Low Latency Direct Broadcast Data Products using Ground Station Observation Network (GSON) and Amazon Ground Stations

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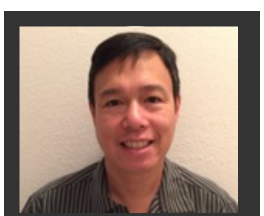
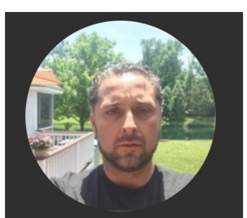
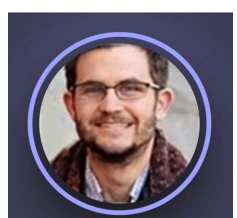
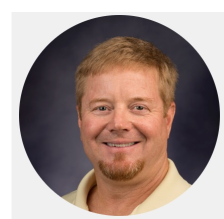
CSPP User Group Meeting

Langley SatCORPS GSON Team
Funded by NASA ESTO AIST-QRS-20









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Background: LEO Satellite Data Latency

Problem: Latencies occur at data acquisition, ground station, data transfer, data center processing and distribution (**1.5 - 3+ hrs**)

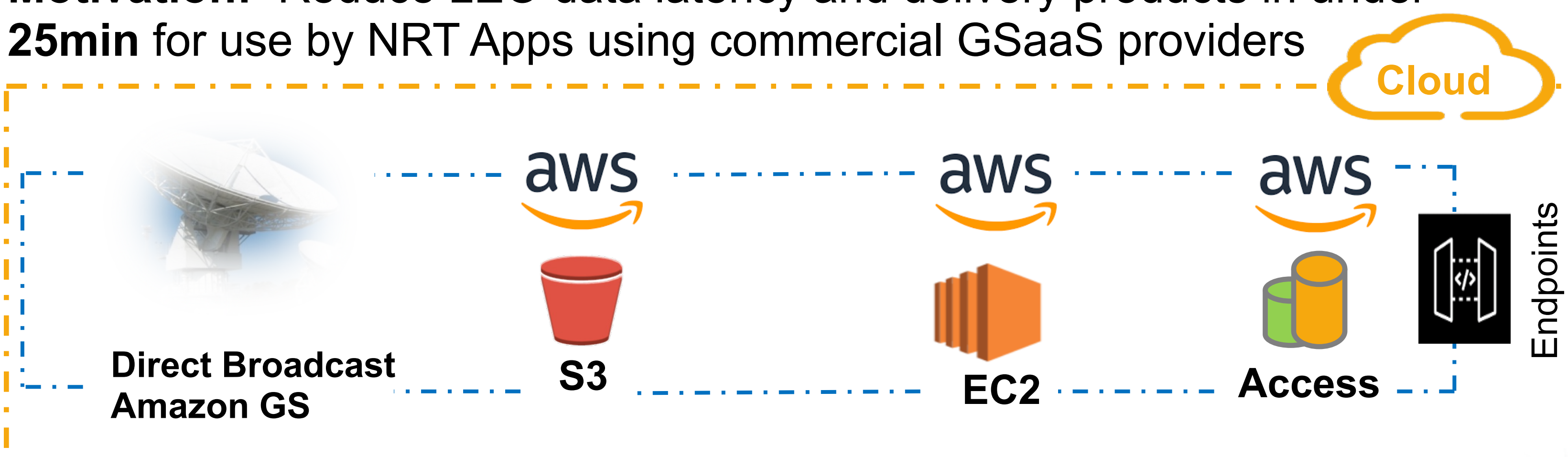
Reception at Svalbard GS

Transfer to Data Center

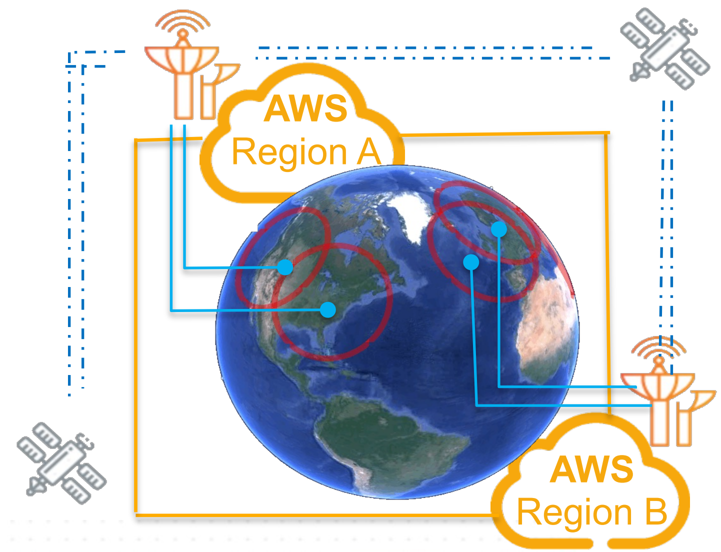
Data Center Processing

Access and Distribution

Motivation: Reduce LEO data latency and delivery products in under **25min** for use by NRT Apps using commercial GSaaS providers

