



Data Requirements Definition and Data Services Options for RAPP

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- The observation and measurement requirements for RAPP are very similar to GEOGLAM.
- We have developed a set of tables (following charts) to capture the details.

Consider these questions ...

- Are the requirements accurate and do they need updates?
- Are the RAPP test sites getting the data they need?

Requirements Table #1a



Req#	How?		When?	Where?		Rangelands and Pastures (RP)						
	Spatial Resolution	Spectral Range	Effective Observ. frequency (cloud free)*	Sample Type	Field Size	Mask	Calendar	Vegetation Cover	Variables (NDVI/LAI)	Quantity and Growth Rates	Quality and Digestibility	Environ. Variables (e.g. Soil moisture)
Coarse Resolution Sampling (>100m)												
1	>500-2000m	optical	Daily	Wall-to-Wall	All		X	X		X		
2	100-500m	optical	2 to 5 per week	Cropland Extent	All	X	X	L		X	X	
3	5-50km	microwave	Daily	Cropland Extent	All							X
Moderate Resolution Sampling (10 to 100m)												
4	10-70m	optical	Monthly (min 2 out of 3 seasons in season). Required every 1-3 years.	Cropland Extent	All	X	X					
5	10-70m	optical	~Weekly (8 days; min. 1 per 6 days)	Sample	All	X	X	X	X	X	X	X
6	10-100m	SAR Dual Polarization	~Weekly (8 days; min. 1 per 6 days)	Cropland Extent or Sample	All	X	X	X	X	X	X	X
6+	10-100m	Hyperspectral	Seasonal (3-4 per year)	Sample	All	X		X		X	X	

Requirements Table #1b



Req#	How?		When?	Where?		Rangelands and Pastures (RP)						
	Spatial Resolution	Spectral Range	Effective Observ. frequency (cloud free)*	Sample Type	Field Size	Mask	Calendar	Vegetation Cover	Variables (NDVI/LAI)	Quantity and Growth Rates	Quality and Digestibility	Environ. Variables (e.g. soil moisture)
Fine Resolution Sampling (5 to 10m)												
7	5-10m	VIS, NIR, SWIR	Monthly (min. 3 in season)	Cropland Extent	M/S							
8	5-10m	VIS, NIR, SWIR	~Weekly (8 days; min. 1 per 16 days)	Sample	All	M/S	X	X	X	X	X	X
9	5-10m	SAR Dual Polarization	Monthly	Cropland Extent or Sample	M/S	M/S		X		X		
Very Fine Resolution Sampling (<5m)												
10	<5m	VIS, NIR	3 per year (2 in season; 1 out of season); Required every 3 years	Cropland Extent	S	S		S		S	X	
11	<5m	VIS, NIR	1 to 2 per month	Refined Sample	All			S		S		

Measurements Table #2a



Req#	How?			Where?	When?		
	Core Missions (future)	Contributing Missions (future)	Spatial Resolution	Spectral Range	Sample Type	Effective Observ. frequency (cloud-free)*	Growing Season Calendar
Coarse Resolution Sampling (>100m)							
1	MODIS (1000m)	Suomi-NPP (750m) Proba-V (1000m)	>500-2000m	optical	Wall-to-Wall	Daily	all year
2	MODIS (250/500m) Sentinel-3A (500m)	Suomi-NPP (375m) Proba-V (100/333m)	100-500m	optical	Cropland Extent	2 to 5 per week	all year
3	Aqua GCOM-W1/W2	SMOS SMAP	5-50km	microwave	Cropland Extent	Daily	all year
Moderate Resolution Sampling (10 to 100m)							
4	Landsat 7/8 (30m) Sentinel-2A/2B (10-20m)	ResourceSat-2 (56m) CBERS-4 (20-40m)	10-70m	optical	Cropland Extent	Monthly (min. 2 out of season, 3 in season). Required every 1-3 years.	all year
5	Landsat 7/8 (30m) Sentinel-2A/2B (10-20m)	ResourceSat-2 (56m) CBERS-4 (20-40m)	10-70m	optical	Sample	~Weekly (8 days; min. 1 per 16 days)	growing season
6	Sentinel-1A/1B (C) Radarsat-2 (C), RCM (C) ALOS-2 (L)	RISAT-1/1A (C) RISAT-3 (L)	10-100m	SAR Dual Polarization	Cropland Extent or Sample	~Weekly (8 days; min. 1 per 16 days)	growing season



