# Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness Feedback

Presented at GSAW 2016

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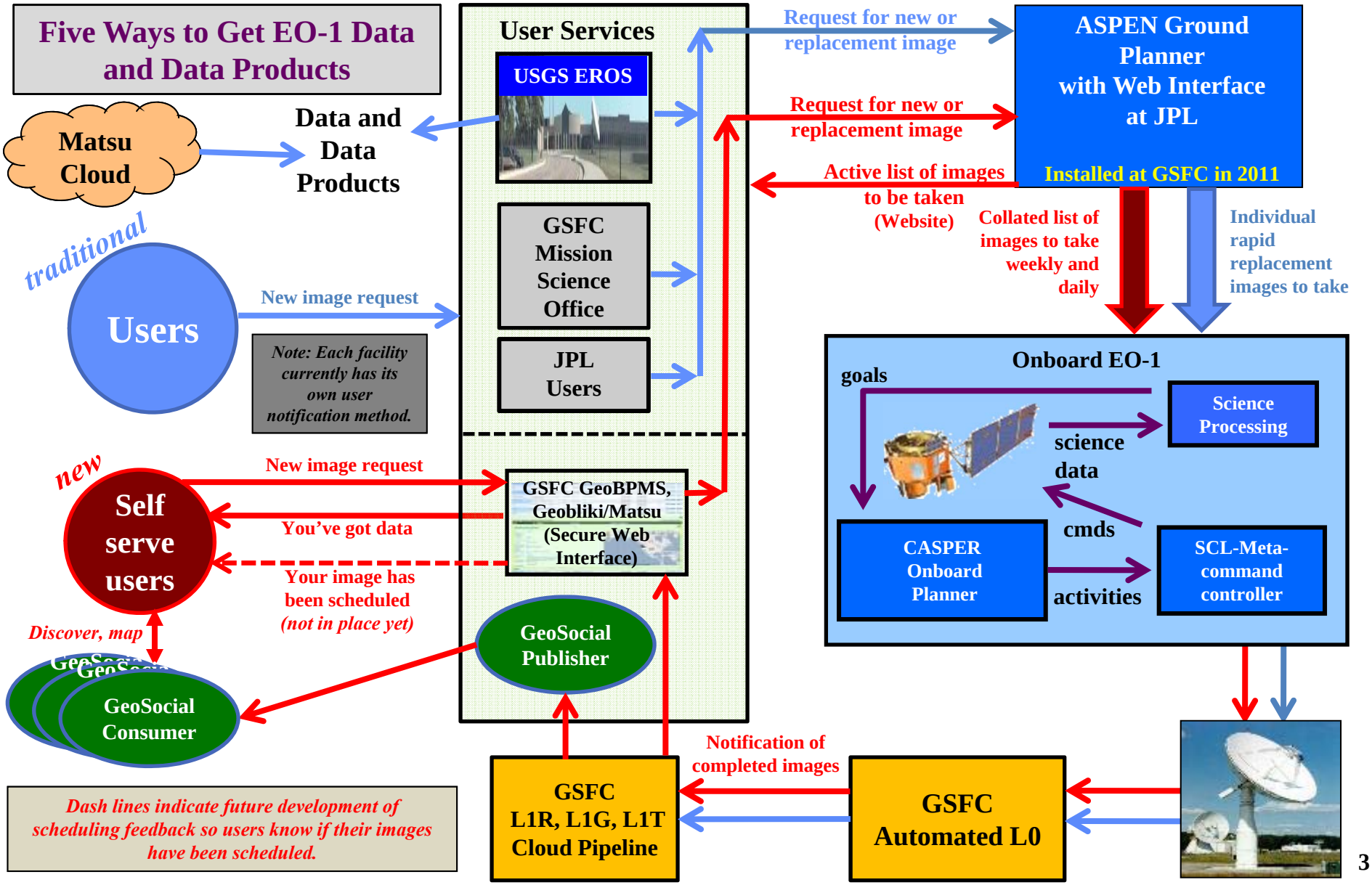
# Overview of Features

- Closed loop satellite autonomy closes the gap between the users and the assets
- Base layer is distributed architecture based on GMSEC bus so each asset still under independent control
- Situational awareness provided by middleware layer through common application programmer interface to GMSEC components developed at GSFC
- User setup their own tasking requests, receive views into immediate past acquisitions in their area of interest, and into future feasibilities for acquisition across all assets
- Automated notifications via pub/sub feeds returned to users containing published links to image footprints, algorithm results, and full data sets
- Theme-based algorithms available for on-demand and processing

