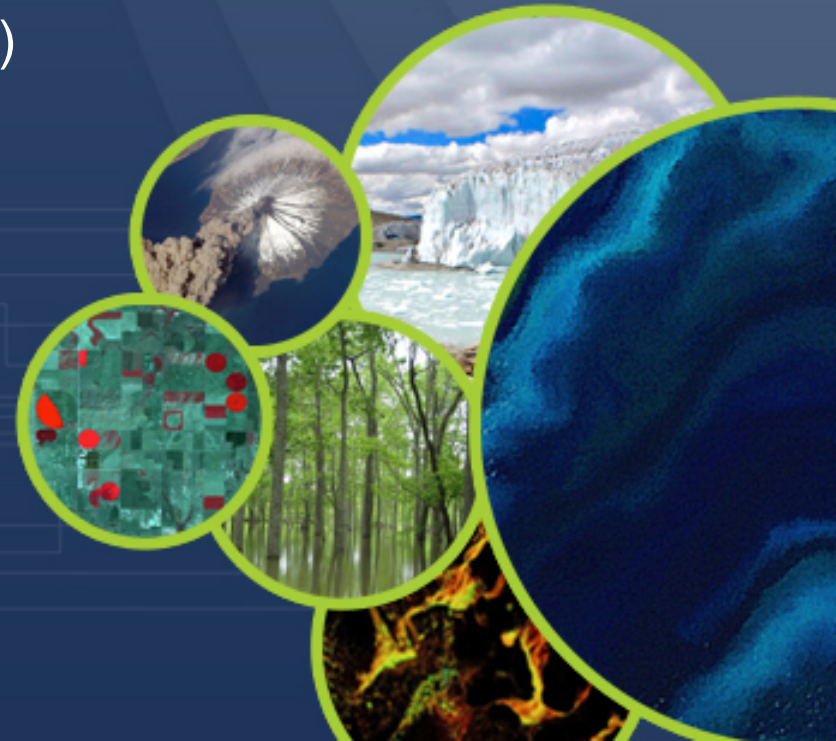


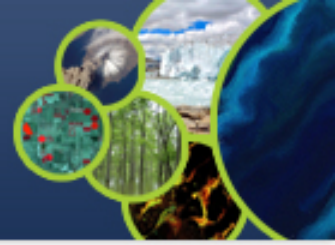


CEOS Data Cube Concept and the Colombia Prototype Project Plans

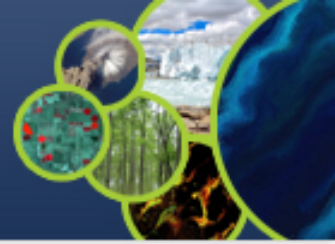
Brian Killough
CEOS Systems Engineering Office (SEO)

September 14-15, 2015
Bogota, Colombia





The Committee on Earth Observation Satellites (CEOS) serves as a focal point for international coordination and data exchange to optimize societal benefit from space-based Earth observations. CEOS represents 22 countries through its 31 space agencies and 24 associate members.



CEOS agencies collaborate on a variety of international projects that address key global issues ...

Data Access ... Promoting space data use

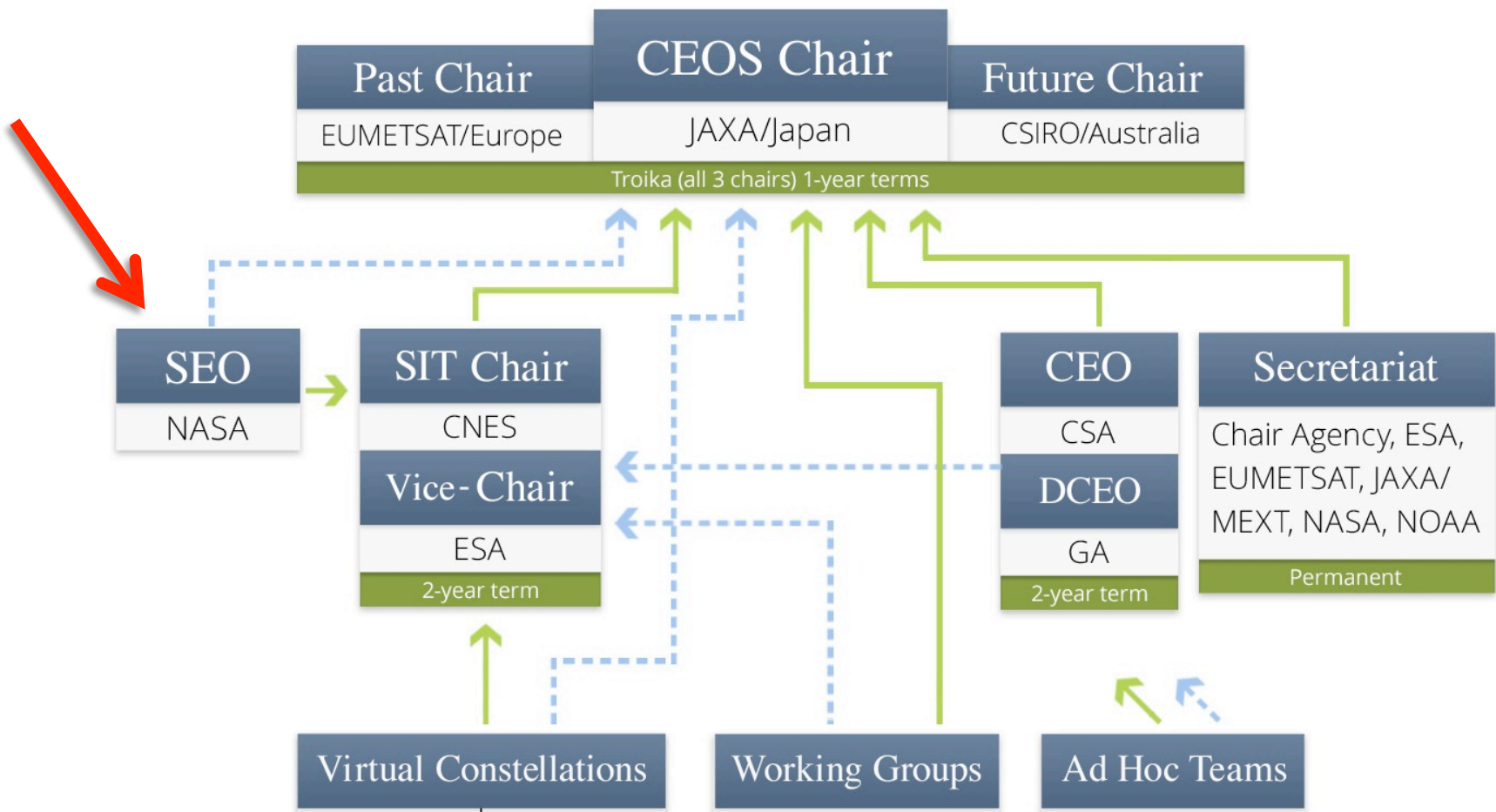
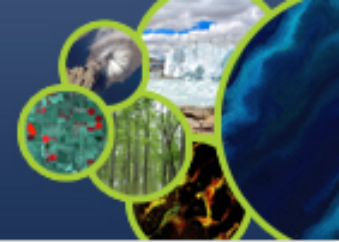
Agriculture ... Global Food Security (GEOGLAM, UN-FAO)

