JPSS STAR Science Team Annual Meeting
Surface Type

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BU Team: Mark Friedl, Damien Sulla-Menashe

May 14, 2014

Outline

- Overview
  - Products, Requirements, Team Members, Users, Accomplishments
- Surface Type Algorithm Evaluation:
  - Algorithm Description
  - Validation Approach and Results
  - Challenges, New Progress, Next Steps
- Plans JPSS-1 and Future Missions
- Summary

Overview

- VIIRS Surface Type
  - Describe surface condition using 17 IGBP classes
  - Two groups of products
    - QST IP:
      - Generated quarterly using 12 months VIIRS data
      - Continuity with NASA EOS MODIS and NOAA POES AVHRR land cover products
    - EDR:
      - Provides type info for each VIIRS overpass
      - QST IP updated for fire and snow
  - Required accuracy is 70%

Overview-continue

- Product users:
  - Essential Climate Variable
    - Modeling studies
      - Land surface parameterization for GCM
      - Biogeochemical cycles
      - Hydrological processes
    - Carbon and ecosystem studies
    - Biodiversity
  - Feed to other VIIRS products
    - BRDF/Albedo
    - Land surface temperature (LST)

Overview-continue

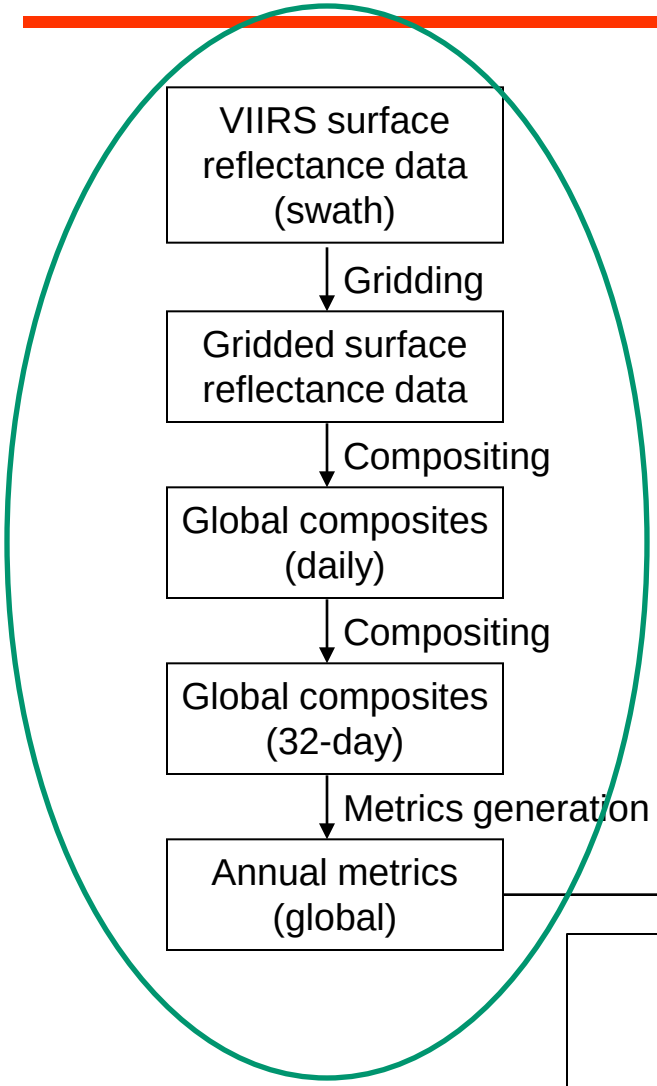
- Team member:
  - STAR: Xiwu Zhan, Task Lead
  - UMD: Chengquan Huang, Rui Zhang
  - BU: Mark Friedl, Damien Sulla-Menashe

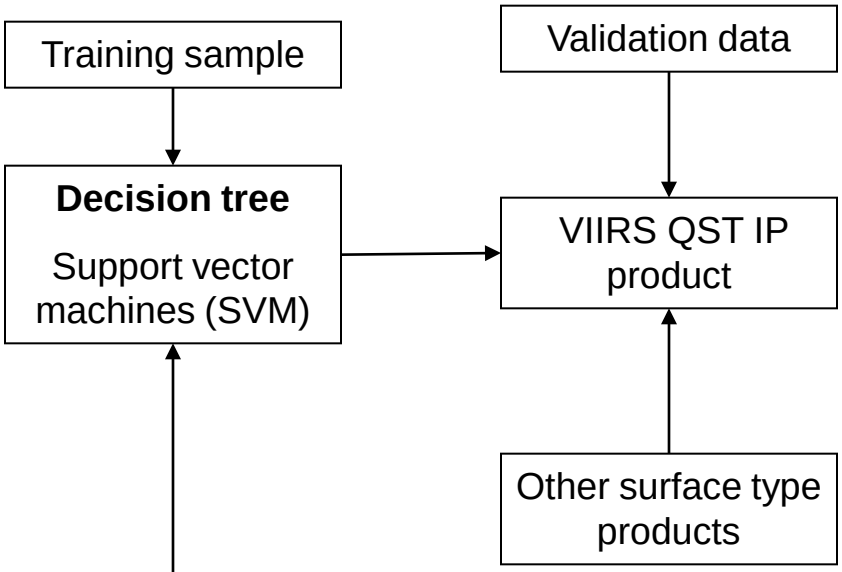
- Accomplishment:
  - ST EDR beta maturity passed
  - QST IP provisional maturity delivery (in progress),
  - Preliminary validation,
  - Recent improvements: product derived using a new alternative algorithm Support Vector Machines (SVM).

Algorithm Evaluation

- Algorithm Description:
  - ST-EDR is primarily based on QST-IP updated with snow/ice and fire flags.
    - Passed beta maturity review
  - The QST-IP is generated using C5.0 decision tree algorithm from one full year's (2012) surface reflectance data.
    - Provisional delivery in progress
- Validation approach and dataset:
  - Use an independent global validation dataset
    - stratified random sample of 500 blocks, 10-35 VIIRS 1km pixels per block
    - 17 IGBP classes
    - "Truth" determined by human interpretation of available high resolution images.

