Validated Stage 1 Science Maturity Readiness Review for Surface Type EDR

Presented by Xiwu Zhan

December 11, 2014

Outline

- Algorithm Cal/Val Team Members
- Product overview and requirements
- Previous validation results revisit
- Evaluation of algorithm performance to specification requirements
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- Documentation
- Identification of Processing Environment
- Users & User Feedback
- Path Forward
- Summary

Surface Type EDR Cal/Val Team

Name	Organization	Major Task
Xiwu Zhan	NOAA/STAR	Surface Type EDR team lead, User outreach
Chengquan Huang	UMD/Geography	Algorithm development lead
Rui Zhang	UMD/Geography	Algorithm development, user readiness
Mark Friedl	BU/Geography	Validation lead
Damien Sulla-Menashe	BU/Geography	Ground truth data development and product validation
Marina Tsidulko	STAR/AIT	Product delivery

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Overview of VIIRS Surface Type EDR

- Describes surface condition at time of each VIIRS overpass
- Produced for every VIIRS swath/granule
  - Same geometry as any VIIRS 750m granule
- Two major components
  - Gridded Quarterly Surface Type (QST) IP
    - Remapped to the swath/granule space for each VIIRS acquisition
    - Requires at least one full year of VIIRS composited data
  - Includes flags to indicate snow and fire based on
    - Active fire Application Related Product (ARP/EDR)
    - Snow EDR
- Vegetation Fraction is included, but is replaced with NDE GVF (By Marco Vargas)

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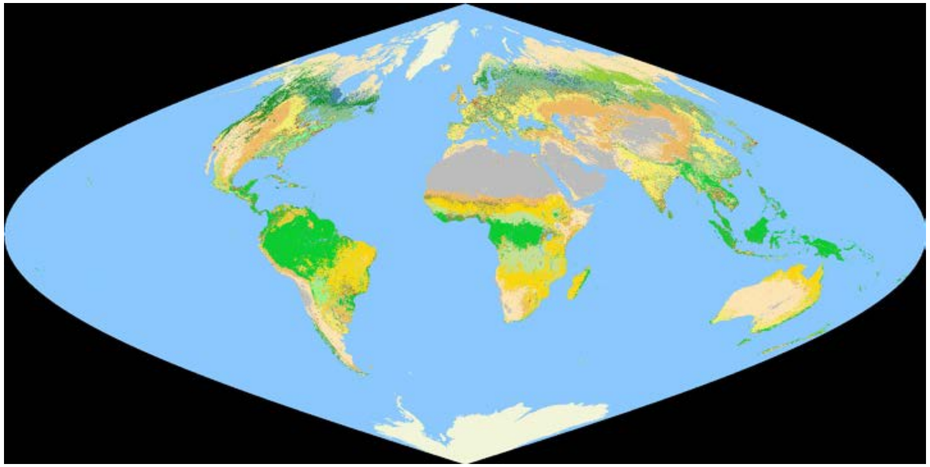
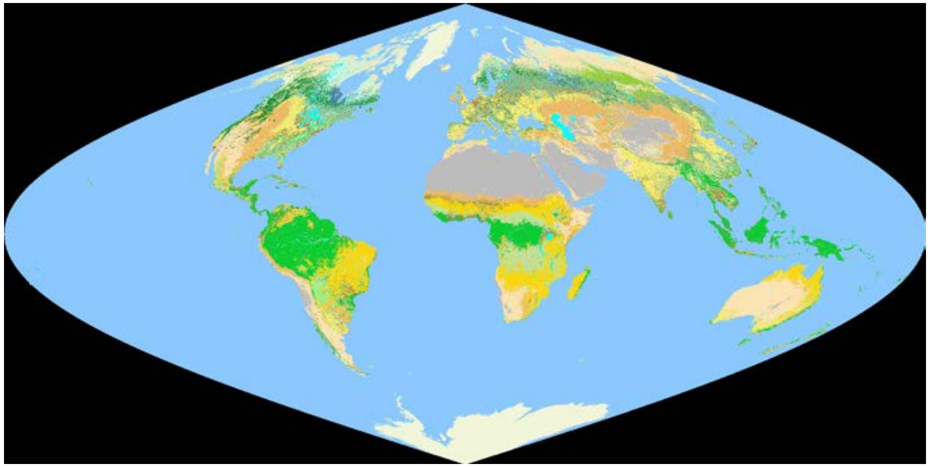
VIIRS ST IP Overview

- Global surface type / land water mask product
  - Gridded, 1km, 17 IGBP surface type classes. Required typing accuracy ~70%
  - Generated annually to reflect recent changes
    - Based on gridded surface reflectance products
    - Use decision tree (C5.0) classifier, requires training data



Global VIIRS Surface Type IP



Global Surface Type IP with land water mask

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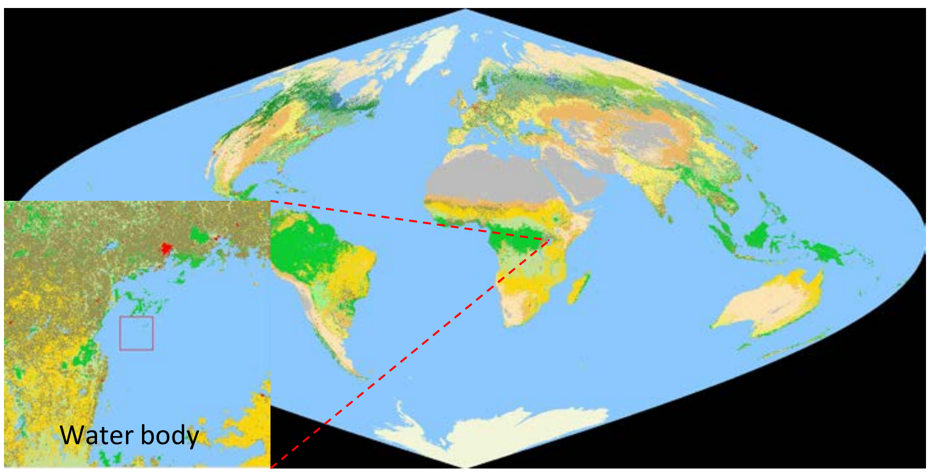
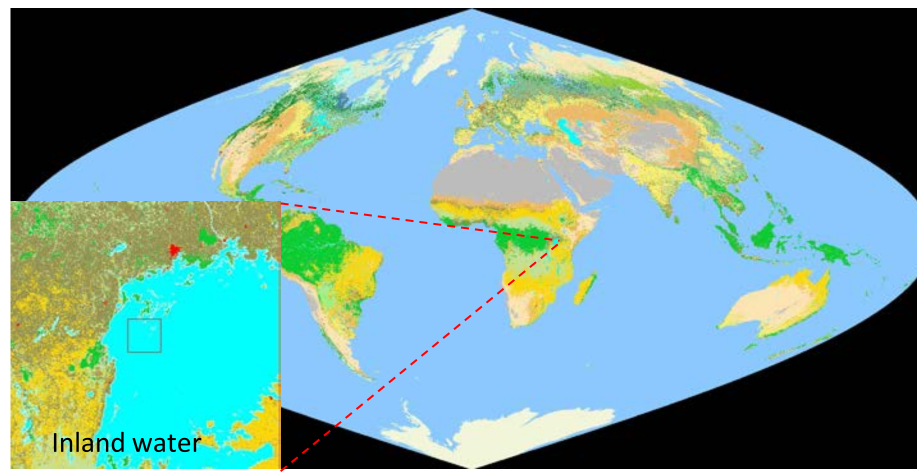
VIIRS QST IP Overview

- Global surface type / land water mask product
  - Gridded, 1km, 17 IGBP surface type classes. Required typing accuracy ~70%
  - Generated annually to reflect recent changes
    - Based on gridded surface reflectance products
    - Use decision tree (C5.0) classifier, requires training data



Global VIIRS Quarterly Surface Type IP



VIIRS QST IP with land water mask

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Requirements

ST EDR/QST IP Requirements from JPSS L1RD

Attribute	Threshold	Objective
Geographic coverage	Global	Global
Vertical Coverage		
Vertical Cell Size	N/A	N/A
Horizontal Cell Size	1 km at nadir	1 km at edge of scan
Mapping Uncertainty	5 km	1 km
Measurement Range	17 IGBP classes	17 IGBP classes
Measurement Accuracy	70% correct for 17 types	70% correct for 17 types
Measurement Precision	10%	10%
Measurement Uncertainty		

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Current Status of Surface Type EDR

- Provisional maturity science review done in Jan 2014
  - 1st VIIRS QST IP (gridded) based on pure VIIRS 2012 data was generated and reviewed in Jan 2014;
  - Preliminary quality check indicates reasonable quality in Apr 2014

- Provisional maturity AERB review done in Oct 2014
  - CCR-1653 approved: VIIRS ST EDR Veg Fraction fixes in May 2014;
  - CCR-1700 approved: Improved VIIRS QST IP implemented in IDPS in Oct 2014;
  - CCR-1700 verified: VIIRS ST EDR from Mx8.5 offline verified consistent with QST IP delivered from science team in Nov 2014

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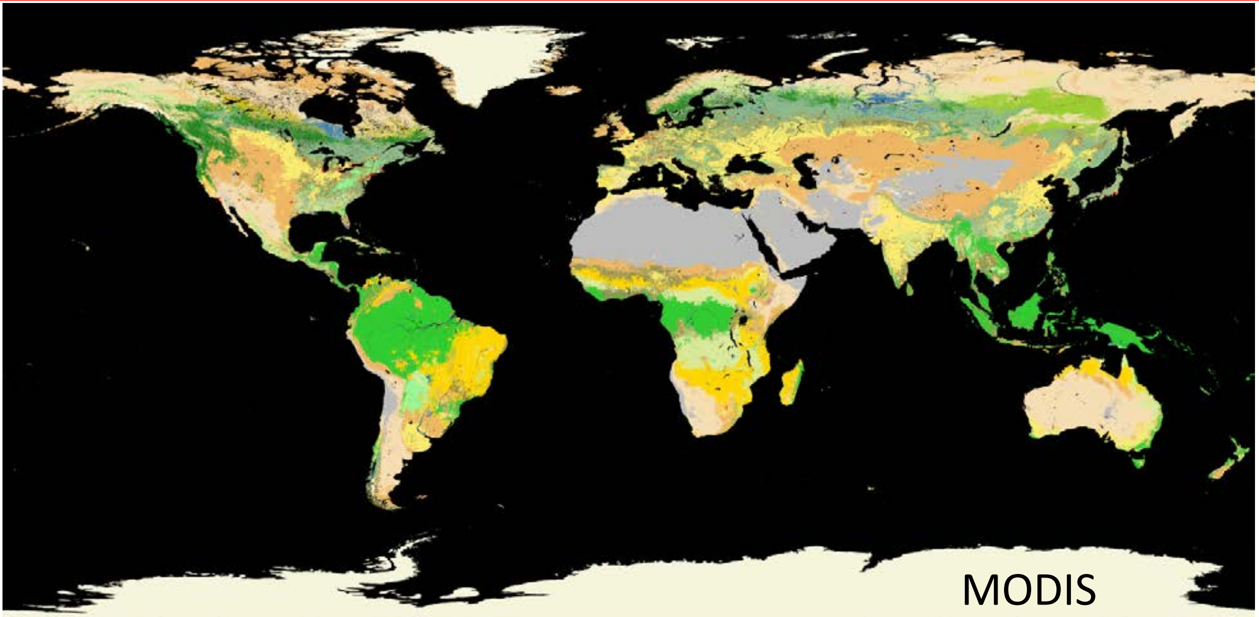
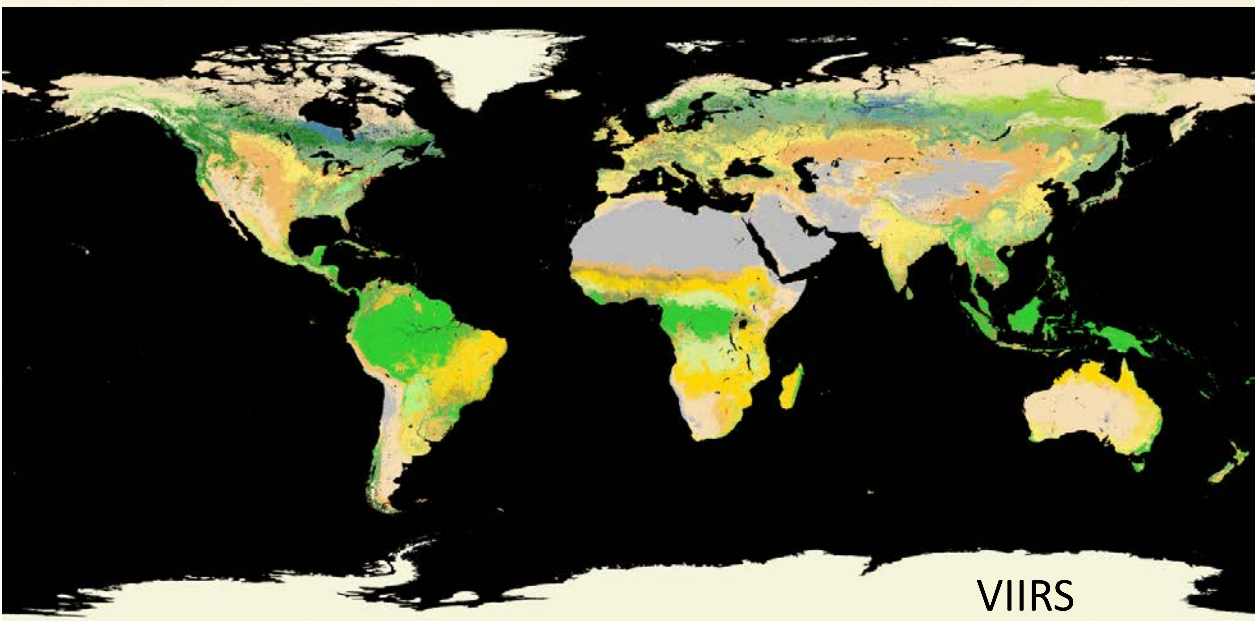
Previous Validation: VIIRS QST vs MODIS LC





IGBP Legend

- Water Bodies
- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forests
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-up Lands
- Cropland/Natural Vegetation Mosaics
- Snow and Ice
- Barren

The new VIIRS ST map compares favorably to the MODIS C5 (IDPS seed).

