

SERVIR Training

Mangrove Forest and Radar

Huntsville, AL

September 10 – 14, 2018



Kenneth Mubea
SERVIR E&SA
mubea@rcmrd.org

Twitter: [@RCMRD_](https://twitter.com/RCMRD_)

Emily Adams
SERVIR SCO

[@SERVIRGlobal](https://twitter.com/SERVIRGlobal)

Course outline: Day 1



| | |
|---------------|---|
| 9:00 – 9:30 | Session 1a Introduction to Mangrove Forest and |
| 9:30 – 10:00 | Session 1b Radar Remote Sensing |
| 10:00 – 10h30 | Photo Session/Tea Break |
| 10:30 – 11:00 | Session 2a Sources of Radar Remote Sensing Data |
| 11:00 – 12:30 | Session 2b Process radar images |
| 12:30 – 14:00 | Lunch Break |
| 14:00 – 15:00 | Session 2c Data processing in QGIS |
| 15:00 – 16:00 | Session 3a Biomass estimation |
| 16:00 – 16:15 | Tea/Coffee Break |

Course outline: Day 2

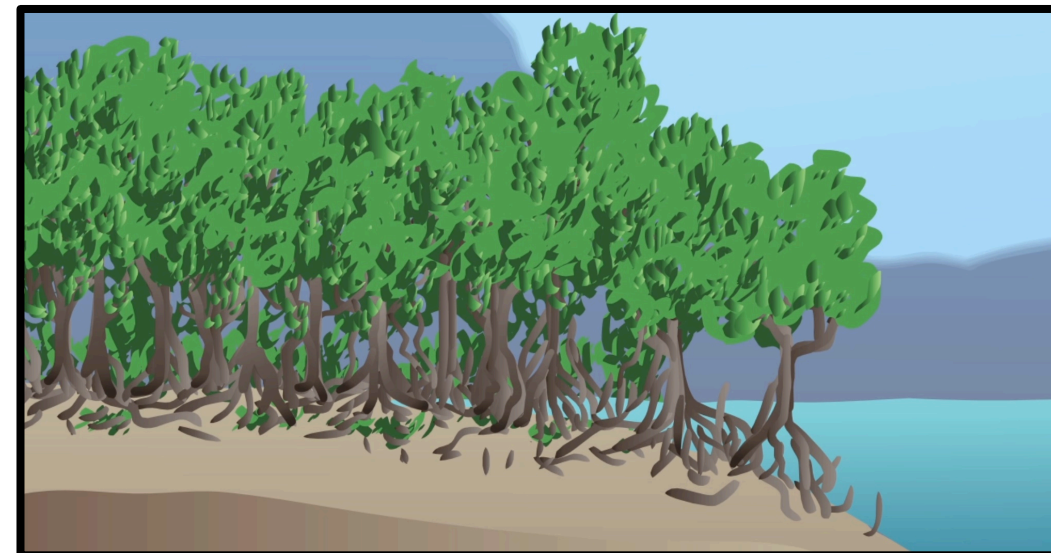


| | |
|---------------|---|
| 09:00 – 10:00 | Session 3b Biomass estimation |
| 10:00 – 10:30 | Tea/Coffee Break |
| 10:30– 13:00 | Session 3c Biomass estimation |
| 13:00 – 14:00 | Lunch Break |
| 14:00 – 16:00 | Session 4 Monitoring mangrove loss and gain |
| 16:00 – 16:10 | Tea/Coffee Break |

Introduction to Mangroves



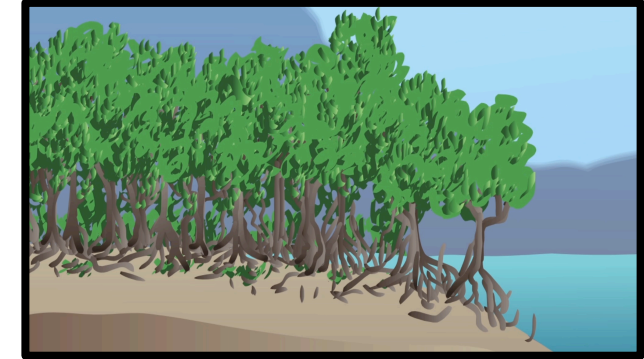
- Most **productive ecosystems** in the World.
- Thrive in the **tropical and sub-tropical regions** along the coastal regions within the intertidal zone.
- Cover a small land area (<1%) and responsible for 10% of global carbon export to Oceans.
- Provide a number of both direct and indirect services to local populations.
- Can grow up to about 60m in height and to attain high values of Above Ground Biomass (AGB)
- Occupy the riparian zone.
- Straddle both terrestrial and marine environments enabling them to support a very broad range of biodiversity.



Mangroves provides critical ecosystem services to society

SERVIR

- Coastal protection against tsunamis, hurricanes, storm surges, sea level rise and erosion
- Nurseries for fish, crustaceans and amphibians maintaining fish stocks and biodiversity
- Provide lumber and coal to local communities
- Store an extraordinary amount of carbon from the atmosphere and store in soils reducing global warming rates. (up to 1000t/ha including soil C)
 - Note that Carbon is used a mitigation to reduce destruction of mangrove for other unsustainable uses.
- The estimated **economical** value varies between \$200k to **\$900k** per km² per year (UNEP report 2006);
 - Note: These numbers need to be updated with our improved knowledge and also information on forest structure which drives their economical value.

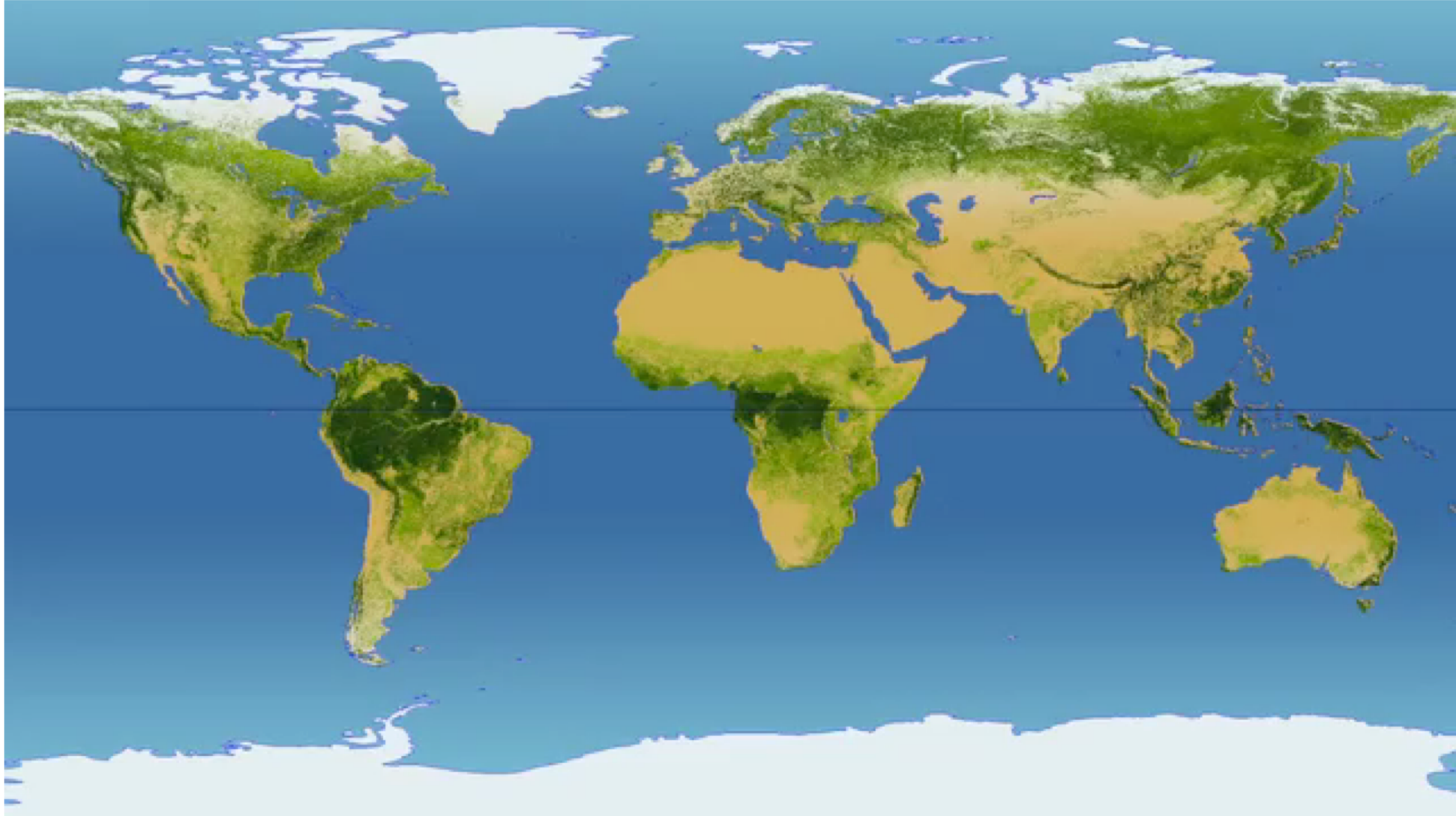


Mangroves are endangered

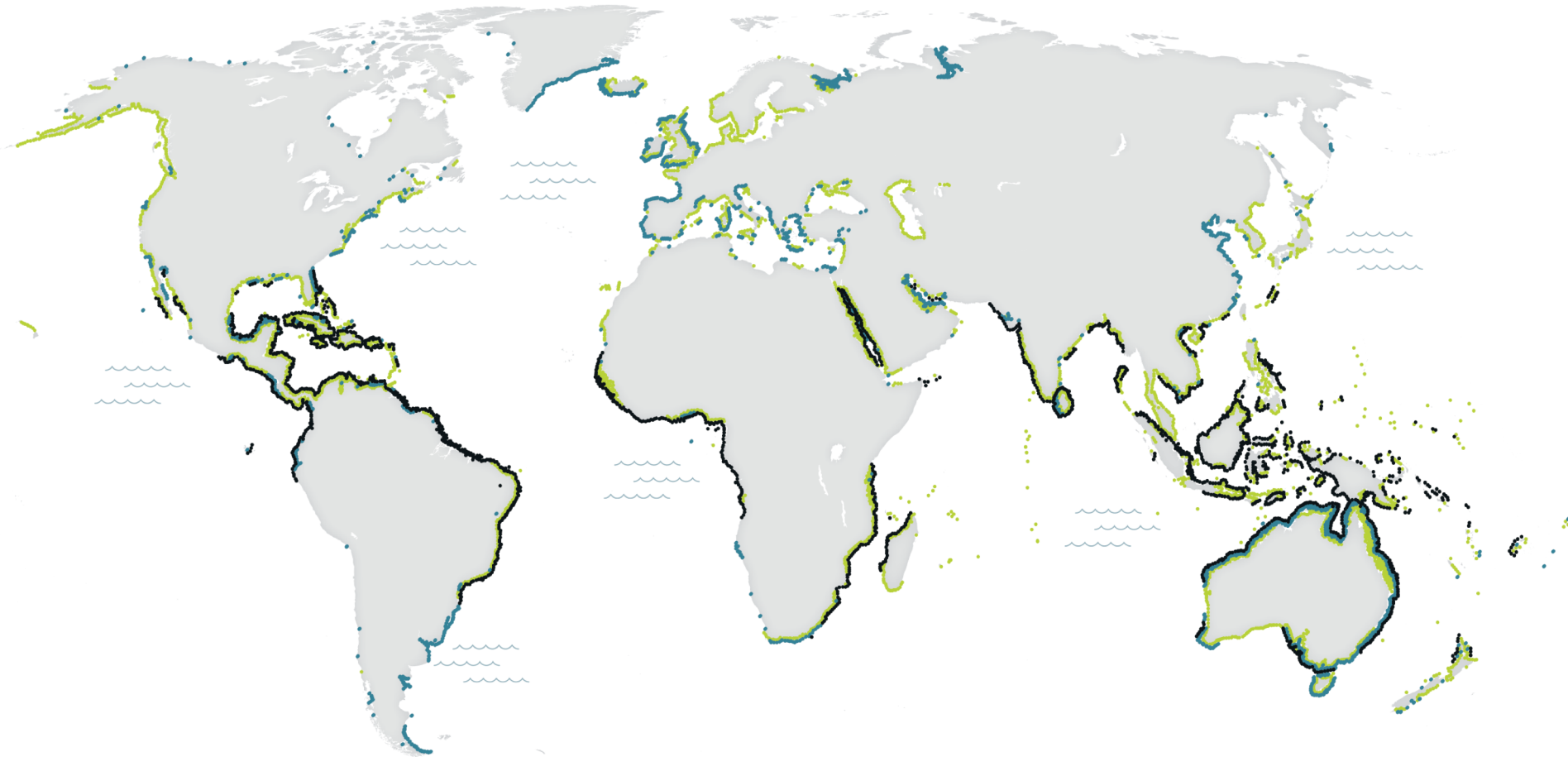
- Already **35%** of mangrove forests have **disappeared** and **60%** could be lost by **2030**;
- Endangered by climate change: sea level rise
- Mostly threatened by human activity (e.g. Urbanization, over exploitation for lumber, fresh water diversion due to construction of roads, levees and canals, pollution)

Mangrove are very important to society, however they are endangered. Most World population lives near the coasts.

Global Distribution of Mangrove Forests



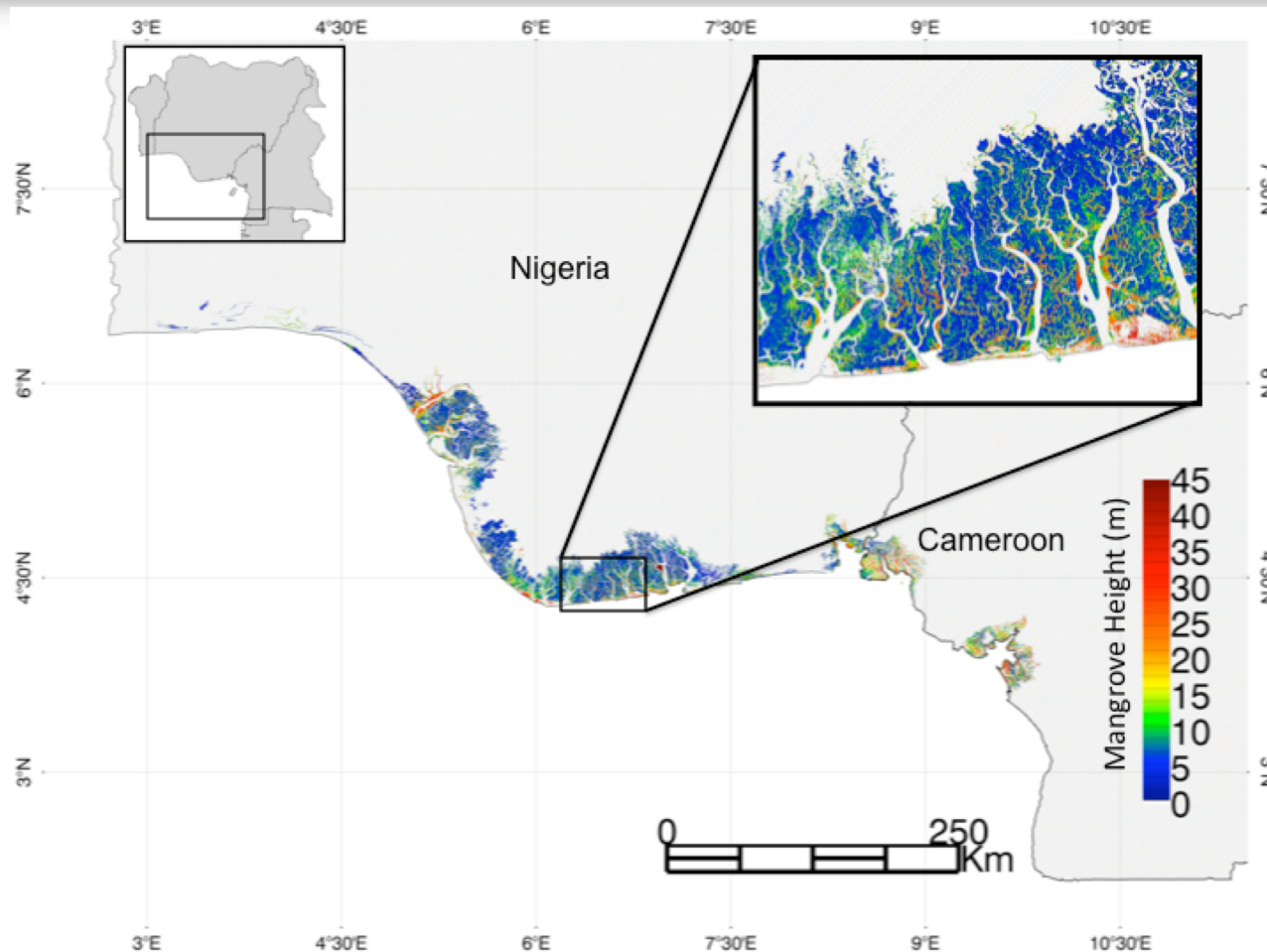
Global Distribution of Blue Carbon Ecosystems



 Mangroves  Salt Marsh  Seagrass

Mangroves occupy 137,600-152,308 km² globally (Spalding et al., 2010; Giri et al., 2011)

Height and Biomass Map of All Mangrove Forests of Africa



| Country | Area in km ² | Total Biomass in Mg | Mean Biomass in Mg/ha |
|-------------------|-------------------------|---------------------|-----------------------|
| Angola | 154 | 1,441,200 | 93 |
| Benin | 18 | 137,719 | 76 |
| Cameroon | 1,483 | 25,334,900 | 171 |
| Congo | 15 | 267,603 | 178 |
| Cote d'Ivoire | 32 | 406,516 | 124 |
| Djibouti | 17 | 1,653,170 | 90 |
| DRC | 183 | 51,570 | 140 |
| Egypt | 1 | 8,344 | 117 |
| Equatorial Guinee | 181 | 2,922,420 | 161 |
| Eritrea | 49 | 640,038 | 129 |
| Gabon | 1,457 | 23,840,000 | 162 |
| Gambia | 519.11 | 5,509,300 | 106 |
| Ghana | 76 | 742,925 | 97 |
| Guinea | 1,889 | 18,153,800 | 108 |
| Guinea Bissao | 2,806 | 31,712,300 | 113 |
| Kenya | 192 | 2,294,820 | 119 |
| Liberia | 189 | 2,141,860 | 113 |
| Madagascar | 2,059 | 24,856,900 | 121 |
| Mauritania | 0.4 | 4,156 | 95 |
| Mozambique | 3,054 | 30,974,100 | 101 |
| Nigeria | 8,573 | 94,788,000 | 111 |
| Senegal | 1,200 | 11,462,100 | 95 |
| Sierra Leone | 955 | 10,655,600 | 112 |
| Somalia | 30 | 436,907 | 143 |
| Soudan | 4 | 135,626 | 113 |
| South Africa | 12 | 40,018 | 100 |
| Togo | 2 | 15,861 | 78 |
| Tanzania | 809 | 11,037,800 | 136 |
| Africa | 25,960 | 301,665,553 | 116 |

Fatoyinbo & Simard, IJRSE 2012

Courtesy: Marc.simard@jpl.nasa.gov

Countries (10) with most biomass (tons) - World



| Country | Max Height (m) | Mean height (m) | Max AGB (Mg/ha) | Mean AGB (Mg/ha) | Total AGB (Mg) | Total C (Mg) | Mangrove area (ha) |
|------------------|-------------------|--------------------|--------------------|---------------------|----------------|---------------|-----------------------|
| Indonesia | 47.5 | 24.7 | 456.4 | 218.5 | 578,630,876 | 1,138,076,289 | 2,647,499 |
| Papua New Guinea | 45.8 | 28.6 | 432.5 | 248.1 | 114,089,528 | 206,806,176 | 459,856 |
| Australia | 28.8 | 12.2 | 241.8 | 121.7 | 111,643,417 | 333,910,624 | 914,796 |
| Brazil | 40.7 | 20.3 | 260.5 | 94.6 | 97,367,688 | 354,985,555 | 1,023,164 |
| Malaysia | 35.6 | 20.4 | 308.3 | 176.5 | 92,120,954 | 209,655,257 | 522,088 |
| Bangladesh | 25.5 | 15.5 | 421.2 | 173.0 | 73,916,017 | 170,612,893 | 427,357 |
| Nigeria | 33.9 | 13.9 | 355.3 | 99.6 | 68,016,334 | 238,906,942 | 682,688 |
| Venezuela | 52.6 | 31.7 | 392.8 | 190.1 | 45,442,016 | 98,147,684 | 238,908 |
| Cameroon | 49.2 | 23.1 | 627.3 | 215.1 | 42,491,621 | 84,449,634 | 197,511 |

Mangrove continuum is threatened by sea level rise



Anthropogenic



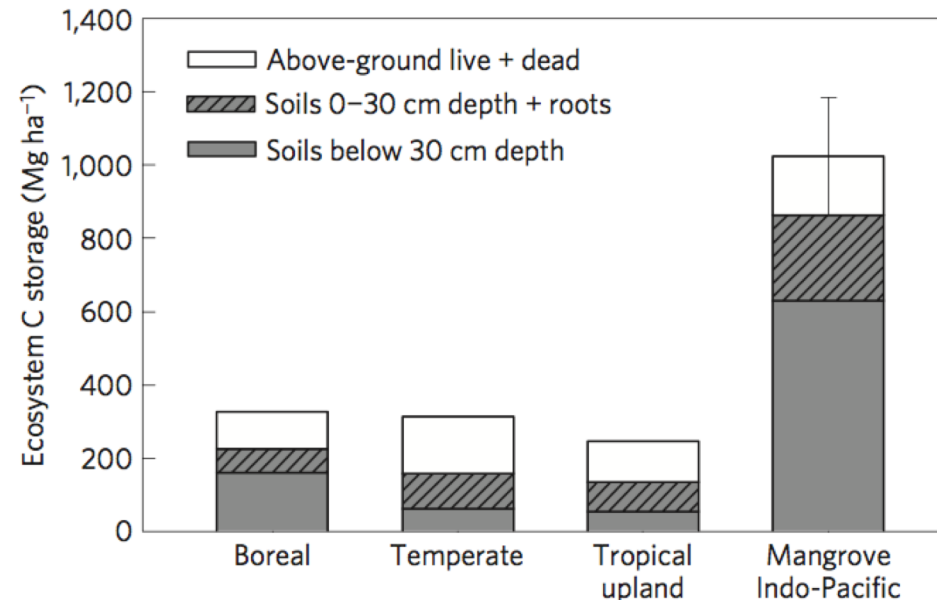
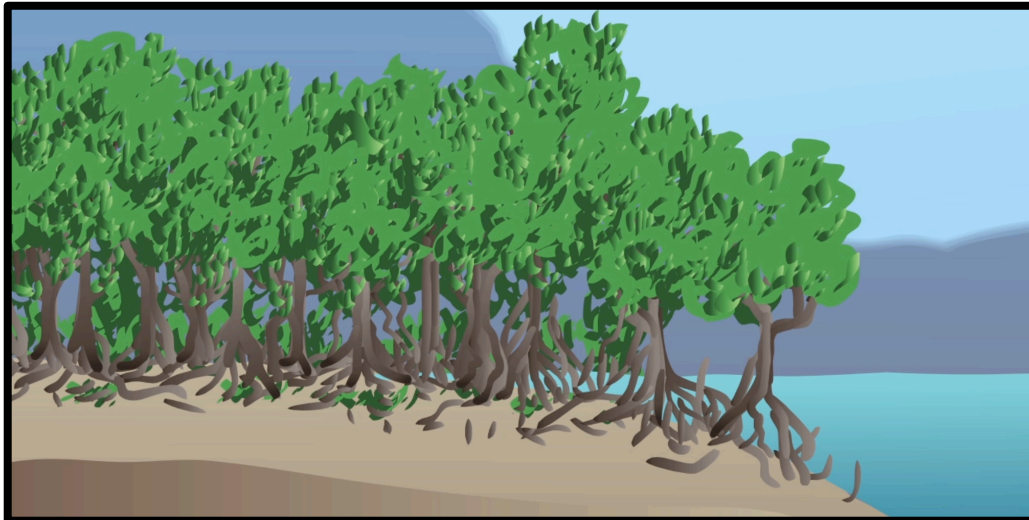
Marshes-Mangroves



Ocean

Mangroves and ecosystem services

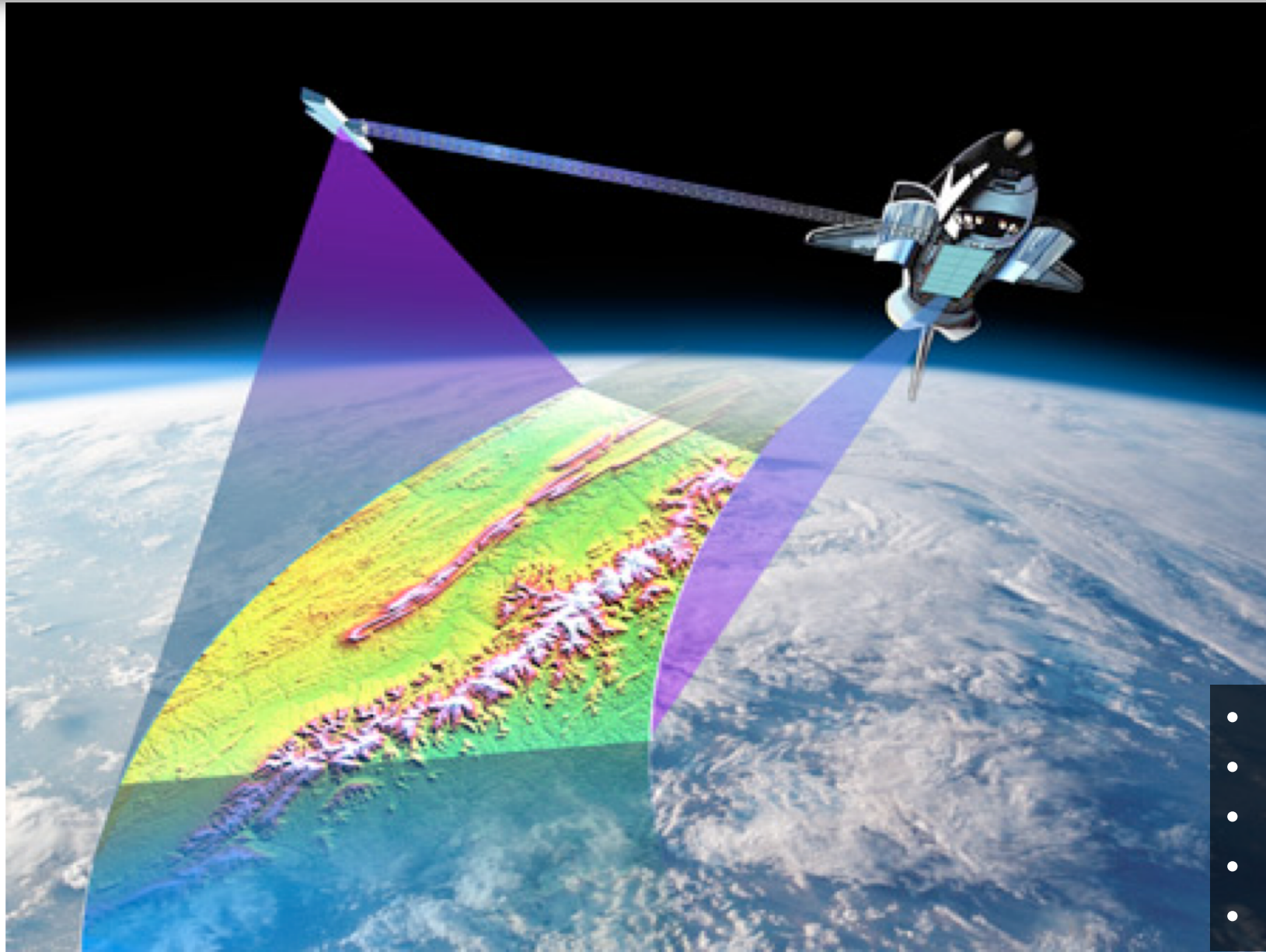
- Environmental drivers of mangrove structure: precipitation, temperature, availability of nutrients and salinity - *climate change*
- Mangroves structure divided into 4 eco-types - landscape characteristics: riverine, basin, fringe and scrub.
- Remote sensing can measure the ecosystem response in term of canopy height, above ground biomass (AGB), species distribution and spatial patterns.
- The largest driver of this loss has been the conversion of mangrove forest to aquaculture, mariculture



Comparison of mangrove C storage with that of major forest domains (from Donato et al. 2011).

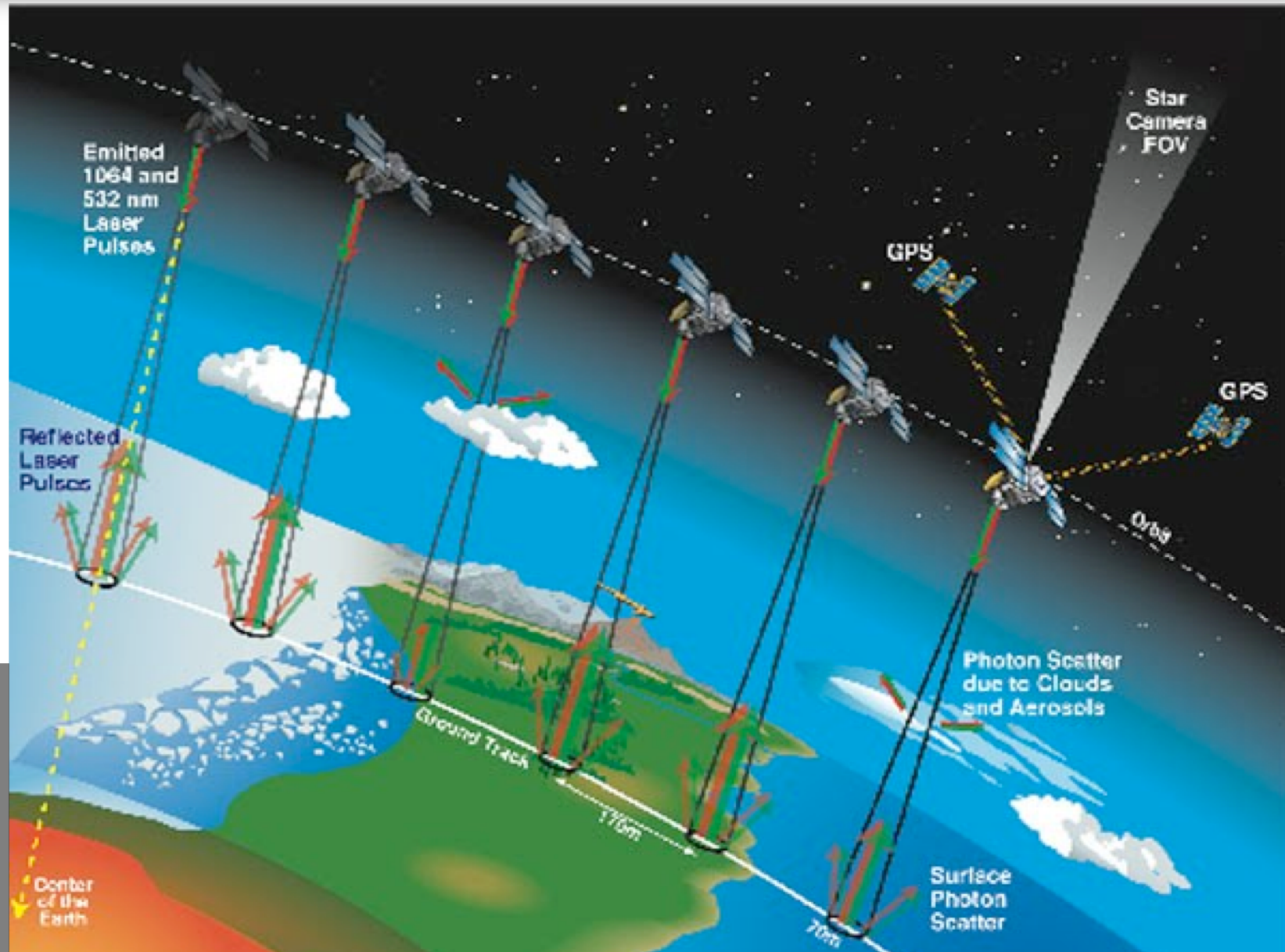
SRTM (Shuttle Radar Topography Mission)

SERVIR 



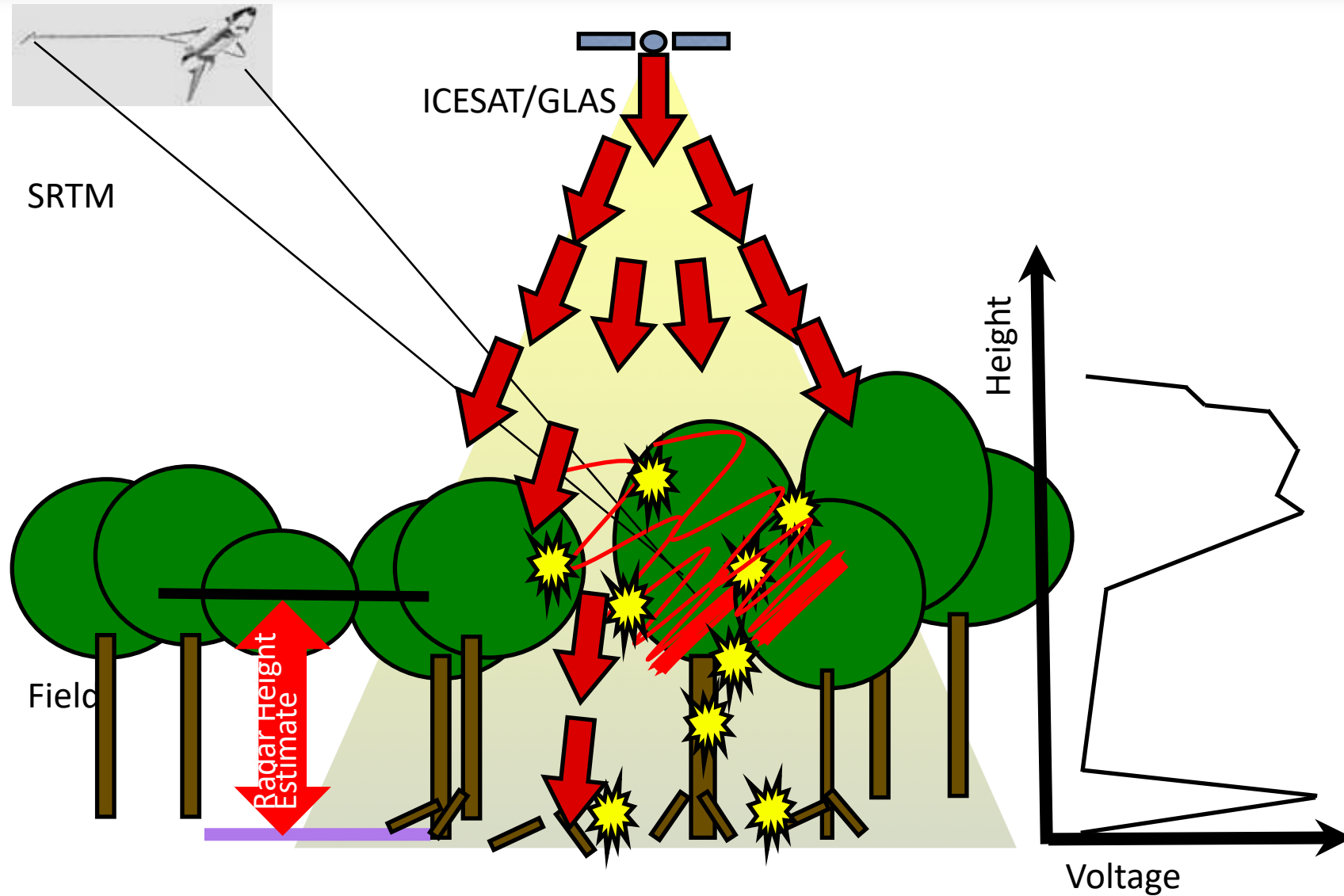
- 11-day mission, February 2000
- Mapped DSM 80% of land surface
- Spatial Sampling (30m)
- Intrinsic resolution ~60m
- New version soon NASADEM

ICESAT/GLAS (Geoscience Laser Altimeter System)



Full waveform recording
-ground elevation and forest structure
Operational period 2003-2009
~2 billion shots
70 m footprints

