Improvement of deforestation detection algorithm using in JJ-FAST

Manabu Watanabe
Tokyo denki university
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3. Summary
What is JJ-FAST?

- **“First SAR-based global”** early warning system for tropical forest
- **“Rainy season”** operation, not only dry season (PALSAR-2/ScanSAR)
- **“77 countries”** cover
- **“Every ~1.5 month”** monitoring
- **“Free access”** from PC or mobile phone

### JJ-FAST history

<table>
<thead>
<tr>
<th></th>
<th>JFY 2016</th>
<th>JFY 2017</th>
<th>JFY 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South America</td>
<td>11</td>
<td>12-3</td>
<td>4-6</td>
</tr>
<tr>
<td>South America</td>
<td>7-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South America</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa, SE-Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(77 countries)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deforestation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection algorithm</td>
<td>V0</td>
<td>V1</td>
<td>V2</td>
</tr>
<tr>
<td>V0 (Semi-automatic)</td>
<td></td>
<td>(Automatic)</td>
<td>(Automatic)</td>
</tr>
<tr>
<td><strong>Num. of data used</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td><strong>Polarization</strong></td>
<td>HV</td>
<td>HV, HH</td>
<td>HH/HV</td>
</tr>
<tr>
<td><strong>Minimum detection size</strong></td>
<td>5ha</td>
<td></td>
<td>3ha</td>
</tr>
</tbody>
</table>
Effectiveness of “L-band HH” polarization

**Place:** Brazilian Amazon (Sinop ~ Juina)

**Date:** Feb. 19 – March 2, 2018

**Rainy season in Brazil, 6 – 16 days** after PALSAR-2 ScanSAR observation

PALSAR-2 observation

Jan. 19, Feb. 2, 16 2018 for Path 126., Jan. 15, 28 Feb. 22 2018 for Path 125

**Num. of site visited**

12 site (**7 of 12**) were sites detected by **HH pol.**
Effectiveness of “L-band HH” polarization

After the field experiment in 12 sites in the rainy season,

✓ **2,600 ha** assigned as illegal deforestation.
✓ Four farms were fined.
✓ The fines total R $13.7 million (US$ 3,500,000!)
Number of deforestation detection are increasing

![Graph showing the increase in deforestation detection in Brazil.](image)

- **PALSAR (2010-11)**
- **Ver. 1 PALSAR2 (2017)**
- **Ver. 2 PALSAR2 (2018)**

6 times?

JJ-FAST
Two major problems
(Current deforestation detection algorithm in JJ-FAST)

1. Many un-detected deforestation sites left
2. Minimum detection size of 3ha is not enough

Site: Brazil/Porto Velho
Target term: Sept. 20-Nov. 10, 2018
Num. of data used: 11
Validation data: GLAD

<table>
<thead>
<tr>
<th>Detected polygons</th>
<th>Correct polygons</th>
<th>Validation polygons</th>
<th>User's acc.</th>
<th>Prod.'s acc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>332</td>
<td>265</td>
<td>705</td>
<td>79.8</td>
<td>37.6</td>
</tr>
</tbody>
</table>

GLAD: Global land analysis & discovery https://glad.umd.edu/
2 Improvement 1

Number of data used: 15 → 20
Smaller threshold level.

15 → 20 data

HV pol.

\[ \gamma_{HV}^0 (\text{dB}) \]

Date

2016/8/18 2017/9/22 2018/10/27

Ave.

3.0 dB? or 2.0 \( \sigma \)? → 2.5 dB? or 2.0 \( \sigma \)?

HH pol.

(HH/HV ratio)

\[ \gamma_{HH}^0 (\text{dB}) \]

Date

2016/8/18 2017/9/22 2018/10/27

Max.

2.0 dB? or 2.0 \( \sigma \)? → 1.0 dB? or 2.0 \( \sigma \)?

(or 3.0 \( \sigma \)?) (or 2.5 \( \sigma \)?)