# Example Ground System Architecture (NASA EO-1) for Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness Feedback

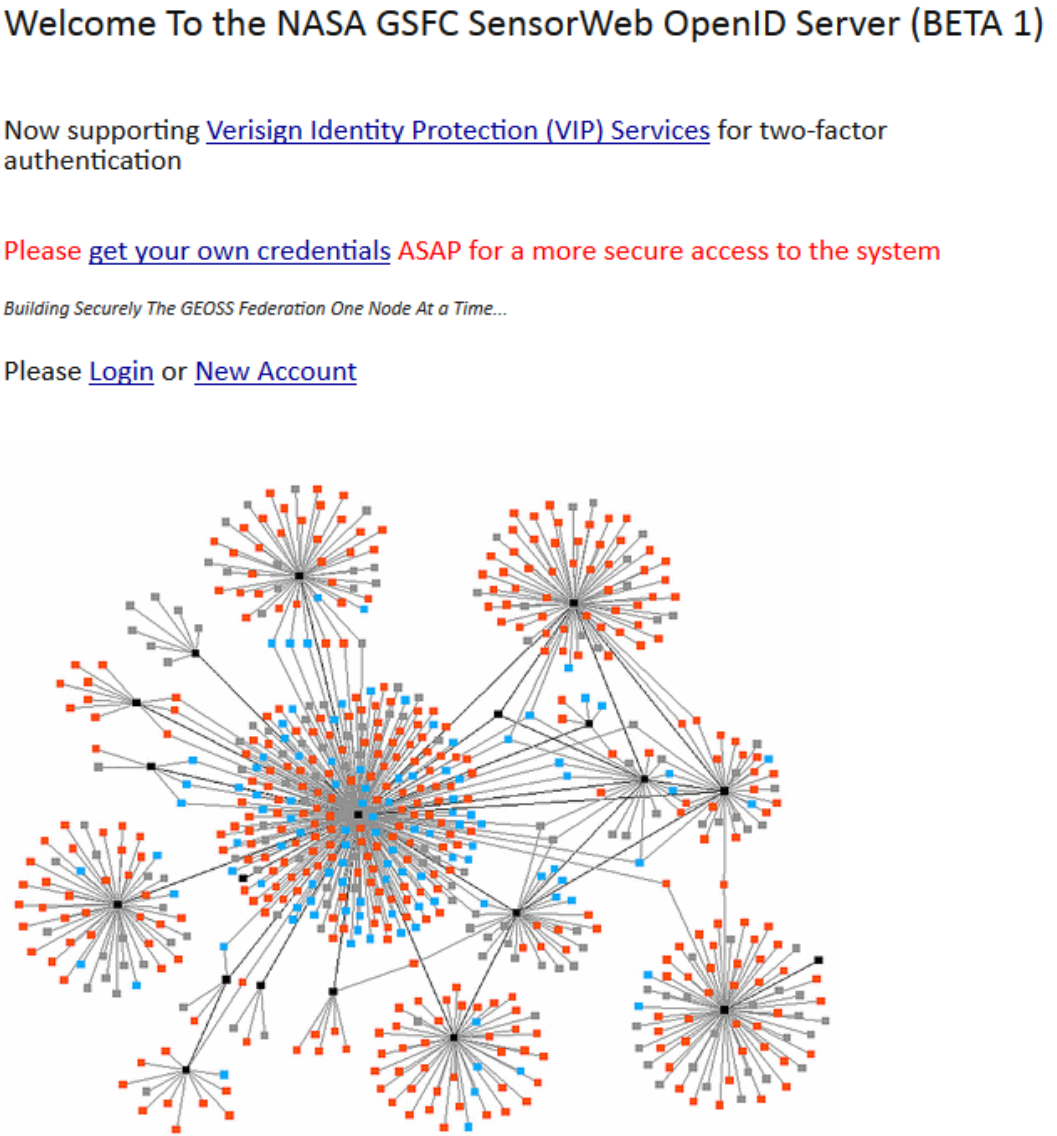


# Distributed Architecture on GMSEC Bus

- Middleware services provide rest-ful API (not SOAP-WSDL interface)
- Nothing is centralized so no single point of failure
- Based on free-ware or open-source tools under the hood so minimal license fees
- Client workflows are orchestrated in javascript or Python using browser on user platform
- Servers run on Linux

# Single Sign-On to All Middleware Services

- Security for access to services should be single sign-on handled by a distributed network of security servers that allow users to sign on once, then as they access other services in the network, those services verify with the security servers that the user is allowed to access and perform certain functions.
- This should apply not only to human interactions with the system, but with delegated authority to have machine-to-machine automated interactions on the users behalf.



# Target Identification and Submittal

- Users setup their own target requests using either coordinate entry, map box, or geonames (similar to an archive search tool)
- Users view their target requests as footprint locations on a map tool
- In-view dates and acquisition times for the target requests are automatically generated as feasibilities for all satellite assets going out at least 5 days
- Total column cloud predictions for each target in-view time and footprint location automatically supplied and updated every 3 hours going forward about 3 days
- Users are made aware of asset engineering activities that could block their request submittal from being executed
- Users view competing requests from other users to be able to judge likelihood of acquisition in support of task submittal decision making
- Near-term target requests are submitted to the scheduling system of each asset and the status of each request is maintained and visible to the users (status = submitted, scheduled, uplinked, acquired, downlinked, posted)
- Setup of a user target request automatically generates a subscription to receive notifications of data receipt for all images acquired in that target request area
- (See next page for example display)

