

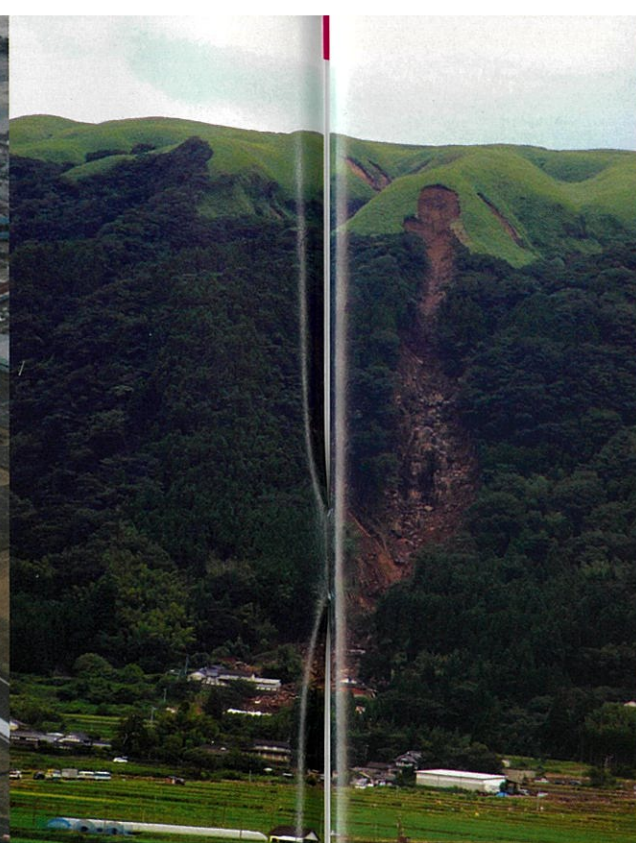
Japan Meteorological Agency

The national meteorological service of Japan



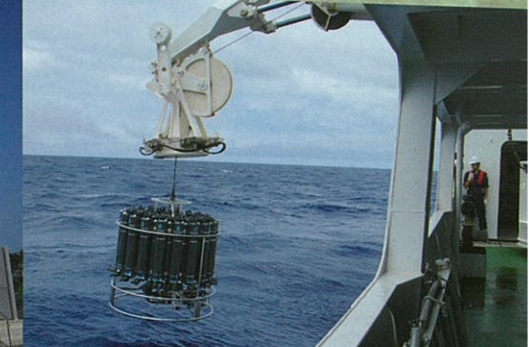
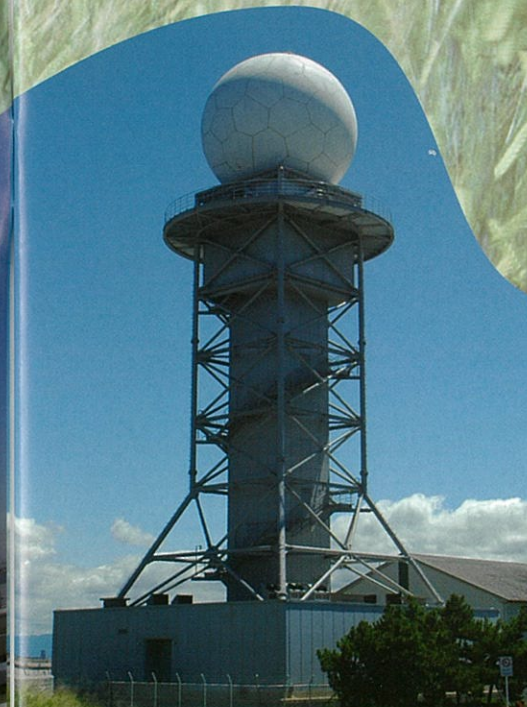
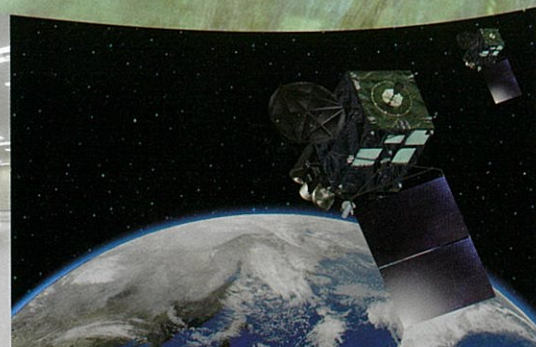


Photo courtesy of the Japan Coast Guard



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Japan has four clearly defined seasons and is blessed with a beautiful natural environment. However, nature sometimes strikes mercilessly with torrential rains and big earthquakes. Global warming caused by greenhouse gases emitted from human activities has also led to increasingly pressing concerns in recent years. The Japan Meteorological Agency (JMA) has provided services to protect people and their property from disasters by monitoring and predicting natural events for over a century since it was inaugurated as the Tokyo Meteorological Observatory in June 1875. Today, its 5,200 employees nationwide constantly monitor heavy rain, typhoons, earthquakes, volcanoes, climate change and other variables. This pamphlet highlights the services of JMA.



Emergency Warning System

A New Service to Protect Life

Massive damage is caused by natural phenomena of extraordinary magnitude in Japan, as exemplified by the major tsunami caused by the 2011 Great East Japan Earthquake and heavy rain caused by Typhoon Talas in the same year. In response to these natural hazards, JMA issued warnings and various other messages. However, in some cases there was no effective means of informing municipalities and residents of a significant risk of imminent fatal disaster in association with natural phenomena on a scale far exceeding the regular warning criteria, and existing warnings and other information did not prompt residents to evacuate urgently. Based on these experiences, JMA introduced a system of Emergency Warnings on 30 August 2013, to highlight such hazards.



Great East Japan Earthquake (2011)



Miyakejima volcanic eruption (2000)

Typhoon Talas (2011)

For Severe Weather

Emergency Warnings are issued if heavy rain or other phenomena on a scale observed only once every few decades is predicted.

Criteria for Emergency Warnings

Phenomenon	Criteria
Heavy rain	<ul style="list-style-type: none"> Heavy rainfall with a level of intensity observed only once every few decades is predicted in association with a typhoon or similar. Or: Heavy rainfall is predicted in association with a typhoon expected to have a level of intensity observed only once every few decades or an extratropical cyclone with comparable intensity.
Storm	A storm is predicted
Storm surge	A storm surge is predicted
High waves	High waves are predicted
Snowstorm	A snowstorm is predicted in association with an extratropical cyclone expected to have a level of intensity observed only once every few decades.
Heavy snow	Heavy snowfall with a level of intensity observed only once every few decades is predicted.

JMA's website provides objective criteria for variables such as rainfall amounts used for the definition of a level of intensity observed only once every few decades.

Emergency Warnings are issued to alert people to the significant likelihood of catastrophes in association with natural phenomena of extraordinary magnitude.

If an Emergency Warning is issued:

- An extraordinary phenomenon of a magnitude never experienced by local residents is likely to occur.
- The possibility of a catastrophe is significant.
- Immediate action should be taken to protect life.

Routine preparedness and early action for natural hazards saves lives.

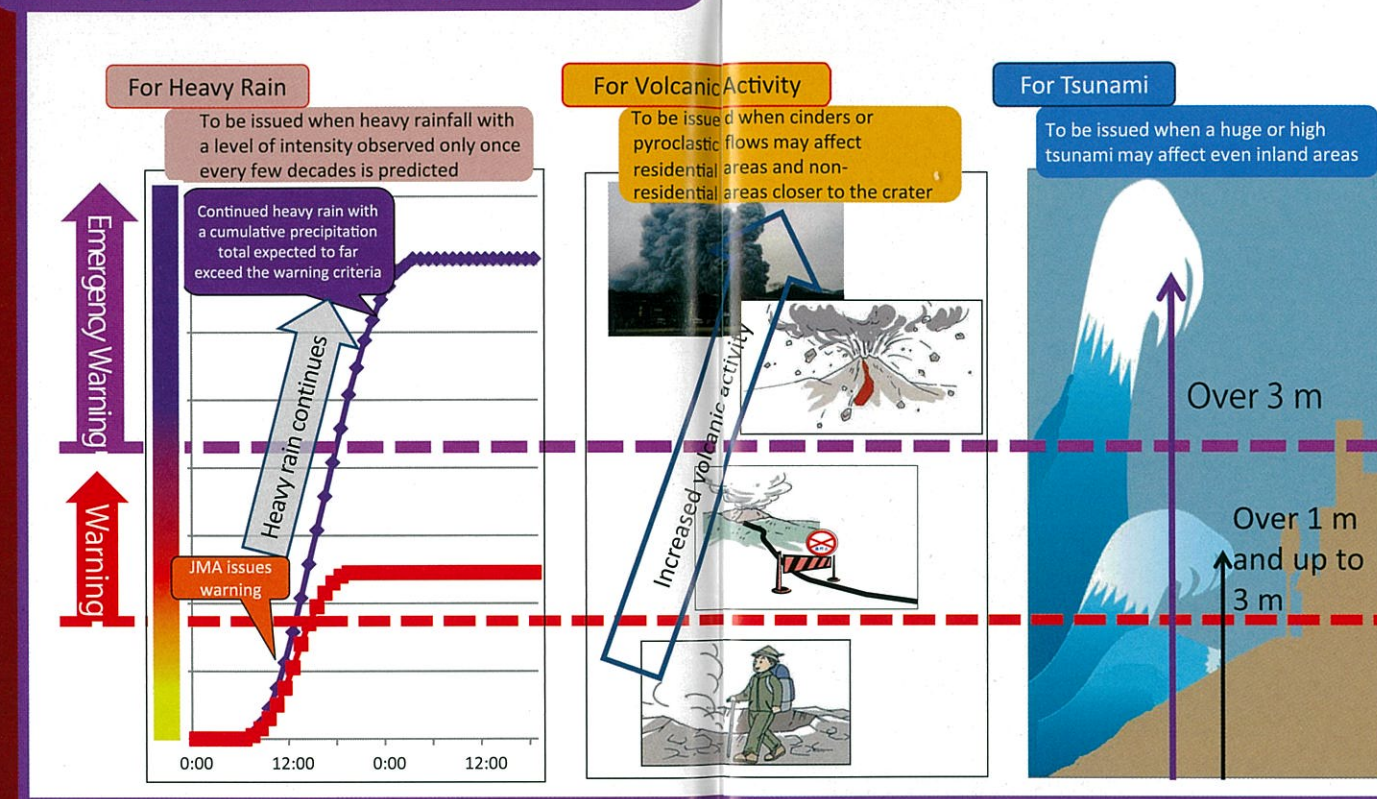
- Remember that catastrophes may occur even if no Emergency Warning is in effect.
- Take early action with reference to Warnings, Advisories and relevant bulletins.
- Check evacuation routes and centers constantly.

Pay attention to the latest bulletins and follow municipal evacuation advisories and orders in order to protect your life

Emergency Warnings are disseminated through administrative organs and wide variety of media. Residents should look out for relevant messages.



Emergency Warning Overview



For Earthquakes, Tsunami and Volcanic eruptions

Major Tsunami Warnings and certain other warnings are issued in the classification of Emergency Warnings.

Phenomenon	Criteria
Earthquake	Seismic intensity of 6-lower or more is expected (Earthquake Early Warnings incorporating prediction of tremors measuring 6-lower or more on JMA's seismic intensity scale are issued in the classification of Emergency Warnings.)
Tsunami	Tsunami height is expected to be greater than 3 meters (Major Tsunami Warnings are issued in the classification of Emergency Warnings.)
Volcanic eruptions	Eruption or possibility of eruption that may cause serious damage in residential areas and non-residential areas nearer the crater (Volcanic Warning (Level 4 and 5) and Volcanic Warning (residential areas)* are issued in the classification of Emergency Warnings.)

