USGS-NASA Landsat Science Team (LST) and USGS Landsat Science Update

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U.S. Geological Survey Earth Resources Observation and Science (EROS) Center

USGS-NASA LST Current Status

- The LST is in the 2nd year of their 5-year term (2018-2023)

- Prior and current meeting schedule:

  - **Winter 2018 meeting** – U.S. Geological Survey EROS
  - **Summer 2018 meeting** – University of Colorado-Boulder
  - **Winter 2019 meeting** – planned for Desert Research Institute (DRI) but cancelled due to partial government shutdown
  - **Summer 2019 meeting** – upcoming at U.S. Geological Survey EROS, June 19-21st

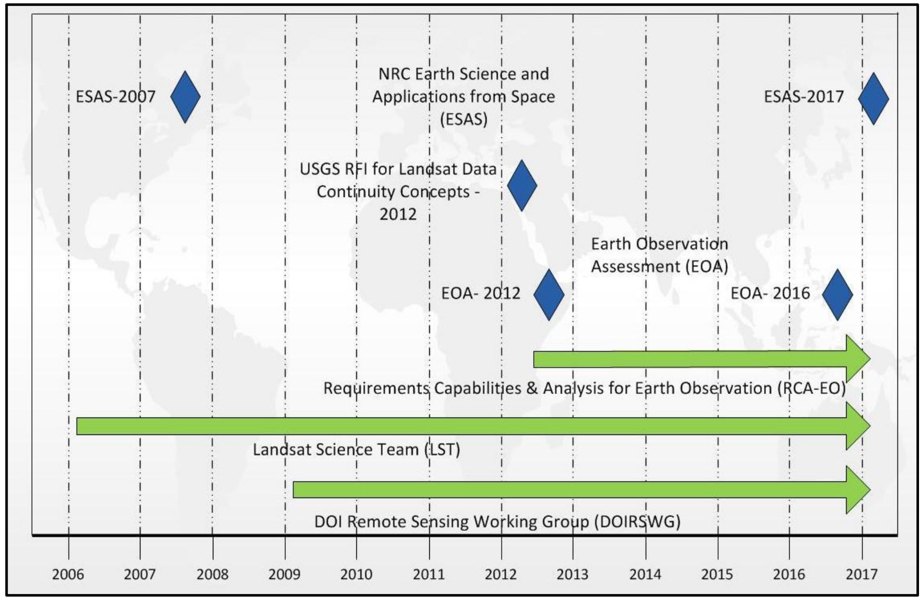
All LST meeting proceedings, presentations, publications found here
https://www.usgs.gov/land-resources/nli/landsat

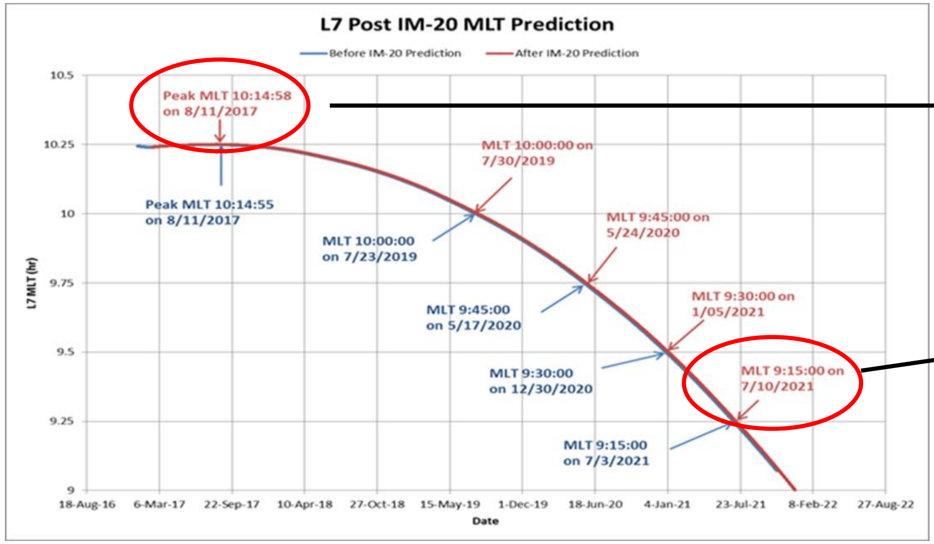
USGS-NASA 2018-2023 LST

2018-2023 USGS-NASA LST Priorities

- The end of the Landsat 7 mission
- Evaluating Landsat 9 data quality and potential science impacts
- Science requirements for future Landsat missions
- Improving Landsat data products and their compatibility with data from other missions
- Communicating the role of Landsat in understanding global land & near-shore change; managing land and water resources

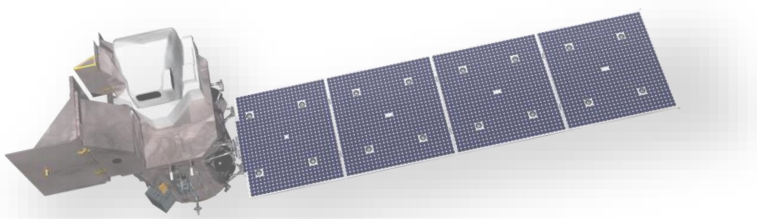
Future Measurement Requirements Process





- Landsat 7 achieved maximum MLT of 10:14:58 on August 12, 2017
- Anticipated end of science mission July 10, 2021

Landsat 9 Spacecraft



Credit: Del Jenstrom, NASA

USGS

What has happen since the 2018 LCLUC/MuSLI meeting?

- Key outcomes from the Summer 2018 LST meeting:

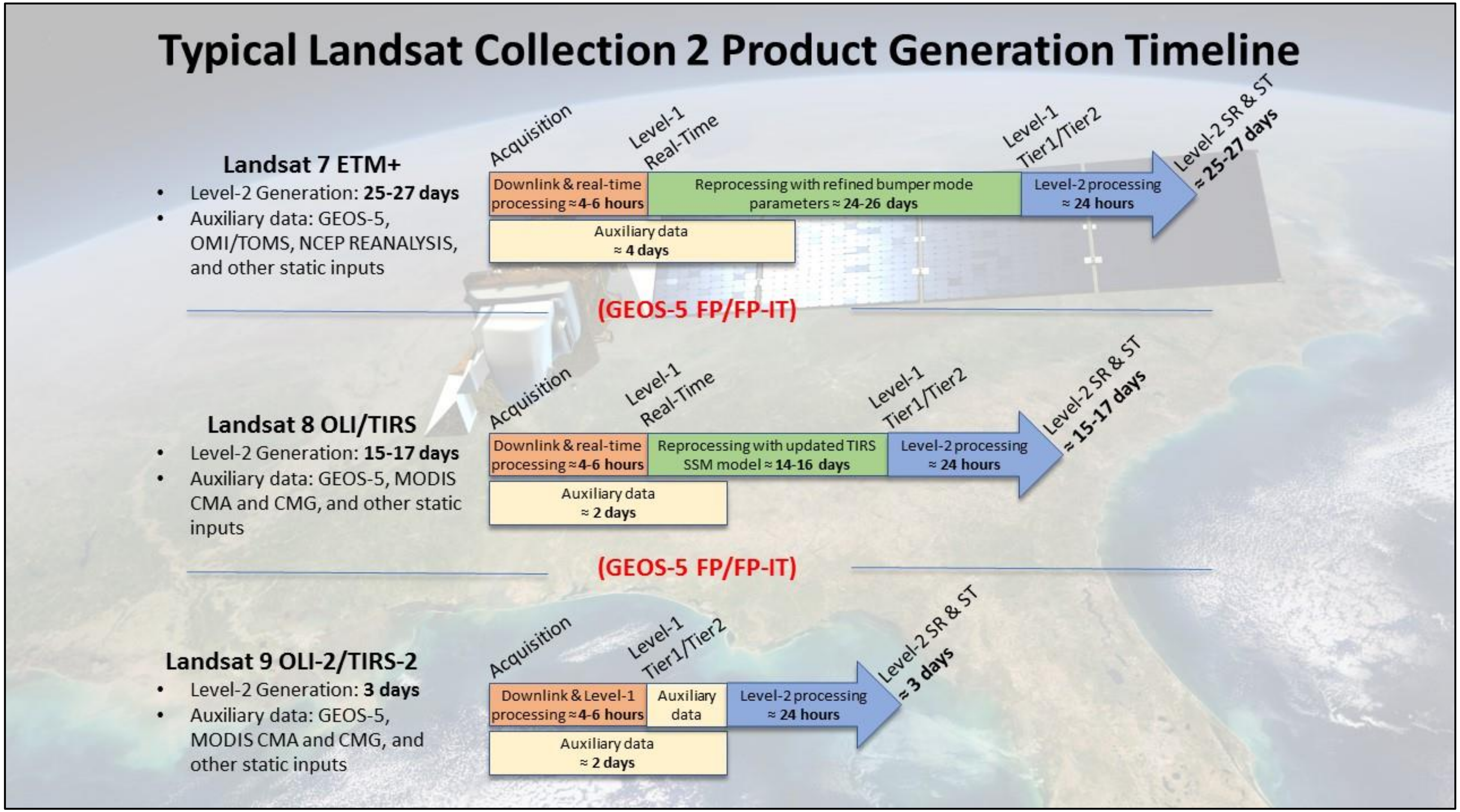
  - Landsat 9 is progressing quickly with planned launch in December 2020
  - Deliberation on future Landsat Collection 2 (C2) definition and timeline
  - Input on future Landsat data products [i.e., evolution of global Analysis-Ready Data (ARD)]
  - Provided NASA-USGS 2019 Architecture Study Team (AST) with preliminary science requirements for Landsat 9 follow-on

- Partial government shutdown in early 2019 impacted the LST schedule

- Formulated Landsat Thermal Infrared and Data Products working groups

- Streamlining Landsat data product offerings, external dependencies, and latencies information for the user community

