EOSDIS
NASA'S EARTH OBSERVING SYSTEM
DATA AND INFORMATION SYSTEM

# FOSS4G NA 2018:
# How NASA is Building a Petabyte Scale Geospatial Archive in the Cloud

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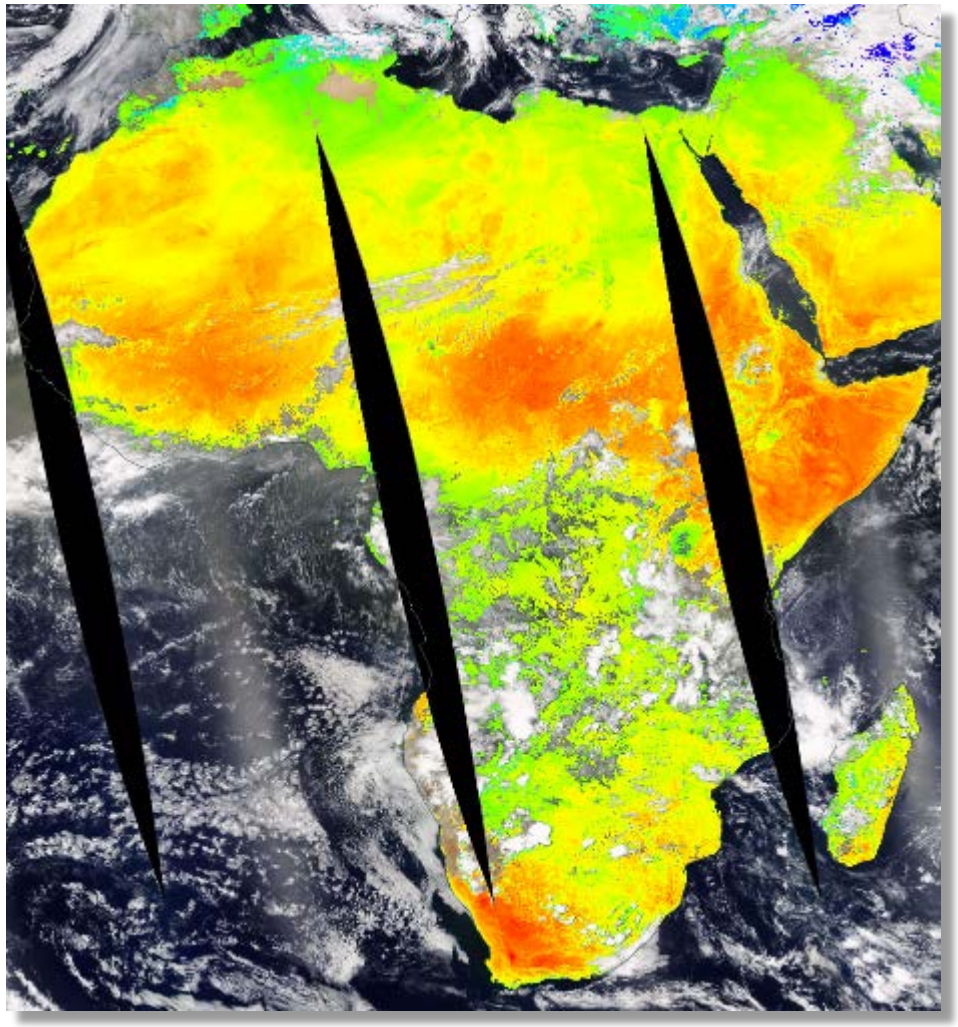
# NASA's Earth Science Data Systems Program

- Actively manages NASA's Earth science data as a national asset (satellite, airborne, and field)
- Develops capabilities optimized to support rigorous science investigations
- Processes (and reprocesses) instrument data to create high quality long-term earth science data records.

Single largest repository of Earth Science Data, integrating **multivariate/heterogeneous** data from diverse observational platforms.



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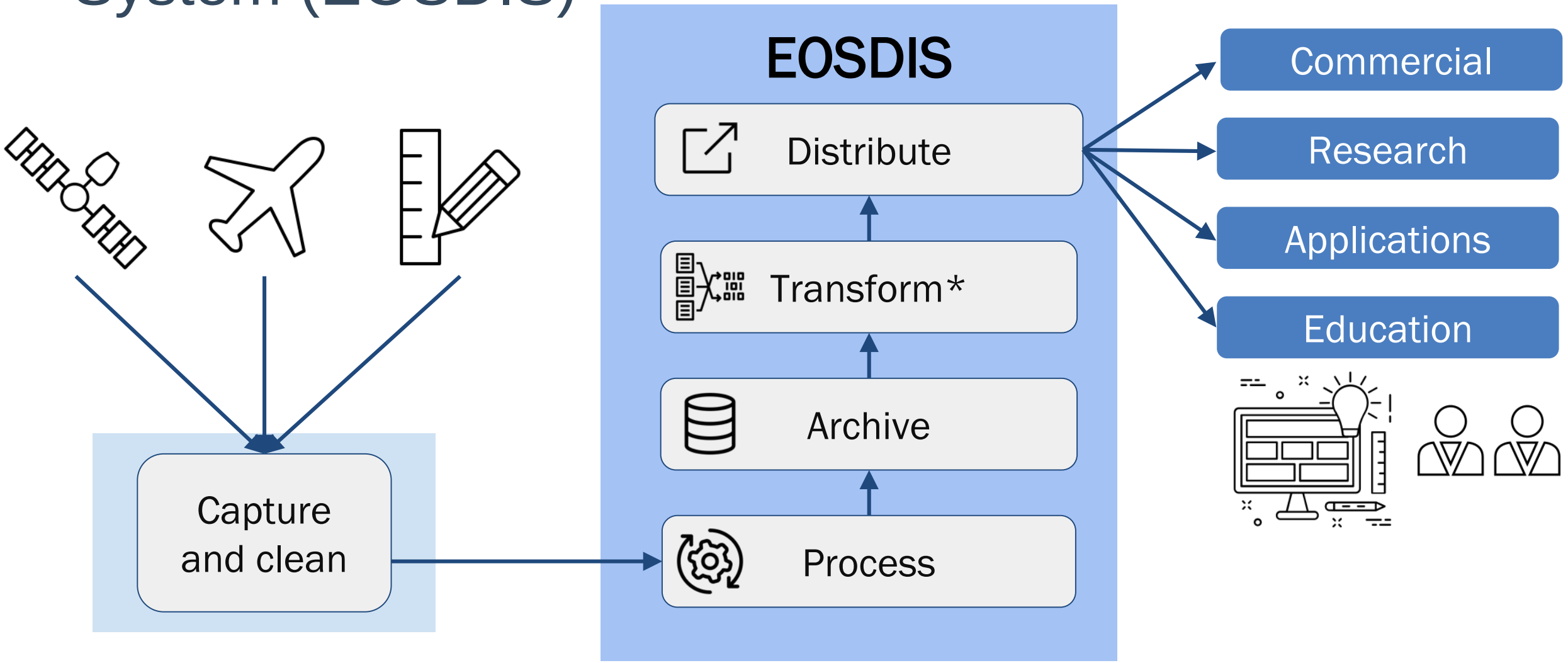
http://go.nasa.gov/2mMd5g1

# Earth science open data policy

- NASA’s Earth Observation data is collected continuously. For over half a century these invaluable records of Earth processes have provided a critical resource for scientists and researchers.

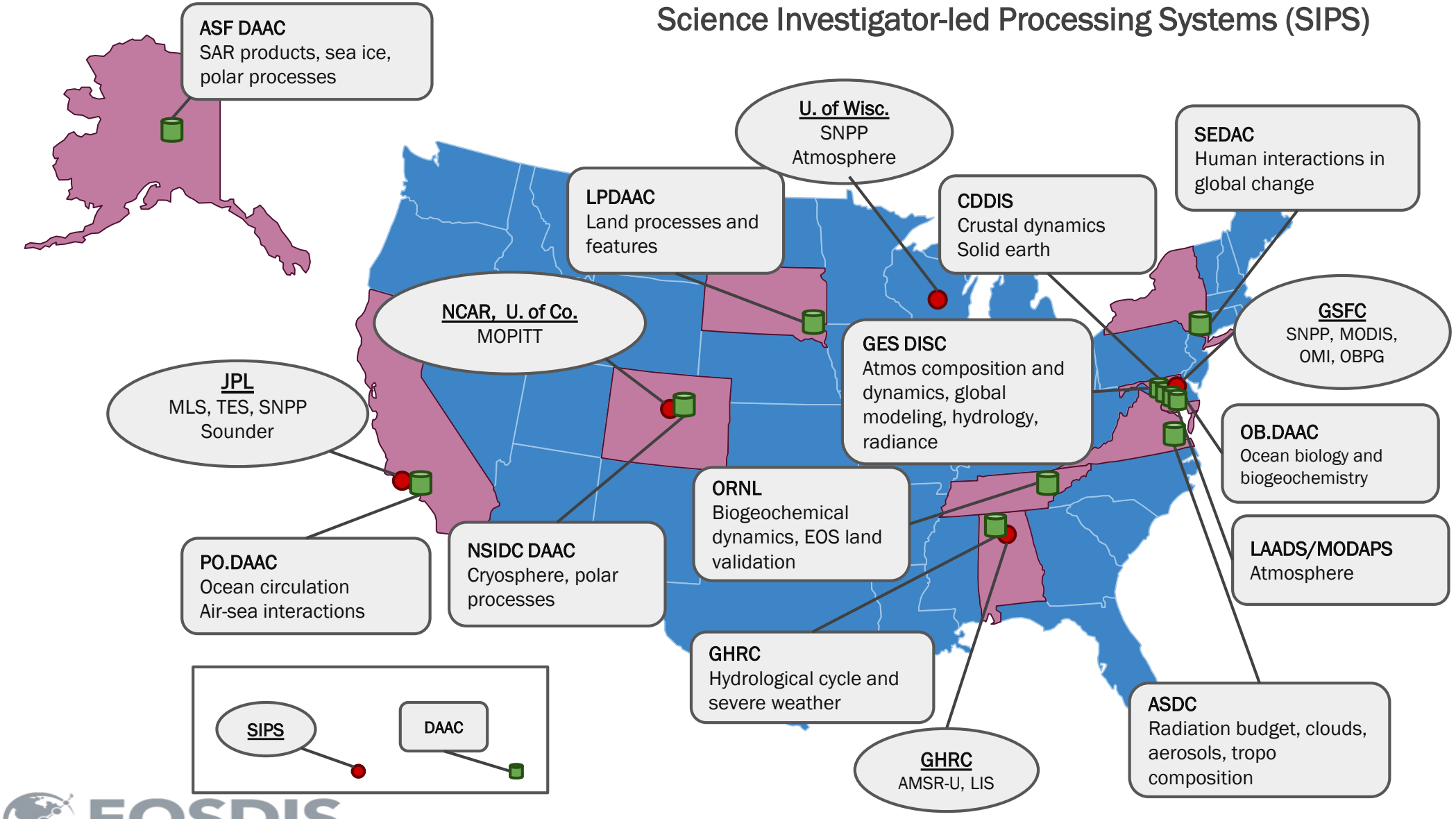
- Since 1994 NASA Earth science data have been free and open to all users for any purpose as quickly as practical after instrument checkout and calibration.

# Earth Observing System Data and Information System (EOSDIS)




*Subset, reformat, reproject

# Distributed Active Archive Centers (DAACs), collocated with centers of science discipline expertise, archive and distribute standard data products produced by Science Investigator-led Processing Systems (SIPS)

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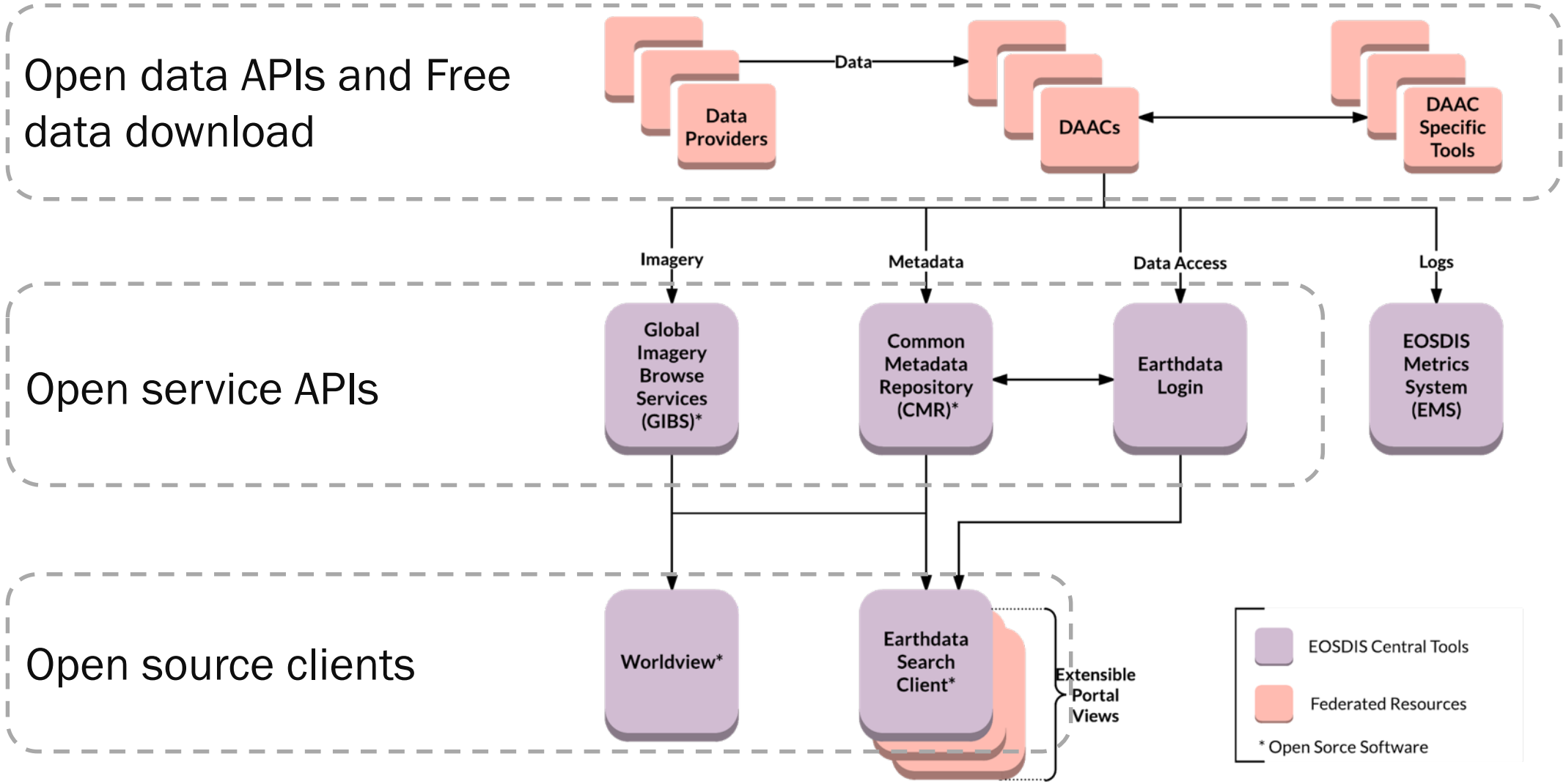
# EOSDIS core services