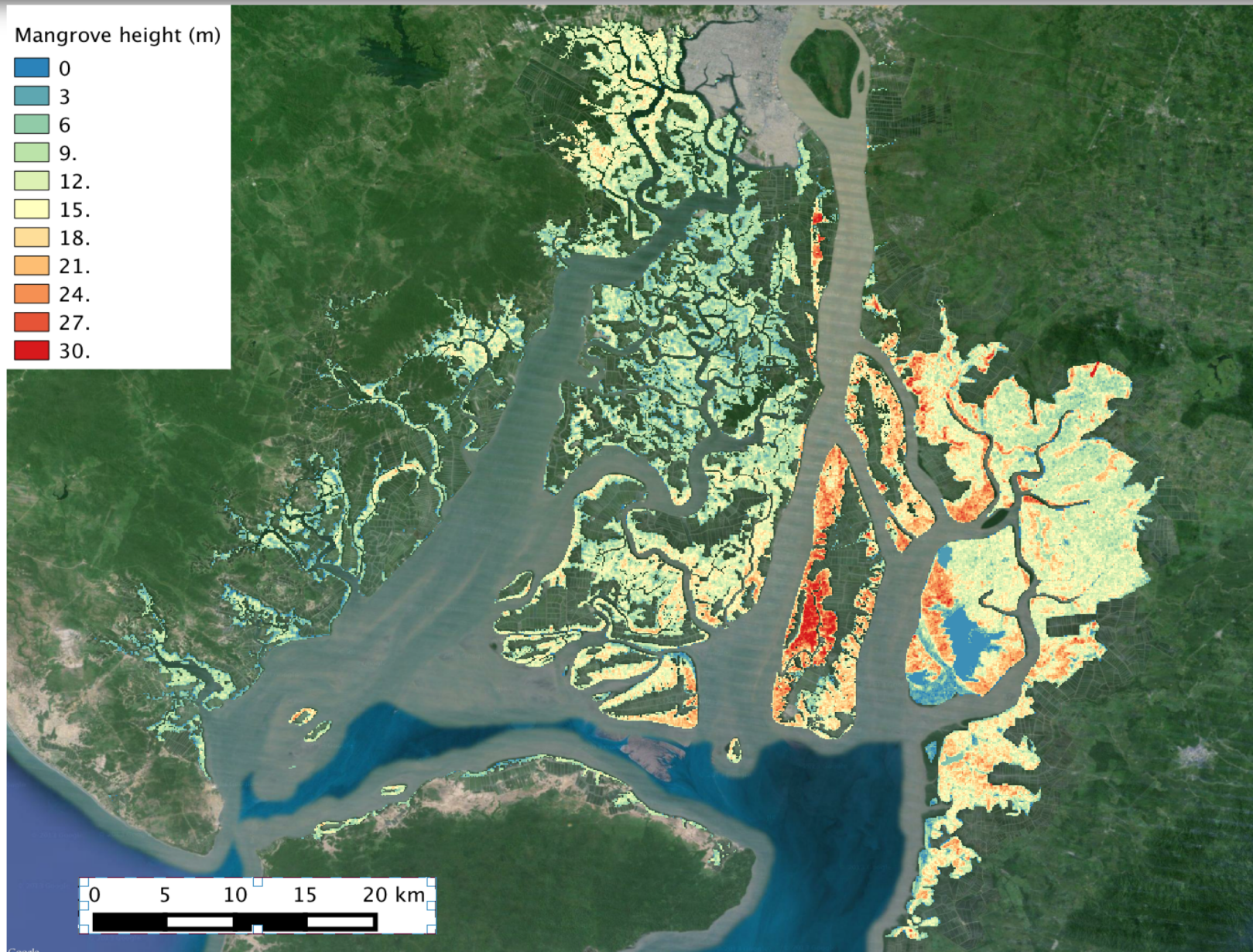
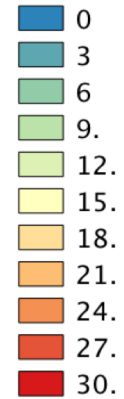
Mapping Mangrove Canopy Structure



Example: Mangroves of Guayaquil, Ecuador

SRTM

Mangrove height (m)



Forest Canopy Height derived from UAVSAR (polinSAR)

SERVIR

Uninhabited Aerial Vehicle Synthetic Aperture Radar – UAVSAR <https://uavsar.jpl.nasa.gov/>

UAVSAR

Uninhabited Aerial Vehicle Synthetic Aperture Radar



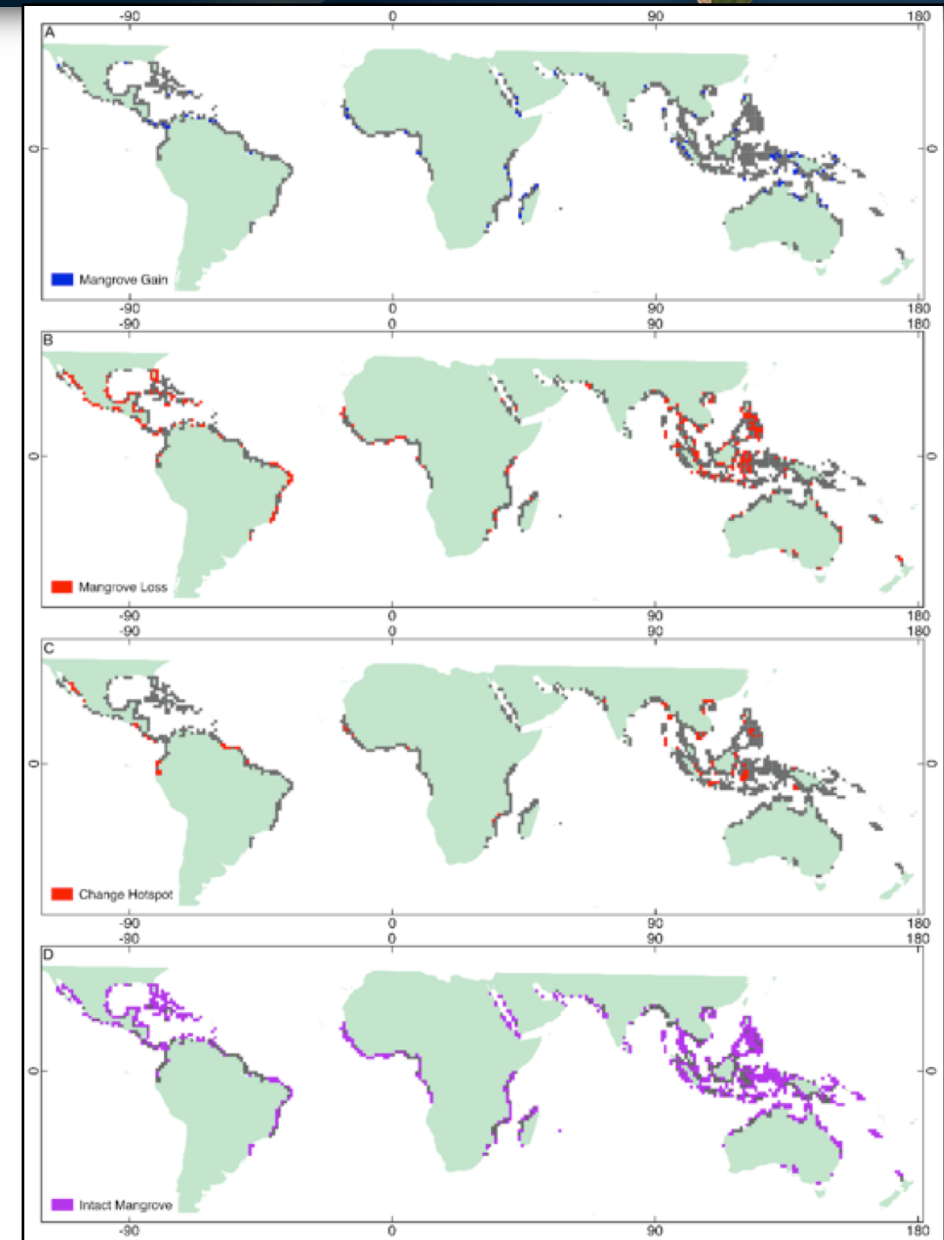
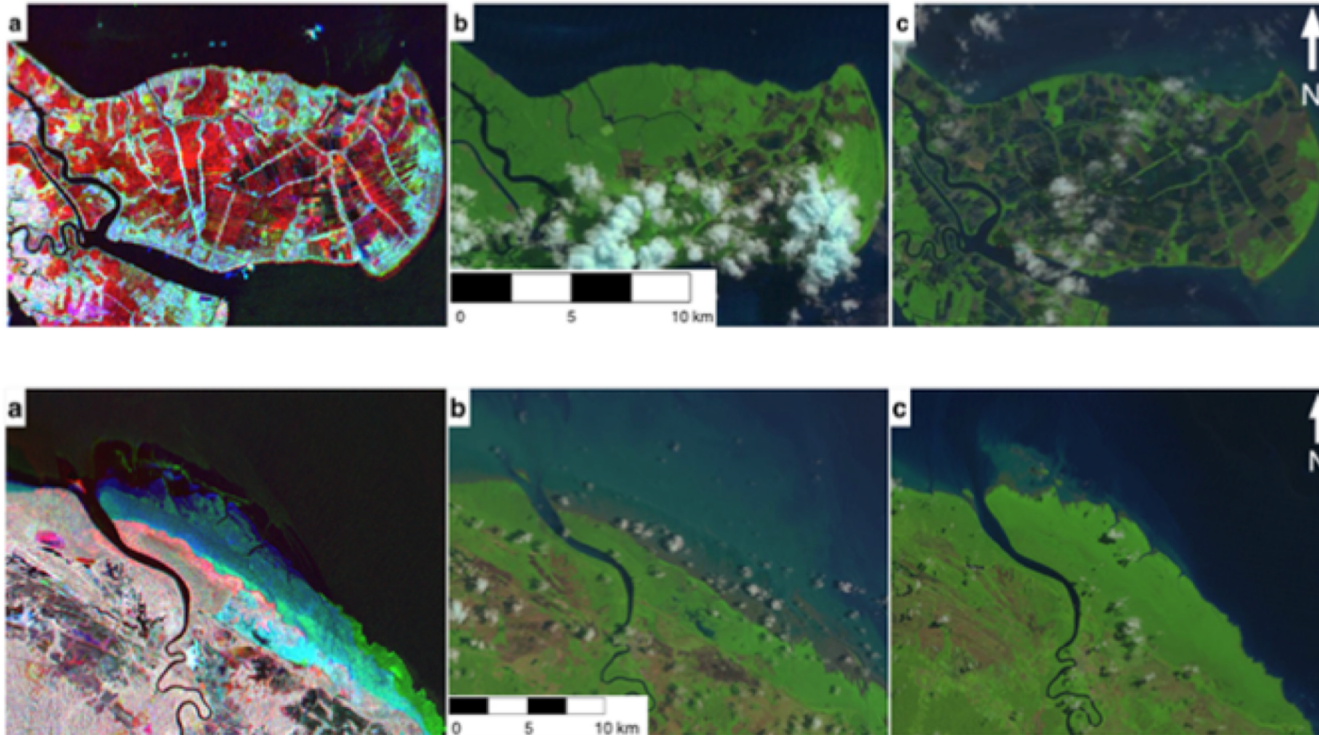
Canopy Height (m)



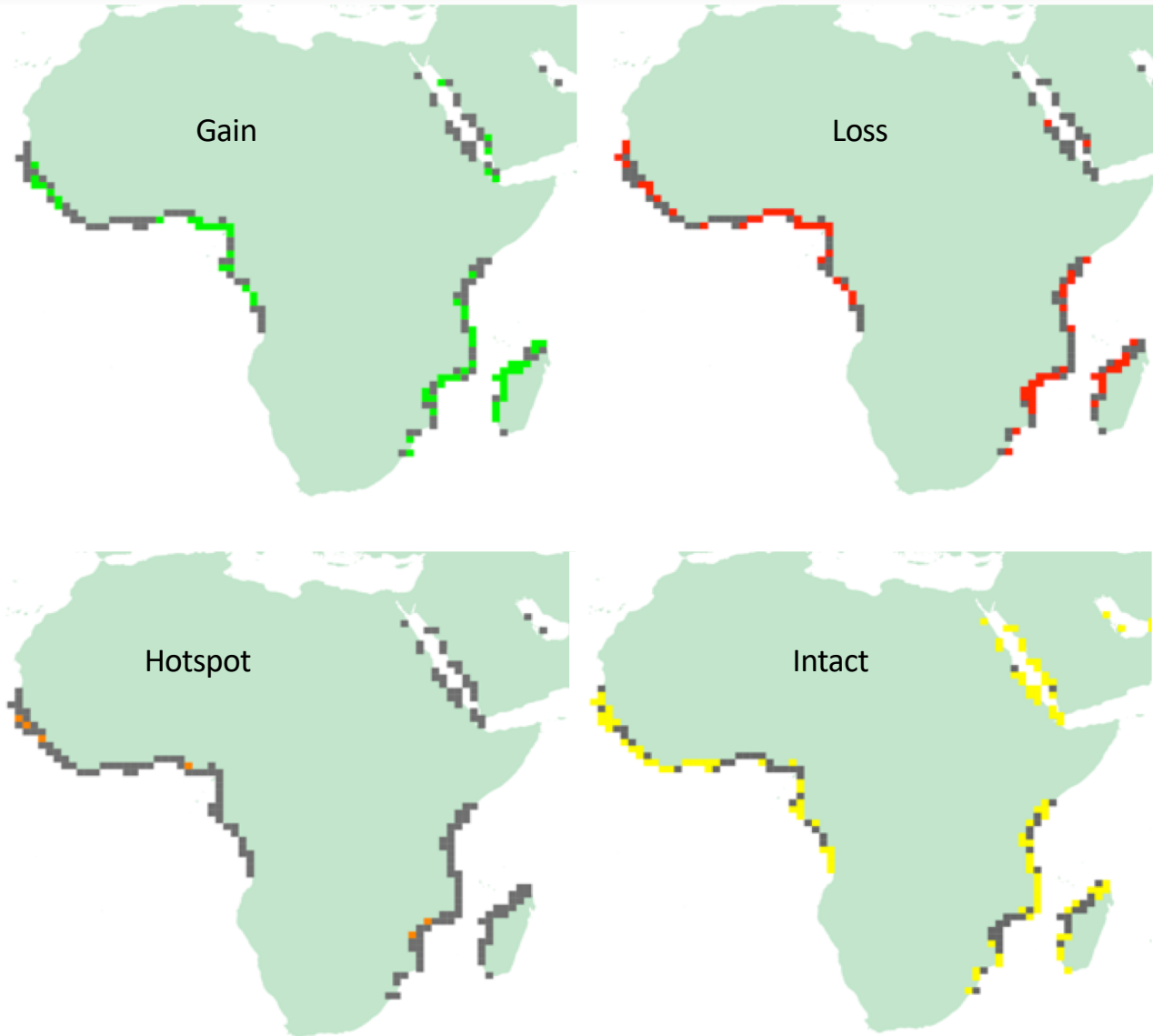
Jet Propulsion Laboratory, 2016

Mapping Change in Mangrove Extent and Identify Proximate Drivers of Changes and Geographical Hotspots.

Distribution and Drivers of Global Mangrove Forest Change, 1996-2010 (Thomas et al., 2017, *PLOS ONE*)



Mapping Change in Mangrove Extent and Identify Proximate Drivers of Changes and Geographical Hotspots.

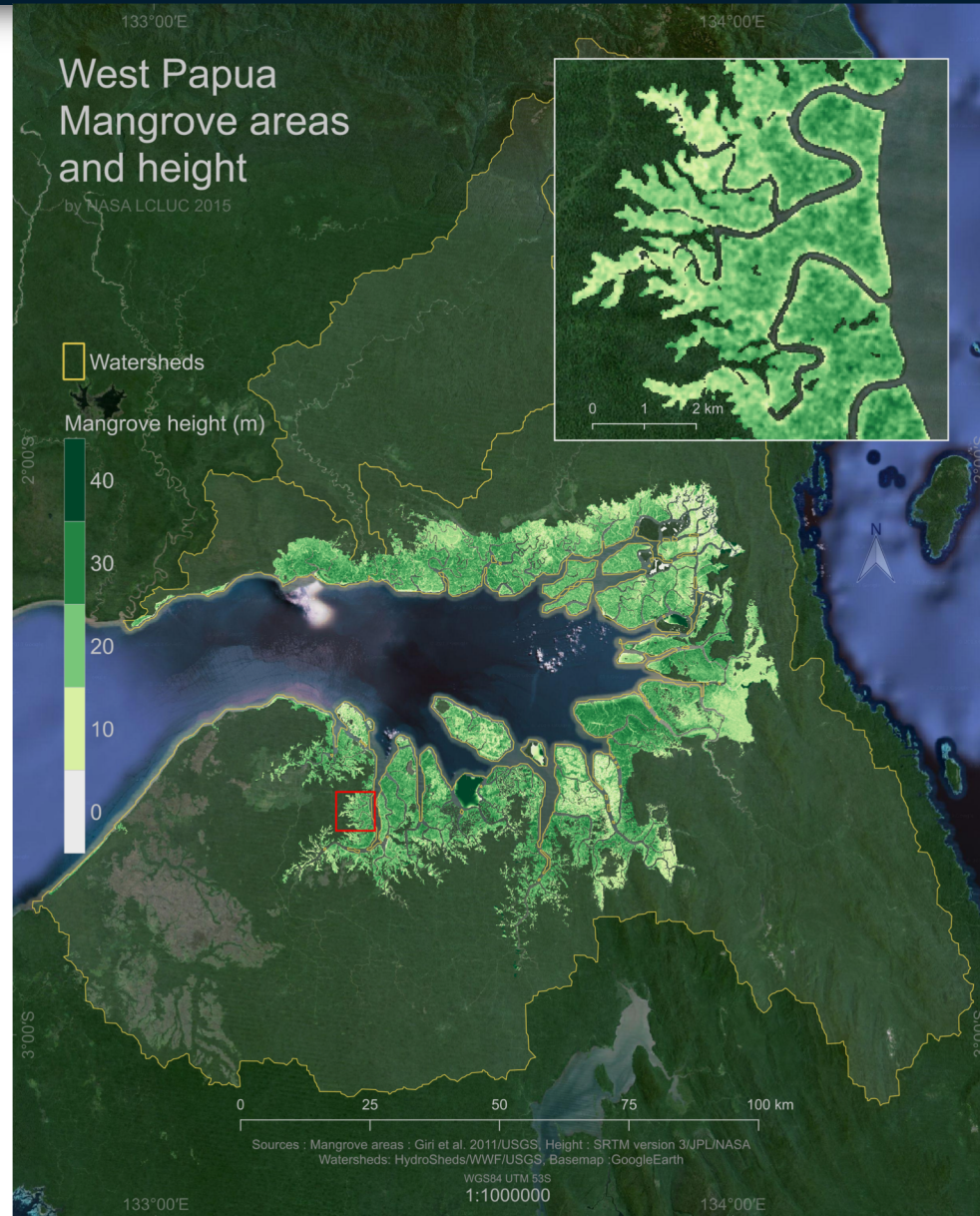


Distribution of different drivers of change in mangrove forest extent

- A) Advance and regrowth of mangrove extent (1996-2010)
- B) Degradation from anthropogenic drivers of change including evidence of prior disturbance
- C) Hotspots where substantial changes in mangrove forest extent were observed (1996-2010)
- D) Tiles that contained intact mangrove (1996-2010).

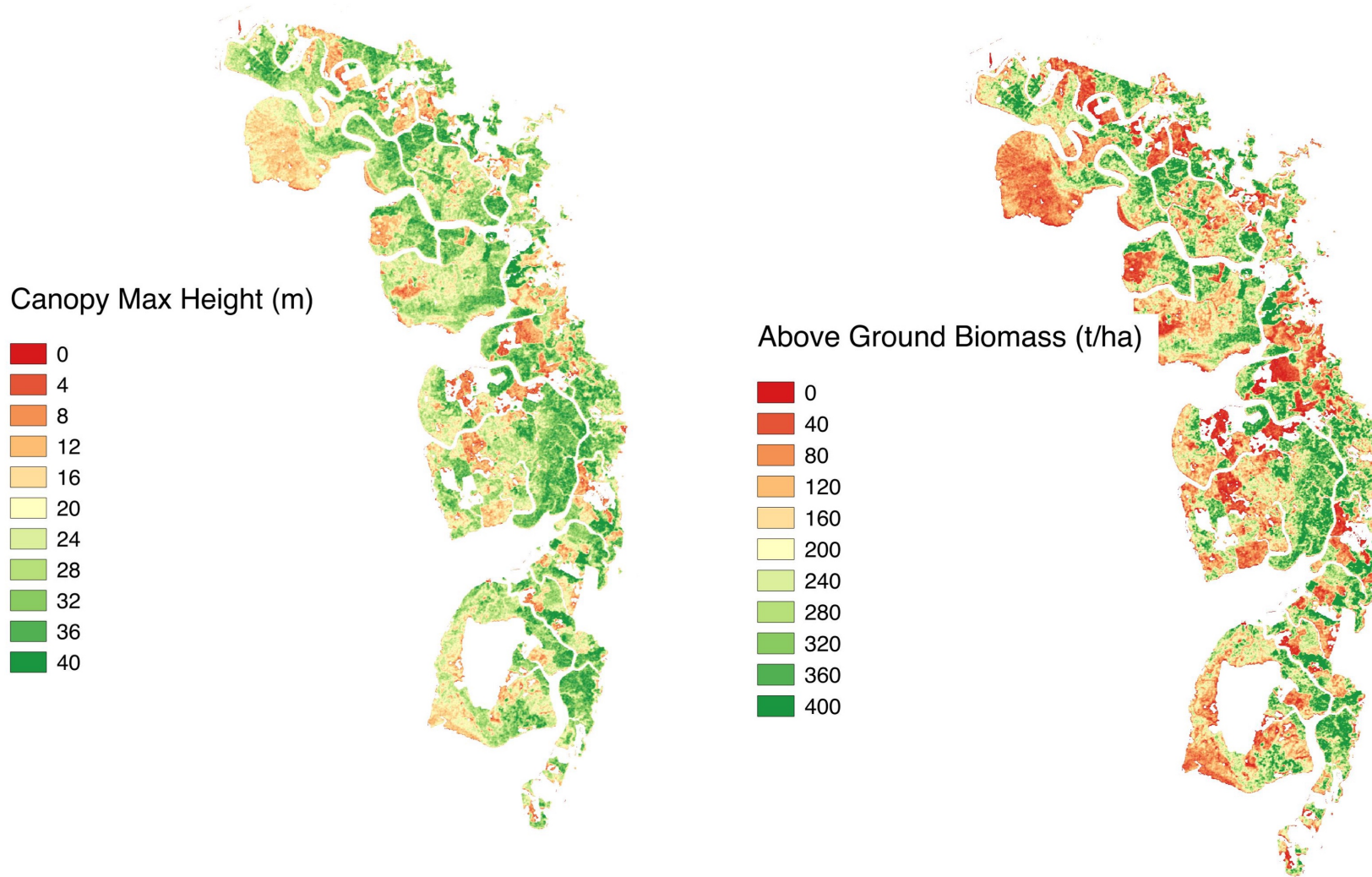
The total distribution of mangrove tiles is provided in gray.

Management of entire watershed is important to the health of mangrove forests.



- Environmental drivers of mangrove structure:
- precipitation,
 - temperature,
 - availability of nutrients and
 - salinity.

Forest Height (m) and Above Ground Biomass - Kuala Sepetang



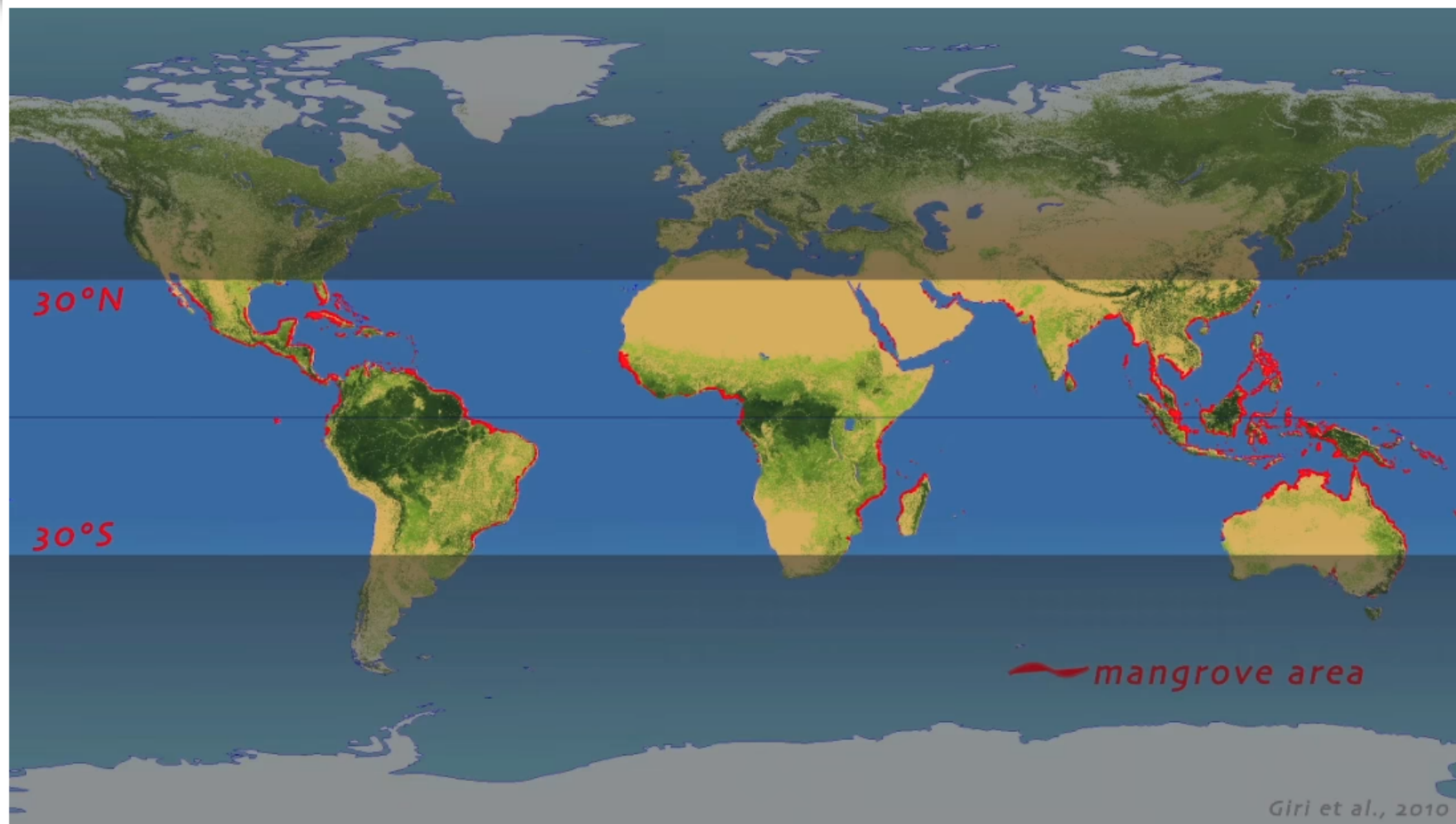
Kuala Sepetang

Town in Malaysia

Kuala Sepetang is a coastal town located in the Perak District, Perak, Malaysia.

- Environmental drivers of mangrove structure:
 - precipitation
 - temperature
 - availability of nutrients
 - salinity.

In 2000, there were about 30Mt of above ground biomass in Sepatang.

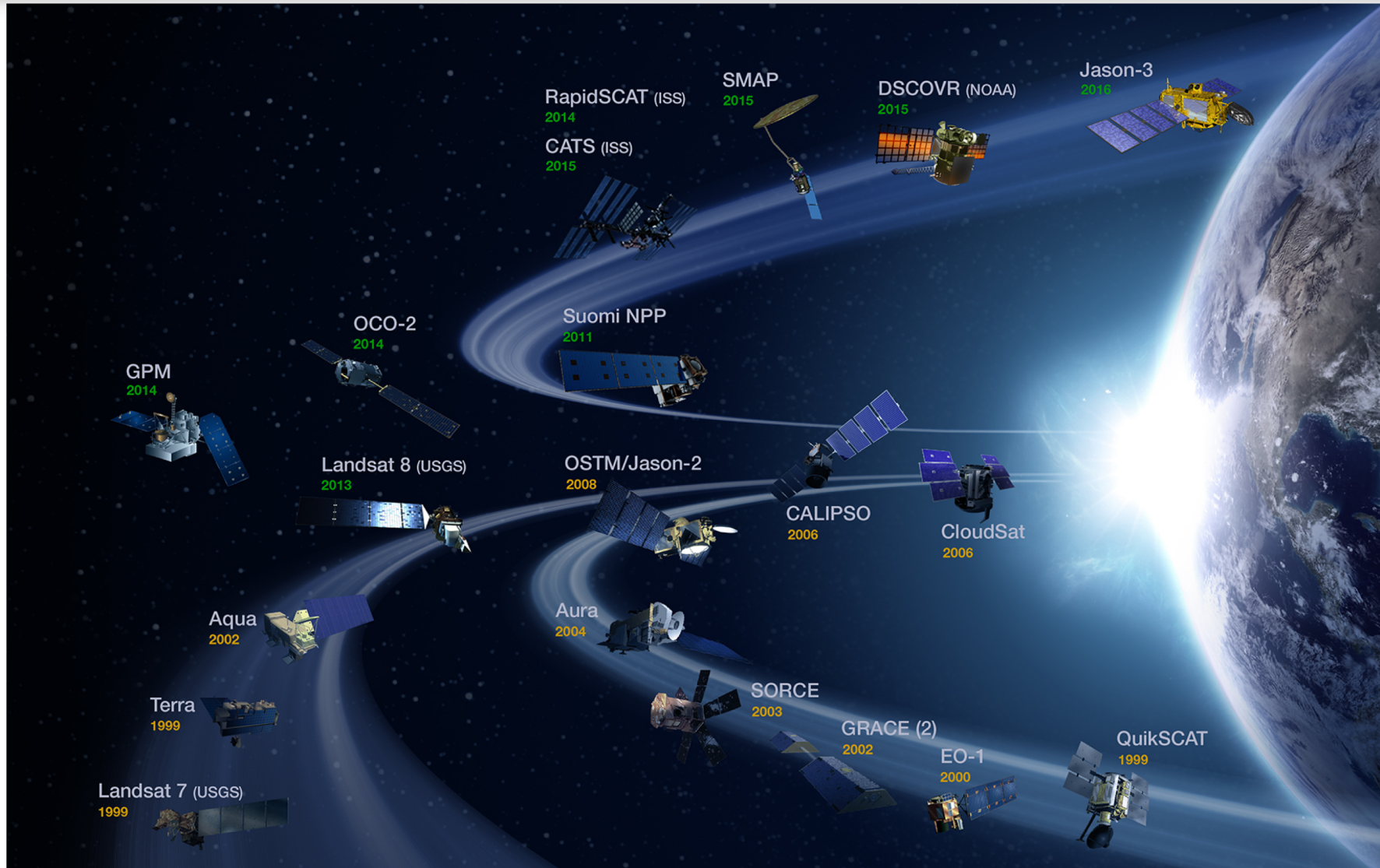


- Mangroves are coastal ecosystems that provide important services to coastal populations. They offer natural protection against storm surges, hurricanes and tsunamis. Mangroves also contribute to fish stocks by providing nursing grounds for fish and crustaceans.

<https://www.youtube.com/watch?v=RjSTKItUUX0>

NASA Earth Observing Satellites

SERVIR



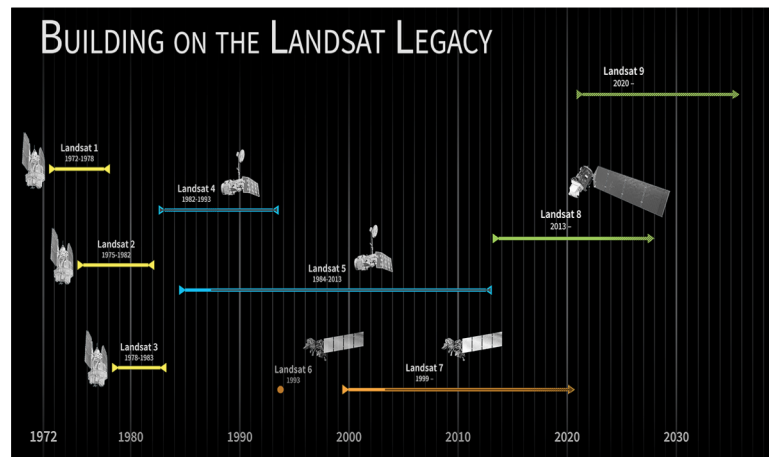
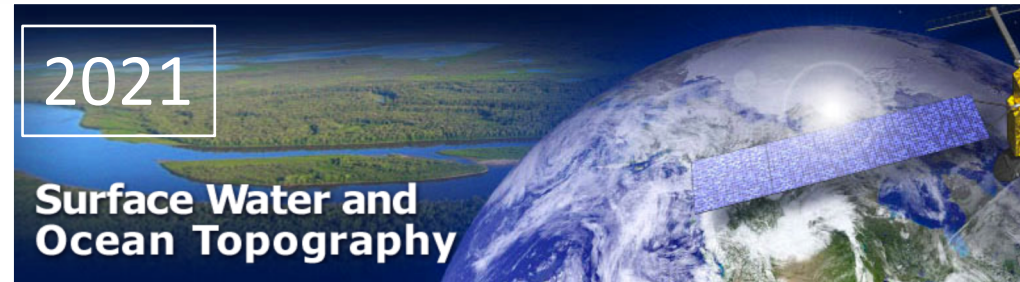
NASA's Earth Observing System is a coordinated series of polar-orbiting satellites that monitor the land surface, biosphere, solid Earth, atmosphere, and oceans for long-term global observations.

We will focus on the satellites that provide information on the Earth's biosphere.

