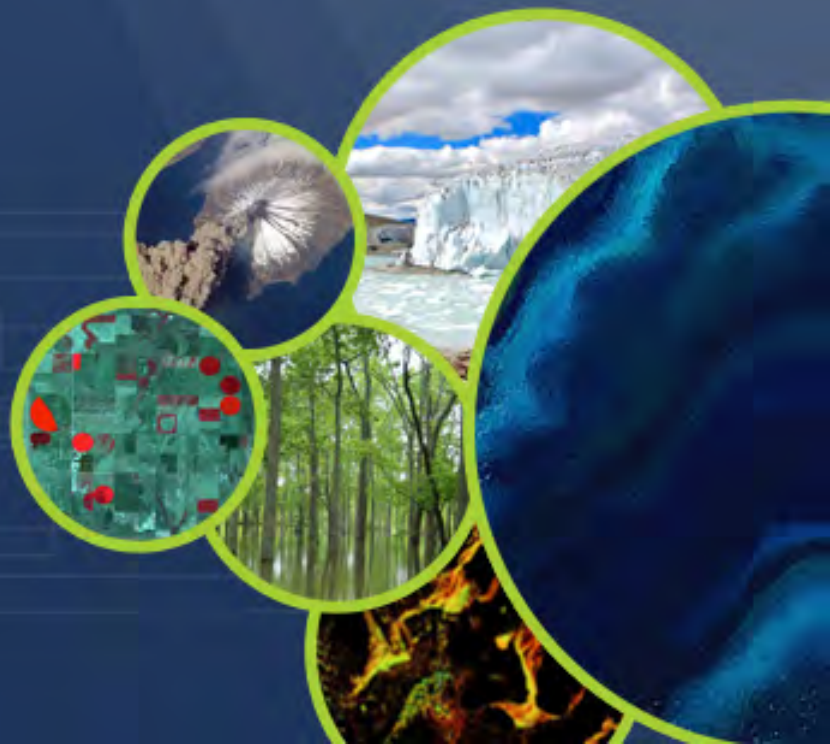
Open Data Cube

An Introduction and Demonstration

GEO-14 Plenary – Side Event
Washington, D.C, USA
October 23, 2017

Brian Killough
CEOS Systems Engineering Office
NASA Langley Research Center
Email: Brian.D.Killough@nasa.gov



Data Cube Sessions

- **(Session 1) 8:00 to 9:30, Monday, October 23**
  Introduction and Demo … **THIS SESSION**
- **(Session 2) 16:30 to 18:00, Monday, October 23**
  Digital Earth Australia
- **(Session 3) 11:30 to 13:00, Tuesday, October 24**
  Country experiences and plans from Colombia, Switzerland, United Kingdom and Uganda
- **(Session 4) 15:00 to 16:30, Tuesday, October 24**
  Hands-on Demonstration using the Amazon Cloud with Python Notebooks and the CEOS Data Cube User Interface

What is CEOS?

www.ceos.org

Group photo from the 2017 CEOS Plenary in Rapid City, South Dakota, USA (Hosted by USGS)

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 32 space agencies and 28 associate members and is operating 152 satellites as of October 2017.

What is changing?

Free and Open Resources

- Free and open Satellite Data
- Open Source Software and Tools

Global Engagement

- Improved communications through internet technology
- Increased global cooperation and collaboration

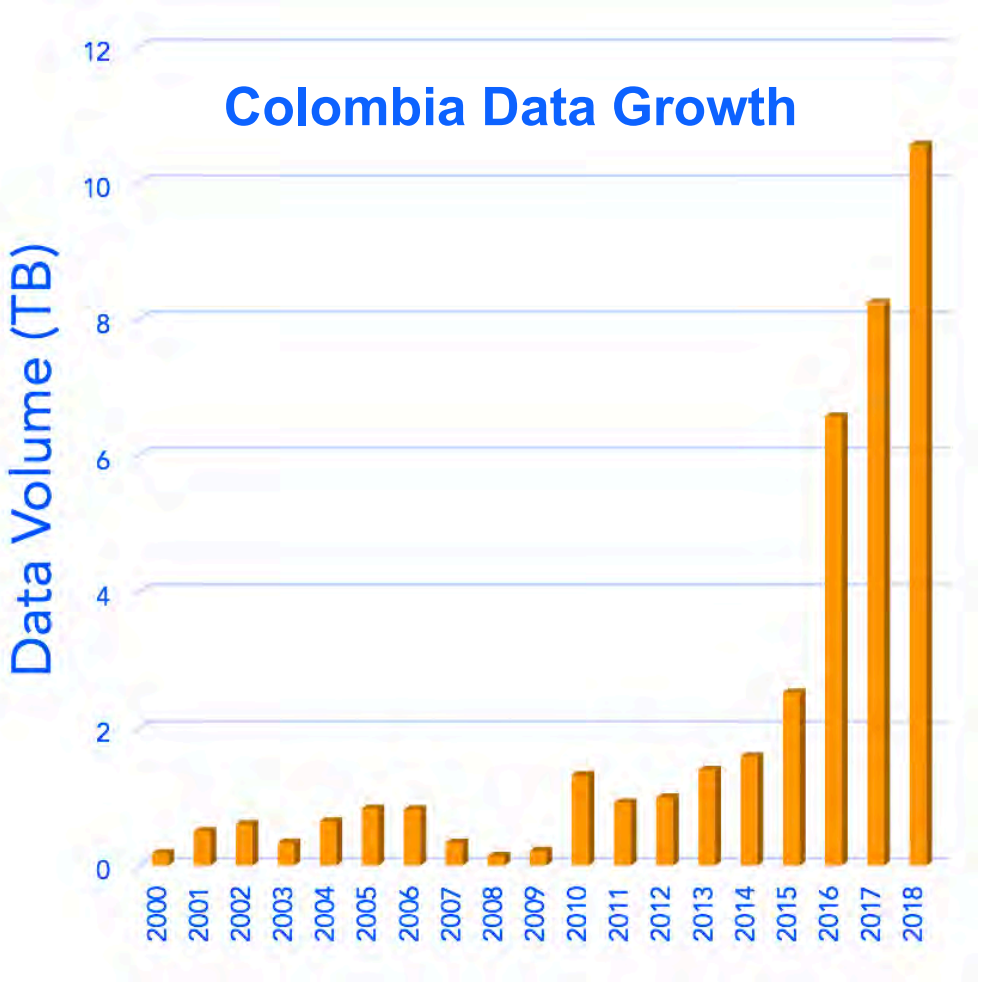
Philanthropy connected to Satellite Data

- Google Earth Engine
- Governments, Foundations and World Bank

Improved Technology

- Cloud Storage and Computing
- Data Cubes … **the focus of this talk!**

Solving a Problem

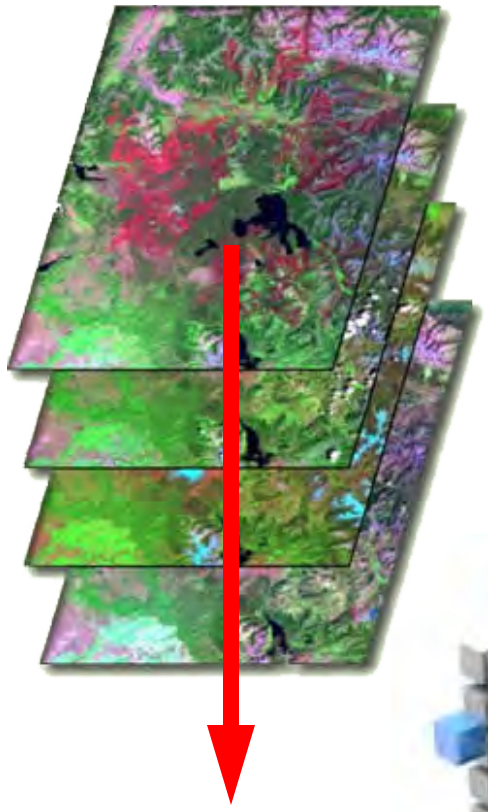


- A significant growth in FREE/OPEN land imagery data (e.g. Landsat, Sentinel) has **increased data volumes** by 10x in the last 5 years.
- Most developing countries **lack the knowledge, infrastructure, and resources** to access and use the available space-based data.
- Countries have requested support from CEOS for data access, processing, and analysis. They **want to learn** how to access and use satellite data to support their country needs.

*The new **Open Data Cube** provides a solution and new opportunities*

What are Data Cubes?

- **Data Cube** = Time-series multi-dimensional (space, time, data type) stack of spatially aligned pixels ready for analysis
- **Proven concept** by Australian and planned for the USGS Landsat archive.
- **Analysis Ready Data (ARD) ...** Dependent on processed products to reduce processing burden on users
- **Open source** software approach allows free access, promotes expanded capabilities, and increases data usage.
- **Unique features:** exploits time series, increases data interoperability, and supports many new applications.



Benefits of Data Cubes

- Expanded use of satellite data
- Reduced data preparation burden
- Enables data interoperability
- Efficient time series analyses
- Free and open access
- Flexible deployment (local or cloud)
- Use of a common architecture
- Community development and sharing

*Our goal is **NOT** to sell a product or give out a tool.*
*Our goal is to provide a **SOLUTION** that has **VALUE** and increases the **IMPACT** of satellite data.*

The Data Cube Vision

A solution supporting priority objectives …

- Build capability of users to apply CEOS satellite data
- Support Group on Earth Observations (GEO) and United Nations agendas

Involves many CEOS Agencies …

- Through provision of processed satellite data products
- Contributing to development and uptake of solutions

Customer focused …

- Easy to install and maintain with training materials
- A brand that people know and trust
- An active global community of users

Scalable solution …

- Operational Data Cubes in **20 countries by 2022**
- Key partners (e.g. World Bank, Google, Amazon) supporting the data cube development and use

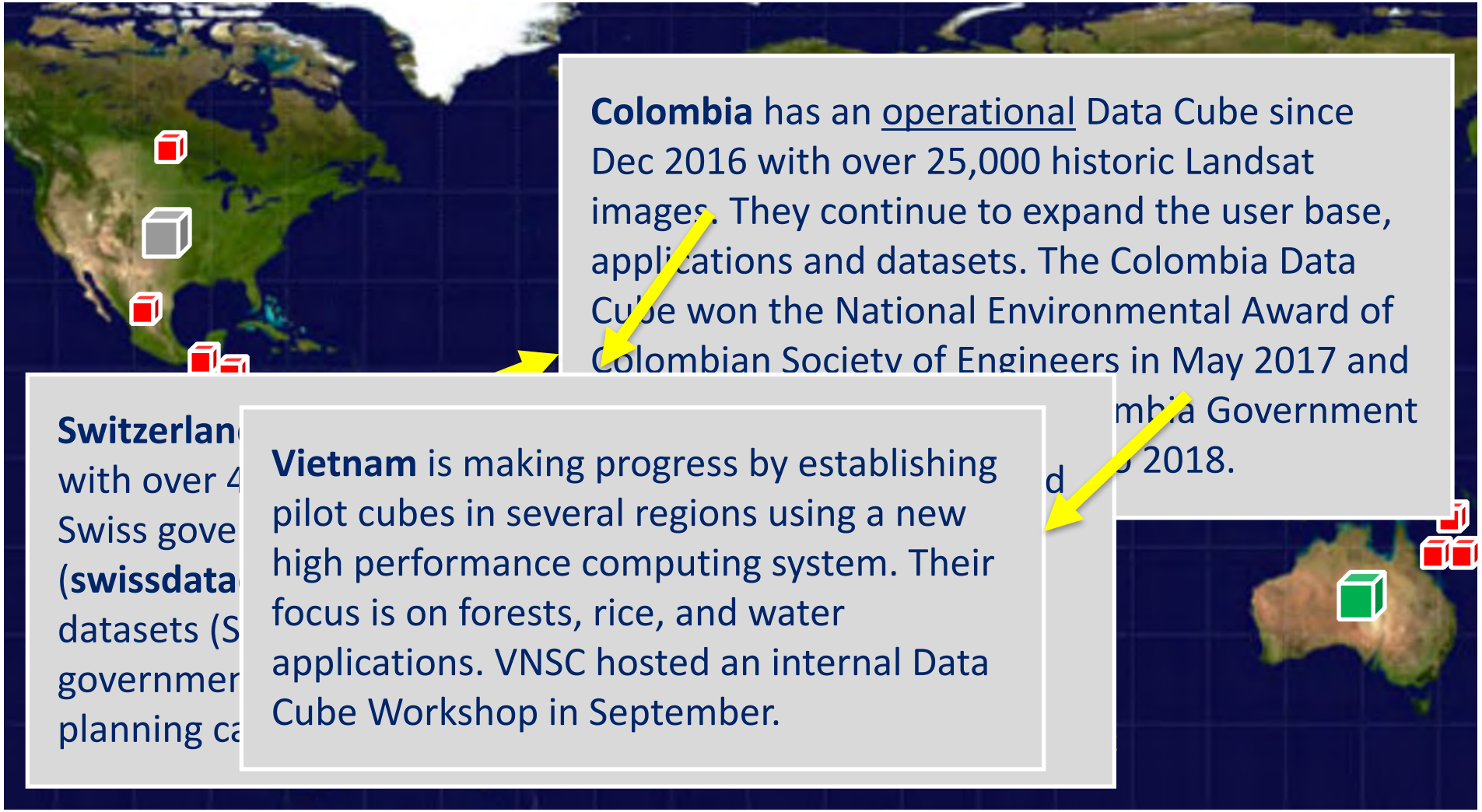
Open Data Cube Progress

- The initiative is named "**Open Data Cube**" or ODC. Website: opendatacube.org
- We established a "**Partners**" group and "**Steering**" group which includes representatives from NASA-SEO, GA, CSIRO, USGS, and UK-Catapult to manage the strategic and technical tasks.
- We developed strategic "**white papers**", open source governance plans, and documentation for deployment and operation.
- We conducted the 1st ODC Workshop at the 2017 IGARSS conference in Fort Worth, Texas in July and are planning another in 2018.
- We are actively working with World Bank, Google, and Amazon.
- We are interacting with **30 countries**!

Open vs. CEOS Data Cubes

- The **ODC** initiative is larger than CEOS.
- The **Open Data Cube** (ODC) initiative was established by CEOS, with a goal to create and foster an open “community” of contributors.
- The **ODC** uses a common architecture among the various implementations so that all users can share tools and applications.
- The **CEOS Data Cube** (CDC) is one “implementation” of the ODC. Similarly, Digital Earth Australia (DEA) and USGS Land Change Monitoring, Assessment, and Projection (LCMAP) are implementations.
- The **CDC** goal is to focus on building global capacity to utilise satellite data and contribute to global initiatives (e.g. UN-SDG, GFOI, GEOGLAM) through the use of Data Cubes.

The “Road to 20”



Colombia has an operational Data Cube since Dec 2016 with over 25,000 historic Landsat images. They continue to expand the user base, applications and datasets. The Colombia Data Cube won the National Environmental Award of Colombian Society of Engineers in May 2017 and mbia Government 2018.

Switzerlan with over 4 Swiss gove (**swissdata** datasets (S governmer planning ca d

Vietnam is making progress by establishing pilot cubes in several regions using a new high performance computing system. Their focus is on forests, rice, and water applications. VNSC hosted an internal Data Cube Workshop in September.

3 operational, 4 under development, 23 expressing interest = **30 total**

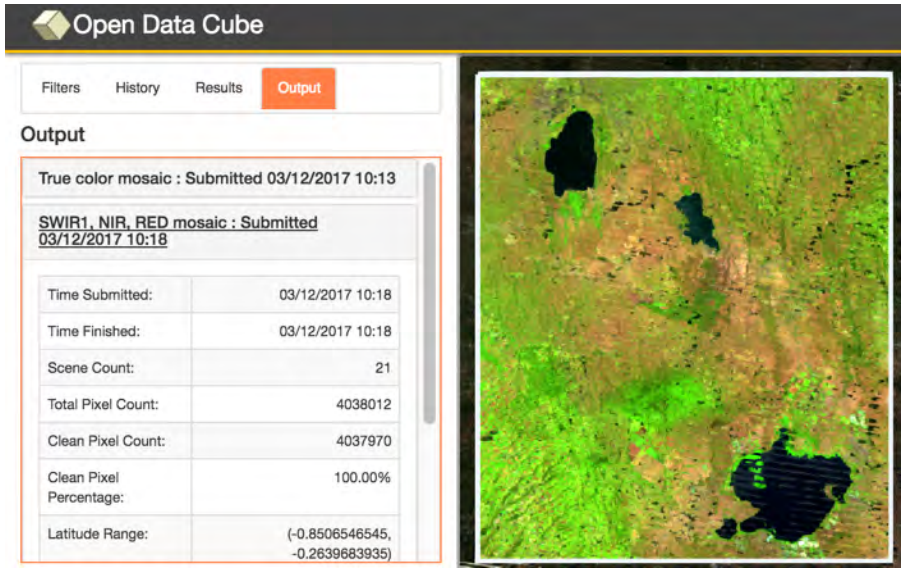
Amazon Cloud (AWS) Data Cube Portal

Data Cubes

- 16 cubes with 10+ years each.
- Kenya, Cameroon (Lake Chad), Togo (coastal Africa), Ghana, Colombia, Tonga (Pacific Island), Vietnam, Australia (Menindee Lakes), Bangladesh.

User Interface Features

- 9 applications: cloud coverage maps, custom cloud-free mosaics, fractional cover, NDVI anomaly, water detection, water quality, landslides, coastal change and urbanization.
- Outputs in GeoTIFF and GIF animation.
- **New features** added in Sept 2017: data visualization tools, ingestion "on demand" for new cubes or subsetting, indices, mosaics (medoid, geometric median)



This is the first "hands-on" global demo of the Data Cube to show its potential for rapid time series analysis and diverse applications

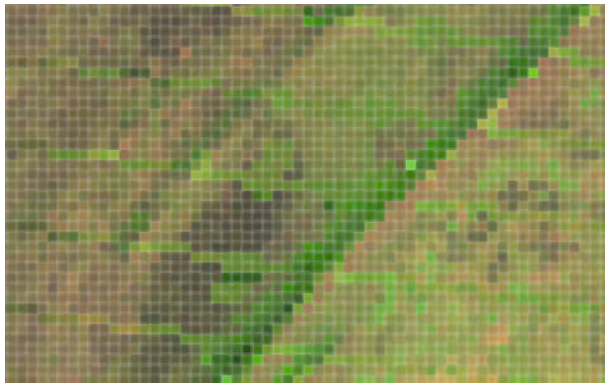
http://tinyurl.com/datacubeui

Free and Open!

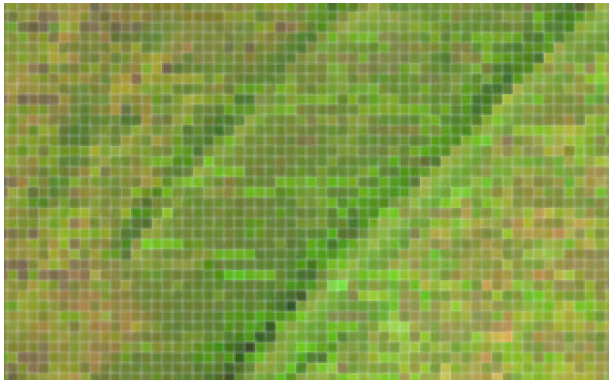
Custom Mosaics

- There are 6 custom mosaic products available in the User Interface tool and also in Python code: Least/Most Recent Pixel, Min/Max NDVI, Median, and Medoid
- **Medoid** = an ”real” mosaic based on pixels in the time series that represent minimal dissimilarity
- **Median** = a mosaic product based on the ”midpoint” spectral response from each band in a time series. For shorter time series, this may represent a “real” pixel.

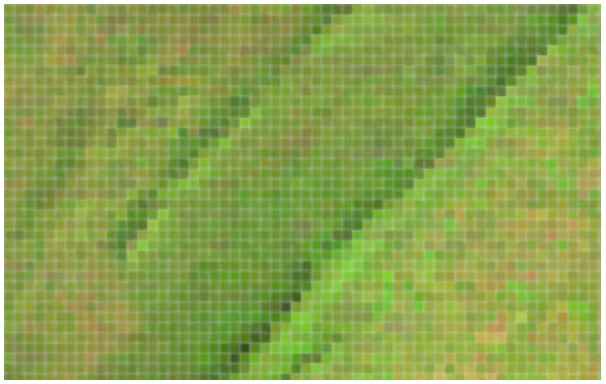
Most Recent Pixel



Medoid

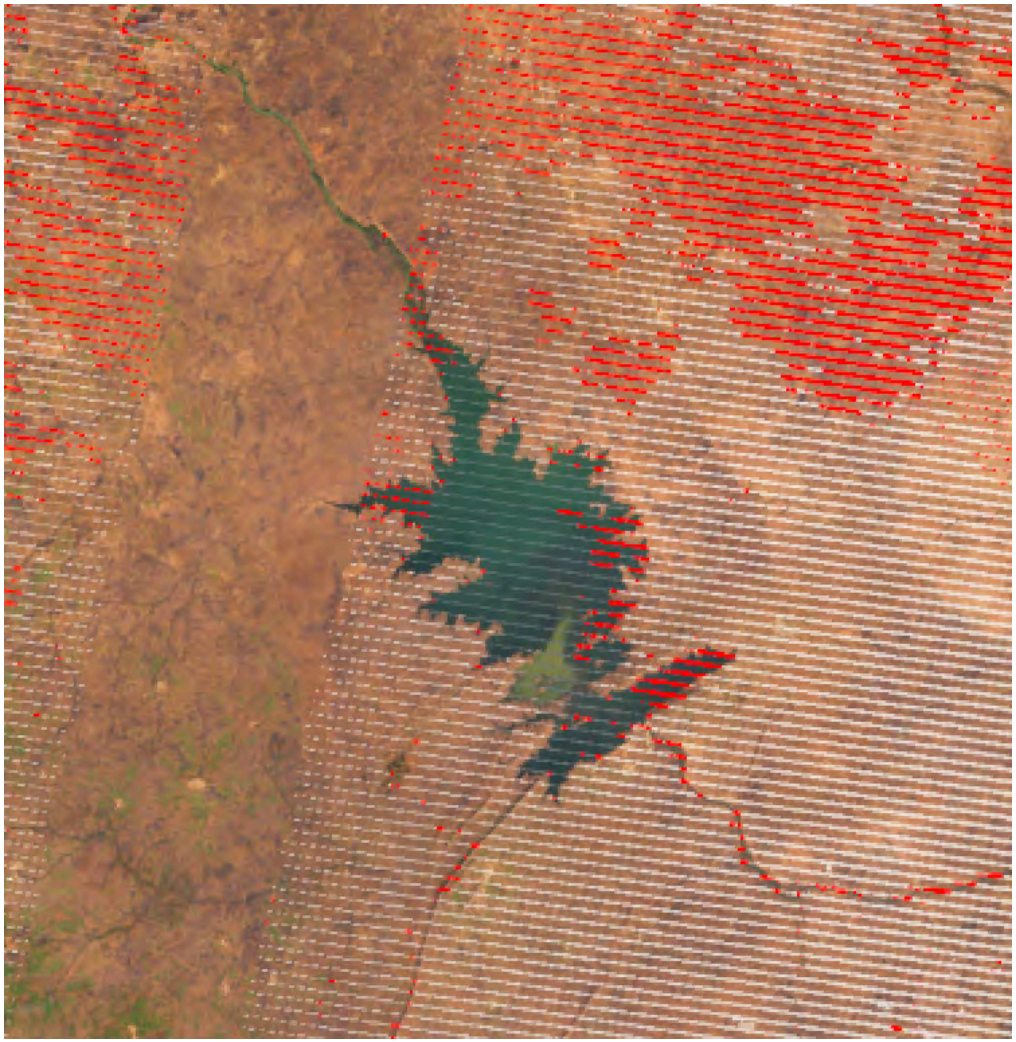


Median



Sample Mosaics over Uganda. 11 total scenes from Landsat-7 in 2015.

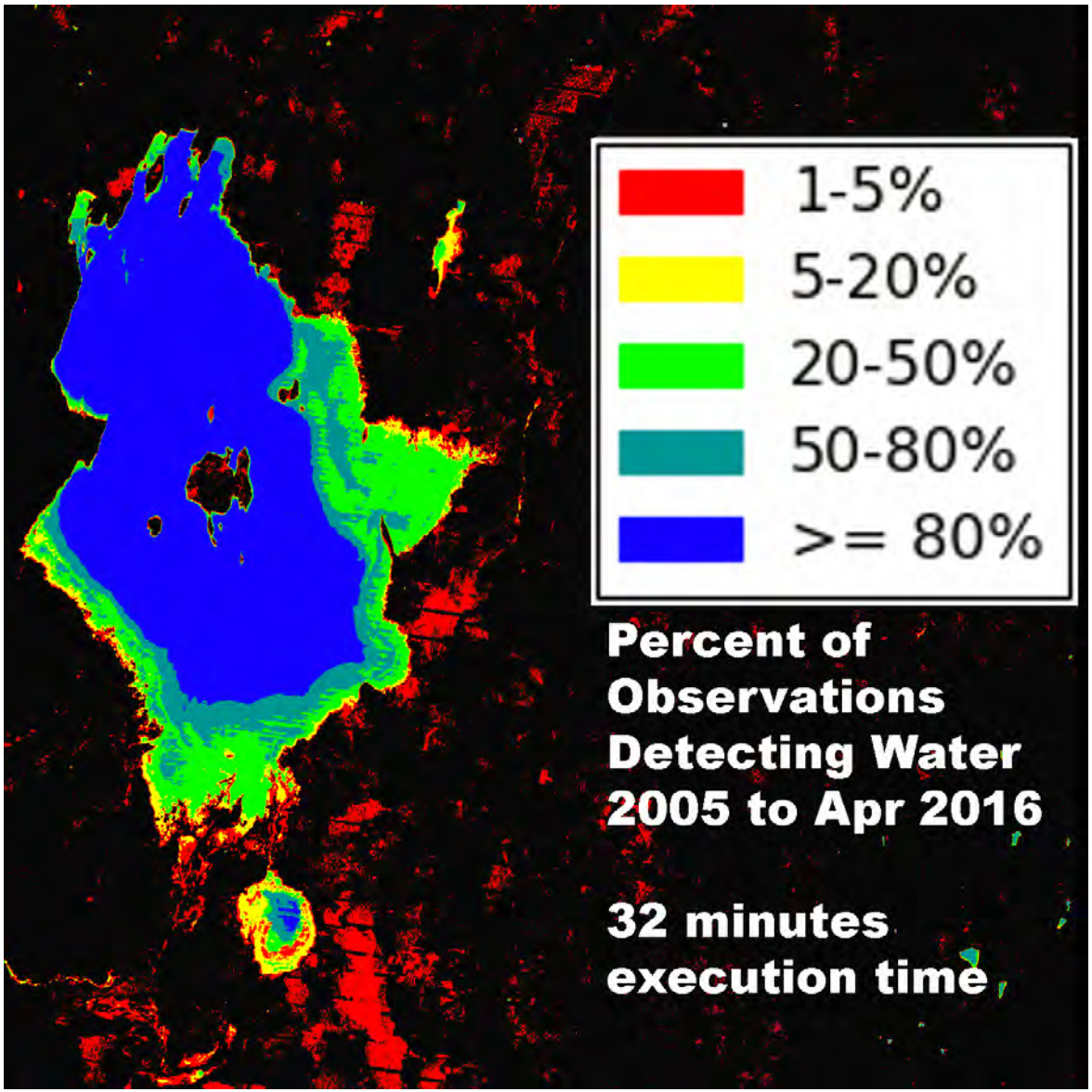
Cloud-filtered Mosaic



Bui National Park
Black Volta River
Western Ghana

The final product (left) is a cloud-filtered “recent pixel” mosaic for Jan-Mar 2016 (3 months). The result is compiled from four (4) Landsat-7 scenes to produce a 97% cloud-free image. The baseline scenes (left) are 15% to 80% cloudy. The cloud or no-data pixels are highlighted in **RED**. This analysis is produced very rapidly (~1 minute).

Lake Baringo, Kenya
Time Series Water Detection



Blue = frequent or permanent water

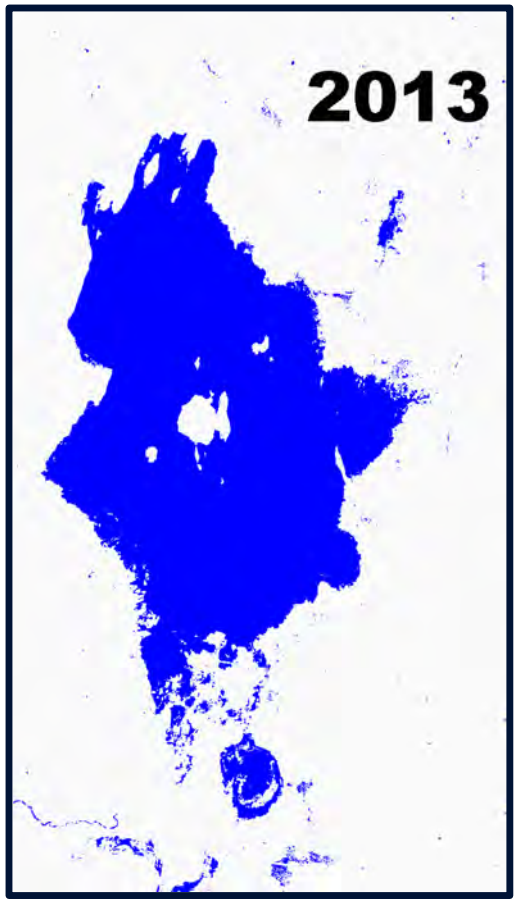
Red/Yellow = infrequent water or flood events

Flood risk can be easily inferred from the 23-step, multi-band Australian WOFS algorithm.

30-meter Landsat resolution allows detailed assessments that are far better than MODIS (250-m).

Annual Water Extent

Extreme droughts in the Baringo region in 2009 had severe impacts on pastures and farming

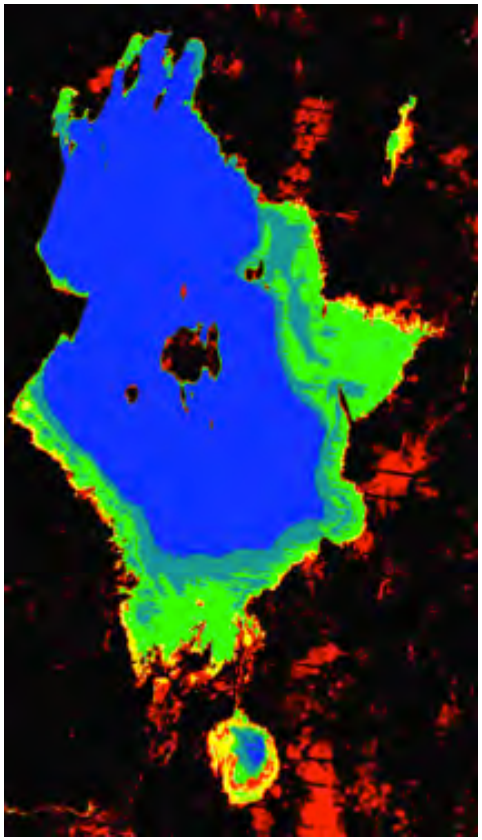


Extreme floods displaced 600 families and swept away livestock near Lake Baringo in 2013

4 months of dry season data resulted in little water detected outside the lake boundary

WOFS vs. Other Water Tools

Australian WOFS
2005 to 2016



EC-JRC
1984 to 2015

Pekel et al. 2016

Limited to a fixed time range and monthly output.

Aqua Monitor
2005 to 2016

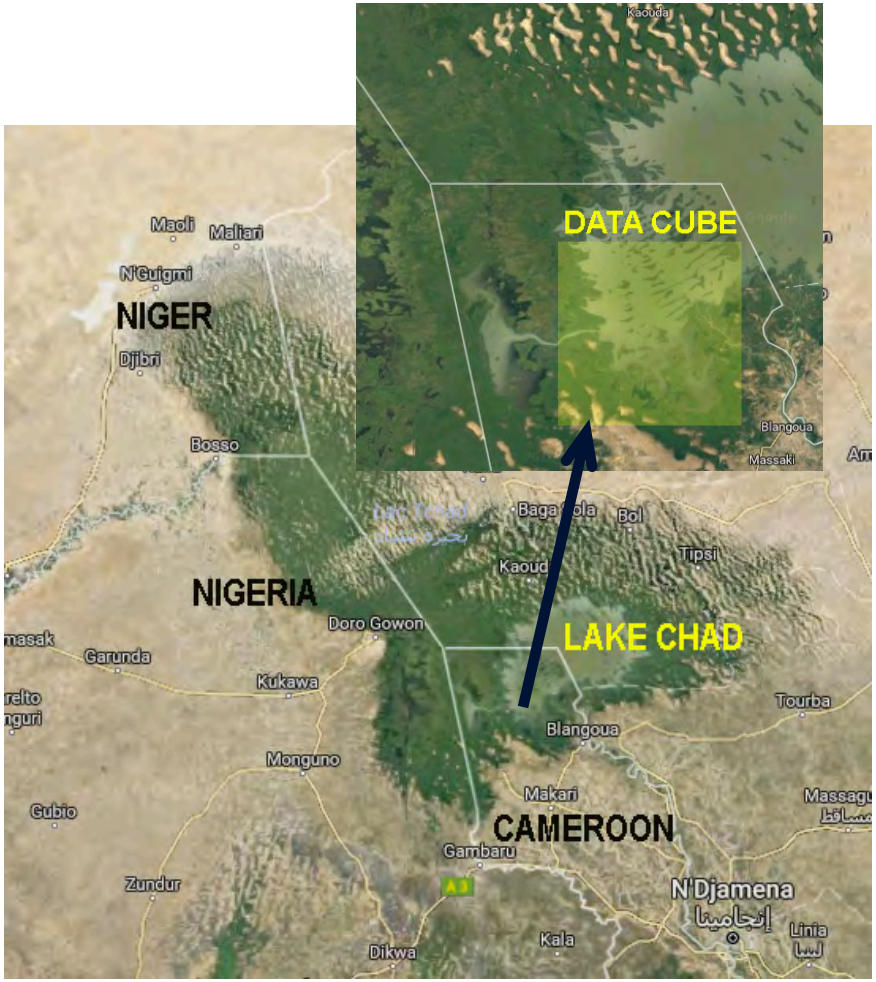
Donchyts et al. 2016

Limited to land-water and water-land changes. No download.

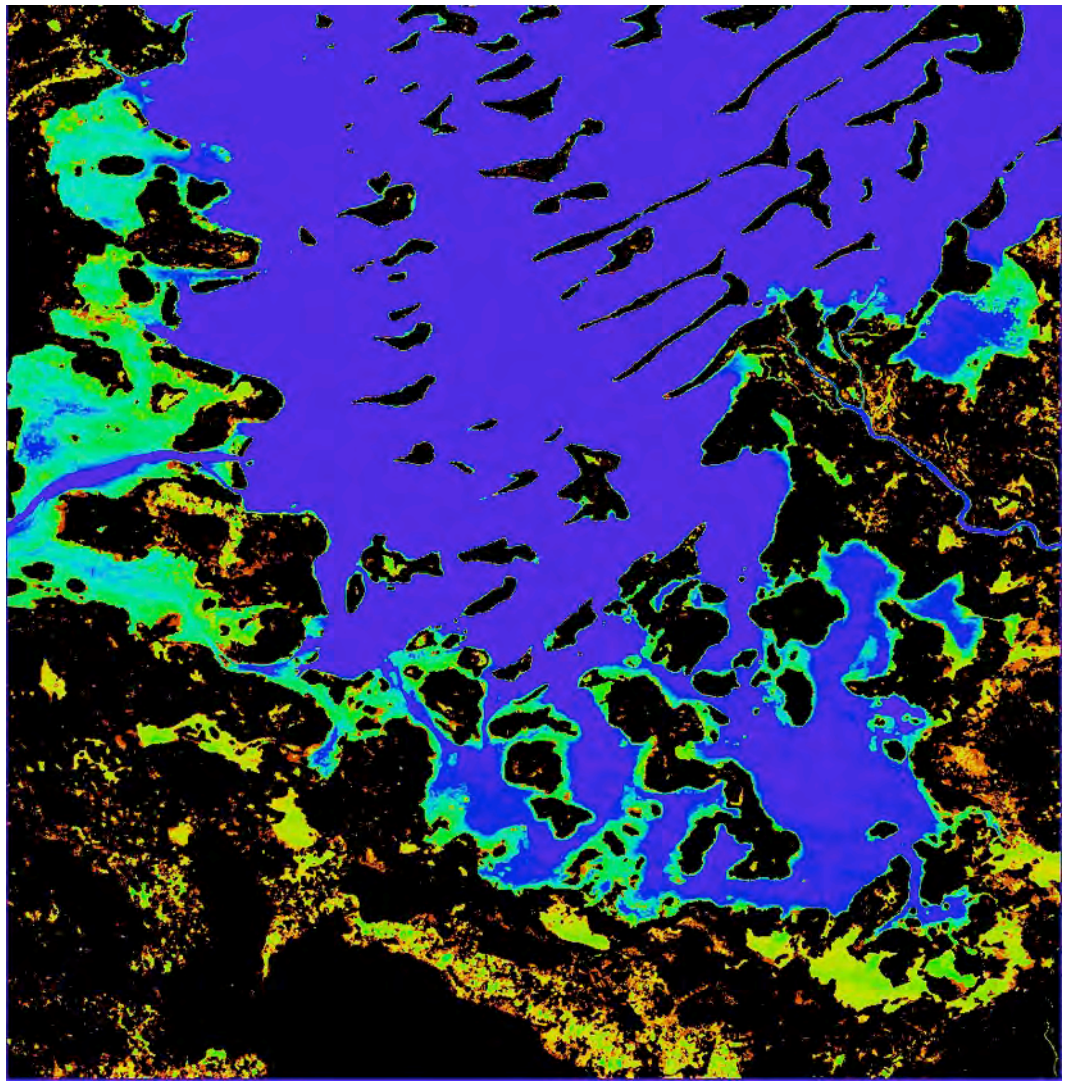
Lake Chad, Africa
Water Detection Demonstration

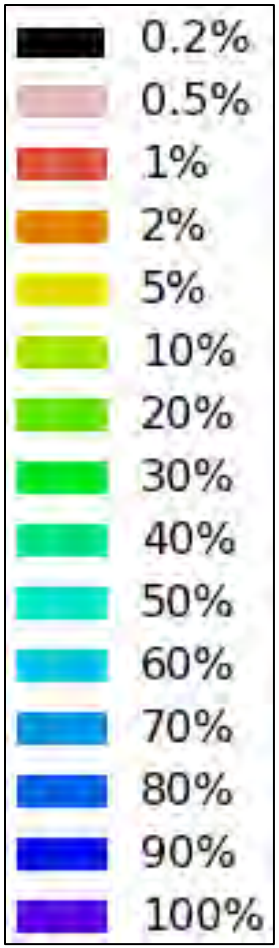
Historically large and shallow lake has shrunk by 95% from 1963 to 1998 due to increased population demand (reference United Nations). Provides water to 68 million people in 4 bordering countries.

Annual rainy season (May-June) gives rise to floods (Aug-Sept) which fill the lake (Oct-Jan) before evaporation during the dry season (Feb-Mar).



Lake Chad, Cameroon, Africa
Time Series Water Detection



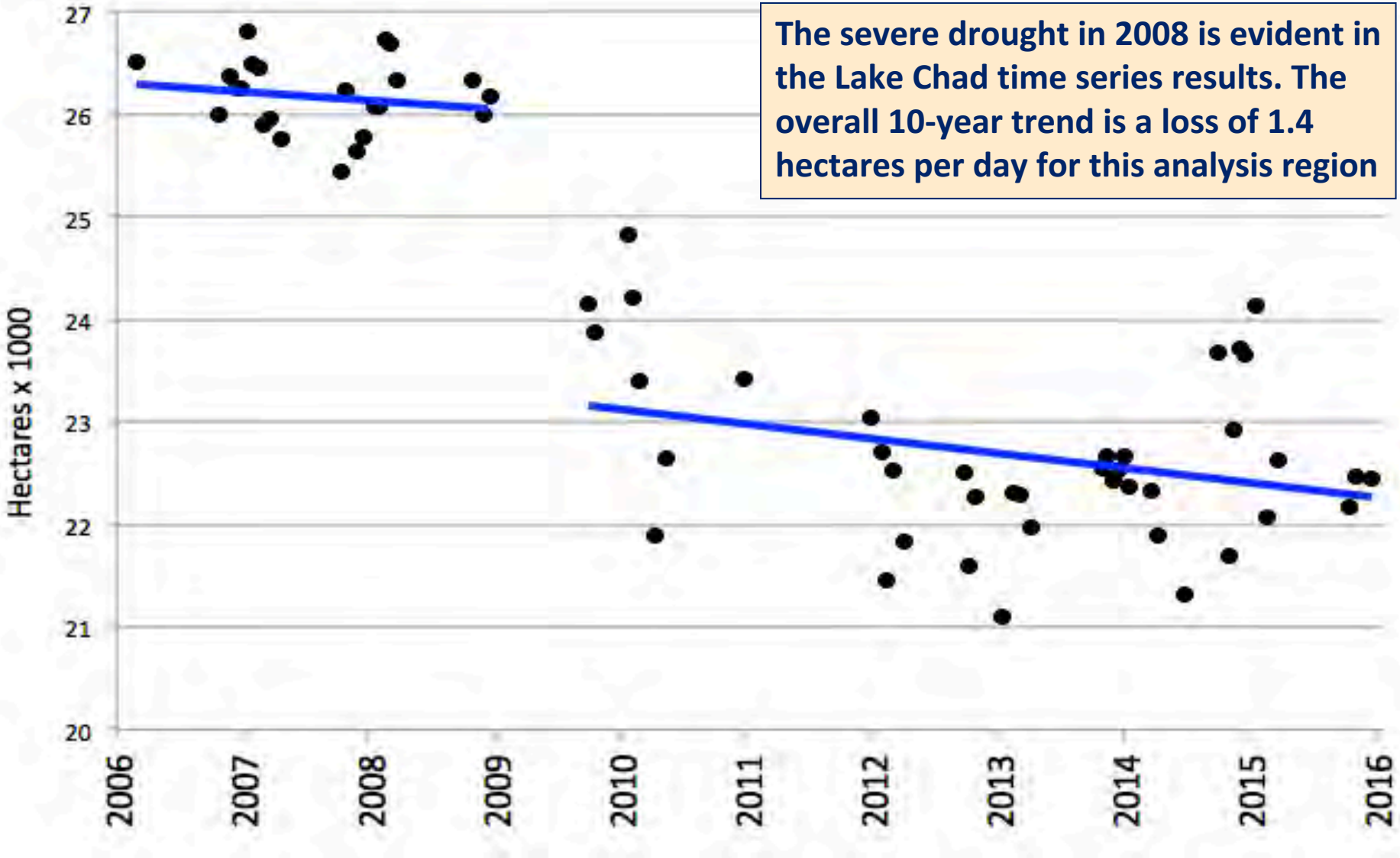


The product shows the percent of observations detected as water over the **17-year time series** (water observations / clear observations).

Purple/Blue:
Frequent or permanent water

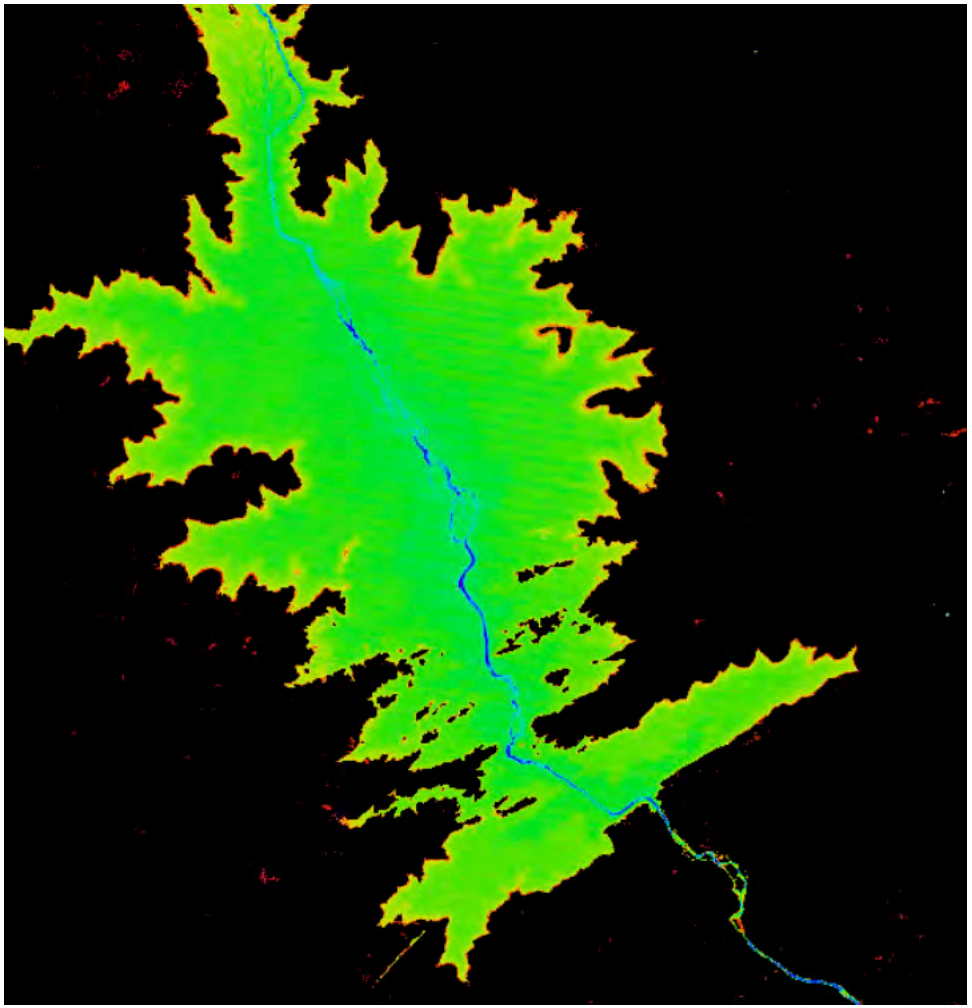
Red/Yellow:
Infrequent water and/or flood events

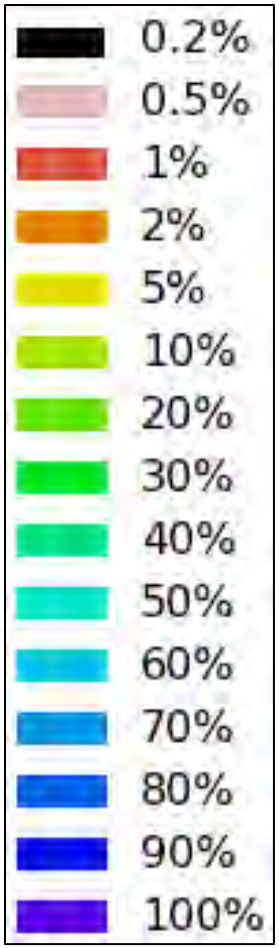
Lake Chad, Cameroon, Africa
10-year Time Series Results



The severe drought in 2008 is evident in the Lake Chad time series results. The overall 10-year trend is a loss of 1.4 hectares per day for this analysis region

Time Series Water Detection





The Australian Water Observations from Space (WOFS) product shows the percent of observations detected as water over the **17-year time series** (water observations / clear observations).