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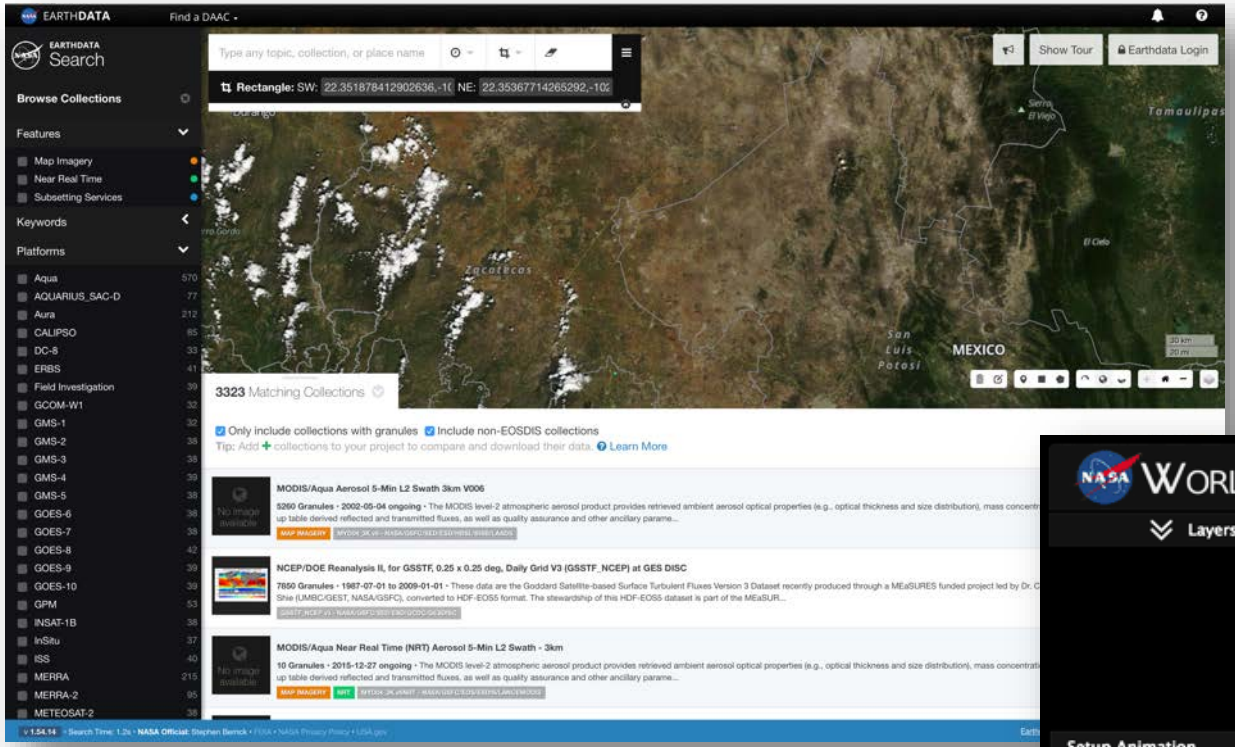
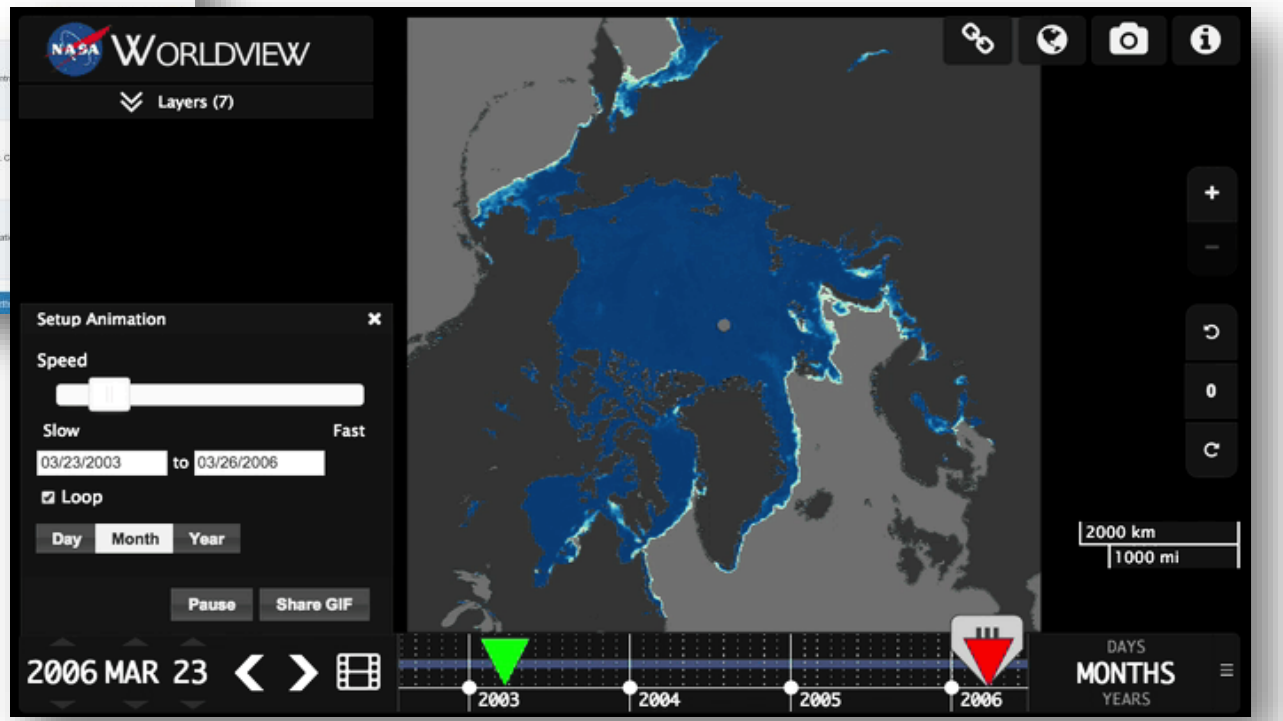



Data-centric users
https://search.earthdata.nasa.gov




Imagery-centric users
https://worldview.earthdata.nasa.gov

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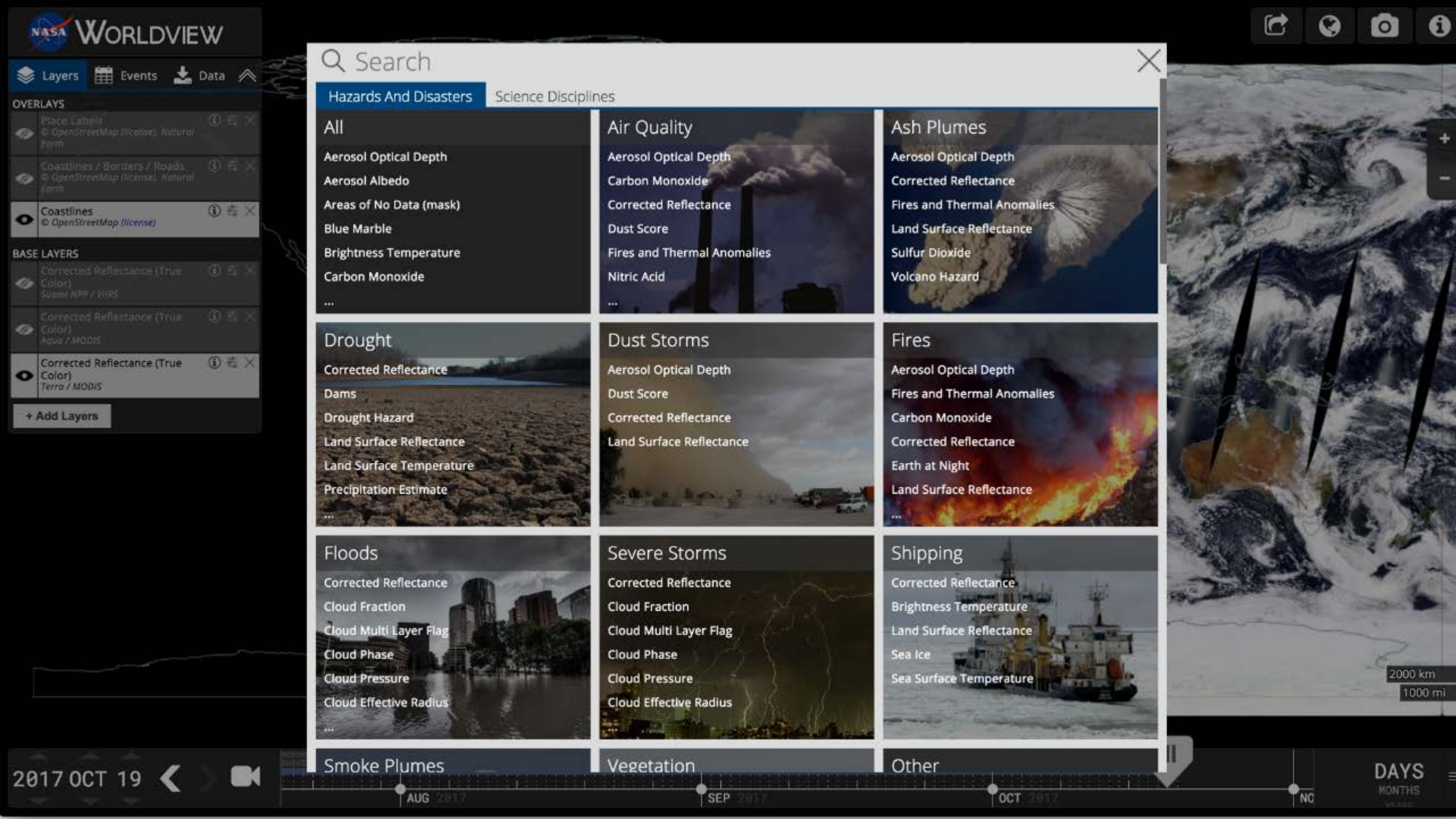
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Air Quality
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Fires and Thermal Anomalies
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Ash Plumes
Aerosol Optical Depth
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Sulfur Dioxide
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Cloud Fraction
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Cloud Effective Radius
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Severe Storms
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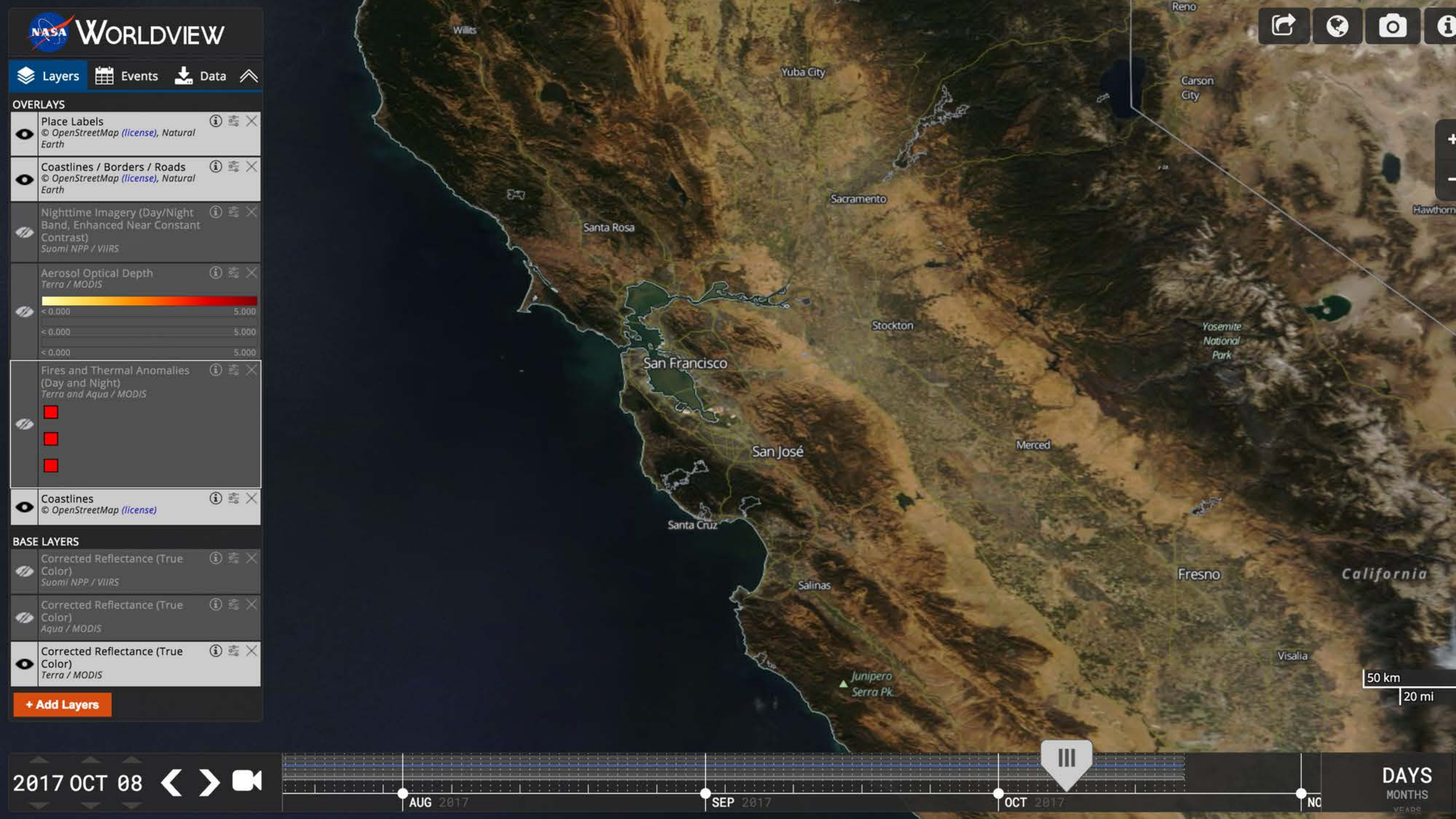
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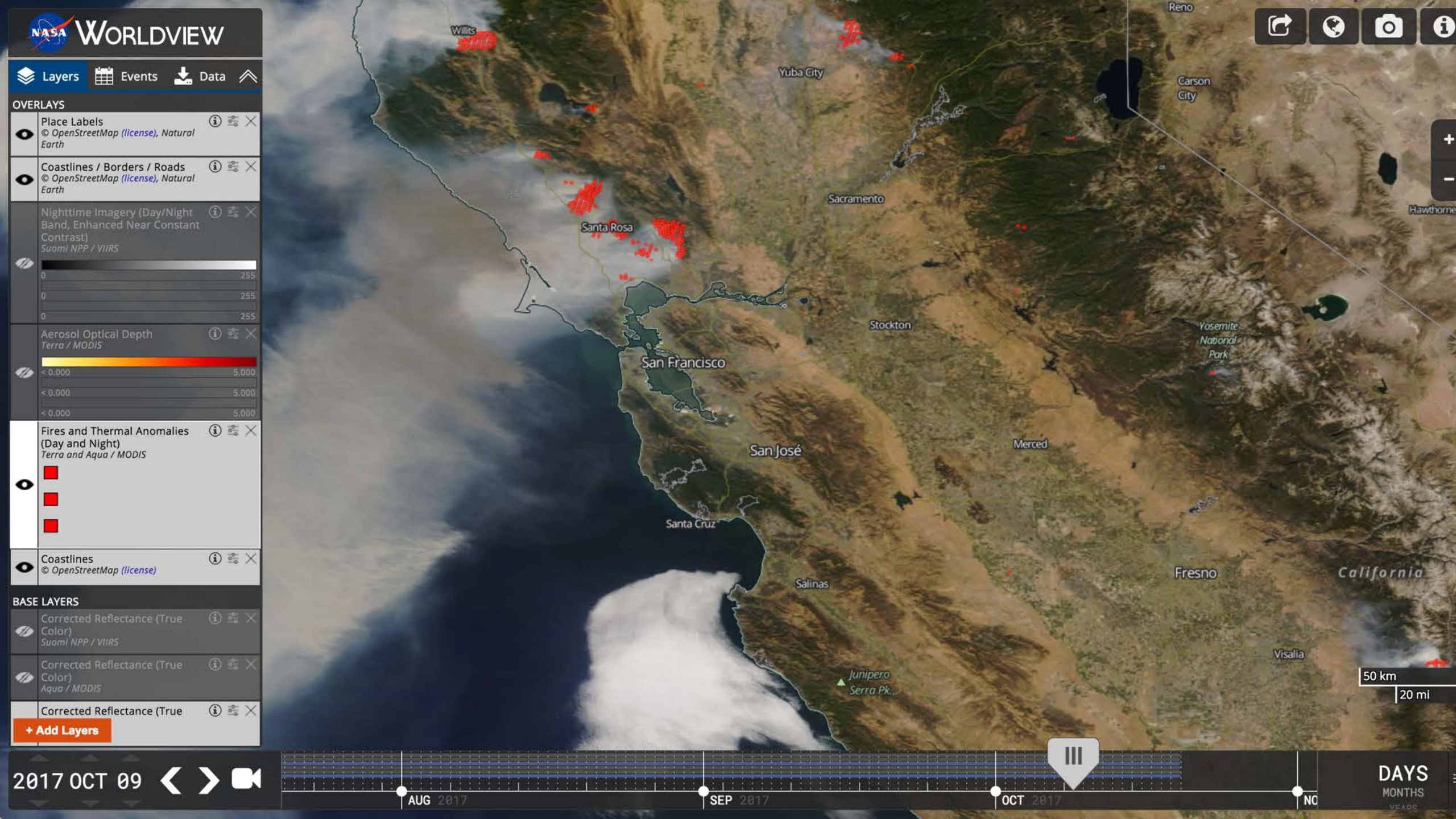
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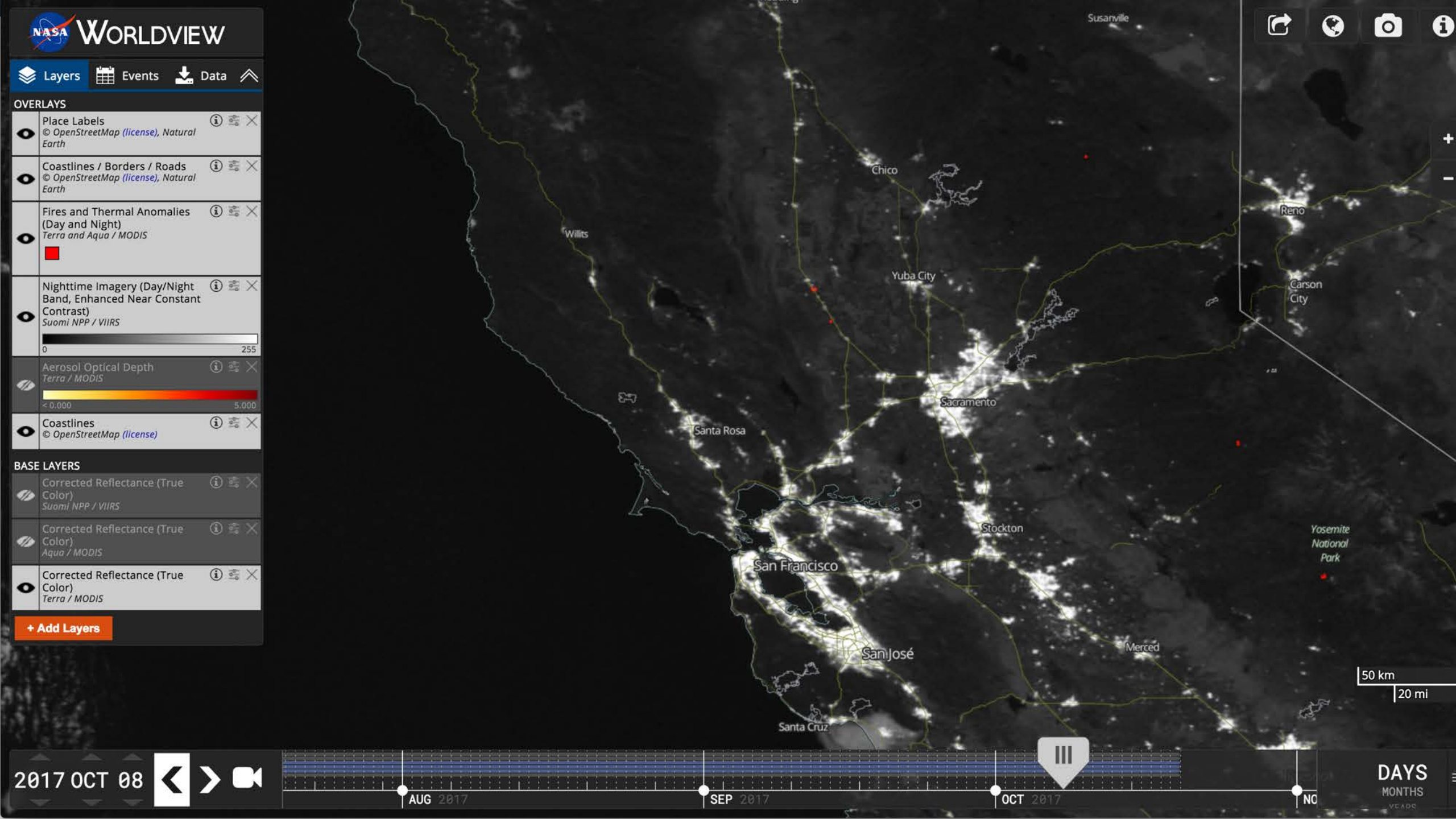
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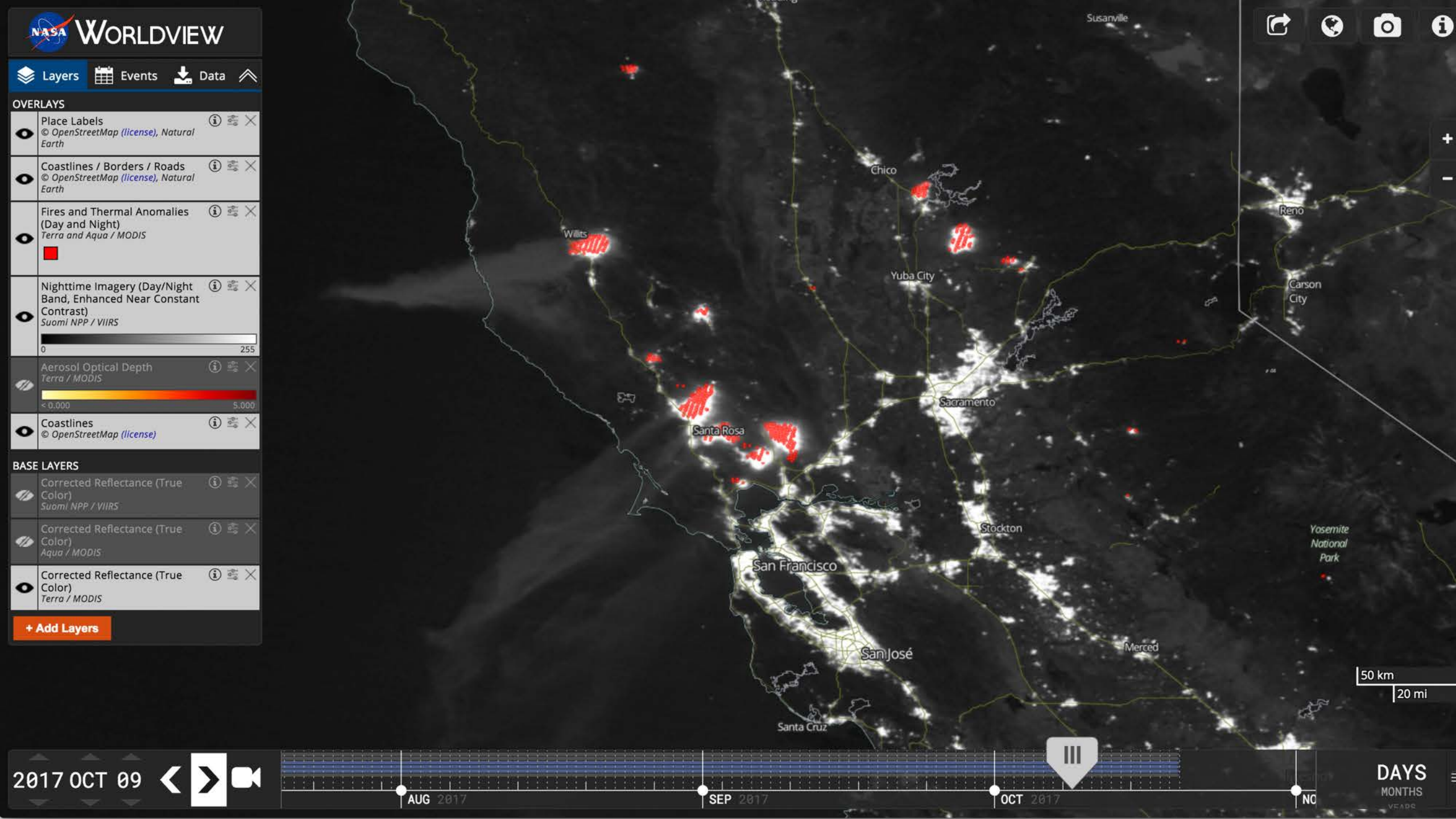
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# Preparing for the future

