JPSS VIIRS Surface Type Products Development and Validation

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Team Members /Users

Product Team	Organization	Major Task
Xiwu Zhan	NOAA/STAR	Surface Type team lead, User outreach
Chengquan Huang	UMD/Geography	Algorithm development lead
Rui Zhang	UMD/Geography	Algorithm development, user readiness
Huilin Jin	UMD/Geography	Validation lead
Marina Tsidulko	STAR	Land Product Production Coordinator
Ivan Csiszar	STAR	Land Team Lead

Users	Organization	Usage
Bob Yu/Ivan Csiszar	NESDIS/STAR	NOAA VIIRS LST, fire and albedo product input
Michael Ek	NWS/NCEP	Noah land surface model input
Brian Cosgrove	NWS/NWC	Hydrological model input
Mike Barlage	NCAR/RAL	Land surface model input
Ranga Myneni	Boston University	NASA MODIS & VIIRS LAI product input
Others	Univ/gov research/operations	Inputs for most hydrological and ecological models

Requirement Summary

Global Surface Type 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		

Background

- **Products:**
  - Surface type is one of the most essential inputs of many land surface models (weather, climate, hydrology, ecology, etc)
  - Surface type is mostly static (e.g. forests, cities) within a time period (e.g. one to a few years)
  - but may also change sometimes (e.g. snow cover, flooding, burning, deforest, reforest, urbanization, etc)
- **Challenges:**
  - Static surface types are identified or distinguished from each other through their spectrum trajectories in optical satellite observations
  - Accurate training data (prior knowledge), classification metrics based on previous year observational data, and classification algorithm are required to generate a static surface type map
  - Near real time surface type conditions need to be identified with current day observations of spectrum signatures

