Maximizing Earth Science Observations With Data Harmonization: Harmonized Landsat/Sentinel-2

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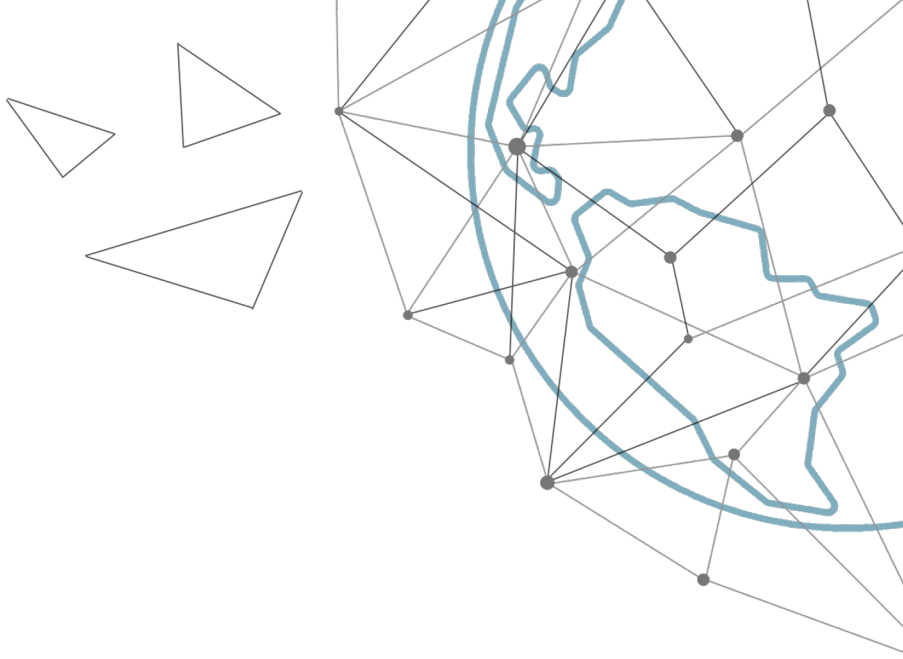
IMPACT
Interagency Implementation and Advanced Concepts Team

Agenda

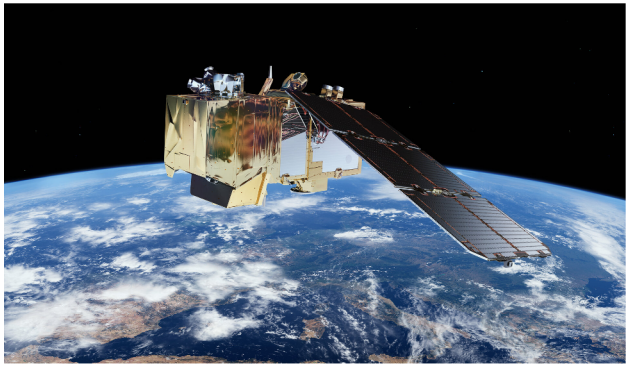
1. HLS Overview
2. HLS Processing
3. HLS Supporting SNWG
4. HLS Science Applications



HLS Overview

What is HLS?

- What is “harmonized”?
  - Using data from two similar instruments and constructing an algorithm so products from each instrument can be used interchangeably
- Initiative to produce a virtual constellation of surface reflectance data from Landsat 8 OLI and Sentinel-2 MSI
  - Spectral similarities of L8 and S2 allow for harmonization



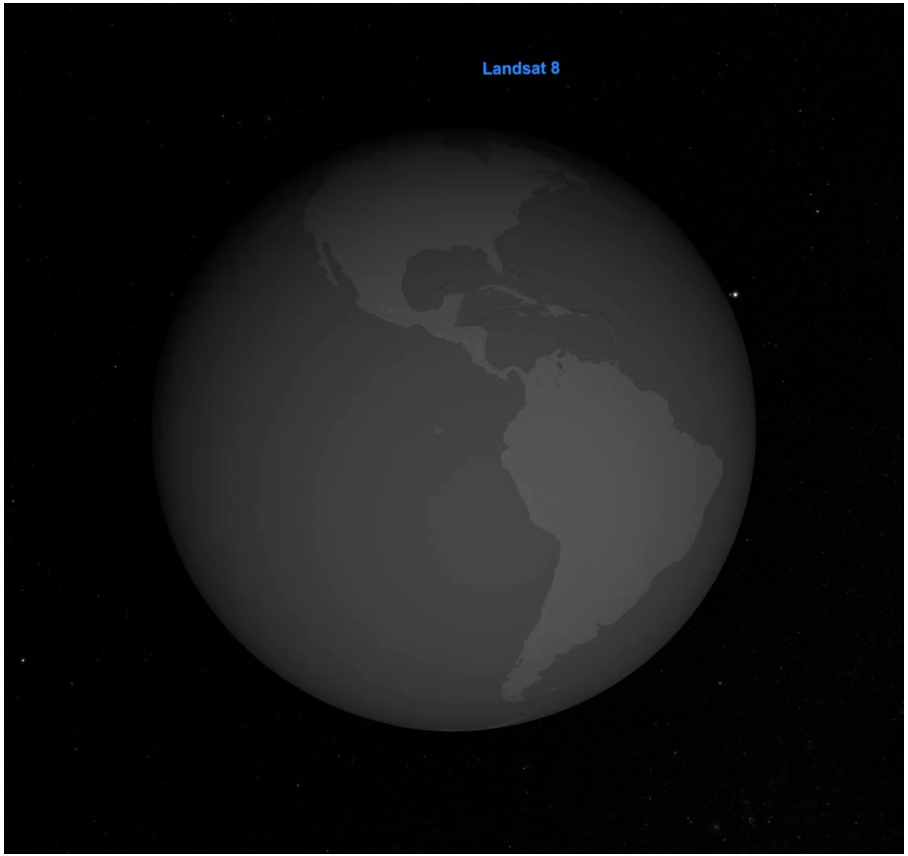
Sentinel-2 photo credit: ESA

Landsat 8 photo credit: NASA

MSI vs. OLI

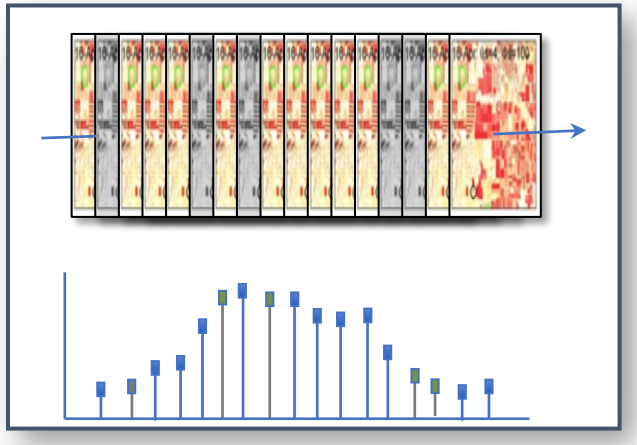
Parameter	MSI	OLI
Swath	290 km	185 km
Repeat Cycle	10 (5)	16 (8)
Field of View	20.6	15
Equatorial Crossing	10:30 AM	10:13 AM
Spectral Coverage	440-2300 nm	440-2300 nm
Spectral Bands	13	9
IFOV	4 VNIR Bands @10 m 6 Bands @ 20 m 3 Atmospheric Bands @ 60m	8 Bands @ 30m 1 Pan Band @ 15m
Data Quantization	12 bits	12 bits
Saturation Radiances	~100% diffuse solar	~100% diffuse solar

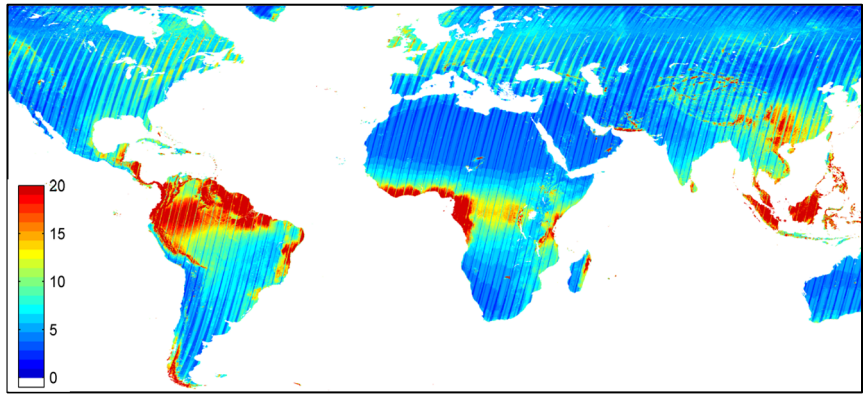
HLS Constellation Overview (courtesy: NASA SVS)