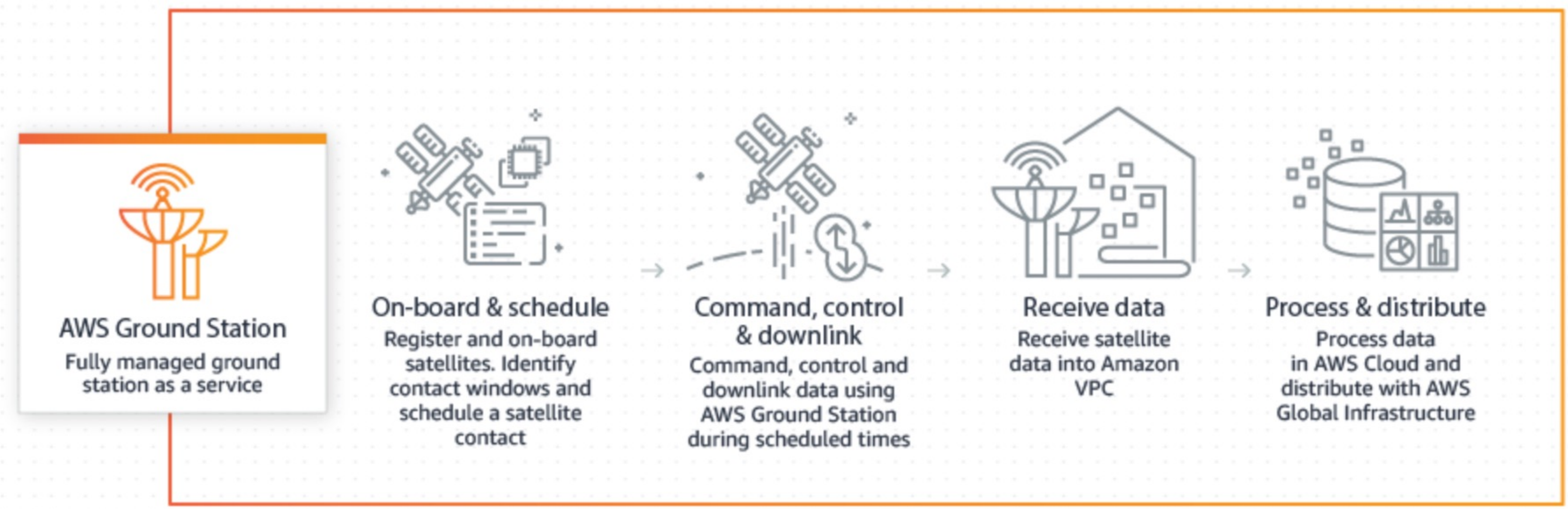


Amazon Ground Station as a Service (GSaaS)



