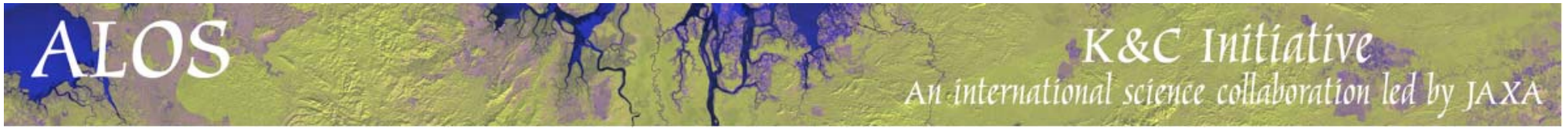

K&C Phase 3

Support to JAXA's Global Mangrove Watch

Richard Lucas, Takuya Itoh[1], Nathan Thomas, Marc Simard[2], Lola Fatoyinbo[3], Joao Carreiras[4], Arnon Accad[5], Dirk Hoekman[6], Lisa Rebelo[7]., Ake Rosenqvist[8]

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[2]NASA JPL and [3]Goddard Space Flight Centre (GSFC)

[4]Tropical Research Institute, Portugal

[5]Queensland Herbarium/ Department of Science Information Technology Innovation and the Arts.

[6]Wageningen University, The Netherlands

[7]IWMI, Laos.

[8]soloEO, Japan

Science Team meeting #17 – Phase 3 JAXA TKSC/RESTEC HQ, Tokyo, November 6-9 2012

[1]Now at USC with Mahta Moghaddam

Additional 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.

Links with Tandem-X mangrove canopy height maps.

Content

- Introduction
- Aim and Objectives
- Identifying and Classifying Change
- Updating the Mangrove Baseline
- Identifying Influences upon Mangrove Dynamics
- Project Schedule and Deliverables
- Support to JAXA's Global Forest Mapping Effort

Introduction to Mangroves

- Distributed along Every Coastline in the Tropics
- Thrive in Saline Environments with Freshwater Influxes
- Repositories of Biodiversity
- Carbon Rich Ecosystems (increasing interest in their role in carbon budgets, REDD)
- Important Anthropogenic Resource
- Increasingly Under Threat

Image Sources: MSN Encarta, Coastalcare.org, Mongabay.com

Mangroves Under Threat

Image Sources: e360.com, Mongabay.com, Google, Allianz.com

Project aims and objectives

- To contribute to the development and implementation of a global mangrove characterization and monitoring system (K&C Global Mangrove Watch).

  - Based primarily on ALOS PALSAR and ALOS-2 PALSAR data

- To evaluate the use of existing Landsat-derived (with SRTM where available) baselines (Giri et al., 2011; Fatoyinbo et al., 2011) against which to assess change and the potential for establishing new or refining existing baselines.

- To assess the added contribution of other remote sensing data (e.g., Landsat, Tandem-X, Sentinnel-1).

- To generate and collate available ‘ground truth’ data to support development of algorithms.

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 (e.g., USGS) 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

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).

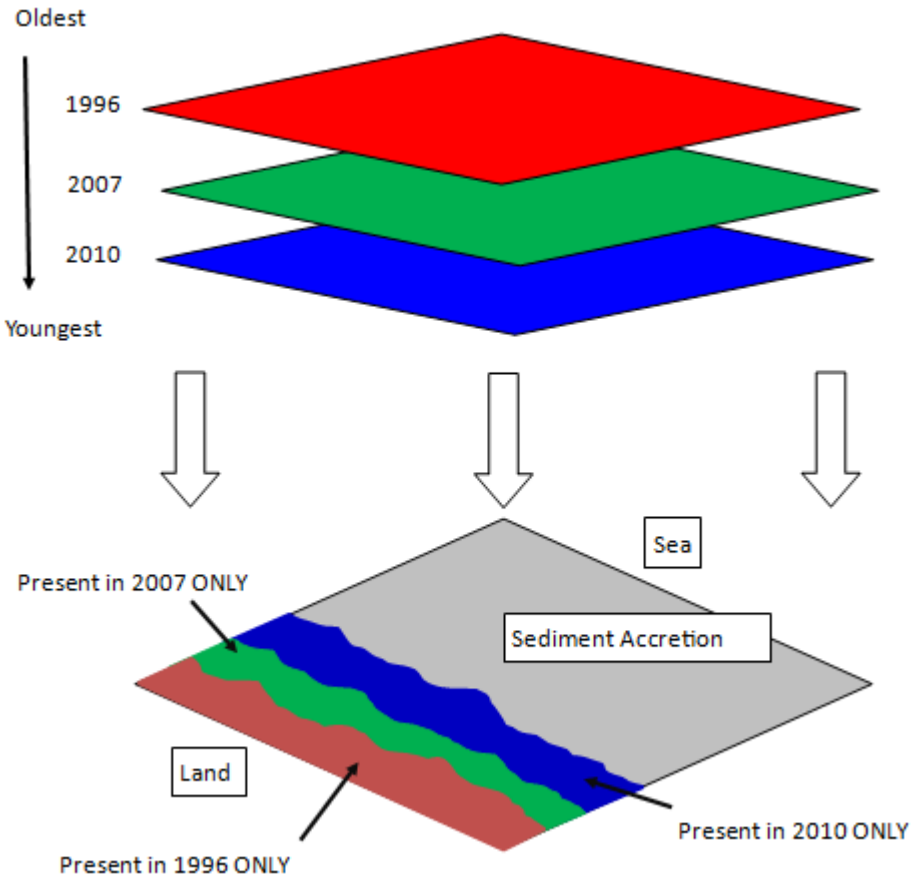
Project Schedule (Three Phases)

- **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 updated 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.**

Location of mangroves (USGS)

Preliminary Visual Assessment of Trends

- Assess Mangrove Dynamics over a 14 year period with focus on tropics initially
- ALOS PALSAR (2007-2010)
- JERS-1 (1996) required as changes are often decadal, particularly if natural
- Approximately 100 sites and 30 analysed image stacks analysed to date.
- Benefits of cloud-free observations, consistent globally



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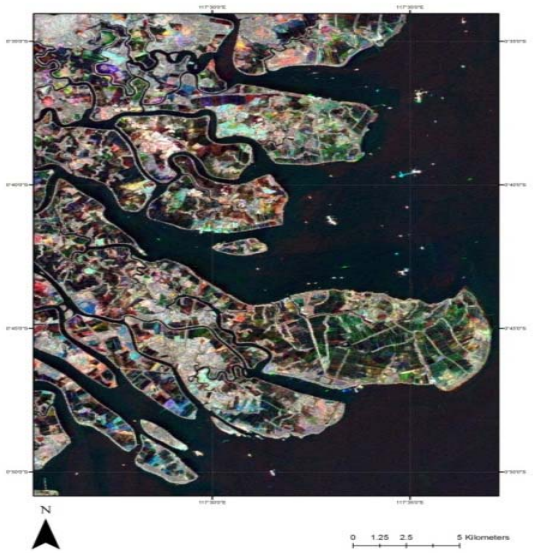
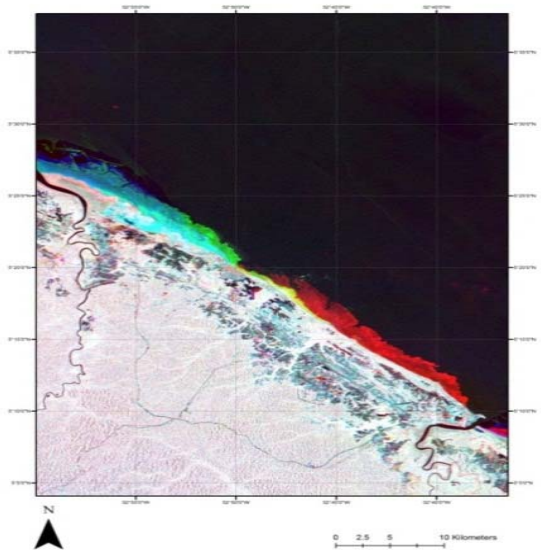
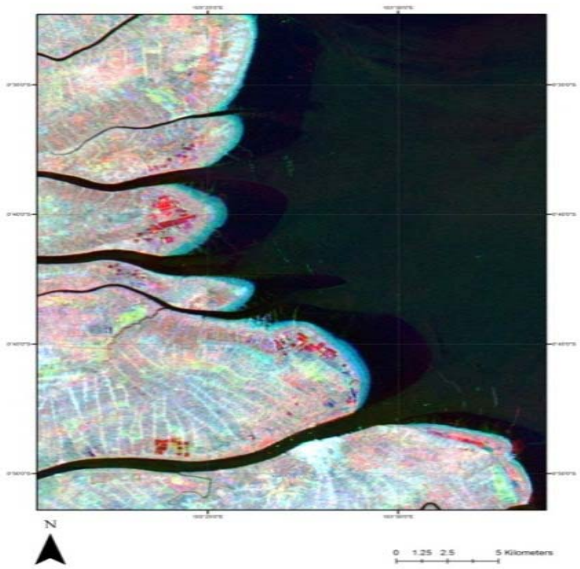
Causes of Change

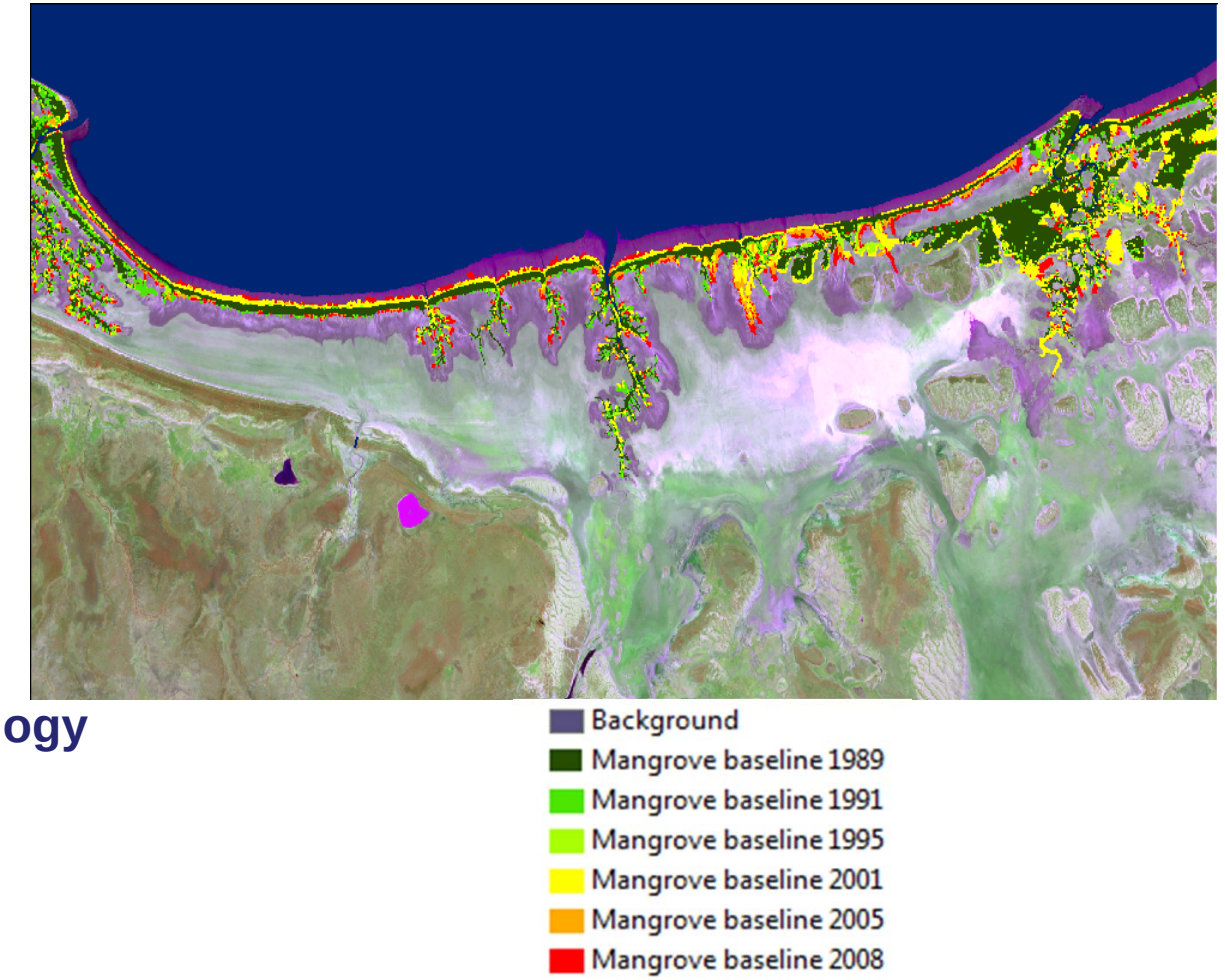






Causes of Change

- **Natural Variability**
  - Seasonal Flooding
  - Sediment deposition/erosion
- **Anthropogenic**
  - Deforestation for Timber
  - Pollution
  - Aquaculture
  - Coastal Development
- **Climatic Change**
  - Sea Level Rise
  - Ocean Salinity
  - Water flows and mixing/hydrology
  - Rainfall
  - Temperature
  - Atmospheric composition



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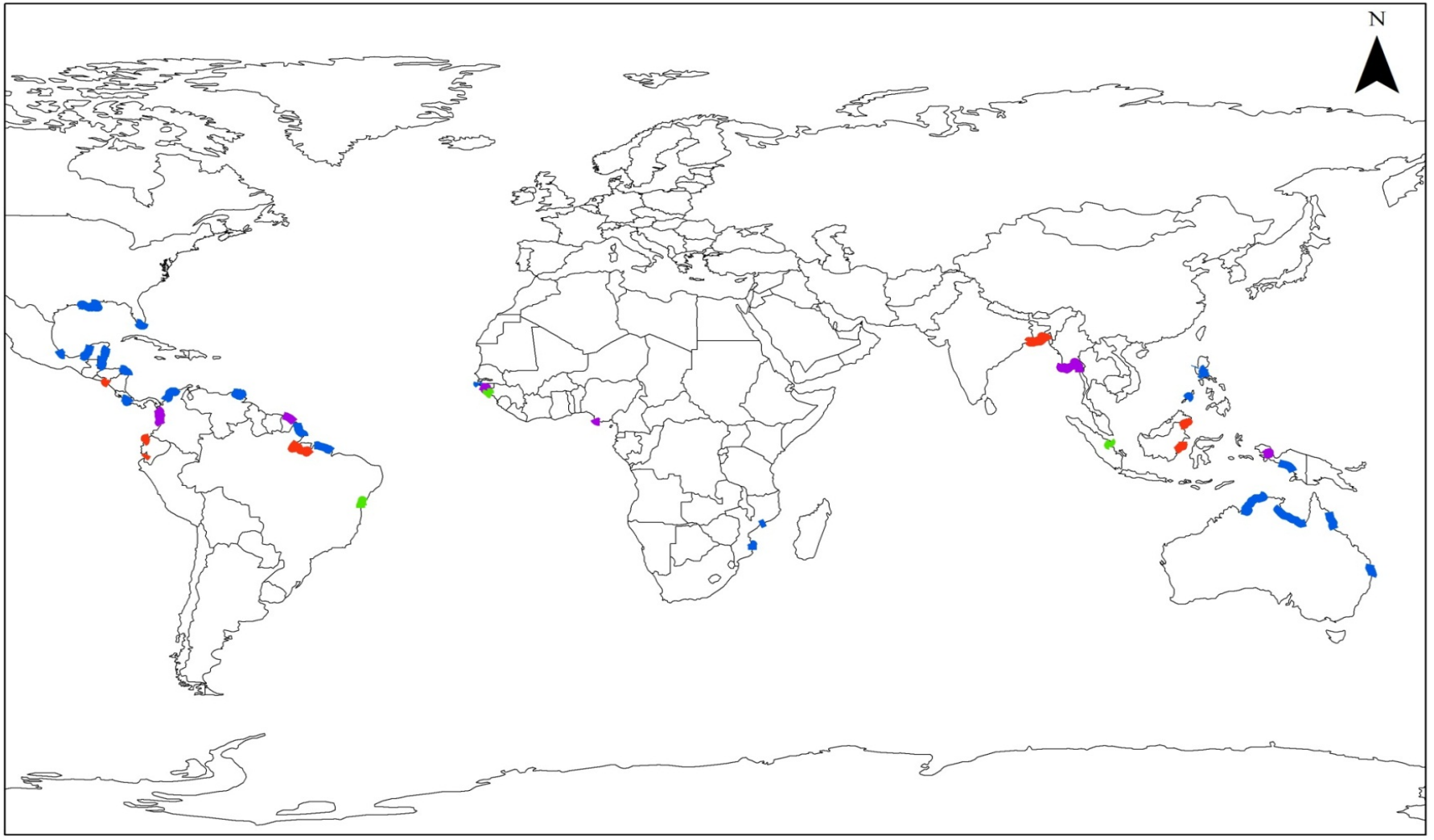
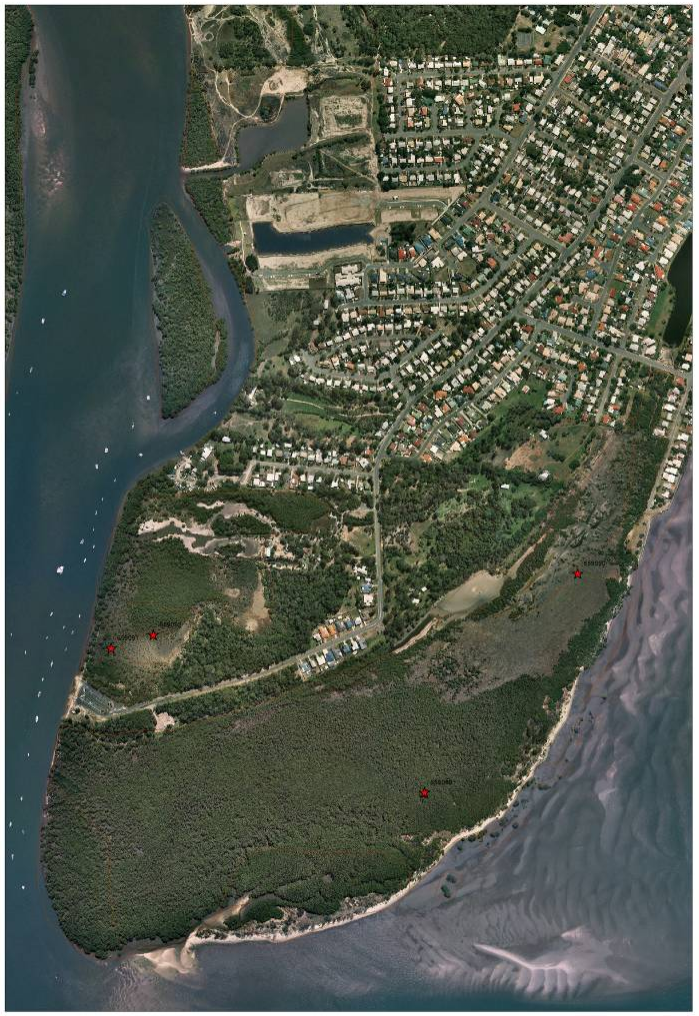
Preliminary assessment of the Global Mangrove Trend



Classification of Change

- **Identification of the 'mangrove zone'**
  - **Elevation < 50 m**
  - **Sea areas (historical)**
- **Identification of sea areas**
  - **Minimum HV over 2007 to 2010 (ALOS PALSAR)**
  - **JERS-1 SAR**
- **Separation of mangroves from non-mangroves**
  - **Closed forest (mean texture)**
  - **Plantations**
  - **Coastal scrub**
  - **Mudflats (backscatter thresholds)**
- **Identification of seaward expansion**
  - **Increase in L-band HH and/or HV into sea area**
- **Identification of landward expansion**
  - **Elevation restrictions**



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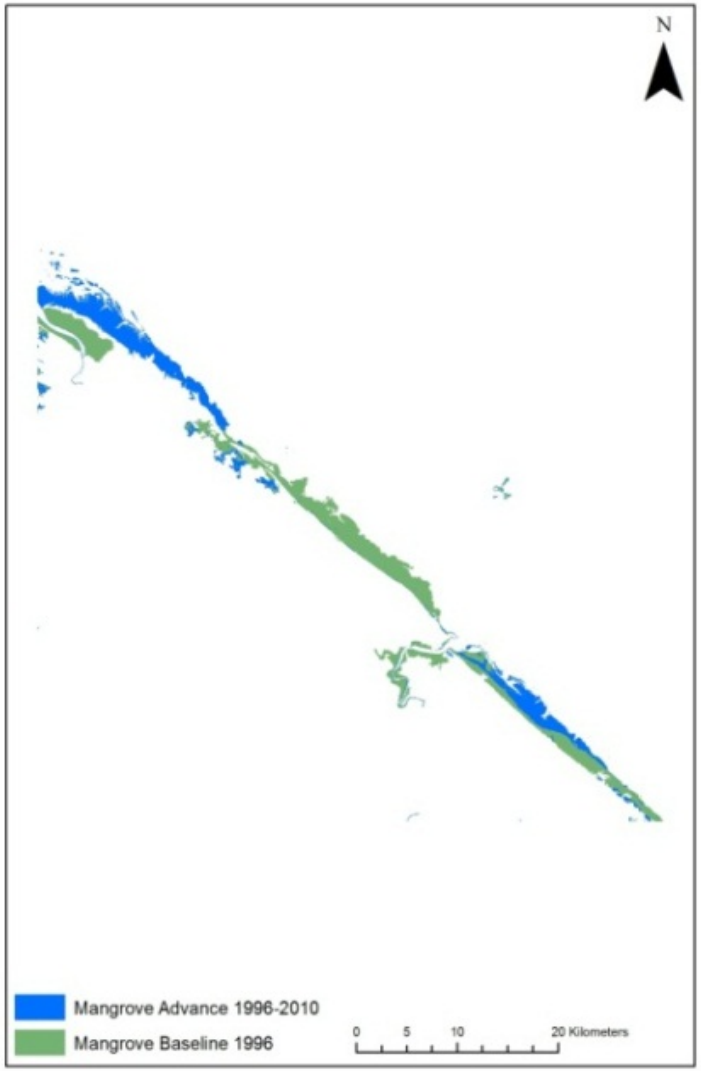
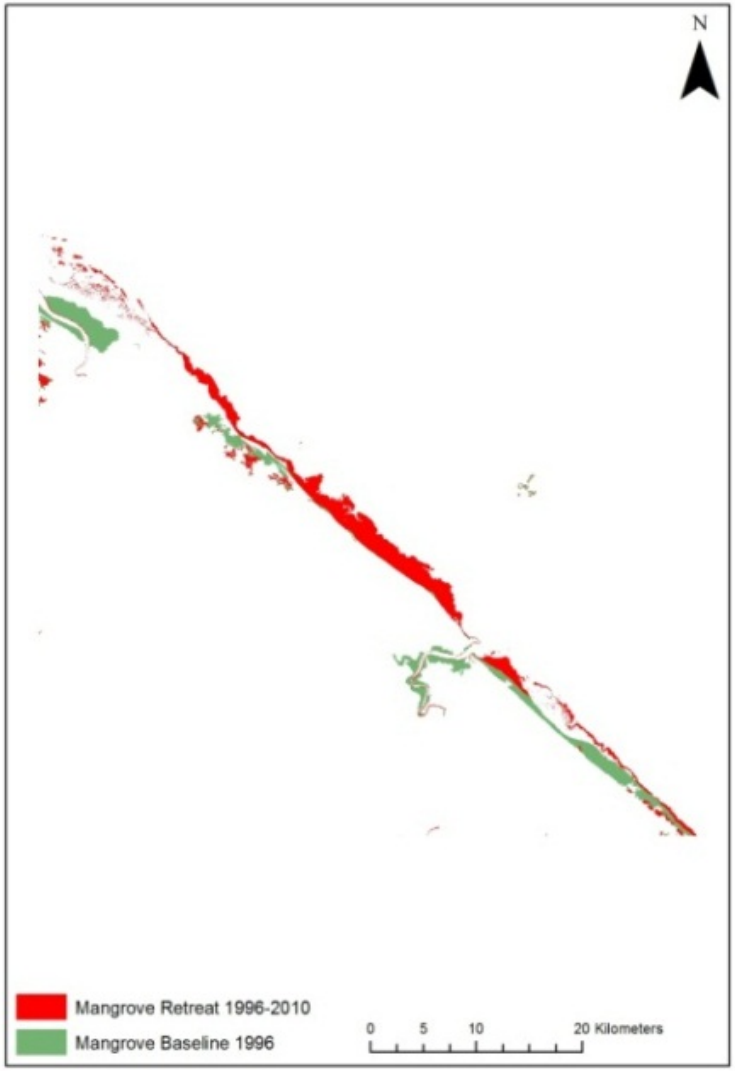
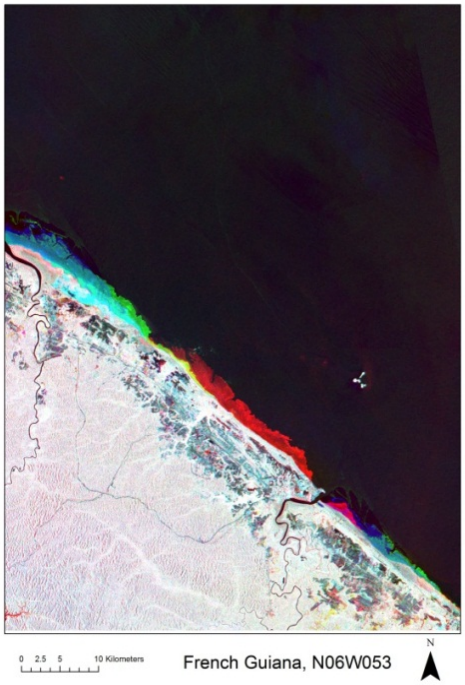
French Guiana

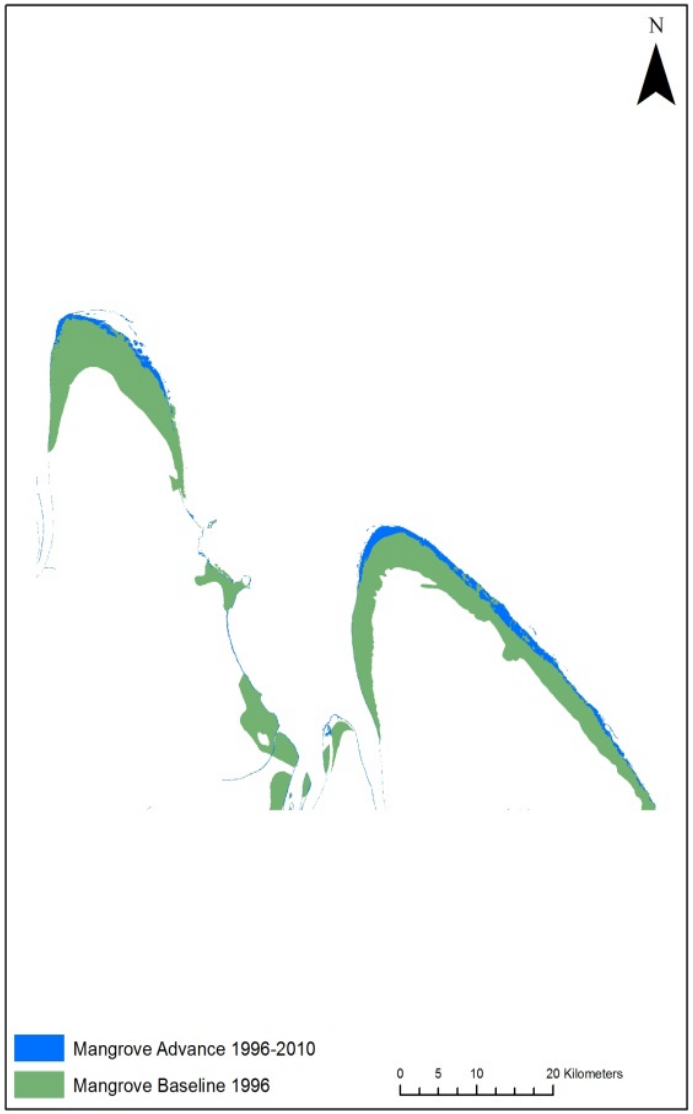


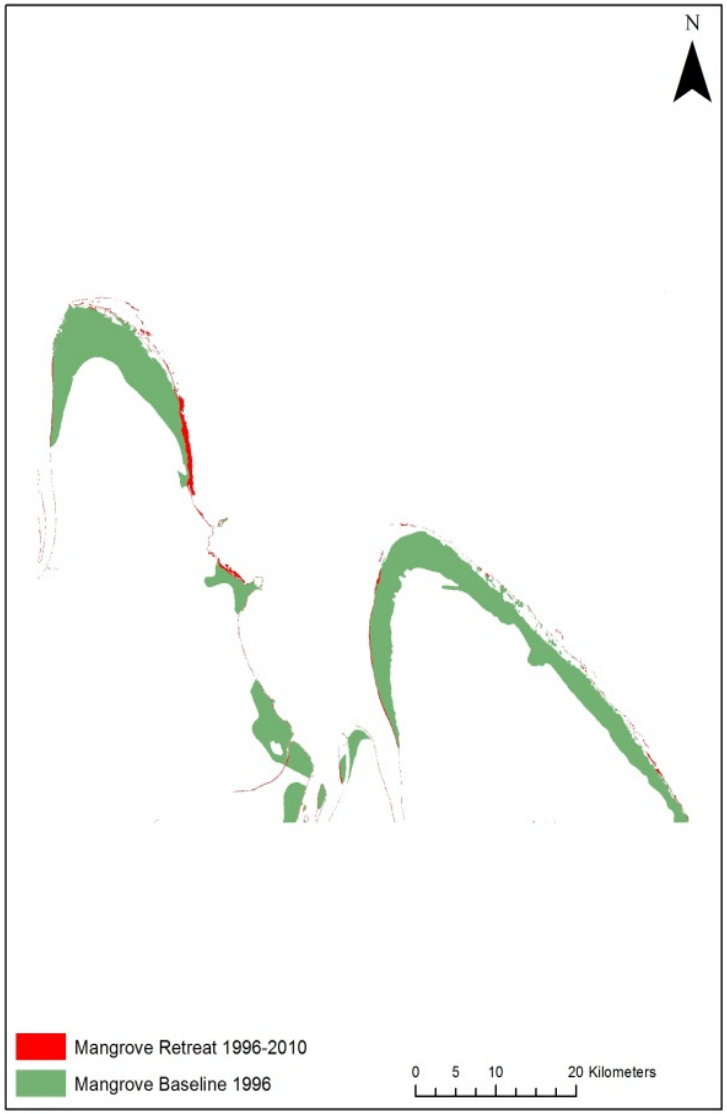


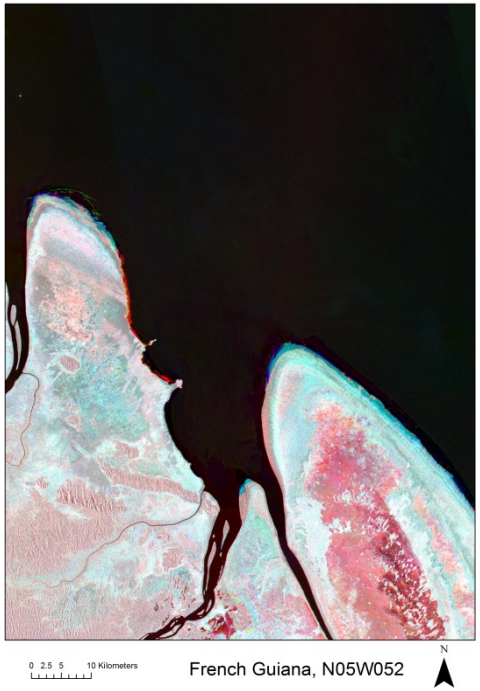


French Guiana, N06W053

French Guiana







French Guiana, N05W052

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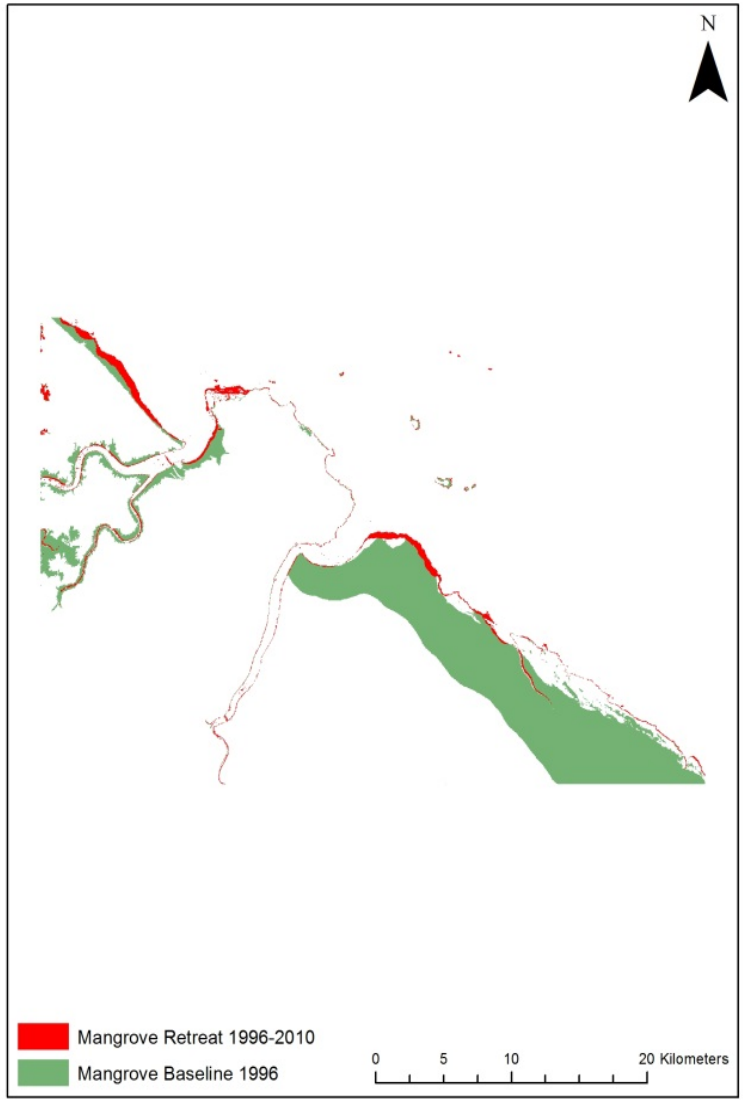
French Guiana



French Guiana, N05W053

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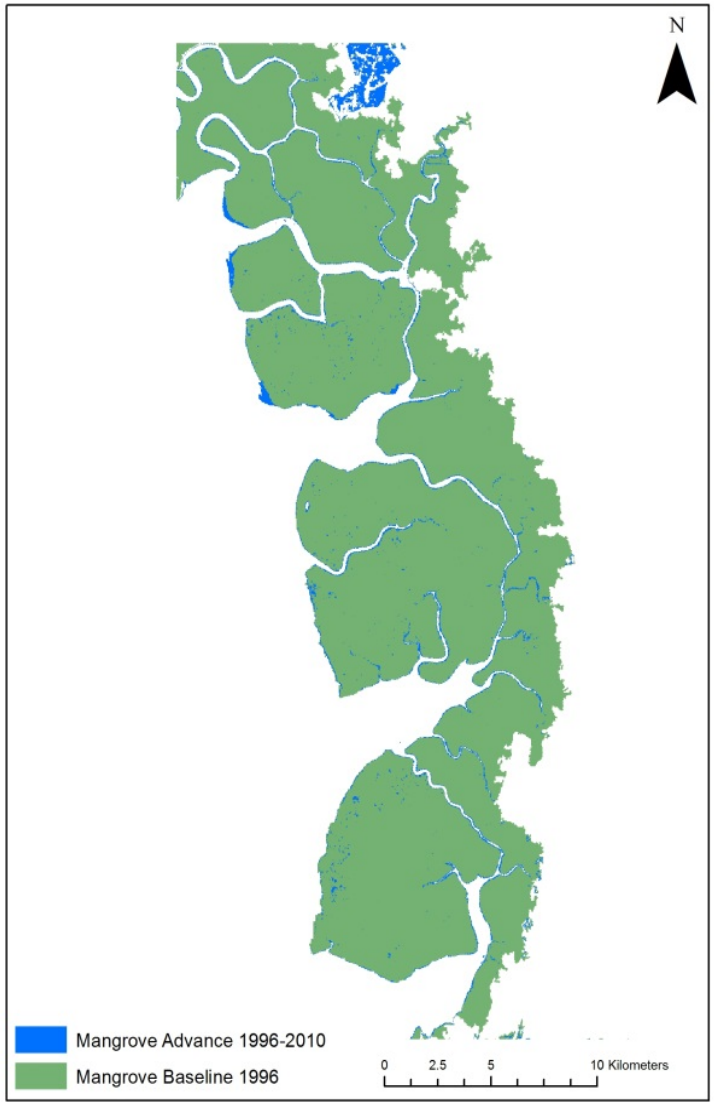
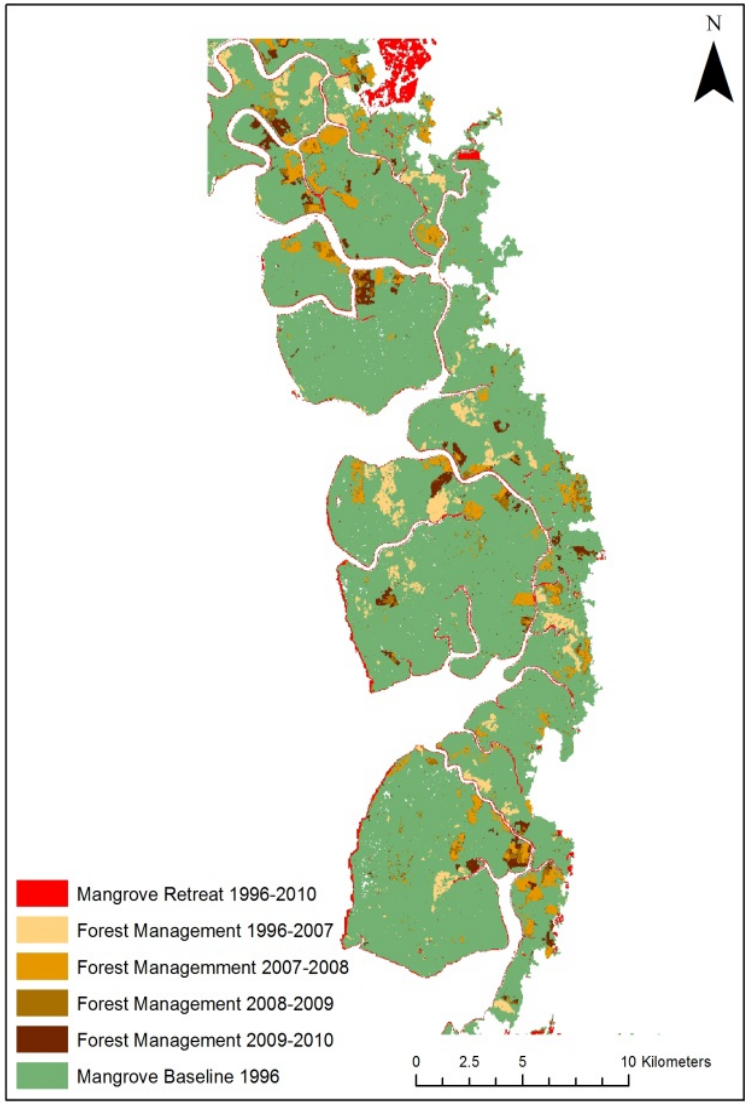
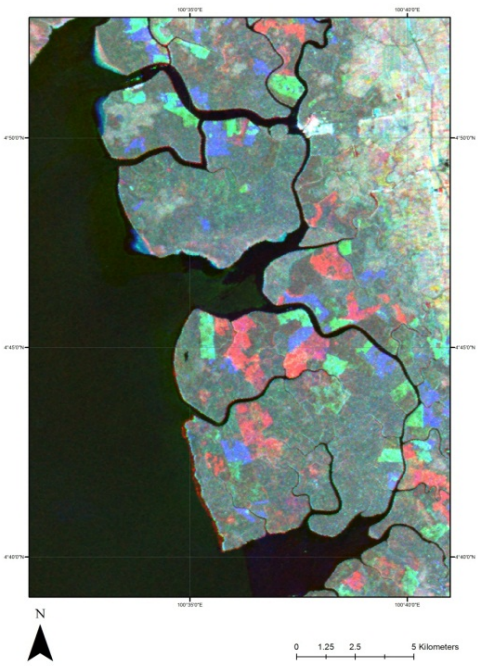
Perak, Malaysia







