FIRE_CCI

# Special Case Study on Fires in Indonesia and El Niño:

# Object-based burned area detection and related fire emission estimations based on Sentinel-1 data

D4

Burned area 2016

Prepared for European Space Agency (ESA-ESRIN)

In response to ESRIN/Contract No. 4000115006/15/I_NB

October 2017

Revision History

| | | | |
|---|---|---|---|
| **Deliverable** | **D4** | | |
| **Work Package** | Phase II | | |
| **Due date** | KO+16 postponed to KO+18 | | |
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| **Distribution** | | | |
| **Reason for change** | | | |
| **Issue** | | | |
| **Revision** | | | |
| **Date** | | 27 November 2017 | |
| **Release** | 1 | | |
| **Version** | 01 | | |

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# 1 General overview

The aim of this project is to estimate the damage caused by these fires in Indonesia 2015/2016 using Sentinel-1 imagery. Comprehensive burned area maps derived from Sentinel-1 imagery were created for Indonesia's three largest islands, namely Sumatra (480,000 km$^2$), Kalimantan (536,000 km$^2$) (part of the island Borneo) and West-Papua (460,000 km$^2$) for the dry season of 2015 and 2016. Fire emission estimates were then derived for the study period using existing carbon stock and land cover maps with corresponding emission factors. This report is an extension to the ATBD (Fire_cci_Ph1_RSS_D1_ATBD_v1_2.pdf) explaining the further developed methodology and results of the burned area classification and emission estimation of the year 2016.

# 2 Burned area detection

Table 1 provides an overview of Sentinel-1 data used for burned area mapping of 2016. Since Sentinel-1B became operational in 2016, the higher temporal resolution is available for burned area assessments.

*Table 1: Sentinel-1 data used for burned area mapping of 2016 showing the different characteristics (polarization, orbit and acquisition dates). All available data used for this classification were acquired by Sentinel-1A.*

| Area | Polarization | Relative Orbit | Internal Orbit number | Pass | 1. acquisition (dd.mm.yy) | 2. acquisition (dd.mm.yy) | 3. acquisition (dd.mm.yy) | 4. acquisition (dd.mm.yy) | 5. acquisition (dd.mm.yy) | 6. acquisition (dd.mm.yy) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sumatra | VV | 41 | 1 | asc. | 19.01.16 | 12.02.16 | 29.07.16 | 22.08.16 | 09.10.16 | |
| Sumatra | VV | 143 | 2 | asc. | 26.01.16 | 16.10.16 | 03.12.16 | | | |
| Sumatra | VV | 70 | 3 | asc. | 21.01.16 | 24.08.16 | 04.11.16 | | | |
| Sumatra | VV | 171 | 4 | asc. | 28.01.16 | 09.04.16 | 07.08.16 | 29.12.16 | | |
| Sumatra | VV | 98 | 5 | asc. | 22.05.16 | 09.07.16 | 02.08.16 | 26.08.16 | 06.11.16 | |
| Kalimantan | VV/VH | 149 | 1 | desc. | 26.03.16 | 30.06.16 | 17.08.16 | 10.09.16 | 04.10.16 | 28.10.16 |
| Kalimantan | VV/VH | 76 | 2 | desc. | 14.04.16 | 12.08.16 | 23.10.16 | | | |
| Kalimantan | VV/VH | 3 | 3 | desc. | 09.04.16 | 14.07.16 | 07.08.16 | 24.09.16 | 05.12.16 | |
| Kalimantan | VV/VH | 105 | 4 | desc. | 04.02.16 | 23.03.16 | 10.05.16 | 14.08.16 | 07.09.16 | 12.12.16 |
| Kalimantan | VV/VH | 32 | 5 | desc. | 30.01.16 | 05.05.16 | 09.08.16 | 13.11.16 | | |
| Papua | VV | 97 | 1 | asc. | 23.03.16 | 10.05.16 | 01.10.16 | 18.11.16 | | |
| Papua | VV | 24 | 2 | asc. | 18.03.16 | 09.08.16 | 07.12.16 | | | |
| Papua | VV | 126 | 3 | asc. | 13.01.16 | 16.08.16 | 03.10.16 | | | |
| Papua | VV | 53 | 4 | asc. | 20.03.16 | 28.09.16 | 09.12.16 | | | |
| Papua | VV | 155 | 5 | asc. | 08.02.16 | 14.05.16 | 29.10.16 | | | |
| Papua | VV | 82 | 6 | asc. | 27.02.16 | 09.05.16 | 13.08.16 | 17.11.16 | | |

The selection process for the data has not changed and was based on three criteria, which needed to be met as well as possible (sorted by importance): data availability, fire season and precipitation. Figure 1 shows a comparison of the 2015 and 2016 fire season based on Modis hotspots for the three islands. The amount of 2016 fire detections is much less than in 2015 which is due to the fact that 2016 was a relatively wet year in comparison to the super dry El Niño year 2015. It is also visible that the dry season did not occur in the typical months July – October. Fire detections rather occurred all over the year. Due to this fact, we used every available Sentinel-1 scene that was dry enough to be analyzed (precipitation criteria based on TRMM data).

