

Spatial and temporal distribution of heavy rainfall during 9-10 September 2015 in East Kanto region, Japan

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East Kanto region of Japan experienced a record heavy rainfall on 09-10 September 2015, caused severe damage of life and properties. Rainfall amount of this event was recorded by Automated Meteorological Data Acquisition System (AMeDAS) rain gauges at every 10 minute time interval. The maximum 24-hrs rainfall (0600 UTC 09 Sept 2015 to 0600 UTC 10 Sept 2015) was reached about 500 mm in some part of the Tochigi prefecture. Estimated rainfall rate from Japan Meteorological Agency (JMA) C-band radar and X-band polarimetric Radar Information Network (XRAIN) are also available for the event at different scale. Spatial and temporal resolution of JMA radar data are 1000-m and 5-min and for XRAIN radar, it is 250-m and 1-min. Both estimated radar rainfall data were compared with rain gauge data to examine their performance.

Based on 24-hrs total rainfall, JMA and XRAIN radar display different rainfall distribution especially in the case of higher rain intensities. Both radar data do not show the dependency of rainfall with respect to elevation for this case. In higher rainfall zone of the event, JMA radar rainfall is overestimated. XRAIN radar reflects some underestimation especially over mountain region, but it provides close rainfall with rain gauge data in the rest part of the Kanto region. XRAIN also shows remarkable variation of rainfall with respect to time but, it is almost not possible to get such information from the JMA radar because of its coarse spatial and temporal resolution observation.

Keywords: Radar rainfall, Heavy rainfall, Spatial and temporal variation, Frequency distribution, Rain gauge

Osaka Urban Phased Array Radar and Lightning Network Experiment

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Osaka University, Toshiba and the Osaka Local Government started a new project to create the Osaka Urban Demonstration Network. The main sensors of the Osaka Network are 2-node Phased Array Radar Network and Broadband Observation Network for Lightning and Thunderstorm. Data products which are created both in locally and Toshiba Computer Cloud, include single and multi-radar data, vector wind, quantitative precipitation estimation, VIL, Lightning location, nowcasting, and analysis. These new products are transferred to Osaka Local Government in operational mode and evaluated by several section in Osaka Prefecture.

Keywords: Radar, Lightning

Airborne campaign using LCTF multi-spectral camera in the Philippines

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The airborne campaign using the Liquid Crystal Tunable Filter (LCTF) multi-spectral camera has been conducted in the Philippines on August 2015 and March 2016. In this campaign, a simultaneous ground validation using spectrometer as well as an on-site discerning of vegetation types were carried out. The main purpose of this campaign is the spectral data acquisition and validation for the Philippine Scientific Earth Observation Microsatellite (PHL-MICROSAT).

The Department of Science and Technology (DOST) and University of the Philippines-Diliman (UPD) have started an international joint program for the development of microsatellites with two Japanese universities, Hokkaido and Tohoku University. The LCTF is a light weight (80 g) and small size (30mm cube) component for spectroscopy, developed by Hokkaido University, was applied for the Spaceborne Multi-spectral Imager (SMI) mounted on the Philippines' first microsatellite, Diwata-1. As the spectrum of vegetation includes several kinds of information such as vegetation types and growth stages, forests and agricultural crops have been studied using spectral instruments in past publications [e.g., Schmidt and Skidmore, 2003; Shibayama and Watanabe, 2007]. Besides, it is well known that such spectral information changes due to several observational factors, such as the influence of specular reflection, difference of spatial resolution and also varying weather condition at the time of acquisition [e.g., Shaw and Burke 2003; Peltoniemi et al., 2015]. In order to evaluate the LCTF spectral image, we compared the spectral data obtained by the LCTF camera with that of other sensors, and investigated the characteristic of the LCTF spectral image. In this paper, we report the latest results and discuss the relationship between these spectral data.

Keywords: Microsatellite, Spectral measurement

Impacts of extreme climate events on coastal environment: A case study from Southwest Sea in Vietnam

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Climate change related to emission of greenhouse gas from human activities is the most important environmental problem of twenty-first century. Such climate change maybe influence to marine ecosystems through extreme weather events like El Nino Southern Oscillation (ENSO), or monsoon causing damage on both fishery and aquaculture. Therefore, the relationship between climate events (such as Monsoon, ENSO) and the variation of marine environment can be used as a proxy to access the damage of climate change on marine ecosystems. However, the mechanisms linking climate events and ecosystem change depend on geographical features, and are difficult to identify due to the synergistic effects of multiple climates and stressors. To understand the response of marine ecosystem to the variation of climate events, satellite remote-sensing data, in-situ observations, and climate indices data in Southwest Sea of Vietnam are combined to examine the spatio-temporal distribution of environment factors for a long period (2002-2012). Beside that, statistical analysis was also implemented to test whether the relationship between paired factors. By combining the results with meteorological knowledge, mechanisms driving the variation of marine ecosystem in this region were explored and discussed.

