Food and Agriculture Organization of the United Nations

SEPAL

SYSTEM FOR EARTH OBSERVATION DATA ACCESS, PROCESSING & ANALYSIS FOR LAND MONITORING

FAO / Norway SEPAL
April 2016

Problem

- Deforestation in the tropics constitutes of 15-20% of global greenhouse gas emissions (GHG)
- Reduction of GHG needed to achieve the two-degree target
- Norway advocates internationally for performance-based measures in developing countries
  - Land should be paid in order to reduce deforestation
- This requires qualified measurements of forest cover in developing countries
- Poor access to satellite data, limited expertise and computing power are bottlenecks
  - Particularly challenging to turn data into useful information / country statistics
- Many players working in the field
  - United Nations (UN-REDD), World Bank, USAID, JICA, Space centers/agencies, NGOs
  - Fragmented, overlapping, poorly coordinated, insufficient coverage

Main Points

- SEPAL is a MRV catalyst
- Allows easy and fast query, access and processing of earth observation data
- Expandable with user inputs
- Efficient processing anywhere in the world

SEPAL Objectives

Improve data access and delivery of (pre)processed satellite data and forest information products to enable developing countries to build the autonomous capacity to monitor their forest-related REDD+ activities.

Problem – Current Situation

- Data is free but still disaggregated and can be non-intuitive to search, query and download
- Software is free but complicated to maintain
- Computers are cheaper but infrastructure required for high performance processing is challenging for developing nations
- Internet is ubiquitous but many ministry departments have challenges to access

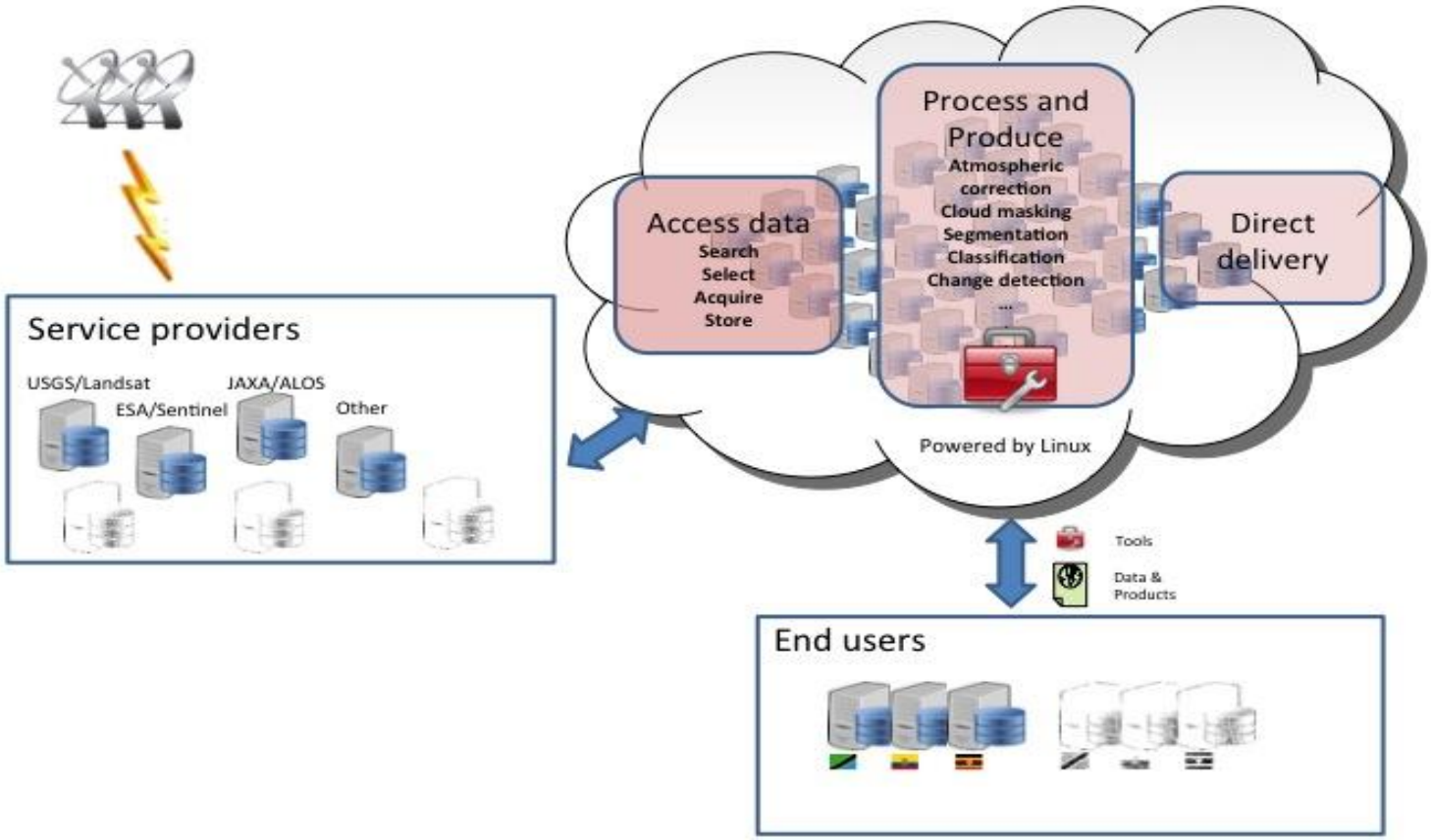
Solution

- Easy(er) access to space data;
- Easy(er) access to processing tools;
- More intuitive / streamlined / automatic (pre) processing;
- Reduce burden of computing infrastructure;
- Reduce data for download;
- Cloud-based or desktop functionality;
- National ‘ownership’ / ‘control’ of data and products;
- Fully open-source…

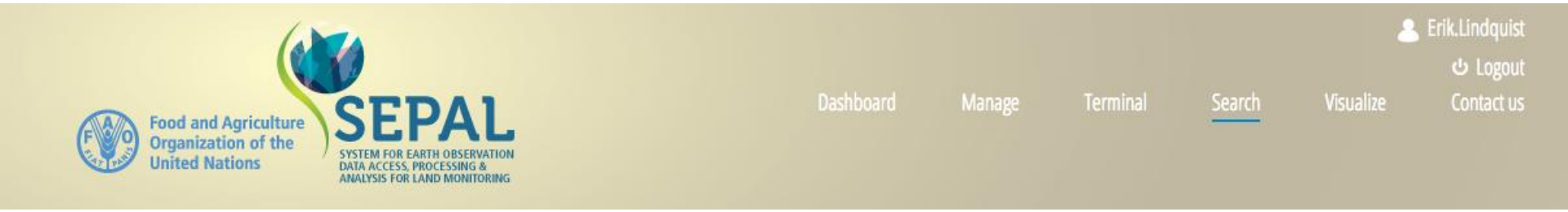
Cloud computing structure

FAO Space Data and Product management System

(SEPAL)

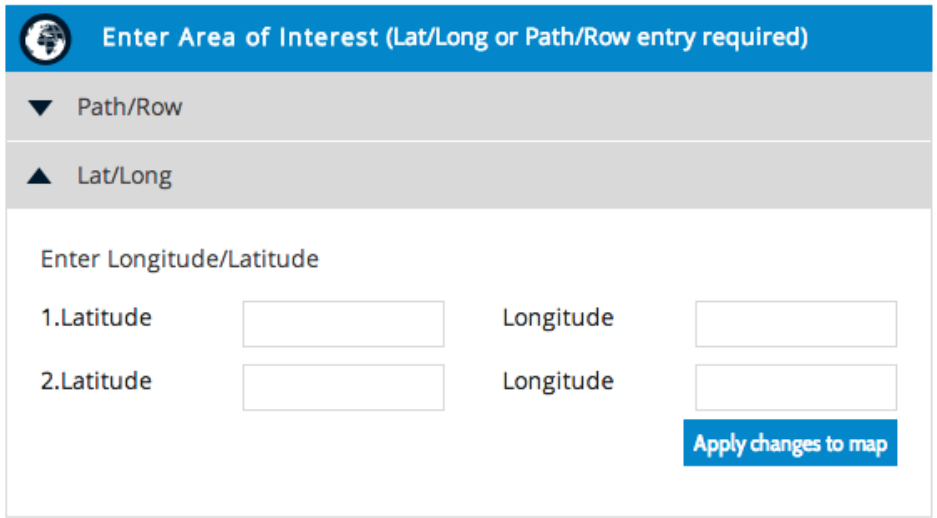


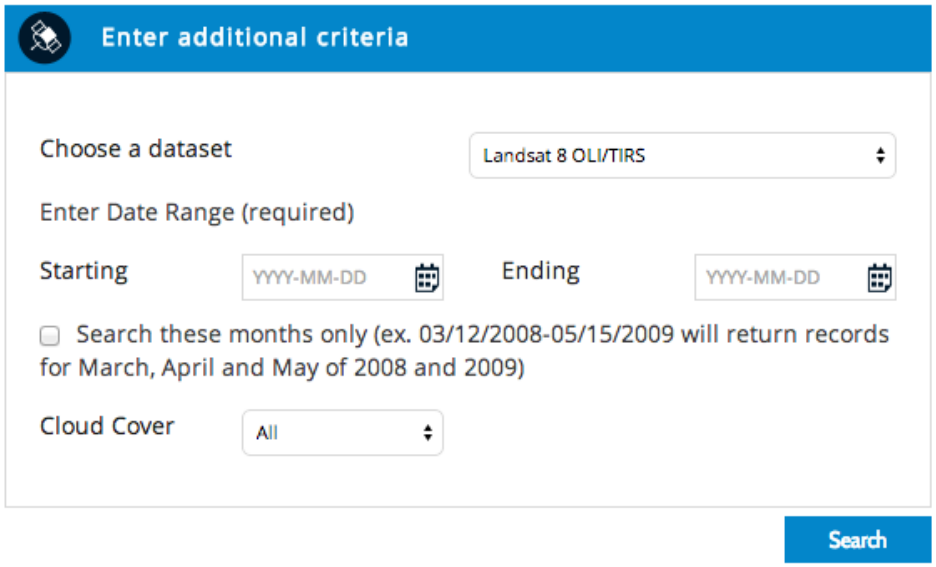
SEPAL User Interface



- Dashboard – easy viewing of file contents and download to local drive
- Manage – administer users and groups
- Terminal – UNIX terminal for OFGT processing operations
- Search – query and access satellite data

