Numerical simulation of a local wind, Hijikawa-Arashi, by use of JMANHM

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“Hijikawa-Arashi” is one of the most famous local wind in Japan and occasionally observed at the estuary of Hjijikwa River in Ehime prefecture in the morning of the autumn and winter seasons. A land breeze of a cold air formed in the night in the Ozu basin, which locates upstream of the Hijikawa River, flows thorough a very narrow valley whose width is several hundreds meters. This flow may cause a hydraulic jump accompanying a strong surface wind near the estuary in the downstream of the valley.
This study conducts fine resolution numerical simulation by means of a regional weather prediction model, Japan Meteorological Agency’s Non-Hydrostatic Model (JMANHM), which include realistic topography and cloud physics, and so on, to simulate several real cases of Hjijikawa-Arashi. The Meso-Analysis provided by JMA (MANL) is used for initial and boundary conditions.
When horizontal resolution is 400 m that can vaguely represent topography of the valley and basin while vertical resolution is 40 m, the moderately strong winds (~10 m/s) occur near the estuary, but the fog do no form at all in the basin. If the vertical resolution is improved to be 10 m, the model does form a radiation fog in the night. Due to the longwave radiation, the air in the basin become further cool by 5 K, and stronger surface winds near the estuary occur. Furthermore, we increase horizontal resolution up to 80 m. In the fine resolution run can simulate the realistic Hjijikawa-Arashi: strong winds near the estuary accompany the fog formed in the basin.
A vertical cross-section along with Hijikawa River is analyzed, and we do see characteristics of the hydraulic jump in the downstream of the narrow valley. We will also compare with available aerial videos and surface observations of wind speeds at the estuary for one of the simulated case.
Acknowledgement
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Keywords: Regional weather prediction model, Local wind, Fog, Micro-scale meteorology

Sea breeze analysis on LES simulations and the particle trace calculations in MM21 district

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We have performed thermal and wind environment LES simulations in MM21 district in Yokohama. The used simulation model is MSSG (Multi-Scale Simulator for the Geo-environment). The spatial resolution is about 5m in horizontal and vertical axis. We have also performed the particle trace analysis in order to investigate the route of the sea-breeze. We have found the cool wind is gradually warmed up as flowing into the district, then it blows up and is diffused. We will discuss the diffusion coefficient in comparison with the several cases of vegetation and the DHC (District Heating & Cooling) system in the area.

Keywords: Thermal and wind environment simulation, particle trace

Development of low-cost meteorological detecting system for poor visibility occurred by snowstorm

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1. Background
Snowstorm occurs frequently in winter of cold regions. Occurring the poor visibility with the snowstorm, we might die getting lost, and sometimes a car crash also causes. Depending on weather conditions, a dangerous situation can be created called as whiteout. About the whiteout, however, the definition remains ambiguous, and there is no sufficient explanation in physics. On the other hand, the snowstorm has been well explained by many researchers; the snowstorm refers to a condition in which snow particles move by the strong wind. The snowstorm generation condition is below; the temperature is less than 2.0 ℃, the wind speed is more than 5.0 m/s, in general. To avoid the accidents due to the snowstorm, some studies for snowstorm danger alert system have been reported. However, there are some problems in the monitoring of the poor visibility, using video analyses or using visibility-meters, because these systems require constantly video monitoring and the cost is high. Although the risk of snowstorm (whiteout) has been forecasted from the entire weather situation, we have to develop further local observation network, because the snowstorm itself depends largely on the local terrain and local weather.
2. Purpose of this study
In this study, we have developed the low-cost meteorological detecting system for poor visibility occurred by the snowstorm or the whiteout. This work is the first step for setting up the observation network to minimize the weather disaster suffered by the poor visibility.
3. Summary of system
On the basis of the weather conditions of the snowstorm generation (the wind speed 5 m/s over and the temperature below 2 ℃), the first step was to develop the poor visibility detecting system within the total cost of 20,000 yen. The features are follows.
Battery driving to measure the temperature and the wind speed, and to send the detecting data by wireless apparatus (Xbee). This is for micro-scale meteorological measurements in the near future.
The system to measure the change of visibility by using the intensity changes of semiconductor laser.
Especially, relating to the 2), we measured the intensity of laser, which was placed at a distance of 2-20 m. We found that the laser should be set within 10m from the photodetector, considering from the signal-to-noise ratio. We also checked our developing system using video recording, and we found that it can be the alternative for visibility meter.

Keywords: snowstorm, poor visibility, disaster prevention, whiteout

Multi-point meteorological observation for Cross-country skiing

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On the performance in cross-country skiing, weather data, such as the temperature, the humidity, and the snow surface temperature, is essential information to select the wax that is covered to reduce the friction between the ski and the snow surface. Generally, the wax is empirically selected from the judgment of weather data measured in one place of competition venue. The above mentioned weather conditions, however, are must be different between the sunny and the shade place, and depend on the degrees of wind speed. Therefore, judging from the weather data obtained at a specific area, we should not select the wax. The whole weather data on the cross-country course are needed.
To compensate for the drawback, the simulation softwares have been used to estimate the snow temperature on the course; the idea has been adopted in a foreign national team. Since it has been estimated from meteorological measurements at very limited position, it is unclear whether the simulated data is consistent with the actual weather conditions. Thus, if we could analyze the weather based on multi-point observation, the wax can be scientifically selected and we can make the strategy of the race.
This study aims 1) multi-point meteorological observations, and 2) measurements of the coefficient of dynamic friction for cross-country skiing. In this study, we focused on 1).
We have developed a multi-point meteorological observation system which can record every minute, temperature, humidity, illuminance to judge whether it is sunny place or not, and wind speed which affect snow surface condition in actual cross-country skiing course (Hokkaido, Date-city). We made ~60 sets of the above sensors, and set up the observation system on the actual course. Observed meteorological data was recorded through the collection in a coordinator (Arduino) and through the sending by wireless communication (XBee pro). Next, we discuss the way to select optimal wax in comparison the actual meteorological data with the simulated using software (snowpack).

