OIL SPILL POLLUTION DETECTION USING PALSAR DATA IN TIMOR SEA

By: **Tri Muji Susantoro[1), Suliantara[2), and Djoko Sunardjanto[3)**

[1)Technological Assessor, [2) Earth Investigator, [3)Researcher at "LEMIGAS" R & D Centre for Oil and Gas Technology
Jl. Ciledug Raya, Kav. 109, Cipulir, Kebayoran Lama, P.O. Box 1089/JKT, Jakarta Selatan 12230 INDONESIA
RS&GIS GROUP, phone: 021-7222583. Email: trimujis@lemigas.esdm.go.id,
Suliantara@lemigas.esdm.go.id, djokosnj@lemigas.esdm.go.id

First Registered on 07 April 2010; Received after Corection on 17 May 2010
Publication Approval on : 30 September 2010

ABSTRACT

The processing of Palsar imagery has been conducted for detecting an oil spill in Timor Sea. Three series of Palsar imageries i.e. Sept 2nd, Oct 3rd and Oct 6th, 2009 are used to analysis in this area. At September 2nd, 2009 based on Palsar Imagery, oil spill was detected around of Montara Platform. Oil spill seen appeared as dark tone The area that has been covered by oil spill is more than 100 km^2. At September 24rd, 2009 oil spill was dispersed to North and West Montara Field. At October 3, 2009 showed that oil spill was detected in the north of Seba Coast, Sawu Island. Oil spill in this area clearly showed in Palsar Imagery base on a long dark lines. Oil spill at October 6th, 2009 were still dispersed in Timor Sea. Based on Palsar imagery, oil spill is identified in South Rote Island about 150 km long, appeared as dark lines in Palsar imagery.

Key Words: *oil spill, palsar, timor sea, montara field*

I. BACKGROUND

Oil spills may happen when operators make mistakes or are careless as to cause an oil tanker and oil field blow out to leak oil into the ocean. There are a seweral ways an oil spill can occur. Equipment breaking down may cause an oil spill. If the equipment breaks down, the tanker may get stuck on shallow land. When they start to drive the tanker again, they can put a hole in the tanker causing it to leak oil. Oil spill has become urgent problem in the world. Large spills of oil and related petroleum products in the marine environment can have serious biological and economic impacts. Oil can be a major threat to the sea ecosystems.

Samad et al (2000) explained several oil spill incidents caused by oil tankers that occurred on offshore of Malaysia during 1977 – 1997. These include Showa Maru in 1975, Diego Silang in 1976, M.V. Fortune in 1979, Century Dawn in 1988, collision between Nagasaki Spirit and Ocean Blesing in 1992 and collision between M.T. Evoikos and M.T. Orapin Global in 1997. The last accident occurred in the north of Australia in August 21st, 2009 when the Montara offshore drilling rig, owned by the Thai Oil Company PTTEP, suffered a well head accident, so that around 403,000 litres of oil have been pumped into the Timor Sea at a rate of 300 to 400 barrels a day (http://www.guardian.co.uk).

Many tools have capabilities to detect and monitor oil spills, such as vessels, airplanes, and satellites. Vessels, especially if equipped with specialised radars, can detect oil at sea but they can cover a very limited area. The vessel, however, remains necessary in case oil sampling is required. The main systems to monitor sea-based oil pollution are the use of airplanes and satellites equipped with Synthetic Aperture Radar (SAR). SAR is an active microwave sensor, which captures two dimensional images. The advantages of SAR data are day and night obersevation, all weather capability, high spatial resolution and wide area coverage. The brightness of the captured image is a reflection of the properties of the target-surface. The possibility of detecting an oil spill in a SAR image relies on the fact that the oil film

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 2, SEPTEMBER 2010: 135 - 142

decreases the backscattering of the sea surface resulting in a dark tone that contrasts with the brightness of the surrounding spill-free sea. Spaceborne SAR sensors are extensively used for the detection of oil spills in the marine environment, as they are independent from sun light, they are not affected by cloudiness, they cover large areas and are more cost-effective than air patrolling (Tapouzelis, 2008).

