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Institute of
Digital Image Processing

GAFAG

Reducing Emissions from Deforestation and Forest Degradation (REDD)

Pilot Project Cameroon

Manuela Hirschmugl

Joanneum Research

Content:

The IPCC WGIII (2007) estimated emissions from deforestation in the 1990s to be at 5.8 GtCO2/yr. Deforestation and degradation together account for approximately 20% of the GHG emissions worldwide.

Reducing
Emissions from
Deforestation and Forest
Degradation in Developing Countries

→ **post-Kyoto reporting**
→ **reducing green house gas (GHG) emissions**
→ **carbon trading**
→ **financial benefit for developing countries, who avoid deforestation and forest degradation**

Further information:
http://unfccc.int/methods_science/redd/items/4531.php

Partners and Support for the pilot study Cameroon:

GTZ-COMIFAC programme supports REDD pilot in Cameroon for the Region

KfW provides funding for REDD Pilot

GAF AG is a globally active Consultancy Company in Germany in the field of development assistance, Earth Observation technology, spatial information systems.

GAF AG is leading the GSE Forest Monitoring Consortium, financed by ESA. GAF AG provides forestry expertise, standards, technical design, dialogue with Stakeholders, Quality assurance, uncertainty assessment.

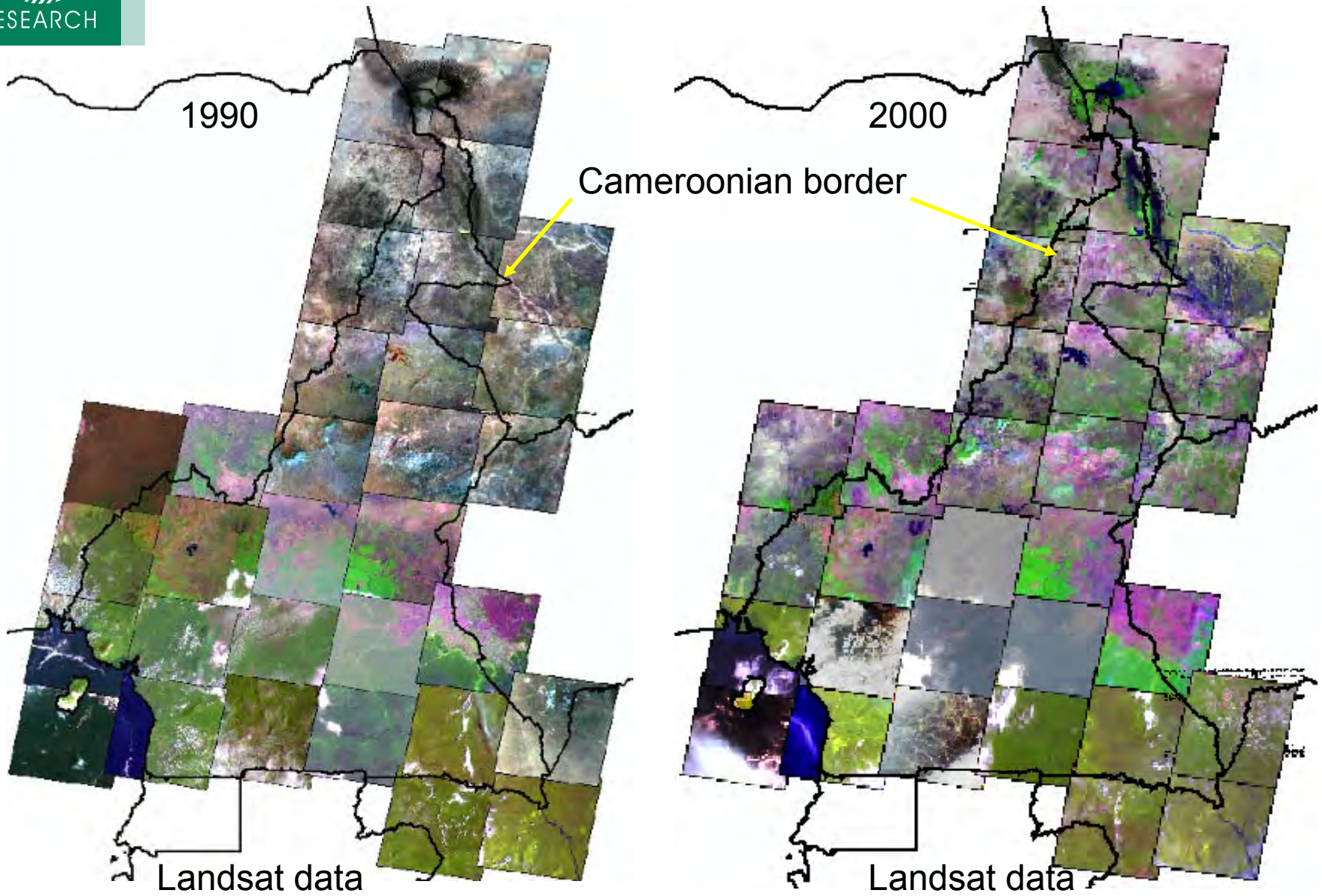
Joanneum Research – Austria. Supports the project with newest technology in satellite image processing

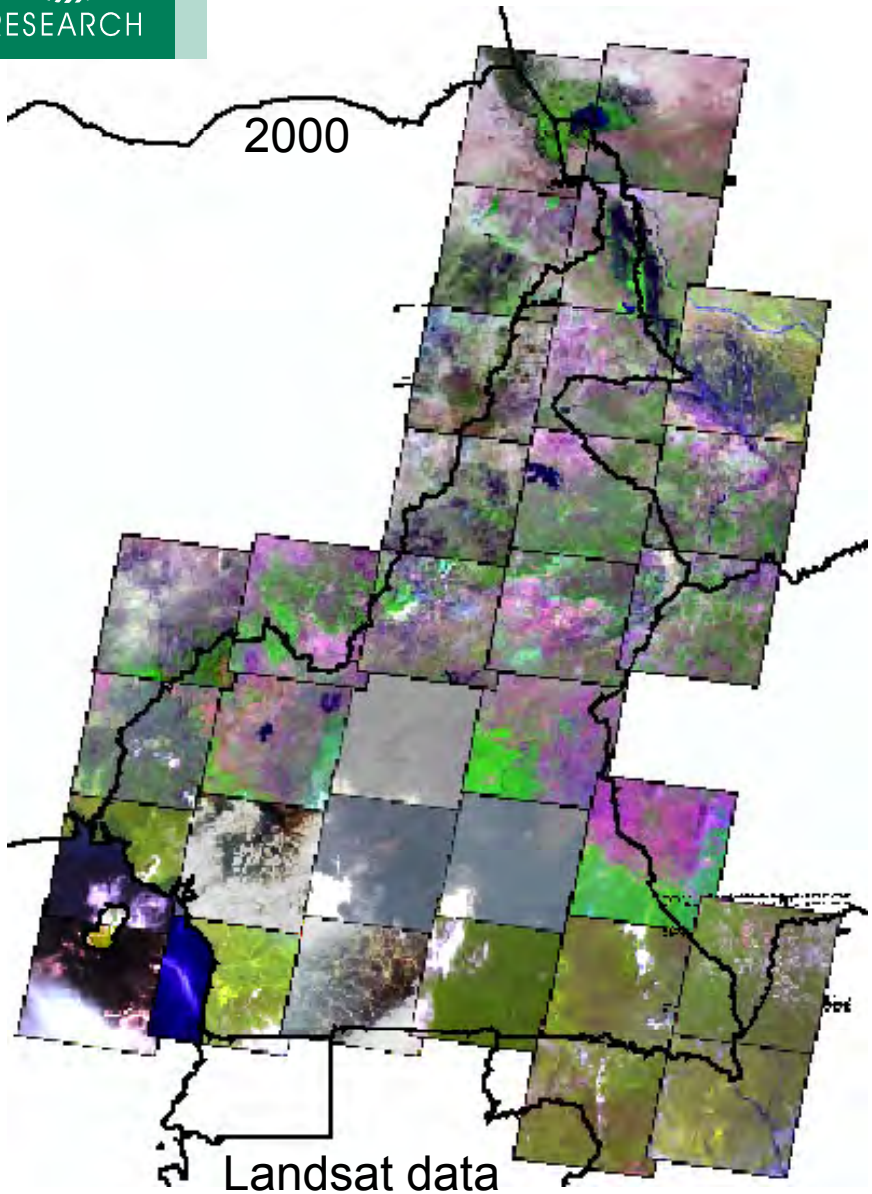
Fan and Super Intendecia Forestal Bolivia have experience from Noel Kempff Mercator Park Project and support biomass measurements, landuse change scenarios and deforestation emissions projection

Aims of this pilot study:

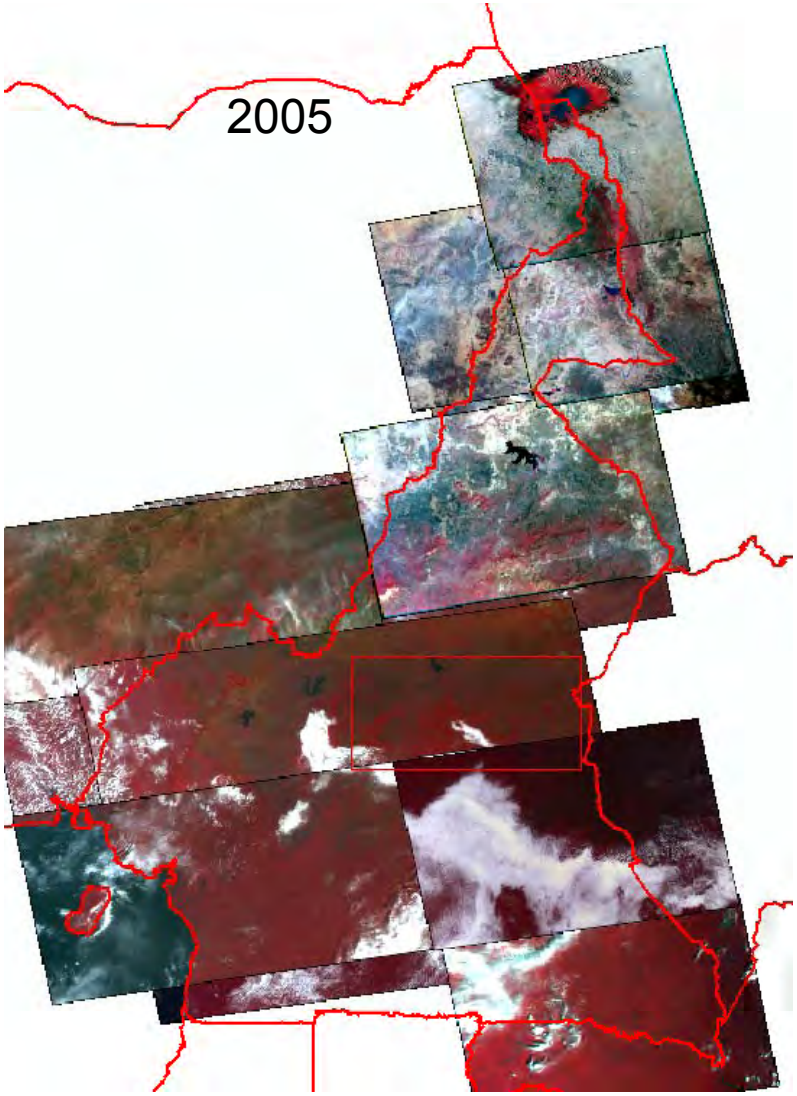
- development of a robust method based on EO and limited terrestrial data
- country-wide mapping of deforestation
- land cover classification of the deforested areas
- method test for degradation mapping
- implementation in the country
- policy development and political awareness
- support in UNFCCC negotiations

