

Estimation of Several Kilometer Scale PWV Distribution using GNSS Slant Path Delay for Monitoring of Cumulus Convection

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A procedure for estimating precipitable water vapor (PWV) distribution around each ground-based station of the global navigation satellite system (GNSS) on a scale of several kilometers is presented. This procedure utilizes the difference between zenith total delay above a GNSS station and zenith mapped slant path delay (SPD). By assuming an exponential distribution for the horizontal water vapor gradient, this difference can be used to estimate the PWV gradient in each SPD direction. Shoji (2013) proposed the WVI index, which is defined as the standard deviation of the PWV_{SPD} . The retrieved PWV gradient in this study can be regarded as another utilization of PWV_{SPD} . In the WVI index, ray path direction data is not utilized. The PWV gradient proposed in this paper utilizes both the deviation of PWV_{SPD} and information on its direction.

The procedure was tested for an estimation of the PWV variation associated with the parent storm of an F3 Fujita scale tornado that occurred in Ibaraki prefecture on May 6, 2012. Differential reflectivity observed by a dual-polarimetric radar showed the existence of a developed parent cloud approximately 1 h before the tornado occurred. A high-resolution numerical weather model simulation showed the existence of a strong PWV gradient around the parent cloud, made evident by the co-existence of a strong updraft and downdraft within an approximately 5-km radius. The PWV gradient calculated using the GNSS observation network with an average spacing of approximately 17 km could not detect such a small-scale, strong PWV gradient. The PWV gradient estimated using the proposed procedure revealed a strong PWV gradient and its enhancement. In this case, higher order inhomogeneity component of each SPD played a critical role.

However, the gradient was weaker than the NWP simulation. This might be partly because of the insufficient observation density. Horizontal scale of the higher order inhomogeneity component of each SPD is about several kilometers and we adopt distance cutoff of 5 km. In order to analyze several kilometer scale PWV distribution, we need denser GNSS network with at least 10 km horizontal spacing. Another possible reason for the weaker gradient may be insufficient and inhomogeneous coverage of GPS satellites. As of 2012, carrier waves transmitted from six to twelve GPS satellites could be observed simultaneously at each GNSS site in Japan. This might be insufficient for estimating the water vapor gradient in all directions. Also, we need to carefully check the quality of each SPD. In this study, following Shoji (2013), the effects of the satellite clock error and multi-path (reflected wave) are tried to eliminate. However it is difficult to distinguish atmospheric signal with those noises, especially under local severe weather.

The number of GNSSs has been increasing. As of December 2013, 24 satellites of the Russian GLONASS are in operation. The European Union's GNSS (Galileo) is in the experimental phase and China is also developing an independent GNSS system named COMPASS. Furthermore, a number of space-based augmentation systems (e.g., Japan's QZSS) and regional navigation satellite systems (e.g. the Indian Regional Navigation Satellite System, or IRNSS) will contribute further satellites and signals to the multi-constellation GNSS. In the next step of this study, we will assess the impact of the increased number of SPDs on multi-GNSS.

Keywords: Mesoscale meteorology, Watervapor, Global Navigation Satellite System

Numerical Simulation on Retrieval of Meso-gamma Scale PWV Distribution with the Quasi-Zenith Satellite System (QZSS)

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A simulation study was conducted to investigate the retrieval of meso-gamma scale Precipitable Water Vapor (PWV) distribution with QZSS, using the output of a non-hydrostatic numerical weather prediction model. The evaluation was performed on PWV values obtained by simulating three different methods: using all GPS satellites above an elevation angle higher than 10 degree (PWVG) (conventional GPS meteorology method), using only the QZSS satellite at highest elevation (PWVQ) and using only the GPS satellite at highest elevation (PWVHG).