VIIRS QST IP Generation



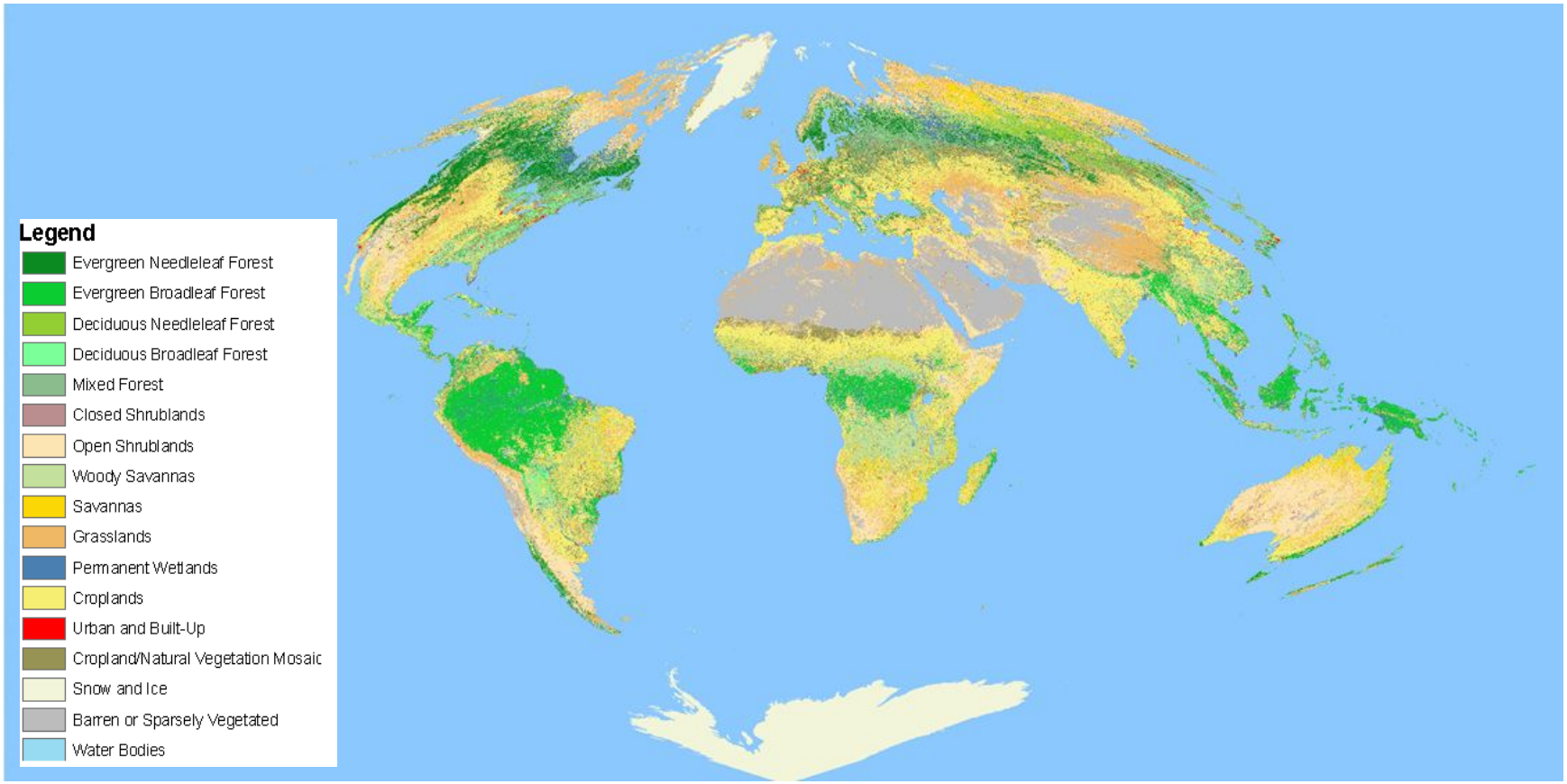


All 2012 VIIRS data required by QST IP processed at UMD:

~880,000 files (80,000 granules x 11 bands), totaling ~150 TB

> 30,000 CPU hours

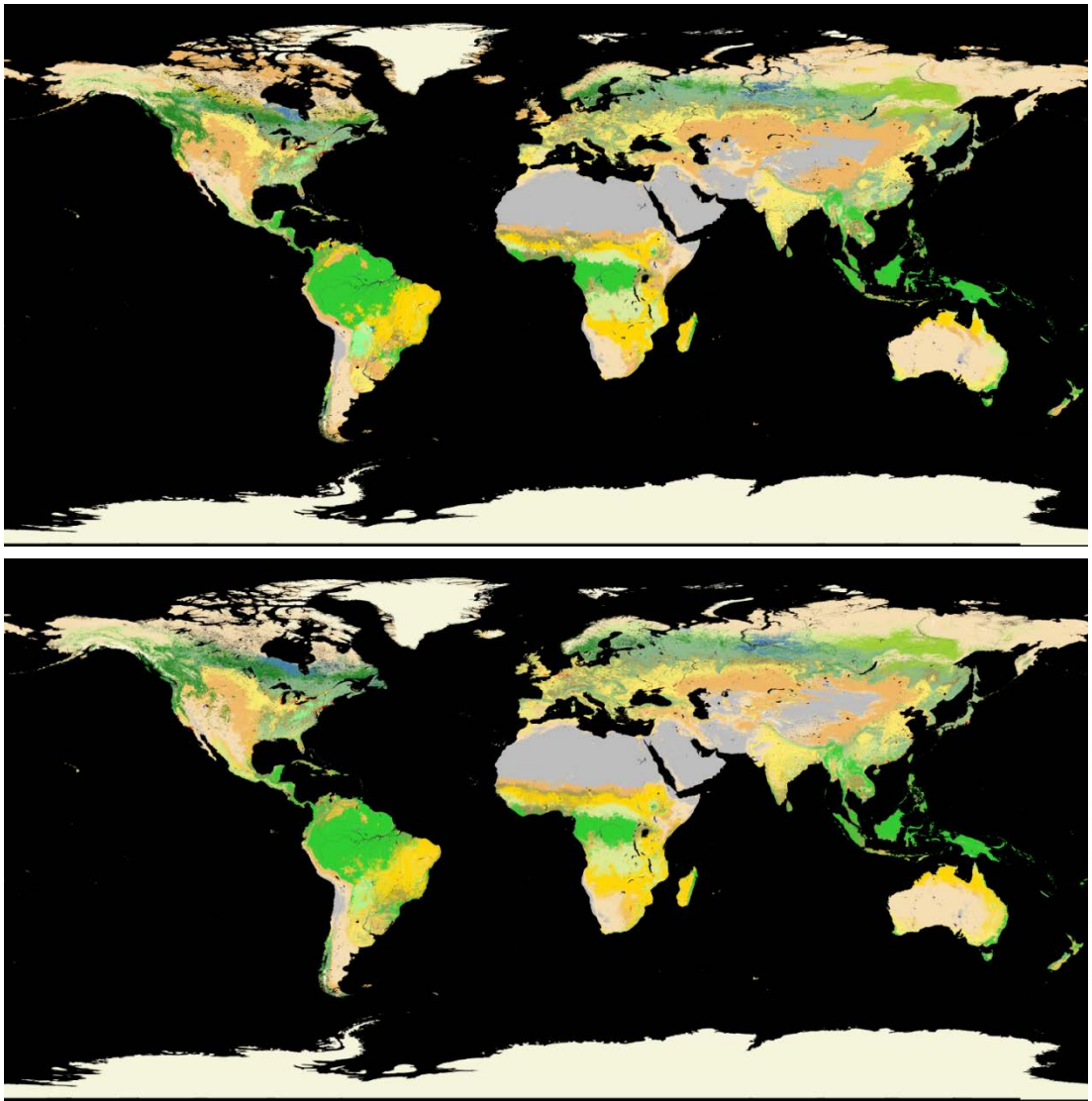
First VIIRS QST IP from 2012 VIIRS Data



Similar Patterns between VIIRS QST IP and MODIS Seed

MODIS Seed

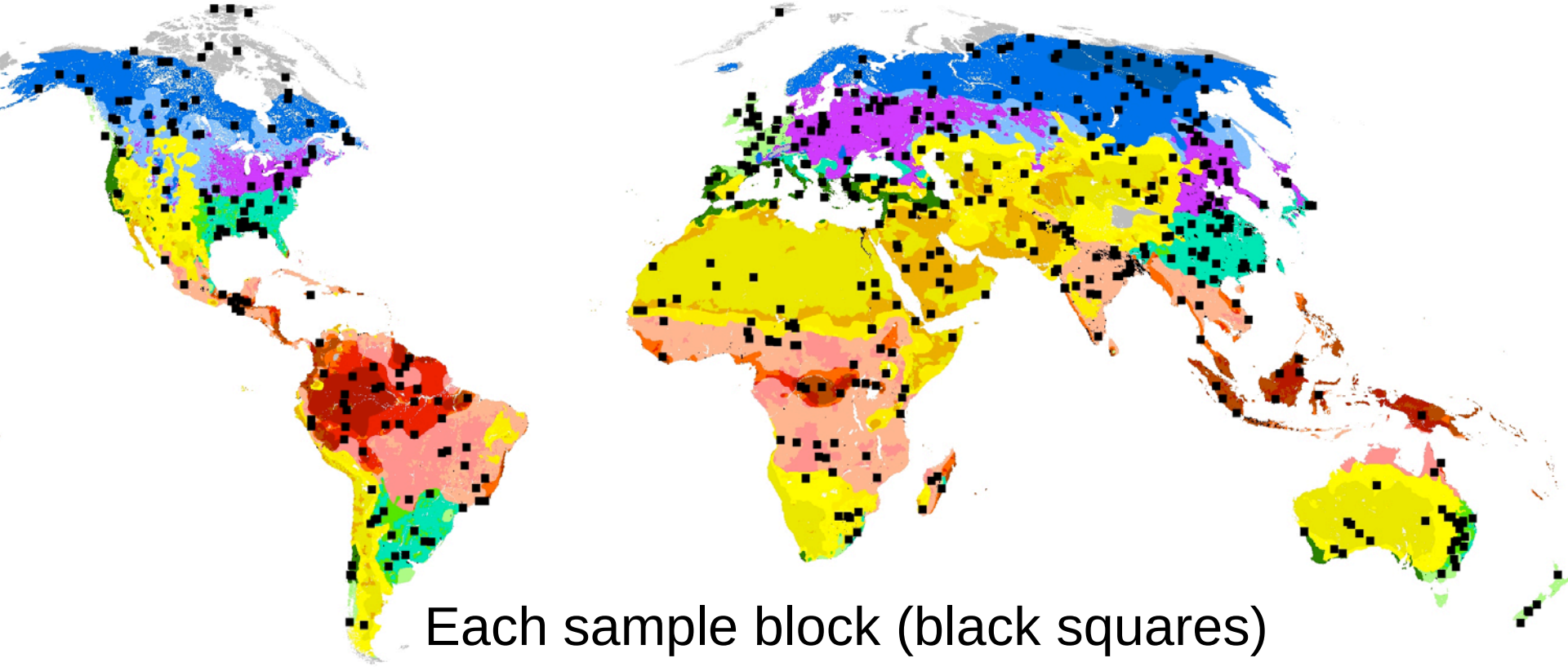
VIIRS QST IP



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

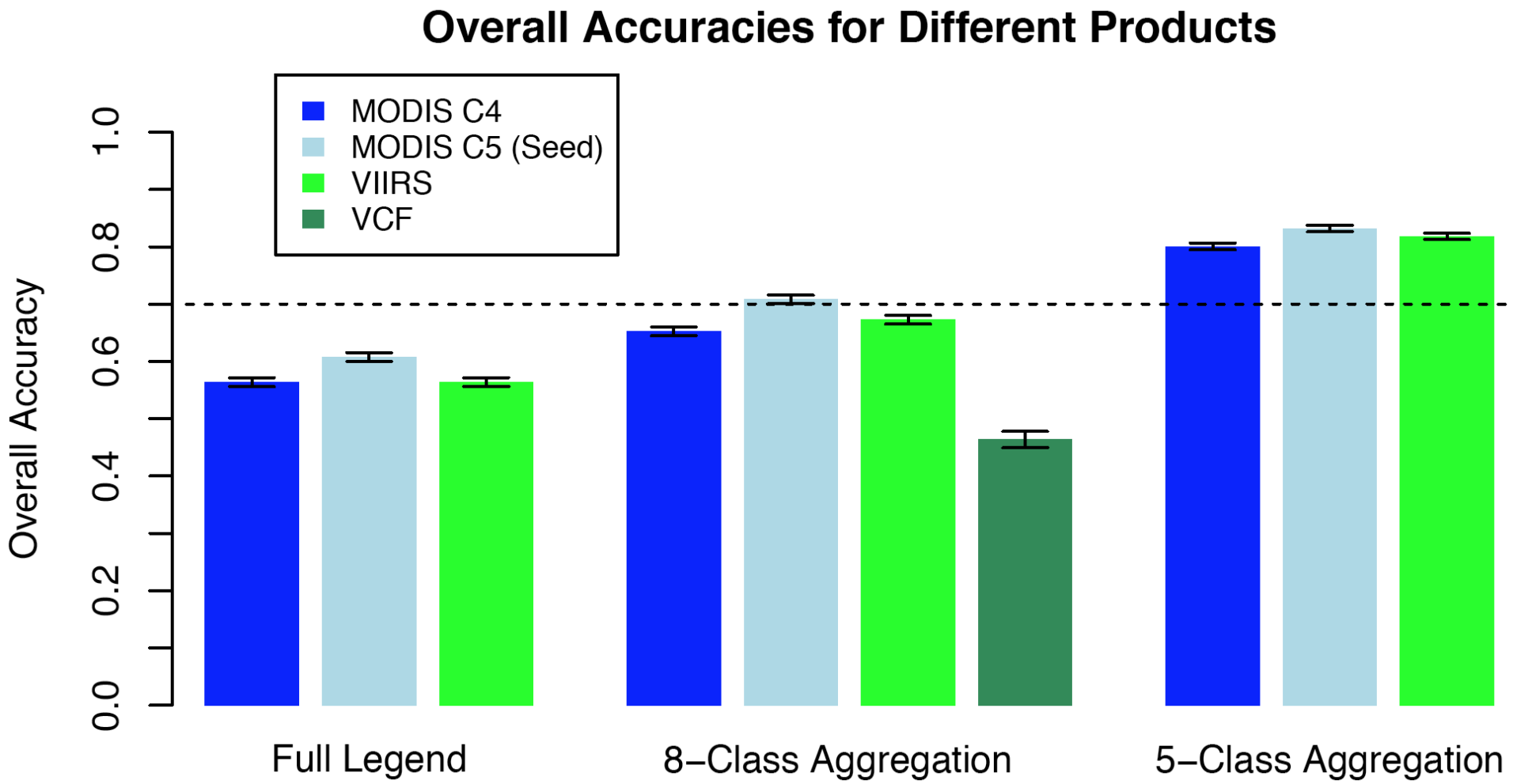
Validation Sample Design



Each sample block (black squares) contains between 10 and 35 1-km VIIRS pixels.

- Tropical Rainforest
- Tropical Seasonal Forest
- Tropical Savannah
- Desert
- Steppe
- Mediterranean
- Temperate Evergreen Forest
- Marine West-coast
- Continental Forest
- Boreal Forest