# 5 Years from Today

New instruments and missions.

2017 NRC Decadal Survey - **Earth Science** and Applications from Space: National Imperatives for the Next Decade and Beyond

User expectations continue to evolve.

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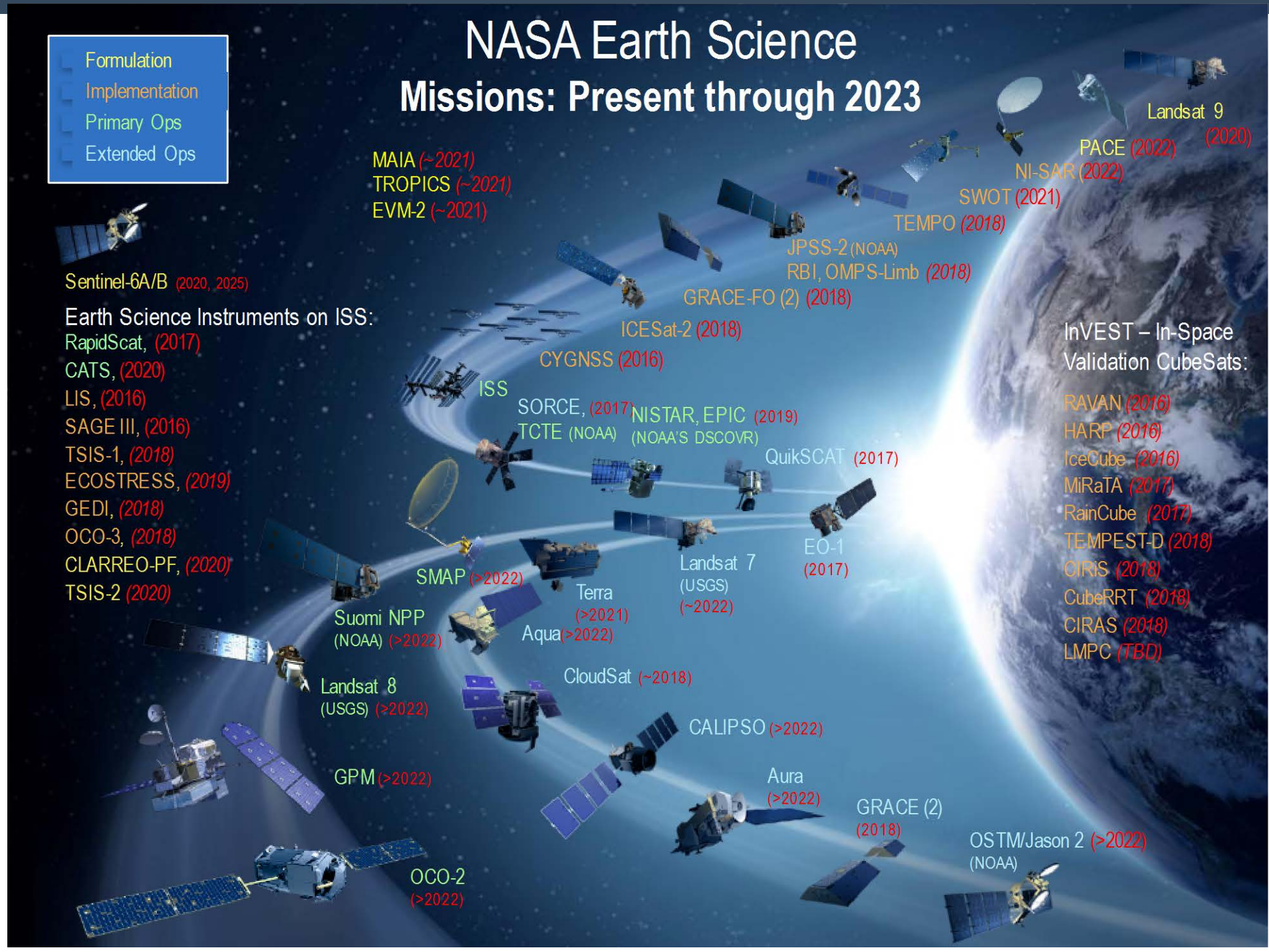


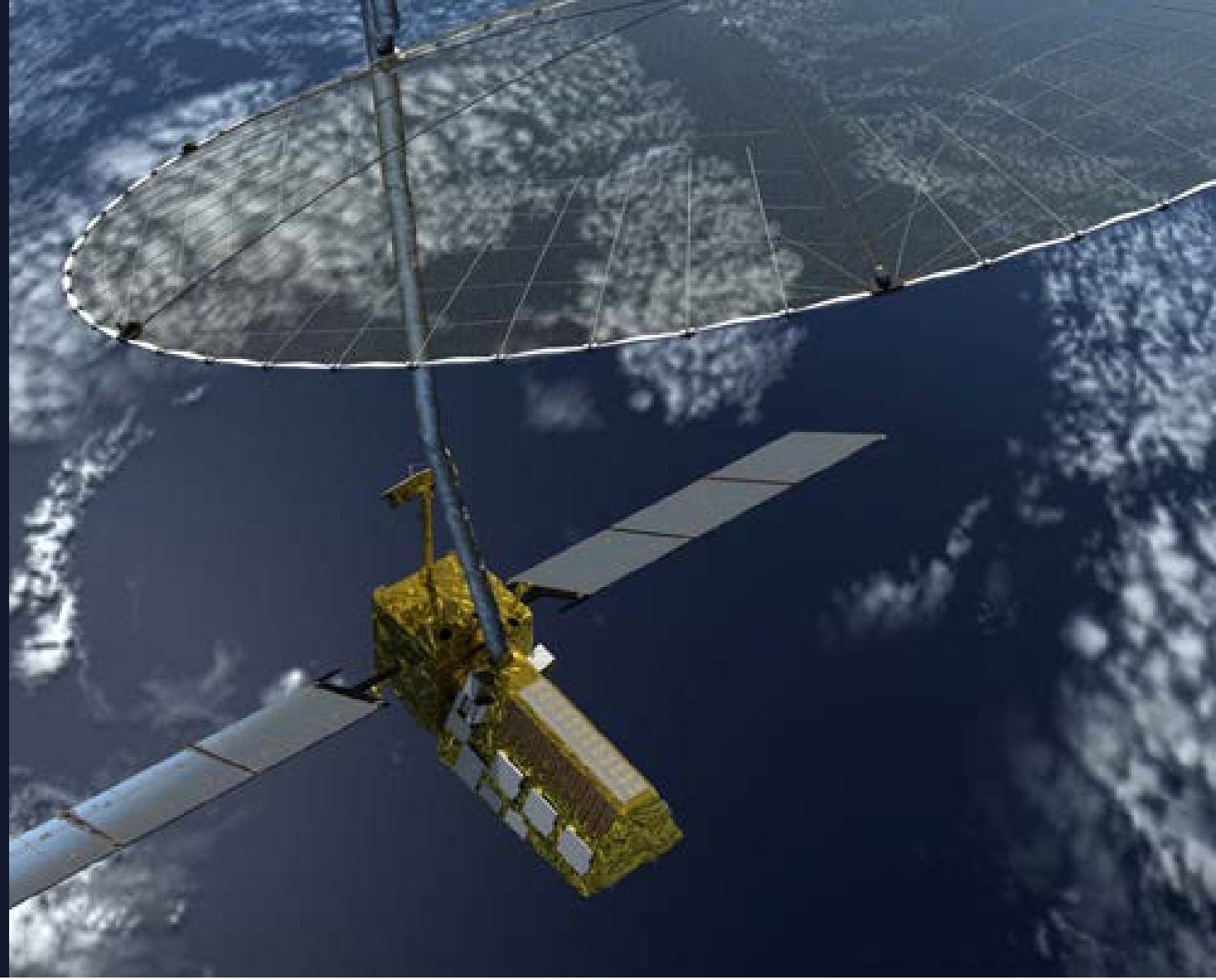
# EOSDIS is many interconnected systems…

**80 TBs**/day
generation

**400 TBs**/day
reprocessing

**300 GB**
Granules

**150 PBs @ 50 Gbps**
processing speed for months



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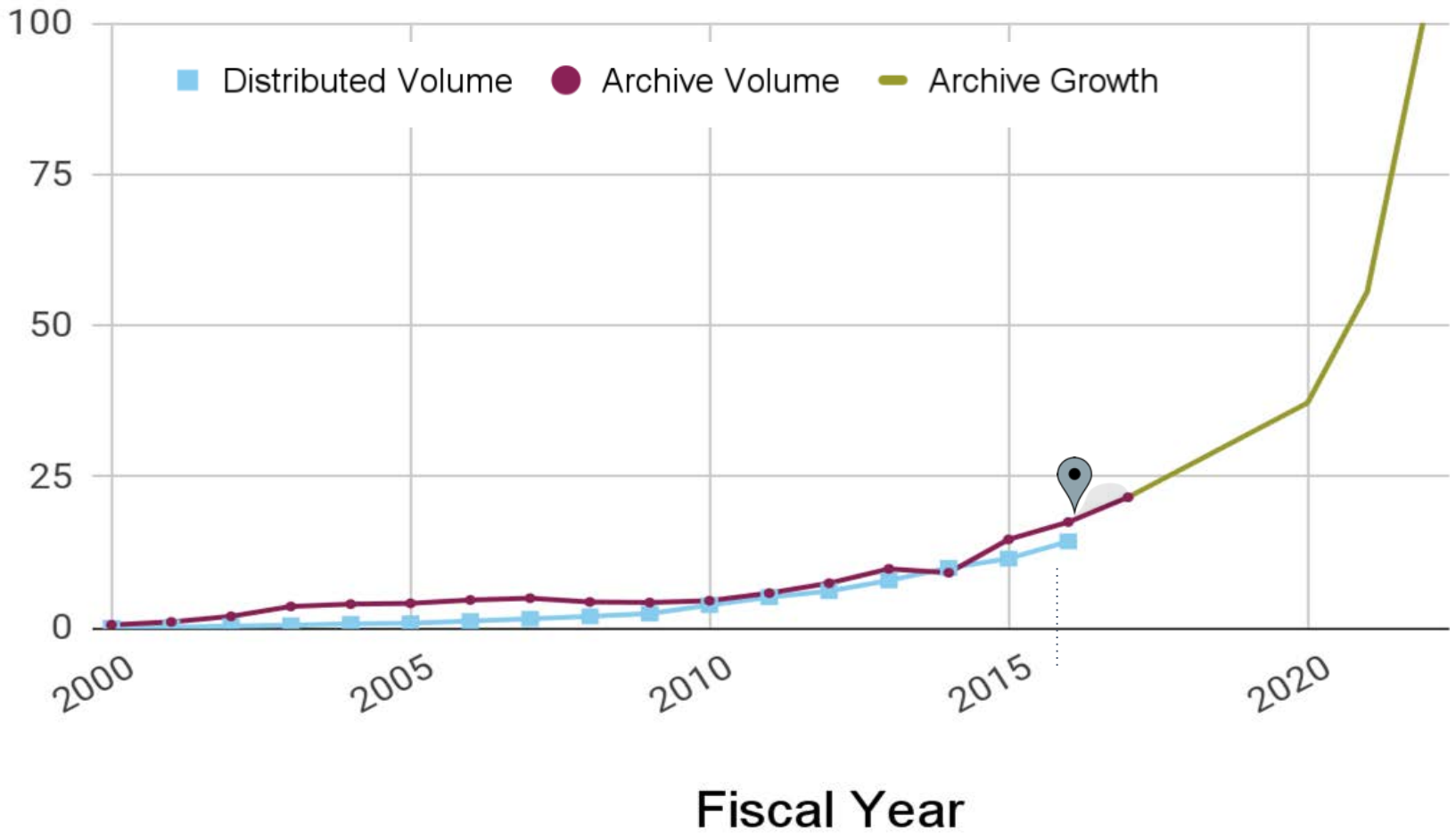
# EOSDIS Data System Evolution

