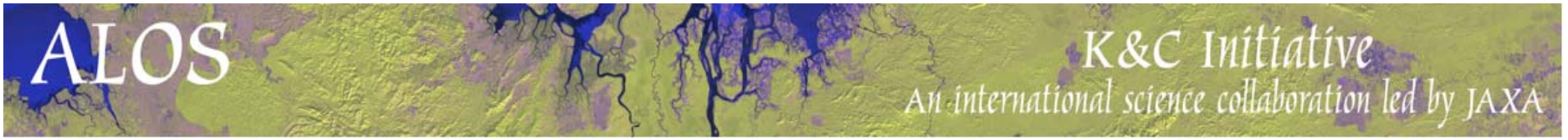


K&C Phase 3

K&C GLOBAL MANGROVE WATCH

Richard Lucas, Ake Rosenqvist,
Lisa Rebelo and Dirk Hoekman

Aberystwyth University,
soloEO, *IWMI-Laos, Wageningen University*

Project objectives and schedule

- To contribute to the development and implementation of a global mangrove characterization and monitoring system, with the latter based primarily on ALOS PALSAR data but using existing Landsat-derived (with SRTM where available) baselines (Giri et al., 2011; Fatoyinbo et al., 2011).

Project area(s)

Global Mangrove Watch (primarily tropics and subtropics)

Project Schedule (Three Phases)

- Phase 1
  - Request for tiles and coverages of selected coastal areas (25 m)
  - Generate initial classifications of mangrove change away from the established baselines as well as structure/biomass using eCognition.
    - JERS-1 and ALOS 2007, 2008, 2009 and 2010.
  - Evaluate classification accuracy and approach in collaboration with JAXA and partners.
  - Assess potential to run through global ALOS PALSAR mosaics, even at 10 m.
- Phase 2
  - Review and implement algorithms for assessing mangrove structure and biomass and change.
  - Assess procedures and datasets required for mapping within eCognition.
  - Evaluate classification accuracy and approach, again in collaboration with JAXA and partners.
  - Generate first regional maps of mangrove change and characteristics.
  - Understand observed changes (e.g., sea level rise).
- Phase 3
  - Implement classification and change detection methods using the global mosaic at the same time as the production of the forest/non-forest map.
  - Provide validation through recent field data and remote sensing data collection campaigns
  - Design and have pre-operational, a Global Mangrove Watch system in preparation for launch of ALOS-2.

Project Schedule (Phase 1 April/July 2012)

- Complete review of sites for detailed study and selection of additional sites where change has been significant (i.e., current 'hotspots') (Completed and on shared dropbox)
- Following provision of sample 25 m tiles/regional mosaics for each selected site by JAXA and review of existing algorithms, complete implementation of a 'standard' eCognition ruleset (to be provided initially by Aberystwyth University/JAXA following consultation with partners) for:
  - Mapping changes in mangrove extent and state (e.g., structure, biomass, broad species) and attributing such changes to a particular event or process.
  - Characterising mangroves (e.g., high/low height/biomass, with or without prop roots).

  (Draft ruleset generated in Aberystwyth, to be evaluated during visit to JAXA in April for sites and then by partners; finalising contract to allow distribution of tiles)
- Critique the approach and provide suggested improvements to the ruleset and necessary refinements (e.g., in terms of geometric fitting with existing mangrove datasets). (April visit)
- Provide revised ruleset and appropriate validation information to JAXA, following consultation between partners, with this collated and standardized within and between study areas where possible (validation data being collected/collated by partners)
- Critically evaluate the revised ruleset by partners (at K&C meeting and in subsequent workshop at Tsukuba, Japan) and agree on optimal ruleset for regional and potentially global application (April)

Project Schedule (Phase 2 April 2013)

- Generate first 'sample' regional maps of mangrove change and characteristics.
- Understand and explain observed changes (e.g.,in relation to sea level rise, human impacts). (In progress)
- Complete joint paper to international journal outlining the consistency of the approach for mapping mangroves and detecting change within and between regions. (Conference presentations submitted/accepted by IGARSS and Intecol, some journal articles in preparation)
- Following provision of further sample 25 m tiles/regional mosaics by JAXA (for the same or new areas), complete algorithm refinement and protocol for regional to global mapping, for implementation by JAXA at 25 and potentially 10 m spatial resolution.
- Completed validation of global mangrove characterization and change map (Version 1.0) (based on key sample areas).

Project Schedule (Phase 3 April 2014)

- Develop a web-based map product delivery system with JAXA that allows open access to mangrove characteristics and change datasets; this is to be discussed with JAXA.
- Completed update on global change and structural/biomass maps (to 2010).
- Review global products
- Complete major joint paper and other material publicizing a global ‘mangrove watch’ system and a suite of papers highlighting application for specific regions and/or globally.
- Publish operational global mangrove monitoring ruleset (for external review) that primarily utilizes ALOS PALSAR data and allows up-to-date maps of mangrove characteristics and change to be generated at a global level.
- Design, and have pre-operational, a Global Mangrove Watch system in preparation for launch of ALOS-2, including system for continued update and validation.

Support to JAXA's global forest mapping effort

- Support from collaborating organisations, including RAMSAR
- Field-based measurements of structure, biomass, species composition (examples below)
- Airborne-derived and high-resolution spaceborne measures of structure, biomass, species composition (examples below)
- Change maps generated for selected sites/regions using optical remote sensing data (examples below)
- Rulesets and improvements on these for characterizing mangroves and detecting change (in development)
- Working group (opportunities for funding and more regular meetings between participants) (April visit)

Support to JAXA's global forest mapping effort

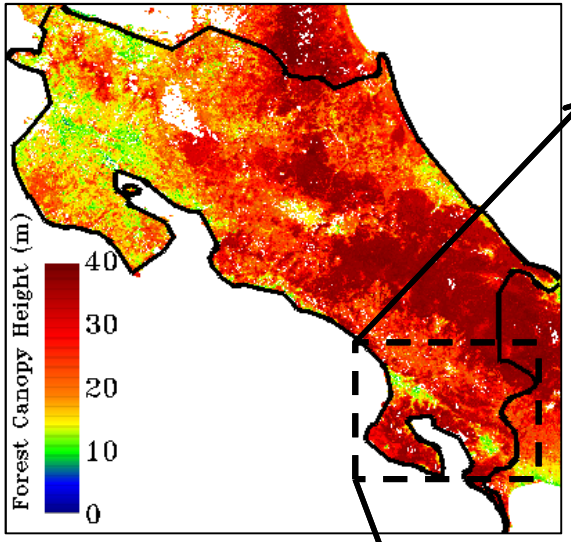
The GMW members seek to work collaboratively with JAXA by participating in K&C Science Team meetings with wetlands sessions that focus specifically on the characterization and detection of change within mangroves, the advancement of the eCognition rule-set and other classification systems and the development of the global mangrove watch system.

