# NOAA-20 VIIRS Surface Type Beta Maturity

March 19, 2018


**VIIRS Surface Type Team**

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# Outline

- Surface Type Team Members
- Product Requirements
- Findings/Issues for Beta maturity
- Documentation (Science Maturity Check List)
- Conclusions and Path Forward

# VIIRS Surface Type Team

| Name | Organization | Major Task |
| --- | --- | --- |
| Xiwu Zhan | NESDIS/STAR | Surface Type lead |
| Chengquan Huang | UMD | Surface type algorithm/product lead |
| Ben DeVries | UMD | Algorithm development and testing |
| Zhenhua Zou | UMD | Code refinement and optimization |
| Jiaming Lu | UMD | Training data collection, validation |
| Ivan Csiszar | NESDIS-STAR | VIIRS Land Team Lead |
| | | |
| | | |

# AST Requirements from JPSS L1RD

| Attribute | Objective |
|---|---|
| Geographic coverage | Global |
| Vertical Coverage | |
| Vertical Cell Size | N/A |
| Horizontal Cell Size | 1 km at nadir |
| Mapping Uncertainty | 1 km |
| Measurement Range | 17 IGBP classes |
| Measurement Accuracy | 70% correct |
| | |
| | |
| | |
| | |

Evergreen Needleleaf Forests
Evergreen Broadleaf Forests
Deciduous Needleleaf Forests
Deciduous Broadleaf Forest
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
Water Bodies

# JPSS Data Products Maturity Definition

## JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)

### 1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

### 2. Provisional

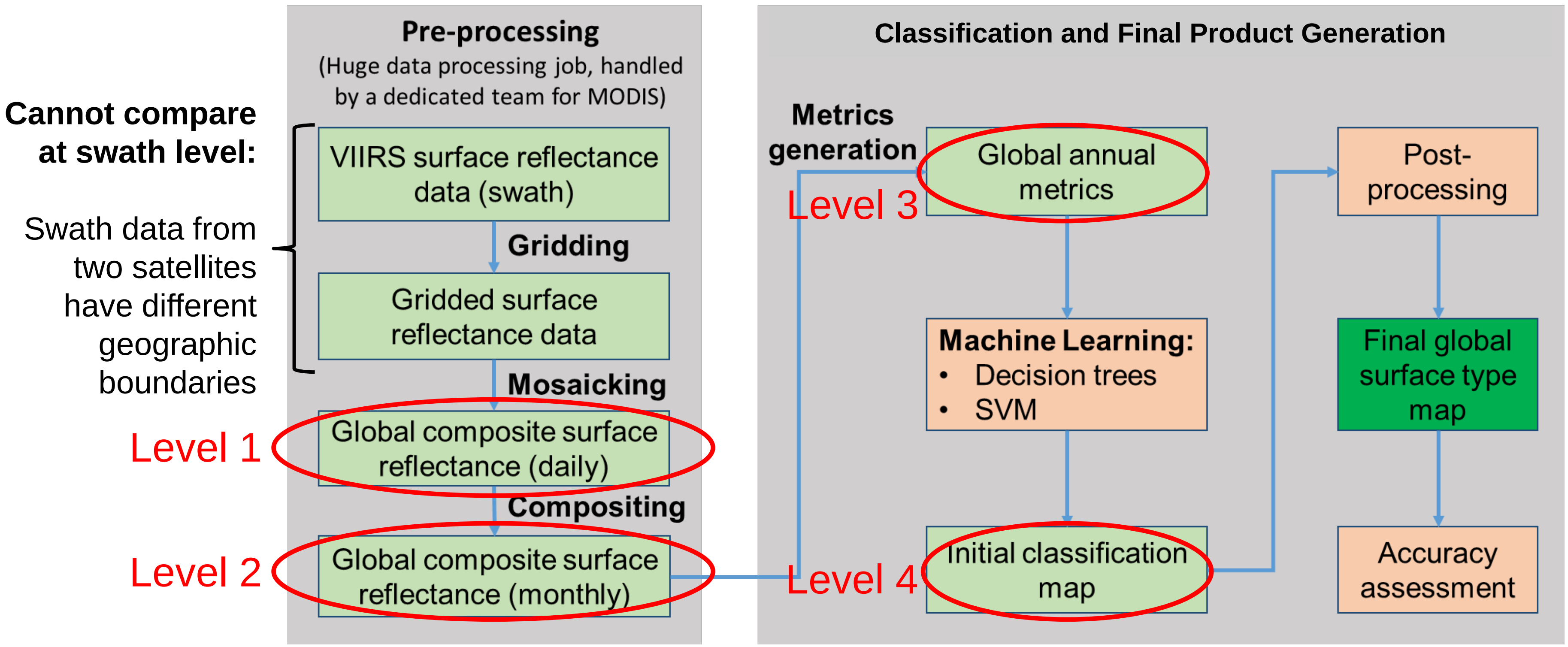
- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

### 3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

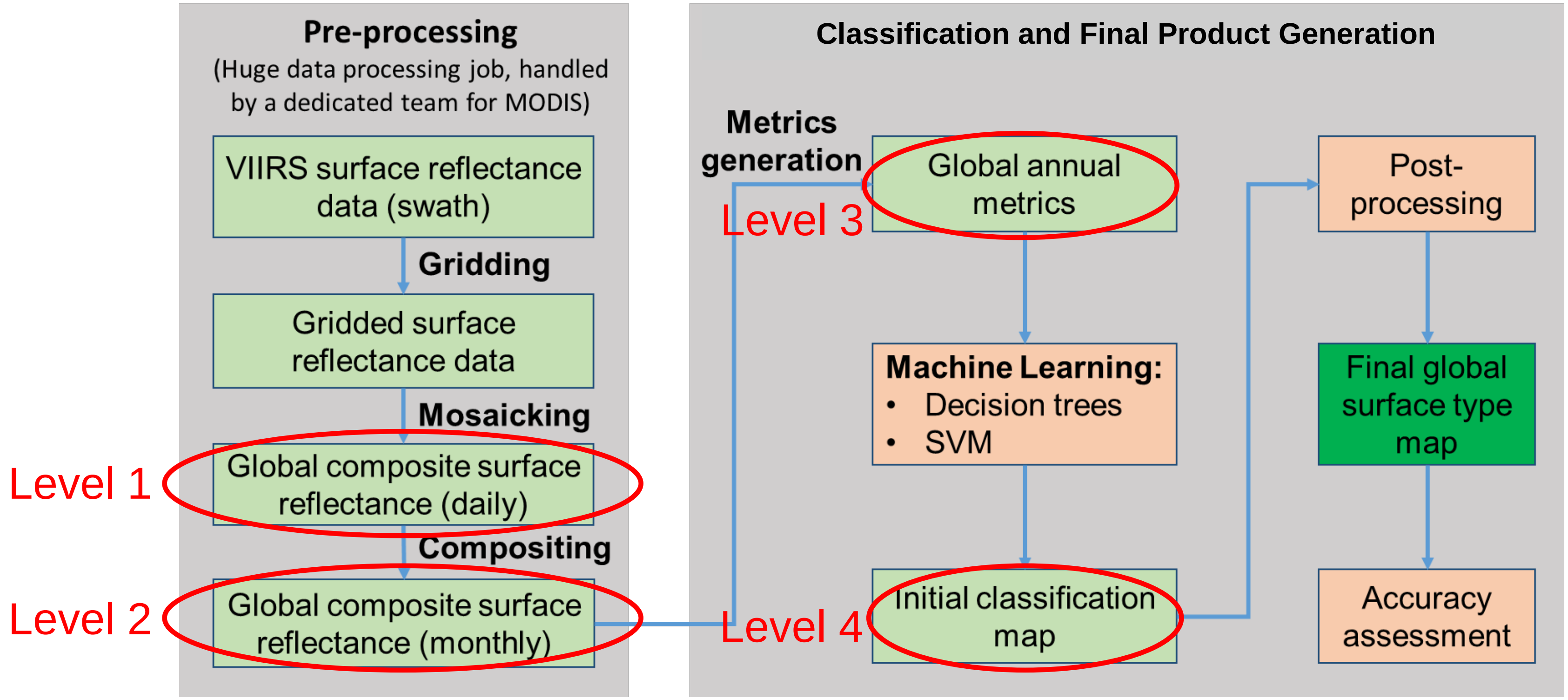
# Beta Evaluation Methodology

- Use Suomi NPP as reference, compare NOAA-20 data to SNPP data for key steps of the AST algorithm
  - Surface reflectance data
    - Gridded daily data (Level 1)
    - Monthly composites (Level 2)
    - Annual metrics (Level 3)
  - Annual surface type classification (Level 4)



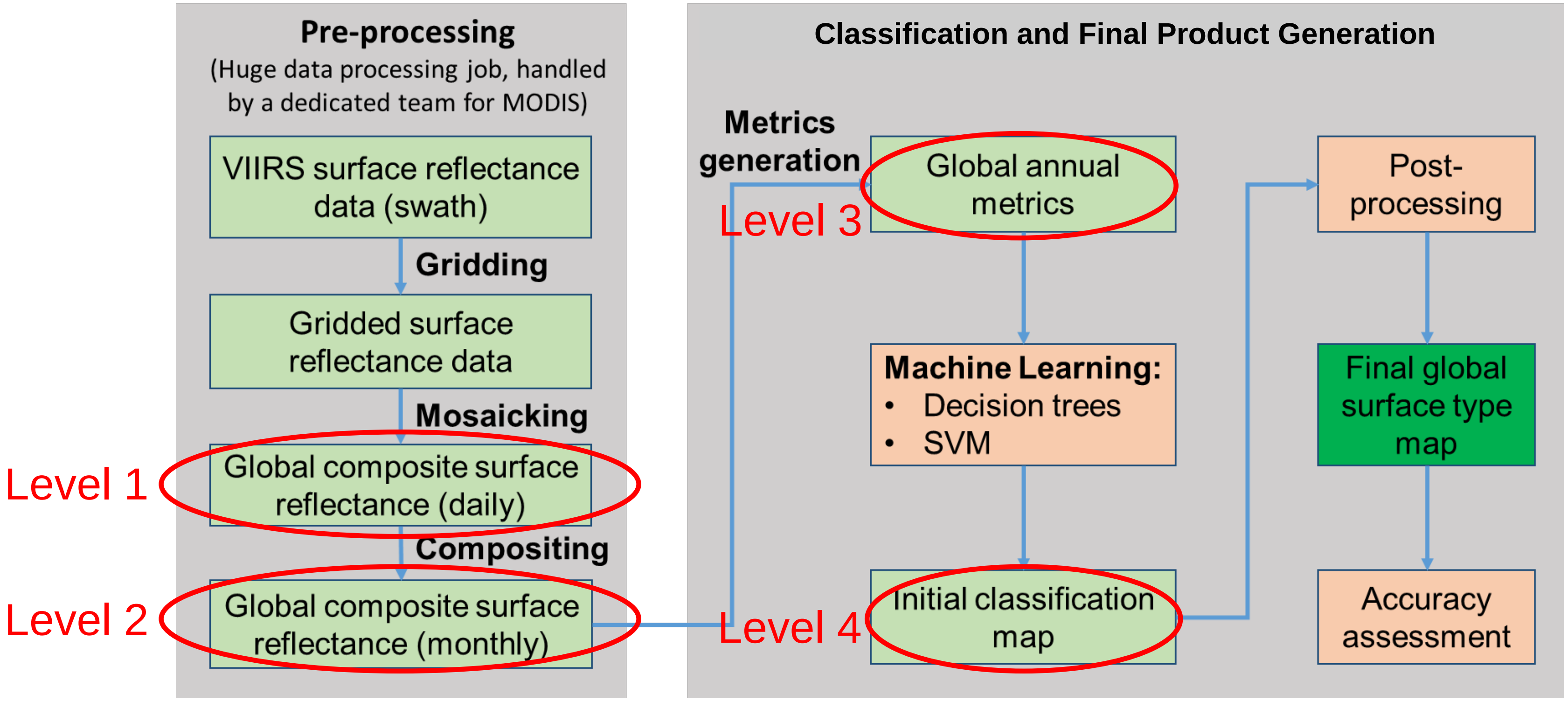
# Beta Evaluation Methodology

- Comparison methods
  - Image/map level
    - Visual comparison
  - Pixel level
    - Scatter plots



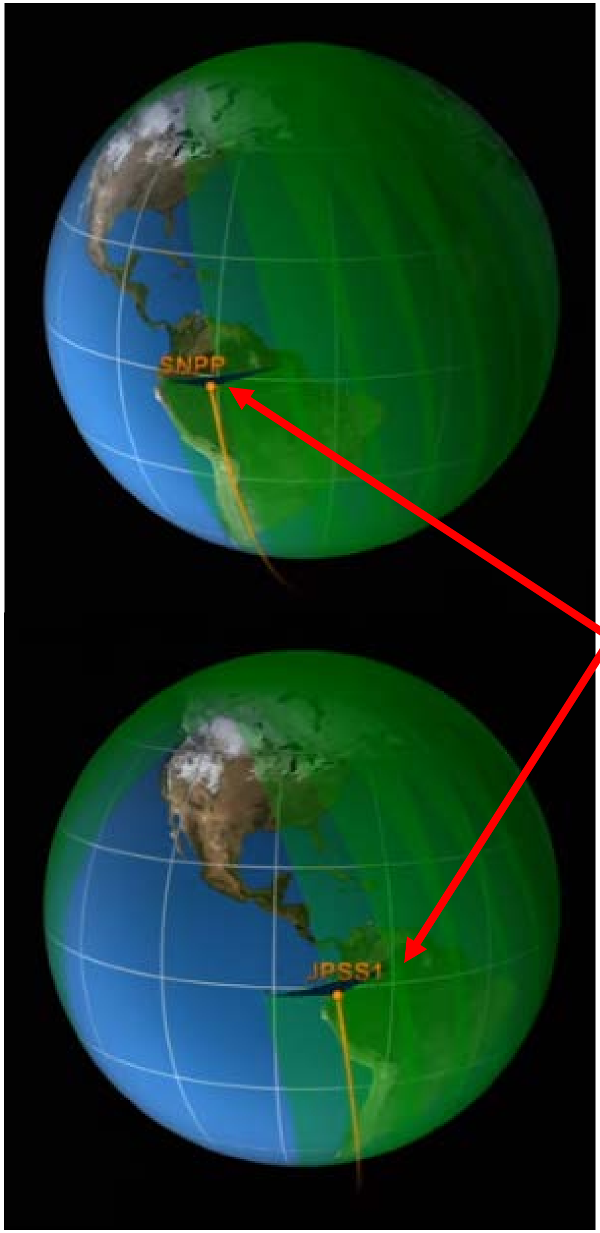
# Beta Evaluation Methodology

- Focus on bands used in surface type mapping
  - M1-M5, M7, M8, M10, M11
- Conducted a comprehensive assessment, but only a sample of representative results presented
  - Important, commonly used bands/indices
  - Selected sites
  - Selected day/month



