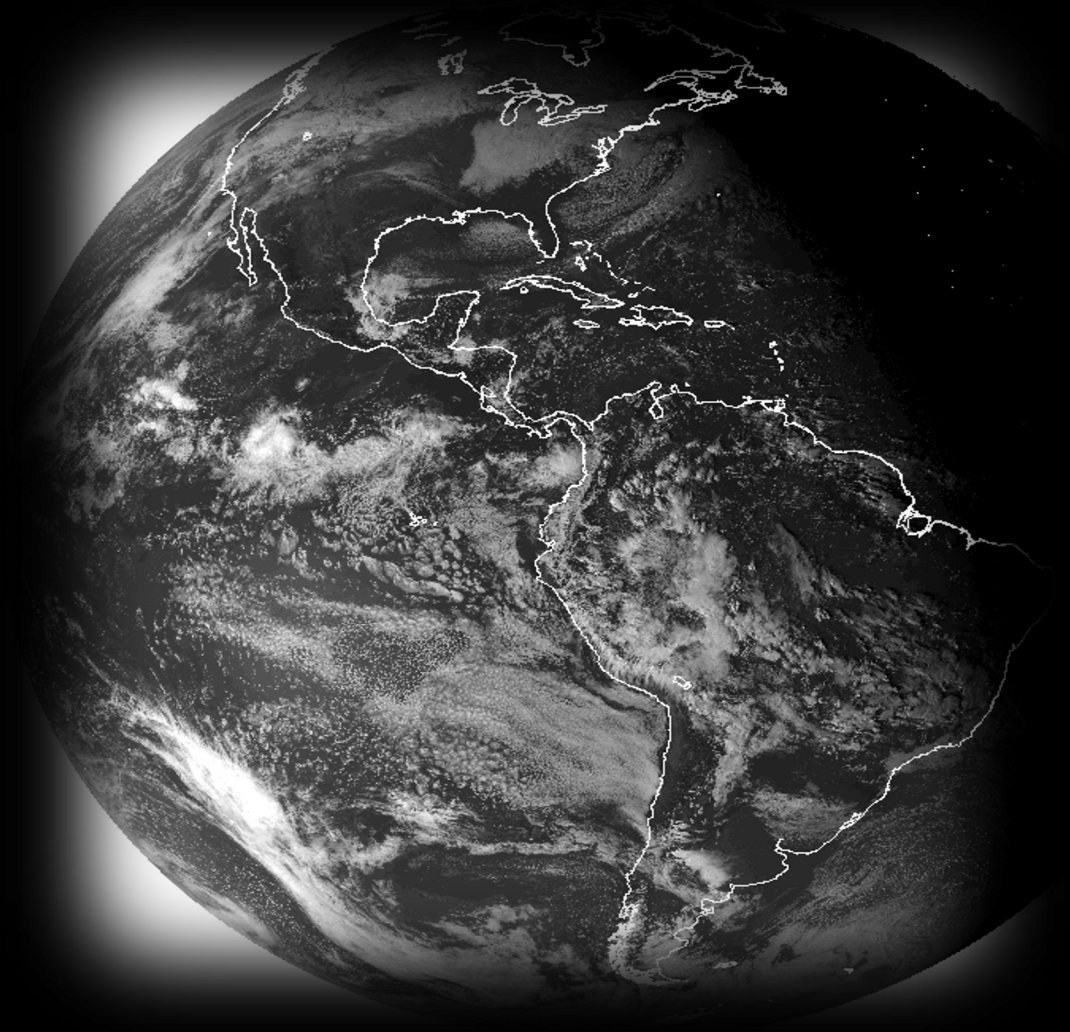
Deployment of Ground Station Observation Network (GSON) to Deliver Low Latency Satellite Cloud Products



DoD Cloud Post-Processing and Veriifcation Workshop

Sept 13-14, 2023 Boulder, CO

Louis Nguyen
NASA Langley Research Center

Thad L. Chee
ADNet, Inc.

Jason Barnett
Booz Allen Hamilton

David Painemal
Analytical Mechanics Associates

William L. Smith
NASA Langley Research Center

Andrei Vakhnin
ADNet, Inc.

