Effect of neutralization scheme on lighting simulation using a cloud-resolving model

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Introducing the lightning parameterization to the Cloud Resolving Storm Simulator (CReSS: Tsuboki and Sakakibara, 2002), we have simulated the location, number and types of lightning flashes. The lightning simulation includes three processes, (1) charge generation, (2) lightning propagation, and (3) charge neutralization. This study focuses on the charge neutralization scheme.
We The CReSS model adopted adopts riming electrification as the charge generation process (Takahashi, 1978). Lightning propagates along the maximum gradient of the electric potential (MacGorman et al, 2001). The net electric charge is neutralized along and around the lightning path. In this study, we used examined four neutralization schemes to evaluate the effect of neutralization scheme on lightning simulation. (1)The scheme I assumes that The the net electric charge for neutralization is distributed into each hydrometeor category according to its relative surface area (MacGorman et al, 2001). In this scheme, each category’ s charge is not necessarily decrease. (2) This The scheme II is more of the samesimilar to the scheme (1) I, but each category’ s charge is necessarily decreased. (3) This scheme is more of the same (1), butIn the scheme III, neutralization hydrometeor category is limited to same polarity as the net charge. (4) Ain the scheme IVVfter neutralization, the net electric charge is redistributed into each hydrometeor category according to its relative surface area after neutralization.
In this study, the lightning simulation calculates a case of the heavy rainfall system in the Kinki Area of Japan with a horizontal grid size of 2 km performed from 18:00 to 22:00 LST 23 August 2013. This result is compared with the observations. Compared The observation data is the Broadband Observation network for Lightning and Thunderstorm (BOLT: Yoshida et al, 2014). BOLT is a three-dimensional low-frequency lightning location system. It observes cloud-to-ground (CG) and intracloud (IC) flashes.
In the simulation of the presentthis case, thunderstorms are successfully simulated (Figure 1). This The result is compared with the observations about with regard to the temporal variation of lightning frequency. In the simulation, lightning occurred around a local maximum of rain rate, this result consistent with the observations. The temporal variation in numbers of simulated lightning is similar to observationed. However, simulated lightning number is larger than observations. Lightning number is dependent on lightning parameters and neutralization scheme. Therefore, optimizing the lightning parameter and understanding the neutralization scheme are essential for quantitative comparing comparison between the simulation and observation. Vertical cross sections of calculated lightning initiation is different from observations. In the observations, lightning initiation level is higher with higher lightning frequency is higher. However, simulated lightning height is almost constant, occurred around -10℃. This indicates that the Lightning lightning initiation height is without independent on dependence of neutralization schemes. We will investigate this result and improve lightning model in our future work.
Figure1. Locations of lightning flashes (a) observations (BOLT), (b) Scheme1Scheme I, (c)Scheme2Scheme II, (d)Scheme3Scheme III, (e)Scheme4 Scheme IVV in 19:30 LST 23 August 2013. Color indicates precipitation intensity observed JMA-radar and simulation experiments.

Keywords: lightning

Energetic radiation generated by winter thunderstorm and lightning observed in Uchinada, Japan

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We conducted energetic radiation measurement at Uchinada town, Kanazawa, during the winter thunderstorm. Active winter thunderstorm approaches the sea coast at Uchinada town and a number of cloud-to-ground winter lightning frequently occur. During our campagine observation on 2015-2016, we observed two short burst generated by lightnign stroke and five long burst attributed to electric field inside the thunderstorm . In this presentation, we introduce our results

Keywords: Energetic radiation, Winter Lightning, Thunderstorm

Latitudinal and Regional dependences of IC/CG ratio derived from JEM-GLIMS lightning observations

