The Associated Satellite imagery and Coastal Radar for Oil Spill Monitoring

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ABSTRACT: The event of oil spill and an oil release into the sea were often found in the gulf of Thailand and it caused serious effects and damages to natural resources, environment and communities. A prompt collection and limiting the spread area of oil spill can reduce some damages and losses. An associated remote sensing technology of the high frequency radar system along the coast (coastal radar) together with passive and active satellite images can be used to follow up the movement direction of oil spill. This paper focused on two cases study consisting of 1) an event of an oil tanker ship collapsed in Ban Pramong estuary, Samut Sakhorn Province on 7th April 2014 and 2) an oil spill event at Ban Chang District, Rayong Province on 15th August 2014. For the first case, Landsat-8 had been applied and studied together with circulation pattern gained from the coastal radar and it was found that after a false color mixture by using wave range 7, 6, 4 and underline histograms equalized images it presented clearly the expected area of oil spill. The analysis was done using supervised maximum-likelihood classification in order to find a boundary and prospective of oil spill. The accuracy was evaluated by using the oil spill coordinate informed by Department of Marine and Coastal Resources comparing to the coordinate from satellite image. Its accuracy was at 82%. The second case, Radarsat-2 image in HV polarization was processed using backscatter detection of different surface roughness. The percentage of accuracy assessment that was validated from data of local government agency is 80%. For both cases, the oil film was tracked by surface circulation derived from coastal radar system. However, during the oil spill of both cases, the oil direction analysis was also reported from a related party in order to confirmed effective processing done by coastal radar system. The finding of this study was that the associated technology is deemed one of the most useful accurate and continuous data. The wide covering area of satellite images and coastal radar system will enhance confidence to monitor such event and support the ground administration with effectiveness and enhance the capability of oil pollution management plan in order to reduce the impact to coastal resources, environment and local people.

1. INTRODUCTION

The Office of Permanent Secretary of Science and Technology has assigned GISTDA (Geo-Informatics and Space Technology Development Agency) to take responsibility of Coastal Radar of Land and Sea Disaster Warning Development. The project is to establish and implement the Coast Radar system to check and measure the tide and waves in Real time in order to get the information by installing total 18 stations in the gulf of Thailand, the data collection of each station will cover 60 Km from the coast with the data resolution per a point of 2 Km and the covering areas have been divided into 3 zones ; the upper part of the gulf of Thailand (Chonburi - Prachuap Khiri Khan), the central part of the gulf of Thailand (Chumporn – Surat Thani) and the lower part of the gulf of Thailand (Nakhon Si Thammarat – Songkhla). The data derived from coastal radar system consists of information regarding direction, tide speed and wave height which can be applied for an oceanographic purpose including environment reservation and water management, disaster warning, public disaster relief and tourism promotion, fisheries such as sea resource reservation and natural resources, pollution control and sea guard, meteorology and weather forecast (Jack H., et.al. 2010)

Besides coastal erosion there are also impacts of water pollution such as the oil spill or illegal release into the sea affecting the sea resources and people making a living by aquatic animal culture. Statistics of oil leaks occurred in Thailand during 1973-2011 totaled 215 times both at seaside, river and canal and the coastal areas such as Rayong, Chonburi, Chachoengsao, Samut Prakan, Bangkok, Chumporn, Nakhon Si Thammarat, Songkhla, Phang Nga, Phuket, Krabi and Satun province. (Department of Sea and Coastal Resources, 2013) and during the year 2012-2014 the similar situation occurred for more than 10 times in Chumporn, Rayong, Chonburi and Samut Sakhon province.

