Assessing Forest Degradation in the tropics using Time Series of Fine Spatial Resolution Imagery

Astrid Verhegghen, Jukka Miettinen, Lorena Hojas Gascon, Baudouin Desclée, Hugh Eva, René Beuchle, Hans-Jurgen Stibig and Frédéric Achard

European Commission
Joint Research Centre

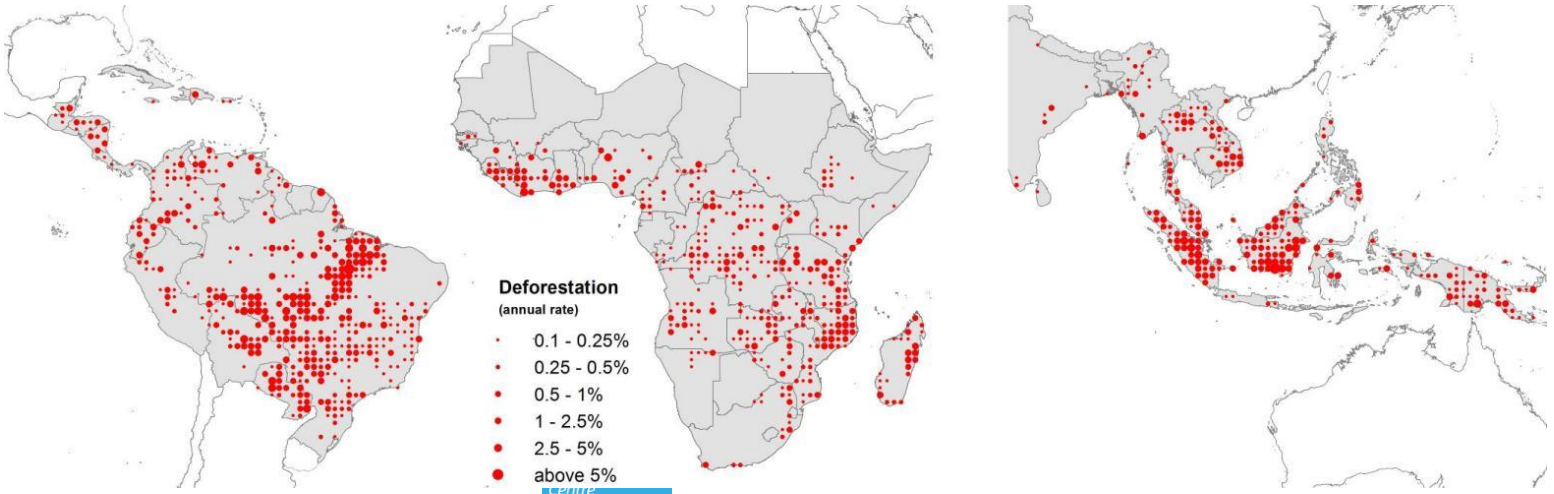
TAKE 5 Days
18-19 November 2014 CNES (Toulouse)

ReCaREDD project

REDD + : reducing emissions from **deforestation**, **forest degradation**, conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

ReCaREDD project - Strengthening national and regional capacities for reporting on the mitigation actions of the forest sector in tropical countries

TREES 3: Tropical Forest Cover Change Assessment 1990-2010



Lead institution & project name	Key products of project for MRV of REDD+	Spatial Coverage of project	Capacity building	Policy support	Specific Comments
FAO FRA-RSS JRC TREES-3	Deforestation estimates 1990-2000-2005 by regions	Tropics (JRC) / Global (FAO)	Regional workshops	REDD phase 1	Spatial information. Deforestation only
JRC/CIRAD/ UCL OFAC	Regional forest map Deforestation estimates 1990-2005 at national level	Central Africa	Project embedded in COMIFAC	Yes	Spatial information. Biodiversity safeguard considered
FAO UN-REDD	Deforestation estimates at national level	16 countries (with Cent. Africa)	Support to National Progr.	Yes	Based on existing methods
WB FCPF (Grants)	No maps	12 countries	Support to National Progr.	Yes	Based on existing methods
EC/AUC AMESD & MESA	Real-time Environmental monitoring	Africa (Regional Economic Comm.)	In regional centres	Yes	Complementary to forest-cover (fires, …)
FAO FRA Country Survey	Global report from national statistics	Global	-	-	No spatial information
WB REDD Regional Capacity-building	Allometric equations	Central Africa	Workshops and training sessions	Yes	
JRC ReCaREDD	Regional Forest maps Degradation estimates at regional and national levels	Focus on selected regions and countries	In regional and national institutions	REDD phases 1 & 2	Spatial information for all activities

ReCaREDD projet

- Funded by the European Commission (2014-2017)
- Joint Research Center (Ispra and Brussel) in collaboration with target countries (Africa, South America, South East Asia)
- Focusing on **Forest Degradation**

Joint methodological development for the monitoring of forest degradation

Strengthening of regional forest observatories and national institutions

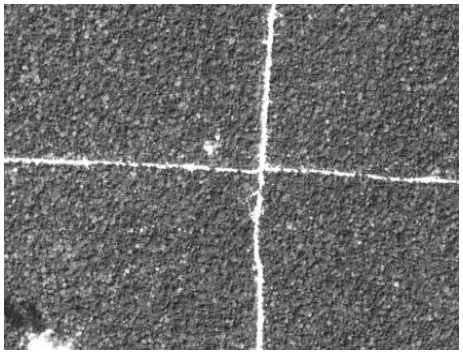
Provision of information of forest-cover evolution to policy makers

Sentinel 2

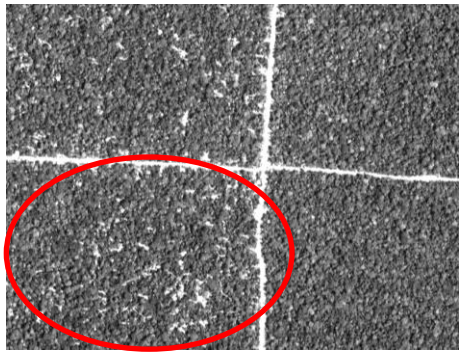
Forest Degradation

- **Complex definition**
  - *FAO (2009)* : *Reduction of the capacity of a forest to provide goods and services*
  - *UN-REDD*: *Reduction of carbon stocks*

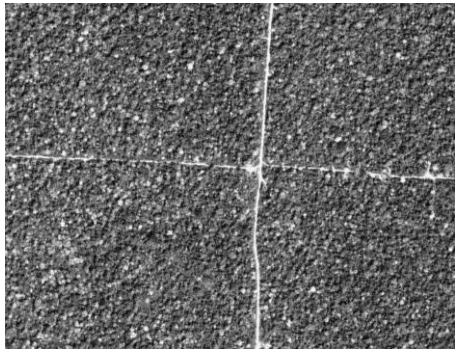
- **Important to define the spatial and temporal scales**



2 month before exploitation

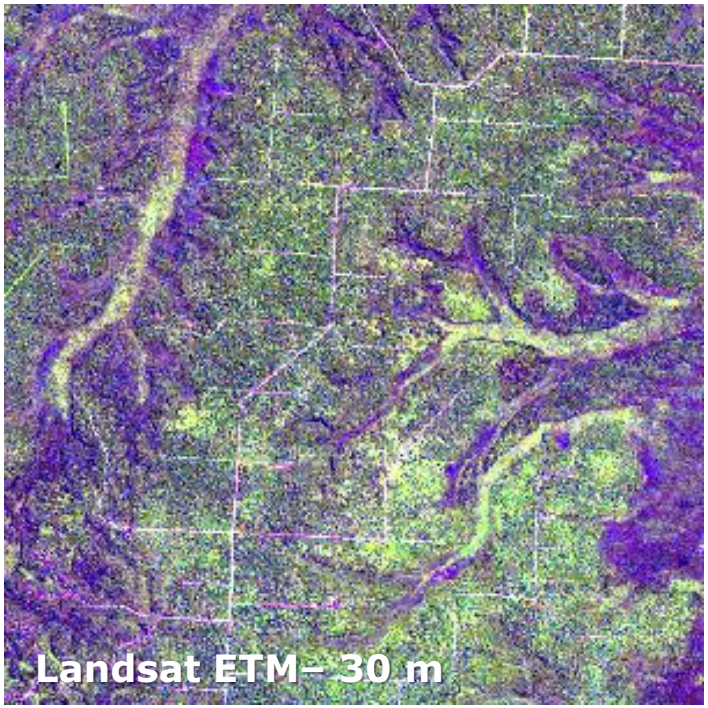


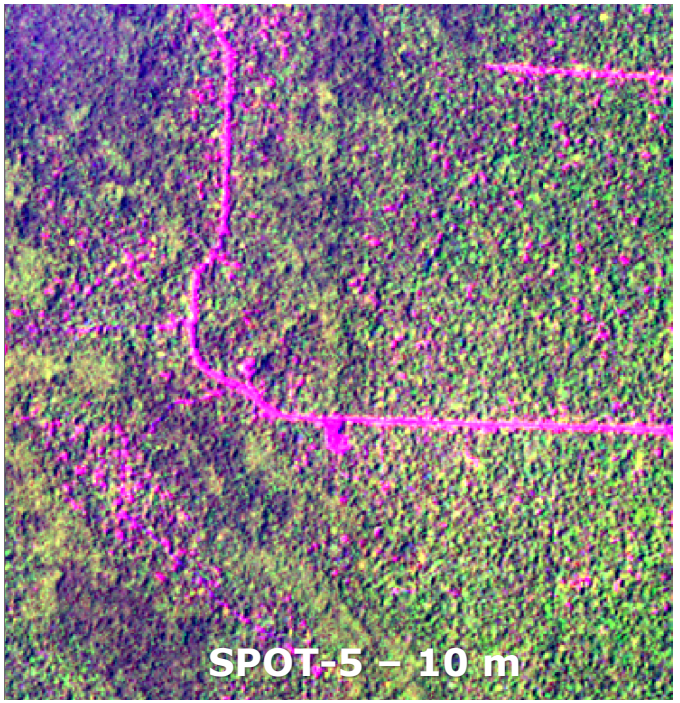
1 month after exploitation



2 years after exploitation

Source B. Desclée

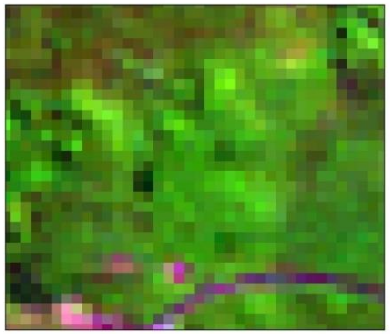




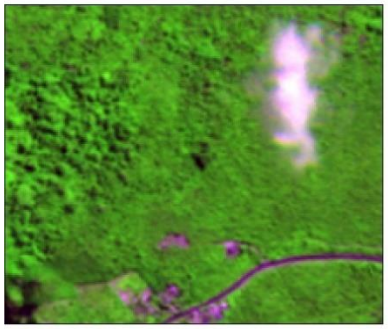
Source B. Desclée

Challenges for forest degradation monitoring by remote sensing

1) Complex forest cover change
   - Reference state: Regional/National forest types maps
   - Small areas of change
   - Various change trajectories
2) Exploit higher resolution (10 m) to detect and quantify areas of degraded forests
3) Multi-temporal: Exploit new sensors with higher frequency acquisition → From single image to time series analysis
4) Automation



Landsat-5 TM image (30m)