Req#	How?				Where?	When?	
	Core Missions (future)	Contributing Missions (future)	Spatial Resolution	Spectral Range	Sample Type	Effective observ. frequency (cloud free)*	Growing Season Calendar
Fine Resolution Sampling (5 to 10m)							
7	RapidEye	SPOT-6, SPOT-7 CBERS-4	5-10m	VIS, NIR, SWIR	Cropland Extent	Monthly (min. 3 in season)	growing season
8	RapidEye	SPOT-6, SPOT-7 CBERS-4	5-10m	VIS, NIR, SWIR	Sample	~Weekly (8 days; min. 1 per 16 days)	growing season
9	Sentinel-1A/1B (C) Radarsat-2 (C), RCM (C) ALOS-2 (L)	RISAT-1/1A (C) RISAT-3 (L)	5-10m	SAR Dual Polarization	Cropland Extent or Sample	Monthly	growing season
Very Fine Resolution Sampling (<5m)							
10		Pleiades, SPOT-6, SPOT-7	<5m	VIS, NIR	Cropland Extent	3 per year (2 in season + 1 out of season); Required every 3 years	all year
11		Pleiades, SPOT-6, SPOT-7	<5m	VIS, NIR	Refined Sample	1 to 2 per month	growing season



- It is assumed that most of the RAPP data supply will NOT require support from CEOS, as the data is free/open and easily obtained and understood. We believe the primary datasets are Landsat, Sentinel 1-2, and MODIS.
- It is assumed the local RAPP test sites will host and manage their own data. Are there plans for a larger regional or global service that would depend on much larger data storage and processing? Is there an interest in cloud-based storage and processing?
- Are any RAPP groups using Radarsat or ALOS radar data?
- Are any RAPP groups using high resolution RapidEye, SPOT or Pleiades data?
- Is there any desire for ResourceSat-2 and CBERS-4 data?

Now lets talk about Data Cubes and how they might help ...



A solution supporting CEOS objectives ...

- Build capability of users to apply CEOS satellite data
- Supporting priority CEOS/GEO agendas (SDGs, Paris and Sendai)

CEOS Agencies wanting to participate ...

- Through provision of CEOS Analysis Ready Data (ARD) products
- Contributing to development and uptake of solutions

Customers feel that they are the focus ...

- Training materials and easy installation/maintenance
- A CEOS “Open Data Cube” brand that people know and trust
- Users helping each other through an active Data Cube community

Scalable solution ...

- Supporting Data Cubes in **20 countries by 2022**
- Key partners (e.g. GEO, World Bank) supporting data cube projects





3 operational, 2 under development, 17 under review – **April 2017**



Data Cubes

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

User Interface Features

- User-selected spatial region and time
- **7 applications**: custom cloud-free mosaics, **fractional cover**, **NDVI anomaly**, water detection, water quality (Total Suspended Matter), landslides (SLIP) and coastal change.
- Outputs in GeoTIFF and GIF animation.
- Free and open!