The cause of oil leaks in the sea and the coast are 1) Oil leaks in industrial zones, Laem Chabang industrial estate in Chonburi province as a seaport and warehouse including the middle size industry and Map Ta Phut industrial estate in Rayong province as a location of the natural gas factory, Oil refineries, Petrochemical factory and from the oil drilling, oil transportation, navigation entry and out of the ferry, 2) Tarball occurred from the oil release into the sea from cleaning activities of the ship and all types of boat without water treatment such as all size of ships, fishing boat and tourism boat; it had been brown and mixed by tide and wind to make it become an oil-soil at many tourism beaches. Due to many events of oil spill in Thailand, so follow up and gain of its movement direction are very important and it must be done timely for its collect and restoration, prevention before it comes to the coast or any sensitive areas, this is in order to reduce effects and damages probably occurred against natural resources.

Geographic Information technology can be effectively applied to use to follow up the resources changes by Alireza Taravat and Fabio Del Frate. 2012 by using a technique of color mixture in appropriate wave range to able separate differences between the oily surface and water and by using the satellite images of MODIS, MERIS, Landsat-7 in Arabia gulf which able to separate difference of the oil spill and the oil spill from plankton bloom which is suitable to be applied in a shallow area nearby the estuary (Zhao J, Temimi M, Ghedira H, Hu C.2014).

In addition the incidence of crude oil leak in the oil transfer point in the sea far from Map Ta Phut deep seaport around 18-20 Km. on July 27, 2013 and follow it by using satellite images RADARSAT2 in ScanSAR system : Narrow with image resolution 60 meters together with data from the coast radar system in Rayong province which giving a high accuracy of analysis result of the oil spill movement direction (the Office of Geo-Informatics and Space Technology Development Agency (Public Organization) 2013). Therefore, researcher had continuously followed up the situation regarding the oil spill whereas upon a notice of a crude oil ship collapse at Parkklong Pramong estuary in Samut Sakhon province on April 7, 2014 far from the coast around 5.2 Km which in the data of such coast radar system therefore this case has been analyzed, studied and researched with hope to have a part of information notice to some agents in charge to be able to proceed the oil spill collect or give a warning notice to the people living nearby promptly.

2. OBJECTIVES

To apply the satellite images together with data from the coastal radar system to monitor the oil spill event in the coastal zone.

3. LOCATION OF THE CASE AREA

(A.) Samut Sakhon Province

(B.) Rayong Province

Figure 1. (A) Ban Pramomg, Mueng Samut Sakhon District, Samut Sakhon Province. (B) Ban Chang beach, Ban Chang District, Rayong Province.

4. MATERIALS AND METHODS

4.1 Conceptual Framework

This framework is oil spill processing plan of GISTDA using satellite imagery and coastal RADAR system for oil spill prevention and monitoring.

