GLOBAL SURFACE TYPE PRODUCTS FROM VIIRS

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Land–atmosphere-society processes under global change (Suni et al. 2015)
Multi-Decade Efforts to Characterize the Earth's Surface Cover

AVHRR Series

IGBP DIS UMD

MODIS Land Cover (Annual, 2000 - 2017)

VIIRS Surface Type (Annual, 2012 - )

VIIRS

MODIS

EU CCI Land Cover (Annual, 1990 - 2015)

Other satellites

SPOT VEGETATION

MERIS

Sentinel-3

(Matthews 1983)
Inheritance and Continuity of VIIRS

### Comparison of 22-band NPOESS VIIRS with MODIS bands

<table>
<thead>
<tr>
<th>Band number</th>
<th>NPOESS VIIRS</th>
<th>MODIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central wavelength (µm)</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>0.412</td>
<td>8</td>
</tr>
<tr>
<td>M2</td>
<td>0.445</td>
<td>9</td>
</tr>
<tr>
<td>M3 (blue)</td>
<td>0.488</td>
<td>3 (blue)</td>
</tr>
<tr>
<td>M4 (green)</td>
<td>0.555</td>
<td>4 (green)</td>
</tr>
<tr>
<td>M5 (red)</td>
<td>0.672</td>
<td>1 (red)</td>
</tr>
<tr>
<td>M6</td>
<td>0.746</td>
<td>15</td>
</tr>
</tbody>
</table>

### S-NPP

<table>
<thead>
<tr>
<th>Year</th>
<th>JPSS-1/NOAA-20</th>
<th>JPSS-2</th>
<th>JPSS-3</th>
<th>JPSS-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td></td>
<td>2017</td>
<td>2021</td>
<td>2026</td>
</tr>
</tbody>
</table>

### Table:

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength (µm)</th>
<th>Equivalent Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>1.2013</td>
<td>No equivalent width</td>
</tr>
<tr>
<td>M16</td>
<td>0.7</td>
<td>No equivalent width</td>
</tr>
<tr>
<td>DNB</td>
<td>0.7</td>
<td>No equivalent width</td>
</tr>
<tr>
<td>I1</td>
<td>0.64</td>
<td>1 (red)</td>
</tr>
<tr>
<td>I2</td>
<td>0.865</td>
<td>2</td>
</tr>
<tr>
<td>I3</td>
<td>1.61</td>
<td>6</td>
</tr>
<tr>
<td>I4</td>
<td>3.74</td>
<td>22</td>
</tr>
<tr>
<td>I5</td>
<td>11.45</td>
<td>31</td>
</tr>
</tbody>
</table>

### Diagram:

- MODIS 1 km Global Coverage
- Modis 2330 km Swath

- JPSS-2 (2021)
- JPSS-3 (2026)
- JPSS-4 (2031)
VIIRS Surface Type Mapping Approach

Follows best practice developed for MODIS/AVHRR

• Preprocessing to reduce noises and improve data consistency
  • Monthly composites to reduce cloud/shadow
  • Annual metrics to describe seasonal/annual dynamics

• Robust machine learning algorithms
  • Decision trees
  • Support vector machines

• Globally distributed training/validation data

• Post-processing necessary


New Compositing Approach Adaptive to Different Surface Cover Conditions

Globally Distributed Training Data

- Some inherited from previous studies
  - UMD 1km (Hansen et al. 2000)
  - MODIS C5 (Friedl et al. 2010)
- Most samples collected recently
Available VIIRS Surface Type Products

Available from
### Classification Schemes

<table>
<thead>
<tr>
<th>IGBP class number</th>
<th>IGBP class name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evergreen needleleaf forests</td>
</tr>
<tr>
<td>2</td>
<td>Evergreen broadleaf forests</td>
</tr>
<tr>
<td>3</td>
<td>Deciduous needleleaf forests</td>
</tr>
<tr>
<td>4</td>
<td>Deciduous broadleaf forest</td>
</tr>
<tr>
<td>5</td>
<td>Mixed forests</td>
</tr>
<tr>
<td>6</td>
<td>Closed shrublands</td>
</tr>
<tr>
<td>7</td>
<td>Open shrublands</td>
</tr>
<tr>
<td>8</td>
<td>Woody savannas</td>
</tr>
<tr>
<td>9</td>
<td>Savannas</td>
</tr>
<tr>
<td>10</td>
<td>Grasslands</td>
</tr>
<tr>
<td>11</td>
<td>Permanent wetlands</td>
</tr>
<tr>
<td>12</td>
<td>Croplands</td>
</tr>
<tr>
<td>13</td>
<td>Urban and built-up lands</td>
</tr>
<tr>
<td>14</td>
<td>Cropland/natural vegetation mosaics</td>
</tr>
<tr>
<td>15</td>
<td>Snow and ice</td>
</tr>
<tr>
<td>16</td>
<td>Barren</td>
</tr>
<tr>
<td>17</td>
<td>Water bodies</td>
</tr>
</tbody>
</table>