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The ratio between intracloud discharge (IC) and cloud-to-ground discharge (CG), denoted by Z, is important parameter for the studies on the severe weather prediction, the production of NO_X by lightning discharges, and the quantitative contribution of lightning to the global circuit. However, the difficulties of Z-value estimation in previous studies are originated in (1) the ground-based lightning data obtained at limited and specific areas, (2) difficulties in detecting IC discharges, and (3) difficulties in distinguishing the discharge types (IC or CG) in the previous space observation data. So, the latitudinal and regional dependence of Z-value are not resolved yet. In order to solve these problems, the Global Lightning and Sprite Measurements on Japanese Experiment Module (JEM-GLIMS) mission was launched in 2012, and it conducted nadir observations of lightning discharges using both optical instruments (Lightning and Sprite Imager: LSI and six-channel spectrophotometers: PH) and electromagnetic wave receivers. Thus, the final goal of this study is to estimate Z-value and to clarify its latitudinal and regional dependences and to evaluate the contribution of lightning to the global circuit as a generator. For this purpose, we have developed new methods to distinguish IC and CG using JEM-GLIMS optical data and ground-based lightning data. As a first step, we selected 707 lightning events detected by LSI and PH on board JEM-GLIMS in the period from Nov. 2012 to Aug. 2015. These lightning events were detected over both land and oceanic regions. Then, we compared the JEM-GLIMS data to the ground-based lightning data obtained by the Japanese Lightning Detection Network (JLDN), the National Lightning Detection Network (NLDN), and the World Wide Lightning Location Network (WWLLN) and identified the type of the lightning discharge detected by JEM-GLIMS, As a next step, we have calculated intensity ratios between blue and red PH channels, such as 337nm/762nm, 316nm/762nm, 392nm/762nm, 337nm/(599-900nm), 316nm/(599-900nm), and 392nm/(599-900nm) for each lightning event. It is found that 400 of 707 lightning events (56.6%) were identified to be CG discharges while 307 of 707 (43.4%) were IC discharges. It is also found that the PH intensity ratio of IC discharges is clearly higher than that of CG discharges. In the case of IC discharge, the ratio of 337nm/762nm, 316nm/762nm, 392nm/762nm, 337nm/(599-900nm), 316nm/(599-900nm), and 392nm/(599-900nm) are estimated to be 1.06, 0.21, 1.04, 0.16, 0.04, and 0.17, respectively, while those of CG discharges are 0.46, 0.16, 0.74, 0.03, 0.03, and 0.13, respectively. As the difference of the 337nm/762nm and 337nm/(599-900nm) ratio in IC case and in CG case is relatively large, these two ratios are the useful proxy to classify the discharge types for other 7650 lightning events detected by JEM-GLIMS. At the presentation, we will also show detailed results derived from the analyses of LSI data and ground-based ELF observation data.

Readiness in DOST-ASTI for SATREPS project for development of extreme weather monitoring and alert system in the Philippines

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Advanced Science and Technology Institute (ASTI) in Department of Science and Technology, Philippines (DOST) is the representative of Philippines side in SATREPS project “Development of extreme weather monitoring and alert system in the Philippines”. In this project we will construct lightning detection networks in Philippines with ~10 sites in nation-wide and ~50 sites in Metro Manila and operate micro-satellites in order to make stereo imaging of thunderstorm. ASTI has experiences to install water level sensors and automated rain gauges at more than 1000 sites in Philippines. Also ASTI together with University of Philippines, Diliman (UPD) has been contributing to the first Philippine micro-satellite project in development of satellite itself in Japanese universities and in ground operation in Philippines. ASTI and UPD will play essential roles in the development of software to estimate present and future precipitations based on the lightning activities and 3-demensional structure of thunderstorm captured by Philippine satellite “DIWATA-1” and others, as well as in the installation of lightning sensors at 60 sites and satellite operation.

Keywords: lightning, micro-satellite, thunderstorm, typhoon

Remote Sensing Assessment of Typhoon-Induced Vegetation Damage over the Philippines

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Philippines is an archipelago composed of 7,107 islands, located in the Southeast Asia. It is one of the the 18 mega-biodiverse countries in the world, containing two-thirds of the earth's biodiversity and between 70 - 80% of the world's plant and animal species. It is a country rich in natural resources but at the same time, it is vulnerable to numerous natural hazards. According to a study conducted by the United Nations Office for Disaster Risk Reduction (UNISDR) and the Centre on the Epidemiology of Disasters (CRED), over the past two decades (from 1995-2015), the Philippines endured a total of 274 natural calamities, making it the fourth most disaster prone country in the world. The main reason for this is its location. The country is located in the pacific ring of fire which explains the presence of numerous volcanoes, faults and trenches in the country. Its location in the pacific has also a high exposure to tropical cyclones. From 1990-2006, it was estimated by the Climate Change Commission of the Philippines that of the PHP 12.43 billion or USD 248.7 million average annual cost of natural disasters to the agricultural sector, about 70% is from damages brought by typhoons.

Remote Sensing is a cost-effective tool in analyzing areas that are challenging to observe with field surveys. With the presence of numerous satellites equipped with high resolution and multi-spectral sensors, images of areas hit by natural calamities are easily obtained few days after the disaster struck. Comparison of the Normalized Difference Vegetation Index (NDVI) method obtained pre- and post-storm is commonly used by numerous researches in detecting damages after a storm's passing.