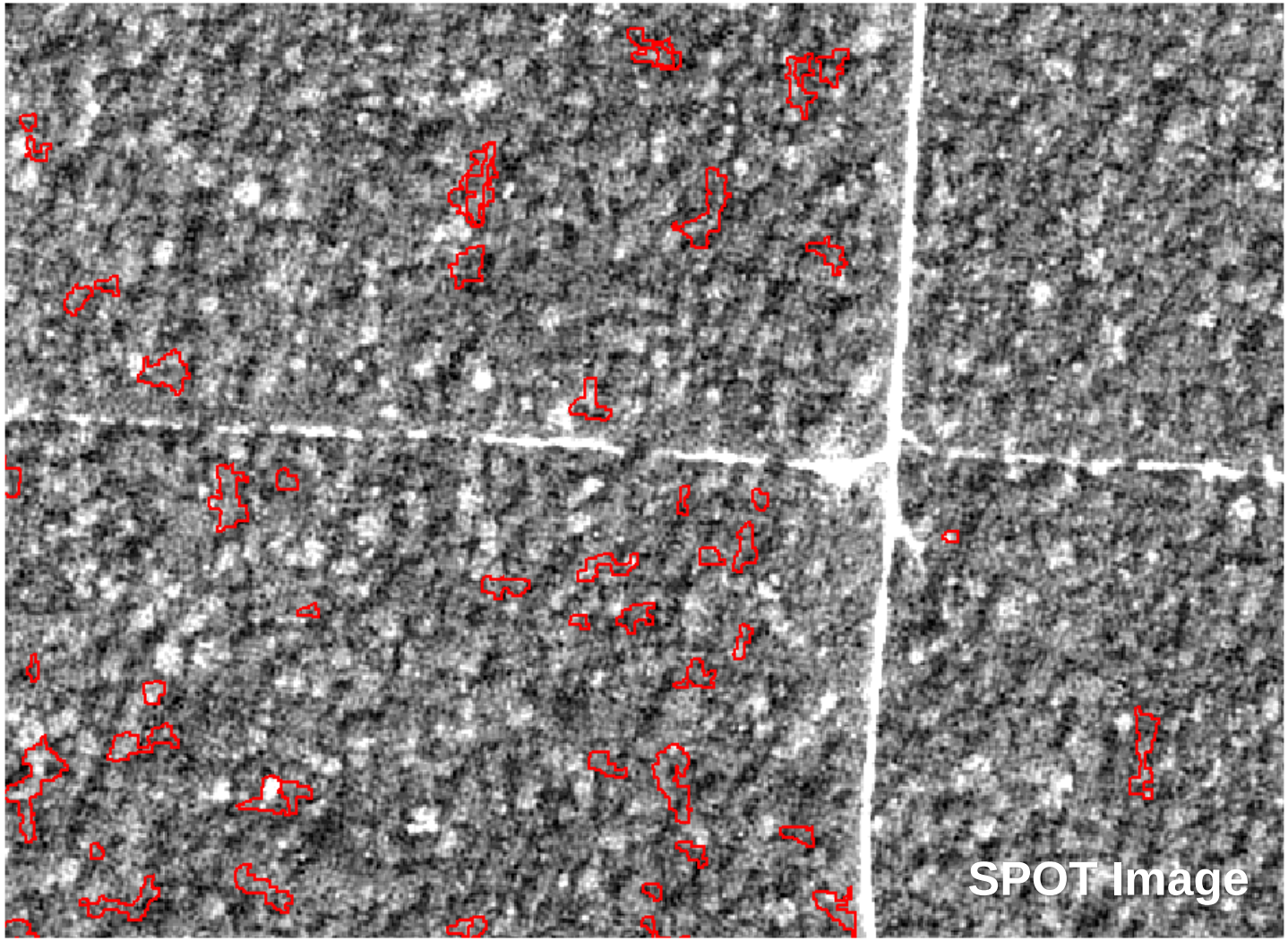
dEye image (5m)

World-View image (0.5 m)

Jan 2005

Mar 2005

Jan 2007

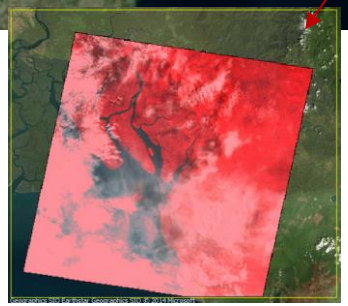


Detected gap **Logged tree**

Source B. Desclée

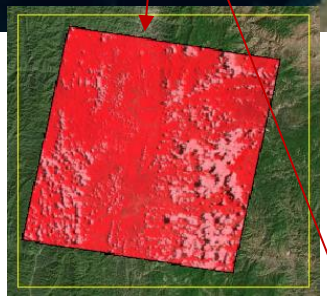
Spot 4 Take 5 – sites explored for degradation monitoring

Honduras

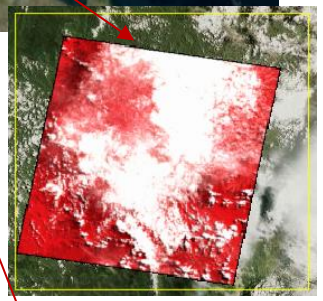


Cameroon

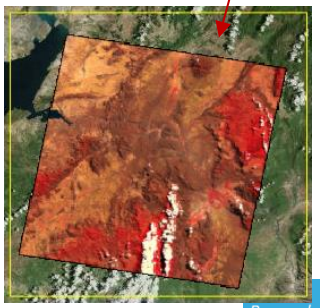
Congo (2)



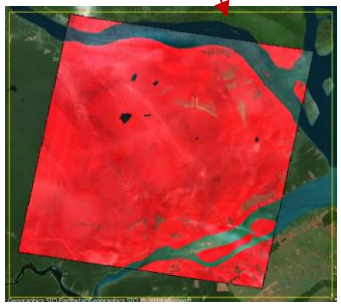
Thailand



Borneo



Tanzania



Sumatra

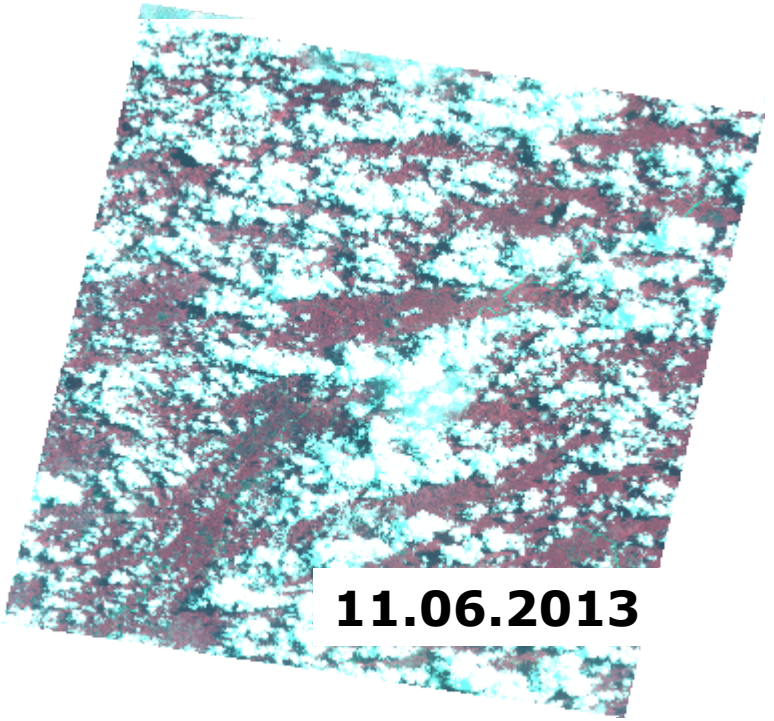
Research Centre

European Commission

Cloud cover in the tropics

Spot4 – Take5 acquisition over Honduras (ca. 15° N / 85° W)

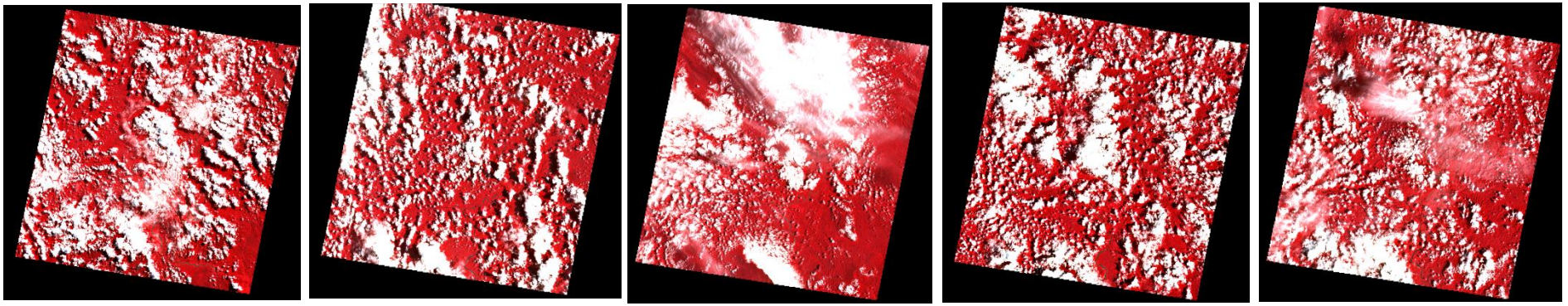
In theory the S4T5 acquisition time (February to June) is a period with less rain in Honduras. However only one good SPOT image available for the area of interest (on 16.02.2013)



Source R. Beuchle

JRC-Borneo site

- Perhumid tropical climate.
- 11 scenes between 1st Feb and 6th June
- Pristine and selectively logged forests with up to 1600 m elevation.



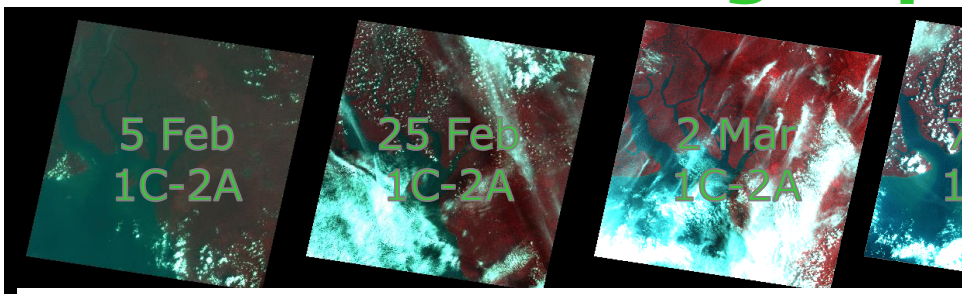
Joint Research Centre

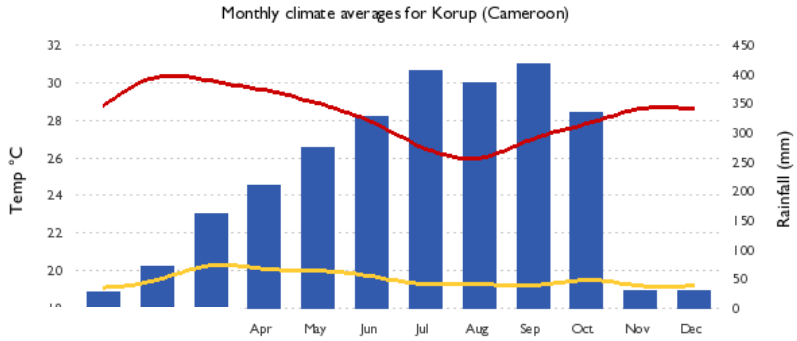
Source J. Miettinen

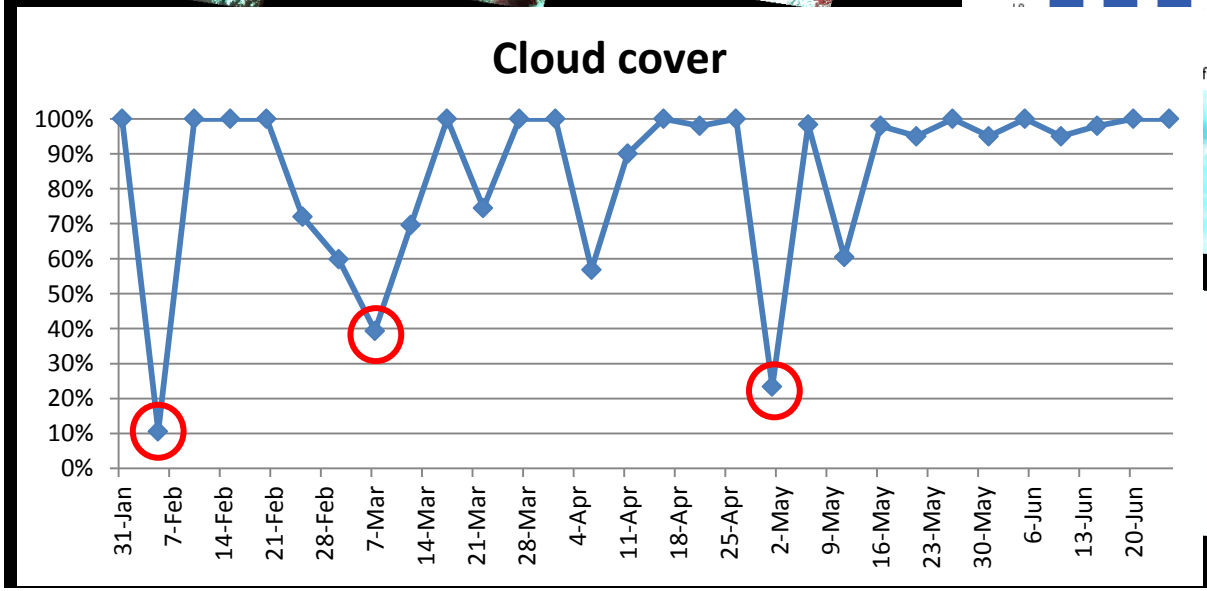
JRC-Cameroon site

17 acquisitions (out of 30)

