Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

AAS01-01 Room:423 Time:April 30 09:00-09:20

Analysis of the PWV variations observed by a hyper-dense network of GNSS receivers prior to localized rainfall

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Sudden and localized heavy rainfall events are posing increasing danger to urban areas, not only for the generation of floods, but also for the possibility to trigger landslides and damage crucial infrastructures. Numerical weather prediction models need to be supported by observations with sufficiently high spatial resolution, in order to be able to successfully forecast such localized precipitation events. To this aim, a crucial parameter to be monitored is the amount of precipitable water vapor (PWV), as well as its spatial distribution over the area of interest, and its variation over time. The Global Positioning System (GPS), which is one of the Global Navigation Satellite Systems (GNSS) currently available, has been increasingly used not only for positioning, but also for the remote sensing of physical parameters useful in Earth sciences. The PWV, or integrated amount of water vapor along the zenith direction, can be estimated by GPS (or GNSS) meteorology, which is a method that associates the amount of water vapor to the tropospheric delays which affect the signals of positioning satellites.

We deployed a dual-frequency (DF) GNSS network around Uji campus of Kyoto University, Japan, with inter-station distances of about 1-2 km. By using this network, we built a basic system to observe PWV fluctuations occurring within a small horizontal scale (less than 10 km), which are then analyzed to identify possible precursors of local torrential rain. Results from two observation campaigns (executed in the summer of 2011 and 2012) to retrieve and study GPS-derived PWV showed that its difference from other meteorological instruments was at most 2 mm in RMSE. We analyzed the variations of PWV detected when localized heavy rain was observed on July 9 and 25, 2012. Both the averaged value and the variance of PWV among GNSS stations increased before a nearby meteorological radar detected the rain clouds. In the latter case, the relative value of PWV among stations was larger than 5 mm.

For turning this system into practical use, e.g. for supporting a heavy rain early warning system, real-time satellite orbit and clock products are required. To estimate and correct the error of predicted satellite clock information, we used stations from the existing nation-wide GPS network in Japan (GEONET), with long baselines (~100 km). The difference between the real-time PWV and that obtained in post-processing by means of precise orbit and clock products was 1.5 mm in RMSE.

Furthermore, the cost-effective deployment of hyper-dense GNSS networks over urban areas would benefit from the usage of inexpensive single-frequency (SF) receivers. We implemented and tested a software application that estimates and interpolates the ionospheric delay from DF stations surrounding the hyper-dense network, in order to compensate SF observations for the effect of the ionosphere, according to a method called SEID (Satellite-specific Epoch-differenced Ionospheric Delay), which was originally developed at the GFZ in Potsdam, Germany. By applying SEID for SF PWV retrieval, the error in terms of PWV with respect to the DF solution was about 1.6 mm in RMSE. The PWV horizontal distribution obtained by SF analysis with this model could detect localized PWV inhomogeneity emerging prior to a rainfall which occurred within a small horizontal scale (less than 10 km).

Keywords: GNSS, GPS, PWV, precipitation, tropospheric delay, ionospheric delay

AAS01-02 Room:423 Time:April 30 09:20-09:35

PWV retrieval by radiosondes and GPS receivers in Indonesia: spatial and time variations associated to rain events

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Flooding due to local convective rain is a serious problem in the urban area of Jakarta, Indonesia. However, accurate prediction of local heavy rainfall events by means of current mesoscale numerical prediction models is difficult, partly because of lacking meteorological observations in Indonesia. Spatial and time variations of water vapor over a given area are expected to increase before precipitation occurs, due to the accumulation of water vapor in the lower troposphere, followed by convective instability. A means to reliably and continuously monitor Precipitable Water Vapor (PWV) is needed in order to detect such variations before the formation of rain clouds. GPS meteorology, i.e. the retrieval of PWV above a GPS station of known coordinates, is a useful technique to achieve this objective. 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, therefore each fixed GPS station can be effectively employed as a sensor that continuously monitors the PWV with high temporal resolution (down to few seconds). By deploying multiple GPS stations that concurrently estimate the amount of PWV at different locations within an area of interest, one can evaluate the spatial and time fluctuations of the water vapor field, and investigate their relation to rain events.

We conducted a PWV observation campaign from 23 July to 5 August 2010 by using five GPS receivers installed at four different locations in Jakarta and Bogor, on Java island, Indonesia. Radiosondes were launched three to four times a day, from a site co-located with two of the receivers, in order to validate the GPS-derived PWV data. The validation resulted in a root mean square error of 2-3 mm. The influence of atmospheric pressure and temperature on GPS-derived PWV can be significant, therefore it was evaluated by referring to ground pressure and temperature measured by weather stations, and radiosonde temperature profiles. A regular semi-diurnal pressure oscillation was observed, showing an amplitude ranging from 3 to 5 hPa, which corresponds to 1.1-1.8 mm in PWV. A temperature inversion layer was observed in the radiosonde profiles during the night, which resulted in an error of about 0.5 mm in the retrieved PWV.