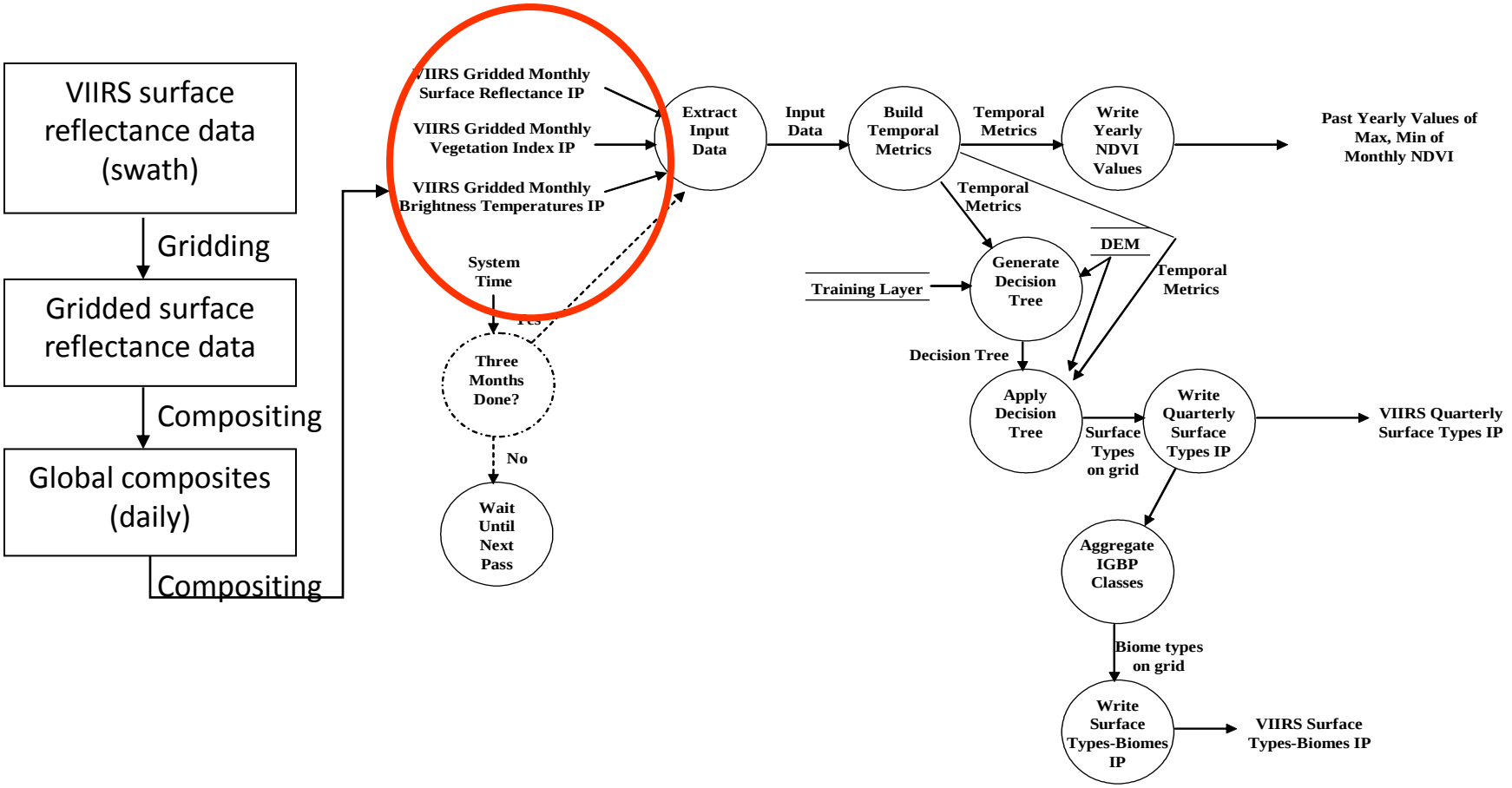
Current Operational Product

- ✓ Current Gridded Global Surface Type ancillary data:
  - Generated annually based on at least one full year data
  - Generated at 1km Sinusoidal grid
  - Reproject/resampled to other projection/resolutions
  - IGBP 17 type classification scheme as L1RD required
- ✓ Users:
  - Input for NWS NWP models
  - Input for models of weather, climate, hydrology, ecology, etc
- ✓ Pros:
  - Reflect surface type situation based on last year data
  - Offline production convenient for post processing after classification algorithm (Decision Tree, now Support Vector Machine – SVM)
  - Directly disseminated to users only once a year
- ✓ Cons:
  - Offline preparation of gridded/composited classification metrics is tedious
  - Does not have surface type change information (e.g. flood, fire, snow, deforestation, urbanization, reforestation, etc)