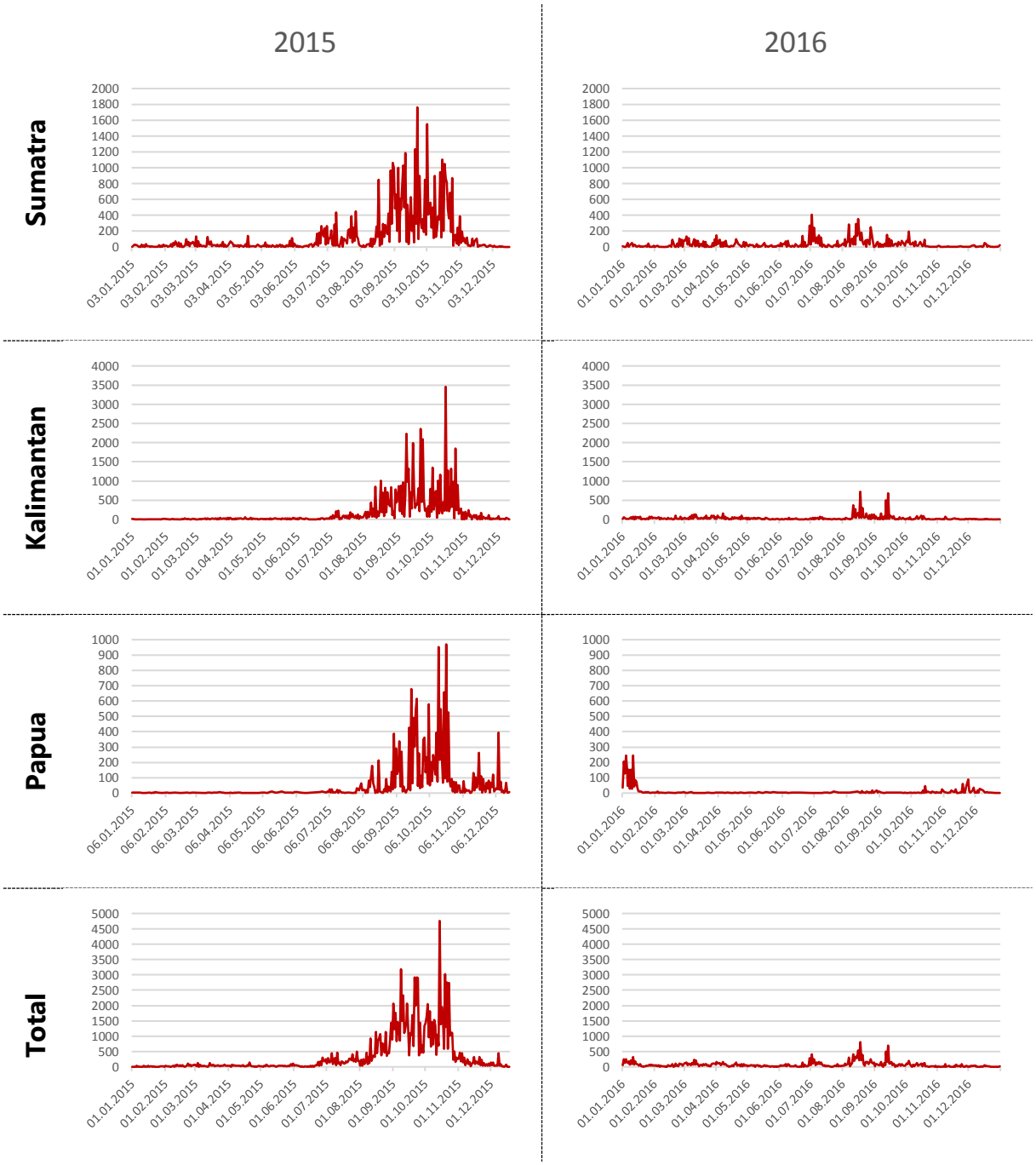


*Figure 1: Comparison of Modis hotspots for 215 and 2016 fire season for Sumatra, Borneo, Papua and all islands (total).*

The burned area was classified by stepwise analysis of available Sentinel-1 imagery depicted in Table 1. This included temporal information of burned area as well as the coverage of large time intervals. Due to the stepwise classification of multi-temporal Sentinel-1 imagery, the information of the date of the detected burned area could be included in the product. The acquisition date of the Sentinel-1 image on which the burned area was first classified was used. In contrast, in 2015 no date information was given, as only two Sentinel-1 acquisitions per orbit were available.