During the campaign, there was a passage of precipitation clouds over western Java, moving southwestward from the Equator towards the Indian Ocean, from 26 to 29 July. A second precipitation event, with localized rain clouds near Bogor, occurred on 2 August. Both events were observed also by a C-band Doppler Radar, operated in Serpong by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as part of the HARIMAU project. The highest value of GPS-derived PWV (about 68 mm) was observed on 27 July, coinciding with the first rainfall event. Spatial and time variations in the estimated PWV between the four sites were enhanced before both the analyzed rainfall events, on 27 July and 2 August. We thus suggest the possibility that the spatial and time inhomogeneity of PWV detected by a network of GPS receivers could be used to support the prediction of rainfall events.

Keywords: PWV, GPS, precipitation, Indonesia

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A Dense Observation of the Tokyo Metropolitan Area Convective Study for Extreme Weather Resilient Cities (TOMACS)

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It is recognized that large cities with populations of several million people are inherently vulnerable to severe weather, such as torrential rainfall, lightning, and tornados. An increase in the occurrence of torrential rainfall and strong typhoons, which can be caused by global warming, can cause extensive damage to large cities (Ishihara, 2013). The number of days with thunderstorms has been increasing in Tokyo in recent years, and the requirement of an advanced monitoring and forecasting system for extreme weather is becoming greater.

An unprecedented dense observation campaign and relevant modeling and societal studies have been conducted since April 2010 by the National Research Institute for Earth Science and Disaster Prevention (NIED), Meteorological Research Institute (MRI), and more than 25 national institutions and universities in Japan that target local high-impact weather (LHIW) in the Tokyo metropolitan area. The objectives of the project, the Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS), include the 1) elucidation of the mechanism of LHIW in urban areas (e.g., local torrential rain, flash flood, strong wind, lightening), 2) improvement of nowcasting and forecasting techniques of LHIW, and 3) the implementation of high resolution weather information to end-users through social experiments.

One of the unique features of TOMACS is the utilization of dense meteorological instruments in the Tokyo Metropolitan area, which is one of the most urbanized areas in the world. Their objectives are to target the tropospheric environment, boundary layer, initiation of convections and the lifecycles of thunderstorms. For the study of the mechanism of LHIW, data are used from the advanced observational instruments owned by participating organizations (including X-band and C-band polarimetric radars, a Ku-band fast scanning radar, Doppler lidars, microwave radiometers, a network of Global Positioning Systems (GPS), radiosondes and unmanned aerial vehicles), which are currently deployed in the Tokyo metropolitan area in addition to the operational observation networks of the Japan Meteorological Agency (JMA) and the Ministry of Land, Infrastructure, Transport and Tourism (MILT) of Japan. The intensive operational period (IOP) of the observations was set to the summers of 2011, 2012 and 2013.

During the IOP, several LHIW events occurred and have been energetically studied. In this topic, we briefly overview the necessity of this study, observation system, and results obtained so far.

Keywords: Mesoscale Meteorology, Dense Observation, Climate Change, Extreme Weather

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AAS01-04 Room:423 Time:April 30 09:55-10:10

A case study on the local front prior to the cumulonimbus cloud and the verification of JMA-NHM simulation

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The local fronts observed over the Kanto plain on July 23, 2013 have been analyzed that is the origin of the isolated cumulonimbus cloud in Tokyo metropolitan area and verified numerical simulation by JMA-NHM.

The local fronts and cumulonimbus cloud formation have been examined based on the data from dense observation network around Kanto plain including Doppler radar for Airport Weather (DRAW) at Haneda, Doppler lidar installed in Tokyo Institute of Technology (Ookayama Campus) and surface meteorological data by Japan Meteorological Agency (JMA). The verification of numerical simulation was based on the results of 500 m horizontal resolution of Japan Meteorological Agency Non-Hydrostatic Model (JMA-NHM). As the initial and boundary data, JMA Meso-analysis data of 15 UTC July 22, 2013 have been adopted. The first simulations have been done with 5 km resolution covering East Japan and then nesting of 1 km and 500 m resolution have been done covering a large part of Kanto Plain. The simulation of 500 m resolution has been analyzed for 10 hours from 02UTC July 22, 2013 and the boundary process is based on Deardorff (1980).