- Tundra
- Snow and Ice
- Cold Boreal Forest
- pTropical Rainforest
- pTropical Seasonal Forest
- pTropical Savannah
- pDesert
- pSteppe
- pTemperate Evergreen Forest
- pContinental Forest
- Urban

Algorithm Evaluation

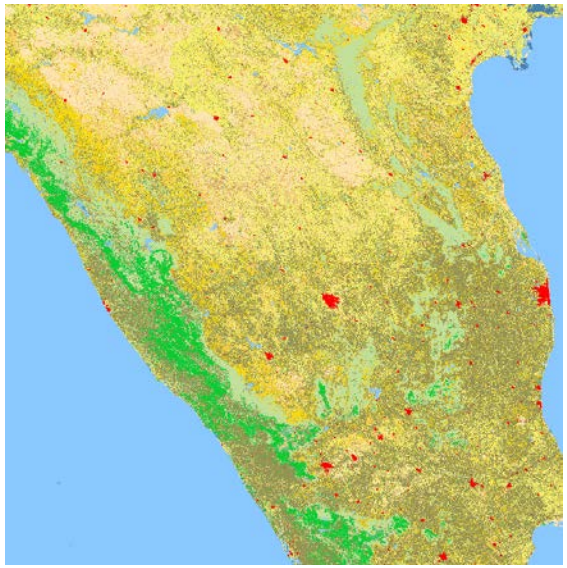


VIIRS QST overall accuracies are similar to MODIS C4 and C5 (Seed)

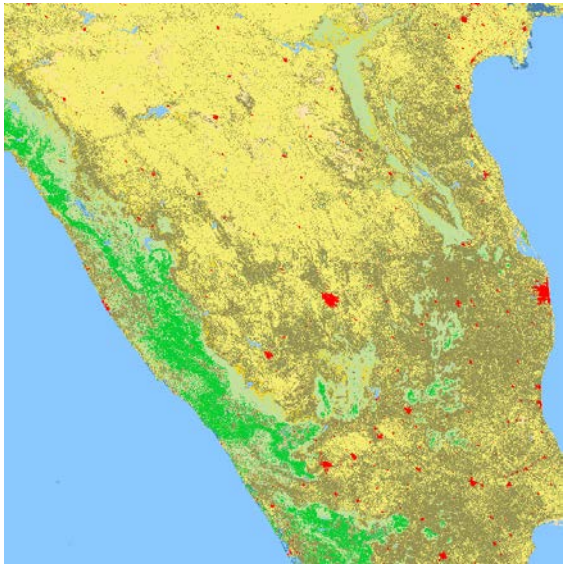
Issues from Preliminary Assessment

- Most confusions are between:
  - Cropland and grassland
  - Cropland and agriculture-nature vegetation mosaic
    - Post classification modeling
  - Grassland and open shrubland
  - Shrubland and grassland
  - Woody savanna and deciduous forest
  - Woody savanna and savanna

