Recent Improvement of Integrated Observation Systems in JMA

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Abstract

The Japan Meteorological Agency (JMA) operates surface weather stations, radiosondes and remote sensing technologies such as weather radar, wind profiler, lidar and lightning monitoring system across Japan to collect the comprehensive observational information necessary for severe weather watching and related nowcasting, numerical weather prediction (NWP) and climate monitoring. This report details improvements made in these operations since 2010.

In surface observation, JMA strives to maintain the quality and reliability of observational data via a three-pronged approach involving 1) monitoring of observation environment conditions, 2) periodical maintenance and management of instruments, and 3) quality control for observation data via anomaly analysis tool usage. Based on its expertise in surface observation, the Agency works to support observation capability improvement among National Meteorological and Hydrological Services (NMHSs) through the WMO Integrated Global Observing System (WIGOS) Project in the Regional Association (RA) II (Asia) area and other international activities.

In upper-air observation, JMA has introduced GPS radiosonde for all 16 stations in 2010. As the new type of radiosonde introduced in 2013 for eight stations is much lighter than its predecessor, less impact is expected upon landing. Between 2012 and 2014, the Agency also upgraded its network of 33 wind profiler stations to enable the acquisition of wind data up to 12 km above the ground.

JMA operates a nationwide weather radar network consisting of 20 Doppler radar stations. Upgrading of the data processing equipment used for this network enables observation with a higher resolution of 250 m. Together with data from the X-band multi-parameter (MP) radars operated by Japan’s Ministry of Land, Infrastructure, Transport and Tourism, JMA plans to start providing precipitation nowcasts with 250 m resolution in 2014.

JMA has operated geostationary meteorological satellites over the East Asia and Western Pacific areas for more than 35 years. The Himawari-8 next-generation satellite carrying a highly improved imager is scheduled for launch in 2014, and is expected to start operation in summer 2015.

1. Introduction

Meteorological observation supports the provision of meteorological services, including warnings, advisories and forecasts, to prevent and mitigate damage from natural disasters. In order to provide reliable forecasts and early warnings for such catastrophes, it is necessary to strengthen weather condition monitoring capacity, particularly for meso-scale weather events that bring extreme natural disasters. To this end, JMA continuously strives to promote observational system capacity.

JMA operates surface weather stations, radiosondes and remote sensing technologies such as weather radar, wind profiler, lidar and lightning monitoring system across Japan to collect the comprehensive observational information necessary for severe weather watching and related nowcasting, NWP and climate monitoring. This report details improvements made in these operations since the previous report presented at TECO 2010.

2. Surface Observation

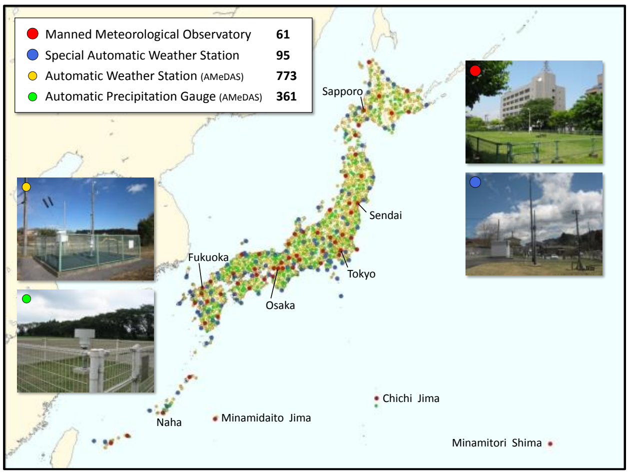


Figure 1: JMA surface observation stations.

Figure 1 shows JMA's surface observation network, in which 156 weather stations including Local Meteorological Offices across Japan collect surface meteorological data on temperature, relative humidity, pressure, wind speed/direction, precipitation, snow depth, sunshine duration, visibility and current weather conditions. As many as 1,289 AMeDAS (Automated Meteorological Data Acquisition System) stations also automatically observe precipitation with an approximate spatial resolution of 17 km throughout Japan. Among these, 929 stations observe temperature and wind with a spatial resolution of around 21 km, and 322 stations are equipped with automatic snow depth sensors. All data collected are sent to a central system in Tokyo every 10 seconds via dedicated lines or every 10 minutes via a communication satellite.

The requirement for quality and reliability in surface observation data grows in line with the improvement of Warnings and Advisories and increased public interest in such data. To meet related needs, JMA adopts a three-pronged approach involving 1) monitoring of observation environment conditions, 2) periodical maintenance and management of instruments, and 3) quality control for observation data.