* When residential areas are not defined, residential areas is replaced with foot-of-mountain areas.

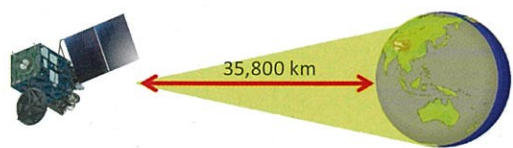
Observation Networks

For Better Monitoring of Atmospheric Phenomena

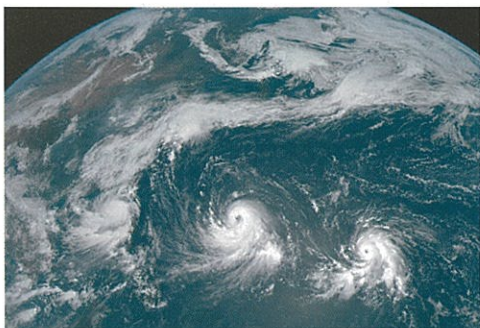
JMA operates an array of networks involving surface-based observation and the use of meteorological satellites to monitor the atmosphere around the clock. After a process of stringent quality control, the results are made available to the public and related users. The data produced are essential in clarifying atmospheric conditions, and are used for daily weather forecasts, severe weather monitoring, typhoon analysis and climate change monitoring.

Satellite Observation

Satellite observation is indispensable for obtaining a clear picture of typhoons over ocean areas and other global atmospheric conditions. The Eastern Asia, Western Pacific and Oceania regions are covered by JMA's Himawari geostationary meteorological satellites (*himawari* is the Japanese word for sunflower), whose 10-minute interval observations from 35,800 km above the equator produce data on the distributions of clouds, moisture and volcanic ash, upper-air winds and sea surface temperatures. JMA and a variety of National Meteorological and Hydrological Services (NMHSs) make extensive use of Himawari data in daily operations.

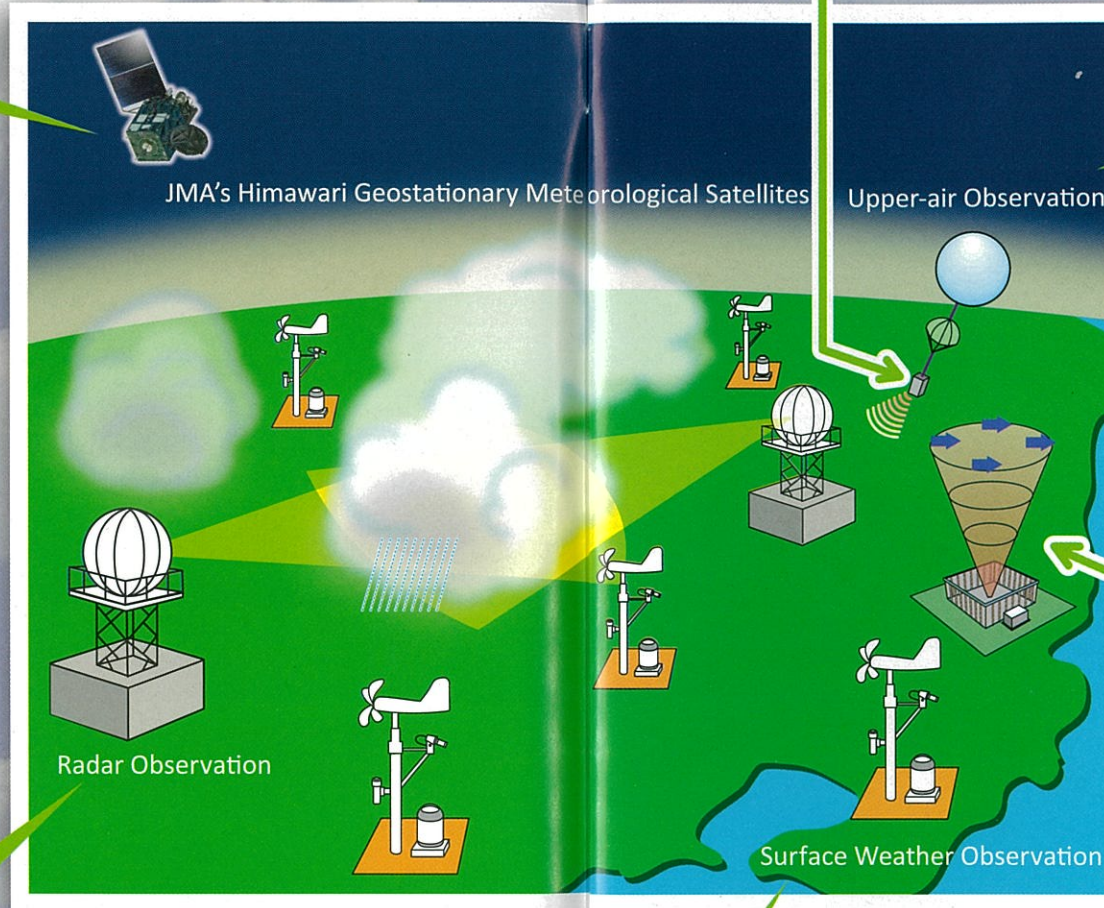


▲ Observation from space



▲ Cloud distribution as observed by Himawari

Observation networks for atmospheric monitoring



Radiosonde

Radiosondes measure pressure, temperature, humidity and wind in the atmosphere at altitudes of up to 30 km from the surface twice daily.

Upper-air Observation

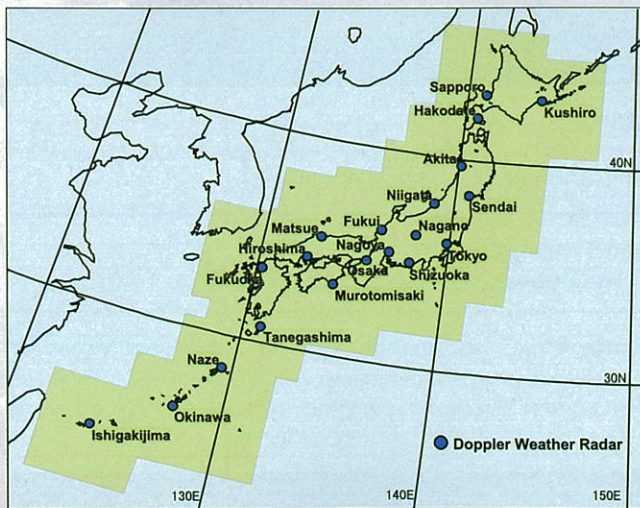
To clarify meteorological conditions and three-dimensional atmospheric activity, upper-air monitoring is performed via radiosonde and wind profiler observation networks.

Upper-Air Observation Network

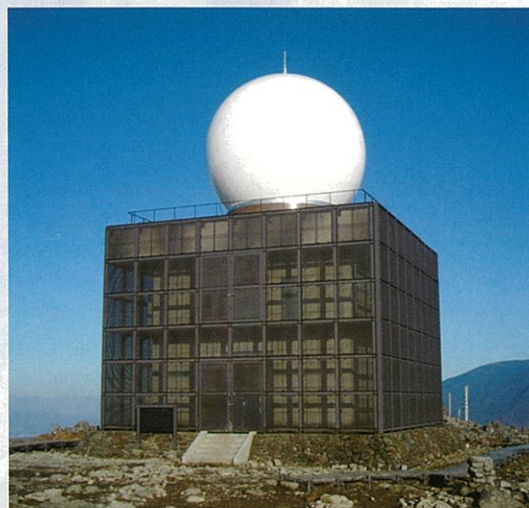


Radar Observation

Twenty Doppler weather radars are used to observe rainfall/snowfall intensity nationwide, and also provide information on the movement of thunderclouds that may bring hazardous rainy/snowy conditions. The radars also observe upper-air wind fields, and enable the detection of potentially tornado-generating meso-cyclones.



▲ JMA's radars and observation areas



▲ Nagano Radar

Surface Weather Observation

A total of 160 JMA weather stations, including Local Meteorological Offices, across the country routinely collect data on variables such as surface pressure, temperature, humidity, wind, precipitation, sunshine duration, snow depth, visibility and current weather conditions. As many as 1,300 AMeDAS (Automated Meteorological Data Acquisition System) stations automatically observe precipitation, temperature, wind and sunshine duration. Around 320 of these also observe snow depth.

Wind profiler

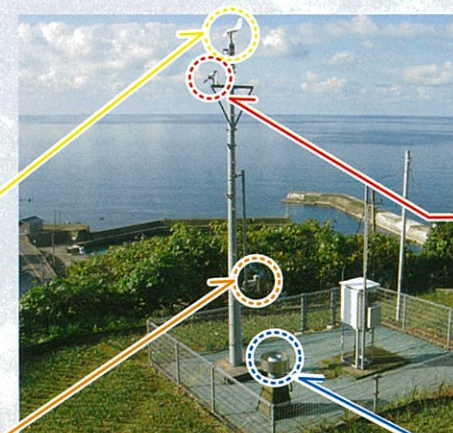
Wind profilers measure wind in the upper atmosphere at altitudes of up to about 12 km every 10 minutes.



Anemometer



Thermometer



Sunshine recorder



Raingauge

Weather Analysis and Prediction

For Appropriate Forecasts and Warnings

JMA monitors weather conditions 24 hours a day and issues Emergency Warnings, Warnings and Advisories to mitigate the effects of possible natural disasters and allow preparations for other disasters they may trigger. The Agency also issues weather forecasts based on observation and numerical weather prediction (NWP) for the general benefit of society.

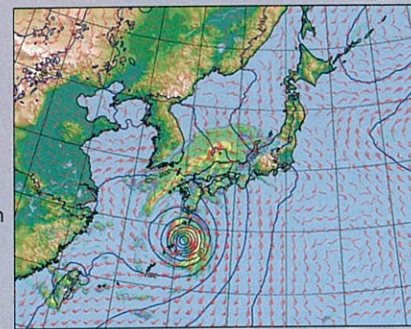
Numerical Weather Prediction

Future weather is predicted by calculating differences from current conditions using a numerical weather prediction (NWP) model on a supercomputer.

▼ Typhoon forecast example



▲ Supercomputer system

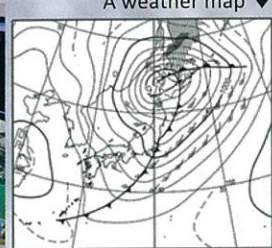


Weather Maps

Weather maps showing isobars, center positions/intensities of highs and lows and locations of fronts are made using a variety of weather observation data.

Forecasters use various weather maps to determine future weather conditions.

▼ A weather map



Weather Forecasting

Weather forecasts, Emergency Warnings, Warnings and Advisories are issued mainly for natural disaster preparedness and mitigation based on observation data from around the world and NWP products. The service's accuracy, reliability and level of detail have been improved over the years based on forecaster expertise and the progress of NWP.



Monitoring

Forecasters monitor changes in weather conditions such as torrential rain, tornadoes and thunderstorms to enable the issuance of appropriate weather information that will help mitigate the effects of natural disasters.