Due to the wet year, burned area classifications inside water-influenced land cover classes had to be excluded. The specific MoEF (Indonesian Ministry of Environment and Forestry) land cover classes were:

bodies of water, fish pond, swamp, dry rice land and rice land. This was not necessary for 2015 as it was a very dry year.

In total, a burned area of 504,396 ha was detected for 2016 with 312,215 ha in Sumatra, 144,411 ha in Kalimantan and 47,771 ha in Papua. Figure 2 shows the distribution of the detected burned areas per MoEF land cover and island.

An accuracy assessment and verification of the burned area classification result is an essential component of the processing chain. As there was no independent reference data available for 2016, we refer to the validation of the 2015 burned area classification with an overall accuracy of 83.85 % (see Fire_cci_Ph1_RSS_D2_PVR_v1_3.pdf). Based on the fact that the maps of 2015 and 2016 are not independent as they are based on the same input data, processing chain and rule-sets, the accuracy of both classifications can be assumed as similar [1].

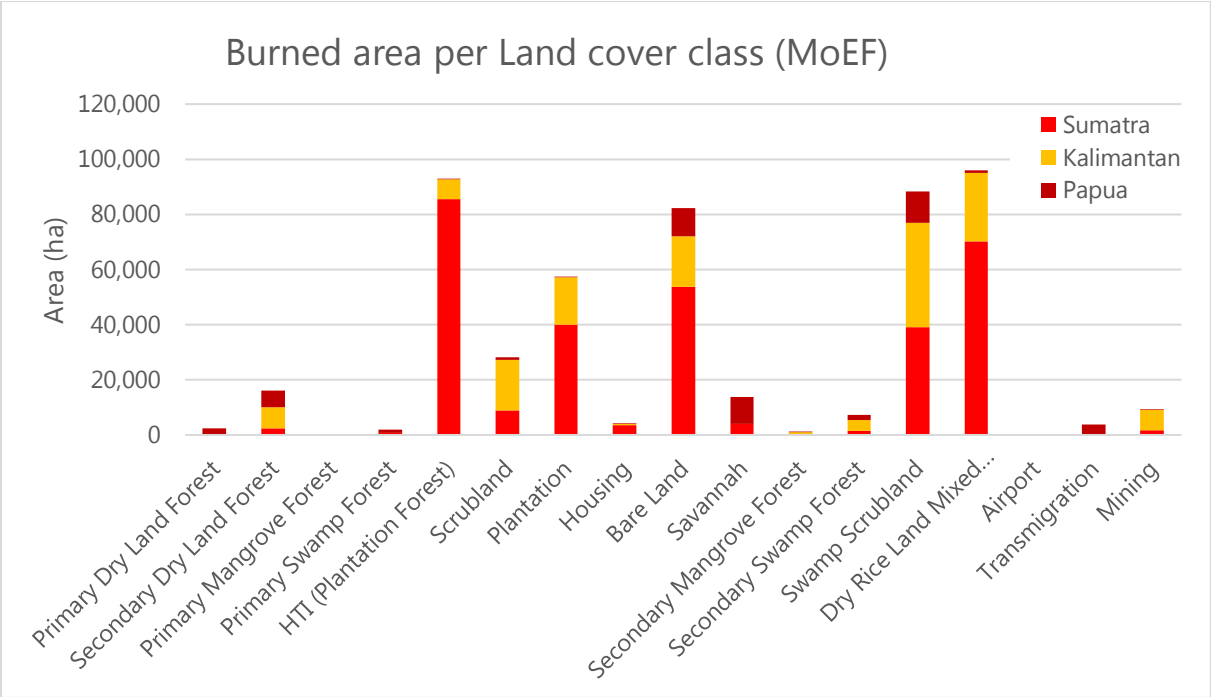


*Figure 2: Amount of classified burned area per MoEF land cover class for the three Indonesian islands.*

# 3 Fire Emission estimation

Total fire emissions were calculated based on a combination of aboveground emissions from vegetation as well as peat emissions. The methodology has not changed from the 2015 emission calculation. Vegetation emissions were only calculated using the most recent MoEF land cover classification of 2015 as it is supposed to be the most accurate land cover information for Indonesia and it is an official national product. The ESA CCI land cover classification is, in contrast, a global product and has a lower spatial resolution (300 m compared to 30 m) and it was shown in the 2015 case study that it is not as accurate as the MoEF classification within our study area.