10 images processed





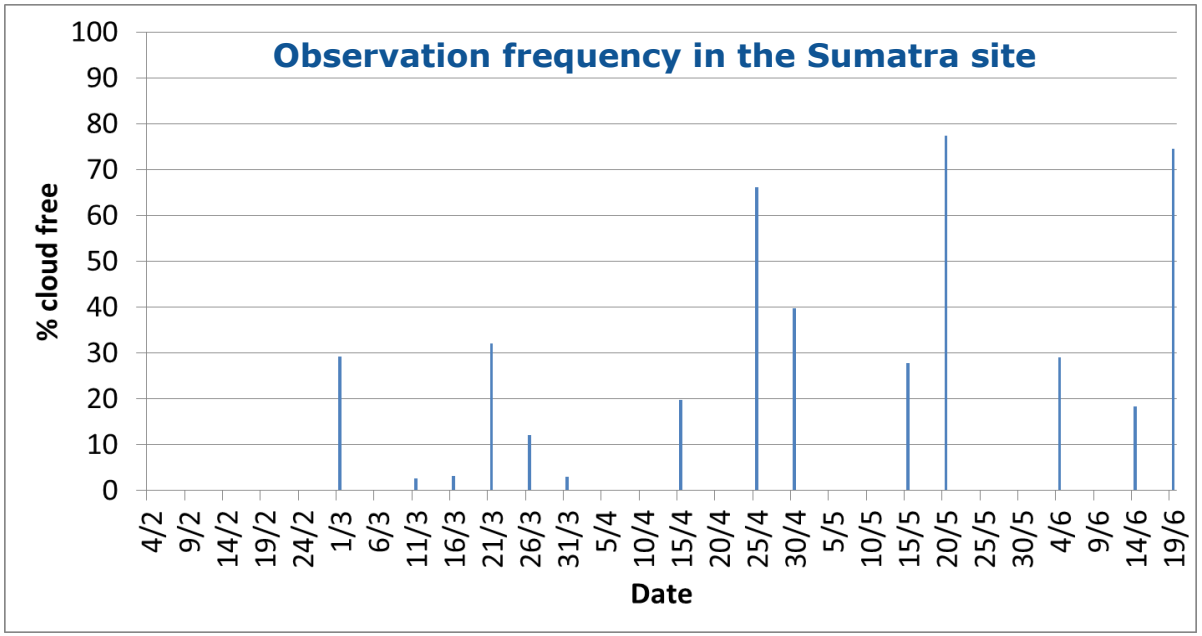


Source B. Desclée

Compositing in humid forest

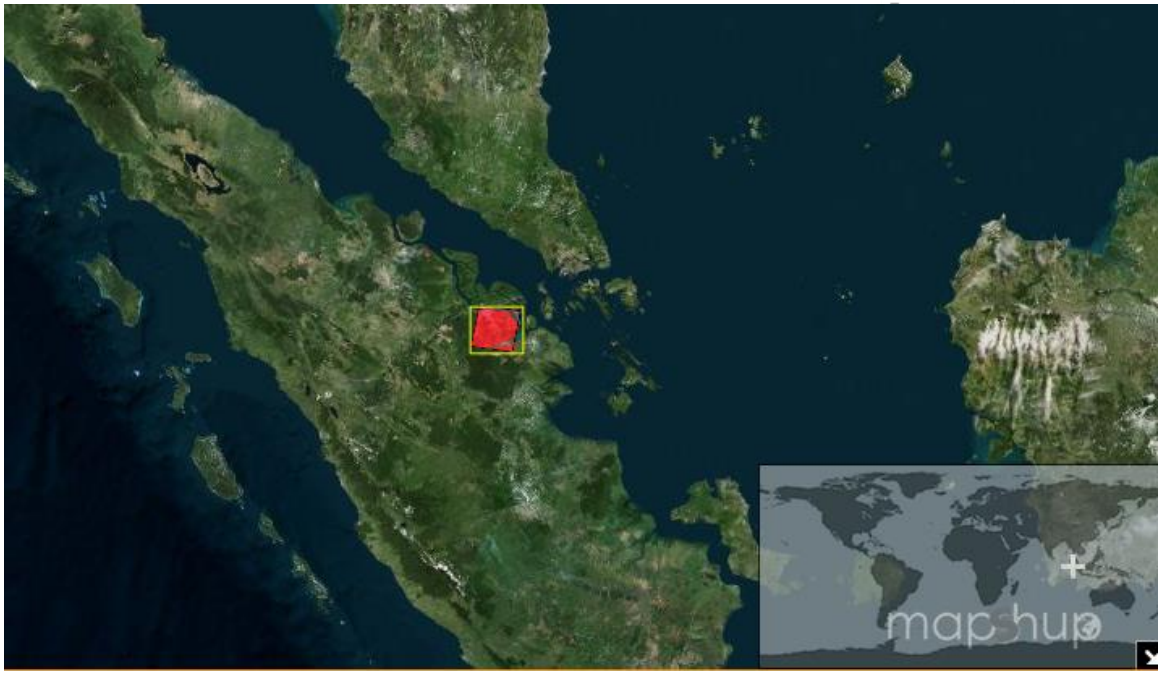
Sumatra (~ 102.5˚ E and 0.5˚ N)

- Perhumid insular SEA, coastal peatlands
- Selectively logged peat swamp forest and some *Acacia mangium* and oil palm plantations



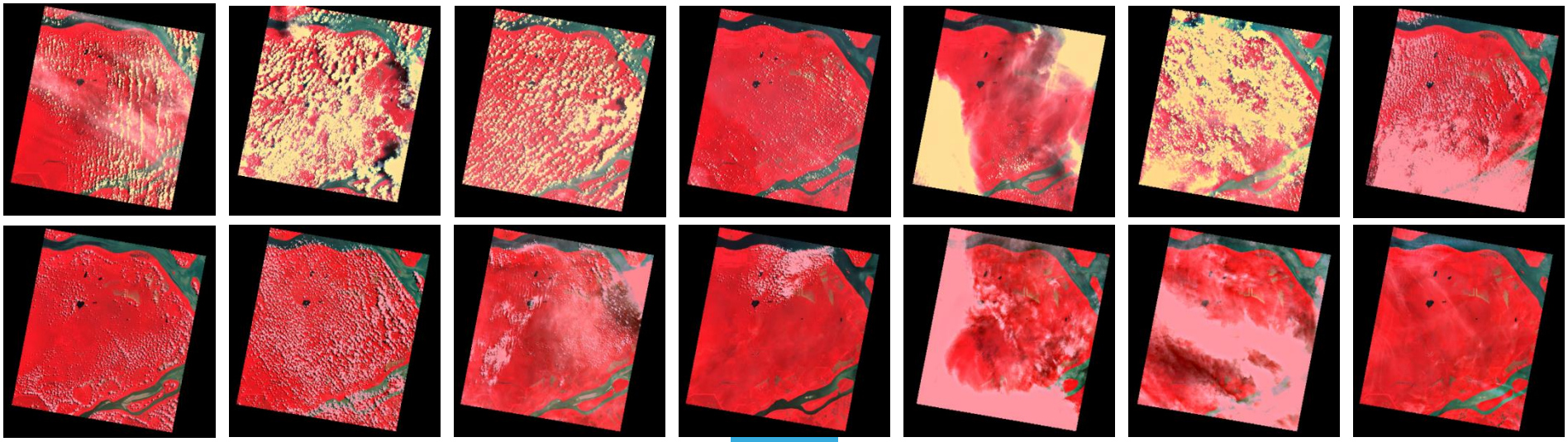
Source J. Miettinen

JRC-Sumatra site



- Perhumid tropical climate.
- 14 scenes between 1st Mar and 19th Jun.
- Selectively logged peat swamp forest and some plantations.

