Monitoring Surface Type Changes Toward a Daily Surface Type Product

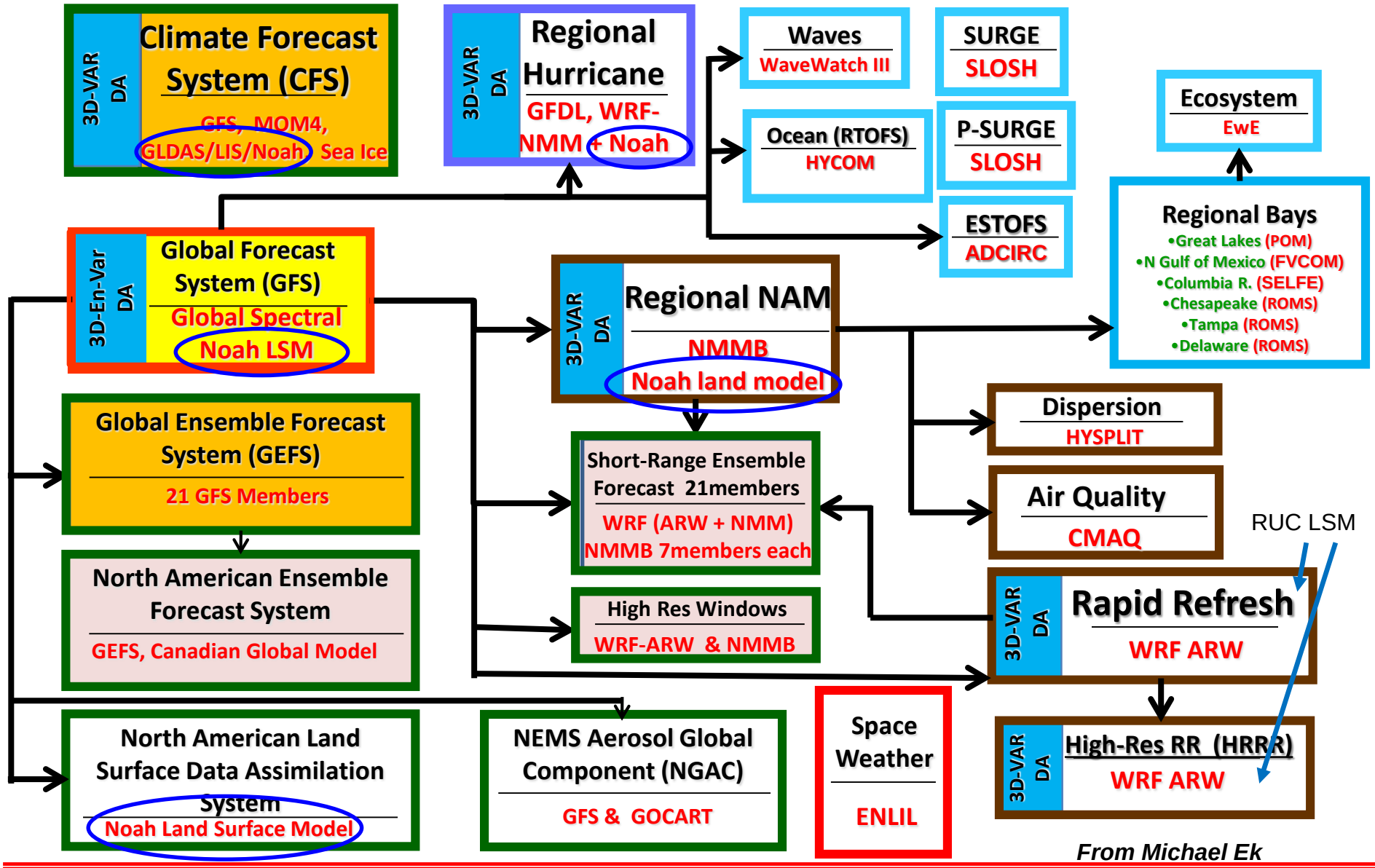
Xiwu Zhan[1], Rui Zhang[2], **Panshi Wang**[2], Chengquan Huang[2], Ivan Csiszar[1], Lihang Zhou[1], Fuzhong Weng[1]

[1] NOAA NESDIS Center for Satellite Applications and Research
[2] UMD-ESSIC-CICS/UMD-Department of Geography

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

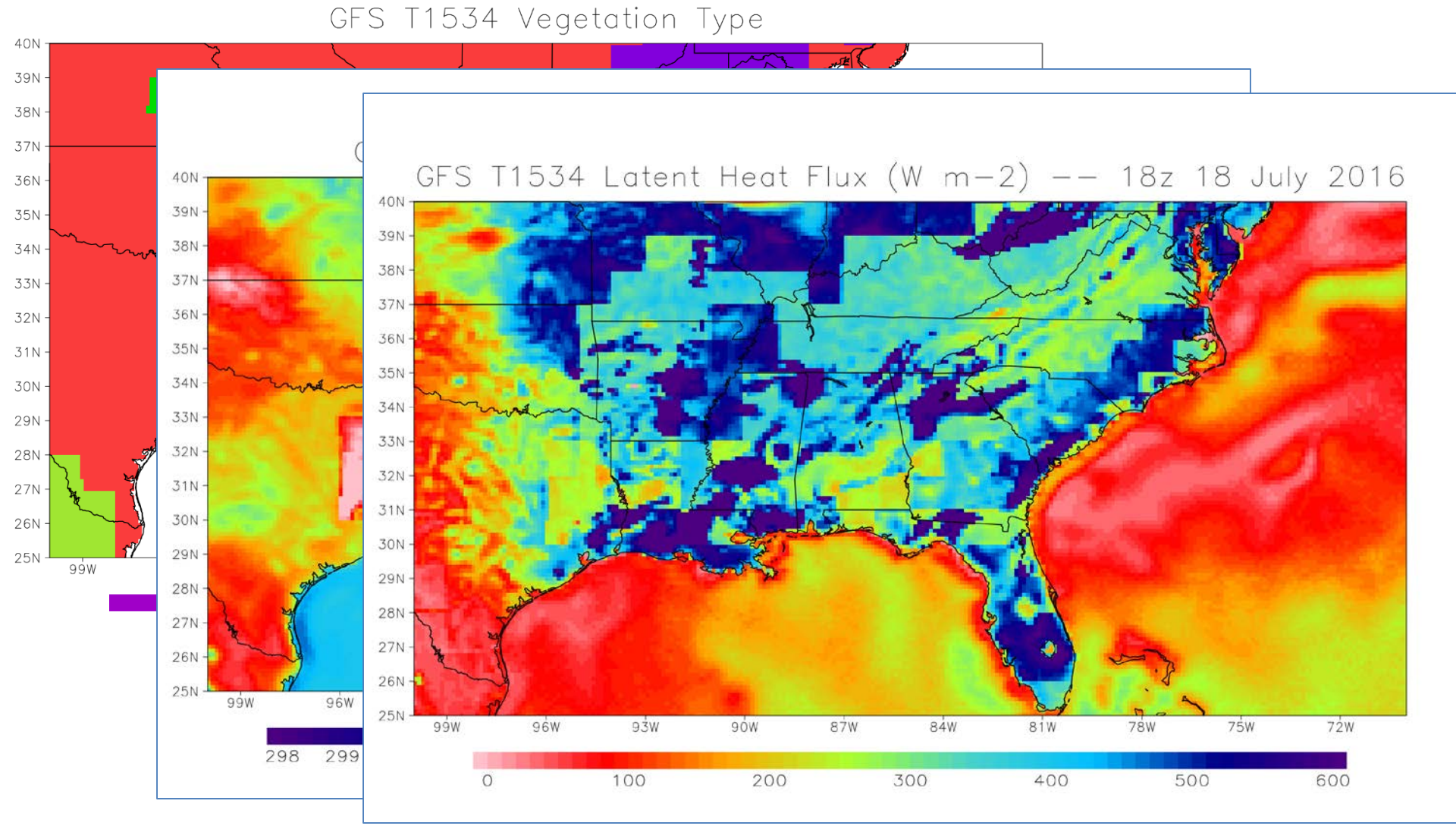
Land Prediction in Weather & Climate Models: NOAA's Operational Numerical Guidance Suite