# Sample User Target Setup



## Scenario/Campaign Entries

Search Create New

| Name | Content | Theme | User | Scenario Requests | Created At | Updated At | Weight | |
|---|---|---|---|---|---|---|---|---|
| South America Science 2016 | South America Science 2016 | air | sfrye | King Sejong Station site , La Ciguena Santa Fe, Sinop-Mato Grosso, ... | 01/26/2016 02:48 PM | 01/26/2016 02:48 PM | 0.0 | Edit Delete Show |
| Kwando River Blockage | Kwando River Blockage Namibia/Angola border | flooding | sfrye | Kwando River Blockage | 01/19/2016 01:52 PM | 01/19/2016 01:52 PM | 0.0 | Edit Delete Show |
| Argentina Floods 20160105 | Charter Activation for Argentina Floods 20160105 | flooding | sfrye | Formosa Argentina 20160105 Charter, Asuncion Argentina 20160105 Charter | 01/06/2016 07:07 PM | 01/06/2016 07:07 PM | 0.0 | Edit Delete Show |

Scenario/Campaign Tasking Requests for Argentina Floods 20160105

Search Create New

| Id | Name | Content | Geolocation | Daynight Time | Center | Duration | Scenario Feasibilities | Scenario Requests Tasks | |
|---|---|---|---|---|---|---|---|---|---|
| 5307 | Asuncion Argentina 20160105 Charter | Asuncion Argentina 20160105 Charter | -25.3, -57.78 | day time | Hyperion | 12s | , , | - | Edit Delete Show |
| 5306 | Formosa Argentina 20160105 Charter | Formosa Argentina 20160105 Charter | -26.158, -58.265 | day time | Hyperion | 12s | , , | - | Edit Delete Show |

2 Found

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mississippi River 20151229 | Mississippi River 20151229 | flooding | sfrye | Cape Girardeau MO 20151229, Vicksburg MS 20151229, St. Louis 20151229, ... | 12/30/2015 01:09 AM | 12/30/2015 02:15 PM | 0.0 | Edit Delete Show |
| Garland Texas 20151227 | Garland Texas 20151227 | flooding | sfrye | Garland Texas 20151227 | 12/28/2015 03:19 PM | 12/28/2015 03:19 PM | 0.0 | Edit Delete Show |
| Holly Springs MS 20151223 | Holly Springs MS 20151223 | flooding | sfrye | Holly Springs/Ashland MS 20151223, Booneville MS 201512/23 | 12/24/2015 07:28 PM | 12/24/2015 07:28 PM | 0.0 | Edit Delete Show |
| Shenzen China Landslide | Shenzen China Landslide 20151221 | landslide | sfrye | Shenzen China Landslide20151221 | 12/21/2015 09:26 PM | 12/21/2015 09:26 PM | 0.0 | Edit Delete Show |
| Phillippines Typhoon Melor | Phillippines Typhoon Melor 20151214 | flooding | sfrye | Phillippines Typhoon Melor 20151214, Phillippines Typhoon Melor Naga, Phillippines Typhoon Melor Manila | 12/14/2015 02:07 PM | 12/14/2015 02:07 PM | 0.0 | Edit Delete Show |
| Nevado del Ruiz, Colombia | Volcan Nevado del Ruiz activity | volcano | eanderson | Nevado del Ruis activity | 12/10/2015 08:13 PM | 12/11/2015 06:04 PM | 0.0 | Edit Delete Show |

# Awareness for Timing of Delivery

- Users know in advance on a constantly updated basis exactly when to expect data from the next day's acquisitions from all satellites
- Image delivery availability and quality assessment used as input to the planning/scheduling for the following day's collections
  - For example, Landsat-8 data is acquired and assessed in time to affect decision about tasking for next EO-1 in-view target-by-target



## Scenario/Campaign Tasking Opportunities

Search Update Forecast

| Scenario Name | Theme | Id | Request | User | Org | Asset | Instrument Center | Date | Weather | Score | Tasks | Veto | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belm Germany | technology | 79218 | Osnabrück Germany | bsiegmann | IGF Osnabrueck | EO-1 | hyperion | 2016-02-03T08:35:00Z | 21 | 0 | EO11960242013112110KF(NOT FOUND), EO11960242013125110KF(rejected), EO11960242013159110KF(NOT FOUND) | - | Veto Task Edit Delete Show |
| West Africa - Rangeland | tropical | 79599 | Nazinga | Sumisu | UNKNOWN | EO-1 | hyperion | 2016-02-03T08:46:00Z | 0 | 16 | | - | Veto Task Edit Delete Show |
| West Africa - Rangeland | tropical | 79276 | Aniabiisi | Sumisu | UNKNOWN | EO-1 | hyperion | 2016-02-03T08:47:00Z | 0 | 16 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79397 | Santarem-Km67-Primary Forest | sfrye | SGT | EO-1 | hyperion | 2016-02-03T12:07:00Z | 90 | 15 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79370 | Sinop-Mato Grosso | sfrye | SGT | EO-1 | hyperion | 2016-02-03T12:09:00Z | 32 | 15 | | - | Veto Task Edit Delete Show |
| Argentina Floods 20160105 | flooding | 79083 | Asuncion Argentina 20160105 Charter | sfrye | SGT | EO-1 | hyperion | 2016-02-03T12:13:00Z | 98 | 15 | | - | Veto Task Edit Delete Show |
| Argentina Floods 20160105 | flooding | 79072 | Formosa Argentina 20160105 Charter | sfrye | SGT | EO-1 | hyperion | 2016-02-03T12:13:00Z | 100 | 15 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79361 | La Ciguena Santa Fe | sfrye | SGT | EO-1 | hyperion | 2016-02-03T12:14:00Z | 13 | 15 | | - | Veto Task Edit Delete Show |
| Hong Kong, Shing Mun | tropical | 79229 | Fluorescence mapping | syedirteza | UNKNOWN | EO-1 | hyperion | 2016-02-04T01:07:00Z | 42 | 0 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79415 | Panderos | sfrye | SGT | EO-1 | hyperion | 2016-02-04T11:08:00Z | 70 | 15 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79434 | Eucaliptus Sao Paulo | sfrye | SGT | EO-1 | hyperion | 2016-02-04T11:10:00Z | 99 | 15 | | - | Veto Task Edit Delete Show |
| South America Science 2016 | air | 79476 | Atlantic Forest Sao Paulo | sfrye | SGT | EO-1 | hyperion | 2016-02-04T11:10:00Z | 79 | 15 | | - | Veto Task Edit Delete Show |