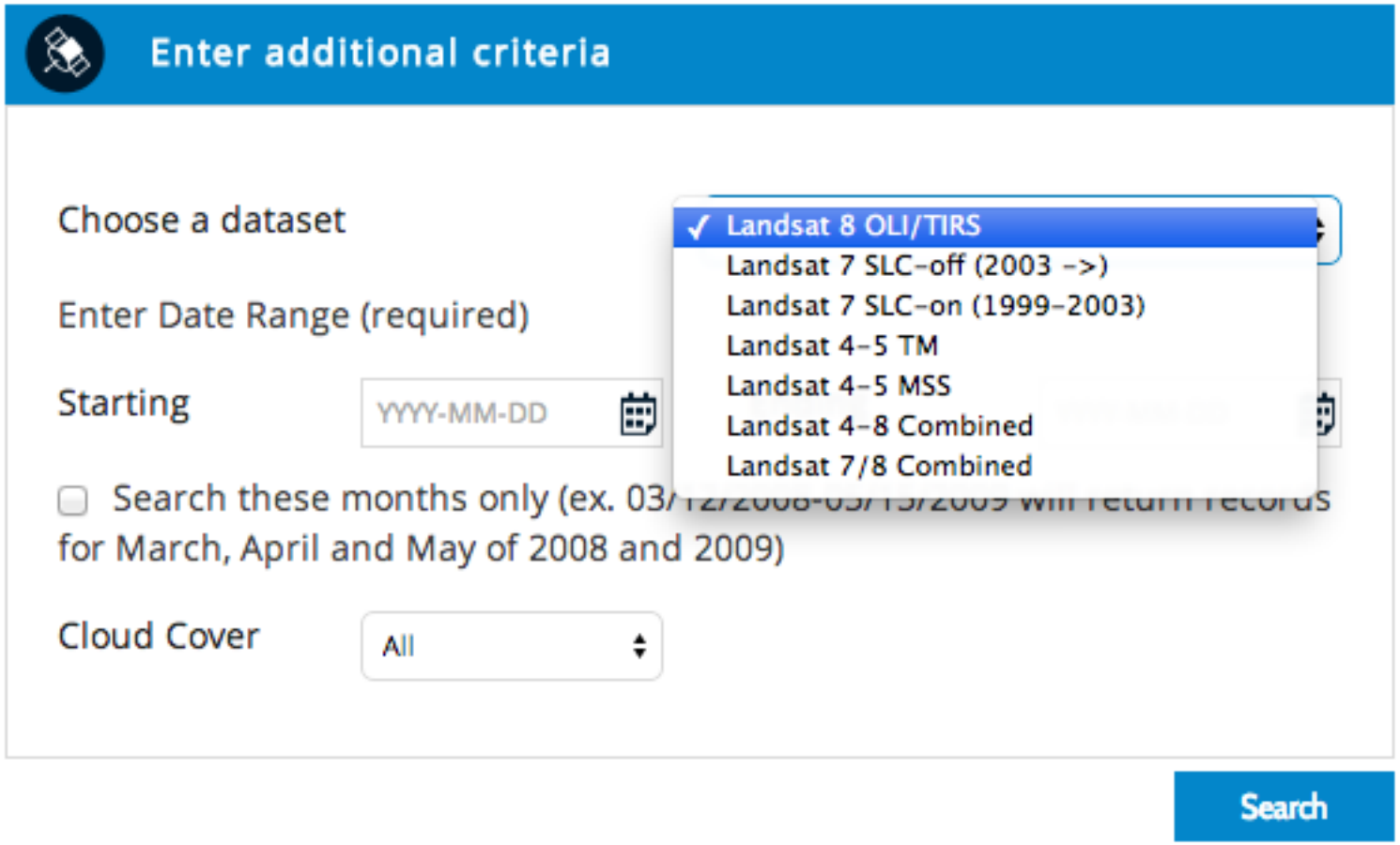
SEPAL Image Search and Access





SEPAL Image Search and Access

SEPAL Image Search and Access



SEPAL Image Search and Access

Dashboard/Search Results

Reset Search

Enter Area of Interest (Lat/Long or Path/Row entry required)

Path/Row

Lat/Long

Enter additional criteria

Choose a dataset

Landsat 4-8 Combined

Enter Date Range (required)

Starting

1980-01-01

Ending

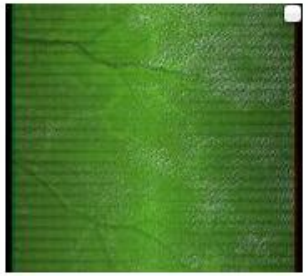
2015-01-14

Search these months only (ex. 03/12/2008-05/15/2009 will return records for March, April and May of 2008 and 2009)

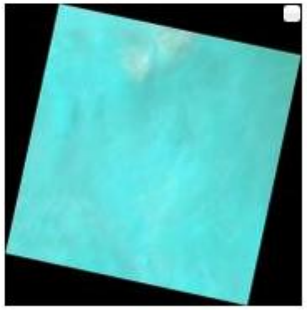
Enter Cloud Cover

Sort by : -select-

Select All



Scene ID: LE71770612014313SG100
Sensor: LANDSAT_ETM_SLC_OFF
Date: 2014-11-09
Path: 177
Row: 61
Cloud Cover : 6.39



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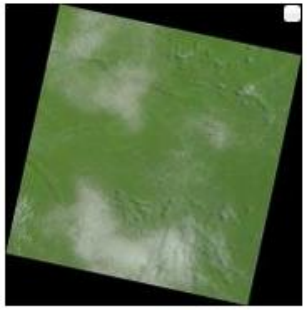
Sensor: OLI_TIRS
Date: 2014-11-01
Path: 177
Row: 61
Cloud Cover : 9.91



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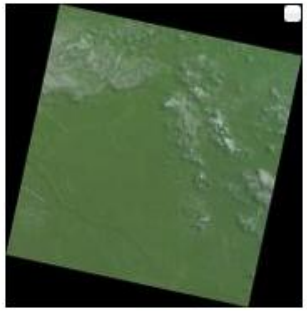
Sensor: OLI_TIRS
Date: 2014-08-29
Path: 177
Row: 61
Cloud Cover : 28.35



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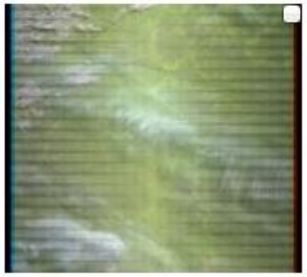
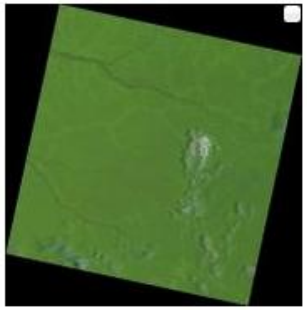
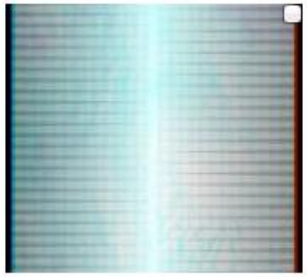
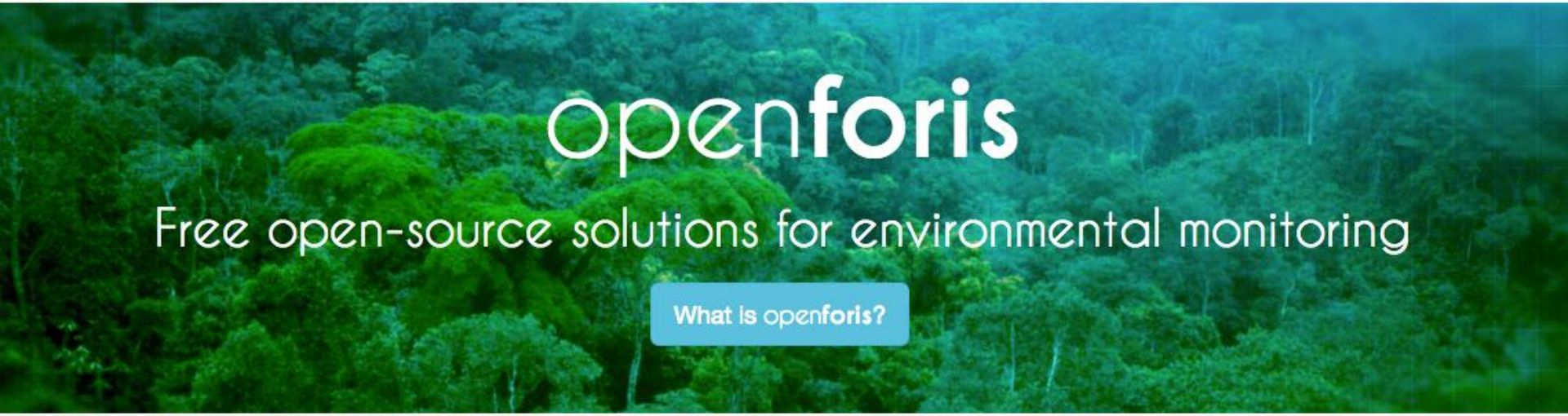
Date: 2014-07-28
Path: 177
Row: 61
Cloud Cover : 28.12







SEPAL Image Processing



Collect

Collect Mobile

Collect Earth

Calc

Geospatial Toolkit

SEPAL program update – End 2015

1) Country Experience

2) Building Internal Capacity

3) System architecture advancing

4) Advances in Data Processing / Partnerships

5) Immediate Next Steps

Country Experience

SEPAL fully in-use:

- Ecuador
- Uganda
- Paraguay

SEPAL in partial use:

- Zambia
- Guyana

Building Internal Capacity

Uganda – 1 full-time FAO consultant (UN-REDD)
Paraguay – same (UN-REDD)
Ecuador – 1 full-time FAO consultant (UN-REDD)
Zambia – 1 full-time FAO staff

Continue to open system internally to RS specialists

2 full-time developers
1 full-time LTO

System architecture

Instances currently operating in:
S. America, N. America, Europe

Landsat download time in minutes

‘Docker’ architecture which allows running SEPAL on any cloud – full country ownership

Security and maintenance improved

Parallel processing enabled

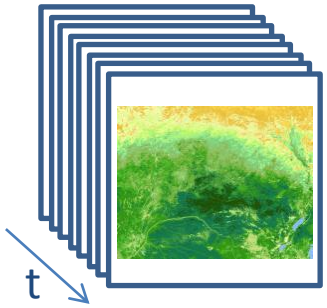
Qgis / R

SEPAL Optical Processing

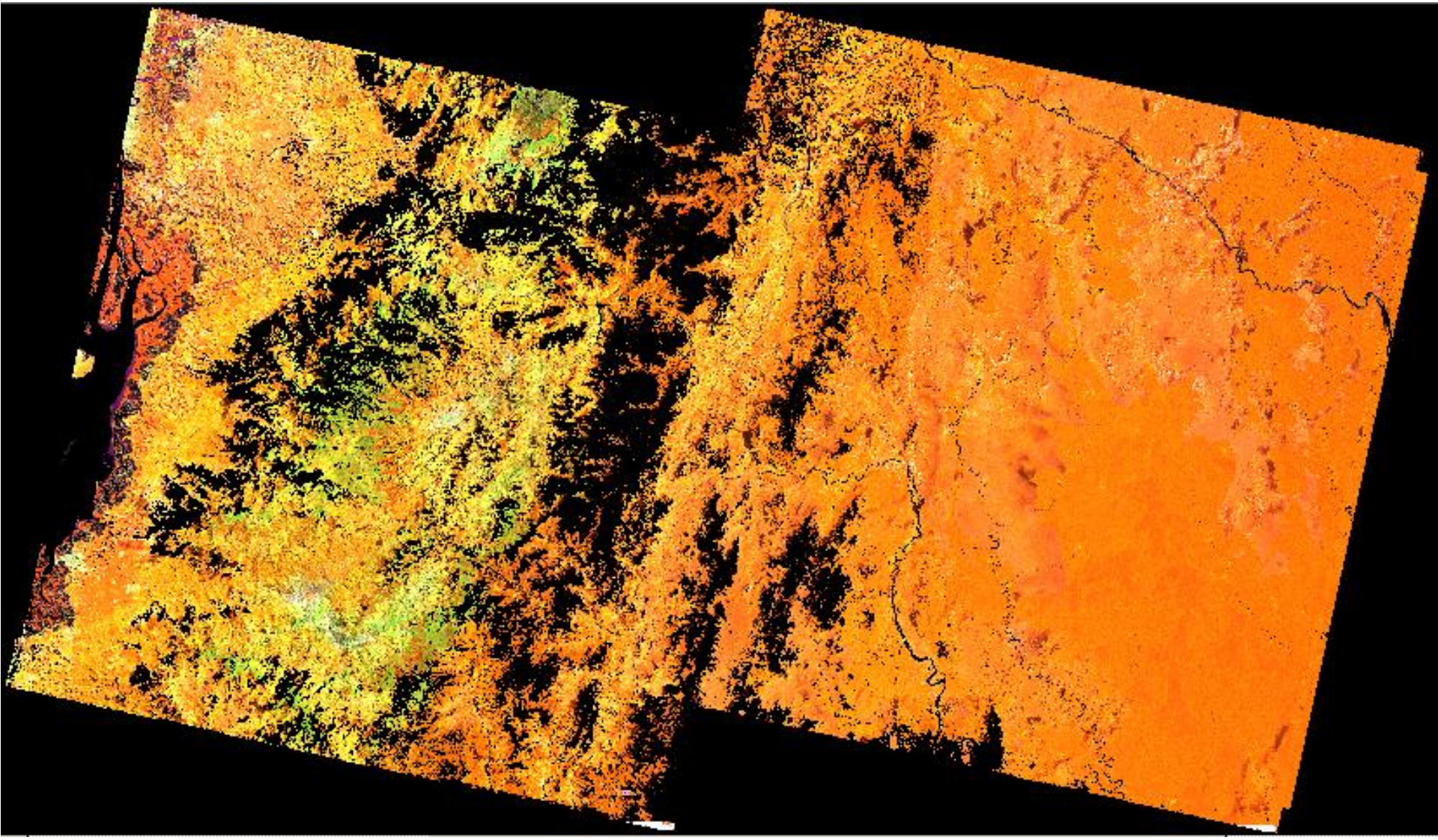
- Best Pixel Compositing
- Mosaicing
- Atmospheric Correction
- Cloud Screening
- Normalization