Upcoming NASA Missions

SERVIR

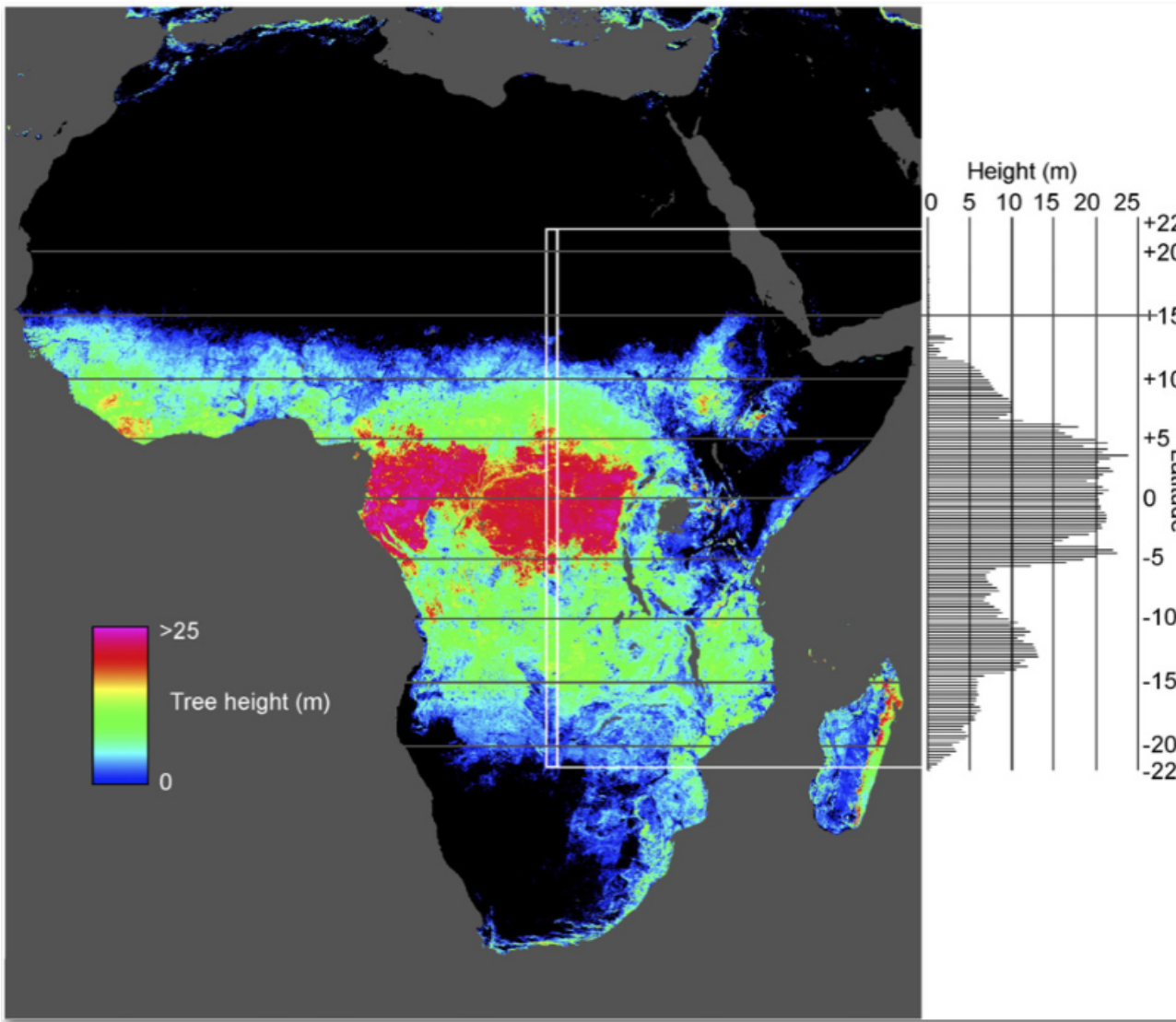
Global Ecosystem Dynamics
Investigation LIDAR (GEDI)
<https://gedi.umd.edu/>



NASA Missions - Global Ecosystem Dynamics Investigation LIDAR (GEDI)

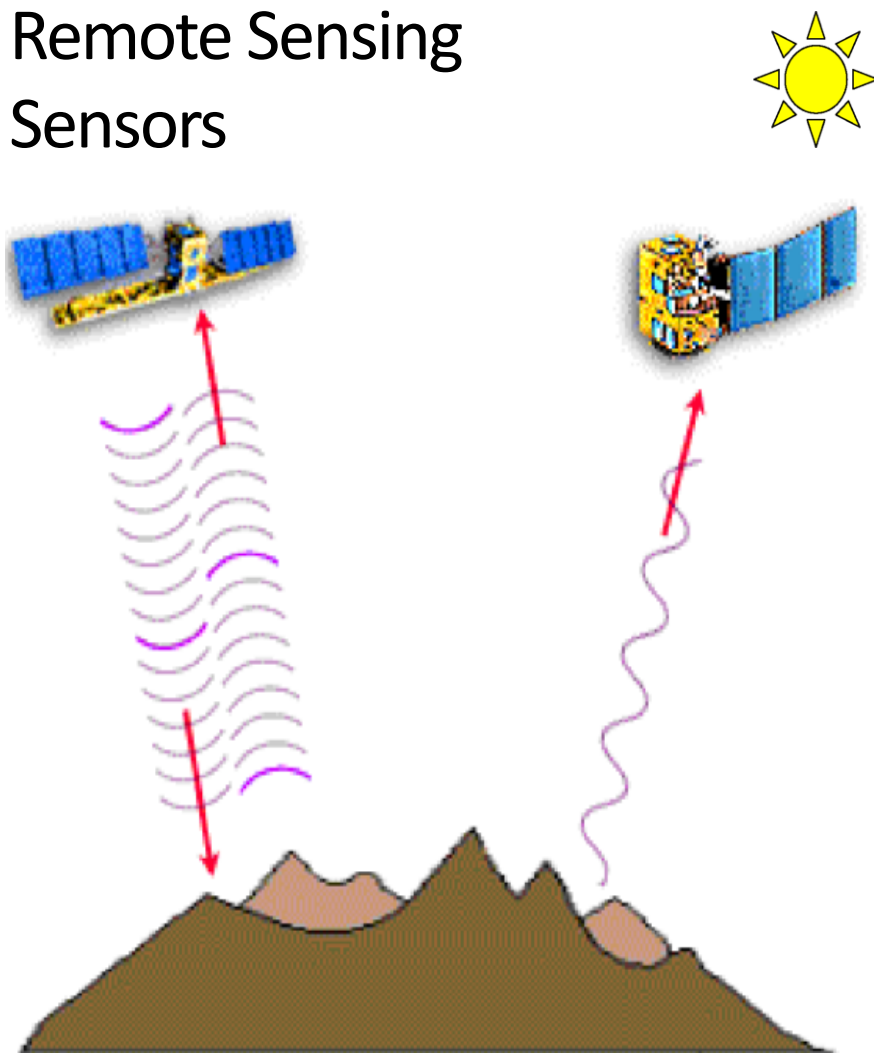


Enhanced Height/Biomass Using Fusion With Landsat <https://gedi.umd.edu/>

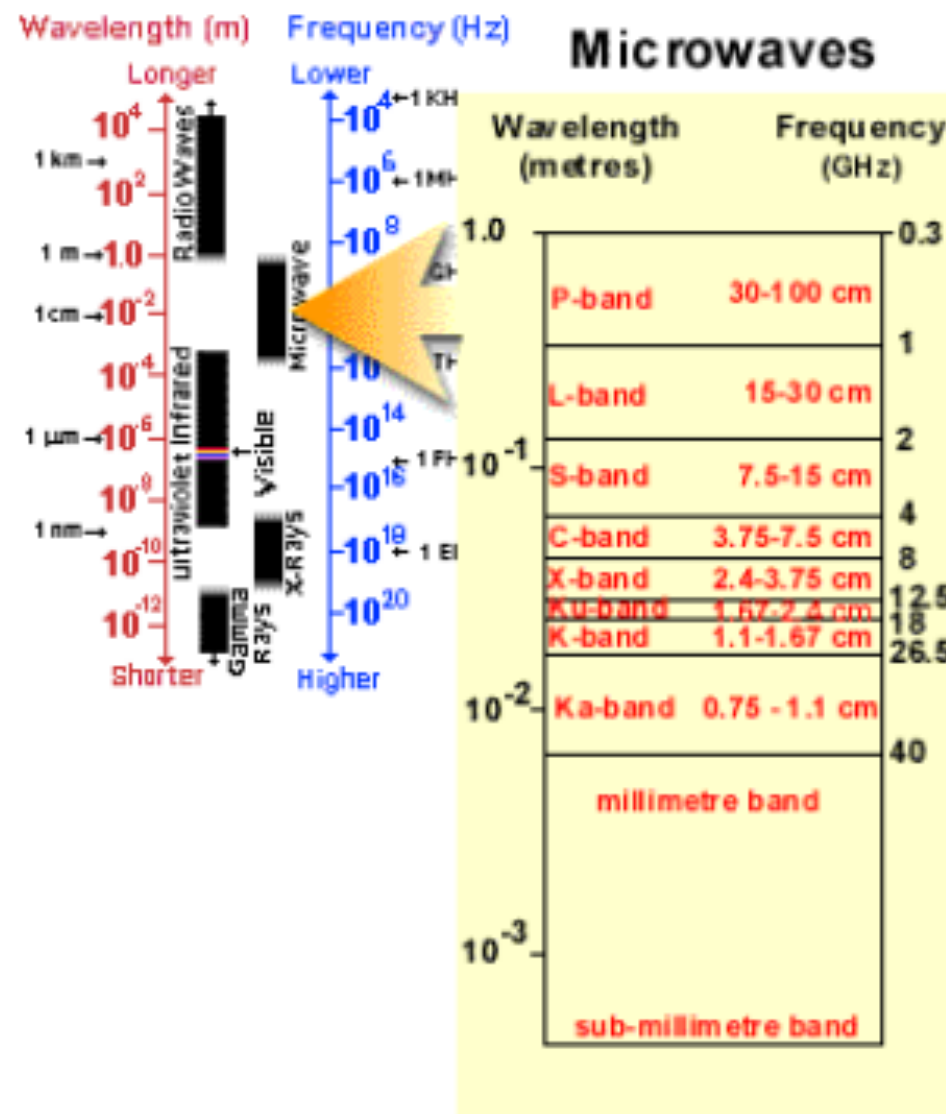


| ATBD # | Data products | Product leads | Resolution |
|------------------------|--|---|------------------------|
| L1A-2A | 1A: Raw waveforms, 2A: Ground elevation, canopy top height, relative height (RH) metrics | Michelle Hofton Bryan Blair | 25 m (~82 ft) diameter |
| L1B | Geolocated waveforms | Scott Luthcke Tim Rebold Taylor Thomas Teresa Pennington | 25 m (~82 ft) diameter |
| L2B | Canopy Cover Fraction (CCF), CCF profile, Leaf Area Index (LAI), LAI profile | Hao Tang John Armston | 25 m (~82 ft) diameter |
| L3 | Gridded Level 2 metrics | Scott Luthcke Terence Sabaka Sandra Preaux | 25 m (~82 ft) diameter |
| L4A | Footprint level above ground biomass | Jim Kellner Laura Duncanson John Armston | 25 m (~82 ft) diameter |
| L4B | Gridded Above Ground Biomass Density (AGBD) | Sean Healey Paul Patterson | 1 km (~0.6 mi) grid |
| Demonstrative products | Prognostic ecosystem model outputs | George Hurtt | Grid size: Variable |
| Demonstrative products | Enhanced height/biomass using fusion with TanDEM-X | Lola Fatoyinbo Seung-Kuk Lee | Grid size: Variable |
| Demonstrative products | Enhanced height/biomass and biomass change using fusion with Landsat | Matt Hansen Chenquan Huang | Grid size: Variable |
| Demonstrative products | Biodiversity/habitat model outputs | Scott Goetz Patrick Jantz Pat Burns | Grid size: Variable |

Remote Sensing Sensors



© CCRS / CCT



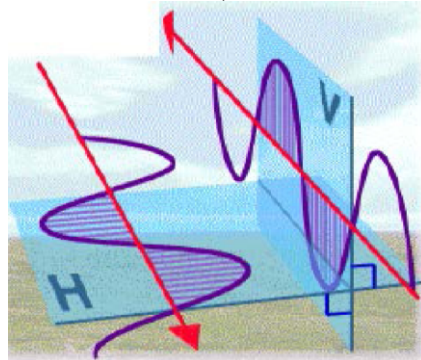


Radar frequencies and wavelength range used for remote sensing of land surfaces

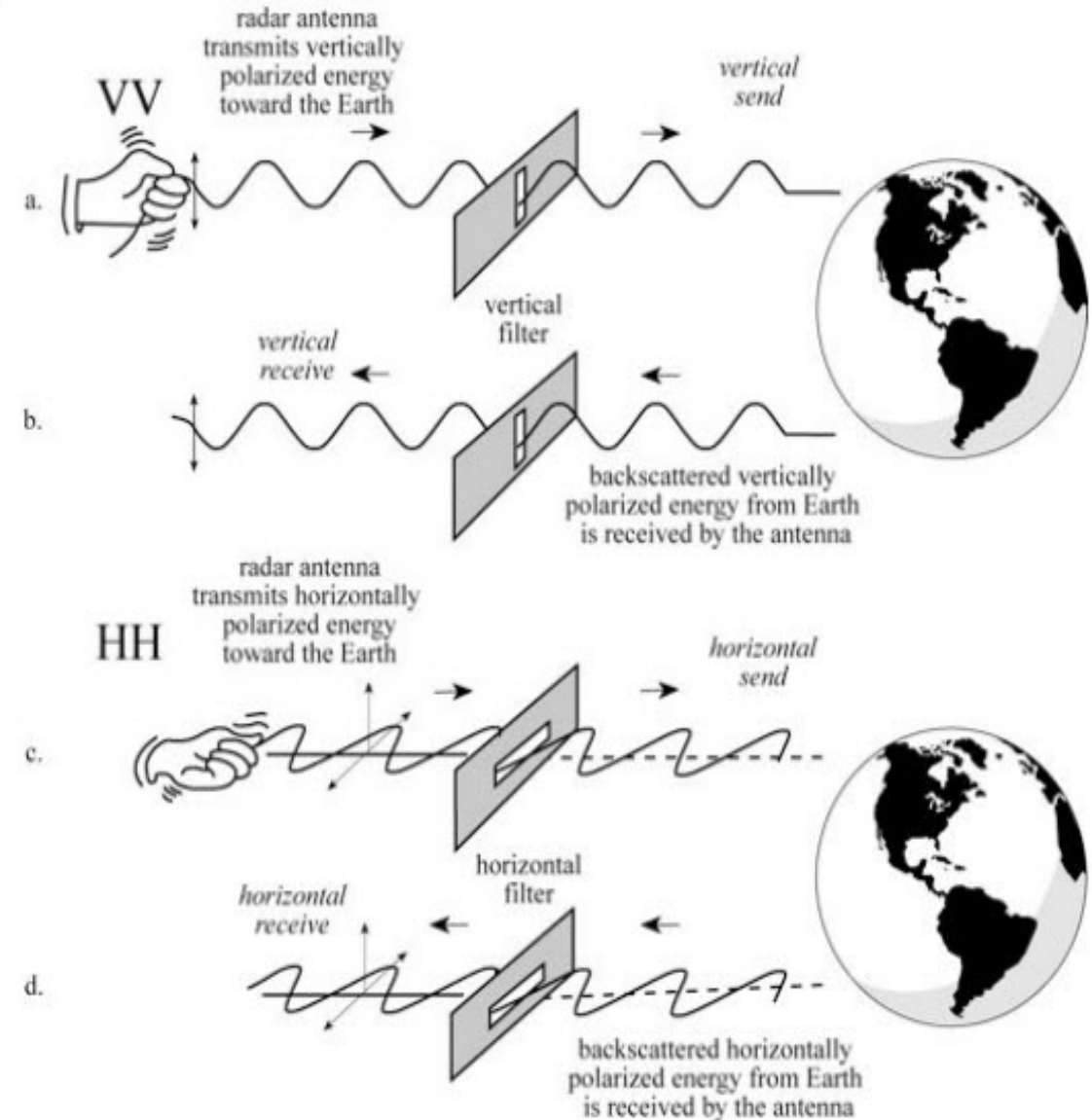
| Radar Band | Wavelengths | Frequency band | Typical use |
|------------|-------------------------------|----------------------------|---|
| P | 0.60cm to 1.2m | 250-500 MHz | Biomass |
| L | 15-30 cm | 1-2 GHz | Biomass, soil moisture and ground deformation |
| S | 8-15 cm | 2-4 GHz | Agriculture monitoring |
| C | 4-8 cm | 4-8 GHz | Ice, ocean, maritime navigation |
| X | 2.5-4 | 8-12 GHz | Ice and snow |
| Ku-Ka | 1.7-2.5 cm and 0.75-1.2 cm | 12-18 GHz and 27-40 GHz | Ice and snow, sea surface winds |

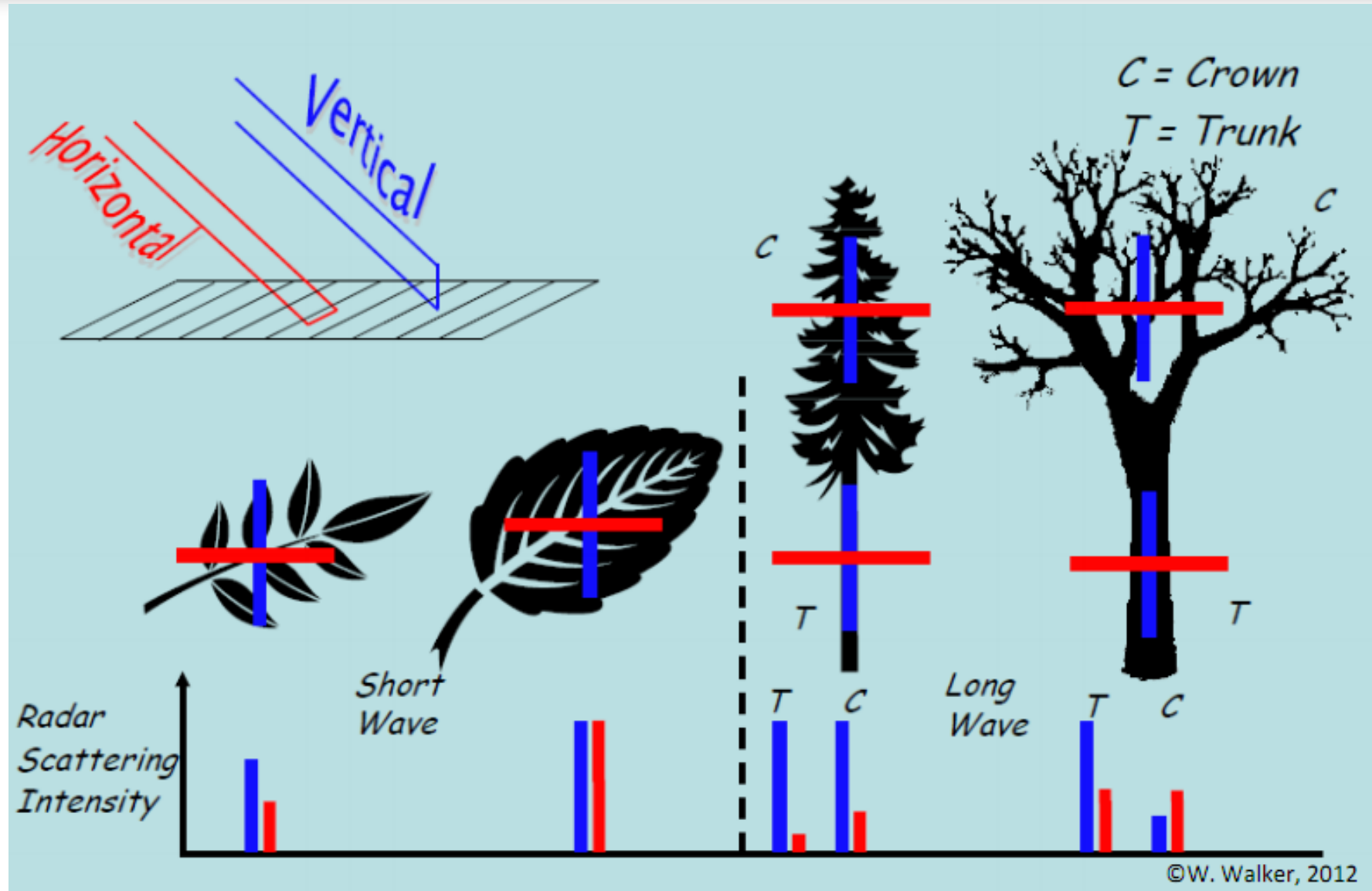
Polarization

Irrespective of wavelength, radar signals can transmit horizontal (H) or vertical (V) electric- field vectors, and receive either horizontal (H) or vertical (V) return signals, or both. The basic physical processes responsible for the like-polarised (HH or VV) return are quasi-specular surface reflection. For instance, calm water (i.e. without waves) appears black. The cross-polarised (HV or VH) return is usually weaker, and often associated with different reflections due to, for instance, surface roughness.

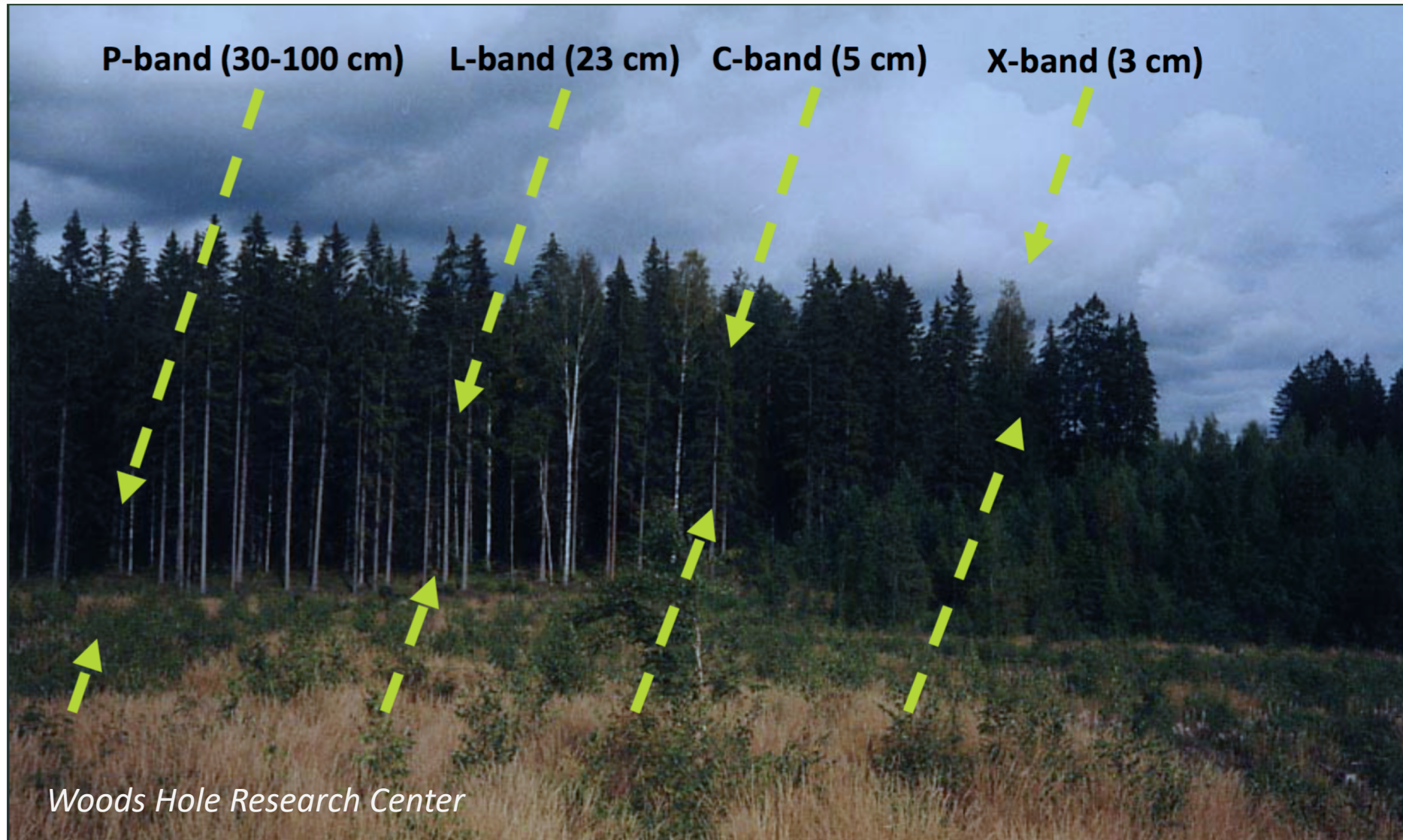


HH - for horizontal transmit and horizontal receive,
VV - for vertical transmit and vertical receive,
HV - for horizontal transmit and vertical receive,
VH - for vertical transmit and horizontal receive.





Radar Wavelength Interaction with Vegetation



Radar Wavelength Interaction with Vegetation

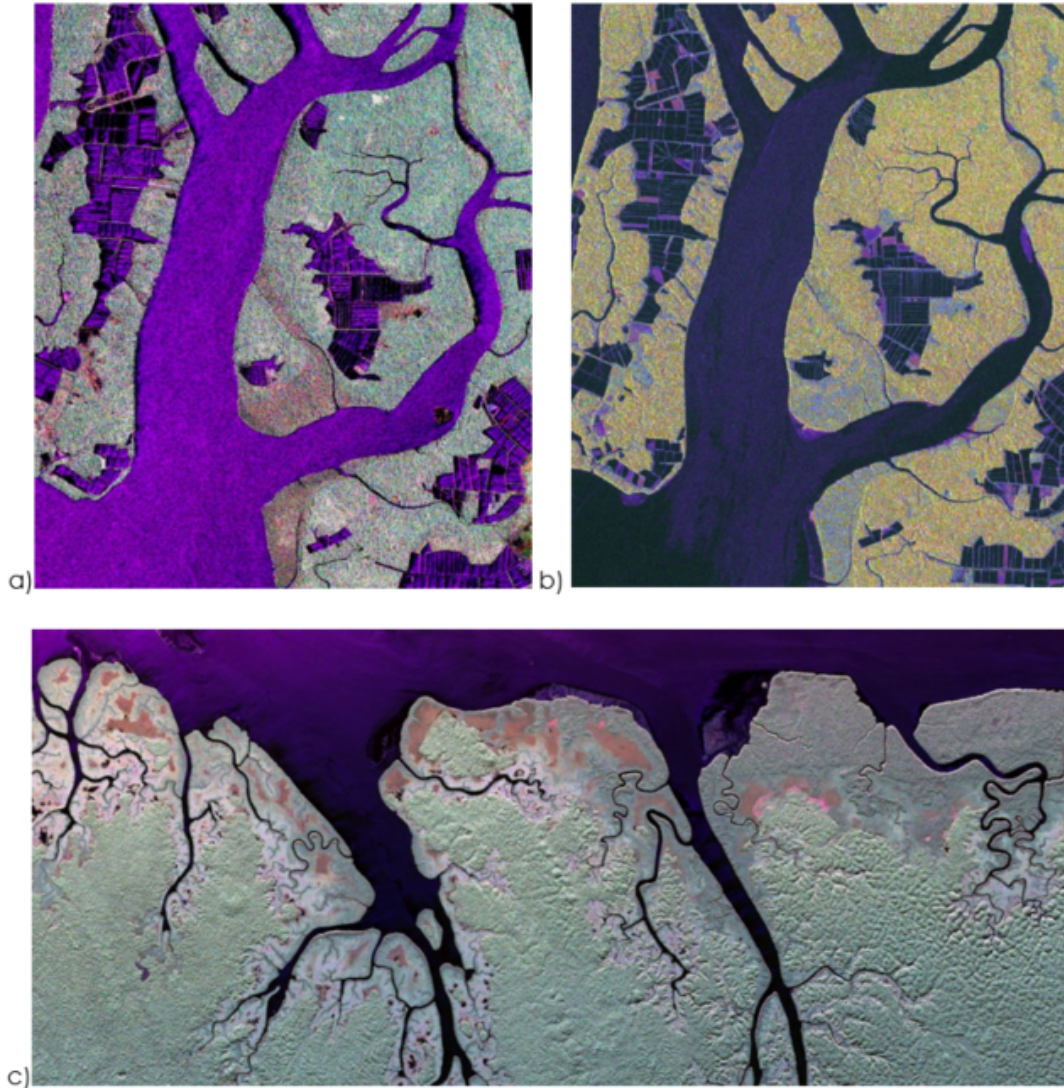


Figure: Color composite images of mangrove forests of the Guayas Estuary in Ecuador:

a) ALOS-PALSAR-1 HH, HV and VV in RGB respectively, and
b) Sentinel-1 VV, VH, VV in RGB respectively.

Volume scattering dominate at all polarization and at both L- and C-band.

Lower backscatter is observed for younger low density forest (<100t/ha) found along the coast at the bottom of the images.

c) A color composite (HH, HV, VV) of a 6m resolution L-band airborne (from UAVSAR) image show the distinct signature of mangrove forest whether tall (East) or short shrub forest (West).

Green indicates the dominance over HV in inland forest is more significant than in mangrove forest where all polarization configurations (HH, HV and VV)



Tea Break...!

Sources of Radar Remote Sensing Data

The Timeline of Past, Current, and Future SAR Sensors

The Legacy:



1978



SEASAT



'91-2011



ERS-1/2



'02-2012



ENVISAT



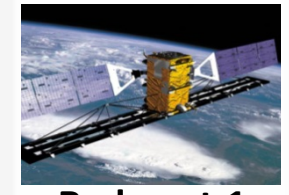
'02-2012



ALOS-1



'95-2013



Radarsat-1

The Now:



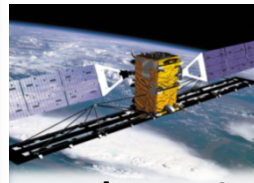
2007



TanDEM-X



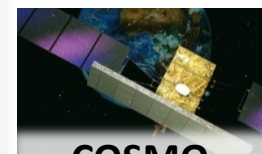
2007



Radarsat-2



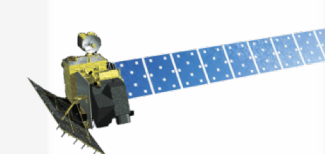
2007



COSMO-SkyMed



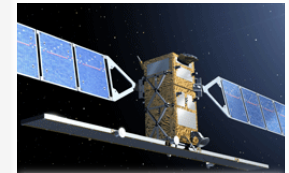
2014



ALOS-2



2014

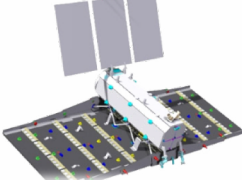


Sentinel-1

The Future:



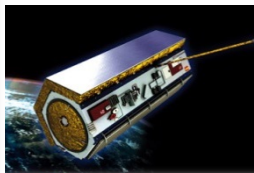
2018



SAOCOM



2018



PAZ SAR



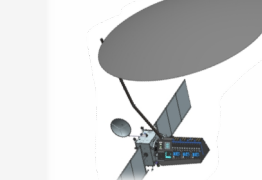
2018



RCM



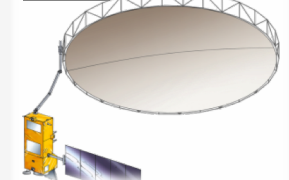
2021



NISAR



2021



BIOMASS

Sources of Radar Remote Sensing Data



| Platform/Instrument | Band | Where to get the data |
|----------------------------------|----------------------------------|--|
| JERS-1 | L-band | http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm |
| ALOS-1/PALSAR | L-band | http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm |
| ALOS-2/PALSAR | L-band | http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm |
| Sentinel-1A | C-band | https://scihub.copernicus.eu/dhus/#/home |
| Sentinel-1B | C-band | https://scihub.copernicus.eu/dhus/#/home |
| NASA's SRTM (NASADEM in 2019) | C-band DEM and | https://earthexplorer.usgs.gov/ or https://search.earthdata.nasa.gov/search?q=SRTMGL1%20V003 |
| DLR's SRTM | X-band DEM | https://centaurus.caf.dlr.de:8443/eoweb-ng/template/default/welcome/entryPage.vm |
| TanDEM-X | X-band DEM (from TerraSAR-X) | https://centaurus.caf.dlr.de:8443/eoweb-ng/template/default/welcome/entryPage.vm (as of June 2018, not yet freely available) |



- Install SNAP
- Install QGIS
- Explore data sources:
 - ❑ ALOS Mosaics - http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm
 - ❑ ALOS - <https://vertex.daac.asf.alaska.edu/>
 - ❑ Sentinel 1 - <https://scihub.copernicus.eu/dhus/#/home>

SNAP

SNAP bundles all ESA tools for the processing of Sentinel data (both SAR and optical)

Free and Open source

Download SNAP

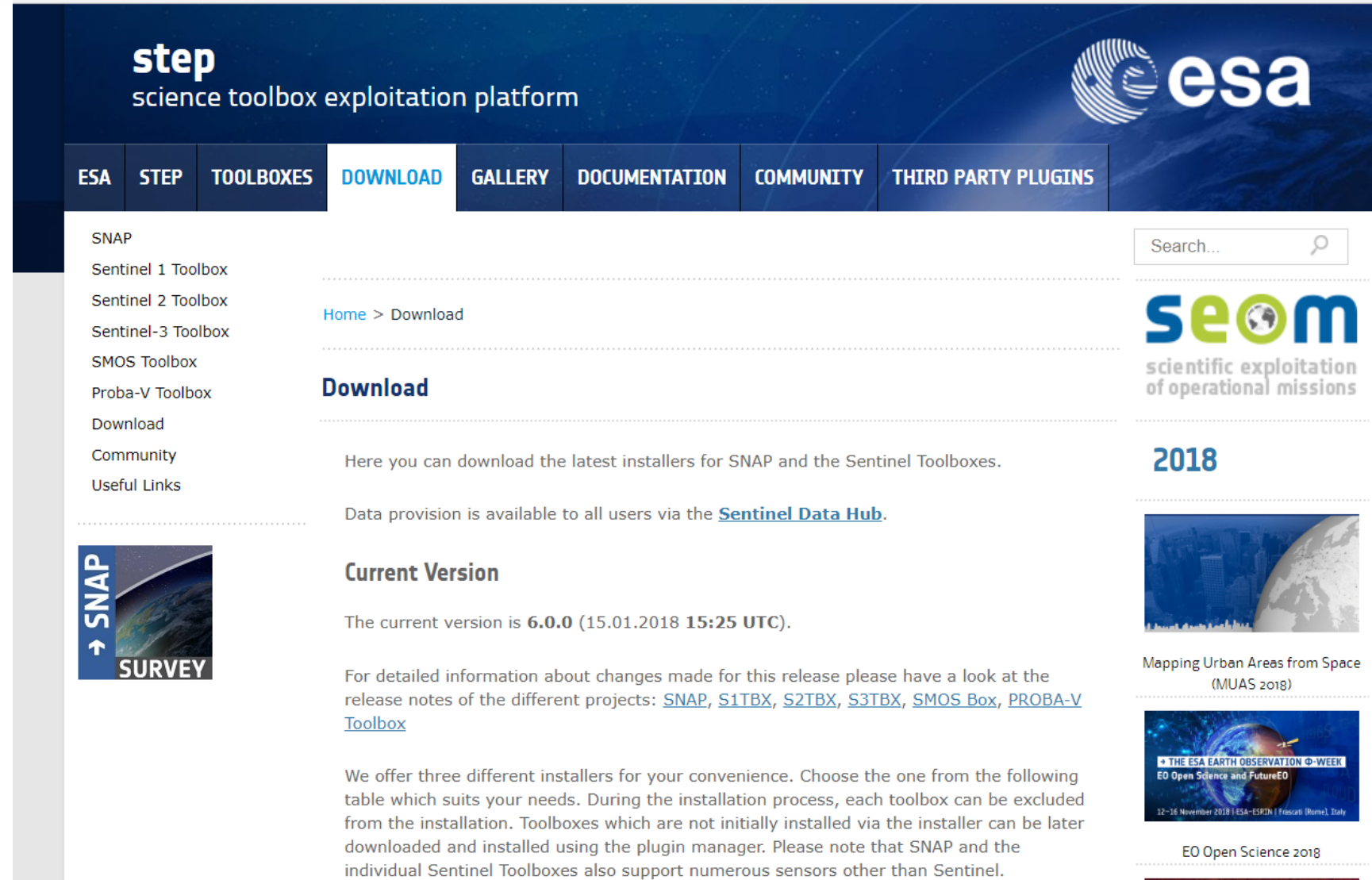
SNAP=Sentinel Application Platform

<http://step.esa.int/main/download/>

Read info:

<http://step.esa.int/main/toolboxes/snap/>, **STEP:** <http://step.esa.int/main/>

step.esa.int/main/download/



step
science toolbox exploitation platform

ESA STEP TOOLBOXES **DOWNLOAD** GALLERY DOCUMENTATION COMMUNITY THIRD PARTY PLUGINS

SNAP
Sentinel 1 Toolbox
Sentinel 2 Toolbox
Sentinel-3 Toolbox
SMOS Toolbox
Proba-V Toolbox
Download
Community
Useful Links

Home > Download

Download

Here you can download the latest installers for SNAP and the Sentinel Toolboxes.

Data provision is available to all users via the [Sentinel Data Hub](#).

Current Version

The current version is **6.0.0** (15.01.2018 15:25 UTC).

For detailed information about changes made for this release please have a look at the release notes of the different projects: [SNAP](#), [S1TBX](#), [S2TBX](#), [S3TBX](#), [SMOS Box](#), [PROBA-V Toolbox](#)

We offer three different installers for your convenience. Choose the one from the following table which suits your needs. During the installation process, each toolbox can be excluded from the installation. Toolboxes which are not initially installed via the installer can be later downloaded and installed using the plugin manager. Please note that SNAP and the individual Sentinel Toolboxes also support numerous sensors other than Sentinel.

