# Creating the Future: The Joint ESA-NASA Multi-Mission Algorithm and Analysis Platform's Data Ecosystem

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# Introduction: Open Science in the 2.0 Era

**Open Science – "the idea that scientific knowledge of all kinds should be openly shared as early as it is practical in the discovery process" (University of Cambridge)**

**Science 2.0 – "all scientific culture, including scientific communication, which employs features enabled by Web 2.0 and the Internet"**

**What does open science look like in the 2.0 era?**
Open Science = Open Data + Open Software + Open Information Sharing

Scientists collaborate through sharing these components & research can begin with any one of these aspects

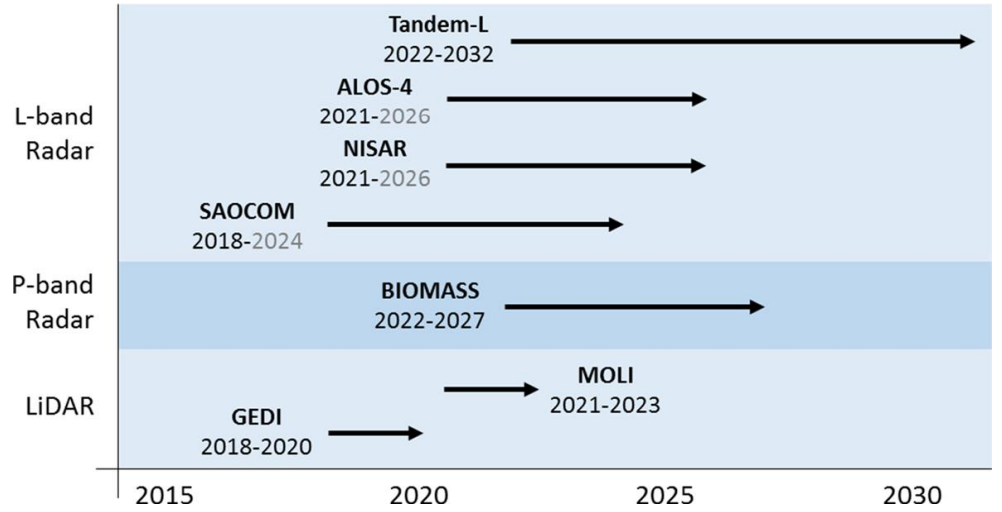
***Scientists want and need to work more collaboratively and openly in the 2.0 era***

Created by Olena Panasovska
from Noun Project

# Science Community Use Case

**Global Aboveground Terrestrial Carbon Dynamics Research Community**

- Understanding biomass distribution and changes in biomass is critical to understanding the global carbon cycle and global climate change
- Space-based data can improve understanding by providing (Herold at al)
  - Improved geographic coverage
  - Better spatial resolutions
  - Ongoing period of temporal observations
- These data, in combination with field and airborne observations for calibration/validation, can greatly improve the community's understanding




Upcoming space-based missions which may contribute to biomass monitoring.
Image Credit: Herold, M., Carter, S., Avitabile, V. et al. Surv Geophys (2019) 40: 757. https://doi.org/10.1007/s10712-019-09510-6