- Downloaded all Landsat data (TM, ETM+ and OLI) with cloud cover below 80%
- Fully automated download via ESPA using bulk downloader python script
- Cloud-based storage and processing using FAO SEPAL system (based on AWS)
- Products ordered:
  - LEDAPS pre-processed surface reflectance and NDMI
  - FMASK cloud mask

$$NDMI = \frac{NIR - SWIR1}{NIR + SWIR1}$$



Ecuador – composite / mosaic



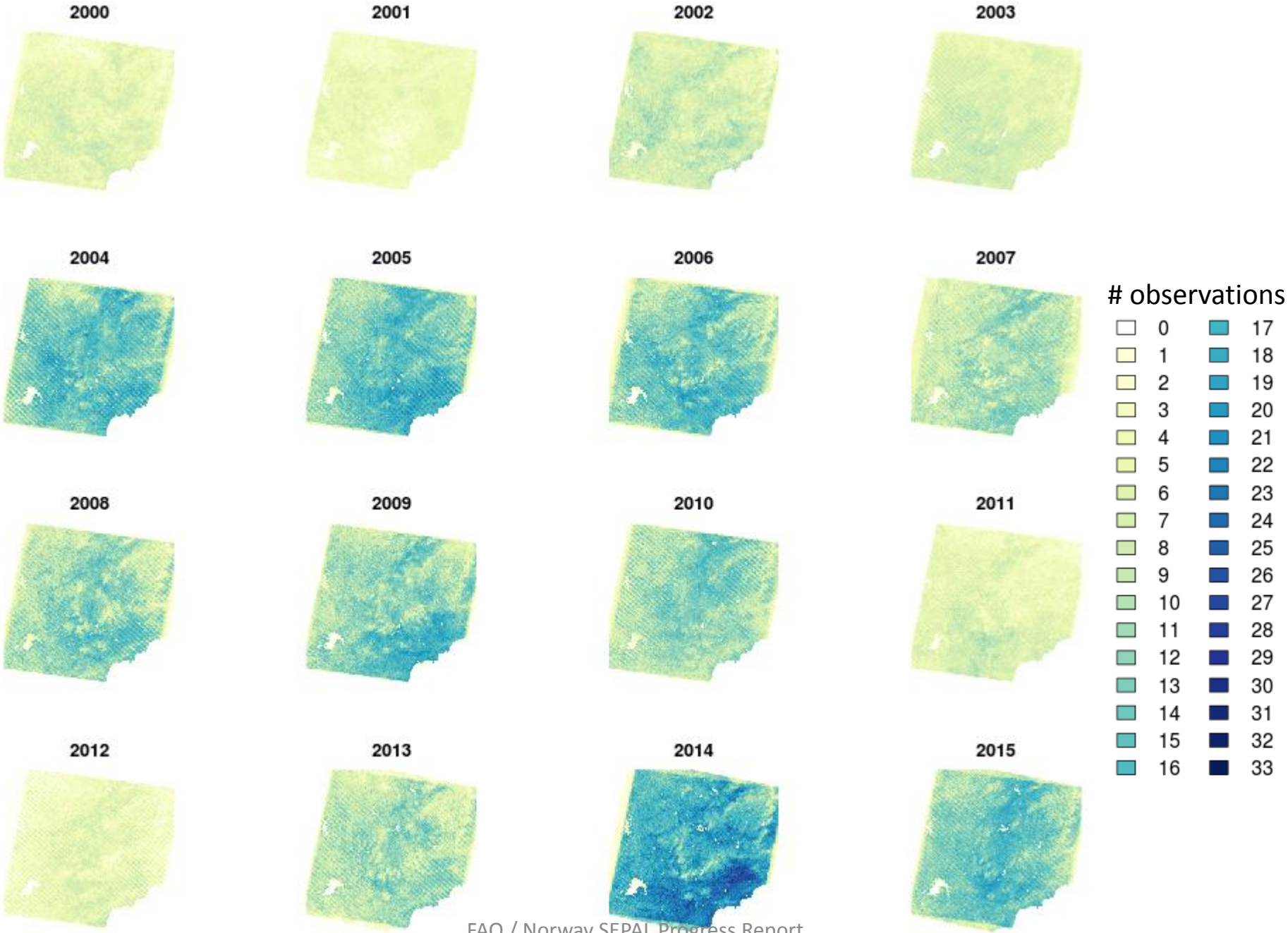
Monitoring forest changes in tropical forests with dense Landsat time series

Ben DeVries[1], Jan Verbesselt[1],
Erik van Schalk[2], Erik Lindquist[3]

1 Laboratory of Geo-Information Science and Remote Sensing, Wageningen University
2 Earth System Science Group, Wageningen University
3 Food and Agriculture Organization of the United Nations (UN-FAO)

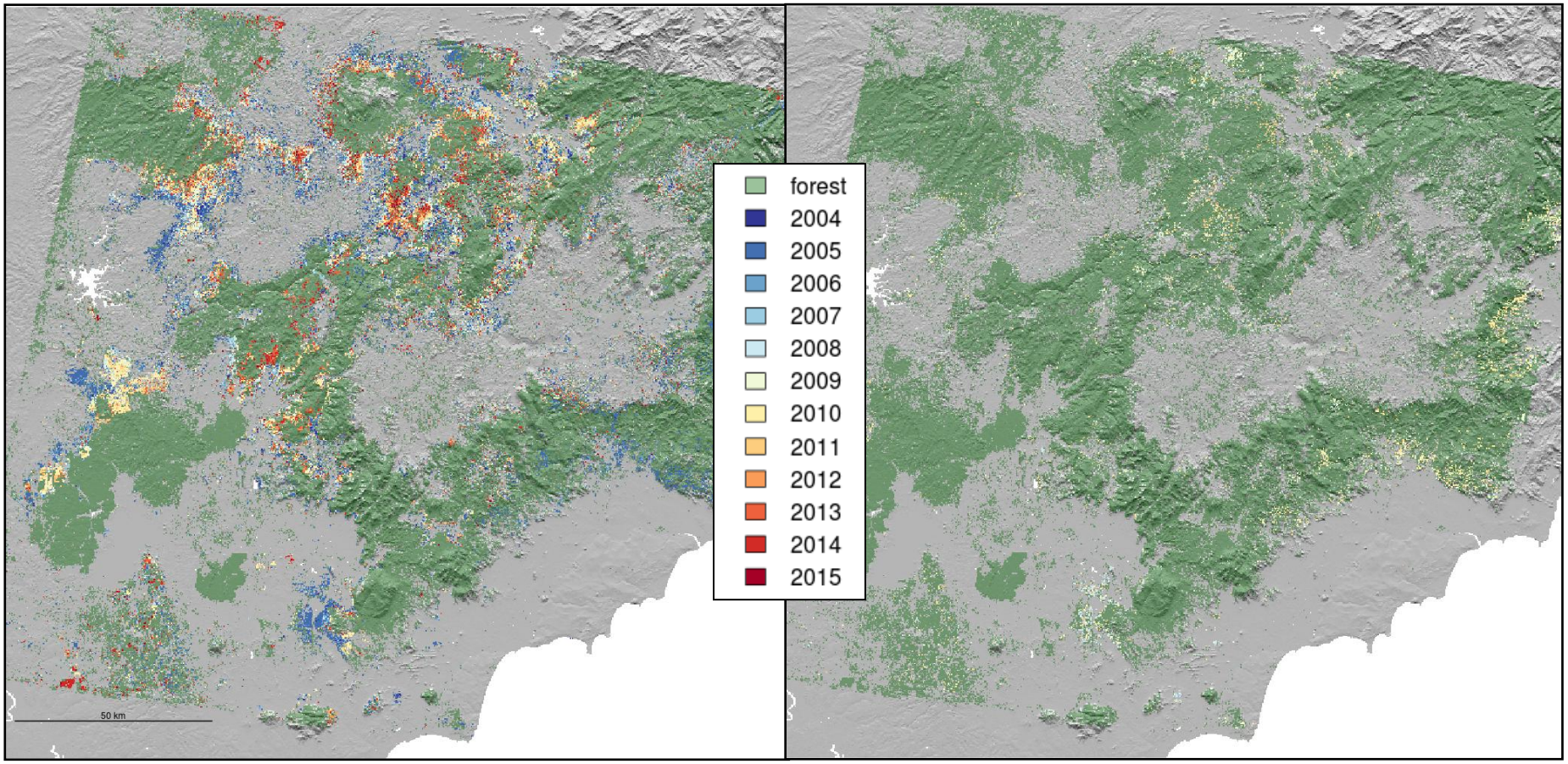
Dense Landsat Time Series

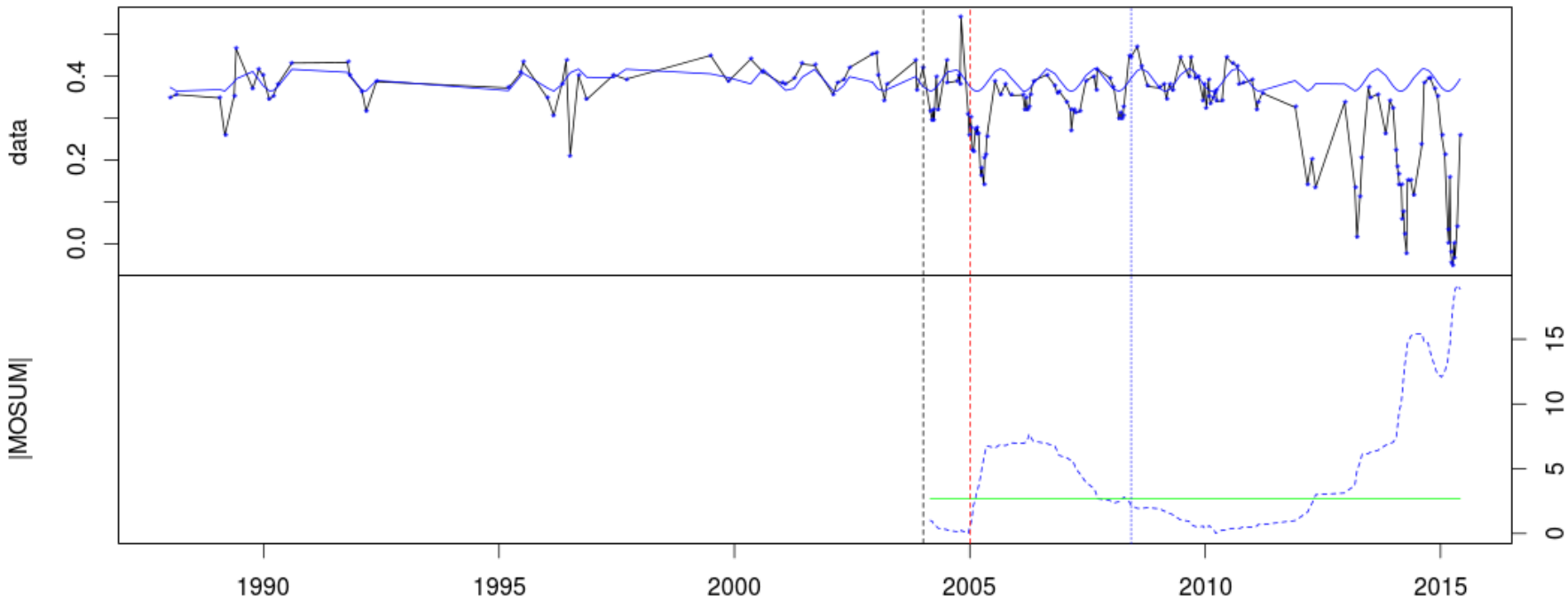
- All data used, regardless of sensor
- Land cover types are often distinguishable based on time series signature
- (Usually) no problems with using ETM+ SLC-off data, if pixel-based methods are used
- Yearly data density (# observations / year) variable due to sensor lifetimes, climate variability (cloud cover), etc.