- Wiki site and dropbox established and kmls generated for image outlines with some image kmls generated. Ground truth data to be collated as kmls.
- SRTM-derived height maps generated for sites by Marc Simard and Fatoyinbo Agueh, NASA (completed or in progress).
- Aberystwyth University visiting JAXA in April to advance practical elements of project and evaluate rulesets.
- Two dedicated Ph.D. students applied for by Aberystwyth University, both going through to final round (For September, 2012).
- New mapping from Chandra Giri made available

Case Studies

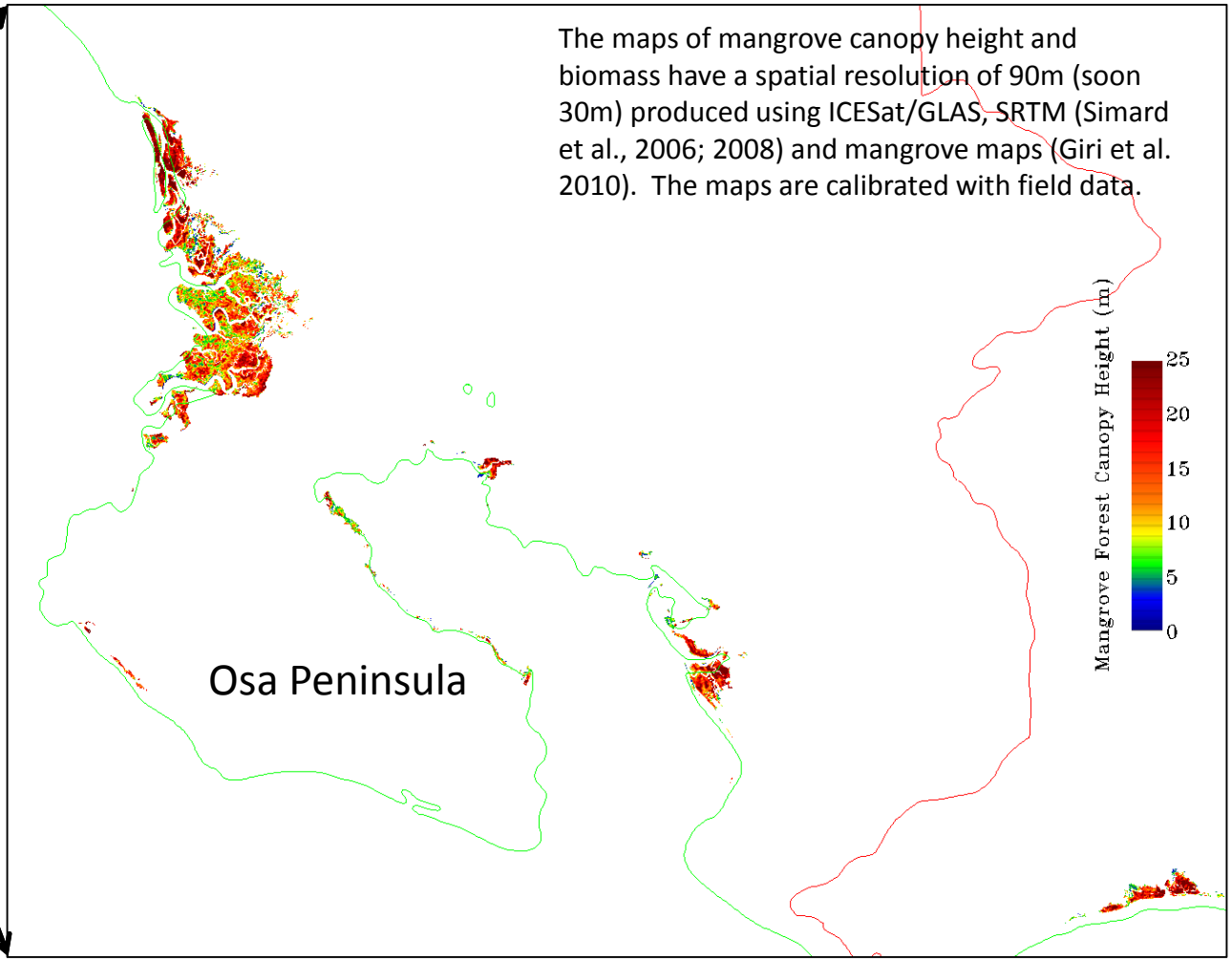
Lidar+Radar Mapping of Forest Canopy Height and Above Ground Biomass in Costa Rica

(Simard et al., JPL, 2012)



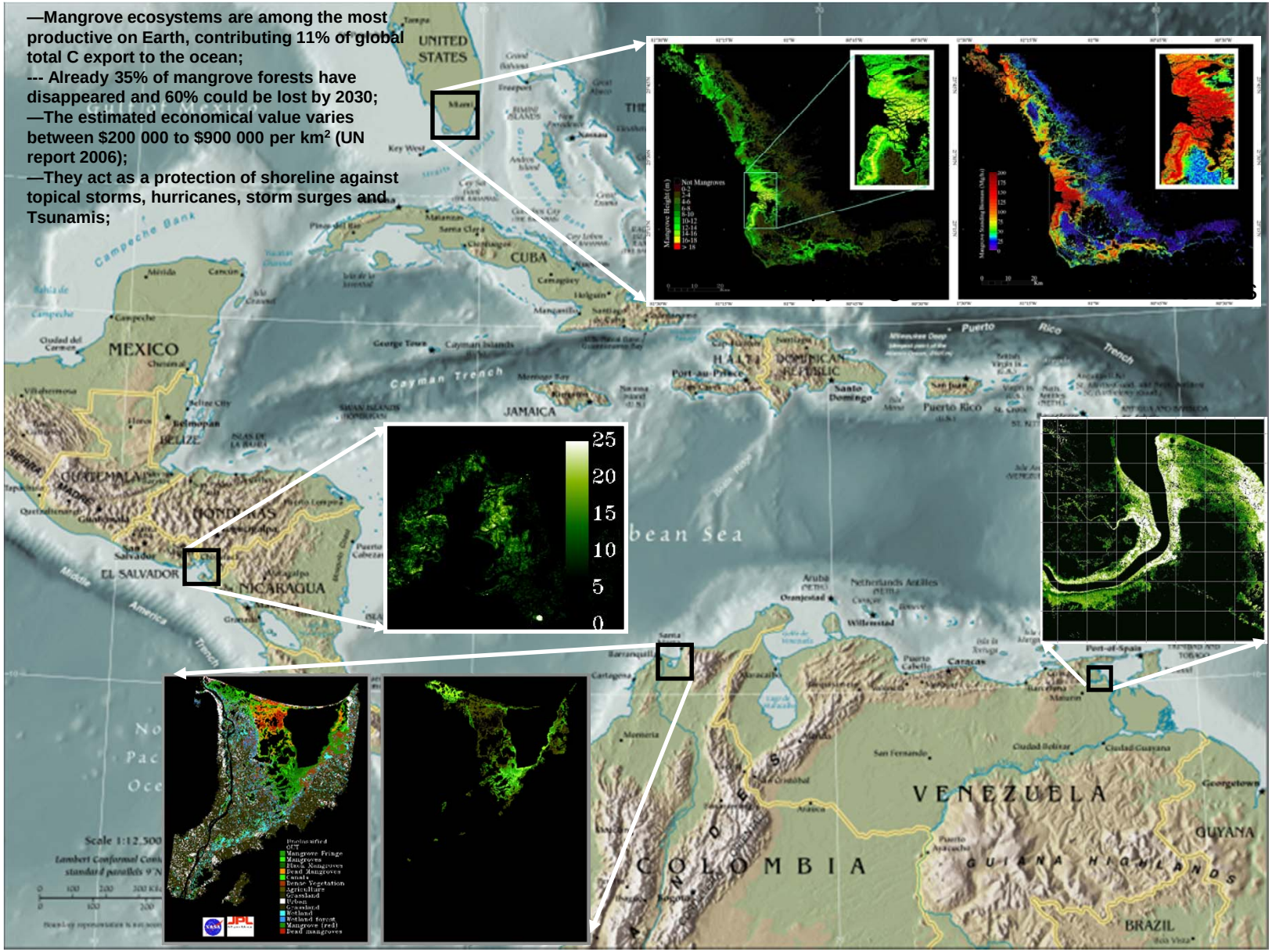
The Canopy Height is a 1km resolution map produced using ICESat/GLAS, MODIS and environmental variables (Simard et al.,2011).