# Rapid Assessment of Recent Images

- User is provided rapid assessment immediately after new images have been taken to visualize the image quality/cloud cover
  - Geolocated scene overlays of recently acquired data are published and notifications automatically fed to users in a compact file format that is appropriately named (asset ID, date, time, center-point coordinates, relevant geonames)
- Users are sent the image overlays and combine them with planned future footprints without having to search for them
  - Each asset posts image data in a centralized system, but users have particular information delivered to their consumer client on a distributed basis from regional product publishers
- The users can track which targets have been acquired vs. which ones aren't yet including not only the user's own target requests, but all images in the users' area of interest regardless of who submitted them
  - If an image was just taken of an area that fulfills the needs of some other user that was about to submit it for scheduling, then that user doesn't have to submit their request

# Recent Acquisition Notification Process

**Acquisition notifications are sorted with links to products**

**Upcoming collections are displayable on a map and on a timeline**

EO1 Task Requests

Things you can do

All Tasks  All Tasks for past three months  All Tasks for past year

Stuart,

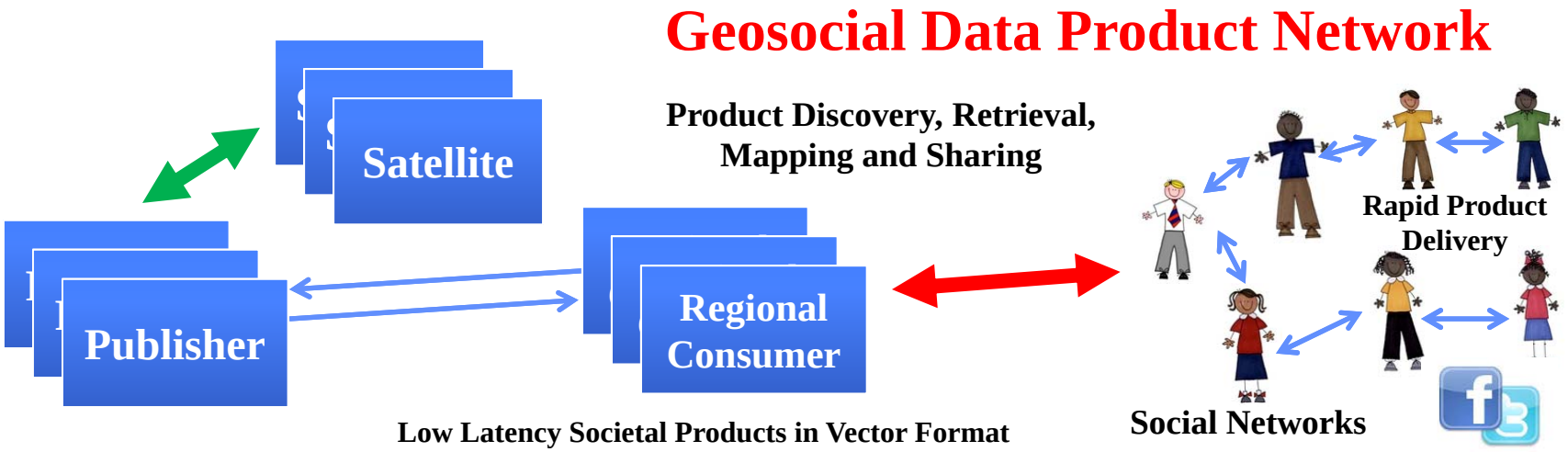
**EO1 Task Requests are:**

| Taskid | Login | Acquisition Time | DOY | Scene ID | Lat | Long | Comments | Status |
|---|---|---|---|---|---|---|---|---|
| 5137 | sfrye | 2016-02-04T01:07Z | 035 | EO1121045201603511OKF | 22.384306 | 114.142194 | Fluorescence mapping Hong Kong country park Shing Mun | submitted |