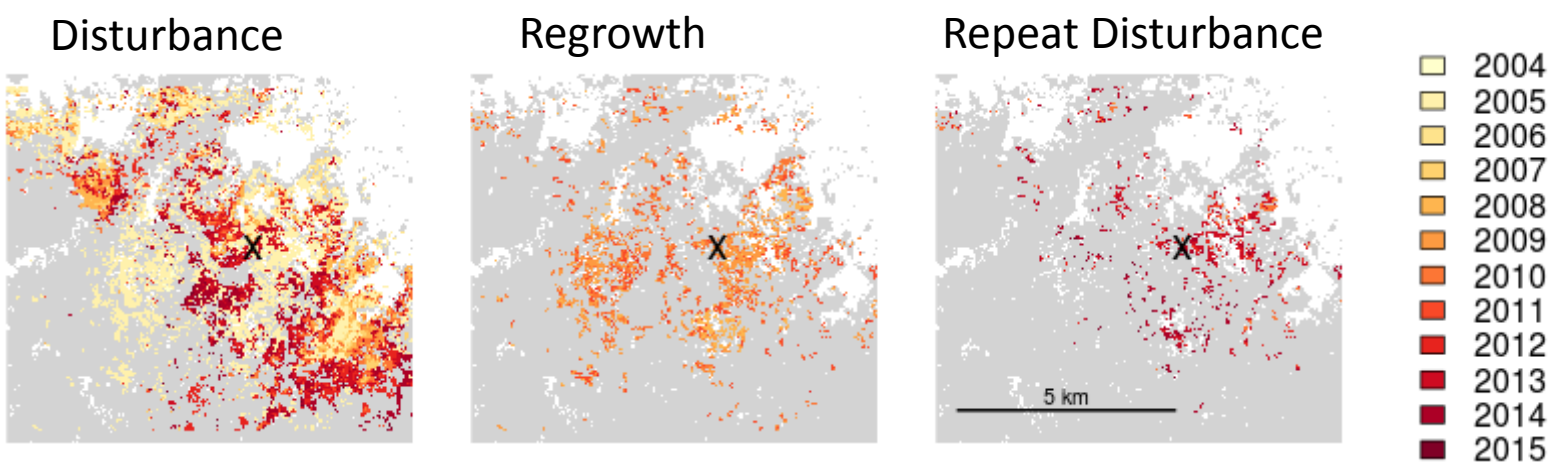

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
observations
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

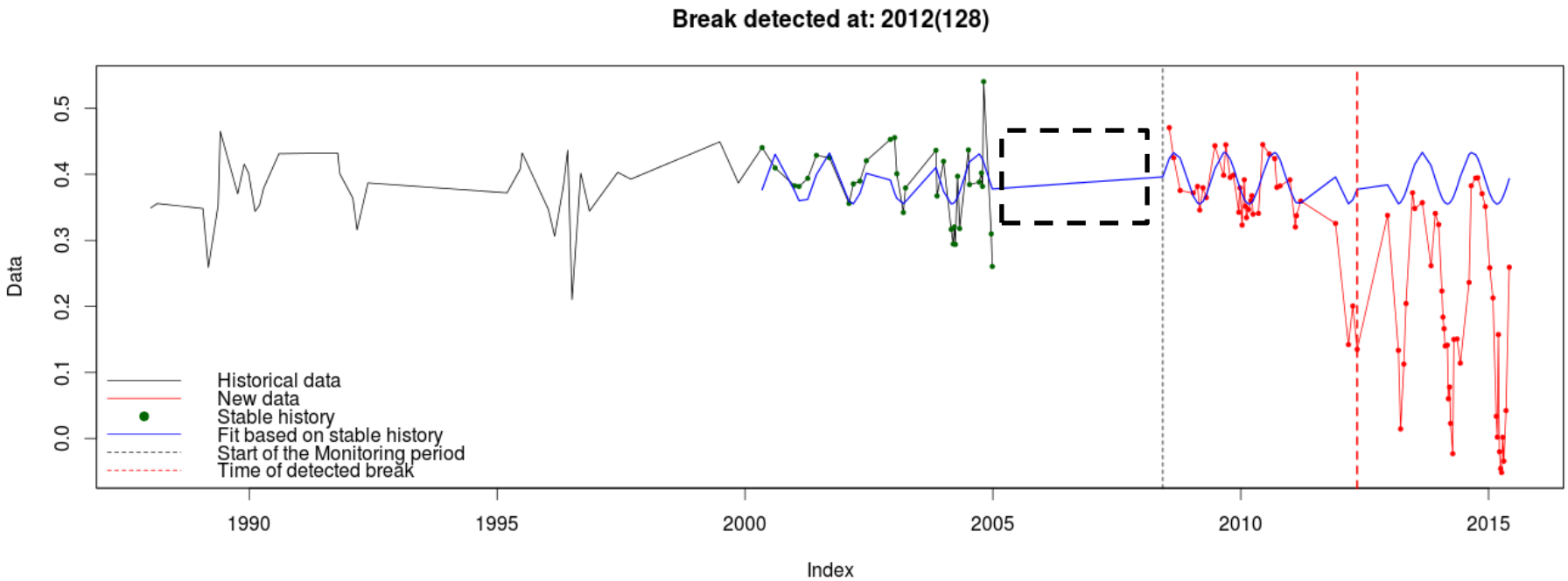
Disturbance

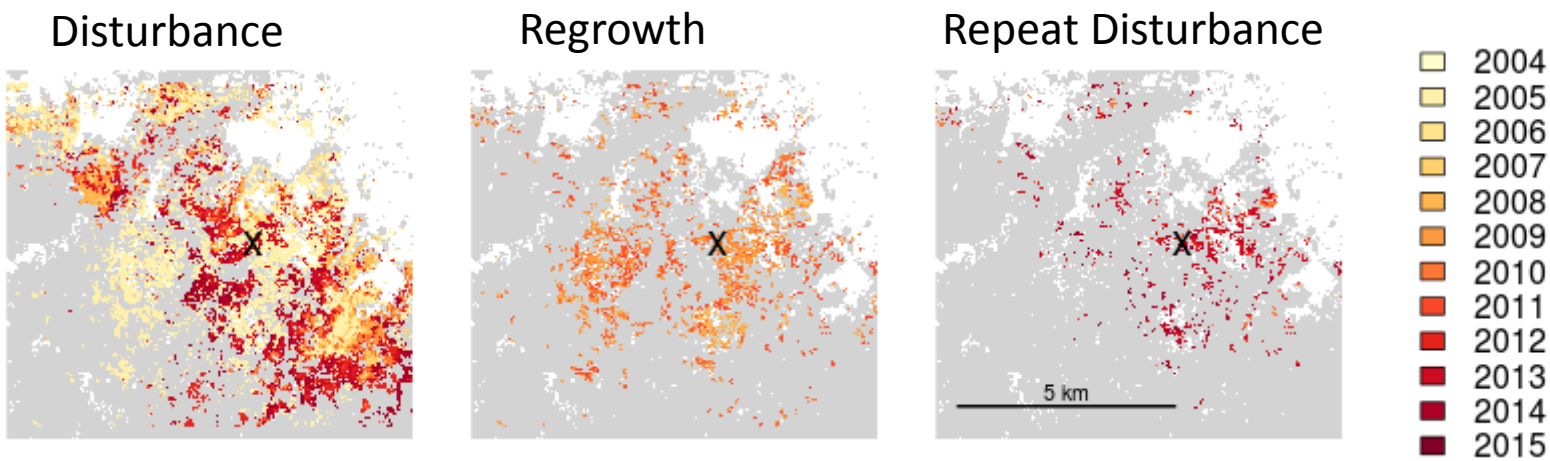
Regrowth




data
0.0
0.2
0.4
|MOSUM|
0
5
10
15
1990
1995
2000
2005
2010
2015


Disturbance
Regrowth
Repeat Disturbance
5 km
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


Break detected at: 2012(128)
Data
0.0
0.1
0.2
0.3
0.4
0.5
1990
1995
2000
2005
2010
2015
Index
Historical data
New data
Stable history
Fit based on stable history
Start of the Monitoring period
Time of detected break

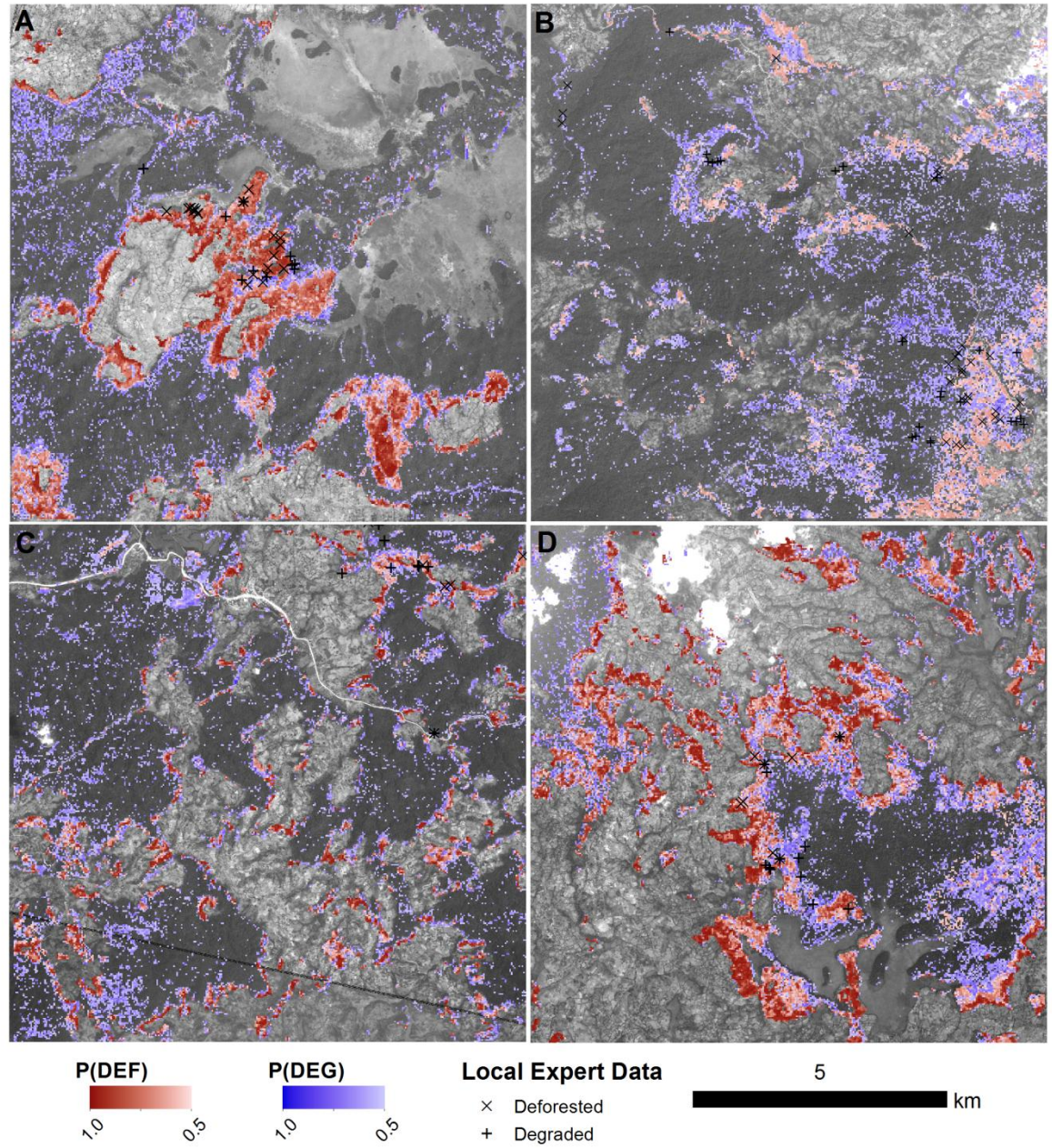

Disturbance
Regrowth
Repeat Disturbance
5 km
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Area Change

Disturbance
Regrowth
Repeat Disturbance
Net Change
Area (%)
0
2
4
6
8
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
year

> 1500 field reports

bfast + randomForest



DeVries et al. 2015. PLoS ONE Forests, in review.