Utilization of Data from Other Organizations

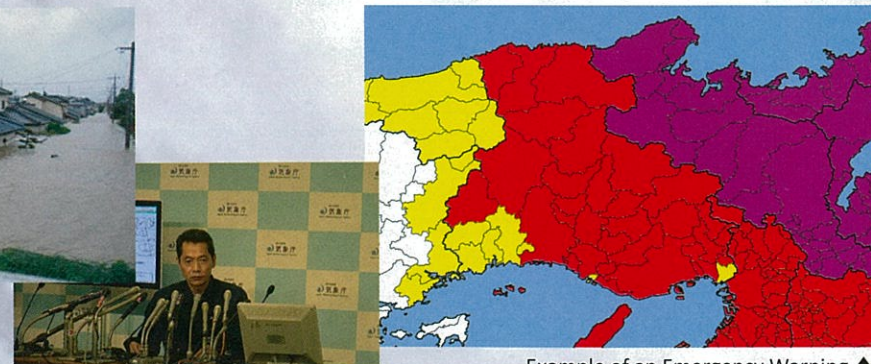
JMA also collects data gathered by other national and local organizations in Japan as well as National Meteorological and Hydrological Services (NMHSs) and relevant organizations around the world.



For Weather Disaster Preparedness and Mitigation

Local Meteorological Offices (LMOs) issue a variety of bulletins such as Emergency Warnings, Warnings and Advisories (see page 18) so that appropriate measures can be taken to mitigate possible disasters. LMOs also issue Flood Warnings and Advisories for designated rivers and Landslide Alert Information (see page 18) in collaboration with national and prefectural government.

LMOs hold briefing sessions on typhoon forecasting for prefectural disaster management agencies and the media, and also caution municipalities on adverse weather conditions.



Example of an Emergency Warning ▲
LMOs issue Emergency Warnings, Warnings and Advisories for individual municipalities and their residents



▲ Typhoon forecast briefing (at Tokyo Metropolitan Gov. Office)



▲ Telephone briefing on weather conditions for a local government

If a catastrophe is expected to result from an extraordinary natural phenomenon such as a typhoon, LMOs inform national and local government staff of forecast peak times and durations of severe weather conditions such as heavy rain and gales at disaster mitigation meetings. LMO staff also provide governments with advice on weather condition by telephone and other means.

Monitoring of the Global Environment

For a Better Understanding of Our Earth

Monitoring of the Global Environment

Observation

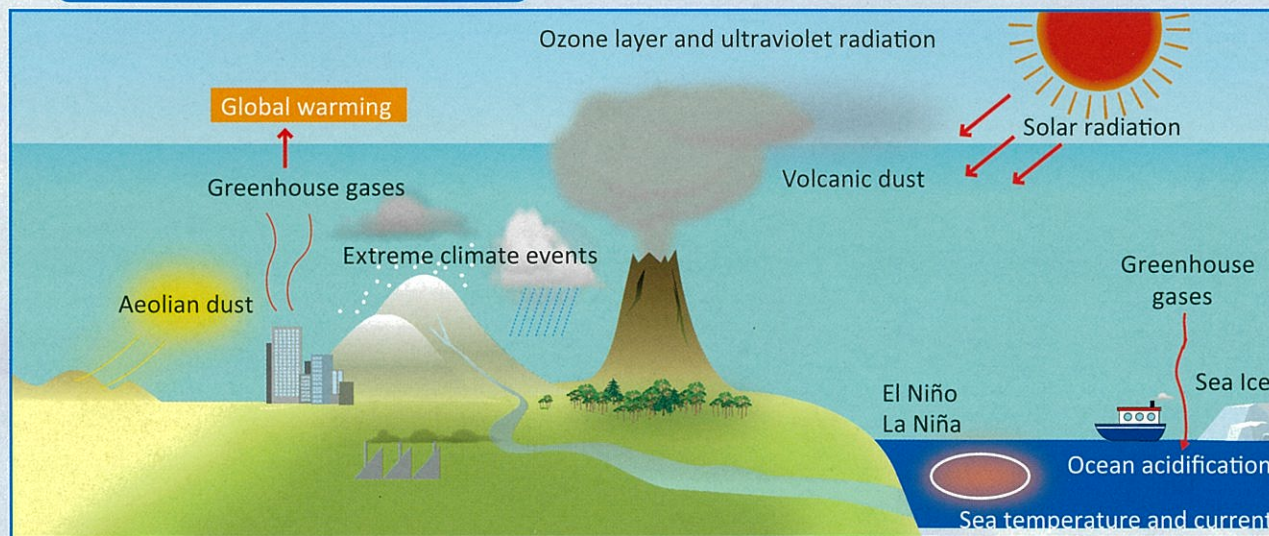
- Weather conditions/phenomena
- Greenhouse gases
- Ozone layer and ultraviolet radiation
- Oceanographic conditions/phenomena

Analysis and Prediction

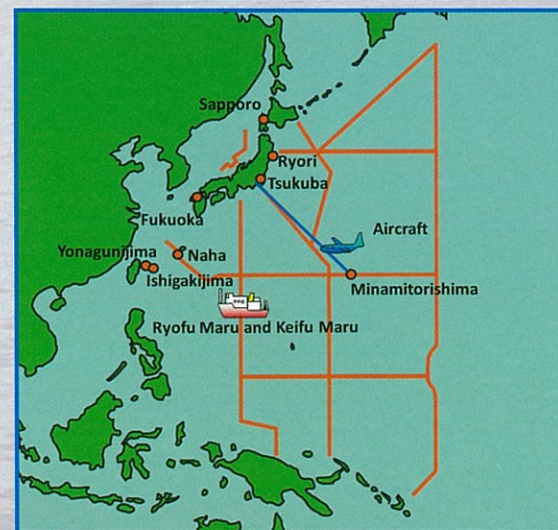
Information

- Global warming projection
- Extreme climate events
- Ozone layer and ultraviolet radiation
- Marine Diagnosis Reports

Monitoring of Phenomena



Observation Network for the Global Environment



▲ Global environment observation network

JMA monitors greenhouse gases, ozone, solar radiation and other atmospheric components at several ground observation stations.

The Agency also observes greenhouse gases in seawater using research vessels and carries out greenhouse gas observation in the upper air using aircraft in collaboration with Japan's Ministry of Defense.

- (●) Global environment observation station)
- (—) Research vessel observation route)
- (—) Aircraft observation route)

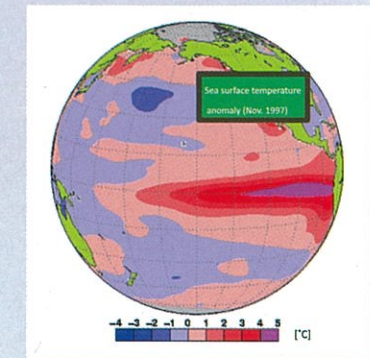
JMA carries out observation and monitoring related to environmental issues such as global warming and ozone layer depletion as well as prediction of global warming, and makes the results public. The Agency also provides information on oceanic phenomena such as El Niño, which significantly affects extreme climate events around the world.

Monitoring of the Climate

JMA monitors extreme climate events around the world and related phenomena such as El Niño and La Niña. The Agency also runs and develops a global general circulation model to calculate variables such as wind and sea currents for seasonal climate outlooks and future climate projection (see pages 21 and 22).



▲ Assessment of recent extreme climate events



▲ Sea surface temperature anomaly during an El Niño event (Nov. 1997)

Monitoring of the Atmospheric Environment

JMA observes elements of the atmospheric environment such as greenhouse gases at several stations. Its Minamitorishima location is one of the most important monitoring spots in the world because it is located more than 2,000 km from the continent and is therefore relatively unaffected by local anthropogenic emissions.



▲ Overview of Minamitorishima



▲ Greenhouse gas observation at Minamitorishima

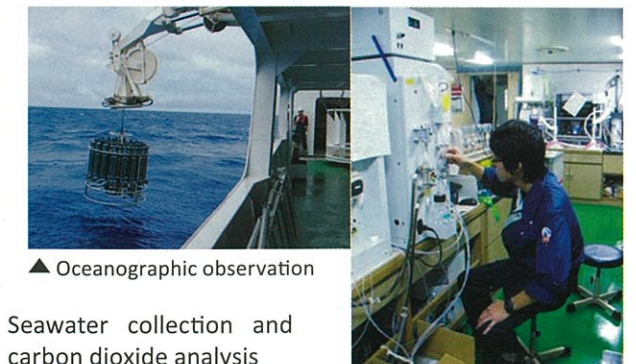
Monitoring of Oceans

JMA conducts oceanographic observation (water temperature, salinity, carbon dioxide, etc.) using two research vessels and operates profiling floats to monitor the long-term variability of the marine environment and global warming.



Keifu Maru (1,483 tons)

▲ JMA's two research vessels are named the Ryofu Maru (1,380 tons) and the Keifu Maru.



▲ Oceanographic observation

Seawater collection and carbon dioxide analysis

▲ On-board analysis

Monitoring of Earthquakes, Tsunamis and Volcanic Activity

For the Provision of Timely Information

Japan is one of the world's most earthquake- and volcano-prone countries, and has suffered repeated damage from such disasters as well as tsunamis.

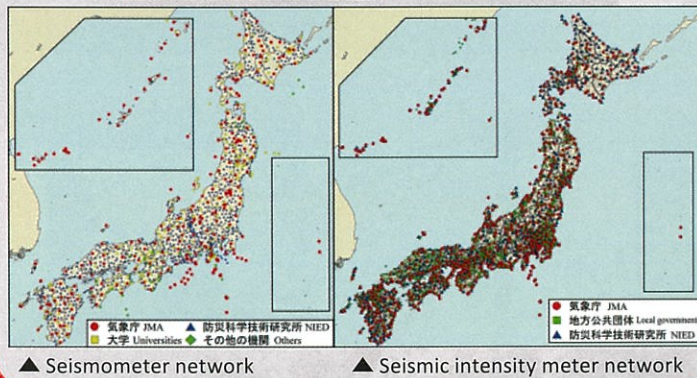
To reduce damage caused by earthquakes, tsunamis and volcanic eruptions and to protect life and property, JMA monitors real-time data from seismometers, tsunami observation facilities and instruments installed near active volcanoes around the clock and issues a range of disaster mitigation information.

Monitoring of Earthquakes

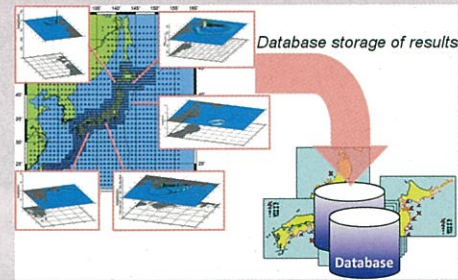
JMA collects real-time data from around 1,600 seismometers and around 4,400 seismic intensity meters deployed throughout Japan to support the monitoring of earthquakes around the clock.



Collection of data
← Seismometer and seismic intensity meter



Tsunami Database

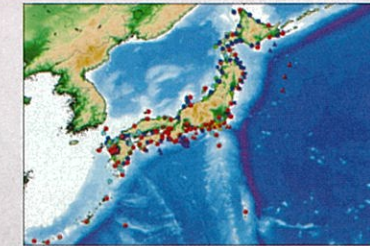


To enable immediate issuance, JMA has conducted computer simulation of tsunamis with earthquake scenarios involving various locations and magnitudes. The results detailing tsunami arrival times/heights and other outcomes are stored in a database.

Earthquakes Analysis, Tsunami Forecasting and Monitoring

When an earthquake occurs, JMA promptly estimates its location, magnitude and related tsunami risk. Seismic intensities observed throughout Japan are promptly announced in Seismic Intensity Information bulletins, which are used to support the implementation of disaster mitigation measures by related management authorities. If disastrous waves are expected in coastal regions of Japan, JMA issues a Tsunami Warning/Advisory for each region expected to be affected based on estimated tsunami heights. The Agency also collects real-time data from around 230 sea-level gauges and tsunami meters for tsunami monitoring.