Current Operational Product

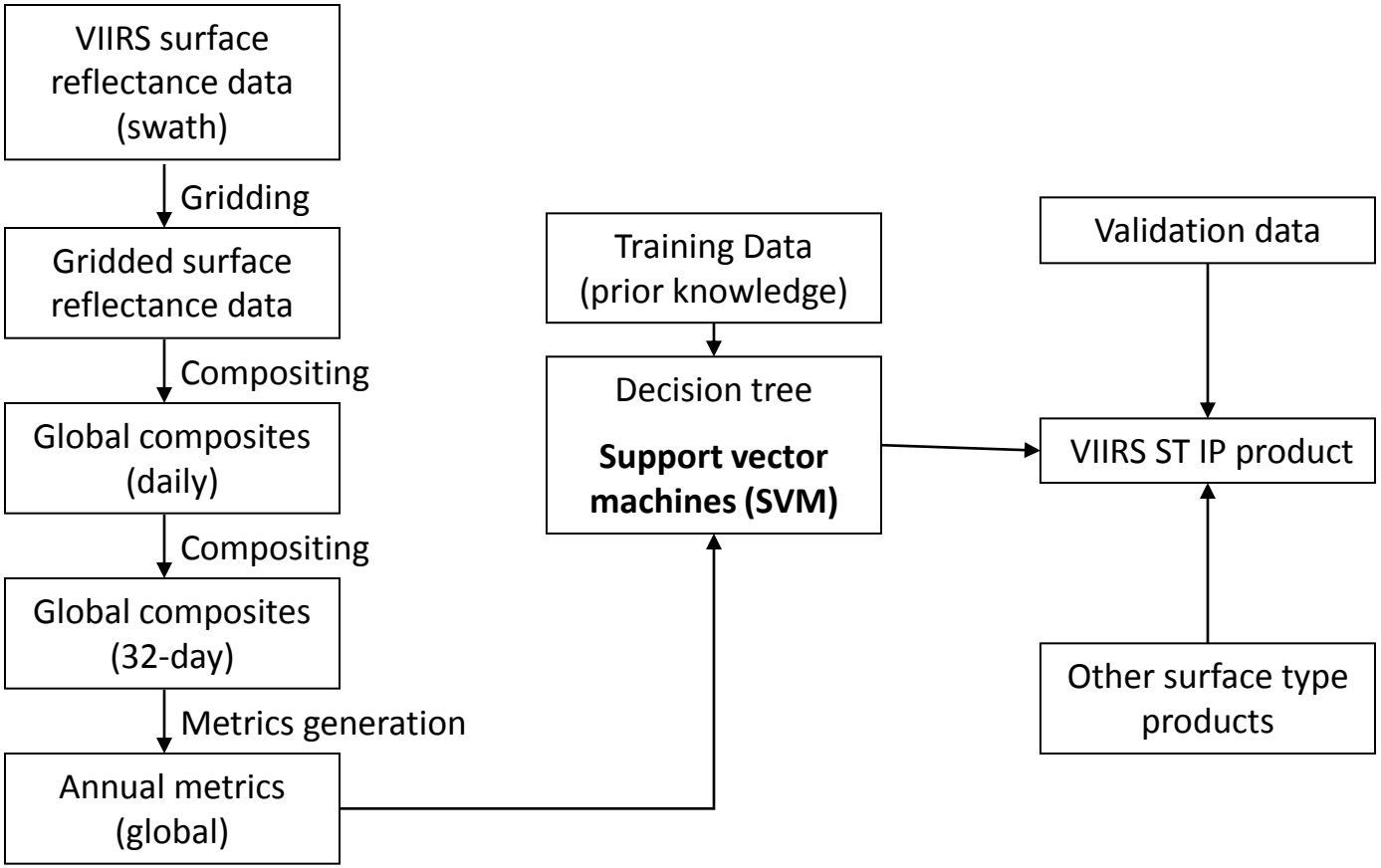
Data Flow of Global Surface Type Product

(IDPS version/design)