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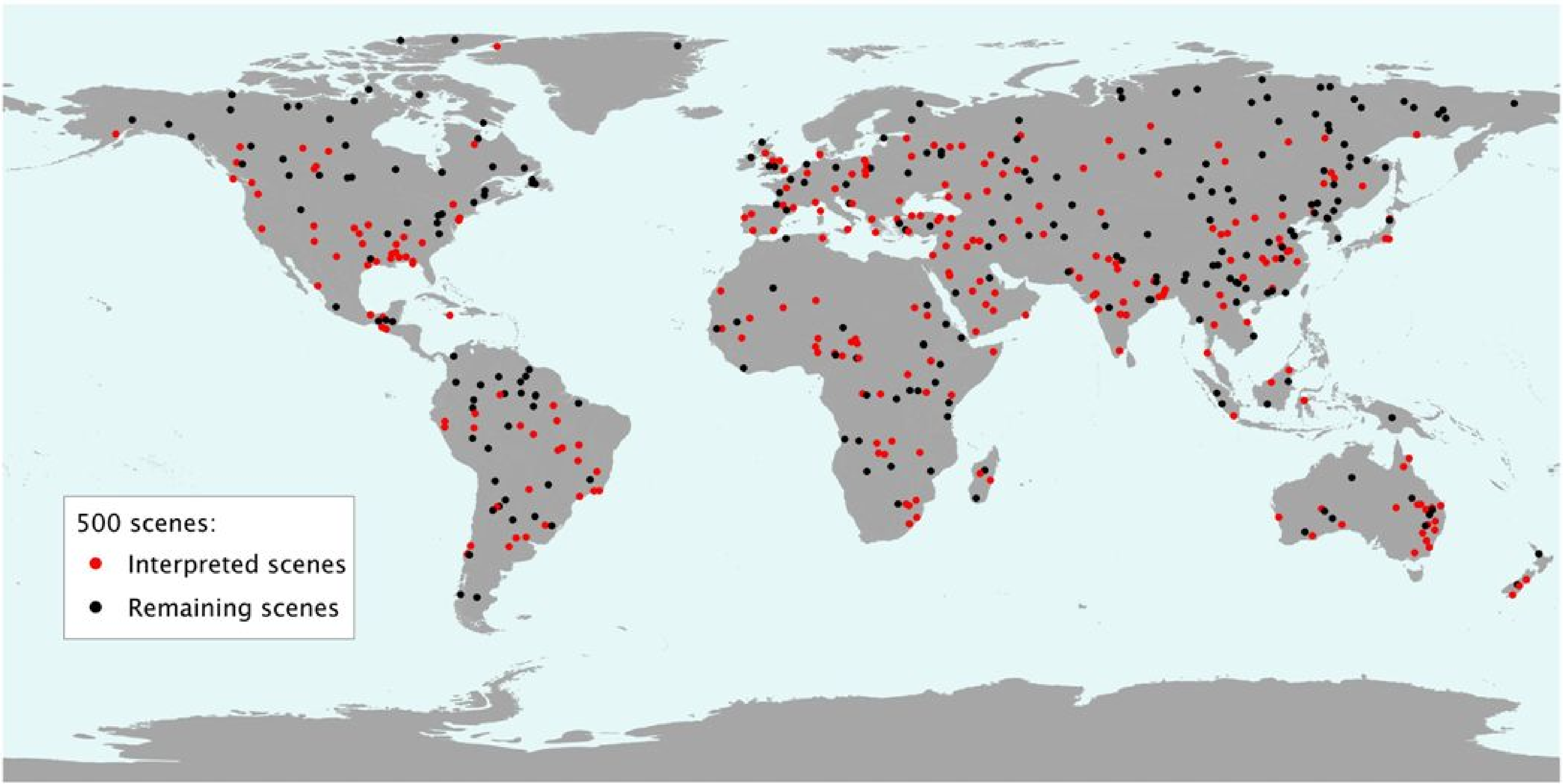
Previous Validation: 500 Validation Site Blocks



BU has completed 290 of the 500 sample blocks (5km x 5km) (red points).

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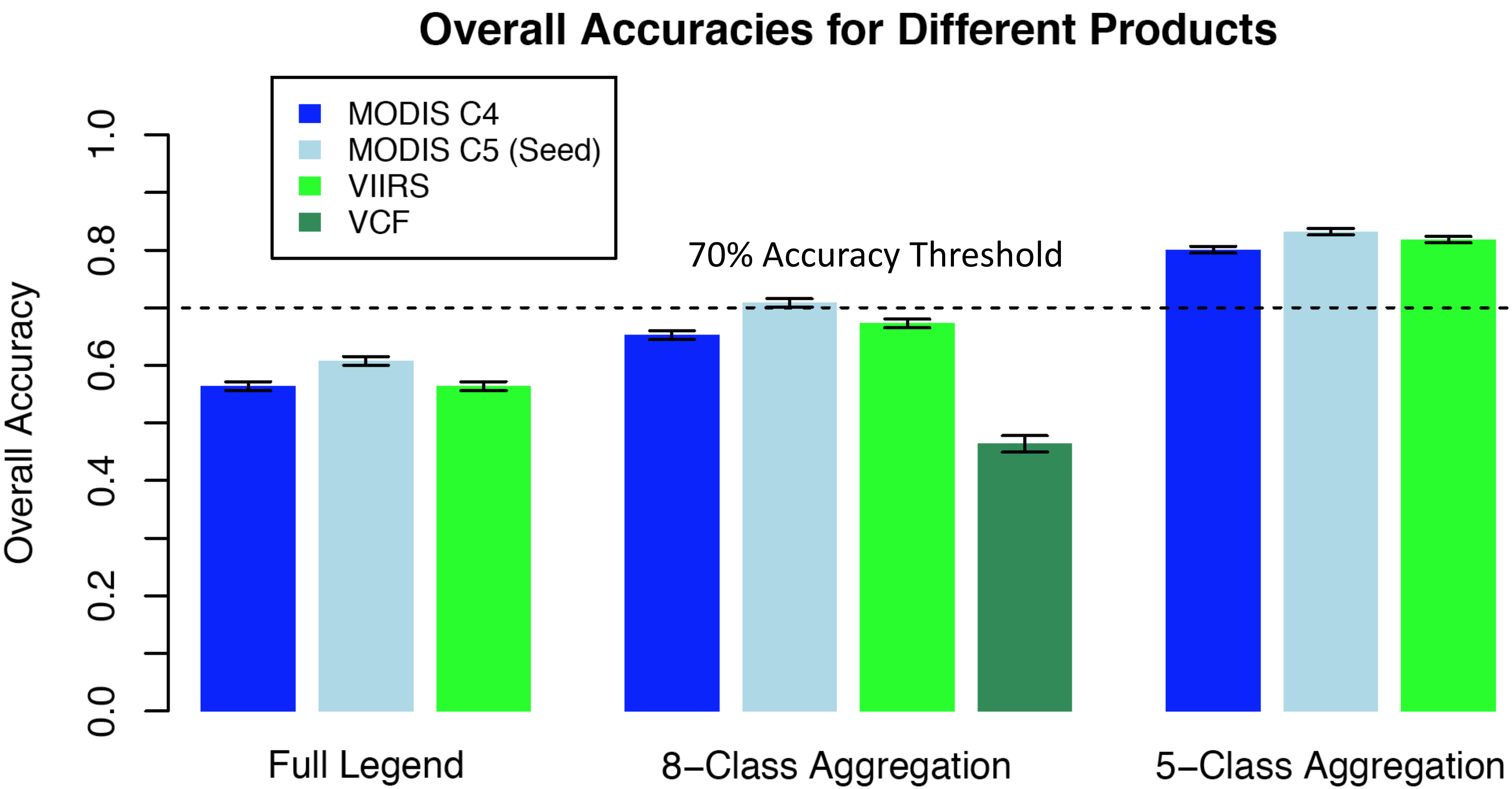
Previous Validation: Result



BU's previous validation suggested that overall accuracies are similar between the MODIS seed and the new VIIRS ST-IP.

Data Product Maturity Definition

Validated Stage 1:

Using a limited set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

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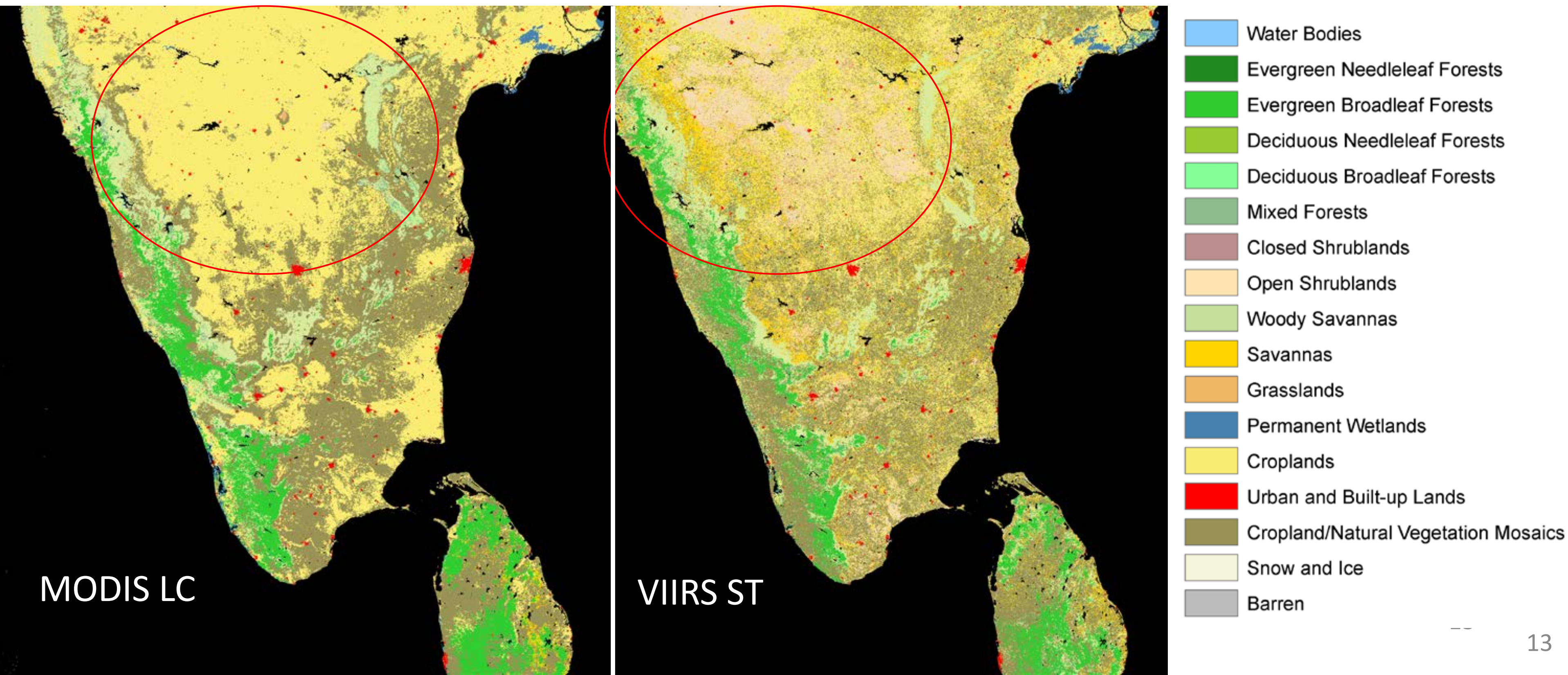
Evaluation of algorithm performance to specification requirements