The RMSEs of PWVG, PWVQ and PWVHG were compared, assuming the vertically integrated water vapor amount of the model as true PWV. As a result, the RMSEs of PWVG, PWVQ and PWVHG were 2.78, 0.13 and 0.59 mm, respectively, 5 minutes before the rainfall. The PWVHG time series had a large discontinuity (~2 mm) when the GPS satellite at the highest elevation changed, whereas that of the PWVQ time series was small, because the elevation angle at which the replacement of the highest elevation QZSS satellite occurs is much higher. The standard deviation of PWVQ was smaller than those of PWVG and PWVHG, which vary largely depending on the GPS satellites geometry.

When the spatial distributions of PWVG and PWVQ were compared to the meso-gamma scale distribution of the reference PWV, PWVG smoothed out the PWV fluctuations whereas PWVQ captured them well, due to the higher spatial resolution achievable by using only high-elevation slant paths. These results suggest that meso-gamma scale water vapor fluctuations associated with a thunderstorm can be retrieved by using a dense GNSS receiver network and analyzing PWV derived from a single high elevation GNSS satellite. In this paper we focus on QZSS, as this constellation is especially promising in this context since it is going to provide nearly continuous PWV observations also as its highest satellite changes, contrary to using highest satellites from multiple GNSS constellations.

Keywords: precipitable water vapor, Quasi-Zenith Satellite System, thunderstorm, non-hydrostatic model

Data assimilation experiments of refractivity distribution observed by an operational Doppler Radar of JMA

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Because low-level convergence of water vapor generates the convections, accuracy of local heavy rainfall forecasts is expected to be improved when horizontal distribution of low-level water vapor is observed. We focused on radio waves of Doppler Radars that are returned from fixed structures. Because the radio waves are delayed by water vapor while passing atmosphere, we can estimate refractivity, which is a function of temperature and water vapor, from the delay of radio waves. If radio waves of many Doppler Radars that have been deployed in Japan are used in producing initial conditions of numerical forecasts, the forecast accuracy of thunderstorms is expected to be improved through improvement of water vapor fields by using this technique.

In this presentation, temporal variations of refractivity observed by Tokyo Radar and the impacts of refractivity on the rainfall forecasts will be presented.

Acknowledgements:

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Keywords: Doppler Radar, Refractivity, Water vapor, Data assimilation

Overview and future strategy of docomo Environmental Sensor Network(ESN)

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NTT docomo had launched a nation-wide and hyper-dense network for the measurement of both weather and environmental element since 2008 and provide them as new information contents to the markets. Its realtime data could be applied to various industrial issues, namely hazard prediction, agriculture, and medical&healthcare. docomo make the new network infrastructure more sophisticated and is planning to expand its sensor stations, which has been set only to its radio base stations up to now, to any customers who need to measure their own environment.

High Dense Ground Observation Network "POTEKA" in Gunma, Japan

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Meisei developed compact weather sensor (POTEKA Sta.) and cloud data-transfer system (POTEKA Lab.) to achieve high dense observation network. "POTEKA" stands for "Point Tenki Kansoku". POTEKA project has been demonstrated the validity for the use of disaster prevention, health and medical care, teaching material, agriculture and energy management, and comfortable living environment in cooperation with local companies and education board since August 2013.

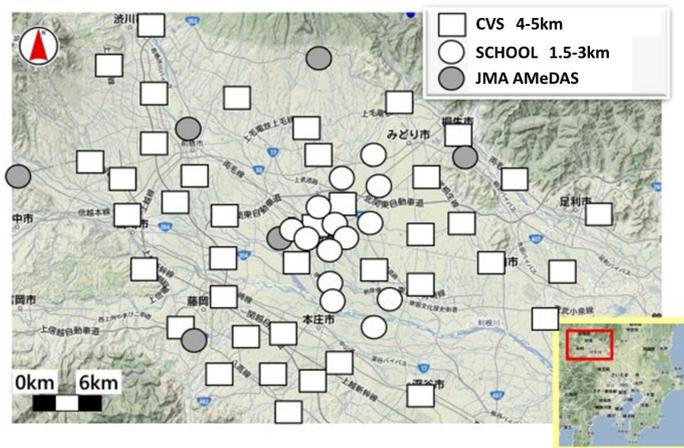
POTEKA Sta. measures wide range of meteorological and environmental variables such as temperature, relative humidity, pressure, sunlight, and rain detection with a one minute resolution. This low-cost weather sensor enables us to achieve finer-meshed or higher density weather observation system economically. Finer-meshed and more extensive data collected are easily accessible through ordinal Web sites (PC, Tablets, etc.) without any special software.