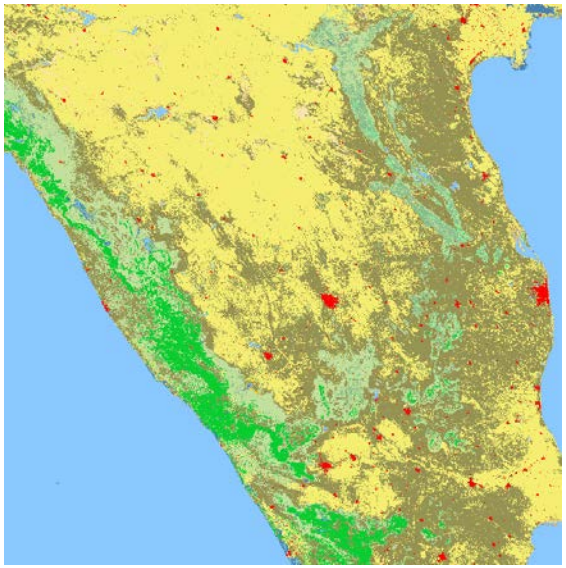
Post-Classification Modeling of Cropland



Initial QSTIP



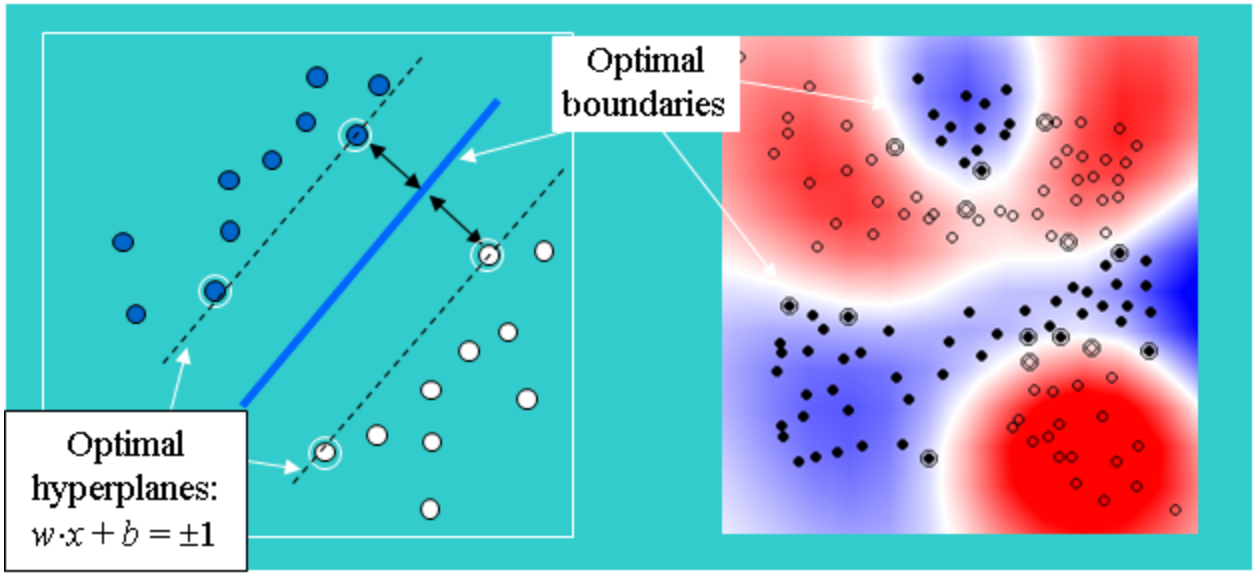
QSTIP R2 (post-classification modeling)



