Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS24-01 Room:105 Time:May 21 09:02-09:18

Practical Use of the MP Radar by the Tokyo Fire Department

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1. MP Radar Information Experimentally Used by the Tokyo Fire Department (TFD)

In 2009, the TFD concluded with the National Research Institute for Earth Science and Disaster Prevention (NIED) a memorandum about the mutual cooperation in collecting and sharing information on storm and flood damage. Since the conclusion of this disaster information memorandum, the TFD has been experimentally using the MP radar for fact-finding to identify typhoons, localized heavy rains or others most clearly. The radar has been in use mainly for (i) the earlier preparation for flood protection/control and (ii) the better, more specific monitoring of weather conditions.

2. TFD's Flood Protection Activities

The TFD, based on the Flood Protection Law, goes on the alert for the overflow of rivers, and decides on the "areas to be protected from water damage" together with local communities. The TFD, as a fire service organization, is missioned to conduct search and rescue in such disasters according to the related laws and regulations. The Department, then, puts itself on the alert for storms and floods, and may issue the emergency flood protection order after learning overall and judging from the weather conditions, the typhoon's path and severity, the possibilities of major water damage, the actual disaster facts, etc. With a flood protection order given, more firefighters are mobilized, and some of them are incorporated into lifeboat units. The flood protection order is put out based on the weather conditions and the actual disaster damage. Knowing these facts quickly and correctly, emergency responders can get ready for flood protection activities sooner.

3. Access to MP Radar Images

For information about local heavy rains and others, fire stations can have access to the TFD website which is specially opened on the NIED home page showing the images taken by the NIED-operated MP radar. Starting in 2011, the MP radar-provided data can be viewed on the TFD's Disaster Information System (web-GIS) as well as on this "MP radar site."

(1) MP Radar Site
The MP radar site indicates how hard it rains, how much it has rained, which areas will be in the path of the rain, etc. The site, then, activates its alert sound system when precipitation reaches a warning level, showing the fire stations in the "areas of danger" so that they can quickly prepare for an upcoming rainstorm.

(2) TFD's Disaster Information System (web-GIS)
The TFD's Disaster Information System demonstrates both the MP radar information and the detailed area data simultaneously on its map. This duality conveniently helps firefighters quickly decide on the action to take for flood protection.

4. When and How Is the MP Radar Information Used?

(1) Access for Fact-finding
Under rough weather, in case of necessity, fire stations have access to the MP radar site to check out rainfall continuously.

(2) Rainfall "Confirmation" and Rainfall Conditions Assessment
The "sudden rise in water level resulting in inundation" may well occur after the sudden increase in rainfall strength within a short period of time (10 to 20 minutes) which goes beyond the flood control standard (50 mm/h) of the Tokyo Metropolitan Government. Information needs to be collected without fail in the following cases:
a. When the MP radar site activates its alert sound system.
b. When localized heavy rains are observed.

(3) Practical Use of the TFD's Disaster Information System (web-GIS)
When localized heavy rains are expected with the MP radar information given, the TFD's Disaster Information System (web-

GIS) is used to obtain detailed area data. With the following, expected dangers can be understood with ease:
a. Enlarged area maps and the MP radar information are shown simultaneously.
b. River water levels and the MP radar information are shown simultaneously.
c. Past inundation damage and the MP radar information are shown simultaneously.

Keywords: MP radar, Tokyo Fire Department (TFD), Flood protection activities, Method of specific use

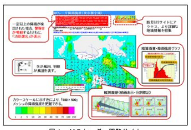
図１　ＭＰレーダー閲覧サイト


図２　防災情報システム（ｗｅｂ－ＧＩＳ）


図３　該当署の表示状況

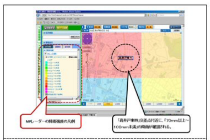
図 4 各消防署管轄区域内の詳細な降雨状況を確認できる。

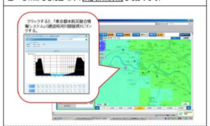
図 5
①降雨状況とあわせて、河川の水位状況をモニタリングできる。
②水位の変化で、降雨状況の地上への影響を把握できる。


図 6 過去に浸水被害が発生した地域の降雨状況を確認できる。

AAS24-02 Room:105 Time:May 21 09:18-09:33

Radiosonde observation network in Tokyo metropolitan area

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Severe weathers such as torrential rainfall is one of the serious atmospheric environmental issues in Tokyo metropolitan area. Intent monitoring network is necessary for understanding mechanism and process of severe meteorological events in cities. Furthermore, improvement of urban weather prediction model is also required.