How GSaaS works

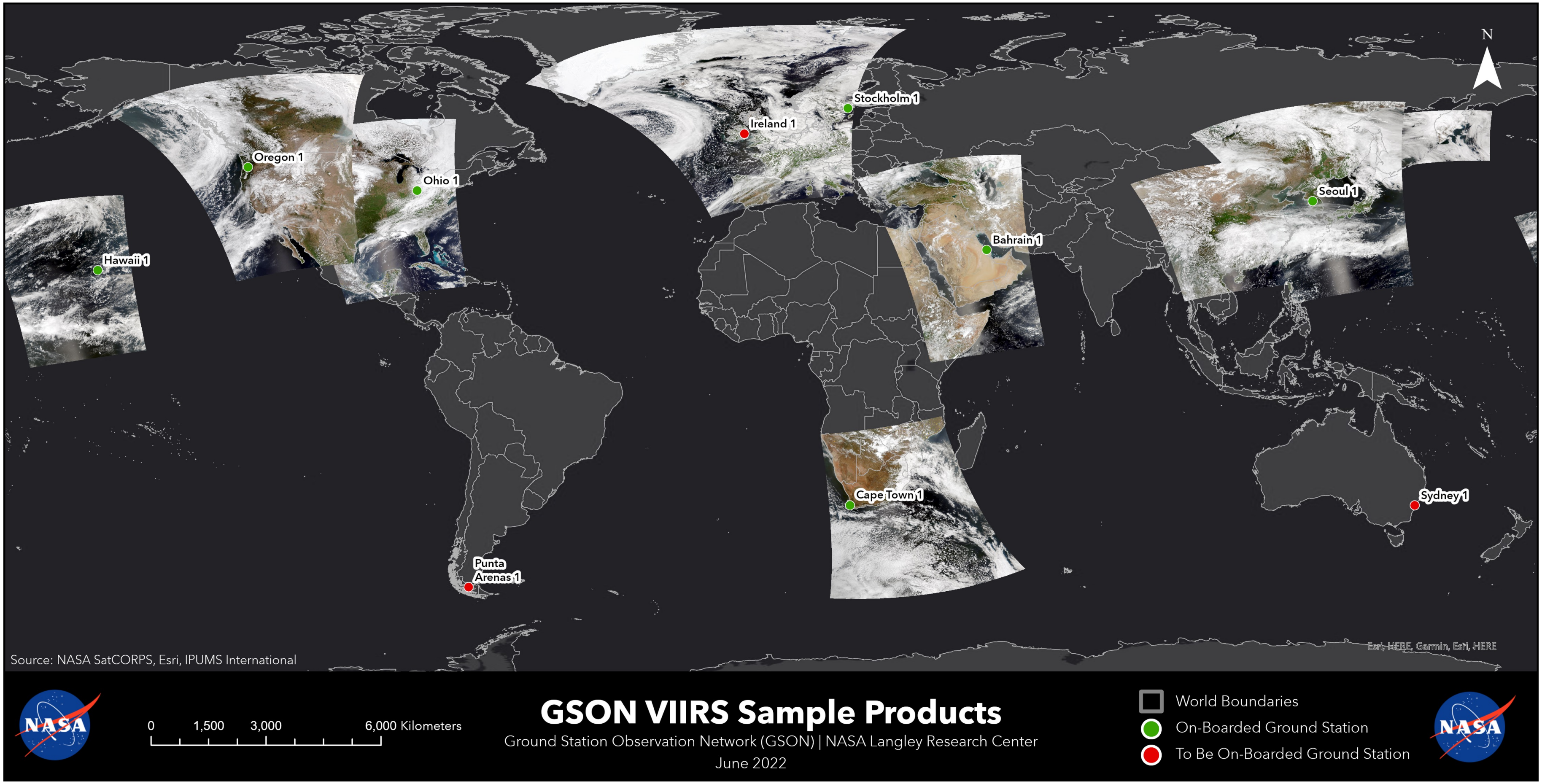
- Provides global network of ground stations
- On-boarding and Scheduling
- Downlink direct broadcast data
- Allows uplink for command and control
- DB data received by VPC instance
- Data delivered to S3 for processing and distribution



Amazon Ground Stations

Successful VIIRS DB Data Reception using GSON:
- Ohio, Oregon, Bahrain, Stockholm, Dublin, Hawaii, Cape Town, Seoul

