Recent Improvement of Integrated Observation Systems in JMA

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Abstract

The Japan Meteorological Agency (JMA) has intensively promoted the improvement and integration of observation systems in response to ongoing natural disasters caused by meso-scale weather events. In the area of automatic surface wind observation using the AWS network called AMeDAS (Automated Meteorological Data Acquisition System), 2008 saw the commencement of JMA's use of a new AMeDAS capable of observing maximum instantaneous wind speeds as well as 10-minute average wind speeds.

JMA operates a nationwide weather radar observation network consisting of 20 radars. In March 2008, remote control of all radars from JMA's headquarters in Tokyo became possible. In July 2009, the interval between weather radar observations was shortened from 10 to 5 minutes. JMA also upgraded 16 conventional radars to Doppler radars between 2006 and 2010, and JMA started to issue new information related to nowcasting on tornadoes and lightning at the end of May 2010. At TECO-2006, preparations for the operational processing of integrated water vapor (IWV) data derived from GPS by JMA were introduced (Ishihara et al., 2006a), and JMA subsequently started operational use of IWV data in Numerical Weather Prediction (NWP) in October 2009. By March 2010, the Agency had also completed the upgrading of its upper-air observation systems using GPS radiosondes at all 16 of its upper-sounding sites, 8 of which are operated with Automatic Balloon Launchers (ABLs). Operation and data quality control of all ABLs are implemented remotely using the integrated system at JMA's headquarters in Tokyo.

1. Introduction

In 2009, Japan was hit by a series of torrential rain events. In particular, heavy downpours from 19 to 26 July caused 35 fatalities, and 2,137 houses were inundated above floor level. Typhoon No. 9 (Etau) (a typhoon being defined as a tropical cyclone with maximum sustained winds of 34 knots or greater in the western North Pacific Ocean) also caused 27 casualties , and 973 houses were inundated above floor level (2010, Cabinet Office, Government of Japan). Every year in Japan, numerous heavy rain events during the Baiu (the Japanese rainy season) and typhoons cause severe natural disasters accompanied by violent winds, high waves, storm surges and heavy rain.

JMA operates meteorological observation systems to monitor weather conditions all over the country, and this paper describes recent advanced activities to improve these systems. In the last few years, the Agency has installed a new integrated operation system for automated surface observations, transformed its network of conventional weather radars to one featuring Doppler radars, started operational GPS-IWV processing and upgraded its upper soundings with GPS radiosondes.

Meteorological observation forms a basis for 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, especially for meso-scale weather events that bring extreme natural disasters. JMA makes continuous efforts aimed at promoting the capability of observational systems to monitor severe meso-scale weather events.

2. New integrated system for automated surface observation data

JMA runs 156 meteorological observatories monitoring air pressure/temperature, wind, precipitation, visibility, weather and other elements to meet the general requirements of meteorological stations. Of these, 68 are observer-staffed weather stations, while the others are unmanned stations equipped with fully automatic instrumentation including visibility sensors. All these observatories are integrated into the AWS network known as AMeDAS (Automated Meteorological Data Acquisition System), which consists of 1,300 local observation stations all over the country. All AMeDAS stations measure precipitation, and approximately 690 of them also observe air temperature, wind and sunshine duration.

