Related mission updates: MOLI

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Japan Aerospace Exploration Agency (JAXA)
Introduction
MOLI’s feature
Products of MOLI
Preliminary results of airborne lidar experiment
Summary
What's MOLI?

MOLI = 森 forest
<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission instruments</td>
<td>○ LIDAR</td>
</tr>
<tr>
<td></td>
<td>Laser wavelength/ 1064nm</td>
</tr>
<tr>
<td></td>
<td><strong>Number of beam / 2 beam (Split from one beam)</strong></td>
</tr>
<tr>
<td></td>
<td>Beam power/ 20mJ each</td>
</tr>
<tr>
<td></td>
<td>Pulse width / less than 7ns</td>
</tr>
<tr>
<td></td>
<td>○ Imager</td>
</tr>
<tr>
<td></td>
<td>Band / Green; 550-630nm</td>
</tr>
<tr>
<td></td>
<td>Red; 630-740nm</td>
</tr>
<tr>
<td></td>
<td>NIR; 740-880nm</td>
</tr>
<tr>
<td></td>
<td>Spatial resolution / 5m</td>
</tr>
<tr>
<td></td>
<td>Swath / 1km</td>
</tr>
<tr>
<td>Size</td>
<td>1605 × 640 × 830 [mm]</td>
</tr>
<tr>
<td>Mass</td>
<td>About 300 kg</td>
</tr>
<tr>
<td>Power</td>
<td>Less than 400W</td>
</tr>
<tr>
<td>Operation</td>
<td>Over 1 year</td>
</tr>
<tr>
<td>Operational orbit</td>
<td>ISS orbit(Inclination : 51.6 deg) Non-synchronous at an altitude of 400km</td>
</tr>
</tbody>
</table>
Introduction

MOLI’s feature

Products of MOLI

Preliminary results of airborne lidar experiment

Summary
MOLI’s feature → Improvement of canopy high observation by “Multi footprint”

Canopy height = Distance between Signal start and last pulse

Expected effect by “Multi footprint”

Before: Correction using DEM data.

Estimate slope angle from altitude information of three footprints (observation points)
Introduction

MOLI’s feature

Products of MOLI

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Summary
<table>
<thead>
<tr>
<th>Product level</th>
<th>Product category</th>
<th>Products</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L1</strong> (Standard)</td>
<td>Lidar footprint products</td>
<td><strong>Waveforms (≧500Msps)</strong></td>
<td>including geolocation data Footprint Position Accuracy ≦ 15m</td>
</tr>
<tr>
<td></td>
<td>Imager product (1km swath)</td>
<td><strong>Image (Red, Green,</strong></td>
<td>geometrically corrected</td>
</tr>
<tr>
<td><strong>L2</strong> (Standard)</td>
<td>Lidar footprint products</td>
<td><strong>Canopy heights</strong></td>
<td>±3m(Canopy Height is under 15m) ±20% (Canopy Height is over 15m)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Forest biomass</strong></td>
<td>±25t/ha (Biomass density is under 100t/ha) ±25% (Biomass density is over 100t/ha)</td>
</tr>
</tbody>
</table>

※ Multi-footprint is expected to compensates each product up to 30 degrees of slope.
<table>
<thead>
<tr>
<th>Product level</th>
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</tr>
</thead>
</table>
| L3 (Research) | Integrated products with Lidar and imager (1km swath) | Canopy heights | Target  
[Canopy heights] ±~5m (Canopy Height is under 15m) ±~40% (Canopy Height is over 15m) |
|               | Forest biomass  | **Forest biomass** | [Forest biomass] ±~40 t/ha (Biomass density is under 100 t/ha) ±~40% (Biomass density is over 100 t/ha) |
| L4 (Research) | Wall-to-Wall map products (Integrated with GCOM-C/SGLI Data) | Canopy height map |  |
|               | Forest biomass map | **Forest biomass** | |

※ Multi-footprint is expected to compensates each product up to 30 degrees of slope.
Image of L1 product at GIS software
(Using airborne lidar experiment at Ise forest)
Introduction
MOLI’s feature
Products of MOLI
Preliminary results of airborne lidar experiment
Summary
Test configuration

We installed a multi-foot print lidar system on aircraft (King Air 200T) with CCD camera (Canon EOS 5D Mark III).

Overview of King Air 200T

① Lidar
② CCD camera
③ Reflection mirror
④ Window (AR Coating)
Preliminary results of airborne lidar experiment (2/5)

Data processing

- **LIDAR waveform**
  - Peak fitting
    - Signal Start
    - Last pulse
  - Calculate distance between airborne LIDAR to ground
  - POS_data
  - Calculate footprint geolocation position

- Calculate RH100
- Correction by estimated slope
  \[ \text{CanpyHeight} = RH100 - 0.382D \cdot \tan(slope) \]
- \( D = \) Footprint diameter

Estimated ground slope (Vertex normal method)
First, we compared estimated some footprint slope angle calculated by “Multi footprint” with DEM data.

The DEM was resampled to 25 m square and calculated slope according to the footprint diameter of MOLI.

From this result, we confirmed that the Multi footprint method can estimate roughly ground slope.
Verification (Muroto forest)

We validated the canopy height directly to verify the observation results at 3 sites. (Muroto, Gero)

Verification Site #1

- Error of before the correction: 4.94[m]
- Error of after the correction: 1.54[m]

Verification Site #2

- Error of before the correction: 4.30[m]
- Error of after the correction: 1.08[m]
Verification (Gero forest)

35°49'51.78"N 137°17'8.08"E

Verification Site #3

Error of before the correction : 4.63[m]
Error of after the correction : 1.18[m]

These results show validity of the observation method using Multi-footprint for the mission requirement in 3 verification sites.
Introduction
MOLI’s feature
Products of MOLI
System Design
Preliminary results of airborne lidar experiment
Summary
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- MOLI Target launch: 2022~ (Now Phase A to B)
- JAXA/EORC called for MOLI’s research proposals.
  (EO-RA2)

Future Work

- Method of slope angle calculation will improve.
- To evaluate the accuracy using Airborne Laser Scanning (ALS) data.
- To trial Integrated products with large footprint airborne Lidar data and imager (CCD camera) data.
Estimated ground slope result

Improve the estimated result?
Summary

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Prototype MOLI L3 product to airborne lidar experiment
(Algorithm under development)

Raw CCD camera data
Spatial resolution ~10cm

Adjust to MOLI Imager resolution (5m) and Smoothing local contrast

Integrated products with Lidar and imager data (40m mesh, RH 100)
Thank you so much for your kind attention