- Findings/Issues from Provisional Review
  - Confusions among croplands, cropland/natural vegetation mosaics, and other similar vegetative type, such as grasslands, savannas, and open shrublands



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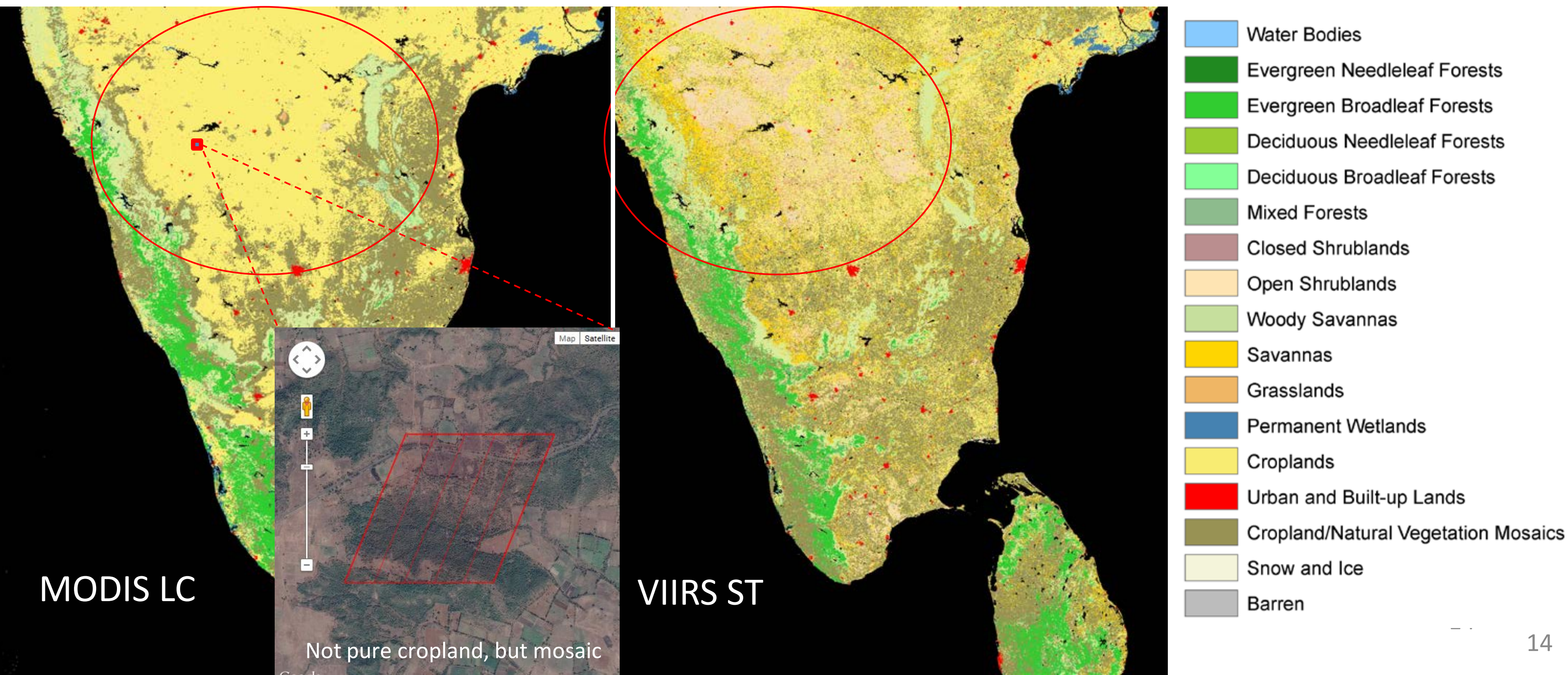
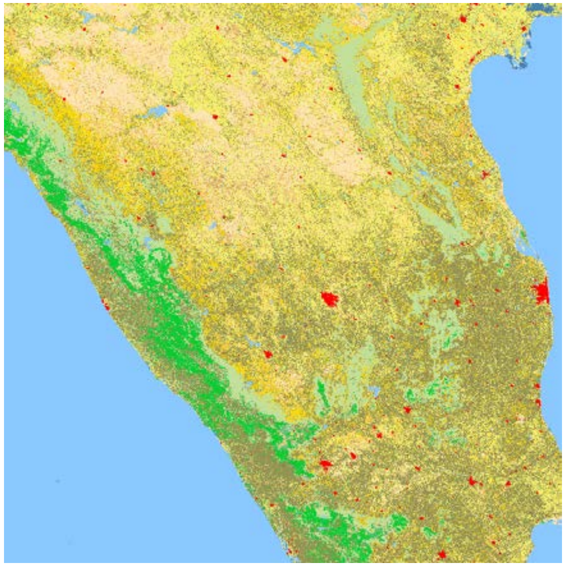
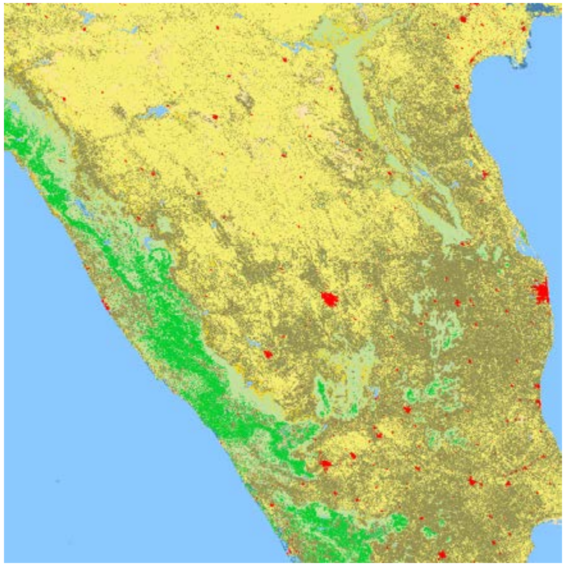


Evaluation of algorithm performance to specification requirements

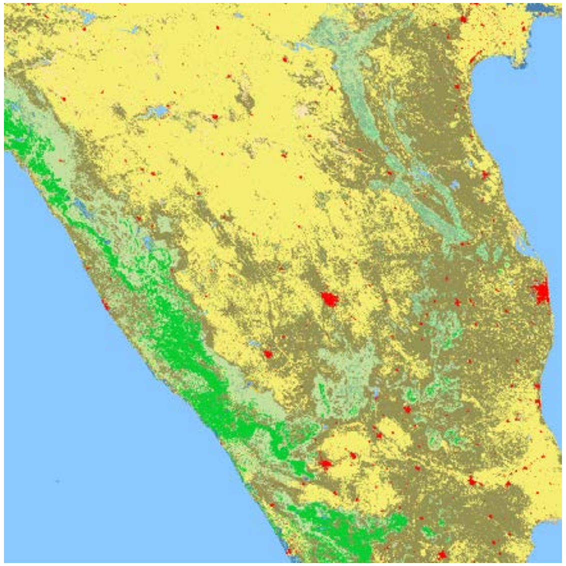
- Improvements since Provisional
  - Algorithm Improvements: post-classification modeling for croplands. An four land cover (GLC2000, GLC, MODIS LC, UMD LC) agreement data set is used as reference to improve croplands class.



Initial QST IP (April'14)



Improved QSTIP (post-classification modeling)



MODIS-based Seed

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Evaluation of algorithm performance to specification requirements

- Cal/Val Activities for evaluating algorithm performance: Validation strategy / method
  - Additional validation after Provisional
    - Confusion matrices and total accuracy are used to assess the classification performances.
    - Reference data derived through visual interpretation of high resolution satellite images.
      - Google Map
      - Google Earth
      - Other existing surface type products for references
    - Developed an integrated GUI tool to improve visual interpretation efficiency

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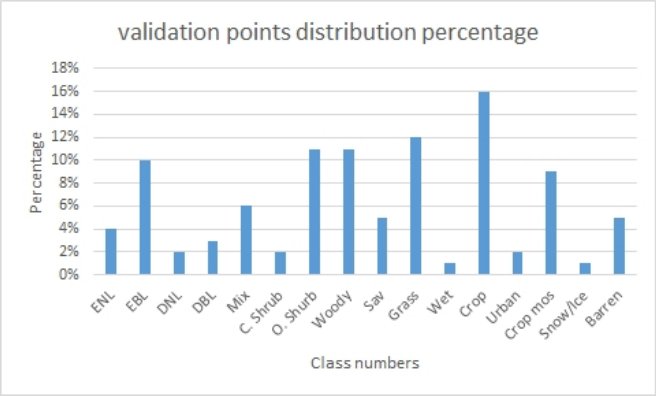
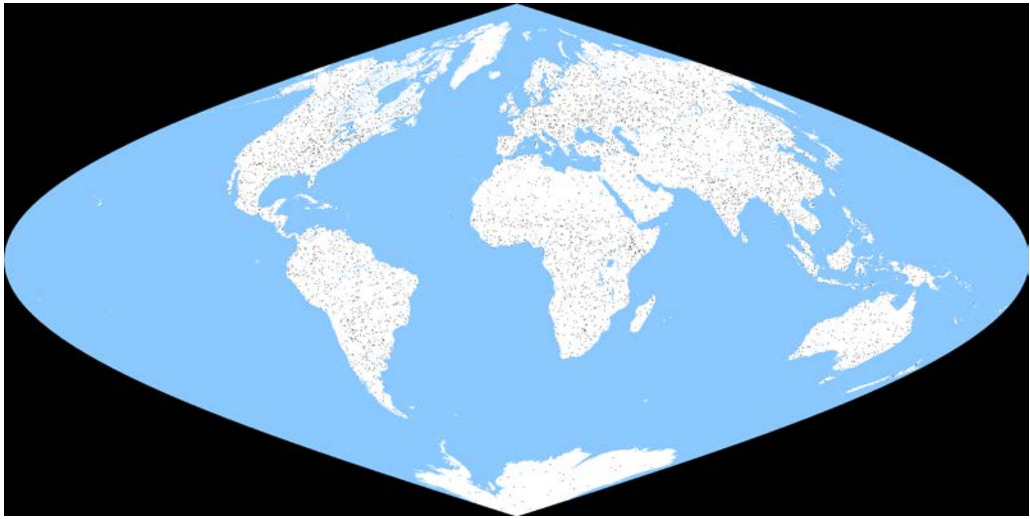
Evaluation of algorithm performance to specification requirements

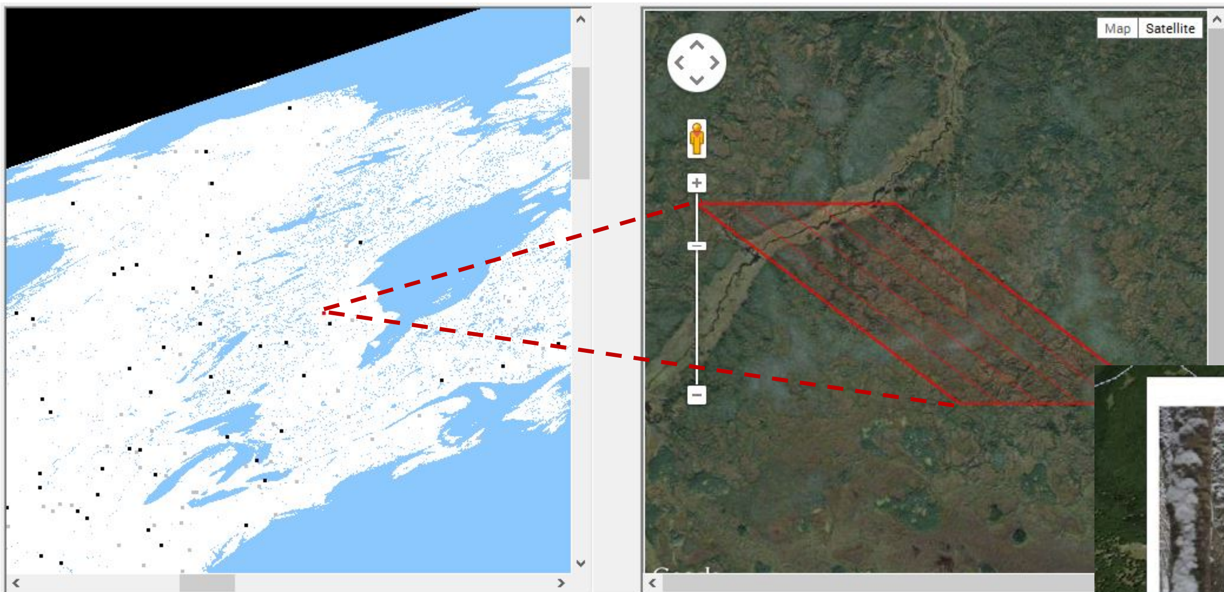
- Cal/Val Activities for evaluating algorithm performance: Test / ground truth data sets
  - 5000 validation pixels were selected globally using stratified random sampling strategy (Olofsson et al., 2012 in IJRS), the same method with previous validations conducted by BU.
    - Stratified random sampling
    - More emphasis on
      - Important classes
      - Classes affected by human activities
      - Rare classes





