SURVEY OF BIOMASS, CARBON STOCKS, BIODIVERSITY, AND ASSESSMENT OF THE HISTORIC FIRE REGIME FOR INTEGRATION INTO A FOREST MONITORING SYSTEM IN SOUTH SUMATRA, INDONESIA

Assessment of historic fire regime
Current status

BIOCLIME Workshop
Palembang 21 January 2016

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RSS Remote Sensing Solutions GmbH

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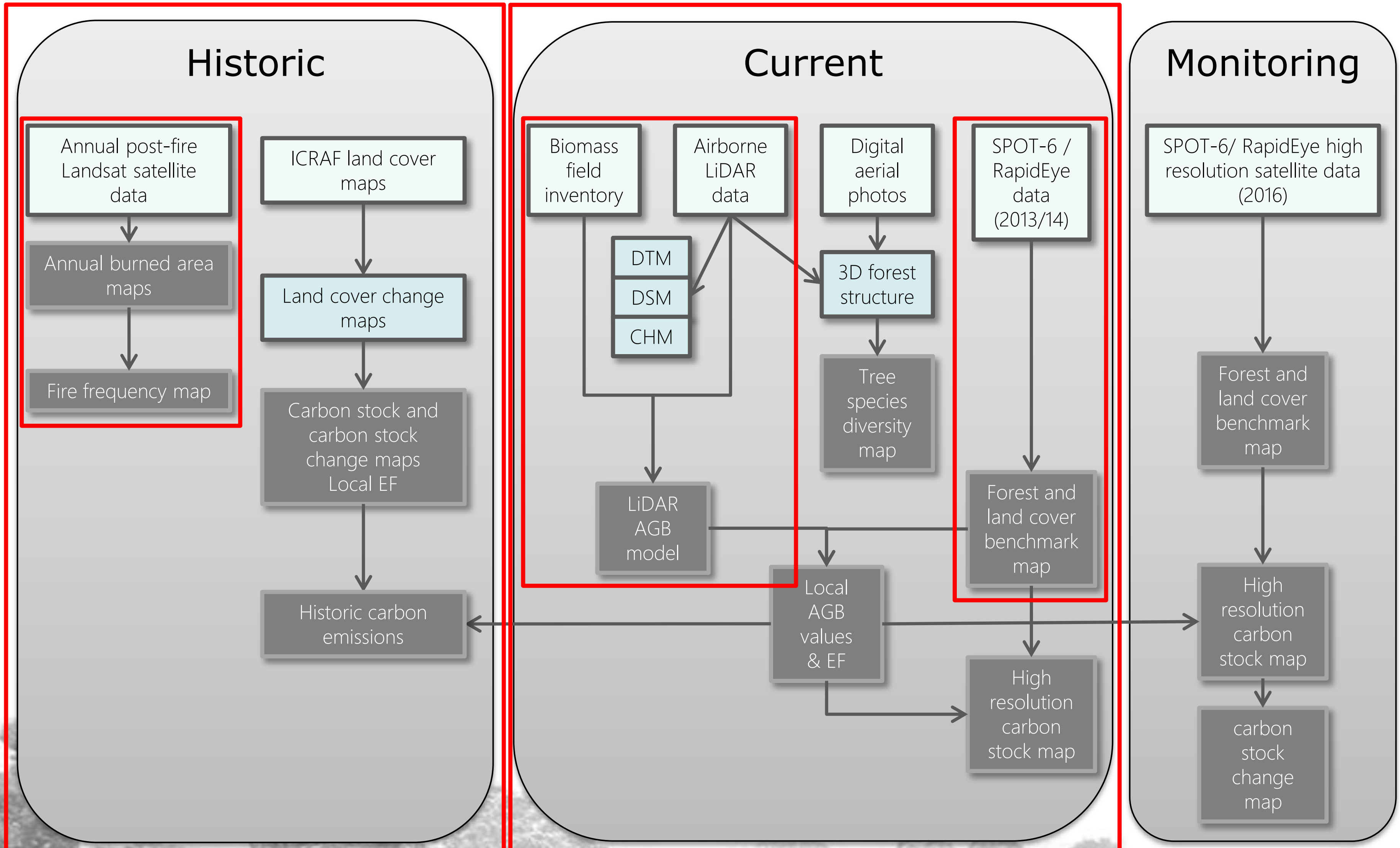
Concept of the monitoring system



The 2015 fire events in the press


THE STRAITS TIMES
ASIA

Indonesia set to be world's No. 3 air polluter

An Indonesian soldier drags a hose while fighting a peatland fire in Ogan Ilir, South Sumatra province on the island of Sumatra. PHOTO: REUTERS

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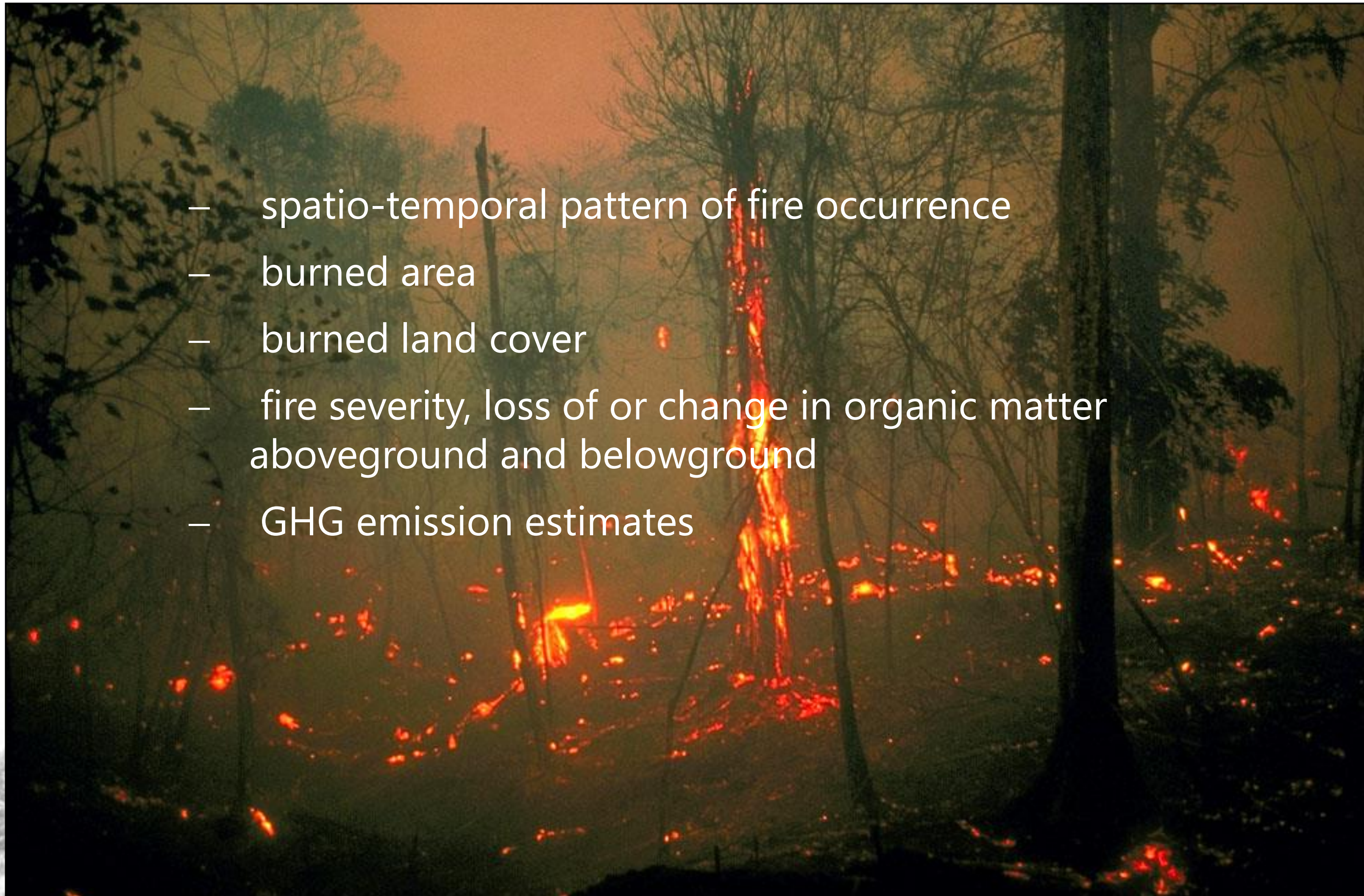
David Fogarty Assistant Foreign Editor

Indonesia is on track to become the world's third-largest greenhouse gas polluter this year, surpassing India, as raging forest and land fires pump out huge volumes of carbon dioxide and thick smoke.

Happening just weeks before a major global climate conference, the fires underscore Indonesia's immense challenge in curbing emissions from agriculture and put into question its ability to meet its climate targets.

Indonesia has just released a detailed climate action plan for the United Nations conference in Paris from Nov 30 to Dec 11. The UN hopes

Historic component:
Fire regime



- spatio-temporal pattern of fire occurrence
- burned area
- burned land cover
- fire severity, loss of or change in organic matter aboveground and belowground
- GHG emission estimates

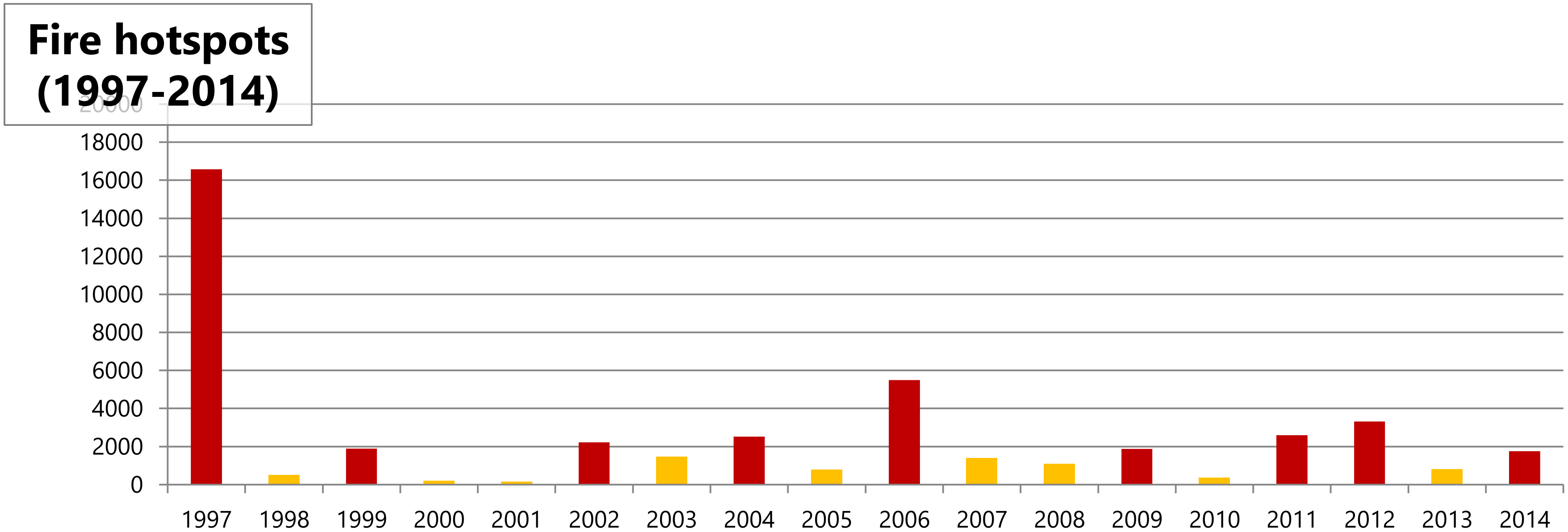
Historic component:
Fire regime

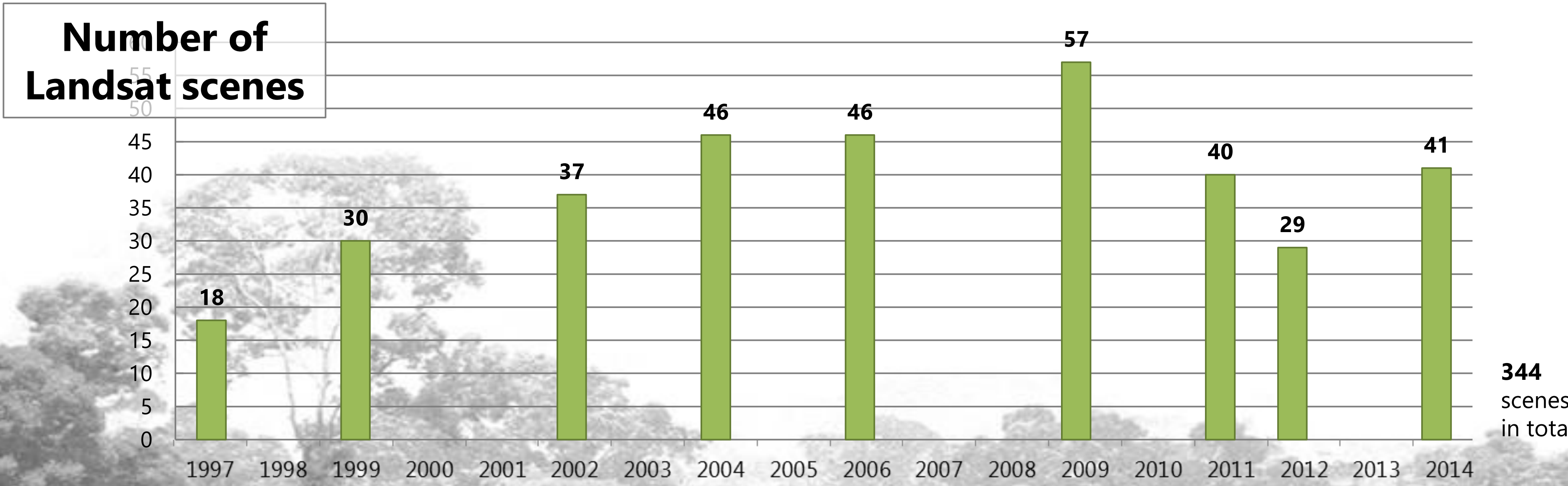
Objectives:

- Utilize historic satellite data from 1990 onwards
- Assess burned areas on an annual basis for all “fire years”
- Quantify fire occurrence and impact for each fire year
- Correlate with data on biodiversity and carbon stock and assess impact on these factors

Fire regime workflow

Determination of fire-intensive years





Landsat tiles

- 5 Landsat tiles
- Landsat-5, Landsat-7, and Landsat-8

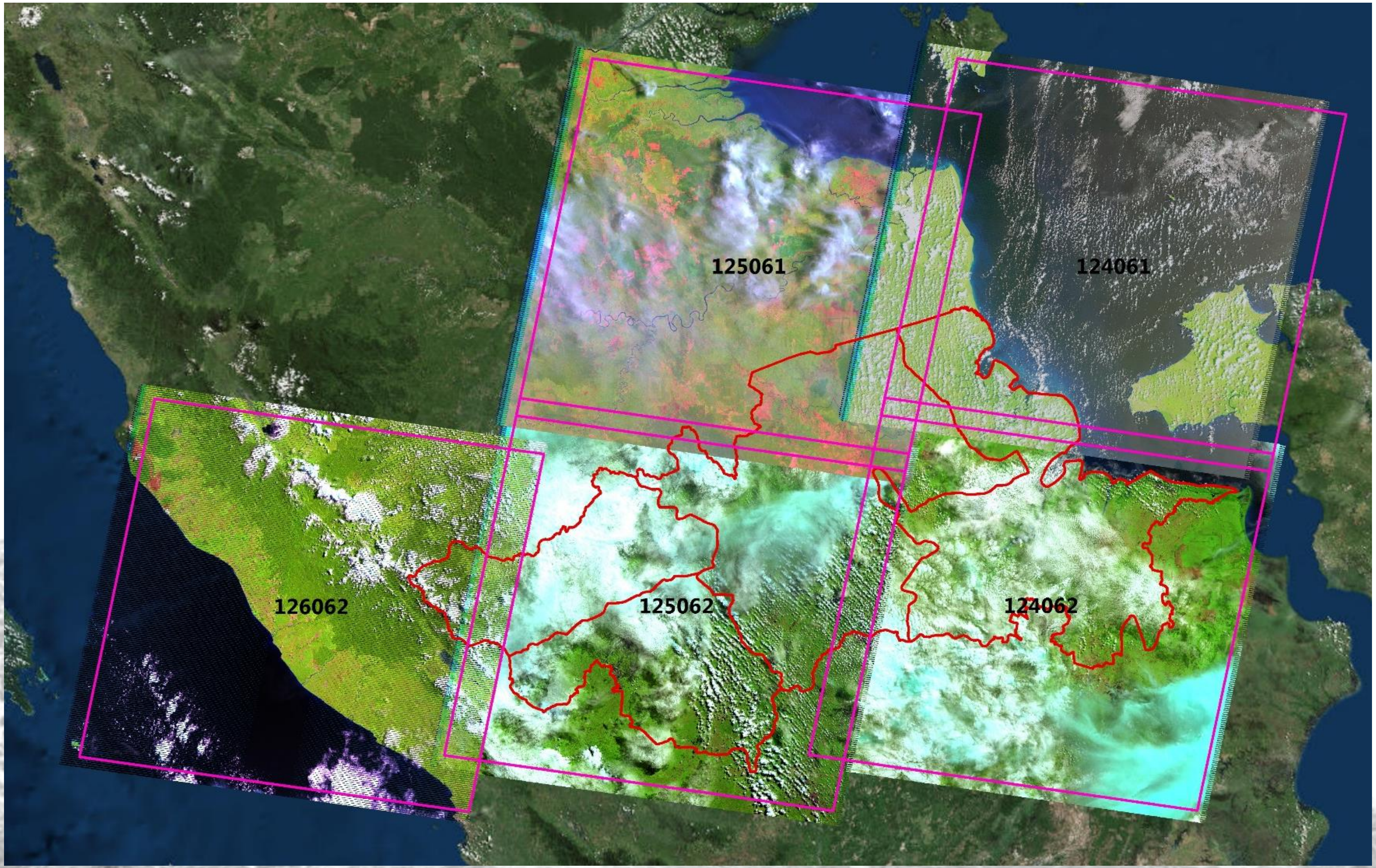


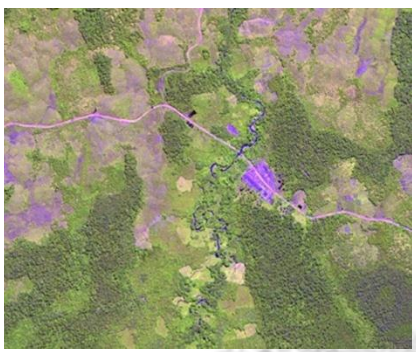
Image processing

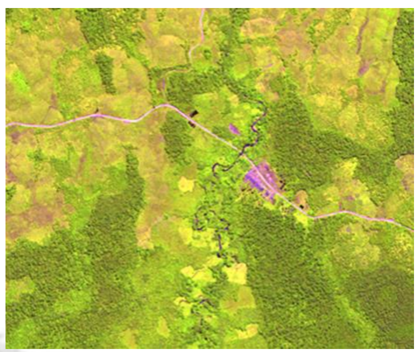
- Atmospheric correction
- Cloud masking
- Object-based classification with hierarchical rule-set based on burn ratios

