NATIONAL REPORT
Submitted by Japan

BASIC INFORMATION

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2. ICG/PTWS Tsunami Warning Focal Point (TWFP)

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TWFP 24x7 point of contact (office, operational unit or position, not a person):
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3. Tsunami Advisor(s), if applicable

N/A

4. Tsunami Standard Operating Procedures for a Local Tsunami

(when a local tsunami hazard exists)

Japan Meteorological Agency (JMA) is the national authority for issuing tsunami warnings/advisories in Japan. JMA continuously monitors seismic activities in and around Japan. When an earthquake hits, JMA immediately determines the hypocenter and magnitude of the quake. If the earthquake occurs in an ocean area with tsunamigenic potential, JMA conducts tsunami forecast operations using a local tsunami database containing tsunami amplitude and travel time calculated in advance by numerical simulation. Tsunami warnings/advisories are classified into three categories as shown in Table 1: "Major Tsunami Warning," “Tsunami Warning” and "Tsunami Advisory". JMA issues warnings and/or advisories for 66 coastal regions which cover all the coastal areas of the country. Such warning and advisory messages consist of expected maximum tsunami heights and arrival times. However, it takes time to determine the exact scale of earthquakes with a magnitude of 8.0 or more; therefore, in such cases, JMA issues an initial tsunami warning based on the predefined maximum magnitude to avoid underestimation, with qualitative terms such as “Huge” and “High” for estimated maximum tsunami heights instead of quantitative expressions.

JMA provides tsunami warning/advisory messages, via dedicated land line, for the national and local authorities and broadcasting stations for disaster prevention and/or mitigation. Mayors of municipalities are responsible for issuing evacuation order to the residents. In addition, those messages are directly communicated to the public via JMA’s website and emergency mail service for mobile phones.

Real time sea level data are gathered in JMA to monitor tsunami arrivals at coasts. When detecting tsunami waves at tide gauges, JMA announces observed tsunami height and arrival time at each station.

Tsunami warnings and/or advisories are cleared when JMA concludes that the dangerous situation has been over, namely, when the tsunami attenuates and the observed height becomes adequately lower.

Category	Classification of forecast Tsunami Height	Tsunami Height to be Issued	
		Quantitative expression	For huge earthquakes
Major Tsunami Warning	10 m < Height	over 10 m	Huge
	5 m < Height ≤ 10 m	10 m	
	3 m < Height ≤ 5 m	5 m	
Tsunami Warning	1 m < Height ≤ 3 m	3 m	High
Tsunami Advisory	0.2 m ≤ Height ≤ 1 m	1 m	(N/A)

* Tsunami Height is defined as the height of wave crest on the coast relative to normal sea level.

Table 1: Tsunami Warnings/Advisories

5. Tsunami Standard Operating Procedures for a Distant Tsunami

When a large earthquake with a magnitude 7.0 or more occurs in an area distant from Japan, JMA determines the hypocenter and magnitude using seismic waveform data from global seismological observation network. At the same time, JMA exchanges earthquake information with the Pacific Tsunami Warning Center (PTWC), and uses focal parameters provided by PTWC for tsunami forecast where appropriate.

If there is a possibility of tsunami generation that might affect the coasts of Japan, JMA immediately conducts tsunami forecast operations in the same manner and criteria as the local tsunami procedures using a distant tsunami database. In addition, JMA also runs a real-time simulation based on CMT analysis outcomes for more detailed evaluation of tsunami impact. Results of the real-time simulation can be modified before the Tsunami Warning/Advisory issuance based on historical records and/or a comparison between simulated and observed tsunami height at overseas monitoring stations.

6. National Sea Level Network

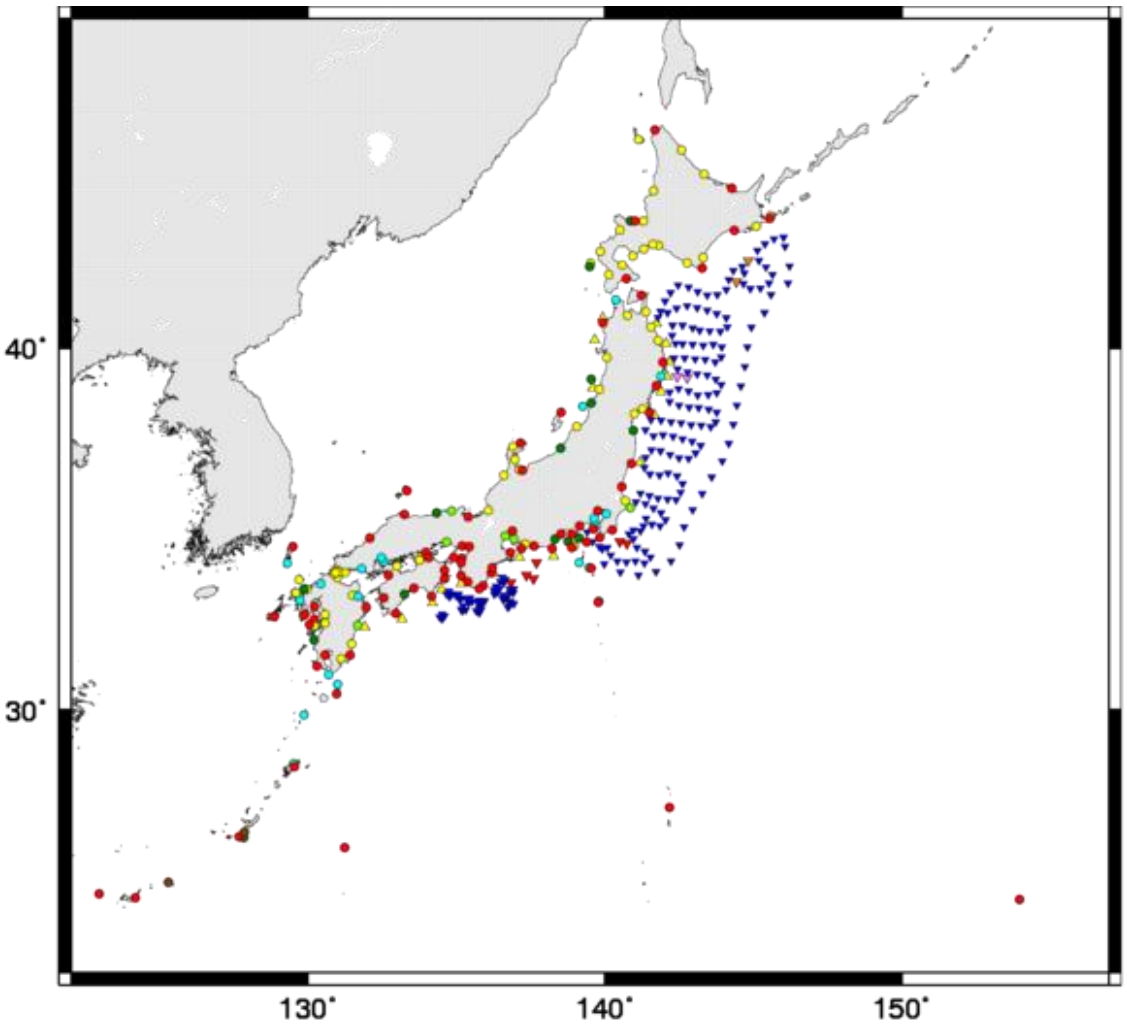
JMA collects tsunami data from various kinds of sea level observation stations all over Japan, such as microwave gauges, float-type gauges, acoustic sensors, huge tsunami gauges, offshore GPS buoys and offshore water pressure gauges installed on the sea floor. These stations are operated by JMA, the Ports and Harbours Bureau (PHB) of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the Geospatial Information Authority of Japan (GSI), the Japan Coast Guard (JCG), the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the National Research Institute for Earth Science and Disaster Prevention (NIED), and the Earthquake Research Institute (ERI) of the University of Tokyo and other institutions.