Torrential rainfall in Tokyo metropolitan area is due to the boundary-layer processes such as convergence of sea breeze, large roughness and heat flux in urban area. In this study, we investigate the relationship between the surface forcing in urban area and the spatial variation of the development of atmospheric boundary-layer height based on the radiosonde observation in Tokyo metropolitan area. This is carried out as a part of the Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS) project.

This experiment was conducted from 27 September to 7 October 2011 at some observational points, where are Tsukuba(Aerological Observatory, Japan Meteorological Agency; 36.05^{o}N, 140.12^{o}E), Ukima(Ukima Water Reclamation Cente; 35.80^{o}N, 139.69^{o}E), Koganei(National Institute of Information and Communications Technology; 35.71^{o}N, 139.49^{o}E) and Yokosuka(National Defense Academy of Japan; 35.26^{o}N, 139.72^{o}E). GPS radiosonde (RS-06G, Meisei Electric Co., Ltd) was launched every 3 hours from 9:00 to 21:00.

On 4 October 2011, it was almost fine weather except at Yokosuka, and inflow of the sea breeze was clearly observed below the height of 1 km after 15:00. Potential temperature profiles show that the mixing layer height was developed about 2 km at Tsukuba, 2.5 km at Ukima and from 2 to 2.5 km at Koganei although it was not clearly determined at Yokosuka due to cloud cover.

Among the observation points, the highest mixing layer height was observed at Ukima where is located on the northern part of central Tokyo. When the sea breeze (southerly wind) blows over the land in daytime, the evolution of the atmospheric boundary layer is enhanced by the flow stagnation due to large roughness and by anthropogenic heat supply in central Tokyo.

Acknowledgements: This research was financially supported by the Strategic Funds for the Promotion of Science and Technology of the Japan Science and Technology Agency (JST) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Keywords: radiosonde, atmospheric boundary layer, torrential rainfall, sea breeze, urban

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AAS24-03 Room:105 Time:May 21 09:33-09:48

Isolated cumulonimbus initiation observed by 95-GHz cloud radar, X-band radar, MTSAT-1R (rapid scan), and photogrammetry

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Simultaneous observations of cumulonimbi using the MTSAT-1R (rapid scan), the 95-GHz FM-CW cloud radar (the Chiba site), the X-band radar (the Yokosuka site), and photogrammetry were carried out during the summer of 2010 in the Kanto region, Japan to understand the convection initiation (CI) and the structure of heavy rainfall in the Tokyo metropolitan area. The formation process of an isolated cumulonimbus which generated in the afternoon on a fine mid-summer day on 24 July and 23 August 2010 would be presented.

The generation of the cumulonimbus was initiated by cloud turrets. A continuous generation of turrets was observed from the visible images, and a total of four turrets (24 July) and five turrets (23 August) formed. The growth rates of turrets were quite different among the turrets in these cases. The first radar echo of the X-band radar was detected at 3 km AGL, three minutes after the turret reached its maximum height. The cloud radar detected echoes, approximately two minutes after the generation of the turret and 15 minutes before the turret reached its maximum height. The intermittent echo pattern observed by the cloud radar denotes fine structures in the Cb, such as cloud and precipitation.

Based on the rapid scan data, cumulus and cumulonimbus can be detected by the visible brightness data at the formation stage of the cumulonimbus. The temporal change of the visible brightness suggests the evolution of the cumulonimbus turrets.

Keywords: cumulonimbus, turret, first radar echo, cloud radar, MTSAT rapid scan

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AAS24-04 Room:105 Time:May 21 09:48-10:03

Temporal-spatial structure of cumulonimbus of rainband observed by Ku-band radar and surface observation network

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We are operating a Ku-band radar with high temporal-spatial resolution (range: 2.38 m, beam width: 3 deg., 1 volume scan : approximately 1 min.) at Musashino city, Tokyo (SEIKEI Univ.) during the field campaign of the Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS). We present the temporal-spatial structure of cumulonimbus clouds of rain band on November, 20, 2011 based on observation of Ku-band radar, dense surface observation network, and AMeDAS (Automated Meteorological Data Acquisition System).

The Ku-band radar observation clearly shows that new cumulonimbus initiated at leading edge of rain band. Analysis of wind field based on surface observation network and AMeDAS shows that the cumulonimbus generated at convergence field. Using reflectivity of Ku-band radar, development of three-dimensional structure of precipitation core of the cumulonimbus was analyzed. The precipitation core initiated at approximately 4 km height and dropped at surface within 6 min.