Offline Production for SNPP & J-1

Data Flow of Global Surface Type Product Planned for J-1

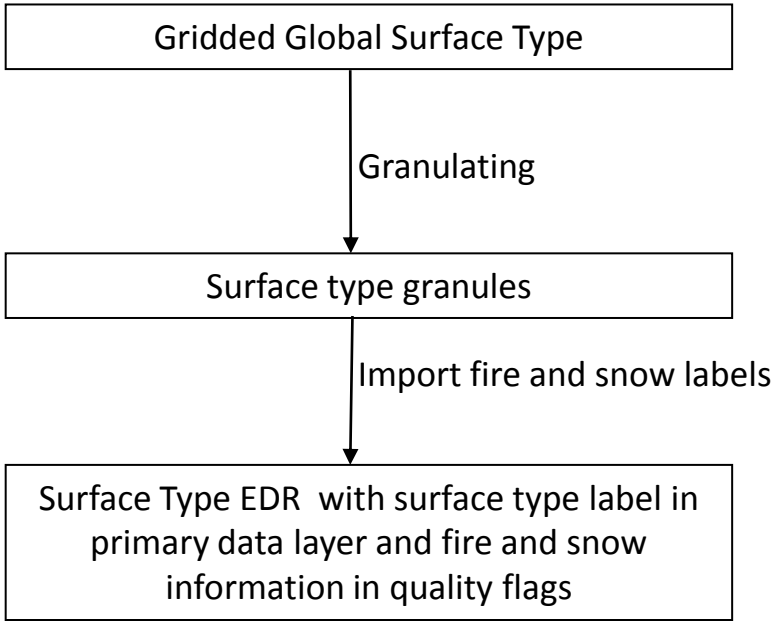


Current Operational Product

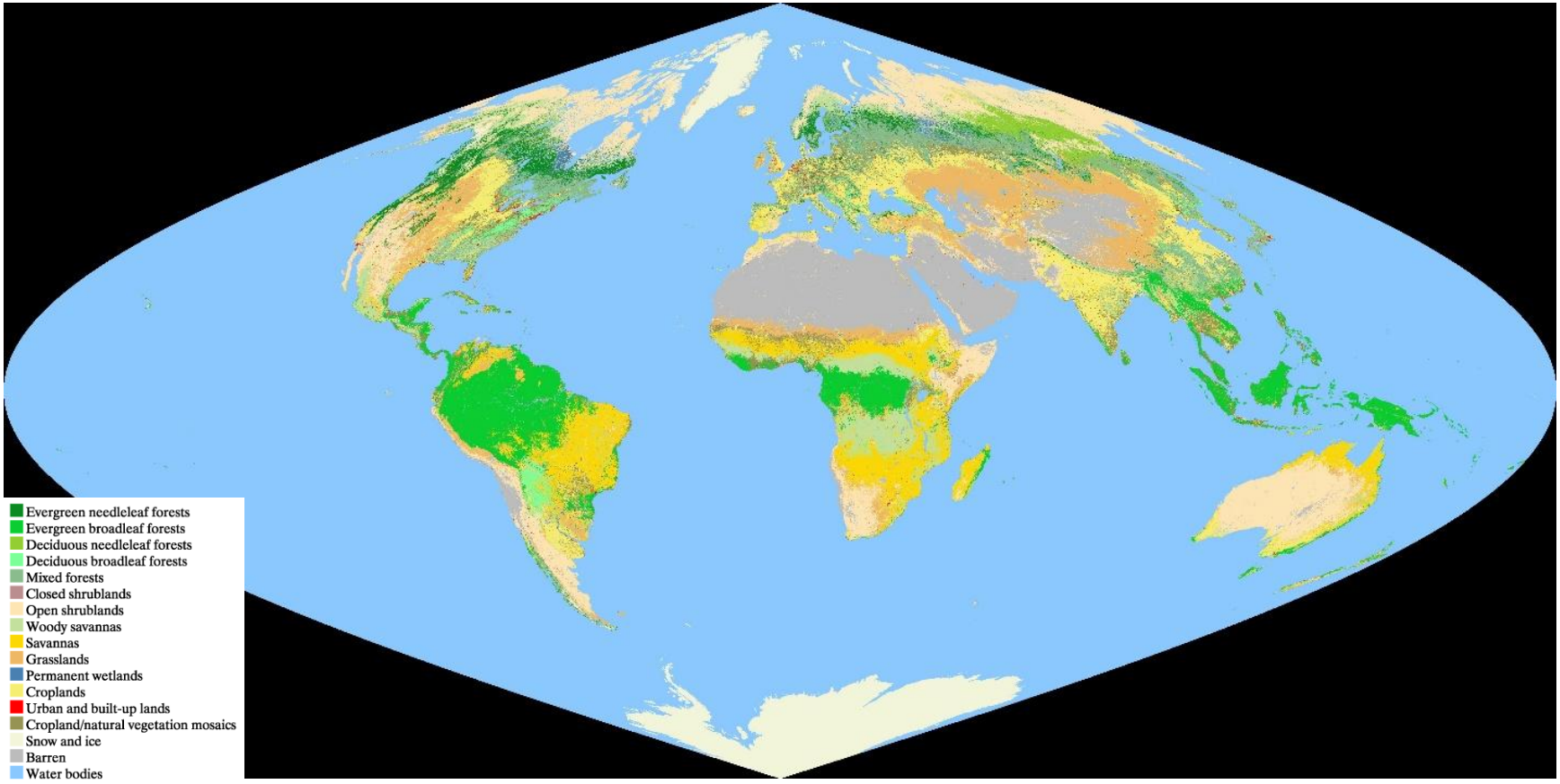
- ✓ Current IDPS generates VIIRS Surface Type EDR:
  - Produced for every VIIRS swath/granule
  - Same geometry as any VIIRS 750m granule
  - Has two major components:
    - Gridded Global Annual Surface Type ancillary data input
      - Remapped to the swath/granule space for each VIIRS acquisition
      - Developed offline at science computing facility
      - Requires one full year of VIIRS data
      - Requires accurate training data, classification metrics and classifier
      - Requires intensive post processing after classification algorithm
    - Includes flags to indicate snow and fire based on
      - Active fire Application Related Product (ARP)
      - Snow EDR
- ✓ Users:
  - VIIRS LST EDR based on current algorithm
  - Modelers requires surface type as essential input
- ✓ Pros:
  - Swath/granule files convenient for LST EDR production
- ✓ Cons:
  - Other users require global gridded products of current surface type status