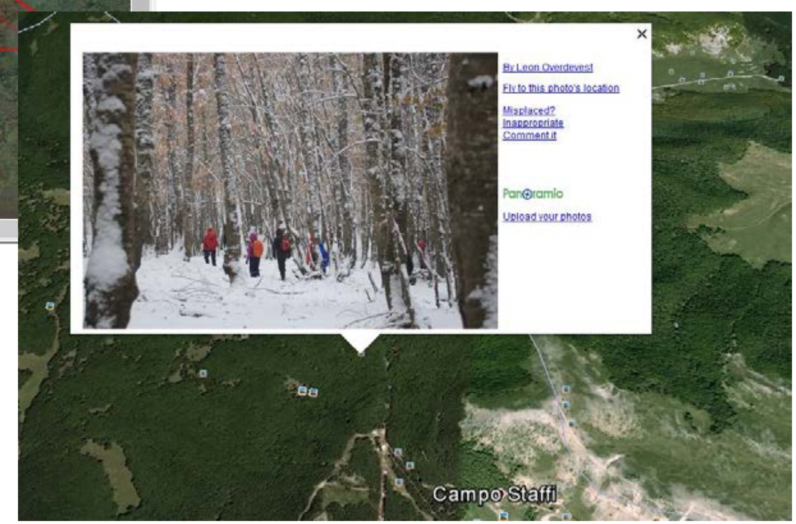
Evaluation of algorithm performance to specification requirements

- Cal/Val Activities for evaluating algorithm performance: Test / ground truth data sets
  - Integrated validation GUI tool developed.



1. Automatically load in Google map high resolution image for each reference point (1km)

2. Ground photo from Google Earth can be used to improve interpretation confidence.



Evaluation of algorithm performance to specification requirements

- Cal/Val Activities for evaluating algorithm performance: Validation results
  - Overall accuracy: 73.92% (required 70%)
  - Confusion Matrix (in percent):

	ENL	EBL	DNL	DBL	Mix	C. Shurb	O. Shurb	Woody	Sav	Grass	Wet	Crop	Urban	Crop mos	Snow/Ice	Barren
ENL	85.98	0	3.85	1.43	10.74	0	0.2	3.4	1.12	0.18	2.38	0.13	0	0	0	0
EBL	0	94.09	0	1.9	3.7	0	0	4.29	2.8	0	0	0.13	0	0.73	0	0
DNL	2.44	0	71.15	0	2.59	0.9	0	1.61	0.28	0	0	0	0	0	0	0
DBL	0	0	0.96	55.24	2.59	0	0	2.15	2.52	0.36	0	0	0	0.73	0	0
Mix	4.88	0.61	17.31	22.38	66.3	0	0	6.44	1.68	0.36	0	0.13	1.02	1.95	0	0
C. Shrub	0.61	0	0	1.43	0.37	62.16	1.81	0.36	0.84	0	0	0.13	0	0.97	0	0
O. Shurb	1.22	0	0	0.48	1.48	15.32	80.89	0.89	0.84	9.79	9.52	1.73	1.02	2.19	0	8.42
Woody	3.05	2.24	4.81	9.05	6.3	5.41	1.21	64.04	15.69	1.42	2.38	1.33	2.04	7.3	0	0
Sav	0	0.61	0	0.48	0.74	4.5	1.41	4.83	47.9	1.42	0	0.66	1.02	3.41	0	0
Grass	0.61	0	0	1.9	1.11	9.91	10.06	2.33	5.88	72.06	0	6.12	2.04	3.41	0	5.26
Wet	0.61	0	0	0.48	1.48	0	0.8	0.36	1.12	0.36	80.95	0.13	0	0	0	0
Crop	0.61	0	0.96	1.9	0.74	0.9	1.01	0.89	5.32	9.07	4.76	83.38	8.16	15.57	0	0
Urban	0	0.2	0	0	0	0	0.2	0.36	0.28	0.18	0	1.33	81.63	0.97	0	0.35
Crop mos	0	2.24	0.96	3.33	1.85	0.9	1.81	8.05	13.73	4.27	0	4.65	3.06	62.77	0	0.35
Snow/Ice	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Barren	0	0	0	0	0	0	0.6	0	0	0.53	0	0.13	0	0	0	85.61

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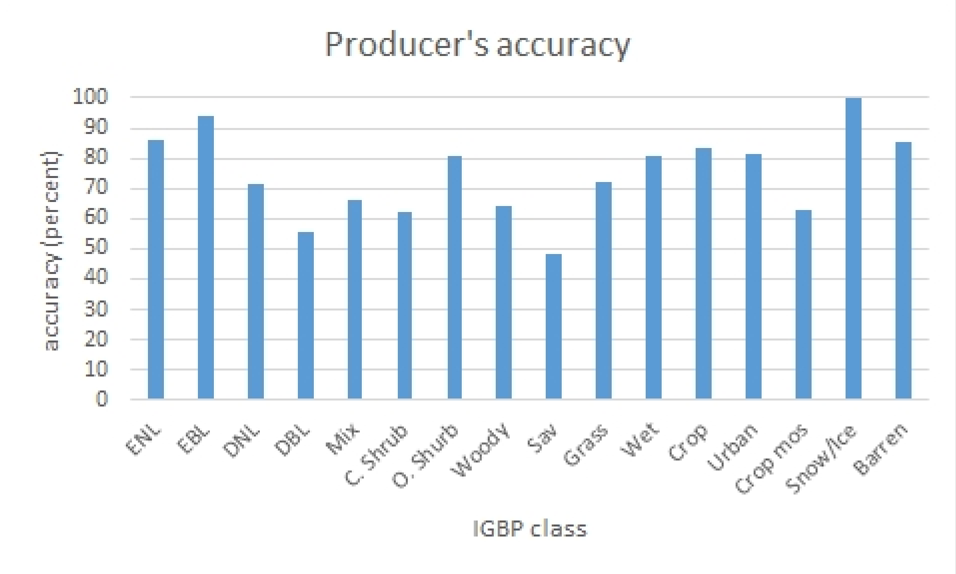
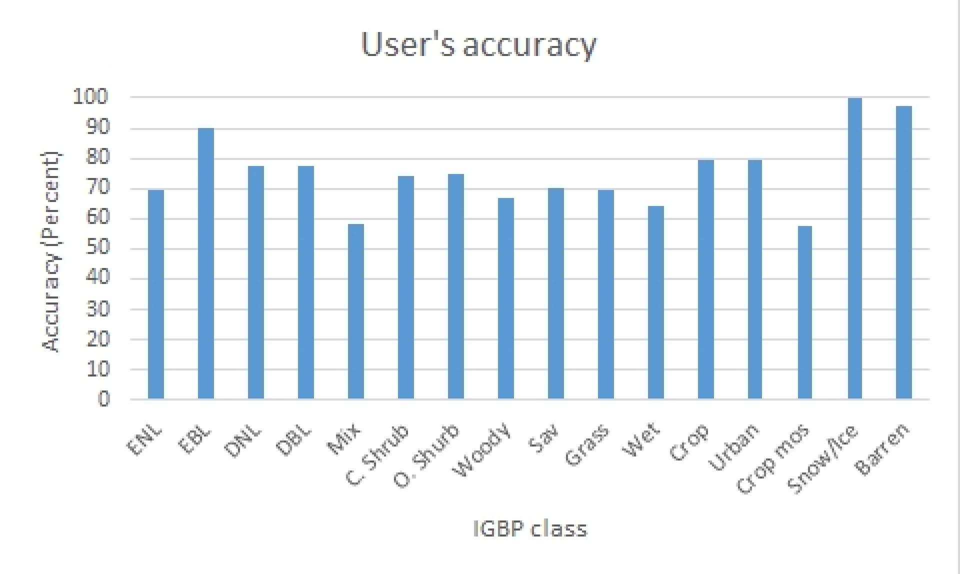
Evaluation of algorithm performance to specification requirements

- Cal/Val Activities for evaluating algorithm performance: Validation results
  - Producer's accuracy and user's accuracy





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Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs for QST-IP
  - Primary Sensor Data
    - TOA reflectance or surface reflectance data
  - Ancillary Data
    - Training samples from BU and agreement dataset (both from non VIIRS sources)
  - Upstream algorithms
    - Snow Cover EDR, Active Fire, Cloud Mask, TOC NDVI
  - LUTs / PCTs
    - EDR processing coefficients

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Evaluation of the effect of required algorithm inputs

- Evaluation of the effect of required algorithm inputs
  - Individual VIIRS acquisitions very noisy
    - Cloud/cloud shadow
  - Multi-stage compositing to remove/reduce cloud/shadow contamination
    - Cloud/shadow greatly reduced in 32-day and annual composites
    - Classification by pattern classifiers has high tolerance on residual bad data in the annual metrics
  - Other upstream EDR inputs look normal based on examinations of the quality flags

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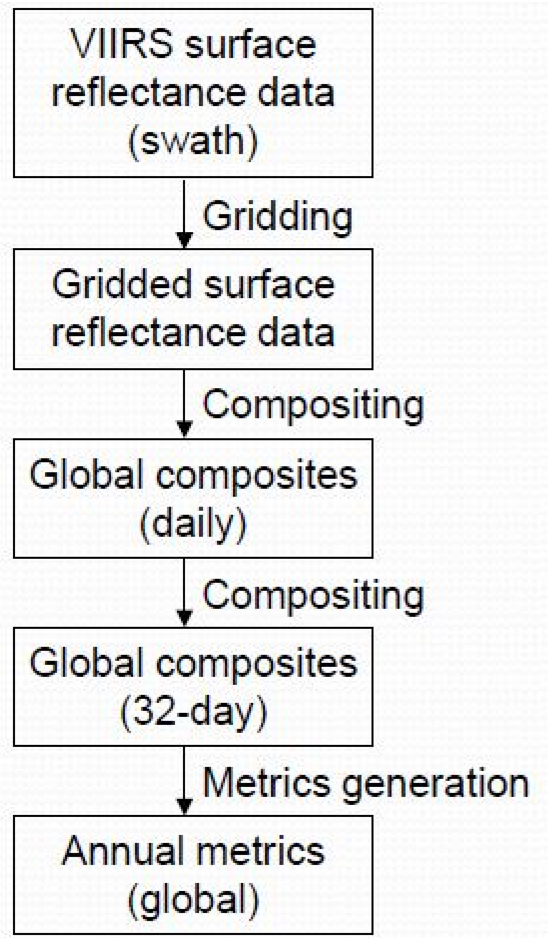
Evaluation of the effect of required algorithm inputs

- Evaluation of the effect of required algorithm inputs



- Only is QST-IP generation required reflectance data evaluated.
- A series of gridding, compositing and metrics calculation were performed in processing required reflectance input data, quality of individual reflectance has minimum impact on final annual metrics.
- The procedure is designed to filter out all kinds of noises, such as cloud and anomaly data, therefore, the algorithm has relatively high tolerance to negative effects of input data errors as long as their spectral resolutions are satisfactory.

