AAS23-01 Room:101A Time:May 23 14:15-14:30

Convective systems causing heavy rainfall and severe wind damage in Japan in recent years

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In Japan, we have serious damage almost every year by larger-scale heavy rainfalls resulting from typhoons, the Baiu front and midlatitude cyclones. Local heavy rainfalls in less than several ten km2 area during a few hours which come from one or a few thunderstorms also give us flash flooding, particularly in urban areas. Severe winds including tornado also give us pin-point heavy damage. They have been giving us many subjects in the fields of monitoring/forecasting, disaster prevention and information services.

First, the rainfall and severe wind damage which occurred in Japan during seven years from 2006 to 2012 are classified according to the atmospheric situation, characteristics of the heavy rainfalls and severe winds, scale and feature of the damage. Second, focusing on the convective systems and thunderstorms composing the systems which caused the heavy rainfalls and the severe winds, we examine our degree of comprehension about their behavior, types of convection and generation mechanisms of the heavy rainfalls and the severe winds. Finally, what kind of research should be extended and what issues should be solved will be discussed.

Keywords: extreme weather conditions, flooding damage, severe wind damage, convective system

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(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS23-02 Room:101A Time:May 23 14:30-14:45

A review on X-band radar for quantitative precipitation estimate

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Development of X-band weather radar from the end of World War II to the present is reviewed. It has been believed for long time that X-band wavelength was not adequate for QPE, however, this changed drastically after differential phase shift measurements became practical. The sensitivity of differential phase shift to rain rate at X-band wavelength is higher than that that of C- and S-band wavelength. Its smaller size compared to C- and S-band radars and its high spatiotemporal resolution has accelerated its use as a gap-filling radar and a networked radar in urban areas. Multidisciplinary projects are ongoing in Japan, the US, and Europe, with the aim of developing more effective information from X-band polarimetric radar networks. The products from these experiments will provide the variety of information required by end-users, which cannot otherwise be attained from the nation-wide radar network.

Keywords: X-band radar, polarimetric radar, QPE, X-NET, XRAIN

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS23-03 Room:101A Time:May 23 14:45-15:00

Development and Observation of the Phased Array Radar

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A new phased array radar system for meteorological application has been developed by Toshiba Corporation and Osaka University under the grant of NICT. It is now well known that the rapidly evolving severe weather phenomena (e.g., microbursts, severe thunderstorms, tornadoes) is a threat to our lives particularly in densely populated area and the number of the phenomena tends to increase as the result of the global warming. Over the past decade, mechanically rotating radar systems at C-band or S-band have been proved to be effective for weather surveillance especially in wide area more than 100 km in rage. However, the rapidly evolving weather phenomena has the temporal and spatial scales comparable to the resolution limit (-10 min. and -500m) of the S-band or C-band radar systems, and cannot be fully resolved with these radar systems. In order to understand the fundamental process and dynamics of such fast changing weather phenomena, volumetric observation with both high temporal and spatial resolution are required.

The phased array radar system developed has the unique capability of scanning the whole sky with 100m and 10 or 30 second resolution up to 60 km in a cost effective manner. The system adopts the digital beam forming technique for elevation scanning and mechanically rotates the array antenna in azimuth direction within 10 or 30 seconds. The radar transmits a broad beam of several degrees with 24 elements and receives the back scattered signal with 128 elements digitizing at each elements. Then by digitally forming the beam in signal processor, the fast scanning is realized.

The system was installed at the top of the building in Osaka University in May 2012, and has been operated continuously since then. In this presentation, the system and the initial observation results will be talked.

Keywords: RADAR, Phase Array

AAS23-04 Room:101A Time:May 23 15:00-15:15

Characteristics of reflectivity cores observed by Ku-band radar

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In Tokyo Metropolitan Area Convection Study(TOMACS) project, we installed a Ku-band radar in Musashino-shi, Tokyo in 2011 in order to clarify mechanisms of extreme weathers such as local heavy rain in an urban area. In this research, our main target is the motion of upper reflectivity cores, since motions of the reflectivity cores must affect the motion of the cumulonimbus itself.

On Sep. 1, 2012, many small cumulonimbi were generated all over Japan although there wasn't significant disturbance in a surface weather map. These were due to warm and humid air and an upper cold low, however, it is difficult to predict motions of cumulonimbi generated in such a condition. In this presentation, characteristics of heights and motions of reflectivity cores observed in this case will be shown.