Purple/Blue: Frequent or permanent water

Red/Yellow: Infrequent water and/or flood events

Bui National Park along the Black Volta River, western Ghana, Africa

Why does the water only exist for 20% of the 17 years?

Bui National Park Land Change

Dec 2010
Dam under construction

Dec 2016
Dam complete … New Lake!

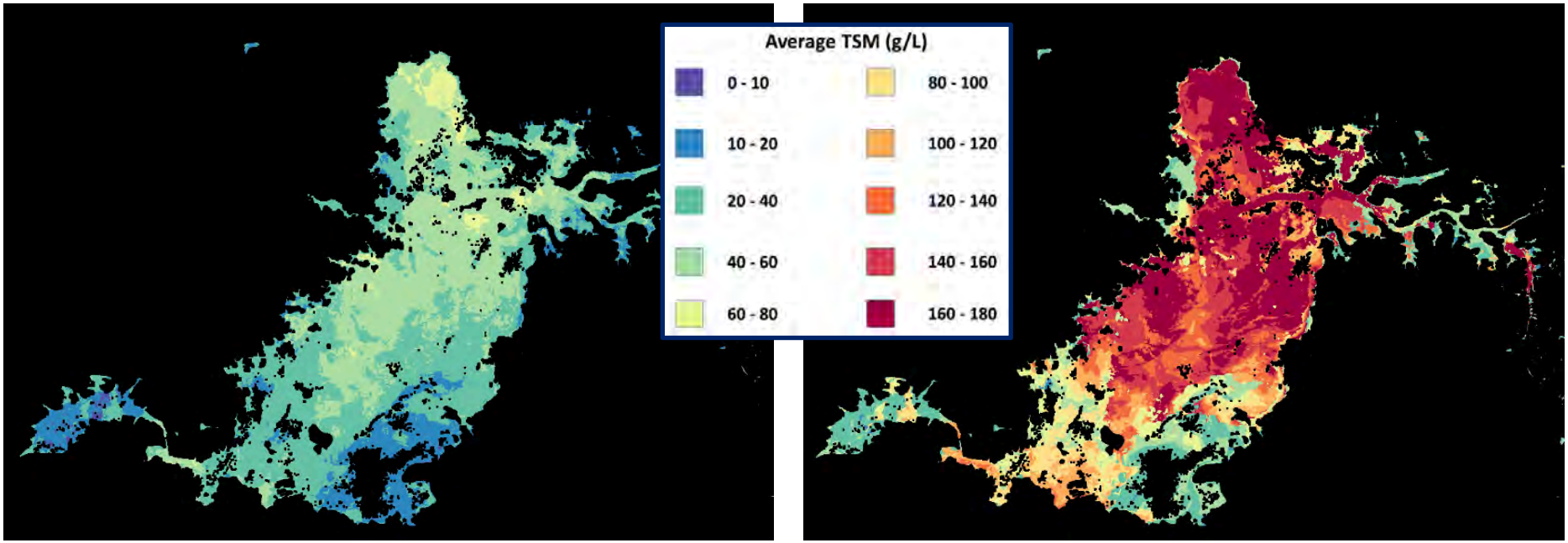
Bui National Park started construction of a Dam in Dec 2009. This explains the short existence of water from 2000 through 2016. The images to the left support these results.

Time series observations of water can be used to track the progress of water management projects, such as this project in Ghana.

Water Quality
Total Suspended Matter (TSM)

Average TSM

Maximum TSM

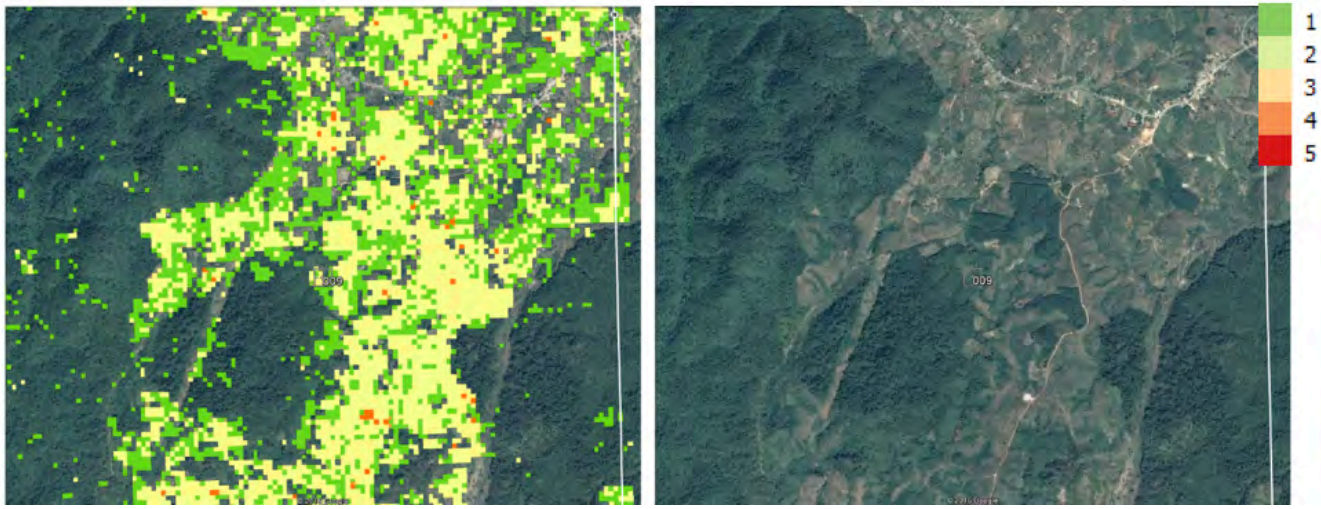


The Tri An Reservior in southern **Vietnam** (near Ho Chi Minh City) supplies drinking water to millions of people.

The results show the average and maximum TSM (mg/L) levels over the 2016 annual time series for persistant water. The product is calculated using Landsat 8 data and the Lymburner TSM Index Algorithm. TSM is closely related to turbidity which is an indicator of water condition for drinking or fisheries

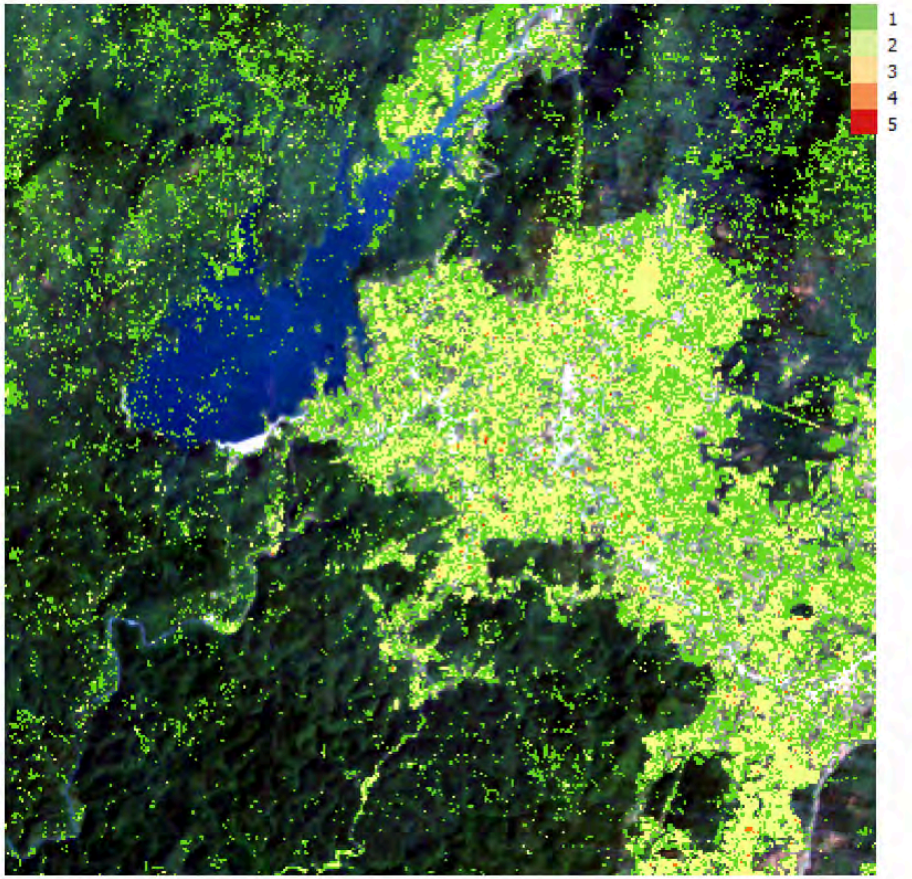
Land Change Detection

CCDC (Zhu and Woodcock, 2012) was converted to Python by USGS and recently tested on the Vietnam Data Cube. We now call this"**PyCCD**".



PyCCD time series model fits 7 bands to 6 weighted SINE and COSINE functions in order to find "breaks" that equate to potential land change.

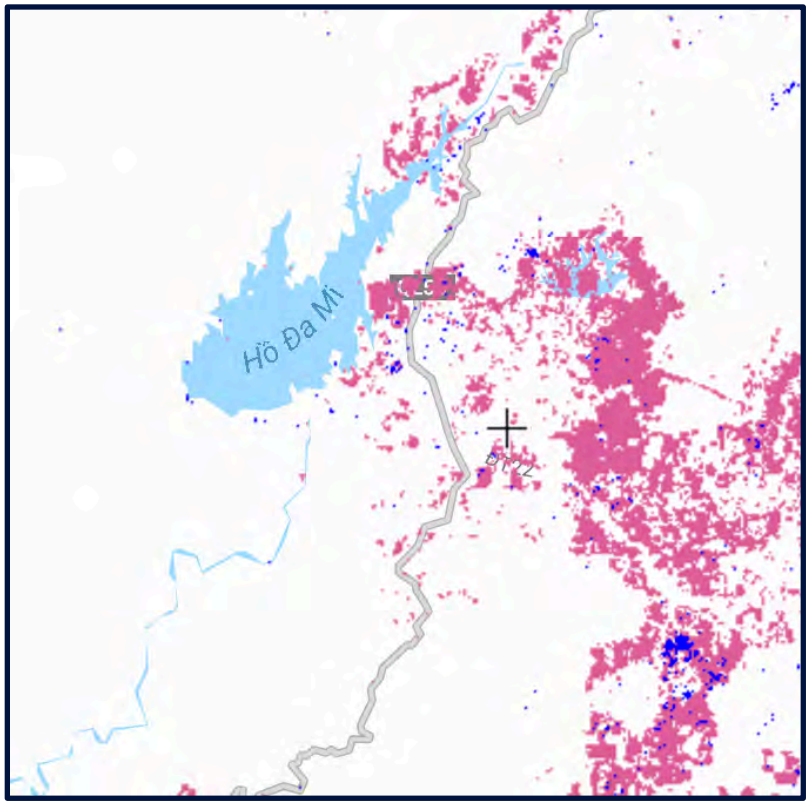
Vietnam Land Change



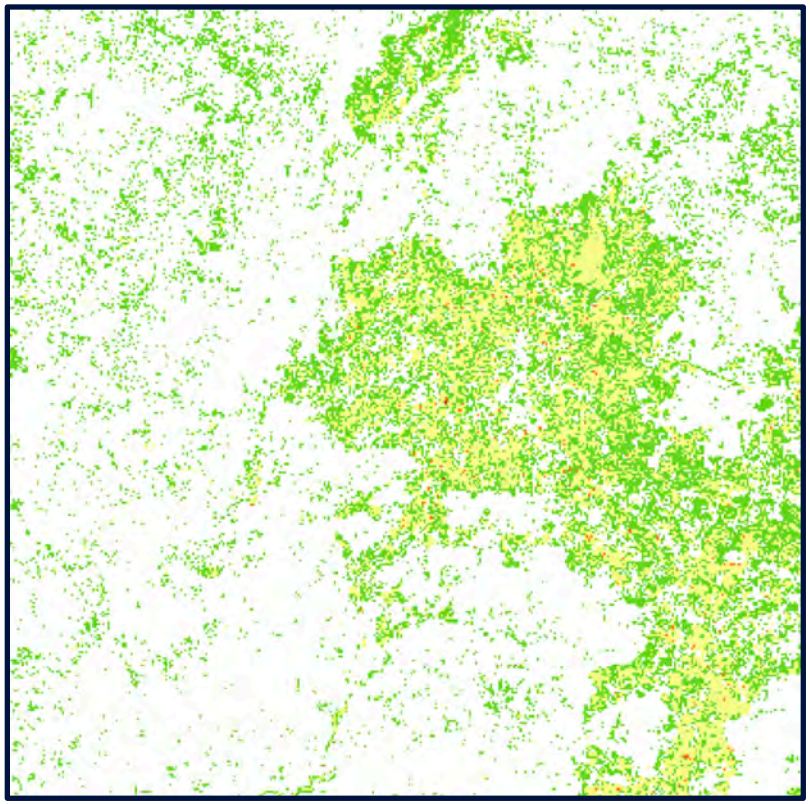
Bediaye, Vietnam – Data Cube Median Mosaic (left), **PyCCD Results** (right)

2000 to 2016, 192 Landsat scenes

Global Forest Watch vs. PyCCD



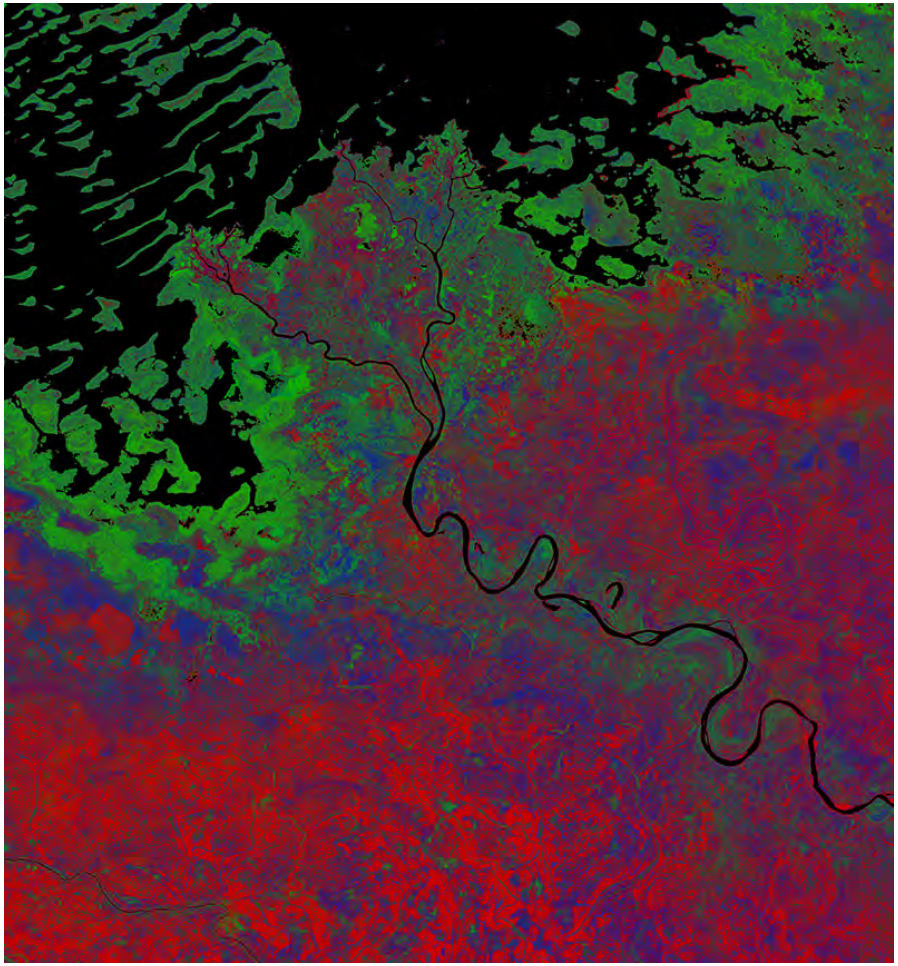
Global Forest Watch – **Forest Loss**
2000 to 2015



PyCCD with a Data Cube – **Land Change**
2000 to 2016

***PyCCD Execution**: 372 x 372 pixels, 8 parallel cores, 2.3 hours (~1 msec / clear pixel)*

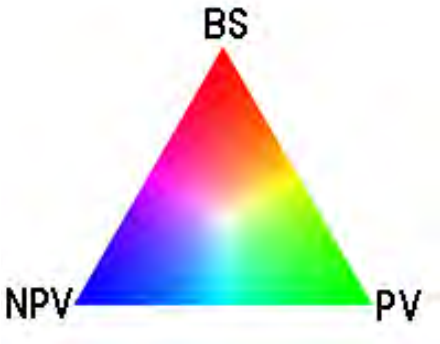
Fractional Cover



Southern Lake Chad
Cameroon, Africa

2015 Fractional Cover

R = Base Soil (BS)
G = Photosynthetic Vegetation (PV)
B = Non-Photosynthetic Vegetation (NPV)
** NPV is dead vegetation, wood, stems, leaves*

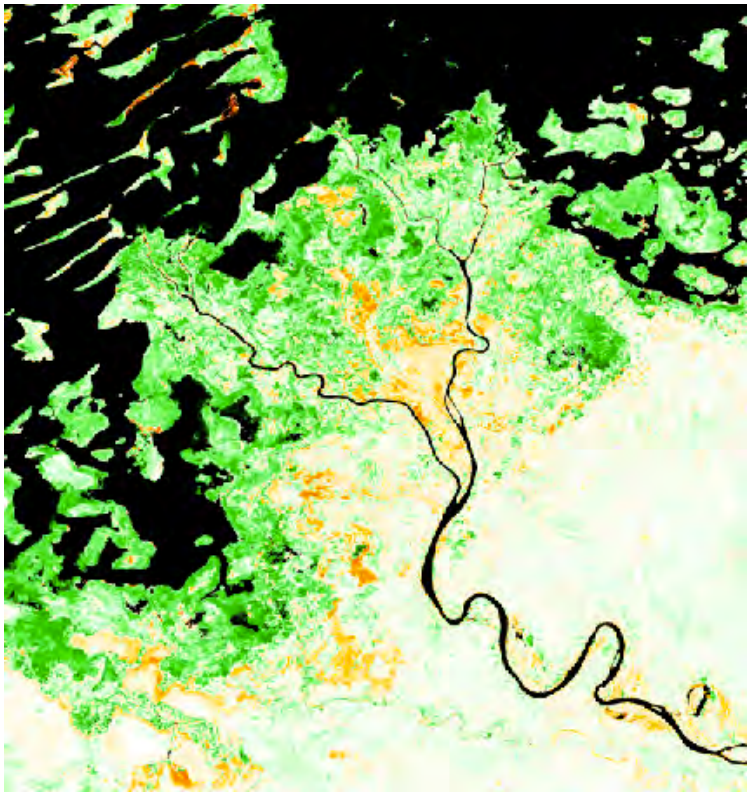


The fractional coverage algorithm (right) estimates the average vegetation fractional cover over the time period using a linear unmixing technique developed by Juan P. Guerschman (CSIRO).

NDVI Anomaly

Chari River inlet to Lake Chad in Cameroon, Africa

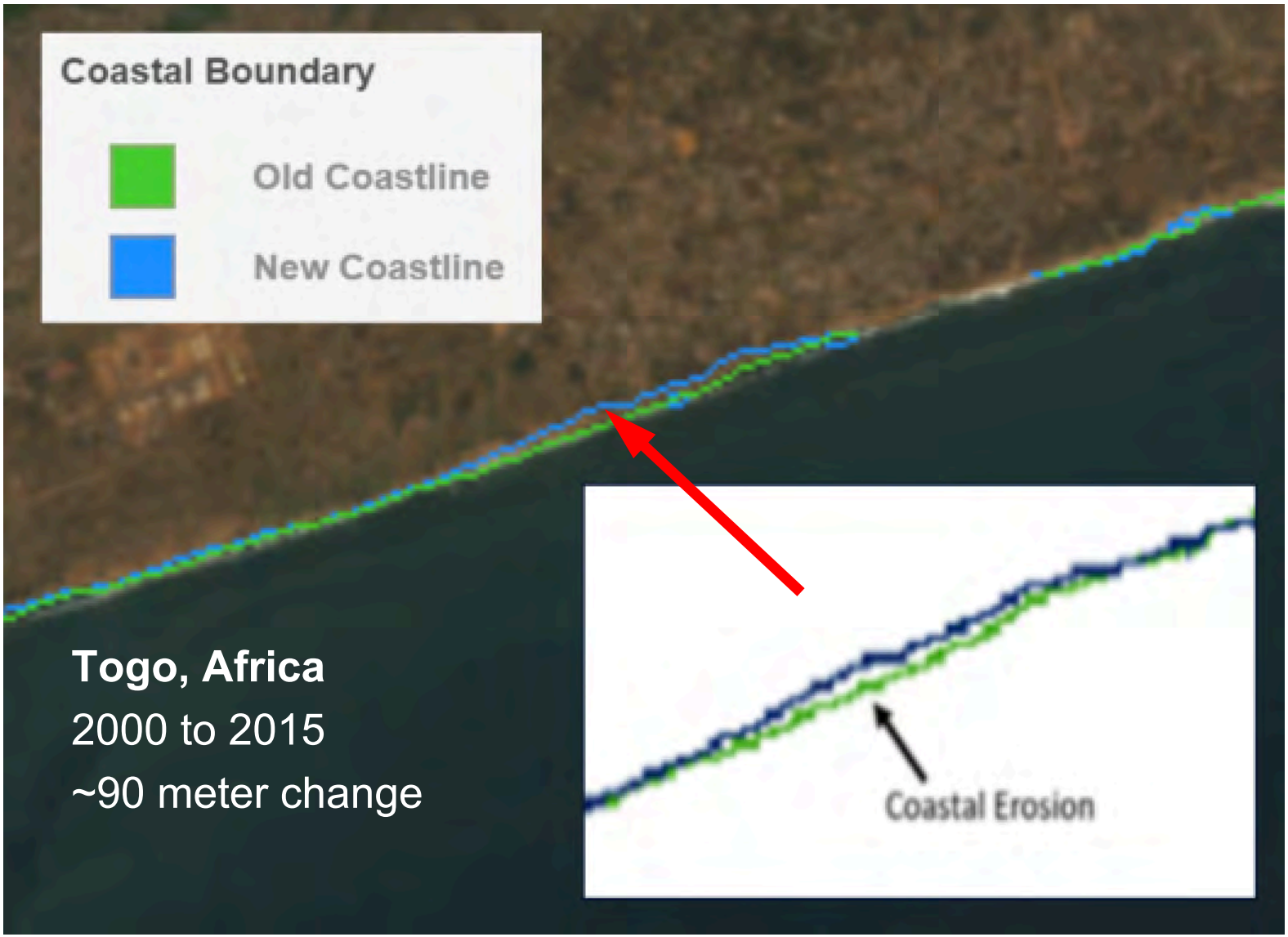
NDVI Anomaly comparison of a single Landsat 8 scene on April 4, 2016 to a 4-year median NDVI for the same month (April, 2013 to 2016)



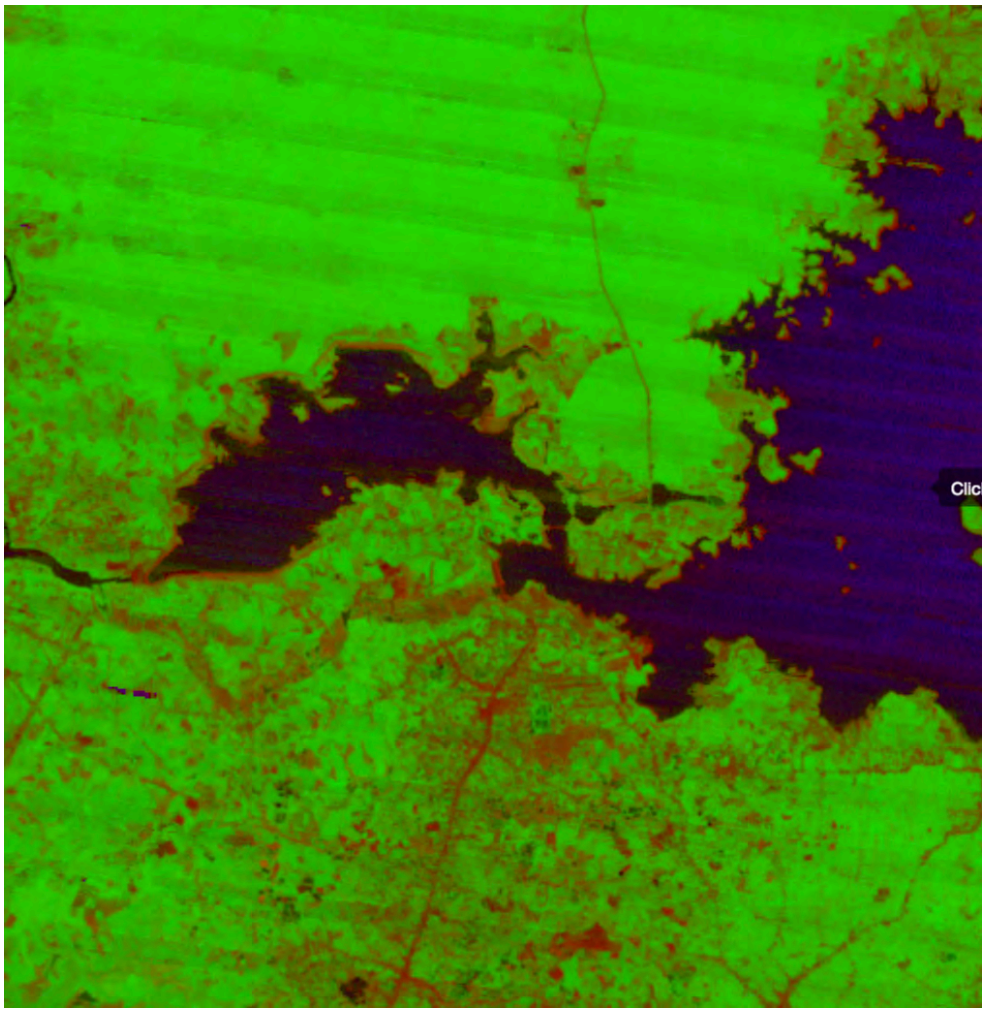
- Consistent with the GEOGLAM Crop Monitor product, but MUCH higher resolution (they use MODIS).
- BLACK regions are masks for either clouds or water
- Most vegetated areas near the Chari River entrance to Lake Chad show an increased NDVI (green) as compared to the historical median.Some reduced NDVI (brown) is seen in a few areas.

Coastal Change Detection

Lome, Togo, Africa

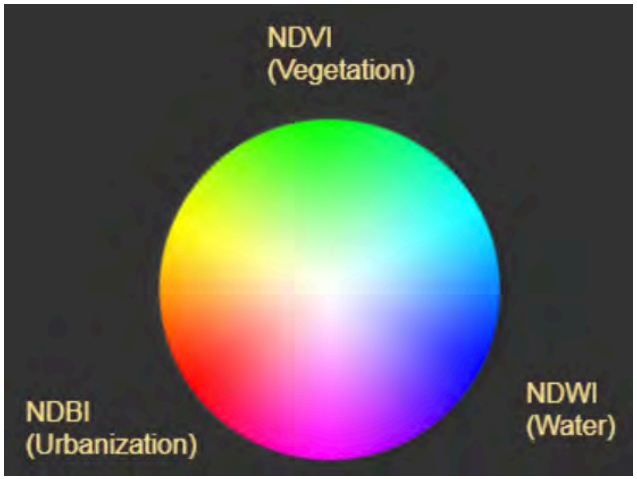


Urbanization



Ho Tri An Lake and Vinh An
near Ho Chi Minh City, **Vietnam**
Median: Year 2016

Red = Urbanization
Green = Vegetation
Blue = Water



The urbanization product combines 3 separate spectral index products: NDBI (Red), NDVI (Green) and NDWI (Blue).

Technical Progress

- We have established detailed content to support Data Cube deployments
  - **Installation** – system requirements, installation guide
  - **Data Preparation** – ARD guidance, data acquisition guidance
  - **Data Cube Creation** – ingestors for all popular datasets
  - **Applications** – AWS demo, Python notebooks, growing list of algorithms
  - **User Forum** – discussion groups for user support
- Data Cube ingestion has demonstrated significant reduction in data storage requirements when comparing the ingested Data Cubes to the original data.
  - **Landsat** = 3x to 7x reduction (varies with data parameter selections).
  - **Sentinel-1 GRD** = 6x reduction (based on 30m grid, VV and VH only)

Lessons Learned

Through our initial country interactions, we have learned a number of **lessons** …

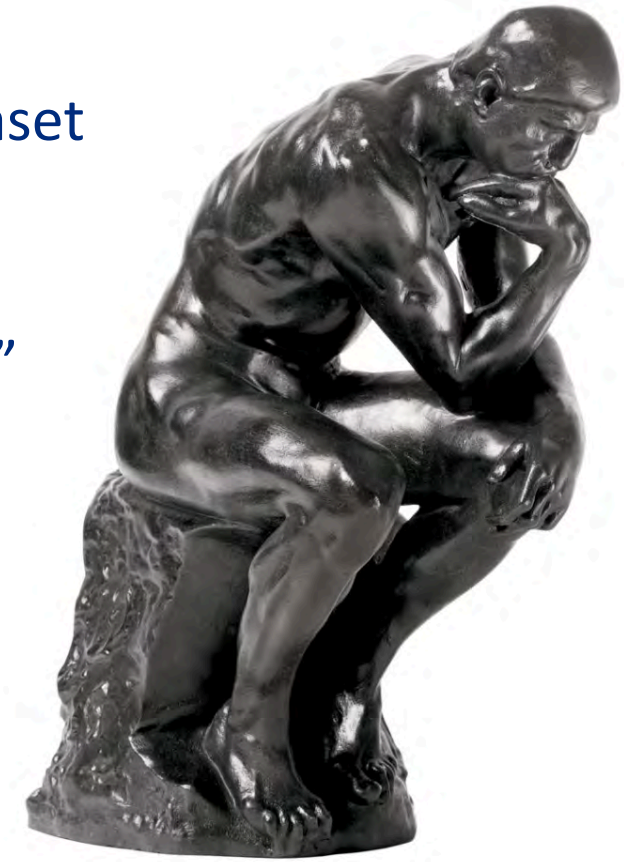
- Users should have Python programming skills
- We must clearly understand country needs to guide users toward the needed satellite data and application tools
- We must maintain consistent customer communication (both face-to-face and remote) to sustain deployment progress and build trust
- We must utilise relationships with investment banks (e.g. World Bank) and GEO to increase access to country contacts and facilitate deployment and testing
- The ODC community needs to continue to grow and expand to build confidence towards desired outcomes and to build the supply of open source tools and applications

The Future

- We expect to complete several **operational Data Cube** deployments in 2018: Vietnam, Taiwan, United Kingdom, Uganda and Uruguay.
- Anticipated collaborations with **Google and World Bank**.
- 2nd Annual **ODC Technical Meeting** in Canberra, Australia (Feb 2018), 2nd **Training Workshop** and dedicated **Data Cube Paper Session** at the IGARSS Conference in Valencia, Spain (July 2018).
- Develop new **technical additions**: Python Notebook demos, "Data Cube On-Demand" feature from the cloud, User Interface tools (pixel plotting, transect plots, clustering), Plugin for the QGIS tool.
- Develop and test new **applications**: land change detection (radar datasets),
  Water Quality (Chlorophyll) and land classification clustering.
- Add new **satellite dataset compatibility**: European Sentinel missions, France's SPOT-5, and Japan's ALOS.

Other Thoughts

- **How can users contribute?**
  Application algorithms, feedback, new dataset ingesters, capacity building, validation data
- **How can organizations help?**
  Capacity building, Data Cubes ”on-demand” from data archives “in the cloud”
- **How can we help you?**
  Sample cubes, installation support, troubleshooting
- **How to contact us?**
  Contact page on OpenDataCube.org



Data Cube Sessions

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Thank You

http://www.ceos.org

https://www.opendatacube.org

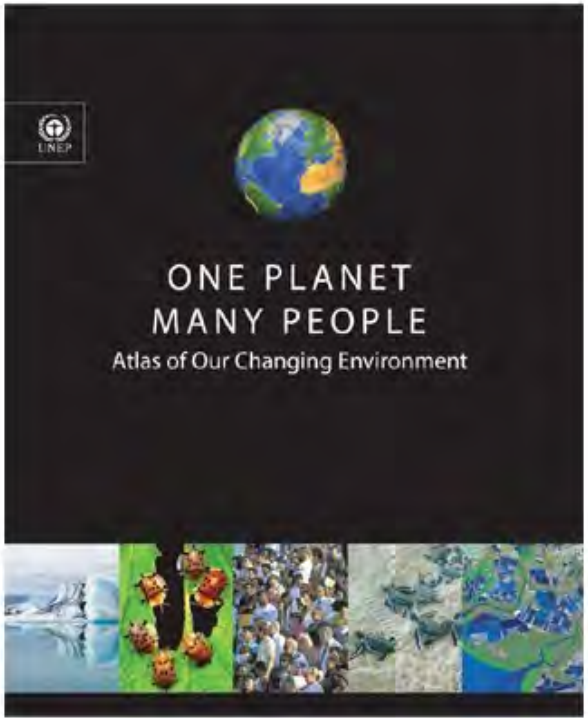
http://tinyurl.com/datacubeui

GROUP ON EARTH OBSERVATIONS

The Swiss Data Cube (SDC)

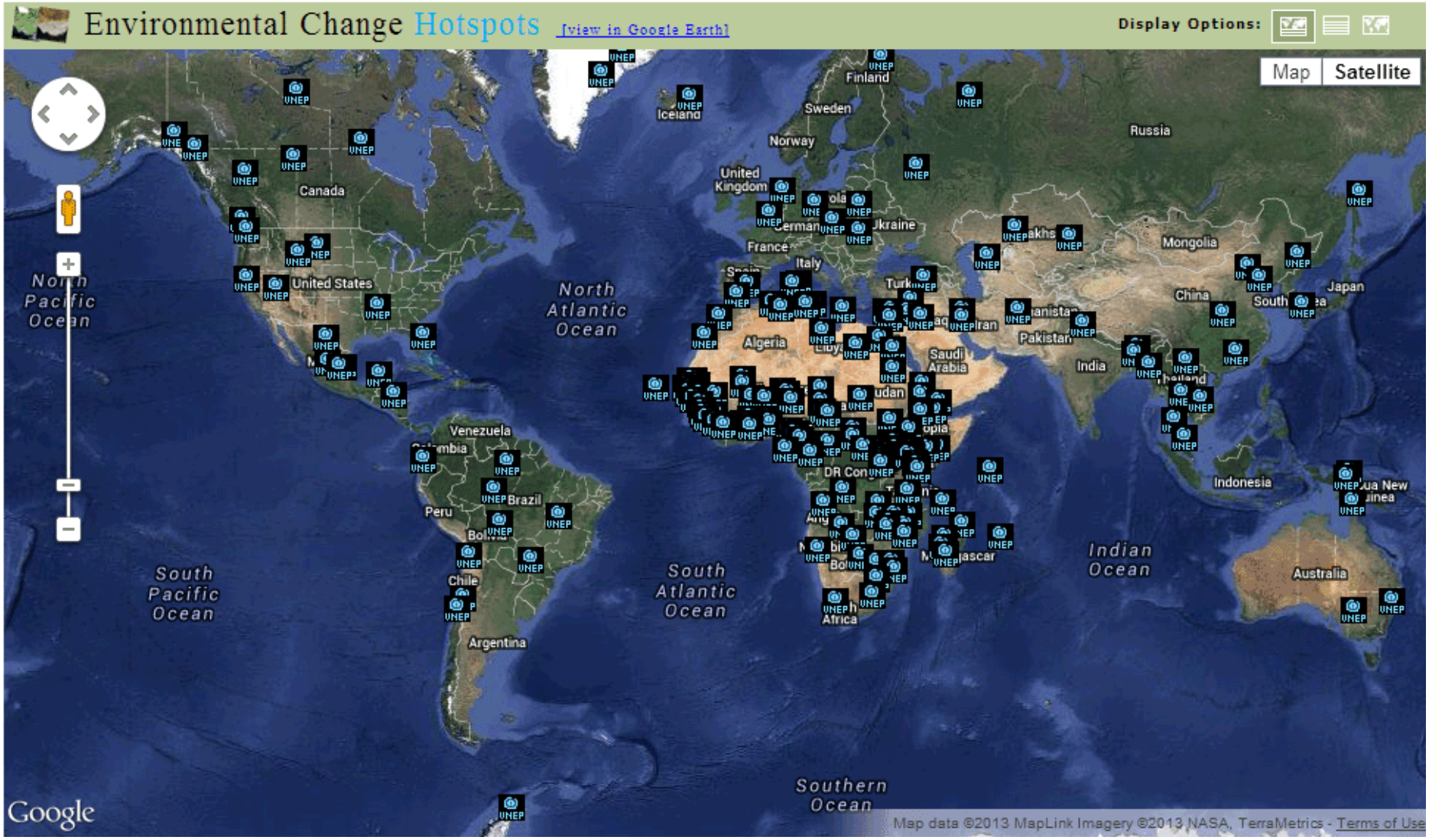
EO for monitoring the environment of Switzerland in space and time

Gregory Giuliani / 24.10.2017


UNEP
ONE PLANET
MANY PEOPLE
Atlas of Our Changing Environment


1974
UNEP


2000
UNEP



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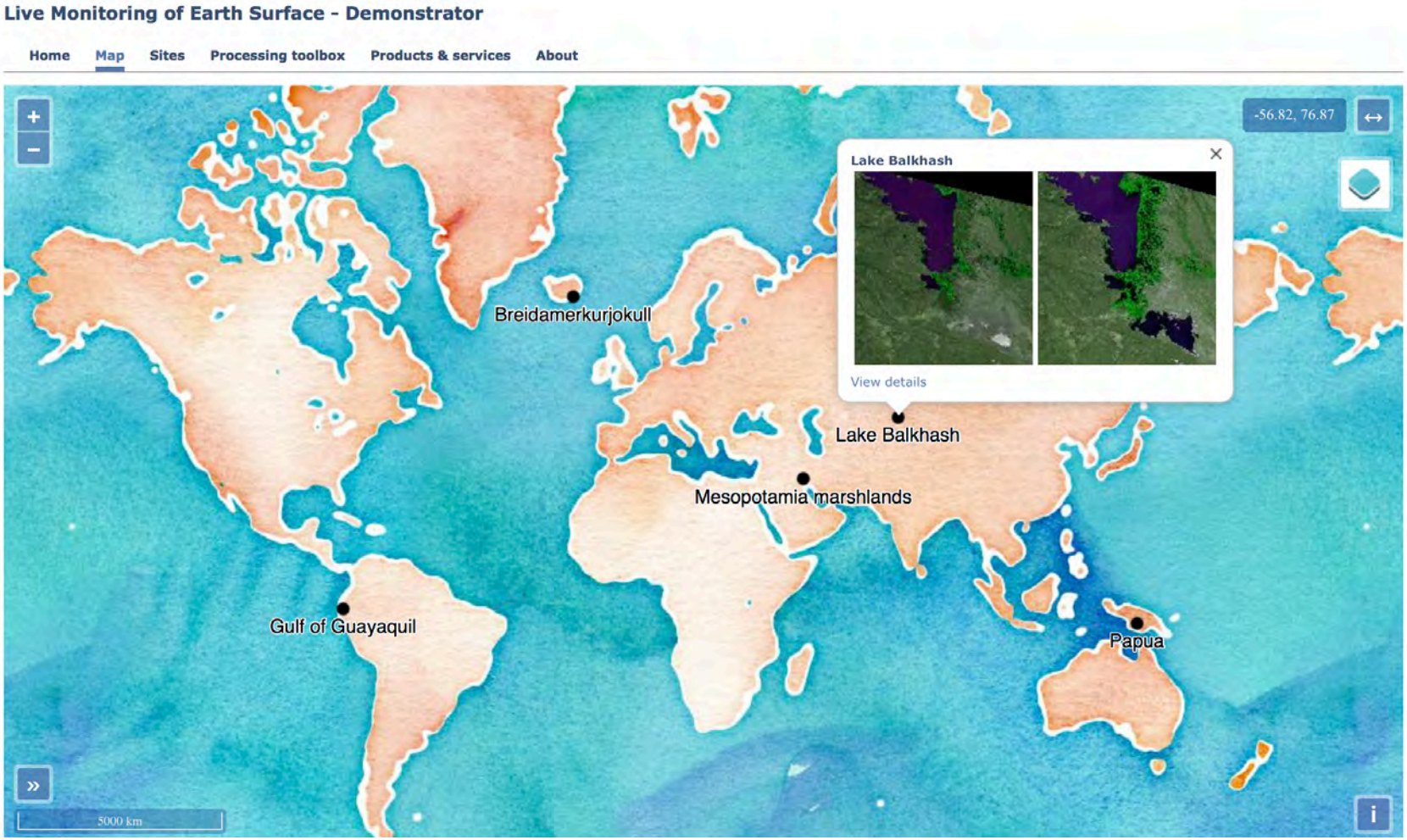
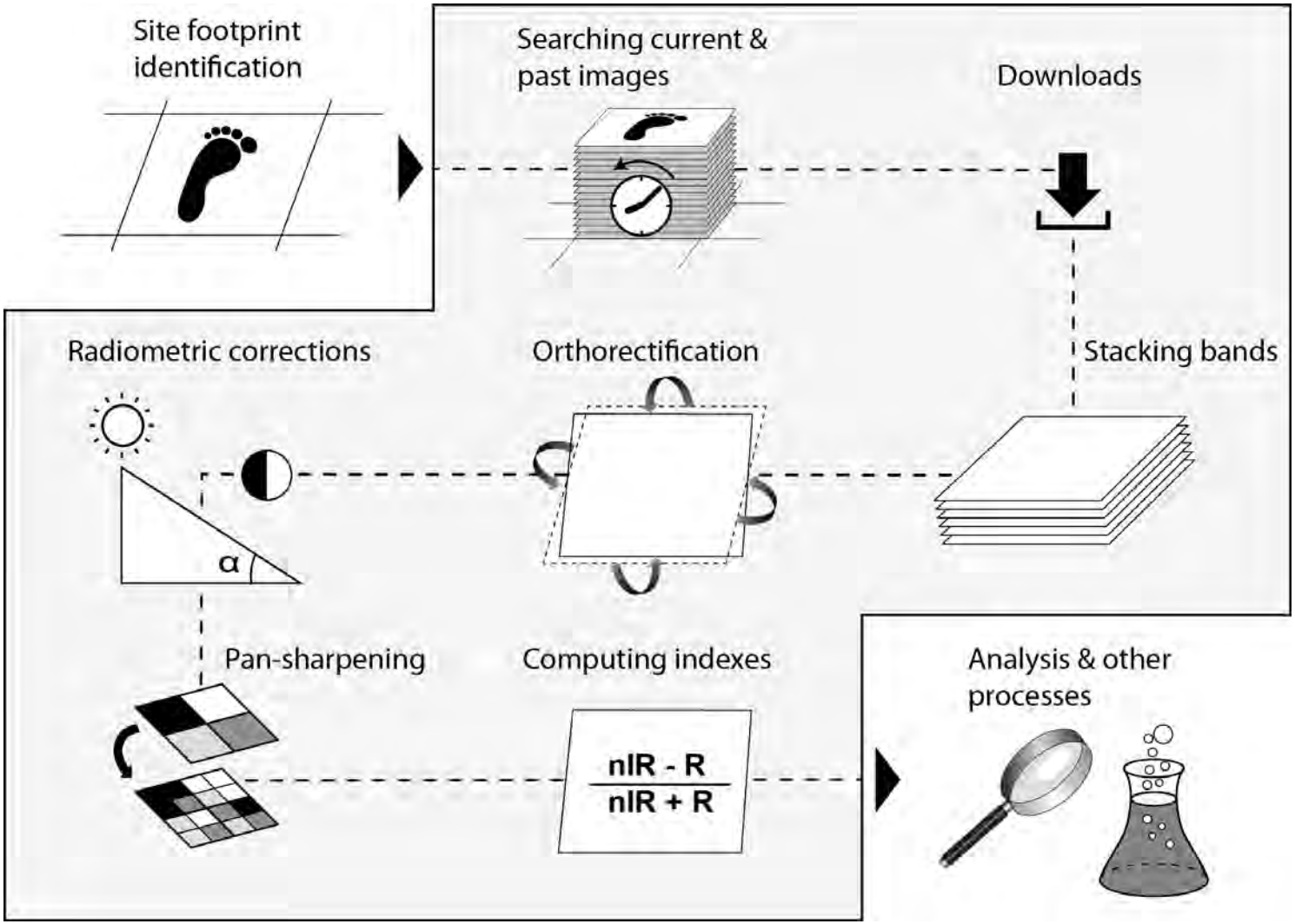
Live Monitoring of Earth Surface (LiMES)

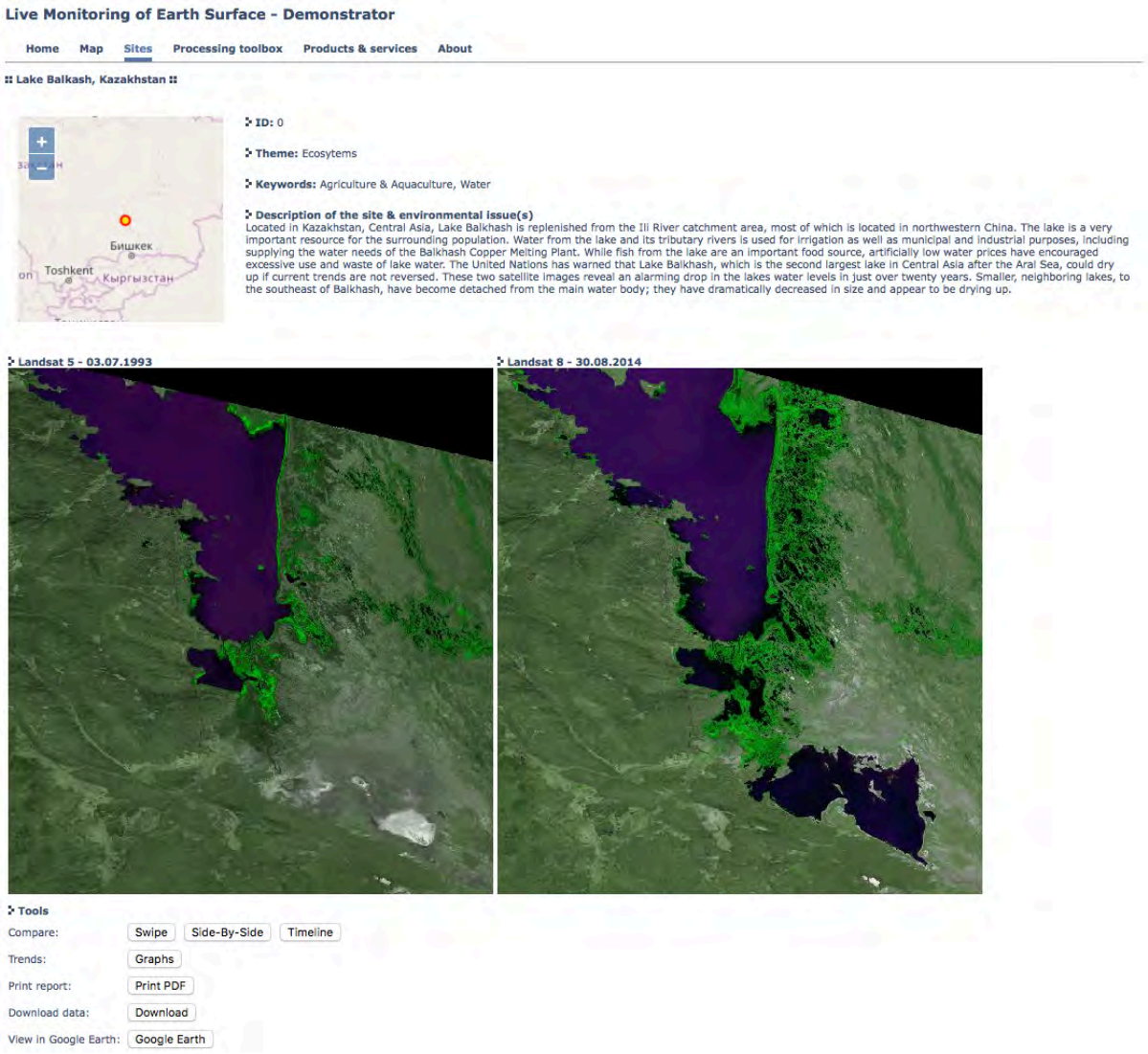


Giuliani, G., Dao, H.,De Bono, A., Chatenoux, B., Allenbach, K., De Laborie, P., Rodila, D.,Alexandris, N. and Peduzzi, P. (2017) Live Monitoring of Earth Surface (LiMES): A Framework for Monitoring Environmental Changes from Earth Observations. Remote Sensing of Environment.