Satellite data covering the whole country of Cameroon – 475.400 km²



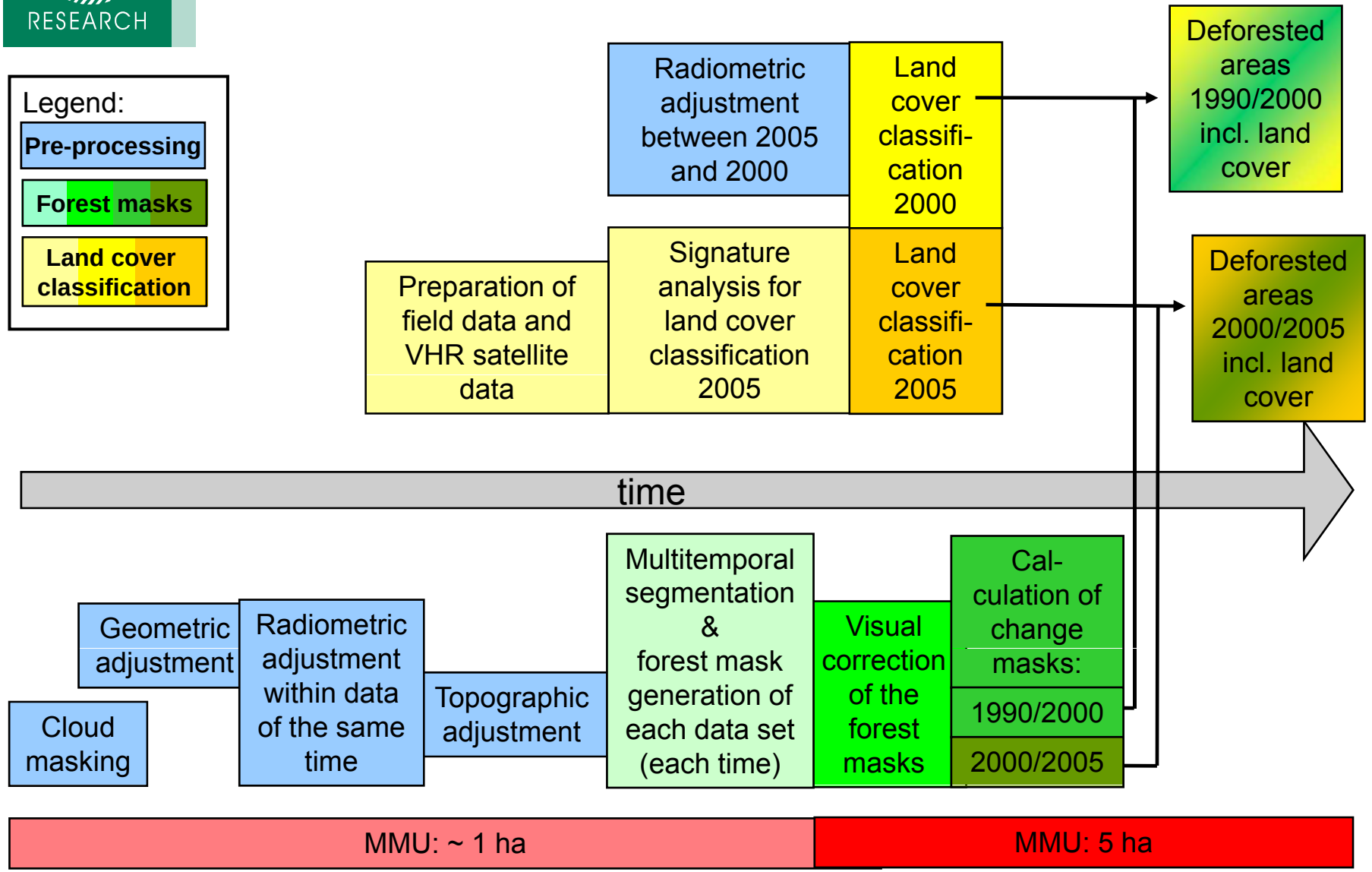


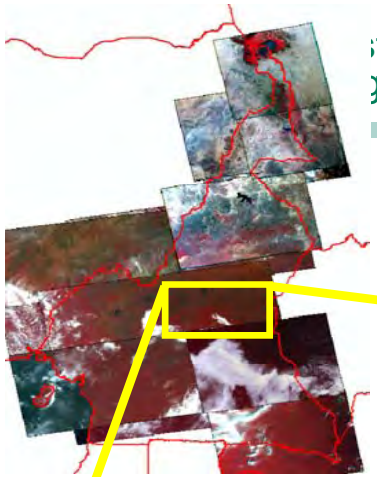
Landsat data



DMC data

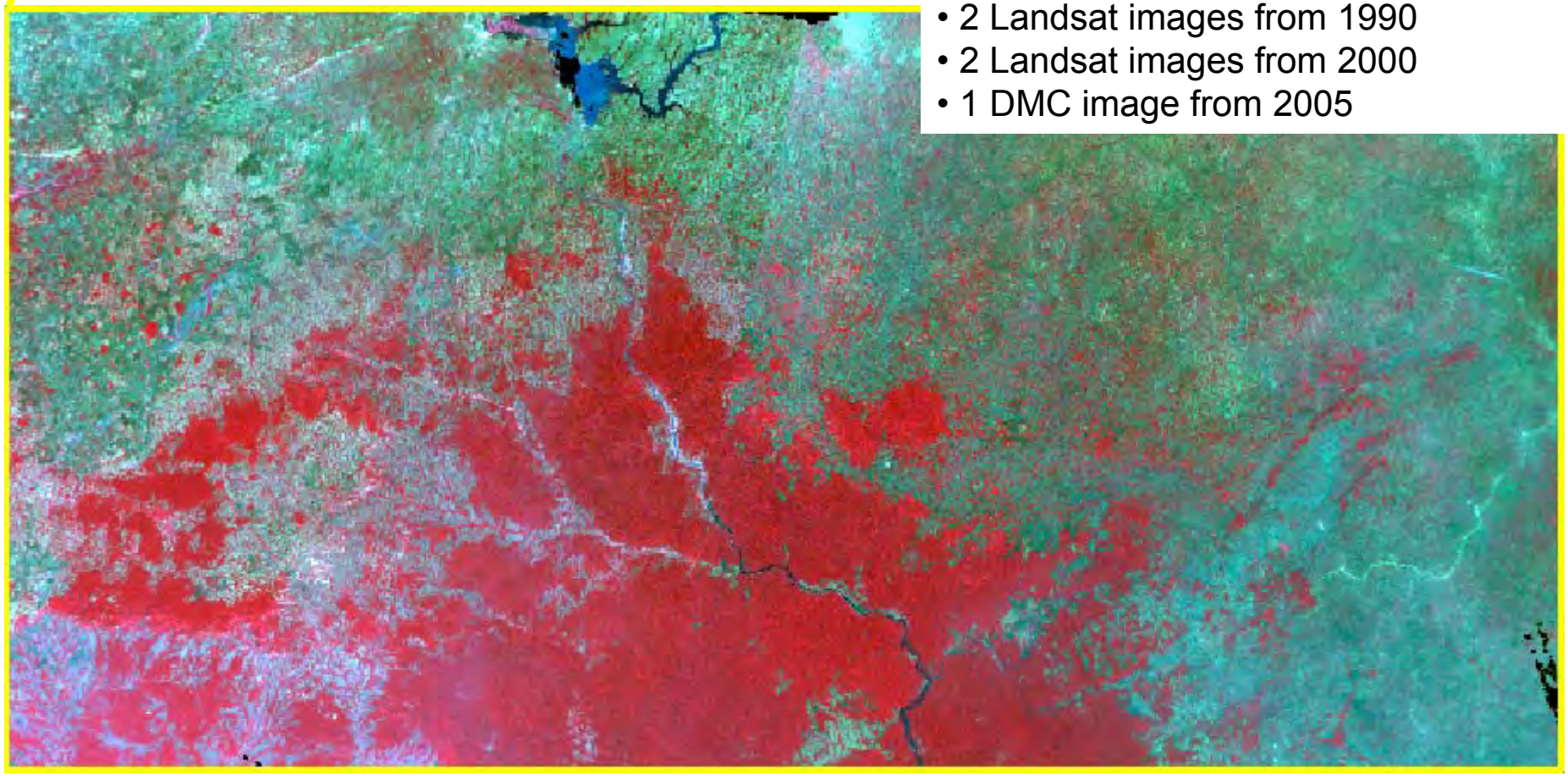
Processing chain for preprocessing, deforestation and land cover mapping



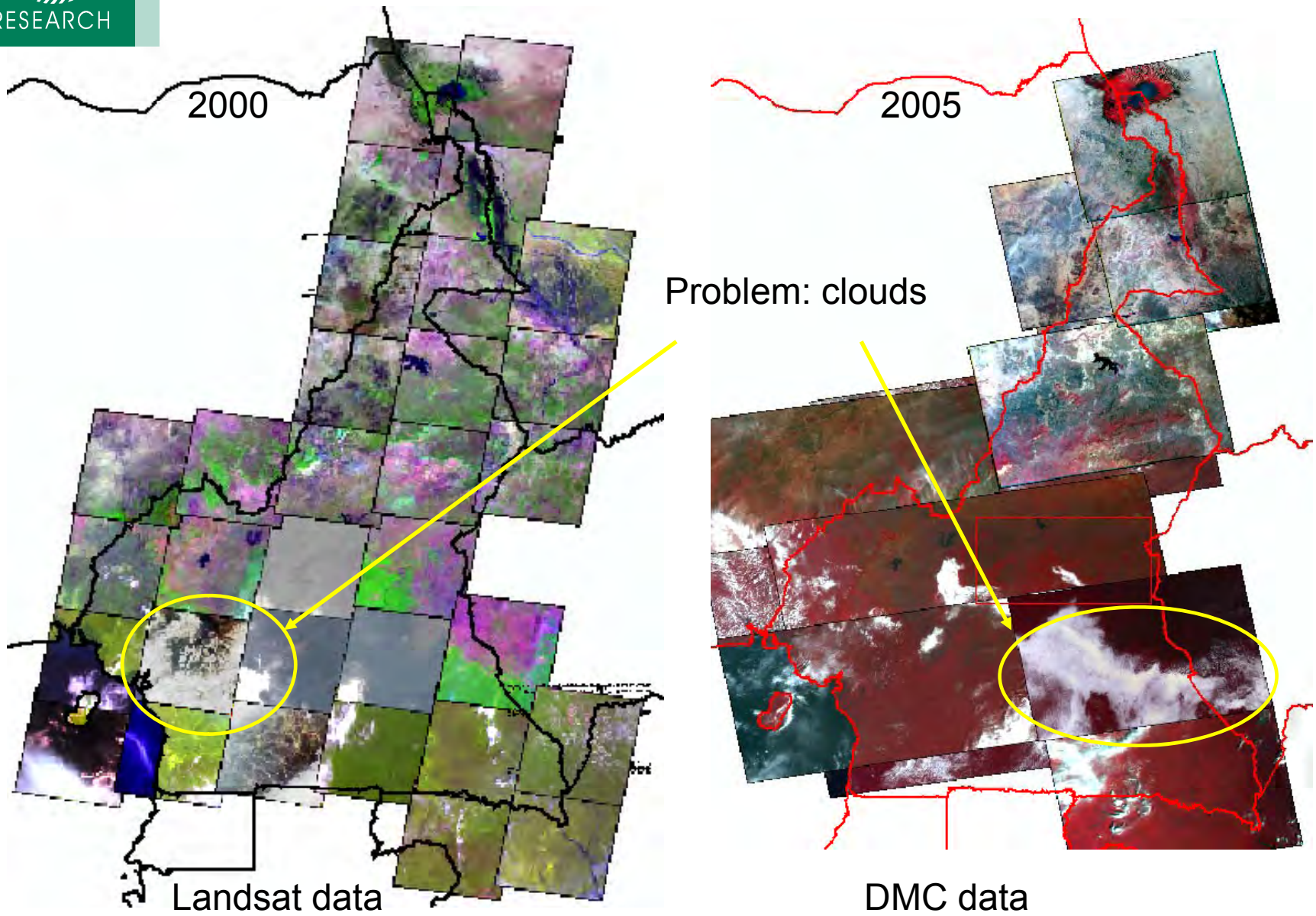


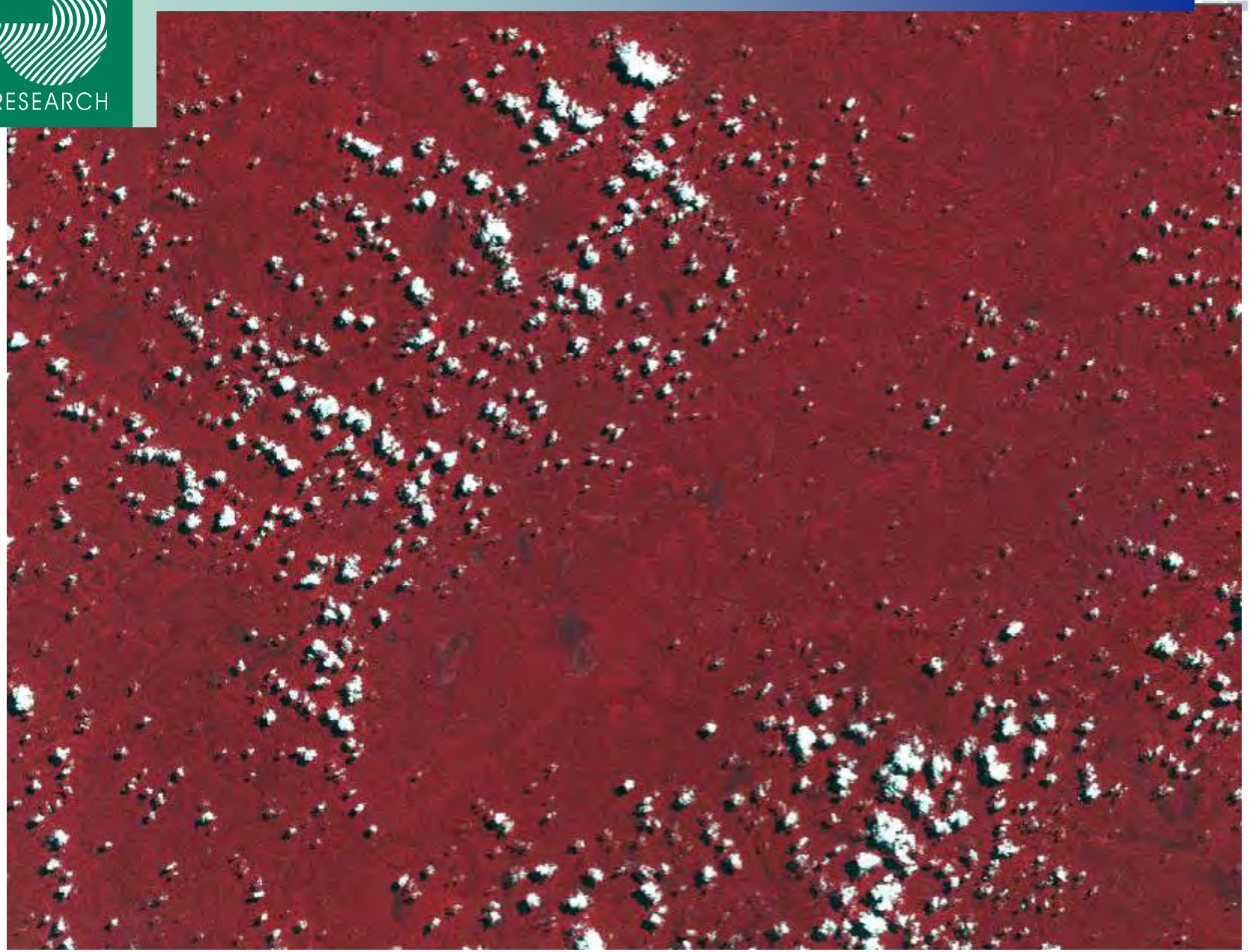
Phase I: Development of the processing chain for a test area

Test site area: 44.691 km^2
Vegetation: transition area between closed evergreen forests and savanna
Data used in the analysis:
- 2 Landsat images from 1990
- 2 Landsat images from 2000
- 1 DMC image from 2005