Search...

seom
scientific exploitation of operational missions

2018

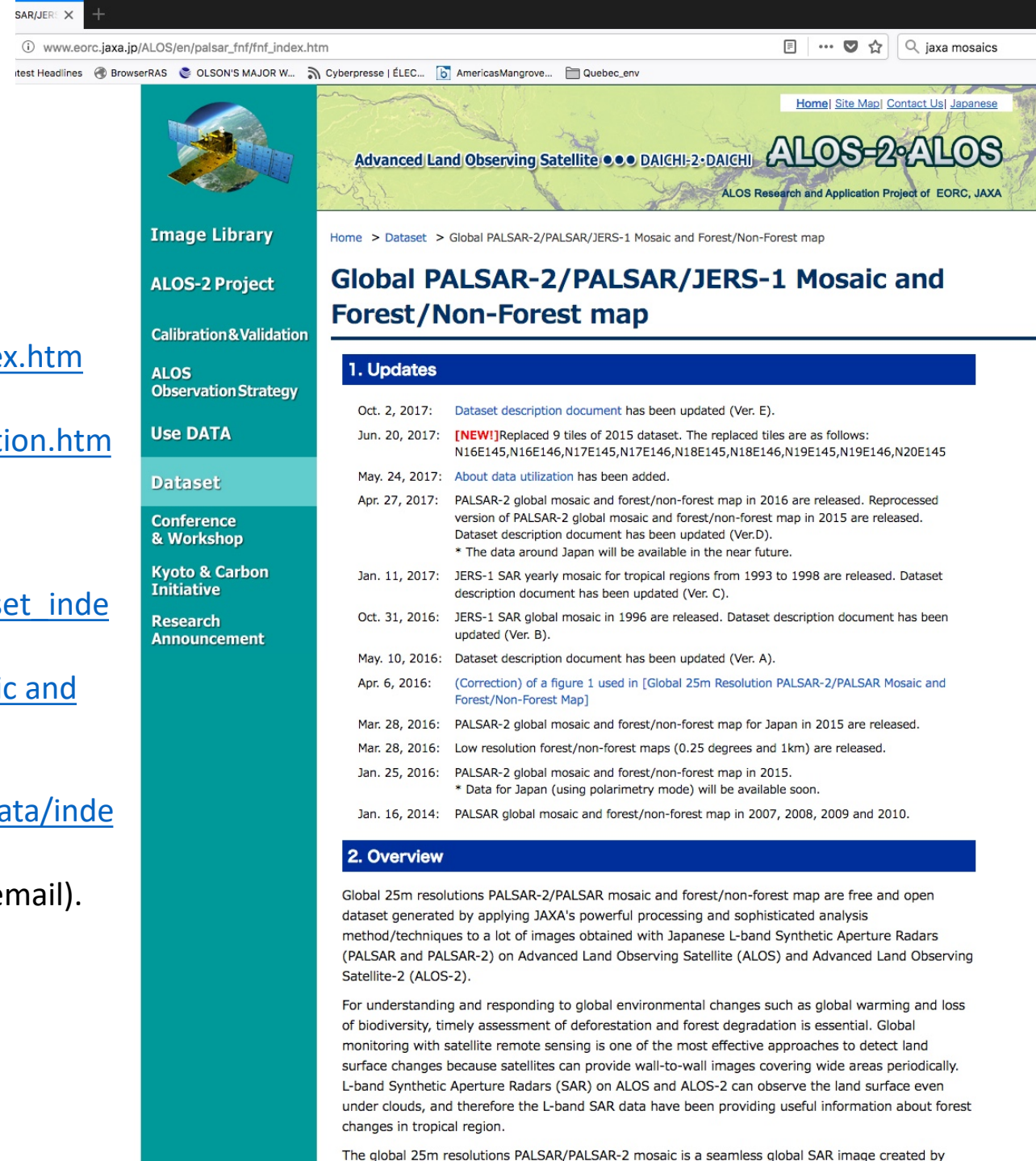
Mapping Urban Areas from Space (MUAS 2018)

THE ESA EARTH OBSERVATION WEEK
EO Open Science and FutureEO
12-16 November 2018 | ESA-ESRIN | Frascati (Rome), Italy

EO Open Science 2018

Download Data

1. Click here:
 - http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm
2. Scroll down to #4 “Download” and register:
 - http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/registration.htm
3. Follow instruction including confirming your email.
4. Once registered:
 1. Click on Dataset on the left hand side:
 - http://www.eorc.jaxa.jp/ALOS/en/dataset/dataset_index.htm
 - Click on “Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest/Non-Forest map”
 - Scroll down to “4.Download” and click on “http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/data/index.htm”
 - Enter username (email) and password (sent by email).



The screenshot shows a web browser window with the URL www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm. The page features a header with navigation links (Home, Site Map, Contact Us, Japanese) and a banner for the ALOS-2/ALOS project. A left sidebar contains a menu with items like Image Library, ALOS-2 Project, Calibration&Validation, ALOS Observation Strategy, Use DATA, Dataset, Conference & Workshop, Kyoto & Carbon Initiative, and Research Announcement. The main content area is titled "Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest/Non-Forest map" and includes a "1. Updates" section with a list of recent dataset updates and their descriptions. A "2. Overview" section is also visible at the bottom.

Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest/Non-Forest map

1. Updates

- Oct. 2, 2017: Dataset description document has been updated (Ver. E).
- Jun. 20, 2017: **[NEW!]** Replaced 9 tiles of 2015 dataset. The replaced tiles are as follows: N16E145, N16E146, N17E145, N17E146, N18E145, N18E146, N19E145, N19E146, N20E145
- May. 24, 2017: About data utilization has been added.
- Apr. 27, 2017: PALSAR-2 global mosaic and forest/non-forest map in 2016 are released. Reprocessed version of PALSAR-2 global mosaic and forest/non-forest map in 2015 are released. Dataset description document has been updated (Ver.D).
* The data around Japan will be available in the near future.
- Jan. 11, 2017: JERS-1 SAR yearly mosaic for tropical regions from 1993 to 1998 are released. Dataset description document has been updated (Ver. C).
- Oct. 31, 2016: JERS-1 SAR global mosaic in 1996 are released. Dataset description document has been updated (Ver. B).
- May. 10, 2016: Dataset description document has been updated (Ver. A).
- Apr. 6, 2016: (Correction) of a figure 1 used in [Global 25m Resolution PALSAR-2/PALSAR Mosaic and Forest/Non-Forest Map]
- Mar. 28, 2016: PALSAR-2 global mosaic and forest/non-forest map for Japan in 2015 are released.
- Mar. 28, 2016: Low resolution forest/non-forest maps (0.25 degrees and 1km) are released.
- Jan. 25, 2016: PALSAR-2 global mosaic and forest/non-forest map in 2015.
* Data for Japan (using polarimetry mode) will be available soon.
- Jan. 16, 2014: PALSAR global mosaic and forest/non-forest map in 2007, 2008, 2009 and 2010.

2. Overview

Global 25m resolutions PALSAR-2/PALSAR mosaic and forest/non-forest map are free and open dataset generated by applying JAXA's powerful processing and sophisticated analysis method/techniques to a lot of images obtained with Japanese L-band Synthetic Aperture Radars (PALSAR and PALSAR-2) on Advanced Land Observing Satellite (ALOS) and Advanced Land Observing Satellite-2 (ALOS-2).

For understanding and responding to global environmental changes such as global warming and loss of biodiversity, timely assessment of deforestation and forest degradation is essential. Global monitoring with satellite remote sensing is one of the most effective approaches to detect land surface changes because satellites can provide wall-to-wall images covering wide areas periodically. L-band Synthetic Aperture Radars (SAR) on ALOS and ALOS-2 can observe the land surface even under clouds, and therefore the L-band SAR data have been providing useful information about forest changes in tropical region.

The global 25m resolutions PALSAR/PALSAR-2 mosaic is a seamless global SAR image created by

Jaxa Mosaics

- JERS-1 is a L-band HH-only instrument. Global mosaic only available for 1996
- For PALSAR, JAXA plans on generating yearly mosaics.
 - PALSAR mosaics are available for 2007, 2008, 2009 and 2010
 - PALSAR-2 mosaics are available for 2015, 2016, 2017 and soon 2018.
- Click on PALSAR 2007 for example.

Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest/Non-Forest map

ALOS Home > about PALSAR-2/PALSAR Global Forest / Non-forest Map > Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest / Non-forest Map

Global PALSAR-2/PALSAR/JERS-1 Mosaic and Forest / Non-forest Map

• These map uses Javascript. Please enable JavaScript on your browser.

25m resolution product

Global

- JERS-1 SAR Mosaic:
>> 1996
- PALSAR/PALSAR-2 mosaic and forest/non-forest (FNF) map:
>> 2007 >> 2008 >> 2009 >> 2010 >> 2015
>> 2016 >> 2017

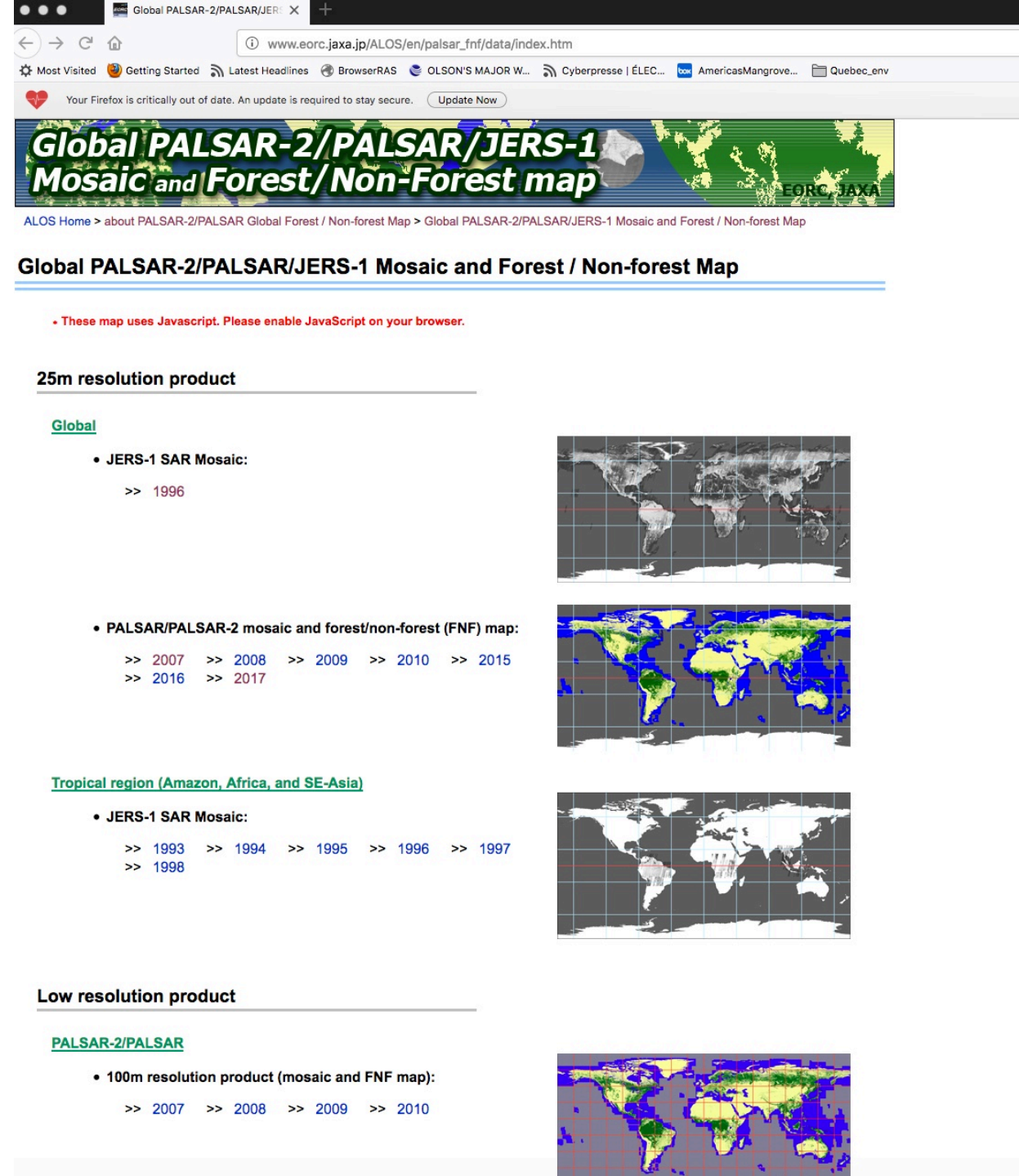
Tropical region (Amazon, Africa, and SE-Asia)

- JERS-1 SAR Mosaic:
>> 1993 >> 1994 >> 1995 >> 1996 >> 1997
>> 1998

Low resolution product

PALSAR-2/PALSAR

- 100m resolution product (mosaic and FNF map):
>> 2007 >> 2008 >> 2009 >> 2010



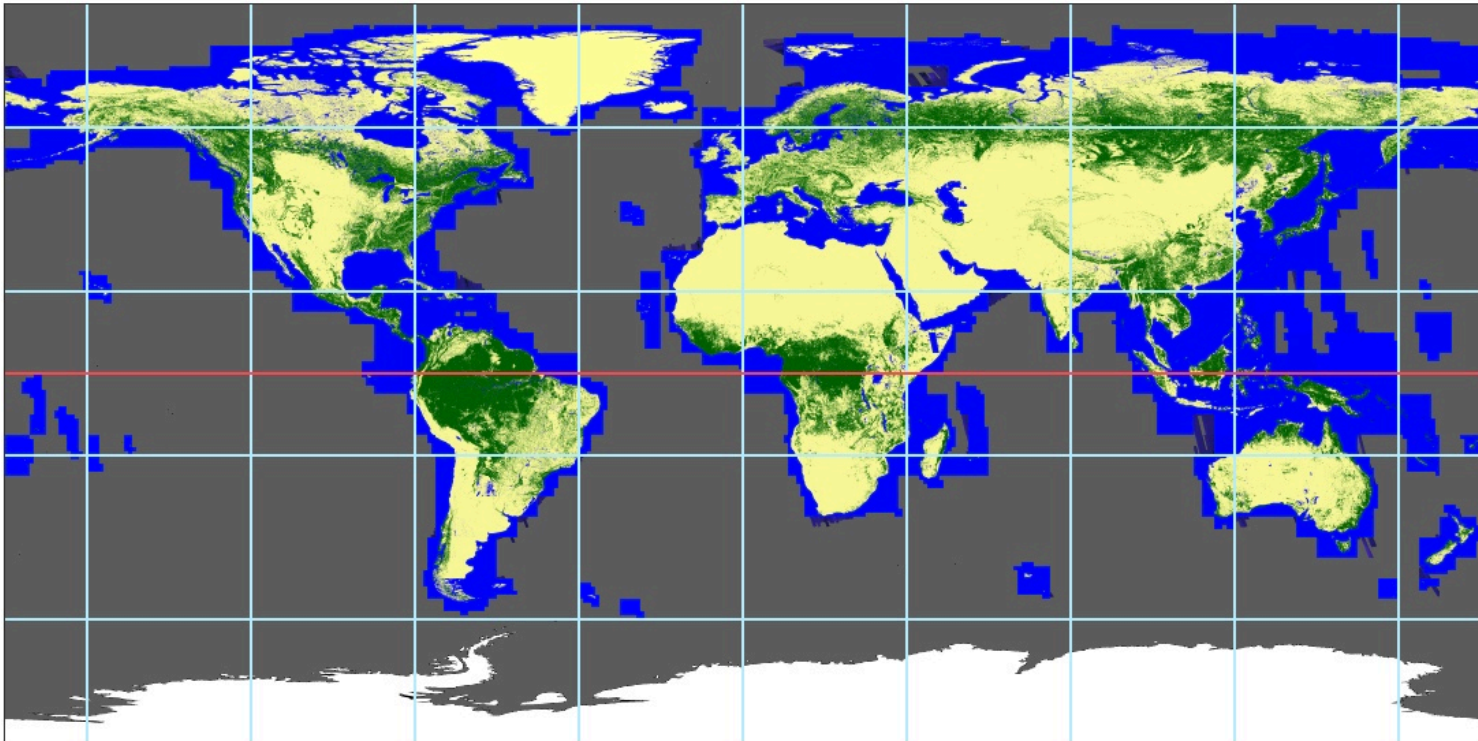
Example: ALOS/PALSAR-1 Mosaic 2007

- Click on your favorite region.
- Example in this workshop: Kenya's coast
- Click until you end-up at the desired location.
- Note all mosaic grid-cells are 1°x1°.

PALSAR Global Forest / Non-forest Map "2007"

>> 2017 >> 2016 >> 2015 >> 2010 >> 2009 >> 2008

Please click the area which downloads a mosaic.

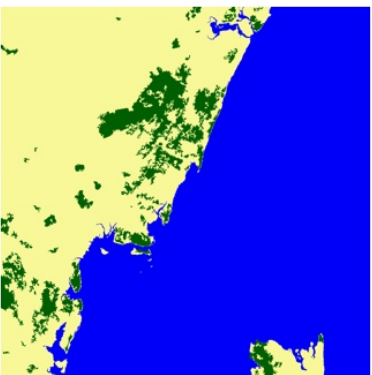
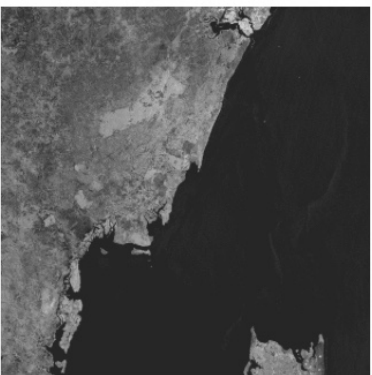
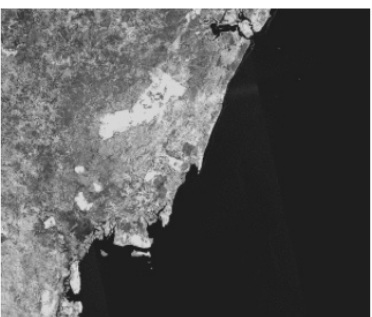


Earth Observation Research Center
Copyright©1997- JAXA EORC All rights reserved.

JAXA

Download 1 degree cell.

- For PALSAR-1 and PALSAR-2, there are 3 mosaics:
 - FNF=Forest vs Non-Forest map (M. Shimada, T. Itoh, T. Motooka, M. Watanabe, T. Shiraishi, R. **Thapa**, and R. Lucas, “New global forest/non-forest maps from ALOS PALSAR data (2007-2010),” *Remote Sens. Environ.*, vol. 155, pp. 13–31, 2014.)
 - HH. Mosaic of Horizontal-transmit and Horizontal-receive polarization. Sensitive to both volume and surface. Excellent for monitoring wetlands, forest-inundations, urban infrastructure and expansion.
 - HV. Mosaic of Horizontal-transmit and Vertical-receive polarization. Sensitive to volumes such as vegetation density. Excellent to distinguish and monitor forests.
- Download file by clicking on “DownLoad”. The file will automatically download to computer (zipped file for HH and HV is about 65MB)
- Unzip files. They are in ENVI format that can be opened in ENVI or QGIS. You can also use `gdal_translate` to convert in any format.

| S04E039_2007 | | | |
|--------------|------|---|--------------------------|
| Year | Type | Image | Download |
| 2007 | FNF |  | Download |
| | HH |  | Download |
| | HV |  | Download |

Download raw ALOS/PALSAR-1 data

- Go to the Aalska Satellite Facility Vertex interface: <https://vertex.daac.asf.alaska.edu/>
- Click on “Geographic Search”
- Follow interactive instructions steps.
- Then click on top right “Earthdata Login” to register (free)
 - Follow instructions and email receipt
- Go back to:
 - <https://vertex.daac.asf.alaska.edu/>
 - Log in.
- Use mouse cursor to top left corner of your favorite site, click and take cursor to the bottom right corner of your site, and click again. A box will be drawn on your site. These coordinates will be written automatically in the “Geographic Region” tab.
- Enter range of dates for which you seek data.
 - For PALSAR-1, it should include dates between 2007 and 2010.
- The “Path” and “Frame” are optional.
- Click “Search” at the bottom.

The screenshot displays the Vertex: ASF's Data Portal website. The main navigation bar includes 'Vertex', 'Interactive Tours', 'Help', and 'ASF Home'. The 'Geospatial' tab is active, showing options for 'Geographic Region', 'Granule', and 'Missions'. The 'Geographic Region' section provides instructions for selecting a region on a map or by coordinates. The 'Date' section allows for seasonal or specific date range searches. The 'Dataset' section lists various satellite datasets, including Sentinel-1B, Sentinel-1A, SMAP, UAVSAR, ALOS PALSAR, RADARSAT-1, ERS-2, JERS-1, ERS-1, AIRSAR, and SEASAT. The 'Path & Frame' section offers optional search criteria. A world map is displayed on the right, with a search box and a legend for the number of frames. The bottom of the page features a color-coded legend for the number of frames: 1 (blue), 2-5 (green), 6-10 (yellow), 11-20 (orange), and 21+ (red).

Vertex: ASF's Data Portal

Vertex is the Alaska Satellite Facility's data portal for remotely sensed imagery of the Earth.

Geospatial Granule Missions

Geographic Region

Option 1: Click on map and move cursor

Option 2: Enter coordinates:

e.g., -102.37.59,-94.37,-94.39,-102.39,-102.37.59
Counterclockwise, decimal degrees, (long,lat)

Date

Seasonal Search

Start Date (yyyy-mm-dd)

1978-01-01

End Date (yyyy-mm-dd)

2018-08-20

Dataset

Select: All | None

| Dataset | Info |
|---|-----------|
| <input checked="" type="checkbox"/> Sentinel-1B | 2016-now |
| <input checked="" type="checkbox"/> Sentinel-1A | 2014-now |
| <input type="checkbox"/> SMAP | 2015-now |
| <input type="checkbox"/> UAVSAR | 2008-now |
| <input type="checkbox"/> ALOS PALSAR | 2006-2011 |
| <input type="checkbox"/> RADARSAT-1 | 1995-2008 |
| <input type="checkbox"/> ERS-2 | 1995-2011 |
| <input type="checkbox"/> JERS-1 | 1992-1998 |
| <input type="checkbox"/> ERS-1 | 1991-1997 |
| <input type="checkbox"/> AIRSAR | 1990-2004 |
| <input type="checkbox"/> SEASAT | 1978-1978 |

Path & Frame (optional)

Path Start End

Frame Start End

☐ Omit Geographic Region from search

World Map South Polar

Satellite Map

Please use the map and/or the search parameters on the left to select your search criteria.

EARTHDATA LOGIN

UAF ALASKA SATELLITE FACILITY

Google

Imagery ©2018 NASA, TerraMetrics Terms of Use

Number of Frames

1 2-5 6-10 11-20 21+

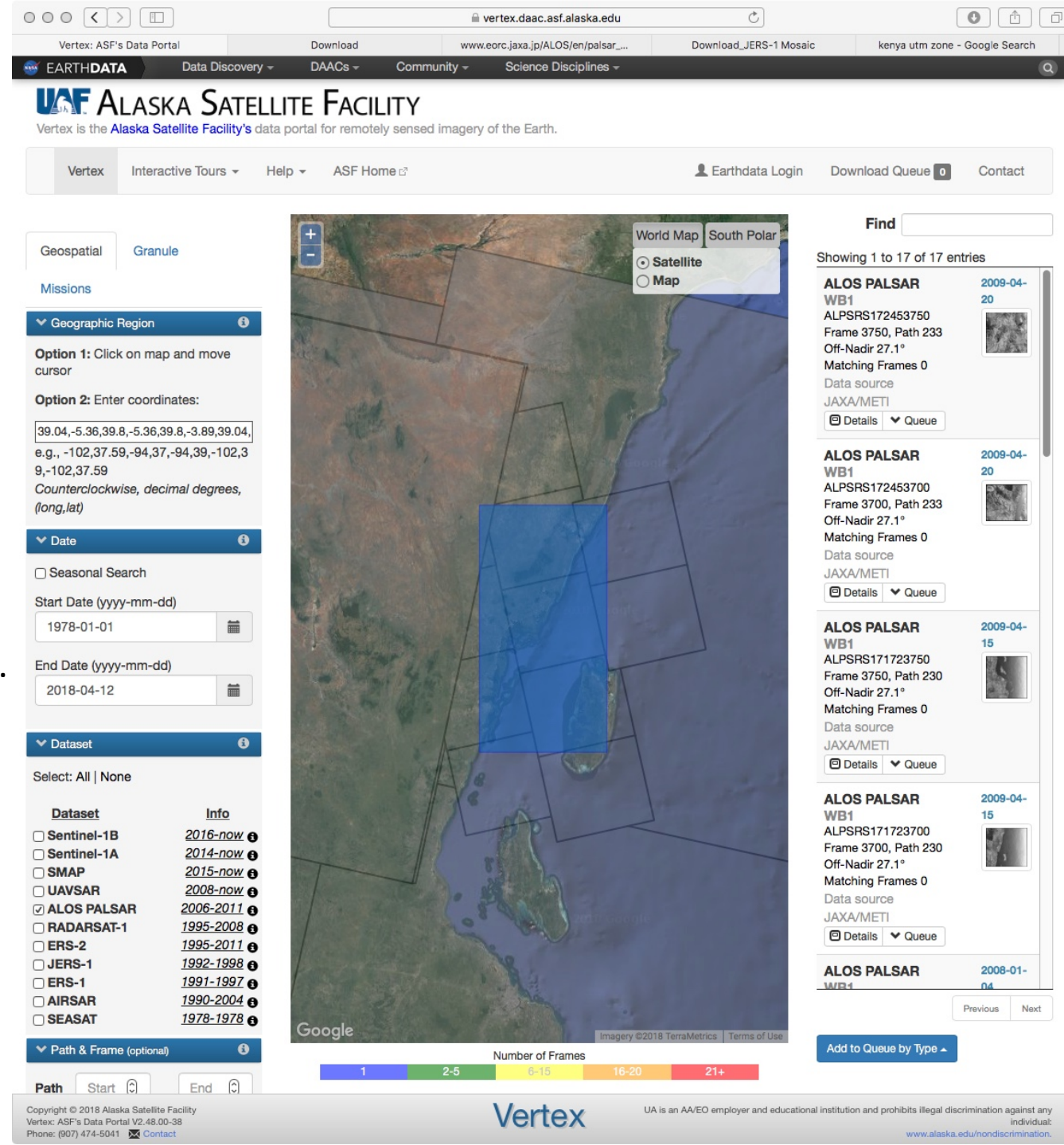
Select data

1. A list of files will appear on the right with browse images (i.e. low-resolution thumbnail)
2. Files with different imaging modes will be available.
 1. “WB1” is (ScanSAR) Wide-Beam #1,
 2. PLR is fully polarimetric dataset with HH, HV and VV
 3. FBD is Fine-Beam Dual polarization including HH and HV.
 4. FBS is Fine-Beam Single polarization (HH).
3. In our example, high resolution ascending-orbit images are available, along with WB1 descending-orbit images. Ascending and descending mean the targets are seen from the West and East respectively.

| | WB | FBD | FBS | PLR |
|-----------------|------------------|-------|-------|-------|
| Swath | 240km | 70km | 70km | 30km |
| Resolution | 100m | 20m | 10m | 30m |
| Incidence angle | 18-43° (27.1) | 34.3° | 34.3° | 21.5° |

Hint: Long 39.182111, lat -5.0220668

Path: 233, Frame: 3750



Vertex: ASF's Data Portal

Download www.eorc.jaxa.jp/ALOS/en/palsar... Download_JERS-1 Mosaic kenya utm zone - Google Search

EARTHDATA Data Discovery DAACs Community Science Disciplines

ALASKA SATELLITE FACILITY

Vertex is the Alaska Satellite Facility's data portal for remotely sensed imagery of the Earth.

Vertex Interactive Tours Help ASF Home

Earthdata Login Download Queue 0 Contact

Geospatial Granule

Missions

Geographic Region

Option 1: Click on map and move cursor

Option 2: Enter coordinates:

39.04,-5.36,39.8,-5.36,39.8,-3.89,39.04, e.g., -102,37.59,-94,37,-94,39,-102,39,-102,37.59 Counterclockwise, decimal degrees, (long,lat)

Date

Seasonal Search

Start Date (yyyy-mm-dd) 1978-01-01

End Date (yyyy-mm-dd) 2018-04-12

Dataset

Select: All | None

Dataset Info

☐ Sentinel-1B 2016-now

☐ Sentinel-1A 2014-now

☐ SMAP 2015-now

☐ UAVSAR 2008-now

☒ ALOS PALSAR 2006-2011

☐ RADARSAT-1 1995-2008

☐ ERS-2 1995-2011

☐ JERS-1 1992-1998

☐ ERS-1 1991-1997

☐ AIRSAR 1990-2004

☐ SEASAT 1978-1978

Path & Frame (optional)

Path Start End

Number of Frames

1 2-5 6-15 16-20 21+

Find

Showing 1 to 17 of 17 entries

ALOS PALSAR WB1 2009-04-20

ALPSRS172453750

Frame 3750, Path 233

Off-Nadir 27.1°

Matching Frames 0

Data source JAXA/METI

Details Queue

ALOS PALSAR WB1 2009-04-20

ALPSRS172453700

Frame 3700, Path 233

Off-Nadir 27.1°

Matching Frames 0

Data source JAXA/METI

Details Queue

ALOS PALSAR WB1 2009-04-15

ALPSRS171723750

Frame 3750, Path 230

Off-Nadir 27.1°

Matching Frames 0

Data source JAXA/METI

Details Queue

ALOS PALSAR WB1 2009-04-15

ALPSRS171723700

Frame 3700, Path 230

Off-Nadir 27.1°

Matching Frames 0

Data source JAXA/METI

Details Queue

ALOS PALSAR WB1 2008-01-04

Previous Next

Add to Queue by Type

Copyright © 2018 Alaska Satellite Facility

Vertex: ASF's Data Portal V2.48.00-38

Phone: (907) 474-5041 Contact

Vertex

UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual.

www.alaska.edu/nondiscrimination.

Select data



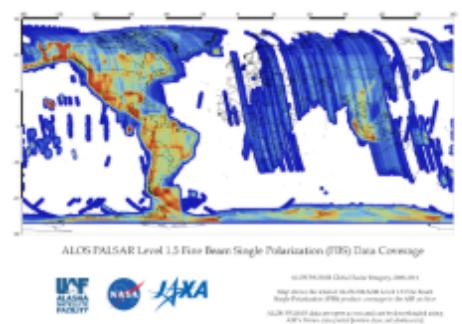
- Click on “Details” if you want information on available images
- Click on “Queue” to add them to the queue for download:
 - A drop down menu will appear with a choice of Level 1.0, 1.1, 1.5, or radiometrically terrain-corrected (RTC). This choice depends on mode. Try it out.

| | 1.0 | 1.1 | 1.5 | RTC |
|-----------------------|-------------------|---|--|---------------|
| Geographic projection | Radar (SLC) | Radar (SLC) | Geographic | geographic |
| Radiometric format | Single look pixel | Equally spaced single look pixel in radar coordinates | Multilook and calibrated but with topographic features. Data equally spaced on ground. | Science-ready |

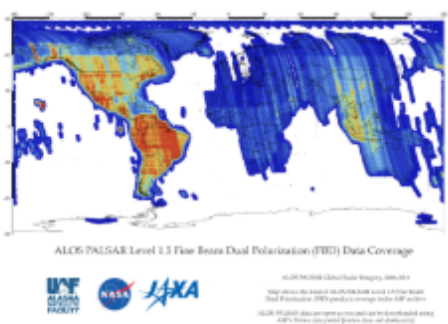
The screenshot displays the Alaska Satellite Facility (ASF) Vertex data portal. The main map shows Alaska with a blue selection box. The left sidebar contains filters for Geographic Region, Date, and Dataset. The Dataset filter shows 'ALOS PALSAR' selected. The right sidebar shows search results for 'ALOS PALSAR' with details like frame numbers and data sources. At the bottom, there is a 'Number of Frames' legend and a 'Vertex' logo.

Data coverage by processing level

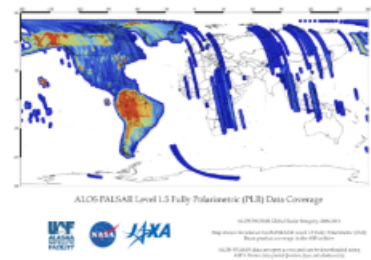
- To see if a given processing level is available at your site, click on <https://www.asf.alaska.edu/sar-data/palsar/alos-acquisition-maps/>



ALOS L1.5 FBS Coverage Map



ALOS L1.5 FBD Coverage Map



ALOS L1.5 Polarimetric Coverage Map



ASAR Datasets / ALOS PALSAR / AL...

Download

www.eorc.jaxa.jp/ALOS/en/palsar_...

Download_JERS-1 Mosaic

kenya utm zone - Google Search

+

ALASKA SATELLITE FACILITY

Making remote-sensing data accessible since 1991

Home

Get Started

Get Data

Datasets

Data Tools

Tutorials

About ASF

Search...

/ SAR Datasets / ALOS PALSAR / ALOS Coverage Maps

ALOS PALSAR

About ALOS PALSAR

Terrain Corrected (RTC)

Get Data

Documents & Tools

ALOS Coverage Maps

Terms & Conditions

How to Cite

Sentinel-1

AIRSAR

ERS-1

ERS-2

InSAR

JERS-1

RADARSAT-1

Sea Ice MEaSURES

Seasat

SMAP

Terrestrial Ecology

UAVSAR

Wetlands MEaSURES

Feedback

ALOS L1.5 FBS Coverage Map

ALOS L1.5 FBD Coverage Map

ALOS L1.5 Wide Beam Coverage Map

ALOS L1.5 Polarimetric Coverage Map

ALOS L1.1 Coverage Map

ALOS RTC Coverage Map

ALASKA SATELLITE FACILITY

The Alaska Satellite Facility downlinks, processes, archives, and distributes remote-sensing data to scientific users around the world. ASF's mission is to make remote-sensing data accessible.

