European Commission

Forest Degradation Monitoring by Crown Cover Disturbance Detection in Evergreen Forests

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Joint Research Centre

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Background to DeltaNBR

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Canopy Cover Disturbance Detection

Methodology (Background)

- Changes in canopy cover are monitored applying a ΔNBR approach using Landsat 8 or Sentinel-2 imagery
- Analysis within evergreen forest mask to avoid artifacts due to seasonality (leaf shedding)
- Recent openings in canopy cover (even sub-pixel scale) can be detected using the Normalized Burned Ratio (NBR)

1 $$NBR = \frac{NIR - SWIR_2}{NIR + SWIR_2}$$

- Atmospheric influences as well as other effects (e.g. sun incidence angle) can result in artifacts, which interfere with faint disturbance signals → Self-referencing
- Self-referencing restricts detection to small-scale openings → Larger gaps identified as deforestation restricts detection to small-scale openings

2 $$NBR_{self\text{-}referenced} = NBR - NBR_{n\_median}$$

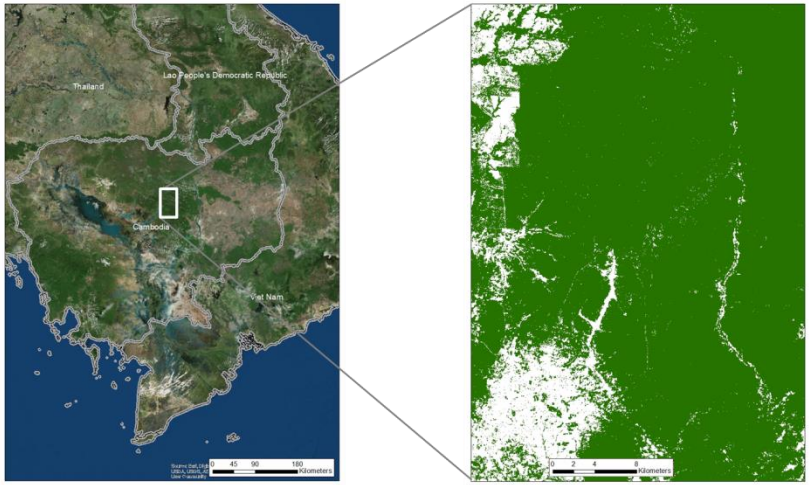
Choice of Median filter kernel (radius of n pixel)depends on spatial resolution of satellite (Landsat: 7pixel; Sentinel: 21pixel)

- Normalization allows comparison of disturbance levels

3 $$\Delta NBR = NBR_{self\text{-}referenced\_time1} - NBR_{self\text{-}referenced\_time2}$$

→ Monitoring based on crown cover closure change detection
→ Differentiation from naturally open crown cover possible

- Up to this point no thresholds applied → Continuous disturbance value finally translated into disturbance info



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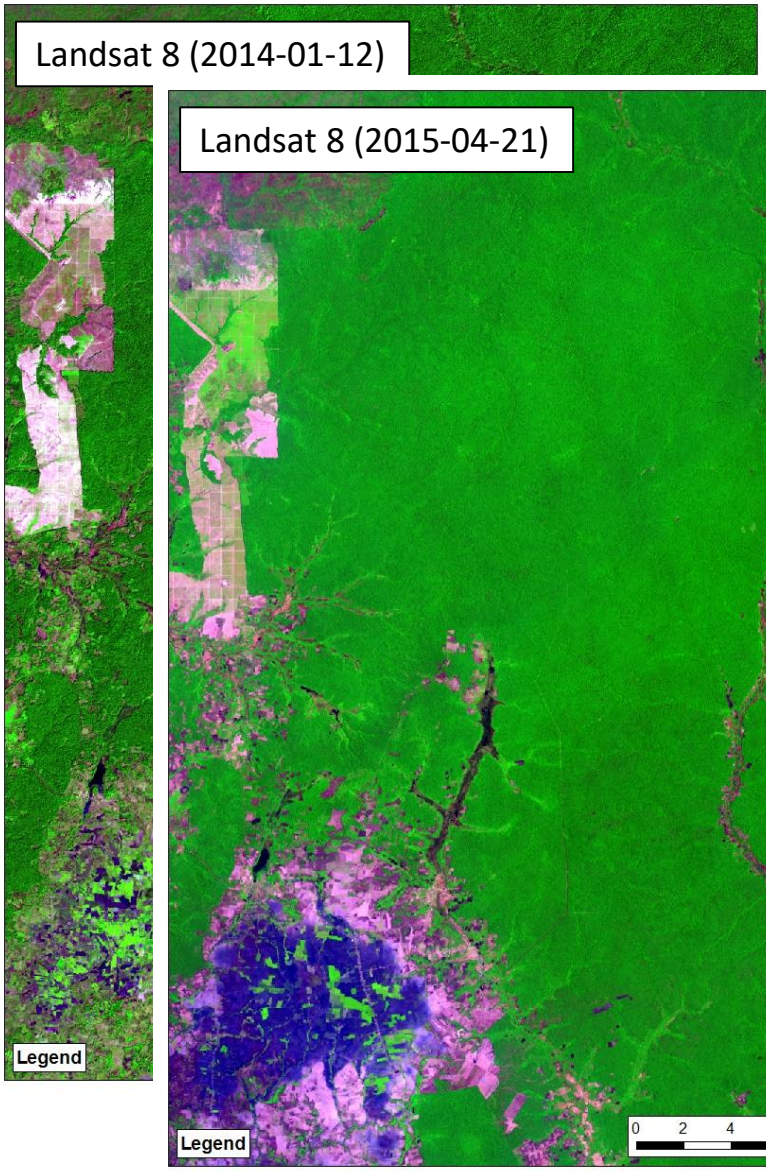
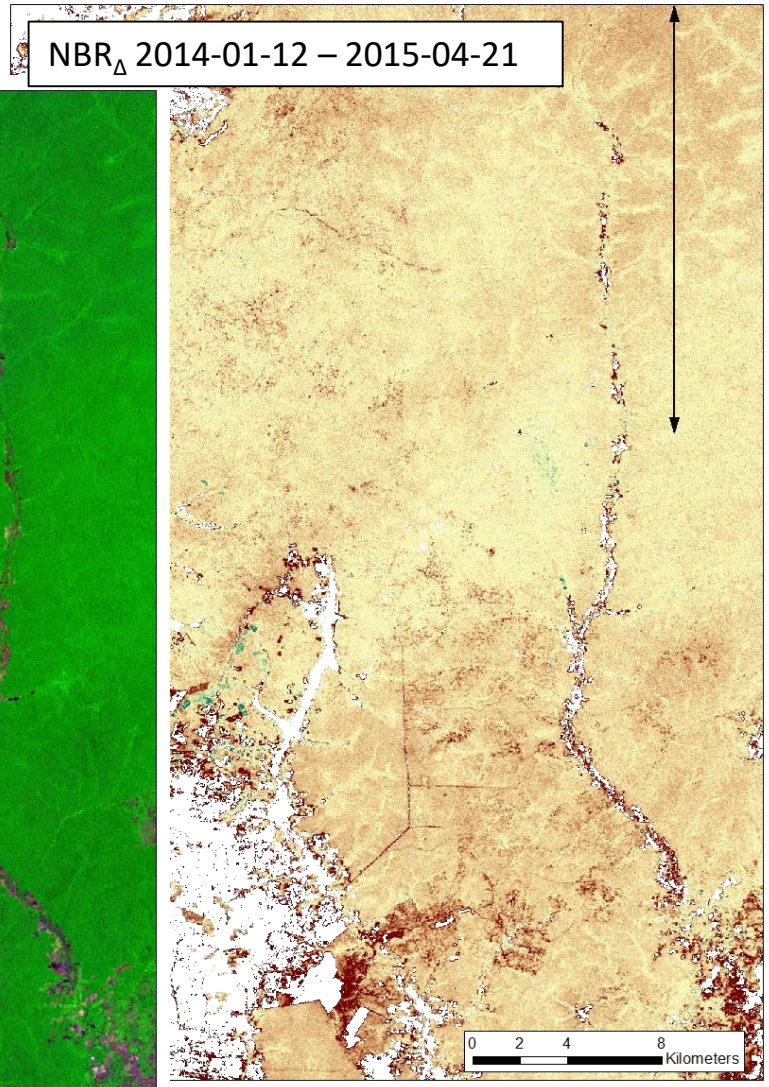
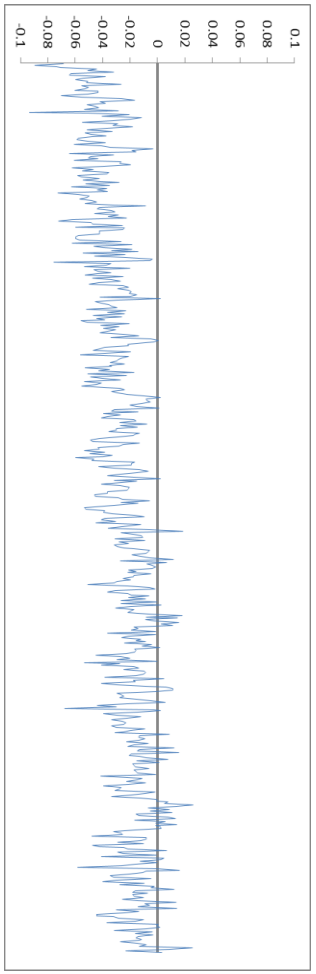
Crown Cover Disturbance Detection – Self-Normalization





Transect



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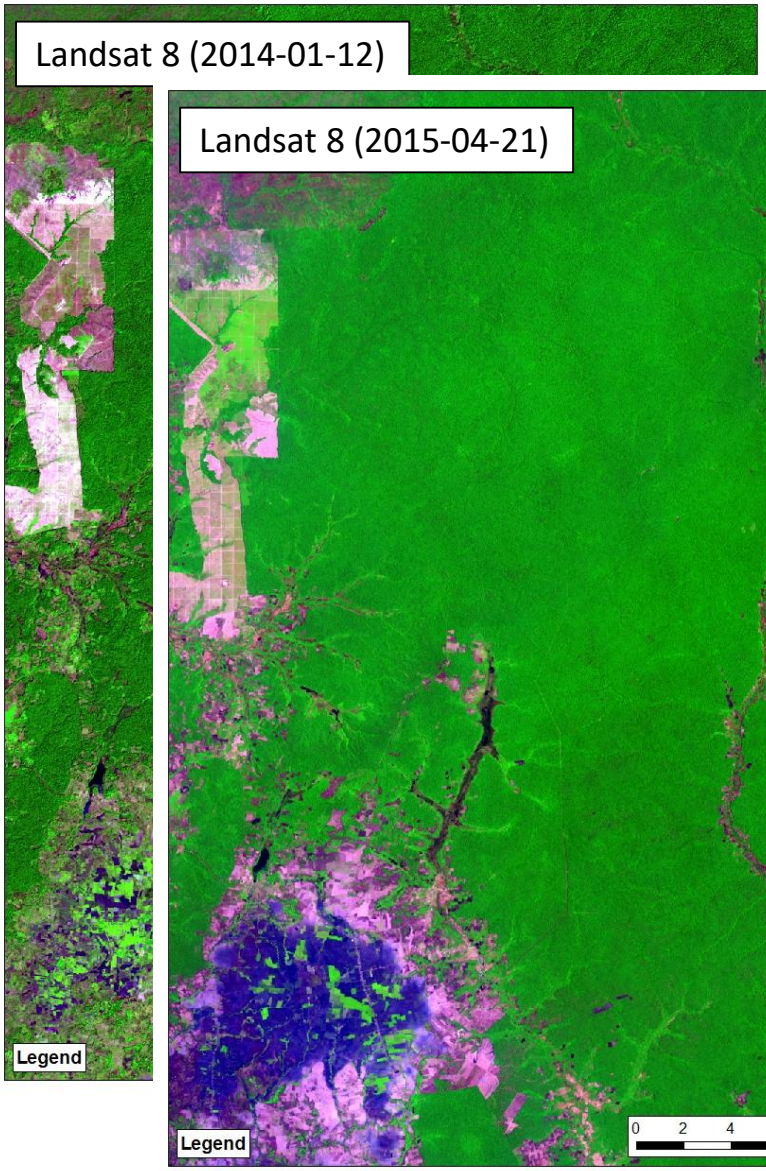
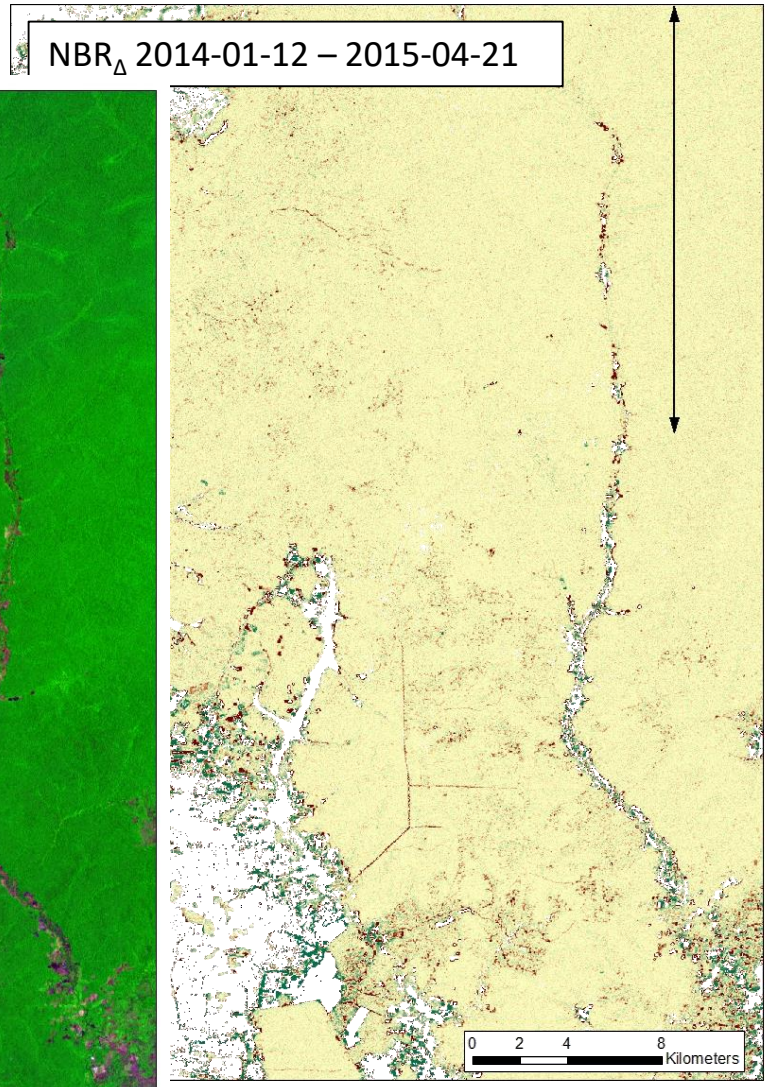
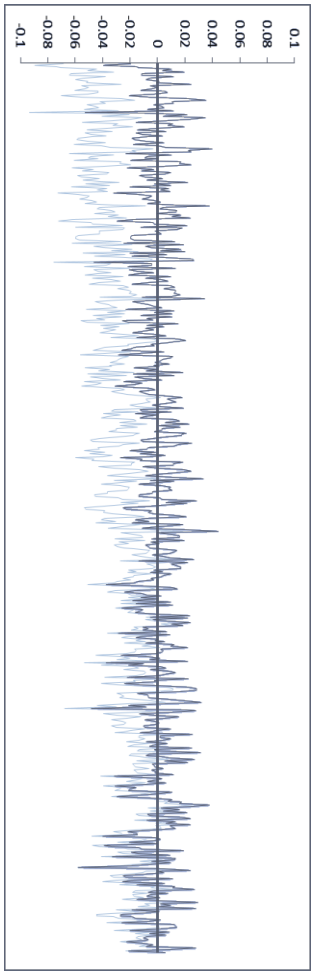
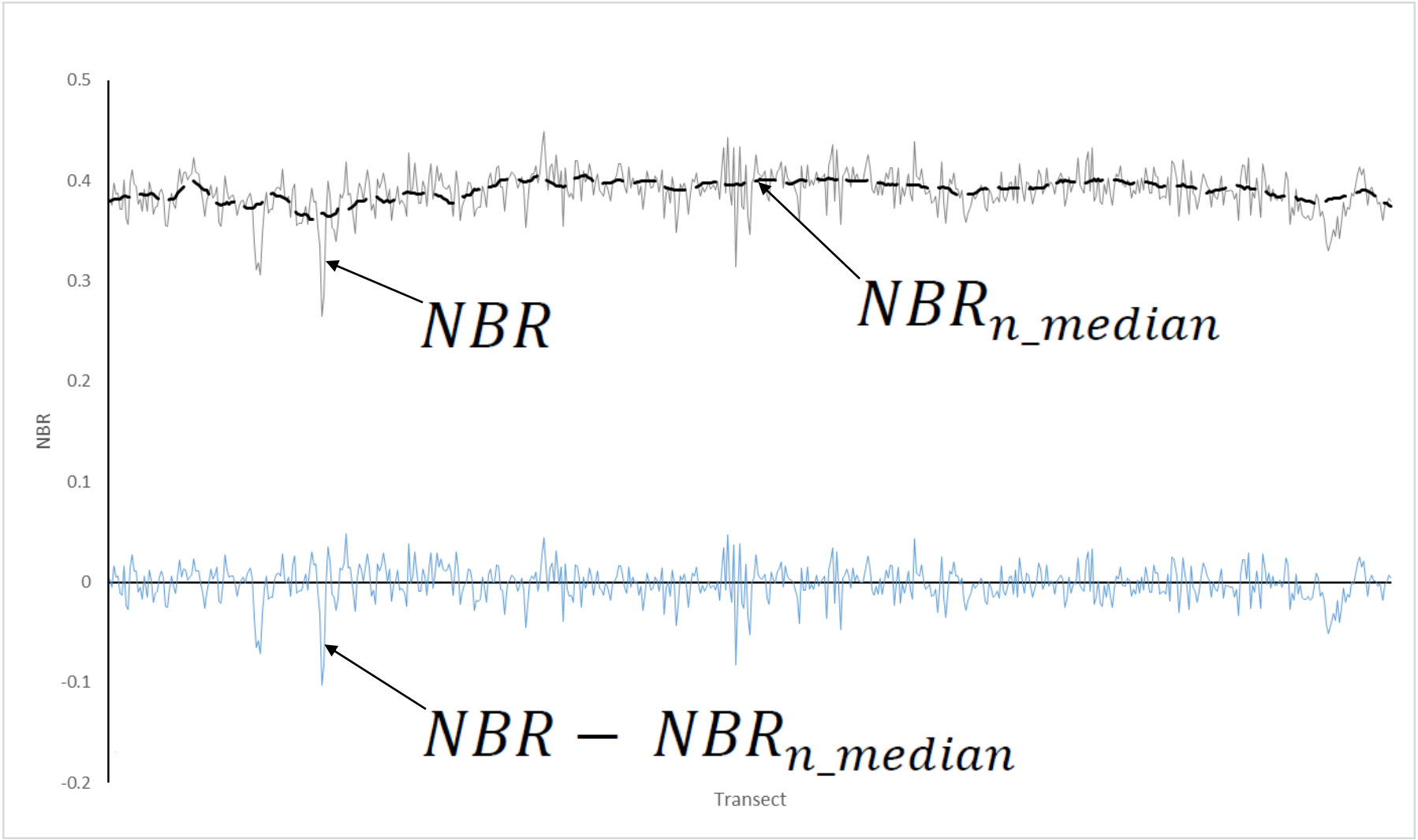






Crown Cover Disturbance Detection – Self-Normalization



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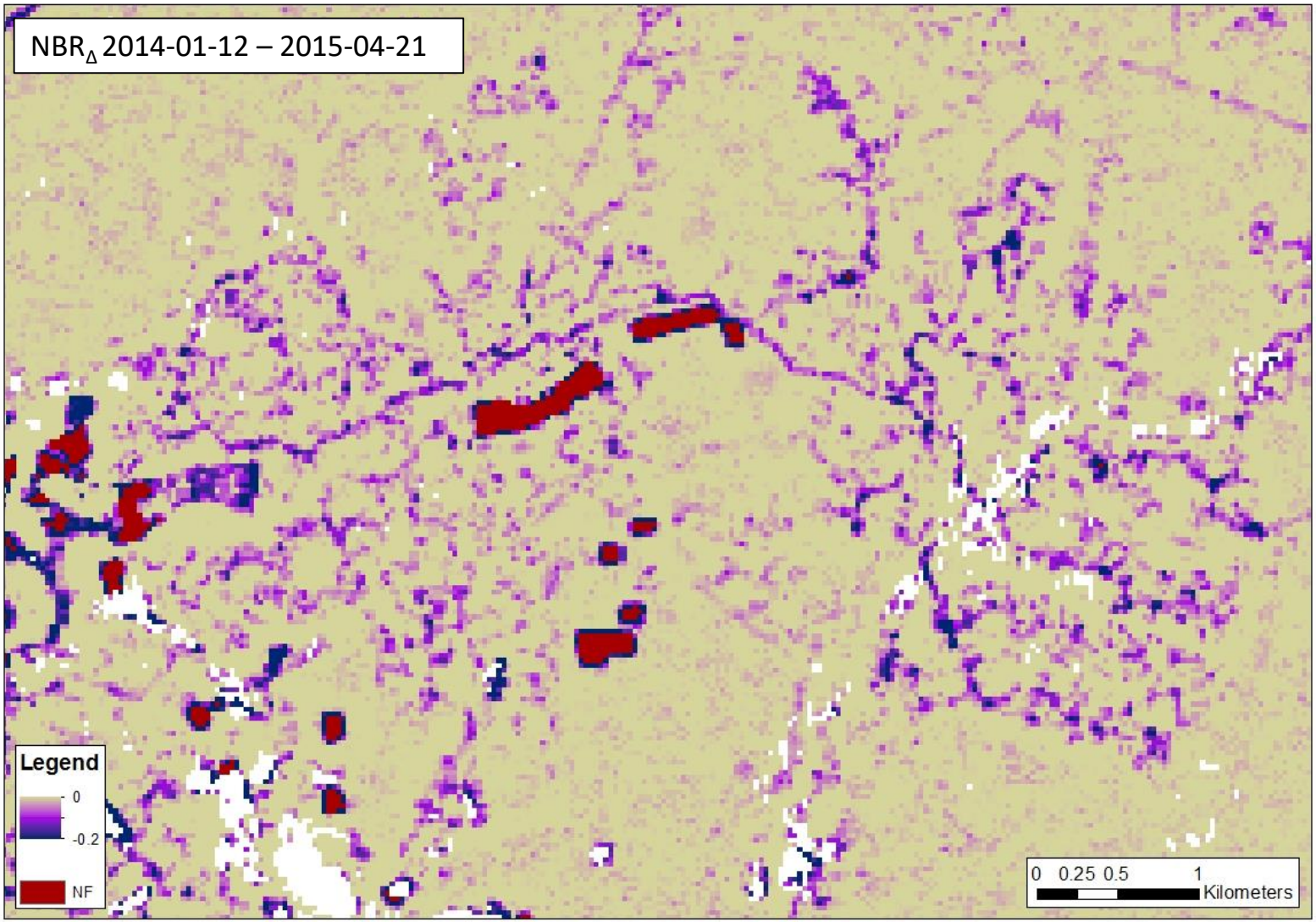
Crown Cover Disturbance Detection



