Modeling of LiDAR and Imager data on MOLI instruments

– Algorithms for MOLI along-track 1 km-width products –

Yoshito Sawada (NIES)
Contents

1. Outlines along-track products

2. Process Flow to make along-track products

3. Spatial Modeling Algorithms
   • Statistical Modeling
   • Machine Learning
Outlines along-track products

• Along-track 1km width (same as swath of MOLI imager)

• Expanding LiDAR data by spatial modeling

• Data Sets:
  1. Tree-height
     Canopy Height (RH100), RH90, RH80, RH70,..., RH10

  2. Above Ground Biomass

• Spatial Resolution:
  50(m) (TBD)

• Input for
  Producing L3 wall-to-wall tree-height / biomass maps with uncertainty at global scale
Process Flow to make along-track products

L2 Tree-height / AGB Products

L1B Imager Products

LiDAR Footprints

ISS Flight Path

Spatial Modeling
(Statistical Models, Machine-Learning,...)

• Terrains (Elevation, slope, curvature)
• Landcover type
• Forest type
• Other Environmental Parameters

1km Swath

1km-width products
(Tree-height / AGB)

ISS Flight Path

5m resolution/3 bands
Development of Spatial Modeling Algorithms

Objectives:
To develop methodologies of producing Tree-height maps by using LiDAR and Imager data

We are trying three approaches:
1. **Statistical Model** (FOTO, Proisy et al., 2012)
2. Convolutional Neural Network (Krizhevsky et al., 2012)
3. **Machine Learning Method** (SOR, Sawada et al. 2015)

Data used:
LiDAR: ICESat/GLAS (GLA01, GLA14)
Imager: RapidEye (1 and 2) 5m/5bands
         MODIS, GSMaP, SRTM (3)
Spatial Modeling of LiDAR and Imager

- RapidEye (5m/5 bands) → Vegetation Fraction, Spatial Frequency (Texture)
Making A Forest Mask

R/G/B = 4/5/2

R/G/B = Soil/Vegetation/Water

Enhance:
R  0.0~0.5
G  0.5~1.0
B  0.0~0.2
Preliminary Results by modified FOTO:
A Canopy-Height (RH100) Map with 100m resolution

• Need to validation (by Cross-Validation, canopy height from UAV measurements, ...
Machine Learning Method (Course Resolution)

Self-Organizing Relationships algorithm (SOR, Yamakawa et al., 1999, 2005) are used.

Tree Height by ICESat/GLAS + PCA score (PC1~12) → Training Dataset

Training Dataset were classified by SOM algorithm

To scale up by SOR algorithm

<table>
<thead>
<tr>
<th>PC1</th>
<th>annual average of NDVI and/or NDII</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC2</td>
<td>Land Surface Temperature (LST)</td>
</tr>
<tr>
<td>PC3</td>
<td>Rainfall</td>
</tr>
<tr>
<td>PC4</td>
<td>Slope, Plateau ratio</td>
</tr>
<tr>
<td>PC5,PC6</td>
<td>DEM, Seasonal Change of LST</td>
</tr>
<tr>
<td>PC7</td>
<td>DEM</td>
</tr>
<tr>
<td>PC8</td>
<td>Seasonal Change of rainfall</td>
</tr>
<tr>
<td>PC9</td>
<td>Seasonal Change of NDVI and/or NDII</td>
</tr>
<tr>
<td>PC10</td>
<td>Vegetation Dryness</td>
</tr>
</tbody>
</table>

Tree Height (m)
A map of estimated tree height (RH100)
Validation of estimated tree heights

- **Hdom** was calculated from data of ground surveys
- **RH100** was estimated by using only satellite data such as ICESat/GLAS, MODIS
- Error bars mean $1\sigma$
Summary

Our Objectives:
To develop methodologies of producing Tree-height maps by using LiDAR and Imager data

We are trying three approaches:
1. Statistical Model (FOTO, Proisy et al., 2012)
2. Convolutional Neural Network (Krizhevsky et al., 2012)
   • To validate results and to improve methodology are necessary
   • A Coarse Resolution (500m) Canopy height map was created successfully.
   • To apply to 5m resolution data

Future Plan:
• To produce above-ground biomass maps