Keywords: Ku-band radar, cumulonimbus, reflectivity core

AAS23-05 Room:101A Time:May 23 15:15-15:30

Precipitation core behavior and surface rainfall variation in cumulonimbus clouds in the Kanto region, on 18 August 2011

Yukari Shusse[1*], Masayuki Maki[1], Koyuru Iwanami[1], Ryohei Misumi[1], Shin-ichi Suzuki[1], Takeshi Maesaka[1], Shingo Shimizu[1], Namiko Sakurai[1]

[1]National Research Institute for Earth Science and Disaster Prevention

Descending precipitation cores in cumulonimbus clouds which caused localized heavy rainfall have been reported in several previous studies. The surveillance of precipitation cores aloft is expected to improve nowcast or short-time forecast methods of localized heavy rainfall. In addition, the investigation of correspondence between detailed behavior of precipitation cores and surface rainfall is important to understand developing and maintenance processes of vigorous cumulonimbus clouds. The National Research Institute for Earth Science and Disaster Prevention conducted a three-dimensional observation of cumulonimbus clouds which occurred on 18 August 2011 in Kanto region, Japan, at two-minute intervals using an X-band polarimetric radar at Ebina City. In this study, the detailed behavior of precipitation cores in these cumulonimbus clouds and its correspondence to the time variation of surface rainfall are presented.

In this study, precipitation core is defined as the closed area of radar reflectivity (Zh) right before merging with other closed area when the Zh threshold level is lower from 60 dBZ to 10 dBZ by 1 dB. Precipitation core is automatically detected in three-dimensional data sets (dx = 1 km, dy = 1 km, dz = 0.25 km) every two minutes and manually tracked. Core height is defined by the level of the maximum Zh within the detected precipitation cores at each time. This precipitation-core detection method was applied to the three precipitation cells (Cell A1, B1 and C1) observed on 18 August.

Cells A1 and C1 consisted of a single precipitation core each. Precipitation cores aloft in Cells A1 and C1 were detected 12 and 16 minutes before the time of maximum rainfall intensity at the surface, respectively. Descent of precipitation cores was observed once in Cells A1 and C1 each. Cell B1 composed of 5 precipitation cores. Five surface rainfall peaks were observed for Cell B1. First rainfall peak was observed after 18 minutes of the first detection of precipitation core aloft. At that time, the core height was 5-km altitude, which did not descend to the surface. Other 4 peaks in surface rainfall were observed in association with precipitation core descent. Thus, 6 of 7 rainfall peaks in three precipitation cells were observed in association with descents of precipitation cores.

Keywords: Localized heavy rainfall, precipitation core, Polarimetric radar

AAS23-06 Room:101A Time:May 23 15:30-15:45

Surface Meteorological Monitoring Network for Observation of Extreme Weather (1):Meteorological Characteristics in Tokyo

Hitoshi Yokoyama[1*], Haruo Ando[1], Yoshihito Seto[2], Kei Hiroi[3], Masaya Nakayama[4], Ken-ichi Kusunoki[5], Masayuki Maki[7], Yuto Saitoh[6], Hideo Takahashi[6]

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The purpose of this study is to clarify extreme weather in cities including short time heavy rainfall and high temperature in summer. High-density surface meteorological monitoring network were expanded in Tokyo. Meteorological characteristics in summer were examined by using high-density data in Tokyo obtained from this monitoring network.This study is supported by the S-8 Project, Comprehensive Research on Climate Change Impact Assessment and Adaptation Policies, implemented by the Environment Research and Technology Development Fund of the Ministry of the Environment, Japan and Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS) under the Special Coordination Funds for Promoting Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Keywords: Extreme Weather, Surface Meteorological Monitoring, Summer Season, Tokyo Metropolitan Area, Meteorological Characteristics

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AAS23-07 Room:101A Time:May 23 15:45-16:00

Relationship between rainfall distribution and surface wind during heavy rainfall occurred in central Tokyo in summer

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In recent years, it has been reported that short time heavy rainfall that occurs in summer tends to increase. The purpose of this study is to clarify the evolution process of short time heavy rainfall towards the short-range forecasting of heavy rainfall that showed clear regional characteristics.

Typical heavy rainfall days were selected and the relationship between rainfall distribution and the convergence of surface winds were examined by using high-density data obtained from meteorological observations in central Tokyo from 2011 to 2012. The values of convergence tended to be larger from several tens of minutes before the occurrence of heavy rainfall in the case of August 26, 2011. The similar temporal change was observed in approximately half of the selected cases. From these results, the possibility to predict the occurrence of heavy rainfall is expected by using the surface wind data obtained from high-density observation network.