| 5138 | sfrye | 2016-02-03T12:09Z | 034 | EO1226068201603411OKF | -11.4122916 | -55.3247 | Sinop-Mato Grosso Sinop-Mato Grosso | submitted |
| 5136 | sfrye | 2016-02-02T14:41Z | 033 | EO1020046201603311OKF | 20.0929 | -89.5639 | Kaxil Kiuic Kaxil Kiuic | submitted |
| 5135 | sfrye | 2016-02-02T11:34Z | 033 | EO1221071201603311OKF | -15.95 | -47.8666 | Brasilia - Campo Sujo Quadrienal and Bienal Tardia Brasilia - Campo Sujo Quadrienal and Bienal Tardia | submitted |
| 5134 | sfrye | 2016-02-01T14:08Z | 032 | EO1016052201603211OKF | 11.0166 | -85.5 | Los Inocentes Los Inocentes | finished |
| 5132 | sfrye | 2016-01-31T12:04Z | 031 | EO1227080201603111OKF | -29.264 | -61.028 | La Ciguena Santa Fe La Ciguena Santa Fe | finished |
| 5133 | sfrye | 2016-01-31T08:36Z | 031 | EO1195052201603111OKF | 11.186017 | -1.568458 | Nazinga Model important forage characteristics | finished |
| 5131 | sfrye | 2016-01-30T12:59Z | 030 | EO1002060201603011OKF | 0.212333 | -66.76473 | Sao Gabriel da Cachoeira Sao Gabriel da Cachoeira | finished |
| 5130 | sfrye | 2016-01-30T11:24Z | 030 | EO1219070201603011OKF | -14.848277 | -43.9879 | Panderos Panderos | finished |
| 5129 | sfrye | 2016-01-28T08:27Z | 028 | EO1194052201602811OKF | 10.84603 | -0.911855 | Aniabiisi Model important forage characteristics | finished |
| 5128 | sfrye | 2016-01-28T06:56Z | 028 | EO1175072201602811OKF | -17.63 | 23.16 | Kwando River Blockage Kwando River Blockage Namibia border | finished |

KML file available here

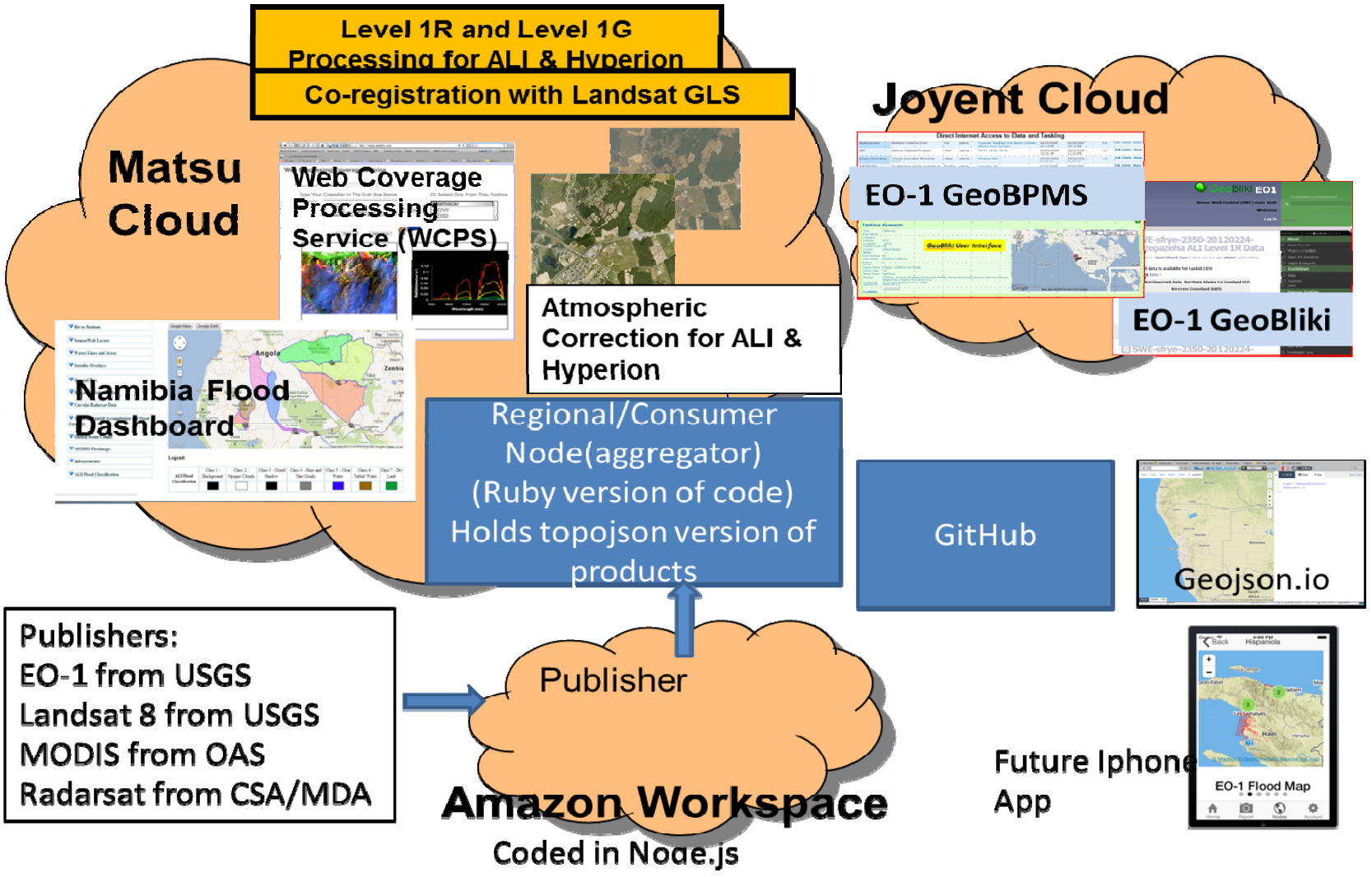
# Autonomous Delivery of Recent Acquisitions to Regional Publishers for Browse Imagery and Classification/Detection Product Processing