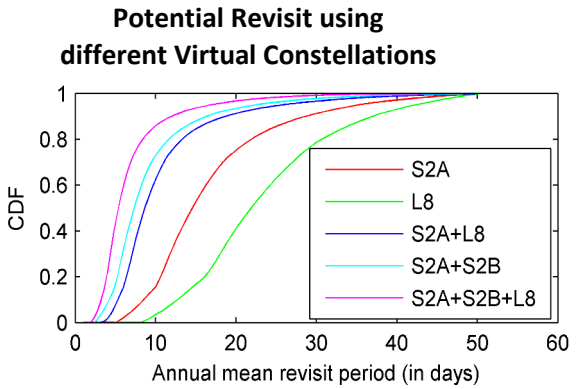


HLS Overview

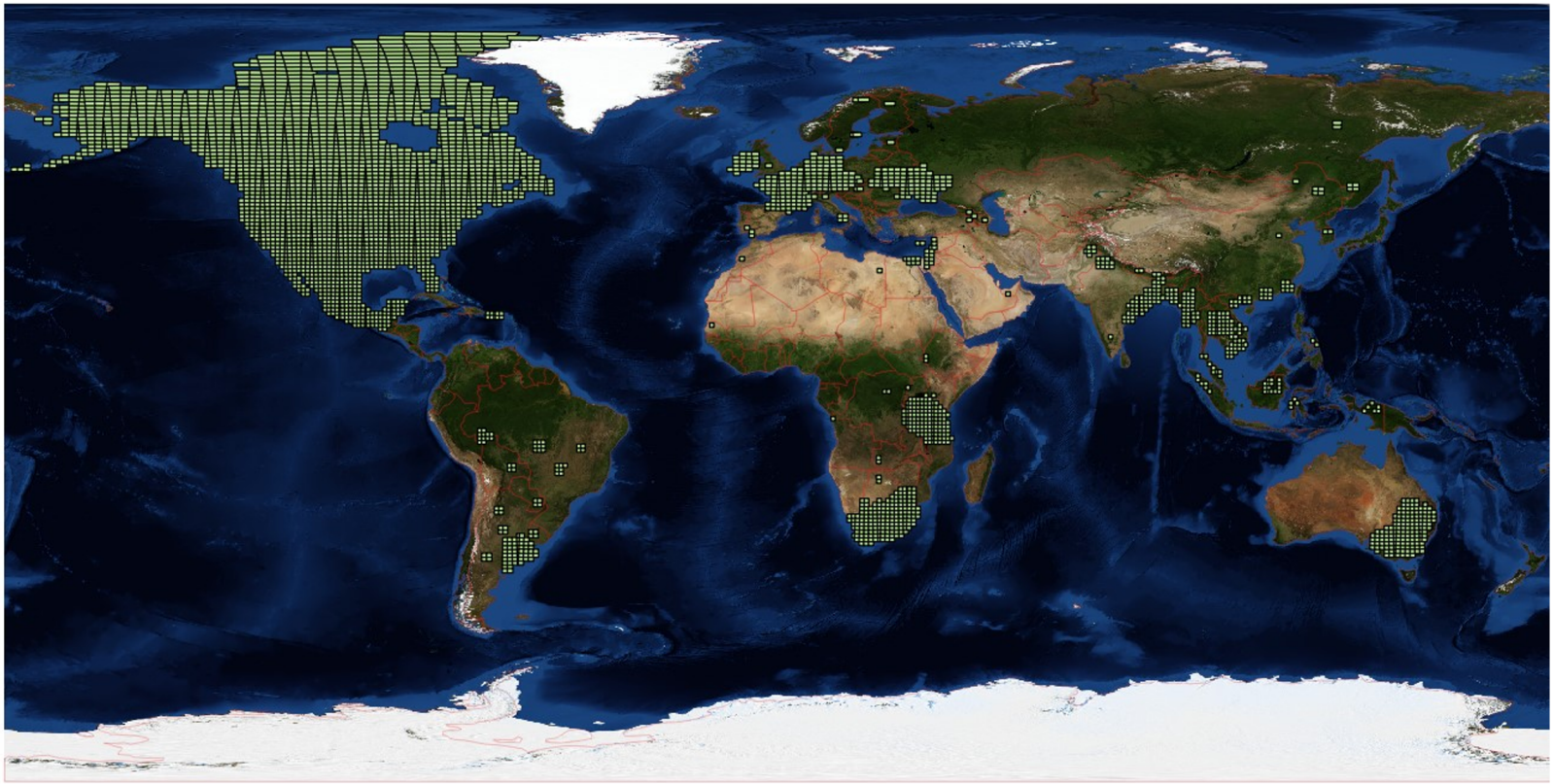
- Merging Sentinel-2 and Landsat data streams can provide **2-4 day global coverage**
- Goal is “seamless” near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding
- Project initiated as collaboration among NASA GSFC, UMD, NASA Ames







HLS v1.4 Algorithm Coverage



S30 Band Information

Band Name	S30 Band	Wavelength (µm)	Units
Coastal Aerosol	B01	0.43 - 0.45	reflectance
Blue	B02	0.45 - 0.51	reflectance
Green	B03	0.53 - 0.59	reflectance
Red	B04	0.64 - 0.67	reflectance
Red-Edge 1	B05	0.69 - 0.71	reflectance
Red-Edge 2	B06	0.73 - 0.75	reflectance
Red-Edge 3	B07	0.77 - 0.79	reflectance
NIR Broad	B08	0.78 - 0.88	reflectance
NIR Narrow	B8A	0.85 - 0.88	reflectance
Water Vapor	B09	0.93 - 0.95	reflectance
Cirrus	B10	1.36 - 1.38	reflectance
SWIR 1	B11	1.57 - 1.65	reflectance
SWIR 2	B12	2.11 - 2.29	reflectance

L30 Band Information

Band Name	L30 Band	Wavelength (µm)	Units
Coastal Aerosol	B01	0.43 - 0.45	reflectance
Blue	B02	0.45 - 0.51	reflectance
Green	B03	0.53 - 0.59	reflectance
Red	B04	0.64 - 0.67	reflectance
NIR Narrow	B05	0.85 - 0.88	reflectance
SWIR 1	B06	1.57 - 1.65	reflectance
SWIR 2	B07	2.11 - 2.29	reflectance
Cirrus	B09	1.36 - 1.38	reflectance
Thermal IR 1	B10	10.60 - 11.19	degrees (C)
Thermal IR 2	B11	11.50 - 12.51	degrees (C)

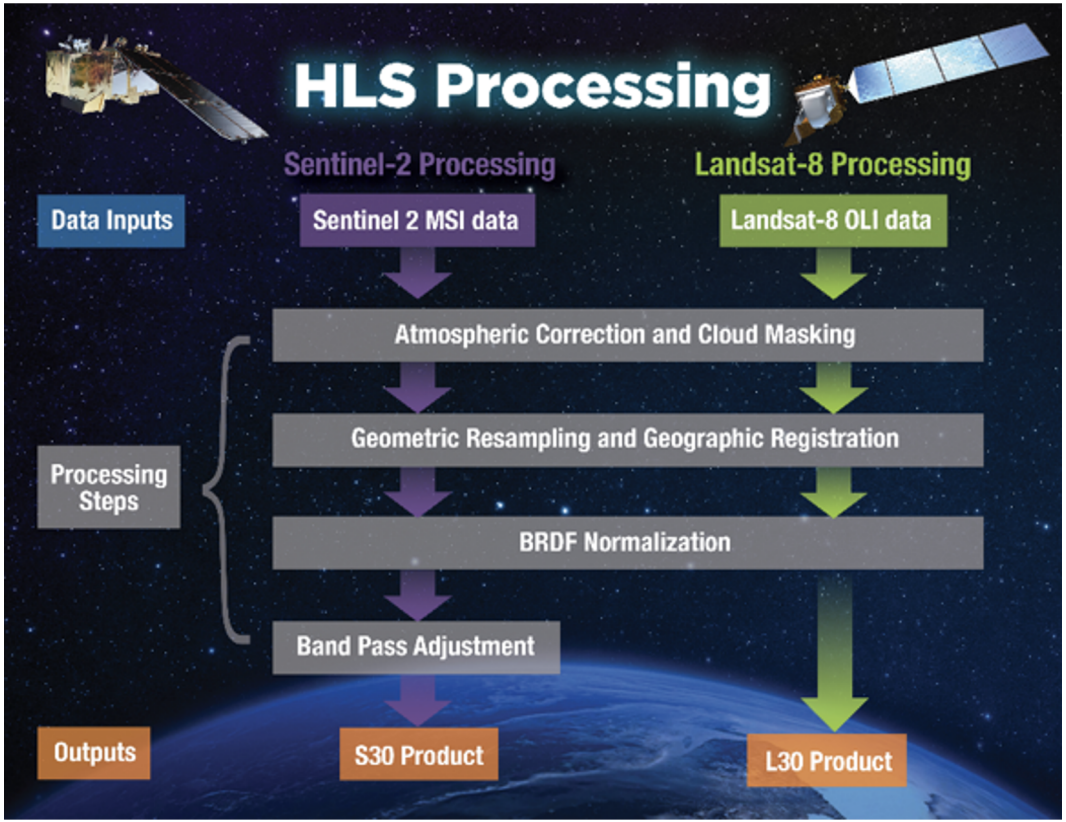
HLS Processing at NASA IMPACT

HLS Objectives for IMPACT

1. Expand existing algorithm to near global coverage and optimize for cloud compute environment
   a. Land and coastal waters only (defined by NOAA shoreline dataset)
   b. Excludes Antarctica
2. Produce full archive of S30/L30 data products
3. Ensure HLS products are discoverable in common metadata repository and the Earthdata Search client
4. Make HLS imagery available through NASA Worldview client via the Global Imagery Browse Service
5. Archive and distribute HLS products using the cloud
   a. Full workflow from product development to data distribution should be contained in the cloud