Current USGS Landsat Level-1/2 (L1/2) Data Product Latencies



Credit: Landsat Science Office, USGS

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Current USGS Landsat C2 Definition & Implementation Timeline

C2 definition/implementation is progressing along Landsat 9 development timeline (i.e., ground system) and could start as early as late 2019

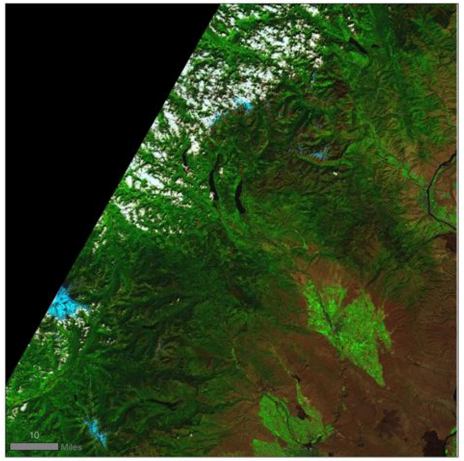
Key features of C2:
(1) Improved geodetic accuracy for Landsats 1-8
(2) Standard global inventory of Landsats 4-9 L2 surface reflectance (SR) and surface temperature (ST) products

Landsat Collection 1 (C1) will continue to be available for ~6-12 months once C2 processing starts

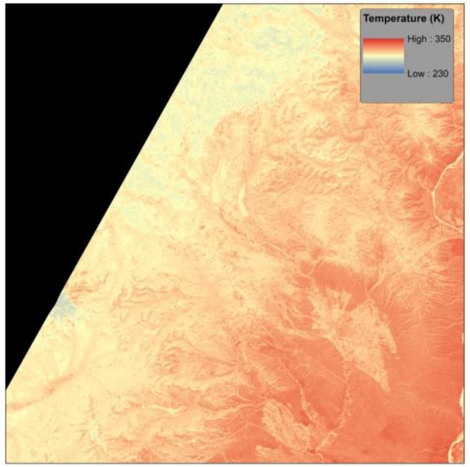
Course of Action #1 – moving towards Landsat ARD visualization interface and distribution services (i.e., scene-based, tiled, and Region of Interest)

Course of Action #2 – moving towards C2 processing in the cloud but forward processing will continue at EROS for the foreseeable future

Source: Landsat Science Office, USGS



Landsat 8 L2 SR Example

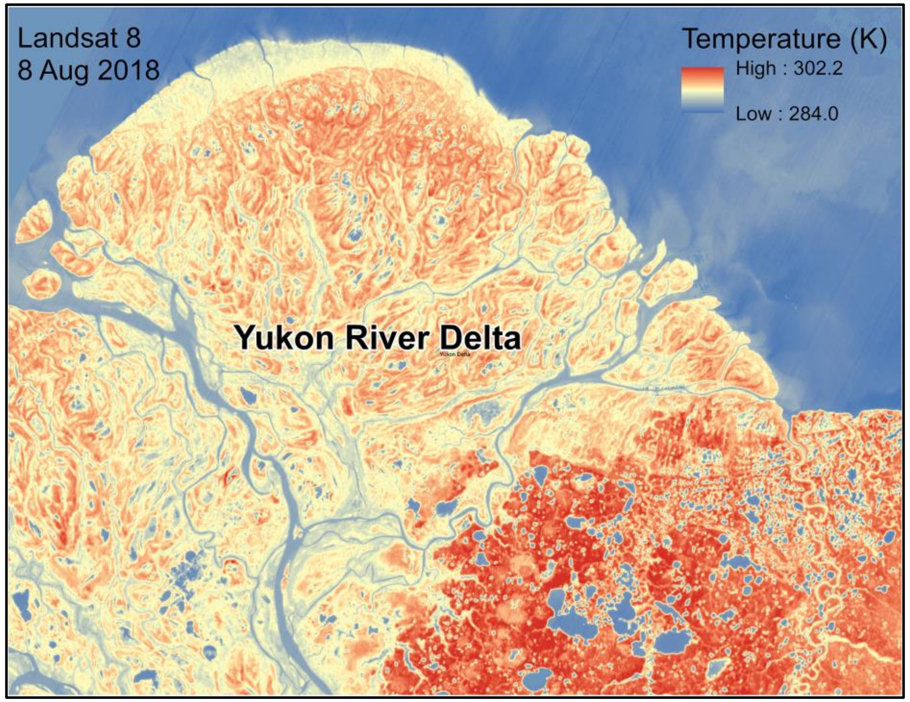


Landsat 8 L2 ST Example

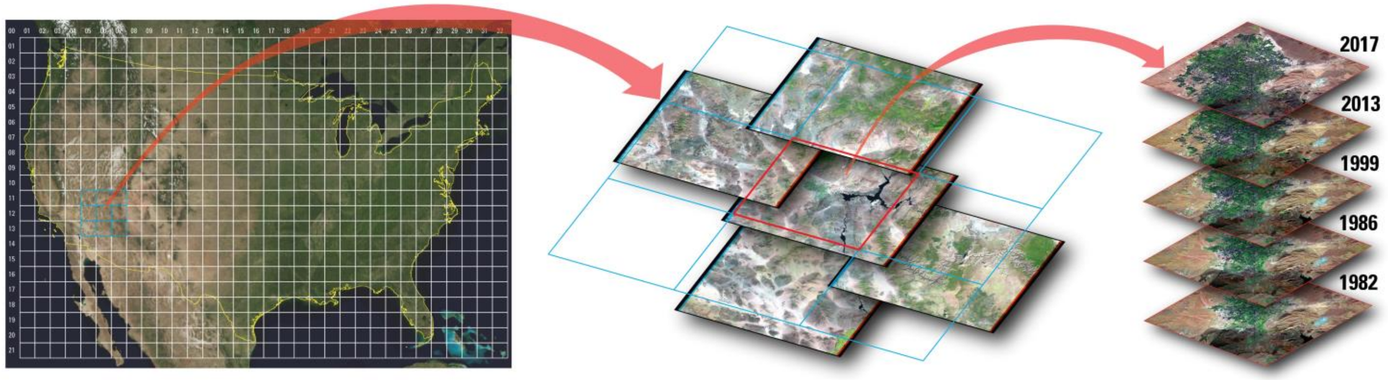
2018 USGS Landsat L2 Product Release

Surface Temperature (ST)

- Includes Landsats 4-8
- Single-channel ST retrieval algorithm
- Available via U.S. Analysis-Ready Data (ARD) distribution
- Forward processing
- Provisional status [known caveats & considerations]



Source: Landsat Science Office, USGS



Source: Landsat Science Office, USGS

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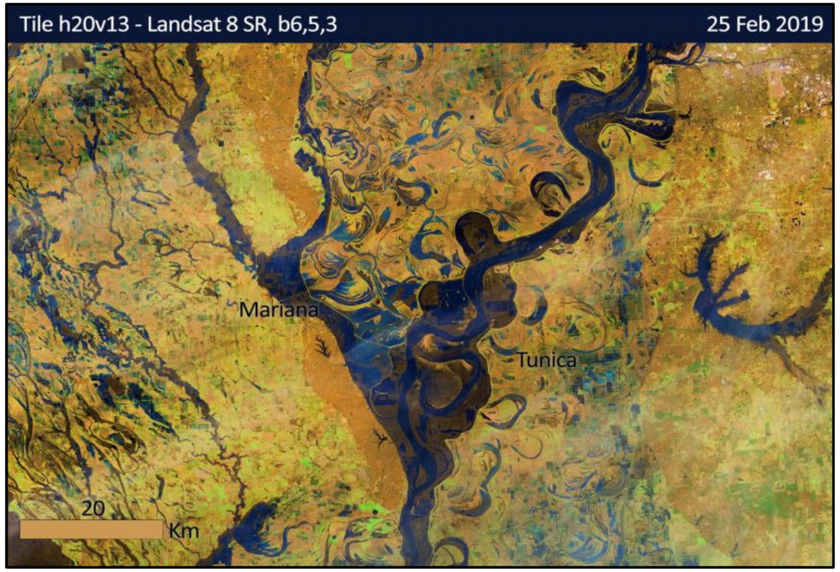
2018 USGS Landsat Level-3 (L3) Science Product(s) Release

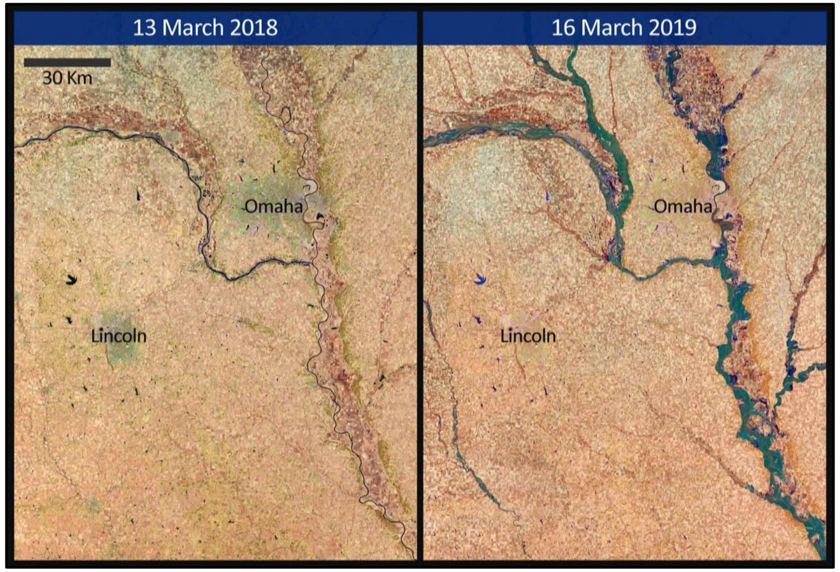
Dynamic Surface Water Extent (DSWE)
- Includes Landsats 4-8
- Available via U.S. ARD distribution
- Forward processing

