



Low Latency LEO Satellite Data Processing using Ground Station Observation Network (GSON) Framework: Towards a Near Real-time Global Cloud Composite (GCC)

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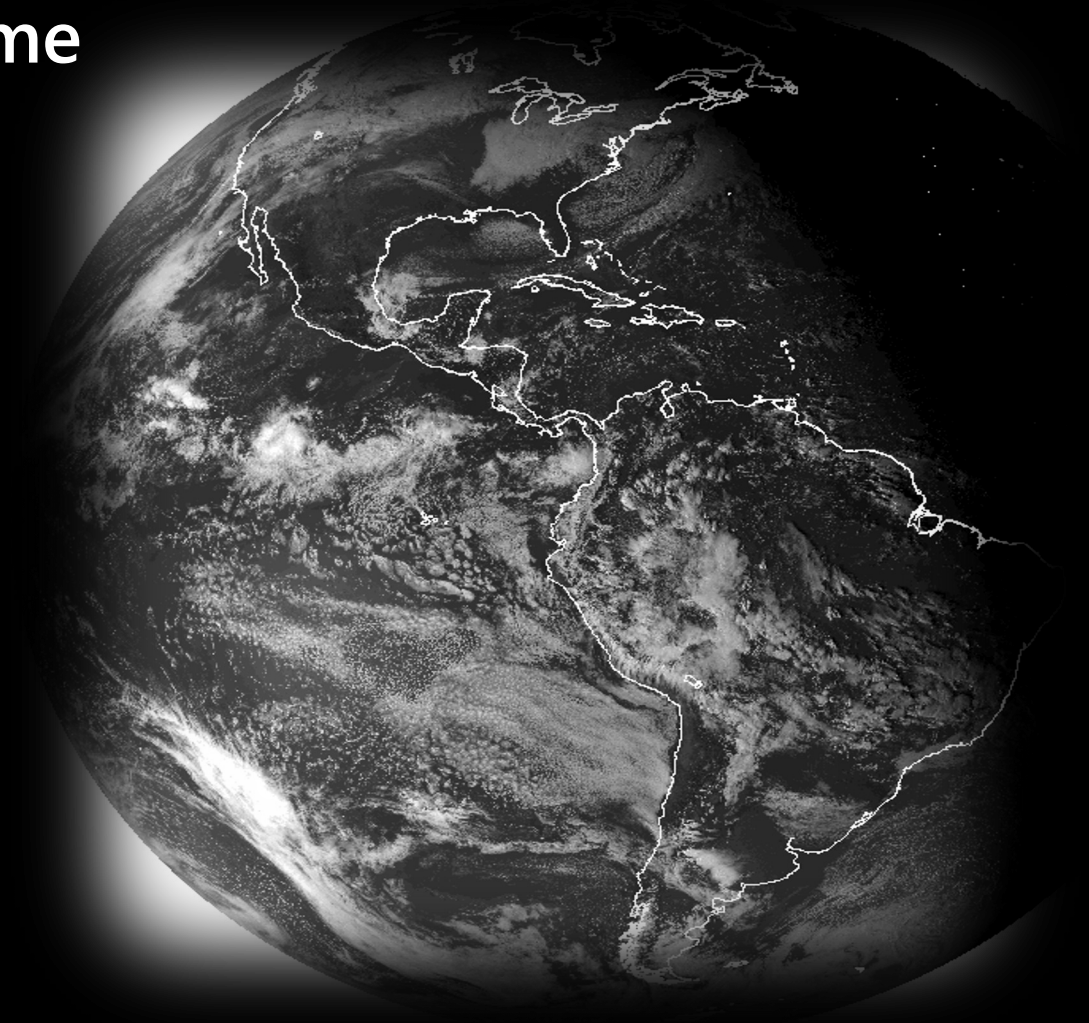
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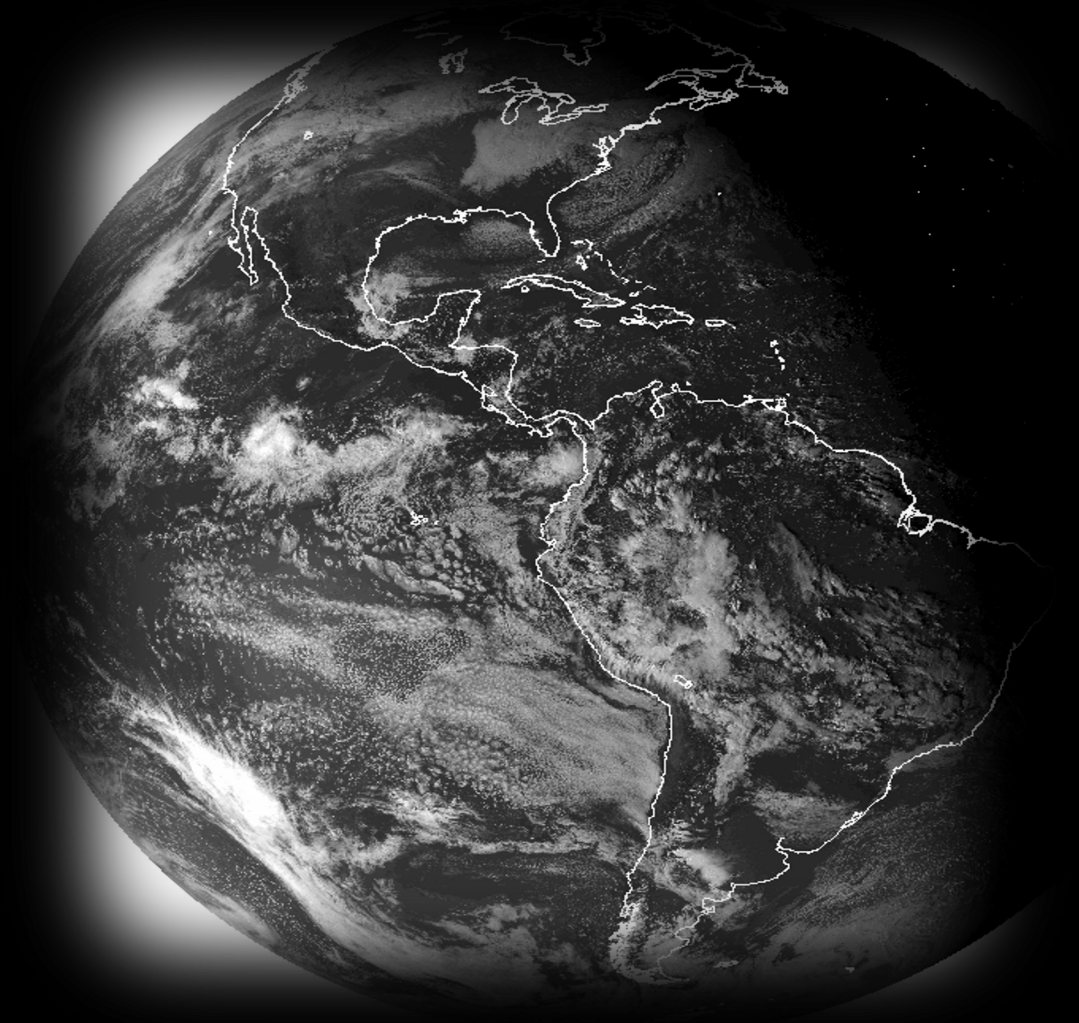
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Outline

- Motivation
- Reducing Latency with GSON
- SatCORPS GCC
- ArcGIS Viz and Data Access
- Summary and Future Work



