

National Report of Japan

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▪ Sea Level Variations around Japan

Sea levels vary in a wide range of time scale from a few minutes to several decades within directly measurable limits, and even over several tens of thousands of years in geological records.

In a short time scale less than one day, sea levels can fluctuate largely due to meteorological factors such as storm surges, and also due to seismological factors represented by tsunamis as well as astronomical tides. Since Japan is located along the northwestern periphery of the Pacific Ocean, where tropical cyclones pass most frequently among all the oceans on the earth, Japan is one of the most storm surge prone countries in the world. Additionally, the geographical location of Japan means it is on or very close to a belt where huge earthquakes and tsunamis occur quite frequently. As Japan has suffered huge disasters from these natural hazards through its history, one major purpose of sea level observations in Japan is to monitor storm surges and tsunamis on a real-time basis.

In a medium time scale from several days to several decades, sea levels vary mainly for oceanographic reasons. For example, “Kuroshio”, which is a strong western boundary current in the western North Pacific and is flowing northeastward along Japan, sometimes affects sea levels along the Japanese coast on a time scale from days to months by changing its path or with the warm water intrusion.

Sea level observations are indispensable to monitor and analyze these oceanographic phenomena.

▪ National Sea Level Observation Network

More than 200 tide stations are operated by several national and local governmental organizations in Japan, including the Japan Meteorological Agency (JMA), the Japan Coast Guard (JCG), the Geospatial Information Authority of Japan (GSI), Ports and Harbours Bureau (PHB) and Water and Disaster Management Bureau (WDMB) of Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Data from those stations are sent to JMA in real-time.

JMA runs 72 stations: 70 radar tide gauges stations, one Fuess (float) type tide gauge station with digital encoders, and one hydraulic pressure sensor tide station at the Minami-tori-shima (Marcus Island). Those instruments measure sea levels with a resolution of 1 cm.

Fourteen JMA's tide stations and one JCG's tide station, the Syowa in the Antarctic, are registered at the GLOSS Core Network (GCN) (see Fig. 1 and Table1).

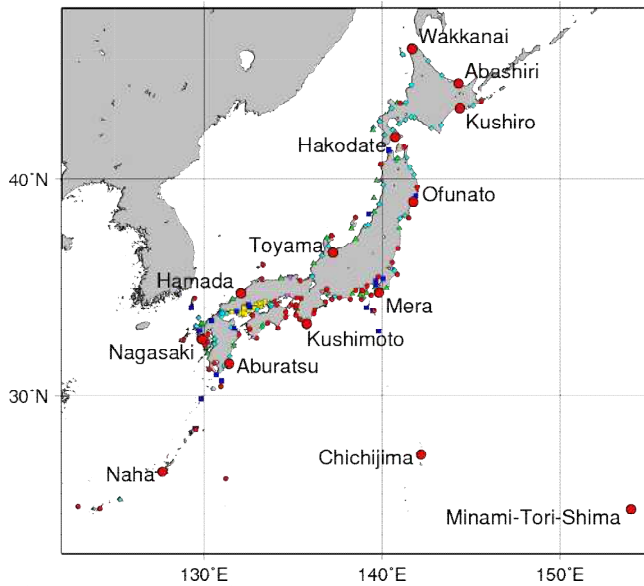


Fig. 1: Tide stations in Japan.

JMA (red circles; large ones registered at GCN), JCG (blue squares), GSI (green triangles), PHB (light blue diamonds), WDMB (yellow squares), Others (purple upside-down triangles).

Table 1: Tide stations registered at GCN

STATION NAME	CODE	LAT	LON
ABASHIRI	AS	44°01'N	144°17'E
ABURATSU	AB	31°35'N	131°25'E
CHICHIJIMA	CC	27°06'N	142°12'E
HAKODATE	HK	41°47'N	140°43'E
HAMADA	HA	34°54'N	132°04'E
KUSHIMOTO	KS	33°29'N	135°46'E
KUSHIRO	KR	42°59'N	144°22'E
MERA	MR	34°55'N	139°50'E
MINAMI-TORI-SHIMA	MC	24°17'N	153°59'E
NAGASAKI	NS	32°44'N	129°52'E
NAHA	NH	26°13'N	127°40'E
OFUNATO	OF	39°01'N	141°45'E
TOYAMA	TY	36°46'N	137°13'E
WAKKANAI	WN	45°24'N	141°41'E
SYOWA		69°00'S	39°34'E

▪ Acquisition, Processing and Dissemination of Sea Level Data by JMA

JMA has been conducting the measurements of sea levels at approximately 1 second interval at all the 72 tide stations. The observed sea level data except those at the Minami-tori-shima tide station are transmitted to the headquarters of JMA through a public IP network on a real-time basis, while the data at Minami-tori-shima are transmitted via the Data Collection System (DCS) of the geostationary satellite, Himawari-8 every 10 minutes. The data are distributed from JMA headquarters to local meteorological observatories every 5 minutes. The observed data at 22 stations, including the 14 GCN stations, are distributed to all over the world through the GTS line in real-time every 10 minutes.