Live Monitoring of Earth Surface (LiMES)

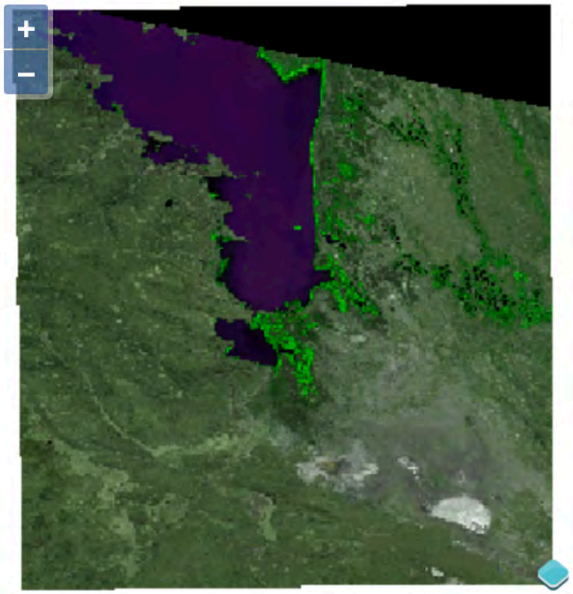


Live Monitoring of Earth Surface (LiMES)

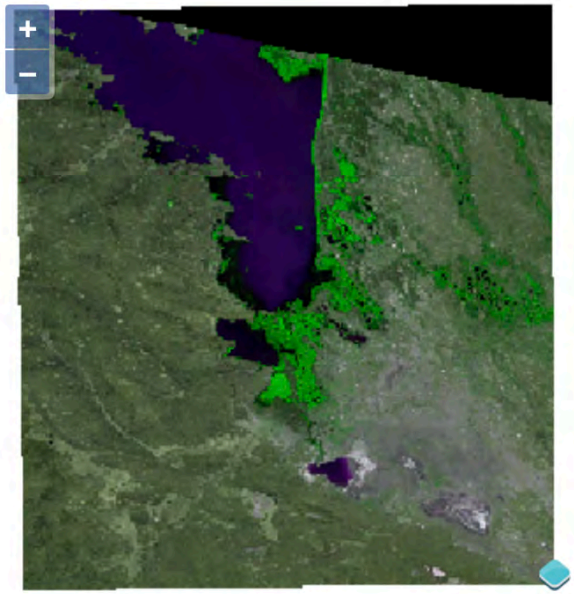


Live Monitoring of Earth Surface (LiMES)

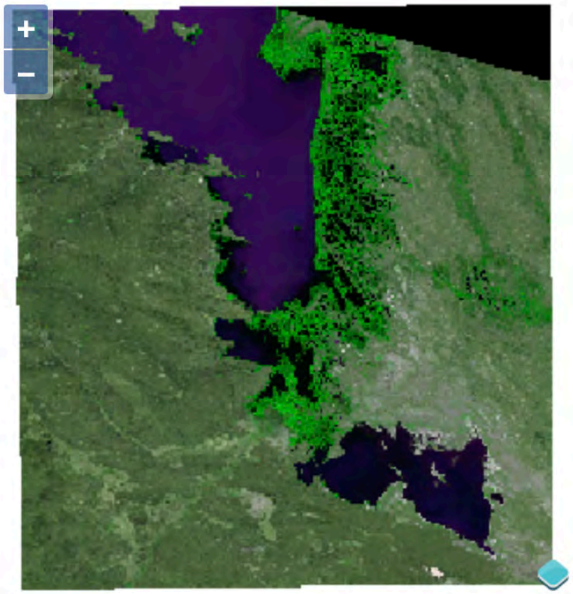
Landsat 5 - 03.07.1993



Landsat 7 - 30.07.2000



Landsat 8 - 30.08.2014



Swiss Data Cube mandate

- Data Cube Feasibility study: testing the new data cube concept over Switzerland using all Landsat images covering Switzerland for 5 years (26 passes per year). This would provide a real case study for a Complete Swiss Data Cube.
- Prepare the Data Cube platform on a virtual server.
- Populate the platform with 5 years of data and testing.

Support from: GEO/GEOSS, CEOS, GeoScience Australia

Special thanks to Brian Killough & Alfredo Delos Santos (CEOS)

Swiss Data Cube - Team

Coordination:

Dr. Gregory Giuliani
EO & SDI Officer

Prof. Pascal Peduzzi
Director, GRID-Geneva

Infrastructure:

Jean-Philippe Richard
IT Officer

Data preparation:

Bruno Chatenoux
GIS Officer

Data ingestion & analysis:

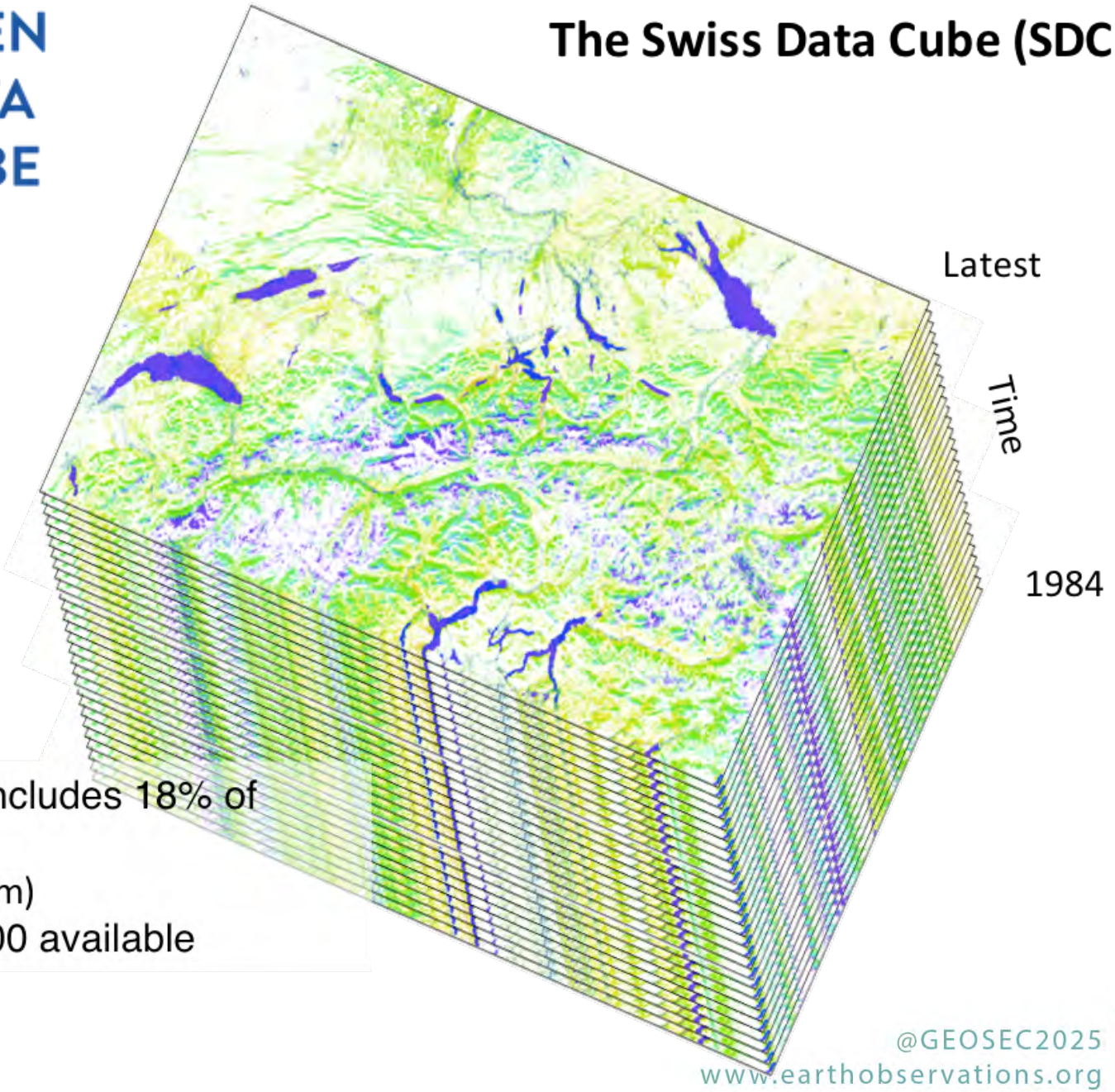
Dr. Andrea De Bono
Data Officer

Karin Allenbach
Remote Sensing Officer

+ 3 interns (L.Brossin, E.Honeck, L.Frau) working on data usage & analysis
+ 1 MSc student (C.Pittard) who will work on Land Cover & Habitat mapping

OPEN DATA CUBE

The Swiss Data Cube (SDC)



SDC prototype includes 18% of Landsat
5, 7, 8 scenes (30 m)
(880 out of > 5200 available for 1984 – now)

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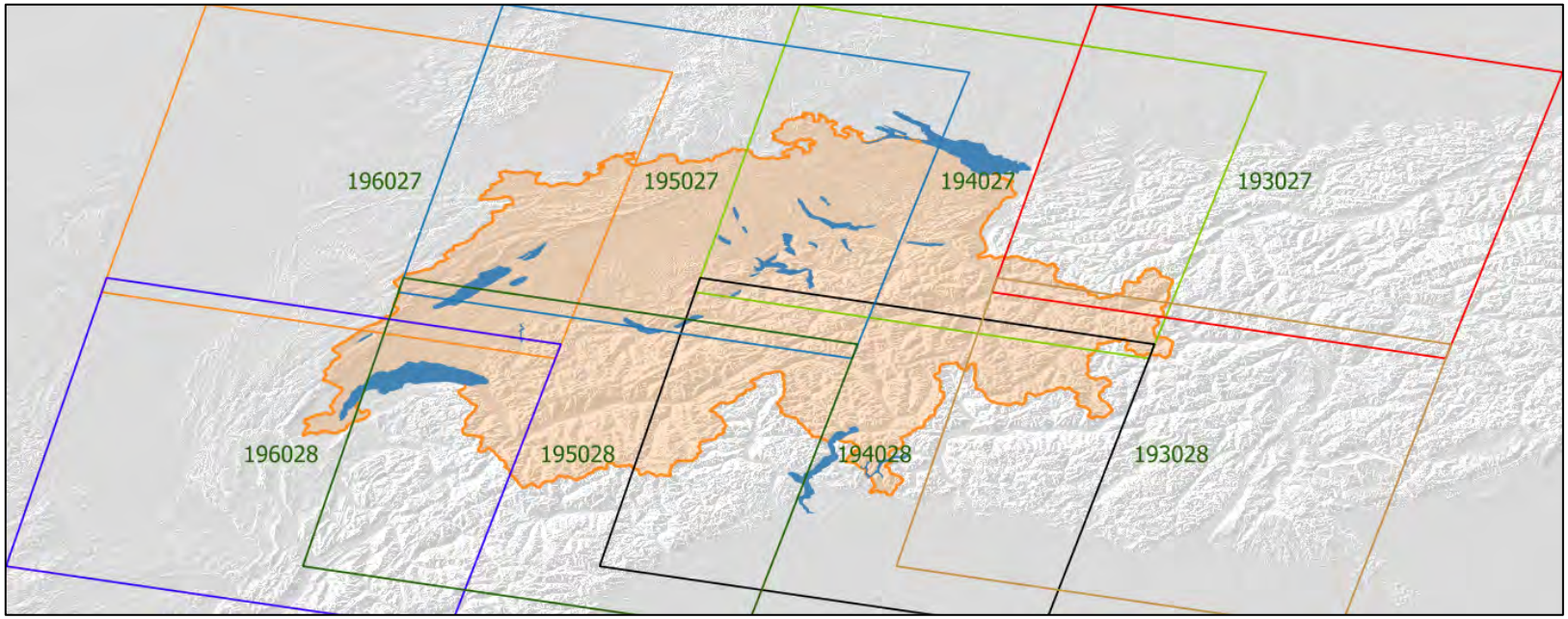
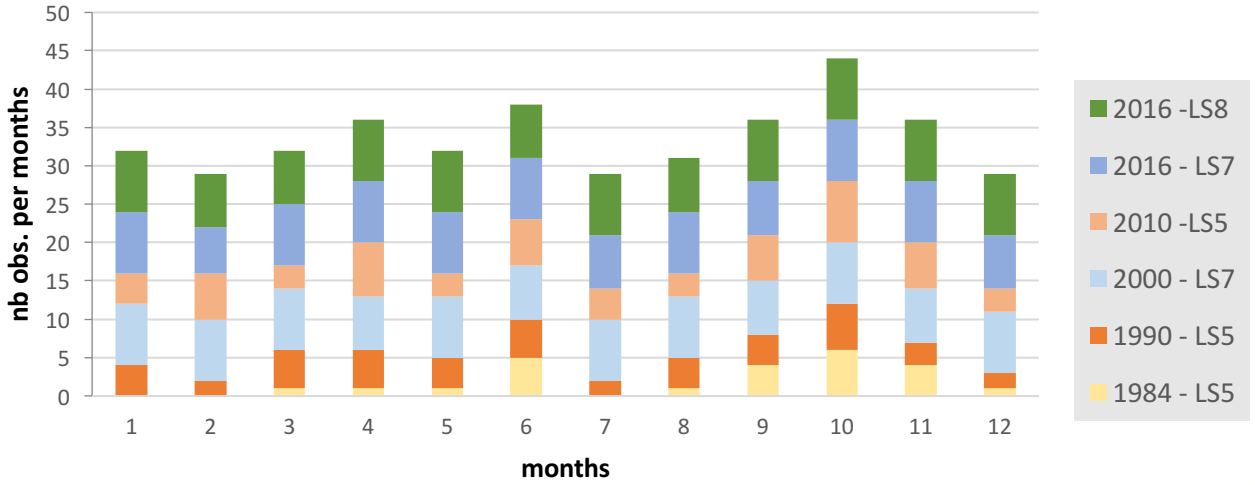
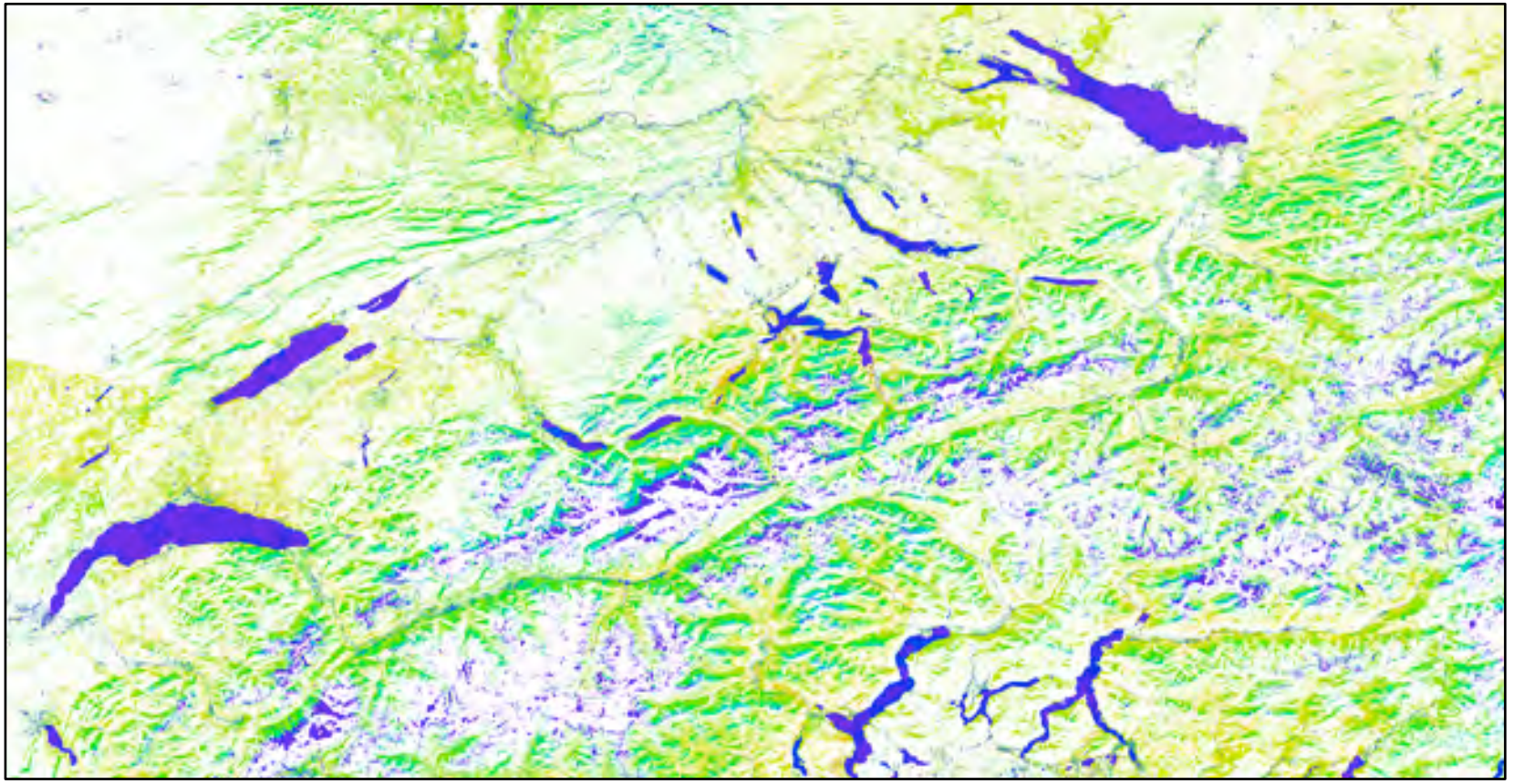


Number of observations per month (1984, 1990, 2000, 2010, 2016)





Example of water detection over 2 years of data Landsat 8 (8 x 26 x 2 = 416 scenes) on a small server (16 Gb Ram, 4 core,… 30 minutes) - Just a quick test need further improvements as the Australian algorithm is also picking shadows and some roads.

Summer (May-Sept 2016) mosaic Landsat 8, maximum NDVI.

Analysis Ready Data generation is key to reduce the burden on EO data users!

Challenges and lessons learned on ARD

- Landsat scenes discovery and availability
- Landsat scenes access
- Landsat scenes pre-processing
- Data storage strategy
- Computing performances

From LiMES to ARD for DataCube

Building an Earth Observations Data Cube: lessons learned from the Swiss Data Cube (SDC) on generating Analysis Ready Data (ARD)

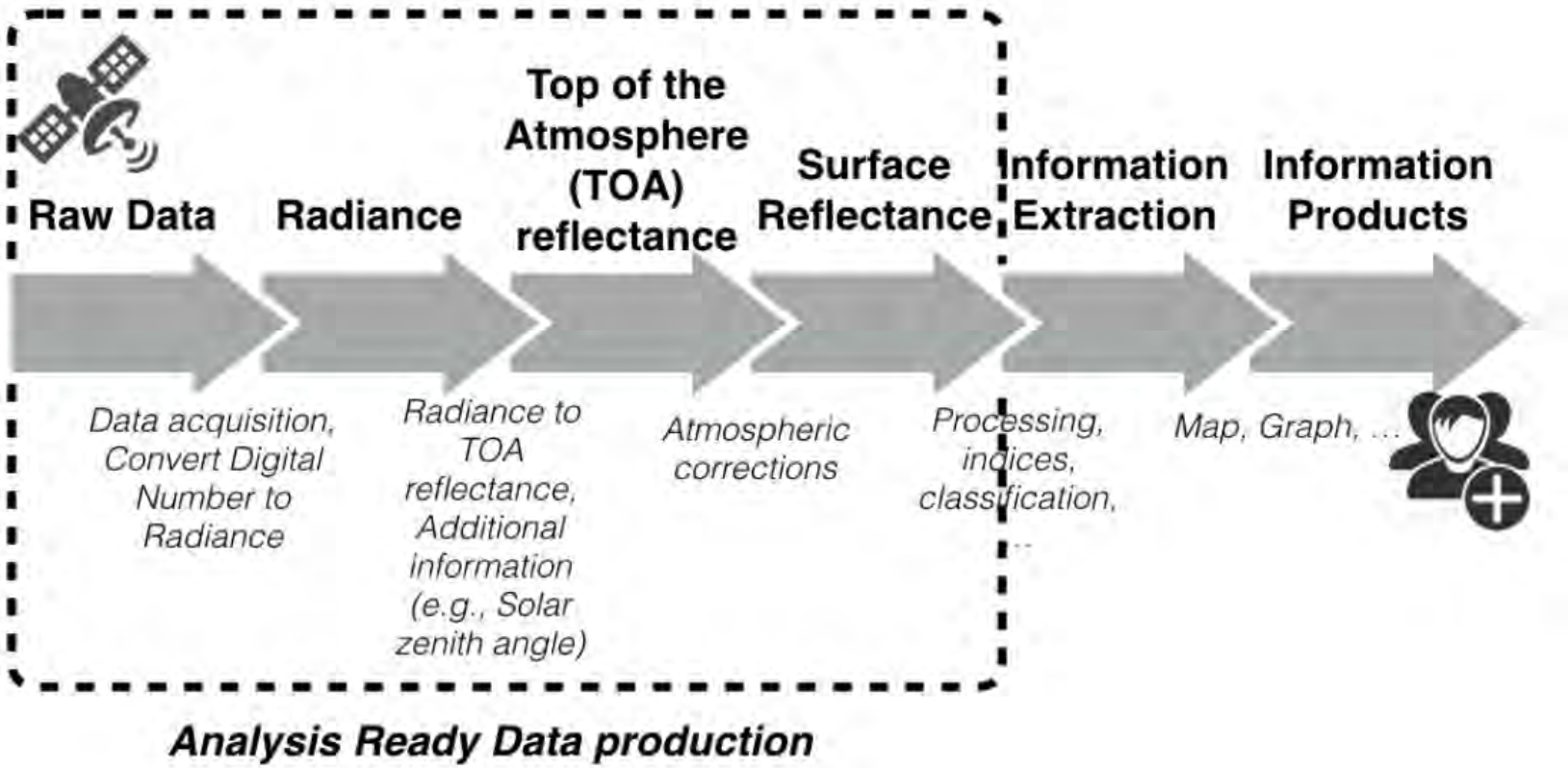
Gregory Giuliani[a,b]*, Bruno Chatenoux[a], Andrea De Bono[a], Denisa Rodila[a,b], Jean-Philippe Richard[a], Karin Allenbach[a], Hy Dao[a,c], Pascal Peduzzi[a,c,d]

[a]Institute for Environmental Sciences/GRID-Geneva, University of Geneva, Geneva, Switzerland; [b]Institute for Environmental Sciences/EnviroSPACE, University of Geneva, Geneva, Switzerland; [c]Institute for Environmental Sciences/Environmental Governance and Territorial Development, University of Geneva, Geneva, Switzerland; [d]Science Division, United Nations Environment Programme, Geneva, Switzerland;

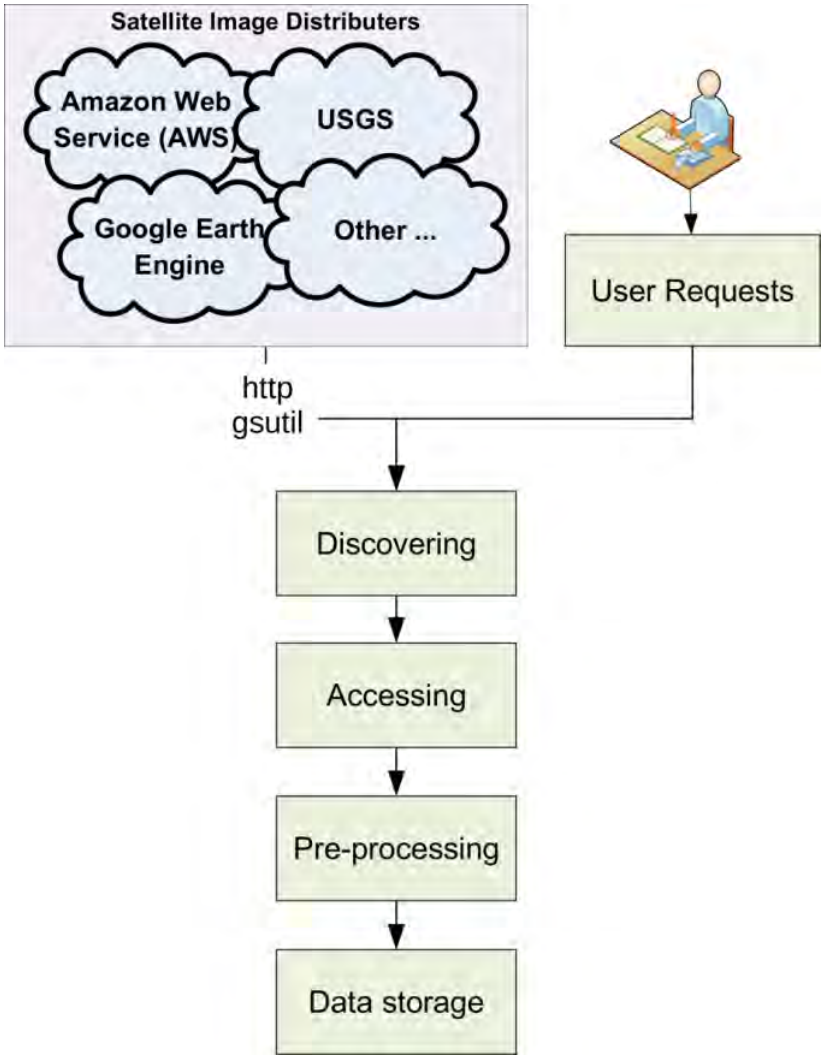
*Corresponding author: Gregory Giuliani, University of Geneva, Institute for Environmental Sciences, GRID-Geneva, Bd Carl-Vogt 66, CH-1211 Geneva, Switzerland. Email: gregory.giuliani@unige.ch

Accepted by Big Earth Data

From LiMES to ARD for DataCube



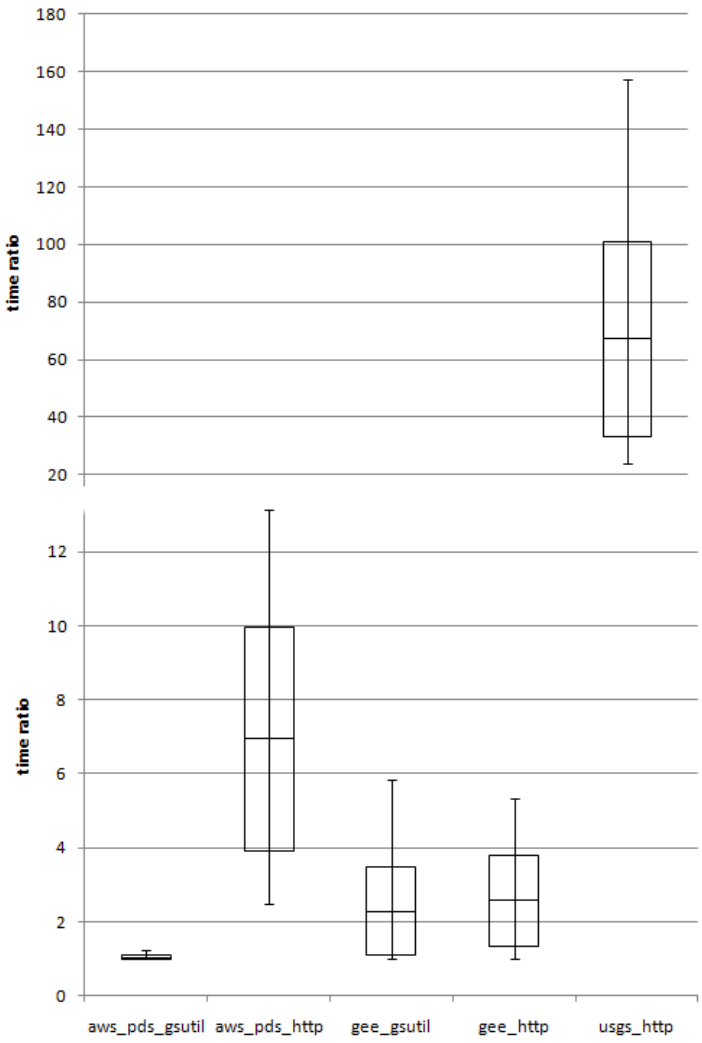
From LiMES to ARD for DataCube



ARD processing

Assumptions and constrains

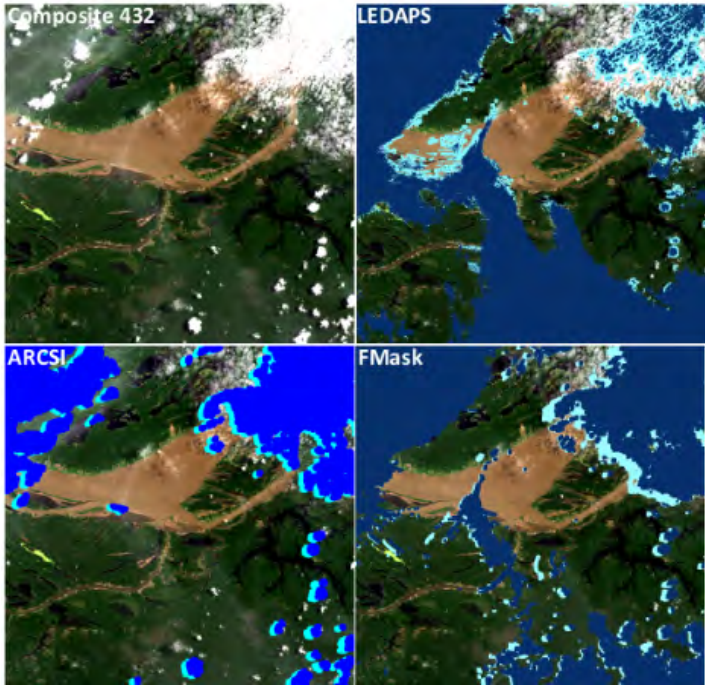
1. ARD from ESPA cannot be fully automated (manual order) and requires undefined delay for their preparation
2. USGS Pre-collection not kept updated
3. USGS Collection not fully back processed
4. GEE and AWS archive almost complete Landsat imagery and have a large bandwidth



ARD processing

Selected tools

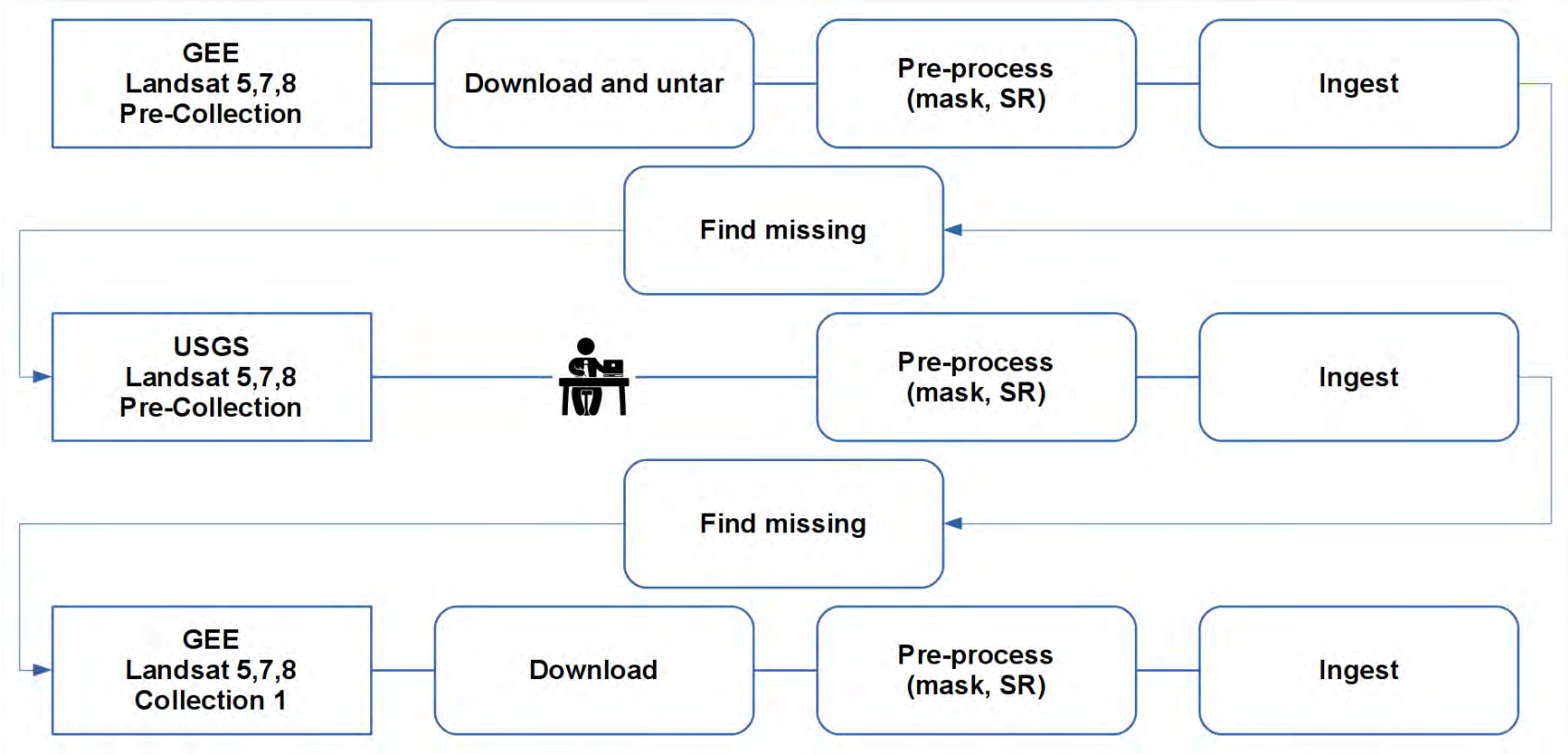
- Download when possible with gsutil (https://cloud.google.com/storage/docs/gsutil)
- Cloud and cloud shadow mask with FMask (https://code.google.com/archive/p/fmask)
- conversion to SR with ARCSI (http://rsgislib.org/arcsi)



Software	Tool	Comment	Status
Python	LEDAPS/LASRC	Little non updated documentation from USGS	KO
R	RStoolbox	Landsat 8 not implemented	KO
R	landsat	Used in RStoolbox, lot's of manual input	KO
Grass	i.landsat.toar	Linear transformation, no atmospheric correction	KO
Grass	i.atcorr	Lot's of manual input	KO
Python	ARCSI	Easy to implement and fast	OK
Python	Py6S	Used in ARCSI, lot's of manual input	KO
Python	SMAC	Lot's of manual input, not tested	KO
Python	LEDAPS/LASRC	Conda installation in 3 command (including FMask) > need huge aux files (500 Mb - x Gb / day) from 2 servers (impossible to register to second one)	KO
Python	GEE	Incomplete collections, corrupted zip files	KO

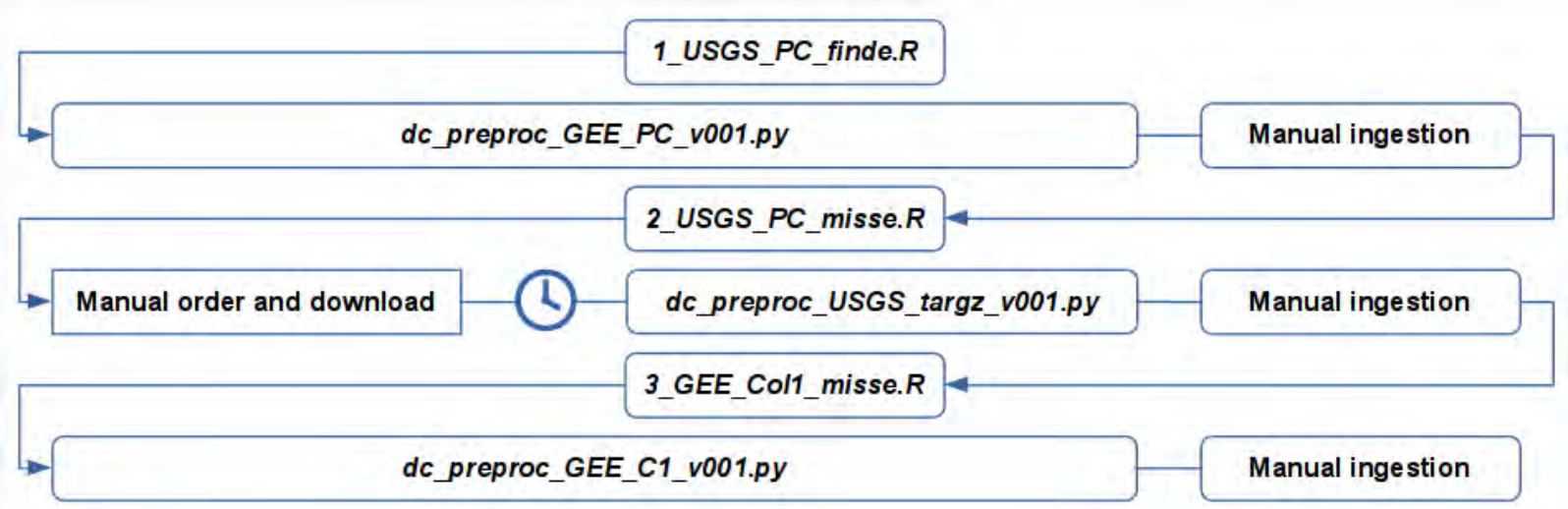
ARD processing

Primary workflow

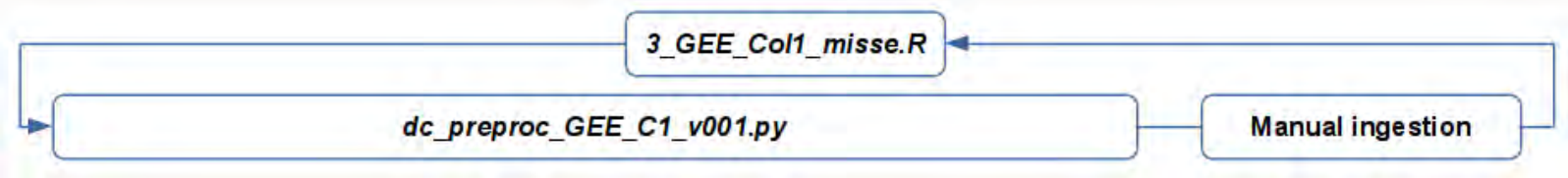


ARD processing

Primary scriptkflow

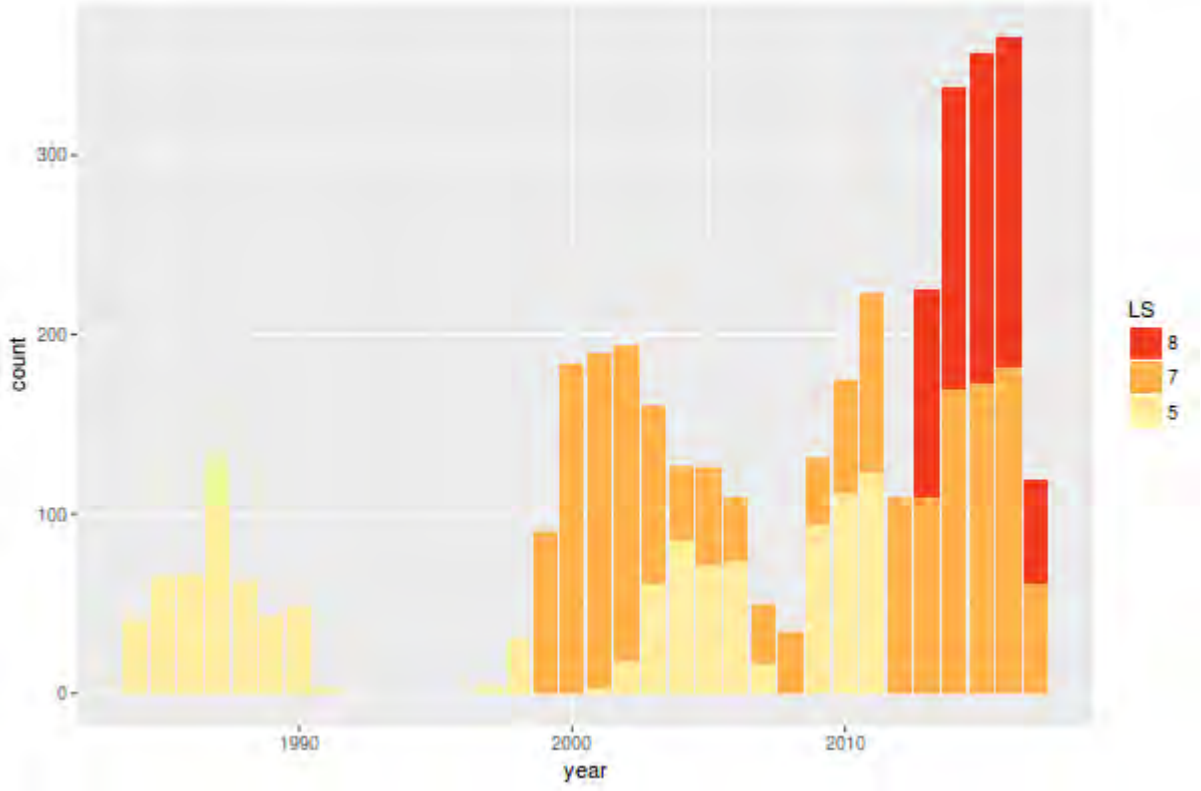


Update scriptkflow



Swiss Datacube completed

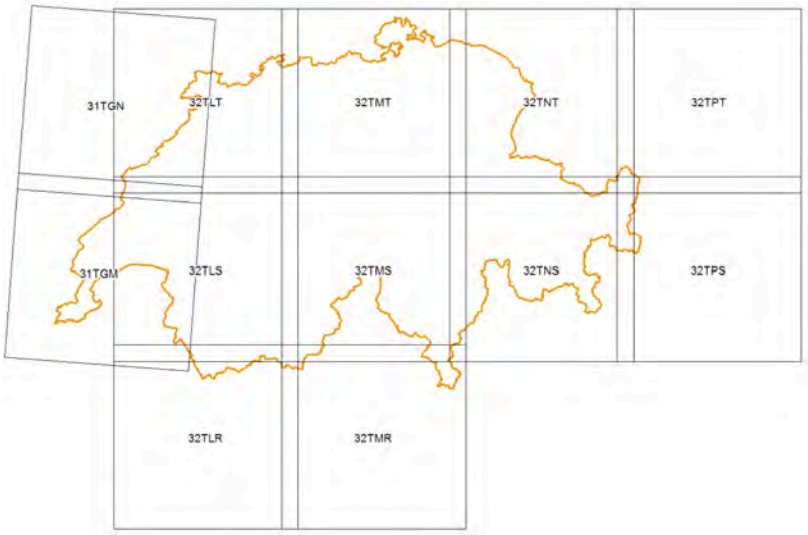
- Ingestion of 3808 L5/L7/L8 scenes (PC), for the whole Switzerland (1984-2017)