The formation of cumulonimbus clouds in Kanto plain is often explained by the convergence of southerly wind and easterly wind. The southerly warm moist wind flows from Sagami Bay and Tokyo Bay by high pressure system in the south of Japan or sea breeze. The easterly wind flows from Kashima Bay. However, in one case of on July 23, it was found that the trigger of cumulonimbus was convergence with two different directions of sea breeze fronts and in addition gust front also plays an important role. The daytime sea breeze front is formed along the Sagami and Tokyo Bay, has entered inland at 1 m/s approximately. Several isolated cumulonimbus clouds have been formed in the rear of sea breeze front and some of them have been lost later, to form a gust front. The spread speed of gust front was about 3 m/s. The sea breeze front that was located in front of the gust front turned the direction to northwest. This sea breeze front and original northeast direction of front from Tokyo Bay have formed the convergence over Tokyo metropolitan area.

On the other hand, numerical simulations have predicted the strong rainfall in the Kanto plain but not all precipitation have been expressed. Comparing JMA-NHM 500 m resolution simulation with DRAW at Haneda, the horizontal distribution of sea breeze front was close to the position of real position. The simulations also have expressed the isolated cumulonimbus rear of sea breeze front. But the gust front spreading was small to the real one.

Doppler lidar had identified the horizontal and vertical structure of these fronts. The simulated structure by JMA-NHM can be compared with Observation. The knowledge of the representation of simulation leads to improve forecast accuracy. We would like to go on to investigate the similarities or difference between simulation and observation of these front structures.

Keywords: convective cloud, local front, numerical simulation

AAS01-05 Room:423 Time:April 30 10:10-10:25

Numerical simulations using WRF model for reproducing localized delay signals derived from InSAR

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For elucidating the mechanism of meso-scale phenomena involving a phase change of water molecule, water vapor is one of the most important but poorly understood parameter in meteorology. Recently, the Global Navigation Satellite System (GNSS) are routinely used to provide near-real-time estimates of PWV (Foster et al., 2005) and to assimilate routine weather forecasts (e.g. Nakamura et al., 2004). However, the limitation using GNSS atmospheric delay for meteorology is its spatial resolution, for example about 20 km for the Japanese GNSS network (GEONET). Interferometric Synthetic Aperture Radar (InSAR) phase signals, which can detect surface deformations with high-spatial resolution, are affected by earth's atmosphere like GNSS. Therefore, InSAR can detect water vapor distribution with high spatial resolution without any surface deformation signals or other errors and thus is potentially useful for meteorological applications. In previous studies, Hanssen et al. (1999) showed the coincidence between water vapor signals detected by InSAR and spatial distributions of rainfall echo detected by a weather radar (WR), indicating the possibility of InSAR as a water vapor sensor. Kinoshita et al. (2013) showed the water vapor distribution during the heavy rain event using ALOS/PALSAR emergency observation data. They conducted the estimation of the three-dimensional (3D) water vapor distribution and performed numerical simulations by means of the Weather Research and Forecast (WRF) model, which could reproduce a convective system observed as a localized signal in the InSAR image. However, there were still few cases detecting localized water vapor signals with InSAR and few studies using InSAR for meteorological applications.

In our past presentations, we reported several case studies detecting localized water vapor signals associated with deep convective systems with InSAR derived from ALOS/PALSAR data (Kinoshita et al., JpGU 2013), some of which reached over 20 cm in the line-of-sight direction within 10 km square. Observed locations of these interferograms are at Niigata (two cases), Shizuoka, Kyoto, Saga and Miyazaki. These signals are equivalent to about 21 mm in the precipitable water vapor, and are higher than that around each signal. Each signal located at the very location of high rainfall intensity in the WR data, and is regarded as including few ionospheric effects because of the use of PALSAR data with descending orbit. Such localized signals strongly suggest the existence of developed convective systems at SAR observation time. However, it is difficult to elucidate mechanisms of phenomena that caused these localized signals.

In this study, we will perform numerical simulations using the WRF model for the purpose of investigate mechanisms of these phenomena and compare simulation results with derived InSAR data. At the presentation, we will show these results and discuss them.

Keywords: InSAR, Water vapor, WRF, Propagation delay, Numerical simulation

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AAS01-06 Room:423 Time:April 30 10:25-10:45

Development and Observation of the Phased Array Radar at X band

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A new Phased Array Radar (PAR) system for meteorological application has been developed by Toshiba Corporation and Osaka University under a grant of NICT, and installed in Osaka University, Japan last year. It is now well known that rapidly evolving severe weather phenomena (e.g., microbursts, severe thunderstorms, tornadoes) are a threat to our lives particularly in a densely populated area and the number of such phenomena tends to increase as a result of the global warming. Over the past decade, mechanically rotating radar systems at the C-band or S-band have been proved to be effective for weather surveillance especially in a wide area more than 100 km in range. However, rapidly evolving weather phenomena have temporal and spatial scales comparable to the resolution limit (-10 min. and -500m) of typical 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 observations 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 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 initial observation campaign was conducted in Osaka urban area with Ku-band Broad Band Radar (BBR) network, C-band weather radar, and lightning location system. The initial comparison with C band radar system shows that the developed PAR system can observe the behavior of the thunderstorm structure in much more detail than any other radar system. The observed high temporal resolution images of the severe thunderstorm are introduced, showing the potential capabilities of the PAR system. The correlation coefficient of the reflectivity in PAR with C band radar ranges from 0.6 to 0.9 as a function of the distance from the PAR.

