Potential of Maritime Monitoring by using Space-Born Synthetic Aperture Radar

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***Abstract*—According to UNCTAD, the amount of global seaborne trade to have increased by 4.3%, with the reaching over 9 billion tons in 2012 for the first time ever. Nowadays, the number of Earth observation Satellite onboard Synthetic Aperture Rader (SAR) sensor. The ALOS-2 is the successor to the ALOS has been lunched in 2014. Japanese L-band radar keep monitoring for disaster, agriculture, as well as several maritime events to improve the protection of the marine environment and safety. This study aims to investigate several applications of space-born SAR sensors for maritime activity. In this paper, SAR Application has been discussed in order to assess the potential to be used for maritime activities. It was used to evaluate the performance of maritime monitoring in wide ocean area and visualizing information by SAR imagery.**

Keywords—SAR; ALOS-2;PALSAR-2; TerraSAR-X

I. INTRODUCTION

According to UNCTAD (United Nations Conference on Trade and Development), the amount of global seaborne trade to have increased by 4.3%, with the reaching over 9 billion tons in 2012 for the first ever[1]. Nowadays, the number of Earth observation Satellite onboard Synthetic Aperture Rader (SAR) sensor. This study aims to investigate several applications of space-born SAR sensors for maritime activity.

II. MARITIME MONITORING USING TERRASAR-X

In general, Earth Observation Satellite is having on board two types of sensors, an optical sensor and SAR. The SAR is its ability to observe day and night regardless of weather conditions. Hence, it can be recognizing the earth surface covered by clouds is captured on the SAR imagery, even though the same area is covered by clouds on the optical image.

SAR imagery is delivered in near-real time through several service providers. In this chapter, continuous monitoring against volcanic activity on wide ocean area and understanding suspended matter after the Great East Japan Earthquake and Tsunami by TerraSAR-X are presented.

A. Volcanic island "Nishino-shima" Eruption

Newly "Nii-jima" was born in the sea near Nishino-shima of the Ogasawara Islands in Japan on November 20, 2013.We have been monitoring over Nishino-shima from Nov 22 by using TerraSAR-X. Fig.1 shows TerraSAR-X imagery over Nishino-shima and expanding Nii-jima within one year. Nii-jima continues to expand and its area is 238,000squere meter at January 5, 2014. New Island is still actively erupting at point November 30, 2014. This result indicates SAR imagery clearly show volcanic activity during rising smoke.

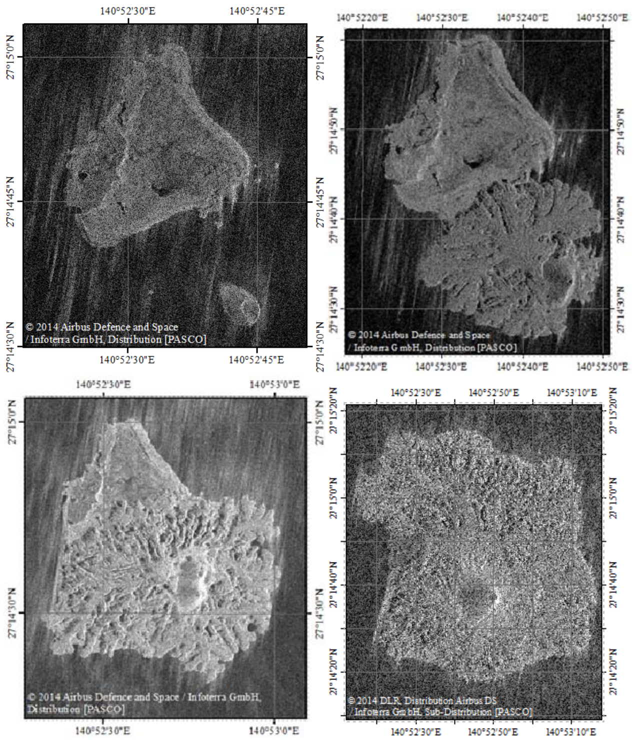

Fig. 1. TerraSAR-X imagery over Nishino-shima and expanding Nii-jima from 22th November 2013 to 30th November 2014. ©2014 DLR, Distribution Airbus DS / Infoterra GmbH, Sub-Distribution [PASCO]

B. Suspended matter after The Great East Japan Earthquake and Tsunami in 2011

The authors have focused attention on disaster monitoring for maritime safety after the Great East Japan earthquake and Tsunami in 2011. Fig.2 shows TerraSAR-X imagery over around Souma Harbor at two days after Tsunami. By analyzing SAR imagery, the suspended matter and drifting ship are recognized (Fig.3). Providing near-real time imagery as a hazard map can be useful applications for decision-makers.