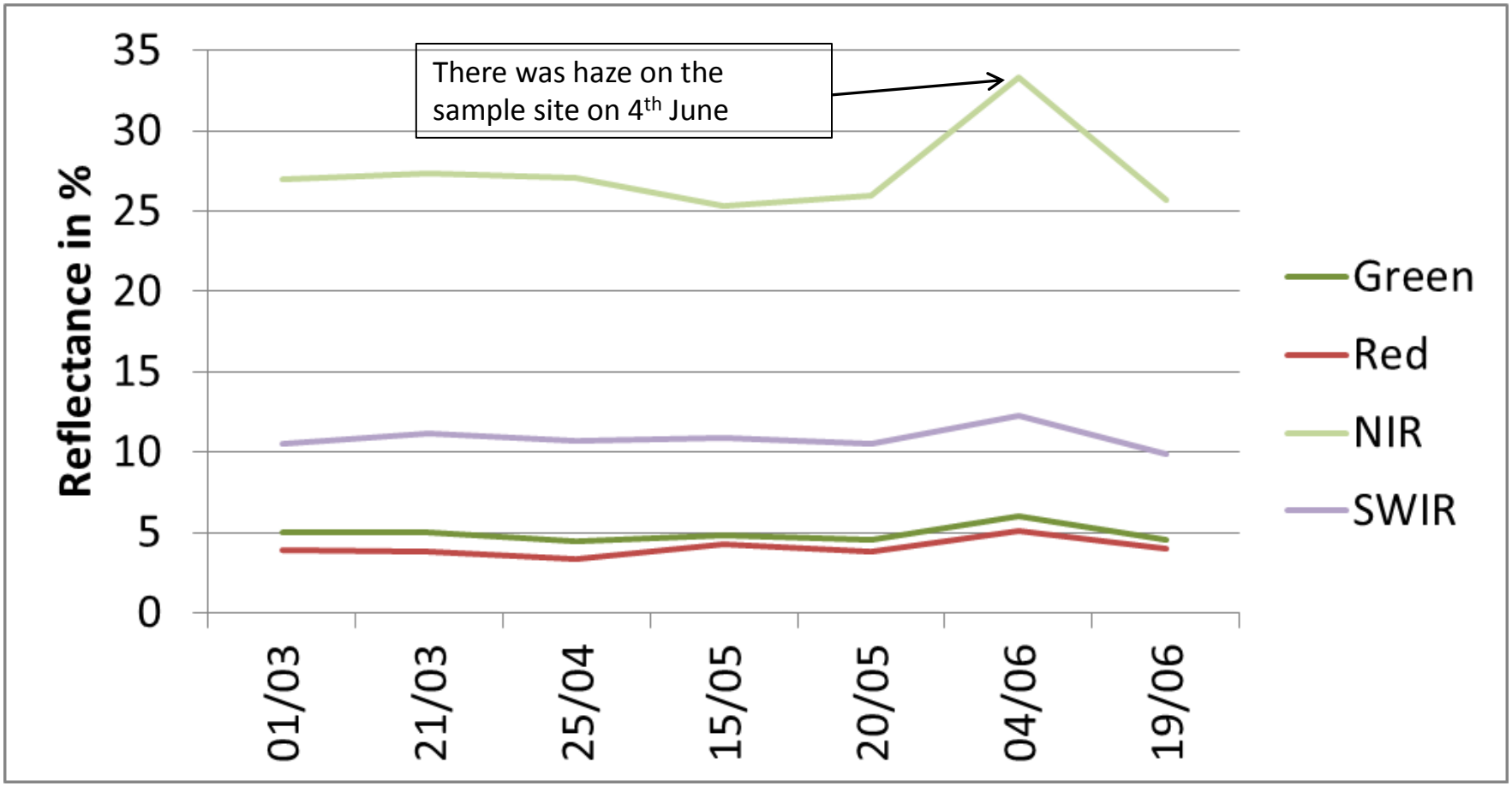
Source J. Miettinen



JRC-Sumatra site

European Commission

Development of surface reflectance on forest in the Sumatra site



Based on a sample site of around 90 000 pixels covered by seven images

Joint Research Centre

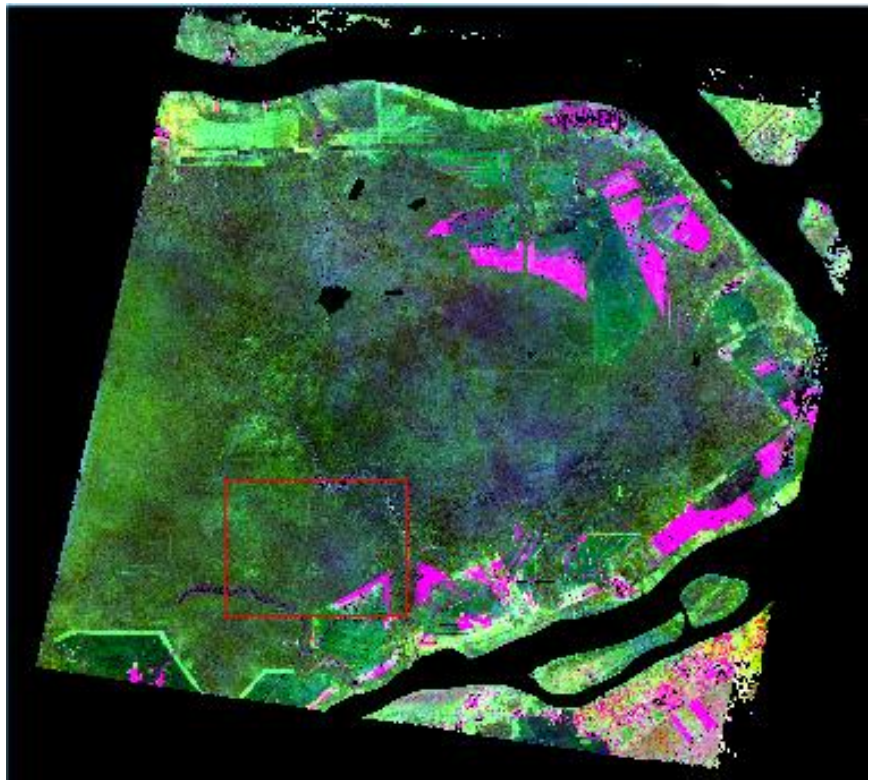
Source J. Miettinen

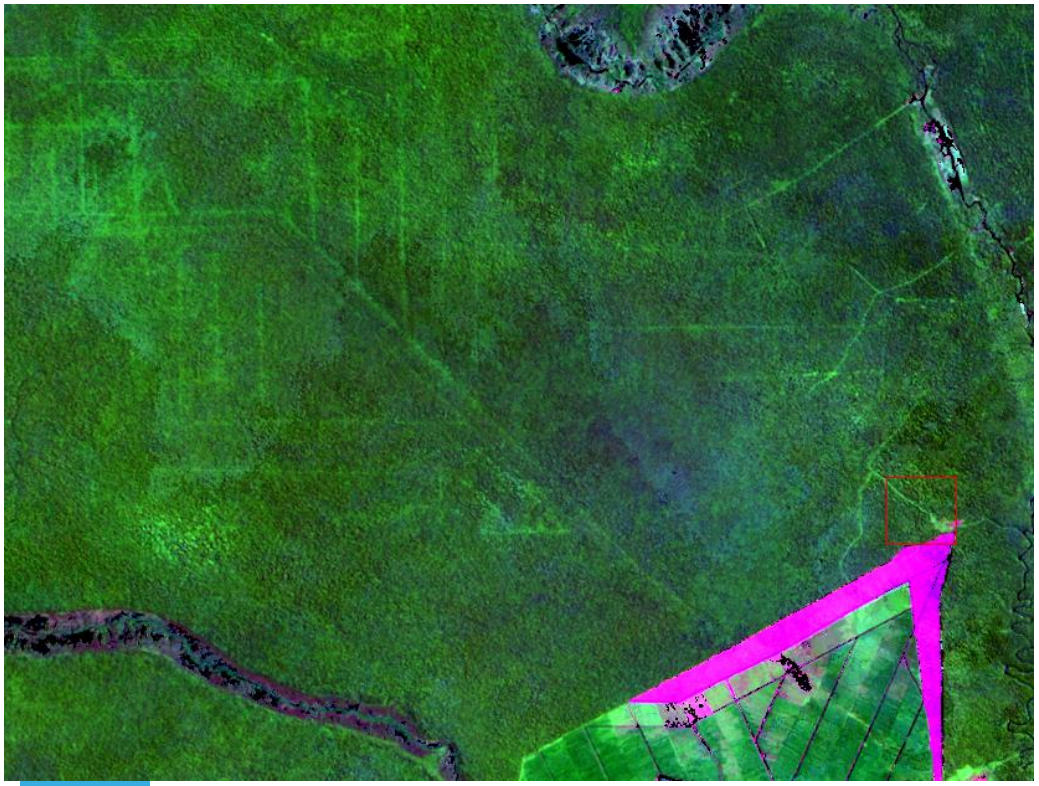
JRC-Sumatra site

Sumatra - Simulation of Level 3A product (average composite)

- We used our own cloud and shadow masking and utilized all images
- The quality was generally good, although some haze effects remain
- Average number of valid observations per pixel was 4.3 (std 1.5)
- Only 0.7% did not have any valid observations during this 4.5 months (and part of this is due to erroneously masked out drainage canals in peat!)

Source J. Miettinen

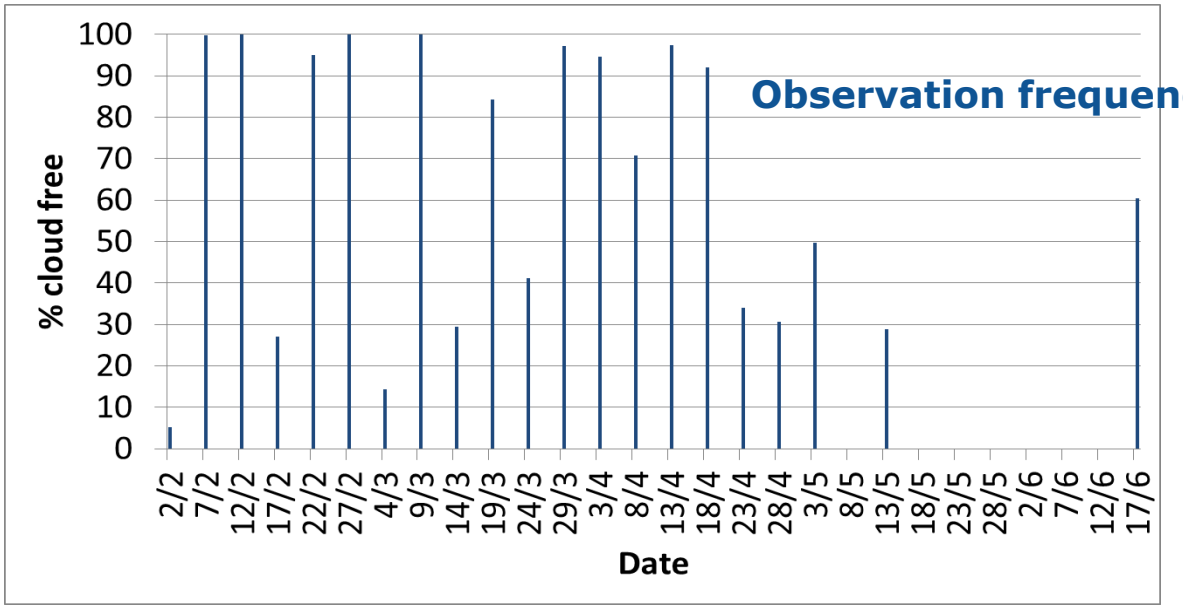




Time series in dry forest

Thailand (~ 98° E and 19° N)

- Dry continental SEA, dry season from November to April
- Evergreen and deciduous forests, shrub and agriculture
- Latter half of dry and the beginning of rainy season covered



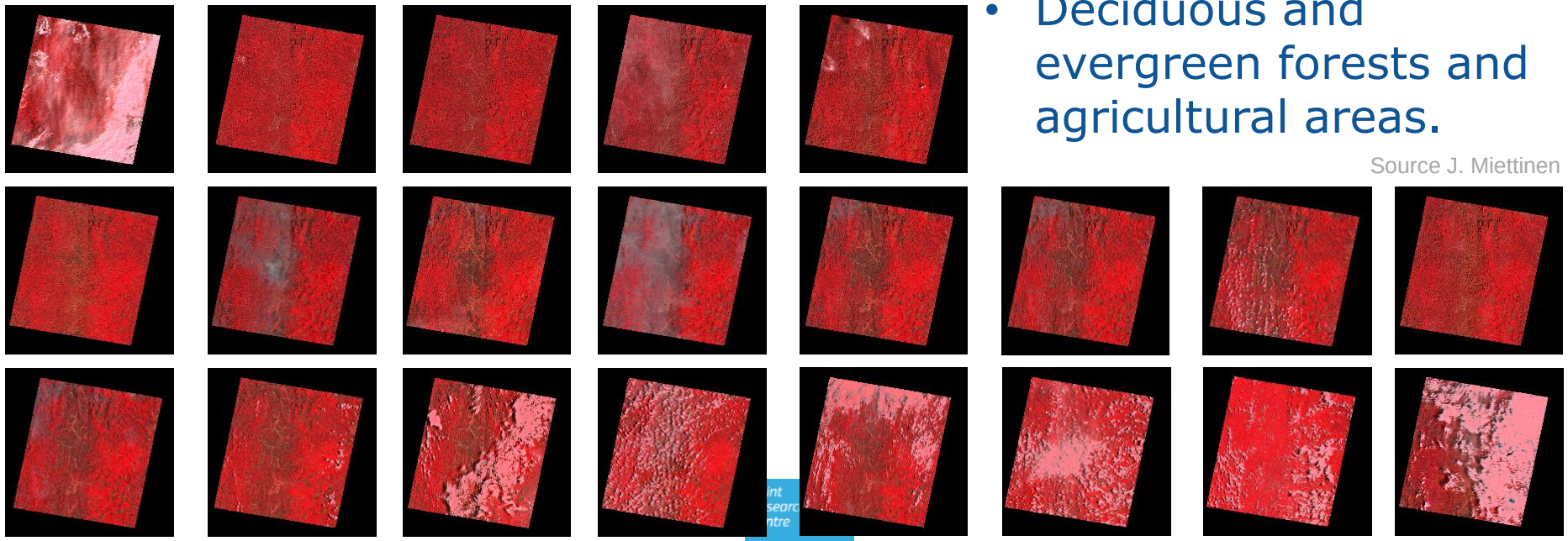
Observation frequency in the Thailand site

Source J. Miettinen

JRC-Thailand site

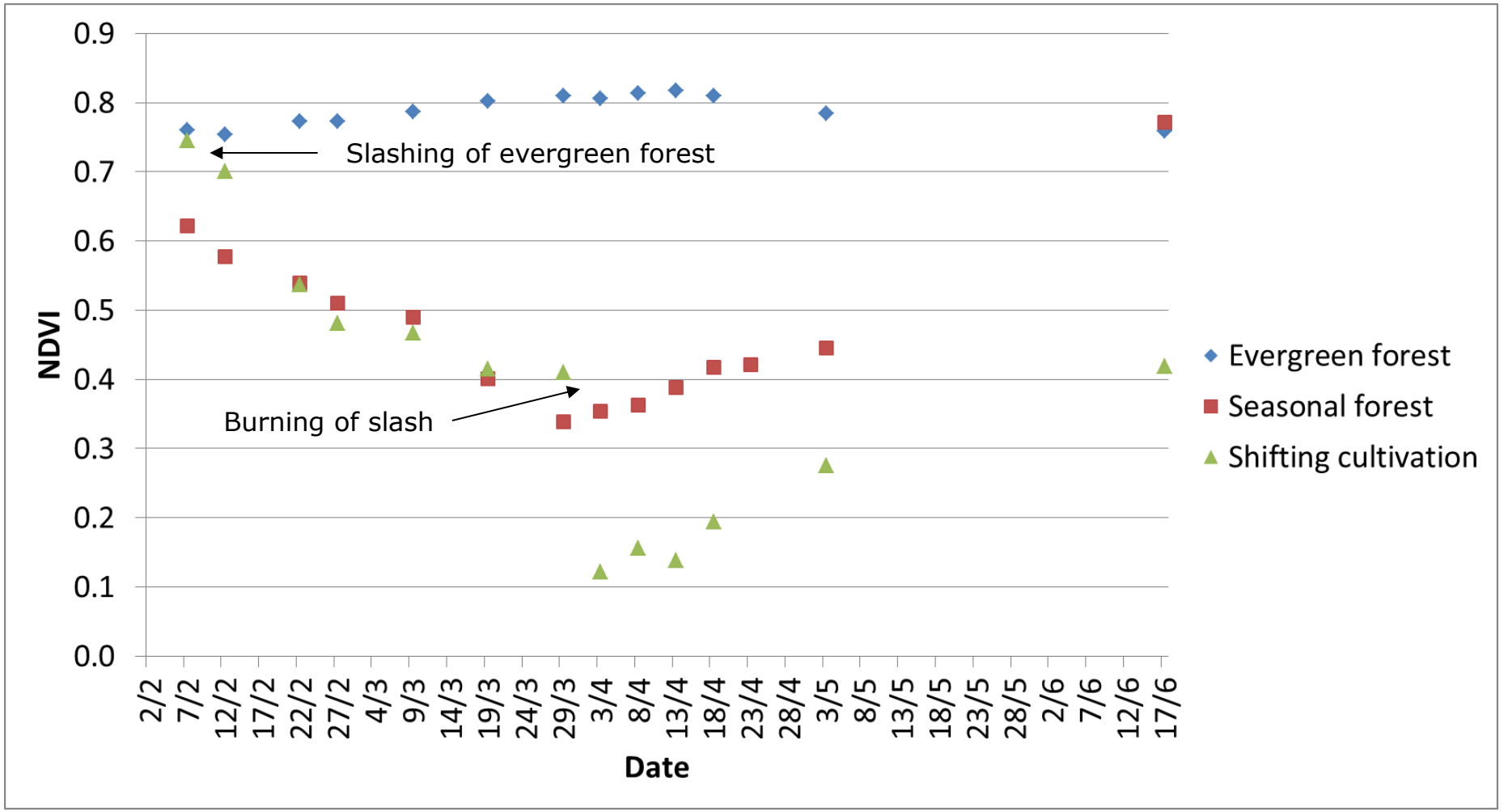
- Dry tropical climate: end of dry season and beginning of rainy season covered.
- 21 scenes between 2nd Feb and 17th Jun.
- Deciduous and evergreen forests and agricultural areas.