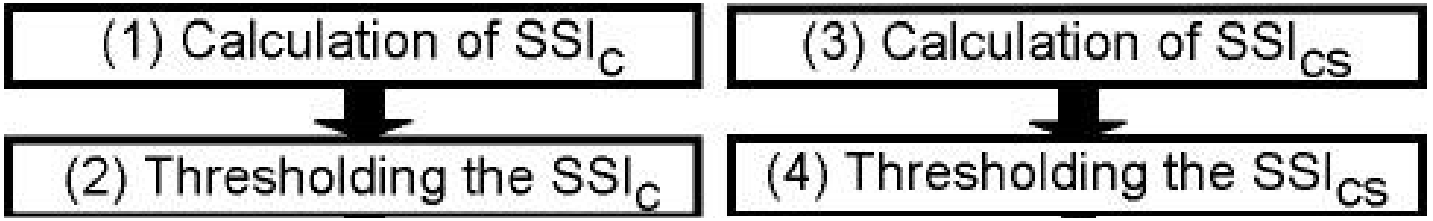


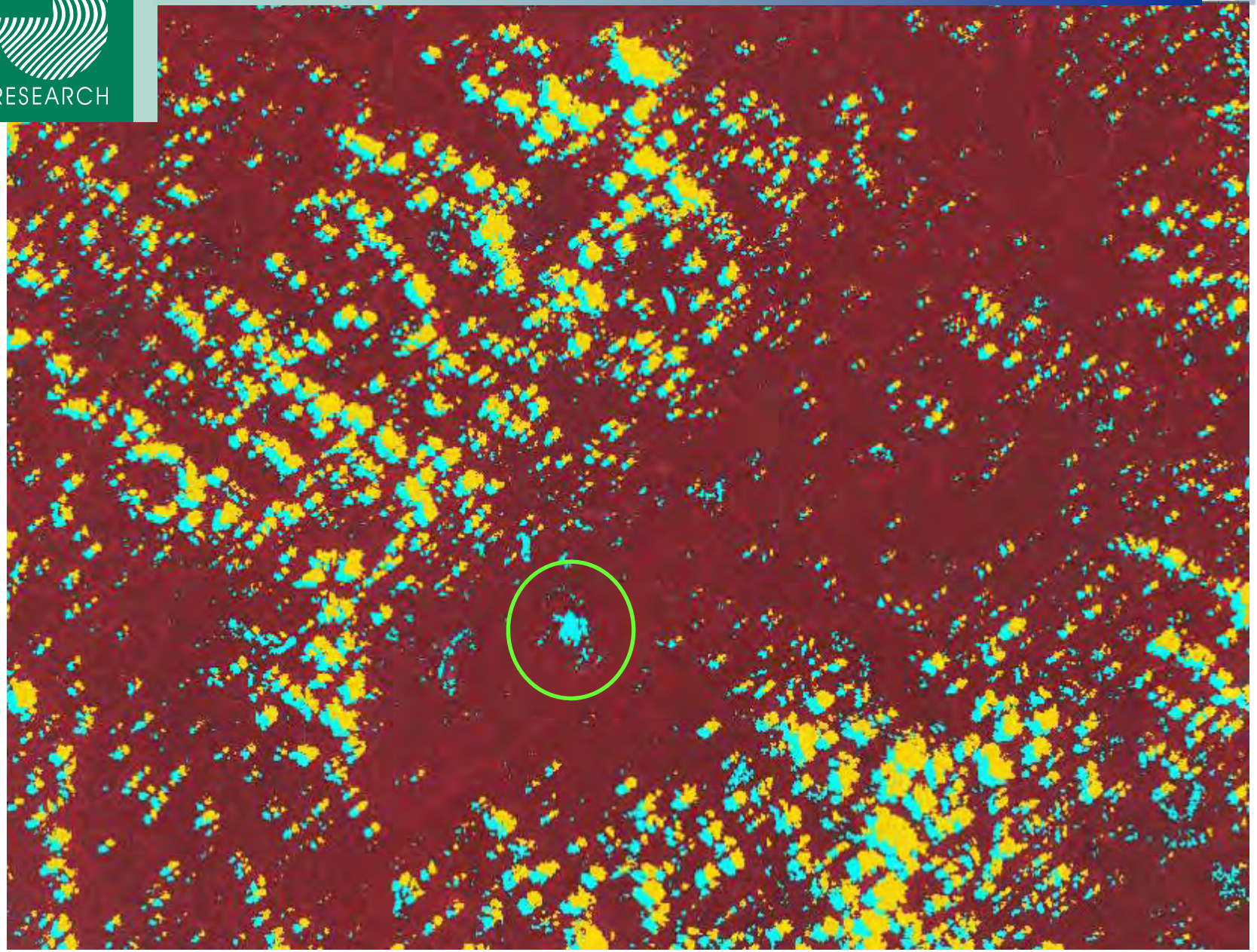
3.1.1. Cloud and cloud shadow masking



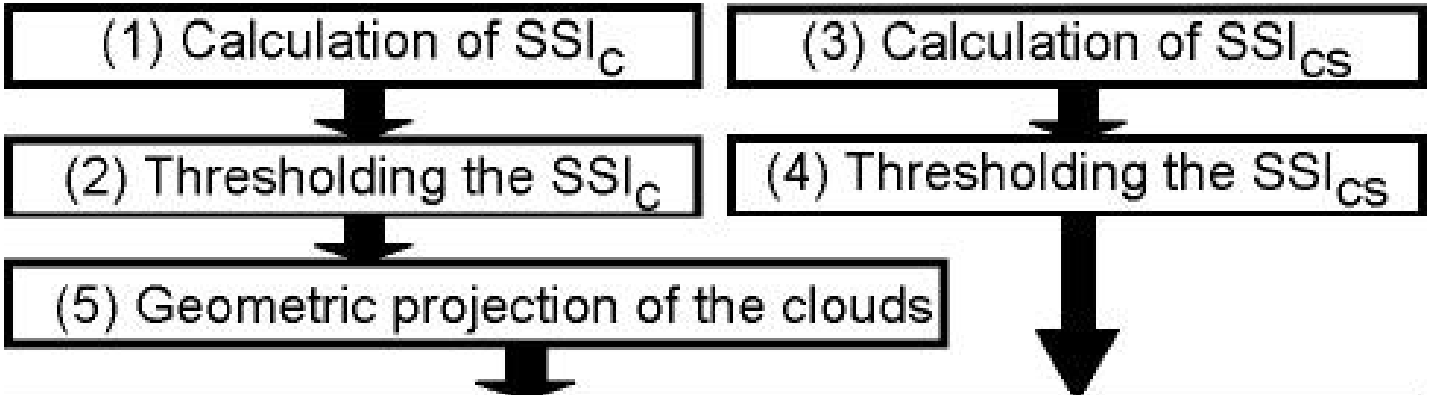


Original scene

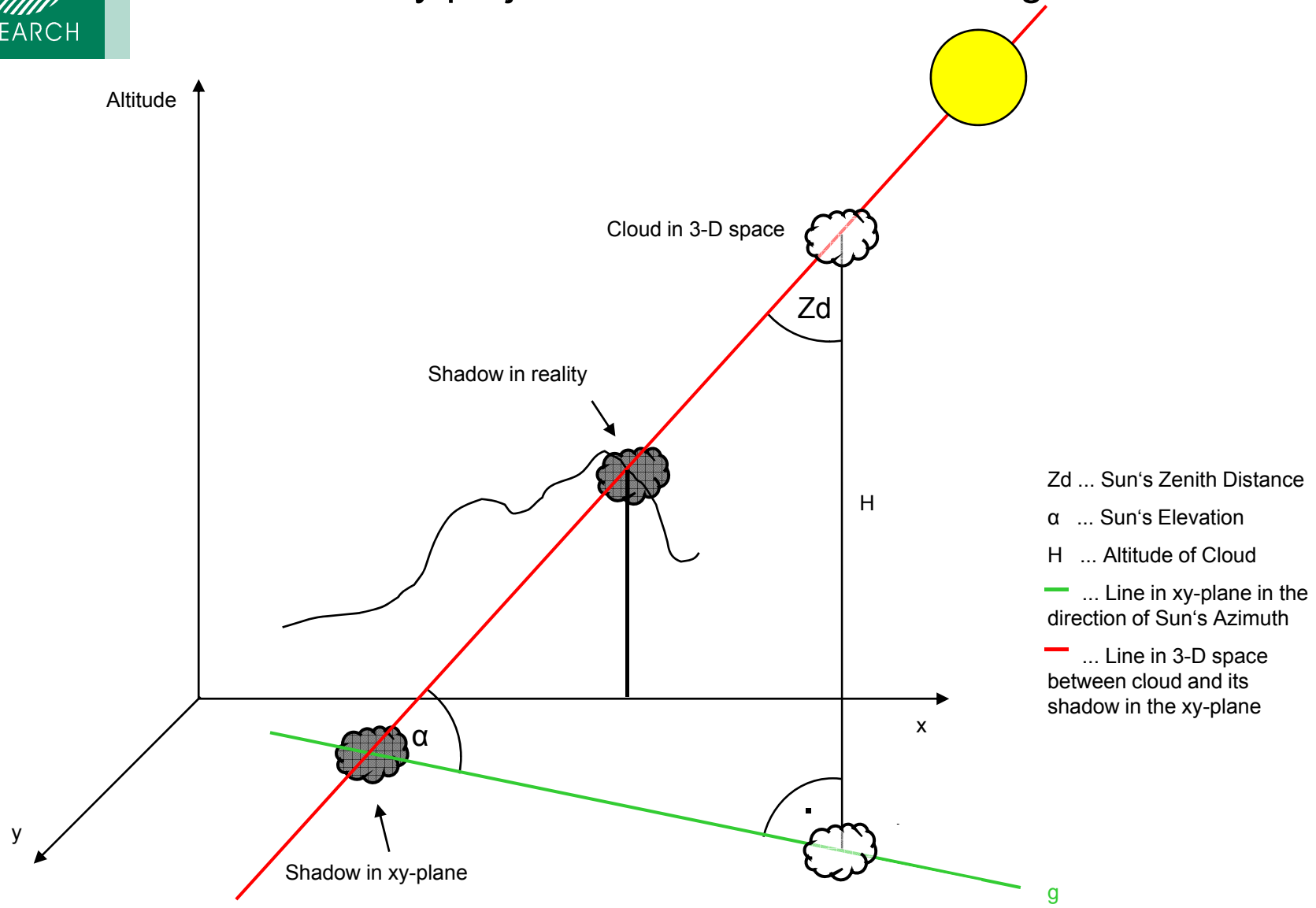

(1) Calculation of SSI_C
(2) Thresholding the SSI_C
(3) Calculation of SSI_{CS}
(4) Thresholding the SSI_{CS}



Cloud and shadowmask – based on SSI tresholding


(1) Calculation of SSI_C
(2) Thresholding the SSI_C
(3) Calculation of SSI_{CS}
(4) Thresholding the SSI_{CS}
(5) Geometric projection of the clouds

Geometrically project the cloud shadows using the DTM



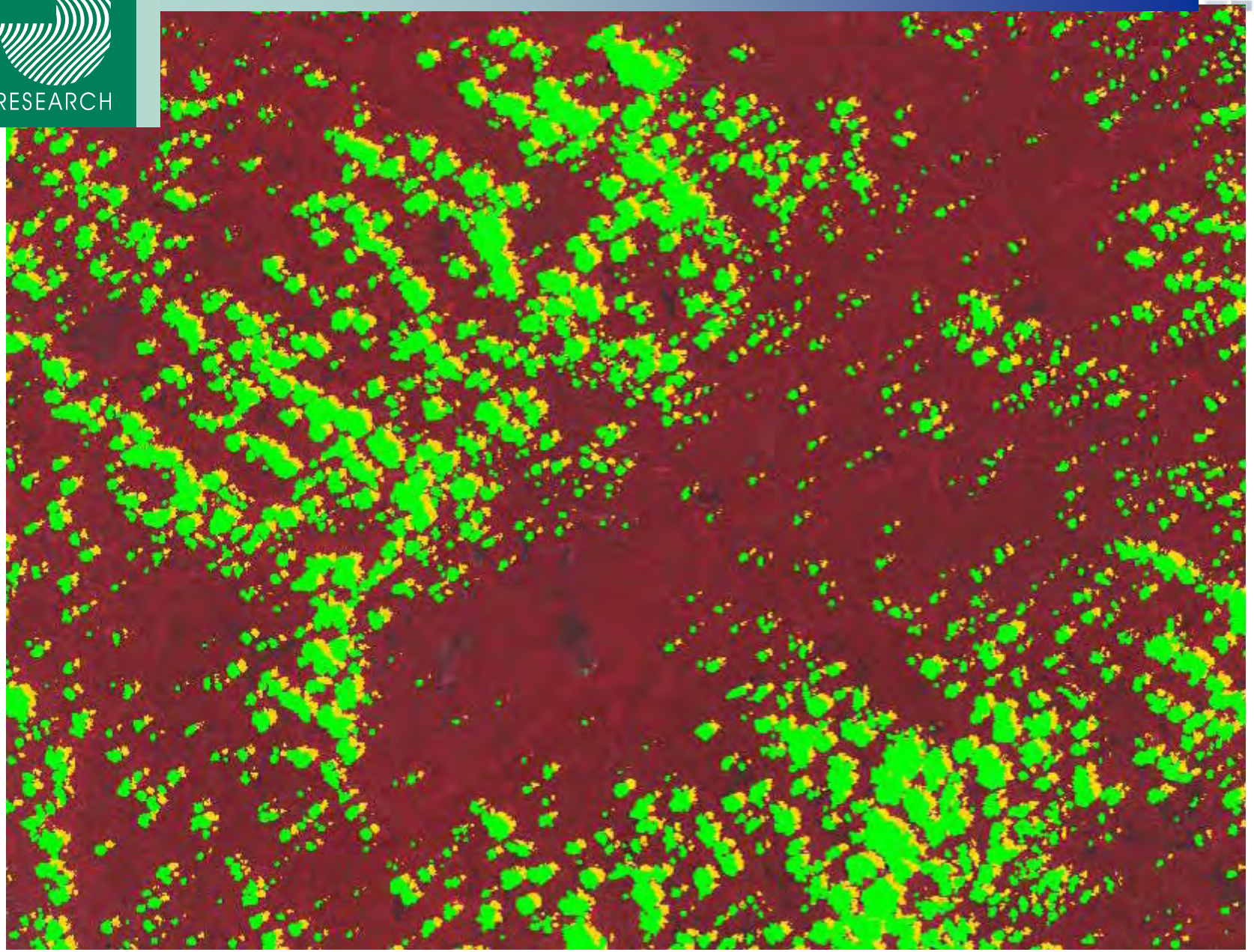
Zd ... Sun‘s Zenith Distance

α ... Sun‘s Elevation

H ... Altitude of Cloud

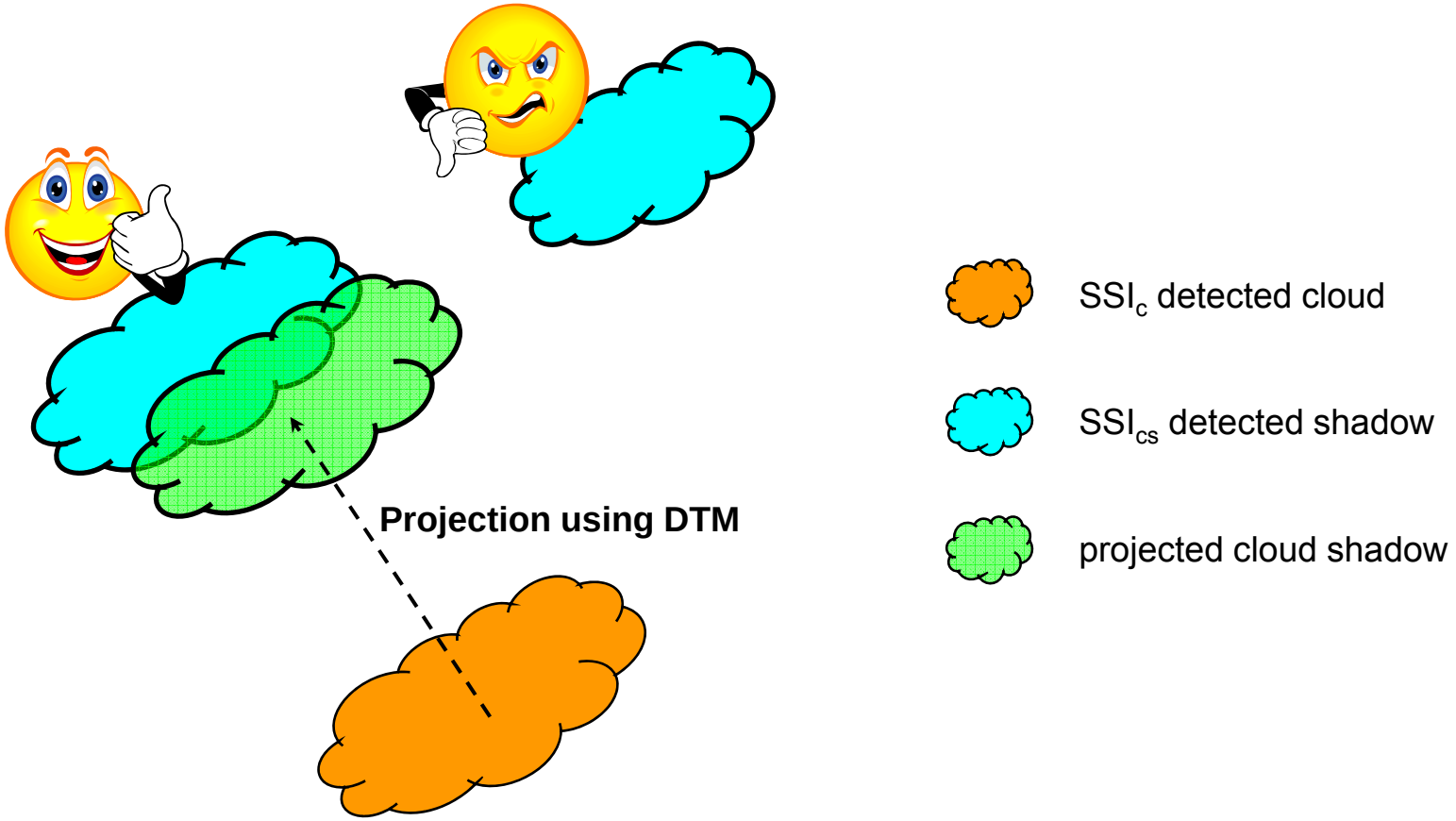
... Line in xy-plane in the direction of Sun‘s Azimuth