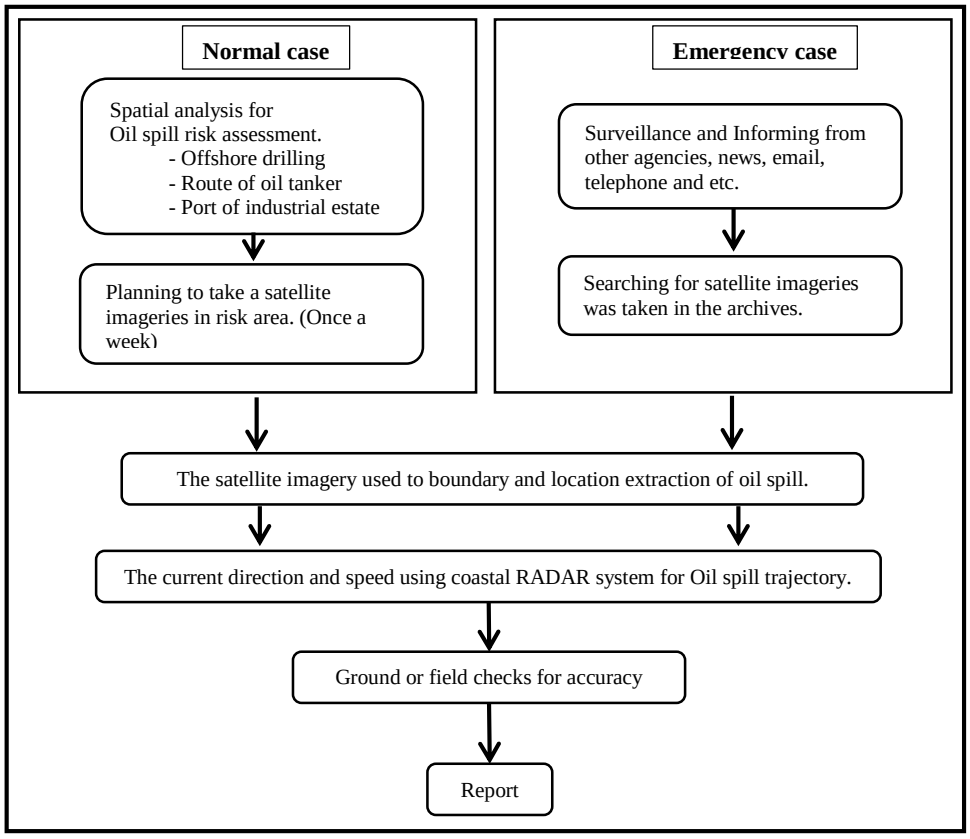

Figure 2. Oil spill processing plan of GISTDA under Saensuk Municipality Ad-Hoc Operation Center.

4.2 Datasets Used

We used Landsat-8 of the Ban Pramomg, Mueng Samut Sakhon District, Samut Sakhon Province taken on 7th April 2014 and Radarsat-2 of the Ban Chang beach, Ban Chang District, Rayong Province taken on 15th August 2014 (Figure1). The 30 m. resolution Landsat-8 was downloaded from GISTDA Catalog Dissemination System while the Radarsat-2 in HV polarization was downloaded from the GISTDA satellite operation office. They both have GeoTIFF format with World Geodetic System (WGS) 1984 and Universal Transverse Mercator (UTM) Zone 47 North projection. The current direction and speed from coastal RADAR system were downloaded from coastal RADAR website (http://coastalradar.gistda.or.th) and convert from ASCII format to shape file format. They used to calculate for oil spill trajectory. The software in this case are Envi, NEST and ArcGIS for image processing and mapping.

4.3 Satellite Image processing

The first step of the procedure is the preprocessing of Landsat-8 multispectral band and Radarsat-2 HV polarization. Landsat-8 was processed through a layer stack and image enhancement, while Radarsat-2 data was convertd from latitude longitude to UTM and enhancedment.

The next step is oil spill boundary and location extraction from the processed Landsat-8 and Radarsat-2. Landsat-8 classification procedure is maximum likelihood supervised classification. Radarsat-2 is used to identify thin oil film on sea surface by visual interpretation classification technique.

4.4 Oil spill trajectory

This step is the creation of the oil spill trajectory from current speed and direction data with a SeaDrift model from the coastal radar system. It must use the oil spill boundary and location from image satellite to start oil spill trajectory model.