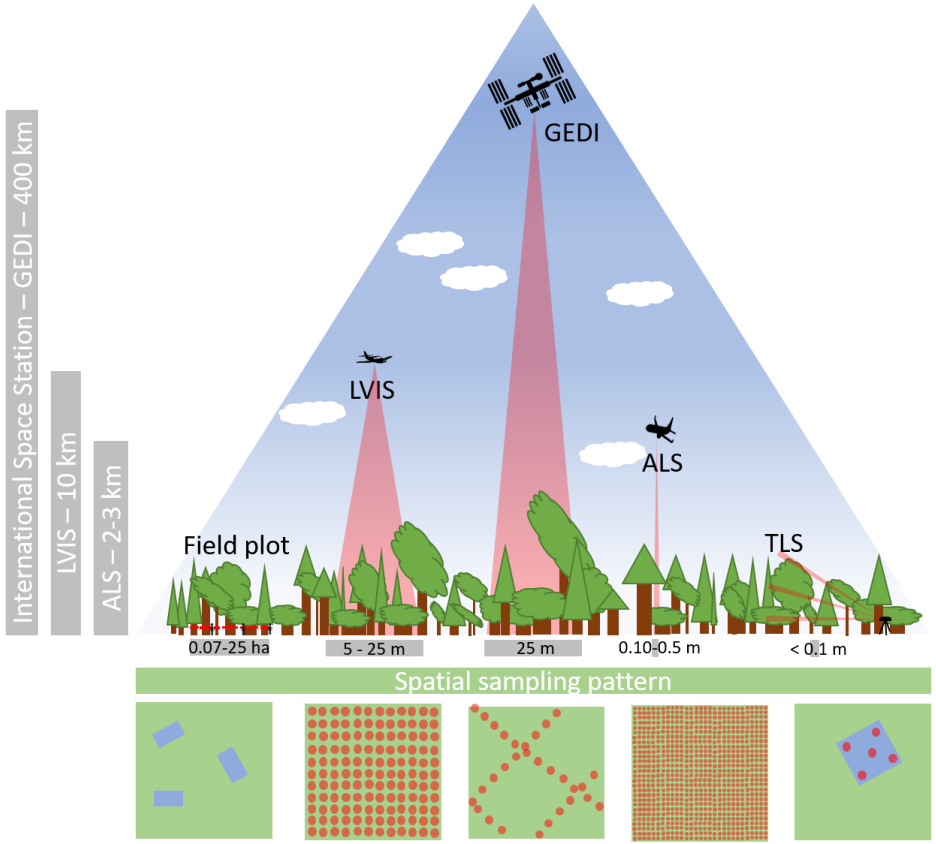
https://www.jpl.nasa.gov/images/earth/africa/20160225/earth20160225d.jpg

# Science Community Use Case

**Obstacles to Research**

- Relevant data are dispersed, making global analysis of data from various sources difficult
- Not all data and algorithms are openly shared
- Data for biomass research are heterogeneous in nature
  - Multiple spatial scales
  - Various observation geometries (footprints vs pixels vs plots)
- Researchers want to share algorithms and data easily and quickly since these algorithms are highly customizable

***What can we do to support the open data, information and compute needs of this research community?***




An example of various spatial sampling patterns used by the biomass community.
Image Credit: https://gedi.umd.edu/science/calibration-validation/

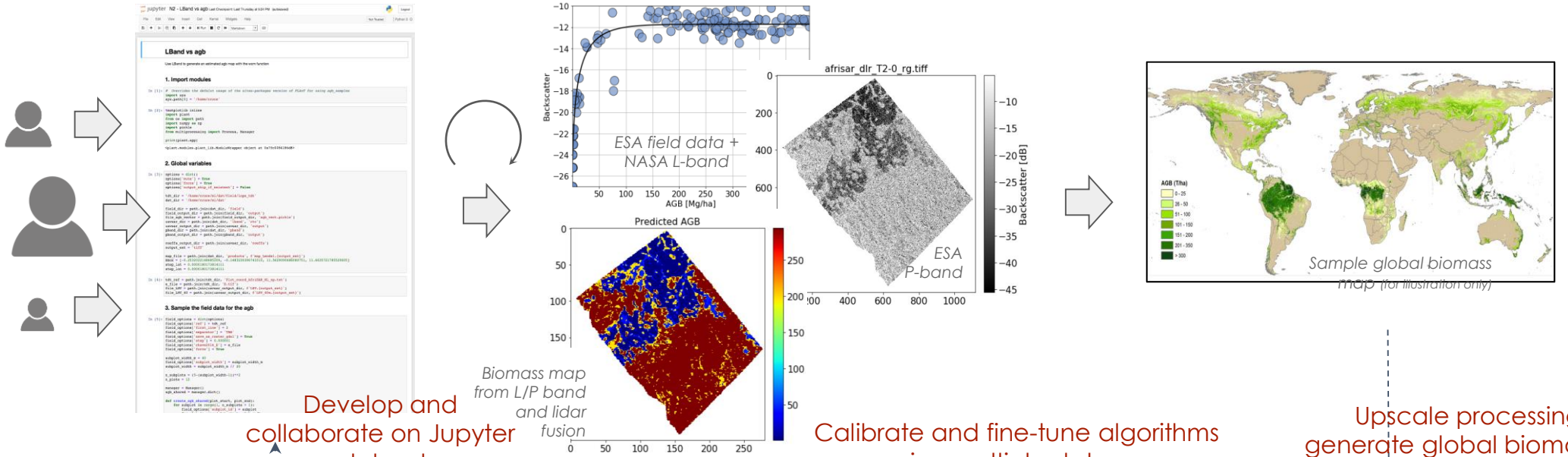
# What is MAAP?