The maps of mangrove canopy height and biomass have a spatial resolution of 90m (soon 30m) produced using ICESat/GLAS, SRTM (Simard et al., 2006; 2008) and mangrove maps (Giri et al. 2010). The maps are calibrated with field data.

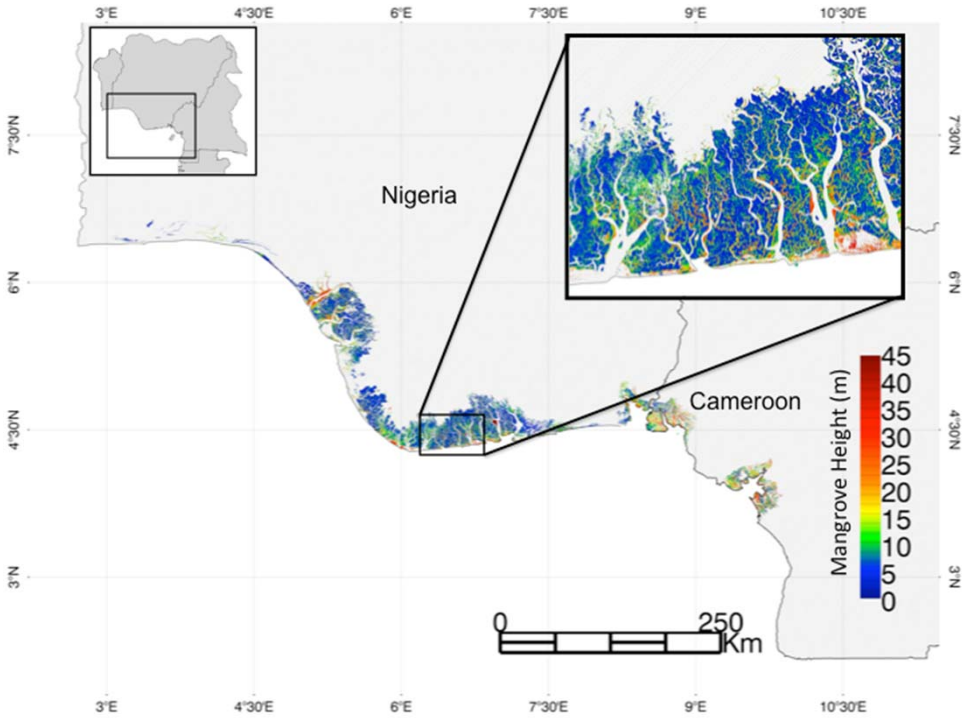


Americas

Marc Simard (marc.simard@jpl.nasa.gov)



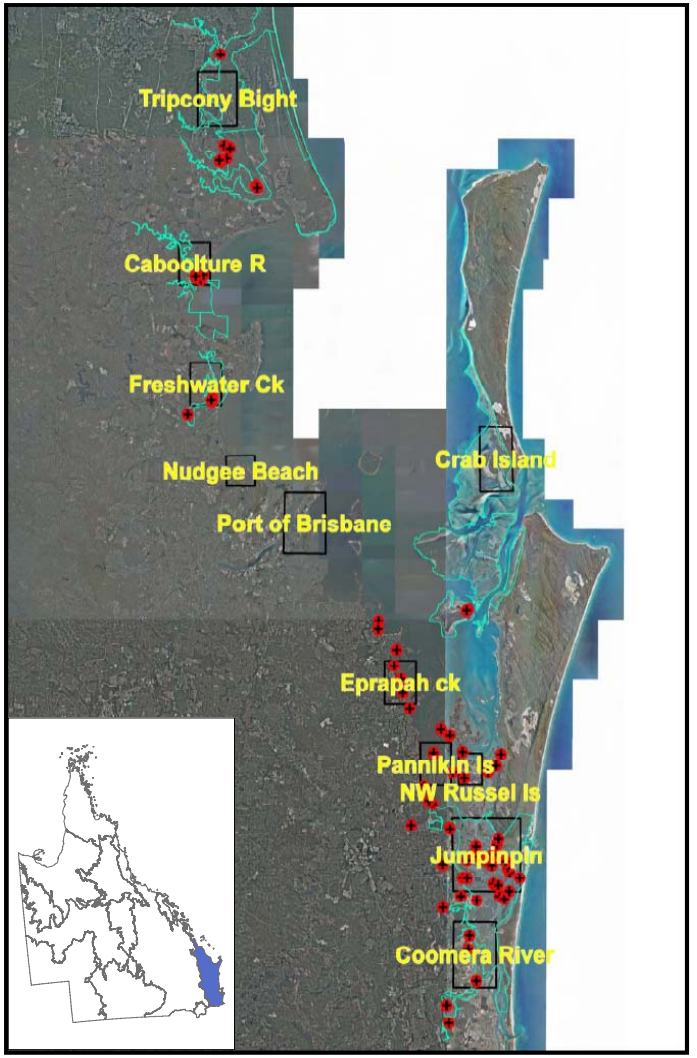
Height and Biomass Map



Country	Mean height in m	Total biomass in Mg	Mean Biomass in Mg/ha
Angola	7.6	2,226,915	144
Benin	3.9	171,326	95
Cameroon	16.3	14,393,930	97
Congo	17.05	122,583	81
Cote d'Ivoire	10.73	595,186	186
Djibouti	4.5	179,667	103
DRC	7.24	2,554,017	140
Egypt	6.1	8,849	124
Equatorial Guinee	12.3	3,719,552	205
Eritrea	5.15	550,347	112
Gabon	14.09	35,230,691	242
Ghana	7.56	7,607,178	147
Guinea	7.92	28,104,993	149
Guinea Bissao	9.4	47,291,626	168
Kenya	6.33	2,455,214	127
Liberia	8.96	3,069,580	163
Madagascar	8.53	31,888,567	155
Mauritania	5.1	4,862	111
Mozambique	7.33	43,007,973	141
Nigeria	8.35	132,242,206	154
Senegal	5.06	13,286,938	111
Sierra Leone	9.03	15,619,508	164
Somalia	2.98	248,894	83
Soudan	3.34	35,235	88
South Africa	9.81	208,514	174
Tanzania	11.77	16,181,258	200
Togo	4.67	21518.064	105
AFRICA	9	401,027,126	158

