Date:22nd August, 14:00~17:30
Venue: Inna Grand Bali Beach Hotel, Bali, Indonesia
Host:SGRA/Atsumi International Foundation
Co-host : Center for Environmental Remote Sensing, Chiba University
In Cooperation : IEEE AES & GRSS Indonesia Chapter

Aim at :

Recently, global environment changes caused by human activities, natural disaster etc. Remote sensing technology is very important tool to observe the environmental change. This session will discuss remote sensing technology and applications, especially sensor, unmanned aerial vehicle, microsatellite, image analysis and applications etc.

AFC SGRA Sekiguchi Global Research Association 関口グローバル研究会 CHIBA UNIVERSITY

The 21th CEReS International Symposium
SOMIRES 2014
Symposium on Microsatellites for Remote Sensing

JMRSL

The 21th CEReS International Symposium

SOMIRES 2014

Symposium on Microsatellites for Remote Sensing

Baris Room, Inna Grand Bali Beach Hotel, Bali, Indonesia August 22, 2014

AFC Forum C1: Environmental Remote Sensing, The 21nd CEReS International Symposium and The 2nd Symposium on Microsatellites for Remote Sensing (SOMIRES 2014)

Time: Friday, 22 August 2014: 2:00pm – 3:30pm

Session Chair: Josaphat Tetuko Sri Sumantyo, Chiba University, Japan

Location: Baris Room, Inna Grand Bali Beach Hotel

Language: English

The 2nd Symposium on Microsatellites for Remote Sensing (SOMIRES 2014) has been held at Sanur, Indonesia on 22 August 2014 to discuss the progress of our microsatellites project with nine invited talks. This symposium was collaborating with The 2nd Asia Future Conference (AFC 2014) as AFC Forum C1: Environmental Remote Sensing and The 21th CEReS International Symposium 2014. This symposium was attended by about 60 participants.

Session Abstract

Recently, global environment changes caused by human activities, natural disaster etc. Remote sensing technology is very important tool to observe the environmental change. This session will discuss remote sensing technology and applications, especially sensor, unmanned aerial vehicle, microsatellite, image analysis and applications etc.

近年、人間活動、自然災害などによって、アジア地域をはじめ、世界各国に環境変化が起きている。この環境変化を監視するために、リモートセンシング技術が欠かせないツールである。本セッションでは、リモートセンシング関連のセンサ、無人航空機、小型衛星、画像処理と応用などを議論する予定である。

Bali, 22 August 2014

J.T. Sri Sumantyo

千葉大学環境リモセン JMRSL

Prof. Josaphat Tetuko Sri Sumantyo, Ph.D

General Chairman

Abstract Collection

Microwave Remote Sensing for Environmental Monitoring

Josaphat Tetuko Sri Sumantyo
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Abstract :
Synthetic Aperture Radar (SAR) is well-known as a multi-purpose sensor that can be operated in all-weather and day-night time. In this research, we propose Circularly Polarized Synthetic Aperture Radar (CP-SAR) or Elliptically Polarized Synthetic Aperture Radar (EP-SAR) onboard unmanned aerial vehicle (UAV) and microsatellite to retrieve the physical information of land surface and disaster monitoring. The sensor is designed as a low cost, light, low profile configuration to transmit and receive left-handed circular polarization (LHCP) and right-handed circular polarization (RHCP). For this purpose, we develop UAV JX series for ground experiment of this sensor. The main mission of CP-SAR is to hold the basic research on elliptically polarized scattering and its application developments. In the basic research, we will investigate the elliptical (including circular and linear polarizations) scattering wave from the land surface, generation of axial ratio image (ARI), ellipticity and tilted angle images etc. We will hold the analysis and experiment of circularly polarized wave scattering on vegetation, snow, ice, soil, rock, sand, grass etc to investigate the elliptical scattering wave. CP-SAR sensor transmits only one polarization, RHCP or LCHP, then this sensor will receive RHCP and LHCP scattering waves simultaneously. The image is employed to investigate the relationship between the physical characteristics of vegetation, soils, snow etc. The image of tilted angle as the response of land surface also will be extracted to mapping the physical information of the surface. In application development, CP-SAR sensor will be implemented for land cover mapping, disaster monitoring, Cryosphere monitoring, oceanographic monitoring etc. In disaster monitoring, CP-SAR sensor will be employed for monitoring of earthquake area, volcano activity, landslide etc. This paper introduces progress on development of our CP-SAR onboard UAV and microsatellite, including the applications.

Scope of Asian Micro-satellite Consortium with Super-constellation

Yukihiro Takahashi

Hokkaido University, Japan; yukihiro@mail.sci.hokudai.ac.jp

Abstract :

Micro-satellite with a weight of 50-100 kg has a great potential with various merits compared to larger sized satellite, that is, 1) very low cost development, that is, around 5 M USD including BUS and mission payloads. The launch cost will be about 3-5 M USD as piggyback or assembling launch, 2) quick fabrication in two years for flight model, enabling application of the latest technologies, 3) on-demand operation, taking detail information at a point of interest, and 4) the low cost and quick fabrication make us possible to launch not a small number of satellites, which is called as "constellation" flight. If we have a budget for one large satellite, it's possible to fabricate and launch 50 or more micro-satellites. Here we suggest the international organization, "Asian micro-satellite consortium" (AMC), which promotes and accelerates the micro-satellite development and the discussion of data utilization. AMC will consist of domestic working group in each country. The each working group is composed of 3 parts: BUS development team, payload development team and data user team, involving various field scientists or engineers, such as forestry, agriculture, fishery, forest fire, bio-diversity, flood, meteorology, climate change, ionospheric / magnetospheric science, etc. Also in AMC we will discuss the possibility of future projects, such as "on-demand operation" or "super constellation" involving more than tens of micro-satellites and unmanned air vehicles (UAVs) under international collaboration. At this moment, institutes/universities in about 10 countries in SE-Asia show strong interest in that collaboration.

Observations of Ionosphere with Mini/Microsatellites –Problems and Solutions-

Koichiro Oyama
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koh_ichiro@yahoo.co.jp

Abstract :
DC Langmuir probe is one of the key in-situ instruments to study ionosphere. It needs a counter electrode whose conductive surface area is at least 1000 times larger than that of surface area of the electrode. This requirement is usually fulfilled for large satellites which have been launched so far for ionosphere study. Now we are jumping into an era to use tiny satellites. Then we will encounter serious problems if we try to use DC Langmuir probe. One of the problems is related to a small ratio of conductive surfaces of counter electrode to that of the electrode. The second serious problem is associated with contamination of electrode as well as satellite surface. These two factors make it impossible to use DC Langmuir probe as an instrument of tiny satellite. We review problems which appear for the ionosphere measurement by using tiny satellites, and propose ways avoid the problems to accomplish accurate measurements.

Development of Space-based Magnetic Activities Measurement Mission in LAPAN's Micro-Satellites

Robertus Heru Triharjanto1, Harry Bangkit 2, M. Arif Saifudin 1

1 Center for Satellite Technology, LAPAN, Indonesia; 2 Center for Space Science, LAPAN, Indonesia; rtriharjanto@yahoo.com

Abstract :

LAPAN has been observing space weather data using ground-based sensor, among others magnetometer. With the develoment of micro-satellite technology in LAPAN, it become possible for LAPAN to have space-based magnetometer. The paper elaborate the mission concept of the payload, and the development progress that has been done to achieve the mission objectives. The learning process done on the satellite-based magnetometer data handling at the Center of Satellite Technology and Center for Space Science was started with the data handling of magnetometer in attitude control system of LAPAN-A2 micro-satellite. With such knowledge, the specification and the test procedures of magnetometer that will be on-board of LAPAN-A3 and LAPAN-A4 micro-satellite was defined. The paper also discuss further planning that was drawn for the development of more scientific class geomagnetic measurement mission in LAPAN-A4 micro-satellite.

Development of a Ground-based Synthetic Aperture Radar for Land Deformation Monitoring

Voon Chet Koo 1, Tetuko Sri Sumantyo Josaphat 2, Tien Sze Lim 1, Yee Kit Chan 1, Habibah Lateh 3

1 Multimedia University, Malaysia; 2 Chiba University, Japan; 3 Universiti Sains Malaysia, Malaysia; vckoo@mmu.edu.my

Abstract :

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 the recent development of a ground-based synthetic aperture radar (GBSAR) for continuous monitoring of landslide-prone areas in Malaysia. It is an ultra-wideband system operating at 17 GHz with spatial resolution of 0.3 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 field experiments using the new GBSAR system.

The challenge for still unresolved development of Multi-band Equatorially Orbiting POLSAR satellite sensors – an integral task for the major space-SAR technology centers world-wide – focused on the Indonesian Islands Environment

Wolfgang-Martin Boerner

University of Illinois at Chicago, United States of America; wmb1uic@yahoo.com

Abstract :

We need to mobilize and draw full responsible attention of the main SAR Development Centres worldwide such as NASA/JPL, ESA/ESTEC, JAXA/EORC, CSA/SAR, DLR/SAR, DSTO/SAR, ISRO/SAC, INPE/SERE plus NTU-Temasek, NCU-CSRSR, LAPAN/RANCABUNGUR, and so on; joining forces and strongly contributing to a viable multi-band general bi-static (including cross/along)-track POLSAR sensor technology, well suited for equatorial monitoring within orbits of +/- 20* latitude. Then, local regions such as the Indonesian islands could be observed daily up to 12 to 14 times, covering both the land and ocean regions essential for environmental protection and meteorological forecasting, respectively, on a hitherto unprecedented global level. With the relentless increase in population density, the anthropogenic expansion into natural terrestrial hazard zones has become irreversible resulting in ever more catastrophic disasters, not only in the Asia-Pacific region more so within the entire tropical belts engulfing Mother Earth. Thus not only the Indonesian-Pacific Islands, so also South America, Africa and back via the Indian Ocean Islands to Asia-Pacific, these natural events like volcano eruptions, earthquakes with emerging tsunami, cyclones and severe down pours have caused havoc, loss of lives, destruction of infrastructure and above all intentional manmade interference resulting in the deterioration of pristine tropical jungle forests. What is required is around-the-clock local and wide-area surveillance and remote sensing of the vegetative cover for which first well designed optical equatorially orbiting satellite sensors had been developed but their successful implementation failed because of the ever increasing cloud, precipitation, humidity and aerosol cover within the entire equatorial belt of +/- 15* ~ 20* latitude rendering penetration at optical wavelength mostly ineffective. Hence, we must take recourse to microwave sensing, and implement radar and synthetic aperture sensors from air and space operational at day & night independent of weather; and the sensors especially suited are the fully polarimetric POL-SAR sensors developed for satellite remote sensing by the major SAR technology development centers worldwide. As first and main test case, we will explore the Indonesian Island region.

The plan for space observation network installation in Southeast Asian region

Tu Hwan Kim, Sung Ho Na, Seoung Yong Kang

Ajou University, Korea, Republic of (South Korea); thkim@ajou.ac.kr

Abstract :

In the near future, after spread of the small SAR satellites in Southeast Asian region, each countries will install small ground stations for receiving satellite data. If the ground stations will be equipped with a broadband (2～14 GHz) receiving system, they may be used as VGOS (VLBI Geodetic Observing System) station. In other words, it is possible to do VLBI (Very Long Baseline Interferometry) observation with a main station which has a 20 m class antenna equipped with broadband receiving system. And then it can be used for multiple purposes, such as resource exploration, crustal deformation, monitoring of natural disasters and so on.

On the other hand, there is no geodetic VLBI observation networks in Southeast Asia, and they do not use the World Geodetic System (WGS), which is adopted worldwide. To use the WGS, one should determine accurately the reference origin of each the country, and then build its local reference coordinate system. For this purpose, after installing the geodetic VLBI observation station, it is necessary to accurately determine the reference point of the observation station. In this way we can build the new national reference coordinate system based on the WGS. To perform the geodetic VLBI observation thereof, we should construct the international joint, space observation network with small ground stations and the hub observing station with a 22m antenna of Korea.

This paper discuss the multi-purpose space observation network installation in Southeast Asian region.

Image Quality Comparison of Linear Polarized and Circular Polarized SAR

Heein Yang 1, Bambang Setiadi 2, Josaphat Tetuko Sri Sumantyo 2, Jae-Hyun Kim 1

1 Ajou University, Korea, Korea, Republic of (South Korea); 2 Chiba university, Japan; jkim@ajou.ac.kr

Abstract :

Synthetic Aperture Radar (SAR) is recognized as a powerful surveillance and land observation purpose system these days. An SAR sensor is usually loaded on moving platform such as aerial vehicle or satellite then acquires the images of remote area in interest. Also this system uses microwave for its own illumination source, therefore it can be operated regardless of the weather condition. When SAR system performs its mission in space, there are ionosphere and air in the path of satellite and the target as a propagation medium. Conventional SAR system uses linearly polarized (LP) microwave and as LP wave traverses through the ionosphere, Faraday rotation (FR) effect occurs. FR makes the reference plane of microwave tilt slightly, consequently causes polarization mismatch when receiving the backscattered signal. This polarization mismatch eventually degrades the image quality such as image burling, degradation of contrast, and etc. To cover up the problems of conventional LP-SAR system, this paper proposes that circularly polarized (CP) SAR system which can get rid of polarization mismatch theoretically and compare the pros and cons between LP and CP SAR images with simulated image data.

International cooperative studies on environment and disaster mitigation with satellite remote sensing

Fusanori Miura

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Abstract :

The center for Remote Sensing and Ocean Science (CReSOS) was established with the aid of JAXA and LAPAN in Udayana University (UNUD) in 2003. Objectives of CReSOS are: i) to educate graduate school students for environment studies such as research on climate change and oceanography, coastal environment & fishery, land process and precipitation, mechanism of natural disasters and its effects on human society etc., ii) to set up and maintain Indonesia ocean data archives, iii) to promote international cooperative research between UNUD and Japanese research institutions, iv) to be a national node for remote sensing research through these activities. JAXA PILOT PROJECT was started in 2003 and continued until 2008. UNUD and Yamaguchi University (YU) has established joint master course program in 2009 with the support of Grant from Government of Japan for International Graduate School Cooperation by Satellite Remote-Sensing. Then UNUD and YU started double degree program in 2011. Some UNUD students come to YU and study in the second academic year and some of them enter Doctoral course and acquire PhD. Many valuable papers have been published through the program. The program is now expanded not only for Indonesian students, but also for students in Southeast Asia countries.

Paper Collection

MICROWAVE REMOTE SENSING FOR ENVIRONMENTAL MONITORING

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ABSTRACT

This paper introduces the progress of circularly polarized synthetic aperture radar (CP-SAR) development in Center for Environmental Remote Sensing, Chiba University, Japan for unmanned aerial vehicle (UAV, JX series) and microsatellites (GAIA series). This sensor will be used to monitor global land deformation and disaster area.

Index Terms— CP-SAR, Synthetic Aperture Radar, UAV, Microsatellite

1. INTRODUCTION

Synthetic Aperture Radar (SAR) is well-known as a multi-purpose sensor that can be operated in all-weather and day-night time. As our laboratory roadmap for microsatellites and unmanned aerial vehicles development (refer Fig. 1 and Fig. 2), our laboratory develops Circularly Polarized Synthetic Aperture Radar (CP-SAR) or Elliptically Polarized Synthetic Aperture Radar (EP-SAR) to retrieve the physical information of land surface and disaster monitoring. The sensor is designed as a low cost, light, low profile configuration to transmit and receive left-handed circular polarization (LHCP) and right-handed circular polarization (RHCP), see Fig. 3. For this purpose, we also develop unmanned aerial vehicle (UAV) for ground experiment of this sensor [1]-[2], see Fig. 4 and Fig. 5

The main mission of CP-SAR is to hold the basic research on elliptically polarized scattering and its application developments. In the basic research, we will investigate the elliptical (including circular and linear polarizations) scattering wave from the land surface, generation of axial ratio image (ARI), ellipticity and tilted angle images etc. We will hold the analysis and experiment of circularly polarized wave scattering on vegetation, snow, ice, soil, rock, sand, grass etc to investigate the elliptical scattering wave. These images will be extracted by using the received RHCP and LHCP wave. CP-SAR sensor transmits only one polarization, RHCP or LCHP, then this sensor will receive RHCP and LHCP scattering waves simultaneously. The image is employed to investigate the relationship between the physical characteristics of vegetation, soils, snow etc. The image of tilted angle as the response of land surface also will be extracted to mapping the physical information of the surface, i.e. geological matters, contour, snow-ice classification, vegetation characteristics etc.

In application development, CP-SAR sensor will be implemented for land cover mapping, disaster monitoring, Cryosphere monitoring, oceanographic monitoring etc.

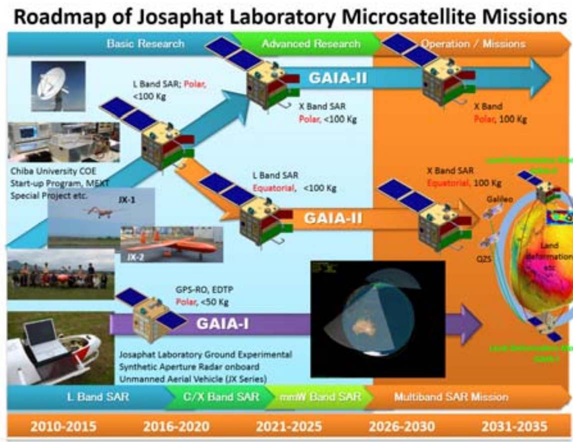

Fig. 1. Road map of Microsatellite development

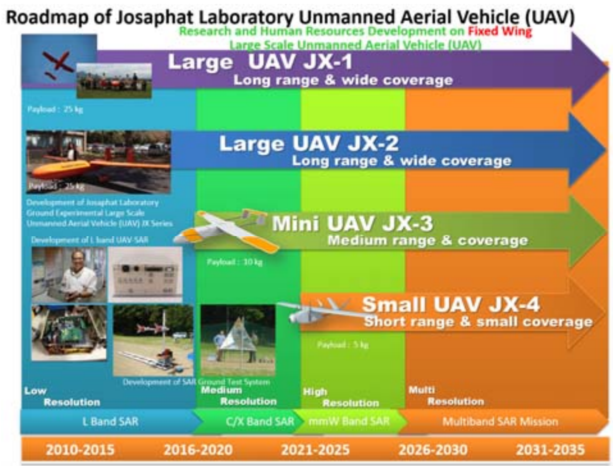

Fig.2. Roadmap of UAV development

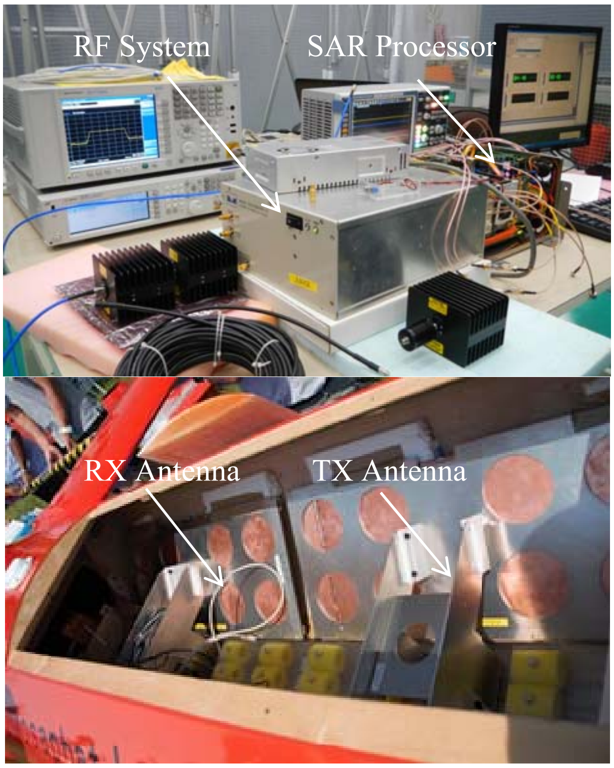

Fig. 3. Circularly Polarized Synthetic Aperture Radar (CP-SAR) and antenna for Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-1)

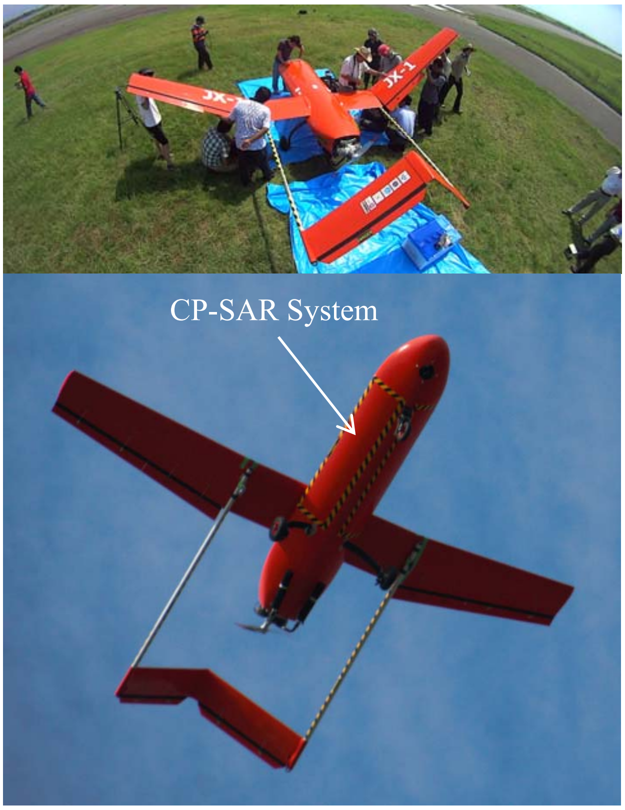

Fig. 4. Flight test of CP-SAR onboard UAV JX-1 at Fujikawa Airport, Japan on 29 August 2013.