<http://tinyurl.com/datacubeui>

Open Data Cube

Filters History Results **Output**

Output

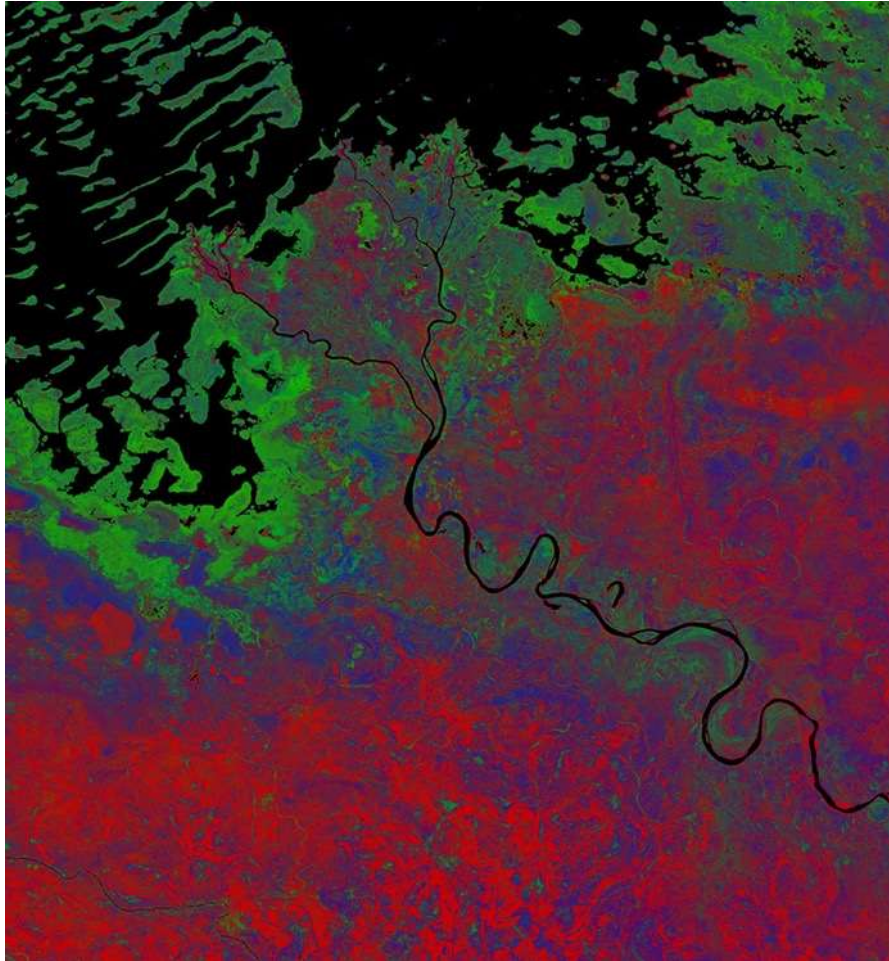
True color mosaic : Submitted 03/12/2017 10:13

SWIR1, NIR, RED mosaic : Submitted 03/12/2017 10:18

Time Submitted:	03/12/2017 10:18
Time Finished:	03/12/2017 10:18
Scene Count:	21
Total Pixel Count:	4038012
Clean Pixel Count:	4037970
Clean Pixel Percentage:	100.00%
Latitude Range:	(-0.8506546545, -0.2639683935)

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





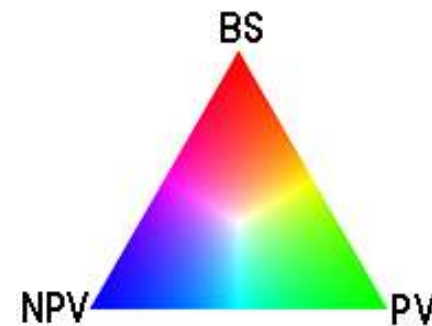
Southern Lake Chad Cameroon, Africa 2015 Fractional Cover

R = Base Soil (BS)

G = Photosynthetic Vegetation (PV)

B = Non-Photosynthetic Vegetation (NPV)

