We thank the reviewer for the many useful comments. They have been incorporated into the revised draft, and we detail here how we have done so.

1-The author is supposed to provide the main theory about how microwave remote sensing can be used for monitoring oil spill? Then address the other SAR sensors are used in general which are followed by Cosmo-skymed. This is supposed to be at the

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first paragraph of introduction.

SAR sensors are imagined oil spill based on Bragg scattering theory. Bragg scattering is a significant concept to understand the radar signal interaction with ocean surface. Parenthetically, the presence of capillary wave will produce backscatter that assists radar in imagining sea surface. Short gravity and capillary waves by the oil spill are damped by dynamic elasticity of the water surface, that is by changes in surface tension which occur when the surface is stretched or compressed (Alpers et al., 2002; Marghany et al., 2009 and Zhang et al., 2014). As stated by Caruso et al., (2013), the imaging of oil on the sea surface with SAR have confidence in the damping influence of the oil on the Bragg waves. Inappropriately, the reduced radar backscatter on the sea surface is not unique to oil. Gade et al., (1998) stated that low winds, biogenic films, wind sheltering by land or oceanic structures, grease ice, internal waves, ship wakes, and convergence zones also generate zones of reduced SAR backscatter (Fiscella et al., 2000). Moreover, thunderstorms, rain, and atmospheric and oceanic fronts can mask surface roughness or produce so-called “lookalike” features (Caruso et al., 2013).

The detectability of oil with SAR is also function on the sensor configuration. For C-band SAR, the detectability relies on polarization, incidence angle, spatial resolution, and noise equivalent sigma zero (Cheng et al., 2011). For single polarization images, VV-polarization produces better results than HH-polarization. The backscatter intensity decreases with increased incidence angle; therefore, small spills cannot be discriminated with lower-resolution beam modes. Although the NESZ (a measure of the sensitivity of the SAR system) potentially limits the effectiveness at high incidence angles, the effects of wind speed are more important (Cheng et al., 2011).

Consequently, the highly accurate detectability of oil with SAR is exposed to the identification of oil spill parameters. However, the detailed parameters of oil spill are challenging task to be identified because of complicated sea surface statutes and smoothing interaction of oil spill with SAR signal. Mainly, oil spill can be classified into light Sheen, silver sheen, rainbow sheen, brown oil, mousse, black oil, streamers, tar balls, tar mats and pancakes. Zhang et al., (2014) declared that dielectric constant (permittivity) is significant key of oil spill parameter recognitions. It describes the material's capability of holding electro-magnetic energy or polarizing, which is helpful in identifying the types and conditions of the oil.

Conversely, Skrunes et al., (2012) reported several disadvantages associated with oil spill detection using the current SAR sensors and stated that SAR sensors cannot detect the thickness distribution, volume, oil/water emulsion ratio or chemical properties of an oil slick. Instead, that group recommended the use of multi-polarization observations, i.e., the data acquired by the RADARSAT-2 and TerraSAR-X satellites. In addition, quad-pol RADARSAT-2 SAR (Zhang et al., 2011) can provide information about oil spill thickness compared to other SAR single channel such as RADARSAT-1 SAR, ERS-1/2 and Terra SAR. In this regard, range of theoretical polarimetric SAR developments has gradually qualified the accurate distinction between mineral oil slicks and biogenic slicks (Liu et al., 2011;Minchew et al., 2012; Skrunes et al., 2012). Recently, Minchew et al., (2012) used

Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) L-band polarimetric for retrieving the oil volumetric concentration in a thick slick that is based on Cloude-Pottier entropy algorithm (Cloude and Pottier, 1996).

2-Author are required to address the work done on oil spill monitoring using Cosmo-skymed.

Currently, COSMO-SkyMed satellite data have been used successfully for monitoring and detecting oil spills Trivero et al., 2007). In fact, the availability of high resolution X-band images (supplied by COSMO-SkyMed satellites and managed by the Italian Space Agency) has encouraged further investigation aimed at extending the scope of this methodology to X band images with the final goal of employing it for detecting oil spills. X-SAR data (obtained from airplane multi-band experiments and from SIR-C X-SAR mission carried out by NASA's space shuttle in 1994) are analyzed in order to compare SAR images in different bands and spot locations contaminated by an oil slick. The COSMO- SkyMed constellation (supplying high spatial and temporal coverage of the Mediterranean basin) makes it possible to develop an operational oil spill survey system, particularly in protected areas and areas close to the coast. In this context, Marghany (2014) has implemented multi-objective genetic algorithm with COSMO- SkyMed for oil spill detection along the coastal waters of Thailand. He stated that COSMO- SkyMed with X-band is able to detect oil spill due to the sensitivity of X-band for sea surface.

3- After three steps of oil spill automatic detection, it is better to follow by using intelligent learning machine algorithms such as GA and multi-objective algorithms.

Consequently, three steps are expected to automatically detect oil spills in SAR images: (i) dark spot detection; (ii) dark spot feature extraction; and (iii) dark spot classification. Various classification algorithms for oil spill detection have been utilized, including pattern recognition algorithms (Teivero et al., 1998), spatial frequency spectrum gradient algorithms (Lombardini et al., 1989; Nirchio et al., 2005) and algorithms based on fuzzy and neural networks (Barni et al., 1995; Calabresi et al., 1999; Garcia-Pineda et al., 2013).Further, intelligent learning machine algorithm such as Genetic algorithm and multi-objective algorithms have been used for oil spill automatic detection from SAR data (Topouzelis et al. 2009 and Marghany 2014).

