GFOI

Global Forest Observations Initiative

Baseline Global Acquisition Strategy For Satellite Data

2014 Implementation Report

for the

Global Forest Observations Initiative

Version 1.0
July 2015

CEOS

Committee on Earth Observation Satellites

GEO

1 Background and Scope

This document constitutes the CEOS SDCG 2014 Annual Implementation Report defined in the *SDCG Three-Year Work Plan 2015-2017* Baseline Global Data Acquisitions Outcome 1 describing the progress toward achieving the goals set forth in the *Global Baseline Acquisition Strategy for Global Forest Observations Initiative 2014 Update* (CEOS, 2014) which was endorsed by the CEOS Strategic Implementation Team (SIT) at the SIT-29 meeting in March, 2013.

The primary purpose of the CEOS Global Baseline Data Acquisition Strategy for GFOI is to ensure systematic and sustained wall-to-wall acquisitions of forested areas world-wide, involving a number of so called *Core data streams*, i.e. CEOS satellite missions that can be used free-of-charge and openly for GFOI purposes (see main document, section 3.2), in order to ensure that national governments have routine access to sufficient satellite data for national forest monitoring purposes and for reporting of greenhouse gas emissions and forest carbon stocks to UNFCCC under the REDD+ provisions..

The scope of the Global Baseline Data Acquisition Strategy is limited to acquisition planning and coordination of acquisition component only, while issues relating to the physical provision of the satellite data acquired are dealt with under Element 2 of the CEOS Data Strategy, the *SDCG Space Data Services Strategy* (CEOS SDCG, 2014b).

As outlined in section 3.3 of the main document, the Global Baseline Data Acquisition Strategy is being implemented in a phased approach to reflect the schedule of gradually increasing availability of the anticipated *Core data streams* between now and 2016. In 2014, 36 countries were added to the 15 countries were defined by GFOI as first priority in case of resource limitations by the *Core data streams,* which in 2014 were limited to USGS/NASA Landsat-7 and Landsat-8 and ESA Sentinel-1.

2 Space Data Availability

2.1 Core Data Streams in 2014

The Landsat-7 and -8 and Sentinel-1A were the only *Core data streams* in operations in 2014, with Sentinel-1 data available for operational use from 3 October 2014. The two Landsat satellites were found to provide adequate frequency of optical coverage for GFOI requirements in 2014 for all regions of the world other than those most affected by persistent cloud cover. Sentinel-1 imagery was available for evaluation as the mission continued its transition to an operational scheduling paradigm into 2015.

Landsat

Acquisitions by the Landsat-7 and Landsat-8 missions are guided by a Long Term Acquisition Plans (LTAP). The plans are used to set priorities for the acquisition of Landsat images as a function of seasonality; land definition; time since last successful acquisition, forecasted cloud cover; cloud climatology; and sun angle. Each day the opportunities are ranked by their priorities and images are acquired up to the daily limit. Physical constraints, such as duty cycle, manoeuvres, on-board memory and downlink opportunities, may limit acquisition opportunities.

Landsat-7 and -8 are managed as a constellation. As of November 2013, Landsat-7 is managed as a continental mission. Open ocean, islands and Antarctica are no longer routinely imaged with Landsat-7. The focus of Landsat-7 on continental land masses increased the average number of daily images from 375 to 438 (90.5% of 479 opportunities), while at the same time reducing the number of times the sensor needs to be power cycled. Between June and August 2013, the average increased from 392 to 470 images per day (85.5% of 550 opportunities). Between December 2013 and February 2014, the average increased from 354 to 357 images per day (99% of 358 opportunities). The 22% missing data in the Landsat-7 images results in a no-data rate similar to 22% cloud cover. However, cloud-free Landsat-7 data is preferred to 22% cloud cover, since cloud contamination and cloud shadow will have effects beyond the areas identified as clouds.