# Level 1 Comparison: Daily Surface Reflectance

- VIIRS on NOAA-20 and S-NPP near identical
  - Same spectral bands
  - Same spatial resolutions
  - Follow each other on the same orbit
  - Near identical equator crossing time
- However, NOAA-20 and S-NPP data from same day over same ground targets not identical
  - NOAA-20 and SNPP are about half an orbit apart: ~50 minutes
  - When a ground location is observed by the two satellites in any given day, it
    - has different local solar time
      - 50 minutes difference
    - is viewed at very different sensor zenith angles



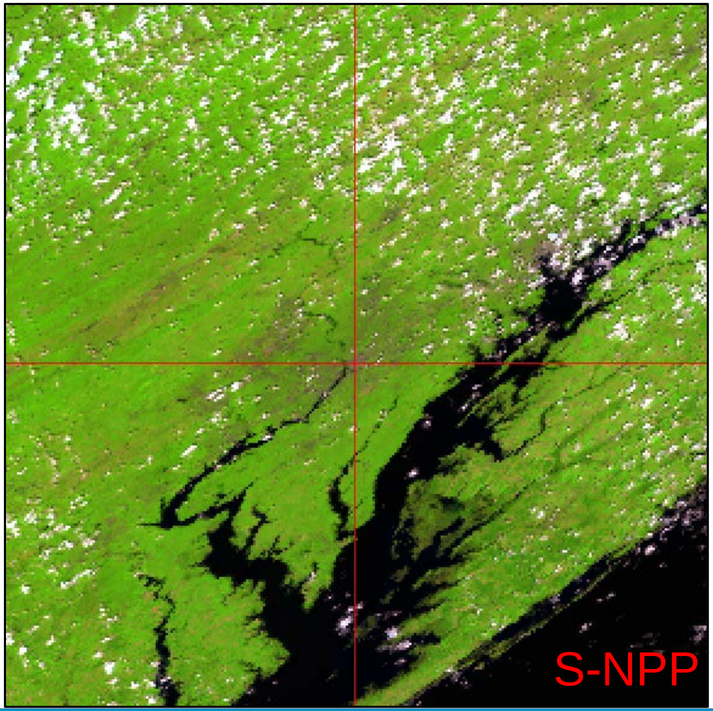

Nadir view by SNPP

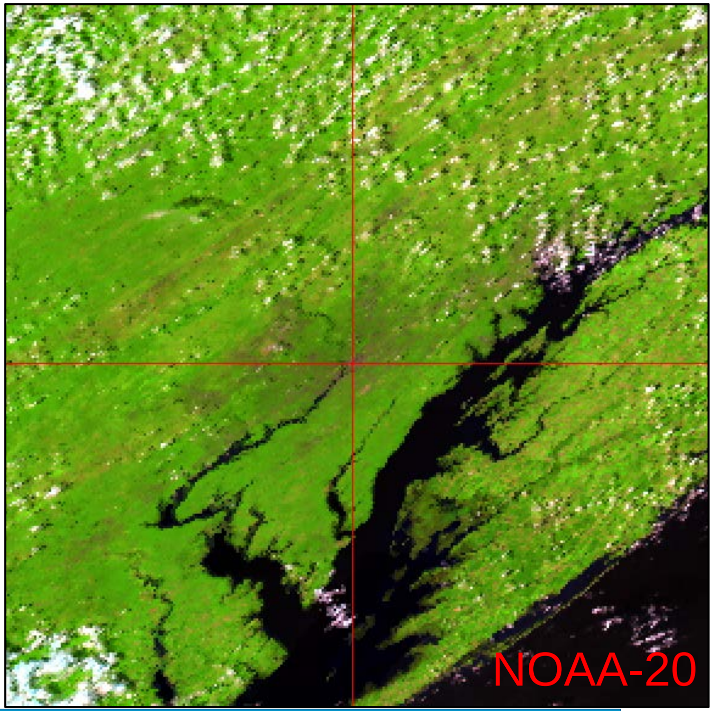
Off-nadir view (near swath edge) by NOAA-20

# Comparison of Daily Surface Reflectance Data

- Same Day NOAA-20 and SNPP Data Not Identical
  - Correlated but not identical due to BRDF effect
    - Sun angle changes substantially in 50 minutes
    - Large differences in view geometry
  - Not comparable when clouds/shadow present
    - Clouds can move a lot in 50 minutes
    - Shadow will follow