Spatio-temporal high dense observation network (total 55 stations, 1.5~4km-mesh) was installed in Isesaki city, Gunma, Japan. Observation with elementary/junior high school and convenience store (SAVE ON) are performed at 14 stations and 41 stations, respectively, which spatially captured local surface weather phenomenon (fig. 1).

This paper presents some examples including 1. local distribution of surface temperature around Isesaki, 2. preventing heat stroke at school, and 3. school education for class and research.

Acknowledgments: The authors would like to thank SANDEN Corporation, SAVE ON, and Board of Education of Isesaki city for support POTEKA project.

Keywords: dense, big data, instrument, network, observation



Observation of downburst in Takasaki and Maebashi city, Gunma on 11 August 2013

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On the evening of 11 August 2013, a severe thunderstorm passed over the Takasaki and Maebashi city, Gunma prefecture, and produced gusty wind damages. The change of surface weather elements was recorded by dense observation network POTEKA when gust occurred. In this study, we follow the development and propagation of gust-front and downburst through the analysis of features of the pressure field observed by POTEKA. The result of this analysis reveals that the reason of gust caused damages in Maebashi city is downburst.

Helicopter-borne thermocamera measurements of surface temperatures in downtown Tokyo -Comparison of 2013 with 2007-

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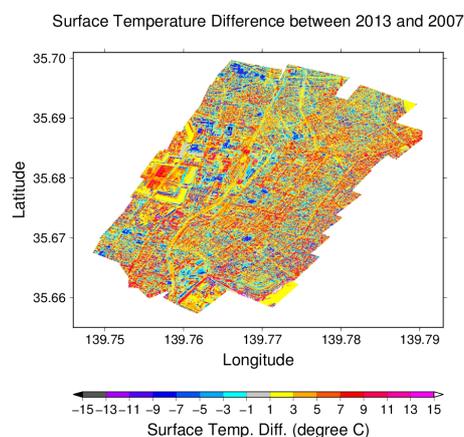
Annual mean air temperatures in downtown Tokyo have increased about 3 degrees Celsius in the past 100 years due to global warming and urban heat island. The frequency of heat stroke outbreaks in Tokyo tends to increase in recent years. The Tokyo metropolitan research institute for Environmental Protection has therefore investigated the current situation of the temperature rises in Tokyo through the monitoring of urban heat island. This can contribute to verification of measure effects on urban heat island.

As part of the investigations, we performed helicopter-borne infrared thermocamera measurements of surface temperatures in downtown Tokyo (mainly an Otemachi-Marunouchi-Yurakucho area) on two different extremely hot days, Aug. 19, 2013 (hereafter, HTM13) and Aug. 7, 2007 (HTM07). The measurements were carried out in the daytime (12-13 local time) and the nighttime (20-22 local time), using a Robinson R22 helicopter with a longwave (8-14um) infrared thermocamera (TS7302) developed at NEC Avio Infrared Technologies Co., Ltd. An altitude of the helicopter flight was 610 m. The daytime air temperatures on those days reached 32-33 degrees Celsius although southerly sea breezes prevailed in the area. Compared with the HTM07 case, a higher air temperature condition was predominant prior to HTM13.

Results of analyses of data from the thermocamera-derived images (a 2 m ground resolution) show that surface temperatures obtained from HTM13 are relatively large in the greater part of the area, compared with HTM07 (refer to a figure shown below), whereas, smaller surface temperatures can be recognized in redevelopment areas where new buildings have been constructed after 2007. (Note that the emissivity of each surface material can influence it.) Also, the thermocamera-derived images projected on Google Earth show higher surface temperatures on intersections.