Landsat-8 started 2014 with a 550 images per day daily limit. On 20 May 2014 the daily limit was slowly increased until it reached 725 images/day daily limit on 28 July 2014. The daily limit of 725 has been approved as the new operational limit. On 5 December a new seasonality file was released to tune the LTAP for this limit. For mid-latitude (57 degrees North and South) scenes (rows 21 through 104) all scenes not pre-empted by manoeuvers or calibration should be collected. High latitude scenes North and South of these rows have more than 50% overlap between paths providing an 8-day revisit time, so the priority is decreased as a function of overlap. Even at high latitudes more than 90% of the day-lit opportunities are acquired.

Together, the Landsat-7 and Landsat-8 missions offer an 8-day minimum revisit time, with each individual satellite revisiting every 16 days. Data are acquired during every opportunity over U.S. territory, and within the Brazilian and Australian ground station masks. Globally, the LTAP aims at achieving at least four seasonal global land coverages each year optimized for cloud cover. Over the continental land masses in 2014 over 40 images (23 with Landsat-8 and 17 with Landsat-7) are acquired each year (Figures 2.1 - 2.4). For oceanic island nations 23 images are acquired each year with Landsat-8.

An 8-day revisit time is not sufficient to create annual cloud-free mosaics in regions with persistent cloud cover (Figure 2.5). The change to the Landsat-7 continental model increased the probability of acquiring cloud-free images and helped compensate for the missing data caused by the scan line corrector failure on Landsat-7. Multiple acquisitions will often be necessary to provide annual complete data coverage to compensate for persistent clouds and Landsat-7 missing data. The estimates for Landsat-7 do not compensate for the 22% data loss due to the Scan Line Corrector failure in 2003. The middle 22 km of the image has no data loss. On the edge of the scene the data loss is approximately 50%.

The combination of Landsat-7 and -8 provided global coverage in 2014. The question for GFOI is whether the number of acquisitions over the priority countries has been sufficient to obtain at least one clear-sky coverage per year, which is the minimum optical data requirement for GFOI.