Number of data used: 15 → 20

Smaller threshold level.
## Accuracy estimation

| Place          | Pucallpa/Peru          | Target term     | Sept. 27-Nov. 8, 2018 | Num. of data used | 15, 20 | Validation data | GLAD & visual inspection |

### Current algorithm

<table>
<thead>
<tr>
<th>Pol.</th>
<th>Threshold values</th>
<th>15data</th>
<th>20data</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dB</td>
<td>σ</td>
<td>Detected polygons</td>
<td>Correct polygons</td>
<td>user's acc.</td>
<td>Detected polygons</td>
<td>Correct polygons</td>
</tr>
<tr>
<td>All</td>
<td>129</td>
<td>110</td>
<td>85</td>
<td>110</td>
<td>99</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>HV_mean</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>nan</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HH</td>
<td>2</td>
<td>2</td>
<td>120</td>
<td>103</td>
<td>86</td>
<td>103</td>
<td>92</td>
</tr>
<tr>
<td>HH/HV</td>
<td>2</td>
<td>3</td>
<td>15</td>
<td>12</td>
<td>80</td>
<td>13</td>
<td>12</td>
</tr>
</tbody>
</table>

### Suggested algorithm

<table>
<thead>
<tr>
<th>Pol.</th>
<th>Threshold values</th>
<th>15data</th>
<th>20data</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dB</td>
<td>σ</td>
<td>Detected polygons</td>
<td>Correct polygons</td>
<td>user's acc.</td>
<td>Detected polygons</td>
<td>Correct polygons</td>
</tr>
<tr>
<td>All</td>
<td>273</td>
<td>209</td>
<td>77</td>
<td>232</td>
<td>197</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>All (Visual inspection)</td>
<td></td>
<td></td>
<td></td>
<td>232</td>
<td>211</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>HV_mean</td>
<td>2.5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>nan</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HH</td>
<td>1</td>
<td>2</td>
<td>254</td>
<td>194</td>
<td>76</td>
<td>211</td>
<td>181</td>
</tr>
<tr>
<td>HH/HV</td>
<td>1</td>
<td>2.5</td>
<td>35</td>
<td>25</td>
<td>71</td>
<td>35</td>
<td>26</td>
</tr>
</tbody>
</table>

**User’s accuracies**: 85% → 85%, Correct polygons 1.8 times
2. Improvement 1

Number of data used: 15 → 20
Smaller threshold level.

**User’s accuracies**: Almost same
**Correct polygons**: 1.3~2 times

<table>
<thead>
<tr>
<th>Sites</th>
<th>Num. of data used</th>
<th>User’s accuracies</th>
<th>Correct polygons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peru /West Pucallpa</td>
<td>15 → 20</td>
<td>85 → 85(91)</td>
<td>110 → 197 (1.8)</td>
</tr>
<tr>
<td>Brazil/ Porto Velho</td>
<td>11 → 11</td>
<td>80 → 71(77)</td>
<td>265 → 536 (2.0)</td>
</tr>
<tr>
<td>Brazil/ Sinop 1</td>
<td>15 → 20</td>
<td>65 → 61(95)</td>
<td>68 → 88 (1.3)</td>
</tr>
<tr>
<td>Brazil/ Sinop 2</td>
<td>15 → 20</td>
<td>59 → 55(86)</td>
<td>103 → 147 (1.4)</td>
</tr>
<tr>
<td>Brazil/ Sinop 3</td>
<td>15 → 20</td>
<td>54 → 59(70)</td>
<td>91 → 144 (1.6)</td>
</tr>
<tr>
<td>Cambodia</td>
<td>15 → 20</td>
<td>37 → 45(73)</td>
<td>33 → 42 (1.3)</td>
</tr>
<tr>
<td>Africa/Mozambique</td>
<td>15 → 15</td>
<td>21 → 17(100)</td>
<td>11 → 14 (1.3)</td>
</tr>
</tbody>
</table>

() Estimated by visual inspection
() Increase rate
Forest fire detection in dry forest with JJ-FAST