Radar Processing

- OpenSARKit
- Command line tools for quasi-fully automatic preprocessing of nationwide SAR mosaics
- Up to date: ALOS Palsar FBD data
- 30m output resolution
- Output Stack: Backscatter values, Ratio, Texture measures, DEM + aspect + slope

Radar Processing

- ALOS Palsar FBD data
- From Alaska Space Facility (vast archive for South America, Africa, SE Asia)
- Can be used from NGOs etc.
- End User License Agreement, on every image should be stated:
- Includes Material (c) JAXA, METI [year]

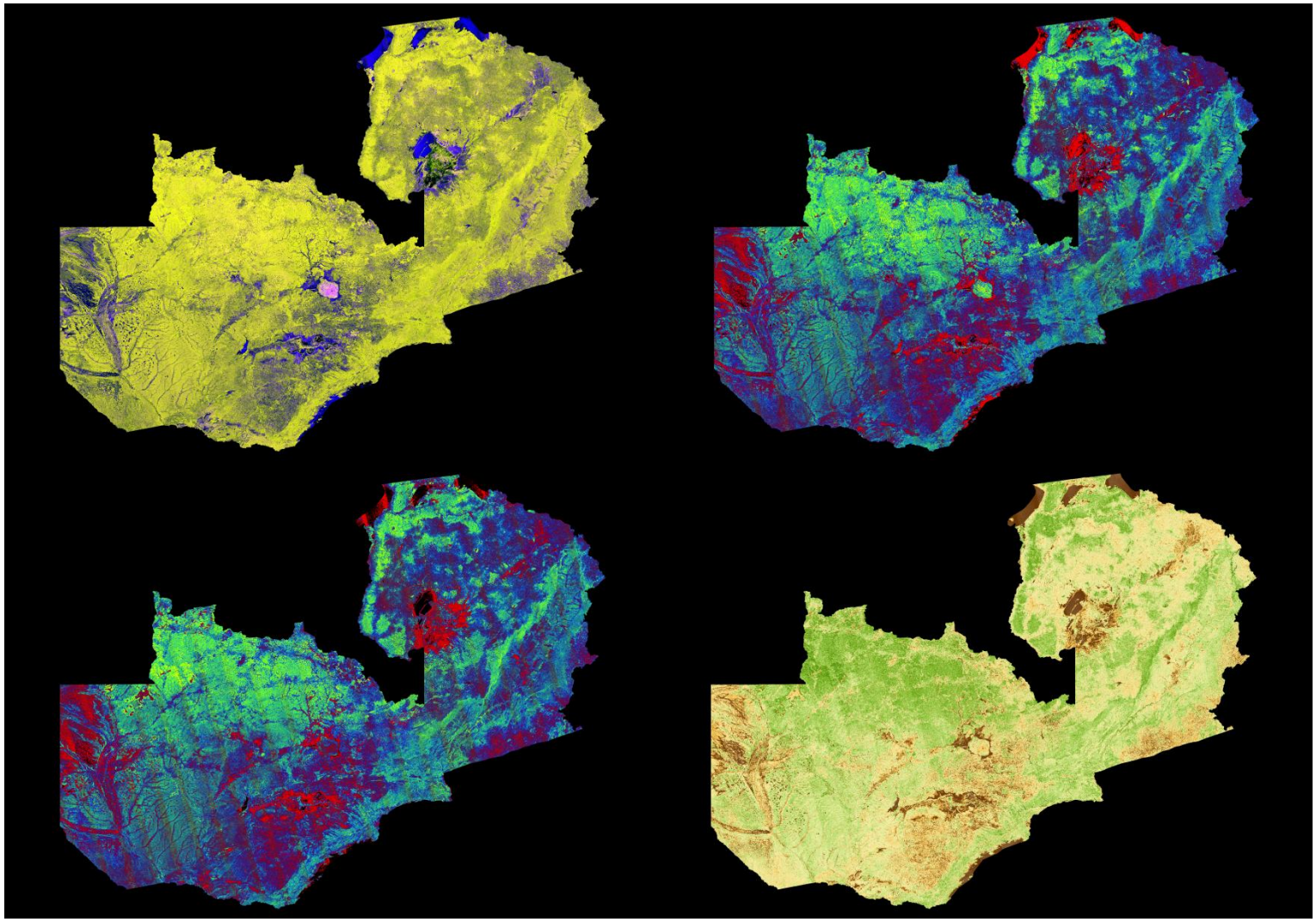
Radar Processing

- SAR data
  - Main advantages:
    - No clouds
    - Day and nighttime (i.e. active sensor)
    - Sensitive to biomass (especially L-Band like ALOS Palsar)
- Example Zambia
  - ~ 400 scenes (750000km2)
  - Processing duration: ~ 5 days
  - Output data size of final stack: 77GB

Layers of the Output Stack

R: Gamma HH G: Gamma HV B: HH/HV

R: HH Homogeneity G: HH Variance B: HH Dissimilarity



Texture HH analysis:
-Possible also with ALOS PALSAR single Pol data
- Possible also with JERS (operating from 1992 - 1998)

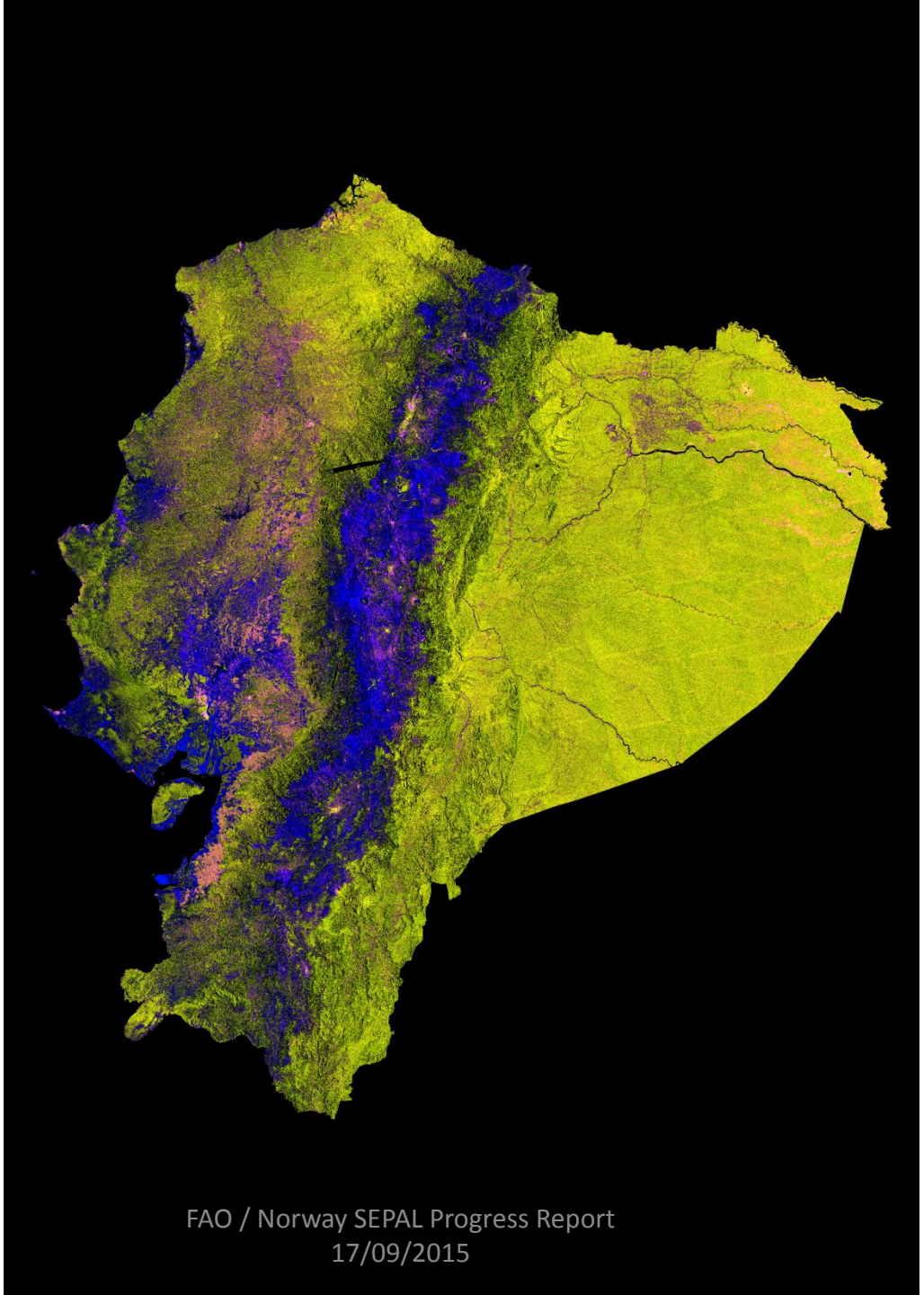
L-Band HV is most sensitive to woody biomass