Keywords: Climate Change, Remote Sensing, El Nino Southern Oscillation, Monsoon, Coastal environment

Relation between charge amounts of lightning discharges derived from ELF waveform data and severe weather

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In order to measure the lightning currents and to estimate charge amounts, induction magnetic coils named as Rogowski coils installed at tall towers are generally used. However, such Rogowski coils can measure only the lightning discharges directly hitting the towers. Recently, it is shown that the ELF magnetic field waveforms measured at the 300 km distance from the lightning is comparable to the lightning current waveforms. Therefore, the charge amounts of any lightning discharges occurring within the area where the induction magnetic fields are measured can be easily estimated from ELF waveforms by quantitatively evaluating the relation between ELF waveforms and the current waveforms. Lightning discharges usually occur within active thunderclouds, and previous studies suggested that there are close relations between lightning activities and severe meteorological phenomena. However, in these studies, only the occurrence frequencies of lightning discharges are considered to estimate such relation. As lightning is a discharge phenomenon, it is more important to investigate the relation between electrical properties of lightning discharges, such as polarities, peak currents, and charge amounts, and the meteorological parameters of the severe weather.

In this study, the lightning current waveforms measured by a Rogowski coil installed at Mt. Ogami and ELF waveforms measured at Onagawa observatory are analyzed as a first step. To validate the similarity between current waveforms and ELF waveforms, we investigated the correlation of these two waveforms. Then, the average correlation coefficient and standard deviation are estimated to be $r=-0.84$ and $\sigma=0.14$, respectively. This result indicates that there are high similarities between these two waveforms. From these quantitative analyses, empirical equations that enable us to directly convert from the magnetic field intensities into the charge amounts were obtained.

As a next step, using ELF waveform data obtained at Kuju station in Kyushu and lightning data of the Japan Lightning Detection Network (JLDN), charge amounts for the lightning discharges occurring when down bursts were confirmed in the Kanto Plain are estimated by applying the empirical equations. Then, we newly found a clear characteristics showing that the time variation of charge amounts was drastically changed just before the downburst onset. At the presentation, we will show the results in one down burst event more in detail, and we will also show the statistical results for other downburst events.

Keywords: lightning

Future Observations of Lightning-exciting ELF Waves in Asian Region for the Nowcasting of Severe Weather Development

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We analyzed the characteristics of the electromagnetic waves in the ELF range measured near the lightning discharges (~300 km distance) and compared them to the lightning current waveform measured by Rogowski coils. From these data analyses, it is found that the shape of the ELF magnetic field waveforms is highly correlated with that of the lightning current waveform, which implies that the measured ELF magnetic field is not the radiative magnetic field but the induction magnetic field. By appropriately scaling the ELF magnetic field waveform and by integrating the waveform, we can estimate the lightning current waveform and the charge amount of any lightning discharges occurring within ~1000 km range from the observation site. Recently, it is shown that the charge amount of the lightning discharges derived from the ELF waveform data and its temporal variation may become a good proxy to nowcast severe weather development [Shimizu *et al.*, 2015; presented at this meeting]. The estimation of the lightning charge amount is also useful to evaluate the damage on the urban information and communication technology (ICT) systems caused by lightning discharges. From these reasons, we have installed ELF observation system at two observation sites in Japan. In Asian region, the VLF observation system (AVON) was already installed to continuously monitor the lightning activities. However, the ELF observation system has not been installed in Asian region, yet. At the presentation, the importance of the measurements of the ELF magnetic field waveforms will be presented. In addition, the future plan of the ELF magnetic field waveform measurements in Asian region will be discussed.