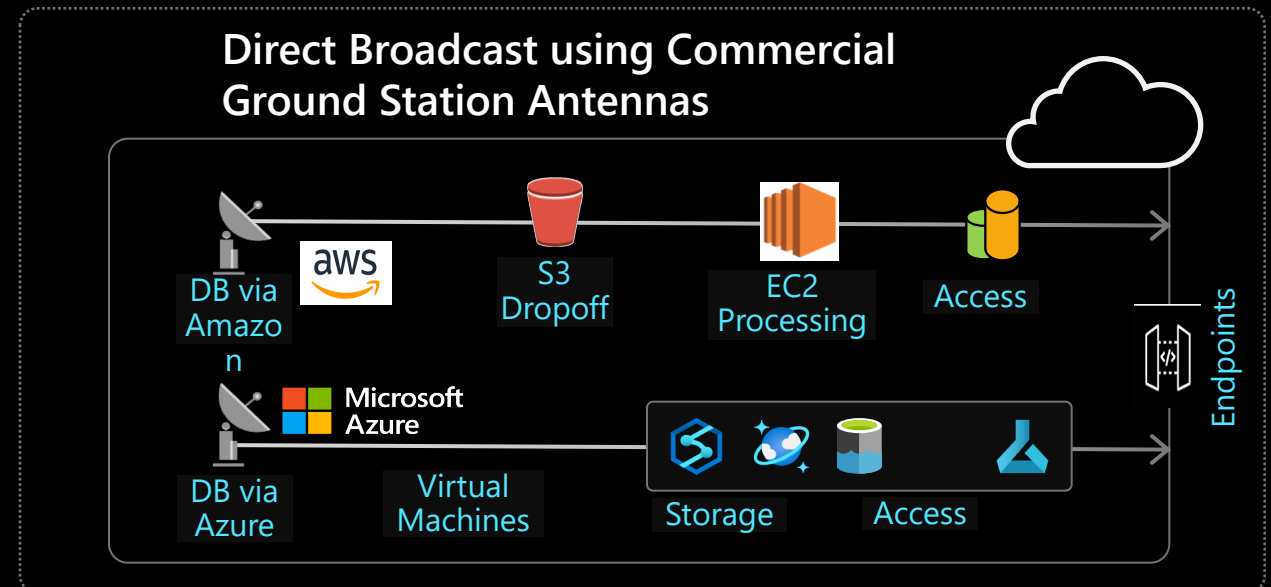
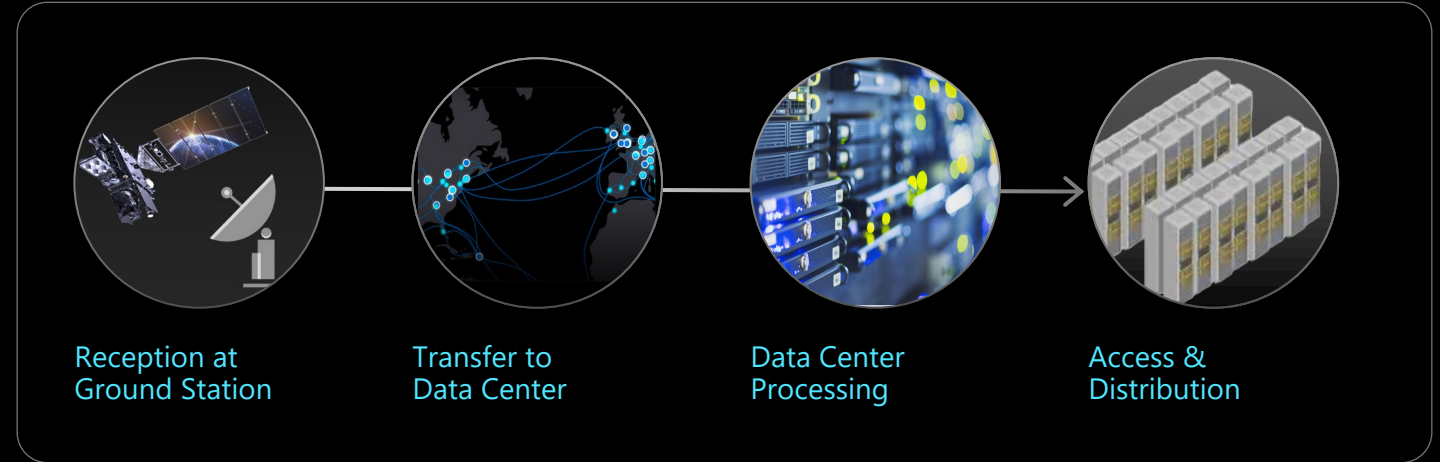
Motivation

LEO data latency problem (3-6 hours) poses a significant impact on data product optimal use due to delay

Need to **improve data latency** to better support weather diagnoses and forecasting, disaster management (FIRMS), airborne science research, and other Earth Science applications

Solution to Improving Latency:

1. Use cloud-based open framework for satellite processing system
2. Use AWS Open Data Registry
3. Use direct broadcast data capabilities from Ground Station Observation Network (GSON) using Amazon and Azure Orbital