Washington DC
June 30, 2019
RGB: M10/7/5

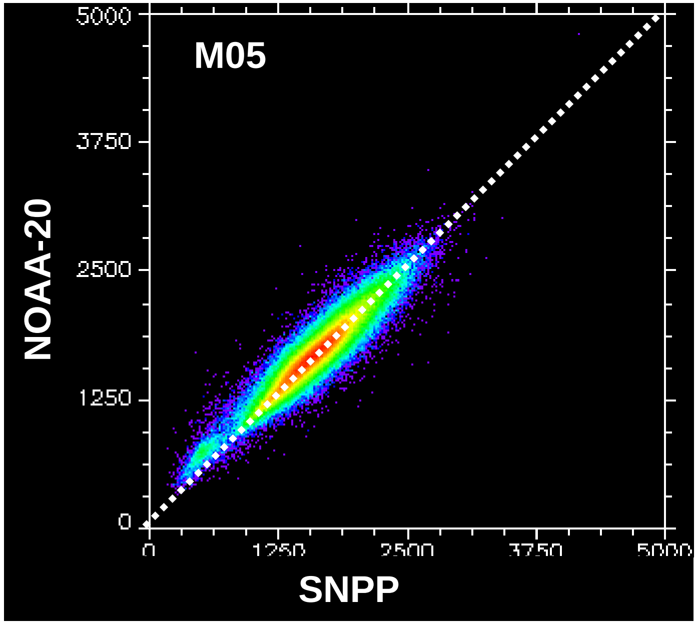


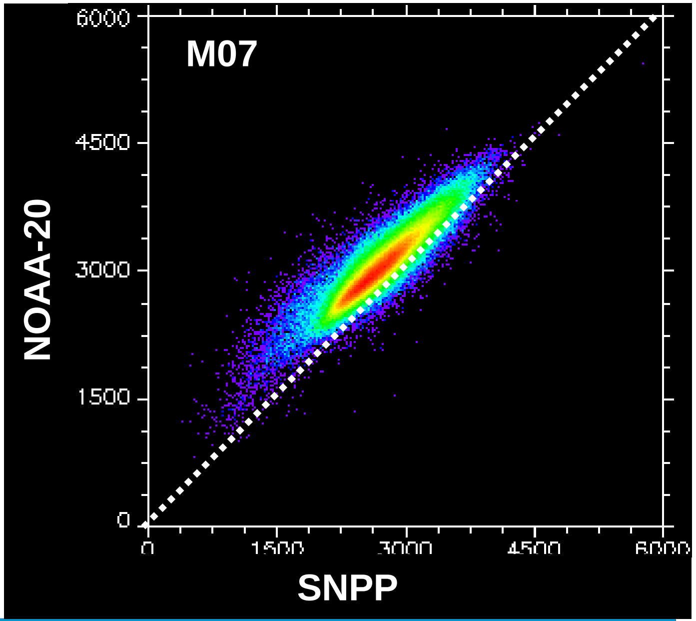



# Clear View NOAA-20 and SNPP Data Correlated

Southwest Africa
June 28, 2019
RGB: M10/7/5

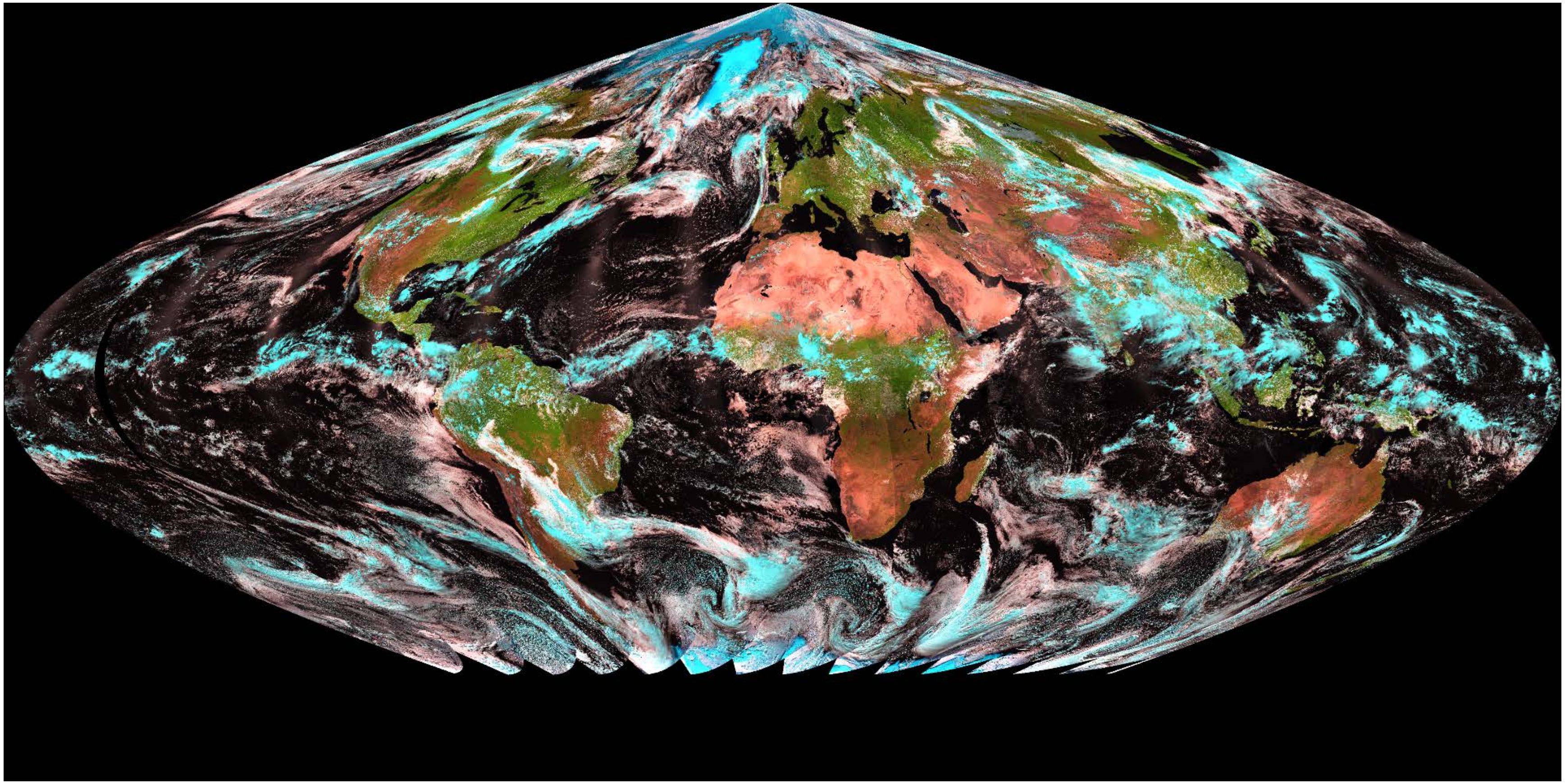




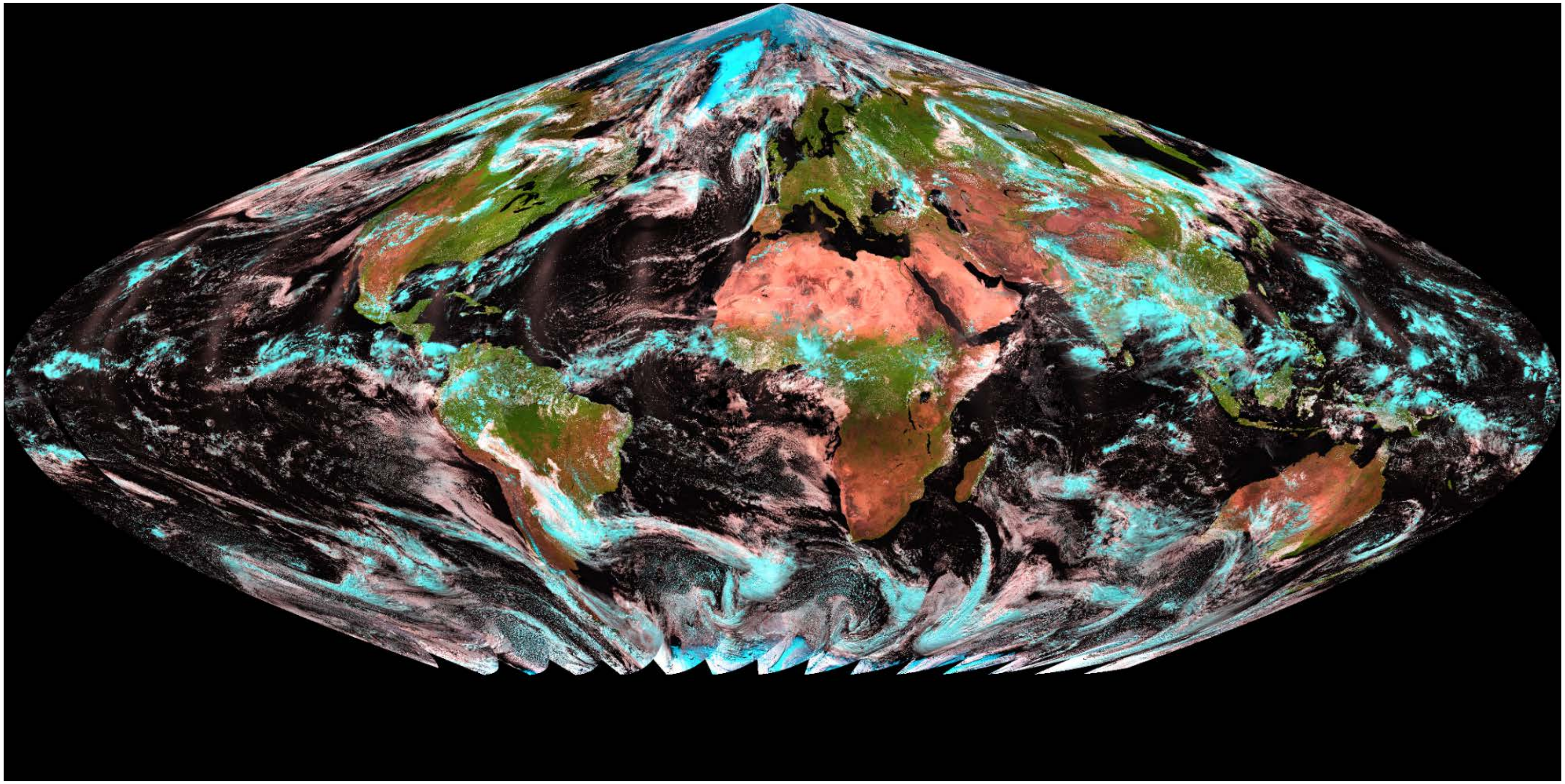
# Global Daily Mosaics Are Very Similar

NOAA-20 Mosaic, July 25, 2019, RGB: M10, M7, M5



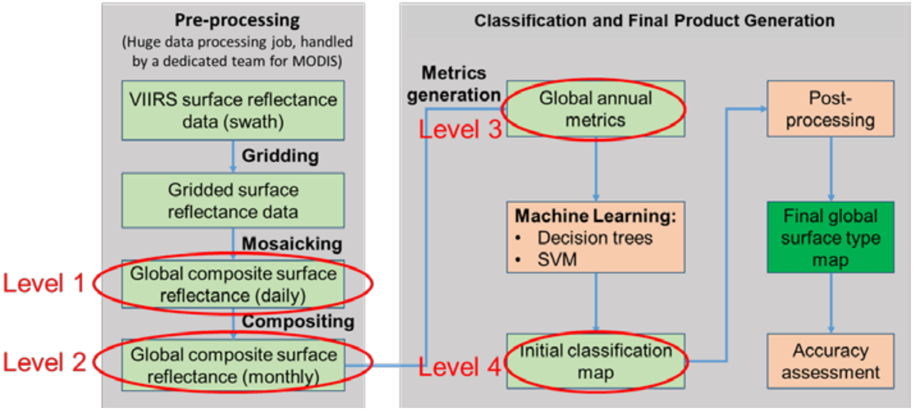
# Global Daily Mosaics Are Very Similar

S-NPP Mosaic, July 25, 2019, RGB: M10, M7, M5

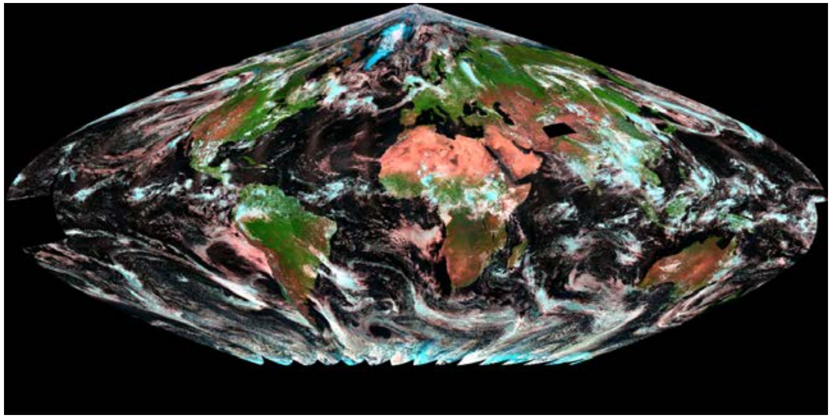


# Level 2: Monthly Composites

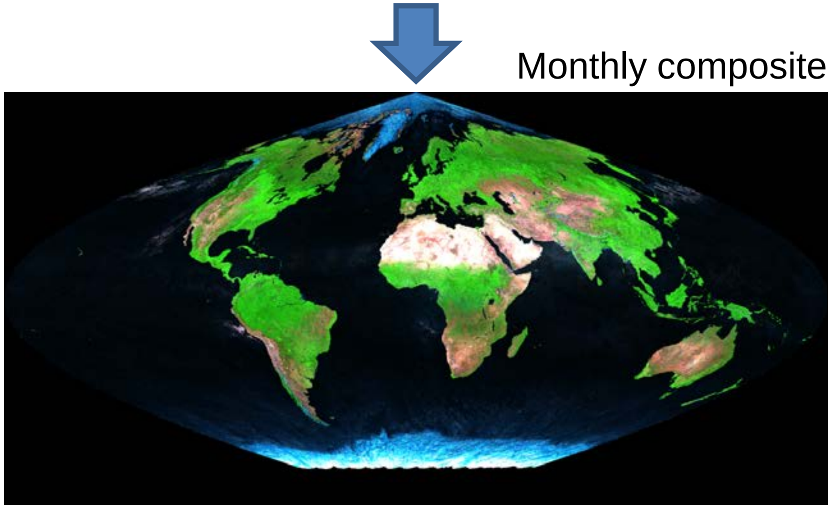
- Purpose: create global data with minimum or no cloud cover
- General idea:
  - Define compositing period: one month
  - At each pixel location, select the best observation within each month as the composited observation for that month
- Input:
  - Gridded daily surface reflectance for all days within a month
- Output
  - One composite per month, near cloud free



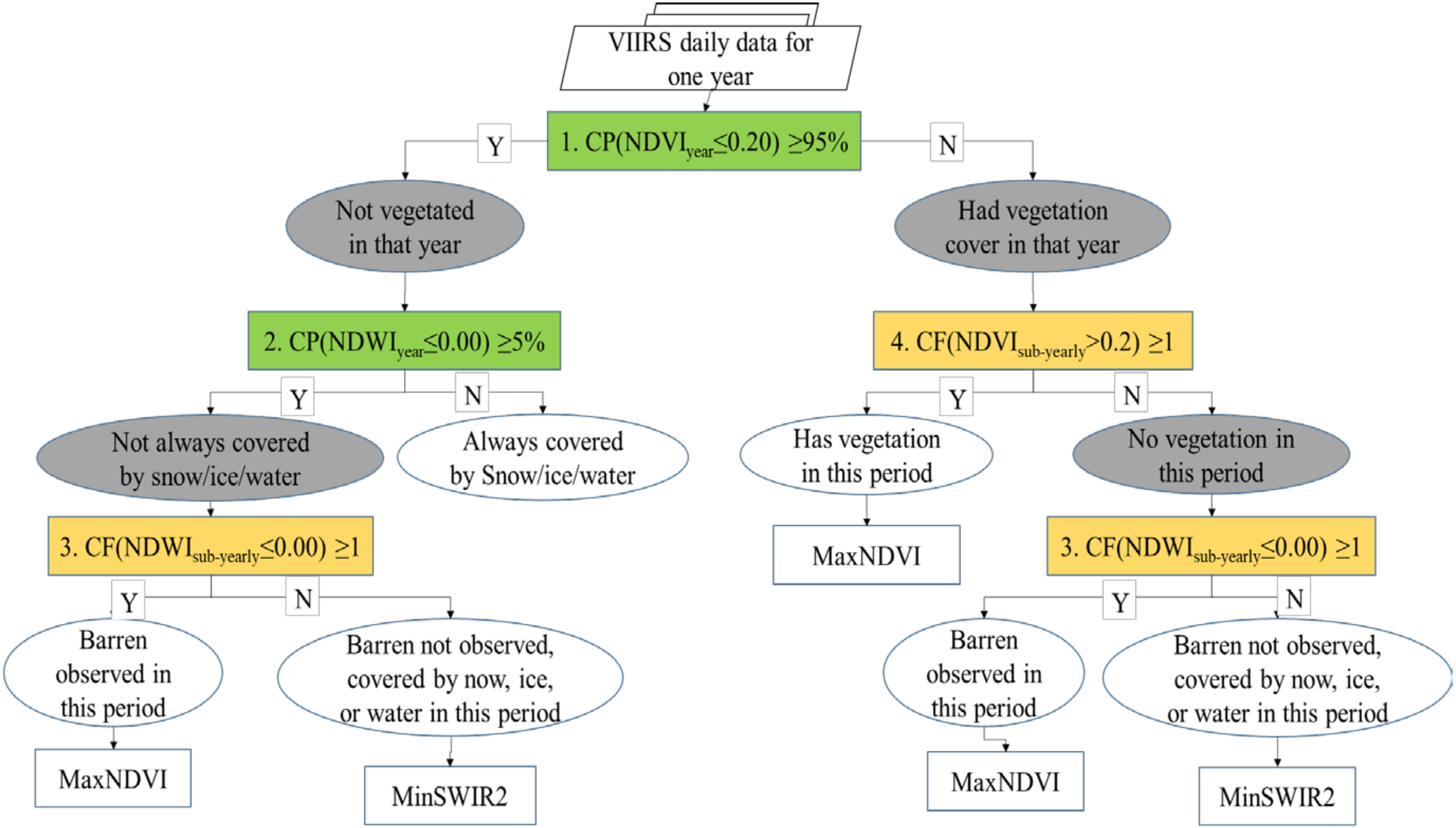

Daily surface reflectance



Monthly composite

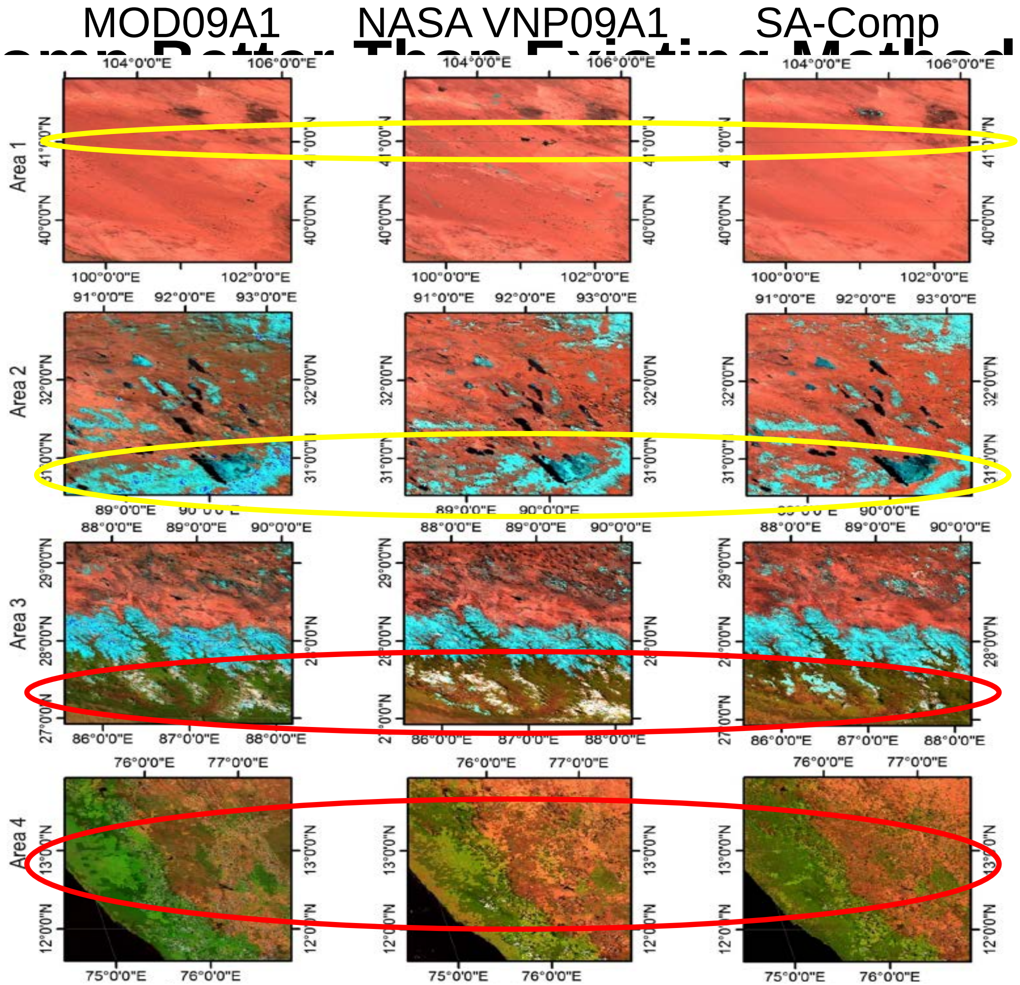


# Self-Adaptive Compositing (SA-Comp) Algorithm




Bian, J., Li, A., Huang, C., Zhang, R., & Zhan, X. (2018). A self-adaptive approach for producing clear-sky composites from VIIRS surface reflectance datasets. *ISPRS Journal of Photogrammetry and Remote Sensing, 144, 189-201.*