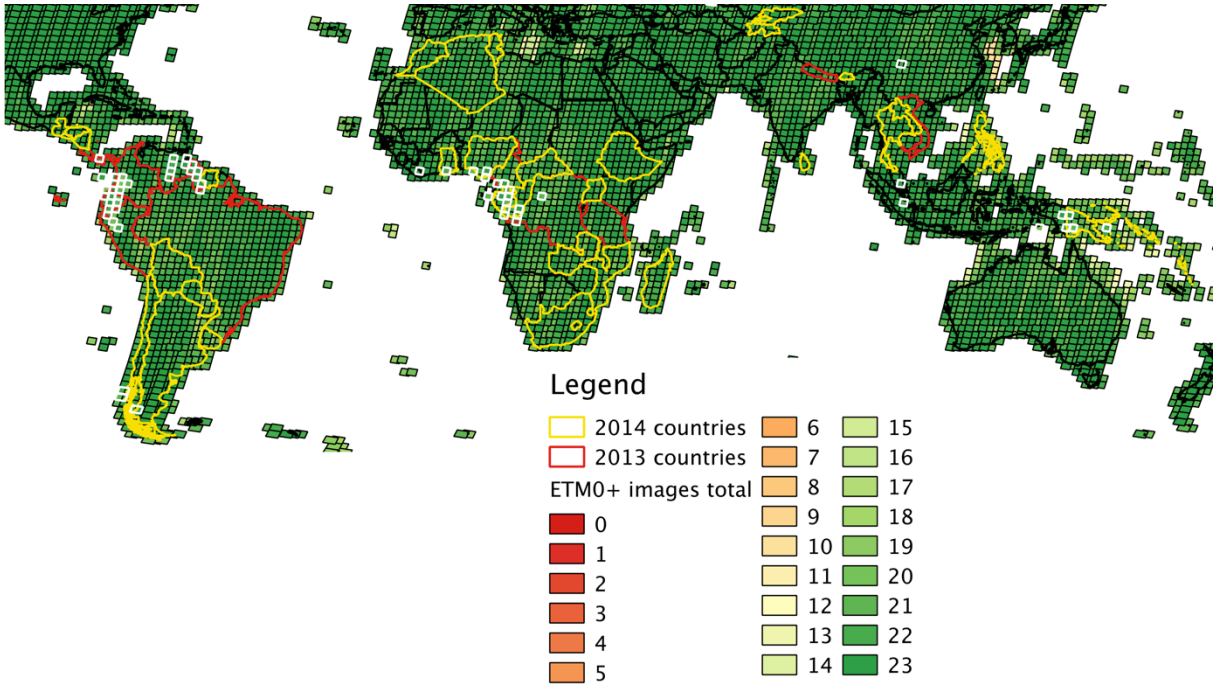

Figure 2.1. Landsat-8 acquired 95% of the day-lit land opportunities over tropical and temperate zone countries in 2014. Scenes with minimum cloud cover greater than 20% are outlined in white.

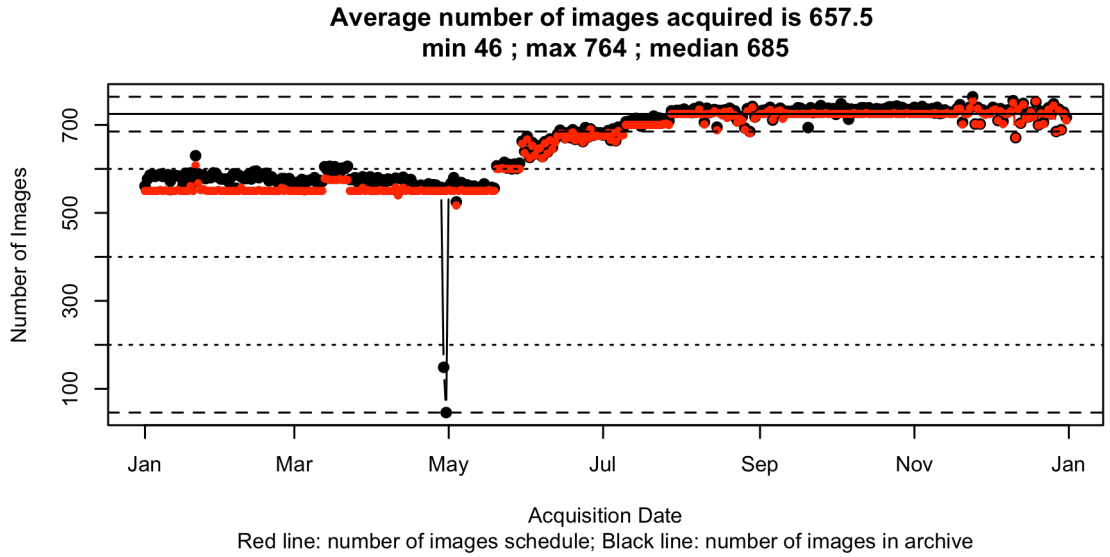

Figure 2.2. Landsat-8 acquired 550 images per day early in 2014 and in July increased the number of images acquired to 725 images per day.