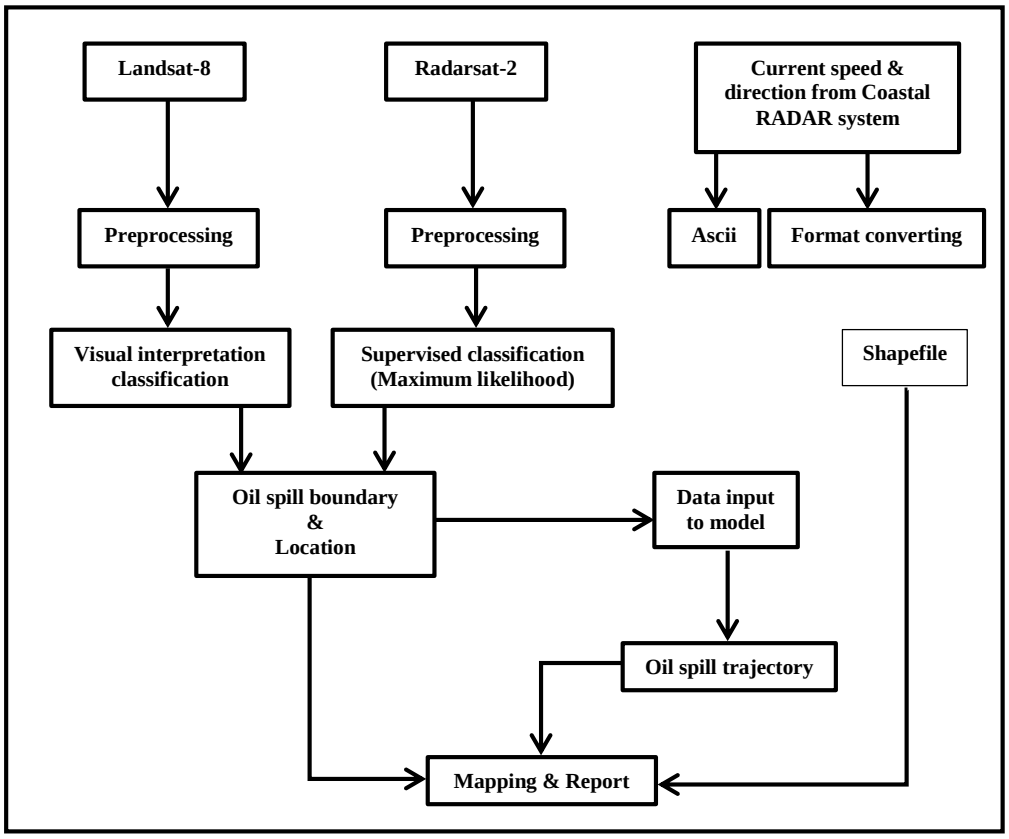

Figure 3. Showing steps of processing methodology

5. RESULT AND DISCUSSION

5.1 Oil spill at Parkklong Pramong, Samut Sakhon province

The study found that the False Color composite of bands: 7,6,4 and stressing on Histograms Equalization expressing showed the clearest spot of oil spill (figure 5 and 6) and later confirmed with an analysis with Supervise classification of maximum likelihood technique. The data accuracy was checked by using data coordinate of the oil spill location obtained from a local agency and the fishermen and get analysis accuracy result of 82%. The area of oil spill was 10.00 O'clock spreading over 0.34 Km and the oil spill moved forwards to the North from the incident point for about 3.5 Km.

Figure 4. Showing the images from Landsat-8 in true color composite: 4, 3, 2. It is difficult to separate the oil spill area from the sea surface and sediment.

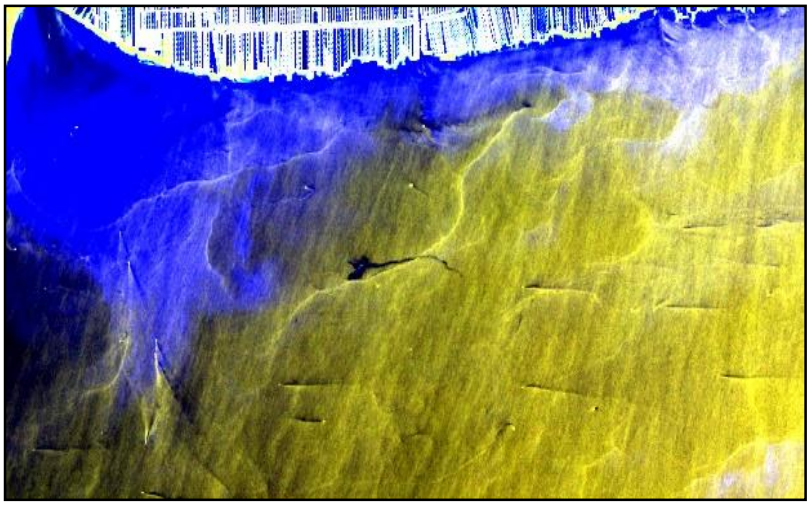

Figure 5. Showing the images from Landsat-8 in False Color composite: 7, 6, 4. It is able to show the oil spill boundary clearly.

