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# National Report of Japan

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## ▪ Natural Conditions Characterizing 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 short time scale less than one day, sea levels can fluctuate by very large amplitudes due to meteorological factors such as storm surges, and also due to seismological factors represented by tsunamis. Since Japan is located along the northwestern periphery of the Pacific Ocean, where tropical cyclones pass most frequently in all the oceans on the earth, Japan is one of the most storm surge prone countries in the world. Additionally, the geographical location means that Japan 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 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 found in the western North Pacific and is flowing northeastward along Japan, sometimes affects sea levels along the Japanese coast on a time scale of days to months by meandering its path or with the warm water intrusion.

Sea level observation is indispensable to monitor and analyze these oceanographic phenomena.

## ▪ Tide Gauges of JMA

The original purpose of sea level observations of the Japan Meteorological Agency (JMA) is to watch storm surges and tsunamis that Japan has suffered since ancient times, but these days, sea level data are also used to monitor long-term sea level rise caused by global warming.

JMA uses Fuess (float) type tide gauges with digital encoders at 30 tide stations, acoustic tide gauges at 28 stations, radar tide gauges at 16 stations and a hydraulic pressure sensor at the Minami-tori-shima (Marcus Island) tide station. Those instruments measure sea levels with a resolution of 1 cm.

## ▪ National Sea Level Observation Network

Tide stations are operated by several national and local governmental organizations in Japan, including JMA, the Japan Coast Guard (JCG), the Geographical Survey Institute (GSI), Ports and Harbors Bureau (PHB) and Water and Disaster Management Bureau (WDMB). JMA runs 74 stations and the observed data at more than 200 tide stations operated by Japanese governmental organizations, mainly the ones mentioned above, are sent to JMA in real-time aiming at disaster

prevention. Among them, 14 JMA tide stations and Syowa tide station in the Antarctic are registered at GLOSS Core Network (GCN) (see Fig.1 and Table1).

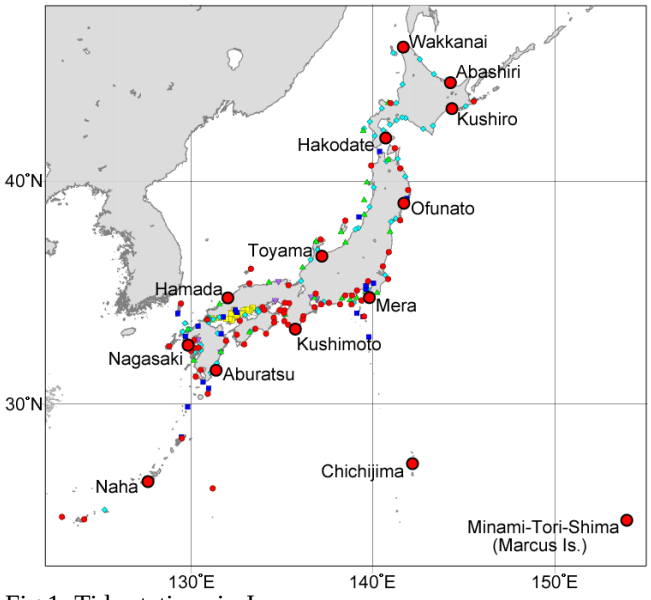


Fig.1: Tide stations in Japan.
JMA (red circles; large ones registered at GCN), JCG (blue squares), GSI (green triangles), PHB (light blue diamonds), WDMB (yellow squares), Others (purple upside-down triangles).

Table1: 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

All the tide stations of JMA make measurements at approximately 1 second interval. Observed 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. The data at Minami-tori-shima are transmitted to the JMA headquarters via the Data Collection Platform (DCP) system of the Geostationary Multi-Functional Transport Satellite (MTSAT-2) every 10 minutes. The data collected by the JMA headquarters are distributed to the local meteorological observatories every 5 minutes. Also, the observed data at 6 stations in Japan are distributed to all over the world through the GTS line in real-time for tsunami monitoring.

JMA processes the data to produce hourly sea level data and monthly mean sea level data. Hourly data of the 14 GCN stations are sent to the GLOSS, University of Hawaii Sea Level Center, and monthly mean sea level data at the 55 JMA tide stations are sent to the Permanent Service for Mean Sea Level (PSMSL). Hourly sea level data are provided from JMA within a few days after the calculation at:

http://www.data.kishou.go.jp/kaiyou/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. Note that these are quick estimations. JMA finalizes the previous month's data on or around the 20th of every month and the values may change from those of quick estimations. The final hourly sea level data are provided at:

http://www.data.kishou.go.jp/kaiyou/db/tide/genbo/YYYY/YYYYMM/hryYYYYMMCD.txt

## ▪ Monitoring Storm Surges and Tsunamis

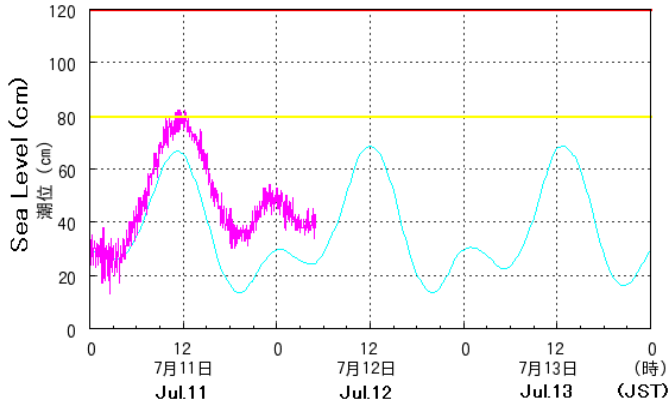


Fig.2: Observed sea level at Hamada tide station during typhoon Dianmu in July, 2010.
The pink line indicates the observed data and the blue line is the astronomical tide. The red and yellow lines are the criteria for the storm surge warning and advisory, respectively.

Almost real-time tide data (5 minutes latency) from 188 tide stations are posted (in Japanese) on the JMA web site for disaster prevention:

http://www.jma.go.jp/jp/choi/

Fig.2 is an example of a storm surge observed at Hamada tide station during typhoon Dianmu in July, 2010, posted on the JMA web site at that time. Real-time sea level observation plays an important role for storm surge warnings/advisories, tsunami observation information and tide information.

## ▪ Monitoring Long-Term Sea Level Changes

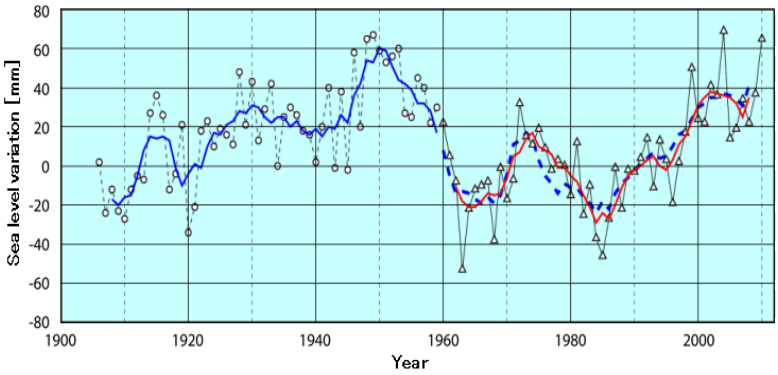


Fig.3(a): Time-series representation of annual mean sea level values around Japan. The blue line indicates the 5-year running mean of sea level anomalies at the 4 stations, while the red line shows this value for the 4 regions.

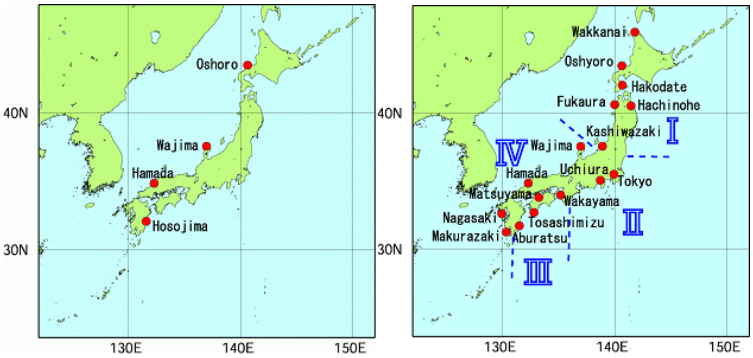


Fig.3(b), 3(c): Location of tide stations

Long-term sea level changes are monitored using the tide gauge data. Fig.3(a) shows the time series representation of annual mean sea level anomalies for each year, obtained using the 1971 – 2000 average as the normal.

There are 11 tide stations in Japan that have measured sea levels for more than 100 years. 4 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 islands 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 a sea level fluctuation with approximately twenty-year period is dominant, and sea level had its maximum around the year of 1950. Also, sea level around Japan has remained higher than normal since the latter half of the 1990s.

For clearer understanding of the mechanism of sea level variations, JMA has been carrying out oceanographic observations by research vessels, numerical ocean models, 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 observation of crustal movement at the GPS-based control stations, which network is called GEONET (GPS Earth Observation Network System) and consists of about 1,200 stations in Japan. In cooperation with GSI, GPS systems are also equipped at all Japanese GCN stations except Minami-tori-shima and Syowa.

- **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 14 GCN stations and other oceanographic data are available at the JODC website:

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