- The MAAP is a virtual environment dedicated to the unique needs of sharing and processing data from relevant field, airborne and satellite measurements related to ESA and NASA missions
  - Jointly managed by ESA and NASA and accessible to designated ESA and NASA scientists.
  - Initially populated with pre-launch and complimentary data from other projects.
- Science focus is to improve the understanding of global terrestrial carbon dynamics & to support algorithm development
- Addresses a need expressed by the science community to more easily share and process data collected by NASA and ESA activities



# MAAP Goals

- **Seamless open access** to airborne, spaceborne and field ESA and NASA data for biomass mapping
- **Ability to upscale user's algorithms** (Jupyter notebooks) from small regions of interest to global scale
- **Collaboration** on end-to-end calibration and validation of higher-level science products



# NASA MAAP Data Ecosystem

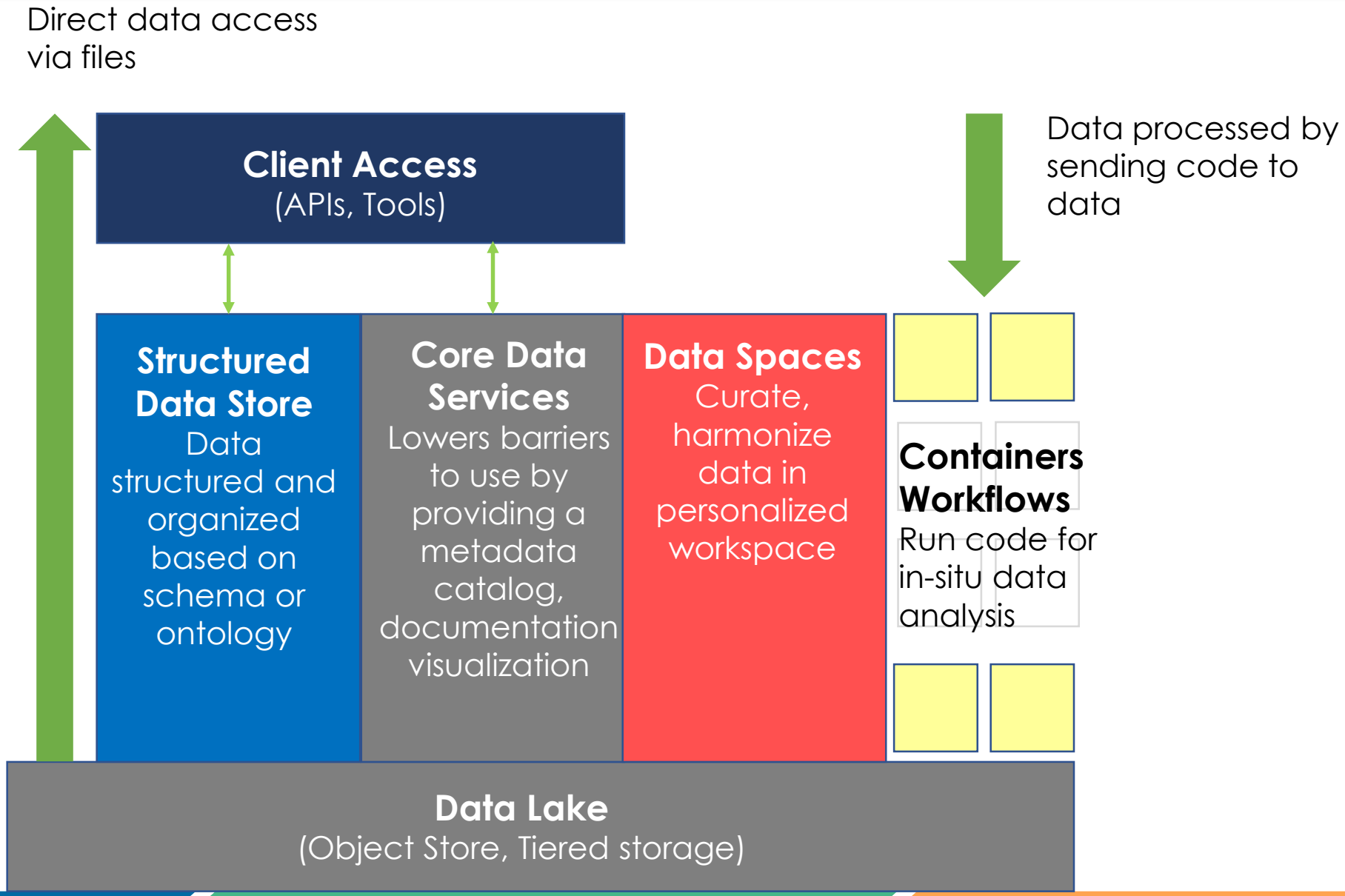
'the people and technologies collecting, handling, and using the data and the interactions between them" (Parsons et al 2011)