Although the phased array radar system using the digital beam forming technique can estimate the 3 dimensional structure of the precipitation system within 10 to 30 seconds with 100 meter resolution, the observation results also shows the received signal was seriously contaminated by the relatively high received power from ground clutter and strong precipitation echoes through the side lobes of the transmitting beam. To avoid this problem, a beam forming technique using the MMSE (Minimum Mean Square Error) formulation was proposed and tested. This approach can adaptively mitigate the masking interference that results from the standard digital beam forming method in the vicinity of ground clutter and strong precipitation area. The proposed method is compared with the standard beam forming technique by applying to the huge raw IF signal data digitized at each 128 antenna elements. The results show that the proposed technique can correctly estimate the precipitation echo within a few dB even in the presence of a strong ground clutter that is more than 20 dB higher than the precipitation echo with 15 pulse repetition number. The MMSE based technique is shown to be superior to the standard DBF scenarios under the small number of pulse repetitions to achieve the rapid scanning.

Keywords: Phased Array Radar, Precipitation

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AAS01-07 Room:423 Time:April 30 11:00-11:15

Descending reflectivity core analysis by Ku-band radar

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In order to observe extreme weather such as localized heavy rainfall, tornado etc., we installed a Ku-band radar in Musashino-shi, Tokyo in 2011. Since the radar can create a 3D volume scan per minute, we expect that the data observed by the radar will contribute to understanding mechanisms of such phenomena.

In our research, we defined a cell as an area whose reflectivity is $\geq$ 25dBZ, and a core as a reflectivity peak in the cell. The procedures of the cell/core detection are as follows: 1) conversion from rθ data to xyz data, 2) cell detection by binarization and labeling, and 3) core detection by method of steepest descent(ascent).

In this presentation, results of an automatic cell/core detection algorithm will be shown.

Keywords: descending reflectivity core, Ku-band radar, fast scan radar, extreme weather

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AAS01-08 Room:423 Time:April 30 11:15-11:30

Influence of urban heat excess on heavy rain environment

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There are several observed fact that cities give influence on the precipitation, or cumulus generation. However the mechanism of urban influence on precipitation is not clarified. There would be three physical processes. Buildings could form updraft through a roughness effect. Much heat excess from cars, air conditioners and asphalt roads could also form updraft. Urban aerosol can be a condensation nuclei and gives chance to form cloud, however too much nuclei should suppress cloud droplets growing.

This study focuses on the heat effect. We measured surface sensible heat flux in urban, suburban and rural areas, and evaluated the urban heat excess quantitatively. The resulted heat excess amount was used to in calculation of atmospheric stability index.

In the heat flux measurement, the eddy correlation method which should be the most reliable way of heat flux measurement was used at the rural and suburban site. At urban site, we used the scintillation method which has a advantage of larger scale of measurement (km scale) than that of the eddy correlation method (100 m scale). The reason for taking scintillation method at urban site is severe heterogeneity in urban area. Urban area is mosaic of buildings, roads, parks, bare soil on the school ground field, and sometimes rivers or channels. Scintillation method enable us to measure the area-averaged heat flux in the urban heterogeneity. We used a modified scintillation method which takes into account of surface unevenness by the buildings. We operated measurement site for three years and analyzed a hourly composite of 50 fine days in July. As a result, urban heat flux is largest followed by suburban and rural. The difference between urban and rural was 140 Wm-2 at noon time.

We evaluated CAPE index for each site. We used simple 1D model to calculate the change of temperature profile by the surface flux. The morning initial condition to calculate daytime growing of mixed layer was acquired from the sonde observation. We adopted same initial profile for urban, suburban and rural, and give observed surface heat flux for each. This way of analysis evaluates thermal influence of land-use on CAPE index. The CAPE at 1500 LST is largest in cities and the difference between rural and city is 15%.