Keywords: lightning, ELF waves, severe weather, nowcasting

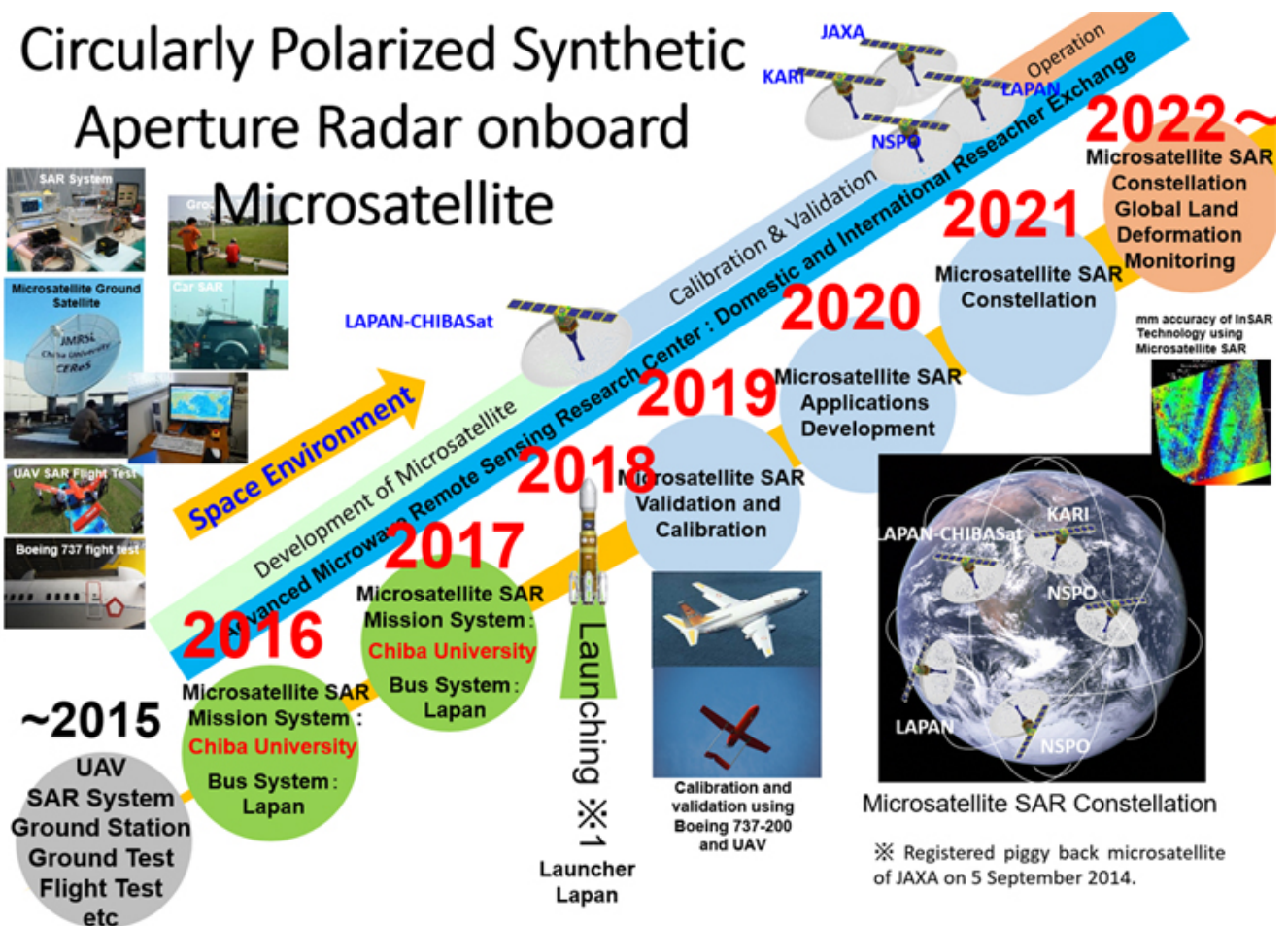
CP-SAR onboard Microsatellite for Global Land Deformation Observation

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Chiba University and Indonesian National Institute of Aeronautics and Space (Lapan) are collaborating to develop Circularly Polarized Synthetic Aperture Radar (CP-SAR) onboard microsatellite (150 kg class) for global land deformation monitoring. This paper explains the progress report of development of CP-SAR sensors (L, C and X bands) for flight tests using unmanned aerial vehicle (UAV) and Boeing 737-200 as microsatellite prelaunch experiments, including anechoic chamber experiment for full polarization of CP-SAR scattering. This paper also introduces application developments of SAR images using InSAR, DInSAR and PS-InSAR techniques for high precision land deformation observation to monitor and predict natural disasters.

Keywords: CP-SAR, microsatellite, land deformation, InSAR, disaster



Optimum micro-satellite constellation for disaster monitoring

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Artificial satellites are generally categorized according to weight: pico-satellites (<1 kg), nano-satellites (1-10 kg), micro-satellites (10-100 kg), mini-satellites (100-1000 kg), and large satellites (>1000 kg). Among the above categories, micro-satellites have made the most remarkable progress over the past few years, and a few hundred of universities, institutes, and companies have launched their own micro-satellites into space. A significant feature of recent micro-satellites is that their missions are getting closer to practical applications of remote-sensing data, such as disaster monitoring. However, due to limitations of spatial resolution and data rate, a single micro-satellite cannot cover a large area in the same way as a larger satellite covers the Earth's surface globally and periodically. In addition, designed life time of micro-satellites is not so long compared with larger satellites. Therefore, a constellation of microsatellites is essentially important, especially for disaster monitoring application that requires rapid response to the specific disaster area. This paper reviews previous satellite constellations for disaster monitoring and discusses a micro-satellite constellation optimized for disaster monitoring.