This study is supported by the S-8 Project, *Comprehensive Research on Climate Change Impact Assessment and Adaptation Policies*, implemented by the Environment Research and Technology Development Fund of the Ministry of the Environment, Japan and *Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS)* under the *Special Coordination Funds for P* of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Keywords: heavy rainfall, convergence field, high-density observation network, central Tokyo

Japan Geoscience Union Meeting 2013
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AAS23-08 Room:101A Time:May 23 16:15-16:30

Retrieval of Water Vapor Anisotropy from GPS and it's Relation with Convective Precipitation

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Procedures for retrieving two indices indicating the degree of inhomogeneity of water vapor using the carrier phase of a Global Positioning System (GPS) have been introduced. One index describes the spatial concentration of water vapor (WVC); the other indicates higher order water vapor inhomogeneity (WVI). Horizontal scales of the two indices are roughly thought of as 60 km and 2-3 km, respectively.

The relationships between these indices and precipitation were examined statistically. The results indicate that the inhomogeneity indices are more strongly correlated with strong rainfall than PWV. PWV seemed to relate to precipitation of less than 10 mm/h but did not exhibit much of a relationship with precipitation greater than 10 mm/h. These relationships hold true for both present and imminent precipitation.

The spatiotemporal variations in the indices associated with an F3 tornado occurred on 6 May 2012 were also examined. WVI showed distinct variation around the event.

The results suggest that the two GPS-derived indices of water vapor inhomogeneity reflect local variations in the water vapor associated with the convection phenomena and could potentially be used for the monitoring of extreme weather like thunderstorms and tornados.

Keywords: Extreme weather, GPS, Water vapor, inhomogeneity, convective precipitation

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(May 19-24 2013 at Makuhari, Chiba, Japan)

AAS23-09 Room:101A Time:May 23 16:30-16:45

Numerical study on precipitable water vapor variation associated with heavy rainfall using a non-hydrostatic model

Masanori Oigawa[1*], Toshitaka Tsuda[1], Kazutoshi Sato[2], Eugenio Realini[1], Yuya Iwaki[1], Hiromu Seko[3], Yoshinori Shoji[3], Takuya Kawabata[3]

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The frequency of weather disasters caused by local heavy rainfall is increasing due to the global warming. For the mitigation of these disasters, it is important to monitor the variation of water vapor before the rainfall.

Global Navigation Satellite Systems (GNSS), that include GPS, are now widely used to perform precise positioning. In addition to this, the vertically accumulated water vapor amount, precipitable water vapor (PWV) can be estimated from GNSS observations. The Geospatial Information Authority of Japan is operating a nationwide GNSS network, called GPS Earth Observation Network System (GEONET), and PWV from GEONET can be estimated with a mean horizontal spacing of about 20 km. To improve the horizontal resolution of PWV, we have installed a dense GNSS receiver network with horizontal spacing of 1-2 km near the Uji campus of Kyoto University.

In parallel to dense GNSS observations, down-scale experiments using a non-hydrostatic regional model (JMANHM) with grid intervals of 2 km and 250 m were performed to investigate the PWV variation associated with a thunderstorm observed on 28 July 2011 and 14 August 2012 within the dense GNSS network.

In the 250 m forecast for the case on 14 August 2012, a rainband located south of Kyoto was roughly reproduced. In the model, small regions in which PWV values started to increase about 10 minutes before the rainfall were found. At the 850 hPa surface over these regions, vertical wind velocity and cloud water content became large in conjunction with the rapid increase of PWV. It is expected that the increase of pwv value was occured because low level moist air was lifted up by the upward wind. Similarly, increasing of PWV value before rainfall was observed by the GNSS receiver at the Uji campus. These results suggest that PWV variation could be predictive of heavy rainfall.

Keywords: heavy rainfall, GPS meteorology, non-hydrostatic model

AAS23-10 Room:101A Time:May 23 16:45-17:00

Cloud resolving ensemble prediction of a local heavy rainfall event on 26 August 2011 observed by TOMACS

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[1]Meteorological Research Institute

On 26 August 2011, a local heavy rainfall event occurred in the Tokyo metropolitan area. In Tokyo and Kanagawa prefectures, very intense rains more than 90 mm hr-1 were observed (Fig. 1a) and several houses were inundated. This heavy rainfall event was caused by a mesoscale convective system (MCS) which was triggered by low level convergence, and its characteristics were captured by a dense observation network deployed by the Tokyo Metropolitan Area Convection Study (TOMACS). Despite its relatively larger spatial scale as a local rainfall in Japan and existence of well-defined low level convergence by a front, operational mesoscale model (MSM) of JMA failed to predict this event. Studies on model physics, predictability, and data assimilation should be conducted to improve the forecasts.

Preliminary numerical experiments for this event have been performed. As a first trial, a downscale ensemble experiment from the mesoscale analysis of JMA was conducted using the JMA nonhydrostatic model (NHM) with horizontal resolutions of 10 km and 2 km. With perturbations from the JMA one-week global ensemble prediction system (WEP) at 12 UTC 25 August, only a few members intensified the rainfall around Tokyo and some fake precipitations appeared in the Hokuriku district.