About Us

Contact Info

Social Networks

2156 Koyukuk Drive
Fairbanks, AK 99775

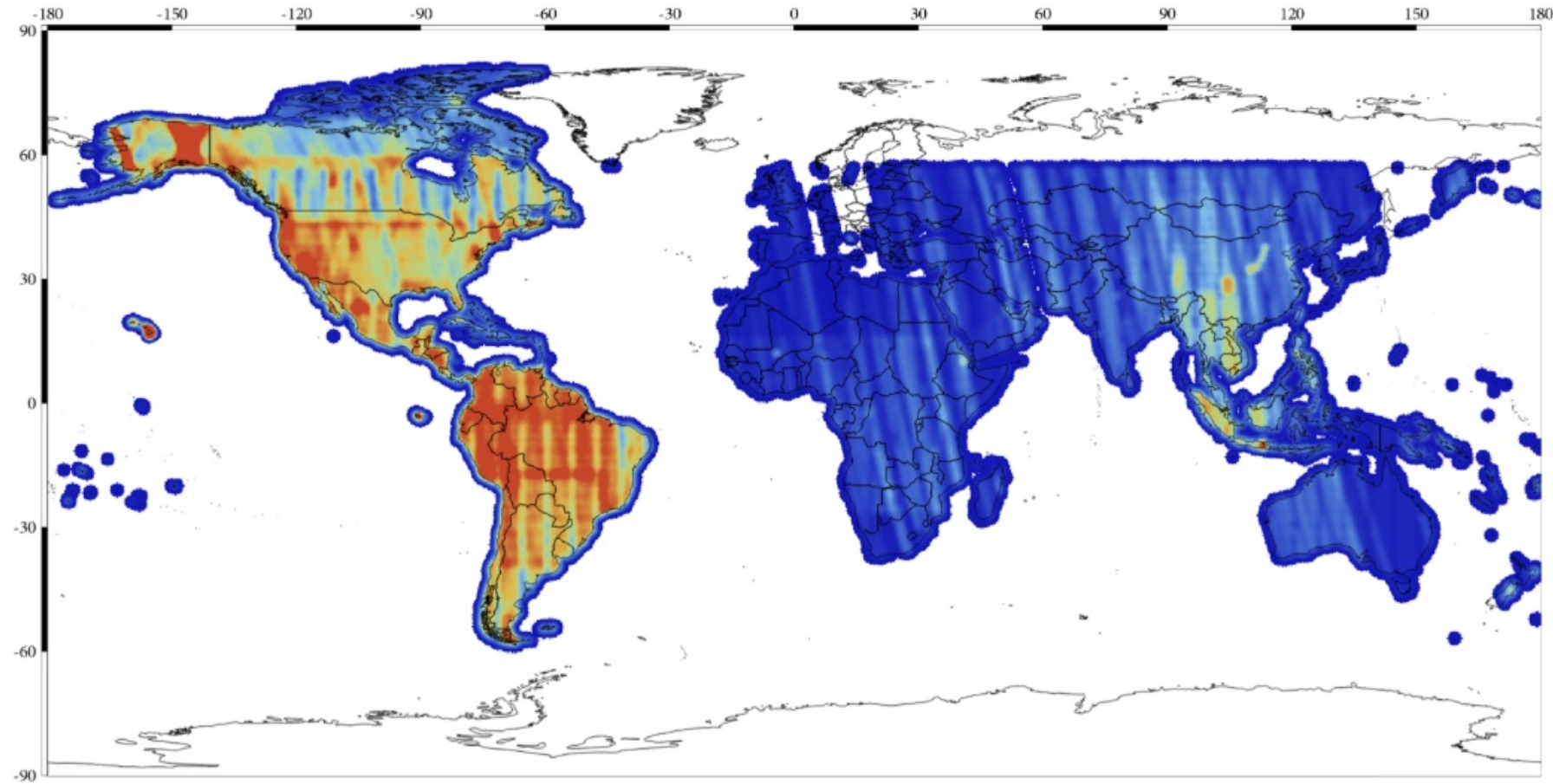
(907) 474-5041

Contact Us

Like 151

Tweet

Example of processed RTC data (by ASF): colors indicate the number of available processed scenes



ALOS PALSAR Radiometric Terrain Correction (RTC) Data Coverage

<https://www.asf.alaska.edu/sar-data/palsar/alos-acquisition-maps/>

ALOS PALSAR Global Radar Imagery, 2006-2011

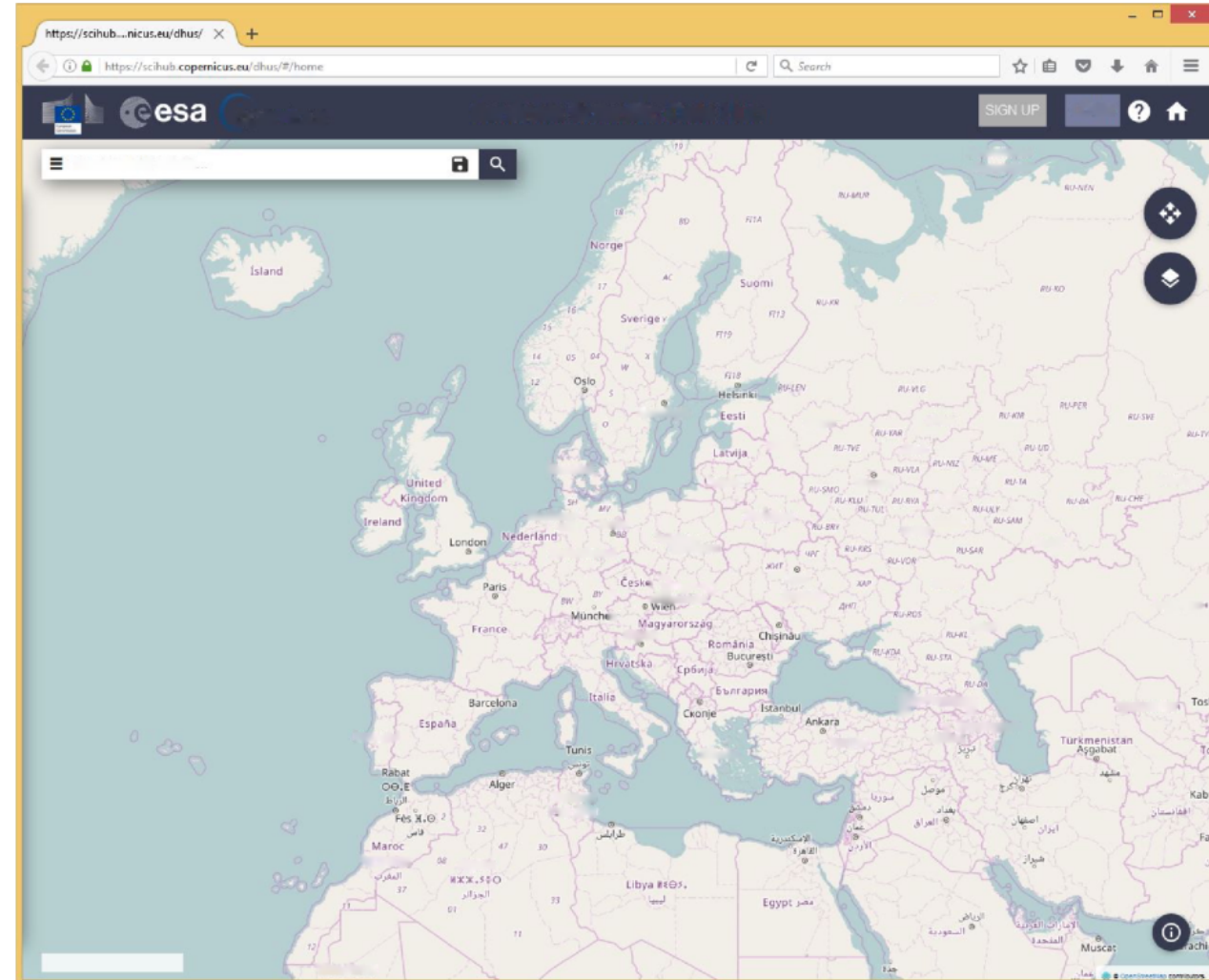
Map shows the total of ALOS PALSAR Radiometric Terrain Correction (RTC) product coverage in the ASF archive

ALOS-PALSAR data are open access and can be downloaded using ASF's Vertex data portal [vertex.daac.asf.alaska.edu]

Access and Download of Sentinel-1

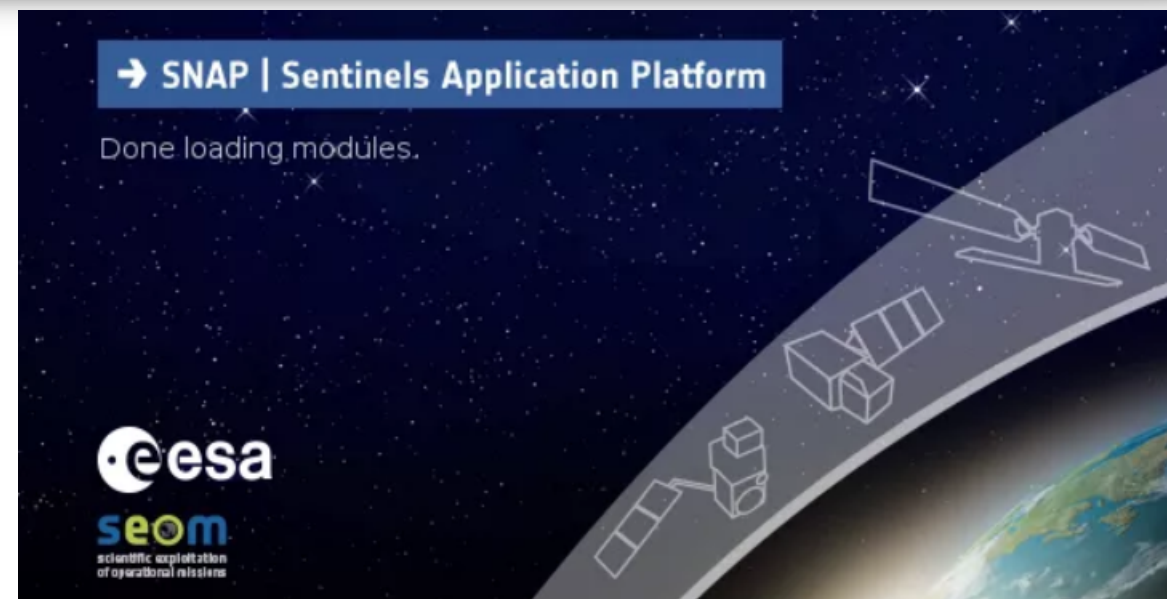
<https://scihub.copernicus.eu/dhus/#/home>

- Free access to the full Sentinel archive (1,2, and 3)
- The archive can be filtered spatially and/or based on several
- Results are displayed as entries in the result list and as footprints on the map



Data processing

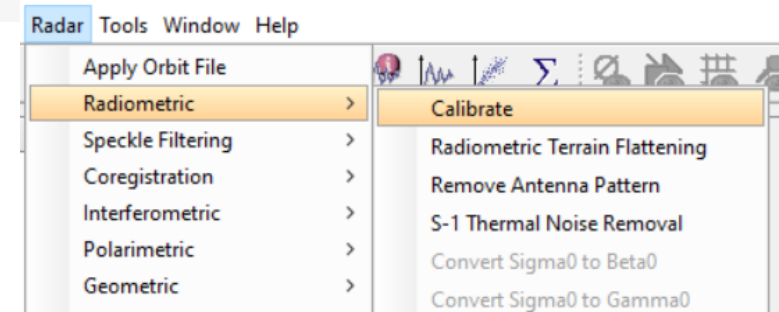
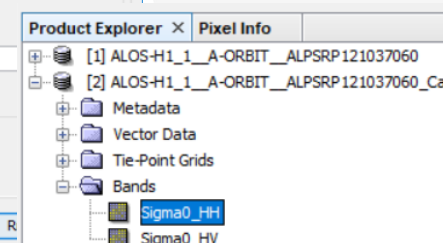
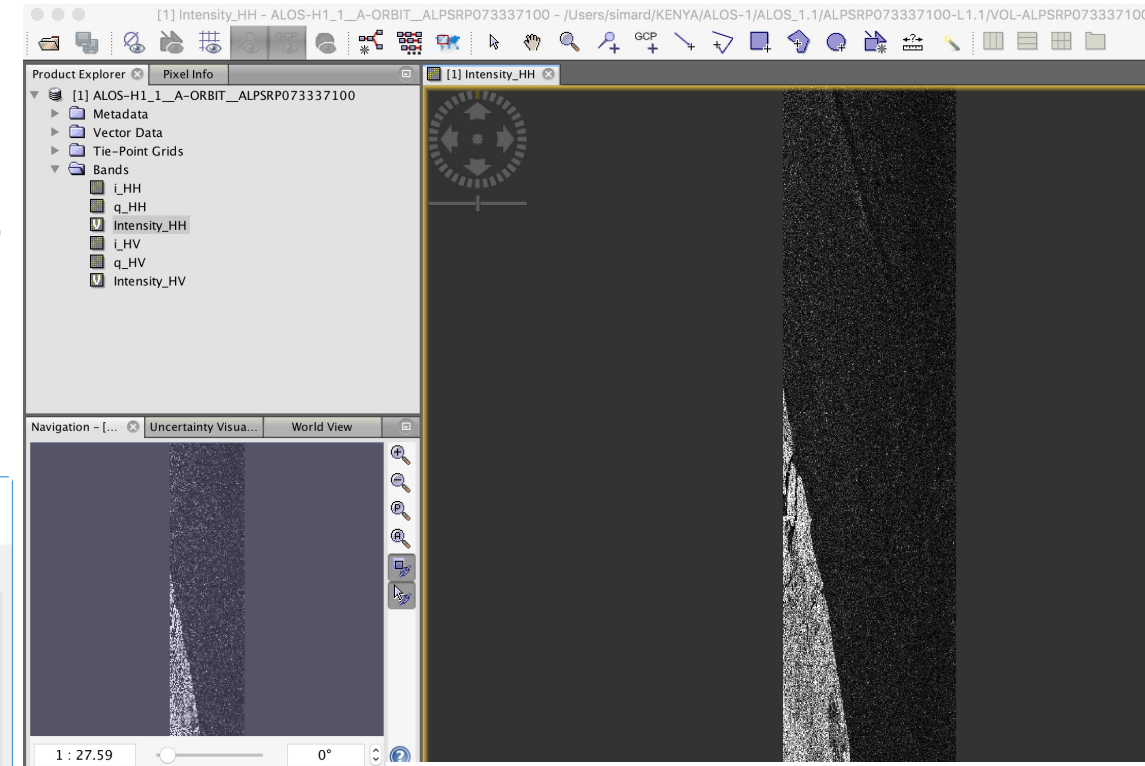
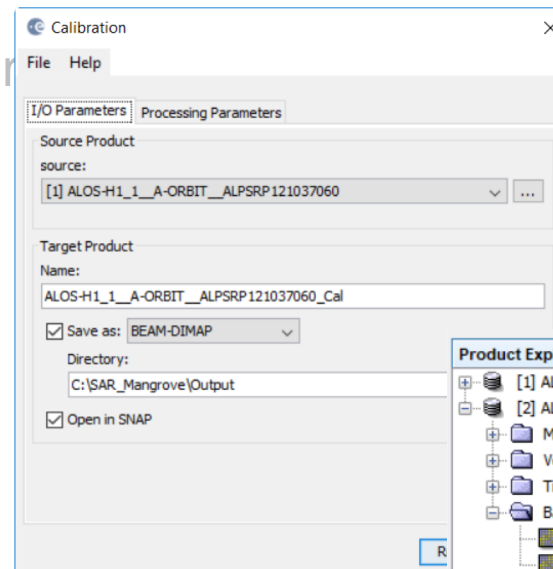
- Open radar images in SNAP
- Radiometric calibration
- Image filtering to reduce speckle
- Open in QGIS
- dB conversion



| | Windows 64-Bit | Windows 32-Bit | Mac OS X | Unix 64-bit |
|--------------------|---|--------------------------|--------------------------|--------------------------|
| Sentinel Toolboxes | These installers contain the Sentinel-1 , Sentinel-2 , Sentinel-3 Toolboxes | | | |
| | Download | Download | Download | Download |
| SMOS Toolbox | This installer contains only the SMOS Toolbox . Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual . | | | |
| | Download | Download | Download | Download |
| All Toolboxes | These installers contain the Sentinel-1 , Sentinel-2 , Sentinel-3 Toolboxes, SMOS and PROBA-V Toolbox | | | |
| | Download | Download | Download | Download |

Using SNAP to process raw radar data

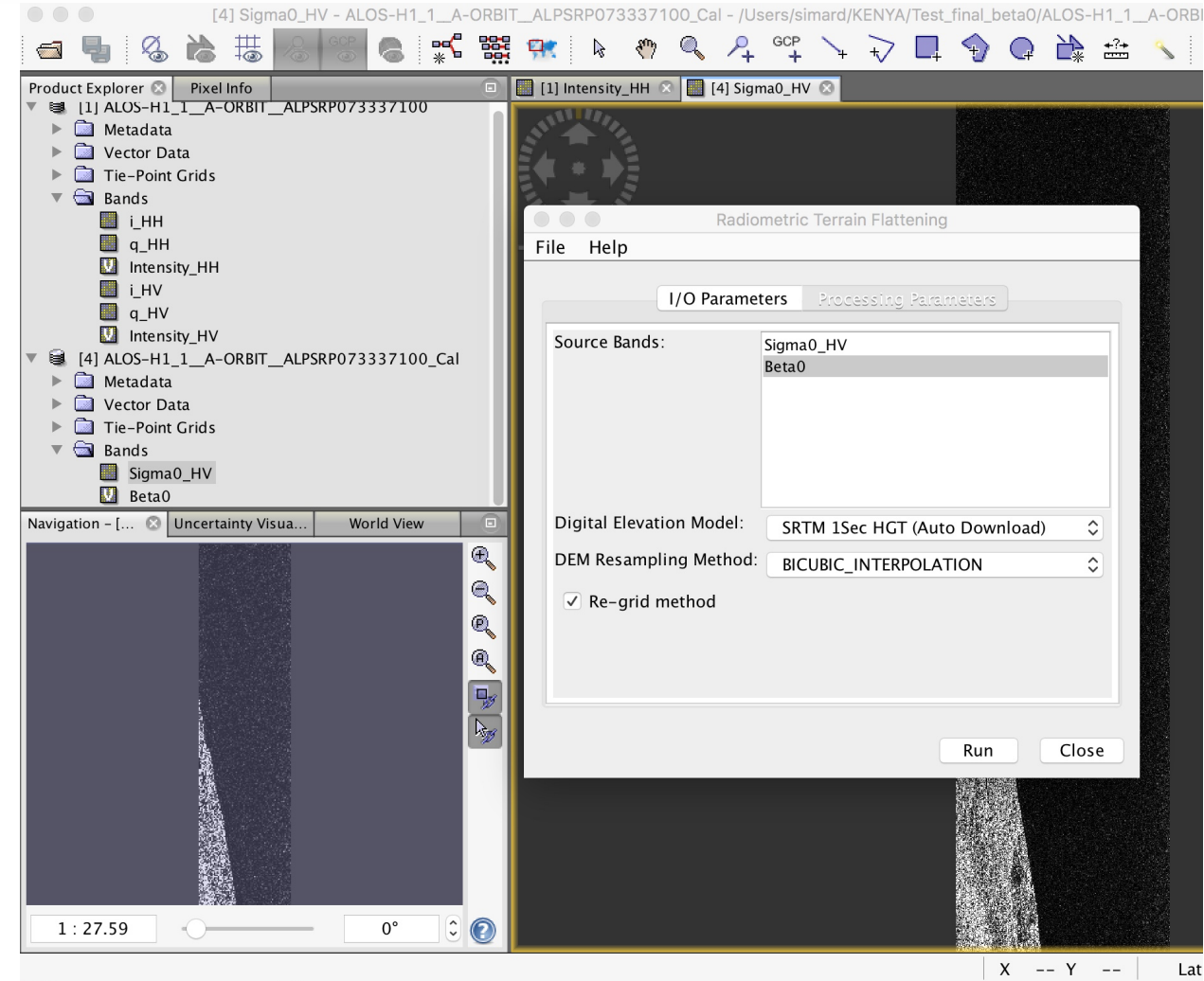
- Read
 - Begin processing with Level 1.1 data. The 1.5 and RTC product data are already processed. Try to use SNAP and process Level 1.1 to RTC!
 - Drag and drop the Vol* file into “Product Explorer” window
- Calibrate
 - Go to “Radar” menu at top of screen. A window pops-up.
 - In the window, specify the input band and output file location.
 - In the same window, click on the “Processing Parameters” tab:
 - Select any “intensity” band.
 - Select beta0 band.
- Apply terrain correction
- Filter radar image (e.g. Lee Filter)
- Project to ground range
- Convert linear to decibels (dB)
- Write output



Using SNAP to process raw radar data

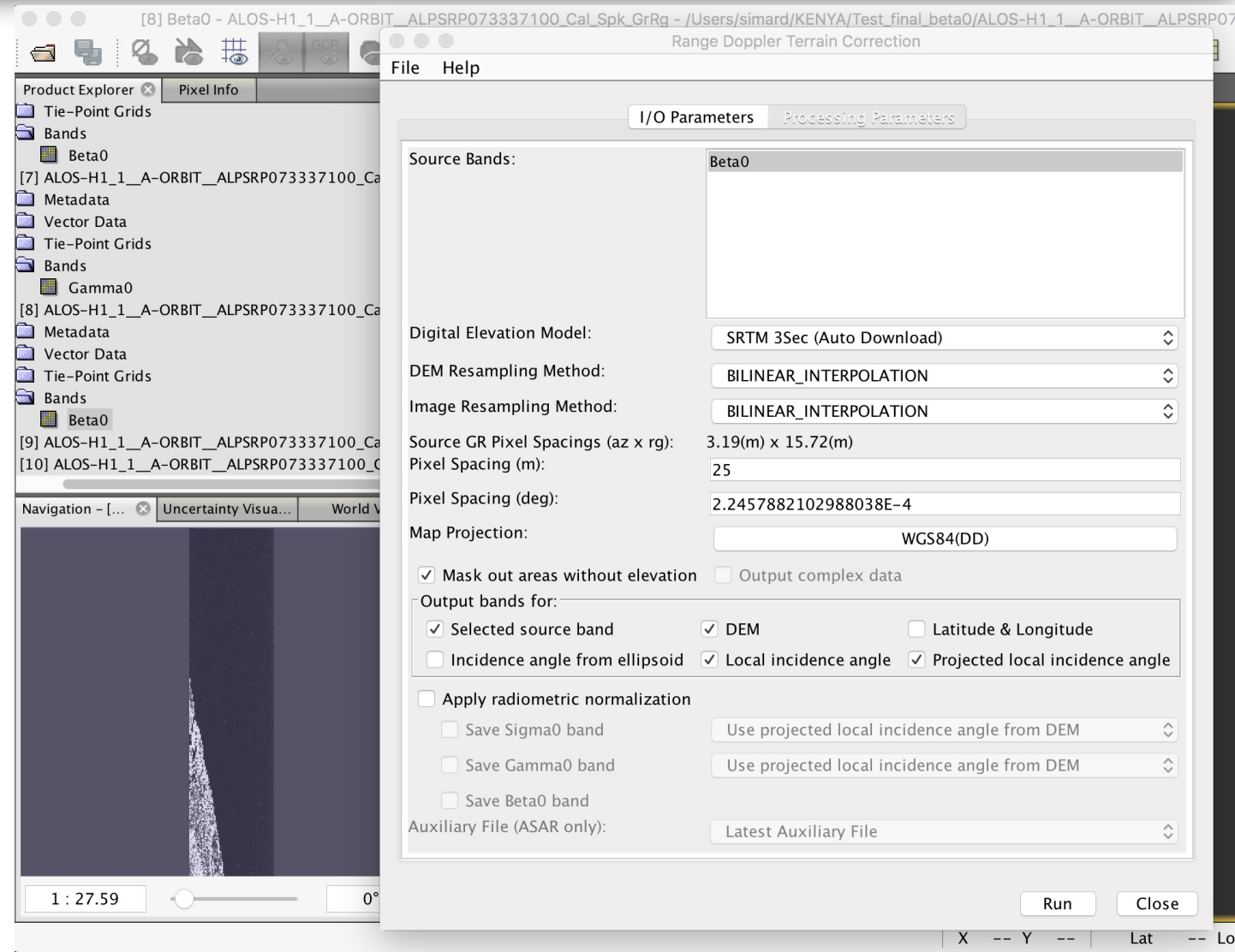


- Read
- Calibrate
- Apply terrain correction
 - Go to: “Radar” top menu and select “Radiometric”->“Radiometric Terrain Flattening”
 - In “Processing Parameters” tab, select “Beta0”
 - Click “Run”
 - Note this brings the image from Beta0 to Gamma0. i.e. removing topographic effects on backscatter.
- Filter radar image (e.g. Lee Filter)
- Project to ground range
- Convert linear to decibels (dB)
- Write output



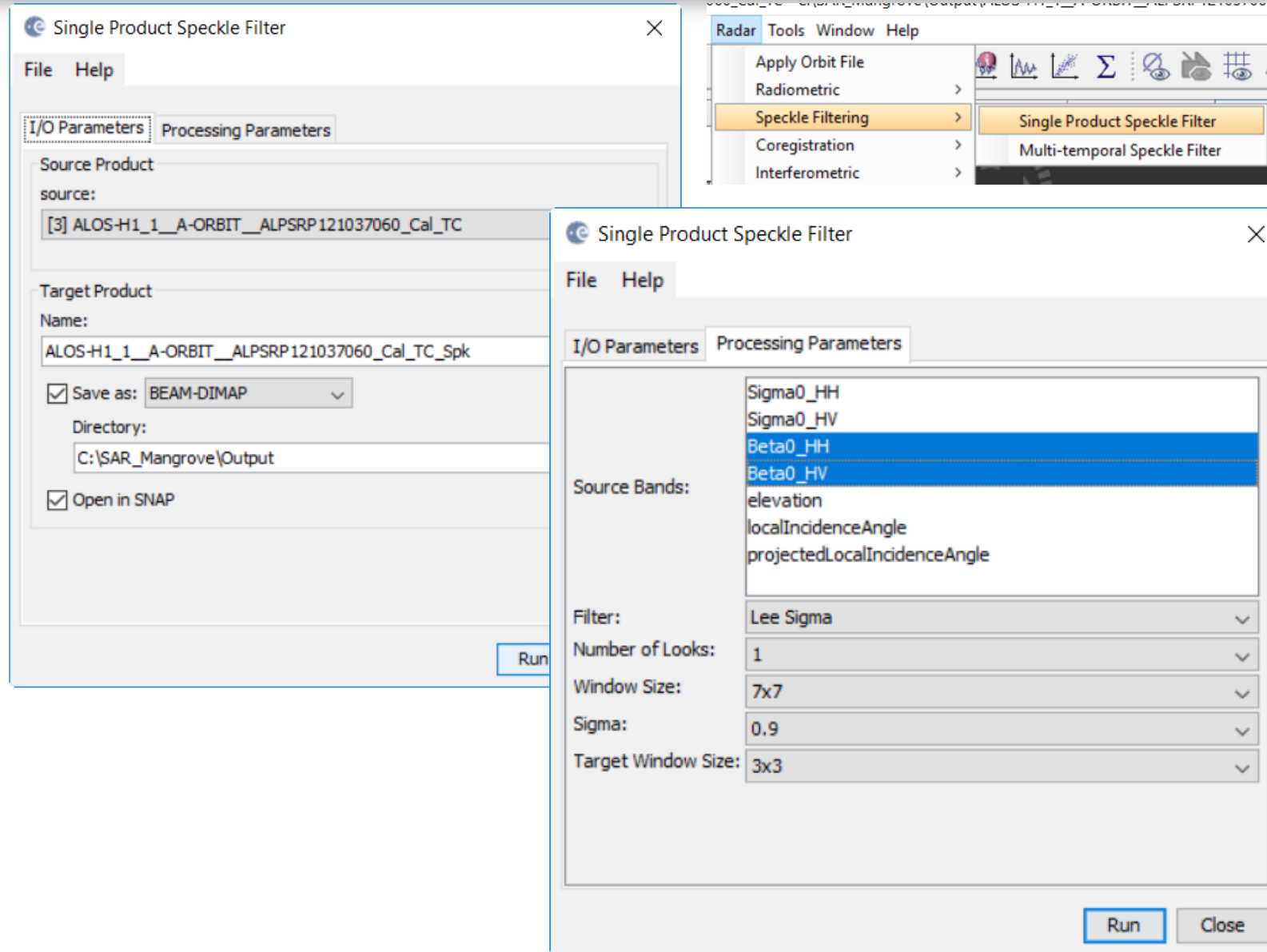
Using SNAP to process raw radar data

- Read
- Calibrate
- Apply terrain correction (Project to ground range)
 - “Radar”->”Geometric”->”Terrain Correction”->”Range-Doppler Terrain Correction”. Window pops-up.
 - Select input filtered band and specify output.
 - In “Processing parameters”, select Gamma0_HH or Beta
 - Select spatial resolution of output file (default is radar sampling)
 - Save useful bands: e.g. “Selected source band”, “DEM”, “projected local incidence angle”
 - If ground projection is incorrect, use the “Radar”->”Geometric”->”Terraint Correction”->”SAR-Simulation Terrain Correction”
- Filter radar image (e.g. Lee Filter)
- Convert linear to decibels (dB)
- Write output



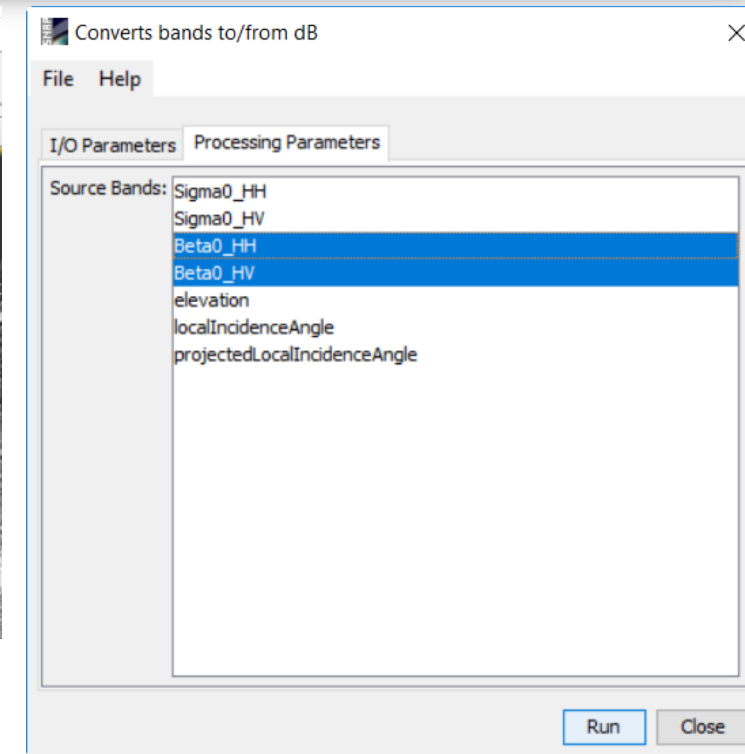
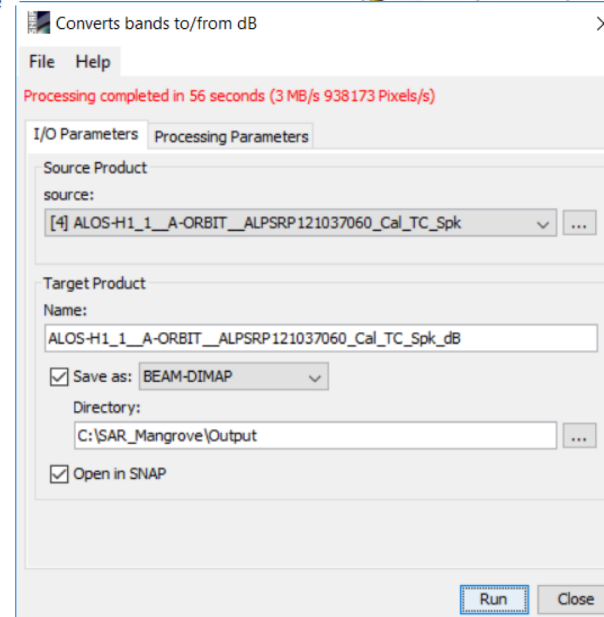
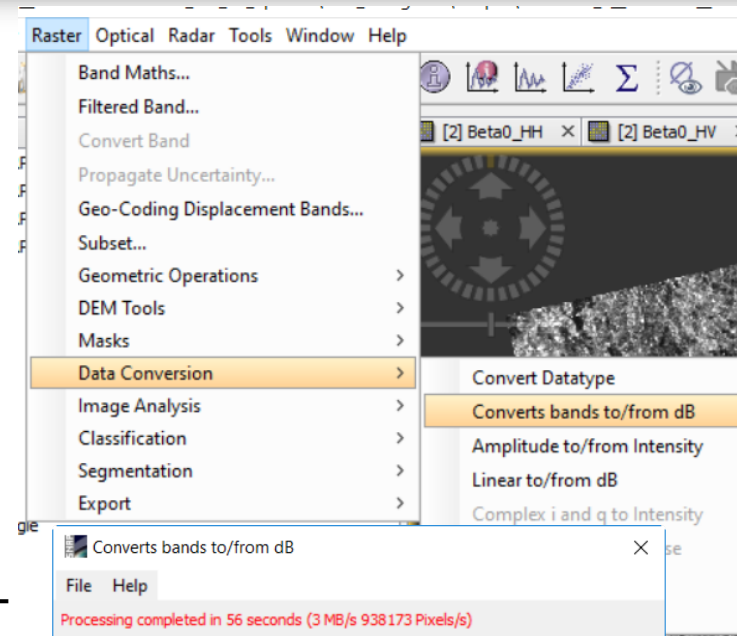
Using SNAP to process raw radar data

- Read
- Calibrate
- Apply terrain correction
- Filter radar image (e.g. Lee Filter)
 - Select Speckle Filtering -> Single Product Speckle Filter
 - Select Lee Sigma
- Convert linear to decibels (dB)
- Write output



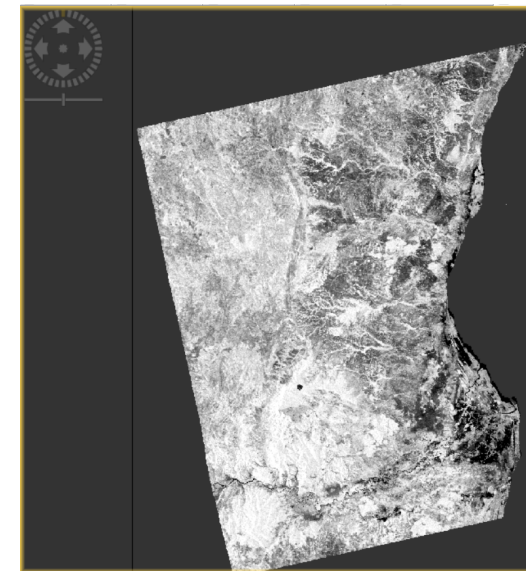
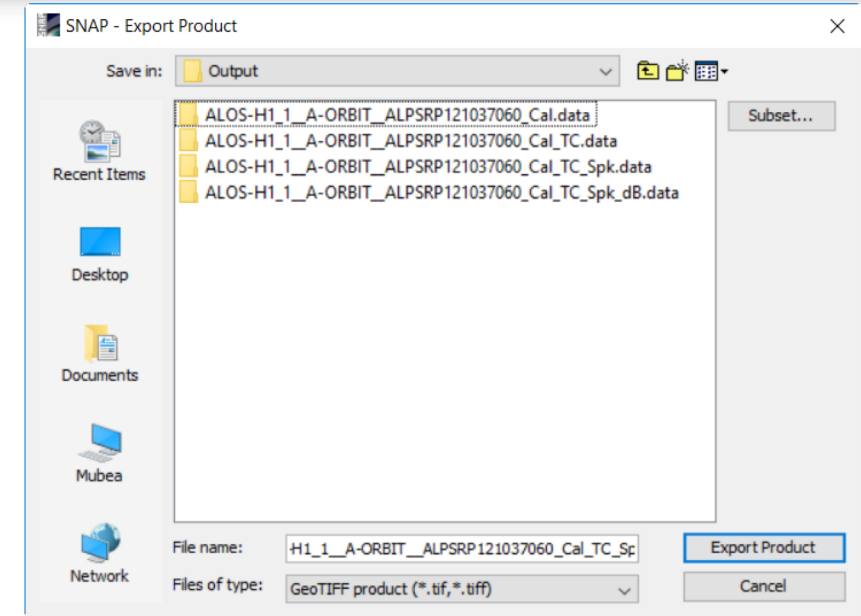
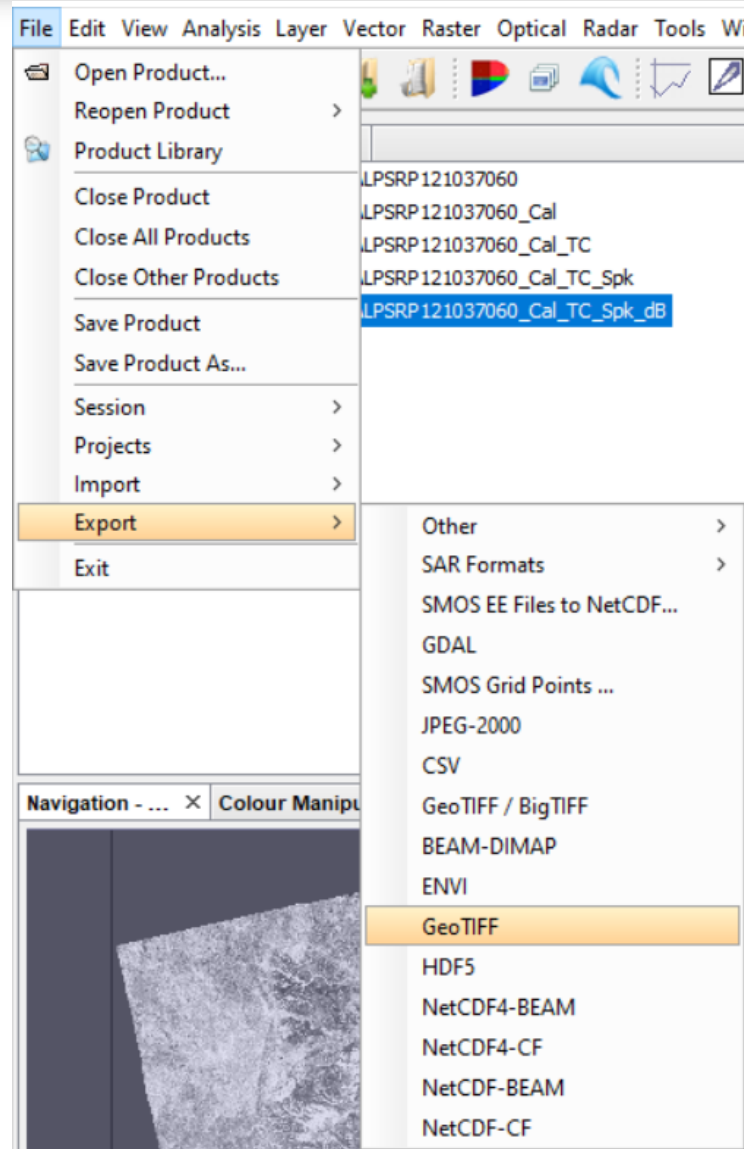
Using SNAP to process raw radar data

- Read
- Calibrate
- Apply terrain correction
- Filter radar image (e.g. Lee Filter)
- Project to ground range
- Convert linear to decibels (dB)
 - Top menu “Raster”->”Data Conversion”->”Converts bands to/from dB”
 - Select input band and output file.
- Write output
 - ”File”->”Export”->”Geotiff” for convenience



Using SNAP to process raw radar data

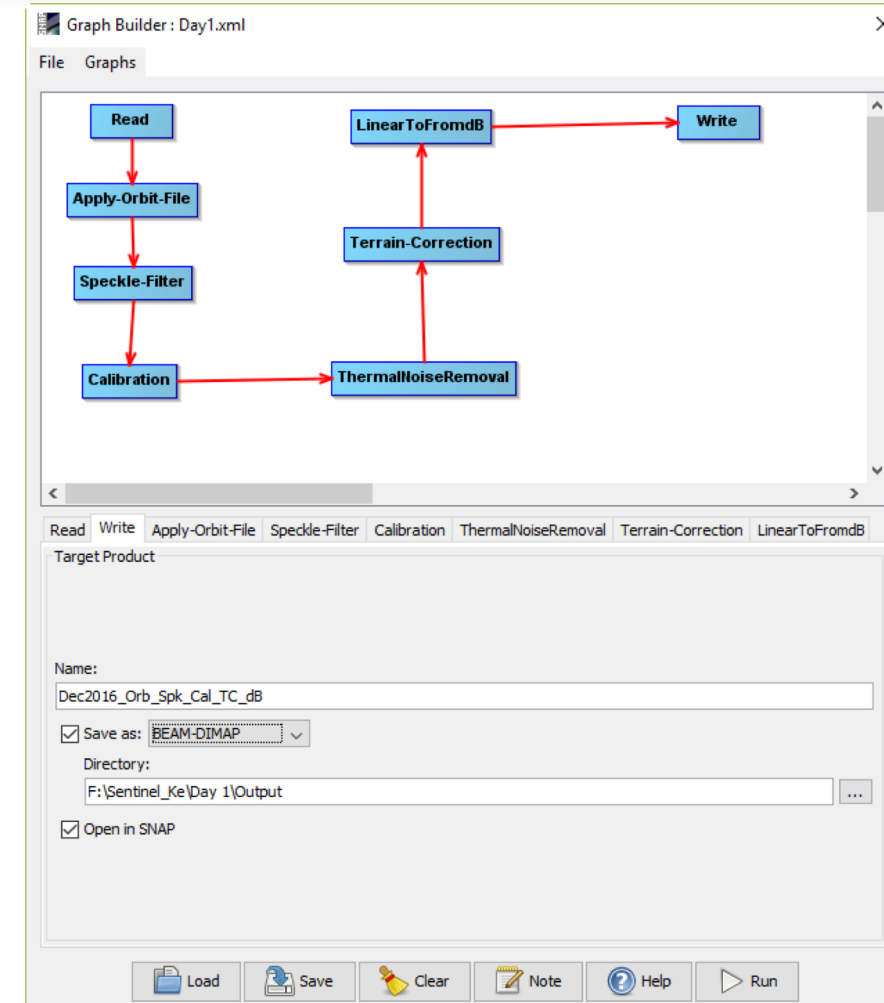
- Read
- Calibrate
- Apply terrain correction
- Filter radar image (e.g. Lee Filter)
- Project to ground range
- Convert linear to decibels (dB)
- Write output
 - "File" -> "Export" -> "Geotiff" for convenience



Using SNAP to process raw radar data - automation

SERVIR

- ☐ Read
 - ☐ Calibrate
 - ☐ Apply terrain correction
 - ☐ Filter radar image (e.g. Lee Filter)
 - ☐ Project to ground range
 - ☐ Convert linear to decibels (dB)
 - ☐ Write output
1. Select "Graph Builder"
 2. Inset processing steps using right-click
 3. Insert and connect all processing graphs
 4. Processing step parameters can be set by clicking on the respective box
 5. Output can be specified as GeoTIFF or BEAM-DIMAP
 6. Save graph in a folder.
 7. The graph can be used with other images
 8. Replace the input and output paths with \$infile and \$outfile, respectively



Sentinel processing - Alaska Satellite Facility

SERVIR

<http://hyp3.asf.alaska.edu/>



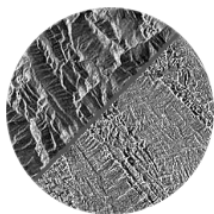
Home ▾

Subscriptions

One-Time Processing

Products ▾

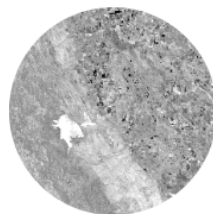
mubea ▾



Terrain Correction

Radiometric correction involves removing the misleading influence of topography on backscatter values. Terrain correction is the process of correcting geometric distortions that lead to geolocation errors.