R: HV Homogeneity G: HV Variance B: HV Dissimilarity

Pseudocolour HV backscatter

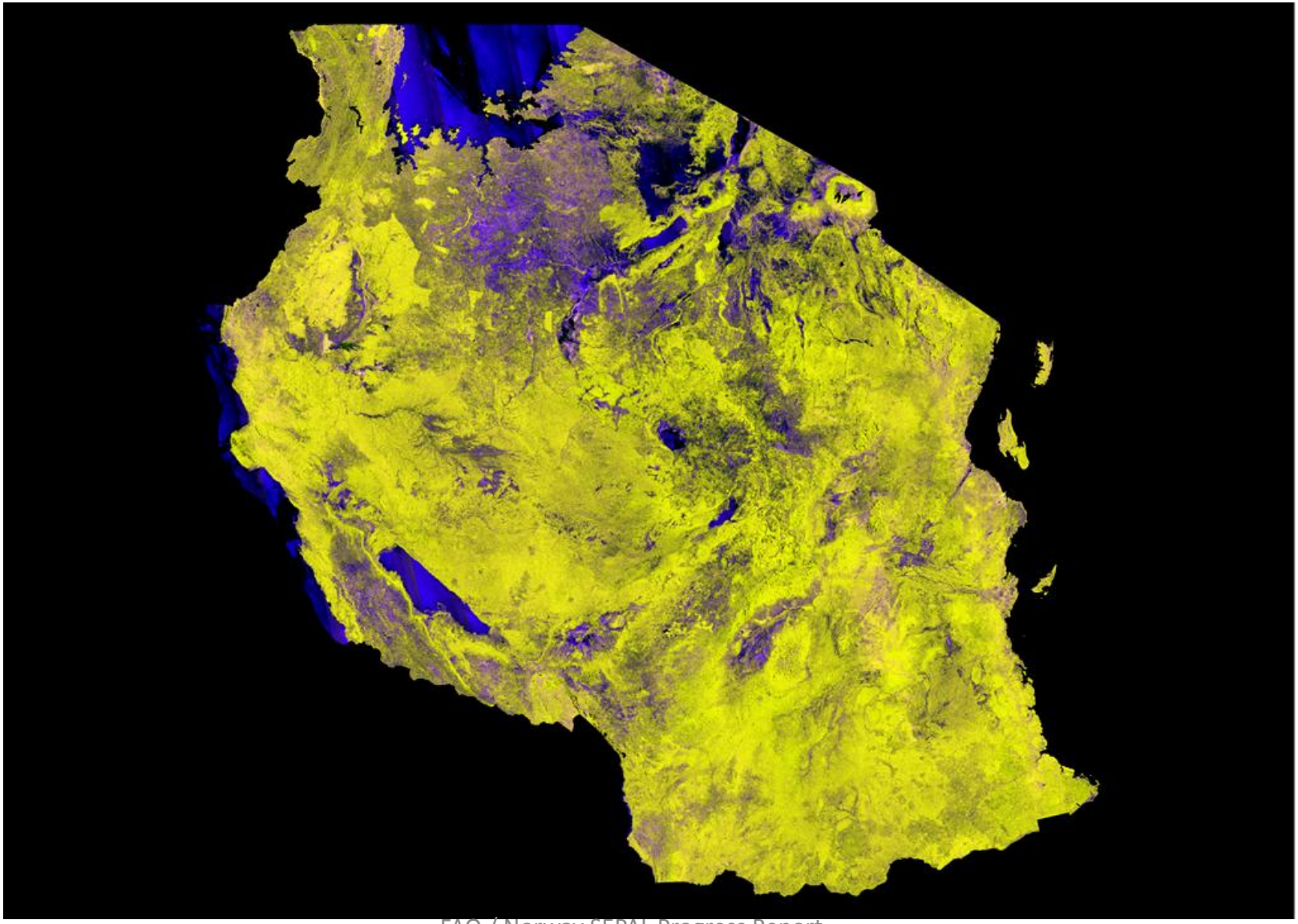
Includes Material (c) JAXA, METI 2010

Ecuador 2007



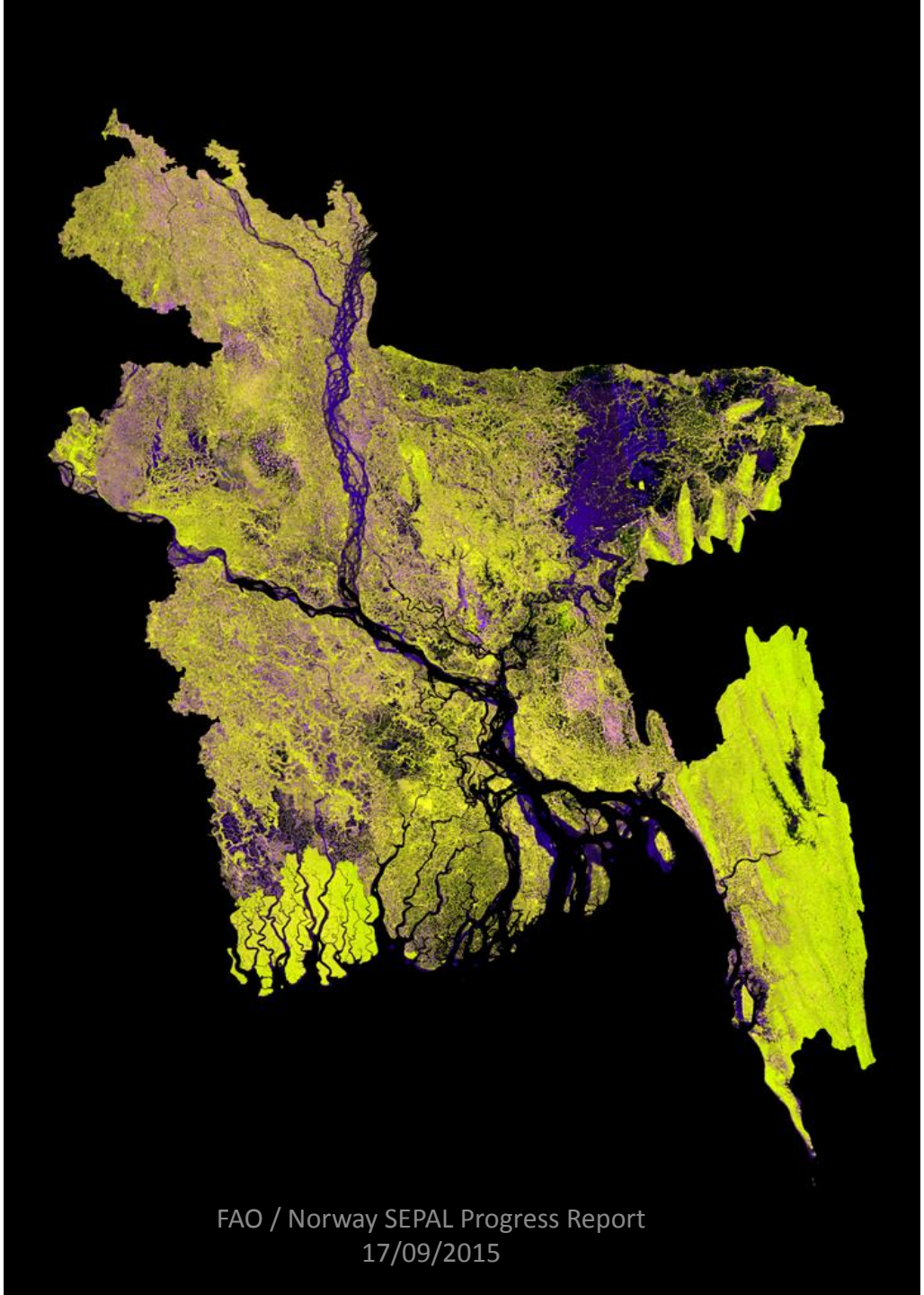
Includes Material (c) JAXA, METI 2010

Tanzania 2007



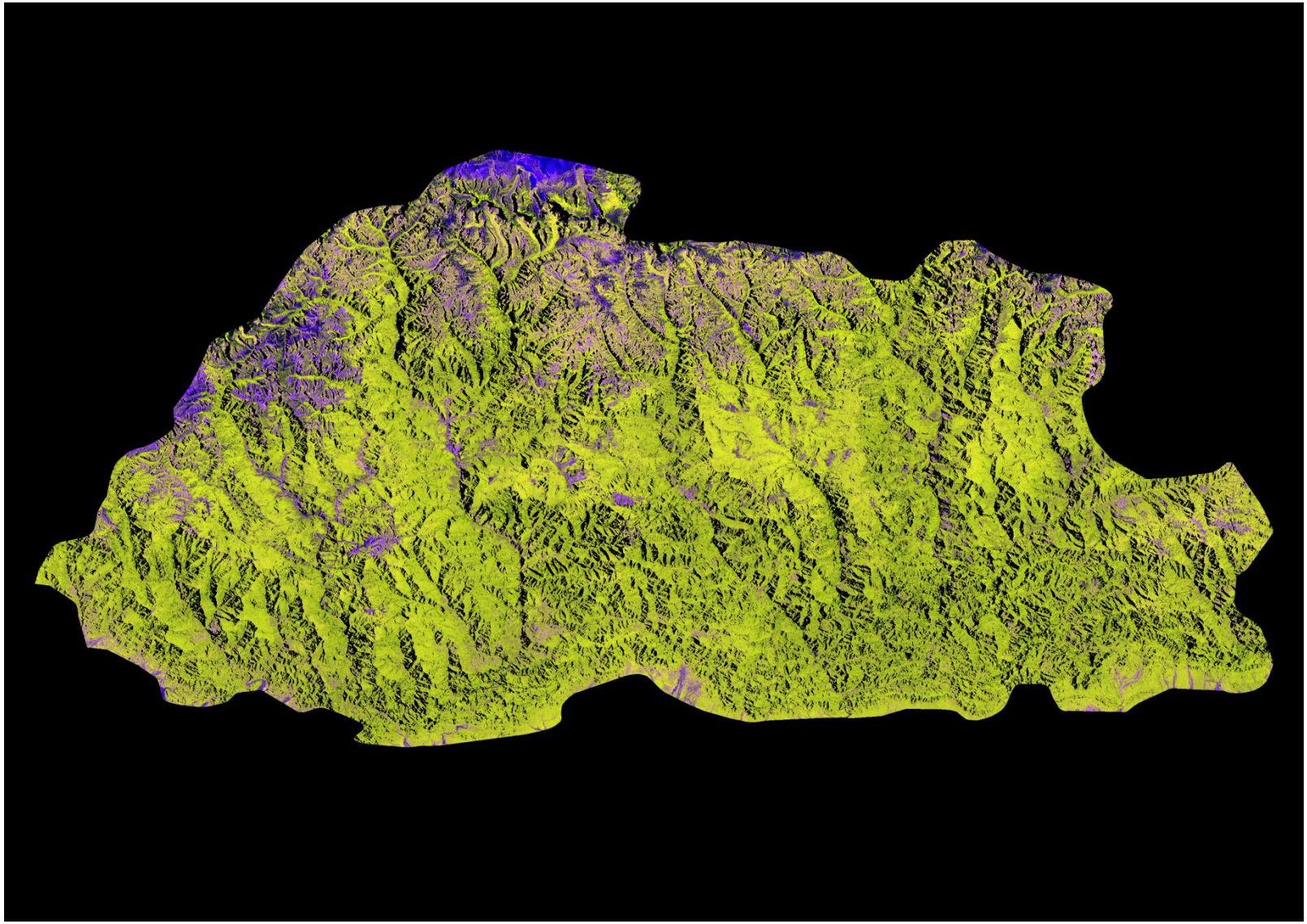
Includes Material (c) JAXA, METI 2010

Bangladesh 2007



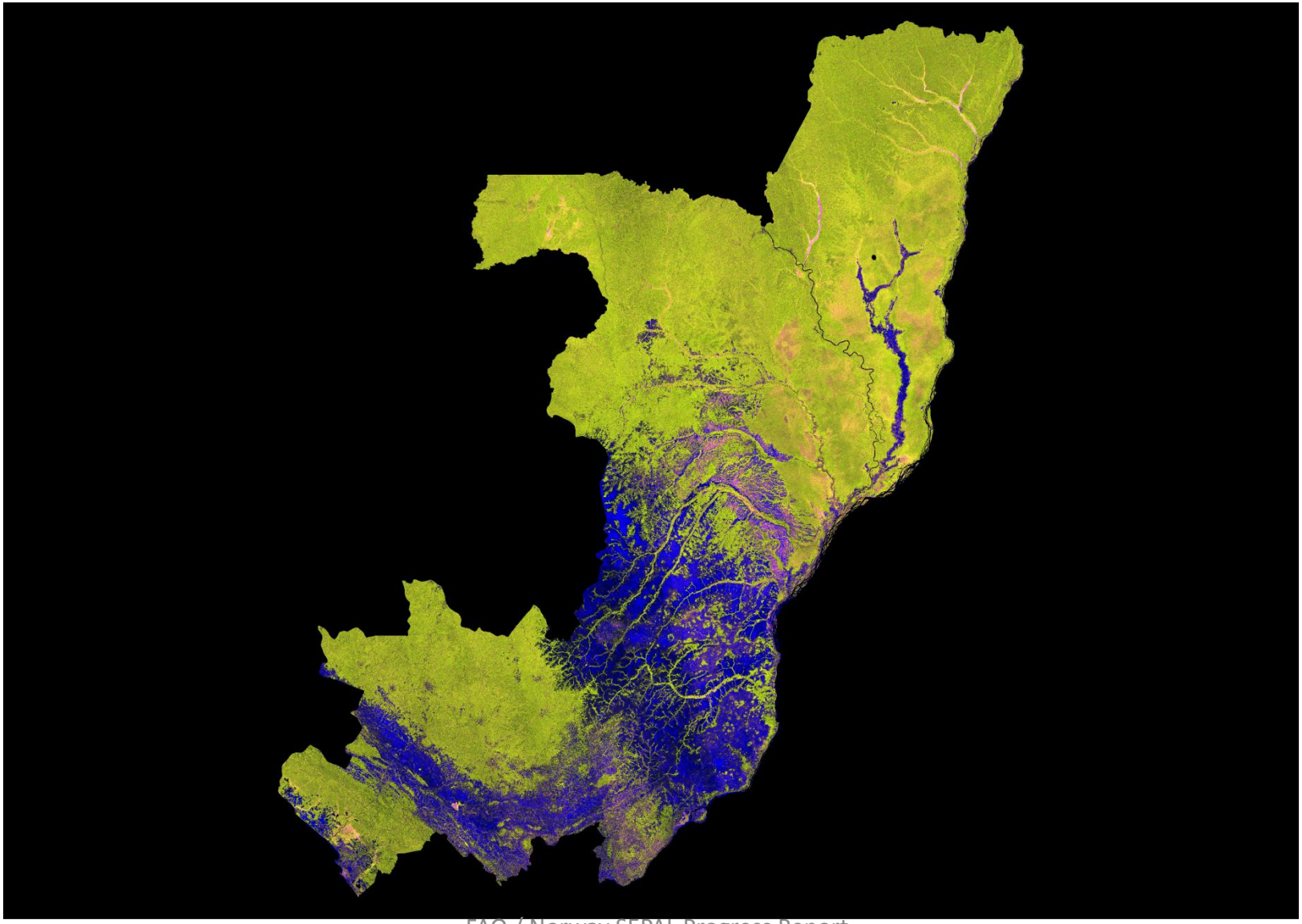