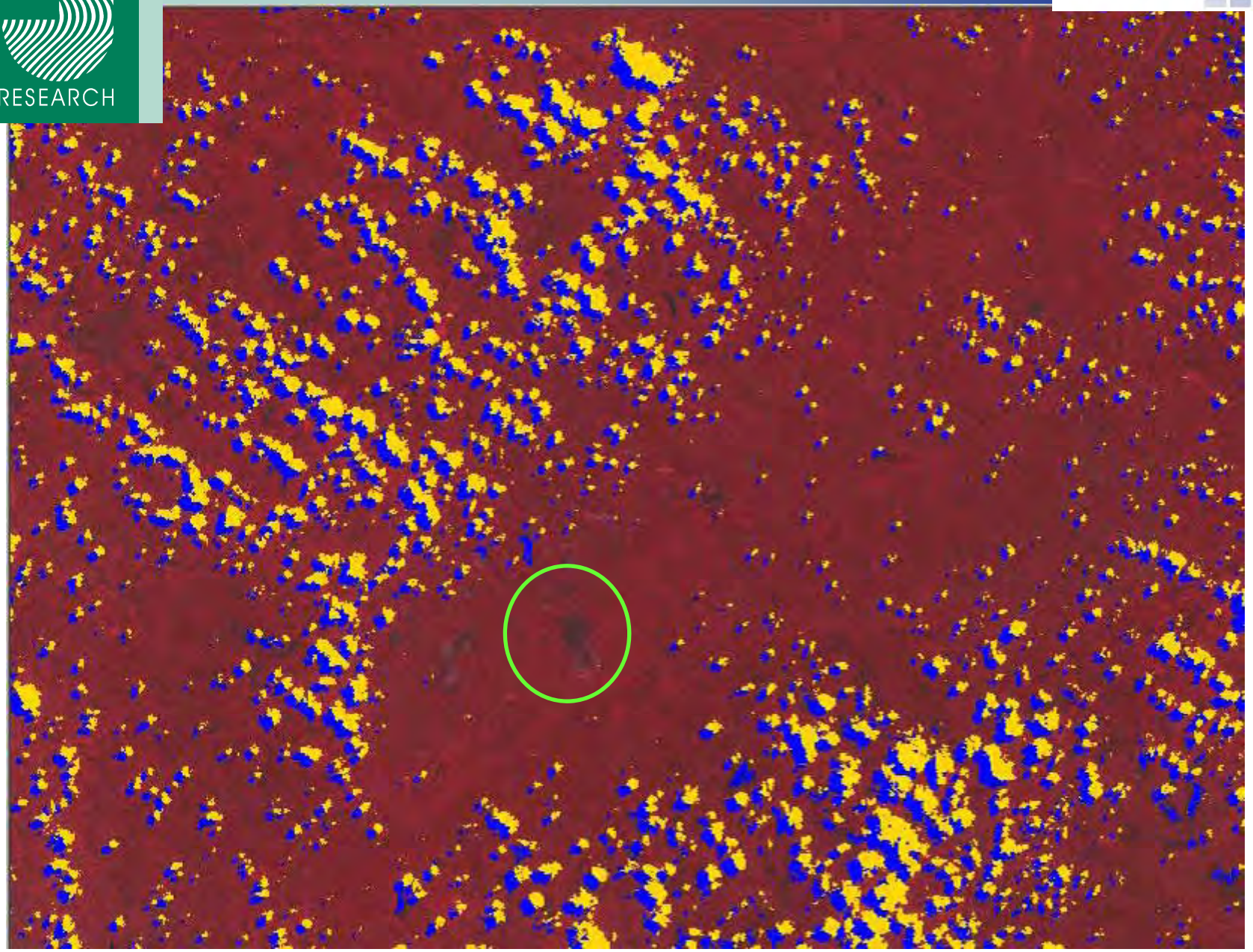
... Line in 3-D space between cloud and its shadow in the xy-plane



Projected cloud shadows

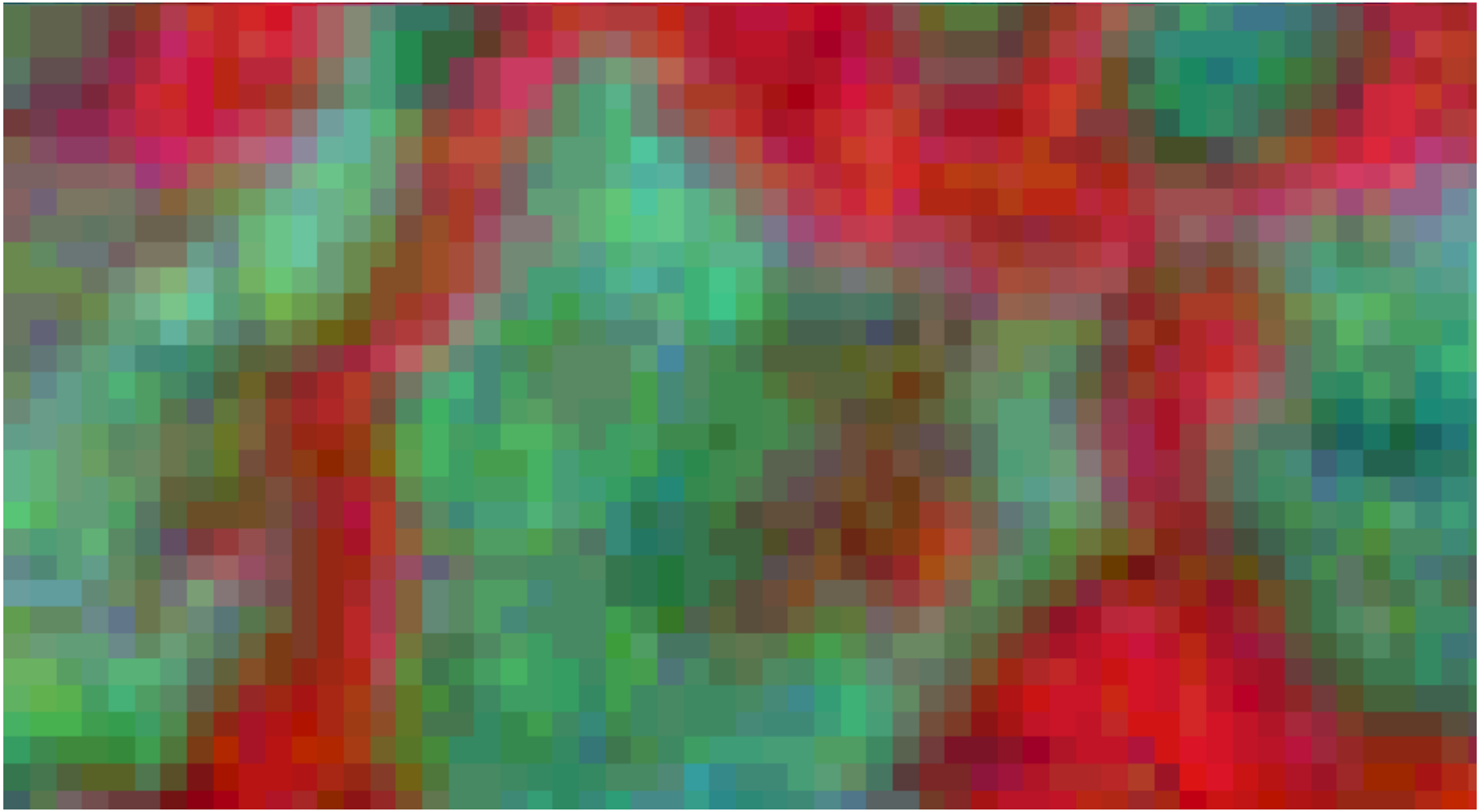
SSI_{cs} Shadow is only valid, if it is connected to a cloud (overlap between detected shadow and ***projected cloud shadow*** according to sun position)