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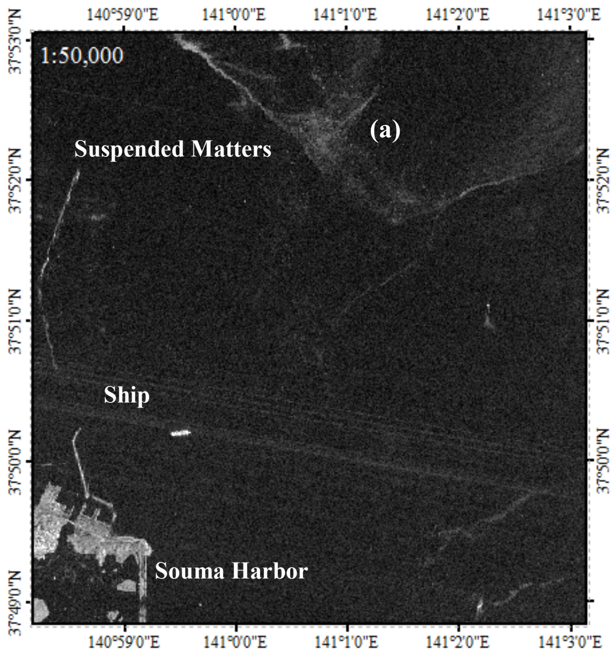

Fig. 2. TerraSAR-X imagery capturing suspended matter around Souma Harbor on 13th March, 2011.©2014 DLR, Distribution Airbus DS / Infoterra GmbH, Sub-Distribution [PASCO]

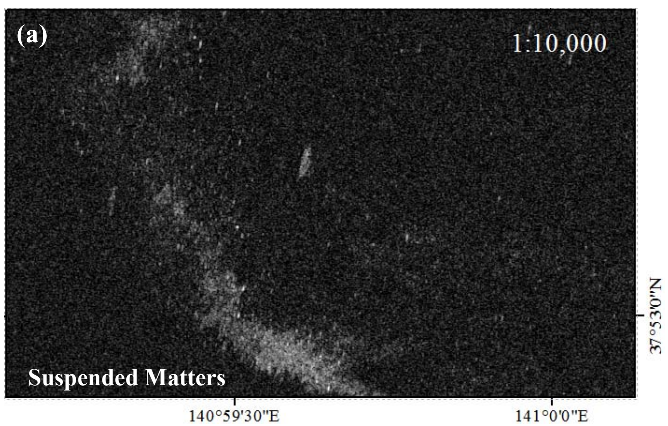

Fig. 3. TerraSAR-X imagery capturing suspended matter in area (a) at 1:10,000 scale.

III. Monitoring of Vessel Traffic using ALOS-2

The Advanced Land Observing Satellite (ALOS) was launched for earth observation of global land coverage and so on. ALOS acquired more than 6 million scenes of archives including coastal areas during period of five years. The Phased Array type L-band Synthetic Aperture Radar (PALSAR) on board of the ALOS is an L-band SAR with 10 and 100 m resolutions that are capable of detailed, all-weather, day and night observations [2]. The ALOS-2 is the successor to the ALOS has been lunched in 2014[3]. Japanese L-band radar keep monitoring for disaster, agriculture, as well as several maritime events to improve the protection of the marine environment.

In this chapter, monitoring of vessel traffic in the Straits of Malacca and Singapore by ALOS-2 is presented. The wealth of satellite imagery of ALOS-2 is noticeable for investigating monitoring methods such as ship detection in wide ocean area.

A. ALOS-2 Specifications

The capacity of the radar, the PALSAR-2 of the ALOS-2, has been significantly improved form the ALOS's PALSAR in all aspects including resolution, observation band, and time lag for data provision. In addition, the satellite's basic capacity has been enhanced for supporting the radar performance such as data transmission speed and high accuracy position retention [4]. Table.1 shows ALOS-2 main specification.

