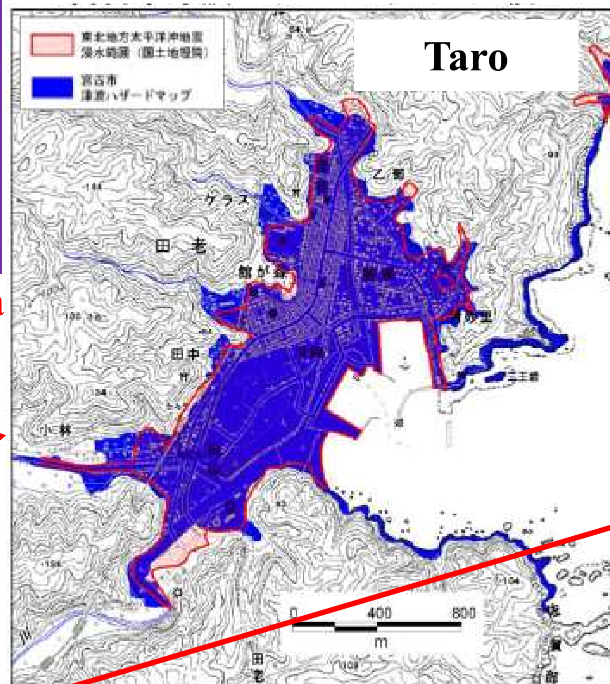

## 20xx Nankai earthquake

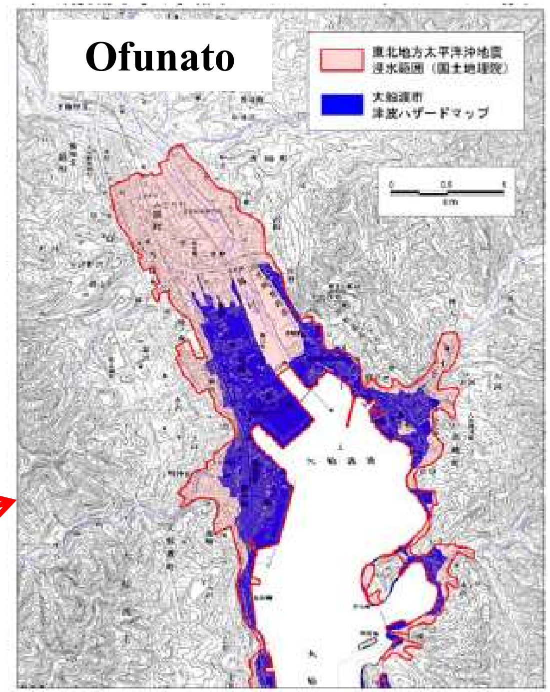


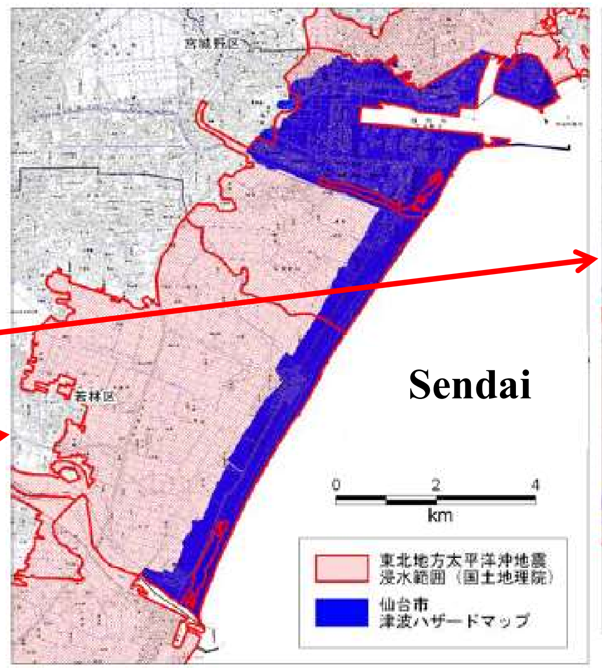

Source: NHK

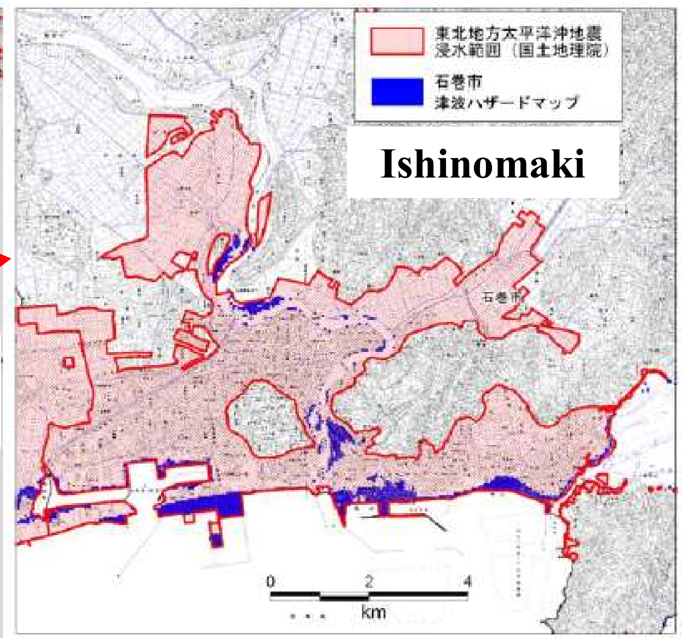
# The 2011 tsunami: Large different in tsunami hazard map

**Red: 2011 tsunami inundation area**
**Blue: Predicted inundation area**

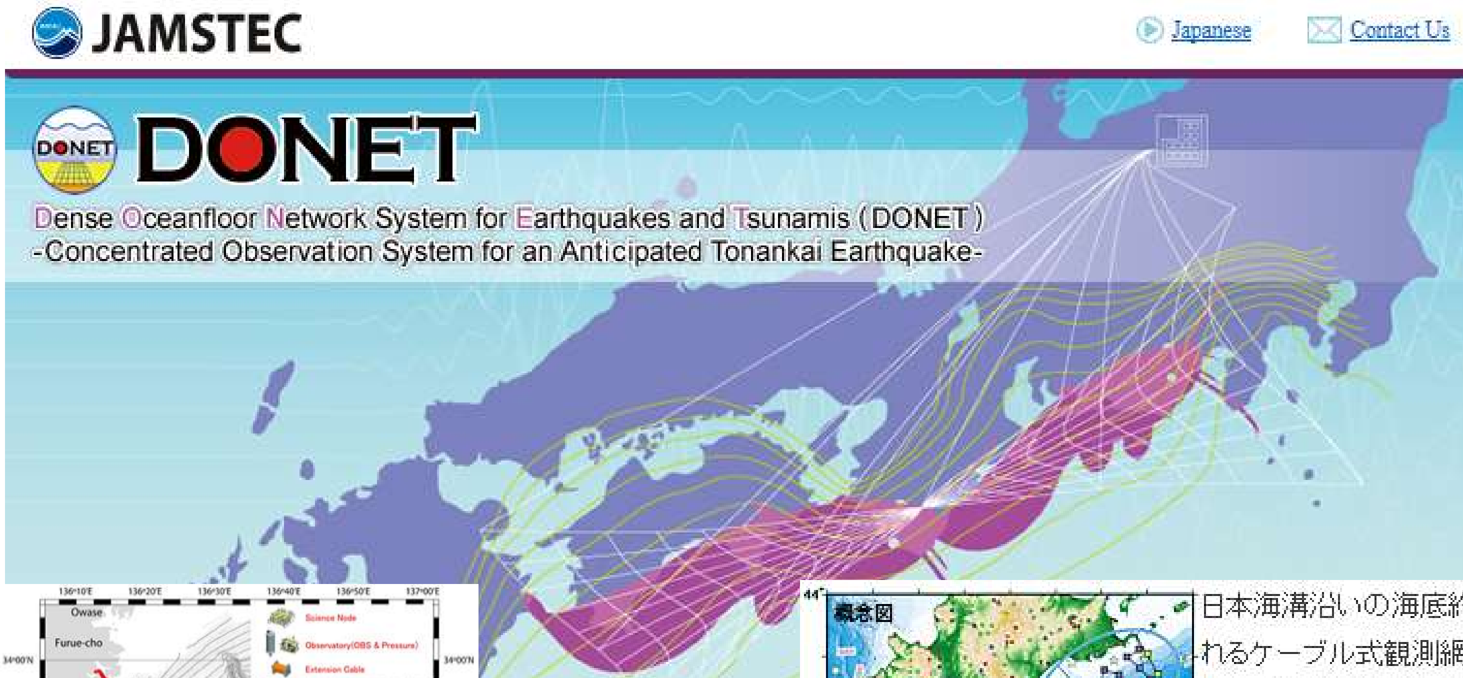



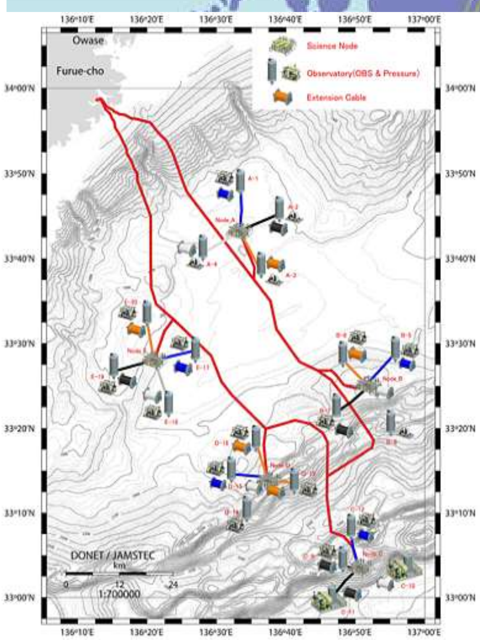




（出典）・東北地方太平洋沖地震浸水範囲：国土地理院資料より作図
・ハザードマップ：仙台市「仙台市津波ハザードマップ」、石巻市「石巻市津波ハザードマップ」

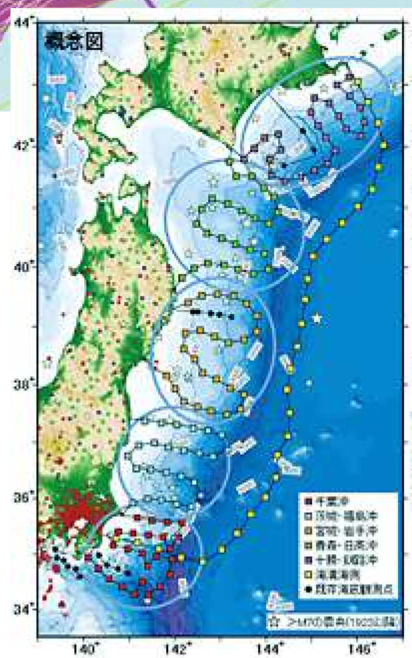
# Advance observation technology




http://www.jamstec.go.jp/jamstec-e/maritec/donet/index.html




*State of Network as of July 31, 2011.*




日本海溝沿いの海底約150カ所に、地震計と津波計で構成されるケーブル式観測網が整備されます。震源の近くで地震動と海面変動を精度よく迅速に捉え、大地震と津波のモニタリング、精度の高い警報の早期伝達、地殻構造の詳しい解明等に役立てられます。

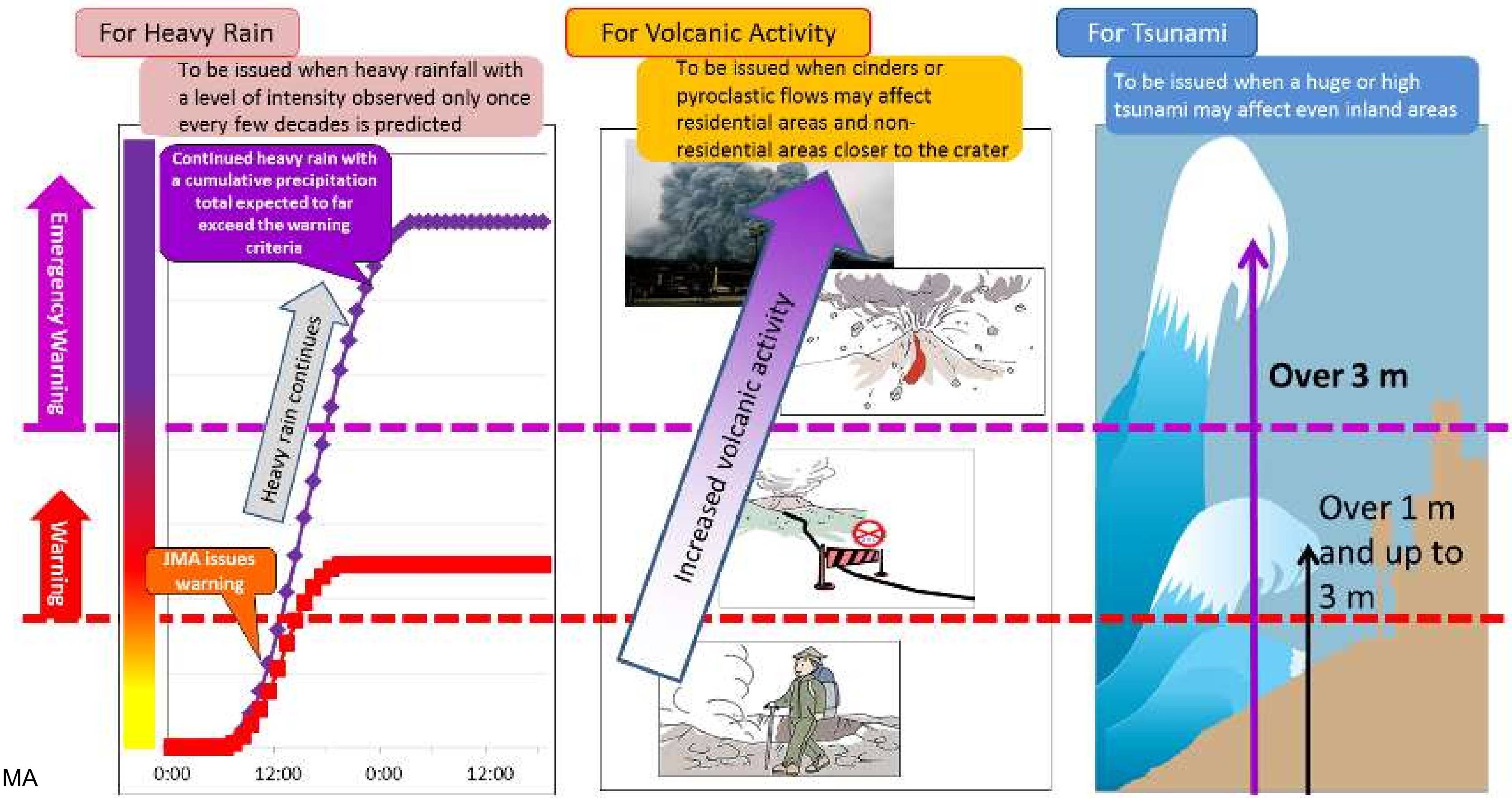
日本海溝沿いに整備される海底地震津波観測網(概念図)