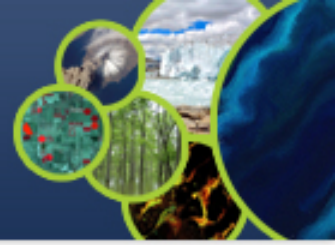
Deforestation ... Carbon and Deforestation (GFOI, UN-REDD)

Climate Change ... Global Climate Change (UNFCCC)

Disaster Management ... Floods, Earthquakes (UNISDR)







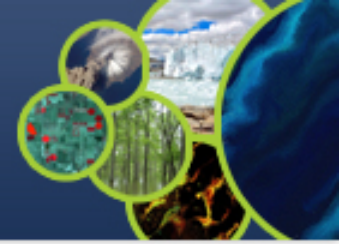
SEO = Systems Engineering Office
Funded by NASA, 100% support to CEOS

Technical Functions

- **Systems Engineering Tool Development:** COVE suite: Data Acquisition Planning, Coverage Assessment (unique, free and open tools)
- **Space Data Coordination** - GEOGLAM (Agriculture and Food Security) and GFOI (Carbon/Deforestation)
- **Special Projects** – Data Services Prototypes (e.g. Data Cubes), Data Policy Portal, Gap Analyses
- **MIM** (Missions, Instruments, Measurements) Database ... with ESA
- **ECV Database** (Essential Climate Variable) ... with NOAA, ESA, EUMETSAT

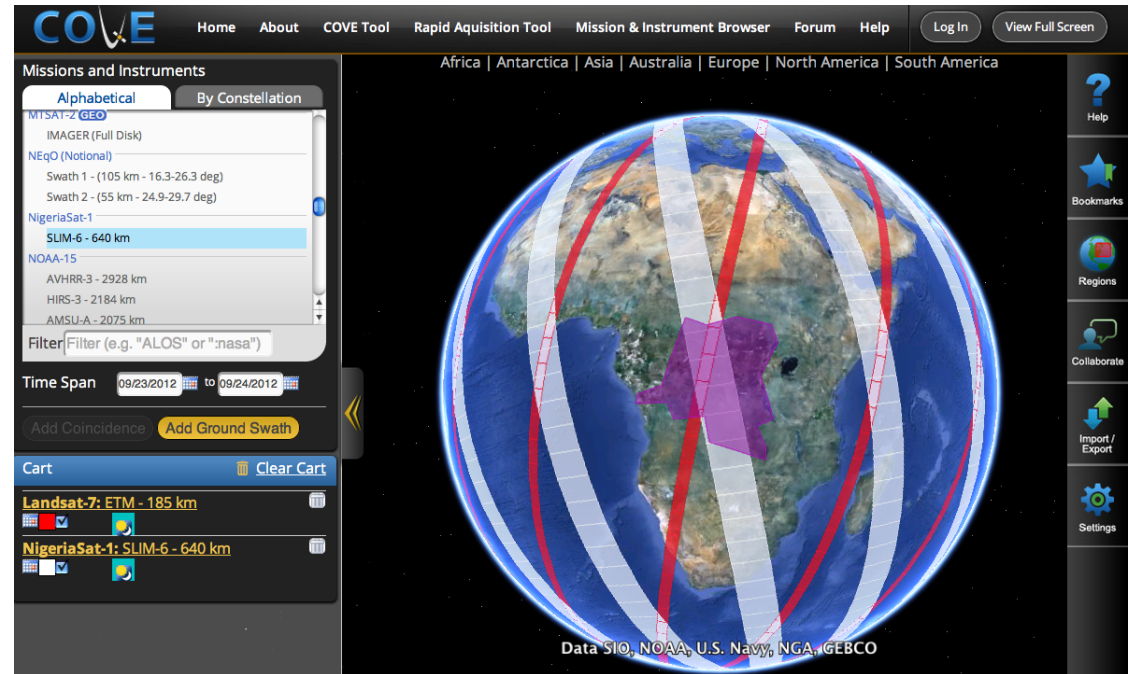
Management Functions

- CEOS Websites, Mailing Lists, Document Management System, and Deliverables Tracking Database
- Education Outreach, Training and Capacity Building