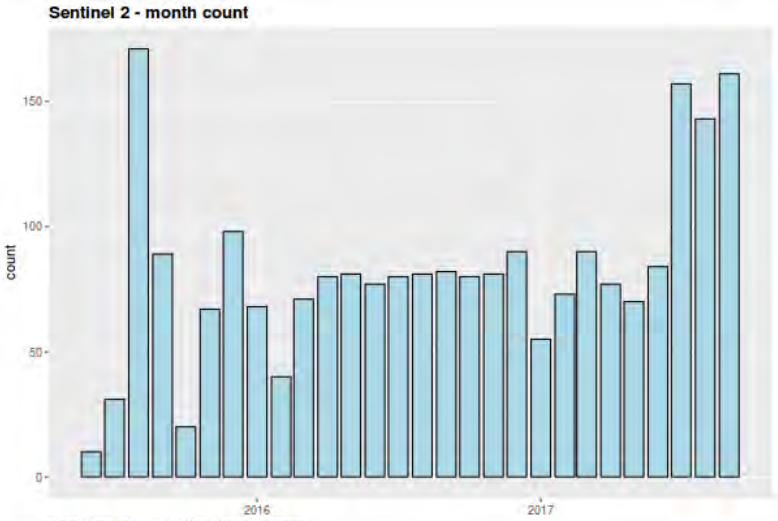


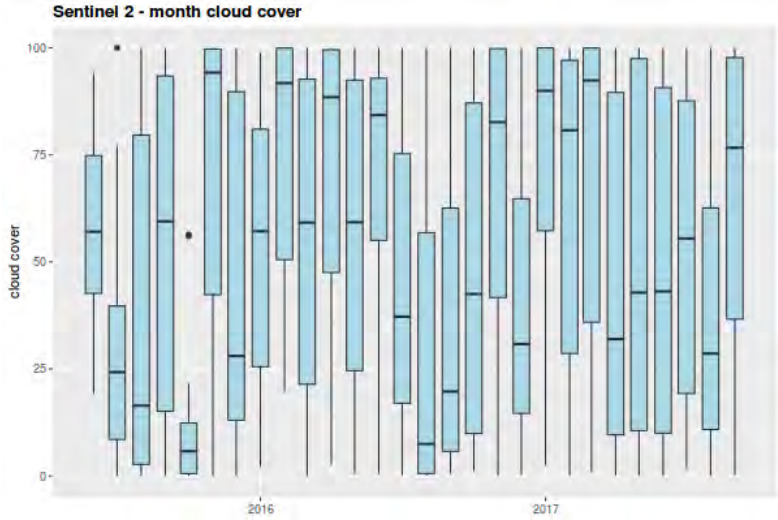
- 90's gap

Adding Sentinel 2

- 12 tiles identified > 2307 scenes available on GEE
- cloud coverage quite high

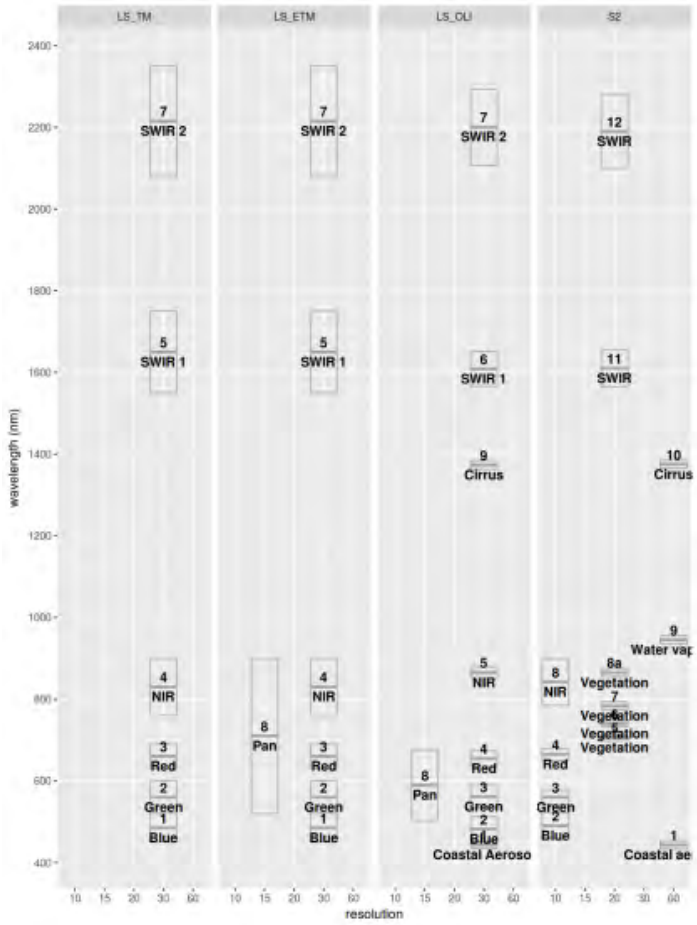




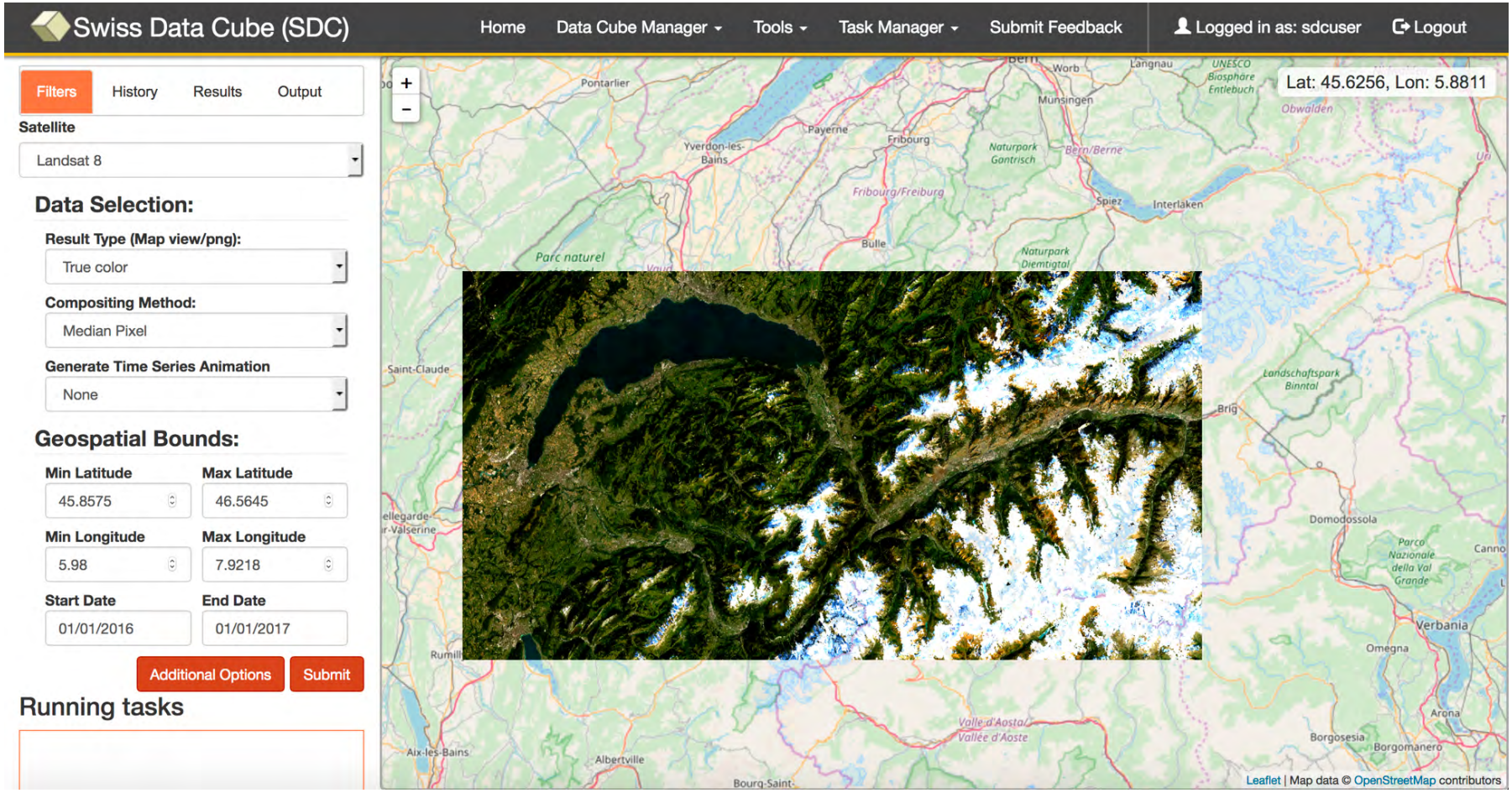


Adding Sentinel 2

- Download from GEE
- pre-processing with Sen2Cor (http://step.esa.int/main/third-party-plugins-2/sen2cor/)
  - Testing phase
- Define the kind of product(s) to be ingested
  - Brainstorming phase



SDC in action



SDC in action: snow cover & glacier

SDC in action: land cover change

Summer 1990
Summer 2000

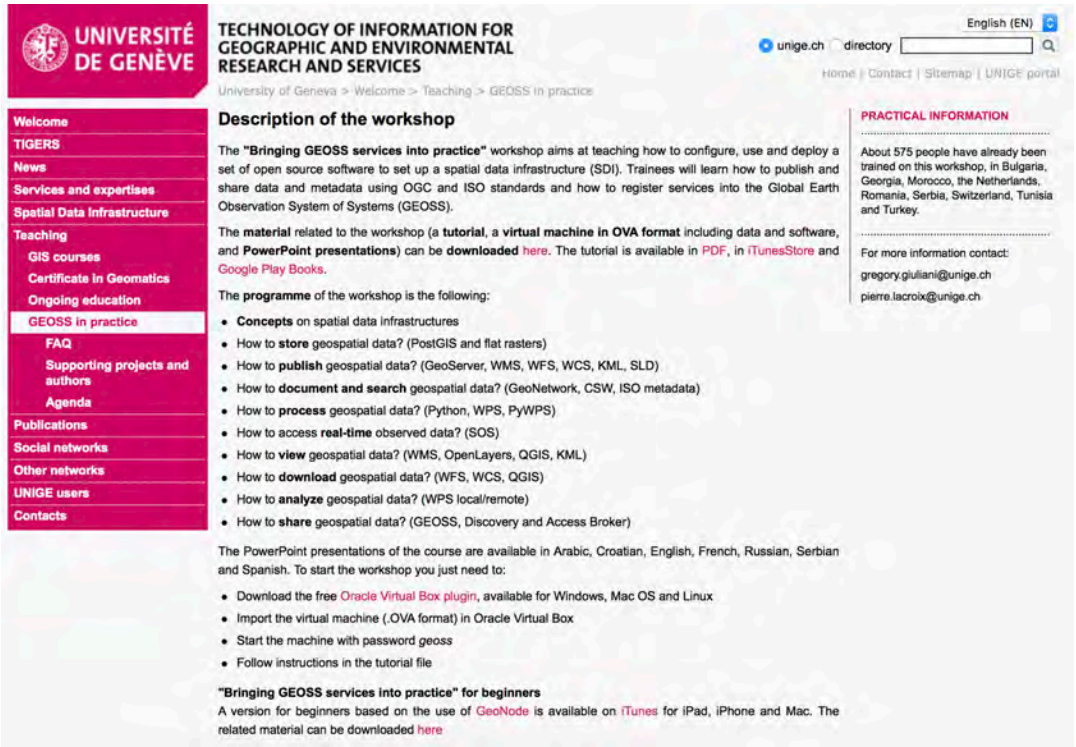
SDC recommendation

Need to have tutorial and CB material on using the web interface as well as the Python API!

SDC recommendation

We can have a “Bringing Data Cube into practice” CB material similar to the “Bringing GEOSS services into practice series (http://www.geossintopractice.org).

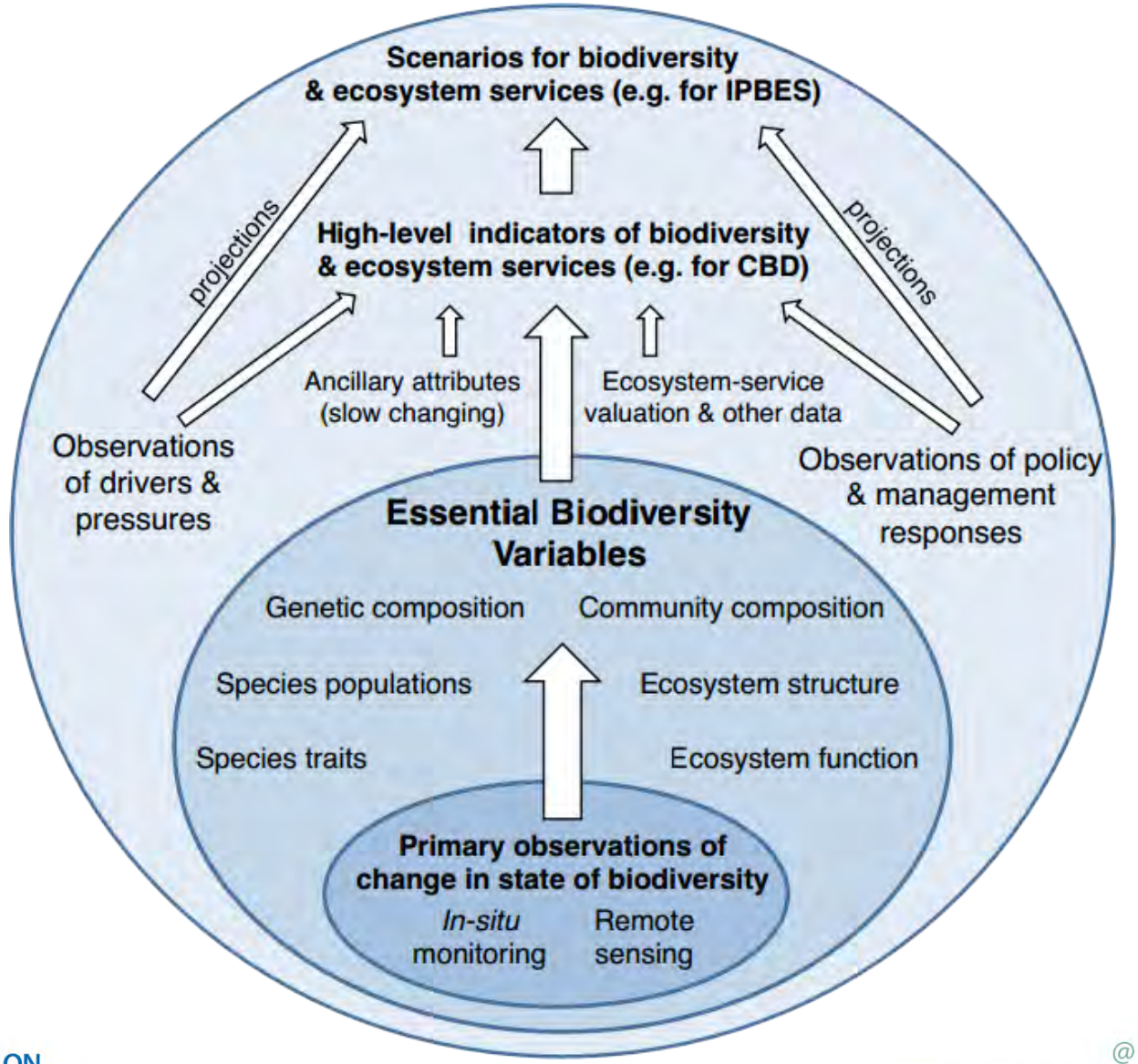
Giuliani G., Lacroix P., Guigoz Y., Roncella R., Bigagli L., Santoro M., Mazzetti P., Nativi S., Ray N., Lehmann A. (2017) Bringing GEOSS services into practice: a capacity building resource on spatial data infrastructures (SDI). Transactions in GIS 21(4):811-824



Potential applications

- Monitoring land cover change
- Glacier monitoring, ice extent mapping, snow cover monitoring
- Agricultural applications: crop monitoring, food security
- Vegetation and forest monitoring, parameter generation (chlorophyll concentration, carbon mass estimations)
- Water quality monitoring
- Flood mapping and management
- Urban mapping & monitoring

Essential Variables & indicators



Earth Observations

in support of the

2030 Agenda for Sustainable Development

EARTH OBSERVATION AND GEOSPATIAL INFORMATION LINKAGES TO SDG GOALS, TARGETS AND INDICATORS

SUSTAINABLE DEVELOPMENT GOALS

Target Contribute to progress on the Target, not necessarily the Indicator									Goal	Indicator Direct measure or indirect support to the Indicator					
							1.4	1.5	1 No poverty	1.4.2					
						2.3	2.4	2.c	2 Zero hunger	2.4.1					
					3.3	3.4	3.9	3.d	3 Good health and well-being	3.9.1					
									4 Quality education						
								5.a	5 Gender equality	5.a.1					
		6.1	6.3	6.4	6.5	6.6	6.a	6.b	6 Clean water and sanitation	6.3.1	6.3.2	6.4.2	6.5.1	6.6.1	
					7.2	7.3	7.a	7.b	7 Affordable and clean energy	7.1.1					
								8.4	8 Decent work and economic growth						
					9.1	9.4	9.5	9.a	9 Industry, innovation and infrastructure	9.1.1	9.4.1				
						10.6	10.7	10.a	10 Reduced inequalities						
	11.1	11.3	11.4	11.5	11.6	11.7	11.b	11.c	11 Sustainable cities and communities	11.1.1	11.2.1	11.3.1	11.6.2	11.7.1	
				12.2	12.4	12.8	12.a	12.b	12 Responsible consumption and production	12.a.1					
					13.1	13.2	13.3	13.b	13 Climate action	13.1.1					
		14.1	14.2	14.3	14.4	14.6	14.7	14.a	14 Life below water	14.3.1	14.4.1	14.5.1			
	15.1	15.2	15.3	15.4	15.5	15.7	15.8	15.9	15 Life on land	15.1.1	15.2.1	15.3.1	15.4.1	15.4.2	
								16.8	16 Peace, justice and strong institutions						
17.2	17.3	17.6	17.7	17.8	17.9	17.16	17.17	17.18	17 Partnerships for the goals	17.6.1	17.18.1				

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SDC hackathon in 2018

SDC website: http://www.swissdatacube.org

Georgian and Moldovian Data Cubes

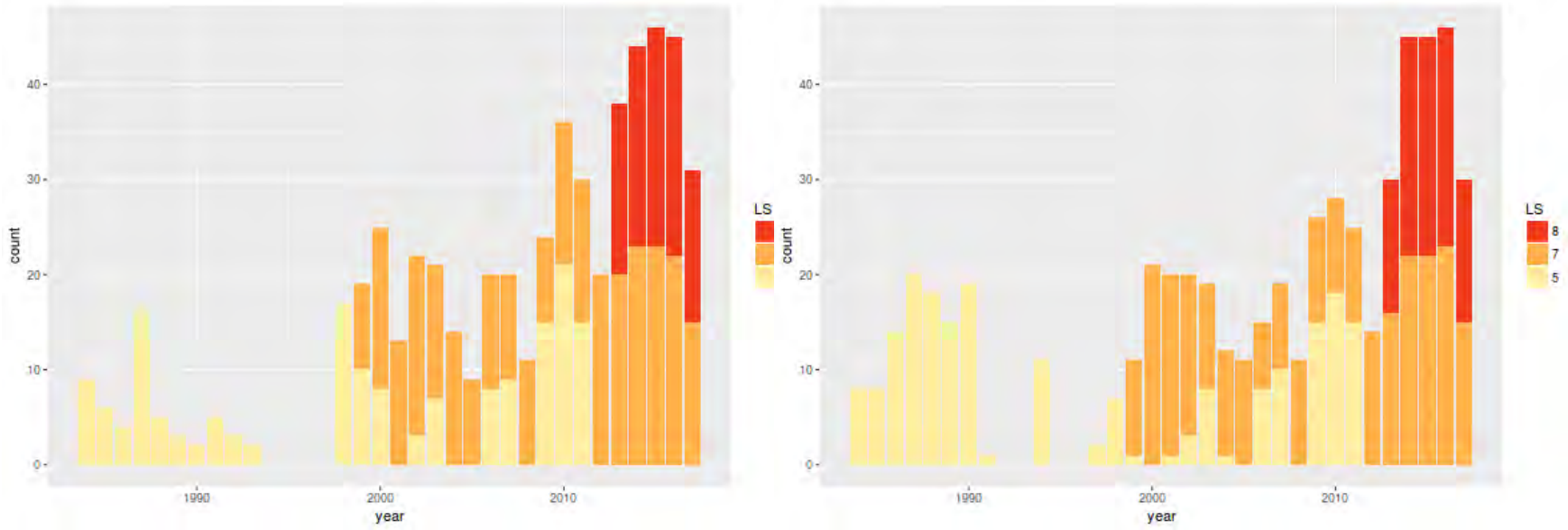
- Mainstreaming biodiversity and ecosystem services in Eastern Europe and Caucasus
- The project will provide new tools and techniques to national experts in order to help in the identification of threatened ecosystems and for their sustainable management through transfer of technology and capacity building

Georgian and Moldovian Data Cubes

- Mini 1 tile DC per country to be used
- DC on GRID-Geneva server to be transferred to national IT infrastructures

Georgian and Moldovian Data Cubes

- Mini 1 tile DC per country to be used
- DC on GRID-Geneva server to be transferred to national IT infrastructures



- 90's gap

Thank You

Communicate and Collaborate with GEO:

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CDCOL

Colombian Data Cube

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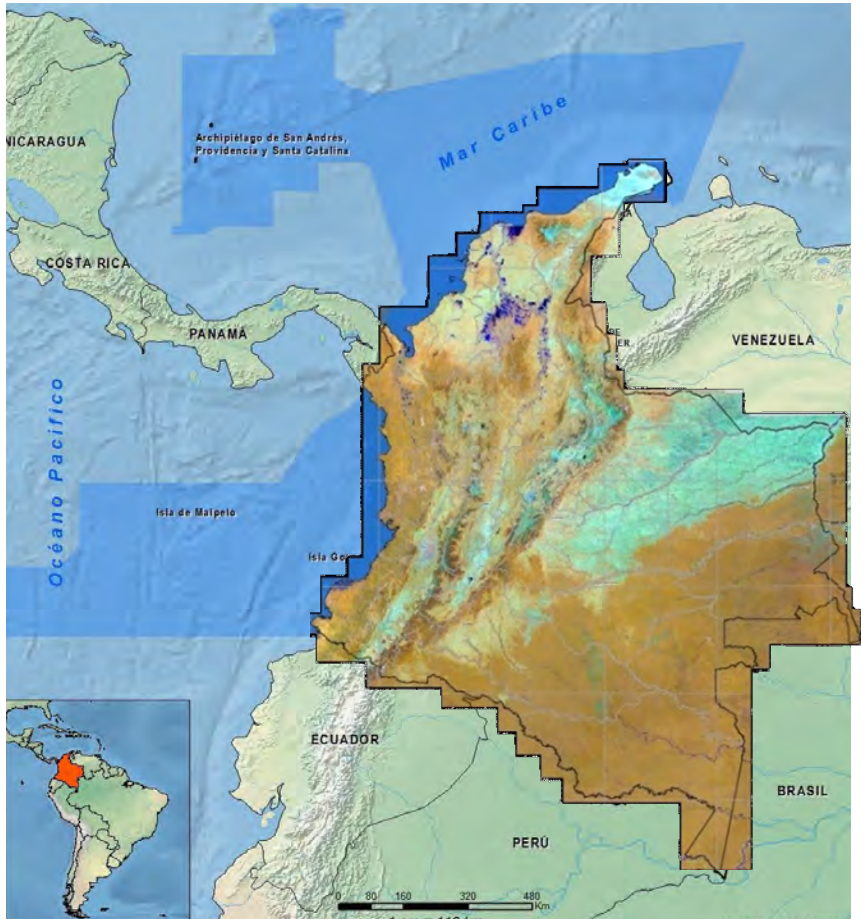
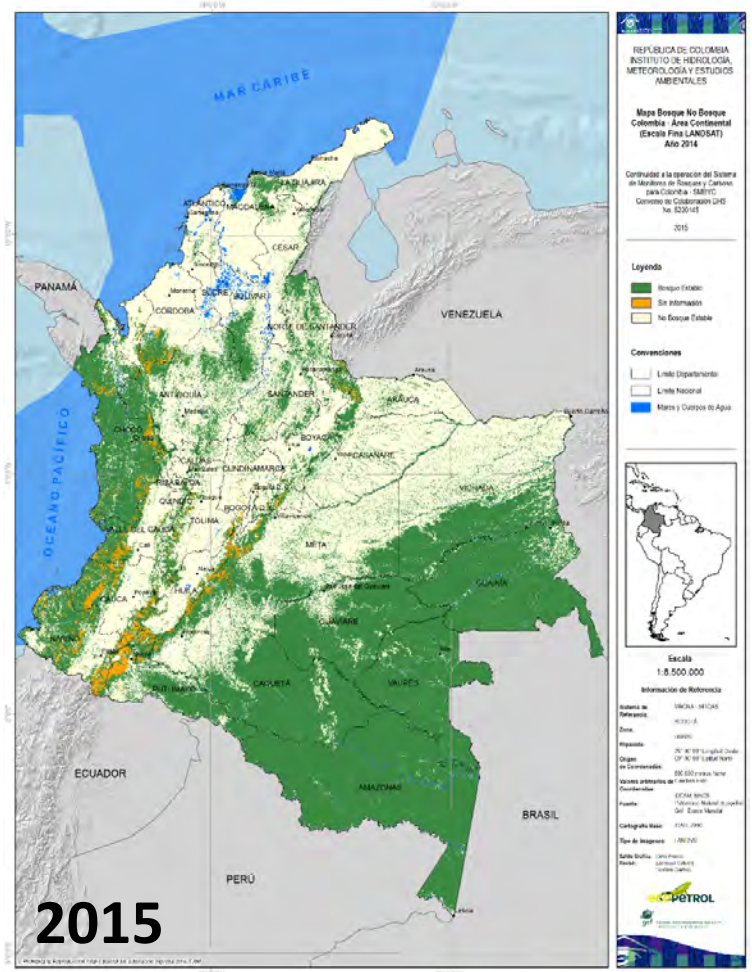
COLOMBIA



- Colombia has a total area of 2.070.408 km²
- 55.14% of land area
- 44.85% of sea surface

FOREST AND CARBON MONITORING SYSTEM



Since 2016
Quarterly

Early warning
Identifying hot spots

C&A Deforestation and Degradation
- Caracterization
- Modelation

Carbon monitoring
- Carbon stocks
- GHG Emissions

National quantification of deforestation
- Forest areas
- Forest change detection
Deforestation rate

Since 2013 Annual

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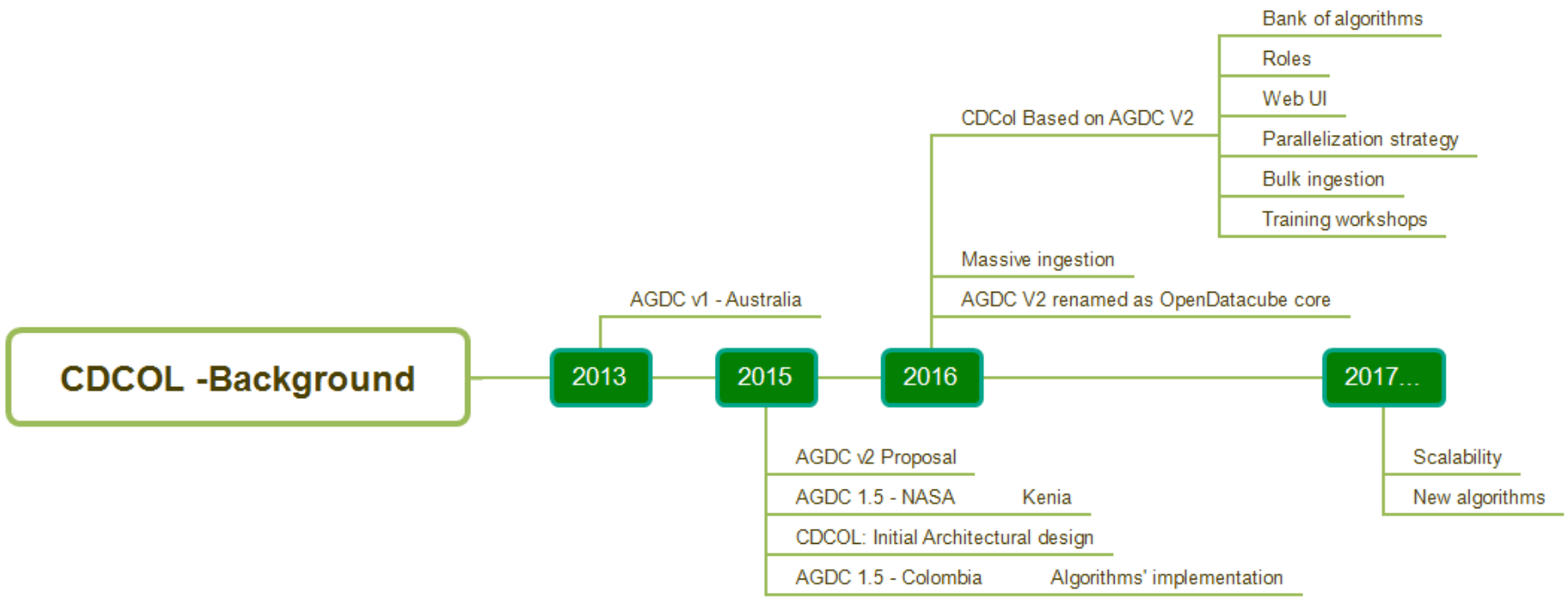
CDCol Timeline



Product| feature	Planet	Earth Engine	AGDC v1	AGDC V1.5	AGDC V2 (now OpenDatacube)	CDCOL
Data ownership	✗	✗	✓	✓	✓	✓
Add new algorithms	✓	✓	✓	✓	✓	✓
Use new sources	✗	✗	Limited	Limited	✓	✓
Lineage	✓	✓	✓	✓	✓	✓
Enforced Replicability	✗	✗	✗	✗	✗	✓
Complexity Abstraction	✗	✗	✗	✗	Limited	✓
Algorithms publication	✗	Script sharing	✗	✗	✗	✓
Usability	✓	✓	✗	Limited	✗	✓
Parallelization	N/A	N/A	✓	✓	In development	✓
Fit to IDEAM's Standards	✓	✓	✗	✓	✓	✓

Related works - Analysis

Advances of Colombian Data Cube CDCol

17 years
FROM 2000-2016

30 meters
PIXEL RESOLUTION

3 sensors
LANDSAT 5/7/8

27.070 downloaded images
LANDSAT 5/7/8

16.400 ingested images
LANDSAT 5/7/8

17.2 TB
NO DATA CUBE

135.441 tiles
LANDSAT 5/7/8

3.8 TB
DATA CUBE - NETCDF

1.4x 10^{12}
PIXELS

Downloading and ingestión of all country (Landsat 5-7-8)

Interface WEB: user management, algorithms bank

Workshops and capacity building

Applicacions: temporal composed imagery, change detection PCA, WOFS, land cover classification

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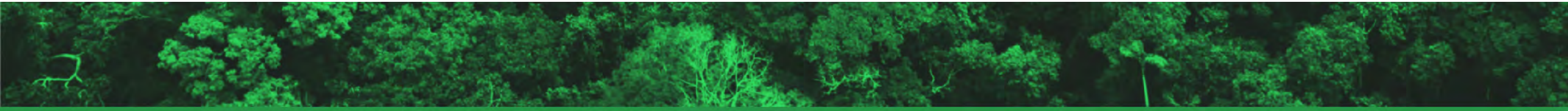
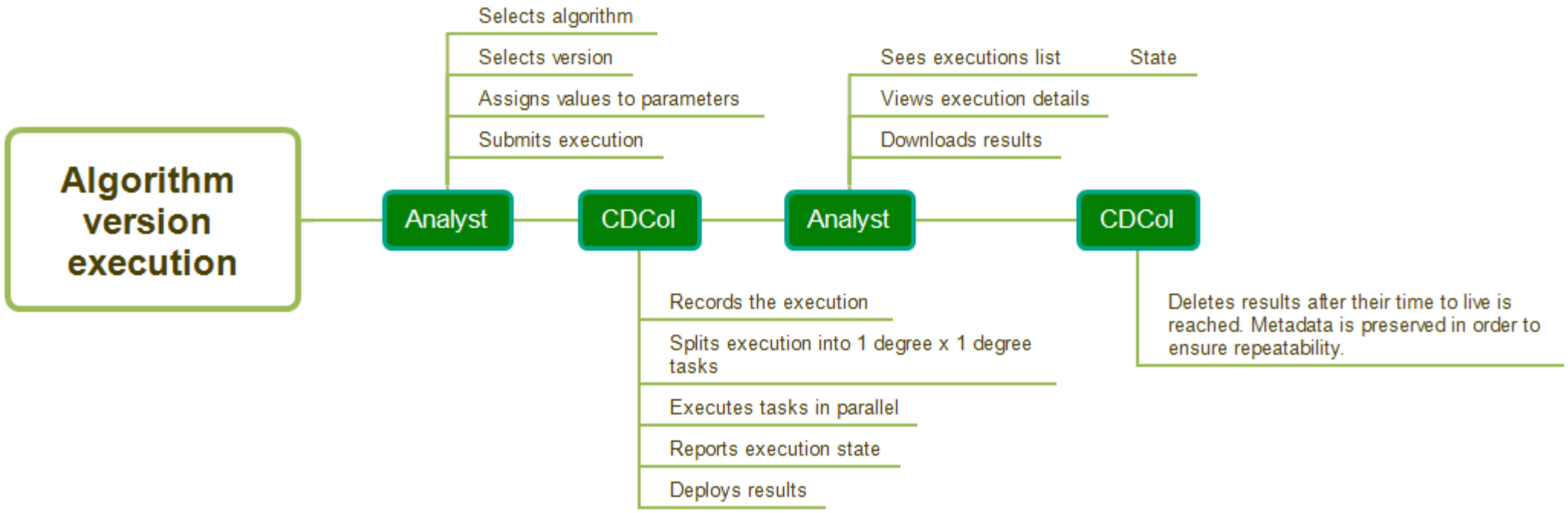
CDCol User Roles

- System Administrator
- Data Administrator
- Developer
- Analyst



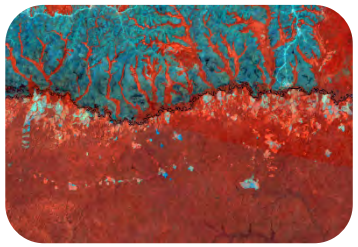
Execution

Roles	Bank of algorithms and results	Web UI
Parallelization strategy	Bulk Ingestion	Training Workshop

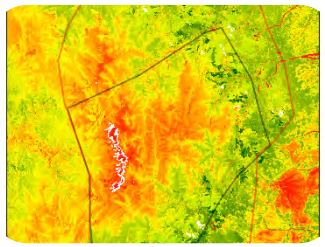


Roles	Bank of algorithms and results	Web UI
Parallelization strategy	Bulk Ingestion	Training Workshop

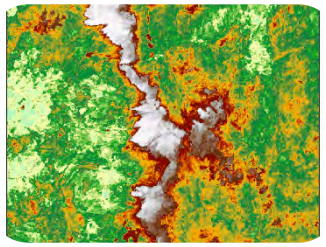
Algorithms



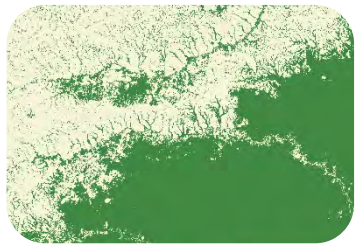
Temporal medians compounds



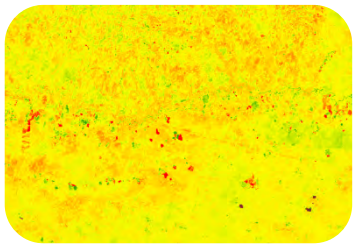
NDVI



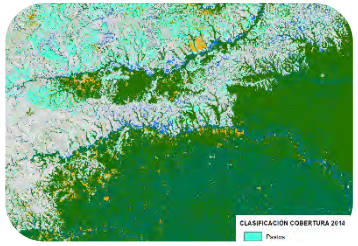
NDSI



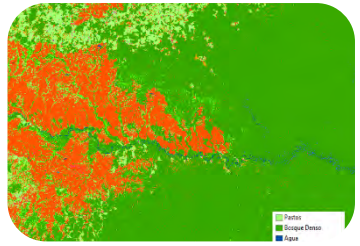
Forest-No forest classification



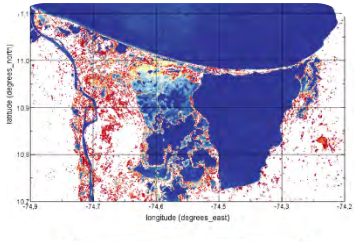
Change detection using PCA



Unsupervised Classification



Random Forest



WOFS –adapted

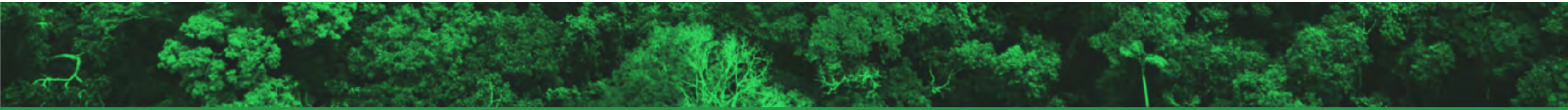
CDCol Web UI

Roles	Bank of algorithms and results	Web UI
Parallelization strategy	Bulk Ingestion	Training Workshop

Empowers users to work on a large set of satellite images from any device

Reduces learning curve

Authentication and roles management



Tematica:	CLASIFICACIONES
Nombre:	Bosque - No bosque
Versión a ejecutar:	4 - Bosque - No bosque 1.0
Fecha de creación:	13 de Diciembre de 2016 a las 18:44
Creada por:	ef.nobmann10@uniandes.edu.co

Calificación de la versión

Estadísticas de la versión del algoritmo:

Calificación	# de Calificaciones	# de Ejecuciones
5.0/5	1	2

Ver Calificaciones

Descripción de la ejecución

Análisis de la costa

Mapa *

Area

Latitud S

9

Latitud N

10

Longitud W

-74

Longitud E

-73

Periodo de consulta *

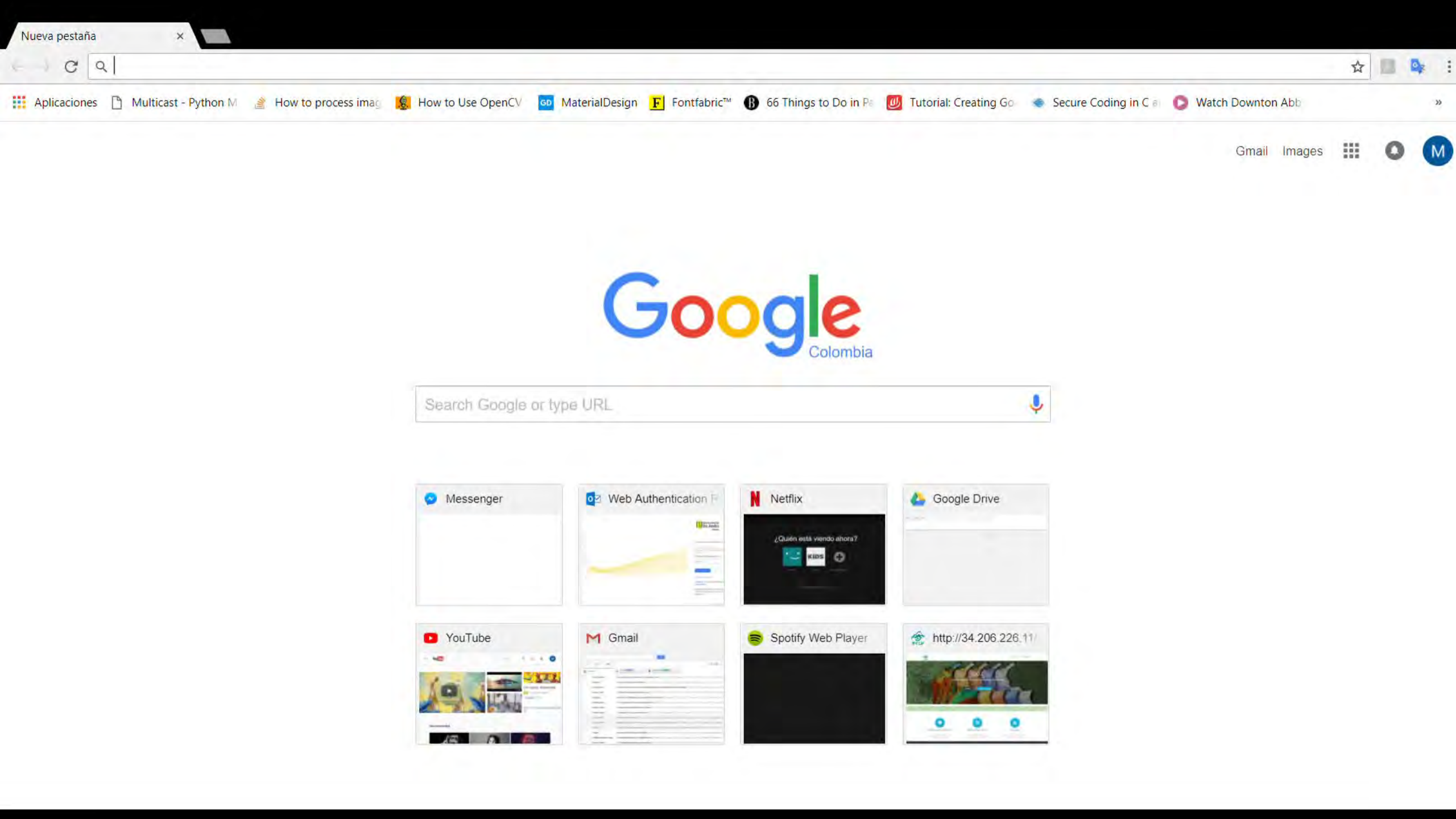
Desde

01/01/2014

Hasta

01/07/2014

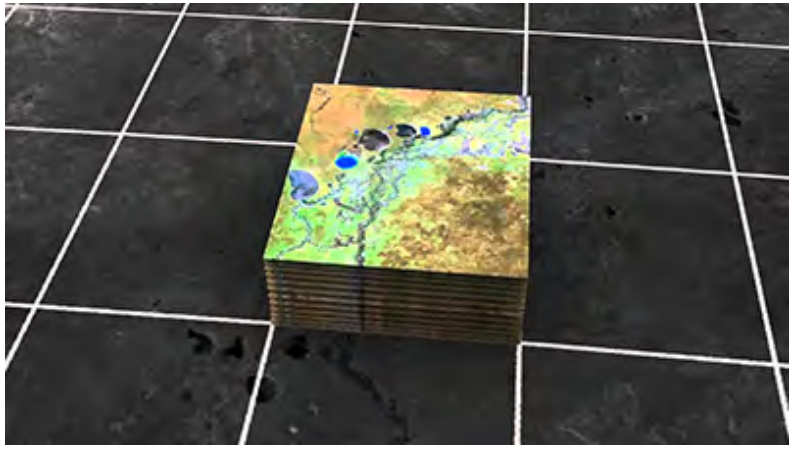
Periodo


Nueva pestaña
Aplicaciones
Multicast - Python M
How to process imag
How to Use OpenCV
MaterialDesign
Fontfabric™
66 Things to Do in Pa
Tutorial: Creating Go
Secure Coding in C a
Watch Downton Abb
Gmail
Images
M
Google
Colombia
Search Google or type URL
Messenger
Web Authentication F
Netflix
¿Quién está viendo ahora?
Google Drive
YouTube
Gmail
Spotify Web Player
http://34.206.226.11/

Roles	Bank of algorithms and results	Web UI
Parallelization strategy	Bulk Ingestion	Training Workshop

