

Time-Series and Applications of Advanced Sentinel-1 Analysis Ready Data for Africa (SAR-4-Africa)

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NORCE - Norwegian Research Centre AS



Overall Goal: Support Earth Observation for the 2030 Agenda of Sustainable Development with Synthetic Aperture Radar (SAR)

EU Copernicus Program – Sentinel-1

- SAR Game Changer in 2014
- From research to fully operational set-up
- Worldwide consistent dense time series of cloud and sunlight independent radar imagery.
- Many still unexploited monitoring applications in general and especially in persistently cloud-covered areas.



	Population distribution	Cities and infrastructure mapping	Elevation and topography	Land cover and use mapping	Oceanographic observations	Hydrological and water quality observations	Atmospheric and air quality monitoring	Biodiversity and ecosystem observations	Agricultural monitoring	Hazards, disasters and environmental impact monitoring
1 No poverty										
2 Zero hunger										
3 Good health and well-being										
4 Quality education										
5 Gender equality										
6 Clean water and sanitation										
7 Affordable and clean energy										
8 Decent work and economic growth										
9 Industry, innovation and infrastructure										
10 Reduced inequalities										
11 Sustainable cities and communities										
12 Responsible consumption and production										
13 Climate action										
14 Life below water										
15 Life on land										
16 Peace, justice and strong institutions										
17 Partnerships for the goals										

SAR Imagery Challenges

Strong reluctance by a large user community to use SAR data because of its:

- *unfamiliar appearance compared to optical data for untrained users*
- *complexity in regard to sensor-specific noise (speckle), topographic effects,*
- *(pre-) processing requirements,*
- *vast amount of data*



Solution: Provide easy-to-use Advanced SAR Analysis Ready Data

- Monthly & yearly averaged mosaics as RGB backscatter images (VV,VH,NDI)
- Yearly statistical parameters (variance, max,min, median, nr of acquisitions),
→ Visually attractive, ease visual interpretation, reduce amount of data

Focus on African Users

Demonstration Sites in 5 countries

(2°x 2° latlon, 12000x12000 pixels, 20m)