In this case we try to monitor the oil spill at sea in north of the Australia using Palsar imagery. Palsar imagery is a part of radar. Palsar seems to be one of the suitable instruments for oil spill detection. After oil spill occurred, Palsar imagery has been collected, imageries over the area from September to October 2009. Three of Palsar Imageries has been processed to monitor the oil spill in Timor Sea. The purpose of the study is to detect and monitor the oil spill in Timor Sea using Palsar Imageries.

II. STUDY AREA AND DATA USED

The area in this study is located in Timor Sea, border area between Indonesia and Australia. The study area is extended from Montara Platform to Sawu Sea, where the Palsar data covered (Figure 1). The satellite data of various times acquisition has been used. Data used in this study are shown in Table 1.

III. THEORY

Deguchi (2007) explains that Palsar is the succession sensor of JERS-1/SAR and launched on January 2006. Synthetic Aperture Radar (SAR) is active radar device. SAR images the radar backscatter of earth surface with a high spatial resolution. SAR sensor transmits microwave to earth surface and receives the backscatter from earth surface. JERS-1 is the first Japanese satellite which installed SAR sensor. JERS-1/SAR had operated from 1992 to 1998. SAR can observe earth surface at nighttime as well as daytime and signal of SAR can penetrate cloud, smoke, fog and small vegetation. It is possible to observe earth surface at any time. Japan Association Remote Sensing, (1992) explains that raw data of SAR are records of backscatterini in time sequence which are returned from the ground targets. Data processing to generate an image in gray tone corresponding to the backscattering intensity each point on the ground is called image reconstruction of synthetic aperture radar). Some existing public SAR imageries data shown as Table 2.

Figure 1
Montara Platform Blow Out and Spill
(SkyTruth, 2009)

Table 1
Satellite data used in the study

Satellite/ Sensor	Spatial Resolution	Acquisition Date
Palsar	10 m	September 2nd, 2009
Palsar	10 m	October 3rd, 2009
Palsar	10 m	October 6th, 2009

The ripples of ocean mainly affect backscatter of SAR. As ripples on the surface of ocean increase, backscatter gets stronger. Analysis of backscatter strength of SAR data over ocean leads to understand the condition of ocean surface, which reflects various phenomena occurring in the ocean. For example, when a part of the ocean surface is covered by spilled oil, the area generates fewer ripples than the surrounding area, and the backscatter appears weaker over the area. By using this phenomenon, it is used for an exploration of the subsea oilfield by detecting natural oil slick that gushes out from bottom of the sea, an oil outflow accident of the tanker, and an environmental monitoring of other oil pollutions, etc. Likewise, the junction line between two sea currents, known as a rich fishing ground, has coarse surface due to the clash of currents and drifting substances gathered by the currents, both of which contribute to strengthen backscatter. Also, a wave behind a sailing ship reduces generation of ripples, causing weaker

Table 2
Satellites carrying SAR instruments focusing in ocean observation.

Satellite (sensor)	Operative	Owner	Band
SEASAT	1978 – 1978	NASA	L
ALMAZ	1991 – 1992	RSA	S
ERS-1	1991 – 1996	ESA	C
ERS-2	1995 – operating	ESA	C
RADARSAT-1	1995 – operating	CSA	C
RADARSAR-2	2007– operating	CSA	C
ENVISAT (ASAR)	2002 – operating	ESA	C
ALOS (PALSAR)	2006 – operating	JAXA	L
TerraSAR-X	2007 – operating	DLR	X
Cosmos Skymed-1/2	2007 – operating	ASI	X

Remaks:
ASI = Italian Space Agency, DLR = German Aerospace Centre, ESA = European Space agency, JAXA = Japan Aerospace Exploration Agency, NASA = National
Aeronautics and Space Administration (USA).