Place: Mozambique
Target term: Aug. 13-Nov. 5, 2018

Place: South Africa
Target term: Nov. 11-Dec. 23, 2018

Severely burned areas can be detected by JJ-FAST algorithm.
2. Improvement 2

Image resolution : 50m $\rightarrow$ 25m

Target term : Sept. 27, 2018~Nov. 8
Place : Peru (West Pucallpa)
Num. of data used : 26
Validation data : GLAD
Processing : Specan (25m, 50m),
              Full aperture (25m)
              (Current: Specan 50m)
## Accuracy estimation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>15data</td>
<td>Specan</td>
<td>50m</td>
<td>All</td>
<td>196</td>
<td>161</td>
<td>82</td>
<td>354</td>
<td>247</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HV</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>7</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HH</td>
<td>173</td>
<td>146</td>
<td>84</td>
<td>286</td>
<td>210</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HH/HV</td>
<td>39</td>
<td>30</td>
<td>77</td>
<td>102</td>
<td>70</td>
<td>69</td>
</tr>
<tr>
<td>Suggested</td>
<td>26data</td>
<td>Specan</td>
<td>25m</td>
<td>All</td>
<td>445</td>
<td>375</td>
<td>84</td>
<td>707</td>
<td>563</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HV</td>
<td>2</td>
<td>1</td>
<td>50</td>
<td>7</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HH</td>
<td>419</td>
<td>358</td>
<td>85</td>
<td>648</td>
<td>527</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HH/HV</td>
<td>70</td>
<td>59</td>
<td>84</td>
<td>156</td>
<td>121</td>
<td>78</td>
</tr>
</tbody>
</table>

Specan(25m) + 26 data

- **Correct polygons**: More than 2 times for 3ha
- **More than 3** times for 1ha
- **User’s accuracies**: almost same (1ha, 3ha)
Example for ~1ha detection

- Specan (50m)
- Specan (25m)
- Full Aperture (25m)
- GLAD
2 Improvement 3

Process unit: A segmented polygon → A pixel

Place: Pucallpa/Peru
Target term: Oct. 21-Dec. 2, 2017
Num. of data used: 6

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Process unit</th>
<th>Num. of polygons Detected</th>
<th>Num. of polygons correct</th>
<th>user's acc. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JJ–FAST</td>
<td>Polygon</td>
<td>51</td>
<td>21</td>
<td>41.2</td>
</tr>
<tr>
<td></td>
<td>Pixel</td>
<td>447</td>
<td>83</td>
<td>18.6</td>
</tr>
<tr>
<td>Dr. Nagatani</td>
<td></td>
<td>252</td>
<td>68</td>
<td>27.0</td>
</tr>
</tbody>
</table>

Minimum detection
Size 1 ha

Under developing
3. Summary

1. JJ–FAST current status
   ✓ Effectiveness of “L-band HH” polarization
   ✓ Deforestation detection number are increasing from PALSAR.
   ✓ Two major problems
     1. Many un-detected deforestation sites left
     2. Minimum detection size of 3ha is not enough

2. Improvement of deforestation detection algorithm
   a. Number of data used: 15 → 20, Smaller threshold level.
      Correct polygons: 1.3~2 times
      User’s accuracies: Almost same
   b. Image resolution: 50m → 25m
      Correct polygons: More than 2 times for 3ha
                       More than 3 times for 1ha
      User’s accuracies: Almost same (1ha, 3ha)
   c. Process unit: A segmented polygon → A pixel
      Under developing
ACKNOWLEDGMENT

This research was supported by the research budget of JAXA. The research results will be used for the JJ-FAST system funded by Japan International Cooperation Agency (JICA) and JAXA. We also express our gratitude to Dr. Edson E. Sano and Dr. Daniel Freitas for supporting our field experiment and giving us helpful advices and fruitful information.
以下の2ケースも正解とする

ケース1）検証データで、期首の2か月前までに伐採があった場合

対象期間

2か月

期首2か月前

期首

期末

ケース2）検出された場所が、検証データで、3ha以下で検出されたポリゴンとオーバーラップした場合

JJ-FAST検出(3.5ha)

GLAD検出(1.5ha)