Source J. Miettinen



JRC-Thailand site

Development of NDVI in different land cover features in the Thailand site



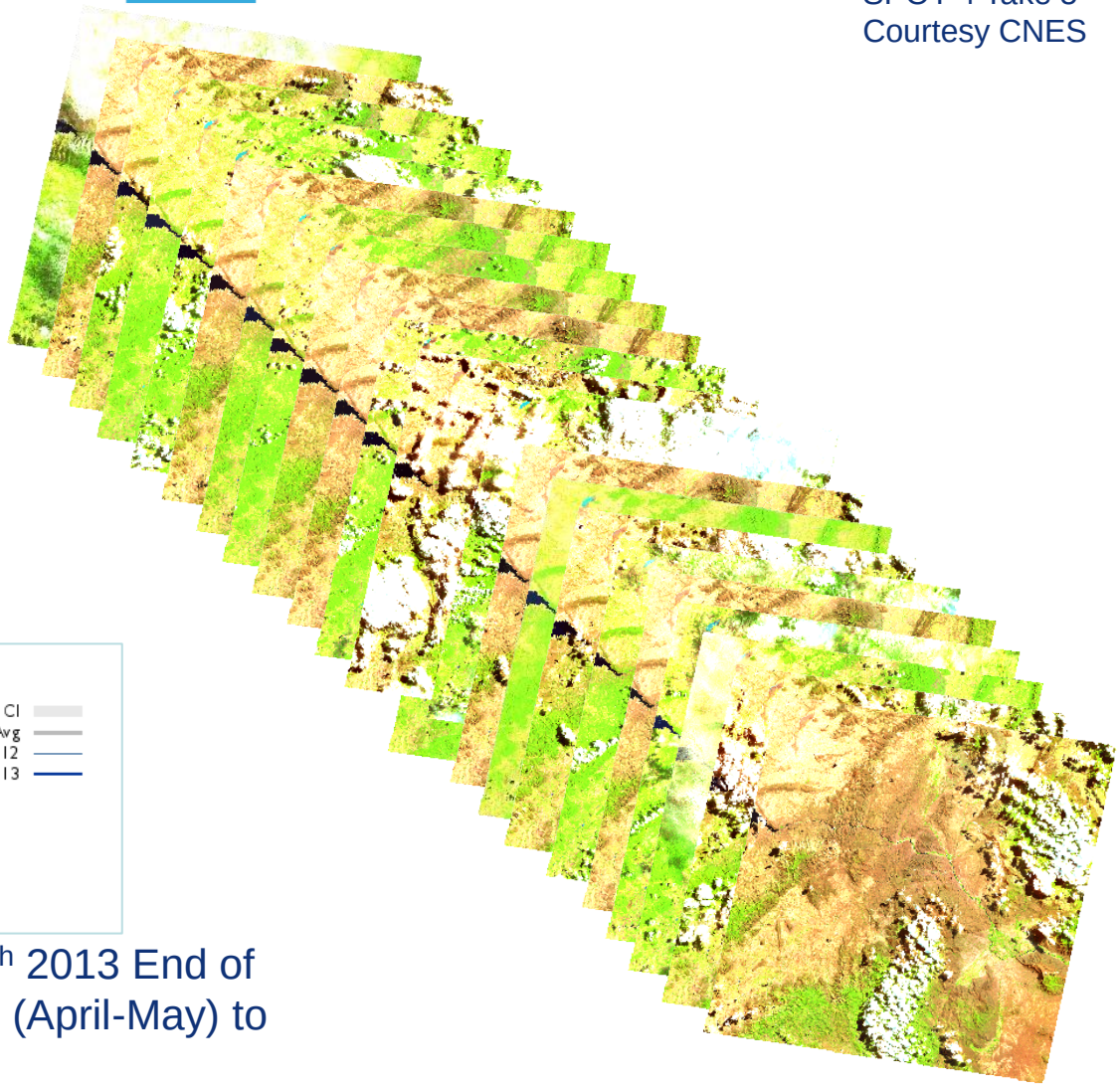
Source J. Miettinen

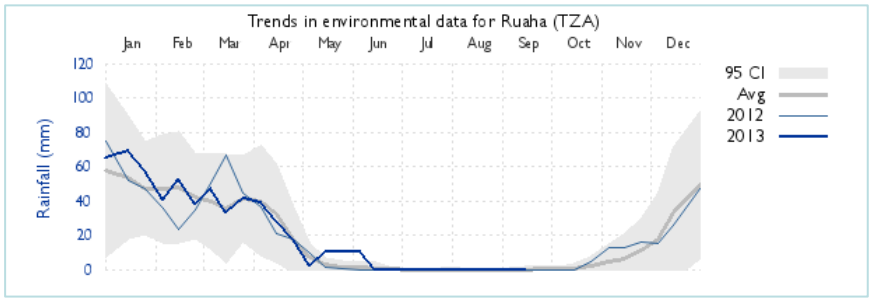
JRC-Tanzania site

European Commission

SPOT 4 Take 5
Courtesy CNES

Mtera, Tanzania 7S 36E





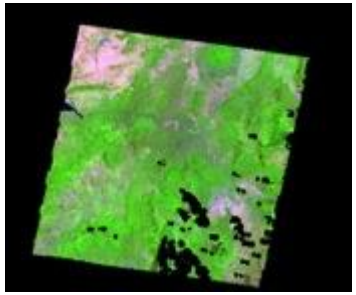
23 acquisitions; February 6th - June 16th 2013 End of wet season (Feb.), to short wet season (April-May) to dry season (June)