Tsunami Observation



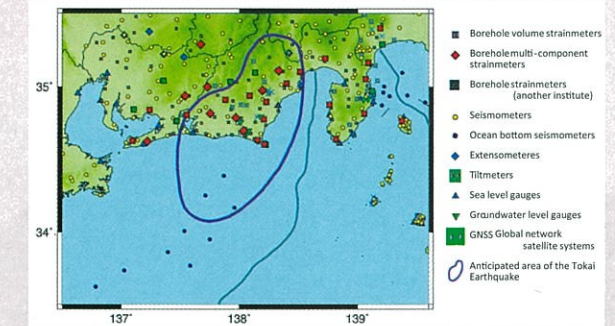
JMA operates around 80 tide gauges and also collects real-time sea level data from gauges operated by other organizations. The Agency further uses 18 GPS buoys and 38 offshore-water-pressure gauges managed in conjunction with other organizations for Tsunami Information.



Operation room: work on earthquake analysis

Monitoring for Tokai Earthquake Prediction

Earthquake prediction largely remains in the research stage except in relation to the Tokai Earthquake. To support the prediction of this expected tremor, JMA has developed a seismic and crustal deformation observation network covering the region in conjunction with related organizations, and observes relevant data around the clock. The Agency is responsible for convening the Earthquake Assessment Committee for Areas under Intensified Measures against Earthquake Disaster in the event of anomalous phenomena to determine whether such abnormalities are precursors to the Tokai Earthquake.



▲ Observation network in the Tokai region



▲ Earthquake Assessment Committee for Areas under Intensified Measures against Earthquake Disaster

Monitoring of Volcanic Activity and Issuance of Volcanic Warnings

Among Japan's 110 active volcanoes, 47 selected by the Coordinating Committee for Prediction of Volcanic Eruptions are continuously monitored using seismometers, tiltmeters, GNSS and other tools. When unusual phenomena are observed, JMA reinforces its monitoring efforts and implements mobile observation if necessary. The Agency also issues Volcanic Warnings (see page 20) specifying target areas for caution based on the results of observation, monitoring and evaluation.



▲ Volcano monitoring

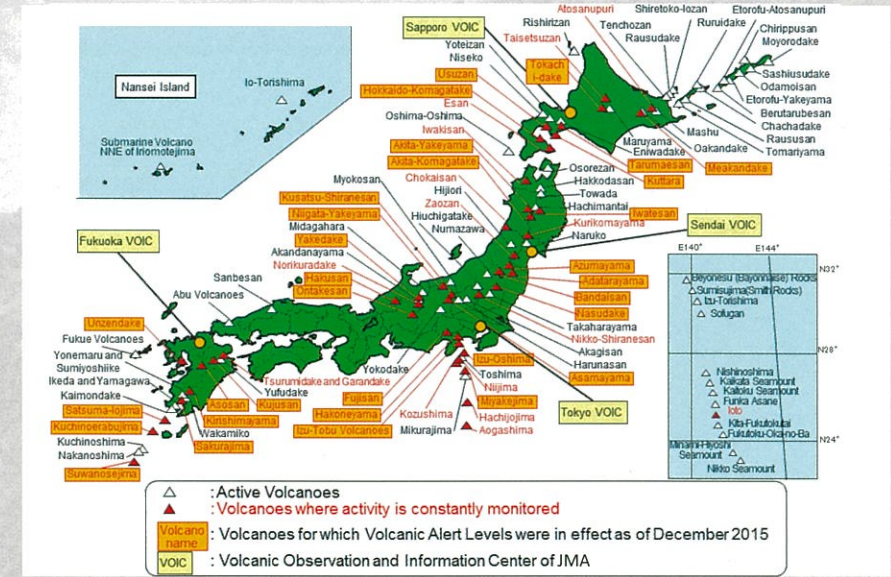


▲ Investigation of volcanic deposits

Active volcanoes in Japan



▲ Volcano monitoring with a high-sensitivity camera



International Cooperation

JMA plays a key role in the development and implementation of the Global Observation System (GOS) through its Regional Instrument Centre and via the operation of its geostationary meteorological satellites. It is also actively involved in international programs relating to oceans and tsunami.

International Cooperation

Takuya HOSOMI

Senior Coordinator for International Cooperation, Office of International Affairs

As Japan is located in one of the world's most disaster-prone areas, JMA has long striven to develop various technologies based on lessons learned from previous disasters. Against such a background, JMA's research and development encompasses a variety of areas including earthquakes, tsunami, and information/communications in addition to its regular weather and climate-related work. My principal duty involves sharing JMA's expertise in these areas internationally with operational services of National Meteorological and Hydrological Services (NMHSs) and other relevant government organizations based on communication with partners. To achieve this goal in technical cooperation activities, it is necessary to share information widely and promote the exchange of frank views among the parties involved. My mission is to act as a bridge between JMA experts and their counterparts overseas for the betterment of operational services in various countries.



Tsunamis

Tomoaki OZAKI

Senior Coordinator for International Earthquake and Tsunami Information, Earthquake and Tsunami Observation Division

Tsunamis move across oceans without regard to national borders, often causing serious damage over extensive coastal areas. JMA works with UNESCO/IOC*1 and contributes to tsunami disaster mitigation all over the world. In particular, the Agency makes a major contribution to the Pacific intergovernmental cooperation framework known as ICG/PTWS*2 through 1) the leading role I have played as Vice-Chair since April 2015, and 2) the operation of the Northwest Pacific Tsunami Advisory Center, which provides information on tsunami forecasting in the western North Pacific and, on an interim basis, the South China Sea. JMA also helps with the development of the CTBT*3 verification regime by providing seismic waveform data from its stations. I very much enjoy working with my colleagues around the world to coordinate such joint efforts among international organizations and to collaborate with a variety of organizations in the field of earthquakes and tsunamis.



*1 Intergovernmental Oceanographic Commission

*2 Intergovernmental Coordination Group for the Pacific Tsunami Warning and mitigation System

*3 Comprehensive Nuclear-Test-Ban Treaty

Satellite

Shuji NISHIMURA

Senior Scientific Officer, Tokyo Typhoon Center

Koki MORI

Senior Scientific Officer, System Engineering Division, Meteorological Satellite Center

Haruka KITAHATA

Scientific Officer, Office of International Affairs

JMA's new geostationary meteorological satellite, Himawari-8, began operation in July 2015. Its high-frequency, high-resolution and multi-band imagery appeals to a range of NMHSs and other users in the East Asia/West Pacific regions and elsewhere. The variety of channels used to deliver such imagery includes the HimawariCast communication service. JMA assists NMHSs in the operational use of Himawari-8 imagery through supportive measures such as the provision of a HimawariCast reception system in collaboration with the World Meteorological Organization (WMO). The Agency also runs training seminars for NMHSs to maximize the benefit they can derive from Himawari-8 imagery. The trainers at these sessions truly feel the trainees' enthusiasm for learning about satellite meteorology. As presenters at the seminars, we feel honored to have the opportunity to support the enhancement of NMHS weather monitoring and forecasting capacity based on the use of satellite imagery. We believe such enhancement will contribute to the prevention and mitigation of natural disasters in these regions. We are also keenly aware of the importance of communicating with international users face to face. We look forward to strengthening partnerships with users and supporting their work in satellite data utilization.



Disaster Mitigation

Naohisa KOIDE

Senior Scientific Officer, Tokyo Typhoon Center

The mission of the Tokyo Typhoon Center (TTC) is to mitigate damage and loss associated with tropical cyclones and other severe weather conditions in the Asian-Pacific region. To this end, the Center works to issue optimal tropical cyclone advisories in its role as the WMO tropical cyclone Regional Specialized Meteorological Center (RSMC) for the western North Pacific, and provides technical assistance via training sessions and expert missions to regional NMHSs for the improvement of forecasting capacity. Working at TTC provides me with invaluable opportunities to communicate with operational forecasters around the world. This helps to broaden my views and knowledge, motivates me in my related duties, and makes me realize that the Center's meteorological services support the development of international collaboration among NMHSs. As the unique early warning capacities of NMHSs become more important in today's changing climate, I believe that international cooperation is essential in helping NMHSs fulfill their national responsibilities and better respond to the growing needs of the global community.



Oceans

Hiroshi HASEGAWA

Scientific Officer, Office of Marine Prediction

The enhancement of storm surge prediction information has become increasingly important for risk management in coastal areas. I develop and manage JMA's storm surge model for operational use. Within the framework of the Storm Surge Watch Scheme proposed by WMO, JMA developed an Asian-Area Storm Surge Model in collaboration with Typhoon Committee members to support the issuance of storm surge predictions and help members take related countermeasures. JMA began issuing this information to members in 2011, and has since continued its efforts to improve such provision. I am currently tasked with establishing a new storm surge prediction system that will provide more accurate and useful information for risk management. I have a sense of responsibility for contributing to international cooperation, and feel that my job is very challenging and worthwhile.



International Cooperation

As the atmosphere has no national borders, international cooperation and coordination are essential for the development of worldwide activity in the field of meteorology. JMA devotes considerable resources to a number of WMO regional and global centers in a variety of fields, including weather forecasting, international communications and the global environment.

Climate

Atsushi GOTO

Scientific officer, Tokyo Climate Center



The Tokyo Climate Center (TCC) assists operational climate services provided by National Meteorological and Hydrological Services (NMHSs) in the Asia and Pacific region. Its main activities involve the provision of climate data and products to NMHSs through its website and assistance with capacity development at NMHSs in the region. TCC serves as a World Meteorological Organization (WMO) Regional Climate Center for Regional Association II (Asia) (RCC Tokyo) and a Global Producing Center for Long-range Forecasts (GPC Tokyo) for JMA. I have served as a TCC focal point since October 2014. From my daily work I feel that interest in climate issues is growing worldwide, and it's a pleasure for me to be able to contribute to the field.

In its capacity development activity role, TCC organizes annual training seminars on the application of its climate products for regional NMHSs officials. The course is characterized by its inclusion of practical exercises in addition to classroom lectures. Training seminars provide important opportunities for all TCC members to deepen mutual understanding and friendship with officials in charge of climate services in the region. As a coordinator of these seminars, I look forward to welcoming them and discussing climatic characteristics, current climate services and related challenges. The Center also arranges visits by TCC experts to and hosts visitors from NMHSs. I'm always very pleased to see increasing interest in and demand for TCC's products and services. I remain committed to TCC's activities toward the development of a society in which science-based climate information is applied to support better decision-making.

Team GISC Tokyo



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Senior Scientific Officer

Kentaro TSUBOI, Yoritsugi ONO, Atsushi SUGANO

Scientific Officer

Yasutaka HOKASE, Shingo ICHIKAWA

Assistant Scientific Officer

JMA operates the Global Information System Centre (GISC) of WMO Information System (WIS; the name given to WMO's coordinated global telecommunication/data management infrastructure). GISCs are elements of the WIS core network, interacting via high-speed dedicated networks to collect and distribute information available for global provision. These centers also play major roles in data management, including coordination for reliable and efficient data communication and data catalogue updates.

The GISC Tokyo team is actively involved in all aspects of operation and development of WIS, particularly in activities for capacity development regarding operational meteorological data exchange at NMHSs in Southeast Asia and elsewhere. Various training workshops and collaboration meeting events provide valuable opportunities to communicate WIS concepts and work with colleagues worldwide to materialize these ideas. These efforts to make WIS beneficial to NMHSs around the world undoubtedly help to make a difference in the meteorological community.