In this research we examine typhoon-induced damage to vegetation by utilizing NDVI and relating it to the typhoon's features: wind and rainfall, and to the characteristic of the area hit: elevation, aspect and land cover type. This research is in support of the goal of rapid post-typhoon assessment in the Philippines with the use of its microsatellite, Diwata. In the future, we want to use images taken by Diwata in post disaster assessment.

Two typhoons were analyzed, Typhoons Haiyan and Koppu. Both hit the Philippines and brought devastating damages to the country. The area analyzed are the provinces of Leyte and Nueva Ecija for Typhoon Haiyan and Koppu, respectively. The main difference between these two storms is that Typhoon Haiyan carried with it strong winds more than heavy rainfall while Typhoon Koppu, on the other hand, carried more heavy rain than strong winds. In both cases the NDVI significantly decreased after the typhoon hit with values of -0.12 +- 0.13 (mean +- standard deviation) and -0.14 +- 0.14 with paired t-test p values < 0.001 for Typhoons Haiyan and Koppu, respectively. Damage as a function of rainfall, aspect, land cover type and elevation were analyzed for each case. We also calculated the influence of each variable to the measured damage using Artificial Neural Network. We found that the elevation is the strongest influence, followed by aspect, rainfall and lastly land cover.

Keywords: Typhoon, damage asessment, Philippines, Landsat

An observational study on lightning activities over the coastal region of Sumatra, Indonesian maritime continent

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Indonesian maritime continent (IMC) is an archipelago of large and small islands with complex terrain surrounded by warmer sea water. Convection and lightning activities over the IMC is very active in the tropics and acts as a global heat source of large-scale atmospheric circulation. In this study, we investigate lightning activities over the IMC by using worldwide lightning location network (WWLLN) data and sounding and weather radar data of pre-YMC (Years of the Maritime Continent) campaign observation on and off western coast of Sumatra, IMC in November-December, 2015.

As described in previous studies, diurnal cycle of lightning with clear land-sea contrast is predominant over the IMC. Frequent lightnings are observed over the Sumatra in the afternoon/evening, whereas the night/early morning peaks are predominant in the off coastal region of southern Sumatra and Malacca straight. Intra-seasonal variations of lighting are also observed in relation to the phases of MJO (Madden-Julian Oscillation). The causes of the spatial and temporal lightning variability in the coastal heavy rainfall region will be discussed by using in situ observation data. In addition, we will introduce an ongoing lightning observation project in Philippine, one of the maritime continent.

Monitoring of lightning activity with the combination of radio observation in ELF-VLF band and electrostatic measurement.

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In the recent, heavy rain and lightning associated with thunderstorm become a representative of severe weather in urban region. Lightning observation has been focused on as an efficient tool to monitor thunderstorm activity.
Main objective of this study is to established methodology for early detection of thunderstorm formation with simple and low-cost system. To observe lightning activity, electromagnetic field radiated from lightning discharge in ELF (Extremely Low Frequency: less than 3 kHz) and VLF (Very Low Frequency: 3-30kHz) bands has been measured. ELF-VLF wave can propagates long distance (more than several hundreds kilometers). Receivers are installed about 100 km apart in the Kanto Plan, Japan to make detection sensitivity to be high.
In this presentation, initial results of the combination of radio observation in ELF-VLF band and electrostatic measurement are summarized. As an electrostatic measurement, flat-plate sensor called as slow antenna is newly developed and installed at Machida, Tokyo. Based on the comparison between electric field data and electrostatic one, detection sensitivity and discharge-type identification of radio observation in ELF-VLF bands is validated.

Keywords: lightning discharge, thunderstorm, ELF, VLF, electrostatic field

Characteristics of Downburst Occurrences Derived from Ground-based Lightning and Meteorological Observations