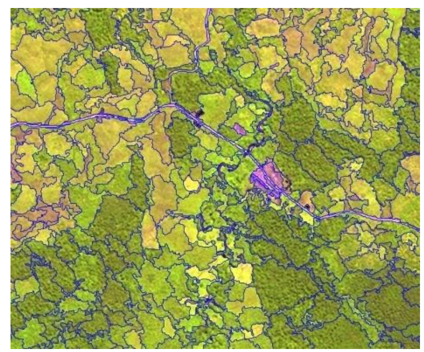
Atmospheric correction

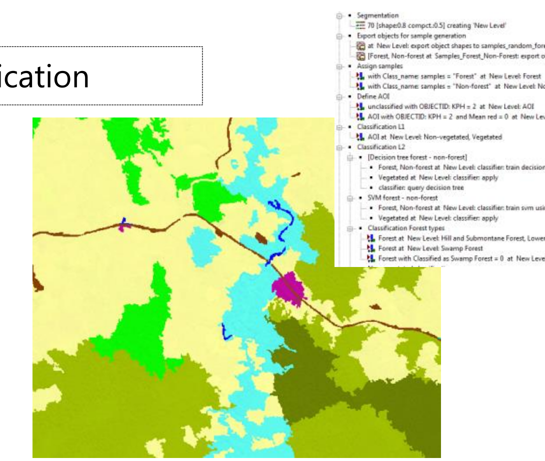
Segmentation

Classification





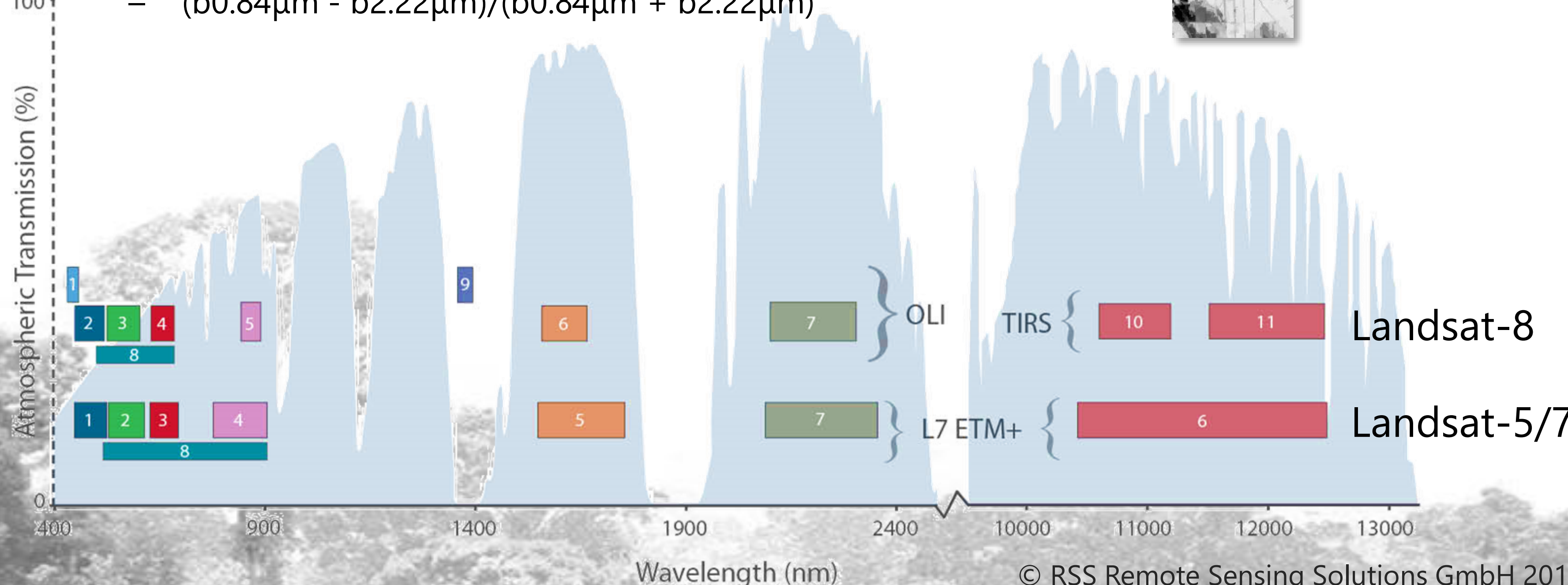




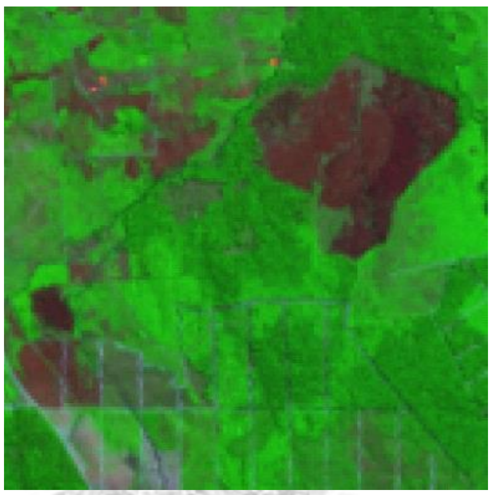
Burn ratios

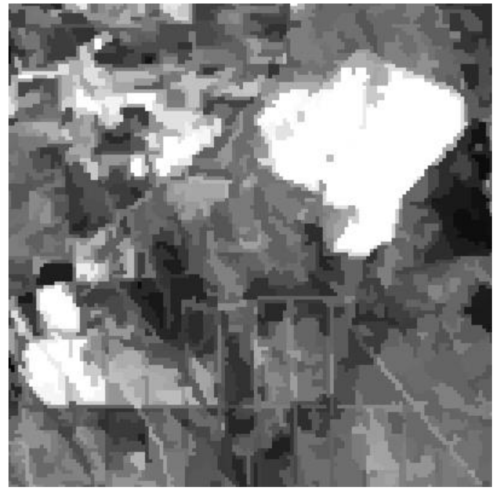
Burn ratios

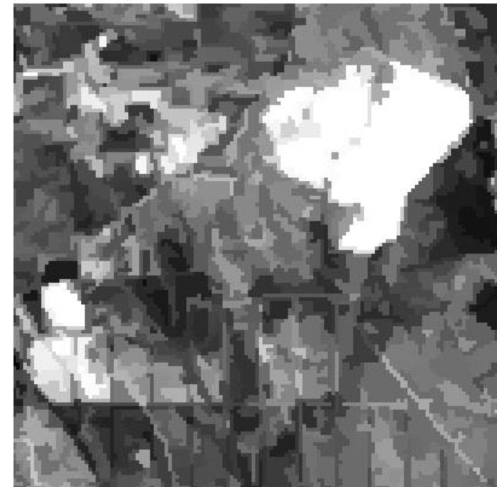
- BR1
  - (NIR– TIR) \ (NIR + TIR)
  - (b0.84µm - b11.45µm) / (b0.84µm + b11.45µm)
- BR2
  - (NIR - SWIR) \ (NIR + TIR)
  - (b0.84µm - b2.22µm) / (b0.84µm + b11.45µm)
- NBR
  - (NIR - SWIR) \ (NIR + SWIR)
  - (b0.84µm - b2.22µm)/(b0.84µm + b2.22µm)



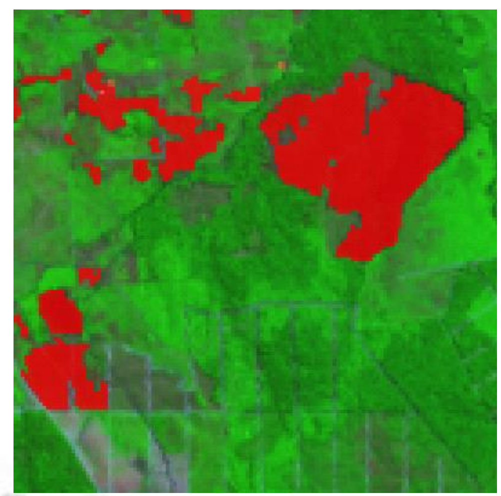
Burn ratios


Landsat


BR1


BR2


NBR

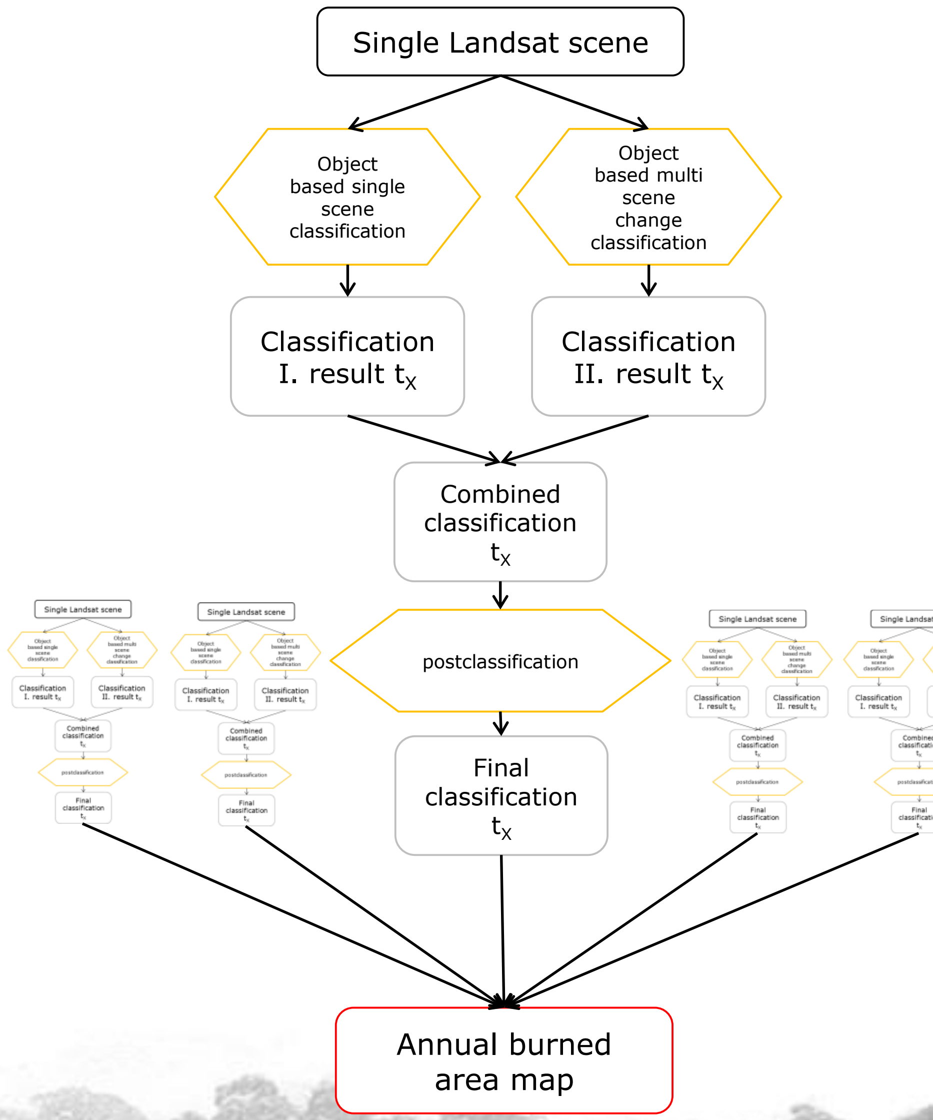

Burned area classification

Classification approaches

- Object based classification based on **single scene** using burn indices (BR1, BR2, NBR)
- Object based **multi scene** change detection ($t_1 - t_2$) (based on NDVI and NBR) and classification
  - Based on paper by MELCHIORI et al. (2014): A Landsat-TM/OLI algorithm for burned areas in the Brazilian Cerrado: preliminary results
  - Every scene compared to each other within one year

➢ **The final Classification is a combination of these two approaches to grant high accuracy and diminish false positives**

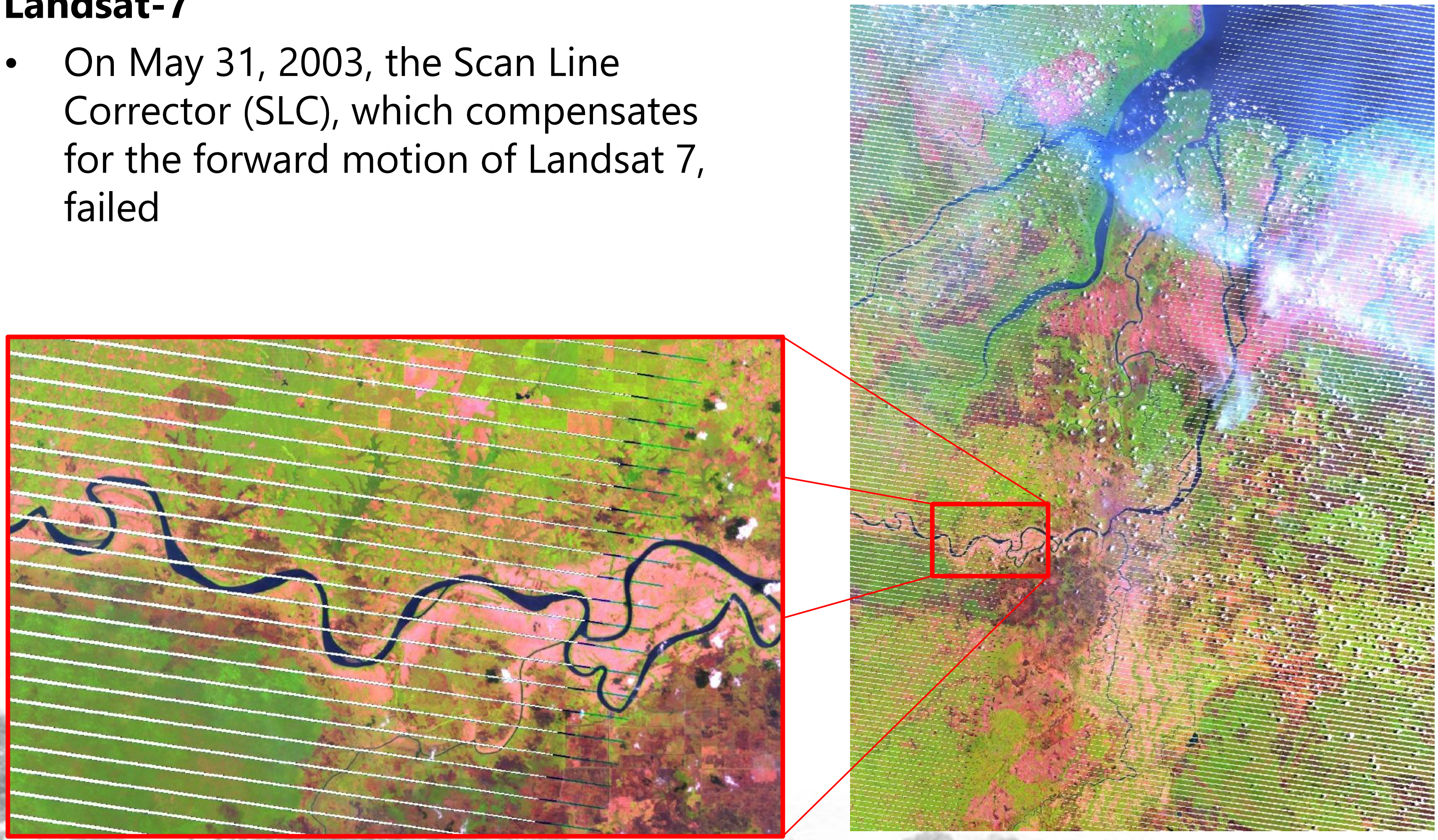
➢ **No cloud masking necessary**



Limitations

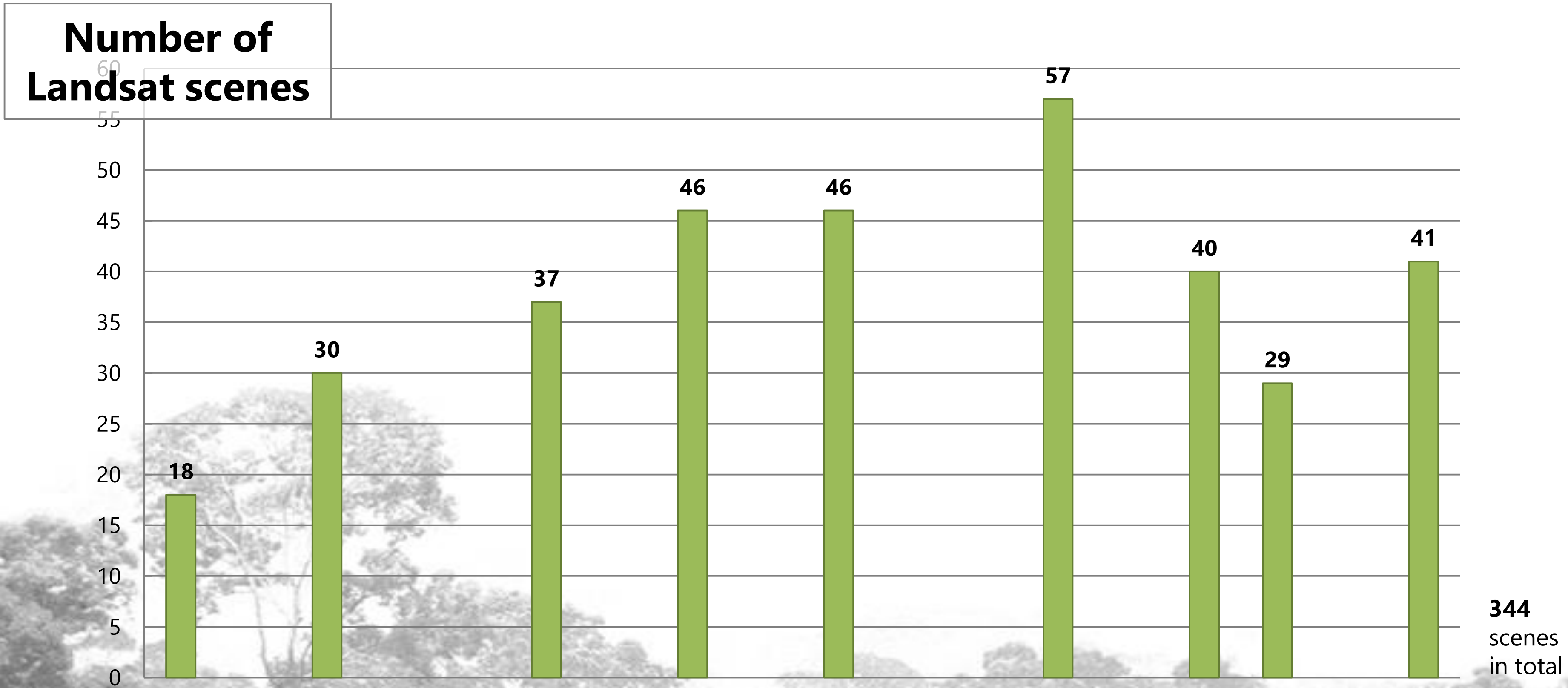
Landsat-7

- On May 31, 2003, the Scan Line Corrector (SLC), which compensates for the forward motion of Landsat 7, failed



Limitations

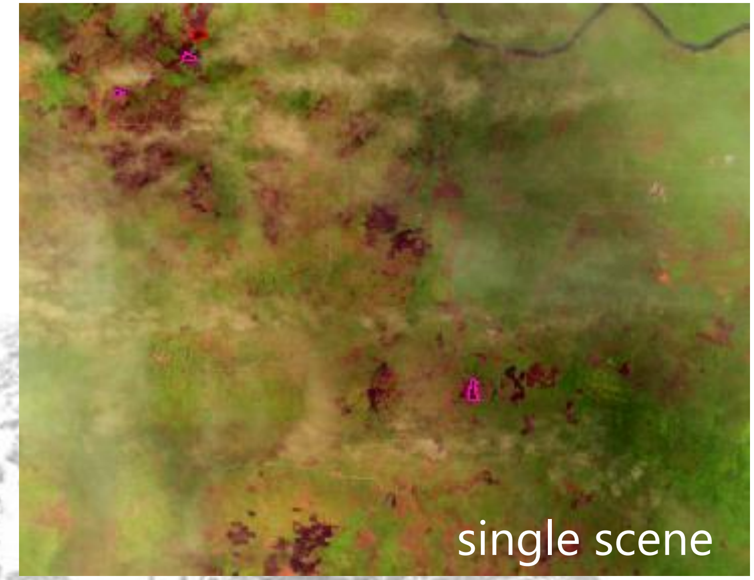
- Total number of scenes
  - Fewer scenes mean smaller area to classify and lower probability having a cloud-free scene

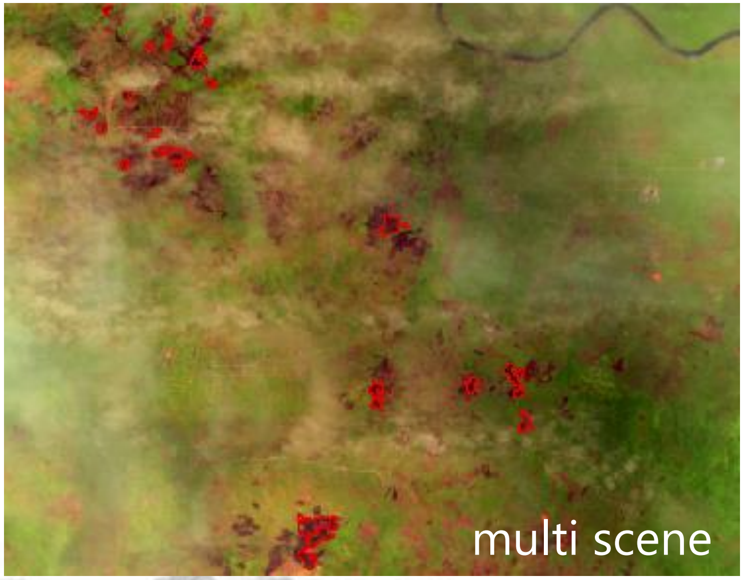


Limitations

Single scene approach

- In unique situations **cloud shadow** is falsely classified as burned area
- Limitation by **haze**
  - Haze leads to low detection of burned areas
  - Not a problem for the multi scene approach