As of 1 July 2023, JMA receives real time sea level data from 406 stations as shown in Figure 1 and uses the data for monitoring tsunamis and issuing tsunami information to the public.

Observed sea level data from the 22 sites listed in Table 2 are available via GTS with the heading of SWJP40. The sampling rate is one minute and the transmission interval is 15 minutes.

Station Name	Latitude	Longitude	Sensor Type
Wakkanai	45°24´ N	141°41´ E	Microwave-type
Abashiri	44°01´ N	144°17´ E	Microwave-type
Hanasaki	43°17´ N	145°34´ E	Microwave-type
Kushiro	42°59´ N	144°22´ E	Microwave-type
Hakodate	41°47´ N	140°43´ E	Microwave-type
Ofunato	39°01´ N	141°45´ E	Microwave-type
Mera	34°55´ N	139°50´ E	Microwave-type
Chichijima	27°06´ N	142°12´ E	Microwave-type
Minamitorishima	24°17´ N	153°59´ E	Pressure-type
Omaezaki	34°37´ N	138°13´ E	Microwave-type
Kushimoto	33°29´ N	135°46´ E	Microwave-type
Tosashimizu	32°47´ N	132°58´ E	Microwave-type
Aburatsu	31°35´ N	131°25´ E	Microwave-type
Naha	26°13´ N	127°40´ E	Microwave-type
Ishigakijima	24°20´ N	124°10´ E	Microwave-type
Nagasaki	32°44´ N	129°52´ E	Microwave-type
Hamada	34°54´ N	132°04´ E	Microwave-type
Saigo	36°12´ N	133°20´ E	Microwave-type
Toyama	36°46´ N	137°13´ E	Microwave-type
Noto	37°30´ N	137°09´ E	Microwave-type
Sado	38°19´ N	138°31´ E	Microwave-type
Fukaura	40°39´ N	139°56´ E	Microwave-type

Table 2: Sea Level Monitoring Stations available via GTS



Legend (Station Types)

●: Tide gauges / tsunami meters

▲: GPS buoys

▼: Offshore-water-pressure gauges (Cable)

Color Legend (Institutions)

- Japan Meteorological Agency (JMA)
- Ports and Harbours Bureau (PHB) of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
- Geospatial Information Authority of Japan (GSI)
- Japan Coast Guard (JCG)
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
- National Research Institute for Earth Science and Disaster Prevention (NIED)
- Earthquake Research Institute (ERI), the University of Tokyo
- Other Institutions

Figure 1: Sea Level Monitoring Network in Japan (406 stations in total, as of 1 July 2023)

7. Information on Tsunami occurrences (April 2019 – July 2023)

7.1. Earthquake West off Yamagata Prefecture, Japan

a) Hypocentral parameters (determined by JMA)

Date	18 June 2019
Time	13:22 UTC
Latitude	38°36′29″ N
Longitude	139°28′46″ E
Depth	14 km
Magnitude	6.7 (Mjma), 6.5 (Mw)

b) Observed tsunami

Station			Arrival Time [UTC]	Maximum Amplitude	
Name	Latitude	Longitude		Time [UTC]	Height [cm]
Akita	39°45′ N	140°04′ E	unclear	16:42, 18 Jun	8
Sakata	38°55′ N	139°49′ E	unclear	14:35, 18 Jun	5
Tsuruoka-shi Nezugaseki	38°34′ N	139°33′ E	13:27, 18 Jun	13:34, 18 Jun	11
Awashima	38°28′ N	139°15′ E	13:29, 18 Jun	13:48, 18 Jun	5
Niigata	37°56′ N	139°04′ E	unclear	15:06, 18 Jun	8
Kashiwazaki-shi Kujiranami	37°21′ N	138°31′ E	unclear	16:18, 18 Jun	4
Sado-shi Washizaki	38°19′ N	138°31′ E	unclear	15:24, 18 Jun	4
Wajima-ko	37°24′ N	136°54′ E	unclear	15:07, 18 Jun	8

Table 3: Observed Tsunami (Earthquake West off Yamagata Prefecture, 18 June 2019)

c) Tsunami warning operations

13:22 UTC --- Earthquake occurrence
13:24 UTC --- Tsunami Advisory
15:30 UTC --- Press Conference
16:02 UTC --- Tsunami Advisory (cancellation)

d) Lessons learned

The tsunami prediction results were generally consistent with the observed tsunami characteristics.