Keywords: heat island, urban climate

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AAS01-09 Room:423 Time:April 30 11:30-11:50

OROGRAPHIC PRECIPITATION OBSERVATION IN JEJU ISLABD, KOREA (2012-2013)

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In summer monsoon season, a Korean Peninsula is influenced by several weather phenomena such as the Changma-front, typhoon, strong low pressure, and local heavy precipitation. Especially, the orography plays an important role in controlling the cloud formation, amount and precipitation distribution. To find out the precipitation development mechanism by orographic effect, we performed the intensive field observation around Mt. Halla in Jeju island (33.21 N and 126.32 E, width 78 km and length 35 km) which is located at the southern part of Korea with JNU (Jeju National University), KNU (Kyungpook National University), IJU (Inje University), KMA (Korea Meteorological Administration), and NIMR (National Institute of Meteorological Research). We installed and arranged the observational instruments such as, AWS, radiosonde (including mobile sonde and ship sonde), Parsivel, 2DVD, ultrasonic anemometer, and raingauge along the altitudes in Jeju island. Each disdrometer sites were located in straight line considering topography between two S-band Doppler radars. We analyzed synoptic condition by NCEP/NCAR reanalysis data and kinematic characteristics of precipitation by dual Doppler radar analysis using S-band radars in KMA.

In 2012 case, the Changma-front was located in the northern part of the Jeju island and the precipitation system passed from the southwest to the northeast. The accumulated precipitation (31.7 mm) was recorded at the site PR4 which was placed in the highest (H: 975 m). During the passage of precipitation, the south westerly wind (>12 m s^{-1}) with warm and humid air and the cold (lower layer) and warm advection (upper layer) were observed. From the microphysical analyses, PR2 (windward side, H: 571 m) and PR6 (leeward side, H: 324 m) sites indicated high rain rate about 60 to 75 mm hr^{-1} by orographic effect.

In 2013 case, the Changma-front located in the center of Jeju island and precipitation system passed from the southwest to northeast. The warm advection in lower layer and cold advection in upper layer were observed by radiosonde analyses, relatively. Strong southwesterly winds were blown with moist environment in surface layer. By the wind field analysis, convergence in west and divergence in east were existed and updraft in Jeju island and downdraft in ocean area, relatively. High number concentration at PR4, 5 and PR8 were shown with small size raindrops (less than 2 mm), however large size raindrops (lager than 6 mm) were distributed at PR7(northeast in island) and PR9(southwest in island).

Keywords: Orographic precipitation, intensive field observation, Jeju island

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AAS01-10 Room:423 Time:April 30 11:50-12:05

Characteristics of distribution and preceding surface conditions of cumulonimbus clouds appeared on Kofu Basin on a calm

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On a calm summer day, cumulonimbus clouds often appear on complex terrains with the thermal induced local circulations. The appearance of such cumulonimbus clouds on a basin is not so frequent ordinarily. Once a cumulonimbus cloud appears on a basin, it often brings much rainfall in a short time, which becomes triggers of weather related disaster in urban city on a basin. However, the characteristics of the generation of cumulonimbus clouds on a basin and the conditions in a basin preceding the generation of them have not been known enough. In this study, for the example of above situation, we analyze the distribution of the appearance of cumulonimbus clouds on Kofu Basin and the conditions in Kofu Basin preceding the appearance of them.

The days of the appearances of cumulonimbus clouds on Kofu basin in a calm day confirmed by the observation of X-MP radar of University of Yamanashi (UYR) were 8 days out of 1 July to 30 September on 2012. Although the number of the events was limited, they brought large rainfall amount of 20 to 30 mm in an hour. The positions of the appearance concentrated from center to eastern side on Kofu Basin.

Before the appearance, south-southwesterly (SSW-ly) and southeasterly (SE-ly) surface wind was measured on western and eastern sides on Kofu Basin, respectively. When SSW-ly or SE-ly wind expanded to reach Kofu city that locates center of Kofu Basin, surface equivalent potential temperature (θe) increased. From The meso-scale objective analyzed data of Japan Meteorology Agency (JMA-MANAL) shows strong south-component wind with high-θe toward Kofu Basin from Suruga Bay through a valley connecting Suruga Bay to Kofu basin at the level of about 900 hPa. At the eastern side of Kofu Basin, strong east-component wind with high-θe crossing the mountains on the eastern side was appeared. Then, the south-component wind and the east-component wind formed horizontal convergence on Kofu basin. So, we consider that, the winds entering from the outer side of Kofu Basin, conditional instability intensified and horizontal convergence formed in Kofu Basin, which played a role as trigger of precipitating cell on Kofu Basin.

Keywords: Cumulonimbus cloud, Kofu Basin, Conditions preceding the appearance of a cumulonimbus cloud

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AAS01-11 Room:423 Time:April 30 12:05-12:25

Transition to resilience to extreme weather ,high-resolution monitoring and international synergies

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Transition from high vulnerability to extreme weather to resilience is a major challenge for megacities in response to two main drivers: urban sprawling and climate change. The functioning of cities, particularly the large ones, should be observed, understood, simulated and monitored on much larger ranges of scales than usually done. This requires at first observations of many geophysical fields with an unprecedented resolution to achieve high-resolution monitoring. However, this also require an advanced understanding/modeling of the nonlocal interactions between large and small scales, e.g. between weather and climate scales.