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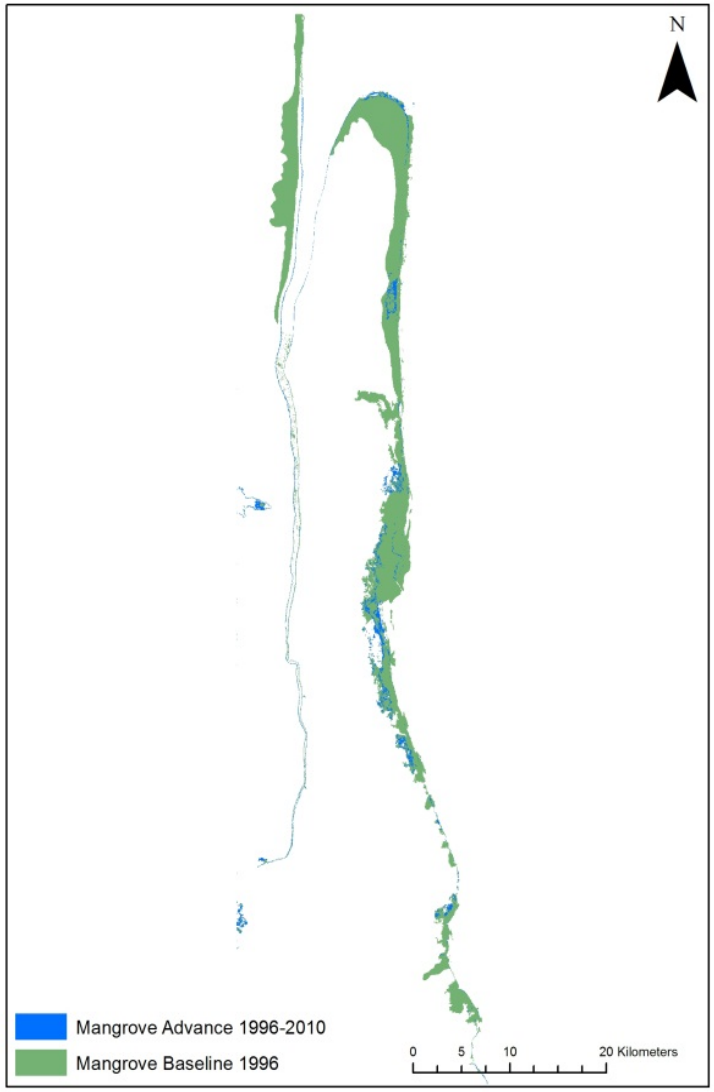
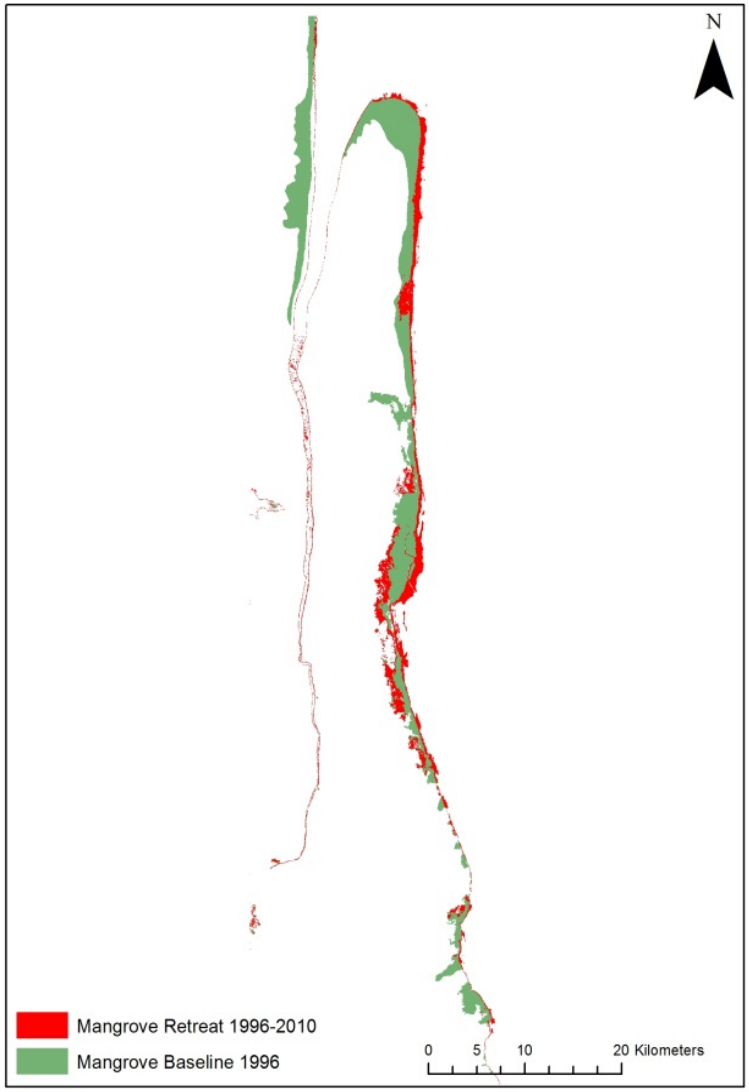
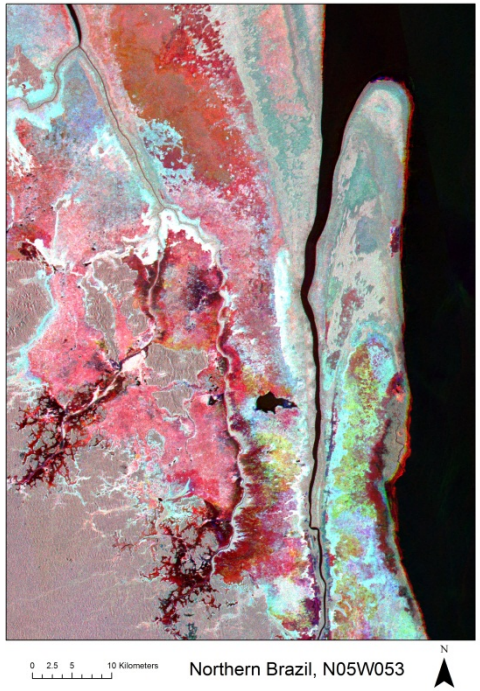
Northern Brazil







Northern Brazil, N05W053

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Sumatra

0 2.5 5 10 Kilometers

Sumatra, Indonesia, N00E103

N

ALOS

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Amazon Delta

0 2.5 5 10 Kilometers

Amazon Delta, S02W045

N

Area changes

AREA km^2 (2 d.p)	Sumatra	Perak, Malaysia, N05 E100	French Guiana, N06 W053	French Guiana, N05 W052	French Guiana, N05 W053	Northern Brazil, N04 W052
Baseline 1996	534.37	366.76	96.47	345.45	165.3	196.36
Gain 1996-2007	20.44	5.39	33.97	37.68	23.4	4.71
Loss 1996-2007	8.99	8.62	39.23	10.71	8.61	42.24
Gain 2007-2008	3.92	13.76	10.70	1.73	2.99	4.47
Loss 2007-2008	6.08	6.72	7.03	3.92	3.46	8.57
Gain 2008-2009	7.08	2.8	12.29	7.25	2.03	5.89
Loss 2008-2009	4.74	16.89	8.58	3.26	3.85	6.05
Gain 2009-2010	7.6	2.92	8.63	7.36	2.94	5.33
Loss 2009-2010	5.73	4.76	11.45	2.92	1.86	9.5