NIED 独立行政法人 防災科学技術研究所
National Research Institute for Earth Science and Disaster Prevention

http://www.bosai.go.jp/activity_special/the_third/ev/earthvol-04.html

# New tsunami warning classification

| Tsunami warning and watch | | Old system (8 levels) | New system (5 levels) | | |
|---|---|---|---|---|---|
| | | Announce tsunami height | Number | Message | Estimated tsunami height |
| Warning | Major tsunami | > 10 m | > 10 m | Major | > 10 m |
| | | 8 m, 6 m | 10 m | | 5 m - 10 m |
| | | 4 m, 3 m | 5 m | | 3 m - 5 m |
| | Tsunami | 2 m, 1 m | 3 m | High | 1 m - 3 m |
| Advisory | Tsunami advisory | 0.5 m | 1 m | - | 20 cm - 1m |




Source: JMA

# Questionnaire survey related to tsunami evacuation (1)

**By Cabinet Office, Fire Agency and Japan Meteorological Agency**

-Total answers: 870 (Iwate = 391, Miyagi = 385 and Fukushima = 94), period: During July 2011

-A: Soon evacuated (57%), B: Evacuated after some actions (31%), C: Tsunami came during doing some actions (11%) and D: Did not evacuated (they were already in high ground) (1%)

-[A+B] Main reasons for starting evacuation: large shaking (48%), were asked to evacuate by family or surrounding people (20%) and surrounding people start their evacuation (15%)

→ Less amount of calling out for evacuation

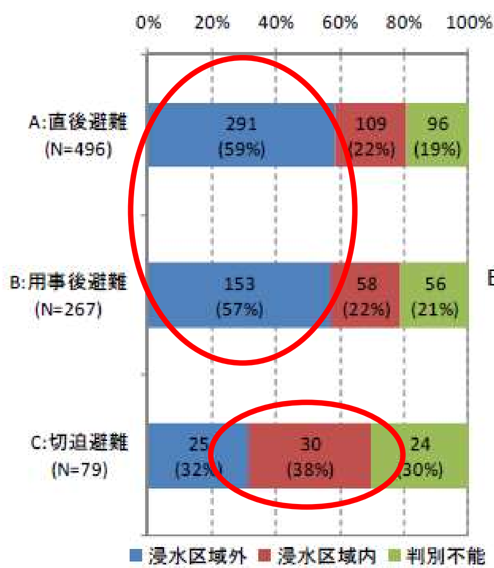
-[B+C] Why they did not evacuated as soon as possible: Went back home (22%), looking for family or picking up family (21%), tsunami did not come in the past (11%) and did not think about tsunami coming (9%)

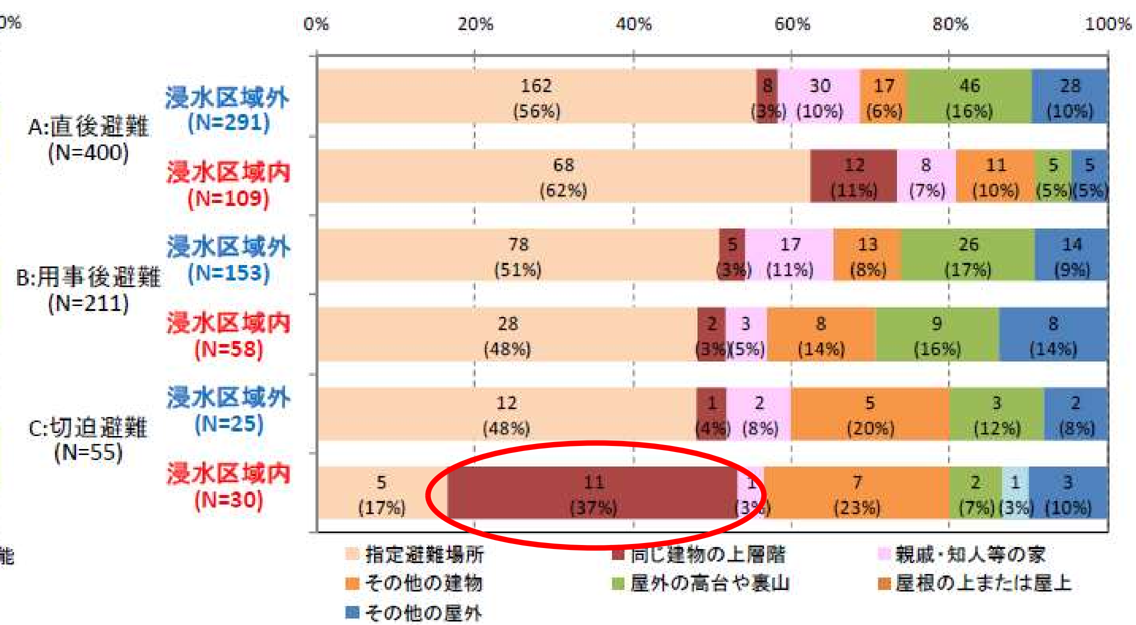
→ Have to reduce the amount of people going back home or seeking family

**Condition of evacuation shelter**

- C has the highest ratio of people who were inside the inundation area (38%)
- A and B are both mostly evacuated to designated evacuation shelters but C is large on the highest floor of the same building

Blue = outside inundation area
Red = inside inundation area
Green = could not identify




Source: Cabinet office of Japan

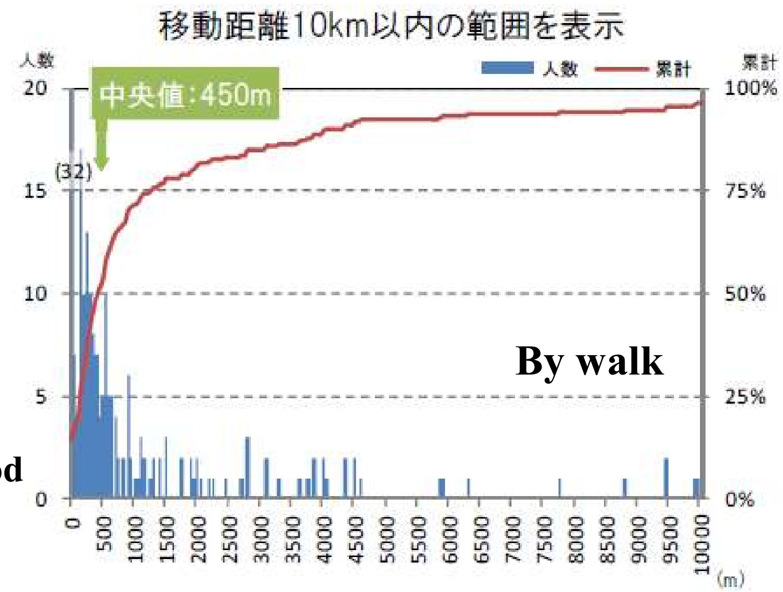
# Questionnaire survey related to tsunami evacuation (2)

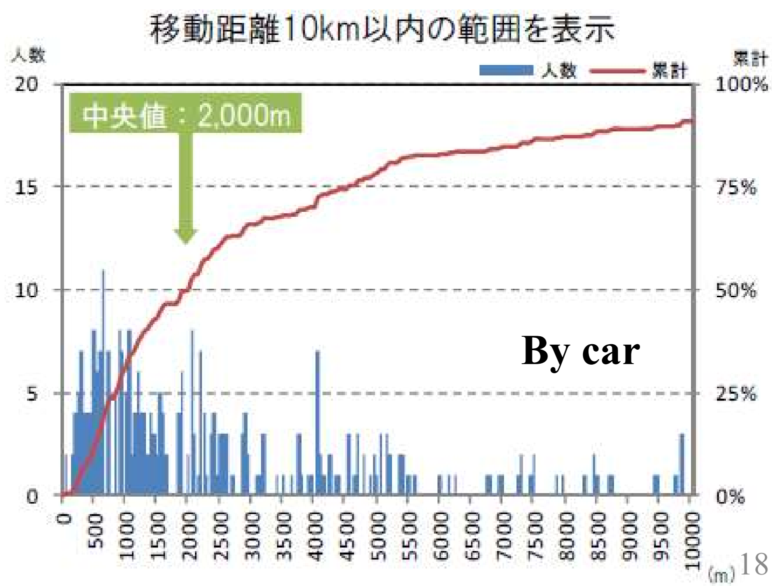
**Evacuation method**

- In general, about 57% of people evacuated using car.
- Reason for using car: Not enough time without using car (34%), wanted to evacuate together with family (32%), far from safe place (20%)
- About 34% of them were trapped in the serious traffic.
- In general, limit distance for evacuation by walking was about 500 m and by car was 2 km.

**Moving distance to the first evacuation shelter by evacuation method**

| 種別 | | 移動手段 | 人数 | Median distance |
|---|---|---|---|---|
| Total | | By walk | 218 | 450m |
| | | By car | 327 | 2,000m |
| 県別 | Iwate | By walk | 128 | 350m |
| | | By car | 118 | 1,225m |
| | Miyagi | By walk | 78 | 550m |
| | | By car | 150 | 1,550m |
| | Fukushima | By walk | 12 | 675m |
| | | By car | 59 | 5,050m |




**Tsunami hazard map**

- Number of people who had seen tsunami hazard map or had hazard map in their house was less than 20%

Source: Cabinet office of Japan

# Questionnaire survey related to tsunami evacuation (3)

**By Weathernews**

- Target area: Hokkaido, Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba
- Total answers: 5,296 (3,298 from survivors and 1,998 related to people who were casualty)

1) Time from earthquake generation to starting evacuation
   - Survivor = 19 min and casualty = 21 min
2) Reason for starting evacuation
   - Major tsunami warning or tsunami warning and only 28 % of the survivors soon evacuated
3) Evacuation condition
   - Reason for not evacuated was they believe they were safe and 20% of victim could not evacuated
4) Selected evacuation place
   - 75% of survivor could evacuated to safe place while 75% of victim could not
   - 40% could not evacuate to high ground and 50% evacuated to non-designated evacuation place
5) Why they could not evacuate from the tsunami
   - 18% of victim was because they were obstructed during their evacuation
6) Evacuated elevation from tsunami
   - Approximately 2.9$^{th}$ floor for survivor and 1.7$^{th}$ floor for victim
7) Moving from evacuation place
   - 60% of victim moved to tsunami inundation zone again
8) Reason for moving from evacuation place
   - Looking for their family was the main reason

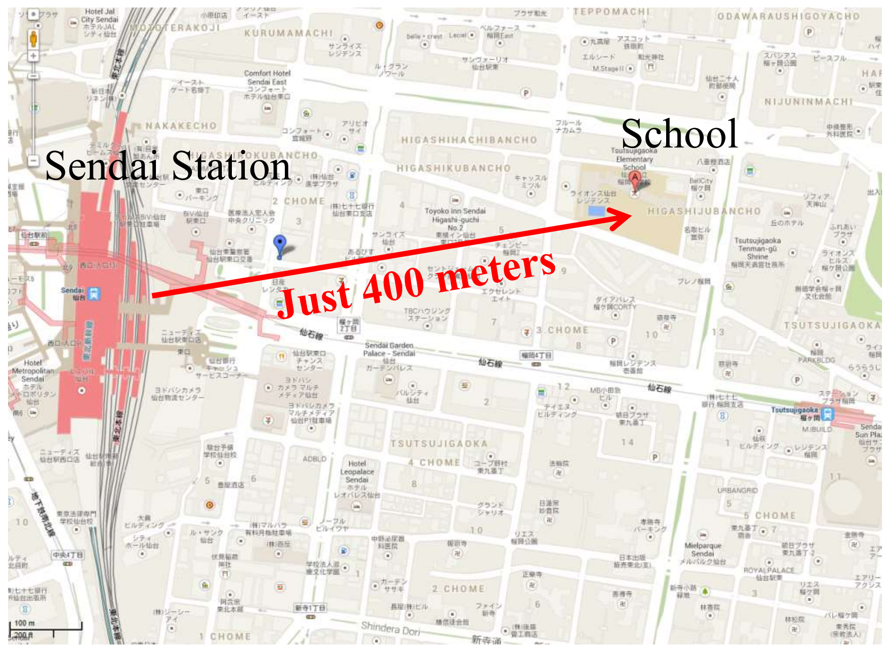
# Lessons # 1: Tsutsujigaoka Elementary School

Number of evacuee = 2,500 !! (four times over than the estimation!!)

避難者で埋め尽くされた榴岡小の体育館＝3月12日午前、仙台市宮城野区

榴岡小の避難訓練。周辺施設から避難者が殺到した教訓を関係機関がどう生かすかが問われている＝5月16日、仙台市宮城野区

- Sendai station suffered serious damage → Failed to serve as evacuation shelter
- Just 10 min by walk from Sendai station
- Estimated no. of evacuee was only based on the local residence population which was 600
- About 1,200 meals were stored for 600 persons (1 person = 2 meals). After asking from other community, finally got 3,080 meals on the following day
- Most evacuee started leaving the school from 12$^{th}$ night
- The school served as evacuation shelter until 24$^{th}$ March