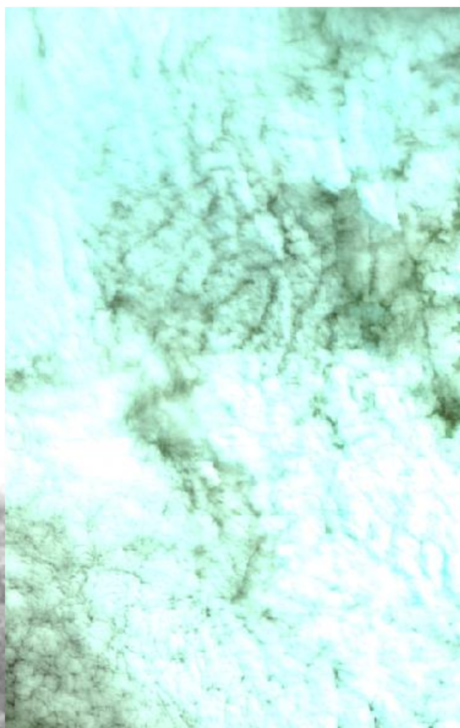


Limitations

Multi scene approach

- Bare areas in oil palms plantations can be classified as burned
- Both scenes have to be cloud free for classification
- Usually high cloud cover percentage in tropics
- This “problem” is tackled via change calculation of all possible combinations

  t_1-t_4 | t_2-t_4 | t_3-t_4



t_1

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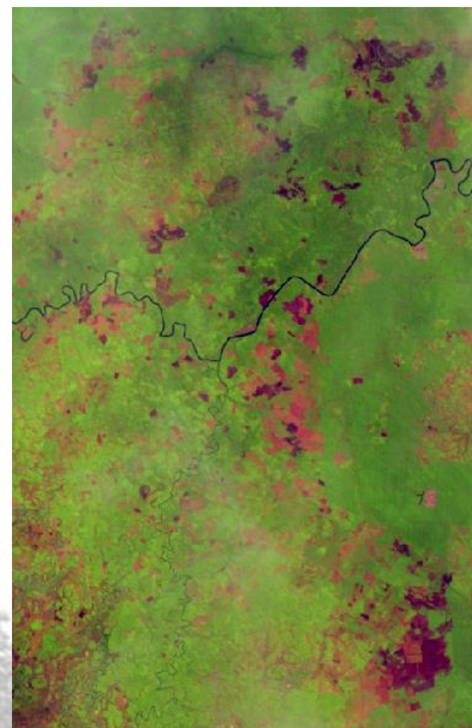


t_4

=

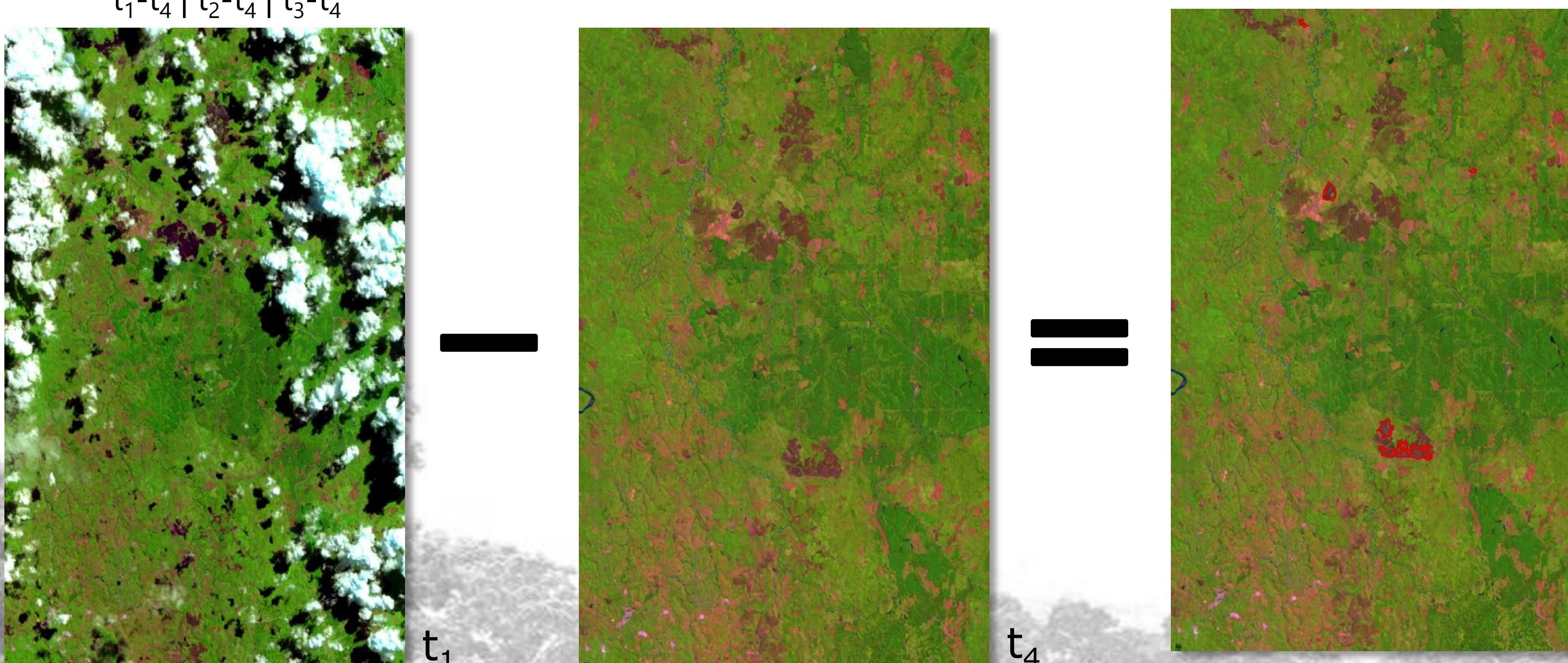
No classification possible

Limitations

Multi scene approach

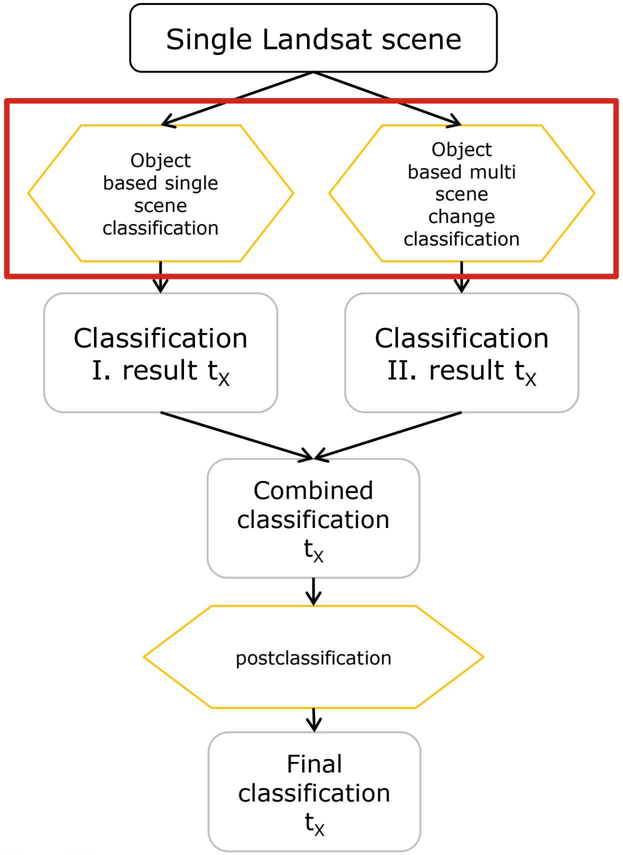
- Bare areas in oil palms plantations can be classified as burned
- Both scenes have to be cloud free for classification
- Usually high cloud cover percentage in tropics
- This “problem” is tackled via change calculation of all possible combinations

t_1-t_4 | t_2-t_4 | t_3-t_4



Classification approach

- The combination of both approaches represents a robust approach which overcomes the respective limitations of the single- and the multi-scene approach
- The results are merged for **each month** and **each year**
- **Manual editing** needs to be conducted to grant high accuracies and to overcome the limitations



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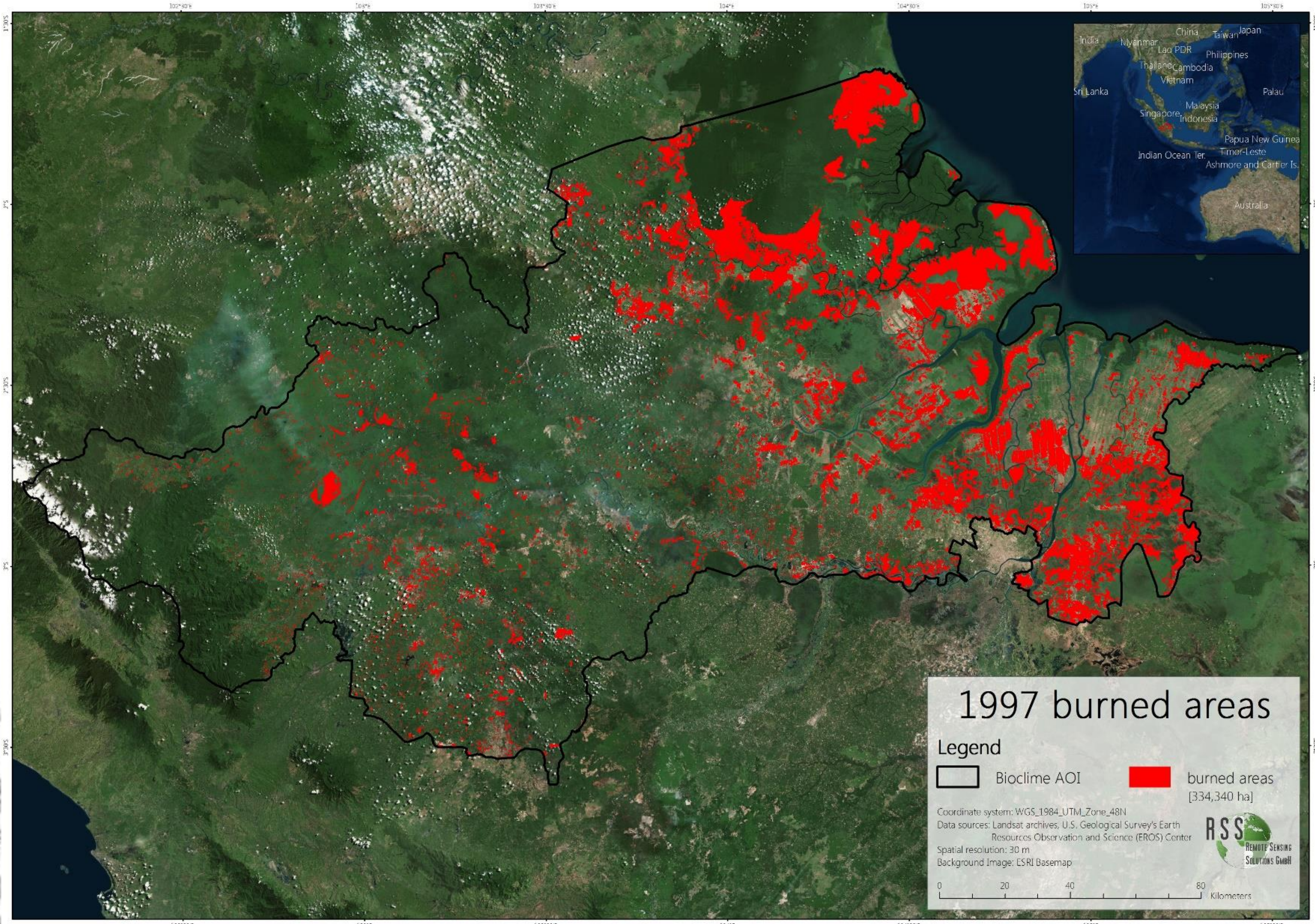

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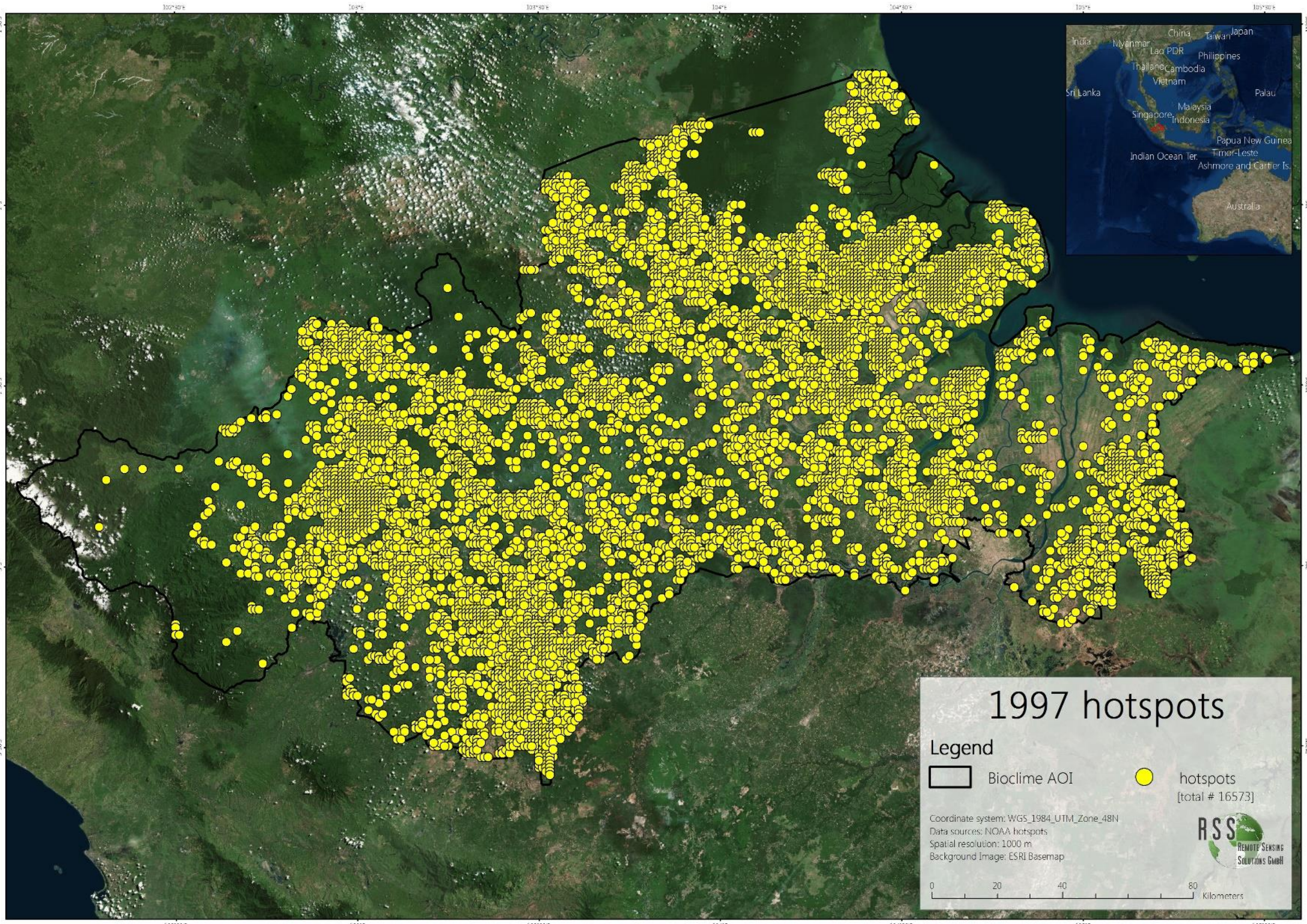
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia
1997 burned areas
Legend
Bioclime AOI
burned areas
[334,340 ha]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: Landsat archives, U.S. Geological Survey's Earth Resources Observation and Science (EROS) Center
Spatial resolution: 30 m
Background Image: ESRI Basemap
0 20 40 80 Kilometers

1997



1997 hotspots
Legend
Bioclime AOI
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[total # 16573]
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Data sources: NOAA hotspots
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Background Image: ESRI Basemap
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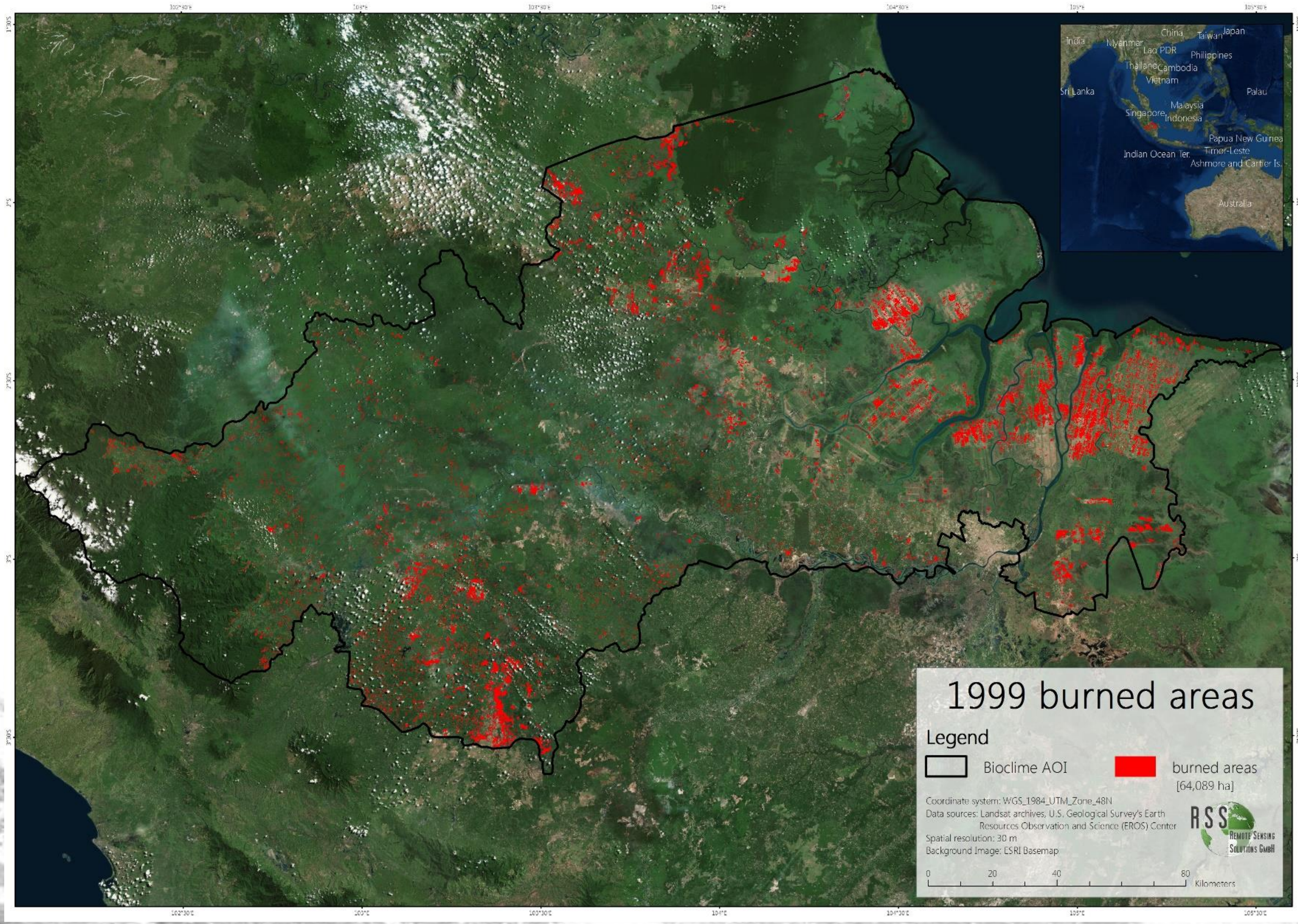
Timor-Leste
Ashmore and Cartier Is.
Australia