Fig. 5. The 2nd Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-2) for microwave sensor ground test

Especially, land cover mapping will classify the forest and non-forest area, estimation of tree trunk height, mangrove area monitoring, Arctic and Antarctic environment monitoring etc. In disaster monitoring, CP-SAR sensor will be employed for monitoring of earthquake area, volcano activity, landslide etc. This paper introduces progress on development of our CP-SAR onboard UAV JX-1/JX-2 and microsatellites.

2. CP-SAR ONBOARD UNMANNED AERIAL VEHICLE (UAV)

The CP-SAR onboard UAV (Fig. 6) is mainly composed by Flight Control System, Telemetry and Command Data Handling, Attitude Controller, and Sensors. Telemetry and Command Data Handling subsystems use S-band communications between UAV and ground station. Attitude Controller is composed by Inertial Measurement Unit (IMU) and GPS units. Sensors are composed by CP-SAR as main mission sensor, and other sensors. CP-SAR sub-system itself is composed by chirp pulse generator module, Transmitter and Receiver (Tx-Rx) module, and Image Signal Processing module. Ground control segment was used for CP-SAR sensor monitoring and image processing. The CP-SAR system is composed by transmitter and receiver sub modules.

The input of transmitter is In-phase (I) and Quadrature (Q) signal of chirp pulse generated by pulse generator with baseband range is DC to 150 MHz (normally 50 MHz). Then chirp pulse is modulated by frequency 1,270 MHz, where our Tx-Rx system has frequency range 1270 MHz ±50 MHz (maximum ± 150 MHz). The transmission system has gain tuning function as 1, 2, 3, 8, 16 dB or 0 to -31 dB, and receiver has gain tuning function as 1, 2, 3, 8 and 16 x 2 or 0 to -62 dB. Power amplifier (PA) is available to control pulse transmission output power 50 W with pulse width

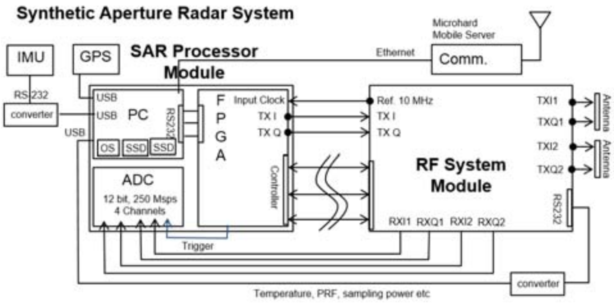

Fig. 6. CP-SAR UAV System

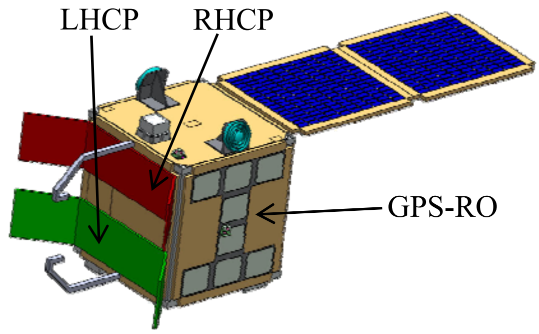

Fig. 7. CP-SAR onboard microsatellite

maximum 10 μs, and maximum duty circle is 2%. The switching speed of transmission and receiver system antennas (RHCP and LHCP) is typically 1 μs and maximum 2 μs. The antenna is composed by two sets of CP microstrip array antenna (LHCP and RHCP panels), totally 4 panels to realize full polarimetric CP-SAR sensor. We could control the pulse length and bandwidth of chirp pulse (max 150 MHz), and save data to SSD memory.

In this research, the CP-SAR onboard unmanned aerial vehicle (CP-SAR UAV, Fig. 4 and 5) is developed for ground testing of CP-SAR and other sensors. The platform called Josaphat Laboratory Experimental UAV (JX-1 and JX-2) has 25 kg of payload availability for various microwave sensors (CP-SAR, GPS-SAR etc) and optic sensors, i.e. hyper spectral camera. The operation altitude is 1,000 m to 4,000 m. The specification of CP-SAR sensor for UAV is center frequency 1,270 MHz, ground resolution up to 1 m, pulse length could be tuned from 4.5 to 48 μs, maximum pulse bandwidth 150 MHz, off nadir angle 30° to 60°, swath width 1 km, antenna size for 4 panels of CP-SAR 1.5 m x 0.4 m, PRF 1,000 Hz, and peak power 8.65W (1 km) to 95W (4 km). We held ground experiment with altitude less than 2 km with pulse transmission output power 50 W. The data retrieved by LHCP and RHCP antenna [3] is employed to investigate the characteristics of elliptical polarization, including circular and linear polarizations. In the future, further investigation of characteristics of circular polarization will be done by using our new CP-SAR UAV JX-2.

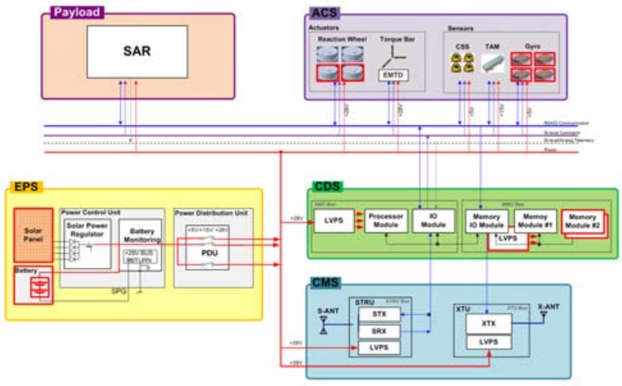

Fig. 8. Modules of CP-SAR onboard microsatellite

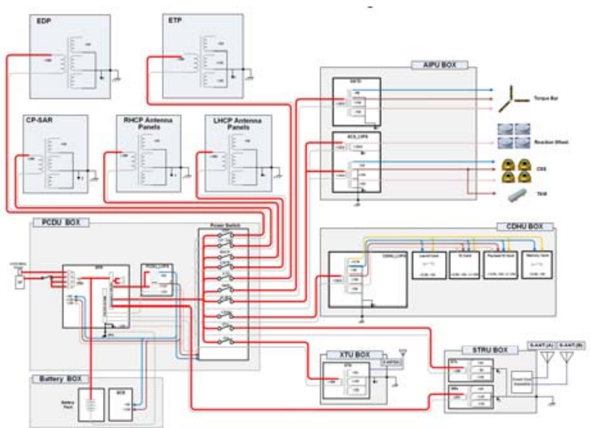

Fig. 9. Power network of CP-SAR microsatellite

3. CP-SAR ONBOARD MICROSATELLITE

Fig. 7 and Fig. 8 shows model and main components of CP-SAR onboard microsatellite that developed in Josaphat Microwave Remote Sensing Laboratory (JMRSL), Center for Environmental Remote Sensing, Chiba University. This microsatellite is composed by Command and Data Handling Sub-system (CDS), Communication Subsystem (CMS), Electrical Power Subsystem (EPS), Altitude Control Subsystem (ACS) and payload. CDS uses Leon3 card, low power supply card (LVPS), IO card, payload IO card, and non-volatile memory card. CMS is composed by LVPS, low power supply card, S band transmitter & receiver (STX and SRX) and antenna for telemetry, X band transmitter and antenna for data downlink. EPS is composed solar panel, solar power regulator, power supply card, power distribution card, Li-Ion battery pack and battery control card. ACS employs LVPS, actuators (reaction wheels assembly–RWA and electromagnetic torque bar-EMTB) and sensors (coarse sun sensor-CSS and three-axis magnetometer-TAM), and GPS Receiver-GPSR. Payload is composed by main sensor CP-SAR for Earth surface monitoring and minor sensors: electron density – temperature probe (EDTP) for ionospheric monitoring.

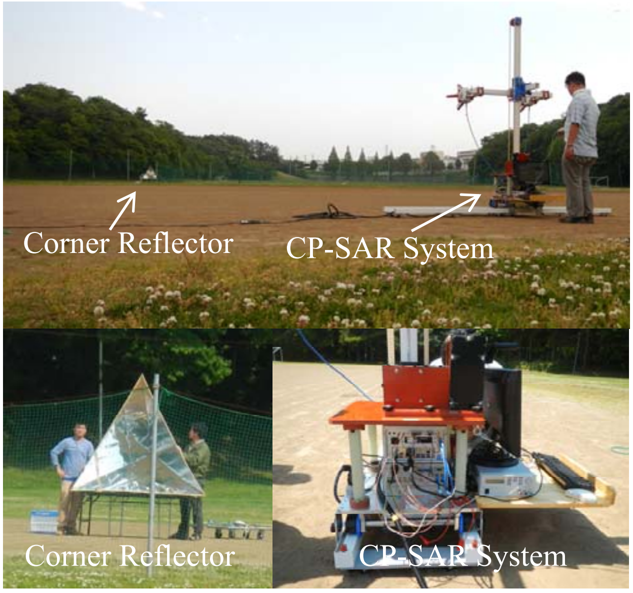

Fig. 10. Ground test of CP-SAR system for UAV

Power network of our microsatellite is shown on Fig. 9. We also develop SAR ground test measurement system as shown on Fig. 10 with moving precision 0.1 mm.

We also develop sub mission sensors, i.e. GPS-RO and electron density – temperature probe (EDTP) to monitor ionospheric phenomena. We will employs these ionospheric observation sensors simultaneously with our CP-SAR to monitor ionosphere and global land deformation. Therefore we could mapping pre-cursors of earthquake by using our microsatellites in the future. Fig. 11 shows experiment of our EDTP in vacuum chamber to investigate the performance in plasma environment.

4. SUMMARY

In this paper, we introduce the progress of development on CP-SAR onboard UAV and microsatellite in our laboratory. The CP-SAR sensor is designed as small, light in weight and low power consumption system. The CP-SAR sensor is developed to radiate and receive elliptically polarized wave, including circularly and linearly polarized waves. In the near future, this sensor will be installed in our UAV and microsatellite that will be applicable for land cover mapping, disaster monitoring, snow cover and oceanography monitoring etc. We also develop some ionospheric observation sensors that is introduced in this paper too. In the future, these sensors could be employed for observation of ionosphere and global land deformation simultaneously for disaster monitoring and prediction.

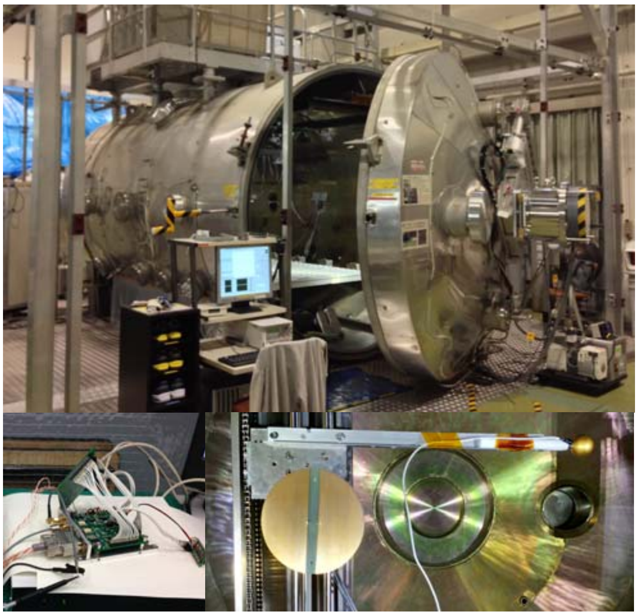

Fig. 11. Electron Density – Temperature Probes (EDTP) test in vacuum chamber

ACKNOWLEDGEMENT

Josaphat Microwave Remote Sensing Laboratory (JMRSL) thanks to Chiba University, the Japan Society for the Promotion of Science (JSPS); Chiba University COE Start-up Program; the Japanese Ministry of Education and Technology (Monbukagakusho); JICA-JST SATREPS Program, PASCO, Weathernews, Venture Business Laboratory – Chiba University etc for supporting this research.

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[2] J.T. Sri Sumantyo, Chapter 11. Circularly Polarized Synthetic Aperture Radar onboard Unmanned Aerial Vehicle (CP-SAR UAV), Autonomous Control Systems and Vehicles, Kenzo Nonami edn., Springer, December 2012.

[3] Yohandri, V. Wissan, I. Firmansyah, P. Rizki Akbar, J.T. Sri Sumantyo, and H. Kuze, "Development of Circularly Polarized Array Antenna for Synthetic Aperture Radar Sensor Installed on UAV," Progress in Electromagnetics Research C, Vol. 19, pp. 119-133, January 2011.

Scope of Asian Micro-satellite Consortium with Super-constellation

Yukihiro Takahashi[1]
[1]Space Mission Center and Department of Cosmosience, Hokkaodo University

ABSTRACT

Micro-satellite with weight of 50-100 kg or less has unique characteristics and various merits compared to existing large, middle and, even small (~200-300 kg) satellites. With advanced sensors, the micro-satellites could play important roles as an operational tool in many applications including climate studies and disaster management in the very near future. Here we would propose and discuss the establishment of international organization, "Asian micro-satellite consortium" (AMC), which promotes and accelerates the micro-satellite development and the discussion of data utilization. In AMC we will discuss the possibility of future projects, such as “super constellation” involving more than tens of microsatellites and unmanned air vehicles (UAVs) under international collaboration. At this moment, institutes/universities in about 10 countries in SE-Asia show strong interest in that collaboration.

Keywords: Micro-satellite, UAV, consortium, constellation, Asia

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e-mail: yukihiro@mail.sci.hokudai.ac.jp

Introduction

Remote-sensing with satellite is one of the most strongest way to monitor the earth without doubt. However, large satellite is expensive and sometimes its development takes about 10 years or more. Here we consider micro-satellite with weight of 50-100 kg or less, which has unique characteristics and merits compared to existing large, middle and, even small (~200-300 kg) satellites. With advanced sensors, the micro-satellites could play important roles in various applications including climate studies, disaster management, smart agriculture and fisheries in the very near future. Hokkaido University has been developing micro-satellite technologies and promoting data utilization involving experts in wide-ranging research fields together with Tohoku University and other institutes/universities. We introduce advantages of micro-satellite with advanced sensors and discuss the future applications, considering the combination with ground observing facilities.

Advantages of Micro-satellite

Advantages of 50-100kg class micro-satellite would be a key for future space development dedicated to climate studies, disaster management, and smart agriculture and fisheries. Its characteristics and merits compared to middle and large sized satellite are: 1) low cost fabrication compared to middle or large sized satellite, namely, 2-4 M USD for BUS and 1-2 M USD for mission payloads. The launch cost will be about 2-3 M USD as piggyback and 5-6 M USD as scheduled launch, 2) quick fabrication: about one or two years for flight model would be sufficient, enabling application of the latest technologies, that could be even better than existing equipments onboard large satellites, 3) on-demand operation in order to obtain detail information at a point of interest, and 4) the low cost and quick fabrication make us possible to launch not a small number of satellites and operate them as a network, which is called as constellation flight. In order to make the utilization of micro-satellite, the highly-functionable advanced optical and radio-wave sensors are essential, especially in conducting spectral imaging and radar measurement. On the other hand, UAV (uninhabited airborne vehicle) has a great potential in measuring local area with higher spatial resolution than satellite with lower cost as well as “test bed” of spacecraft equipment in developing phase. The important thing is to find the "best mix" among micro-satellite, larger satellite, UAV and ground equipment.

Advanced Sensor development for Micro-satellite

Hyperspectral data will be one of the main players in optical remote-sensing from space in the future, though there exist only few large satellites which carry hyperspectral imager at this moment. For example, if we want to classify tree species or to estimate growth rate of trees or grasses in order to conduct effective carbon management related to REDD+, the 3 color (RGB) imaging is absolutely insufficient. However, at this moment, the very limited satellites carry hyperspectral sensor using grating device, which is generally heavy, large and expensive compared to multicolor camera with filters and its typical spatial resolution is only 30 m/s. Hokkaido University has been developing a super multicolor camera using LCTF (Liquid Crystal Tunable Filter) technology. We can select any colors with bandwidth of about 20 nm (5 nm in the future) in the range of 420-700 nm or 650-1050 nm at 1 nm step, just controlling voltage for liquid crystal. This kind of LCTF camera is the only instrument that satisfies both precise spectral measurement and high-spatial resolution up to 5 m (2.5 m in the future) GSD.

Hokkaido University also has been developing thermal infrared camera using "commercial grade" micro bolometer array technology, which is very useful to measure the surface temperature of ocean, ground and cloud. Especially this camera may play an important role in detecting forest fire in the future. The costs of those micro-satellite sensors are 1/10 or less than normal IR sensors used in space missions. But their absolute temperature and resolution are about +/- 3 K and +/-0.1 K, respectively, which are good enough for various purposes.

All those advanced sensors are small and light, and require less power consumption, which are very well match to micro-satellite or UAV. The first LCTF camera will be onboard RISING-2 launched in May 2014 and RISESAT planned to be launched in a couple of years.