1. DRC (OSFAC)



2. Ethiopia (ESSTI)

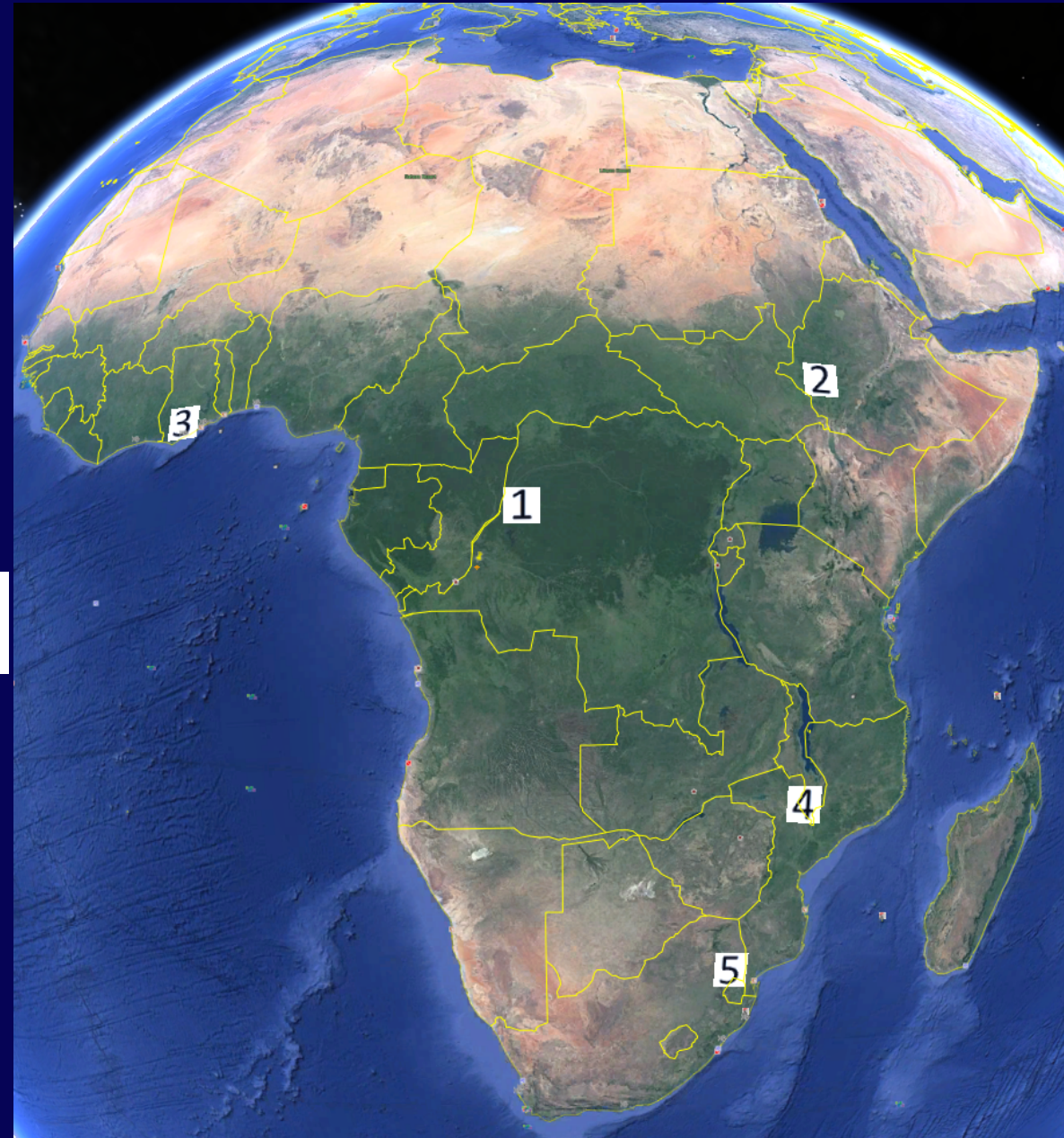


3. Ghana



4. Malawi

5. South Africa

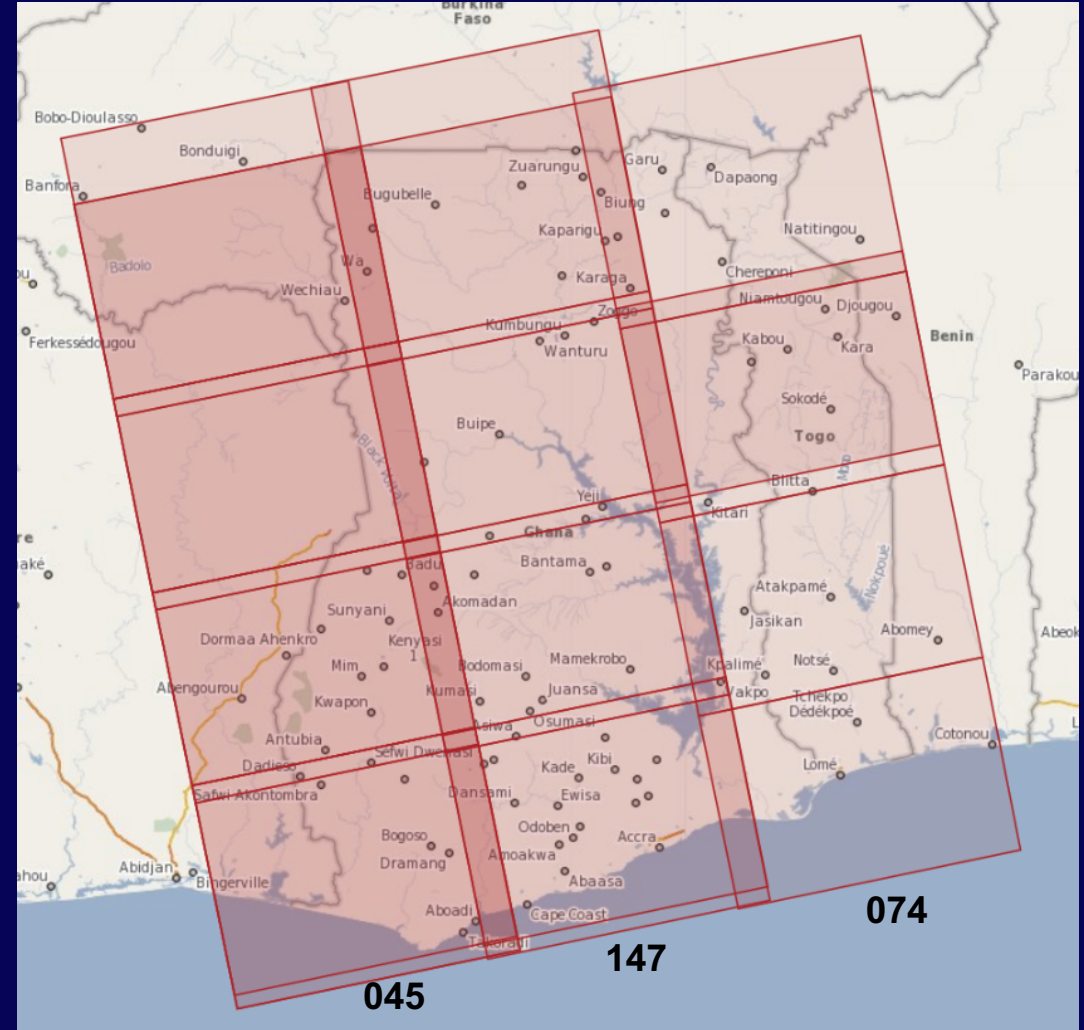


User driven approach through user assessment and feedback

Ghana

- Whole country (239,460 km²) has been processed for the African Regional Data Cube (~1TB / year)
- Dividing Ghana into **5x7 tiles** of about 1° lat x 1°lon (5200x5200 pixels).
- **Pre-processing** all S1 data into γ° : georeferencing, radiometric calibration, terrain & slope correction
- **Averaging into monthly and yearly mosaics** RGB = [VV,VH,NDI=(VV-VH)/(VV+VH)]
- **Yearly statistical analysis for each polarization VV and VH (6 bands)**: Mean, variance, nr_of_acquisitions, minimum, maximum, mask for SAR shadow and overlay.

- **13 Mosaics/year (3 bands)**
- **2 Statistic files/year (6 bands)**
- **175 GB / year (can be reduced)**