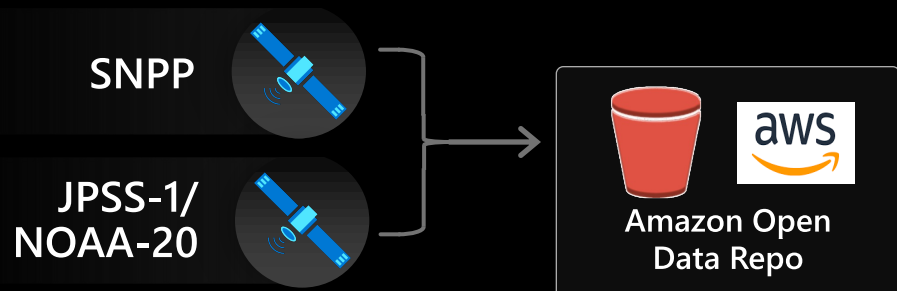


Using Cloud Services to Reduce Latency



GSON Architecture Overview

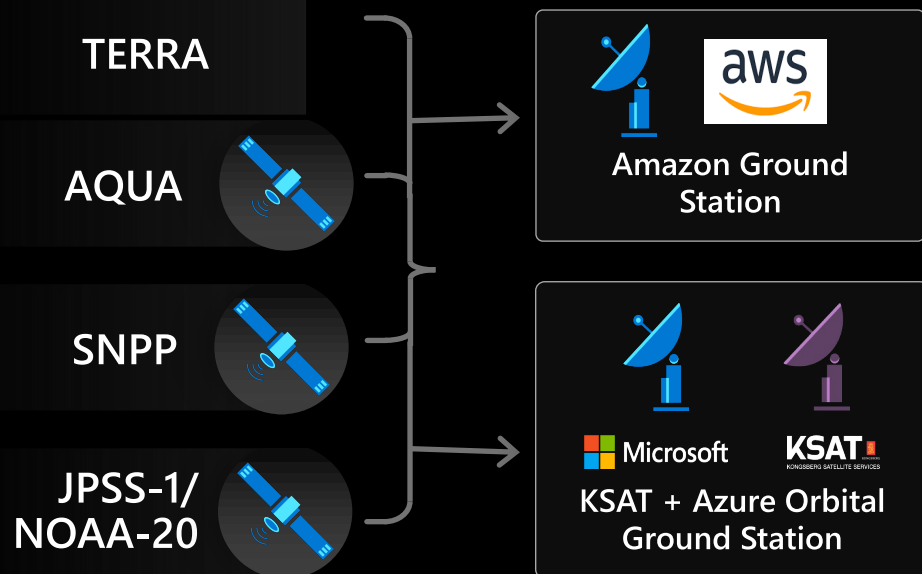
LEO Data via AWS Cloud



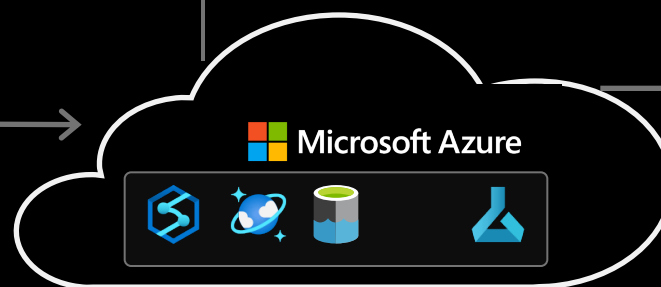
GEO Data via RT Feed



LEO Data via Direct Broadcast



GSON Processing Framework



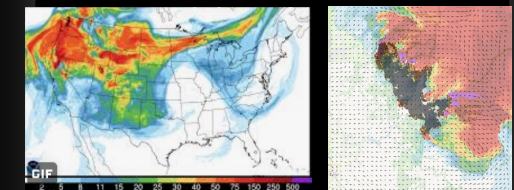
Near Real-time Science Data Products



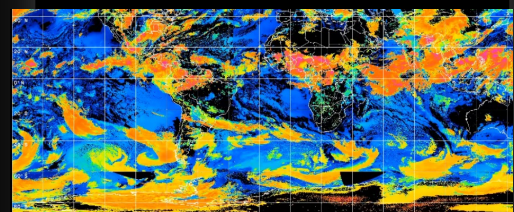
VIIRS Active Fires



VIIRS Flood Detection

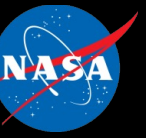


4D Data Assimilation Forecast



SatCORPS GEO+LEO Global Cloud

Use Amazon Open Data Registry to Reduce Latency

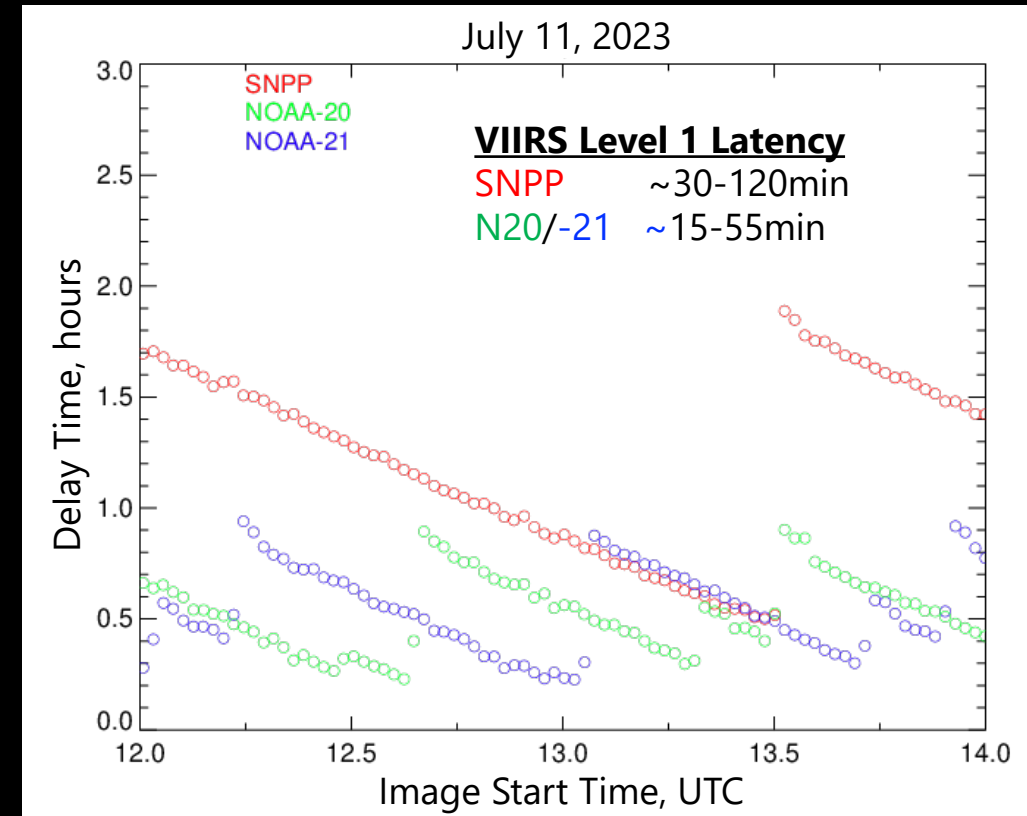
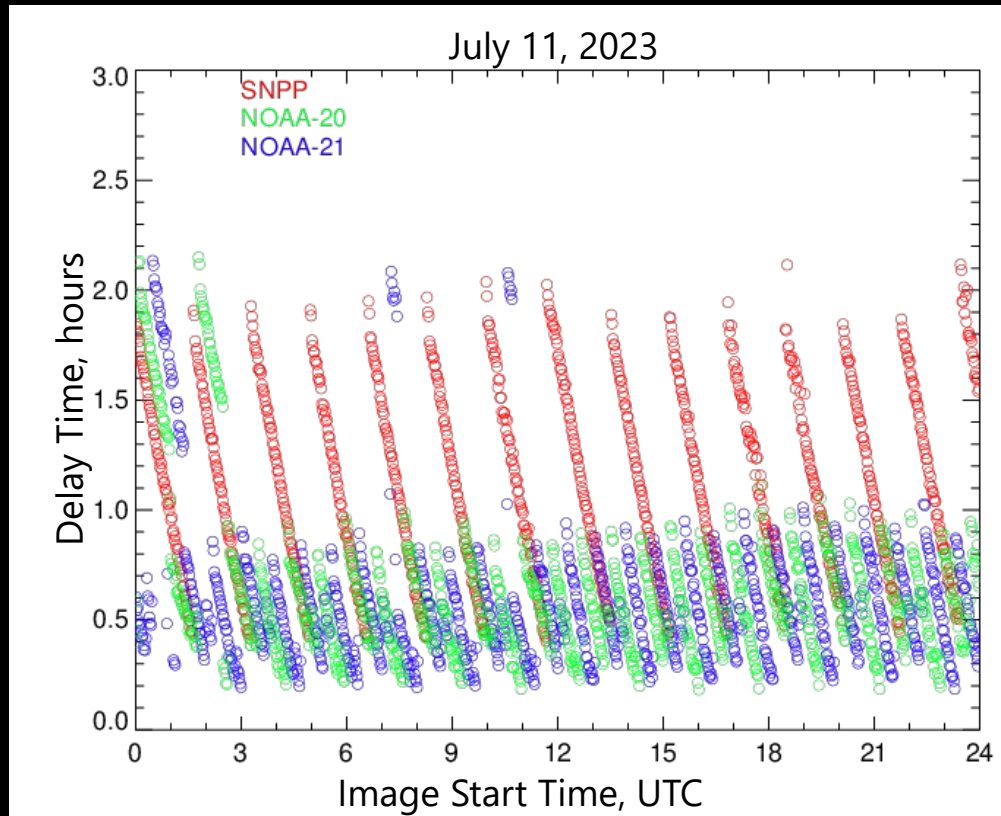


- NOAA Joint Polar Satellite System (JPSS)

- <https://registry.opendata.aws/noaa-jpss/>



- SNPP/N20/N21 VIIRS L1 Granule Latencies on S3 Buckets

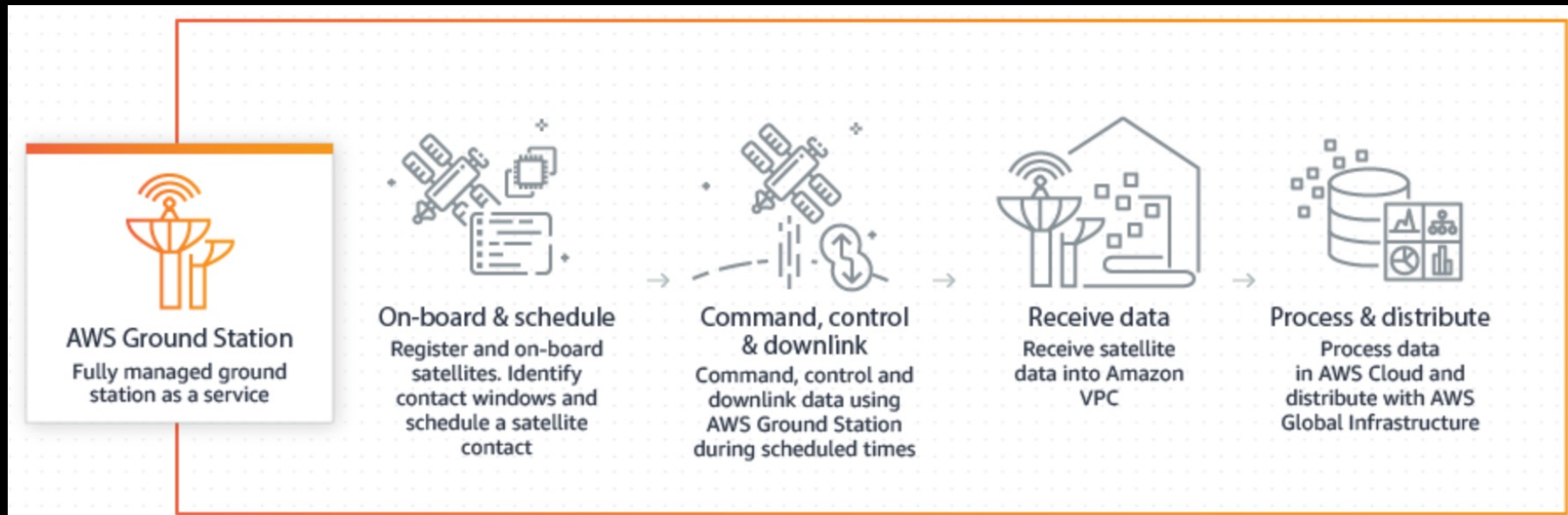
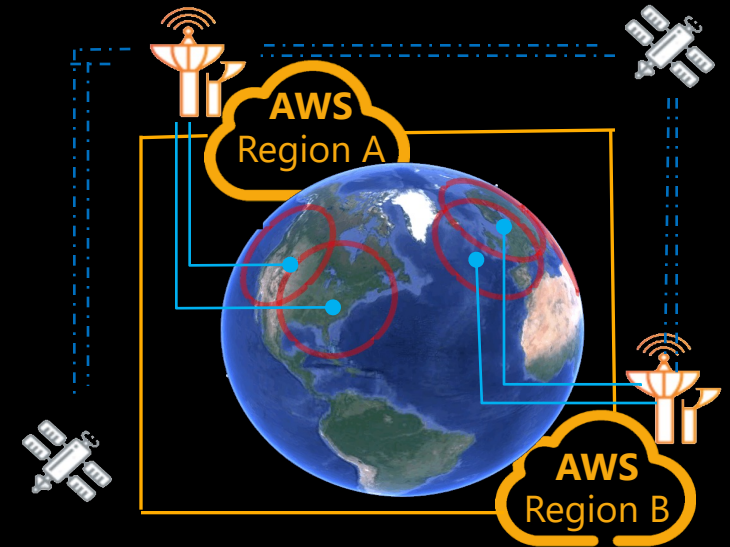