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A prediction of the downburst occurrence using the existing meteorological observation networks is very difficult because the typical spatial and temporal scale size of downbursts are ~1.8 km and a few minutes, respectively. Once a downburst occurs in a metropolis, various infrastructures suffer huge damage. For this reason, a prediction of the downburst occurrence based on other observation methods is desired. At the convection cell accompanied by a downburst, active lightning activities are confirmed in many cases. In addition to this, we expect that not only the lightning occurrence number but also the charge amount neutralized by lightning discharges may be related to the vertical convection intensities in thunderclouds. So, the purpose of this study is (1) to develop a new method to estimate charge amounts neutralized by lightning discharges, (2) to clarify the relation between lightning activities and downburst occurrences, and (3) to identify the characteristics of downburst occurrences that can be used for the prediction of the downburst occurrence. As a first step, we have analyzed ELF data obtained at Onagawa and Kuju stations and compared ELF waveforms with the lightning current waveforms measured by the Rogowski coil at Mt. Ogami, Niigata. It is found that the cross correlation coefficient between these two waveforms became 0.80, which implies that the dominant component of the observed ELF waves is not the radiative but induction magnetic fields. We further estimated an empirical equation to calculate the charge amounts neutralized by lightning discharges (Q) from the time-integrated ELF magnetic field amplitude (ΣB). Using this empirical equation, it is first possible to estimate charge amounts of any lightning discharges occurred within ~1000 km distance from the observation site. As a next step, we analyzed 8 downburst events occurred in 2015 in Japan using ELF data, JLDN (Japan Lightning Detection Network) data, meteorological (C-band radar, AMEDAS) data provided by JMA, and POTEKA data provided by Meisei Electric Co., Ltd. It is found that the occurrence number of −CG discharges and the lightning charge amounts reached their peak just before/after the occurrence of the downburst in many cases and that the temporal variation of the lightning charge amounts is comparable to that of rain volumes. Thus, we can deduce that these characteristics of lightning activities are the good proxy for the prediction of the downburst occurrence. At the presentation, we will show the relation between ELF waveforms and lightning current waveforms and the results of lightning and meteorological data analyses in the downburst events in detail.

Keywords: lightning, downburst, prediction

Deployment Plan of ELF Observation System in Asian Countries to Monitor Severe Weather Development

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Recent studies on the relation between lightning activity and severe weather activity revealed that lightning occurrence numbers and charge amounts neutralized by lightning discharges are the good proxy to predict the intensity development of severe weathers. We installed an ELF observation system at Onagawa station in 2001 and Kuju station in 2013 and are conducting continuous measurements of ELF waveforms excited by lightning discharges. Using the ELF data and lightning current waveform data obtained by the Rogowski coil, which is installed at Mt. Ogami in Niigata, we found that the shape of the lightning-exciting ELF waveform is comparable to that of lightning current waveform. As the distance between the ELF station and the Rogowski coil is about 300 km, observed ELF waveforms are mainly induction magnetic fields and become proportional to lightning current waveforms. By comparing time-integrated magnetic field amplitude (ΣB) to time-integrated current waveform amplitude, which becomes the charge amount neutralized by lightning discharges (Q), we obtained an empirical equation to estimate the neutralized charge amount of any lightning discharges. Then, we analyzed the relation between the lightning charge amount and temporal development of thundercloud activity using both ELF and meteorological C-band radar data. It is found that the temporal variation of neutralized charge amounts of lightning discharges occurred at active thunderclouds is proportional to that of rain volumes, and it is also found that downbursts occurred just after/before the variations of lightning charge amounts and −CG occurrence numbers reached their peak. These facts imply that the measurement of ELF waveforms is a good and cheap way to continuously monitor meteorological conditions in active thunderclouds. From April 2017, the project of Science and Technology Research Partnership for Sustainable Development (SATREPS) will start. In this project, methodologies on a short term forecast of severe weather and typhoon intensities will be developed. For this purpose, 60 automatic weather stations equipped with slow-antenna lightning sensors and VLF receivers will be installed in Philippines. We will also install the same type of the ELF observation system in this project and will conduct continuous measurements of ELF waveforms excited by lightning discharges and meteorological conditions in active thunderclouds occurred near Philippines and other Asian countries. At the presentation, we will show the basic specification of the ELF observation system and discuss the usefulness of ELF measurements for the short term forecast of severe weather and typhoon intensities more in detail.

Keywords: lightning discharges, ELF waves, severe weather, extreme weather

Detection of natural hazards with very low frequency acoustic wave, infrasound

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Very low frequency acoustic waves so-called infrasound are often observed accompanied with severe natural hazards. One of the most prominent events are detected after earthquakes. The infrasound is emitted by the ground/sea surface motion arising from the earthquake. The infrasound reaches at several hundred km altitude, then disturb ionospheric plasma through collision with neutral atmosphere. These disturbances are often detected in the data of GNSS total electron contents (TEC). Furthermore, TEC disturbance was also found over a huge thunderstorm. Since the infrasound propagates not only vertical direction but also horizontal direction, the ground-based infrasound sensors also detect tsunami signature after the large earthquake under the sea. Therefore, the infrasound from the huge thunderstorm showing TEC disturbance is possibly detectable. In fact, detection of concentrated heavy rain using the infrasound has been attempted and the results show the potential ability of the detection. In addition, it was found that the infrasound was emitted from snowslides. The observation suggests that the infrasound is also emitted from land slide. Therefore, the infrasound is useful tool to detect the land slide accompanying with the heavy rain. When array observations are arranged, the location of the event can be estimated using time delay of the signals. Therefore, the infrasound observation can contribute the nowcast system to detect the heavy rain. Since the sensors are easy to maintain and operate, they are easy to install in the developing countries. Philippines also has many earthquakes. The infrasound observation can also contribute to reduce tsunami disasters as well as thunderous.