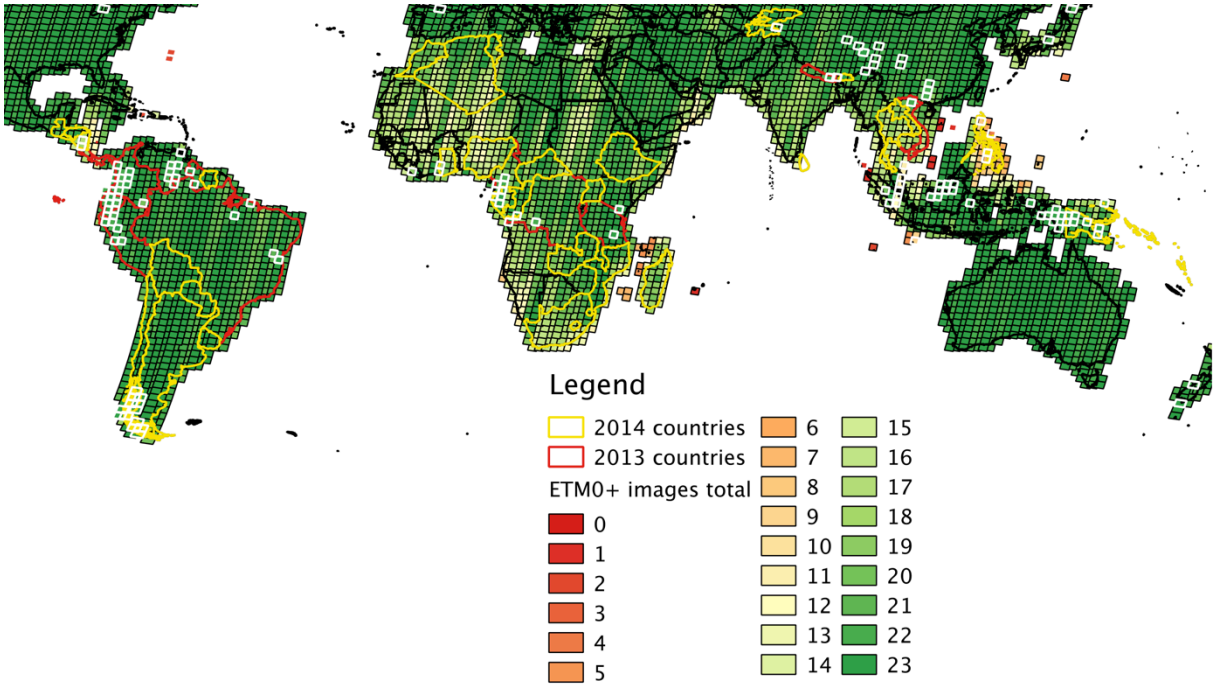

Figure 2.3. Landsat-7 acquired over 90% of the candidate images in 2014. Scenes with minimum cloud cover greater than 20% are outlined in white

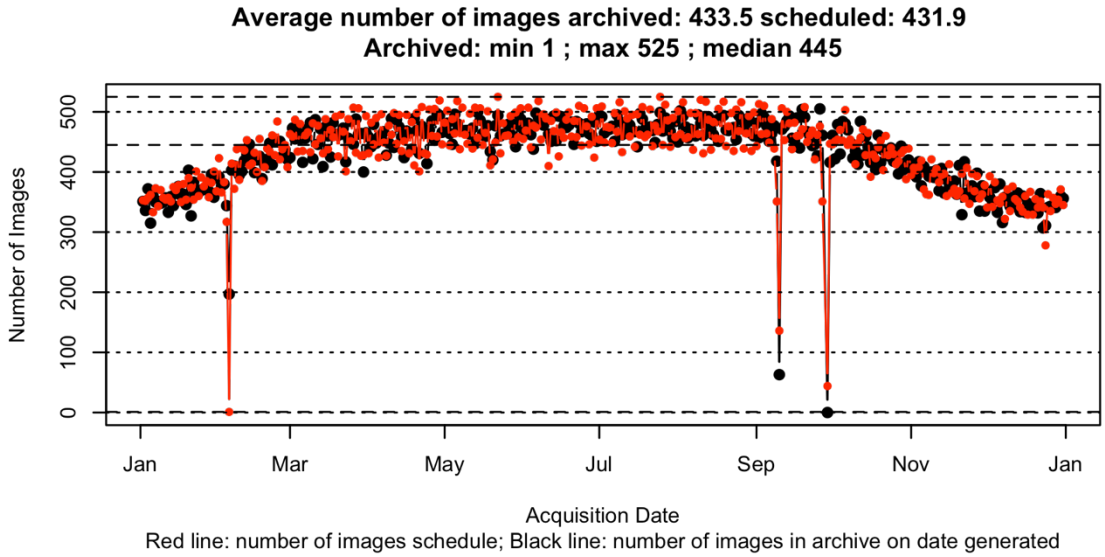

Figure 2.4. Landsat-7 acquires all candidate images in the southern hemisphere summer and 85% of the candidate images in the northern hemisphere summer in 2014