Keywords: Cumulonimbus, Ku-band radar, surface observation network

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AAS24-05 Room:105 Time:May 21 10:03-10:18

Case study on first echo associated with cumulonimbus development observed by Ka-band radar in the Kanto region, Japan

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cumulonimbus. A cumulonimbus developed in the mountainous area in the west of the Kanto region in the morning on 18 August 2011, and initiation and developing process of the cumulonimbus were observed by the KDR and the XPDR. In this study, we defined an echo newly observed in RHI and PPI scans as "first echo". In the developing stage, first echoes occurred one after another, and maximum echo top height and maximum reflectivity of individual first echoes gradually increased. The maximum echo top height of the cumulonimbus grew up to 12 km in height. In the beginning of developing stage, only the KDR could detect several first echoes and no first echo was detected by the XPDR for more than 25 minutes. After first echo was detected by the XPDR, the time lag of first echo detection between the KDR and the XPDR tended to be shorter as the cumulonimbus developed. In the first half of the developing stage, the height of first echo appeared between 2 and 5 km in height. In the latter half of the developing stage, on the other hand, the appearance height of first echo stepped up between 5 and 12 km in height.

Keywords: first echo, Ka-band radar

AAS24-06 Room:105 Time:May 21 10:45-11:01

A Real-time Monitoring System of Precipitable Water Vapor (PWV) Using a Dense GNSS Receiver Network

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Because of on-going global warming, frequency and intensity of abnormal weather are projected to increase, resulting in serious hydrological hazards, such as a land slide, an unexpected increase of river level and so on. A torrential rain in urban area is becoming a serious problem, which is caused by a strong thunderstorm abruptly developing associated with a sudden heavy rainfall.

Horizontal scale of a local heavy rainfall is as small as a few kilometers, which is difficult to predict with a current numerical weather forecast. A weather radar can detect a cloud only after the event becomes evident. It is required, therefore, to develop an observation system to monitor the behavior of water vapor in advance to formation of clouds.

A Global Navigation Satellite System (GNSS), represented by GPS, is now widely used for precise determination of coordinates. The ultimate error in the satellite positioning comes from the propagation delay of the GNSS radio signal within the atmosphere. The delay can, however, be related to the accumulated water vapor along the ray path, which can be mapped onto the vertical detection to estimate the precipitable water vapor (PWV). This is the basic concept of GPS Meteorology.

In a conventional method of GPS Meteorology, all available GPS satellites seen above an elevation angle of 5-10 degrees are used to estimate PWV, therefore, the horizontal resolution of GPS-PWV is as wide as about 20 km. We here propose to use GNSS satellites at high elevation angle only, then, the horizontal resolution of the PWV estimates is significantly improved. In particular, we will employ Quasi-Zenith Satellite System (QZSS), launched in September 2010 by JAXA. One of QZSS satellites stays overhead of Japan continuously for about eight hours each day, so, it is suitable to monitor PWV with a better horizontal resolution.

We have installed a dense GNSS receiver network (10-17 QZSS receivers) with the horizontal spacing of 1-2 km near the Uji campus of Kyoto Unviersity. In this paper, we report initial results of PWV measurements focusing on the horizontal inhomogeneity of water vapor distribution, and its application for now-casting of a cloud development.

Keywords: GNSS, Precipitable Water Vapor (PWV), QZSS, real-time, dense network, ionosphere

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AAS24-07 Room:105 Time:May 21 11:01-11:16

Characterizing atmospheric turbulence with a dense GNSS network: temporal and spatial analysis of high-rate slant delays

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Forecasting sudden thunderstorms and torrential rain in urban areas is a crucial objective for disaster prevention and mitigation. Such severe storms are often abrupt and highly localized phenomena with a horizontal scale of few kilometers, which makes them difficult to be predicted by current numerical weather models. Short-term predictions on such small scales could potentially benefit from reliable measurements of the temporal and spatial fluctuations of water vapor in the atmosphere. Since most of the atmospheric water vapor is contained in the troposphere, it is possible to estimate the amount of precipitable water vapor (PWV) from the analysis of Global Navigation Satellite System (GNSS) tropospheric delays: the estimated signal delay due to the tropospheric refractivity along each receiver-satellite line-of-sight, or slant delay, is mapped to the zenith direction and divided in its hydrostatic and wet components in order to estimate the PWV over a GNSS station. The water vapor distribution and its variability can be monitored by employing a network of continuously operating stations. Atmospheric turbulence can be characterized by analyzing the temporal and spatial fluctuations of tropospheric delays.