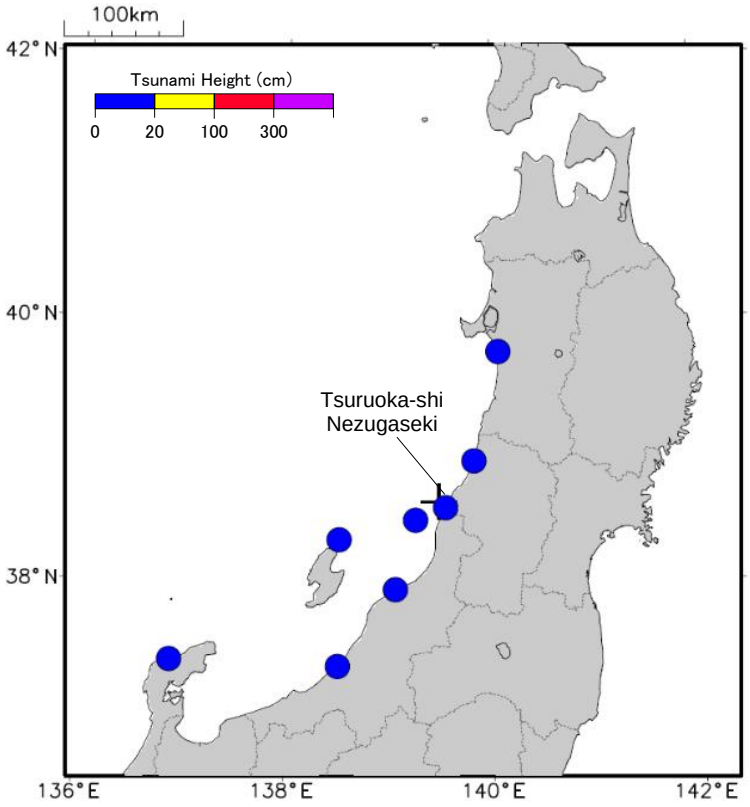


Figure 2: Observed Tsunami (Earthquake West off Yamagata Prefecture, 18 June 2019)

7.2. Hunga Tonga–Hunga Ha‘apai eruption

a) Eruption parameters

Date	15 January 2022
Time	Around 04:00 UTC
Latitude	20°33 S
Longitude	175°24″ W

b) Observed tsunami

Station			Arrival Time [UTC]	Maximum Amplitude	
Name	Latitude	Longitude		Time [UTC]	Height [cm]
Nemuro-shi Hanasaki	43°17'N	145°34'E	11:55, 15 Jan	20:03, 15 Jan	59
Kushiro	42°59'N	144°22'E	11:55, 15 Jan	16:50, 15 Jan	44
Nemuro-ko	43°21'N	145°35'E	unclear	20:52, 15 Jan	23
Hamanaka-cho Kiritappu-ko	43°05'N	145°07'E	12:02, 15 Jan	16:05, 15 Jan	100
Tokachi-ko	42°18'N	143°19'E	12:03, 15 Jan	15:23, 15 Jan	59
Erimo-cho Shoya	42°03'N	143°18'E	11:51, 15 Jan	15:47, 15 Jan	0.8m
Urakawa	42°10'N	142°46'E	unclear	20:15, 15 Jan	64
Muroran-ko	42°21'N	140°57'E	unclear	18:55, 15 Jan	12
Tomakomai-higashiko	42°36'N	141°49'E	unclear	17:42, 15 Jan	37
Tomakomai-nishiko	42°38'N	141°37'E	unclear	15:38, 15 Jan	24
Shiraoi-ko	42°31'N	141°19'E	12:22, 15 Jan	15:28, 15 Jan	33
Hakodate	41°47'N	140°43'E	unclear	17:41, 15 Jan	30
Oshima Mori-ko	42°07'N	140°36'E	unclear	03:34, 16 Jan	21
Wakkanai	45°24'N	141°41'E	unclear	03:41, 16 Jan	13
Rishiri-to Kutsugata-ko	45°11'N	141°08'E	unclear	22:15, 15 Jan	9
Rumoi	43°57'N	141°38'E	unclear	20:48, 15 Jan	12
Otaru	43°12'N	141°00'E	unclear	21:47, 15 Jan	13
Ishikariwan-shinko	43°13'N	141°18'E	unclear	19:41, 15 Jan	11
Iwanai-ko	42°59'N	140°30'E	unclear	16:40, 15 Jan	18
Setana-ko	42°27'N	139°51'E	unclear	23:01, 15 Jan	14
Okushiri-to Okushiri-ko	42°10'N	139°31'E	unclear	22:16, 15 Jan	10
Esashi	41°52'N	140°08'E	unclear	21:22, 15 Jan	10
Esashi-ko	44°56'N	142°35'E	unclear	03:42, 16 Jan	26
Abashiri	44°01'N	144°17'E	unclear	00:02, 16 Jan	21
Mombetsu-ko	44°21'N	143°22'E	unclear	19:18, 15 Jan	20
Tappi	41°15'N	140°23'E	unclear	20:31, 15 Jan	14
Mutsu-shi Sekinehama	41°22'N	141°14'E	unclear	17:55, 15 Jan	40
Mutsuogawara-ko	40°56'N	141°23'E	12:07, 15 Jan	17:45, 15 Jan	42
Hachinohe-ko	40°32'N	141°33'E	12:12, 15 Jan	16:21, 15 Jan	54
Aomori	40°50'N	140°46'E	unclear	01:14, 16 Jan	12
Aomori Hachinohe-oki	40°38'N	141°45'E	12:38, 15 Jan	14:50, 15 Jan	0.2m
Miyako	39°39'N	141°59'E	11:44, 15 Jan	18:05, 15 Jan	38
Ofunato	39°01'N	141°45'E	11:52, 15 Jan	14:32, 15 Jan	30
Kamaishi	39°16'N	141°53'E	11:47, 15 Jan	18:21, 15 Jan	36
Kuji-ko	40°12'N	141°48'E	12:08, 15 Jan	17:26, 15 Jan	107
Iwate Kuji-oki	40°07'N	142°04'E	unclear	17:41, 15 Jan	0.2m
Iwate Miyako-oki	39°38'N	142°11'E	unclear	14:21, 15 Jan	0.1m
Iwate Kamaishi-oki	39°16'N	142°06'E	11:46, 15 Jan	14:38, 15 Jan	0.2m
Ishinomaki-shi Ayukawa	38°18'N	141°30'E	unclear	17:11, 15 Jan	74
Sendai-ko	38°16'N	141°00'E	12:26, 15 Jan	15:39, 15 Jan	72
Ishinomaki-ko	38°24'N	141°16'E	12:07, 15 Jan	22:03, 15 Jan	48