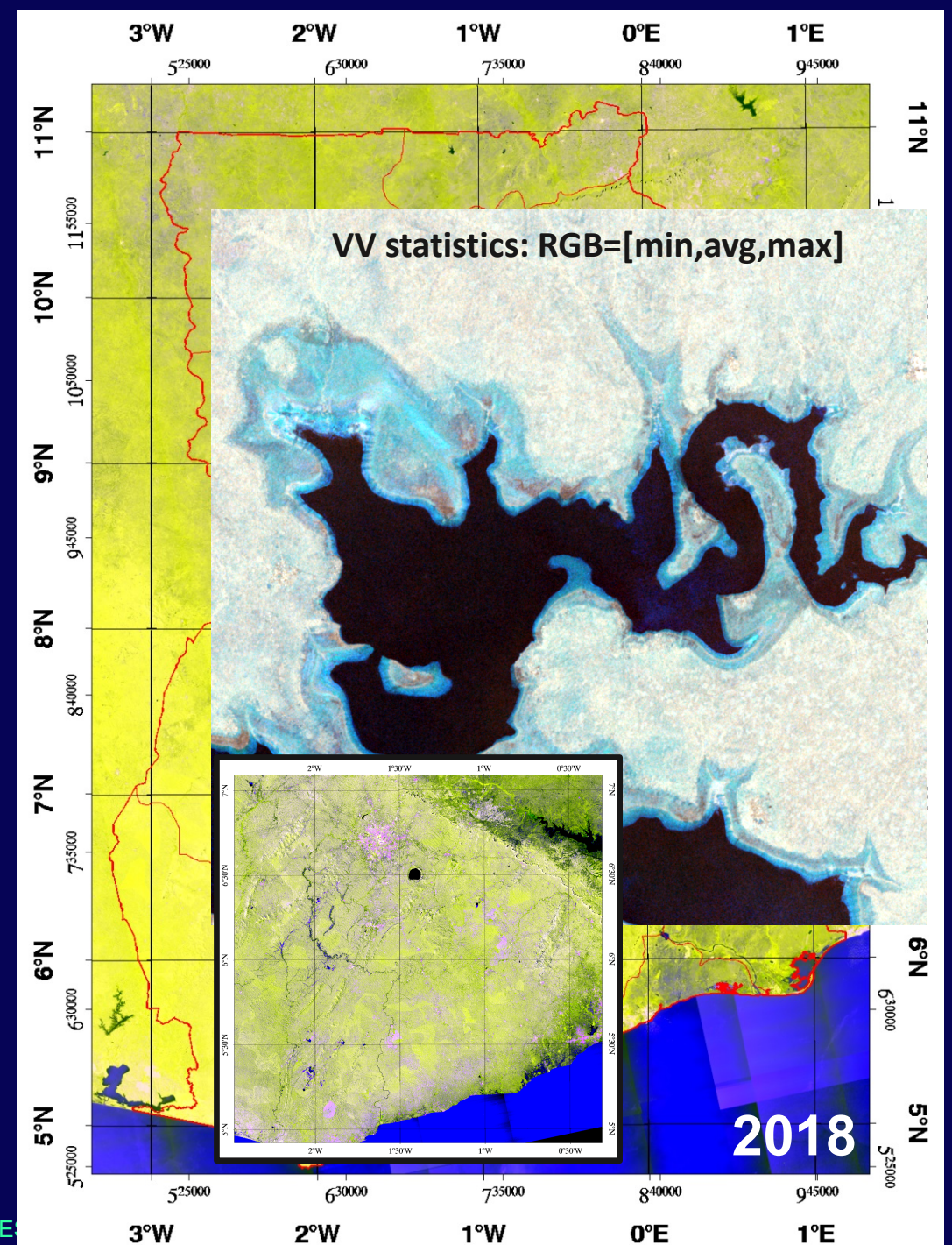
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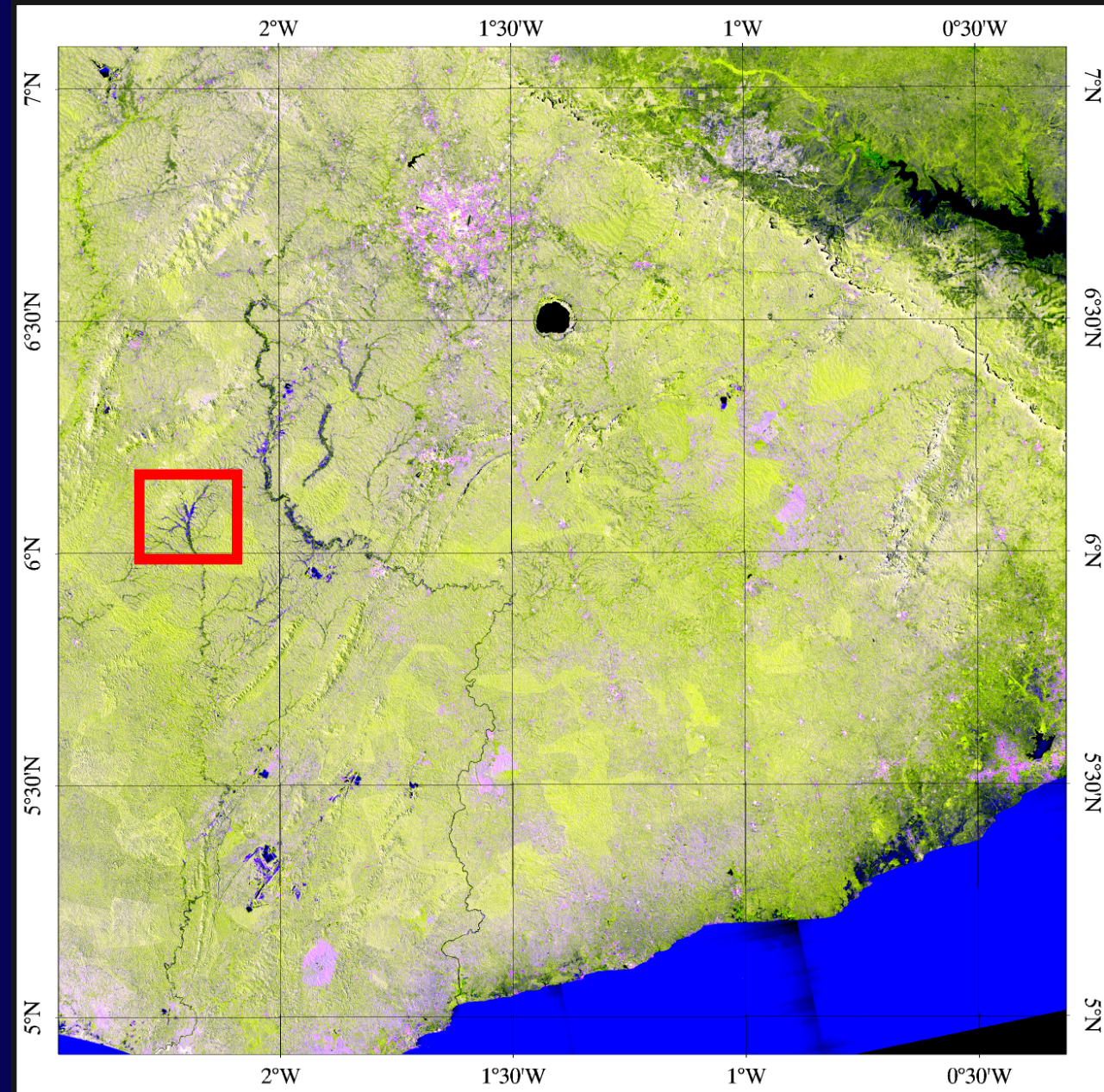
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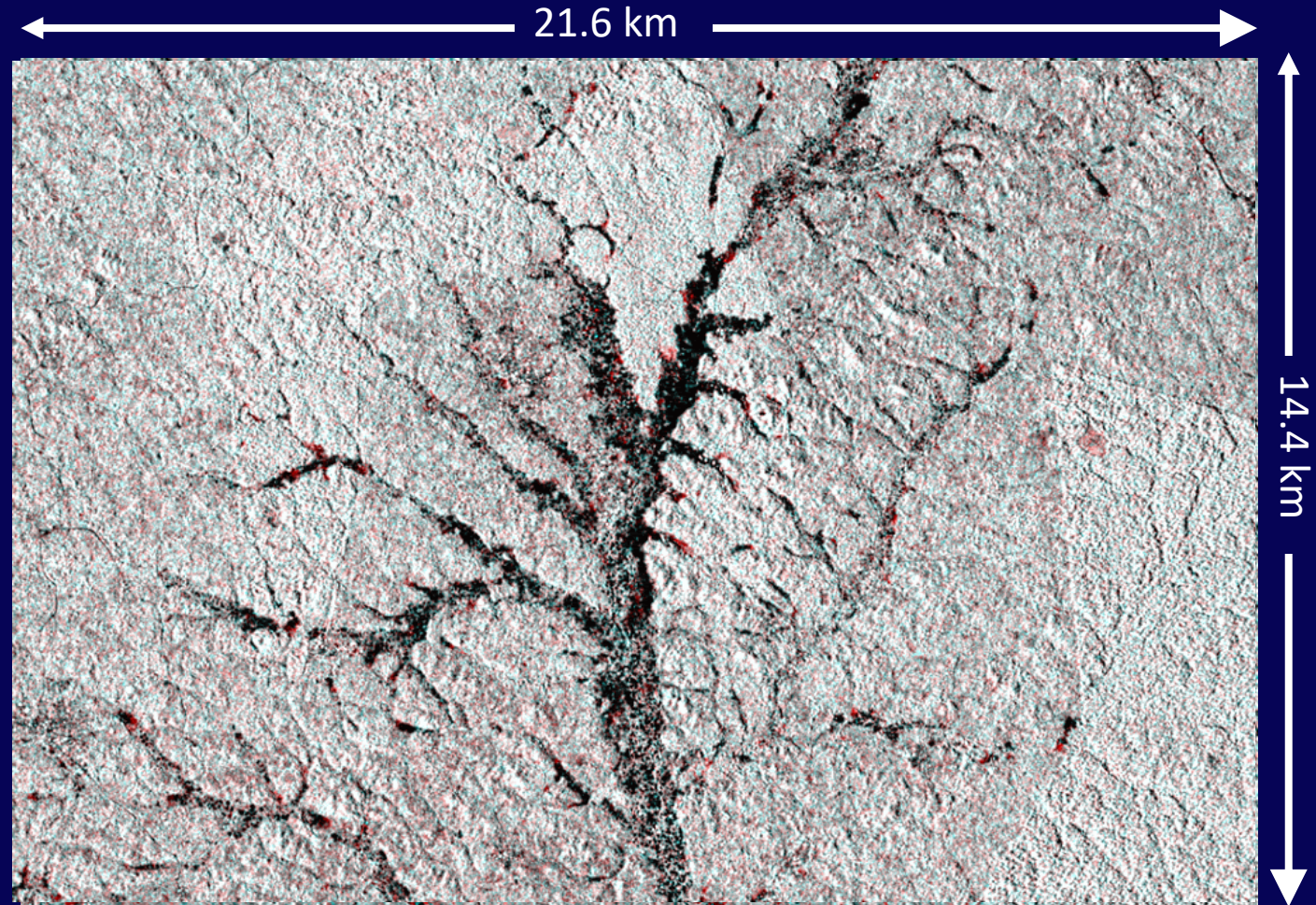
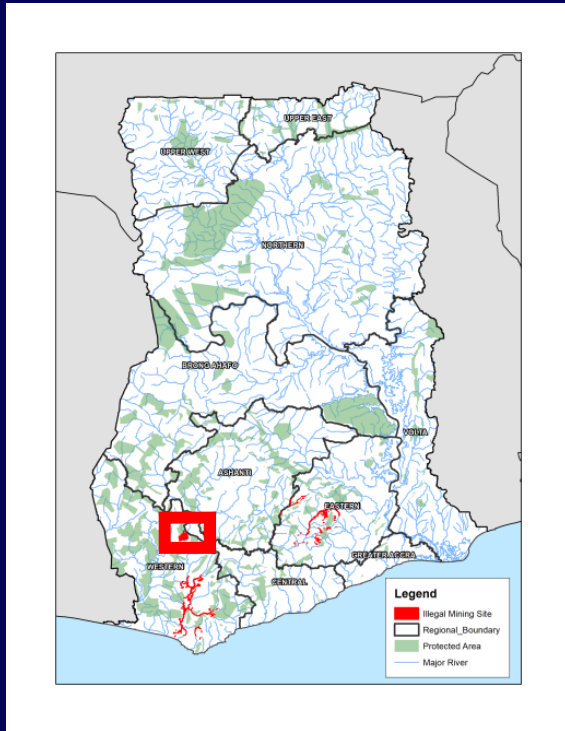