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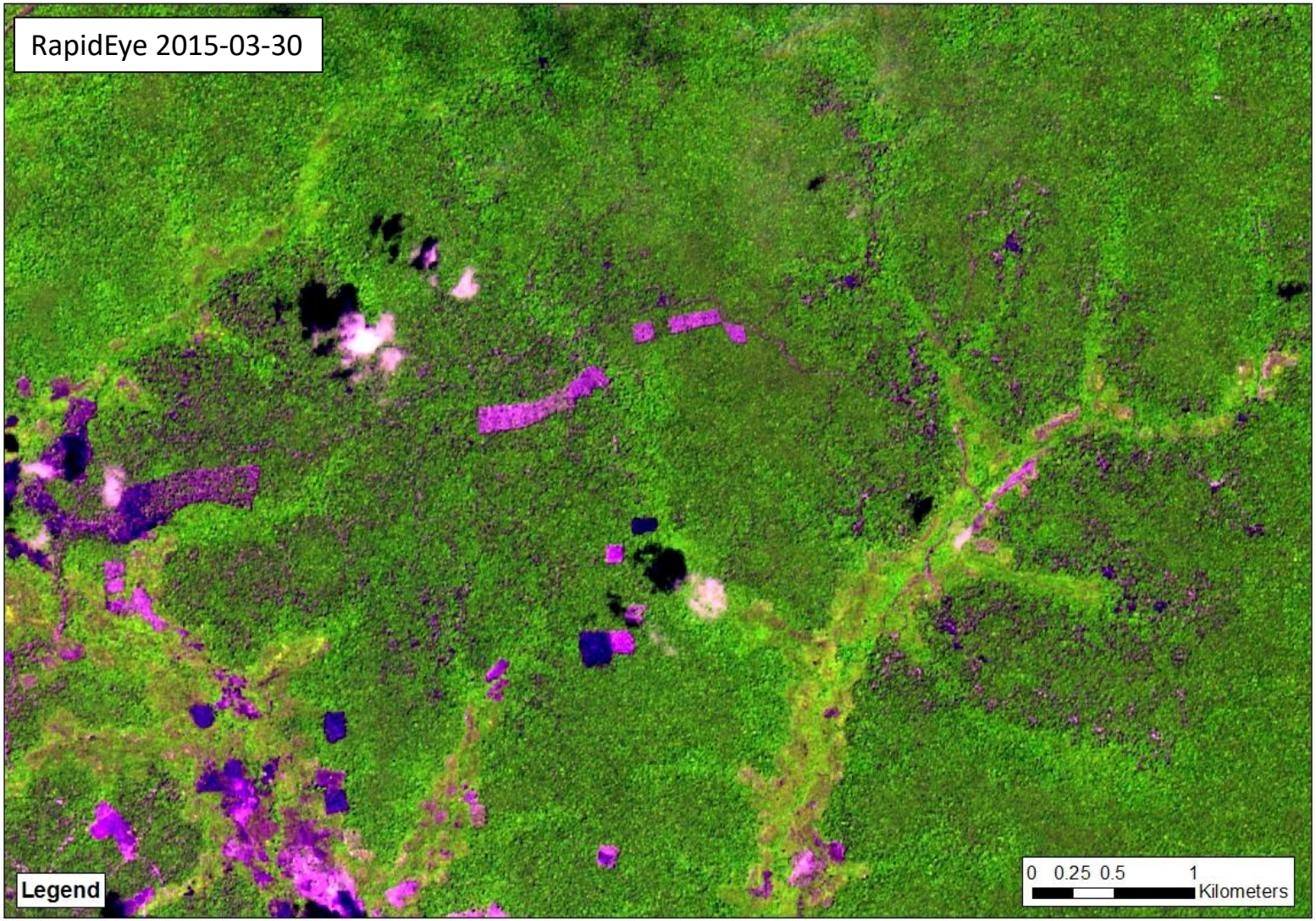
Crown Cover Disturbance Detection



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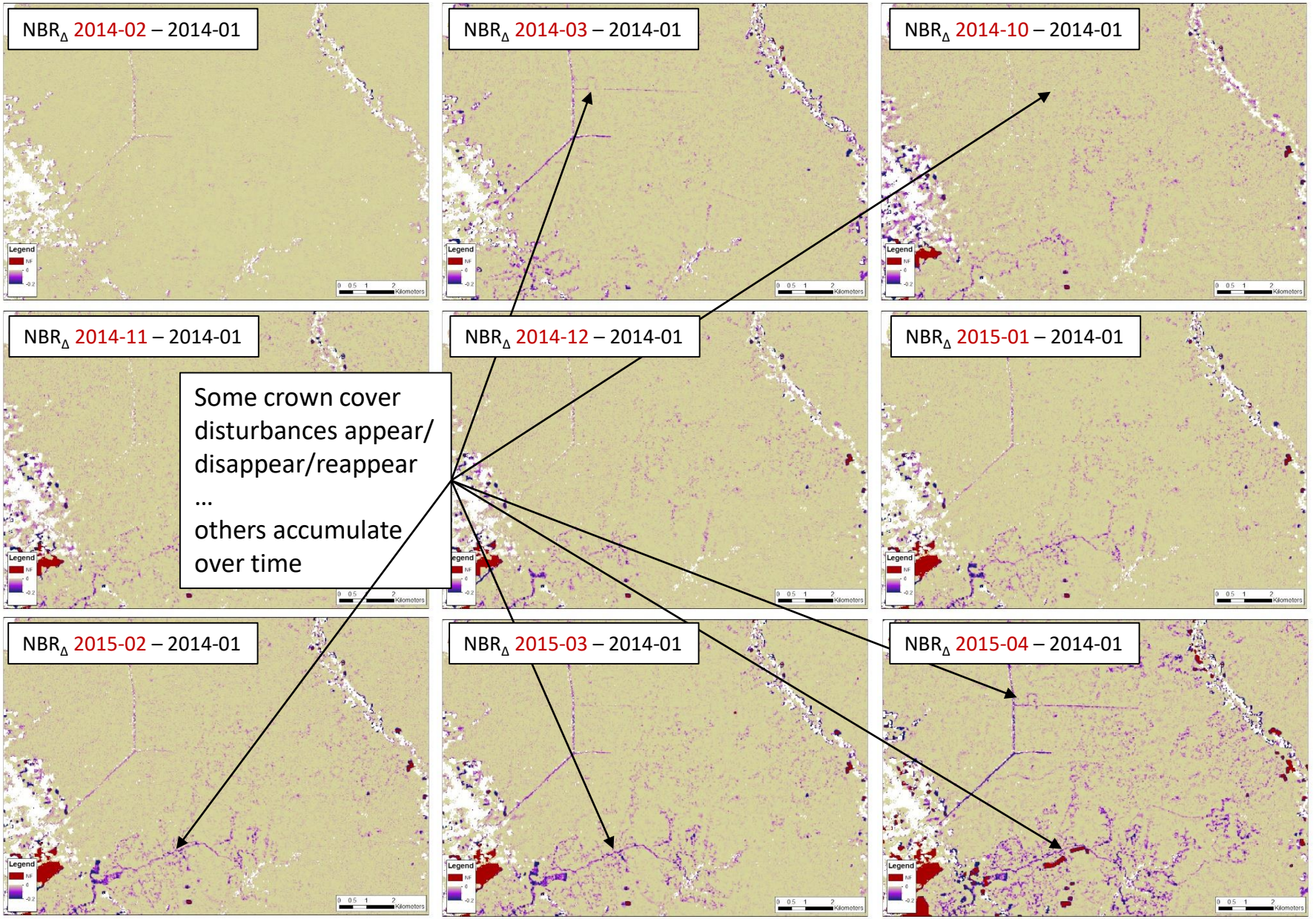

NBR$_\Delta$ 2014-02 – 2014-01
NBR$_\Delta$ 2014-03 – 2014-01
NBR$_\Delta$ 2014-10 – 2014-01
NBR$_\Delta$ 2014-11 – 2014-01
NBR$_\Delta$ 2014-12 – 2014-01
NBR$_\Delta$ 2015-01 – 2014-01
NBR$_\Delta$ 2015-02 – 2014-01
NBR$_\Delta$ 2015-03 – 2014-01
NBR$_\Delta$ 2015-04 – 2014-01
Some crown cover disturbances appear/ disappear/reappear
…
others accumulate over time

Crown Cover Disturbance Detection – Operational

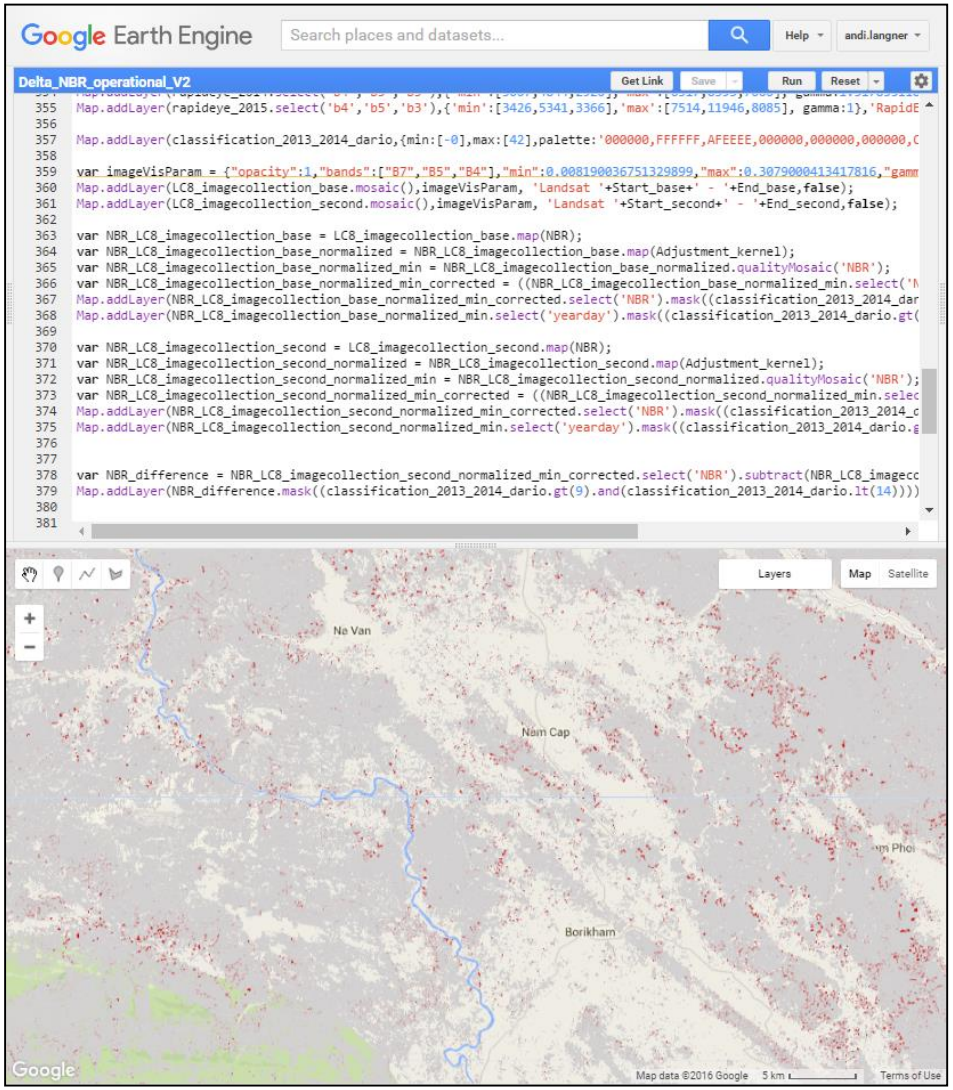
Methodology (Operational Application – GEE script)

- Using Evergreen forest mask for SE-Asia (*Roadless project*)
- Cloud masking (*Fmask*)
- Accumulation of all crown cover openings over certain period (e.g. over 1 year; length can be modified) (Methodology: *Max of disturbance events per pixel-location over time period*)
- Comparison with accumulated differences of second time period (1 year; length can be modified)

  → Automatic collection of changes in crown cover closure between defined time periods

- GEE cloud-computing abilities
  → Quick processing times
  → Deriving seamless large-scale datasets (e.g. country-wide)
  → Deriving time-series datasets (e.g. every year) (combining Landsat 5, 7 and 8)

- No user interaction during processing
  → Transparent + reproducible results



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Overview of GEE Script

… and some further 800+ lines

User-defined variables (user interaction)

(Investigation periods, study area, sensor types, …)

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step (1- to 0)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

User-Defined Variables

```
20 // ********************************************************************************************************************************************************
21 // Definition of variables that can be modified by the user ***********************************************************************************************
22 // ********************************************************************************************************************************************************
23
24 // Investigation periods (enter in format 'yyy-mm-dd')
25 var Start_base = '2014-01-01';
26 var End_base = '2014-12-31';
27 var Start_second = '2015-01-01';
28 var End_second = '2015-12-31';
29
30 // Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
31 var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white
32                    // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated w
33                    // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
34                    // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
35                    // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
36                    // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
37 var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
38 var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing
39
40 // Geographic area to be investigated (e.g. by loading any other geometry)
41 var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
42 // var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border
43 var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)
44
45 var center = 0; // Type '1' to automatically center on study area
46
47 // Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
48 var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
49 var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
50 var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
51 var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
52 var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)
53
54 // Here the forest masks and their 'forest thresholds' are selected
55 var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen
56 var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
57 var hansen_treecover = 70; // Possible values:  0 - 100
58
59 // Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
60 var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delive
61                        // however value can be adjusted)
62
63 // Here variables regarding a possible disturbance-density-related filtering are selected
64 var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cl
65 var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (r
66 var kernel_clean_size = 45; // Kernel (circular) radius size in meters for the disturbance density related cleaning
67 var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel
68
69 // Here the option of an export of the results is selected
70 var export_select = 'No'; // Options: 'Yes'; 'No'
71   var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
72   var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''
73
74 // ********************************************************************************************************************************************************
75 // End of the section that can be modified by the user ****************************************************************************************************
76 // ********************************************************************************************************************************************************
```