EOSDIS is the premier Earth science archive, but we are always looking for ways to improve

The current architecture will not be cost effective as the annual ingest rate increases from **4** to **50PB/year**

It will become increasingly difficult and expensive to maintain and improve our current system as data volumes and research demands continue to increase exponentially

EOSDIS is developing **open source cloud native software** for reuse across the agency and throughout the government




*Cloud offers benefits like the ability to analyze data at scale, analyze multiple data sets together easily and avoid lengthy expensive moves of large data sets allowing scientists to work on data "in place"*

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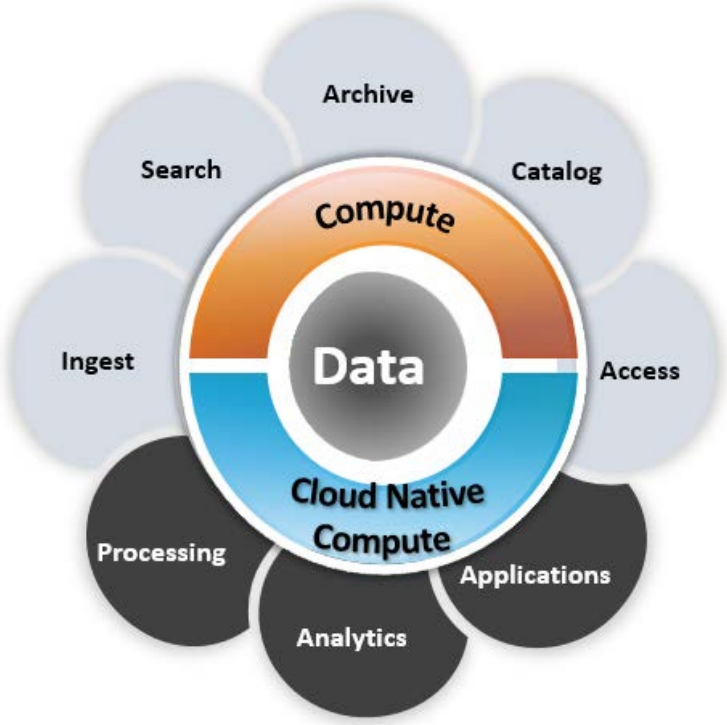
We **have** to change the paradigm

# EOSDIS works well, but can we do better?

- *Can we evolve NASA archives to better support interdisciplinary Earth science researchers?*
- *What system architecture(s) will allow our holdings to become interactive and easier to use for research and commercial users?*
- *Can we afford additional functionality?*
- *How will data from multiple agencies, international partners, and the private sector be combined to study the earth as a system?*
  - *GOES-R, CubeSats, Copernicus…*

# Conceptual ‘data close to compute’




*The operational model of consolidating data—allowing users to compute on the data in place with a platform of common tools—is natural to cloud; it is a cost-effective way to leverage cloud and could be applicable to many businesses and missions*

**Bring customers to the data**

**Large volume data storage:** Centralized mission observation and model datasets stored in auto graduated AWS object storage (Amazon S3, Amazon S3 IA, Amazon Glacier)

**Scalable compute**: Provision, access, and terminate dynamically based on need. Cost by use

**Cloud Native Compute:** Cloud vendor service software stacks and microservices easing deployment of user based applications

**EOSDIS applications and services:** Application and service layer using AWS compute, storage (Amazon S3, Amazon S3 IA, Amazon Glacier), and cloud native technologies

**Non-EOSDIS/public applications and services**: Science community brings algorithms to the data. Support for NASA and non-NASA

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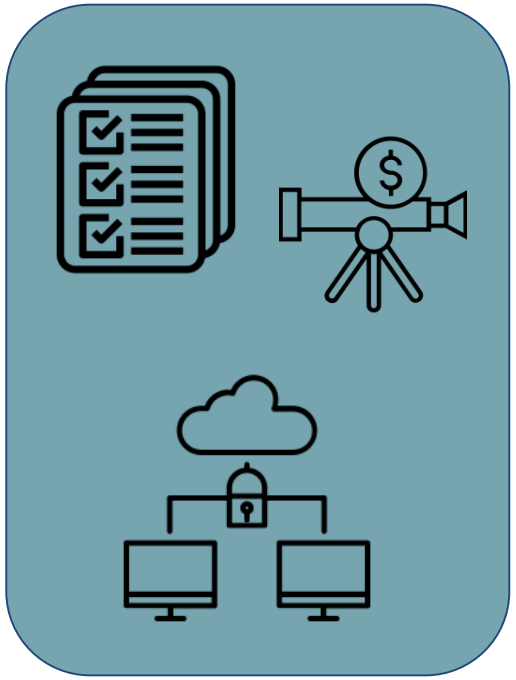
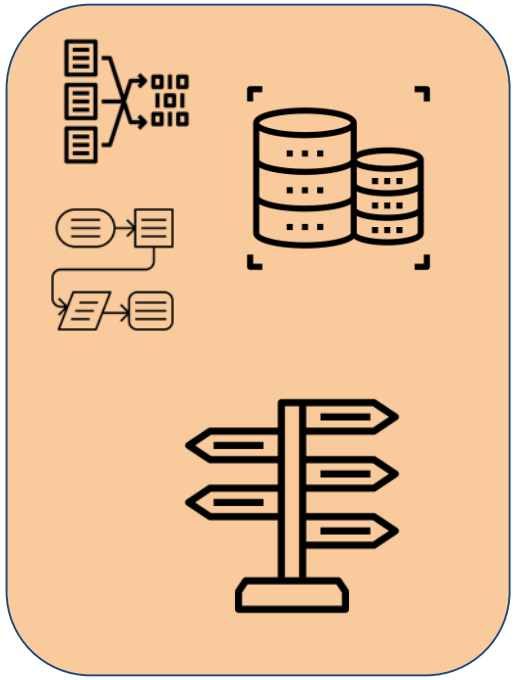
# Past 24 Months: Focused on evaluation and planning for a cloud migration in 4 areas

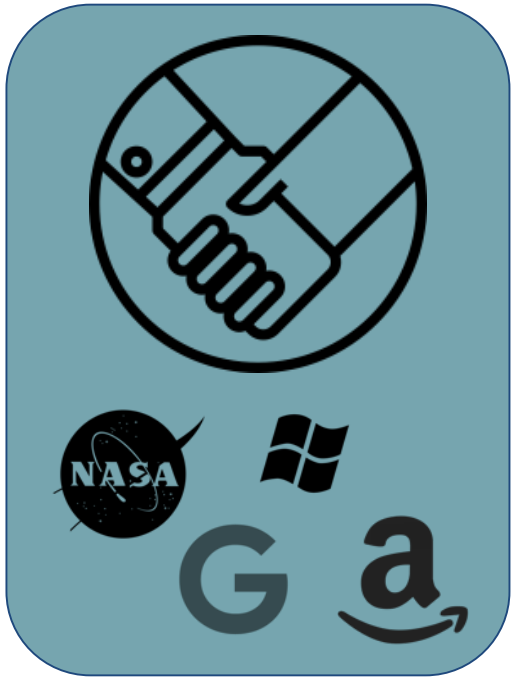


Compliance, Security, Cost Tracking



Core Archive Functionality and Processing

End-User Application Migration




Pursuing Cloud Partnerships

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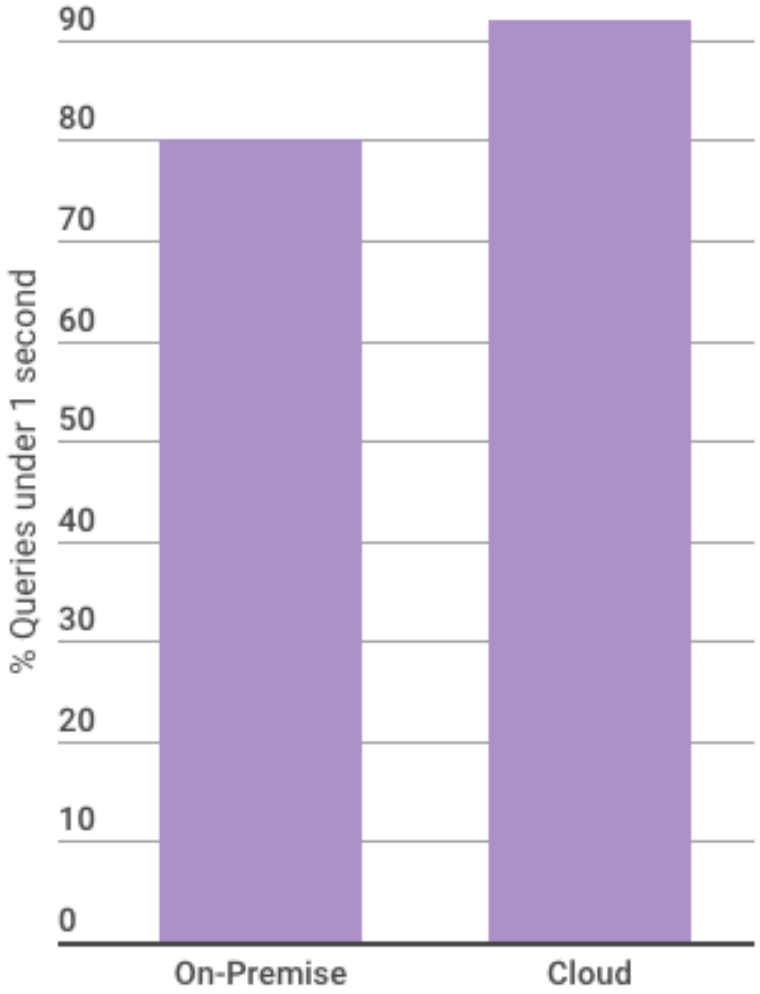
# Starting AWS migration

Since September 2016, EOSDIS has migrated two of its core systems, Common Metadata Repository (CMR) and Earthdata Search, into the Amazon cloud to immense success

- One year migration effort
- Over 500K queries per day
- Open source
- Open access API