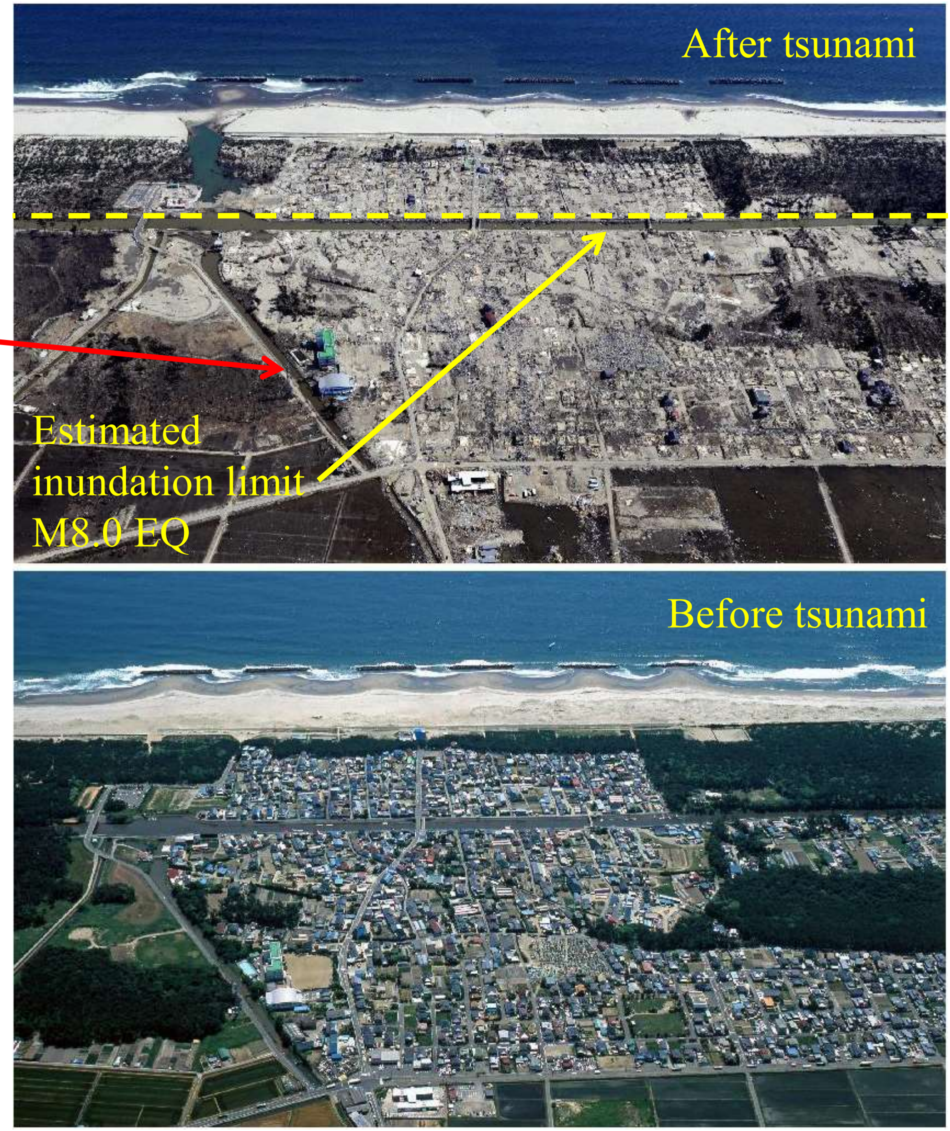

Source: Kahoku Shinpo
http://www.kahoku.co.jp/spe/spe_sys1071/20110726_01.htm

# Lessons # 2: Arahama Elementary School

Most children survived excepted those who went back home with family


http://www.city.sendai.jp/fukko/__icsFiles/artimage/2011/09/09/c_70_70/110311tunami2.jpg

http://pub.ne.jp/ebinet/image/user/1312539194.jpg




http://blog-imgs-36.fc2.com/j/o/s/josua1113/20110331204858158.jpg

# Lessons # 3: Unosumai Disaster Prevention Center

One actual disaster differ from million drills

- 34 survived and 128 or more becoming deaths
- Original evacuation places are on the high ground
- The center was newly opened on Feb 2010 and were used as a goal of tsunami evacuation drill on 3rd March 2011 or just 8 days before the event
- Tsunami reached almost the roof of the second floor
- As results, 150-200 residences selected this center as their evacuation destination

http://www.at-s.com/news/2012/03/07/images/11.jpg


http://www.chunichi.co.jp/article/earthquake/sonae/20120312/images/PK2012031202100063_size0.jpg

# Lessons # 4: Unosumai Elementary and Junior high schools

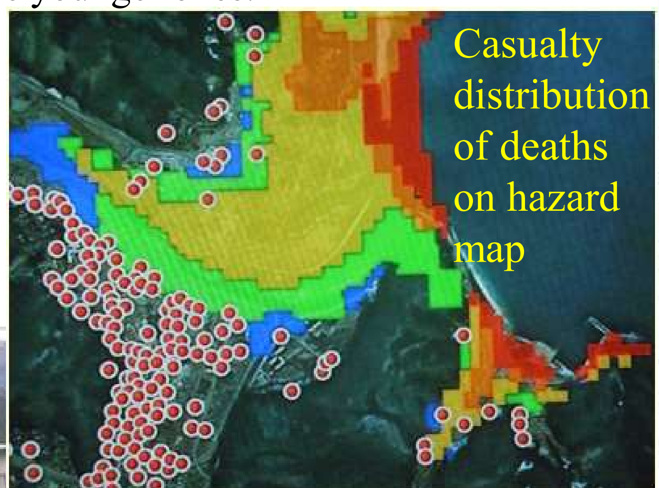
## Miracle of Kamaishi…Awareness for expected event

- All nearly 3,000 students survived

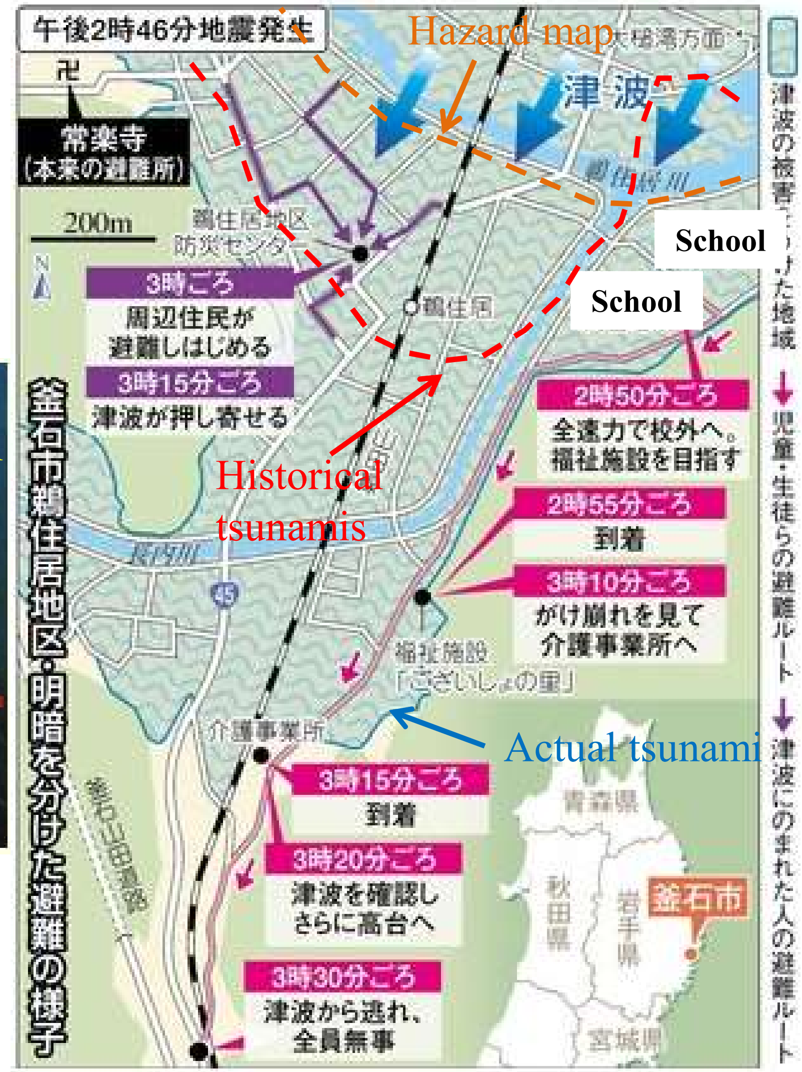
**Three principles**

- First, don't put too much faith in outdated assumptions. “In other words, don't trust hazard maps.
- The second rule of thumb is for people to make their best efforts to deal with the situation. They urged the teachers to keep moving higher, adding that the older kids also remembered to help the younger ones.
- And finally, to take the initiative in any evacuation.

http://mnj.gov-online.go.jp/kamaishi.html




http://insite.typepad.jp/.a/6a0120a6885bf1970b01543336c30e970c-320wi




http://www.chunichi.co.jp/article/earthquake/sonae/20120312/images/PK2012031202100063_size0.jpg

# Tsunami countermeasures in Japan

- 1896 Meiji-Sanriku tsunami: by individual

  Moving high ground
- 1933 Showa-Sanriku tsunami: by country and prefecture

  Moving high ground + Seawall in some areas
- 1960 Chile tsunami: Structural measures

  Seawalls, breakwaters and tsunami gates
- 1993 Okushiri tsunami:

  Structural measures, town planning and combination with soft measures
- 2011 Great East Japan tsunami:

  Prevention → Reduction

# Structural measures for tsunamis

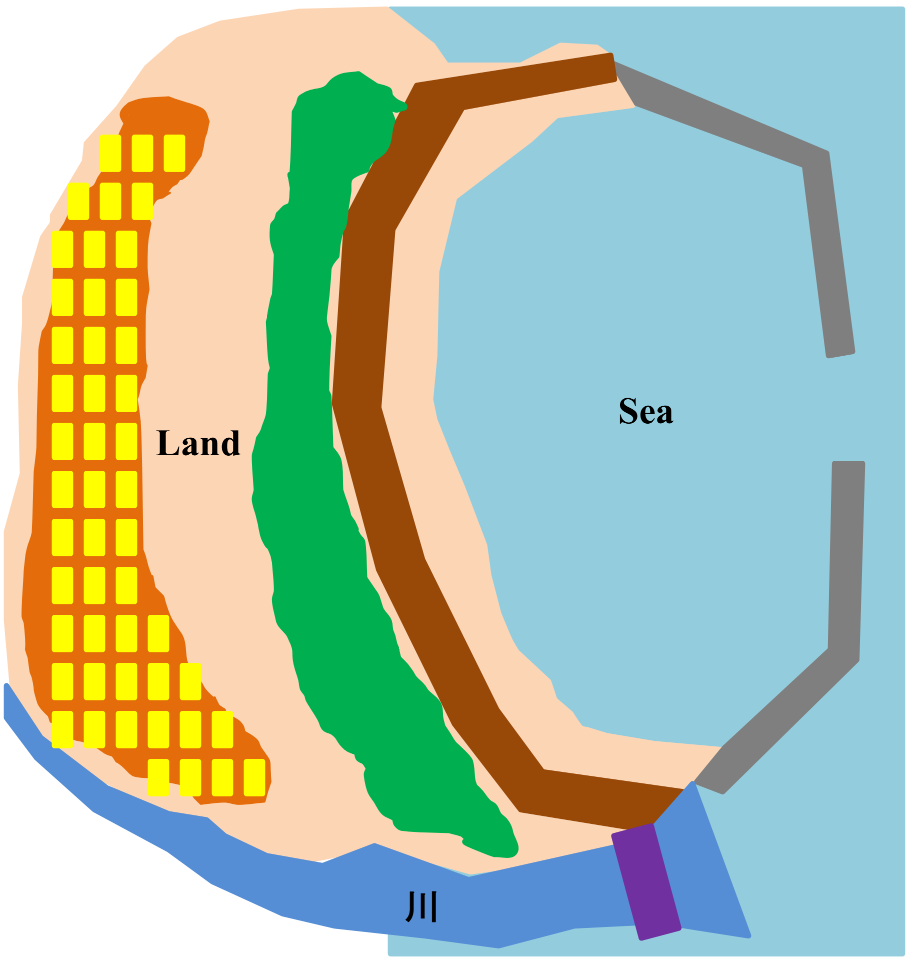
Breakwater: Kamaishi

Water gate: Fudai

Seawall: Taro

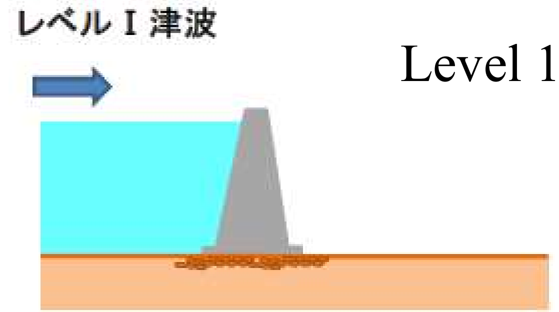
Highland residence: Toni-hongo

Control forest: Rikuzenakata

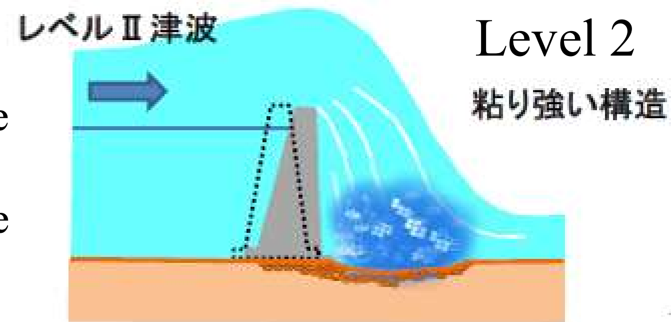


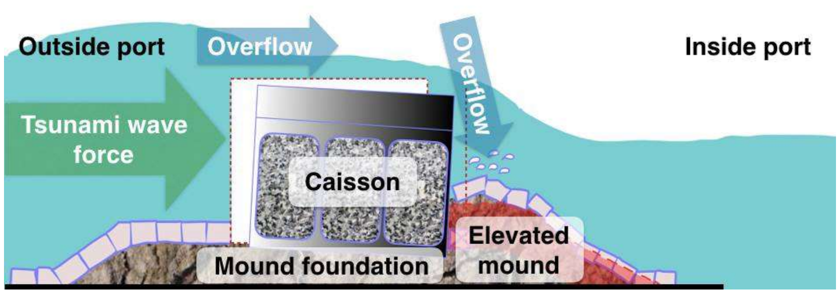
# Level 1 & Level 2 tsunami

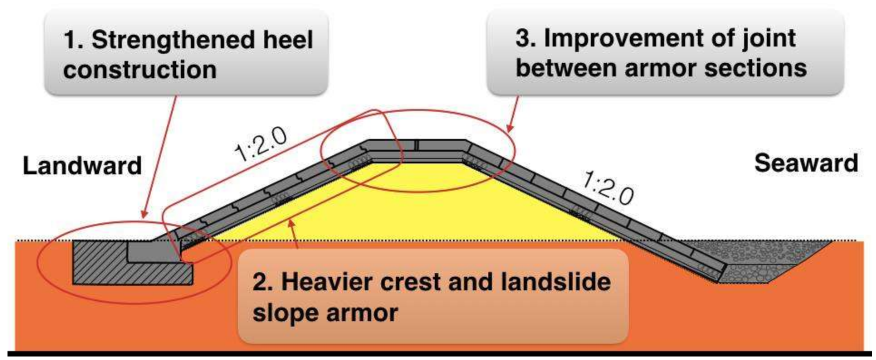
**Level 1**:
High frequency (30-200 years) but small to moderate tsunami.
Community should be mostly protected by coastal defense structures.
Height of coastal structures were decided by past Level 1 tsunami events



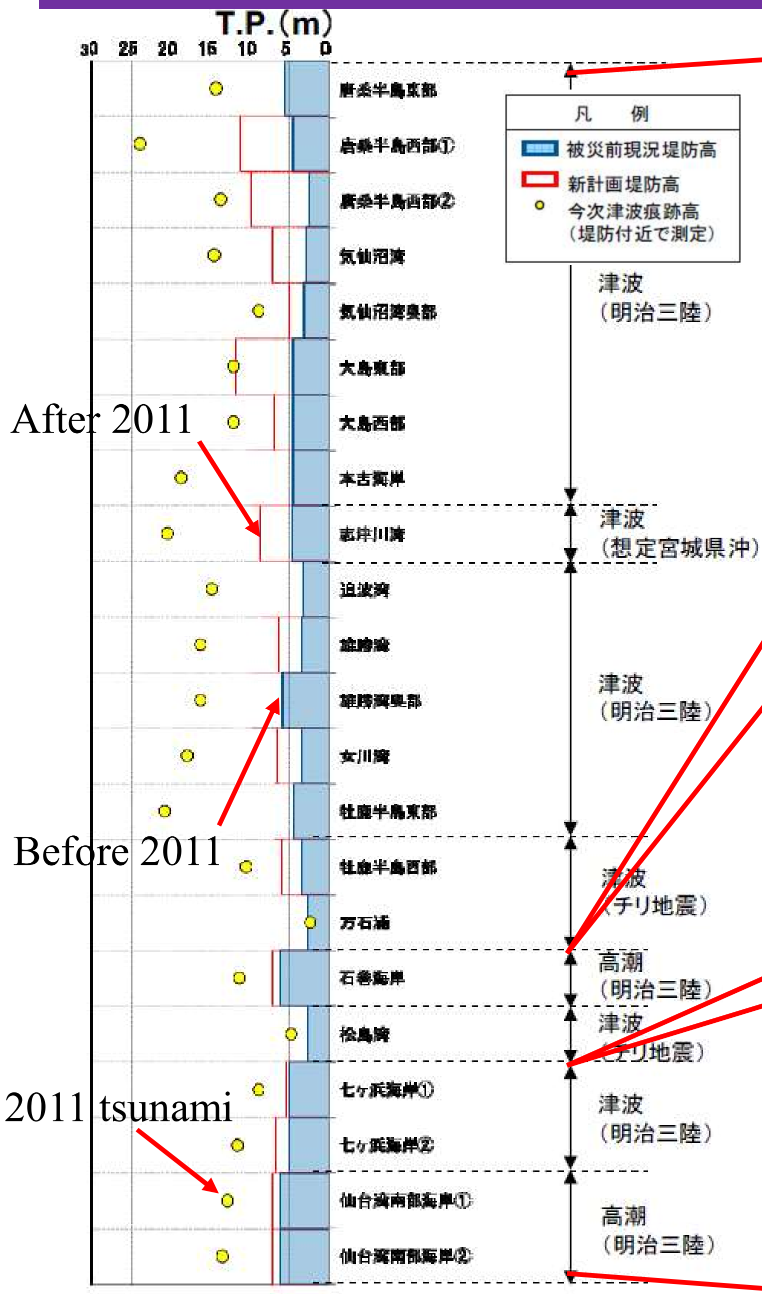

**Level 2**:
Low frequency (200-1,000 years) but very high tsunami.
Forget about properties but secure evacuation routes for safe evacuation.
Coastal structures should be strong enough even in case of the overtopping.