In addition, we would like to show geographical distributions of the observed surface temperatures in the nighttime, differences between the daytime and nighttime surface temperatures, and a relationship between surface temperatures and sky view factors.

Keywords: Helicopter-borne measurements, thermocamera, surface temperature, downtown Tokyo, verification of measure effects on urban heat island, extremely hot days



How Does A Typhoon Affect The Local Downslope Wind Hirodo-Kaze In Japan?

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The Hirodo-kaze is one of the well-known strong local winds in Japan. Hirodo-kaze occurs at the southern base of Mt. Nagi (1240 m) in the northeastern Okayama Prefecture, when the lower-troposphere synoptic wind is strong northerly in association with a typhoon. Previous studies have described the mechanisms that force downslope winds and large-amplitude mountain waves. However, descriptions of the effect of temporal changes in the large-scale environment on the severe downslope wind are not enough. The purpose of present study is to examine the forcing mechanisms during a Hirodo-kaze and the effects of typhoons on the occurrence of a Hirodo-kaze.

The Hirodo-kaze that occurred in association with Typhoon Pabuk was investigated as a case study. At 06 UTC on 21 August 2001, when Pabuk was located over the sea about 80 km southwest of the Kii peninsula, strong surface winds related to the cyclonic circulation of Pabuk were observed in Shikoku and Kinki districts. Relatively weak northerlies prevailed in Chugoku district far from Pabuk, but a strong northerly was observed at the station located in the lee of Mt. Nagi, about 5 km south of the crest of Mt. Nagi, namely Hirodo-kaze.

The mesoscale model, MM5, successfully reproduces the major features of the observed Hirodo-kaze and Typhoon Pabuk. During the Hirodo-kaze, the severe downslope winds in the transitional flow develop in the lower troposphere below the mean-state critical layer. The Hirodo-kaze is closely linked to the strong wind region accompanying the severe downslope winds. After the cessation of the Hirodo-kaze, distinct mountain waves dominate in the lower troposphere where the Scorer parameter decreases with height. The region of strong wind retreat windward as the Hirodo-kaze ceases. Temporal changes in the characteristics of mountain waves in the lee of Mt. Nagi are primarily attributed to the changes in the large-scale environmental winds due to the movement of Typhoon Pabuk.

The effects of intense typhoons on the occurrence of the Hirodo-kaze were also investigated statistically using data using European Center for Medium Range Weather Forecast 40-year reanalysis data (ERA-40). According to the several reports of Okayama meteorological station, twelve Hirodo-kaze events occurred between 1989 and 2001. During these events, strong lower-tropospheric northerlies were overlain by middle-tropospheric southerlies. These favorable conditions occur only as an intense typhoon moves over the sea southwest of Kii peninsula. Thus, the intense typhoon that moves over the sea southwest of the Kii peninsula creates favorable environmental conditions that support the occurrence of the Hirodo-kaze.

Keywords: typhoon, local downslope wind, MM5

Observation and application of the Phased Array Radar

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The phased array radar system which was installed in 2012 in Osaka University has the unique capability of scanning the whole sky with 100m and 10 to 30 second resolution up to 60 km. The system adopts the digital beam forming technique for elevation scanning and mechanically rotates the array antenna in azimuth direction within 10 to 30 seconds. The radar transmits a broad beam of several degrees with 24 antenna elements and receives the back scattered signal with 128 elements digitizing at each elements. Then by digitally forming the beam in the signal processor, the fast scanning is realized. After the installation of the PAR system in Osaka University, the continuous operation has been done and succeeded in getting several hazardous rain fall events with lightning locations. The data for these events captured by the Phased Array Radar shows the unique capability of the high resolution weather radar. In this presentation, over view of the Phased Array Radar is firstly given, and after that observation results and future direction of the Phased Array Radar Network with polarimetric capability is shown.

Keywords: Radar, Phased Array, Precipitation

Statistical analyses on the characteristics of heavy rainfall events

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In this study, to clarify general characteristics of heavy rainfall events in Japan, we have conducted various statistical analyses on them.