Moreton Bay Area, Queensland

- South East Queensland massive population boom
- Moreton Bay (defined as the area from Caloundra to Southport) is being impacted
- Moreton Bay in 1997 contained in excess of **18,500 ha** of mangroves and associated saltmarsh communities (Dowling and Stephens 2001).
- Eleven AOI have been selected and subset of sites were designated to be re-visited



Mangrove and Associated Vegetation Communities Selected for Monitoring

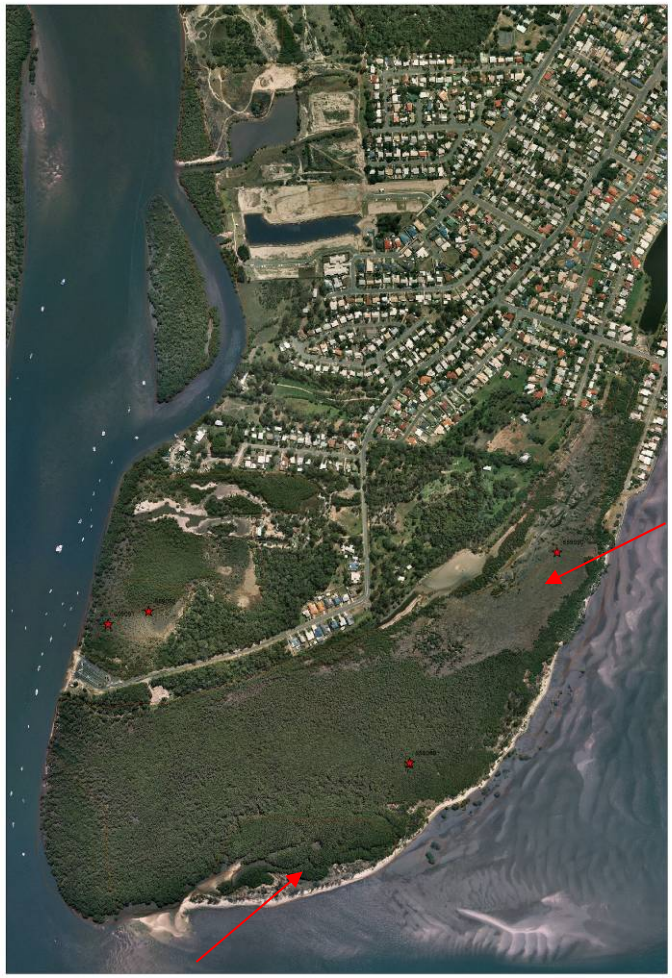
- The area of these nine monitored vegetation communities represent 82.7% of the area of mangroves and associated communities within Moreton Bay.
- Over 44 percent of the area of the nine monitored communities within Moreton Bay is captured by the eleven AOI.

Vegetation Code (Dowling and Stephens 2001)	Total Area in Moreton Bay (ha)	Area in the Eleven AOIs	Percentage of Vegetation Type in Moreton Bay within each AOI	Map Unit Description
1B(i)	4673	2231	48%	*Avicennia marina* closed-forest, open-forest, woodland, low closed-forest, low open-forest, low woodland, low open-woodland
1B(ii)a	4034	1598	40%	*Avicennia marina* closed-scrub, open-scrub
1B(ii)b	1873	934	50%	*Avicennia marina* tall shrubland, tall open-shrubland
1B(ii)c	70	43	61%	*Avicennia marina* tall shrubland, tall open-shrubland that are dying due to waterlogging
1B(iii)	687	189	28%	*Avicennia marina* low open-scrub, low shrubland, low open-shrubland
1D(ii)	198	78	39%	*Ceriops tagal* low open-scrub, low shrubland, low open-shrubland
2	2095	911	43%	Claypan
3A(i)	397	174	44%	*Sarcocornia* spp., *Suaeda australis*, *Suaeda arbusculoides* dwarf closed shrubland,dwarf shrubland, dwarf open-shrubland, dwarf sparse-shrubland
4A(i)	1330	673	51%	*Sporobolus virginicus* closed grassland, grassland
Total	15357	6831	44.5%	

Dynamic Mangrove Communities
Hays Inlet Dohles Rocks Rd

- 1950s,
- 1970s,
- 1990s and
- 2009

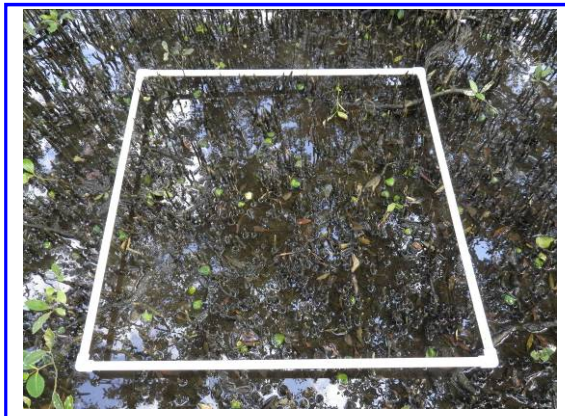
- 1950s,
- 1970s,
- 1990s, and
- 2009
- Expansion to the sea on one hand
- Dieback on the other



Field Site Attributes

Site A

659096



Site B

659095



Tree Heights

- Field measurements of 51 tree heights within the CORVEG site (A) estimated average tree height to be 8.28 meters
- Lidar measurements from 39 evenly distributed tree surface locations estimated average tree height as 7.5m (-78cm)
- In site (B) with uniform tree heights (avg 4.43m) the lidar average is -7cm

Foliage Projected Cover (FPC)

- Field measurements of 200 random locations within 50 x 10 m CORVEG site estimated FPC to be 77.5%

- Lidar measurements from evenly distributed tree surface locations estimated FPC to be about 79%