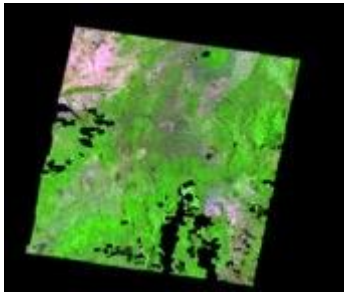
Joint Research Centre

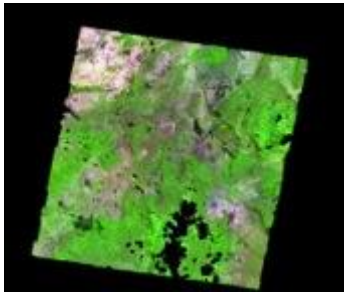
Source Hugh Eva, Lorena Hojas Gascon

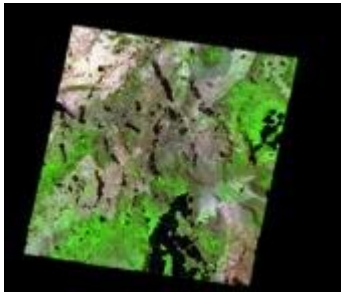
JRC-Tanzania site

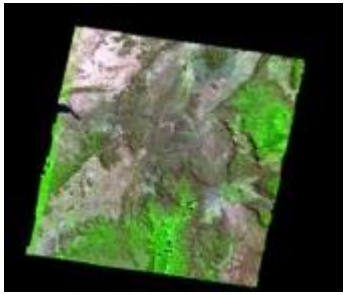
Source Hugh Eva, Lorena Hojas Gascon


Feb

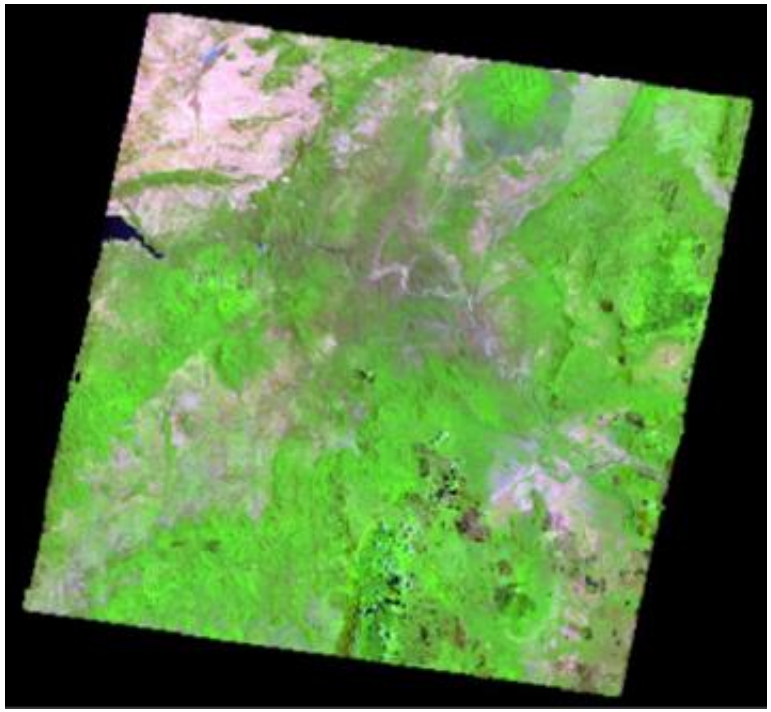

March

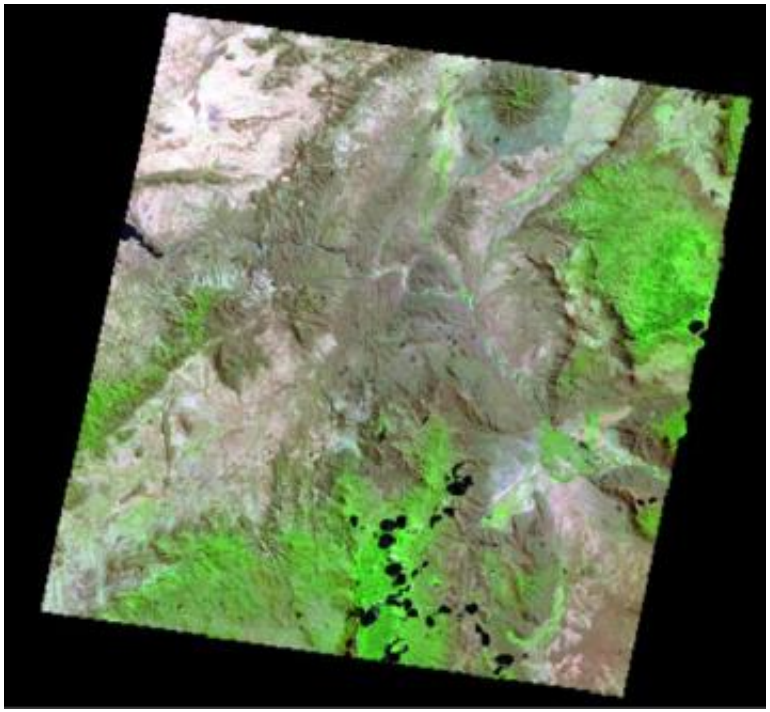

April


May


June

Monthly composites based on median after cloud masking


Based on median of all images


Based dry season (June) image

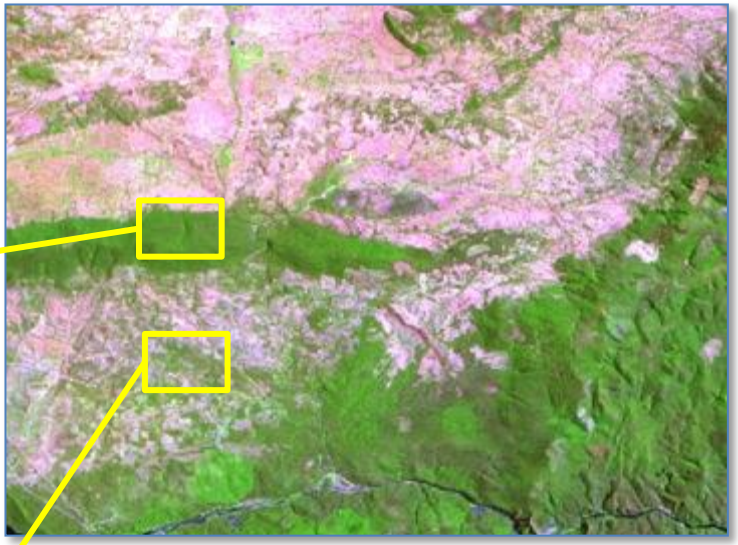
Joint Research Centre

JRC-Tanzania site

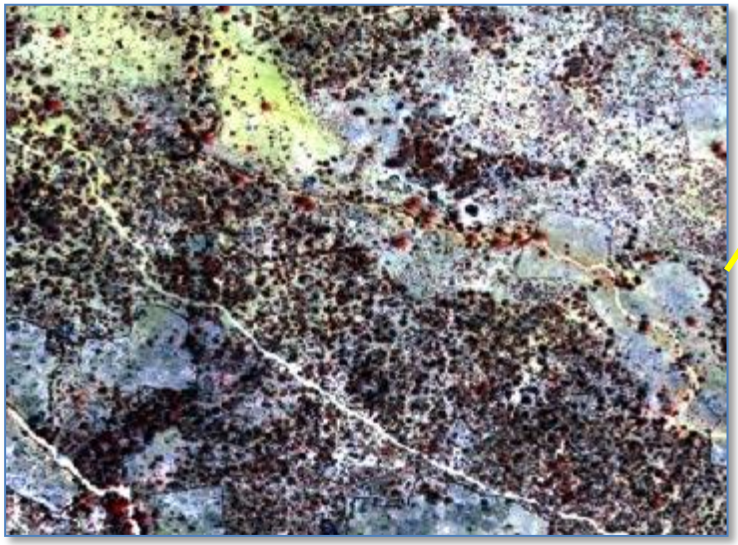
European Commission

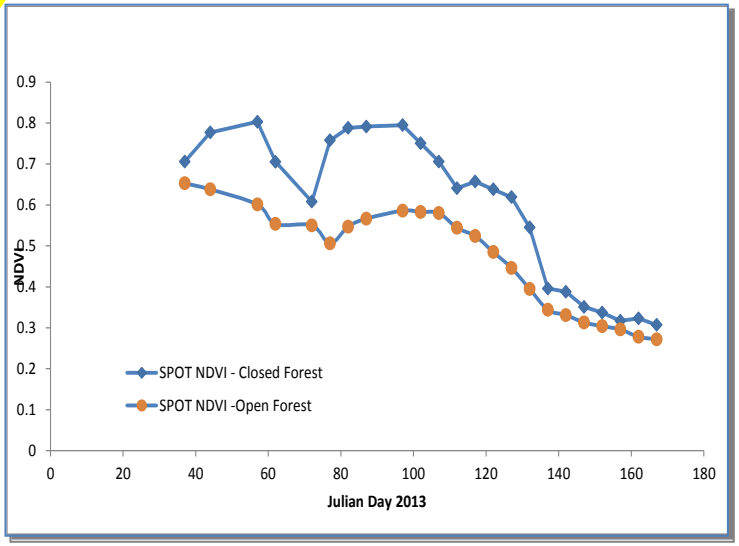
Closed dry forest World View 2

S2 simulation



12 km





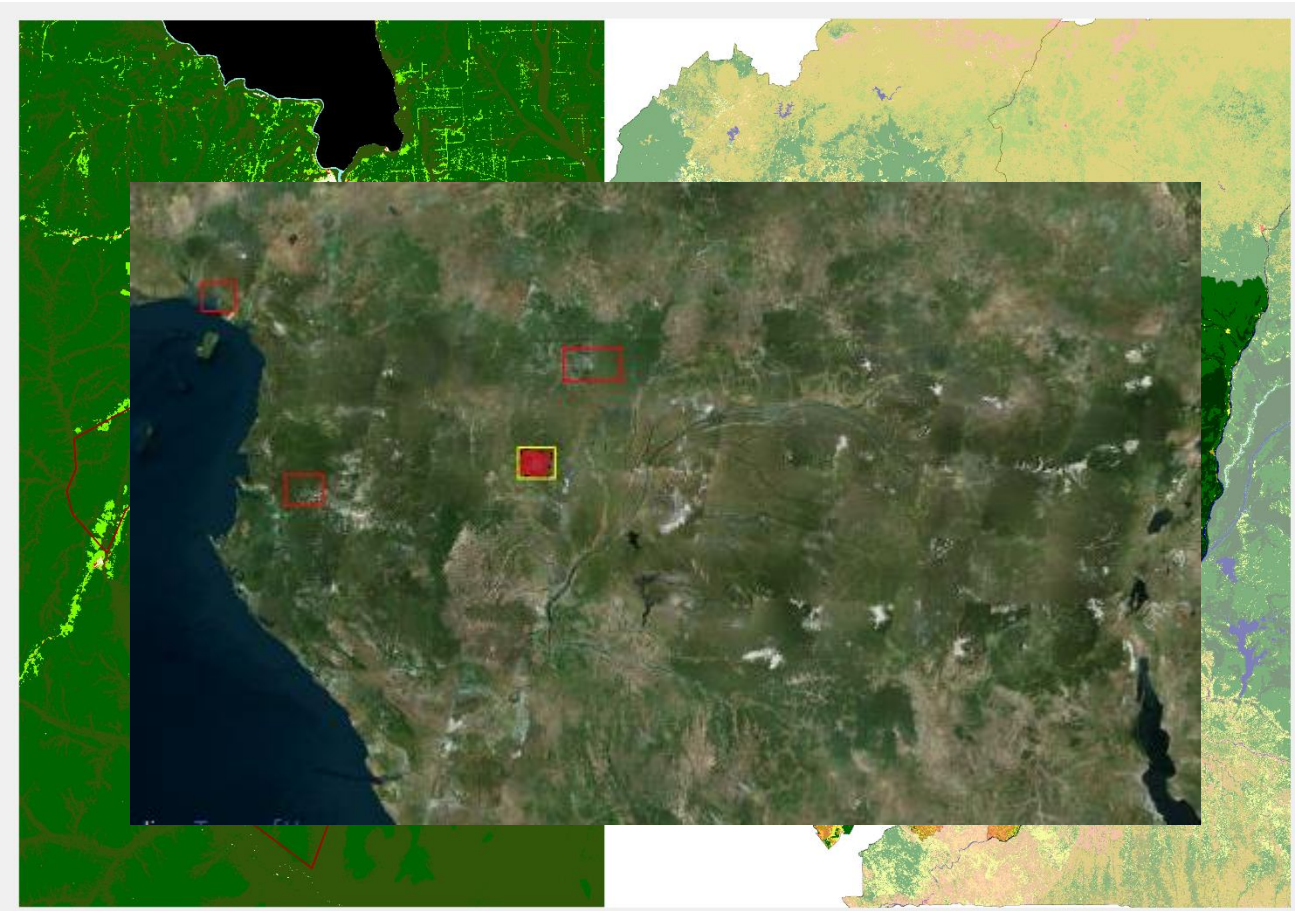
Open dry forest World View 2

Joint Research Centre

Source Hugh Eva, Lorena Hojas Gascon

European Commission

Selective logging



Logging concessions – selective logging

Exploitation in 2013

Concomitant with Spot4Take5 acquisition

30500 ha

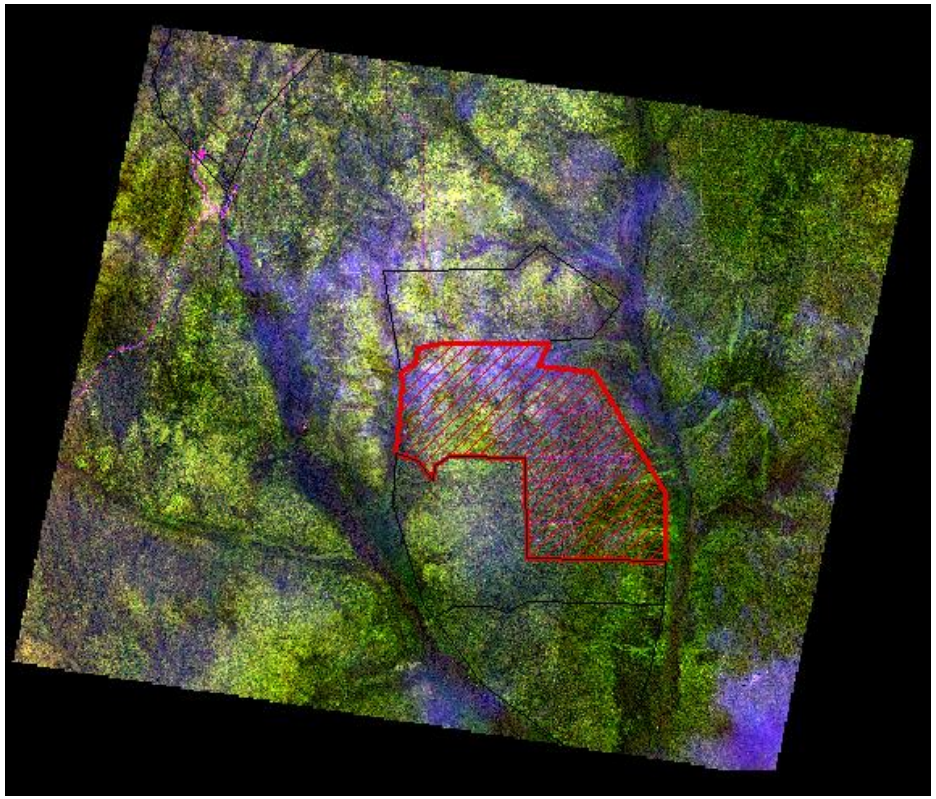
ESA-Congo(2) site

Time series of 20 images
acquired between 1/02/2013
and 16/06/2013

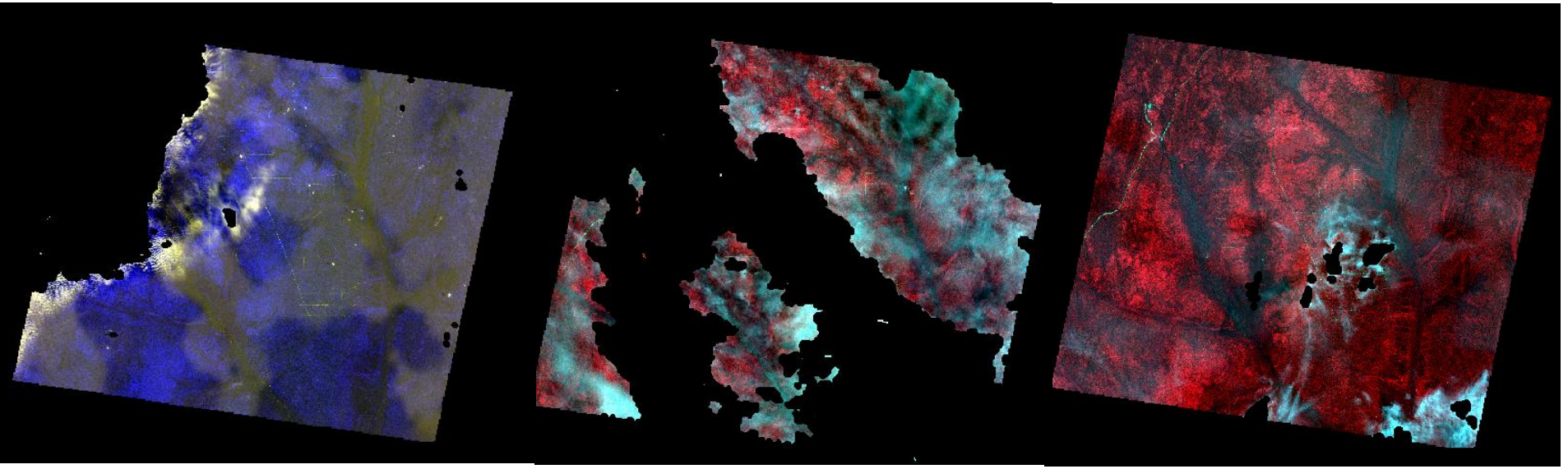
CNES/CESBIO
V2.0 version (march 2014)

- Improvement in the ortho-rectification
- Cloud mask, still haze and small clouds