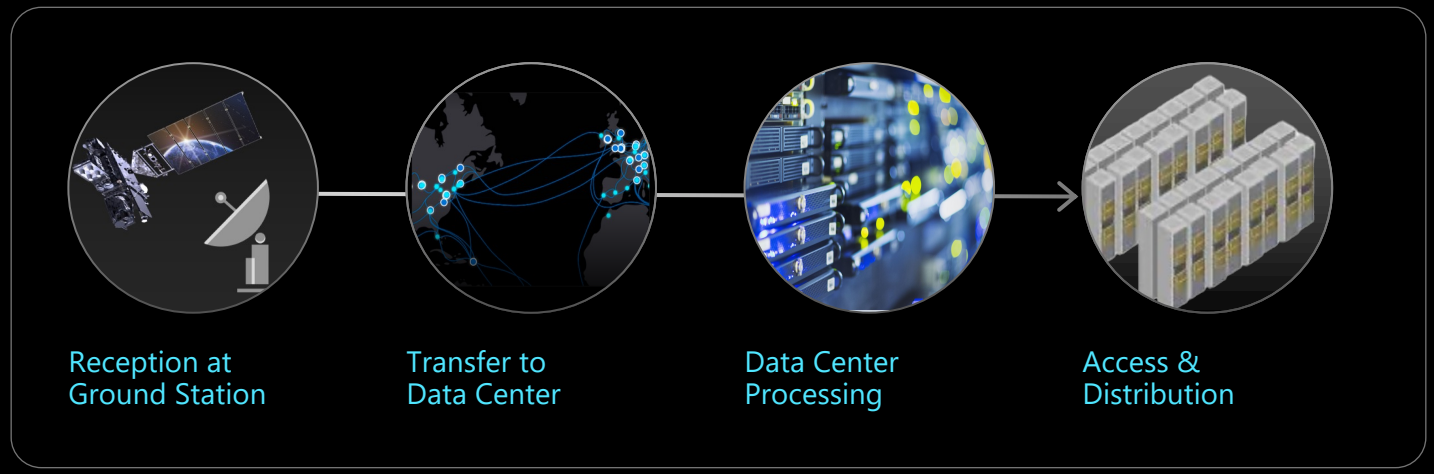
Motivation

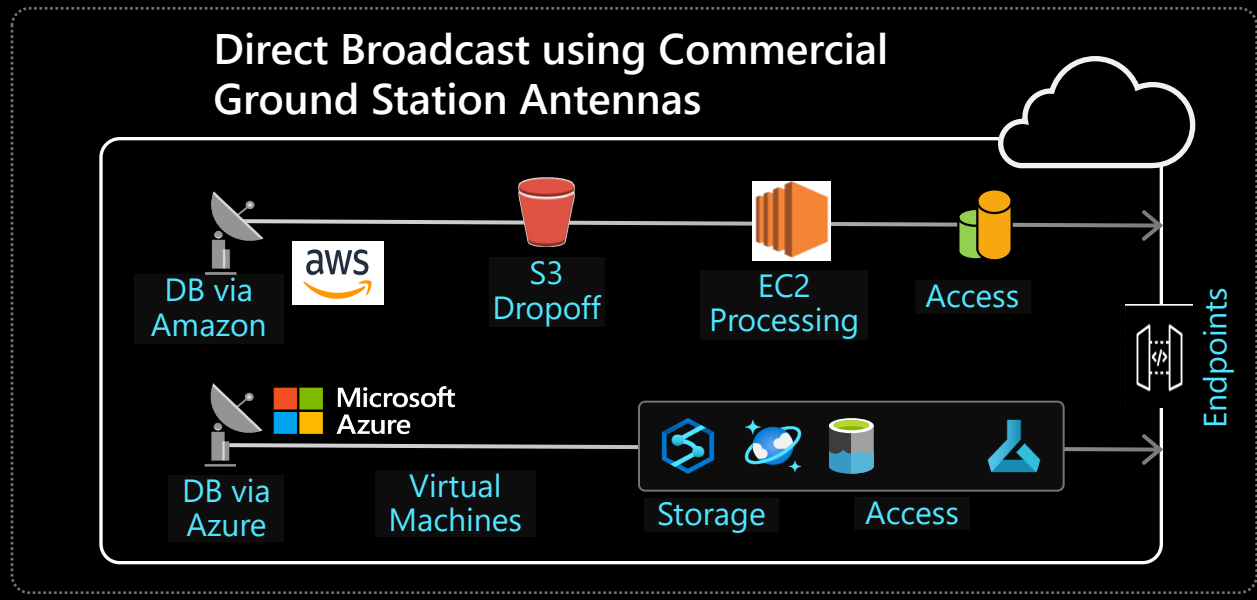
LEO data latency problem (3-6 hours) poses a significant impact on data product optimal use due to delay

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

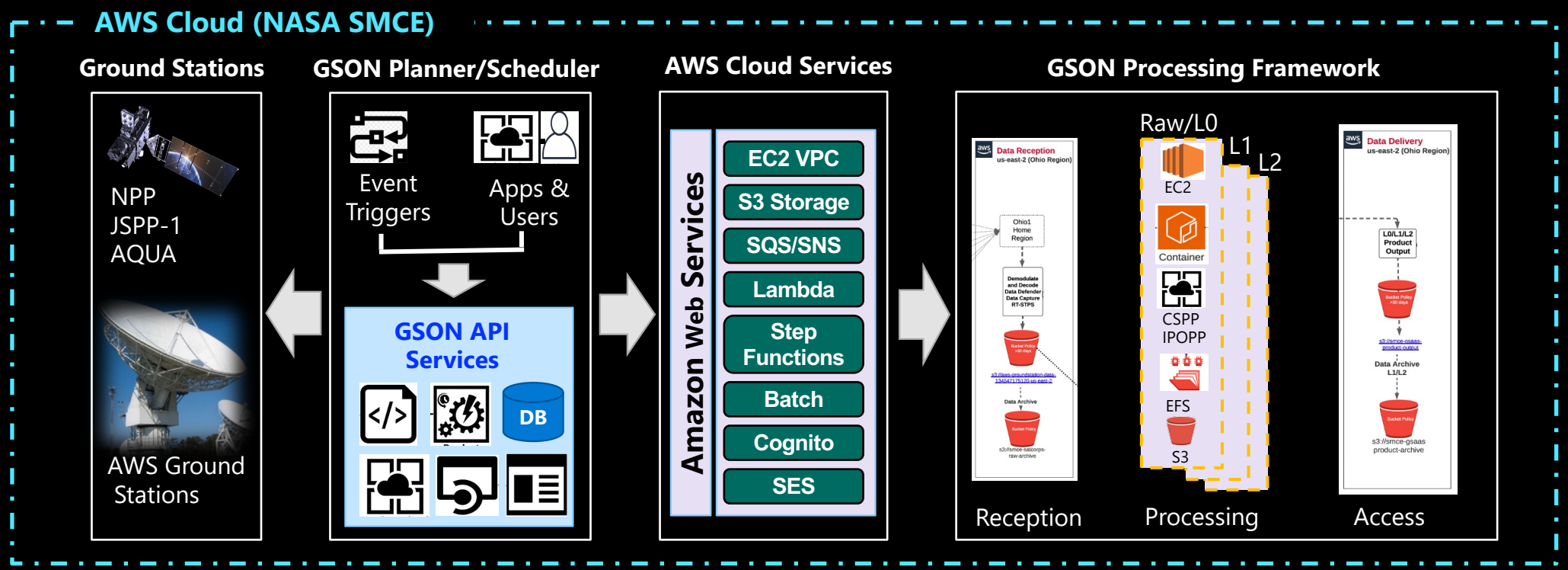




Ground Station Observation Network (GSON)

GSON Components:

- Commercial Ground Station: Amazon GS
- **GSON Planner and Scheduling Services (tasks/job orchestration)**
- Amazon Cloud and CloudWatch Services
- **GSON Processing Engine Framework**