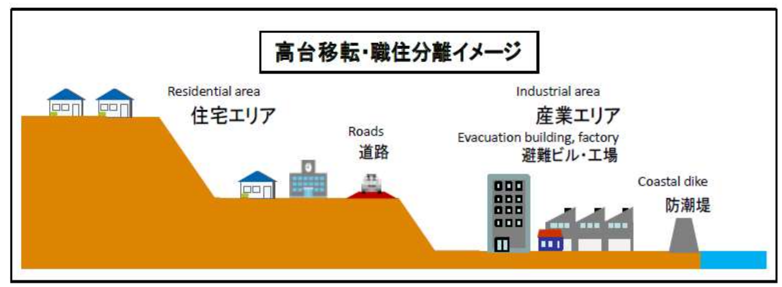
# New height of seawalls in Miyagi prefecture



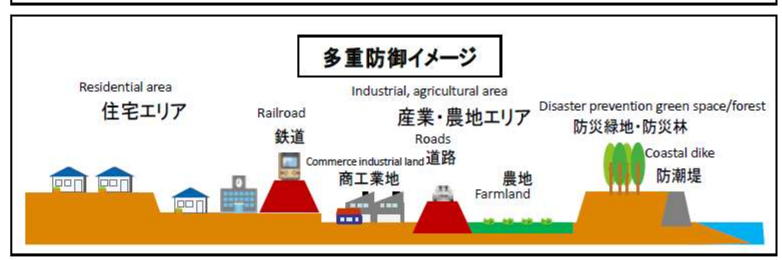

# Reconstruction plan of Miyagi prefecture




- Relocation to high ground, separation of business and residence
- Assemble and reorganize fishing ports, branding of marine processed products, "sixth industry"
- Tourism promotion that draws on the nature of the Sanriku area
- Promoting the maintenance of Sanriku expressway




- Relocation to high ground, separation of business and residence
- Multiple barriers
- Assemble and integrate fishing ports, assemble and advance industries
- Tourism promotion that makes use of Matsushima and Oshika peninsula




- Multiple barriers
- Advancing logistics function by utilizing airport and ports, and advancing business location to Miyagi
- Agricultural land accumulation, "sixth industry"
- Maintenance of national public park and disaster prevention green space
- Promoting the maintenance of Joban Expressway

http://www.pref.miyagi.jp/seisaku/sinsaihukkou/keikaku/index.htm

# Characteristics of the 2016 Fukushima tsunami

① The highest observed tsunami was in Sendai

② The second wave was the largest

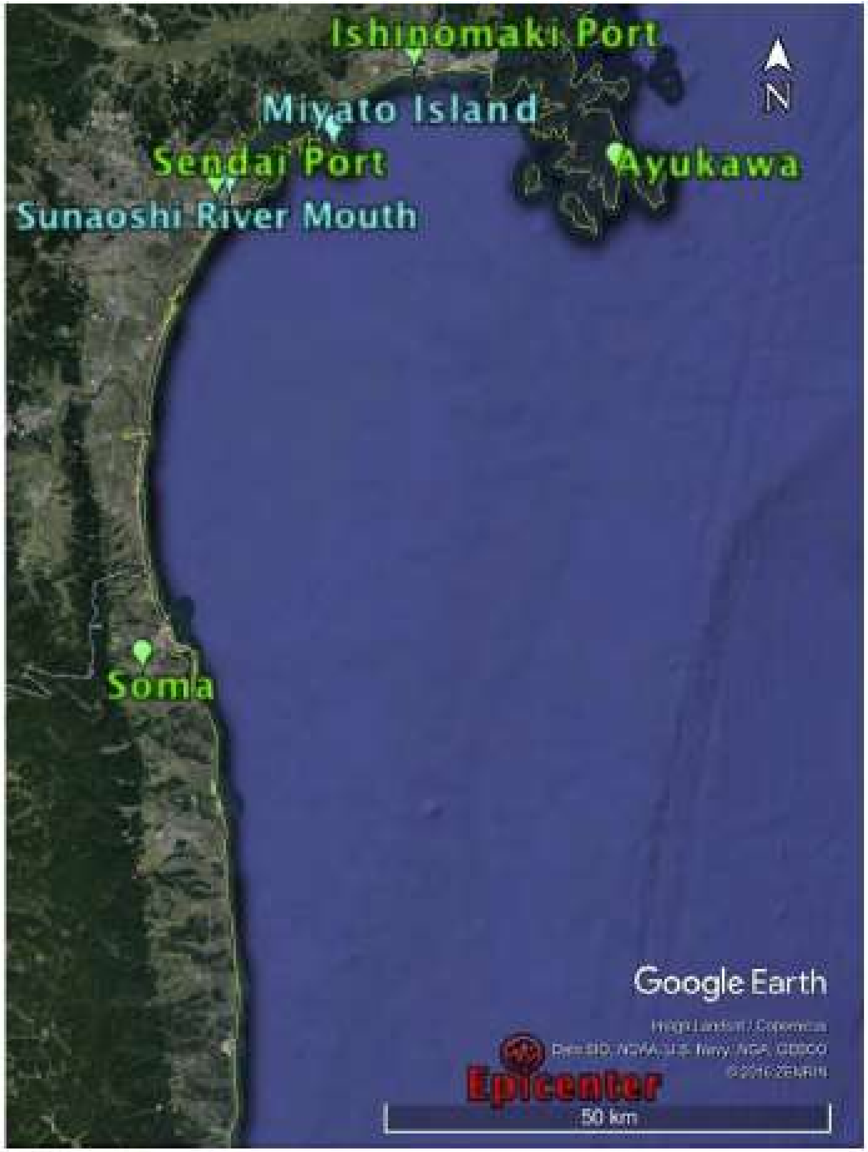
③ Tsunami threat level was elevated from “advisory” to “warning”

④ Local runup was higher than the observed amplitude

⑤ Tsunami intrusion into rivers

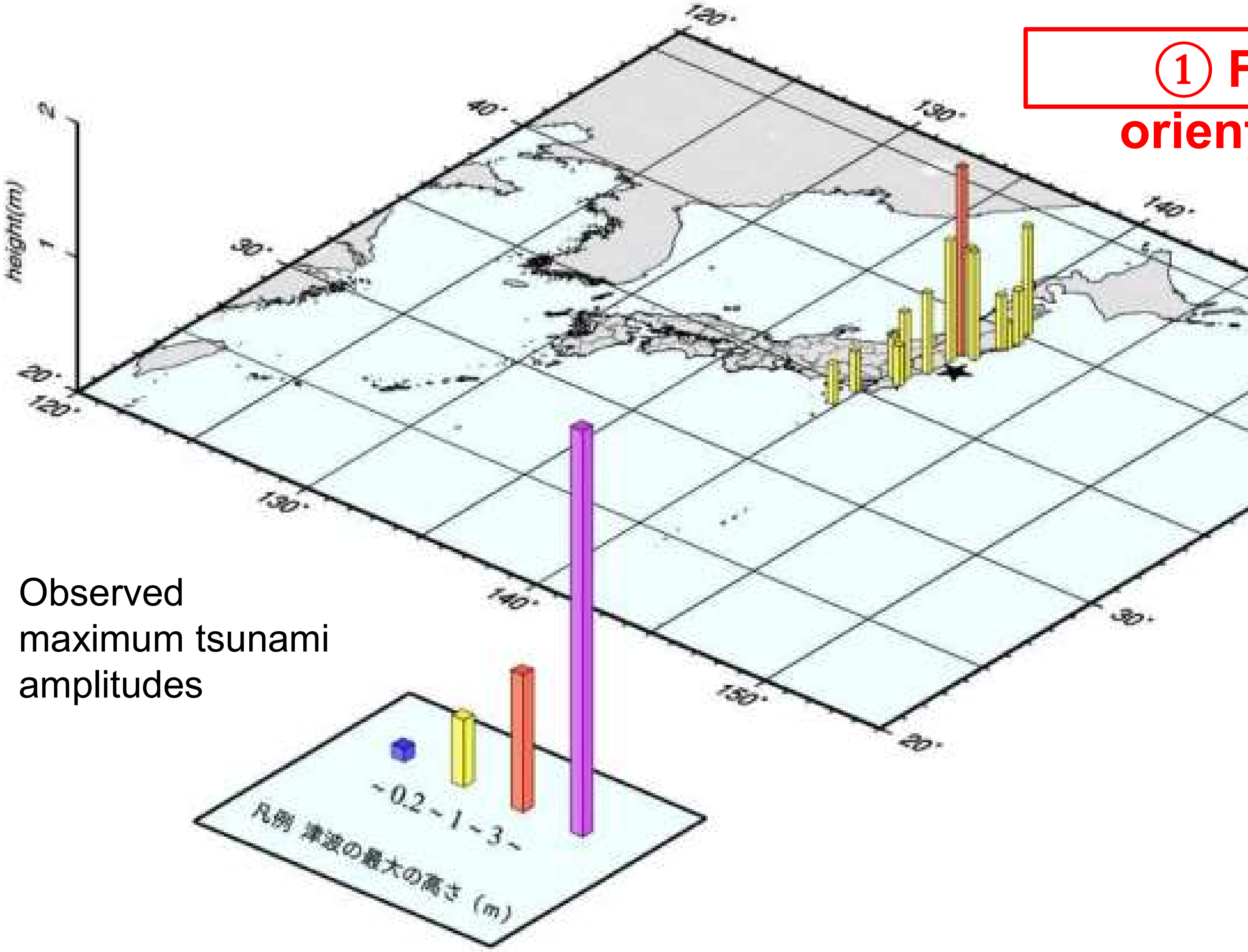
⑥ Tsunami warning and broadcasting

# ① The highest observed tsunami was in Sendai


Locations of study area, tide gauges and surveyed

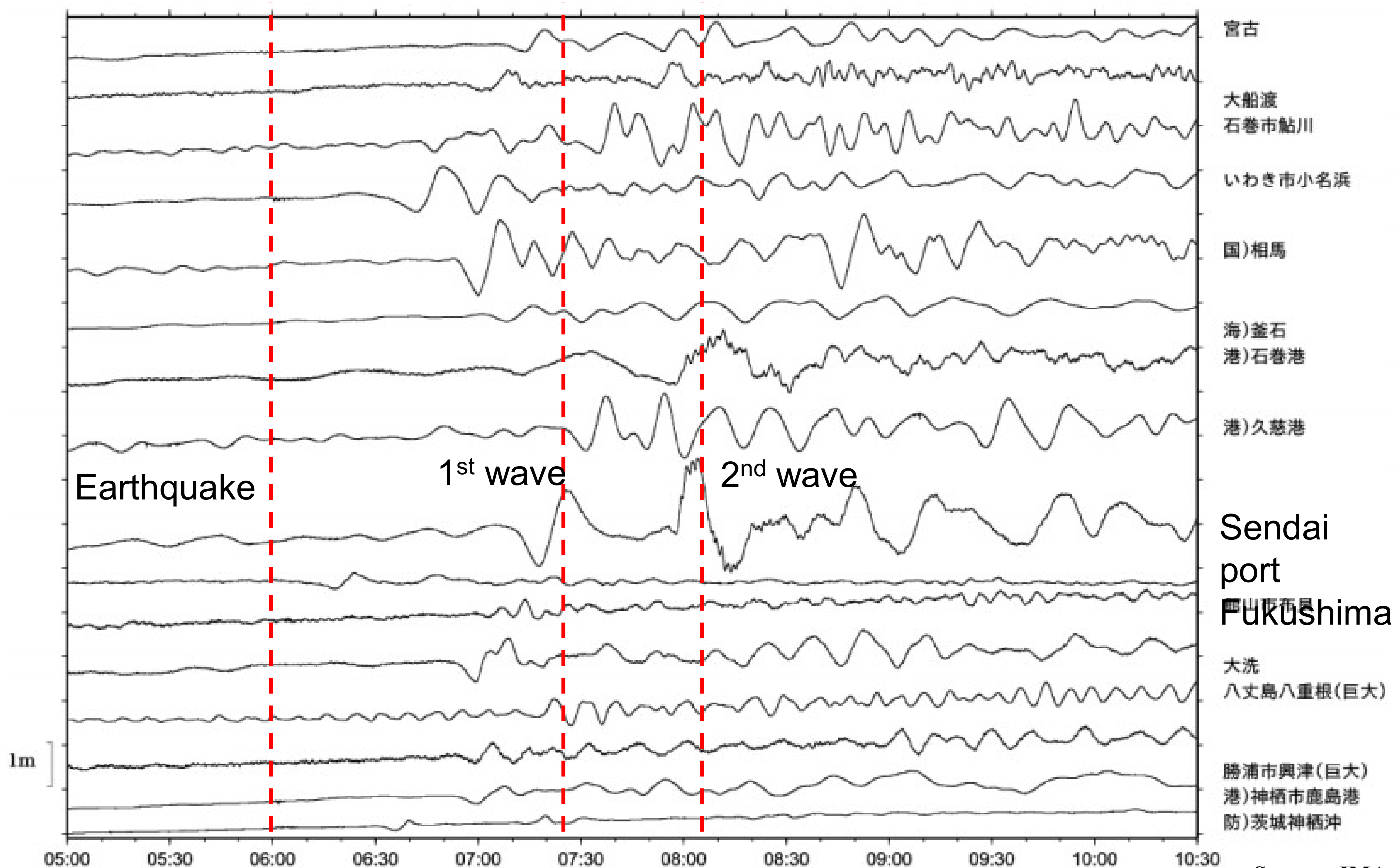
# ① The highest observed tsunami was in Sendai