** NPV is dead vegetation, wood, stems, leaves*

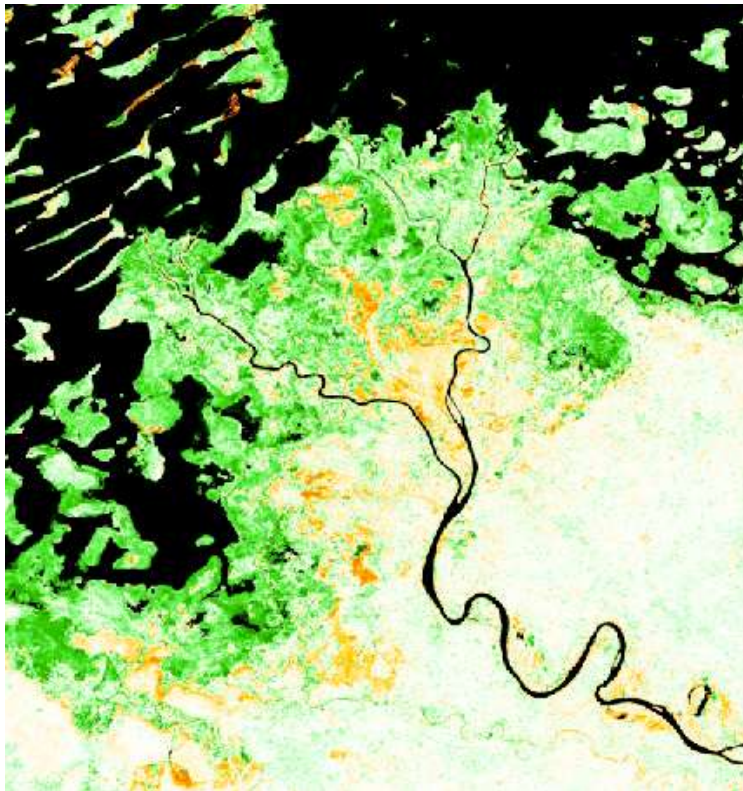


The fractional coverage algorithm (right) estimates the average vegetation fractional cover over the time period using a linear unmixing technique developed by Juan P. Guerschman (CSIRO).



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)