To be On-boarded:
- Sydney, Punta Arenas

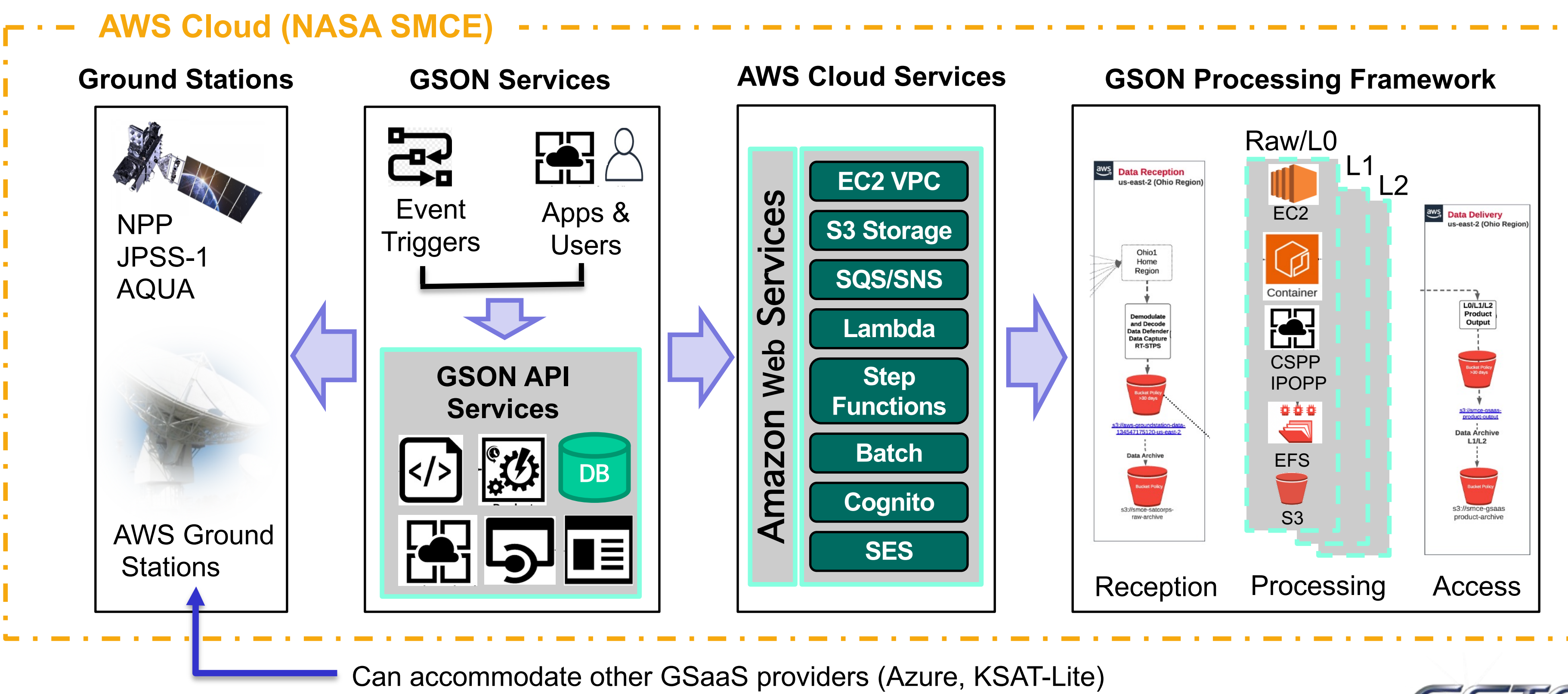


- Antennas capable of receiving X- and S- Band frequencies from LEO and MEO
- Pay as you go service, antenna use; reserved $3 per min and $10 for on-demand

GSON System Architecture

GSON Framework Components

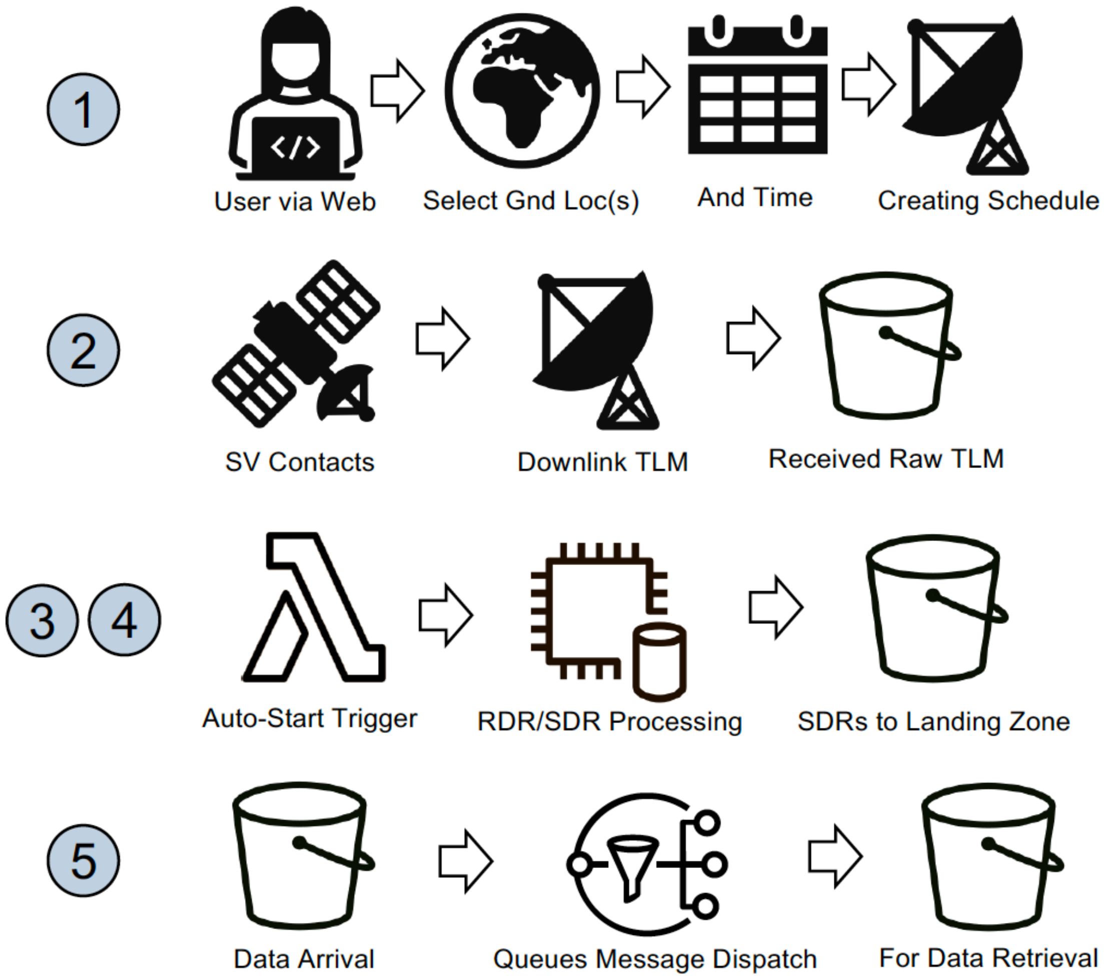
- AWS Ground Stations
- GSON API Services (planner, scheduling, tasking, job orchestration)
- Amazon Cloud and CloudWatch services
- Processing Framework & Workflows (data ingest, processing, distribution)