Observed maximum tsunami amplitudes

① Fault orientation

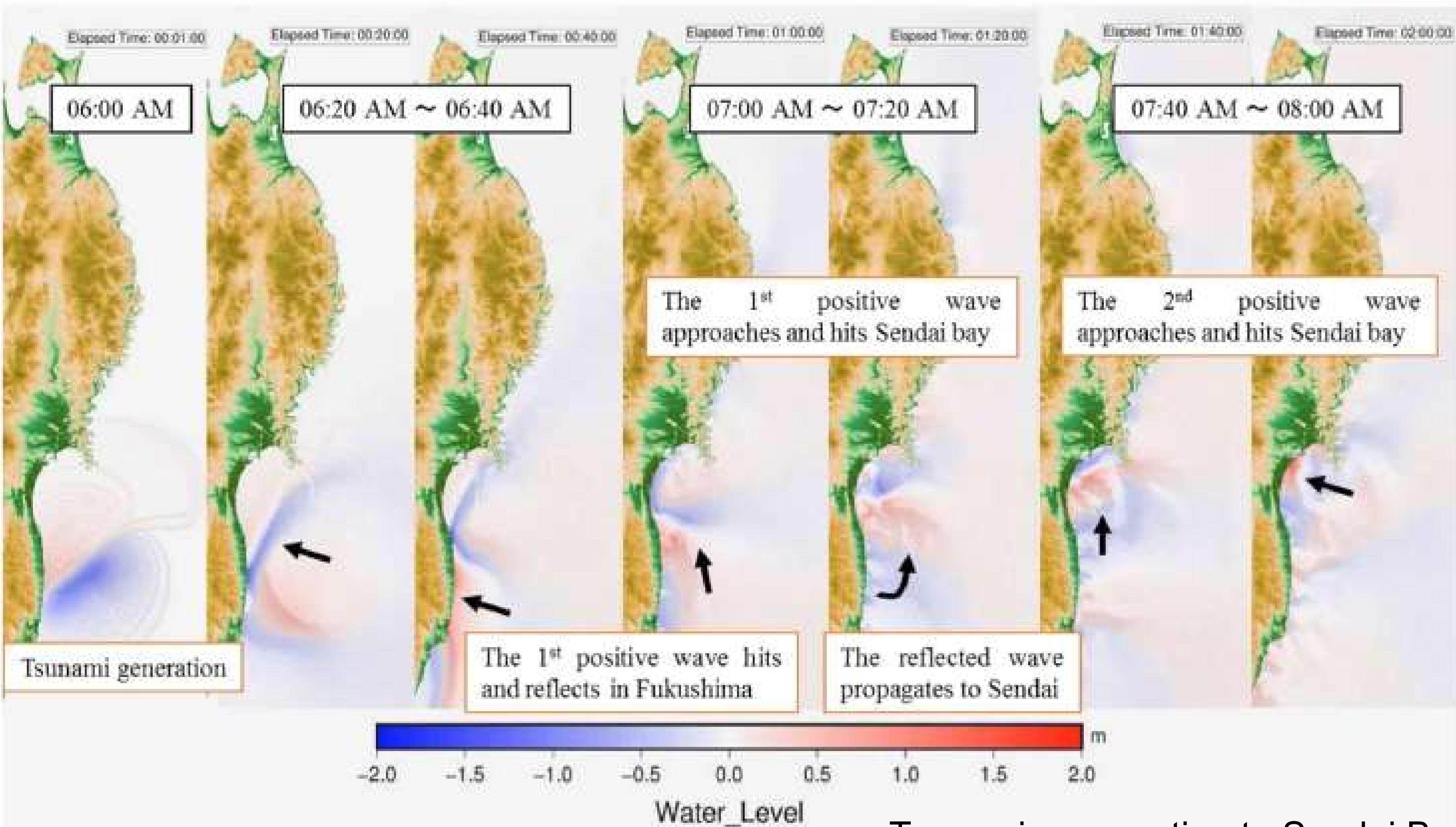
# ② The second wave was the largest




Observed tsunami waveforms

Source: JMA

# ② The second wave was the largest



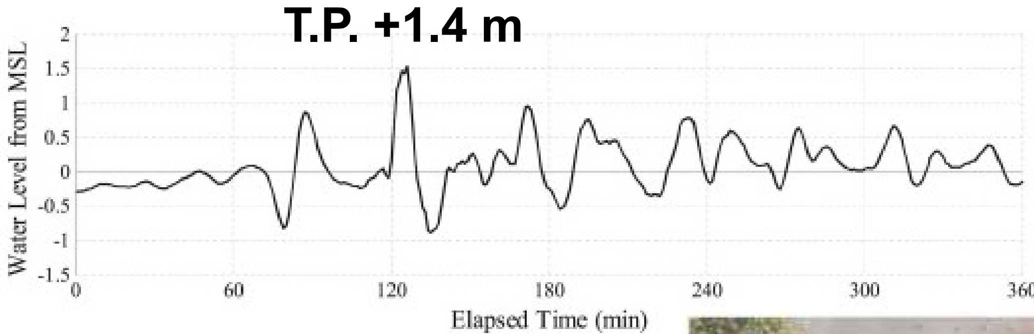

Tsunami propagation to Sendai Bay

## ③ Tsunami threat level was elevated from “advisory” to “warning”

| 津波予報区 | 発表時刻 | | | |
|---|---|---|---|---|
| | 22日06時02分 | 22日07時26分 | 22日08時09分 | 22日09時46分 |
| 青森県太平洋沿岸 | 津波注意報 | 津波注意報 | 津波注意報 | 若干の海面変動 |
| 岩手県 | 津波注意報 | 津波注意報 | 津波注意報 | 津波注意報 |
| Miyagi Prefecture | 津波注意報 | 津波注意報 | Tsunami warning | 津波注意報 |
| Fukushima | Tsunami warning | | | 津波注意報 |
| Ibaraki Prefecture | 津波注意報 | 津波注意報 | 津波注意報 | 津波注意報 |
| 千葉県九十九里・外房 | 津波注意報 | 津波注意報 | 津波注意報 | 若干の海面変動 |
| 千葉県内房 | 若干の海面変動 | 津波注意報 | 津波注意報 | 若干の海面変動 |
| 伊豆諸島 | 若干の海面変動 | 津波注意報 | 津波注意報 | 若干の海面変動 |

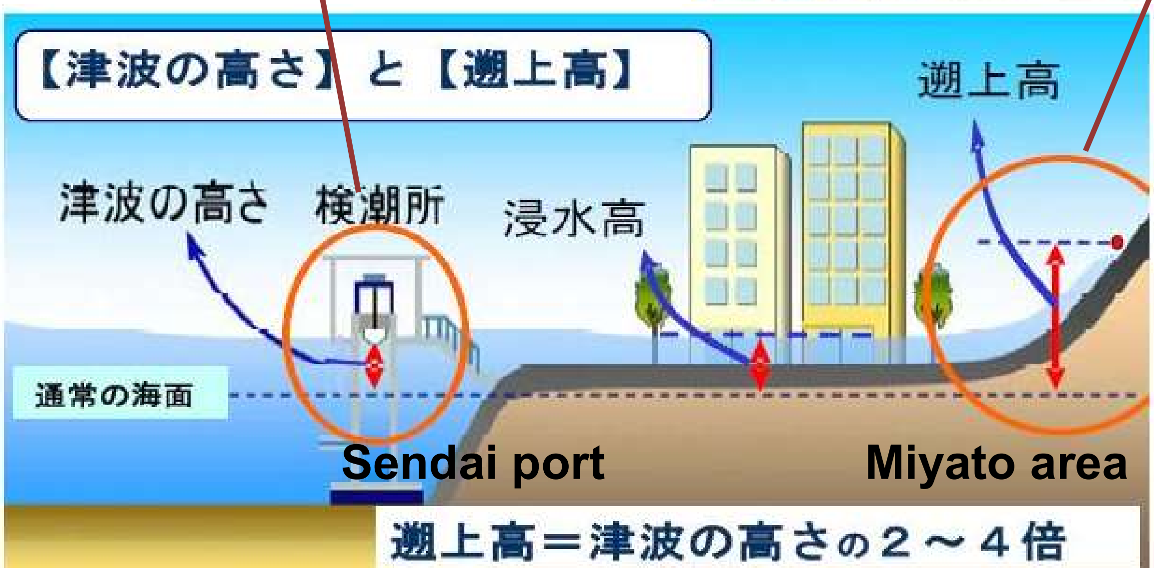
Status of the tsunami warnings and advisories

# ④ Local runup was higher than the observed amplitude




**Observed tsunami amplitude**

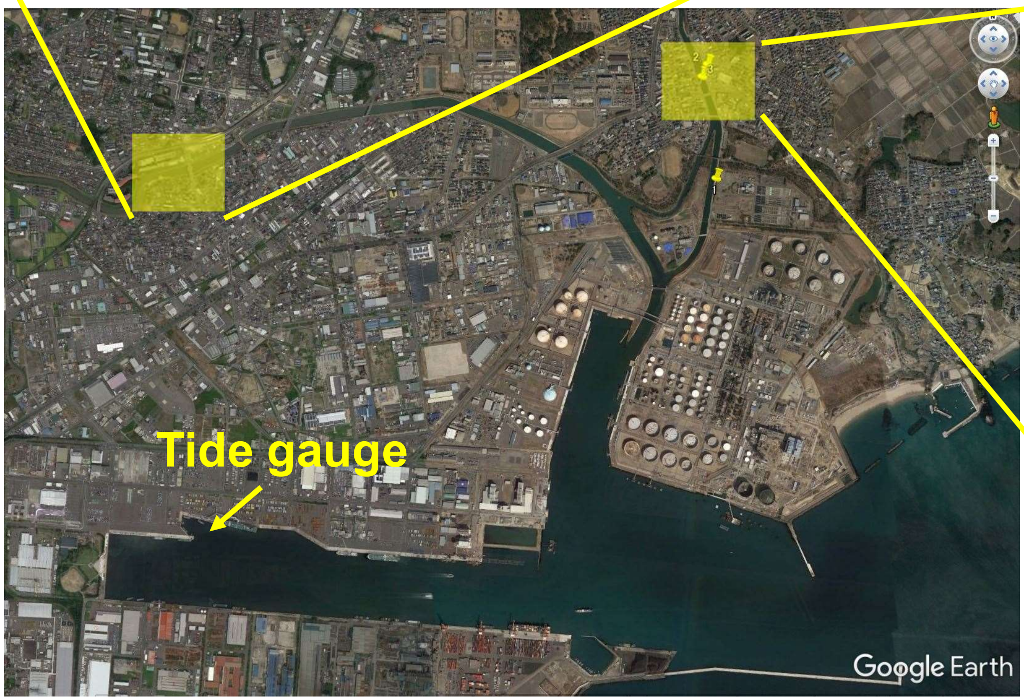
**Local tsunami runup**

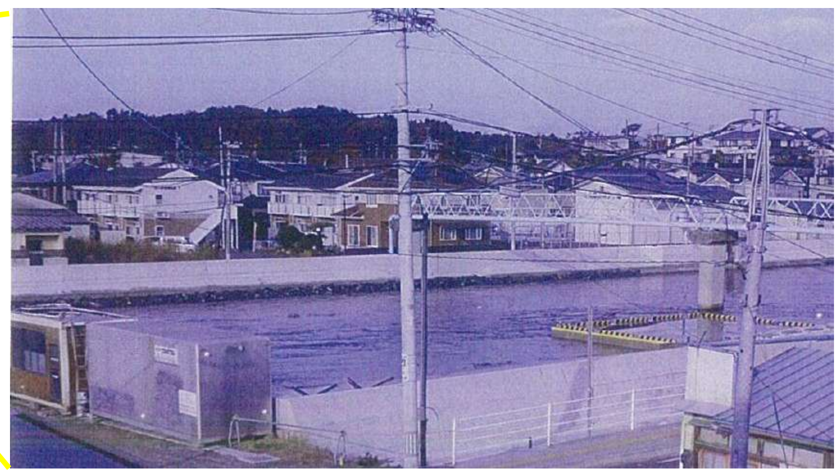




Based on our preliminary survey, tsunami runup higher than the observed tsunami wave amplitude of 1.4 m at Sendai Port was measured at several sites. In the Miyato area of Higashi-Matsushima City in Miyagi Prefecture, tsunami runup heights of more than 2–3 m were found caused by nearshore processes over the coastal topography.

# ⑤ Tsunami intrusion into rivers


This phenomenon was clearly observed at Sunaoshi River in Tagajo City, where the tsunami propagated over 3 km into the river. The tsunami speed is estimated to be about 14 km/s and the maximum rising of the river level reached 0.9 m (0.6–0.7 m above the normal level).