Investigation periods

Sensor types

Study area

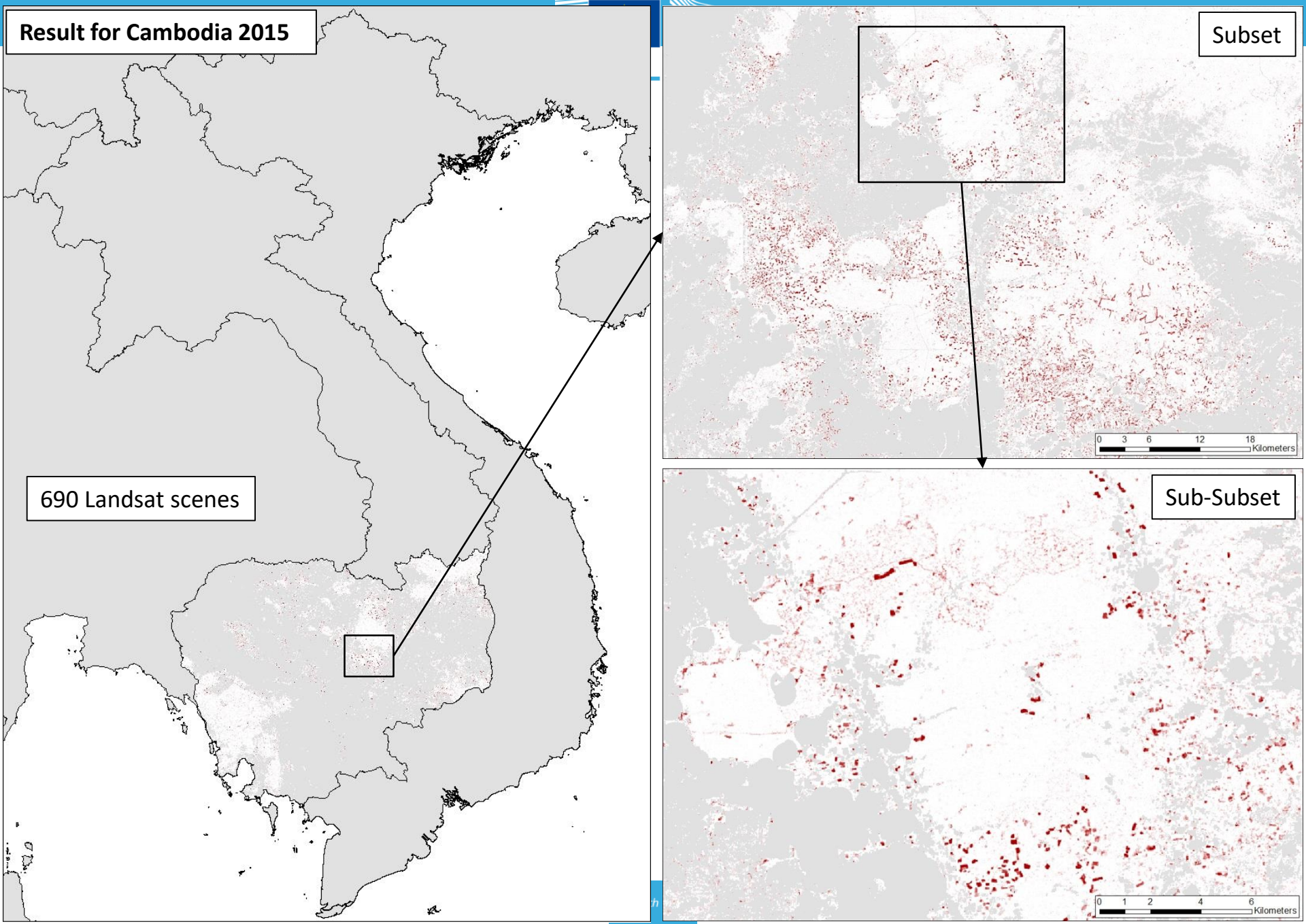
Cloud masking

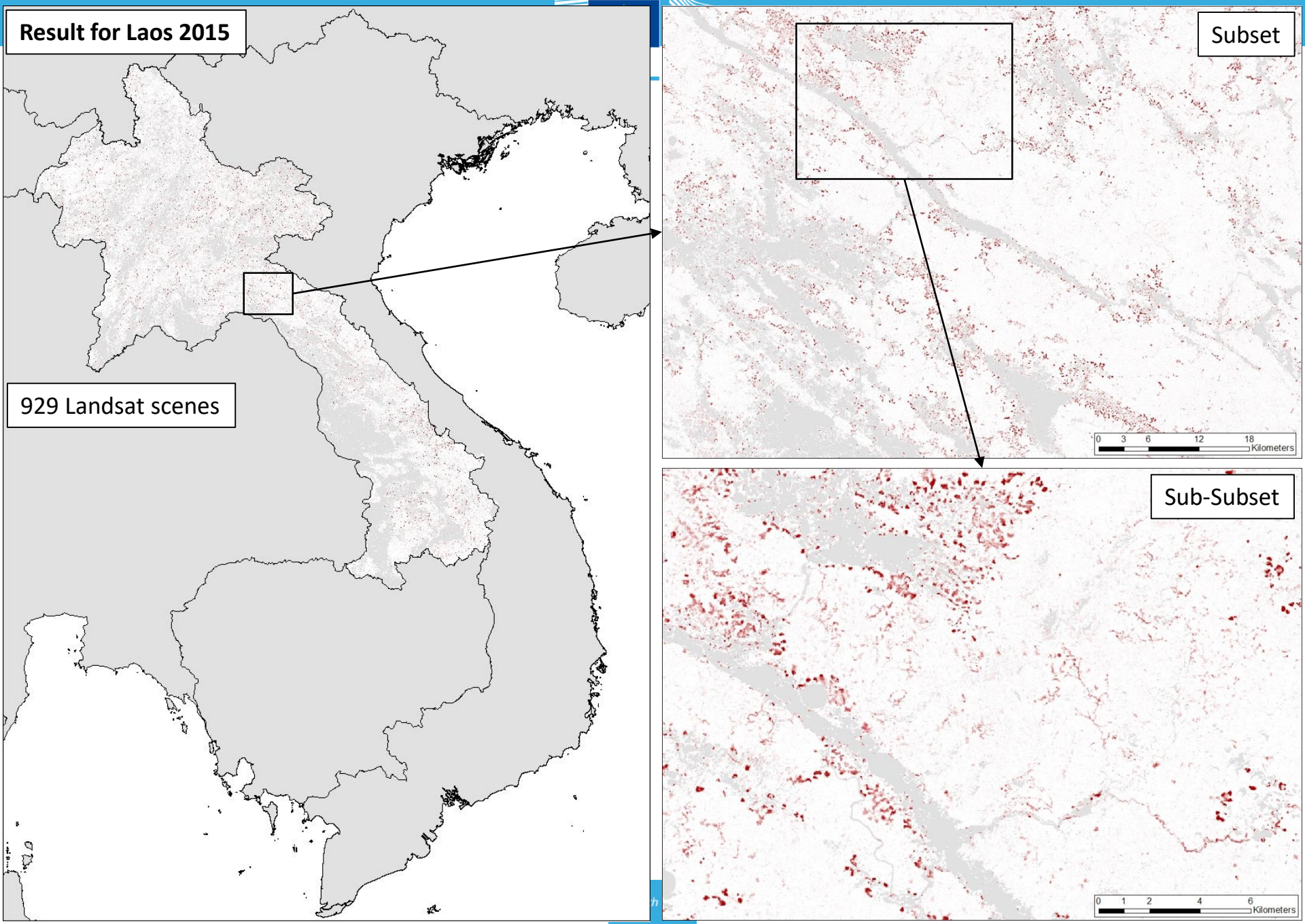
Forest masking

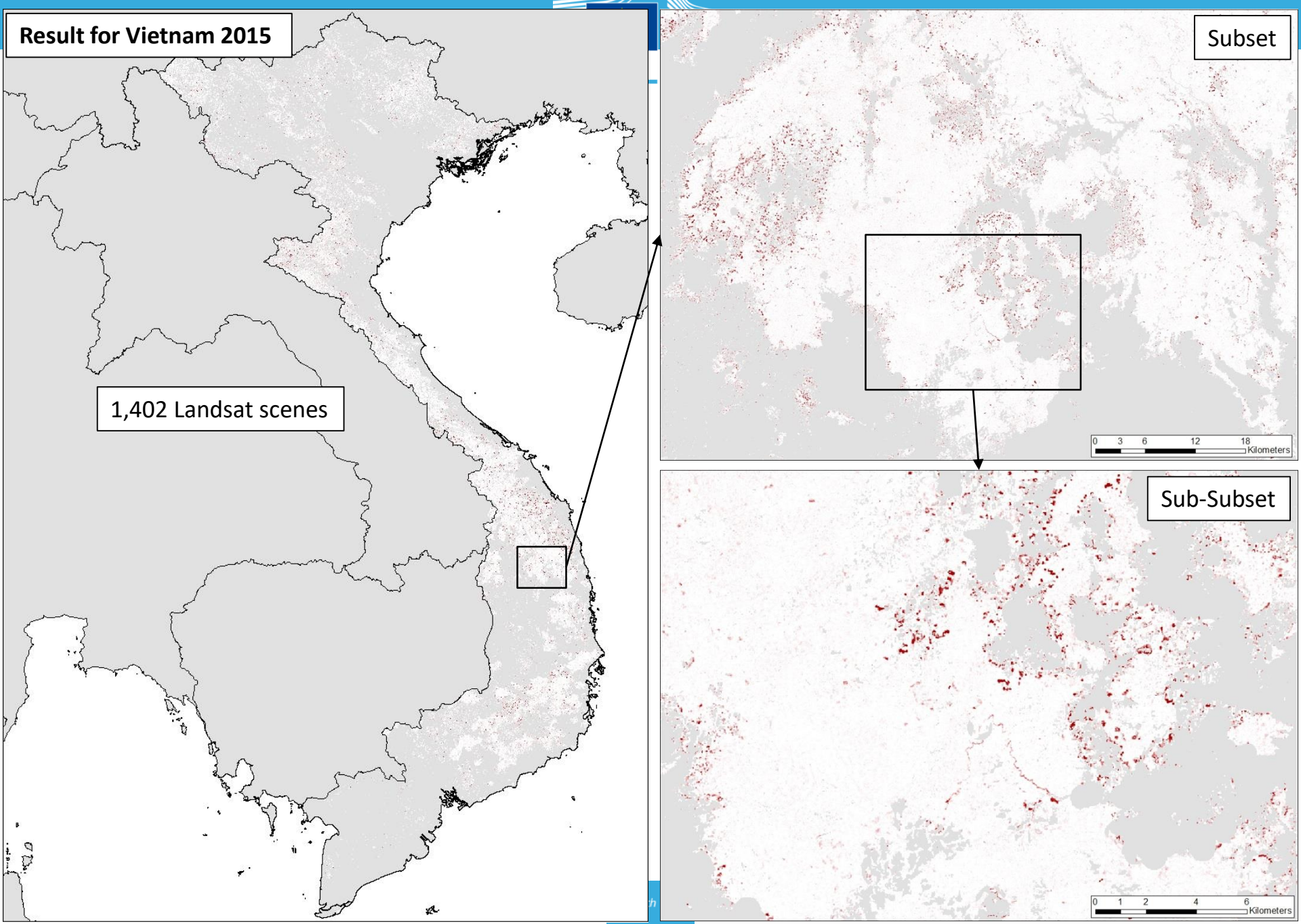
Self-referencing

(Disturbance-density-related) filtering

Export option


Result for Cambodia 2015
690 Landsat scenes
Subset
0 3 6 12 18
Kilometers
Sub-Subset
0 1 2 4 6
Kilometers

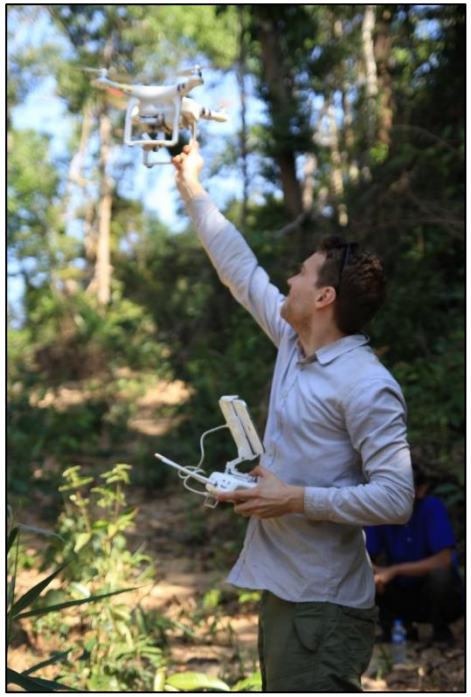

Result for Laos 2015
929 Landsat scenes
Subset
0 3 6 12 18 Kilometers
Sub-Subset
0 1 2 4 6 Kilometers

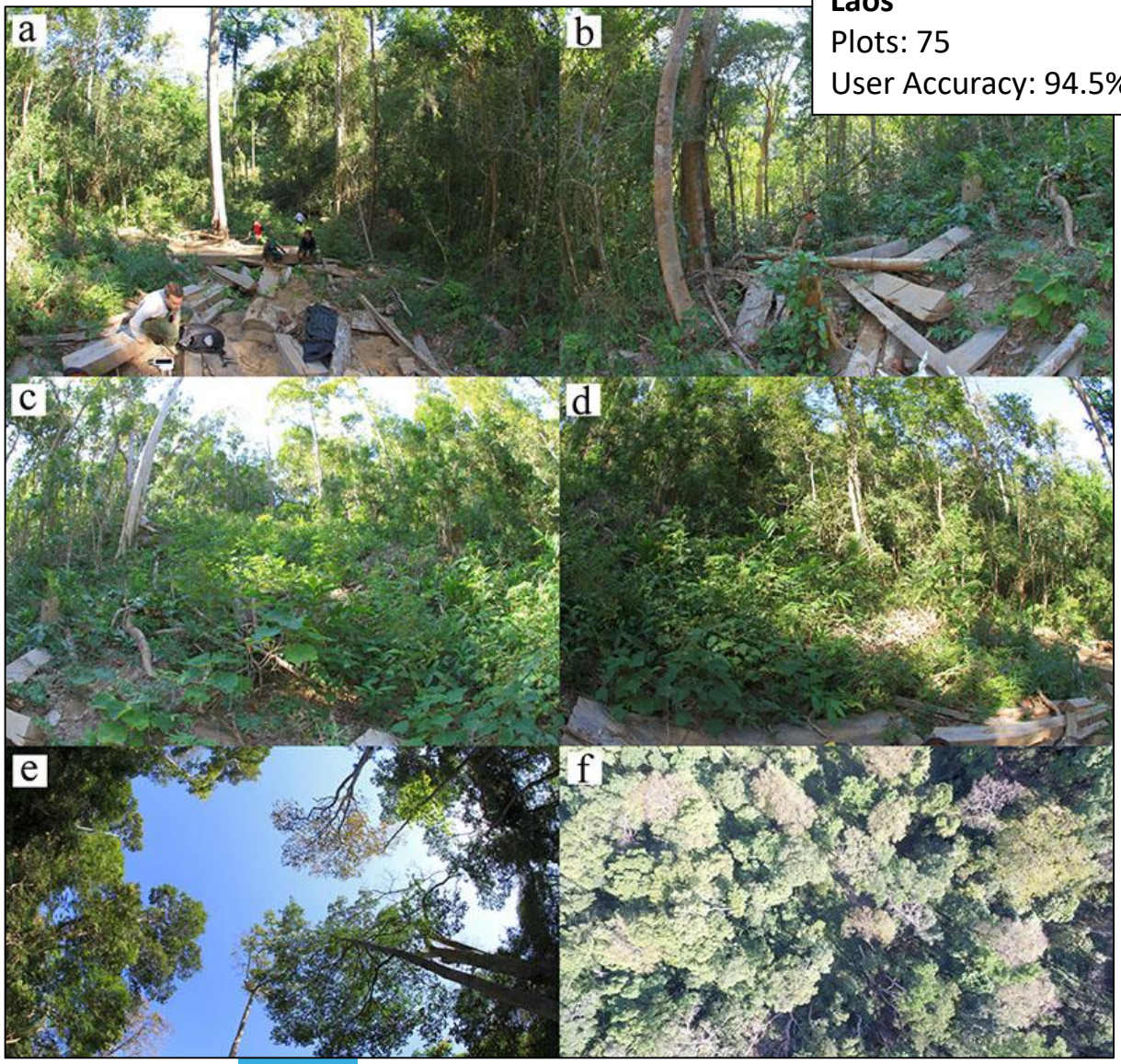

Result for Vietnam 2015
1,402 Landsat scenes
Subset
0 3 6 12 18
Kilometers
Sub-Subset
0 1 2 4 6
Kilometers

Fieldwork in Laos and Cambodia

Cambodia
Plots: 107
User Accuracy: 97.1%

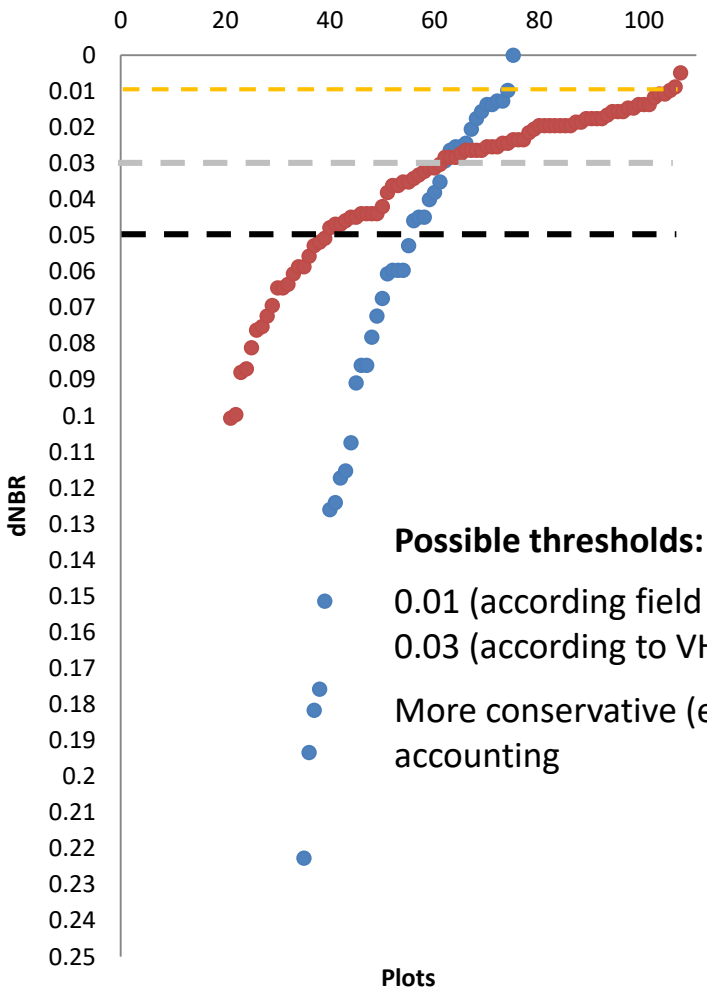
Laos
Plots: 75
User Accuracy: 94.5%





Analysis of Plots

Magnitude-ordered dNBR values



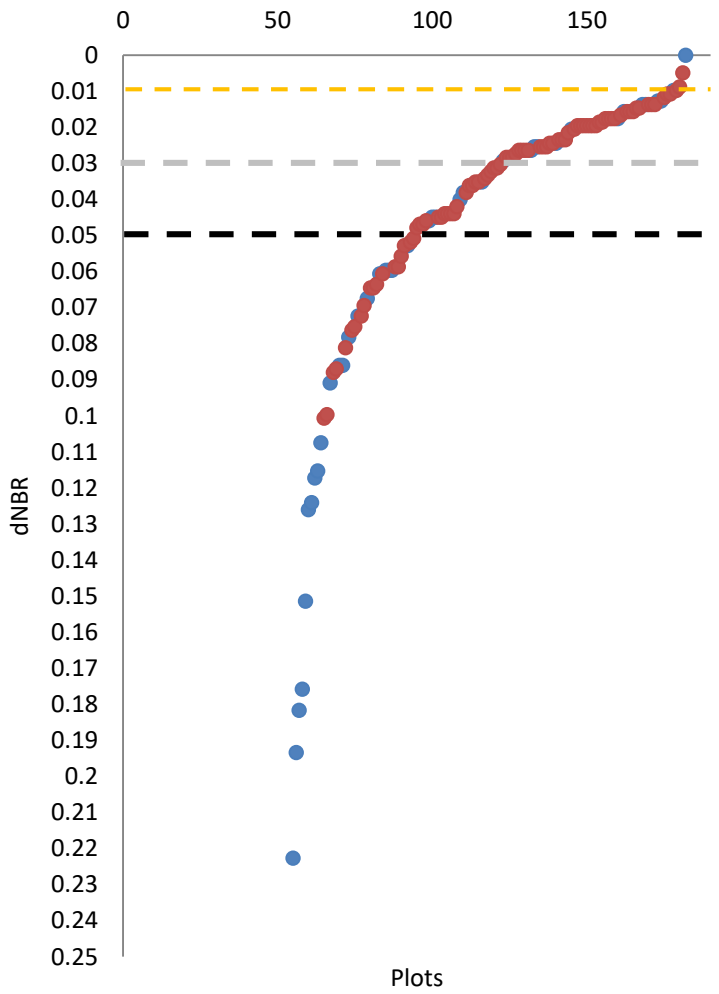
Cambodia (red)
Laos (blue)

Possible thresholds:

0.01 (according field plots)
0.03 (according to VHR reference data)

More conservative (e.g. 0.05) for REDD accounting

Magnitude-ordered dNBR values



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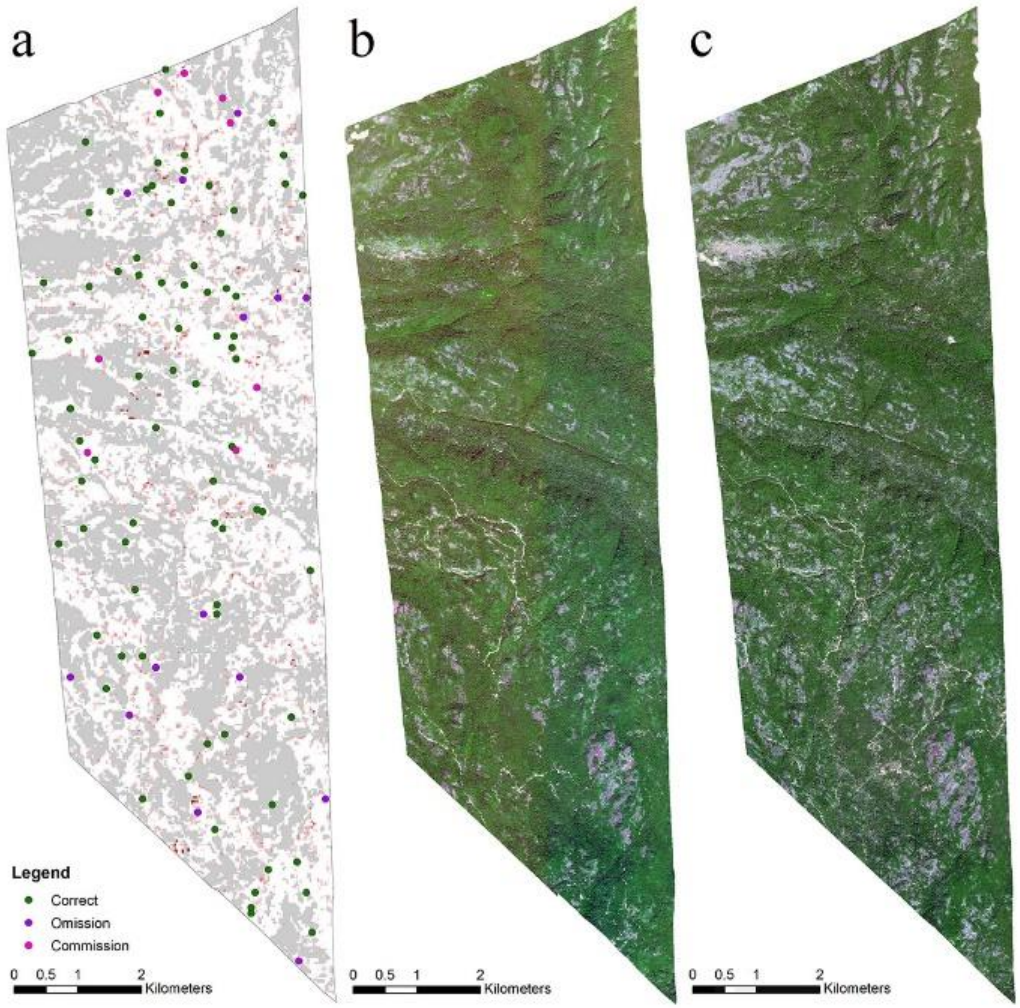
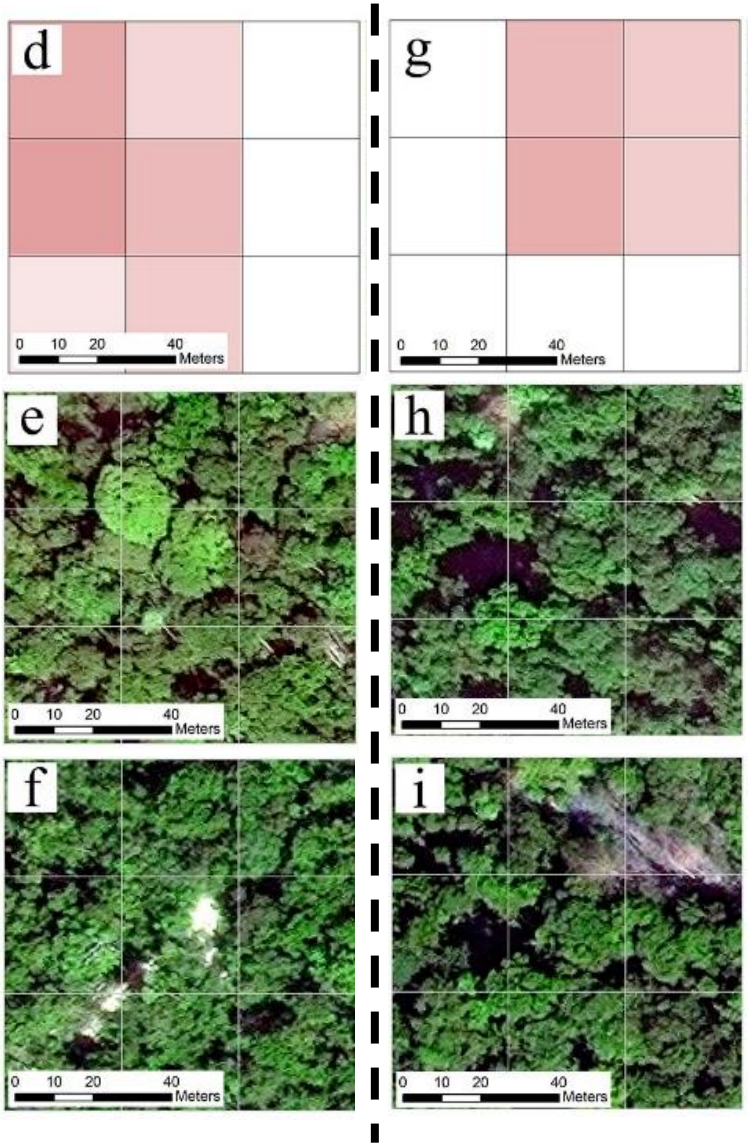
Accuracy Assessment