Finally, this pleads in favor of methodological approaches across scales, rather than over very limited ranges of scales. Such methodologies aim in fact to quotient out non trivial symmetries and therefore should enable us to dig out the relevant information from otherwise under-exploited big data.

Such approaches have been often invoked, but barely achieved because they correspond to formidable tasks that require an unprecedented development of international cooperation on both advanced technologies and methodologies. We will illustrate these questions with examples of research and innovation programs on flood resilience which seem rather complementary across national boundaries but require nevertheless much stronger international synergies.

Keywords: extreme weather, cities, resilience, high-resolution, synergies, international

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AAS01-12 Room:423 Time:April 30 12:25-12:40

The effect of scaling anisotropy on weather extremes

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Predicting extreme weather events in and around cities is far from straight forward. Even in a stable and unbounded atmosphere, crude numerical approximations of the Navier-Stokes equations are required for reasonable computation times. Hence, numerical simulations of the weather in and around cities become even more complex, and therefore require much coarser space and time scales to model both the macro weather and the complex boundary conditions created by buildings and other urban structures. Such models will severely underestimate extremes due to the necessary truncation of scales to deal with these additional complexities.

While progress in numerical simulation depends on the next fastest processor, measurement techniques on the other hand are becoming rapidly more and sophisticated. There appears however to be a gap forming in the ability to utilise the enormous datasets produced from new measurement techniques. This seems mainly due to outdated statistical methods that are used to make sense of these overwhelming databases.

In this study we propose a method, based on the structure function, that allows one to easily estimate the Levy index α of the wind. We show that due to the complex nature of a three-dimensional wind a rotated frame of reference is necessary in order to obtain a universal multifractal structure function exponent. We show that the angular dependency of the scaling exponent results in either an increase or decrease in dimension. This increase or decrease in dimension causes a first or second-order phase transition respectively. The kind of phase-transition that occurs is directly related to the generation of extremes of the wind.

The combination of this kind of analysis with the advancements in measurement techniques that are coming to light should allow for the better prediction of extreme weather events in and around cities.

Keywords: Extremes, Weather, Universal Multifractals, Wind, Anisotropy, Scaling

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AAS01-13 Room:423 Time:April 30 14:15-14:30

The Impacts of extreme weather on urban water bodies

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In the event of heavy rainfall, large amounts of storm water will carry roof runoff pollutants into urban lakes. This kind of discharge not only changes the dynamics of the lake (i.e. the mixing processes that occur) but also complicates ones ability to predict pollutant concentrations. Being able to quantify these changes in pollutant during and after extreme weather events is important for water quality management.

In the interest of understanding the impact of extreme weather events on water bodies, we set-up an Acoustic Doppler Current Profiler (ADCP) next to a storm water discharge point at the bottom of a shallow urban lake in Creteil, a region in Paris.

The ADCP is particularly useful for analysing the turbulent boundary-layer (TBL) during these extreme weather events as it is able to measure the 3D velocity, in 127 vertical cells, over 3 meters. This is a unique situation compared to the atmospheric boundary-layer where profilers are typically coarsely spaced in the vertical.

To analyse the TBL dynamics we look only at the scaling properties of the velocity field. If the velocity is scaling the log-log plot of the energy spectra will be linear in wavenumber (or frequency). The slope of the log-log plot of the spectra gives the spectral scaling exponent. Performing the analysis we find a spectral exponent close to -1. Dimensional arguments suggest that this exponent occurs when the energy flux becomes dependent on the friction velocity instead of the length scale; likely a result of the strong inflow during extreme rainfall events. The ADCP data allows us to observe a smooth transition from a free stream turbulent regime (-5/3) to a bounded-turbulent exponent (-1) through depth.

This kind of analysis suggests the possibility for a general scaling model of the TBL that can be used to predict the mixing of pollutants during and after extreme weather events.

Keywords: Urban Lake, Turbulence, Extreme Weather, Boundary-Layer

AAS01-14 Room:423 Time:April 30 14:30-14:45

Statistical Analysis of Large Drop Occurrence and Its Effect on Drop Size Distribution

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A large data set of raindrop size distribution (DSD) measured by 2-Dimensional Video Distrometer (2DVD) on 12 locations in Japan is analyzed using the truncated modified gamma DSD model and the normalized gamma DSD model. The present study seeks to: 1) explore the general properties of DSD observed at Kanto, Hokuriku, Nagoya, Kinki and Kyushu in Japan; 2) find the governing parameters of DSD models in different geographycal and seasonal regime; 3) statistics of big drops occurrence and instrinsic shape of the DSD with extremely large drops; 4) find relationships between DSD parameters such as the shape and slope parameters, the generalized intercept parameter and volume-weighted mean diameter, and etc. The present study on stratistical analysis of DSD provide us information which is nesessary to understand big drop microphysics and precipitation.