Radar Observation

Kazuhiko NAGATA

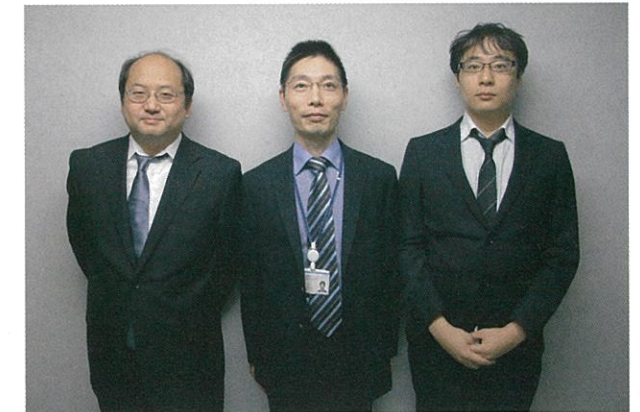
Senior Scientific Officer, Tokyo Typhoon Center

Hiroshi YAMAUCHI

Senior Scientific Officer, Observation Division

Takanori SAKANASHI

*Scientific Officer,
Office of Observation Systems Operation*



Radar observation is indispensable for weather monitoring and forecasting. Today most countries have weather radar systems, and capacity development for related techniques at NMHSs is a common challenge in maximizing system performance.

JMA's long history of weather radar operation stretches back to the technology's introduction in 1954. Based on its wealth of experience and expertise, JMA promotes cooperation with sharing of its know-how and technical expertise in order to contribute to related capacity development under international frameworks such as the ESCAP/WMO Typhoon Committee and the WMO Integrated Global Observing System (WIGOS).

Such collaboration is intended to help NMHSs enhance their capacity in relation to early warning systems, which are essential for disaster risk reduction, based on competent weather radar observation and quantitative precipitation estimation/forecasting (QPE/QPF). JMA's staff very much enjoy working with their counterparts in ASEAN countries and around the world.

Aviation Weather Forecasting

Naoko KOMATSU

Scientific Officer, Office of Aviation Weather Forecasting

In recent years, air traffic volume has been increasing worldwide, especially in Asia. Accordingly, it has become more important to ensure the safety and efficiency of air traffic services and reduce related impacts on environment. To address this situation, the International Civil Aviation Organization (ICAO) formulated the One Sky concept toward the establishment of a globally harmonized air traffic system. The achievement of this goal requires the improvement of aeronautical meteorological services and the provision of regionally and globally harmonized information. In this context, international collaboration is taking on increased importance in the field of aviation meteorology.

I am in charge of fostering cooperative relationships with other Asian countries via the provision of technical training on aeronautical meteorological services such as SIGMET utilizing my experience as an operational aeronautical meteorological forecaster. I have been to several Asian countries to provide training and discuss approaches to related collaboration. I also give lectures on services provided by JMA, which hosts trainees from numerous countries every year. I additionally participate in discussions with other countries' representatives on the improvement of aeronautical meteorological services at international meetings held by ICAO and WMO.



Meteorological Information for Aviation and Maritime Safety

Meteorological information is imperative for the safe operation of aircraft and marine vessels. JMA provides aviation stakeholders and maritime operators with specialized information to meet their specific needs.

For Aviation Safety

Aircraft are continuously affected by weather conditions from take-off to landing. To support safe, efficient aircraft operation, JMA provides air traffic service units of the Japan Civil Aviation Bureau (JCAB) and airlines with meteorological information collected/produced both for aerodromes and airspace in compliance with the standards of the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO).

Monitoring at Aerodromes



Issuance of forecasts and warnings



Observation by human observers



Observation using instruments (wind direction/speed, etc.)

JMA provides timely meteorological reports to air traffic controllers and pilots based on minute-to-minute monitoring of constantly changing weather conditions.

Monitoring of Airspace



Monitoring and forecasting of weather in airspace



Monitoring and forecasting of volcanic ash clouds

Provision to JCAB and Airlines



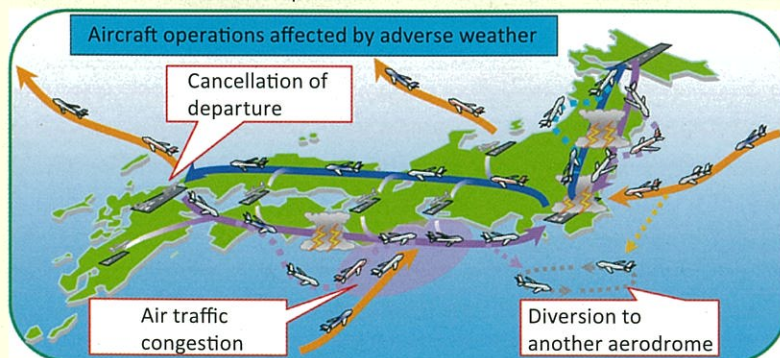
Pilots and operators



Air traffic controllers at aerodromes



Air traffic controllers at ATMC



JMA's Air Traffic Meteorology Center (ATMetC) staff work in the same operation room as JCAB's Air Traffic Management Center (ATMC) staff in Fukuoka to ensure smooth and flexible operation of aircraft en route.

For Maritime Safety

To support safe, cost-effective maritime navigation in bad weather, JMA issues various kinds of information such as data on marine weather, ocean winds, wave heights, sea surface temperatures and ocean currents for ships in the western North Pacific and coastal areas around Japan. The Agency is responsible for creating and issuing warnings and weather/marine information through the international SafetyNET system under the framework of the Global Maritime Distress and Safety System (GMDSS) for high seas in the western North Pacific and elsewhere.

Issuance of Marine Warnings and Wave Forecast Charts



Support for Private-sector Services

JMA provides a variety of meteorological data and products to private operators in the weather service sector to aid their commercial services.

Real-time and archived data are provided online and via electronic media, respectively, through the Japan Meteorological Business Support Center (JMBSC; a general incorporated foundation designated by the Director-General of JMA).

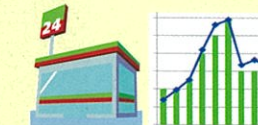


Private-sector Services



Personalized Distribution

For the safety of people engaging in outdoor activities



Merchandising

Purchase and inventory control based on forecasting



Machine Control

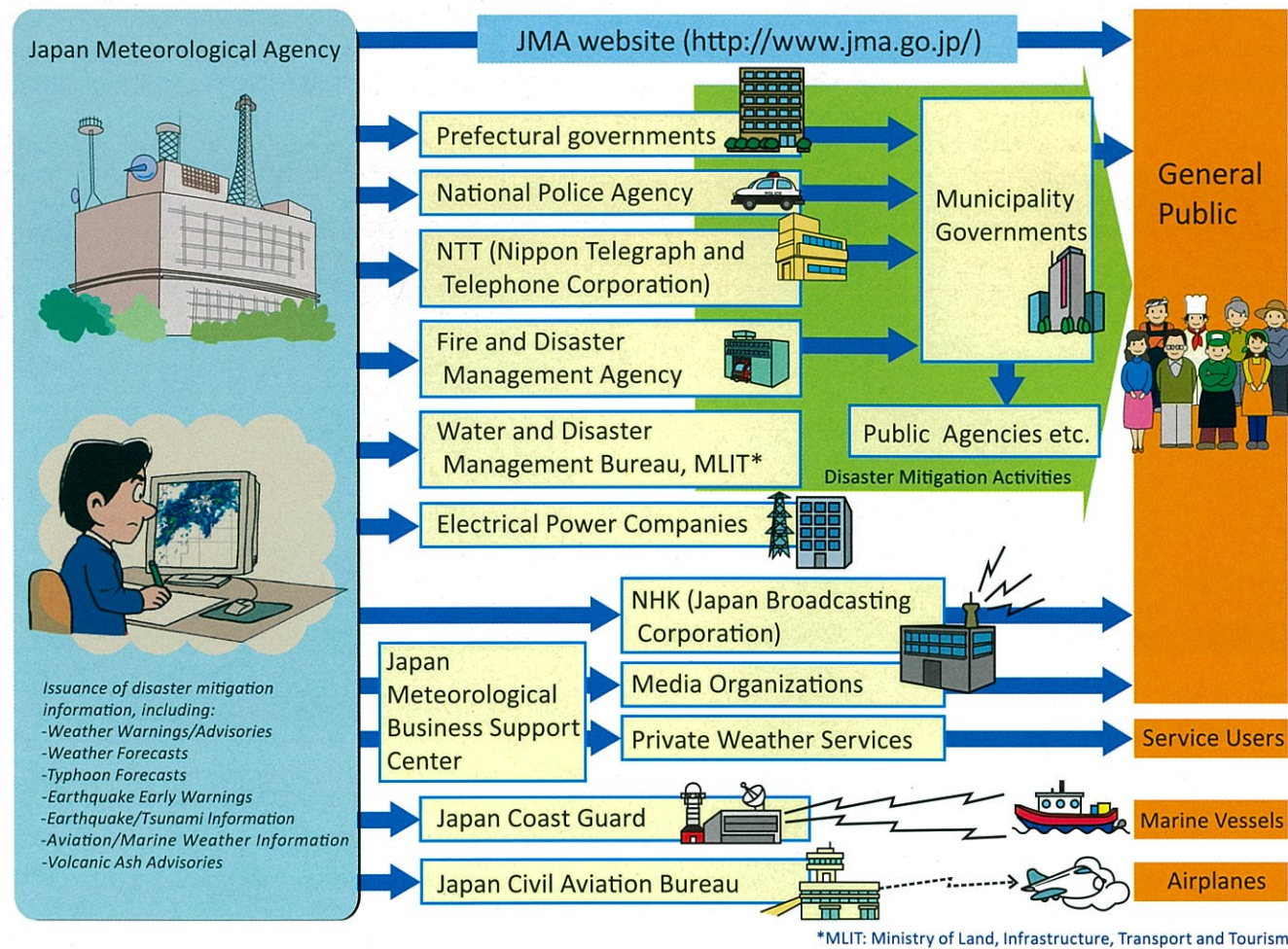
Automated machine control using the Earthquake Early Warning System

Information Provided by JMA

For Weather Disaster Mitigation

To limit the extent of damage caused by natural disasters and support the prompt execution of related activities, JMA provides disaster mitigation information via various channels to government disaster management agencies, local governments, the media and the public.

Provision of Disaster Mitigation Information



Information for Severe Weather Preparedness

JMA issues a variety of messages as detailed below in response to current and forecast weather conditions so that appropriate measures can be taken to mitigate possible issues such as damage from storms/flooding and damage brought by such hazards as debris flow and concentrated slope failure caused by tropical or extra-tropical cyclones and fronts.

Emergency Warnings/Warnings/Advisories

Emergency Warnings are issued if there is significant likelihood that a catastrophe will be caused by a natural phenomenon of a scale far exceeding the warning criteria. Warnings are issued if there is a chance of catastrophe caused by weather conditions that meet the relevant warning criteria. Advisories are issued if there is potential for the development of serious adverse conditions that meet advisory criteria but remain below the warning criteria.