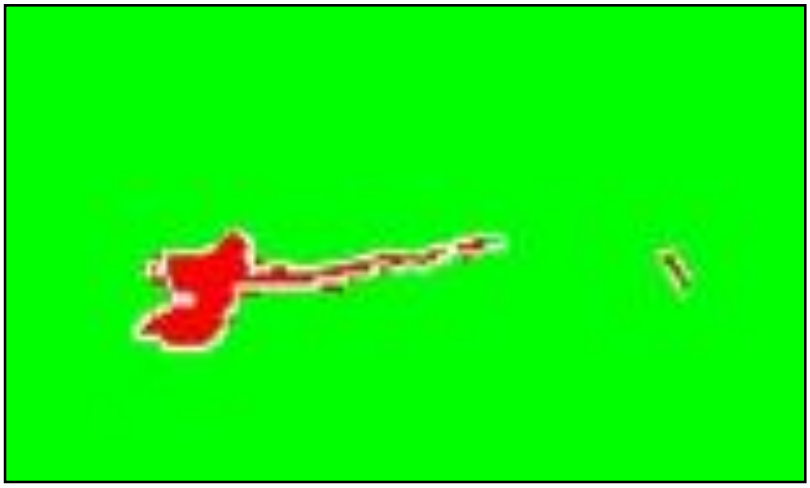

Figure 6. Shows the result classifying areas with oil spill from the sea water with supervised classification method in a red frame showing a red area as the representative of the oil spill area and the green area as the normal sea surface representative.

The result from the oil movement model derived from the coast radar system showed the tide movement during 7-9th April 2014 at the collapse point of and oil tanker ship in 2 directions as follows:

1. Movement in the North-South direction, the tide moved to the North (onshore) during 17.00-04.00 on 7-8th April with speed 20-30 cm / sec and move towards the South (offshore) during 06.00-16.00 o'clock on 8-9 April with speed 10-20 cm/sec so it affected the coast area and the mangrove nearby with such oil spill.

2. Movement in the East–West direction, the movement in the South-east during a shot time 2-4 hours before change its direction from the North into the South and moved towards the South-North in a short time 2-4 hours during its direction change from the South into the North with speed less than 10 cm/sec

The oil spill movement was within a radius of about 5 Km. One of the oil spill portion moving onshore in the coast area, Parkklong Pramong and the mangrove coastline nearby. The accuracy was evaluated by using the oil spill coordinate informed by Department of Marine and Coastal Resources comparing to the coordinate from satellite image, and was found to be 82%.

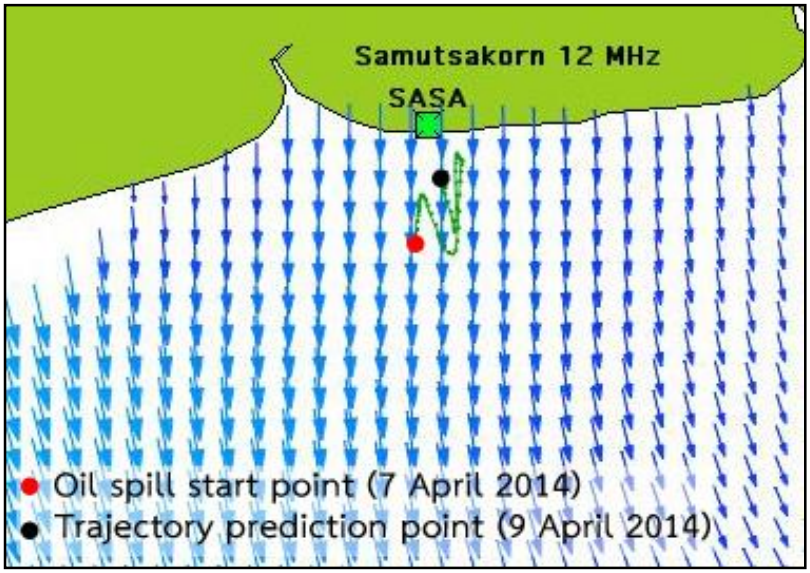

Figure 7. Showing the oil spill trajectory during 7-9th April 2014 from a SeaDrift model.