Ground Station Observation Network

GSON Architecture Overview

LEO Data via AWS Cloud

SNPP

JPSS-1/ NOAA-20

Amazon Open Data Repo

GEO Data via RT Feed

GOES-W, GOES-E, MET-11, MET-8, HIM-8

GSON Processing Framework

LEO Data via Direct Broadcast

TERRA

AQUA

SNPP

JPSS-1/ NOAA-20

Amazon Ground Station

Microsoft KSAT

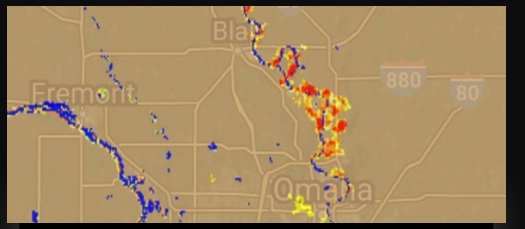
KSAT + Azure Orbital Ground Station

NASA SMCE Amazon Cloud

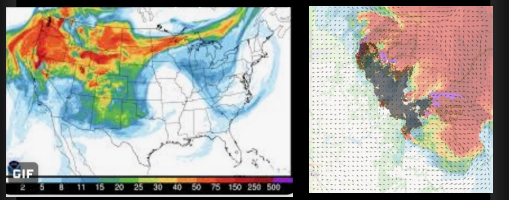
Microsoft Azure

Near Real-time Science Data Products

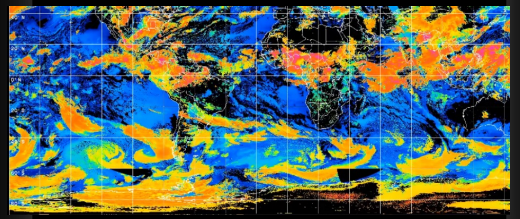