Keywords: Multi-point observation, Cross-country skiing, Wax, XBee, snowpack

Spatially and temporally dense monitoring of global solar radiation using solar panels

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1. INTRODUCTION

In recent years, factors such as climate change and unplanned land use might have resulted in intense and frequent localized torrential rainfall in urban areas. Thus to understand about these urban phenomena, much attention has been paid on urban local climate. The magnitude of the solar radiation becomes an index of the thickness of the cloud aloft. However, there are many difficulties in measuring the amount of solar radiation with high spatial resolution due to the limitation of the number of the meteorological observatories. Large scale cloud information is available from satellite observations, but such data might be provided in a low resolution and may contain error. According to Long et al. 2006, it is difficult to determine the solar obstruction from the satellite sensor which is of utmost importance in radiation/cloud studies. Thus the use of solar panels as a solar radiometer can be a solution to such problems.
The use of solar panels has been increasing from houses, commercial building and schools, and thus, the main objective of this study is to propose a method to estimate the global solar radiation using the Photovoltaic (hereafter PV) system. The temporal variation pattern of the solar radiation and PV power of the solar panel is in high agreement with each other which indicates that the estimation of the global solar radiation using a PV system might be possible. The proposed method was further validated using dataset of the pyranometer observation.

2. METHODOLOGY

Solar panels (single crystal hybrid module VBHN233SJ01A manufactured by Panasonic cooperation) were installed on the rooftop of Engineering building, Ehime University, Matsuyama (132.771509 E, 33.850238 N). The solar panels were installed horizontally and at a tilt angle due south. A dataset of pyranometer was used to validate the proposed method for the estimation of the global solar radiation. In order to incorporate the effects of environmental factors, power ratio is corrected using a conversion factor for the estimation of the global solar radiation.
The PV power of solar panels installed at an inclination is considered to be proportional to the amount of solar radiation on the slope. Therefore, to estimate the global solar radiation, it is necessary to convert the solar radiation on a slope to the global solar radiation on a horizontal plane. Thus, for this conversion the separation of the solar radiation into the direct beam solar radiation and the diffuse solar radiation was conducted.

3. RESULTS AND REMARKS

In the case of horizontally equipped solar panel, once a calibration parameter was attained using one day in one season, solar radiation estimated from photovoltaic generation using the parameter highly agreed with measured data in other days. The good performance was not only fair weather days but also for other cloudy days. In the case of tilted solar panel, it was demonstrated that the conversion using direct/scatter separation improved the estimation. The validity of the method proposed for the estimation of global solar radiation using solar panels at a tilt angle of 20deg and 30deg was also confirmed with high correlation.
The spatial distribution of global solar radiation was obtained from the datasets of power generation of solar panels installed at 25 locations in the Matsuyama and compared to images of sky camera and the direct and scattering pyranometer. While the spatial variation of solar radiation

under clear-sky days or cloudy days (stratus covering) was small, that under partially fair weather days (cumulus existing) clouds was large. The place where the solar radiation is locally small corresponded to clouds observed by sky camera. The estimation provided in this study is promising for monitoring of spatial and temporal variation of short wave radiation.

Keywords: solar radiation, solar panel, local climate

Nocturnal Temperature Distribution under Fine and Weak Wind Conditions Based on Spatially High Density Observation Data in the Tokyo Metropolitan Area: Features in Summer

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Temperature distribution in urban areas varies in response to factors such as daily weather conditions and interactions with local wind systems such as land and sea breezes. In the present study, we first examined the variability in the nocturnal temperature difference (*TD*) between central Tokyo and the outside of Tokyo wards area in summer. We considered *TD* in terms of weather conditions (cloud amounts, wind speed, water vapor content and solar radiation during the previous daytime) using the hourly meteorological data from five summers (2006–2010). We next analyzed characteristic features of the nocturnal temperature distribution in and around the Tokyo wards area using datasets from spatially dense observation networks (208 observation stations) for three summers (2006–2008). During the analysis, we focused on relations between temporal changes in the nocturnal temperature distribution and those in wind systems. Finally, we compared the results of this study with those of winter nights.
The observation networks used for temperature distribution analyses were the Automated Meteorological Data Acquisition System (AMeDAS) of the Japan Meteorological Agency (JMA), air pollution monitoring system (APMS) of the Tokyo Metropolitan Government and adjacent prefectures, and Meteorological Environmental Temperature and Rainfall Observation System (Extended-METROS). The AMeDAS and APMS datasets were also used to obtain the wind data.
The results obtained in this study are summarized as follows:
(1) According to multiple regression analysis (stepwise method), wind speed and cloud amounts showed equally large effects on *TD* between central Tokyo (Otemachi, JMA) and the outside of Tokyo wards area (average temperature from four AMeDAS stations). This result was different from that of winter nights, indicating that cloud amounts have a larger effect than wind speed on *TD*.
(2) A steep horizontal temperature gradient zone (HTGZ) in the western part of Tokyo wards area was unclear even during nights with fine and low wind speeds in comparison with winter nights, where the steep HTGZ was clear under the same conditions. This may be related to the relatively lower decrease rate of temperature in summer, especially around sunset when the wintertime HTGZ begins to become conspicuous. It is considered that the difference in radiation cooling by season is one of the key factors. In addition, because high-temperature areas tended to remain in the northwestern part of Tokyo wards area in summer, central Tokyo did not become the highest-temperature area until after midnight, which was also different from the findings of winter nights.
(3) To identify effective factors for large differences in *TD* for fine and weak wind nights, the corresponding cases were divided into three categories in accordance with the observed values of *TD* at 04:00 JST just before sunrise. For cases of large *TD*, in which high-temperature areas were concentrated in central Tokyo, inland wind systems initiated relatively earlier and showed a relatively larger wind speed before midnight. Subsequently, the local wind front migrated to the coastal area of Tokyo Bay by early morning. For cases of low *TD*, inland winds were weak, and the local wind front could not be clearly observed. For cases of intermediate *TD*, a large amount of solar radiation and a relatively strong sea breeze system were observed during the preceding daytime. Clear high-temperature areas remained from the northern part of Tokyo wards area to southern Saitama prefecture throughout the night, and the local wind front stagnated in this area. We conclude that the nocturnal *TD* in and around the Tokyo wards area in summer is affected by

inland wind systems and the location of the local wind front.

