

平成 23 年（2011 年）東北地方太平洋沖地震調査報告

気 象 庁

Report on The 2011 off the Pacific coast of Tohoku Earthquake

Japan Meteorological Agency

Abstract

1. Seismicity

At 14:46 JST on March 11, 2011, a massive earthquake with a magnitude of 9.0 occurred off the coast of Sanriku on northeastern Japan's main island of Honshu. A maximum seismic intensity of 7 was recorded in Kurihara City (Miyagi Prefecture), intensities of 6 upper were observed in 37 cities and towns in the prefectures of Miyagi, Fukushima, Ibaraki and Tochigi, and values of 1 or more were seen over large parts of the Japanese archipelago from Hokkaido in the north to Kyushu in the south. The quake triggered an enormous tsunami with major waves hitting the Pacific coast of the Tohoku and Kanto areas, where serious damage was caused. The Japan Meteorological Agency (JMA) named this earthquake – the biggest ever instrumentally recorded in Japan – the 2011 off the Pacific Coast of Tohoku Earthquake. On April 1, 2011, the Cabinet gave the collective name Great East Japan Earthquake to the disasters it caused.

The earthquake resulted from extensive fault ruptures on or near the boundary between the Pacific and North American tectonic plates. The focal mechanism of the tremor indicates a reverse fault type with a pressure axis in the WNW-ESE direction.

The results of source process analysis based on local strong-motion records indicate that the fault rupture gradually extended near the hypocenter and propagated north and south, resulting in a main rupture located to the east and northeast of the hypocenter with a maximum slip of about 30 meters.

Aftershocks were densely distributed in the area off the coast from Iwate Prefecture to Ibaraki Prefecture, corresponding to the hypocenter's area of approximately 500 kilometers in length by 200 kilometers in width extending in a NNE-SSW direction. Aftershock activity was also observed in the area east of the Japan Trench near the hypocenter area and in shallow locations on land in the prefectures of Fukushima and Ibaraki. The largest aftershock, with a magnitude of 7.6 and a maximum seismic intensity of 6 upper, occurred off the coast of Ibaraki Prefecture at 15:15 JST on March 11, 2011. As of March 31, 2012, there had been 6 aftershocks exceeding 7.0 in magnitude. The extremely intense aftershock activity seen until April 2011 has now died down over the whole area affected.

After the main tremor, other major earthquakes with maximum seismic intensities larger than 5 upper occurred

outside the aftershock zone, such as in the area from the north of Nagano Prefecture to the Chuetsu region of Niigata Prefecture, the east of Shizuoka Prefecture, the northern inland part of Akita Prefecture, the south of Ibaraki Prefecture, and the middle of Nagano Prefecture.

2. Damage caused by the tsunami and earthquake motion

“The 2011 off the Pacific Coast of Tohoku Earthquake triggered an enormous tsunami with major waves hitting the Pacific coast of the Tohoku and Kanto areas, where serious damage was caused.

As a result of the quake, the tsunami and aftershocks, 16,278 people died, 2,994 remain unaccounted for and 6,179 were injured, 129,198 houses were destroyed, 254,238 were severely damaged, 715,192 were partially damaged, 20,427 were flooded above floor level and 15,502 were flooded below floor level (statistics as of March 11, 2012, from the Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communications).

3. Damage to JMA observation networks

The earthquake and the associated tsunami widely affected JMA observation network facilities and operations. On March 11 after the main shock, communication with all JMA seismographs in the prefectures of Aomori, Akita and Iwate was lost, which severely hindered the operation of the Earthquake Early Warning system in the Tohoku region. Contact with around 50 seismic intensity meters in the area was lost due to power and communication line failures. Almost all tsunami observation facilities run by JMA and other organizations along the Pacific coast of Honshu from Aomori Prefecture to Ibaraki Prefecture were down. Automated Meteorological Data Acquisition System (AMeDAS) stations were also down in coastal Tohoku. Power and communication line failures also affected volcanic observation in the Tohoku region, including some cases in which all observation stations were down.

Operations of almost all seismographs, seismic intensity meters, AMeDAS stations and volcano observation stations were resumed after the restoration of power supply and communication line services. Tsunami observation in the prefectures of Iwate, Miyagi and Aomori were resumed thanks to installation by the end of March 2011 of temporary tsunami observation facilities at Ofunato and Sendaishinko, and the use of a tidal observation station operated by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism for tsunami monitoring in Hachinohe by the end of April 2011. Temporary seismic intensity meters had been installed by the middle of April in six cities and towns in the prefectures of Iwate, Miyagi and Fukushima, where no seismic intensity information had been available since the main shock.