VIIRS Active Fires



VIIRS Flood Detection



4D Data Assimilation Forecast

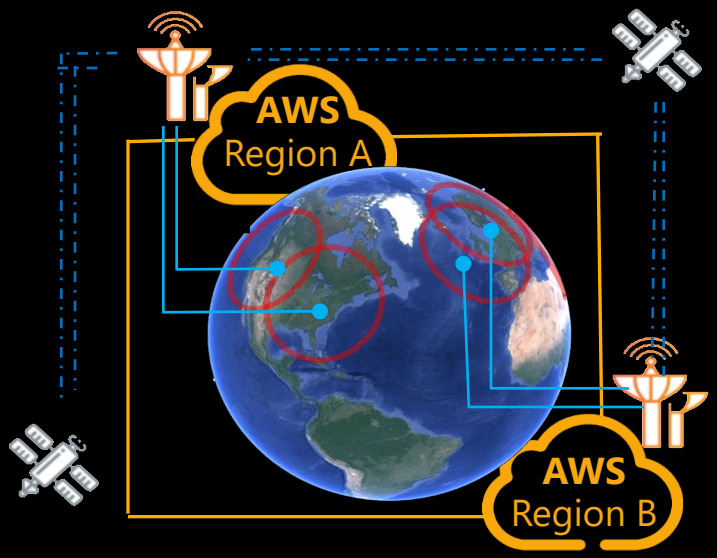


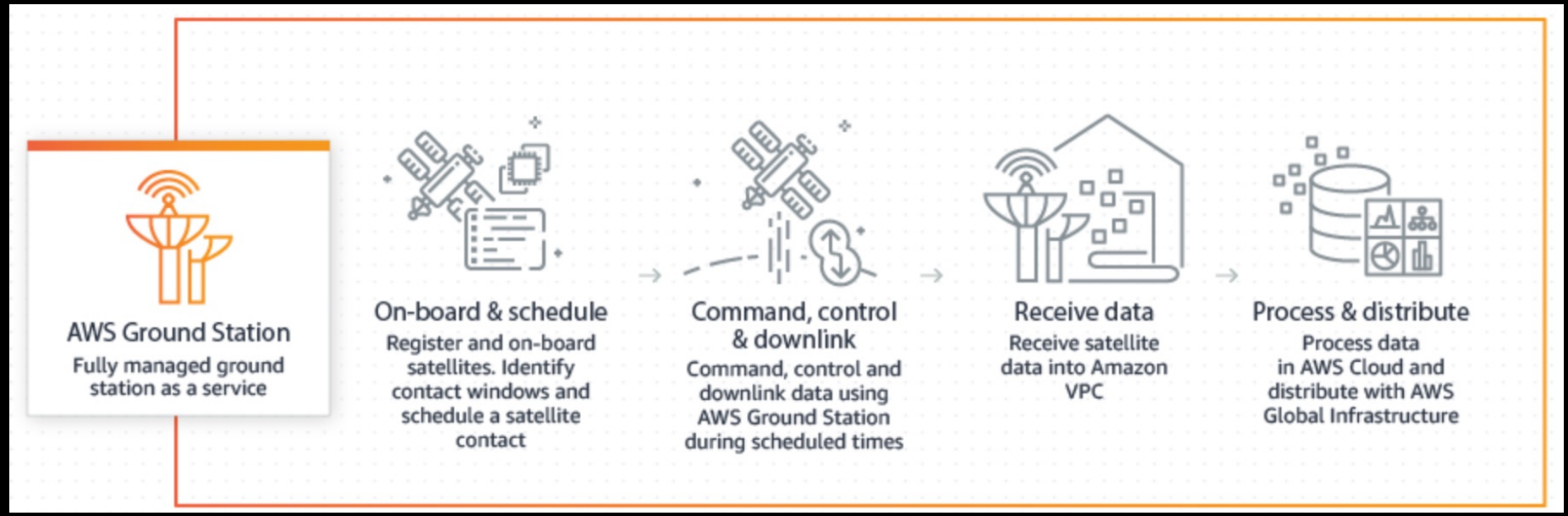
SatCORPS GEO+LEO Global Cloud

Amazon Ground Station as a Service

How GSaaS 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



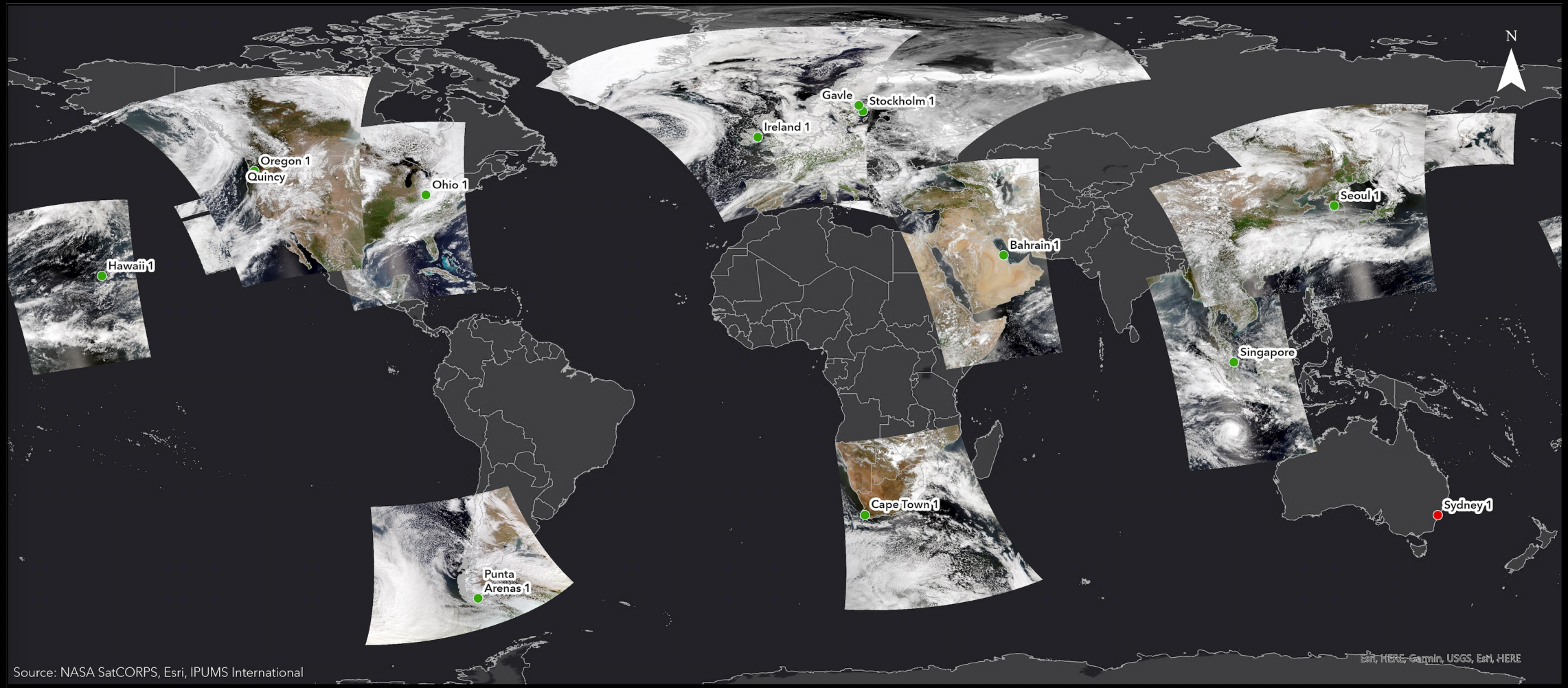


Ground Station Coverage from Amazon and Azure

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

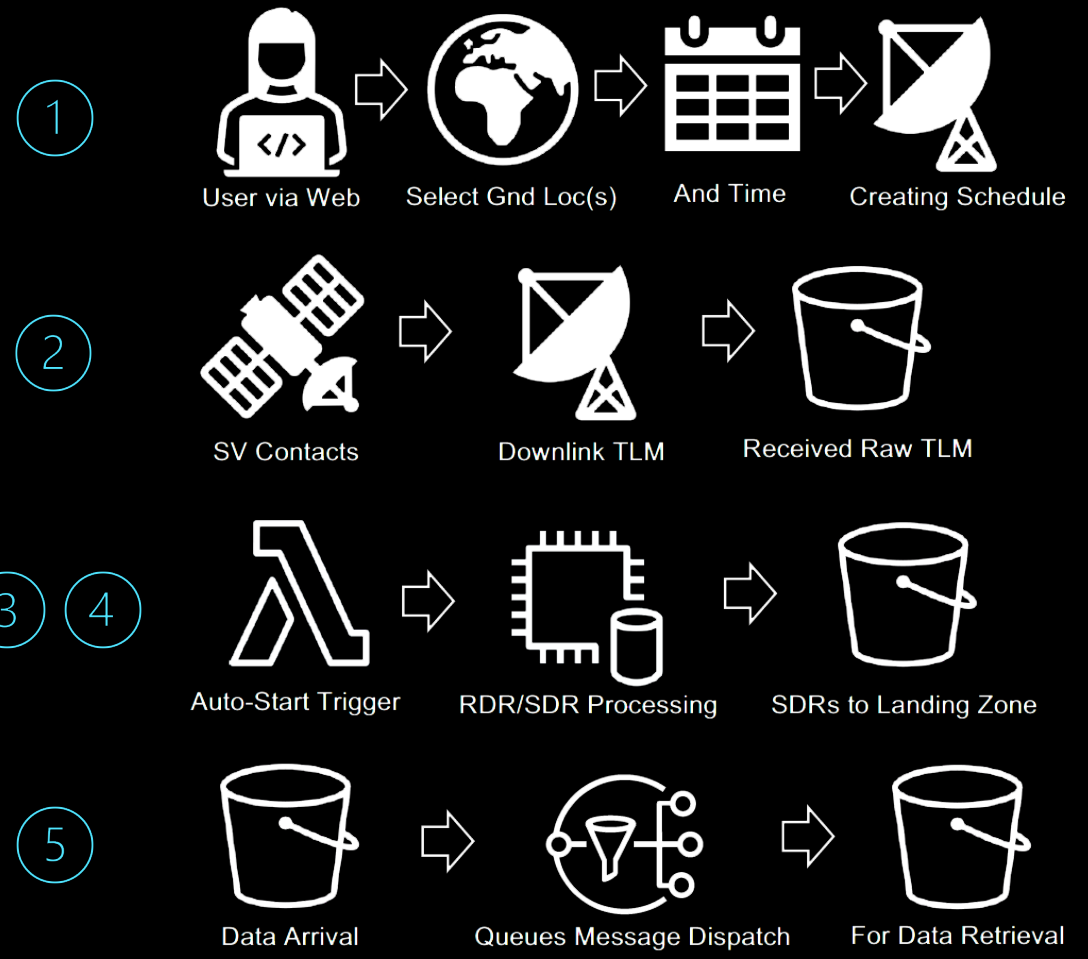
- World Boundaries
- On-Boarded Ground Station
- To Be On-Boarded Ground Station