Kesennuma Hirotawan-oki	38°51'N	141°54'E	11:39, 15 Jan	14:24, 15 Jan	0.1m
Miyagi Kinkasan-oki	38°14'N	141°41'E	11:42, 15 Jan	16:01, 15 Jan	0.2m
Miyagi Oshika-oki	38°06'N	141°33'E	unclear	16:05, 15 Jan	0.1m
Akita	39°45'N	140°04'E	unclear	23:33, 15 Jan	11
Sakata	38°55'N	139°49'E	unclear	20:03, 15 Jan	21
Tsuruoka-shi Nezugaseki	38°34'N	139°33'E	unclear	18:54, 15 Jan	6
Iwaki-shi Onahama	36°56'N	140°54'E	11:43, 15 Jan	14:55, 15 Jan	65
Soma	37°50'N	140°58'E	12:20, 15 Jan	16:50, 15 Jan	52
Fukushima Onahama-oki	36°58'N	141°11'E	unclear	14:38, 15 Jan	0.1m
Oarai	36°18'N	140°34'E	11:44, 15 Jan	15:57, 15 Jan	56
Kamisu-shi Kashima-ko	35°56'N	140°42'E	11:32, 15 Jan	15:48, 15 Jan	47
Ibaraki Kamisu-oki	35°54'N	141°03'E	unclear	13:39, 15 Jan	0.1m
Choshi	35°45'N	140°52'E	11:34, 15 Jan	19:00, 15 Jan	32
Tateyama-shi Mera	34°55'N	139°50'E	unclear	17:24, 15 Jan	50
Katsuura-shi Okitsu	35°08'N	140°15'E	11:16, 15 Jan	15:01, 15 Jan	0.3m
Chiba	35°34'N	140°03'E	12:38, 15 Jan	19:26, 15 Jan	7
Tokyo Harumi	35°39'N	139°46'E	12:40, 15 Jan	19:29, 15 Jan	17
Izu-oshima Okada	34°47'N	139°23'E	unclear	12:58, 15 Jan	25
Miyakejima Tsubota	34°03'N	139°33'E	unclear	21:56, 15 Jan	27
Kozushima Kozushima-ko	34°13'N	139°08'E	unclear	15:53, 15 Jan	46
Miyakejima Ako	34°04'N	139°29'E	unclear	16:39, 15 Jan	45
Hachijojima Kaminato	33°08'N	139°48'E	unclear	18:02, 15 Jan	44
Hachijojima Yaene	33°06'N	139°47'E	unclear	18:03, 15 Jan	0.9m
Chichijima Futami	27°06'N	142°12'E	10:59, 15 Jan	14:34, 15 Jan	88
Yokohama	35°27'N	139°39'E	12:08, 15 Jan	17:48, 15 Jan	14
Yokosuka	35°17'N	139°39'E	11:52, 15 Jan	16:34, 15 Jan	16
Miurashi Aburatsubo	35°10'N	139°37'E	unclear	18:21, 15 Jan	32
Odawara	35°14'N	139°09'E	11:27, 15 Jan	18:16, 15 Jan	13
Miura-shi Misaki-gyoko	35°09'N	139°37'E	unclear	18:01, 15 Jan	0.4m
Niigata	37°56'N	139°04'E	unclear	04:07, 16 Jan	11
Nanao-ko	37°03'N	136°58'E	unclear	22:37, 15 Jan	7
Kanazawa	36°37'N	136°36'E	unclear	15:17, 15 Jan	15
Tsuruga-ko	35°40'N	136°04'E	unclear	11:07, 16 Jan	12
Minami-izu-cho Irozaki	34°37'N	138°51'E	unclear	16:57, 15 Jan	41
Numazu-shi Uchiura	35°01'N	138°53'E	11:59, 15 Jan	15:06, 15 Jan	42
Shimizu	35°01'N	138°31'E	12:02, 15 Jan	14:24, 15 Jan	25
Omaezaki	34°37'N	138°13'E	11:58, 15 Jan	15:16, 15 Jan	66
Maisaka	34°41'N	137°37'E	12:08, 15 Jan	15:54, 15 Jan	26
Shimoda-ko	34°41'N	138°58'E	11:45, 15 Jan	14:46, 15 Jan	26
Ito	34°54'N	139°08'E	11:28, 15 Jan	14:14, 15 Jan	10
Nishiizu-cho Tago	34°48'N	138°46'E	11:55, 15 Jan	18:32, 15 Jan	14
Yaizu	34°52'N	138°20'E	unclear	17:22, 15 Jan	30
Shizuoka Omaezaki-oki	34°24'N	138°17'E	unclear	14:25, 15 Jan	0.1m
Tahara-shi Akabane	34°36'N	137°11'E	unclear	16:15, 15 Jan	63
Nagoya	35°05'N	136°53'E	unclear	18:07, 15 Jan	20
Toyohashi-shi Mikawa-ko	34°44'N	137°19'E	unclear	19:04, 15 Jan	10
Handa-shi Kinuura	34°53'N	136°57'E	unclear	17:27, 15 Jan	16
Yokkaichi	34°58'N	136°38'E	13:20, 15 Jan	02:31, 16 Jan	13
Toba	34°29'N	136°49'E	unclear	16:46, 15 Jan	53
Owase	34°05'N	136°12'E	11:40, 15 Jan	17:38, 15 Jan	42
Kumano-shi Yuki	33°56'N	136°10'E	unclear	15:56, 15 Jan	45
Maizuru	35°29'N	135°23'E	unclear	23:41, 15 Jan	16
Misaki-cho Tannowa	34°20'N	135°11'E	unclear	17:35, 15 Jan	10