GSON Services: Data Driven Processing

Components of Ops Architecture include:

1. Web API service for User to make data requests
2. Automated Contact 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



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

Slide credit: Stew Sutton, Aerospace Corporation

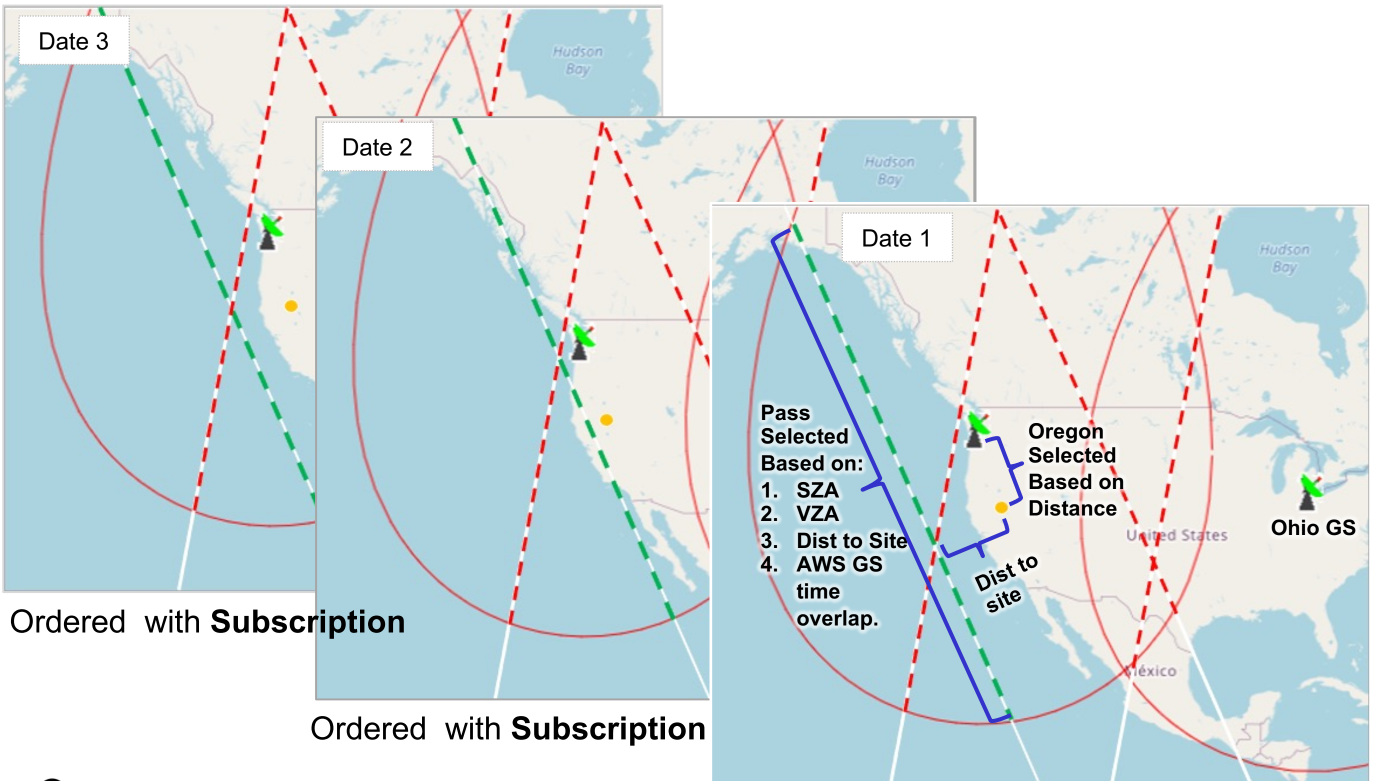
ESTO Earth Science Technology Office

GSON API Services

Planner and Scheduling Services (tasks/job orchestration)

Multiple Date Request for ‘All Dates’ and ‘Subscription’