For the warm seasons (April - November) from 1995 to 2009, we objectively extracted heavy rainfall events occurring in Japan by using Radar-Raingauge analyzed rainfall dataset produced by the Japan Meteorological Agency. As a result, 386 events were extracted. Over 75 % of all events occurred during three months of July, August, and September, and many events were distributed around the coastal areas of the Pacific Ocean in Kyushu, Shikoku, Kinki, and Tokai regions. Synoptic weather conditions causing the heavy rainfall events were clarified, and consequently the pattern associated with typhoons or tropical cyclones was the most predominant, which accounted for 32.4 % of all events. Then, stationary fronts, remote precipitation of typhoons or tropical cyclones, and low depressions accounted for 21.2 %, 17.9 %, and 14.2 %, respectively. The classification for the shape of the precipitation systems causing the heavy rainfall events showed that the most predominant system was "band-shaped", which accounted for 43.5 % of all events.

The environmental fields of heavy rainfall events (>130 mm/3hr) were statistically analyzed using the Japanese 55-year reanalysis data (JRA-55). Characteristics of them were elucidated by comparing the environmental fields of moderate rainfall events (10-30 mm/3hr). In July (the late Baiu season) in Kyushu region, the low-level equivalent potential temperature and water vapor flux in the vicinity of Kyushu Island were significantly larger in heavy rainfall events than in moderate ones, and the atmospheric stability became more unstable in heavy rainfall events. Furthermore, to distinguish heavy rainfall events from moderate ones, the combination of two elements of low-level water vapor flux and atmospheric stability was more effective than the unique usage of each element.

Keywords: heavy rainfall, statistical analysis

MRI Rapid-Scan and Super-Resolution Observations in severe storms: Recent Progress and Future Plans

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In this presentation, we will introduce the recent progress, present examples, and future plans of rapid-scan and super-resolution observations in severe storms of the Meteorological Research Institute (MRI).

1. A linear array of pressure and wind sensors for high resolution in situ measurements in winter tornadoes

In order to improve our understanding of near-surface tornadic features, we developed a linear array of wind and pressure sensors (LAWPS) for high resolution in situ measurements in winter tornado cores. The pressure and wind sensors were deployed along a 1.2km-long linear array that is located parallel to and about 100m from the shoreline. Wind data are obtained using 12 two-dimensional fast-response ultrasonic anemometers placed at a height of 5 m at intervals of 100 m. Pressure data are obtained using 25 barometers placed at a height of 50cm at intervals of 50m. The pressure ports are designed and loaded to the barometers to reduce the dynamic pressure associated with wind and turbulence. In this presentation, the system overview and the measurement technique will be described, as well as some examples of actual winter tornado observations of the system and X-band Doppler radar simultaneously.

2. An X-band phased array Doppler radar for the research of severe storms

Many severe storms evolve on time scales shorter than that resolved by conventional mechanically scanning radar systems. MRI has a new project of development of severe storm observations and detections from a phased array radar. The azimuth scan is similar to the conventional scan with a mechanically rotating antenna and at a variable rate between 1- 6 rpm. 128 slotted waveguide array elements fixed above the antenna panel produce transmit beam and an electronic elevation scanning will be performed. With the electronic elevation and mechanical azimuth scanning, the radar can observe the entire sky in less than a minute. Such high temporal resolution sampling will be expected to provide a realistic structure of rapidly evolving storm. In this presentation, some basic characteristics of the radar and a brief description of future tasks for detection and prediction of severe storms will be presented.

Keywords: tornado, rapid-scan and super-resolution observations, phased array radar

Fine radar echo structure revealed by a high scanning and high-range-resolution X-band marine radar

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We used an X-band (9410 MHz) marine radar (KODEN Co., Ltd.), which is not powerful and not very sensitive (its peak transmitted power is 25 kW and minimum detection power is -90 dbm); however, the radar has a high range resolution (15 m). Although its antenna usually rotates horizontally to detect ships, we changed the rotation direction of the slot antenna (2 m in length) from horizontal to vertical (Range Elevation Indicator-scan), and recorded every 2 s. We deployed this radar at various places. We will report very interesting phenomena that are firstly detected by this high-scanning and high-resolution radar.