From Michael Ek

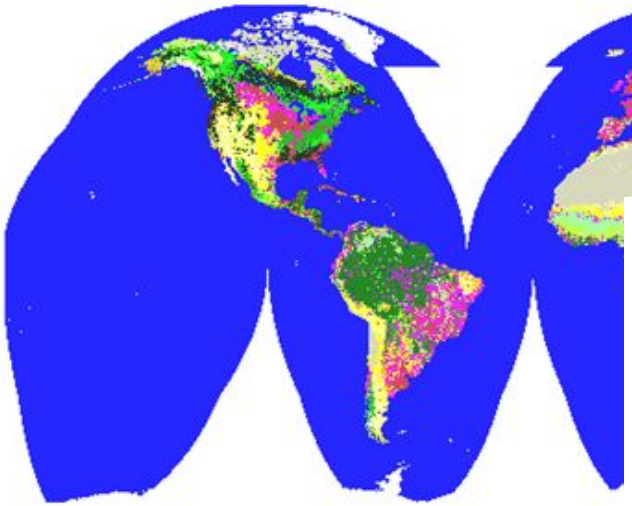
Surface Type Impacts on NWP Performance

From Chris Hain



Old Satellite Surface Type Data Products

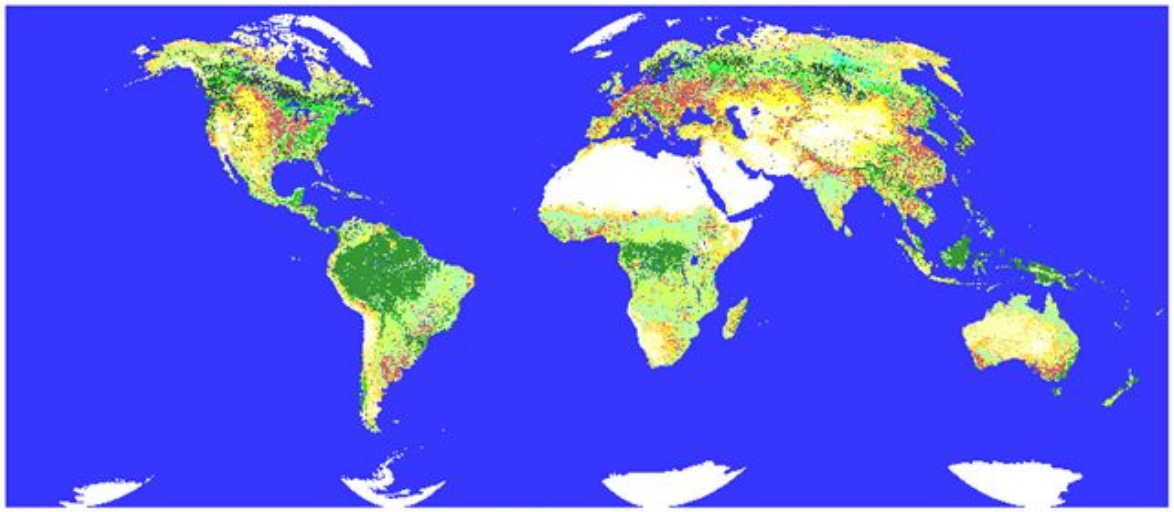
EDC IGBP 1km Global Classification



Evergreen Needleleaf For.
Evergreen Broadleaf For.
Deciduous Needleleaf For.
Deciduous Broadleaf For.
Mixed Forests
Closed Shrublands
Open Shr
Woody Sa
Savannas
Grassland
Permaner
Croplands