Keywords: micro-satellite constellation, disaster monitoring

Diwata, the Philippines first earth-observation microsatellite

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Diwata, the Philippines first earth-observation microsatellite

The Philippines, a country in the southeast asia, is vulnerable to a lot of natural hazards. It is located in the pacific ring of fire making it susceptible to earthquakes and volcanic activities. Due to its location, the country also experiences a lot of tropical storms. In a year, on average, about eighteen to nineteen typhoons enter the Philippine area of responsibility. Aside from the large volume of rainfall that these typhoon carry, it also bring strong winds. According to the Philippines' Climate Change Commission, from 1990 to 2006, the annual average damage of typhoons to the agricultural sector alone amounted to 184 million USD. Driven by these hazards, the Philippine government is continuously investing in different technologies that will help in disaster mitigation and management. One of these project is the program, "*Development of Philippine Earth Observation Microsatellite (PHL-MICROSAT)*", funded through the Department of Science and Technology (DOST) which aims to build, launch and effectively utilize the Philippines' first microsatellite for earth-observation.

PHL-MICROSAT is a collaboration between scientists, engineers and professors from the University of the Philippines, the Advanced Science and Technology Institute (ASTI) of the DOST and two Japanese universities, Hokkaido and Tohoku University. Under the program, the Philippine will launch two microsatellites. The first one, named Diwata, will be released from the International Space Station, in the first quarter of 2016. Onboard Diwata are three scientific and one engineering payload. The High Precision Telescope (HPT) which will have a GSD of 3 m at 400 km altitude is equipped with 4 CCDs for each red, green, blue and near infrared region. The HPT, due to its high resolution of 3 m will be used in monitoring the extent of damages from natural disasters such as storms. Images from the HPT will be useful in disaster management and resource allocation. The Space-borne Multispectral Imager (SMI) with Liquid Crystal Tunable Filter (LCTF) which will have a GSD of 65 m at 400 km and has 2 CCDs for both visible (433-740 nm) and near infrared (730-1020 nm) regions with a 1 nm step interval. It will be used in monitoring changes in vegetation and estimating the phytoplankton biomass of the Philippine oceans. The Wide Field Camera (WFC) with a panchromatic CCD will have a field of view of 180x134 degrees and a GSD of 7 km will be used in observing cloud patterns as well as weather disturbances such as tropical storms. And lastly the Middle Field Camera (MFC) which is an engineering payload with a colored CCD and an expected GSD of 185 m will assist in locating the images captured by the HPT and SMI.

In order to know the feasibility of our mission objectives, we simulated the pass of the microsatellite over the Philippines for a specific period of time. Using this, we were able to obtain the frequency of image acquisition of a target location. From our findings, Diwata will be able to provide the Philippines with robust and efficient near real-time status of the country's environment which will enhance its response to calamity and disaster management and will improve land-use and aquatic resource assessment and monitoring.

Keywords: Microsatellite, Natural disaster

Micro-Dragon, the microsatellite for observing ocean environment in Vietnam

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MicroDragon is the first 50 kg class microsatellite of Vietnam National Satellite Center (VNSC). It is being developed by VNSC researchers under instruction of the Japanese professors come from five universities including Hokkaido University, The University of Tokyo, Keio University, Tohoku University and Kyushu Institute of Technology. Hokkaido University has been responsible for the development of the science payloads based on the demands and requirements from the scientific point of view.

Mission of MicroDragon is ocean color observation over Vietnam Ocean to provide data for assessing water data by using two imagers being composed of Space-borne multispectral Imager and Triple Polarization Imager onboard and Fluoro probes in the sea for the missions. Micro-Dragon is Sun-synchronous orbit satellite integrated Attitude determination and control system (ADCS) that is able to receive ocean color data over Vietnam Ocean many times per day. Therefore, one of its applications will be a response system to quickly cope with harmful algae (e.g. red tides and harmful algal blooms) over Vietnam Ocean that has damaged human and marine ecosystems. By using the space-borne ocean color observation system and the marine sensor, networks which can detects ocean anomalies in-real time and disaster information. The system are suitable for capturing subtle changes and detect anomalies in ocean environments in real-time. The end of 2017, the development of MicroDragon will be finished. By now, the project is heading to Critical Design Review in September 2016 after three years implementation since 2013.

