Early Findings of the Enhancement of MSG Fire Product by Using Regionalized Thresholds

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Abstract. The possible enhancement of the METEOSAT Second Generation (MSG) fire detection product for the study area of Turkey (FIR) is investigated in this study. Regionalized threshold use is proposed for the FIR tests rather than using the static thresholds for the whole MSG scan disc area. Regionalized thresholds for the month of July 2007 is obtained by using the ground truth data from Ministry of Forest & Water Affairs (MoFWA) and Spinning Enhanced Visible and Infrared Imager instrument channels' of IR3.9, IR10.8, and IR13.4 data. The thresholds are used to generate the enhanced new product (enhFIR) for the month of July 2008. The MoFWA ground data for the same month is used to validate enhFIR and FIR product sub-classes of 'possible' and 'probable'. The monthly contingency tables are obtained separately for each product type and categorical statistics of probability of detection (POD) and false alarm rate (FAR) statistics are introduced. The test statistics showed that POD rate for the enhFIR product is almost twice the 'probable' type of FIR product while it is one and half for the 'possible' type. On the other hand, the FAR rate for enhFIR product and 'probable' type of FIR product are about the same where it is doubled for the 'possible' type of FIR product.

Keywords. MSG, forest fire, regionalized threshold, fire product, Turkey.

1. Introduction

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Wildfires are among the most harmful disasters that Mediterranean countries suffer. Each year not only remarkable amount of property and settlements are destroyed but also lives of the inhabitants are threatened [1]. Possible effect of wildfires from regional to global scale such as, effecting air/water quality and climate change are some other reasons to pay specific attention to wildfires [2,3,4,5]. For these reasons, intense and comprehensive studies about monitoring active fires and fire prone areas are being conducted worldwide. Among these studies, satellite data is gradually used in fire detection and monitoring where various algorithms are proposed for polar orbiting and geostationary satellites data [6,7].

Along with the other products, Meteorological Operations Division in EUMETSAT is providing the fire product (FIR) via EUMETCast in 15 minute cycle with the full disc coverage [8]. The FIR algorithm considers the brightness temperatures (BT) of the 3.9μm and 10.8μm channel data obtained from Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument onboard on METEOSAT Second Generation (MSG) satellites. The predefined 4 tests in the algorithm uses the BT of IR3.9μm; BT difference of IR3.9μm and IR10.8μm; standard deviation of IR3.9μm and difference of the standard deviations of 3.9μm and 10.8μm in a 3x3 pixel area. Depending on the preset thresholds, each pixel is classified as either 'possible', 'probable', or 'no fire'.

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Considering the 2007-2009 period dataset over Turkey, [9] indicated less than 5 and 10% match between the FIR product and the ground fire records for the 'possible', 'probable' product types respectively. Static thresholds used in the product algorithm for the whole disc area is mentioned to be the main reason for such low detection rates and regionalized threshold use is recommended in the same study for obtaining higher detection rates for the FIR product.

The main objective of this study is to investigate the possible enhancement for the FIR product due to the regionalized thresholds use over Turkey. As the early findings of the study are presented in here, study period is chosen as one month. The ground truth data from the Ministry of Forest & Water Affairs (MoFWA) and FIR product data for the month of July 2007 is used to determine the most suitable thresholds for the FIR tests. The new FIR product with the regionalized threshold (called enhFIR hereafter) is generated for the month of July 2008. The FIR and enhFIR product is validated separately for the July 2008 using the MoFWA ground truth data and categorical statistics are introduced for the comparison between the FIR and enhFIR products.

2. Methods

2.1. ***Dataset***

The ground truth data for the month of July (2007 and 2008) is obtained from MoFWA. EUMETSAT is the other data provider for the FIR and cloud mask product (CLM) product as well as the 3.9µm (IR3.9), 10.8µm (IR10.8) and 13.4µm (IR13.4) SEVIRI channel data for the study area of Turkey (Figure 1).