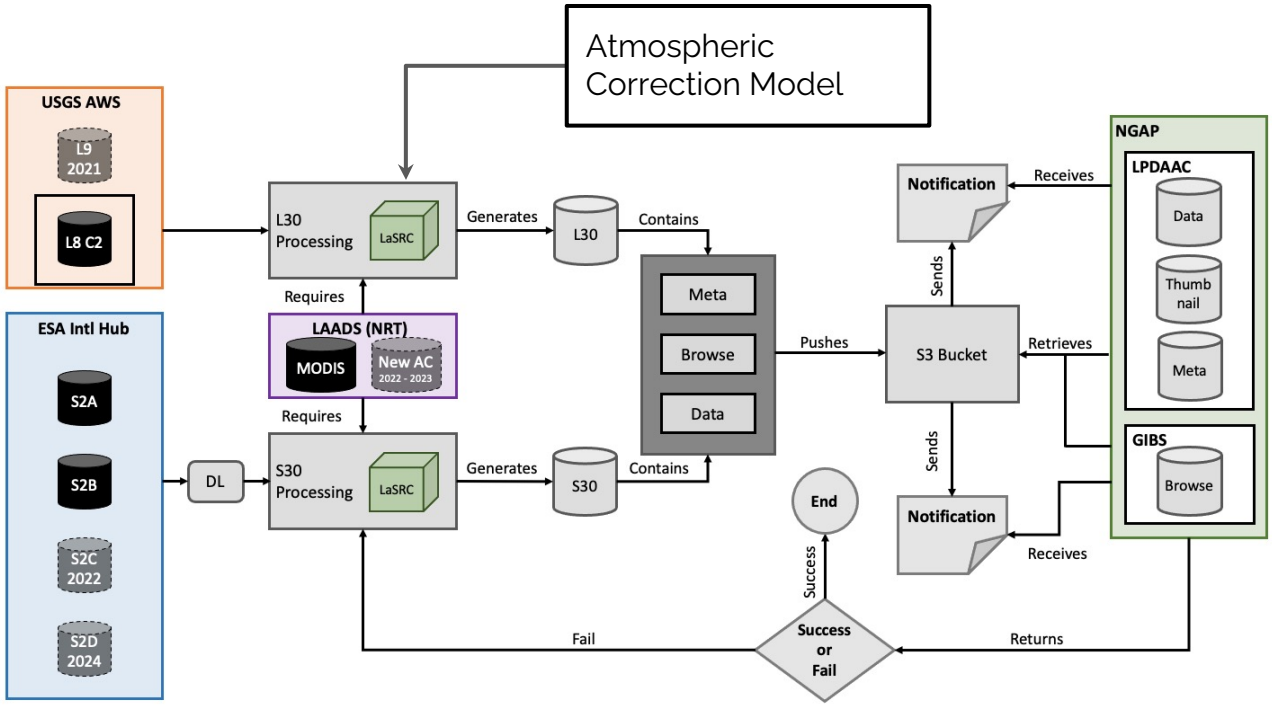
“Global” HLS Coverage Area

HLS Algorithm Workflow



Data Processing Workflow

1. Data downloaded or notifications received from external agencies.
2. Processing pipeline triggered with each new granule.
3. Access MODIS data from LAADS for atmospheric correction (2-3 day latency)
4. Generate data, metadata, and browse imagery.
5. Notify LPDAAC and GIBS of data availability with SQS message containing manifest of new files.

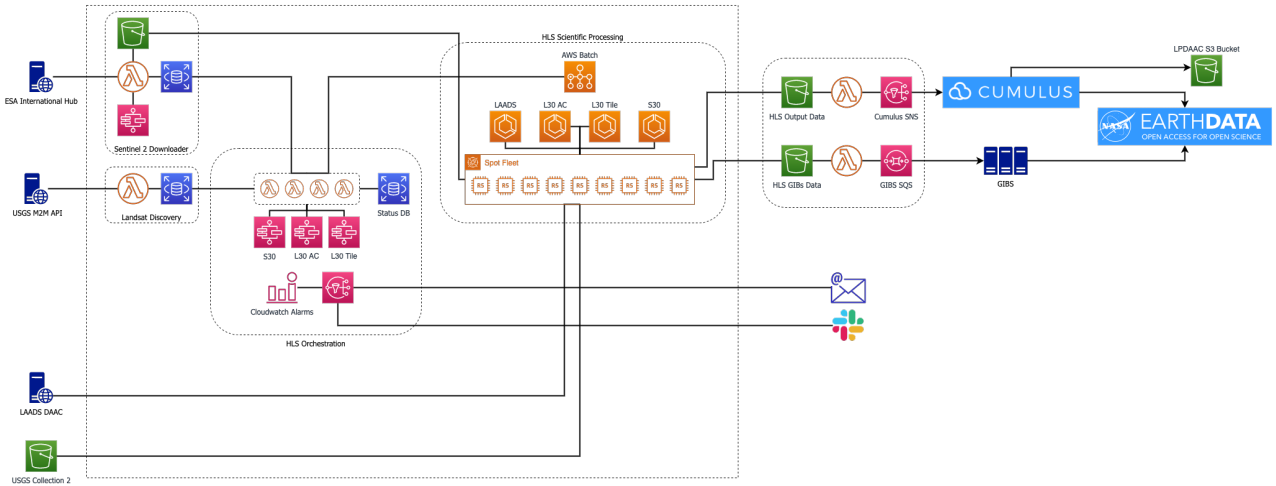


System Architecture

GCC AWS: Stage data for LPDAAC and GIBS retrieval, notify LPDAAC and GIBS for data availability, 90-day temporary archive

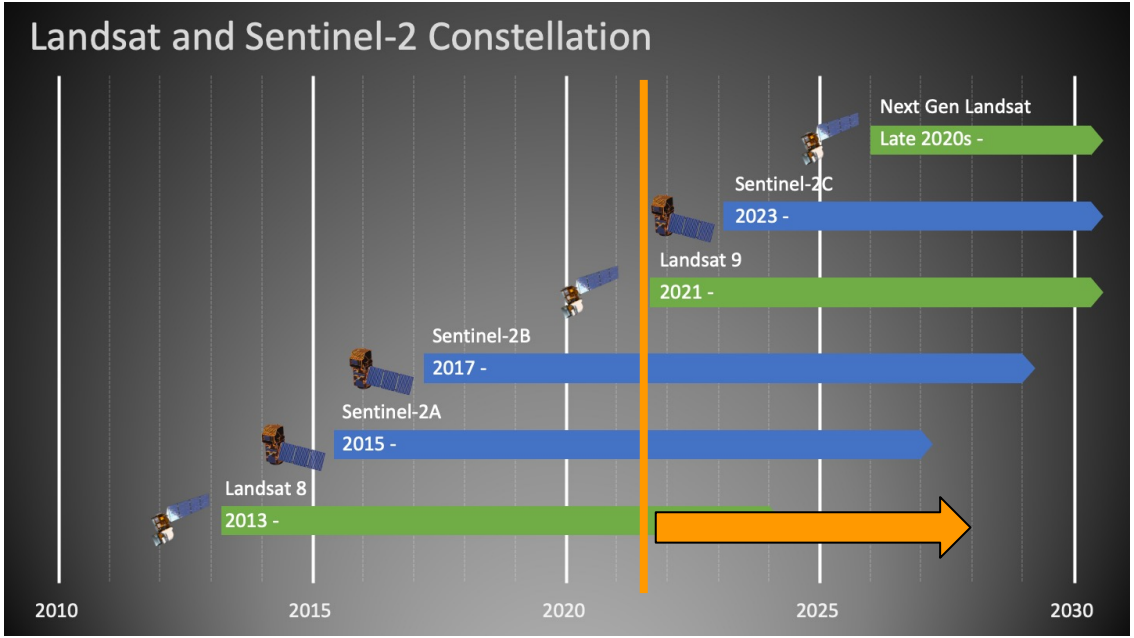
LPDAAC NGAP: Ingest, archive, and publication of HLS data products, full archive backup