Operations of AMeDAS stations whose facilities were severely damaged and stations in areas where quick restoration was difficult were resumed through the use of portable meteorological instruments, mobile phones and satellite communications.

4. Action taken by JMA

As early as 8.6 seconds after the detection of the main quake, JMA issued earthquake early warnings calling for attention to strong tremors for the prefectures of Miyagi, Iwate, Fukushima, Akita and Yamagata. The first tsunami warnings and advisories were issued at 14:49 about three minutes after the quake. They included major tsunami warnings for coastal areas in the prefectures of Iwate, Miyagi and Fukushima and tsunami warnings/advisories for other areas along the Pacific coast of Hokkaido, Honshu, Shikoku and Kyushu and the Ogasawara Islands. The warnings/advisories were upgraded several times, and the warning area was extended. Eventually, JMA issued warnings/advisories for Japan's entire coastline at 3:20 on March 12. Other related information, such as tsunami observation results and Northwest Pacific tsunami advisories, was issued until all warnings and advisories were lifted at 17:58 on March 13.

JMA held several press conferences on the quake, its aftershocks and other large tremors occurring after March 11 to provide information on seismic activity, tsunami waves and related matters. From March 13 onward, the Agency issued a series of press releases on the aftershock status and outlook.

JMA set up special web pages as a way of efficiently providing information to residents of affected areas, evacuees and people involved in restoration and reconstruction activities.

The Agency's headquarters and local offices conducted field surveys on tsunami run-up and damage caused by earthquakes and tsunamis.

As the disaster increased vulnerability to water-related problems stemming from ground instability, subsidence, and infrastructure damage to embankments, drainage facilities and other elements, JMA temporarily lowered its trigger criteria for the issuance of sediment disaster alerts and warnings/advisories for heavy rain, flooding and high tides.

All seismic, meteorological and oceanographic facilities in the affected area were quickly examined by staff from JMA's headquarters and its local offices to restore observational functionality. The restoration included enhancement of the power supply and installation of portable meteorological instruments. Observation and monitoring by other organizations also helped to maintain observational functionality.

JMA opened the Disaster Management Headquarters at 14:46 on March 11, 2011, immediately after the main shock, and strengthened its information collection functions. All District Meteorological Observatories and Okinawa Observatory also set up their own Disaster Management Headquarters immediately after the main shock or in response to tsunami warnings, and similarly strengthened their information collection functions.

5. Action taken by the Japanese Government

The Japanese Government established the Response Office at the Crisis Management Center of the Prime Minister's Office and convened the Emergency Response Team at 14:50 on March 11. The Extreme Disaster Management Headquarters was then established in response to a Cabinet decision at 15:14 on March 11. At the first meeting of the headquarters, which was convened at 15:37, a basic policy on disaster response countermeasures was adopted.

JMA sent its Deputy Director-General to the Emergency Response Team immediately after the main shock to attend the first and second meetings of the Extreme Disaster Management Headquarters and provide information

on the earthquake, tsunami and weather conditions in order to support rescue and relief activities. JMA's Director-General took over this role from the third meeting onward.

The Japanese Government established the Nuclear Emergency Response Headquarters at 19:03 on March 11. JMA provided earthquake, tsunami and weather information to the headquarters, and dispatched personnel to the Nuclear Emergency Response Headquarters Secretariat established in the Emergency Response Center of the Nuclear and Industrial Safety Agency to provide information on the earthquake, tsunami and weather conditions.

The Government then established the Local Headquarters for Extreme Disaster Management with the Senior Vice-Minister of the Cabinet Office as its chief on March 12 at Miyagi Prefectural Office, and also set up Government Local Liaison Disaster Response Offices at the prefectural offices of Iwate and Fukushima in accordance with a Cabinet decision of March 11. JMA Headquarters, Sendai District Meteorological Observatory and Fukushima Local Meteorological Observatory dispatched personnel to each office to provide information on the earthquake, tsunami and weather conditions in order to support response measures.

In addition, Sendai District Meteorological Observatory and local meteorological observatories sent personnel to the Disaster Management Headquarters of each prefecture to provide earthquake information, earthquake commentary papers and disaster weather support papers.