# SA-Comp Better Than Existing Methods




Less shadow

Non-snow selected when exist

Less cloud

Smoother results over vegetated and non-vegetated areas

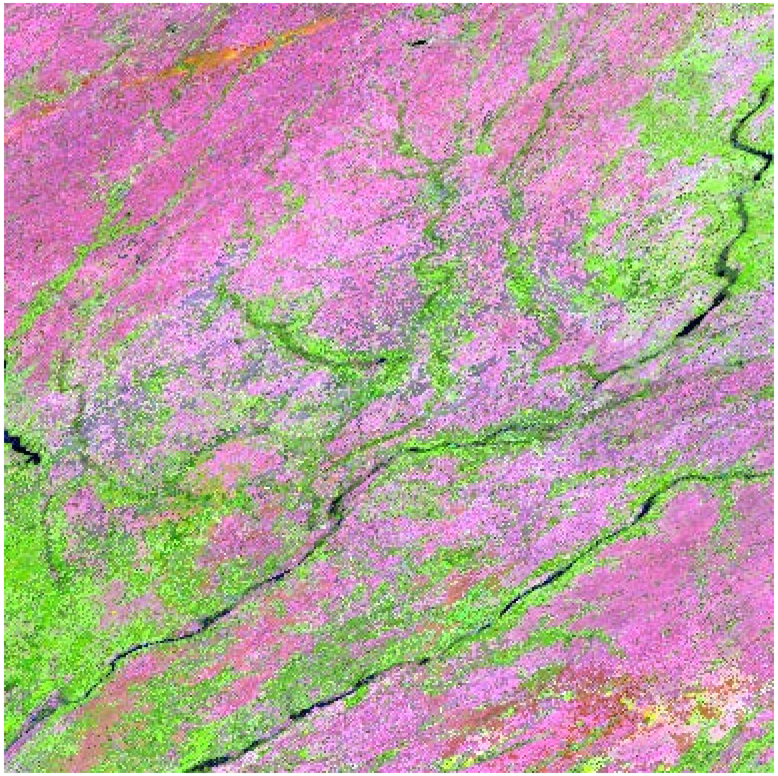
*Better Than MODIS Heritage Methods*

# Monthly Composites Assessment:
## Scope and Expectations

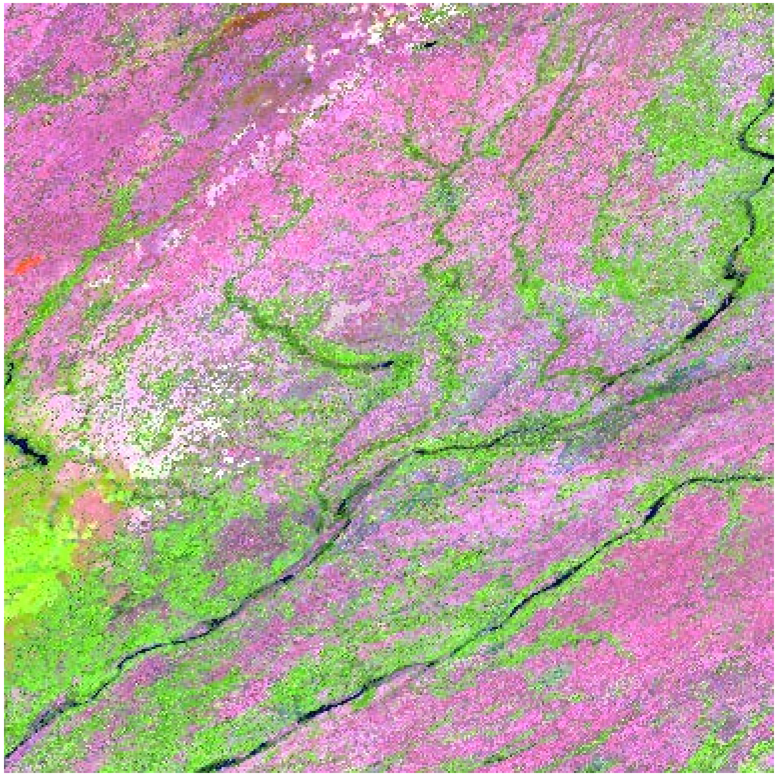
- Monthly composites generated
  - Month: May, June, July, 2019
    - Full month NOAA-20 not available until May 2019
- How comparable can NOAA-20 and S-NPP monthly composites be?
  - Not always identical at individual pixel level
    - Not identical in each individual day
    - NOAA-20 and S-NPP composites may be selected from different dates
  - Statistically comparable, visually very similar

# Monthly Composites Comparison Examples

May 2019, US Midwest
RGB: M10, M7, M5



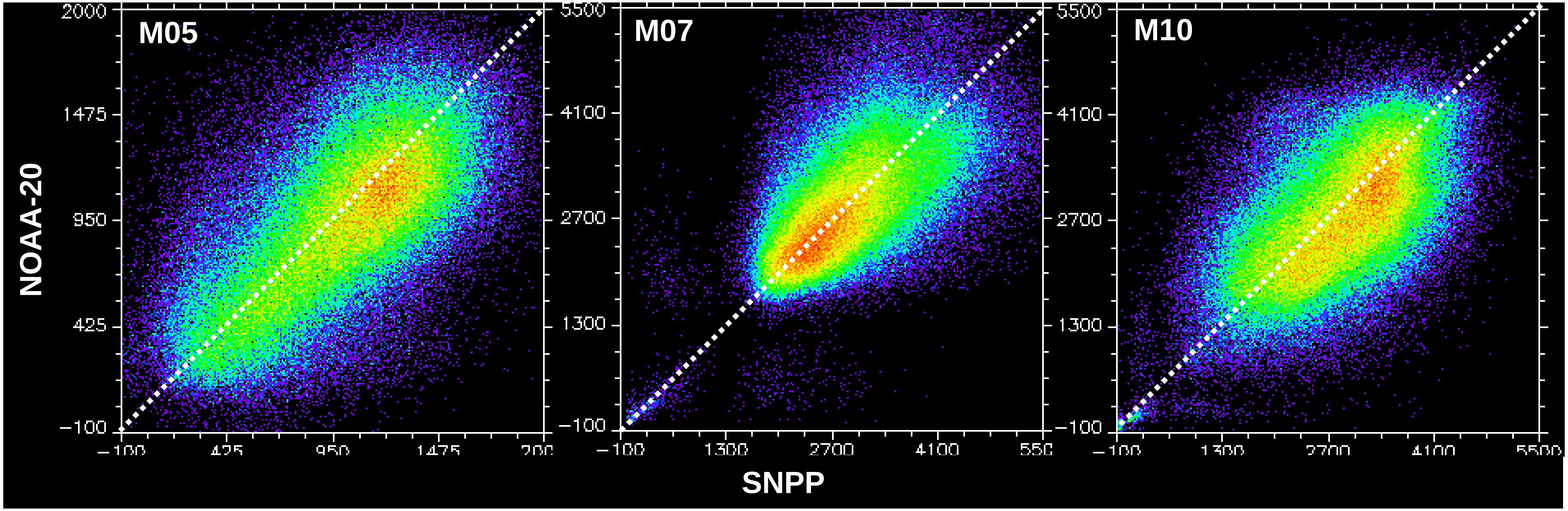
S-NPP



NOAA-20

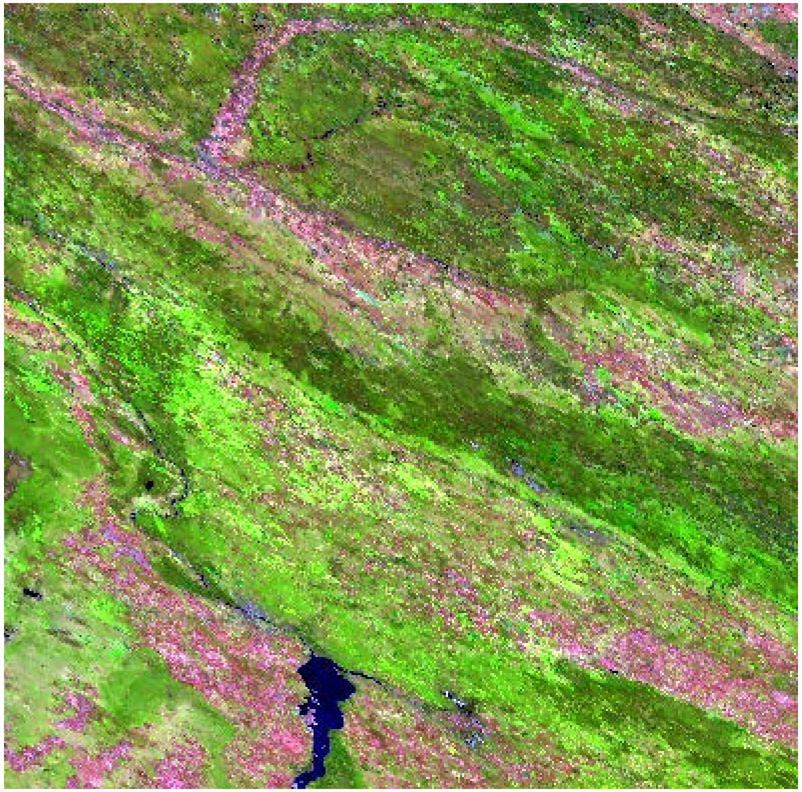
# Monthly Composites Comparison Examples