Osaka Tempozan	34°39'N	135°26'E	13:23, 15 Jan	18:37, 15 Jan	17
Kobe	34°41'N	135°11'E	unclear	20:10, 15 Jan	11
Himeji	34°47'N	134°40'E	unclear	18:23, 15 Jan	8
Sumoto	34°21'N	134°54'E	unclear	17:22, 15 Jan	8
Nachi-katsuura-cho Uragami	33°34'N	135°54'E	11:34, 15 Jan	15:18, 15 Jan	44
Kushimoto-cho Fukuro-ko	33°29'N	135°46'E	unclear	16:23, 15 Jan	93
Shirahama-cho Katata	33°41'N	135°23'E	12:04, 15 Jan	16:18, 15 Jan	40
Wakayama	34°13'N	135°09'E	12:51, 15 Jan	17:13, 15 Jan	23
Gobo-shi Haraido	33°51'N	135°10'E	unclear	15:31, 15 Jan	82
Sakaiminato-shi Sakai	35°33'N	133°15'E	unclear	15:57, 15 Jan	15
Komatsushima	34°01'N	134°35'E	unclear	14:57, 15 Jan	14
Tokushima Yuki	33°46'N	134°36'E	11:46, 15 Jan	15:35, 15 Jan	59
Takamatsu	34°21'N	134°03'E	unclear	18:21, 15 Jan	5
Uwajima	33°14'N	132°33'E	unclear	18:53, 15 Jan	16
Muroto-shi Muroto-misaki	33°16'N	134°10'E	unclear	15:15, 15 Jan	81
Kochi	33°30'N	133°34'E	11:59, 15 Jan	16:57, 15 Jan	33
Tosa-shimizu	32°47'N	132°58'E	11:52, 15 Jan	15:23, 15 Jan	100
Naka-tosa-cho Kure-ko	33°20'N	133°15'E	12:02, 15 Jan	18:17, 15 Jan	51
Shimonoseki-shi Hikoshima-deshimatsu	33°56'N	130°56'E	unclear	21:20, 15 Jan	12
Tokuyama	34°02'N	131°48'E	unclear	19:35, 15 Jan	8
Kitakyushu-shi Moji	33°57'N	130°57'E	unclear	21:22, 15 Jan	13
Kitakyushu-ko Hiagari	33°55'N	130°53'E	unclear	21:13, 15 Jan	10
Amakusa-shi Hondo-ko	32°26'N	130°13'E	unclear	18:36, 15 Jan	19
Reihoku-machi Tororo	32°28'N	130°02'E	unclear	20:01, 15 Jan	16
Nagasaki	32°44'N	129°52'E	unclear	21:04, 15 Jan	28
Fukuejima Fukue-ko	32°42'N	128°51'E	unclear	18:20, 15 Jan	10
Sasebo	33°09'N	129°43'E	unclear	21:00, 15 Jan	18
Nagasaki-ko Kogo	32°43'N	129°50'E	unclear	21:43, 15 Jan	15
Hirado-shi Tabira-ko	33°22'N	129°35'E	unclear	19:05, 15 Jan	10
Oita	33°16'N	131°41'E	unclear	17:45, 17 Jan	8
Beppu-ko	33°18'N	131°30'E	unclear	18:03, 15 Jan	11
Saiki-shi Matsuura	32°57'N	131°58'E	unclear	17:03, 15 Jan	19
Nichinan-shi Aburatsu	31°35'N	131°25'E	11:54, 15 Jan	16:30, 15 Jan	63
Miyazaki-ko	31°54'N	131°27'E	unclear	21:48, 15 Jan	68
Hyuga-shi Hososhima	32°27'N	131°40'E	11:55, 15 Jan	14:47, 15 Jan	28
Minami-osumi-cho Odomari	31°01'N	130°41'E	unclear	16:18, 15 Jan	72
Shibushi-ko	31°29'N	131°07'E	unclear	16:12, 15 Jan	58
Tanegashima Kumano	30°28'N	130°58'E	unclear	14:50, 15 Jan	68
Tanegashima Nishino-omote	30°44'N	131°00'E	unclear	16:39, 15 Jan	45
Amami-shi Kominato	28°19'N	129°32'E	unclear	14:56, 15 Jan	134
Nakanoshima	29°51'N	129°51'E	unclear	15:41, 15 Jan	52
Amami-shi Naze	28°24'N	129°30'E	unclear	16:21, 15 Jan	28
Kagoshima	31°36'N	130°34'E	unclear	20:28, 15 Jan	12
Makurazaki	31°16'N	130°18'E	unclear	16:53, 15 Jan	59
Akune	32°01'N	130°11'E	unclear	17:04, 15 Jan	24
Naha	26°13'N	127°40'E	unclear	14:33, 15 Jan	28
Nanjo-shi Azama	26°11'N	127°49'E	11:39, 15 Jan	14:35, 15 Jan	27
Okinawa-shi Nakagusukuwan-ko	26°20'N	127°50'E	11:47, 15 Jan	14:36, 15 Jan	25
Minami-daito-gyoko	25°52'N	131°14'E	unclear	14:11, 15 Jan	13

Miyakojima Hirara	24°49'N	125°17'E	12:04, 15 Jan	15:04, 15 Jan	35
Ishigakijima Ishigaki-ko	24°20'N	124°10'E	11:42, 15 Jan	15:02, 15 Jan	20
Yonagunijima Kubura	24°27'N	122°57'E	unclear	18:05, 15 Jan	19

* Height values described in meter were measured with huge tsunami gauges (resolution: 0.1 m), and GPS buoy, ocean-bottom pressure gauges.
* The data contained in this tabe is provisional and subject to change.

Table 4: Observed Tsunami (Hunga Tonga–Hunga Ha‘apai eruption, 15 Jan 2022)

c) Tsunami warning operations

(15 January)
Around 04:00 UTC --- Eruption occurrence
15:15 UTC --- Tsunami Warning
17:00 UTC --- Press Conference
17:54 UTC --- Tsunami Warning(revised)
19:07 UTC --- Tsunami Warning(revised)
22:30 UTC --- Tsunami Warning(revised)
(16 January)
02:20 UTC --- Tsunami Warning (cancellation)
05:00 UTC --- Tsunami Advisory (cancellation)

d) Lessons learned

Based on the lessons learned from this event, JMA revised the operating procedures for volcanic tsunamis, as described in Chapter11.