Keywords: urban heat island, nocturnal temperature distribution, spatially high density observation, Tokyo wards area, summer

Study on Applicability of Mobile Measurement in a High-Density Urban Area -Measurement for Detailed Temperature Distribution in Shinjuku-

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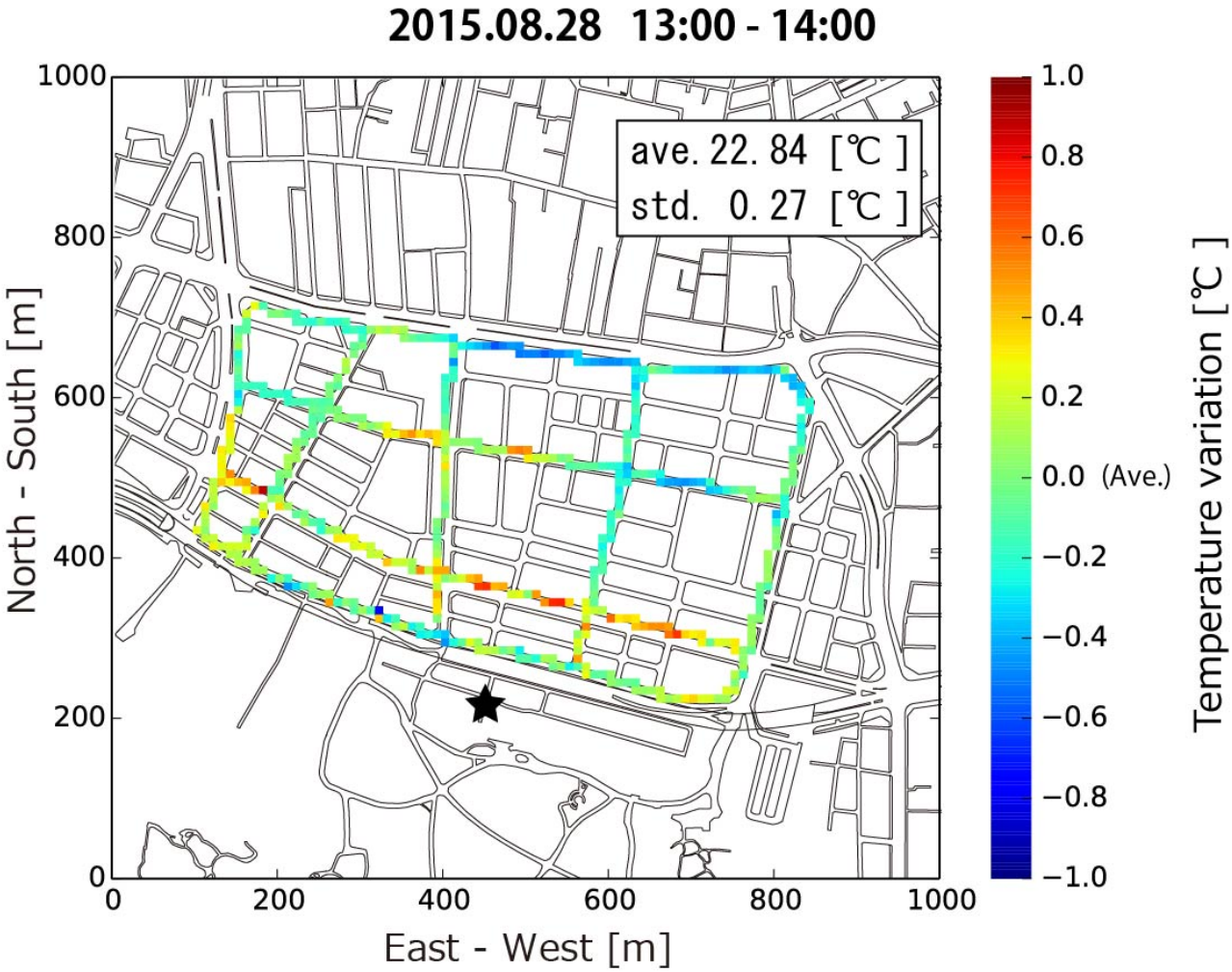
Recently, urban environmental issues related to heat and aerial pollutants have been become more serious. Atmospheric properties such as air temperature, wind velocity, and pollutant concentrations are typically measured at meteorological observation stations. However, due to the low spatial resolution of meteorological observation stations, it is difficult to observe urban environmental issues occurring on a scale relevant to people's daily lives. To overcome this, mobile measurement is an effective method of investigating the distribution of environmental conditions in urban areas. However, there are two problems with mobile measurement. (1) Obtaining accurate position data is essential during sampling. However, due to the reflective properties of building surfaces, Global Positioning System (GPS) data collected in urban areas tends to include a large degree of error. (2) There has not been enough discussion in the scientific community to form a consensus around representativeness of measurement values obtained by mobile measurements. Therefore, in this study, we investigate the range of GPS errors and the spatial distribution of air temperature obtained during mobile measurement in a high-density urban area. We discuss the applicability of the method to a high-density urban area based on results.
The mobile measurement was conducted from August 25-28, 2015 in cloudy days. The measurement site selected is one of the densest urban areas in Japan, several city blocks in Shinjuku, Tokyo. The site, which is essentially laid out on a grid plan, covers an area of 26.2 hectare (ha) and has a mean building height of 17 m. The site is contiguous to Shinjuku Gyoen, a large green space (58.3 ha). To make the measurement, we equipped bicycles with platinum resistance thermometers, a temperature logger, and a GPS logger. Additionally, the bicycle was outfitted with a cycle computer to confirm travelling speed, and a time-lapse camera to record experiment conditions. The sampling interval of the measuring devices is 1 s and the spatial resolution is approximately 3 m (mean travelling speed of the mobile platform is 12 km/h). Additionally, we installed a weather station in Shinjuku Gyoen as, a fixed measurement point, to record weather conditions during the measurement period.
Results showed that the average GPS error in an urban area was 20 m (std: 50 m) when GPS position data was corrected by the method which we developed. Within the site, we identified spatial variations of air temperature on an hourly-average basis. The standard deviation of the variation was approximately 0.2 ºC and the range of the variation was approximately -0.9 to 0.9 °C. We could figure out a general spatial distribution of air temperature when the mesh size of spatial resolution was 100 m. However, a mesh size of 10 m was necessary to observe hot spots in the densely developed urban area. We found the mobile measurement was the effective method in a high-density urban area when GPS position data was appropriately corrected.