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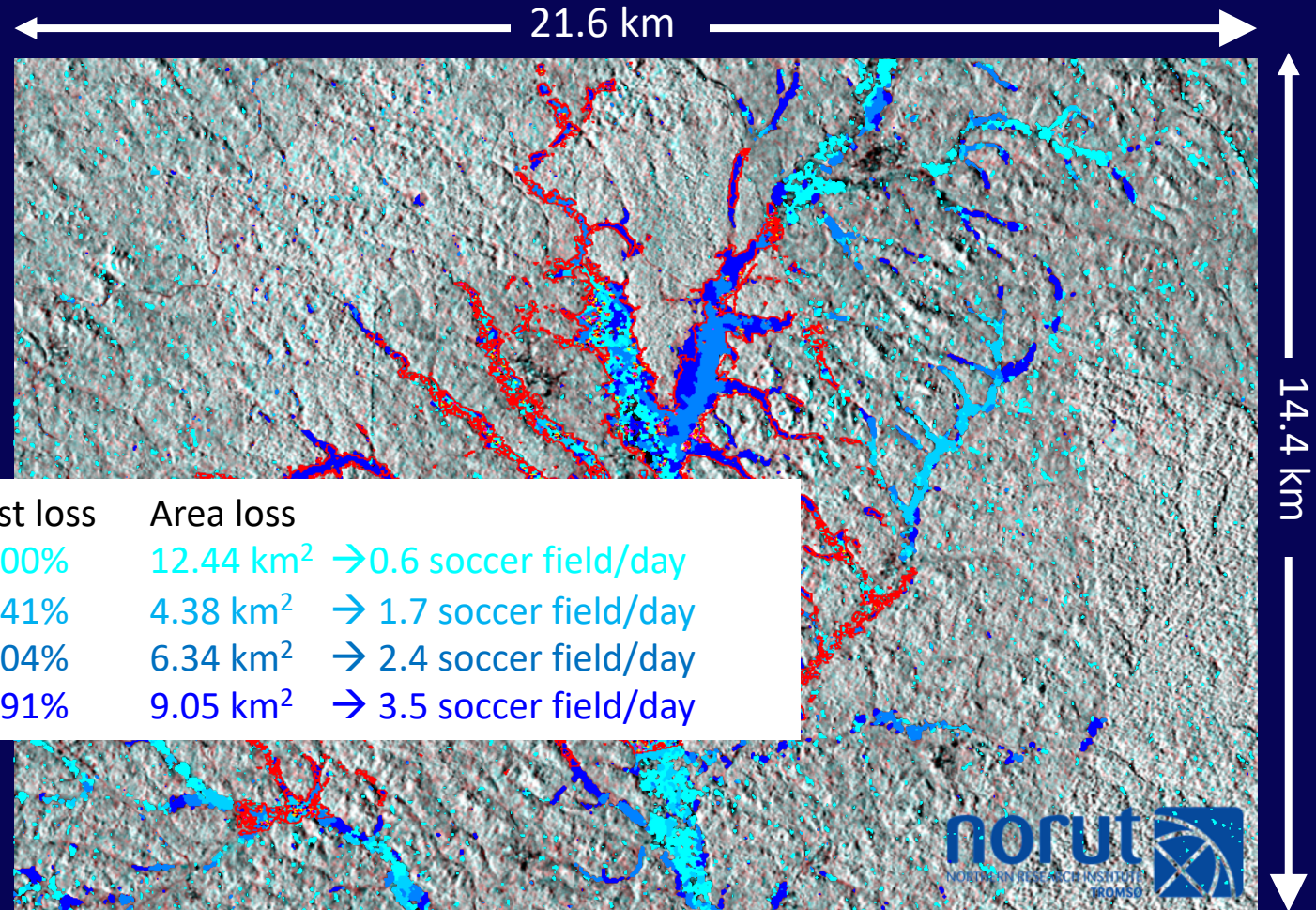
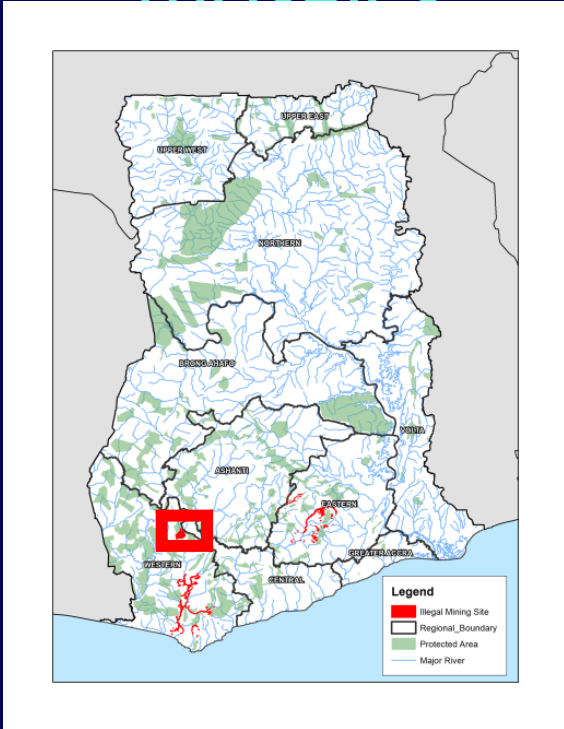
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Illegal Mining (Galamsey) detection with monthly time series of 2018