Figure 1: Study area of Turkey (Adapted from [10])

2.2. ***Test definitions for FIR and enhFIR product***

The predefined 4 tests in the FIR algorithm use the BT of IR3.9µm; BT difference of IR3.9µm and IR10.8µm; standard deviation of IR3.9µm and difference of the standard deviations (std) of 3.9µm and 10.8µm in a 3x3 pixel area. The test number and the test contents are provided in Table 1. Similarly, 4 tests are offered for the enhFIR product. The first two tests among them are identical with the FIR product. Rather than the std used for 3x3 pixel area in FIR product, mean positive differences (mpd) is used for enhFIR product (See Table 1). For instance, mpd(BT3.9) operation compares the BT of the centre pixel with the surroundings and excludes the surrounding pixels with higher BT values. Then the average of the differences of the centre pixel and the remaining pixels are assigned as mpd(BT3.9) for the corresponding centre pixel. The reason for us-

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ing *mpd* rather than *std* is to minimize the possible false alarms since fire pixel is expected to have higher BT amounts than the surrounding pixels.

Table 1: Test definitions for the FIR and enhFIR products.

	FIR	enhFIR
TEST1	BT3.9	BT3.9
TEST2	BT3.9-BT108	BT3.9-BT108
TEST3	std(BT3.9)	mpd(BT3.9)
TEST4	std(BT3.9) - std(BT10.8)	mpd (BT3.9) - mpd (BT10.8)

2.3. ***Test thresholds estimation for enhFIR product***

The thresholds for the enhFIR product are obtained by using the MoFWA ground truth data and the SEVIRI channels' data for IR3.9, IR10.8, and IR13.4. The MoFWA data contains geographical location (latitude-longitude), starting and ending time and burnt area information for each fire event record. As the first step, the corresponding MSG pixels for each MoFWA record are determined. Secondly, the starting and ending time information for each record is turned into discrete quarter-hour intervals since MSG data and products are only available in quarter-hour intervals.

For the TEST1 threshold estimation for instance, quarterly time step starting from the first day and first hour (00:00) till the last day and last hour (23:45) of July is taken into account. In each quarterly step, the MSG pixel where each MoFWA record taking place is considered. If the CLM product for the pixel indicated 'cloud' then the corresponding record for the quarterly step is skipped, otherwise the BT3.9 is estimated(CO_2 correction is applied using IR13.4 data) and cumulated in a matrix. Finally, the histogram of the TEST1 data is examined and a threshold is set to exclude the dataset especially originated from mislocation of the fires, which might be a possible case for the ground truth records [11,12]. Visual checks and some case studies indicated that cumulative histogram value of 35% is reasonable to exclude such uncertainty. So the cumulative histogram value of 35% is set to determine the TEST1 threshold for the enhFIR product. The same procedure is repeated for TEST2, TEST3, TEST4 and test thresholds are determined separately in the same manner. The sample histogram of the TEST2 is shown in Figure 2 and the final thresholds for the enhFIR product tests are presented in Table 2.