Keywords: Mobile Measurement, Urban Area, Spatial Temperature Variation, GPS



Evaluation of radiative effect on the measurement of the surface air temperature by thermometers using the ground-based microwave radiometer

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Radiative effect is inevitable in surface air temperature measurement by the thermometer. Although thermometer screens/shields are used to reduce this effect, impacts remains affected due to influence of radiation on radiation screens/shields. Their characteristics are different for each type of screens/shields. It is considered that reference temperature measurements have little effect of radiation in principle are effective to evaluate to this characteristics. Very thin resistive wire (ISO 2007) and ultrasonic anemometer and thermometer (Lacombe et al. 2011) have been proposed as candidates for measuring the reference air temperature. Brightness temperature of the atmospheric radiation is examined in this study.
Multi-channel ground-based microwave radiometer (MWR) MP-3000A (Radiometrics) measures brightness temperature 14 frequencies in the band of oxygen resonances between 50 and 60 GHz in multiple elevations. The data of strong atmospheric absorption channel (58.8GHz) at minimum elevation angle (9.45 degree) is compared to surface air temperature measured by two thermometers: the platinum resistance thermometer in the artificial ventilated screen (METIC TD-500) and Rotronic S3 temperature and relative humidity sensor in the air-inlet of MWR with an artificial ventilation. The daily boxplot variation of the difference between them is shown in Figure.
Although they display considerable variation, on average variation is small and almost constant in the night time and quite large in daytime with the maximum on around noon. In addition to radiative characteristics of the instruments, the difference of the observation space is possible cause of the difference.
Brightness temperature of the infrared atmospheric radiation indicating a stronger atmospheric absorption should be examined. Comparison with another measurement methods whose radiative effect is small in principle such as very thin resistive wire and ultrasonic anemometer and thermometer is also necessary.
Acknowledgments
The observation at Kagami observation site was supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan under the program of Special Coordination Funds for Promoting Science and Technology, “Japanese Cloud Seeding Experiments for Precipitation Augmentation (JCSEPA)”.
Figure
(a) The boxplot variation of the difference between the air temperature measured by the platinum resistance thermometer in the artificial ventilated screen and the 58.8GHz brightness temperature at elevation angle 9.45 degrees measured by MWR (subtracting the latter from the former) measured in May, 2010 at Kagami observation site, Kochi, Japan. Exclude data with one hour precipitation more than 0.5mm. The line inside the box is the median value. The bottom of the box is the first quartile value and the top of the box is the third quartile. The vertical line from the top of the box extends to the maximum value and the vertical line from the bottom of the box extends to the minimum value. The upper (lower) fence is defined as the third (first) quartile plus (minus) 1.5 times the interquartile range.
(b) Same as (a) but for the difference between the air temperature measured by the platinum resistance thermometer in the artificial ventilated screen and Rotronic S3 temperature and relative humidity sensor in the air-inlet of MWR with an artificial ventilation.

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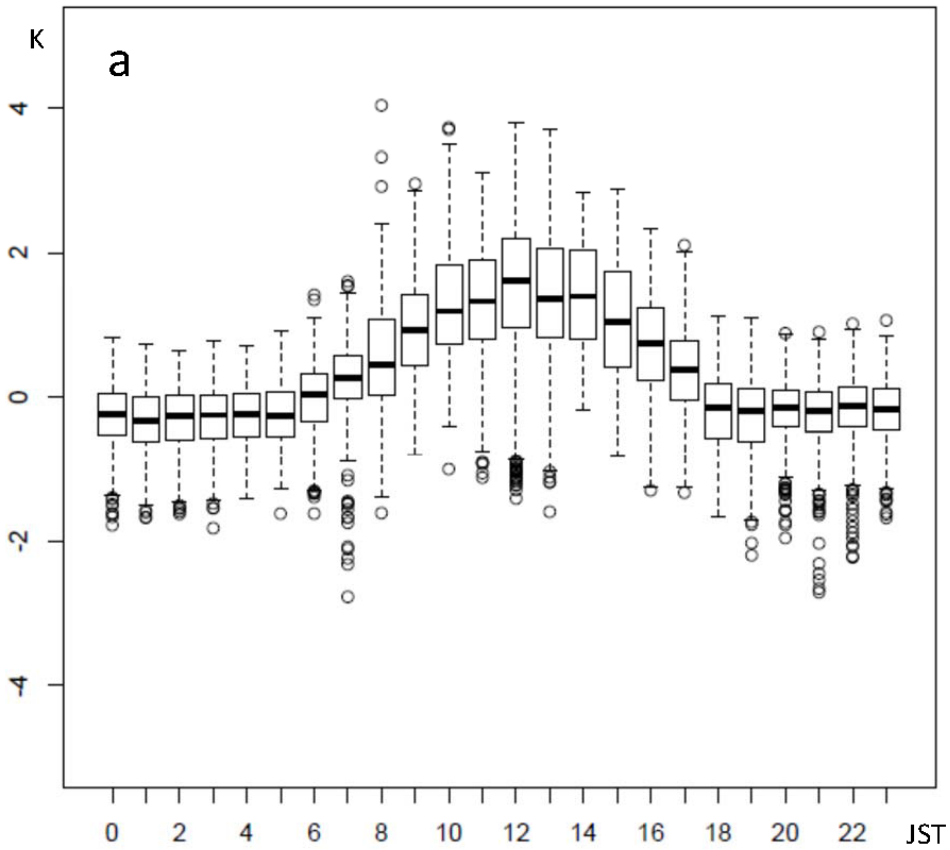
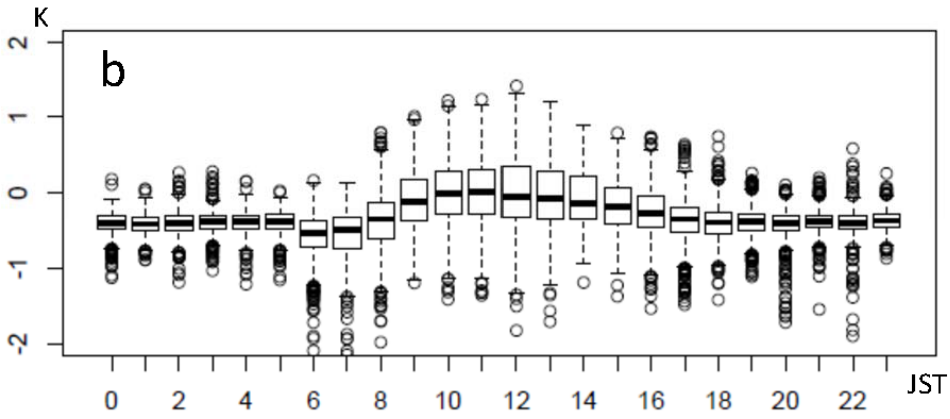
Keywords: surface meteorological observation, measurement of surface air temperature , thermometer, ground-based microwave radiometer, thermometer screen/shield





Development of next-generation microwave radiometer “KUMODeS” for multi-band atmospheric observation