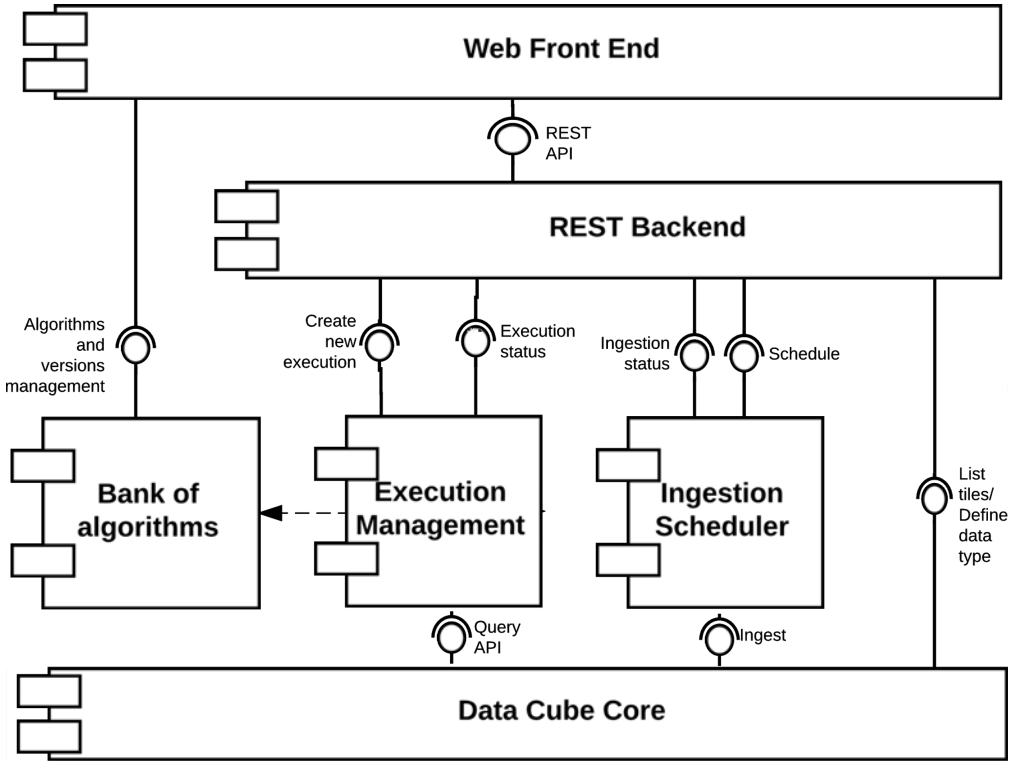
Parallelization Strategy

- Automatic
- By Tile
- Generic Task
- Celery

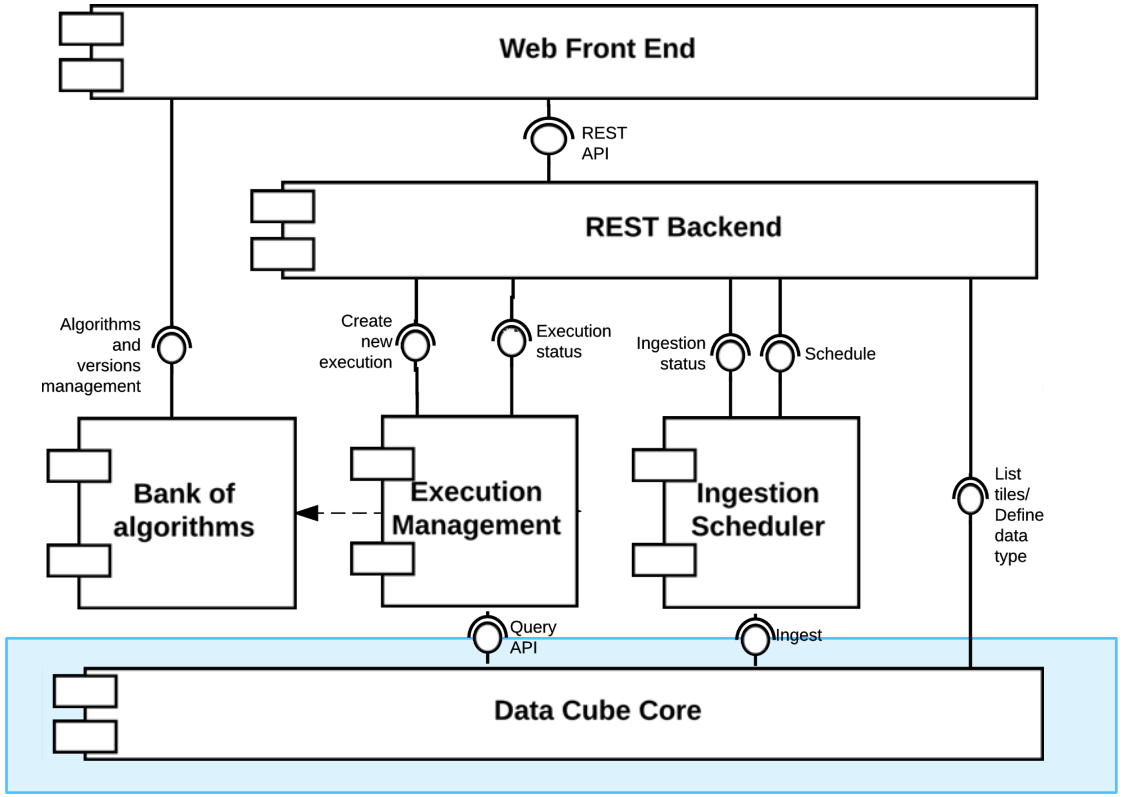


Celery

CDCol Components



CDCol Components



OpenDatacube/
datacube-core

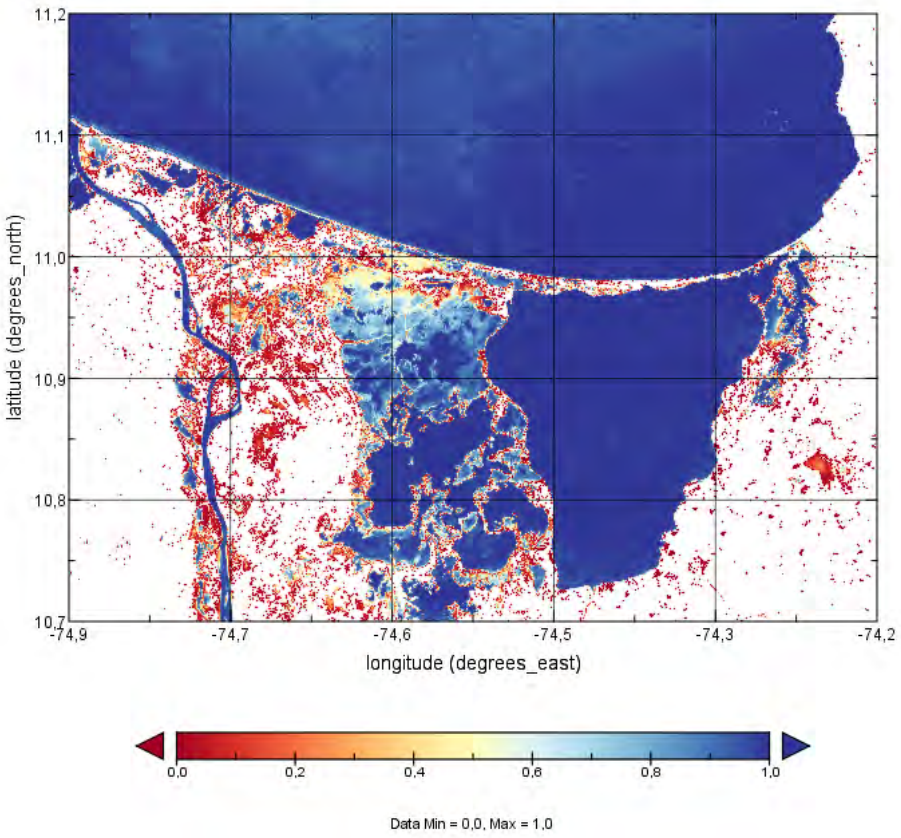
Results - WOFS

15 years
FROM 2000 TO 2015

30 meters
PIXEL RESOLUTION

342 images
LANDSAT 7/8

2h
PROCESSING



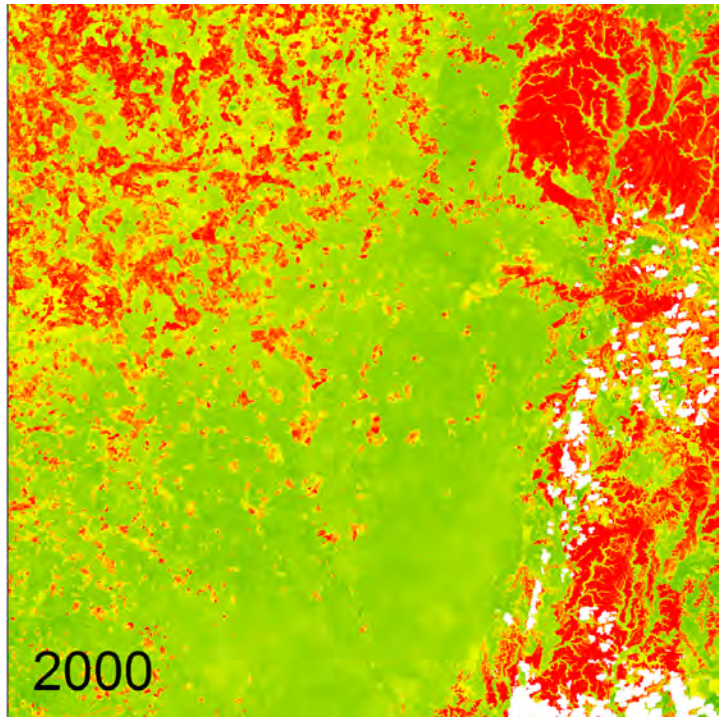
Results - NDVI

15 years
DATOS DE 2000-2015

30 meters
PIXEL RESOLUTION

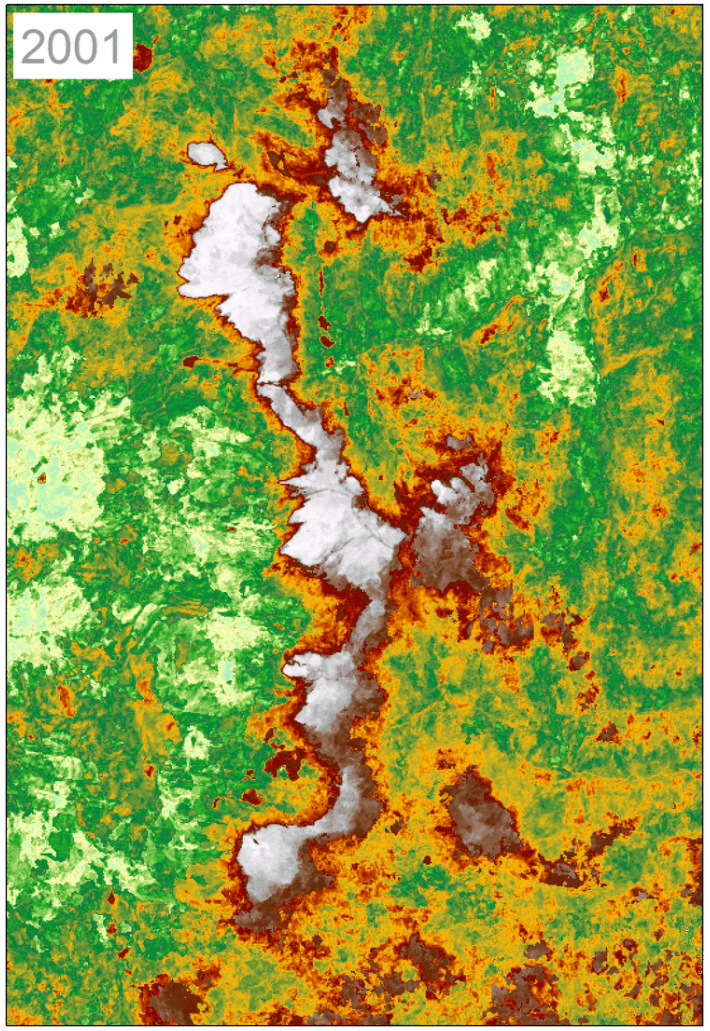
466 images
LANDSAT 7/8

26 min
PROCESSING



Results - NDSI

16 years FROM 2000-2016	30 meters PIXEL RESOLUTION
342 scenes LANDSAT 7/8	22 min PROCESSING



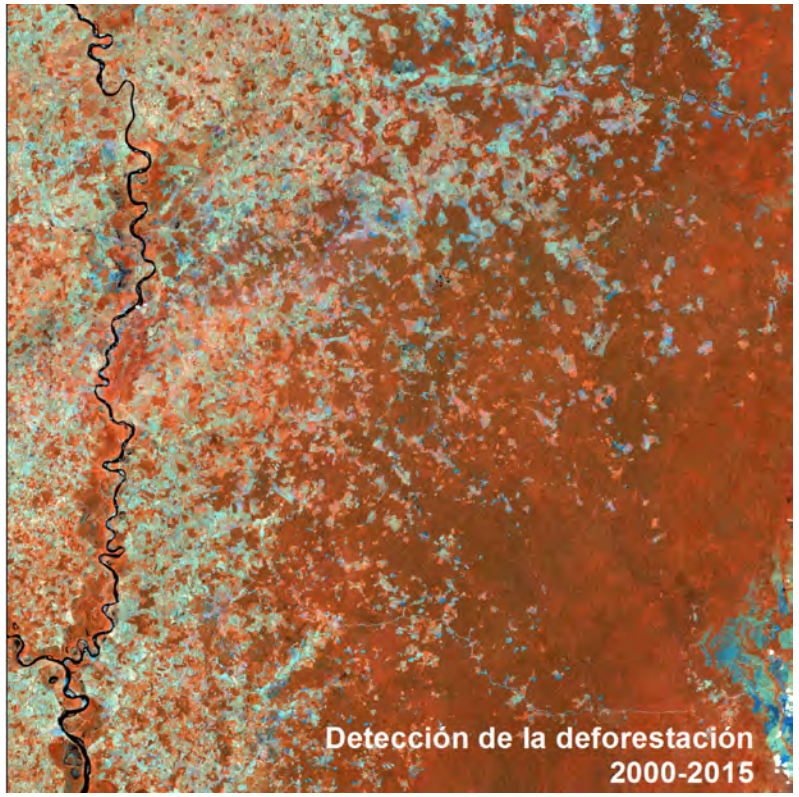
Results - PCA

16 years
FROM 2000-2015

30meters
PIXEL RESOLUTION

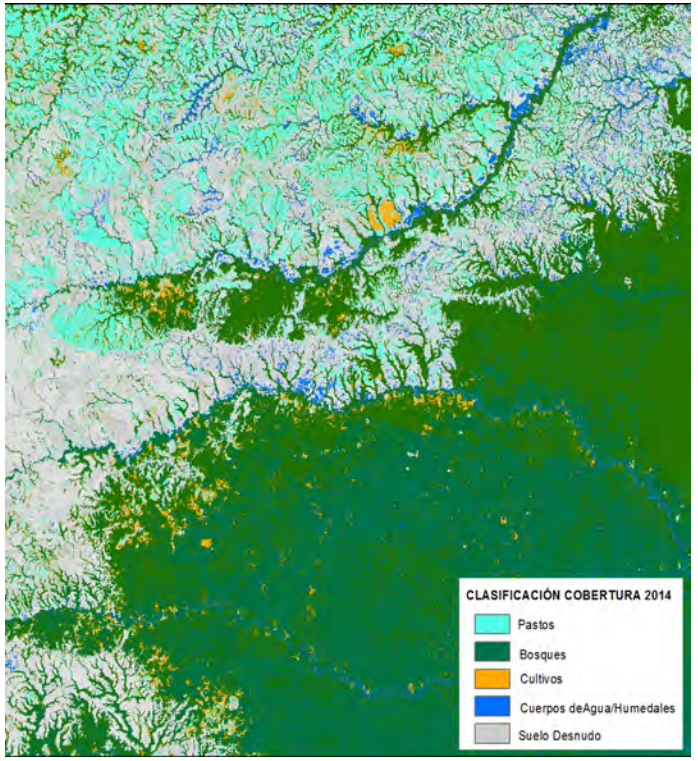
45 images
LANDSAT 7/8

2 min x time step
PROCESSING



Results – Unsupervised Classification

1 year 2014	30 meters PIXEL RESOLUTION
45 imágenes LANDSAT 8	2 min x time step PROCESSING



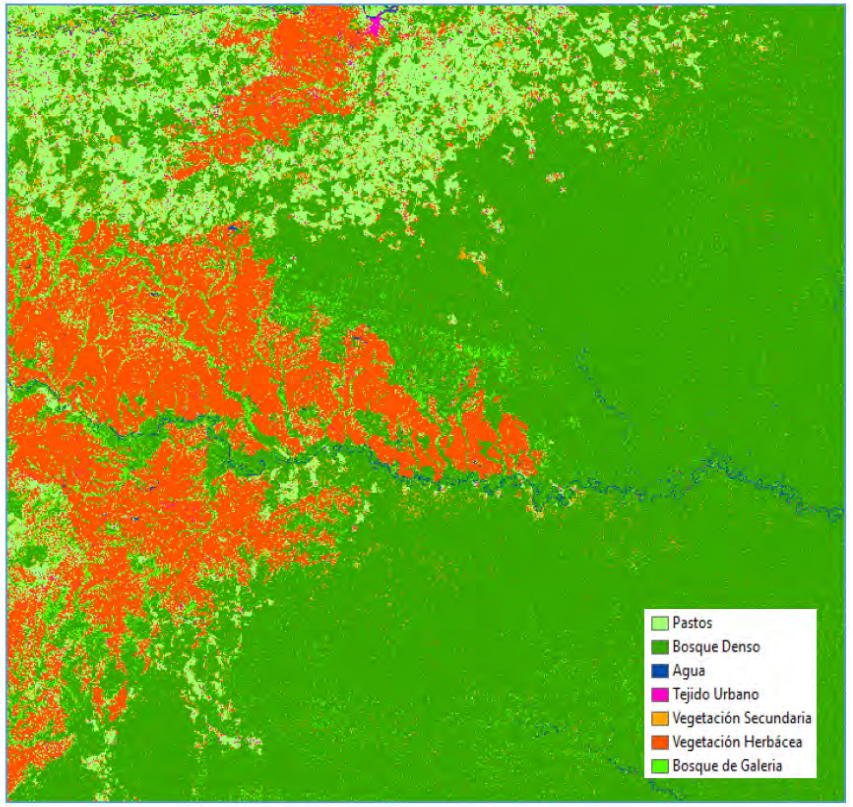
Results – Random Forest

1 year
2014

30 meters
PIXEL RESOLUTION

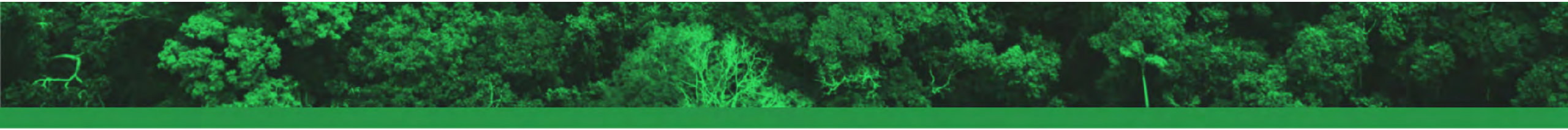
45 imágenes
LANDSAT 8

2 min x time step
PROCESSING



Some conclusions

- Is needed build a national capacity for administration the Data Cube and coding (or adapt) new algorithms (python)
- Powerful technological infrastructure is needed to manage the Big Data of EO (which is growing exponentially)
- It will be a challenge face the storage and processing EO data at the cloud
- Future work:
  - Horizontal scalability
  - New sensors (Sentinel 1 y 2) and New algorithms
  - Training
  - Workflows management
  - Fusion of radar data to time series ana
  - Integration of cal/val data (climate data)



Thanks for your attention…
Any question?

María Teresa Becerra mtbecerra@ideam.gov-co

Edersson Cabrera ecabreram@ideam.gov.co

Gustavo Galindo ggalindo@ideam.gov.co

Pilar Lozano-Rivera plozano@ideam.gov.co

DFMS Overview / (ODC)

Miguel Morgado

Senior Systems Architect

24th October 2017

Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): AgriTechTal International, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

ABOUT RHEA GROUP

25 YEARS TRAJECTORY IN SECURITY AND SPACE SYSTEMS ENGINEERING

VENDOR INDEPENDENT INTERNATIONAL SYSTEM ENGINEERING COMPANY

OPERATING IN TEN COUNTRIES WITH MORE THAN 300 SPECIALISTS FROM DIVERSE FIELDS OF ENGINEERING

WORKING WITH GOVERNMENTAL, INSTITUTIONAL, AND PRIVATE SECTOR CLIENTS

- SPACE SYSTEMS & APPLICATIONS
- SECURITY AND CRISIS MANAGEMENT
- GROUND SYSTEMS ENGINEERING
- CONCURRENT ENGINEERING
- CLOUD COMPUTING SOLUTIONS
- PROFESSIONAL ENGINEERING SERVICES

Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA GROUP

Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Project Overview

Funded by the **UK Space Agency (IPP[1])**, the project is led by **RHEA Group** in partnership with the **Ugandan Ministry of Water and Environment,** working with other **Ugandan Government Departments** (OPM, UNMA, NARO, MAAIF).

OBJECTIVE: to provide decision makers in Uganda with practical information that will improve knowledge and help mitigate response to climate induced effects:

[1] The International Partnership Programme (IPP) is a five year, £152 million programme run by the UK Space Agency

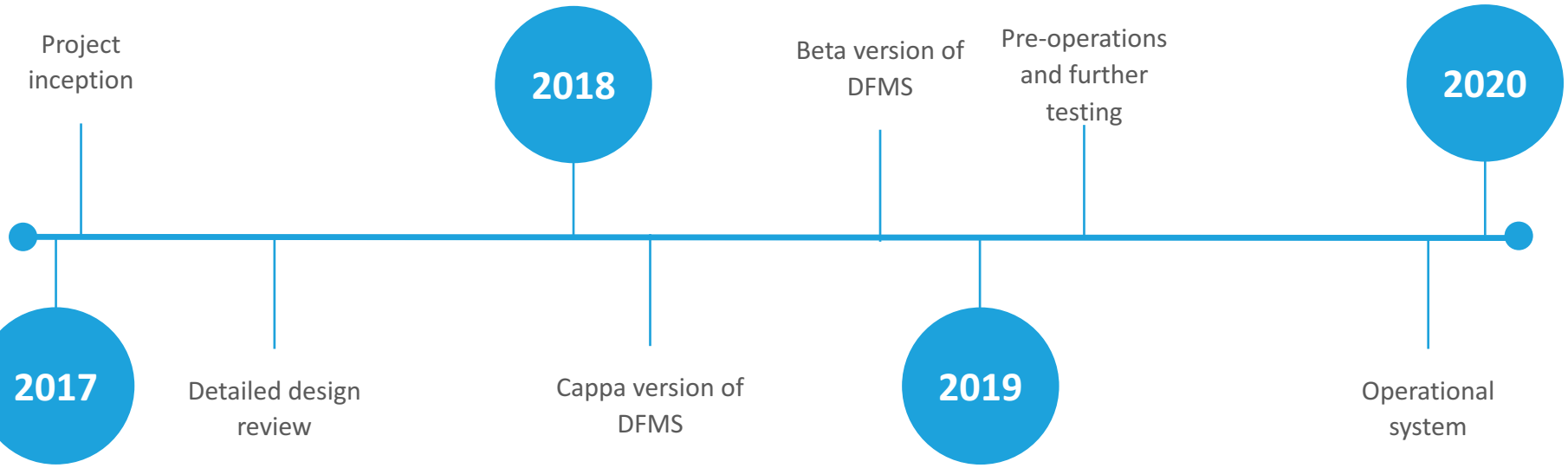
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): EOMAP, AgriTechTalk International, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Timesclaes and key Milestones



Engagement and training

- **Conducted focus group discussion** and stakeholder discussion
- **Trained beneficiaries** on record keeping

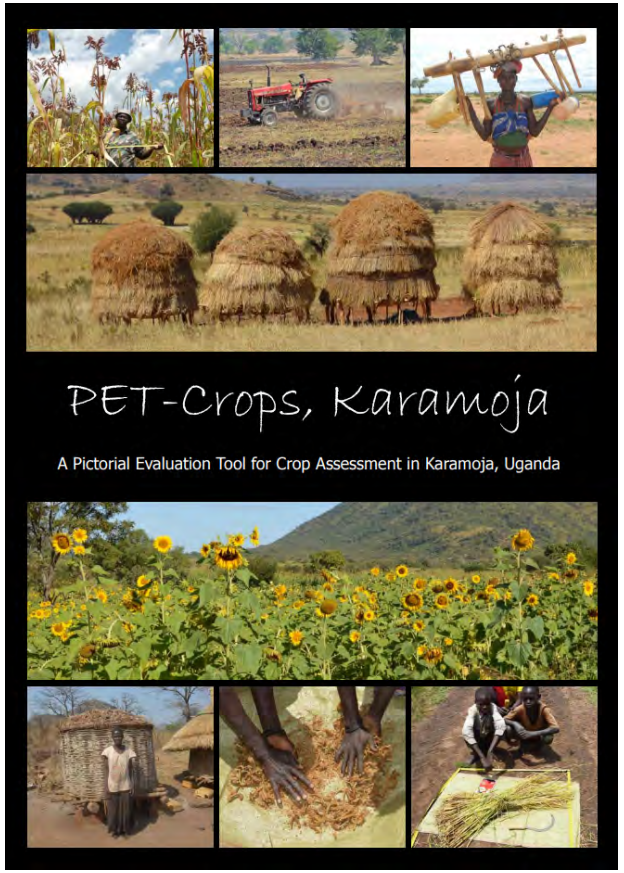
  PET tool - 9 farmers' clusters established in the 7 district of Karamoja

  135 farmers involved

  5 herders' clusters established in Moroto, Napak, Kotido, Abim, Nakapiripirit

  75 shepherds involved

- **Collected community feedback**



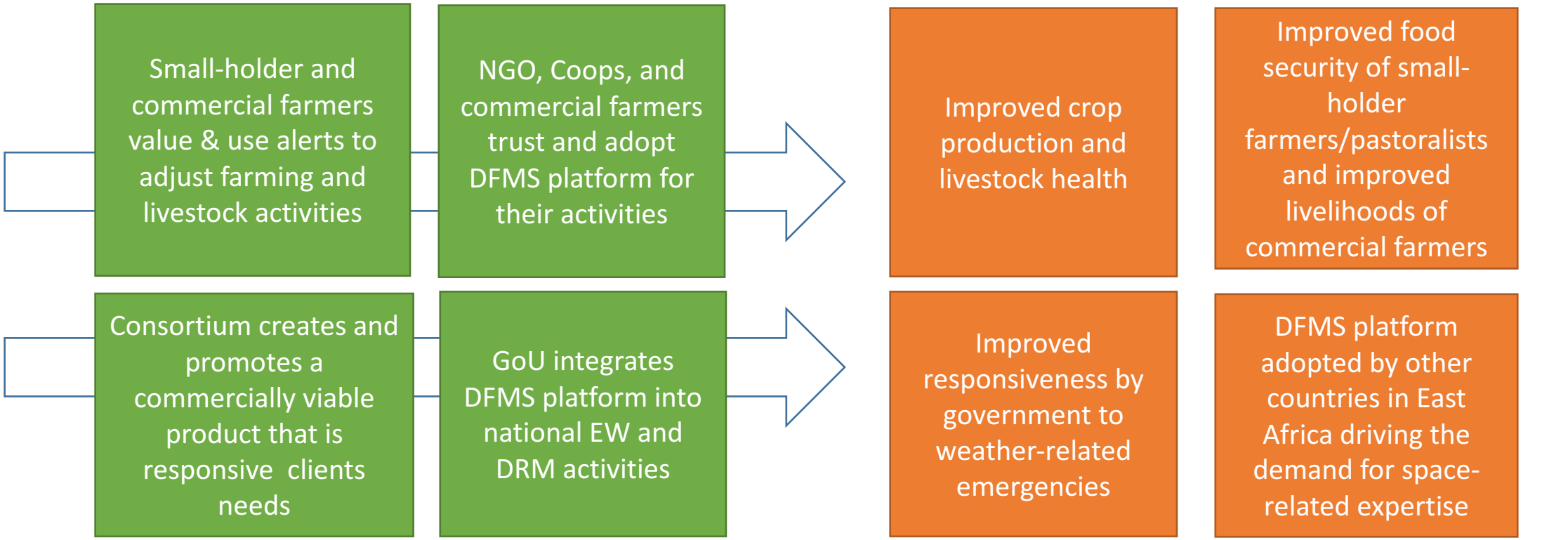
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Outcomes and Impacts



Funded by: UK Space Agency

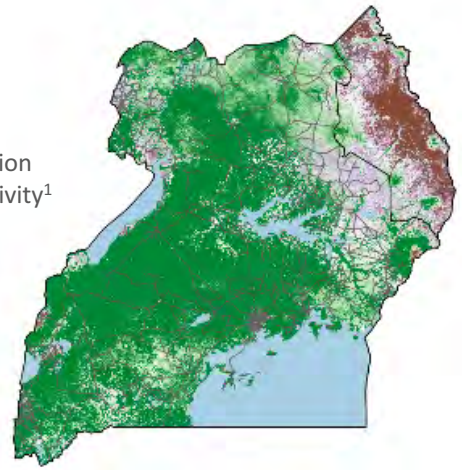
Ministry of Water and Environment, Uganda

Project leader: RHEA Group

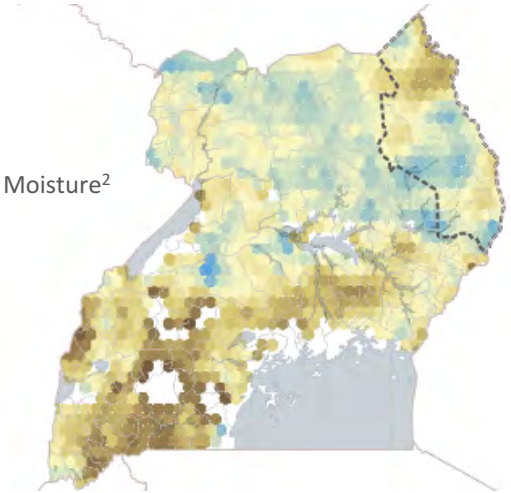
Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

The DFMS project will provide **drought and flood forecasting** products, **based upon satellite imagery covering the whole of Uganda** and higher resolution/tailored products in the targeted regions.

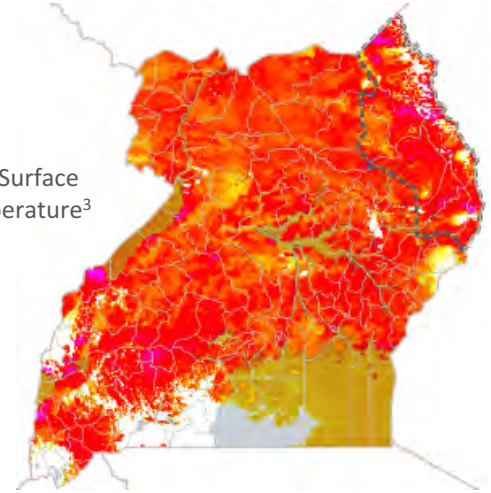
Vegetation Productivity[1]



Soil Moisture[2]



Land Surface Temperature[3]



[1] Vegetation Productivity MODIS 2014 NPP Product, MOD17 – Zhoa et al. (2005),

[2] Soil Moisture, input data courtesy of ESA,

[3] Land Surface Temperature , input data courtesy of NASA

The model will analyse changes in soil moisture, agricultural performance, vegetation indexes, water resources and weather forecasts among other datasets to detect early signs of risk to support management decisions from National level through to individual farmers.

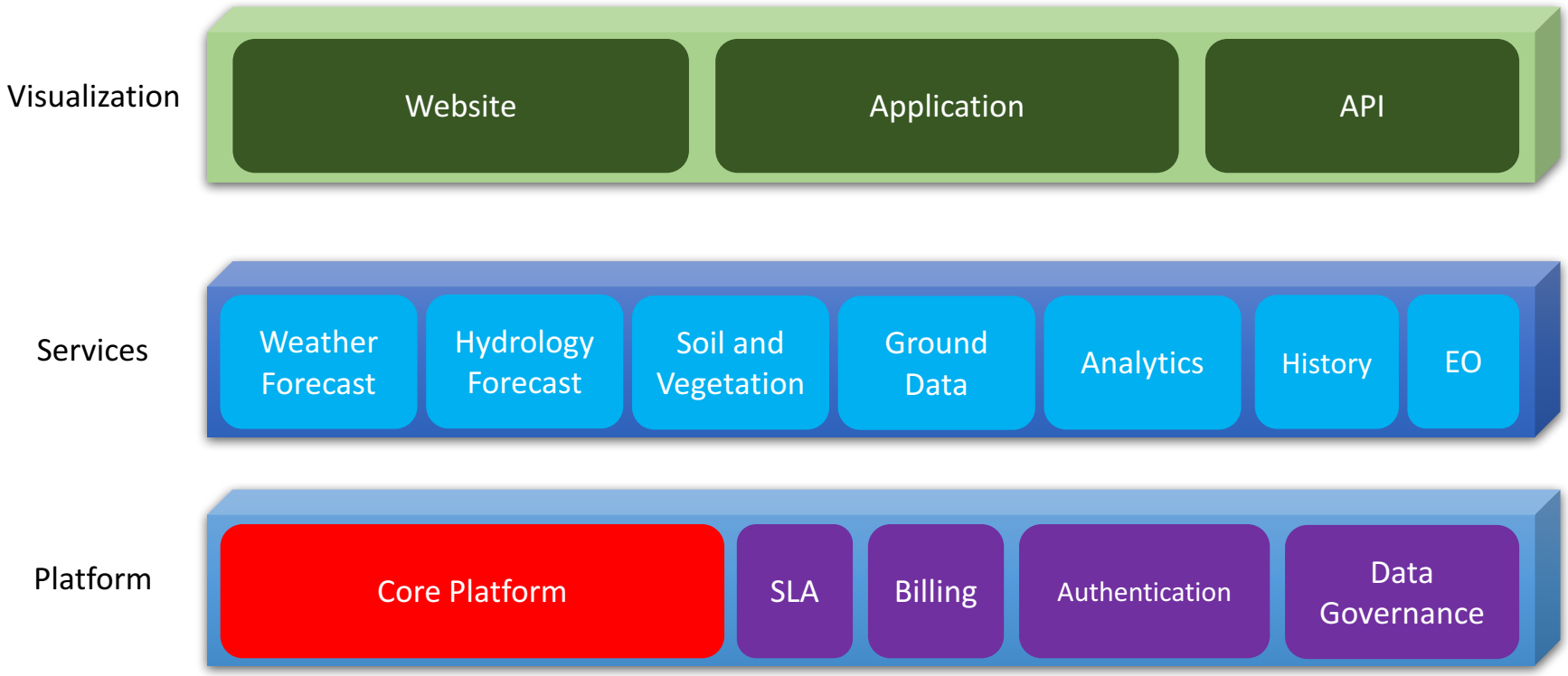
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Architecture overview



Funded by: UK Space Agency
Ministry of Water and Environment, Uganda
Project leader: RHEA Group
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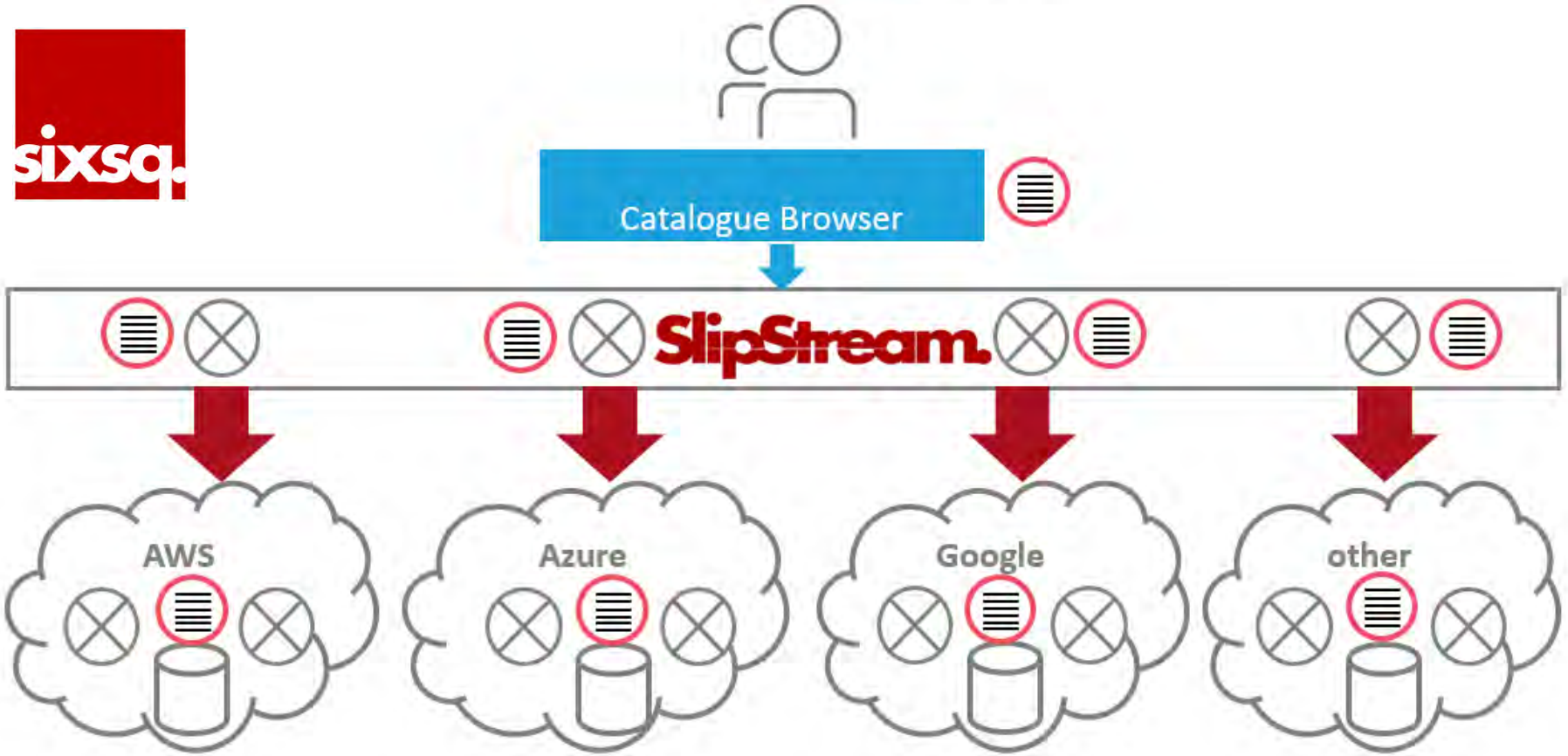


Cloud Agnostic Infrastructure

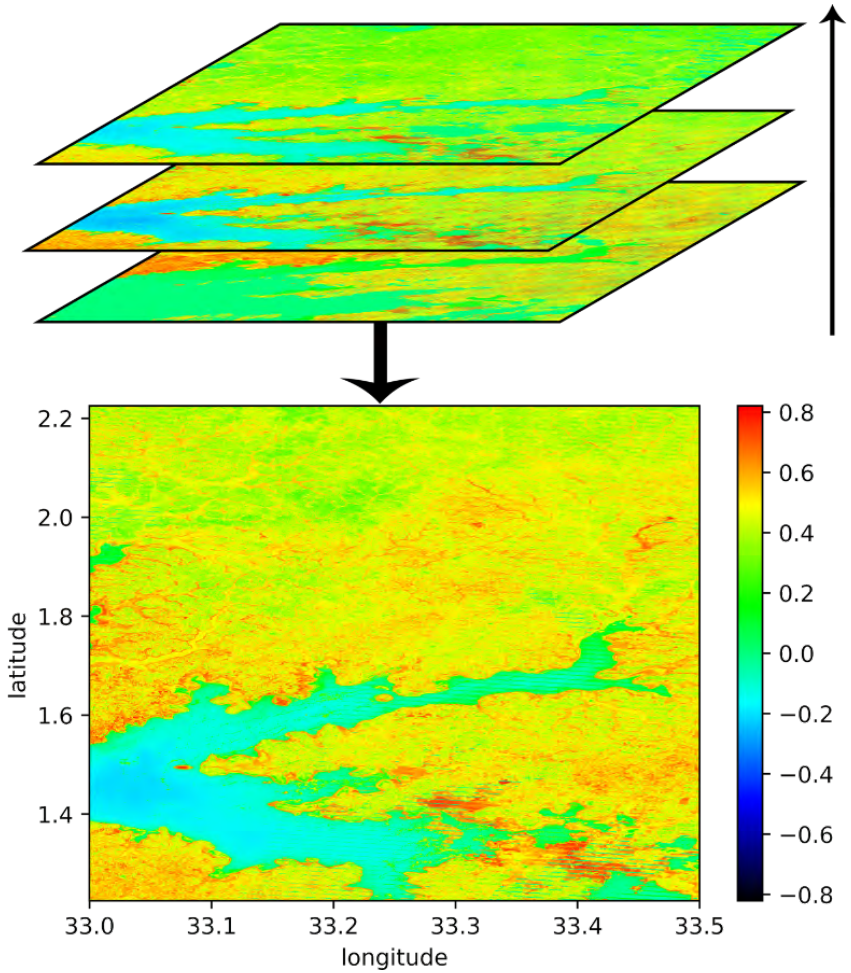
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Data Cube Overview



Open Source system designed to:

- **Catalogue** large amounts of EO data;
- Store data in 3D dimensional arrays (latitude, longitude and time).
- Provide a Python based API for **high performance querying** and data access;
- Easy Exploratory Data Analysis (especially over a time series);
- Allow scalable continent scale processing of the stored data;
- Track the provenance of all the contained data to allow for quality control and updates

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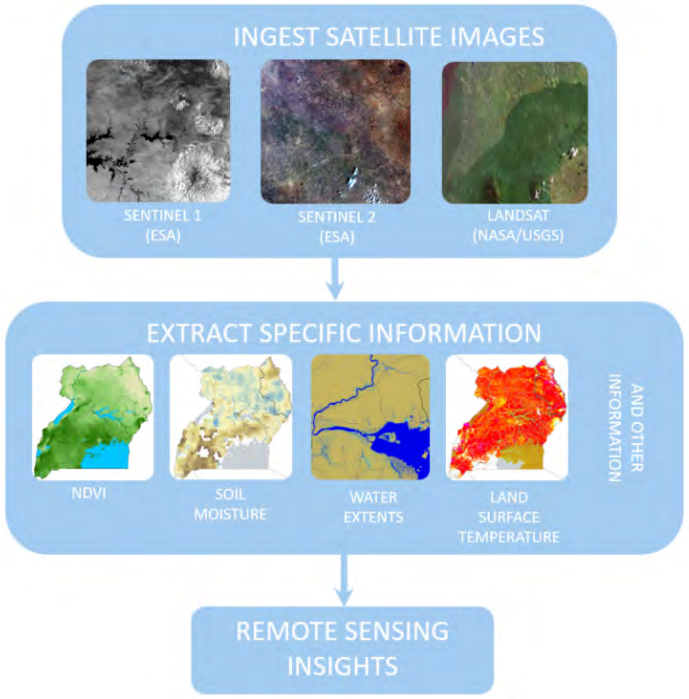
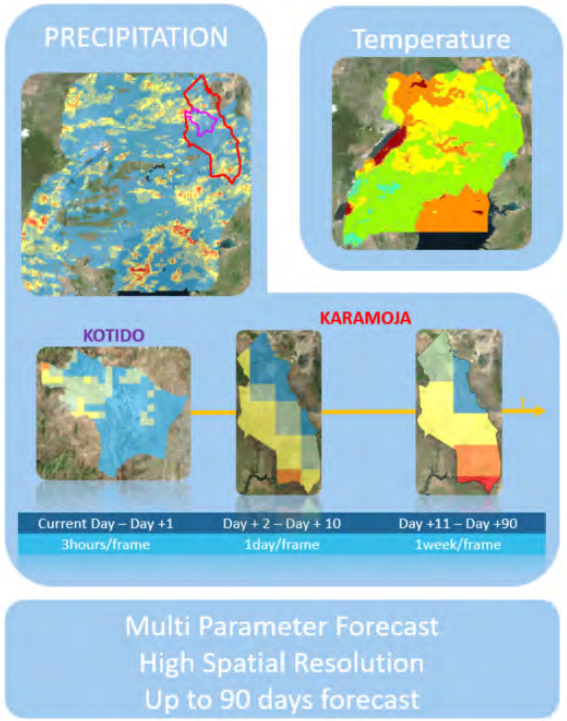
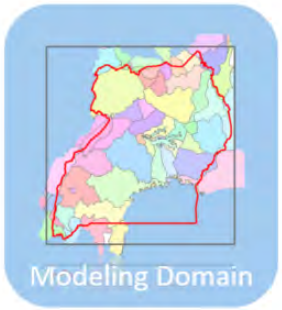
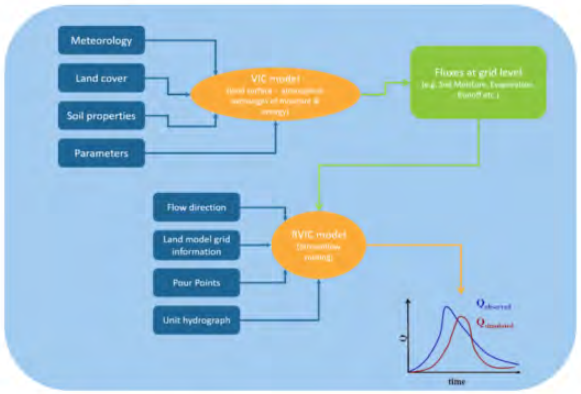
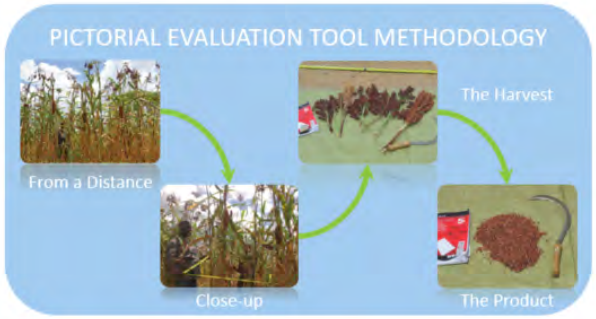
Datasets overview

