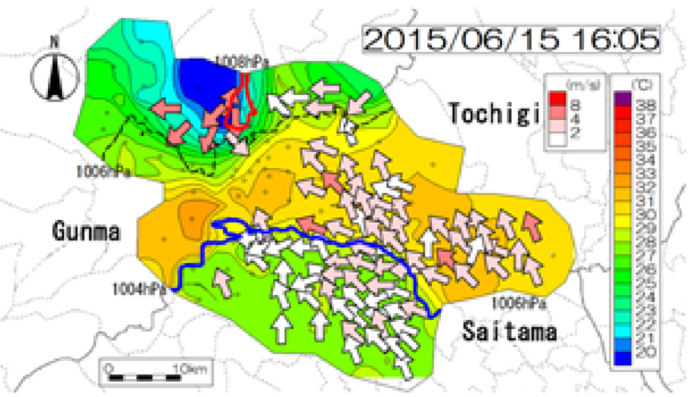
Downbursts captured by High Dense Ground Observation Network and Forecasting Possibility.

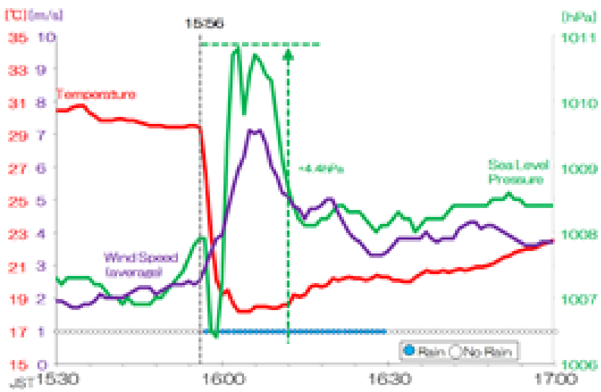
*Kae Sato[1], Hisato Iwashita[1], Takuya Yada[1], Hirotaka Kure[1], Fumiaki Kobaashi[2]

1.Meisei Electric Co., Ltd., 2.National Defense Academy

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

*Masaharu Tsutsumi[1], TAKAHASHIi Hideo[1], YAMATO Hiroaki[2], YOKOYAMA Hitoshi[3], MIKAMI Takehiko[4]

1.Tokyo Metropolitan University, 2.Nihon University, 3.Tokyo Metropolitan Research Institute for Environmental Protection, 4.Teikyo University

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

*Kentaro Araki[1], Masataka Murakami[1], Teruyuki Kato[1], Takuya Tajiri[1]

1.Meteorological Research Institute

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

*Nobumitsu Tsunematsu[1], Hitoshi Yokoyama[1], Tsuyoshi Honjo[2], Arata Ichihashi[1], Haruo Ando[1], Nobuhiko Shigyo[2]

1.Tokyo Metropolitan Research Institute for Environmental Protection, 2.Chiba University

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.

*Kenya Yano[1], Jun-ichi Furumoto[1], Kuniaki Higashi[1], Hideaki Takanami[2]

1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Mitsui Fudosan Co.,Ltd.

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

*Jun-ichi Furumoto[1], Kuniaki Higashi[2]

1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.Metroweather Co. Ltd.

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

*Kuniaki Higashi[1], Kenya Yano[2], Jun-ichi Furumoto[2], Nobumitsu Tsunematsu[3]

1.Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd., 2.Research Institute for Sustainable Humanosphere, Kyoto University , 3.Tokyo Metropolitan Research Institute for Environmental Protection

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

*Akari Yasuda[1], Shozo Yamane[1]

1.Doshisha University

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

*Hayato Kakihara[1], Masanori Yabuki[1], Toshitaka Tsuda[1]

1.Research Institute for Sustainable Humanosphere, Kyoto University

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

*Keigo Nishida[1], Jun-ichi Furumoto[1], Toshitaka Tsuda[1]

1.Kyoto University Research Institute for Sustainable Humanosphere

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

*Yoshihito Seto[1], Hideo Takahashi[1], Kiyotaka Sakaida[2], Yasunori Sawada[3], Takehiko Mikami[4], Hitoshi Yokoyama[5]

1.Tokyo Metropolitan University, 2.Tohoku University, 3.Tokyo Gakugei University, 4.Teikyo University, 5.Tokyo Metropolitan Research Institute for Environmental Protection

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