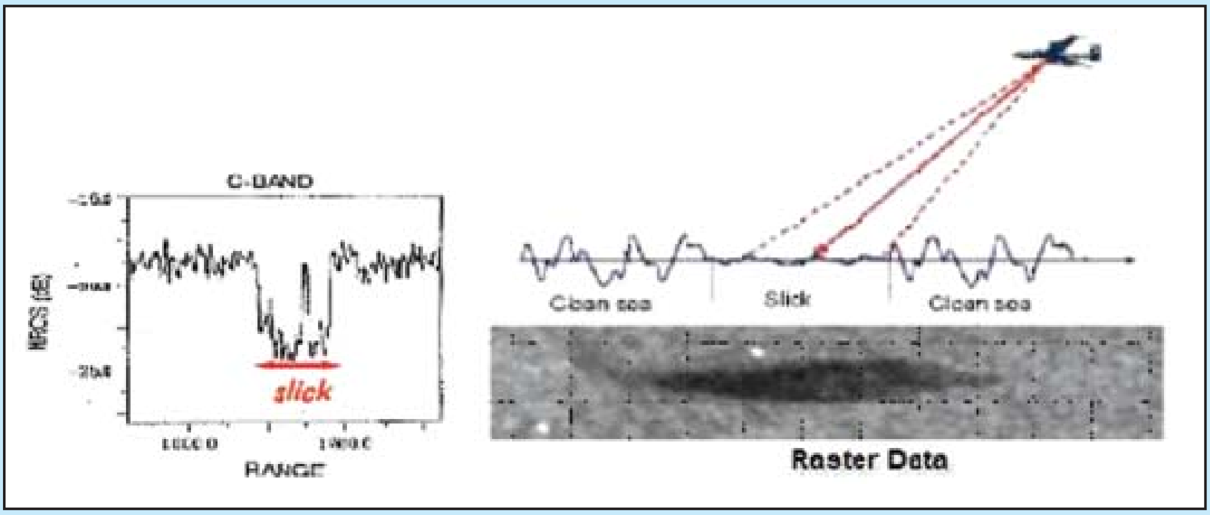

Figure 2
Difference Appareance of Oil Spill and Clean Sea

backscatter, indicating the possibility of extracting traces of ships from SAR data (ERSDAC, 2006).

Yonggang (2009) explains that oil spill detection by means of Palsar imagery is possible because of the damping effect of the short wind waves caused by the presence of oil on the sea surface. Oil slicks dampen the Bragg waves on the ocean surface and reduce the radar backscattering. This results in dark patches in SAR images. An oil spill is physically a low backscatter area and appears as a dark area in SAR images (Figure 2).