May 2019
US Midwest

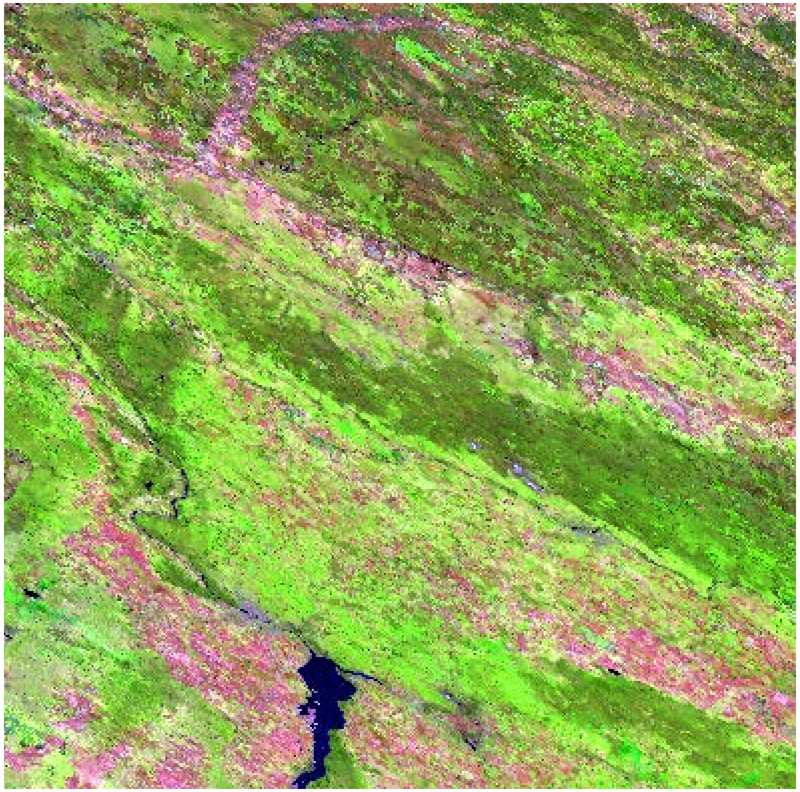


# Monthly Composites Comparison Examples

May 2019, Central Asia
RGB: M10, M7, M5



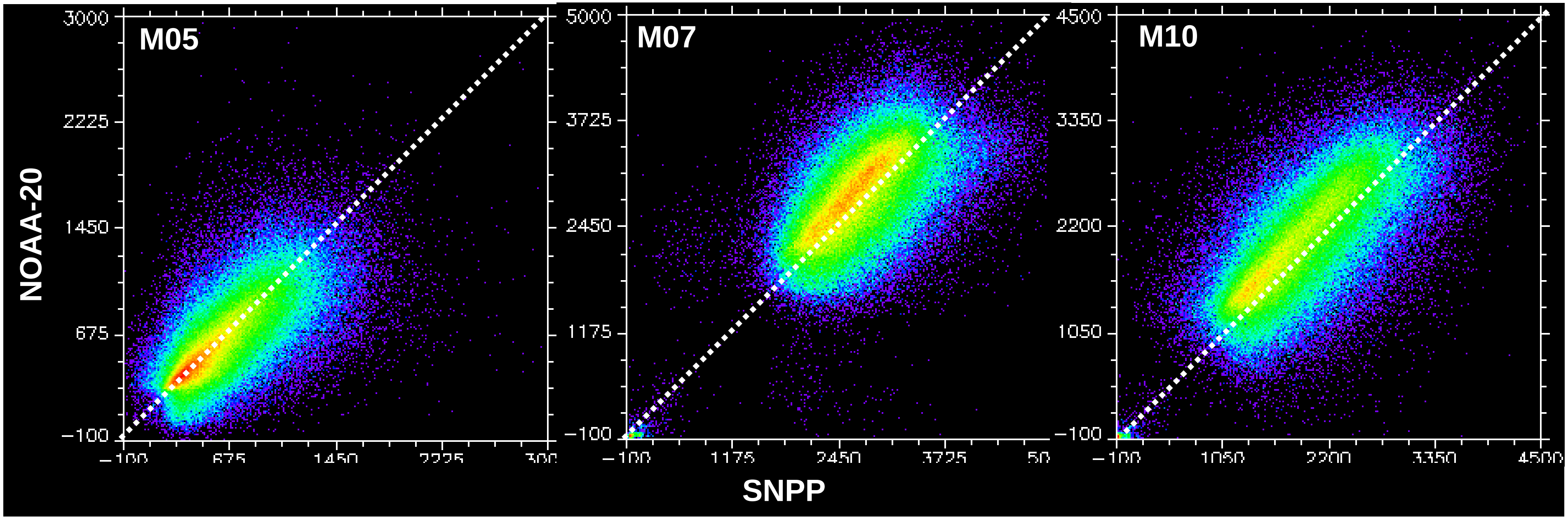
S-NPP



NOAA-20

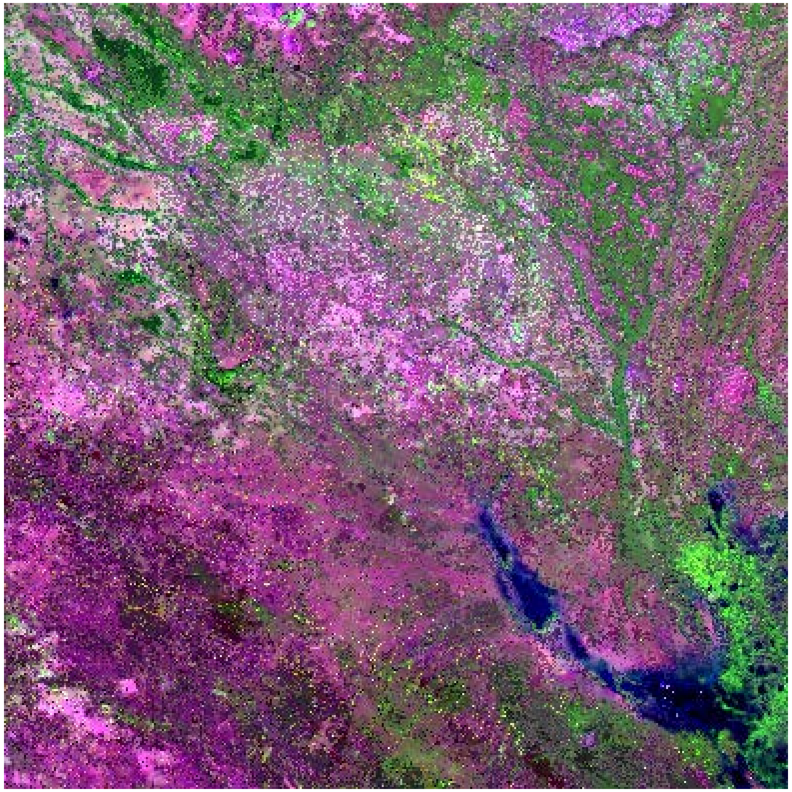
# Monthly Composites Comparison Examples

May 2019
Central Asia

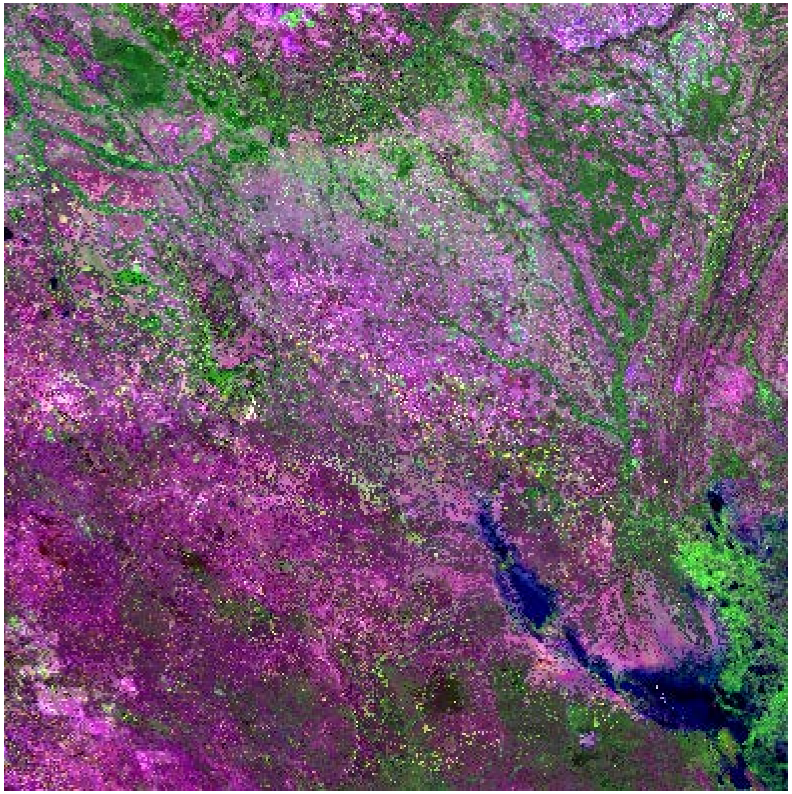


# Monthly Composites Comparison Examples

July 2019, Central South America
RGB: M10, M7, M5



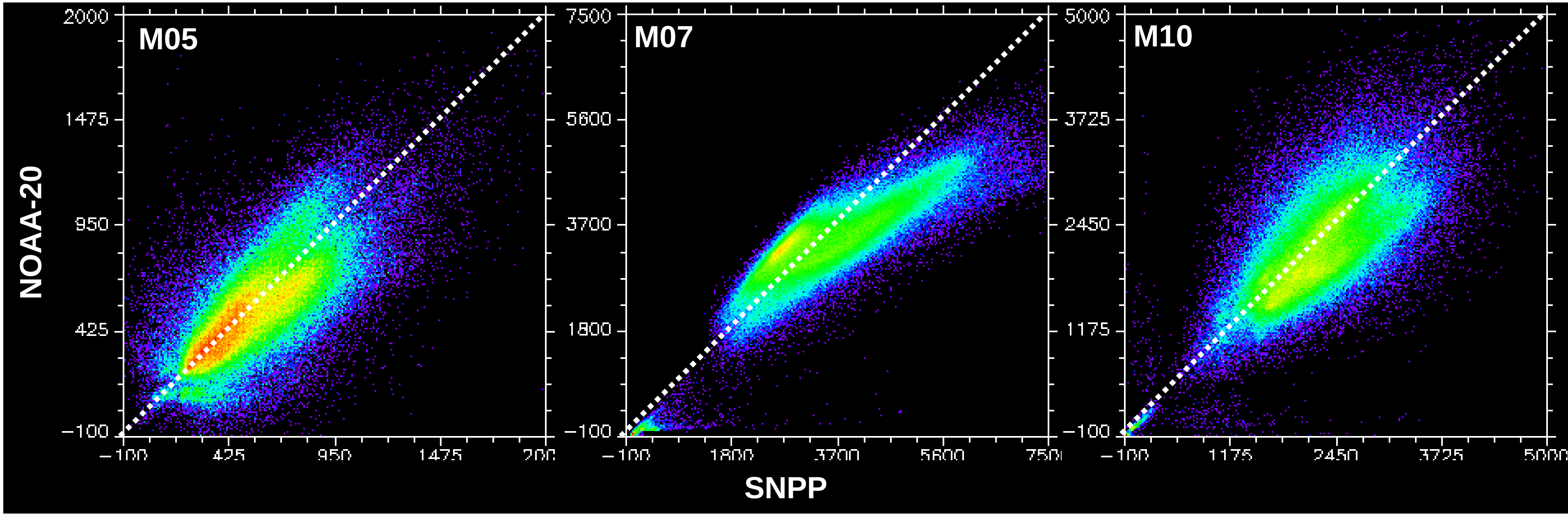
S-NPP



NOAA-20

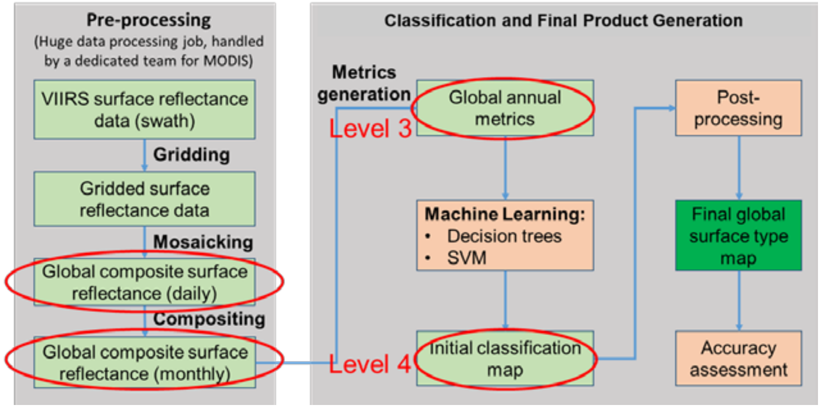
# Monthly Composites Comparison Examples

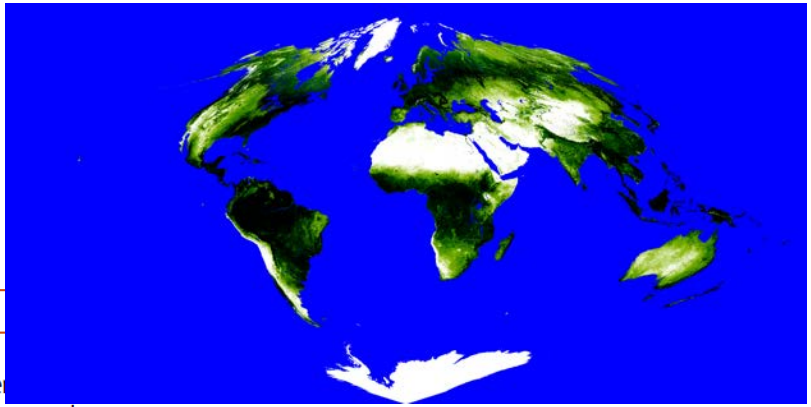
July 2019
South America



# Level 3: Annual Metrics

- Purpose:
  - minimize spectral differences between northern and southern hemispheres and/or along other geographical gradients
- Input: Monthly composites in "one year"
  - May, June, July
    - 2019 NOAA-20 used to create NOAA-20 metrics
    - 2019 S-NPP data used to create S-NPP metrics
  - Other months
    - 2018 SNPP data used to create both sets: No NOAA-20 composites before May 2019
- Output
  - A set of 69 metrics (Zhang et al. 2016, 2017)



mean NDVI

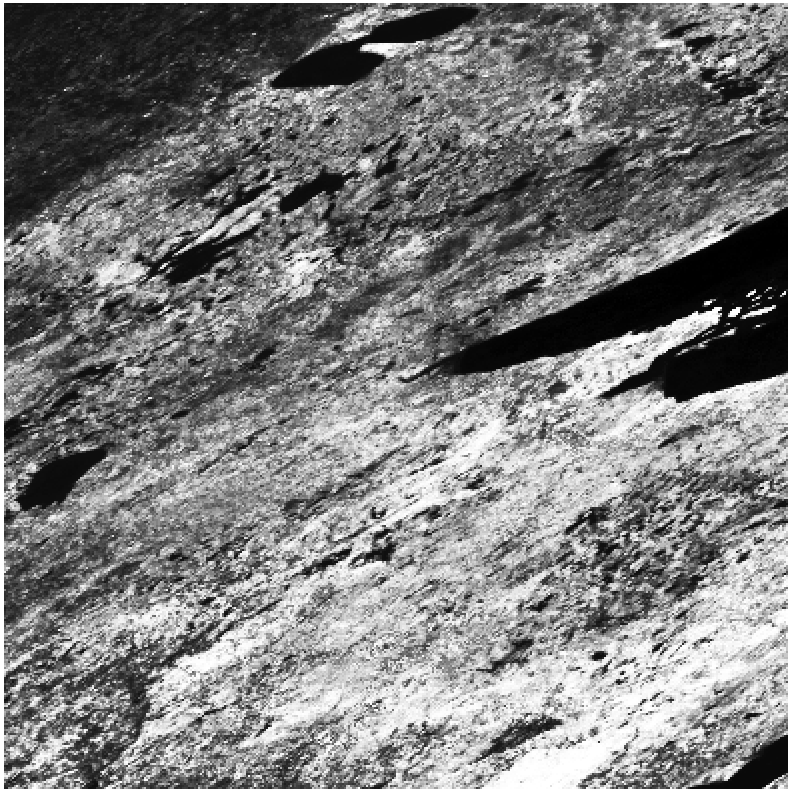
Table 2. Details of annual metrics used in classification.

| Metrics number(s) | Description |
|---|---|
| 1 | Maximum NDVI value |
| 2 | Minimum NDVI value of eight gree |
| 3 | Mean NDVI value of eight greenest months |
| 4 | Amplitude of NDVI over eight greenest months |
| 5 | Mean NDVI value of four warmest months |
| 6 | NDVI value of warmest month |
| 7,14,21,28,35,42,49,56,63 | Maximum band *x* value of eight greenest months |
| 8,15,22,29,36,43,50,57,64 | Minimum band *x* value of eight greenest months |
| 9,16,23,30,37,44,51,58,65 | Mean band *x* value of eight greenest months |
| 10,17,24,31,38,45,52,59,66 | Amplitude of band *x* value over eight greenest months |
| 11,18,25,32,39,46,53,60,67 | Band *x* value from month of maximum NDVI |
| 12,19,26,33,40,47,54,61,68 | Mean band *x* value of four warmest months |
| 13,20,27,34,41,48,55,62,69 | Band *x* value of warmest month |

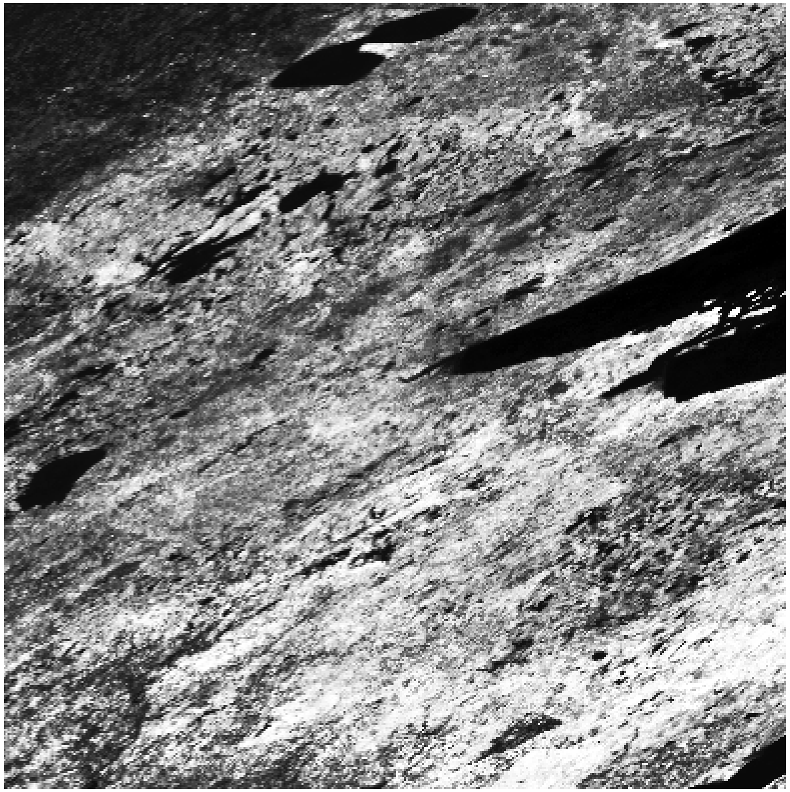
Note: *x* is the band used in annual metrics, which includes M1, M2, M3, M4, M5, M7, M8, M10 and M11.