Keywords: microsatellite, ocean environment, red tides, harmful algal blooms, ocean hazard

Preliminary Analysis on Rising 2 images' spectral information and its potential for disaster monitoring and prediction

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Importance of disaster monitoring, prediction and mitigation has increased in the past years mainly due to climate change. Based from the Inter-governmental Panel on Climate Change-Fifth Assessment Report (IPCC-AR 5), regions in West, East and South-East Asia will experience an increased in mean annual temperature and precipitation will likely be more extreme in mid- and late- 21st century. The increase on the occurrence of severe typhoons and droughts will be observed in the said regions. In-order to cope up and adapt with the problems brought by Climate change, remote sensing with the use of micro-satellite as a platform has become an indispensable tool. Satellite remote sensing can cover a very large area and produce detailed image of the land and can repeatedly observe the area in a short period of time.

One of the most recent earth-observation microsatellite is Rising-2, which was launched last May 24, 2014. It is equipped with 5 scientific payloads: High Precision Telescope (HPT) with 5m spatial resolution at nadir and has four (4) CCD detector, for Red, Green and Blue region and the fourth CCD has Liquid Crystal Tunable Filter (LCTF) for 650 to 1000 nm spectral range; Bolometer (BOL) with 1km spatial resolution and spectral range of 8 to 14 μm ; Lightning Spectrum Imager-1 (LSI-1) and Lightning Spectrum Imager-2 (LSI-2) with a field of view of 342 km and a spectral range of 744 to 826 nm and 762 nm respectively; Wide Field Camera (WFC) with a field of view of 140 degrees. In this study, six (6) images captured in Japan observed at 665 nm, 683 nm, 700 nm, 720 nm, 750 nm and 873 nm wavelengths using Rising-2's High Precision Telescope were acquired and analysed. Image matching and geo-referencing were done to get the overlap and spatial resolution of the 6 images. Spectral information then is acquired by using calibration parameters for the HPT. From the spectral information, land cover and condition of the vegetation were then classified by using different indices like NDVI and NDWI. Preliminary results show that spectral analysis has a very huge potential for disaster monitoring, prediction and mitigation.

Keywords: Remote Sensing, Microsatellite, Disaster monitoring

Monitoring and prediction of extreme weather using lightning detection network and micro-satellites in Asia

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Thunderstorm causes torrential rainfall and is the energy source of typhoon. In these decades it has been revealed that lightning discharge is a very good proxy of thunderstorm activity. We have constructed the most advanced lightning detection network using VLF radio wave in Southeast Asia, AVON. On the other hand, some developing countries in SE-Asia are going to own few micro-satellites dedicated to meteorological remote-sensing in several years as well as Japan. Making use of the lightning activity data measured by the ground-based VLF network, and information on the extent and 3-D structures of thunderclouds observed by the on-demand operation of remote-sensing micro-satellites, we will get a new way to obtain very detail semi-real time information that cannot be achieved only with existing observation methods, such as meteorological radar or surface meteorological data acquisition system. Based on those measures, we will establish the methodology to grasp the development of thunderstorms occurring in whole area of Southeast Asia and to predict their near future activities as well as typhoon intensity.

Keywords: lightning, micro-satellite, extreme weather, prediction, monitoring, Asia