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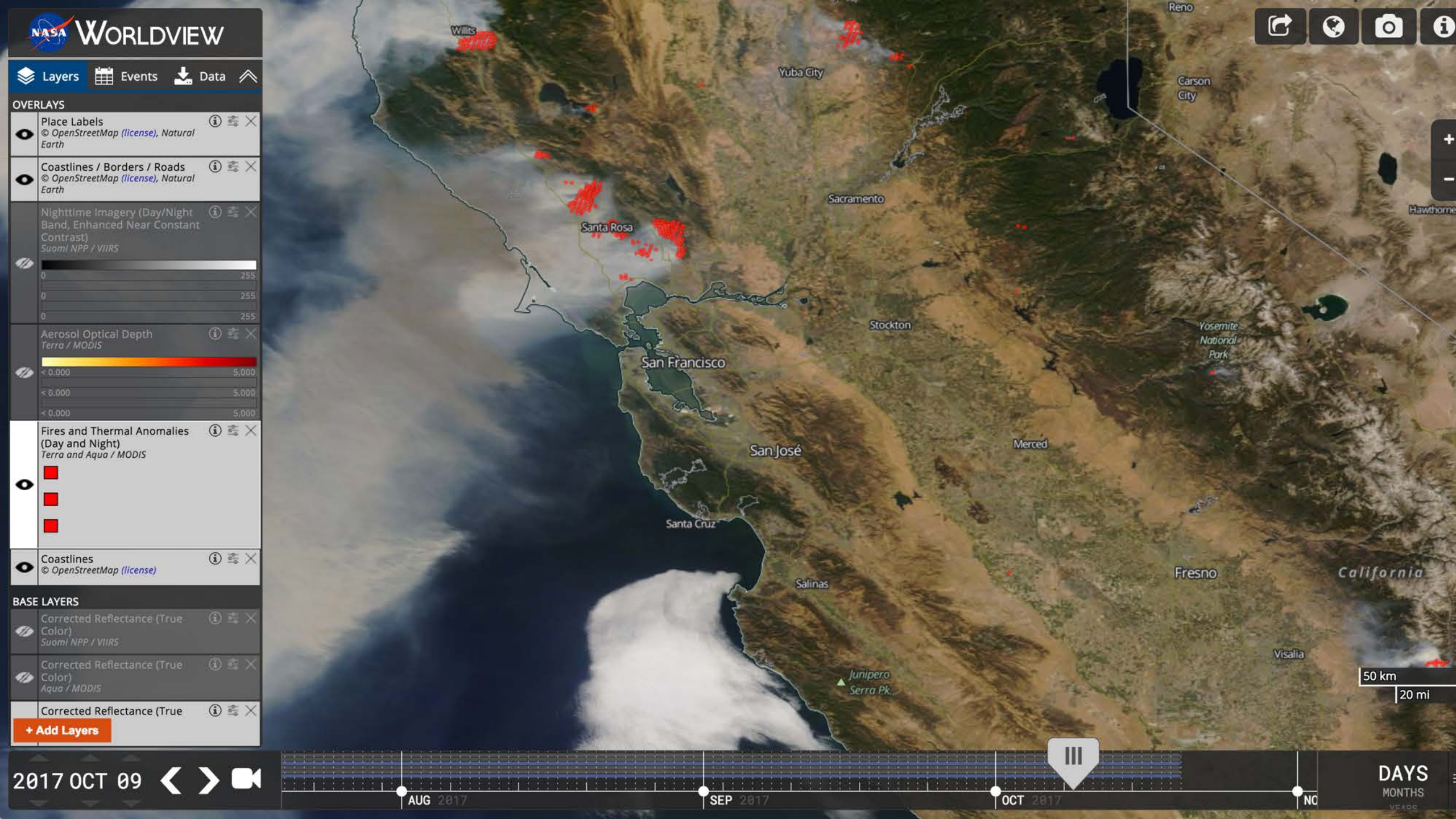
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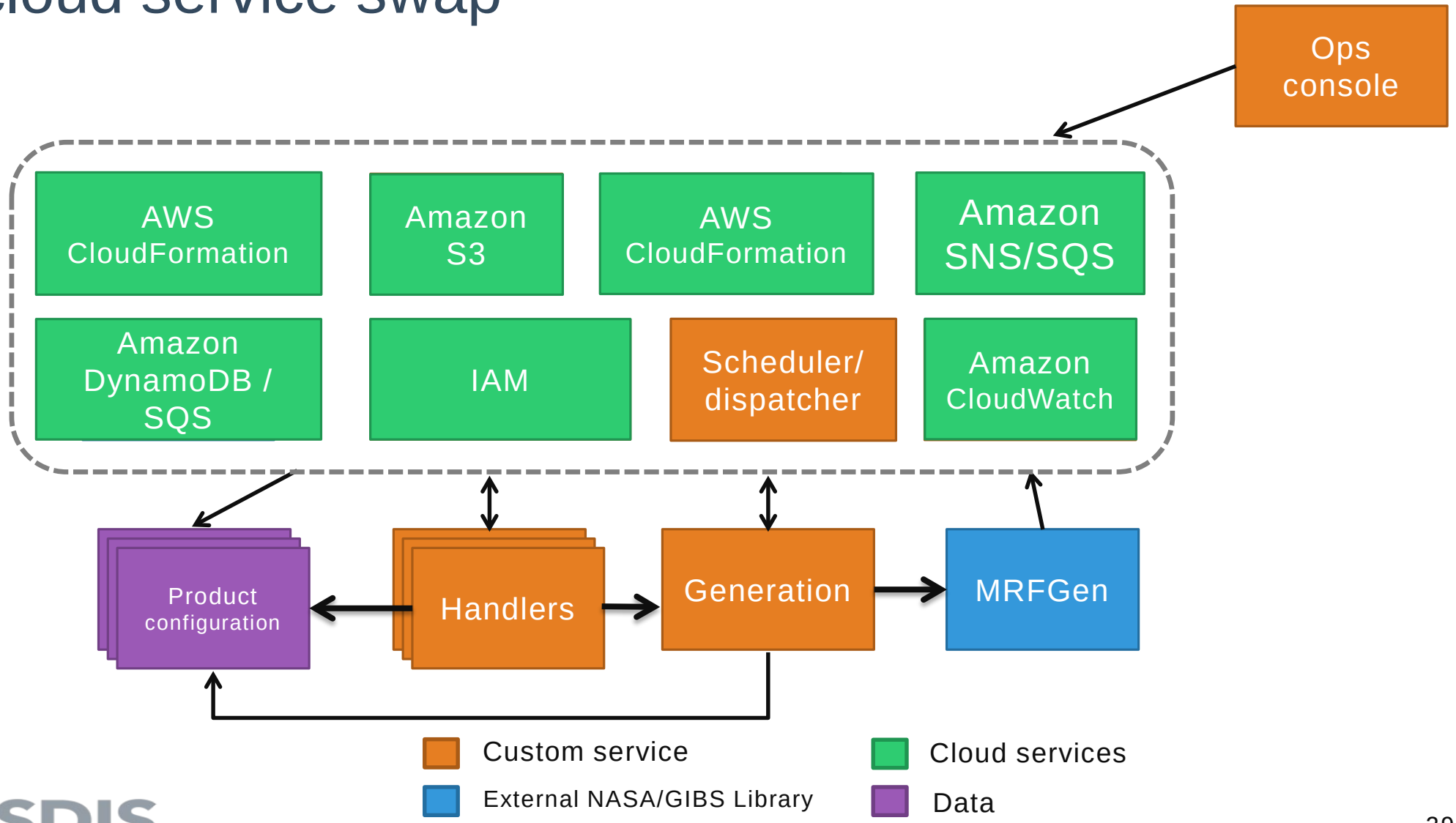
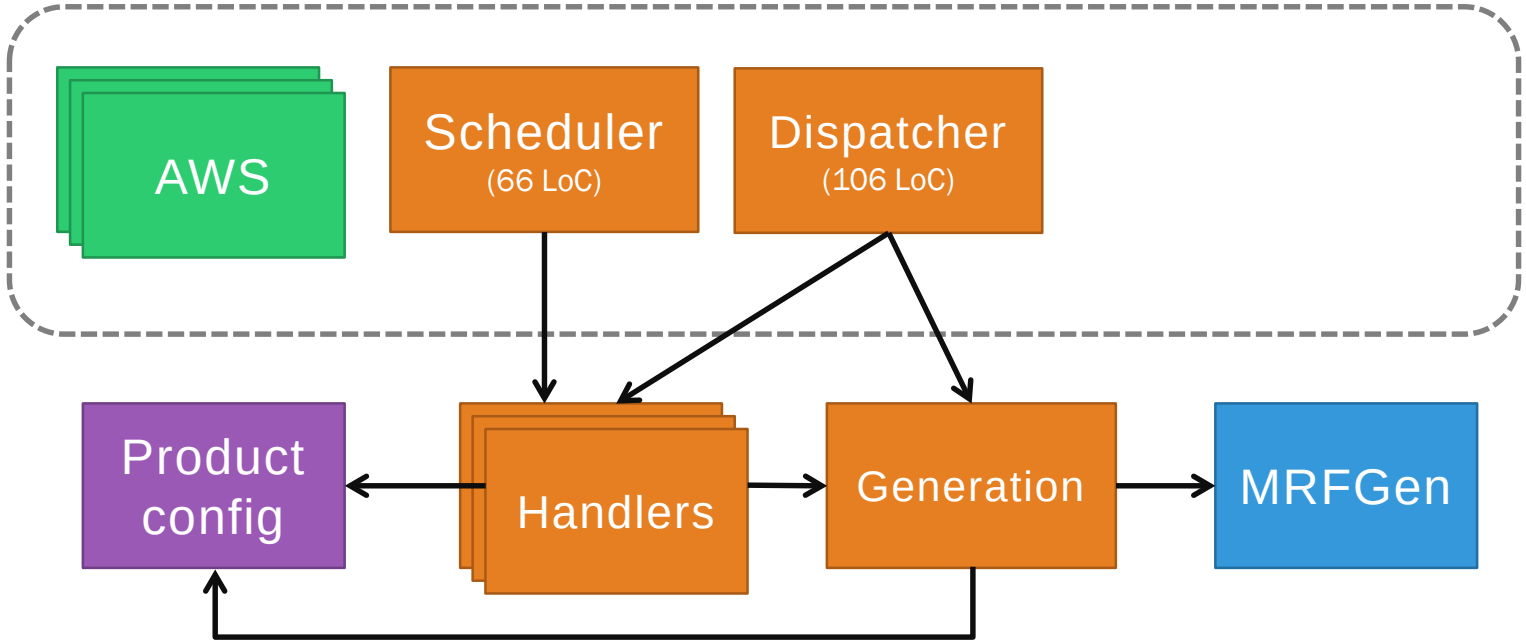
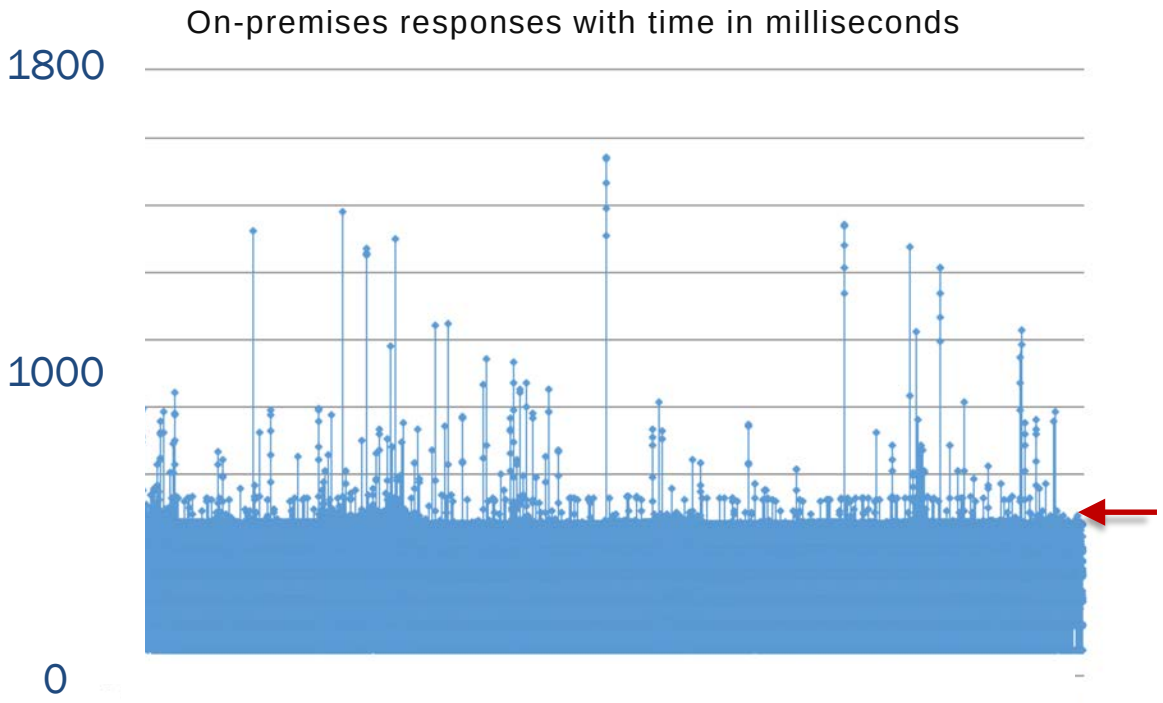
# Global Imagery Browse Service (GIBS) in the cloud service swap

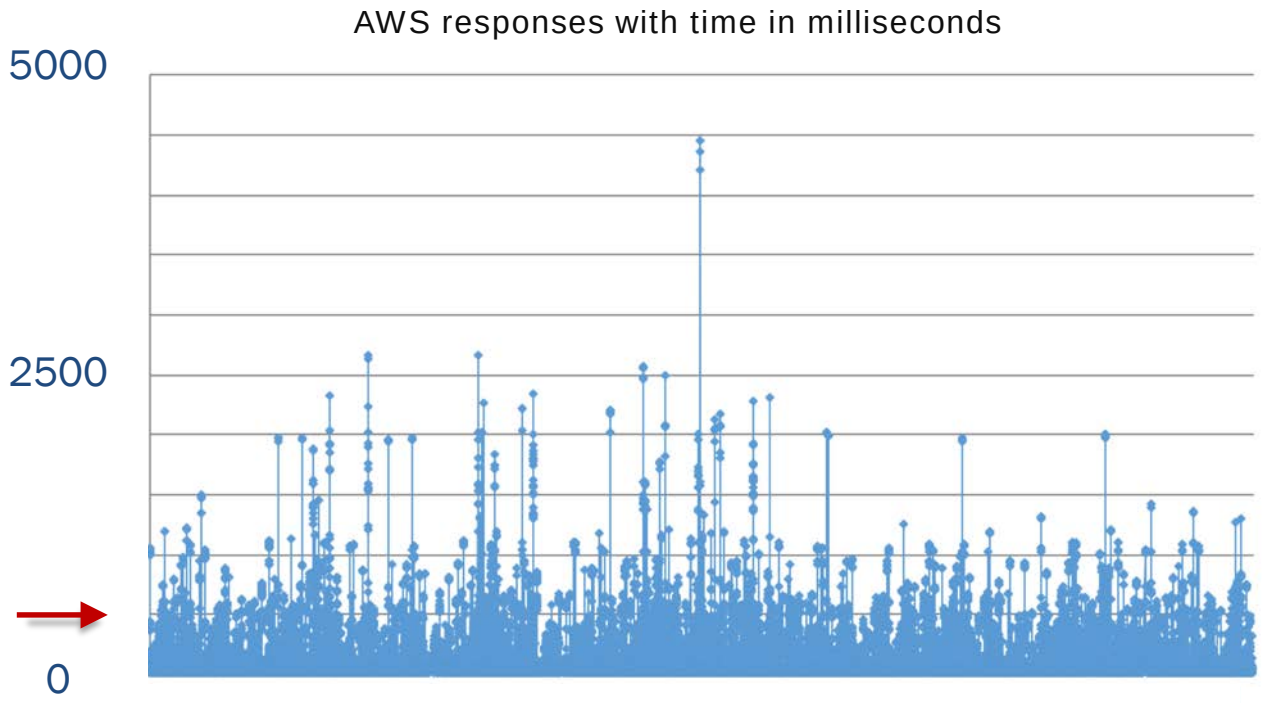


# GIBS-in-the-cloud ingest & processing



# Cloud performance affected architecture




On-premises implementation showed consistent performance during load testing vs. more sporadic latencies in AWS

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# Ingest: Earth science Imagery Processing


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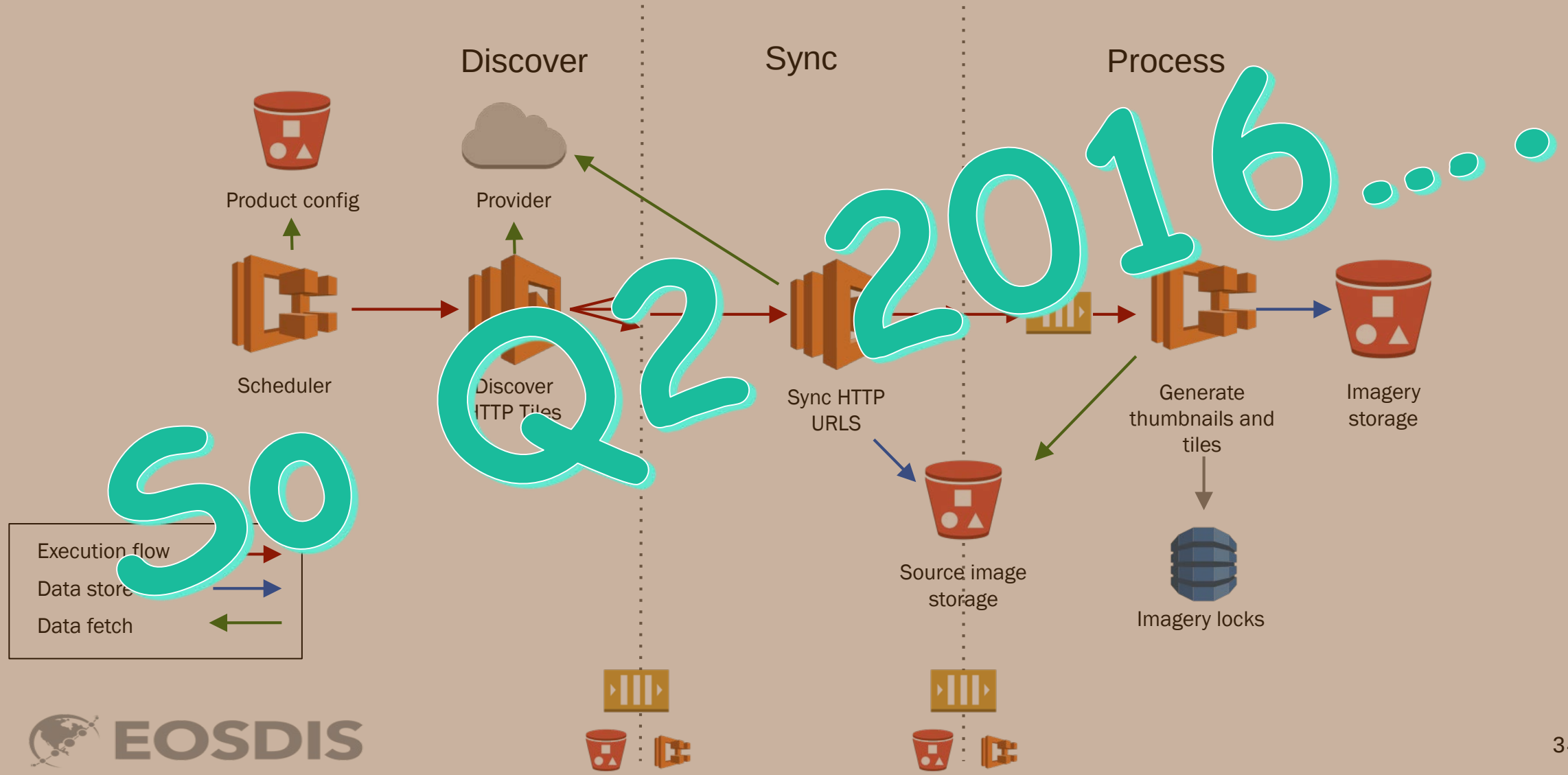
# OCTOBER 17-20, 2017 AWS announcements!