The detectability of oil spills in a Palsar image

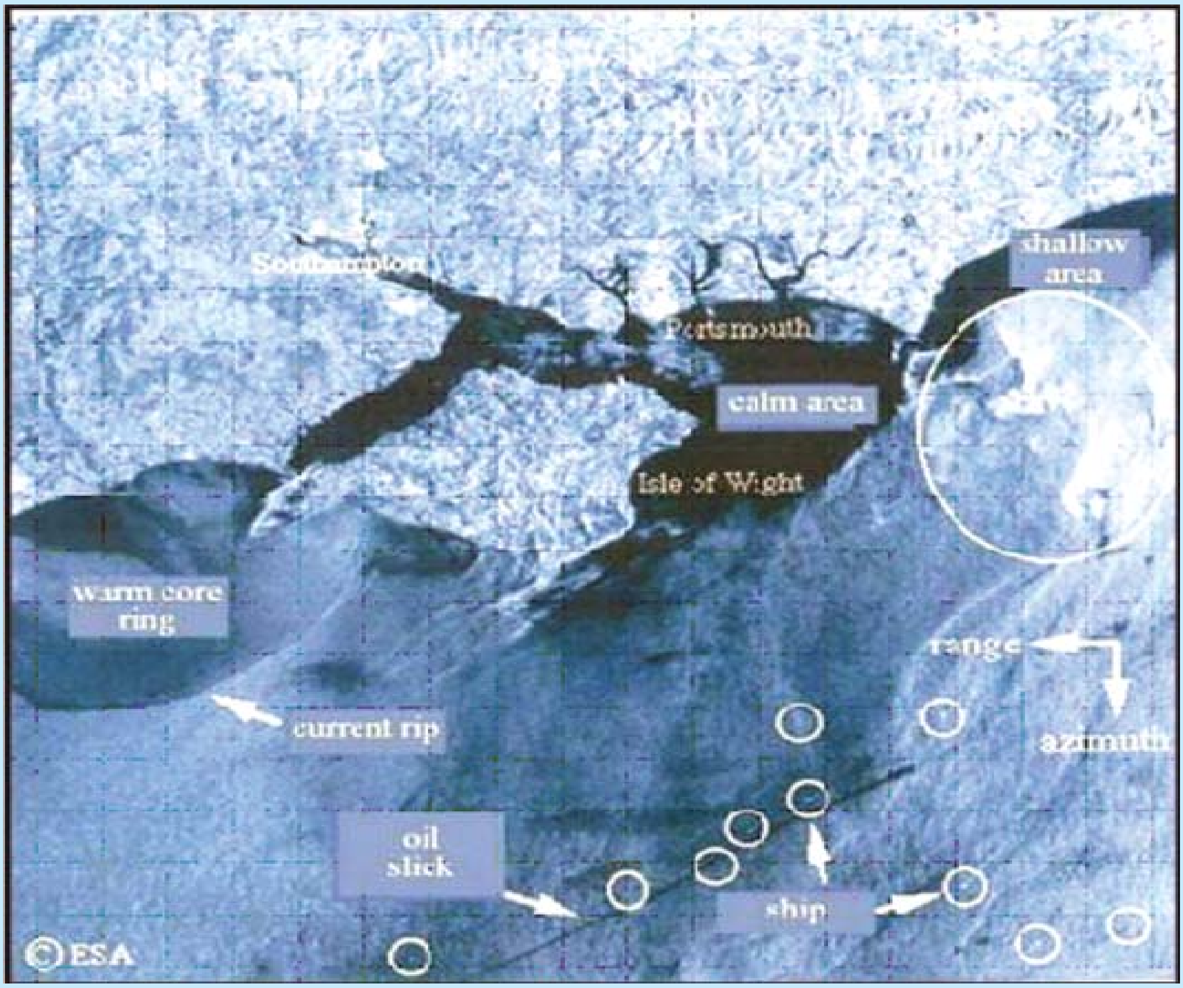

Figure 3
Example of Ocean Observation by Palsar (ERSDAC, 2006)

depends on the ocean surface wind speed. If the wind speed is too low (below 2 – 3m/s), the sea surface background does not have roughness to contrast with that of the oil spill. On the other hand, if the wind speed is too high (about 15m/s), the oil can be dispersed by the surface waves and the slick can disappear below the sea surface. Optimum condition to identify the oil slick on the sea surface is where wind speed is between 3 m/s to 14 m/s. However, careful interpretation is required because dark areas might also be caused by locally low winds or by natural sea slicks. Nature dark patches are termed oil slick look – alike (Figure 3).

IV. METHODOLOGY

Palsar data have been corrected geometrically from ERSDAC, so the researcher is by not conducting geometric correction. Oil spill mapping of this research is using Palsar data. Data recording of Palsar are at Sept 2nd, 2009; October 3rd, 2009 and October 6th, 2009. The data processing is by using ENVI (The Environtment for Visualizing Images) software and visualising by Mapinfo software. Processing of radar image for detection of oil spill included of image enhancement, texture analysis, dark slick detection, feature extraction and filtering.

Oil spill can be detected and classified by visual interpretation. Visual interpretation is the method used when oil spill is visually interpreted by operator. All dark slicks are detected in SAR images manually. In the visual interpretation, oil spill analysis is based on the contrast level to the surroundings, shape characteristic of the slicks and position of the slicks. This research was just conducted on the desk and with-

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 2, SEPTEMBER 2010: 135 - 142