4- The novelty of the work must include Pareto optimal solutions. Then the objective must be revised based on Pareto optimal solutions. I suggest also to address Pareto optimal solutions more in discussion 's section.

The novelty of this work is designing best optimization tool based on Pareto optimal solutions for the real time oil spill automatic detection by comapring between Entropy-Based Multi-objective Evolutionary algorithm and non-dominated sorting genetic algorithm-II (NSGA-II) without involving others tool such as neural network or any image processing classification tools.

Incidentally, the main objective of this work is to minimalize the look-alike dark pixels for accurate oil spill automatic detection in COSMO-SkyMed SAR satellite data which could be involved with oil spill footprint was detected by involving Pareto optimal solution for both Entropy-Based Multi-objective Evolutionary algorithm and non-dominated sorting genetic algorithm-II (NSGA-II). The Entropy-Based Multi-objective Evolutionary Algorithm uses both basic and advanced operators. For illustrative purposes, the method has been operated to oil spill footprint boundaries shape optimization which allows local and global optimizations. Indeed, global optimization which involves finding the optimal oil spill boundary shapes in COSMO-SkyMed data. Look-alike pixels can be removed to reach the optimal oil spill automatic shape detection. On the other hand, investigate the best algorithm among Entropy-Based Multi-objective Evolutionary algorithm and non-dominated sorting genetic algorithm-II (NSGA-II) for oil spill automatic detection.

6- Improve figure 1 based on Pareto optimal solutions.

We add the following figure 1b.

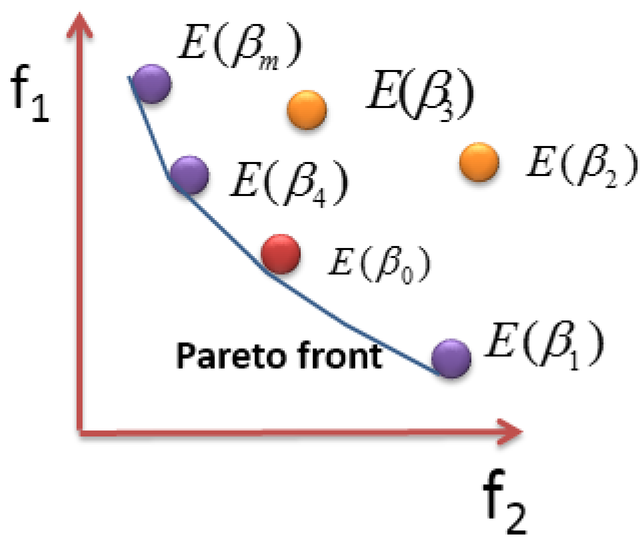

Figure 1b. Entropy random generation for Pareto Optimization.

7- Accuracy by using ROC need to be replaced by statistical significant difference between different classes which are addressed in Figures 6 and 7.

We done as follows:

Table 3 also indicates that NGSA-II has highest performance for oil spill detection with smallest standard error of 0.11 and a ρ value of 0.000004 (Table 3) as compared to the sea surface roughness and look-alikes which confirms the study of Marghany (2014).

Table 3: Accuracy of feature detections by NGSA-II

Features	Standard error	P<0.005
Oil spill	0.04	0.000004
Look-alikes	0.10	0.000006
Sea surface roughness	0.11	0.000007

8- Revised the conclusion based on Pareto optimal solutions and suggestion number 7.

This study has demonstrated work to optimize the oil spill footprint detection in synthetic aperture radar (SAR) data. Therefore, Entropy-based Multi-objective Evolutionary Algorithm (E-MMGA) and non-dominated sorting genetic algorithm-II (NSGA-II) have implemented with COSMO-SkyMed data during the oil spill event along the coastal water of along Koh Samet island, Thailand. Besides, Pareto optimal solution is implemented with both E-MMGA and NSGA-II to minimize the difficulties of oil spill footprint boundary detection because of the existence of look-alike in SAR data. The study shows that the implementation of Pareto optimal solution and weight sum in E-MMGA and NSGA-II generated accurate pattern of oil slick. Furthermore, thick oil spill has highest value of 2.3 NSGA-II than thin and medium spills. The NSGA-II has highest performance as compared to E-MMGA, which is able to preserve the morphology of oil spill footprint boundaries i.e. thick, medium, and light. In addition NSGA-II is able to identify the look-alike footprint boundaries and discriminate accurately between, oil spill and look-alike, and surrounding sea surface with standard error of 0.04 within 65 sec. In conclusion, NSGA-II is considered as excellent algorithm to discriminate oil spill from look-alikes and also to identify thick oil spill from thin one within shortest computing time.

References

Trivero, P., Biamino, W. and Nirchio, F., 2007, July. High resolution COSMO-SkyMed SAR images for oil spills automatic detection. In *Geoscience and Remote Sensing Symposium, 2007. IGARSS 2007. IEEE International* (pp. 2-5). IEEE.