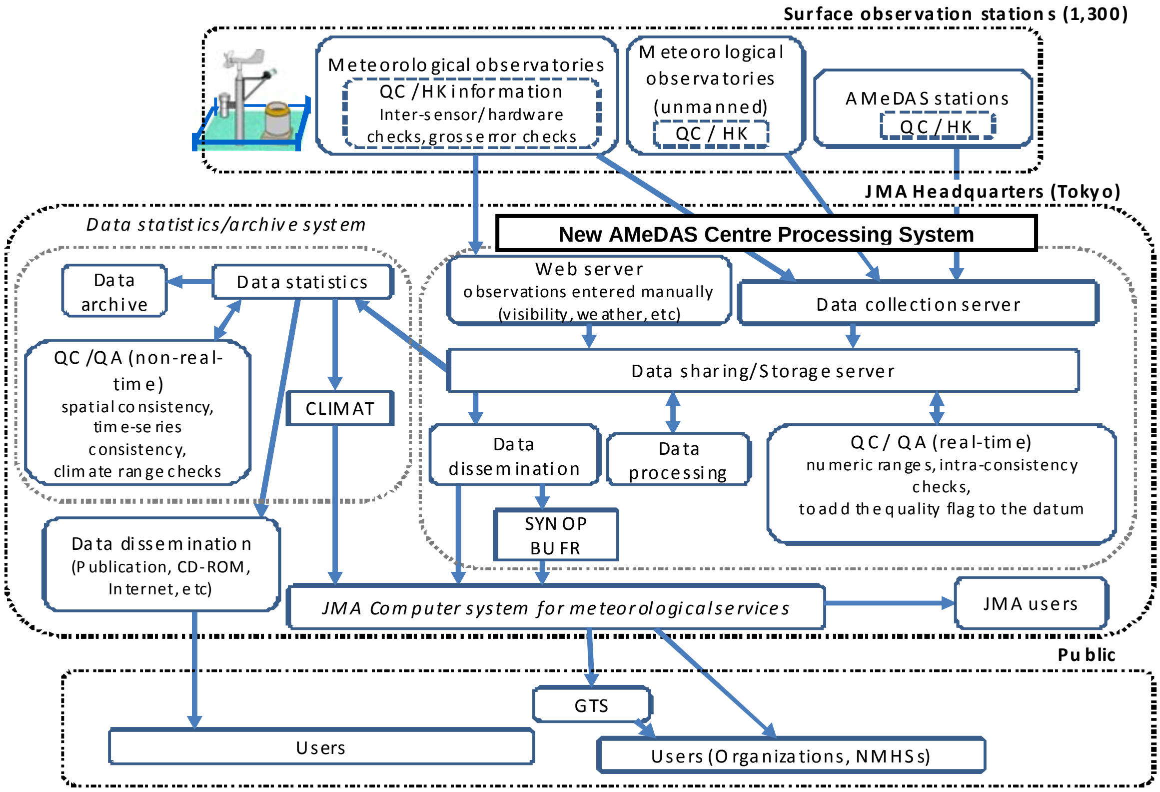

Fig. 1. Flow of surface observation data to users and archives in JMA

In 2008, JMA started to use a new AMeDAS capable of observing maximum instantaneous wind speeds as well as 10-minute average wind speeds, and the transition from the old AMeDAS to the new one for all stations was completed in March 2010. Primary raw data, including information on the current working status of each instrument, from all meteorological observatories (156 stations) are transmitted every 10 seconds, while data acquired at other AWSs are transmitted every 10 minutes to the new AMeDAS centre processing system at JMA's headquarters in Tokyo. All surface observation data (e.g., SYNOP, BUFR) provided by JMA are intensively processed and automatically quality-controlled by this system (Fig. 1).

3. Doppler radar observation network and nowcasting on tornadoes and lightning

JMA operates a nationwide weather radar observation network consisting of 20 radars to enable three-dimensional observation, and issues nowcasting for precipitation over the whole country (Fig. 2). In March 2008, an upgrade of the related processing systems made it possible to control all radars remotely from JMA's headquarters in Tokyo. In July 2009, the interval between weather radar observations was shortened from 10 to 5 minutes by reconfiguring the scan sequence of each radar.