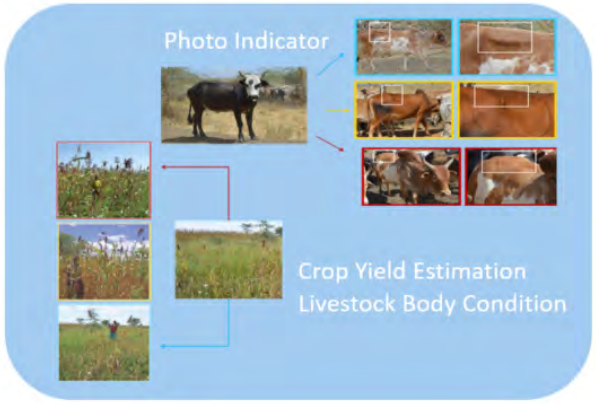












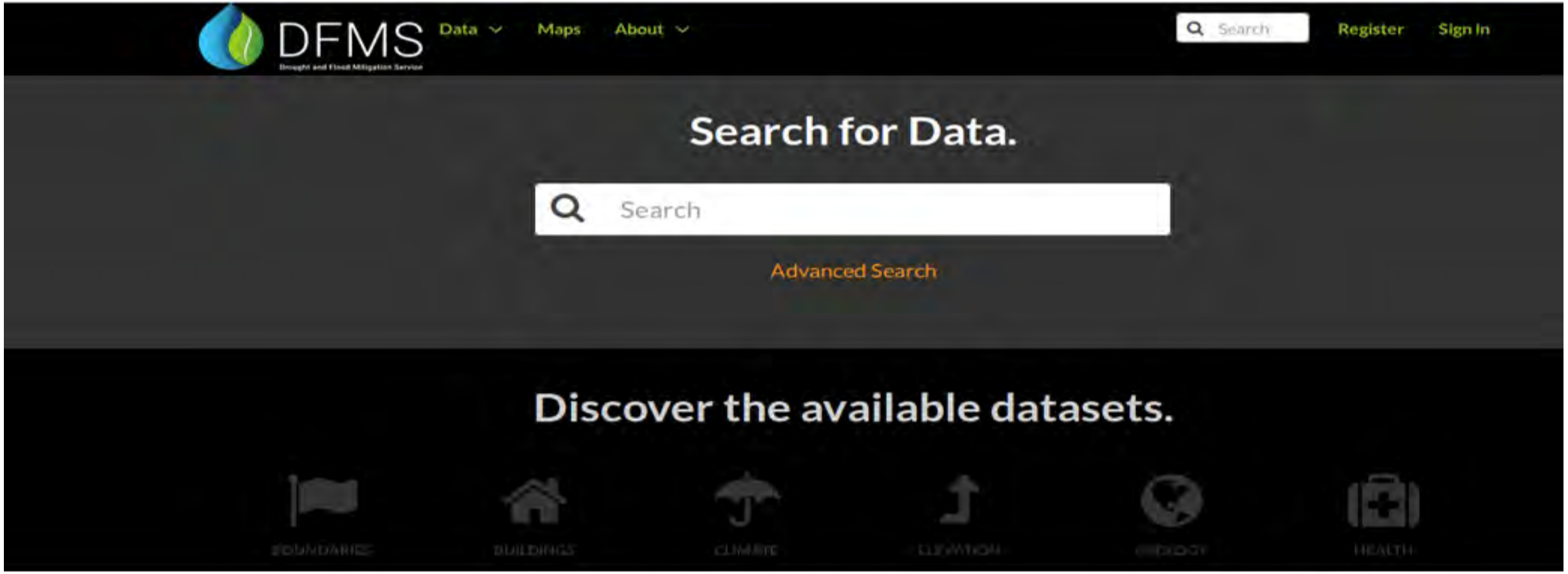
Funded by:
UK SPACE AGENCY

Ministry of Water and Environment, Uganda

Project leader:
RHEA GROUP

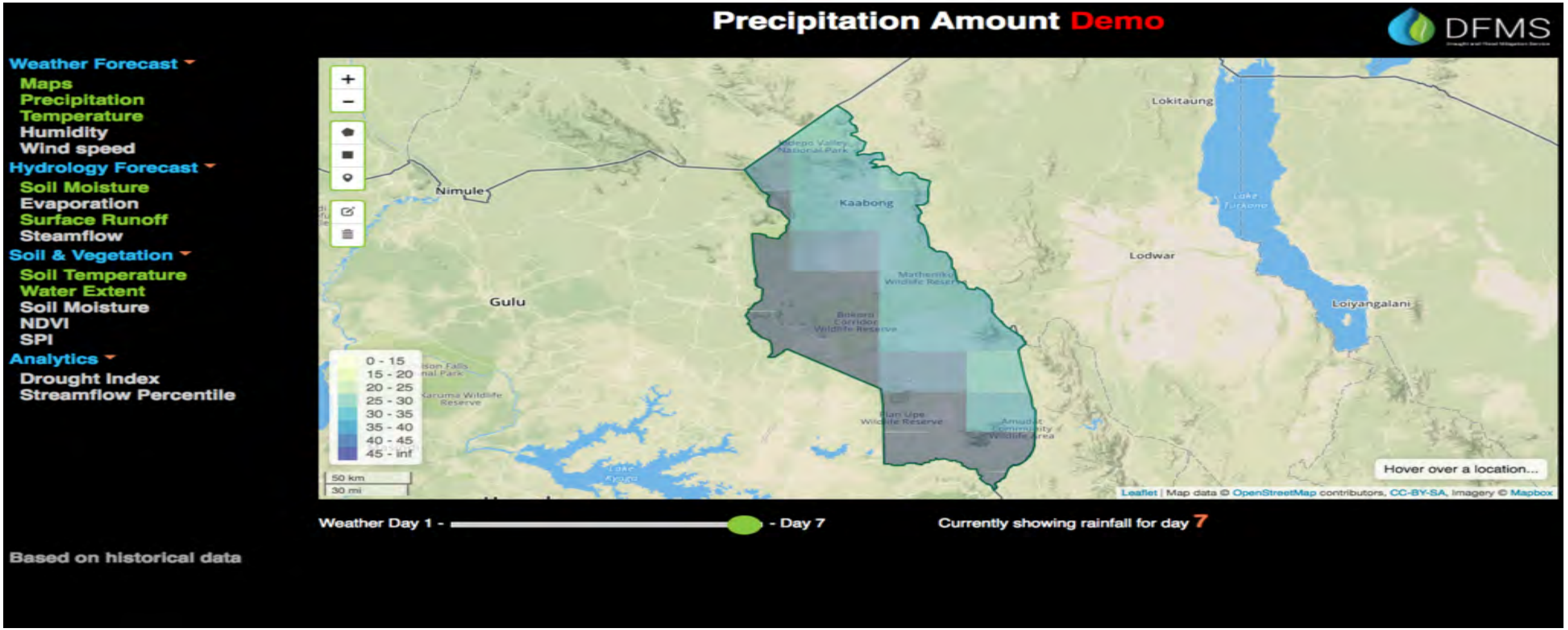
Project partners (Europe):
databasix
Environment SYSTEMS
HR Wallingford
MercyCorps
Met Office
Oxford Policy Management
Pixalytics

User Interface - prototype



Funded by:
Ministry of Water and Environment, Uganda
Project leader:
Project partners (Europe):

User Interface - prototype



Funded by: UK Space Agency

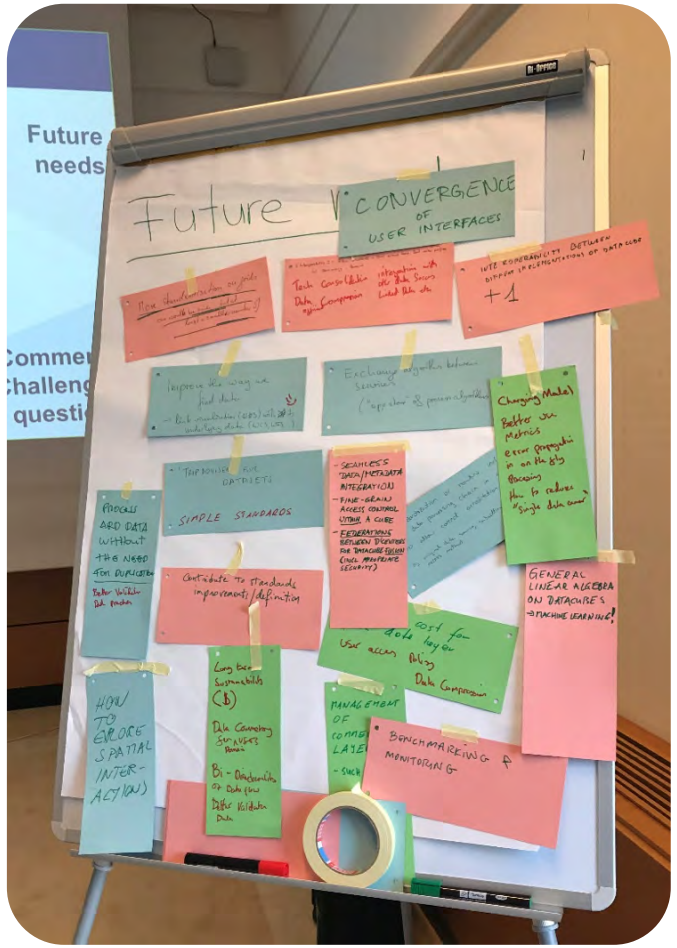
Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

ODC – Implementation and suggestions

- Open and great support from the ODC team
- Easy to implement/setup
- What is a datacube? (e.g. a database containing images indexed in a certain way, a database plus a certain set of functionalities, a database plus a certain set of functionalities meeting the **OCS standards**)
- Benchmarks available to show proof of how convenient can it be to use Open Data Cube with respect to processing the raw data
- Improve documentation - full list of functionalities available required
- Make the delete operation more user-friendly
- Quality certification / Propagation of uncertainties



Funded by: UK Space Agency
Ministry of Water and Environment, Uganda
Project leader: RHEA GROUP
Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Thank you!

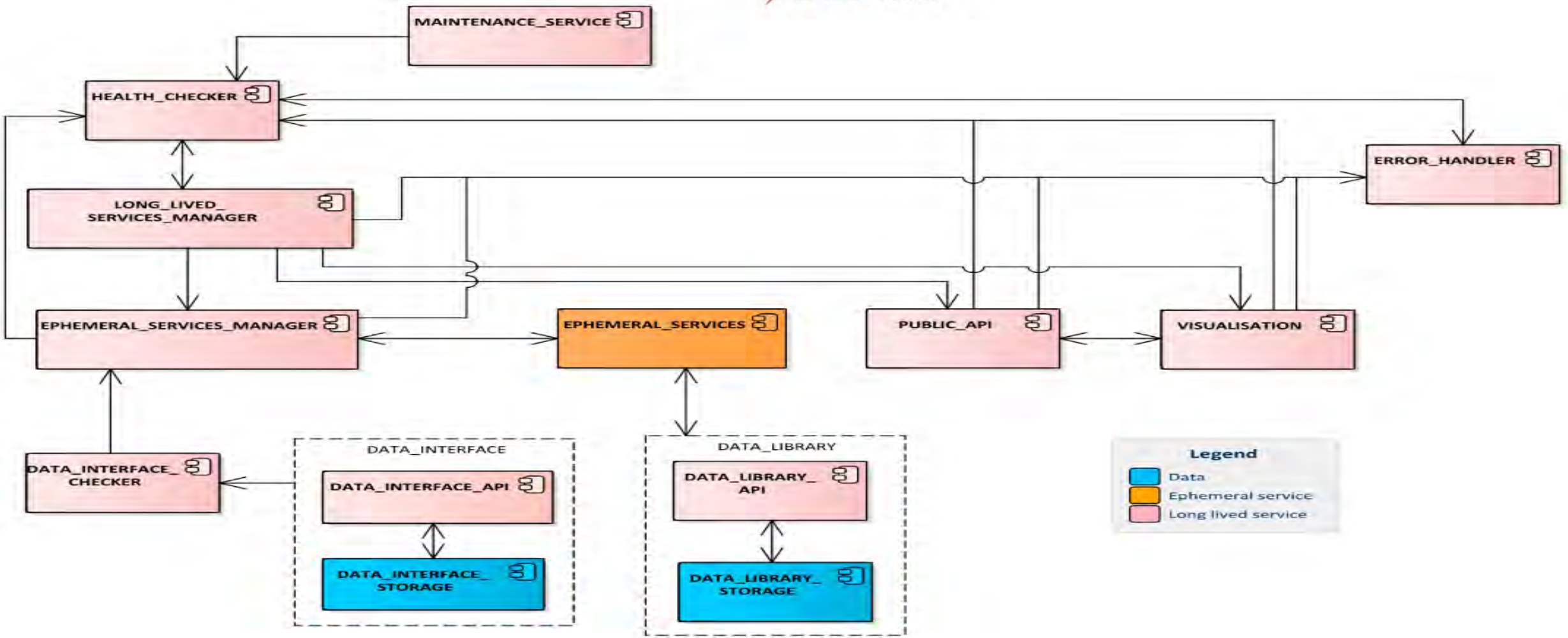
Funded by:

Ministry of Water and Environment, Uganda

Project leader:

Project partners (Europe):

Annex 1- Platform overview



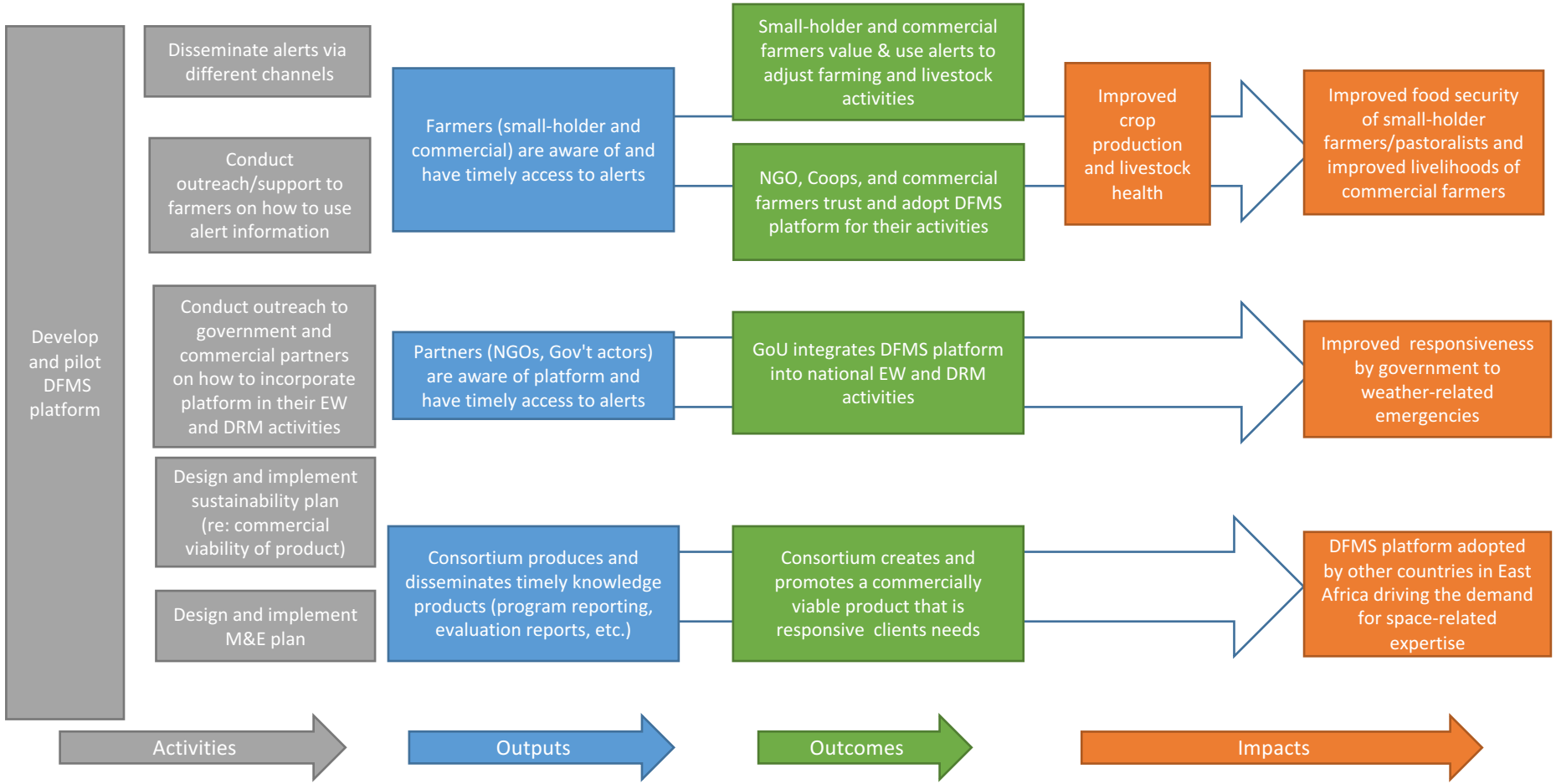
Funded by: UK SPACE AGENCY

Ministry of Water and Environment, Uganda

Project leader: RHEA GROUP

Project partners (Europe): databasix, Environment SYSTEMS, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Annex 2 - Impacts



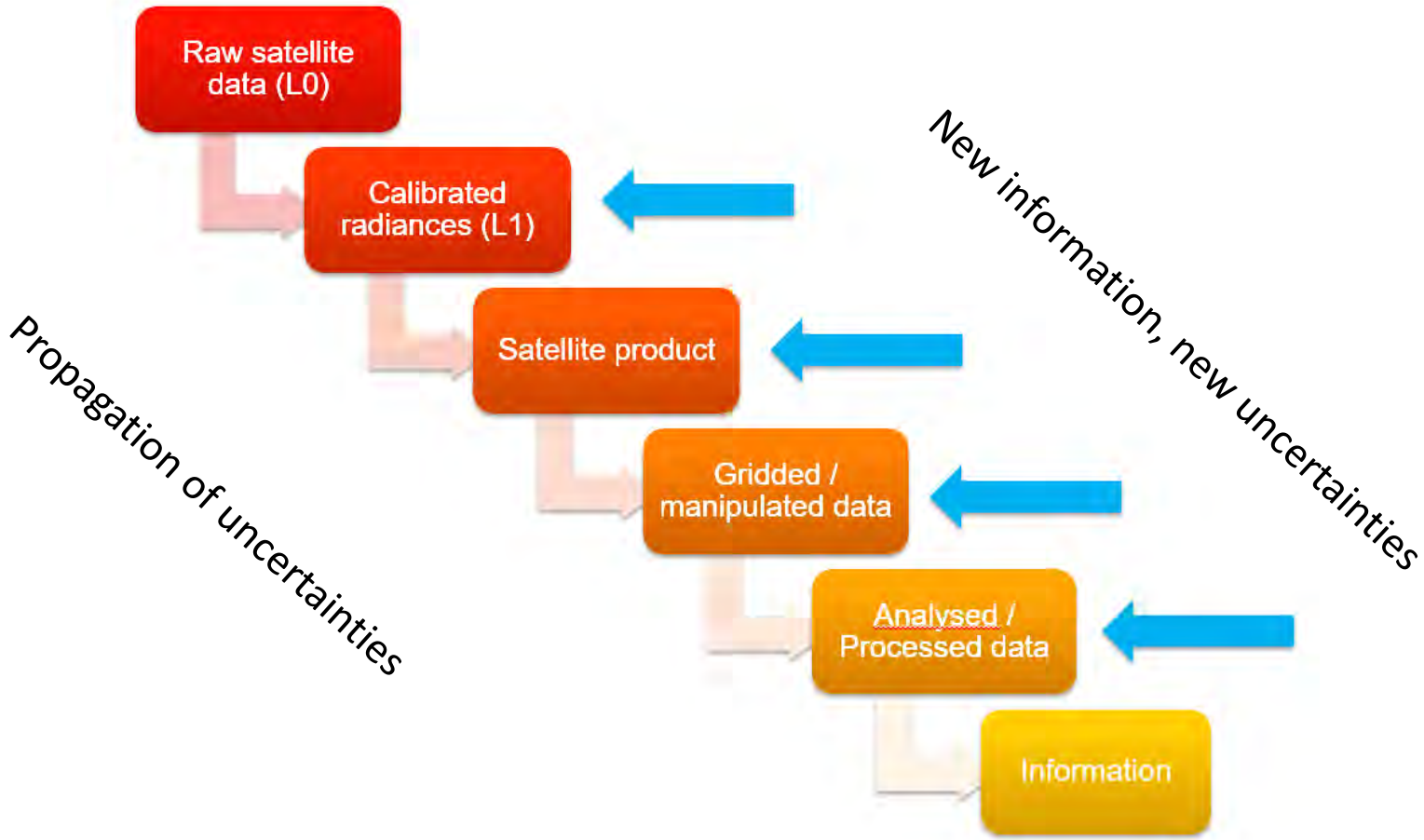
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

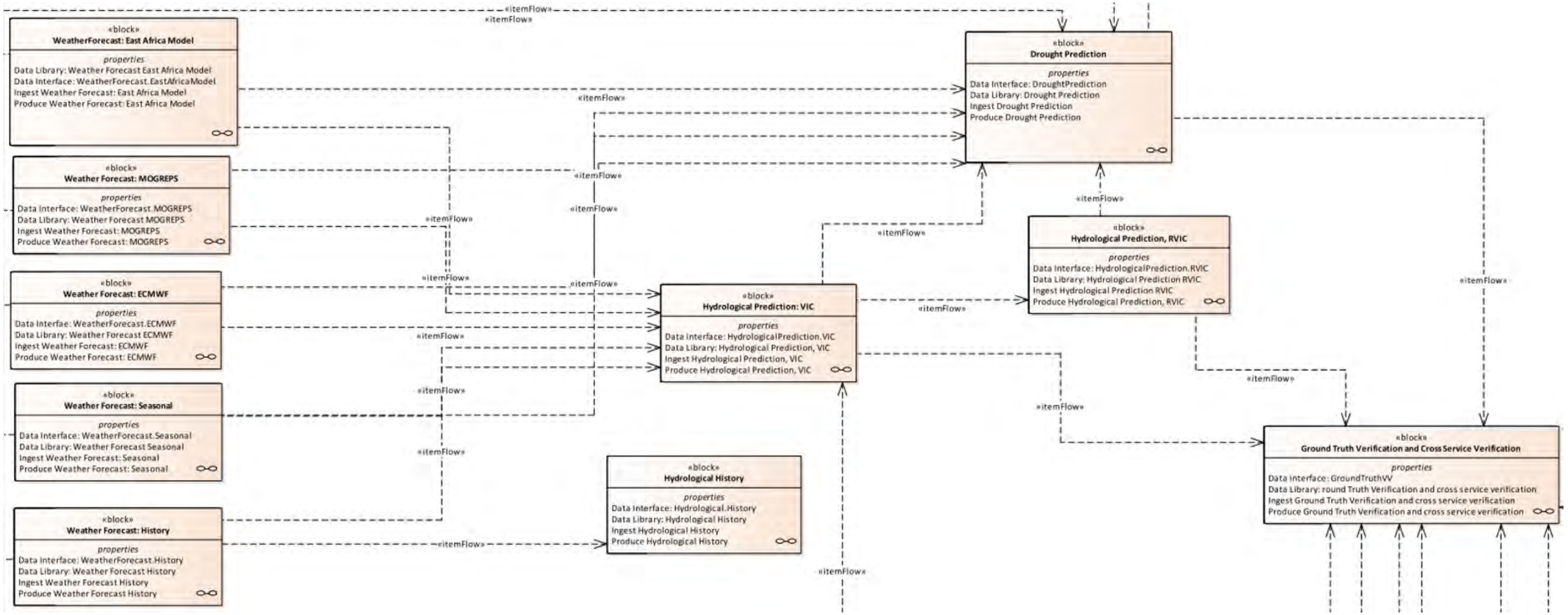
Project partners (Europe): EOMAP, AgriTechTalk, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Annex 3 - Uncertainties



Funded by: UK SPACE AGENCY
Ministry of Water and Environment, Uganda
Project leader: RHEA GROUP
Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Annex 4 – Services Software



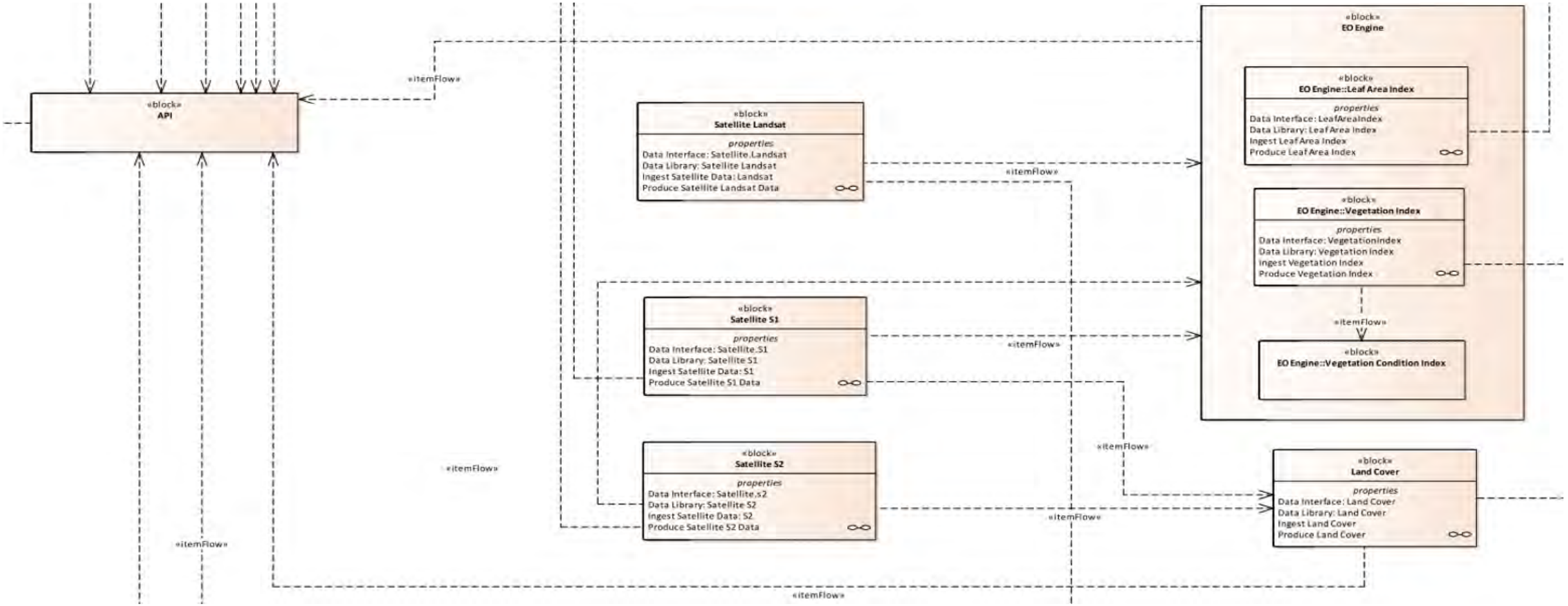
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): EA International, AgriTechTalk International CIC, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Annex 5 – Services Software



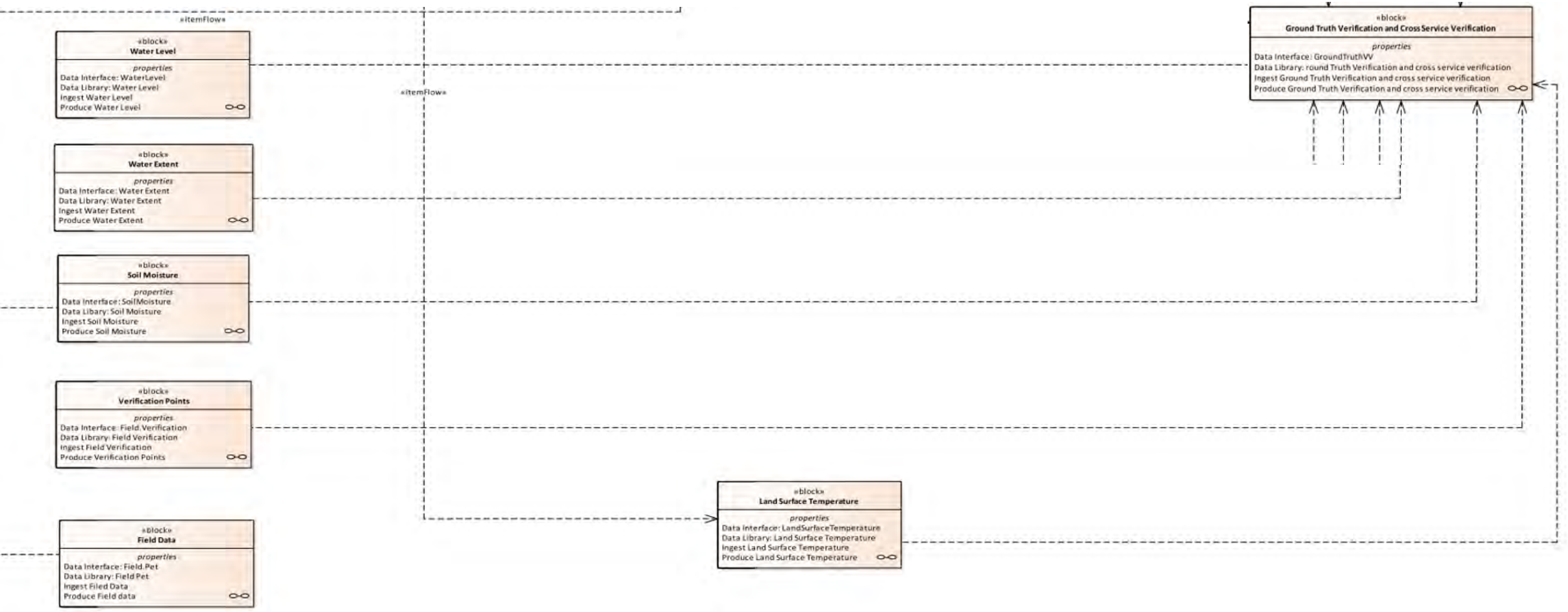
Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): EOMAP, AgriTechTalk, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Annex 6 – Services Software



Funded by: UK Space Agency

Ministry of Water and Environment, Uganda

Project leader: RHEA Group

Project partners (Europe): EOMAP, AgriTechTalk, databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Quality Assurance and review

- Core principles of metrological quality assurance
  - Traceability: documents, full chain, links to references
  - Uncertainty analysis: At each step and propagated through
  - Comparison: against references, validation of uncertainties (not product)

Image data source: www.qa4ecv.eu

Funded by: UK Space Agency
Ministry of Water and Environment, Uganda
Project leader: RHEA Group
Project partners (Europe): databasix, Environment Systems, HR Wallingford, MercyCorps, Met Office, Oxford Policy Management, Pixalytics

Australian Government
Geoscience Australia

Digital Earth
AUSTRALIA

Digital Earth Australia: Big Data for a Big Country

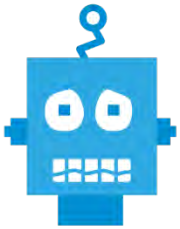
Dr Stuart Minchin,

Geoscience Australia

Traditional remote sensing process

Petabyte hierarchical archive:

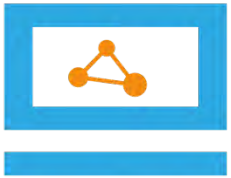
Millions of individual scenes. Tape store accessed by robot.



Search catalogue order scenes.

Identify footprint of product in space or time.

Client requests product.

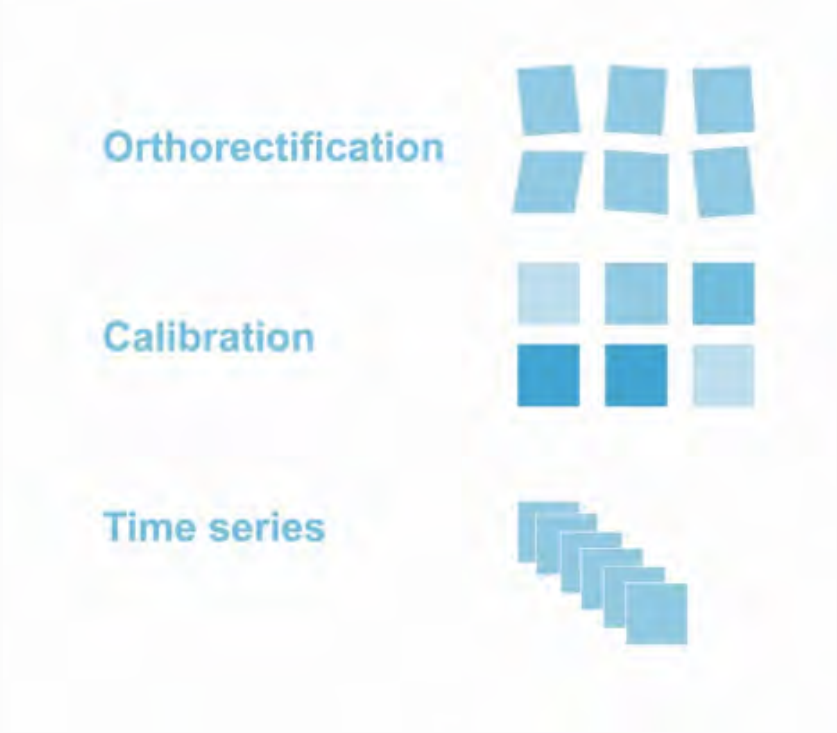


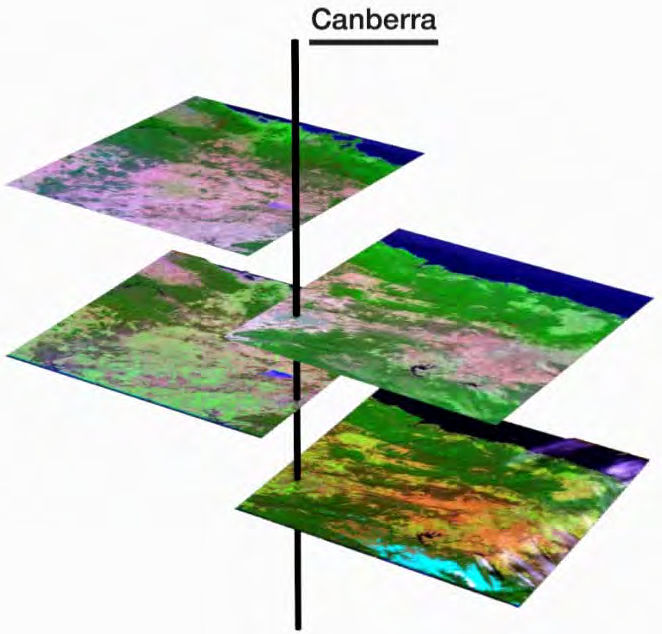
Orthorectification calibration, cloud masking, atmospheric correction, mosaicing.

Feature extraction, algorithm application spectral unmixing.

Product packaging and delivery.

Developing the Australian Geoscience Data Cube



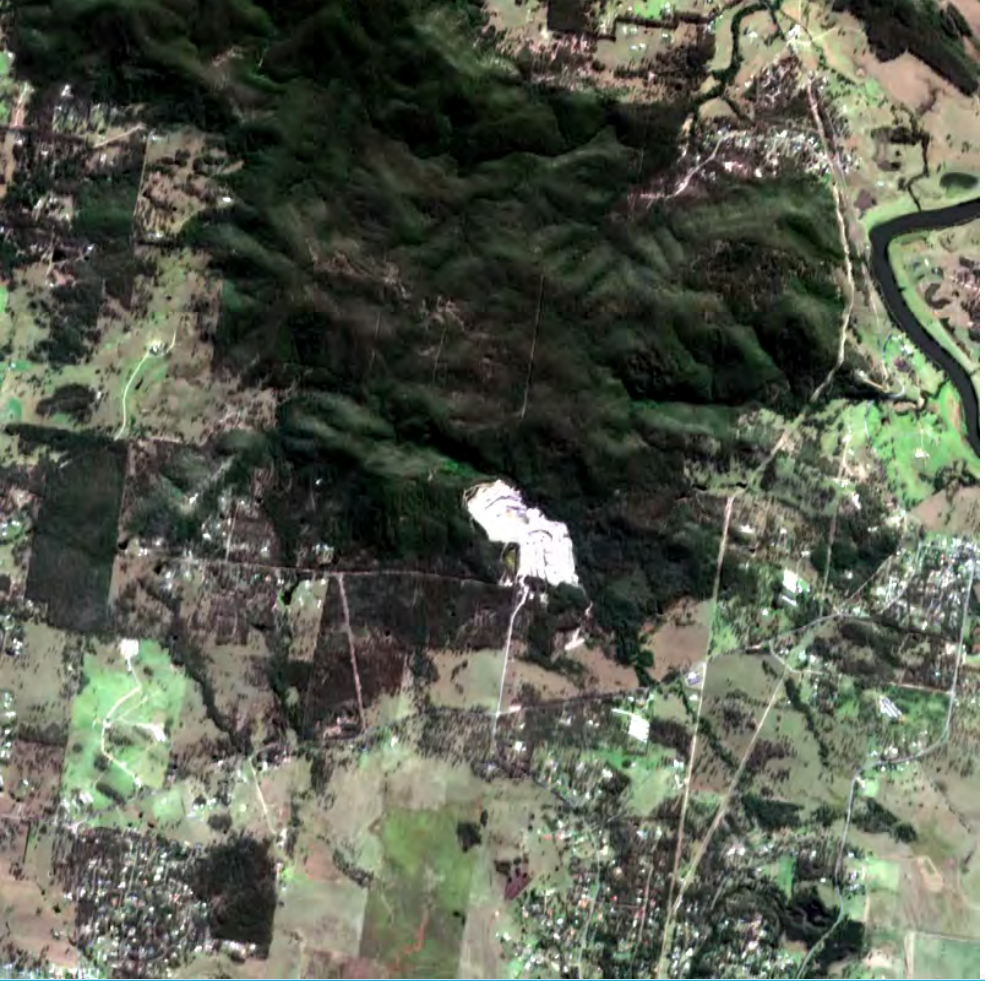


Why the need for analysis ready data?

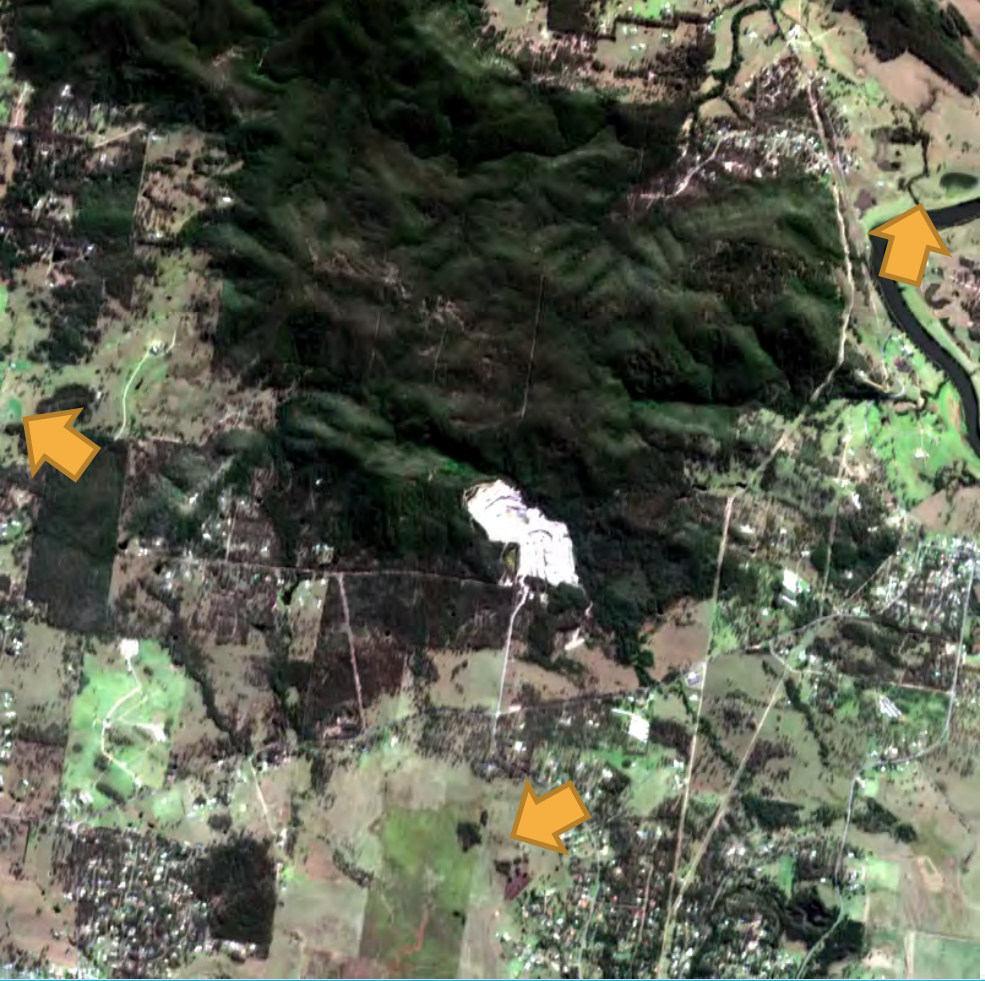
Consider **Sentinel-2 L1T** data, the **difficulties** are:

- No atmospheric or topographic correction
- No cloud mask
- No pixel quality
- Missing sections due to scenes not overlapping