■ Emergency Warnings:	Storm, Snow-storm, Heavy rain, Heavy snow, Storm surge and High waves
■ Warnings:	Storm, Snow-storm, Heavy rain, Heavy snow, Storm surge, High waves and Flood
■ Advisories:	Gale and snow, Gale, Heavy rain, Heavy snow, Dense fog, Thunderstorm, Dry air, Avalanche, Ice/Snow accretion, Frost, Low temperature, Snow-melting, Storm surge, High waves and Flood

Bulletins

Bulletins are issued to alert the public to weather conditions before Warning/Advisories are issued and to supplement Warnings.

Bulletins on Exceptionally Heavy Downpours

Bulletins on Exceptionally Heavy Downpours are issued when a downpour with a scale seen only once every few years has been observed or analyzed in the last hour.

Landslide Alert Information

In association with the issuance of Heavy Rain Warnings, Landslide Alert Information is issued jointly by LMOs and civil engineering bureaus of prefectural governments when damage from debris flows and concentrated slope failures caused by heavy rain is considered likely within the next few hours.

Flood Warnings and Advisories for designated rivers

JMA issues Flood Warnings and Advisories for designated rivers with information on water levels or flow rates in collaboration with national and prefectural river authorities for rivers deemed prone to flood disasters by these organizations.

Hazardous Wind Watch

Hazardous Wind Watches supplement Thunderstorm Advisories to warn of a high probability of hazardous winds such as tornadoes and downbursts.

Radar/Raingauge-Analyzed Precipitation and Very-Short-Range Forecasts of Precipitation

Radar/Raingauge-Analyzed Precipitation data show the distribution of one-hour precipitation. Very-Short-Range Forecast of Precipitation reports are issued to provide forecasts of hourly precipitation amounts for the next six hours.

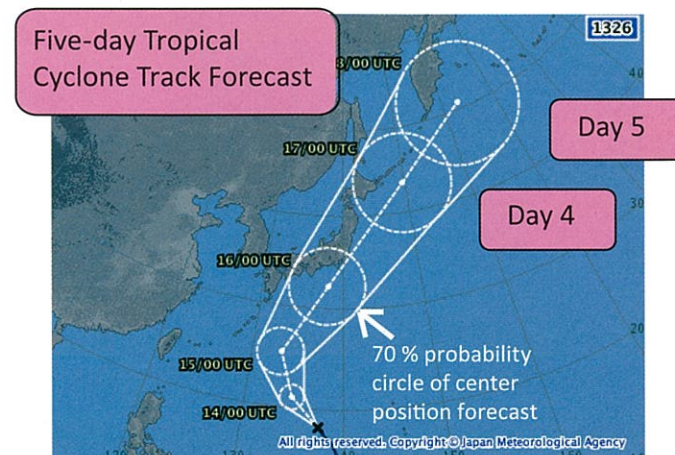
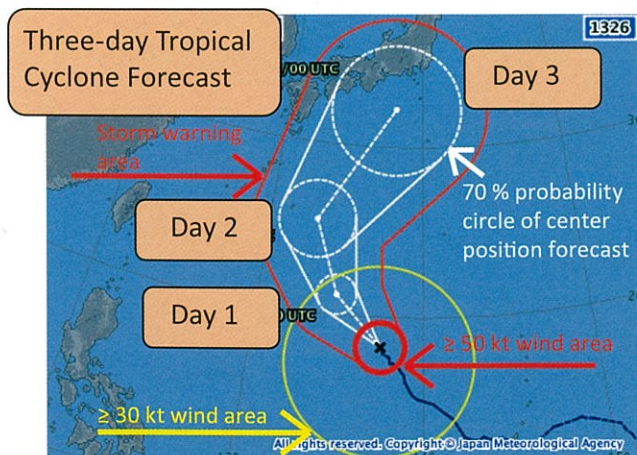
Nowcasts (High-resolution Precipitation, Precipitation, Thunder and Tornadoes)

Nowcasts provide forecasts of precipitation intensity, thunder activity and the probability of hazardous winds such as tornadoes and downbursts up to an hour ahead.

Tropical Cyclone Information

JMA monitors tropical cyclone (TC) activity over the western North Pacific and the South China Sea, and issues TC advisories every three hours to provide relevant information including analysis and forecasts of location, intensity and movement up to three days ahead.

The Agency also issues five-day TC track forecasts every six hours for TCs expected to maintain tropical storm intensity or more severe levels over the next three days.



Responses advised to protect life (for heavy rain)

On a routine basis: Check weather bulletins and look out for changes in the weather.

Onset of rain

If the rain gets heavier, Pay attention to the latest bulletins and prepare for disaster conditions. Early action is recommended for people in areas vulnerable to rain/wind-related disasters and people needing assistance to evacuate.

Advisory

If heavy rain continues, Pay attention to evacuation orders/advisories and other related information issued by municipalities, and start voluntary and early evacuation as needed.

Warning

If heavy rain continues, Take immediate action to protect life.

EMERGENCY!

Emergency Warning

Head to an evacuation center in accordance with evacuation advisories/orders and other related information. If it is dangerous to go outside, evacuate to a safer place within the building.

Cool-headed decisions are important because evacuation requirements depend on the location/structure of domiciles and whether inundation has already occurred. Advance consideration of action to be taken is key in protecting life.

Nuts and Bolts

- Check whether you're ready for an impending hazard.
- Be aware of hazardous places such as lower areas prone to flooding.
- Check emergency supplies.
- Check evacuation routes and centers.
- Check the security of windows and storm shutters.
- Monitor weather bulletins on TV, radio and JMA's website.
- Take early action even if no Emergency Warning is in effect!
- Stay calm.
- Respond flexibly depending on the situation.
- Be aware of the extreme danger of evacuation once inundation has occurred.

Information Provided by JMA

For Earthquake, Tsunami and Volcanic Disaster Mitigation

JMA is responsible for issuing warnings and information on earthquakes, tsunamis and volcanoes. As such bulletins are critical for the protection of life, a standard operating procedure and warning categories are set in advance to ensure prompt issuance.

Information on Earthquakes and Tsunamis



Several to tens of seconds

Earthquake Early Warnings

Earthquake Early Warnings (EEWs) provide advance notice of estimated seismic intensities and expected arrival times of principal motion just after an earthquake occurs. If the estimated maximum seismic intensity is 5-lower or more, EEWs (warnings) are issued for regions with estimated seismic intensities of 4 or more.

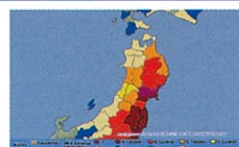


Stay calm and keep safe!

1.5 to 2 minutes

Seismic Intensity Information

This information specifies the time of earthquake occurrence and identifies regions where seismic intensity levels of 3 or greater have been observed (issued within 90 seconds of the earthquake).

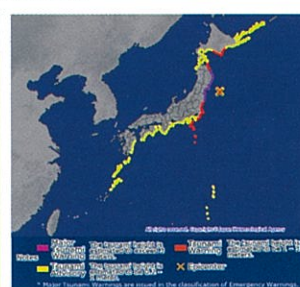


2 to 3 minutes

Tsunami Warning/Advisory

When an earthquake occurs, JMA estimates whether a tsunami has been generated. If disastrous waves are expected in coastal regions, a Tsunami Warning/Advisory is issued.

Category	Indication	Actions to be taken
Major Tsunami Warning*	Tsunami height is estimated to exceed 3 meters.	Evacuate from coastal regions and riversided areas to a safer place such as high ground or a tsunami evacuation building.
Tsunami Warning	Tsunami height is estimated to be 1 - 3 meters.	Evacuate from coastal regions and riversided areas to a safer place such as high ground or a tsunami evacuation building.
Tsunami Advisory	Tsunami height is estimated to be 0.2 - 1 meter.	Get out of the water and leave coastal regions immediately.

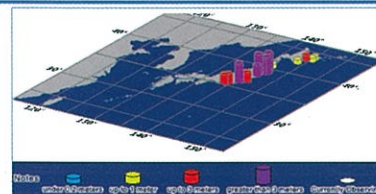


* Major Tsunami Warnings are issued in the classification of Emergency Warnings. → pp. 1-2

Around 5 minutes onward

Tsunami Information

When a Tsunami Warning/Advisory is issued, JMA also issues Tsunami Information with details such as estimated arrival times/heights and recorded tsunami data.



Earthquake and Seismic Intensity Information

This information specifies the tremor's hypocenter and magnitude. It also identifies cities/towns/villages where seismic intensity levels of 3 or greater have been observed and those where the estimated seismic intensity is 5-lower or greater but related observation data are incomplete.

Information on Seismic Intensity for individual locations

This information specifies the tremor's hypocenter and magnitude. It also identifies individual locations where seismic intensity levels of 1 or greater have been observed and those where the estimated seismic intensity is 5-lower or greater but related observation data are incomplete.

Other Information

JMA also issues other reports such as Information on Seismic Activity later.

Information on the Tokai Earthquake

JMA issues Tokai Earthquake Assessment Reports (Regular) after monthly assessment of data collected in the Tokai region. If anomalies are detected, JMA issues other information on the Tokai Earthquake to allow preparatory action and emergency measures for earthquake disaster mitigation.

Information issued by JMA	Action to be taken by public organizations
Tokai Earthquake Prediction Information	Establishment of Headquarters for Earthquake Disaster Prevention
Tokai Earthquake Cautionary Information	Preparatory action based on prevention plans
Tokai Earthquake Assessment Report (Extra)	Collection of information
Tokai Earthquake Assessment Report (Regular)	None

Volcanic Warnings and Alert Levels

JMA issues volcanic Warnings for 110 active volcanoes in Japan when unusual phenomena are observed. It also sets Volcanic Alert Levels for 32 active volcanoes (as of December 2015) specifying target areas and action to be taken based on local evacuation planning coordinated by regional volcanic disaster management councils.

Volcanic Warning (Residential area) is issued in the classification of Emergency Warning. → pp. 1-2

Abbreviated Term	Target area	Levels & Keyword
Volcanic Warning (Residential area) (a.k.a. Residential area Warning)	Residential areas and non-residential areas near the crater	Level 3 Evacuate Level 4 Prepare to evacuate
Volcanic Warning (Near the crater) (a.k.a. Near-crater Warning)	Non-residential areas near the crater Around the crater	Level 3 Do not approach the volcano Level 2 Do not approach the crater
Forecast	Inside the crater	Level 1 Potential for increased activity

Eruption Notice

Eruption notices provide information on volcanic eruptions occurring after a period of inactivity or those on an unprecedented scale that may lead to a change in the volcanic alert level. They allow people such as climbers or entering volcanic areas to take appropriate protective action.

Example of Eruption Notice

Asosan Eruption Notice
9:49 JST 14 September 2015
Asosan eruption

— Note —

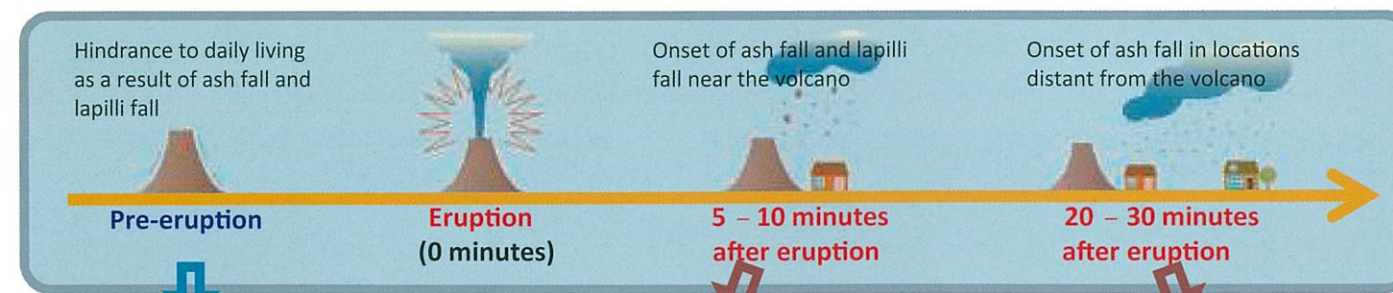
Operational since August 2015, the Eruption Notice system provides information on eruptions of volcanoes under constant observation by JMA. Eruption Notices are not issued in the following cases:
- A volcano that is already frequently active erupts on a scale similar to those of recent eruptions.
- An eruption is so minor that it will take time to confirm whether it has actually happened.