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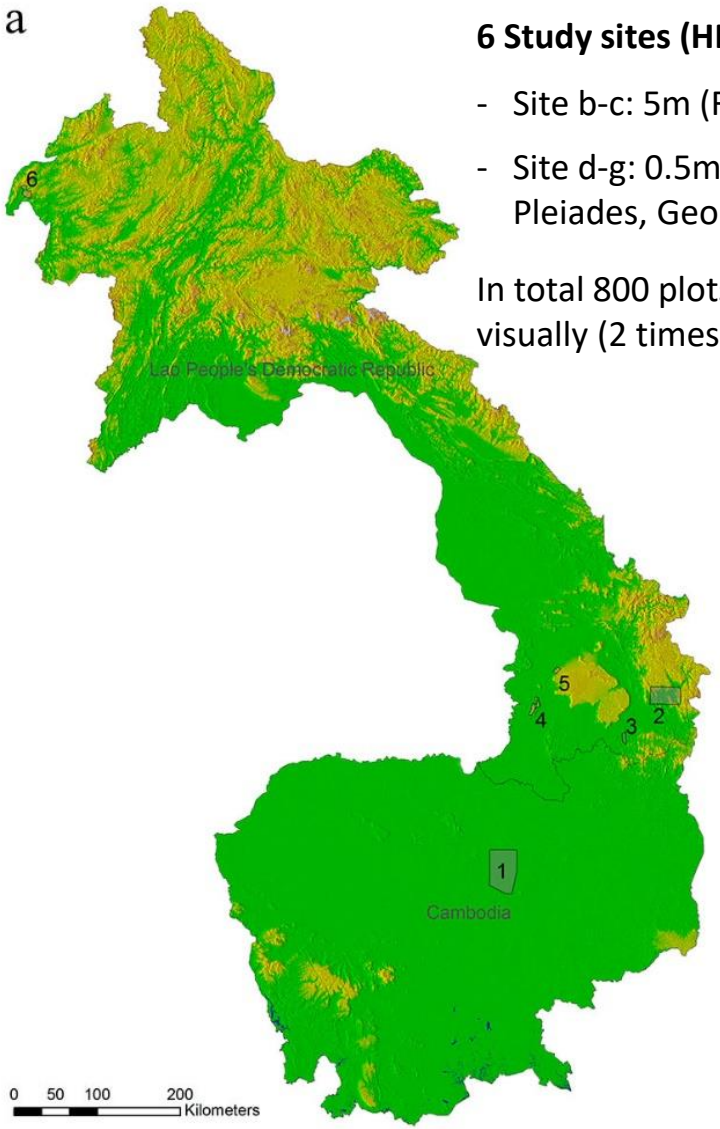
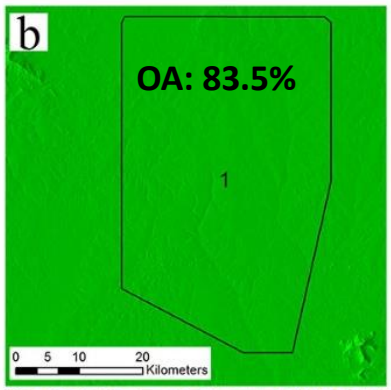
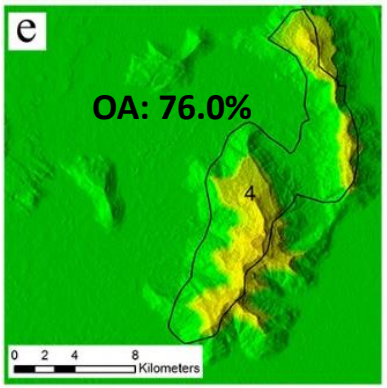


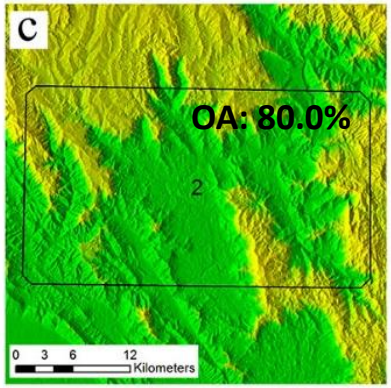
6 Study sites (HR and VHR data)

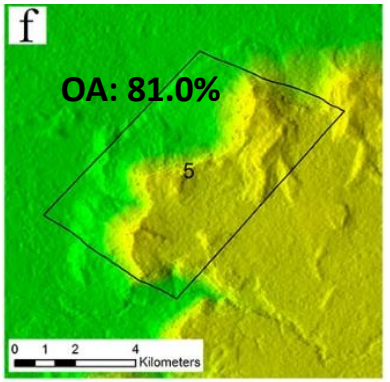
- Site b-c: 5m (RapidEye)
- Site d-g: 0.5m (WorldView-2, Pleiades, GeoEye-1)

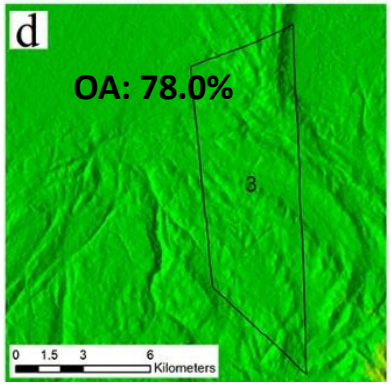
In total 800 plots were checked visually (2 times)

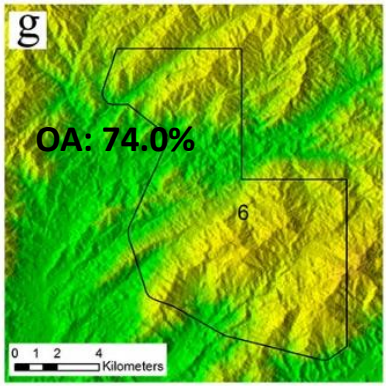












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5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

User-Defined Variables

Investigation periods

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var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
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                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

User-Defined Variables

Sensor types

```
// ********************************************************************************************************************************************************************
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var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

User-Defined Variables

```
// ********************************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************************
// ********************************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
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// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

Study area

User-Defined Variables

Secure | https://en.wikipedia.org/wiki/List_of_FIPS_country_codes

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List of FIPS country codes

From Wikipedia, the free encyclopedia

This is a list of **FIPS 10-4** country codes for *Countries, Dependencies, Areas of Special*

The two-letter country codes were used by the US government for geographical data pro
Intelligence Agency, 1994, "Geopolitical Data Elements and Related Features").

The FIPS standard includes both the codes for independent countries (similar but someti
standard). The ISO 3166 codes are used by the United Nations and for Internet top-level

Non-sovereign entities are in italics.

On September 2, 2008, FIPS 10-4 was one of ten standards withdrawn by NIST as a Fe

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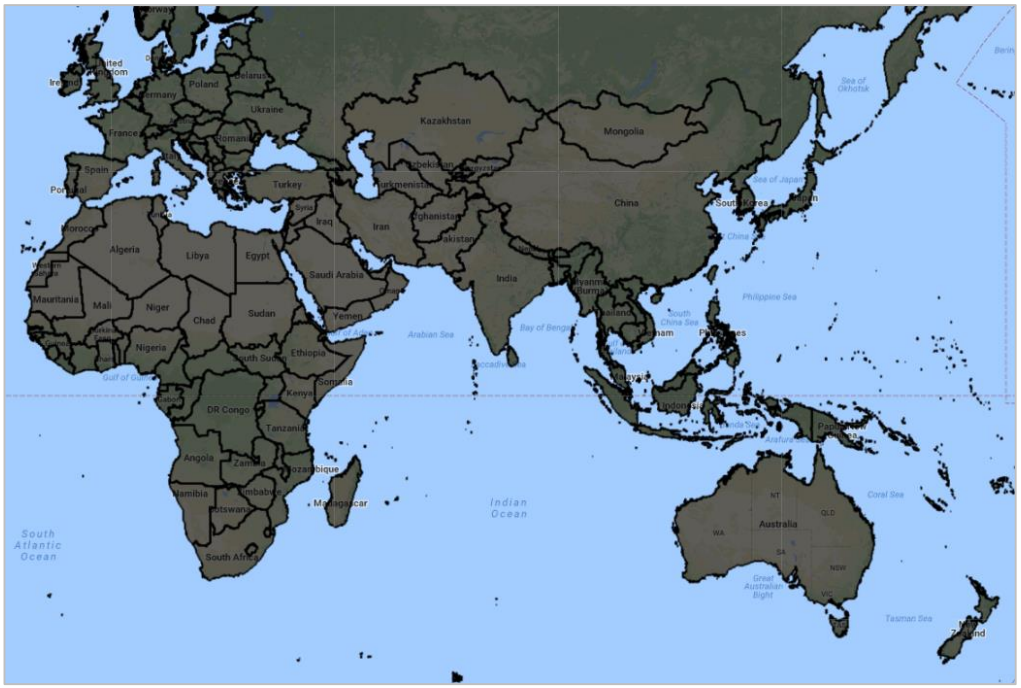
A [edit]

Code	Short-form name
AA	*Aruba*
AC	Antigua and Barbuda
AE	United Arab Emirates
AF	Afghanistan
AG	Algeria
AJ	Azerbaijan
AL	Albania
AM	Armenia
AN	Andorra
AO	Angola
AQ	*American Samoa*

```
// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equ
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname);
```



Joint Research Centre

User-Defined Variables

```
// ********************************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************************
// ********************************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

Cloud masking

User-Defined Variables

```
// ********************************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************************
// ********************************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservati

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

Forest masking

User-Defined Variables

```
// ********************************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************************
// ********************************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map';  Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

Self-referencing

User-Defined Variables

```
// ********************************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************************
// ********************************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
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var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map';
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
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                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************************
// ********************************************************************************************************************************************************************
```

(Disturbance-density-related) filtering

User-Defined Variables

```
// ********************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************
// ********************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different se
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with th
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with th
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with t
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

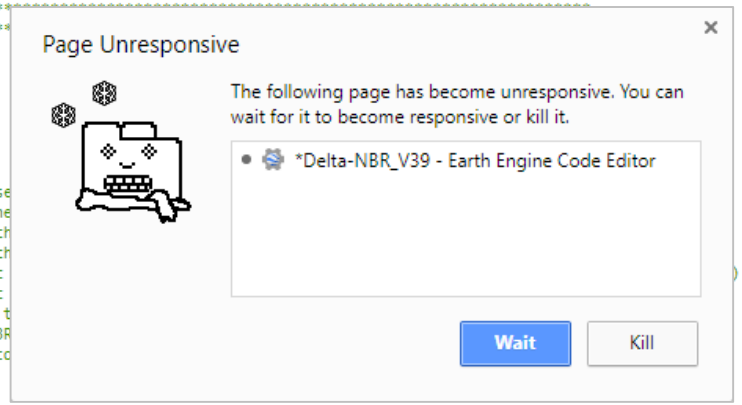
// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