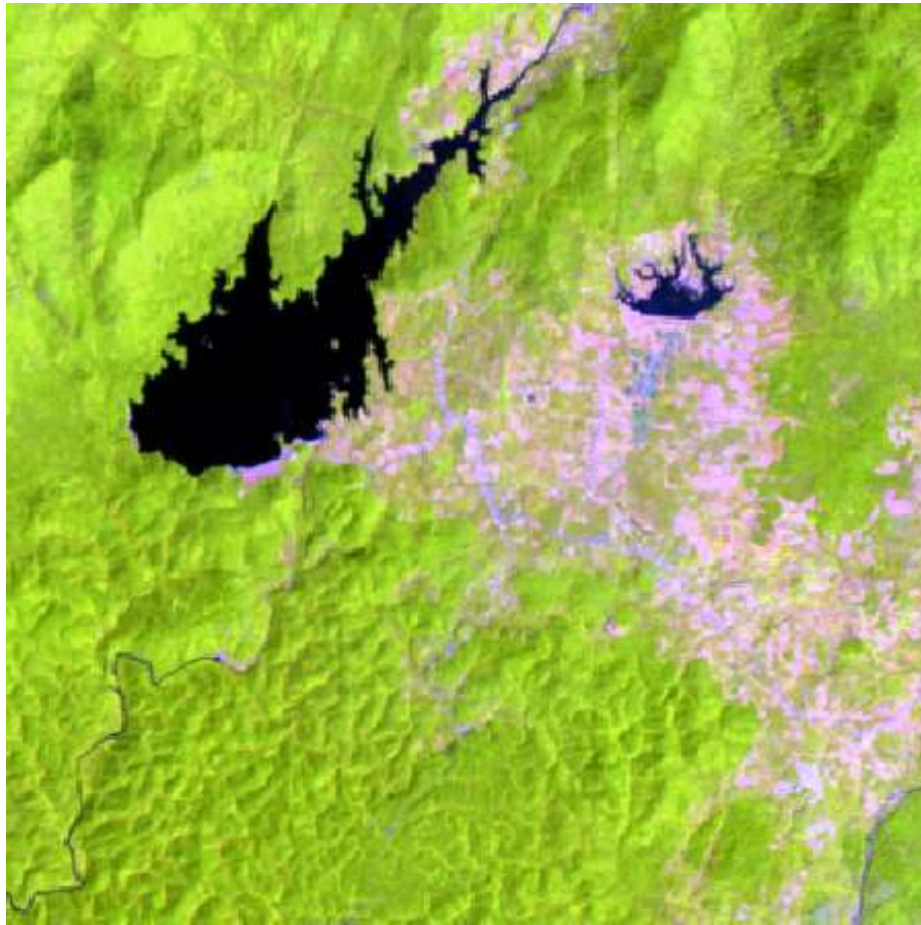


- Consistent with the GEOGLAM Crop Monitor product, but MUCH higher resolution (they use MODIS).
- BLACK regions are masks for either clouds or water
- Most vegetated areas near the Chari River entrance to Lake Chad show an increased NDVI (green) for this scene as compared to the historical median.
-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