1999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Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia
1999 burned areas
Legend
Bioclime AOI
burned areas
[64,089 ha]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: Landsat archives, U.S. Geological Survey's Earth Resources Observation and Science (EROS) Center
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104°30'E
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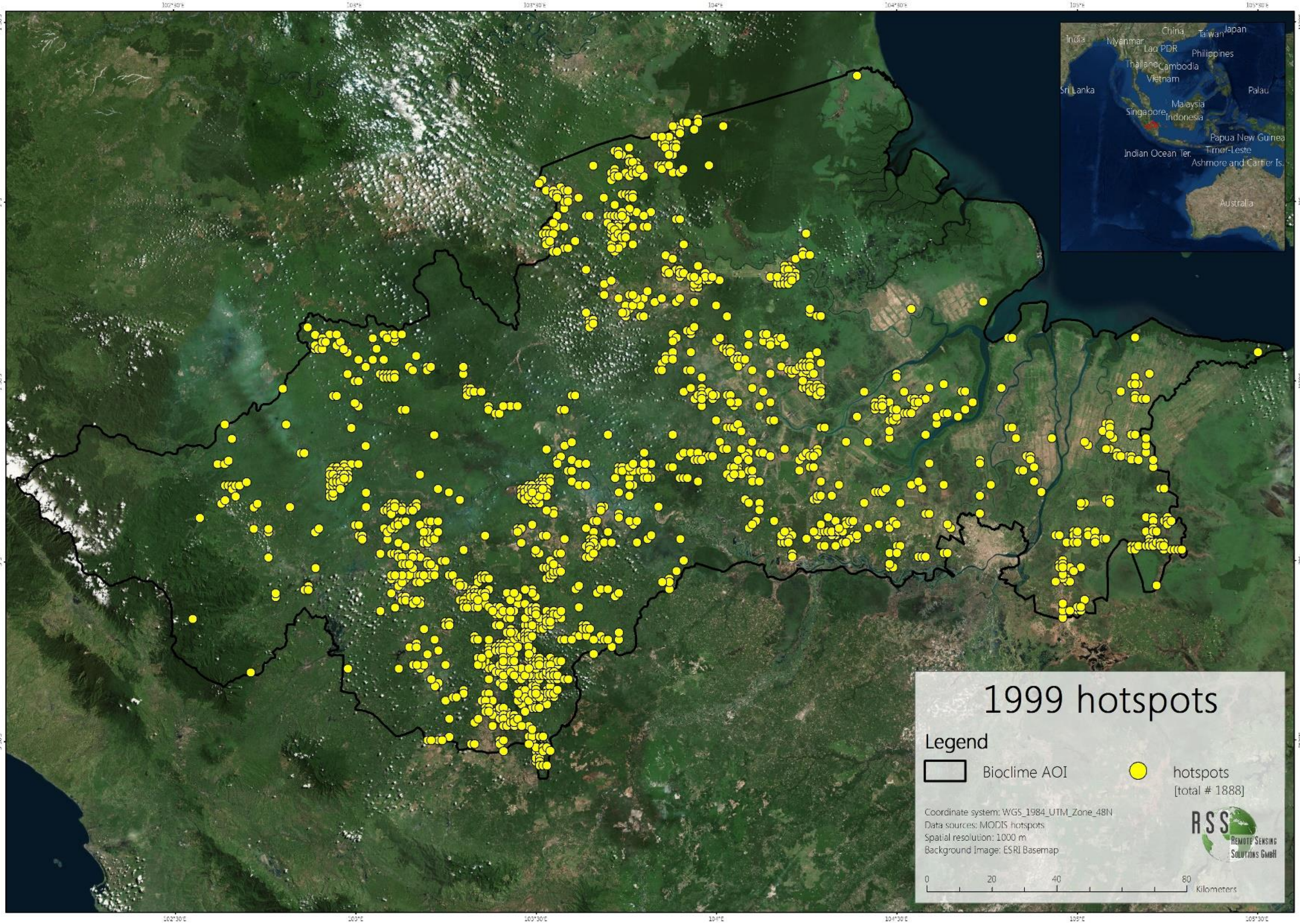
105°30'E

1999


1999 hotspots
Legend
Bioclime AOI
hotspots
[total # 1888]
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Data sources: MODIS hotspots
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Background Image: ESRI Basemap
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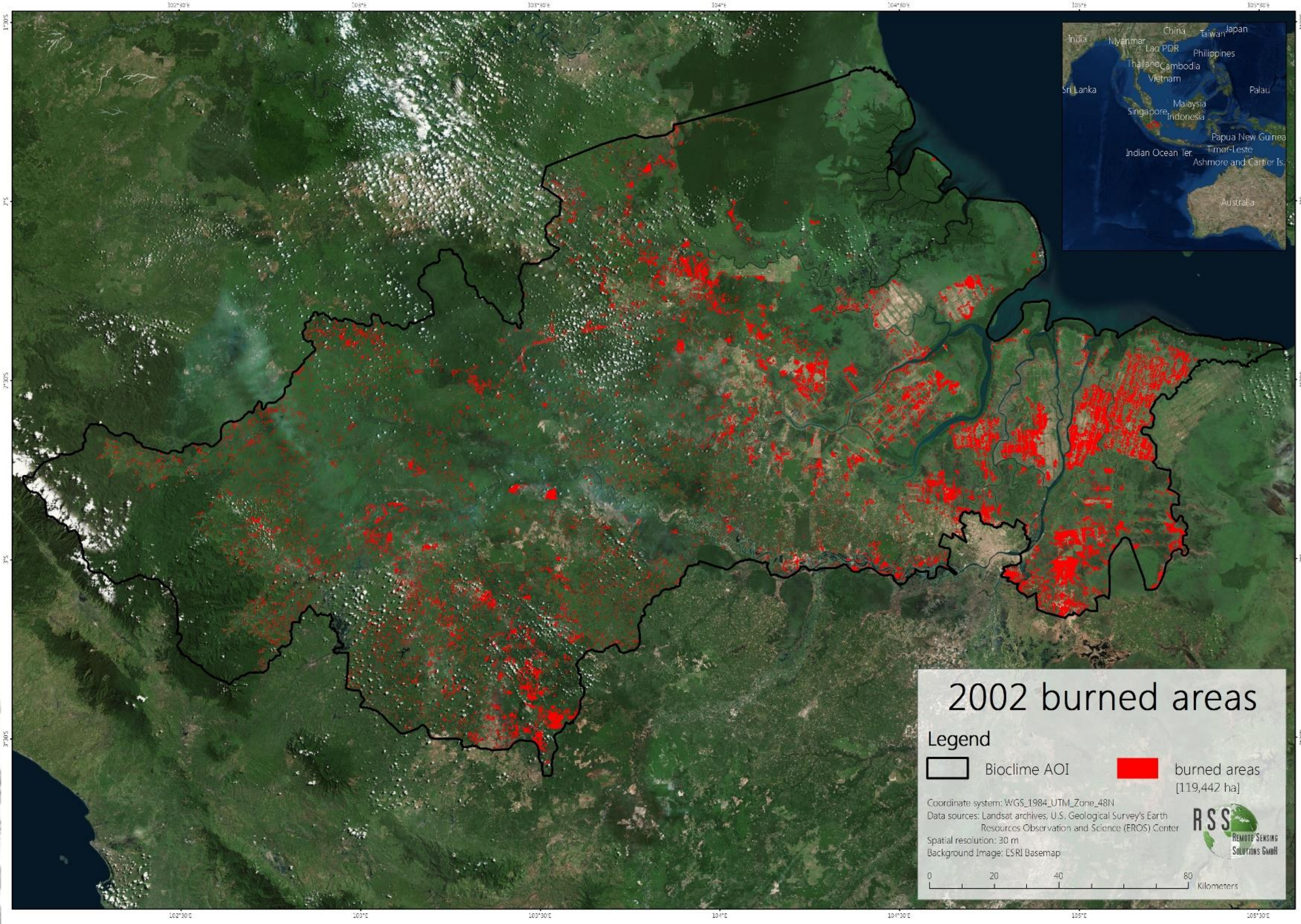
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia

2002



2002 burned areas
Legend
Bioclime AOI
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[119,442 ha]
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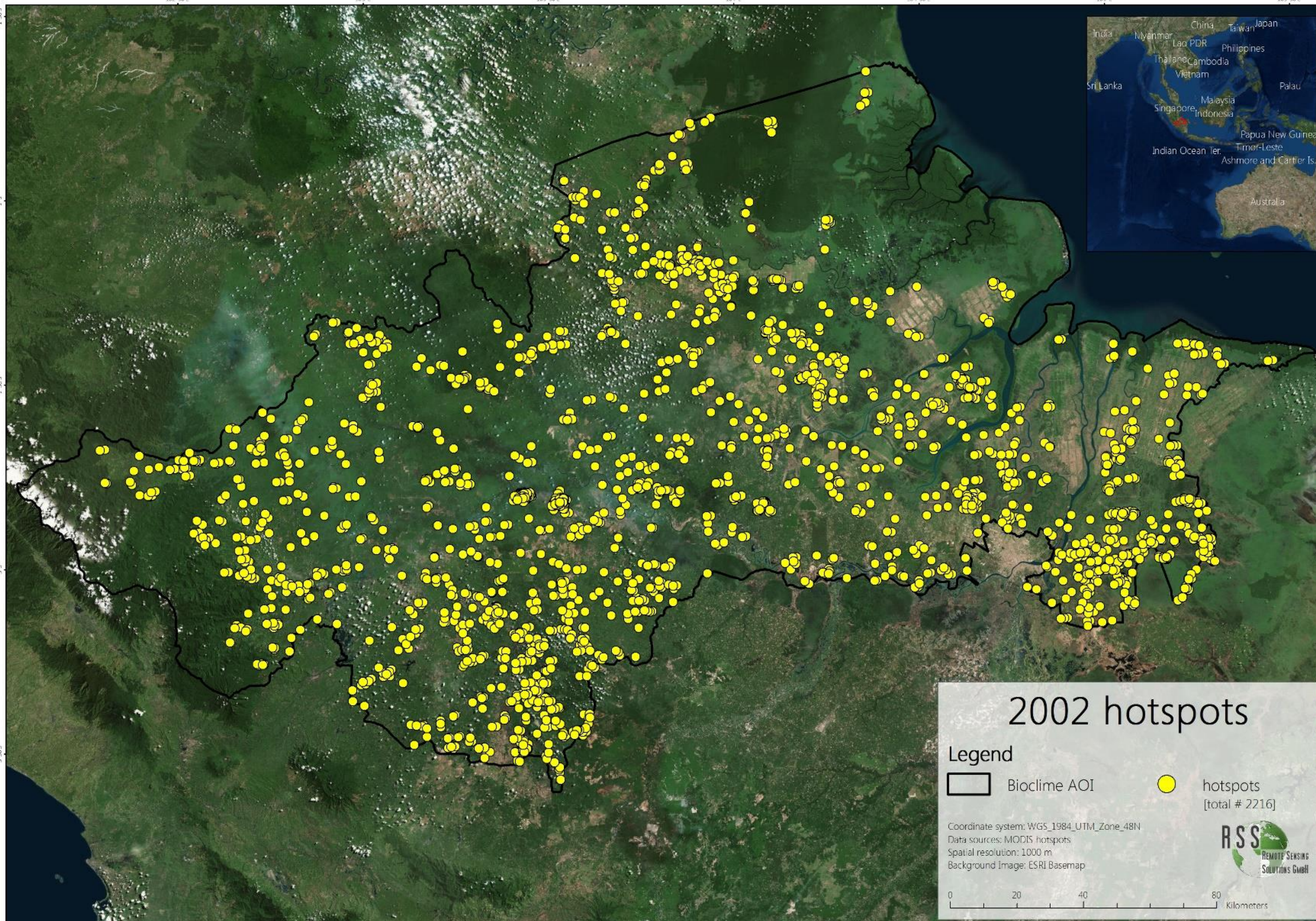
Kilometers

2002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Australia
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Bioclime AOI
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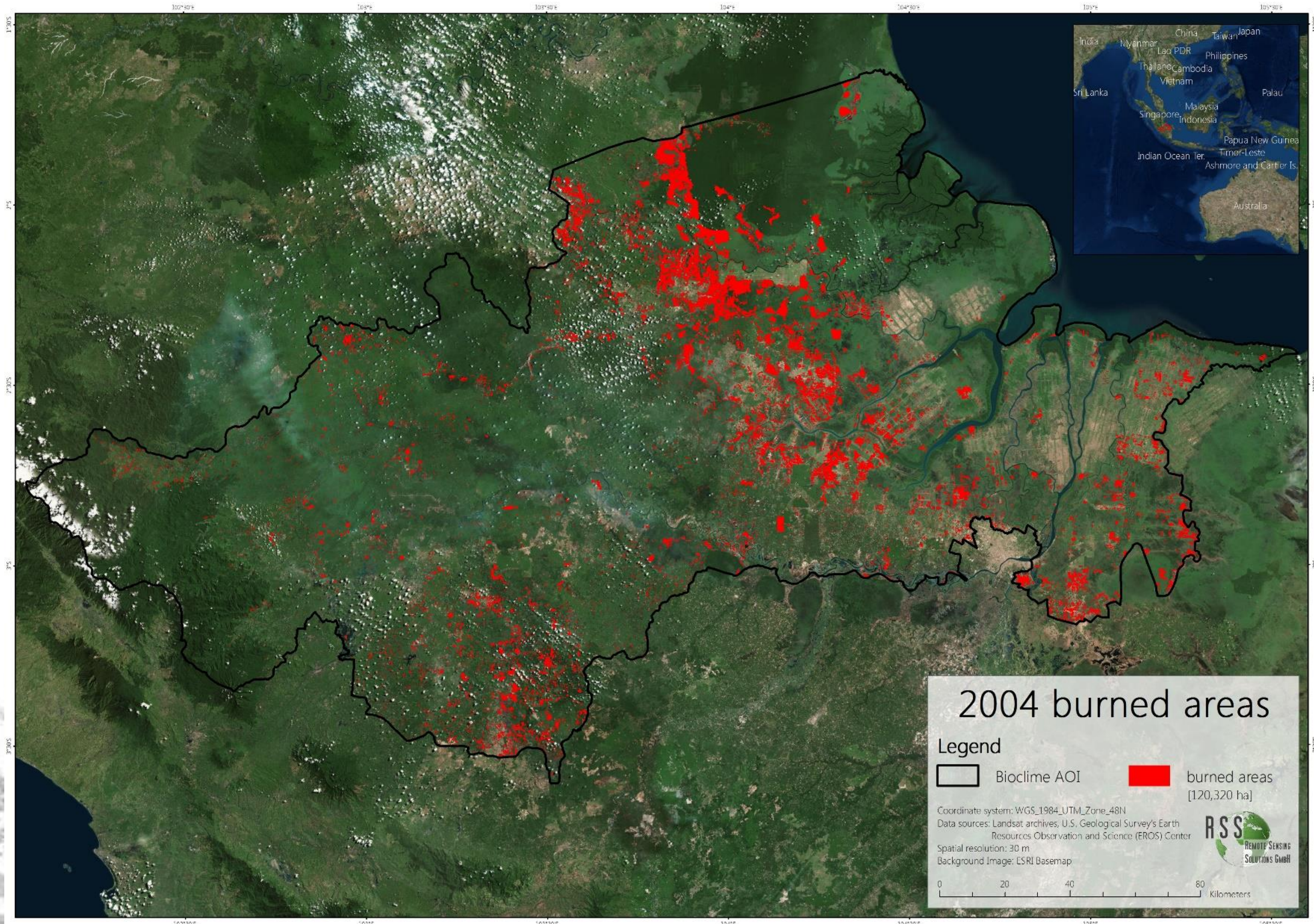
Kilometers

2004



2004 burned areas
Legend
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burned areas
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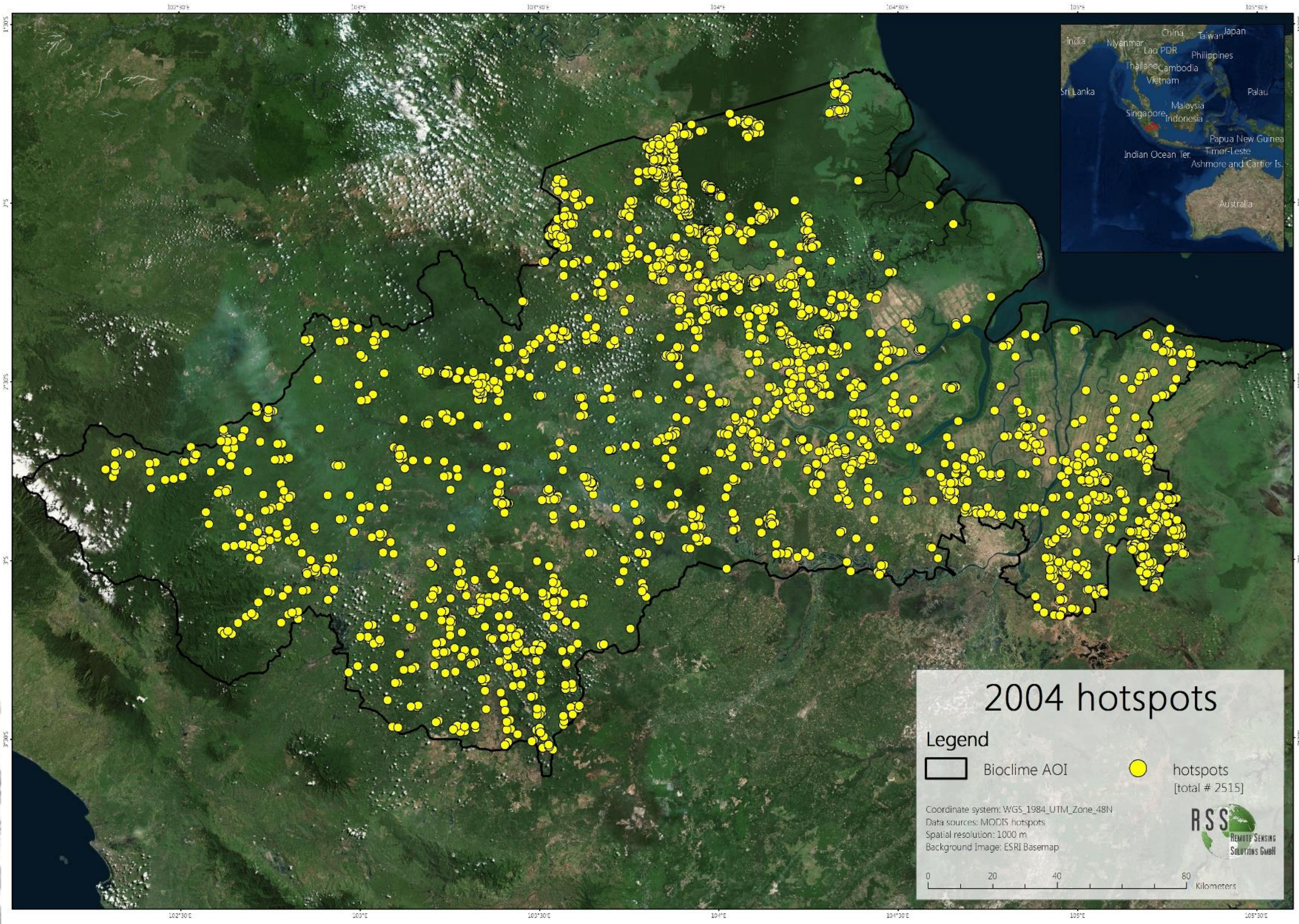
2004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Bioclime AOI
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104°30'E
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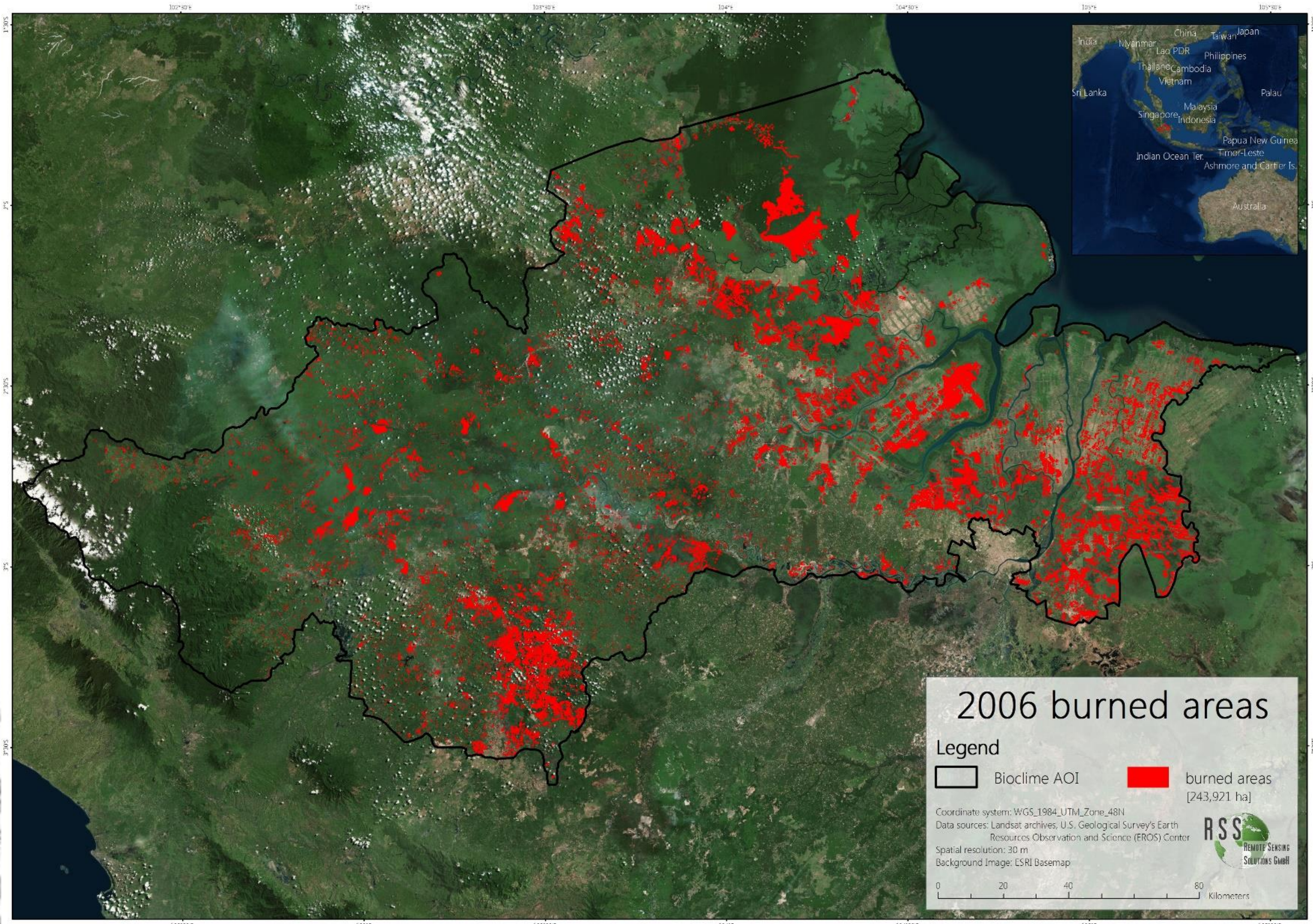
2006