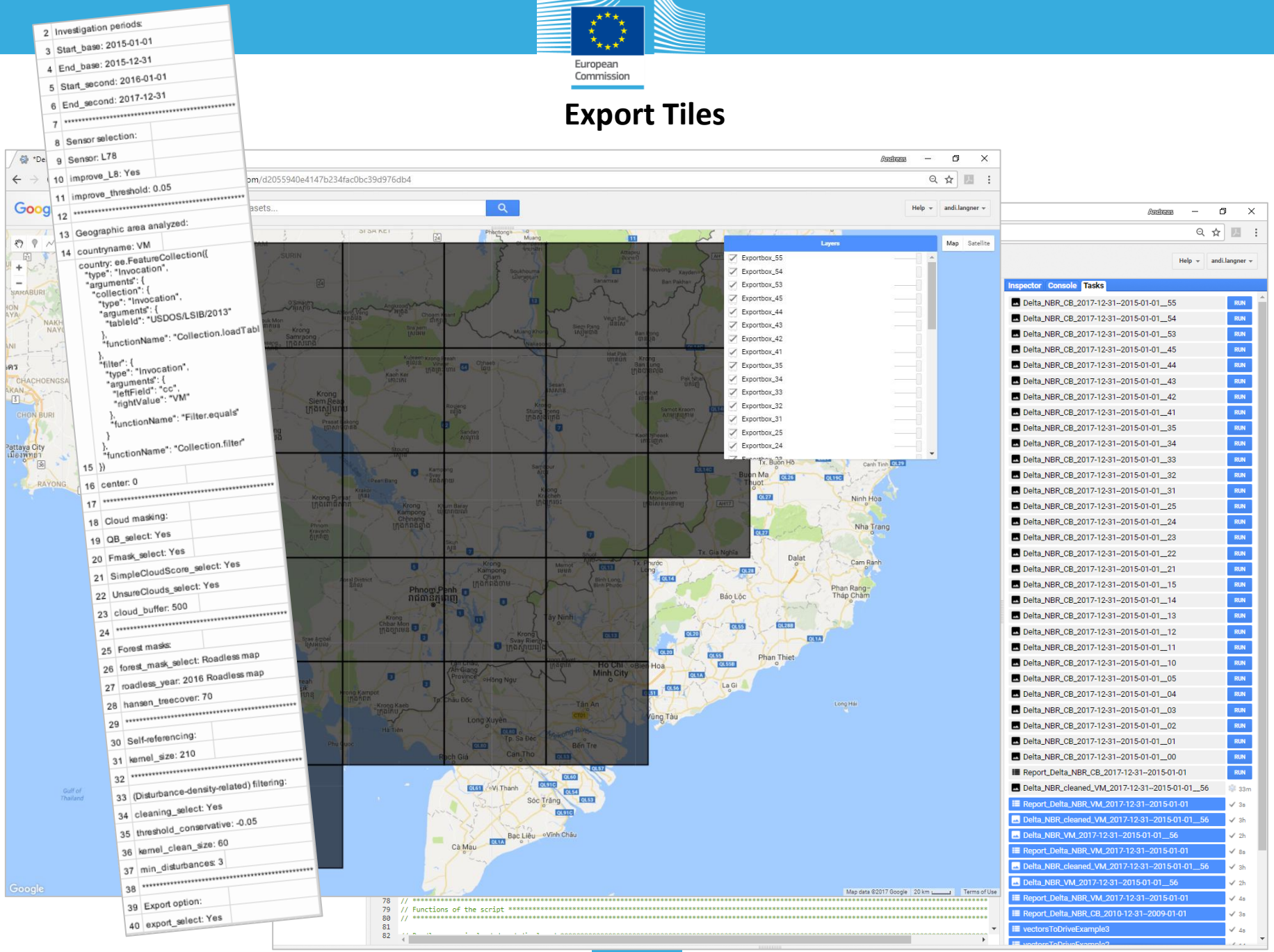
// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************
// ********************************************************************************************************************************************************
```



Export option

Export Tiles



Specific Algorithms used in GEE Script

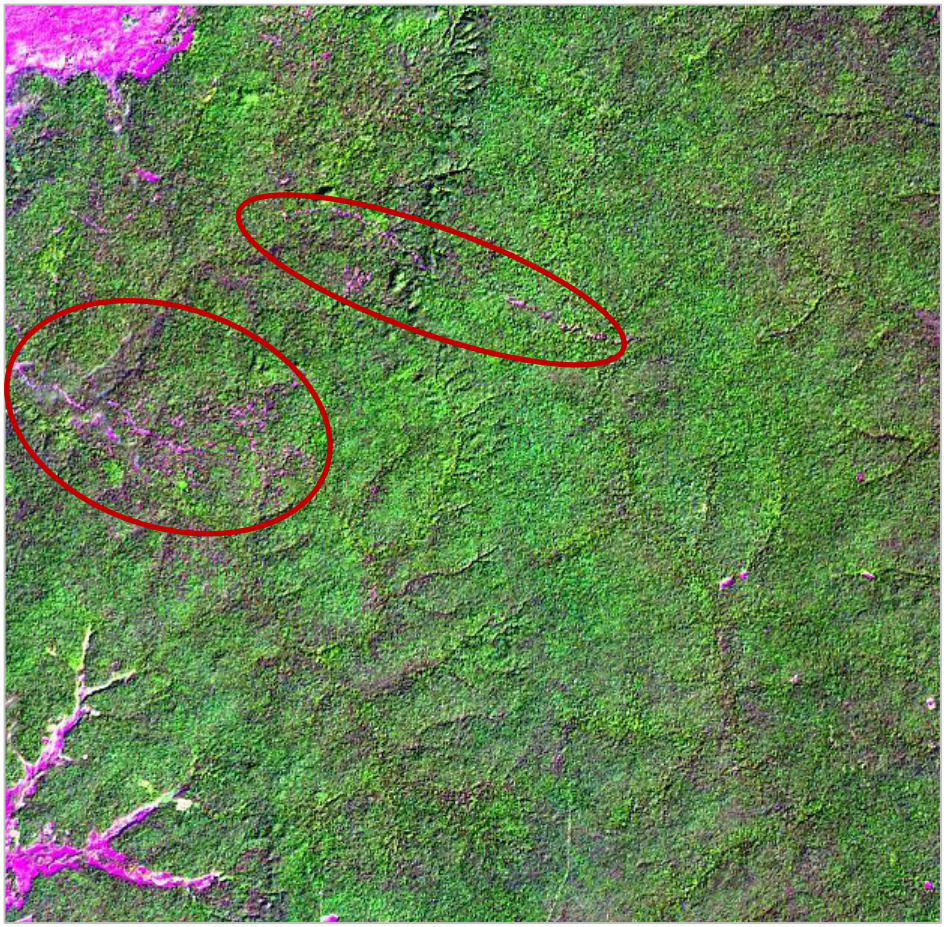
Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

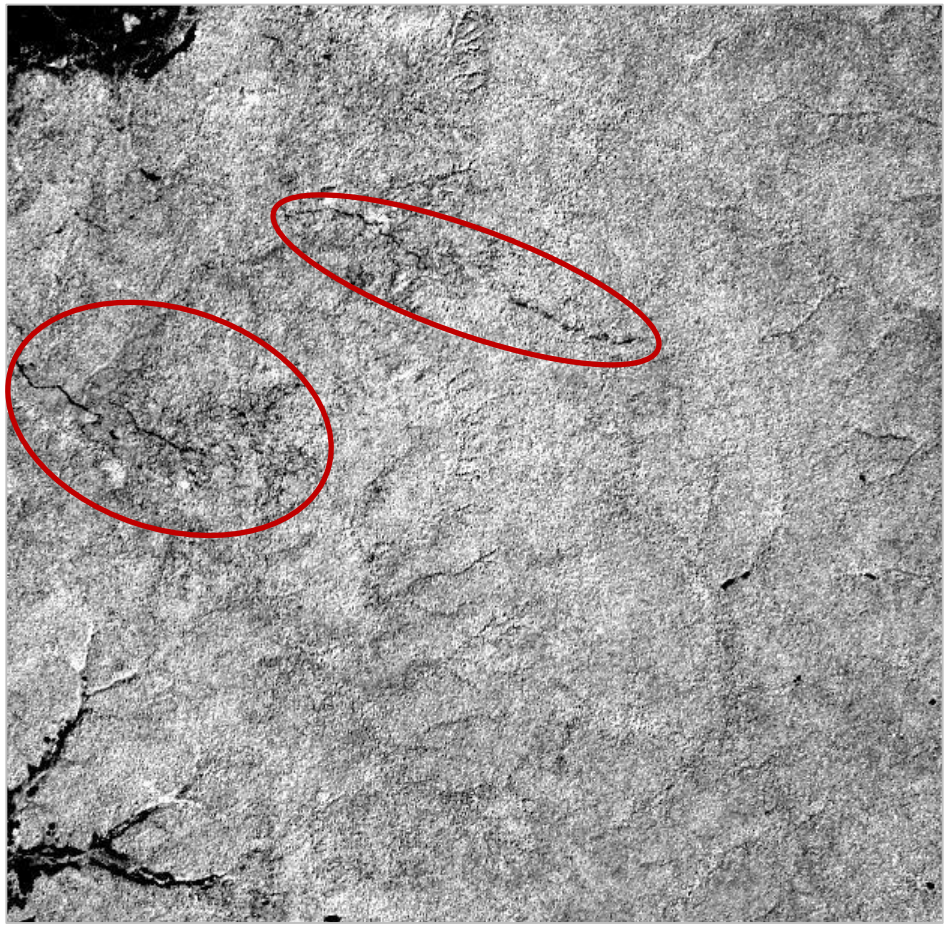
$$NBR = \frac{NIR - SWIR_2}{NIR + SWIR_2}$$

Specific Algorithms used in GEE Script

Landsat 8 (15.01.2015)



NBR Landsat 8 (15.01.2015)



Specific Algorithms used in GEE Script

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
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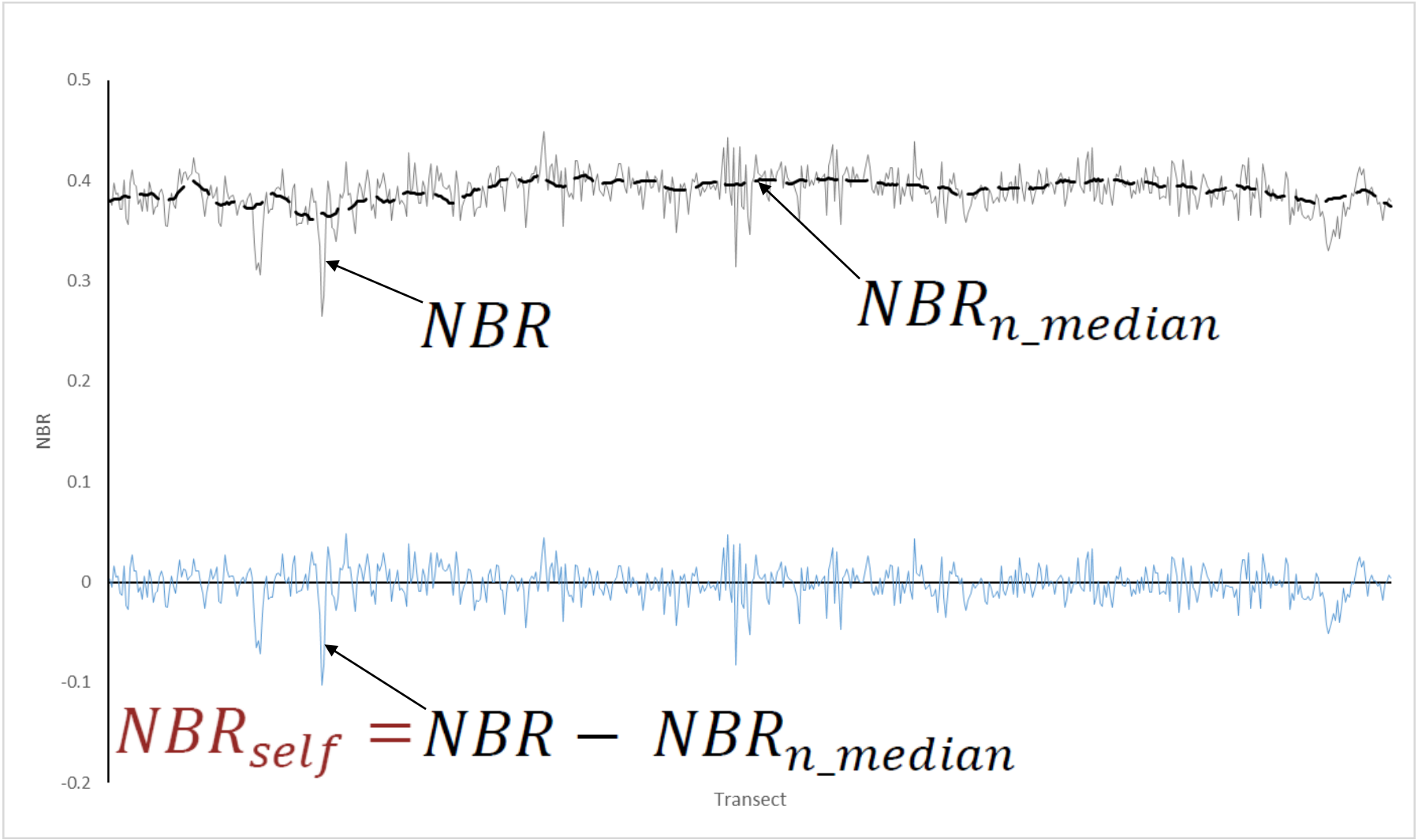
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

$$NBR_{self} = NBR - NBR_{n\_median}$$

Specific Algorithms used in GEE Script



Specific Algorithms used in GEE Script

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
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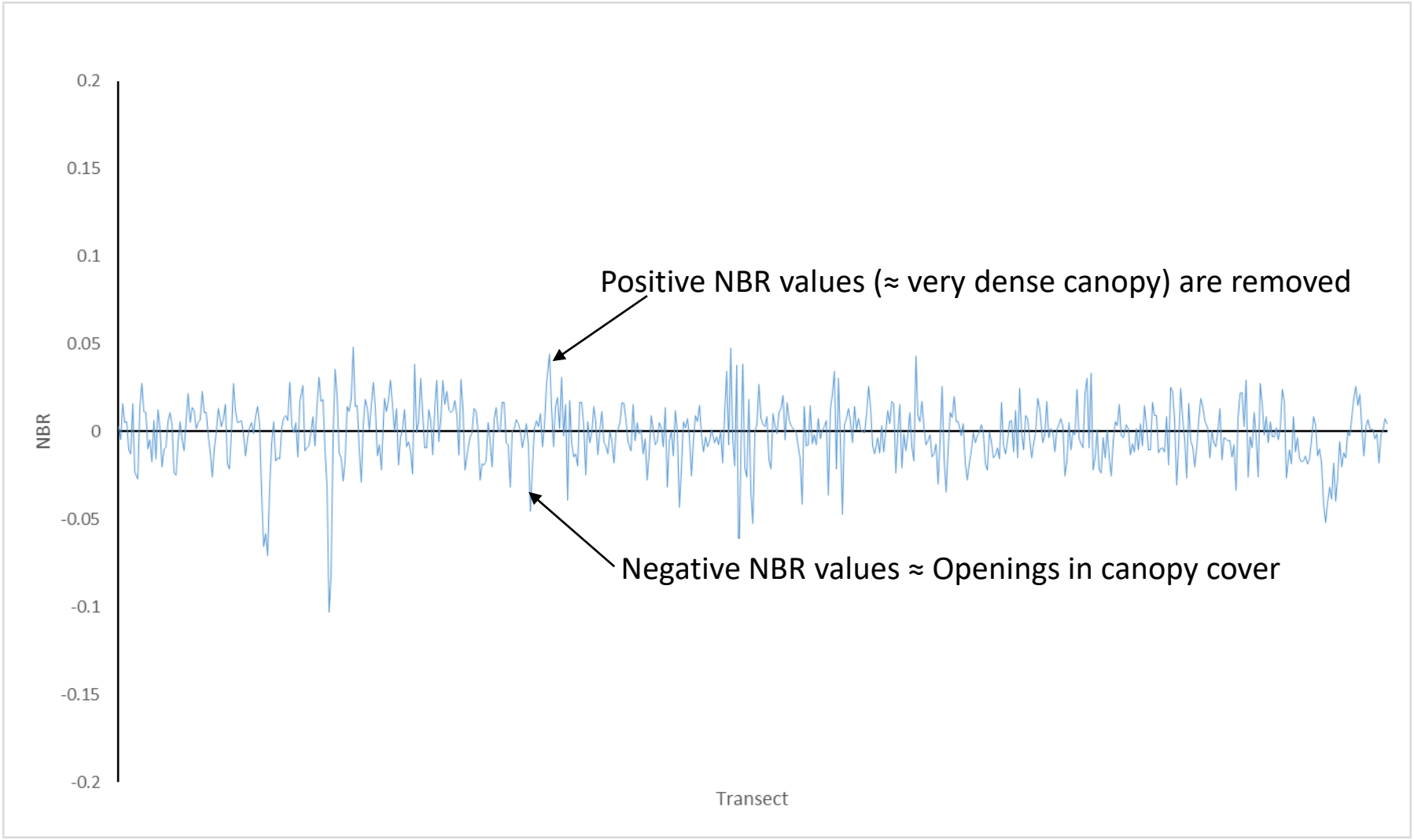
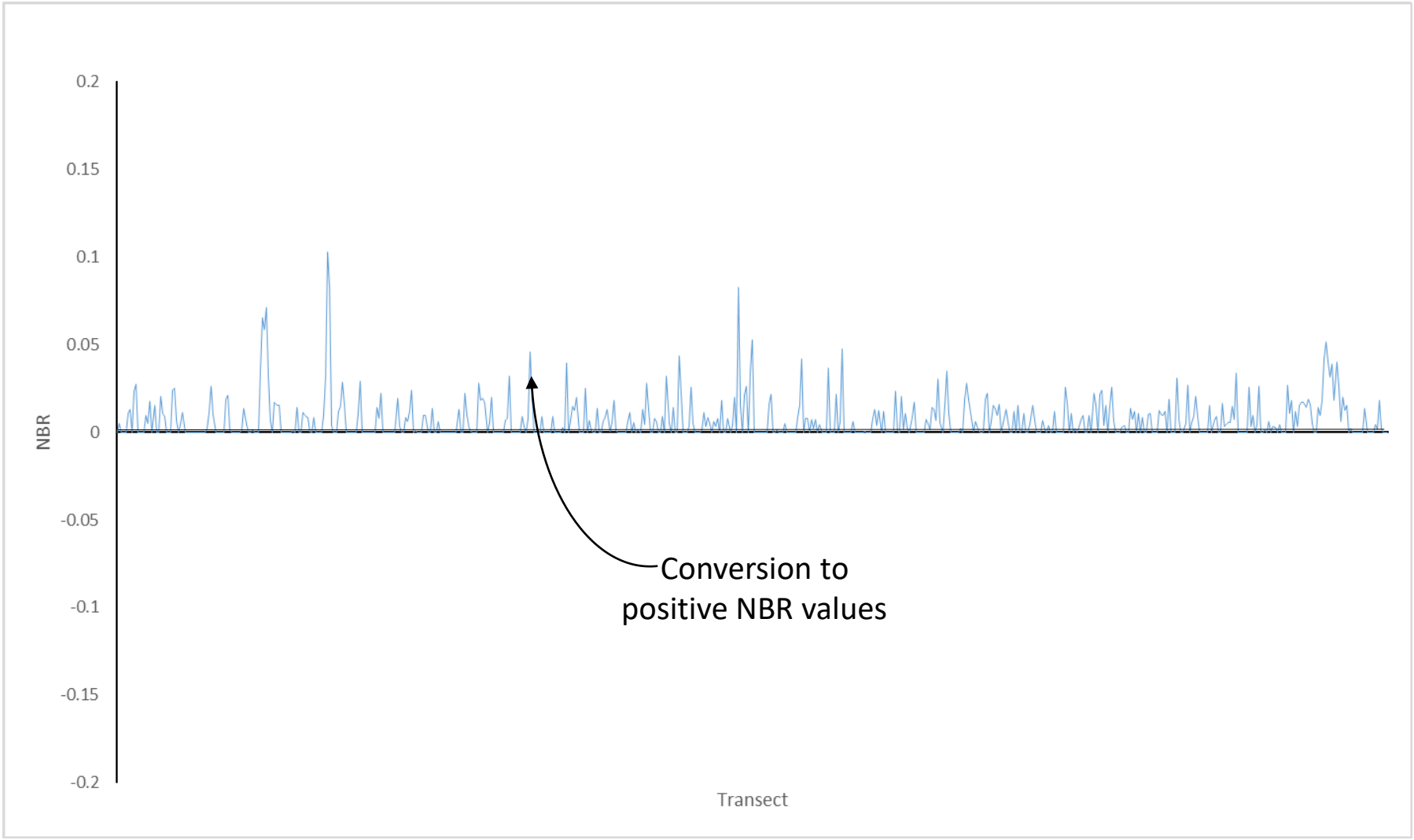
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per

$$NBR_{self\_cap} = \begin{cases} 0 & for \quad NBR_{self} < 0 \\ NBR_{self} & for \quad 0 \leq NBR_{self} \leq 1 \\ 1 & for \quad NBR_{self} > 1 \end{cases}$$

Specific Algorithms used in GEE Script



Specific Algorithms used in GEE Script



Specific Algorithms used in GEE Script

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

$$NBR_{self\_cap\_min\_y} = \min_{start\_period\_n \leq i \leq end\_period\_n} (NBR_{self\_cap\_i})$$

Specific Algorithms used in GEE Script

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
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    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

$$\Delta NBR_{y+1} = NBR_{self\_cap\_min\ \_y+1} - NBR_{self\_cap\_min\ \_y}$$

Specific Algorithms used in GEE Script

Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

Negligence of 'non-forest' regrowth

$$\Delta NBR_{y+1\_cap} = \begin{cases} \Delta NBR_{y+1} & for \quad \Delta NBR_{y+1} > 0 \\ 0 & for \quad \Delta NBR_{y+1} \leq 0 \end{cases}$$

Joint Research Centre

Specific Algorithms used in GEE Script

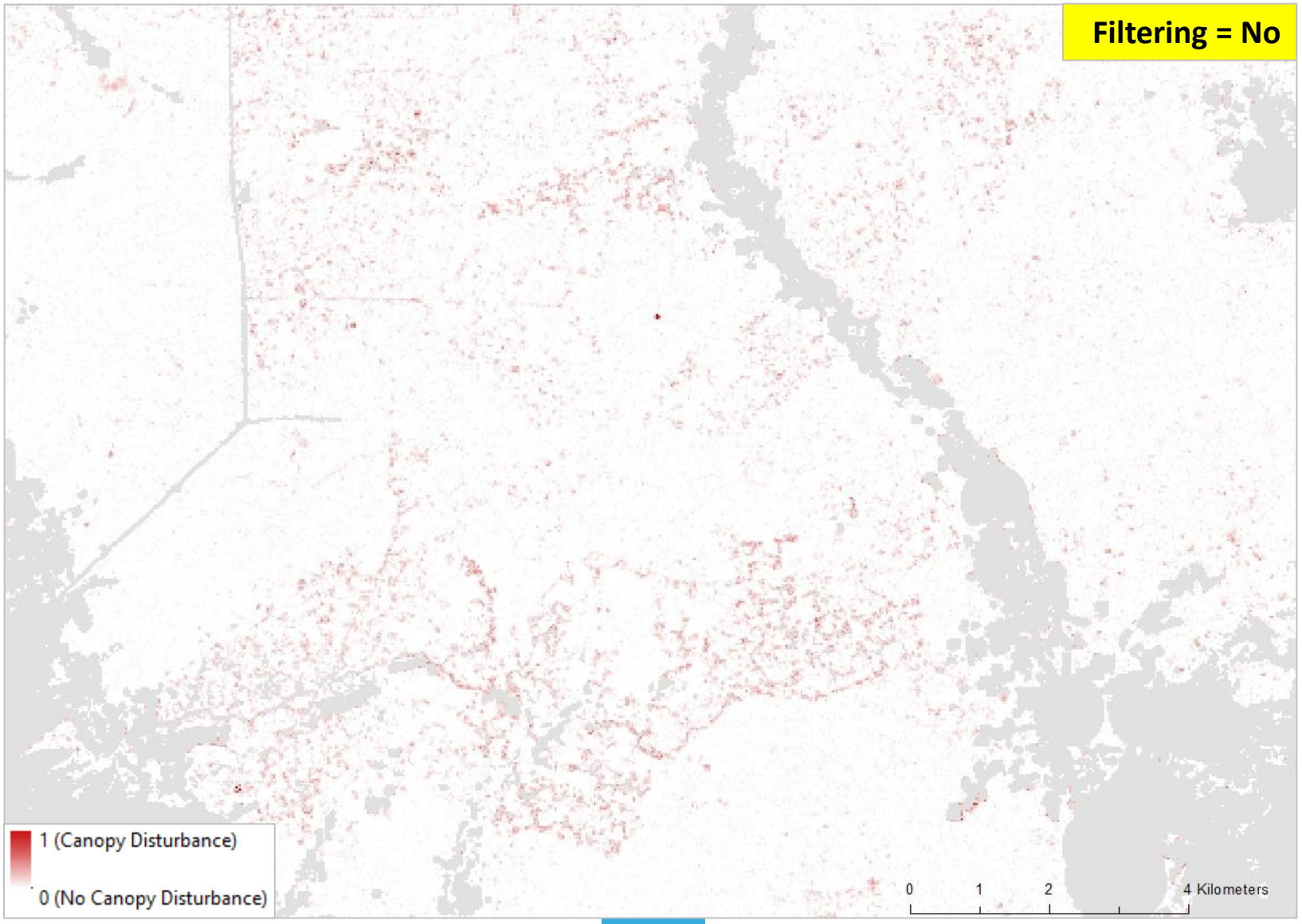
Main GEE script (no user interaction)

1. Reading user-defined variables (user requirements)
2. Preparing the satellite data
3. Processing steps of each single satellite scene
    1. Cloud masking
    2. Masking of non-evergreen forest areas
    3. Calculation of the NBR
    4. Adding information about acquisition date
    5. Self-referencing of the NBR
    6. Capping step (0 to -1) & Multiplication with (-1)
4. Condensation single scene results
    1. Highest NBR per pixel over investigation period
    2. Obtain corresponding acquisition date per pixel
5. Calculation of ΔNBR (period 2 – period 1)
6. Capping step of ΔNBR (0 to 1)
7. Optional disturbance-density-related cleaning of ΔNBR
8. Export of results (per 1x1 degree tile)

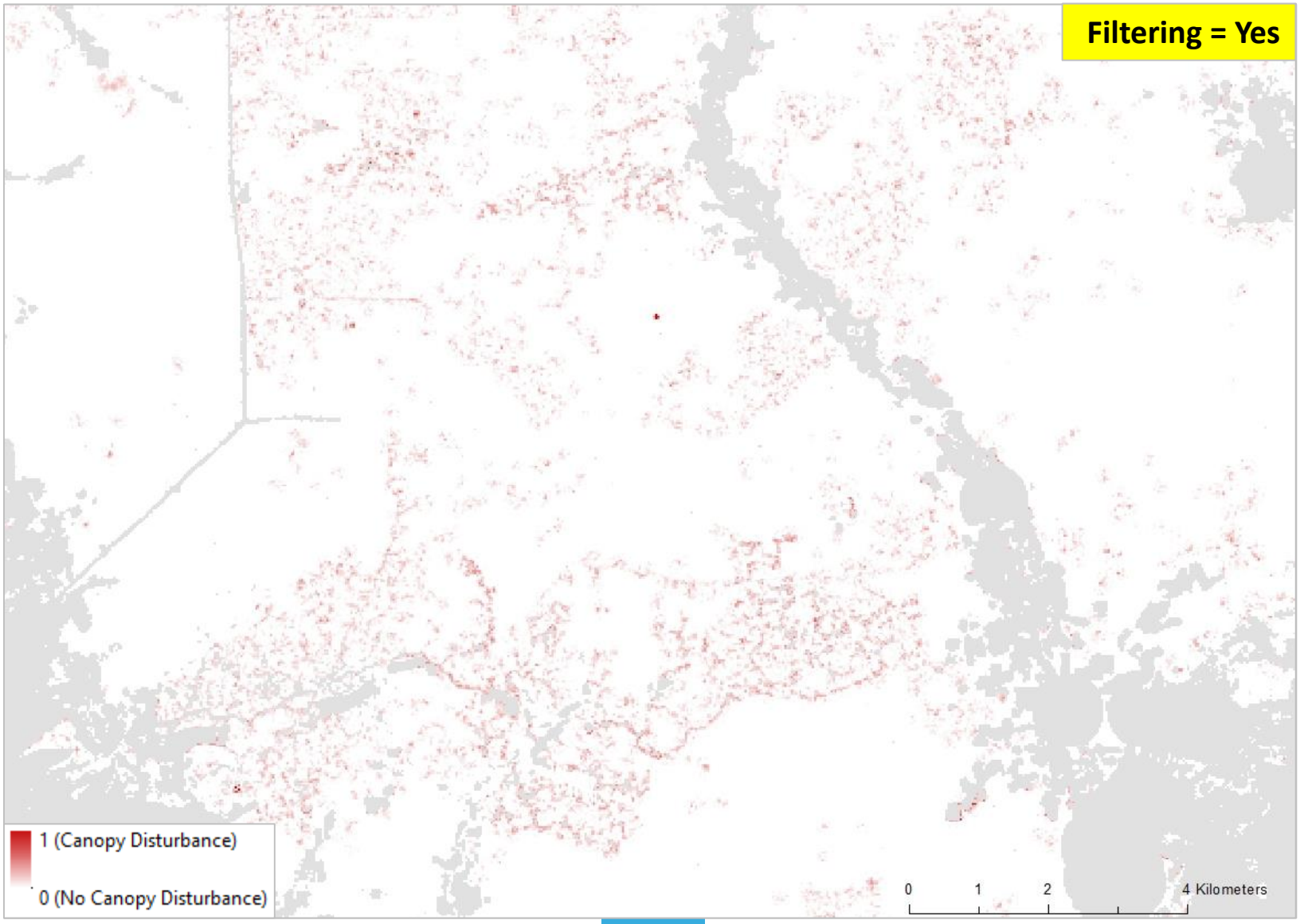
Removal of:

- Single pixels
- Groups of pixels with low density (within specified neighborhood)

Specific Algorithms used in GEE Script



Specific Algorithms used in GEE Script



European Commission

Take Home Message: GEE Script EASY

```
// ********************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************
// ********************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated whi
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated whi
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (redu
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elev
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investiga
var countryname = "CB"; // Options                                    of_FIPS_country_codes for country codes
// var country = ee.FeatureCollect                                   ata('country_co','equals',countryname); // Simplified country border
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; //                                   ersion of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer (                                   ues: 0-? (default value of 2500 meters is already very conserv

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen ma
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters deliver
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c  aning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************
// ********************************************************************************************************************************************************
```

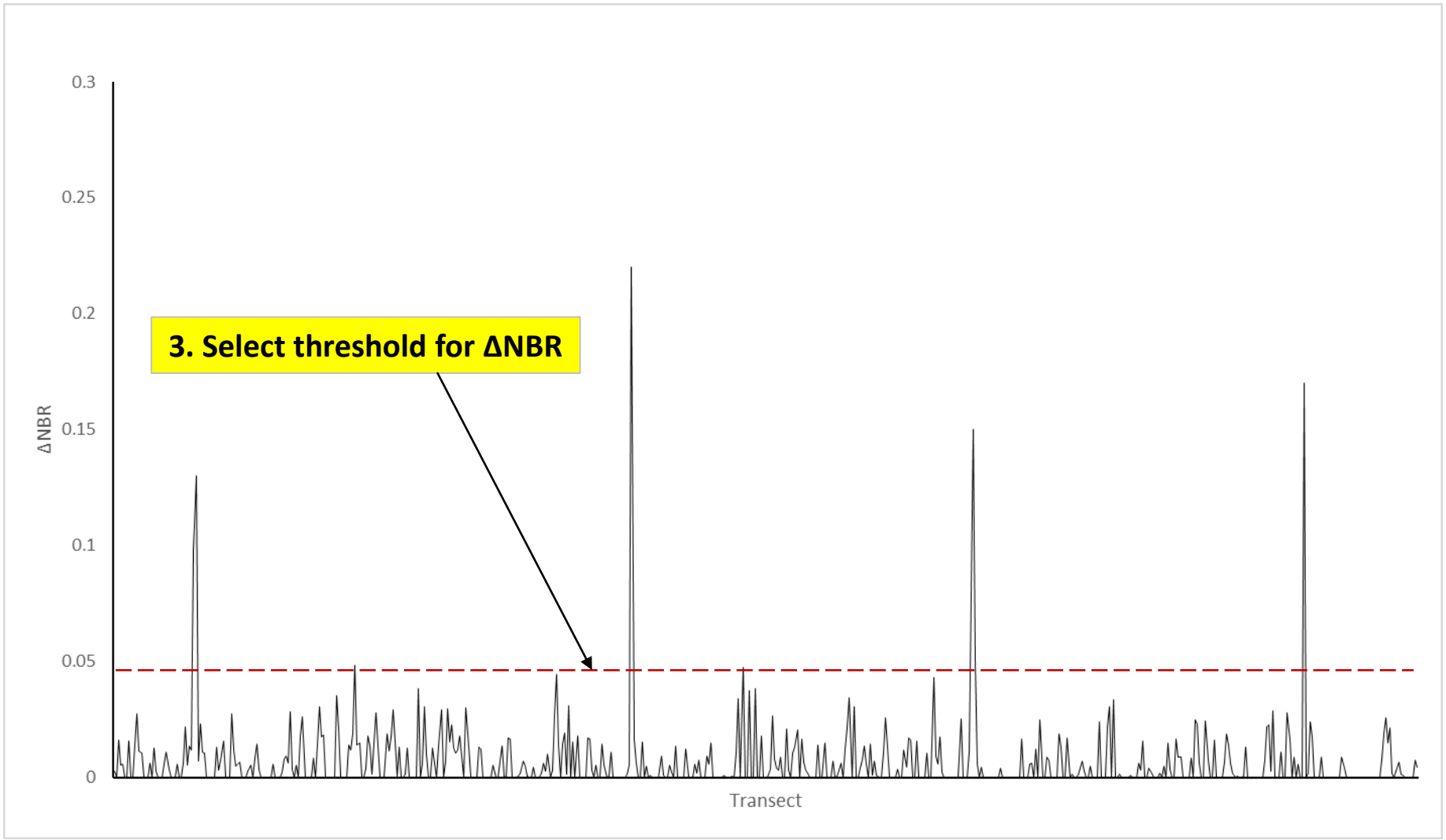
1. Enter investigation periods

2. Enter study area

(Rest: Default values)