JMA also upgraded 16 of its conventional radars to Doppler radars between 2006 and 2010, and started to issue new nowcasting information at the end of May 2010. With precipitation nowcasting introduced in 2004 to give detailed information on heavy rain, JMA now provides nowcasting forecasts of precipitation amounts every 10 minutes up to one hour ahead with a horizontal resolution of about 1 km all over Japan. In addition to precipitation nowcasting, the Agency has also commenced two new types

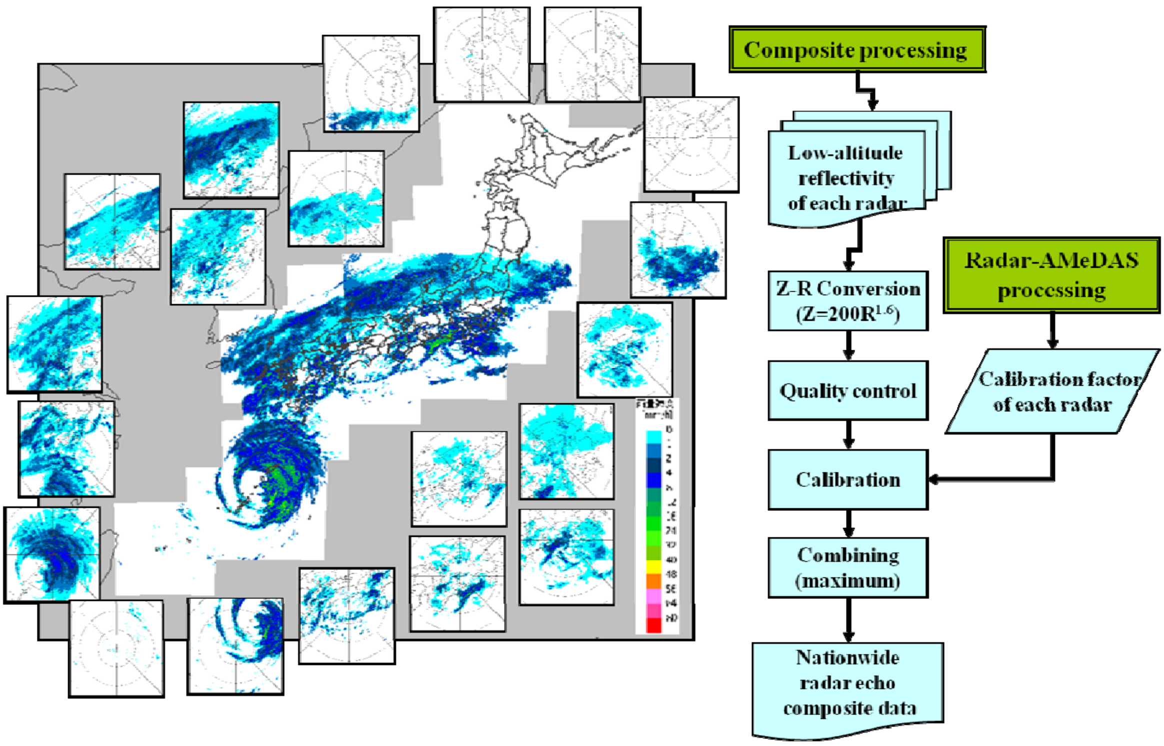

Fig. 2. Nationwide composite radar echo and the data processing flow in JMA

of nowcasting – one for tornadoes and the other for lightning.

Nowcasting for tornadoes is issued every 10 minutes, and provides forecasts in 10-km meshes for the probability of hazardous winds up to one hour ahead divided into two probability level ranks. In Level 2 areas, the probability of hazardous wind conditions such as those accompanying a tornado is 5 – 10% within the hour. Similarly, the probability of such hazardous winds is 1 – 5% in Level 1 areas.

Nowcasting for lightning is produced using three-dimensional weather radar data and lightning data detected by JMA's LIDEN (Lightning Detection Network) system (JMA, 2001). Lightning nowcasting is issued every 10 minutes, and provides forecasts in 1-km meshes for lightning activity up to one hour ahead divided into the following four activity level ranks: Activity 4: many lightning strikes; Activity 3: some lightning strikes; Activity 2: thunder; Activity 1: potential for thunder.