Use Commercial Ground Stations to Reduce Latency

How Amazon Ground Station as a Service works

- Provides global network of ground stations
- On-boarding and Scheduling
- Downlink direct broadcast data
- Allows uplink for command and control
- DB data received by VPC instance
- Data delivered to S3 for processing/distribution



Ground Station Coverage from Amazon and Azure



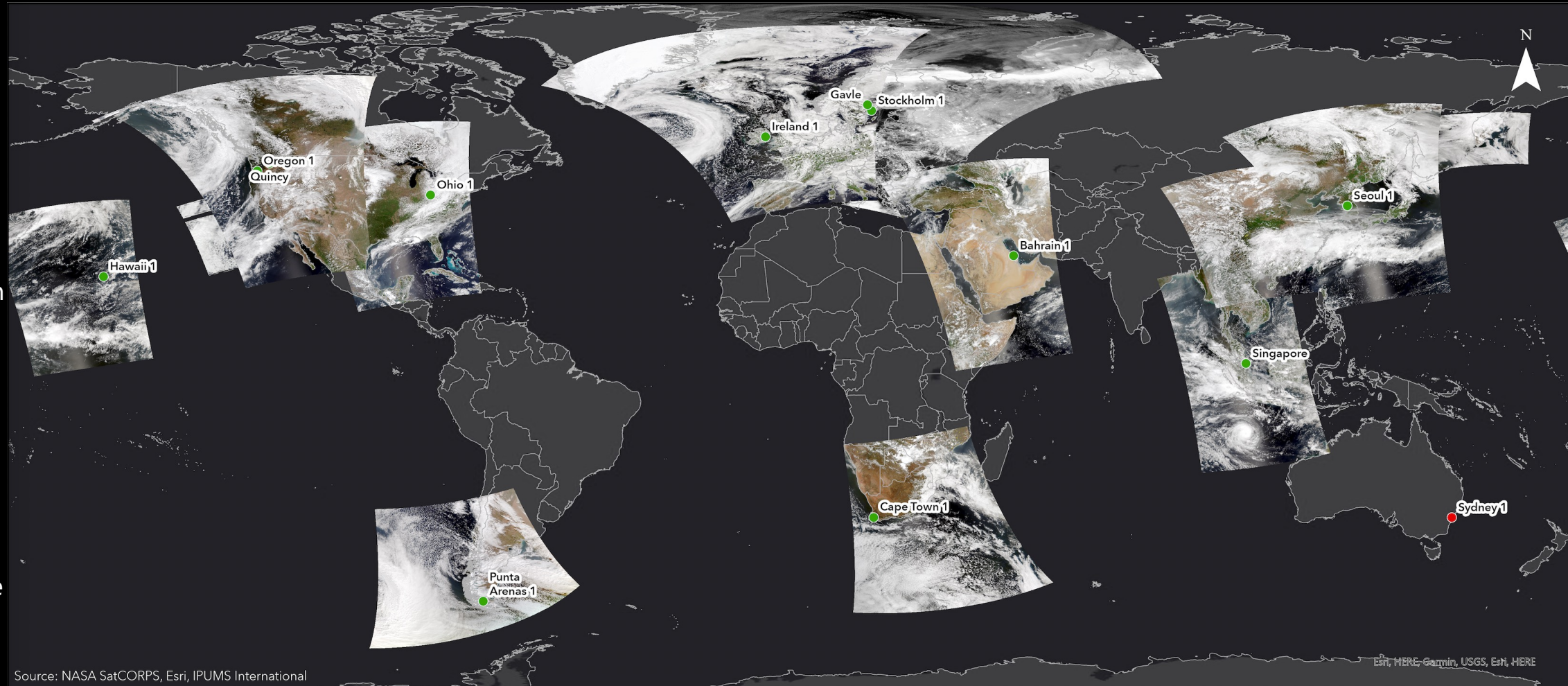
Successful VIIRS Direct Broadcast Capture using GSON System

Amazon

- Ohio
- Oregon
- Bahrain
- Stockholm
- Dublin
- Hawaii
- Cape Town
- Seoul
- Punta Arenas
- Sydney

Azure

- Quincy, Gavle,
- Singapore
- S. Africa



0 1,500 3,000 6,000 Kilometers

GSON VIIRS Sample Products

Ground Station Observation Network (GSON) | NASA Langley Research Center
February 2023

- World Boundaries
- On-Boarded Ground Station
- To Be On-Boarded Ground Station



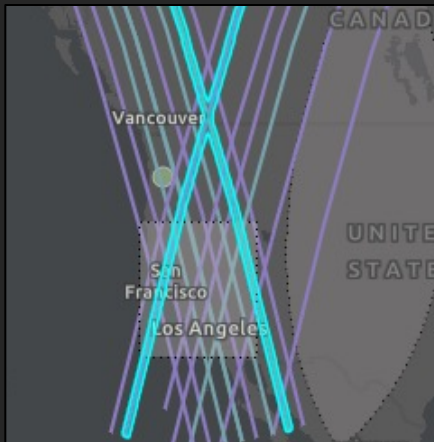
GSON Low Latency VIIRS for WRF-SFIRE Forecasting

- Conducted demo on Oct 1-8, 2021; GSON delivered low latency **VIIRS Radiances and Active Fires products (<12 min)**
- The Weather Research Forecasting – Spread FIRE (WRF-SFIRE, Disasters Program) ingested the low latency VIIRS radiance and fire radiative power data to initialize fire perimeter of the KNP Fire
- WRF-SFIRE produced 48-hour forecast of fuel moisture, fires spread, and smoke at 9 & 21z (with low latency) and at 12 and 0z (regular latency; operational forecast)
- Forecast initialed with low latency matches the observations best over the first 24 hours of the fire (Hilburn, et al., AMS CMM 2022) and is produced 3 hours sooner



October 4, 2021, WRF-SFIRE 24hr Forecast using GSON Low Latency VIIRS Active Fires

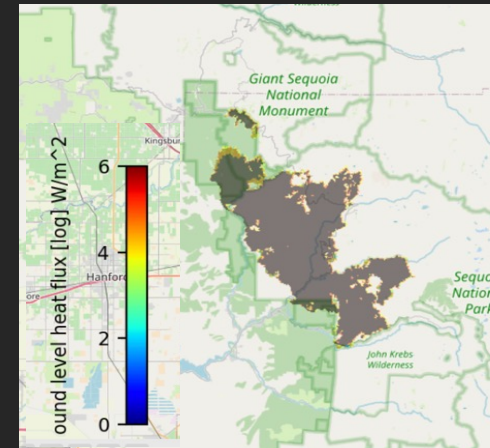
Subscription for
Satellite Selection



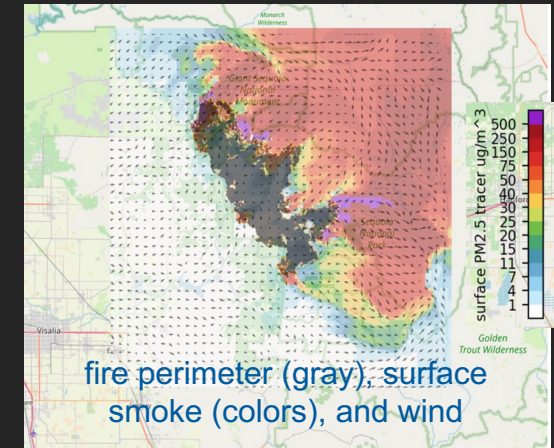
VIIRS Active Fires



Initial Fire Perimeter



WRF-SFIRE 24hr Forecast

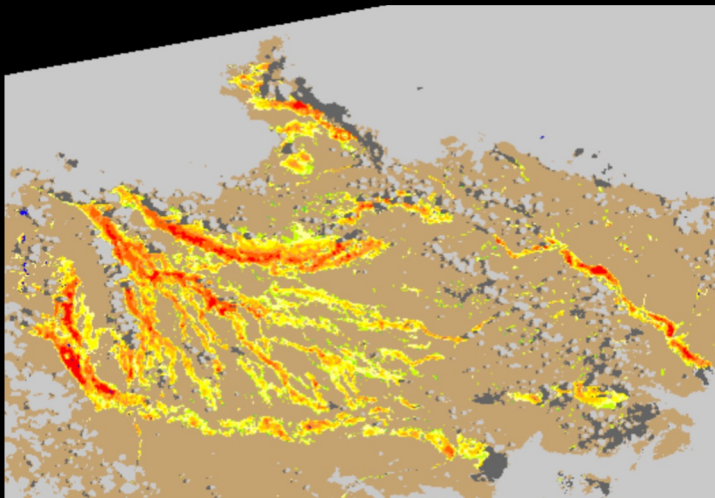
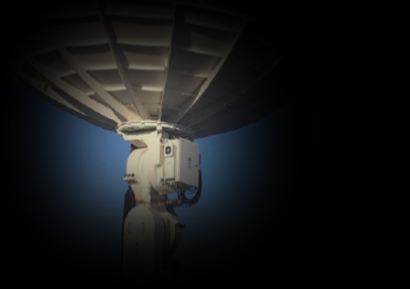