Quick estimations of hourly sea level data are provided from JMA within a few days after the quality check of raw data. It can be found at:

http://www.data.jma.go.jp/gmd/kaiyou/data/db/tide/sokuho/YYYYMM/z_hryYYYYMMCD.txt

where YYYY, MM, and CD indicate year, month and the station code, respectively. The code of each station is shown in Table 1. JMA creates a finalized data set for the previous month around the 20th every month. The values may change from quick estimations of them. The finalized hourly sea level data are provided at:

<http://www.data.jma.go.jp/gmd/kaiyou/data/db/tide/genbo/YYYY/YYYYMM/hryYYYYMMCD.txt>

JMA creates monthly mean sea level data based on the finalized hourly data. The hourly sea level data of the 14 GCN stations are sent to the GLOSS, University of Hawaii Sea Level Center, and the monthly mean data at the 55 JMA tide stations are sent to the Permanent Service for Mean Sea Level (PSMSL).

▪ Monitoring Storm Surges and Tsunamis

Near real-time tide data (5 minutes latency) from 186 tide stations are posted on the JMA web site (in Japanese),

<http://www.jma.go.jp/jp/choi/>,

and you can monitor sea level variations including those caused by storm surges and tsunamis:

Fig. 2 is an example of a storm surge observed at Ishigaki tide station during typhoon Dujuan in September, 2015, posted on the JMA web site at that time. Real-time sea level observations play an important role for issuance of storm surge warnings/advisories, tsunami observation information and tide information.

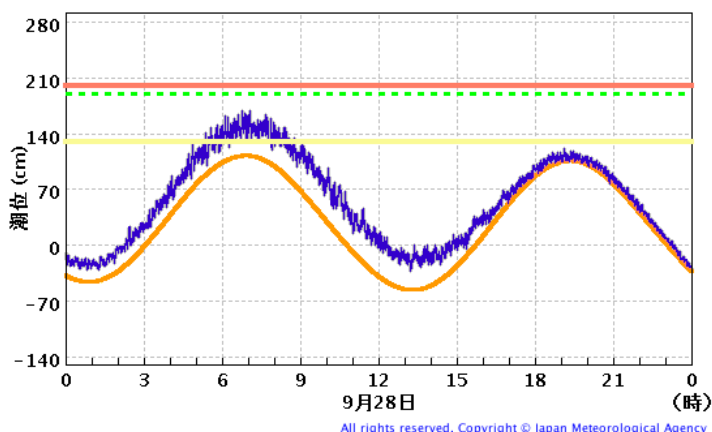


Fig. 2: Observed sea level at Ishigaki tide station during typhoon Dujuan in September 28, 2015.

The dark blue line indicates the observed data and the orange line is the astronomical tide. The red and yellow lines are the criteria for the storm surge warning and advisory, respectively. The dotted green line is the highest observed sea level in the past.

▪ Monitoring Long-Term Sea Level Changes

JMA monitors long-term sea level changes using the tide gauge data. Fig. 3 (a) shows the time series representation of annual mean sea level deviation from the 1981 – 2010 average.

There are 11 tide stations in Japan that have measured sea levels for more than 100 years. Four stations among them, assessed as being affected to a lesser extent by crustal movement, are selected for the period 1906 – 1959 (Fig. 3 (b)), while 16 stations are selected for the period after 1960 for the better spatial representativeness (Fig. 3 (c)). For the period after 1960, cluster analysis was first applied to sea level observation data for the selected stations along the Japanese coast, then the Japanese coast were divided into the 4 regions shown in Fig. 3 (c) according to sea-level variation characteristics, the annual mean sea level anomalies were averaged for the 4 regions, and the variations were plotted in Fig. 3 (a).

The result indicates sea levels had their maximum around the year of 1950, and a sea level variation with approximately twenty-year period is dominant until the 1990s. Also, a rising trend in sea levels has been seen with a near-10-year variation since the 1990s.

For clearer understanding of the mechanism of sea level variations, JMA has been carrying out oceanographic observations by research vessels, numerical ocean modeling, a quantitative analysis of such sea level variations combining sea level and crustal movement data observed at these stations, and so on. As for the crustal movement data, GSI is conducting continuous real-time observations of crustal movements at the GNSS-based control stations, a network of which is called GEONET (GNSS Earth Observation Network System) and consists of about 1,200 stations in Japan. In cooperation with GSI, GPS systems are also equipped at all the Japanese GCN stations except Minami-tori-shima and Syowa.