In NHM, the model cloud amount to compute radiation processes is evaluated from relative humidity considering subgrid scale partial condensation. Magnitude of the subgrid fluctuation is determined by the MYNN3 turbulent closure model. Recently, JMA has changed the lower limit of the fluctuation in their operational local model (LFM) to ameliorate an overestimation tendency of the cloud amount. When the lower limit was changed, surface temperatures increase about 1 C in southern part of the Kanto Plain, and modify the position of low level convergence which triggered the MCS.

Additional mesoscale ensemble experiment was conducted using a mesoscale singular vector method (MSV) based on the adjoint model of NHM. A 2 km simulation using MSV perturbation reproduced the intrusion of sea breezes and associated surface convergence which triggered the mesoscale convective system.

Keywords: local heavy rainfall, mesoscale ensemble prediction, singluar vector, TOMACS

AAS23-11 Room:101A Time:May 23 17:00-17:15

Ensemble forecast experiments of tornadoes occurred on 6th May 2012 using a nested-LETKF system

Hiromu Seko[1*], Kazuo Saito[1], KUNII, Masaru[2], TSUYUKI, Tadashi[2], MIYOSHI, Takemasa[3]

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This presentation is regarding the tornadoes that occurred on 6th May 2012. Some research has already been carried out using Doppler radar data and outputs of the numerical forecast from this event. The analysis of the Doppler radar data showed that the tornadoes occurred in super cell convections. Low level warm moist airflow was supplied into the convections. An intense downdraft from the western sides of the convection cell triggered the tornadoes. If an ensemble forecast was applied to this event, we could obtain the probability of the outbreak of super cell convections and tornadoes. The several scenarios provided by an ensemble forecast also give us the factors that influence the outbreak and duration of tornadoes. In this presentation, the results of an ensemble forecast by the nested-LETKF system will be presented.

Keywords: Ensemble forecast, Data assimilation, Tornado

Japan Geoscience Union Meeting 2013
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AAS23-P01 Room:Convention Hall Time:May 23 18:15-19:30

Formation of Heavy Rainfall over Mountain Slopes Surrounding an Inner Basin Associated with the Passage of a Typhoon

Tetsuya Sano[1*], Satoru Oishi[2], Kengo Sunada[3], Tadashi Suetsugi[1]

[1]International Research Center for River Basin Environment, University of Yamanashi, [2]Research Center for Urban Safety and Security, Kobe University, [3]University of Yamanashi

Heavy rainfall over mountainous regions is often associated with a typhoon (e.g. Misumi 1996 and Yu and Cheng 2008). However, the formation process of such heavy rainfall has not been known enough. On 21 September 2011, heavy rainfall occurred over the inner mountain slopes surrounding Kofu Basin with the passage of Typhoon Roke (2011) (hereafter, T1115), which was observed by the X-band multi-parameter radar installed in Kofu Campus of University of Yamanashi on Kofu Basin (hereafter, the UYR). In the present study, from a case study of the particular event, we investigated the formation process of heavy rainfall over the inner mountain slopes associated with the passage of a typhoon.

T1115 moving toward northeast made landfall near Hamamatsu about 100 km southwest of Kofu Basin at 1400 LST (Local Standard Time = UTC + 9 hours). The center of T1115 moved to Kofu Basin from 1400 LST to 1600 LST; it passed on the south part of Kofu Basin from 1600 LST to 1800 LST.

When the center of T1115 was approaching to Kofu Basin from 1400 LST to 1600 LST, rainfall amount, derived by the UYR observation at 1.5 km above the mean sea level, was large over the inner slopes of Mts. Koma. Many precipitating cells (hereafter, cells) existed continuously over the slope of Mts. Koma on the west side of Kofu Basin. The heights of cells were lower than the altitude of the melting layer in the stratiformed precipitating system associated with T1115. On Kofu Basin, positive Doppler velocity (DV) appeared at the lower elevation angle with surface wind toward Mts. Koma, namely toward the center of T1115. At that time, surface equivalent potential temperature at Kofu was high with east-northeasterly wind. We consider that the air with high equivalent potential temperature transported by the lower wind toward the center of T1115 and was lifted over the slope of Mts. Koma.