Historical Mapping

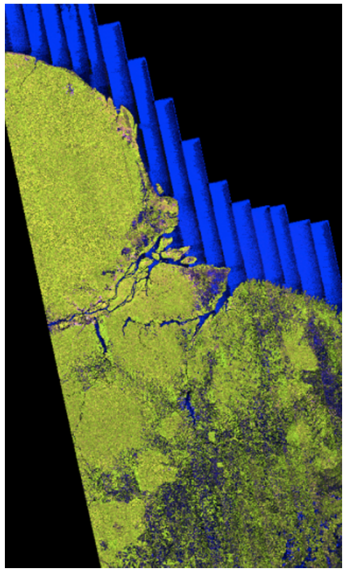
- 1950s and in some cases 1940s
- 1970s
- 1990s
- 2009
- Using mapping
- Or apply statistically viable random points assessment to determine change in extent

Mangrove Change

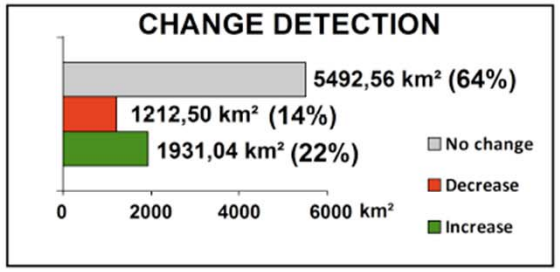
Atlantic Coast South America 1998-2008

215 GCPs were collected with 62 used to validate the classification of mangroves and 153 to validate other classes

> 80% accuracy in the classification of mangroves and also change



NOCHANGE
DECREASE
INCREASE

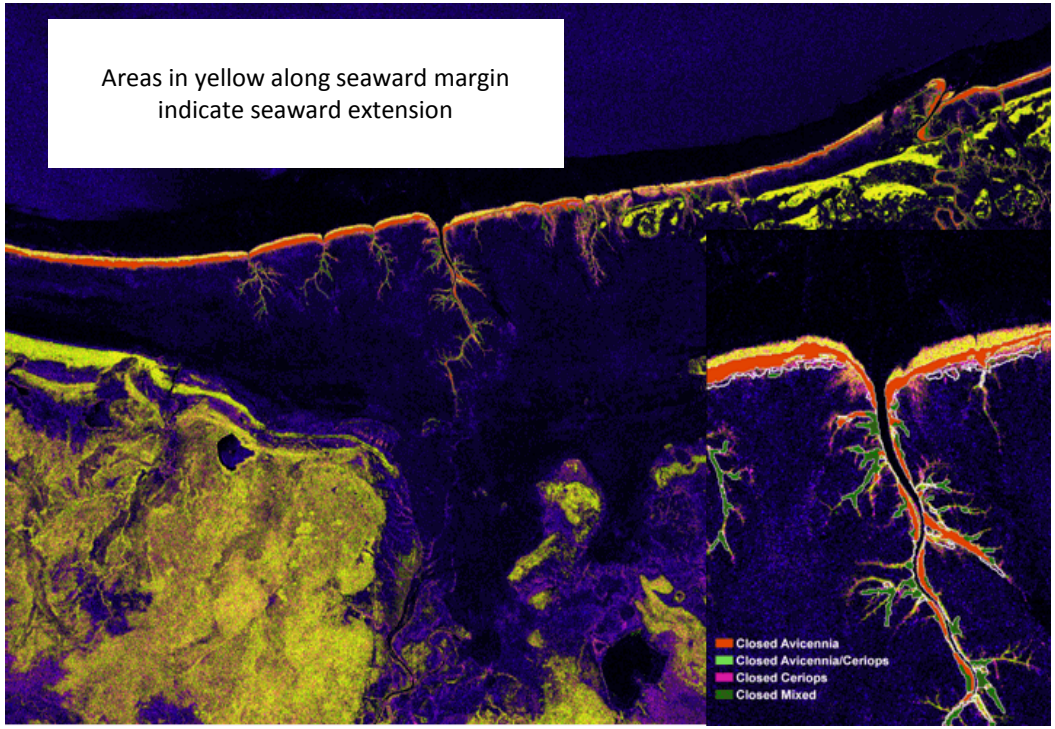


0 15 30 60 90 120 km

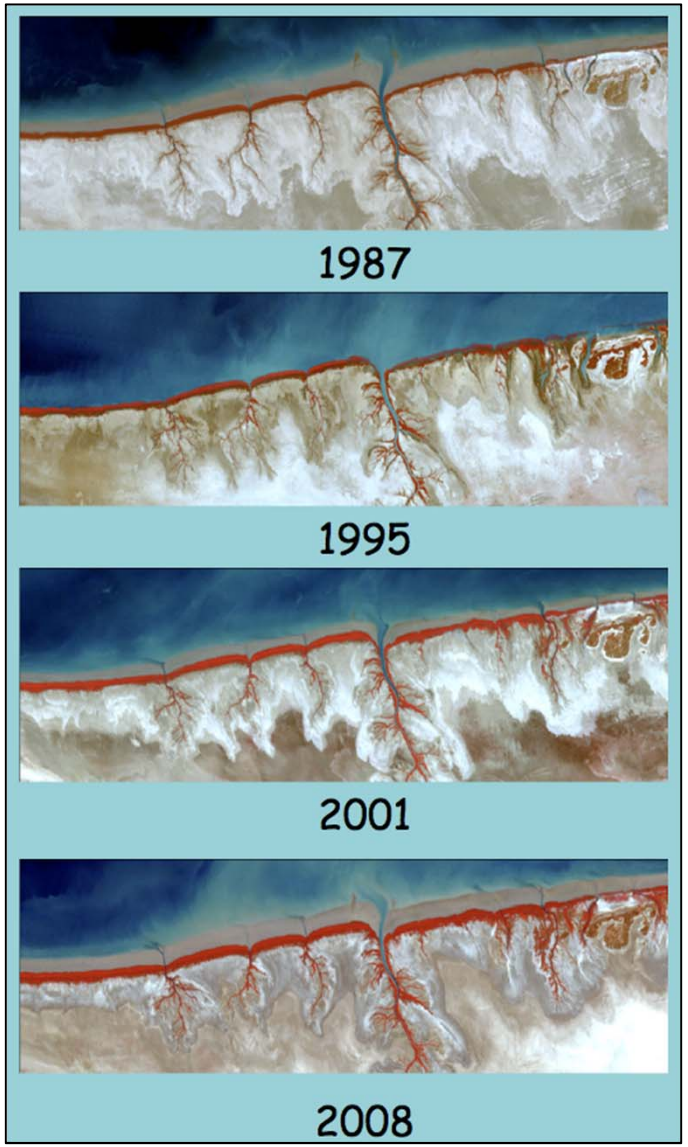
48°0'0"W 47°0'0"W 46°0'0"W 45°0'0"W 44°0'0"W

0°0'0" 1°0'0"S 2°0'0"S 3°0'0"S

Changes in Mangrove Extent, Northern Australia



- Mapping from established baselines using ALOS PALSAR indicated relative general stability along Queensland coast
- Exception is the Gulf of Carpentaria
  - Significant seaward expansion
  - Some inland intrusion
- Associated with:
  - Extensive but periodic flooding and sediment discharge
  - Inland intrusion of sea water