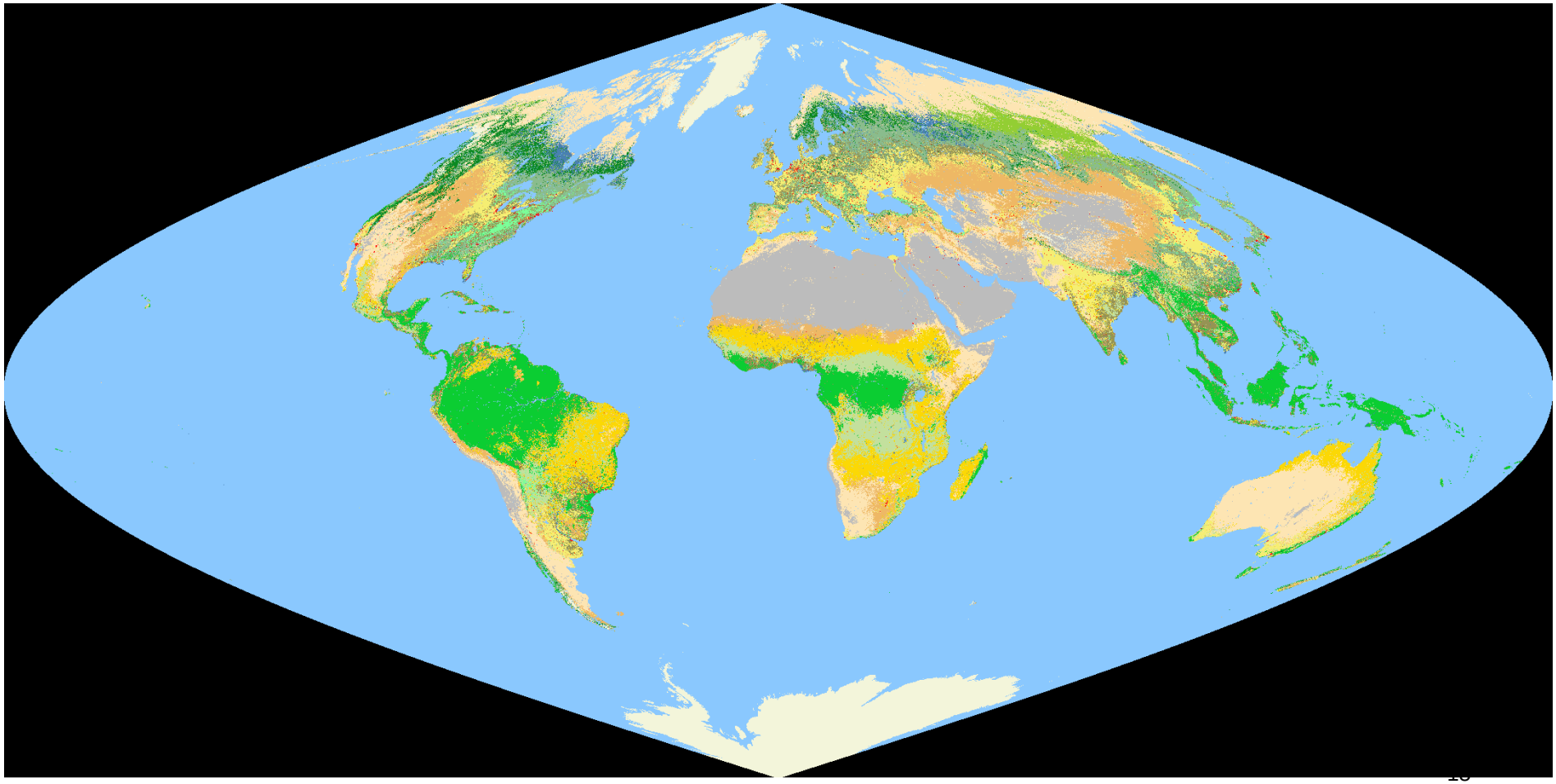
MODIS-based Seed

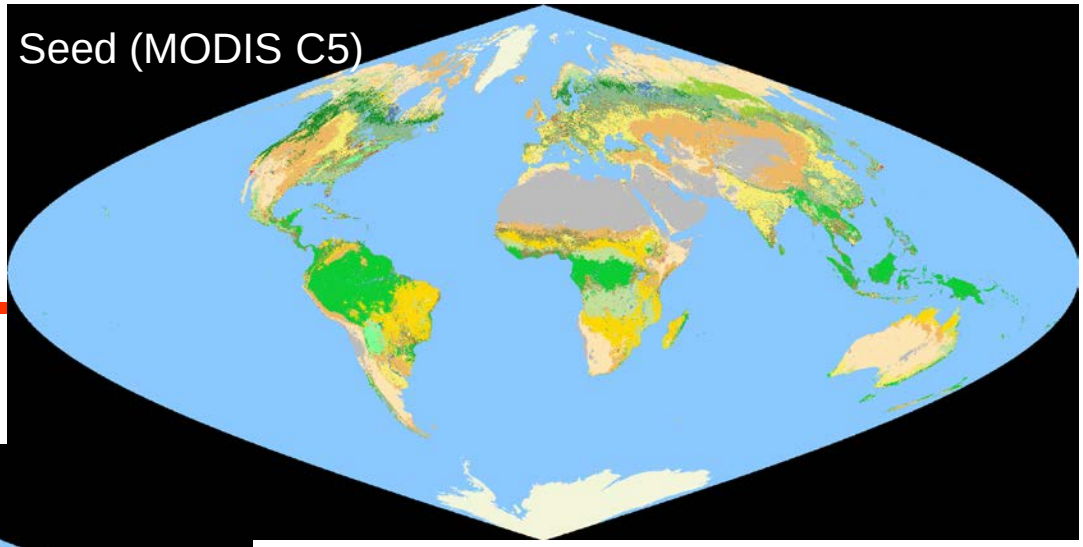
Exploring Better Classifiers

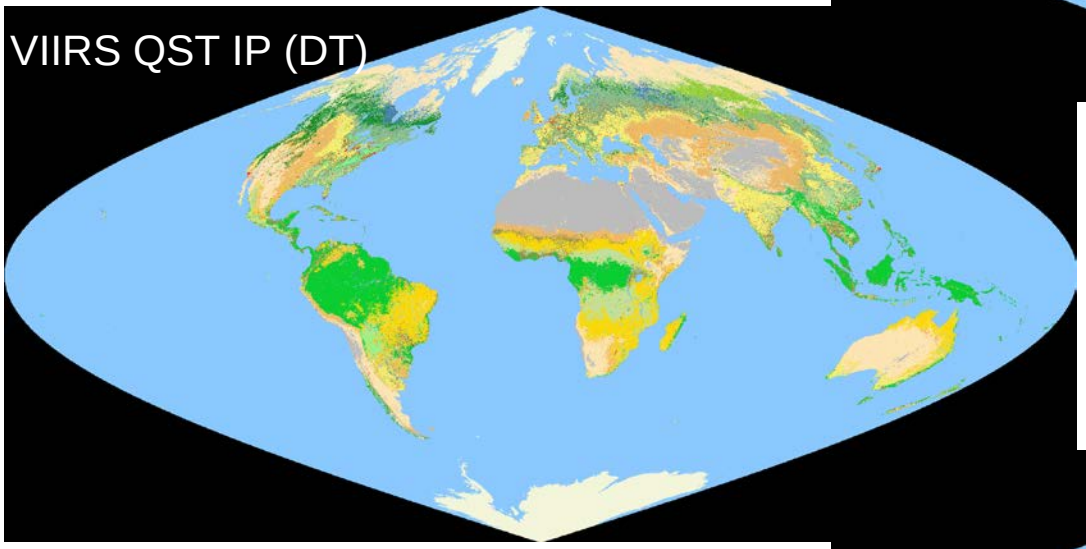
- DT is a MODIS/AVHRR heritage algorithm
- Support Vector Machines (SVM) better
  - Designed to search for optimal solutions
  - Consistently better accuracies than DT
    - (e.g., Huang et al. 2002; Foody and Mathur 2004; Pal and Mather 2005; Mountrakis et al. 2011)
  - More CPU intensive