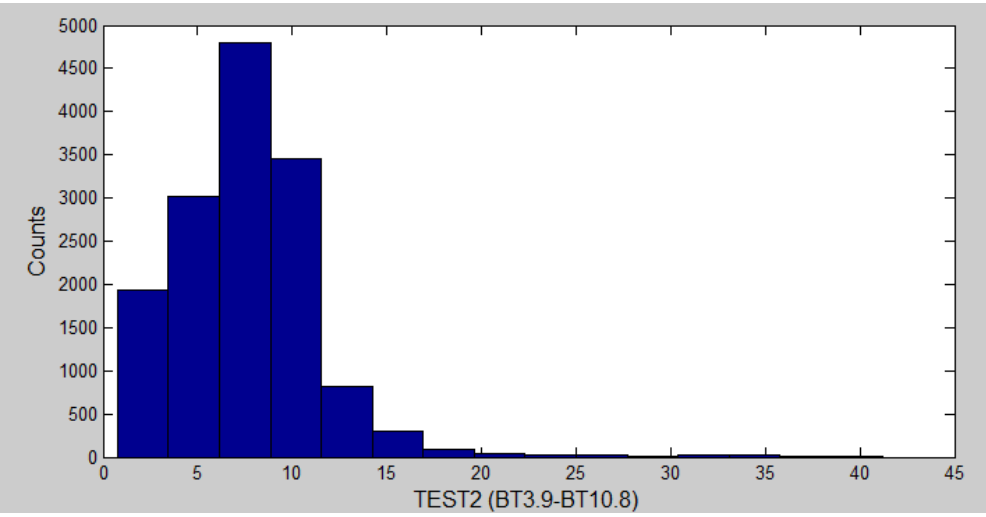

Figure 2: The histogram for the TEST2 (BT3.9-BT10.8) for the month of July 2007

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Table 2: The enhFIR product thresholds for each test.

	TEST1	TEST2	TEST3	TEST4
Thresholds	330 (^{o}K)	6 (^{o}K)	4 (^{o}K)	4 (^{o}K)

2.4. ***The enhFIR product generation***

The enhFIR product is generated for the month of July 2008. The product generation process started from the first day and first hour (00:00) of the month and the IR3.9, IR10.8, and IR13.4 data are used with the test thresholds given in Table 2 for the Turkey area. Any pixel meeting the all requirements are labeled as 'active fire' and pixel information (row, column, latitude, longitude) is recorded in ASCII format with the time information for the validation purposes. The same procedure is repeated in time domain with the quarterly steps till the last day and last quarterly step (23:45) for July 2008.

2.5. ***Validation of the FIR and enhFIR products***

Both FIR and enhFIR products are validated separately by using the ground truth data obtained from MoFWA for the month of July 2008. It is possible that both FIR and enhFIR products may not spatially refer to a forest area or other fire activities such as stubble burning, which is common in some parts of Turkey, are not reported in the MoFWA records anyway [13]. For this reason, forest cover map use is crucial for reliable product validation. Most recent forest cover map is obtained from MoFWA for this purpose with 0.0159x0.0159^{o} spatial resolution and is used to determine the forest cover percentage for each MSG pixel over Turkey (See Figure 3).