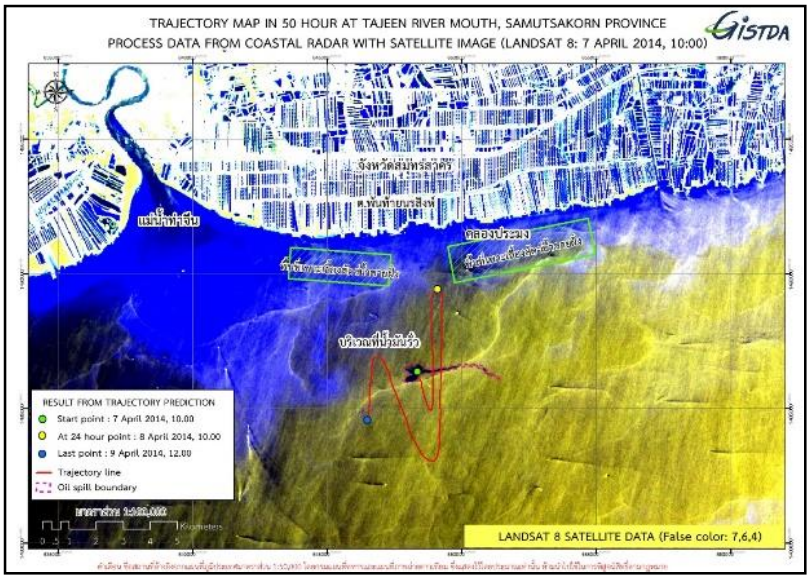

Figure 8. Showing direction and speed of the oil spill trajectory with Lansat-8 satellite image.

5.2 Oil spill at Ban Chang, Rayong province

The second case, Radarsat-2 image in HV polarization, on 15th August 2014 was processed using backscatter detection of different surface roughness. The result shows oil spill boundary on the sea surface 3.5 km. to the south of the beach. The current speed and direction from coastal RADAR system on 15th August 2014 were used to predict oil spill trajectory. The trend of oil spill trajectory was from the south to the north and along the Ban Chang beach. The oil spill affected coastal tourism because there are many hotels, resorts, restaurants and nice beach. And the Ban Chang beach was where tar ball and oil slicks were found on 16th august 2014 by the local government agency. The accuracy assessment that was validated with data from local government agency is 80%.

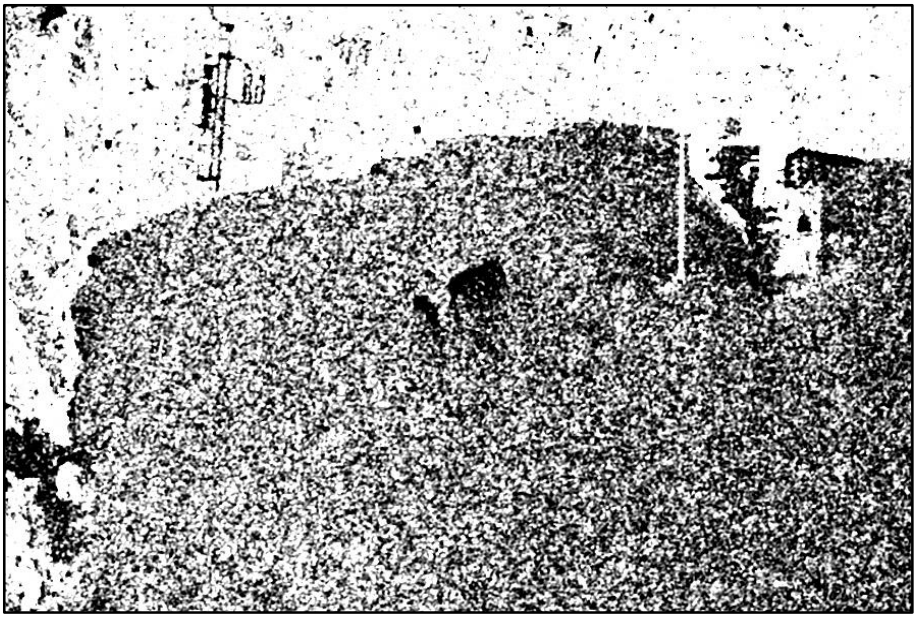

Figure 9. Showing the oil spill boundary from the enhanced image.