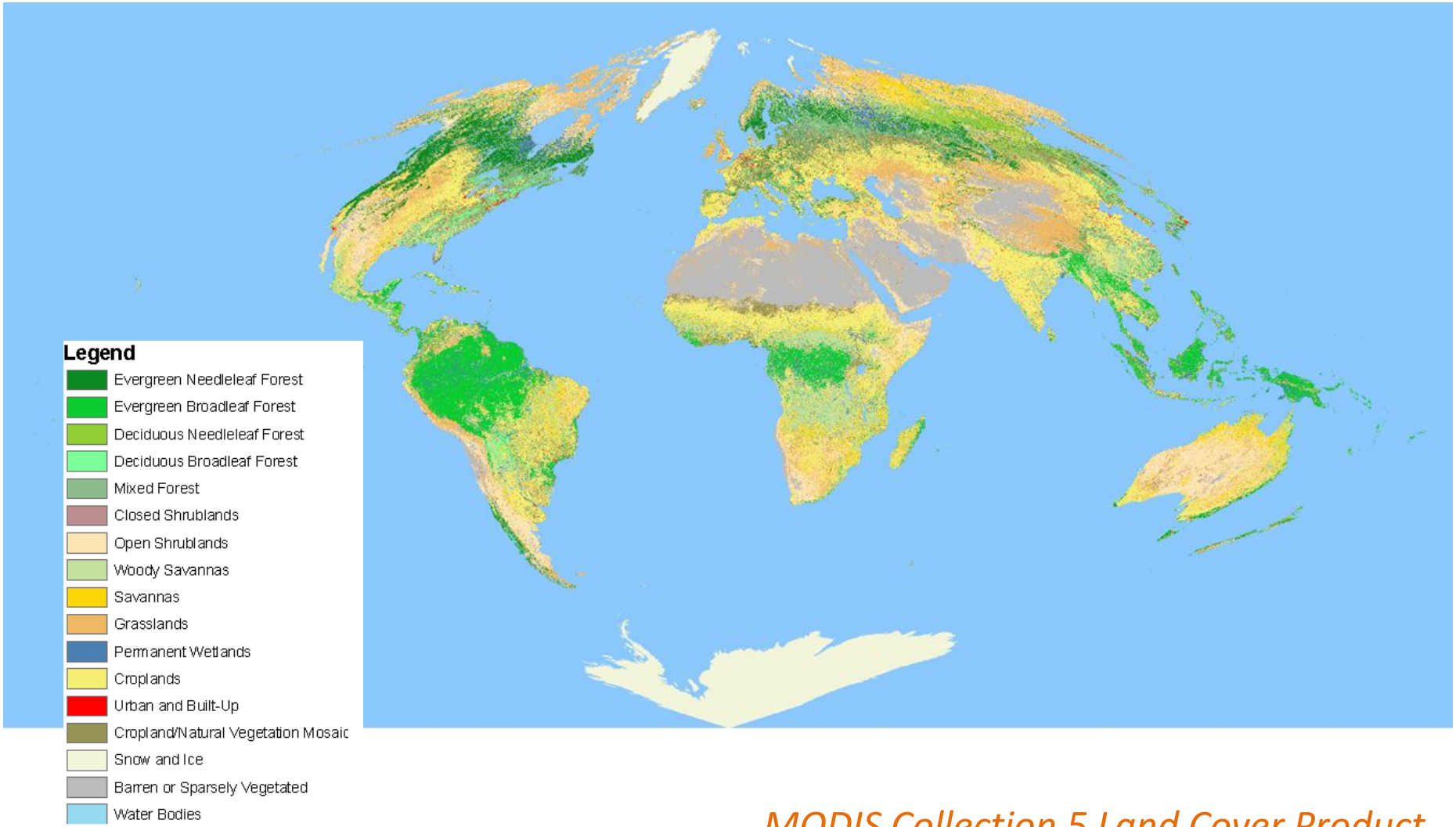
Based on 1992-1993 AVHRR Data

UMD 1km Global Classification



Water
Evergreen Needleleaf Forest
Evergreen Broadleaf Forest
Deciduous Needleleaf Forest
Deciduous Broadleaf Forest
Mixed Forest
Woodland
Wooded Grassland
Closed Shrubland
Open Shrubland
Grassland
Cropland
Bare Ground
Urban and Built-up