GIBS NGAP: Ingest browse imagery and make available for NASA Worldview client



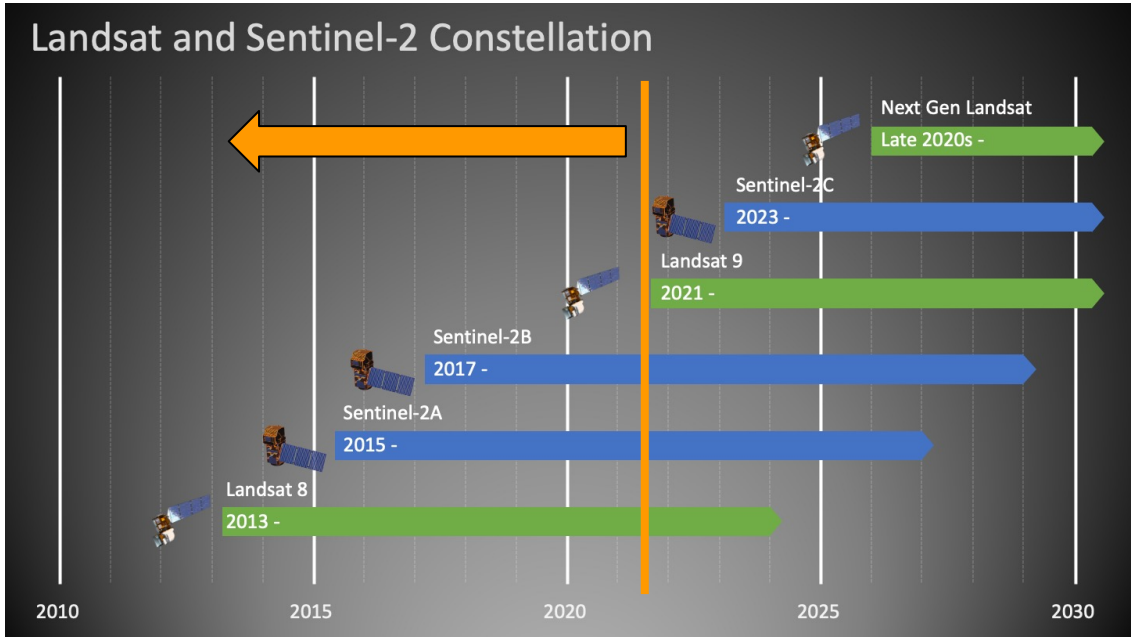
Forward HLS processing

- Data Sources
  - L30 generated using Landsat 8 Collection 2 from USGS
  - S30 generated using Sentinel-2 data from ESA International Hub
- Plan to include Landsat 9 and Sentinel-2c when data becomes available
- HLS data products available with 2-3 days latency
  - Dependent upon availability of MODIS data



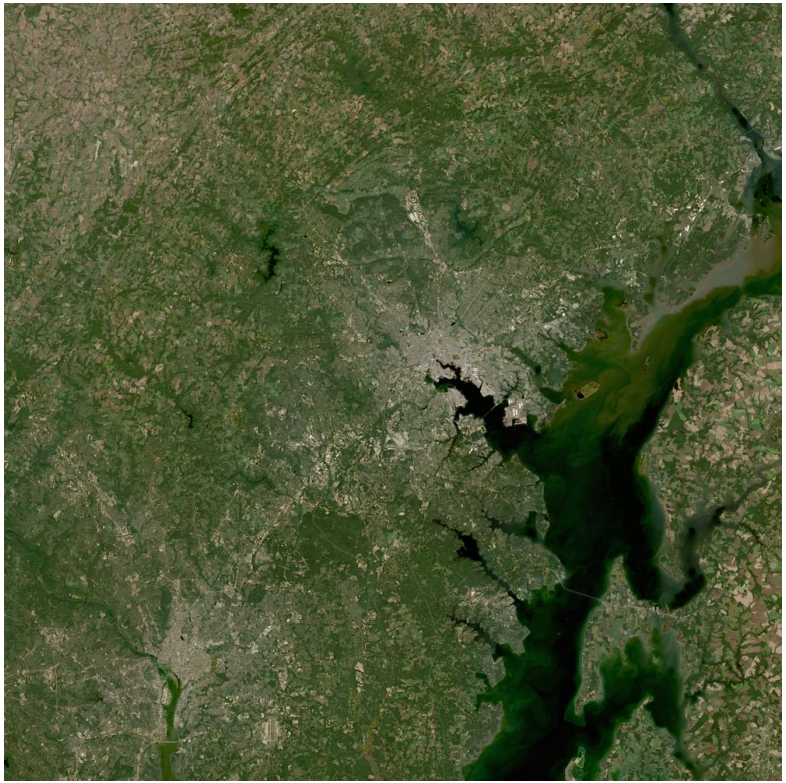
Historical HLS processing

- Phased approach to developing the archive
  - L30 extends back to 2013 and S30 to 2015
- Expected to complete by mid-2022
- Processed in reverse chronological order
- Historical Sentinel-2 data provided by ESA and USGS



Current Status of Data Production

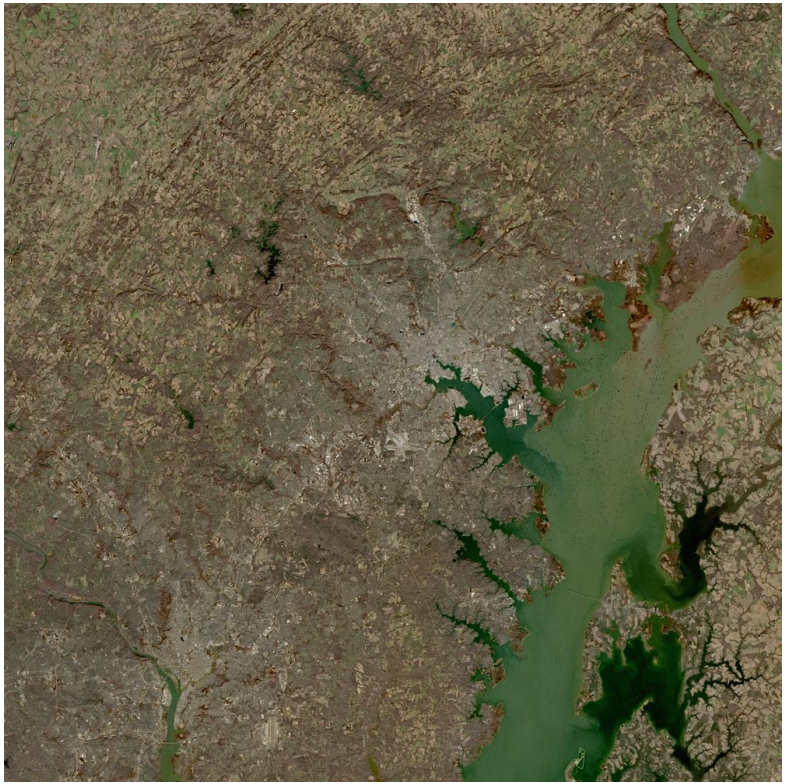
- L30 and S30 data products publicly available in a provisional state –version 1.5
  - L30 release: 20 Jan 2021
  - S30 release: 5 Oct 2020
- Why provisional?
  - Unusual artifacts in atmospheric correction code output detected by HLS science team



Current Status of Data Production

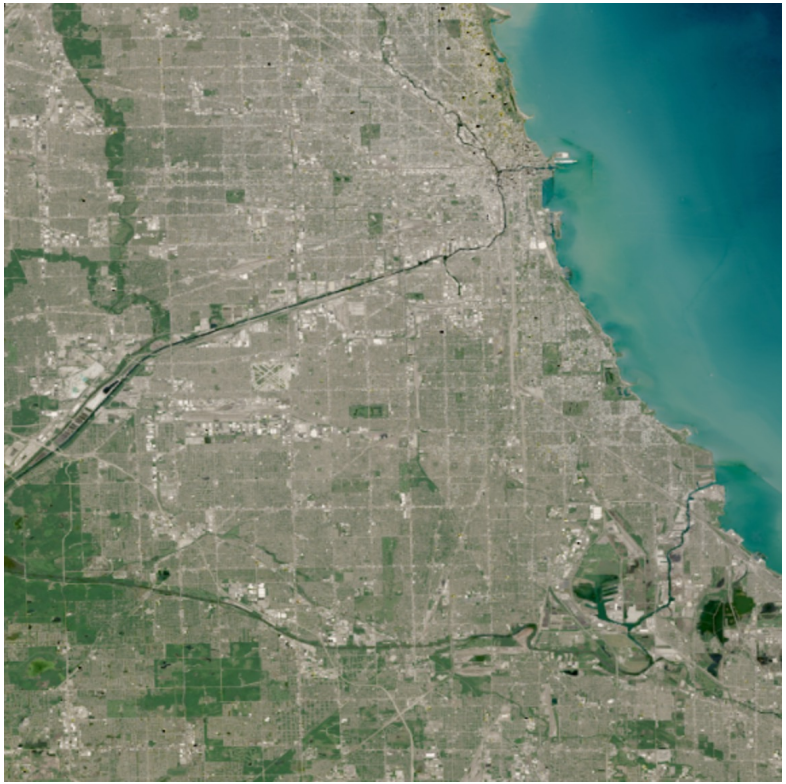
- Provisional data products available via Earthdata Search
  - L30 – 375k granules
  - S30 – 1.3M granules
- Data product statistics per day (on average):