Also Hokkaido University is promoting the development of active sensors collaborating with other university and institute. We are very much positive to realize the SAR micro-satellite with Chiba University. On the other hand, LIDAR would be another key technology which could provide information not only on the surface structure of forest, land or cloud, but also on the spectral data with very narrow bandwidth of wavelength. We should consider all these passive and active methodologies in order to maximize the output of micro-satellite.

Potential of Micro-satellite Constellation

The constellation realizes a frequent monitoring from the low earth orbit. If we inserted 48 satellites into proper orbits, we can watch any location in the world about every 7.5 min. Since the time duration of one satellite passage over a certain place is 10-15 min, the 7.5 min interval means actually continuous monitoring. Here we suggest the establishment of such "super constellation" with micro-satellites (Figure 1). Though it's not easy to launch and operate more than several tens of satellites by single country, if several or 10 countries establish a consortium and each country launches 5 or 10 micro-satellites, the total number could be easily over 50. On the other hand, each owning countries would like to operate satellites for their own purposes. One solution might be that the a certain percentage of machine time of the satellite, for example, 80 percent, is used for their own purposes, but 20 percent should be remained for international public use, such as serious disaster monitoring or periodic survey dedicated to such as climate study planned by international committee. In order to construct the effective and practicable constellation, the key would be standardized remote-sensing payloads with optimized satellite BUS and establishment of the new methodology for ground network for micro-satellites tracking. Further, combining larger satellites designed for heavy or large payloads such as SAR with higher resolution or hyperspectral sensor, this micro-satellite constellation would be a part of this comprehensive collaboration (Figure 2).

Figure 1. Schematic drawing of super constellation with 48 micro-satellites

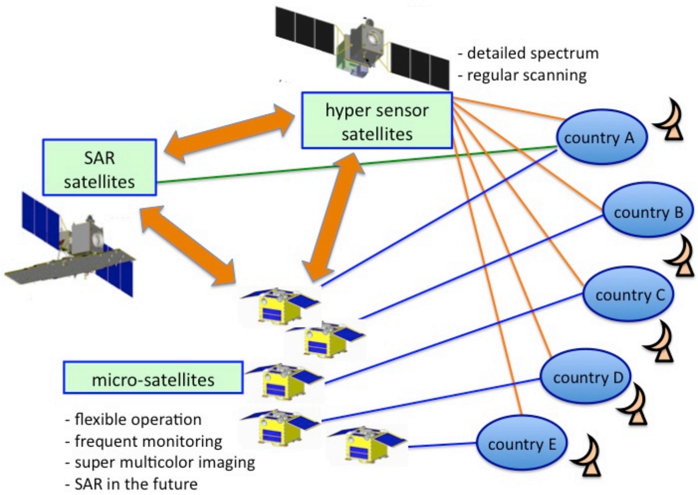

Figure 2. Concept of satellite coordination for earth observation

Suggestion of Asia Micro-satellite Consortium

We would propose and discuss here the establishment of international organization, "Asian micro-satellite consortium" (AMC), which promotes and accelerates the micro-satellite development and the discussion of data utilization. Note that having the on-going micro-satellite project is not a necessary condition to join this consortium. AMC will consist of a domestic working group in each country. The each working group is composed of 3 parts: BUS development team, payload development team and data user team, involving various field scientists or engineers, such as forestry, agriculture, fishery, flood, meteorology, climate, ionospheric/magnetospheric science, etc. The schematic concept is shown in Figure 3. Also in AMC we will discuss the possibility of future projects, such as “super constellation” consisting of more than tens of microsatellites and unmanned air vehicles (UAVs) under international collaboration. Examples of the basic functions of AMC might be 1) information exchange not only in hardware development but also in data utilization methodologies such as estimation of carbon fixation for RED++, identification of the best fishing place, the first detection of forest fire, 2) international people-to-people exchange, 3) capacity building, 4) organizing workshops and TV conferences, 5) discussion of future missions including super constellation. At this moment, we are contacting and encouraging institutes/universities in more than seven countries in SE-Asia to be the founding member of AMC. Most of the institutes are interested in and/or basically agreed to the concept of AMC and we would like to establish AMC formally in this conference or focus meeting in the near future.

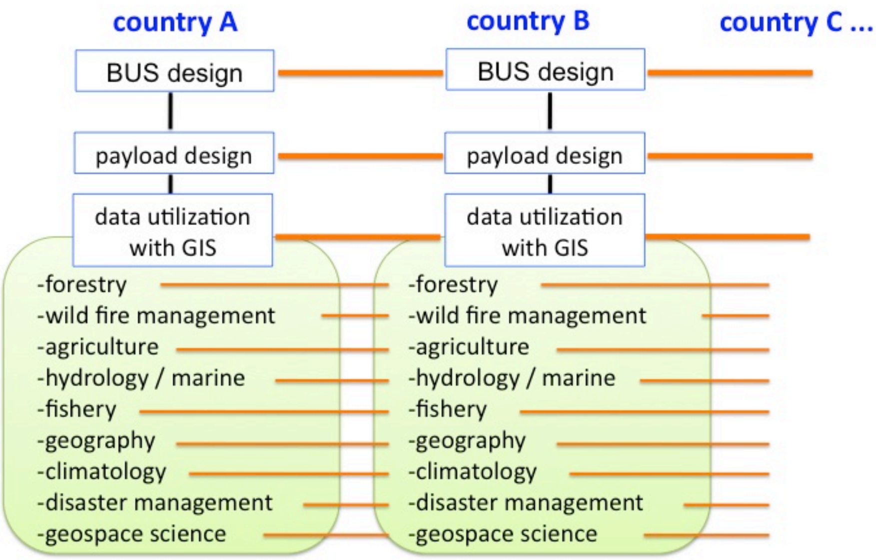

Figure 3. Concept of Asian Micro-satellite Consortium (AMC)

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Observations of ionosphere with Mini/Microsatellites
- problems and solutions-

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Abstract
Two problems which rise in ionosphere measurements by using DC Langmuir probe onboard Mini/micro satellite are discussed. The first problem is related to the ratio of the conductive area of satellite surface to that of the electrode which is used for the DC Langmuir probe measurement.
Insufficient surface area ratio causes the satellite potential to further negative when the electrode is biased to positive. This means that the potential of the electrode is reduced with respect to the ambient plasma. This makes the Ne measurement from electron current region impossible. Measurement of Te becomes less reliable, because exponetial potion to calculate reduces. The second issue is related to contamination layer which cover both satellite surface and electrode surface. Te which is measured by contaminated electrode is, without exception, estimated higher than the true value. Although contamination effects are removed by sweeping the electrode potential so fast, generally, the measurement becomes difficult because frequency response of the amplifier system does not have enough frequency bands.

Keywords Ionosphere, microsatellite , measurements, contamination

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1.Introduction

DC Langmuir probe (Langmuir and Motto-Smith,1924) is one of the key in-situ instruments to study ionosphere. It needs a counter electrode whose conductive surface area is at least 1000 times larger than that of surface area of the electrode.

This requirement is usually fulfilled for large satellites which have been launched so far for ionosphere study. Now we are jumping into an era to use tiny satellites. Although a tiny satellite does not accommodate many scientific payloads, to distribute many tiny satellites in space (the constellation) has a tremendous potential to further advance the ionosphere study. However we will encounter serious problems when we use conventional DC Langmuir probe to measure ionosphere parameter.

One of the problems is related to a small ratio of conductive surfaces of counter electrode to that of the electrode. Conductive surface area of the satellite for DC Langmuir probe should be more than 1000 times to get electron density from the probe current at space potential. Surface area of the tiny satellite is much smaller, or even equal to the surface area of electrode. As a result, measurement of electron density which uses electron saturation bias range becomes difficult, because the potential of the electrode with respect to the satellite (counter electrode) cannot reach ambient plasma

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potential. For the worst case, the maximum electron current is limited by ion current. Accordingly an electronics needs to measure low current flowing through the electrode. Low ion current very often is comparable to secondary electron current from the electrode surface.

The second serious problem is associated with contamination of electrode as well as satellite surface. When the triangular wave is applied to a probe, current/voltage characteristic (I-V) curve shows different curve depending on the increasing and decreasing bias, which is called "hysteresis". The hysteresis is caused by the contamination on the electrode surface as well as contamination of the satellite surface. To avoid the hysteresis, frequency of the triangular wave which is usually used should be increased up to 10Hz.

These two factors make it impossible to use DC Langmuir probe as an instrument of tiny satellite. We review problems which appear for the ionosphere measurement by using tiny satellites, and propose ways avoid the problems to accomplish accurate measurements.

2.Laboratory Experiments

2.1 Effect of surface area

So far we assumed that the conductive surface area of counter electrode (satellite) is much larger than that of an electrode. In case of tiny satellite, conductive area is not enough to apply DC Langmuir probe theory which assumes infinite counter electrode. The positive voltage which is supposed to be applied to a DC Langmuir probe reduces, because the potential of the satellite is automatically shifted to more negative with respect to ambient plasma. As a result, to get accurate N_e from the I-V curve becomes difficult, although we can use the ion current to get N_e roughly.

In order to see the effect of conductive area, one cube which is supposed to be a picosatellite (Dimension: 24cm x24cmcx 20cm) is installed in a Space Plasma Operation Chamber (SPOC). Electron density (Ne) and electron temperature (Te) in the SPOC are 10^3-10^5 els/cm3, and 1000-3000K respectively, depending on the working voltage of plasma generator. Plasma which is almost similar to F region ionosphere plasma is produced by Back -Diffusion type plasma source (Hui-Kuan et al., 2014).

3 conductive panels of different surface area (S1:75.08 cm^2 ,S2:80.0 cm^2,and S3: 80.09cm^2) are placed on the satellite walls. By connecting these three panels, we change the ratios of surface area of cylinder electrode and conductive planes as 2.83, 5.82, and 19.4 . The floating potential of the satellite , and the voltage which is applied to the electrodes with respect to the satellite are measured with respect to the SPOC ground.

A cylindrical electrode (3mm in diameter, and 20 cm in length) is attached in order to use for DC Langmuir probe measurement . The voltage which was applied to the electrode with respect to the satellite was changed from 0-3 V, and then from 3 to 0 V in one second as a pink colored triangular wave shows in Fig.1a . The voltage of the electrode (for example, for the area ratio of 2.83; green line) with respect to the chamber ground varies from about 1.1 Volts to about 2 Volts almost linearly until first 0.2sec, and then the voltage increase slows down. This statement is also true for other surface area ratios. We measured floating potential of the satellite with respect to the SPOC ground. The potential keeps almost constant value until 0.2 sec, and starts dropping to -0.25V for the surface area ratio of 2.83 (green color) . Other two cases show almost the same feature.

The behavior of electrode potential changes with the frequenncy of the seep voltage, and shows a different value between increasing and decreasing potential (hysteresis) due to the contamination of satelliet surface. Detail discusson will be made in a separate paper in the near future.

2.2 Contamination of satellite surface

As mentioned above, contamination of the satellite surface as well as of the electrode becomes serious for DC probe measurement. The current makes a closed circuit, starting from electrode, contamination layer of the electrode (parallel combination of R_{pc} and C_{pc}), sheath impedance of the probe (parallel connection of P_{ps} and C_{ps}), plasma impedance (parallel connection of L_p and C_p), sheath around the satellite (parallel connection of R_{ss} and C_{ss}), contamination layer of the satellite (parallel connection of R_{sc} and C_{sc}), then finally to the satellite frame.

When conductive area of satellite is large enough compared with the surface area of electrode, $C_{sc} >> C_{pc}$, and $R_{sc} << R_{pc}$. As C_{sc} is much larger than C_{pc}, the satellite potential does not change during the voltage sweep of DC Langmuir probe , and therefore the effect of contamination layer of satellite is negligible. However, when conductive surface of the satellite (A_{sa}) becomes nearly the same as that of the electrode (A_{pr}), I-V curve is influenced both by electrode contamination , the contamination of satellite wall, electrode sheath resistance, and satellite sheath resistance.

3. Countermoves for accurate measurements

To measure electron temperature, Te and electron density accurately, Electron temperature probe (ETP), and impedance probe(Gyro Plasma Probe) are available. These two probes were developed by Japanese scientists (Oyama and Chen, 2013). ETP applies small sine wave signal to the electrode to detect the floating potential shift which is caused as a result of the sine wave application. Te is calculated from the floating potential shift. Gyro plasma probe applies the sweep frequency signal from about 500 Khz to 10 Mhz (Wakabayashi et al., 2013). As plasma impedance is a function of frequency of the signal applied. Usually one peak (sheath resonance) and one minimum (Upper hybrid resonance) appears in the output signal. Electron density is obtained from the upper hybrid resonance.

These two instruments are not influenced by electrode contamination as well as satellite contamination. One more instrument which can now be accommodated is TeNeP. The TeNeP is a modified version of ETP. Instead of a fixed frequency oscillator of ETP, TeNeP uses a circuit which changes the frequency from 500 Khz to 10 Mhz. TeNeP is compact with low power consumption, and low data bit rate, low cost but still provides an excellent information. TeNeP was especially invented for tiny satellite mission. The TeNep can be accommodated in tiny many satellites, which will be planned for the study of ionosphere modified before large earthquake.

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Development of Space-based Magnetic Activities Measurement Mission in LAPAN's Micro-Satellites

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Abstract

LAPAN has been observing space weather data using ground-based sensor, among others magnetometer. With the develoment of micro-satellite technology in LAPAN, it become possible for LAPAN to have space-based magnetometer. The paper elaborate the mission concept of the payload, and the development progress that has been done to achieve the mission objectives. The learning process done on the satellite-based magnetometer data handling at the Center of Satellite Technology and Center for Space Science was started with the data handling of magnetometer in attitude control system of LAPAN-A2 micro-satellite. With such knowledge, the specification and the test procedures of magnetometer that will be on-board of LAPAN-A3 and LAPAN-A4 micro-satellite was defined. The paper also discuss further planning that was drawn for the development of more scientific class geomagnetic measurement mission in LAPAN-A4 micro-satellite.

Keywords : micro-satellite, science mission, geomagnet

1. Introduction

Space weather is the condition in the sun, solar wind, magnetosfer, ionosfer and thermosfer, may influence the capacity of space-based technology, such as telecomunication and navigation satellites. Sun phenomenon that may effect space weather the most are flare, coronal mass ejection (CME), and coronal holes (CH). One of their effect is magnetic storm. Magnetic storm occur when particles from Sun the came toward the Earth and meet its magnetosfer. Here, the indication of the storm may be read from the change in geomagnet data.

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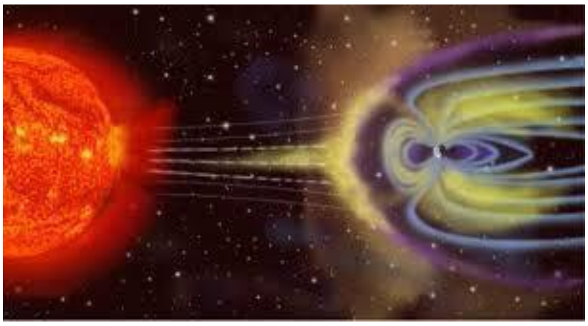

Fig 1. Solar wind interaction with Earth magnetic field [ref 1]

1.1. Geomagnet research at Center for Space Science LAPAN

The geomagnet data observation can be done using ground-based and space-based sensor. In Indonesia at the moment, there are 11 sensor locations, that use fluxgate magnetometer and magdas, which belongs to Center for Space Science, National Institute of Aeronautics and Space (LAPAN). The sensors are also used in international collaboration research, among other, between LAPAN and SERC (Space Environment Research Center), Kyushu University [Ref 2]

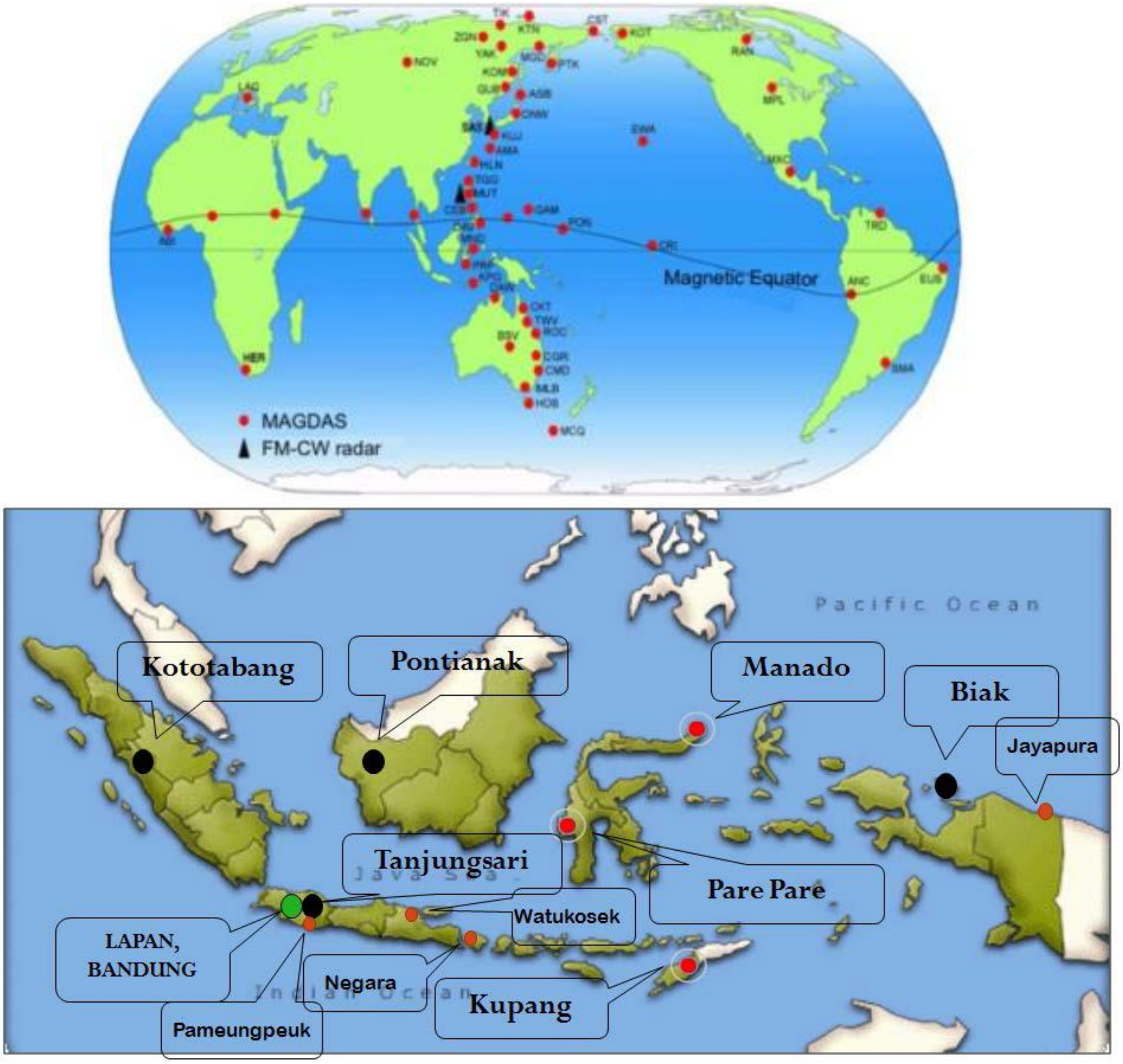

Fig 2. Geomagnet sensor location in Indonesia, and their international network [ref 2]

1.2. Microsatellite development at Center for Satellite Technology LAPAN

The development of micro-satellite at Center for Satellite Technology of LAPAN has made it possible for LAPAN to have space-based sensors. The microsatellite program was started with LAPAN-A1/TUBSAT. The project received funding aproval in 2003, where the satellite development was done in Berlin, Germany, and launched in 2007 as auxilary payload on Indian PSLV-C7 rocket [ref Hardhienata]. Its 2nd and 3rd satellite, LAPAN-A2/ORARI and LAPAN-A3/IPB received their approval from in 2008, which the satellite development is to be done in Bogor, Indonesia. With the establishment of microsatellite integration and test facilities in Indonesia (Fig 3A) and the completion of LAPAN-A2 integration in 2012, the planning was drafted for further satellite tecnology development in Indonesia as illustrated in Fig 3B [ref 3].