Burned Area (BA)
- Includes Landsats 4-8
- Available via U.S. ARD distribution
- Forward processing

fractional Snow Cover Area (fSCA)
- Includes Landsats 4-8
- Available via U.S. ARD distribution (western U.S./Alaska)
- Forward processing



Source: Landsat Science Office, USGS



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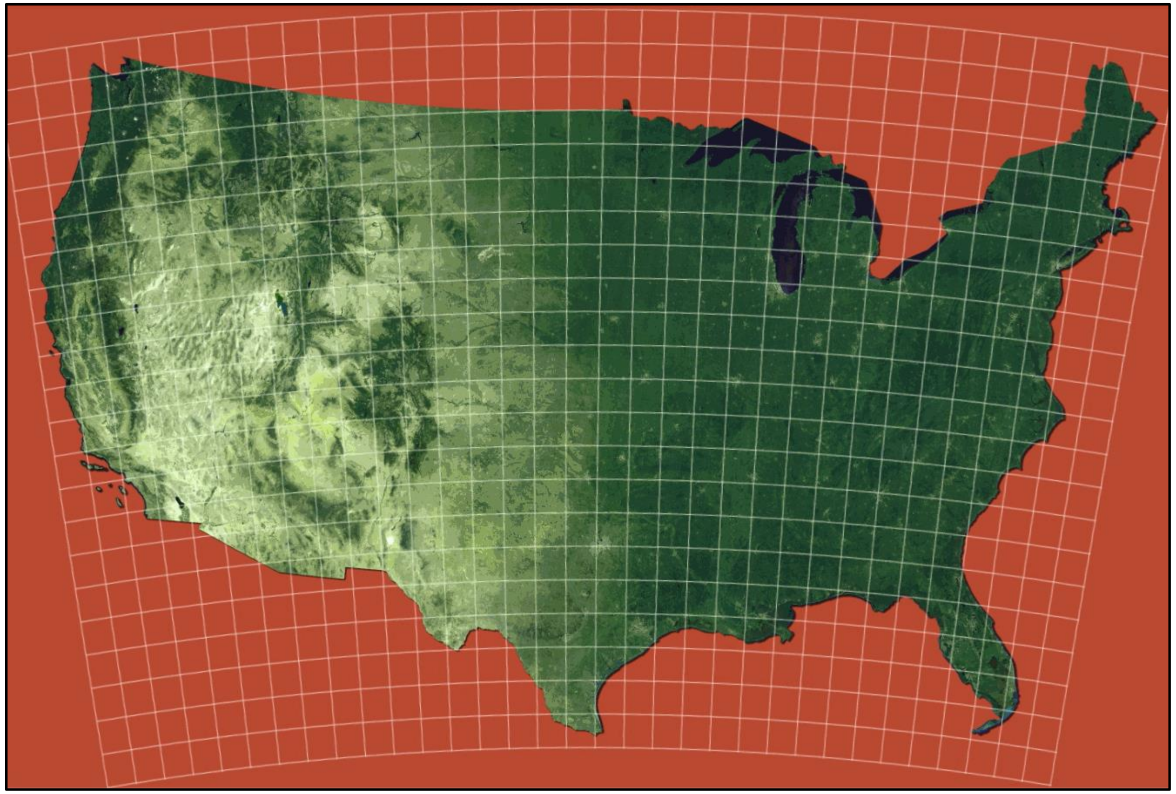
Questions and User Community Feedback is Welcomed

Specifically on:

- Current Landsat C1 scene-based data products
- C1 U.S. ARD tiled data products
- C1 on-demand L2 surface reflectance (SR) and Quality Assurance (QA) data products
- L3 science products

Submit feedback to:

USGS/EROS Customer Services at:
custserv@usgs.gov, 800-252-4547



Source: Landsat Science Office, USGS

USGS


MuSLI & HLS Update

Jeffrey Masek[1], Junchang Ju[2], Jean-Claude Roger[2], Sergii Skakun[2], Belen Franch[2], Martin Claverie[3], Jennifer Dungan[4], Chris Justice[2]

(1) NASA GSFC, (2) Univ. of Maryland, (3) Univ. Catholique de Louvain, (4) NASA ARC

NASA MuSLI Program

- NASA Multi-Source Land Imaging (MuSLI) Team is a research program designed to advance use of multi-source remote sensing data for land monitoring
    - Solicited 2014 through NASA Land Cover/Land Use Change Program
    - Three-year projects (2015-17)
    - Re-competed in 2017 for second three year cycle

- Objectives:
    - **Develop algorithms and prototype products** that make use of multiple satellite sources & time series approaches
        - *Focus on Landsat and Sentinel-1 & 2*
        - *Focus on evolving continental-scale products analogous to what is available from MODIS, but at moderate resolution (<100m)*
    - Understand challenges associated with algorithms & processing streams that incorporate multiple satellite systems
    - Develop stronger community of practice among US and international (especially EU) researchers

2018-2020 MuSLI Projects

Mark Friedl (Boston U)	An Operational Multisource Land Surface Phenology Product from Landsat and Sentinel 2
David Roy (South Dakota State U.)	Africa Burned Area Product Generation, Quality Assessment and Validation - Demonstrating a Multi-Source Land Imaging (MuSLI) Landsat-8 Sentinel-2 Capability
Crystal Schaaf (U. Mass - Boston)	Circumpolar Albedo of Northern Lands from Landsat-8 and Sentinel-2
Martha Anderson (USDA)	Characterizing Field-Scale Water Use, Phenology and Productivity in Agricultural Landscapes Using Multi-Sensor Data Fusion
Petya Campbell (U. Maryland - Baltimore County)	Prototyping MuSLI canopy Chlorophyll Content for Assessment of Vegetation Function and Productivity
Glynn Hulley (JPL)	A High Spatio-Temporal Resolution Land Surface Temperature (LST) Product for Urban Environments
Volker Radeloff (U. Wisconsin)	Monitoring Abandoned Agriculture, Fallow Fields, and Grasslands with Landsat and Sentinel-2
Sergii Skakun (U. Maryland - College Park)	Crop Yield Assessment and Mapping by a Combined use of Landsat-8, Sentinel-2 and Sentinel-1 Images

Type 1: Continental-scale products

Type 2: Regional-scale prototypes

12

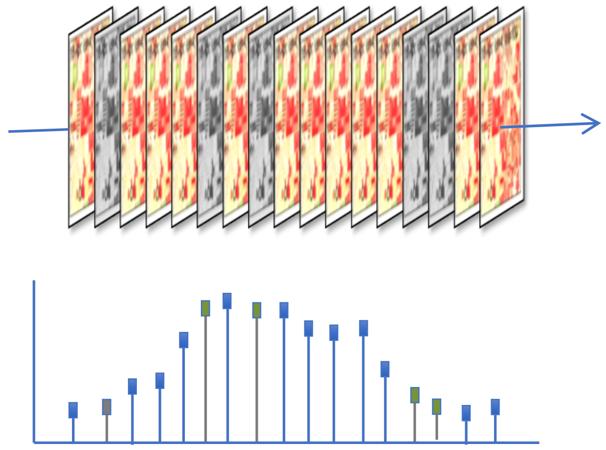
ESA Living Planet 2019

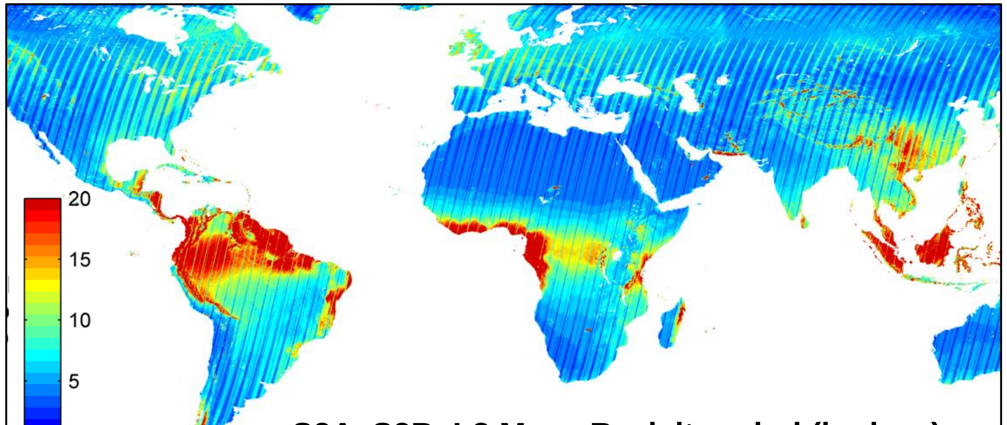
13-17 May 2019

Special Session: **Multi-Source Data for Next Generation Land Monitoring**

Harmonized Landsat Sentinel-2 (HLS) Project

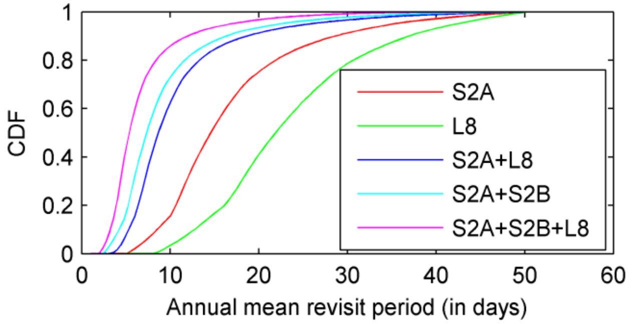
- Merging Sentinel-2 and Landsat data streams can provide **2-3 day global coverage**
- Goal is "seamless" near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding
- Project initiated in 2012 as collaboration among NASA GSFC, UMD, NASA Ames
- Prototype for a multi-sensor Analysis Ready Data product