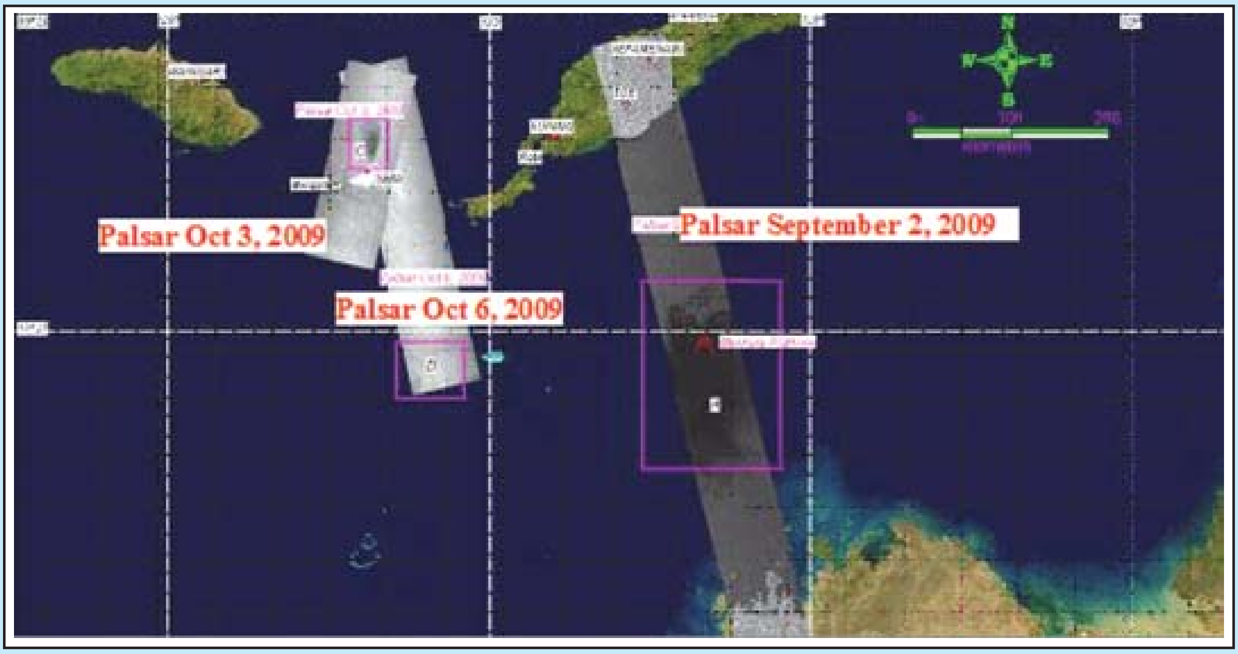

Figure 4
Palsar Imageries Data at Sept 2nd, Oct 3rd, and 6th, 2009 and Overlaid with Regional Citra Satelites Data