2006 burned areas
Legend
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burned areas
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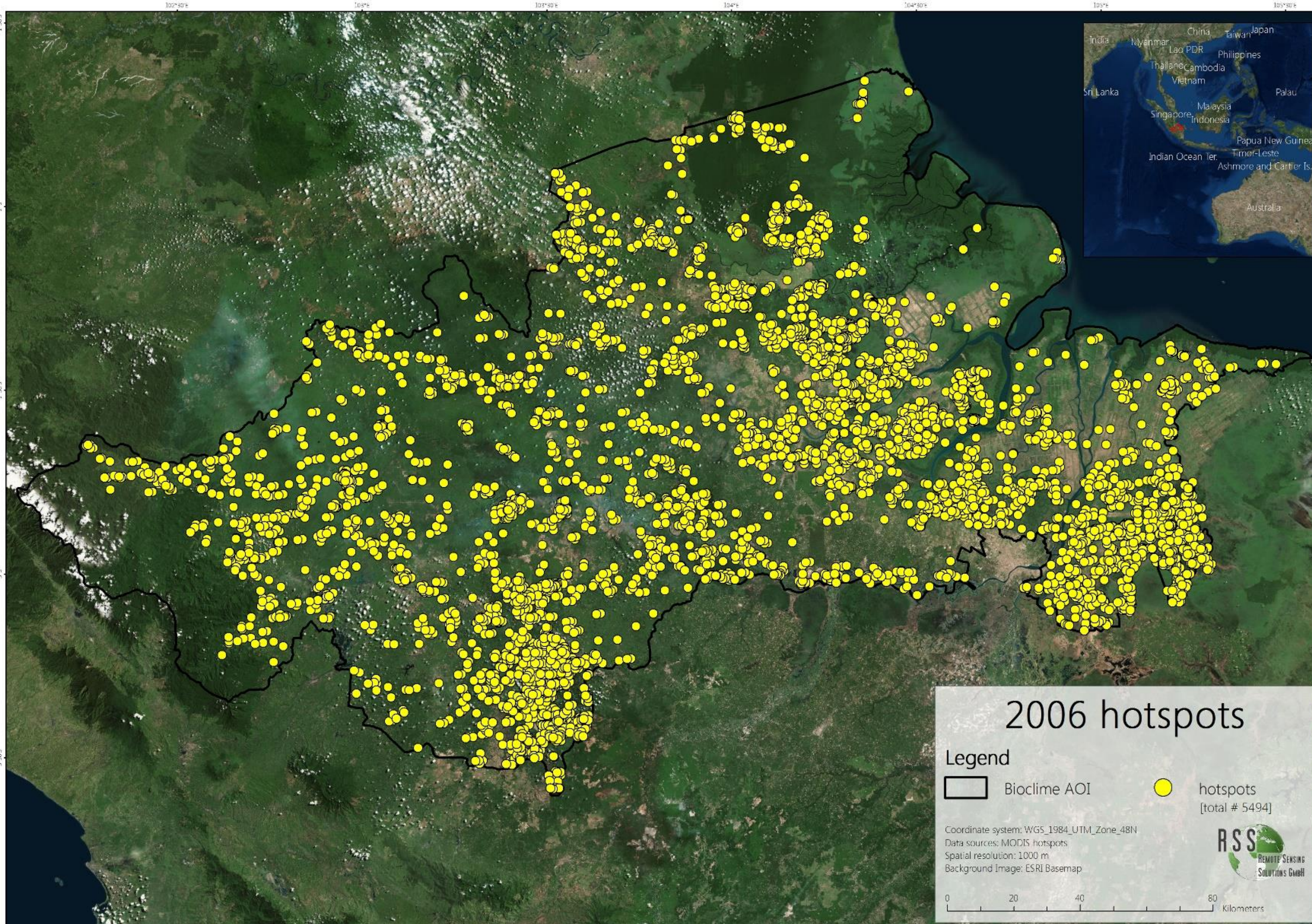
2006



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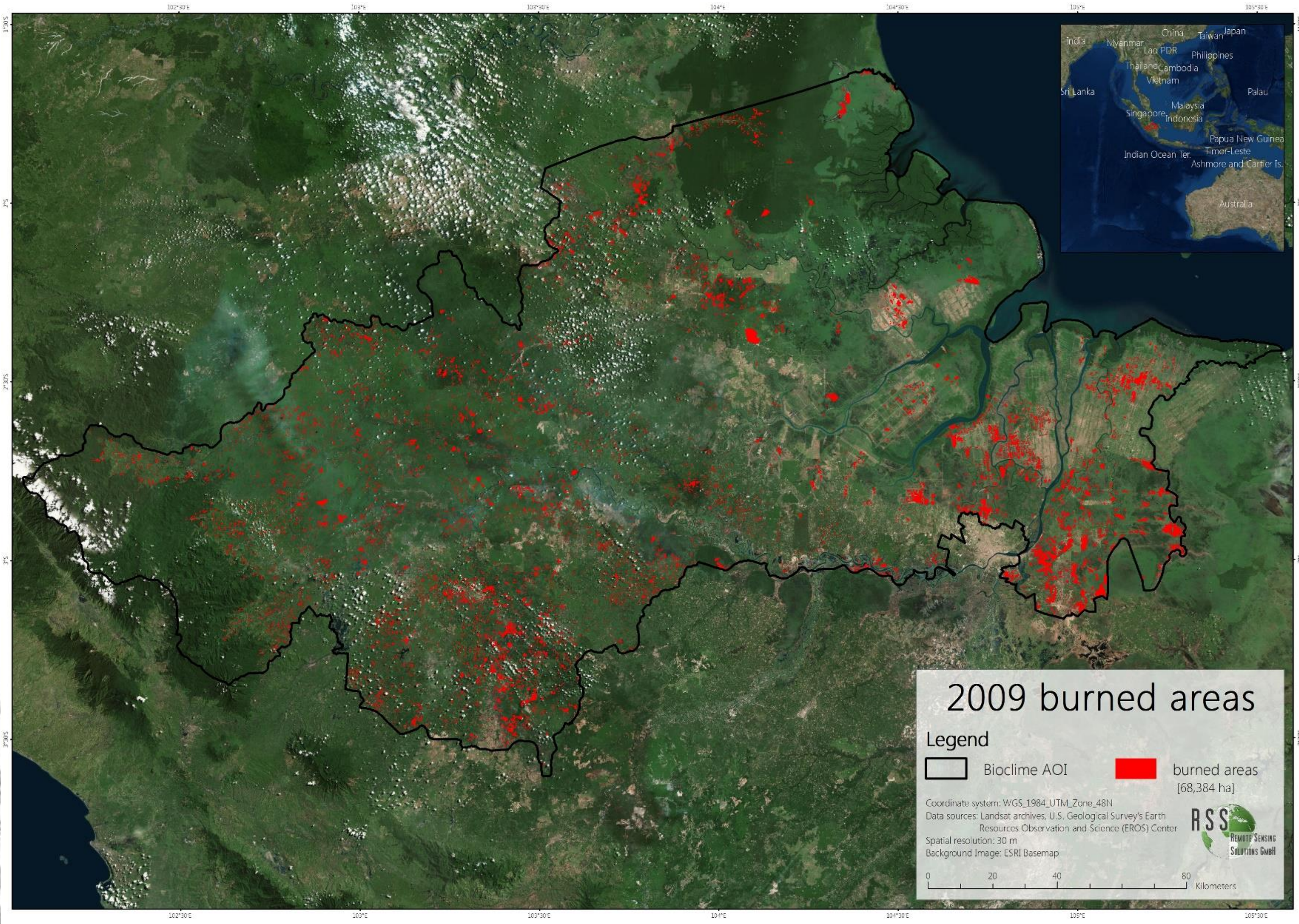
2009



2009 burned areas
Legend
Bioclime AOI
burned areas
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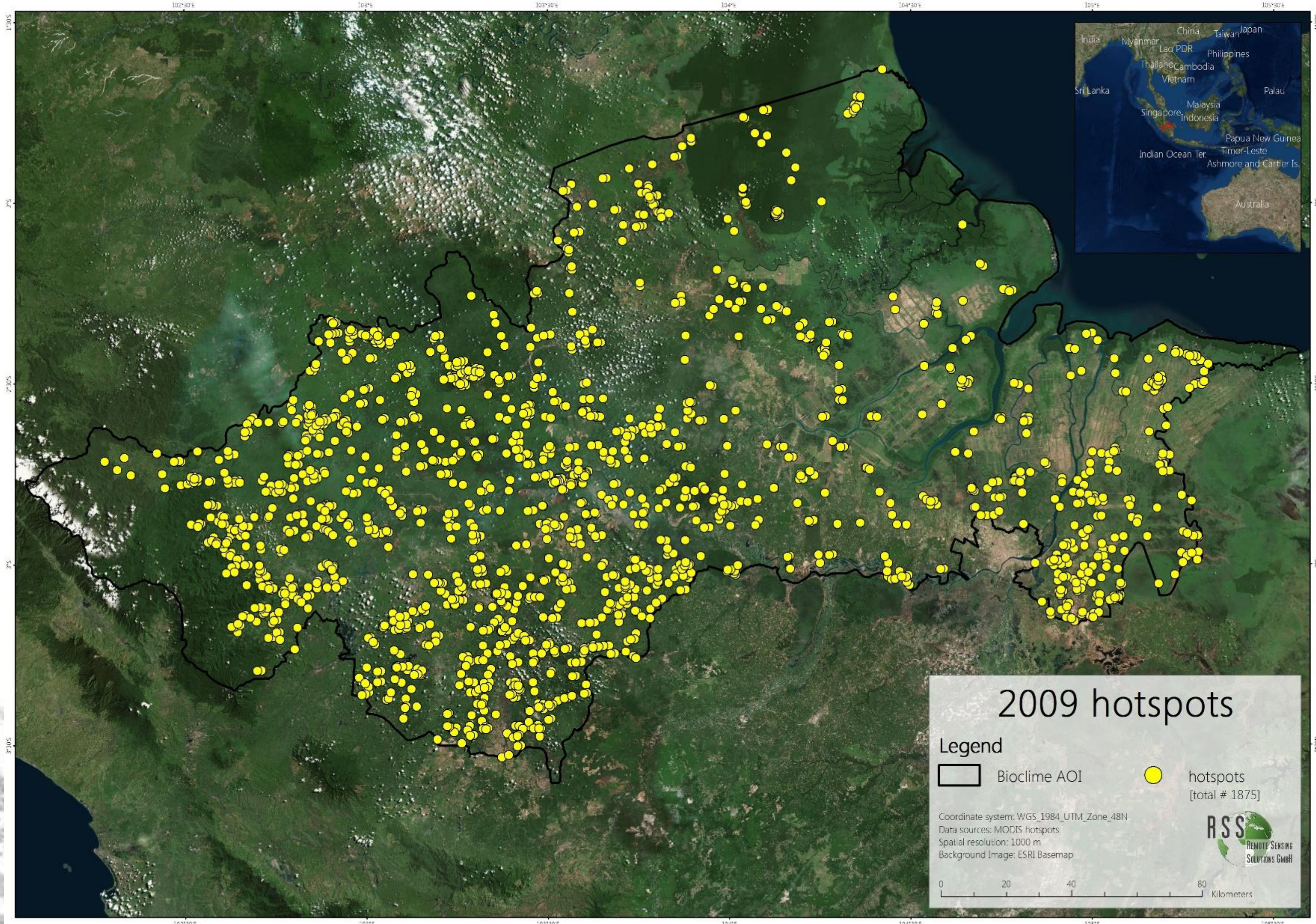
2009



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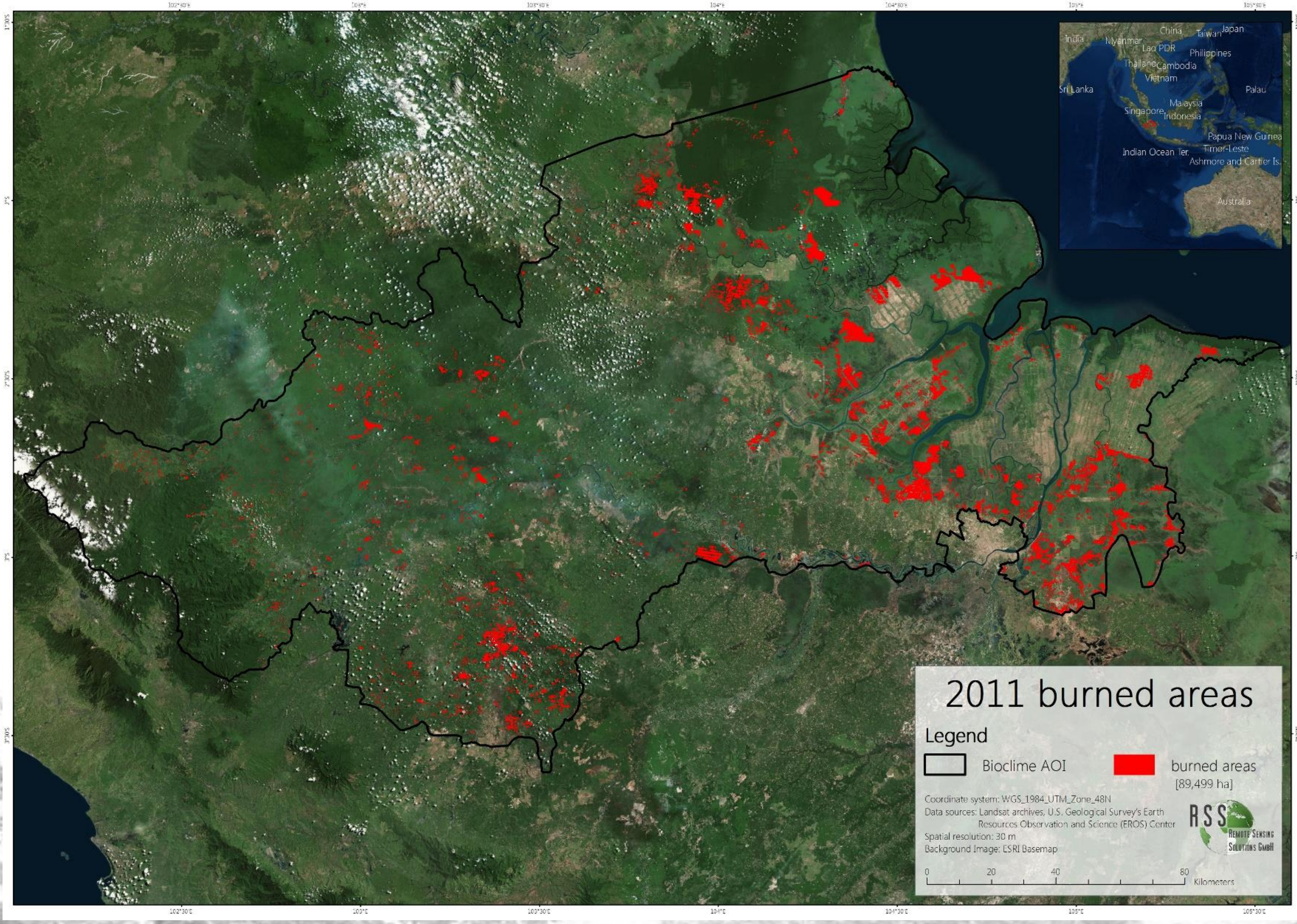
2011



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Australia
2011 burned areas
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burned areas
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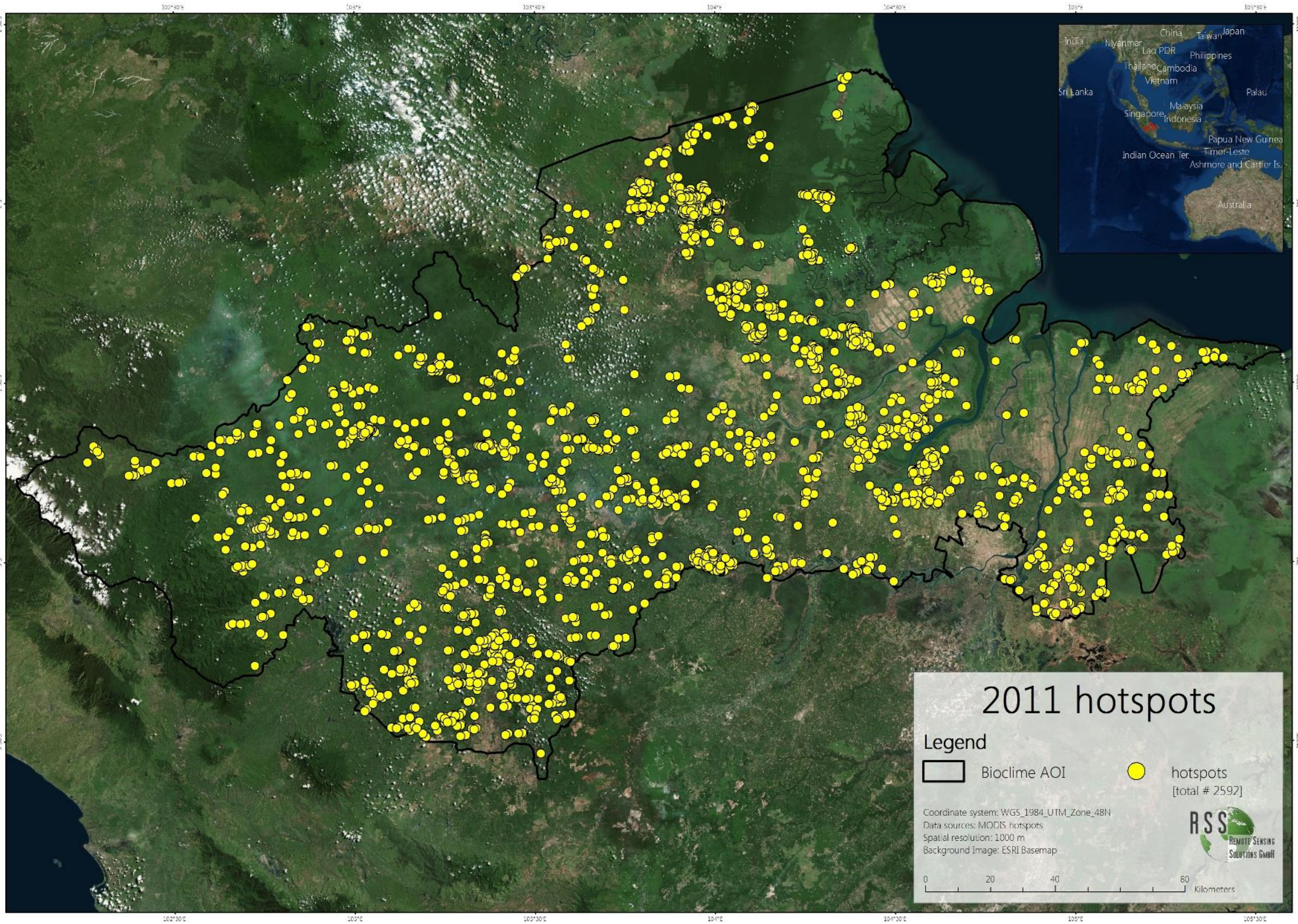
2011



