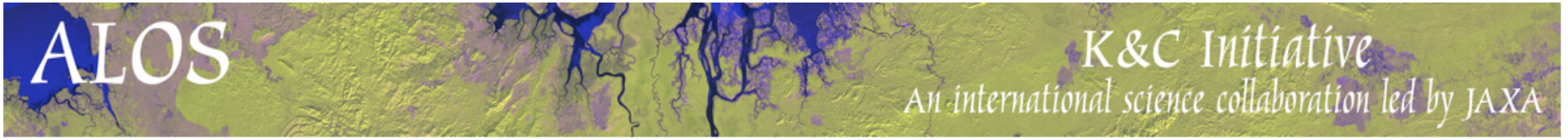


K&C Phase 3

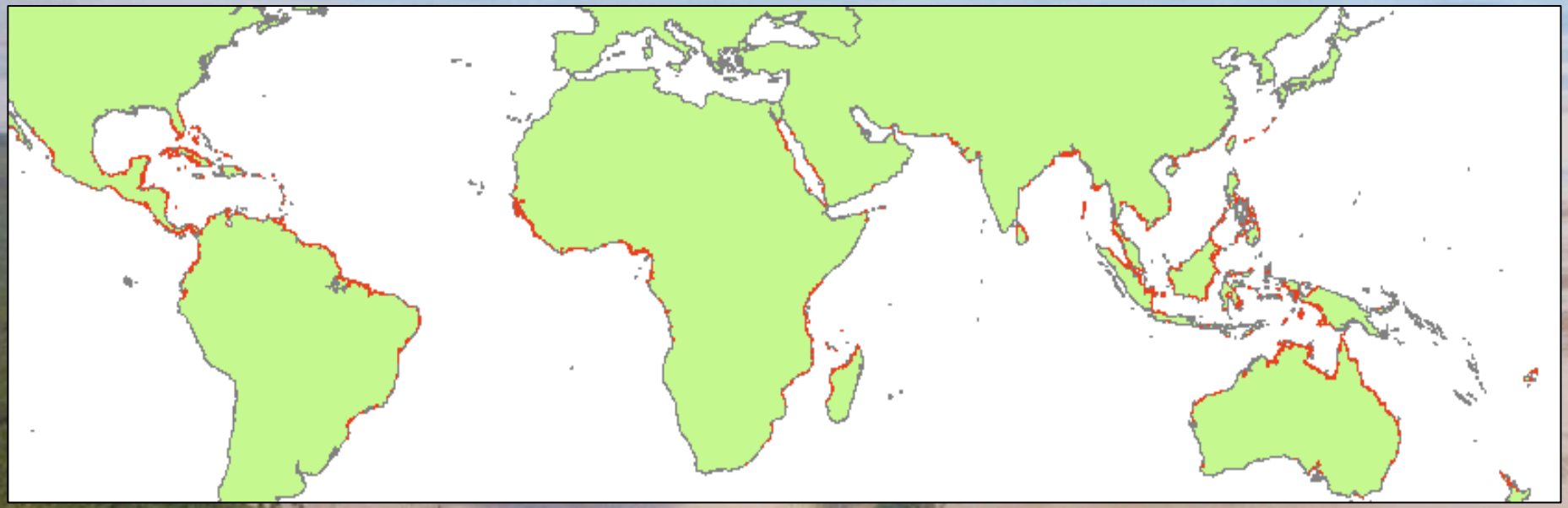
Mangrove Mapping and Monitoring with ALOS PALSAR

Richard Lucas, Lisa Rebelo[1], Ake Rosenqvist[2] and Dirk Hoekman[3]

Aberystwyth University, Aberystwyth, Ceredigion, UK,
IWMI, Ethiopia[1], SoloEO, Tokyo Japan[2], SARVision, the Netherlands[3]

Science Team meeting #16 – Phase 3 Kick-off
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, October 17-21, 2011

ALOS PALSAR for Mangrove Characterisation, Mapping and Monitoring

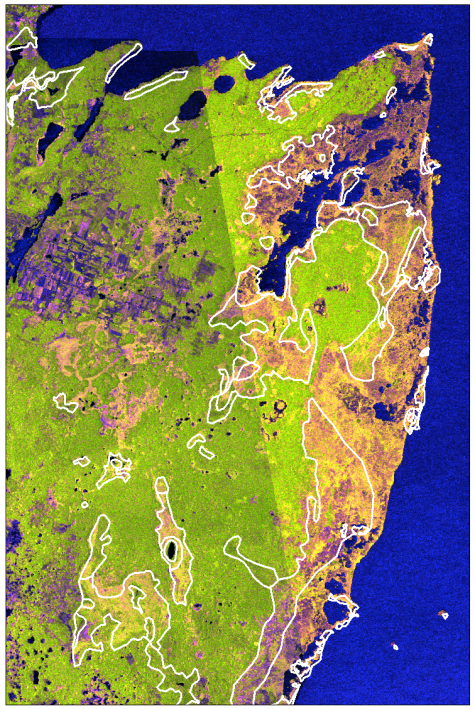


- Australia: ~1.5 million ha
- Atlantic coast, South America ~ 1 million hectare
- SE Asia: ~4.9 million hectare
- Belize

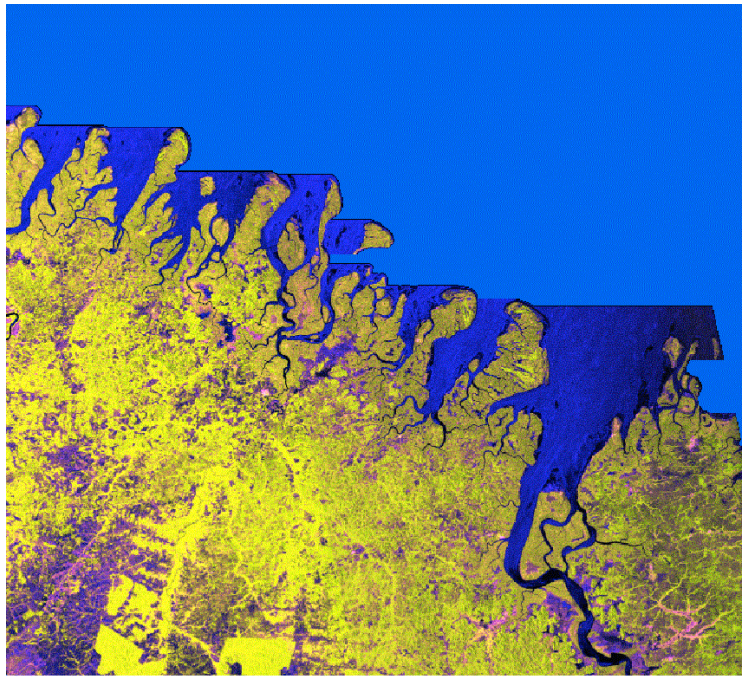
Mapping Mangrove Extent

- Difficulty distinguishing mangroves from adjacent land covers
- Nature of cover varies within and between regions

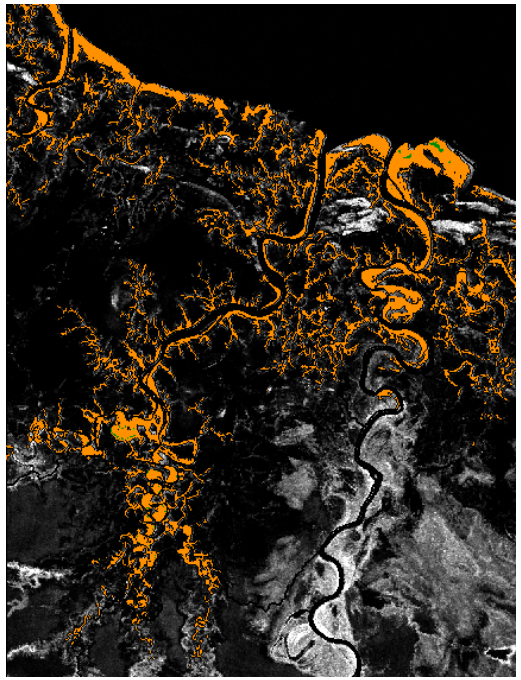
Savannas, Belize



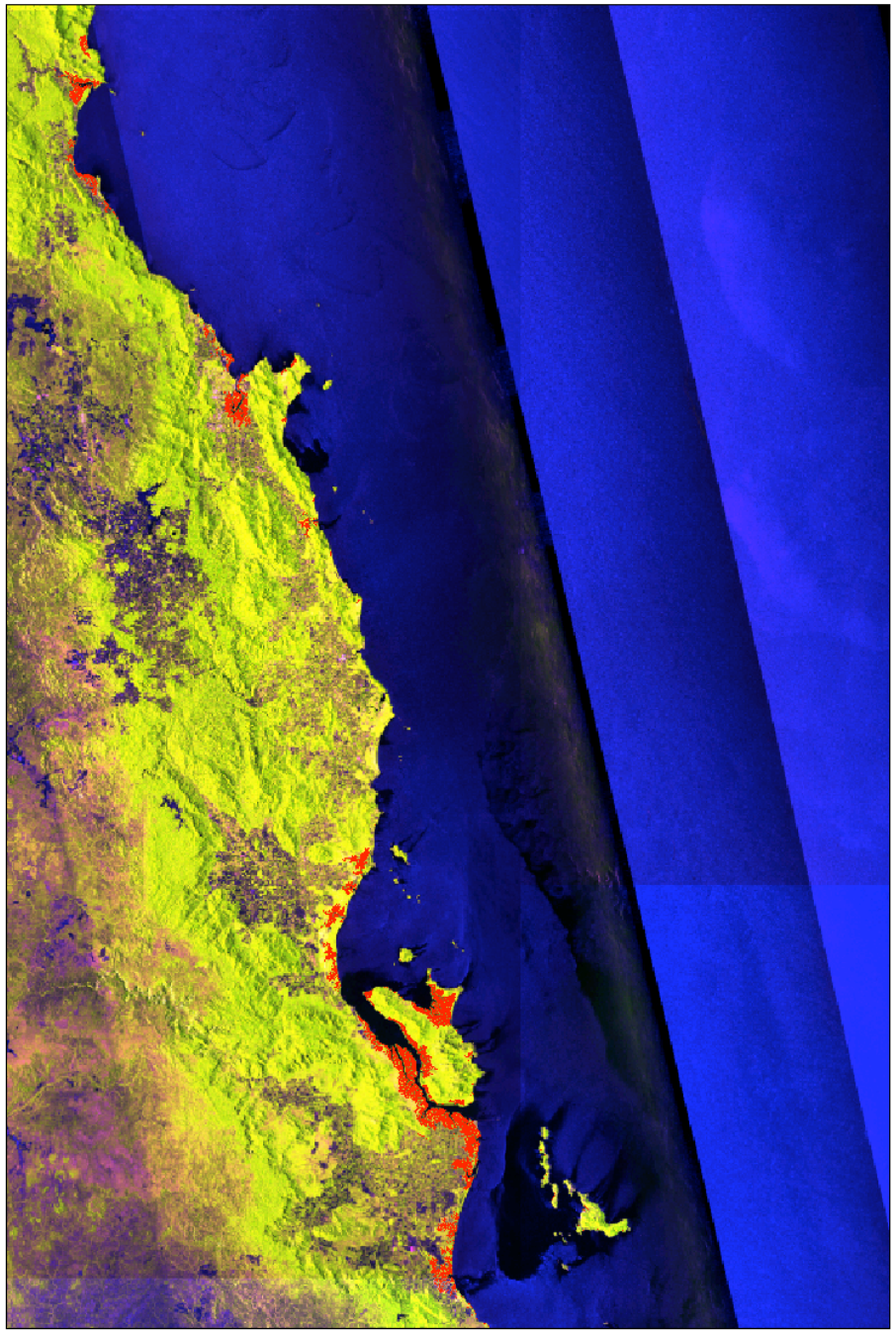
Tropical Forest Brazil



Saltflats, Australia

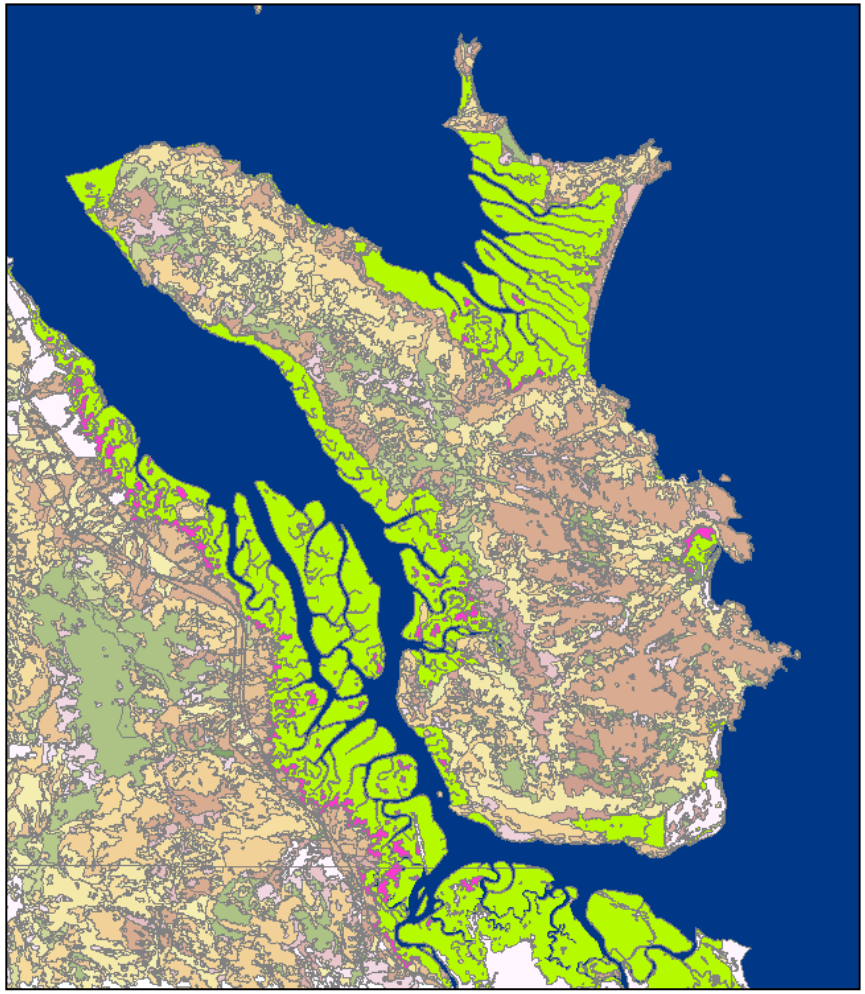


- Requirement for ancillary datasets

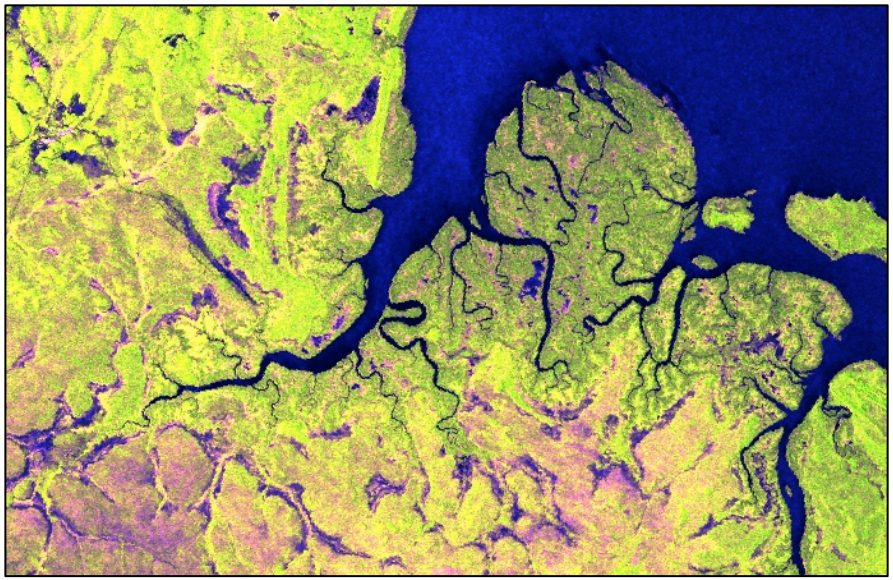


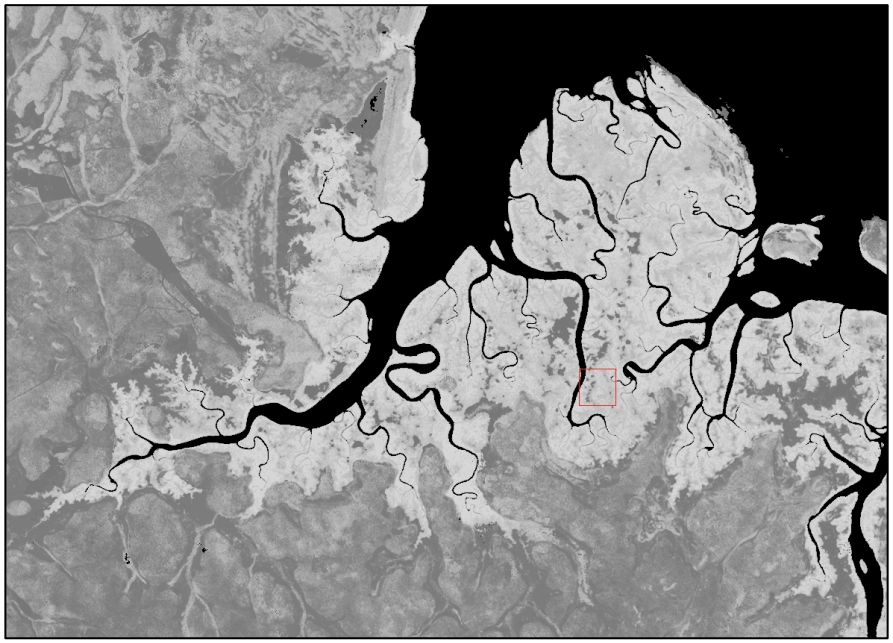
Mapping Mangrove Extent

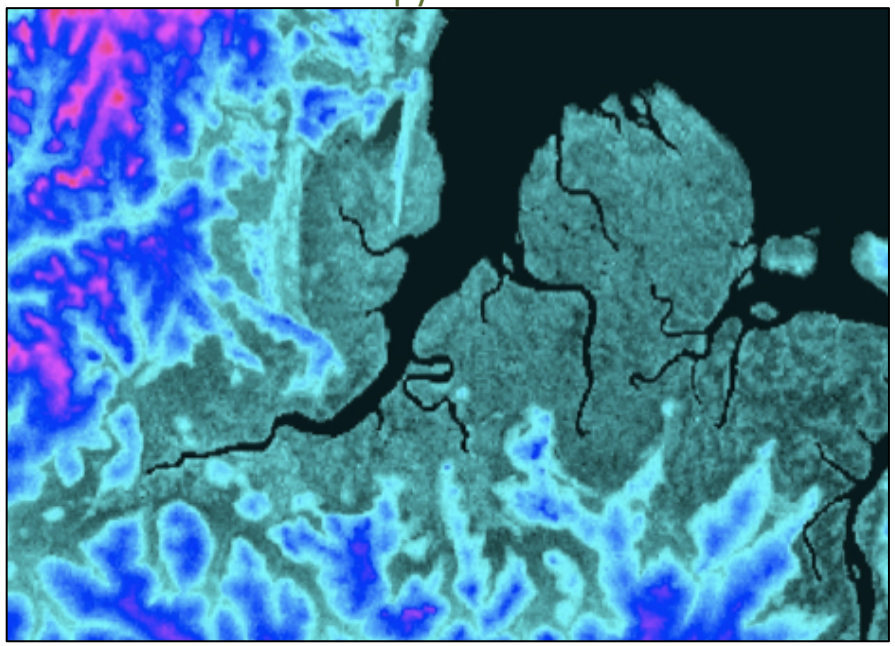
- Queensland Regional Ecosystem mapping



Mapping Mangrove Extent



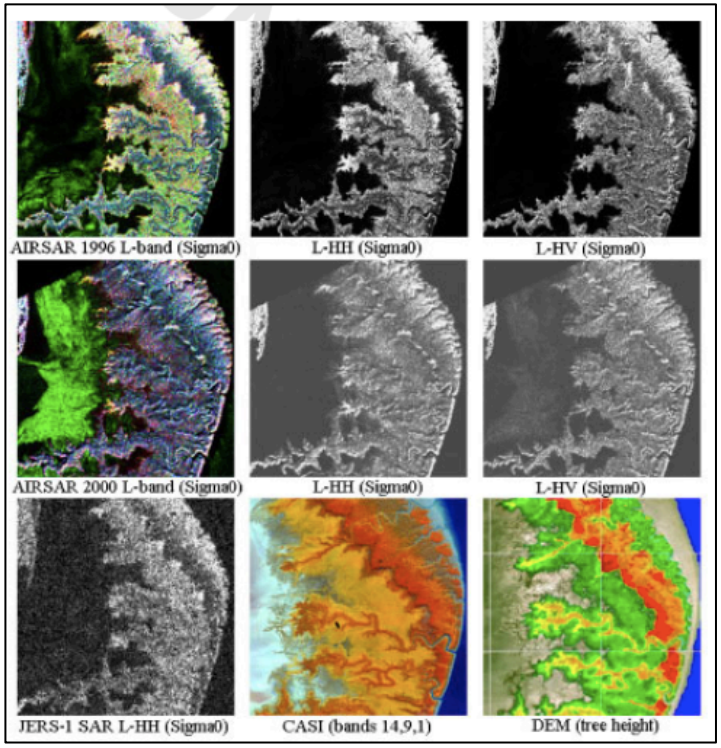




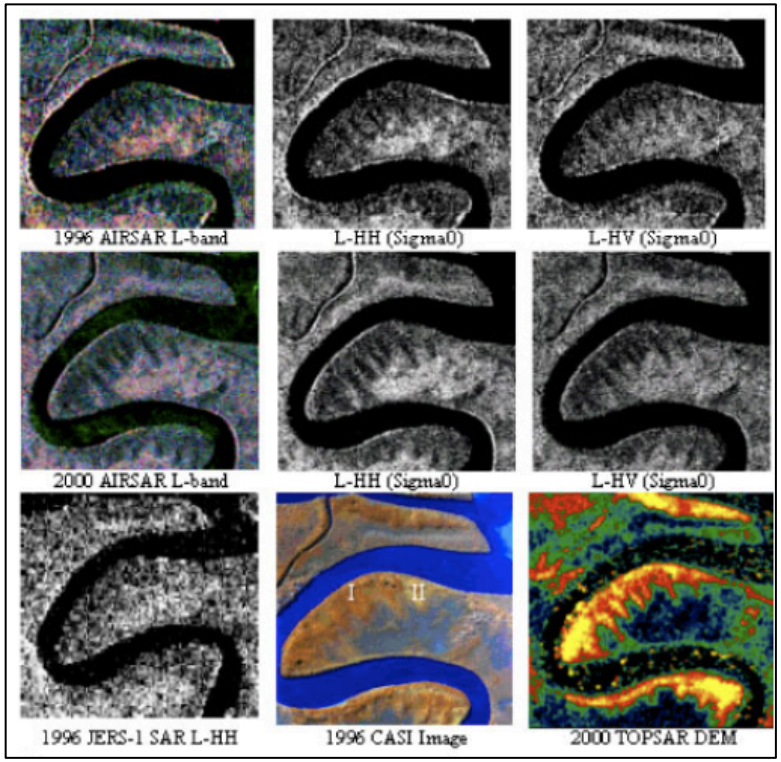
- Landsat FPC
  - Provides clear differentiation of mangrove and non-mangrove areas
- SRTM
  - Focuses classifcation on low-lying coastal areas
  - Subsequently useful for retrieval of mangrove canopy height
    - Height retrieval more succsessful in larger, contiguous areas of closed canopy forest

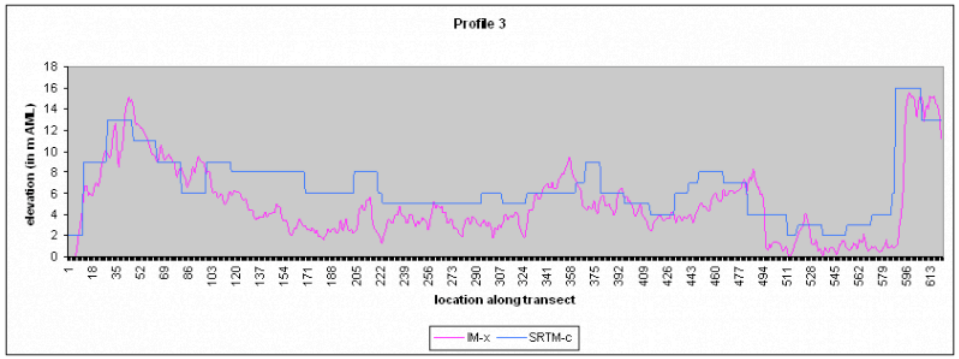
Airborne Observations of Mangrove

Kakadu National Park, NT



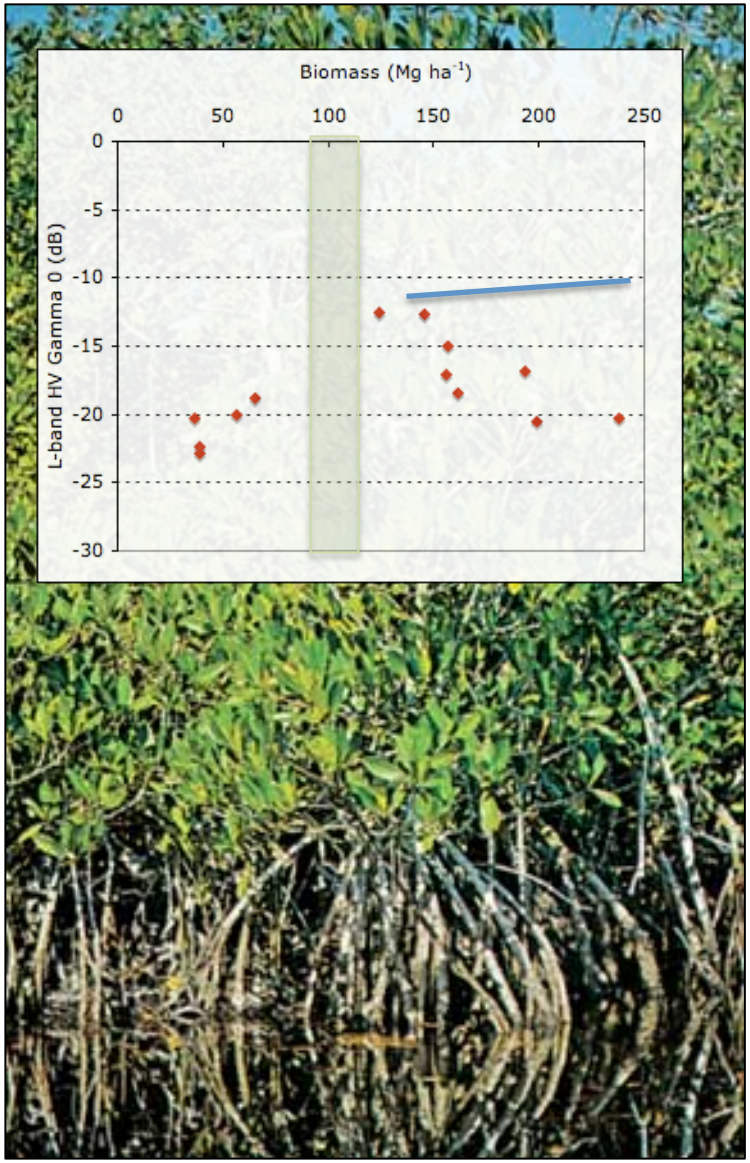
Daintree National Park, QLD





Comparison of Intermap and SRTM DEMs, Belize Mangroves

Approach to classifying mangroves

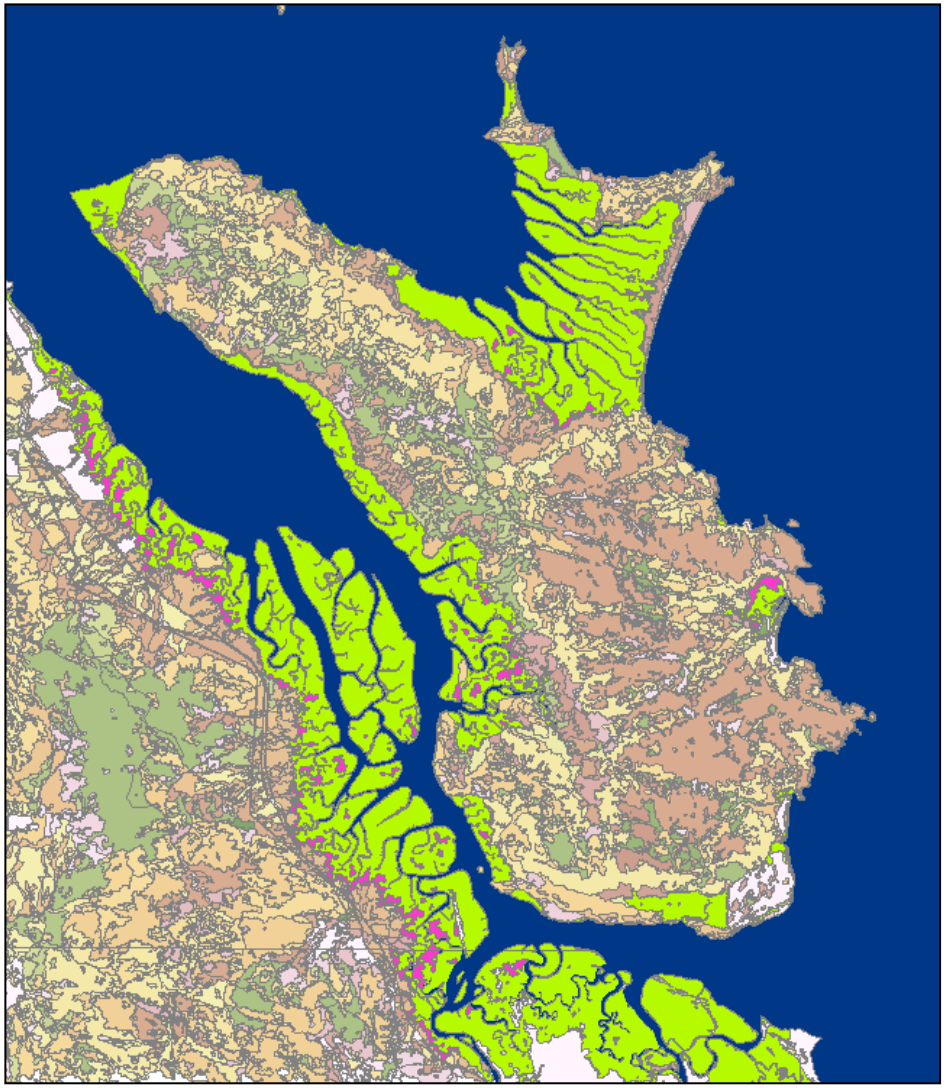


- Define extent of mangroves
  - Existing data layers
  - Landsat FPC
- Separate 'low' from 'high' mangroves
  - SRTM, LiDAR
  - Definition of height locally variable (e.g.., 10 m)
- Separate high mangroves with/without prop root systems
- Assign all remaining objects to 'low mangroves'
- Assign biomass classes (e.g., using relationships with L-band HV; upward & downward trends)

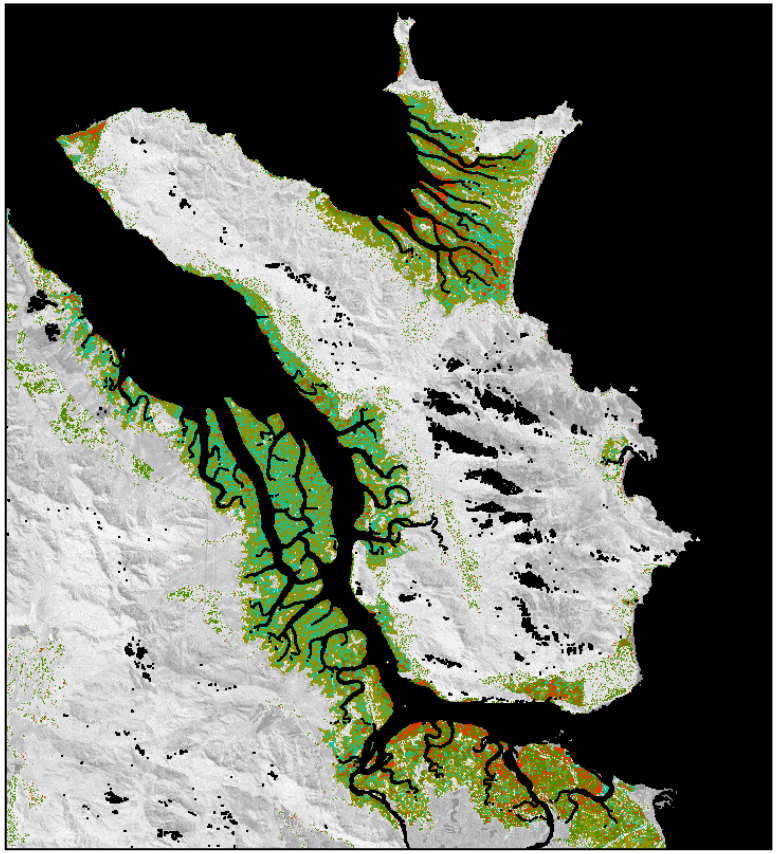
Example of Mangrove Classification

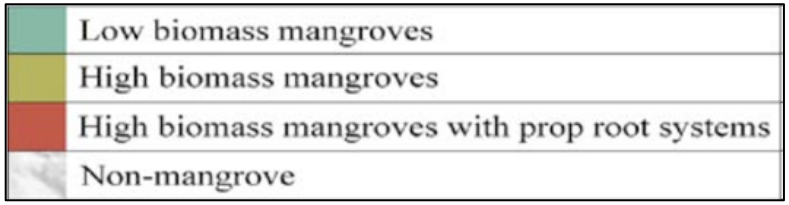
Hinchenbrook Island, Queensland, Australia

Queensland RE Mapping

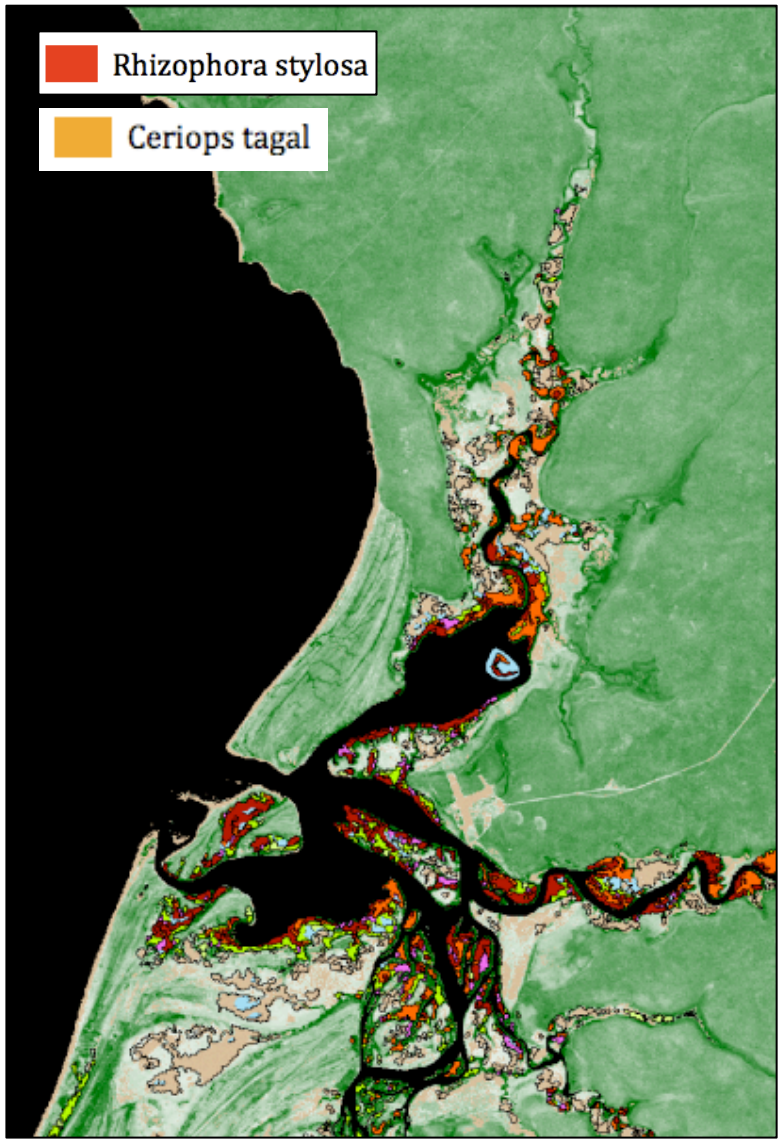


Structural classification

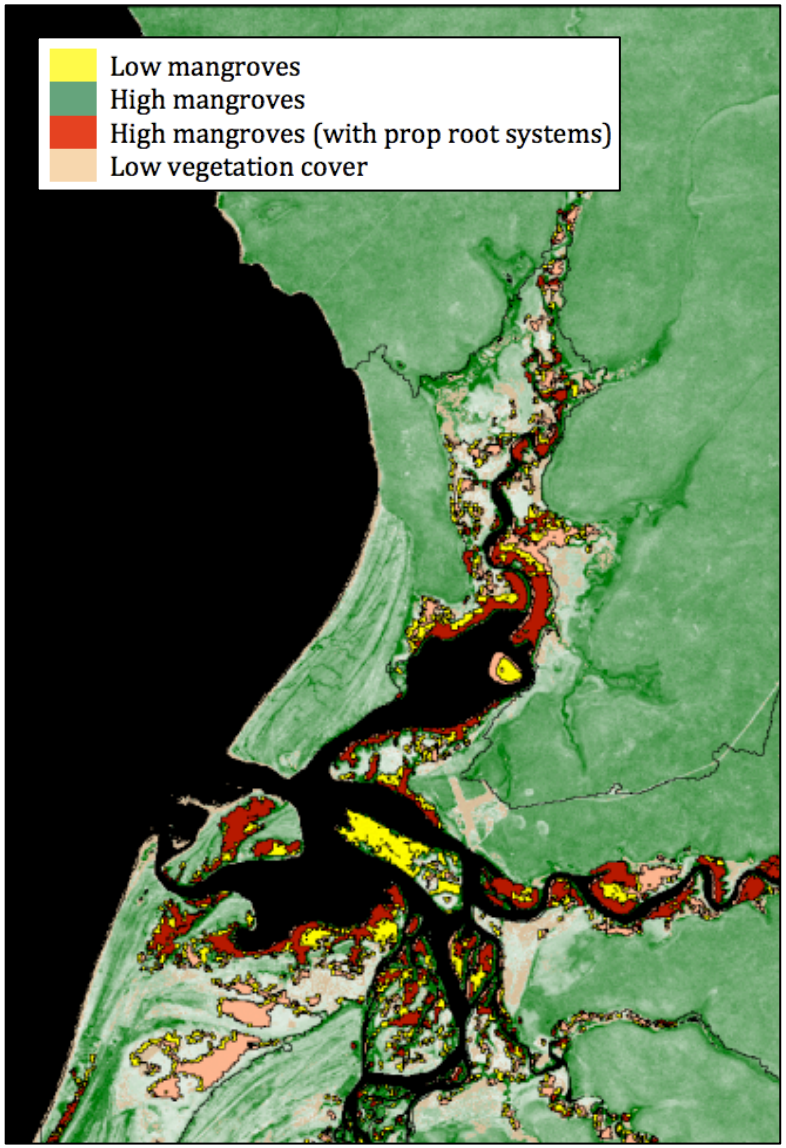




Comparisons of classifications: Cape York

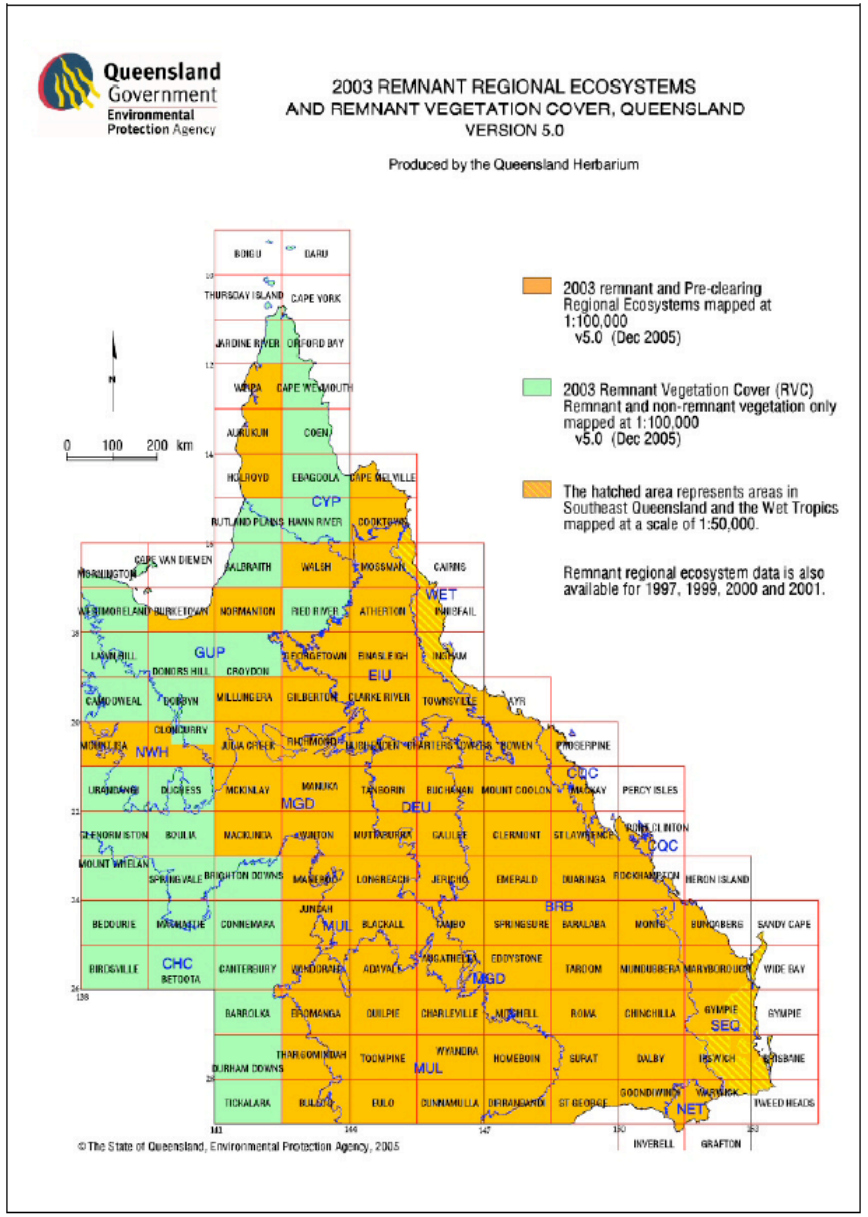


Species mapping based on optical imagery

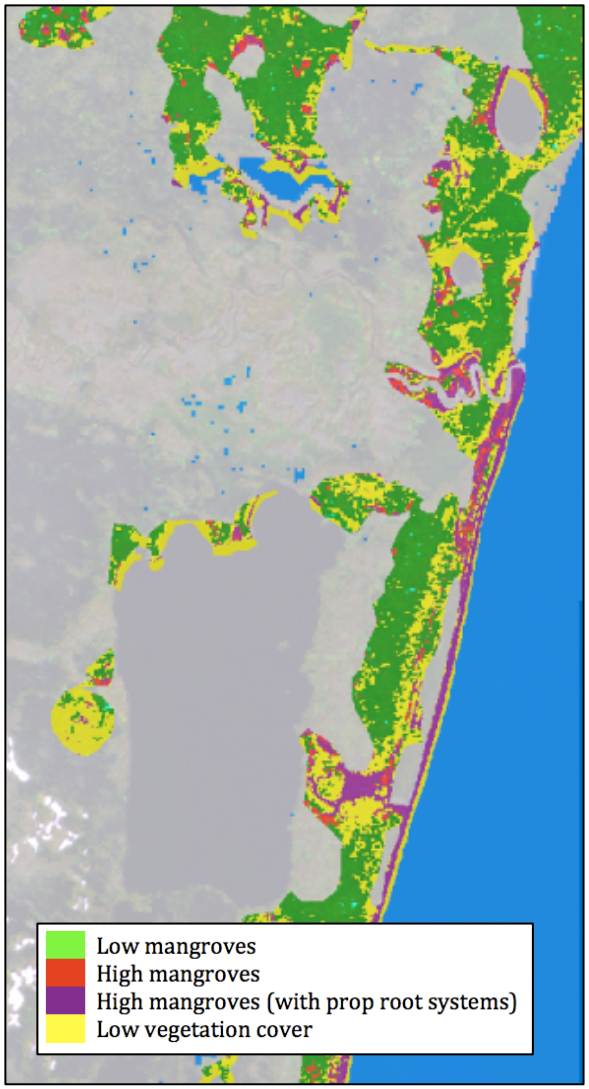


Structural classification based on ALOS, SRTM and FPC

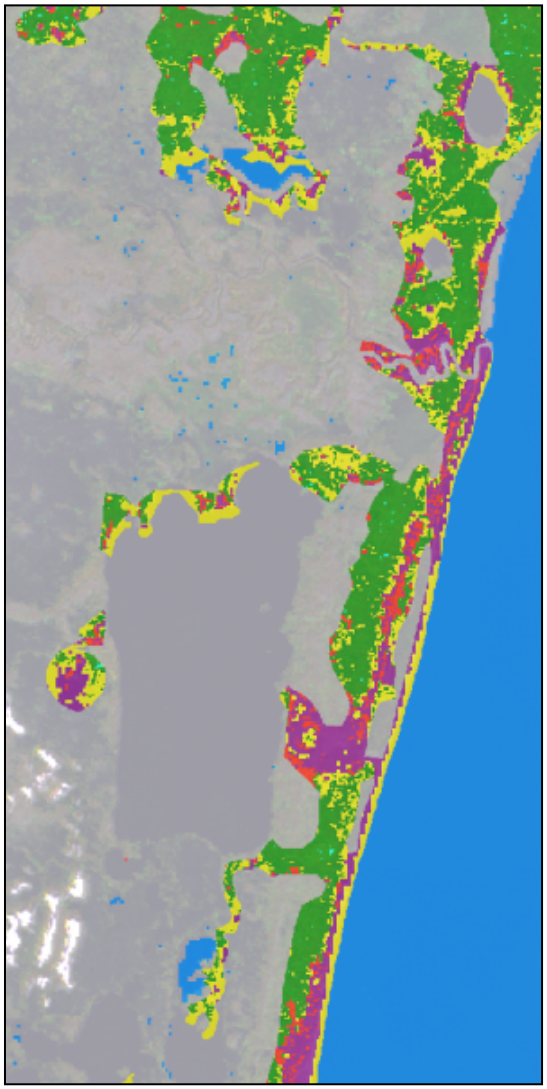
Characterizing Mangroves, Queensland, Australia



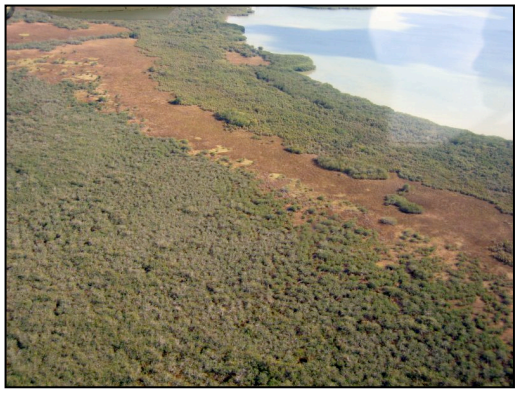
Spatial Resolution of the DEM
Central Belize