Deployment of GSON within NASA SMCE (AWS)

Components of Ops Architecture include:

1. Web API service for User to make data requests via subscription service
2. Automated Contact Planner and Scheduler (responds to #1)
3. Raw Data from #2 is “auto-processed” to SDRs
4. SDRs are placed into Subscription Landing Zone
5. Message is dispatched to Users for data pickup

Data Driven Processing Architecture



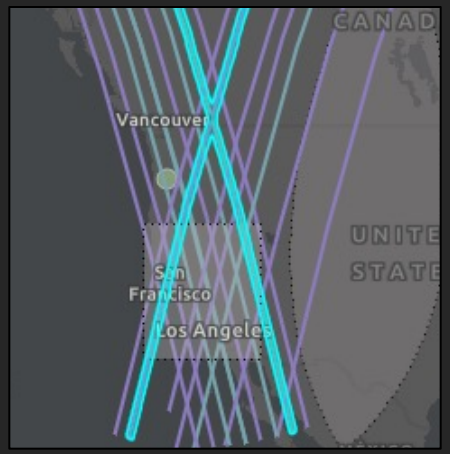
Deployable components: (1) Data-driven Contact Scheduler, (2) SV Data Capture, (3-5) Data Processing /Delivery

GSON Delivers Low Latency VIIRS for WRF-SFIRE Forecasting

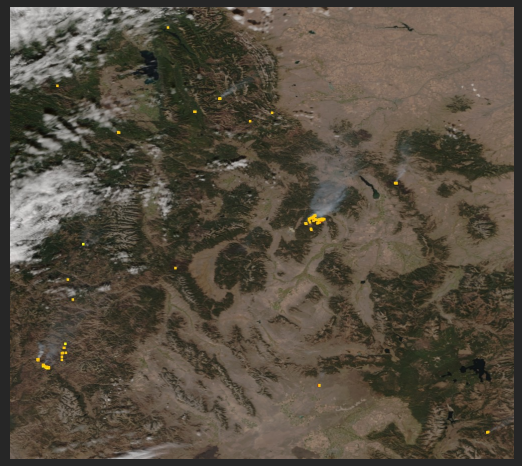
- Conducted demo on Oct 1-8, 2021; GSON delivered low latency **VIIRS Radiances and Active Fires products (<12 min)**
- The Weather Research Forecasting – Spread FIRE (WRF-SFIRE, Disasters Program) ingested the low latency VIIRS radiance and fire radiative power data to initialize fire perimeter
- WRF-SFIRE 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

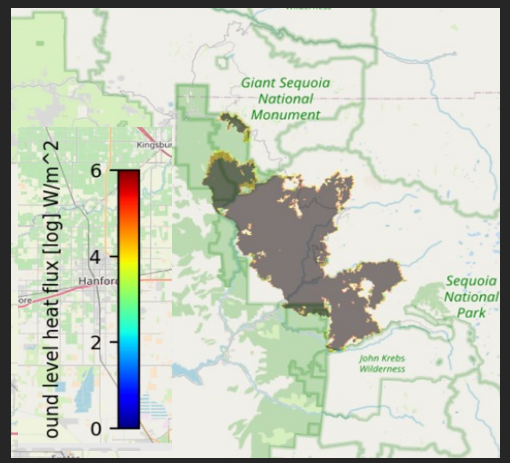
Subscription for Satellite Selection



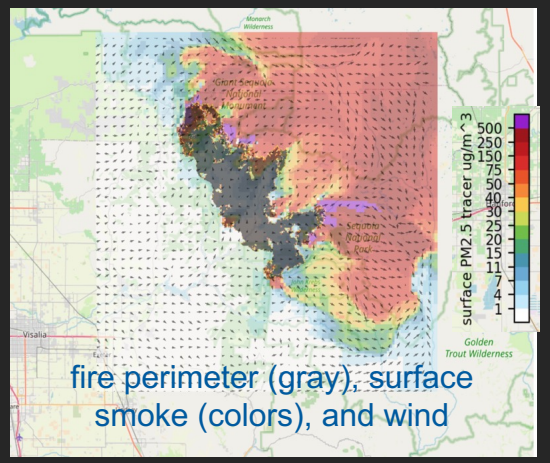
VIIRS Active Fires



Initial Fire Perimeter



WRF-SFIRE 24hr Forecast



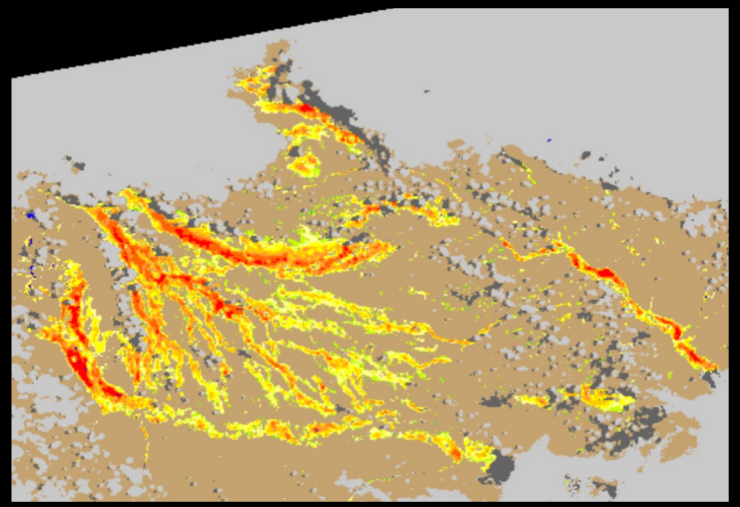
GSON project funded by ESTO NASA AIST (QRS-20) in support of New Observing Strategy Testbed (NOS-T)