Then, rainfall amount was largest over Mts. Misaka on the south side of Kofu Basin when the center of T1115 was passing on the south part of Kofu Basin from 1600 LST to 1800 LST. The heights of cells were also lower than the altitude of the melting layer. On Kofu Basin, DV increasing from northwest to southeast appeared at the lower elevation angles with surface wind toward Mts. Misaka, namely toward the center of T1115. At that time, surface equivalent potential temperature at Kofu decreased with northwesterly wind. We consider that the air with high equivalent potential temperature over the slope was lifted when the lower wind with the air with low equivalent potential temperature arrived at the slope of Mts. Misaka.

The appearance distribution of the cells was varied with the variation of the surface wind associated with the pass of T1115, which contributed to the distribution shift of the heavy rainfall. It is mentioned that the appearance and development of precipitating cells over the mountain slopes controlled by the lower wind blowing to the center of T1115 contributed to the formation of the heavy rainfall.

Acknowledgement: This study is supported by the Global COE Program of University of Yamanashi directed by MEXT, Social System Reformation Program for Adaption to Climate Change of NIED under the Strategic Funds for the Promotion of Science and Technology of JST/MEXT and Grants-in-Aid for Scientific Research of JSPS.

Keywords: Heavy rainfall, Typhoon, Mountain slopes, X-MP radar

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AAS23-P02 Room:Convention Hall Time:May 23 18:15-19:30

Validation of Algorithm for the Identification and Tracking of Convective Cell (AITCC)

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A new method for identifying and tracking convective cells is proposed for the statistical analysis of convective cells embedded within mesoscale convective systems using two-dimensional radar reflectivity dataset. The Algorithm for the Identification and Tracking Convective Cells combines the constant and adaptive threshold methods with a new cell-merging and -splitting scheme, and is termed AITCC. The scheme assumes the

conservation of total area and the relative locations of cells when merging or splitting occur. The performance of AITCC in tracking was evaluated in an analysis of 2004 non-severe convective cells (30-40 dBZ) and in 1268 cell assignments observed within meso-$¥beta$ convective systems in the Meiyu frontal region. We demonstrated that the use of the new cell-merging and -splitting schemes significantly decreased the number of incorrect cell assignments especially in situations where convective cells are located close together.

AITCC showed a promising performance (false-alarm-rate $<$ 10%) in tracking of weak convective cells (30-40 dBZ) that seemed to be difficult for the previous tracking algorithms. AITCC is expected to enable to calculate the statistical features of convective cells from their development to dissipation.

Keywords: Convective cell, cell-tracking

AAS23-P03 Room:Convention Hall Time:May 23 18:15-19:30

Basic research of now-casting system for severe storms by using a dense GPS network

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The frequency and intensity of torrential rains are increasing. Though localized horizontal inhomogeneities of water vapor distribution were observed prior to such kind of rainfalls in historical cases, these phenomena occur suddenly and have a horizontal scale of a few kilometers. So, local heavy rainfalls are difficult to predict by current weather forecasting systems or models.

The integrated amount of water vapor along the zenith direction (or PWV: precipitable water vapor) can be estimated by GPS meteorology, that is a method to compute PWV from troposphere-induced delays in GPS signals. PWV estimation by using the nation-wide Japanese GPS network: GEONET cannot achieve enough horizontal resolution to predict local heavy rainfalls since the network is deployed with inter-station distances of about 20 kilometers.We propose the system for real-time monitoring of high accuracy PWV horizontal distribution with a few kilometers scale which is considered to be beneficial to predict localized heavy rainfall by using a dense GPS network.

We deployed a dual-frequency(DF) GPS network for PWV estimation around Uji campus of Kyoto University, japan, with inter-station distances of about 1-2km. We executed an observation campaign on July and August 2011 and July 2012 for testing the accuracy of GPS-derived PWV. The difference of GPS-derived PWV with radiosondes and radiometer was at most 2mm in RMSE when averaging GPS zenith delays from multiple satellites.

We have developed the basic components of a system for estimating ZTD(Zenith total delay) by the GPS software RTNet, monitoring, interpolating, and visualizing PWV derived from the GPS receiver network, with the aim of producing a heavy rain early warning system based on semi-real time analysis of GPS observations.

For turning this system into practical use, the deployment of single-frequency (SF) GPS receivers is recommended for economic reasons. However, in single frequency receiver processing ionospheric delay information is required to achieve high accuracy troposphere-induced delay solution because small scale perturbation of ionospheric delay between two GPS stations cannot be removed even with differential processing.

We thus investigated the performance of Local Ionosphere Models (LIMs), generated from DF GPS network around the SF receivers. In RTNet, LIMs are generated by estimating the 1st or 2nd order gradient of ionosphere-induced delay between GPS stations. We tested the accuracy of ZTD estimation from ionosphere-corrected SF analysis by analyzing D_ZTD(delta ZTD, ZTD difference between DF_ZTD and SF_ZTD corrected by LIMs). In the test, LIMs are generated from DF GPS network with inter-station distances of about 3km.