Keywords: marine radar, fine structure of radar echo, precipitating cloud, angel echo, gravity current head

Applications of weather radar network in private companies

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Recently, various weather radars have been developed not only with novel functions of observation, but with low cost. As a result, each private companies can deploy their own weather radars and make a radar network. In the US, for example, local TV stations have their weather radars and the current situation is analyzed through their radars' data. However, in Japan weather radars have not been deployed yet. In this paper I would like to introduce the Weathernews (WNI)'s weather radar network in Japan and we would discuss future work in order to expand this type of network in Japan.

Keywords: weather radar, radar network, private company

Temporal Variation of Close-Proximity Soundings within a Significant Tornadoic Supercell Environment

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We examined proximity soundings at intervals of a few minutes and at distances of less than 20 km from a significant tornadoic (SIGTOR) supercell that occurred on 6 May 2012 in Japan. We used a 1-dimensional variational (1DVAR) technique that combined the observations of a ground-based microwave radiometer with outputs from a numerical model. Based on the results of the 1DVAR, several supercell and tornado forecast parameters were calculated and compared with values typical of SIGTOR supercell environments in the United States. One and a half hours before the occurrence of the tornado, the value of convective available potential energy increased significantly to about 1000 J kg^{-1} , a value that is smaller than the typical value in the United States. Low-level vertical wind shear and some composite parameters attained maximum values at the time when the distance to the supercell was the smallest. The vertical wind shear parameters and some composite parameters indicated that the environment fell into the SIGTOR supercell category. This result shows that the thermodynamic environments became unstable before the approach of the supercell, and the low-level vertical wind shear changed locally near the supercell.

Keywords: tornado, supercell, microwave radiometer, 1DVAR

Data Assimilation experiment of Tsukuba tornado on May 6, 2012 using MRI Doppler Radar data

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A strong tornado with F3 scale caused serious damage in Tsukuba city on May 6, 2012. This tornado was generated at the southern tip of a precipitation area, which was moving northeastward over the Kanto Plain. Besides the Tsukuba tornado, two tornadoes were observed a few ten kilometers north of the Tsukuba tornado. The lower vortex associated with the Tsukuba tornado, as well as its precipitation area, was well captured by the Doppler Radar of the Meteorological Research Institute (MRI), because the Tsukuba tornado passed 15 km north of the MRI. However, data assimilation experiments using the high-resolution data, such as Radar data, have not been performed yet. In this study, Doppler wind data observed by the MRI-Radar were assimilated with an ensemble Kalman filter so as to evaluate the impact of the assimilation of Doppler wind.

In this experiment, a Nested Local Ensemble Transform Kalman Filter (Nested- LETKF) system, with 12 ensemble members, was used. In Outer-LETKF (horizontal grid interval: 15 km), hourly operational observation data used in the Japan Meteorological Agency (JMA) operational model were assimilated with 6 hour intervals. In Inner-LETKF (horizontal grid interval: 1.875 km), data obtained every 10 minutes was assimilated with 1 hour intervals. To assess the impact of the Doppler wind observations, we basically performed two experiments. The "CTL" experiment used conventional observations, that is, the original settings of the Nested-LETKF. The other "VR" experiment assimilated the Doppler wind data observed by MRI-Radar additionally in Inner-LETKF, while all other settings were the same as CTL. After the data assimilation experiments, downscaling ensemble experiments (horizontal grid interval: 350m) were carried out by using the analyses and 12 perturbations of each CTL and VR at 10:00 JST on May 6, 2012 as initial conditions.