Prototype VIIRS Node for NOS-T Flood Demonstration

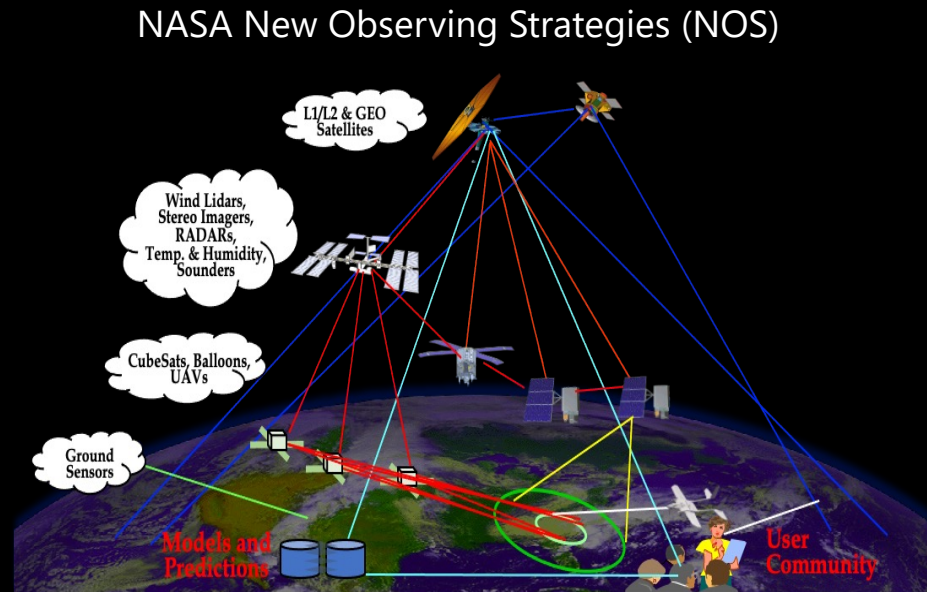
- Funded by NASA ESTO Advanced Information Systems Technology (AIST-QRS-20)
- Supported NASA ESTO AIST New Observing Strategies Testbed (NOS-T) historical flood demo Spring 2021 and real-time demo Fall 2021
- Delivered VIIRS flood product under ~25min

Features

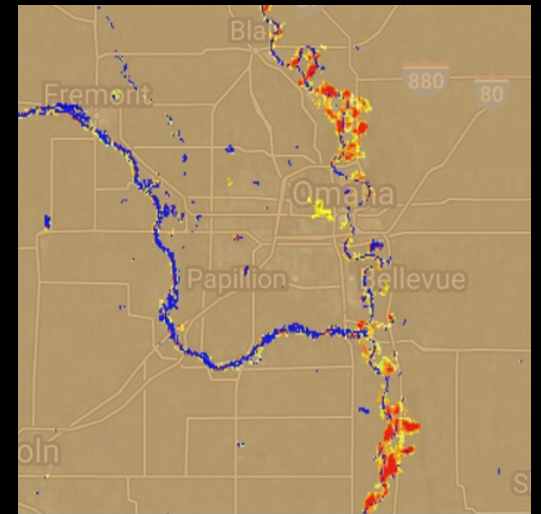
- Triggered by events (stream gauge and/or model) or user/app via GSON subscription
- Automated scheduling and job orchestration (reception & processing workflows)
- Distribution via cloud storage, HTTPS, and ARC-GIS portal endpoints



Floodwaters over South Africa derived from NPP VIIRS



Smith, et al., 2022, IGARSS 2022



VIIRS Flood Detection Mississippi Basin

The Satellite CLOud and Radiative Property retrieval System (SatCORPS)