The result from data among the period 22nd-29th Feb, 2012 showed that SF-ZTD, estimated by using a LIM for each satellite (satellite-specific model), produces D_ZTD at most 17mm in RMSE. This value becomes at most 3mm in PWV, which means not accurate enough to be applied for severe storm monitoring. The difference of this RMSE between 1st order gradient model and 2nd order gradient model was ver small: about 0.05mm.

Analysis of the day-to-day variability of the D_ZTD during a period of 200 days from the 22nd Feb, 2012 shows that the trend is close to that of PDOP. This result suggests that D_ZTD is highly affected by satellite geometry.

Keywords: Extreme weather, GPS meteorology, Precipitable Water Vapor, Dense GPS network, Ionosphere-induced delay

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AAS23-P04 Room:Convention Hall Time:May 23 18:15-19:30

An Observation Campaign for Precipitable Water Vapor in Indonesia using a GPS Network

Kazutoshi Sato[1*], Toshitaka Tsuda[2], Susilo Susilo[3], Timbul Manik[4]

[1]CPIER, Kyoto Univ., [2]RISH, Kyoto Univ., [3]BIG, Indonesia, [4]LAPAN, Indonesia

We conducted a campaign from 23 July to 2 August 2010 to measure the precipitable water vapor (PWV) in the atmosphere using four GPS receivers, stationed at different locations in Jakarta and Bogor, Indonesia. Radiosondes were also launched at an interval of 6 h, in this campaign to validate the recorded GPS-PWV data.

When estimating PWV from the zenith wet delay of a GPS signal, we have assumed a relationship between the surface pressure and the mean temperature (Tm). The presence of the inversion layer which was found in the radiosonde profiles at night resulted in an error of about 0.5 mm in the GPS-PWV. Furthermore, we evaluated the influence of GPS-PWV by the atmospheric pressure and temperature. During this study we observed a regular semi-diurnal pressure oscillation showing an amplitude of 3 to 5 hPa, which corresponds to 0.3 - 0.5 mm in the GPS-PWV.

During the campaign, there was a passage of a cloud moving southwestward from the equator toward the Indian Ocean through the Java Island during the period of 26 to 29 of July 2010. Time variations in the GPS-PWV were observed to be consistent with the satellite images. The peak of GPS-PWV (60-65 mm) occurred on 27 of July, which coincides with the rainfall event. Spatial variations in GPS-PWV between the four sites were observed to have enhanced just before the rains. We thus suggest of a possibility that the spatial inhomogeneity of PWV could be used as an index for predicting a rainfall event.

Keywords: Water vapor, GPS, radiosonde, tropical area, inversion layer, semi-diurnal pressure oscillation

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AAS23-P05 Room:Convention Hall Time:May 23 18:15-19:30

Spatial analysis of GNSS tropospheric slant delays using a dense network of receivers

Eugenio Realini[1*], Toshitaka Tsuda[1], Kazutoshi Sato[1], Masanori Ohigawa[1], Yuya Iwaki[1]

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Urban areas are facing increasing threats due to the sudden development of localized thunderstorms and torrential rain, which can cause floods, trigger landslides and damage crucial infrastructures. While such local heavy rain events are difficult to be forecasted by current numerical weather prediction models, short-term predictions at local scales could potentially benefit from reliable measurements of the temporal and spatial variability of water vapor in the atmosphere. In order to support the nowcasting and forecasting of these phenomena and to improve the resilience of local communities against rain-related threats, it is needed to improve the horizontal resolution of water vapor observation sites by deploying sufficiently dense networks of monitoring stations.

Fixed receivers of known coordinates tracking GPS satellites can be used for water vapor monitoring, since the GPS signal delay induced by tropospheric refractivity is related to the amount of water vapor along the slant path between each satellite and the receiver antenna (GPS meteorology). Indeed each receiver-satellite pair can be seen as a device that scans the troposphere along a continuously varying direction as the satellite moves with respect to the position of the receiver. The traditional approach to GPS meteorology sees the averaging of all slant delays above low elevation thresholds, after having mapped them to the zenith direction. When using very dense networks of receivers, however, the averaging cones defined by low elevation thresholds overlap significantly and produce a horizontal smoothing effect. It is thus necessary to select high elevation slant delays for each station in order to preserve the high resolution observation capability of a dense network of receivers.