[View details »](#)



Change Detection

Change Detection is a technique that detects which areas have changed between two synthetic aperture radar scenes. The unique properties of SAR can detect changes that aren't easily visible in optical imagery.



InSAR

Interferometric synthetic aperture radar (InSAR), is a radar technique using two or more synthetic aperture radar (SAR) images to generate maps of surface deformation or digital elevation, using differences in the phase of the waves returning to the satellite or aircraft.



RTC SAR Data Processing

Radiometrically Terrain Correct large amounts of SAR data quickly on our servers.



Obtain SRTM Digital Elevation Model (DEM) - USGS Explorer

- Go to: <https://earthexplorer.usgs.gov/>
- Register to be able to download data
- In "Search Criteria" tab clicke "Use Map"
- Click "Clear Coordinates"
- Generate polygon on map with clicks.
- Go to "Data Sets" tab.
- Select type of data needed. SRTM in "Digital Elevation" than "SRTM" Use the "SRTM 1 Arc-Second Global". Note the future NASADEM will not work for that purpose.
- Click "Results" and select files for download.

USGS
science for a changing world

EarthExplorer - Home

Page Expires In 1:58:56

Home 1 New System Message Login Register RSS Feedback Help

Search Criteria Data Sets Additional Criteria Results

1. Enter Search Criteria
To narrow your search area: type in an address or place name, enter coordinates or click the map to define your search area (for advanced map tools, view the [help documentation](#)), and/or choose a date range.

Address/Place Path/Row Feature Circle

Show Clear

Coordinates Predefined Area Shapefile KML

Degree/Minute/Second Decimal

| | |
|--|---|
| 1. Lat: 04° 11' 58" S, Lon: 039° 02' 18" E | ✖ |
| 2. Lat: 04° 50' 44" S, Lon: 039° 03' 38" E | ✖ |
| 3. Lat: 04° 50' 44" S, Lon: 039° 38' 34" E | ✖ |
| 4. Lat: 04° 13' 36" S, Lon: 039° 35' 36" E | ✖ |

Use Map Add Coordinate Clear Coordinates

Date Range Result Options

Search from: 01/01/1999 to: 03/31/2000

Search months: (all)

Data Sets » Additional Criteria » Results »

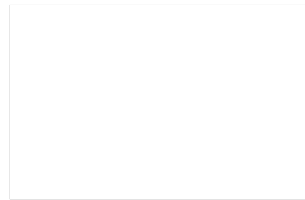
Search Criteria Summary (Show) Clear Criteria

Map Satellite (02° 56' 51" S, 038° 36' 46" E) Options Overlays

Google

Map data ©2018 Google Imagery ©2018 TerraMetrics 20 km Terms of Use

The up-to-date Google map is not for purchase or for download; it is to be used as a guide for reference and search purposes only.



Break..!

Mapping mangrove canopy structure



- Forest structure can be described: spatial extent, tree cover, canopy height and above ground biomass (AGB).
- Tree cover, canopy height and above ground biomass (AGB) are correlated.
- Different Radar parameters are used to estimate AGB and forest canopy height.
- A generic formulation relating radar backscatter to AGB is:

$$\sigma^0(dB) = a + b \times \text{Log} (AGB)$$

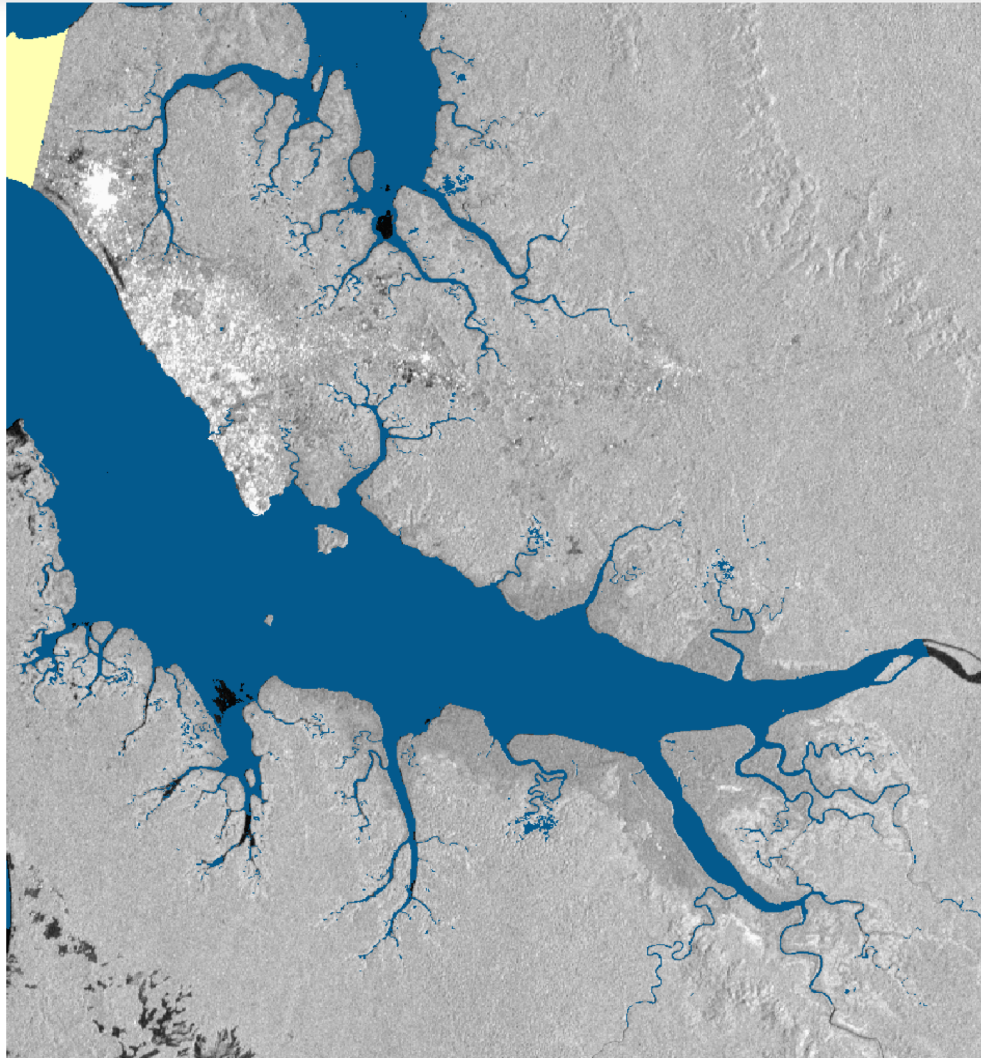
Where a and b are determined by the user from in situ data

- In wet tropical forests, values are about -22.5 and 3 for a and b respectively.
- The values for mangrove forests can change significantly: large variation in structure, species and the inundation state
- The longer the wavelength (equivalent to lower frequency), the larger is the biomass saturation point.
- Approximate mangrove backscatter values (σ^0) range from 200, 100, 50, 25 for P, L, C and X respectively.



- The observed backscatter (σ_0) reduces due to absorption by the dense aerial root especially for HV polarization.
- Observation of scrub mangroves at HH and VV display high backscatter (σ_0) due to increased penetration within the canopy and double-bounce interaction with the water surface
- It is recommended to use a combination of datasets from different sensing technologies to map mangroves.
- Land cover classification can be performed with the radar backscatter as one of the layers along with data from optical instruments such as Landsat.
- One can build upon existing global maps of mangrove extent

Mapping mangrove canopy structure

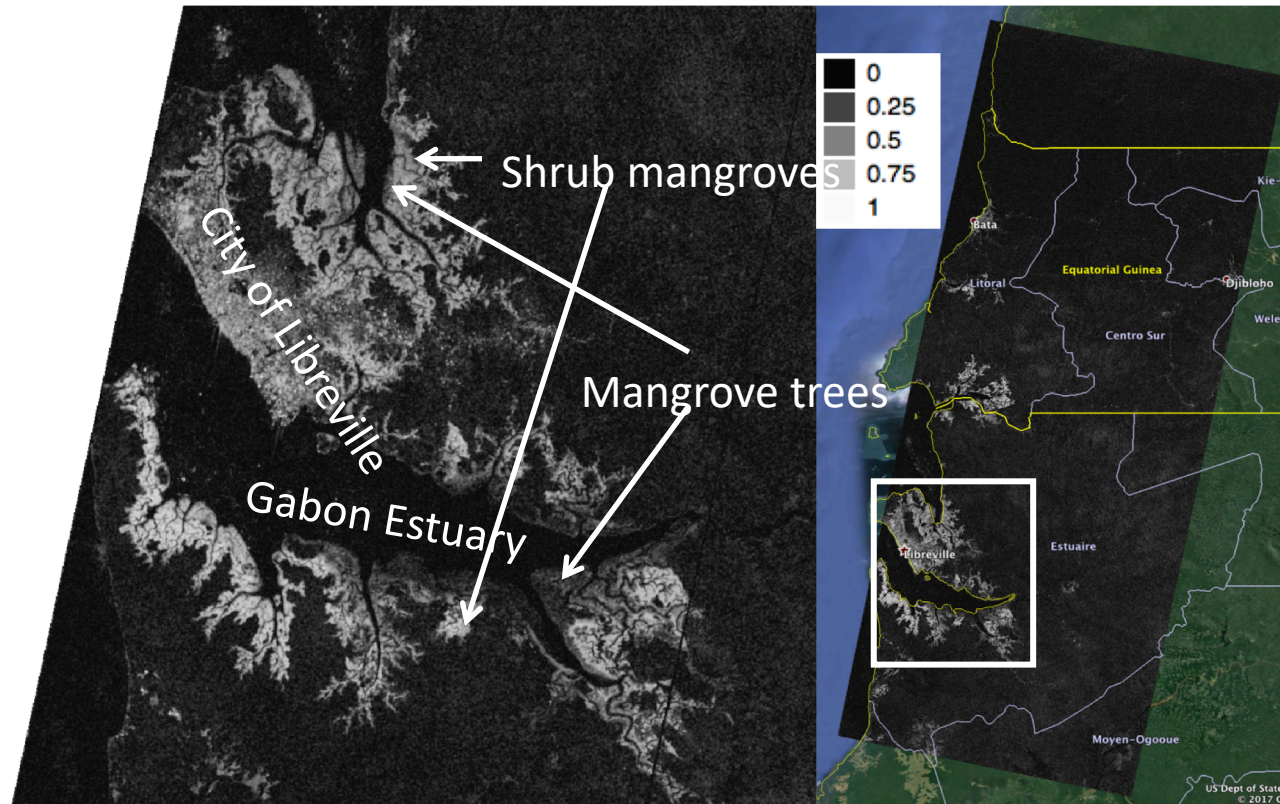


- Radar backscatter at L band HH acquired by ALOS-2 over the Gabon Estuary, Gabon. Bright areas to the North West result from strong double bounce effect in urban structures of the city of Libreville.
- Large medium backscatter (mid-gray tones) are due to volume scattering in forests. Water was easily masked based on darker backscatter (in particular at LHV).
- Interestingly, due to strong attenuation from roots, tall mangrove forest with red mangrove trees reaching several tens of meters exhibit lower backscatter along the South Eastern portion of the Estuary.



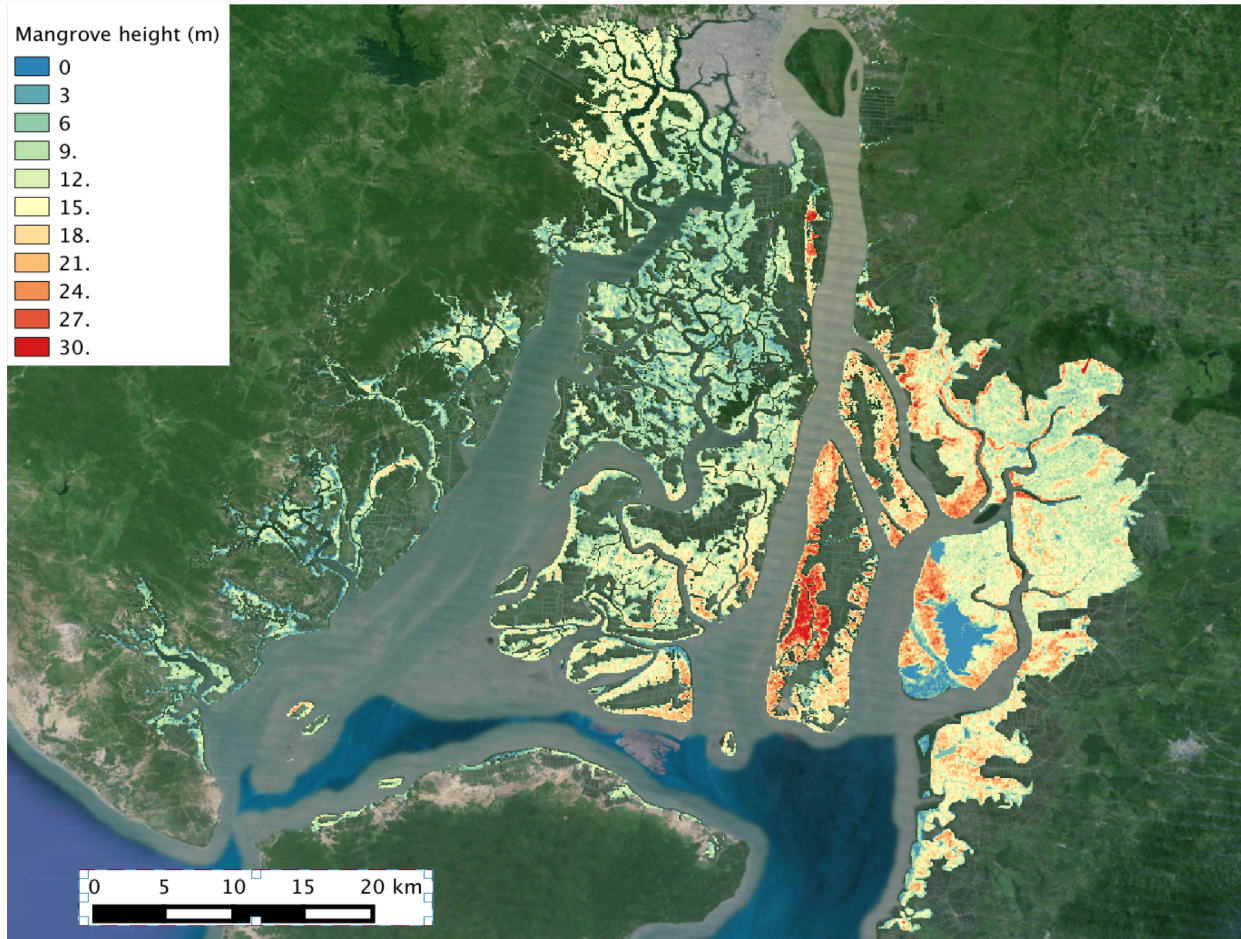
- Significant advances in the use of Radar interferometry to map mangrove canopy height.
- Data from the Shuttle Radar Topography Mission has been used to measure canopy height
- SRTM was designed to measure elevation, but due to the interaction of the radar microwave with the canopy volume, the SRTM elevation measurement is biased for forest height and density.
- SRTM helps determine patterns of mangrove height at the landscape to global scales
- New elevation measurements derived with interferometric data acquired by **TanDEM-X** (e.g. [World DEM](#)) providing a second and more recent dataset.
- [TanDEM-X](#) elevation datasets are currently available through a proposal process or can be purchased. <https://tandemx-science.dlr.de/>

Mapping mangrove canopy structure



- Interferometric radar coherence obtained from ALOS-2 LHH.
- The bright areas represent coherence close to 1 indicating strong similarity between images collected successively after 24 days.
- These are observed in shrub mangrove as well as in urban areas.
- Tall mangrove trees exhibit lower coherence due to temporal decorrelation caused by scattering in the canopy which changes between the two radar acquisition (i.e. 24 days in this case).
- Open water surface also displays low coherence due to waves constantly changing surface scattering.

Mapping mangrove canopy structure



- Map of mangrove canopy height in the Guayas Estuary of Ecuador obtained from SRTM elevation data, calibrated with in situ field data.

Tree Allometry for Aboveground Biomass Estimation

Above Ground Biomass Density (AGBD) = $\text{Vol}_{\text{wood}} \times W$

$$AGBD = \frac{1}{A} \sum_i \frac{\rho D_i^2}{4} H_i T_i W_i$$

$$\text{Vol} = \frac{1}{A} \sum_i \frac{\rho D_i^2}{4} H_i$$

$$BA = \frac{1}{A} \sum_i \frac{\rho D_i^2}{4}$$

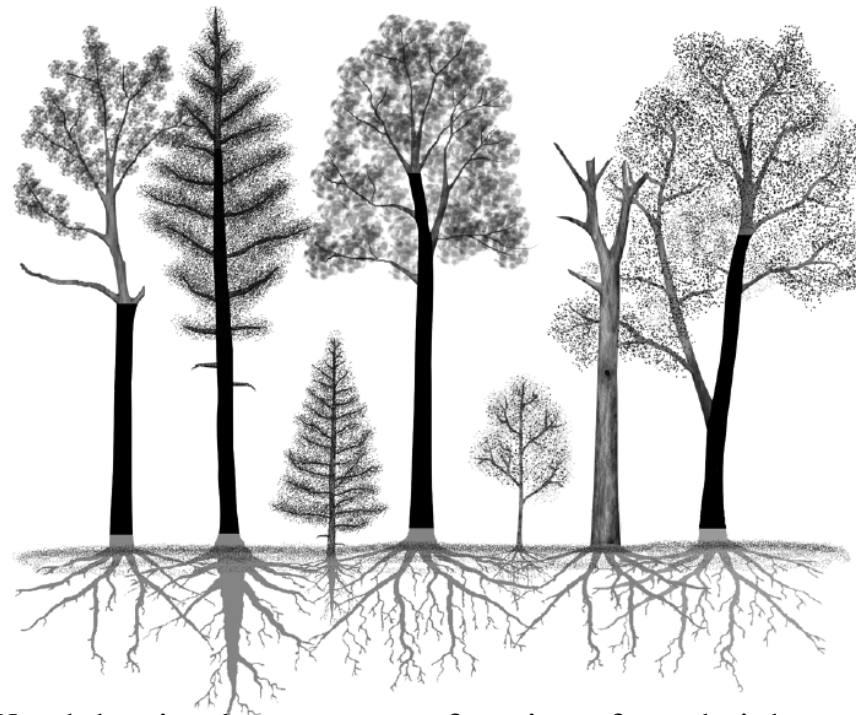
A: Area sampled

D: Diameter at Breast Height, DBH

H: Tree Height

T: Tapering Factor (species dependent)

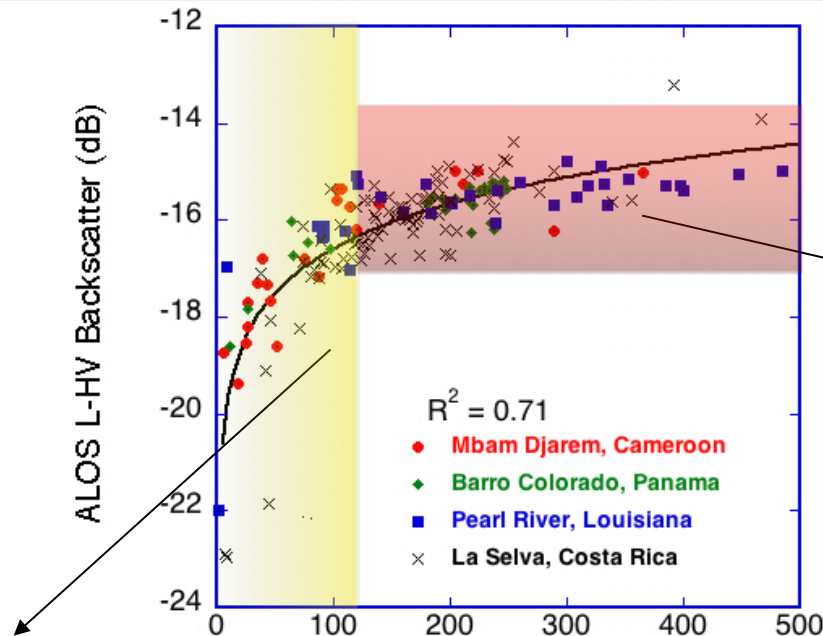
W: Wood Density (species dependent)



Wood density decreases as a function of tree height

Water content(dielectric constant) increases as a function of tree height

Radar Sensitivity to Biomass



$$\text{LHV (dB)} = -22.5 + 3.0\text{Log(AGB)}$$

Biomass < 100 Mg/ha
Low Priority Fusion Region
Higher sensitivity of radar
Domain of NISAR Performance

High Priority Fusion Region
Lower to no sensitivity of radar
Domain of data fusion and synergism
with GEDI and BIOMASS

Global Biomass Product must be derived from Fusion Approach

For low biomass density (100 Mg/ha) radar sensitivity is high but impacted by structure & environment

For high biomass density (>100 Mg/ha) data fusion with GEDI and/or BIOMASS required

GEDI

Characterizing the Effects of
Climate Change and Land Use

On ISS



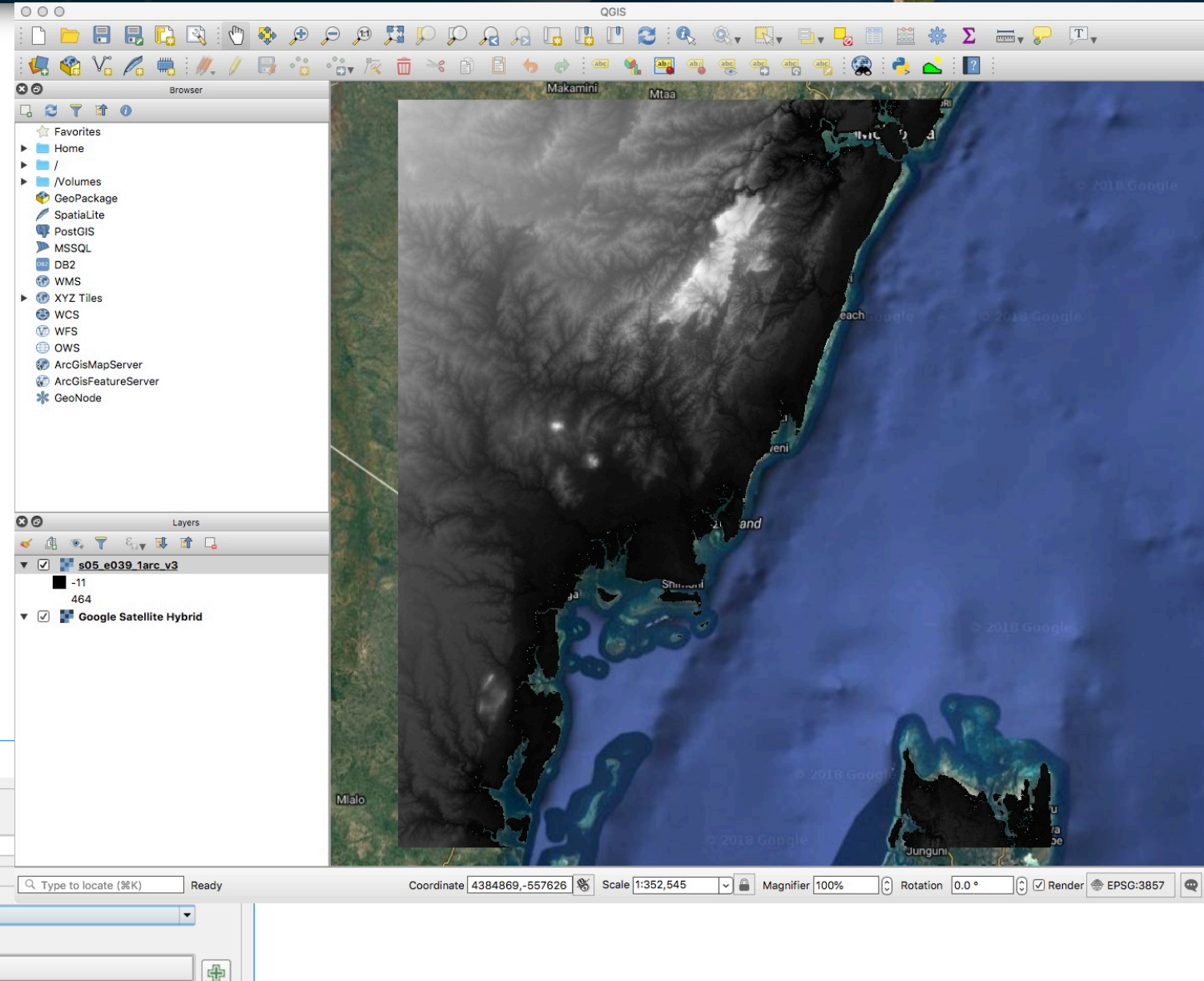
2018

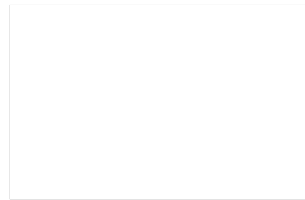


- Two methods
 - Using Canopy height from SRTM
 - Could also be TanDEM-X or lidar data or stereophotogrammetry
 - Using radar backscatter
 - From previous exercise

Read and Display SRTM DEM in QGIS

- Drag and drop the DEM (default .tif format) into QGIS.
- Go to “properties” by right clicking on DEM file name in QGIS->”Transparency”->”Additional value”=0
- Set background as Google Satellite using the “XYZ Tiles” setup.
- Drag and drop available bands in QGIS to set which is on top or below.
- To select an area of mangroves, open vector file.





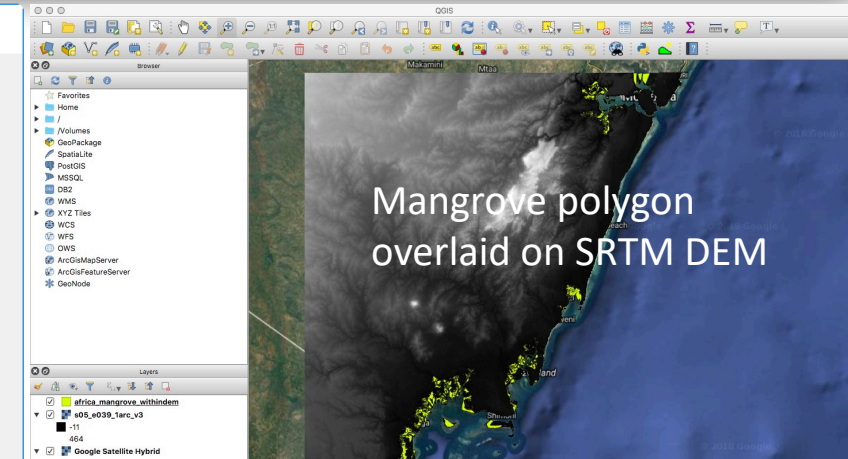
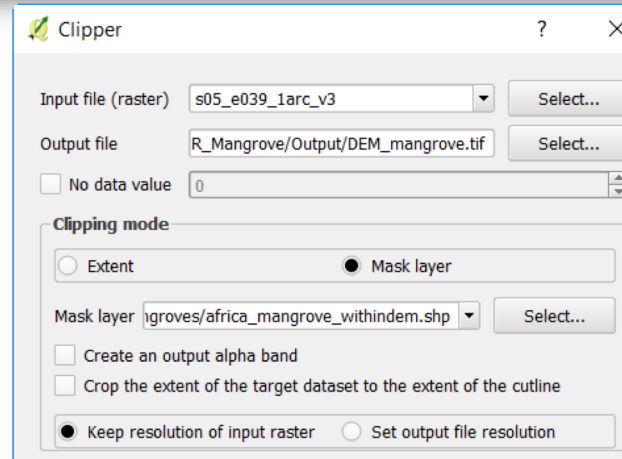
Break..!

Course outline: Day 2

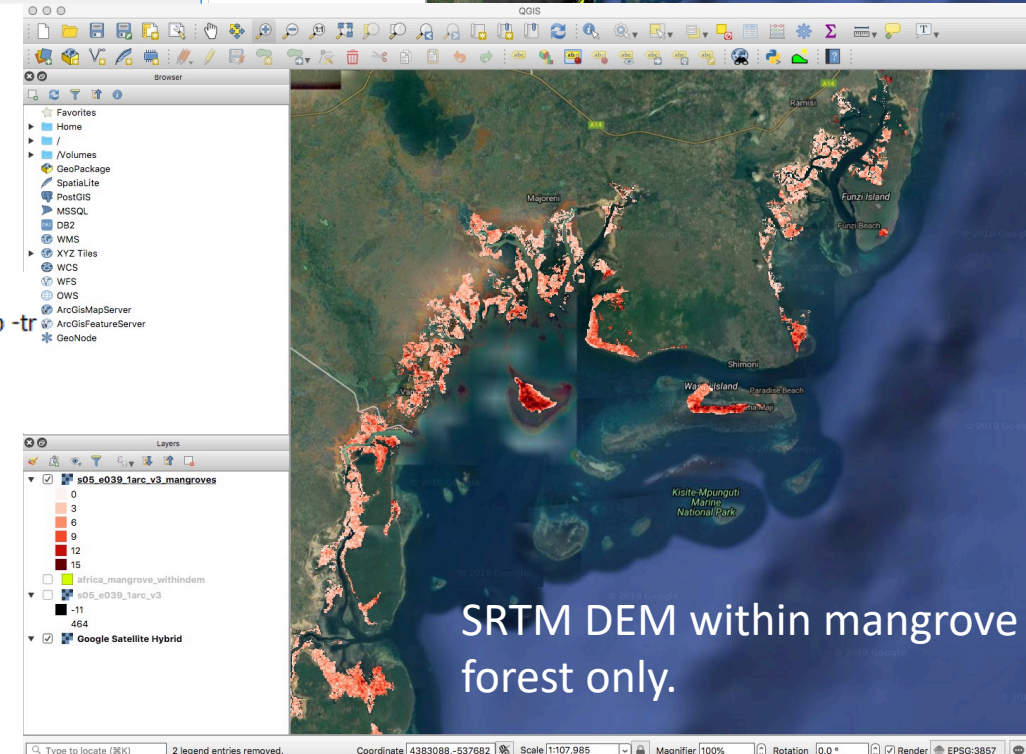
| | |
|---------------|---|
| 09:00 – 10:00 | Session 3b Biomass estimation |
| 10:00 – 10:30 | Tea/Coffee Break |
| 10:30– 12:30 | Session 3c Biomass estimation |
| 12:30 – 14:00 | Lunch Break |
| 14:00 – 16:00 | Session 4 Monitoring mangrove loss and gain |
| 16:00 – 16:10 | Tea/Coffee Break |

Read, load and use polygons to cut a raster in QGIS

1. Drag and drop shapefile into QGIS
2. Change colors within polygons with a right click->"Properties"
3. Cut SRTM DEM with polygon
 - Top menu "Raster"->"extraction"->"Clip Raster by Mask Layer"
 - If QGIS fails in cutting the SRTM DEM, you may need use a command line such as (copy from QGIS into terminal. The shapefile directory did not come up right in this execution): `gdalwarp -ot Float32 -of GTiff -tr 0.00027778 -0.00027778 -tap -cutline /YourDirectoryWithShapeFile/africa_mangrove_withindem.shp -crop to cutline -dstnodata 0.0 / YourDirectoryWithSRTM /s05_e039_1arc_v3.tif / YourDirectoryWithOutputs /s05_e039_1arc_v3_mangroves.tif`
4. You now have a canopy height map. It is SRTM, the height correspond to basal area weighted height (also called Lorey's height). The maximum height is generally 1.6X this value. (Simard et al., 2018)



```
gdalwarp -q -cutline
C:/SAR_Mangrove/Mangroves/africa_mangrove_withindem.shp -tr
0.000277777777778 0.000277777777778 -of GTiff
C:/SAR_Mangrove/DEM_SRTM/s05_e039_1arc_v3.tif
C:/SAR_Mangrove/Output/DEM_mangrove.tif
```



1. Generic equation relating SRTM to canopy height and aboveground biomass (Simard et al., 2018):
 - Basal area weighted height $H_{ba} \sim 1.08 * SRTM$
 - Maximum canopy height $H_{max} \sim 0.93 * 1.7 * SRTM$
 - Aboveground Biomass – AGB, $B \sim 3.25 * H_{ba}^{1.53}$
2. Generic equation relating aboveground biomass B in tons per hectare (t/ha) to backscatter in decibels (dB):
 - $s^o_{HV}(dB) \sim -22.5 + 3.0 * \ln(B)$
 - $s^o_{HV}(dB) \sim A.B^a (1 - e^{-B.D}) + C$, with $A=0.013682$, $a=0.21116$, $D=0.051846$, $C=0.02192$ (Yu & Saatchi, 2016). To simplify: $B = \exp(0.038 s^o_{HV}^3 + 1.6089 s^o_{HV}^2 + 23.007 s^o_{HV} + 112.28)$
 - $s^o_{HV} / 0.013682$
 - Note: There is no definite relationship for mangrove because of water presence and also increased absorption by roots at high biomass levels, but the shape of the logarithmic shape remains.