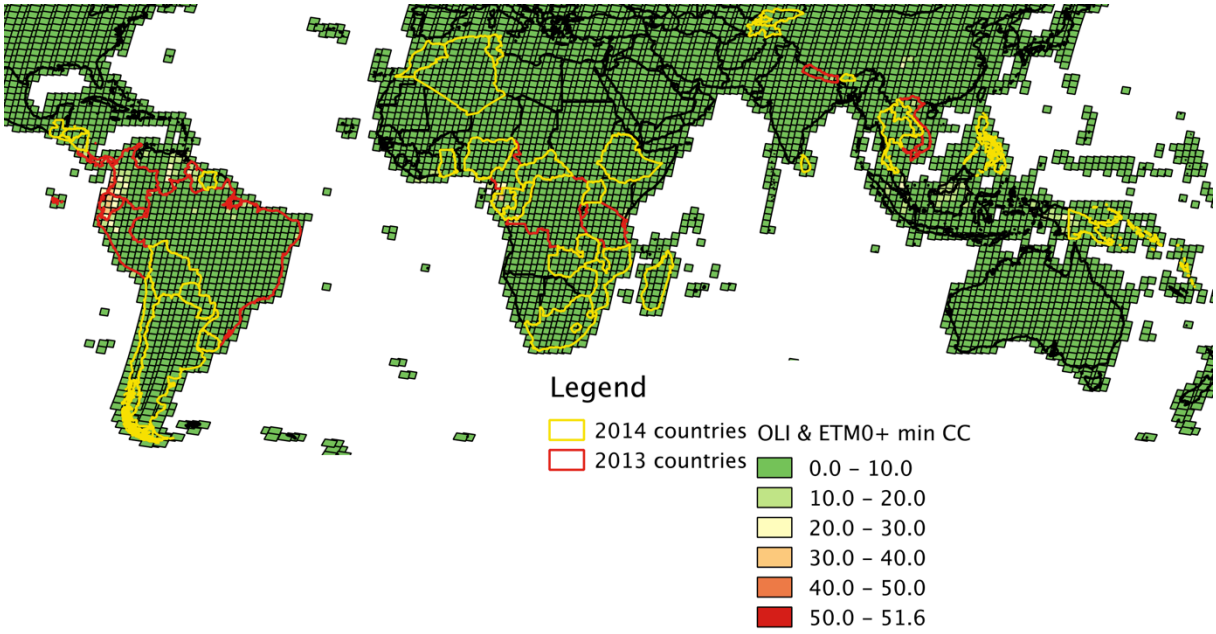

Figure 2.5. Minimum cloud cover for each scene for Landsat-7 and -8 during 2014.

Sentinel-1

The Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, operating day and night performing C-band synthetic aperture radar imaging, enabling them to acquire imagery regardless of the weather. Sentinel-1A was launched on 3 April 2014 and Sentinel-1B will follow in spring 2016. The satellites work in a pre-programmed operation mode to avoid conflicts and to produce a consistent long-term data archive built for applications based on long time series.

Sentinel-1A began its operation ramp-up phase in September 2014 and acquired a significant number of intervals over GFOI priority areas. Interferometric Wide Swath (IW) in dual polarisation is the preferred mode for forestry applications.

Country	Total number of images (VV)	Number of dual-polarization images (VV/VH)	Country	Total number of images (VV)	Number of dual-polarization images (VV/VH)
Colombia	521	21	Cameroon	19	11
Ecuador	236	0	DRC	198	36
Peru	574	5	Cambodia	19	11
Tanzania	452	61	Viet-Nam	253	99
Kenya	269	34	Sumatra	379	150
Uganda	211	30		Status 19 March 2015	

Table 2.1 Sentinel-1 acquisitions in GFOI priority areas

During the ramp-up exploitation phase, the Sentinel-1 observation plan gradually evolved in line with the increasing operational capacity. The high-level observation plan for Sentinel-1A foresees that all global landmasses are regularly covered following a zonal concept in a stable one pass IWS mode, VV-VH polarization (Cycle 34 as example in Figure 2.5). The revisit frequency for all zones increased in line with the gradual mission capacity increase.