MODIS Surface Type Data Products



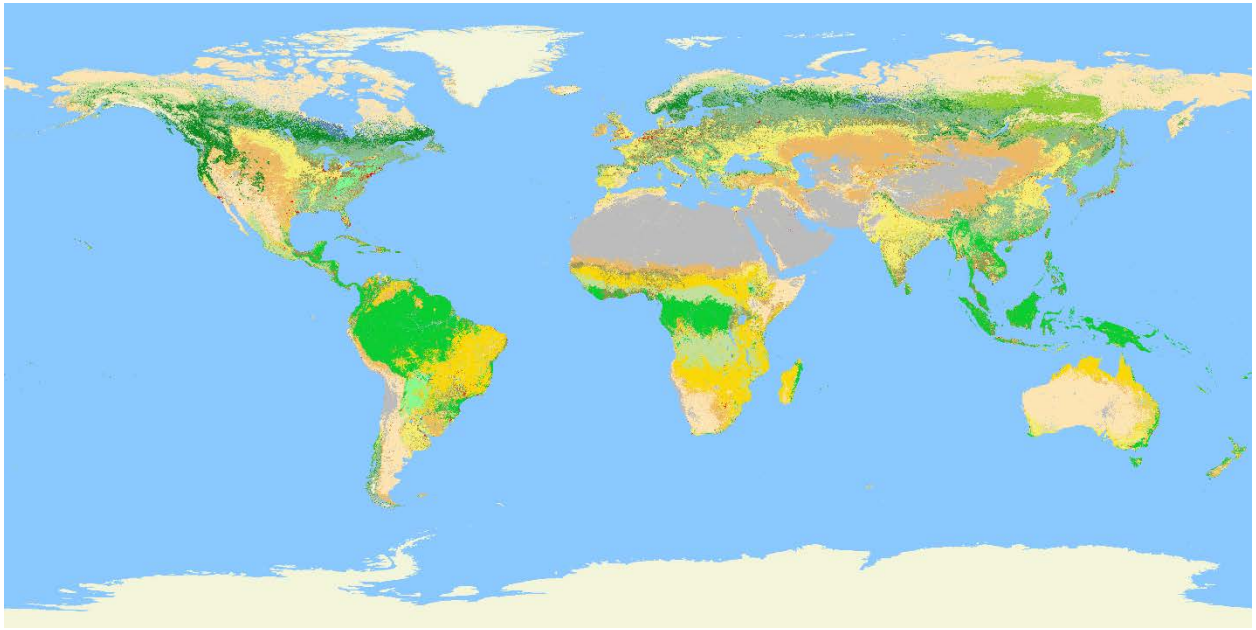
MODIS Collection 5 Land Cover Product

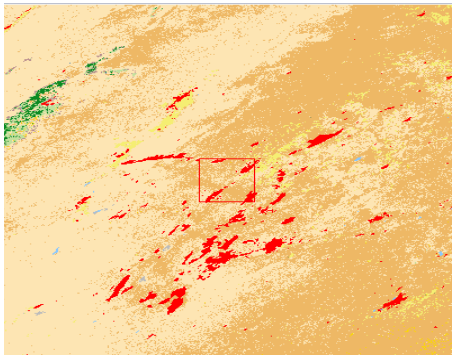
VIIRS Surface Type Products Overview

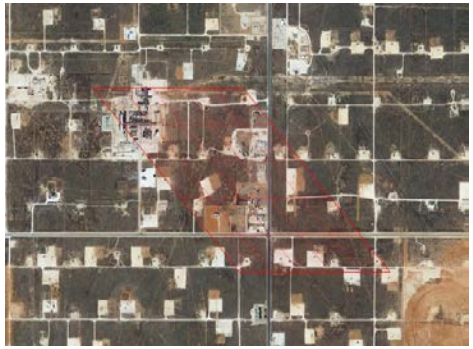
- Surface Type products include Surface Type EDR (**ST EDR**) and Global Annual Surface Type Maps (**AST**)
- Global Annual Surface Type Maps provide static labels for each 1km land grid for NWP models and other users
- Surface Type EDR is to provide current day surface type status for LST EDR in IDPS 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 Annual Surface Type Products

VIIRS Gridded Annual Surface Type (AST) map using 2016 VIIRS data was delivered in 2016





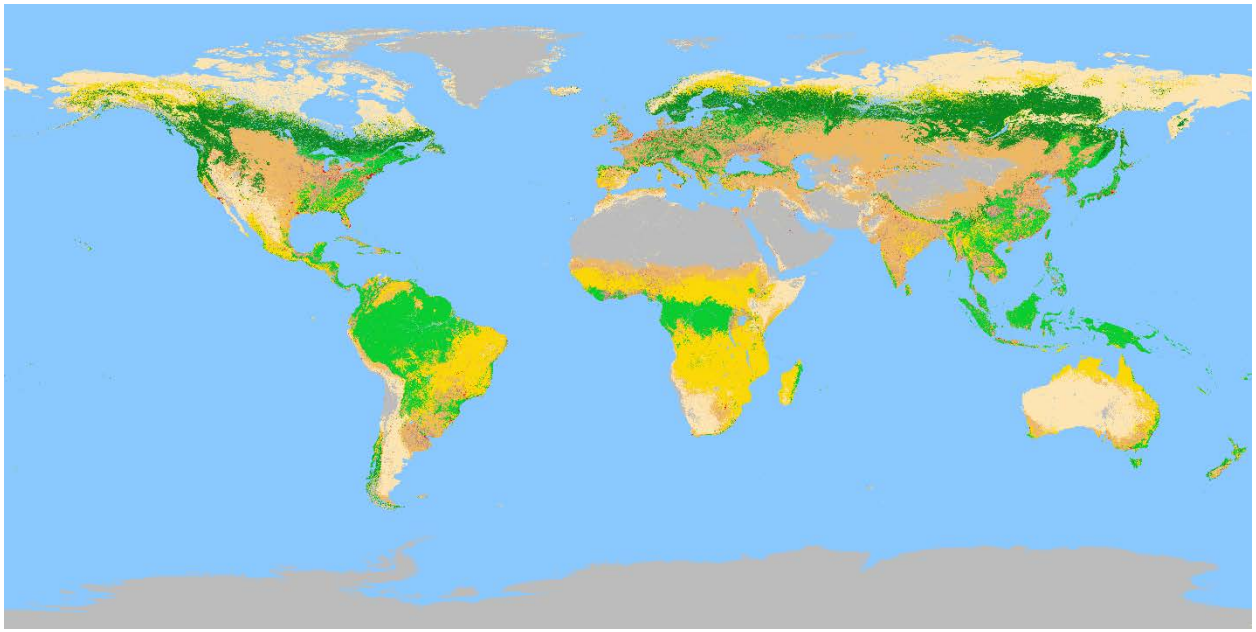


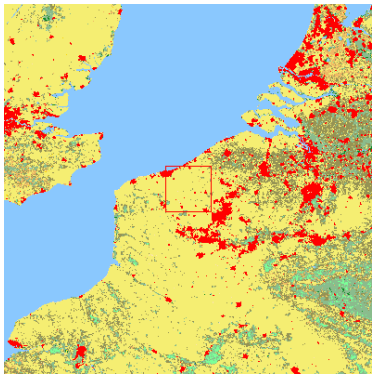
Oil drilling land in TX, US in 2016 map

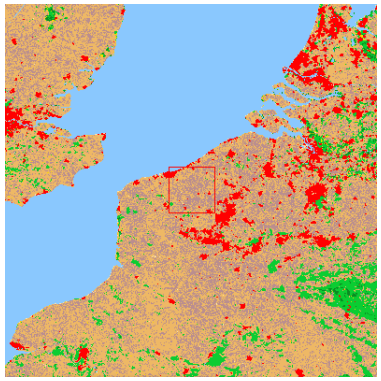
While the overall classification accuracy (~78%) of the new map is similar to 2015 delivery, some accuracy improvements are observed, such as urban/built-up lands. The images shown left demonstrate an examples of the newly labeled oil drilling land in Texas, US, which is considered built-up lands, where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

VIIRS Biome Classification Types

New global surface type map in biome classification types to support LAI/FPAR and other studies