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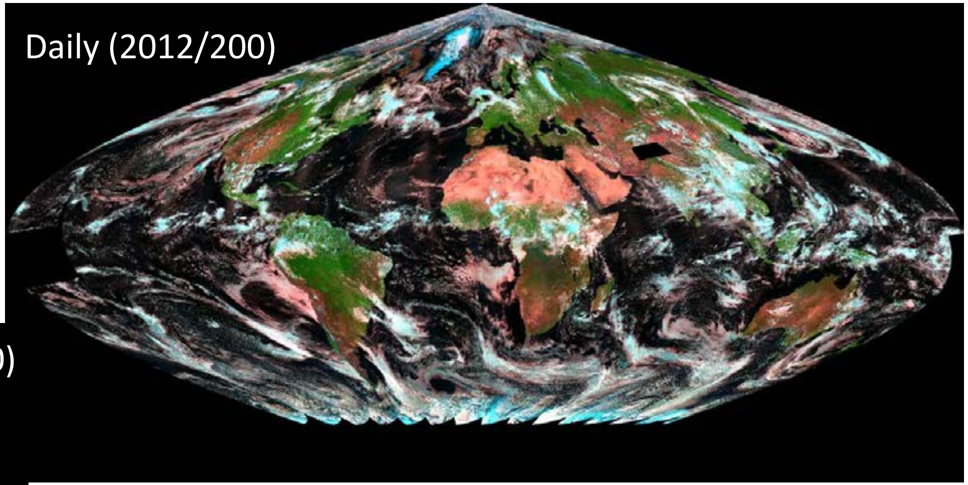
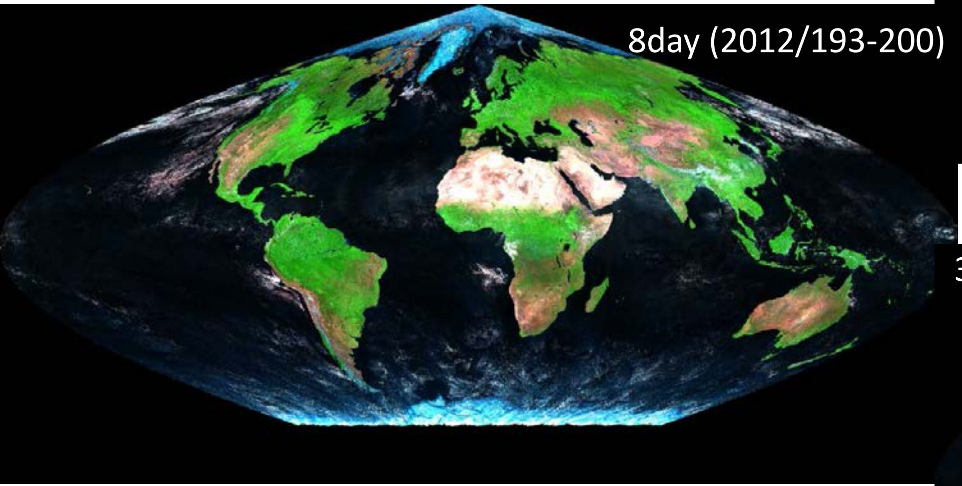
Evaluation of the effect of required algorithm inputs

- Evaluation of the effect of required algorithm inputs
  - Study / test cases

Cloud reduction through composting

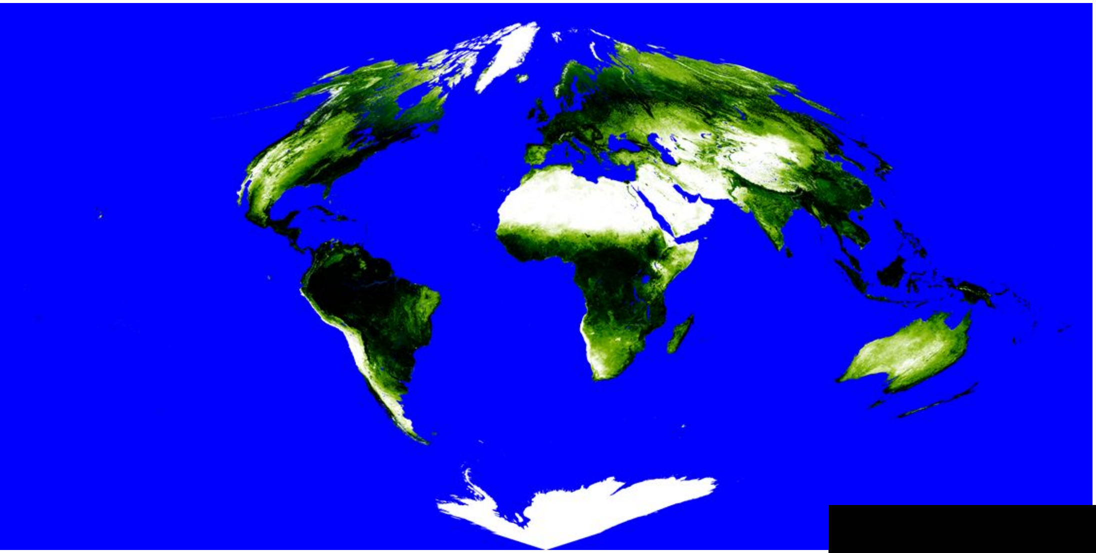


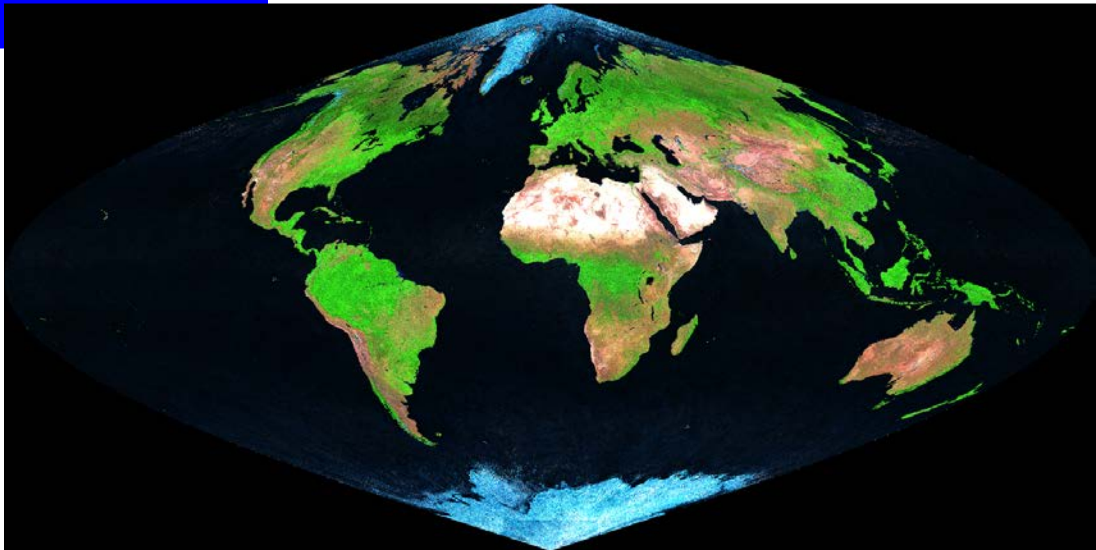


Evaluation of the effect of required algorithm inputs

Noises reduced further in annual metrics

2012 Median NDVI





Median of the Three Warmest 32-day Composites

Quality flag analysis/validation

- Defined Quality Flags (ST EDR)

Bit	Description	Result
0	Fire Detection in Pixel	1 = Fire 0 = No Fire
1	Snow/Ice in Pixel	1 = Snow 0 = No Snow
2	Vegetation in Pixel	1 = Vegetation 0 = No Vegetation
3-4	Cloud Confidence Indicatior	11 = Confident Cloudy 10 = Probably Cloudy 01 = Probably Clear 00 = Confident Clear
5	Excl – Sun Glint	1 = In Sun Glint 0 = Not In Sun Glint
6	Input Data Quality	1 = Degraded/Bad 0 = Good
7	Spare Bit	Initialized to 0

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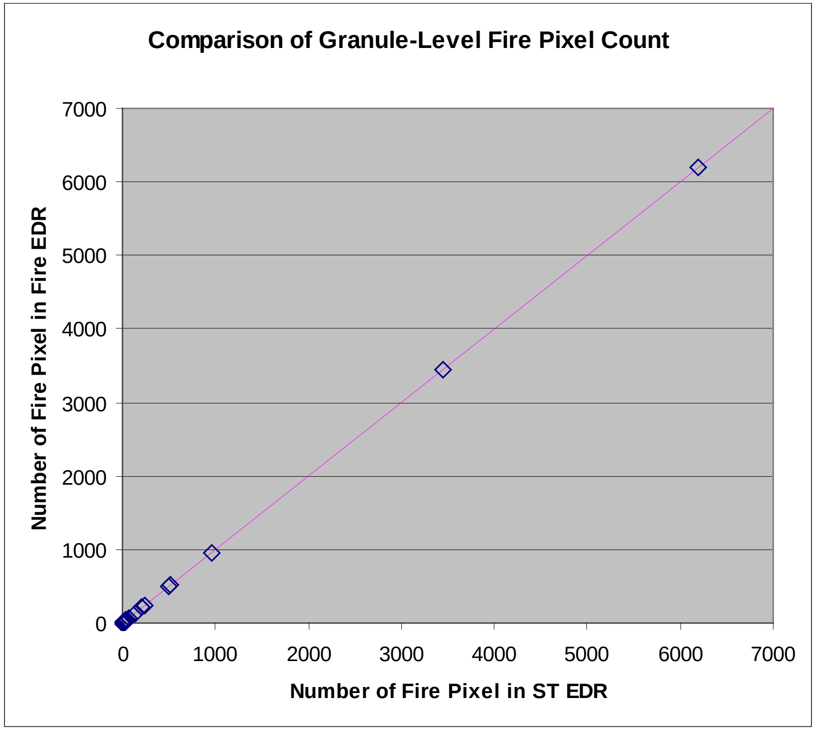
Comparison of Fire ARP and Fire QC flag in ST EDR

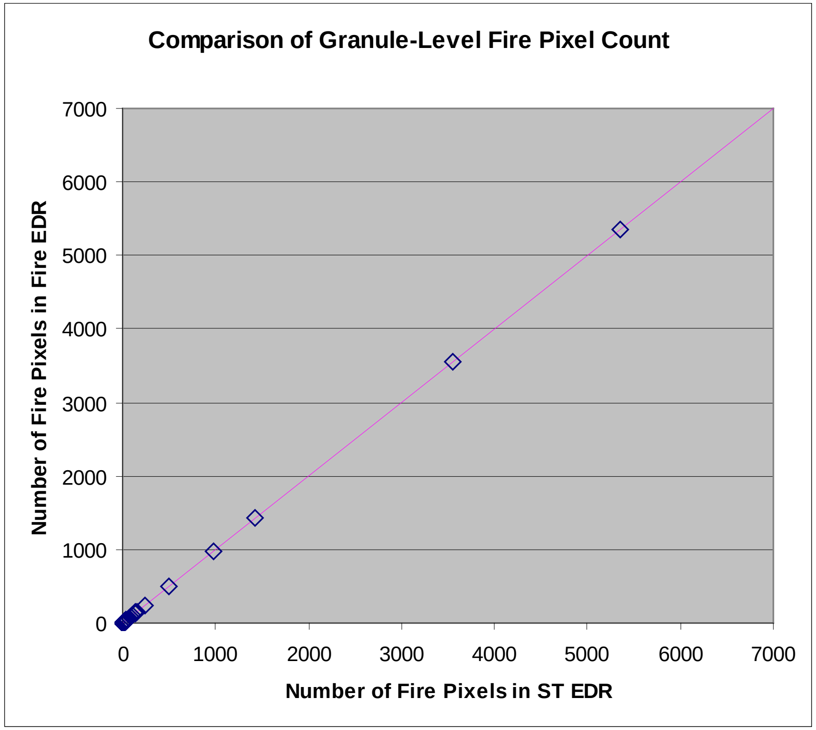
- ST EDR
  - Swath, 750 m @ nadir
  - Fire pixels has value of 1 in QC flag
  - From LPEATE's IDPS copy
- Fire ARP
  - Vector format showing location of fire pixels, no imagery product
  - From LPEATE's IDPS copy
- Data preparation for comparison
  - Convert Fire ARP vector file to imagery product (used in the following comparison)
  - Compare Fire ARP with fire flag in ST EDR

