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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 reasons (storm surges) and seismological reasons (tsunamis). Since Japan is located along the northwestern periphery of the western North Pacific, where tropical cyclones pass most frequently in all the oceans on the globe, it is one of the countries which are most prone to tropical cyclone strikes and storm surges associated with them. The geographical location also means that Japan resides on or very close to one of the belts where huge earthquakes and tsunamis occur most frequently. Because Japan has suffered huge disasters from these natural hazards through its history, one of the major purposes 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 one of the greatest western boundary currents found in the western North Pacific and flowing northeastward along Japan, sometimes affects sea levels along the Japan coasts on a time scale of days to months by the meandering of its path or returning the current.

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

▪ **Tide Gauges of JMA**

The principal purpose of sea level observations of the Japan Meteorological Agency (JMA) is to watch storm surges and tsunamis which Japan has suffered since ancient times. Recently, monitoring of long-term sea level rise caused by global warming has been added to the purposes.

JMA uses Fuess (float) type tide gauges with digital encoders at 37 tide stations, acoustic tide gauges at 33 stations and a hydraulic pressure sensor at the Minami-tori-shima (Marcus Island) tide station. Those instruments measure the sea level with a resolution of 1 cm. Newly developed acoustic tide gauges with sounding tube have been installed at the 13 GLOSS Core Network (GCN) stations in Japan except Minami-tori-shima, and put into operation since January 2006, after a one-year testing phase.

▪ **National Sea Level Observation Network**

In Japan, tide stations are operated by several national and local governmental organizations including JMA, the Japan Coast Guard (JCG) and the Geographical Survey Institute (GSI). These three organizations run 71, 21 (including Syowa tide station in the Antarctic), and 25 tide stations, respectively. The observed data at about 200 tide stations operated by these organizations are sent to JMA in real-time to aim at disaster prevention.

Among the stations, 14 tide stations of JMA and Syowa tide station are registered at GCN (see Fig.1 and Table1).

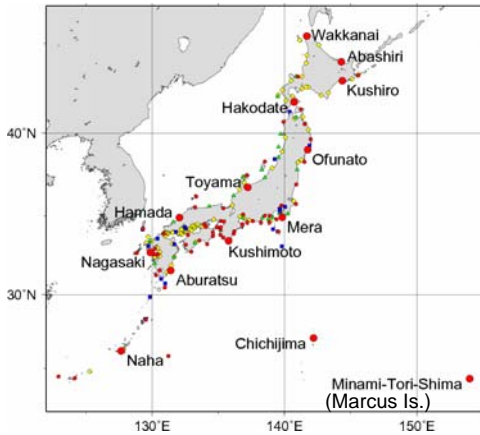


Fig.1: Tide stations in Japan. JMA (red circles, large circles registered in GLOSS Core Network), JCG (blue squares), GSI (green triangles), Other Organizations (yellow diamonds).

Table1: Tide stations registered at GCN

STATION NAME	CODE	LAT	LON
ABASHIRI	AS	44 01N	144 17E
ABURATSU	AB	31 35N	131 25E
CHICHIJIMA	CC	27 06N	142 11E
HAKODATE	HK	41 47N	140 43E
HAMADA	HA	34 54N	132 04E
KUSHIMOTO	KS	33 29N	135 46E
KUSHIRO	KR	42 58N	144 22E
MERA	MR	34 55N	139 49E
MINAMI-TORI-SHIMA	MC	24 18N	153 58E
NAGASAKI	NS	32 44N	129 52E
NAHA	NH	26 13N	127 40E
OFUNATO	OF	39 01N	141 45E
TOYAMA	TY	36 46N	137 14E
WAKKANAI	WN	45 24N	141 41E
SYOWA		69 00S	39 34E

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

All of the tide stations of JMA make measurements at approximately one-second interval. Observed data except those at Minami-tori-shima are transmitted to the headquarters of JMA through a public IP network on real-time basis. The data observed at the Minami-tori-shima tide stations are transmitted to the JMA headquarters via the Data Collection Platform (DCP) system of the Geostationary Multi-functional Transport Satellite (MTSAT-1R) every 10 minutes. The data collected by the JMA headquarters are distributed to the local meteorological observatories every 5 minutes.

JMA also processes the data to produce hourly sea level data and monthly mean sea level data. Hourly data of the GCN 14 stations are sent to the GLOSS Fast Data Center at Hawaii University and monthly mean sea level data at the all tide stations of JMA are sent to 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 stand for year, month and the code of a station, respectively. The code of each station is shown in Table 1.

The observed data at six stations in Japan are also distributed to all over the world by using the GTS line connection in real-time for tsunami monitoring.

JMA analyzes hourly data to determine tidal harmonic constants for the calculation of astronomical tides and posts them on its website.