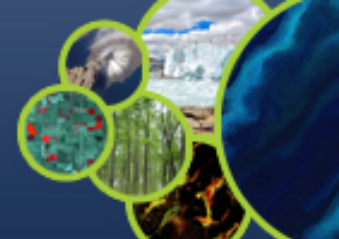


- **Free and Open** browser-based tool using **Google-Earth** to display satellite coverage swaths and calculate coincidence scene locations.
- Automated daily satellite position data from **CelesTrak**.
- Saved bookmarks and states, Google-Earth KML and Shapefile compatibility, collaborative sessions.
- Output: position, UTC time, viewing angles, solar angles, day/night, and EXCEL tables
- Large mission database:
254 missions, 692 Mission-Instrument combinations
- Data Archive Links:
Landsat 7/8, SPOT 1-6, Pleiades, Radarsat-2, ALOS-1

Calculate coincident satellite locations and past and future mission coverage.



>20,000 unique users in 2014.



January 1-8, 2014 over Africa ... Data Acquisitions

COVE

[COVE Tool](#)
[Rapid Acquisition Tool](#)
[Coverage Analyzer \(BETA\)](#)
[Mission & Instrument Browser](#)
[Help](#)

[Español \(ES\)](#)
[Log In](#)
[View Full](#)

Missions and Instruments

Alphabetical

ASTER (Full Accessible) - 711 km

MISR - 360 km

CERES - 2717 km

MODIS - 2330 km

MOPITT - 640 km

TerraSAR-X

TSX-SAR (Full Range) - 622 km

TSX-SAR (StripMap-SM) - 287 km

TSX-SAR (ScanSAR (Full Accessible 20-60 deg)) - 578 km

Filter

terr

more

Time Span

1/1/2014

to

1/8/2014

Add Coincidence

Add Ground Swaths

Add Actual Acquisitions (BETA)

Add Planned Acquisitions (BETA)

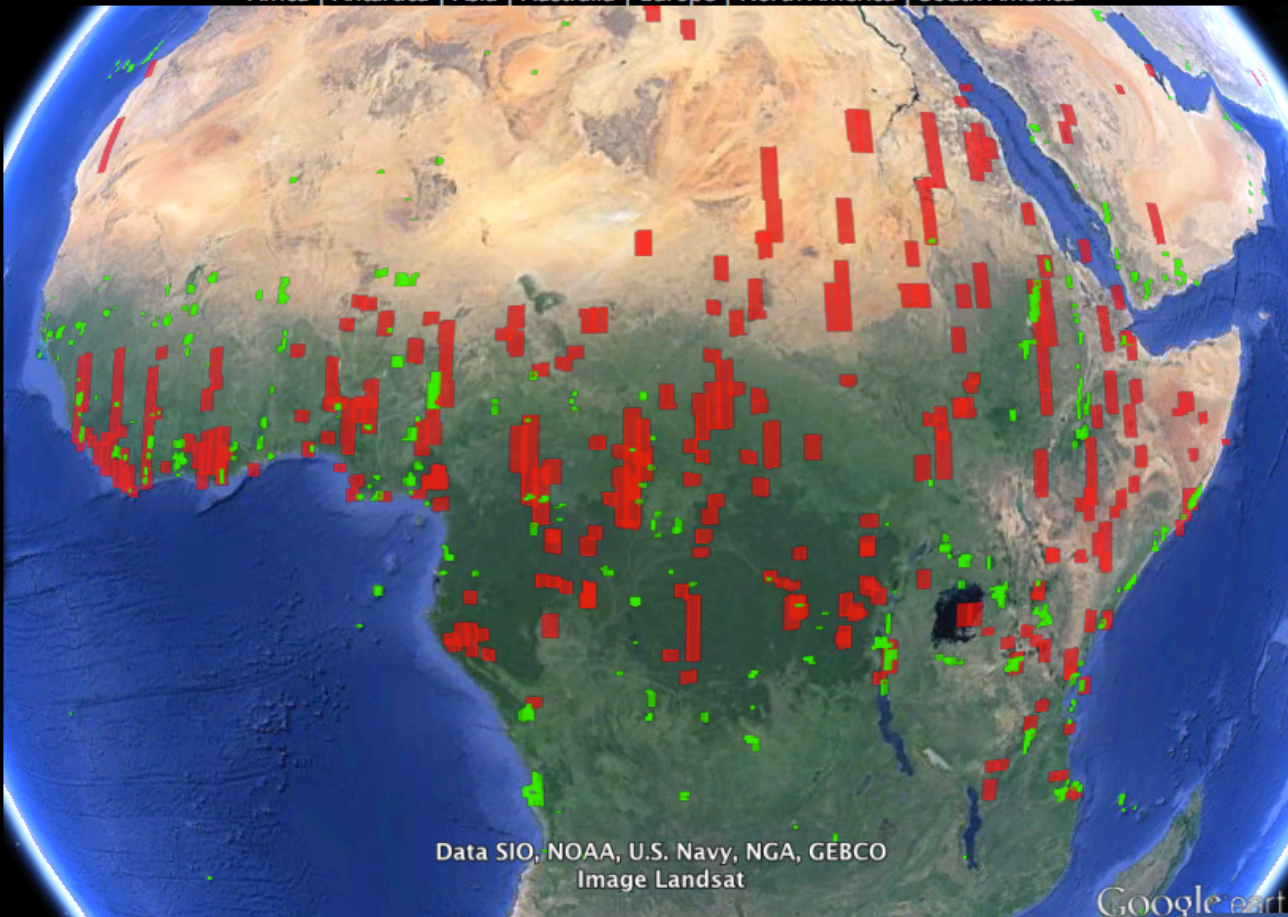
Cart

Clear Cart

SPOT-6: NAOMI (Standard) (Actual)