In the downscaling ensemble experiments, two vortices were formed although three vortices were actually observed. The southern vortex in VR was stronger and passed about 2 km closer to the observed tornado than that in CTL. To clarify those differences, we focused on Storm Relative Helicity (SReH) and low level humidity (Low-Qv) at 10:00 JST. The SReH and Low-Qv were compared to the maximum velocity of the Tsukuba tornado vortex (Vmax) and to the latitude where the vortex existed when it passed 140E (L140), using the analyses and 12 perturbations of VR. As a result, Vmax had a positive correlation to SReH in and south of the precipitation area. It also had a positive correlation to the Low-Qv in the south of the precipitation area, and in the south of the genesis point of the vortices. In fact, Low-Qv in the south of the genesis point of vortices in VR was increased by the assimilation of Doppler wind. On the other hand, L140 had a negative correlation with Low-Qv in the south of the precipitation area. It shows that the precipitation area was elongated in the meridian directions and that the vortex was generated further to the south if humidity was higher in the south of the precipitation area.

The wind speed and location of the vortex had correlations with SReH in and south of the precipitation area. They also had correlations with Low-Qv in the south of the precipitation area and in the south of the genesis point of vortices. Therefore, proper correction of these values by data assimilation is important to better reproduce the vortex.

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Keywords: data assimilation, tornado, Doppler Radar

Development of Phased Array Weather Radar and Doppler Lidar Network Fusion Data System

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At National Institute of Information and Communications Technology (NICT), we promote advanced research and development of remote sensing technology, to reduce the damage of severe weather disasters caused by localized heavy rainfalls or tornadoes. An industry-academia-government team consisting of Toshiba, Osaka University, and NICT developed one-dimensional phased array weather radar (PAWR) that it is possible to seamless 3D observation in 10 ? 30 seconds. In May 2012, we installed PAWR at Osaka University Suita Campus, and started test observation. From the observation, a first echo appeared in an isolated cumulonimbus cloud was falling to the ground for about 10 minutes. In order to predict the generation point of the cumulonimbus cloud, we need other data which includes wind fields before cloud generation, distributions of water vapor and aerosol, and so on. For that reason, we develop a sensor fusion system with PAWR, Doppler lidar, and others. We install the systems to both NICT Advanced ICT Research Institute (Iwaoka, Nishi-ku, Kobe, Hyogo) and NICT Okinawa Electromagnetic Technology Center (Onna, Kunigami, Okinawa), and install the network data system to NICT headquarters (Koganei, Tokyo).

The sensor fusion system consists of the PAWR antenna in a radome installed on the roof of a 20 m tower, Doppler lidar (Leosphere 400s) on the deck at the height of 15 m of the tower, microwave radiometer to measure water vapor, and sky-radiometer to measure aerosol. Also, temperature, humidity, wind speed components (u, v, w), pressure, rainfall amount, radiation budget, and cloud images (4 directions and whole sky) are measured. All sensors are connected by network for remote operation and automatic data acquisition. The observation data are transferred in real-time through the fast network lines (JGN-X) from Kobe and Okinawa to Koganei for data processing to make a composite map, and so on. The processing data are displayed on a big 4K display TV, and are published using a web server.

We will start test observation after the system completion in March, 2014. At NICT, we also promote research and development of network data system using advanced ICT for big-data processing, transfer, visualization. We give this system a nickname of PANDA: **P**hased **A**rray weather radar and **D**oppler lidar **N**etwork fusion **D**Ata system, and will publish the data from <http://panda.nict.go.jp/>.

Keywords: phased array weather radar, Doppler lidar, network data system, remote sensing, localized heavy rainfall

Campaign Observation at Keihanshin Area for Detecting Convection Genesis

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In 2008, around 50 people who enjoyed sunny days along the riverside were flushed away by a sudden flash flood in a small river channel (Toga River) in Kobe urban area of Japan. This extreme event was a combinational result of steep basin slope, paved urban area, and severely localized heavy rainfall, which is more frequent happening in the recent summer of Japan. There are many short and steep rivers passing through urban areas in Japan, and the most of riverside along these rivers are used as a public open place. Because of the steep basin slope and the paved urban area, only short time of the localized heavy rainfall, such as 30 minutes of rainfall with 50mm/hr of intensity, can cause very dangerous situation in urban areas as in the Toga River case.