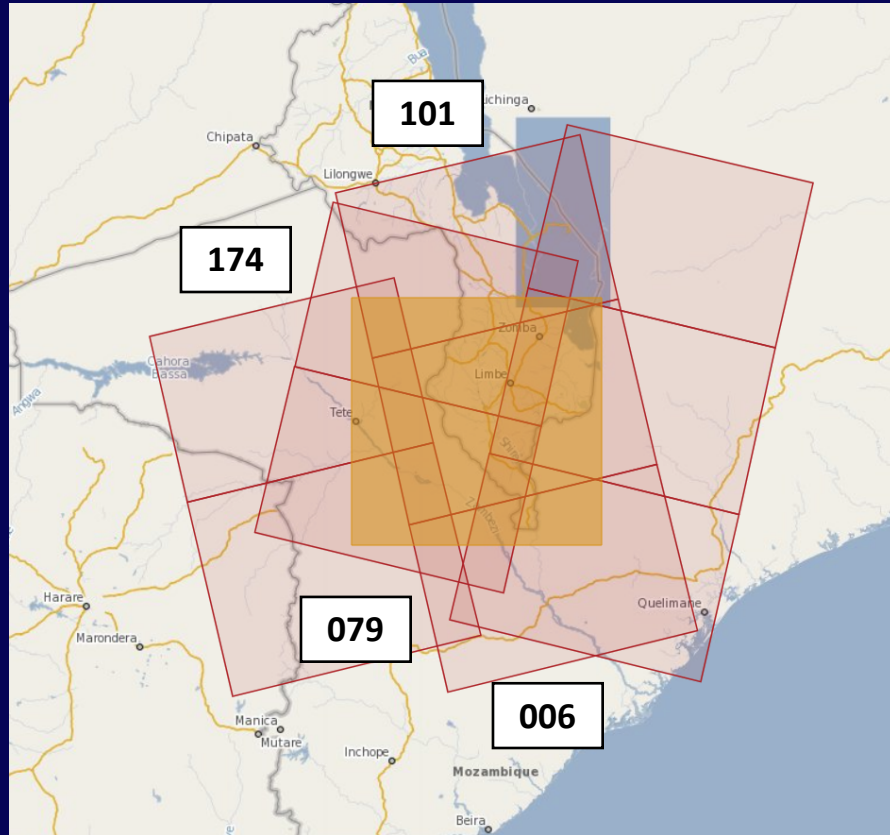
Galamsey detected with Sentinel-1 (2015-2018) comparing yearly mosaics