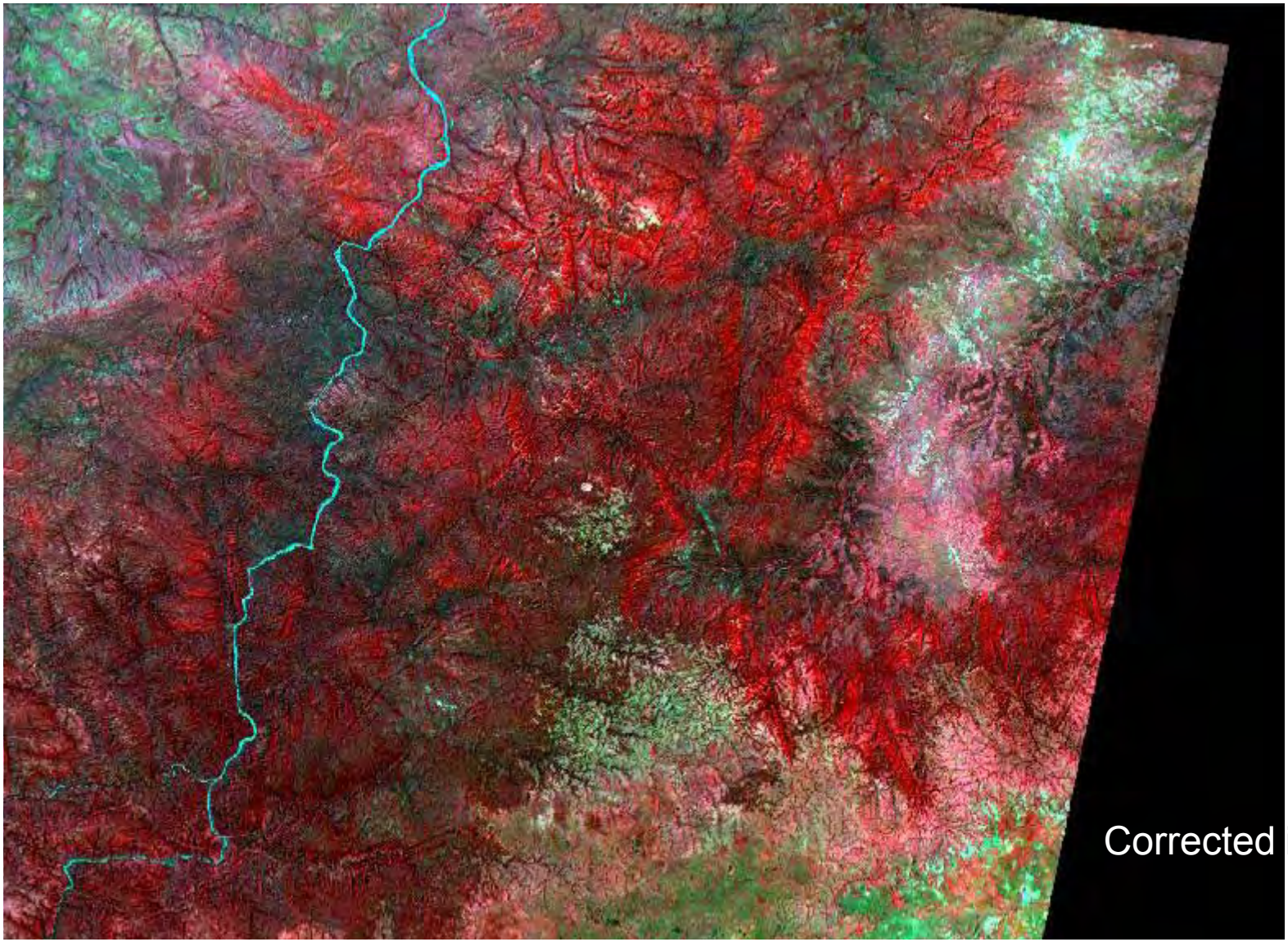


3.1.2. Geometric adjustment

Adjusted data from 2005



3.1.3. Pre-processing: Topographic Normalization to generate similar signature on the south- and north-facing slopes

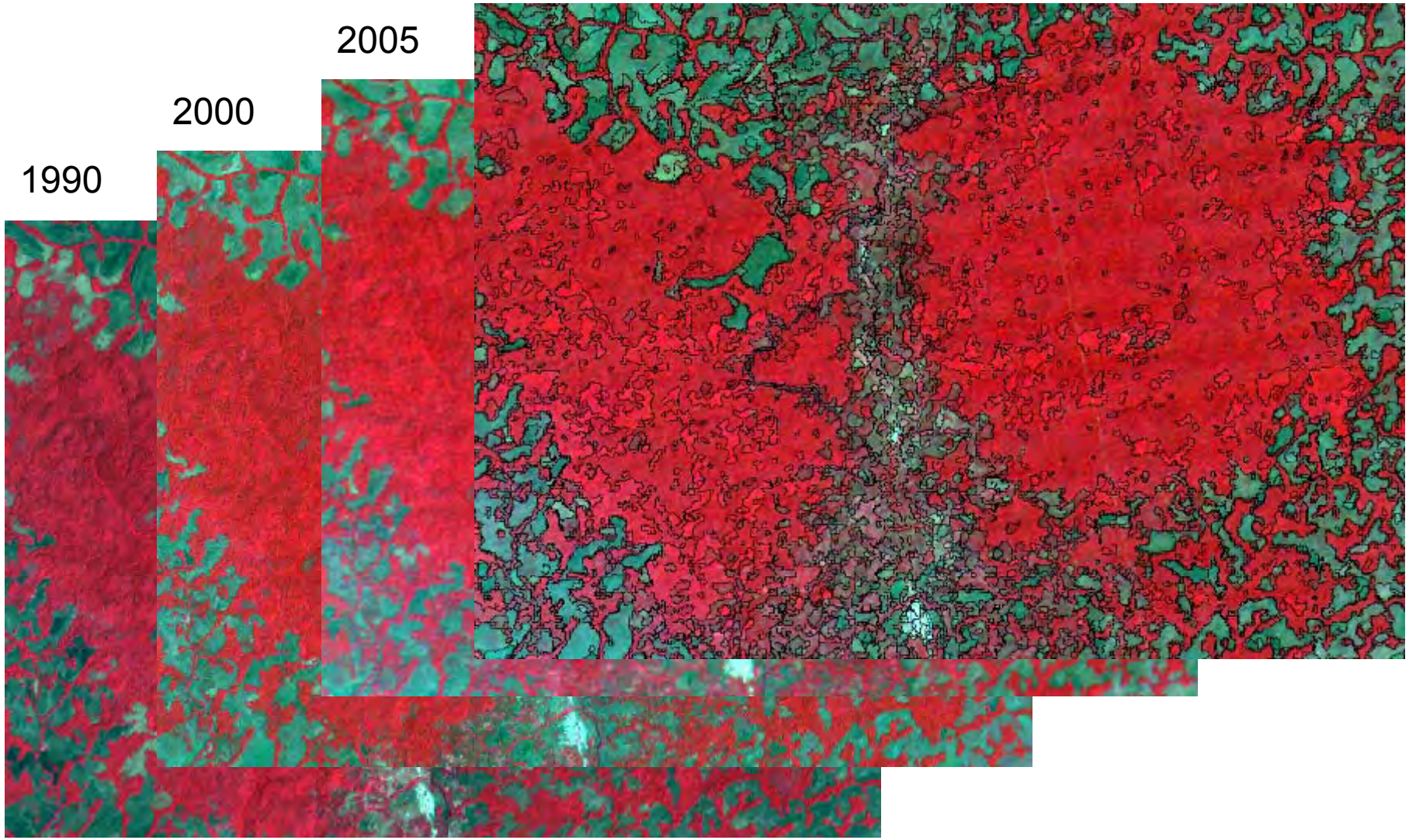


Corrected image

3.2. - Deforestation

Derivation of forest masks for each time based on image segmentation

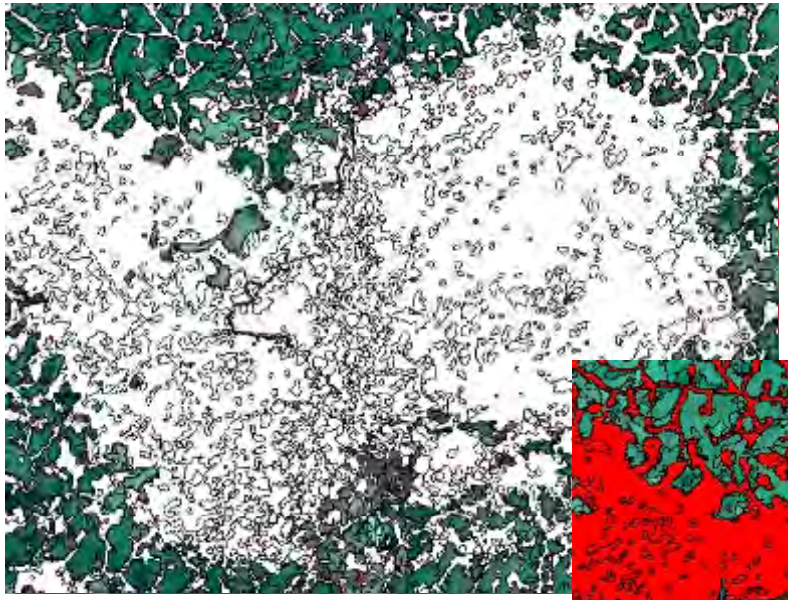
Layerstack, filtering and segmentation



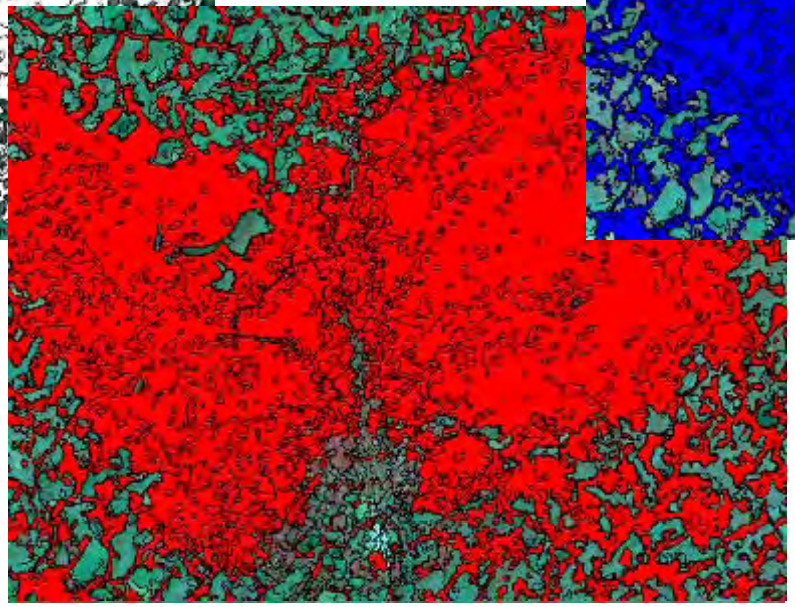
3.2. - Deforestation

Derivation of forest masks for each time based on image segmentation

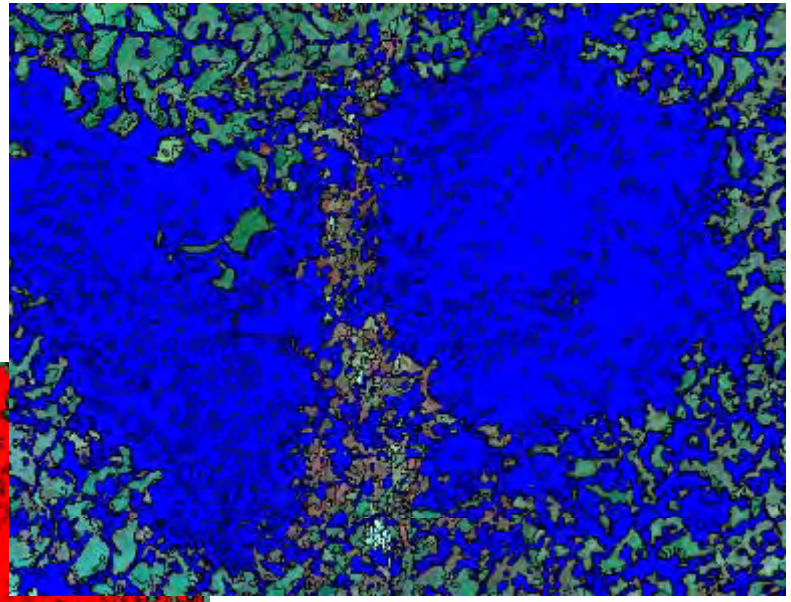
forest mask 1990



forest mask 2000

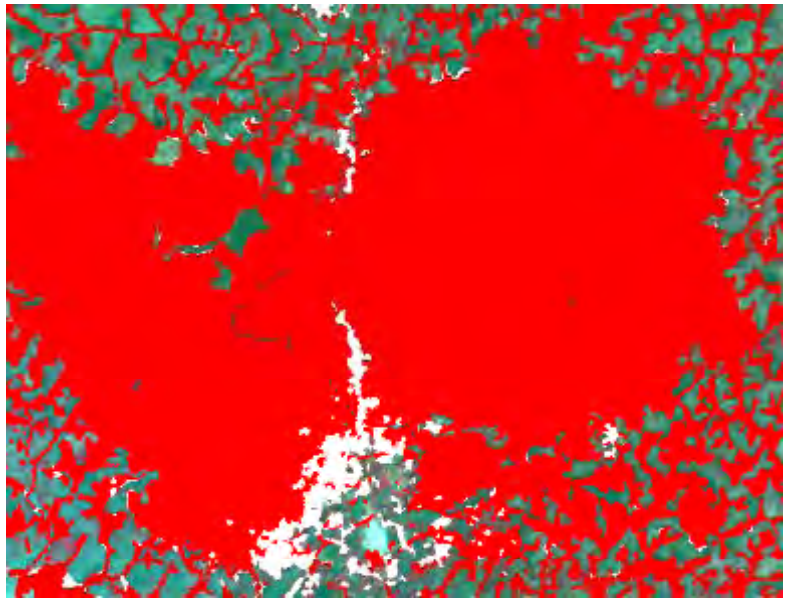


forest mask 2005

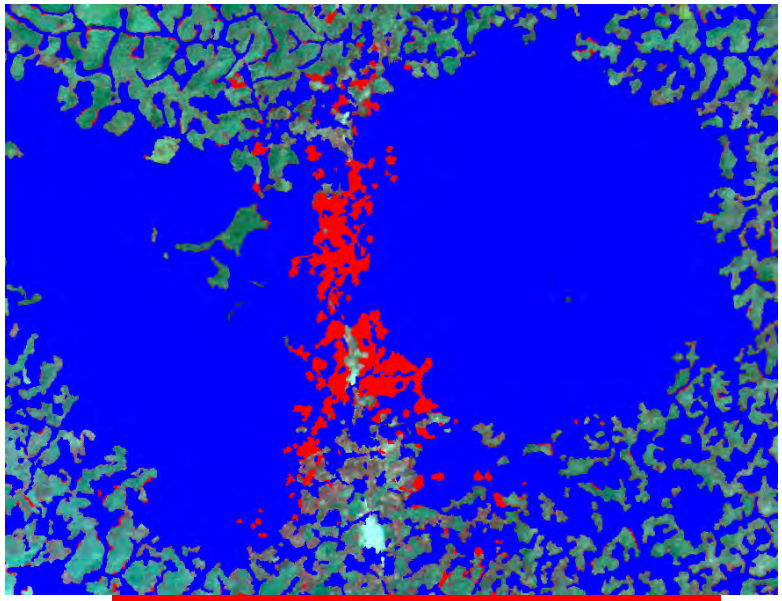


Derivation of the change masks for both epochs

forest mask 1990 **forest mask 2000** **forest mask 2005**

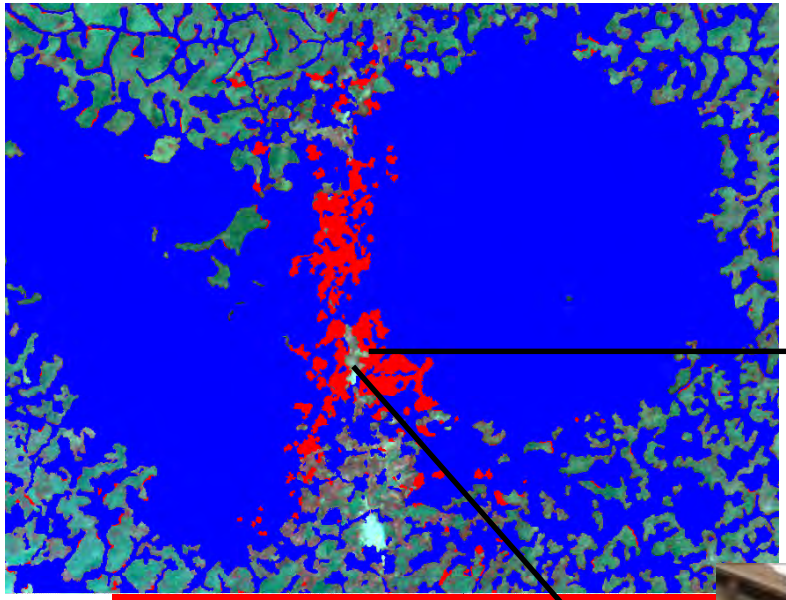


change mask 1990/2000 (white)



change mask 2000/2005 (red)

Derivation of the change masks for both epochs



change mask 2000/2005 (red)

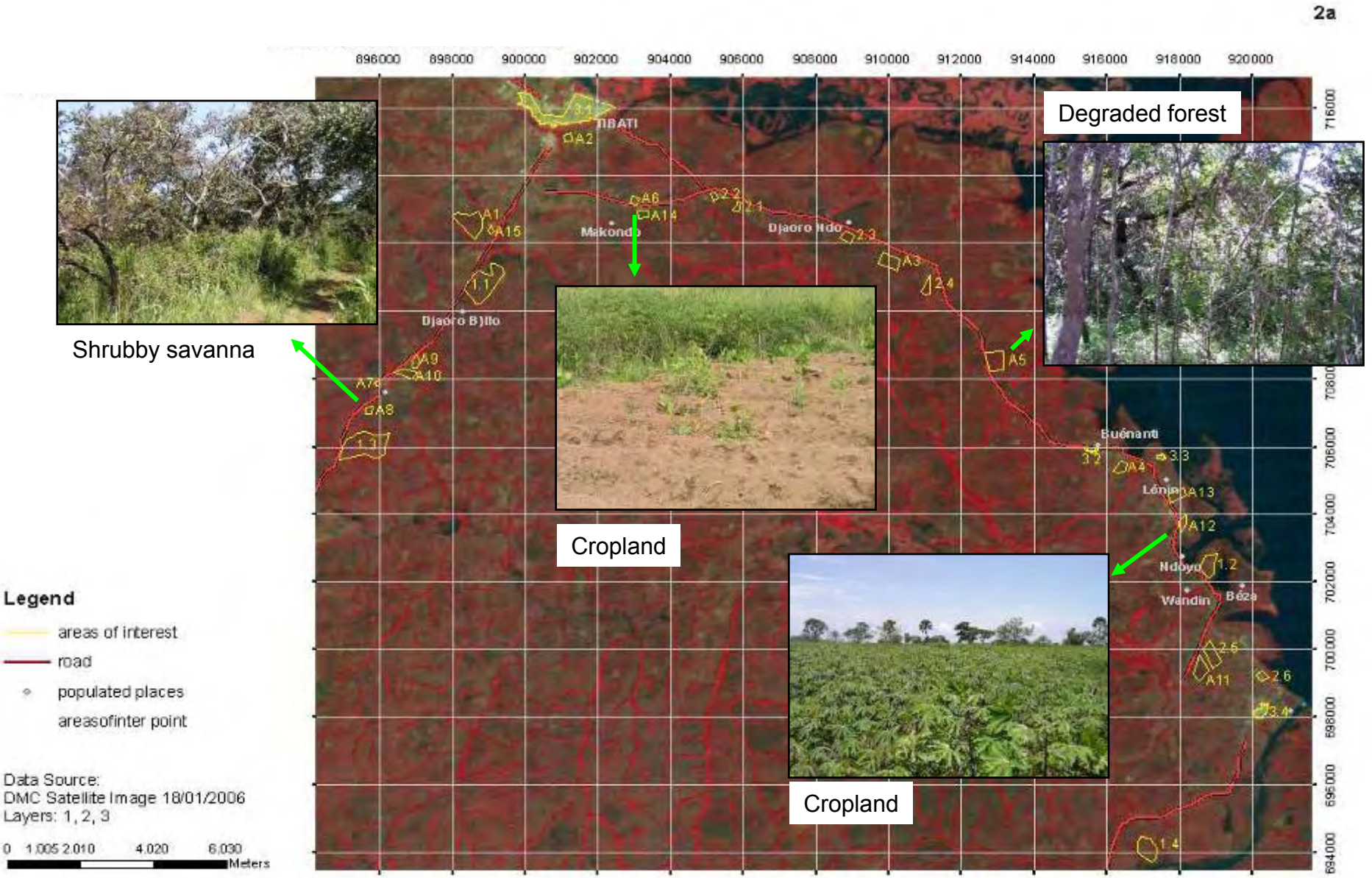
Preparation of training data for classification

Two sources:

A) Field work

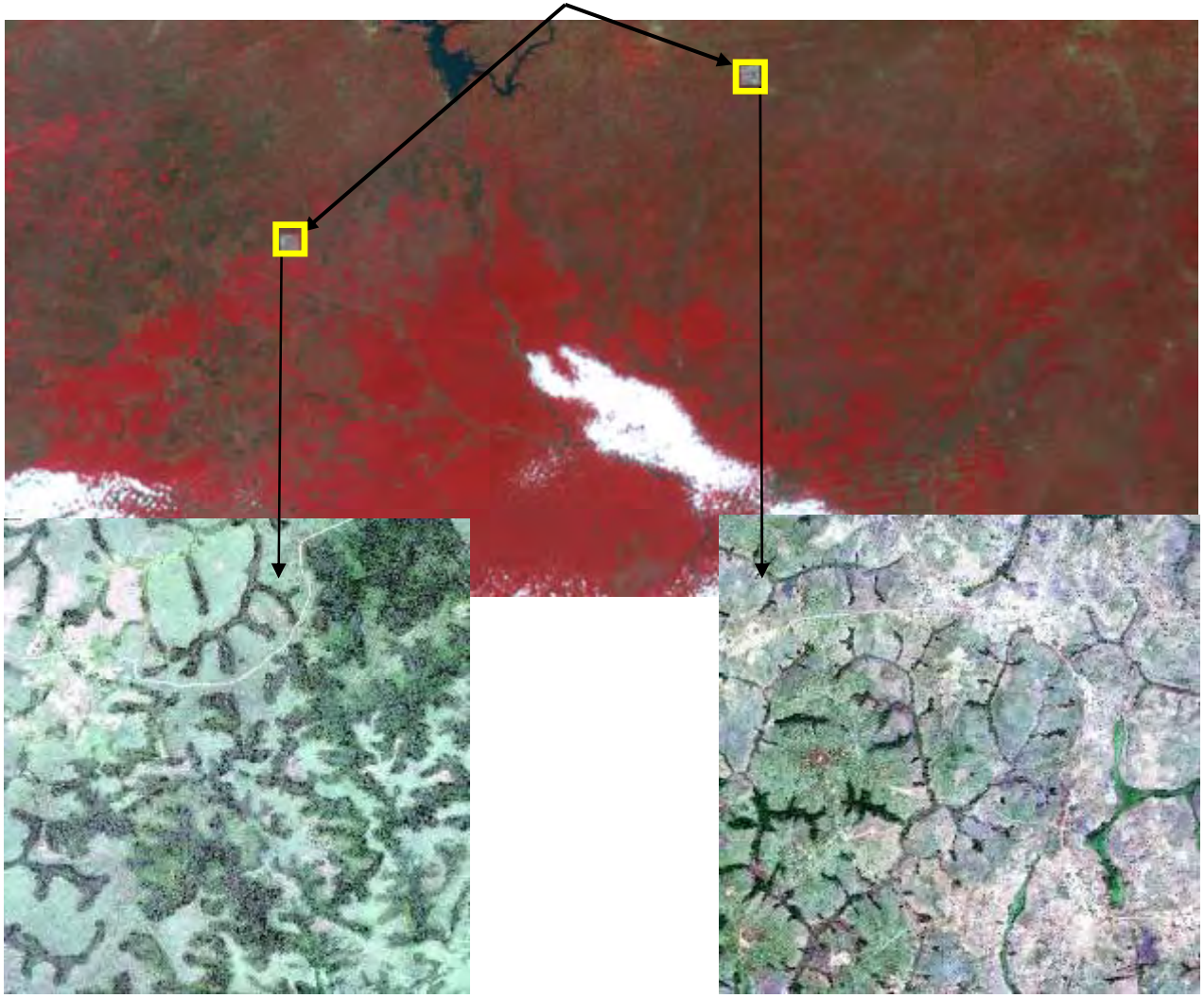
B) Very high resolution satellite data

A) Field work


2a
Degraded forest
Shrubby savanna
Cropland
Cropland
Legend
areas of interest
road
populated places
areasofinter point
Data Source:
DMC Satellite Image 18/01/2006
Layers: 1, 2, 3
0 1.005 2.010 4.020 6.030
Meters
Djaoro Bjllo
Makondo
Djaoro Ndo
Buénanti
Lónja
Ndoyu
Wandin
Béza

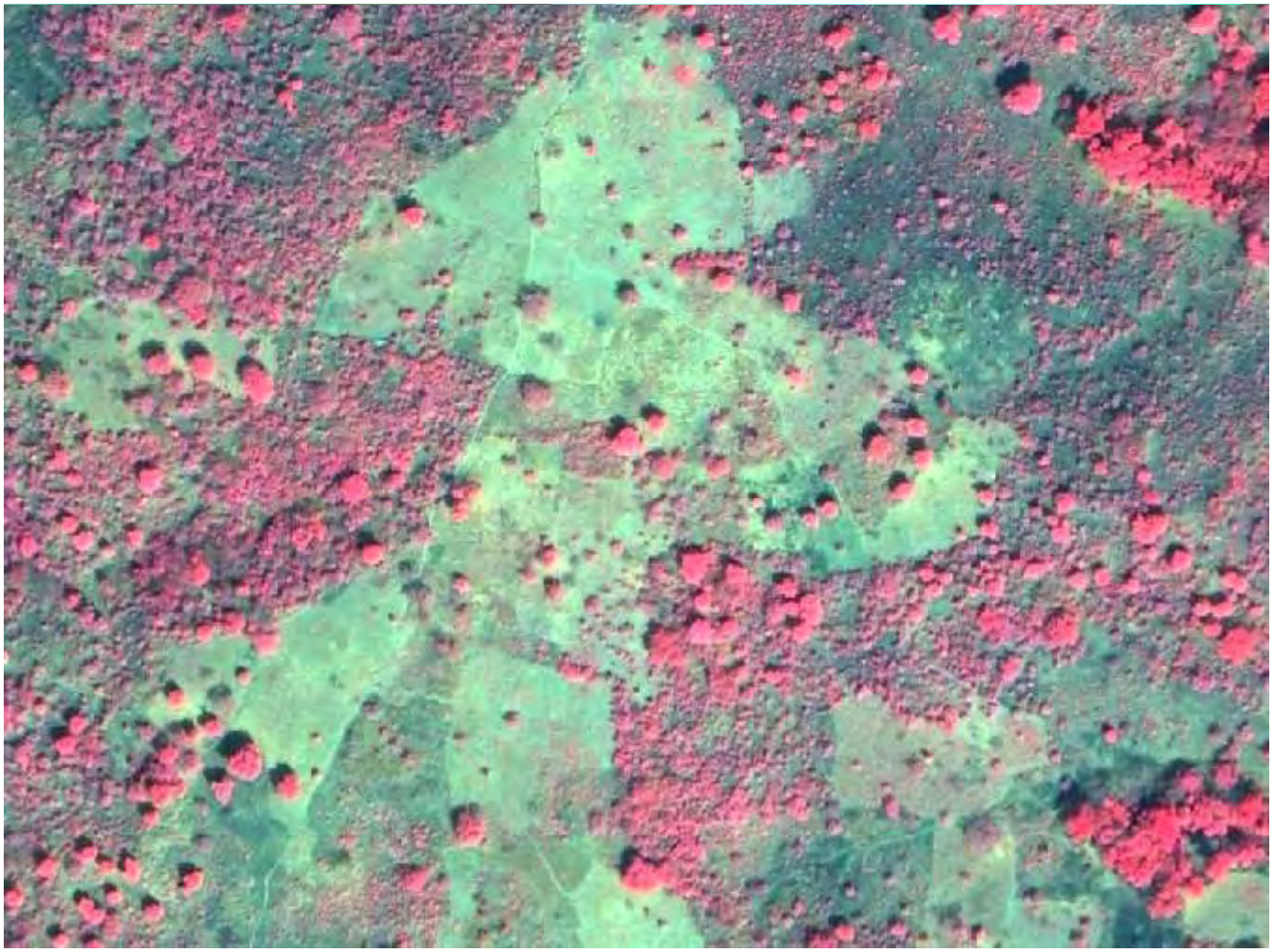
B) Very high resolution satellite data

Quickbird scenes



B) Very high resolution satellite data

Quickbird data



Classification

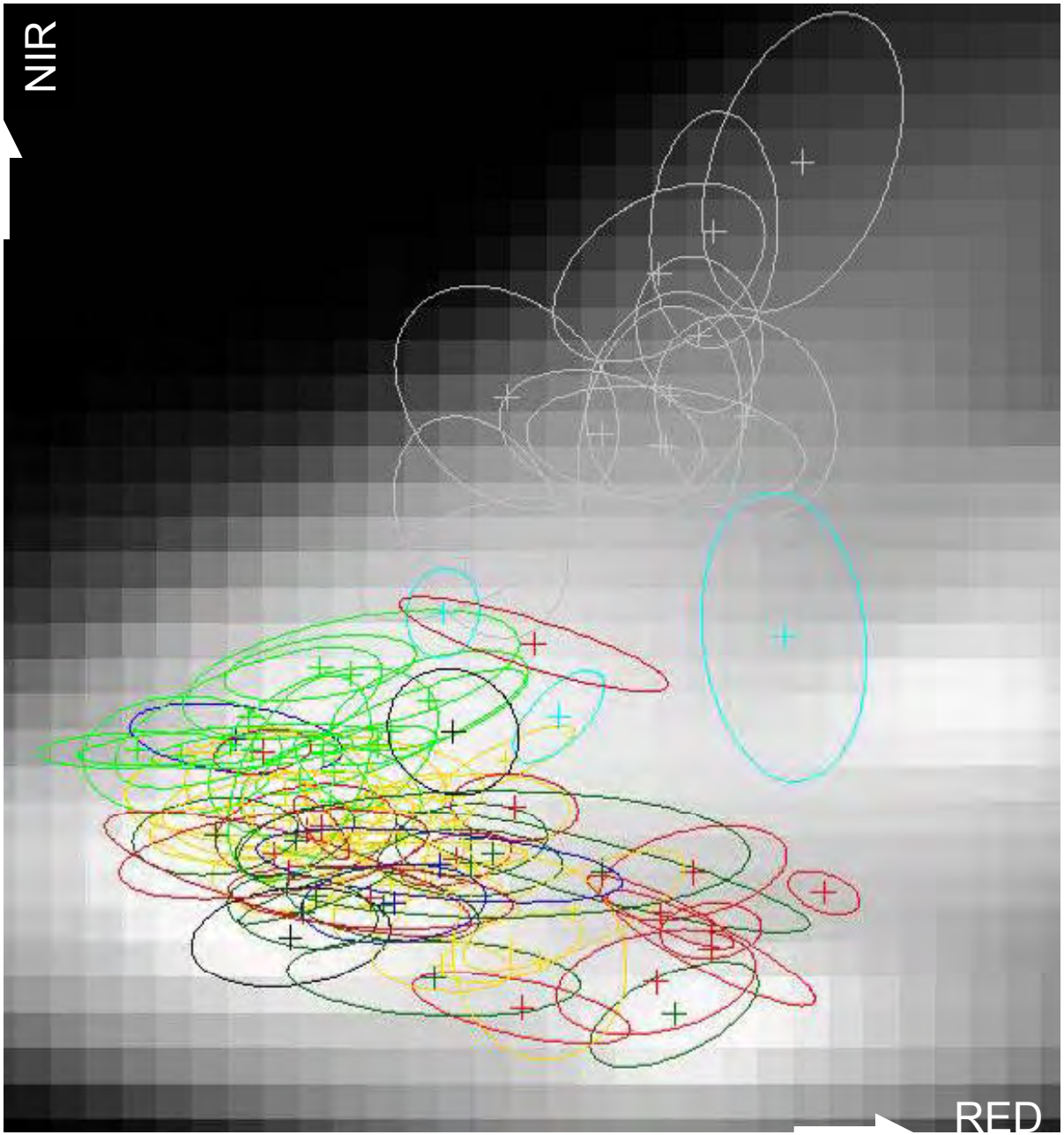
Original field data →

Problems:

- too many mixed pixels
- some classes not covered
- sometimes errors in naming (shrubland / secondary forest / …)

Solution:

- Careful signature analysis
- Sorting out mixed pixels
- Searching for „pure“ areas
- Including additional areas from Quickbird data



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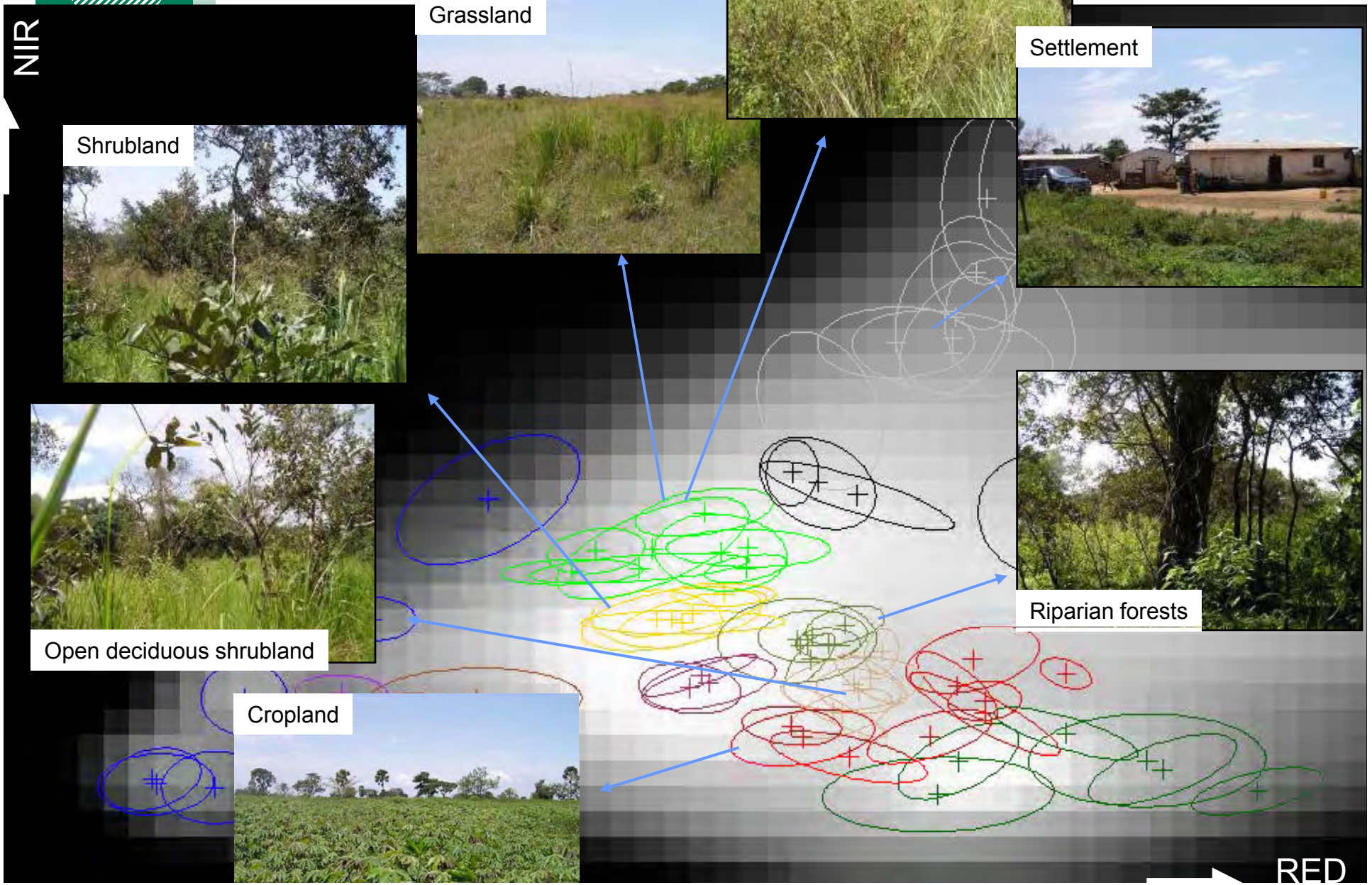
5. Classification



Classification: the problem of shifting cultivation OR:
the difference between land cover and land use

Field work: „abandoned farmland“

Human usage

Transition: different succession stages

Secondary forest (partly with signs of abandoned farms)

Degradation can be defined in many different ways, the one to be used in REDD was formulated by IPCC:

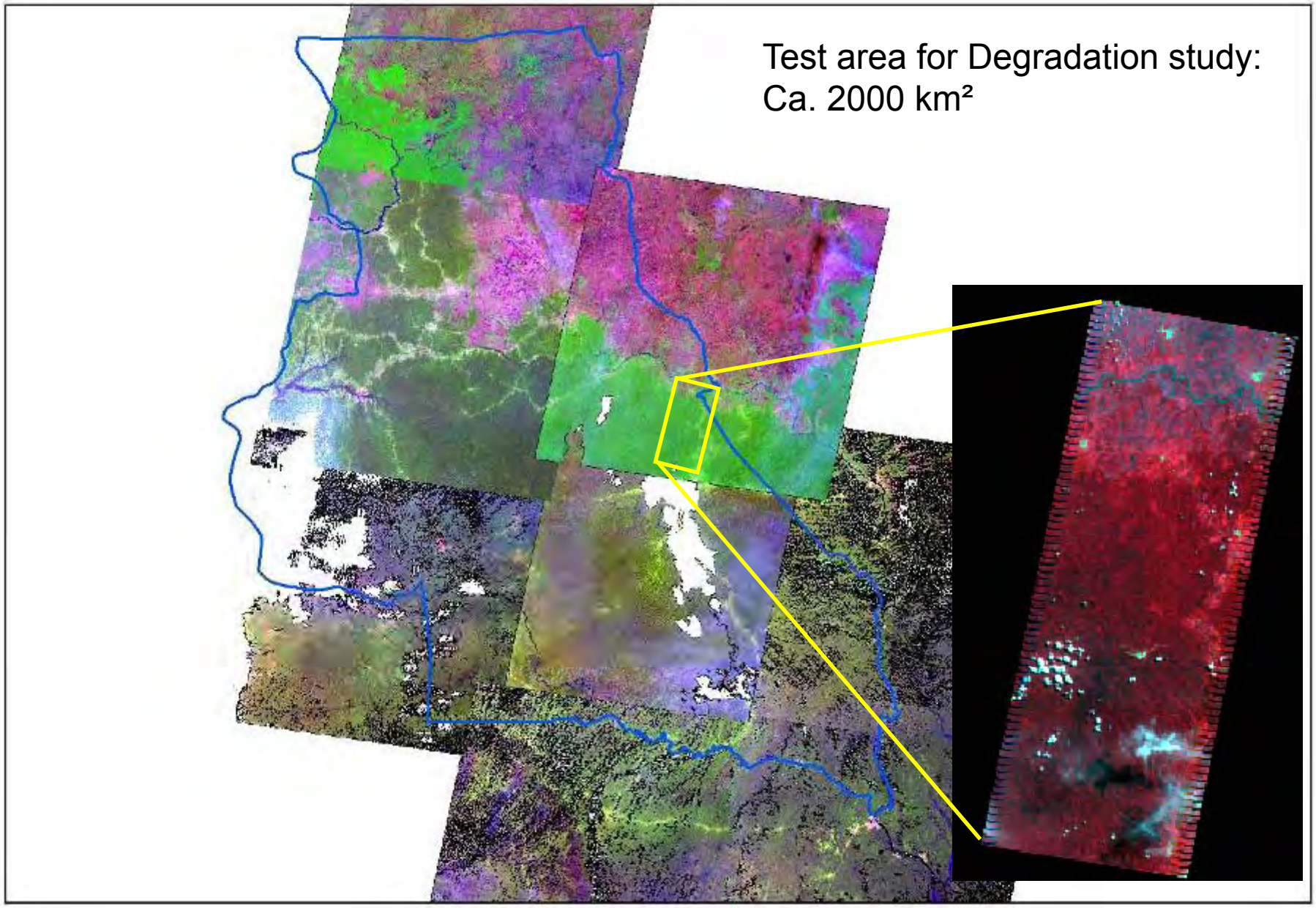
"A direct human-induced long-term loss (persisting for X years or more) of at least Y% of forest carbon stocks [and forest values] since time T and not qualifying as deforestation or an elected activity under Article 3.4 of the Kyoto Protocol."

[IPCC, 2004]

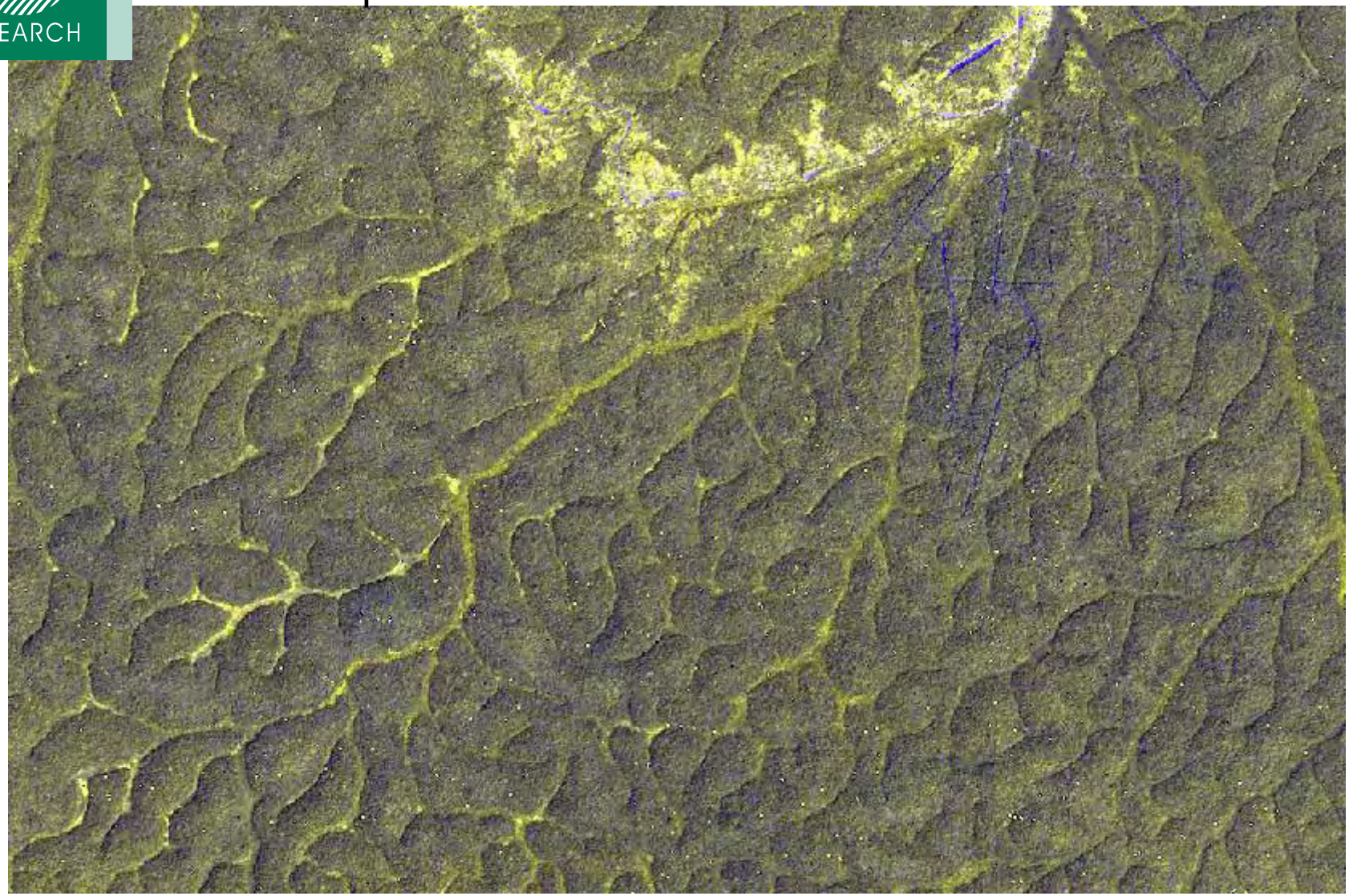
→ Degradation is connected to the forest definition
e.g. FAO forest per definition:

crown coverage > 10 %
height >= 5m
area >= 0.5 ha

Deforestation would be a change of cc from 30 % to 10 %
Degradation would be a change of cc from 90 % to 25 %

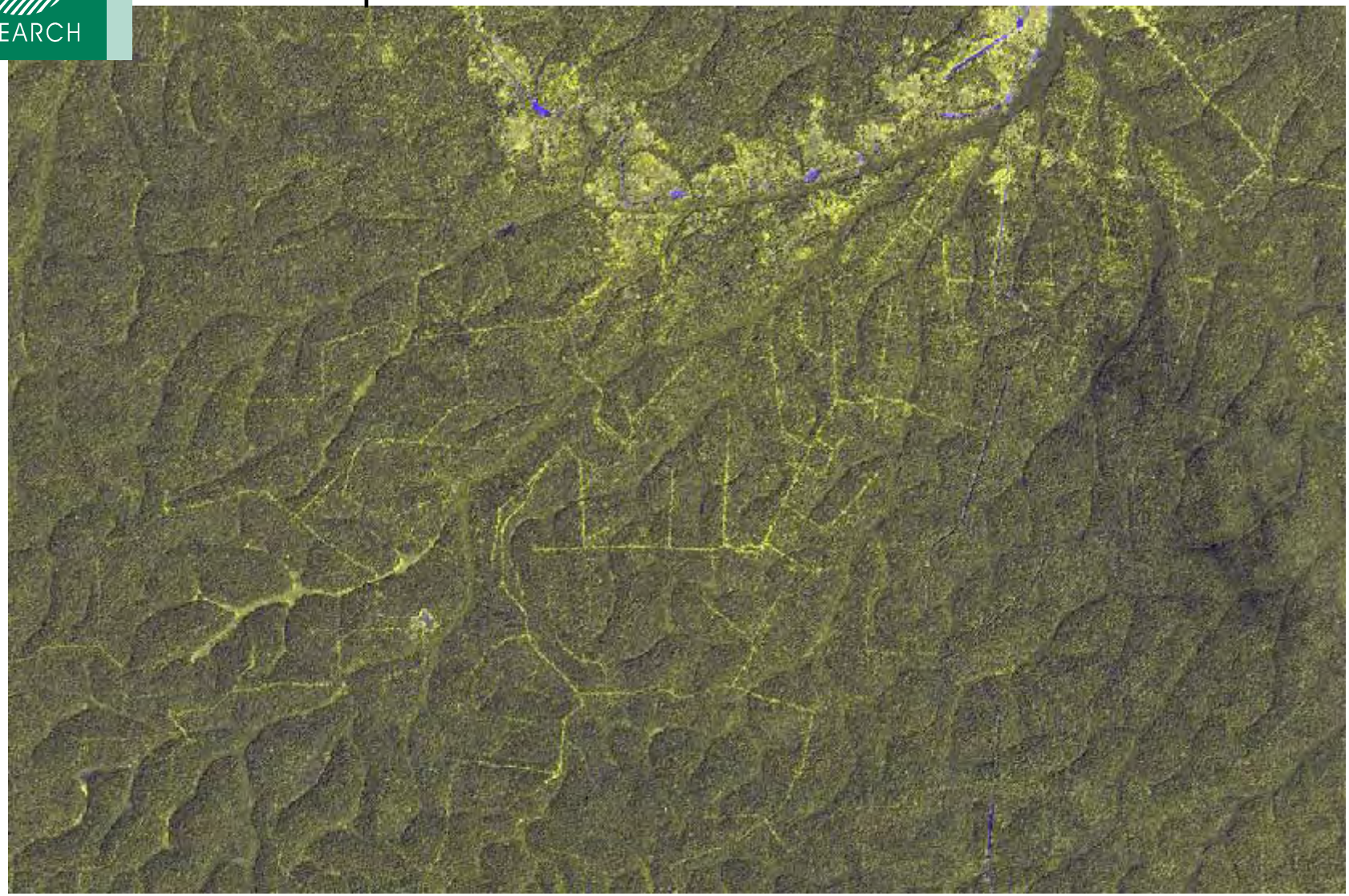

Test area for Degradation study:
Ca. 2000 km²

Visual interpretation



Degradation on Landsat TM 1990 (R/G/B – 4/4/6)

Visual interpretation



Degradation on Landsat TM 2000 (R/G/B – 4/4/6)

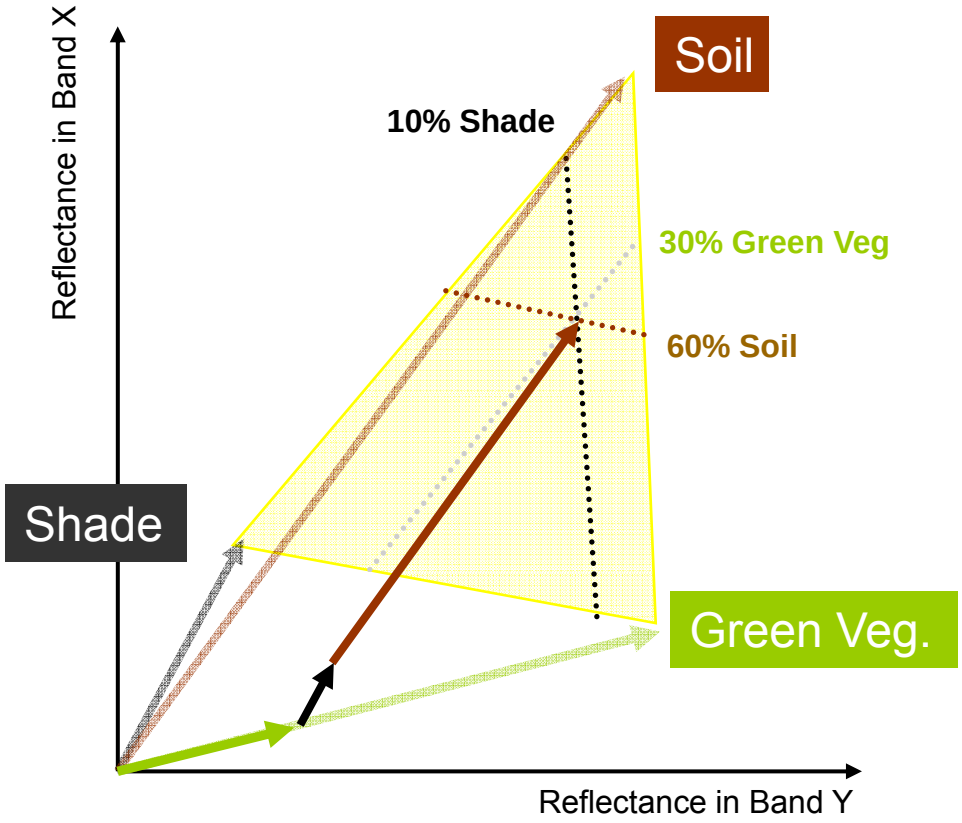
Automatic estimation of degradation using spectral mixture analysis (SMA)

Idea:
Pixel reflectance is the sum of reflectance for each pure cover type (Endmember), weighted by their fractional presence within each pixel.