For mission realiability, subsystem technology heritage is implemented in the development plan, i.e. LAPAN-A2 will cary the same analog video camera payload as LAPAN-A1, in addition to a newly developed of digital camera payload that has better resolution and swath. LAPAN-A2 will also cary space-borne ship monitoring system (AIS) and employ better automation in satellite attitude control [ref Triharjanto, 2012].

LAPAN-A3 will carry the same digital camera payload as LAPAN-A2, and newly developed 4-band multispectral imager payload. The major improvement in the satellite is its data transmition system, which are 16 times faster than its predecesor [ref Hasbi, 2013].

In LAPAN-A4, in addition to the 2nd flight of multispectral imager, the satellite will cary thermal camera based on coolingless bolometer technology, and a scientific magnetometer payload from Center for Space Sience of LAPAN.

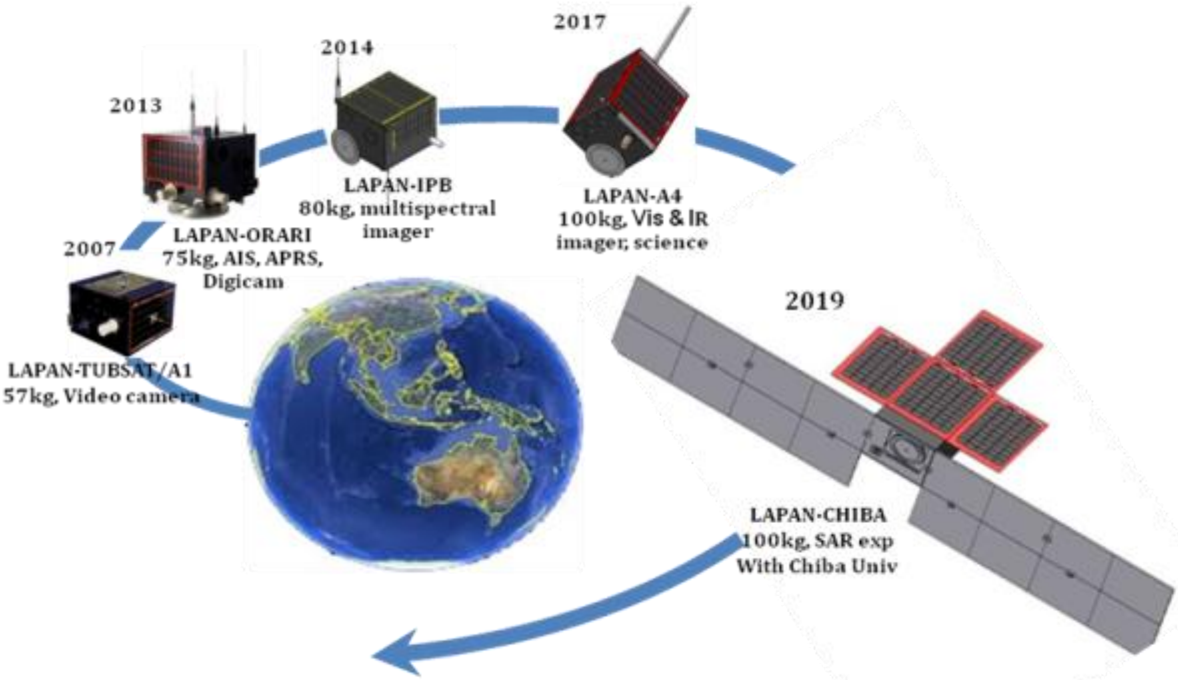

Fig 3. (A) LAPAN's microsatellite integration facility (B) LAPAN's microsatellite roadmap

2. The Magnetometer Payload Definition

Center for Space Science and Center for Satellite Technology so far has studied 2 scientific microsatellites that carry magnetometer payload, i.e. Australian Fedsat, and Brazilian SACI-1. Fedsat is a 58 kg, 50x50x50 cm microsatellite dedicated for several scientific missions, while SACI-1 is a 60 kg, 57x44x44 cm microsatellite also dedicated for several scientific missions.

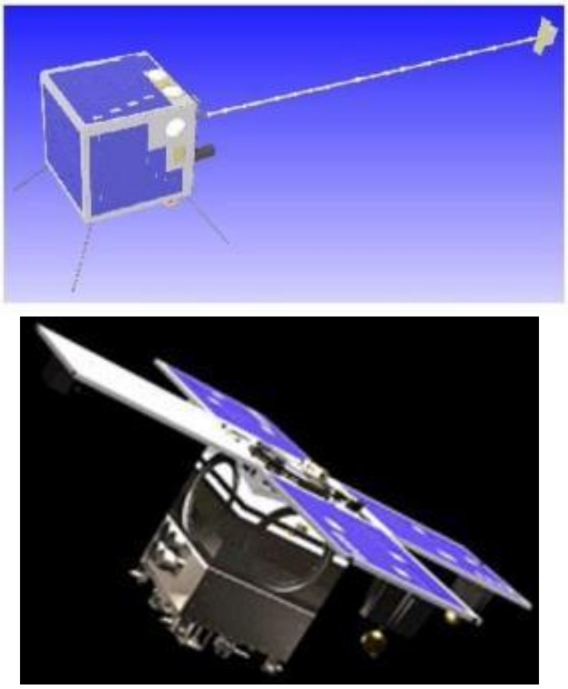

Fig 4. Fedsat & SACI-1 [ref http://space.skyrocket.de/]

The geomagnet mission of Fedsat is to contribute to the monitoring and mapping of the geomagnetic field in the Australian region. The satellite payload is high precision triaxial fluxgate magnetometer with a reading range of $\pm$ 65.000 nT. Since the satellite orbit altitude is at about 800 km, the magnetometer needs to be sensitive enough to measure the magnetic perturbations of the order of 10 nT. In such orbit, to measure field-aligned current structures, the payload has a sample rate of 10 vector samples per second (vs/s) so that 1 km structures can be identified.

Fedsat magnetometer is built by Institute of Geophysics and Planetary Physics, UCLA, which already has space heritage. The sensor dimension is 11,4 x 5,4 x 6,1 cm, with mass of 1,62 kg (sensor 420 g, electronics 1,2 kg), and power consumption of 3,5 W. To ensure magnetic cleanliness from other satellite's subsystems, the sensor was placed on 2,5 m boom, which also serve to give gravity gradient stabilization for the satellite. [ref Fraser]

SACI-1 magnetic sensor, which is also from UCLA, is mounted at the tip of one of the four solar panel arms. Therefore, the sensor is 50 cm away from the main body of the satellite for the reason of magnetic cleanliness. The sensor assembly is covered with a thermal blanket in order to protect the sensors from large temperature variations. The magnetometer is capable of measuring geomagnetic field intensity in the range of $\pm$ 65.000 nT with reading resolution of ± 1 nT. In SACI-1, the magnetometer data will be sampled at 10 samples per second. [ref Trivedi]

From the data of the two satellites it is known that micro-satellites that has magnetometer mission employ space-proven sensor with reading range of $\pm$ 60.000 nT, and the reading resolution no less 10 nT, in which, such specification will become the base of LAPAN's magnetometer payload design.

Off-the-shelf option for magnetometer payload with above specification are the space-proven German magnetometer of Magson and space-proven US made magnetometer of TFM65. Magson magnetometer has weight of 280 g, and dimension of 3,5 x 5 x 5 cm, reading acuracy 100 pT and reading range of $\pm$60.000 nT. Its power consumption is about 1 W. TFM65 magnetometer payload has weight of 117 g, dimension of 3,5 x 3,2 x 8,2 cm, reading range of $\pm$60.000 nT, and reading resolution of 35 pT. [ref 9]

3. LAPAN Satellite's Magnetic Noise

In LAPAN-A2, the magnetometer used in its attitude control system (ACS) is fluxgate VMFS-51, wich has reading resolution of 200 nT. Such magnetometer is designed for navigation purposes of satellite and not mean for scientific measurement. However, since the sensor has been integrated in the satellite, it can be used to learn about the magnetic noise LAPAN's satellite platform generate and about the sensor's data handling system.

The study about the satellite magnetic noise was done by the Center for Space Science, by reading the emision from LAPAN-A2 satellite using its ground-based magnetometer, a Magson type. The reading range of the sensor is $\pm$60.000 nT and its accuracy is 10 pT. The experiment set-up is shown in Fig 4, where the magnetometer is placed at about 20 cm from the satellite body. The magnetic noise emited by the satellite during its operation mode is then read.

Fig 5. Satellite’s magnetic noise test set up [ref 8]

The study shows that LAPAN’s satellite AIT facilities in Rancabungur, Bogor, is not suitable to calibrate scientific class magnetometer. The personel activities, which may cary electromagnetic devices, as well as other devices arround the laboratory (including car park nearby) disturb the reading. The differential magnetic field reading shows that the magnetic noise from satellite subsystem is less than the noise coming from the environment. Therefore, the reading is repeated at LAPAN facilities at Pameungpeuk, Garut. Knowing that the magnetic feld from the air coil can be predicted, and therefore can be filetered in the reading software, the test the focus on the magnetic noise that come from reaction wheels. The test in Pameungpeuk use the engineering model of the satellite that contain the flight model reaction wheels (platform wheel in Fig 5).

4. LAPAN-A3 and LAPAN-A4 Magnetometer Configuration

The magnetometer chosen to be used in LAPAN-A3 is Hybrid Fluxgate Magnetometer (HFGM) type, which are are commonly used for scientific space mission. The HFGM is using a vector compensated ringcore sensor and the electronics for the digital signal processing. The soft-magnetic material of the ringcores is driven into saturation by an AC excitation current. The external magnetic field distorts the symmetry of the magnetic flux in the core, which generates a signal at even harmonics of the excitation frequency. Sensor and electronics are designed for the selective measurement of the second harmonics of the excitation frequency. A feedback current is generated to compensate the external field at the ringcore position by a Helmholtz coil system. The component values of the external field are calculated by the settings of field proportional feedback current and the remaining field at the core position. [ref 9]

In LAPAN-A3, the magnetometer will be used for attitude control system. However, since investigation is to be done to prepare the dedicated scientific mission in LAPAN-A4. Therefore, high accuracy fluxgate magnetometer will be used. To minimize magnetic noise from other the satellite components, the sensor will be placed outside the satellite body (Fig 6). In LAPAN-A4, its is planned that the sensor is placed on deployable boom at length of more than 1 m from the satellite body.

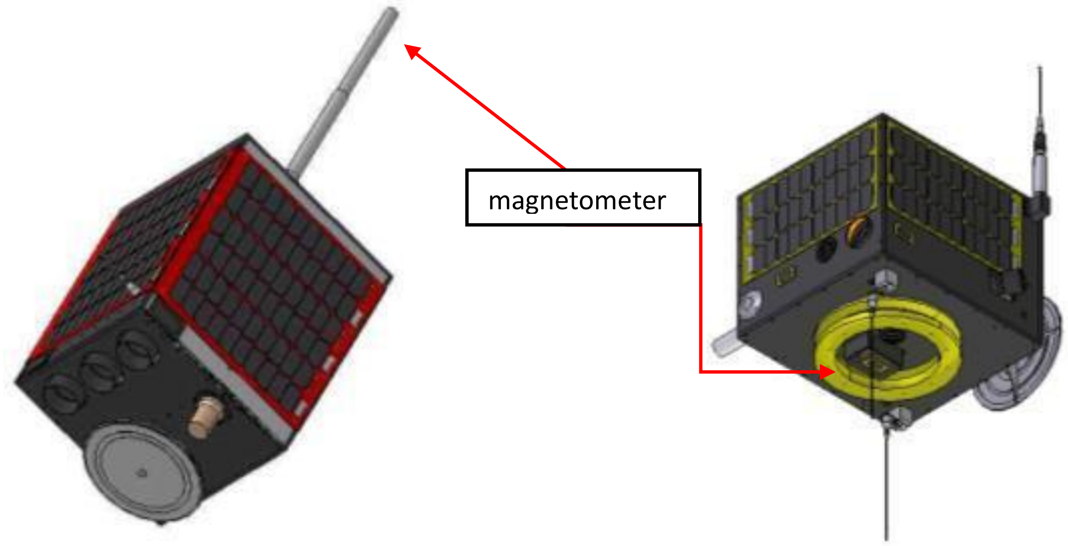

Figure 6. LAPAN-A4 and LAPAN-A3 showing their posible magnetometer position

The magnetometer of LAPAN-A3 will be operated continuously and take data with sampling rate of 1 Hz. A 2,4 Mb memory space is reserved on the satellite main computer for the magnetometer data, which will be downloaded via TTC link over Spitzberg and Indonesia. The reding will be synchronized with the satellite's clock so that the location of the reading can be identified.

For the calibration of the sensor, the Center for Space Science is currently procuring Triaxial Helmholtz Coil with dimension of no less than 1 x 1 x 1 m. The coils will be used to callibrate all the center's magnetic sensors, and to performed functional and calibration test on LAPAN-A4's magnetometer payload.

Kalibrator magnetometer merupakan suatu sistem peralatan yang digunakan untuk mengkalibrasi peralatan pengamat geomagnet (magnetometer). Magnetometer lama ataupun yang baru dibangun perlu dikalibrasi untuk mengetahui/menjaga akurasinya. Kalibrator ini mengukur sekaligus tiga komponen magnet (sumbu X komponen horizontal Utara-Selatan, sumbu Y komponen horizontal Timur-Barat dan sumbu Z komponen Vertikal).

5. Summary and Further Plan

The development progress of geomagnet measurement mission in LAPAN's micro-satellites is :

1. Has finished defining specification for scientific class magnetometer payload
2. Has performed study on the magnetic noise emmited by LAPAN's micro-satellite components
3. Based on the study, has made preliminary design on the payload placement, and payload operation scenario
4. Has prepared scenario on the payload functional test, as subsystem and system, as well its necesary facilities

Further research to be done is the study the effect of boom on the attitude control of satellite. The study is important since the other payload of LAPAN-A4 is an imager, which require good attitude stability.

6. Acknowledgement

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Title: A New Millimeter-wave GBSAR for Landslide Monitoring

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Abstract

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 the recent development of a ground-based synthetic aperture radar (GBSAR) for continuous monitoring of landslide-prone areas in Malaysia. It is an ultra-wideband system operating at 17 GHz with spatial resolution of 0.3 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 field experiments using the new GBSAR system.

Keywords: Synthetic Aperture Radar, Interferometry, Landslides, Millimeter-wave, Environmental Monitoring

1. Introduction

Synthetic Aperture Radar (SAR) is an active sensor which can achieve fine *along* track resolution by taking the advantage of radar motion to synthesize a large antenna aperture. Over the past few decades, SAR has been widely used as an important and efficient tool for Earth remote sensing [1]-[3]. SAR is typically operated in microwave frequencies and capable of providing high resolution two-dimensional images independent from cloud coverage and weather conditions. SAR interferometry is a powerful and well-established technique for the determination of object displacements with high precision and accuracy. Examples of applications using interferometric SAR (InSAR) include detection and precise measurement of surface topography, glacier movements, as well as ground deformation and subsidence [4]-[5].

The feasibility and the effectiveness of space-borne InSAR for monitoring ground displacements at a global scale due to landslides have been well demonstrated [6]-[7]. On the other hand, ground-based InSAR has the advantage of providing continuous monitoring of landslide-prone areas at relatively low cost and simple setup. For small-scale features or change detection, a higher frequency band at millimeter wave region is preferred as it is more sensitive to surface roughness and small-scale structures such as rocks and debris. Examples of millimeter wave Ku-band (16 GHz LISA, 17.2 GHz IBIS) and W-band (95 GHz) ground-based SAR (GBSAR) systems have also been reported in [8]-[10], which clearly shows the capabilities of InSAR in detecting small-scale features at a regional scale.

This paper reports the design and development of a Ku-band ground-based SAR (GBSAR) system for timely landslide monitoring. The system is mounted on a linear rail that moves along an azimuth range of 1.5 m. The key idea is to compare the phase of two or more complex InSAR images that have been acquired at different times. When terrain displacements occur in the time elapsed between two image acquisitions, the phase change due to the tiny path length difference of the radar wavelength can be accurately measured in the order of millimetric accuracy. By continuously measuring these displacements, timely information can be extracted for landslide monitoring and early warning system.

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2. System-Level Specifications

Table 1 summarizes the technical specifications of the GBSAR system. The proposed system operates at 17.26 GHz (Ku-band) with a bandwidth of 500 MHz. Millimeter-waves are chosen to allow the monitoring of small-scale changes. The spatial resolution is 0.5 m in range and 5.8 mrad in azimuth range. FMCW configuration is chosen for short-range operation. The millimetre-wave radar front-end and antennas are mounted on linear rail with 1.5 m in length.

Table 1: Design Specifications

No.	Specifications	Design Value	Remarks
1.	Operating Frequency	17.26 GHZ	Ku-Band, λ = 17.4 mm
2.	Bandwidth	500 MHz	range resolution = 30 cm
3.	Waveform	FMCW	For short range operation.
4.	Polarization	single, HH	Dual antenna, H transmit and H receive
5.	Transmit Power	1 W	30 dBm
6.	Antenna Aperture	5 cm	Pyramidal Horn Antenna
7.	Antenna Gain	16 dB	
8.	3dB beamwidth	24.0° (azimuth) 24.0° (elevation)	Azimuth range illumination: ~420 m at range distance 1000 m
9.	Synthetic Length	1.5 m	For easy transportation and installation
10.	Range Resolution	0.5 m	
11.	Azimuth Resolution	5.8 mrad	2.9 m at 500 m, 5.8 m at 1000 m.
12.	Maximum Sensing Distance	1500 m	
13.	Sigma naught	−20 dB	
14.	SNR	> 10 dB	at 1000 m

Figure 1 shows the geometry of the GBSAR. At a sensing distance of 1000 m, the azimuth illumination is approximately 420 m. The GBSAR will move along a high precision motorized linear rail at 10 mm per step, which is equivalent to 150 sample points in azimuth direction. At each azimuth position, the radar transmits a FMCW signal at Ku-band with total bandwidth of 500 MHz to yield the range resolution of 0.3 m. After SAR processing, the azimuth resolution is 5.8 m at 1000 m.

