Monitoring Surface Type Changes Toward a Daily Surface Type Product

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OUTLINE

- Needs for satellite surface type data products
- Current satellite surface type data products
- S-NPP VIIRS Surface Type EDR Status
- Monitoring Surface Type Changes toward a VIIRS Daily Surface Type Change product
- Summary
Surface Type Impacts on NWP Performance

From Chris Hain
Old Satellite Surface Type Data Products

EDC IGBP 1km Global Classification

Based on 1992-1993 AVHRR Data

UMD 1km Global Classification

Legend:
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forests
- Water
- Grassland
- Cropland
- Urban and Built-up
- Water
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forests
- Woodland
- Wooded Grassland
- Closed Shrubland
- Open Shrubland
- Permaner
- Savannas
- Grassland

Legend:
- Evergreen Needleleaf For.
- Evergreen Broadleaf For.
- Deciduous Needleleaf For.
- Deciduous Broadleaf For.
- Mixed Forests
- Closed Shrublands
- Open Shrubs
MODIS Surface Type Data Products

MODIS Collection 5 Land Cover Product
VIIRS Surface Type Products Overview

- Surface Type products include Surface Type EDR (ST EDR) and Global Annual Surface Type Maps (AST)
- Global Annual Surface Type Maps provide static labels for each 1km land grid for NWP models and other users
- Surface Type EDR is to provide current day surface type status for LST EDR in IDPS and other users including NWP
- AST is generated using Decision Tree or Support Vector Machine algorithm based on global training polygons database and dozens of classification metrics that are computed from daily surface reflectance and brightness temperature observations from VIIRS
VIIRS Gridded Annual Surface Type (AST) map using 2016 VIIRS data was delivered in 2016

While the overall classification accuracy (~78%) of the new map is similar to 2015 delivery, some accuracy improvements are observed, such as urban/built-up lands. The images shown left demonstrate an examples of the newly labeled oil drilling land in Texas, US, which is considered built-up lands, where the old version presented wrong type labels. Google images verified the mapping results.
New global surface type map in biome classification types to support LAI/FPAR and other studies.

The biome scheme surface type map was generated using an IGBP-biome LUT plus a second SVM classification to further separate cereal crops and broadleaf crops. Validation in progress. The two images shown left is an example of crop mapping result in IGBP and biome legends. Cereal and broadleaf croplands are further separated in biome ST map.
**VIIRS Annual Surface Type Production**

**VIIRS surface reflectance data (swath)**

- **Band number (comparable in MODIS)**
  - M1 (8)
  - M2 (9)
  - M3 (3 or 10)
  - M4 (4 or 12)
  - I1 (1)
  - M5 (13 or 14)
  - M6 (15)
  - I2 (2)
  - M7 (16 or 2)
  - DNB
  - M8 (5)
  - M9 (26)
  - **M10 (6)**
  - I3 (6)
  - M11 (7)
  - M12 (20)
  - I4 (20)
  - M13 (21 or 22)
  - M14 (29)
  - M15 (31)
  - I5 (31 or 32)
  - M16 (32)

- **VIIRS wavelength (µm):**
  - 0.412
  - 0.445
  - 0.488
  - 0.555
  - 0.640
  - 0.672
  - 0.746
  - 0.865
  - 0.865
  - 0.7
  - 1.24
  - 1.38
  - 1.61
  - 1.61
  - 2.25
  - 3.70
  - 3.74
  - 4.05
  - 8.55
  - 10.76
  - 11.45
  - 12.01

**Gridding**

- **Gridded surface reflectance data**

**Compositing**

- **Global composite surface reflectance (daily)**

**Compositing**

- **Global composite surface reflectance (monthly)**

**Metrics generation**

- **Global annual metrics**

**Training samples**

- **Support vector machines (SVM) Decision Tree**

**Post-processing**

- **Ancillary data**

- **Global surface type classification map**

**Ancillary data source**

- Land cover agreement map
- Urban mask
- Land/water mask
- Ecoregion map
- Crop probability map
- Google Map/Earth data
- Local Landsat data

**Metrics**

- Maximum NDVI value
- Minimum NDVI value of 8 greenest months
- Mean NDVI value of 8 greenest months
- Amplitude of NDVI over 8 greenest months
- Mean NDVI value of 4 warmest months
- NDVI value of warmest month
- Maximum band x value of 8 greenest months
- Minimum band x value of 8 greenest months
- Mean band x value of 8 greenest months
- Amplitude of band x value over 8 greenest months
- Band x value from month of maximum NDVI
- Mean band x value of 4 warmest months
- Band x value of warmest month.
## Error matrix of estimated area proportions (in percentage)

Overall accuracy is \(77.9 \pm 0.6\)%.