Seaham, NSW



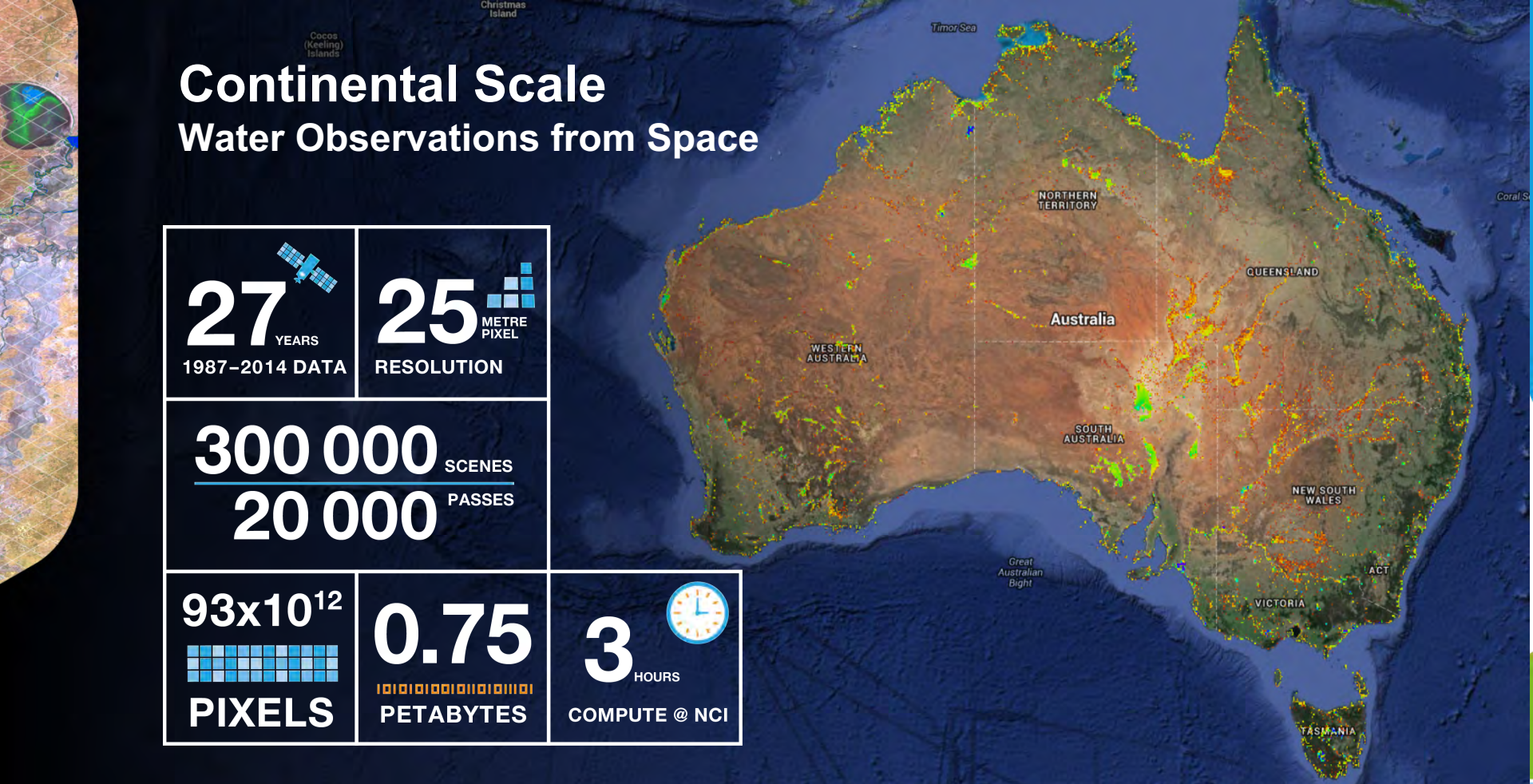
Seaham, NSW



Seaham, NSW

Continental Scale

Water Observations from Space



27 YEARS
1987–2014 DATA

25 METRE PIXEL
RESOLUTION

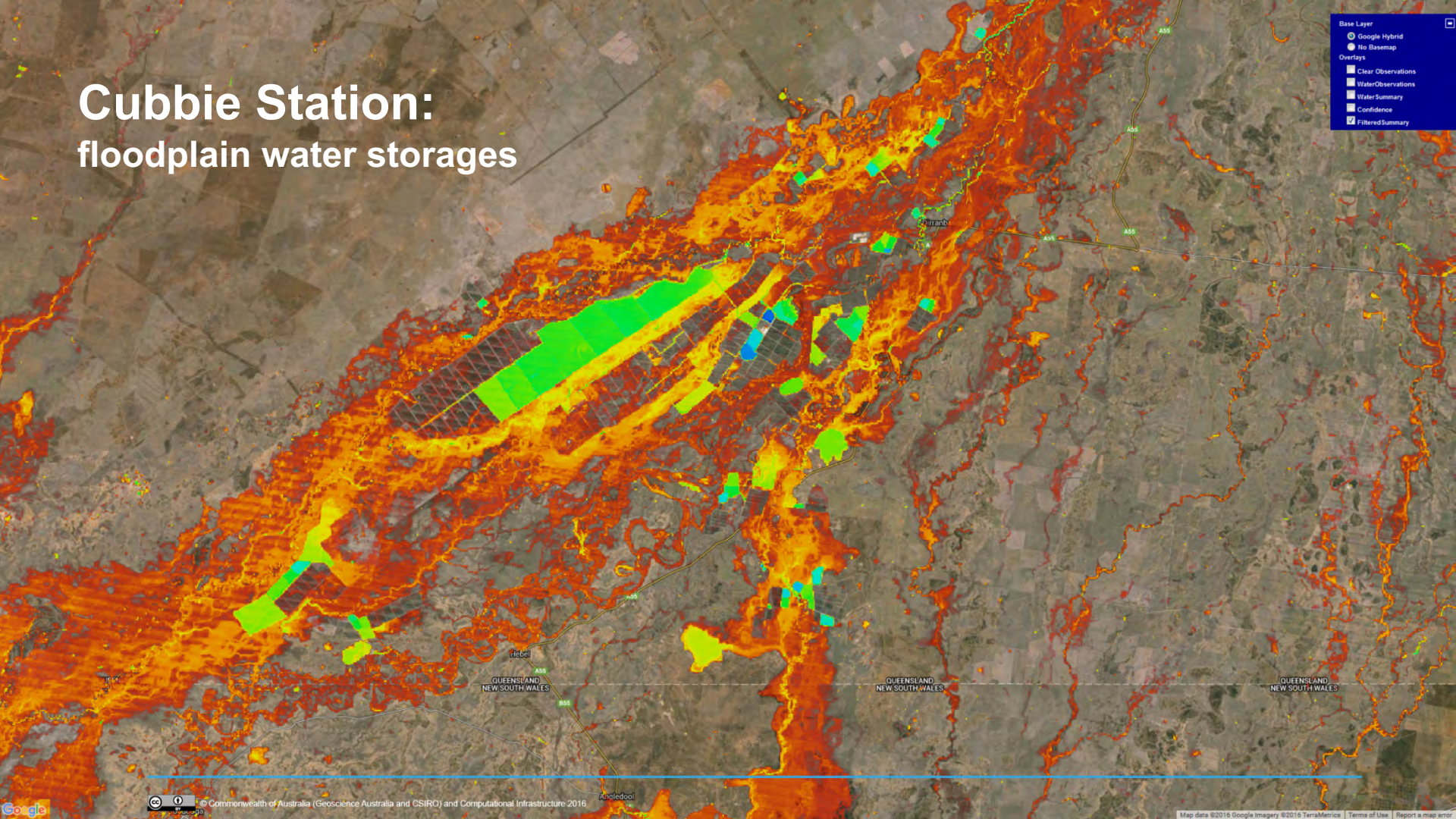
300 000 SCENES
20 000 PASSES

93x10^{12}
PIXELS

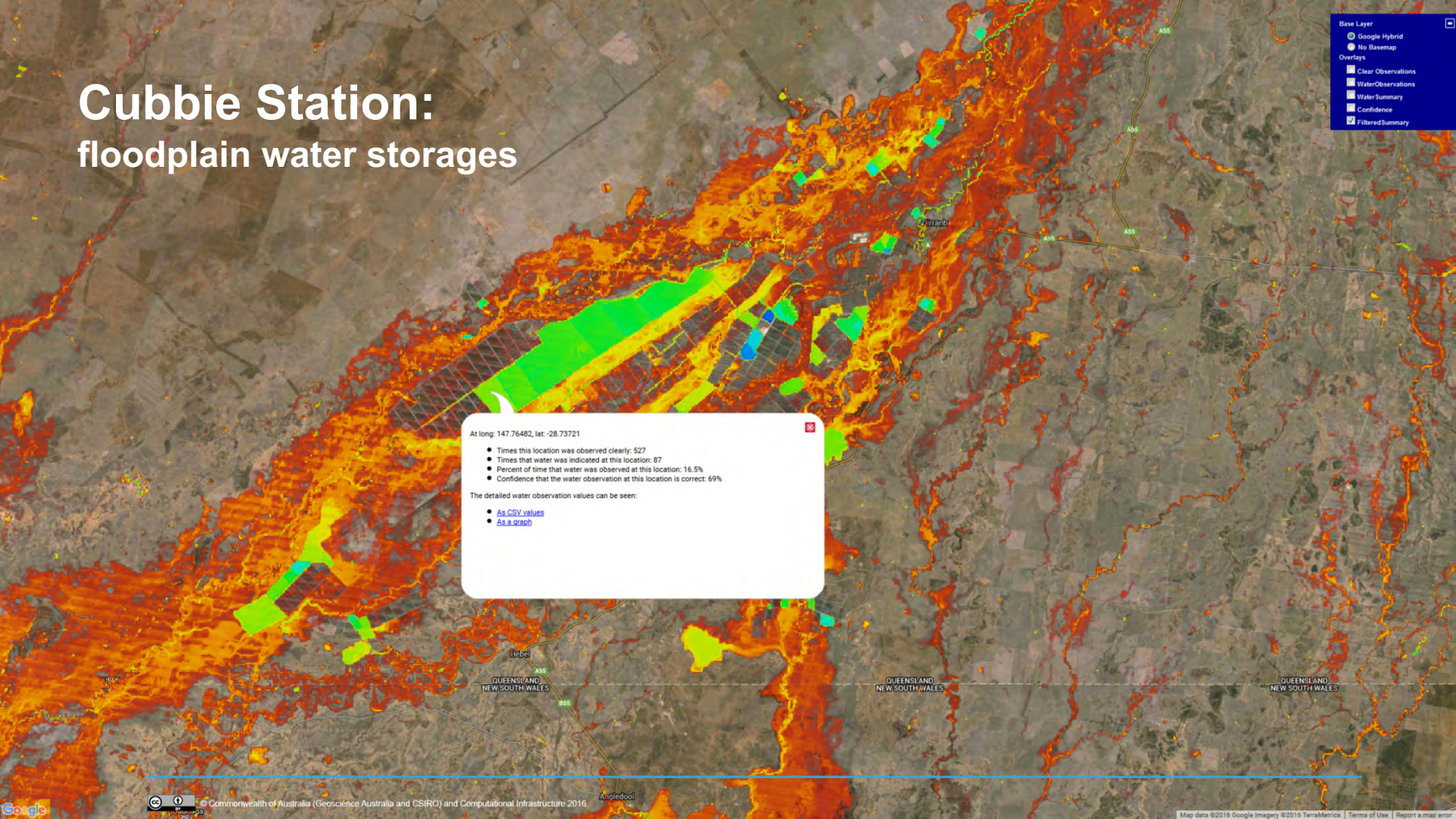
0.75
PETABYTES

3 HOURS
COMPUTE @ NCI

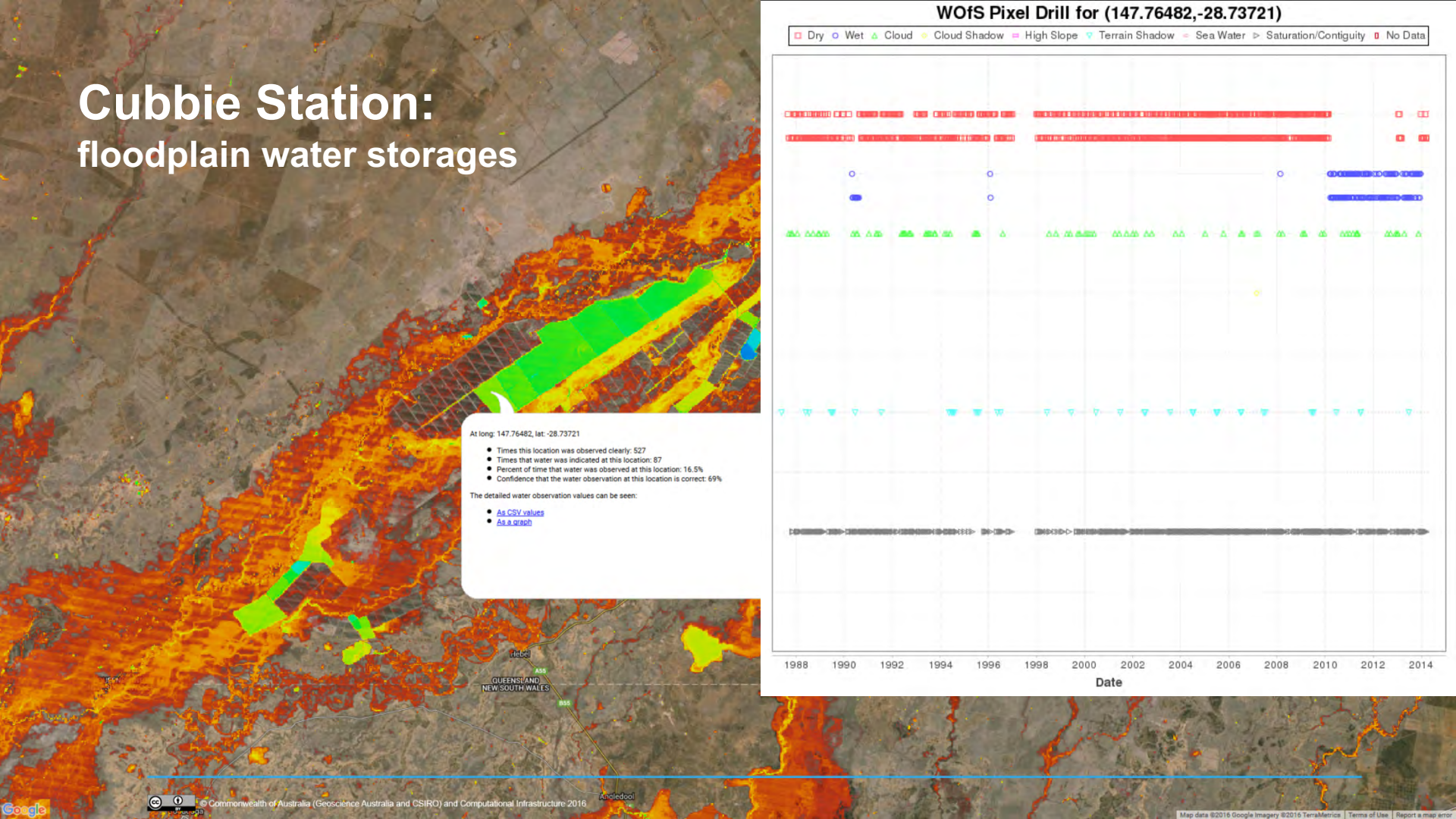
Cubbie Station:
floodplain water storages



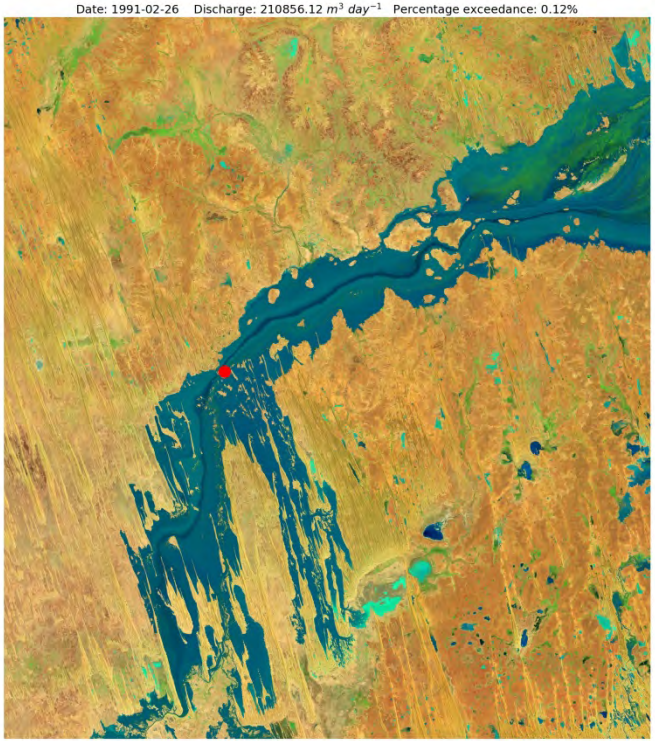
Cubbie Station:
floodplain water storages

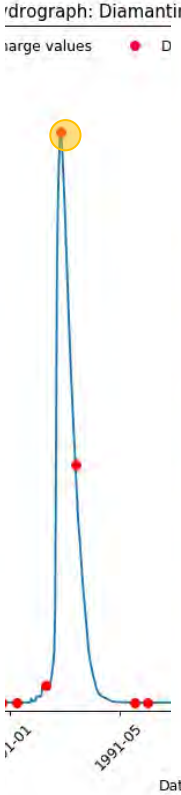


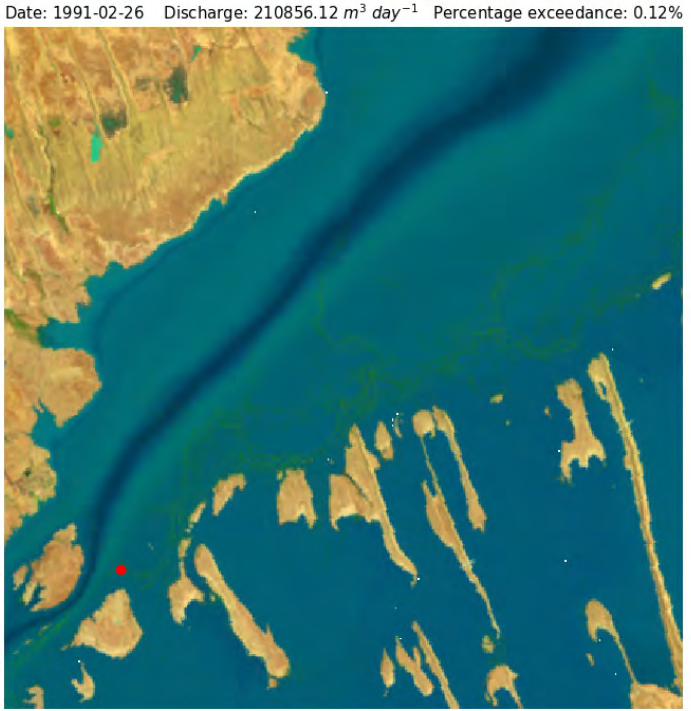
Cubbie Station:
floodplain water storages



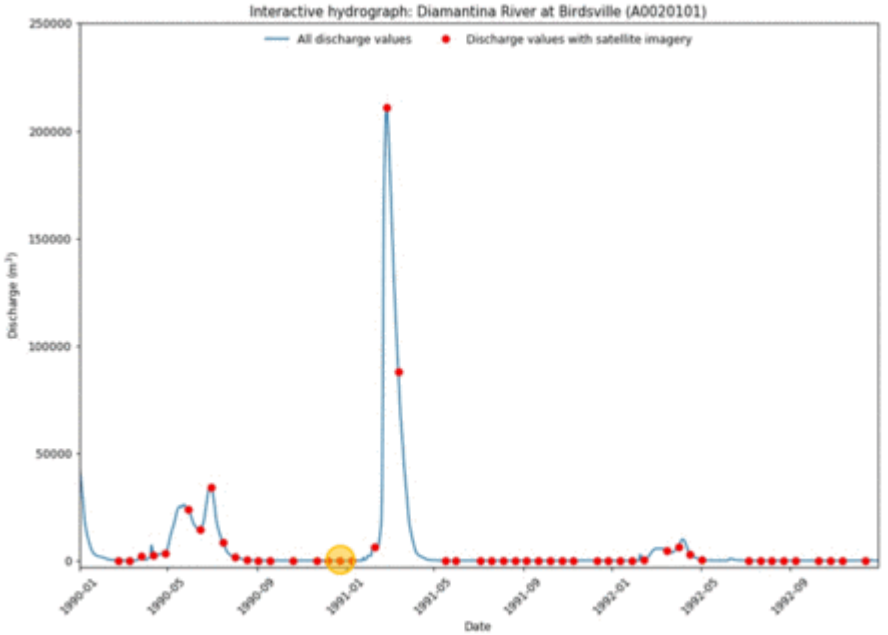
Stream hydrograph



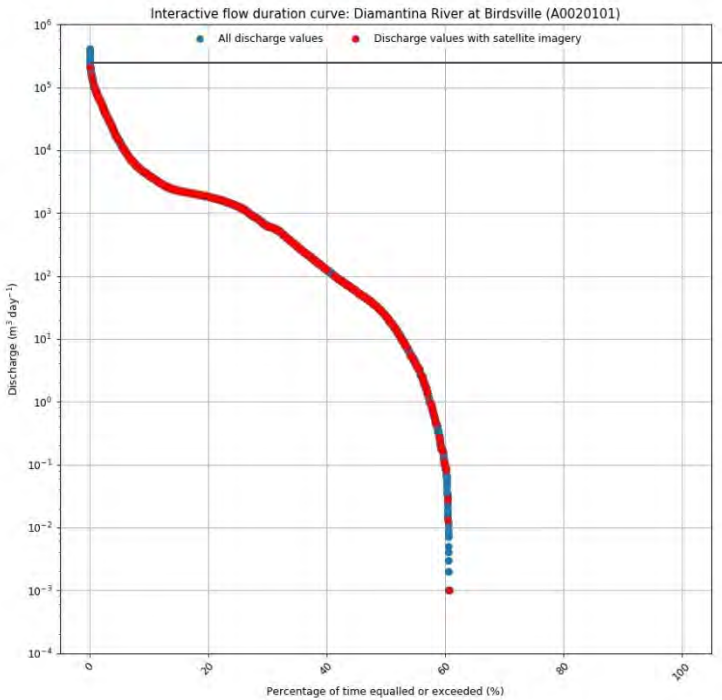


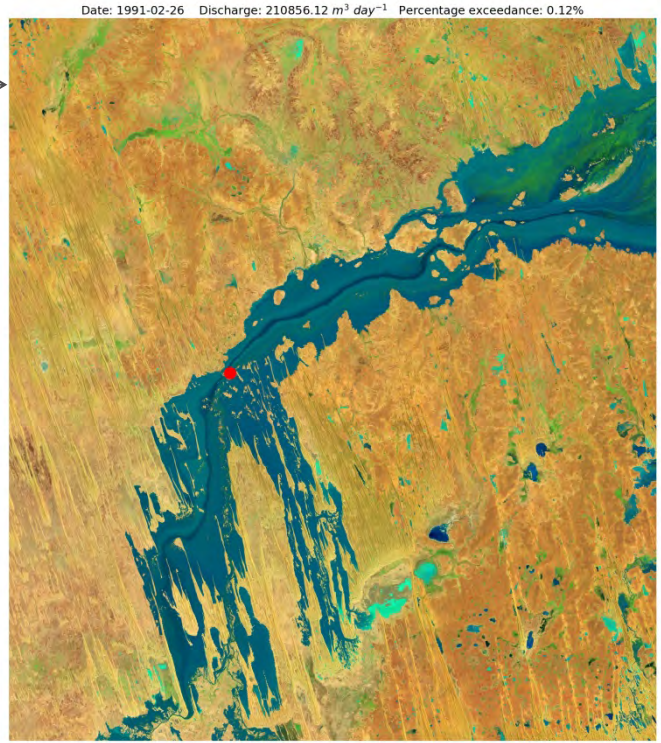


Stream hydrograph

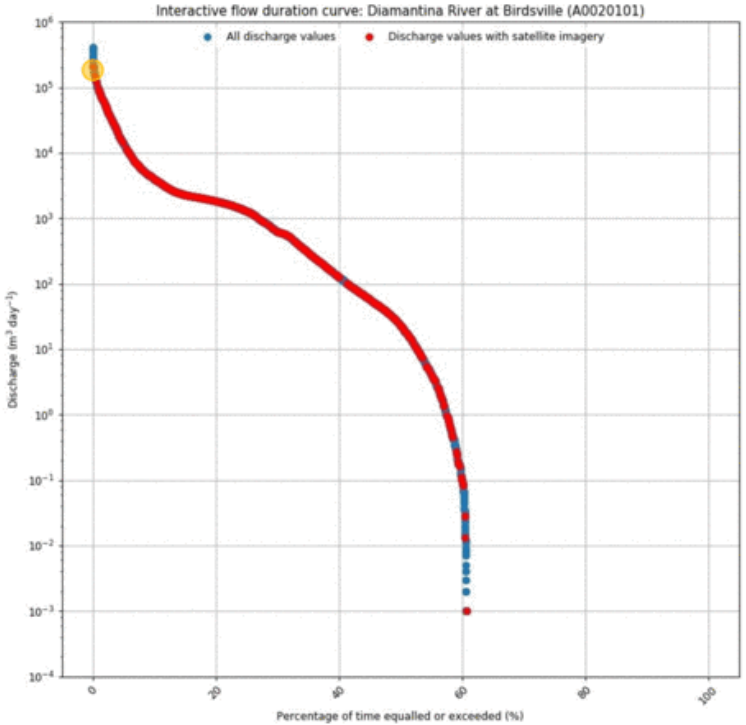


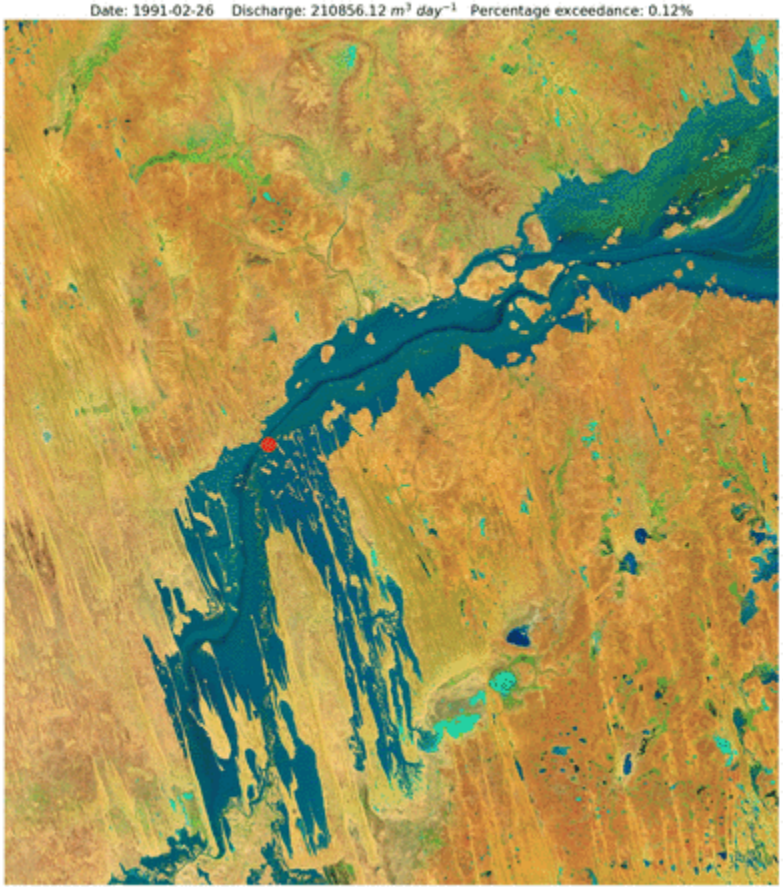
Flow duration curve



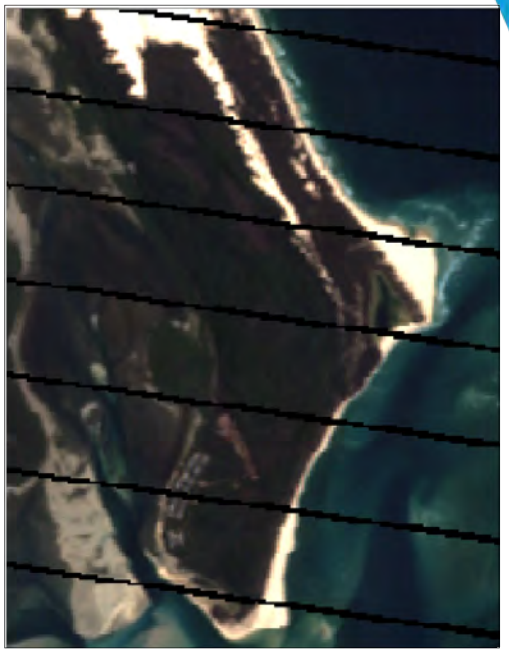


Flow duration curve

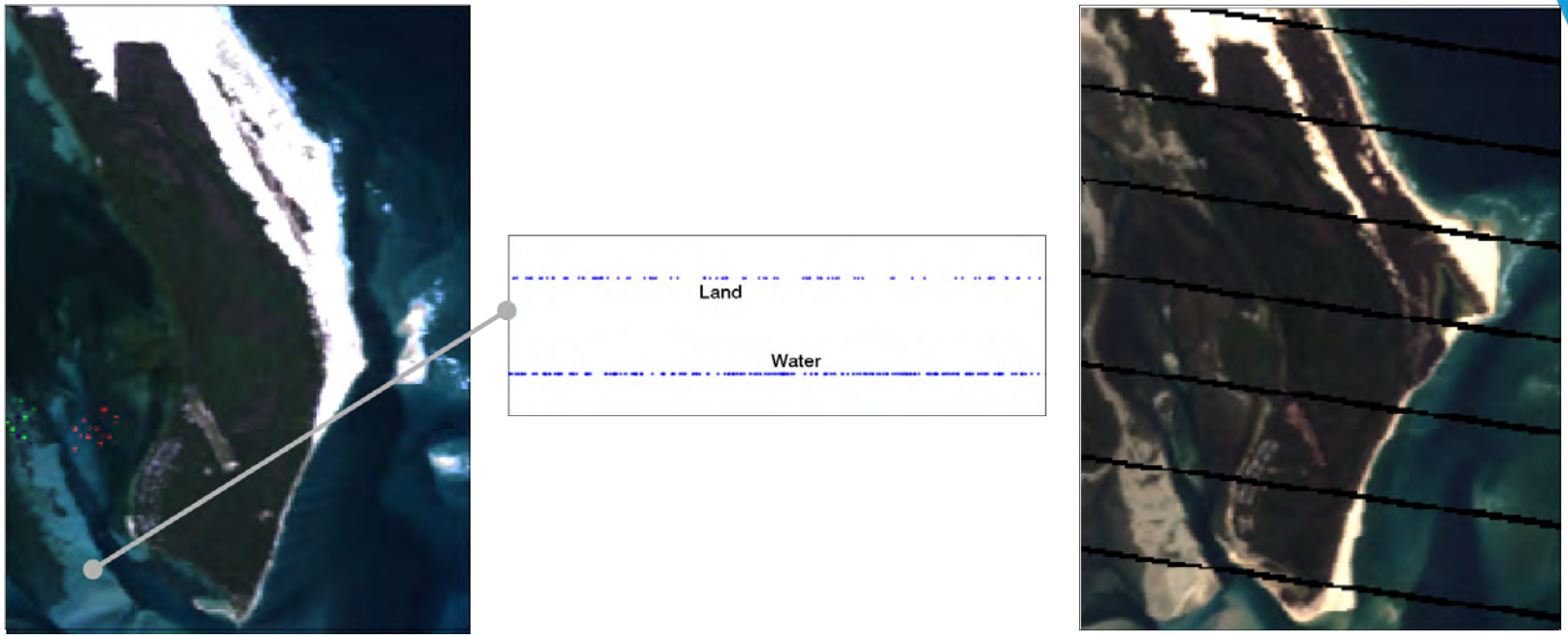




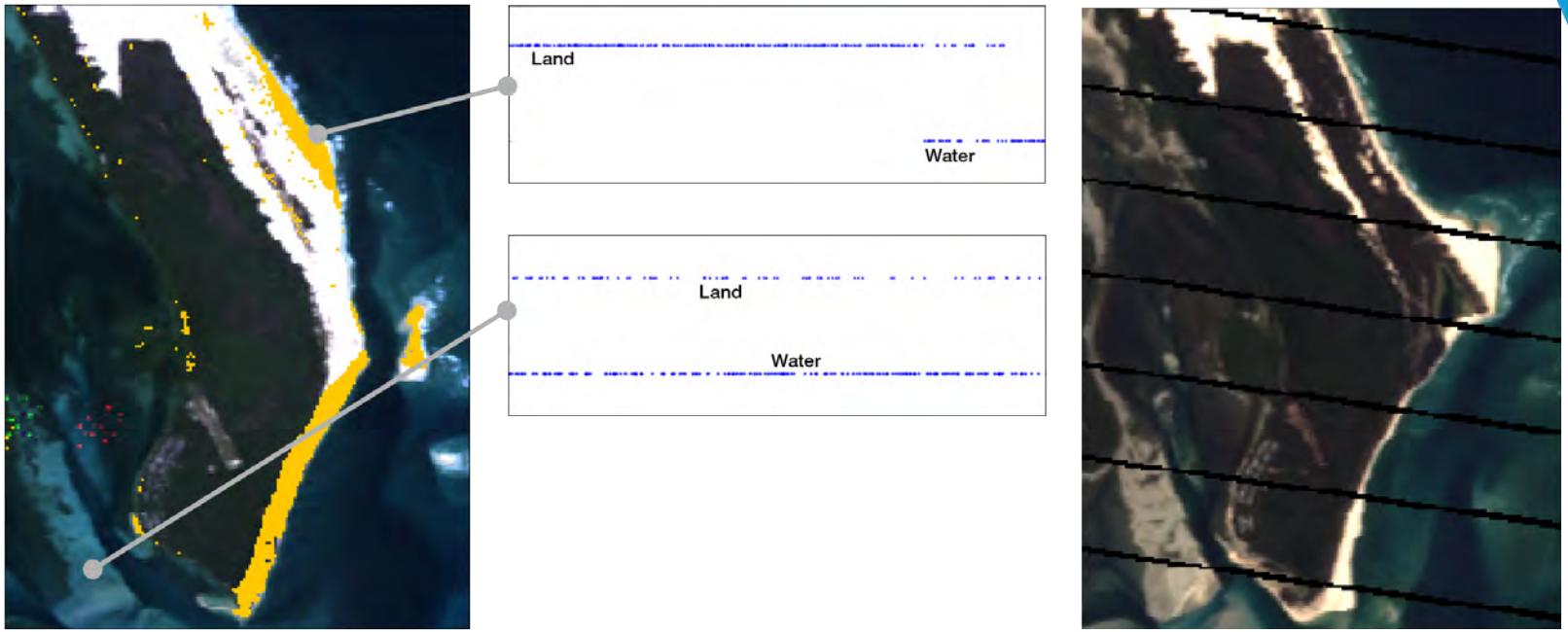
Coastal Change Detection



Coastal Change Detection

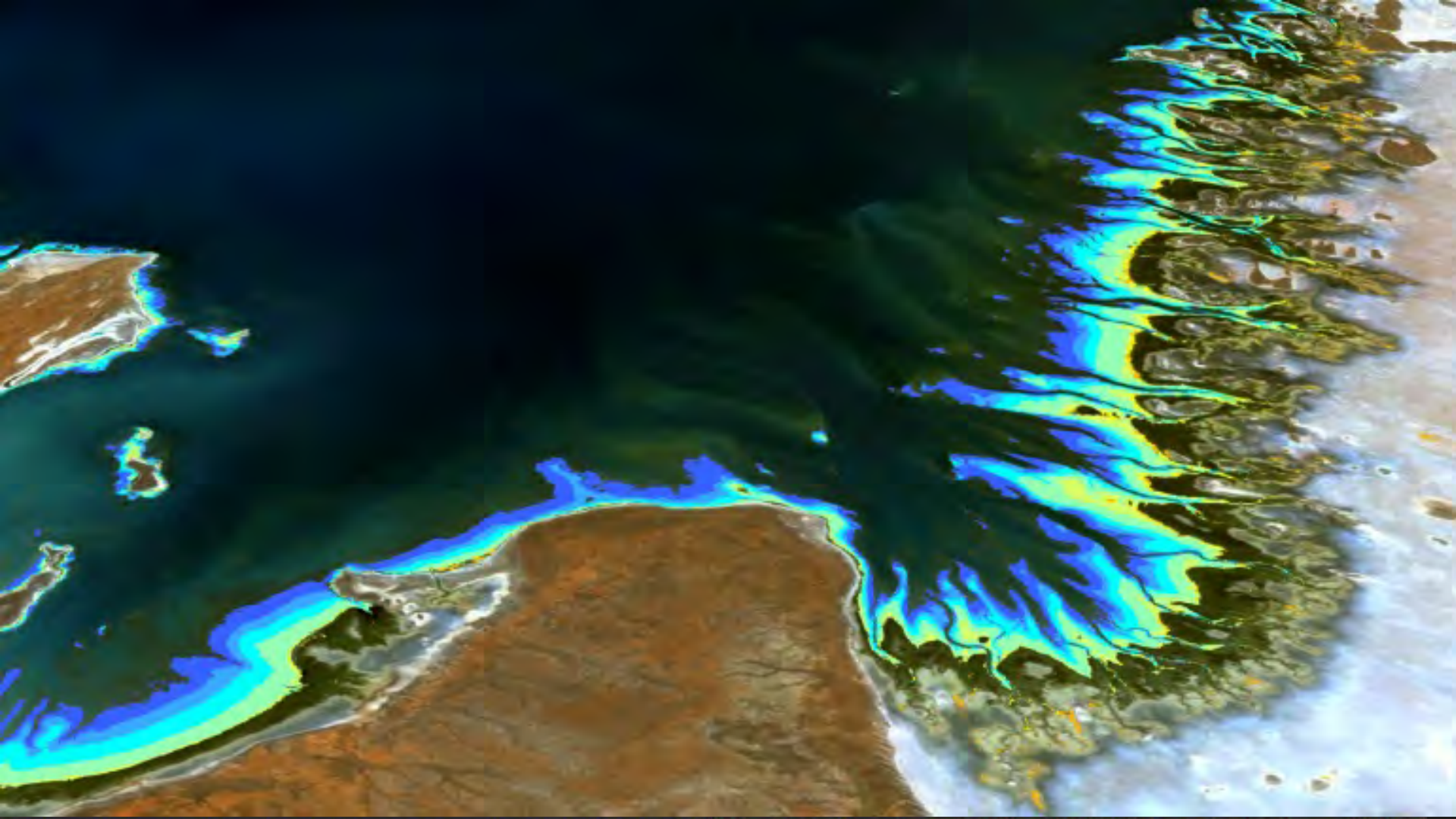


Coastal Change Detection

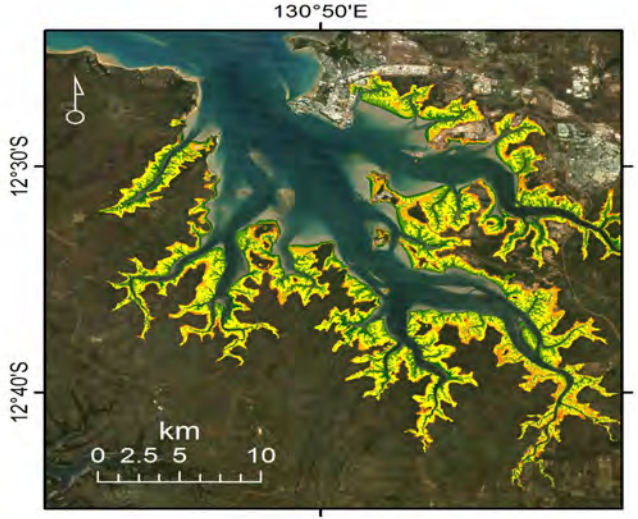


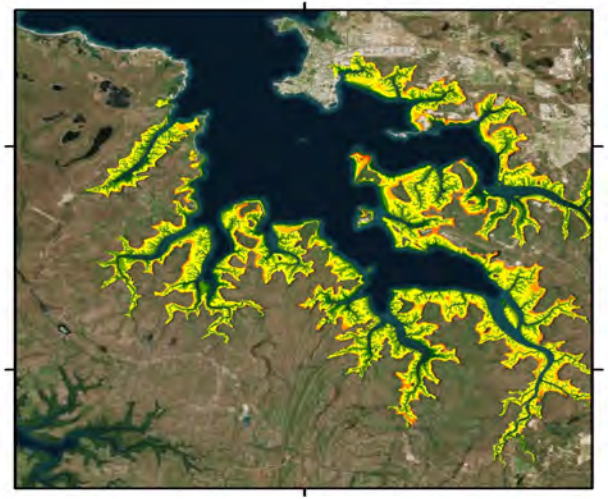
Coastal Change Detection

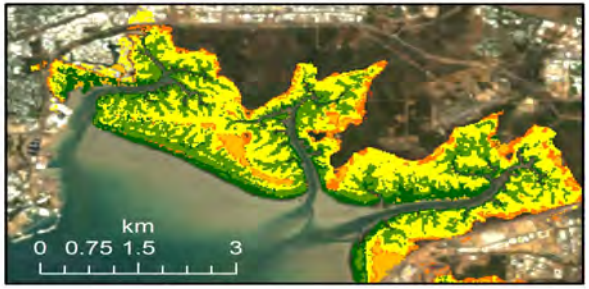

1987



Comparing datacube derived mangrove map with detailed aerial survey

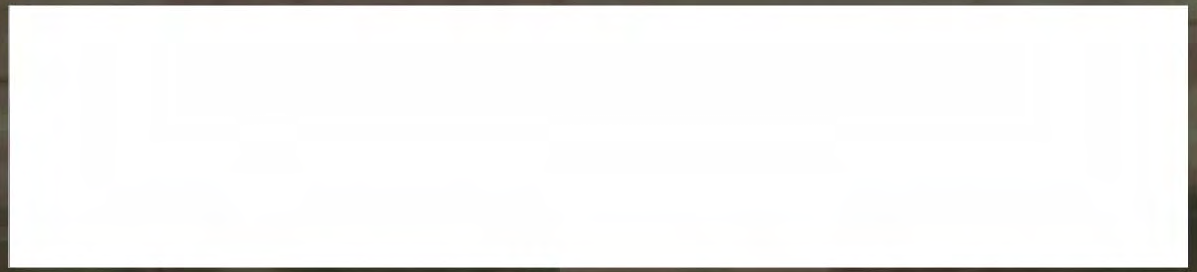






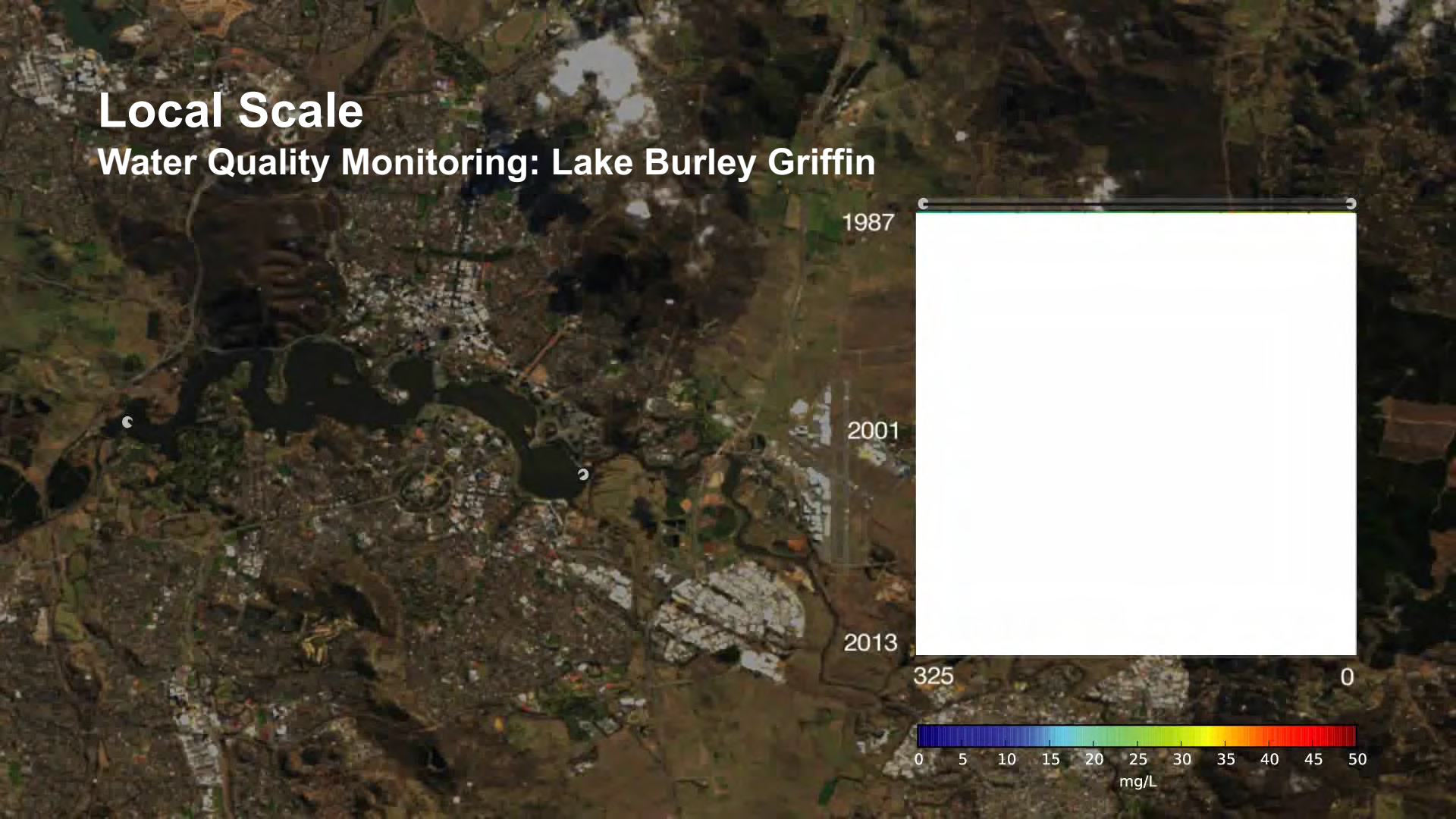
DATACUBE	Kappa	Overall Accuracy
High	0.73	79%
Low	0.74	79%
Low-High	0.84	87%

- Seaward margin
- Rhizophora zone
- Transition zone
- Tidal flat
- Salt flat
- Hinterland margin
- Beach


green
dry
soil
1988
2000
2006
2014

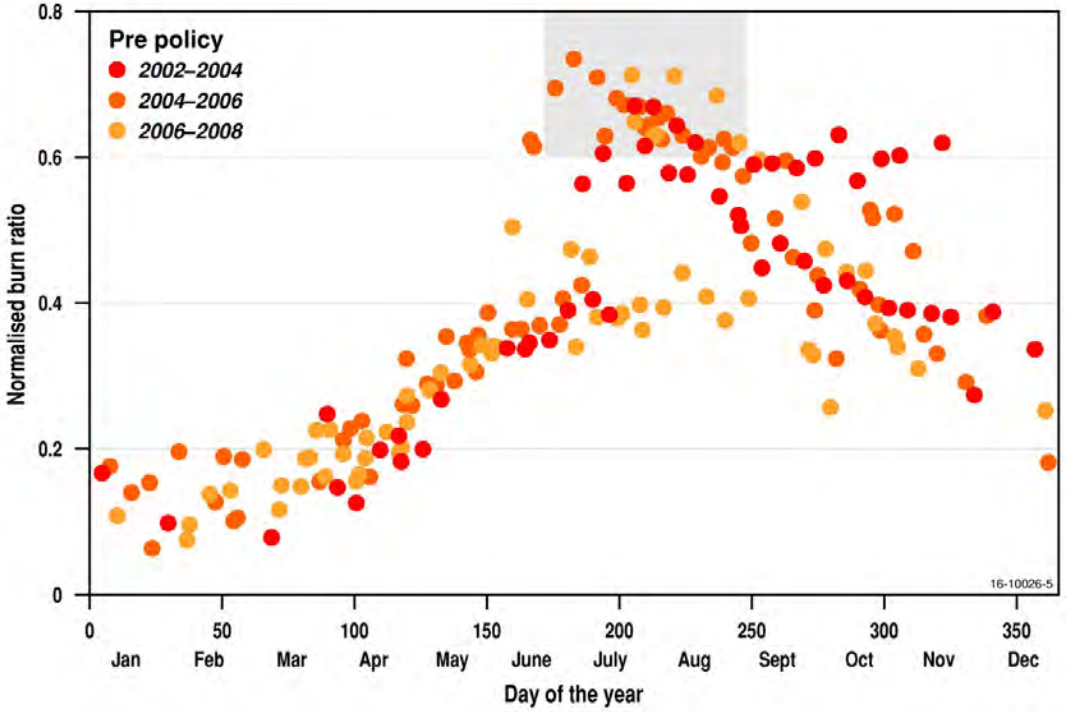
Local Scale

Water Quality Monitoring: Lake Burley Griffin

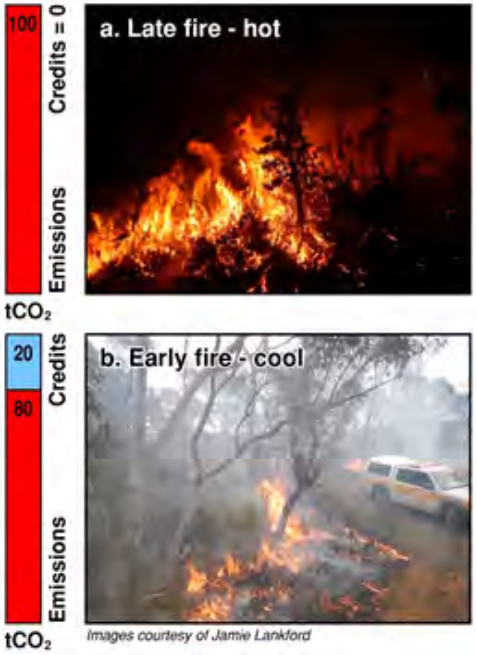


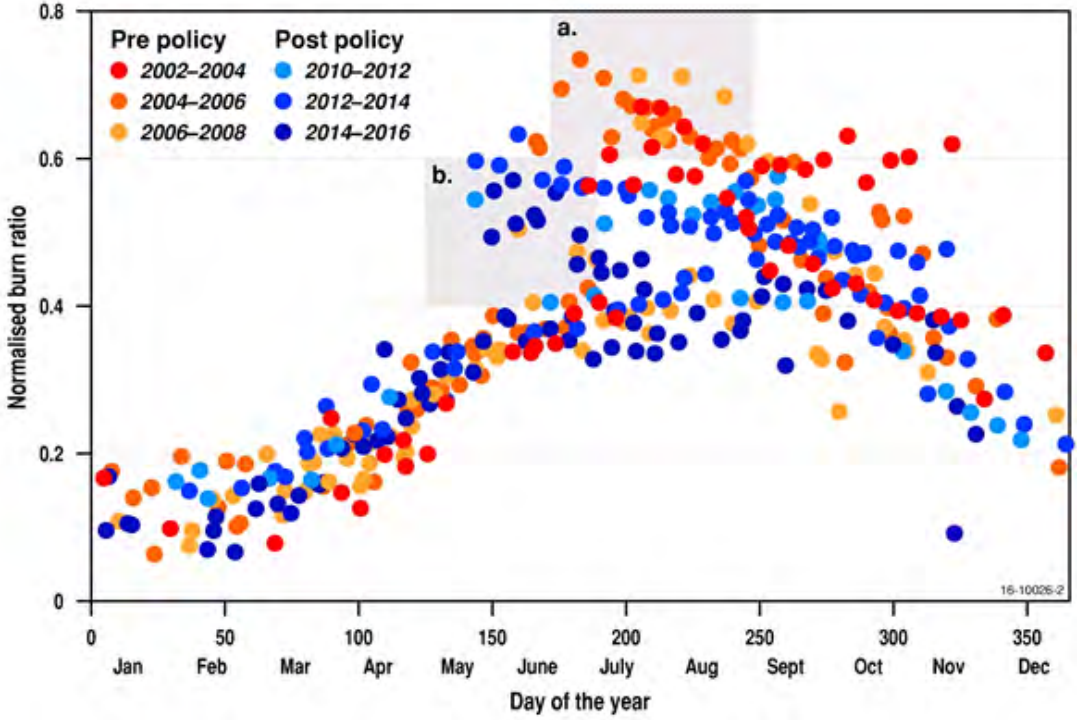
Changes in fire management practices

Image courtesy of Jamie Lankford



Changes in fire management practices



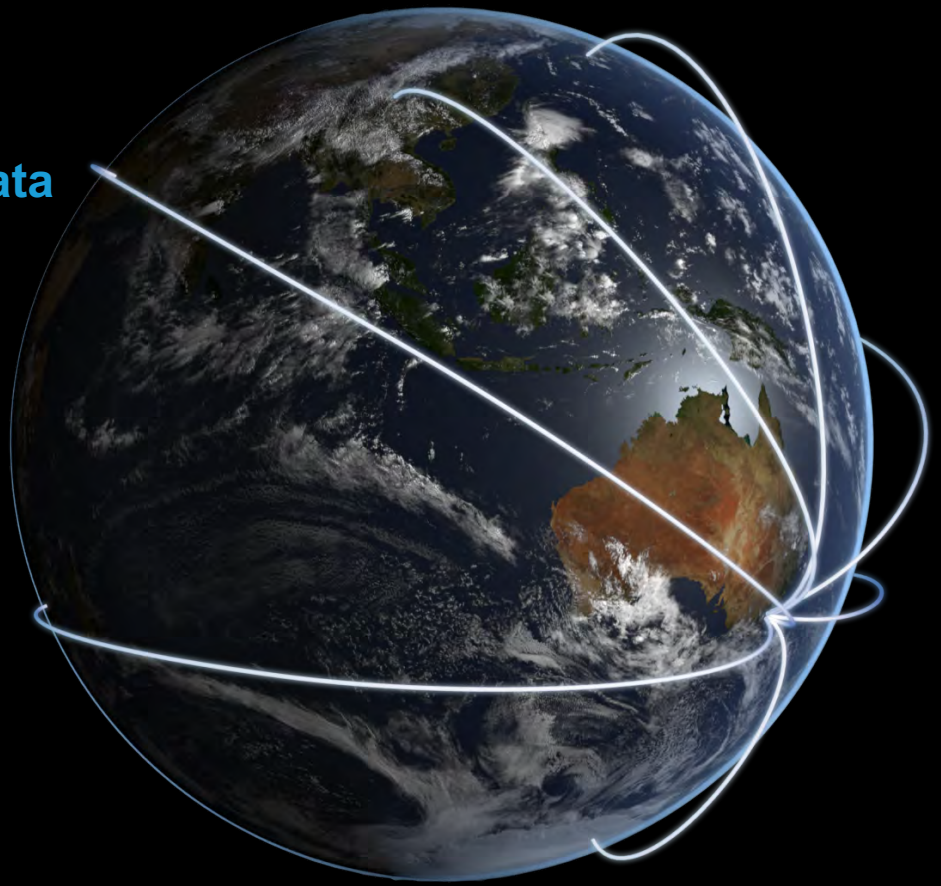


Some prototyped applications for the data cube:

- Vegetation change, agricultural production
- Flood inundation mapping, farm dam development
- Wetland management and characterisation
- Carbon accounting
- Seagrass and substrate mapping
- Coastal change and water quality
- Shallow water bathymetry
- Mining footprint and urban development
- Bushfire scar mapping and forestry inventory

Big Data for a Big Planet:

a global network of regional data cubes?