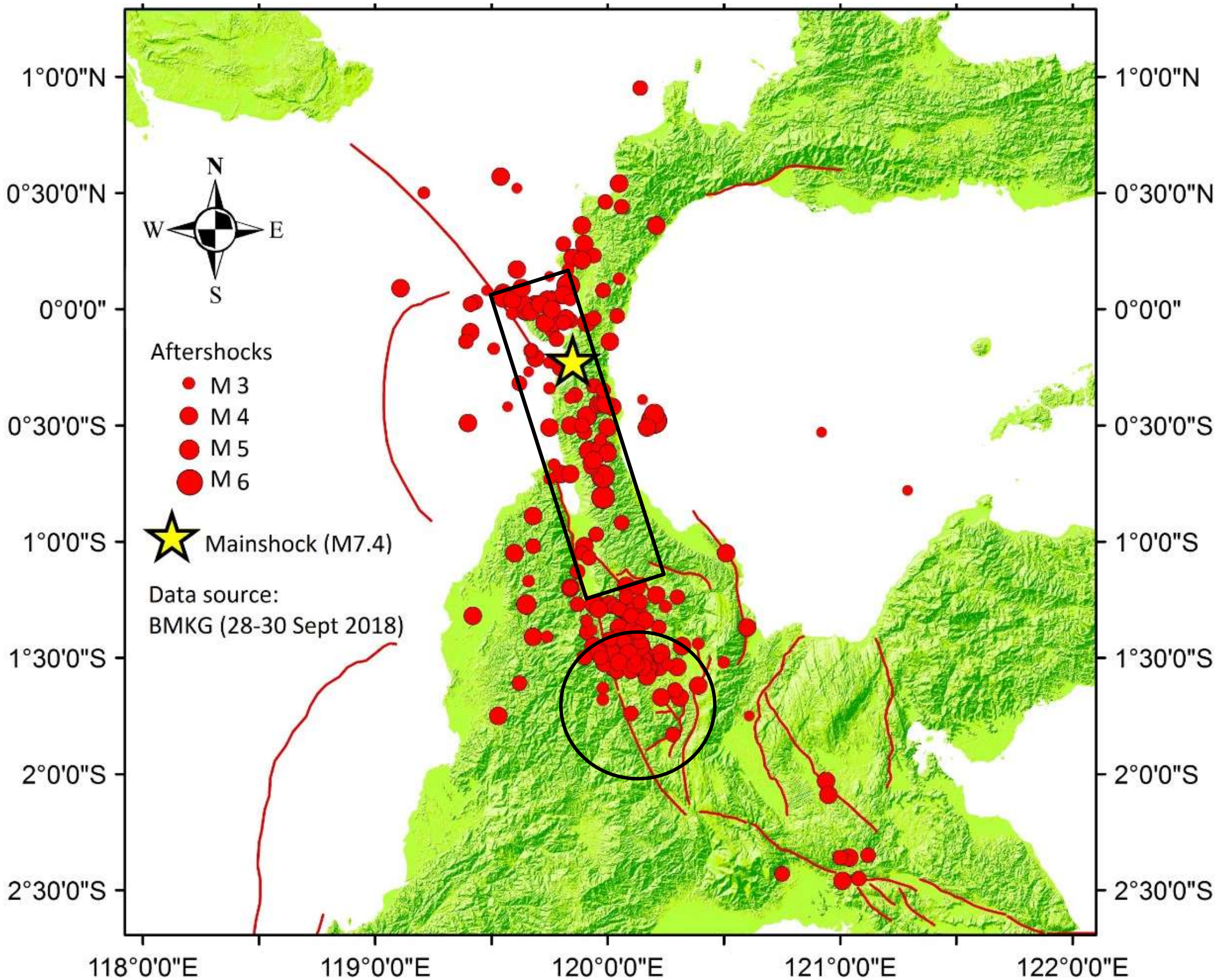



# ⑥ Tsunami warning and broadcasting

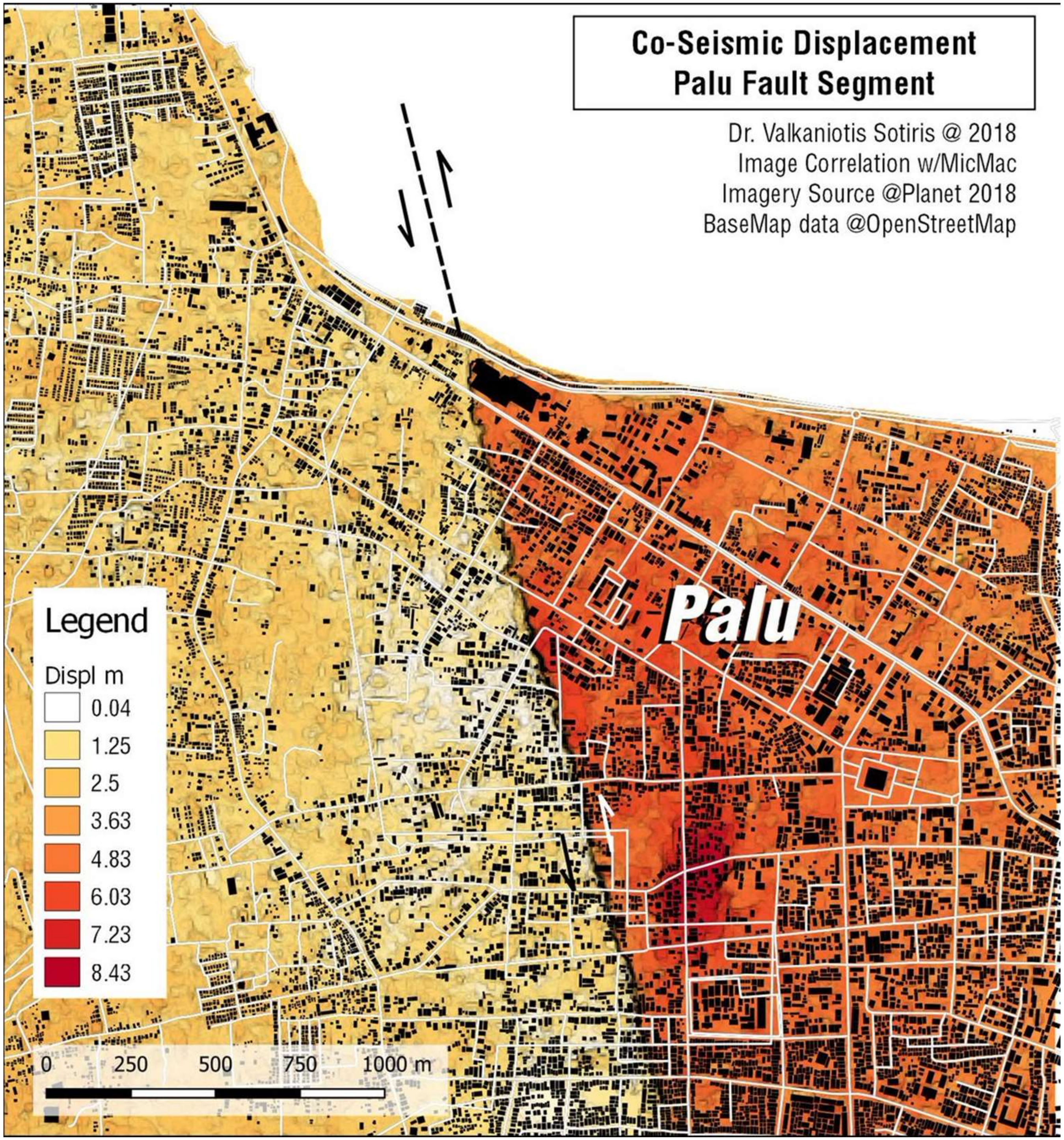

Source: NHK

In contrast to the calm voice used during the 2011 tsunami, terms such as “Evacuate immediately!”, “Tsunami! Evacuate!”, etc. were used to warn people to evacuate from locations expected to be hit by the tsunami. Also, some phases such as “Please remember the Great East Japan Earthquake and move to higher ground”, were used to remind the audience of the 2011 devastation. The warnings were also released in Chinese and Korean languages.

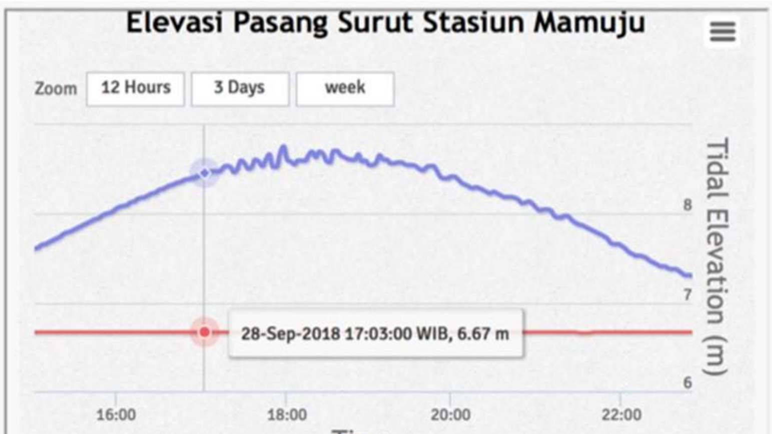
# 2018 Sulawesi tsunami



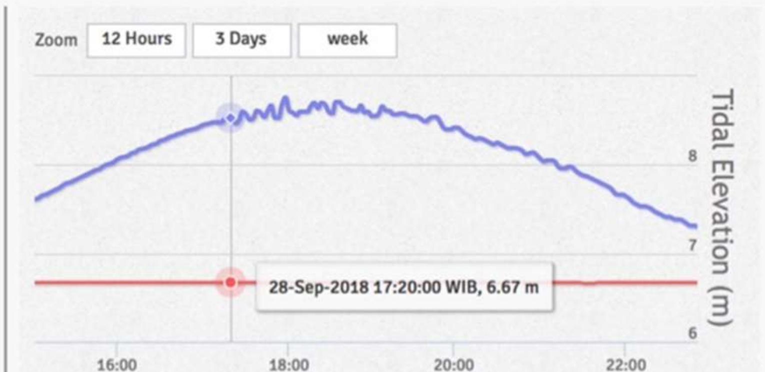

BMKG - http://lipi.go.id/public/uploads/berita/berita_palu.jpg


Co-Seismic Displacement
Palu Fault Segment
Dr. Valkaniotis Sotiris @ 2018
Image Correlation w/MicMac
Imagery Source @Planet 2018
BaseMap data @OpenStreetMap
Palu
Legend
Displ m
0.04
1.25
2.5
3.63
4.83
6.03
7.23
8.43
0
250
500
750
1000 m