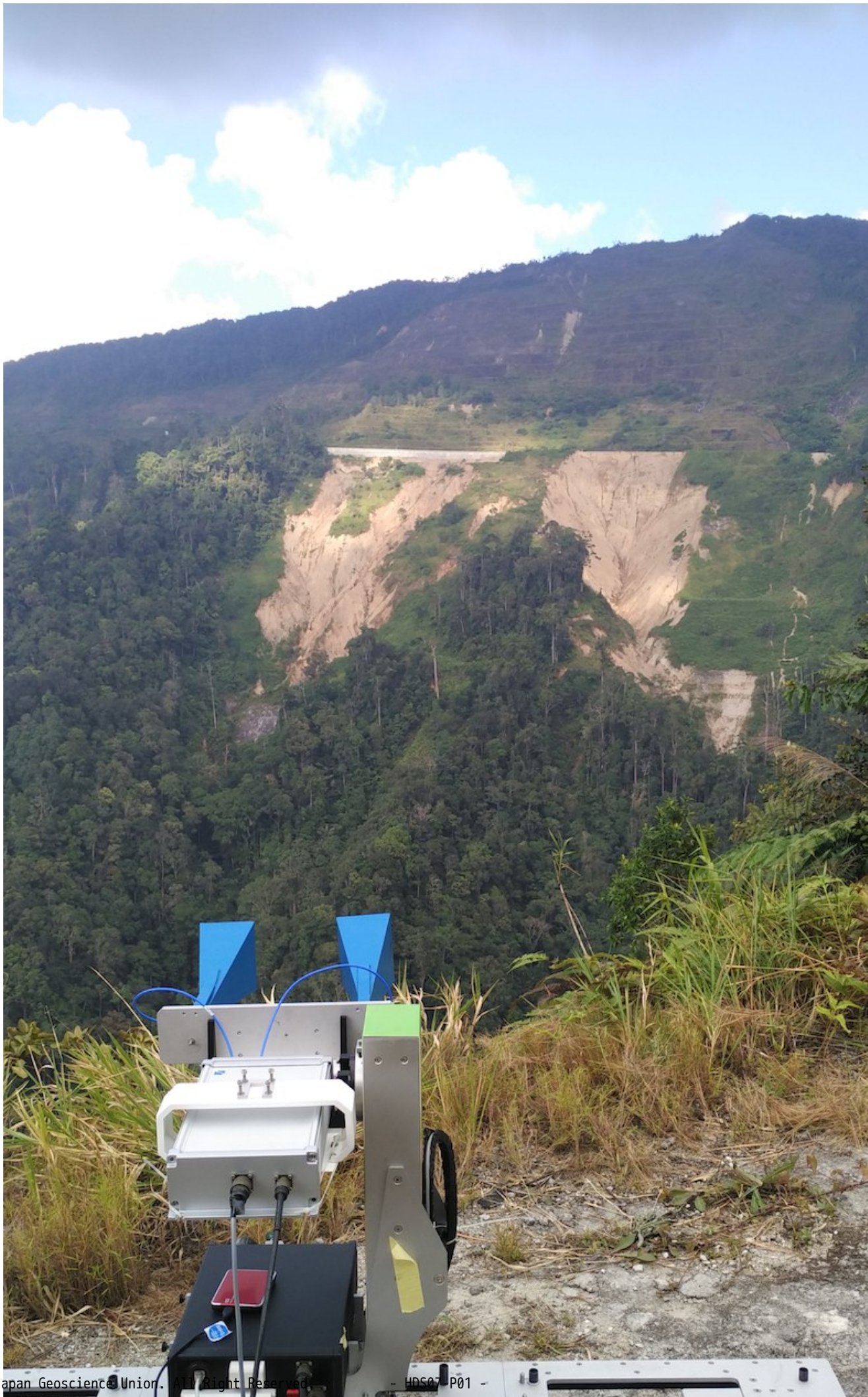
A New Ground-based SAR for Landslide Monitoring: Development and Preliminary Results

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Every year, over one million people are exposed to weather-related landslide hazards around the world. Due to the recent climate change, it is likely that the decrease of permafrost areas, changes in precipitation patterns and increase of extreme weather events will influence the weather-related mass movement activities. This paper reports on the recent development of a ground-based synthetic aperture radar (GBSAR) for continuous monitoring of landslide-prone areas in Malaysia. It operates at Ku-band with spatial resolution of 0.5 m in range and 5.8 mrad in cross range. The system is mounted on a rail which travels along a linear guide to achieve SAR imaging. The GBSAR has been installed at a test site to provide timely information for landslide monitoring and early warning system. The paper discusses the design, development and preliminary field experiments using the new GBSAR system.

Keywords: Synthetic Aperture Radar, Interferometry, Landslide Monitoring



An idea to create a satellite with the capability to rescue

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Until now, satellite is considered by many to be an untouchable system once launched into space. That means we are unable to physically expand, repair or replace any component or sub-system, etc... once a satellite is operating in orbit. That is why satellites have been developed under very stringent design & production process using high-reliability hardware and qualification test to ensure them being able to work smoothly in harsh space environment for a long time without failure. The thing is, people can't manage all risks in space.

This paper suggests a solution which may help to repair a part of hardware problems or fulfil a request for system expansion after launching.

Any satellite is proposed to simply be equipped with a wireless connection port which supports inter-satellite link once requested. The main idea is how to apply it and design the satellite orbit. With this configuration, once this satellite needs:

to add more functions (networking, relay communication...) or increase capacity (adding more memory, data exchange with other satellites...); or

to replace the failed hardware such as data storage; downlink system (for example: space debris damaging the downlink antenna, or problem with the transmitter)...

We will launch a "rescue" satellite for instance a micro-satellite which is able to support the request system or the faulty system. This "rescue" satellite will connect to the "request" satellite via the inter-satellite link.

Here are some technical supports for this solution:

The "rescue" satellite will be launched into the same orbit, maybe as close as possible with the "request" satellite in order to reduce as much as possible the power of transmission of both satellites. That also means a simple and small antenna system is required (we can even use omnidirectional antenna). By the way, the distance and pointing direction between the two satellites is almost unchanged therefore the Doppler's effect is removed and the satellite pointing is easy. It also allows any wireless transmission technology such as that from Ka, Ku band and even optical communication to be easily applied, too.