```
Investigation periods:
Start_base: 2015-01-01
End_base: 2015-12-31
Start_second: 2016-01-01
End_second: 2017-12-31
**********
Sensor selection:
Sensor: L78
improve_L8: Yes
improve_threshold: 0.05
**********
Geographic area analyzed:
countryname: VM
country: ee.FeatureCollection({
  "type": "Invocation",
  "arguments": {
    "collection": {
      "type": "Invocation",
      "arguments": {
        "tableId": "USDOS/LSIB/2013"
      },
      "functionName": "Collection.loadTabl
    },
    "filter": {
      "type": "Invocation",
      "arguments": {
        "leftField": "cc",
        "rightValue": "VM"
      },
      "functionName": "Filter.equals"
    }
  },
  "functionName": "Collection.filter"
})
center: 0
**********
Cloud masking:
QB_select: Yes
Fmask_select: Yes
SimpleCloudScore_select: Yes
UnsureClouds_select: Yes
cloud_buffer: 500
**********
Forest masks:
forest_mask_select: Roadless map
roadless_year: 2016 Roadless map
hansen_treecover: 70
**********
Self-referencing:
kernel_size: 210
**********
(Disturbance-density-related) filtering:
cleaning_select: Yes
threshold_conservative: -0.05
kernel_clean_size: 60
min_disturbances: 3
**********
Export option:
export_select: Yes
```

Take Home Message: GEE Script EASY



European Commission

Hands-on the GEE Script

Joint Research Centre

Study Area: Subset of Prey Lang Forest (Cambodia)

Settings as indicated

```
// ********************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************
// ********************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
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// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
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var kernel_clean_size = 45; // Kernel (circular) radius size in meters for the disturbance density related cleaning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

// Here the option of an export of the results is selected
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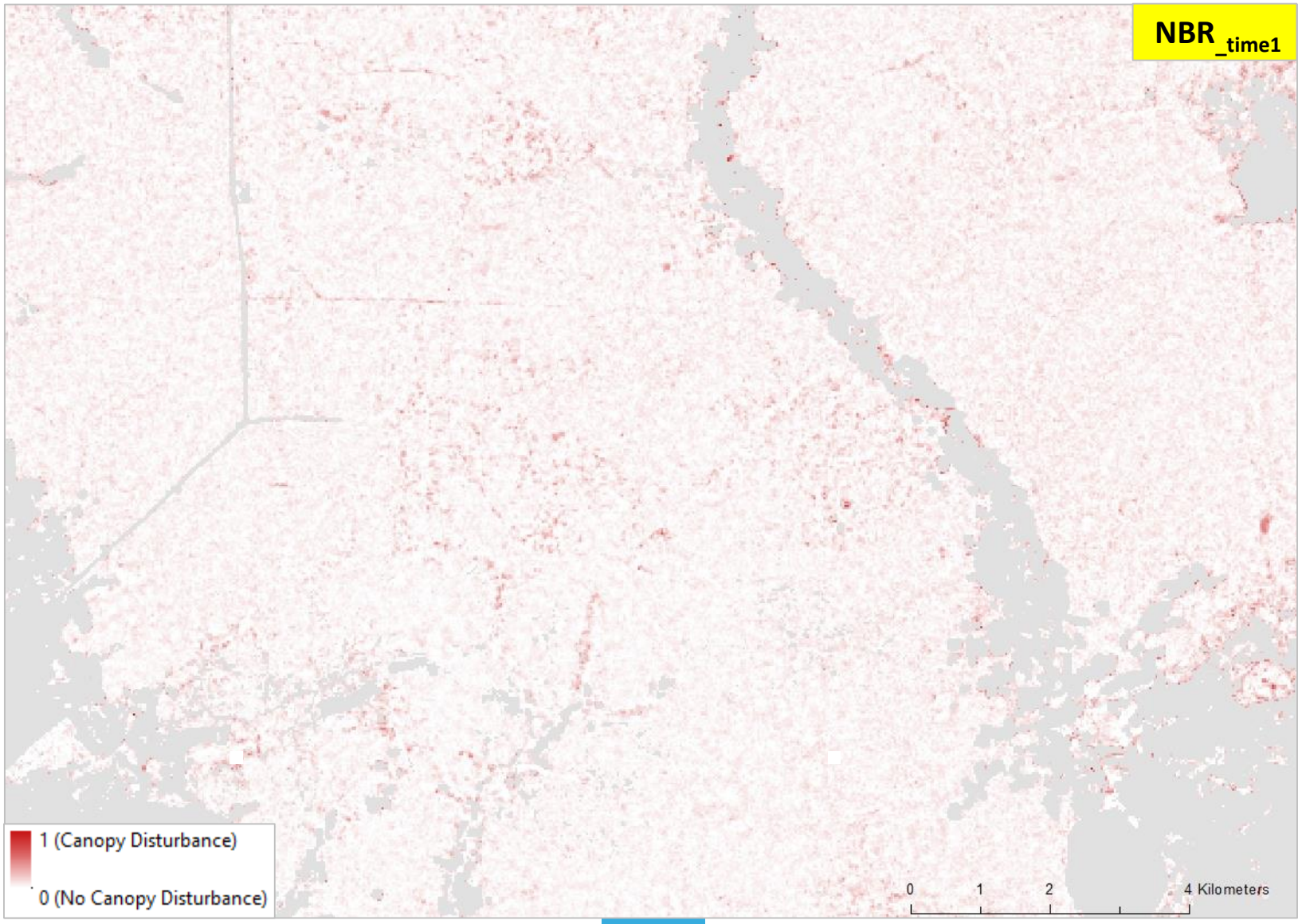
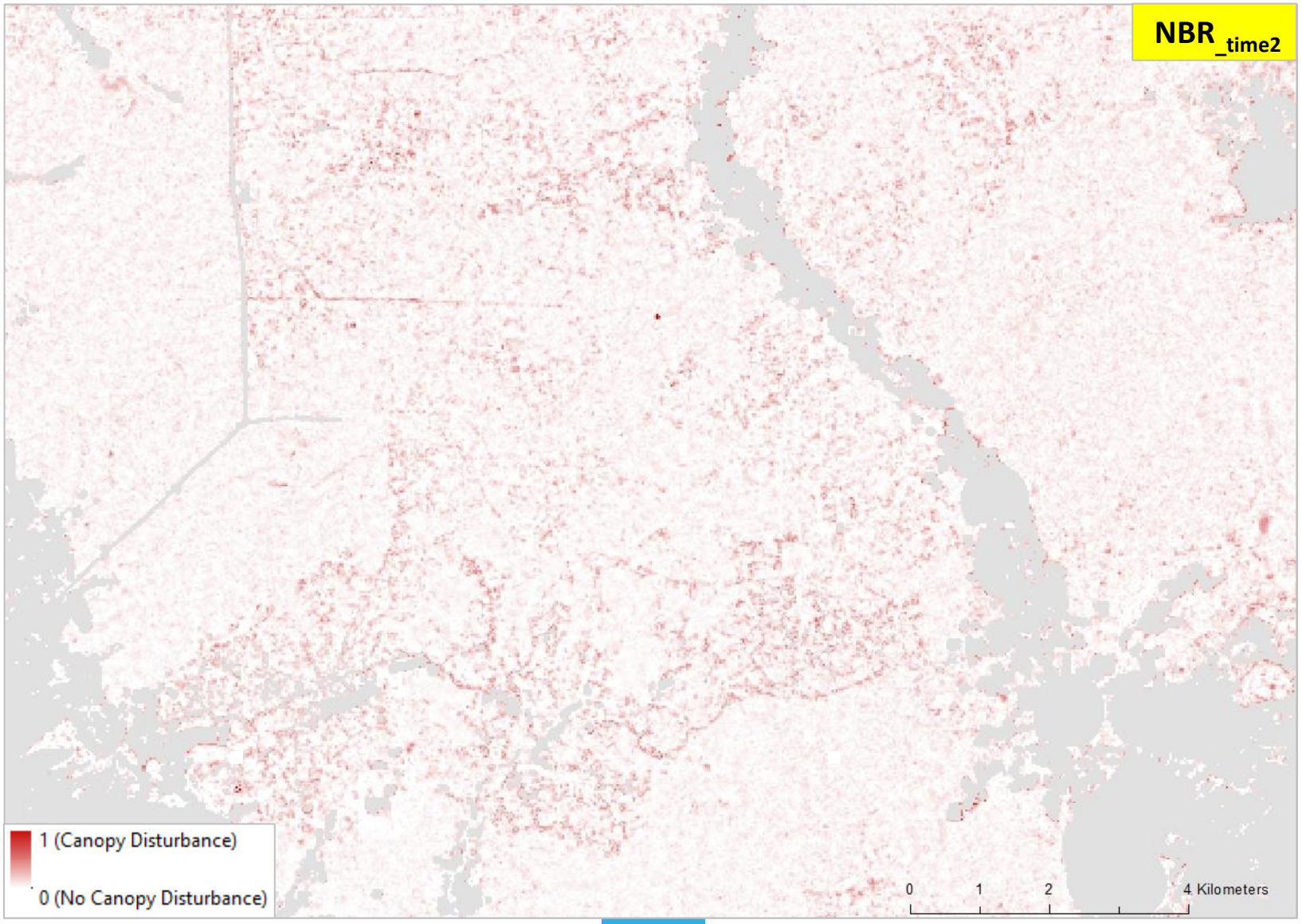
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************
// ********************************************************************************************************************************************************
```

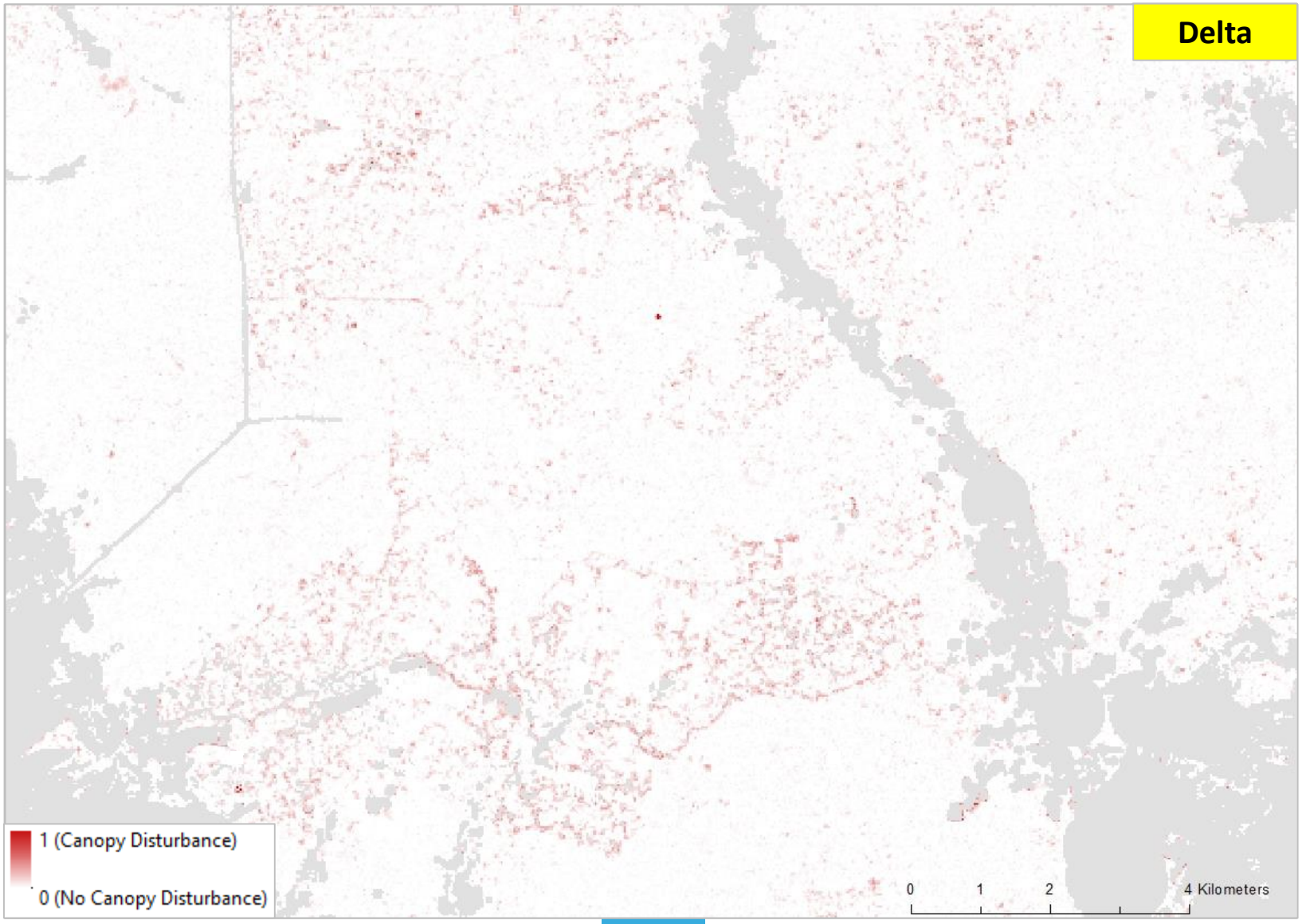
Reminder: ΔNBR is Difference between $NBR_{\_time1}$ and $NBR_{\_time2}$



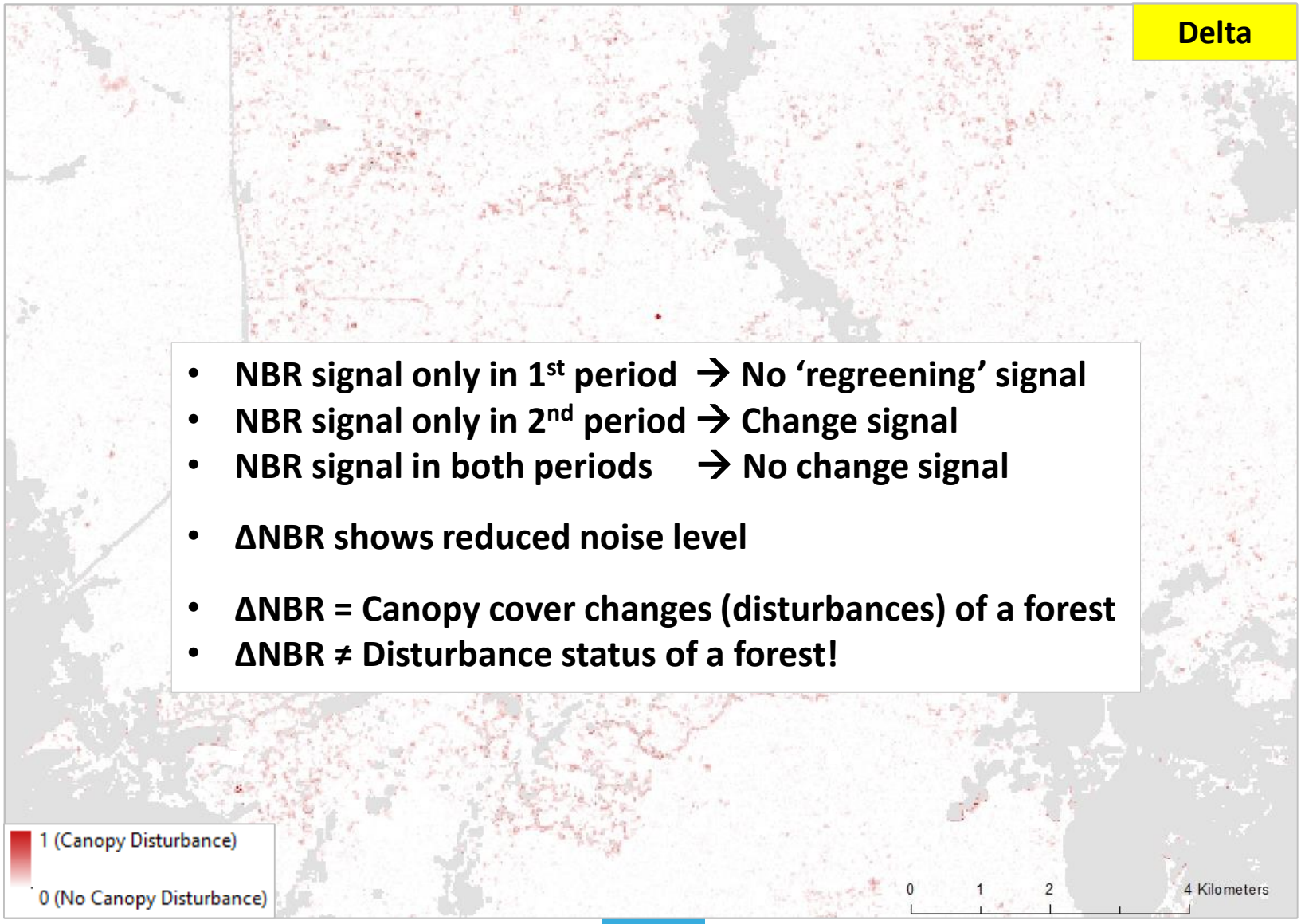
Reminder: ΔNBR is Difference between $NBR_{\_time1}$ and $NBR_{\_time2}$



Reminder: ΔNBR is Difference between $NBR_{\_time1}$ and $NBR_{\_time2}$



Reminder: ΔNBR is Difference between $NBR_{\_time1}$ and $NBR_{\_time2}$



- NBR signal only in 1st period → No 'regreening' signal
- NBR signal only in 2nd period → Change signal
- NBR signal in both periods → No change signal

- ΔNBR shows reduced noise level

- ΔNBR = Canopy cover changes (disturbances) of a forest
- ΔNBR ≠ Disturbance status of a forest!

Exercise 1: Sensor Selection

```
// *********************************************************************************************************************
// Definition of variables that can be modified by the user ************************************************************
// *********************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing
```

Sensor types

Selection:

a) L7

b) 8

c) L78 + improve_L8

```
 by loading any other geometry)
ps://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
S/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
SIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

y center on study area

ific variables are selected (all cloud masks can be combined and used together)
No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
; 'No' (for using the GEE Fmask algorithm)
ptions: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

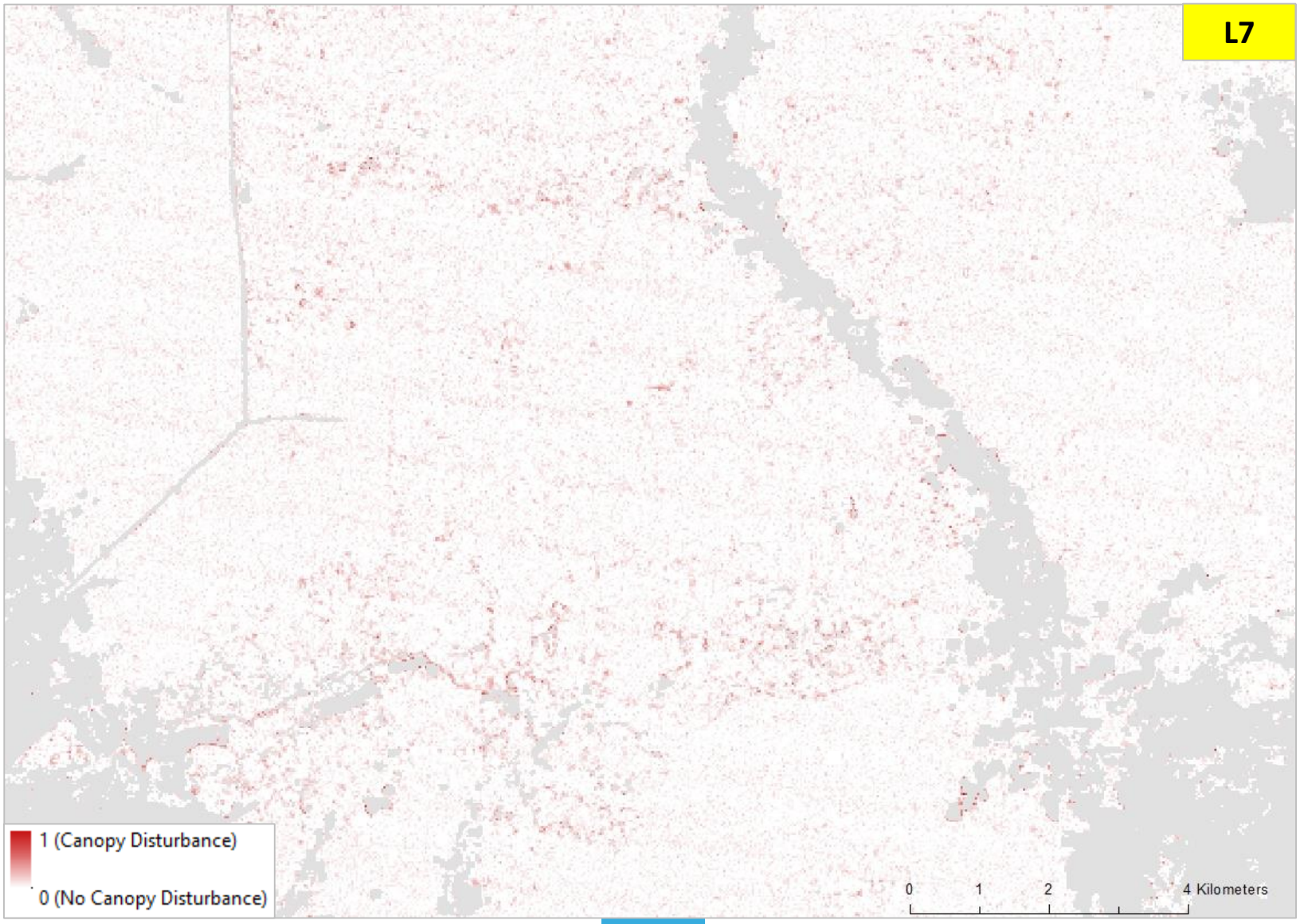
// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45; // Kernel (circular) radius size in meters for the disturbance density related cleaning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