GSON 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**

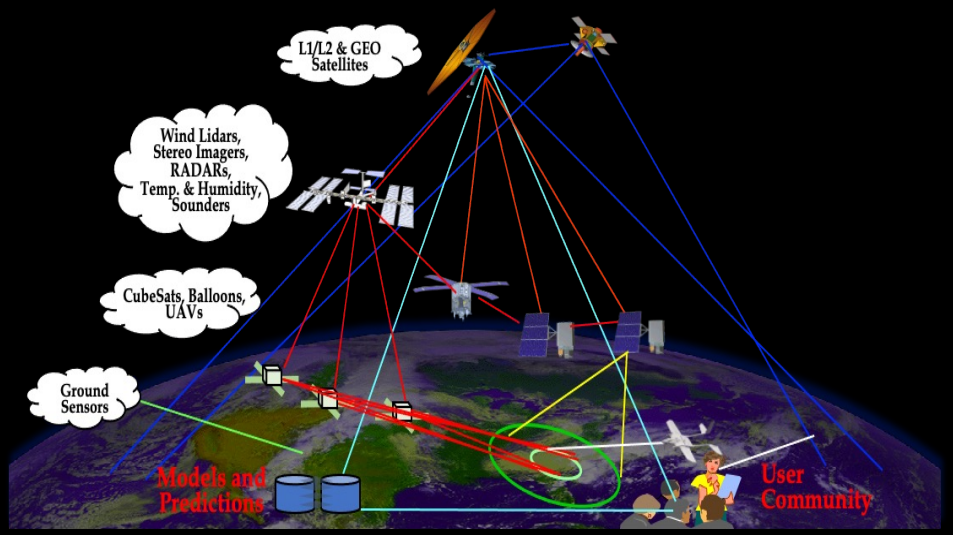
Features

- 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

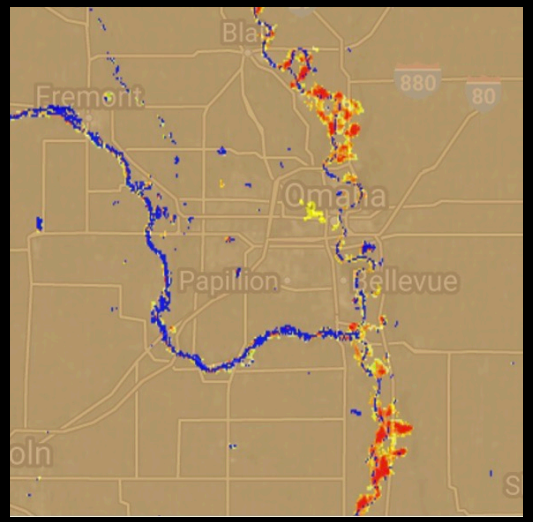


Floodwaters over South Africa derived from NPP VIIRS

NASA New Observing Strategies (NOS)



Smith, et al., 2022, IGARSS 2022



VIIRS Flood Detection Mississippi Basin

GSON Project funded by ESTO NASA AIST (QRS-20) in support of New Observing Strategy Testbed (NOS-T)

The Satellite ClOud and Radiative Property retrieval System (SatCORPS)