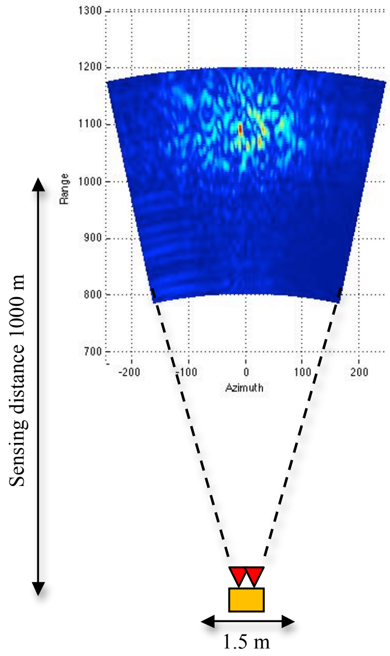

Figure 1: The GBSAR Geometry

3. GBSAR System Design

Figure 2 shows the functional block diagram of the GBSAR system. It consists of three major components, namely (1) RF and antenna subsystem, (2) embedded radar processing subsystem, and (3) high precision linear scanning platform.

3.1. RF and Antenna Subsystem

The RF front-end module is depicted in Figure 3. The baseband FMCW waveform is generated by a custom-designed direct digital synthesizer (DDS). The clock frequency to drive this generator is delivered by a 10 MHz phase-locked oscillator. The FM frequency is set at 156 Hz, and the sweep bandwidth is 500 MHz. This signal is then upconverted to Ku-band (17 GHz), amplified and sent out through a transmitting horn antenna. The transmit power is about 30 dBm. A directional coupler is used to couple a small portion of this power to the RF receiver's mixer. The transmitting antenna is a miniature pyramidal horn with aperture size of 5 cm. It has 14 dB gain and 24° beamwidth in both azimuth and elevation planes. The antenna pattern is shown in Figure 4.

The RF receiver has multiple stages of low noise amplifiers (LNAs), to amplify the weak signal returns from the receiving antenna. The amplified signals will then be mixed with a reference transmit signal to produce the in-phase (I) and the quadrature-phase (Q) intermediate frequency (IF) signals. The maximum IF signals are approximately 1.5 MHz at 1500 m.

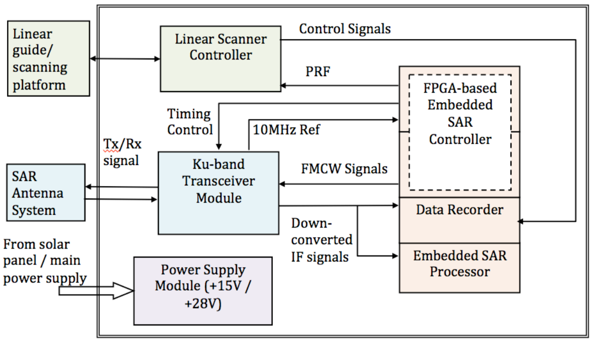

Figure 2: Functional Block Diagram of the GBSAR

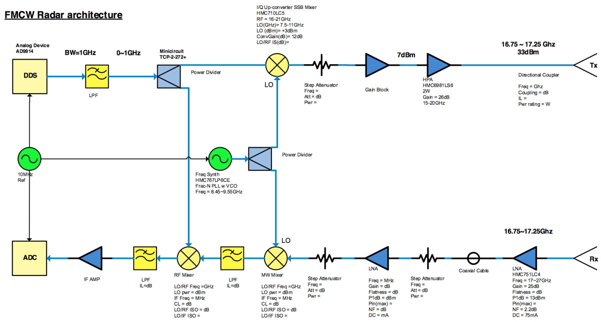

Figure 3: RF Front-end Module

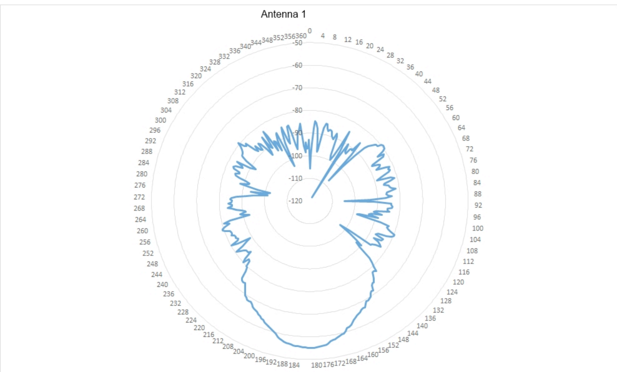

Figure 4: Antenna Radiation Pattern

3.2. Embedded Radar Processing Subsystem

The functional block diagram of the embedded radar processing subsystem is shown in Figure 5. The I and the Q of the received IF signals will first be digitized by a 100 MHz analog-to-digital converter (ADC) and stored onto the onboard solid-state hard disk (SSD). Upon completion of every scan (150 steps), the real-time SAR processing module will read in the raw data and perform SAR processing using range-Doppler algorithm. The generated SAR image will then be stored and compared with the next-scan image to yield temporal change detection. The hardware prototype of the embedded radar processing module is shown in Figure 6.

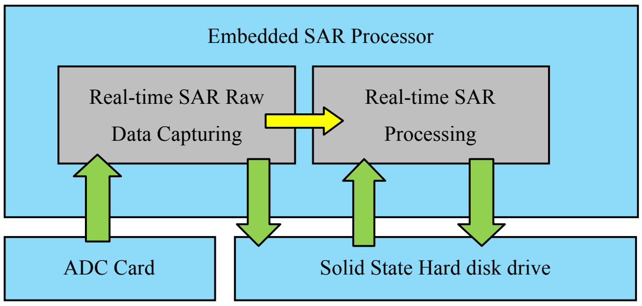

Figure 5: Embedded Radar Processing Module

Figure 6: Hardware Prototype of the Embedded Processing Module

3.3. High Precision Linear Scanning Platform

In order to achieve stable and linear movement at fine resolution, a high precision linear scanning platform has been developed. Figure 7 shows the hardware prototype of the linear scanning platform. Its working length is 1500 mm and its achievable step size is 1 mm. For every SAR acquisition, a total of 150 range samples will be captured at a spatial interval of 10 mm along azimuth direction.

Figure 7: Hardware Prototype of the Linear Scanning Platform

4. Field Experiments and Results

Figure 8 shows the experimental setup during a field test at Melaka, Malaysia. Trihedral corner reflectors are placed on a slope to perform external calibration.

(a) GBSAR In Operation

(b) Test Site

Figure 8: Experimental Setup for GBSAR

For every SAR acquisition, the GBSAR travels along its azimuth direction and collects a total of 150 range samples at every 10 mm interval. The echo of one single target within the antenna beam will be present at every azimuth position and is therefore defocused. After range compression, an ideal point target appears at each pixel of the recorded raw image with the same amplitude but the phase is a function of the antenna position. Azimuth range compression is achieved by multiplying the azimuth range sample with the complex conjugate of the baseband reference signal at frequency domain, and finally, the resultant signal is inverse-Fourier transformed to obtain a focused image in both range and azimuth domain.

A sample of the focused SAR image with single point target is shown in Figure 9. The point target is then shifted by 10 mm for every subsequent scan, for 10 scans. Figure 10 shows a sample of the phase difference plot derived from two SAR images taken at different time. The phase difference $d\phi$ is extracted to compute the displacement dR by using the following equation:

$$dR = \lambda\, d\phi / 4\pi \qquad (1)$$

where λ is the wavelength of the transmit frequency. The measured displacement results are presented in Table 2. It is clearly shown that the GBSAR is capable of detecting sub-centimeter changes with error bound within ± 5 mm.

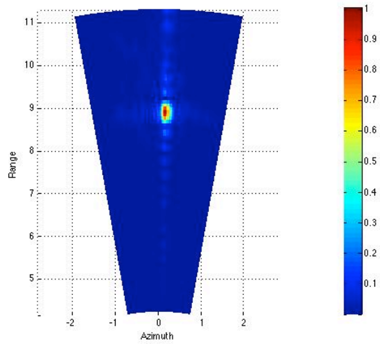

Figure 9: Point Target Return

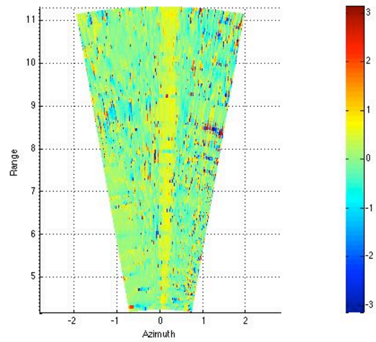

Figure 10: Temporal Change Detection using Two SAR Images

Table 2: Displacement Measurement Results

Target Setup Distance (mm)	Measured Distance (mm)	Error (mm)
10	11.6	1.6
20	21.7	1.7
30	31.6	1.6
40	42.1	2.1
50	51.6	1.6
60	62.0	2.0
70	71.1	1.1
80	84.2	4.2
90	93.4	3.4

5. Conclusions

A new ground-based Synthetic Aperture Radar operating at 17 GHz has been designed and developed. It has 0.3 m × 5.8 mrad spatial resolutions, and change detection capabilities up to 5 mm. The system will be used for landslide monitoring at selected test sites in Malaysia.

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The challenge for still unresolved development of Multi-band Equatorially Orbiting POLSAR satellite sensors - an integral task for the major space-SAR technology centers world-wide – focused on the Indonesian Islands Environment

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Abstract

With the relentless increase in population density, the anthropogenic expansion into natural terrestrial hazard zones has become irreversible resulting in ever more catastrophic disasters, not only in the Asia-Pacific region more so within the entire tropical belts engulfing Mother Earth. Thus not only the Indonesian-Pacific Islands, so also South America, Africa and back via the Indian Ocean Islands to Asia-Pacific, these natural events like volcano eruptions, earthquakes with emerging tsunami, cyclones and severe down pours have caused havoc, loss of lives, destruction of infrastructure and above all intentional manmade interference resulting in the deterioration of pristine tropical jungle forests. What is required is around-the-clock local and wide-area surveillance and remote sensing of the vegetative cover for which first well designed optical equatorially orbiting satellite sensors had been developed but their successful implementation failed because of the ever increasing cloud, precipitation, humidity and aerosol cover within the entire equatorial belt of +/- 15* ~ 20* latitude rendering penetration at optical wavelength mostly ineffective. Hence, we must take recourse to microwave sensing, and implement radar and synthetic aperture sensors from air and space operational at day & night independent of weather; and the sensors especially suited are the fully polarimetric POL-SAR sensors developed for satellite remote sensing by the major SAR technology development centers worldwide. As first and main test case, we will explore the Indonesian Island region.

Keywords: equatorial satellite orbits; polsar imaging; Indonesian islands surveillance

Introduction

The outstanding performance capabilities of the three Satellite POLSAR sensors are well established; and in this exposition the exploitation of the fully polarimetric ALOS-PAL=PPL=SAR mode is demonstrated by implementing the Niigata-University four-scatterer SAR image decomposition with coherency-matrix rotation proving the superior imaging capabilities of the fully polarimetric SAR modes not only for the ALOS-PALSAR L-Band and similarly to the S-Band, C-Band and X-Band. The novel fully polarimetric POL-SAR image processing techniques are then applied to natural hazard detection and subsequent disaster reduction of taiphoons with land-slides, volcano eruptions with plume aftereffects & landslides, and of earthquakes with drop-slips experienced within the SE-Asian/Pacific Ring-of-Fire including next to Japan in Taiwan, the Philippines and Indonesia, promoting equatorially orbiting Single and Tandem L-/S-/X-Band POLSAR sensor deployment. Major emphasis is placed on the development of equatorially orbiting satellite sensors between +/-12 (15)* latitude.

The Indonesian Islands stretch over almost four time zones along the equatorial belt in between +/- 10* latitude, and its lush vegetation along with its mineral resources are exposed to increasing natural hazards like volcano eruptions, earthquakes and seaquakes with ensuing tsunami, cyclones with devastating floods plus ruthless mineral mining and conversion of natural tropical jungles into oil-palm estates for ethanol production. Thus, disaster assessment and prevention has become an ever more pressing topic of top priority. Current ground-based disaster damage assessment methods are cumbersome and costly due to sudden sporadic hazard occurrences; and local point measurements are not representative of larger affected regions. Due to the strong spatial and

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temporal dynamics of geo/bio-environmental constituents enhanced by strong local weather changes, frequent continual observations are necessary for which microwave satellite remote sensing and stress change monitoring provide the sought for repetitive monitoring capability and synoptic coverage subject to equatorially orbiting POL-SAR satellite implementation.

Fig.1. ALOSPALSAR, RADARSAT-2, TerraSAR-X.

Method of approach

The basic radar technologies to do the job are the multimodal Synthetic Aperture Radar (SAR) sensors. In the meantime, fully polarimetric multi-modal high resolution SAR systems at multiple frequencies and incidence angles were introduced first with the multi-band AIRSAR of NASA-JPL culminating in the once-only pair of SIR-C/X-SAR shuttle missions of 1994 April and October as well as the SRTM shuttle mission, which laid the ground work for true day/night space remote sensing of the terrestrial barren and vegetated land and ocean covers using multi-band polarimetric SAR Thereafter, the Canadian CCRS, the German DLR and the Japanese NASDA & CRL {now JAXA & NICT} took over introducing and steadily advancing the Convair-580, the E-SAR (now F-SAR) and Pi-SAR airborne highly advanced fully polarimetric sensors platforms, respectively [1, 2]. These separate international multi-modal fully polarimetric and also interferometric airborne SAR developmental efforts culminated in a well-coordinated group effort of these three independent teams eventually launching and operating Fully Polarimetric Satellite SAR Sensors (Fig. 1) at L-Band (ALOS-PALSAR launched by JAXA/Japan in 2006 January – and to be followed by ALOS-PALSAR-2 &3); at C-Band (RADARSAT-2 launched by CSA-MDA in 2007 December – to be followed by independent RADARSAT-3&4) and at X-Band (TerraSAR-X launched by DLR-Astrium in 2007 July with the follow-on tandem mission TanDEM-X (Fig. 2) launched in June 2010). Thus, international collaboration on advancing day/night global monitoring of the terrestrial covers was decomposed with the launch of the three fully polarimetric multi-modal SAR Satellites currently only at L-, C-, X-Band and its first tandem satellite-pair update of the DLR TanDEM-X. All of these efforts will be topped by near-future joint DLR-JPL DESDynI/Tandem-L wide-swath, high-resolution fully polarimetric sensor implementation, which in due time will be enlarged to accommodate next to the L-, C-, X- also P-Band sensors using one and the same reflector, then enabling full assessment also of dense tropical forests which will for example result in curtailing illegal deforestation, there and elsewhere.

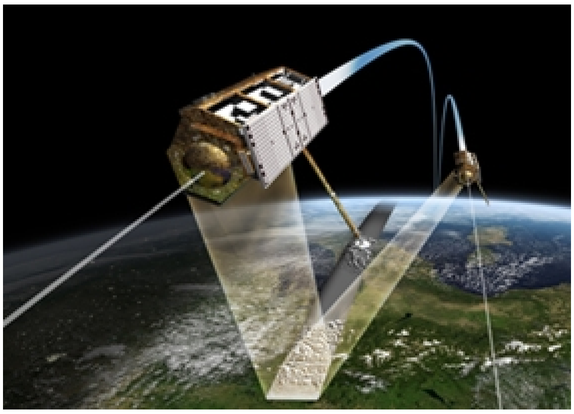

Fig.2. TanDEM-X Configurations.

Fig.3. Indonesian Islands within Equatorial Belt.

Satellite sensor implementation

The ALOS-PALSAR (L-band), the RADAR-SAT-II (C-Band) satellite POLSAR sensors together with TerraSAR-X and TanDEM-X satellite sensors provided spectacular imagery at Indonesian sites chosen at random, whereas in this proposed equatorially orbiting satellite POLSAR sensors are the objective to identifying minute surface changes due to natural hazards and anthropogenic destruction of the precious tropical vegetative ground covers within the equatorial belt of the Indonesian islands stretching over almost four time zones along the equator along which some 120 active volcanoes periodically erupt.

The disastrous destruction of the tropical environment is inflicted mainly by coastal oil rigging, rigorous surface mining (coal, ore, gold, precious and rare minerals), ethanol production by replacing virgin tropical jungles by oil palm monoculture forests, calling for the immediate implementation of the DLR TerraSAR-X/TanDEM-X as well as ALOS-PALSAR-2 and RADAR-SAT-3 satellite sensors.

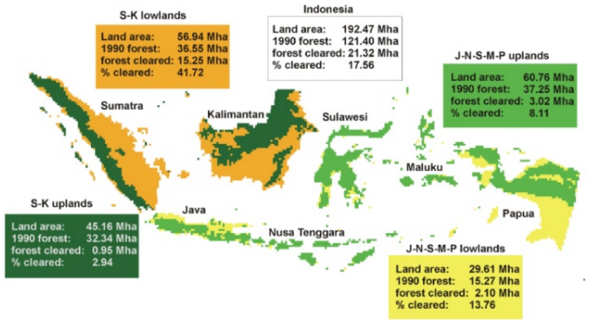

Fig.4. Deforestation Map of Indonesia.

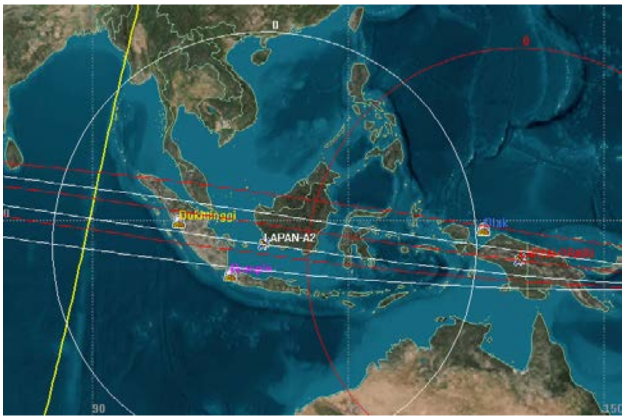

Fig.5. Equatorial Satellite Orbits over Indonesia.

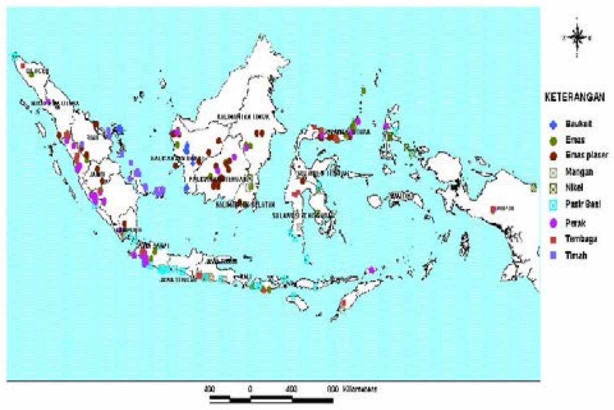

Fig.6. Mineral resources map.