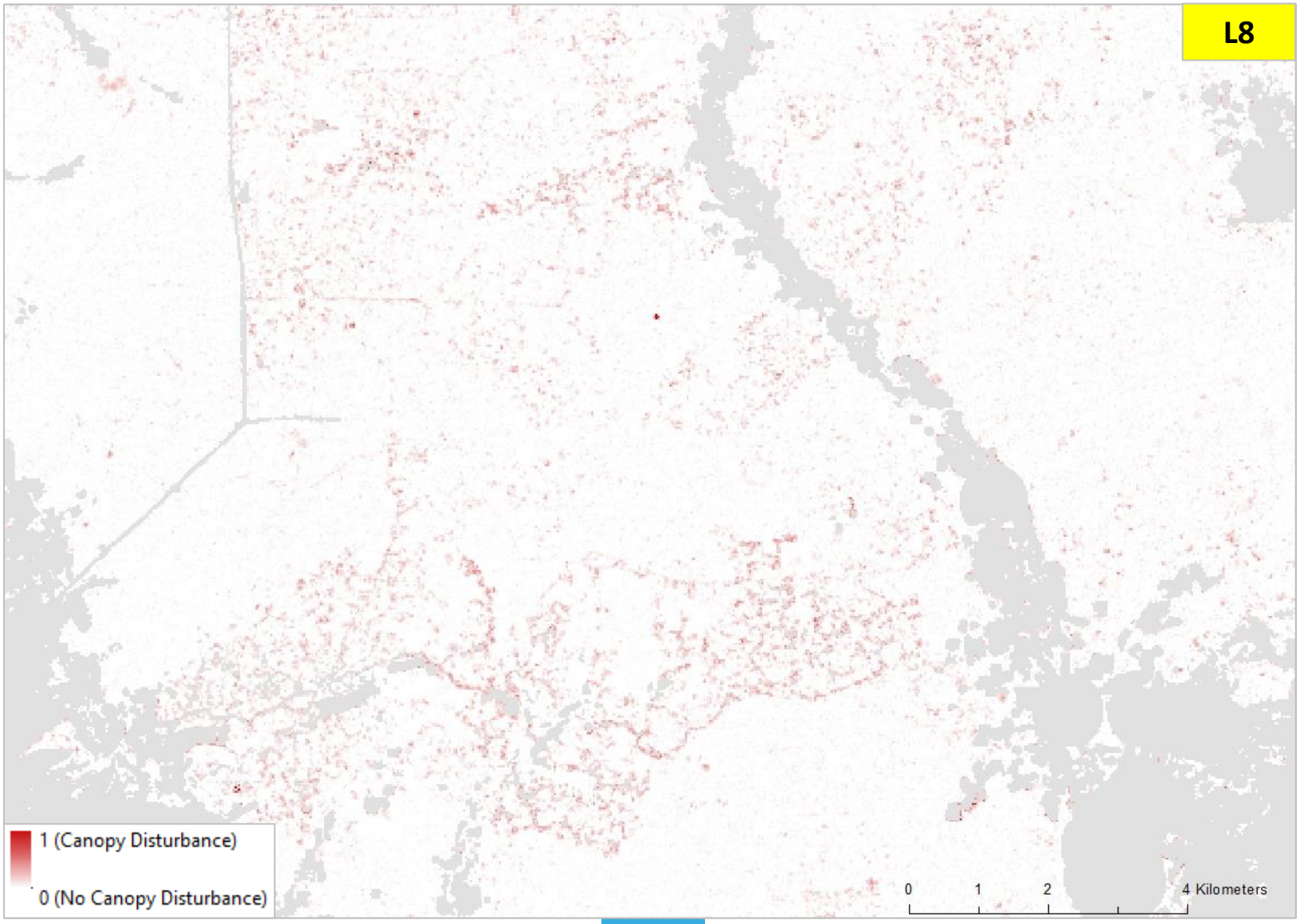
// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// *********************************************************************************************************************
// End of the section that can be modified by the user *****************************************************************
// *********************************************************************************************************************
```

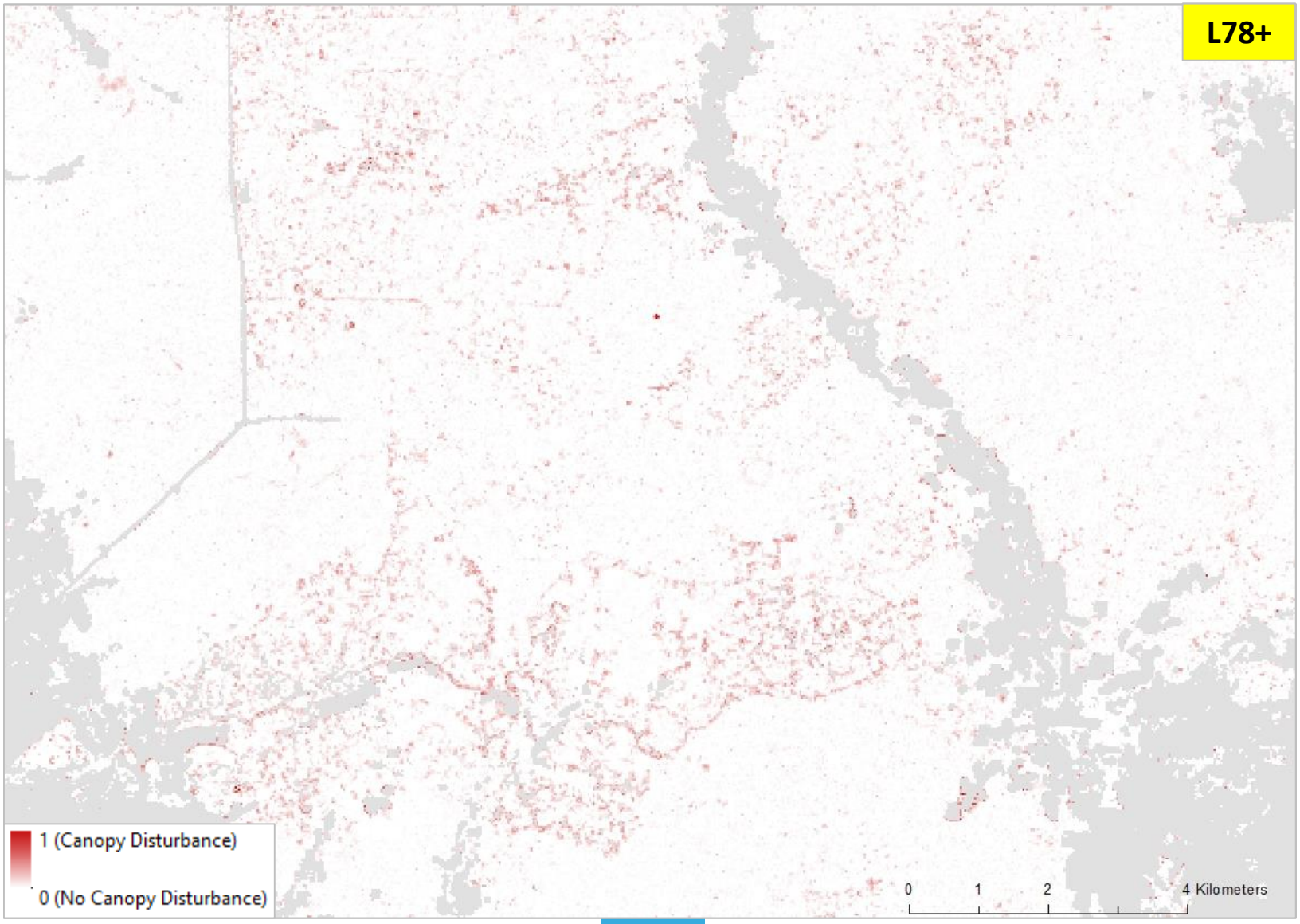
Example: Sensor Selection



Example: Sensor Selection



Example: Sensor Selection



Exercise 2: Cloud Mask Selection

```
// ******************************************************************************************************************************************
// Definition of variables that can be modified by the user *********************************************************************************
// ******************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)
```

Cloud masks

Selection:

a) Cloud_buffer = 0 (meters)
b) Cloud_buffer = 500 (meters)
c) Cloud_buffer = 1500 (meters)

```
cted
t map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
dless map'; '2015 Roadless map'; '2014 Roadless map'

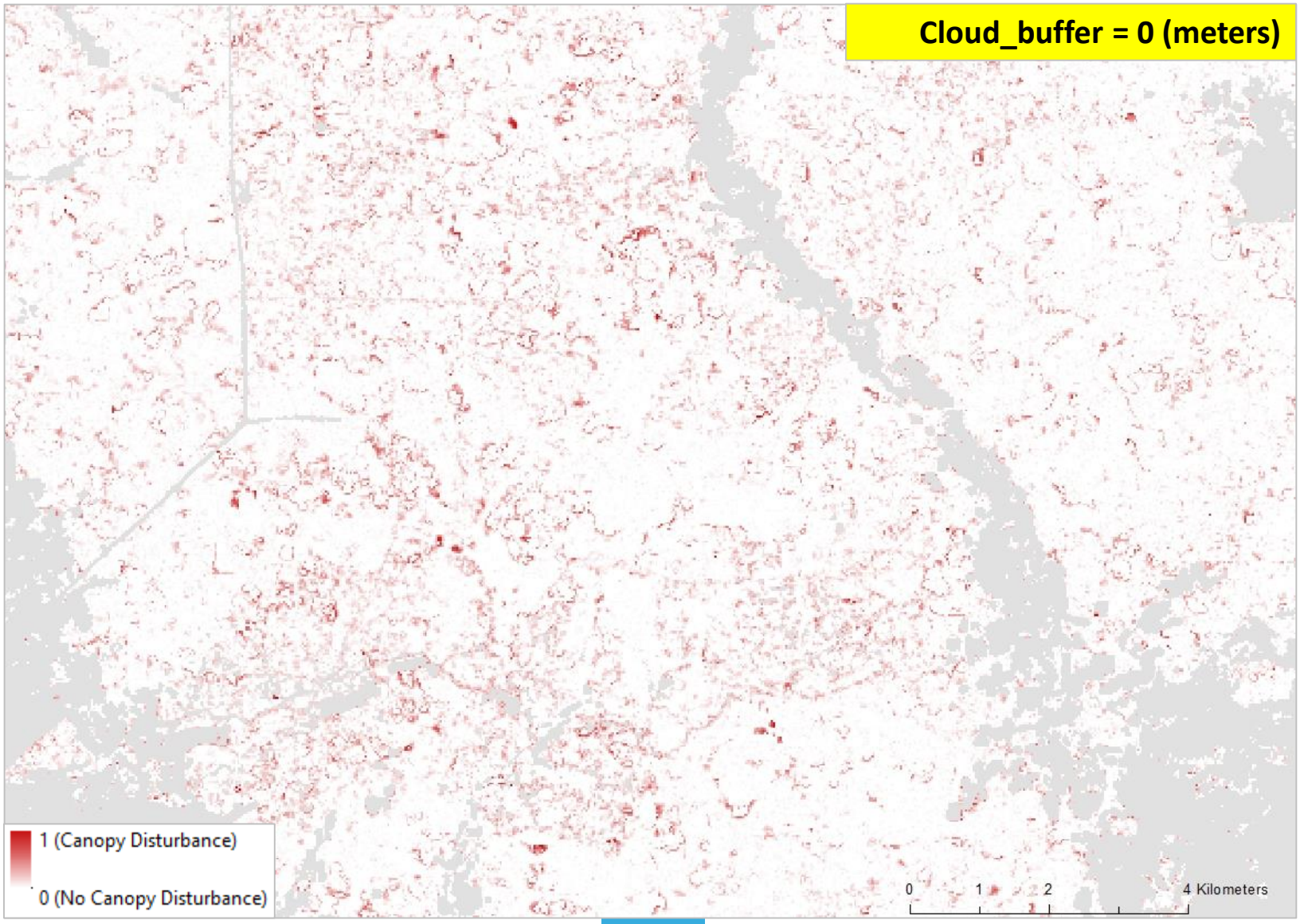
 of the single NBR scenes is selected
possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -

ted filtering are selected
a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c eaning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

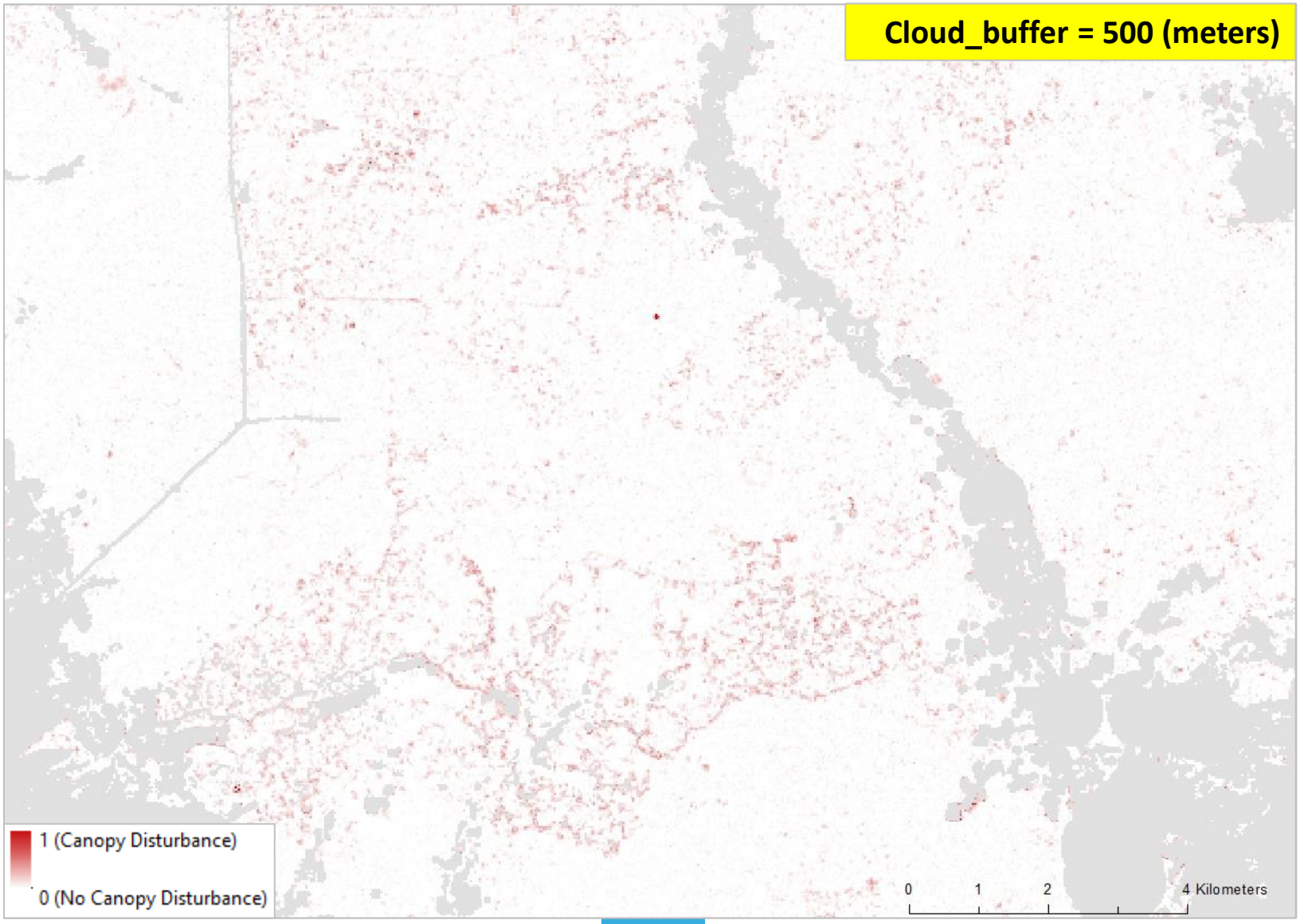
// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ******************************************************************************************************************************************
// End of the section that can be modified by the user *************************************************************************************
// ******************************************************************************************************************************************
```

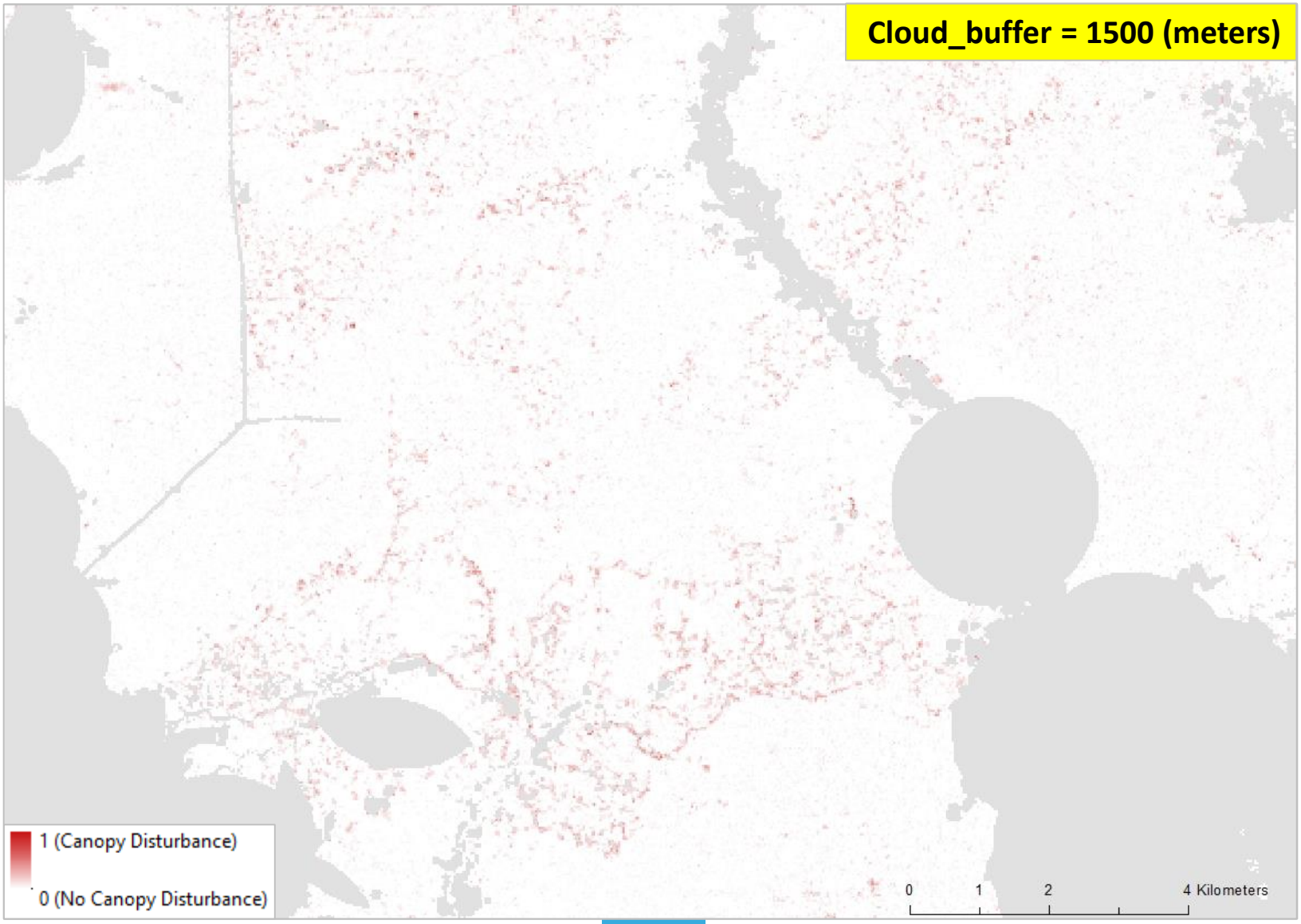
Exercise 2: Cloud Mask Selection



Exercise 2: Cloud Mask Selection



Exercise 2: Cloud Mask Selection



Exercise 3: Noise Filtering