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Meteorological forecasts of local and sudden natural disasters, e.g., tornado, heavy snow, and heavy rain under the cumulonimbus, are important subject.
For early prediction and minimization of its damage, there are two subjects; technology to catch rapid changing of thermodynamic field in high rate, high precision, and analysis based on accurate forecasts and now casts.
We have been developing next-generation radiometer, "KUMODeS", for the observation of atmospheric field.
Multi-band observation at 20 GHz band for the water vapor, and 60 GHz band for the oxygen molecular allows us to estimate thermal dynamics and cloud mass.
KUMODeS is based on technologies developed for radio-astronomy.
Its high sensitivity provides us quick and all-sky observation.
The 20 GHz band receiver employs a cooling receiver to achieve a high sensitivity (low noise) with operating in 10 K.
Cold calibration source is also implemented inside of the cryostat.
Optical pass selection by using mechanical drive allow us to switch the observation and calibration remotely.
In this presentation, we will introduce our prototype system.
We will also present its test observation results in Tsukuba, Japan.
We also discuss about long term forecasts of our attempts based on multi-point observation, e.g., three-dimensional mapping of the water vapor.
This research has been funded by “Program for Creating STart-ups from Advance Research and Technology (START Program)” from the Ministry of Education, Culture, Sports, Science and Technology, Japan, http://www.jst.go.jp/start/en/index.html.

Keywords: atmospheric water vapor, radiometer, thermodynamic environment

Phased Array Weather Radar Observations of Mesocyclone Structures in Okinawa

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We have developed phased array weather radar (PAWR) which can perform the three-dimensional dense observation (100 m range resolution, 100 elevation angles) every 30 seconds. The aim of the PAWR is to watch and predict localized heavy rainfall, tornadoes, and gust of wind. In the observation range of the first PAWR installed at Osaka University, Suita in 2012, it is very rare that tornadoes occur. However, it has been expected that the next PAWR installed at NICT Okinawa in 2014 detects tornadoes in addition to Typhoons and subtropical severe storms. In this study, we investigate a typical mesocyclone, which size is less than several km in diameter, occurred in a linear rainfall band, although there is no evidence of tornado occurrence.

In the afternoon, December 6, 2016, a linear rainfall band accompanied by a stationary front passed over the Okinawa main Island. The rainfall band was composed of some echo cells, which moved from SW to NE along the band direction. A kink echo was found on the CAPPI at 1 km height on 15:29 JST. It changed into a vortex echo, which diameter is 3 to 5 km, on 15:34, and maintained the vortex structure up to around 15:38. The distribution of Doppler velocity showed the two eyes of maximum and minimum of velocity that indicates Rankine's vortex. This feature indicates a mesocyclone (MC) existence. From the maximum and minimum velocities of +17 m/s and -20 m/s, respectively, and the diameter of 3 km, the vorticity of 0.025 s^{-1} is calculated. The MC appeared between 0.25 km and 1.75 km in height, and convergence flow in the lower layer and divergence flows in the upper layers were found. Another stronger MC was found at between 4.0 and 5.0 km in height, which was accompanied by a precipitation core in the upper levels. The echo top height was over 12 km, and anvil echoes extended to the backward (NW) of the linear rain band.

The MC was also observed by C-band polarimetric radar (COBRA), it is possible more advanced data analysis such as dual-Doppler. Although the observed MC has a large vorticity, which is able to generate tornadoes, there are no structures of supercell and there is no evidence of tornado occurrence. From the first kink echo and the next vortex echo may indicate the horizontal wind shear. It seems that the MC has the similarity of the vortex echo appeared in the winter monsoon reported by Fujiyoshi, 2001 (Tenki). However, we have to investigate more carefully about the cause of the upper level MC.

Keywords: Phased Array Weather Radar, Mesocyclone, Three-dimensional Structure

High-speed radar observation of spatiotemporal structure of mesocyclone associated with wall cloud

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The Tokyo Metropolitan area is known as a region where tornados frequently occur in Japan. For mitigating damages caused by tornadoes which happen in a short time scale such as 5-10 minutes, earlier detection of their precursors by means of high-speed volumetric observations of the parent thunderstorm is essential. Phased array weather radar (PAWR) is a recently-developed instrument which, by electronically changing the beam elevation, realizes a quick volume scan in 30 seconds to spatiotemporally resolve thunderstorms within a range of 60 km. Since 8 July 2015, Meteorological Research Institute (MRI) has been operating a PAWR in Tsukuba city to cover the Tokyo Metropolitan area, and succeeded in observing a well-developed thunderstorm on the late afternoon of 12 August. The observed thunderstorm moved toward the east-southeast direction at 5-10 km north of the radar site, accompanying with a mesocyclone and vault structure at the southwest edge, which are characteristics often seen in tornadic supercells. In this presentation, we report high-speed fine-scale properties of the mesocyclone and vault structure observed by MRI-PAWR which would otherwise be difficult to resolve by a mechanically-rotating conventional radar.

Keywords: Mesocyclone, Tornado, Supercell, Phased array radar

Evolution of convective clouds initiated over mountains observed by Ka-band scanning Doppler radar and stereo photogrammetry

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It is known that convective storms are frequently initiated over mountains in warm and humid environment. According to previous studies, shallow cumuli initiated over heated mountains develop into a deep convective storm. However, the transition process from shallow to deep convection is not well understood due to a lack of observation data. In order to elucidate this problem, we observed convective clouds initiated over mountains in Kanto, Japan on 18 August 2011 using a 35 GHz scanning Doppler radar and a pair of digital cameras. The first cloud observed over the mountains reached the 6 km level, while the maximum echo-top height was about 1 km lower than the cloud top. The maximum radar reflectivity in the cloud was about 10 dBZ found around the 2 to 3 km levels. The reason why the echo-top altitude was lower than the cloud-top height was considered to be due to the mixing with surrounding dry air. After such shallow cumuli appeared three times repeatedly, a deep convective cloud developed. These results are consistent with a "pre-conditioning" hypothesis, that shallow cumuli moisten midlevel air and produce favorable condition for development of deep convective storms.

Downbursts captured by High Dense Ground Observation Network and Forecasting Possibility.