As surface observation data are closely related to site environments, JMA works to determine and clarify requirements related to such environments. Table 1 shows the principles of environmental requirements for its 156 weather stations. The Agency selected 41 of these in 2013 for climate monitoring, and the environments of these stations are checked every six months at the time of periodical instrument maintenance. The environments of the 156 stations are also evaluated in detail every five years. If environmental degradation is recognized or expected due to significant construction work near a site, the related change is evaluated, and an alternative site is found in accordance with relocation guidelines if the change is non-negligible. Once a site has been relocated, the climate normals (30-year averages) of the station for observation parameters such as temperature, wind, sunshine duration and relative humidity are adjusted in accordance with statistical guidelines using five-year data collected at the old site and data from the new site.

Observation instruments for all 1,289 stations are maintained in accordance with JMA guidelines. Equipment is checked at the sites every six months to a year, while that at the 41 stations used for climate monitoring is checked every three months. All instruments are further validated at the WMO Regional Instrument Centre Tsukuba for RA II (RIC Tsukuba) every five years, and are calibrated and serviced if necessary.

Table 1: Principles of environment requirements for the 156 weather stations observing the meteorological parameters of temperature, relative humidity, pressure, wind, precipitation, snow depth, sunshine duration, visibility and current weather conditions

Observation area	● At least 20 m square and approx. 600 square meters
Buildings, other structures and trees around sites	● The distance from the observation site to buildings should be at least three times the height of the buildings minus 1.5 m, or buildings should be at least 10 m away. ● At the center of the observation site, the average elevation angles of surrounding buildings should be less than 18 degrees. ● Sunshine recorders and pyranometers should not be shaded by buildings or trees at any time of year.

Observation data are quality-controlled by the Local Meteorological Offices responsible for the stations using automated quality control tools. Checking is performed to determine whether observed values are within the normal range, and temporal/horizontal consistency is evaluated to detect any abrupt swings or gradual deviations in data. Figure 2 shows examples of erroneous temperature data detected using the tools. Once erroneous or suspect data are found, an alert e-mail is automatically sent to the office in charge.

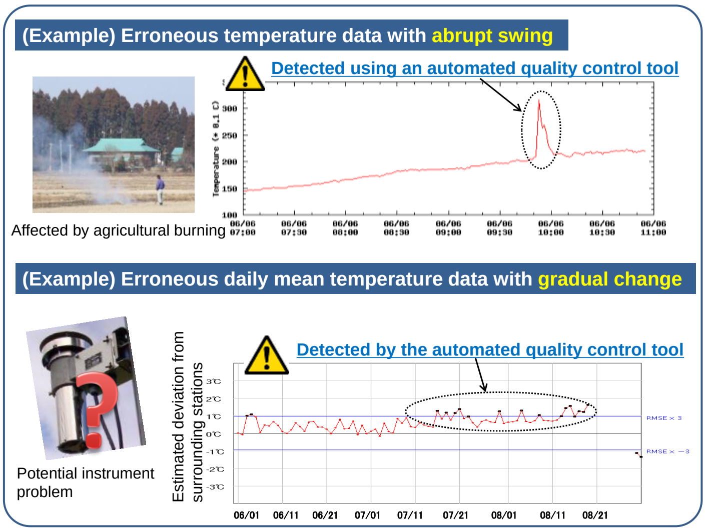


Figure 2: Erroneous surface temperature data found using an automated quality control (AQC) tool

Based on its expertise in surface observation, JMA works to support observation capability improvement among NMHSs through the RA II WIGOS Project to Enhance Availability and Quality Management Support for NMHSs in Surface, Climate and Upper-air Observations, and also engages in related efforts in collaboration with the Japan International Cooperation Agency (JICA).

3. Radiosonde

JMA engages in radiosonde observation across Japan at 16 stations, 6 of which are registered as GCOS Upper-Air Network (GUAN) sites. The Tateno site is also registered as a GCOS Reference Upper-Air Network (GRUAN) site. Two developments in radiosonde observation have been made since 2010.

In 2010, JMA has introduced GPS radiosonde operation at all stations. GPS radiosonde incorporate a GPS signal-processing function to measure wind, and provide observation data with higher spatial resolution and accurate three-dimensional positioning. Figure 3 shows an example of GPS radiosonde observation data from Tateno Station. Data on temperature, relative humidity and wind are recorded every second. Figure 4 shows an example of how GPS radiosonde data usage impacts meso-scale NWP analysis. The effect of the path of a radiosonde launched from Kushiro Station is recognized here.