Applying the Generic Height-Based Allometric Equation

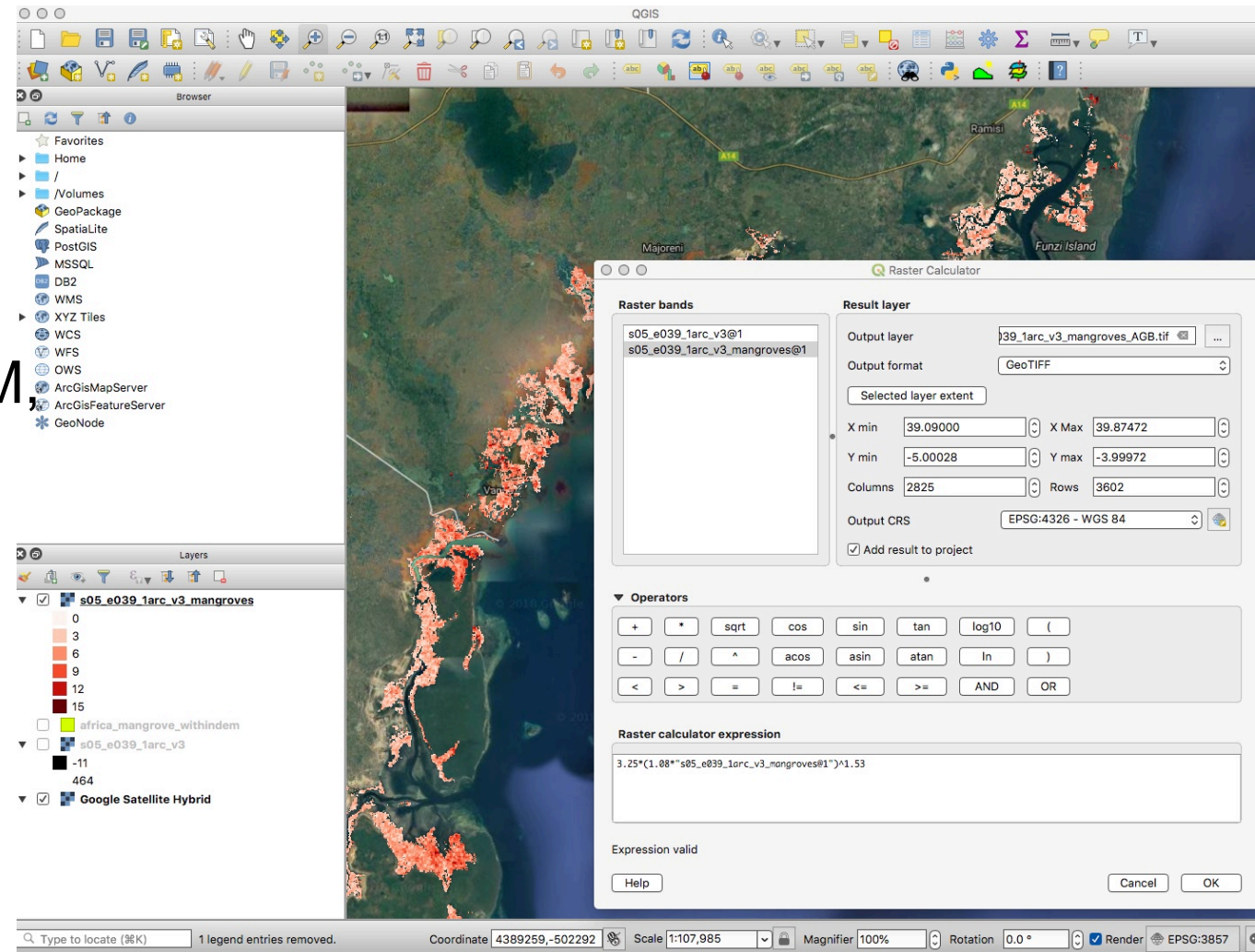
- In QGIS, click on “Raster” in the top menu, then “Raster Calculator”
- Define output layer filename, location and format (Geotiff is a favorite)
- Enter allometric equation for SRTM

$$B = 3.25 * H_{ba}^{1.53}, \text{ where } H_{ba} = 1.08 * \text{SRTM}$$

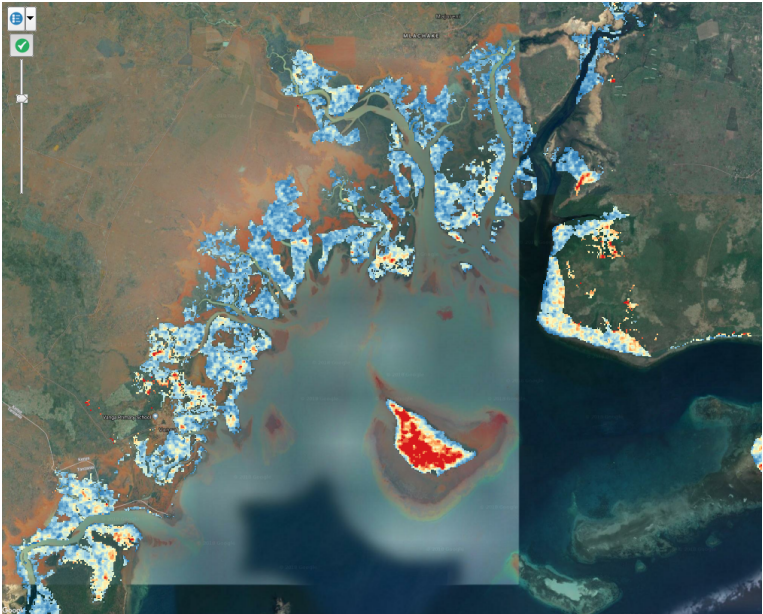
The equation becomes

$$3.25 * (1.08 * \text{SRTM})^{1.53}$$

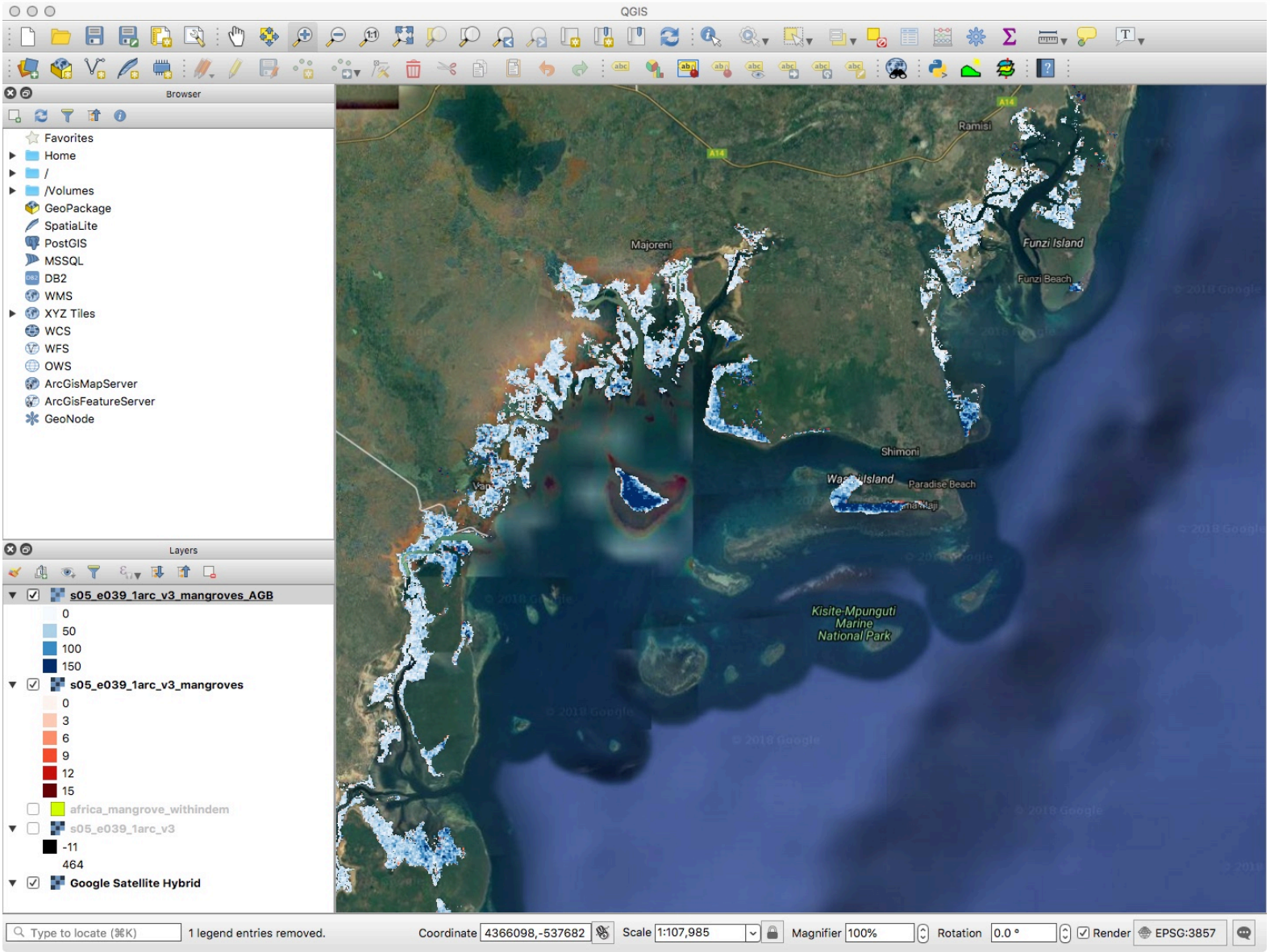
DEM_mangrove_AGB



Applying the Generic Height-Based Allometric Equation



| Value | Color | Label |
|-------|-------|-------|
| 4.03 | | 4.03 |
| 49.1 | | 49.1 |
| 94.3 | | 94.3 |
| 139 | | 139 |
| 185 | | 185 |

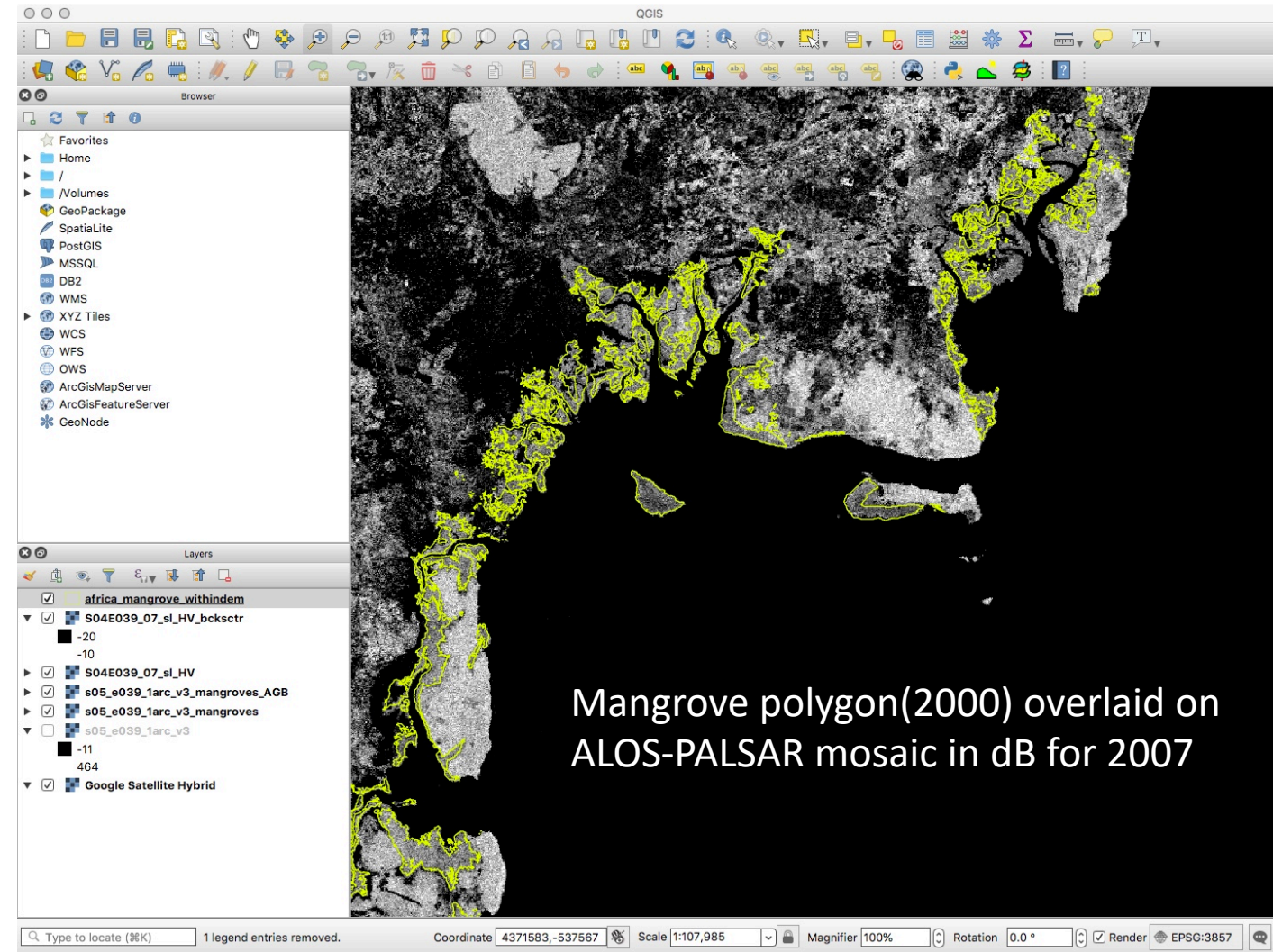


Applying the Generic Backscatter-Based Allometric Equation



1. Upload either the Radar images generated with through SNAP processing in dB, or the ALOS-PALSAR mosaics.
 - Note that in the mosaics, the digital number (DN) value of the pixel must be transformed to dB using the following JAXA-provided formula:
 - $s^o_{HV}(dB) = 20 * \log_{10}(DN) - 83$
2. In top menu, click "Raster", then "Raster Calculator".
3. Enter formula in "Raster Calculator Expression". Double-click on band name to insert in expression.

ALOS PALSAR mosaic S04E039_16_MOS_F02DAR
Dar es Salaam, Tanzania



Mangrove polygon(2000) overlaid on
ALOS-PALSAR mosaic in dB for 2007

Applying the Generic Backscatter-Based Allometric Equation

Convert digital number (DN) value to dB - backscatter

ALOS PALSAR mosaic S04E039_16_MOS_F02DAR
Dar es Salaam, Tanzania

Raster calculator

Raster bands

- DEM_mangrove@1
- DEM_mangrove AGB@1
- S04E039_16_sl_HV_F02DAR@1
- africa_mangrove_withinDEM@1
- s05_e039_1arc_v3@1

Result layer

Output layer: ut/S04E039_16_sl_HV_backscatter

Output format: GeoTIFF

Current layer extent

X min: 38.99986, XMax: 40.00014

Y min: -5.00014, Y max: -3.99986

Columns: 3601, Rows: 3601

Output CRS: Selected CRS (EPSG:4326, WGS 84)

☒ Add result to project

Operators

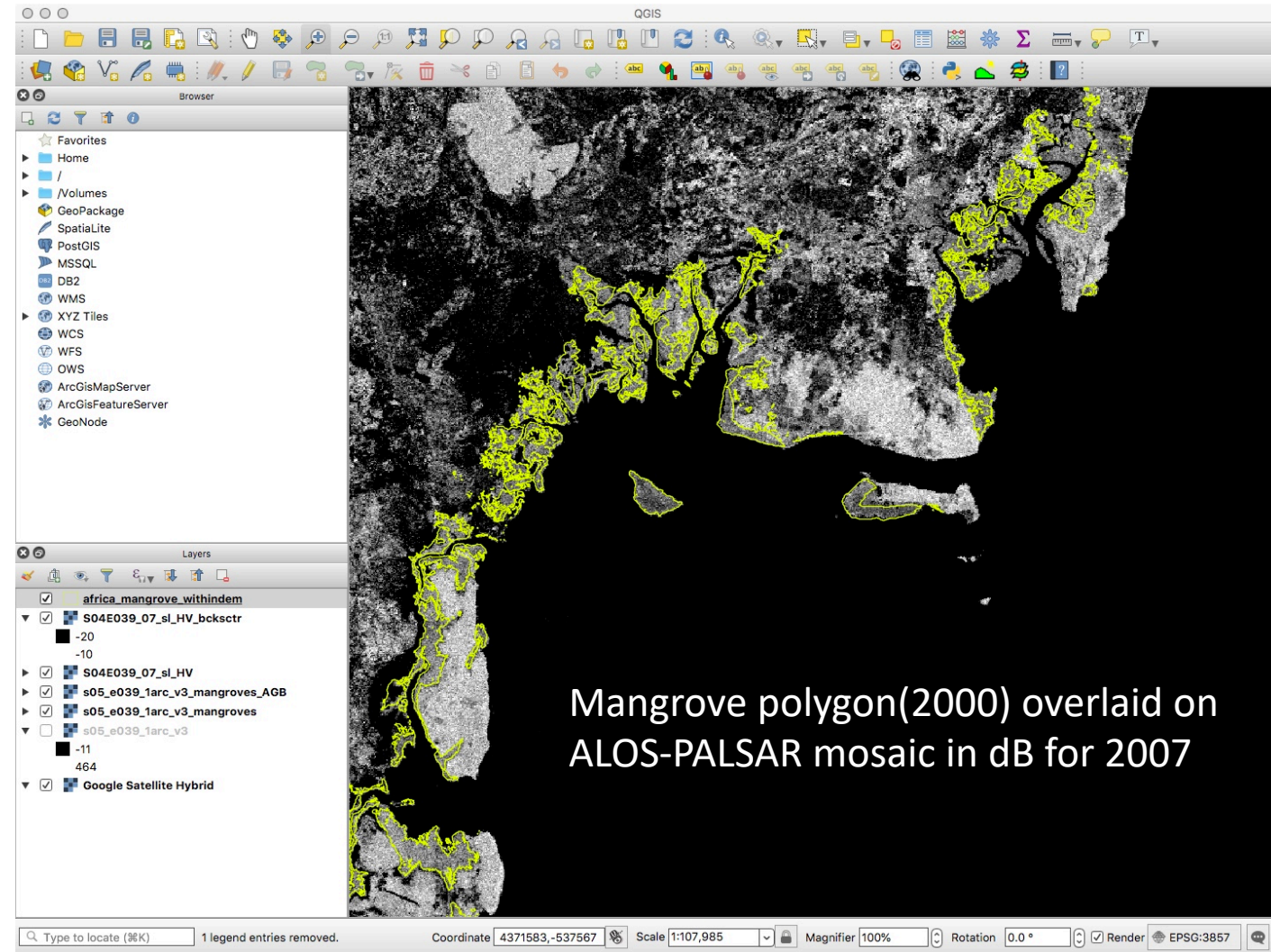
Raster calculator expression

20 * log10 ("S04E039_16_sl_HV_F02DAR@1") - 83

Expression valid

OK Cancel

Formula: $20 \cdot \log_{10}(\text{DN}) - 83$

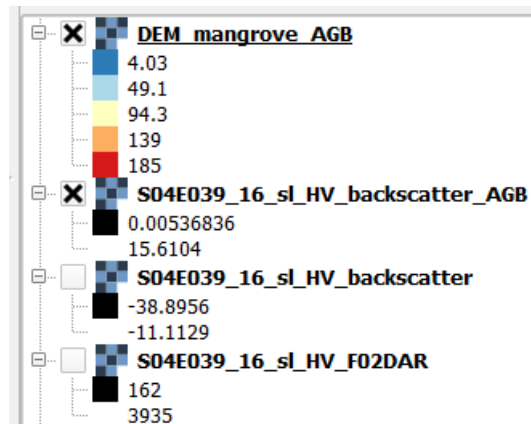


Mangrove polygon(2000) overlaid on
ALOS-PALSAR mosaic in dB for 2007

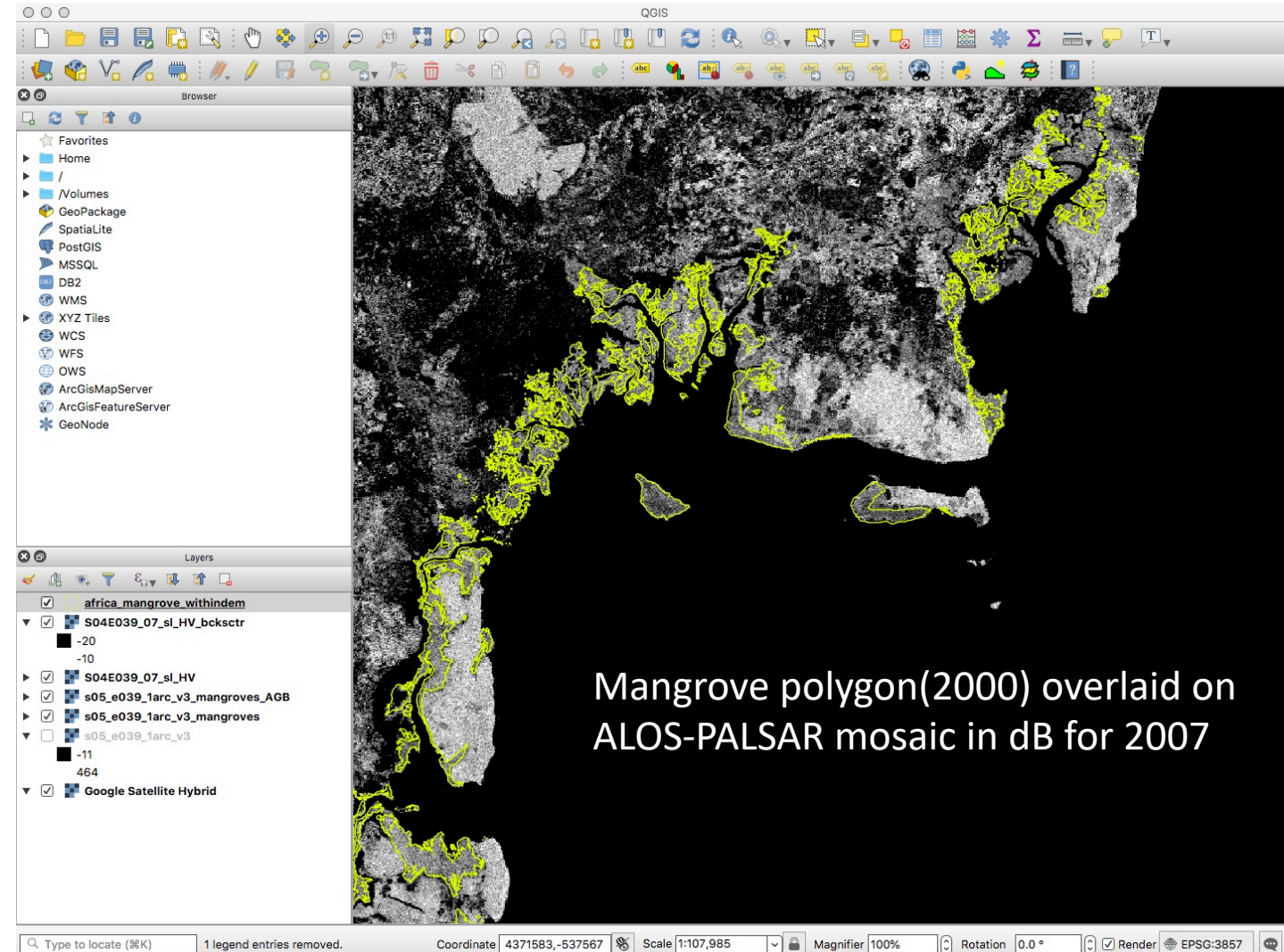
Applying the Generic Backscatter-Based Allometric Equation



4. In top menu, click on "Raster" and then "Raster Calculator". Enter allometric equation in "Raster Calculator Expression", i.e. $0.5 \cdot 10^{(40.2 \cdot \text{RasterImage})}$ with "RasterImage" in linear unit (m^2/m^2). That means if your equation, if using a dB image, becomes:
 $0.5 \cdot 10^{(40.2 \cdot 10^{(\text{RasterImage}/10)})}$



$$0.5 \cdot 10^{(40.2 \cdot 10^{(\text{"S04E039_16_sl_HV_backscatter"}/10)})}$$

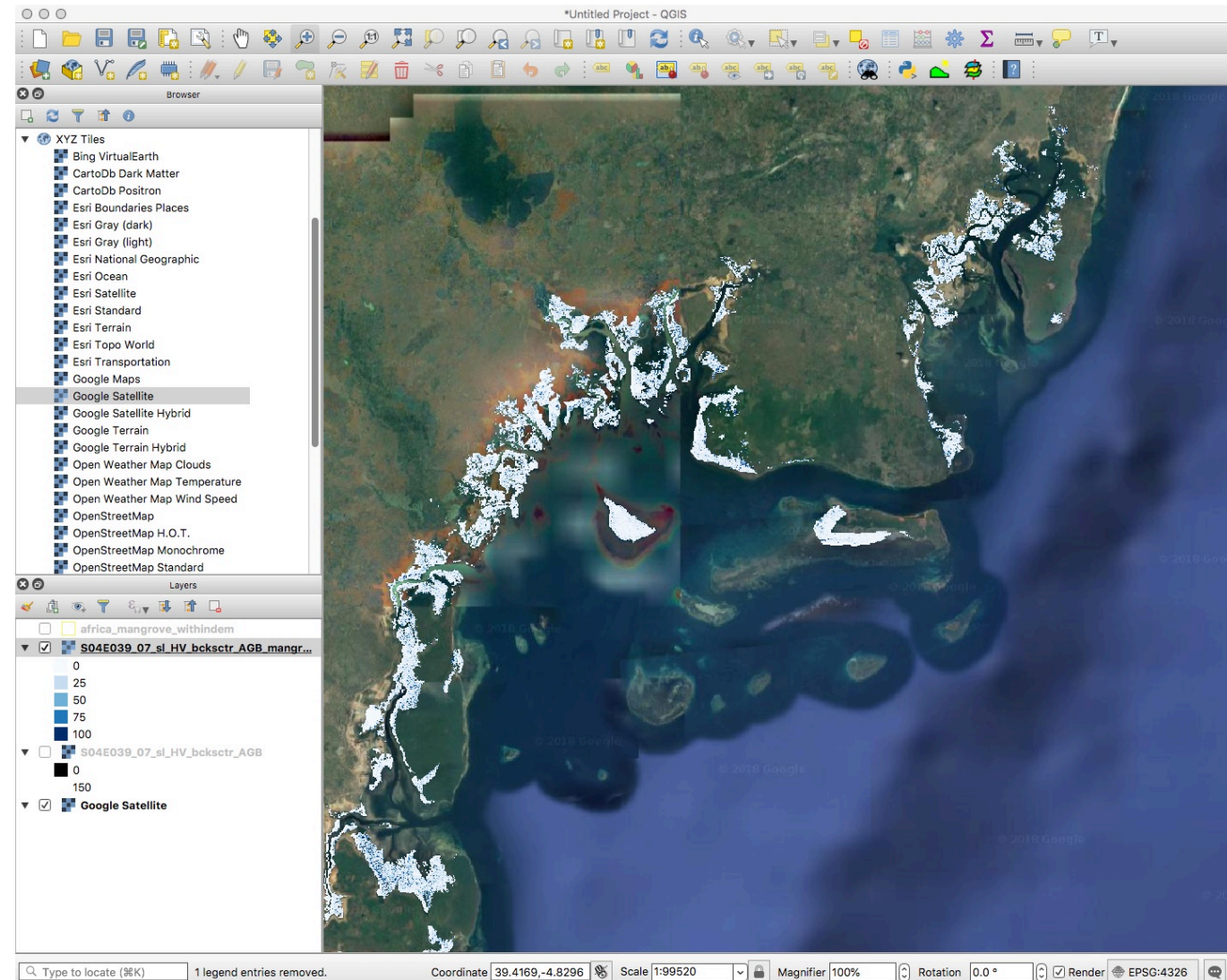


Applying the Generic Backscatter-Based Allometric Equation



5. Use same mangrove polygon file used with SRTM to extract the mangrove extent. Use QGIS (currently not working in 3.0 and 3.2) or copy/paste to your terminal window. E.g. `gdalwarp -ot Float32 -of GTiff -tr 0.0002222 -0.0002222 -tap -cutline /DirectoryWherePolygonLocated/africa_mangrove_withinDEM.shp -crop_to_cutline /DirectoryWhereBiomassTransformedImageIsLocated/S04E039_07_sl_HV_bcksctr_AGB.tif /YourOutputDirectory/S04E039_07_sl_HV_bcksctr_AGB_mangroves.tif`

Mangrove polygon(2000) overlaid on ALOS-PALSAR mosaic in dB for 2007

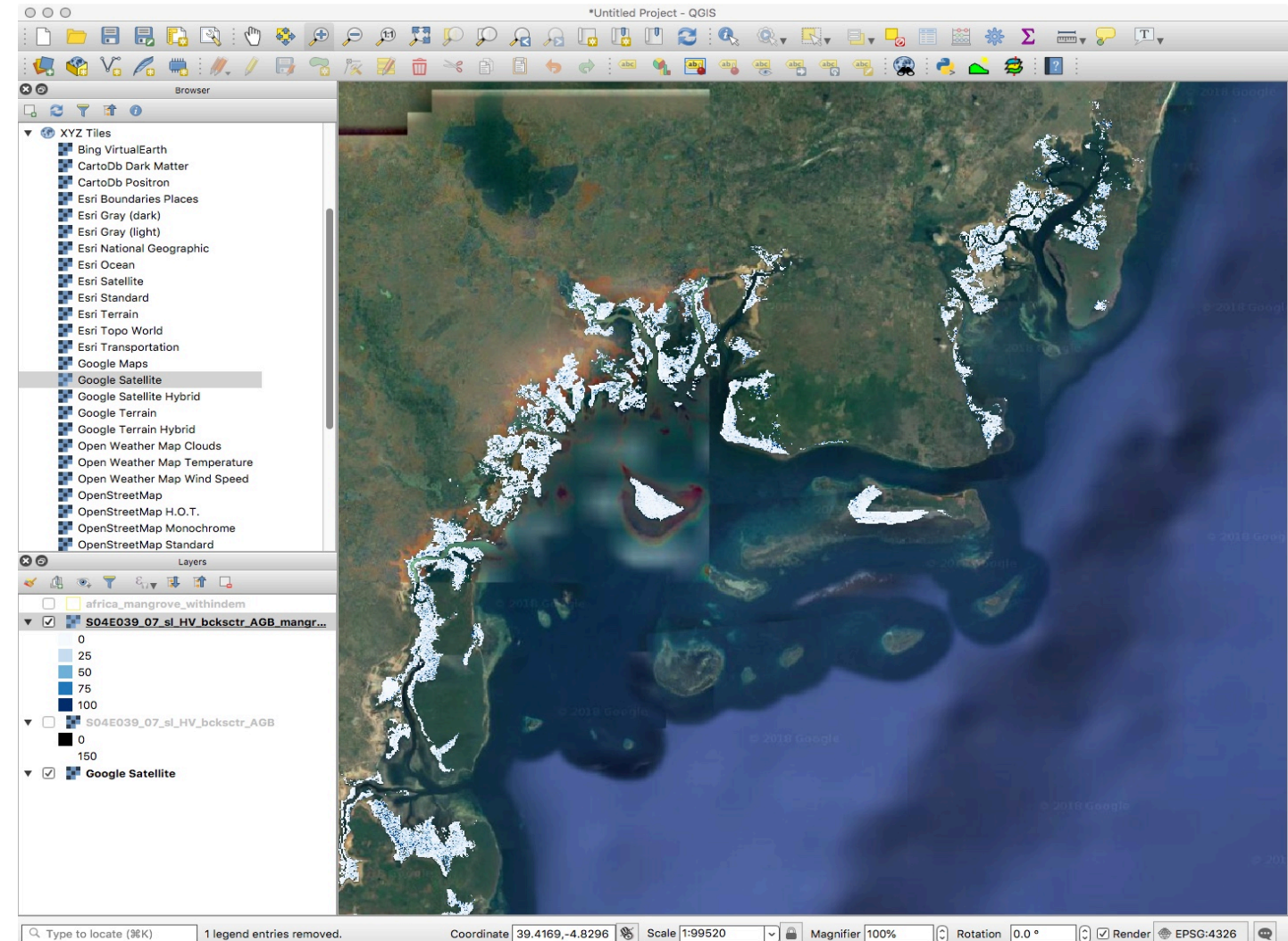


Applying the Generic Backscatter-Based Allometric Equation



- This is the resulting aboveground biomass map for mangrove areas, based on the backscatter curve.
- The retrieved biomass is much lower than that obtained with SRTM.
- Backscatter is known to be limited in mangrove forest, changing with water level and mangrove types, sometimes decreasing at biomass above 100t/ha in red mangroves.

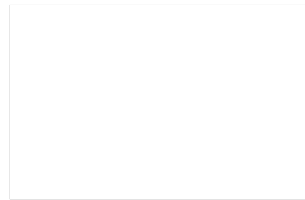
S04E039_07_sl_HV_bcksctr_AGB_mangroves.tif overlay on Google satellite



Optional: Deriving your own allometric equations



- Obtain field data with latitude, longitude and biomass.
- Make a CSV file.
- Read into QGIS:
 - In the top menu: click “Layer”->”Add Layer”-> ”->”Add Delimited Text Layer”. Then search your CSV file and follow instruction. You may need to specify the projection in “Geometry”.
- If you have installed the QGIS “Point Sampling Tool” plugin, click on its icon and select your CSV layer.
 - Select the attributes you want to preserve in the output file.
 - These must, of course, include for example biomass and backscatter.
 - Define your “Output point vector layer”.
 - With the pop-up window, select “Comma Separated Values (*.csv)” as output format.
- Open your new CSV file in Excel and fit equation.
- In QGIS, apply new equation to radar backscatter image using the “Raster Calculator”.
- At this point, you can independently generate your own biomass map.
- Using this same method, you can also validate your biomass maps using available field data.

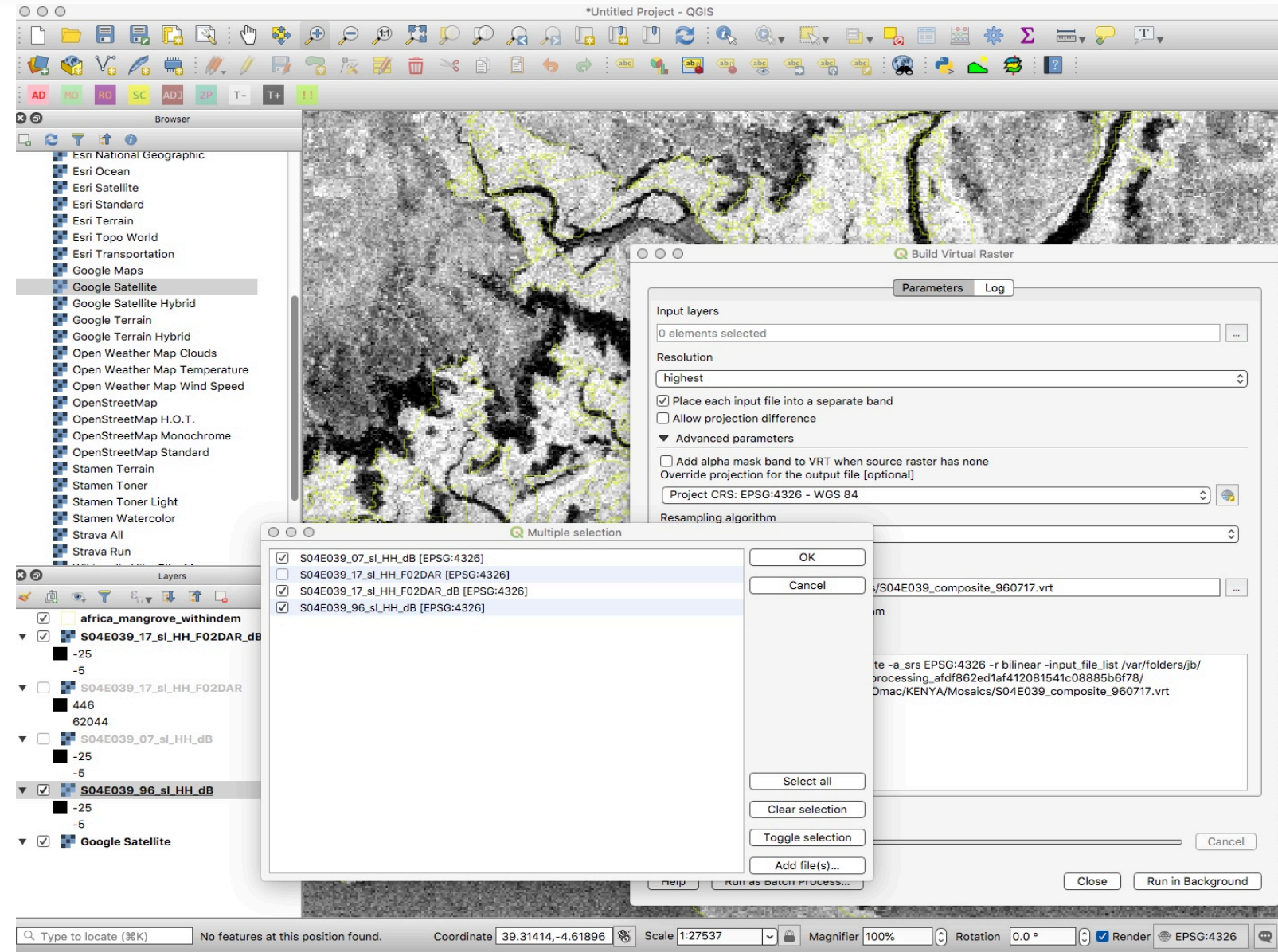


Break..!