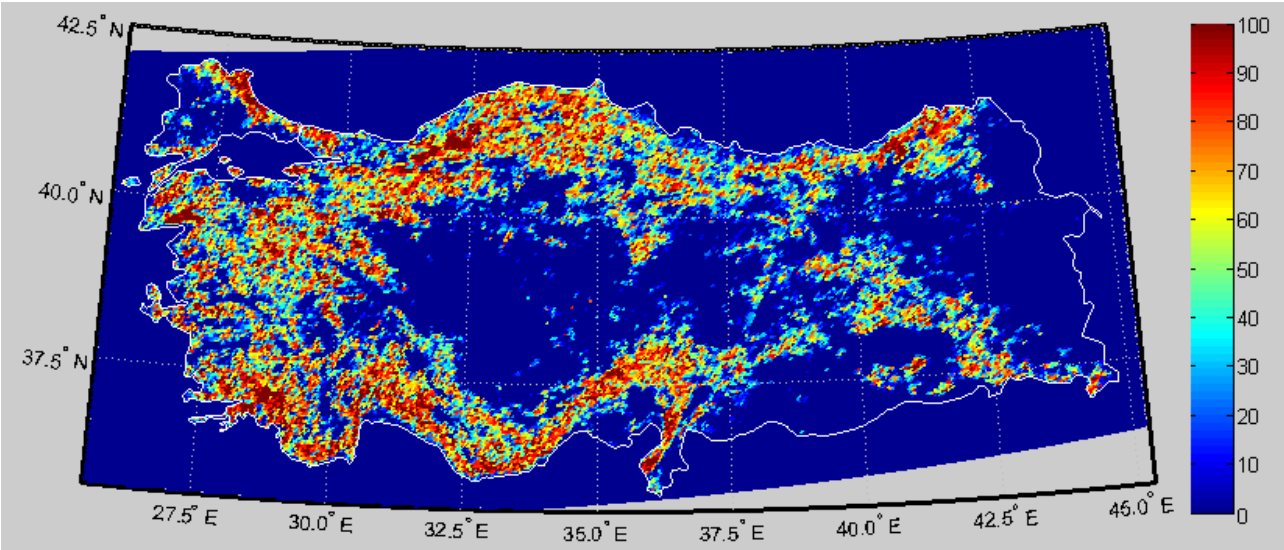

Figure 3: Forest cover percentage with respect to MSG pixels for the study area

As the first step of the validation process, the contingency table is obtained by using the MoFWA-enhFIR product pairs. The comparison is performed in MSG pixelwise and contingency table elements' numbers are updated according to the matching status of the MoFWA and enhFIR pixel information for the quarterly step considered. The update process is performed in quarter-hour intervals starting from the first day and first hour (00:00) till the last day and last quarterly step (23:45) of July 2008. For each time step, if the enhFIR product is referring fire for the MSG pixel but forest cover percentage for the corresponding pixel is zero (Figure 3), then the enhFIR product

is excluded from the validation process. In the same manner, MoFWA and enhFIR product pixels referring 'cloud' with respect to CLM product is also excluded from the validation process to avoid any possible negative bias.

The FIR product is classified with two types namely ‘possible’ and ‘probable’ where MSG pixels with lower confidence in test results are defined as ‘possible’ fire and those with a higher confidence are defined as ‘probable’ fire [14]. For this reason, the monthly contingency table elements are obtained for the MoFWA-FIR product in the same manner explained above but separately for ‘possible’ and ‘probable’ types to be able to distinguish the product performance with respect to both types.

The validation results for each product type is introduced by using the categorical statistics of probability of detection (POD) and false alarm rate (FAR) statistics for the month of July 2008. The results are presented in Table 3.

Table 3: The categorical statistics results for the FIR and enhFIR products.

	POD(%)	FAR(%)
FIR(probable)	0.6	43.2
FIR(possible)	0.7	94.1
enhFIR	1.1	41.0

3. Results

The categorical statistic results in Table 3 showed that enhFIR product is better than ‘possible’ and ‘probable’ types of FIR product in terms of POD and FAR statistics for the month of July 2008. For the POD statistics, enhFIR product is almost 100 % more successful in active fire detection than the probable’ types of FIR product while it is more than 50% for the ‘possible’ type. From the FAR statistic perspective, the enhFIR and probable’ types of FIR product have almost the same miss rate while ‘possible’ type of FIR product is missing more than twice the % enhFIR does. So, the POD and FAR statistics clearly indicate that regionalized threshold use definitely has a positive effect on the fire product performance.

Even the performance of the enhFIR product is better than any of the FIR product, the fire detection rates are around 1% and still is very low, at least for the month of July 2008. One possibility for such low rates is the intense of the existing fires occurring in this month. Month of July is definitely a fire season but usually the small fires are dominant in this month when compared to the August or September. Since the detection of the small fires is the main drawback of the geostationary satellites, such as MSG, the performance of the enhFIR product is expected to be better for the other months.

4. Conclusions

Any possible enhancement in MSG fire detection product (FIR) is investigated in this study. Regionalized test thresholds use in FIR tests is proposed for the study area of Turkey, rather than using static thresholds applied for the whole disc area. The regionalized test thresholds for the month of July 2007 is obtained by using the ground truth data from MoFWA and SEVIRI channels' data of IR3.9, IR10.8, and IR13.4. The new test thresholds are used to produce enhanced FIR product (enhFIR) for the month of July 2008. The FIR and enhFIR product is validated using the ground truth data from MoFWA for the month of July 2008. The categorical statistics results of POD and FAR indicated that enhFIR product performance is better than the ‘possible’ and ‘proba-

ble' types of the FIR product. The results clearly indicate that regionalized threshold use in fire detection products positively contributes to the product performance.

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