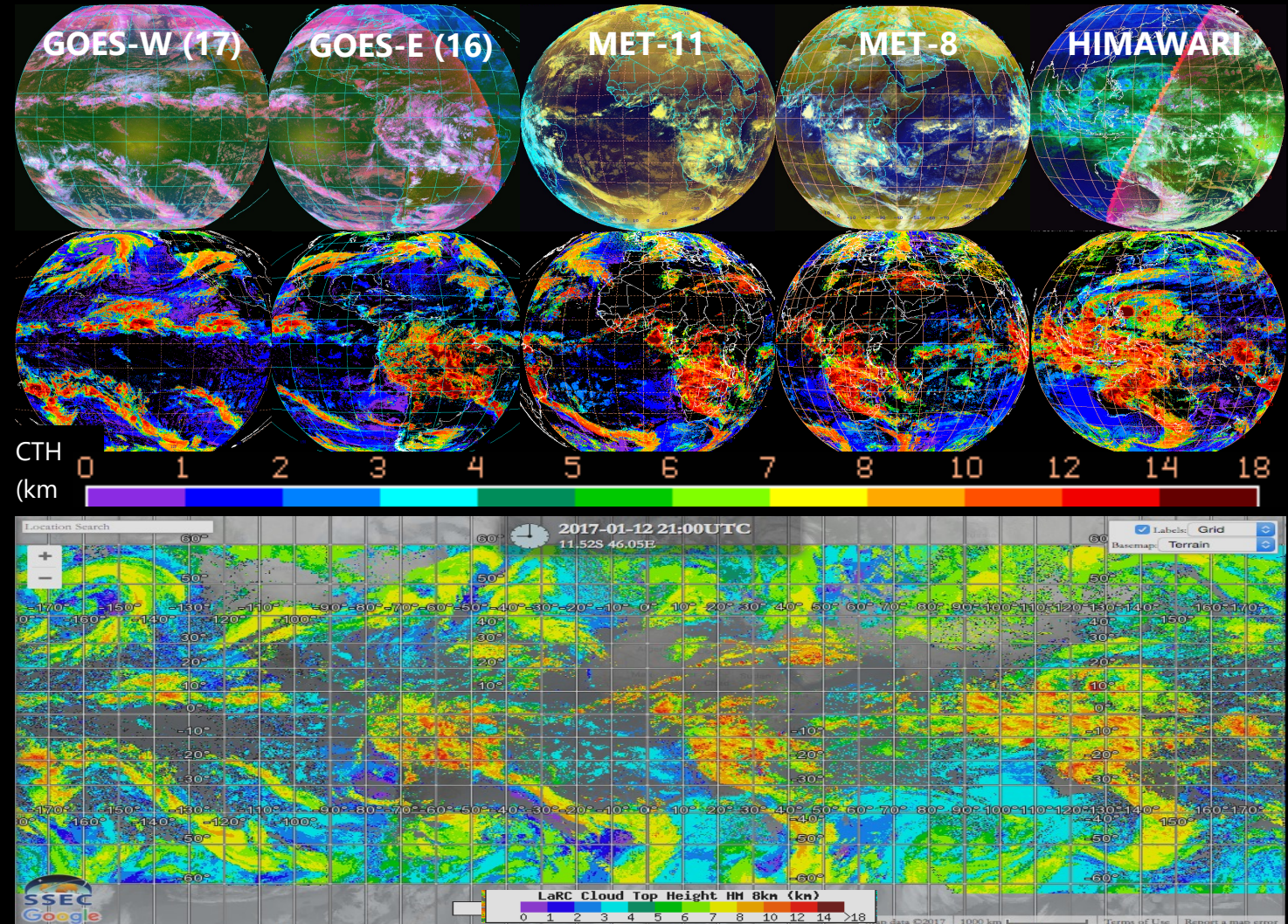
Unique SatCORPS Data Products

Traditional Standard Cloud Products

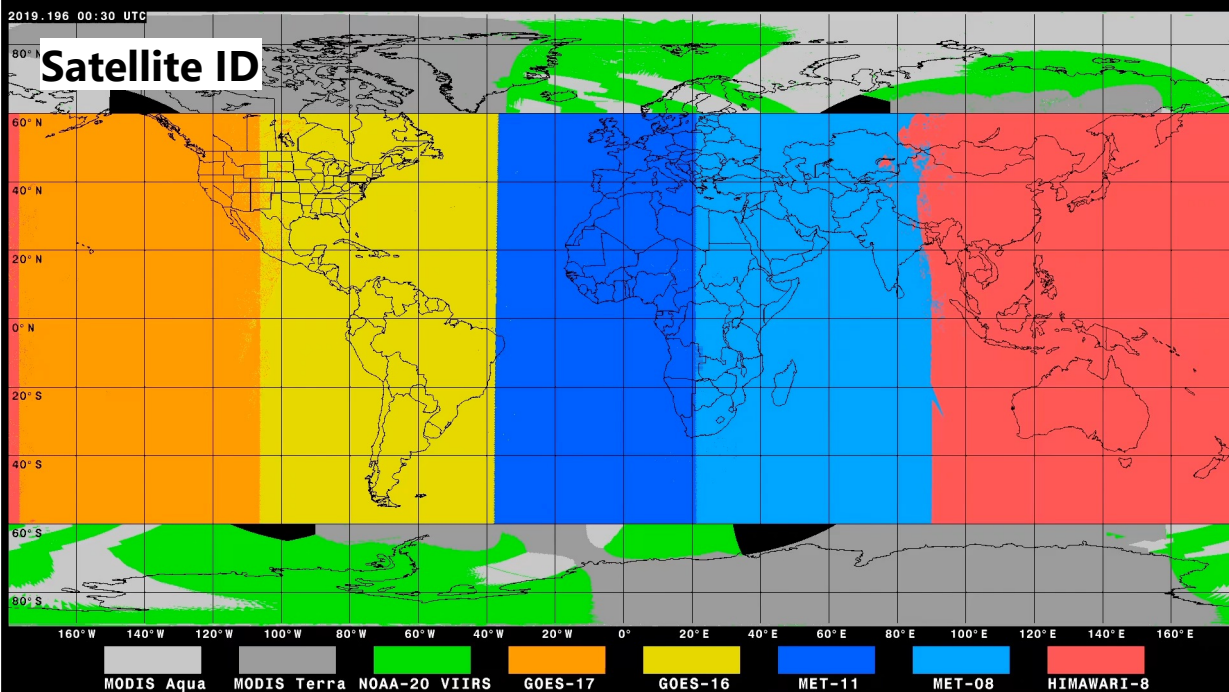
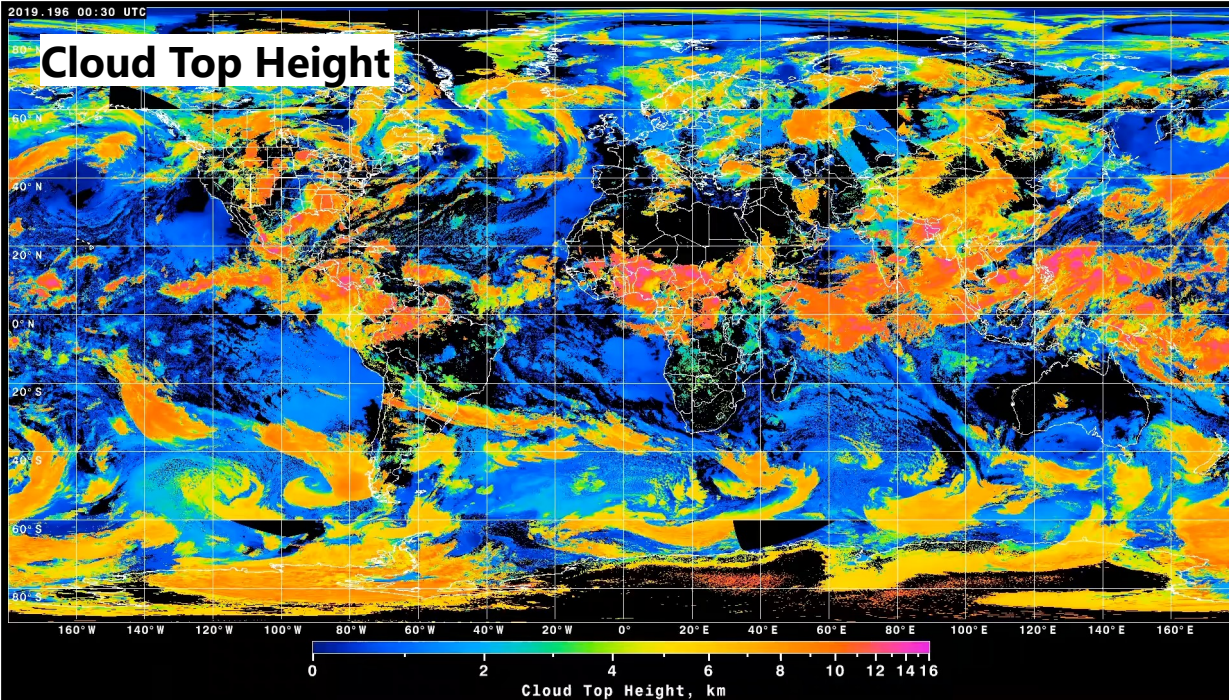
- Mask, Thermodynamic phase
- Cloud Temperature and Height
- Optical Depth, Effective Radius, Water Path
- Droplet number concentration

Innovative SatCORPS Data Products

- Cloud optical properties at Night
 - Physical retrieval for thin cloud optical properties
 - Machine learning for thick clouds (diurnally consistent)
- Cloud vertical structure
 - Cloud layering, thickness, base heights
 - Cloud water content profiles
- Radiative Fluxes (TOA and SFC)
- Surface Skin Temperature
- Aviation weather hazards & climate impacts
 - Icing and convection
 - Contrail optical properties, radiative effects



NRT half-hourly GEO Global Cloud Composite (GCC), 3km subsampled data products



Global Cloud Composites (GCC) from Satellites

Objective: Optimally combine radiances and derived products (cloud properties and radiative fluxes) from multiple GEO and LEO satellite imagers as seamlessly as possible

New system is intended for the broader community

- Day & Night, 3-km grid, 30-60 minutes, cloud algorithm enhancements to improve consistency, all radiances, additional derived parameters
- First charter is to produce a multi-year, hourly dataset beginning in 2019 from the current constellation (ABI, AHI, SEVIRI, MODIS, VIIRS) targeted to serve modeling needs related to cloud parameterizations
- Real-time ingest of LEO satellites using SatCORPS Ground Station Observation Network (GSON) and operational LEO processing (in development)

System is being designed so that it can also run operationally to support NRT & other applications



Analysis Ready Data (ARD)

- Rolling 2-week data parameters stored in cloud-optimized format and full archive access
- Built with transpose to provide more-efficient time series retrieval
- Global composite and regional mosaic availability

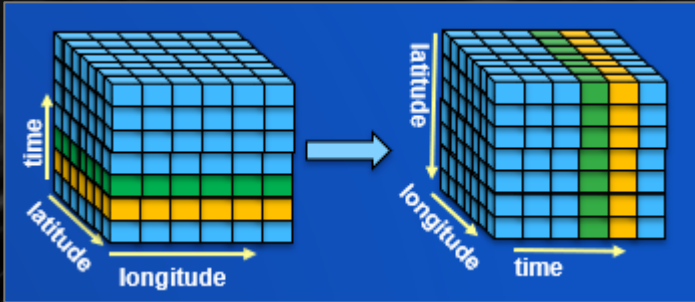


Image Source: [Esri](#)

Cloud Raster Format with
Transpose

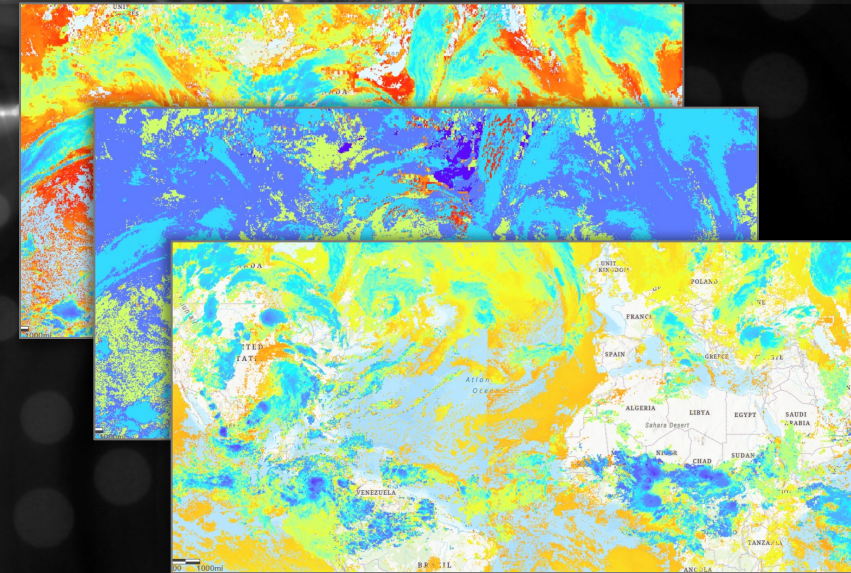
Geospatial Services

- ~28 Multidimensional (time-enabled) parameter-level geospatial services as global and regional composites
- Exposed as RESTful APIs, ArcGIS Image Services, & Open Geospatial Consortium (OGC) Web Mapping Services/Web Coverage Services