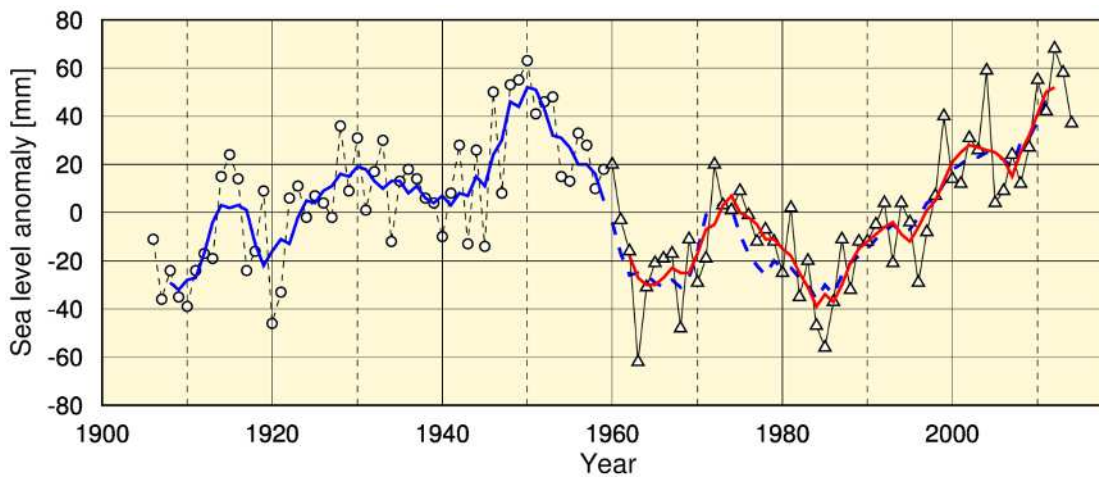


Fig. 3 (a): Time-series representation of annual mean sea level values around Japan. The blue line indicates the 5-year running mean of sea level anomalies at the 4 stations, while the red line shows this value for the 4 regions.

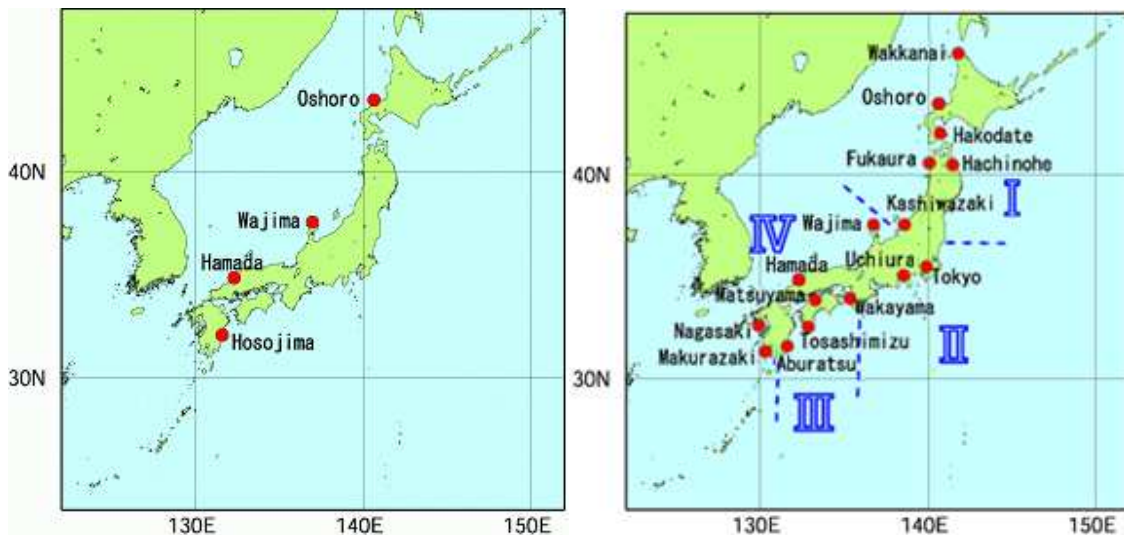


Fig. 3 (b) and 3 (c): Location of tide stations

▪ Online Databank for Oceanographic Data

The oceanographic data and related information obtained by various oceanographic research institutes in Japan are archived in the Japan Oceanographic Data Center (JODC). Hourly sea level data of more than 100 tide stations in Japan including the 14 GCN stations and other oceanographic data are available at the JODC website:

<http://www.jodc.go.jp/index.html>