JMA receives about 300 reports of falling radiosondes a year, and work to mitigate the impact of landing is crucial. In 2013, the Agency began using a much lighter radiosonde with no loss of observation function at eight stations. The new unit weighs 85 g as compared to the previous 275 g, thereby reducing landing impact from 2,000 N or more to about 600 N.

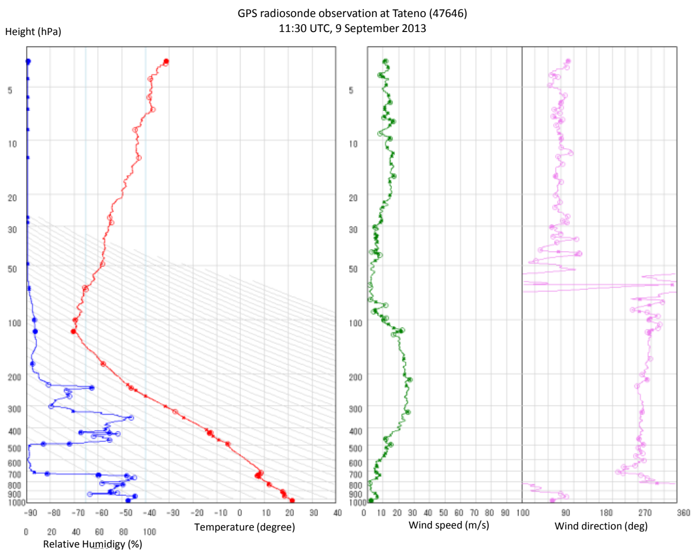


Figure 3: Example of GPS radiosonde observation data from Tateno. Acquiring data every second highlights the details of variations in meteorological parameters.

4. Wind Profiler

JMA began the operation of 25 wind profilers in 2001, and 6 stations were added in 2003. In 2012, two further stations were added, and the 31 aging profilers were upgraded in 2013 and 2014. Figure 5 shows the upper-air observation network, which includes the wind profiler network, operated by JMA. The observation frequency is 1.3 GHz, and the interval between wind observations is 10 minutes. Data are sent to the central system in Tokyo, and are provided to the NWP system and to forecasters, aviation operators and the public.

The profilers introduced from 2012 to 2014 are upgraded versions with increased transmission power, allowing measurement of winds up to 12 km above the ground as shown in Figure 6. The data produced by these units are currently being used to develop turbulence observation information for aviation operators.

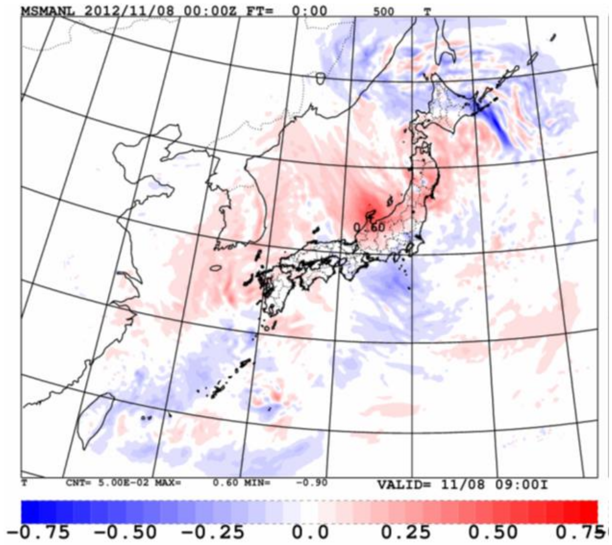


Figure 4: An experiment on the use of GPS radiosonde data with the JMA meso-scale NWP model is under way. Appropriate assimilation of GPS radiosonde data with three-dimensional positioning is expected to improve analysis fields. This figure shows an example of increment on analysis made by assimilating GPS radiosonde data. The impact on analysis along the path of a GPS radiosonde launched from Kushiro Station in Hokkaido is recognized.