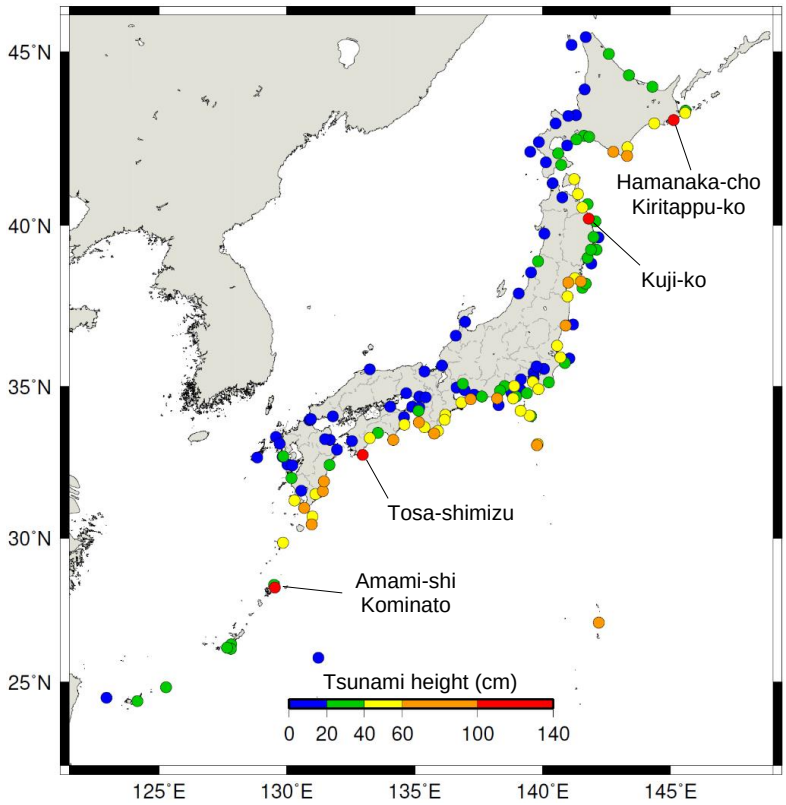


Figure 3: Observed Tsunami (Hunga Tonga-Hunga Ha’apai eruption, 15 Jan 2022)

7.3. Earthquake off Fukushima Prefecture, Japan

a) Hypocentral parameters (determined by JMA)

Date	16 March 2022
Time	14:36 UTC
Latitude	37°41′48″ N
Longitude	141°37′23″ E
Depth	57km
Magnitude	7.4 (Mjma), 7.3 (Mw)

b) Observed tsunami

Station			Arrival Time [UTC]	Maximum Amplitude	
Name	Latitude	Longitude		Time [UTC]	Height [cm]
Hachinohe-ko	40°32' N	141°33' E	unclear	17:04, 16 Mar	10
Miyako	39°39' N	141°59' E	15:14, 16 Mar	16:18, 16 Mar	6
Ofunato	39°01' N	141°45' E	unclear	17:16, 16 Mar	9
Kamaishi	39°16' N	141°53' E	unclear	17:36, 16 Mar	6
Kuji-ko	40°12' N	141°48' E	15:47, 16 Mar	17:26, 16 Mar	13
Iwate Kamaishi-oki	39°16' N	142°06' E	unclear	15:01, 16 Mar	0.1m
Ishinomaki-shi Ayukawa	38°18' N	141°30' E	14:45, 16 Mar	16:41, 16 Mar	10
Sendai-ko	38°16' N	141°00' E	15:06, 16 Mar	16:45, 16 Mar	0.2m
Ishinomaki-ko	38°24' N	141°16' E	15:17, 16 Mar	17:14, 16 Mar	31
Kesennuma Hirotawan-oki	38°51' N	141°54' E	unclear	16:13, 16 Mar	0.1m
Iwaki-shi Onahama	36°56' N	140°54' E	unclear	17:55, 16 Mar	6
Soma	37°50' N	140°58' E	14:56, 16 Mar	18:15, 16 Mar	0.2m
Oarai	36°18' N	140°34' E	unclear	18:29, 16 Mar	12

* Height values described in meter were measured with huge tsunami gauges (resolution: 0.1 m), and GPS buoy.
* The data contained in this tabe is provisional and subject to change.

Table 5: Observed Tsunami (Earthquake off Fukushima Prefecture, Japan, 16 March 2022)

c) Tsunami warning operations

14:36 UTC --- Earthquake occurrence
14:39 UTC --- Tsunami Advisory
16:30 UTC --- Press Conference
20:00 UTC --- Tsunami Advisory (cancellation)

d) Lessons learned

The tsunami prediction results were generally consistent with the observed tsunami characteristics.

8. Web sites (URLs) of national tsunami-related web sites

http://www.jma.go.jp/jma/indexe.html

9. Summary plans of future tsunami warning and mitigation system improvements.

JMA started to use offshore pressure gauges for tsunami warnings/advisories upgrade from 2012, and Offshore Tsunami Observation Information has been issued using their observed data since 2013. Many of offshore pressure gauges belong to the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) and the Seafloor Observation Network for Earthquakes and Tsunamis (S-net). They were deployed off the Kii Peninsura and the Japan Trench and have been oparated by NIED. NIED has been constructing a new seafloor observation network, whisc is called the Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis (N-net), in

the areas (off Kochi to the Hyuga-nada) ,where are currently designated as the expected source area of the Nankai Trough earthquake and where any observation networks have not yet been established. After the construction of the N-net is completed, JMA plans to use it for tsunami warning operations in the same way as the S-net and the DONET.

10. EXECUTIVE SUMMARY

Japan Meteorological Agency (JMA) is responsible for issuing tsunami warnings and advisories in Japan. JMA continuously monitors seismic activity and, upon detecting an earthquake, determines its characteristics. If the earthquake occurs in an ocean area prone to tsunamis, JMA conducts forecasting operations. Tsunami warnings and advisories are communicated to national and local authorities, broadcasting stations, and the public. JMA has collaborated with universities and other research institutions to improve tsunami monitoring and forecasting technology.