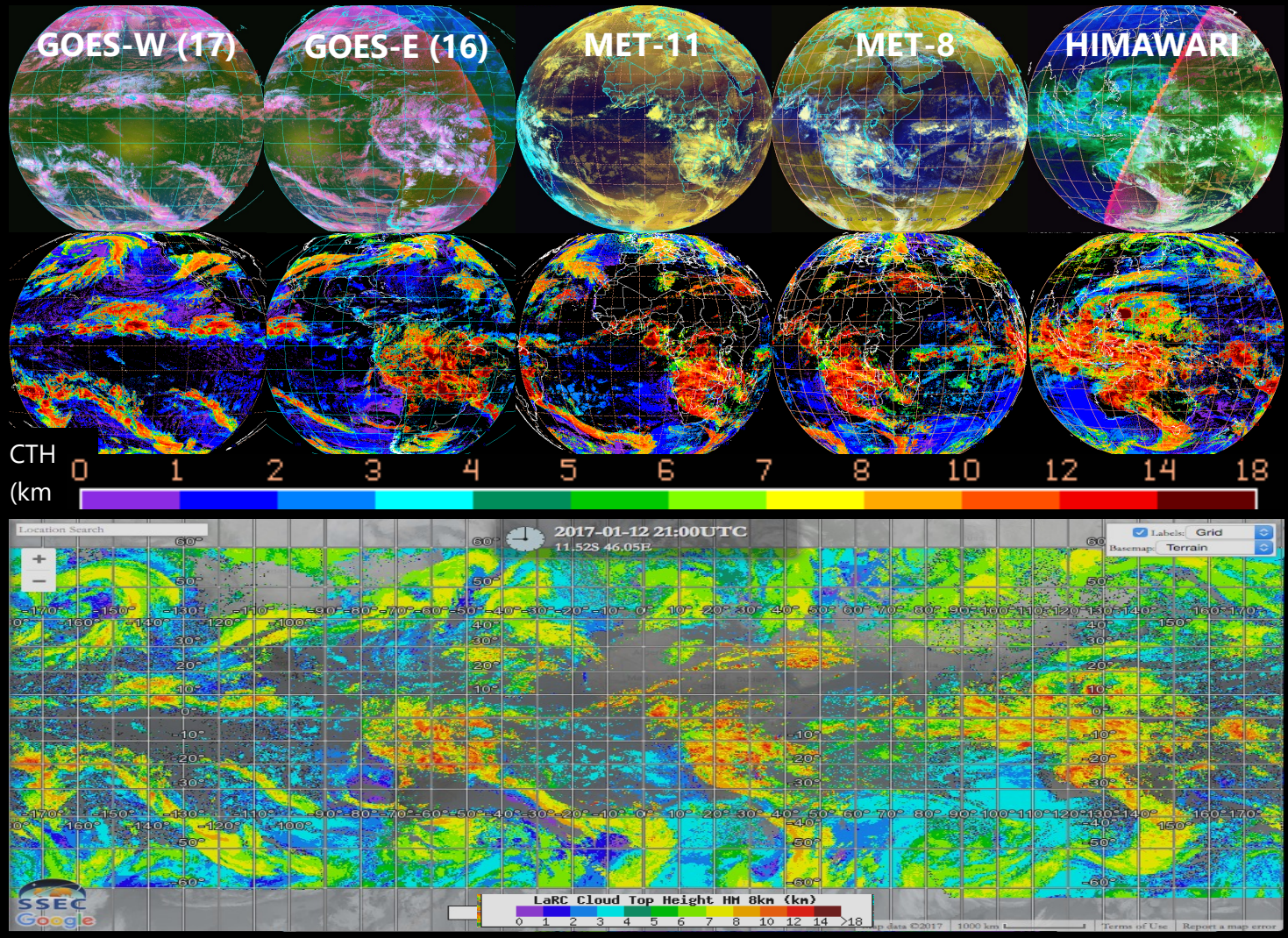
Unique SatCORPS Data Products

Traditional Standard Cloud Products

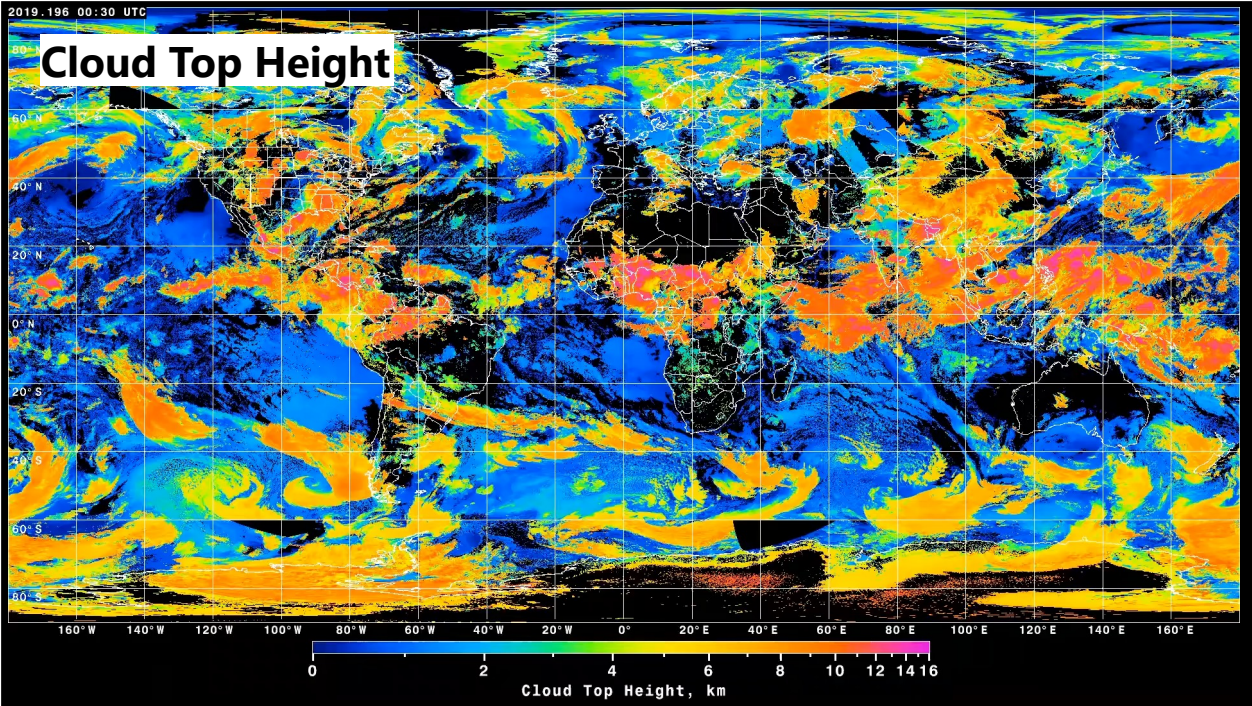
- Cloud Mask, Thermodynamic phase
- Cloud Temperature and Height
- Optical Depth, Effective Radius, Water Path
- Droplet number concentration