```
// ********************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************
// ********************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types result in increased noise)
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (lowest white noise level)
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.1999 - ongoing (elevated white noise level)
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 - 11.2011 (elevated white noise level)
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 - ongoing (reduced noise when 'improve_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.2011 (elevated white noise level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts from remaining clouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
```

Selection:

a) **Filtering = No**

b) **Filtering = Yes (threshold = 0.02; kernel = 45; min_disturbances = 3)**

c) **Filtering = Yes (threshold = 0.02; kernel = 150; min_disturbances = 5)**

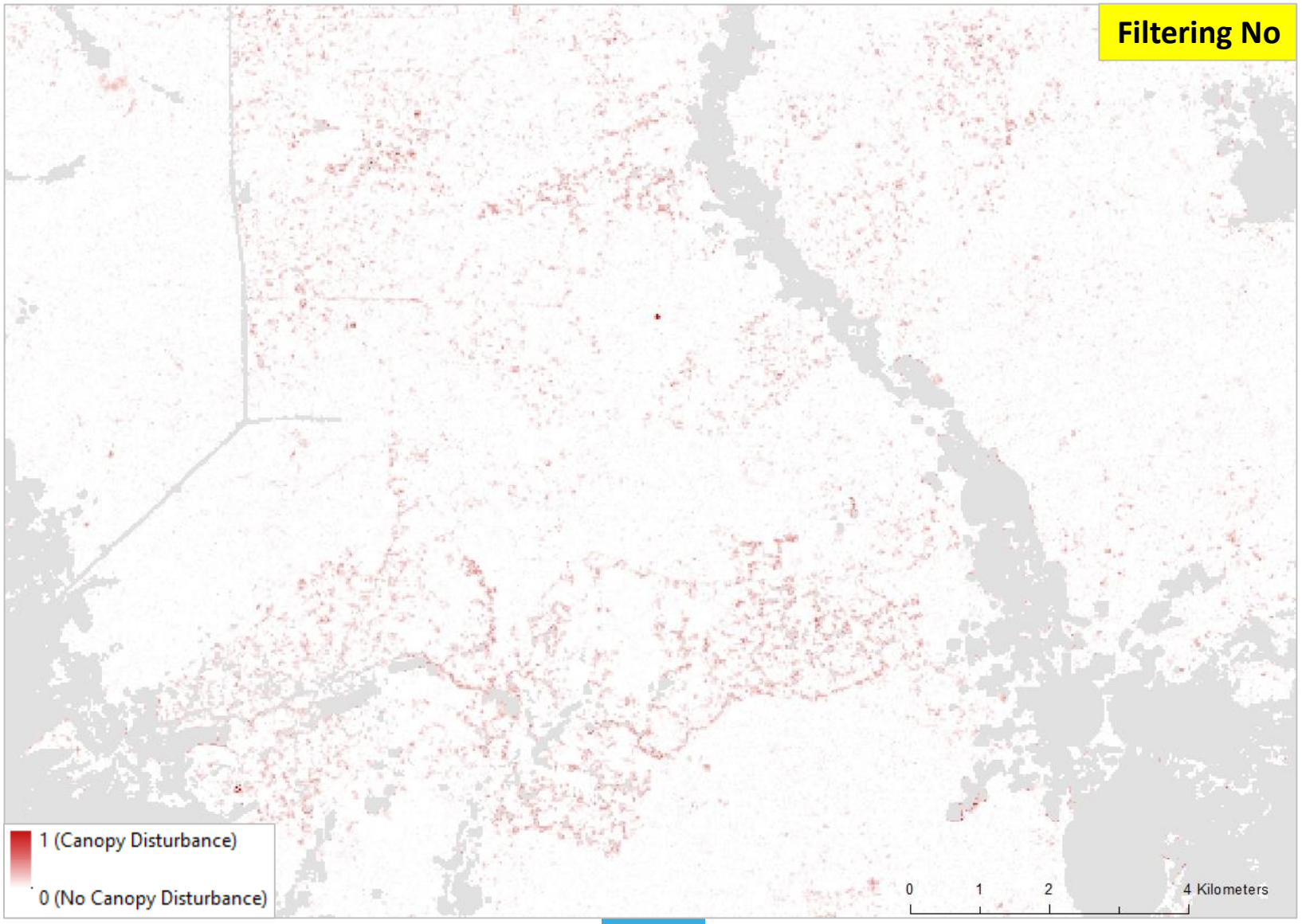
(Disturbance-density-related) filtering

```
// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c eaning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

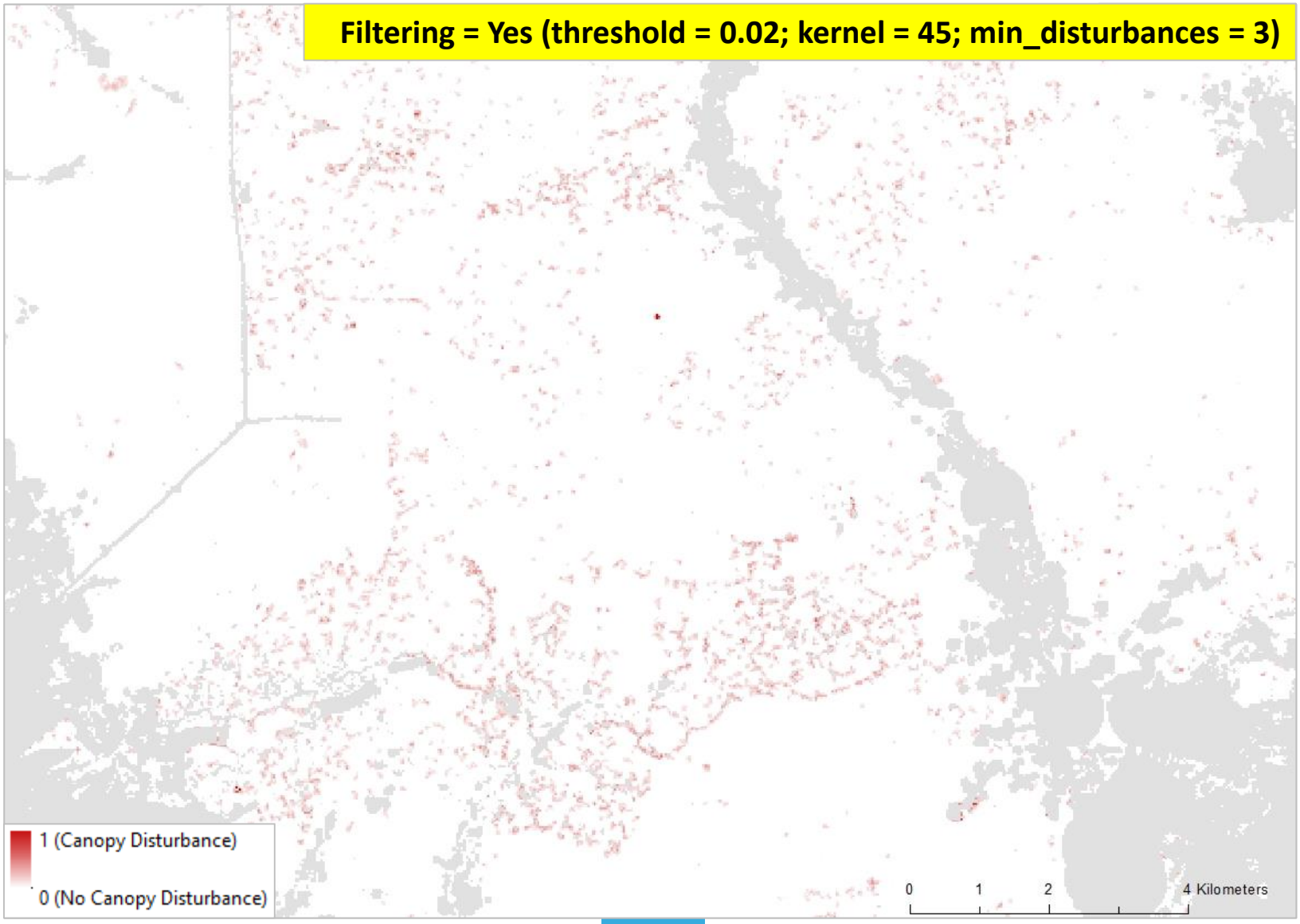
// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************
// ********************************************************************************************************************************************************
```

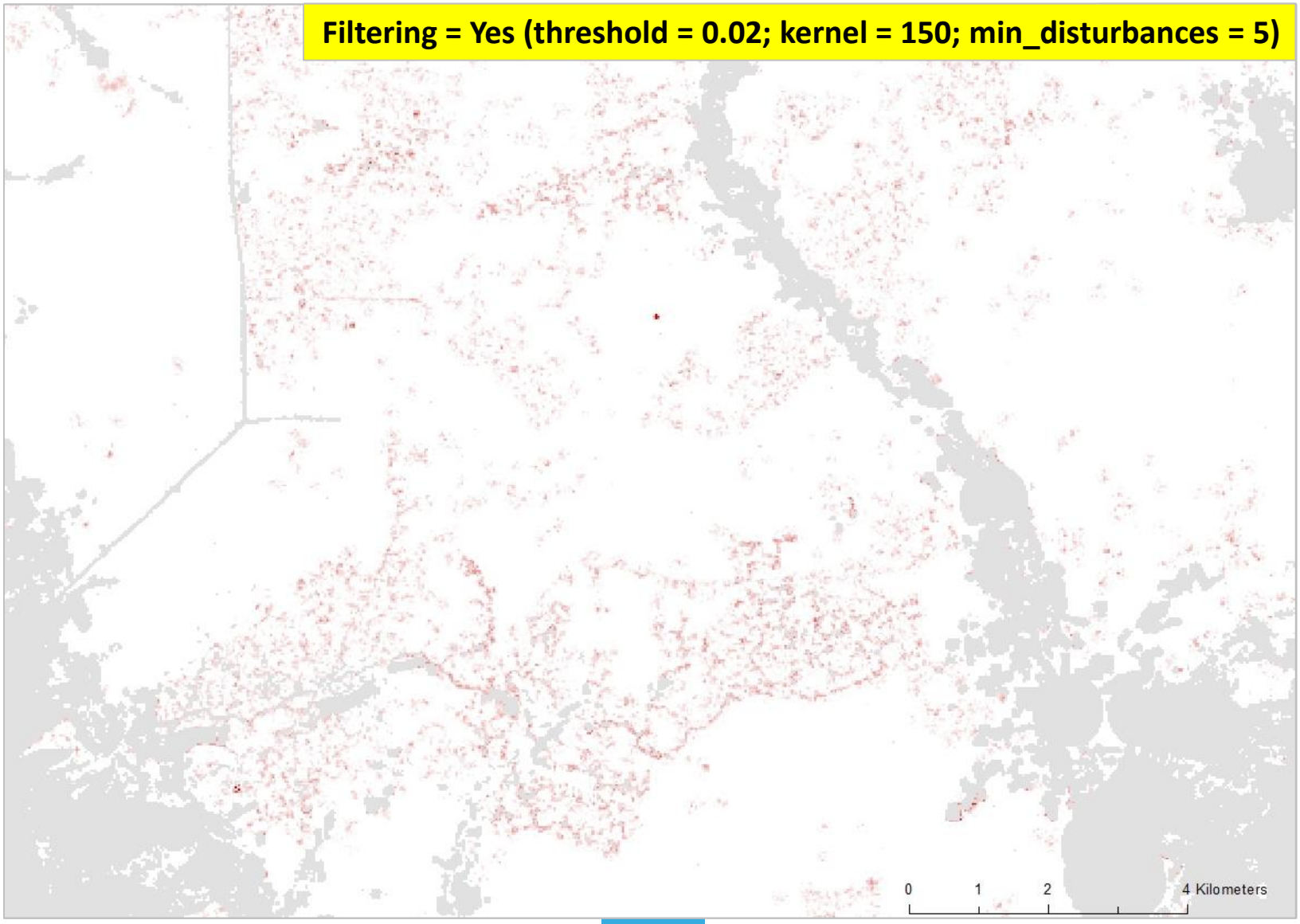
Exercise 3: Noise Filtering



Exercise 3: Noise Filtering



Exercise 3: Noise Filtering



Exercise 4: Threshold Selection in GIS

```
// ********************************************************************************************************************************************************
// Definition of variables that can be modified by the user ***********************************************************************************************
// ********************************************************************************************************************************************************

// Investigation periods (enter in format 'yyy-mm-dd')
var Start_base = '2014-01-01';
var End_base = '2014-12-31';
var Start_second = '2015-01-01';
var End_second = '2015-12-31';

// Sensor to be used (only for overlapping periods because delta-products between different sensor types res
var Sensor = 'L8'; // Type 'L8' for Landsat 8 if both investigation periods intersect with the following perio
                   // Type 'L7' for Landsat 7 if both investigation periods intersect with the following period: 04.
                   // Type 'L5' for Landsat 5 if both investigation periods intersect with the following period: 03.1984 -
                   // Type 'L78' for Landsat 7 and 8 if both investigation periods intersect with the following period: 04.2013 -                    prove_L8')
                   // Type 'L57' for Landsat 5 and 7 if both investigation periods intersect with the following period: 04.1999 - 11.201                  level)
                   // Type 'S2' for Sentinel-2 if both investigation periods intersect with the following period: 06.2015 - ongoing (artifacts                  ouds)
var improve_L8 = 'Yes'; // Options: 'Yes'; 'No' (valid only add information of L7 if Delta-NBR is above certain 'improve_threshold')
var improve_threshold = 0.05; // Threshold of L7 Delta-NBR signal above which it is taken into account for further processing

// Geographic area to be investigated (e.g. by loading any other geometry)
var countryname = "CB"; // Options: see https://en.wikipedia.org/wiki/List_of_FIPS_country_codes for country codes
// var country = ee.FeatureCollection("USDOS/LSIB_SIMPLE/2017").filterMetadata('country_co','equals',countryname); // Simplified country border polygons
var country = ee.FeatureCollection("USDOS/LSIB/2013").filterMetadata('cc','equals',countryname); // Country border polygons of higher accuracy (slower)

var center = 0; // Type '1' to automatically center on study area

// Here the cloud masking approach and specific variables are selected (all cloud masks can be combined and used together)
var QB_select = 'Yes'; // Options: 'Yes'; 'No' (for using the L8-specific quality bands for cloud removal - only applicable with L8 data)
var Fmask_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE Fmask algorithm)
var SimpleCloudScore_select = 'Yes'; // Options: 'Yes'; 'No' (for using the GEE SimpleCloudScore algorithm)
var UnsureClouds_select = 'Yes'; // Options: 'Yes'; 'No' (for using a modified version of the GEE SimpleCloudScore algorithm)
var cloud_buffer = 500; // Buffer distance around detected clouds; possible values: 0-? (default value of 2500 meters is already very conservative!)

// Here the forest masks and their 'forest thresholds' are selected
var forest_mask_select = 'Roadless map';  // Options: 'No forest map'; 'Roadless map'; '2015 Hansen map'; '2014 Hansen map'; '2013 Hansen map'; '2012 Hansen map'
var roadless_year = '2015 Roadless map'; //  Options: '2016 Roadless map'; '2015 Roadless map'; '2014 Roadless map'
var hansen_treecover = 70; // Possible values:  0 - 100

// Here the kernel size in meters for the self-referencing step of the single NBR scenes is selected
var kernel_size = 210; // Radius of circular kernel in meters; possible values:  0 - ? (0 refers to no self-referencing; 210 meters delivers good results -
                       // however value can be adjusted)

// Here variables regarding a possible disturbance-density-related filtering are selected
var cleaning_select = 'No'; // Options: 'Yes'; 'No' (for using a disturbance density related cleaning of the Delta-NBR result)
var threshold_conservative = 0.05; // Threshold creating binary map for filtering; threshold (range: 0 and -1) has to be more conservative as final threshold
var kernel_clean_size = 45;  / Kernel (circular) radius size in meters for the disturbance density related c eaning
var min_disturbances = 3; // Minimum number of crown cover disturbance events per cleaning kernel

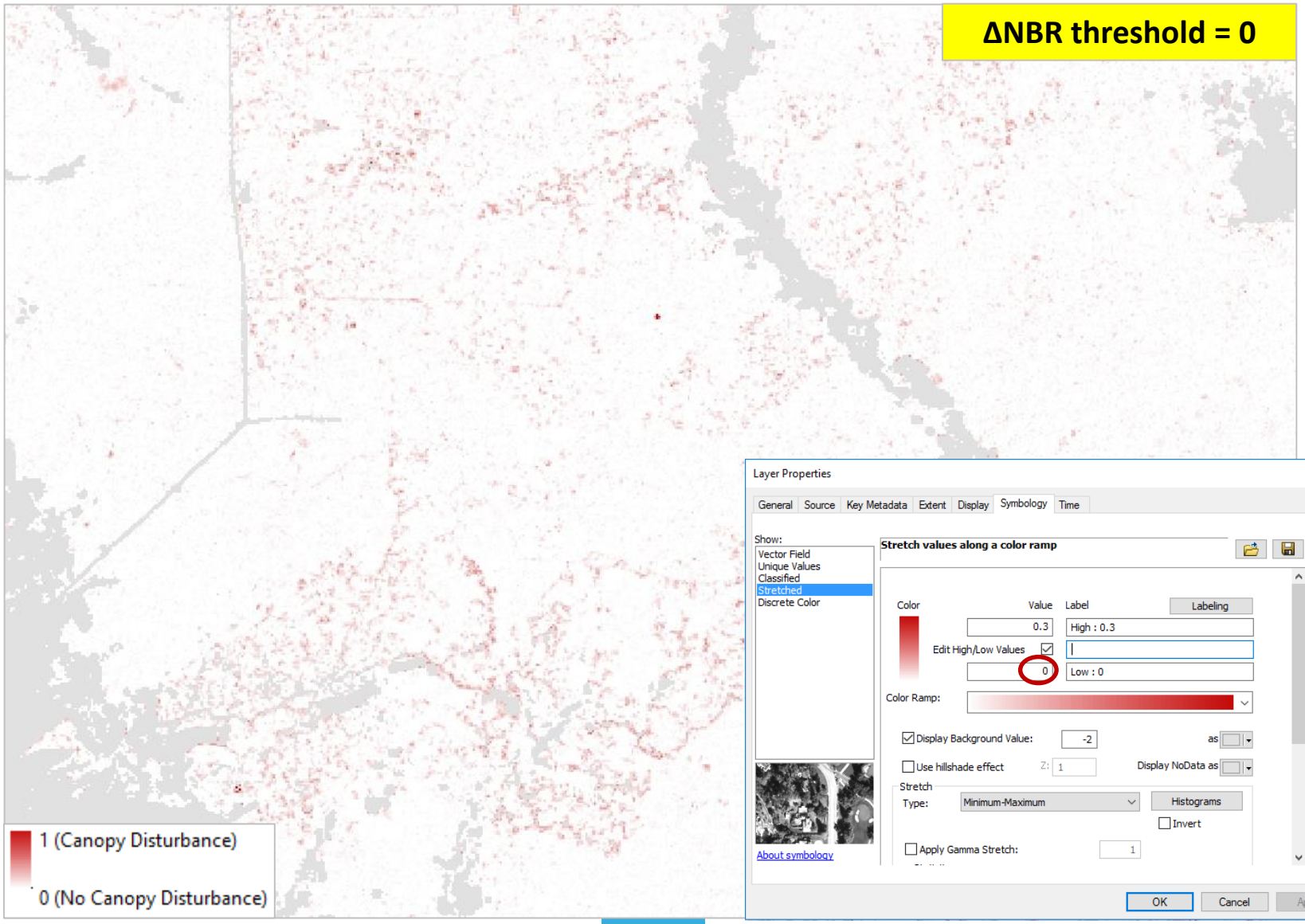
// Here the option of an export of the results is selected
var export_select = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRs = 'No'; // Options: 'Yes'; 'No'
  var export_select_singleNBRdates = 'No'; // Options: 'Yes'; 'No''

// ********************************************************************************************************************************************************
// End of the section that can be modified by the user ****************************************************************************************************
// ********************************************************************************************************************************************************
```

After exporting data → use ArcGIS/QGIS for better visualization

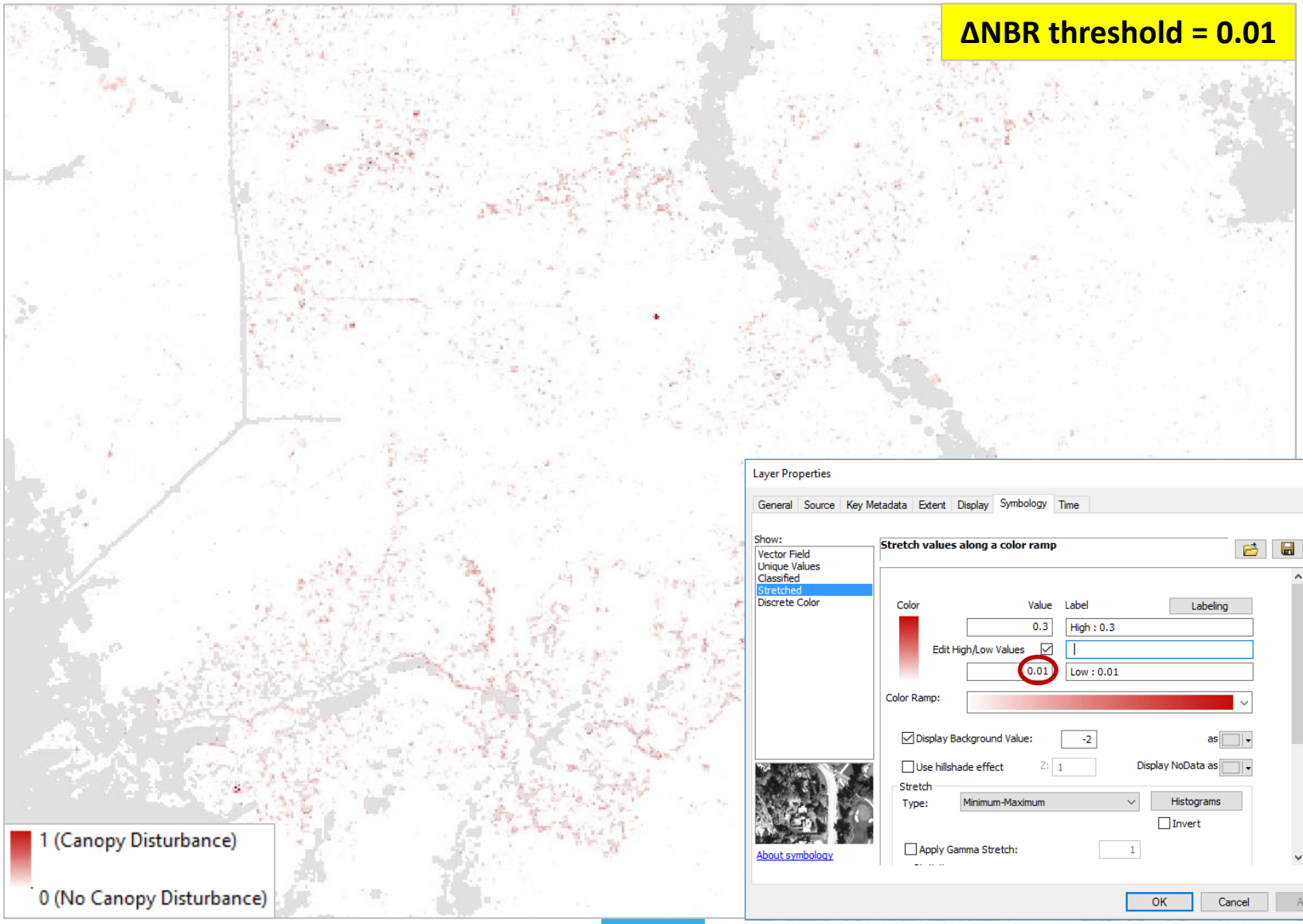
Exercise 4: Threshold Selection in GIS

ΔNBR threshold = 0



Exercise 4: Threshold Selection in GIS

ΔNBR threshold = 0.01



Exercise 4: Threshold Selection in GIS

ΔNBR threshold = 0.02