In order to prevent such flash flood damages, it is very necessary to detect the rain-cells, which may develop to severe storm, as soon as possible and to alert people to evacuate from riverfront before the severe events occur. In this study, we develop a detection technique for the early stage of rain-cell as the first cell aloft (hereafter, baby-cell) in the middle atmospheric layers before it generates heavy rainfall on the ground. The early detection technique is utilizing the 3-D volume scanning data from X-band Multi Parameter radars (X-MP radars), which are equipped near to the most urban area in Japan recently. In our recent study using the 3-D volume scanning information from the X-MP radars, we have successfully developed an algorithm (1) to detect newly generated baby-cells, (2) to identify dangerous level of the baby-cells, and (3) to trace the movement of the baby-cells.

In the developed algorithm, firstly, the detection of newly generated baby-cells is based on the information of 3-D volume scanning data with very fine resolution of the X-MP radars. Secondly, the identification of the dangerous level, whether the detected baby-cells will grow up to heavy rainfall on the ground, is evaluated with the information of vorticity of the baby-cells based on the Doppler velocity information from the radars. Finally, the tracking of the baby-cells is based on the conventional cell tracking scheme. The preliminary test of the algorithm shows that especially, the identification of the developing baby-cells with the vorticity information is very powerful, and most of baby-cells in the early stage of heavy rainfall events were successfully identified. In detail, all the 19 developing baby-cells under our surveillance were successfully detected, and there was only one false alarm (forecasted as a heavy rainfall event, but it was not).

In our presentation, upgraded performance index of our proposed algorithm will be introduced based on various rainfall events happened in Kyoto and Osaka area, Japan. In addition to improving this practical early detection algorithm for localized heavy rainfall events in urban area, we are conducting newly designed observation combination in Kansai area with numerous sensors and equipments as shown in figure to identify the mechanism of the localized heavy rainfall events in urban area, such as Osaka, Kobe and Kyoto. It is definitely our mission to realize a next-generation operational observation network with different types of sensors for earlier detection and/or prediction of generating storm from the stage of air plume and/or cloud. Presentation partly includes current situation and future plan of a plot type field experiment with X-band- polarimetric radar, Ku-band cloud radar, Lidar, and X-band phased array radar.

Keywords: Radar, Lidar, Videosonde, Urban Meteorology



Analysis of fine-scale airflows over complex topography by super-high-resolution numerical model

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With the increase in computational resources, mesoscale meteorological simulations with the grid spacing on the order of 100 m have been conducted not only in idealized studies but also in studies that deal with real cases. In real cases, the benefits from such high-resolution simulations are considered to be better representations of surface topography such as complex terrains and complex distribution of man-made structures. In this presentation, we will demonstrate how fine-scale airflows over complex topography such as terrains and urban districts are represented in numerical simulations of local-scale wind fields under real meteorological settings. Some of the case studies of high wind events are described. For the numerical simulations of specific weather events, we use the Weather Research and Forecasting (WRF) model by downscaling from kilometer-scales to 100-meter-scales with the use of nesting capability. Further downscaling from 100-meter-scales down to 10-meters or higher requires the explicit representation of not only complex terrains but also buildings and structures. For this purpose, we developed an approach to couple a mesoscale meteorological model (i.e., the WRF model) and a computational fluid dynamics (CFD) model (Nakayama et al. 2012). A large-eddy simulation model for airflows over urban geometries (Nakayama et al. 2011) is employed as a CFD model. A unique feature of the present coupling approach, an improved version of the perturbation recycling method of Mayor et al. (2002), is to generate turbulence due to urban-like roughness obstacles with the meteorological effects produced by the mesoscale model being retained. The basic idea of this coupling approach and a case study for a high wind event in the downtown district of Tokyo are demonstrated. Furthermore, some other applications of the present approach for airflow simulations over complex topography including airflows over complex terrain of Fukushima during March 2011 will be briefly introduced.

Keywords: High-resolution numerical model, airflows over complex topography, mesoscale meteorological model, large-eddy simulation