## 験潮記録（2）at Mamuju

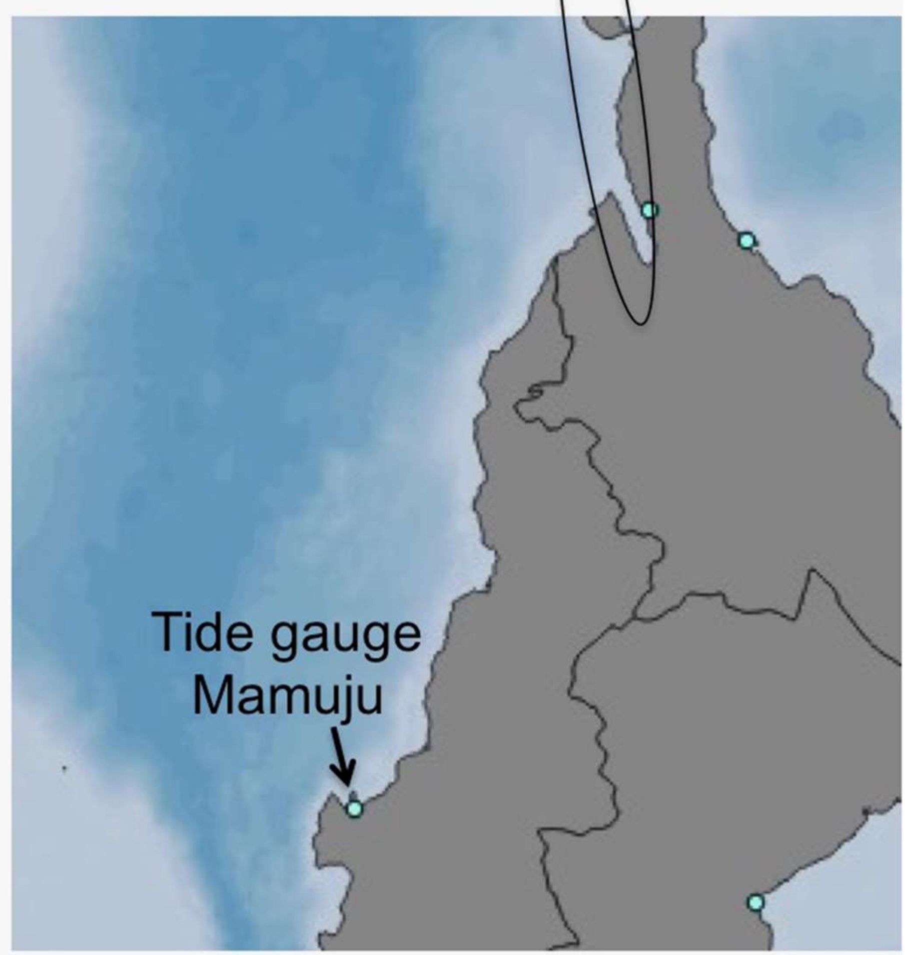



Time of earthquake




1st wave arrival

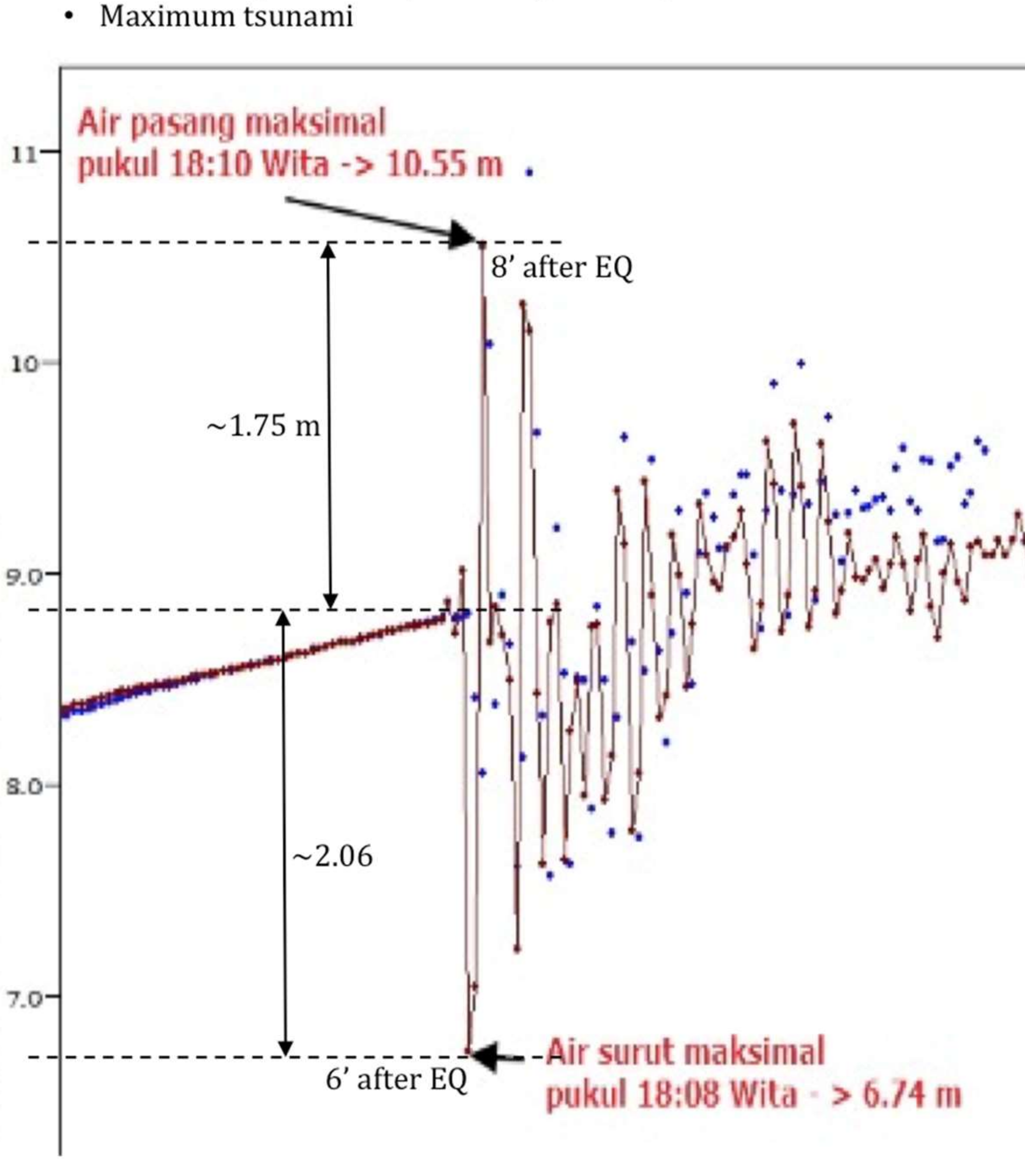

Maximum wave height arrival



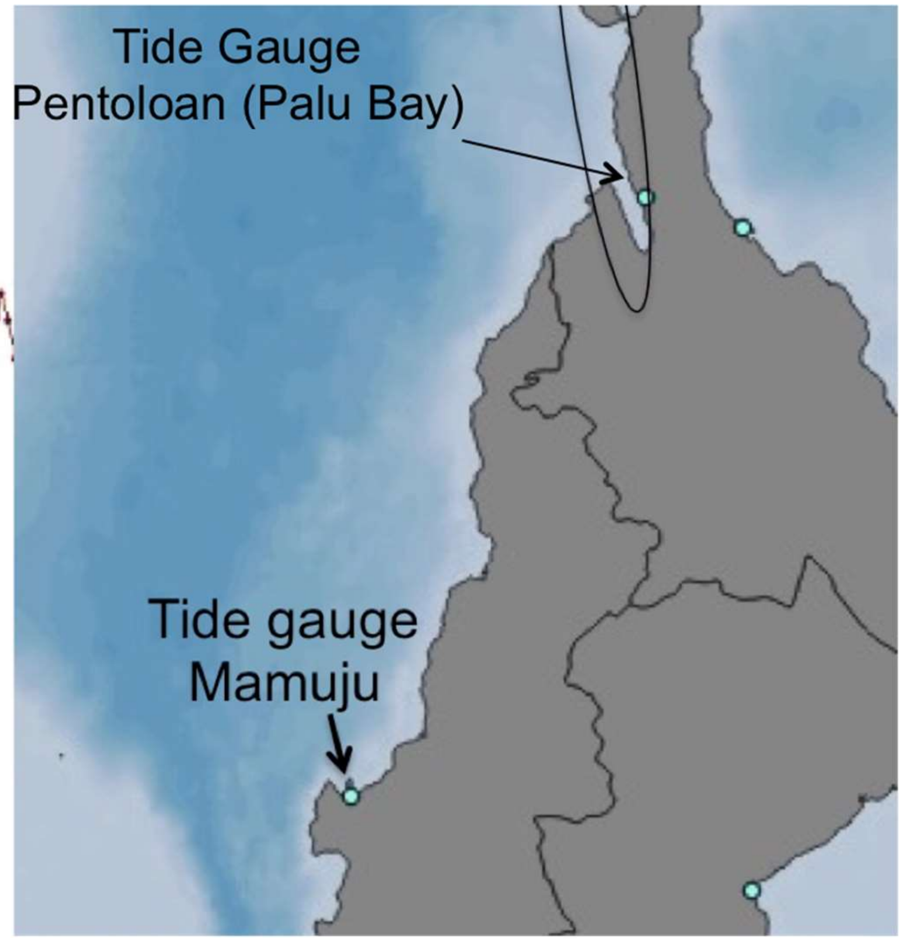

* WIB equal to UTC +7

# 験潮記録（3）at Pantonloan

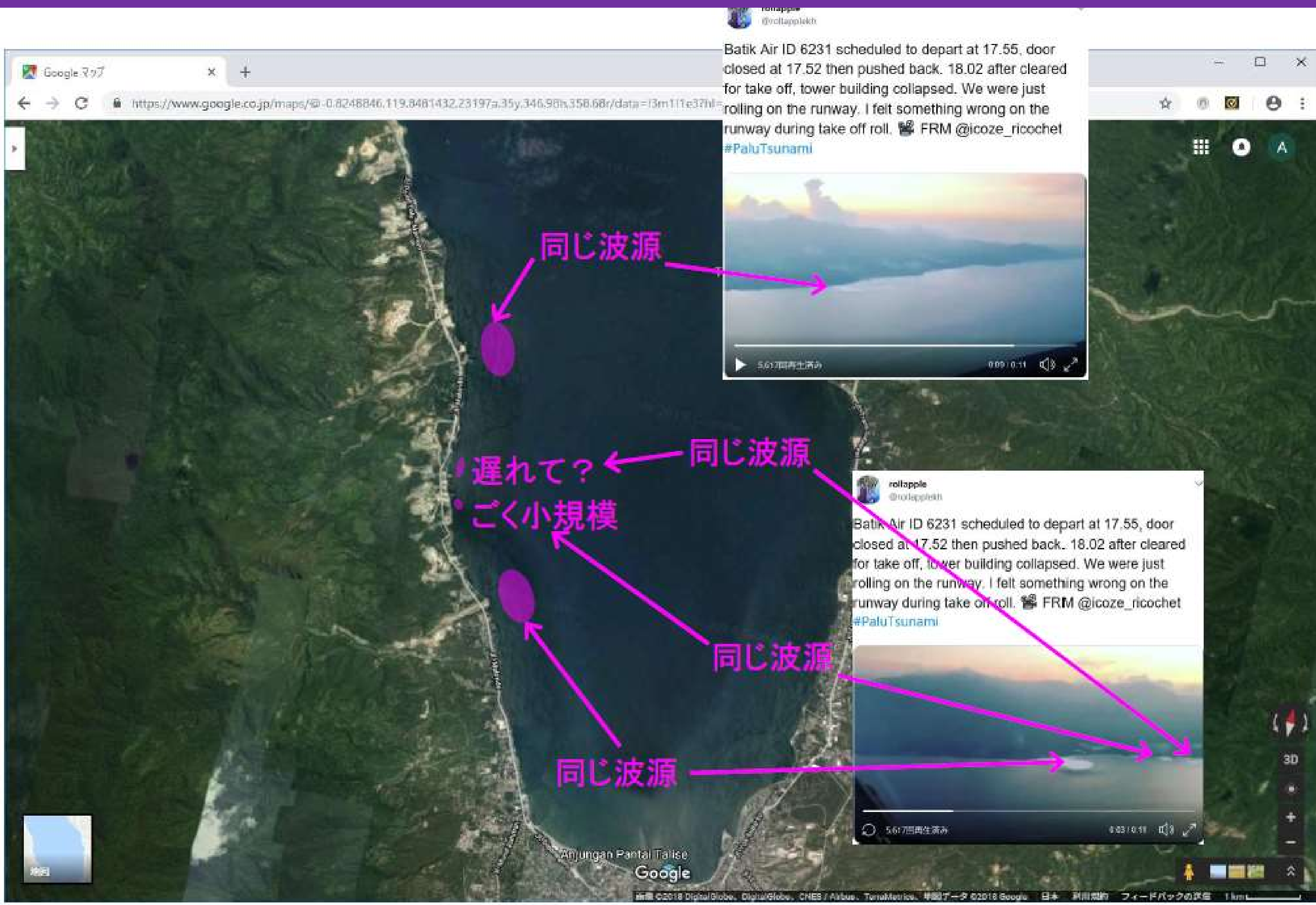
- Tsunami is preceded by receding water up to ~2.06
- Maximum tsunami




Pantoloan Tidal Data Station:
-0.711605 N 119.857279 E

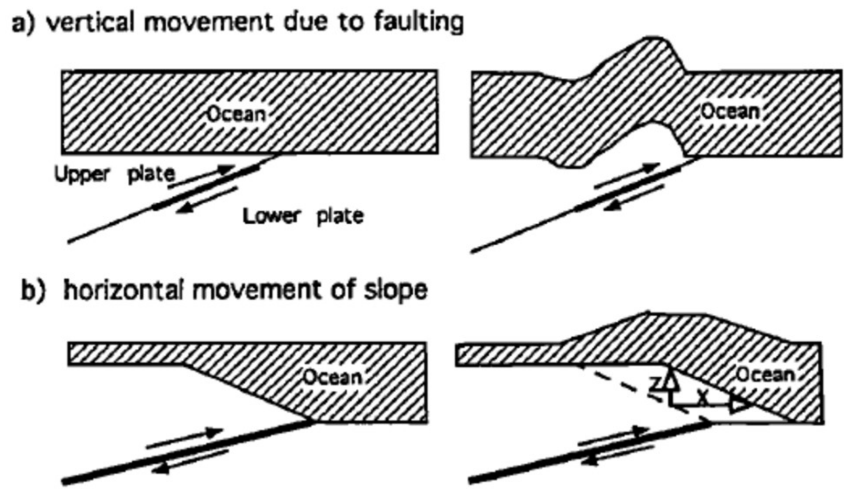


# Location of the landslides

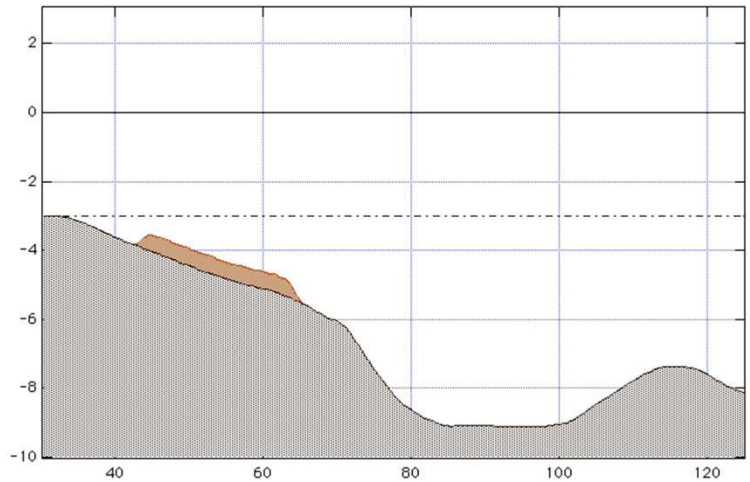


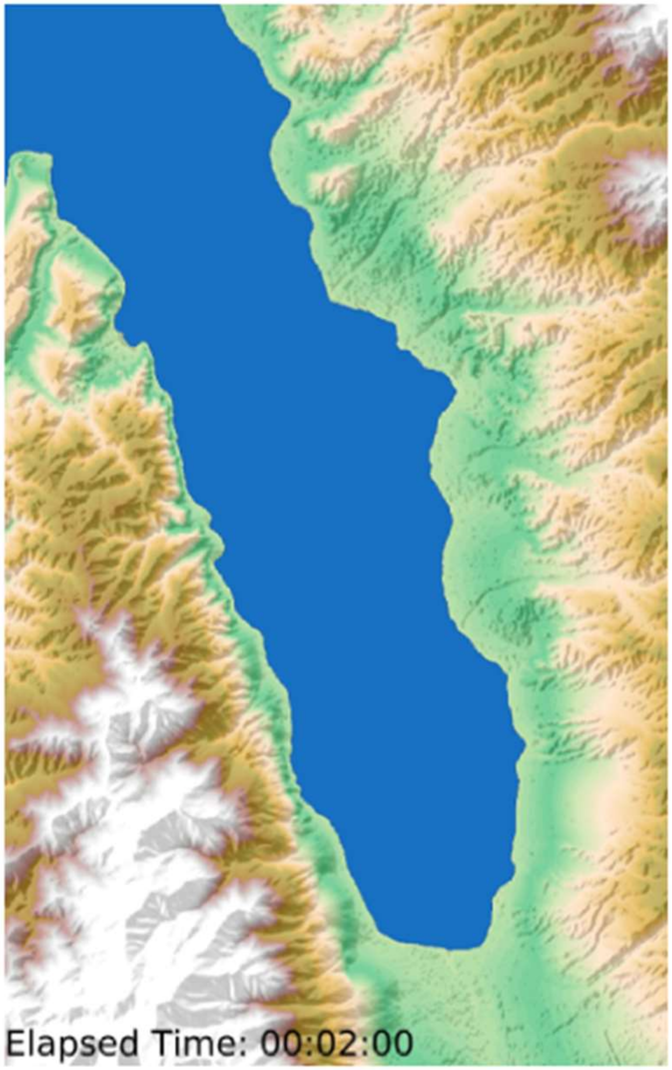
# Difficulty of tsunami prediction
## EX: 2018 Palu tsunami

**1) Horizonal movement of slope (Tanioka and Satake, 1996)**

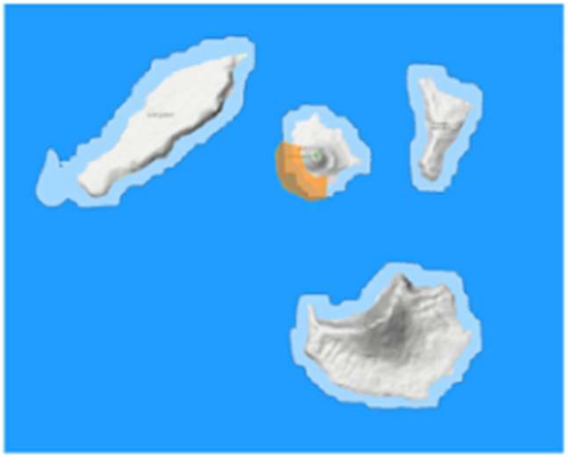


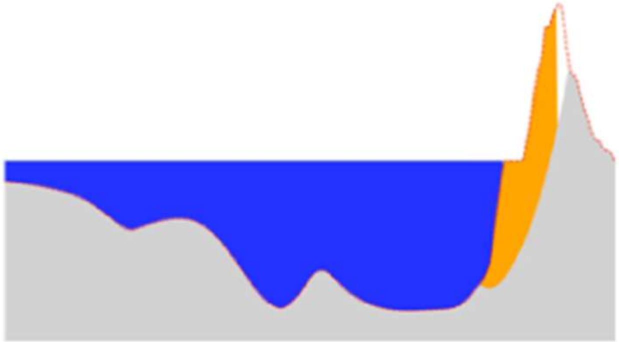

**2) Aerial or submarine landslide (Imamura et al., 2001**



# Difficulty of tsunami prediction
## EX: 2018 Sunda Strait tsunami

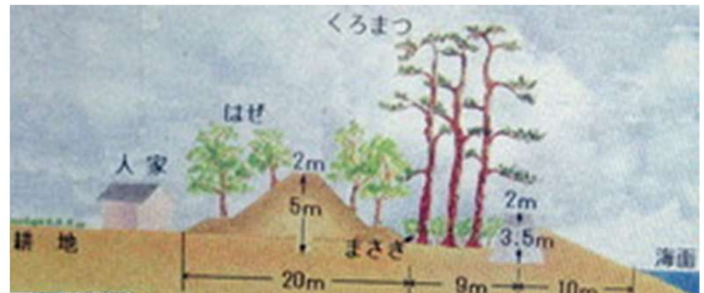





# 5th November: World Tsunami Awareness Day

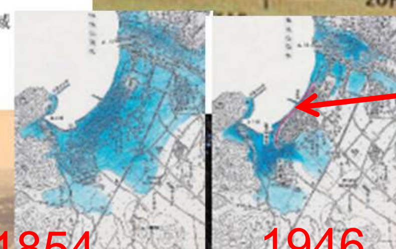
## Story of saving lives as well as reconstruction for resilience city

http://www.pref.wakayama.lg.jp/prefg/000200/nagomi/web/nagomi01/tour.html




安政南海地震津波の浸水域

昭和南海地震津波の浸水域
(2003 津村健四朗氏の研究資料)