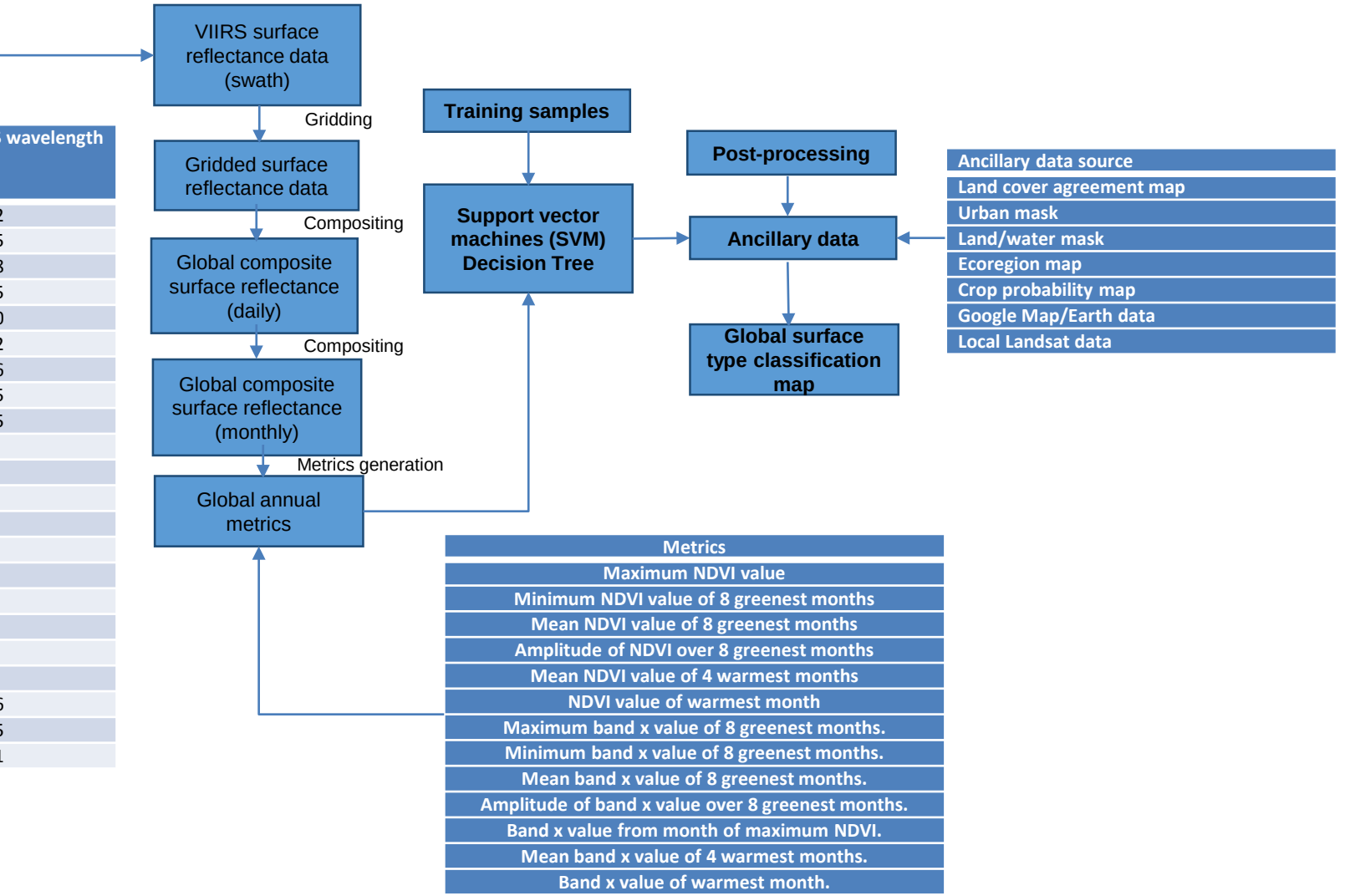


Europe

The biome scheme surface type map was generated using a 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

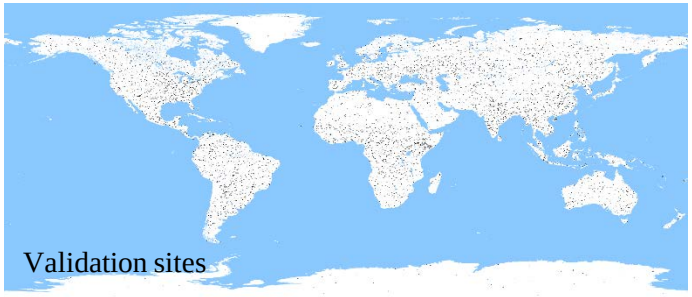
Band number (comparable in MODIS)	VIIRS wavelength (μm)
M1 (8)	0.412
M2 (9)	0.445
M3 (3 or 10)	0.488
M4 (4 or 12)	0.555
I1 (1)	0.640
M5 (13 or 14)	0.672
M6 (15)	0.746
I2 (2)	0.865
M7 (16 or 2)	0.865
DNB	0.7
M8 (5)	1.24
M9 (26)	1.38
M10 (6)	1.61
I3 (6)	1.61
M11 (7)	2.25
M12 (20)	3.70
I4 (20)	3.74
M13 (21 or 22)	4.05
M14 (29)	8.55
M15 (31)	10.76
I5 (31 or 32)	11.45
M16 (32)	12.01



VIIRS Annual Surface Type Validation

		Reference																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total (%)	User's accuracy (%)	Producer's accuracy (%)
Map	1	0.0188	0	0.0006	0.0004	0.0028	0.0001	0	0.0021	0.0002	0.0004	0.0001	0	0	0.0001	0	0	0.0002	0.0259	**72.53±2.93**	**72±3.48**
	2	0	0.0856	0	0.0008	0.0009	0	0	0.0041	0.0011	0.0003	0	0.0003	0	0.0006	0	0	0	0.0938	**91.3±1.15**	**93.02±1.08**
	3	0.0007	0	0.01	0	0.001	0	0.0002	0.001	0	0.0001	0.0005	0	0	0	0	0	0	0.0135	**74.17±4.01**	**66.96±4.75**
	4	0	0	0.0001	0.0078	0.0004	0	0.0001	0.0009	0.0002	0	0	0	0	0.0001	0	0	0	0.0095	**82.32±2.99**	**36.07±3.18**
	5	0.0016	0.0011	0.0029	0.0074	0.0362	0.0002	0	0.0064	0.0011	0.0002	0.0002	0.0002	0.0002	0.0033	0	0	0.0002	0.061	**59.25±2.55**	**77.32±2.53**
	6	0	0	0	0	0	0.0004	0	0	0	0	0	0	0	0	0	0	0	0.0006	**72.41±5.92**	**2.74±0.58**
	7	0.002	0	0.0002	0.0005	0.0022	0.0066	0.1191	0.0051	0.0032	0.0137	0.0015	0.0037	0	0.0017	0	0.0056	0.0002	0.1653	**72.04±1.73**	**84.29±1.77**
	8	0.0027	0.0018	0.0005	0.003	0.0014	0.0007	0.0022	0.0505	0.006	0.0009	0.0006	0.0007	0.0001	0.0037	0	0	0.0002	0.0751	**67.24±1.86**	**58.12±2.18**
	9	0	0.0021	0.0003	0.0003	0.0003	0.004	0.0032	0.0097	0.0469	0.0024	0.0003	0.0021	0	0.004	0	0	0	0.0757	**62.06±2.89**	**68.64±2.64**
	10	0.0001	0	0.0002	0.0002	0.0006	0.0026	0.0069	0.0022	0.0028	0.0632	0	0.0066	0.0001	0.0023	0	0.002	0	0.09	**70.26±1.69**	**68.81±2.44**
	11	0.0001	0.0002	0	0	0.0001	0	0.0006	0.0004	0.0006	0.0002	0.005	0.0002	0	0	0	0	0	0.0076	**65.57±6.13**	**61.45±7.46**
	12	0.0001	0.0001	0	0.0001	0.0003	0.0002	0.0008	0.0005	0.002	0.0042	0.0001	0.069	0.0006	0.0058	0	0	0.0002	0.0841	**82.11±1.24**	**78.47±1.66**
	13	0	0	0	0	0	0	0.0001	0.0003	0	0.0001	0	0.0007	0.0052	0.0004	0	0	0	0.0069	**75±3.62**	**82.46±4.75**
	14	0	0.001	0.0002	0.0011	0.0006	0.0001	0.0007	0.0037	0.0041	0.0018	0	0.004	0.0001	0.0278	0	0.0001	0	0.0451	**61.61±2.08**	**54.62±2.68**
	15	0	0	0	0	0	0	0.0017	0	0	0.0017	0	0	0	0	0.1006	0	0	0.104	**96.72±2.3**	**100±0**
	16	0	0	0	0	0	0	0.0057	0	0	0.0022	0	0.0004	0	0.0009	0	0.1216	0	0.1308	**92.98±1.48**	**94.03±0.98**
	17	0	0	0	0	0	0	0	0	0	0.0002	0	0	0	0	0	0	0.0111	0.0113	**98.33±1.67**	**91.41±3.14**
	Total	0.0261	0.092	0.015	0.0216	0.0468	0.0148	0.1413	0.0868	0.0684	0.0919	0.0081	0.088	0.0063	0.0508	0.1006	0.1293	0.0121	100		

