Improvement of MODIS snow products for Arctic lake ice

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MODIS L1B (MOD/MYD02HKM), and MODIS level 2 snow (MOD/MYD10) and LST (MOD/MYD11) products were obtained from NASA’s Earth Observing System Data and Information System (EOSDIS) via REVERB website as following:
- http://reverb.echo.nasa.gov/reverb/

Garibaldi Lake, BC

Photo Credit: Miranda Lewis
To evaluate and refine the existing MODIS 500-m snow products from Aqua and Terra for lake ice monitoring during freeze-up and break-up periods over large lakes.

Two large Canadian lakes (Great Bear Lake and Great Slave Lake) and two Russian lakes (Lake Ladoga and Lake Onega) were selected for algorithm testing and refinement.
Great Bear Lake and Great Slave Lake have surface areas (average depths) of $31.3 \times 10^3$ km² (76 m) and $28.6 \times 10^3$ km² (88 m), respectively. Lake Ladoga and Lake Onega have surface areas (average depths) of $17.7 \times 10^3$ km² (47 m) and $9.8 \times 10^3$ km² (27.3 m), respectively.
Criteria of the existing snow products’ algorithm were refined for improved detection of lake ice with the NSDI set to greater than 0.4, with near-infrared reflectance (Band 2) greater than 0.025, Band 4 reflectance larger than 0.095, and Band 7 reflectance less than or equal to 0.05.
Results (Great Bear Lake)

Current MYD/ MOD10 L2

RGB image

Refined MYD/ MOD10 L2
Results (Great Slave Lake)
Results (Lake Ladoga)
Results (Lake Onega)

Current MYD/ MOD10 _L2

RGB image

Refined MYD/ MOD10 _L2
Results

- *Error matrices*

- A detailed evaluation of the current and refined versions of the MODIS snow products was performed from a sample of images (n) acquired during 2003-2012 ice seasons over Great Bear Lake (GBL) and Great Slave Lake (GSL), in Canada as well as Lake Ladoga (LLG) and Lake Onega (LOG) in Russia.

- The overall accuracies obtained with the refined MODIS products range from 75-94% (n=11) for GBL and 82-93% (n=14) for GSL as well as 83-99% (n=24) for LLG and 87-99% (n=25) for LOG.
## Results (Error matrices)

<table>
<thead>
<tr>
<th></th>
<th>Current MYD/MOD10_L2</th>
<th>Refined MYD/MOD10_L2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GSL (2007-154)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open water (user defined)</td>
<td>13855 103</td>
<td>34097 0</td>
</tr>
<tr>
<td>Lake Ice</td>
<td>13224 15096</td>
<td>30118 42635</td>
</tr>
<tr>
<td>κ/OA</td>
<td>0.42/65.0</td>
<td>0.47/71.8</td>
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<tr>
<td><strong>LLG (2009-092)</strong></td>
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<tr>
<td>Open water (user defined)</td>
<td>16333 14268</td>
<td>29751 0</td>
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<tr>
<td>Lake Ice</td>
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<td>7385 47942</td>
</tr>
<tr>
<td>κ/OA</td>
<td>0.30/65.0</td>
<td>0.82/91.3</td>
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<tr>
<td><strong>LOG (2004-122)</strong></td>
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<tr>
<td>Open water (user defined)</td>
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<td>5376 0</td>
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<td>Lake Ice</td>
<td>9334 29544</td>
<td>3599 36246</td>
</tr>
<tr>
<td>κ/OA</td>
<td>0.42/78.2</td>
<td>0.71/92.04</td>
</tr>
</tbody>
</table>
Summary

- This is the first time that MODIS snow products (version 5) were evaluated for lake ice cover.

- The refined algorithm presents an improvement in the accuracy of the MODIS snow products by 20-30% overall.

- The refined algorithm can distinguish better lake ice (or thinner ice-cover) from cloud cover during ice seasons.

- There are issues for current MODIS snow products to discriminate cloud cover (or open water) from snow (or lake ice) in the land/inland water mask (MOD03/MYD03) and in the cloud mask (MOD35_L2/MYD35_L2) products.
Thank you very much/Merci beaucoup