Keywords: large drop, DSD, 2DVD

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AAS01-15 Room:423 Time:April 30 14:45-15:00

A Social Experiments on Disaster Prevention by Using of the Advanced Weather Information

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The National Research Institute for Earth Science and Disaster Prevention has been carried out the research project on Tokyo Metropolitan Area Convection Sturdy for Extreme Weather Resilient Cities(TOMACS) in cooperation with 25 research agencies, researchers of more than 100 people and disaster management personnel of local governments. In this project we have been working on the following three research subjects.

(1) Studies on extreme weather with dense meteorological observations

(2) Development of the extreme weather early detection and prediction system

(3) Social experiments on extreme weather resilient cities

The study fields by the social experiment are Rescue Services (Tokyo Fire Department), Risk management(Edogawa ward,Yokohama city, Fujisawa city, Minamiashigara city), Infrastructure(JR East,JR Central, Obayashi) and Education and life(Toyo univ., The Certified and Accredited Meteorologists of Japan). In the social experiments, the each participated institutions have studied on the effective use of advanced weather information into disaster prevention according to their purposes.

The objective of social experiments are to enable the continous use of advanced weather information through the fixing of the monitoring and prediction system of extreme weather.

And also to discuss the problems and issues revealed in the course of social experiment, and to summarize as creating resilient city in extreme weather towards relevant government ministries and agencies, local government, the general population.

In this paper, overview of the social experiments is briefly explained and issues for continue use of advanced weather information are reported through the reference to the case of Edogawa-Ward where the X-band MP radar rainfall information is providing to residents. Finally this project is supported by the Japan Science and Technology Agency and Ministry of Education, Culture, Sports, Science and Technology.

Keywords: Extreme weather, Disaster prevention, Social experiment

AAS01-P01 Room:Poster Time:April 30 18:15-19:30

Analysis of meso-gamma-scale convection in tropical regions using GPS meteorology

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In tropical regions such as Indonesia, strong wind with severe shower called squall occurs frequently, and has a large impact on residents in a rainy season. To predict accurately local heavy rain (occurring in a short time and in the range of a few km) is difficult today. Therefore, it is important to understand generation and development mechanism of the meso-γ-scale convection that leads to locally heavy rain.

"GPS meteorology" is a method to obtain the "atmospheric information" such as water vapor from atmospheric delay of radio waves based on a satellite "positioning error". We can estimate precipitable water vapor (PWV: integrated amount of water vapor along the zenith direction) with a high time resolution by using this method. Occurrence of rainfall associated with the meso-γ-scale convection has good correlation with the spatial non-uniformity and temporal variation of PWV estimated by the GPS meteorology technique (GPS-PWV).

The purpose of this study is to find out the generation mechanism of meso-γ-scale convection in the tropics by focusing on the GPS-PWV.

We analyzed GPS-PWV, radiosonde and rainfall data obtained from the campaign which was conducted during the rainy season of 2013 in Bandung, Indonesia.

We carried out accuracy validation of GPS-PWV by analyzing the radiosonde data. As a result, the rainfall data showed that precipitation occurred often in the late afternoon together with an increase of PWV. Furthermore, we found the daily cycle of PWV showing minimum and maximum values in the morning and late afternoon, respectively. In addition, there is a difference in an altitude of more than 1000 m in each observation point. The difference has a severe influence on GPS-PWV. Therefore, it is need to correct altitude difference effect.

Keywords: GPS meteorology, local heavy rain, meso-gamma-scale convection, tropical regions, Indonesia

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AAS01-P02 Room:Poster Time:April 30 18:15-19:30

Development of high resolution spatio-temporal precipitation data using a network of polarimetric X-band radars in Japan

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Localized convective precipitation develops rapidly in a very short time and is conducive to extreme local rainfall amount. The X-band polarimetric radar is useful to analyze the convective precipitation because it can provide us polarimetric radar parameters which are useful to understand microphysical process in the precipitation. However, the radar observation has some limitations in detecting initial stage of rapidly developing convective cell; the radar volume scan strategy adopted in operational radar is 5 minute interval which is not enough for measuring rapidly developing convective precipitation. To detect the early stage of convective cell, we developed the algorithm which is based on the interpolation method both in space and time. The algorithm reproduces higher resolution spatio-temporal volumetric data using the operational network of four X-band polarimetric radars. The mosaic of multiple radars could be benefit for increased sampling into a certain volume. In addition, different scan strategy at each radar also improve spatio-temporal resolution. The algorithm is applied to radar data of convective precipitations observed in Kanto area in 2012. The new volumetric data can recognize more detail about echo which developed rapidly and detect the first appearance of convective echo at upper layer. Early detection of convective precipitation at upper layer can be useful for nowcasting or very short-term forecasting.