TABLE I. ALOS-2 Main Specifications

Orbit	***Type***	Sun-synchronous sub-recurrent orbit
	Altitude	628km about the Equator
	Local sun time	12:00+/-15min above the equator, at descending node
Lap Time		About 100 min
Revisit Time		14 days
Life		Designed life : 5 years Target : 7 years
Launch data		Launch Date: May 24, 2014
		Launch Vehicle: H2 A24
SAR Frequency		L band(1.2GHz)

ALOS-2 has a Spotlight mode (1m to 3m) and a high resolution mode (3m to 10m), whilst PALSAR has a 10m resolution. ScanSAR cover a wide area in just one observation. It is possible to capture imagery swath width of 350km-490km swath and resolution of 60-100m. Table.2 shows ALOS-2 observation mode and range.

TABLE II. ALOS-2 Observation Mode and range

Observation Mode		**Resolution**	**Swath**
Spotlight		1m(Azimuth) by 3m(Range)	25km(Azimuth) by 25km(Range)
Strip Map	***Ultra-Fine***	3m	50km
	High-sensitive	6m	50km
	Fine	10m	70km
ScanSAR		100m	350km
		60m	490km

B. *Vessel Traffic in Straits of Malacca and Singapore*

The Straits of Malacca and Singapore are geographically important and are used as a gateway for many commercial vessels. More than 70,000 vessels traverse the strait per year from year 2006 to 2010, with the reaching over 120,000 vessels in 2012 for the first ever. The high vessel traffic coupled with the narrowness of the Strait is existing navigational hazards.

To keep monitoring of vessel traffic is an important application for safe navigation of the strait. The number of AIS (Automatic Identification System)-equipped ships is increasing under the international convention for the Safety of Life at Sea (SOLAS). Many research institute installed Coastal AIS receivers and has been stored in the server [5] [6]. It is well known that an analyzing AIS data is also an effective solution for monitoring of vessel traffic.Fig.4 shows the example of vessel trajectories by AIS analysis in the Straits of Malacca and Singapore [7].

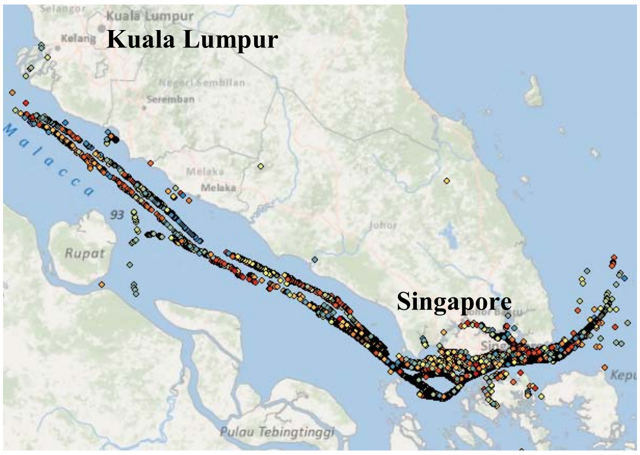

Fig. 4. Vessel trajectories colllected by Coastal AIS reciever in the Straits of Malacca and Singapore. (C)GEBCO, NOAA, National Geographic, DeLorme, and ESRI.

C. *ScanSAR cover over the Straits of Malacca and Singapore*

We used the PALSAR-2 imagery of Straits of Malacca and Singapore that was acquired in WB2 (ScanSAR wide mode with the resolution of 60m, swath with of 490km) and DP (Dual Polarization; HH+HV) on 26th October 2014 in ascending pass (01:21 in local time).

Fig.5 (I) shows coverage of experimental area in the Straits of Malacca and Singapore. From this imagery, ScanSAR mode can be covered over a wide ocean area such as the Straits of Malacca and Singapore in one observation.

PALSAR-2 color-composite image has been generated in Fig.5 (II). The HH information channel was assigned to red, HV was assigned to green, a third channel is derived from the two polarizations (the HV/HH ratio) to create the color-composite image was assigned to blue. Open water, such as rivers, lakes and the seas appear in blue. Green indicates vegetation, light purple and yellowish green are urban areas including building and vessel structure. By analyzing false coloring through the use of polarized wave information, we can understand key land cover types clearly.