Error matrix of estimated area proportions (in percentage). Overall accuracy is **77.9 ± 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%

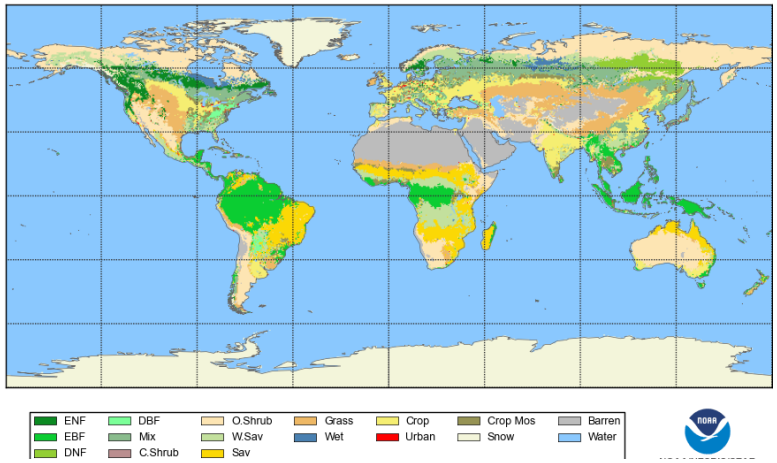
By incorporating new urban mask, the producer's accuracy (omission) for urban/built-up increased approximately 23.5%.

Current IDPS Surface Type EDR Monitor

- http://www.star.nesdis.noaa.gov/jpss/EDRs/products_surfacetype.php

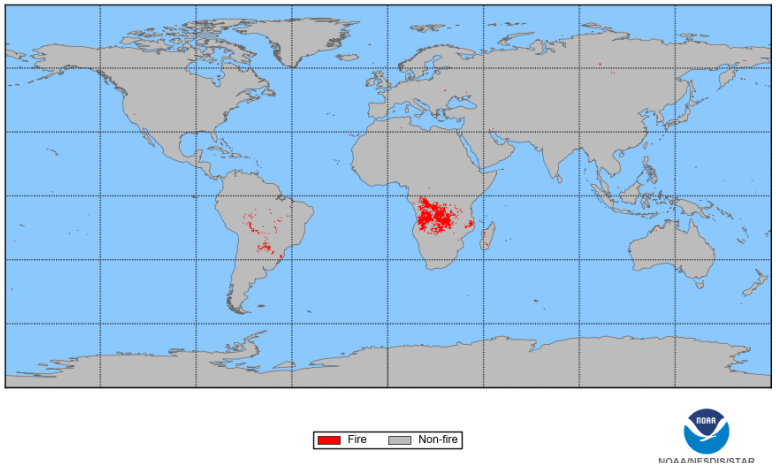
Suomi NPP VIIRS Global Surface Type Composite (ST-EDR)

5 Aug 2016



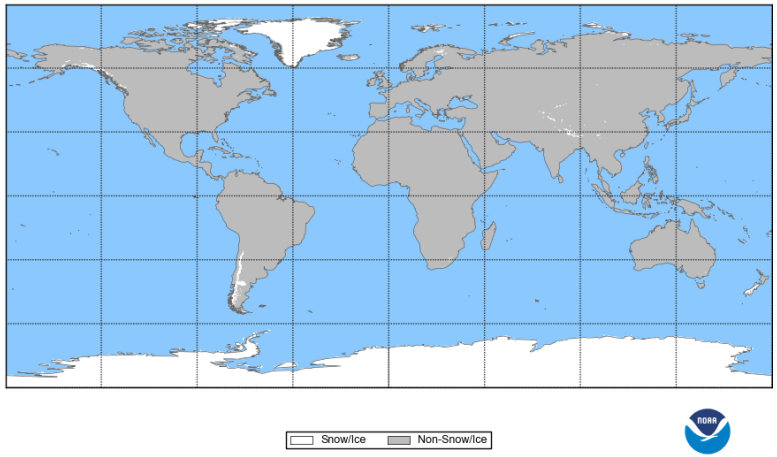
Suomi NPP VIIRS Global Active Fire Composite (ST-EDR)