Monitoring mangrove forests loss and gain

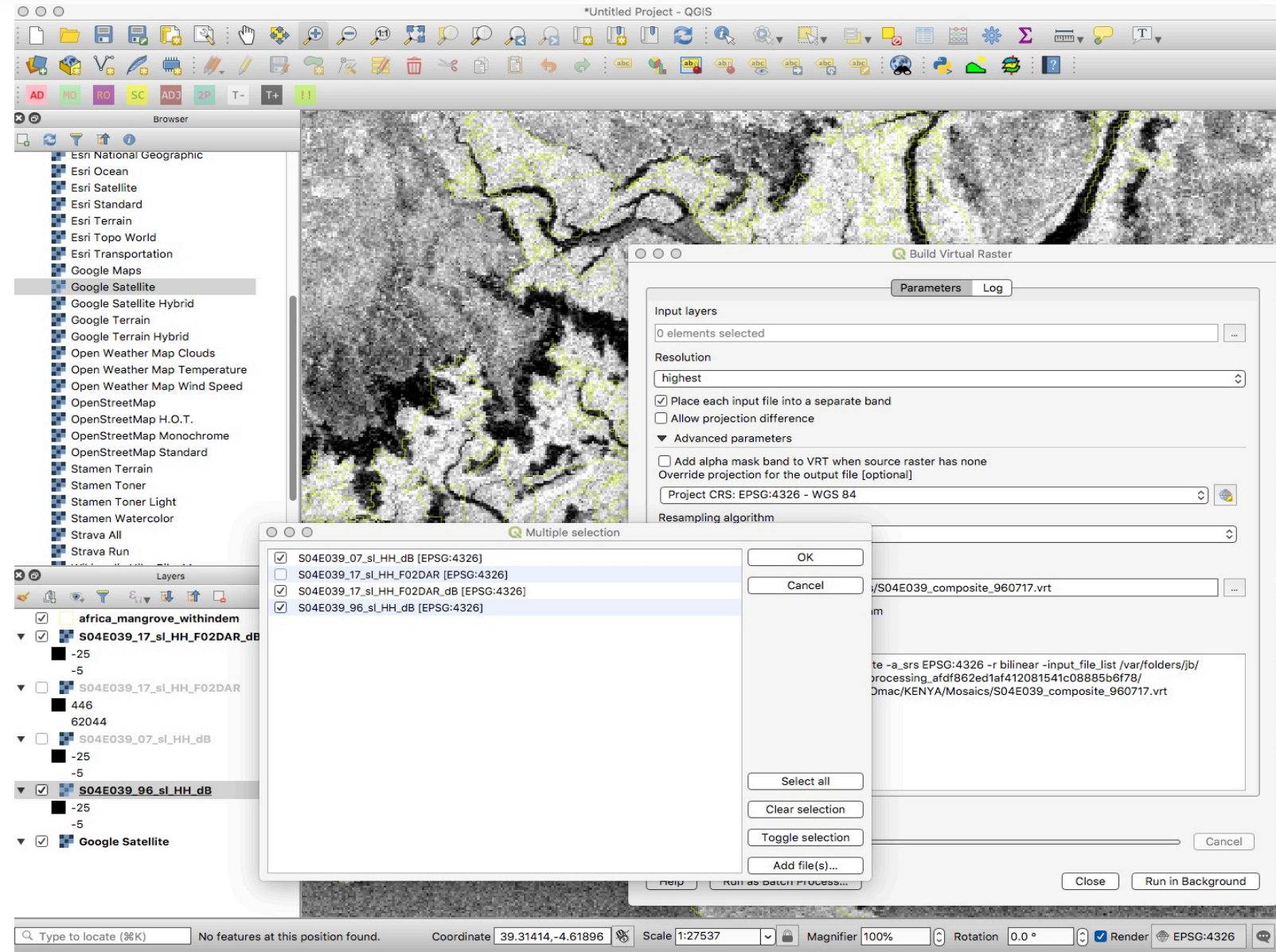
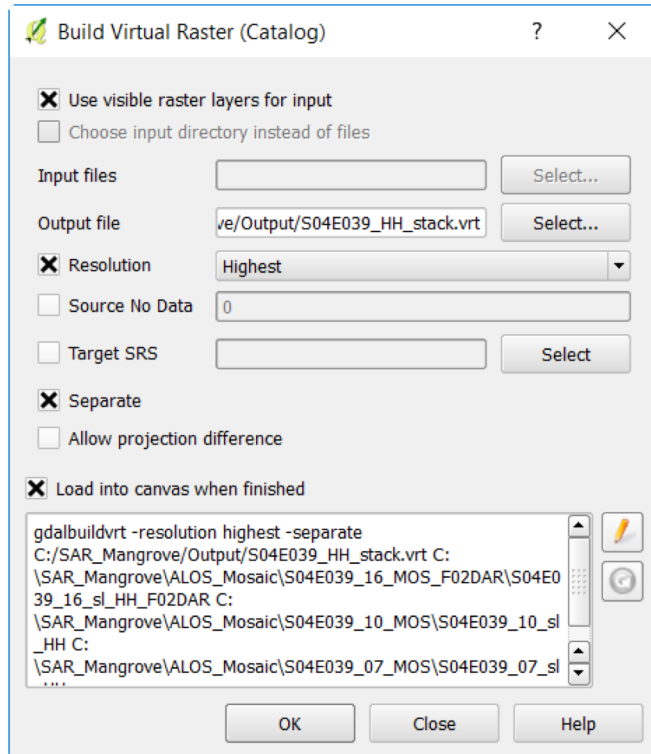


- While radar backscatter is not the best measurement to estimate biomass in mangrove forests, one can use it to monitor mangrove forest loss and gain through time.
- Use color composite to visualize changes:
- Load 3 images from different times into QGIS
 - e.g. JERS-1 (1996), ALOS-1(2007) and ALOS-2 (2017) mosaic tiles.



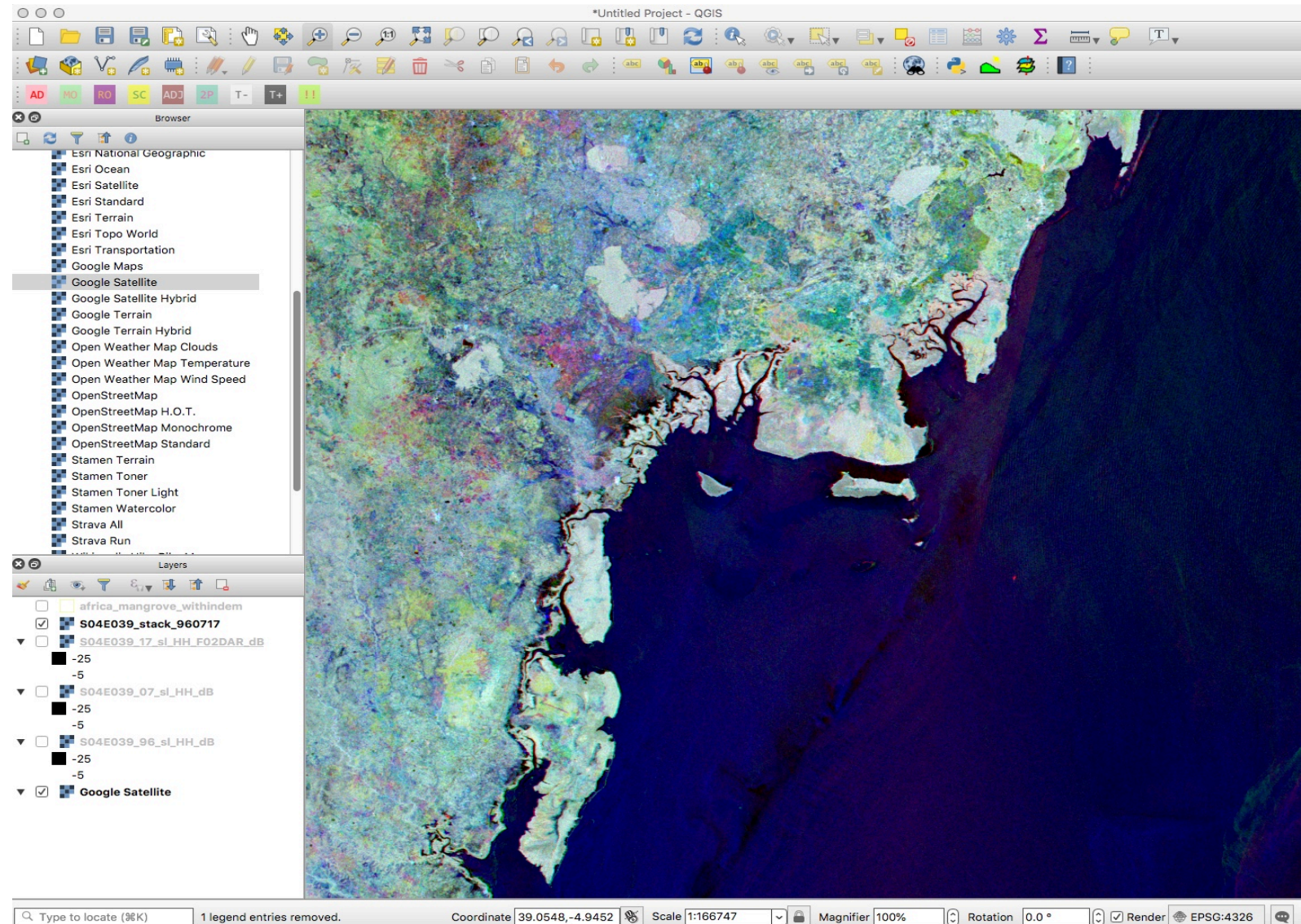
Monitoring mangrove forests loss and gain

- ALOS-2 (2017) mosaic tiles.
- Navigator: Click Raster - > Miscellaneous -> Build Virtual Raster



Monitoring mangrove forests loss and gain

- Load the virtual raster into QGIS.
- Change colors using “Properties” by right clicking on the virtual raster.
- If red, change occurred between you first input band and the others
- If green, change occurred only for the 2nd band. i.e. change occurred between band 1 and 2 but change again, may be returning to original land cover between image 2 and 3.
- If blue, there may have been some regeneration.



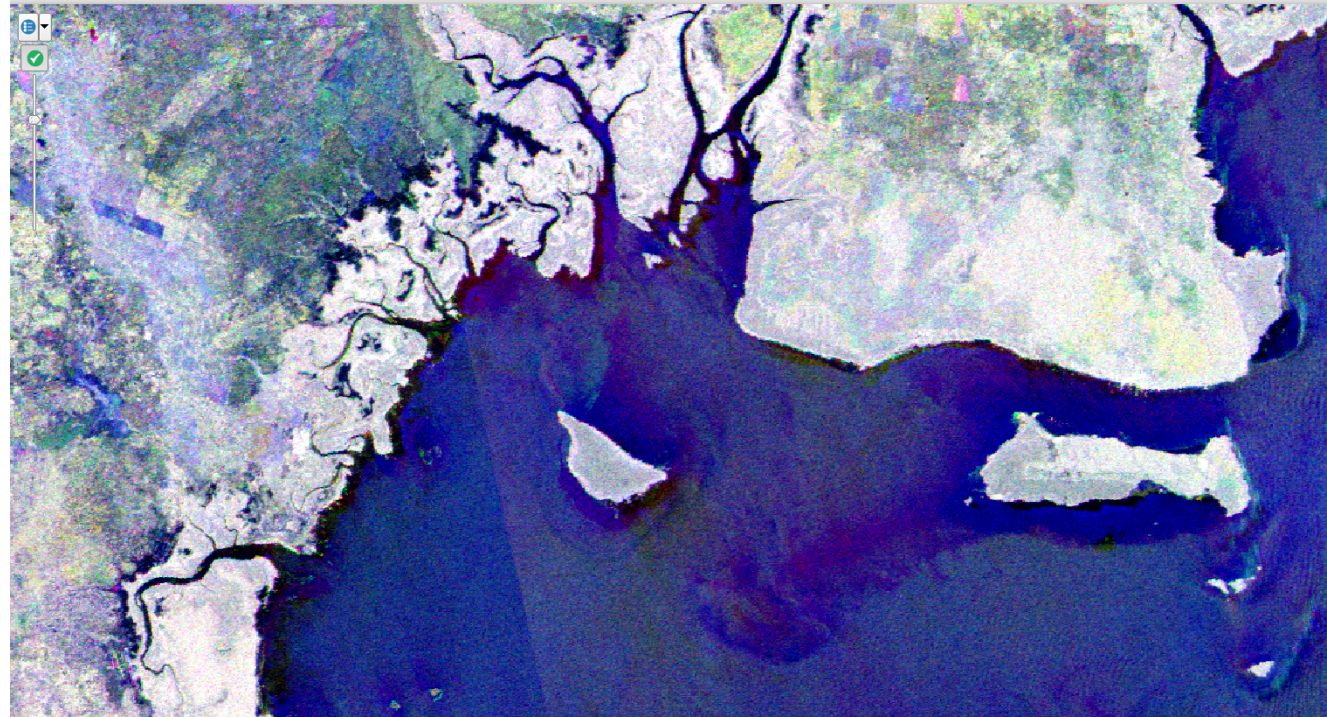
Monitoring mangrove forests loss and gain

Exercise – detect changes in a virtual stack

- Monitor changes, generate your time-series from either ALOS mosaics or Sentinel-1 time-series, processed through SNAP. You can choose the acquisition dates to correspond to plant phenology and climatic trends.
- Convert the images to backscatter values
Hint : Convert DN to db
$$s^{\circ}_{HV}(dB) = 20 \cdot \log_{10}(DN) - 83$$

In dB values; -20 and -5, and -25 and -10 for HH and HV respectively
- Have you found significant changes in mangrove forests for the study region?

ALOS Mosaic – back scatter values: S04E039_HH: 07, 10, 16

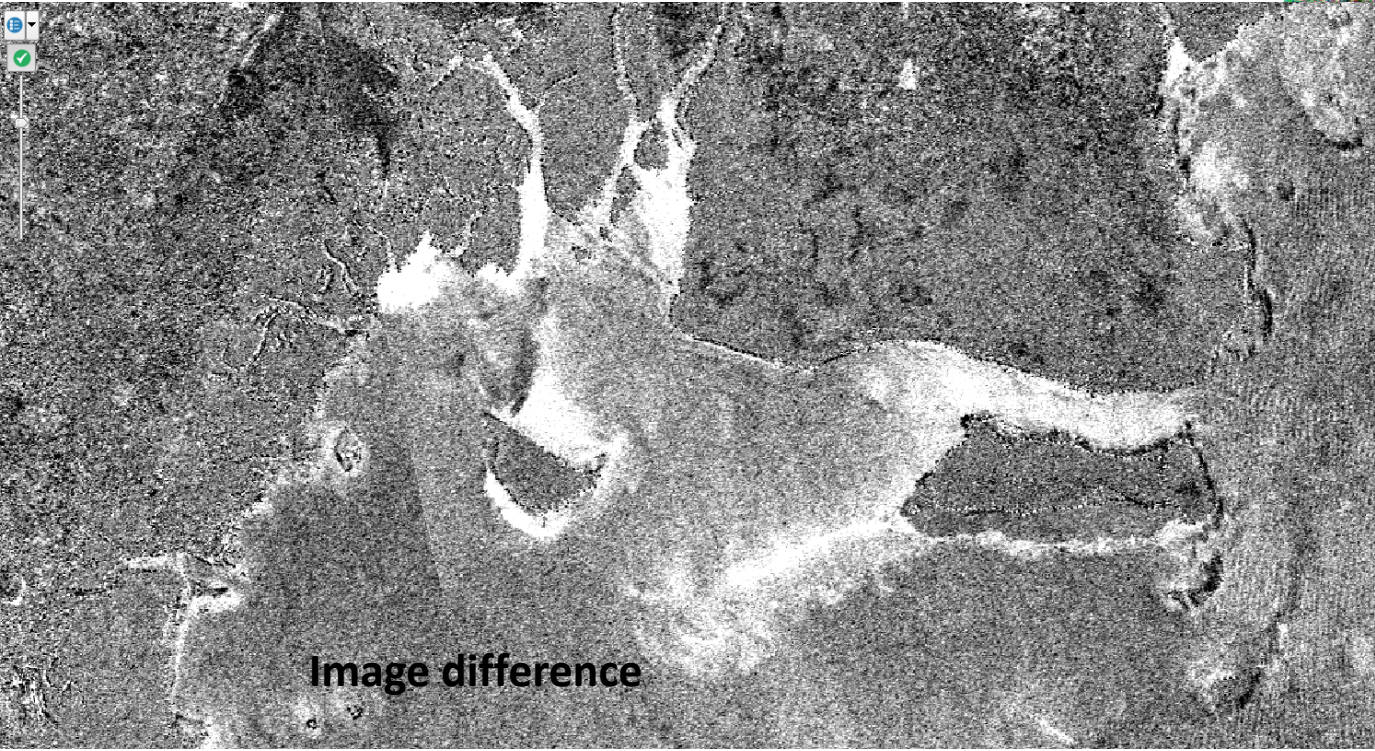


In the example above, we used ALOS mosaics of HH:
S04E039_07_MOS, S04E039_10_MOS,
S04E039_16_MOS_F02DAR

Monitoring mangrove forests loss and gain

- Determine change areas with simple thresholds
- In QIGS, use "Raster" -> "Raster Calculator" to compute the difference between two bands from different years.

ALOS Mosaic – back scatter values: S04E039_HH: 07, 10, 16

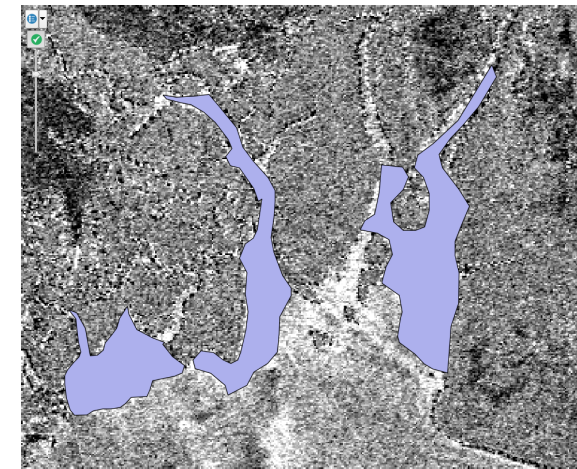
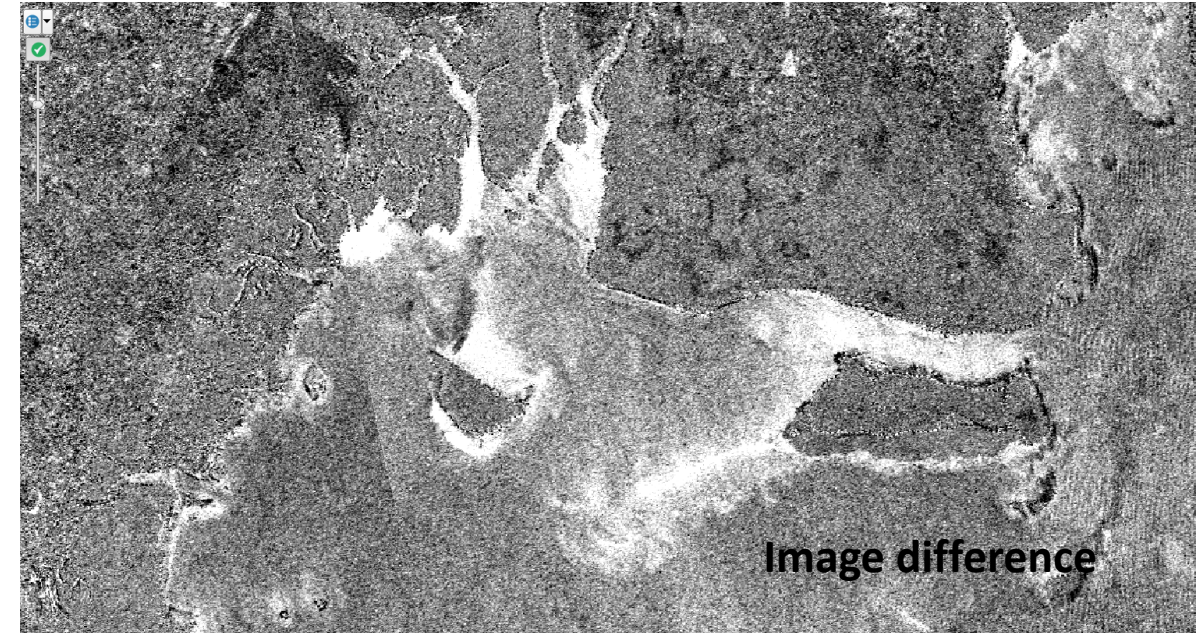


You will notice some changes between the two images. This is the same location over the coast of Kwale, Kenya. Coordinates: -4.66, 39.279

Make a polygon of observed change

- In top menu click “Layer”->“Create Layer”->“New Shapefile Layer”
- Define “Geometry Type” as “polygon”.
- Define output filename in “File Name” and in “New Field” use whole number. We’ll use 1 for change.
- In the “layers” window, click on this new layer
- In top menu click “Layer”->“Toggle Editing”. You can now add features within the file by clicking in the top menu “Edit”->“add polygon feature”
- Draw polygon around observed changes in difference map with mouse click on vertices of polygon. To close polygon, right click. Don’t forget to save after you are done (by clicking “Toggle Editing” again).

ALOS Mosaic – back scatter values: S04E039_HH: 07, 10, 16



Monitoring mangrove forests loss and gain

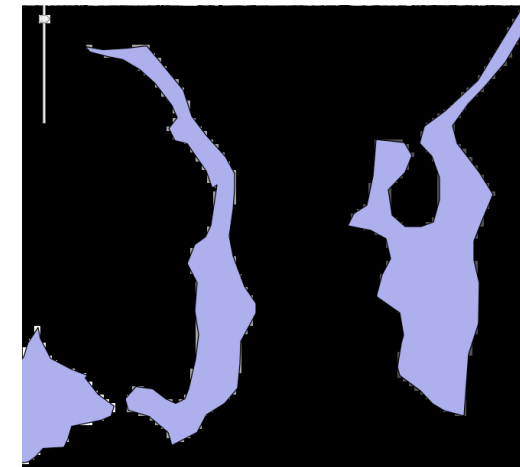
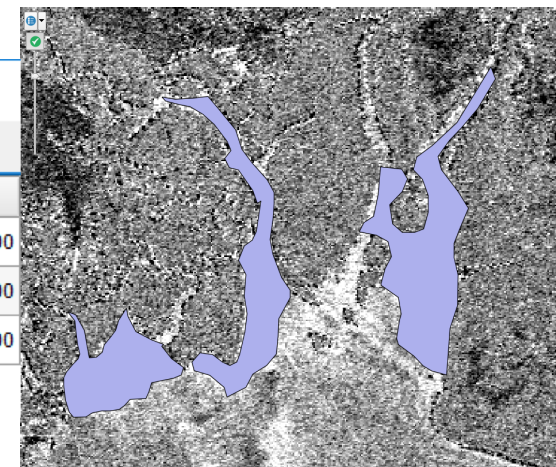
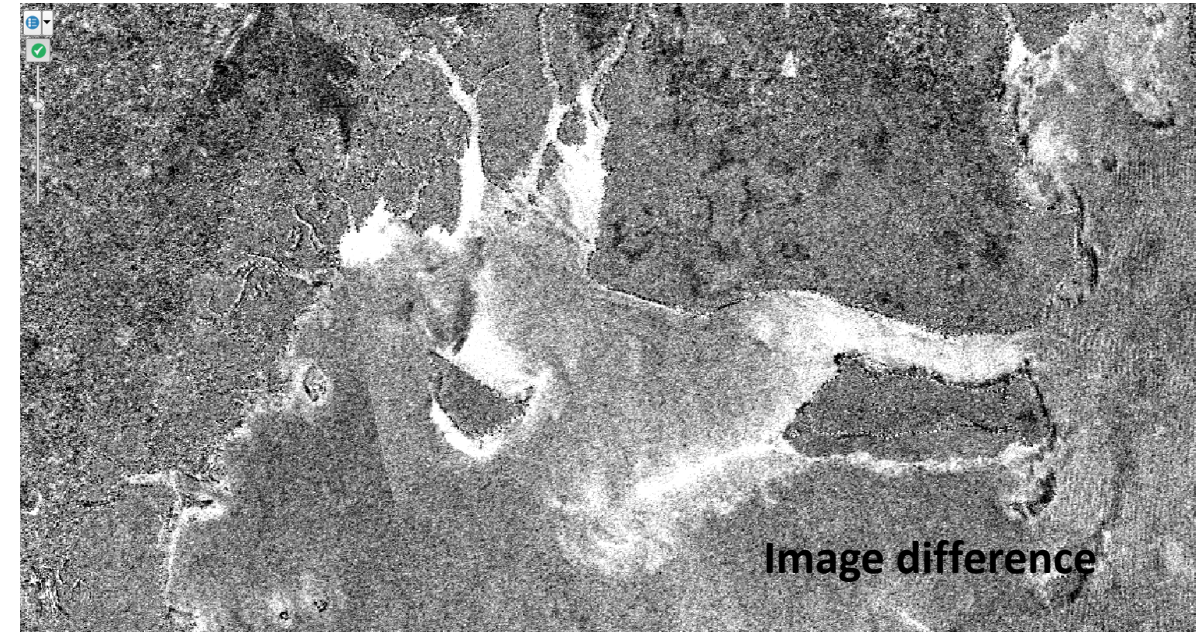
Make a polygon of observed change

- To populate the polygons with attribute values containing statistics from the difference image, use “SAGA” in the toolbox. To see the the toolbox, click “Processing” in the top menu and then “Toolbox”. Navigate to “SAGA”->”Vector-Raster”->”Raster Statistics for polygons”.
- Compute zonal statistics of the polygon
Click “Processing” in the top menu and then “Toolbox”. Type Zonal Statistics and it will appear under Raster tools.

Zonal statistics :: Features total: 3, filtered: 3, selected: 0

| | id | Change | Areas | _min | _max | _sum | _count | _mean |
|---|----|--------|-------|----------|----------|-------------|------------|----------|
| 1 | 2 | 1 | | 2.000000 | 2.000000 | 1226.000000 | 613.000000 | 2.000000 |
| 2 | 3 | 1 | | 3.000000 | 3.000000 | 1464.000000 | 488.000000 | 3.000000 |
| 3 | 1 | 1 | | 1.000000 | 1.000000 | 925.000000 | 925.000000 | 1.000000 |

ALOS Mosaic – back scatter values: S04E039_HH: 07, 10, 16

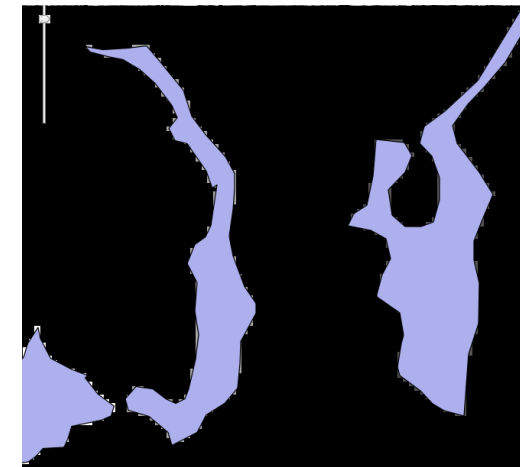
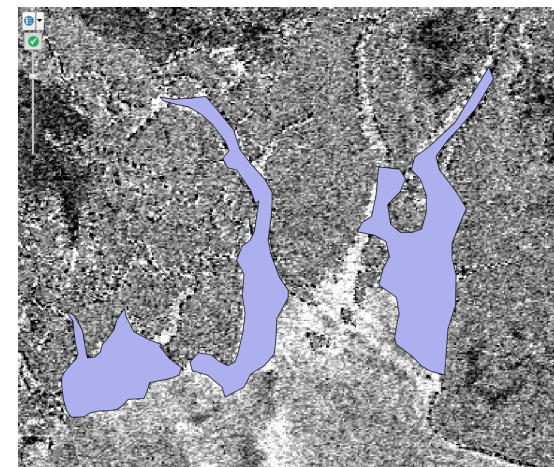
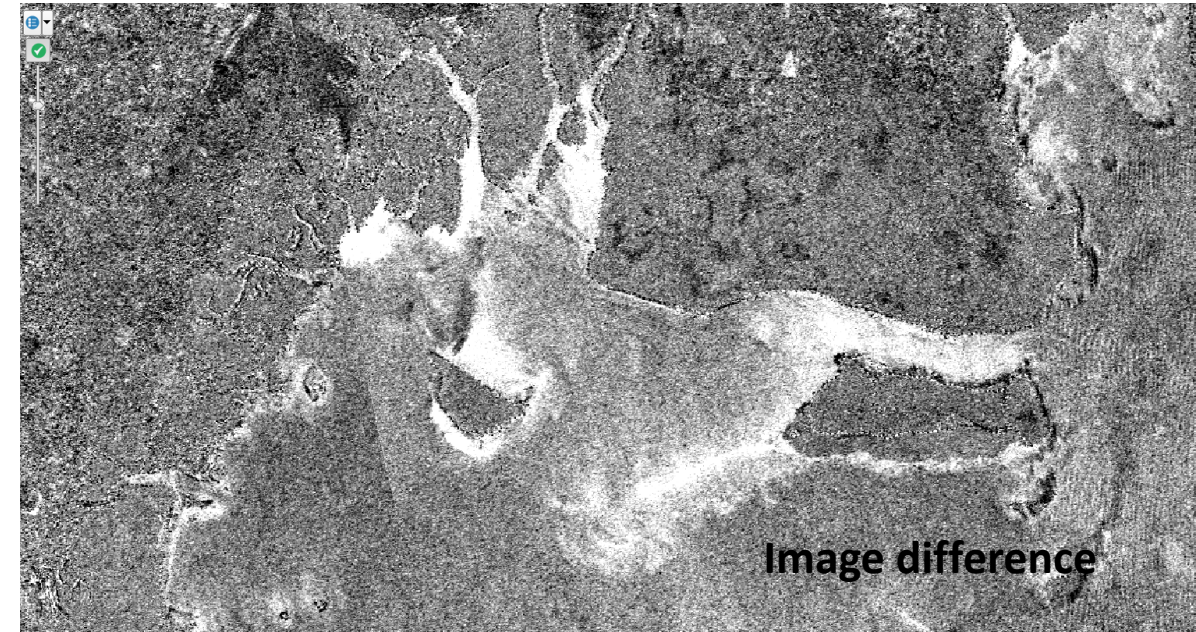


Monitoring mangrove forests loss and gain

Use “Raster”->”Raster Calculator” to make a change map

- The equation can, for example, have the following form ("S04E039_07minus96@1"<-7.0) and ("S04E039_07_sl_HH_dB@1">-15)
 - The logical operators select all values smaller than -7 (i.e. change) that are above -15 in 2007. The latter condition removes some water surfaces when using HH. You can build you own water mask and use it instead.
- To clean-up the *change map*, use the “Majority Filter” found in “SAGA”->”Raster Filter”. A filter of radius 1 is sufficient to remove false changes that may results from radar speckle noise.
- Try again but filter the radar images with the “Multidirectinal Lee Filter” found in “SAGA”->”Raster Filter”

ALOS Mosaic – back scatter values: S04E039_HH: 07, 10, 16

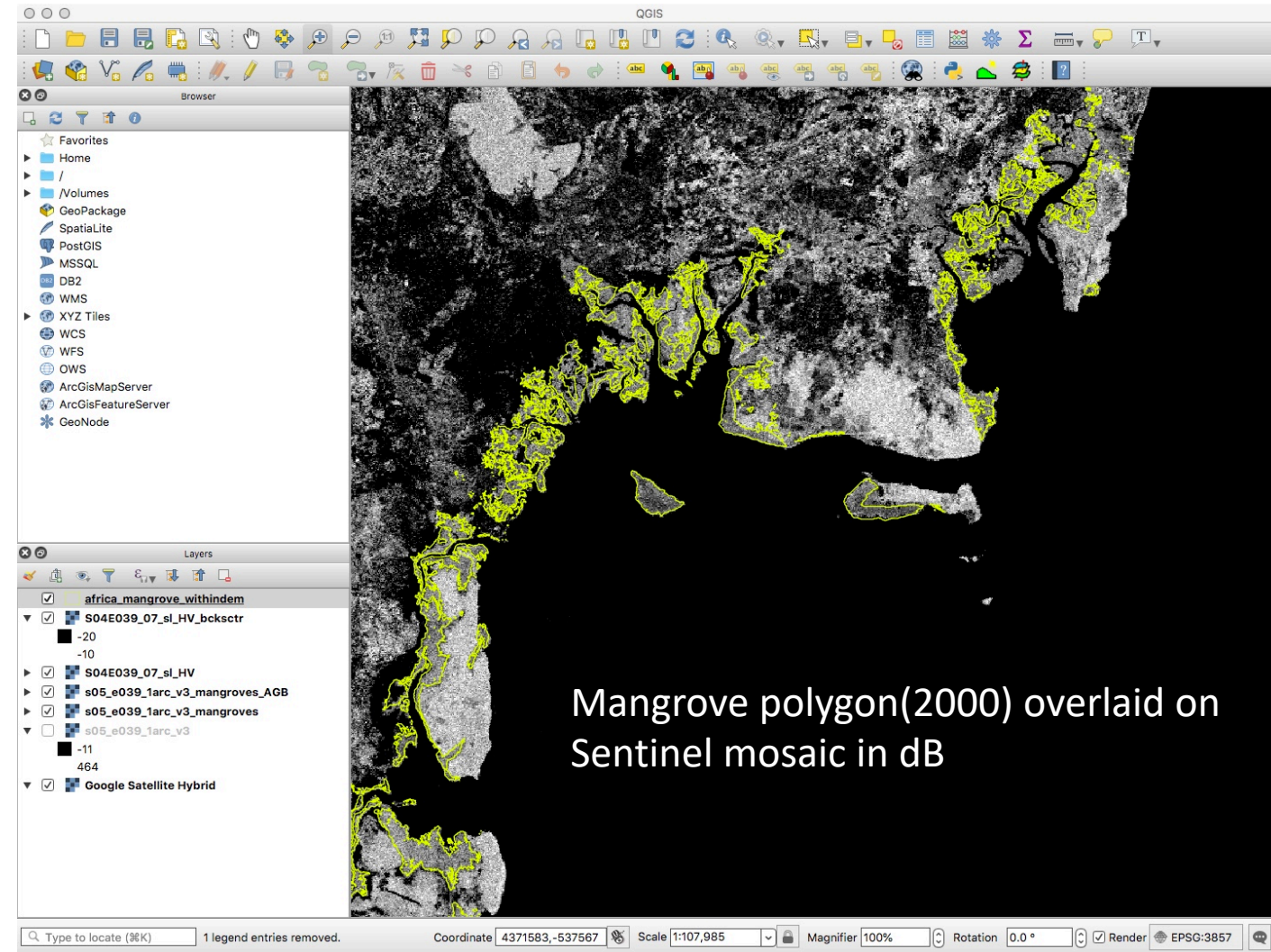


Exercise: Monitoring mangrove forests – Sentinel data



1. Upload the Radar images generated with through SNAP processing in dB from Sentinel 1 in **QGIS**.
 - Note that in the mosaics, the digital number (DN) value of the pixel must be transformed to dB using the following JAXA-provided formula:
 - $\sigma^0_{HV}(dB) = 20 * \log_{10}(DN) - 83$
2. In top menu, click "Raster", then "Raster Calculator".
3. Enter formula in "Raster Calculator Expression". Double-click on band name to insert in expression.

Sentinel 1 data– back scatter values



Thank you



Kenneth Mubea, SERVIR E&SA
mubea@rcmrd.org

Twitter: @RCMRD_ @SERVIRGlobal