S2A+S2B+L8 Mean Revisit period (in days)

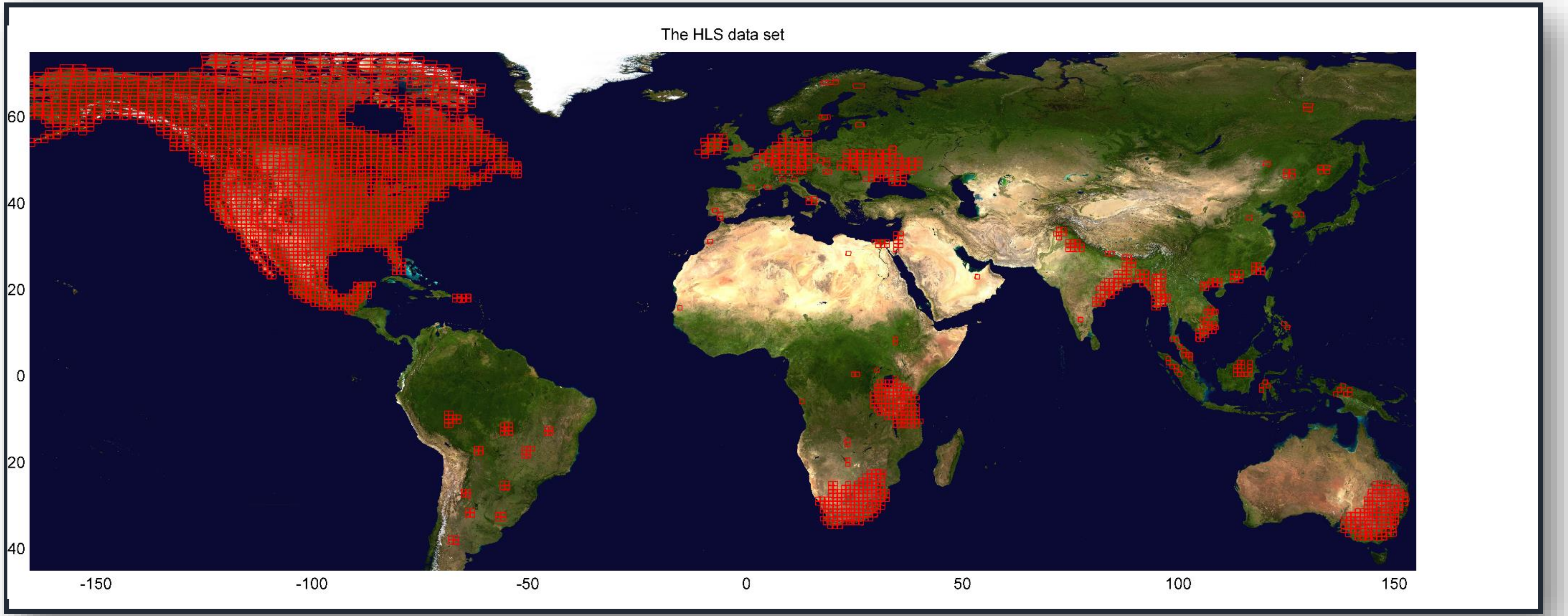
Potential Revisit using different Virtual Constellations



HLS (v1.4) Data Set (released Nov 2018)

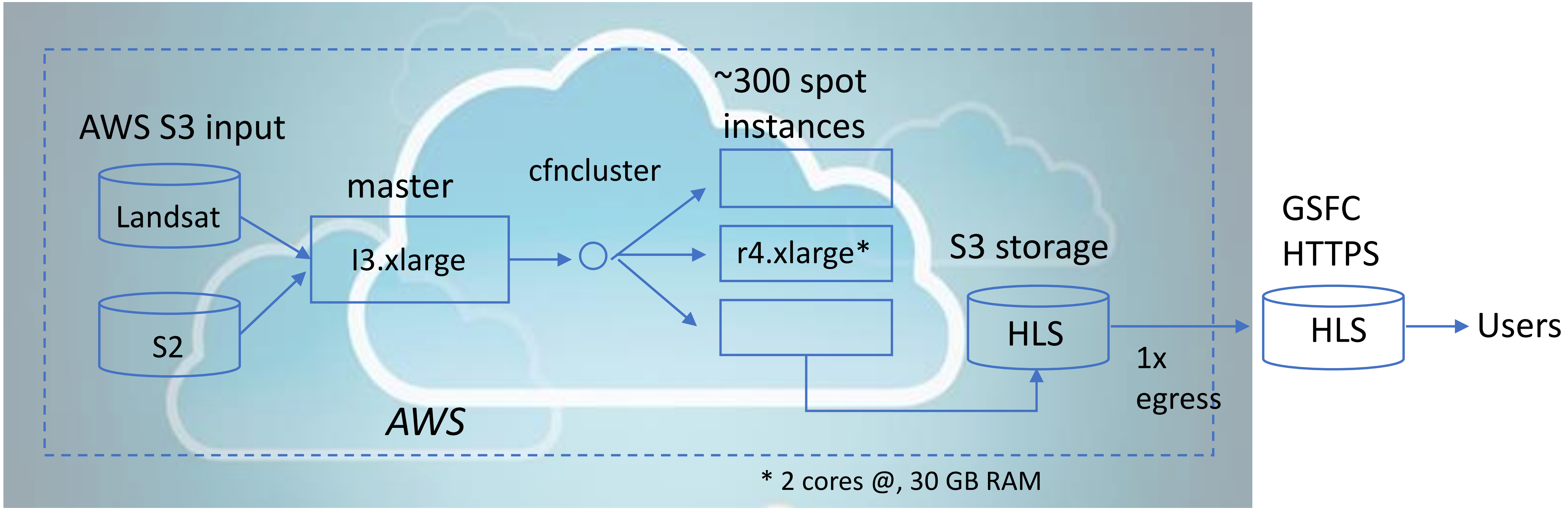
- 105 Global Test Sites (3904 MGRS tiles)
- >37 million sq. km2 (~25% global land)
- < 7 day latency

- Landsat-8 data set: 1,100k products From Mar-2013 to Present (135 TB)
- Sentinel-2 data set: 420k products From Jun-2015 to Present (60 + 274 TB)



Cloud Processing Approach: AWS & AMCE

- Initially HLS was processed via NASA Ames NEX computing cluster
- With Version 1.4, HLS has migrated to Amazon Web Services (AWS) via NASA Earth Sciences Technology Office (ESTO) AIST Managed Cloud Environment (AMCE)



How Much Data?

Version 1.4 (25% global land area)

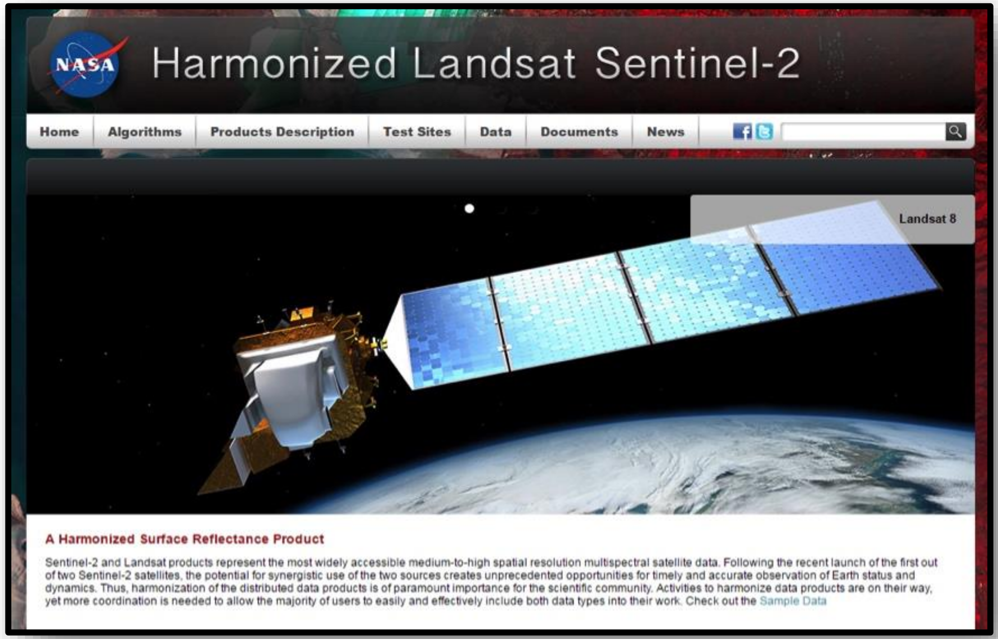
	# input granules	Peak Daily Input Volume (TB)	Peak Daily Output Volume (TB)	Daily Wall-clock processing time	Annual Output Volume (TB)*
Landsat-8	170	0.3	0.1	200 CPU * 3 hours	29
Sentinel-2A/B	2100	1	0.3	800 CPU * 7 hours	91
Total	**2270**	**1.3**	**0.4**	**6200** CPU hr	**120**