# Annual Metrics Comparison Examples

US Midwest, Annual Mean NDVI



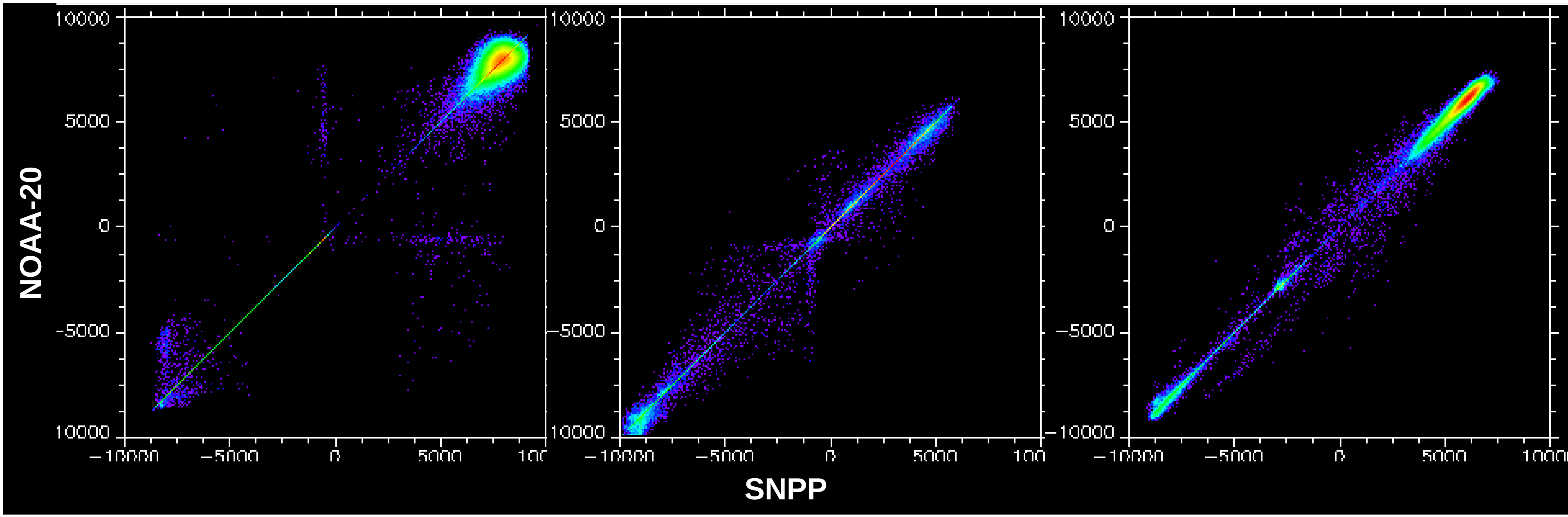
S-NPP



NOAA-20

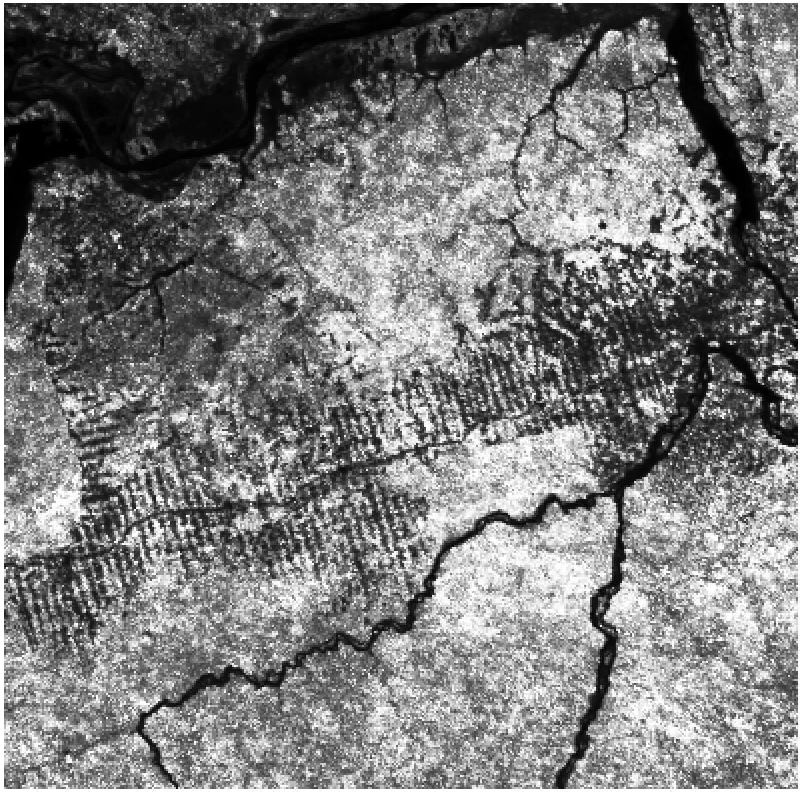
# Annual Metrics Comparison Examples

Max NDVI | Min NDVI | Mean NDVI

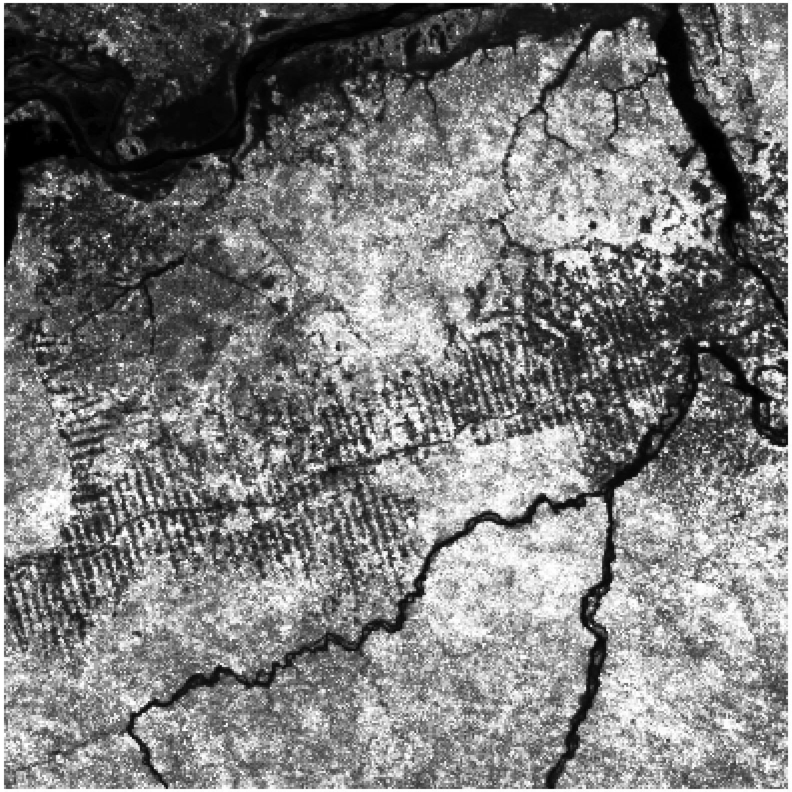


# Annual Metrics Comparison Examples

South America, Annual Mean NDVI

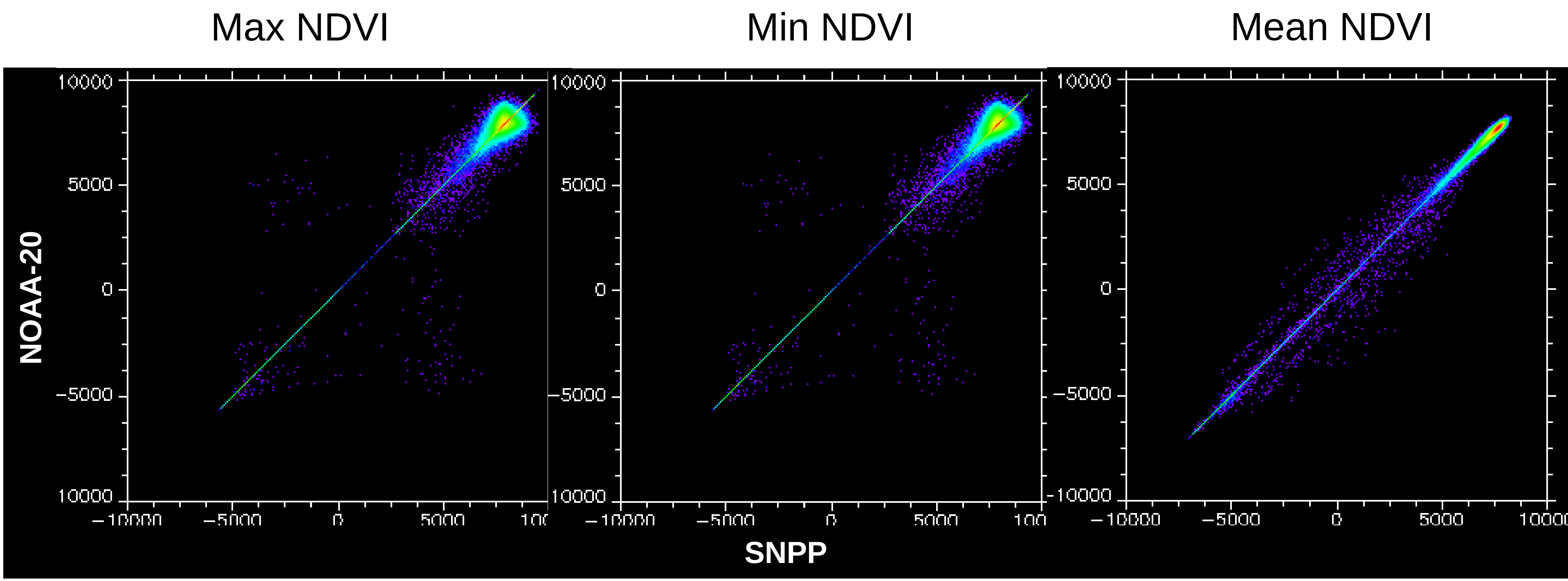


S-NPP



NOAA-20

# Annual Metrics Comparison Examples

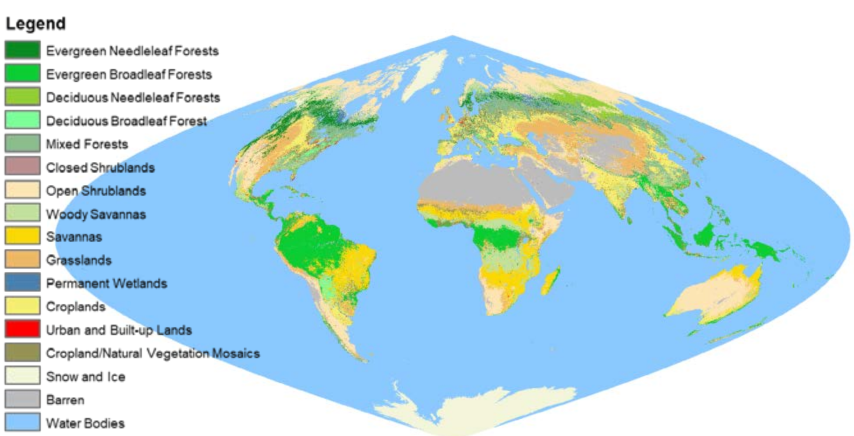


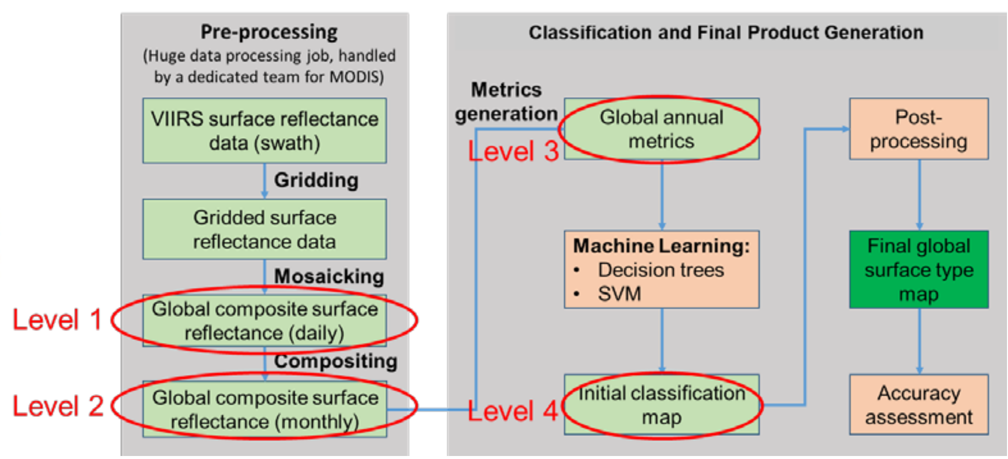
# Level 4: Initial SVM Classification

Derivation of "NOAA-20" and S-NPP based classifications

| | NOAA-20 | S-NPP |
|---|---|---|
| Annual metrics | "NOAA-20" metrics | S-NPP metrics |
| Training sample | same set | |
| Classification algorithm | same: SVM | |
| Classification model | "NOAA-20" based | S-NPP based |
| Classification results | "NOAA-20" based | S-NPP based |