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RSS
Remote Sensing
Solutions GmbH
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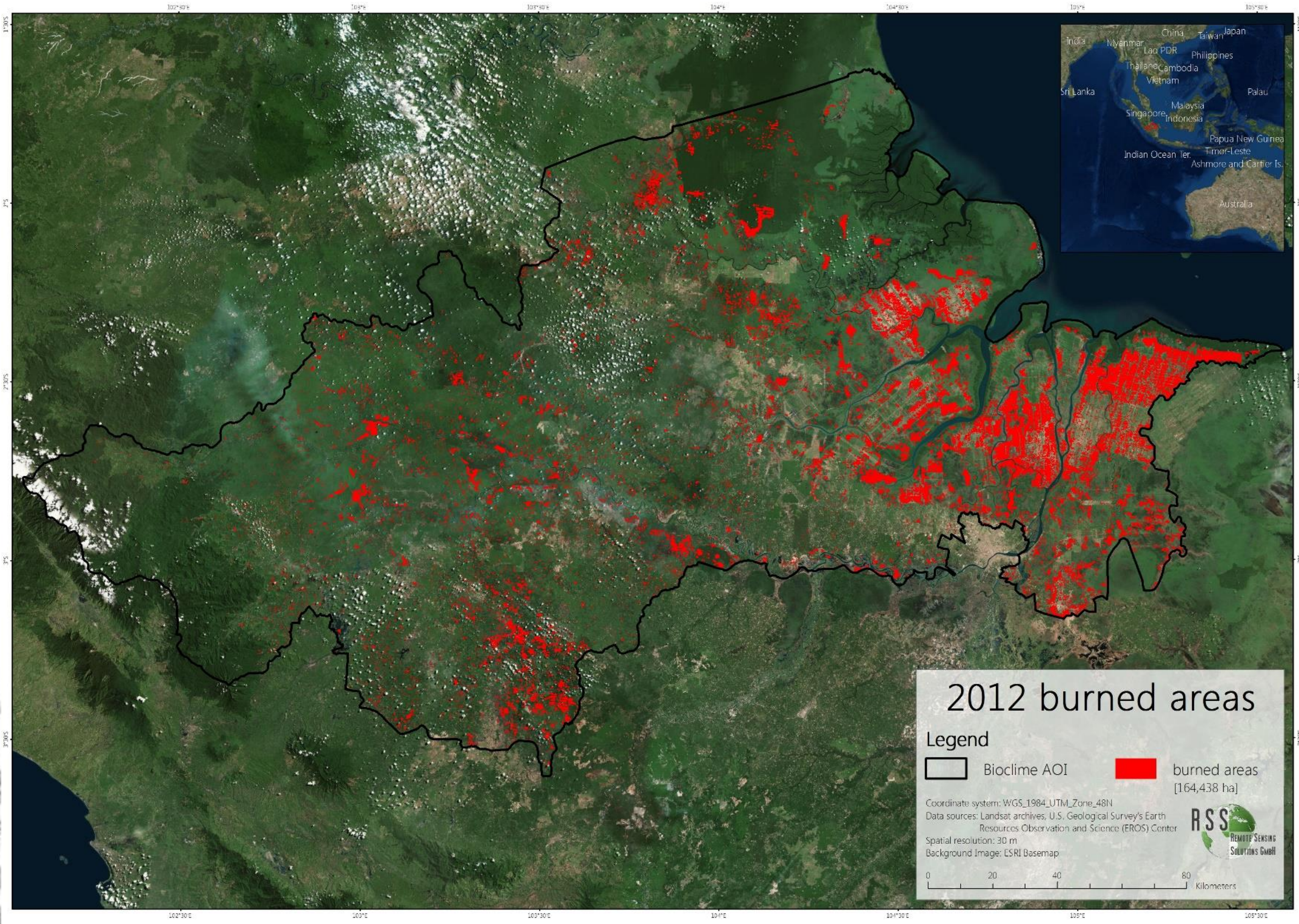
Kilometers

2012



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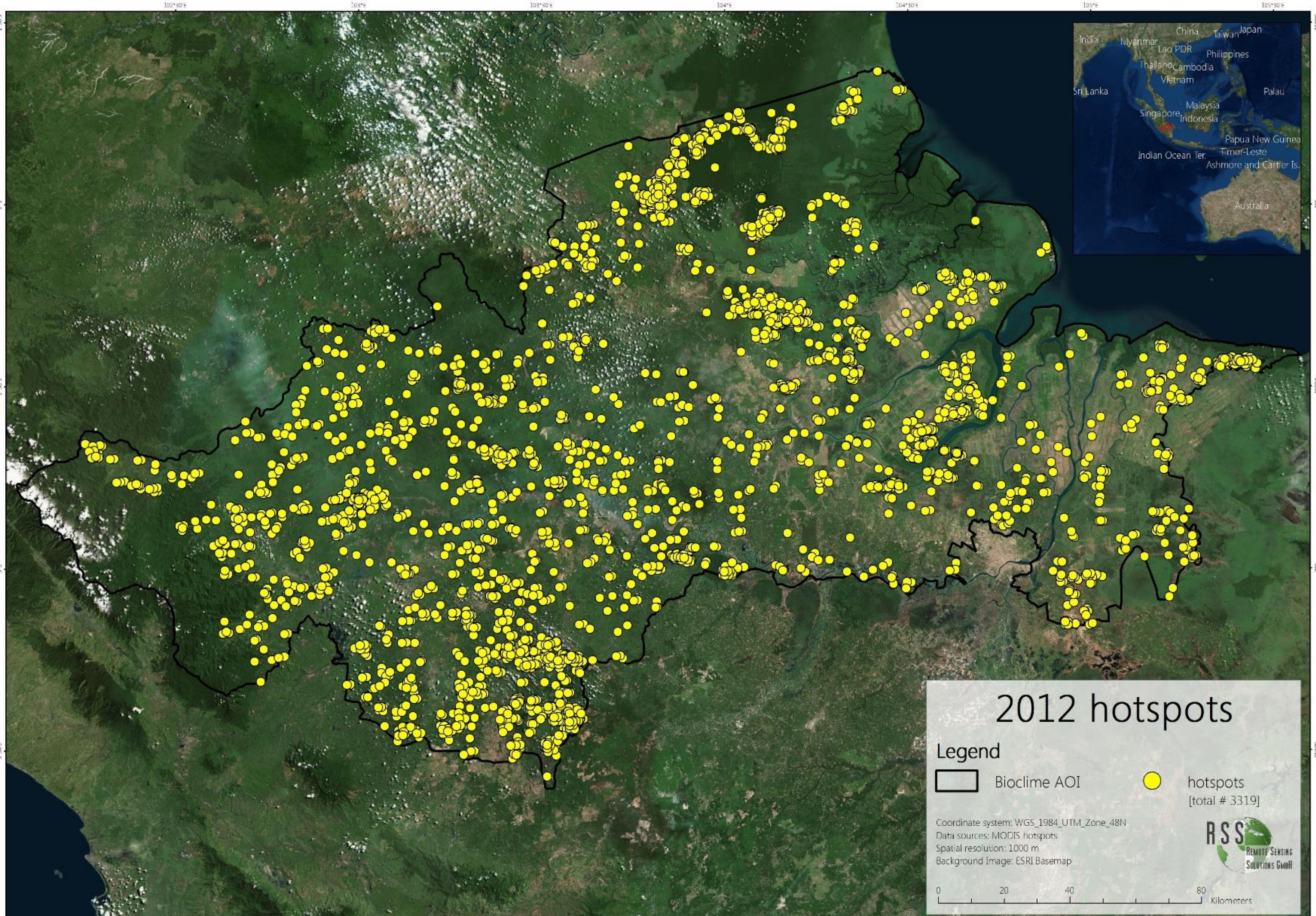
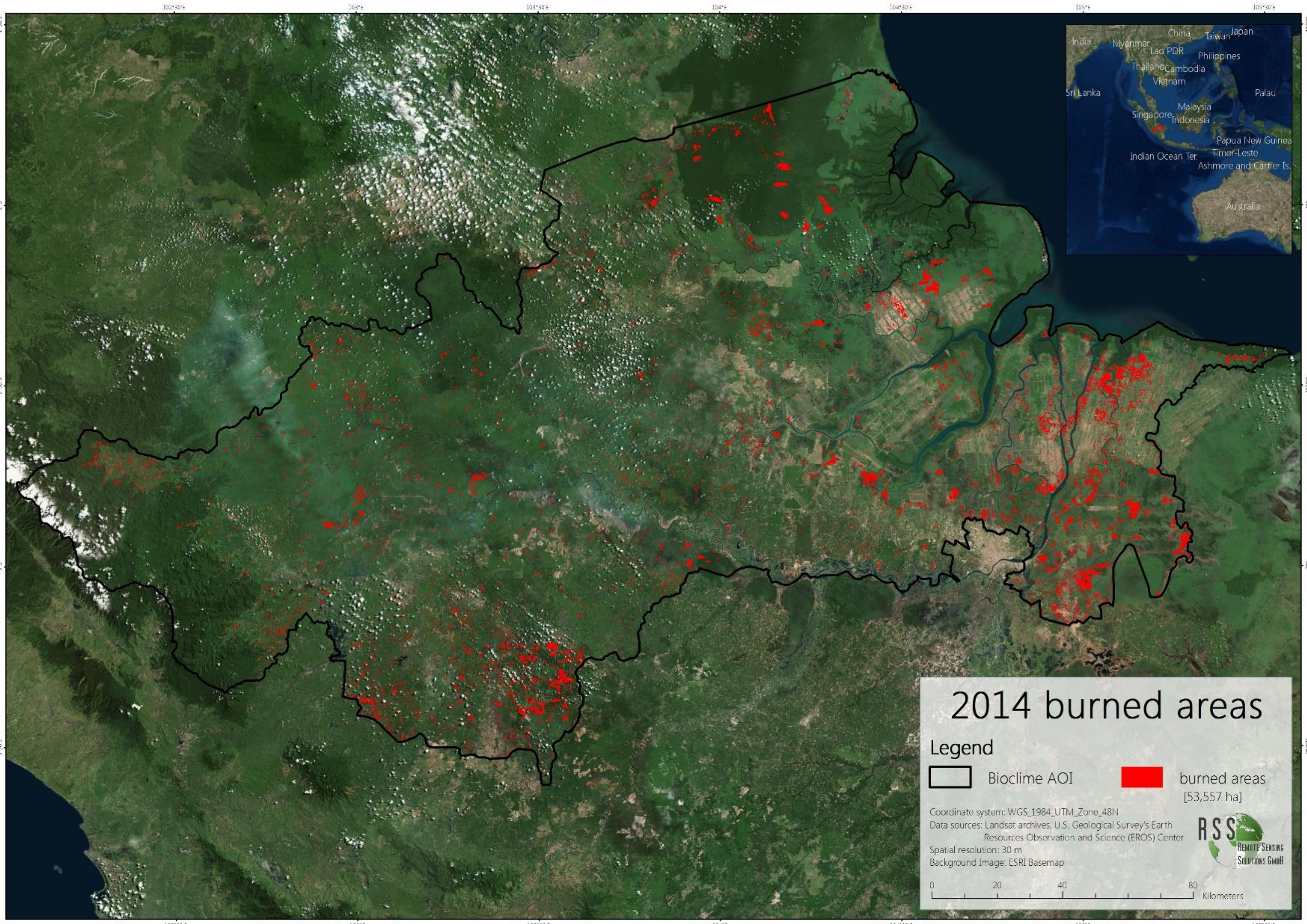
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia
2012 burned areas
Legend
Bioclime AOI
burned areas
[164,438 ha]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: Landsat archives, U.S. Geological Survey's Earth Resources Observation and Science (EROS) Center
Spatial resolution: 30 m
Background Image: ESRI Basemap
0
20
40
80
Kilometers
104°30'E
105°E
105°30'E

2012



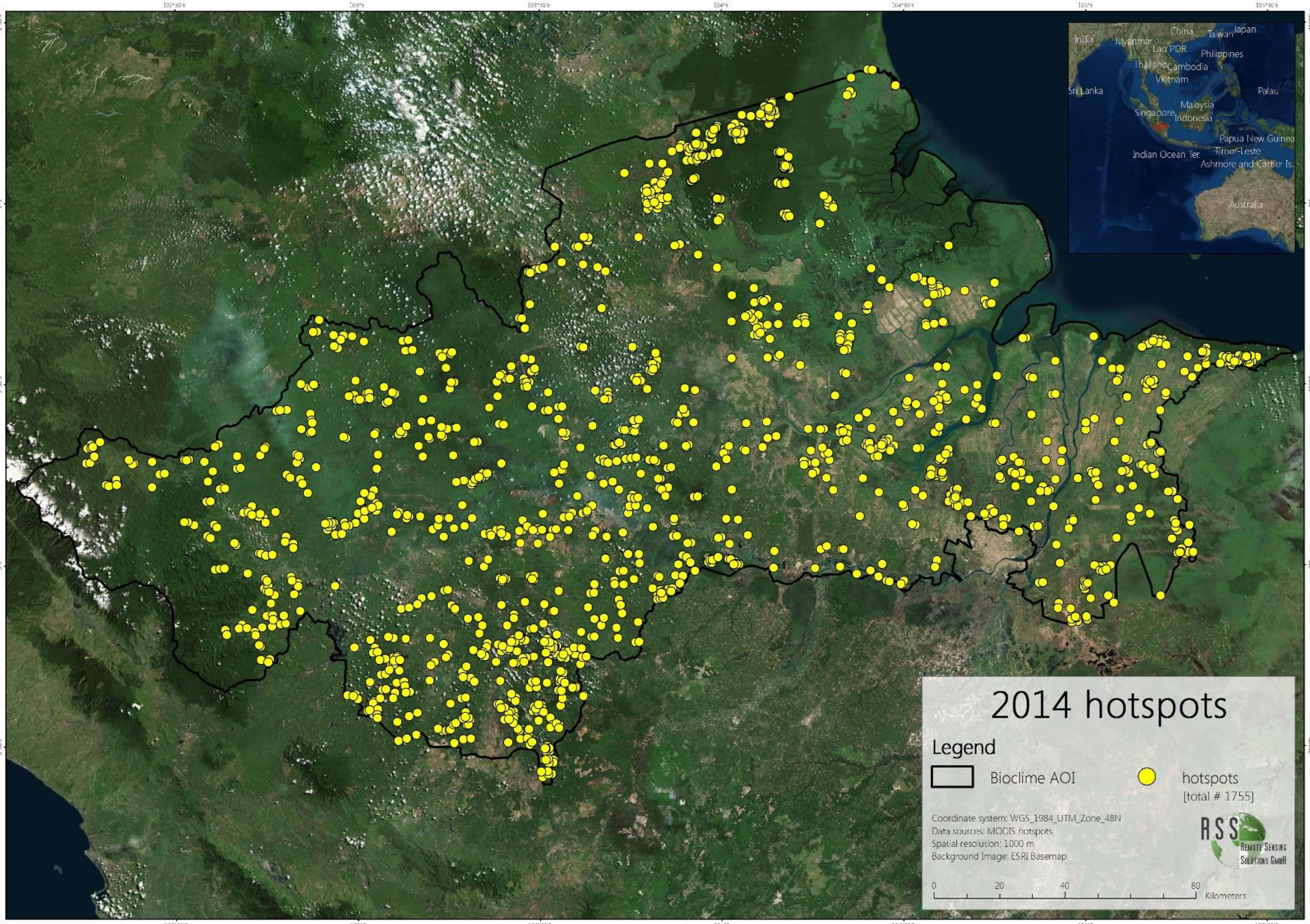
2012 hotspots
Legend
Bioclime AOI
hotspots
[total # 3319]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: MODIS hotspots
Spatial resolution: 1000 m
Background Image: ESRI Basemap
0
20
40
80
Kilometers
India
Myanmar
China
Taiwan
Japan
Lao PDR
Philippines
Thailand
Cambodia
Vietnam
Sri Lanka
Palau
Malaysia
Singapore
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia

2014



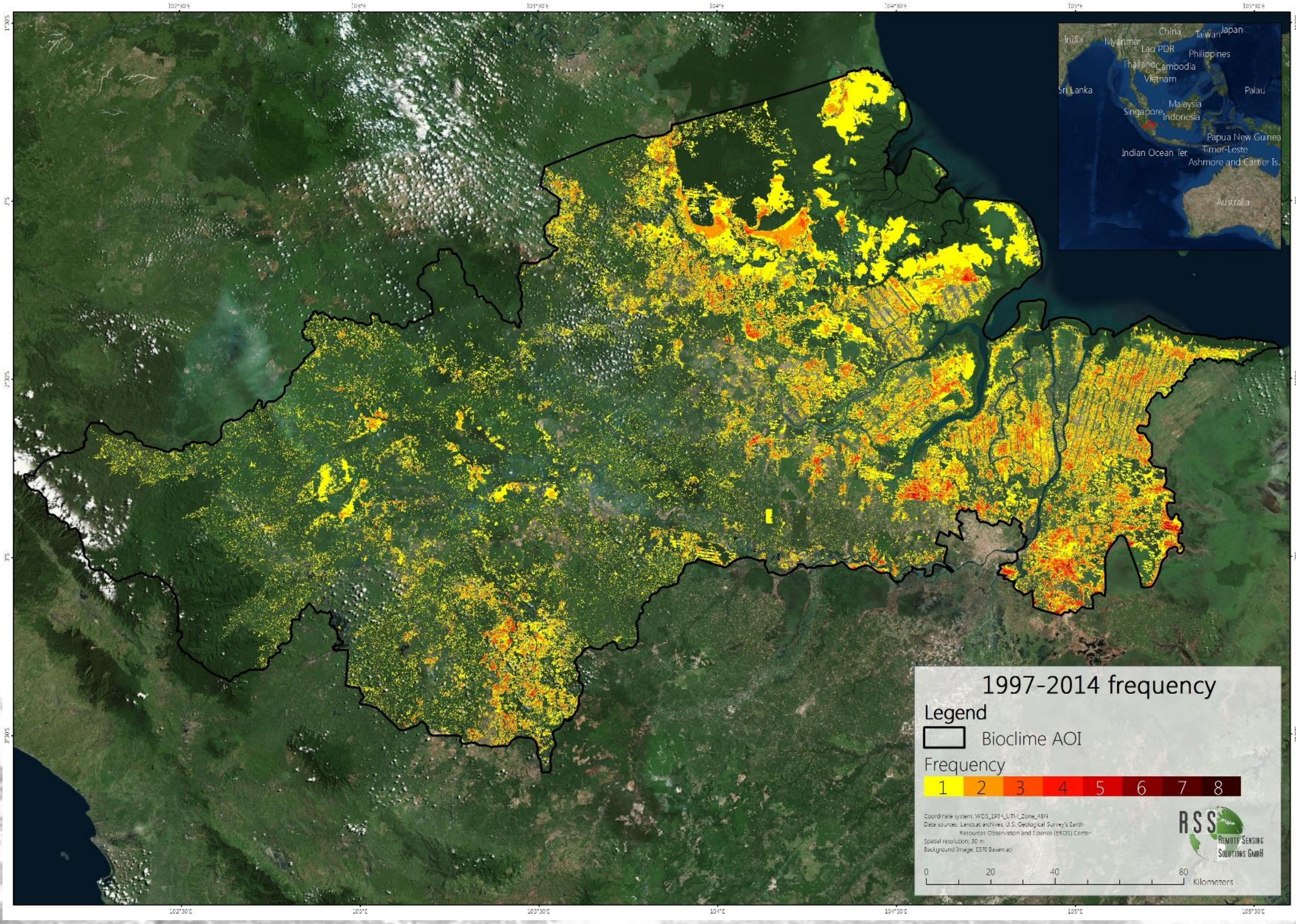
India
Myanmar
China
Taiwan
Japan
Lao PDR
Philippines
Thailand
Cambodia
Vietnam
Sri Lanka
Palau
Malaysia
Singapore
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia
2014 burned areas
Legend
Bioclime AOI
burned areas
[53,557 ha]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: Landsat archives, U.S. Geological Survey's Earth Resources Observation and Science (EROS) Center
Spatial resolution: 30 m
Background Image: ESRI Basemap
0
20
40
80
Kilometers
104°30'E
105°E
105°30'E

2014

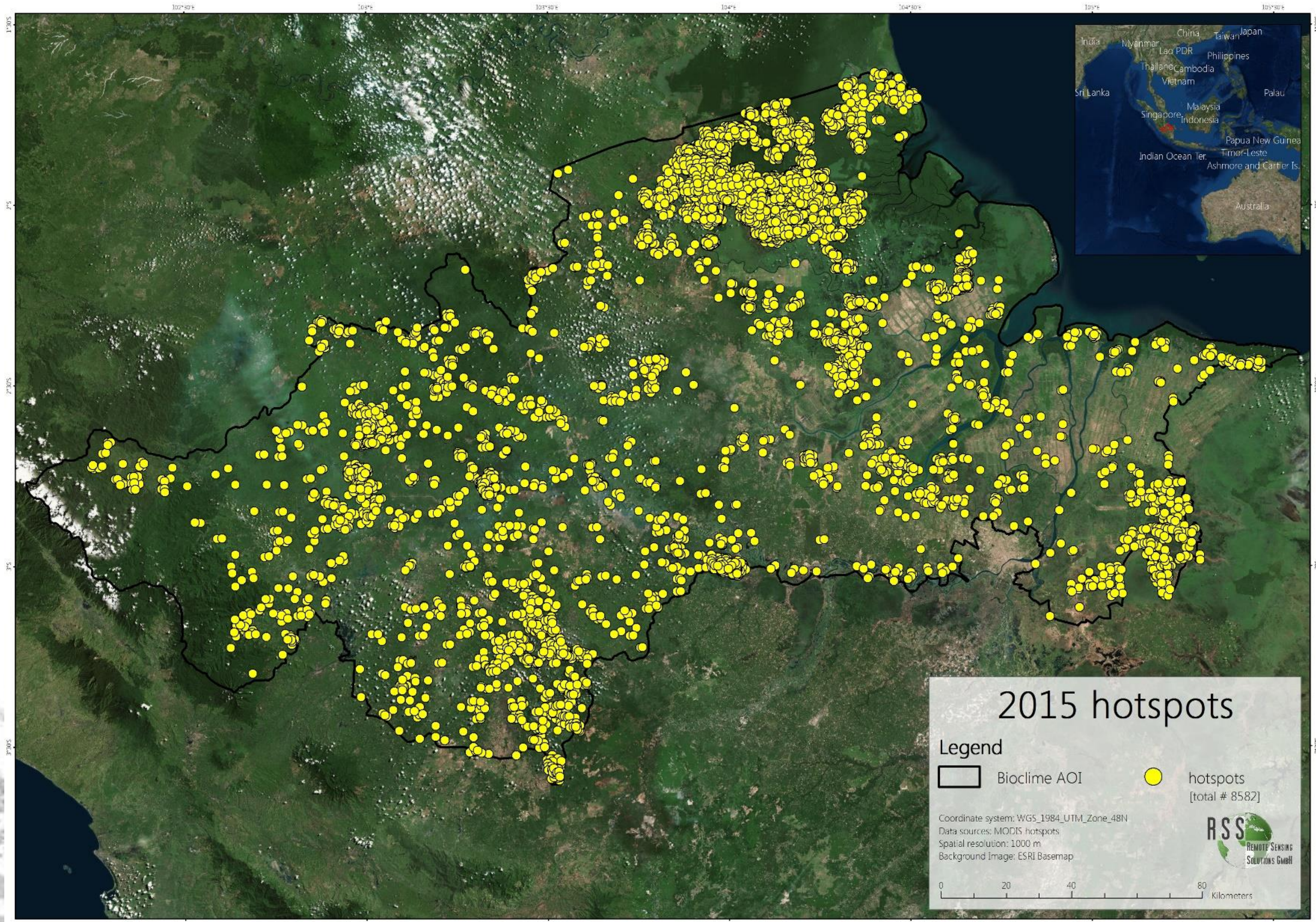


2014 hotspots
Legend
Bioclime AOI
hotspots
[total # 1755]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: MODIS hotspots
Spatial resolution: 1000 m
Background Image: ESRI Basemap
0
20
40
80
Kilometers
China
Taiwan
Japan
India
Myanmar
Lao PDR
Philippines
Thailand
Cambodia
Vietnam
Sri Lanka
Palau
Malaysia
Singapore
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia

1997-2014 frequency

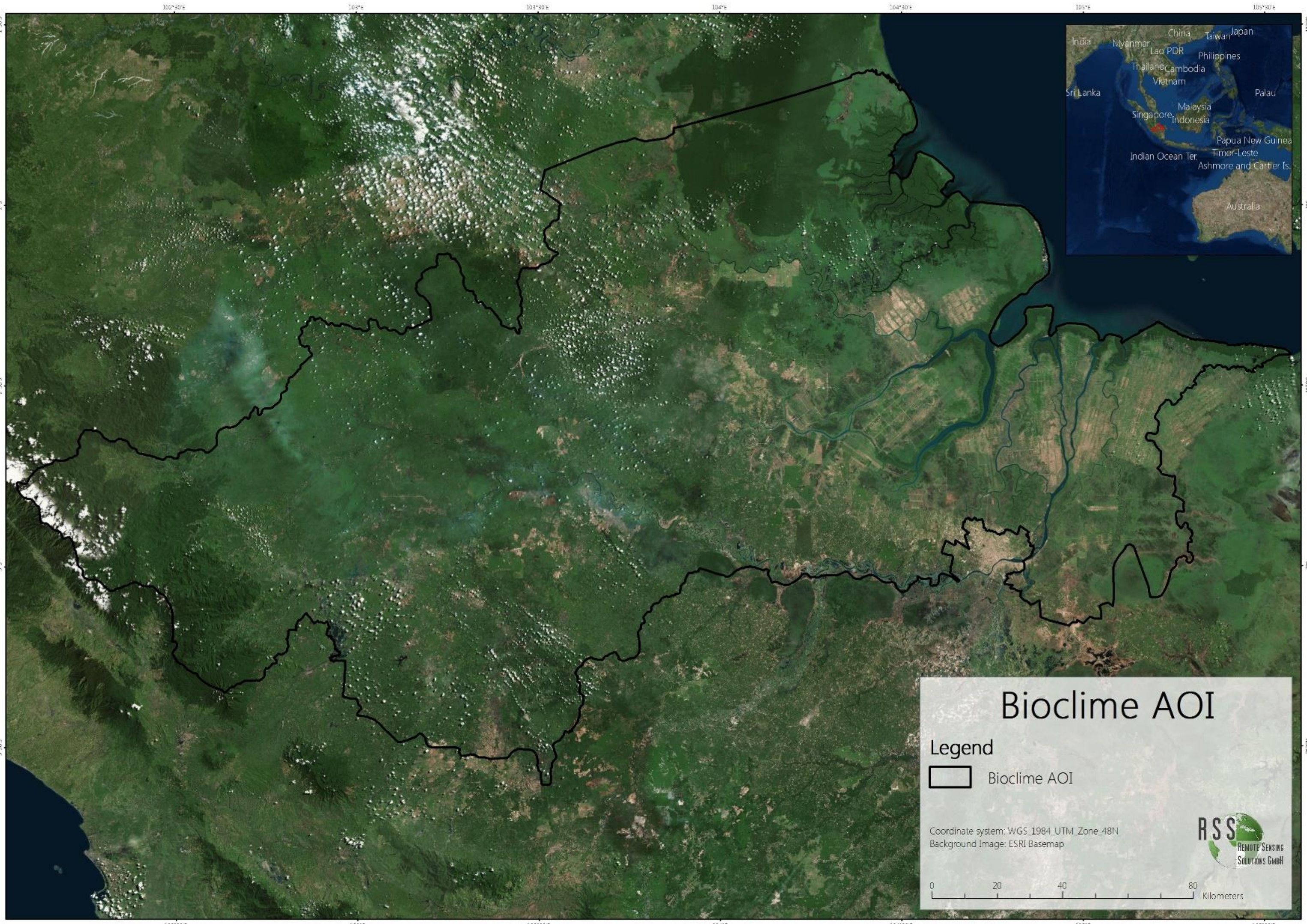


2015



India
Myanmar
China
Taiwan
Japan
Lao PDR
Philippines
Thailand
Cambodia
Vietnam
Sri Lanka
Palau
Malaysia
Singapore
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia
2015 hotspots
Legend
Bioclime AOI
hotspots
[total # 8582]
Coordinate system: WGS_1984_UTM_Zone_48N
Data sources: MODIS hotspots
Spatial resolution: 1000 m
Background Image: ESRI Basemap
0
20
40
80
Kilometers

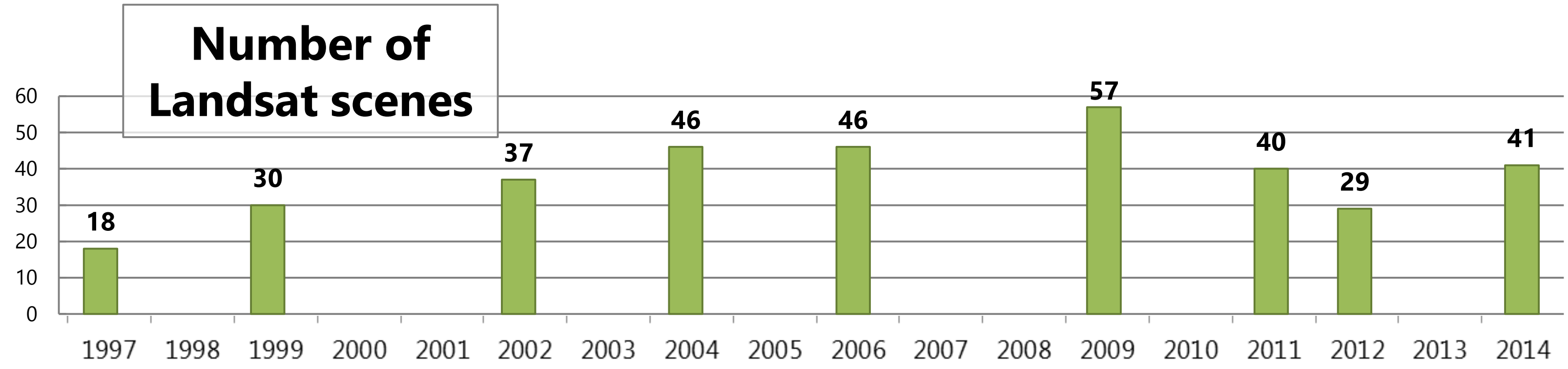
2015

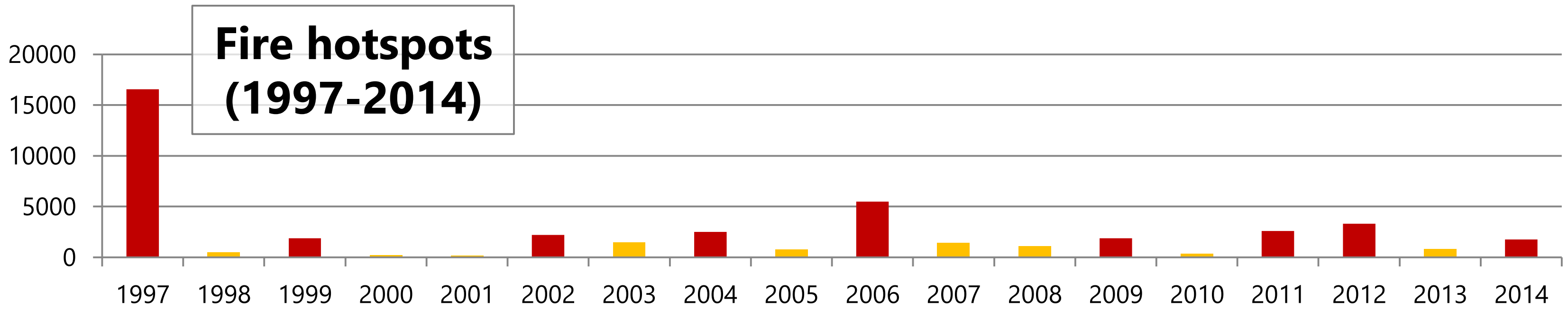

Bioclime AOI
Legend
Bioclime AOI
Coordinate system: WGS_1984_UTM_Zone_48N
Background Image: ESRI Basemap
0
20
40
80
Kilometers
India
Myanmar
China
Taiwan
Japan
Lao PDR
Philippines
Thailand
Cambodia
Vietnam
Sri Lanka
Palau
Malaysia
Singapore
Indonesia
Papua New Guinea
Indian Ocean Ter.
Timor-Leste
Ashmore and Cartier Is.
Australia

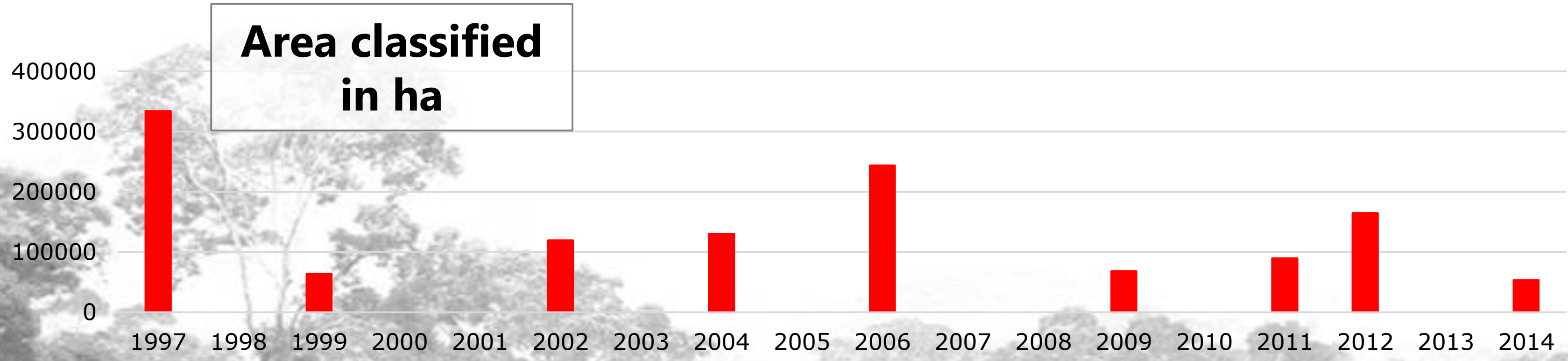
Summary of burned area

Year	No. Scenes	Hotspots	Total Area Burned [ha]
1997	18	16,573	334,340
1999	30	1,888	64,089
2002	37	2,216	119,442
2004	46	2,515	130,320
2006	46	5,494	243,922
2009	57	1,875	68,384
2011	40	2,592	89,499
2012	29	3,319	164,439
2014	41	1,755	53,557
2015	-	8,582	-

Overview

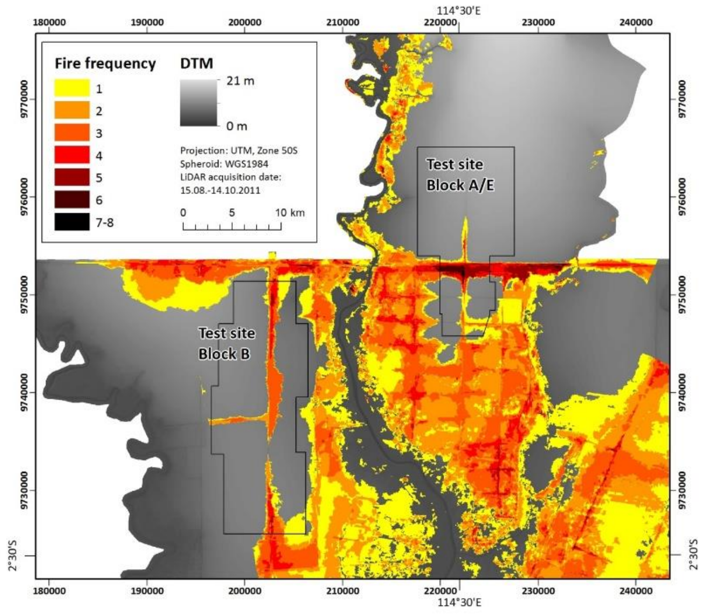

Number of Landsat scenes
60
50
40
30
20
10
0
18
30
37
46
46
57
40
29
41
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

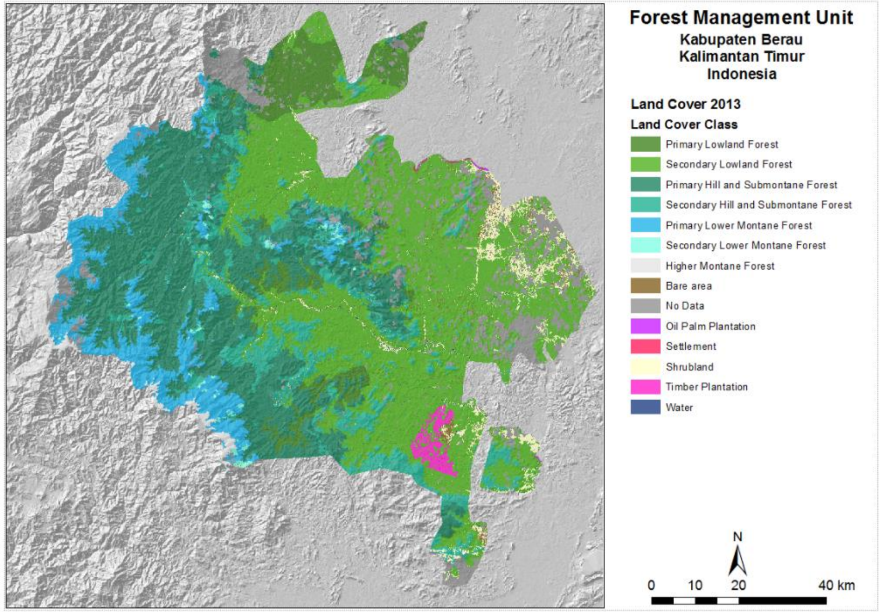

Fire hotspots (1997-2014)
20000
15000
10000
5000
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014


Area classified in ha
400000
300000
200000
100000
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

Next steps:
Determination of fire regime

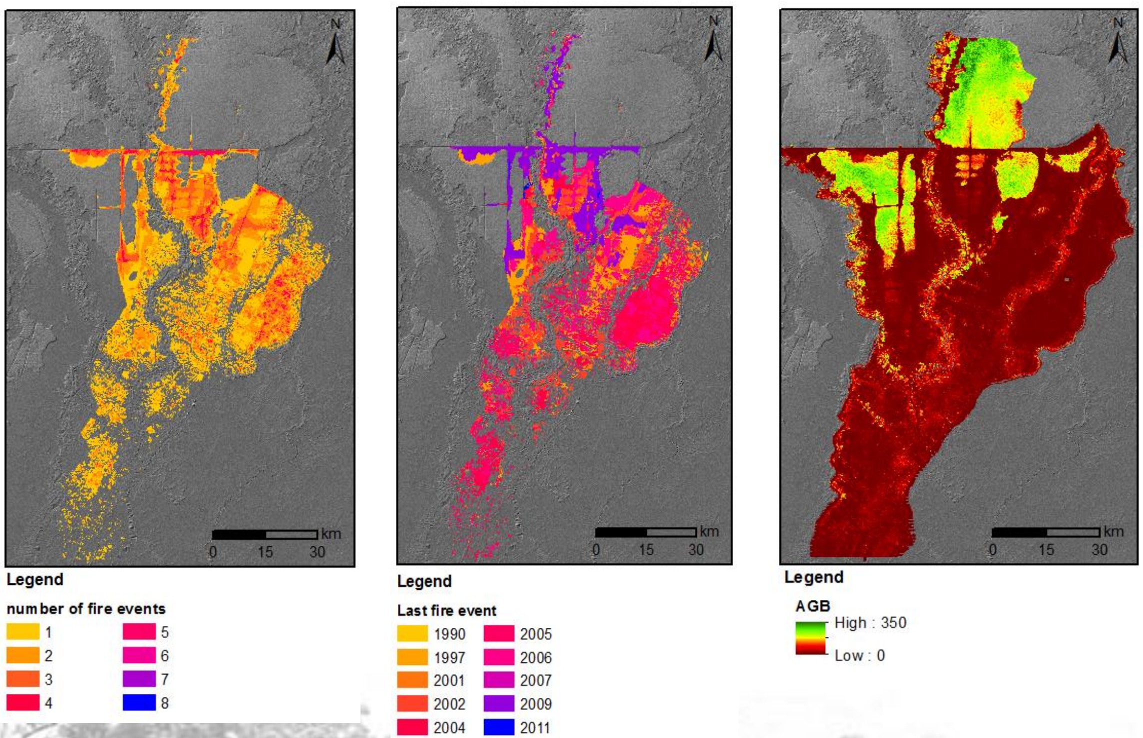
- Fire frequency: Cumulative merge and intersection of annual burned areas
- Pre-fire vegetation: Superimpose land cover classification and LiDAR dataset
- Annual burned area





Next steps:
Estimation of historic fire emissions

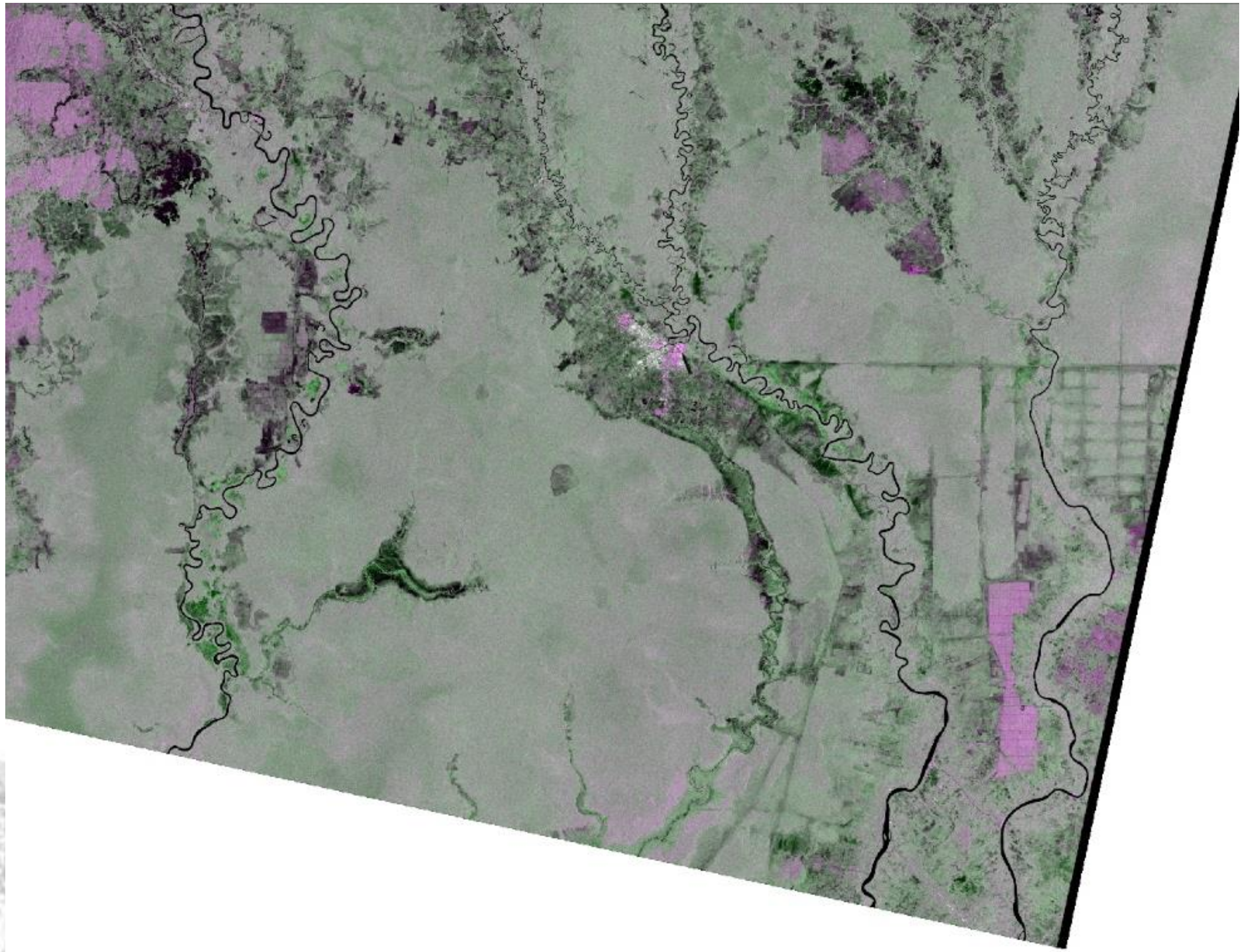
- Superimpose LiDAR derived AGB map with fire frequency
- Superimpose peat map (SSFFMP project)
- Calculate regional emissions from fire for different forest types, fire severity and fire frequencies