▪ **Monitoring Long-Term Sea Level Changes**

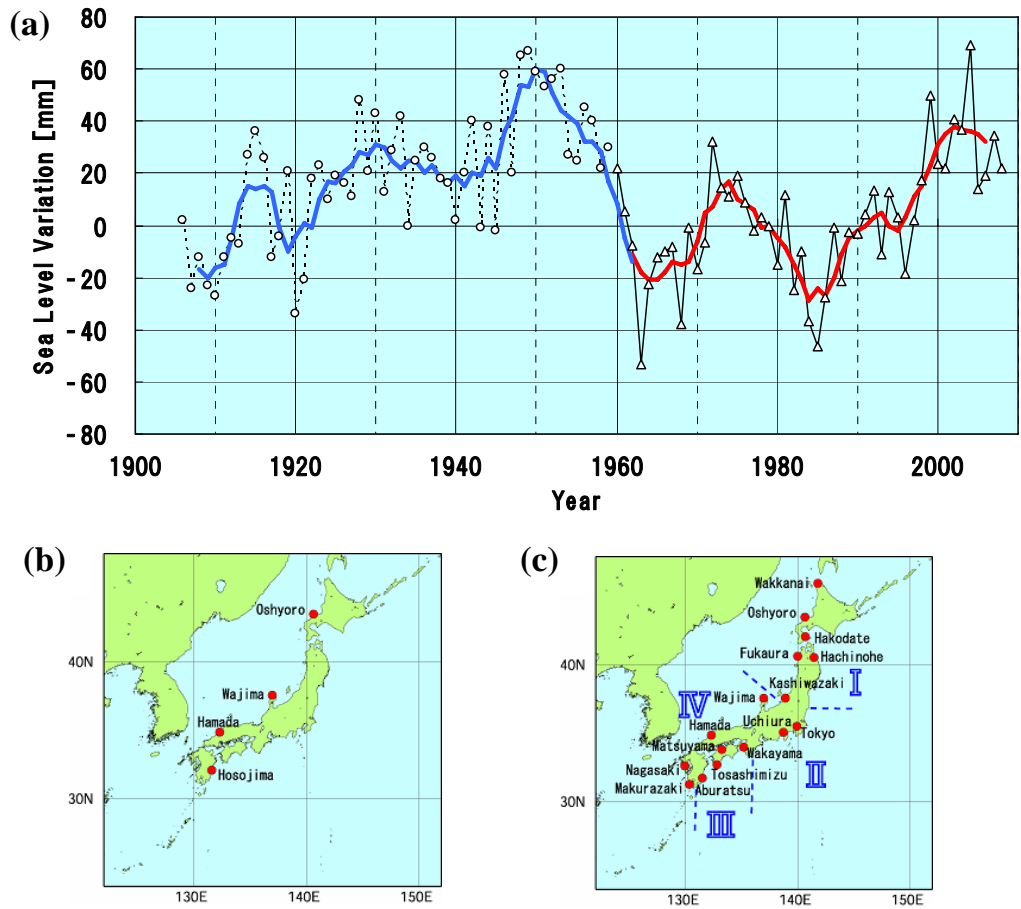


Fig. 2: Time series of annual mean sea level values (1906-2008) around Japan and the location of tide gauge stations used in the analysis

- (a) Time series of annual mean sea level. The dotted black line is MSL averaged for the four stations shown in (b) and the blue line represents the 5-year running mean. The solid black and red lines indicate MSL of the 16 stations shown in (c) and its 5-year running mean, respectively.
- (b) Location of tide gauge stations of which the data are used in the calculation of MSL from 1906 to 1959
- (c) The same as (b) but for the period after 1960

Long-term sea level changes are monitored using the tide gauge data. Fig. 2 shows the time series of sea level variation represented by the annual mean sea level (MSL) anomalies for each year, obtained by using the 1971 to 2000 average as the normal.

There are eleven tide gauge stations in Japan that have measured sea level for more than 100 years. We selected four stations (Fig. 2(b)) less affected by crustal movement among those stations.

For the period after 1960, sixteen stations (Fig. 2(c)) were chosen for the better spatial representativeness. In calculating the MSL for the period, cluster analysis was first applied to the sea-level observation data from the selected stations along the Japan coast, then, we divided the Japanese Islands into the four regions shown in Fig. 2(c) by Roman numerals according to sea-level variation characteristics, and averaged the annual MSL anomalies for each regions.

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 the clearer understanding of the mechanism of sea level variations, JMA has been carrying out quantitative analysis of such a sea level variation using sea level and crustal movements observed at these stations, oceanographic observation by research vessels, the results of numerical ocean models, and so on.

- **Crustal Movement Data**

GSI has been making 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 hundred tide stations in Japan including GCN stations and other oceanographic data are available at the JODC website:

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