PLEIADES-1A: HiRI (Standard) (Actual)

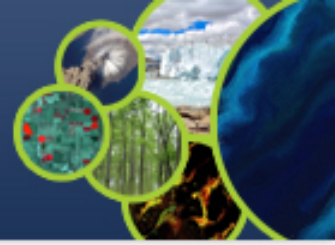
Africa | Antartica | Asia | Australia | Europe | North America | South America



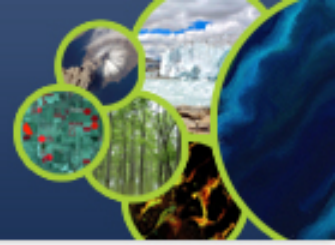
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image Landsat

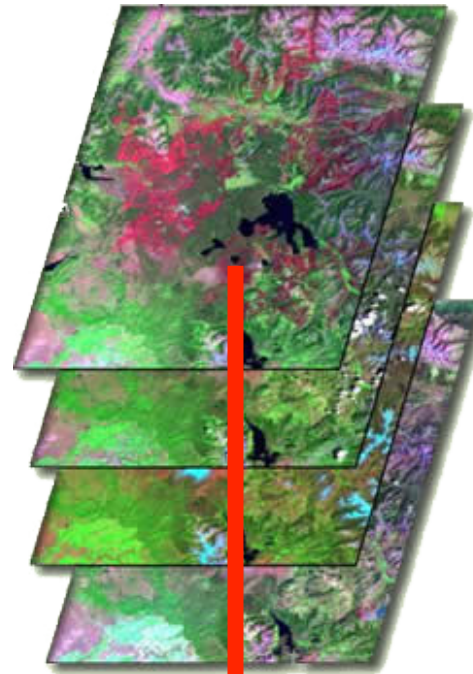
Google earth



- Developing nations do not have the infrastructure (computing storage and processing) to handle large quantities of Earth observation satellite data. They need this data to support resource monitoring, agriculture, disasters and climate change studies.
- To date, countries are spending 90% of their time acquiring and processing satellite data, compared to 10% of their time analyzing this data and supporting applications.
- CEOS is developing a solution using **Data Cubes**. Pixel information will be extracted from scene-based files and stored in a large multi-dimensional data cube. This sustainable approach supports multiple datasets over broad spatial and temporal time scales and reduces the burden on countries for data access and processing.
- Data Cubes can be hosted locally or using cloud-based storage. Internet access for developing nations is an issue. Downloading scenes using traditional methods is not often feasible. Analyses “in the cloud” will minimize bandwidth constraints.



- Proven concept in Australia by Geoscience Australia and the Australian science and research organisation (CSIRO).
- A multi-dimensional (space, time, data layers) **Data Cube** is an efficient and effective solution!
- **Shift in Paradigm** ... Pixels vs Scenes
No scenes lost. All cloud-free pixels used.
- **Analysis Ready” Data** Products vs. Unprocessed Data (leave processing to the Space Agencies).
- **Data Cube** approach supports an infinite number of applications, makes it easier for users to access and use space-based data, and allows efficient time series analyses and data assimilation.