Figure 3 depicts the amount of estimated vegetation emissions and Figure 4 the amount of peat emissions of the year 2016 for each of the MoEF land cover classes. The total amount of estimated emissions is shown in the emission database in Table 2.

Total estimated emissions for 2016 Indonesian fires amount to 117.36 Mt $CO_2$-eq. This is much less than estimated for 2015 (890.4 Mt $CO_2$-eq) which clearly shows the difference between the fire-prone El Niño year in 2015 and the wet La Niña year with reduced fire activity in 2016.

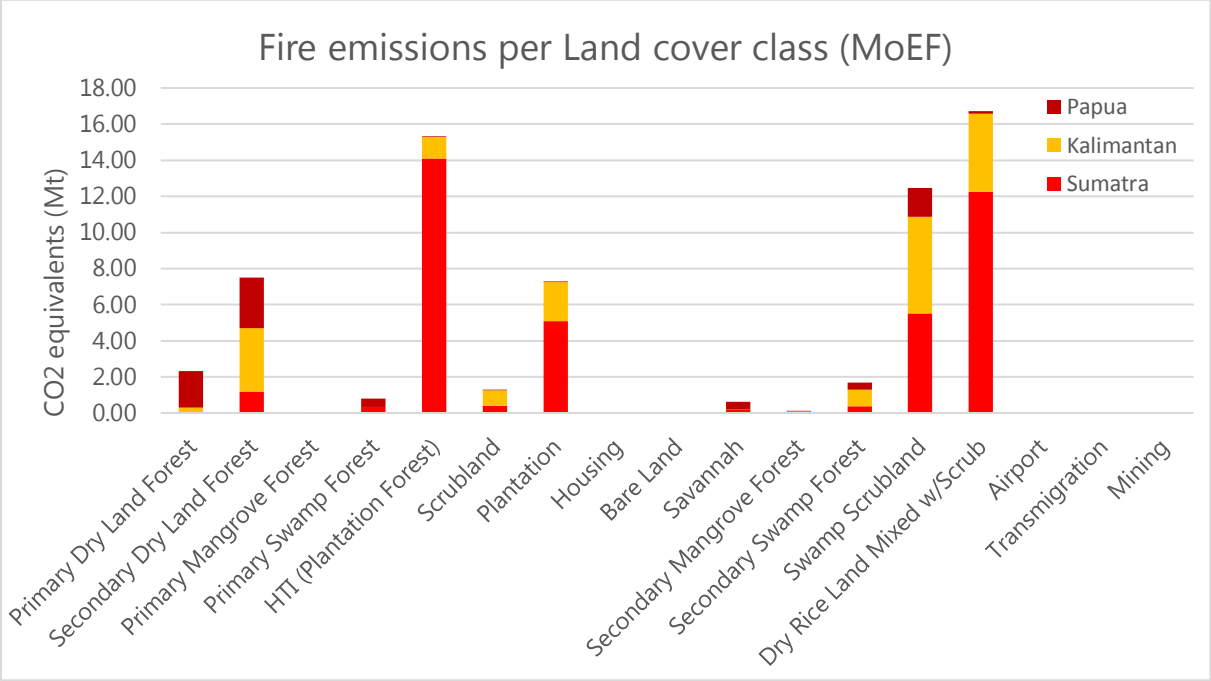


*Figure 3: Vegetation fire emissions for the year 2016 per MoEF land cover class.*