Current Operational Product

Data Flow of IDPS Surface Type EDR

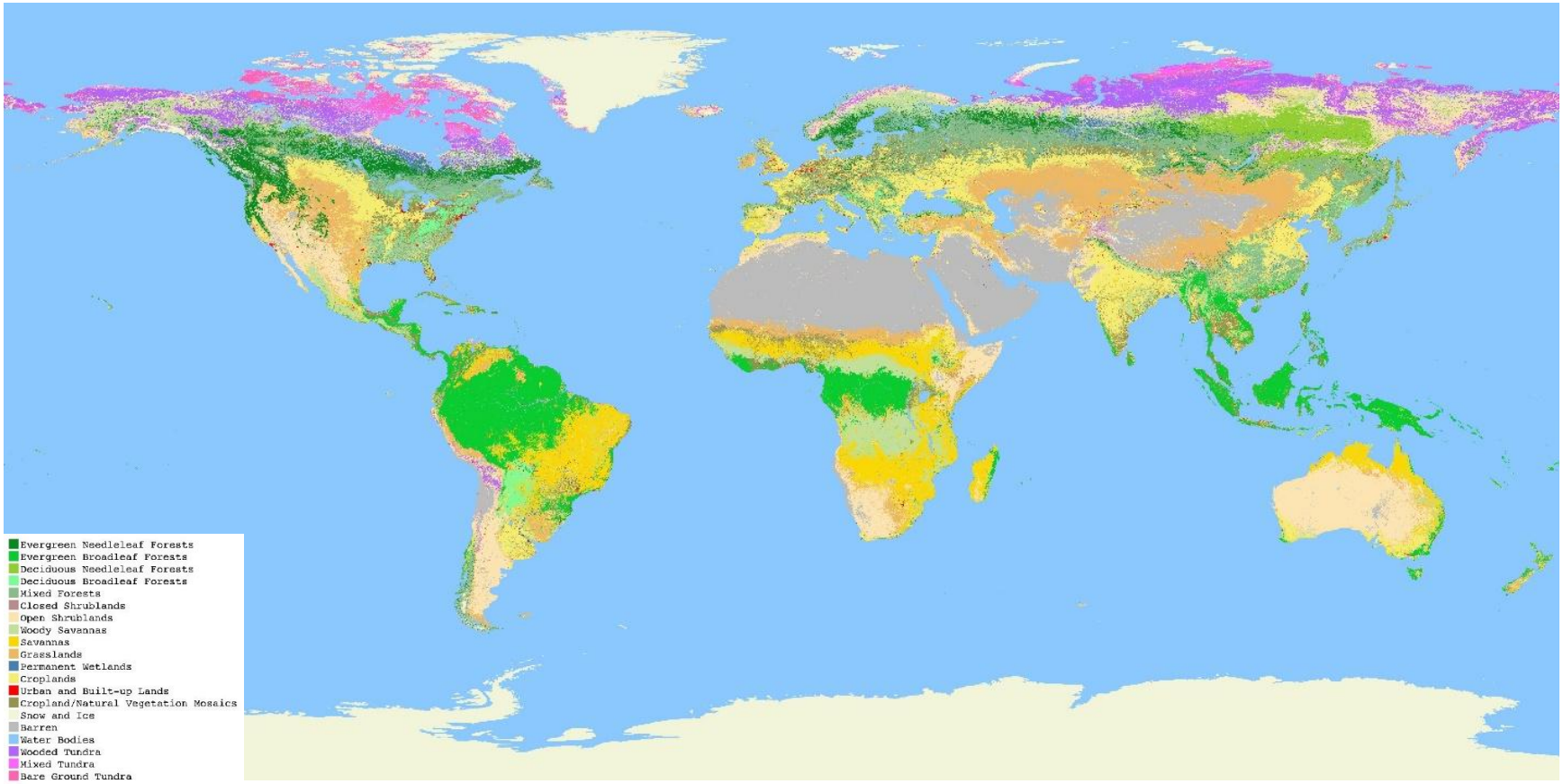


Global gridded annual surface type map