# MAAP Data Ecosystem Architecture

Data Lake: large repository of heterogeneous raw data (Sawadogo et al.)

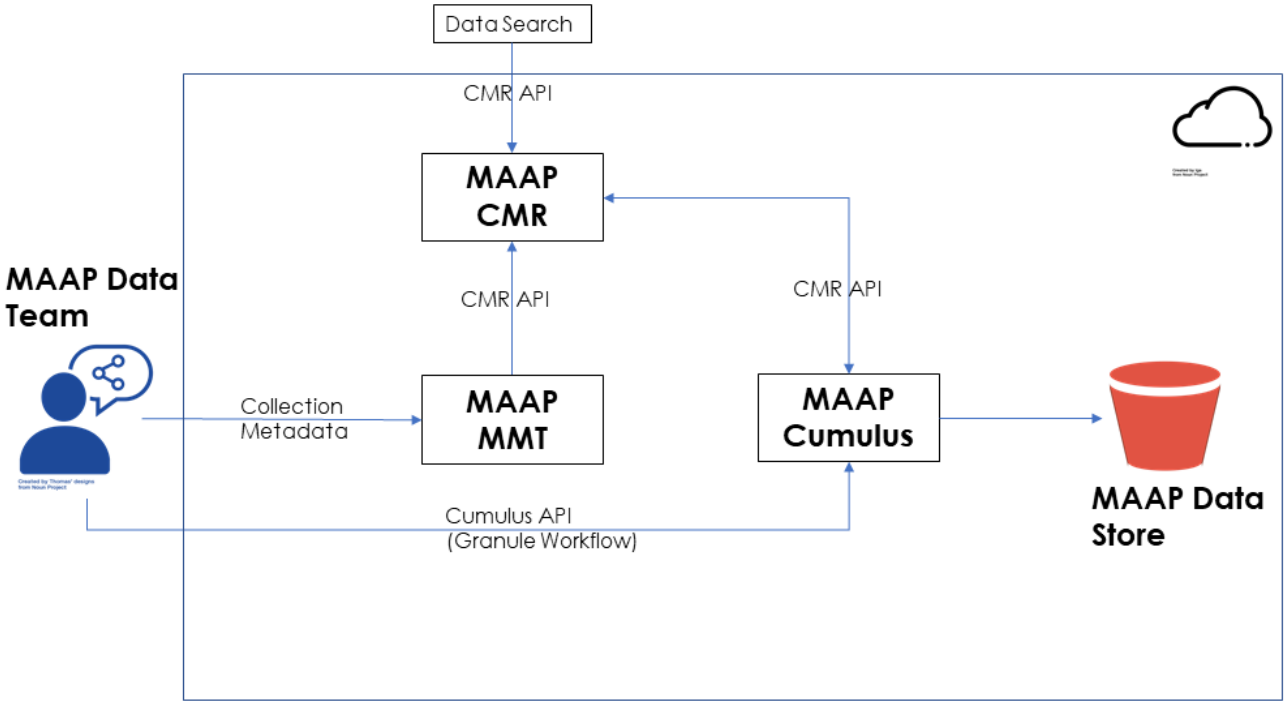
Data spaces highly coupled to containers and workflows