Nowadays, many satellites have applied the SpaceWire standard due to its advantage of standardized interface, network protocol, link management..., as well as plug and play function. That means no new, expensive technology is required and standard system can be applied easily. It may just request some add-in protocols for this standard.

With this solution, my dream is that one day, satellites will be equipped with a small sub-system just like a PC equipped with a Wi-Fi or USB ports. Such inexpensive investment may create huge advantages to help the mission adapt to unforeseen requirements from a dynamic economy or increase the opportunity to recover from some serious satellite failures.

Keywords: micro satellite, repair and service in space, novel/pioneering mission

The diversity of land surface temperatures in the Greater Lyon (France): preliminary characterization with Landsat 8 TIRS to monitor heat waves impacts

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The health impacts of heat waves are a 21st century challenge facing the world and France in particular. Measures have to be taken to avoid disasters like those of 2003, 2006 and 2015 that respectively caused 15,000, 1400 and 3300 deaths, according to the International Disaster Database EM-DAT (Guha-Sapir et al., 2016). The victims were mainly recorded in large cities because of rising temperatures due to global climate change are amplified by the effect of urban heat island (UHI). This study aims to characterize the phenomenon of UHI on the Greater Lyon area. Located in the southeastern part of France, it focuses 1.3 million people about 500 km², with a high rate of elderly. A parallel study identified the sectors with the most vulnerable populations in terms of health criteria, such as age or physical condition (Renard et al., 2015). The aim of this study is to determine the most frequently hot areas of the city and to compare them with the places where people are the most vulnerable, in order to target priority areas for mitigation and adaptation to this risk.

The method is based on remote sensing. The bands 10 and 11 of the landsat-8 thermal infrared sensor (TIRS) are to calculate the land surface temperature (LST). This temperature estimation procedure follows the ones established by Jimenez-Munoz and Sobrino (2003), Sobrino et al., 2004 and Cristobal et al., 2009. This implies to convert in a first step the Landsat thermal band to at-sensor spectral radiance and then to at-sensor brightness temperature. In second time, the land surface emissivity is estimated using the NDVI threshold methods, according to Sobrino et al., 1990 and 2008. Finally, the land surface temperature (LST) is obtained thanks to the single-channel algorithm (Jimenez-Munoz and Sobrino (2003), Sobrino et al., 2004 and Cristobal et al., 2009) and the results are converted from degrees Kelvin to Celsius.

The results show strong LST spatial disparities in the Greater Lyon. Indeed, variations of several tens of degrees in just a few kilometers are found between rural and urban territory, as for the 4th of July, 2015 (fig. 1). The warmest part of the city is located into the ancient town center and the industrial areas. However, the most sensitive persons are located into the town center, where air conditioning is not frequently used. Consequently, strategies of mitigation and adaptation should be quickly focused on these precise areas.

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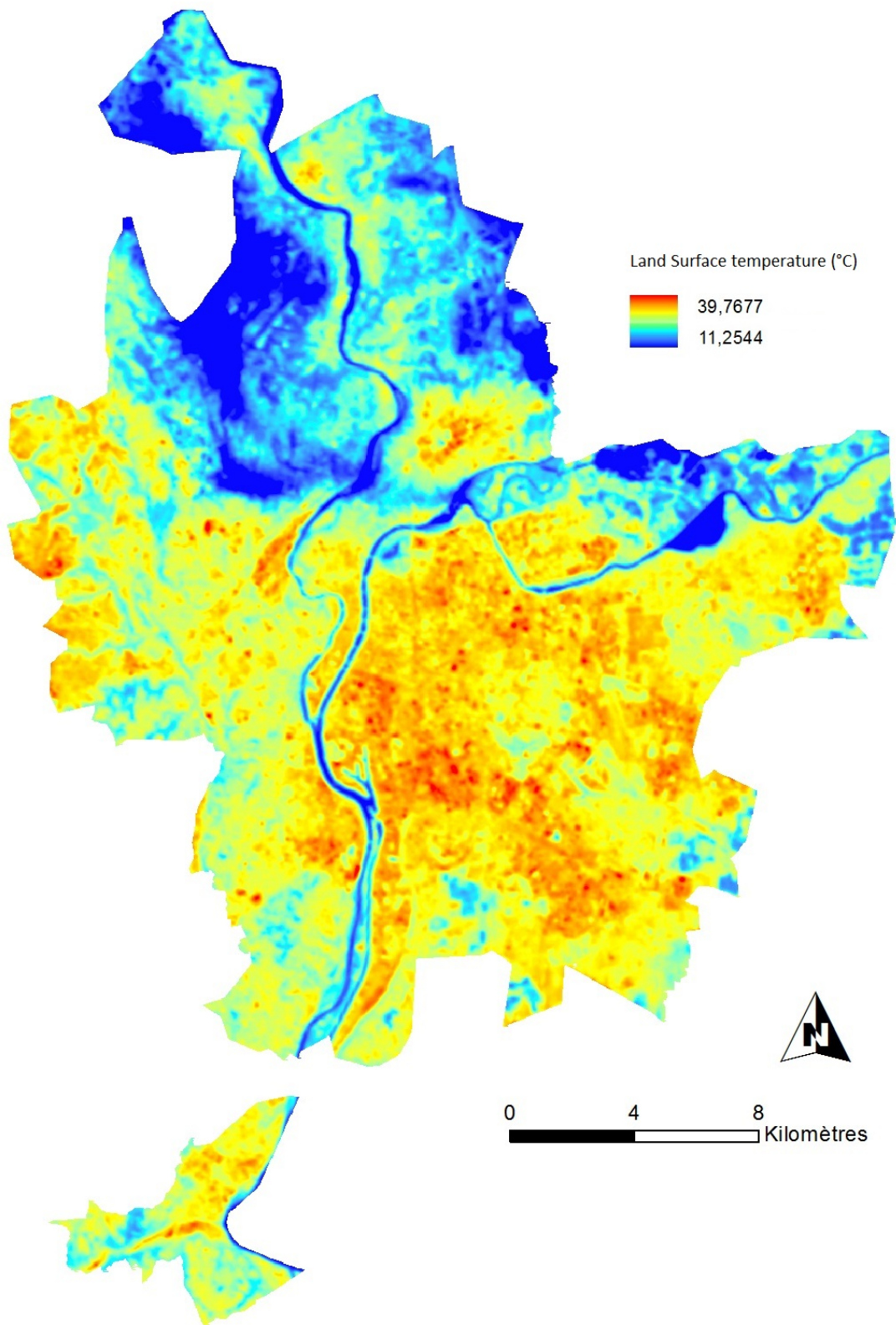
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Keywords: land surface temperature, heat wave, Landsat 8 TIRS, adaptation, mitigation