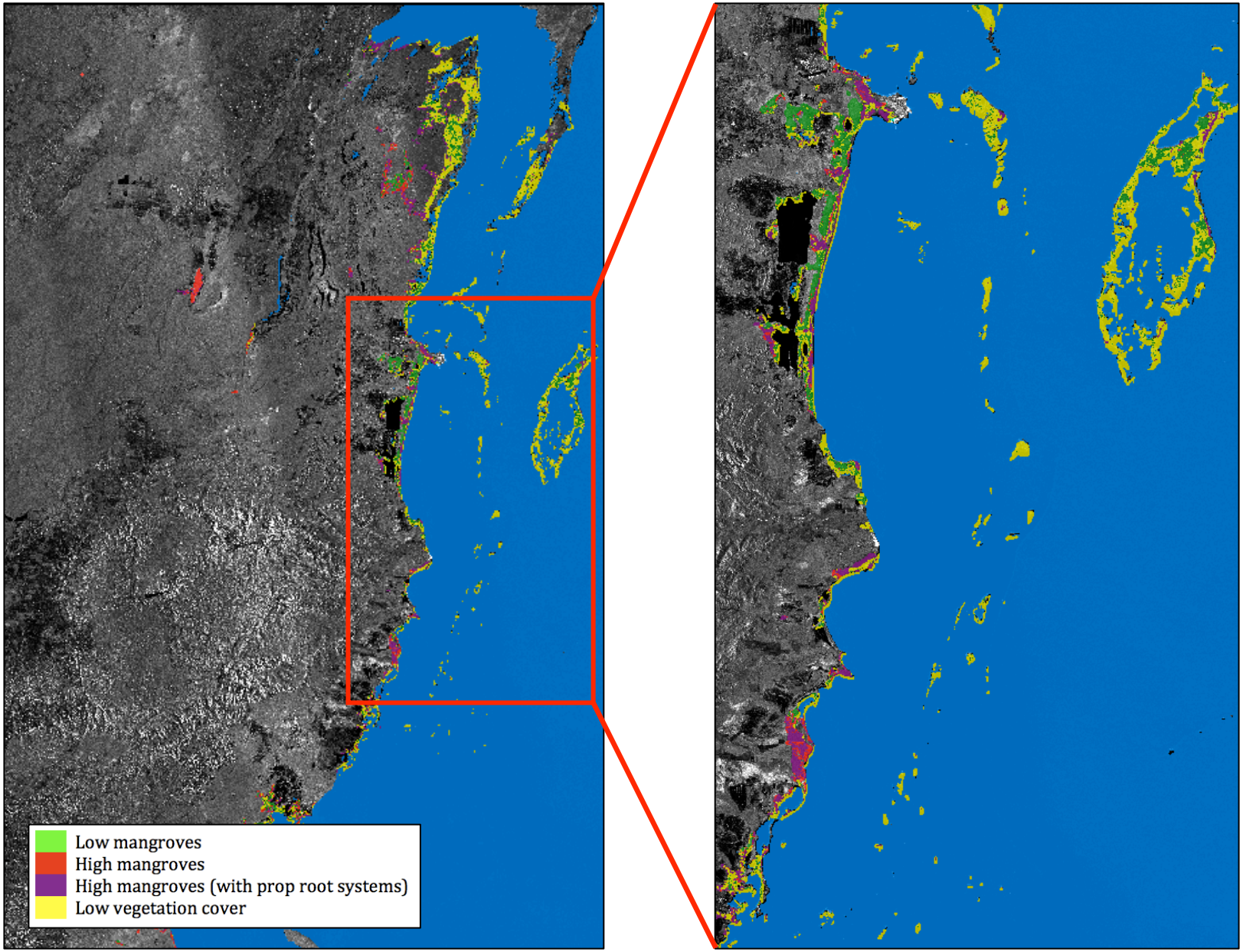
CHM - SRTM



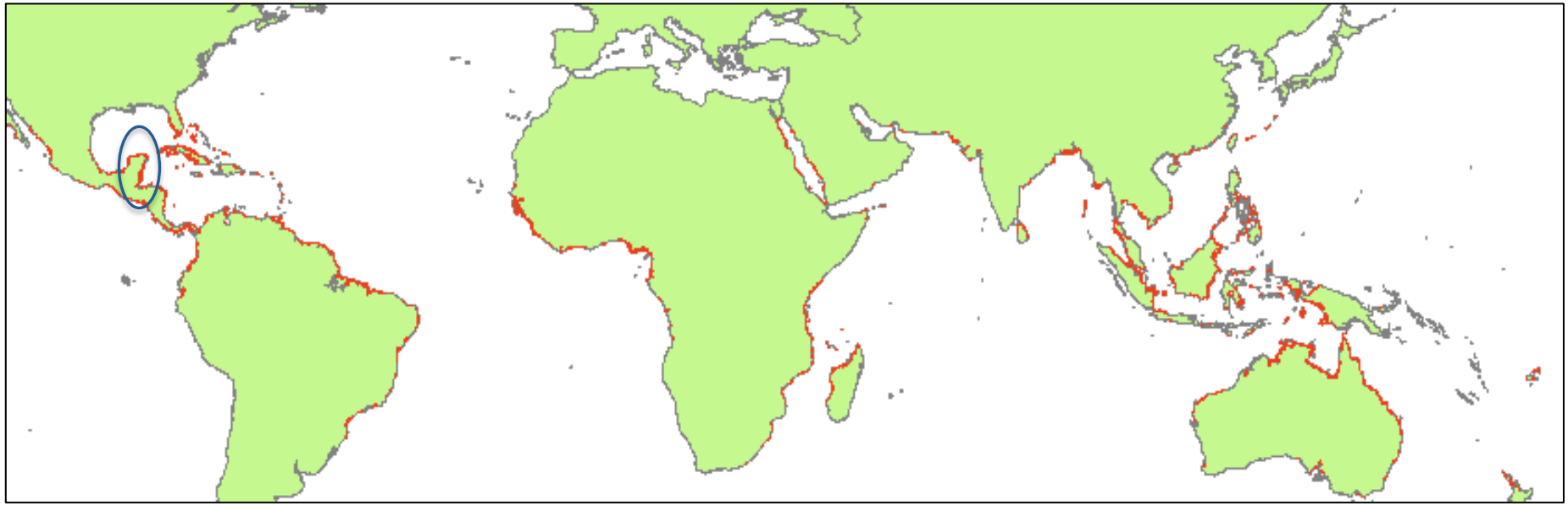
CHM - Nextmap



Regional Demonstration of Mangrove Mapping: Belize

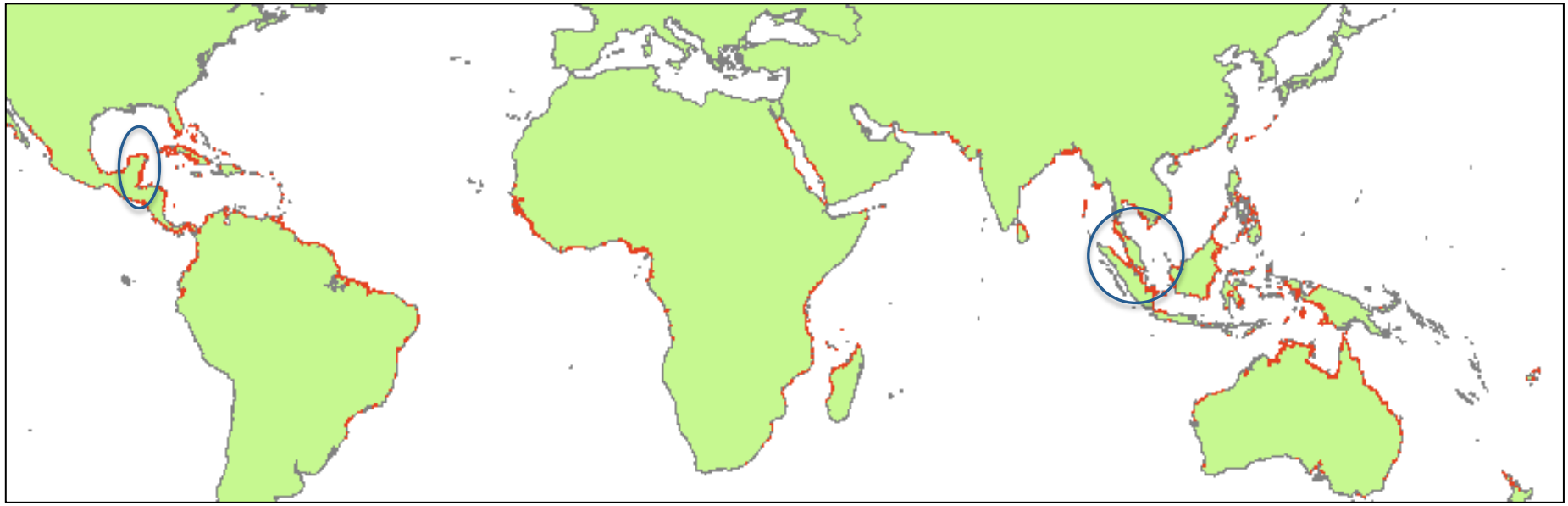


Detection of Change in Mangroves



- Belize:
  - Clearance through urbanisation and tourism
- SE Asia:
  - Clearance (e.g., fisheries, urbanisation, timber)
- Brazil and French Guiana
  - Natural processes linking with Amazonian deforestation: Sediment erosion and accretion
- Australia: Natural changes
  - Natural processes linking with climatic variation

Global Distribution and Focus of Study



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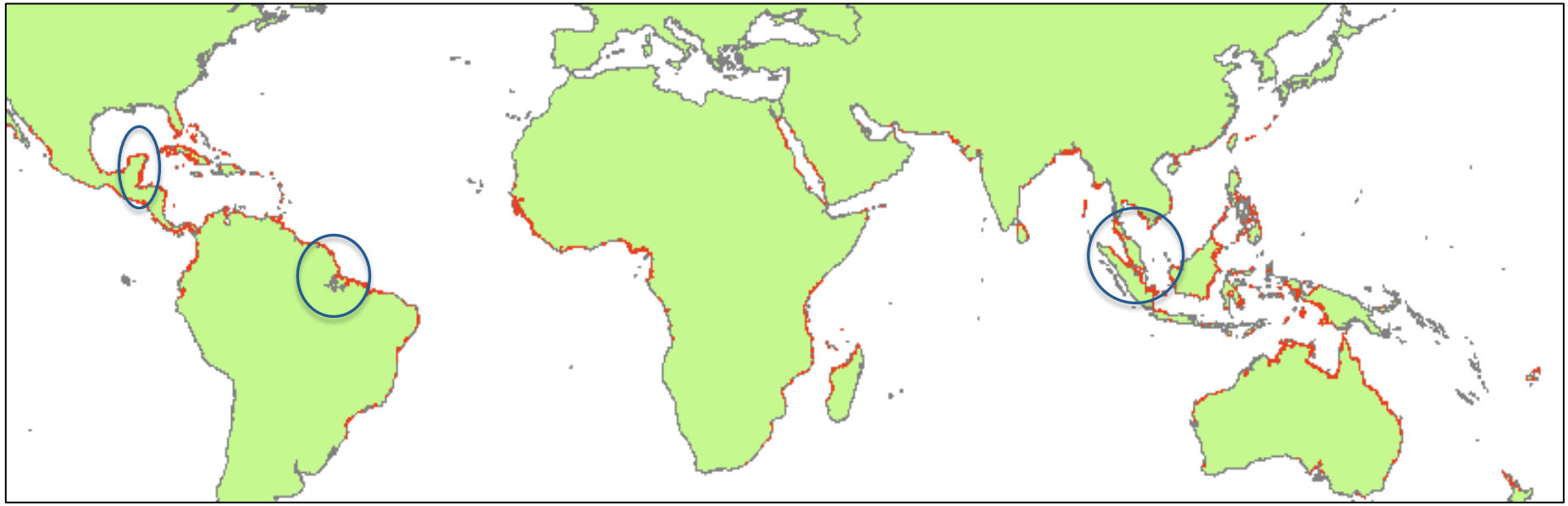
Global Distribution and Focus of Study



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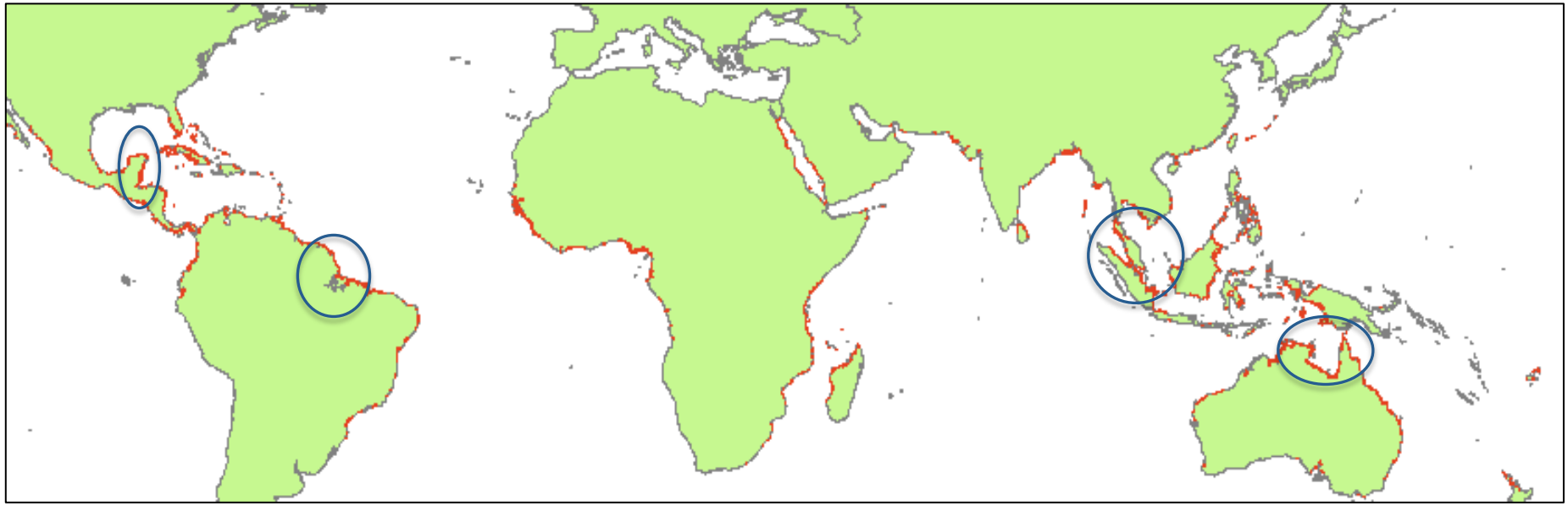

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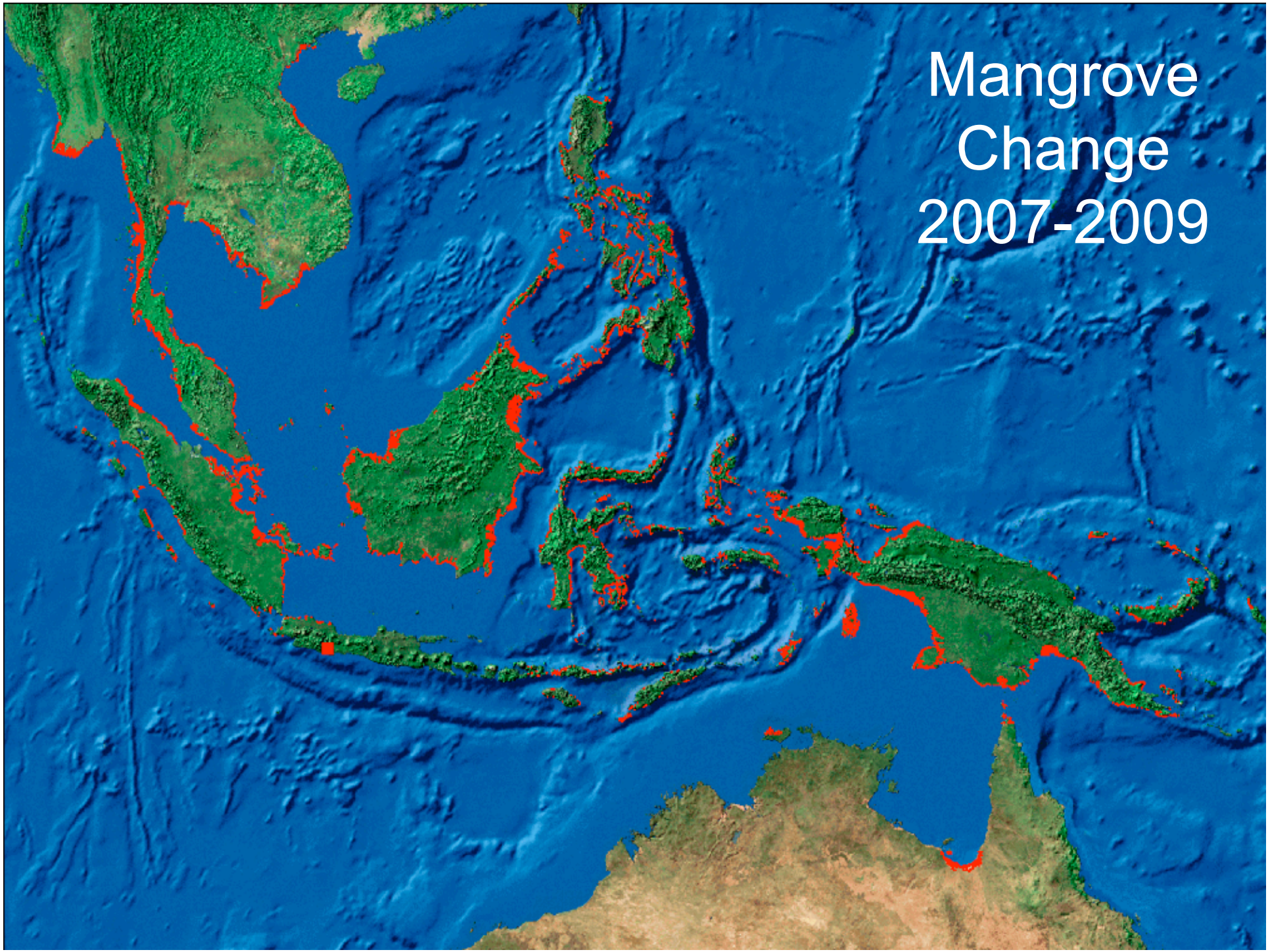
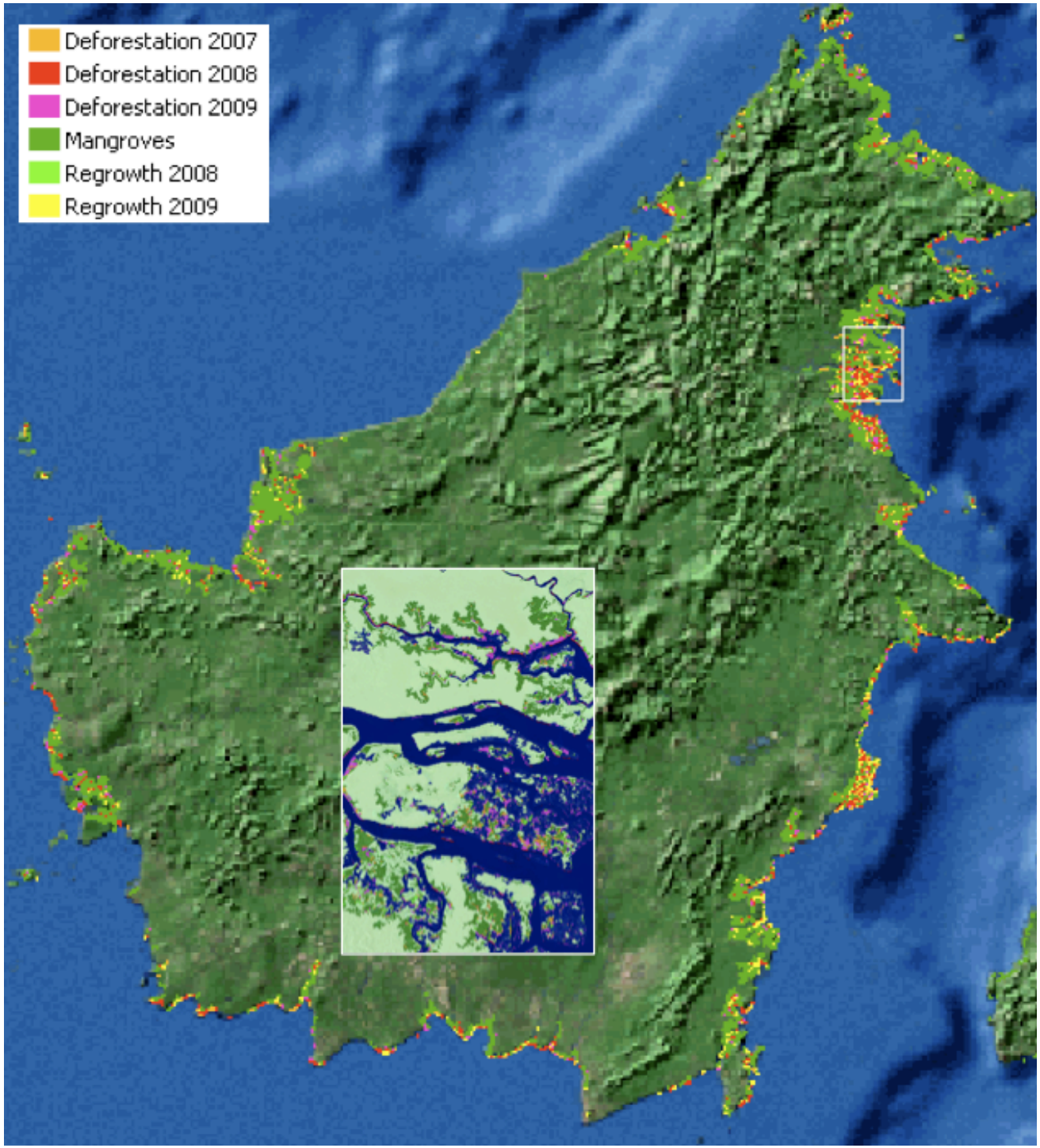
The USGS/NASA Global Mangrove Dataset

[1] C.Giri, E. Ochieng, L.L Tieszen, Z. Shu, A. Singh, T. Loveland and N. Duke. Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecology and Biogeography, 20(1), 154-159.

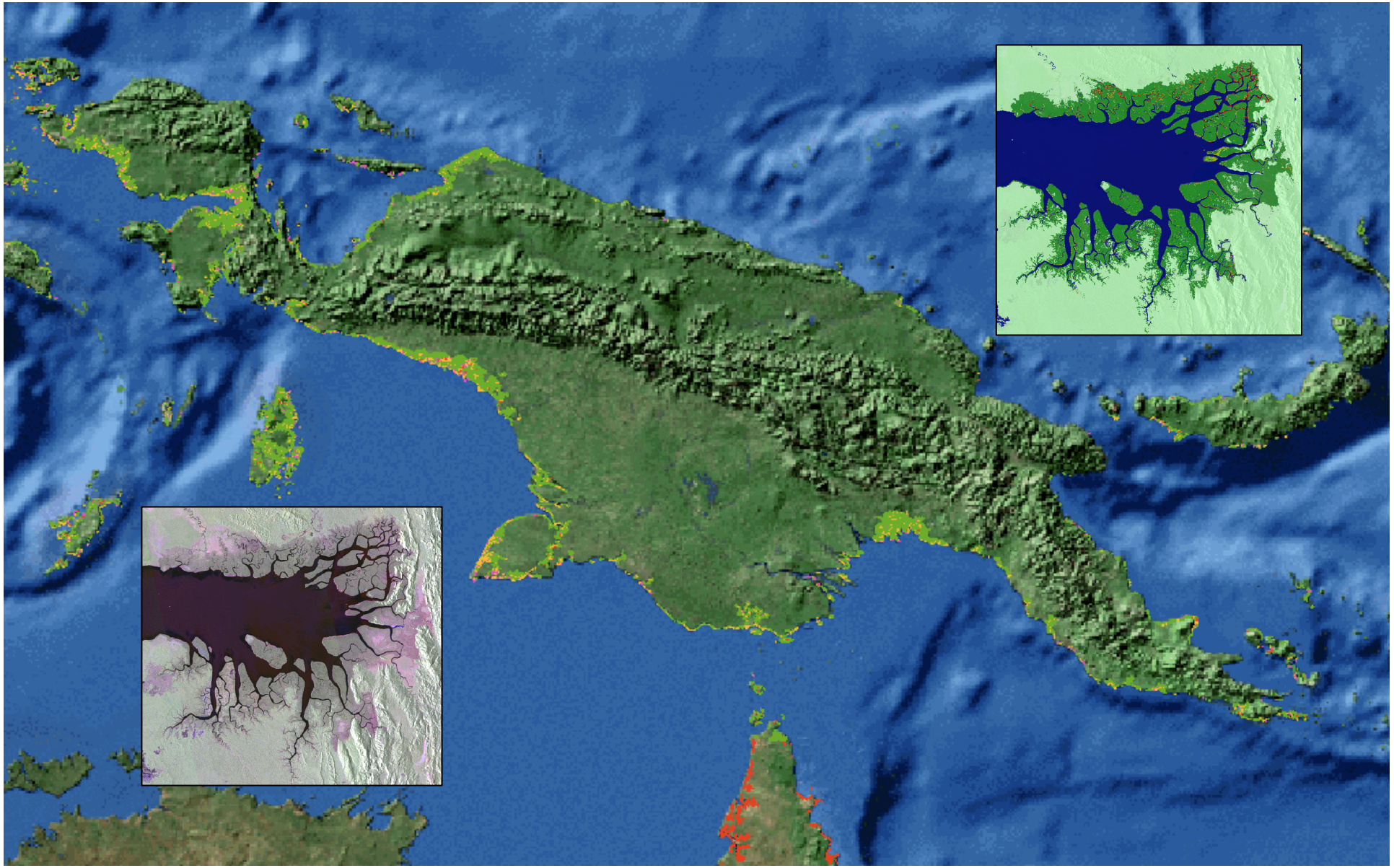

Mangrove
Change
2007-2009

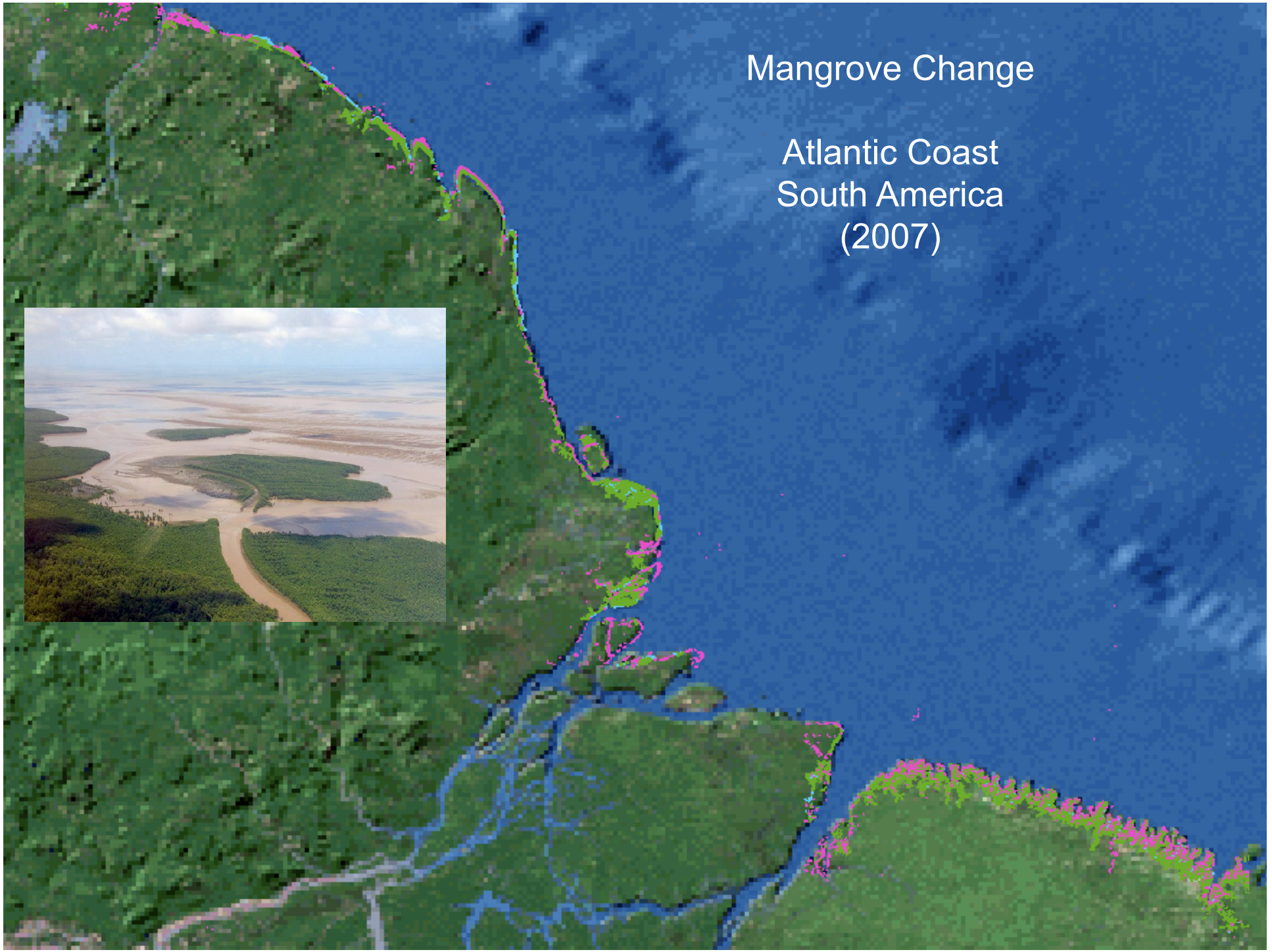


Mangrove Change Assessment

Borneo (2007-2009)

Time-series Classification of Mangroves, 2007 and 2008, New Guinea



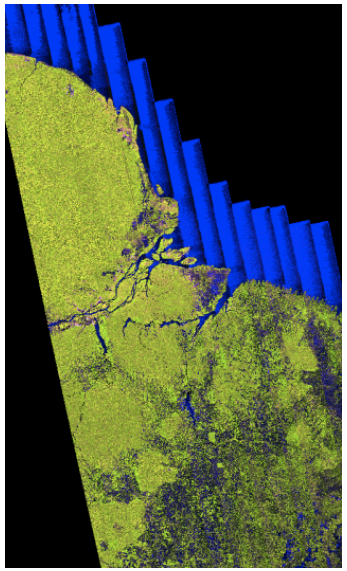

Mangrove Change
Atlantic Coast
South America
(2007)