Want to minimize direct file access



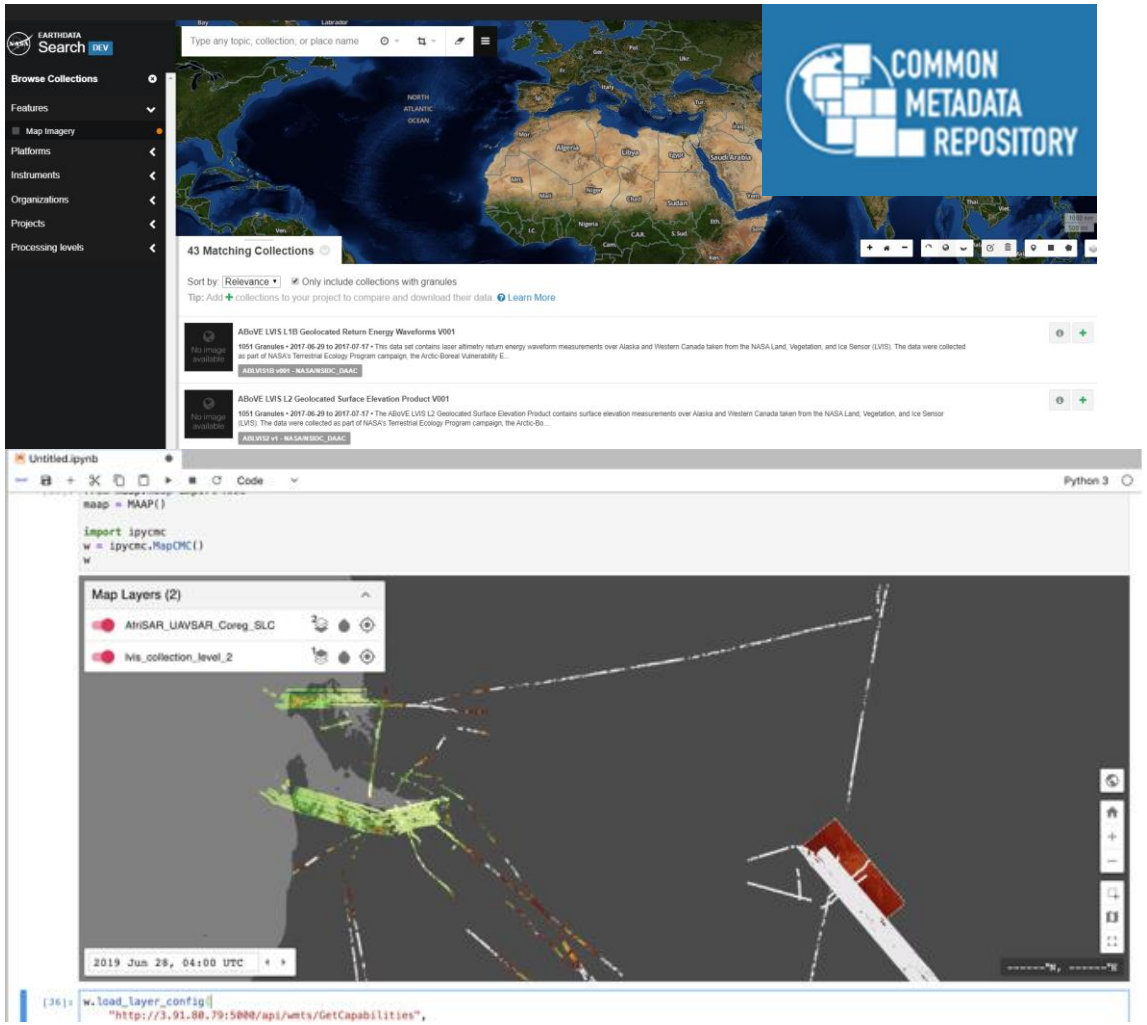
# MAAP Data Lake

- Data publication process into data lake similar to those followed by NASA's archives
  - Over ***30 datasets*** ingested for pilot MAAP
  - Data products identified by SMEs
- Reuses open source components developed by NASA's ESDIS project
  - Data ingested into MAAP data lake enabled by Cumulus – ***available on the cloud***
  - Metadata Management Tool to author and curate metadata
  - Common Metadata Repository to facilitate discovery of objects in the data lake



# MAAP Core Data Services

- Discovery of biomass relevant data via a centralized catalog
  - ESA and NASA are contributing metadata to a single repository (CMR)