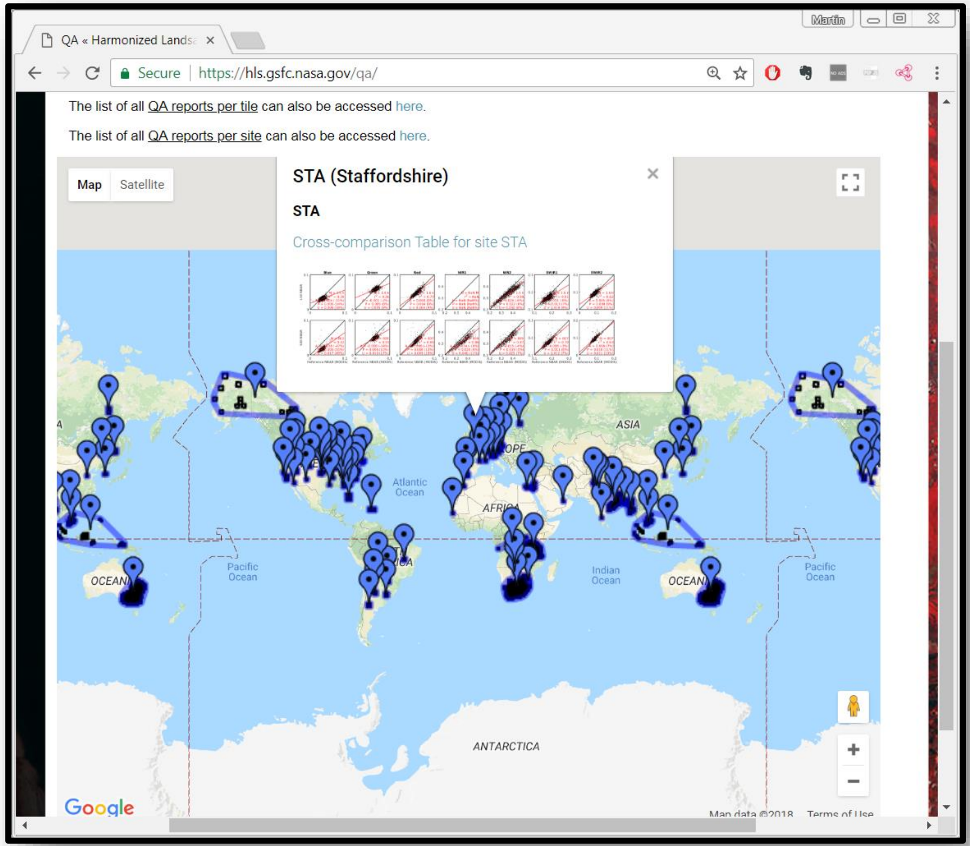
*For comparison, the NASA/ISRO NISAR mission is expected to generate **85 TB** of data each day upon launch*

** Note that annual total is less than equivalent peak daily volume*

Website and Public Interface

- https://hls.gsfc.nasa.gov
- Public access
- S30, L30 data available (via HTTPS)
- QA, Product documentation
- Products also available via S3 storage for AWS users





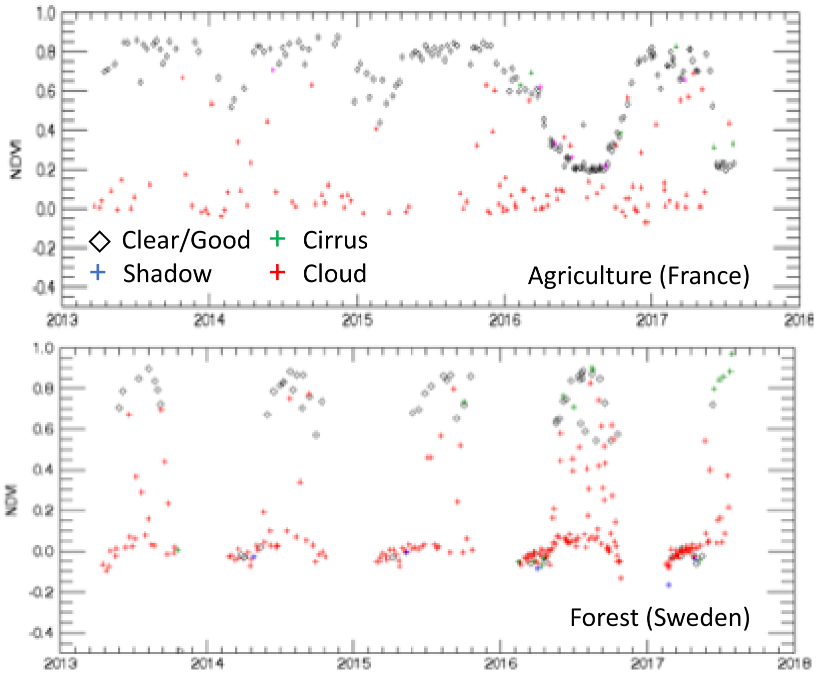
Quality Assurance (QA) & Uncertainty

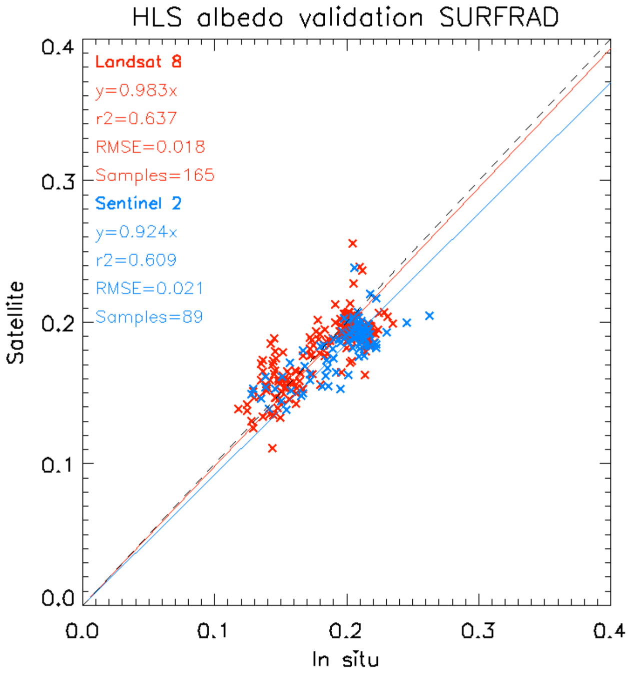
Product Quality Assurance (QA) - Should the user avoid this particular granule or pixel?

- *Per-pixel cloud, shadow, high aerosol bits*
- *Per-granule comparison with contemporary MODIS NBAR*

Product Validation – what is the uncertainty (bias, precision) associated with any given observation compared to the true value?

- *"Bottom-up" error budget based on algorithm validation*
- *Comparison with SURFAD albedometer measurements (B. Franch, UMD)*
- *Short-term stability of PICS sites*





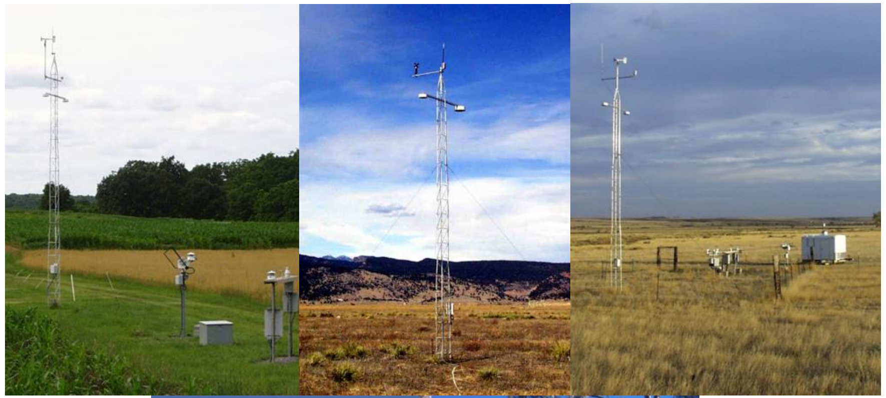
SURFRAD comparison:
RMSE: ~0.02 absolute
(~10% relative)

Short-term variability:
~3-4% relative RMSE

Albedo Estimation from HLS (Belen Franch, UMD)

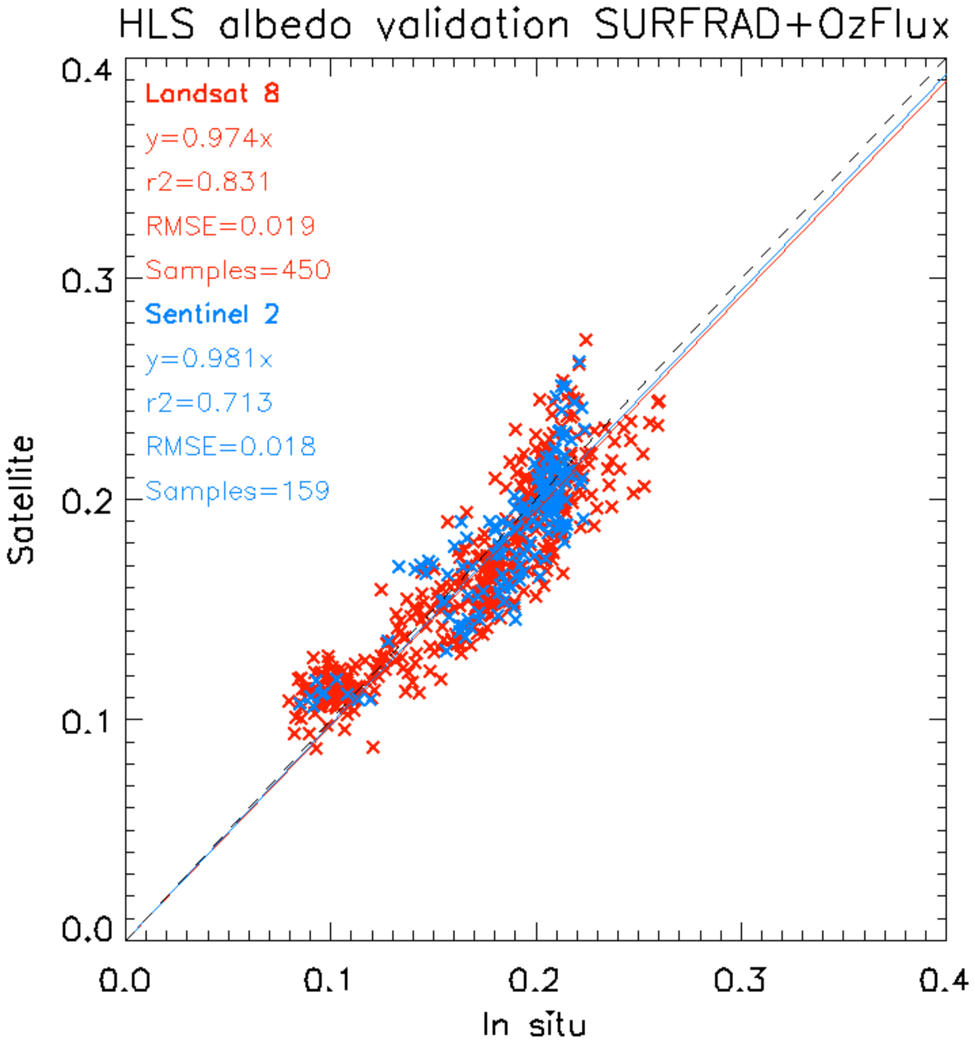
Convert HLS directional reflectance to hemispheric albedo via spectral unmixing and application of MODIS BRDF kernels