5 Aug 2016



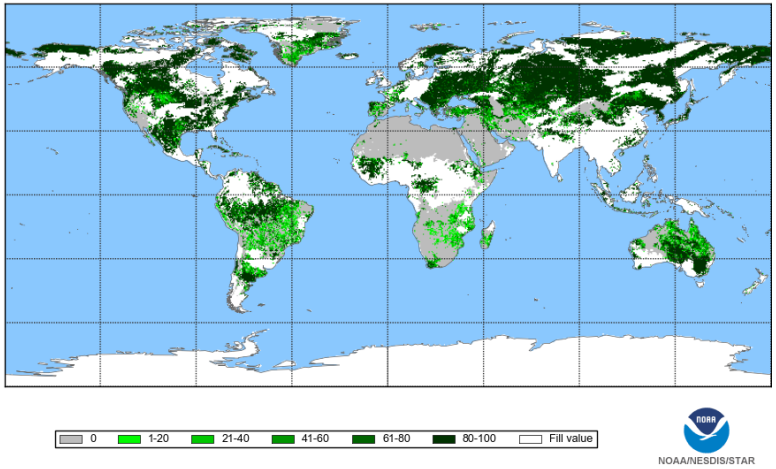
Suomi NPP VIIRS Global Snow/Ice Composite (ST-EDR)

5 Aug 2016



Suomi NPP VIIRS Global Vegetation Fraction (ST-EDR)

5 Aug 2016

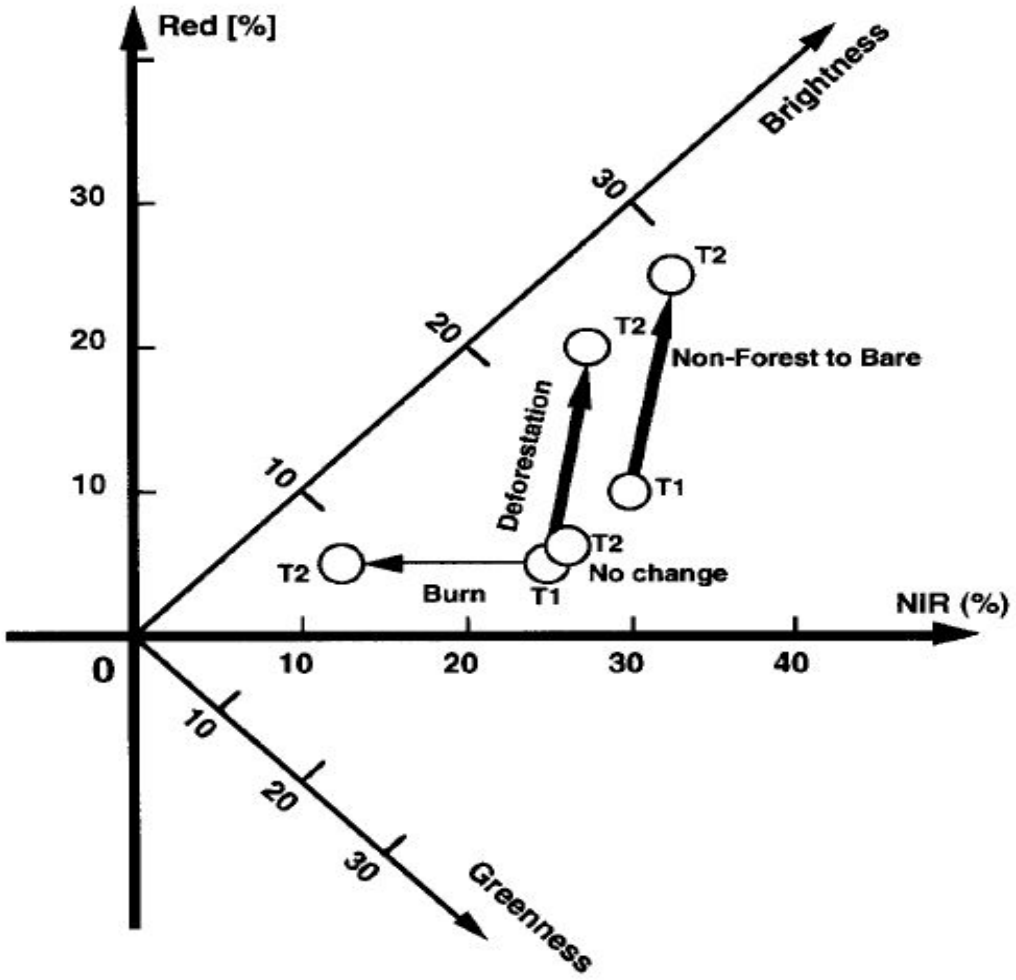


VIIRS Surface Type Products Overview

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

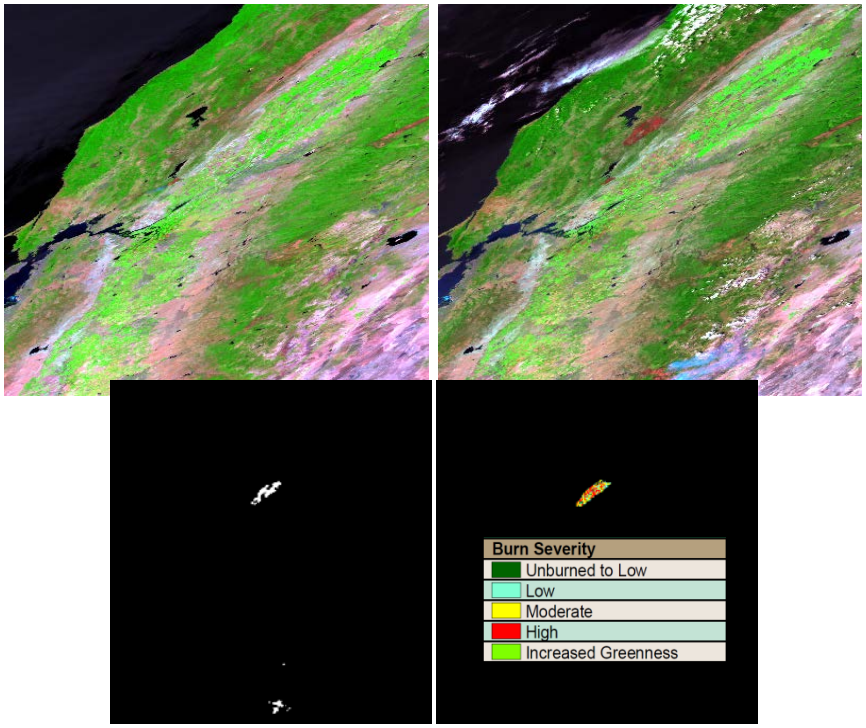


Change Vector Algorithm (Zhan et al, IJRS, 2000)