  - Meta(data) may be discovered via an API in the data spaces environment or via the Earthdata Search client
- Additional metadata information provided to support biomass search needs
- Other core services include:
  - Visualization
    - Fast browse capabilities
  - Documentation
    - Links to data documentation, relevant publications



# Connecting Data Spaces to Core Services

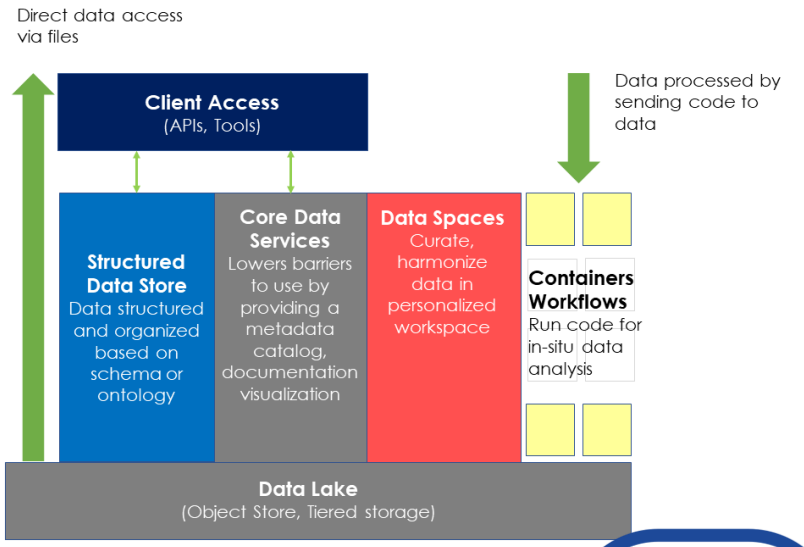
Users leverage the data lake and private data spaces to run analysis at scale via containers or workflows

MAAP enables quick & easy sharing of data from a user's data space to the broader data ecosystem

- Users can share data with select collaborators
- Share data more broadly from their private workspace to the MAAP data lake and CMR catalog so users can discover it