Validation using US SURFRAD and Australia OZFLUX albedometer data



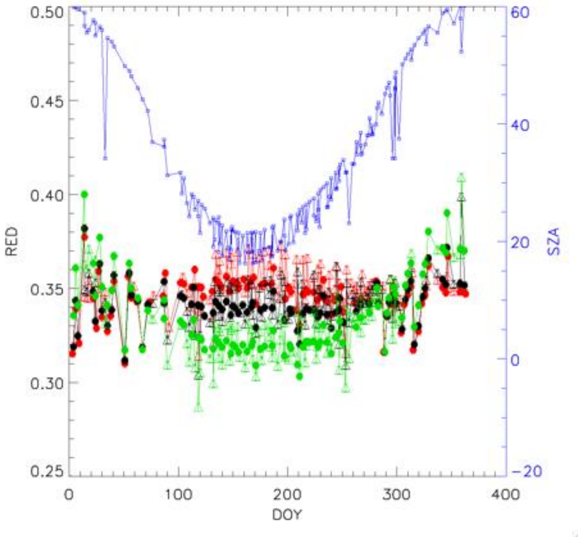
US SURFRAD

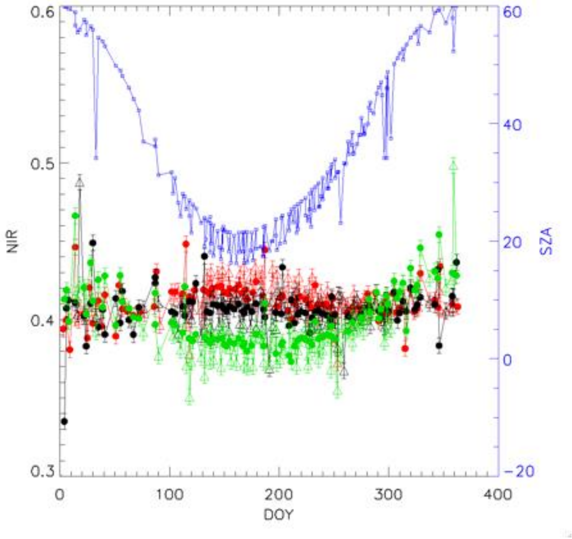
Australia OZFLUX



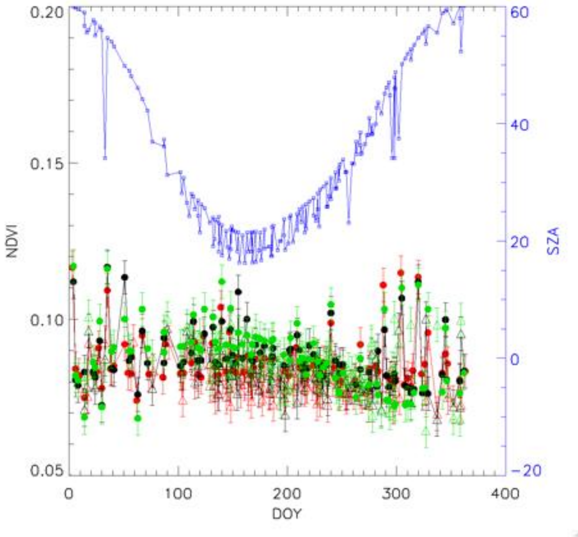
RESULTS

Surface Reflectance Normalization. Homogeneous Desert site

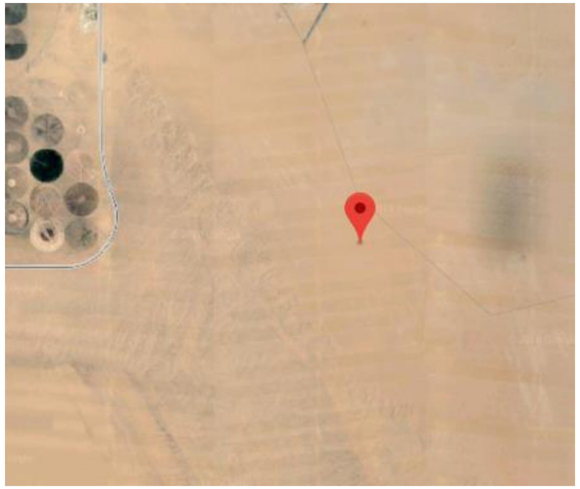


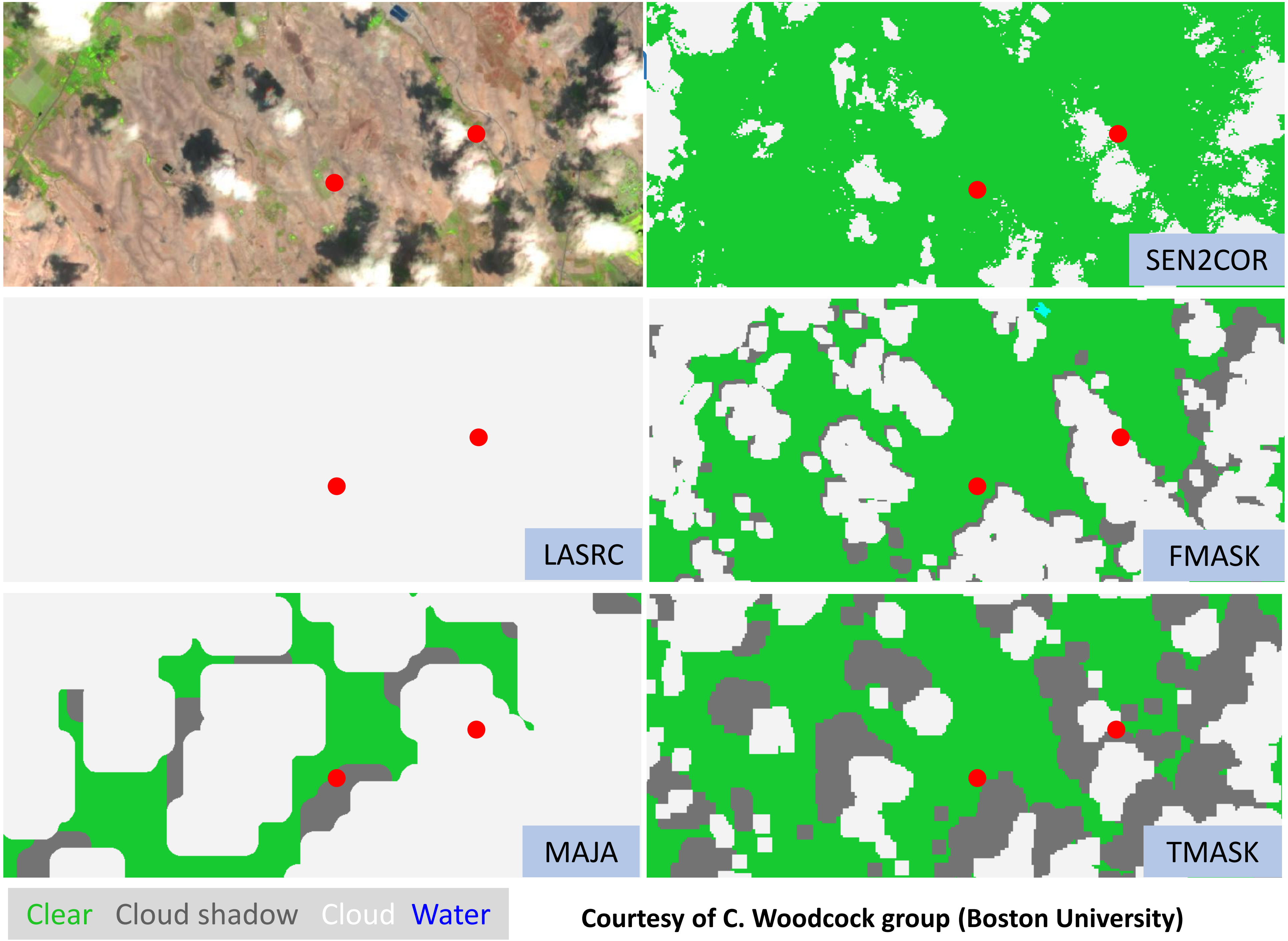


Red: non-corrected
Green: current HLS BRDF correction
Black: Proposed BRDF correction



CV (%)	RED	NIR	NDVI
Non corrected	3.3	2.7	9.4
Current HLS BRDF correction	6.1	5.0	11.0
Proposed BRDF correction	3.5	3.3	9.9