	# Granules	Volume
L30	2,900	0.352 TB
S30	6,200	1.11 TB

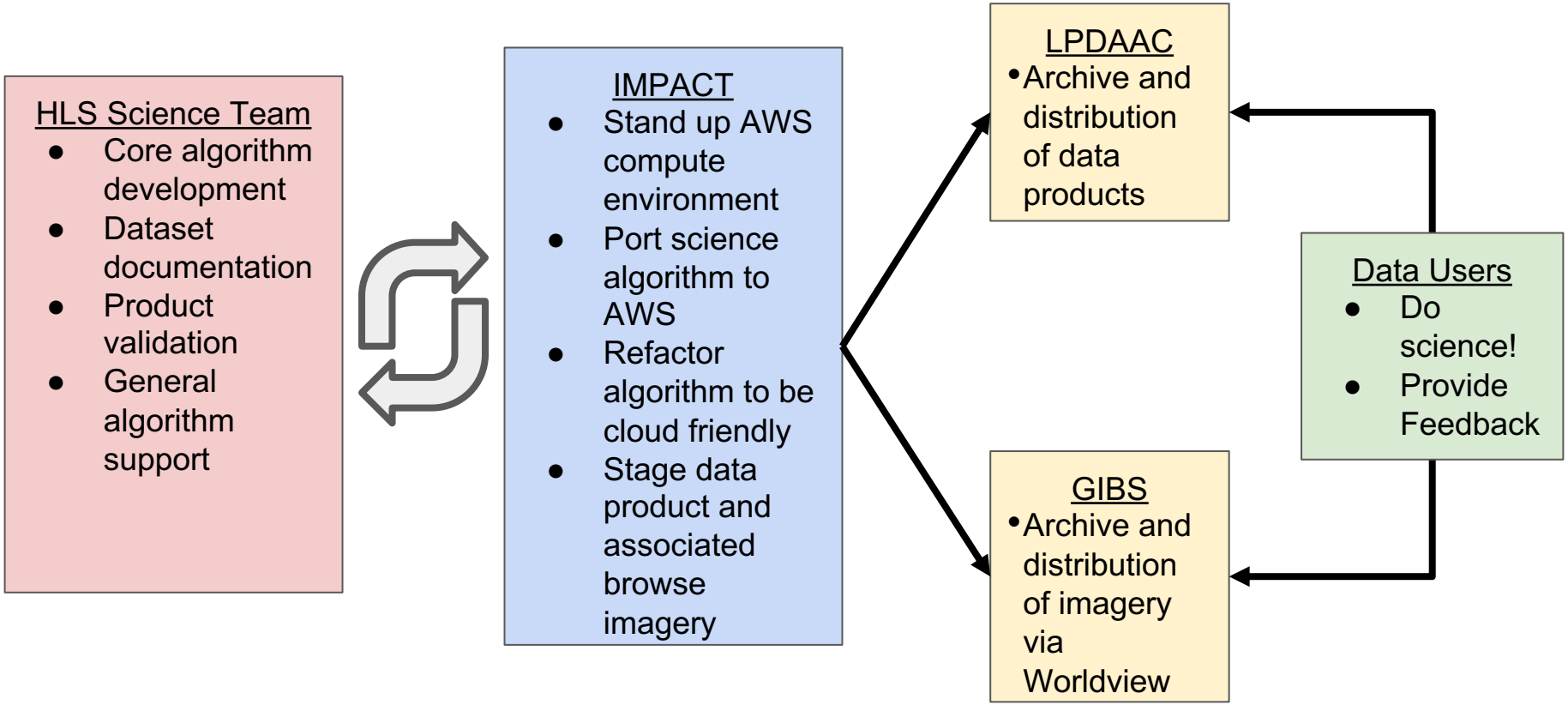


Upcoming Milestones

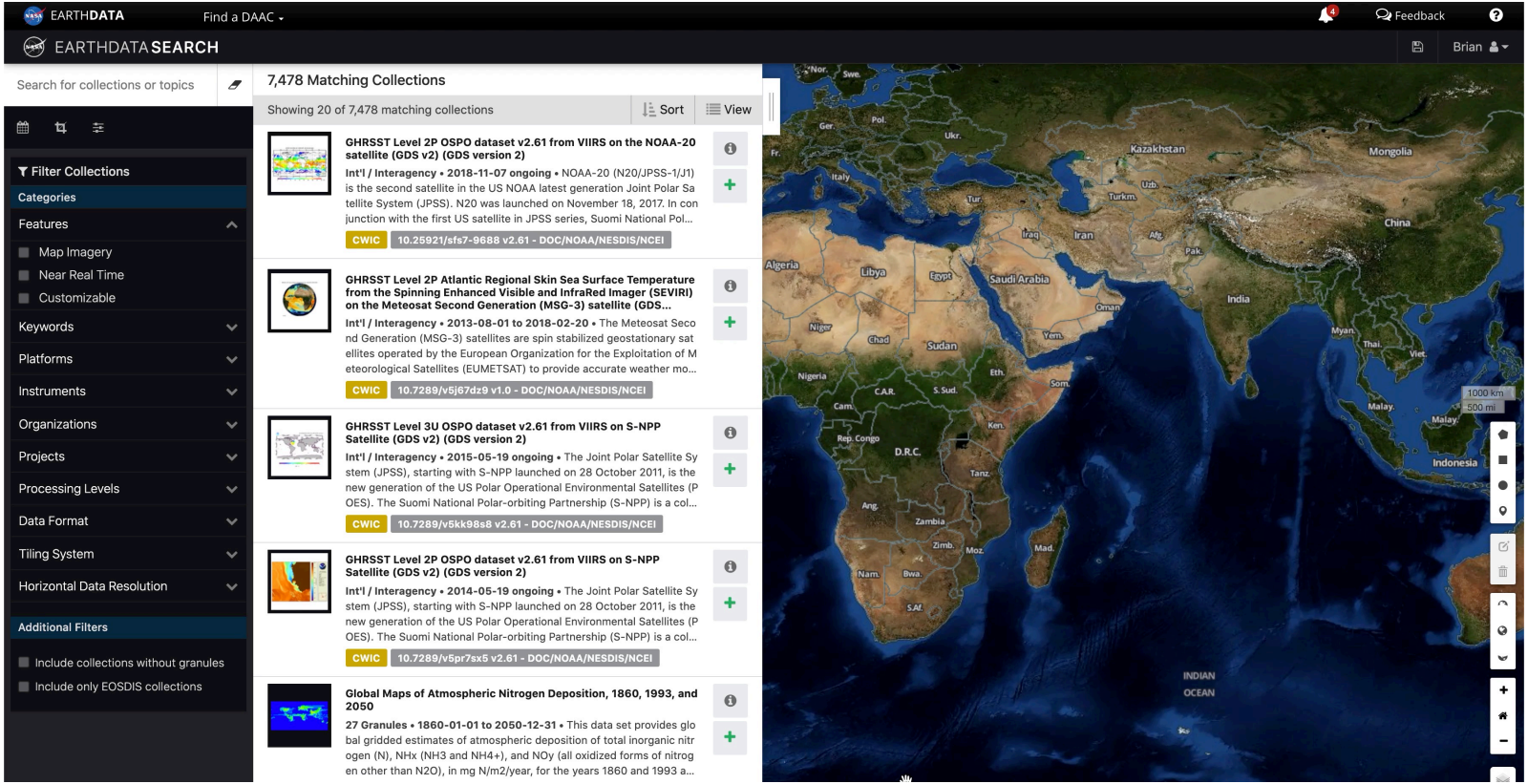
- Public release of science quality v2.0 products – Aug 1, 2021
  - Forward processing to begin July 1, 2021
- Begin historical processing
  - L30 data product – Aug 2021
  - S30 data product – Sept 2021
- Historical processing expected to be complete by mid-2022