4. Operational processing of GPS-IWV

The GPS-IWV processing system has been operated by JMA since May 2008 to monitor the distribution of precipitable water (PW) – a metric related to the generation and development of severe weather cloud systems – over the whole of Japan in real time. The system derives the PW situation every 60 minutes using data from the GEONET (GPS Earth Observation Network) system operated by the Geographical Survey Institute. In GEONET, approximately 1,200 GPS receivers are located throughout Japan to observe crustal deformation with an average horizontal resolution of 20 km (Ishihara et al., 2006a). The root mean square difference between PW data derived from the GPS-IWV processing system and that from upper sounding is around 3.4 mm in summer and 1.6 mm in winter (Shoji, 2009).

JMA started operational use of GPS-IWV in Numerical Weather Prediction (NWP) in October 2009. PW data derived from the GPS-IWV processing system are assimilated into the initial values of

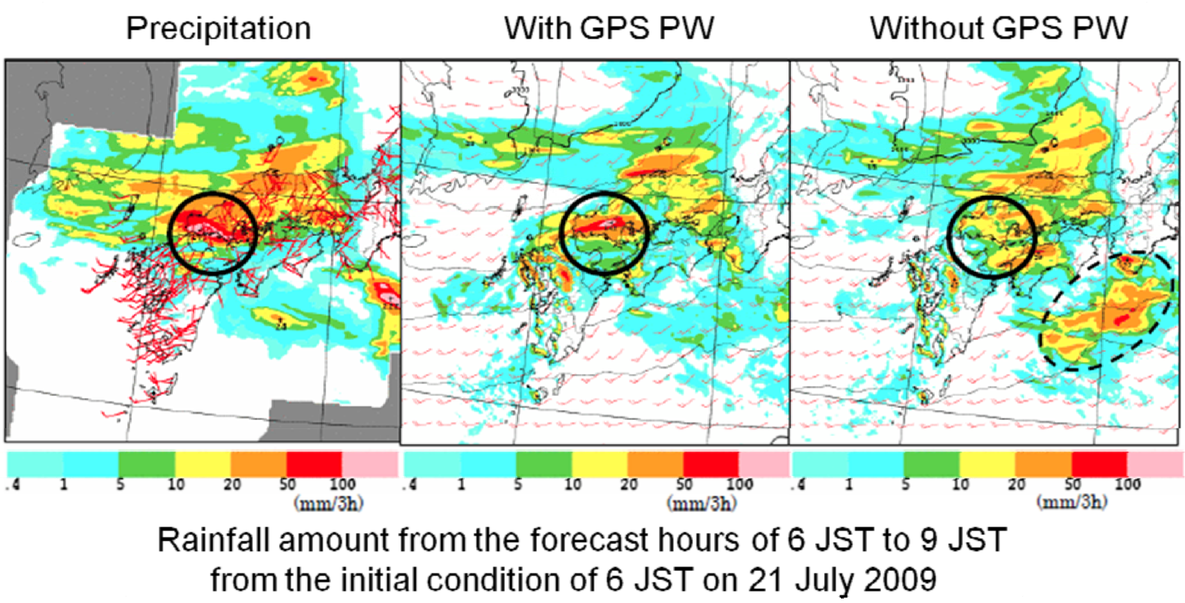

Fig. 3. 3-hour cumulative rainfall predicted by JMA's 5-km MSM for examination

JMA's operational mesoscale model (MSM) using the four-dimensional variational assimilation system. Figure 3 shows the results of an experiment to estimate the impact of GPS PW data on numerical prediction for the case of the above-mentioned torrential rain in 2009. Forecasting with the assimilation of GPS PW data predicts heavy rainfall areas more accurately than that without it.

5. Integrated upper-air observation systems with GPS radiosondes

JMA upper-air observations are performed through two different networks. One is the radiosonde observation network (16 stations) and the other is the wind profiler radar observation network (31 stations) (Ishihara et al., 2006b).

The replacement of upper-sounding systems with GPS radiosondes at all 16 stations was completed in March 2010. Among these, 8 are operated with Automatic Balloon Launchers (ABLs) and the other 8 have manual launching systems. The operation and data quality control of all ABLs are remotely implemented in an effective manner through the integrated system at JMA's headquarters in Tokyo (Fig. 4).