Granule Fire Pixel Counts Identical in ST EDR and Fire EDR

All Granules Acquired on 12/31/2012



All Granules Acquired on 02/05/2013



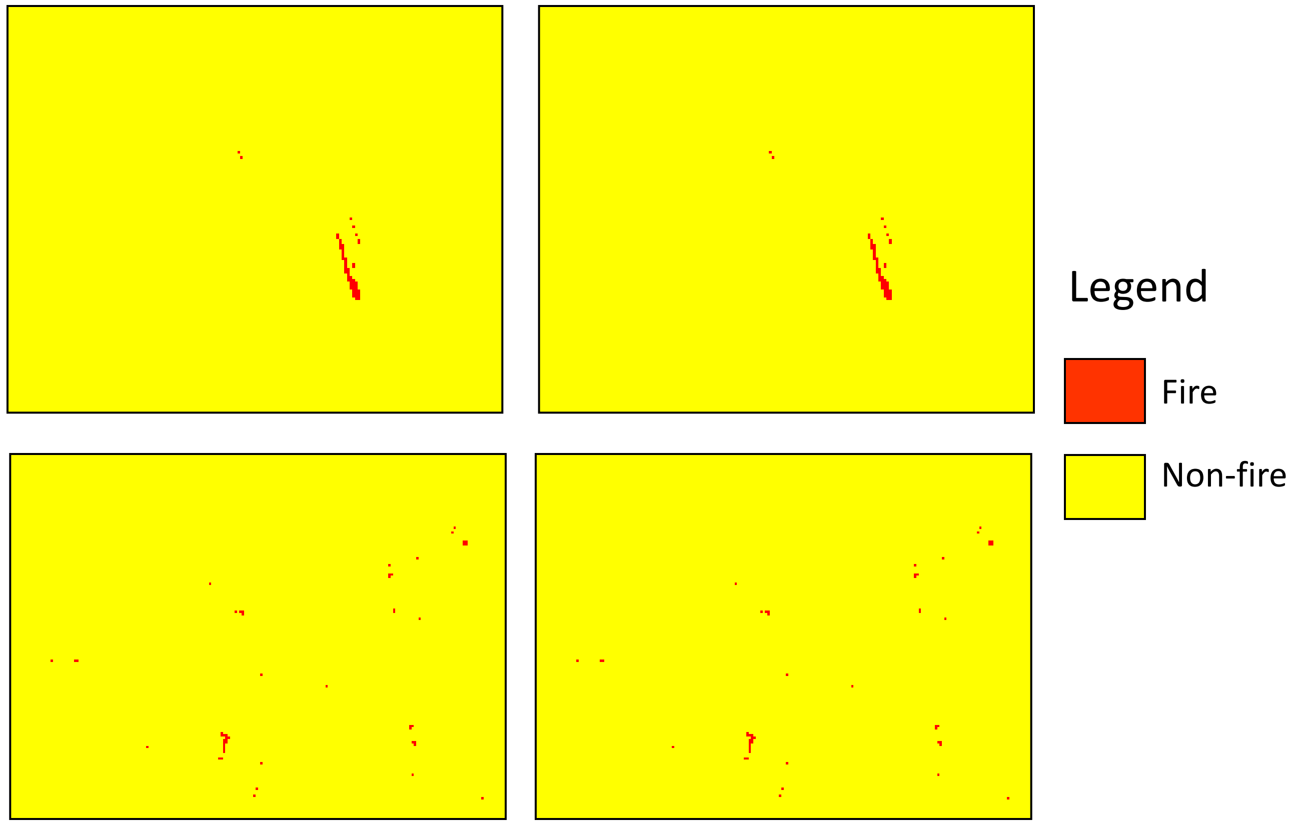
Each point represent one VIIRS granule

Zoom-in Comparison of Fire Flags

Fire ARP | Fire Flag in ST EDR

Algeria
Acquired @ 23:55
on 02/05/2013

El Salvador
Acquired @ 18:05
on 02/05/2013

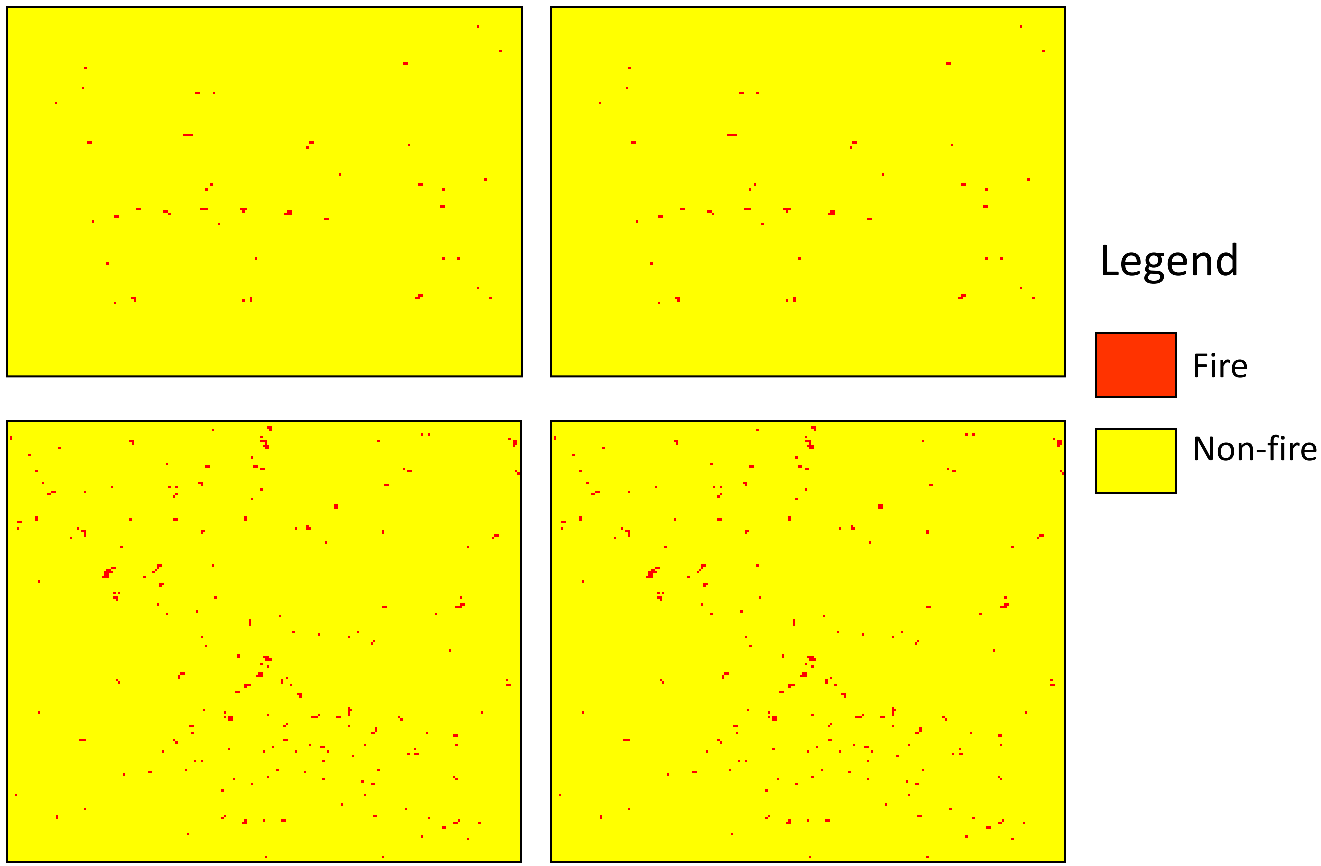


Zoom-in Comparison of Fire Flags

Fire ARP | Fire Flag in ST EDR

Nigeria
Acquired @ 12:35
on 12/31/2012

Scandinavia
Acquired @ 11:20
on 02/05/2013



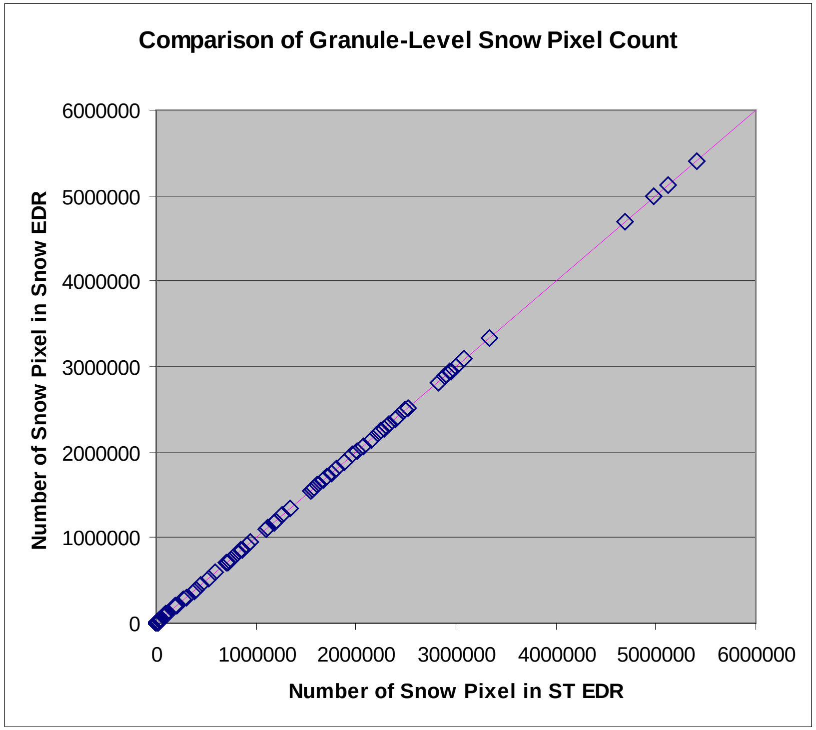
Comparison of Snow EDR and Snow QC flag in ST EDR

- ST EDR
  - Swath, 750 m @ nadir
  - Snow pixels has value of 1 in QC flag
  - From LPEATE's IDPS copy
- Snow EDR
  - Swath, 375 m @ nadir
  - From LPEATE's IDPS copy
- Data processing for comparison
  - Every 2 x 2 snow EDR pixels aggregated to match ST EDR pixels
  - If > 2 pixels in the 2x2 snow EDR window are snow, flag snow in the ST EDR
  - To avoid impact of resampling, comparison made in swath space