Includes Material (c) JAXA, METI 2010

Bhutan 2007



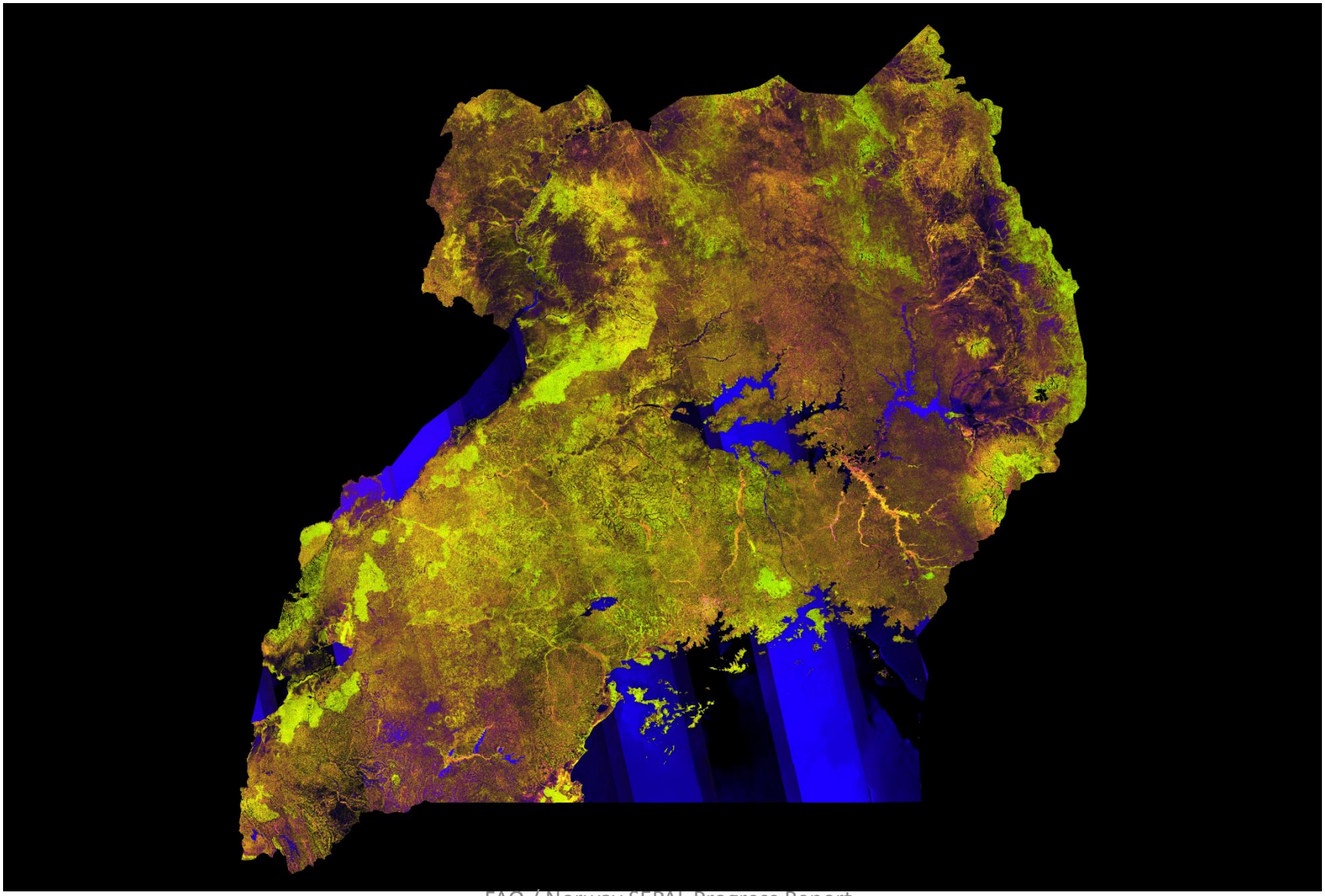
Includes Material (c) JAXA, METI 2010

Congo 2007



Includes Material (c) JAXA, METI 2010

Uganda 2007

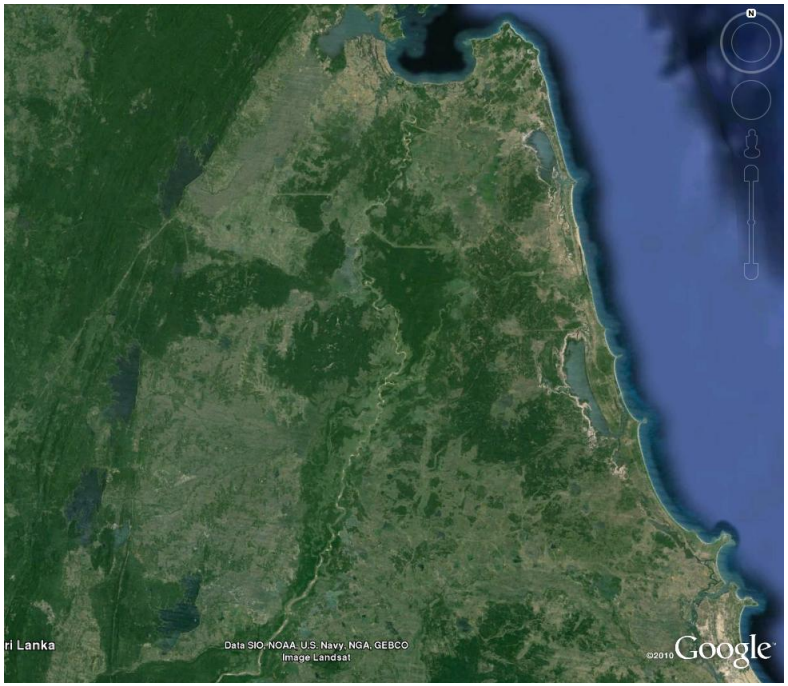


Includes Material (c) JAXA, METI 2010

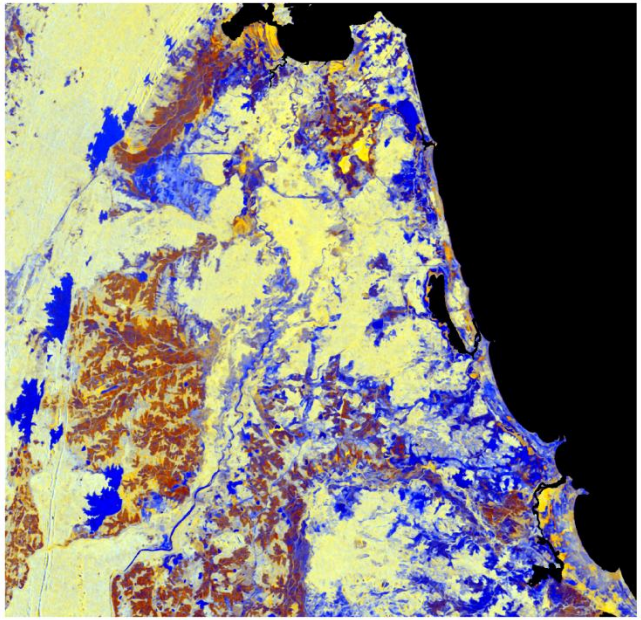
Sri Lanka

- Colors are different because in dB (logarithmic scale)

