Forest structure and biomass mapping using the fusion of GEDI and TanDEM-X data

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Motivation of GEDI-TanDEM-X Data Fusion

- GEDI provides unprecedented lidar observations of ecosystem structure in tropical and temperate forests

- GEDI’s sampling nature limits the spatial resolution of the gridded products to >=1km.
- Finer resolution (<=1 ha) maps are needed
**Goal:** Development and application of methods for mapping forest structure, carbon stocks and their changes using observations from GEDI and TDX.

**Objectives:**

- **Mapping of Entire Pantropics for Height and Biomass**
  - Acquire and process TDX SAR data
  - Refine TDX/GEDI fusion algorithms
  - Derive maps of canopy height and biomass at 25 m, 100 m and 1 km

- **Forest Structure and Biomass Changes (2010-2025)**
  - Canopy structure changes
  - Biomass changes using Landsat Disturbance
  - Biomass changes using GTDX

- **Application of Small Area Estimation (SAE) to US forests**
  - Apply products and methods to produce data sets for temperate US and Hawaii
Background and Fusion Advantages

- **TanDEM-X (TDX) provides high-resolution interferometric coherence observations**
  - Capable of deriving topography and elements of canopy structure globally
  - 2010 - 2025 (complete global coverage every 3 years; potential for structure and biomass change study)

- **Limitations in height estimation from TDX**
  - Lack of penetration by X-band in vegetation
  - Single-polarization data at global scale
  - Prerequisite forest structure information improves height inversion from TDX coherence

- **Higher resolution and more accurate products than from either mission alone**
Current Fusion Framework

We continue algorithm development

GEDI Science Team Meeting, Oct.17-19, 2023
GEDI-TDX Data Fusion
Pantropical Study Areas

- Processed 30,000 TDX scenes covering 10,000,000 sq. km.
- Canopy Height and Biomass (gap-free)
  - 25 m, 100 m, 1 km
  - Mexico, Amazon Basin, French Guiana, Gabon
  - Uncertainty layers available
- Maps were submitted to DAAC:
- Entire pantropics and U.S. forests will be covered to map structure, biomass and their changes in support of MRV activities

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GEDI-TDX Data Fusion
Canopy Height (25 m)

Gabon, Mexico, French Guiana, Amazon Basin

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GEDI-TDX Data Fusion
Biomass (25 m)

- Gabon
- Mexico
- French Guiana
- Amazon Basin

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GEDI-TDX Data Fusion
Canopy Height Uncertainty (25 m)

Biomass Uncertainty (25 m)

The GHMB framework allows for explicit uncertainty estimates at pixel and aggregate scales.
Filling Up GEDI L4B Gaps

Amazon Basin

Biomass

Error

GTDX

GEDI L4B

R²=0.83
bias=3.1
RMSE=45.1 (32.3%)
## Filling Up GEDI L4B Gaps

<table>
<thead>
<tr>
<th>Study Sites</th>
<th>GEDI L4B Grids</th>
<th>GTDX 1 km Grid</th>
<th>Grids Filled</th>
<th>RMSE between GEDI L4B and GTDX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabon</td>
<td>81,985</td>
<td>215,199</td>
<td>133,214 (61.9%)</td>
<td>54.2 mg/ha</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,455,461</td>
<td>1,737,098</td>
<td>281,637 (16.2%)</td>
<td>28.5 mg/ha</td>
</tr>
<tr>
<td>French Guiana</td>
<td>38,837</td>
<td>67,004</td>
<td>28,167 (42.0%)</td>
<td>63.3 mg/ha</td>
</tr>
<tr>
<td>Amazon</td>
<td>4,025,716</td>
<td>5,762,814</td>
<td>1,737,098 (30.1%)</td>
<td>45.1 mg/ha</td>
</tr>
</tbody>
</table>
US Forest Sites (Canopy height)

Cascades, WA  Cherokee  Superior

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GEDI-TDX Data Fusion
Summary and Future Work

- Efficacy of GEDI and TDX data fusion in pantropical and US temperate canopy height and biomass estimation
- Demonstrative height and biomass products are delivered for the GEDI mission

**Future work**
- Expand the fusion framework to other pantropical countries (e.g., ASEAN countries: Indonesia, Vietnam, Fiji, Laos, Brunei Darussalam, Philippines, Cambodia, Malaysia, Myanmar, Singapore, Thailand), temperate US (Maryland, Washington) and Hawaii via CMS project
- Overcoming limitations data transfer pipeline within DLR and between DLR and UMD
- Incorporation of all GEDI data and TDX acquisitions from different epochs
  - Higher spatial resolutions, accuracies, and change are facilitated
Thank You!

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