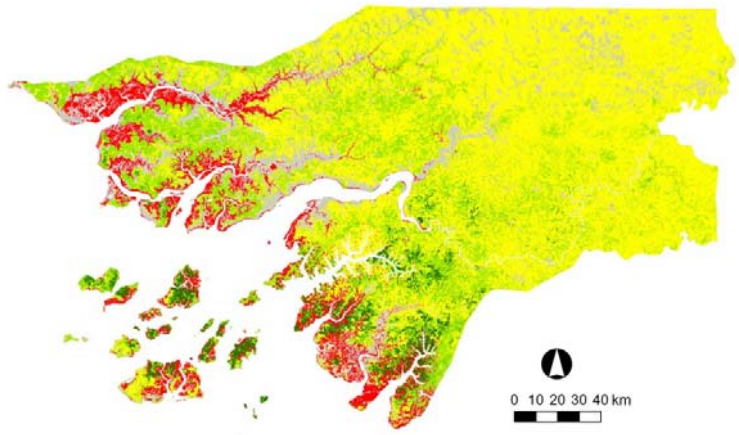


Changes in the extent of mangroves, as observed using time-series of Landsat sensor data

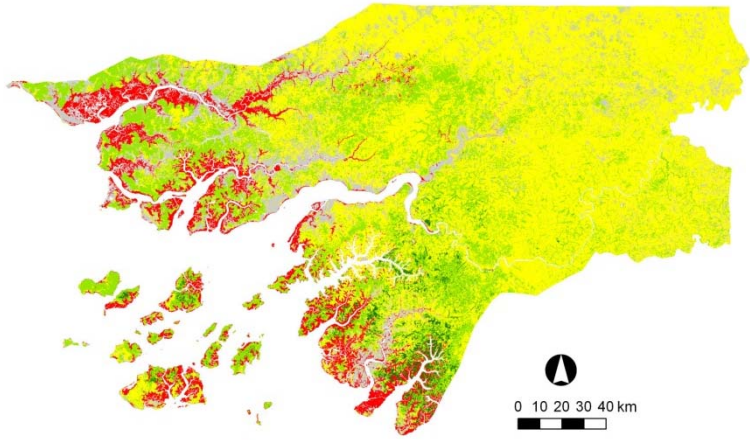
Monitoring Guinea-Bissau mangrove and terrestrial forest with Landsat data