Keywords: convective cell, X-band polarimetric radar, high resolution precipitation data

AAS01-P03 Room:Poster Time:April 30 18:15-19:30

An Ensemble Nowcasting of Rainfall over the Kanto Region, Japan

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Every year weather-related disasters: extreme rainfall, landslides and flooding destroy livelihoods and damage economics somewhere on the planet. Recently, number of flash flooding is believed to be increasing specially in urban areas. It has being a great challenge to forecast flood warning and urban drainage management. Nowcasting of rainfall (very short-range forecasting) is an important tool to minimize or manage all these weather-related disasters since precipitation is the main input. Common practice to forecast heavy precipitation for hydrological application varies from 0-6 hr and there are different kinds of nowcasting based on different method.

Nowcasting of rainfall comprises the detailed description of the current weather along with forecasts obtained by extrapolation for a different time period ahead. In this study, we focus on ensemble nowcasting of rainfall. It refers to the fact that many forecasts are produced, with the rainfall areas moving at slightly different speeds, and with the small rainfall features represented by slightly different random statistics. By comparing these different nowcasting of rainfall, the forecaster can decide how likely a particular weather event will be. It gives a much better idea of what weather events may occur at a particular time. Short Term Ensemble Prediction System (STEPS), one of the most advanced Quantitative Precipitation Forecast (QPF) systems currently available is considered for nowcasting of rainfall. Japan Meteorological Agency (JMA) and X-band multi-parameter (MP) radar data were considered to produce an ensemble nowcasting of rainfall. First, JMA radar rainfall data of Kanto region was fixed to check the performance of STEPS. Skill scores showed that STEPS can give a good forecast for less than one hour. However, more uncertainties can be seen during the starting and ending of rain event. High resolution of data (MP data) also used in the STEPS under the default condition. Overall, an ensemble nowcasting of rainfall seems close with real time data, which could be interesting to use them in hydrological model.

Keywords: nowcasting, ensemble, weather radar, extreme rainfall, STEPS, hydrological model

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AAS01-P04 Room:Poster Time:April 30 18:15-19:30

X-band polarimetric radar and C-band conventional radar composite rainfall map with high spatio-temporal resolution

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Radar with shorter wavelength such as the X-band (3-cm) wavelength has several advantages compared to C- and S-band radar. First, X-band wavelength radar has high sensitivity of the specific differential phase of the rain rate. Second, it is possible to achieve finer spatial resolution more economically; for example, X-band wavelength radar can achieve a 1 degree beam width with a 2 m diameter parabolic antenna, while S-band needs a 7 m diameter antenna to achieve the same beam width. Third, due to advantage number two, X-band radar is easier to setup in mountainous areas, and at lower cost compared to S- and C-band wavelength radar. In Japan, success in the detection of torrential rainfall that occurred in Tokyo in 2008 triggered the deployment of 35 operational X-band polarimetric radars in major urban cities by MLIT. This radar network named XRAIN provides rainfall information with high spatio-temporal resolution. In US, the X-band polarimetric radar network is constructed in Dallas Fort Worth, which is a research and innovation network linking academic researchers, local stakeholders, and industry to address water issues as they relate to urban sustainability. In Europe, The project named RAINGAIN is ongoing to improve fine-scale measurement and prediction of rainfall and to enhance urban pluvial flood prediction. Activities include the implementation and use of advanced radar technologies (X Band) in Leuven, London, Paris, and Rotterdam. Although X-band polarimetric radar has the advantages mentioned above and used in hydrological applications, there are essential disadvantages. First, the maximum range is shorter than that of C-band and S-band radar; maximum ranges of 200km or 300km are easily obtained in case of C- and S- band radar, while that of X-band radar is limited to 30km-60km. Second, signal extinction area which is defined as the area where the received signal is below the receiver noise level occurs behind heavy rainfall areas. These disadvantages will be a fatal flaw when extremely heavy rainfalls occur. Authors have experience that the maximum observation range of X-band radar was shorter than 3km when heavy rainfall passed over the radar site. The present paper aims to develop an algorithm to overcome these disadvantages. The method is based on the C-band and X-band radar composite map which attains the 1 minute time resolution and 250m spatial resolution by the interpolation method. The algorithm is applied to the heavy rainfall case observed on 12-14 July, 2012 in northern Kyusyu, Japan. The algorithm is validated with surface raingauge network: the composite radar rainfall estimation agreed well with raingauge data.

Keywords: polarimetric radar, X-band, precipitation, high resolution, MP radar