Selection of desired test sites

For demonstrating its applicability a selected set of distinct test-regions spread along the entire equatorial extent with its chain of some 120 active volcanoes needs to be specified from North-west Sumatra via Java, Nusa Tenggara, Kalimantan, Sulawesi to the Maluku/Timor islands and Papua. During the recent years, excellent satellite X-Band remote sensing results had already been obtained for some randomly selected regions over Kalimantan on Borneo [3], which needs to be supplemented by a more rigorous selection of pertinent test sites across all of Indonesia with the upgraded TerraSAR-X/TanDEM-X satellite DLR sensors [3]. With the aid of Figures 2, 5 and 6, here we propose a set of possible sites for further selective consideration from West to East, requiring the input of local specialists:

Table 1. Selection of desired test sites

SUMATRA
Banda Aceh Medan Padang Bandar Lampung Krakatao
JAVA
Banten Jakarta/Depok Bogor Bandung Yogyakarta Solo/Surakart Semarang Surabaya Malang Jember
NUSA TENGGARA
Bali/Denpasar Lombok/Mataram Timor/Kapung
KALIMANTAN
Palembang Banjarmasin Palangkraya Pontianak Samarinda/Balikpapan
SULAWESI
Makassar Kendari Palu Menado
MALUKU/PAPUA
Ambon Biak Sorong Merauke/Iran-Jaya

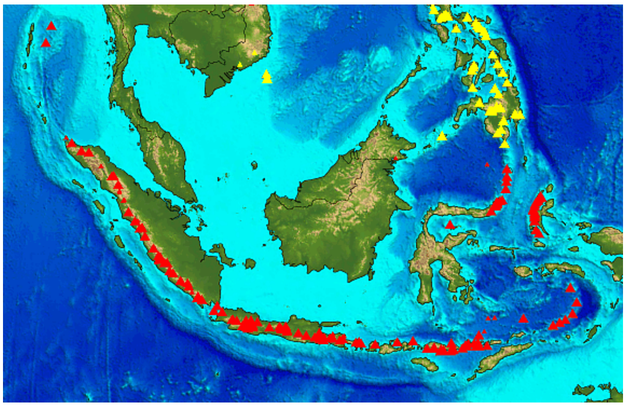

Fig.7. Chain of Indonesian volcanoes.

Fig.8. Natural Hazard Distribution in Indonesia.

Development of equatorially orbiting multi-band polsar satellites

Although LAPN-TUB had initiated the successful development of mini-satellites equipped with Optical sensors for equatorial orbital monitoring over the equatorial belt at very narrow swath-width providing 12 ~ 16 daily local passages, no mission-dedicated microwave sensor was hitherto developed for geo/bio-environmental remote sensing and stress-change monitoring. However, considering the wide plethora of diverse applications a multi-band wide-swath fixed equatorially orbiting satellite of the Multi-band DESDynI-Tandem configuration with beam-shaping capability enabling ~ 400 km to 500 km swath-width at L-, S-, and X-Bands ~ would ideally be desired and should be aimed for to become operational within 5 to 12 years. Not only Indonesia but all tropical environments along entire terrestrial equatorial belt require the urgent deployment of fully polarimetric POL-SAR sensors including the intermittent tropical oceans within which major global weather phenomena like cyclones develop.

Recommendations

At each of the many cited regions, distinct local sites peculiar physical, climatologic and anthropogenic conditions exist, and in order for covering all of these diverse sites, it is indeed essential for not waiting any longer but have a properly chosen set of equatorially orbiting multi-band sensors developed and test sites concurrently monitored with other near field testing methods of for example the local island agricultural, forestry and aquacultural institutions plus mining companies. In order for realizing this urgently required design and development of equatorially orbiting with multi-band POLSAR satellite sensors with sufficiently wide swath-width for covering the entire extent of the Indonesian islands across its equatorial belt, all of the leading multi-band POL-SAR design and development centers need to be called for immediate action without national and/or institutional ego but in view of its superior relevance for the future health of Mother Earth.

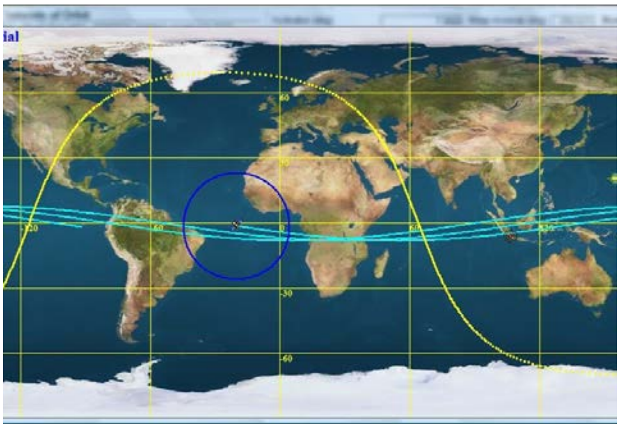

Figure 9 Closed loop Equatorial Satellite Orbits

Conclusions

The challenge is thus to develop equatorially orbiting SAR, preferably POL-SAR satellite sensors, within the desirable P/L/S/C/X/Ka multi-bands, which does pose severe technological problems due to the steep incidence-angle illumination on one hand, and because of the fact that the major SAR Technology Designers reside far outside the equatorial belt not being excited about SAR sensor development for the tropical belt anywhere. Therefore, we need to mobilize and draw full responsible attention of the main SAR Development Centres worldwide such as NASA/JPL, ESA/ESTEC, JAXA/EORC, CSA/SAR, DLR/SAR, DSTO/SAR, ISRO/SAC, INPE/SERE plus

NTU-Temasek,NCU-CSRSR,LAPAN/RANCABUNGUR, and so on; joining forces and strongly contributing to a viable multi-band general bi-static (including cross/along)-track POLSAR sensor technology, well suited for equatorial monitoring within orbits of +/- 20* latitude. Once this urgent goal is achieved, local regions could be observed daily up to 12 to 14 times, covering both the land and ocean regions essential for environmental protection and meteorological forecasting, respectively, on a hitherto unprecedented global level. The Indonesian Islands environment will be considered as a prime test case. More importantly, it must be of top priority to implicate the network of international radar polarimetry community at the National (LIPI, BMKG, LAPAN) and envisioned Indonesian Geomatics & Remote Sensing Centers for influencing a plethora of other local campus wide disciplines engaged in environmental and humanitarian for implanting the benefits of SAR Polarimetry with a special emphasis on monitoring and maintaining the environmental health of our Mother Earth which is under severe attack especially here in Indonesia!

Acknowledgment

The kind provision of figures and maps regarding Equatorial Satellite Orbits by Drs. S. Hardhienata and Roberto Heru Triharjanto of LAPAN as well as the close collaboration of several local IEEE AES/GRSS experts is sincerely acknowledged. The excellent fully polarimetric POL-SAR images contributed by Professor Yoshio Yamaguchi and his team at Niigata University deserve our highest attention. A special note of sincere gratitude is extended to Dr.-Eng. Josaphat Teteku Sri Sumantyo sensei of Chiba University for inviting this presentation for SOMIRES-2014 at Denpasar, Bali, Indonesia. Last and not least, in addition the excellent contributions for preparing this paper by GRA Eng. Tadahiro Negishi are appreciated with highest respect.

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The Plan for Space Observation Network Installation in Southeast Asian Region

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Abstract

In the near future, after spread of the small SAR satellites in Southeast Asian region, each countries will install small ground stations to receive data from satellites. If the ground stations will be equipped with S/X band receiving system, they may be used as Geodetic VLBI (Very Long Baseline Interferometry) station. In other words, it is possible to do VLBI observation with main station which has a 20 m class antenna equipped with broadband receiving system. And then it can be used for multiple purposes, such as resources exploration, crustal deformation, monitoring of natural disasters and so on.

On the other hand, there is no geodetic VLBI observation networks in Southeast Asia, and they do not use the World Geodetic System (WGS), which is adopted worldwide. To use the WGS, one should determine accurately the reference origin for his country, and then build its local reference coordinate system. For this purpose, after installing the geodetic VLBI observation station, it is necessary to accurately determine the coordinates of the observation station. In this way we can build the new national reference coordinate systems based on the WGS. To perform the geodetic VLBI observation thereof, we can construct the international joint space observation network with small ground stations and the hub observing station with a 22m antenna of Korea.

This paper discuss the multi-purpose space observation network installation in Southeast Asian region.

Keywords: Small SAR Satellite, VLBI, Space Observation Network, WGS

1. Introduction

In 1995, Korea determined the origin point of its new national geodetic system which conforms to the world geodetic system by VLBI co-observation with Japan, and the baseline between two VLBI stations in both countries were accurately defined (Figure 1). At this time, the antenna diameter was 26 m (in Japan) and other one was 3.8 m (in Korea). Each observation took 24 hours, and it was repeated 4 times. Likewise, the origin point of the new national geodetic system that conforms to the world geodetic system of each Southeast Asian nation can be determined after 3-m class antenna installations and co-observations with Sejong VLBI center (in Korea). The 3-m class antenna can be operated at the ground station for data transmission from small SAR satellite as well.

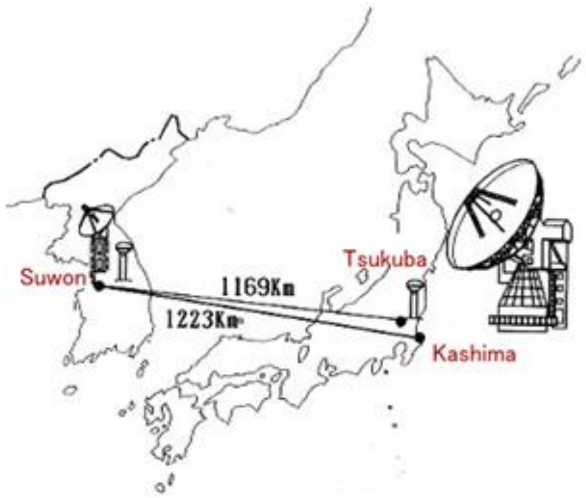

Fig.1. Korea-Japan geodetic VLBI co-observation (1995)

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Table 1. The origin point of Korea reference frame (ITRF 94 EPOCH : 1995. 827)

X = - 3062002.5526 m
Y = 4055436.7504 m
Z = 3841860.8691 m

2. WGS and geodetic VLBI

Earth has very complex surface which is composed of mountains and seas, etc. In order to map geographical characteristics, a spatial reference frame is required. The spatial reference frame must be easy to use and simple, and include clearly defined geodetic control points and reference axes for accurate positioning and intuitive association with the physical world.

Reference frame includes definitions for positioning, commentary coordinates, processing method with necessary constants. SLR and geodetic VLBI have been used to determine International Terrestrial Reference Frames. The origin points of national geodetic system can be defined by geodetic VLBI in Southeast Asia region.

The coordinate systems of Korea and Japan were combined in mm-accuracy from geodetic VLBI co-observation (in 1995). The Cartesian coordinates of the Korean geodetic origin referenced to ITRF 94 are shown in Table 1. It was found that, the baseline between Suwon and Tsukuba has been reduced by 40 mm per year.

VLBI observation is performed as follows. More than 2 antennas simultaneously receive the radio waves coming from compact radio source (Quasar) in the several billion light-years distance. Each station has independent standard frequency of high stability. Received signals are sampled at reference signal which is supplied from standard frequency device. Result of the correlation process for the digitized signal is examined, and then the time difference of the same wavefront to reach both antenna is accurately calculated (time accuracy over 1 part per 10 billion). Main component of this differential time is the geometric delay $\tau_g (\tau_g = D \cdot s/c)$ which is determined

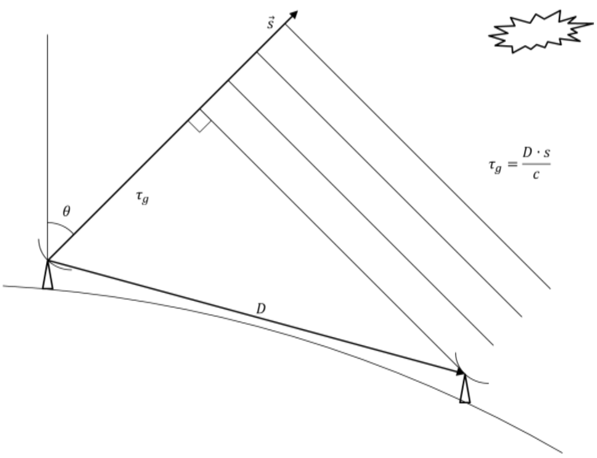

Fig.2. Geometric delay time τ_g

by the vector D (direction to the radio source) and the vector s (baseline between both antennas) (Figure 2).

Observation for geometric delay time is repeatedly performed with different radio sources. After all, the earth direction from the radio source, the position of the antenna on earth surface, the position of the radio source on celestial sphere, all of these can be determined by mm-accuracy (0.1 milliarcsecond in angle). The origin point of new national geodetic system is to be determined accordingly.

3. Small SAR satellite development, manufacture and spread

The small satellite can be developed at low cost in a short period of time while the large satellite development will take a long period of time to research and need a huge amount of investment. Therefore, the small satellite development has an advantage in the development of space technology. As shown in Figure 3, this small satellite development is included as part of the "Korea National Space Development Program Roadmap" by detailed action plan. The proven technology in the small satellite can be adapted to the large multi-purpose satellite in the future.

The multi-purpose satellite can be made in Korea by the using the small satellite technologies. And Korea government has a plan to launch a next generation small satellite per 3-4 years. These technologies have been not studied in Korea before, micro satellite will be priority developed among the plan for small satellite of South Korea. Ajou University has made a MOU with Prof. Josaphat Tetuko Sri Sumantyo in National Chiba University, Japan who are excellent for development of the micro SAR satellite. The micro SAR satellite is most popular as the utility of the micro satellite.

If the micro SAR satellite is developed by National Space Program, Ajou University will develop the standard satellite for micro satellite with corporations and supply it to domestic and Southeast Asian countries (if necessary, perform ODA). Then it will help to accelerate the space industry. Especially, it contributes to the advancement of science and economy of countries in Southeast Asia which have rich resources and many natural disasters.

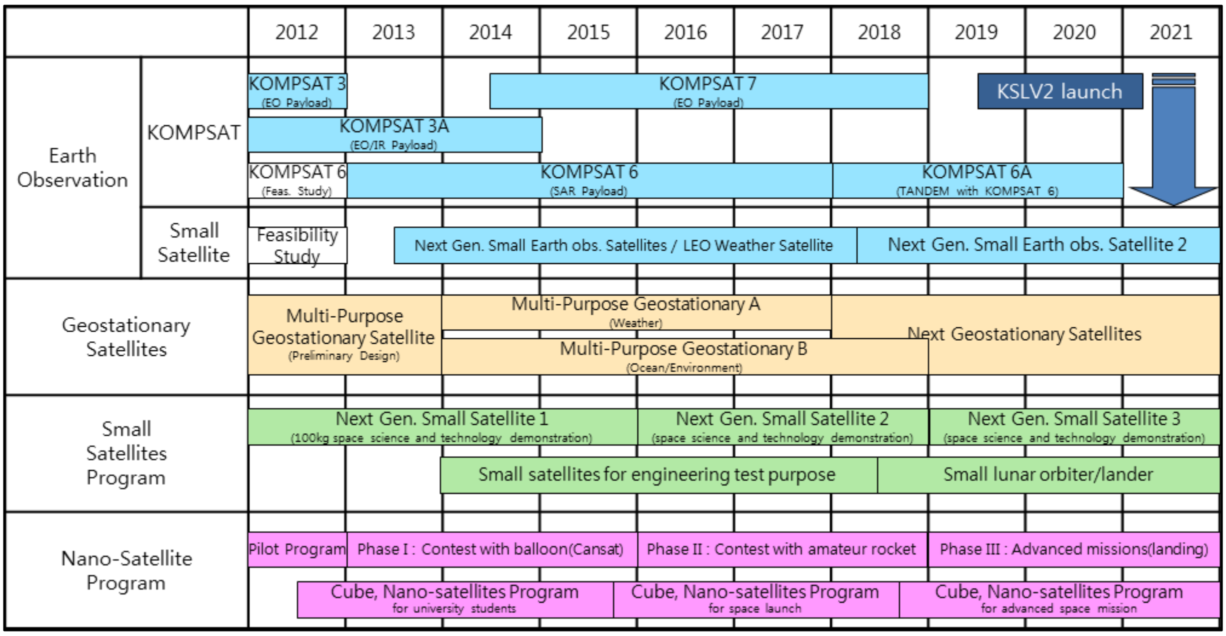

Fig.3. Korea national space program (Satellites) roadmap

4. Southeast Asia space network installation

Countries in Southeast Asia have rich natural resources but they have many natural disasters, too. Thus these countries have needs of earth observations with observing satellite and installing the small ground station to gather and utilize the desired observing data effectively. The space observation network can be utilized as the remote sensing exploration or the observation of natural disasters. Moreover, it is the benefits of the small ground station that the cost of a installing is much cheaper than that of the large ground station.

Meanwhile, in Southeast Asia, the geodetic VLBI observation network is not existed (Figure 4) and the world geodetic system is not used. However, in these days, most countries commonly use the world geodetic system as a national geodetic system. To establish the world geodetic system of a country, the origin point of national geodetic system should be determined exactly.

For determining the origin point, the country should install the geodetic VLBI observatory station and then do the international VLBI observation. The measured point becomes an origin point of the national geodetic system, and the new coordinate system of the whole countries are determined based on it. Finally, the new national geodetic system is established based on the world geodetic system.

For the geodetic VLBI observation, if the diameter of an antenna at one side is more than 20m, then 3m is acceptable as a diameter of the other side antenna. If the Space Geodetic Observation Center (in Sejong-si, Korea) which has the 22m-diameter antenna play a role as the central station, then the geodetic VLBI observation can be possible by using the small ground station with the 3m-diameter antenna in Southeast Asia. For that, only requirement is that the replacement of the antenna receiver for the satellite communication with for the geodetic VLBI receiver.

When the geodetic VLBI observation is possible, each country can not only determine the origin point of the new national geodetic system, but also measure the variation of plate movements in Southeast Asia region.

5. Conclusions

According to the Korea national space program roadmap, Ajou University and Chiba University will develop micro SAR satellite. It will be manufactured by corporates and will be spread to Southeast Asia. Micro SAR satellite will explore resources and monitor natural disaster. It will be supported by ground station which is designed to allow VLBI observation (Figure 5). The ground station can be origin point of national reference frame according to WGS when perform VLBI observation. In that case, Korea can be the hub to support it, and these network will be multi-purpose space network.