Visual representation of API Single Point Capabilities



Ordered with **Subscription**

Ordered with **Subscription**

Ordered when **Submitted**

Request Components

- Location
- Date Range
- Satellite/Instrument
- Pass Criteria
- Product Package
- Subscription *(Optional)*

Authenticated

GeoJSON Enabled

Pass Reserved — Pass Not Reserved — AWS GS Coverage — AWS GS Locations — User Location

GSON API Services

Planner and Scheduling Services (tasks/job orchestration)

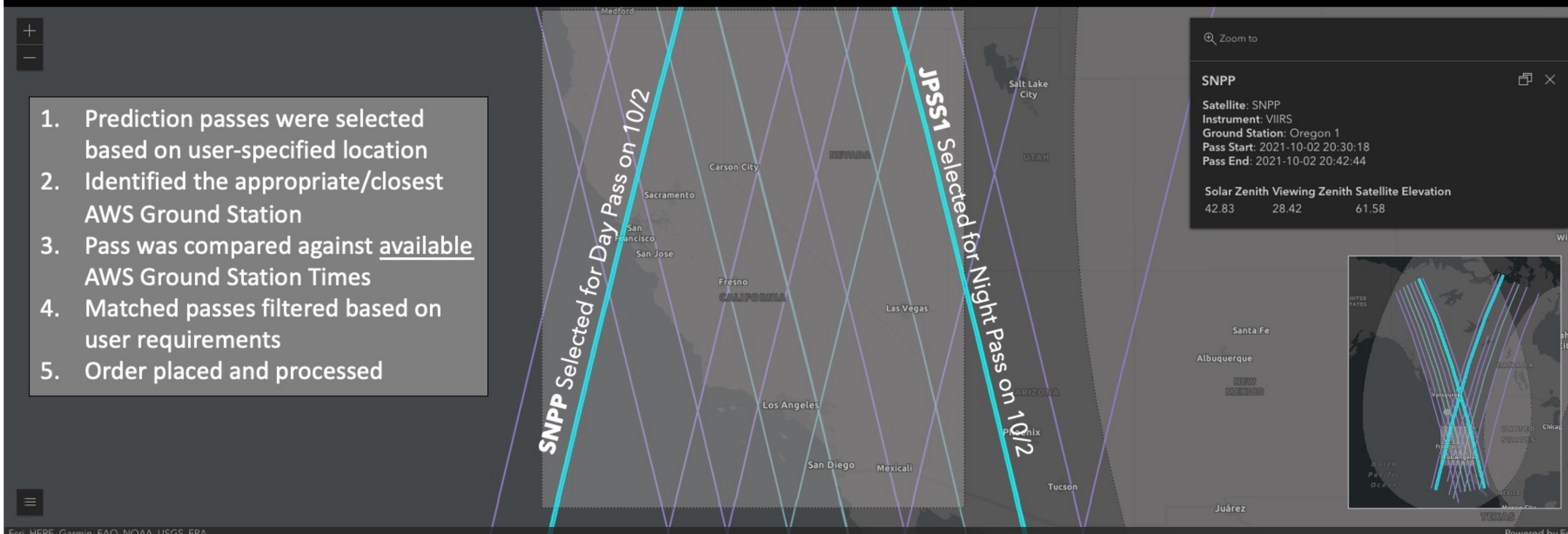
Visual representation of API **Bounding Box** Capabilities

DAY Passes (SZA: 0-90)

Satellite	Predicted Start	Predicted End	Solar Zenith	Viewing Zenith	Distance To Site	Elevation
JPSS1	10/2/21 19:33	10/2/21 19:53	41.08	68.05	1438.98	21.95
SNPP	10/2/21 20:28	10/2/21 20:43	42.83	28.42	392.45	61.58

NIGHT Passes (SZA: 90 – 180)

Satellite	Predicted Start	Predicted End	Solar Zenith	Viewing Zenith	Distance To Site	Elevation
SNPP	10/2/21 9:02	10/2/21 9:22	140.62	45.65	714.13	44.35
JPSS1	10/2/21 9:52	10/2/21 10:12	133.65	27.96	385.14	62.04
SNPP	10/2/21 10:42	10/2/21 11:02	125.1	67.93	1433.08	22.07



Available Passes (Features: 16, Selected: 2)

Satellite	Instrument	Station	Start	End	SZA	VZA	Distance to Site
SNPP	VIIRS	Oregon 1	2021-10-01 20:49:03	2021-10-01 21:01:33	43.85	1.16	14.97
SNPP	VIIRS	Oregon 1	2021-10-01 20:49:03	2021-10-01 21:01:33	43.87	1.19	15.29
JPSS1	VIIRS	Oregon 1	2021-10-02 09:53:33	2021-10-02 10:06:17	133.65	27.96	385.14
SNPP	VIIRS	Oregon 1	2021-10-02 20:30:18	2021-10-02 20:42:44	42.83	28.42	392.45
JPSS1	VIIRS	Oregon 1	2021-10-03 09:34:46	2021-10-03 09:47:41	136.77	1.66	21.31