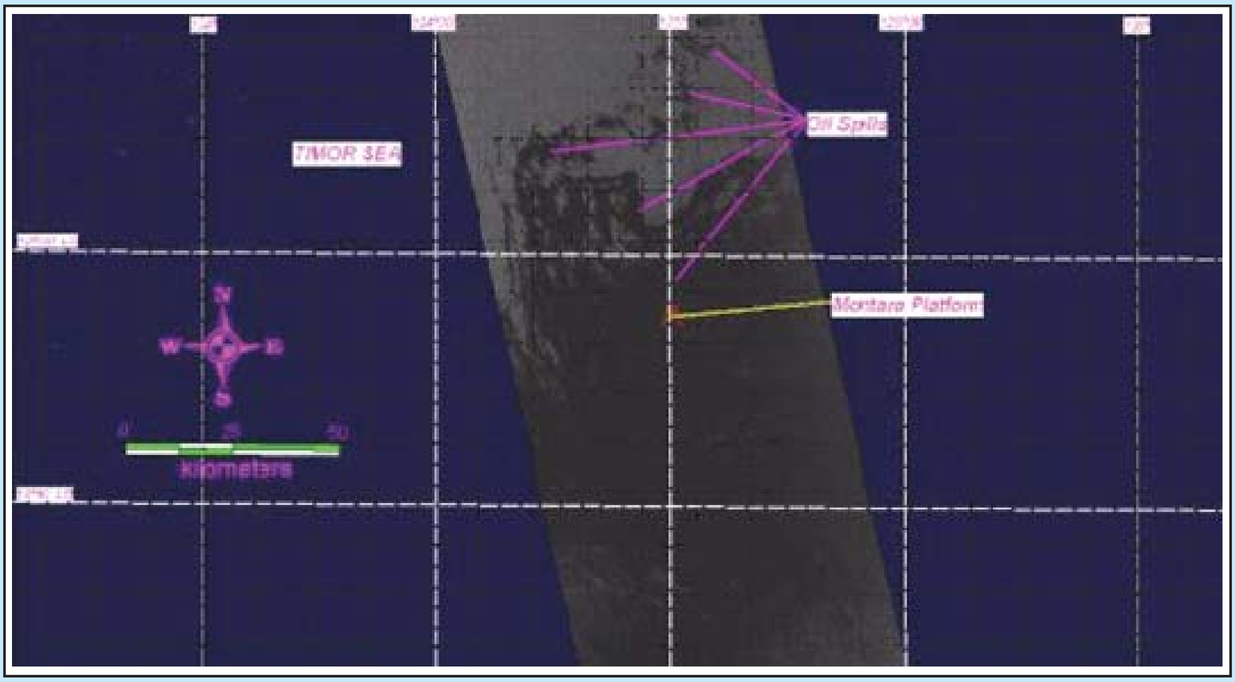

Figure 5
Oil Spill was Detected Around of Montara Platform & Field at Sept 2nd, 2009

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 2, SEPTEMBER 2010: 135 - 142

out field survey, so the results is enabling to open to controversy.

Detection and identification of oil spills in Palsar images is composed of two main steps:

- Detection of dark spot in SAR images.
- Classification of the slicks (oil or lookalike).

Yonggang (2009) explained that oil spill some time is similar with look-alike. The difference of both is descripted as the following:

Criteria of oil spill:

- Dark homogeneous spots in a uniform windy area;
- Linear dark areas, not extremely large, with abrupt turns i.e. most likely abrupt turns due to wind directions change or surface current. Natural slicks in these conditions tend to disappear.
- Near ship or rig; or locations of ship lane;

Criteria for Look-alike:

- Low wind areas;
- Coastal zones due to wind sheltering;
- Elongated dark areas with smooth turnings often in the shape of a spiral;
- Natural film aligned parallel with a bright current shear or convergence zone;

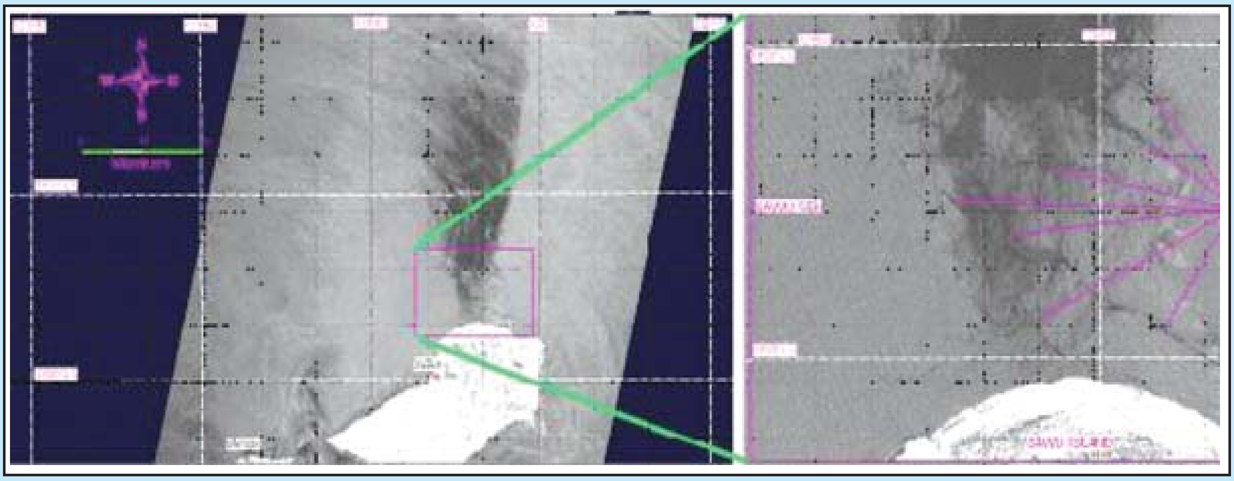

Figure 6
Oil Spill was detected in Sawu Sea, near Seba, Sewu Island, Nusa Tenggara Timor at Oct 3rd, 2009