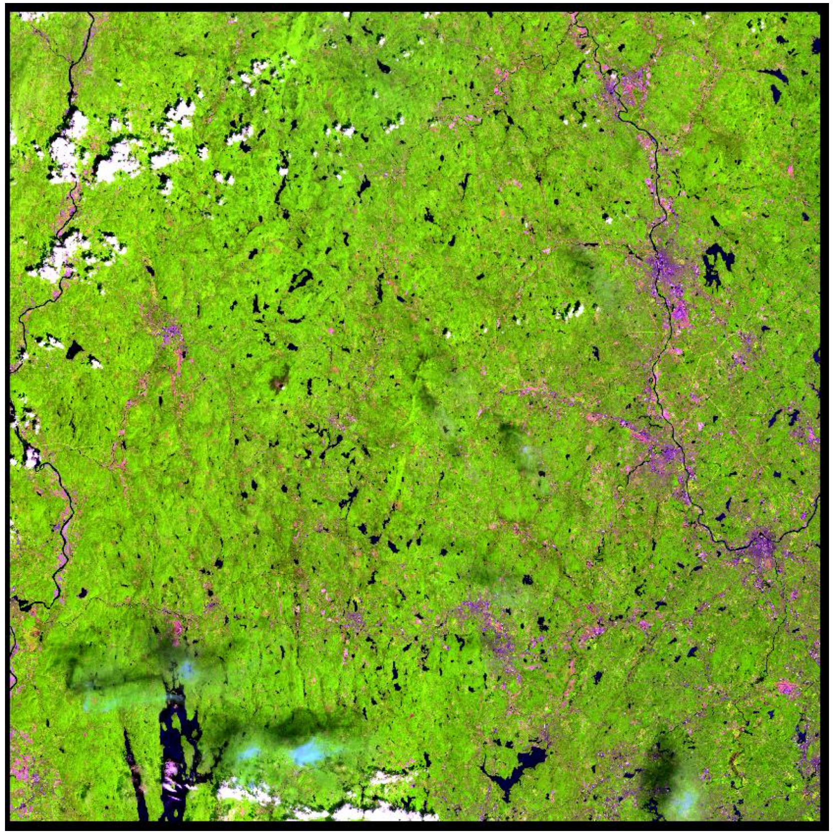


Courtesy of C. Woodcock group (Boston University)

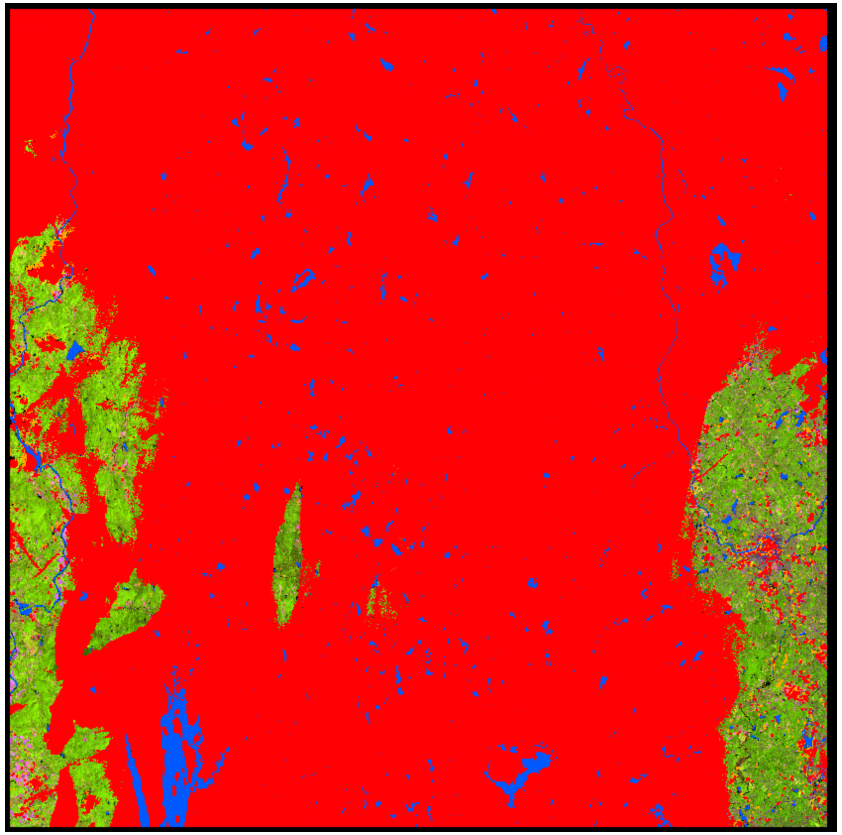
HLS S30 Cloud Mask Error (v1.4)

HLS.S30.18TYN.2018163.3

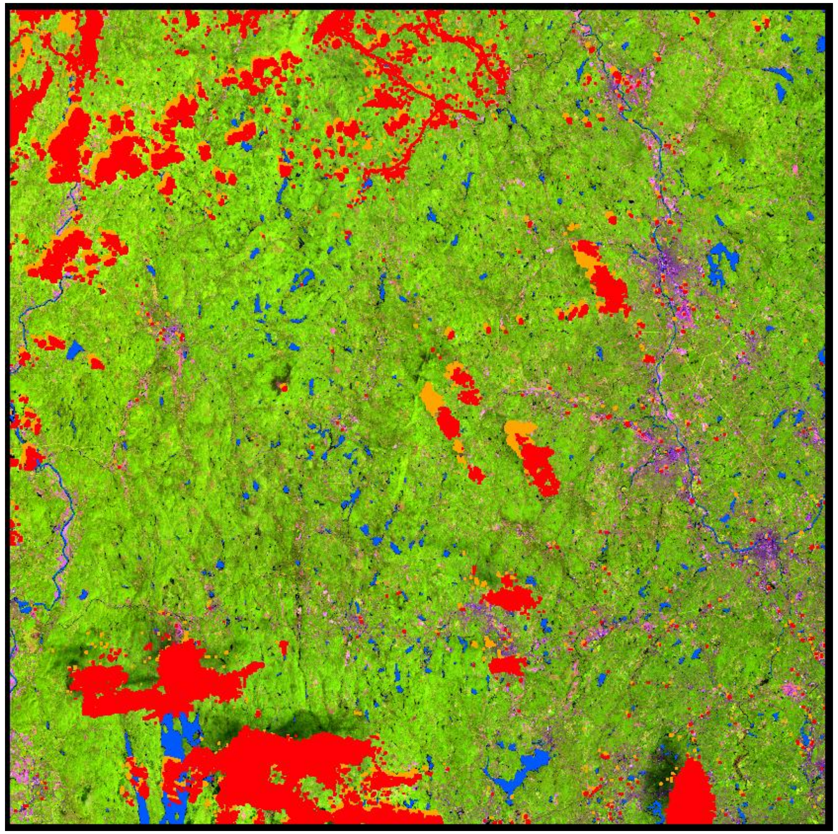
5/4/3 Composite



V1.4 QA flags



Fmask 4.0



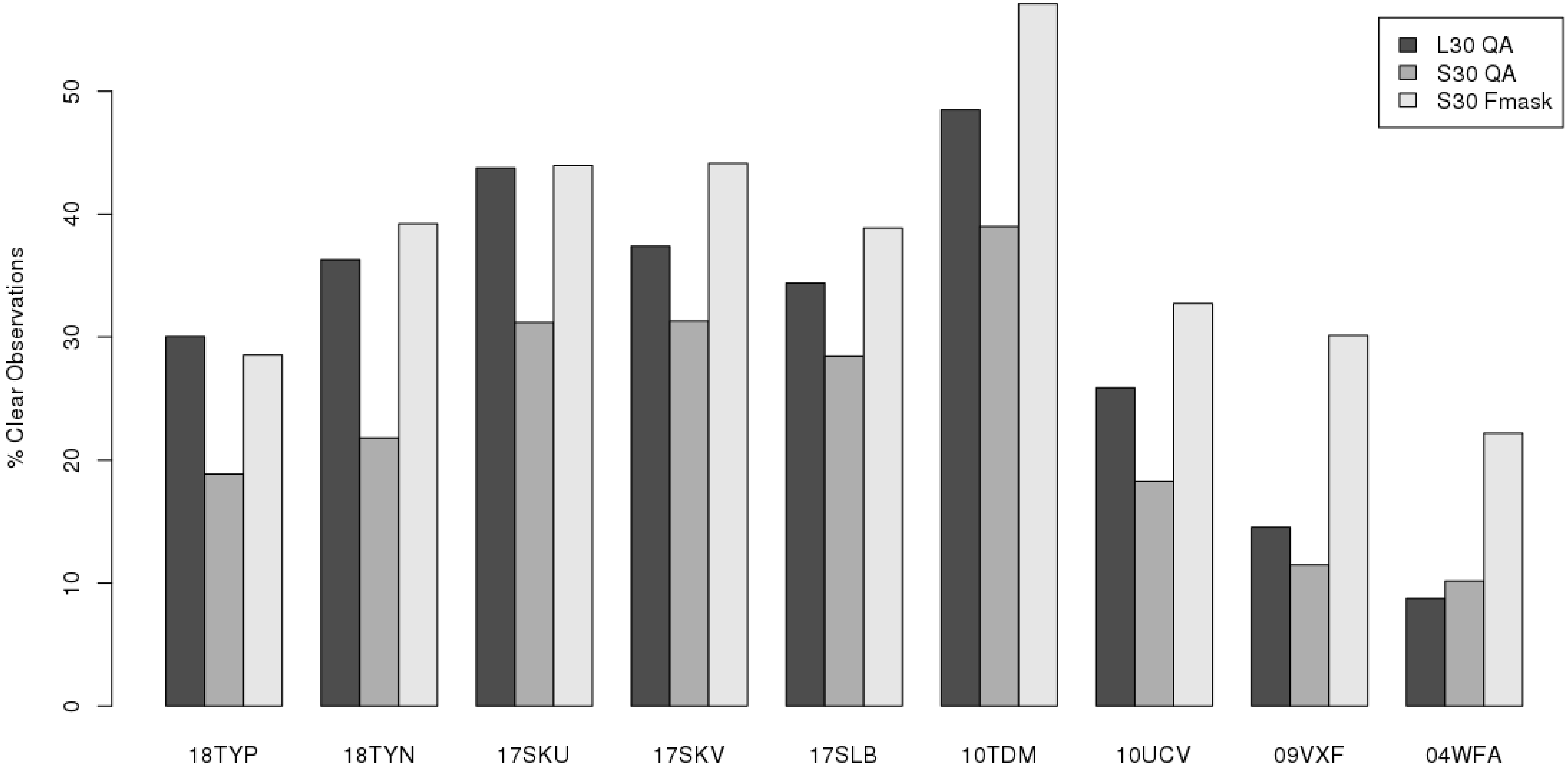
Shadow

Cloud

Snow

Courtesy D. Bolton, Boston U.