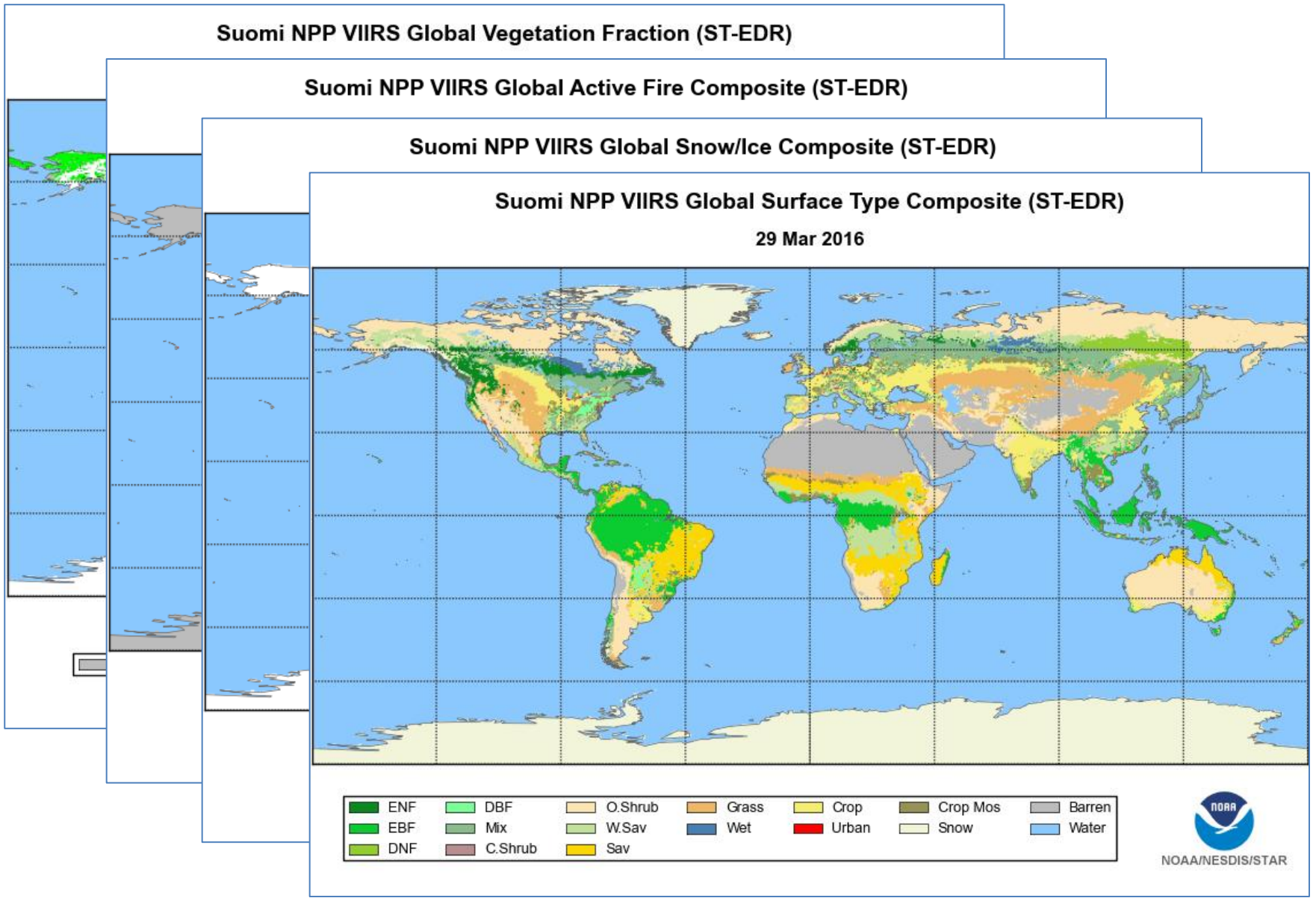
- Based on 2014 SNPP VIIRS data, IGBP legend
- ftp://vct.geog.umd.edu/st