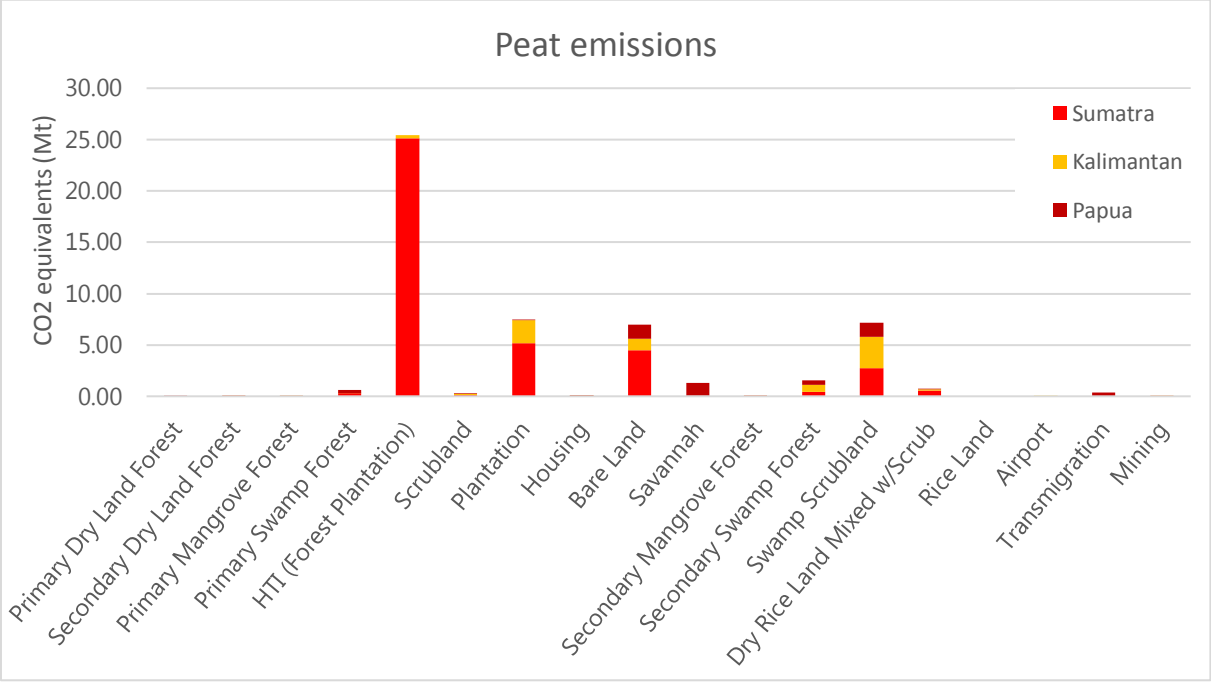


*Figure 4: Peat emissions for the year 2016 per MoEF land cover class.*

*Table 2: Emission database for the 2016 Indonesian fires.*

| | | Emissions per region (Mt $CO_2$-eq) | | | |
|---|---|---|---|---|---|
| | ***Dataset*** | Sumatra | Kalimantan | Papua | **Total area** |
| **Vegetation emissions** | *MoEF LC* | 39.35 | 18.27 | 7.57 | **65.19** |
| **Peat emissions** | *MoEF LC* | 39.02 | 7.76 | 5.39 | **52.17** |
| **Total emissions** | *MoEF LC* | 78.37 | 26.03 | 12.96 | **117.36** |

# 4 Conclusion

To conclude the analysis, it is obvious that the burned area in 2015 was much higher than in 2016. This is a result of the extremely dry conditions in the El Niño year 2015 and the wet conditions in the La Niña yeas 2016. In total, 504,396 ha burned in 2016 which is approximately 11 % of the classified burned area in 2015 (4,604,568.65 ha). In Sumatra, 1,518,127 ha burned in 2015 and 312,215 ha burned in 2016 (which is approximately 22 % of the 2015 burned area). In Kalimantan, 2,268,352 ha burned in 2015 and 144,411 ha in 2016 (which is 6 % of the 2015 burned area). In Papua, 818,090 ha burned in 2015 and 47,771 ha were classified as burned in 2016 (which is also 6 % of the 2015 burned area). Comparing the proportion of burned land cover classes, it stands out that the relative proportion of swamp scrubland in Kalimantan was much higher in 2015 and that the relative proportion of burned HTI (forest plantation) was much higher in 2016.

This comparison of burned area 2015 and 2016 reflects also the relationship of the fire emissions in 2015 and 2016. In 2016, only 13 % of the $CO_2$-eq emissions of 2015 were emitted (117 Mt $CO_2$-eq compared to 890 Mt $CO_2$-eq).

# 5 Products

The final products include burned area maps, pre-fire land cover classification and related carbon dioxide emissions for Sumatra, Kalimantan and West-Papua for the year 2016 (depicted in Table 2).

The burned area product has two layers. The first layer contains burned and not-burned information (exactly the same product as delivered for 2015). The second layer contains the enhanced information of the date on which the burned area was detected.

The products can be downloaded from https://geogra.uah.es/fire_cci/indonesia.php.

# 6 References

[1] R. G. Congalton and K. Green, *Assessing the Accuracy of Remotely Sensed Data: Principles and Practices, Second Edition (Google eBook)*. 2008.