**Regional GeoSocial API Publisher/Consumer Network (HTML/HTTPS)**
**This is a *NEW* method to distribute EO-1 and other satellite data products in a compact vectorized format (small data size TopoJSON). The vision is to have a network of regional publishers automatically pre-generate specific satellite data products for a region and then make them available to all consumers in that region. The user obtains the data product by doing a Web browser query based on latitude-longitude. The publisher then provides the user a list of the available products in the region. The user clicks on the ones he/she wants to map and the vectorized data is downloaded to their computer, tablet, or smartphone for display. It is built in to share the products via Facebook/Twitter or other social media with a single click.**



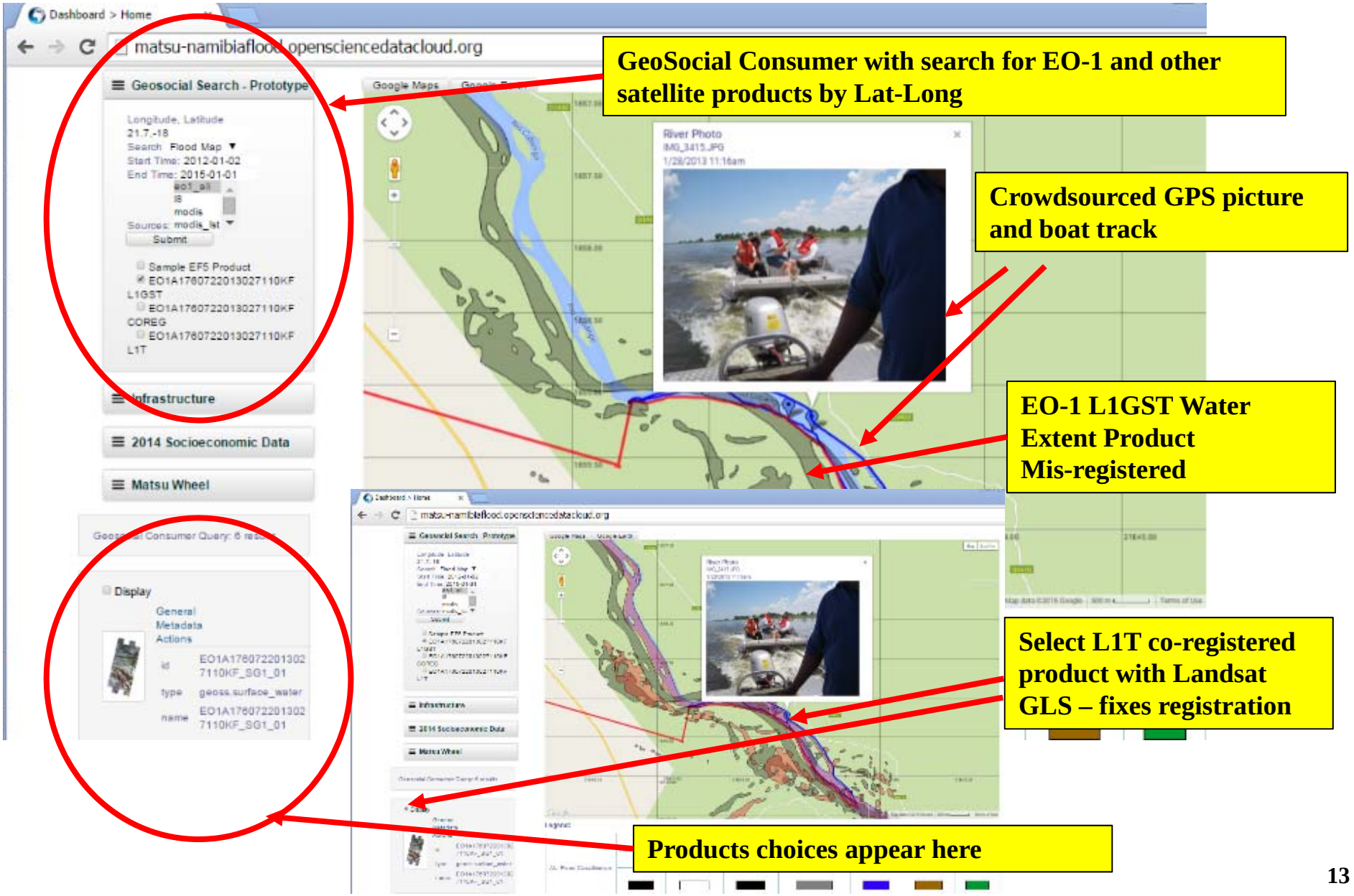
# Cloud-based Processing and Delivery Overview