**17 IGBP Classes**

**17 IGBP Classes + 3 Tundra Classes (for NCEP Modeling)**

**Biome Types (LAI Modeling)**
Product Assessment

MODIS C5 2005 Land Cover (Friedl et al. 2010): 74.8% (Cross-validation)

(Sulla-Menashe et al. 2019)

Fig. 6. The overall cross-validated accuracies for the LCCS and IGBP schemes are shown for the period between 2001 and 2016. The water class is not included in the overall accuracy statistics.
Large Scale Sub-Annual Changes Not Captured in Annual Products

- Green vegetation canopy cover/phenology
- Seasonal snow/ice cover
- Short term water presence over land:
  - Flooding

Fresh snow cover has the highest albedo of any natural surface, reflecting about 90 percent of downwelling shortwave radiation (sunlight). In contrast, the open ocean reflects less than 20 percent (Key et al., 2001)
Interactive Multisensor Snow and Ice Mapping System (IMS)

IMS Daily Northern Hemisphere Snow and Ice Analysis at 1 km, 4 km, and 24 km Resolutions, Version 1

This data set provides maps of snow cover and sea ice for the Northern Hemisphere from February 1997 to the present from the National Ice Center's Interactive Multisensor Snow and Ice Mapping System (IMS). It is derived from a variety of data products including satellite imagery and in situ data. The data are provided in ASCII text and GeoTIFF formats in three different resolutions: 1 km, 4 km, and 24 km.

Note: The IMS product is considered an operational product; however, NIC, who creates this product, does not guarantee availability or timely delivery of data via the NIC Web server. NSIDC, as the data archive, does not guarantee availability of this product via the NSIDC Web server. These servers should not be used to support operational observation, forecasting, emergency, or disaster mitigation operations, either public or private. Users with real-time operational needs should visit the NIC Web site and contact the National Ice Center Liaison to request access to their operational server.
Large Changes Snow/Ice Cover in Northern Hemisphere

Legend
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forest
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-Up
- Cropland/Natural Vegetation Mosaic
- Snow and Ice
- Barren or Sparsely Vegetated
- Water Bodies

2019/01/05

2019/02/05

2019/04/05

2019/08/05
Daily Snow/Ice Cover Change in 2019

![Graph showing daily snow/ice cover change in 2019 with area in million square km on the y-axis and day of year on the x-axis. The graph compares snow/ice free land and snow/ice covered land.]
VIIRS Floodwater Fraction Map Products:

Five-Day Composite:
This is a composite flood extent that saves the max water fraction percentages over a moving window of 5 days to improve obscuration due to cloud cover. For example, if a pixel is covered in clouds 4 out of the 5 days, the one day that it was visible will be the value that saves to this final merged flood extent. Values are made binary so that red = detected flooding and everything else is null. The threshold used for this product to indicate flooding is 30% floodwater fraction, meaning that if a pixel was more than 30% covered in water at any time over the 5-day moving window, it is classified as flooded.

Not Flooded
At Least Partially Flooded
(>40% Flood Water Fraction)
Summary and Future Outlook

• VIIRS is an operational instrument providing MODIS quality global observations

• VIIRS global surface type products have been generated annually since 2012
  • All products have overall accuracies > 75%
  • Available from ftp://ftp.star.nesdis.noaa.gov/pub/smcd/JPSS/VIIRS-AST
Daily Global Surface Type Products Needed to Capture Large Scale Sub-Annual Dynamics

• Sub-annual changes driven by many processes
  • Green vegetation canopy cover/phenology
  • Seasonal snow/ice cover
  • Flooding
  • Other surface inundation dynamics (e.g., wetlands)
  • Grass/shrub fires
  • Multi-cropping
  • .........
  • Conventional land cover changes

• Increasingly more products are being developed to capture these change processes
  • Can be integrated into a single unified product suite -- daily surface type product suite
Thank You!

Long term funding support

STAR JPSS

Some VIIRS data provided by

Suomi NPP - Land Science Investigator-led Processing System

Contact for follow-up discussions
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