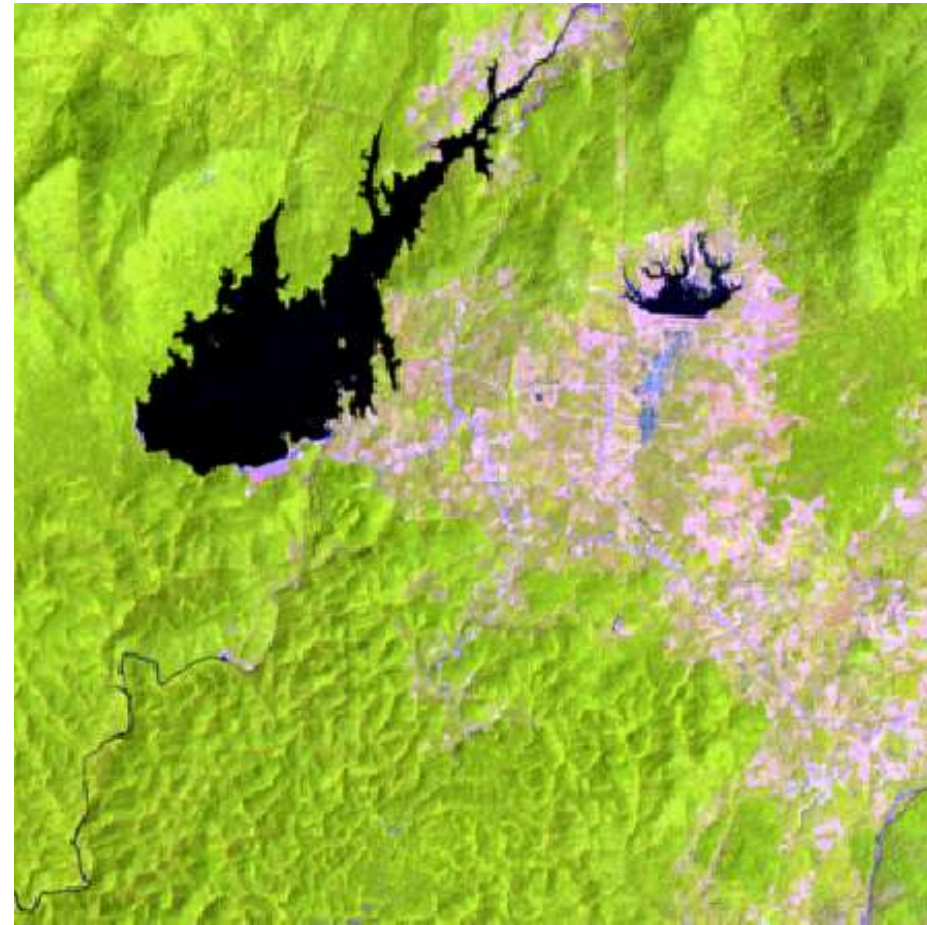




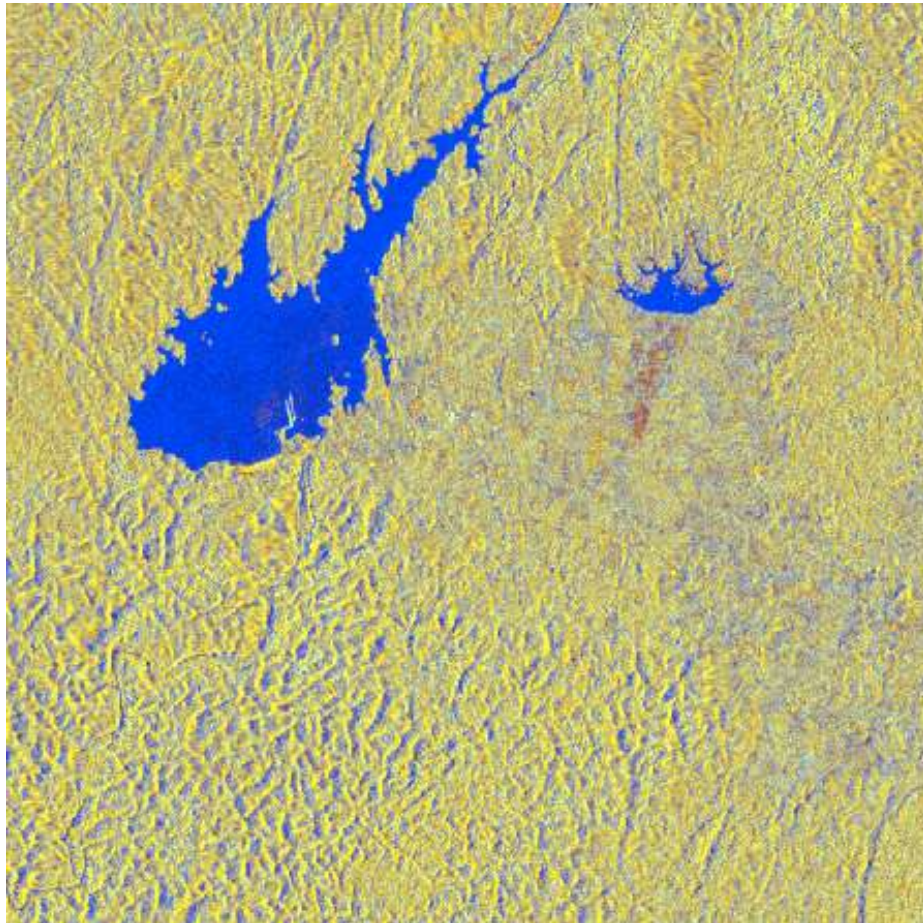
- The SEO is testing data interoperability with multiple datasets: Landsat 7, Landsat 8, Sentinel-1 and ALOS-PALSAR data in a **Vietnam Data Cube**.
- **Sentinel-1** data (10m) = Native EPSG:4326 (WGS 84) projection.
Landsat 7/8 data (30m) = Resampled from UTM to EPSG:4326.
ALOS-PALSAR data (25m) = Resampled from 25m to 30m resolution and reprojected from Lat-Lon (GRS 80) to EPSG:4326 (WGS 84) projection.
- The first goal was to evaluate the spatial alignment of the 3 datasets within a nested grid data cube. Each Landsat and ALOS pixel should align. There will be nine (9) Sentinel-1 pixels within each Landsat/ALOS pixel.
- The second goal is to conduct application analysis where we use all of the datasets. One example is a water detection analysis case where we compare Landsat (WOFS algorithm) to S1 and ALOS band thresholds.