**Distributed Cloud Architecture for EO-1 Data Product Distribution and Tasking Requests**



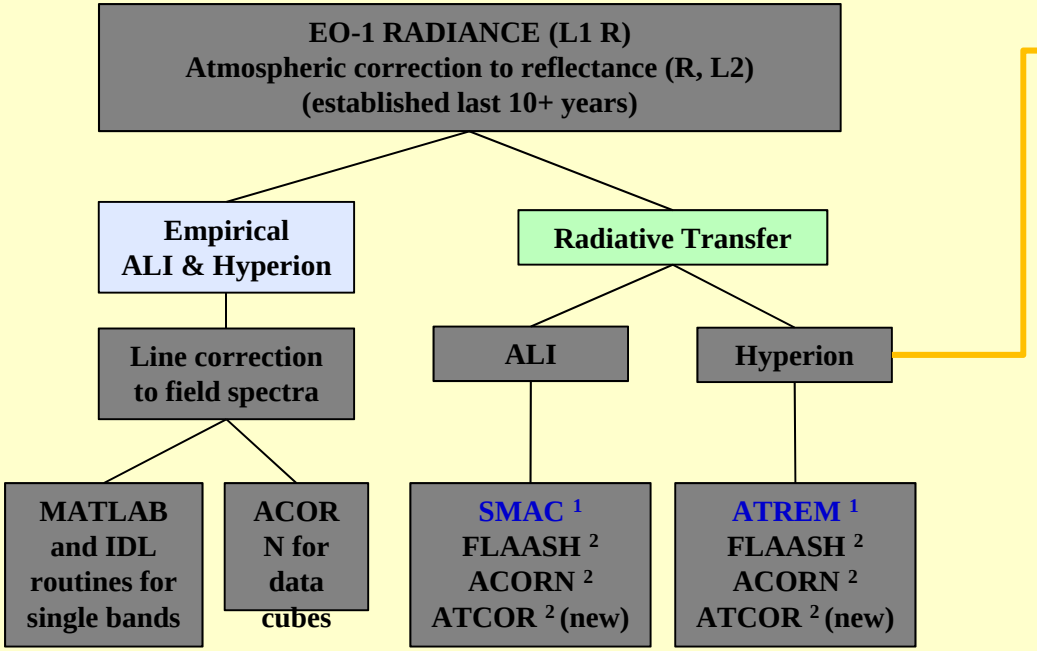
# Distribution Channel for Recently Acquired Products

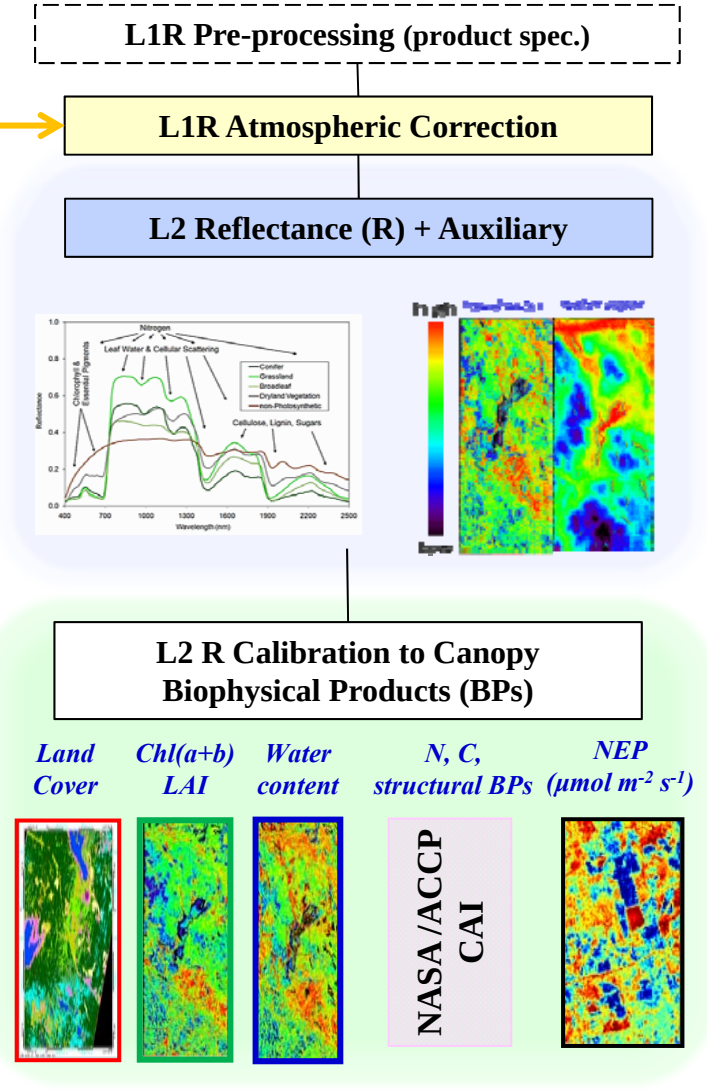
## GeoSocial API (architecture for discovery, retrieval, mapping, evaluation, and sharing)