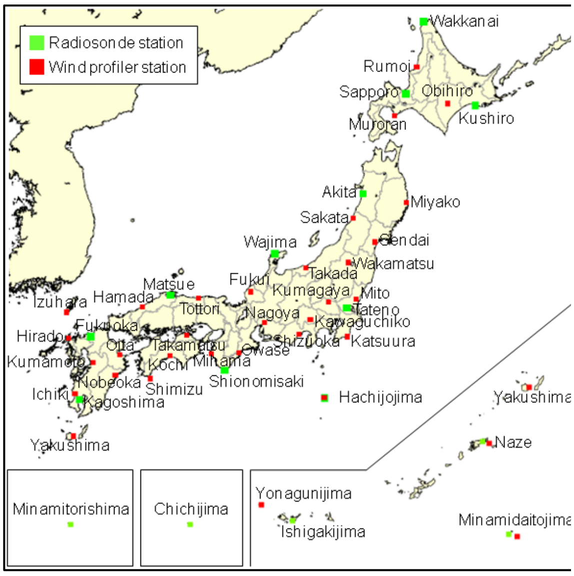


Figure 5: JMA's upper-air observation network consisting of 33 wind profiler stations and 16 radiosonde stations

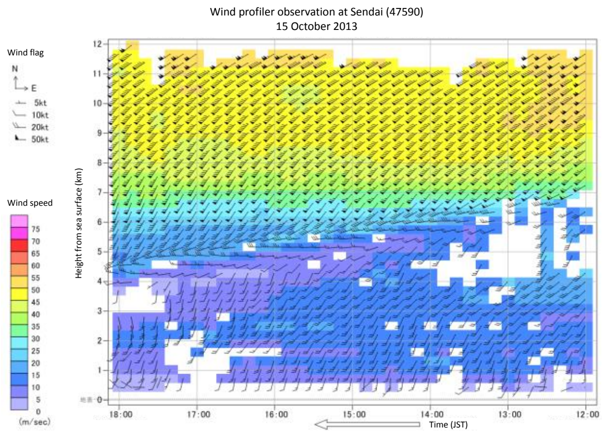


Figure 6: Example of new wind profiler observation data. With favorable atmospheric conditions, the new unit can observe winds up to 12 km above the ground surface.

5. Doppler Weather Radar

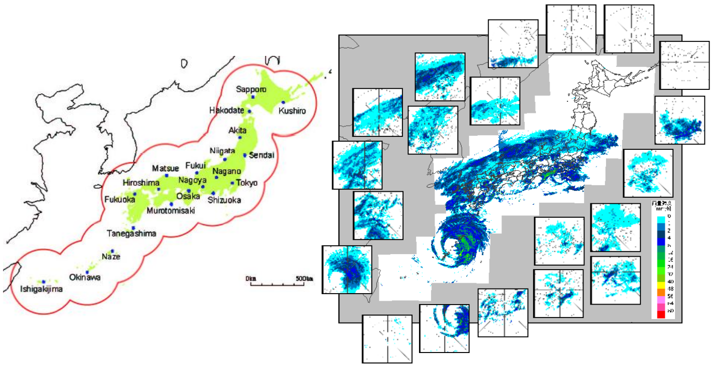


Figure 7: Nationwide weather radar network. Data from all 20 stations are sent to the central system in Tokyo, and a radar-echo composite map is generated.

JMA operates a nationwide weather radar network consisting of 20 C-band meteorological radar stations to observe precipitation over Japan. A process of upgrade to Doppler radars was begun in 2006 in order to enable wind observation, and was completed for all 20 stations in 2013. Observation data for all elevations and azimuth angles are collected and sent to a central system. A nationwide radar echo composite map with a resolution of 1 km is then generated (Figure 7) from the collected volume data of the 20 stations through the processes of quality control including clutter avoidance, Z-R conversion, and calibration using surface rain observation data.

Work conducted to upgrade the data processing systems at radar sites in 2013 and 2014 has enabled the collection of data with a higher resolution (250 m) for beam direction. Together with data from X-band MP radars operated by Japan’s Ministry of Land, Infrastructure, Transport and Tourism, JMA plans to begin providing a 250 m resolution Precipitation Nowcast product (Figure 8) in 2014. In addition, a Hazardous Wind Potential Nowcast product providing information on the probability of hazardous winds such as tornados is being developed with the use of 250 m resolution radar wind data.