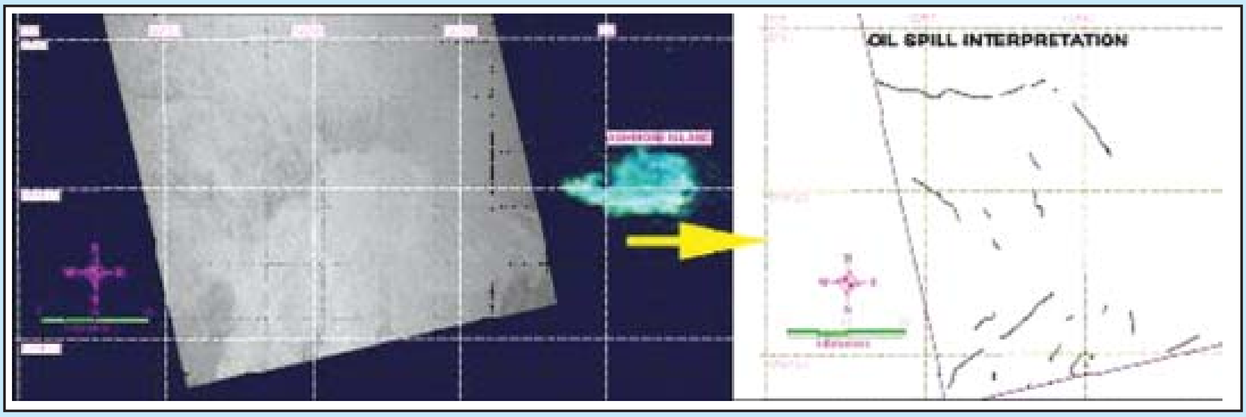

Figure 7
Oil Spill Was detected Near Ashmore Island, Timor Sea at Oct 6th, 2009.

- Cluster of rain cells, the cell centres have a very low backscatter value and are surrounded by squall lines with a higher backscatter.

V. RESULT AND DISCUSSION

Montara Oil Field lies in Timor Sea. The oil field has a distance about 690 km west of Darwin, North Australia and 250 km west of Truscott Sea, West Australia. The big oil field lies near of Sand Island has blow out (http://www.rotendaokab.go.id).

During August 21st, 2009 to Oct 6th, 2009 oil spill from Montara field has been spreading in wide area around of Timor Sea. Base on Palsar data during at three times (Sept 2nd, Oct 3rd and Oct 6th, 2009), the oil spill has been spreading to Sawu Sea, Nusa Tenggara Timur (Figure 4). Palsar Imagery at September 2nd, 2009 showed that oil spill was dispersed widely around of platform. On Palsar Imagery, the tone of sea around of Platform is very dark. Researchers estimate that oil in the sea surface is very thick. The wide area that has been covered by oil spill is more than 100 km^2. This condition generally is occuring in North part of Platform. In South platform, the dark color is very homogenous and spread evenly (Figure 5).

Mustoe (2009) explains that oil spill at September 24th, 2009 was dispersed to North and West Montara Field. He got data from NASA/MODIS Satellite. The interpretation result from NASA/MODIS showed that oil spill was dispersed to north area widely and entering to Indonesian area in south of Rote Island. In west area, the oil spill come near reef islands (Cartier Island dan Ashmore Island). Based on interpretation oil spill in the surface is around 33,850 km^2 (top) and 13,514 km^2 region of ocean partially covered by patchy oil slicks and sheen.