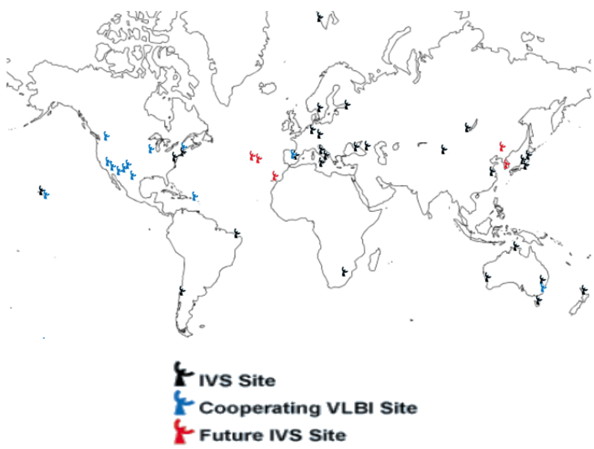

Fig.4. IVS Network Station (2013)

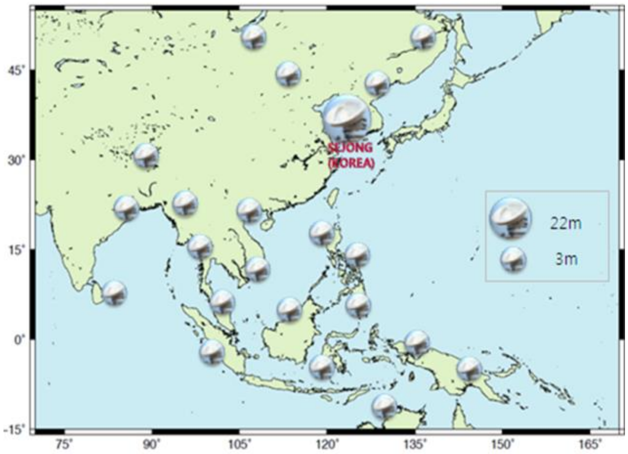

Fig.5. Southeast Asia space observation network (plan)

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Image Quality Comparison of Linearly Polarized and Circularly Polarized SAR

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Abstract

Synthetic Aperture Radar (SAR) is recognized as a powerful surveillance and land observation purpose system these days. An SAR sensor is usually loaded on moving platform such as aerial vehicle or satellite then acquires the images of remote area in interest. Also this system uses microwave for its own illumination source, therefore it can be operated regardless of the weather condition. When SAR system performs its mission in space, there are ionosphere and air in the path of satellite and the target as a propagation medium. Conventional SAR system uses linearly polarized (LP) microwave and as LP wave traverses through the ionosphere, Faraday rotation (FR) effect occurs. FR makes the reference plane of microwave tilt slightly, consequently causes polarization mismatch when receiving the backscattered signal. This polarization mismatch eventually degrades the image quality such as image burling, degradation of contrast, and etc. To cover up the problems of conventional LP-SAR system, this paper proposes that circularly polarized (CP) SAR system which can get rid of polarization mismatch theoretically and compare the pros and cons between LP and CP SAR images with simulated image data.

Keywords: polarization mismatch, synthetic aperture radar, circular polarization, Faraday rotation, ionosphere

1. Introduction

Radar which is an acronym of radio raging and detection is widely used for recent human life as the technology evolves, it is used not only for military purpose but also for agriculture, hydrology, environmental remote sensing, and etc [1]. Synthetic aperture radar (SAR) is a kind of imaging radar that uses microwave to detect target in remote area. As an active sensor, SAR sensor can illuminate the target regardless of light source (e.g. Sun), so compared to optical sensor it can be operated regardless of day-night condition. Furthermore, as it uses microwave that has longer wavelength than visible light, SAR sensor can acquire the high-resolution image of target in all-weather condition.

To acquire the image, SAR sensor is loaded on moving platform typically aircraft and satellite, then transmits and receives the microwave signal along its path. Regarding to space-borne SAR sensor which performs its imaging mission on satellite, the microwave of this case would traverse ionosphere and air as a medium between satellite and target on Earth. Usually, linear polarization (LP) microwave is implemented for transmit signal in conventional SAR systems. When LP microwave traverses ionosphere, the reference plane of LP microwave rotates up to 40° in the case of L-band [5]. This rotation causes the polarization mismatch in receiving stage, and the impairment of transmitted and received signal caused by polarization rotation degrades SAR image quality. The phenomenon causing the rotation on reference plane of polarization is called the Faraday rotation (FR). In this paper, the phenomenon called FR is explained first then the effect of FR on SAR image is presented next. Characteristics of LP and CP SAR systems are introduced and by inspecting their scattering characteristics the performance of CP SAR is drawn out.

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2. Circular Polarization Implementation on SAR

2.1. Polarization Properties of SAR Sensors

Polarization is defined as the reference plane of microwave in free-space due to the distribution of current and voltage on antenna. If the electromagnetic field components of plane wave are not changed during the propagation time it is called LP wave. LP wave can be classified to horizontal and vertical polarization.

SAR sensor transmits and receives the microwave to acquire the image of targets. Electromagnetic wave deals with two modes of radiation: horizontally (H) and vertically (V) polarized waves. When a radiation source transmit and receive LP wave, an H wave impinging on a target could produce V wave as well as H waves and a V wave interacting with a target may also yield H waves as well as V waves. Table 1 presents the types of

Table 1. Types of LP polarizations

O_{HH}	H mode scattering for H mode radiation
O_{HV}	H mode scattering for V mode radiation
O_{VH}	V mode scattering for H mode radiation
O_{VV}	V mode scattering for V mode radiation

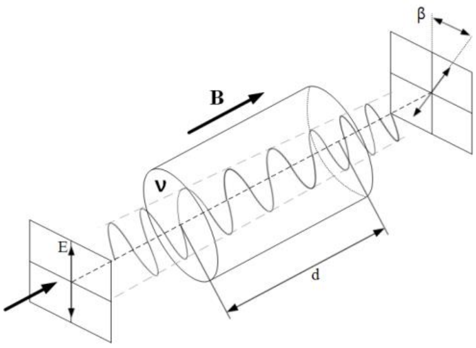

Fig.1. Polarization rotation due to Faraday rotation

LP polarizations [8]. When SAR sensor transmits H wave, two receiving antennas for H and V back-scattered waves are needed. For examples, the target that has V components such as high-tall man made buildings is easy to reflect H waves and less reflects the V waves. In image processing stage, the image obtained from V back-scattered polarization wave with V transmit signal is called VV image.

2.2. The Faraday Rotation Effect

Usually, microwave on Earth propagates through the air as a medium, but microwave from space is transmitted and received through ionosphere that is located between space and air. There is a phenomenon called Faraday rotation effect which is caused by interaction between light and magnetic field in a medium and causes a rotation of the plane of polarization in the direction of propagation. Figure 1 shows the polarization rotation due to Faraday rotation.

Conventional SAR systems adopt LP microwave for its own illuminating source. It transmits LP signal and receives back-scattered signal from target. If the SAR sensor uses only H or V signal and receives only one type of polarizations, it is called single-pol system. When it transmits one type of polarizations and receives H and V simultaneously in two receiving antennas, this system is called dual-pol system. Last, the system adopts two transmitting antennas and two receiving antennas for H and V polarization is called full-pol system.

While LP polarization wave propagates through ionosphere, the polarization plane rotates and the maximum degree of rotation according to frequency bands is presented in Table 2 [2], [4].

Table 2. Plane rotation degree due to FR

Frequency bands	Rotating degree
C-band	326°
L-band	40°
X-band	8°

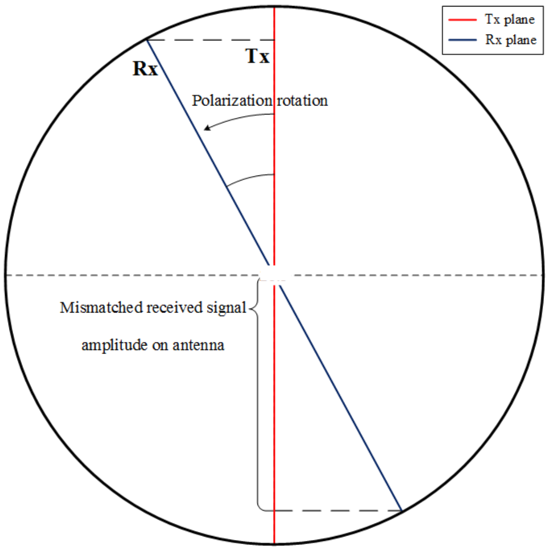

Fig.2. Mismatch of polarization between transmitting and receiving signals

2.3 Faraday Rotation Effect on SAR images

The full-pol space-borne SAR systems receive back-scattered H and V waves. For example, if H wave is transmitted to targets, to acquire HH image SAR sensor stores H back-scattered signal. On image processing stage, SAR processor operates correlation process between received signals and transmitted signals (reference signals).

Here, due to FR effect, mismatch between transmitting (Tx) and receiving (Rx) polarization signal occurs. For example, assume that SAR sensor transmits H polarization wave and receives H back-scattered polarization wave from the target. Theoretically, the plane of both Tx and Rx signals should identical on Rx antenna. However, while microwave traverses ionosphere, due to FR effect, reference plane of Tx and Rx polarization rotates and consequently FR causes polarization mismatch on receiving antenna. Polarization mismatch lowers the amplitude of Rx signal when it compared to Tx polarization plane. Mismatch between Tx and Rx is depicted in Figure 2. Due to the mismatch there occurs polarization mismatch loss between polarization vectors. It degrades image quality such as image blurring, image brightness degrading, and etc.

2.4 CP-SAR Implementation

There is circular polarization wave that is utilized with two, orthogonal components: right- and left-handed circular polarization (RHCP and LHCP). It is

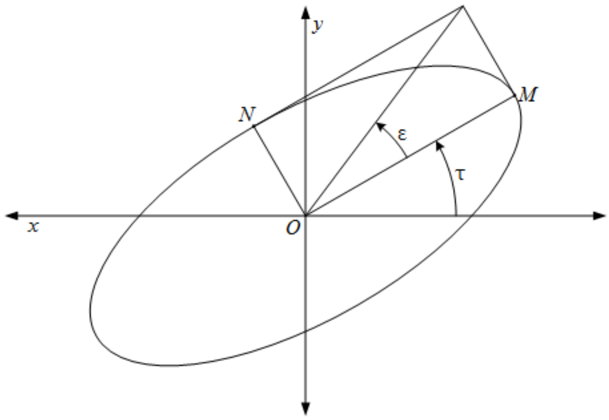

Fig.3. Definition of axial ratio

Table 3. Dataset of SAR image comparison

Parameters	Specification
Satellite	ALOS PALSAR
Data	PLR 1.1
Data size	18432 (row) x 1088 (col)
Output format	8-bit BMP
Processor	PolSARPro v4.2, MATLAB

frequently used in EME (Earth-Moon-Earth) communications and here CP wave implementation on SAR will be presented. Electric field (E-field) and magnetic field (M-field) of CP are perpendicular each other in their propagation direction and the reference plane of CP is circle shape. The characteristics of each type of polarization can be defined by axial ratio that indicate the proportion between E-component and M-component. Definition of axial ratio is defined as

$$\varepsilon = cot^{-1}(R) \tag{1}$$

where ε = ellipicty angle ($-45° \le \varepsilon \le 45°$)
R = value of axial ratio

Because a circle has one same radius in it, axial ratio of CP wave equals 1 [4]. Figure 3 shows definition of axial ratio.

Polarization mismatch loss described in dB scale is defined as (2).

$$\Gamma(dB)=10\log\left[\frac{1+\rho_W^2\rho_A^2+2\rho_W\rho_A\cos 2\theta}{\left(1+\rho_W^2\rho_A^2\right)}\right] \tag{2}$$

ρ_W and ρ_A represent the circular polarization ratio of the transmitted wave and the circular polarization ratio of receiving antenna respectively. Each circular polarization ratio is defined as follow.

$$\begin{aligned}\rho_w&=(r_w+1)(r_w-1)\\ \rho_A&=(r_A+1)(r_A-1)\end{aligned} \tag{3}$$

r_w and r_A indicate axial ratio of transmitted wave and axial ratio of receiving antenna respectively.

Assuming that axial ratio of CP equals 1, the polarization mismatch loss is eliminated completely.

Table 4. Parameters of point target analysis

Parameters	Value
Center frequency	1.27 GHz
Bandwidth	10 MHz
PRF	2346.3 Hz
Pulse width	30 us
Azimuth beamwidth	1.4989°
Range beamwidth	2.9979°
Altitude	600 km
Pixel size	1024 x 1024

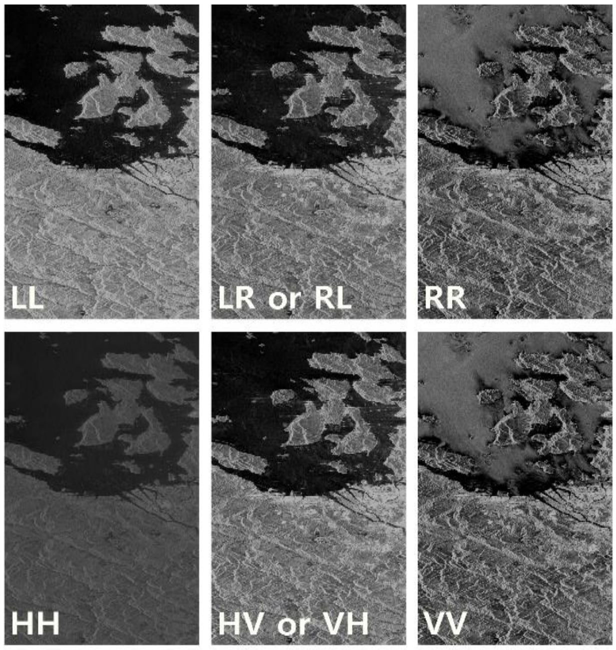

Fig.4. Comparison of CP images (1st row) and LP images (2nd row)

2.5 Simulation and results

Dataset of simulation is defined in Table 3. To compare the LP and CP image, full-pol LP SAR images are used. First, raw data from ALOS PALSAR (Advanced Land Observing Satellite Phased Array L-band SAR) is converted to four SLC (single look complex) images by using PolSARPro V4.2 tool. Each grey-scale image represents polarization types of transmission source and back-scattered components. By converting the scattering matrix from LP to CP with (4), CP images can obtained with MATLAB [6].

$$\begin{bmatrix}O_{LL} & O_{LR}\\ O_{RL} & O_{RR}\end{bmatrix}=\frac{1}{2}\begin{bmatrix}1 & j\\ j & 1\end{bmatrix}\begin{bmatrix}O_{HH} & O_{HV}\\ O_{VH} & O_{VV}\end{bmatrix}\begin{bmatrix}1 & j\\ j & 1\end{bmatrix} \tag{4}$$

To compare the image quality with in the sense of contrast and brightness, CP and LP images are presented in Figure 4. Among the images, especially LL (CP image) and HH (LP image) images show remarkable difference of brightness and contrast.

Not only compare the image as it is but also analyze the point target characteristics, simulation was done with the parameters in Table 4.

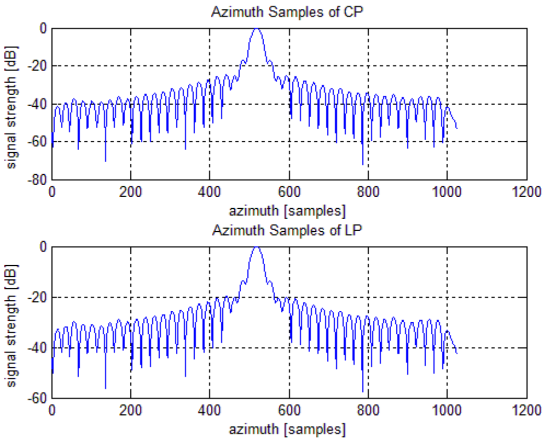

Fig.5. Azimuth sample PSLR of CP and LP

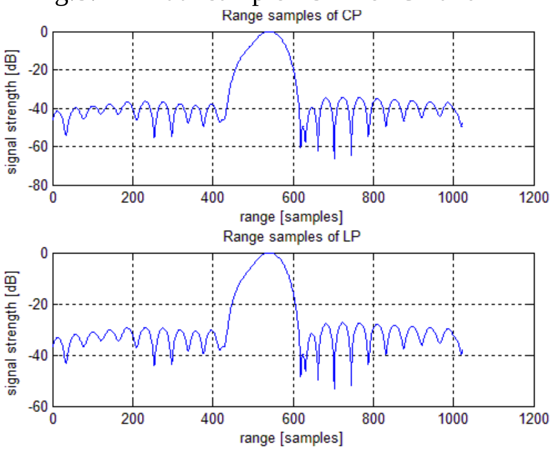

Fig.6. Range sample PSLR of CP and LP

Back-scattered signal strength of CP and LP are compared in Figure 5 and Figure 6 in the sense of PSLR (peak to side-lobe ratio). PSLR indicates the difference between normalized main-lobe peak value and largest side-lobe value. PSLR is a kind of barometer that can evaluate the performance of SAR signal. Parameters used for point target analysis is presented in Table 5. Assuming the one point target is in the field, PSLR is calculated. In the case of azimuth sample, PSLR of LP, -14.01dB, is changed to -17.52dB in CP case. Likewise, range sample PLSR of CP is enhanced from -27.86dB to -35.98dB.

3. Conclusions

In this paper, polarization mismatch loss caused by Faraday rotation is investigated that it degrades SAR image quality. Conventional SAR systems implemented with LP microwave suffer from FR that rotates the polarization plane. CP-SAR that utilizes circularly polarized microwave is proposed and images of LP-SAR and CP-SAR are compared. Comparing the PSLR of azimuth and range samples respectively, in azimuth sample case, PSLR of CP has increased -3.53dB and in range case, PSLR of CP has increased -7.12dB. By comparing the simulation results, it is shown that the image obtained from CP-SAR performs better than conventional LP-SAR when FR occurs and consequently it means that CP-SAR system is robust to FR because this system can eliminate the polarization mismatch loss ideally. Still, performance evaluation methods such as comparing IRF (impulse response function), PLSR, and ISLR (integrated side-lobe ratio) are needed to verify the CP image quality. Next research step will be the precise quantitative analysis on CP-SAR performance.

Table 5. Dataset of point target analysis

Parameters	PSLR (dB)
CP azimuth samples	-17.52 dB
LP azimuth samples	-14.01 dB
CP range samples	-35.98 dB
LP range samples	-27.86dB

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International cooperative studies on environment and disaster mitigation with satellite remote sensing

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Abstract

The center for Remote Sensing and Ocean Science (CReSOS) was established in Udayana University (UNUD) in 2003 with the aid of Japan Aerospace Exploration Agency (JAXA) and National Institute of Aeronautics and Space of Indonesia (Lembaga Penerbangan Dan Antariksa Nasional: LAPAN). According to the objectives of CReSOS, JAXA started pilot project in 2003 and continued it until 2008. During the period, an education program on satellite remote sensing technology has been established in a master course of UNUD. At the same time, international cooperative research has also started between UNUD and Japanese research institutes. UNUD and Yamaguchi University (YU) established joint master course program in 2009 with the support of Grant from Japanese Government under the title of “International Graduate School Cooperation by Satellite Remote-Sensing”. Then UNUD and YU expanded the educational program into the double degree program in 2011. Some students in the program move to YU and study in the second academic year. After getting master degrees from both UNUD and YU, some of them go to Doctoral course and acquire PhD. Many valuable papers have been published through the program. The program is now expanded not only for Indonesian students but also for students in Southeast Asia countries.

Keywords: Satellite remote sensing, International cooperative education and research, Environmental and natural disaster issues

Introduction

The center for Remote Sensing and Ocean Science (CReSOS) was established in Udayana University (UNUD) in 2003 with the aid of Japan Aerospace Exploration Agency (JAXA) and National Institute of Aeronautics and Space of Indonesia (Lembaga Penerbangan Dan Antariksa Nasional: LAPAN). Professor Yasuhiro Sugimori (professor emeritus of Chiba University) is the first Director of CReSOS. Unfortunately he pass away in 2008 and prof. Tasuku Tanaka succeeded him.

In the year 2009 Yamaguchi University (YU) won the Japanese government fund for International Cooperation for Space Technology.

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Based on this fund UNUD and YU established “Joint Master Course for Environment and Disaster Mitigation Research”.

In the year 2012 YU won another Japanese government fund. We are now planning how to further enhance the current cooperation between UNUD and YU.