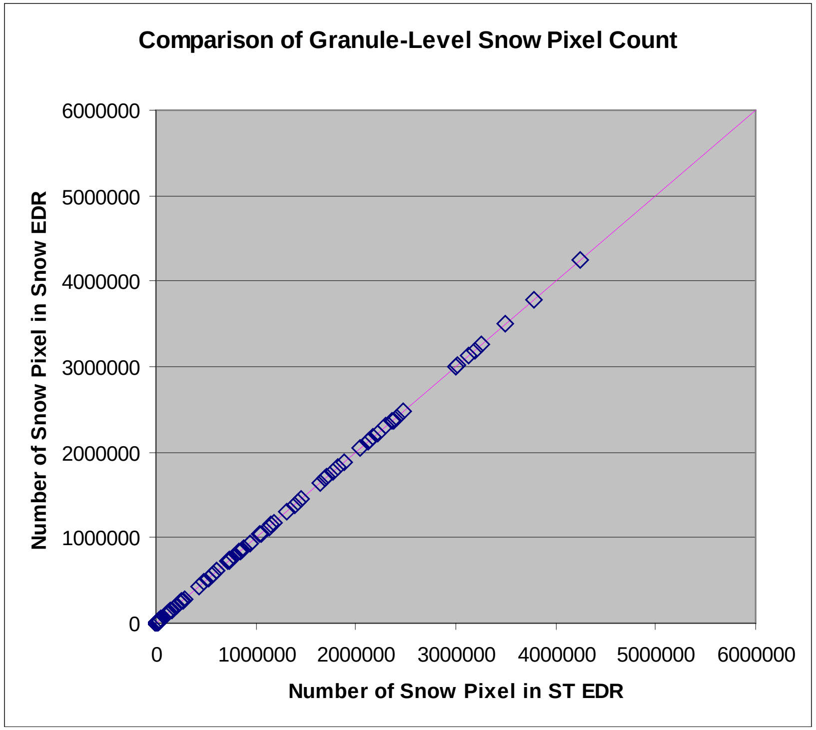
Quality flag analysis/validation

Granule-Level Snow Pixel Counts Near Identical in ST EDR and Snow EDR

All Granules Acquired on 12/31/2012



All Granules Acquired on 02/05/2013



Each point represent one VIIRS granule

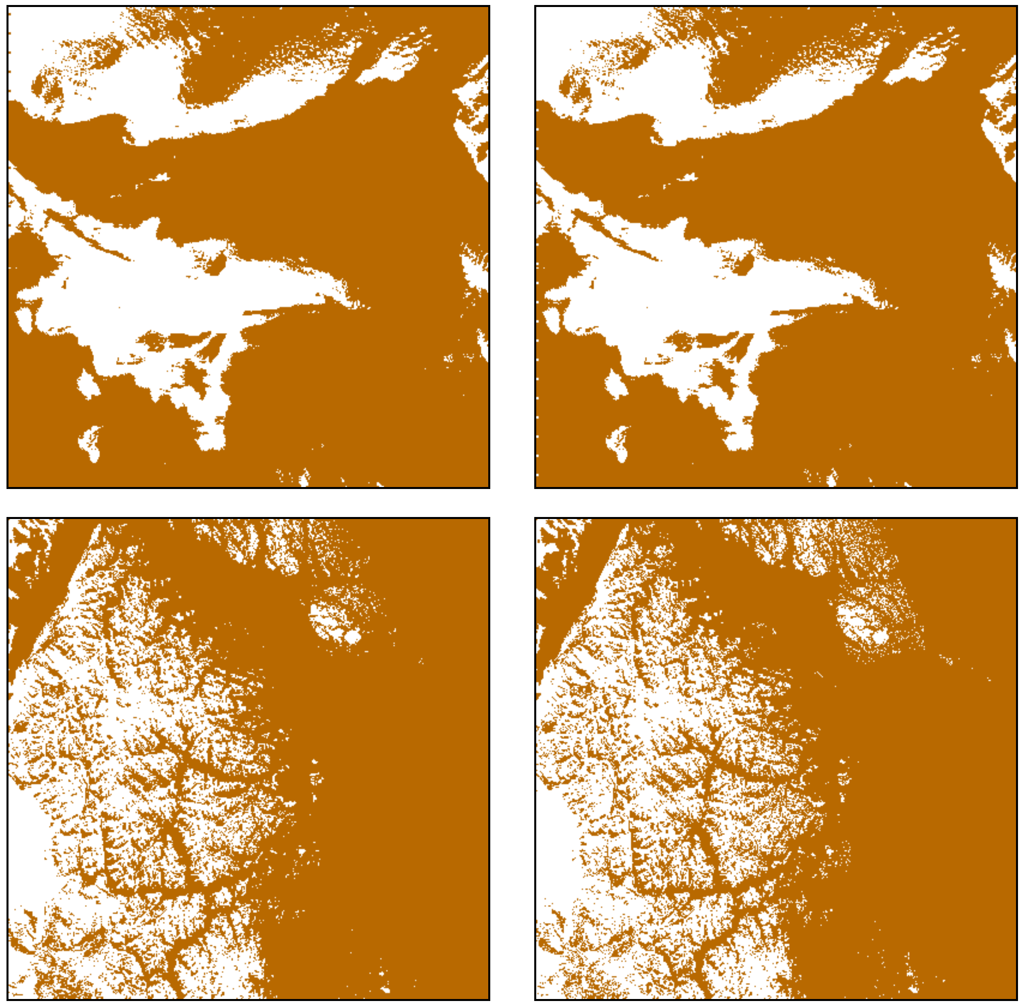
Quality flag analysis/validation

Detailed Comparison of Snow Flags in ST EDR and VIIRS Snow EDR

Snow in Snow EDR | Snow in ST EDR

North Antarctica
Acquired @ 08:50
on 12/31/2012

Eastern Siberia
Acquired @ 21:15
on 12/31/2012



Legend

Snow

Non-snow

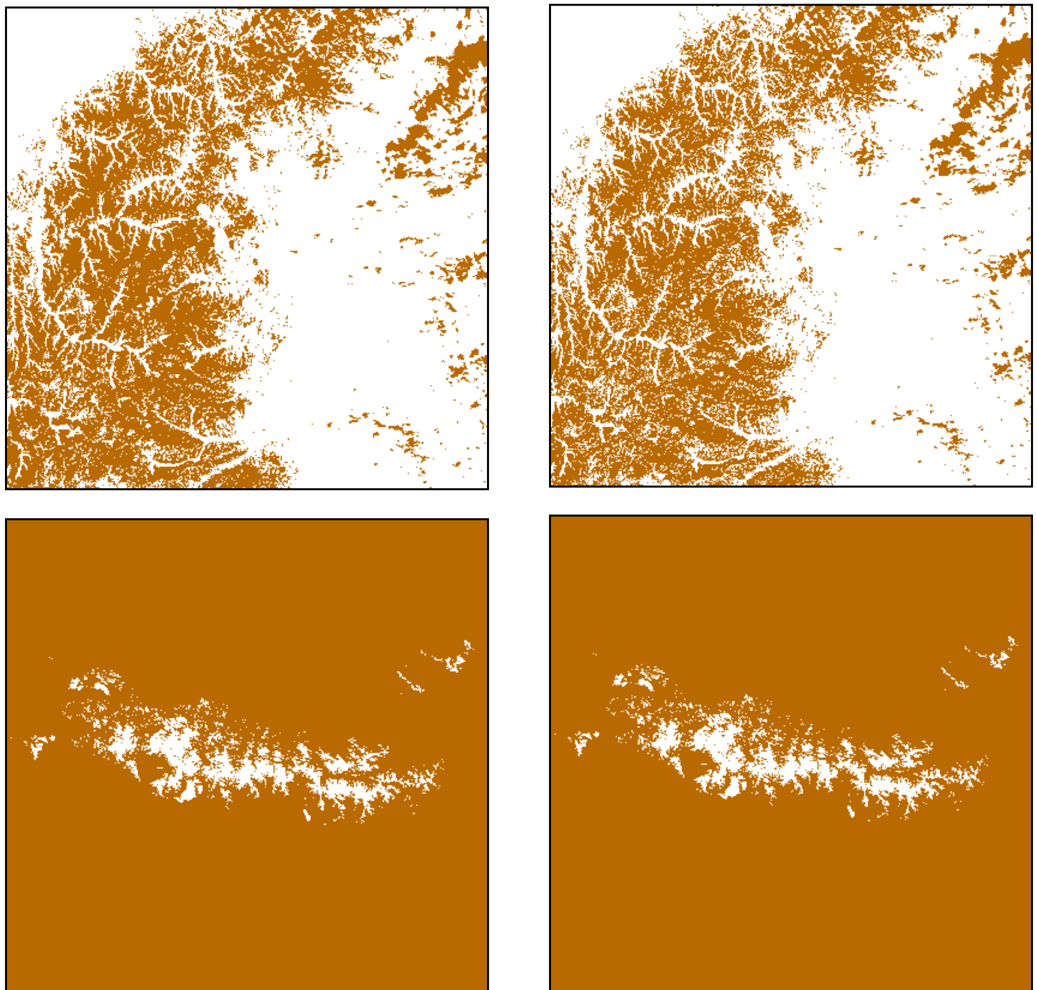
Quality flag analysis/validation

More Comparison of Snow Flags in ST EDR and VIIRS Snow EDR

Snow in Snow EDR | Snow in ST EDR

North of Baikal Russia
Acquired @ 04:45
on 02/05/2013

North Spain
Acquired @ 13:10
on 02/05/2013



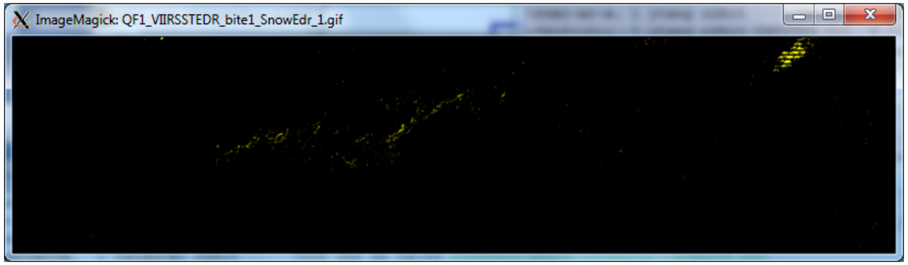
Legend

- Snow
- Non-snow

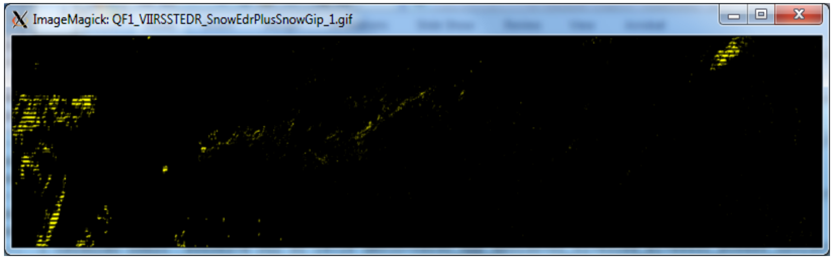
Quality flag analysis/validation

- Quality flag analysis/validation:
  - CCR-1264 approved in Oct 2013
    - Use IVSIC when Snow EDR not available

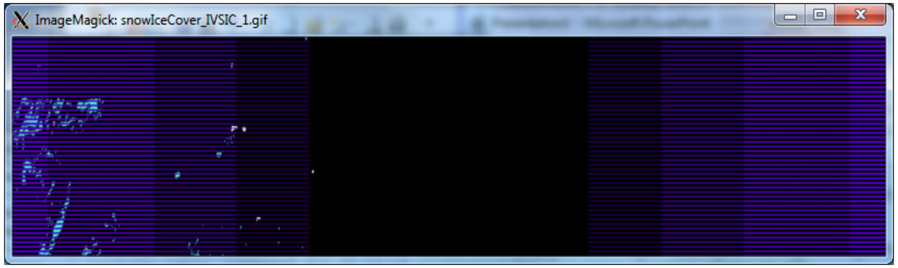
Baseline Surface Type output:
QF1, bit1: Snow (yellow) updated with SnowFraction EDR



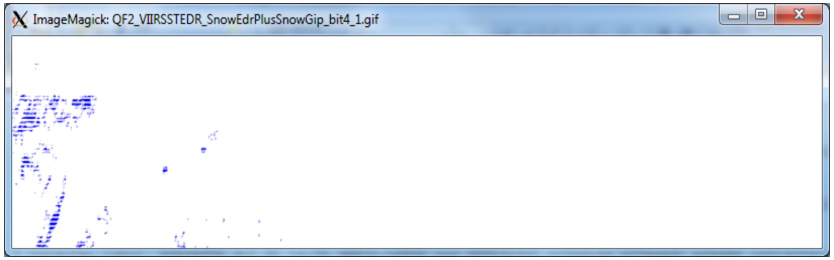
Proposed Surface Type output:
QF1, bit1: Snow (yellow) updated with GIP Snow (IVSIC)



GIP Snow (IVSIC) (blue)



Proposed Surface Type output:
QF2, bit4: Snow source: 0 (white) - SnowFraction EDR; 1(blue) - GIP Snow (IVSIC)



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Error Budget

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvement of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	L1RD Threshold	Analysis/Validation Result	Error Summary
Surface type classification accuracy	70%	73.92%	meets the L1RD threshold spec

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Documentation

- The following documents will be updated and provided to the EDR Review Board before AERB approval:
  - ATBD latest update Jan 29th, 2014
  - OAD last update Apr 30th, 2014
  - README file for CLASS provided in Nov, 2014
  - Product User's Guide (Recommended): document standard to be provided

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Identification of Processing Environment

- IDPS or NDE build (version) number and effective date
  - Mx8.5, Nov. 14, 2014
- Algorithm version
  - 1.O.000.004
- Version of LUTs used
  - NA
- Version of PCTs used
  - NA
- Description of environment used to achieve validated stage 1
  - Mx8.5

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Identification of Processing Environment

- VIIRS surface type EDR is produced in IDPS
- VIIRS QST IP:
  - It is an ancillary data layer (tiles) for VIIRS surface type EDR
  - Its production requires at least one whole year VIIRS gridded composited data of VI, BT and surface reflectance
  - MODIS experience proved that it could not be reliably and practically generated every three months
  - It will be generated once a year at science computing facility (STAR/University of Maryland) and delivered to IDPS by Algorithm Integration Team

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Users & User Feedback

- User list
  - Modeling studies
    - Land surface parameterization for GCMs
    - Biogeochemical cycles
    - Hydrological processes
  - Carbon and ecosystem studies
    - Carbon stock, fluxes
    - Biodiversity
- Feedback from users (*Primary user: NCEP land team led by M. Ek*)
- Downstream product list
  - Land surface temperature (direct)
  - Cloud mask, aerosol products, other products require global land/water location information (indirect)
- Reports from downstream product teams on the dependencies and impacts
  - No significant impacts reported from LST and VCM team

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Path Forward

- Planned further improvements of QST IP
  - Better compositing algorithm
  - Use multiple year data
  - More training data with better representative
  - SVM classification will replace C5.0 decision tree classification
  - Post-classification improvements
  - Name may be revised to "Global Surface Type"
- Potential improvement for ST EDR:
  - To include flags for standing water, burned area in addition to active fire and snow
  - To be used as an surface type change product as well as down stream product input

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Path Forward

- Planned Cal/Val activities / milestones
  - Validate SVM generated surface type EDR
  - Improve validation tool for next phase validation and long term monitoring
  - Develop quality flag monitoring tools

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Summary

- Surface Type EDR/QST IP Validation:
  - Overall accuracy from the new validation effort suggested that the classification accuracy on surface type intermediate product meets the required 70% correct rate.
  - Quality flags verified, no errors found.
  - Team recommends algorithm validated stage 1 maturity

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Thanks!