A wind profiler radar is a ground-based multiple-beam Doppler radar unit covering a range of up to 5 – 8 km from the surface and automatically performing wind measurement every 10 minutes. In addition to wind profiles, it is considered that accurate humidity profiles can be retrieved by combining turbulence echoes detected using wind profiler radars with GPS-IWV (Furumoto et al., 2007). Humidity is one of the most important parameters in advancing the predictability of heavy rain genesis and development.

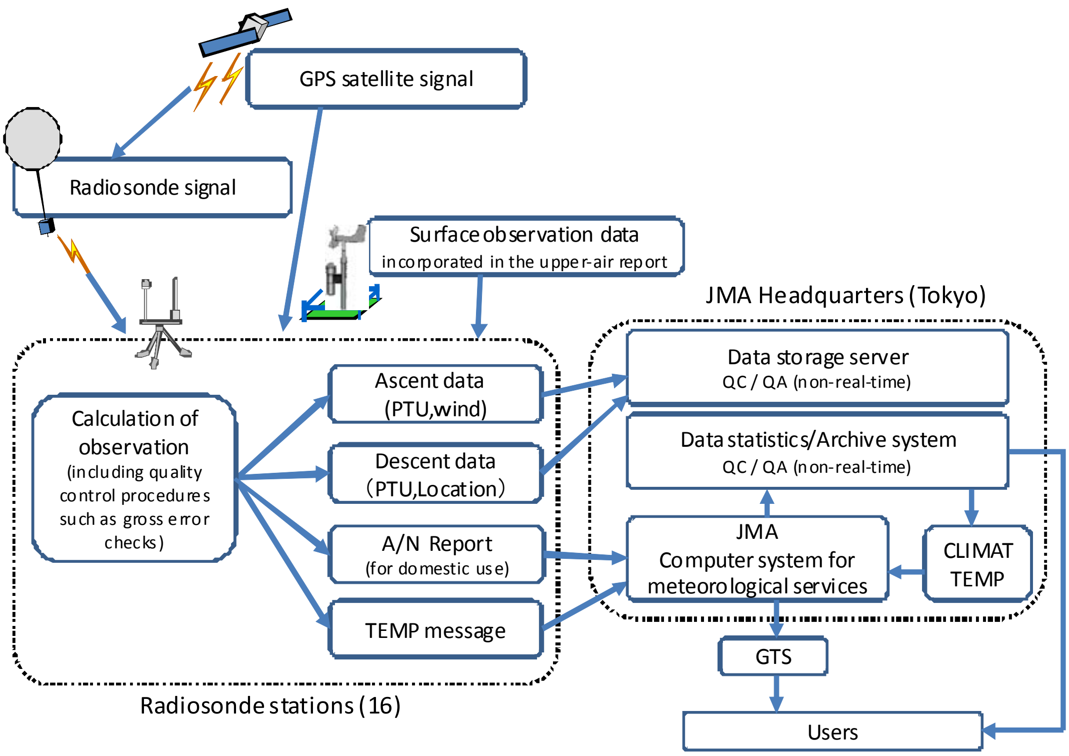

Fig. 4. Flow of radiosonde observation data to users and archives in JMA

6. Cooperation with external parties

As mentioned above, JMA makes efforts to improve existing systems as well as introducing newly developed systems. It also promotes the integration of observation systems by utilizing data obtained from external sources.

JMA has already aggregated more than 8,000 pieces of rain-gauge data obtained from local governments and the River Bureau and Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). These data are combined with weather radar data to allow the processing and provision of nationwide quantitative precipitation data over 1-km meshes. Additionally, to enhance real-time observation of disasters caused by localized and extremely intensified rainfall, MLIT has started a project to implement more detailed, frequent monitoring by introducing X-band MP (multi-parameter) radars. Test operation of these radars is scheduled to start in FY 2010 ahead of their full operational debut in 2013 (2010, ESCAP/WMO TC). JMA is involved in this project, and has started its own research and development work aimed at utilizing the new-radar data to improve very short-range forecasts and nowcasting for precipitation.

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