Quantifying damages brought by tropical typhoons using remote sensing

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Among the world's basins, the northwestern Pacific Ocean has the most number of tropical storm occurrence with an annual average of twenty six from 1981-2010. Many countries including China, Hong Kong, Japan, Korea, and Philippines are affected by these storms. In the Philippines alone, around eighteen to nineteen tropical typhoons enter the country's area of responsibility and of those nine to ten make landfall. The large amount of rainfall that typhoons bring has a big impact in agriculture. According to the Climate Change Commission of the Philippines, from 1990 to 2006, the annual average damage of typhoons to the agricultural sector alone amounted to 184 million USD. Aside from damages in agriculture, strong winds brought by typhoons also result to damages in the infrastructure.

Remote sensing has been widely used in assessing damages from disasters. Compared with field survey, it is a cost effective tool. In this study we compared pre- and post-typhoon satellite images by calculating for different vegetation indices such as Normalized Vegetation Index (NDVI), Normalized Difference Infrared Index (NDII) and Enhanced Vegetation Index (EVI). We found that the largest change is calculated using NDII. We analyzed satellite images from Landsat 8 for tropical storms that passed by the Philippines and Japan. We also correlated the rainfall volume measured by rain gauges to the damages measured by the satellite images.

Keywords: remote sensing, typhoons, damage assessment

Study on early detection of thunderstorm based on electromagnetic measurement in ELF-VLF band

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Recently, heavy rain, tornado and lightning discharge associated with thunderstorm become a representative of severe weather in urban region. Well-established methodology for early detection and nowcast of thunderstorm activity is essential to protect and sustain urban function. Main objective in this study is to verify practical effectiveness of early detection of thunderstorm generation based on lightning observation. Receiver for lightning observation is designed to measure electromagnetic wave radiated from lightning discharge in ELF (Extremely Low Frequency, less than 3 kHz) and VLF (Very Low Frequency, 3-30kHz) band and installed around the Tokyo metropolitan region. Radio wave in ELF-VLF bands can propagate long distance (more than several hundreds kilometers) and makes it possible to detect lightning discharge with high sensitivity with few observation sites.

In this presentation, lightning observation for thundercloud generated above Ebina city, Kanagawa at September 6th, 2014 is summarized as an initial result. First detection of lightning signal in ELF-VLF observation is 30 minutes earlier than that in existing network for observation of cloud-to-ground (CG) lightning discharge. This result indicates the possibility that not only CG lightning discharge but also intracloud (IC) lightning discharge whose electromagnetic radiation is weaker than that from CG could be detected by our network. The IC lightning dominated over CG lightning in the early stages of thunderstorm. Detection of IC in ELF-VLF observation enables us to monitor thunderstorm generation without high-spatial density observation.