***New Data Source***

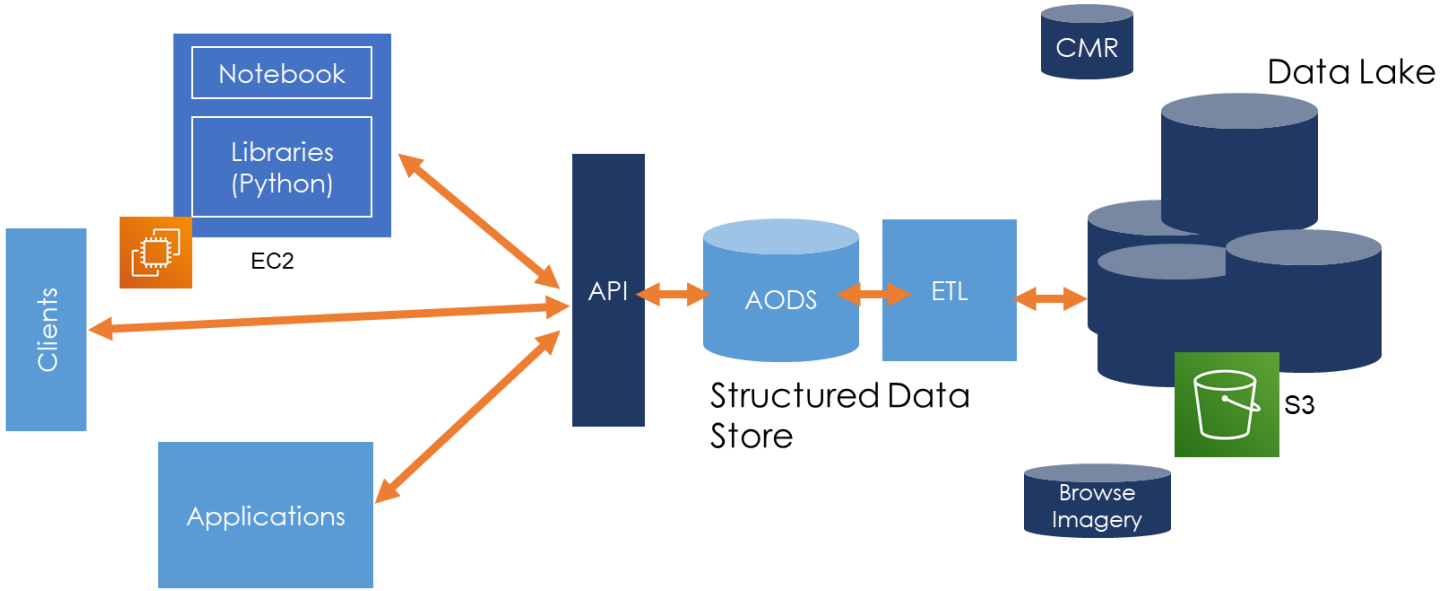
Requires data stewardship and corresponding core services for user shared data

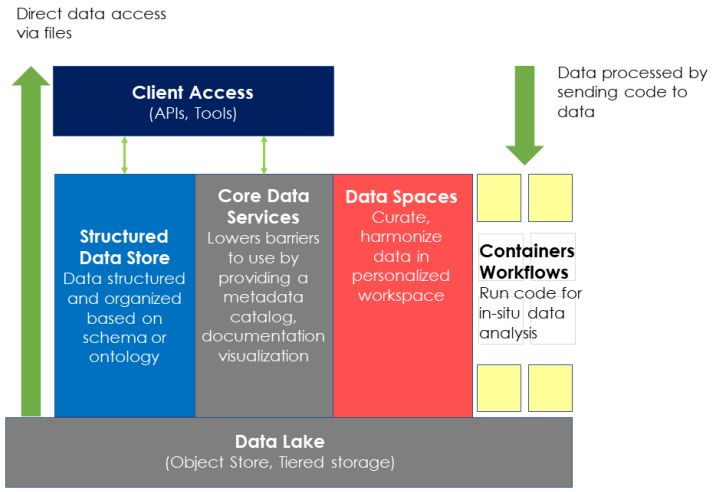



Created by Thomas' designs from Noun Project

# MAAP Structured Data Store

- To continue to evolve, MAAP will also be exploring data engineering through offering structured data stores
  - Optimized for big data analysis tools
  - Preprocessed to meet goals
  - Focus on improved/efficient performance
- Current: Postgres database for cal/val data
- Future: Analytics Optimized Data Stores (AODS) and other solutions



