Mapping Forest Degradation with ALOS PALSAR: Case Studies from Ghana & Mexico

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Overview

• Forest degradation – Why monitor it & why is it so challenging?

• Methodological approach – Combining ground data & radar data

• Case study 1 – Mexico, Jalisco State
  • Degradation issues
  • Case study results

• Case study 2 – Ghana, Brong Ahafo Region/Western Region
  • Degradation issues
  • Case study results

• Summary
What is forest degradation?

**Deforestation** – Total clearance of forest

**Degradation** – Reduction in aboveground biomass from an area that remains forest after disturbance

- Gradual process
- Canopy cover remains
- Changes can be subtle
- E.g. Removal of large trees for timber (selective logging)
  OR
  Sub-canopy – removal of understory trees and replaced with crops (shade grown coffee/cocoa)
Why monitor forest degradation?

• Covers huge area
  • Potentially 2-10 x greater area than tropical deforestation annually (de Andrade et al. 2017 *Car Bal manage*.)

• So emissions from degradation could be substantial
  • ~70% of tropical forest emissions from degradation (Baccini, 2017, *Science*)
  • Degradation emissions twice that of deforestation (Mitchard, 2018, *Nature*)

• Furthermore, degradation often precedes deforestation

• **BUT** estimated poorly constrained

• Need to quantify - extent +
  - rate +
  - magnitude of emissions

• Not a purely academic effort –
  • Countries must report degradation emissions to UNFCCC
Challenges & Opportunities

Challenges
• Degradation can occur below the forest canopy
• Often occurs in regions with persistent cloud cover
  • So traditional optical satellites (e.g. Landsat) not suitable as can’t pass through cloud or forest canopy.
• Differentiating between intact forest canopy and degraded forest canopy challenging
• Degradation events are typically small (<1ha)
  • Optical satellites can detect changes in canopy cover, but big changes in canopy cover are related to heavy degradation

Opportunities
• Radar satellites can pass through forest canopy
  • Interacts with branches & stems - gives information about forest structure
• Radar backscatter signal correlated with biomass
  • Can be used to create biomass maps
  • BUT - Backscatter signal saturates at high biomass
Methodological Approach

Forest Plot Data

Census 1
Census 2
Census 3
Census 4

Calibrate
Calibrate
Calibrate
Calibrate

Alos Palsar/2
L-Band SAR Data

Change 1
Change 2
Change 3
Case Study 1 – Mexico, Jalisco

- Sierra Del Tigre
- 0.5ha
- Census 1 = 2017 (n = 10)
- Census 2 = 2018 (n = 10)
Degradation in Jalisco

Forest affected by:

- Forest fires
- Pests – bark beetles
- Agro-industry (E.g. Avocado)
Mexico - Results

Census 1 (2017) – Linear model has best fit

\[ HV = 0.038 \times (AGB + 14.606) \]

\[ R^2 = 0.68 \]
Mexico – AGB in 2016 & 2017

2016
Mexico – AGB Change & Degradation

Land area affected by -
Major Degradation – 0.3%
Moderate Degradation – 3.9%
Minor Degradation – 12.8%

Forest Change Class
- Major Degradation
- Moderate Degradation
- Minor Degradation
- No Change
- Regrowth

Major Degradation – loss >100 Mg ha⁻¹
Moderate Degradation – loss 50-100 Mg ha⁻¹
Minor Degradation – loss 10-50 Mg ha⁻¹

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Case Study 2 - Ghana

• 11 plots in Sierra del Tigre
  • 1 ha
  • Census 1 = 1996 (n=11)
  • Census 2 = 2007 (n=4)
  • Census 3 = 2010 (n=5)
  • Census 4 = 2018 (n=11)
Degradation in Ghana

Forest affected by:

- Selective logging
- Agricultural encroachment (E.g. Casava, banana)
- Agro-industry (E.g. Cocoa)
Ghana - Results

Change in Biomass

Biomass (Mg ha⁻¹)

Year


Plot
ASN_02  ASU_02  KKS_02  SUI_01
ASN_04  ASU_08  KKS_03  SUI_02
ASU_01  ASU_99  KKS_05
Ghana - AGB

Over 20 years

In some plots there is substantial AGB loss (>100 Mg ha\(^{-1}\))

Losses >60% of AGB in some cases

Mainly due to selective logging

<table>
<thead>
<tr>
<th>Plot</th>
<th>AGB 1996 (Mg ha(^{-1}))</th>
<th>AGB 2018 (Mg ha(^{-1}))</th>
<th>AGB Change (96-18)</th>
<th>% Change (96 – 18)</th>
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Ghana – AGB V’s HH/HV

No relationship between plot data & HH/HV backscatter
Apparent downward trend in HV – Very low predictive power to convert HV to AGB
Saturation of HH/HV backscatter signal in High AGB plots
Ghana – HH Change Signal

Also checked relationship between change in HH backscatter and change in AGB between 1996-2018 but not relationship
Summary

• We are able to detect forest degradation from losses in AGB in lower AGB forest

• Plots in degraded forest are invaluable – we need ground data to pick these processes up and understand them better

• BUT In high AGB forest even large changes are not detected. This is worrying

• Alos Palsar isn’t detecting major degradation events in high AGB forest

• Other instruments might detects major degradation (related to changes in canopy cover)
  • BUT they don’t map minor degradation or quantify the losses of AGB
  • We show Minor degradation covers much larger area than major degradation so we are potentially missing lots of emissions.