GPS satellites alone do not provide continuous coverage at sufficiently high elevation angles (e.g. higher than 70 degrees), therefore the integration of GPS with other Global Navigation Satellite Systems (GNSS) is required. The fast development of new GNSS constellations will soon provide the means to increase the number of receiver-satellite pairs, and consequently to increase the capability of each receiver to continuously observe the troposphere along directions close to the zenith. In addition, the particular geometry of the Quasi-Zenith Satellite System (QZSS), once the constellation is completed, will provide a means to monitor the amount of water vapor along slant paths continuously close to the zenith direction in Japan, without the need to switch between different systems.

In this work we analyze the spatial distribution of GNSS tropospheric slant delays observed by a dense network of receivers deployed near Kyoto, Japan. Slant delays estimated from QZSS observations by the first launched satellite are included in the analysis, comparing them with those estimated using high-elevation GPS satellites and analyzing their azimuthal dependency. The current status of new GNSS constellations and their potential benefits for meteorology are also briefly discussed.

Keywords: GNSS, troposphere, slant delays, water vapor

AAS23-P06 Room:Convention Hall Time:May 23 18:15-19:30

Localized water vapor signals detected by ALOS/PALSAR data in Japan

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Interferometric Synthetic Aperture Radar (InSAR) phase signals, which can detect surface deformations with high-spatial resolution, are affected by earth's atmosphere like GPS, and thus provide a detailed spatial distribution of precipitable water vapor without any surface deformation signals or other errors. Hanssen et al. (1999) showed the coincidence between water vapor signals detected by InSAR and spatial distributions of rain fall echo detected by a weather radar (WR), and indicated the possibility of InSAR as a water vapor sensor. However, there weren't any studies of InSAR water vapor signals for meteorological applications except in the case shown by Hanssen et al. (1999). In our past presentations, we reported two case studies detecting localized water vapor signal associated with deep convective systems with InSAR (Kinoshita et al., GSJ 2011), and conducted the estimation of the three-dimensional (3D) water vapor distribution and numerical weather simulations for reproducing localized water vapor signals (Kinoshita et al., GSJ 2012). However, there were still few cases detecting localized water vapor signals with InSAR.

For elucidating the mechanism of the behavior of water vapor with InSAR, it is necessary to increase case studies of water vapor detection by InSAR. Here we searched SAR data with the potentiality of containing localized water vapor signals in Japan from ALOS/PALSAR archive data with national composite WR echo data. As a result, we could find a number of such SAR data. It is certain that there are many interferograms that include localized water vapor signals beyond expectation. At the time of submitting this abstract, we generated four InSAR data at Niigata, Kyoto, Saga and Oita using ALOS/PALSAR data with descending orbit, which is regarded as including few ionospheric effects, and then we successively detected localized signals from all these InSAR data near locations of maximum WR rainfall echo. Radar line-of-sight changes of some of these signals reach up to 200 mm which exceed amplitudes of water vapor signals in two cases we reported in the past. Additionally, the SAR data of Niigata was derived during a heavy rain event associated with a cold front, and that InSAR data clearly shows the existence of a number of localized water vapor signals due to convective systems near the front.

At the presentation, we will show detection results of localized water vapor signals in generated interferograms. Additionally, we are planning to report results of the estimation of 3D water vapor distribution and the numerical weather simulation what we will do by the presentation.

Keywords: InSAR, water vapor, weather radar, convective system

AAS23-P07 Room:Convention Hall Time:May 23 18:15-19:30

Refractivity distribution observed by an operational Doppler Radar

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Because low-level convergence of water vapor generates the convections, if the horizontal distribution of low-level water vapor can be observed, the accuracy of local heavy rainfall forecasts will be improved. Radio waves transmitted from radars and reflected off fixed structures are delayed by water vapor in the atmosphere. If the delay can be obtained, we can calculate the refractivity which is a function of temperature and water vapor. Because many Dopper radars have been deployed by JMA in Japan, this technique is expected to improve the forecast accuracy of thunderstorms all over Japan. In this presentation, the estimation method of the refractivity will be explained, and the temporal variations of refractivity fields, obtained from IQ data from Tokyo operational radar, will be presented.

Keywords: Doppler radar, Refractivity, Water vapor

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Academic-Industrial collaboration study on the observational database for elucidation of the localized katabatic wind

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Localized meteorological phenomena often cause severe disasters. The dynamics of these severe phenomena has not fully elucidated, because of their small temporal and spatial scale. This thesis focuses on localized katabatic wind called as Hira-Oroshi seen in the region between Hira mountain range and Biwako lake on October-May. Conventional knowledge of the katabatic wind is not enough to fully explain the mechanism of the narrow width and the rapid migration of the strong wind region.

Comprehensive observation for monitoring the horizontal structure of Hira-Oroshi is very useful to solve the puzzle of Hira-Oroshi phenomena.

The Kyoto University started academic-industrial collaboration research for the elucidation of Hira-Oroshi phenomena throughout the dense surface meteorological observation distributed in the whole of Hira-Oroshi area.