Landsat 8 and Rapideye images



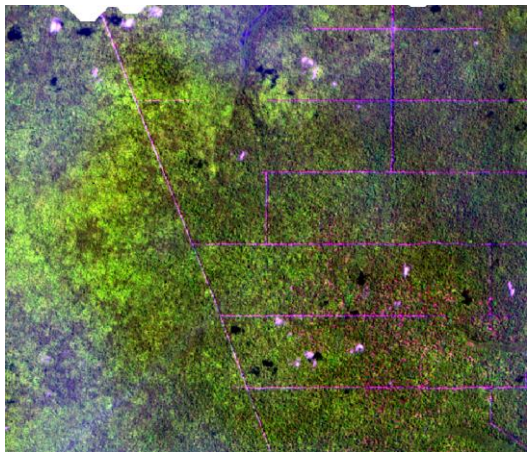
ESA-Congo(2) site



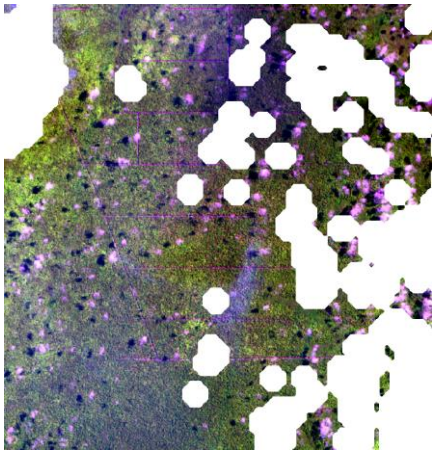
13 03 2013

08 03 2013

01 06 2013



02 05 2013



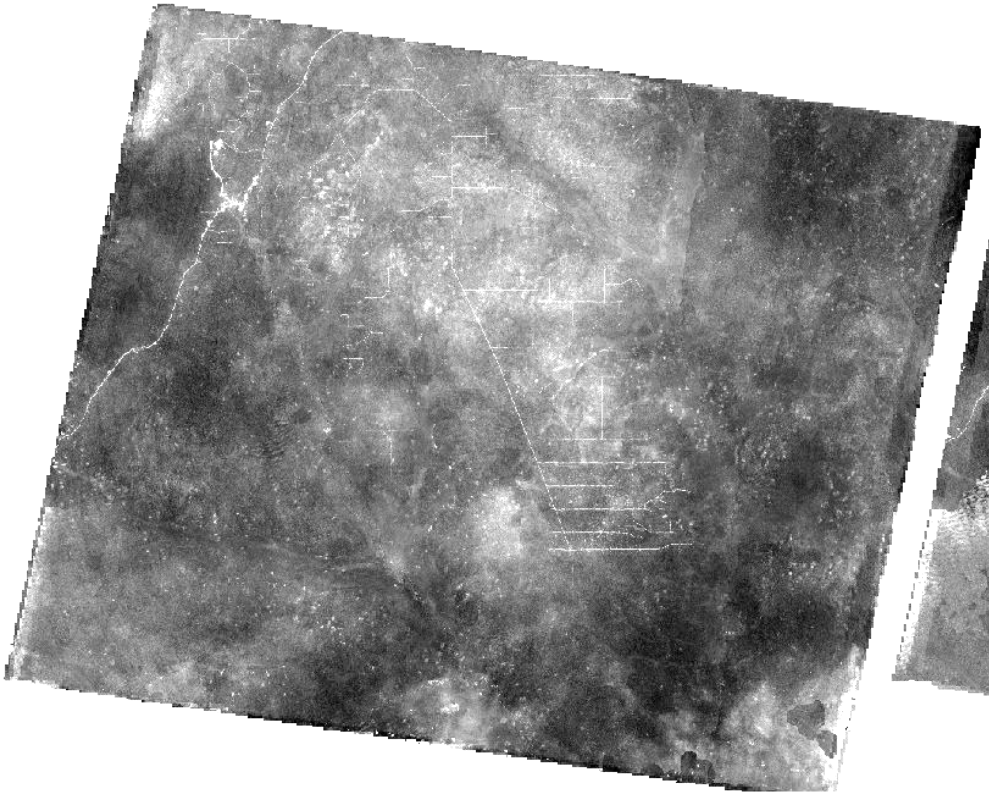
17 05 2013

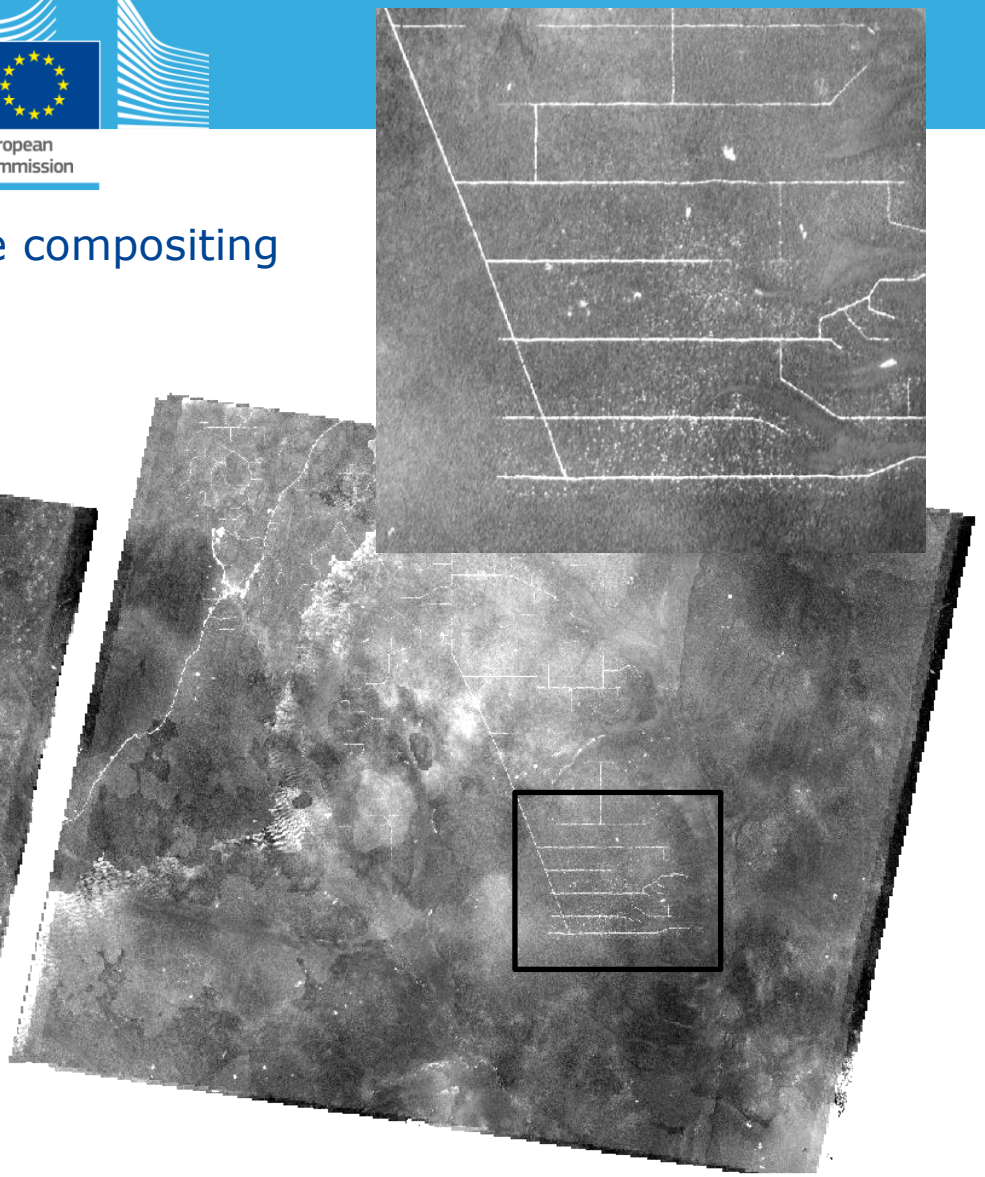
Joint Research Centre

ESA-Congo(2) site

European Commission

Haze and small clouds affect average compositing
Orthorectification seems ok





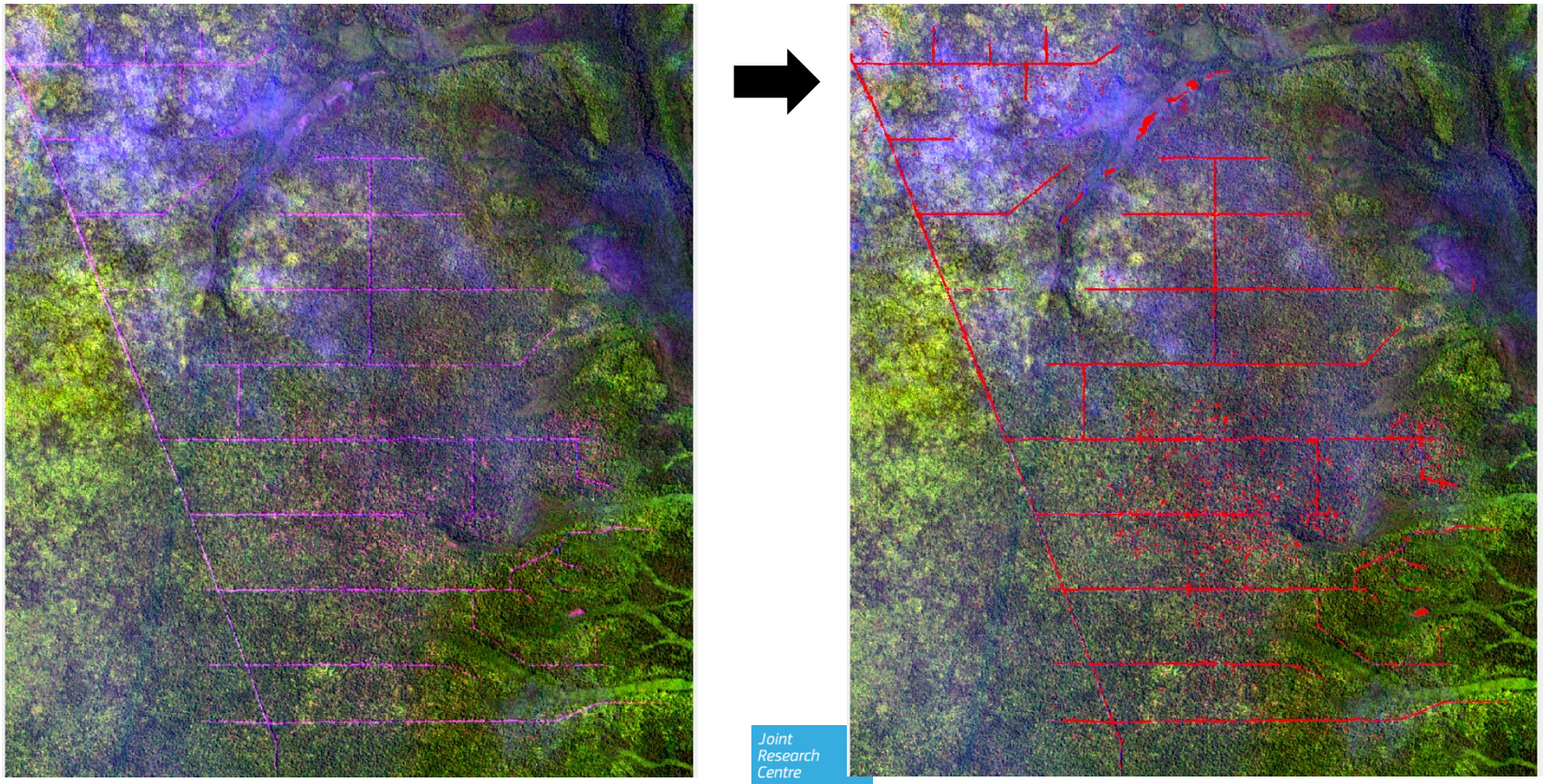
20 images – average band 2 (Red)

6 “best” images – average band 2 (Red)

Joint Research Centre

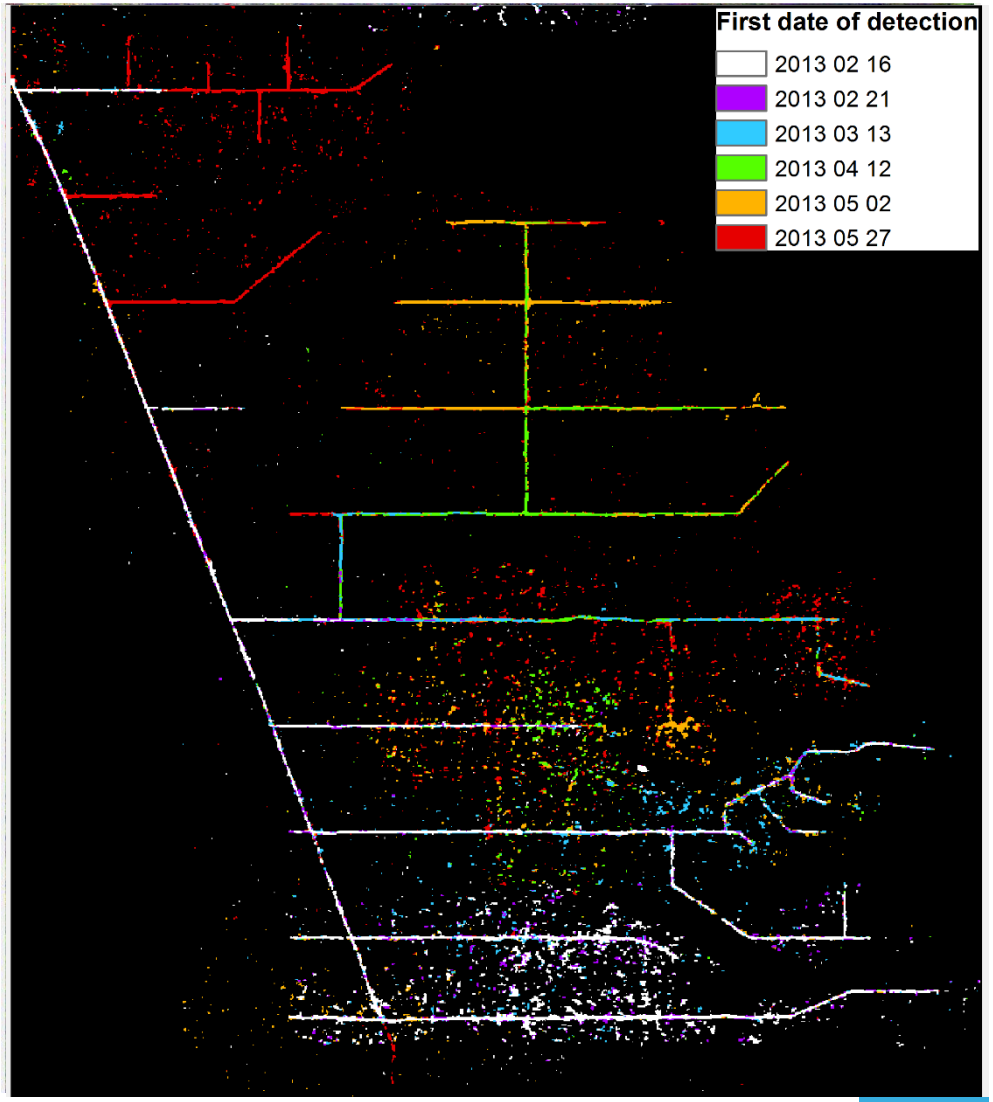
ESA-Congo(2) site

- Analysis of the 6 “best” images
- INPE Spectral unmixing – Enhance logging tracks and logging gaps
- Segmentation on Soil fraction + NDVI ➔ detection of the logging tracks and gaps for each image