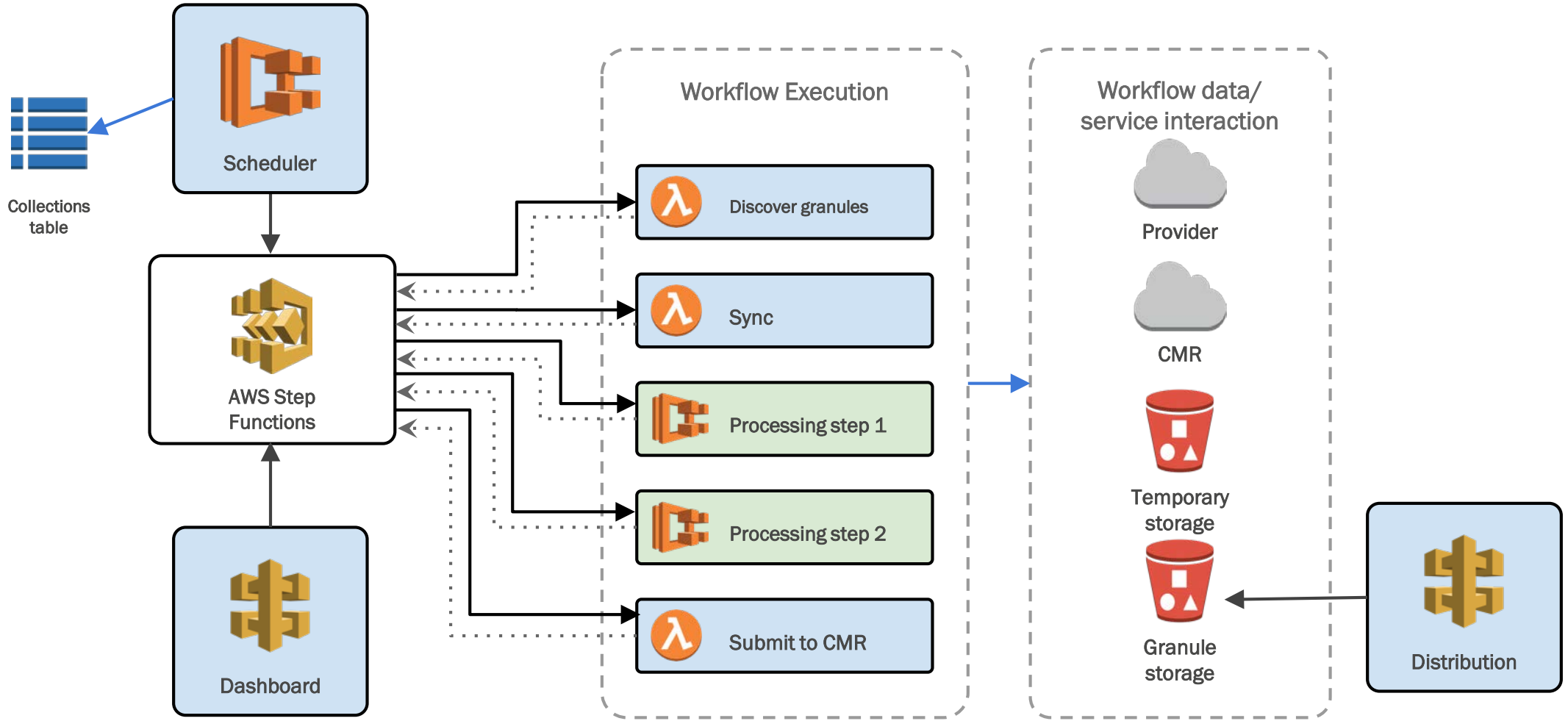
## Most Recent Announcements from AWS

| Date | Announcement |
|---|---|
| Oct 20 | AWS Config Adds Support for AWS CodeBuild |
| Oct 20 | Amazon QuickSight Adds Support for Combo Charts and Row-Level Security |
| Oct 19 | AWS Direct Connect now live in Vancouver, Manchester and Perth |
| Oct 19 | Manage Amazon Simple Queue Service costs using Cost Allocation Tags |
| Oct 19 | Amazon Athena is now available in the EU (Frankfurt) region. |
| Oct 19 | Amazon Redshift Spectrum is now available in Europe (Ireland) and Asia Pacific (Tokyo) |
| Oct 18 | Amazon EC2 Spot Can Now Encrypt your EBS volumes at launch time |
| Oct 18 | AWS Deep Learning AMI Now Supports PyTorch, Keras 2 and Latest Deep Learning Frameworks |
| Oct 17 | Amazon Redshift announces Dense Compute (DC2) nodes with twice the performance as DC1 at the same price |
| Oct 18 | AWS Marketplace: Announcing Availability of Multi-AMI Solutions. |

# Ingest: Earth science imagery processing…



# Ingest & Archive with AWS Step Functions



# Cumulus Major System Components

A lightweight framework consisting of:

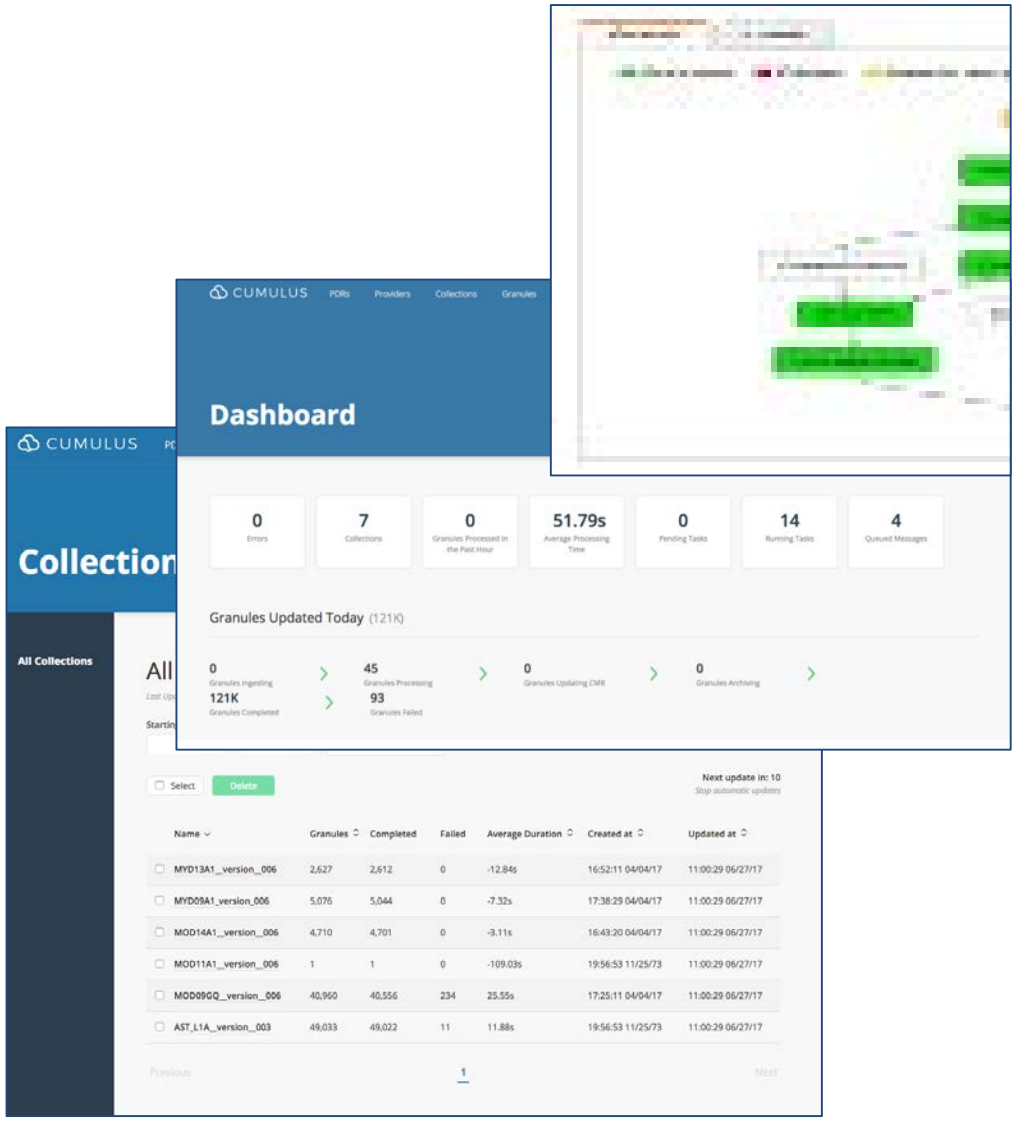
**Tasks** a discrete action in a workflow, invoked as a Lambda function or EC2 service, common protocol supports chaining

**Orchestration engine** (AWS Step Functions) that controls invocation of tasks in a workflow

**Database** store status, logs, and other system state information

**Workflows(s)** file(s) that define the ingest, processing, publication, and archive operations (json)

**Dashboard** create and execute workflows, monitor system

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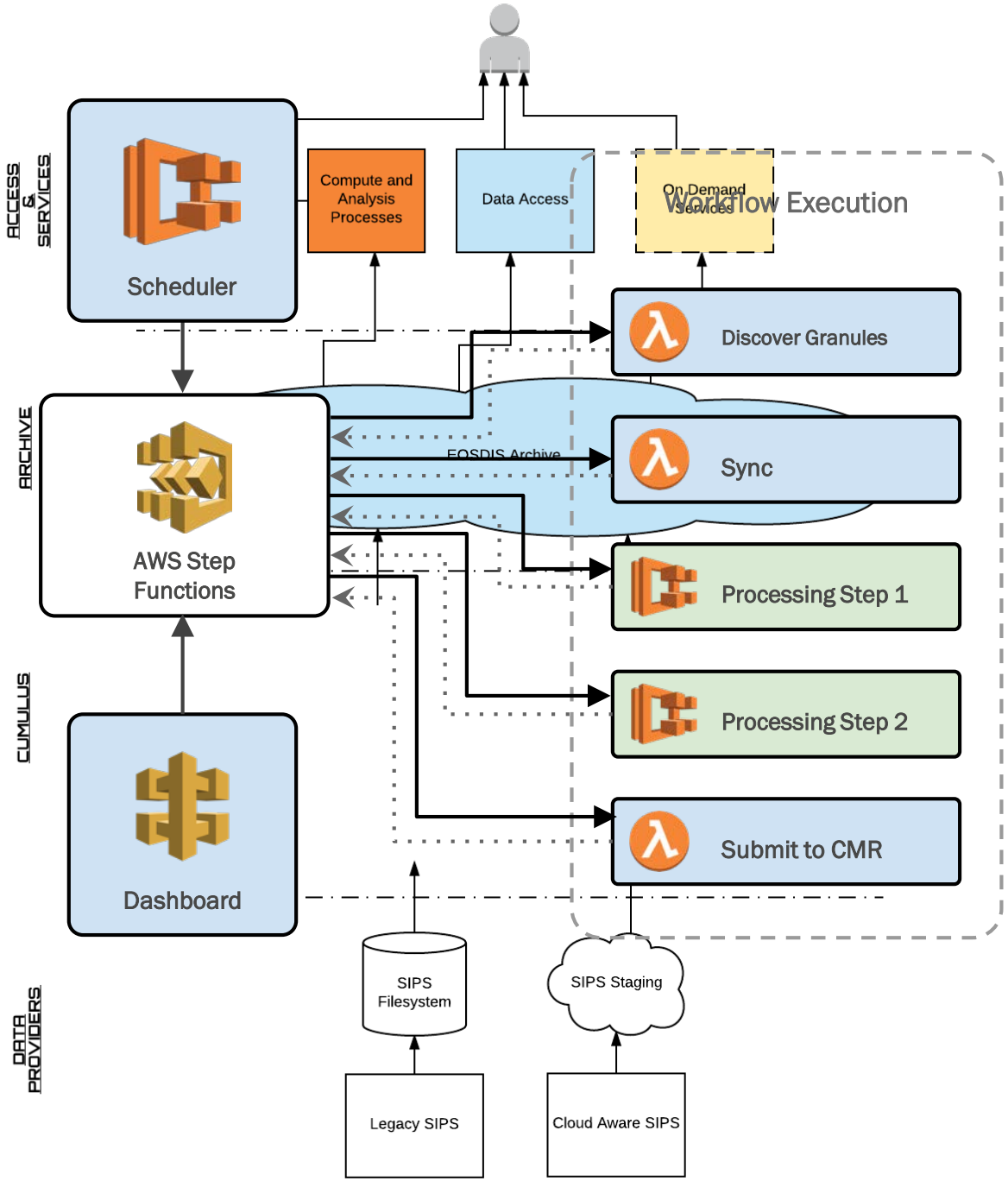
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Workflow Execution
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Submit to CMR
Dashboard
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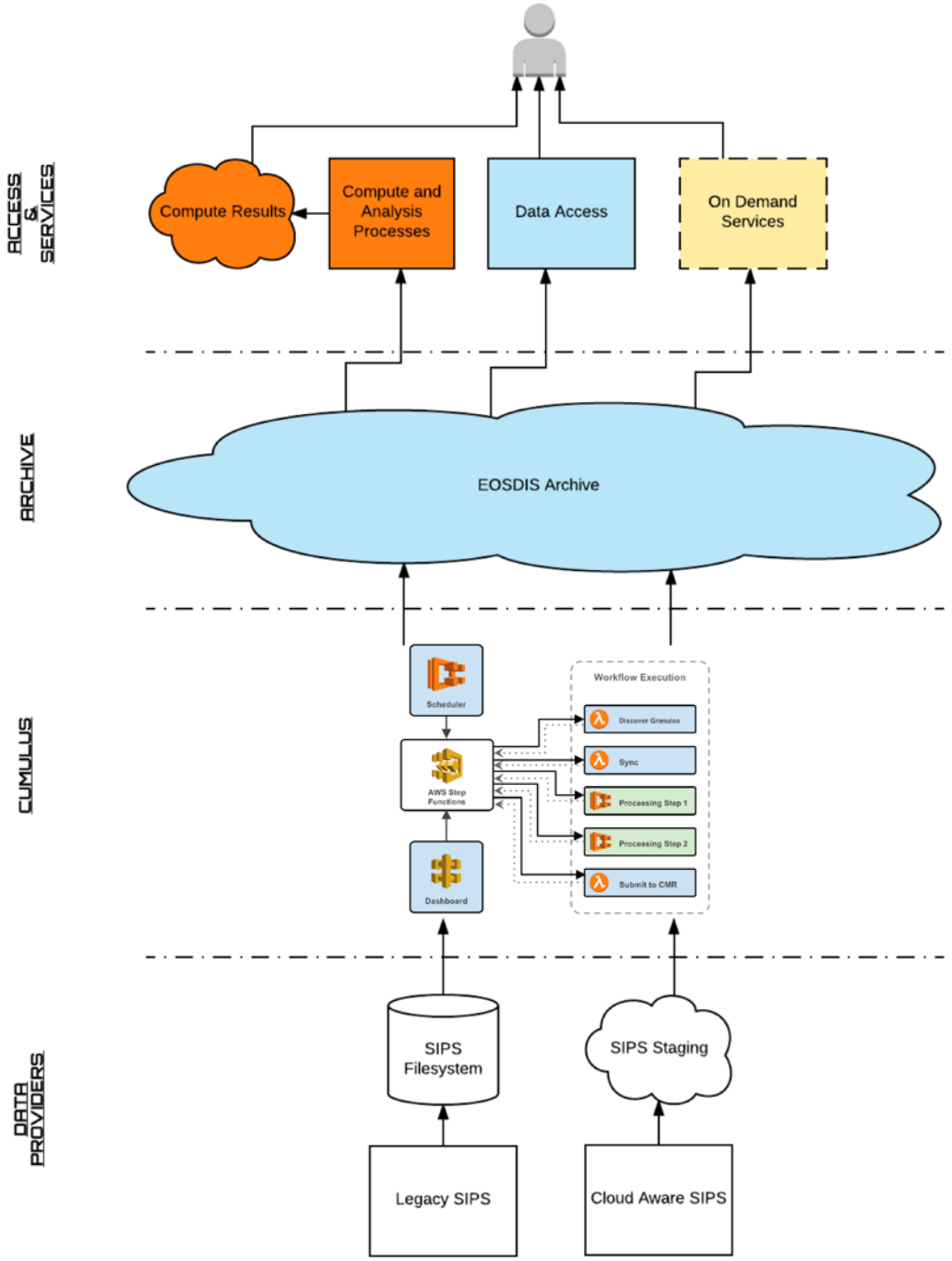
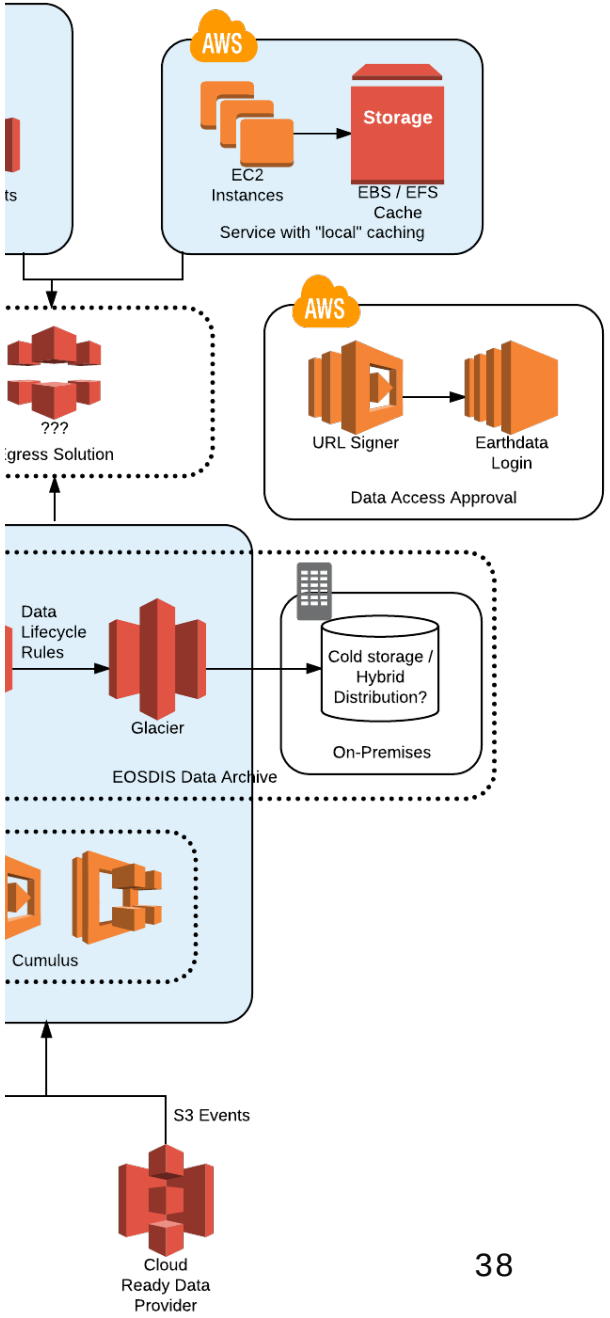
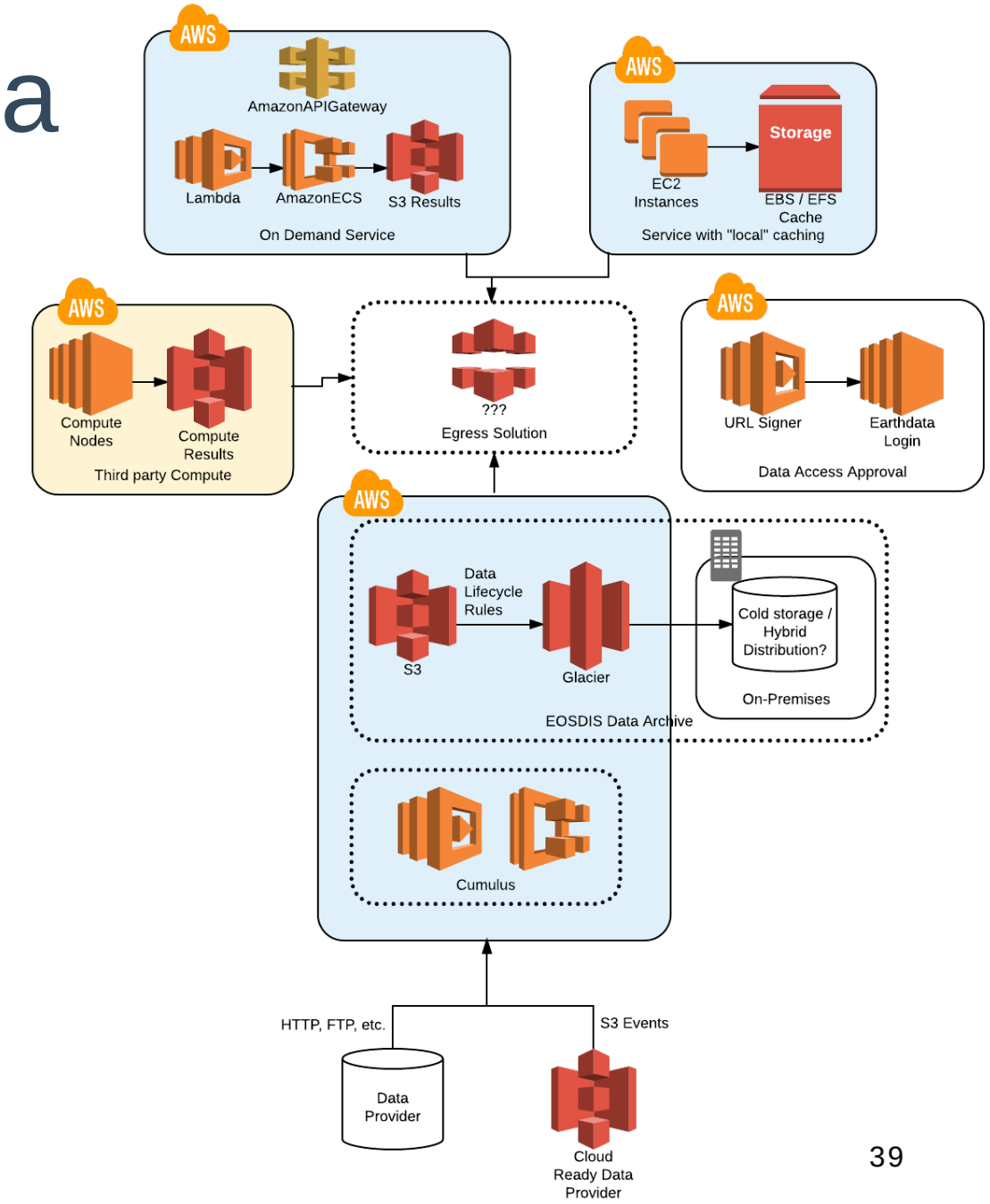
SIPS Filesystem
SIPS Staging
Legacy SIPS
Cloud Aware SIPS