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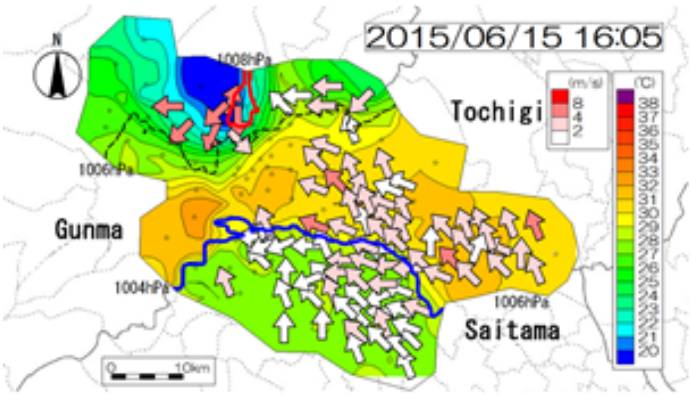
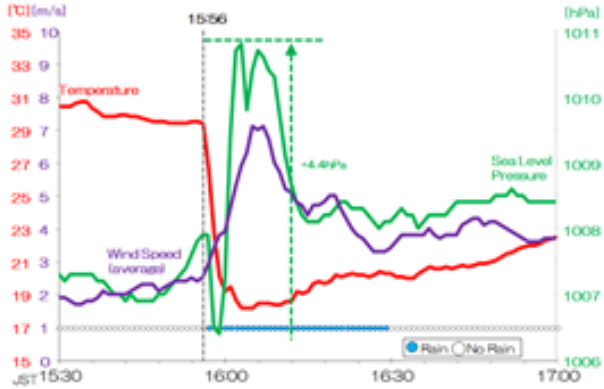
Low cost compact weather station, POTEKA Sta. (hereinafter called POTEKA), has been developed by Meisei Electric co.ltd. There are 145 units installed in 2km interval in Gunma Prefecture since FY2013, sending weather data every 1 minute. On 15 June 2015, downburst occurred in Maebashi City and Isesaki City. The characteristic of downburst from this phenomenon and two other phenomenon in the past will be discussed in this paper.
Downburst occurred on 15 June 2015 was caused by active cumulonimbus passing from Maebashi City towards Isesaki City at around 16:00 JST. According to POTEKA's minutely temperature data, from 15:50, sudden drop in temperature has been captured. The average decrease rate was -2.6ºC per minute. In comparison, air pressure increased 5 minutes before the occurrence of downburst, followed by pressure dip and pressure jump occurred sequentially. It is estimated that pressure change is an outflow front of downburst.
Up to now, POTEKA has captured three downbursts including that of 15 June 2015. From those phenomenon, three similarities have been found: 1) sudden drop in temperature a few minutes before damage, 2) localized jump in air pressure a few minutes before damage, and 3) maximum wind speed after temperature drop. Particularly, sudden temperature drop has been measured clearly in several locations. From these results, observation of sudden temperature drop is considered an effective way in early detection of downburst. We are going to further investigate the characteristic of downburst, build the downburst early detection structure, and verify the effectiveness of the structure.

Keywords: Downburst, Highly Dense Observation





Nocturnal Temperature Distribution under Fine and Weak Wind Conditions Based on Spatially High Density Observation Data in the Tokyo Metropolitan Area: Features in Summer

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Temperature distribution in urban areas varies in response to factors such as daily weather conditions and interactions with local wind systems such as land and sea breezes. In the present study, we first examined the variability in the nocturnal temperature difference (*TD*) between central Tokyo and the outside of Tokyo wards area in summer. We considered *TD* in terms of weather conditions (cloud amounts, wind speed, water vapor content and solar radiation during the previous daytime) using the hourly meteorological data from five summers (2006–2010). We next analyzed characteristic features of the nocturnal temperature distribution in and around the Tokyo wards area using datasets from spatially dense observation networks (208 observation stations) for three summers (2006–2008). During the analysis, we focused on relations between temporal changes in the nocturnal temperature distribution and those in wind systems. Finally, we compared the results of this study with those of winter nights.
The observation networks used for temperature distribution analyses were the Automated Meteorological Data Acquisition System (AMeDAS) of the Japan Meteorological Agency (JMA), air pollution monitoring system (APMS) of the Tokyo Metropolitan Government and adjacent prefectures, and Meteorological Environmental Temperature and Rainfall Observation System (Extended-METROS). The AMeDAS and APMS datasets were also used to obtain the wind data.
The results obtained in this study are summarized as follows:
(1) According to multiple regression analysis (stepwise method), wind speed and cloud amounts showed equally large effects on *TD* between central Tokyo (Otemachi, JMA) and the outside of Tokyo wards area (average temperature from four AMeDAS stations). This result was different from that of winter nights, indicating that cloud amounts have a larger effect than wind speed on *TD*.
(2) A steep horizontal temperature gradient zone (HTGZ) in the western part of Tokyo wards area was unclear even during nights with fine and low wind speeds in comparison with winter nights, where the steep HTGZ was clear under the same conditions. This may be related to the relatively lower decrease rate of temperature in summer, especially around sunset when the wintertime HTGZ begins to become conspicuous. It is considered that the difference in radiation cooling by season is one of the key factors. In addition, because high-temperature areas tended to remain in the northwestern part of Tokyo wards area in summer, central Tokyo did not become the highest-temperature area until after midnight, which was also different from the findings of winter nights.
(3) To identify effective factors for large differences in *TD* for fine and weak wind nights, the corresponding cases were divided into three categories in accordance with the observed values of *TD* at 04:00 JST just before sunrise. For cases of large *TD*, in which high-temperature areas were concentrated in central Tokyo, inland wind systems initiated relatively earlier and showed a relatively larger wind speed before midnight. Subsequently, the local wind front migrated to the coastal area of Tokyo Bay by early morning. For cases of low *TD*, inland winds were weak, and the local wind front could not be clearly observed. For cases of intermediate *TD*, a large amount of solar radiation and a relatively strong sea breeze system were observed during the preceding daytime. Clear high-temperature areas remained from the northern part of Tokyo wards area to southern Saitama prefecture throughout the night, and the local wind front stagnated in this area. We conclude that the nocturnal *TD* in and around the Tokyo wards area in summer is affected by

inland wind systems and the location of the local wind front.