Establishment of CReSOS

The objectives of CReSOS are;

1) to initiate training and education for human resources development and to enhance the image of Bali island as tourist destination, science and technology promotion.
2) to initiate regional and international collaboration among scientists in the field of remote sensing.
3) to invite the researchers from all over the world to do research related to application of remote sensing.
4) host seminars, workshops and conferences.

According to the objectives of CReSOS, JAXA started pilot project in 2003 and continued it until 2008. During the period, an education program on satellite remote sensing technology, the theory and its applications, has been established in a master course of UNUD. At the same time, international cooperative research has also started between UNUD and Japanese research institutes. The research fields/topics were wide as follows;

a. Bio-diversity of coastal waters in Bali and neighboring islands.
b. Monitoring and exploration of the marine resources and environment.
c. Empowering the society in coastal areas to increase their productivity.
d. To attain better understanding of the sea-dynamic, land- atmospheric interaction.
e. Coastal zoning particularly in the region of Southeast Asia.

As can be seen from the above, the research fields/topics were limited to those have been related to the ocean science at first, but have been expanded to disaster mitigation.

We have also established the cooperation with Indonesia Ministry of Education, Bureau of International Cooperation (DIKNASA).

Joint Master Course

In 2009, as mentioned in Introduction, UNUD and YU established joint master course program with the support of Grant from Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) under the title of "International Graduate School Cooperation by Satellite Remote-Sensing". Then UNUD and YU expanded the educational program into the double degree (DD) program in 2011. Some UNUD students who take the DD program move to YU and study in the second academic year. During the stay in YU, they write the first master thesis and then go back to UNUD to write the second thesis at the end of the second year. After getting master degrees from both UNUD and YU, some of them enter Doctoral course and acquire Ph.D. in YU. Through these educational and research activities, many valuable fruits have been obtained. Main published papers are listed at the end of this paper. The program is now expanded not only for Indonesian students but also for students in Southeast Asia countries.

Joint master course education program

To start the education program, we needed to know differences in education system between UNUD and YU and then to adjust them. The organizations which are responsible to the program and the academic system in both universities are as listed in Table 1.

Table 1 Responsible organizations and academic systems in both universities.

UNUD: Environment Study of Post Graduate Course		
Semester	Term	Academic year
I	Sep. to Dec.	1st
II	Feb. to Jun.	1st
III	Sep. to Dec.	2nd
IV	Feb. to Jun.	2nd
YU Remote Sensing Study Team in Graduate School of Science and Engineering		
Semester	Term	Academic year
I	Apr. to Jul.	1st
II	Oct. to Feb.	2nd

The required units in both universities are also different and are listed in Table 2.

Table 2 Required units for master degree.

UNUD	
Lectures (mainly compulsory)	24 units
Thesis	12 units
Field work	1 unit
Proposal for thesis	2 units
Colloquium for thesis	1 unit
Total	40 units
YU	
Lectures (mainly elective)	24 units
Thesis	6 units
Total	30 units

Ten subjects (20 units) listed in Table 3 were designated as sharedlectures. These lectures are delivered simultaneously both to Sudirman campus (Denpasar city) of UNUD and Tokiwa campus (Ube city) of YU through the remote lecture system which we developed using internet. At most students of UNUD work in daytime, the shared lectures start at 15:10 in Bali time (16:10 in Japan time). Two classes are given per day. To perform the shared lecture, many professors and experts participate and contribute not only from UNUD and YU but also from other organizations such as JAXA, Hokkaido University, University of Tokyo, Chiba University, Tokai University and so forth.

Photograph 1 shows a snapshot taken after the shared lecture in UNUD. The back screen is the classroom in YU.

Double degree program

By expanding and making use of the joint

Table 3 Subjects of the joint master course education program,

	Subject	On-site
1	Space Engineering and Satellite Remote Sensing	UNUD 15
2	Digital Image Processing	YU 15
3	Disaster Mitigation	UNUD 10 YU 5
4	Advanced Geoinformatics	UNUD 5 YU 10
5	Environmental Fluid Dynamics	YU 15
6	Environmental Remote Sensing	UNUD 10 YU 5
7	Oceanography	UNUD 5 YU 10
8	Climate Change	UNUD 15
9	Land, Water & Vegetation Conservation	UNUD15
10	Lake & Coastal Environment	UNUD13 YU 2

Photo.1 A snapshot taken after a shared lecture.

Photo.2 Ceremony of the certification of visiting professor.

master course education program, we designed the double degree (DD) program. In the DD program, students in UNUD can obtain the degree of Mater of Engineering (ME) from YU, and Master of Science (MS) from UNUD by staying one year in YU in the second academic year. The DD students can bring 10 units when they are enrolled in YU, that is, they need to take more than 20 units in YU. After finishing the master thesis, they come back to UNUD and starts study for the second master thesis.

To make it easier, joint research tutorial system is provided. In addition, some professors were entitled as "Visiting (associate) professor" each other. Photography 2 shows the ceremony of the certification.

As there is no Ph.D. course for environment or disaster mitigation in UNUD, most DD students go to Ph.D. course in YU. The number of DD students is as follows;

Class 2010: 3 students and
2 students in Ph.D. in YU
Class 2011: 3 students and
2 students in PhD in YU
Class 2012: 3 students
Class 2013: 3 students

The activities by the students have promoted the international cooperative research between UNUD and YU and bore fruitful results as explained in the next section and listed at the end of this paper

Joint master course education Research

The research topics are rich in variety as Ocean environment & fishery, Climate change and oceanography, Weather and land process, Precipitation and natural disasters, Disaster mitigation, such as tsunami disasters, flood, and so forth.

(1) Ocean environment & fishery

Figure 1 shows one of the examples of the results from this research theme. It shows the relationship between the number and locations of Big-eye tuna caches and the spatial distribution of Sea Surface Temperature(SST) in Indian Ocean in March (left) and August (right) in 2010. This research combines the fishery and satellite remote sensing technology. By making use of these results, Efficient and sustainable fishery is expected.

(2) Climate change and oceanography

It is thought that the temperature of the ocean around Indonesian archipelago may have strong effect to the world climate. Figure 2 shows the seasonal variability of SST, U-WS and RR in the Indian and Pacific oceans at the observed locations. The variability is average of ten years observation. These basic data will be useful to understand the cause of abnormal climate phenomena such as El Nino, La Nina and so forth.

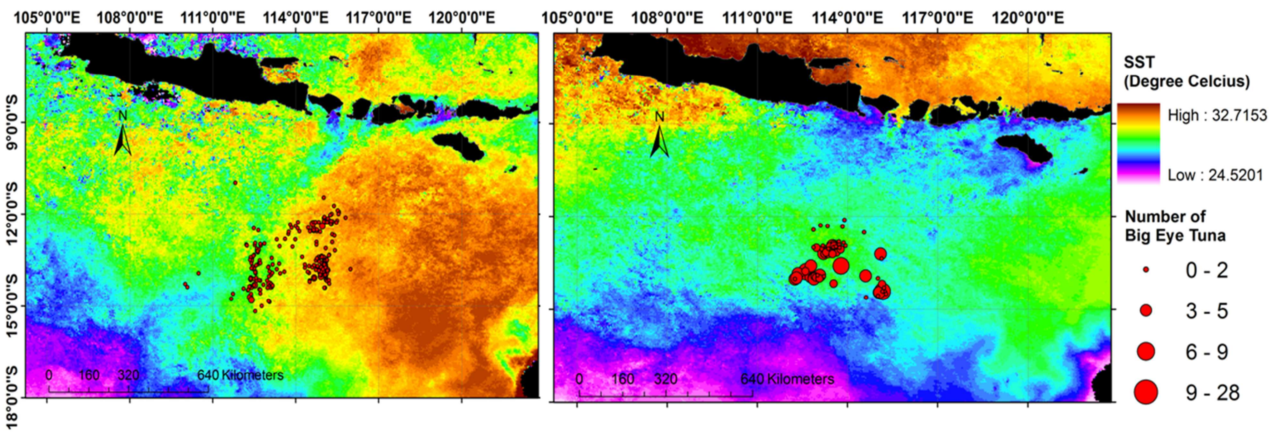

Fig.1 Relationship between the number and locations of Big-eye tuna caches and the spatial distribution of Sea Surface Temperature(SST)

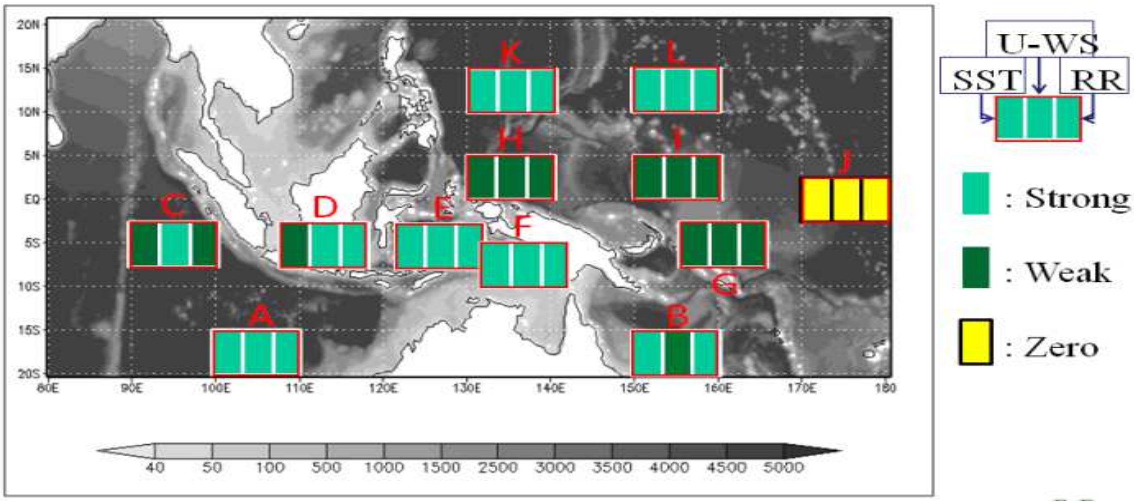

Fig.2 seasonal variability of SST, U-WS and RR in the Indian and Pacific oceans around the Indonesian archipelago

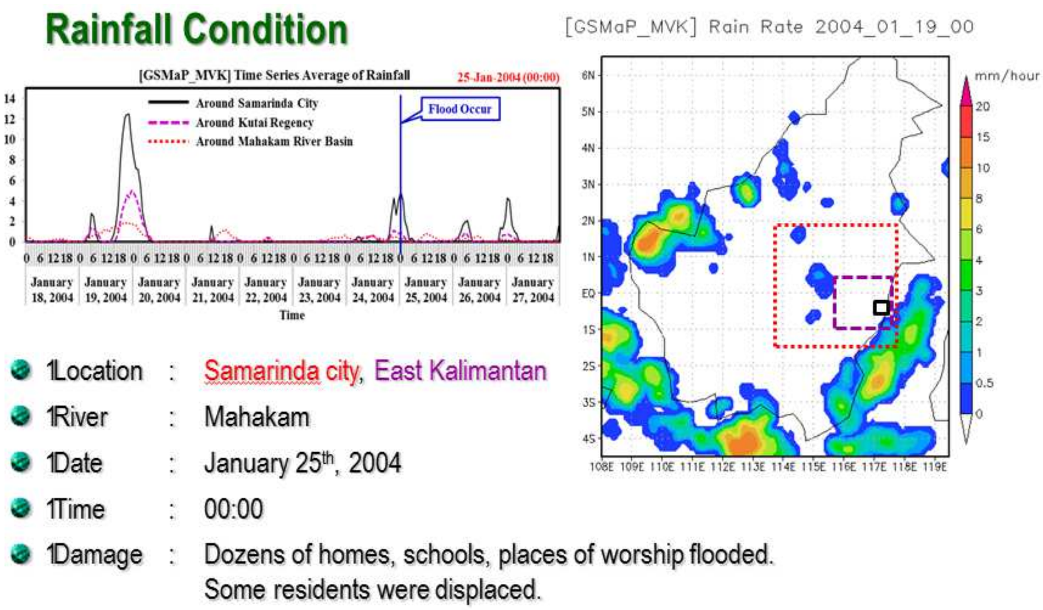

Fig.3 relationship between rainfall and occurrence of flood

(3) Precipitation and groundwater level

Figure 3 shows the relationship between the rainfall and the occurrence of the flood. The time history (upper left figure) and the space distribution (right figure) of the rainfall were observed by GSMaP. This kind of research will be useful to understand the mechanism of the occurrence of flood and disaster reduction.

Fig. 4(a) True-color image of Rikuzentakata after the tsunami attack.

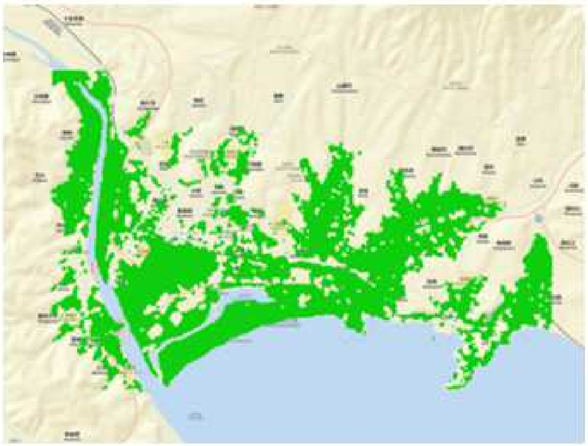

Fig. 4(b) NDVI image of the inundation area due to the tsunami.

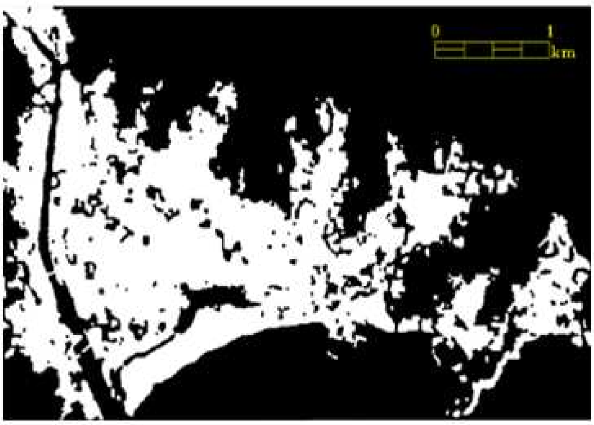

Fig. 4(c) The inundation area obtained from SAR image.

(4)Disaster mitigation

(a) Tsunami inundation area

On March 11 in 2011, a magnitude nine (M9) earthquake attacked the north-east Japan area and severe tsunami devastated very wide area. To determine the attached area by tsunami is very important to grasp the damaged area and damage situation of there. Figure 4 illustrates the obtained inundation area by the tsunami in Rikuzentakata city. Figure(a) is a true-color image obtained from ALOS-AVNIR-2. Green area in Fig.4(b) represents the inundation area by using NDVI. Figure4(c) represents the inundation area (white zone) from ALOS-PALSAR.

(b) Fool inundation area

Figure 5 shows an example analysis of flood inundation area caused by heavy rain in Thailand in 2011. Figure (a) is the image before the occurrence of the flood and (b) that after the occurrence of the flood. They were obtained using NDVI. Blue area represents water zone while red area vegetation zone.

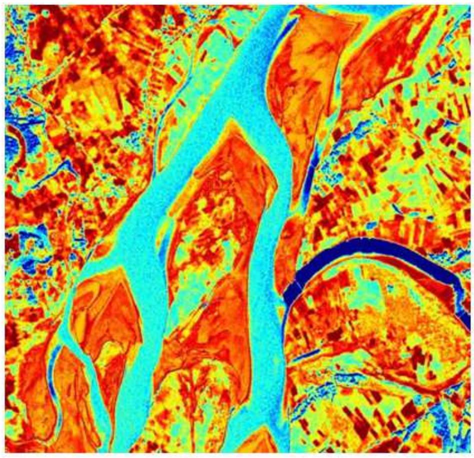

Fig. 5(a) Before the heavy rain

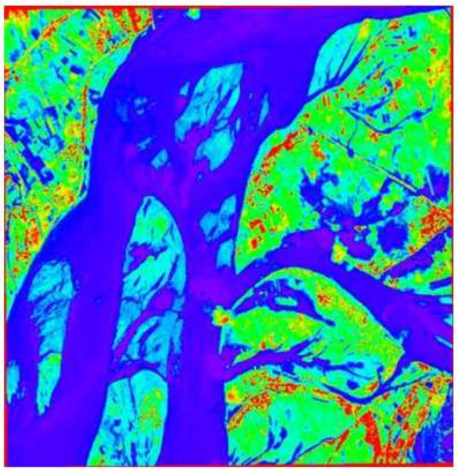

Fig. 5(b) Inundation area after the heavy rain

New Initiative

In 2013, Yamaguchi University won another Japanese Government Fund for enhancing the International Collaboration. We are planning to invite the master course students from the South-East Asian countries, such as Thailand, Malaysia, Vietnam, Philippine, and east Timor to the new academic year 2014 from September 2014. We, Yamaguchi University and Udayana University, jointly enlarge cooperation with the Indonesian Government, Research Institutes and Universities. We are now under way to sign the MOU for cooperation with Ministry of Finance, Indonesia.

The use of Synthetic Aperture Radar (SAR) is promising for the research on Environment and Disaster mitigation, in particular, by virtue of the recently launched ALOS-2 satellite data.

In 2012, the sister cooperative project, "Restoration of Deforest Areas by Symbiosis Technology"" emerged from the current joint project. We have established the pilot site on Batur Mountain north of Bali Island.

Through the cooperative activity, YU joined Sentinel Asia and was assigned as a member of Data Analysis Node (DAN) as the first university in Japan, and have contributed by providing useful imaged through the web-site.

Summary

We reviewed the joint educational and research projects between Udana and Yamaguchi University since 2003. From this project, we accomplished:

(1) Mutual understandings between two countries;
(2) New findings in environment and disaster mitigation research in the South-East Asia;
(3) Growing up young Scientists
(4) Confirmation of capability of space technology for environment and disaster mitigation research.

We are looking forward to expanding the current project to the South-Asian countries and other research institutes and universities.

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List of main published papers

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Speakers

Josaphat Tetuko Sri Sumantyo
Chiba University, Japan
“Microwave Remote Sensing for Environmental Monitoring”

Yukihiro Takahashi
Hokkaido University, Japan
“Scope of Asian Micro-satellite Consortium with Super-constellation”

Koichiro Oyama
University of Cheng Kung, Taiwan
“Observations of ionosphere with Mini/Microsatellites - problems and solutions-”

Robertus Heru Triharjanto
Indonesian Aerospace Agency
“Development of Geomagnet Measurement Mission in LAPAN’s Micro-Satellites”

Voon Chet Koo
Multimedia University, Malaysia
“Development of a Ground-based Synthetic Aperture Radar for Land Deformation Monitoring”

Wolfgang Martin Boerner
University of Illinois, USA
“The challenge for still unresolved development of Multi-band Equatorially Orbiting POLSAR satellite sensors - an integral task for the major space-SAR technology centers world-wide – focused on the Indonesian Islands Environment”

Tu Hwan Kim
Ajou University, Korea
“The plan for space observation network installation in Southeast Asian region”

Fusanori Miura
Yamaguchi University
“International cooperative studies on environment and disaster mitigation with satellite remote sensing

Jae Hyun Kim
Ajou University, Korea
“Image Quality Comparison of LP and CP-SAR”

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