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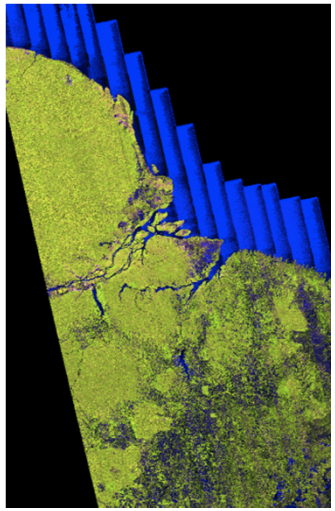
215 GCPs were collected with 62 used to validate the classification of mangroves and 153 to validate other classes

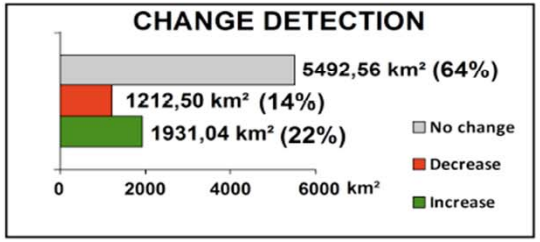
> 80% accuracy in the classification of mangroves and also change

Mangrove Change

Atlantic Coast South America 1998-2008

NOCHANGE
DECREASE
INCREASE





Da Rocha Nascimento, Souza-Filho, Proisy, Rosenqvist (2012). Mapping changes in the largest continuous Amazonian mangrove belt using object-based classification of multi-sensor satellite imagery Estuarine, Coastal and Shelf Science In press)

Updating the Mangrove Baseline

- Minimum changes in HV backscatter over the period of the time-series
- Reference to areas of no change
- L-band HH backscatter unable to be used because of inundation effects
- Revision of baseline back to 1996
- Evaluation in relation to USGS baseline
- Update of baseline in 2010 in preparation for ALOS-2 and ‘operational implementation’ of the Global Mangrove Watch.

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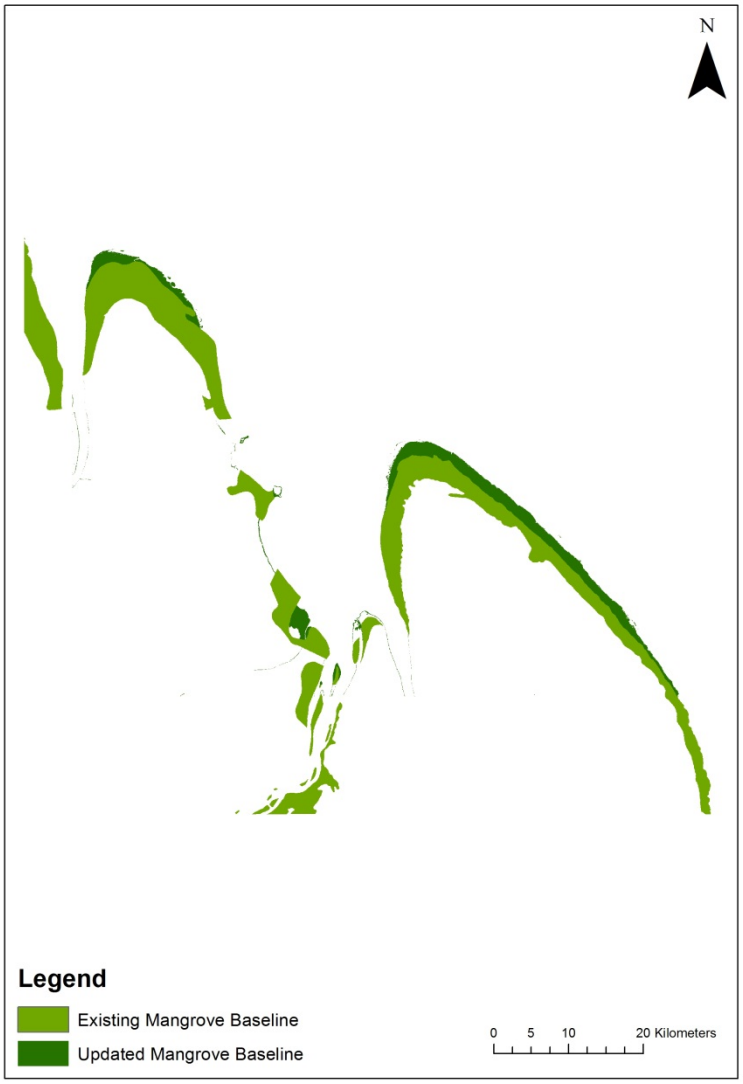
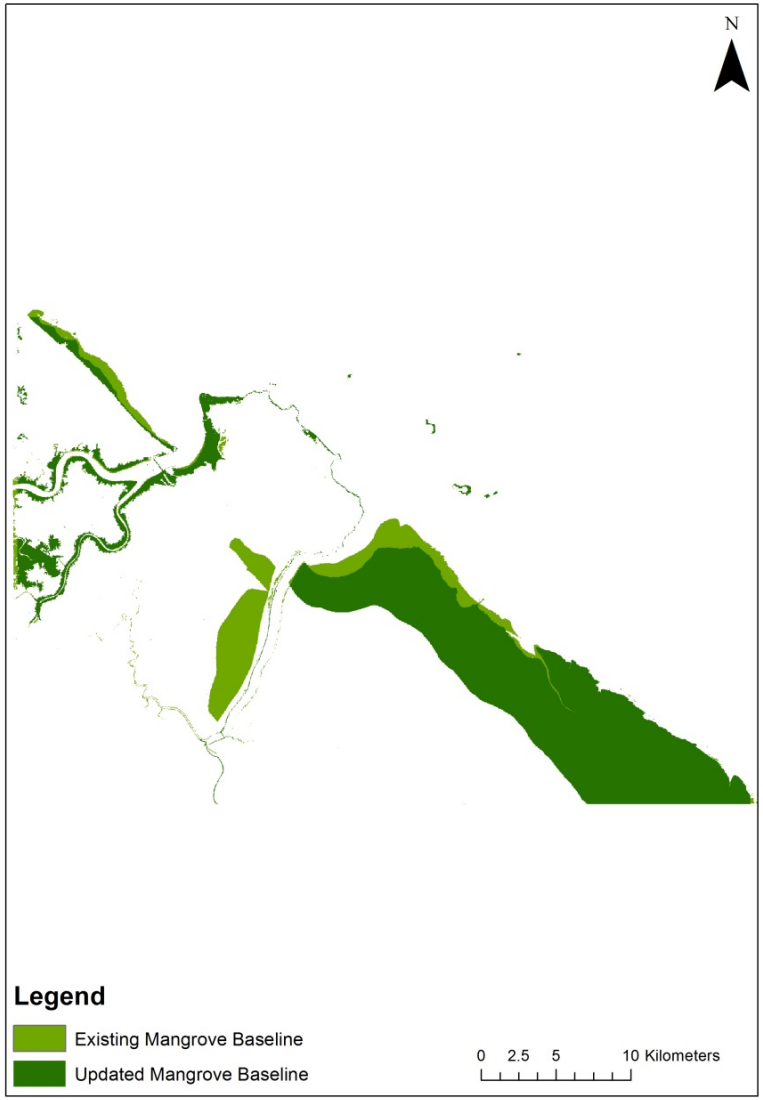
Updating the Mangrove Baseline





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, although ongoing as observations made)

- 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 (ongoing)
  - Characterising mangroves (e.g., high/low height/biomass, with or without prop roots) (ongoing)

  (Draft ruleset generated and evaluated during visit to JAXA in April, 2012, for several sites