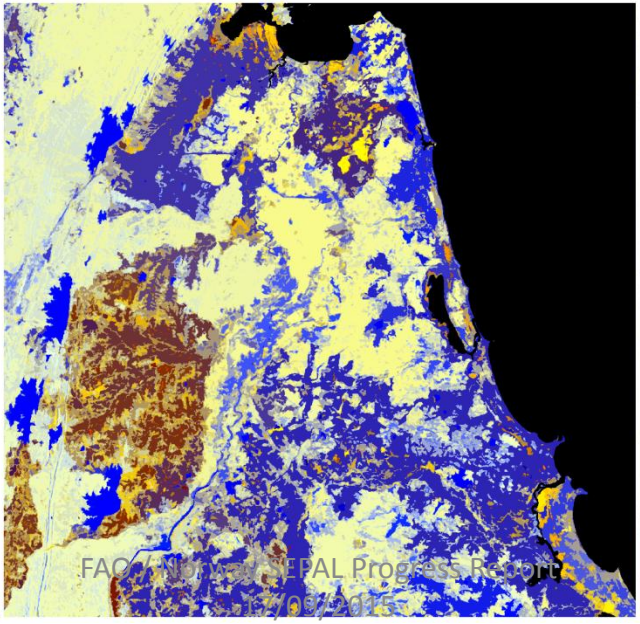
Includes Material (c) JAXA, METI 2010



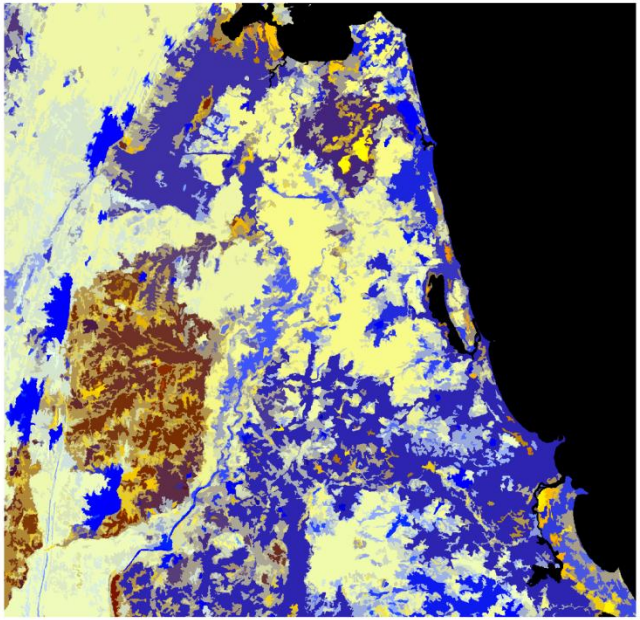
Pixel Level



Segmentation fine



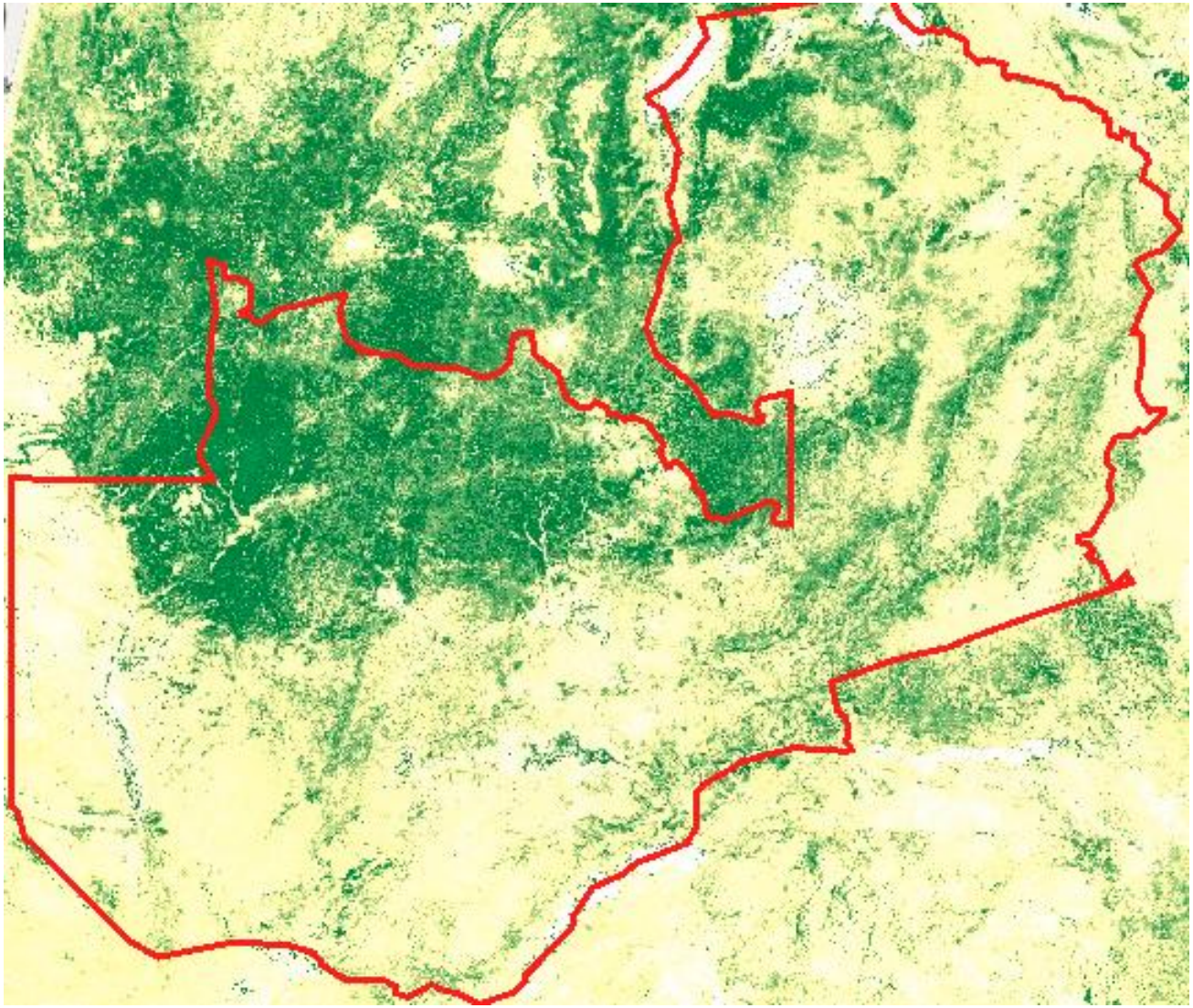
Segmentation rougher



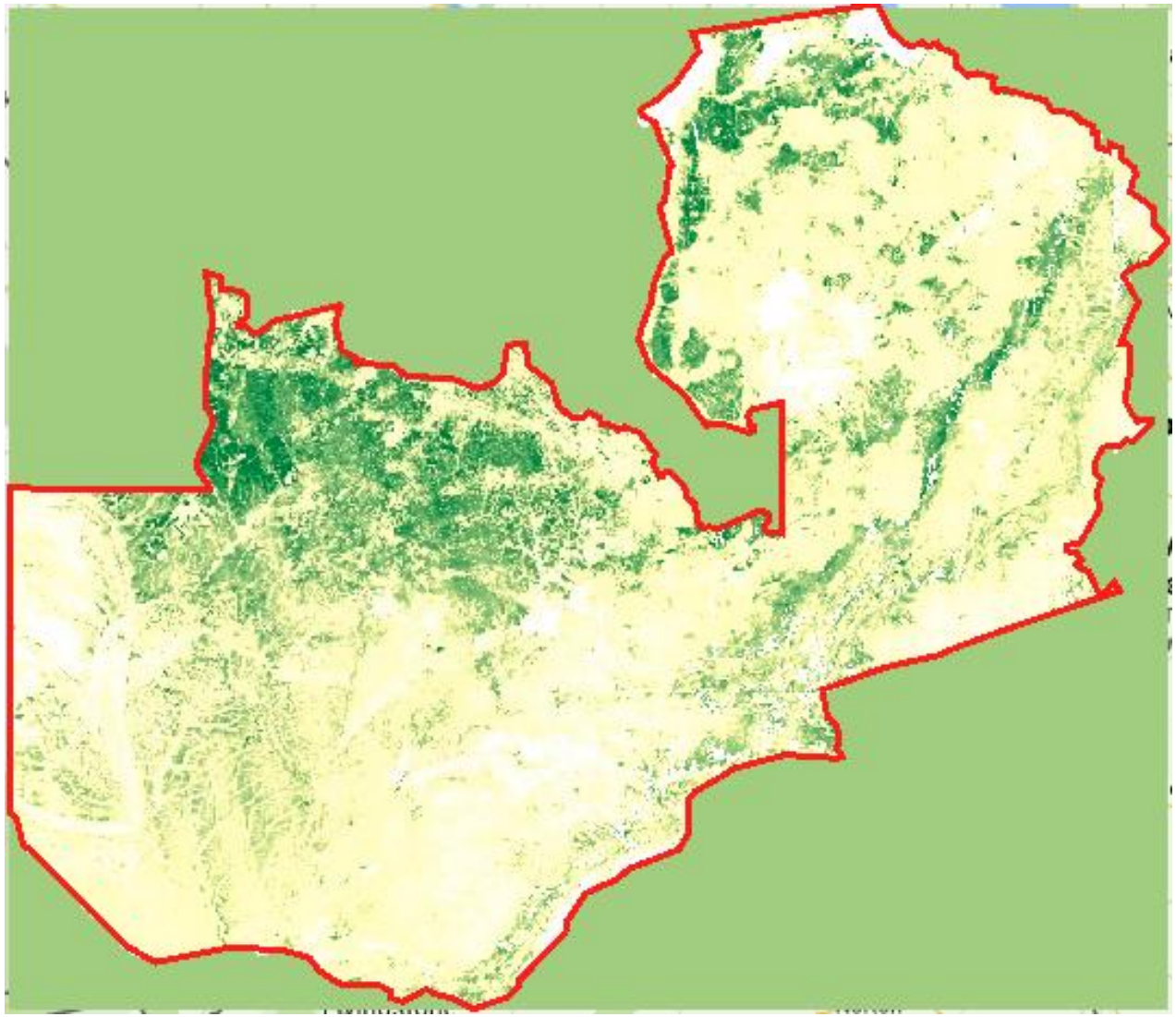
SEPAL Data Integration

- Combining datasets for:
- Forest / non-forest
- Change detection
- Biomass

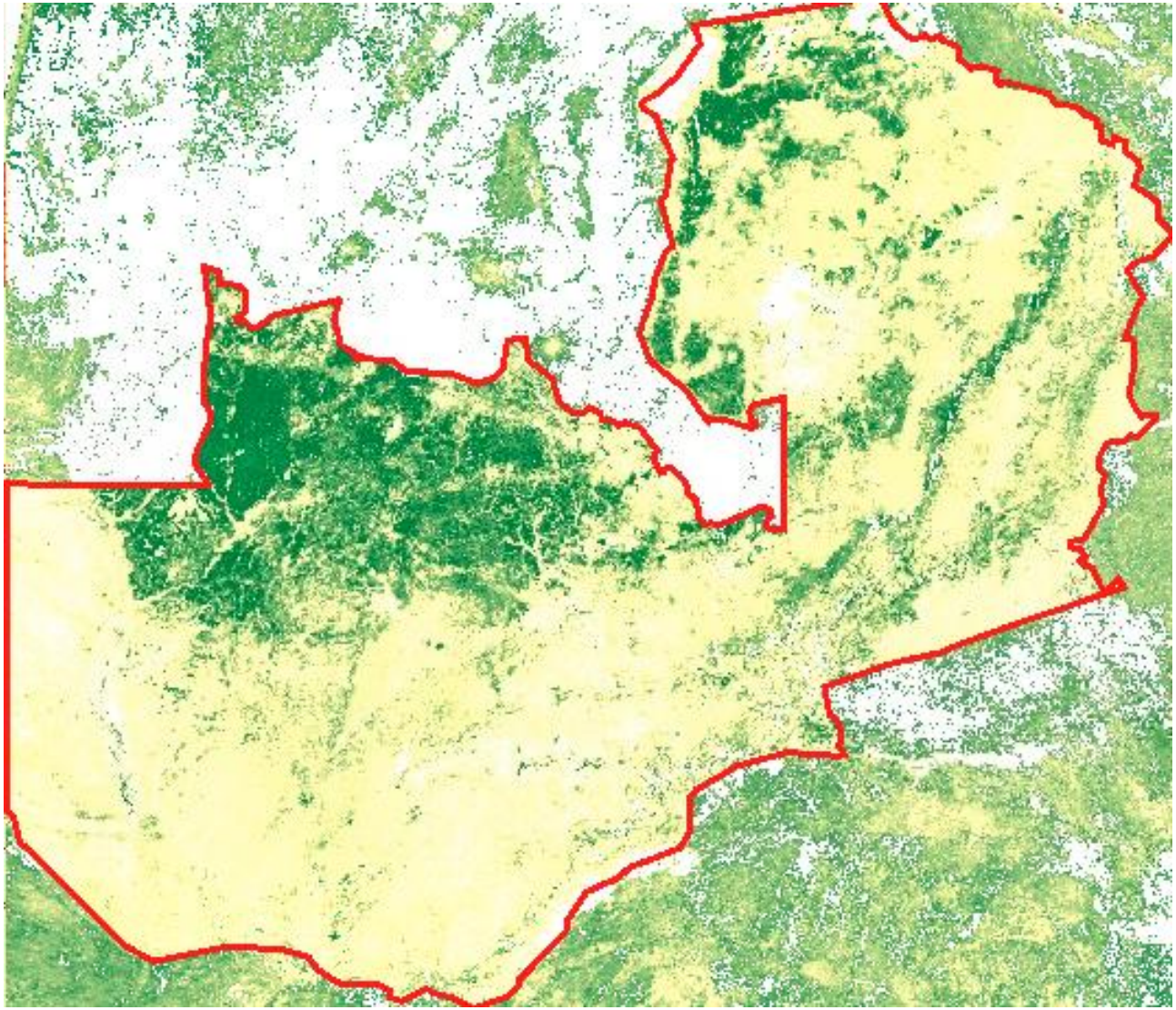
Biomass - Optical (Landsat) Only



Biomass - RADAR (ALOS) Only



Biomass - Optical + RADAR



Immediate Next Steps

Advisory Group / Practitioners Summit

High spatial resolution data processing

Improved interface

Not just data distribution…but methodology dissemination and processing capacity

Integration with SDMS?

SEPAL Conclusion

- Improve connection between data / users / information products for REDD+
- Increase production speed of products required for MRV
- Open, flexible system for rapid and standardized image processing
- Building national capacity for autonomous creation of national statistics
- Cloud-based and desktop functionality

Thanks for your attention!

Contacts:

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erik.lindquist@fao.org

UN-REDD
PROGRAMME