Keywords: urban heat island, nocturnal temperature distribution, spatially high density observation, Tokyo wards area, summer

Vertical structure and diurnal variation of atmospheric environments for convective cloud development around the Central mountains in Japan during warm seasons

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Convective clouds often develop in the afternoon on fair-weather summer days around the Central mountains in Japan. Vertical structure and diurnal variation of the dynamic and thermodynamic environments of the convective clouds have not been well understood because of scarce observation data. In this study, vertical structure and diurnal variation of the environments for both active and non-active convection cases were statistically investigated using the data from a ground-based microwave radiometer (MWR), surface weather observation system, a wind profiler, and radiosonde during July and August from 2012 to 2014.
Firstly, typical cases were extracted and classified into active and non-active convection cases. From the results of surface and wind profiler observations, no significant difference between active and non-active cases was found in vertical structure and diurnal variation of thermally-induced local circulations in term of ability to trigger the convective clouds. Vertical profiles of atmospheric temperature and water vapor were retrieved by a one-dimensional variational (1DVAR) technique combining the MWR observation data and the results of JMA Non-Hydrostatic Model (NHM) simulations. It was confirmed that these profiles were more reliable than NHM-simulated profiles by comparison with radiosonde data, surface weather data, and cloud base temperature obtained from an infrared radiometer. Statistical analysis based on the 1DVAR-derived thermodynamic profiles revealed that the LCL increased and the LFC decreased during daytime for both active and non-active cases. In addition, stability indices had similar diurnal characteristics for both active and non-active cases, although they showed that atmospheric stratification was more unstable for active cases than for non-active cases. It's found that the traditional method based on radiosonde observations at 09 JST (00 UTC) is of benefit for the diagnosis of the afternoon convective activity around the Central mountains in Japan, even if considering the effect of diurnal variations of the dynamic and thermodynamic environments.

Keywords: convective cloud, diurnal variation, ground-based microwave radiometer

Relationship between spatiotemporal changes in amounts of thermal infrared energy and land use variations in downtown Tokyo at summer midday

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We investigated spatial and temporal changes in amounts of thermal infrared (TIR) energy emitted from urban surfaces in downtown Tokyo, using 2 m spatial resolution data obtained from airborne TIR measurements at midday on the four different hot summer days: August 7, 2007, August 19, 2013, August 19, 2014, and August 19, 2015. Also, to analyze relationship between amounts of TIR energy and land use variations, we used detailed land use data provided by Bureau of Urban Development, Tokyo metropolitan government.
The results showed that amounts of TIR energy were especially large in areas with high-density wooden houses, whereas those in areas with office and commercial buildings were relatively small. The difference in average absolute values of amounts of TIR energy between the two areas were approximately 20 W/m^2.
In the areas with office and commercial buildings, amounts of TIR energy in many parts of urban renewal areas clearly decreased between 2007 and 2013. Increases in green surfaces associated with development of public open spaces would be one of the main causes of the decreases in amounts of TIR energy. The development of public open spaces has been promoted by an incentive-based policy that offers an enhancement in the floor area ratio as a reward for constructing public open spaces.
These results indicate that some governmental measures like the incentive-based policy enacted for areas with office and commercial buildings are required to reduce summer heat stress in the high-density wooden residential areas where the larger amounts of TIR energy are observed at summer midday. In downtown Tokyo, the maximum occurrence frequency of heat strokes tends to be recorded in residential areas.

Keywords: thermal infrared energy, land use, summer midday, downtown Tokyo, UHI adaptation and mitigation strategies

Observing horizontal wind for extreme weather mechanism of urban area.

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In the summer season, the disastrous severe rain frequently occurs by Global warming in Japan. The small-scale convergence of humidity in the boundary layer is considered as one of the most important factor to determine the generation of such a disastrous rainstorm. The wind condition near the surface of the ground is affected by the ground condition so we cannot get the detailed information by direct observation. And it is very difficult to capture the urban wind condition in complex surface.
In my study, to get the wind condition of the lower atmosphere, I have started to successfully observe by using coherent doppler lidar (CDL) from May 26, 2015. CDL can observe air convergence of first stage because observing object is not raindrop but aerosol. I got the presence of wind strength in a small scale because the data of CDL is a 100m resolution.
By using the data of high resolution, I made the database for extreme weather mechanism of urban area.

High-performance and Low-cost coherent Doppler lidar: the evaluation test and deployment in Tokyo metroporitan area

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The coherent Doppler lidar (CDL) is very useful tool to measure the horizontal wind field in the clear air condition. As the next generation meteorological remotesensing technique, Multi-CDL combination has a great potential to detect the trigger of localized severe storms by detecting strong conversence.
Our project aims to make an innovation by developing the high performance CDL detectable within the range of around 30 km. The cost of our lidar system is estimated to 1/10 of the conventional instruments. The evatiation test of prototype and the future plan is released in this paper.

Keywords: Coherent Doppler Lidar, Disaster Mitigation of metroporitan area

Data assimilation of Doppler Lidar data with high resolution weather model in Tokyo metropolitan area

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This study aims to investigate the impact of data assimilation of Doppler Lidar data with high resolution non-hydrostatic weather model in Tokyo metropolitan area. The small-scale convergence of surface wind field in the boundary layer is considered as one of the most important factor to determine the generation of heavy rainfall in urban area.
Considering that the complex feature of surface wind field has not fully elucidated, this study compared observation data with control simulation and data assimilation simulation.

Keywords: Atmospheric boundary layer, Data assimilation , High resolution non-hydrostatic weather model

High-density surface observations of a local climate around Kyotanabe Campus of Doshisha University

