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

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

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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

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

Japan Geoscience Union Meeting 2013
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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

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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

Japan Geoscience Union Meeting 2013
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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

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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

Japan Geoscience Union Meeting 2013
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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

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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

Japan Geoscience Union Meeting 2013
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AAS23-P08 Room:Convention Hall Time:May 23 18:15-19:30

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

AAS23-P09 Room:Convention Hall Time:May 23 18:15-19:30

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

AAS23-P10 Room:Convention Hall Time:May 23 18:15-19:30

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

This research was conducted under a contract of R&D for radio resource enhancement, organized by the Ministry of Internal Affairs and Communications, Japan.

Keywords: weather radar, observation system

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

AAS23-P11 Room:Convention Hall Time:May 23 18:15-19:30

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