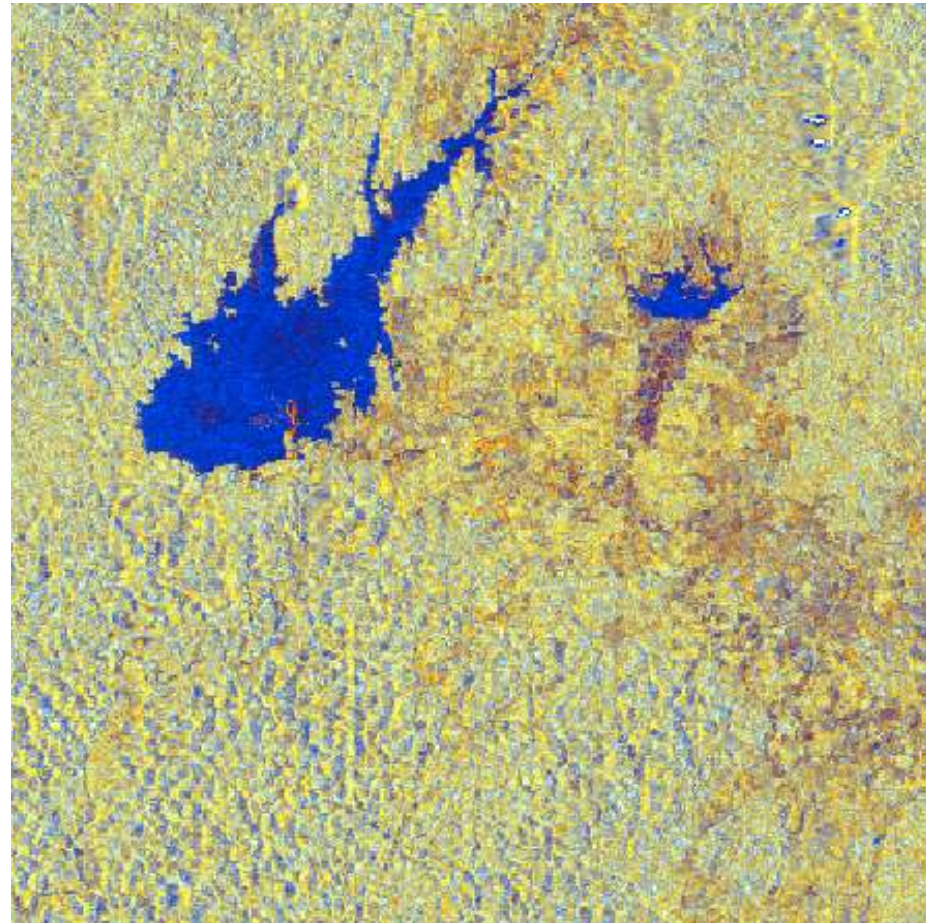
Landsat 7 Median Mosaic – Year 2015
RGB: Bands 5,4,3



Landsat 8 Median Mosaic – Year 2015
RGB: Bands 6,5,4



Sentinel-1 Median Mosaic - Year 2015
RGB: VV, VH, VV/VH



ALOS-PALSAR Median Mosaic - 2015
RGB: HH, HV, HH/HV



- How might we utilize and test the **Open Data Cube** infrastructure to support RAPP?
- Is there a desire to use the **Fractional Cover** algorithm at Landsat scale? If so, the Data Cube would help?
- What other RAPP analysis products, besides Fractional Cover, are needed from satellite data?
- Are there any possible RAPP test cases where there is a desire to test multiple datasets (e.g. optical and radar) in a spatially aligned data cube?
- The SEO team is planning to develop a Data Cube plugin for QGIS that would allow connection from a local computer (running QGIS) to a data cube hosted remotely (e.g. Amazon Cloud). Is this of interest to RAPP?



- The CEOS Open Data Cube team will be offering a free training/tutorial course at the 2017 IGARSS Conference on **Sunday, July 23 from 8:30am to 12:30pm.**
- This course is meant to give attendees an in-depth understanding of how to build data cubes and run application analyses.
- We welcome participation from new and current data cube users.

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Fort Worth, Texas, USA