Global geographic surface type map



- For NCEP use, 20 types.
- ftp://vct.geog.umd.edu/st

Current IDPS ST EDR Products

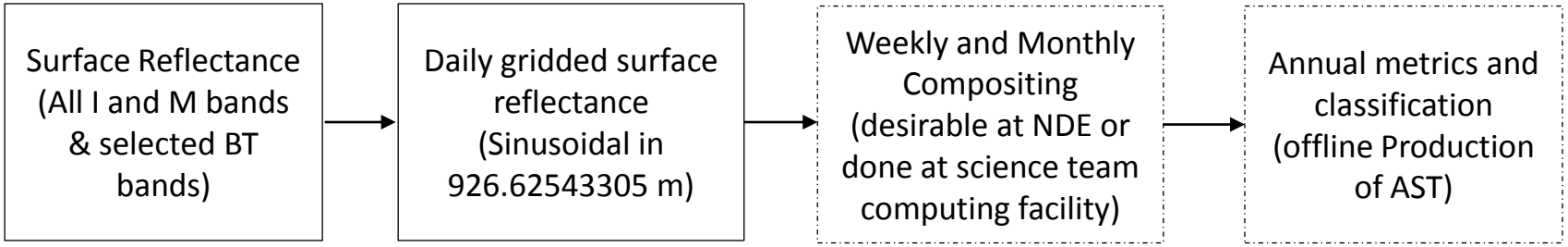


Development Strategy for NDE Production

- NDE surface type product development strategy:
  - Remove granule surface type EDR if LST will not use the granule files
  - Keep production of annual gridded global surface type product offline at science computing facility
  - Develop a surface type change indicator/integrator product (current land surface condition) for users and integrate surface type information for consistency check of other land products like albedo, LST, fire, burned, etc

High Level Process Flow

- Flowchart of proposed processing procedure:



  - Daily surface reflectance in Sinusoidal projection should be provided by the NDE.
  - Weekly or monthly composite in NDE is desirable for offline surface type production of science team.

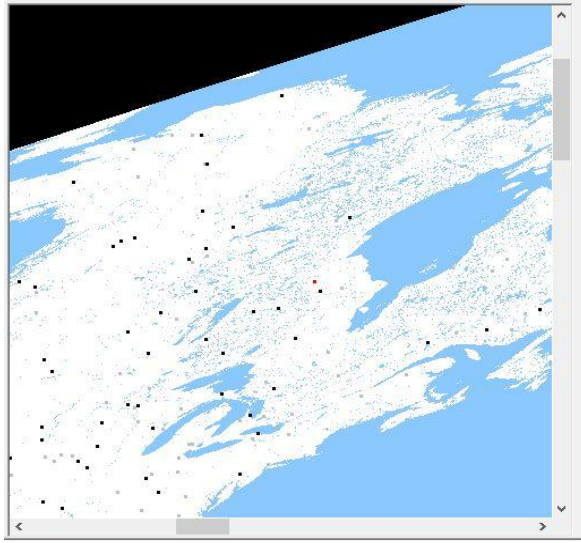
- What instruments will this algorithm support?
  - AVHRR, MODIS, SNPP-VIIRS, J1/2/3-VIIRS, etc.