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Backup slides

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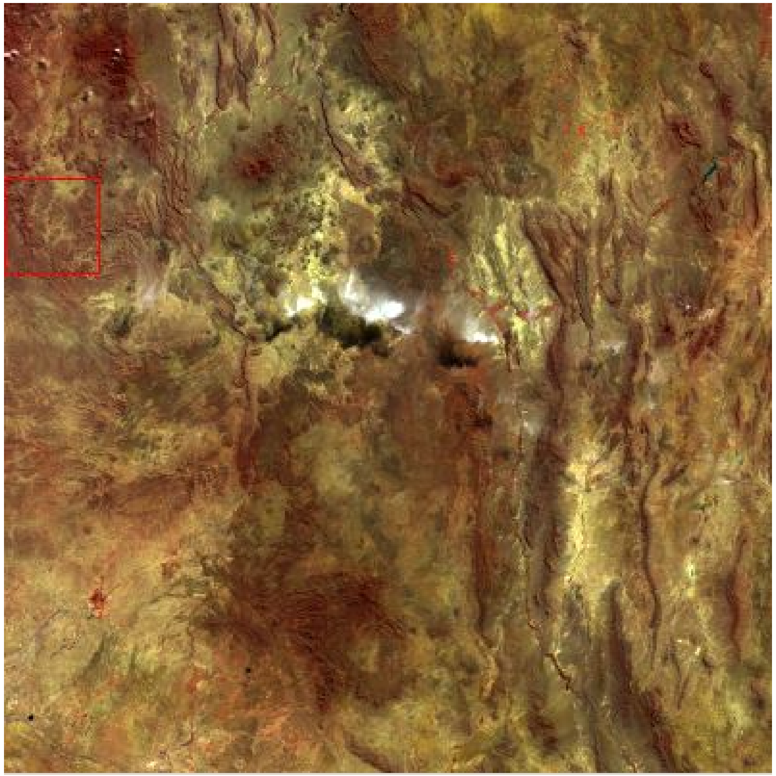
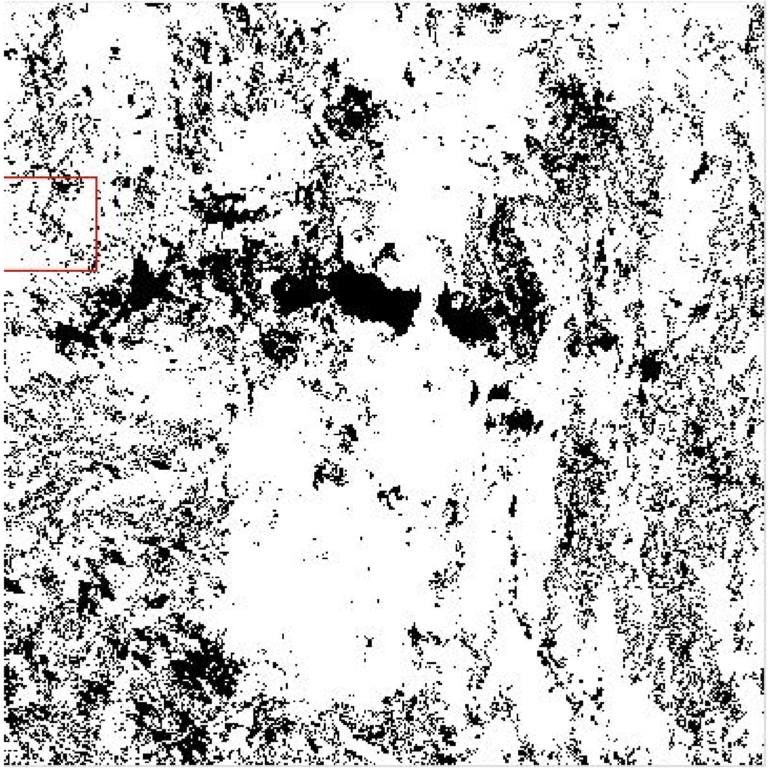
Quality flag analysis/validation

- Quality flag analysis/validation: example
  - Vegetation, validation successful



Nov. 18, 2014, M7, M5, M3 Composite over Texas/Louisiana area, USA



Extracted vegetation quality flag from VSTYO_npp_d20141118_t2000204_e2001446_b15854_c20141119022854205831_noaa_ops.h5

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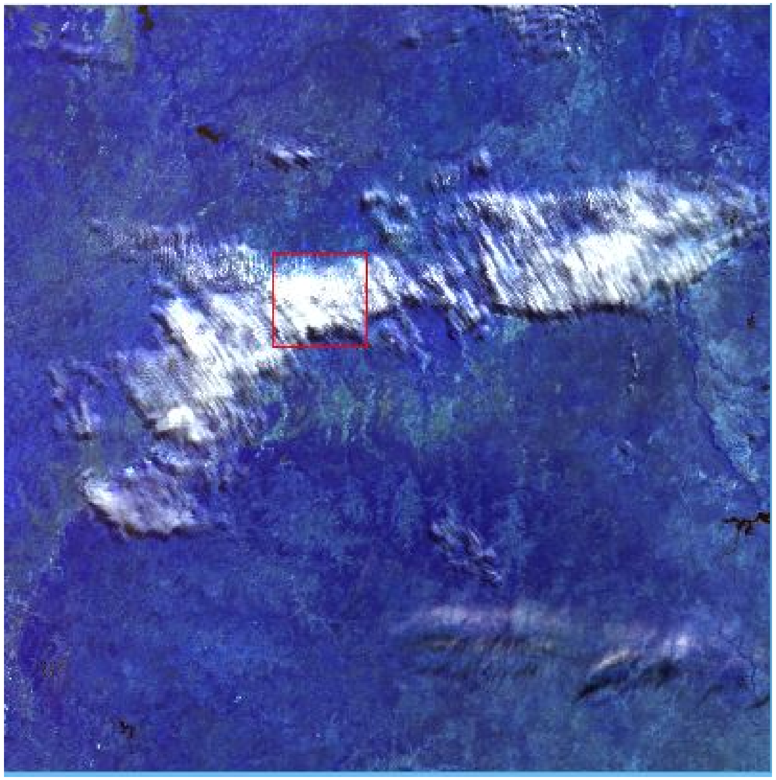
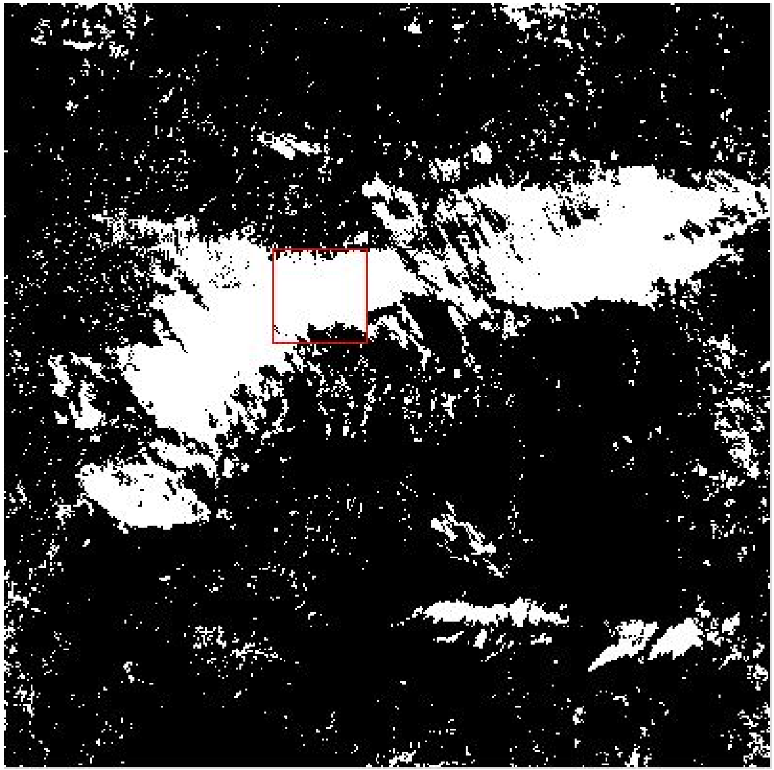
Quality flag analysis/validation

- Quality flag analysis/validation: example
  - Cloud cover, validation successful



Nov. 18, 2014, M3, M5, M7 Composite over Texas/Louisiana area, USA



Extracted cloud cover quality flag from VSTYO_npp_d20141118_t2000204_e2001446_b15854_c20141119022854205831_noaa_ops.h5

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Quality flag analysis/validation

- Quality flag analysis/validation
  - Analysis/validation results
    - Comparisons and analyses suggested all quality flags in documents have been implemented successfully in the ST-EDR, and no errors were found.
  - Analysis/validation plan for next validated stages
    - Quality flag monitoring tools will be developed to automatically check the flags.
    - Input data quality will be evaluated.

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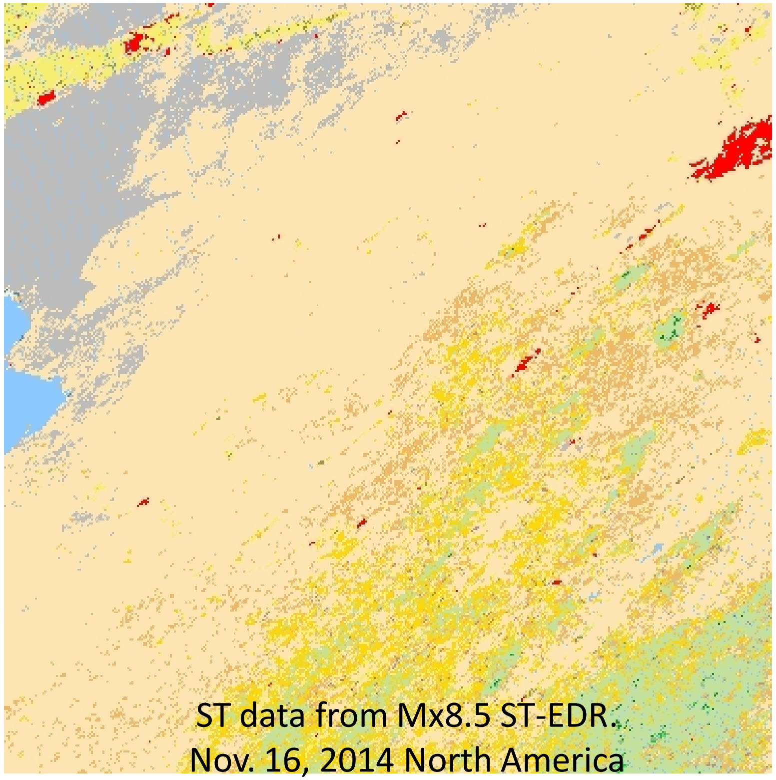
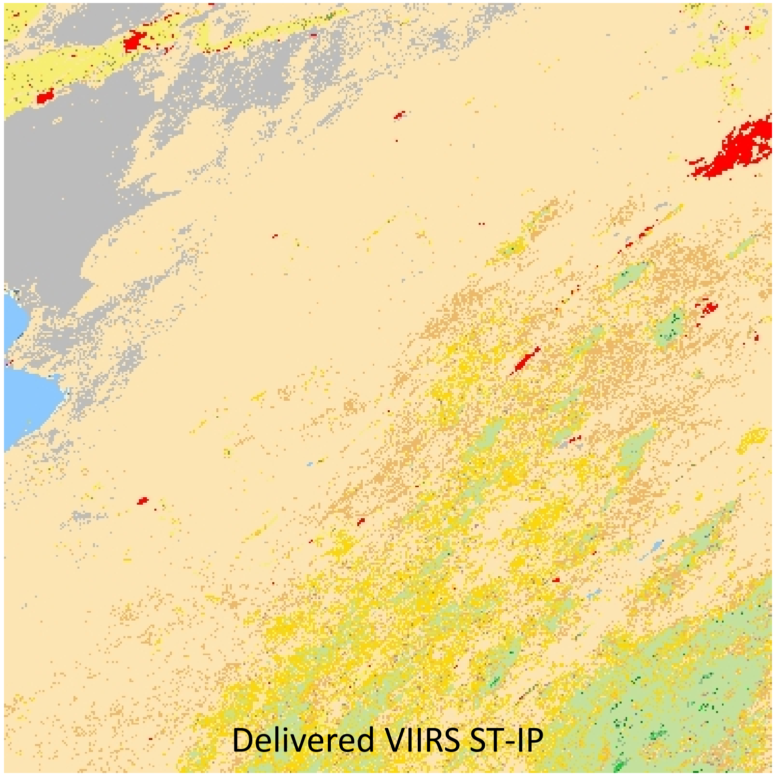
Identification of Processing Environment

- Mx8.5 ST data verification
  - Compare the operational produced ST EDR data with science team delivered ST IP data, should be identical





Comparisons suggest the delivered VIIRS based ST-IP has been implemented in Mx8.5