	Forest loss	Area loss	
2007-2015:	4.00%	12.44 km ²	→ 0.6 soccer field/day
2015-2016:	1.41%	4.38 km ²	→ 1.7 soccer field/day
2016-2017:	2.04%	6.34 km ²	→ 2.4 soccer field/day
2017-2018:	2.91%	9.05 km ²	→ 3.5 soccer field/day

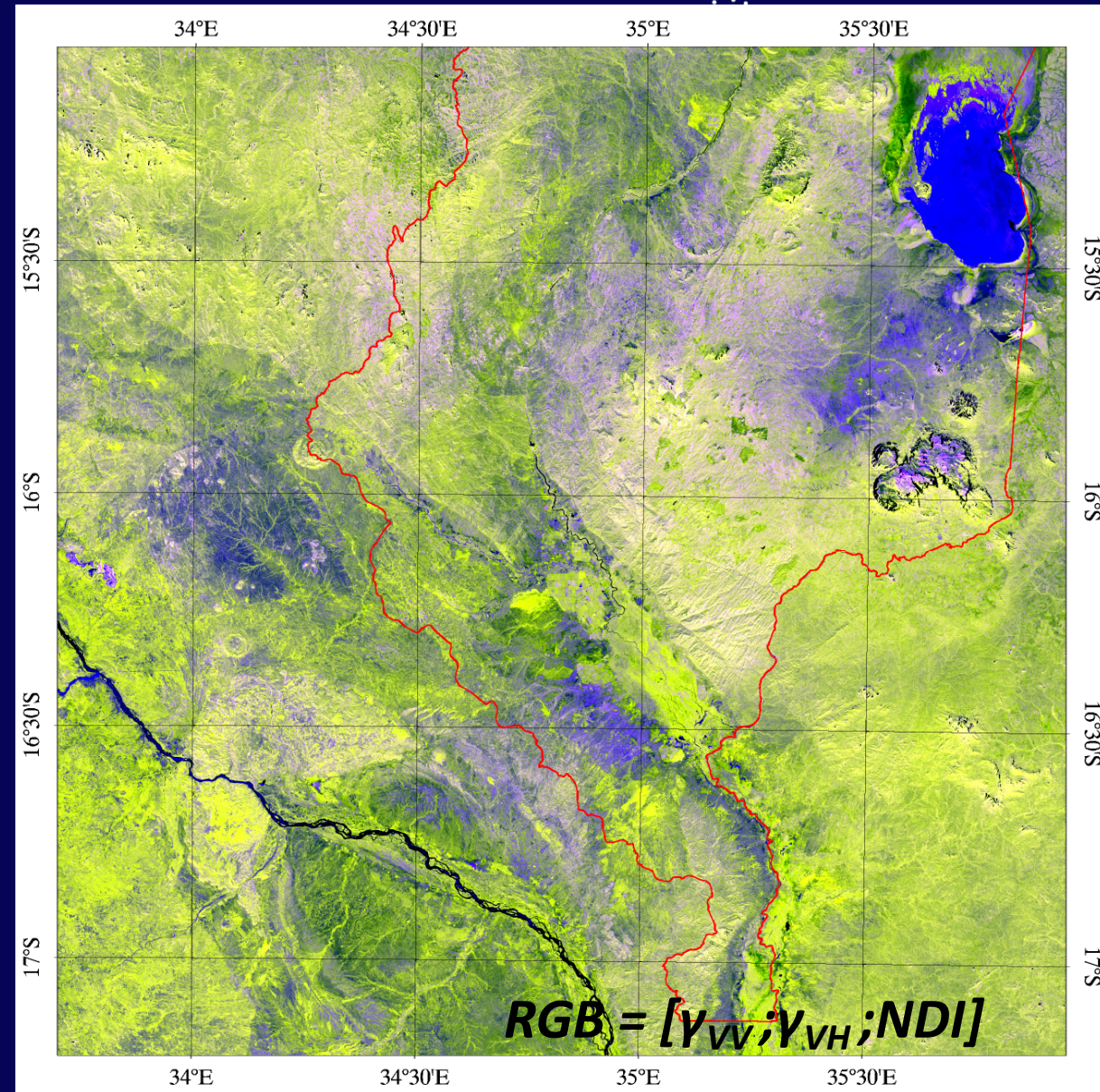
Validation polygons from VHR data

Malawi

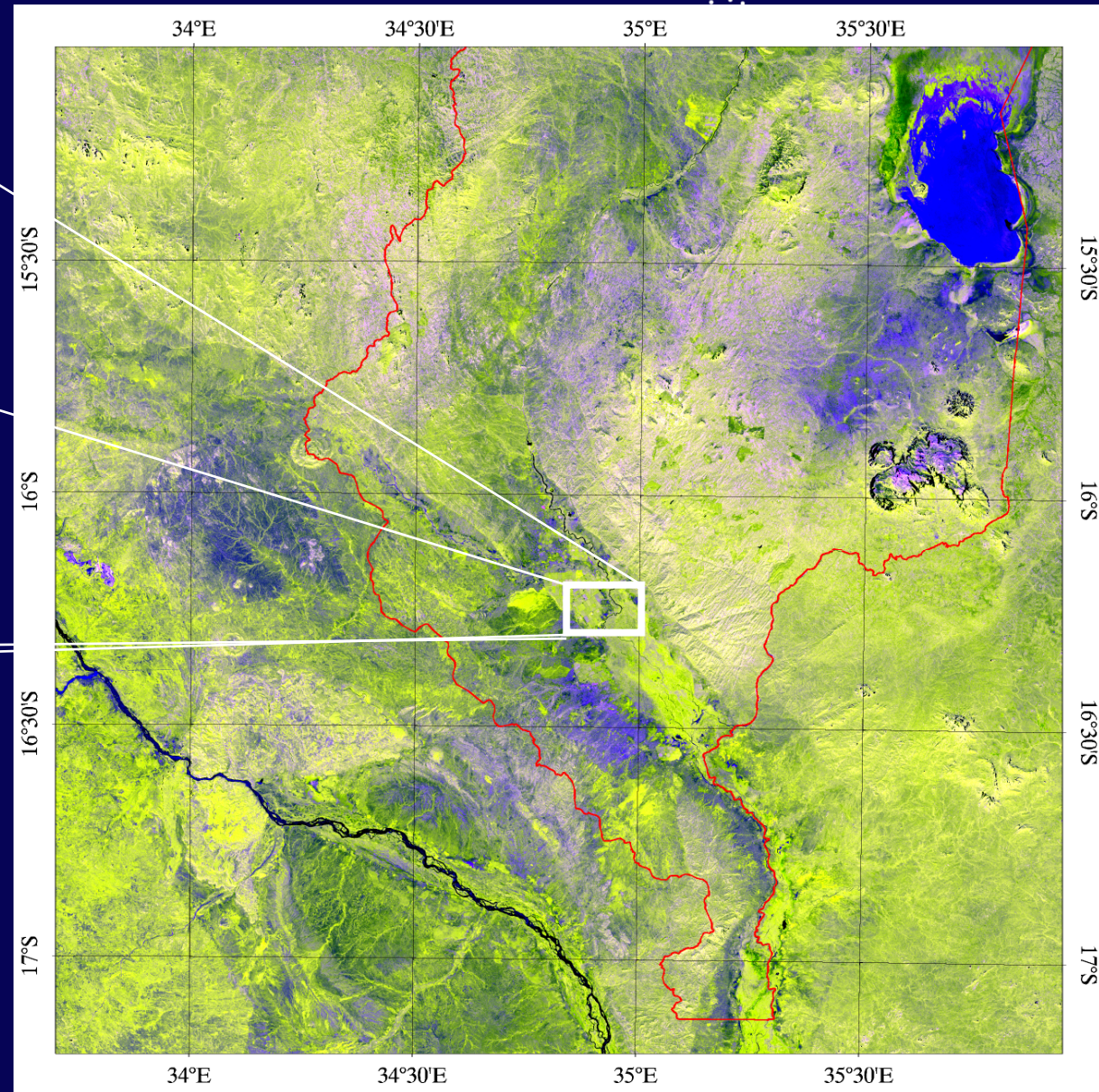
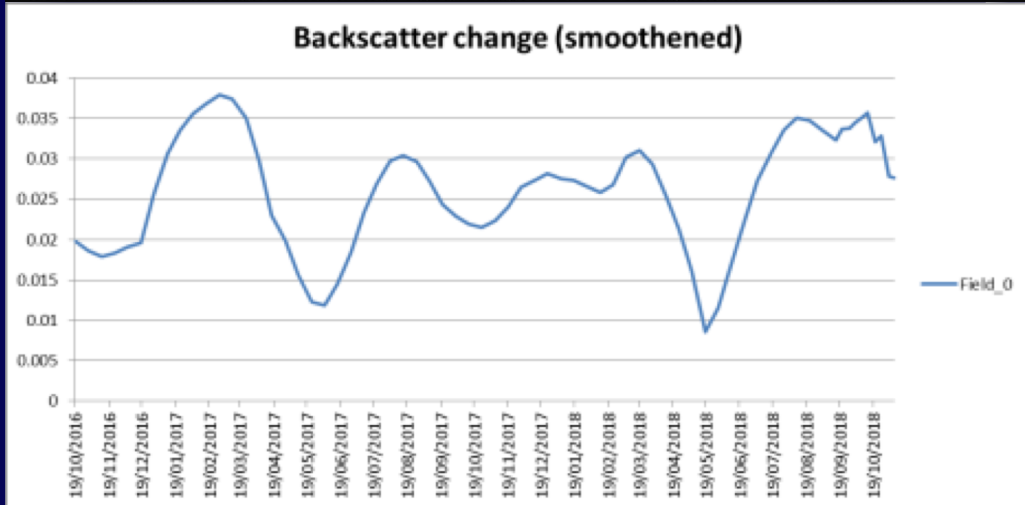


