Multi-resolution quantification and driver assessment of hot spots of global forest disturbance

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Using PlanetScope data to quantify forest loss area: Peru prototype study

Results

- ~3 m reference data (PlanetScope)
- 80 5x5 km reference blocks
- Reference maps loss/no loss for 2017-2018
- Natural vs. anthropogenic forest loss estimates

Regression estimate: 5% SE of total loss area
Current NASA LCLUC-funded project on hotspots of global forest loss

- Global sample: 600 5x5km blocks, stratified random sample;
- Reference satellite data: PlanetScope (~3m) and Sentinel-2 (10m);
- Time interval: 2018 loss + loss drivers based on 3 years of imagery after disturbance.
Reference block mapping method

- One-two minimally cloudy PlanetScope images per month Dec. 2017 - Jan. 2019 + all available Sentinel-2 images for each 5x5 km block;

- Stacking all images (no cloud filtering);

- Supervised classification (decision trees) of each block separately: yes/no year 2018 forest loss;

- Iterative quality assessment and map improvement process;

- Point-based validation of resulting reference block maps (upon completion of all block maps);

- Visual interpretation of PlanetScope basemaps + Landsat + GoogleEarth to assign each reference loss pixel to pre-disturbance forest type and loss driver

*Image stack example, training data and classification result for a cloudy block in Malaysian Borneo: Dec. 2017 – Jan. 2019, 21 PlanetScope images + (not pictured) 30 Sentinel-2 images*
Drivers of forest loss: direct (proximate) drivers vs. underlying causes

“Proximate causes <direct drivers> are human activities or immediate actions at the local level … that originate from intended land use and directly impact forest cover”

- Infrastructure extension
- Agricultural expansion
- Wood extraction

“Underlying driving forces <causes> are fundamental social processes … that … either operate at the local level or have an indirect impact from the national or global level”

- Demographic factors
- Economic factors
- Technological factors
- Policy & Institutional factors
- Cultural factors
- Other factors: social trigger events, natural catastrophes, predisposing environmental conditions

Drivers of global forest loss: legend

**Initial forest cover**
- Natural forest
- Timber plantation
- Non-timber plantation
- Palm plantation

**Initial direct driver of loss**
- Direct human clearing
  - Mechanical (mechanized)
  - Mechanical (manual)
  - Flooding (dams)
  - Fire
- Natural disturbances:
  - Floods (natural, e.g. river meandering)
  - Insects
  - Hurricanes/Windfalls
  - Drought
  - Earthquakes/Land slides

**Land cover / land use 3 years after disturbance**
- Shifting cultivation
- Forestry/Clearcut
- Timber tree plantation
- Non-timber tree plantation
- Palm plantation
- Selective logging
- Cropland
- Pasture
- Settlement
- Commercial construction
- Road
- Mining
- Energy infrastructure
- Flooded (dams)
- Natural disturbances
- Human clearing with uncertain purpose

*Large rubber plantation, palm plantations intermixed with patches of natural forest Côte d’Ivoire, block 372*
Multiple loss drivers per sample block, Côte d'Ivoire

Very high resolution image (Maxar) 03/05/2021

2018 forest loss map based on PlanetScope and Sentinel 2 data
Fire in Sakha Republic, Russia

June 1, 2018

July 19, 2018

August 5, 2018

2018 forest loss
Industrial logging in Malaysia

March 18, 2018

April 8, 2018

July 19, 2018

August 15, 2018

November 18, 2018

December 29, 2018

January 3, 2019

2018 forest loss
Shifting cultivation in the DRC
Clearing for pasture in Argentina

January 3, 2018

May 2, 2018

June 5, 2018

September 3, 2018

2018 forest loss

Cows under canopy visible in VHR
Forestry in Novgorod region, Russia

June 1, 2018

July 17, 2018

September 10, 2018

2018 forest loss
Timber plantation management (thinning) in Brazil
Initial forest disturbance type

**Mechanical clearing: manual vs. mechanized**

**Criteria:** clearing size, presence of access roads for machinery + auxiliary information on land use practices

- **Example of manual clearing**
  - **Shifting cultivation, State of Amazonas, Brazil**
  - **Mechanical (manual) clearing**
  - % block area:
    - 0.1
    - 0.5
    - 1
    - 5
    - 10
    - 25

- **Example of mechanized clearing**
  - **Clearing for pasture, Paraguay**
  - **Mechanical (mechanized) clearing**
  - % block area:
    - 0.1
    - 0.5
    - 1
    - 5
    - 10
    - 25

**Natural disturbances, wildfires and flooding**

- **Example of fire**
  - Tomsk region, Russia
  - Sakha Republic, Russia

- **Example of insect damage**
  - Amazonas state, Venezuela

- **Example of windfalls/hurricanes**
Proximate cause (direct driver) of forest loss

Based on land use 3 years post-disturbance (end of 2021)

Example of conversion to cropland in Bolivia, identified from presence of active cropland in 2021 PlanetScope imagery.
Proximate cause (direct driver) of forest loss

Conversion of tree cover into other land uses

Natural tree cover to:
- Pasture
- Cropland
- Mining
- Reservoirs
- Energy infrastructure
- Non-timber plantations, including palm

Planted trees to:
- Residential and commercial construction, incl. roads

% forest loss from block area:
- 0.1
- 0.5
- 1
- 5
- 10
- 25
### Project timeline

<table>
<thead>
<tr>
<th>Project task</th>
<th>2021 Q1</th>
<th>2021 Q2</th>
<th>2021 Q3</th>
<th>2021 Q4</th>
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<tbody>
<tr>
<td>1. Finalize stratification and sample selection for baseline loss year (2018)</td>
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<td>2. Select, download and pre-process 2018 PlanetScope and Sentinel-2 data for all sampled blocks</td>
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<td>3. Classify forest loss from high resolution reference data for each sampled block</td>
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<td>4. Attribute direct drivers of forest loss and pre-disturbance forest type to mapped loss pixels</td>
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<td>5. Perform accuracy assessment of reference forest loss maps</td>
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<td>6. Perform statistical analysis, finalize findings, share data</td>
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<td>7. Write manuscript and submit it for publication in a peer-reviewed journal</td>
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**Project task status:**
- orange – completed
- green – in process
- blue – not yet started

*We are here*

**QA session – checking block mapping results**

**ESA Living Planet Symposium 2022**
Current LCLUC project augmentation: CSDA BlackSky evaluation

**Purpose:**
Employ BlackSky imagery to validate time-series of global change in **built-up area**, which is one of the drivers of global forest disturbance, and estimate the global built-up area in 2022-23.

**Study Objectives:**
- Estimate built-up land area from the sample of BlackSky and drivers of built-up area change;
- Estimate the accuracy of Landsat- and Planet-based maps.

**Study Design:**
Stratified random sample of 300 2.5 km blocks; stratification is based on existing Landsat-based built-up maps.

**Note from a first-time PI:**
It is exciting to task a satellite!
Thank you for your attention!

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