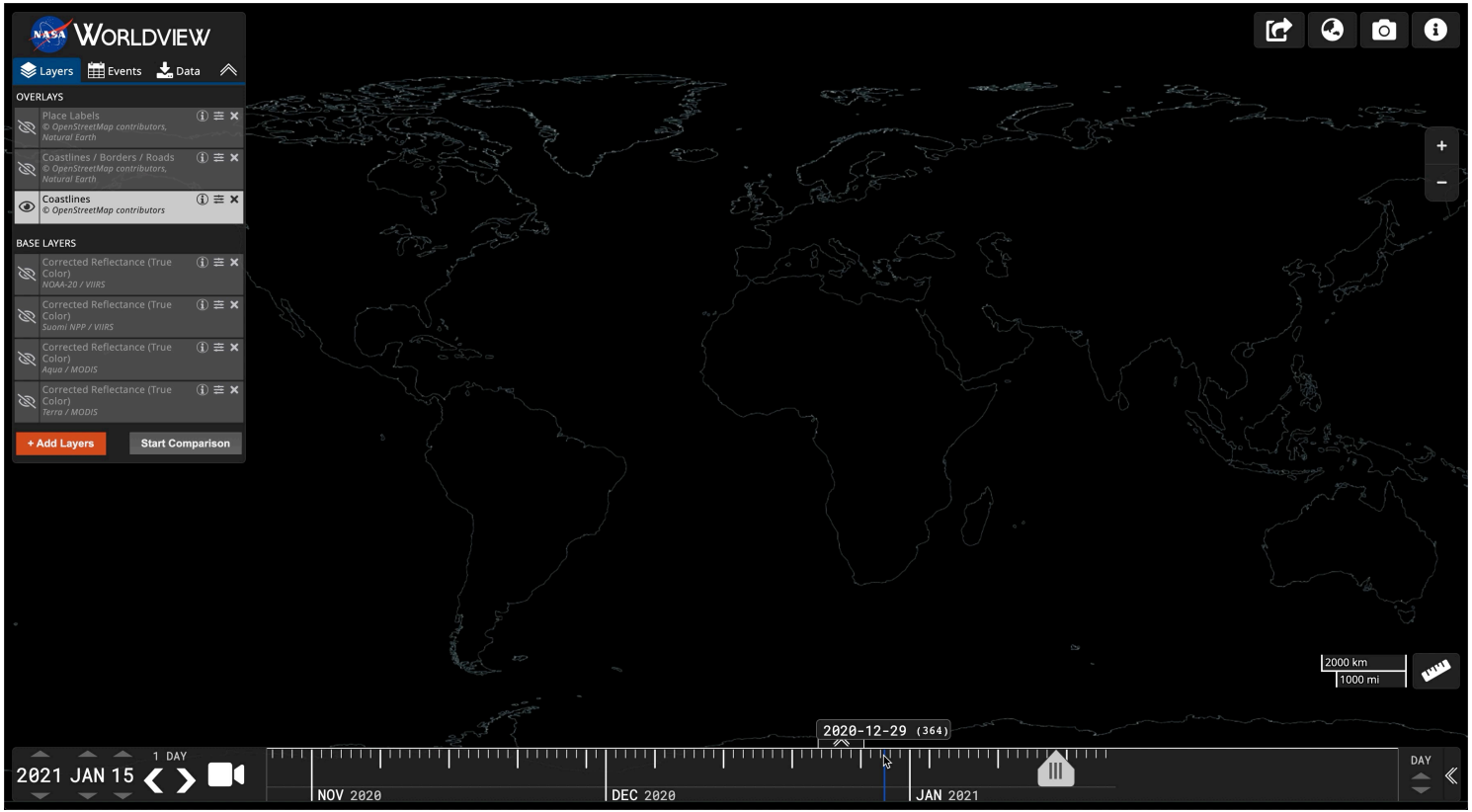
Summary of HLS Stakeholders and Responsibilities



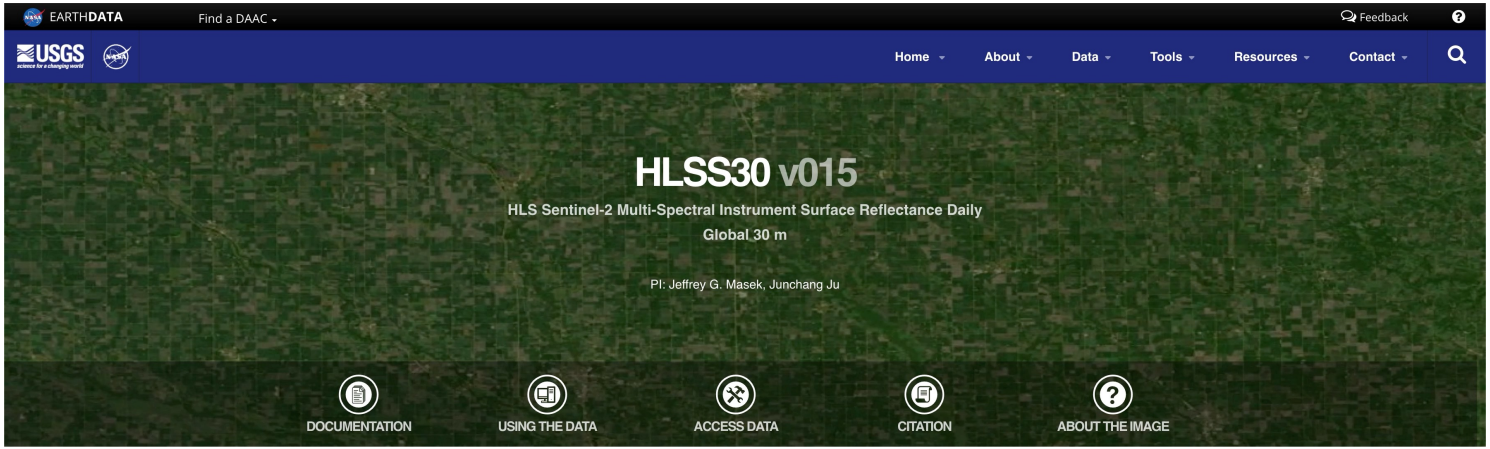
HLS Data Access (Earthdata Search)



HLS Data Access (Worldview)



HLS Data Access (Dataset Landing Page)



Homepage / Data / Search Data Catalog / **HLSS30v015**

Provisional HLS data have not been validated for their science quality and should not be used in science research or applications. If you are interested in exploring these provisional datasets please download the data from NASA's Earthdata Search. If you have any feedback or questions on the data please contact lpdaac@usgs.gov or join our HLS conversation on the Earthdata Forum.

Description

The Harmonized Landsat and Sentinel-2 (HLS) project provides consistent surface reflectance data from the Operational Land Imager (OLI) aboard the joint NASA/USGS Landsat 8 satellite and the Multi-Spectral Instrument (MSI) aboard the European Union's Copernicus Sentinel-2A and Sentinel-2B satellites. The combined measurement enables global observations of the land every 2-3 days at 30 meter (m) spatial resolution. The HLS project uses a set of algorithms to obtain seamless products from OLI and MSI that include atmospheric correction, cloud and cloud-shadow masking, spatial co-registration and common gridding, illumination and view angle normalization, and spectral bandpass adjustment

HLS Contributions to SNWG Activities

HLS SNWG Contributions – Cycle 1 (2016)

- Proposed Activity #2
  - “Archival, maintenance, and distribution of HLS product development and support for associated research”

- Status: Science quality global surface reflectance products beginning August 2021. Provisional data products (1.6M granules) available from the LP DAAC and browse imagery available in Worldview

HLS SNWG Contributions – Cycle 2 (2018)

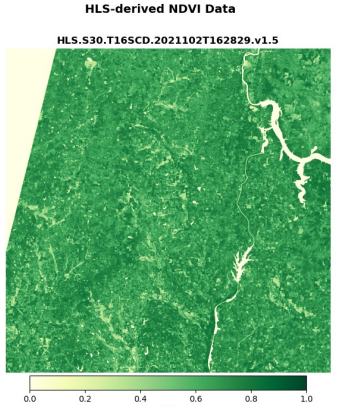
- Proposed Activity #4
  - Global Land Surface Disturbance and Change Detection

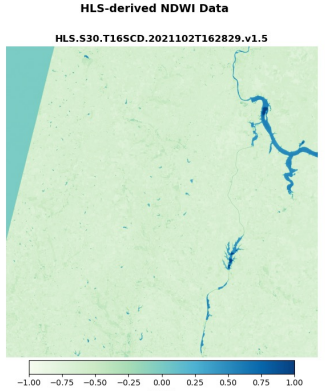
- HLS Contribution: Provide input data for optical component of the land surface/disturbance change product
- Status: Pre-formulation began in FY2020 and the activity is proceeding toward design and implementation reviews.

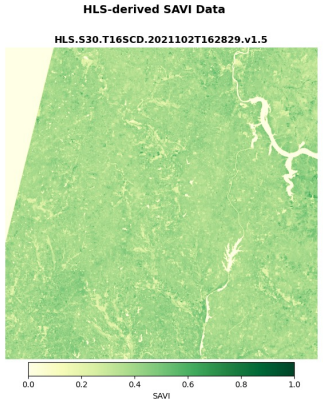
HLS SNWG Contributions – Cycle 3 (2020)

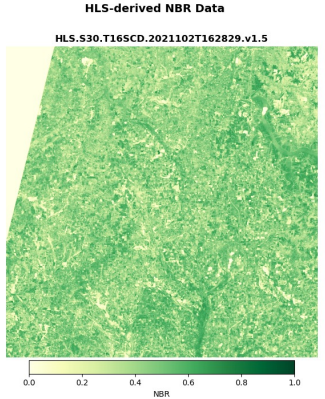
- Proposed Activity #2
  - Global HLS-Derived Vegetation Indices Suite
  - Supports 34/123 needs from 2020

- HLS Contribution: Provide input surface reflectance data layers (i.e. bands) for various band combination data products