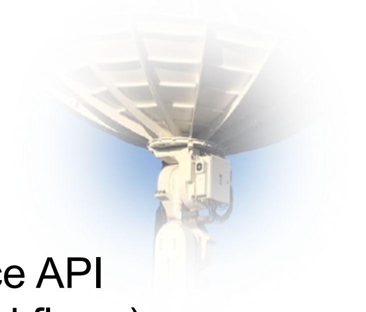
GSON Capabilities

What can GSON capabilities provide?

- Support AIST New Observing Strategies (NOS) testbed demonstrations as a Satellite Ground Station Node
- Ad-hoc usage to respond to events or natural disasters such as fires and flooding'
- Can be use routinely to monitor over a Site or Domain where low latency LEO data and products are needed; w/o owning/operating antenna
- Support Field Campaigns that require near real-time LEO data
- Subscription service via GSON API

Ground Station Observation Network (GSON) : Prototype for NOS-T Flood Demonstration

Funded by NASA ESTO Advanced Information Systems Technology (AIST-QRS-20)

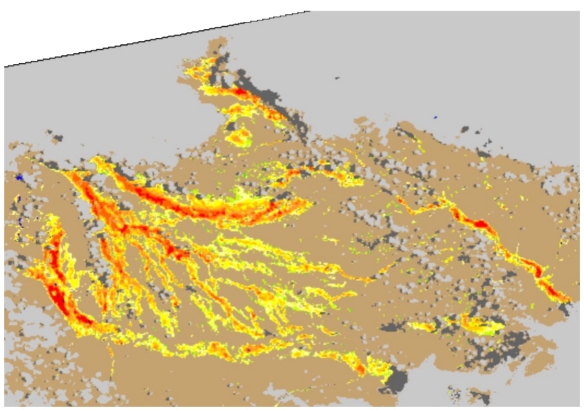


GSON Goals:

- **Support New Observing Strategies Testbed (NOS-T) flood demo**
- **Reduce latency; Delivery of products (L0-L3) < ~25min**

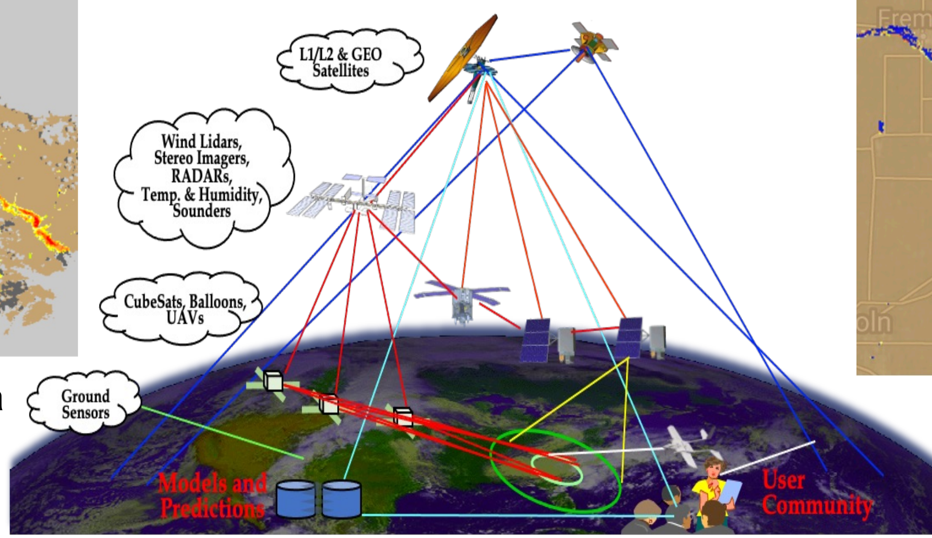
Features:

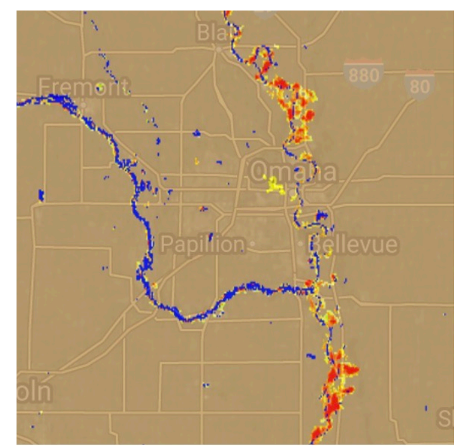
- Functional NOS-T Node, triggered by events, user/app via GSON Service API
- Automated scheduling and job orchestration (reception & processing workflows)
- Distribution via S3, HTTPS, and ARC-GIS portal endpoints