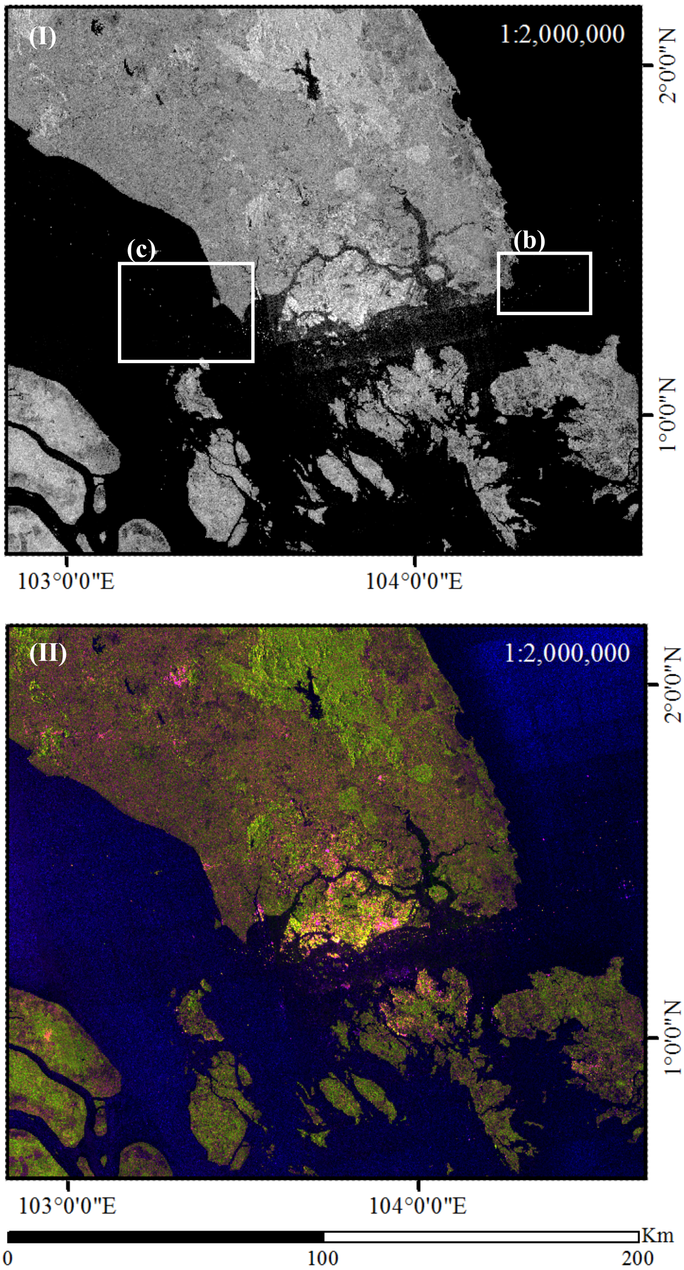

Fig. 5. (I) ALOS-2 ScanSAR wide mode over the Straits of Malacca and Singapore on 26th October, 2014 around acquisition time from 01:21 to 01:22LT (Local Time) at 1:2,000,000 scale. (II) PALSAR-2 color-composite image(Red: HH, Green: HV, Blue: HH/HV) ©JAXA Distributed by ALOS-2 Operation and Data Distribution Consortium.

D. *Vessel Traffics extracted from SAR imagery*

We extracted vessel traffic structure within white line on ALOS-2 imagery. Fig.6 shows that the filtered vessels within the space of experimental area (b) at 1:250,000 scale. Fig.7 shows that the filtered vessels within the space of experimental area (c) at 1:500,000 scale. Several vessel with AIS-equipped or AIS-unequipped are extracted from ALOS-2 imagery. It should be noted that all ships are not equipped with AIS, but the satellite imagery would be enable making observation of vessel with AIS-unequipped.