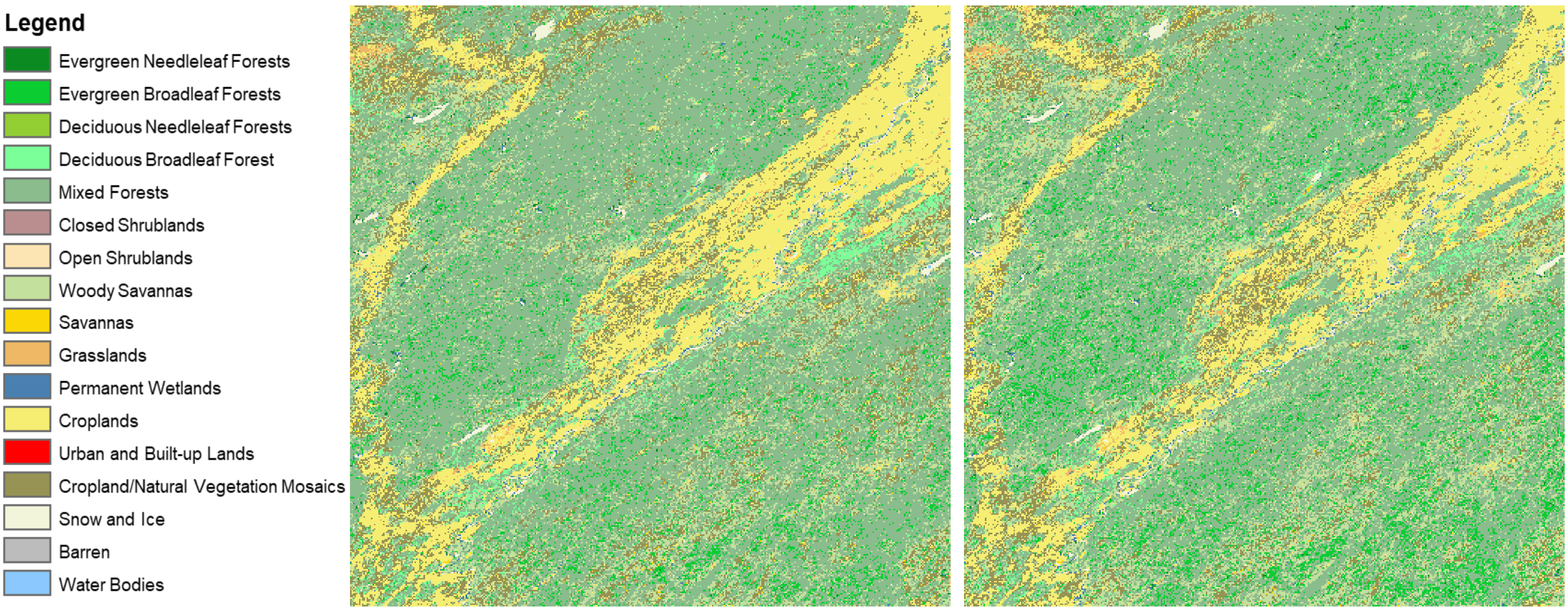
Classifications should be similar but not identical



# Classification Comparison Examples

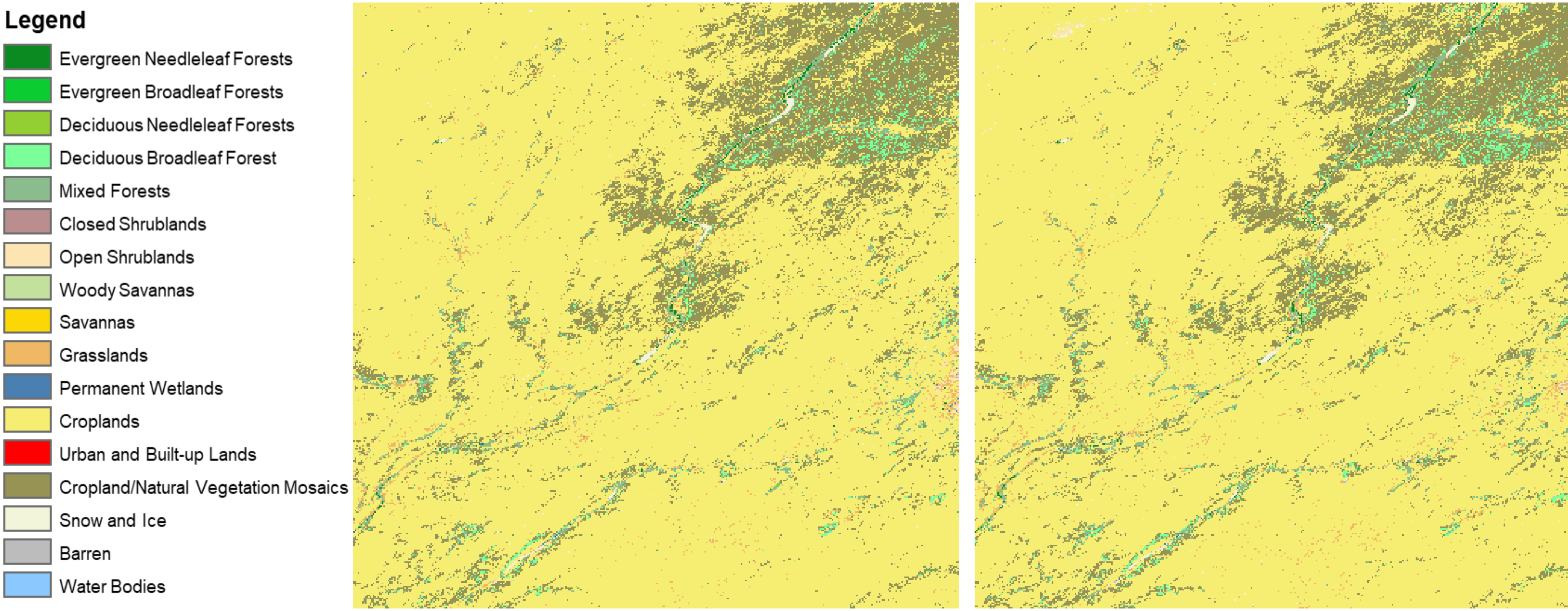
South Central US




S-NPP NOAA-20

# Classification Comparison Examples

US Upper Midwest



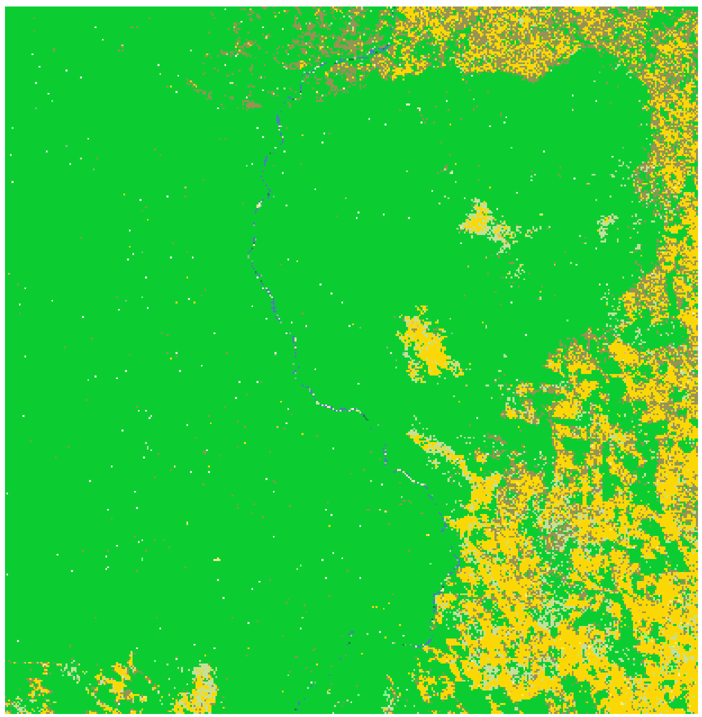

S-NPP NOAA-20

# Classification Comparison Examples

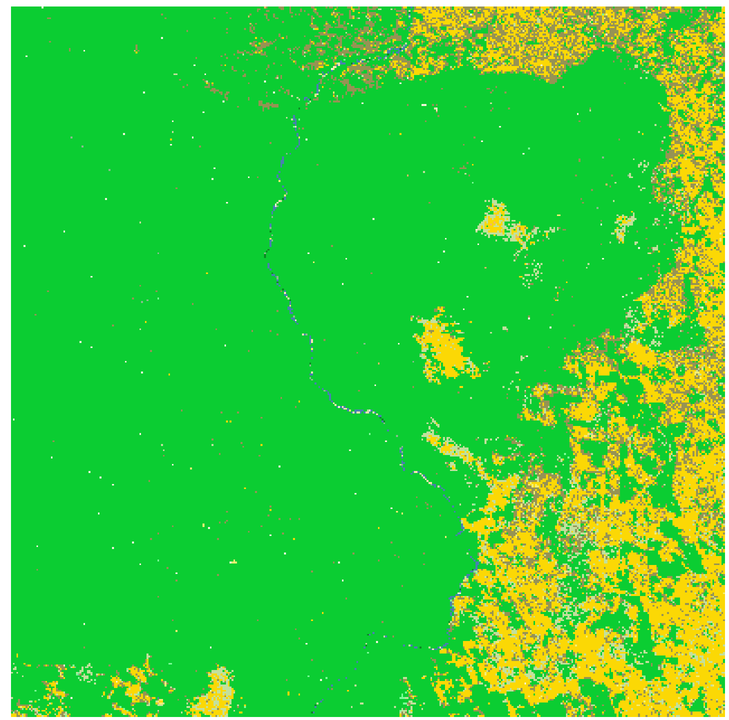
South America

**Legend**

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forest
- 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
- Water Bodies