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- Proposed Activity #2
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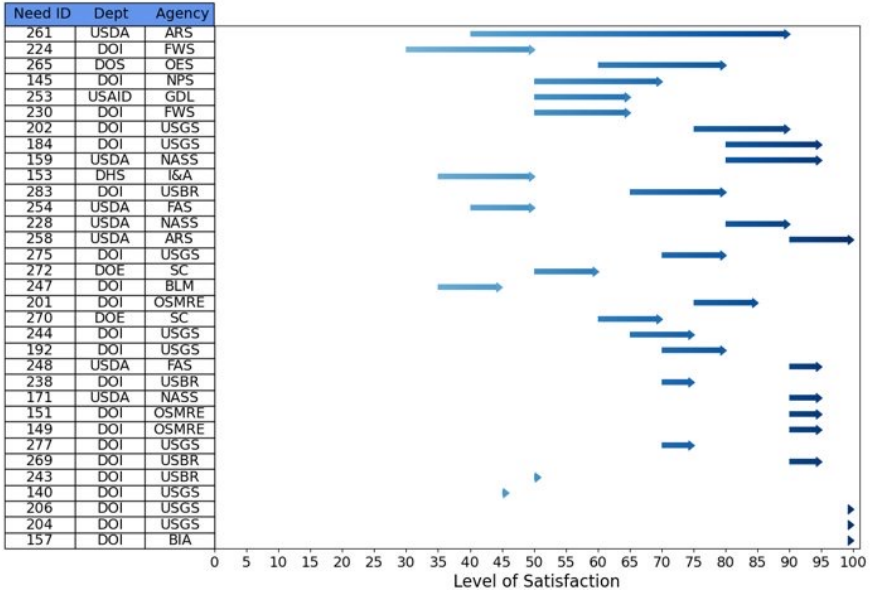
Expected Impact

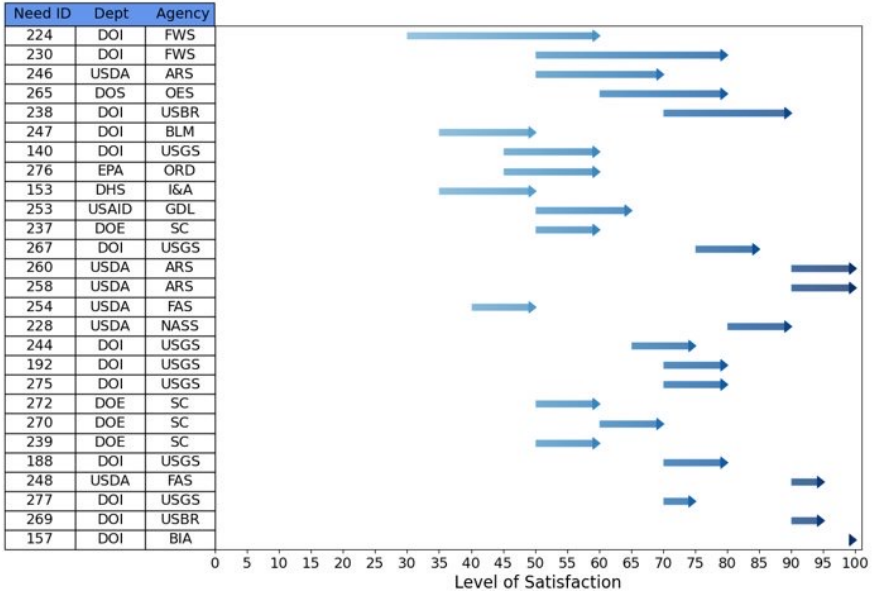


HLS SNWG Contributions – Cycle 3 (2020)

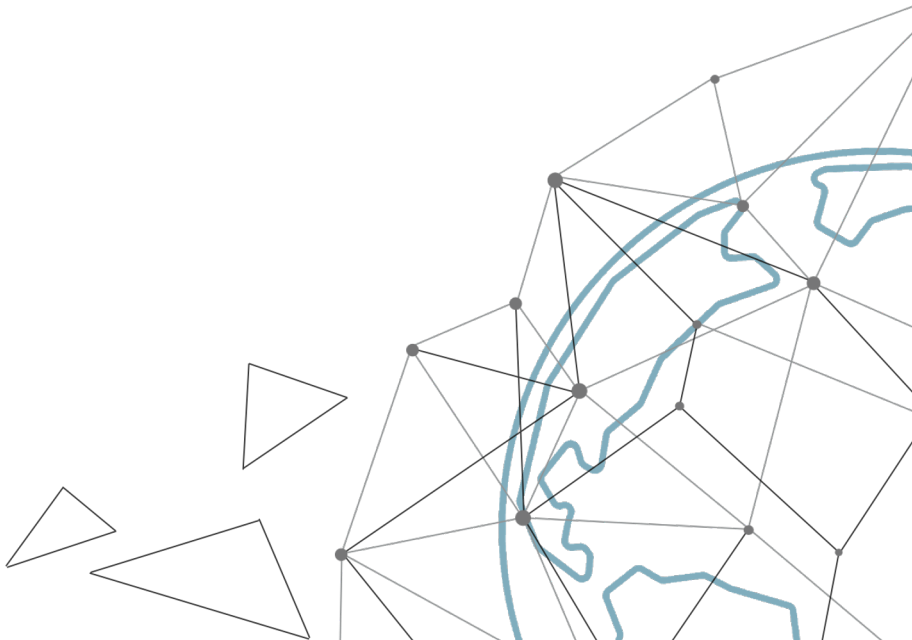
- Proposed Activity #5
  - Harmonized Surface Thermal Infrared Product (H-TIR)
  - Supports 28/123 needs from 2020

- HLS Contribution: Provide input surface reflectance data for sharpening land surface temperature to 30m resolution

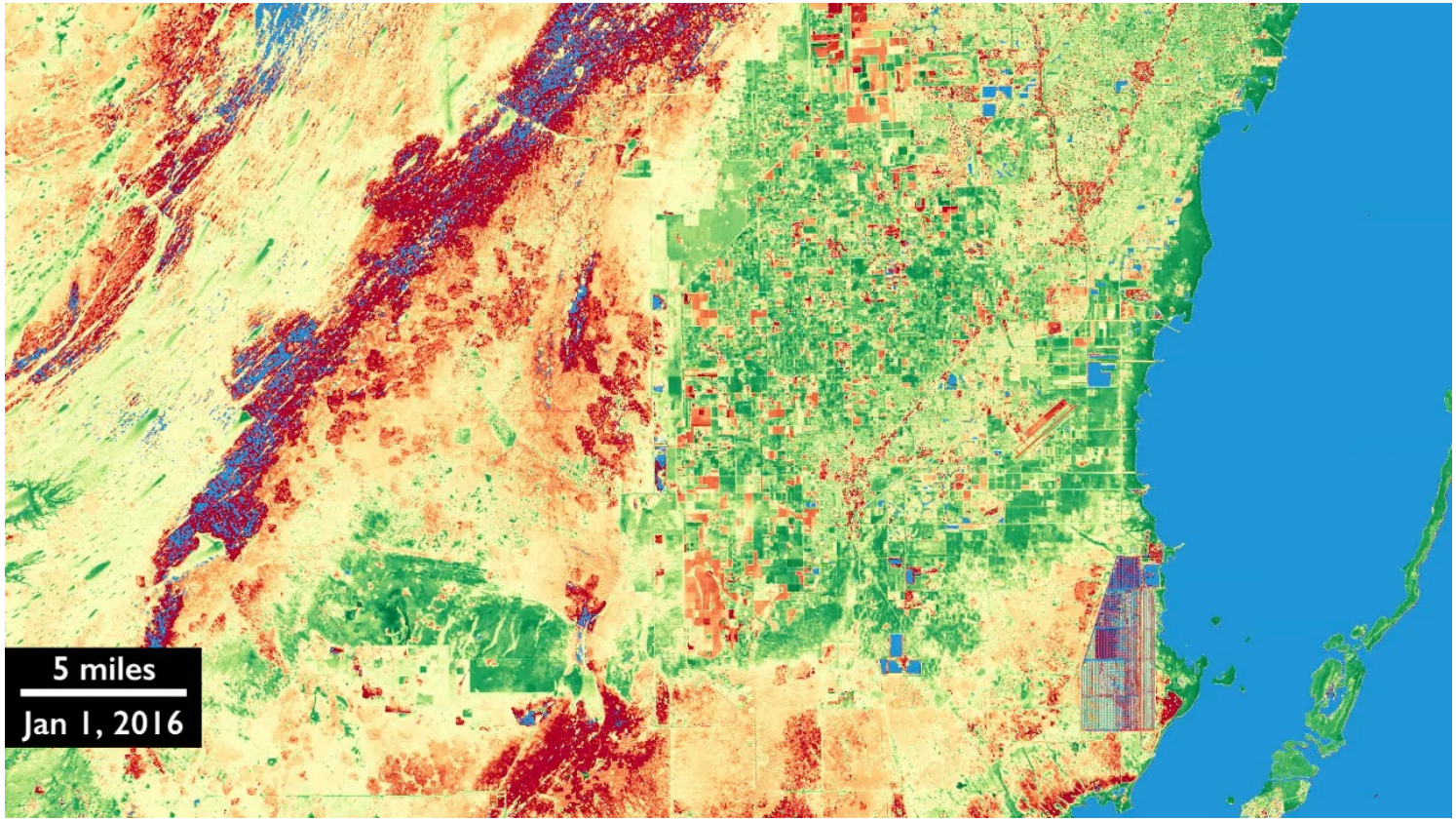
Expected Impact



HLS Science Applications



HLS Science Applications (Courtesy GSFC)