Two further dates are available: 1990, 1994

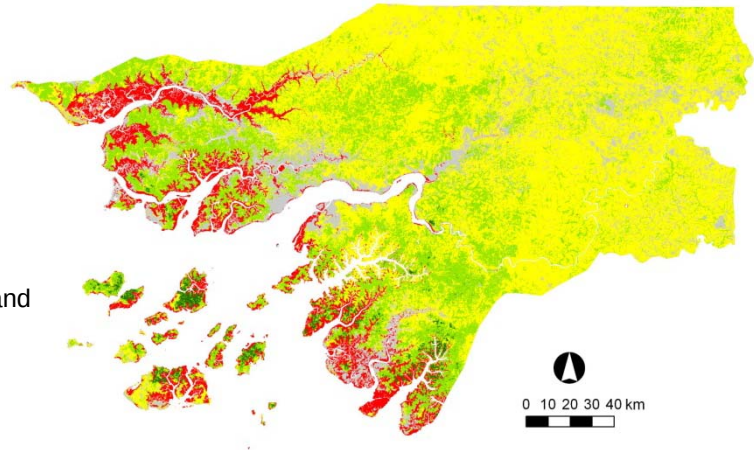
2002



2007



2010



Legend

- Closed forest
- Open forest
- Savanna woodland
- Mangrove
- Non-forest

1883

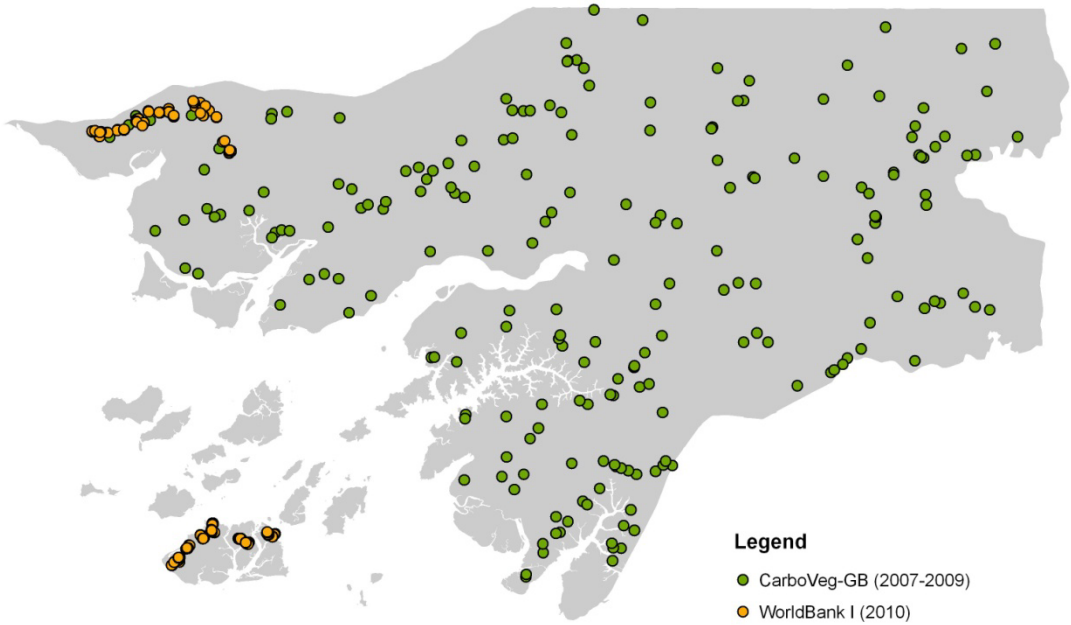
125 anos

Estimate and retrieve forest aboveground biomass in Guinea-Bissau

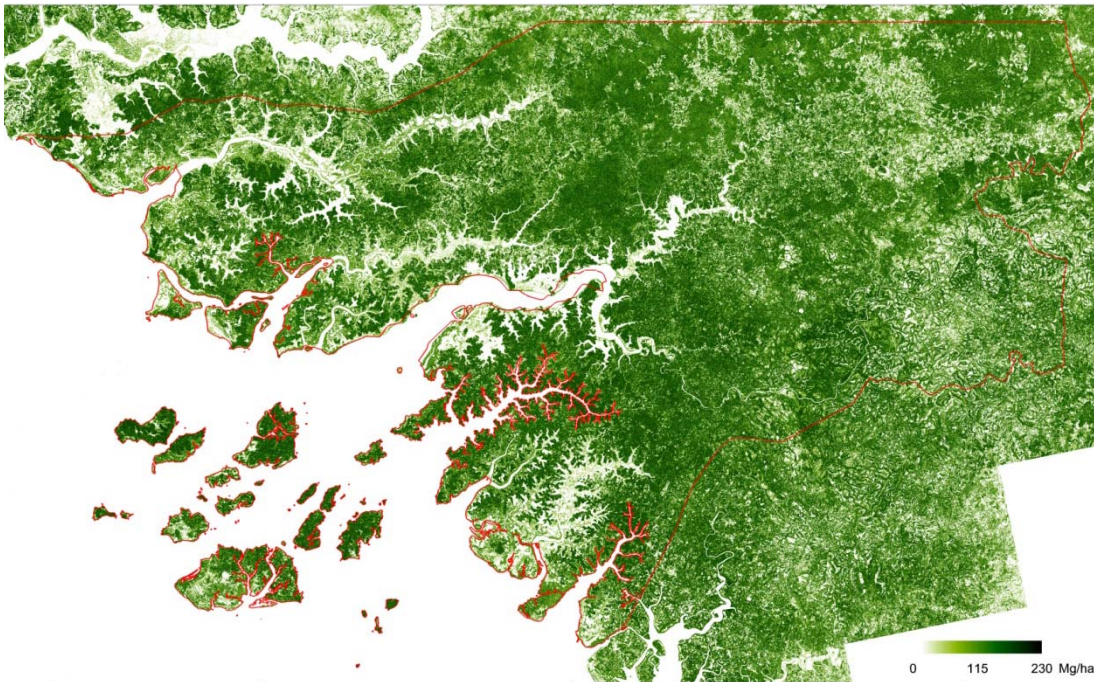
~240 field plots measured 2007-2009 (CarboVeg-GB project) (~20 mangrove)

~200 field plots measured 2010 (World Bank GB project I) (~40 mangrove)

~150 field plots measured 2012 (World Bank GB project II) (~30 mangrove)



Forest aboveground biomass map derived from ALOS PALSAR FBD (2008) and field data (2007-2008)



Carreiras, J.M.B., Vasconcelos, M.J., & Lucas, R.M. (2012). Understanding the relationship between aboveground biomass and ALOS PALSAR data in the forests of Guinea-Bissau (West Africa). *Remote Sensing of Environment*, 121, 426–442.

1883

125 anos

Deliverables

A collaborative JAXA K&C project focusing on:

•Generation of mangrove change maps globally.

•A pre-operational mangrove change detection system for use with ALOS-2 supporting national and international monitoring systems.

•High level publications and mangrove products

Initial Sites for Detecting Change and Characterising mangroves

Location	Airborne and field datasets	Change mechanism
Daintree NP, Queensland, Australia	AIRSAR baseline, hyperspectral data, field	Cyclone damage
Kakadu NP, NT, Australia	AIRSAR baseline, aerial photography, field	Saltwater intrusion and flooding
SE Queensland, Australia	Aerial photography, LiDAR, field	Flooding and urban development
Hinchenbrook Island	Aerial photography, LiDAR, field	Cyclones
Rockhampton	Aerial photography, LiDAR, field	Flooding and urban development
Fly River, PNG	AIRSAR baseline, GeoSAR	Mining pollution
Perak, Malaysia	High resolution satellite	Logging and aquaculture
Placencia lagoon, Belize	Aerial photography	Tourism development
French Guiana coastline	AIRSAR.	Redistribution of sediments
Gulf of Fonseca, Honduras	UAVSAR, AIRSAR, field	Shrimp farms
Sierpe, Costa Rica	UAVSAR, field	Water management
Everglades, Florida	UAVSAR, AIRSAR, lidar, field	Hurricanes, water management
Cienega Grande, Colombia	Field and aerial photos	Water management and lumber
Rio San Juan, Venezuela	Field and historical photos	Lumber.
Bragança, Pará, Brasil	High resolution satellite, field	Saltwater, intrusion, logging and regrowing
Açu Delta, Rio Grande do Norte, Brasil	High resolution satellite, field	Shrimp farms
Guanabara Bay, Rio de Janeiro, Brasil	High resolution satellite, field	Oil and metal pollution
Sundarbans, Bangladesh/India	High resolution satellite	Forest degradation, erosion & aggradation
Saloum River, Senegal	Aerial photography	High salinity, sand dunes
US Virgin Islands, USA	Aerial Photographs, LIDAR	Urbanization, agriculture
Guayaquil, Ecuador	Field Inventory data	Shrimp farming

Initial Sites for Detecting Change
(Regional mosaics required)

Location	Airborne/Spaceborne datasets	Change mechanism
Atlantic coast of South America (including French Guiana)	Field and Landsat sensor data	Deforestation, aquaculture, river discharge and rainfall change, redistribution of sediments
North coast of Australia (sections of),	Extensive Landsat TM/ETM+ and existing mangrove coverages	Sea level rise and sediment transfer from extreme flooding
Guinea-Bissau coastline (West Africa)	Landsat TM/ETM+, field data	Deforestation for rice cultivation and fish smoking
The Guianas	Landsat, high resolution data	Deforestation
Columbian coast	Landsat, high resolution data	Deforestation
Borneo	Landsat, high resolution data	Deforestation
Indonesia	Landsat, high resolution data	Deforestation
Louisiana	Landsat, Aerial Photos	Winter freeze
Belize coast	Landsat, Nextmap Intermap	Tourist development
Sundarbans	Landsat, high resolution data	Sea level rise, sedimentation