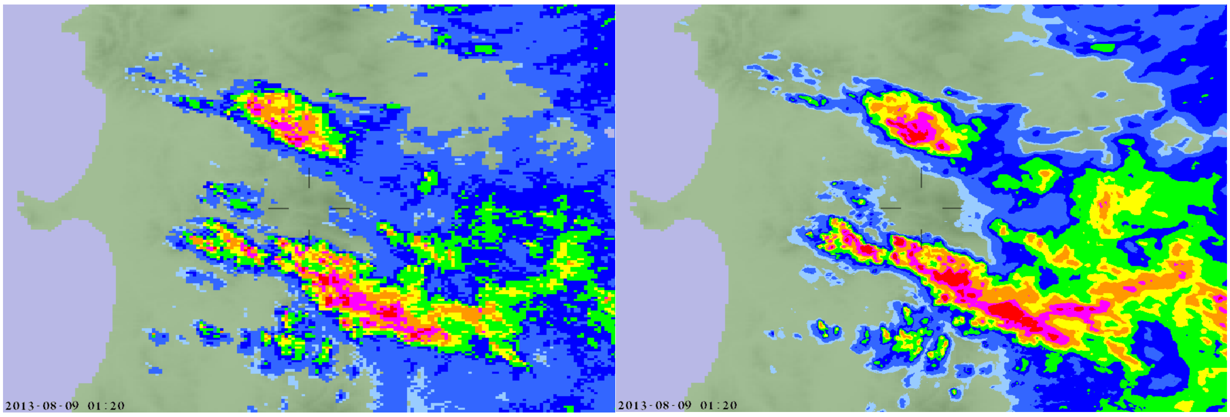


Figure 8: Example of Precipitation Nowcast product data. The chart on the left is from the current product with 1 km resolution, and that on the right is from the high-resolution product (under development) with 250 m resolution.

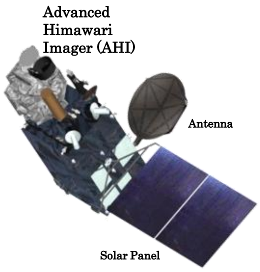
6. Next generation geostationary meteorological satellites "Himawari-8/9"

JMA has operated seven GMS and MTSAT geostationary meteorological satellites at around 140 degrees east to cover the East Asia and Western Pacific regions since 1977, and makes related contributions to the WMO's World Weather Watch (WWW) Programme. The satellite series is called Himawari, which means “sunflower” in Japanese. As a follow-on to the MTSAT satellites, JMA plans to launch the next-generation Himawari-8 in 2014 and start its operation in 2015. Himawari-9 is scheduled for launch in 2016.

Himawari-8 and -9 will be dedicated to meteorological missions, whereas MTSAT performs both meteorological and aeronautical functions. Figure 9 shows the major characteristics of Himawari-8/9. The satellites will carry a new imaging unit called the Advanced Himawari Imager (AHI), whose observing functions and specifications are notably improved from those of the imager on board MTSAT as shown in Figure 10. First, the number of imaging bands is increased from 5 to

16. There are three visible channels (blue: 0.46 µm; green: 0.51 µm; red: 0.64 µm), which enable the derivation of color earth images. Second, the spatial resolutions of images will also be improved from 1 km to 0.5/1 km for visible bands and from 4 km to 2 km for infrared bands. Third, imaging frequency will be increased. Full-disk images will be captured every 10 minutes, as opposed to MTSAT's capture of full- and half-disk images alternately at 30-minute intervals. In addition, the AHI units will enable the capture of rapid-scan images for the Japan area every 2.5 minutes with no break for full-disk observation. These observation function improvements are expected to contribute not only to better nowcasting and NWP accuracy but also to enhanced environmental monitoring.

The imager upgrade will result in a significantly increased volume of imagery data. JMA plans to disseminate all Himawari-8/9 imagery data via the Internet and data essential for NHMS activities via communication satellite.



- Attitude control:
  Three-axis stabilization
- Launch Schedule:
  2014 (Himawari-8)
  2016 (Himawari-9)
- Communication:
  402 MHz (UHF-band)
  13, 14/12 GHz (Ku-Band)
  18 GHz (Ka-band)

Figure 9: Major characteristics of Himawari-8/9

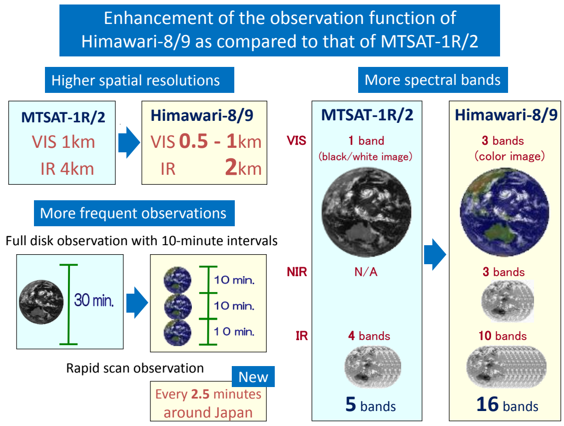


Figure 10: Observation functions of Himawari-8/9 and MTSAT-1/2