Applications

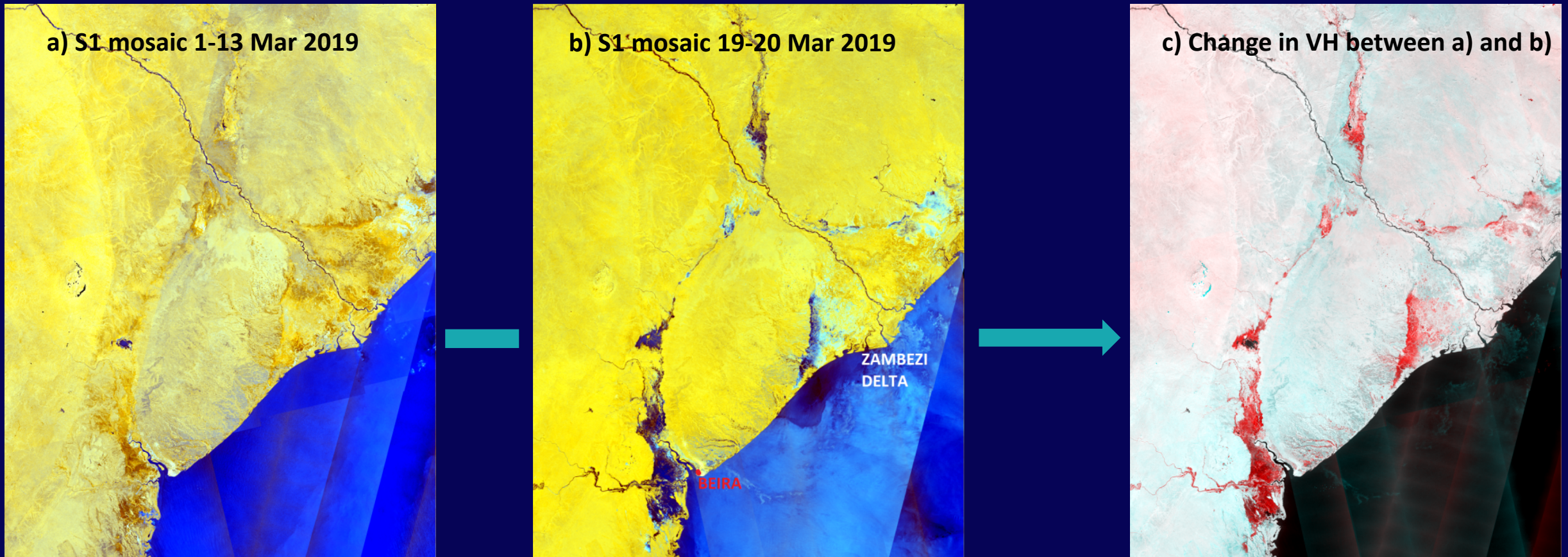
- Agriculture
- Flooding



Malawi

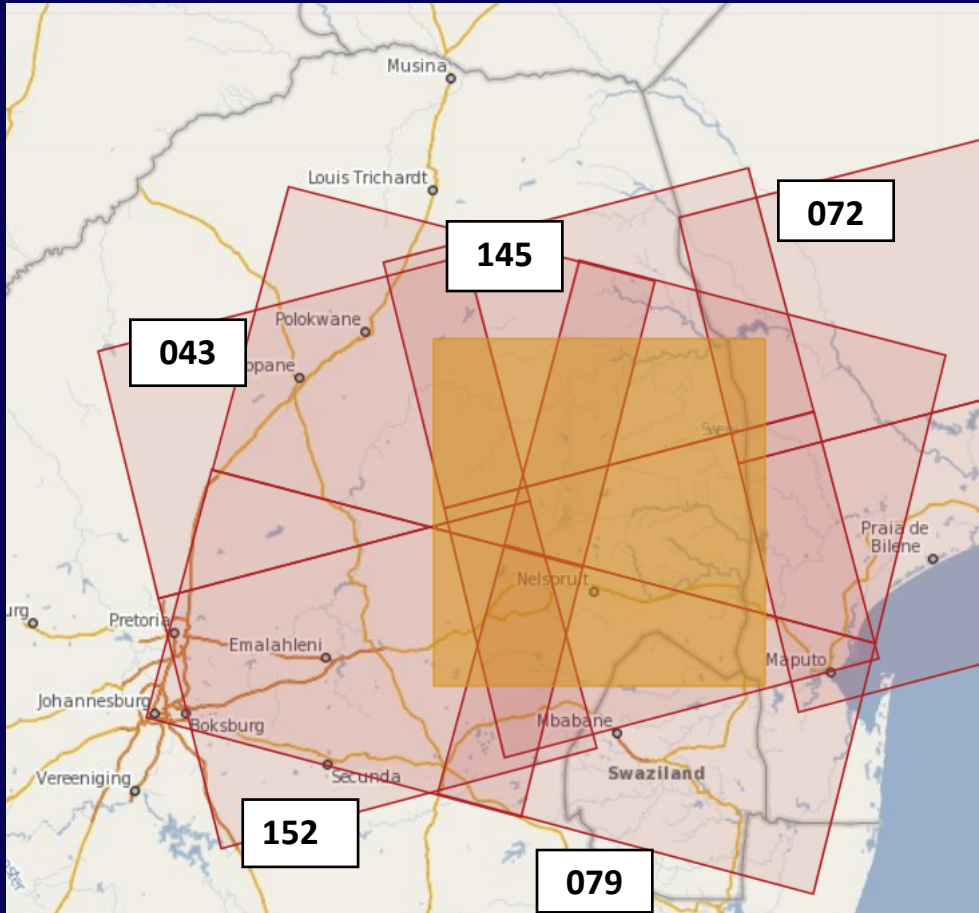


Malawi & Mozambique



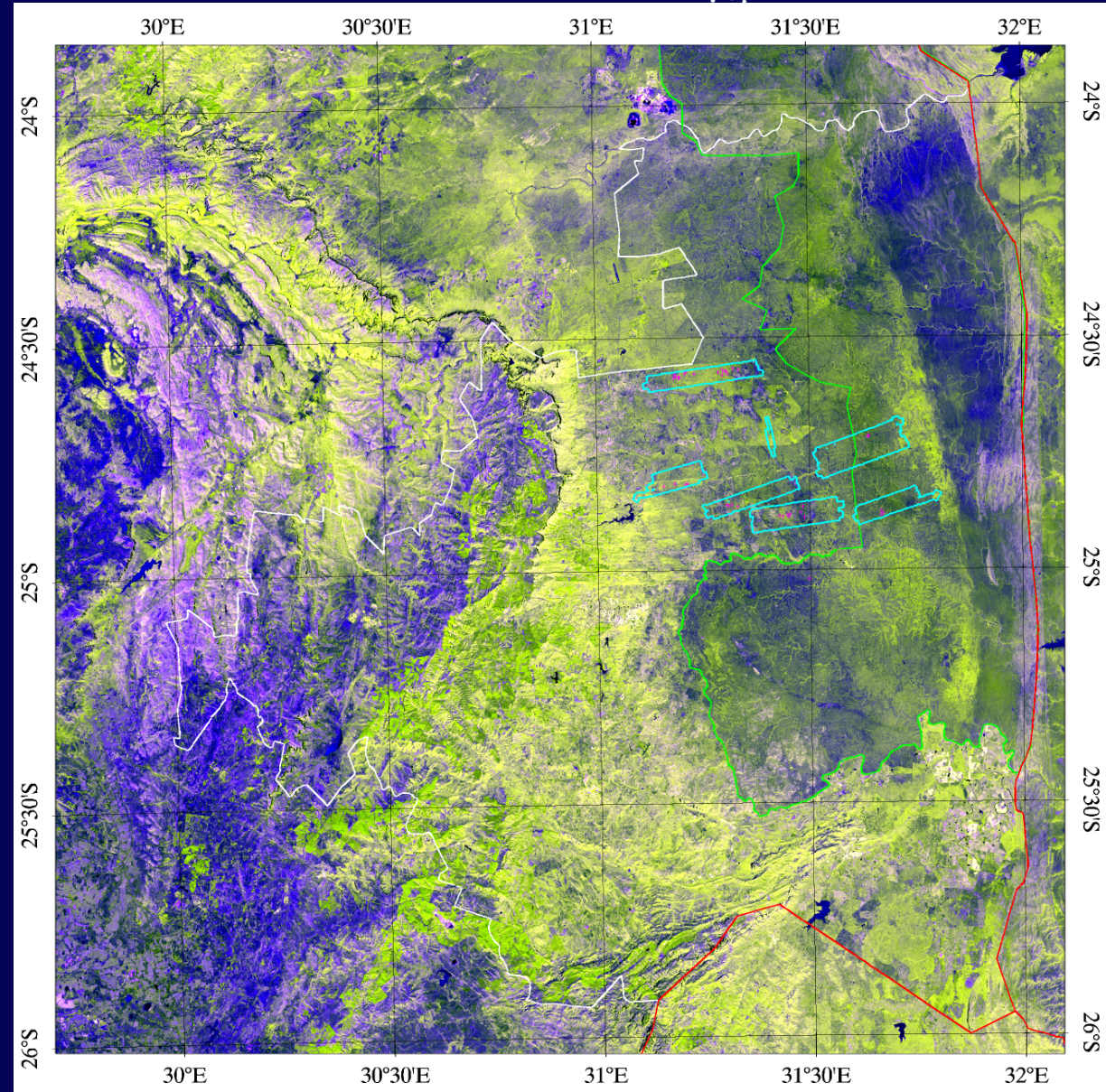
Flood mapping after cyclone Idai in Mozambique/Malawi (March 2019): (a&b) $RGB = [\gamma_{VH}; \gamma_{VV}; NDI]$, (c) Detected flooded areas in red. Contains modified Copernicus Sentinel-1 data (2019).