Palsar imagery at October 3rd, 2009 showed that oil spill was detected in the north of Seba Coast, Sawu Island (Figure 6). Oil spill in this area clearly showed in Palsar Imagery base on a long dark lines. The researchers estimated that the dark tone in wide area of north part of dark lines is oil spill too, because at October 6th, 2009 the dark tone was lost and changed with bright tone. But the wide dark tone in north of Sawu Island needs data from the field to give the true justification about oil spill and or look - alike. Despitefully oil spill in this area needs to analysis about the source, because the distance of this area with Montara field is far, maybe about 390 km. Oil spill at October 6th, 2009 were still dispersed in Timor Sea. Based on Palsar imagery, oil spill showed up in South Rote Island about 150 km. Oil spill in this area showed up as long dark lines in Palsar imagery (Figure 7).

VI. CONCLUSSION

This research has demonstrated the capability of Palsar imageries for oil spill detection. Specifically, in this research, we have shown the interpretation results of Palsar imageries makes it easy to detect oil spill. Visual interpretation of Palsar imageries is one of methods to know the oil spill in a certain place. In the visual interpretation oil spill analysis is based on the contrast level to the surroundings, shape characteristic of the slicks and position of the slicks.

The interpretation result of Palsar Imageries showed that oil spil was dispersed to wide area in Timor Sea. At September 2nd, 2009 oil spill just contaminated around of Montara Platform. But at September 24th, 2009 oil spill was dispersed to Indonesia in the north of Rote Island and to Ashmore and Cartier Islands in the West area. In October, the area of oil spill is becoming wider. Oil spil in the Sawu Sea was identified near coast of Seba city and West of Ashmore Island.

VI. ACKNOWLEDGEMENT

We would like to express our thanks to ERSDAC for supporting the Palsar data for making this paper about oil spill in Timor Sea. This paper would not be done without remote sensing data from ERSDAC. ERSDAC always supported to upgrade our knowledge in remote sensing and give us the remote sensing data freely.

REFERENCES

1. Deguchi, 2007. *Introduction of Palsar and Application of Palsar Data*. Earth Remote Sensing Data Analysis Center (ERSDAC) . http://www.ersdac.or.jp
2. ERSDAC, 2006. Palsar reference Guide 3rd Edition. Earth Remote Sensing Data Analysis Center. Japan.
3. Japan Association Remote Sensing (Editor), 1992. Remote Sensing Note. University of Tokyo. Nihon Printing Co. Ltd.
4 Mustoe, S. 2009 Biodiversity Survey of the Montara Field Oil Leak. Report produced for

LEMIGAS SCIENTIFIC CONTRIBUTIONS
VOL. 33. NO. 2, SEPTEMBER 2010: 135 - 142

WWF- Australia. AES Applied ecology Solution Pty.Ltd. Melbourne Australia.

5. Pemda Rote, 2009. Permukaan Laut Timor Ditutupi Gumpalan Minyak. http://www.rotendaokab.go.id/modules.php?name=Berita Provinsi&op=detail berita provinsi&id=104. *Rabu, 30 September 2009, 09:49 WIB.*
6. Samad, R. And S. Manshor. 1997. Detecting of Oil Spill Polution Using Radarsat SAR Imagery. www.remotesensing.gov.my/tmspublisher/images/.../bulletin02 roslinah .pdf
7. SkyTruth, 2009. Montara Oil Well Blowout and Spill-Location Map. http://www.flickr. com/photos/skytruth/3884430170/
8. Tapouzelis, K.N., 2008. Oil Spill Detection by SAR Images: Dark Formation Detection, Feature Extraction and Classification Algoritms. Joint Research Center (JRC), European Commision, Joint Research Centre (JRC), European Commission, Via Fermi 2749, 21027, Ispra (VA). Italy. SENSOR Journal. ISSN 1424-8220.
9. Yonggang, J.I., 2009. Oil Spill Detection Using Satellite SAR Images. First Institute of Oceanography, SOA, Qingdao, China.
10. www.guardian.co.uk/environment/gallery/2009/oct/23/timor-sea-oil-spill?picture =35467 4790.ˇ