ACCESS & SERVICES
Compute Results
Compute and Analysis Processes
Data Access
On Demand Services
ARCHIVE
EOSDIS Archive
CUMULUS
Scheduler
AWS Step Functions
Dashboard
Workflow Execution
Discover Granules
Sync
Processing Step 1
Processing Step 2
Submit to CMR
DATA PROVIDERS
SIPS Filesystem
SIPS Staging
Legacy SIPS
Cloud Aware SIPS


AWS
Storage
EC2 Instances
EBS / EFS Cache
Service with "local" caching
???
gress Solution
AWS
URL Signer
Earthdata Login
Data Access Approval
Data Lifecycle Rules
Glacier
Cold storage / Hybrid Distribution?
On-Premises
EOSDIS Data Archive
Cumulus
S3 Events
Cloud Ready Data Provider

# Cloud scale science data

- **Data can be generated at scale** in AWS and placed in accessible buckets, avoiding massive data moves
- Ingest, archival, validation, processing, etc. can **scale dynamically** based on incoming data streams, reprocessing needs, etc.
- **Entire petabyte scale archive** is directly accessible, with no transfer time or costs, to science users in the same region for longtime series or multiproduct use
- **Data processing, transformation, and analysis services** can be spun up, NASA funded or completely independently, leveraging the data with scalable compute and cost and access-managed output targets.

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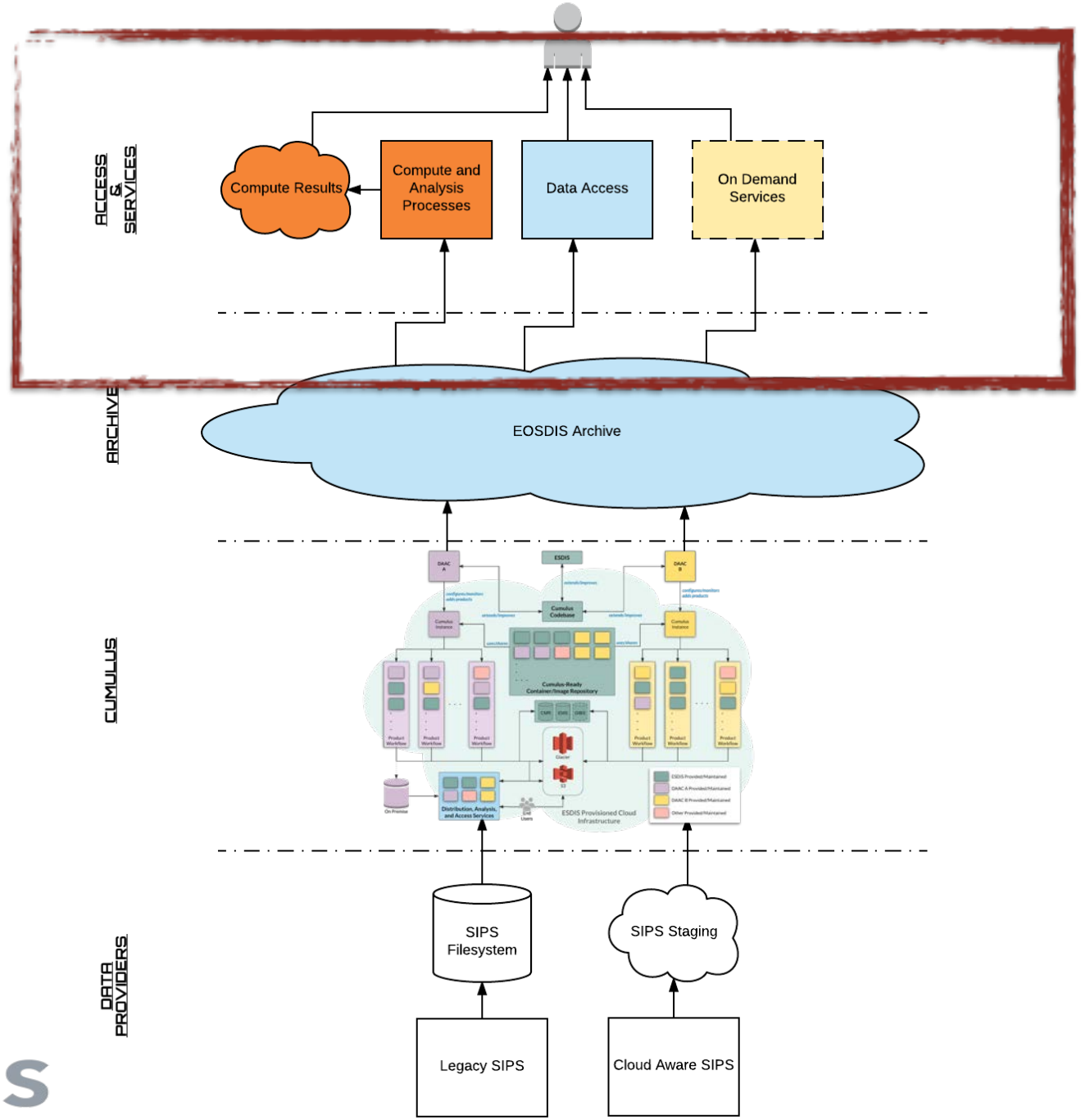
# HOW DO USERS *USE* THIS DATA?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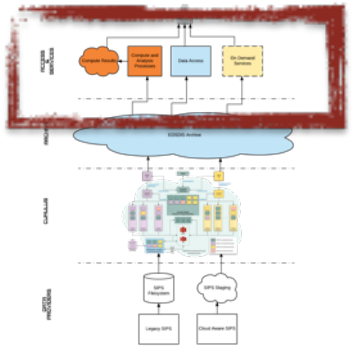
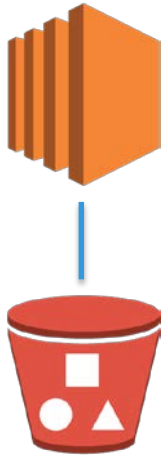
# Data Access Use Cases

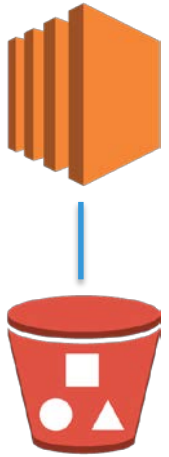


***Traditional file based Data Access***

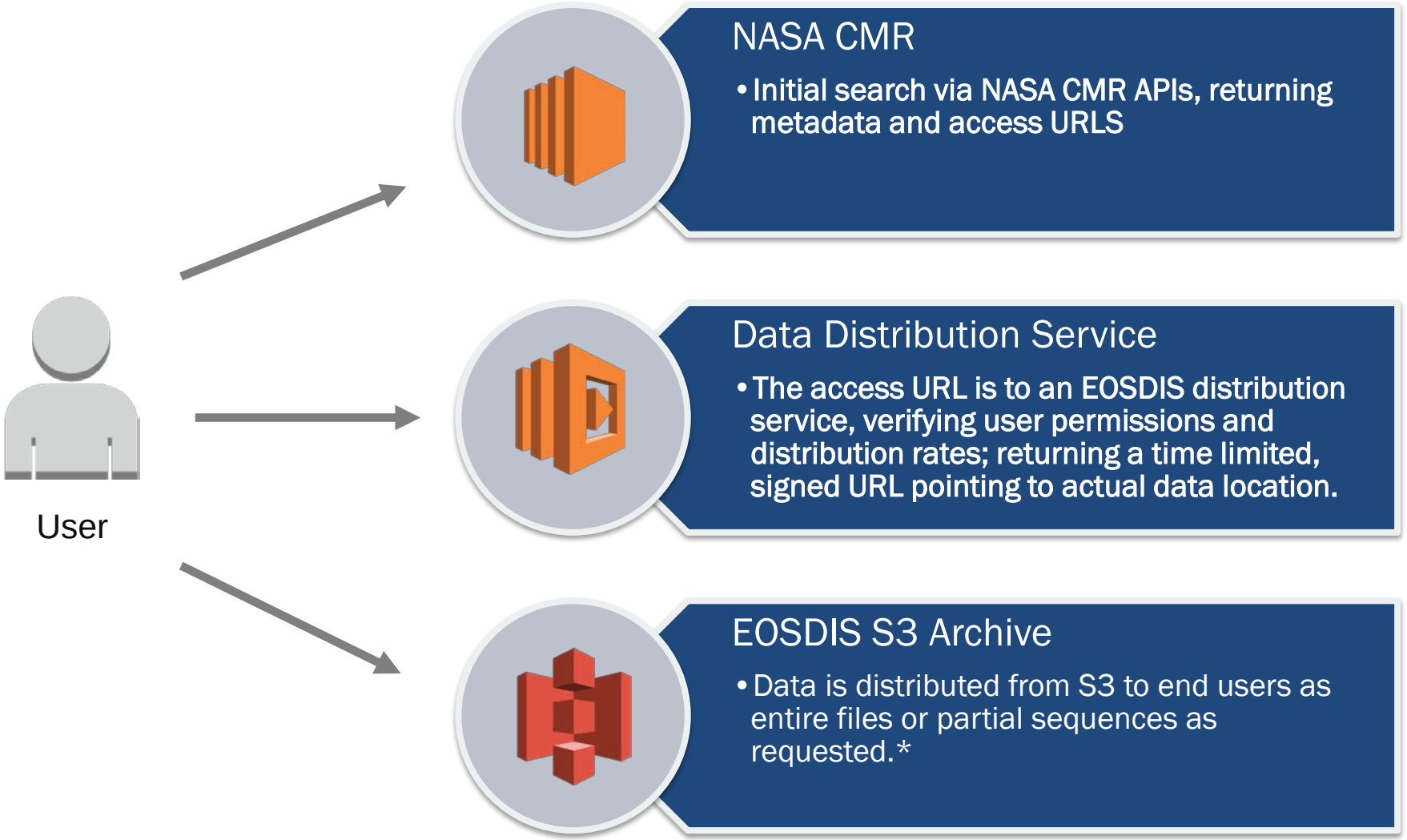
**Distribution from Access Services**



***Computing and Analysis Near the Data***



# Basic Data Access

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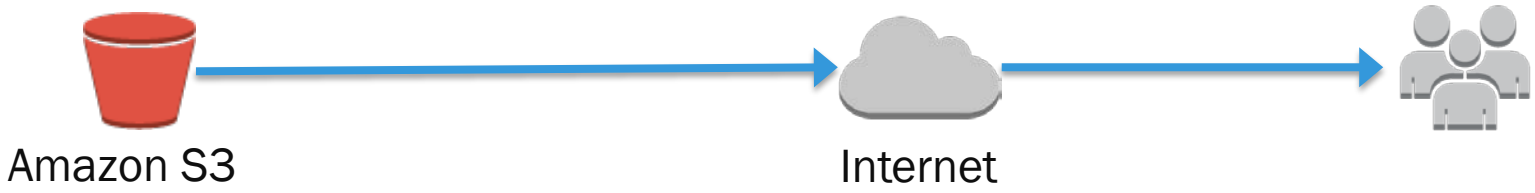
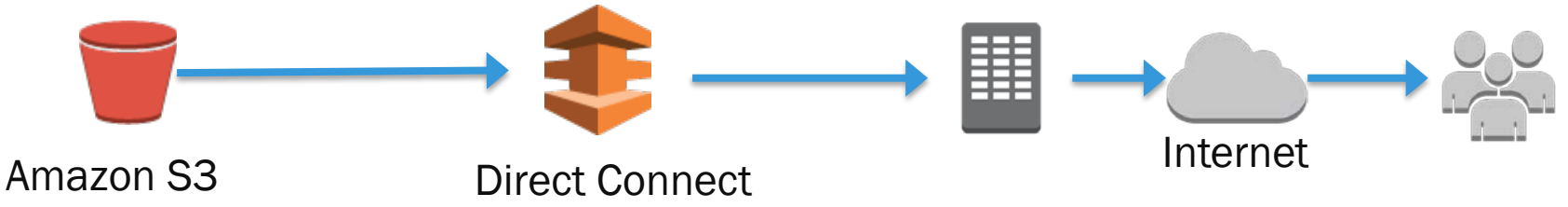
*Egress controls may drive a more sophisticated solution.