As for volcanic tsunamis, JMA has faced challenges in issuing timely warnings due to unclear mechanisms of sea level changes. JMA established new procedures to announce the possibility of a tsunami upon observing major eruptions.

JMA developed a method called tFISH to predict coastal tsunami heights accurately using offshore stations. This method estimates initial tsunami heights in the tsunami sources using inversion analysis of tsunami waveform data and simulates propagation to enhance warning accuracy.

The division of roles among the various agencies regarding tsunami damage mitigation is outlined in Japan's Basic Disaster Management Plan. Tsunami drills are held annually and about 1.95 million people participated in earthquake and tsunami disaster drills in 2022. Events are held to discuss disaster prevention on World Tsunami Awareness Day, 5 November, every year. JMA introduced a "tsunami flag" to communicate warnings visually, especially to those with hearing disabilities and swimmers. Earthquake Advisories are issued in areas prone to subsequent earthquakes following large tremors.

Research projects include studying volcanic tsunamis after the 2022 Hunga Tonga - Hunga Ha'apai eruption. Additionally, a project on Nankai Trough earthquakes focuses on monitoring, simulation, evacuation methods, and disaster preparedness.

Japan has contributed internationally to aiding countries through projects by the Japan International Cooperation Agency (JICA) to enhance their tsunami warning systems and mitigation efforts. Japan has assisted in capacity building for the Central America Tsunami Advisory Center (CATAC) in Nicaragua, which started their operations in an interim capacity in January 2022. JICA collaborates with Indonesia's Meteorology, Climate, and Geophysics Agency (BMKG) to improve their tsunami warning capacity. They also support the Vanuatu Meteorology and Geo-hazards Department (VMGD) and National Disaster Management Office (NDMO) through a technical cooperation project.

11. NARRATIVE

11.1. Tsunami warning system

Japan Meteorological Agency (JMA) is the national authority for issuing tsunami warnings/advisories in Japan. JMA continuously monitors seismic activity in and around Japan. When an earthquake occurs, JMA immediately determines the hypocenter and magnitude of the earthquake. If the earthquake occurs in an ocean area with tsunamigenic potential, JMA conducts tsunami forecasting operations. JMA provides tsunami warnings/advisories, via dedicated land line, for the national and local authorities and broadcasting stations for disaster prevention and/or mitigation. JMA collaborates with universities and other research institutions to improve tsunami monitoring and forecasting technology.

a) Operations for volcanic tsunamis

Tsunamis were observed across Japan following the 2022 eruption of the Hunga Tonga - Hunga Ha'apai volcano and the tsuanmis arrived more than two hours earlier than the arrival time of tsunamis caused by a normal earthquake. JMA used the ordinary tsunami warning mechanisms against a tsunami caused by an earthquake in order to warn the public. However, the following problems were identified in the series of operations.

- It took longer time to issue tsunami warnings because the mechanism of the sea level changes was not clear.
- Information was not sufficiently provided until the tsunami warning was issued after the eruption.

Therefore, JMA convened a science committee of experts and, taking into account their discussions, developed the following operating procedures for the announcement of information to the event of a major eruption abroad.

- JMA announces the possibility of a tsunami when a major eruption with a plume height of more than about 15,000 m occurs.
- JMA updates information as needed until sea level changes are observed in Japan after occurrence of the eruption, and holds a press conference to explain the situation in detail if the possibility of a tsunami increases, for example if a clear change is observed in the image analysis of the weather satellite Himawari operated by JMA.
- When sea level changes are observed in Japan, JMA issues a tsunami warning/advisory in principle when the observed sea level exceeds the criteria for a tsunami warning/advisory. However, if an obvious pressure change is observed and an obvious sea level change is observed at a time consistent with the observed pressure change, a tsunami advisory is issued even if the observed sea level does not exceed the criteria for an advisory. (A tsunami warning is issued when the observed sea level exceeds the criteria for a warning).
- For areas past the expected arrival time of atmospheric Lamb waves, JMA informs the public that they should continue to prepare for sea level changes, even if no sea level changes have been observed. There is no risk of tsunami if sea level changes due to atmospheric pressure waves (internal gravity waves) are not observed *.

* The possibility of sea level changes due to landslides etc. is considered separately.

b) New method for predicting the height of coastal tsunamis utilizing offshore stations

JMA has developed a new method to predict tsunami heights more accurately using tsunami waveform data observed at multiple offshore stations. This method is called tFISH and it has been used operationally to update tsunami warnings since March 2019. The tFISH is a method for predicting the height of coastal tsunamis by estimating initial tsunami heights in the tsunami source using inversion analyis of tsunami waveform data observed by offshore tsunami observation networks and understanding the process of tsunami propagation from the wave source by computer simulation (numerical calculation) before the tsunami arrives.

11.2. Tsunami mitigation activities

Japan has the Basic Disaster Management Plan, which defines the responsibilities of each entity such as the national and local governments, public corporations and other entities. It consists of various plans for each type of disaster. The Basic Disaster Management Plan describes specific countermeasures to be taken by each entity according to the disaster management phases of prevention and preparedness, emergency response, as well as recovery and reconstruction. Disaster drills and public education programmes are carried out in collaboration with related ministries and agencies and local governments under the leadership of the Cabinet Office.

a) Tsunami drills

Earthquake and tsunami disaster drills, which are organised by the national government, local governments and private companies, are held in various parts of the country every year, mainly during the period around the World Tsunami Awareness Day (5 November). About 1.95 million people participated in 2022. The Cabinet Office, in cooperation with local governments, conducted drills with the participation of local residents at 11 locations across the country. These drills included drills for protecting oneself in the event of an earthquake (shakeout drills) and evacuation action from a tsunami after the shaking has subsided, as well as safety confirmation drills and drills to open and operate evacuation shelters in accordanc with a disaster management plan for each community. In addition, workshops were held to provide residents with an opportunity to learn about the estimated damage and the geographical conditions of their communities and to review the local evacuation plans. In total, approximately 12,000 people participated in the drills and workshops.