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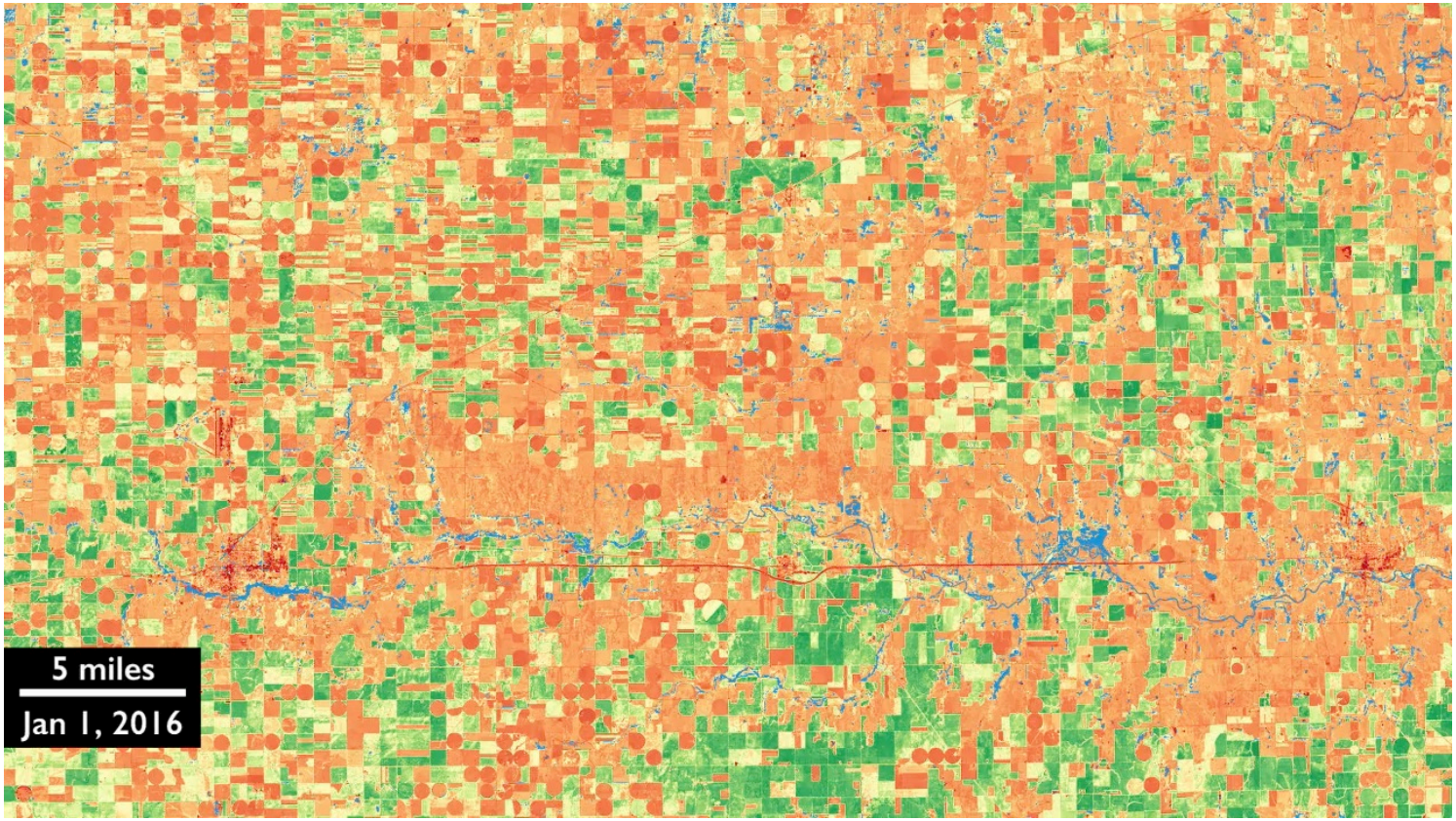
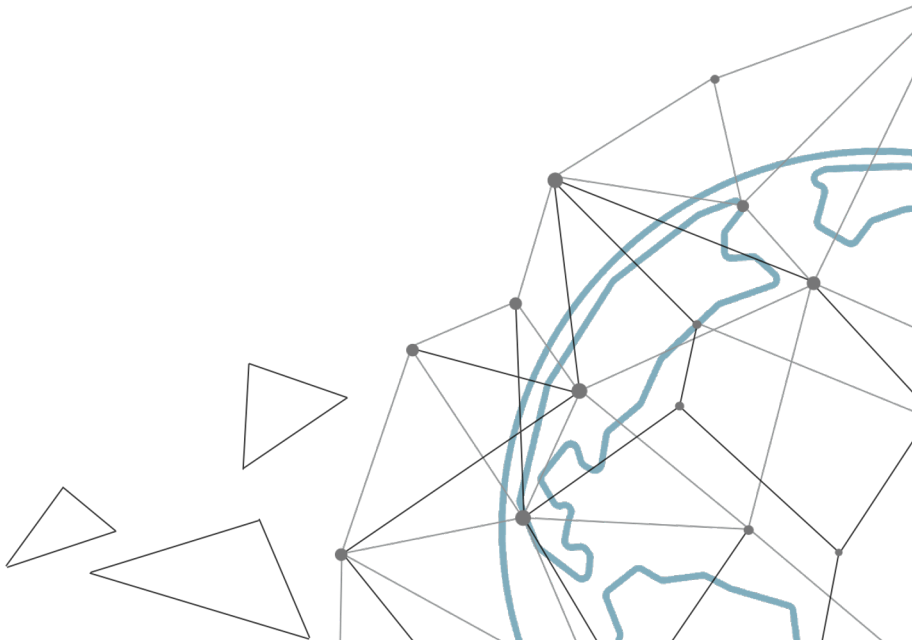
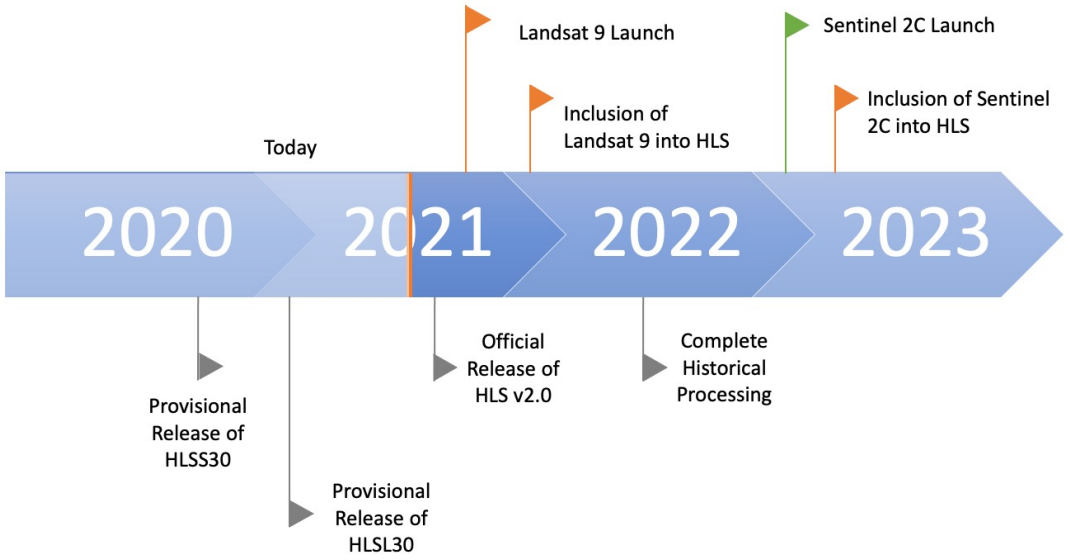


Summary



Next Steps

- Validation and verification of atmospheric correction model
- Official release of HLS version 2.0 in Aug 2021 (forward processing only)
- Full global archive of HLS v2.0 available in mid-2022
    - Processing in reverse chronological order



Data Production System Lessons Learned

- Teamwork is essential
  - Coordination of roles and responsibilities and specific project tasks should be done as early as possible.
- Incorporate buffers in production timeline when external dependencies exist
  - Landsat 8 Collection 2 delays impacted L30 availability
  - LaSRC model for atmospheric correction (S30 specifically) required further scientific validation
  - Access to authoritative historical Sentinel-2 data at scale proven to be challenging
- Allow time for development of a robust production system
  - There are many ways to achieve the same result in AWS – balance between cost/performance takes time
- As data volume and number of granules increases, tools for data ingest by the DAAC require modification

Thank you.