This work focuses on the stochastic analysis of refractivity fluctuations in the wet troposphere by means of temporal and spatial structure functions applied to observed tropospheric delays. High-rate (1 Hz) observations obtained from a dense network of dual frequency GNSS receivers have been processed by precise point positioning, taking into account the effects of satellite clock instability on the estimated tropospheric delay. The resulting structure functions show power-law behaviors varying between 5/3 and 2/3, consistently with Kolmogorov turbulence theory. The impact of different slant delay geometries is evaluated by elevation-based satellite selection. The effect of different tropospheric conditions on the correlation length and magnitude of the measured fluctuations is studied, suggesting the possibility to characterize and monitor turbulence in the wet troposphere at local scale by means of a continuously operating dense GNSS network.

Keywords: GNSS, PPP, troposphere, water vapor, atmospheric turbulence

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AAS24-08 Room:105 Time:May 21 11:16-11:31

Observation system simulation experiments of the meso-scale convergence that causes the local heavy rainfall

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One of aims of the project 'Social system reformation program for adaption to climate change' is to observe thunderstorms that caused local heavy rainfalls in the urban area and to clarify mechanisms of their generation, development and decay by using observation data and outputs of the numerical models. In the Nerima local heavy rainfall, which is one of typical local heavy rainfalls, convection cells were generated by the convergence that was caused by the thermodynamic low system. It is expected that thunderstorms can be reproduced when the large-scale convergence is reproduced by the assimilation.

In this study, the observation system simulation experiments on the data of airplane or Doppler Lidar and temperature profiler that deployed in the urban area, which have the information of horizontal convergence of low-level airflows, was conducted. Truth data was reproduced with the LETKF nest system by the assimilations of GPS precipitable water vapor data and of horizontal wind of Doppler radars. The following three simulant observation data which surrounded the thunderstorm were produced from the truth data of 15 JST, 2 hour before the development of the thunderstorm. First one is the airplane data, which is water vapor, temperature and horizontal wind at the height of 400 m surrounding the Osaka Plain with the horizontal interval of 37.5 km. Second one is the Doppler Lidar data which is the horizontal winds below the height of 200 m at the same points of the airplane data. And the last one is the temperature profiler, of which data is the temperature profiles below the height of 600 m. The impact of these simulant data was investigated by their assimilation into the initial condition of 15 JST which were obtained by assimilation of conventional data only. In this study, the thunderstorm was developed where it was reproduced in the truth data, when the airplane data or the Doppler Lidar and temperature profiler data were assimilated. These results show that observation data surrounding the thunderstorm can improve its rainfall forecast even if the direct observation data of the thunderstorm cannot be used.

Keywords: local heavy rainfall, observation system simulation experiment

AAS24-09 Room:105 Time:May 21 11:31-11:46

Retrieval of buoyancy in thunderstorm from dual-Doppler radar wind with high temporal resolution

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We developed thermodynamical retrieval algorithm using
sector volume scanning observation with high temporal resolution.

The algorithm was applied to severe storm observed around 13 LST on
3 August 2011. It was found that the
relationship between potential temperature and rapid
development of updraft. The estimated perturbation of potential temperature
will be used for initialization of numerical simulation by 3DVAR.

Keywords: Retrieval of thermodynamic variable, High-temporal-resolution sector scan

AAS24-10 Room:105 Time:May 21 11:46-12:01

Cloud Resolving Ensemble Forecast for the 2008 August Tokyo Metropolitan Area Local Heavy Rainfalls

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On 5 August 2008, scattering local heavy rainfalls occurred various places over the Tokyo metropolitan area, and five drainage workers were claimed by abrupt flooding. The JMA's operational mesoscale model of the day failed to predict occurrence of the local heavy rainfalls, which were given by deep convective cells developed on unstable atmospheric conditions without strong synoptic/orographic forcing.

The GPS total precipitation water vapor (TPW) analysis showed that the initial field of the operational MSM produced by the hydrostatic Meso-4DVAR underestimated water vapor over the Tokyo metropolitan area. To modify the initial condition, a reanalysis data assimilation experiment was conducted with the JMA nonhydrostatic 4DVAR (JNoVA), where GPS TPW data from GEONET were assimilated 2.5 days with 3-hour data assimilation cycles. The JMA nonhydrostatic model with the JNoVA reanalysis successfully reproduced weak to moderate rains over the Tokyo metropolitan area, but small scale convective cells and the associated intense rains exceeding 20 mm /3 hour were hardly predicted with a horizontal resolution of 10 km.

Cloud resolving (2 km) ensemble prediction with 11 members was conducted using the JNoVA reanalysis as the initial condition of the control run. The 2 km ensemble run fairly predicted the areas of scattering local heavy rains and showed a appreciable detection rate in the ROC area skill score. Fractions skill score indicated the value of the cloud resolving ensemble forecast for such the unforced convective rain case.

Keywords: local heavy rainfall, ensemble prediction, cloud resolving model, 4DVAR data assimilation, GPS Total precipitable water