Volcanic Ash Fall Forecasts (VAFFs)

Volcanic Ash Fall Forecasts (VAFFs) are issued for volcanoes where Volcanic Warnings or Volcanic Emergency Warnings are in effect. For protection against disaster in the vicinity of active volcanoes and to safeguard human life, JMA provides details of the expected timing, location and amount of ash fall, including areas of lapilli fall, for volcanoes via three types of VAFF.

Ash quantities for volcanic ash fall forecasts

Category	Ash thickness (Response keywords)	Ashfall condition		Effects, action and preparation	
		Ash on roads	Visibility	General public	Drivers
Heavy	≥ 1 mm (Stay Indoors)	Complete cover	Poor (Heavy ashfall)	Stay indoors	Refrain from driving
Moderate	0.1 - 1 mm (Attention required)	Almost complete cover of road markings	Impaired (Visible ashfall)	Wear a mask	Drive slowly
Low	< 0.1 mm	Thin deposit	Normal (Slightly visible ashfall)	Keep windows closed	Wipe windshield



VAFFs (Scheduled)

Scheduled Forecasts are issued every three hours based on an assumed eruption at a specified time, regardless of the occurrence of an actual eruption, for volcanoes posing a hindrance to daily living from ash fall and lapilli fall in order to enable systematic action against possible eruptions. The information provided includes three-hourly potential areas of ash fall and lapilli fall up to 18 hours ahead to support preparedness in local communities.

VAFFs (Preliminary)

Preliminary Forecasts are issued within 5 - 10 minutes of the start of an eruption, and provide initial information on ash fall areas/amounts and lapilli fall areas up to an hour ahead. This helps people to protect themselves from ash fall and lapilli fall. To facilitate early issue, JMA runs various model forecasts with different conditions. When an eruption starts, a Preliminary Forecast is formulated using the model best fit for the observed conditions.

VAFFs (Detailed)

Detailed Forecasts are issued within 20 - 30 minutes of the start of an eruption. They provide accurate information on the expected start time of ash fall for individual municipalities as well as hourly data on ash fall areas and amounts up to six hours ahead to enable appropriate response. Detailed Forecasts are based on eruption times and plume heights as estimated via visual observation, and are more accurate than Preliminary Forecasts.

Information Provided by JMA

For the Safety and Future of Mankind

Information for Life and Industry

Daily Forecasts

Daily forecasts provide information on weather, winds, coastal ocean waves, maximum/minimum temperatures and probabilities of precipitation covering periods up to two days ahead. They include Distribution Forecasts and Three-hourly Forecasts.

One-week Forecasts

One-week Forecasts provide information on weather, precipitation probability, maximum/minimum temperatures and reliability, and cover the period up to seven days ahead.

Early Warning Information on Extreme Weather

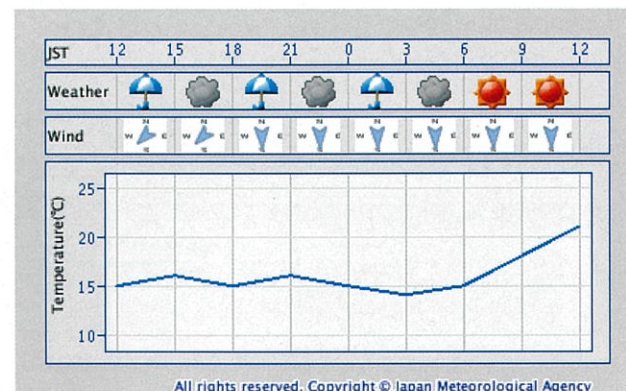
JMA issues such information every Monday and Thursday when a high probability (30% or more) of very high/low seven-day average temperatures or very heavy snowfall is predicted in the week starting five to eight days ahead of the date of announcement.

Seasonal Forecasts

Climate outlook data on variables such as average temperature, precipitation amounts, sunshine durations and snowfall totals for the next one to several months are provided in the form of probability forecasts with three categories of above normal, near normal and below normal.

Tokyo Chiho		Three-hourly Forecasts	Probability of Precipitation	Temperature Forecast
Today 29 October	SHOWERS THROUGHOUT THE DAY	00-06 --% 06-12 --% 12-18 70% 18-24 50%		Daytime High 16°C
Tomorrow 30 October	CLEAR, OCCASIONAL SCATTERED SHOWERS	00-06 50% 06-12 20% 12-18 20% 18-24 10%		Morning Low 14°C Daytime High 23°C
Day after tomorrow 31 October	PARTLY CLOUDY		One-week Forecasts	

▲ Example of a forecast covering the period up to two days ahead

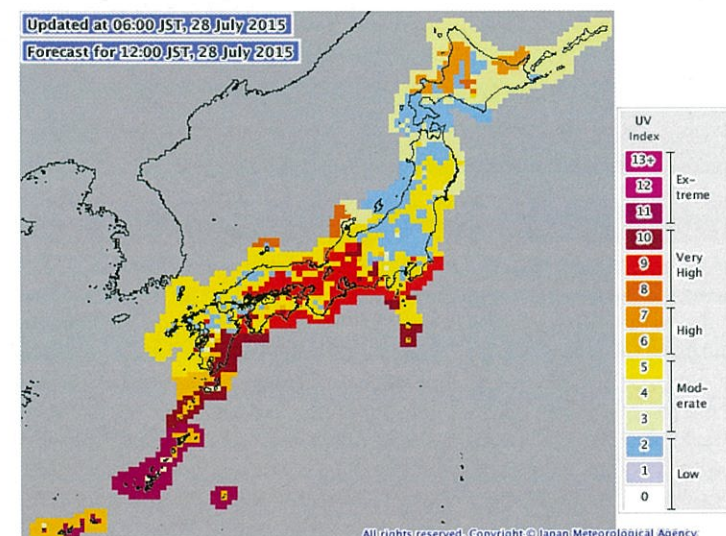


▲ Example of Three-hourly Forecasts

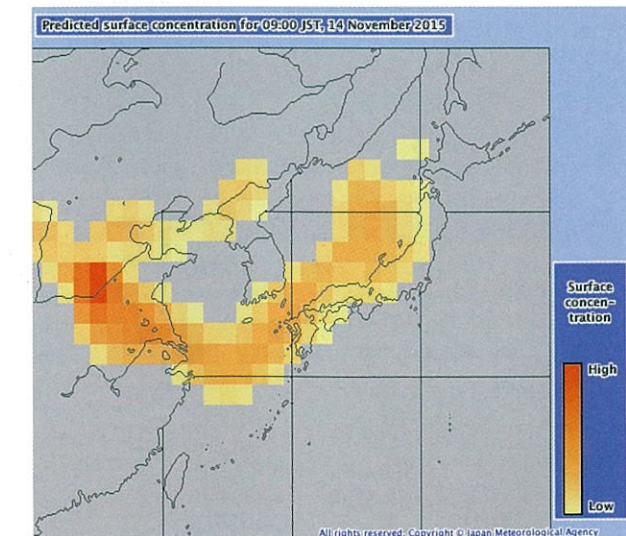
Information on the Global Environment

Information on the Atmospheric Environment

JMA provides atmospheric environment data on variables such as ultraviolet radiation and Aeolian dust (Kosa).



▲ UV Index Forecast

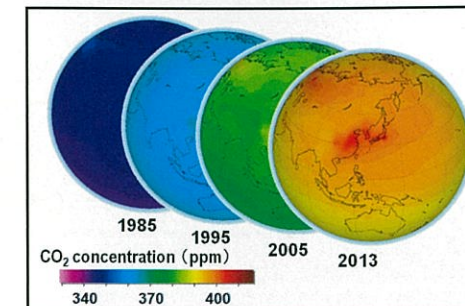


▲ Aeolian Dust Information (Prediction)

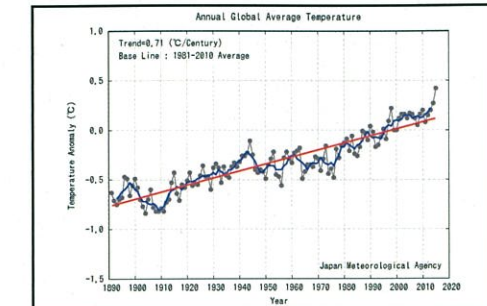
In addition to daily forecasts covering periods up to a week ahead, Early Warning Information on Extreme Weather and climate outlooks with data such as average temperatures and precipitation amounts covering periods up to several months ahead are provided to support agriculture and other industrial operations.

Global Warming

JMA provides global maps of carbon dioxide concentrations based on data from around the world. To contribute to the formulation and implementation of climate change mitigation/adaptation measures, the Agency provides numerical climate projections based on results obtained from a high-resolution general circulation model and a convection-permitting regional climate model.



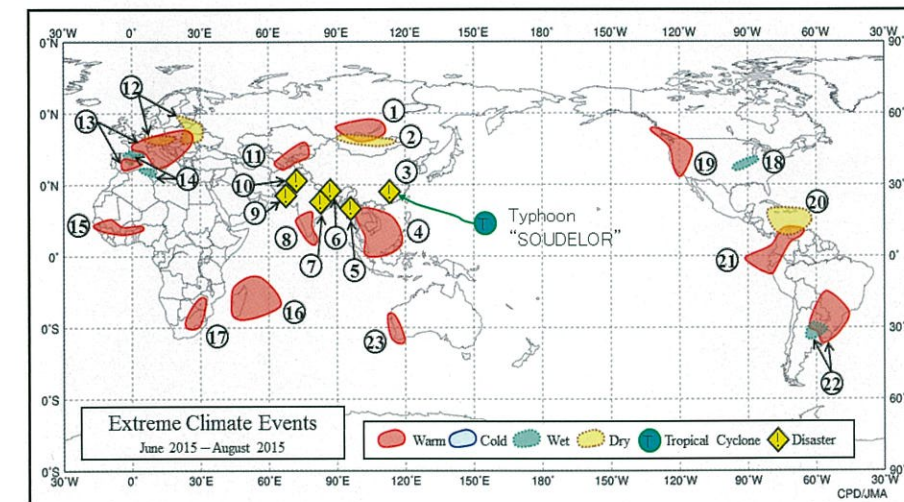
▲ Distribution of atmospheric carbon dioxide concentration based on analysis



▲ Annual global average surface temperature (land + oceans) since 1891

Extreme Climate Events

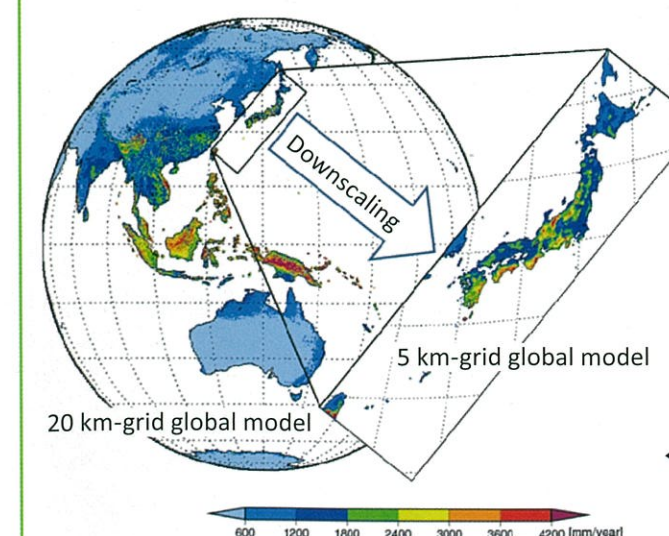
JMA issues information on extreme climate events around the world.