Keywords: infrasound, very low frequency acoustic wave, heavy rain, detection of natural hazard, land slide, tsunami

Cloud Observation by 3D Modeling Based on Camera Images

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Current weather radars used for short-term precipitation forecast mostly detect rain/snow droplets, which prevents from fully observing rapidly growing cumulus clouds that could cause severe weather until rain/snowfall starts. Phased array radars and other new radars have gradually been enabling to detect clouds but building and operating such radars would be expensive. In order to develop inexpensive methods to observe clouds before precipitation starts, images of the clouds captured with visible light cameras could be used to locate and make measurements of clouds. Previous studies have succeeded in locating clouds by calibrating cameras using various objects and landmarks, such as topographic features, locations of an airplane, the sun and stars. However, for the practical monitoring of clouds, it is important to investigate the proper conditions when capturing images to observe the clouds without any external calibration.
In order to observe the clouds, 4 images of the same cloud will be captured simultaneously at different locations using digital cameras (Nikon D5500). The images will then be imported into the 3D modeling software PhotoScanPro to align the photos, build dense cloud, and build 3D mesh model with which the location and size of the cloud will be calculated by tagging GPS location data. Up to now (15 Feb 2017), several experiments have been conducted using a lump of cotton as an object visually similar to clouds. (a) 4 images were captured with different dihedral angle between cloud-camera planes to examine the viability to generate 3D models and the accuracy of the calculated distance and surface area. Also, (b) another 4 images were captured with different light source position to examine the influence on the resulting models.
The results of the experiments are as follows: (a) as the dihedral angle increased, we reached a specific point where the software could not produce 3D models due to insufficient number of points matched by the software among multiple images. Also, as the angle widened, the accuracy of the calculated distance between the object and cameras got fairly high, covering the decent area of the cotton surface. This suggests that the specific angle is ideal even in the real photo-capturing situation. (b) The resulting 3D models did not vary with different locations of the light, which suggests that the slight change in the brightness and contrast caused by different location of the sun does not greatly affect the 3D models.
The results demonstrate some aspects of the proper conditions when capturing images. For further investigation, we are planning to examine the accuracy of volume measurements using a piece of clay and we will keep on looking into other conditions that might affect the resulting 3D models and the accuracy of measurements. Another experiment is also planned to take actual photos of clouds and generate 3D models using them in order to evaluate the validity of the experiments. Finally, we will apply the above optimal conditions to the actual photo-capturing situation to acquire consecutive cloud images to construct 3D models and will make measurements, the accumulation of which helps determine criteria for the future forecast of precipitation and severe weather.

Keywords: Cloud Observation, Cumulus Cloud, 3D Models, Camera Images, Severe Weather Forecast

Demonstration for hyper-dense meteorological observation using low-cost wireless sensor network

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Recent climate changes can increase severe weather events, such as a heavy rainfall, thunderstorm, and a gusty wind. Techniques for monitoring and predicting those are very important to reduce the hazards in disaster-prone areas. To monitor the local severe weather of several km^2, however, remains a challenge. Moreover, most of the disaster-prone areas are located at developing countries. Thus, it is needed for a low-cost and hyper-dense meteorological monitoring system at a spatial resolution better than ~250m. Here, we have developed hyper-dense meteorological observation system (50-100m intervals) using low-cost wireless sensor network, demonstrating it for cross-country skiing course. Hyper-dense meteorological observation in the cross-country skiing can help us to select a suitable glide wax, which work as a reduction of the friction between skiing and snow surface. We must select the wax judged from meteorological conditions, such as temperature, humidity, illuminance, etc. in the whole course. We have measured those using the sensor sets of temperature, humidity, and illuminance at ~30 observation points placed on the interval of 50-100m on the actual cross-country skiing course (Hokkaido). Observed meteorological data were recorded by PC through the wireless sensor network (XBee). We have succeeded in multi-point meteorological observation for the actual of cross-country skiing course. This observation system can not only use in developing country to monitor the local severe weather events, but also provide a basic data to forecast those.

Keywords: Wireless sensor network, Hyper-dense meteorological observation, Cross-country skiing