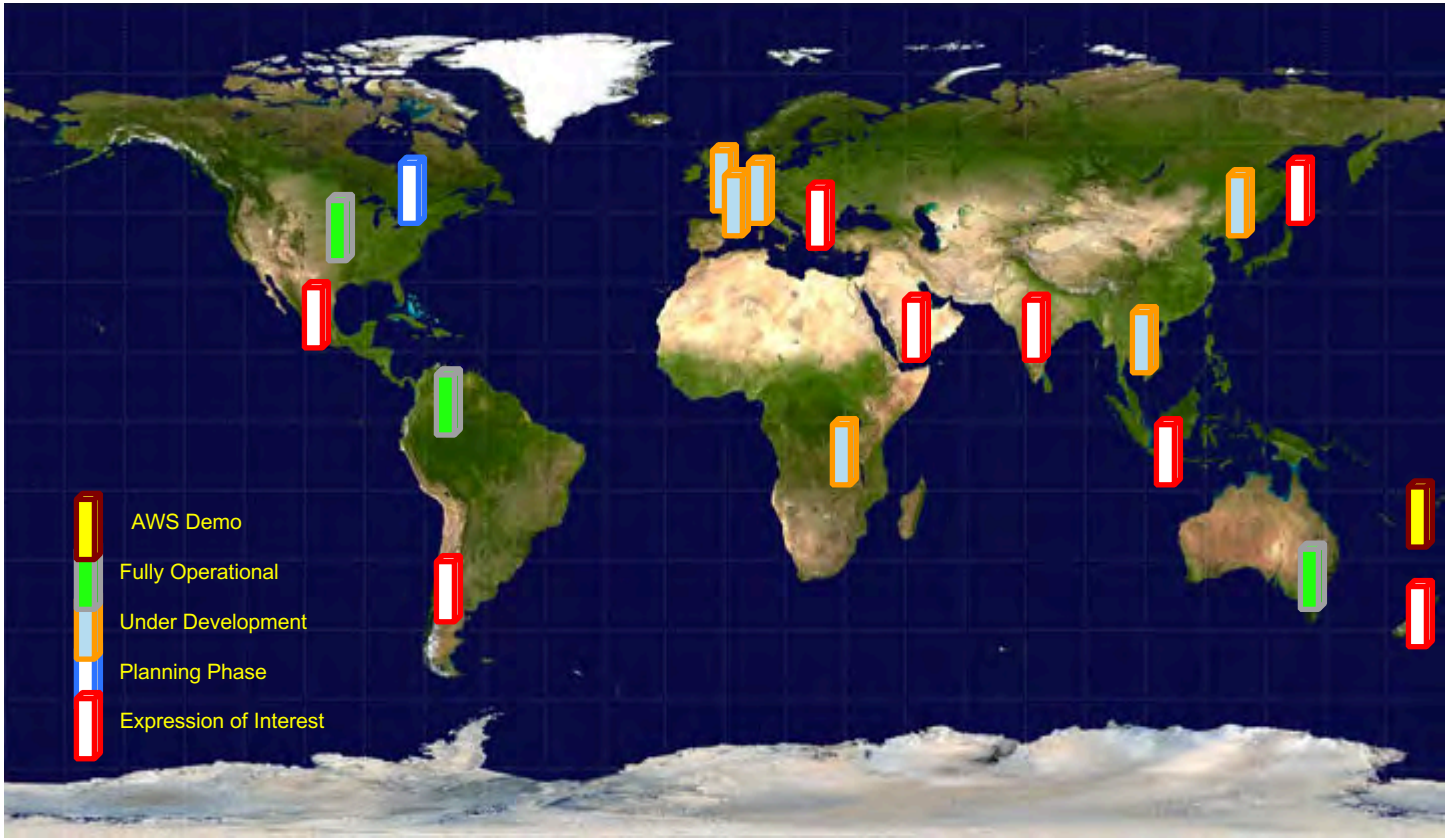


Data Cubes for:

Africa, Antarctica, China, India, Europe, North America, …

Connecting the EO, Spatial and Statistical world to support global SDGs?

Growing a Network of Compatible Open DataCubes



Australian Government
Geoscience Australia

Digital Earth
AUSTRALIA

www.ga.gov.au/dea
opendatacube.org

Further Information

Email: Earth.Observation@ga.gov.au

Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609

GEOSCIENCE AUSTRALIA

Australian Government
Geoscience Australia

Digital Earth
AUSTRALIA

The business case for DEA

Dr Trevor Dhu

Digital Earth Australia – Why?

DEA will improve the efficiency and effectiveness of the Australian Government's investments and improve how we manage our natural resources.

DEA will support innovation and growth in the digital economy and drive increased productivity across a wide range of sectors.

Australia’s huge

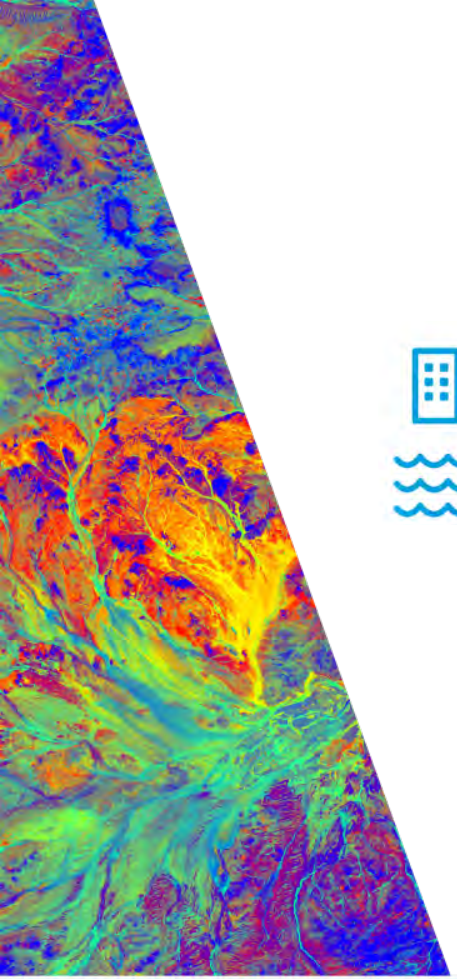
Why Digital Earth Australia?

OF AUSTRALIA LANDMASS

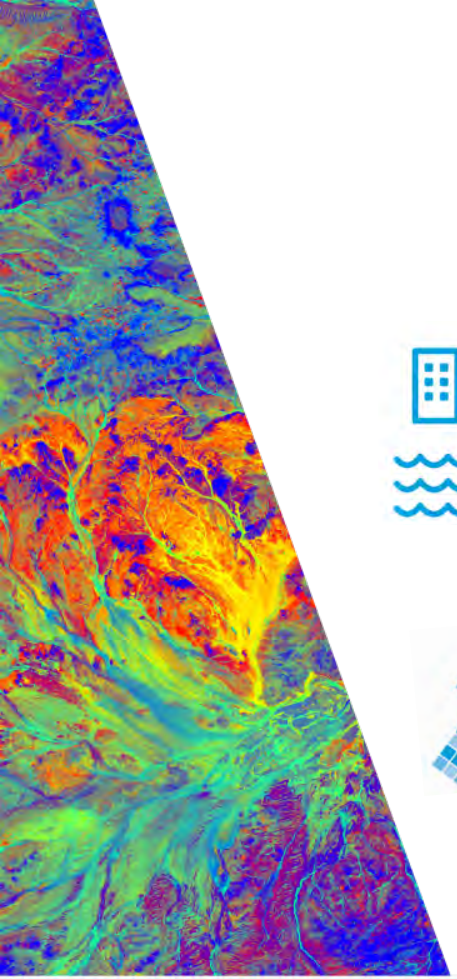
ONLY **2.3%** OF AUSTRALIA'S POPULATION

NINTI ONE · CRC REMOTE™ ECONOMIC PARTICIPATION

Why Digital Earth Australia?



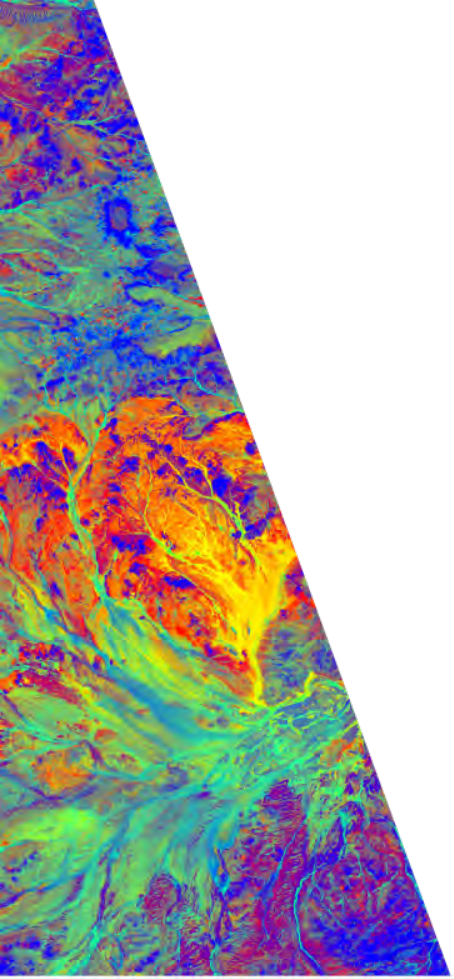
The Australian Government is currently investing over **$500 million a year** on monitoring, protecting or improving the health of our land and oceans



Why Digital Earth Australia?

The Australian Government is currently investing over **$500 million a year** on monitoring, protecting or improving the health of our land and oceans

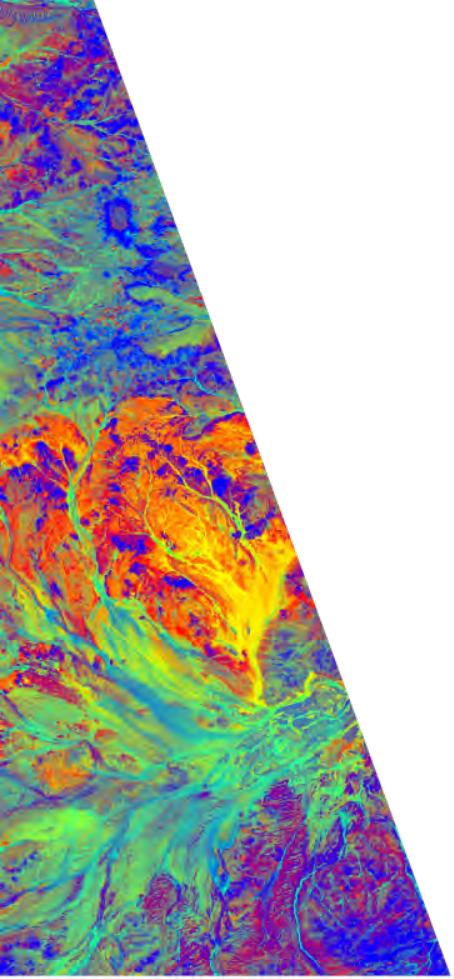
Earth observations from space are the only hope of efficiently monitoring and targeting these investments



Murray-Darling Basin

The Murray Darling Basin is a critical agricultural region which

- accounts for around 20% of Australia’s total agricultural land area (over 850,000 km^2);
- produces one-third of the nation’s food supply;
- contains about 40% of all Australia's farms; and
- produces on average 35–40% of the total gross value of the nation’s agricultural production.



Murray-Darling Basin Authority

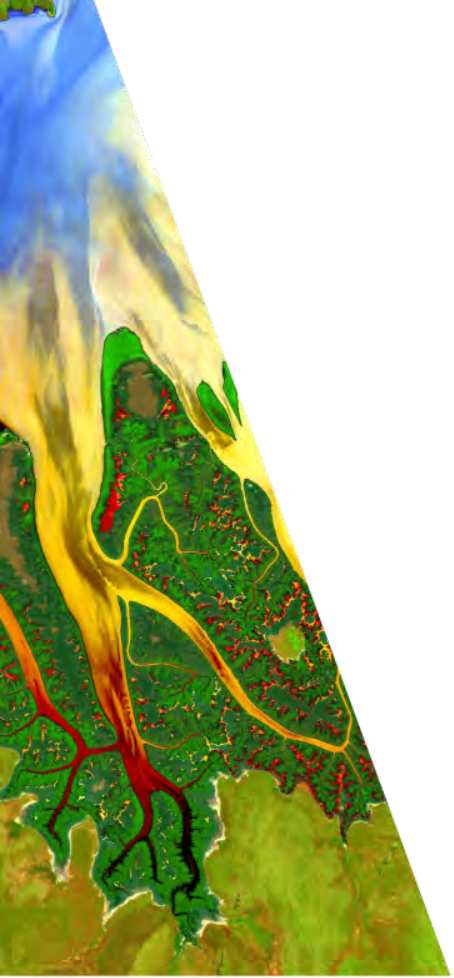
Responsible for operating the River Murray system and efficiently delivering water to users on behalf of partner governments

- ~$150 million of water used for helping the 30,000 wetlands and other water dependant ecosystems across the Basin.

MDBA: Sentinel-2 Surface Reflectance

The MDBA expect that this project will improve the precision of:

- Basin Plan modelling;
- monitoring and modelling of environmental watering; and
- monitoring and modelling of ecological responses.



Clean Energy Regulator

- The Clean Energy Regulator is responsible for monitoring and compliance of land sector projects under the $2.55 billion Emissions Reduction Fund.
- Projects can generate Australian Carbon Credit Units (certificates) for sale through the fund by changing land use practices across the country.

What would you like to do on your land to store, or sequester, carbon and be issued with Australian carbon credit units for that activity?

Store carbon in soil

- Was the land used for agricultural purposes at least once in the 5 years before you apply to run a project?
  - No → Has the land been under permanent pasture or continuously cropped for at least 5 years?
    - Yes → Are you prepared to implement one or more new management actions?
      - Yes → Are you prepared to fund expert technicians to sample and analyse soil from a project?
        - Yes → **Soil Carbon in Grazing Systems**
        - No → There are currently no methods
      - No → There are currently no methods
    - No → There are currently no methods
  - Yes → Are you prepared to run one of three projects?
    1. Sustainable intensification
    2. Stubble retention
    3. Conversion to pasture
    - Yes → Are you prepared to implement one or more new management actions?
      - Yes → Are you prepared to fund expert technicians to sample and analyse soil from a project?
        - Yes → **Soil Carbon using Modelled Abatement Estimates**
        - No → There are currently no methods
      - No → There are currently no methods
    - No → There are currently no methods

Protect or maintain the existing native forest

- Do you have a clearing consent (for the land) that was issued before 1 July 2010?
  - No → Is unrestricted clearing permitted on the land?
    - Yes → Has the land been cleared in the last 7 years or 5 years if it has changed hands?
      - Yes → There are currently no methods
      - No → Has the land been cleared at least twice; was it used for cropping or grazing afterwards?
        - Yes → Is the land now uniformly covered in native forest?
          - Yes → Do you have evidence of native forest regeneration after the clearing events?
            - Yes → **Avoided Clearing**
            - No → There are currently no methods
          - No → There are currently no methods
        - No → There are currently no methods
    - No → There are currently no methods
  - Yes → Are you prepared to manage the native forest to achieve a mix of native forest vegetation?
    - Yes → Are you prepared to fund and/or carry out destructive tests on the mature trees?
      - Yes → **Avoided Deforestation 1.1**
      - No → There are currently no methods
    - No → There are currently no methods

Plant seeds or seedlings on cleared land to establish a permanent forest

- Has the land been used for grazing, cropping or fallow for the last 5 years?
  - No → Has the land been used for settlement, nature conservation or not used at all?
    - Yes → Has the land been clear of forest cover* at least 5 years before application?
      - Yes → **Reforestation by Environmental or Mallee Plantings – FullCAM**
      - No → There are currently no methods
    - No → There are currently no methods
  - Yes → Are you prepared to undertake field measurements of your planted trees?
    - Yes → Are you prepared to fund and/or carry out destructive tests on the mature trees?
      - Yes → **Reforestation and Afforestation 2.0** Or **Farm Forestry**
      - No → There are currently no methods
    - No → There are currently no methods

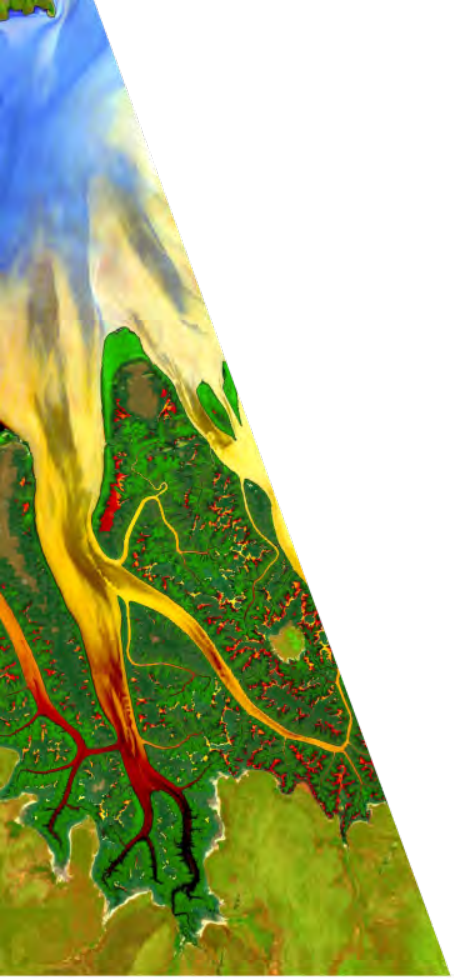
Plant seeds or seedlings on cleared land to establish a forest plantation for harvesting

- Has the land been used for grazing, cropping or fallow for the last 5 years?
  - No → There are currently no methods
  - Yes → Are you prepared to undertake field measurements of your planted trees?
    - Yes → Are you prepared to fund and/or carry out destructive tests on the mature trees?
      - Yes → Are you prepared to harvest and re-establish project trees?
        - Yes → **Farm Forestry**
        - No → There are currently no methods
      - No → There are currently no methods
    - No → There are currently no methods

Let the cleared land revert to native forest

- Have you prevented regrowth on cleared land? eg (ongoing) livestock grazing
  - No → Have you repeatedly cleared forested land for pastoral use? eg mechanical chemical clearing
    - Yes → Are you prepared to change practices to assist regeneration of existing seed or rootstock?
      - Yes → Are native trees expected to regrow on the land?
        - Yes → **Human-Induced Regeneration 1.1**
        - No → There are currently no methods
      - No → There are currently no methods
    - No → There are currently no methods
  - Yes → Are you prepared to change practices to assist regeneration of existing seed or rootstock?
    - Yes → There are currently no methods
    - No → Does the land currently have Forest cover*?
      - Yes → **Managed Regrowth**
      - No → There are currently no methods

*Forest cover is defined as an area of at least 0.2 hectares that includes trees measuring at least 3 metres in height and providing crown cover of at least 20 per cent of the land.

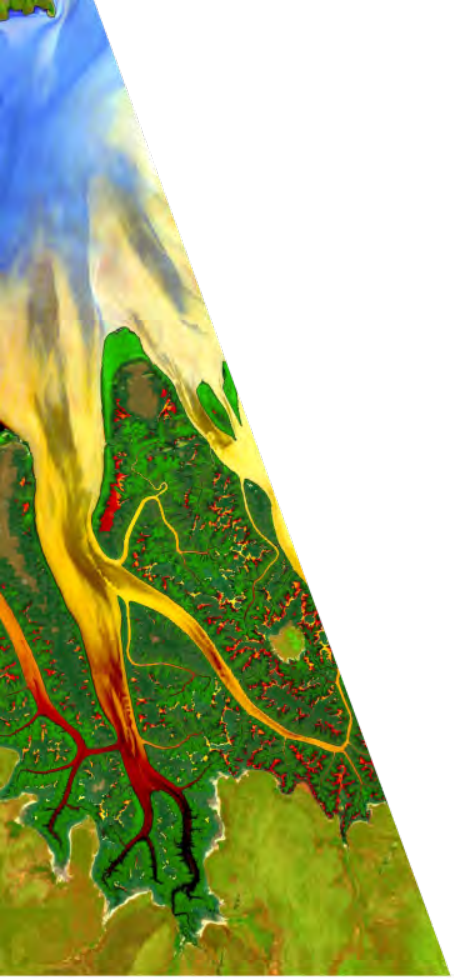


Land Sector Projects

Sequestration projects generate abatement by removing carbon dioxide from the atmosphere and storing it as carbon in plants as they grow.

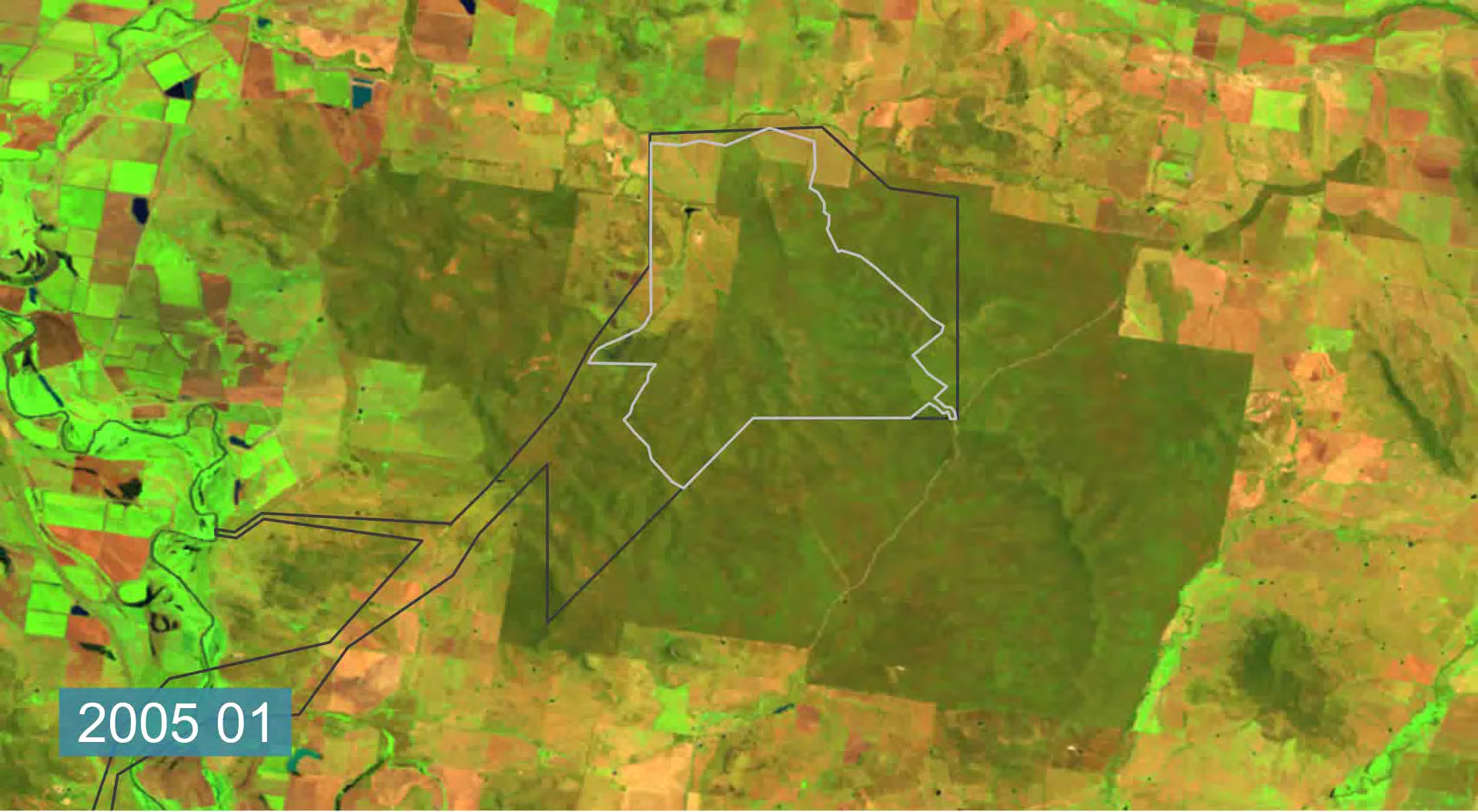
Examples of sequestration activities could include:

- reforestation;
- revegetation;
- restoring rangelands; and
- protecting native forest or vegetation that is at imminent risk of clearing.



Land Sector Projects

- The CER currently oversees 506 land sector projects that generate Australia Carbon Credit Units in return for changes in land use practices
- Monitoring compliance of these projects is currently a time-consuming and largely manual process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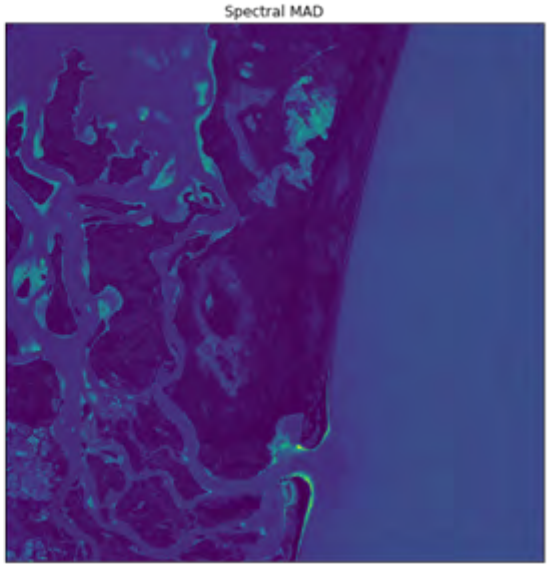
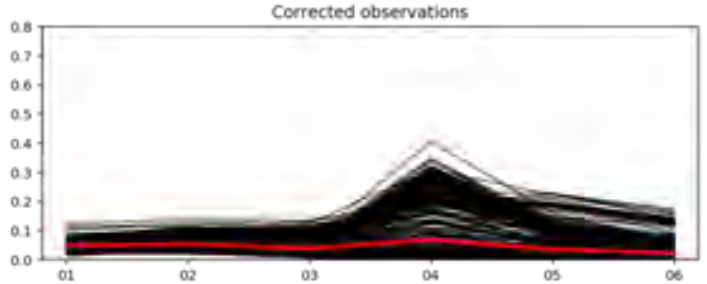
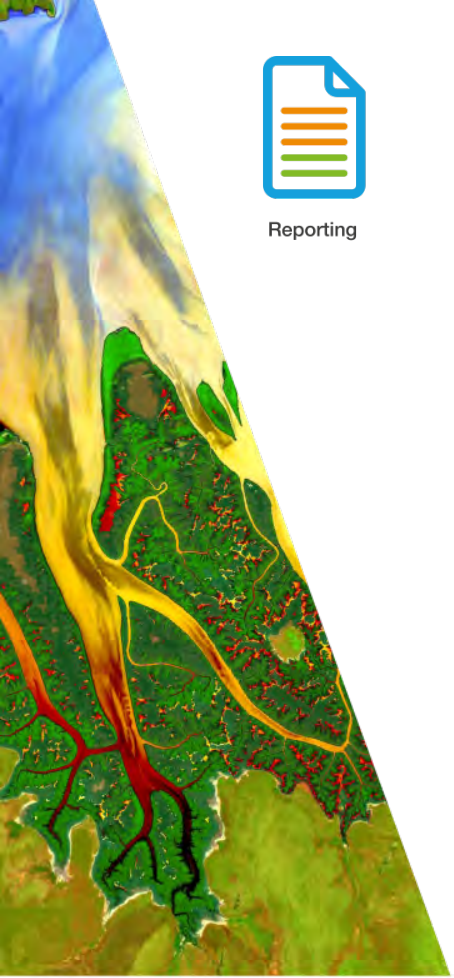
Geomedian based change detection

- GA has pioneered the use of rigorous statistical measures for characterising a region and its variability





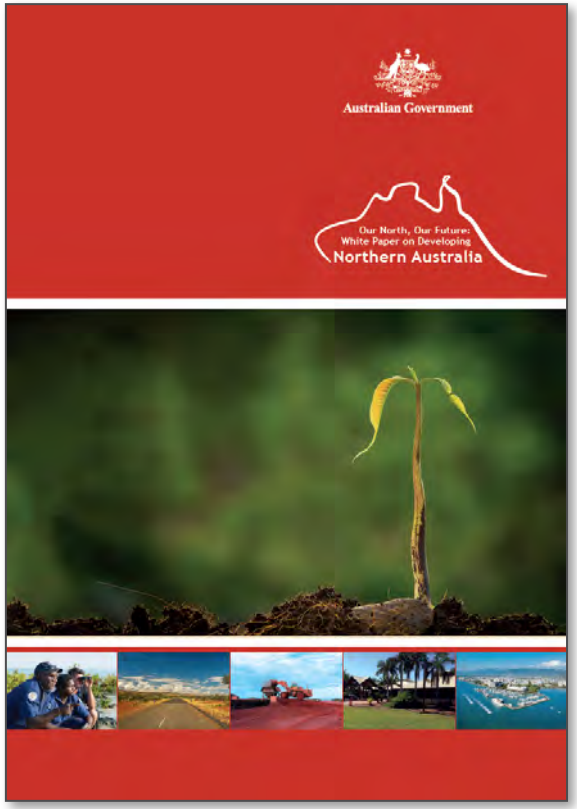


Reporting

Automatic, 6 monthly reports

- Envisage providing a simple, traffic light report describing the amount of change observed at each land sector project location
- The intention would be to then also offer this as a service to other users who want to monitor specific project sites

Developing Northern Australia



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Additional focus area

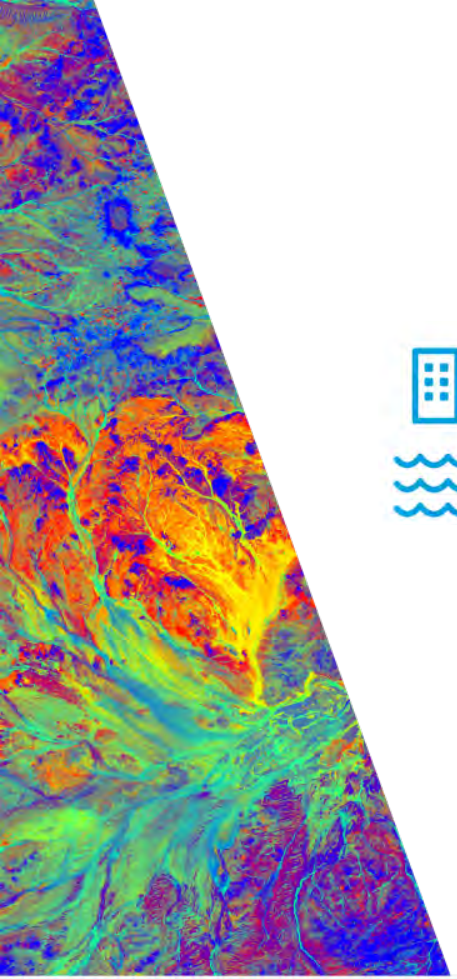
Northern Australia boundary

Tropic of Capricorn

Major road

200 Bathymetry (depth in metres)

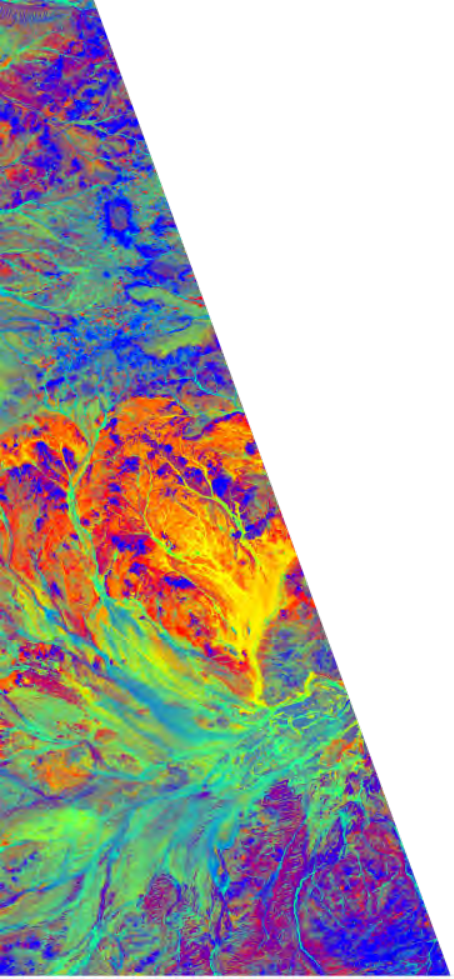
City/town

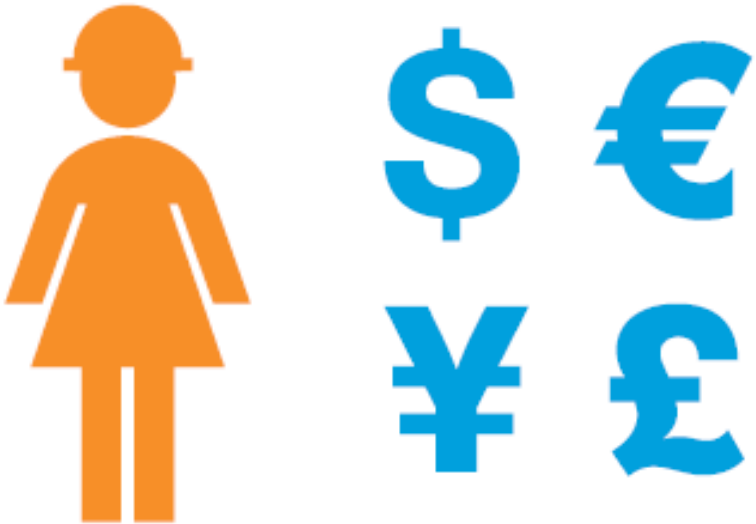


Why Digital Earth Australia?

DEA will improve the efficiency and effectiveness of the Australian Government's investments and improve how we manage our natural resources

Why Digital Earth Australia?



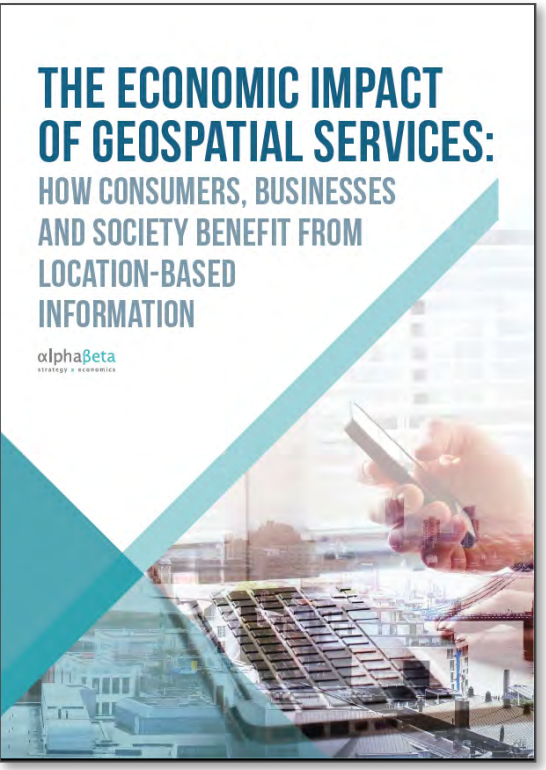


Productivity Commission Report

- Improved data access and use can enable new products and services that transform everyday life, drive efficiency and safety, create productivity gains and allow better decision making.

- The substantive argument for making data more available is that opportunities to use it are largely unknown until the data sources themselves are better known, and until data users have been able to undertake discovery of data.

Potential for Economic Growth



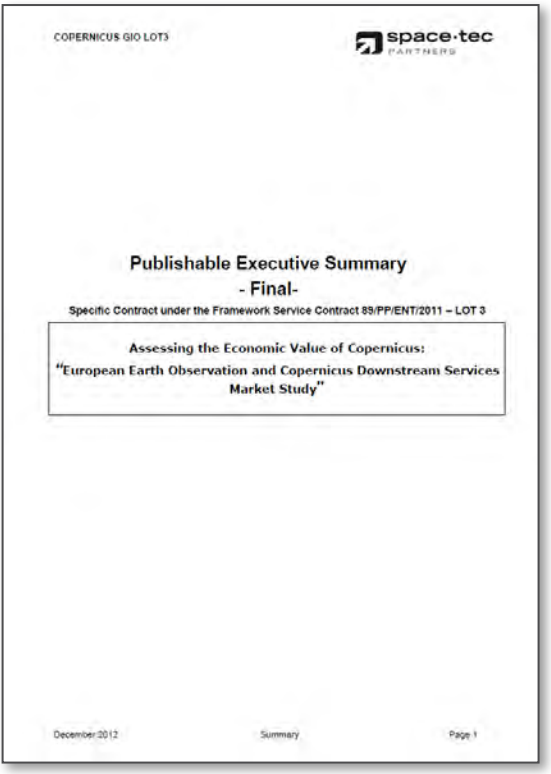
Geospatial services industry generated revenue of approximately

US$400 BILLION IN 2016.

Geospatial services could have a significant productivity impact in sectors representing approximately

75% OF GLOBAL GDP.

Enabling Factors


COPERNICUS GIO LOT3

space·tec PARTNERS

Publishable Executive Summary

- Final-

Specific Contract under the Framework Service Contract 89/PP/ENT/2011 – LOT 3

Assessing the Economic Value of Copernicus:
"European Earth Observation and Copernicus Downstream Services Market Study"

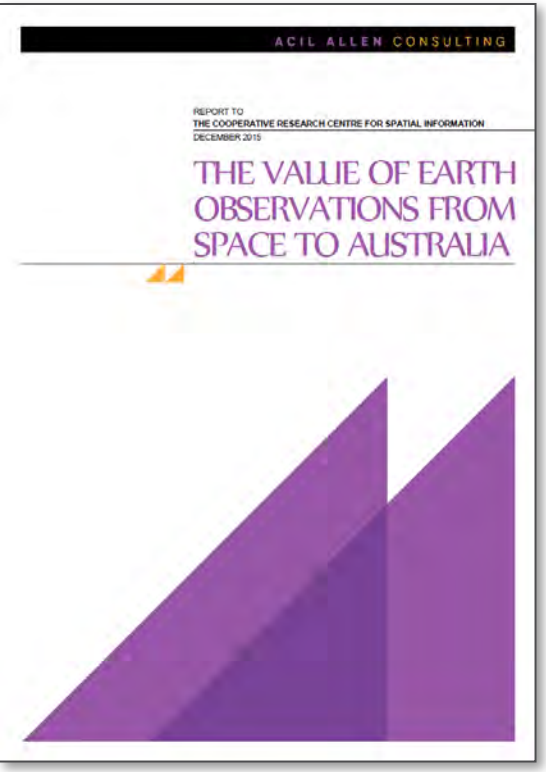
December 2012 Summary Page 1

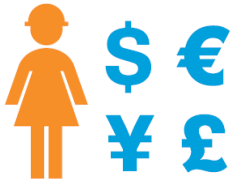
1. Regulation: Free and open data policy; assurance of data continuity; quality assurance and standards-building.

2. Data Availability and Access: Simplified access to Analysis Ready Data

3. Demand/Market: Continued dissemination efforts and regional/local demand incubation and communication schemes aimed at commercial users.

Potential for Economic Growth





Australia's spatial industry is forecast to generate **15,000 new jobs** and contribute over **$8 billion** per annum to Australia's economy by 2025

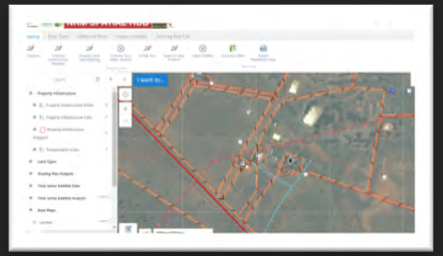
NRM SPATIAL HUB

The NRM Spatial Hub

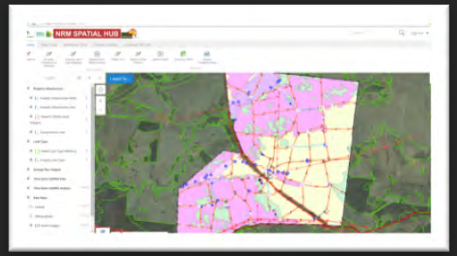
Innovation through collaboration

www.nrmhub.com.a

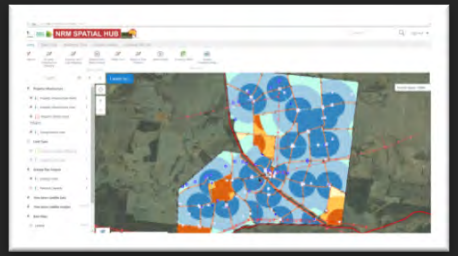
User Drive Applications for the Grazing Sector



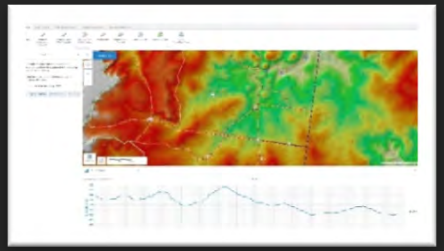
Infrastructure



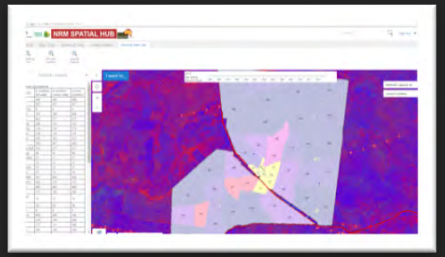
Vegetation/Landtypes



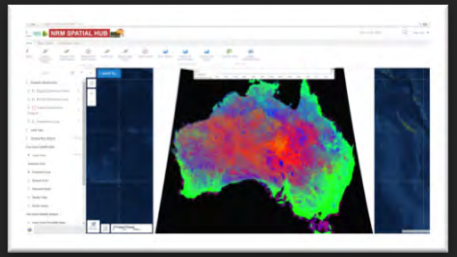
Water Analysis



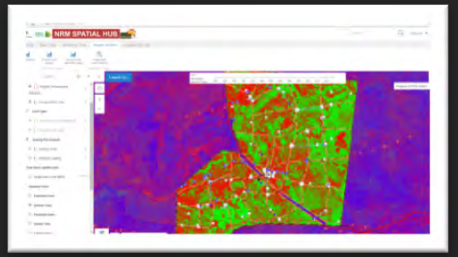
Infrastructure design



Safe Carrying Capacity



Access to national imagery archives



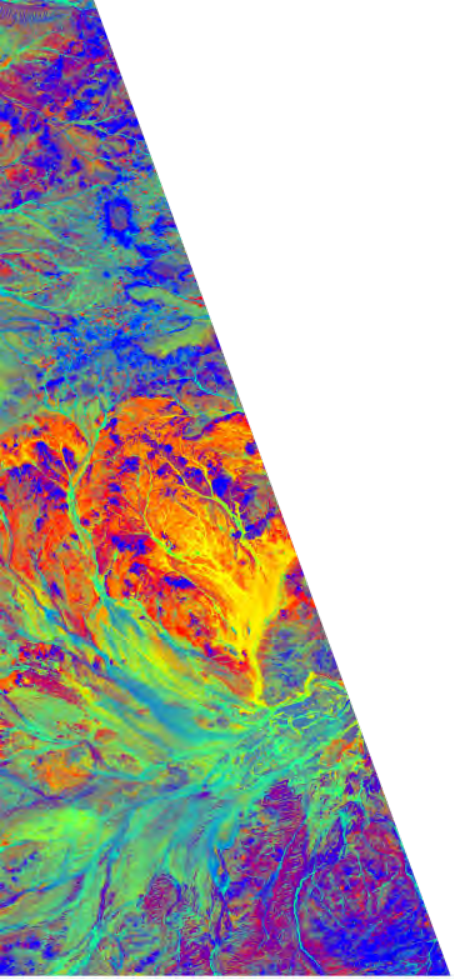
User-driven image analysis

Designed by and for real users

User Surveys – The Benefits

- 90% of respondents said they found the Hub easy to use.
- 95% said the Hub has the potential to measurably improve the productivity, profitability and sustainability of their property.
- More than 50% felt the Hub would save them between 10 and 30 labour days a year.
- 75% said it would measurably increase safe carrying capacity through better pasture utilisation.
- 72% rated this type of technology as important to making their business both viable and sustainable in the future.

The survey also revealed that about half the respondents considered their properties to be around 50% developed. They could conservatively increase annual revenue by more than 35% through improved pasture utilisation and increased stocking rates. This increase does not include the improvements in property value, risk management and labour savings that would also result.



CSIRO's Earth Analytics Industry Innovation Hub

- Powered by DEA and ODC platforms
- Designed to leverage off public investments such as DEA and ODC to stimulate new commercial applications
- Developing a flexible and easy-to-use user interface and 'execution engine' for public and commercial use of various analytics tools
- Several SME's already enthusiastically testing the technology
- Potential to leverage off up to 25 ODC's being implemented around the world.

Thank You