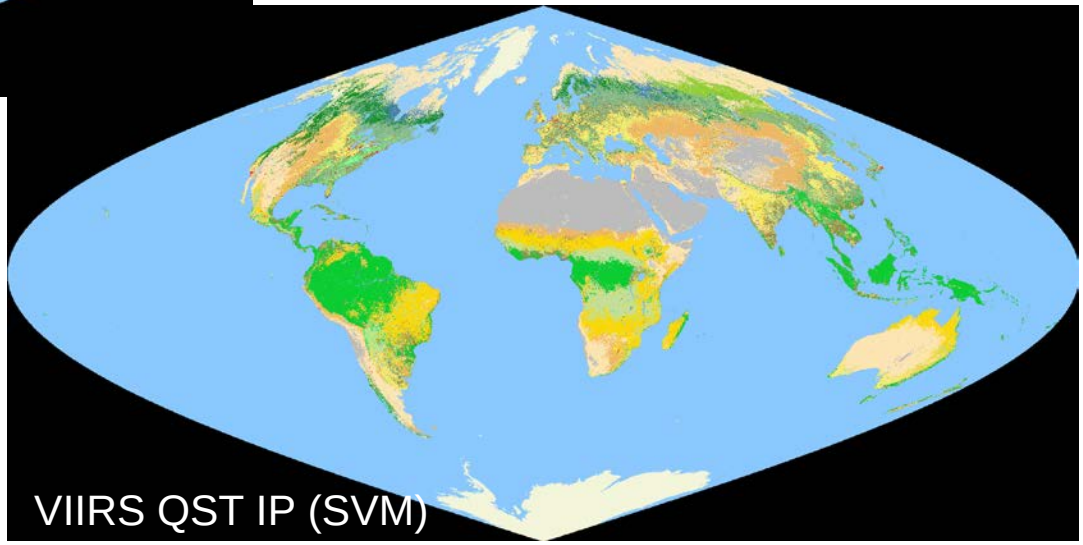


Preliminary QST IP from SVM

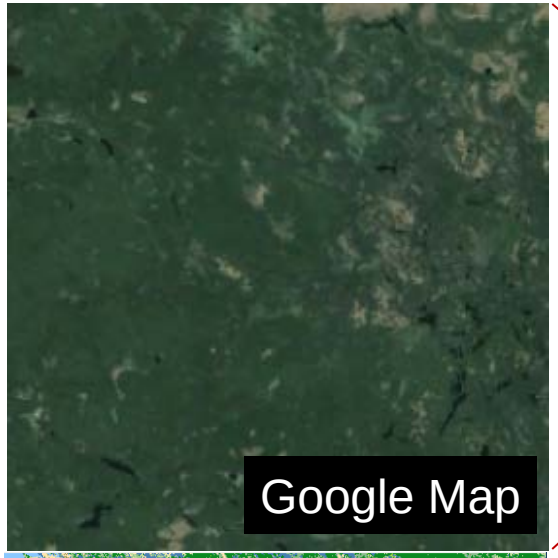


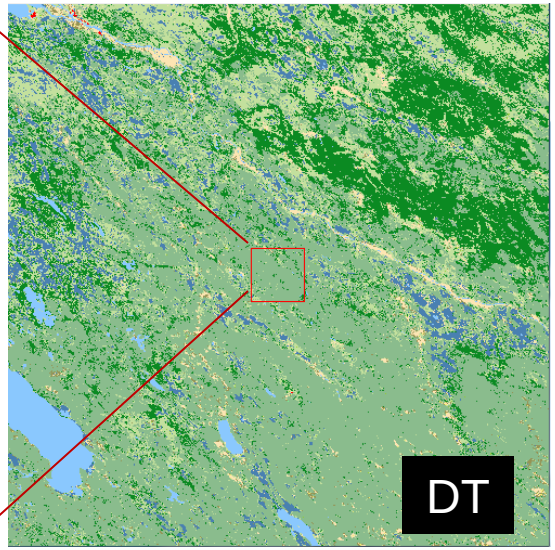

Seed (MODIS C5)

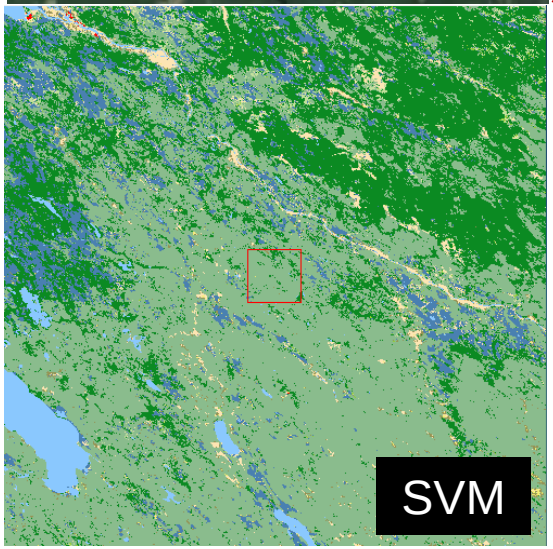

VIIRS QST IP (DT)

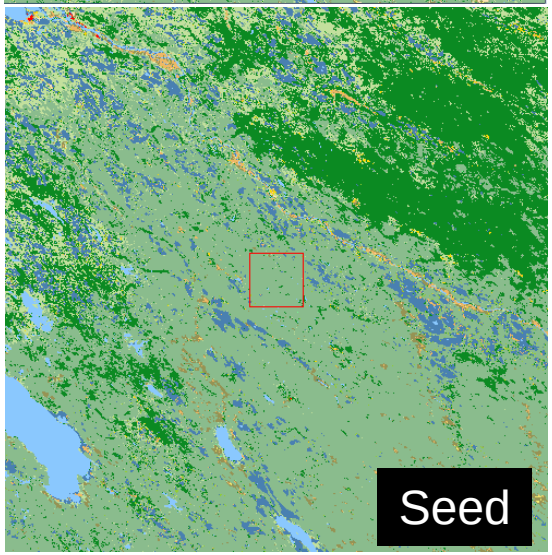

VIIRS QST IP (SVM)

Similar in Forested Areas (Northern Europe)