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  }
}
```

RESTful API Endpoint



ArcGIS Image Services &
OGC WMS/WCS



SatCORPS GIS | Visualization & Analysis

Currently Under Development -

Data Layer Manipulation

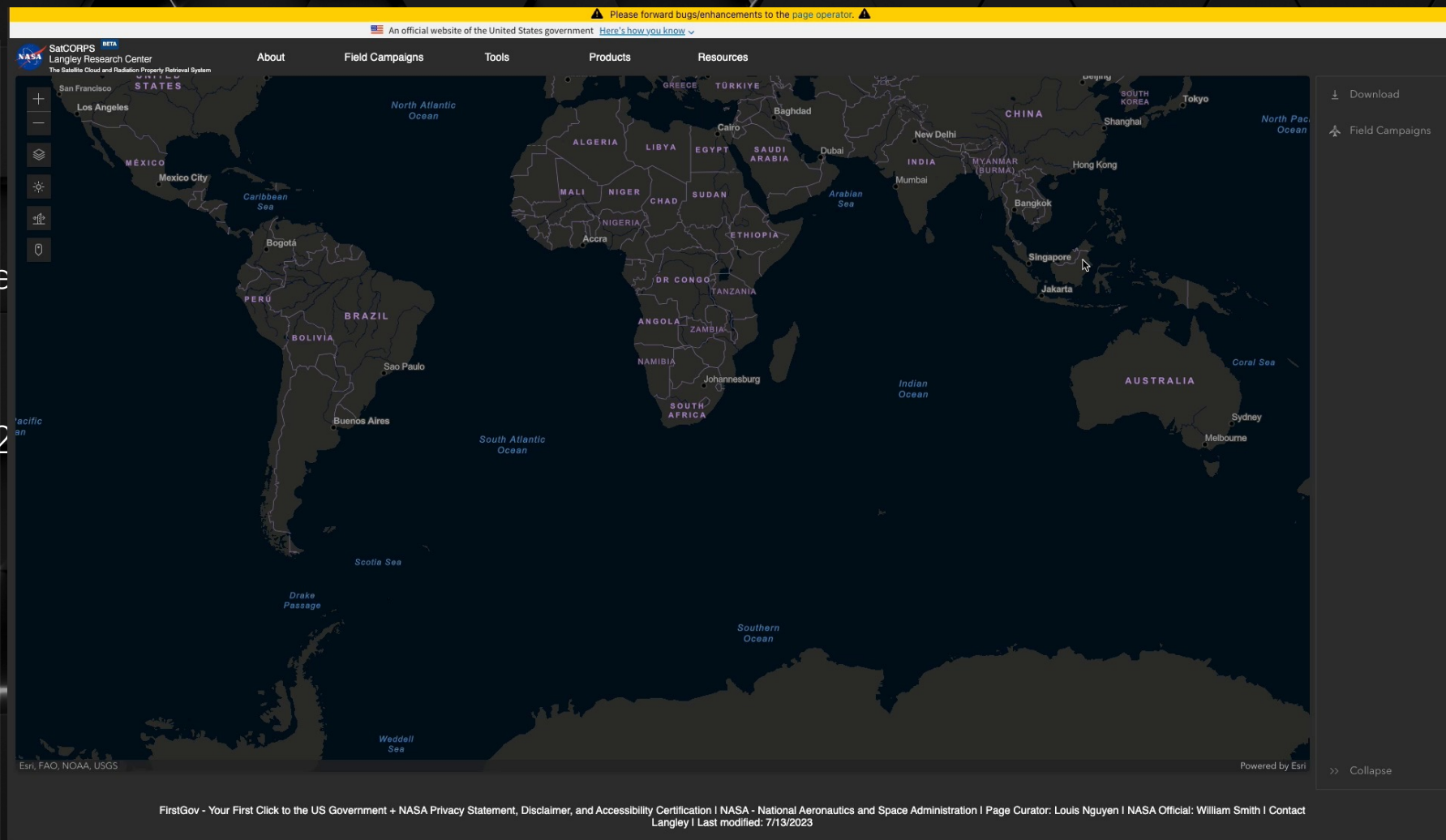
- Layer transparency settings and raw pixel value identification
- On-the-fly filtering of pixel value to identify areas of interest

Multidimensional Analysis

- Single point time series across 2 week rolling ARD service
- Time slider and user-defined animation functionality

Parameter Subsetting

- Regional bounding-box subsetting delivering customized NetCDF/JSON



Play Me



SatCORPS GIS | Visualization & Analysis

Currently Under Development -

Data Layer Manipulation

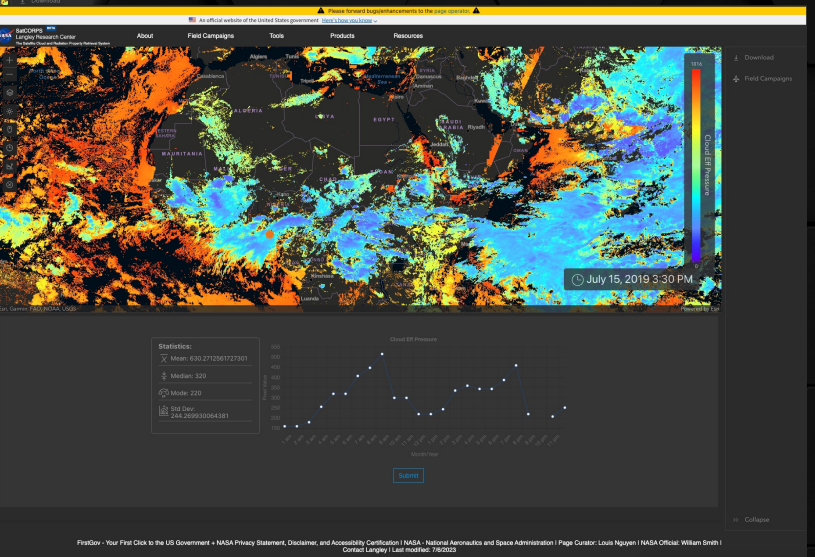
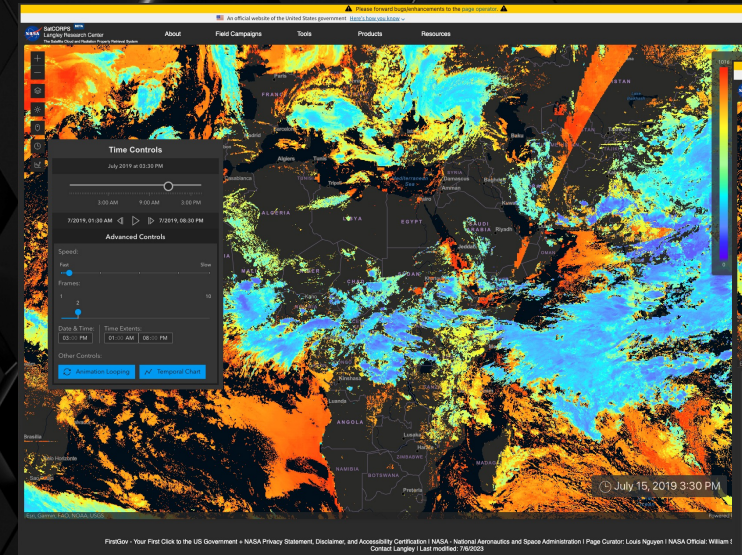
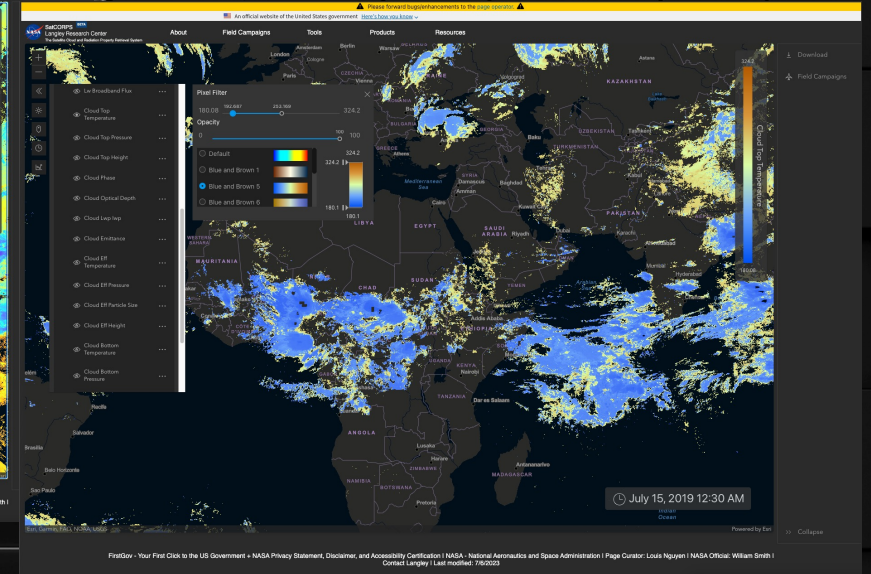
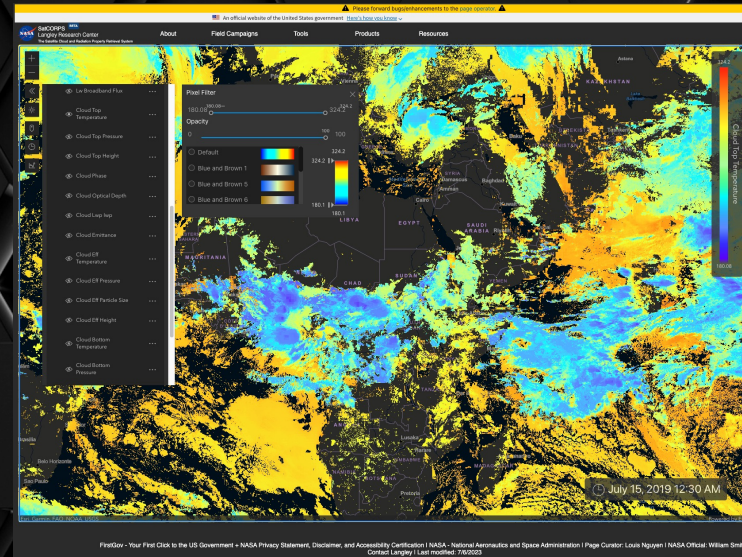
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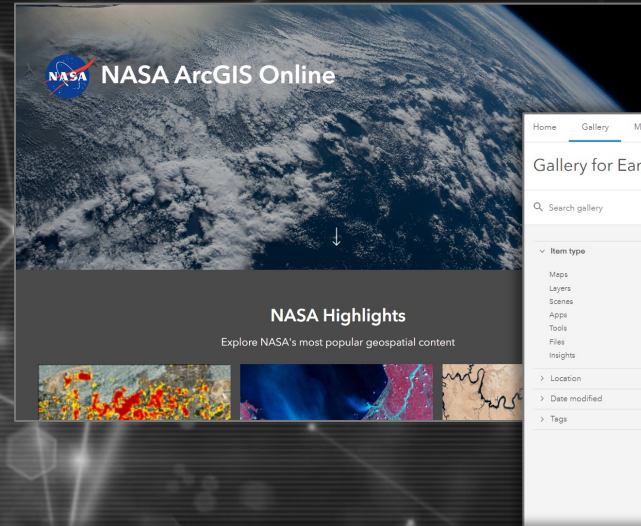


SatCORPS GIS | Discoverability & Capacity Building

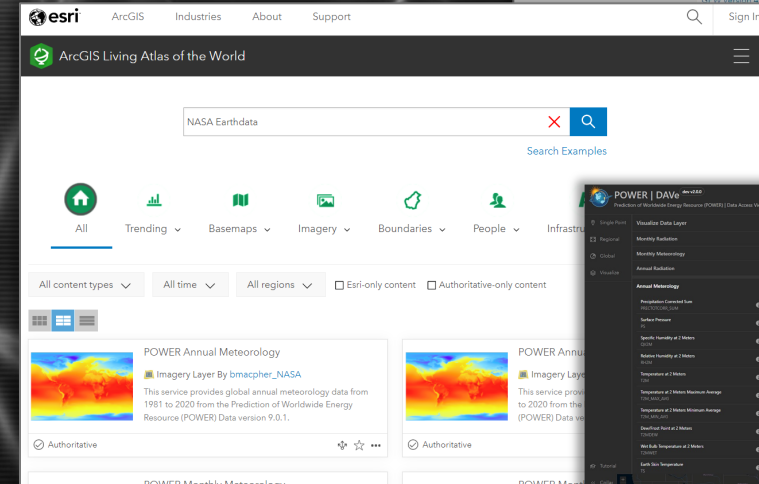
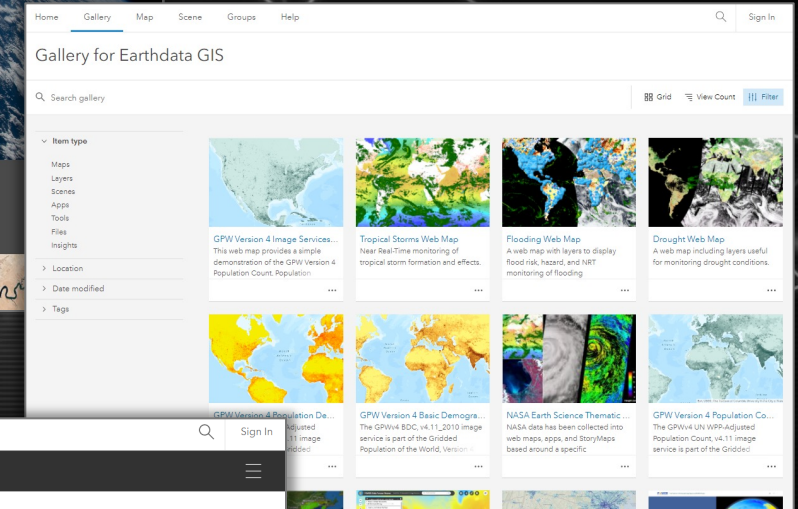
User Engagement & Interoperability

- Establishing SatCORPS group on NASA ArcGIS Online (AGOL) and nomination to popular geospatial data catalogs such as Esri Living Atlas of the World (LAW) for discovery by internal and external users.