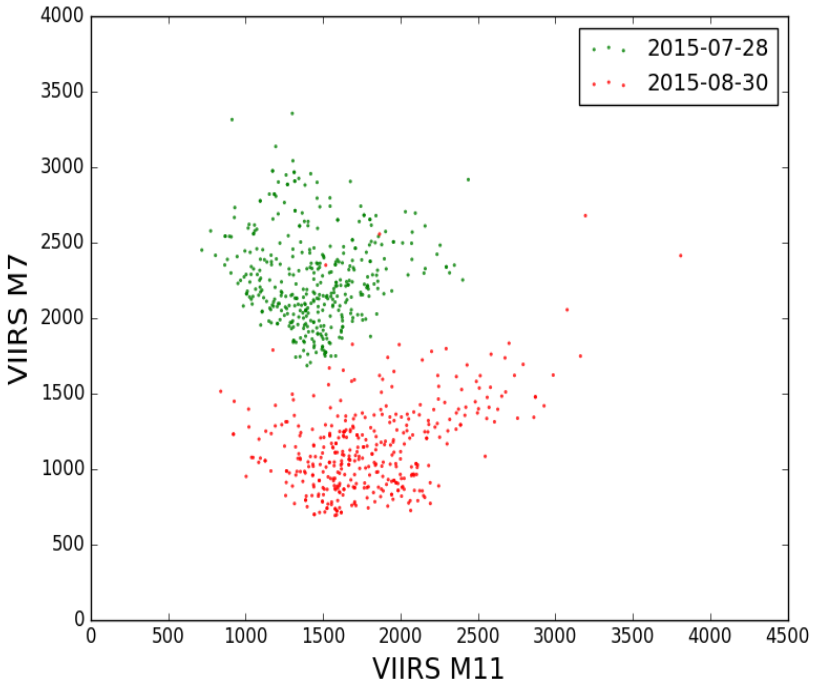
- Typical change vectors in the brightness–greenness space.
- The small circles show the typical signatures at Time 1 (T1) and Time 2 (T2) respectively.

Surface Type Change Detection Results

Burned Areas of Rocky Creek, CA Fires in July 2016



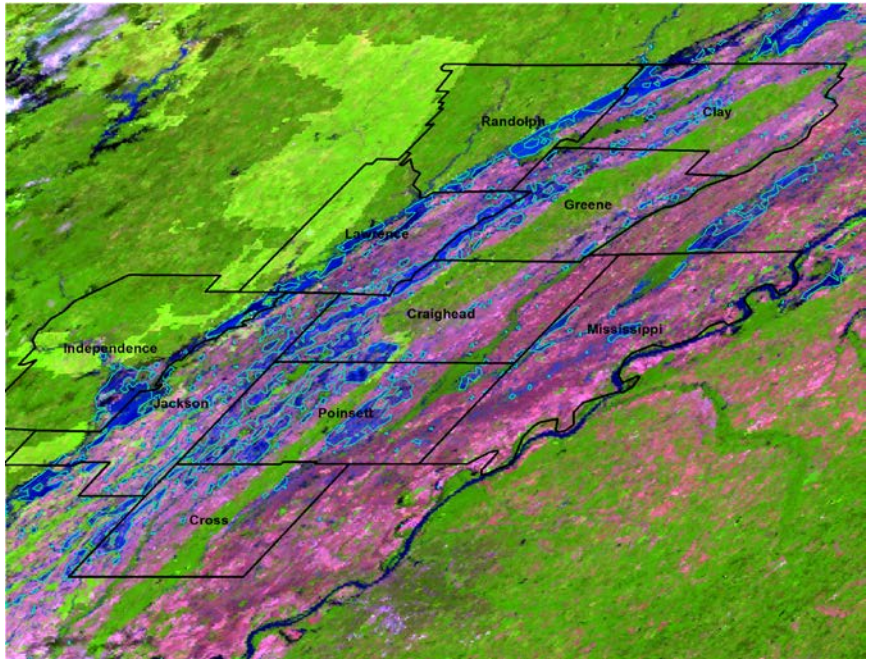
Burned areas of the Rocky fires in July 2015 detected with the change vector method using S-NPP VIIRS images shown in the left figure and verified with MTBS data (right)



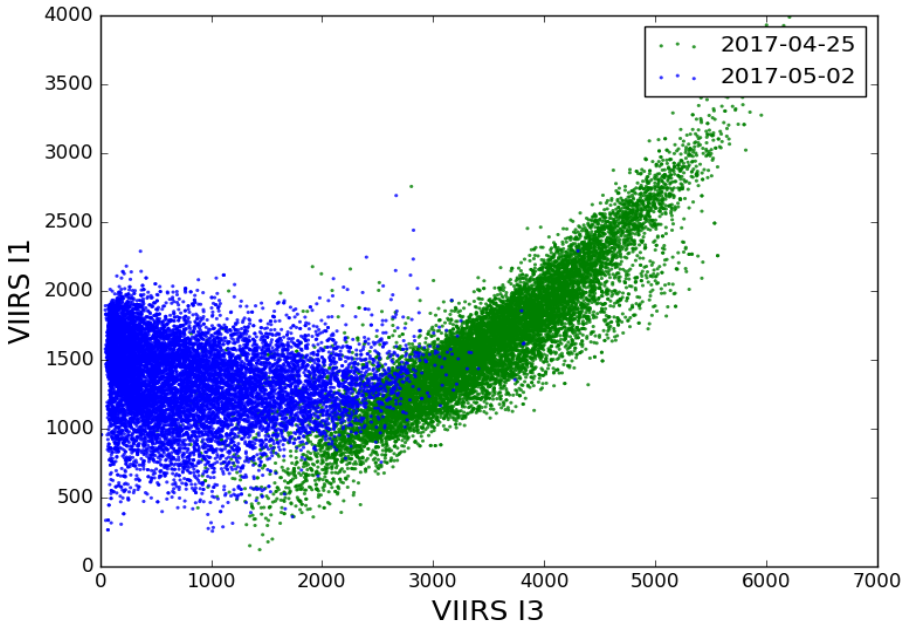
Spectral signatures of the burned areas in VIIRS M11-M7 space before (green) and after (red) the Rocky Creek, CA wildfires from July 29th to August 14th, 2015.

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

Daily Surface Type Product

- 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 !