TIME

Data Layer #1

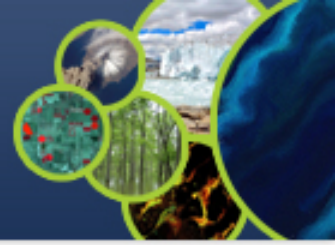
Data Layer #2

Data Layer #3

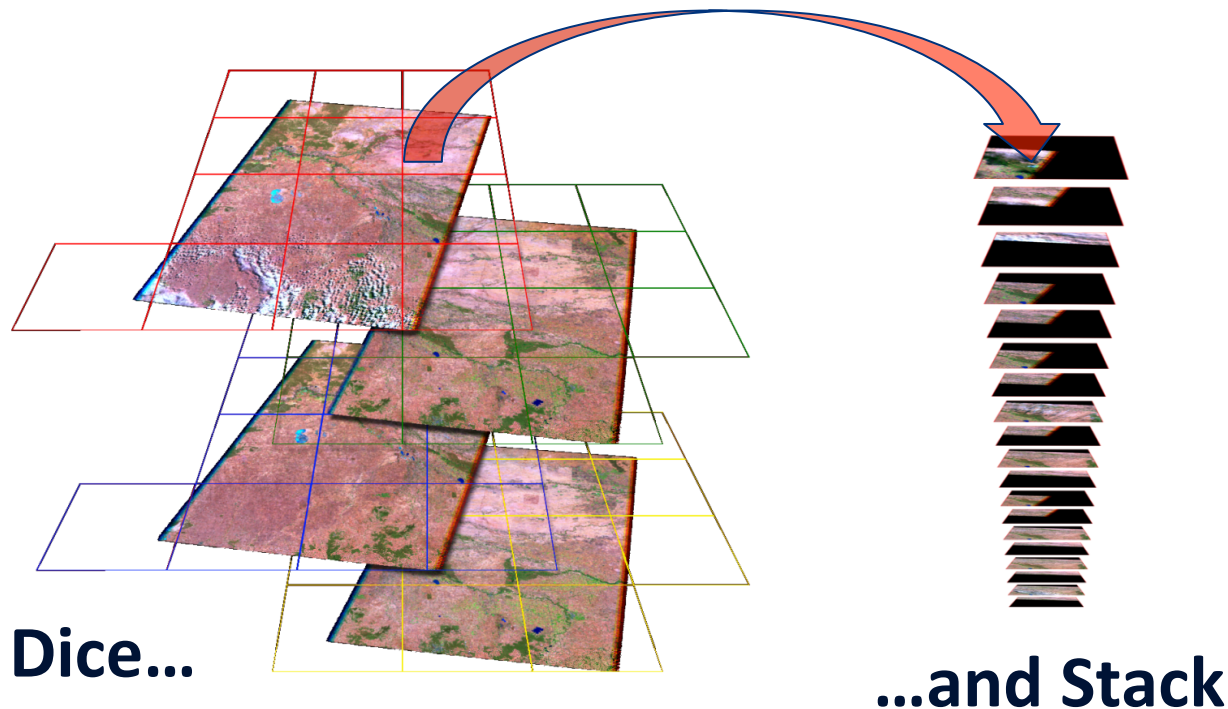
Data Layer #4

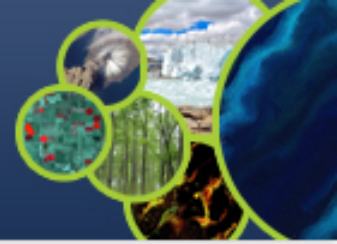


What's different about the Data Cube approach?

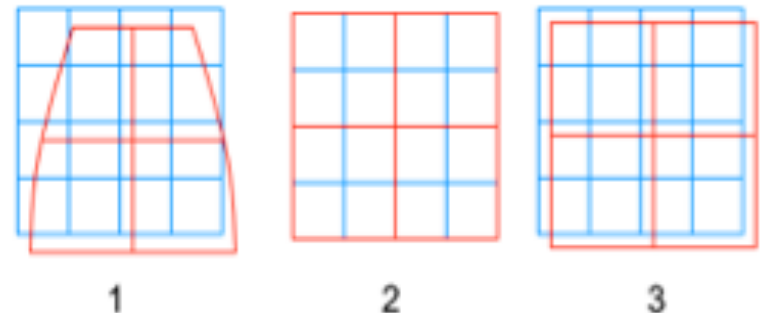
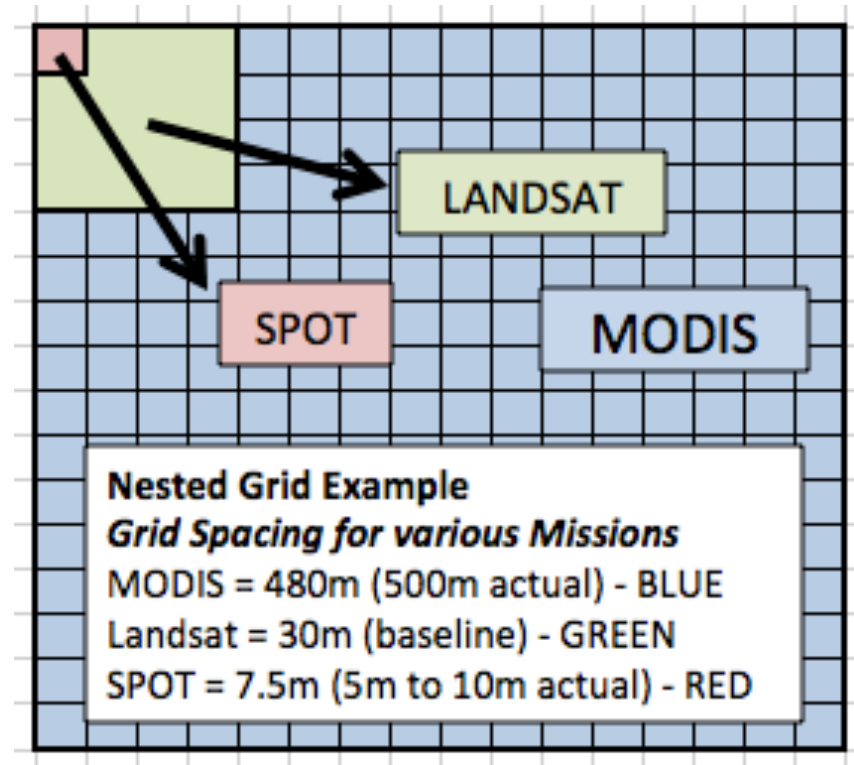


- The Data Cube arranges 2D (spatial) data temporally and spatially to allow flexible and efficient large-scale analysis.
- The “Dice and Stack” method is used to subdivide the data into spatially-regular (discrete grid), time-stamped, band-aggregated layers which can be managed as dense temporal stacks.