NTT DOCOMO environmental sensor network started surface weather observation at nineteen metrological stations from October, 2012. Due to the regulation of observation height, the observed data included the effect of height variations. The excellent cross-correlation coefficient among the neighboring data were confirmed. The wind velocity difference due to the difference of observation height were compensated by using logarithmic raw of wind velocity in the frictional atmospheric boundary layer. After the QC of the data, the comprehensive database of surface wind velocity in Hira-Oroshi area was successfully constructed.

The availability of the database was clearly demonstrated by unveiling the detailed two-dimensional structure of four Hira-Oroshi events occurred on October-December, 2012.

Keywords: academic-industrial collaboration, the dense surface meteorological observation

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Numerical study of moving strong downslope wind Hira-oroshi in Japan

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Strong migrating downslope wind was elucidated using high-resolution non-hydrostatic numerical model. The strong downslope wind appeared at the west side of Lake Biwa is called as Hira-Oroshi. In the Hira-Oroshi region, mountain range over 1000 m-altitude exists in the west side of the lake. The low altitude area exists over the north of mountain range. Hira-oroshi has quite unique characteristics that the strong (-50m/s) wind region with the narrow (-1 km) width migrates within 10 km width in every case.

In authors knowledge, the dynamics of the migrating downslope wind has not been studied yet, although the researchers researched the mechanism of downslope wind in the foot of mountain range through the observations and numerical forecast model. The characteristics of Hira-Oroshi were successfully represented in the high-resolution non-hydrostatic forecast model in this research. The results strongly suggest the synergy effects of the breaking of mountain wave seen at 1 km height and the micro-scale patch of high potential temperature at the surface causes the formation of narrow downslope wind.

Keywords: downslope wind, numarical model

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Study of cooperative weather radar system for radio resource enhancement

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Localized heavy rain, and some other weather disasters in urban area have raised social issues in recent years. To observe these phenomena whose time-space scale is small, X-band weather radar networks are developed in these days. The importance of multi-parameter radar network will be increased. It takes several minutes (about 10 minutes) for conventional (mechanical drive beam steering) radars to get 3D rainfall distribution. We, National Institute of Information and Communications Technology, have developed a 1D phased array weather radar to increase the time resolution. This radar can retrieve 3D rainfall distribution within 10 seconds, and is expected to reveal small time-scale phenomena such as localized heavy rain.

A new research has started to develop the next generation weather radar system. In this system, radars have the function of 2D digital beam forming (DBF). Plural radars and receivers are synchronized and cooperated to realize multi-static observations. In this presentation, preliminary results of consideration for location of radars and cooperative beam steering method.

Acknowledgement

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Keywords: weather radar, observation system

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An evaluation of compact weather sensors

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Some of the extreme weather events such as torrential rain, tornado, microburst, and heat wave are smaller spatial and temporal scale to observe by ground-based measurements. It is very important to monitor and forecast these phenomena for the social impacts of the hazards to the large cities with a population of several million people. Remotely-sensed data by meteorological satellites and radars are extremely useful for the purpose. But improvement of spatial resolution of ground-based observation is also important. In that case, compact weather sensor (CWS), which is composed of several of sensors in the small dimensions to measure meteorological elements, is quite helpful to observe meso/micro-scale weather phenomena with low cost.

Recently, CWSs become commonly available. However we have little knowledge about the data quality of CWSs, especially the effect of the integrated design of sensors which are different from those of conventional meteorological instruments. To evaluate five CWSs (by different manufacturers), we made wind tunnel experiments and field observations for two months at Disaster Prevention Research Institute, Kyoto University. Mean value of wind direction and wind speed are compared with reference values which are measured by pitot tube anemometer in the wind tunnel. The data by some CWSs shows flow distortion by the pillars near the receiver-transmitters of sonic anemometer. During the field observation from July 2011 to September 2011 at Shionomisaki Wind Effect Laboratory, barometric pressure, wind direction, wind speed, atmospheric temperature, and relative humidity are measured by five CWSs. Mean values of each meteorological element by CWSs are compared with reference values which are observed by the conventional meteorological instruments. The difference of the mean values falls within the specification errors of CWS. The fluctuations and gusts of natural wind measured by CWSs are also comparable to those derived by a standard sonic anemometer. Two CWSs observed rain precipitation. The rainfall records in each 10-minute periods by CWSs are not corresponding with the reference value by rain gauge, especially during the heavy rain periods of typhoon No. 15. It is considered that some inconsistencies are caused by the difference of the principle of measurement.

Keywords: compact weather sensor, CWS, ground-based meteorological measurements, meteorological instrument