Next steps:
Update time series with 2015 data

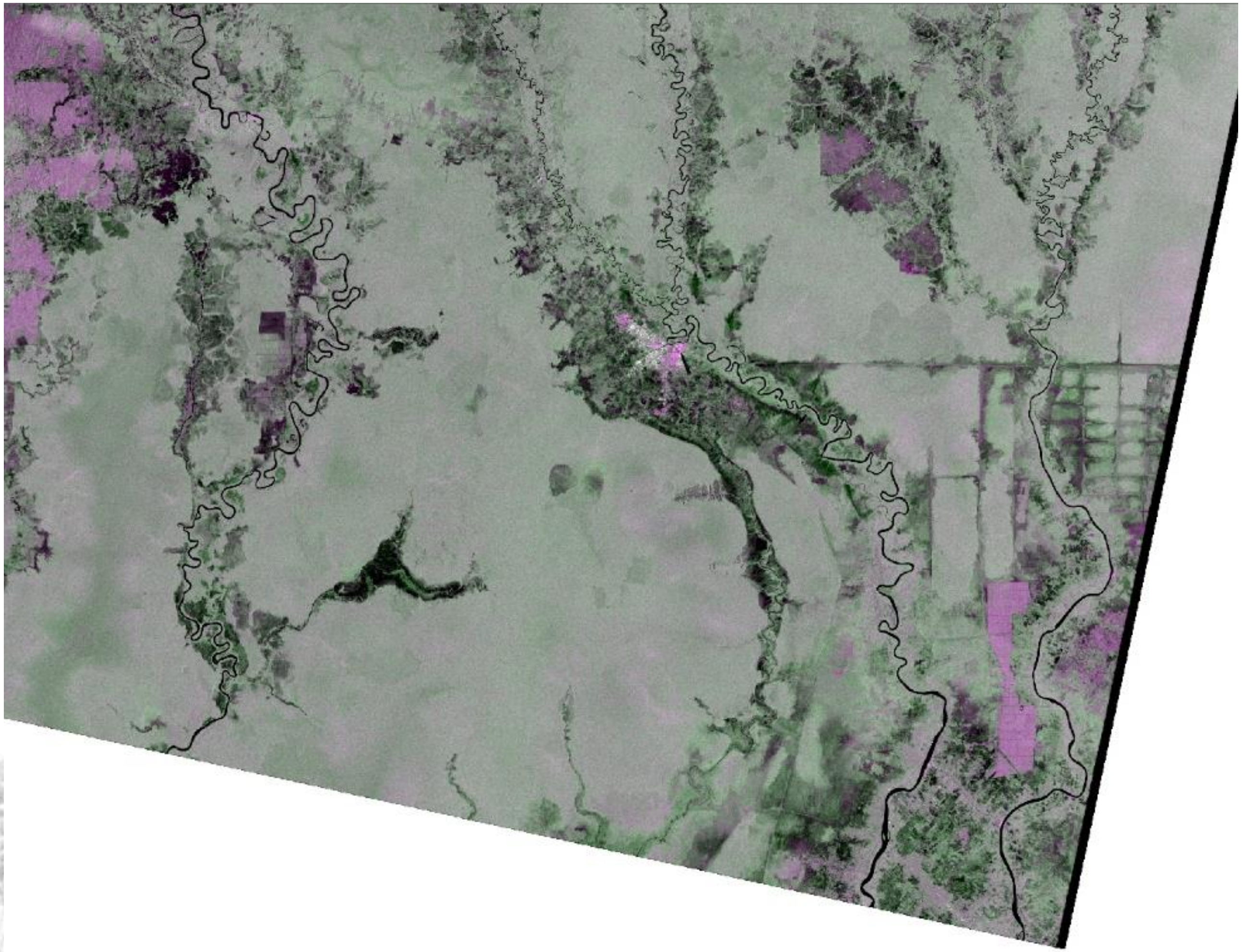
- Challenge: Dense haze cover in late fire season prevents/ hampers the use of optical satellite data
- Solution: Multitemporal Sentinel-1 RADAR data

Next steps:
Update time series with 2015 data



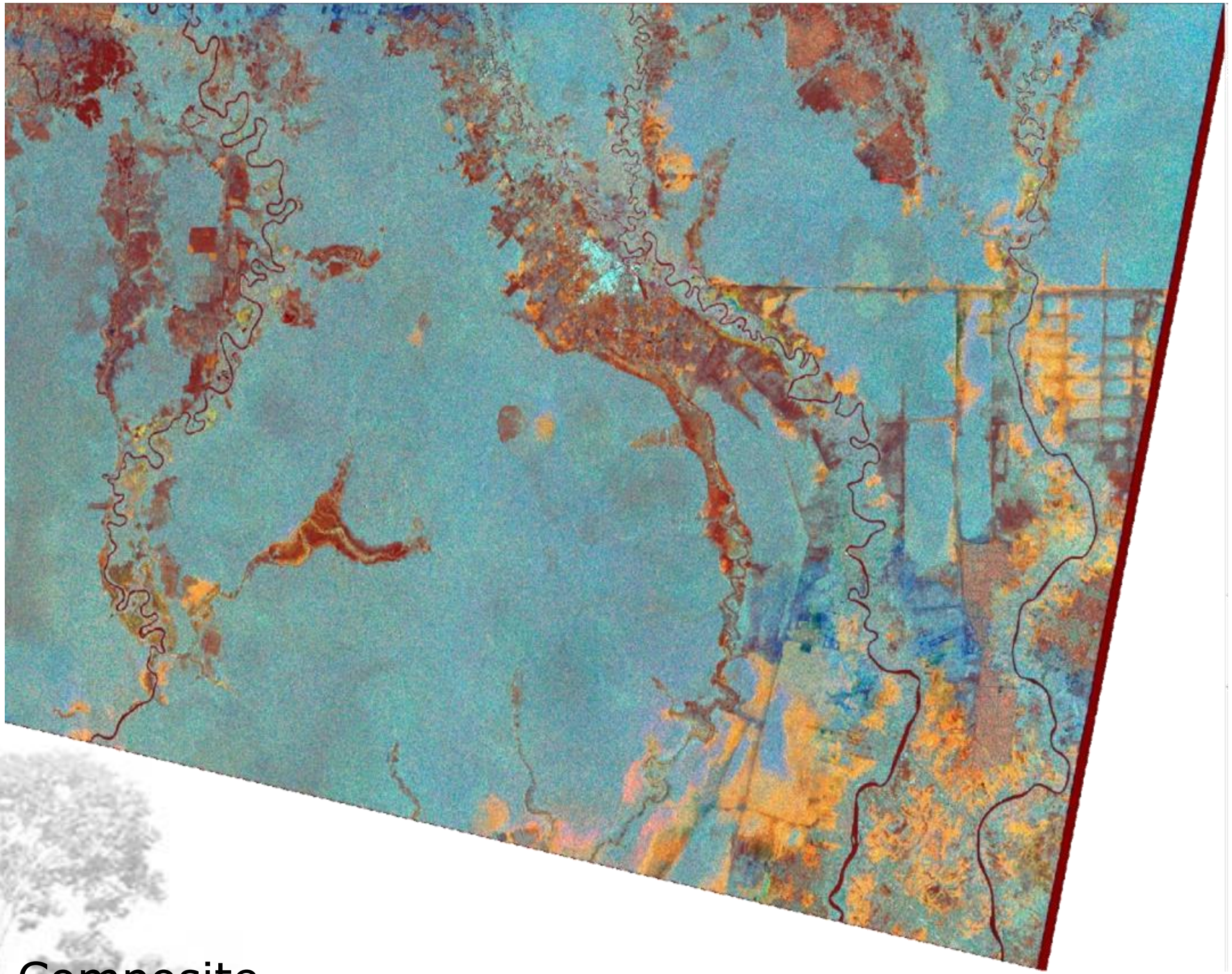
Sentinel-1 VH, VV
13.08.2015
Pre-fire scene

Next steps:
Update time series with 2015 data



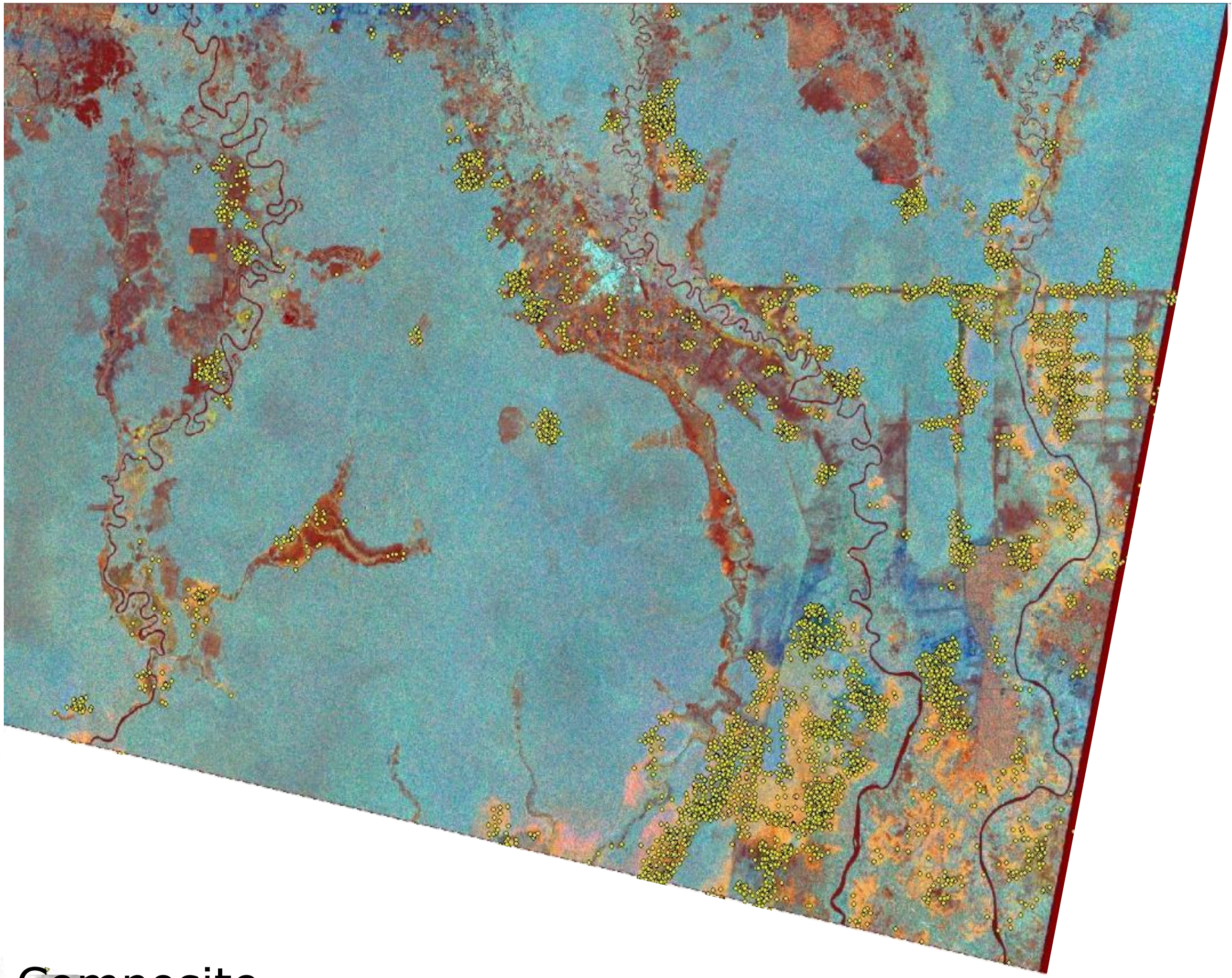
Sentinel-1 VH, VV
30.09.2015
Post-fire scene

Next steps:
Update time series with 2015 data

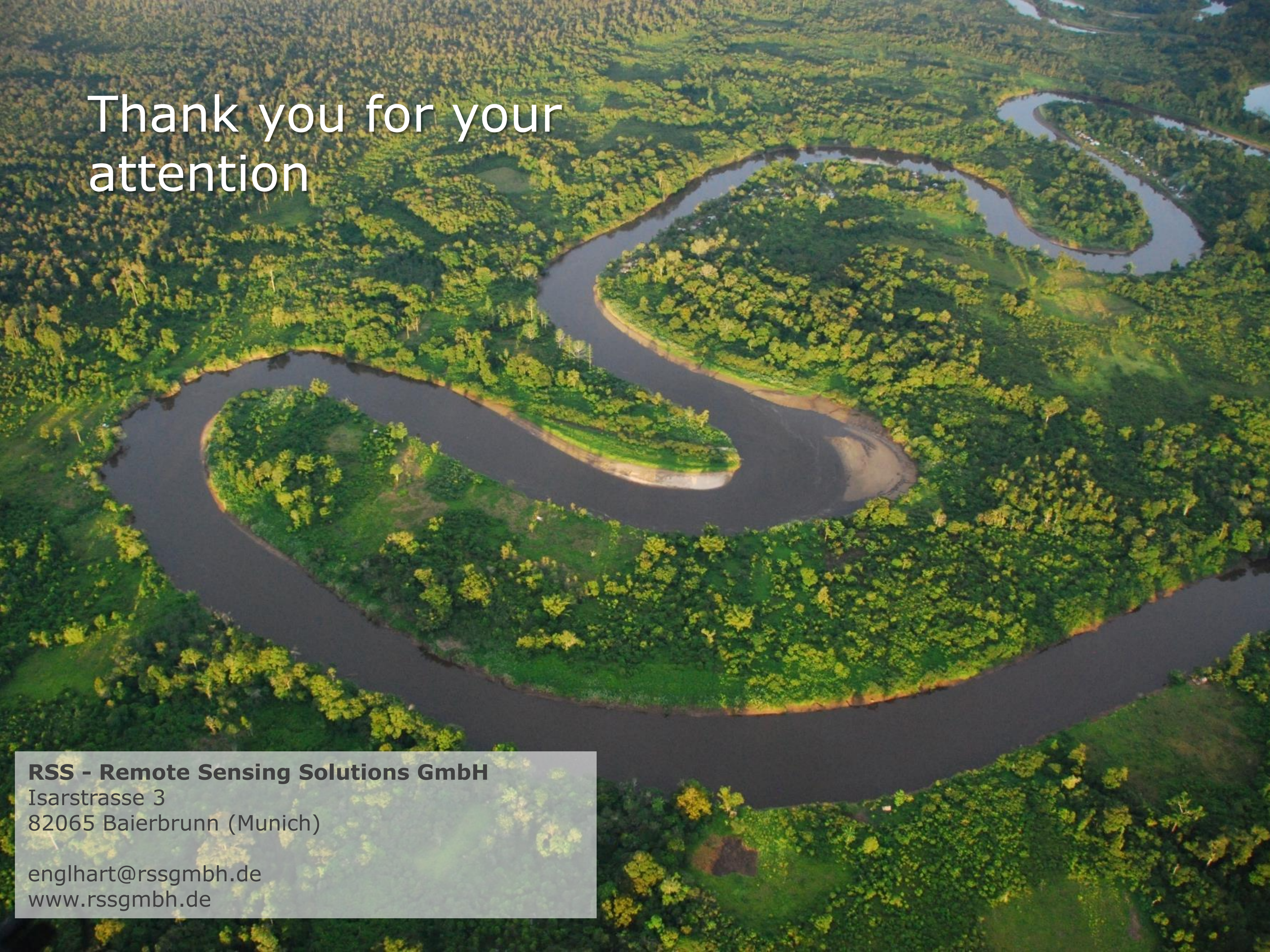


Sentinel-1 Composite
Pre-fire/post-fire/PCA

Next steps:
Update time series with 2015 data



Sentinel-1 Composite
Pre-fire/post-fire/PCA



Thank you for your attention

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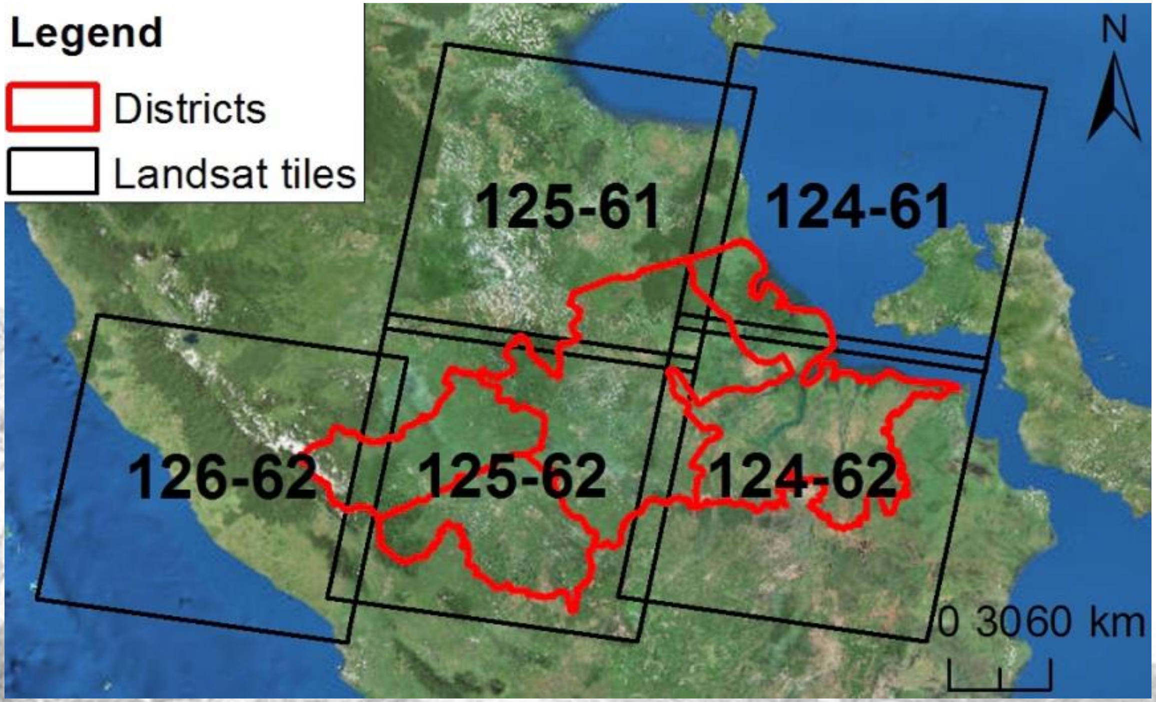
82065 Baierbrunn (Munich)

englhart@rssgmbh.de
www.rssgmbh.de

Historic component: Fire regime

Selection of Landsat data:

- For period of fire season until 2 months after
- Landsat-5, Landsat-7 and Landsat-8
- If not enough images: images before next fire season from following year will be considered



Historic component: Fire regime

Band ratios to be used:

BR1 = (b0.84µm - b11.45µm) / (b0.84µm + b11.45µm)

where b0.84µm is the reflectance value of Near Infrared (0.76-0.90 µm) and b11.45µm is the reflectance value of Thermal Infrared (10.4-12.5µm).

BR2 = (b0.84µm - b2.22µm) / (b0.84µm + b11.45µm)

where b0.84µm is the reflectance value of Near Infrared (0.76-0.90 µm), b2.22µm is the reflectance value of Mid-Infrared (2.08-2.35 µm) and b11.45µm is the reflectance value of Thermal Infrared (10.4-12.5µm).

NBR = (b0.84µm - b2.22µm)/(b0.84µm + b2.22µm)

where b0.84µm is the reflectance value of Near Infrared (0.76-0.90 µm) and b2.22µm is the reflectance value of Mid-Infrared (2.08-2.35 µm).

Historic component: Fire regime

Analysis of fire season of each year: