Project Outline Updated

Issue at Large:

* Since 1993, sea level has risen globally at a rate of 3.2 mm/year. By 2100, sea level is estimated to be 1m higher than at present.
* As of 2007, 40% of the world’s population lives within 100 km of the coast with a continued trend towards coastal migration
* Coastal ecosystems provide numerous resources to both protect and provide for coastal communities
* With sea level rise (SLR) and increased development, coastal ecosystems will experience a “squeeze” as habitat is threatened on both the seaward and landward boundaries

Question at Large:

* How does SLR and anthropogenic land cover change interact to impact coastal ecosystems?

Coastal Ecosystem:

* Mangroves
  + Despite a high degree of “ecological stability” mangroves are now recognized as one of the most vulnerable ecosystem types with about 36% loss globally over the past two decades
  + Mangroves not only protect shorelines from erosion, SLR, and tropical storms, but also:
    - provide essential habitat for aquatic and terrestrial fauna, construction materials and fuel, traditional medicine, textiles
    - improve water quality through filtration and contribute to nutrient recycling
    - provide and store carbon resources
    - Support tourism, spiritual, and recreational needs

Previous Work:

* Identification of physiological thresholds to climatic variables and response to change via laboratory work and remote sensing
* Perception of mangrove forests and usages via community surveys
* Improved Detection/Large-scale Mapping and temporal studies via remote sensing:
* Vulnerability frameworks which aim to both identify and monitor the major components impacting ecosystem change, as well as, quantify levels of risk spatially

Questions

SLR: sedimentation, migration

Storms: sedimentation

* How does land cover change associated with urbanization (clearance, dredging, sand extraction, waste water) impact mangroves capacity to respond to SLR and storms throughout an estuary?
  + Consensus of response to SLR alone: mangroves will either keep pace through rate of sedimentation or migrate landwards
    - How are these adaptive processes impacted by anthropogenic land cover change?
      * Do certain anthropogenic factors exacerbate the impact of SLR on the productivity/extent/biomass of mangroves differently or to a greater magnitude than others?
        + processes related to changing hydroperiods (dredging, sand extraction) or to barriers to migration (land clearance, development, agriculture)?
      * Is there a gradient of impact depending on proximity to the source of anthropogenic change?
        + How localized is the impact?
        + Can changes be observed elsewhere in estuary due to anthropogenic change further up source rivers?

Loss or gain at expense of other habitat types?

* + Response to storms:
    - mangroves are impacted from wind damage, **storm surges** (HWE: high water events), and **sediment depositions**
      * in Douala, HWE and sediment deposition from flooding = biggest concern
    - basin mangroves = more vulnerable than fringe mangroves as flood waters remain in basins longer (inundation period and sedimentation change [fine sediments can cause tree mortality as they interfere with capacity for gas exchange])
    - repeated disturbance can cause shift to different ecosystem
      * Do certain anthropogenic factors exacerbate the impact of high water events on the productivity/extent/biomass of mangroves differently or to a greater magnitude than others?
      * Is there a gradient of impact depending on proximity to the source of anthropogenic change?
        + How localized is the impact?
        + Are certain anthropogenic factors more damaging in terms of capacity to recover after high water events?
        + What is the difference in changes to flood boundaries between areas impacted and non-impacted by different anthropogenic land cover change?

Predictions

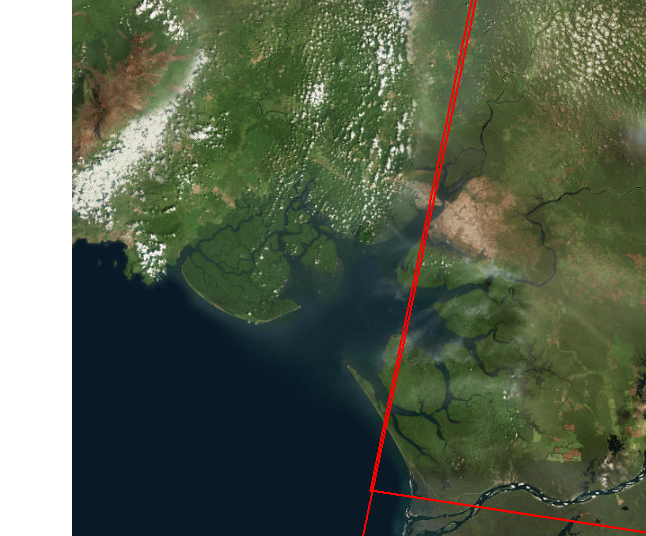
* Dredging/sand extraction
  + Decrease sediment availability
  + Changes to coastal topography, tidal patterns
  + *Impact*:
    - Locally:
      * seaward edge = loss in density/structural complexity due to changes in hydroperiod
      * landward movement if no barriers
      * expansion of flood boundaries
    - Non-Locally:
      * seaward expansion as disturbed sediment is flushed down the estuary
  + *Vulnerability*:
    - SLR:
      * Locally:
        + Heighten vulnerability to erosion and changes to hydroperiod
      * Non-Locally:
        + An extended seaward margin would decrease vulnerability to erosion
    - HWE:
      * Locally:
        + Heightened vulnerability as less biomass to reduce wave height/energy/extent and debris movement
      * Non-Locally:
        + An extended seaward margin would buffer wave energy/debris movement
* Land clearance:
  + Decrease capacity for sediment retention due to reduction in biomass
  + Change coastal topography, elevation, tidal patterns
  + Blocked landward migration
    - physical structures
    - reduced ability of mangroves to colonize bare areas
  + *Impact*:
    - Locally:
      * Landward - loss in biomass/density/structural complexity
      * Seaward contraction due to contemporary SLR and blocked migration pathways
      * Expansion of flood boundaries
    - Non-Locally:
      * Maintenance of seaward boundaries, possible expansion
      * Colonization of new areas like salt marshes as inundation periods increase and more sediment is readily available
  + *Vulnerability*:
    - SLR:
      * Locally:
        + Heightened vulnerability as thinning is occurring on both the seaward and landward side
      * Non-Locally:
        + Less vulnerable as seaward boundary remains the same or expands, plus landward migration paths may still be open
    - HWE:
      * Locally:
        + Heightened vulnerability as less biomass to reduce wave height/energy/extent, and debris movement
      * Non-Locally:
        + Less vulnerable as seaward edge remains the same or expands
* Runoff from agriculture:
  + Change in nutrient availability
  + *Impact*:
    - Locally:
      * Increased biomass
      * Migration into new areas as changes to inundation period due to contemporary SLR favors mangroves (if no other barriers)
  + *Vulnerability*:
    - SLR:
      * Locally:
        + Lower vulnerability due to increased biomass and increased capacity for sedimentation
    - HWE:
      * Locally:
        + Lower vulnerability as greater biomass aids in reduction of wave intensity
* Urban waste waters:
  + Decline in water quality
  + *Impact*:
    - Locally:
      * Reduced biomass
      * Loss in species composition/richness
      * Expanded flood boundaries
    - Non-Locally:
      * Gradient of decline from source?
  + *Vulnerability*:
    - SLR:
      * Locally:
        + Heightened vulnerability to erosion and changes in hydroperiod as less biomass reduces sedimentation accumulation rates
    - HWE:
      * Locally:
        + Heightened vulnerability as less biomass to reduce wave height/energy, and debris movement

Study Area:

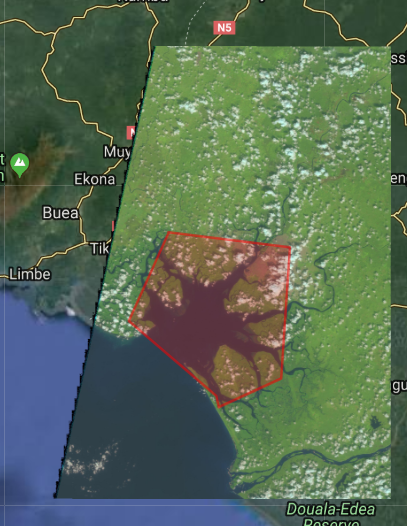
* Douala region Cameroon
* Proposed Regions of Interest (top left)
  + I think it would be interesting to focus on sites impacted by different anthropogenic activities at varying distances from the source as well as sites in the reserve that should not be impacted by development
  + Mungo River and Basin (Blue - MRB)
    - Agricultural zone (northwest of Douala)
      * Several plantations east of reserve as well
    - Sand Extraction (farther up Mungo River)
  + Douala (Orange- D)
    - Along the Wouri River, sites above, within (bridge, airport/Bassa industrial zone), and closer towards Atlantic
    - Might need to cut a few out
  + Douala Edea Wildlife Reserve (yellow -DER)
    - Chose sites closer to Atlantic to avoid areas nearest agricultural activity



**Available Data + Acquired**



Landsat: 187 (left) 186 (right)

Sentinel: T32NNK: NW (left) Except W Mungo (right)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Data Availability - Optical | | |  | | |  |  |  |
| Sensor | Date | Path | | Downloaded | Mosaic | |
| Landsat 5 TM | 1984/11/29 | 186 | Y | | |  |
| Landsat 5 TM | 1986/12/12 | 187 | Y | | | × |
| Landsat 5 TM | 1986/12/21 | 186 | Y | | | × |
| Landsat 5 TM | 1987/04/03 | 187 | Y | | |  |
| Landsat 5 TM | 1989/02/04 | 186 | Y | | |  |
| Landsat 7 ETM | 1999/12/17 | 186 | Y | | |  |
| Landsat 7 ETM | 2000/12/10 | 187 | Y | | |  |
| Landsat 7 ETM | 2003/1/1 | 187 | Y | | |  |
| OLI | 2013/12/15 | 186 | Y | | | × |
| OLI | 2013/12/22 | 187 | Y | | | × |
| OLI | 2014/01/07 | 187 | Y | | |  |
| OLI | 2014/12/18 | 186 | Y | | | × |
| OLI | 2014/12/25 | 187 | Y | | | × |
| OLI | 2015/01/10 | 187 | Y | | |  |
| OLI | 2015/04/25 | 186 | Y | | |  |
| Sentinel -2A | 2015-12-09 | Except W Mungo | Y | | | Δ |
| OLI | 2015/12/12 | 187 | Y | | | × |
| OLI | 2015/12/21 | 186 | Y | | | × |
| Sentinel -2A | 2015/12/22 | NW | Y | | | Δ |
| OLI | 2015/12/28 | 187 | Y | | | × |
| Sentinel -2A | 2015-12-29 | Except W Mungo | Y | | | Δ |
| Sentinel -2A | 2016/01/01 | NW | Y | | | Δ |
| OLI | 2016/1/6 | 186 | Y | | | × |
| Sentinel -2A | 2016-01-11 | NW | Y | | |  |
| Sentinel -2A | 2016-01-21 | NW | Y | | |  |
| Sentinel -2A | 2016-02-07 | Except W Mungo | Y | | | Δ |
| Sentinel -2A | 2016-02-10 | NW | Y | | | Δ |
| OLI | 2016/12/30 | 187 | Y | | | × |
| Sentinel -2A | 2017-01-02 | Except W Mungo | Y | | | Δ |
| Sentinel -2A | 2017-01-05 | NW | Y | | | Δ |
| OLI | 2017/1/8 | 186 | Y | | | × |
| Sentinel -2A | 2017-02-04 | NW | Y | | | Δ |
| SENTINEL-2A | 2017/02/11 | Except W Mungo | Y | | | Δ |
| OLI | 2017/3/29 | 186 | Y | | |  |
| SENTINEL-2A | 2017/05/22 | Except W Mungo | Y | | |  |
| Sentinel-2A | 2017/06/21 | Except W Mungo | Y | | |  |
| Sentinel-2A | 2017/11/08 | Except W Mungo | Y | | |  |
| Sentinel-2B | 2017/11/13 | Except W Mungo | Y | | |  |
| Sentinel-2A | 2017/11/28 | Except W Mungo | Y | | |  |
| Sentinel-2A | 2017/12/11 | NW | Y | | | Δ |
| Sentinel-2B | 2017/12/13 | Except W Mungo | Y | | | Δ |
| OLI | 2017/12/26 | 186 | Y | | | × |
| Sentinel-2A | 2017/12/26 | NW | Y | | | Δ |
| Sentinel-2A | 2017-12-28 | Except W Mungo | Y | | | Δ |
| OLI | 2018/1/2 | 187 | Y | | | × |
| Sentinel-2A | 2018-01-07 | Except W Mungo | Y | | | Δ |
| Sentinel-2A | 2018-01-10 | NW | Y | | | Δ |
| Sentinel-2A | 2018-01-17 | Except W Mungo | Y | | |  |
| OLI | 2018/01/18 | 187 | Y | | |  |
| Sentinel-2B | 2018-01-22 | Except W Mungo | Y | | | Δ |
| Sentinel-2B | 2018-01-25 | NW | Y | | | Δ |
| Sentinel-2A | 2018-01-27 | Except W Mungo | Y | | |  |
| Sentinel-2A | 2018-01-30 | NW | Y | | | Δ |
| Sentinel-2B | 2018-02-01 | Except W Mungo | Y | | | Δ |
| OLI | 2018/02/03 | 187 | Y | | | × |
| OLI | 2018/02/28 | 186 | Y | | | × |
| SENTINEL-2A | 2018/04/30 | NW | Y | | |  |

Optical Summary:

* Full mosaics:
  + Landsat:
    - Total: 8
      * December 1986, December 2013, December 2014, December 2015, December 2015, December 2016, December 2018, February 2018
  + Sentinel
    - Total: 10
      * December 2015, December 2015, February 2016, January 2017, February 2017, December 2017, December 2017, January 2018, January 2018, February 2018

|  |  |  |
| --- | --- | --- |
| Track | Study Region | # |
| 186 | D1, D2, D3, DER 2, DER 1 (S) | 13 |
| 187 | D4, D5, D6, D7, DER 1 (N), M1, M2,M3 | 15 |
| NW | D5, M1,M2,M3 | 13 |
| All except W Mungo | All | 17 |

|  |  |  |
| --- | --- | --- |
| D1: 30  D2: 30  D3: 30  D4: 32  D5: 45  D6: 32  D7: 32 | DER1 (N): 32  DER1 (S): 30  DER2: 30 | M1: 45  M2: 45  M3: 45 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | Data Availability Radar | | | | | | | | | | |
| Sensor | Date | | | | Lat or Track | | Long or Frame | Specs (swath envisat) | | | Downloaded | | |
| ERS-1 | 1994-07-25 | | 897 | | | 3519 | | IMP | VV |  | | Y |
| ERS-1 | 1994-07-25 | | 897 | | | 3537 | | IMP | VV |  | | Y |
| ERS-1 | 1995-12-04 | 408 | | | | 3519 | | IMP | VV |  | | Y |
| ERS-1 | 1995-12-04 | 408 | | | | 3537 | | IMP | VV |  | | Y |
| ERS-1 | 1996-02-12 | 408 | | | | 3519 | | IMP | VV |  | | Y |
| ERS-1 | 1996-02-12 | 408 | | | | 3519 | | IMP | VV |  | | Y |
| ERS-2 | 1996-02-13 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-2 | 1996-02-13 | 408 | | | | 3537 | | IMP | VV |  | |  |
| ERS-1 | 1996-04-22 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-1 | 1996-04-22 | 408 | | | | 3537 | | IMP | VV |  | |  |
| ERS-2 | 1996-04-23 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-2 | 1996-04-23 | 408 | | | | 3537 | | IMP | VV |  | |  |
| ERS-1 | 1999-02-01 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-1 | 1999-02-01 | 408 | | | | 3537 | | IMP | VV |  | |  |
| ERS-2 | 1999-02-02 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-2 | 1999-02-02 | 408 | | | | 3537 | | IMP | VV |  | |  |
| ERS-2 | 2003-03-18 | 408 | | | | 3519 | | IMP | VV |  | |  |
| ERS-2 | 2003-03-18 | 408 | | | | 3537 | | IMP | VV |  | |  |
| Envisat-1 | 2003-12-23 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2003-12-23 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-03-02 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-03-02 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-06-15 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-06-15 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-06-15 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2004-06-15 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| Envisat-1 | 2007-02-20 | 408 | | | | 3519 | | APP | HH,HV | 2 | | Y |
| Envisat-1 | 2007-02-20 | 408 | | | | 3533 | | APP | HH,HV | 2 | | Y |
| Envisat-1 | 2007-03-11 | 179 | | | | 3519 | | APP | HH,HV | 2 | |  |
| Envisat-1 | 2007-03-11 | 179 | | | | 3532 | | APP | HH,HV | 2 | |  |
| ALOS-PALSAR | 2007-7-24 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2007-07-24 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| Envisat-1 | 2007-11-27 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2007-11-27 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| Envisat-1 | 2007-08-14 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2007-08-14 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| ALOS-PALSAR | 2007-08-22 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2007-08-22 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| Envisat-1 | 2008-01-01 | 408 | | | | 3519 | | IMP | VV | 2 | |  |
| Envisat-1 | 2008-01-01 | 408 | | | | 3537 | | IMP | VV | 2 | |  |
| ALOS-PALSAR | 2008-07-26 | 6 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-07-26 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-08-24 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-08-24 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-09-10 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-09-10 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-10-09 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2008-10-09 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-06-13 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-06-13 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-07-12 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-07-12 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-09-13 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-09-13 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-10-12 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-10-12 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2009-11-10 | 70 | | | | 659 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2009-11-10 | 60 | | | | 659 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2009-11-22 | 50 | | | | 657 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2009-11-22 | 70 | | | | 657 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2010-05-30 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-05-30 | 60 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-08-01 | 50 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-08-01 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-09-16 | 40 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-09-16 | 60 | | | | 661 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-11-25 | 60 | | | | 657 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2010-11-25 | 70 | | | | 657 | | PLR | HH,HV,VH,VV | Y | | Y |
| ALOS-PALSAR | 2010-11-30 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| ALOS-PALSAR | 2010-11-30 | 50 | | | | 660 | | FBD | HH,HV | Y | | Y |
| Envisat-1 | 2011-02-19 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-03-21 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-04-20 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-05-20 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-06-19 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-07-19 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-08-18 | 352 | | | | 3537 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-08-18 | 352 | | | | 3539 | | APP | VV,VH | 4 | |  |
| Envisat-1 | 2011-12-24 | 36 | | | | 3519 | | APP | VV,VH | 1 | |  |
| Envisat-1 | 2011-12-24 | 36 | | | | 3537 | | APP | VV,VH | 1 | |  |
| Envisat-1 | 2012-02-22 | 36 | | | | 3519 | | APP | VV,VH | 1 | | Y |
| Envisat-1 | 2012-02-22 | 36 | | | | 3537 | | APP | VV,VH | 1 | | Y |
| Envisat-1 | 2012-03-23 | 36 | | | | 3519 | | APP | VV,VH | 1 | | Y |
| Envisat-1 | 2012-03-23 | 36 | | | | 3537 | | APP | VV,VH | 1 | | Y |
|  |  |  | | | |  | |  |  |  | |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sensor | Dates | Band | Use |  |
| Landsat-5 TM | 1984-1987 |  | * Baseline * Landscape Classification (Vegetation Indices) * Find landward boundary * Find seaward boundary * TSM   Maximum Chlorophyll Index |  |
| Landsat-8 OLI | 2013-2018 |  | * Landscape classification(Vegetation Indices) * TSM * Maximum Chlorophyll Index |  |
| Sentinel-2 | 2015-2018 |  | * Landscape classification(Vegetation Indices) * TSM * Maximum Chlorophyll Index |  |
| SRTM | 2014 |  | * Elevation * Slope * Preprocessing of Radar * Canopy height |  |
| ERS-1/2 | 1994-2003 | C VV | * Changes to canopy parameters * Flood boundaries |  |
| Envisat-1 | 2003-2012 | C VV\*, VH, HH, HV | * Changes to canopy parameters * Flood boundaries |  |
| ALOS/PALSAR | 2007-2010 | L HH, HV, VV, VH | * Seaward Boundary * Biomass Change * Flood boundaries |  |
| Sentinel 1 | 2015-2018 | VV+VH |  |  |

**Methods**

1. Preprocessing
   1. SRTM:
      1. Mosaic (R)
      2. Remove >35m (R)
      3. Clip to general study area bounding box (R)
      4. Derive Slope (radians + degrees) (QGIS)
      5. Resample to size of radar?
   2. Optical:
      1. Landsat (30m)
         1. Mask bands by quality band (R)
         2. Mosaic – might not, instead deal with each ROI separate (R)
         3. Clip by SRTM bounding box (R)
         4. Calculate Vegetation Indices (R)
         5. Derive Chlorophyll-a -- MERIS Maximum Chlorophyll Index (MCI) ( C2RCC in SNAP)
         6. TSM ( C2RCC)
         7. Resample using SRTM
      2. Sentinel (20m)
         1. Pre-processing
            1. Sen2Cor (Command Line)
         2. Clip by SRTM bounding box(R)
         3. Calculate Vegetation Indices (R)
         4. Derive Chlorophyll-a -- MERIS Maximum Chlorophyll Index (MCI) ( C2RCC in SNAP)
         5. TSM ( C2RCC)
         6. Resample using SRTM
   3. Radar
      1. ERS (10-30 m):
      2. Envisat(30m):
      3. ALOS (10m FBS, 30m PLR):
2. Landscape Classification:
   1. Base classification: 1986 (first date with full study area)
   2. Supervised Maximum Likelihood Classifier = most common technique used
   3. Results of PCA of bands in classifier has been found to improve accuracy
      1. Could also include vegetation indices in PCA as in Duncan
         1. Red, NIR, SWIR1, SWIR2, AWEIsh (Automated Water Extraction Index), MNDWI (Modified Normalised Difference Water Index), NDWI, NDVI, SAVI
      2. Brightness Index (Rasolofoharinoro *et al* 1998)
   4. Assessment/Validation:
      1. Compare to Google Earth Imagery
      2. Conservative removal of pixels like in Duncan
3. Quantify changes in regions of interest to:
   1. Seaward/landward mangrove boundaries
      1. Establish both boundaries at base period
         1. Landward from landscape classification
         2. Seaward from radar or from AWEI threshold if radar not available(?)
      2. Track throughout time
         1. If available, we could also use radar before/after big flooding events
            1. Flooding happens annually during the rainy season, but there are a few classified as disasters

Major flooding August 2002, June-July and again in September 2009

* 1. % cover
     1. Sum of area of pixels classified as mangrove throughout study period
     2. Calculation of change
  2. NDVI as proxy for productivity
     1. Temporal change across study sites
     2. If enough pixels, could look at landward/seaward sides separately
  3. Biomass:
     1. Radar:
        1. C Band
           1. Sensitive to canopy crown characteristics – number, density, size, leaf orientation, architecture, and heterogeneity
           2. VV: highest correlations with canopy parameters, tree height, and diameter
        2. L Band (ALOS-PALSAR)
           1. Sensitive to changing forest structures – more interaction with branches and trunks

HV: highest correlation with biomass

* 1. Total suspended matter (TSM)
     1. Where are trends towards gain or loss of sediment occurring?
  2. Chlorophyll-a (eutrophication)
     1. Landsat TM/OLI + Sentinel-2
  3. Canopy Height:
     1. SRTM
  4. Elevation
     1. Slope
  5. Flood Boundaries:
     1. C Band
        1. ERS-1 or 2
           1. VV polarization, incident angle 23 (Schumann 2010)
     2. L Band
        1. Low incidence angle
        2. Forecast amount of risk given sea level rise predictions

1. Compare results derived from sites based upon whether there is anthropogenic pressure and what type
   1. Will think more on statistical methods
2. Full blown vulnerability assessment (i.e, develop categories of risk etc.)
   1. Do we want to do this as part of the investigation into interactions?

Project Time-Line

|  |  |
| --- | --- |
| May 21 - 25 | * Goal: all optical data preprocessed and all indices derived, initial landscape classification * Continue pre-processing and developing methods * Selection of radar (what to resample all derivatives of optical data to) * Derive chlorophyll and TSM data * Initial landscape classification (which means all indices will be calculated) |
| May 28 – June 1 | * Goal: landscape classification done * Continue on landscape classification + assessment * % area change 🡪 look into regions of gain/loss (proximity to anthropogenic land cover changes, slope, elevation) * Begin processing of radar |
| June 4 – June 8 | * Quantify changes in indices (NDVI, chlorophyll, TSM) |
| June 11- June 15 |  |
| June 18-22 |  |
| June 25-29 | * Drafting Intro |
| July 2 -6 |  |
| July 9 -13 |  |
| July 16-20 |  |
| July 23-27 |  |
| July 30 – August 3 | * Results Done |
| August 6-10 |  |
| August 13-17 | * Discussion + Final Figures |
| August 20-24 |  |
| August 27-31 | Hand in Aug 30th |