Project Partners

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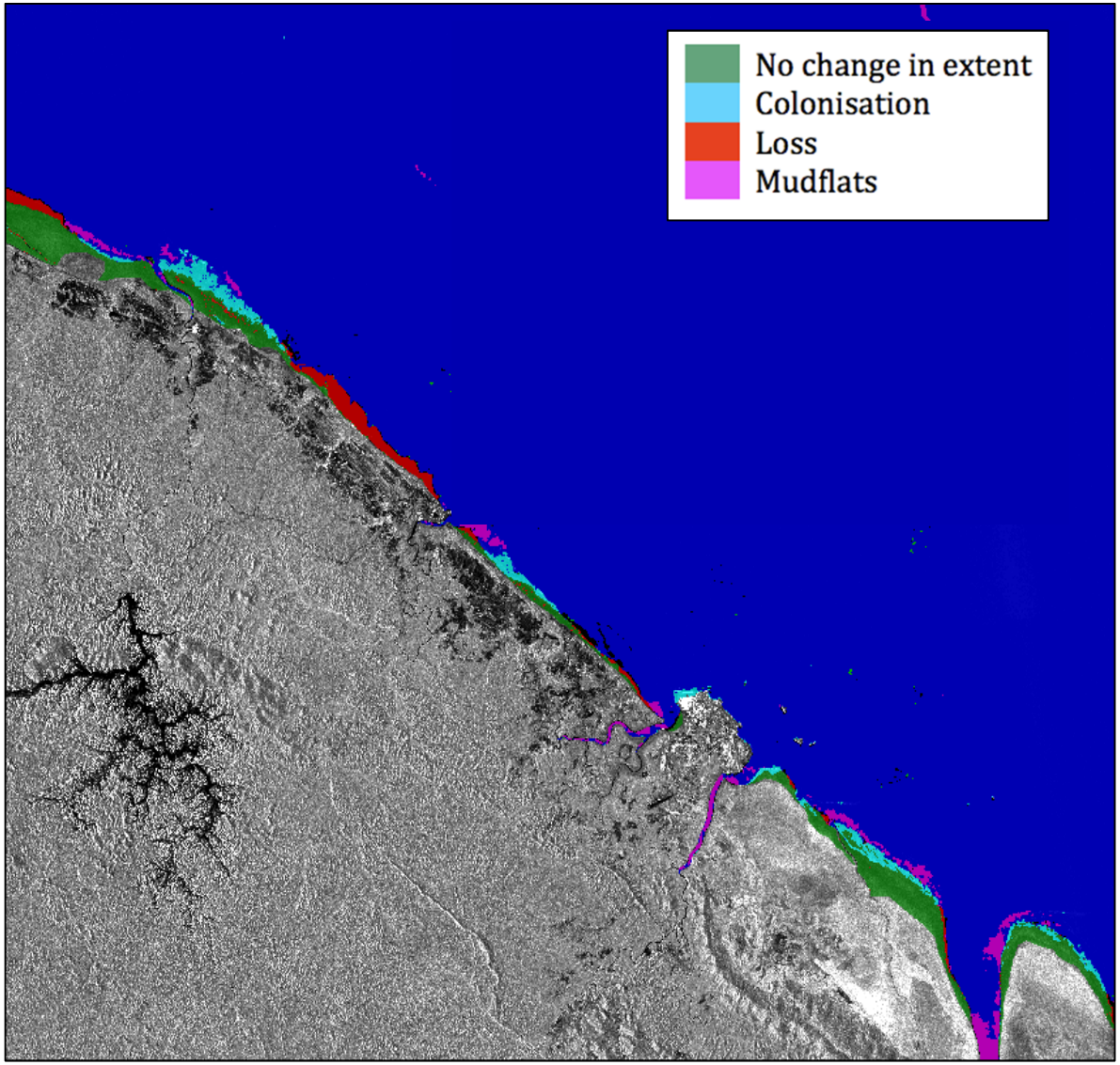
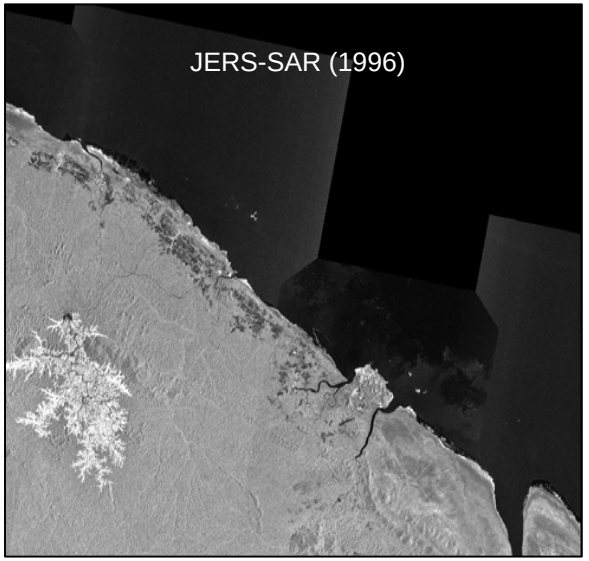
UK

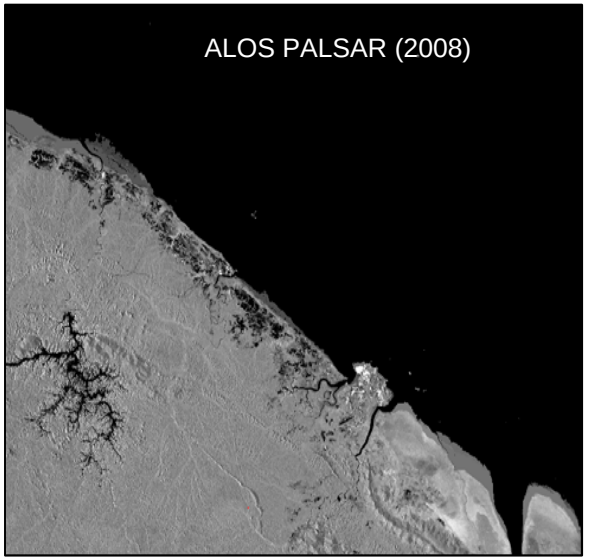
** Dr. Fayotinbo has submitted a proposal on mangroves for K&C Phase 3 and it is suggested that a 'global mangrove theme' be established involving all contributors.

Possible integration with Tandem-X mangrove canopy height maps.

Classification of Change: JERS-1 SAR and ALOS PALSAR comparisons







Changes in mangroves along the French Guiana coast (1996 to 2008)

K&C deliverables

Papers and Reports

1. Published (please provide PDF file)

- K&C Phase-1 and Phase 2 reports
- Lucas, R.M., Mitchell, A.L., Rosenqvist, A., Proisy, C., Melius, A. and Ticehurst, C. (2006) The potential of L-band SAR for quantifying mangrove characteristics and change. Case studies from the tropics and subtropics. Aquatic conservation: marine and freshwater ecosystems - Special Issue: *Radar Applications for Wetlands Management*. 17, 245-264.

2. Submitted/in preparation

- Lucas et al.: Recent response of mangroves to climatic and sea level change, Gulf of Carpentaria, Australia. Remote Sensing of Environment or Wetlands Journal

K&C deliverables

Data sets and Thematic products
(mosaics, classification maps etc.)

1. Completed and Delivered to JAXA

- *Mangrove structural classification*
  - *Belize*
  - *Queensland*
- *Mangrove change maps*
  - *North Queensland*
  - *Atlantic coast South America*
  - *Belize*
  - *Southeast Asia*

K&C deliverables

Data sets and Thematic products
(mosaics, classification maps etc.)

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  - *North Queensland*
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  - *Belize*
  - *Southeast Asia*

Acknowledgements

The Queensland Department of Environment and Resource Management (QDERM), including the Queensland Herbarium, the University of Edinburgh, the University of Belize, Southern Environmental Association (SEA) Belize, and the Toledo Institute for Development and Environment (TIDE), Belize.

Chandra Giri of the US Geological Survey (USGS) is also thanked for provision of the global mangrove data layer. The research has been undertaken within the framework of the JAXA Kyoto & Carbon Initiative. ALOS PALSAR data have been provided by JAXA EORC." All illustrations are copyright of the ALOS K&C *© JAXA/METI, QDERM and Queensland Herbarium EPA.*