▲ Extreme climate events and weather related-disasters in boreal summer 2015

In the boreal summer of 2015, extremely high temperatures were recorded in many parts of the world. Many fatalities caused by torrential rains in Asian countries and by heat waves in southern Pakistan were reported. The western Mediterranean, the Midwest of the USA and the southeastern part of South America experienced extremely wet conditions, while extremely dry conditions were seen in eastern and central Europe, northern Mongolia and around the Caribbean Sea.

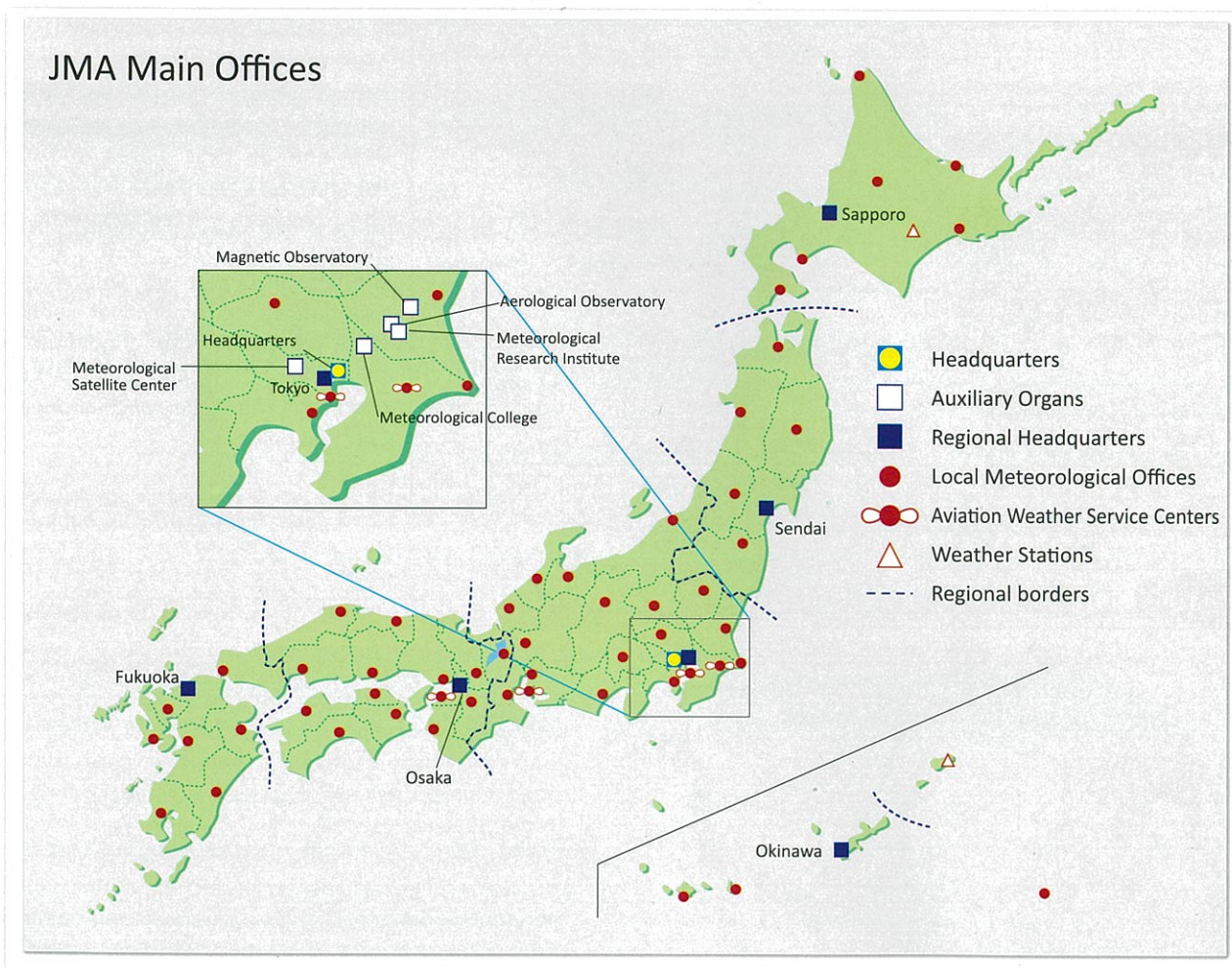
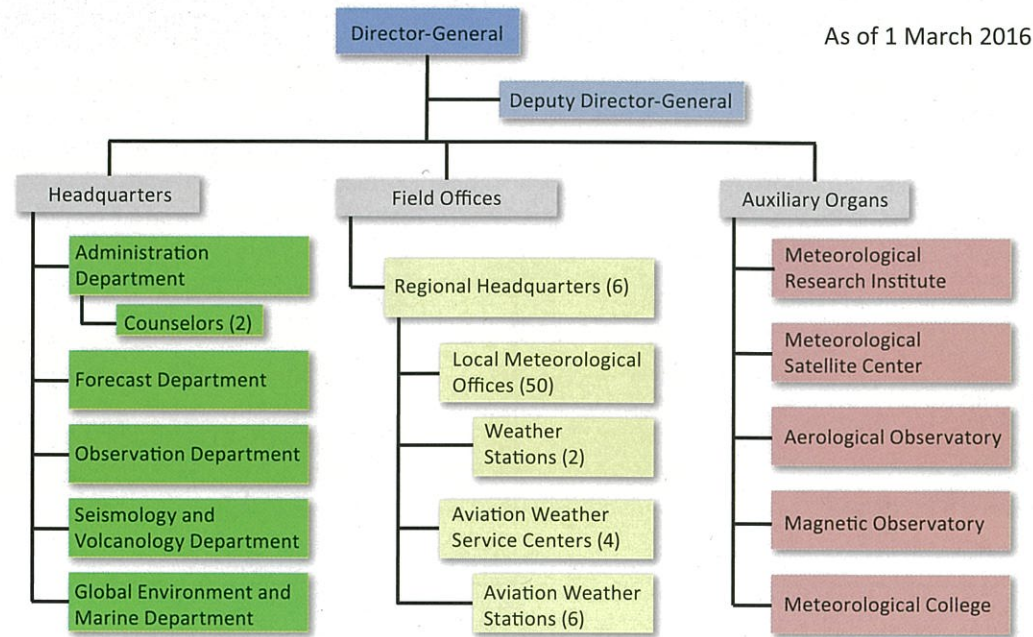
Research Detailed Global Warming Projection



How will individual regions of Japan be affected by changes in temperature and precipitation associated with global warming? How should these changes be handled? High-resolution, high-precision climate projections on a local level are required in order to answer these questions. Such projections of local changes can be achieved by combining a global change projection model with a more detailed model that incorporates the influence of complex geographical characteristics over a specified area.

◀ Distribution of annual average precipitation during the last 20 years of the 21st century over Japan and its surrounding areas assimilated with a downscaling model combined with a global model

Organizational Structure



JMA operates the Sapporo, Sendai, Tokyo, Osaka, Fukuoka and Okinawa Regional Headquarters to observe and monitor weather and earthquakes and to issue forecasts, warnings and bulletins for these regions. The Regional Headquarters give direction to Local Meteorological Offices for the issuance and provision of information and comments on prefectural and sub-prefectural levels. The Agency operates Aviation Weather Service Centers at major airports to support the safe flow of air traffic.

JMA also operates the Meteorological Research Institute, the Meteorological Satellite Center, the Aerological Observatory, the Magnetic Observatory and the Meteorological College as locations for research and training to support meteorological services.

History

Year	Events
1872	First observation station established in Hakodate.
1875	Tokyo Meteorological Observatory (TMO; the predecessor of JMA) established within the Ministry of the Interior.
1883	First weather map issued.
1884	First national weather forecast issued.
1884	Nationwide seismic intensity observation begun.
1887	TMO renamed as the Central Meteorological Observatory (CMO).
1921	Oceanographic and marine meteorological observation begun.
1930	Aviation weather service begun.
1935	Storm Warnings divided into Storm Warnings and Weather Advisories.
1941	Tsunami warning organization for the Sanriku coast established.
1942	Long-range Forecast Service begun.
1952	Meteorological Service Act brought into force.
1953	Japan joins the World Meteorological Organization (WMO).
1956	CMO becomes JMA (an affiliate agency of the Ministry of Transport).
1957	Observation in Antarctica begun.
1959	Numerical weather prediction begun.
1965	Provision of Volcanic Information begun.
1974	Automated Meteorological Data Acquisition System (AMeDAS) established.
1977	GMS (JMA's first geostationary meteorological satellite) launched.
1978	Act on Special Measures for Large-scale Earthquakes brought into force.
1980	Forecast for Probability of Precipitation begun.
1984	Seismology and Volcanology Department established.
1988	Very Short-range Forecast of Precipitation begun.
1991	Seismic intensity meter observation begun.
1996	Distribution Forecasts and Three-hourly Forecasts begun.
1999	Tsunami Forecast Regions segmentalized and Quantitative Tsunami Forecasts begun.
2001	JMA placed under the Ministry of Land, Infrastructure and Transport (MLIT*).
2004	Provision of Precipitation Nowcasts begun.
2005	Global Environment and Marine Department established.
2005	Issuance of information on debris flow, slope failure and other hazards begun.
2007	Provision of Earthquake Early Warning for the public begun.
2007	Earthquake Early Warnings and Volcanic Warnings placed as Warnings under the Meteorological Service Act.
2008	Provision of Early Warning Information on Extreme Weather begun.
2008	Issuance of Tornado Alerts and Weather Warnings/Advisories for the Ogasawara Islands begun.
2009	Issuance of Five-day Track Forecasts of Tropical Cyclones begun.
2010	Issuance of Weather Warnings targeting municipalities begun. Issuance of Hazardous Wind Potential Nowcasts and Thunder Nowcasts begun.
2013	New Tsunami Warning System operation begun.
2013	Issuance of Emergency Warnings begun.
2014	Provision of High-resolution Precipitation Nowcasts begun.

*MLIT became the Ministry of Land, Infrastructure, Transport and Tourism in January 2008. *Picture: JMA Headquarters

Focus Collaborative Activities for Disaster Mitigation in Communities

What should you do if dark clouds approach and it suddenly gets dark?
 What should you do if you feel the ground shaking hard in a coastal area?
 Local Meteorological Offices (LMOs) work on the implementation of various measures in collaboration with disaster management organizations, educational institutions and the media to help people learn how to respond independently to signs of disaster and to raise awareness of information issued by JMA.



▲ A lesson with teaching materials created jointly by LMO staff and teachers



▲ An LMO staff member on a radio show



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The JMA mascot



JMA's mascot is named Harerun (from *hare* - the Japanese word for "fine weather"), and incorporates elements of sun, cloud and rainfall. Harerun holds a green baton representing hopes for a peaceful and disaster-free world. The mascot helps to raise public awareness of meteorological services as well as natural disasters and global environmental issues at various events.

2016