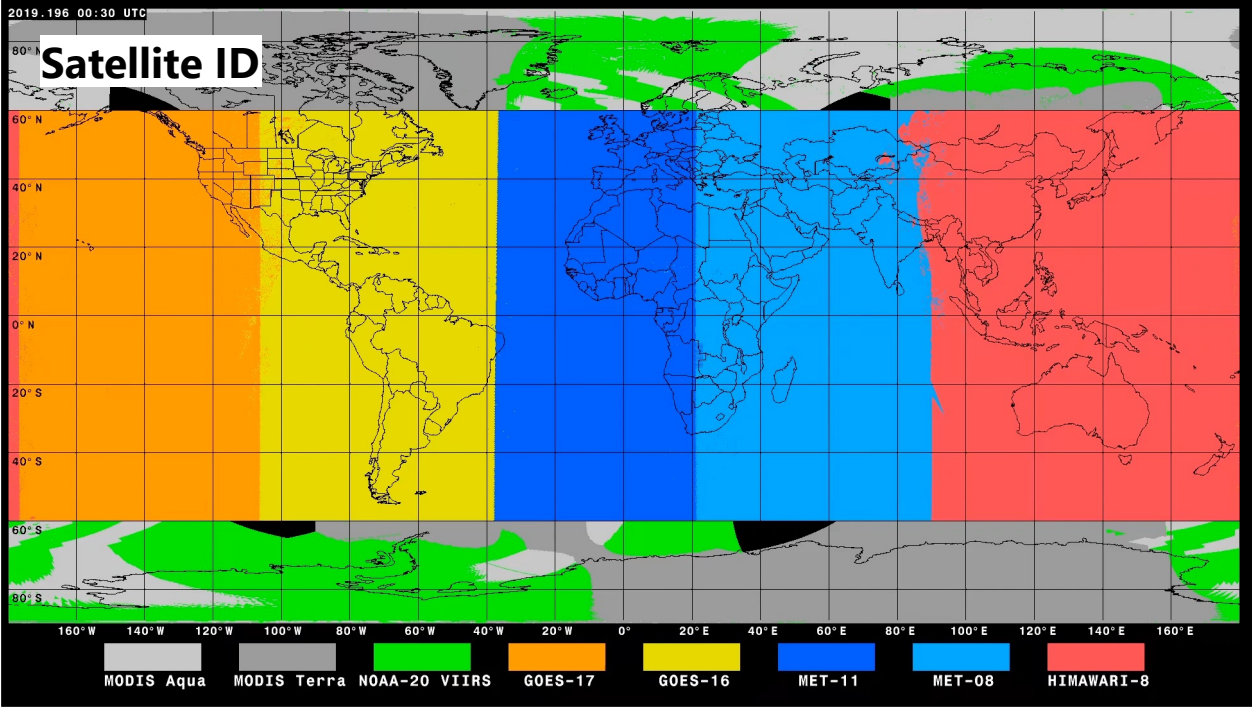
Innovative SatCORPS Data Products

- 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

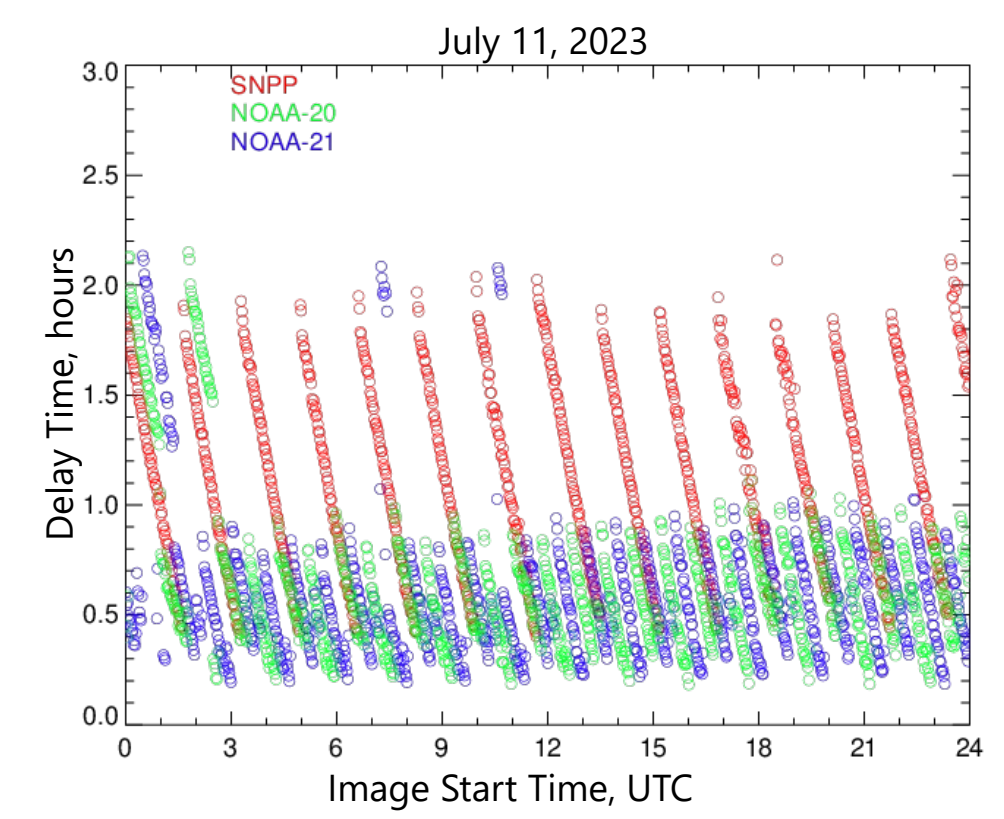
New system is intended for the broader community

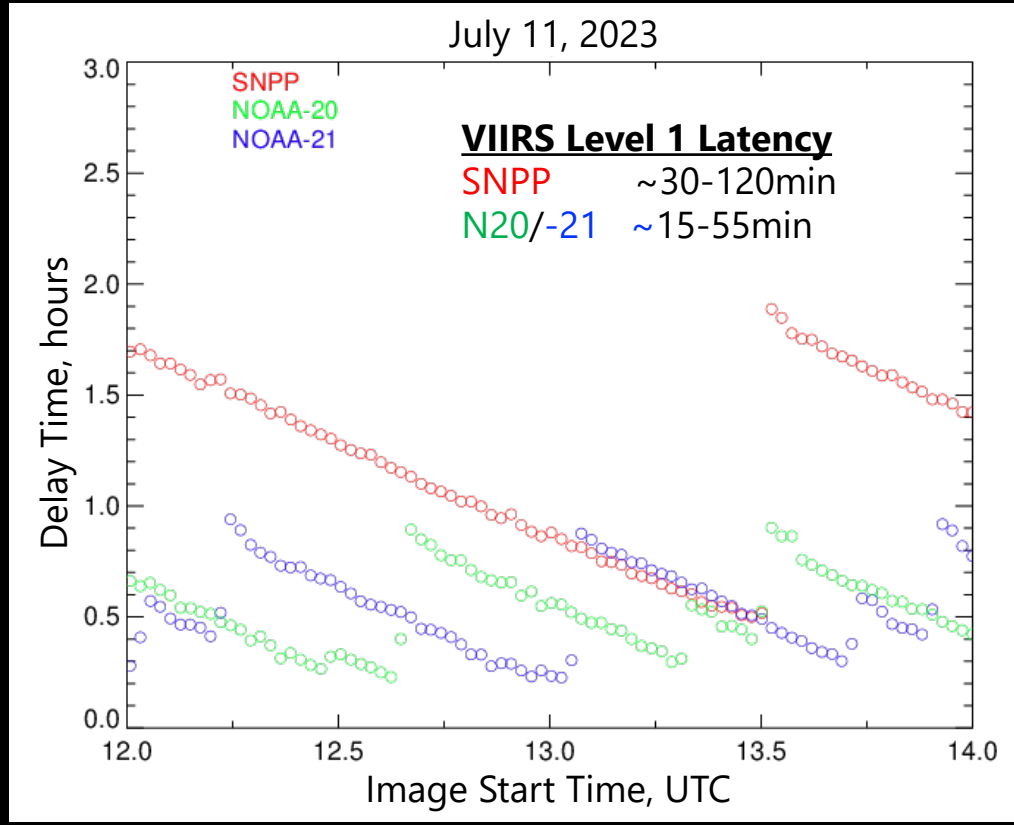
- Day & Night, 3-km grid, 30-60 minutes, cloud algorithm enhancements to improve consistency, all radiances, additional derived parameters
- First charter is to produce a multi-year, hourly dataset beginning in 2019 from the current constellation (ABI, AHI, SEVIRI, MODIS, VIIRS) targeted to serve modeling 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

Reducing Latency with Amazon Open Data Registry

- Global access to VIIRS data:
  - https://registry.opendata.aws/noaa-jpss/
- SNPP/N20/N21 VIIRS L1 Granule Latencies on S3 Buckets





Summary

- GSON flexible and scalable processing framework works with LEO and GEO data
  - Can accommodate other Science Processing Algorithms
- 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 end CY 2023

Author Contact: Louis Nguyen L.Nguyen@nasa.gov

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