Note: the error matrix was created using area proportion of each class in the classification map, which could avoid estimation bias observed in simple pixel count based error matrices, in which the estimated overall classification accuracy is 74.5%.

By incorporating new urban mask, the producer’s accuracy (omission) for urban/built-up increased approximately 23.5%.

### Reference

<table>
<thead>
<tr>
<th>Map</th>
<th>User’s accuracy (%)</th>
<th>Producer’s accuracy (%)</th>
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</thead>
<tbody>
<tr>
<td>Total</td>
<td>(0.0261)</td>
<td>(0.092)</td>
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**STAR-JPSS Annual Science Team Meeting, College Park, MD, August 14-18, 2017**
Current IDPS Surface Type EDR Monitor


Suomi NPP VIIRS Global Surface Type Composite (ST-EDR)
5 Aug 2016

Suomi NPP VIIRS Global Snow/Ice Composite (ST-EDR)
5 Aug 2016

Suomi NPP VIIRS Global Active Fire Composite (ST-EDR)
5 Aug 2016

Suomi NPP VIIRS Global Vegetation Fraction (ST-EDR)
5 Aug 2016
After IDPS is transitioned to NOAA NDE system:

- VIIRS Annual Surface Type (AST) is generated offline by NESDIS STAR and UMD
- Surface Type EDR should/could be replaced as a **Daily Surface Type** product that contains current day information on burned areas and flooded areas in addition to active fire and snow cover to meet user needs
- Generation of the Daily Surface Type product would need an algorithm for detecting surface type changes
Surface Type Change Detection Algorithm

- Typical change vectors in the brightness–greenness space.
- The small circles show the typical signatures at Time 1 (T1) and Time 2 (T2) respectively.

Change Vector Algorithm (Zhan et al, IJRS, 2000)
Burned areas of the Rocky fires in July 2015 detected with the change vector method using S-NPP VIIRS images shown in the left figure and verified with MTBS data (right).

Spectral signatures of the burned areas in VIIRS M11-M7 space before (green) and after (red) the Rocky Creek, CA wildfires from July 29th to August 14th, 2015.
Surface Type Change Detection Results

Flooded Areas by Severe Storms in Arkansas in late April of 2017

Flooded areas (in blue color) detected with Suomi-NPP VIIRS images acquired before and after the severe storms over Arkansas in late April of 2017

Spectral signatures of the flooded areas in VIIRS I1-I3 space before (green) and after (blue) the Arkansas flooding event.
Surface Type Change Detection Results

Flooded Areas in Hungary by Record Flood in Early June 2013

Flooded areas detected with rule-based classification of change vectors between May 19 and June 18, 2013 for the record flood in Hungary.
Rapid surface changes can be caused by many events:
- Flooding, severe drought, snow storm, fire, large scale deforestation

These changes cannot be captured by the annual GST product

A suite of daily products or change indicator products are needed to capture such rapid changes
- Can build on the original ST-EDR concept
- Where available, use existing VIIRS products (e.g., Snow, Fire, vegetation cover)
  - Better temporal consistency needed to allow change detection
  - For fire, post fire surface type information needs to be derived
- Some changes require new products, e.g.:
  - Daily surface inundation needed to capture surface changes due to flooding and flood receding
  - Sub-annual tree cover data needed to capture deforestation
**SUMMARY**

- **Global Annual Surface Type** map from JPSS has been generated offline at STAR for users annually.

- Daily surface type changes with fire and snow information was provided by **Surface Type EDR** in granule files.

- After JPSS land data product generation is transitioned to NOAA NDE environment, a global gridded **daily surface type product** is needed to provide dynamic daily surface type information.

- Using change vector algorithm, **flooded** or **burned** areas could be effectively detected for the daily surface type product in addition to the active **fire** and **snow** covered areas already available from other VIIRS data products.
THANKS!