% Clear observations 2016-2018 (Calculated for full tile area)



Higher % clear observations for S30 Fmask (typically more in line with L30 QA). But in some cases, S30 Fmask is much higher than L30 QA. Need to investigate why. I suspect it has to do with snow (09VXF and 04WFA are both high latitude)

Next Steps

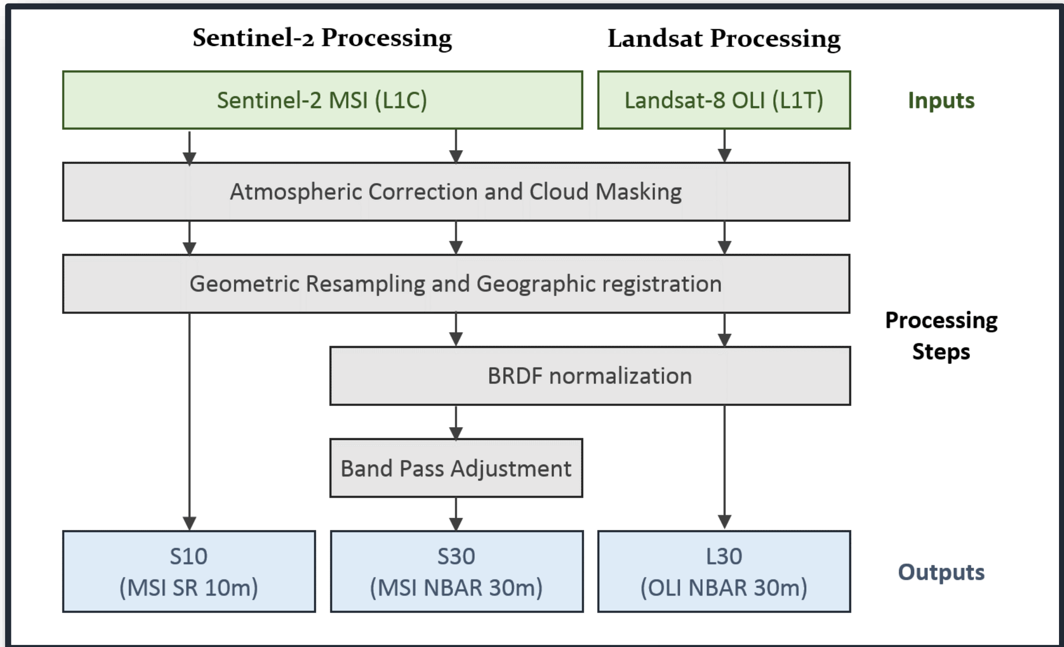
HLS team working on algorithm improvements for v1.5 (end-2019):

- Improved BRDF implementation
    - C-factor (Roy et al., 2016) with only view angle normalization (nadir looking)
    - Franch et al (2019) approach with view and SZA normalization
    - Inclusion of solar & view angles - possibly in separate file
- Improved S30 cloud mask
    - Bug fixes in LaSRC cloud algorithm
    - Substitution with Fmask for Sentinel (Zhu)

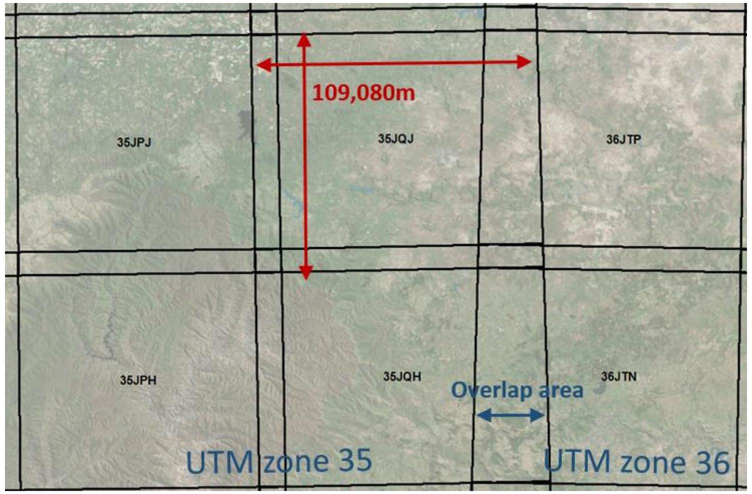
- Working with NASA ESD & USGS to transition operational HLS processing to USGS EROS in 2020

Thank You

HLS Main specs and Algorithm Flow



All 3 products are aligned on the MGRS S2 Tiles system following UTM zones



S10 (from Sentinel-2)

Spatial: 10m, 20m, 60m
Spectral Bands: All MSI
NBAR: No

S30 (from Sentinel-2)

Spatial: 30m
Spectral Bands: OLI-like + MSI Red Edge
NBAR: Yes

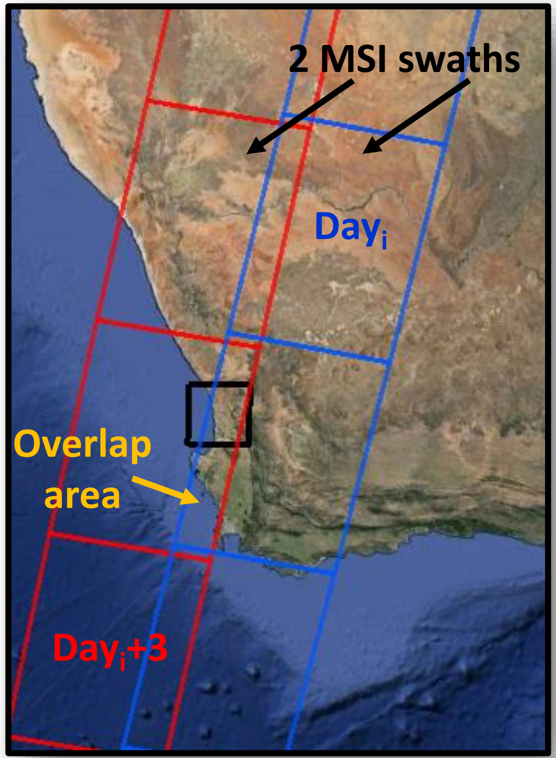
L30 (from Landsat 8)

Spatial: 30m
Spectral Bands: All OLI
NBAR: Yes

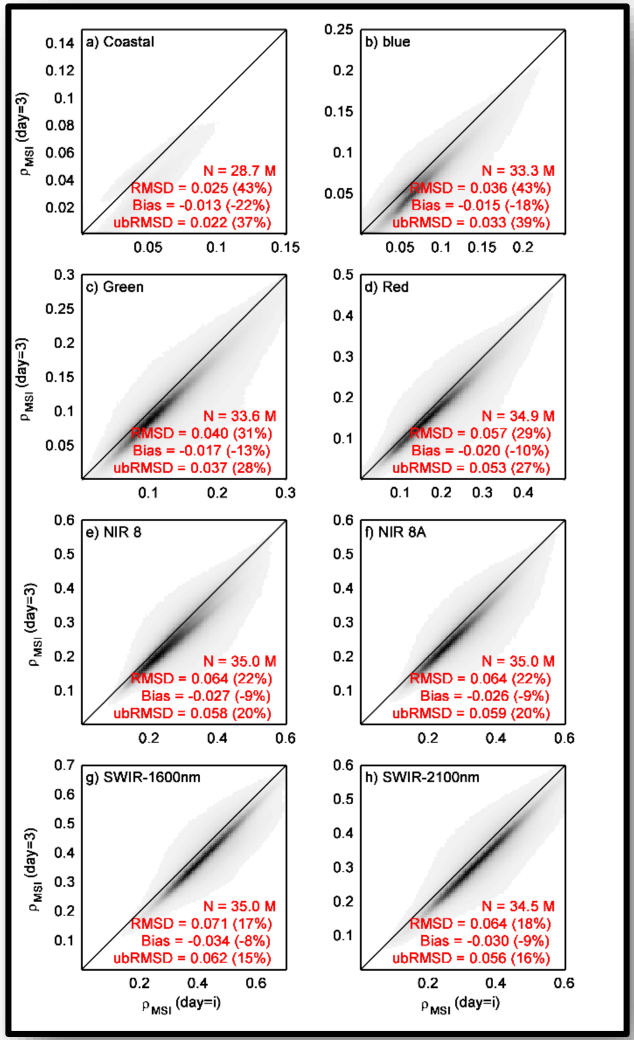
Atmospheric Correction	**LaSRC/6S approach (image-based aerosol)**	**Vermote et al. (2016)**
BRDF normalization	**C-factor technique with the global constant coefficients**	**Roy et al. (2016)**
Spectral bandpass	**Linear regression using global training set from EO-1 Hyperion**	**Claverie et al., (in review)**
Cloud/shadow mask	**Landsat 8: output from LaSRC; Sentinel-2: Boston University Fmask algorithm**	**Vermote et al. (2016); Zhu et al. (2015)**
Geographic registration	AROP: automated registration and orthorectification package	Gao et al. (2009)

Evaluation of the BRDF adjustment

We evaluated the deviation between edge swath acquisitions of MSI with and without BRDF-adj.



Without BRDF-adj.



With BRDF-adj.