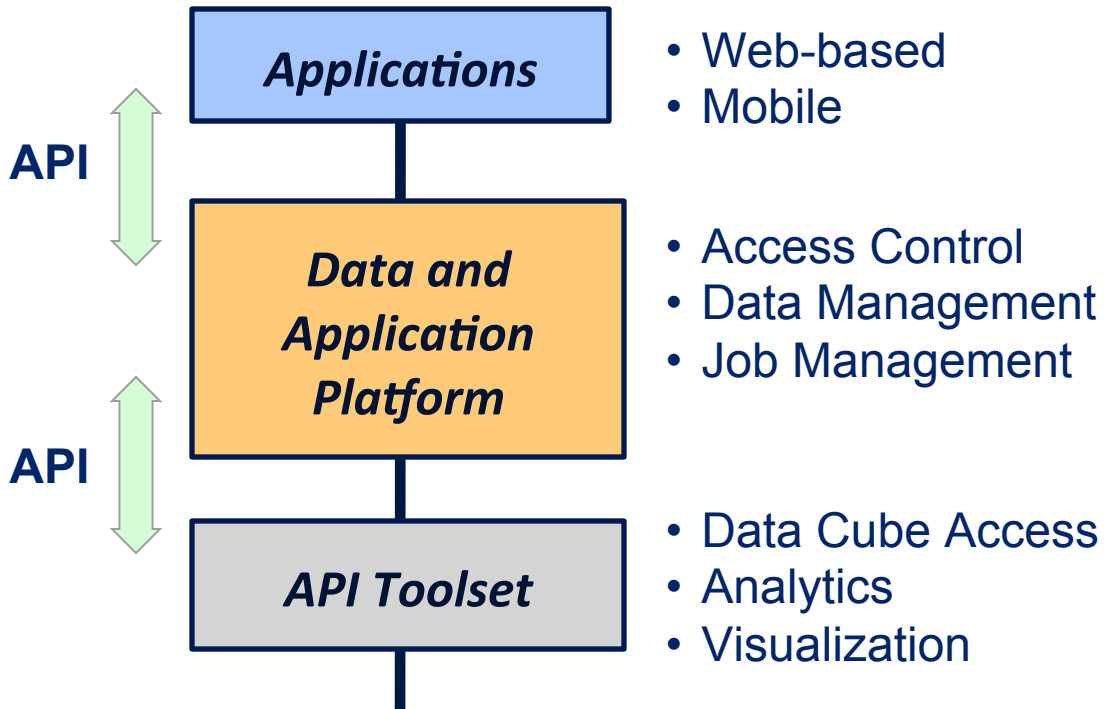
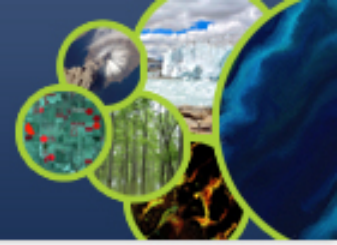




- The Data Cube architecture will ingest data using the native projection of the “analysis ready” products.
- Typical projections include: Universal Transverse Mercator (UTM) (see figure 3) and Equal Area (Albers) (see figure 1).
- The Data Cube user interface will allow regridding into a common “nested grid” for data interoperability analyses (see figure 2 and nested grid example on top-right).
- Preserving native projections will minimize resampling errors.



General Data Cube Architecture



A flexible architecture that supports infinite user applications, increasing and diverse datasets, local or cloud-based deployment, and automated ingestion of new datasets.

Open Source software to allow free and open access, Advanced Programming Interface (API) access, future data and capability growth, and commercial opportunities.



Data Cube

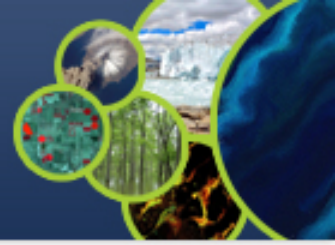


Space Agency



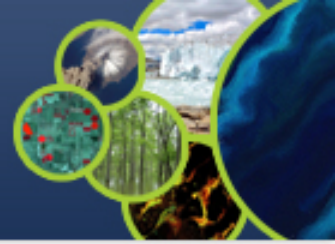
Satellite

High-Level Data Cube Requirements



1. Free and open access to software and APIs
2. Documented processes for data cube generation, new data ingestion, and application interfaces
3. Cloud-based or local deployment
4. “Analysis Ready” data products for satellite data layers
5. Preservation of native data product grid formats
6. Computational flexibility to allow reprojection into “nested grid” formats for multiple dataset interoperability and spatial consistency
7. Baseline user interface that supports data cube statistics/analysis and optical image preparation (e.g., mosaics).
8. Enable user development of applications through flexible APIs
9. Architecture flexibility and standards to support Data Cubes for local, regional or country scales



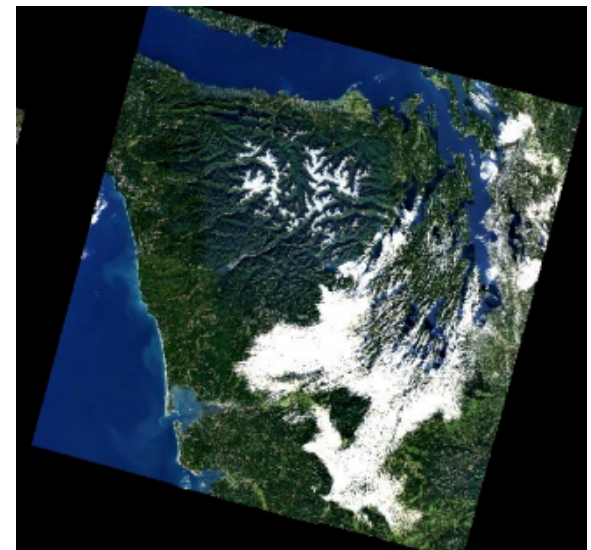


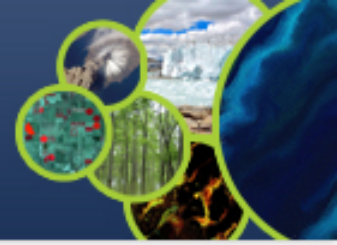
What is the definition of an “Analysis Ready Data (ARD)” product?