- Working with partners (e.g., NASA Prediction Of Worldwide Energy Resources Project, NASA Airborne Science Mission Tool Suite (MTS)) for direct integration into their web mapping applications.
- Future nomination to AWS Open Data Registry (ODR) as part of NASA Space Act agreement and ESDIS Earthdata Pub to encourage in-cloud analysis/use and discoverability.
- Positioning the future of SatCORPS data distribution and analysis for easier integration to NASA Earth Action (e.g., Earth Information Centers, Earthdata GIS Enterprise in the cloud, etc.)
- Development of interactive tutorials and resources for users (e.g., Jupiter Notebooks)

NASA ArcGIS Online

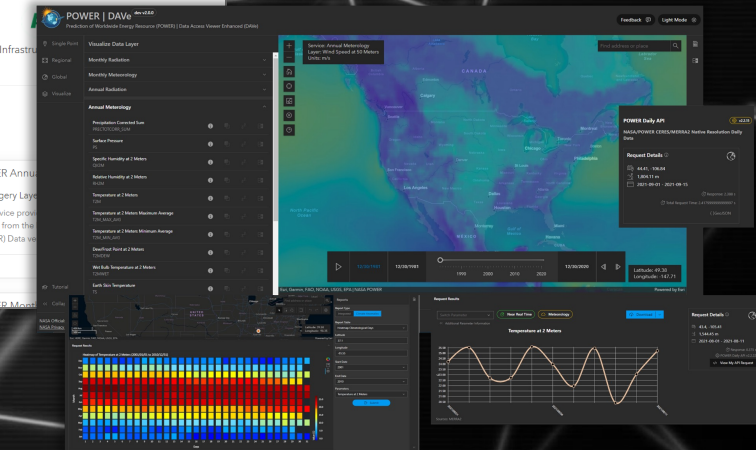


NASA Earthdata ArcGIS Enterprise



Esri Living Atlas of the World

NASA POWER Data Access Viewer





Summary and Future Work

- GSON flexible and scalable processing framework works with LEO and GEO data
- Latency can be reduced when data and resources are co-located on the Cloud
- Near Real-time SatCORPS Global Cloud Composites expected to go operational by Fall 2023

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Visit us at: <https://satcorps.larc.nasa.gov/indexV2.html>

Related Presentation: IGARSS 2023 Paper# 5755 Fri Afternoon (Poster), Thad Chee
"SatCORPS Global Cloud Composite (GCC): The design and delivery of a high quality, high resolution, global cloud product available in near real-time"