Mangrove Change

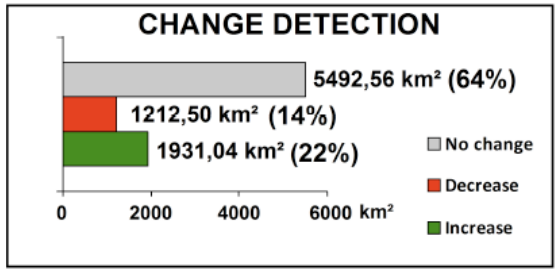
Atlantic Coast South America 1998-2008

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

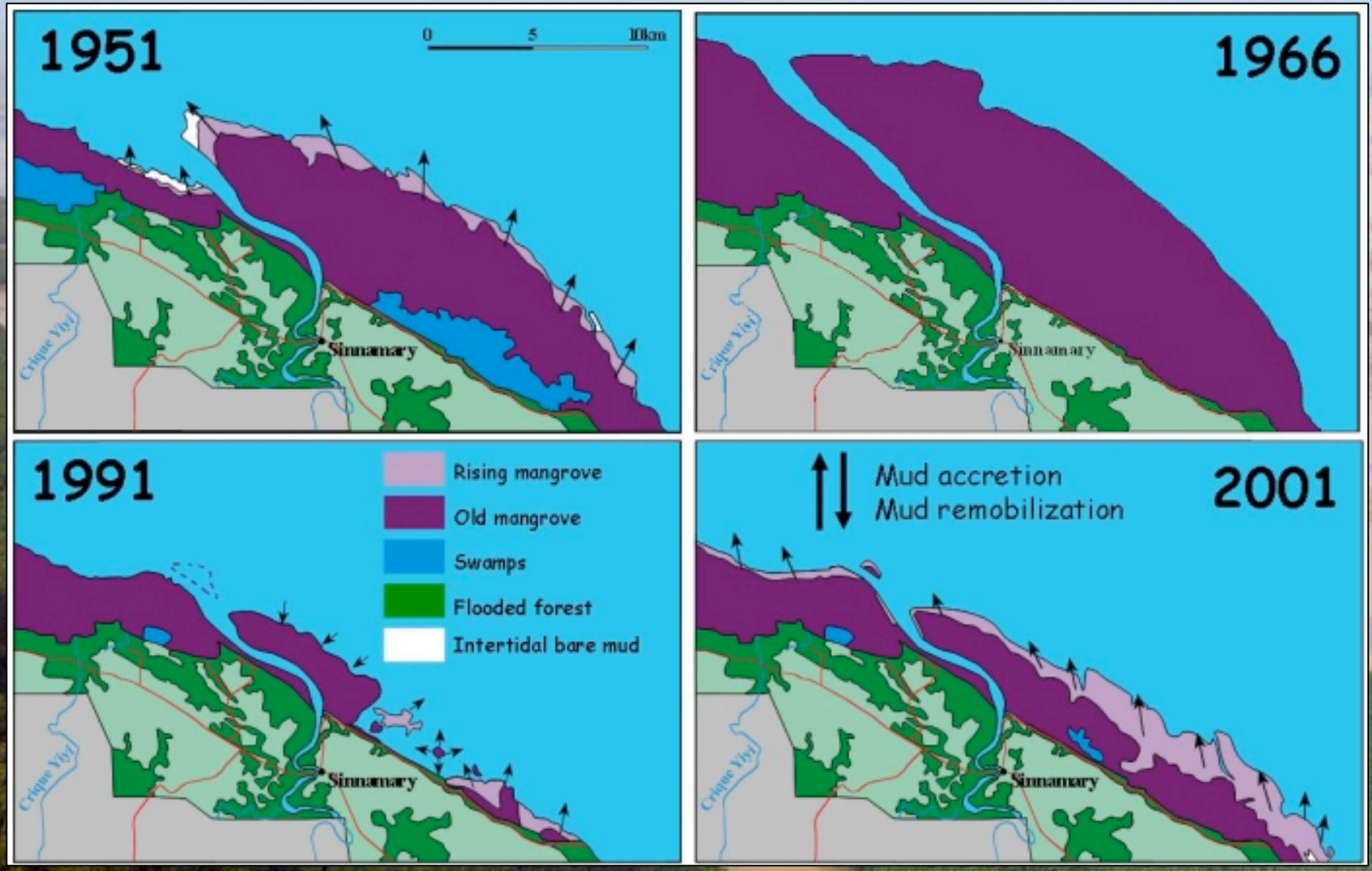


0 15 30 60 90 120 km

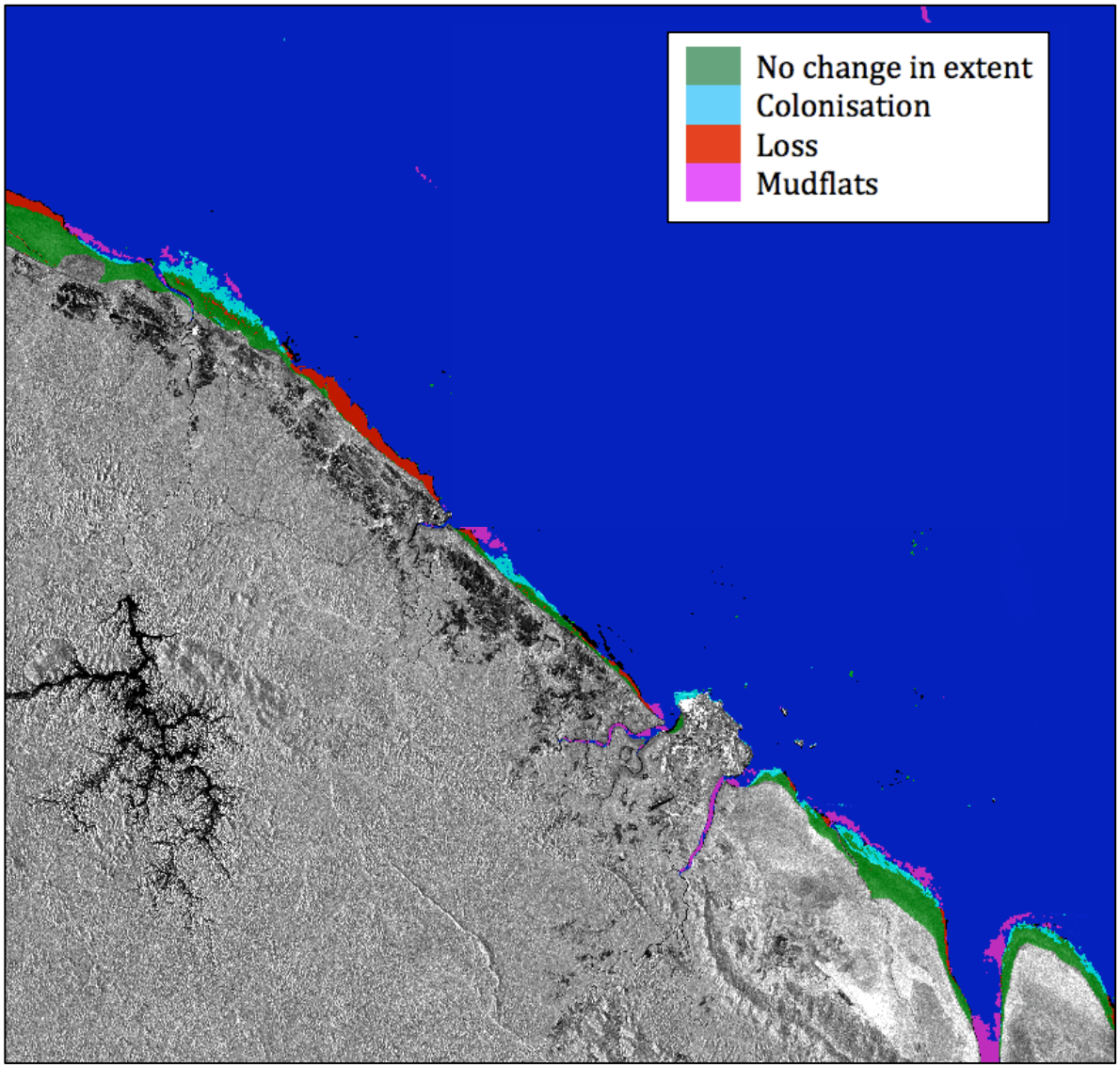
48°0'0"W 47°0'0"W 46°0'0"W 45°0'0"W 44°0'0"W

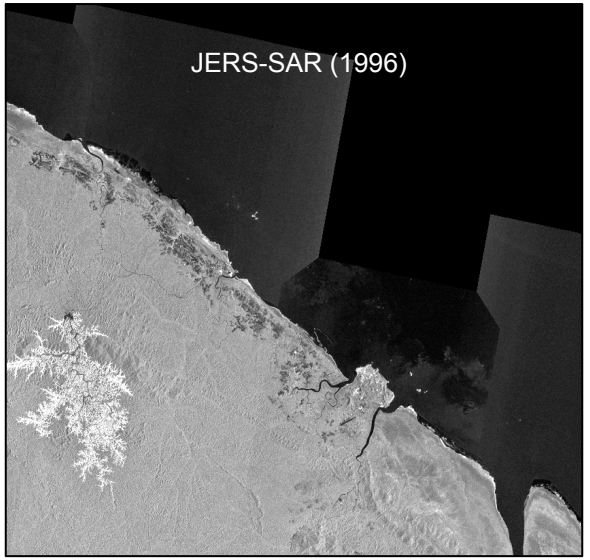
0°0'0" 1°0'0"S 2°0'0"S 3°0'0"S

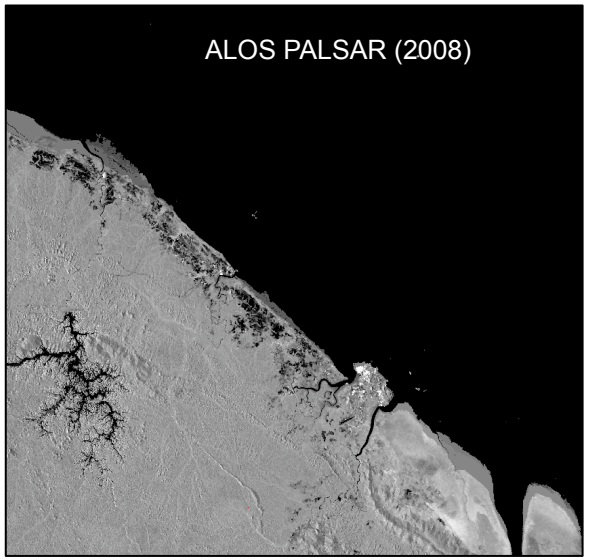
French Guiana: Changes associated with erosion and accretion of sediments



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

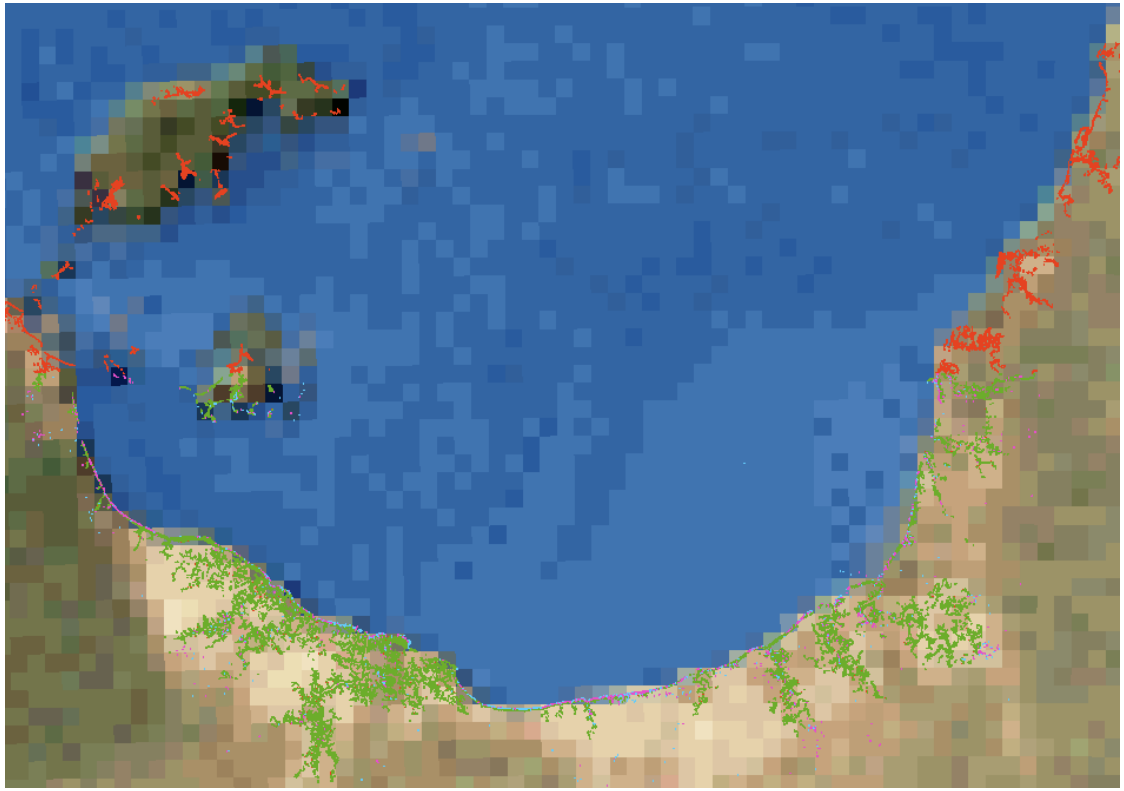


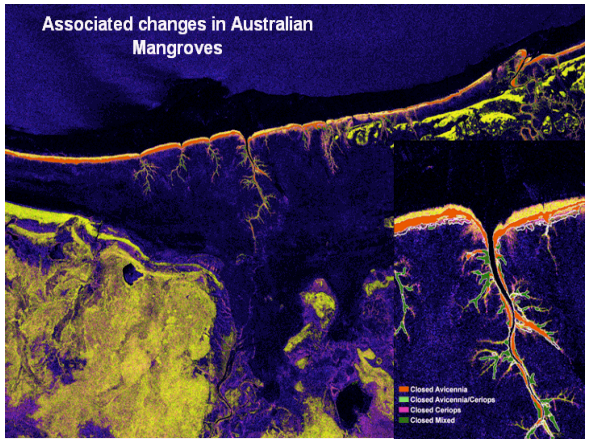




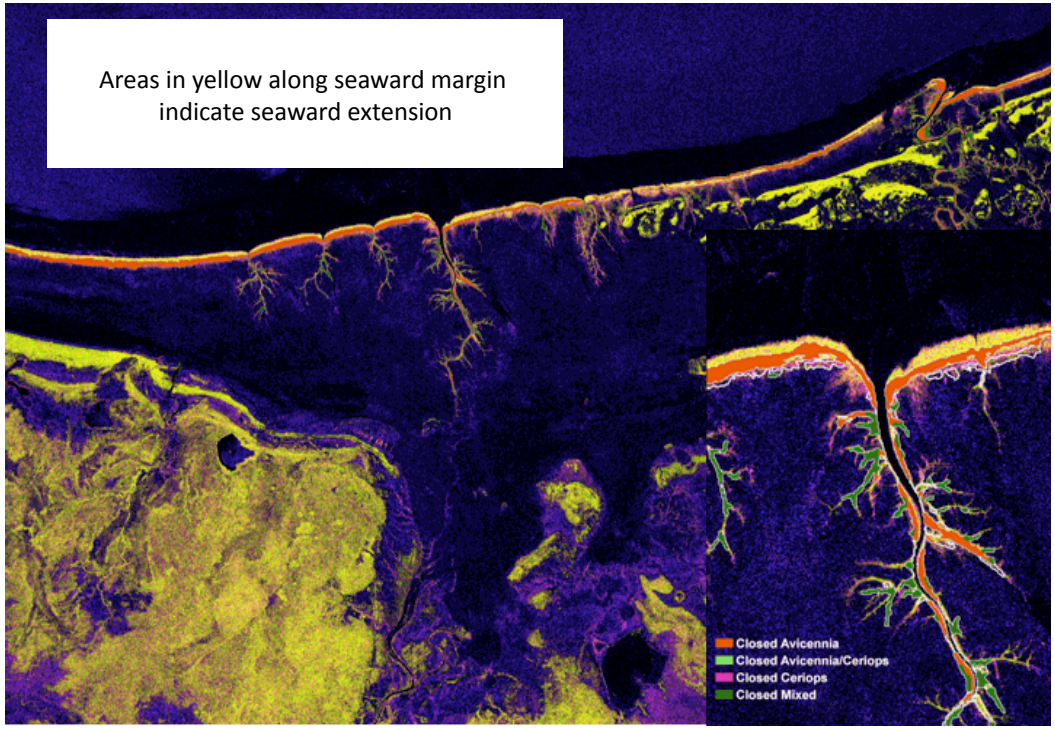
Changes in mangroves along the French Guiana coast (1996 to 2008)