South Africa



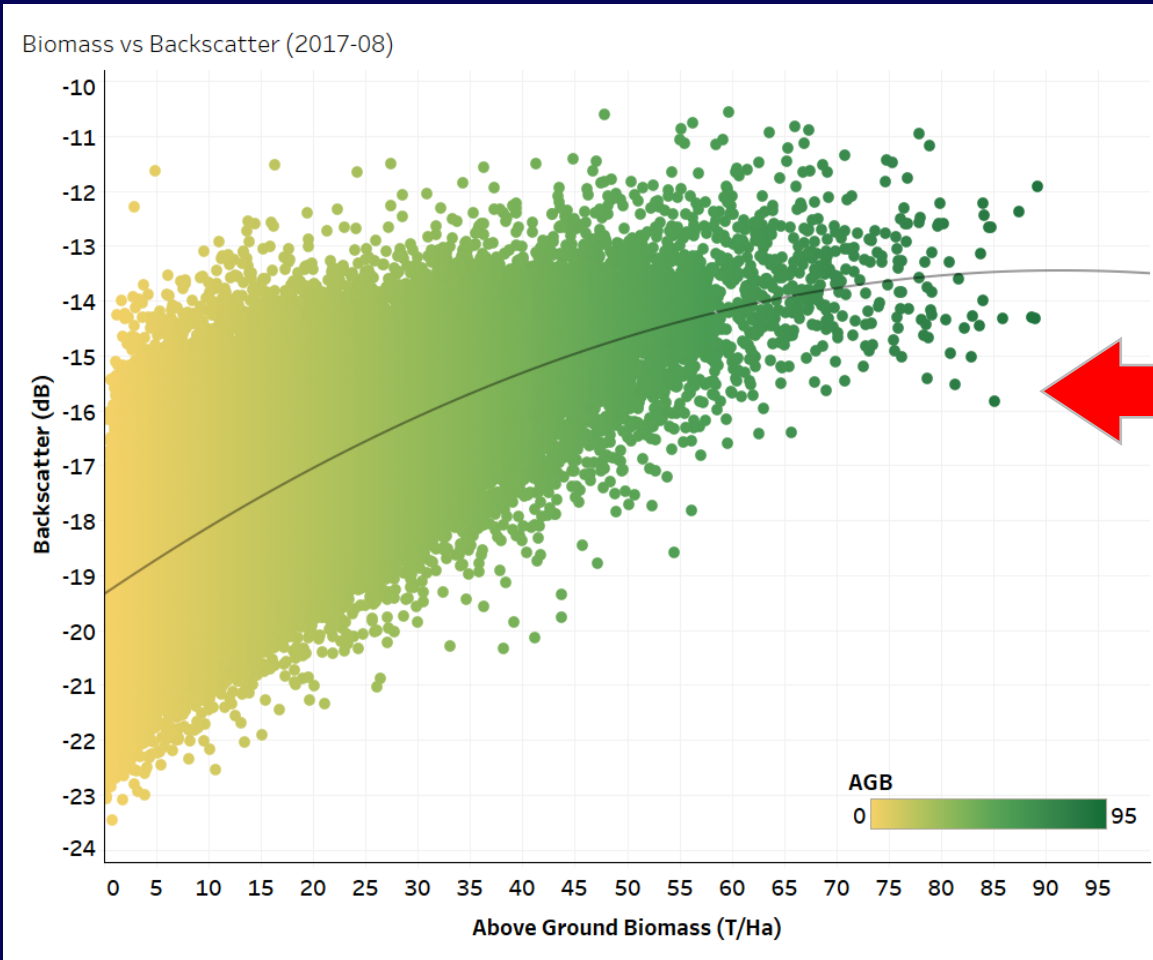
Application

- Savannah biomass estimation

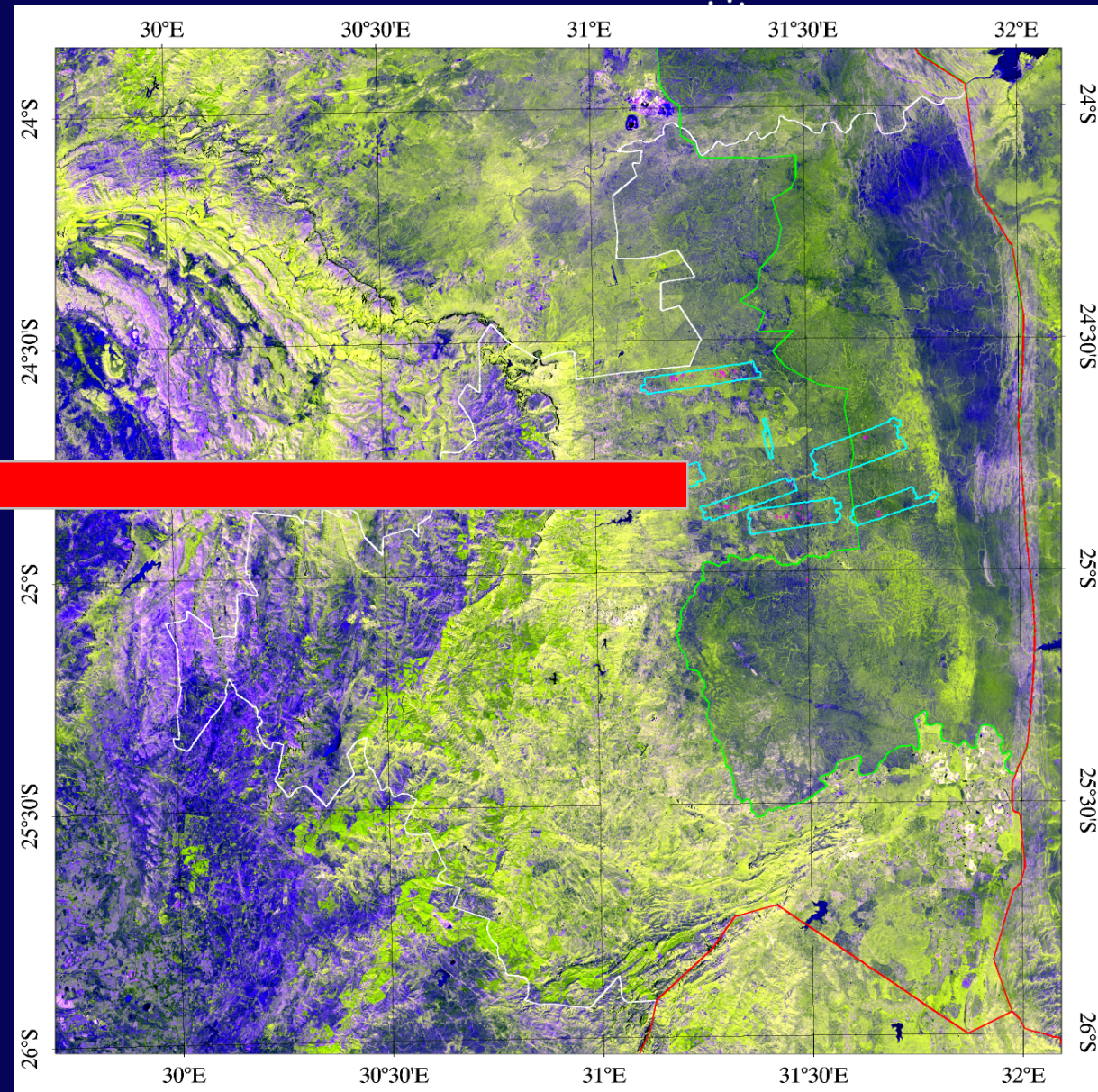


South Africa

VH Backscatter



Biomass



User Feedback

- Was collected about 1-2 month after delivery using a Service Assessment Sheet.
- Not enough time to give a thorough feedback.
- Did not come up with a an alternative ASARD definition

But:

- Users are very satisfied and reported better speckle noise reduction and terrain correction than what they are used to from own processing.
- Reduced their total amount of data download
- Would like to have this country-wide and for the whole Sentinel-1 period.

Conclusion



- SAR averaged mosaics and statistical parameters serve well as Analysis Ready Data → User satisfaction.
- Monthly and yearly time-series are easy to combine and analyze and help to reveal areas with strong dynamics.
- Many potential applications:
 - Forest Monitoring
 - Agricultural Monitoring
 - Illegal Mining Monitoring
 - Disaster monitoring like flooding
 - Etc.
- Transfer processing into the cloud and implementation in data cubes, i.e.
 - the African Regional Data Cube: <http://52.54.26.108>
 - Ghana Sentinel 1 Change Detection: <http://tinyurl.com/ardcs1demo>

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Ghana Sentinel 1 Change Detection

Change Detection

Choose your imagery.
Layer: Sentinel1 RGB dynamic stretch

Choose two different images to compare.
Primary Image : April 15, 2015
3/15/15 10/15/18

Comparison Image : July 15, 2018
3/15/15 10/15/18

Swipe

Configure change detection.
Calculate changes in: Image brightness

Draw polygon(s) to define extent

Apply Clear

Map labels: Bibiani/Anhwiaso/Bekwai, Wasa Amenfi West, CENTRAL WESTERN

Scale: -2.355 6.060 Degrees

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