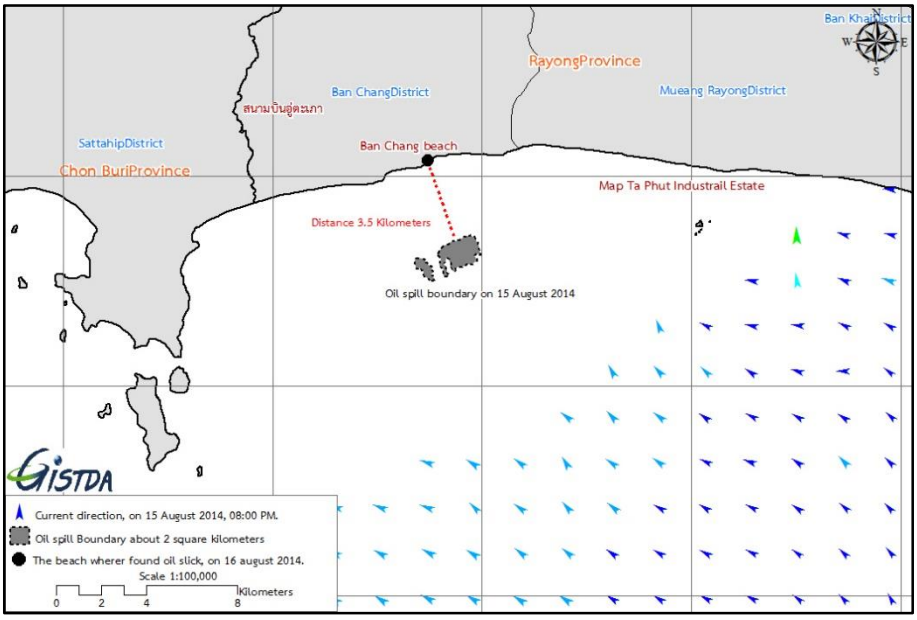

Figure 10. Showing oil spill trajectory prediction derived from satellite image and coastal RADAR system.

6. CONCLUSIONS

Combination of passive and active satellite data together with circulation data gained from the coastal radar system was use to follow up the movement direction of the oil spill in case of the oil tanker ship collapse in Parkloang Pramong estuary, Samut Sakhon province on 7th April 2014 and the case of oil spill at Ban Chang, Rayong province on 15th August 2014. The result of the study showed that the information of the oil spill could be extracted from the satellite image and the start point of oil spill could be identified in a process of the sea drift movement model with the Sea drift movement model program and it can get more accuracy of the movement direction of such oil spill or sea drift.

In case of the time series of satellite imagery is unavailable, the simulation model can be used to forecast the oil spill trajectory as well. Besides, there are other influences such as direction and wind speed, influence of rising tide and ebb tide and the location depth to be concerned. The data and information gained from this research has been continuously distributed to persons in charge for the most benefits of the collection and warning planning to people living in the area in order to prevent any possible losses and damages to themselves.

7. RECOMMENDATION

The follow up of oil spill or any illegal oil release into the sea has been difficult to perform. An important information is the coordinate of geographic data and an explicit occurrence time which shall support and give more accuracy to some data analysis regarding the oil spill movement direction by applying the geography information and the coastal radar system data or its movement direction model with other means. The result gained from the study shall support the concerning persons in planning for collection and recover of the oil spill and Seadrift. At the same time the implementation to resolve this requires problem coordination and exchange of data and information from all sectors in order to tackle the problem quickly and reduce the effects against the nearby area.

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