# User Controlled On-Demand Post Processing for Detailed Evaluation

**Reflectance Processing Protocols Established for ALI and Hyperion Level 2 Products**



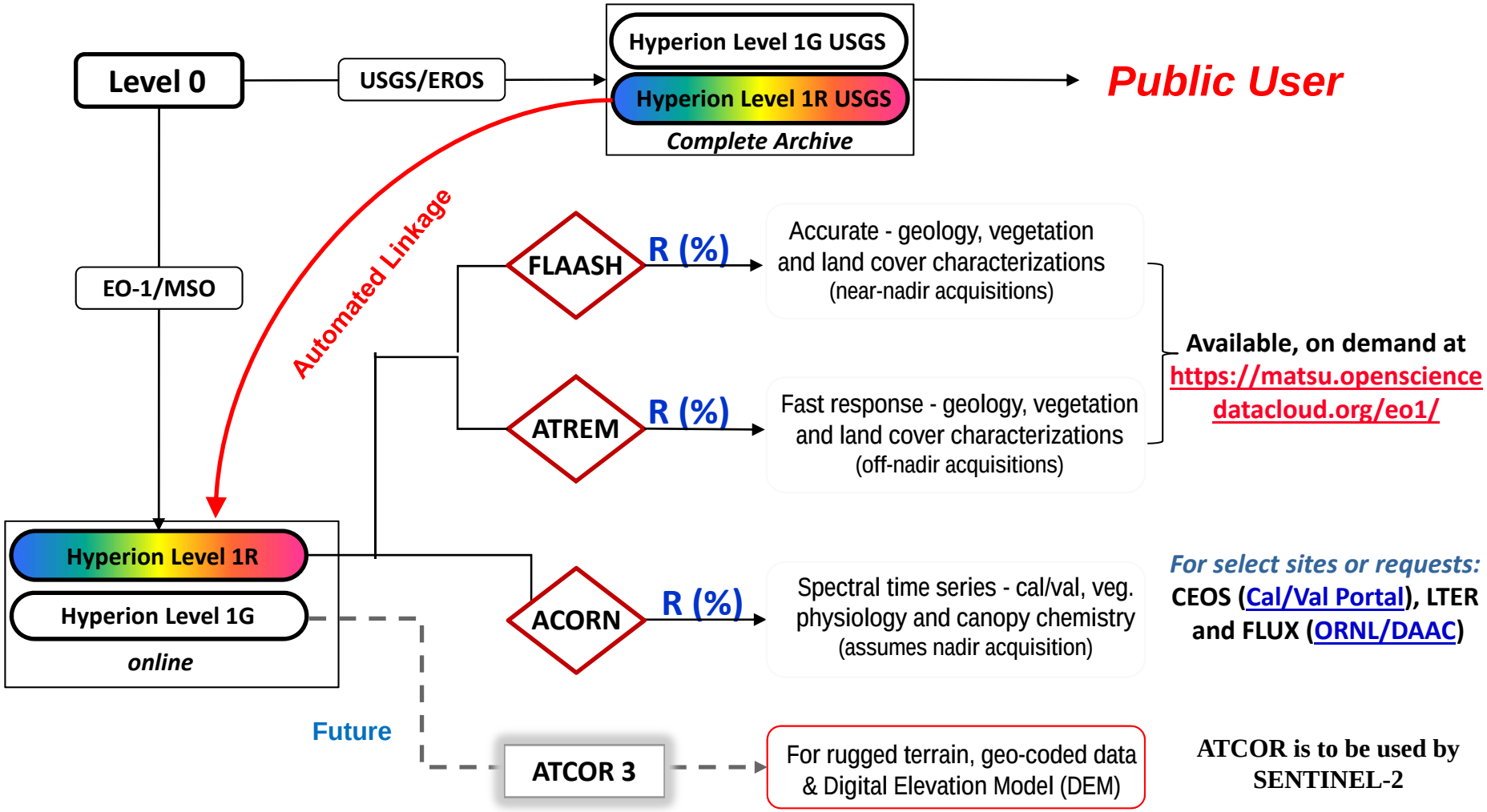





1. **6S: Second Simulation of a Satellite Signal in the Solar Spectrum.** Vermote, E.F., D. Tanre, J.L. Deuze, M. Herman, and J.J. Morcrette (1997b). Second simulation of the satellite signal in the solar spectrum, 6S: An overview, *IEEE Transactions on Geoscience and Remote Sensing*, 35:675–68.
2. **MODTRAN.** Berk, A., G.P. Anderson, L.S. Bernstein, P.K. Acharya, H. Dothe, M.W. Matthew, S.M. Adler-Golden, J.H. Chetwynd, Jr., S.C. Richtsmeier, B. Pukall, C.L. Allred, L.S. Jeong, and M.L. Hoke (1999). MODTRAN4 Radiative Transfer Modeling for Atmospheric Correction, *SPIE Proceeding, Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research III*, Volume 3756

# Algorithms for Atmospheric Correction Processing Available for On-demand User-controlled Execution

## Hyperspectral Level-2 Surface Reflectance Products




*Atmospheric CORrection (ATCOR 3)*

# Coordination of Satellite Acquisitions with Flight Campaigns
# Example: HyspIRI Preparatory Airborne Campaign


**Objectives:**

- **Acquire contemporaneous satellite images over flight boxes**

**Tactics:**

- **Satellite in-views by date and time for each box are visible to the flight team along with cloud predictions and other constraints during morning flight meeting**
- **Which flight area is to be flown today is identified in that meeting 4-5 hours prior to aerial lift-off based on cloudiness, satellite in-views, and engineering considerations**
- **Once flight box is identified, satellite target request for the selected box needs to be submitted, scheduled, uplinked, and executed within 4-5 hours to acquire data coincidentally with flight**

**Results:**

- **Maximum number of contemporaneous satellite and aerial images have been acquired**

# Thank You!

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