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Kyotanabe Campus of Doshisha University is located in Kyotanabe city, southwestern part of Kyoto prefecture, where the paddy fields and farms spread around, the Kidugawa river flows on the east side, and Mt. Kannabi rises on the west side. The population of Kyotanabe city is about 66 thousands, and the plain areas around the railway stations, which are connected to Kyoto, Osaka, and Nara, have been developed as urban districts. Kyotanabe Campus is located on the hill in the west side, and its elevation is about 50 meter higher than the plain areas. In this study, we have constructed a temporally and spatially dense surface observation network to investigate the local climate aroud Kyotanabe Campus using compact meteorological instruments called KY-logger (NT system design).
Surface air temperature, relative humidity, and air pressure were observed by KY-loggers for the period from November 12th to 30th in 2015 at time intervals of one second at 14 observation sites within a circular area of a 1.4 km radius centered at Kodo station of Kintetsu line. A weather station MetPak (Gill company) was installed at one of the observation sites, that is in Kyotanabe Campus, and the data observed by MetPak were compared with those by KY-logger at the same site, and were used for the verification of air pressure of KY-loggers. The dependence of temporal variations of surface air temperature and pressure reduced to mean sea level (PMSL) on the observation sites has been examined during the nighttime on fine weather days, using the data densely observed by KY-loggers together with the meteorological data observed by AMeDAS in Kyotanabe (Automated Meteorological Data Acquisition System) and the downward infrared irradiance observed at the top of the building in Kyotanabe Campus. The AMeDAS in Kyotanabe is about 3.4 kilometers away from Kyotanabe Campus in the north-northwest.
The differences in air temperature and relative humidity observed by KY-logger and MetPak at the same site are within ±0.3 degree Celsius and ±3%RH during the nighttime and within ±1 degree Celsius and ±5%RH during the daytime, respectively. Air temperatures and relative humidities observed by two KY-loggers at the same site with a height difference of about 1 meter each other show approximately the same temporal variations, respectively. It is confirmed that the difference in surface air pressure observed by the two is almost a constant value, which corresponds to their height difference. During the nighttime on the fine weather days, the air temperature at the sites in Kyotanabe Campus decreases with time more slowly than those in the plain areas, and the PMSL at the top of hill in Kyotanabe Campus becomes relatively low by approximately 0.2 hPa compared to that in the plain areas. During the nighttime on the calm fine weather days, when the surface wind was extremely week and the downward infrared irradiance was steadily small, the atmospheric phenomena that air temperature suddenly dropped 0.5-1 degree Celsius in 30 minutes were sometimes observed. This sudden temperature drop occurs in succession from low elevation places, the plain areas, to high elevation places, Kyotanabe Campus.
These results imply that high-density observations with KY-loggers are useful for a detailed investigation of local climate.

Keywords: High-density surface observations, local climate

A study on a UV-C Raman lidar for profiling the water vapor

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Water vapor is an important role in atmospheric processes such as the atmospheric energy budget, atmospheric chemistry, and localized extreme weather events associated with severe weather disasters. Accurate observations of water vapor in the atmospheric boundary layer are essential for improving weather forecasting. We have developed a water vapor Raman lidar using a laser operating in the ultraviolet C (UV-C) region. The UV-C region is known as the "solar-blind" region and has the advantage of having no daytime solar background radiation in the system. However, it is necessary correction for ozone absorption while estimating the atmospheric water vapor because of the strong ozone absorption in the UV-C region. In this study, we estimated the errors in the retrieved water vapor mixing ratio (WVMR) caused by the atmospheric conditions and validated the calibration methods of the lidar system.

The UV-C water vapor Raman lidar used a 35 cm telescope to collect the vibrational Raman of water vapor (294.6 nm), nitrogen (283.6 nm), and oxygen (277.5 nm) for a laser operating at a wavelength of 266 nm. We simulated the WVMR estimation errors using the theoretical Raman signals based on the radiosonde data, assuming several ozone profiles. When the surface ozone concentrations were 60 and 0 ppb, the maximum altitudes for which the WVMR estimation errors were within 10% were 1750 m and 2150 m, respectively. Two calibration methods were investigated to convert the WVMR from the lidar signals: 1) comparison of lidar signals with WVMR profiles of radiosonde; 2) calibration of the detector efficiencies of each Raman channel by the standard calibration lamp technique. While the estimation errors of the calibration factor using the radiosonde data were 1.21 % below the surface ozone concentrations of 60 ppb, those by the standard calibration lamp techniques for the Deuterium lamp and tungsten lamp was 1.07% and 6.91%, respectively.

Keywords: Raman lidar, water vapor

Estimation of water vapor variation with digital terrestrial television broadcasting wave

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This paper is devoted to develop the humidity estimation method by using the atmospheric propagation delay of digital television (DTV) radio-wave. Detailed structure of refractive index is dominantly determined by the temporal and spatial variation of atmospheric water vapor by detecting the propagation delay between DTV transmission and receiving antennas. Previous studies was severely annoyed by the oscillator noise of the transmitter and receiver. Due to the strong phase noise, the propagation delay has not been derived precisely.

This study invented a breakthrough method to solve these problems by detecting two DTV stations signal simultaneously. This method uses two receivers nearby and far away from DTV antenna.

Firstly, each receiver processes the subtraction of pilot signal between two DTV stations. In the next step, the subtraction of the above differential signal between two receivers removes the most of error due to oscillator fluctuations. The receiver system is consisted of software radio receivers and Rubidium oscillators. CP (continuous pilot) and SP (scattering pilot) is extracted from OFDM (orthogonal frequency-division multiplexing) carrier of DTV signal.

Prior to field experiment, the precision of receiver is investigated by comparing the results of two collocated receiver systems at Uji Campus of Kyoto University. Three evaluation test was conducted by detecting DTV signal transmitted from Ikoma station. In the first test, phase difference of CP signals neighboring DTV channel is detected, and found the system noise is much larger by 30 dB than the atmospheric propagation delay.

In order to decrease the system noise, this study developed two new methods to integrate many differential signals of SP from single or double station(s), whose frequency is separated by a constant value of 6 MHz or 3 MHz. Both method show excellent improvement of phase error reduction. The system error of propagation delay significantly decreased to 5.47 mm and 7.80 mm, respectively.

This promising method is very useful to monitor horizontal variation of humidity in the boundary layer and expected to proceed to field test very soon.

Keywords: water vaper, digital television, atmospheric propagation delay, atmospheric boundary layer, localized heavy rain

Frequency distribution of raindrop size observed by an optical disdrometer during heavy rainfall in Tokyo

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Frequency distribution of raindrop size during rainfall varies depending on the rainfall type and its intensity (e.g., Marshall and Palmer, 1948). The frequency distribution of raindrop size shows a lot of information to understand not only the difference in rainfall characteristics by region and season but the development of convective clouds that cause heavy rainfall. The purpose of this study is to clarify the relationship between the life stage of convective clouds and frequency distribution of raindrop size observed in the Tokyo Metropolitan area.
Currently, optical disdrometers (Thies Clima Laser Precipitation Monitor 5.4110, etc.) are installed at six sites in the Tokyo Metropolis and Sendai City. In this study, using the observation data in Tokyo from April to September in 2014, minutely rainfall intensity and the number of raindrops for each 22 class of raindrop size (sphere equivalent diameter) were examined. Contribution ratio of raindrop water for each class to the rainfall amount was calculated to investigate the temporal changes in heavy rainfall case on July 20, 2014. As a result, it was observed that an increase in contribution ratio of large size raindrops corresponds to an increase in rainfall intensity. The difference in frequency distribution due to the relative position within a convective system and the temporal changes in the other heavy rainfall cases will also be investigated.

Keywords: Raindrop size, Frequency distribution, Rainfall intensity, Optical disdrometer