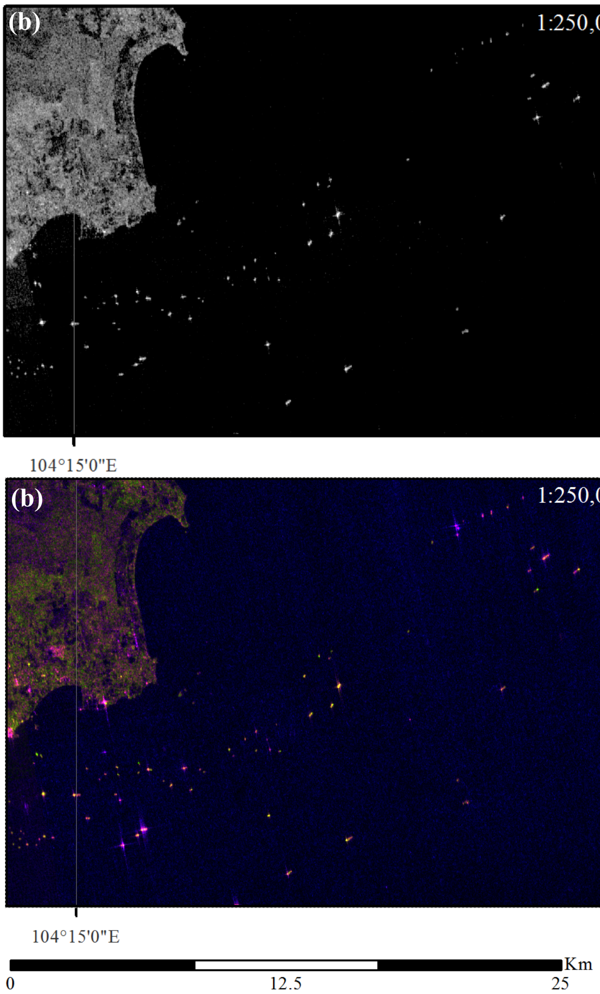

Fig. 6. Extended ALOS-2 imagery in area (b) at 1:250,000 scale. ©JAXA Distributed by ALOS-2 Operation and Data Distribution Consortium.

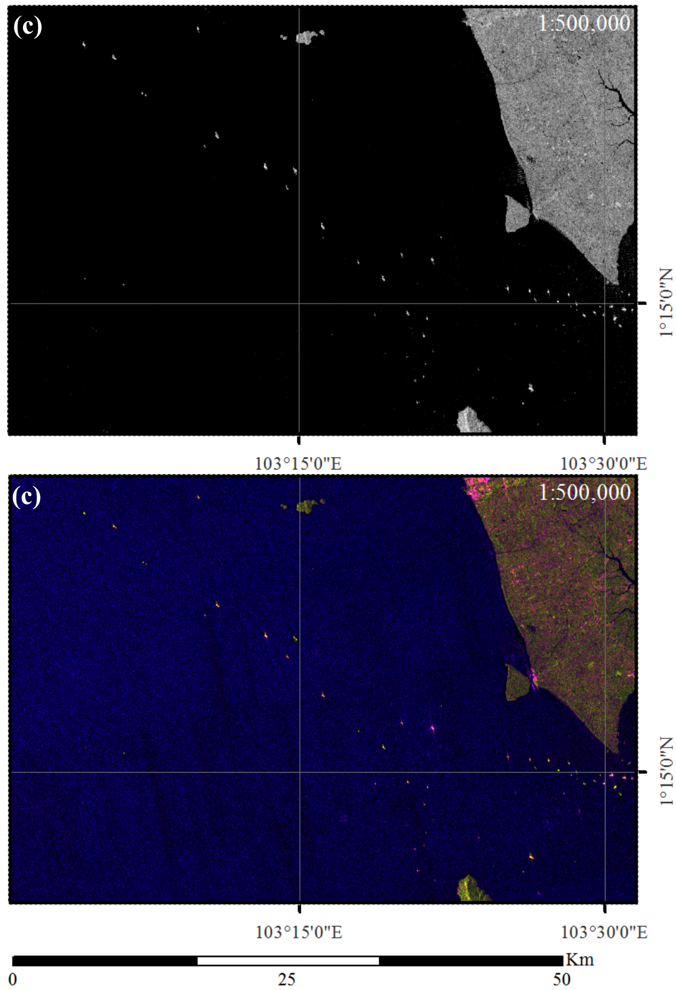

Fig. 7. Extended ALOS-2 imagery in area (c) at 1:500,000 scale. ©JAXA Distributed by ALOS-2 Operation and Data Distribution Consortium.

IV. CONCLUSION

In this paper, SAR Application has been discussed in order to assess the potential to be used for maritime activities. It was used to evaluate the performance of maritime monitoring in wide ocean area and visualizing information by SAR imagery. Additionally, it is useful way to estimate past behavior of vessel traffics or maritime accidents from SAR imagery regardless of weather conditions. We continue to investigate SAR sensors (especially ALOS-2) for maritime safety.

ACKNOWLEDGMENT

The authors would like to thank the Japan Aerospace Exploration Agency (JAXA) for providing the experimental imagery from the ALOS satellite.

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