- Data that have been preprocessed and organized so users are not required to invest time and resources in specialized skills.
- Processing of ARD assumes (1) geolocation correction (spatial alignment, topography); (2) radiometric correction (solar illumination, viewing angles, atmospheric calibration); and (3) data organization (defined structure, metadata, quality flags).

Example: Landsat Surface Reflectance product (on right) that includes geolocated and calibrated surface reflectance along with quality indicators, land classification and cloud masks.

- This processing and organization is best done by Space Agencies, but could be done by other parties (e.g., CEOS, in-country users, projects).
- CEOS Data Cube software will focus on the ingestion of ARD to minimize data preparation and maximize data analysis by users.





Space Agency



**Satellite
Level-1
Data**

BAU

Business-as-Usual

Space Agency Processing
into Level-2 SR products

**Satellite
“Analysis Ready”
Data Products**



**Intermediate Data Storage and Processing
(Cloud-based or Data Hubs)**

- Scene-based tools
- Hosted Data Cube and tools

Scenario-2

Scenario-1



In-Country Users

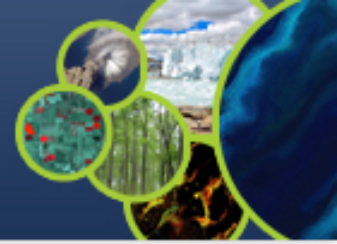
- Hard Drive Delivery or Internet Download
- Countries perform processing and data analysis locally

- Hard drive delivery or internet download
- Local storage and processing
- Country analyses using scene-based tools or a Data Cube (assumes countries create their own Data Cubes using CEOS open source tools or utilize CEOS support to initialize a baseline Data Cube)

- Country analyses performed on Cloud or Data Hub
- Countries download analysis products via Internet

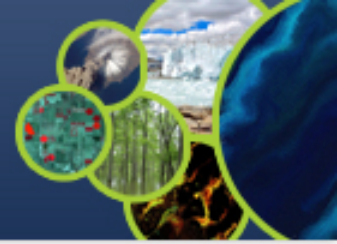
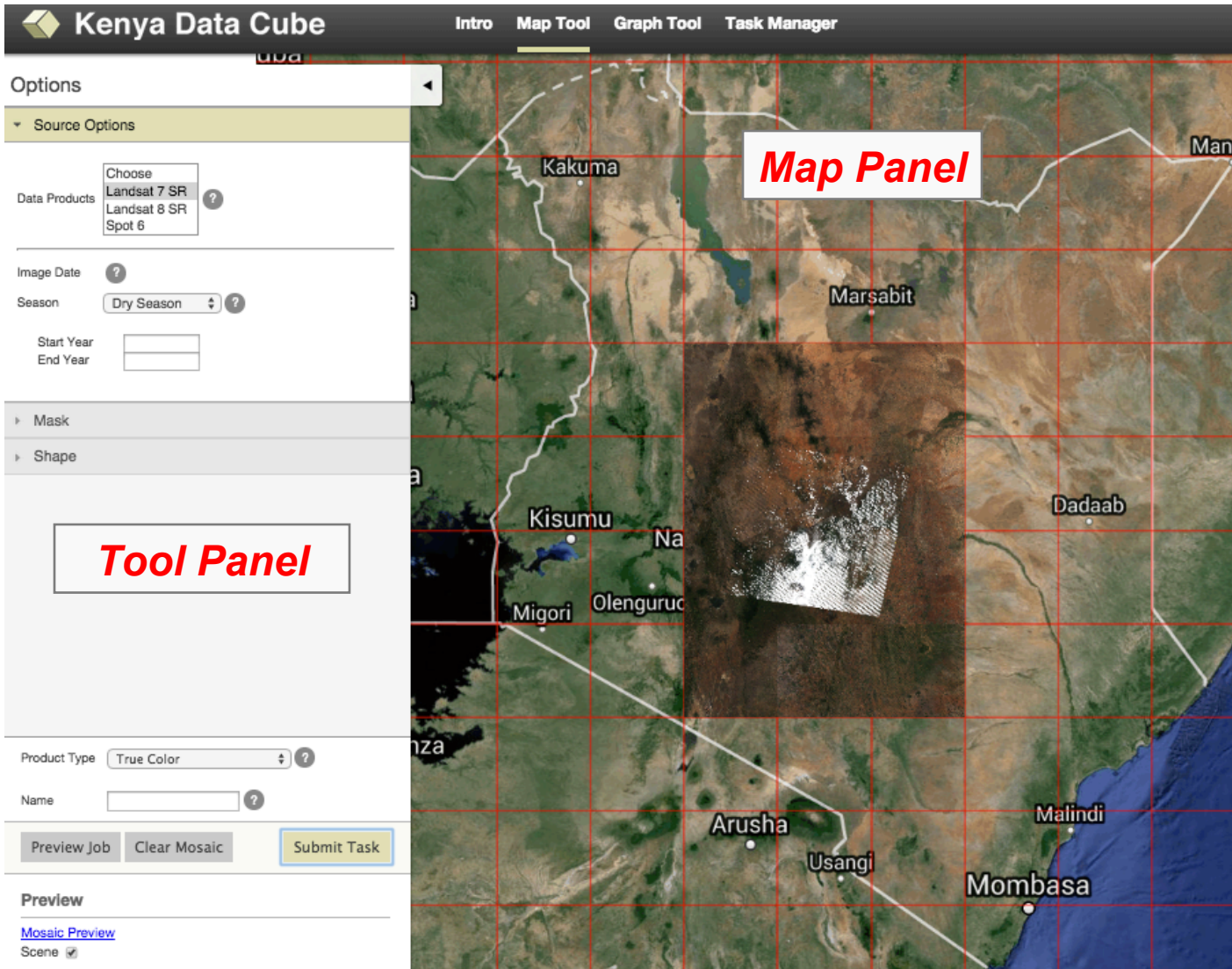
Data Cube Datasets