# Future Work: MAAP User Shared Software

- New core service - encourage sharing of algorithms and software to the broader MAAP community
- Create metadata to support sharing of and creating documentation of algorithm methodology
  - Scientific and mathematical rationale
  - Algorithm Theoretical Basis Documents (ATBDs) or similar
- Create metadata to support sharing of algorithm implementation software
  - Document inputs, outputs, processing steps, computation needed
- Metadata to be stored in MAAP CMR to facilitate discovery


### 3.2 Mathematical Theory

The orbital characteristics of the proposed NASA HyspIRI (Hyperspectral InfraredImager) satellite were used to obtain the Sun zenith and az-imuthal angles at the time the sensor would fly over a point at (latitude, longitude) = (28.75N, 158.00 W) on ***June 21.***

#### 3.2.1 Assumptions

A coupled HydroLight-MODTRAN ocean-atmosphere radiative transfer code was used to compute the in-water and atmospheric radiances both justabove the sea surface and at the top of the atmosphere. (HydroLight is an under-water radia-tive transfer code.)

### 3.3 Algorithm Input Variables

| Name | Unit |
|---|---|
| total Rayleigh radiance at the TOA | rad |

### 3.4 Algorithm Output Variables

| Name | Unit |
|---|---|
| TOA radiance due to scattering by aerosols only Output Variable | Rad2 KHz |

# Discussion

- To be a true data ecosystem that supports open science, MAAP will need to continue to adapt and evolve
  - Extensible to new technologies, changes in data distribution methods
  - New community research needs
- Incentives, recognition or credit in a collaborative platform
  - DOIs for data as a form of recognition
  - Since science can happen using one or multiple parts of the data ecosystem, need to consider giving credit not just for data
- In the 2.0 open science era
  - Technology will continue to evolve and be more widely adopted
  - Data discovery, interoperability, accessibility may look quite different
  - ***Best practices at data repositories will need to continually evolve to support these changing needs and to support the broader open science movement***
    - ***MAAP explores both the technology and data repository best practices***

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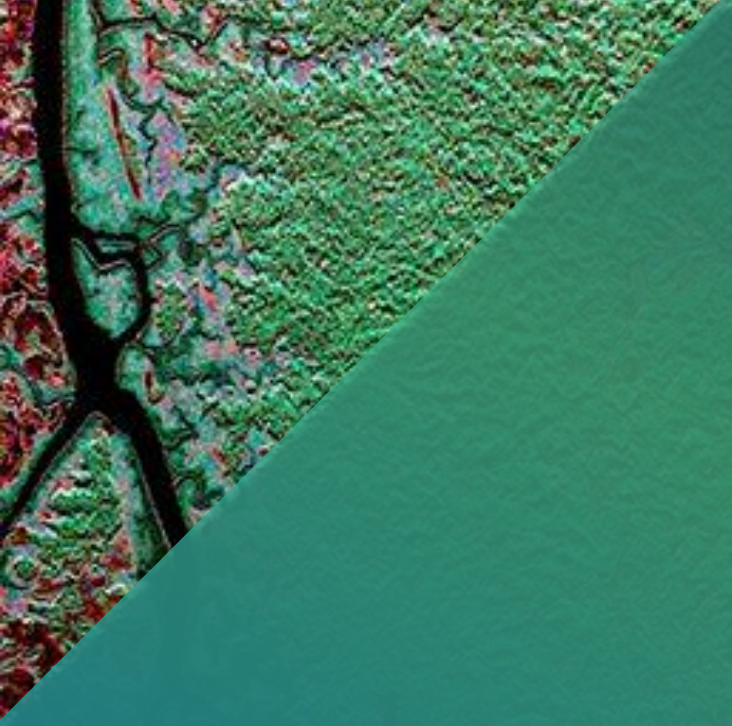

# Questions?

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