ESA-Congo(2) site

Difference in area of changes detected



Cumulative impact observed

16 02 2013	488.6 ha
21 02 2013	96 ha
13 03 2013	160.6 ha
12 04 2013	140.5 ha
02 05 2013	214.2 ha
27 05 2013	307.88 ha
	1407.8 ha

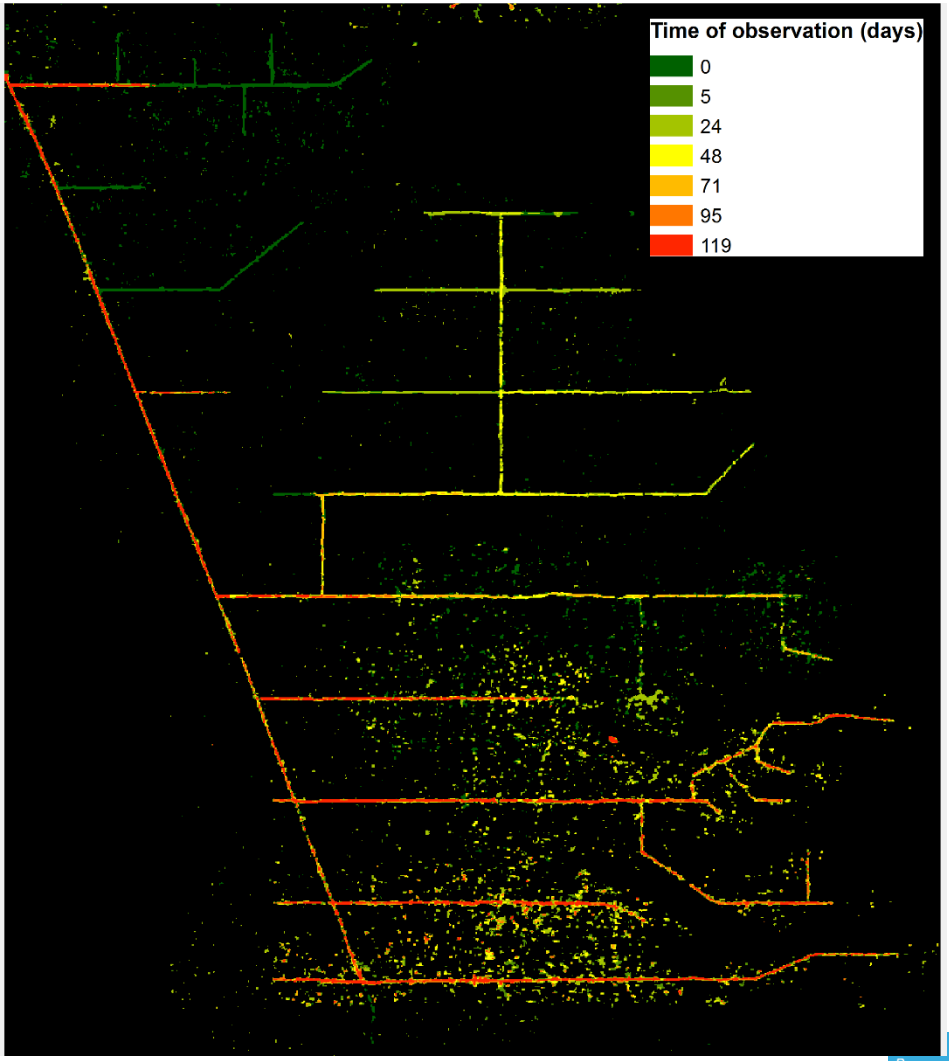
Single image analysis

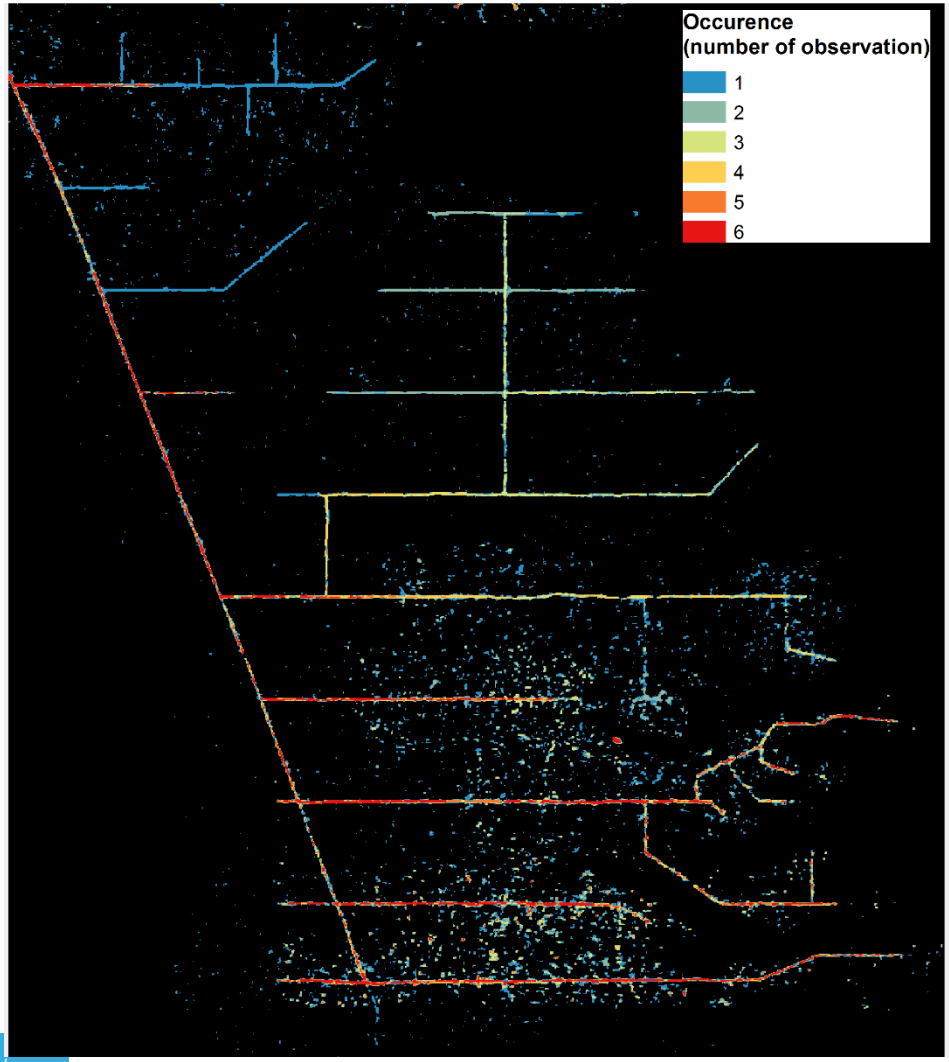
16 02 2013	488.6 ha
21 02 2013	447.8ha
13 03 2013	560.6ha
12 04 2013	463.6 ha
02 05 2013	681.5 ha
27 05 2013	862.3 ha

ESA-Congo(2) site

European Commission

Changes happen fast

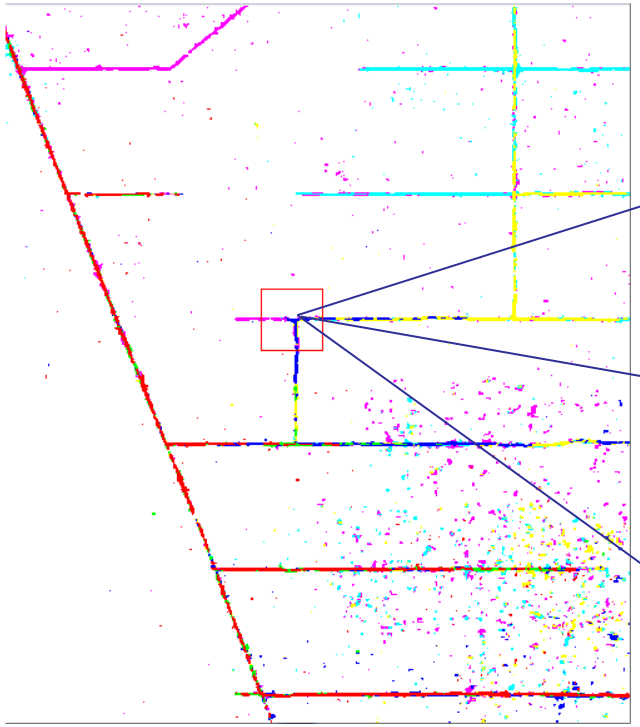




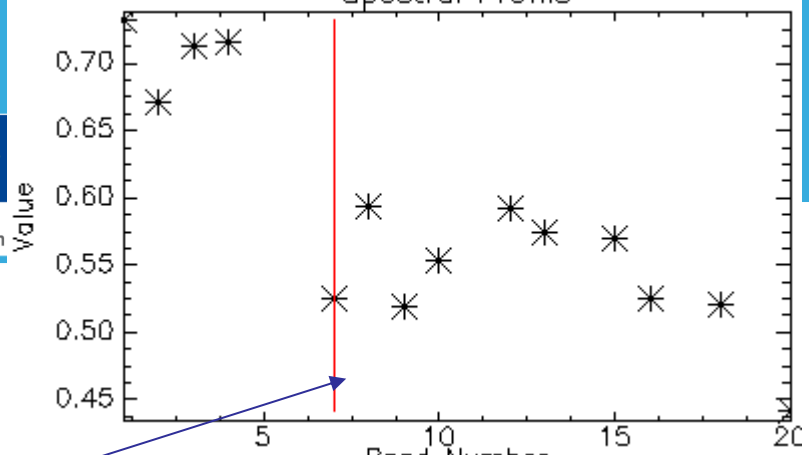
Research Centre

ESA-Congo(2) site

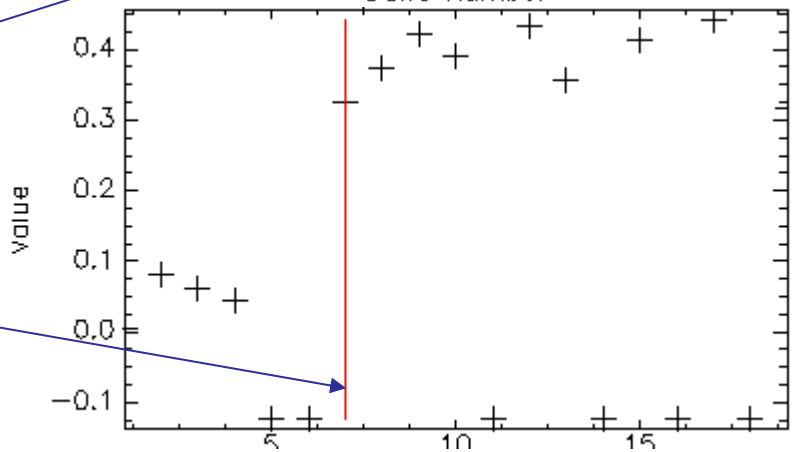
Time series analysis with the 20 images



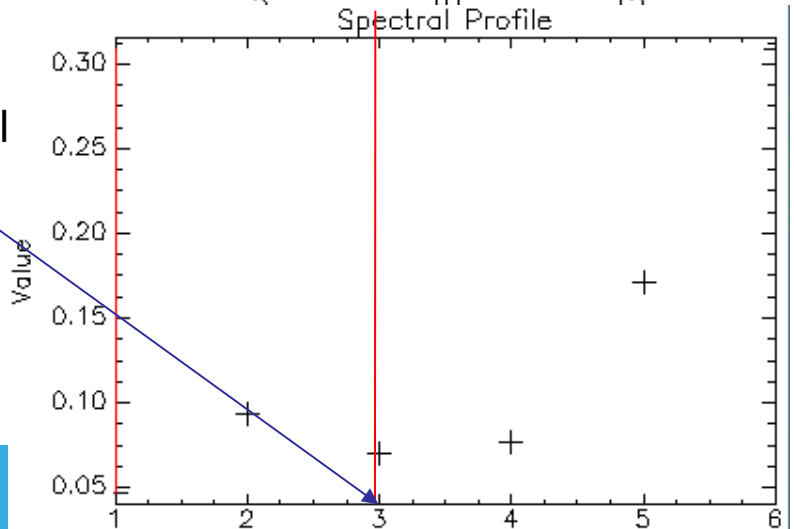
NDVI



Soil



Textural



Change detected 13 03 2013

European Commission

Joint Research Centre

Conclusions from the sites in the tropics

In the tropics, observation frequency varies strongly between the spot4tk5 sites. Some sites are unusable due to cloud coverage

Still some issues with cloud mask – haze removal

Degradation monitoring – Requirement of new methods and data.

- Reference maps at different epochs
- High resolution time series analysis

Potential of S-2 showed by the SPOT4Take5 experiment:

- Low temporal frequency - Potential for cloud-free composites
- High temporal frequency - Time series analysis in dry forests (different types of LC) and humid forests (fast changes)