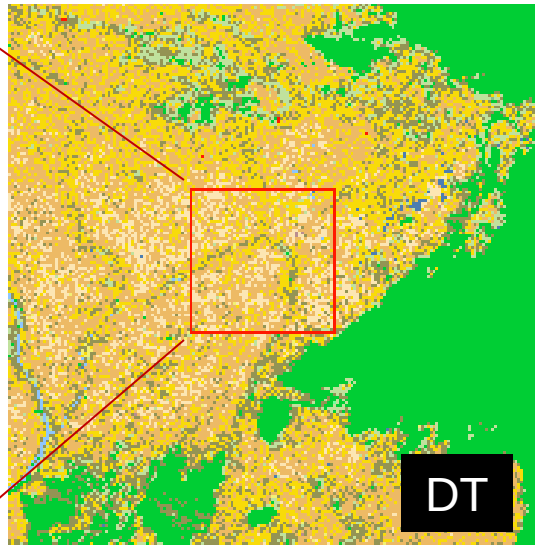


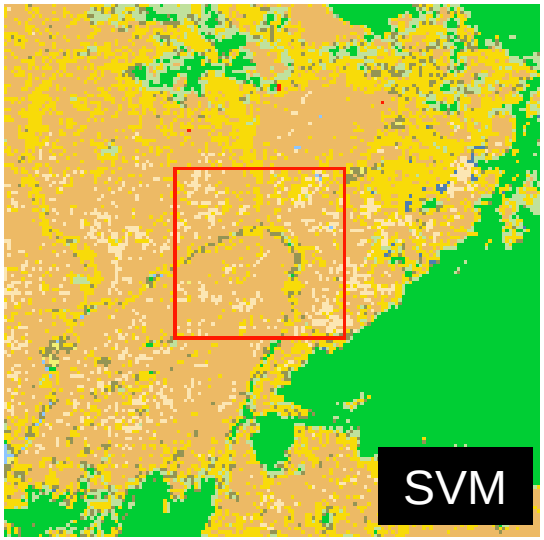


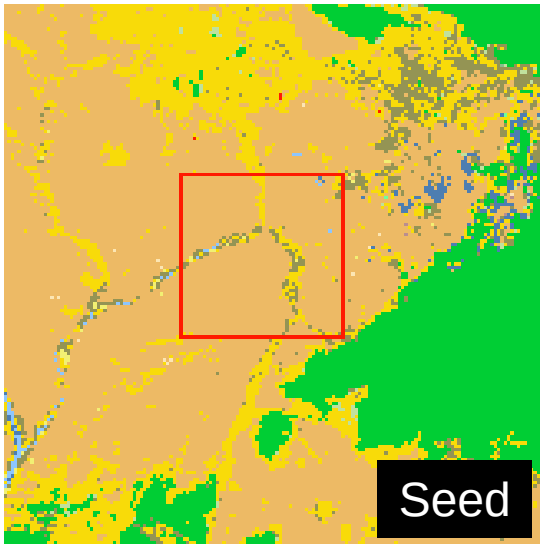
Legend

- 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

SVM Less Salt-Pepper than DT (South America)







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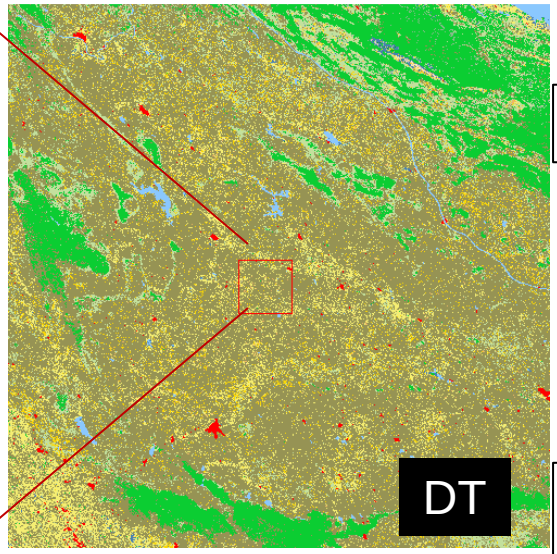
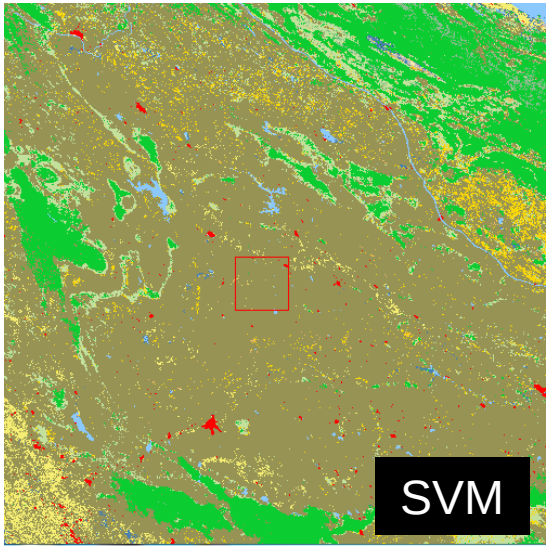
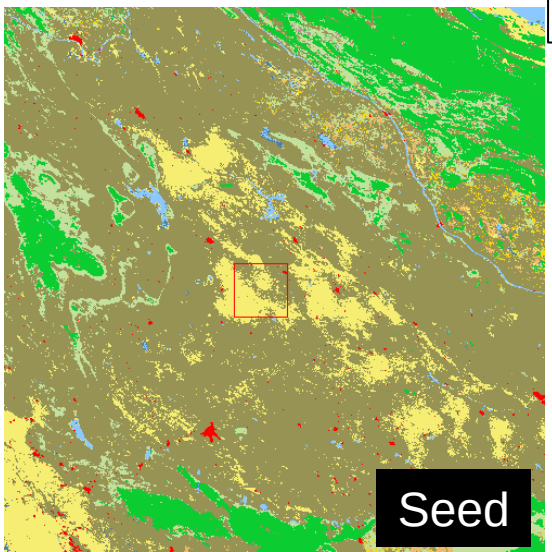
Post-Classification Modeling Needed for Crop and Crop Mosaics (Southeastern Asia)







Cropland

Lands covered with temporary crops followed by harvest and a bare soil period (e.g., single and multiple cropping systems.

Cropland/Natural Vegetation Mosaics

Lands with a mosaic of croplands, forest, shrublands, and grasslands in which no one component comprises more than 60% of the landscape.

Next Steps

- More comprehensive assessment of SVM results
  - Accuracy assessment using validation data (BU)
- Post-classification modeling
  - Cropland
- Use multi-year VIIRS data
  - Reduce cloud contamination
  - Reduce impact of inter-annual variability
  - 3 years used in MODIS C5
- Improve training data representativeness

Future Plans

- Replace DT with SVM in JPSS-1 QST algorithm
  - Further evaluations and comparisons are needed.
- Better characterize classes inherently challenging, e.g. urban, wetland
  - Mostly mixed
  - Subpixel fraction estimation more appropriate
- Harness knowledge in existing products
  - Agreements -> class prior probability
  - Disagreements -> focus of improvement effort
- More comprehensive validation strategy
- Change products

VIIRS Surface Type Algorithm Summary

- Two algorithms
  - Surface Type EDR algorithm
    - Operational on IDPS
    - Perform as designed
    - Issues identified and addressed
  - QST IP algorithm
    - Off-line algorithm running outside IDPS
    - Heritage DT algorithm produces results comparable with MODIS LC
    - Improvements identified
      - Needed to meet requirement