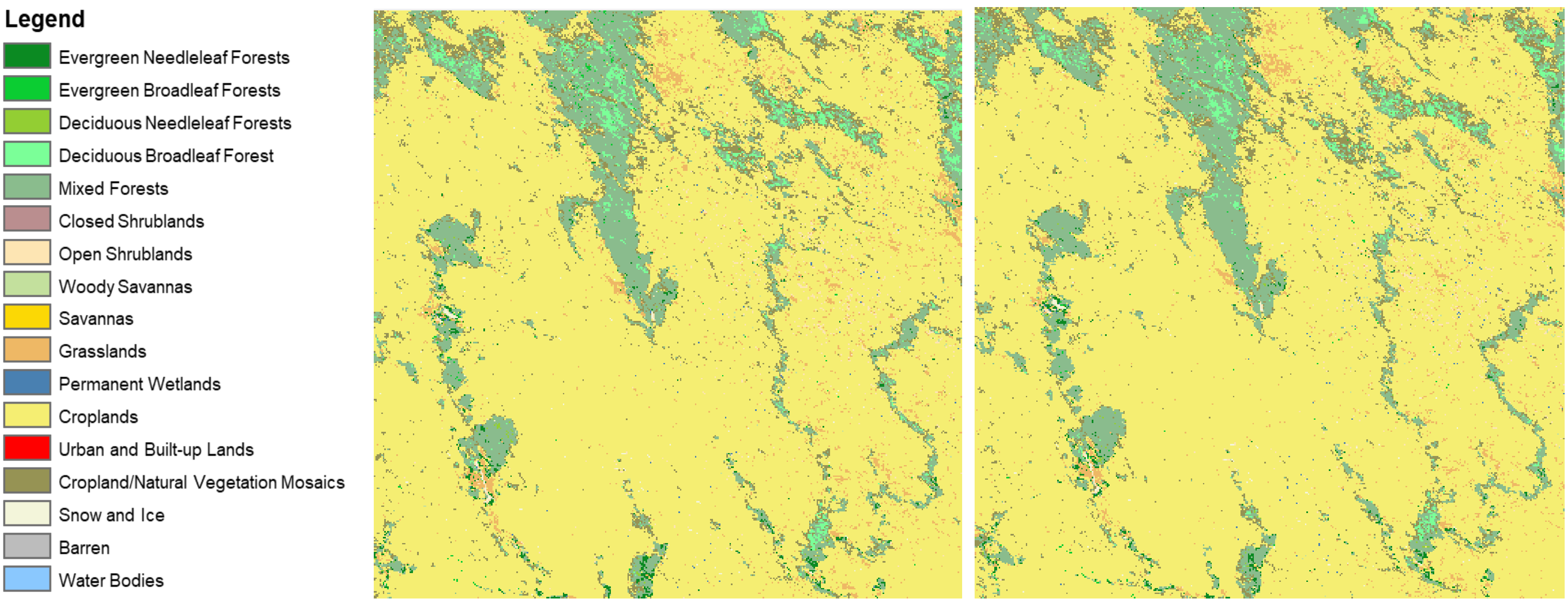
S-NPP



NOAA-20

# Classification Comparison Examples

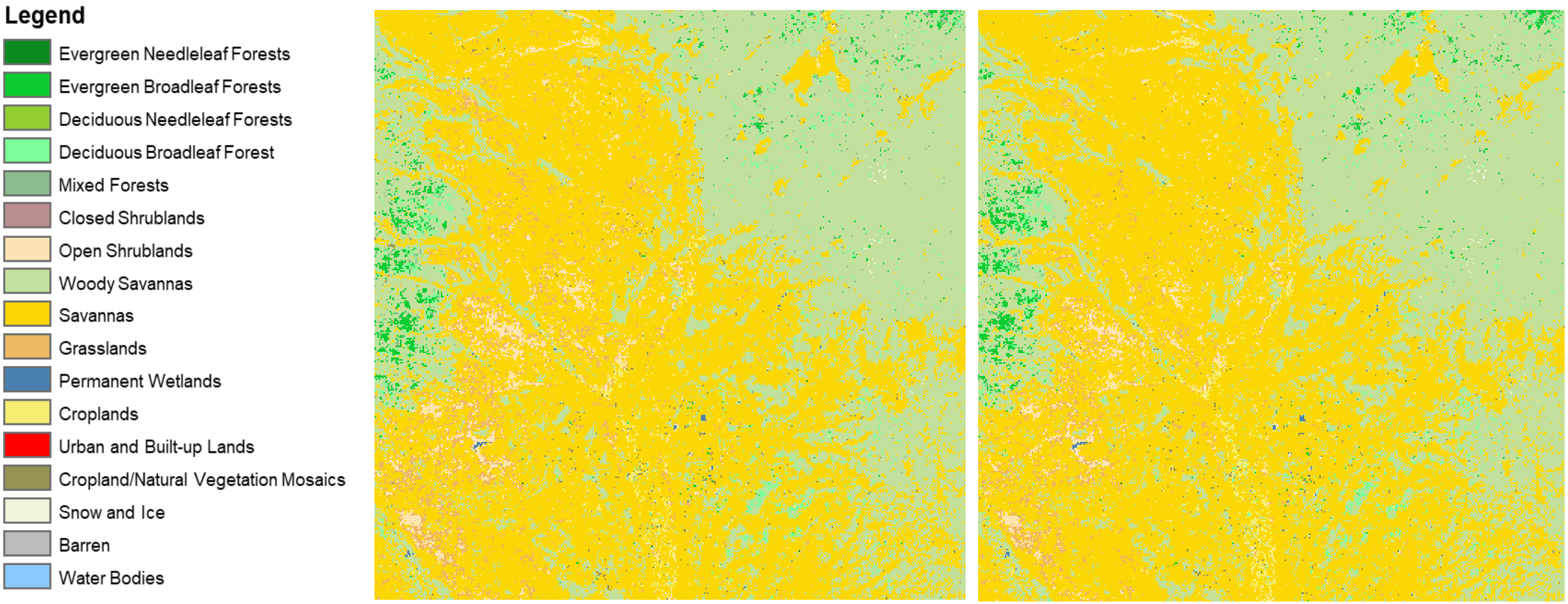
Central Europe




S-NPP NOAA-20

# Classification Comparison Examples

South Central Africa



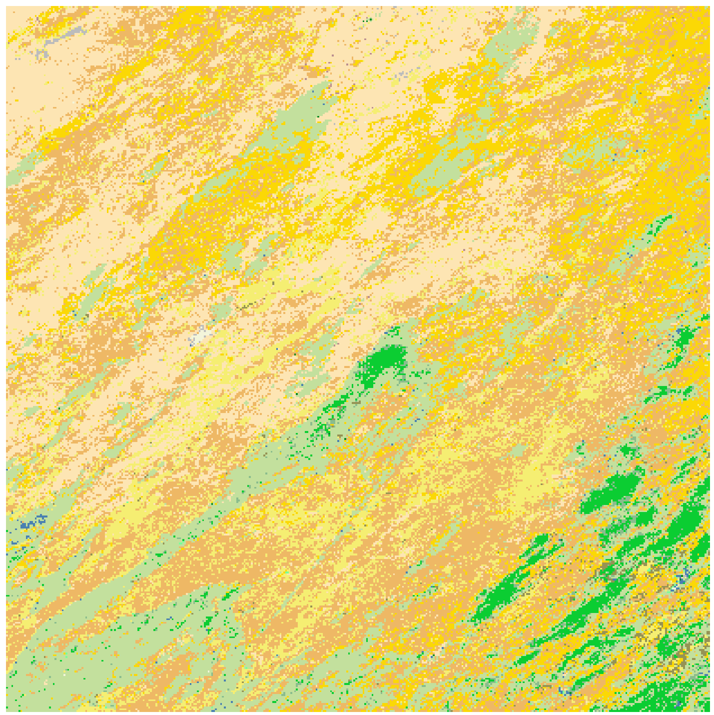

S-NPP NOAA-20

# Classification Comparison Examples

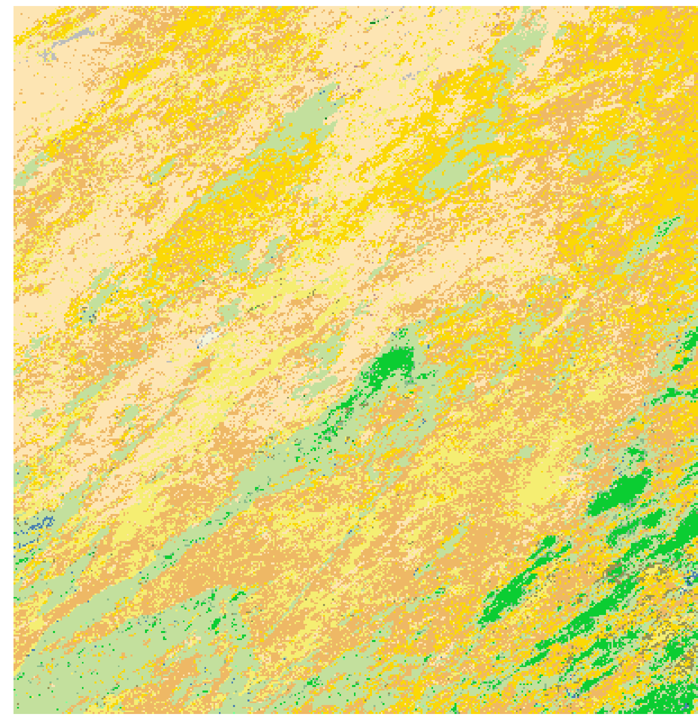
Eastern Australia

**Legend**

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forest
- 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
- Water Bodies



S-NPP



NOAA-20

# Classification Comparison Examples

South Central Asia

**Legend**

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forest
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
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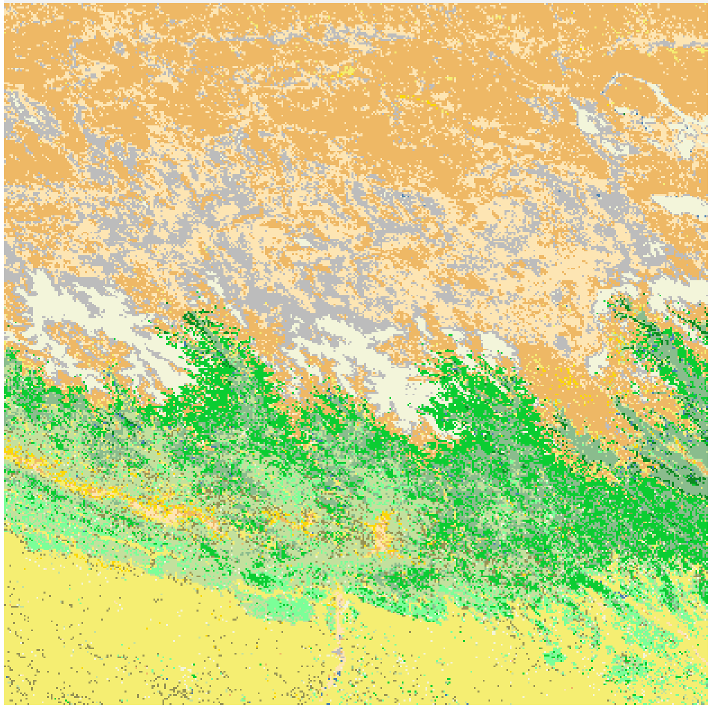
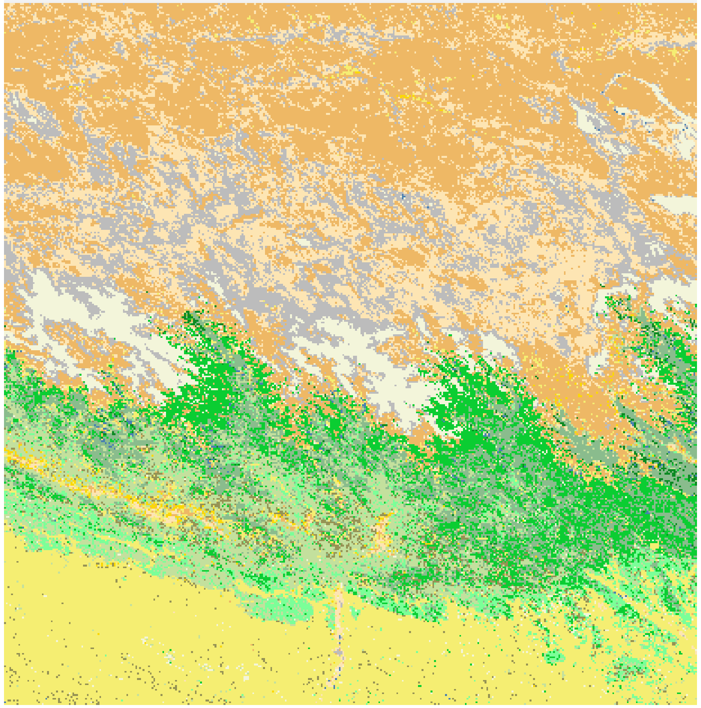


S-NPP



NOAA-20

# Classification Comparison Examples

East Asia

**Legend**

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forest
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
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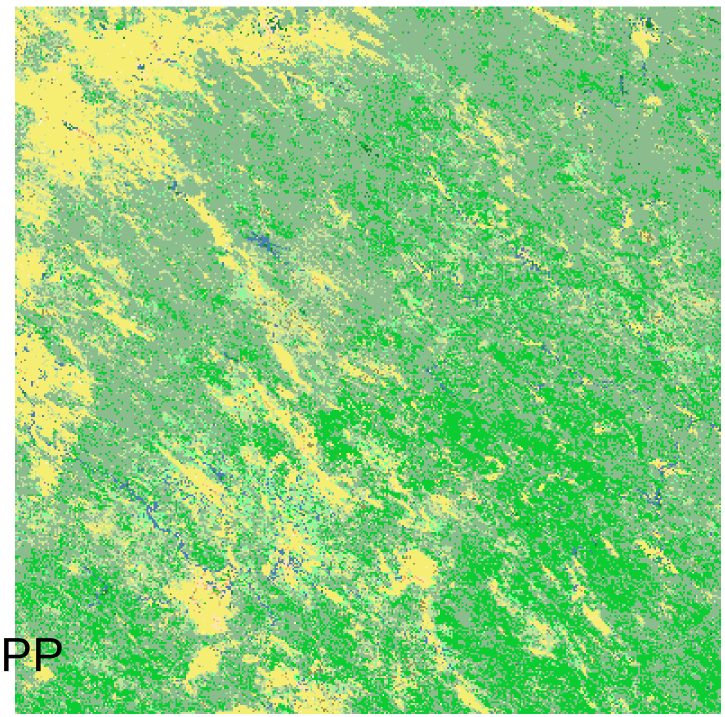
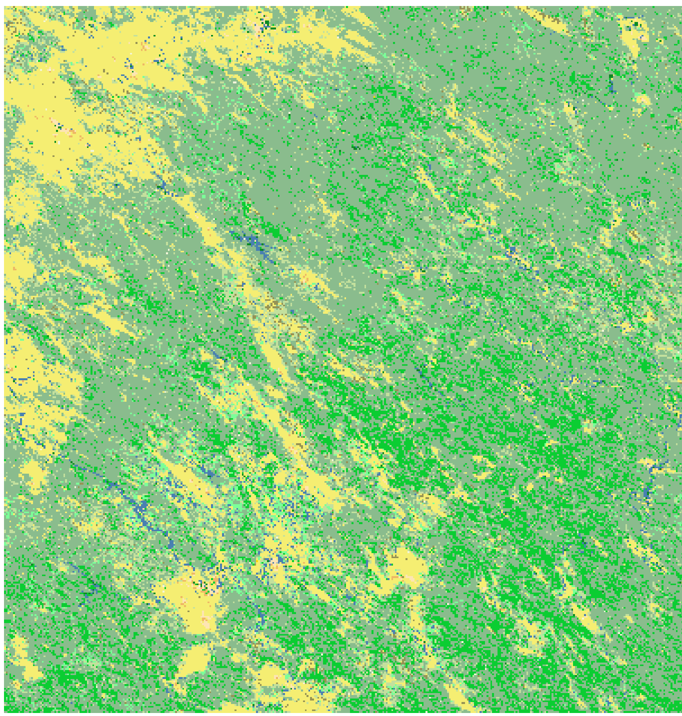
- Water Bodies

S-NPP





NOAA-20

# Summary and Path Forward

- NOAA-20 data are comparable to S-NPP data during 4 key stages of AST development
  - Surface reflectance data
    - Gridded daily data (Level 1): correlated under clear view conditions
    - Monthly composites (Level 2): distributed along 1:1 line
    - Annual metrics (Level 3): highly clustered along 1:1 line
    - Images very similar at each level
  - Annual surface type classification (Level 4):
    - Classification maps have very similar spatial patterns
- Next step: More comprehensive assessment when one full year of NOAA-20 data become available by May 2020