# Basic Amazon S3 egress

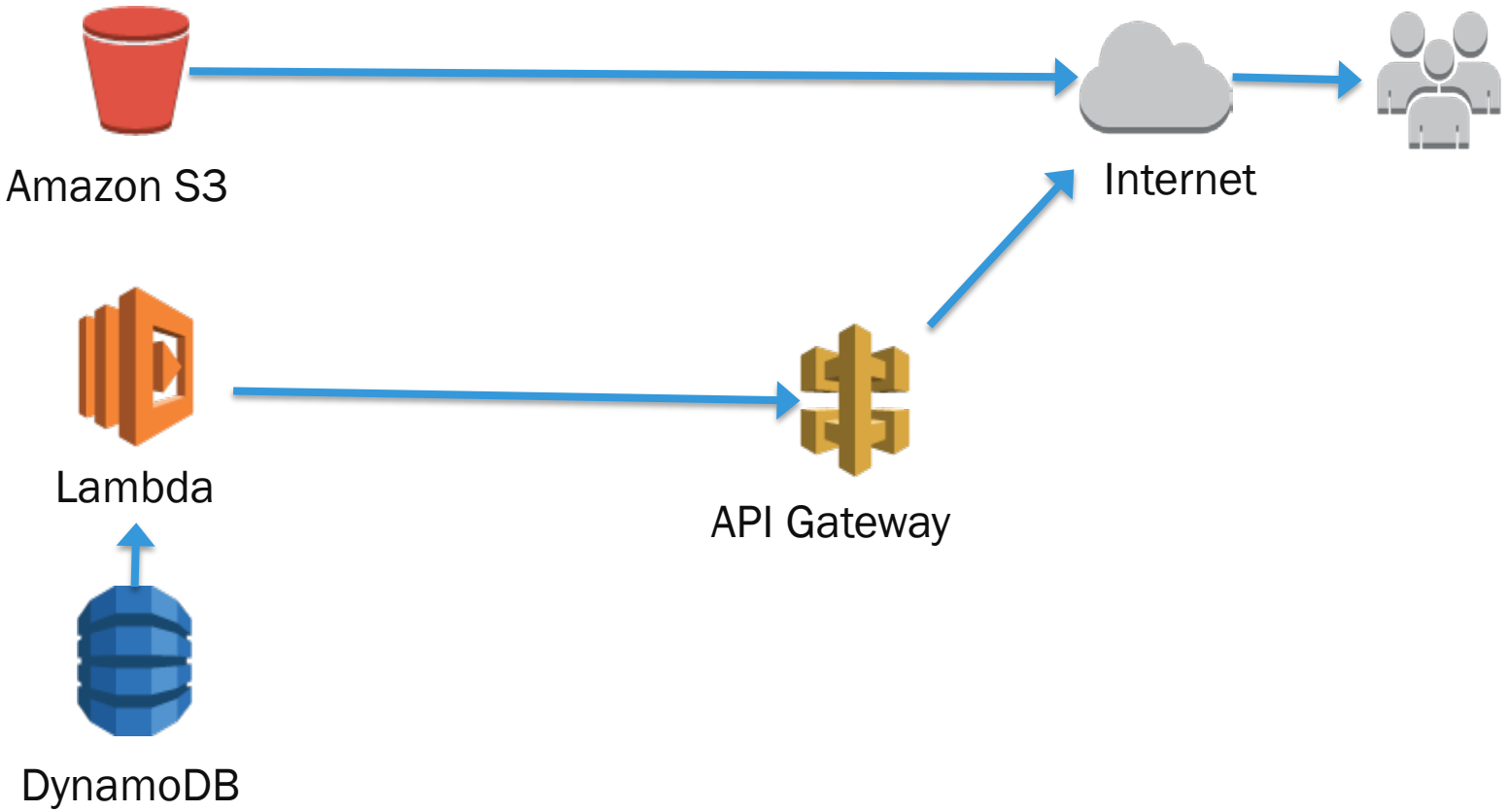


# Amazon S3 with CloudFront

# Amazon S3 through AWS Direct Connect to on-premises distribution pipe



# Request limiting using Lambda and API Gateway



Egress costs range more than

13x across those models

Egress costs are a **big** deal…

…but they weren't our only issue…

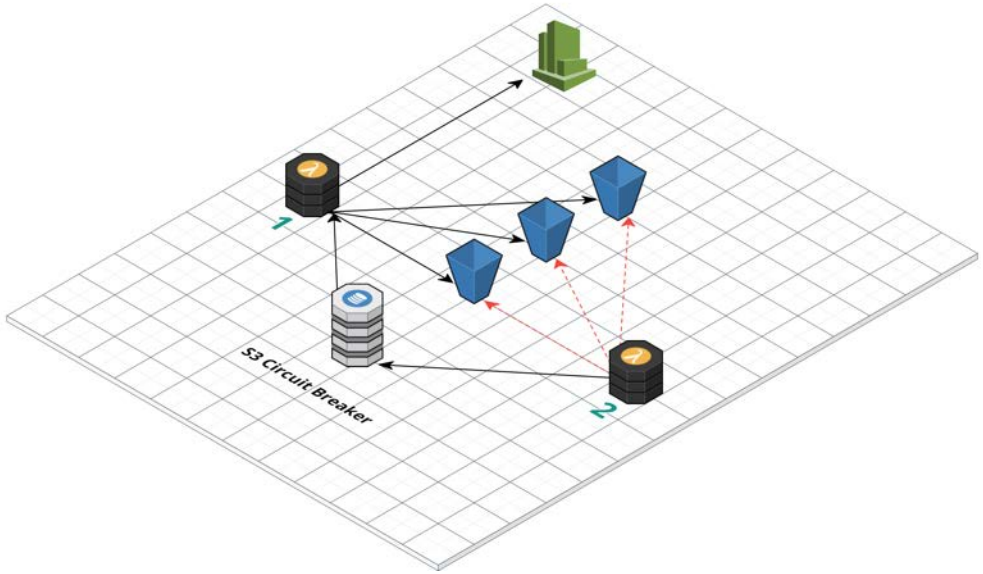
# Hard cost controls are essential

- The Anti-Deficiency Act (ADA) disallows unbounded costs

- We needed a means of **absolutely** limiting egress costs

# Circuit Breaker Conceptual design

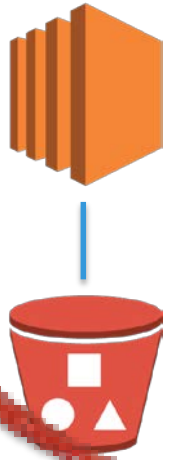
- Lambda 1: Calculate Amazon S3 egress
  - Watch each bucket's "Bytes Downloaded" via CloudWatch
  - Post totals
- Lambda 2: Break the circuit (if needed)
  - If total from first billing period to now exceeds our threshold…
  - …lock down Amazon S3 bucket policy



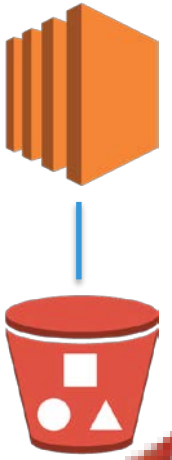
# Data Access Use Cases

***Traditional file based Data Access***

**Distribution from Access Services**



***Computing and Analysis Near the Data***



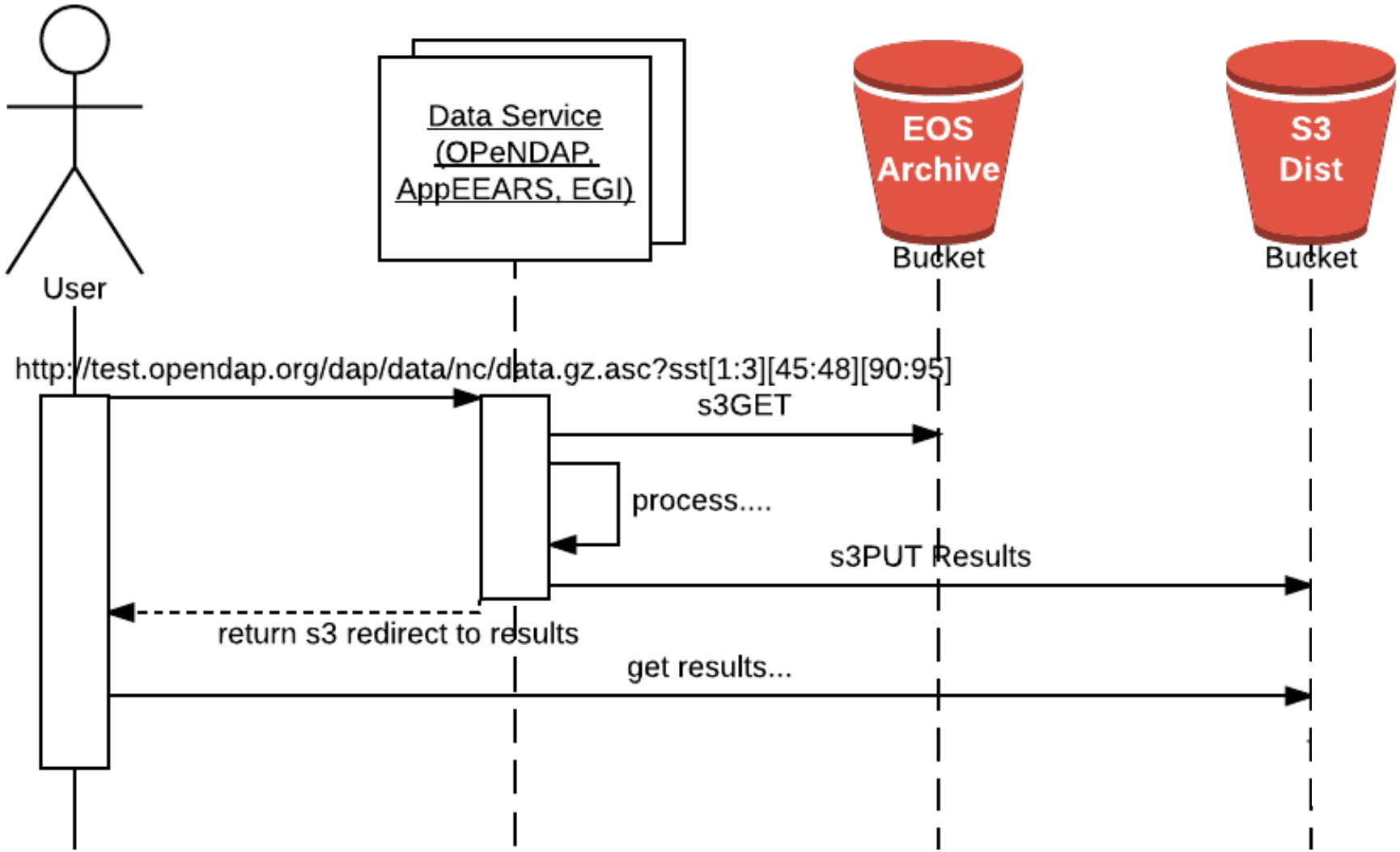
# Distribution from Access Services

# Example access services

- OPeNDAP access
- OGC WxS Implementations
- Format transformations (repackaging)
- Reprojection, mosiacing, etc

*S3 is a Distribution Mechanism*

*- Mark Korver @ AWS*


User
Data Service
(OPeNDAP,
AppEEARS, EGI)
EOS
Archive
Bucket
S3
Dist
Bucket
http://test.opendap.org/dap/data/nc/data.gz.asc?sst[1:3][45:48][90:95]
s3GET
process....
s3PUT Results
return s3 redirect to results
get results...

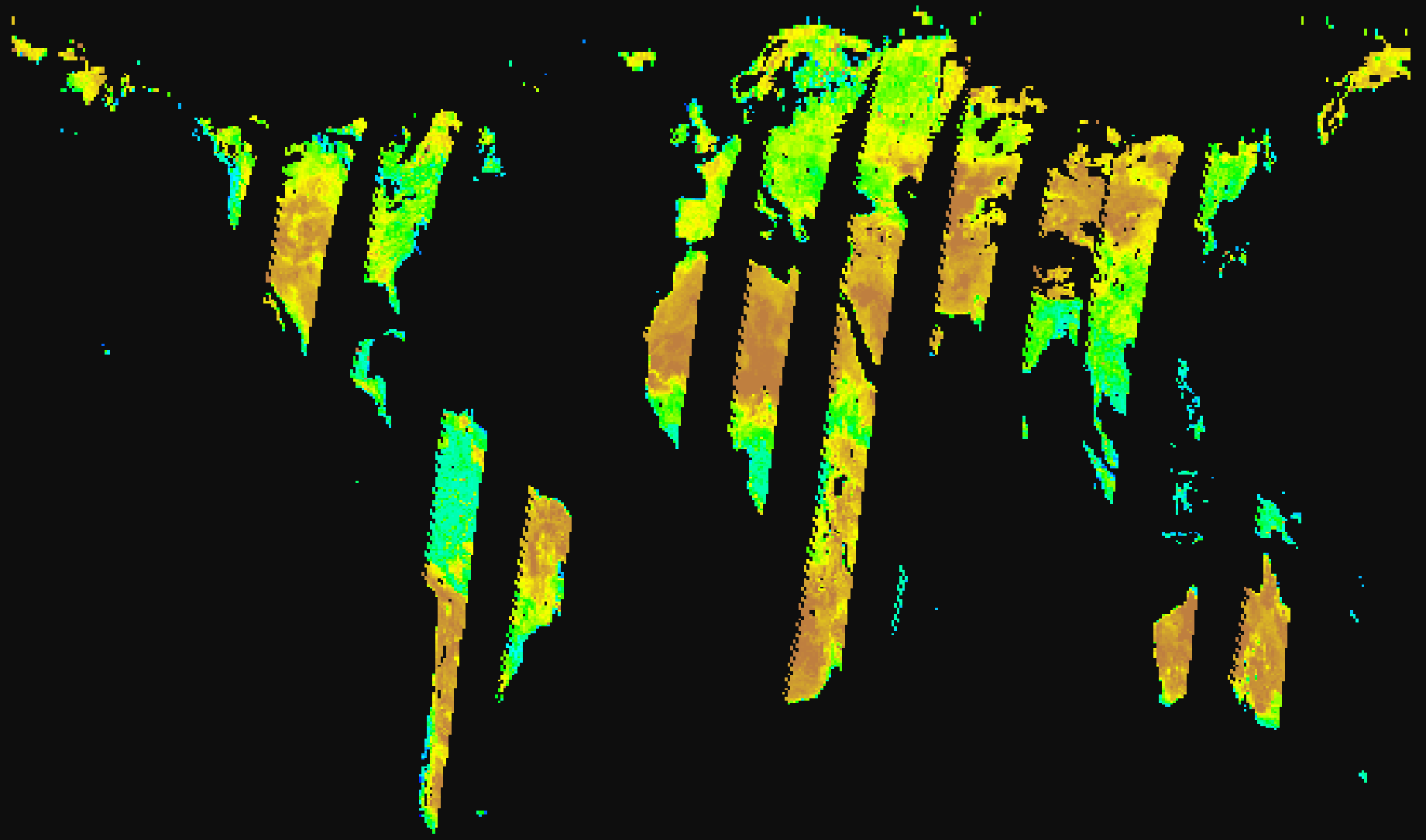
# Favor Re-architecture over "just getting into the cloud"

- Natural Inflection Point
- Managed Services
- Opportunity for Innovation
- Better leverage cloud cost models

Psycho-Social

# GO HANDS-ON QUICKLY


EED2
HACKFEST
2016
CAPABLE OF
SPENDING ENTIRE
ANNUAL BUDGET
EED2
HACKFEST
2016
MOST LIKELY TO
GO INTO
OPERATIONS
EED2
HACKFEST
2016
MOST
INNOVATIVE
EED2
HACKFEST
2016
MOST
POINTS



# LOOKING FORWARD

# What we’re working on now…

- Efficient data services access and distribution
- Cost effective large archive storage
- Data disaster recovery and preservation approaches
- Third party cloud native data use at scale
- Expanding the paradigm of an established community

# Here’s where we want help

# Ways to Compute Near the Data?

- EC2 Instances mounting data via **yas3fs**
- Jupyter Notebooks with **s3contents** or **boto3**
- Serverless implementations with **SNS/SQS** and containerized code **(ECS)**
- Managed solutions like **Athena** or **RedShift Spectrum**

# Call for help

- What can we do to make it easier for you use to use the data in the cloud?
- What are barriers to you using the cloud for processing at scale?
- What kind of sample code, documentation, reference implementations, etc. would help you?
- Would you use / want to use the data as is on S3 or via some other access API?
- Right now discovery and getting a URL to the data goes through the CMR.  Are there other ways you'd like to be able to find and access the data?  Flat file catalogs?

# Thank you!

Majority of code discussed today is Open Source:
https://github.com/nasa

Dan Pilone // dan@element84.com

EOSDIS

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Raytheon

# Acronym List

- AWS – Amazon Web Services
- CNES - Centre national d'études spatiales
- DAAC – Distributed Active Archive Center
- EC2 – Elastic Compute Cloud
- EED2 – EOSDIS Evolution and Development 2
- FOSS4G – Free and Open Source for Geospatial
- GOES-R - Geostationary Operational Environmental Satellite
- IAM – Identity and Access Management
- JSON – JavaScript Object Notation
- OGC – Open Geospatial Consortium
- OPeNDAP - Open-source Project for a Network Data Access Protocol
- MRF – Metadata Raster Format
- NRC – National Resource Council
- S3 – Simple Storage Service
- S3 IA – Simple Storage Service Infrequent Access
- SNS – Simple Notification Service
- SQS – Simple Queuing Service
- URS – User Registration Service