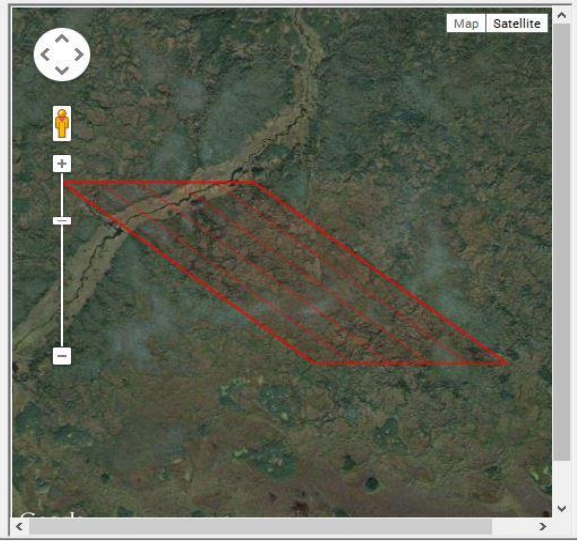
Testing and Validation (1/2)

- How will product be tested/validated
  - Validation against global surface type validation dataset, in which thousands of validation points were visually interpreted as the ground truth.
  - Error matrix and overall accuracy are generated to evaluate the quality of a generated surface type product.
  - Comparison with existing similar maps, such as existing S-NPP VIIRS surface type map, and MODIS Land cover map.

Testing and Validation (2/2)

- An integrated interactive validation data collection tool has been developed for validation.
- Approximate 5000 pixels were generated and updated annually based on stratified random sampling.
- 73.92% of overall classification accuracy has been obtained, which exceeds 70% requirement.





	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

Schedules and Milestones

Annual gridded global surface type		2016				2017				2018			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
2015 GST	Data collection												
	Data composite, metrics generation												
	Classification												
	Validation and delivery												
2016 GST	Data collection												
	Data composite, metrics generation												
	Classification												
	Validation and delivery												
2017 GST	Data collection												
	Data composite, metrics generation												
	Classification												
	Validation and delivery												

- Global gridded surface type classification map is an annually generated ancillary data set, a new map for previous year will be produced and delivered at the end of a calendar year.

Risks and Review Items

- Potential risks including user impact
  - Surface type mapping could have errors if most current data are not used:
    - Daily surface type change indicator/integrator using current day/week observations could mitigate the risk
  - Land surface models using wrong surface type (e.g. most recently changed surface type) could have errors if the changed surface type information is not recognized:
    - Model parameters for flooded, burned, snow covered, deforested, reforested, urbanized areas are different from those based on the old surface type label
  - There is no risk or extra cost if a place holder is created for a future daily surface type change indicator/integrator product in the NDE land gridding/compositing module

Enterprise algorithm path forward

Product	VIIRS	AVHRR	MODIS	GOES-R	Users
Surface type	O	O	O	F	NCEP/NWS

O – current or past operation, F – potential future capability

Path Forward for Enterprise Solution:

- AVHRR land cover was created by UMD
- MODIS land cover products were created by Boston University
- SNPP-VIIRS surface type products are currently operational
- J1/2/3-VIIRS surface type products will be developed using similar algorithm
- Surface type change indicator products could be generated for above satellite sensors using “change vector” algorithms

Summary

- Recommendations
  - Keep the production of the global gridded annual surface type (AST) data product offline at science computing facility
  - Daily gridded surface reflectance data for all VIIRS land channels are required for several land data products including surface type. Centralized daily gridding, product archiving, and direct access to the gridded products at NDE for users are more efficient and reliable than each team's separate processing
  - Surface type change data are needed for some users and could be generated as a daily surface type change indicator/integrator product in the future
- Outstanding issues
  - None.