Pixel

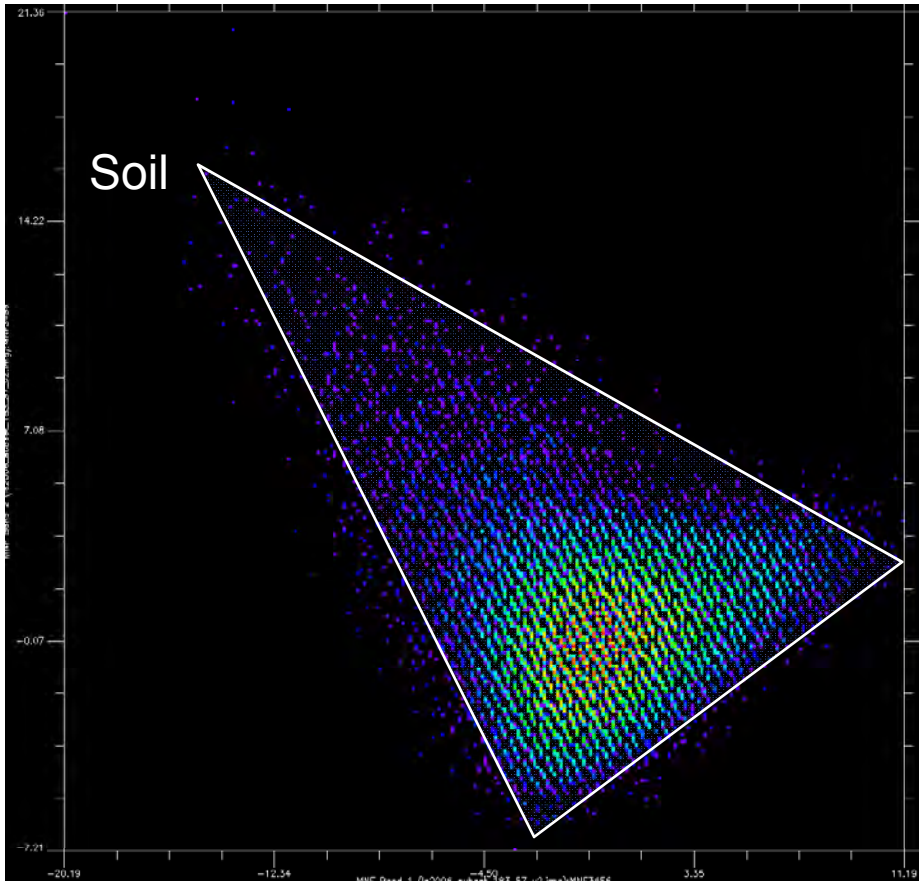
Endmember

- Shade 10%
- Green Veg 30%
- Soil 60%



Automatic estimation of degradation using spectral mixture analysis (SMA)

1) Determination of endmembers



Automatic estimation of degradation using spectral mixture analysis (SMA)

2) Calculation of fraction images

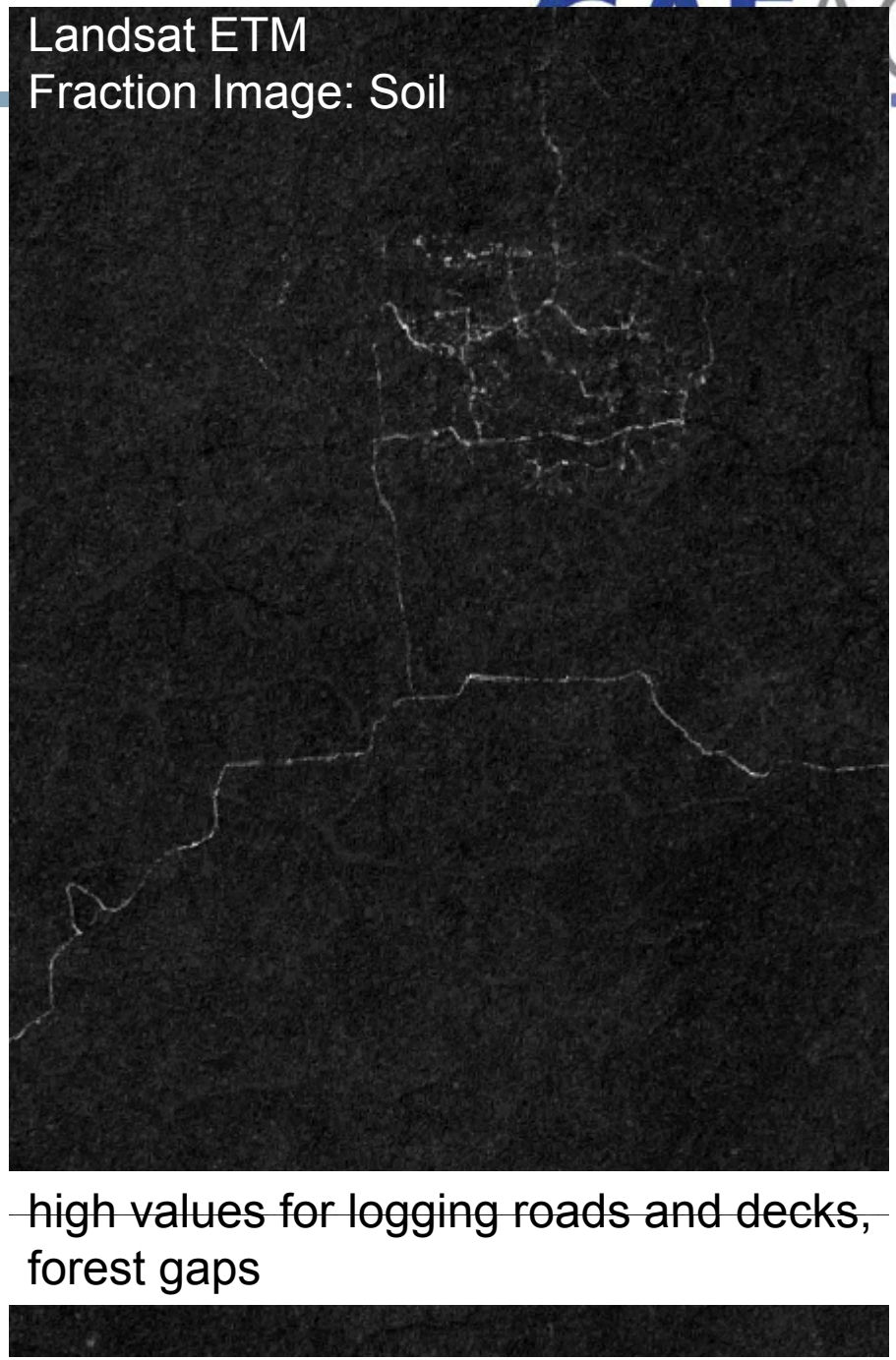
3.4. – Forest degradation

Landsat ETM
R(4), G(3), B(2)

Landsat ETM
Fraction Image: Green Vegetation

high values for regeneration
low values for degradation

Landsat ETM
Fraction Image: Soil



high values for logging roads and decks, forest gaps

Landsat ETM
Fraction Image: Shade

low values for regeneration

Automatic estimation of degradation using spectral mixture analysis (SMA)

3) Calculation of indices

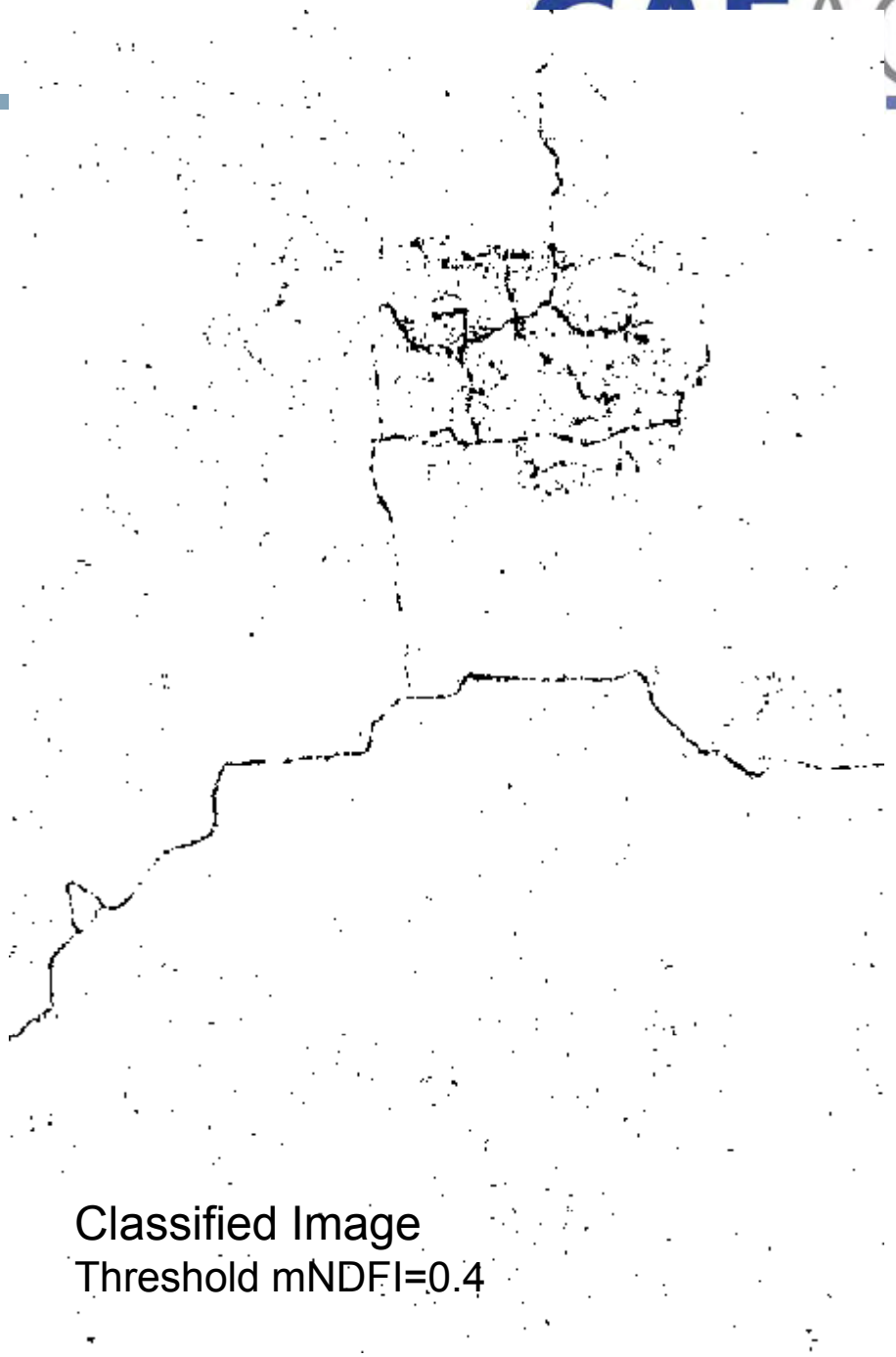
Landsat ETM
R(4), G(3), B(2)

Landsat ETM
mNDFI modified Normalized Difference Fraction Index

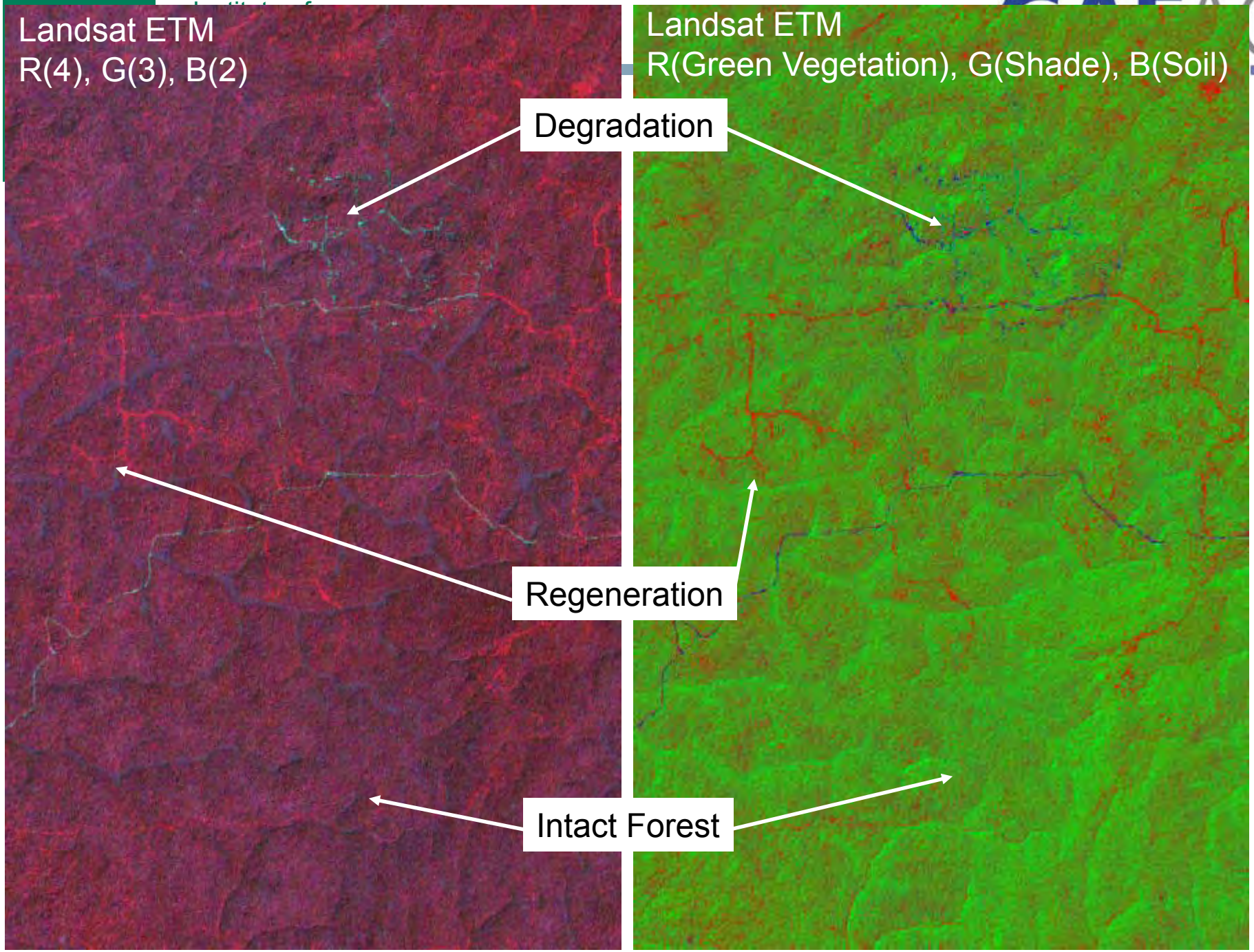
low values for degradation

Automatic estimation of degradation using spectral mixture analysis (SMA)

4) Thresholding of mNDFI



Classified Image
Threshold mNDFI=0.4


Landsat ETM
R(4), G(3), B(2)
Landsat ETM
R(Green Vegetation), G(Shade), B(Soil)
Degradation
Regeneration
Intact Forest


How it looks in the field:


Logging deck


Logging date in the stump

Conclusions:

→ Methodology successfully implemented
→ Deforestation and land cover classification for testsite completed
→ Straightforward method for clouds and cloud shadow detection

→ Roll-out for whole area of Cameroon underway (to be finished in summer)
→ Test results on forest degradation

Outlook:

→ Degradation studies with additional optical (Quickbird, Aster) and SAR (TerraSar X) data
→ Further training and capacity building
→ Roll-out for other Congo-Basin countries

References:

Hirschmugl, M., Schardt, M., Häusler, T., Gomez, S. and Amougou, J. A. (2008): REDD pilot project in Cameroon - method development and first results. In: D. Maktav (Ed.) Remote Sensing for a Changing Europe - Proceedings of the 28th Symposium of the European Association of Remote Sensing Laboratories, Istanbul, Turkey, 2-5 June 2008, pp. 205 - 213.

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Haas, S. (2009): Monitoring Forest Degradation for REDD in Cameroon. Diploma thesis, University of Karlsruhe and Joanneum Research. 104 p.

Thank you for your attention!

Contact: manuela.hirschmugl@joanneum.at