Floodwaters over South Africa derived from NPP VIIRS

New Observing Strategies (NOS)





VIIRS Flood Detection Mississippi Basin

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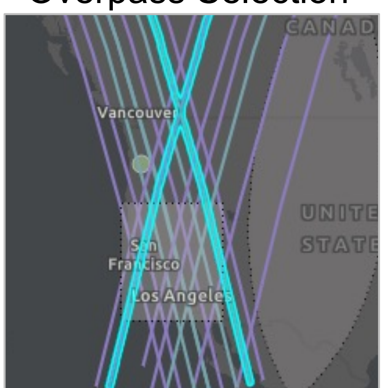
Low Latency VIIRS for WRF-SFIRE Forecasting Demo using Ground Station Observation Network (GSON)

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

- Conducted proof-of-concept demonstration on Oct 1-8, 2021; GSON delivered low latency VIIRS Active Fires products (<12 min) covering a defined bounding box
- The Weather Research Forecasting – Spread FIRE (WRF-SFIRE, Disasters Program) ingested the low latency VIIRS data to initialize fire perimeter of the KNP Fire
- WRF-SFIRE produced 48 hr forecast of fuel moisture, fires spread, and smoke at 9 & 21z; equivalent to operational forecast at 12 and 0z, however produced 3 hours sooner
- Results were qualitatively similar; hence low latency data can successfully be assimilated in WRF-SFIRE; Improvement/accuracy comparison will be conducted

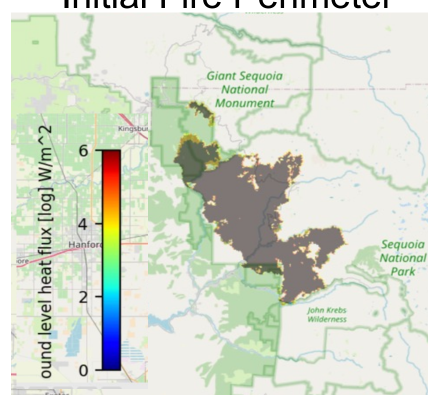
Oct 4, 2021 WRF-SFIRE 24hr Forecast using GSON Low Latency VIIRS Active Fires

Overpass Selection

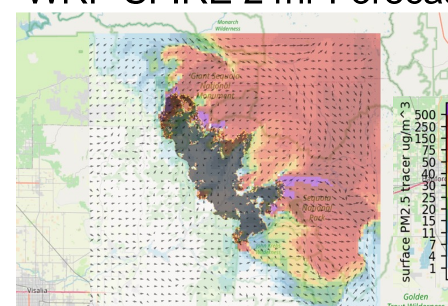


VIIRS Active Fires

Initial Fire Perimeter



WRF-SFIRE 24hr Forecast



fire perimeter (gray), surface smoke (colors), and wind

PI: Louis Nguyen, NASA Langley, SatCORPS **Co-Is:** A. Vakhnin, T. Chee, J. Barnett, W.L. Smith Jr.

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Cost, Reliability, and Availability

Computing Cost:
- EC2, S3, EBS cost is minimal ~$300-500/month with light usage
- Routine usage ~$1-2K/month depending on processing of L2, L3

Antenna Cost:
- $3 per min (reserved plan)
- Coverage over ground site (1 satellite, 2 passes/day): ~$26K / yr

Ground Stations:
- Currently 10 operational GS with additional GS in roadmap
- Can reserve satellite contacts 5 days out
- Contacts can be reserved minimum of 10-30 minutes before satellite flyover
- Very reliable over 2 years of usage; seen only 1 downtime due to bug in software upgrade

Summary and Future Plans

- Designed and deployed GSON on Amazon to receive Direct Broadcast and process and delivery low latency products
- Captured DB from AQUA, NOAA-20, & NPP (MODIS/VIIRS); process and deliver L0->L3 (using DRL and CSPP) in under 25mins for flood and ~12min for Fires
- GSON is also a Processing Framework and is scalable to accommodate additional satellites, instruments, workflows, and science algorithms
- System well suited for ad-hoc use as demonstrated with the Active Fires and Flooding use case scenarios
- Future: Expand beyond Amazon Ground Station for global coverage
  - Azure Orbital by Microsoft or KSATlite
- Future collaborations
  - NASA LANCE; goal is to produce parallel LANCE low latency data stream on the Cloud and conduct fires/flood demo usage with users
  - NASA Langley POWER Solar project
  - DOD Air Force/Space Force
  - Work with NASA ASP to provide Subscription service to support Wildfires
  - Actively looking for collaborators to share/adopt GSON technology

Thank You!

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