(priority order of addition)



- **Landsat-7** (Surface Reflectance) and **Landsat-8** (Surface Reflectance) from USGS.
- **SRTM** ... NASA Space Shuttle Digital Elevation dataset now available globally at 1-arcsec (30 meters) resolution.
- **MODIS** (Terra, Surface Reflectance, 8-day L3 500-m Global, MOD09A1) ... working with Alyssa Whitcraft (GEOGLAM) to demo. Also will work with GA/CSIRO to utilize their experience with this dataset.
- **ALOS** (PALSAR L-Band SAR) ... Free and open annual mosaics from 2007-2010 provided by JAXA. Working with Ake Rosenqvist (GFOI) to demo.
- **SPOT-5** (10-meter multi-spectral) ... Plans to obtain SPOT-5 Take-5 data over Kenya sample site. Over time, CNES plans to process and release all of the past data.
- **Sentinel-1A** ... C-band SAR data, plans to add sample images to prototype in late 2015
- **Sentinel-2A** ... Launched June 21, data available in late 2015
- **In-Situ Data** ... Working with NOAA to investigate approaches for adding in-situ climate data. May also consider global rain gauges and other ground-based data for demos.
- **Radarsat-2** (C-Band SAR) ... Dataset is restricted, so we are not planning to add this data to any of the prototypes. We will consider adding accommodations to the ingester to support this datasets, so others can use the data.

Kenya Data Cube User Interface Demo

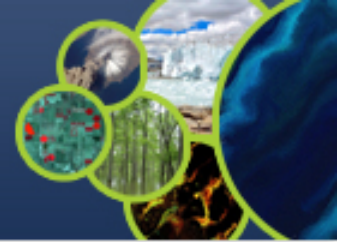
The screenshot displays the Kenya Data Cube User Interface. The top navigation bar includes links for Intro, Map Tool, Graph Tool, and Task Manager. The interface is divided into two main panels:

- Map Panel:** A satellite map of Kenya with a red grid overlay. A white box with the text "Map Panel" in red is positioned over the central part of the map. The map shows various geographical features and labels for cities like Kakuma, Marsabit, Kisumu, Na, Migori, Olenguruc, Arusha, Usangi, Mombasa, Malindi, Dadaab, and Mand.
- Tool Panel:** A sidebar on the left containing various options and controls. It includes:
 - Options:** A dropdown menu for "Source Options" with a "Choose" button and a list of data products: Landsat 7 SR, Landsat 8 SR, and Spot 6.
 - Data Products:** A section with a "Data Products" label and a "Choose" button.
 - Image Date:** A section with a "Season" dropdown menu set to "Dry Season" and a "Start Year" / "End Year" input field.
 - Mask:** A section with a "Mask" label.
 - Shape:** A section with a "Shape" label.
 - Product Type:** A dropdown menu set to "True Color" with a "Product Type" label.
 - Name:** A text input field with a "Name" label.
 - Buttons:** "Preview Job", "Clear Mosaic", and "Submit Task" buttons.
 - Preview:** A section with a "Preview" label and a "Mosaic Preview" link.

- Selectable data products
- Selectable time periods
- Selectable region
- Selectable product (mosaic or latest scene)
- Selectable output image (true color, false color)

Data Cube Prototype Progress

June 2015 – Output Products



- Mosaics and Tasseled Cap Index products generated from Landsat-7 SR products



Natural Color



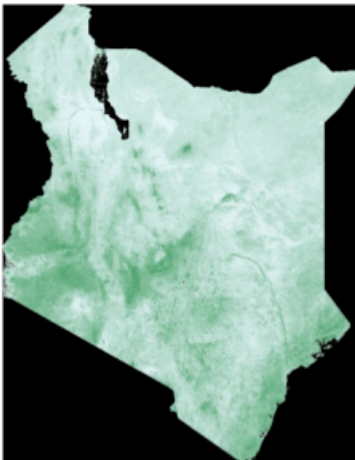
False Color (7,4,2)



NDVI



TCI Brightness

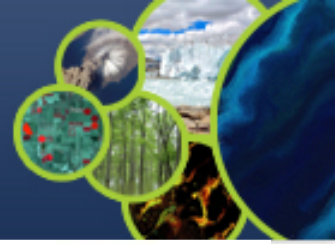


TCI Greenness



TCI Wetness





- The **Colombia Data Cube Project** is led by NASA-SEO and supported by the Australian Government (Geoscience Australia and CSIRO).
- The Colombia team includes participation from: the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) and the Ministry of Environment and Sustainable Development of Colombia.
- After several telecons to discuss the project plans, the team is meeting this week (October 14-15, 2015) for the first time.
- A more detailed project development plan is needed to define the steps for the SEO team and the Colombia team and the outcome and objectives of this project.