b) World Tsunami Awareness Day

World Tsunami Awareness Day, 5 November, is theTsunami Disaster Prevention Day in Japan. The Cabinet Office organizes the Tsunami Disaster Prevention Day Special Event every year. The main venue of the 2022 event was Tokyo. The event opened with an address by Mr Tani, Minister of State for Disaster Management, followed by a keynote speech by Prof Imamura, Director of the International Research Institute of Disaster Science, Tohoku University, on "Evolving Tsunami Disaster Prevention - Challenging Taboos with Tsunami Evacuation Drills and Other Measures". The panel discussion was held after the keynote speech of Prof. Imamuera. In the panel discussion, tsunami damage mitigation measures were actively discussed in online communication with Nemuro City, which is expected to suffer tsunami damage from the Chishima Trenches earthquake , and Nachikatsuura Town, which is expected to suffer tsunami damage from the Nankai Trough earthquake.

c) Tsunami flag

In June 2020, JMA has established a red-and-white checkered flag (so-called "tsunami flag") as a means of visually communicating tsunami warnings to people with hearing disabilities and swimmers who have difficulty hearing because of the sound of waves and wind. JMA has been conducting publicity activities to promote and raise awareness of the tsunami flag in cooperation with organizations such as the Japan Lifesaving Association.

d) The Off the Coast of Hokkaido and Sanriku Subsequent Earthquake Advisory

When a large earthquake occurs in the Nankai Trough or areas along the Japan Trench and the Chishima Trench, it is concerned that the propabilty of occurence of a subsequent large earthquake is relatively high due to the effects of that earthquake. For this reason, JMA issues “Nankai Trough Earthquake Information” or “Off the Coast of Hokkaido and Sanriku Subsequent Earthquake Advisory” when an earthquake of Mw 7.0 or greater occurs in that area. Although this information is highly uncertain, it is believed that residents who hear the information can reduce the damage by raising the alert level. Therefore, this information is a part of the effort to save more lives by calling for necessary disaster prevention measures based on the premise of daily preparedness for sudden earthquakes.

11.3. Research projects

a) Study on volcanic tsunamis

A study on the eruption and tsunami of the Hunga Tonga–Hunga Ha‘apai volcano, entitled "Urgent and comprehensive study of 2022 Tonga submarine eruption and associated tsunami ", will be conducted from February 2022 to March 2024 with the participation of 18 institutions in Japan. This research project has been supported by Grant-in-Aid for Special Purposes from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Japan Society for Promotion of Science (JSPS). This research project analyzes observation data and interviews with local governments to understand the mechanism of the volcanic eruption and the resulting

tsunami, and to analyze the damage and the response of local governments and residents in the Tonga Islands and along the coast of Japan.

Under the Science and Technology Research Partnership for Sustainable Development (SATREPS) of the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA), a research project entitled "Joint Research on Disaster Risk Reduction for Widespread Volcanic Hazards in Southwest Pacific Countries" is underway, led by the University of Tokyo. In this research, the University of Tokyo will improve volcanic tsunami hazard maps and develop operational procedures for volcano monitoring systems and volcanic tsunami warning systems in collaboration with the Tonga Geological Services, the Vanuatu Meteorology and Geohazards Department, and the Fiji Mineral Resources Department.

b) Study on the Nankai Trough Earthquake

Many large earthquakes have occurred in the Nankai Trough in the past. If a large earthquake occurs in this region, intensity 7 (the maximum in the seismic intensity scale of JMA) is expected in some areas, and it is expected that a large tsunami of more than 10 m hits a wide area on the Pacific Ocean side. The "Research Project for Disaster Prevention on the great Earthquakes along the Nankai trough" is a five-year project from 2020. The project sponsored by MEXT has been conducted by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as the principal investigator and nine domestic universities and research institutes, including the National Research Institute for Earth Science and Disaster Prevention (NIED), as the research partners. The project will develop a monitoring system to detect, predict, and disseminate information on earthquake activity in the Nankai Trough based on scientific and quantitative data. The project will also develop a system to simulate the hazards and risks posed by earthquakes, a method to study evacuation sites and evacuation methods, simulation of measures necessary to minimize the suspension of corporate activities and maintain urban functions, and other technologies to study how residents and businesses should take disaster prevention measures. In addition, the project will work with local governments to assess the disaster preparedness issues in their communities and to determine how best to disseminate information.

11.4. International contributions

Japan has supported many countries in capacity building on tsunami warning systems and tsunami mitigation, such as capacity building of the Central America Tsunami Advisory Center (CATAC) in Nicaragua, which has operated in an interim manner since January 2022, through projects implemented by the Japan International Cooperation Agency (JICA).

In February 2022, JICA launched a technical cooperation project, "Capacity Development on Operation of Earthquake and Tsunami Analysis and Warning Dissemination" to improve the tsunami warning capacity of the Indonesian Meteorology, Climate and Geophysics Agency (BMKG). Under this project, JMA is contributing to the capacity building of BMKG by dispatching experts to BMKG and providing lectures on the Standard Operating Procedures (SOP) of the tsunami warning system during the training programs for BMKG officials invited to Japan. In August 2023, JICA will implement another program for BMKG to improve the communication of earthquake information and tsunami warnings and to improve tsunami education and awareness among disaster management agencies and residents.

In March 2019, JICA has launched a technical cooperation project, "Project for Enhancing the Capacity of Issuing Earthquake, Tsunami and Storm Surge Information" for the Vanuatu Meteorology and Geo-hazards Department (VMGD) and the National Disaster Management Office (NDMO) in Vanuatu. In August 2023, as part of this project, JICA plans to hold a training course to learn about the practices of earthquake observation and tsunami warning, as well as innovations and know-how in the warning system, and JMA is also cooperating in this project.

The Asian Disaster Reduction Center (ADRC) has been organizing the Tsunami Seminars to showcase and share latest research findings, technologies, and expertise on tsunami disaster risk reduction to member countries, partner organizations, stakeholders, and the general public. The

ADRC organized an online seminar entitled Understanding Tsunami Risk and Enhancing Practical Countermeasures in 2022.

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