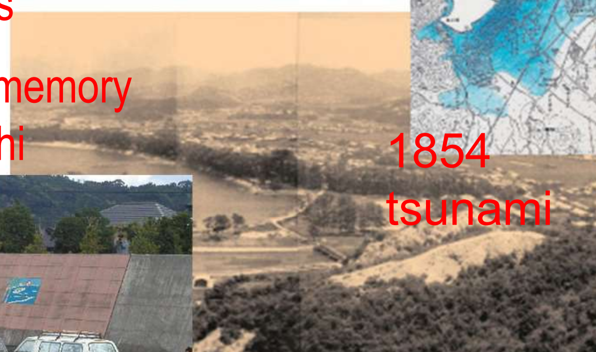
People evacuated to the higher ground by fires

Tsunami festival for memory of hiro; Mr.Hamaguchi

Seawalls

1854 tsunami

1946 tsunami

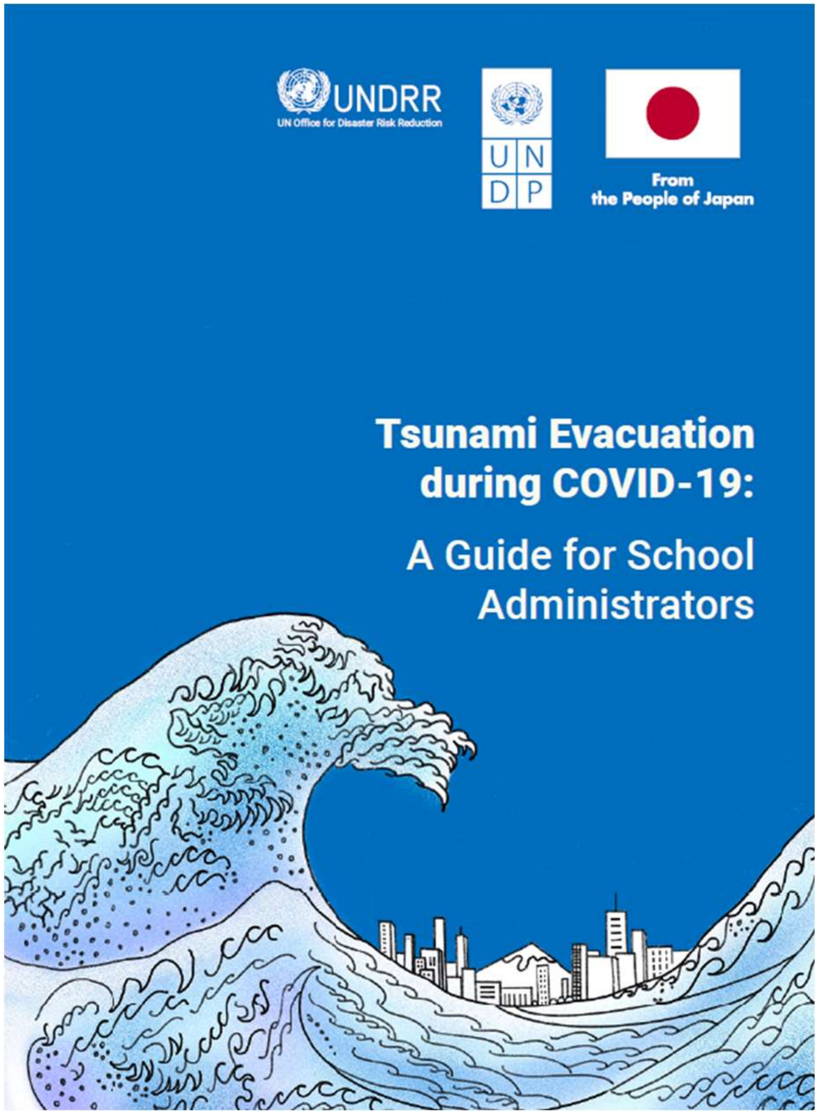


広川町の海岸

史跡広村堤防

Reconstruction with the wall to reduce tsunami inundation in 1946

# Tsunami evacuation during COVID-19



# Tsunami evacuation during COVID-19

## Proposed measures for school administrators to plan and implement a safe evacuation during COVID-19 or similar pandemic

**PLANNING A TSUNAMI EVACUATION DURING COVID 19**

### 01 UNDERSTAND that immediate life-safety is the most urgent priority

As mentioned above, in the case of local tsunamis, the lead-time is short and hence, evacuation should take place immediately and it takes priority over a COVID-19 stay-at-home order. School Administrators must follow official and/or natural warning signs so that school children and staff (and communities where applicable) are evacuated safely whilst following prescribed COVID-19 guidelines.

### 02 UPDATE tsunami/ disaster preparedness evacuation plans

All schools are encouraged to update their tsunami/ disaster preparedness plans to incorporate guidance for COVID-19. Where possible, schools should conduct physical drills to test and improve these plans.

### 03 CLARIFY roles and responsibilities of the School Emergency and Disaster Preparedness Committee and Task Teams[2]

Each school must review the roles and responsibilities of the School Committee and Task Teams. As part of the awareness raising efforts, the team should include COVID-19 awareness and preparedness that incorporate the latest international guidance and official government measures as applicable in the country. The school may consider setting up a special COVID-19 Task Force that would be responsible for taking measures to ensure that safe hygiene and medical care are available at evacuation centres. If required, the school should have an understanding with a local hospital to have trained medical staff at the evacuation centres to support health screening and isolation of possible COVID-19 cases.

### 04 REVIEW and ADJUST evacuation routes

Physical distancing during an evacuation process may require that school administrators identify multiple evacuation routes to reach the designated evacuation centre/s. If this is not possible, priority should be given to evacuate the most vulnerable groups first.

### 05 REASSESS evacuation centre size and designate multiple centres if needed

Evacuation centres are likely to become crowded, increasing the risk of physical contact and disease spread. Ideally, the same amount of physical distancing should be observed as in the classrooms. Additional evacuation centres should be selected so that all school children and staff can be evacuated safely whilst maintaining a safe distance. If the evacuation is carried out alongside the community, it is even more important to have multiple safe evacuation centres. A hazard map of the area can help to identify safe open spaces and/or buildings which could be designated as safe evacuation centres. These could include public and commercial buildings, parks, hotels, sports facilities etc. School administrators should collaborate with local administration to designate these safe evacuation centres particularly during the pandemic. All designated evacuation centres should have clean water and hygienic sanitation facilities.

### 06 ENSURE a sufficient supply of hygiene supplies

The evacuation centres must be equipped with hygiene kits that include enough masks, soap, hand sanitizers and wipes for each evacuee. In addition, each member of the School Disaster Management Team or Evacuation Team should wear Personal Protective Equipment (PPE) as they are likely to interact with outsiders. All evacuation centres must also have disinfectant supplies. Non-school community members should be encouraged to prepare 'go-bags' with basic essentials including hygiene kits, drinking cup, bowl, spoon, etc.

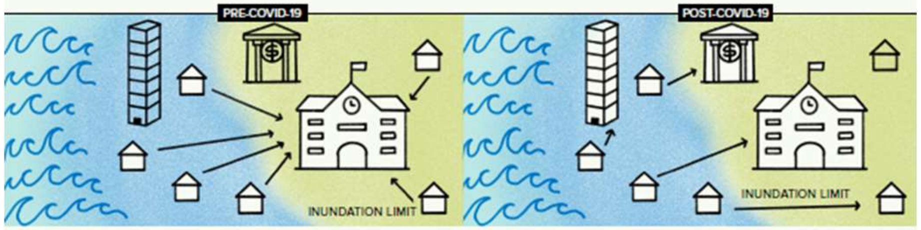



FIG. 2 ADDITIONAL EVACUATION CENTRES DURING COVID-19

# Tsunami evacuation during COVID-19

## DURING EVACUATION

### 01 CHECK health condition of evacuees

In principle, evacuation centres are required to accommodate all designated persons irrespective of their health condition. It is also assumed that temperature checks are conducted for all school staff and students on a daily basis. Therefore, in cases of evacuation centres that accommodate people from outside the school, such as parents and community members, there should be a separate registration process for them. The registration process should include the use of contactless temperature screening and those with a fever or symptoms of any illness should be isolated in a separate area within the evacuation centre. During registration, care should also be taken to identify people requiring special assistance such as the elderly, persons with disabilities and women who are pregnant or nursing.

### 02 PREVENT the spread of infection

A designated task team should be assigned to monitor the evacuees. Strict rules should be followed such as the wearing of masks at all times, physical distancing and frequent handwashing or sanitizing, in line with international guidance and government measures. Depending on the length of the evacuation time, regular temperature checks of all evacuees should be conducted.

### 03 ISOLATE the infected

Any evacuee who shows any signs of illness should be isolated immediately in a designated area within the evacuation centre. All personnel in the isolation area must be full PPE gear. The School Committee should inform the local administration or the health department at the earliest possible chance of any patients suspected of COVID-19 or any other illness so that they can be taken for treatment. The School Committee should have patients complete a form listing all persons they may have been in contact with recently and areas they may have visited.

## AFTER EVACUATION

### SHARE evacuation experiences and lessons learned to improve plans

In the event of a real evacuation or an evacuation drill, evacuation plans may need to be revised to suit the unique needs of the local community and the changing trends of the pandemic. Where physical drills are possible, they should be assessed by a designated team so that lessons can be incorporated to improve and strengthen school preparedness for tsunamis during COVID-19 and similar pandemic events.

# Tsunami evacuation during COVID-19

## Potential for AI to support evacuation management during a pandemic

In August 2020, an experiment using Artificial Intelligence (AI) was conducted in Kawasaki City to prevent congestion in shelters and reduce the risk of COVID-19 infections in the event of a disaster. The experiment was conducted by Kawasaki City and Fujitsu, which is developing the AI, and included about 80 participants who simulated an evacuation from a large typhoon. Three separate evacuation centres were temporarily set up in elementary school buildings and gymnasiums, and AI analysed the images taken by the cameras at each entrance to determine the number, age, and gender of people evacuating. Based on this information, the response headquarters was able to grasp the degree of congestion in each evacuation centre in real-time, and instructed the staff at the site to allocate evacuees accordingly. In addition, the drill assumed that there are a certain number of evacuees were infected with the coronavirus, and thus, the AI guarded against possible infections by accounting for the degree of congestion. When there was a risk of contact, an alarm sounded at the evacuation centre and city officials called on people to distance from each other. The success of the drill highlights the benefits of tapping into advanced technologies to support evacuation management during the COVID-19 pandemic.

## Lessons from Cyclone Amphan

On May 20, 2020, Tropical Cyclone Amphan struck India and Bangladesh. Ahead of its arrival, authorities evacuated millions of people in both countries. In Bangladesh, more than 12,000 shelters and public facilities, such as schools, were prepared for evacuees, which was three times as many than for normal cyclones to minimize COVID-19 risk. These shelters were equipped with masks, sanitizers, and handwashing facilities with soap, and health clinics were prepped in advance to isolate any evacuees exhibiting symptoms.

Some early lessons have emerged that are relevant to planning for tsunami evacuations amid COVID-19, notably:

1- Need to revise evacuation Standard Operating Procedures (SOP): When applying distancing measures, the capacity of shelters is reduced to 40 per cent. This calls for a re-examination of how people can be moved to avoid the risk of cross-infection and the provision of enough PPE and sanitation facilities.

2- Repurpose existing capacities, resources and tools: When the capacity of shelters is reduced authorities should need alternative shelters that are still disaster resilient. The identification of such resilient assets should become part of risk assessments undertaken in coastal areas.

# Tsunami evacuation during COVID-19

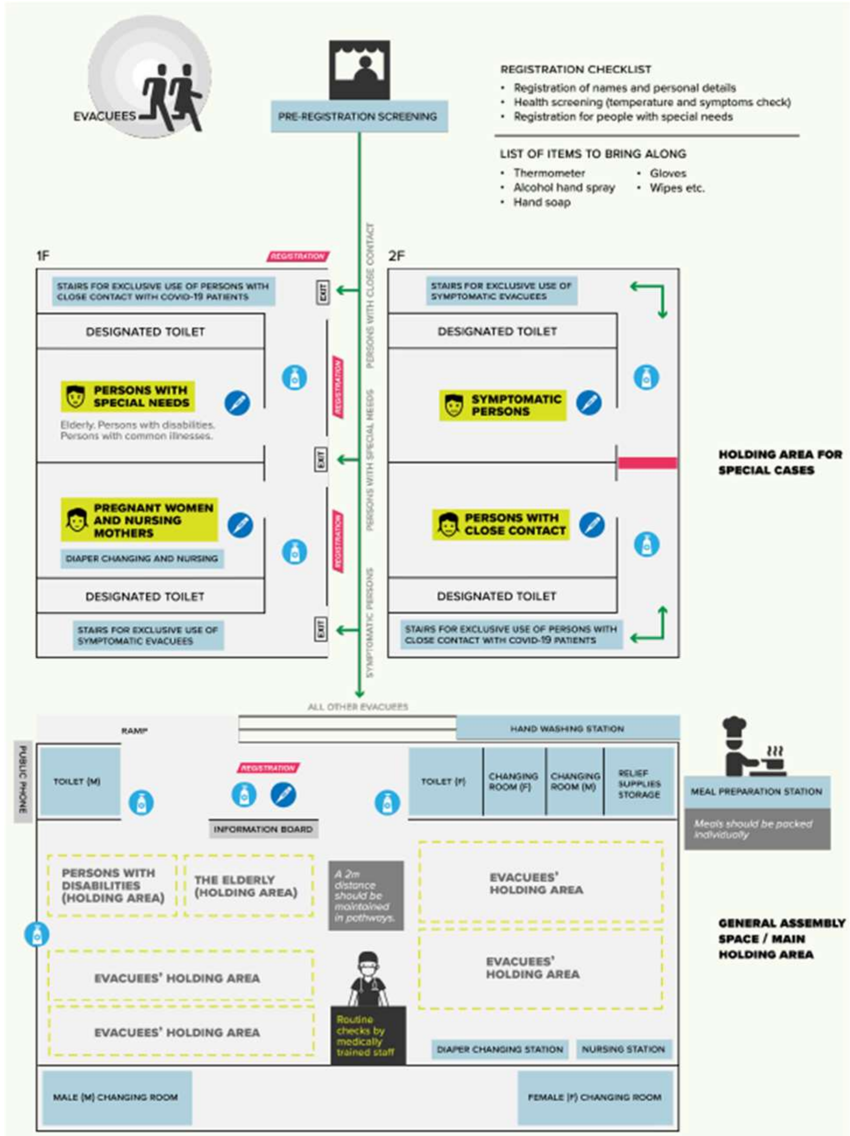



**FIG. 3 LAYOUT EXAMPLE OF THE EVACUATION CENTRE**

SOURCE: Page 3 of Cabinet Office of Japan (2020a)


Thank you
Sendai
Natori
Iwanuma
Watari
Yamamoto