Changes: Gulf of Carpentaria, Queensland, Australia

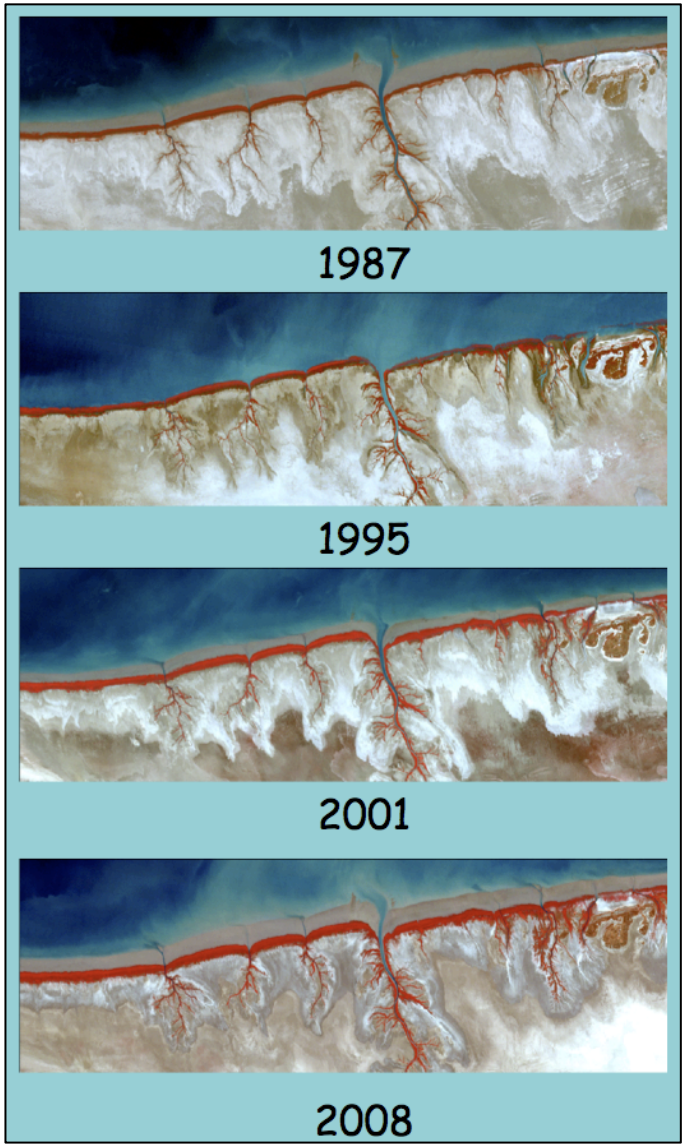




Changes in Mangrove Extent, Northern Australia

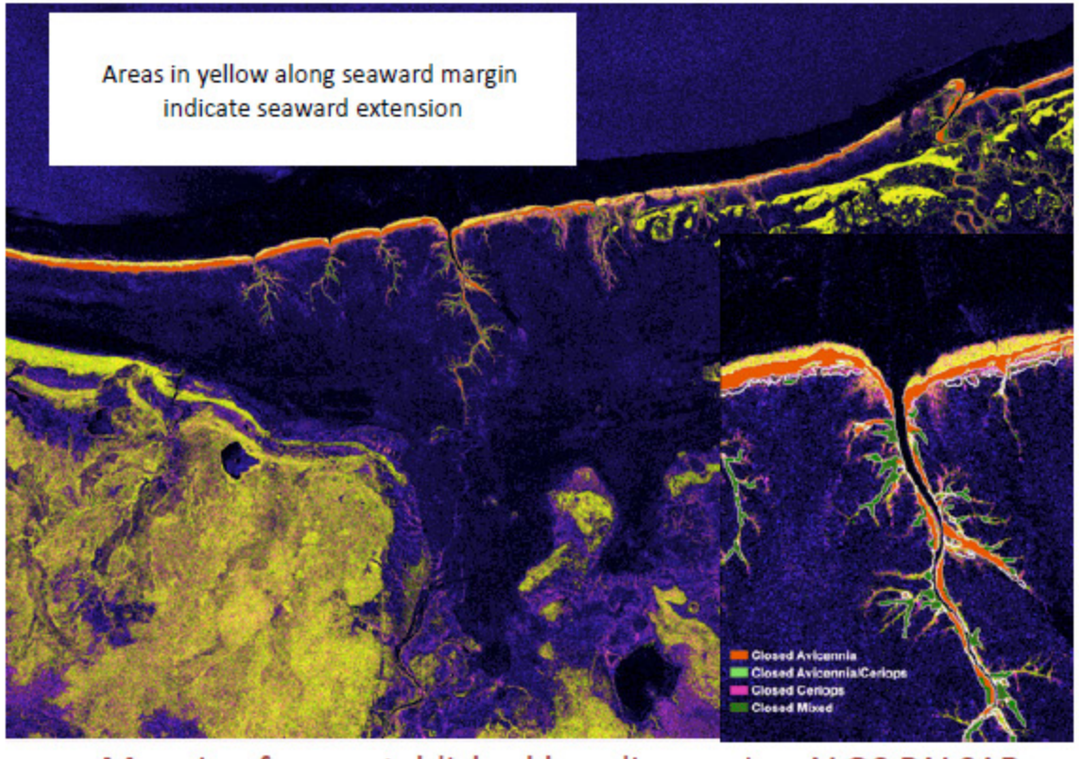


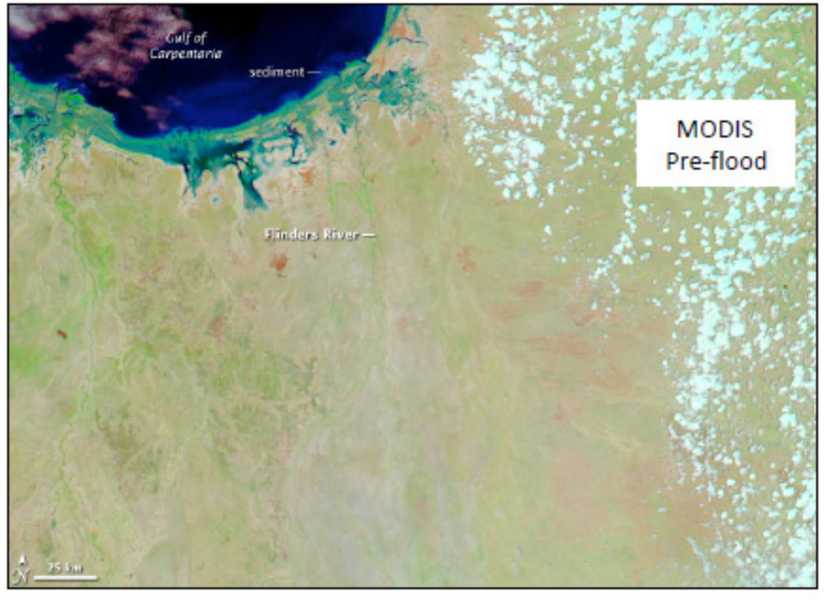
- Mapping from established baselines using ALOS PALSAR indicated relative general stability along Queensland coast
- Exception is the Gulf of Carpentaria
  - Significant seaward expansion
  - Some inland intrusion
- Associated with:
  - Extensive but periodic flooding and sediment discharge
  - Inland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

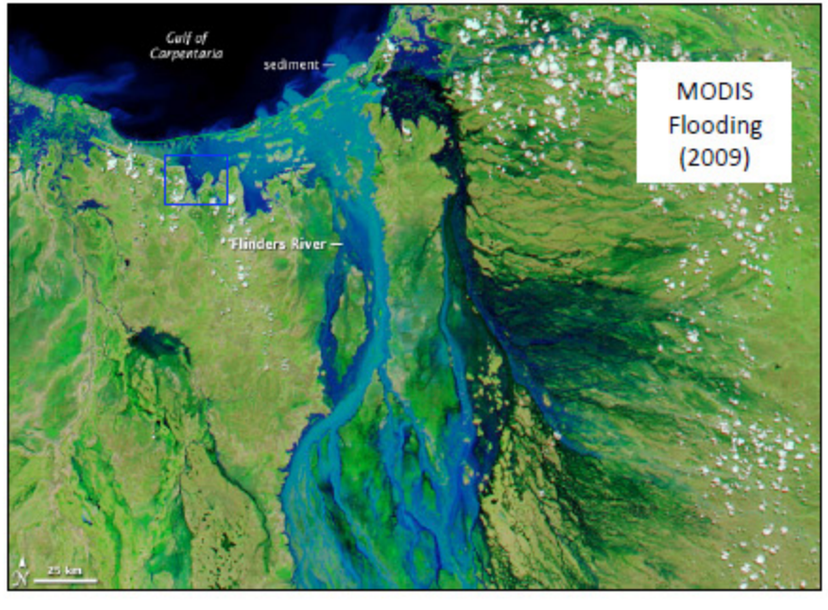


Changes in the extent of mangroves, as observed using time-series of Landsat sensor data

Changes in Mangrove Extent, Northern Australia







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Conclusions

- Mangrove Extent from ALOS PALSAR
  - Depends upon nature of the adjoining land cover
  - In some areas, classification from ALOS can be achieved (e.g., where mangroves with prop root systems adjoin rainforest)
  - Generally requires:
    - Reference to existing regional coverages
    - Optical remote sensing data or derived products (e.g., FPC).
      - Even if for only seeding classifications

- Structural Classification
  - Integration of ALOS PALSAR data with height maps useful for structural classification with potential for:
    - Global application
    - Biomass retrieval
  - Higher resolution and more timely DEMs required
    - Tandem-X
    - Airborne LiDAR
  - Current approach requires validation and refinement of algorithms

- Change detection
  - In cloud-covered regions in particular, time series comparison of ALOS PALSAR and also JERS-1 SAR allows detection of change in extent but also structure/biomass.
  - Useful input to a coastal monitoring system
  - Better understanding of causes and consequences of change
    - Natural
    - Anthropogenic
    - Climate change (sea level fluctuation)

- Requirement for ground truth
  - Airborne remote sensing data (including historical) are needed to provide ground truth and baseline information against which to quantify change but also assess the ability of detecting change from spaceborne sensor data.
  - Collation of existing and new mangrove survey data within a centralized database would be advantageous

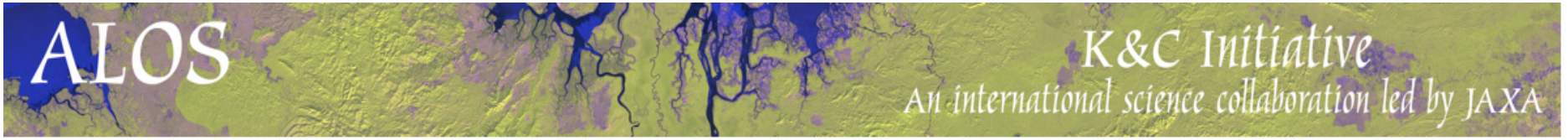
Acknowledgements

- Japanese Space Exploration Agency (JAXA) and the Kyoto and Carbon Initiative
- Definiens AG, Munich
- School of Biological, Earth and Environmental Sciences (BEES), the University of New South Wales, Australia (UNSW).
- The Queensland Department of Environment and Resource Management (QDERM)
  - Queensland Herbarium
- University of Edinburgh
- IRD (France)

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.*



K&C Phase 3

K&C GLOBAL MANGROVE WATCH

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Science Team meeting #16 – Phase 3 Kick-off
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, October 17-21, 2011

Project area(s)

Global mangrove watch (primarily tropics and subtropics)

Project objectives and schedule

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

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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')
- 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).

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

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).
- Complete joint paper to international journal outlining the consistency of the approach for mapping mangroves and detecting change within and between regions.
- 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
- Airborne-derived and high-resolution spaceborne measures of structure, biomass, species composition
- Change maps generated for selected sites/regions using optical remote sensing data.
- Rulesets and improvements on these for characterizing mangroves and detecting change.

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- Working group (opportunities for funding and more regular meetings between participants)

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.

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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** 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.