  Nathan Thomas completed Masters thesis on change detection using tiles

Project Schedule (Phase 1 August 2012 to February 2013)

- Critique the approach and provide suggested improvements to the ruleset and necessary refinements (e.g., in terms of geometric fitting with existing mangrove datasets). (November, 2012)

- Provide revised ruleset and appropriate validation information to JAXA, with this collated and standardized within and between study sites
  - completed for a selection of sites
  - Needs evaluation on other sites using full time-series (November, 2012)

- Collate validation data
  - In progress and discussion needed at the November K&C meeting
- Put in ALOS-2 Proposal for AO
  - Completed

  - Apply ruleset to additional sites and send out for evaluation (December, 2012)

- Critically evaluate the revised ruleset by partners (prior to April K&C meeting) and agreement on optimal ruleset for regional and potentially global application (February, 2013)

- Implement classification across selected regions (April, 2013)

Project Schedule (Phase 2 February to June 2013)

- Generate first 'sample' regional maps of mangrove change and characteristics (April, 2013).
- 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.
  - In preparation
  - Conference presentations submitted/accepted by IGARSS and Intecol
- 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)

- 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 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.
- Design, and have pre-operational, a Global Mangrove Watch system for use with 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
- Rulesets and improvements on these for characterizing mangroves and detecting change (in development)
- Working group (opportunities for funding and more regular meetings between participants) (Exchange visits with JAXA)

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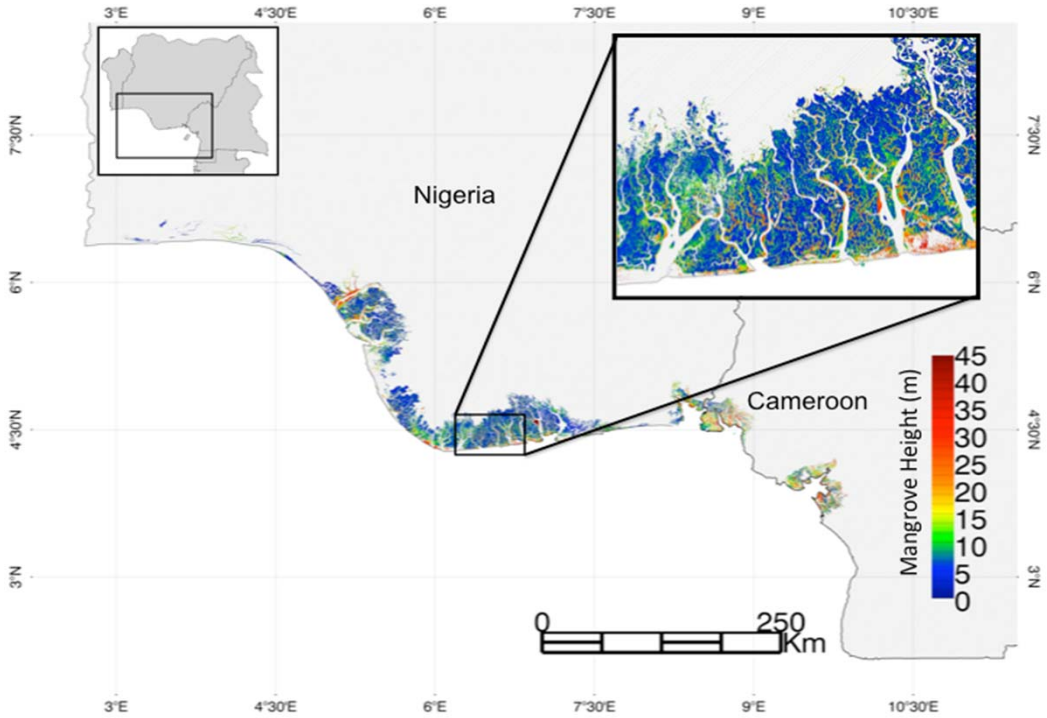
Height and Biomass Map



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	13,286,933	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

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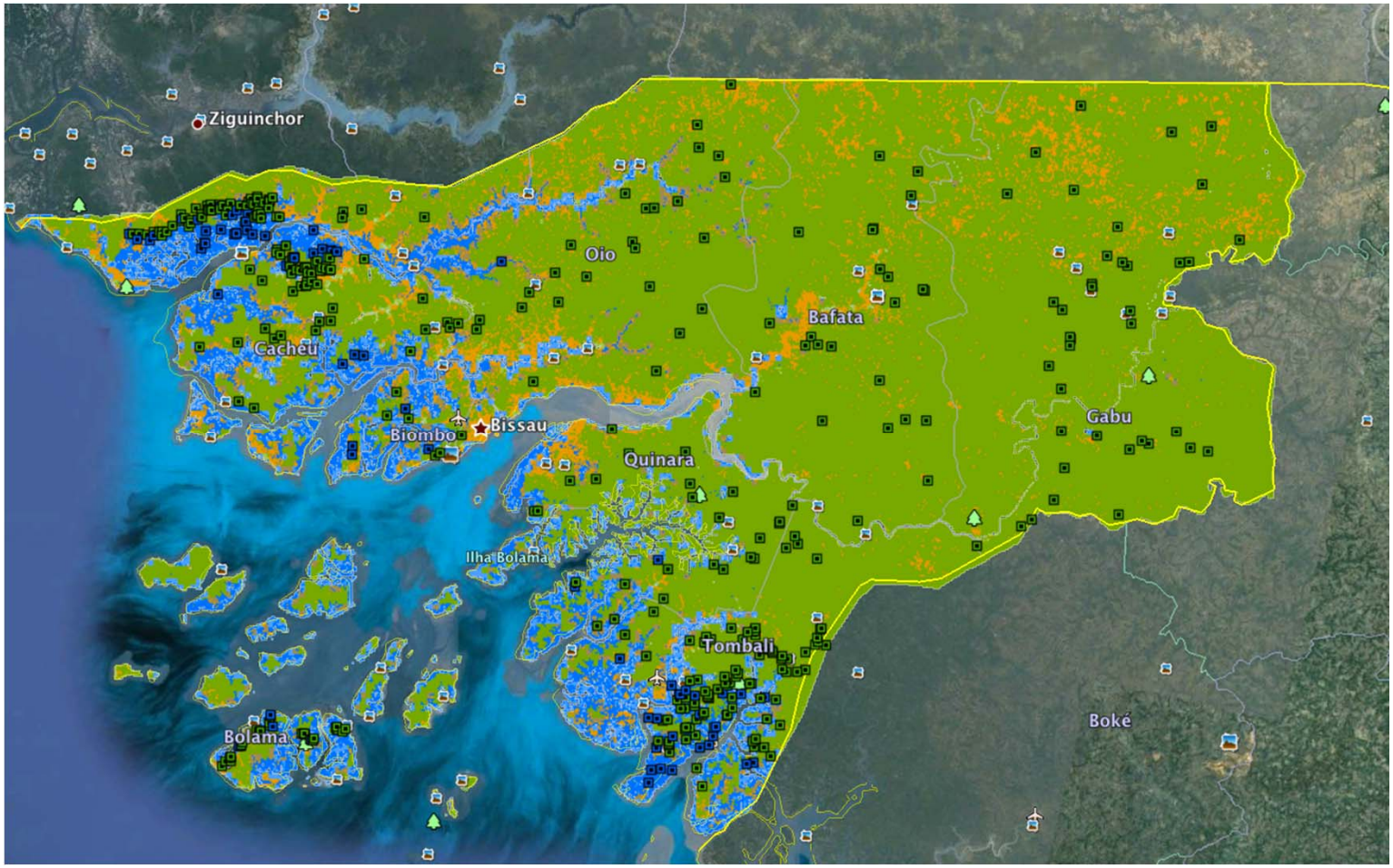
Field Data Collection

Arnon Accad, Queensland, Aus

Field Data, Guinea Bissau, Africa



Joao Carreiras, TRI, Portugal

Support to JAXA's global forest mapping effort

The partners seek to work collaboratively with JAXA by participating in workshops in Japan 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 visited JAXA in April to advance practical elements of project and evaluate rulesets; second visit in November, 2012, and third in April, 2013.**