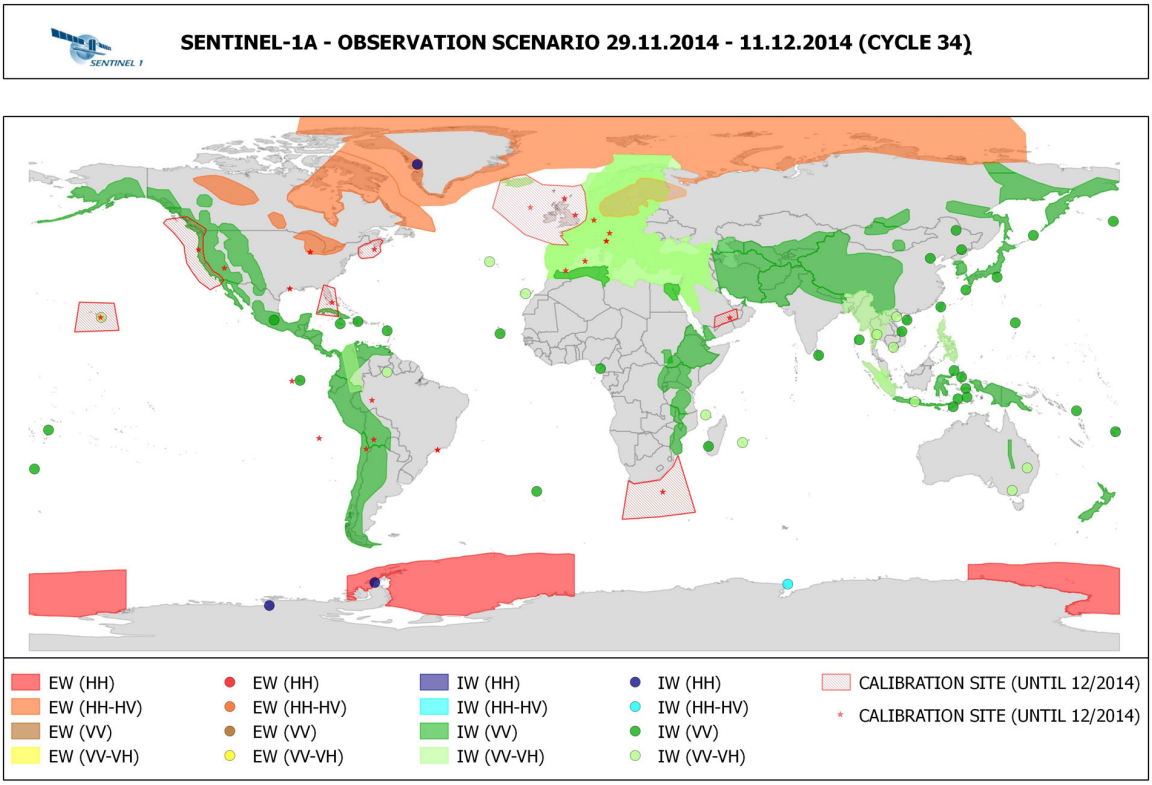

Figure 2.5 Sentinel-1A observation scenario (cycle 34)

The Sentinel-1 Scientific Data Hub at **https://scihub.esa.int/** provides free and open access to a rolling archive of Sentinel-1 Level-0 and Level-1 user products (Figure 2.6). It maintains at least the latest 2 months of products, but until October 2015 no data will be removed from the rolling archive. A long-term archive for public access is planned for the second half of 2015.

The automatic and immediate self-registration is available to anyone. Sentinel-1 products are provided for download via HTTP in the ZIP archive file format where no compression is applied. Click and download, shopping cart, batch download are supported access mechanisms. A maximum of two concurrent downloads per user is allowed in order to ensure a download capacity for all users.

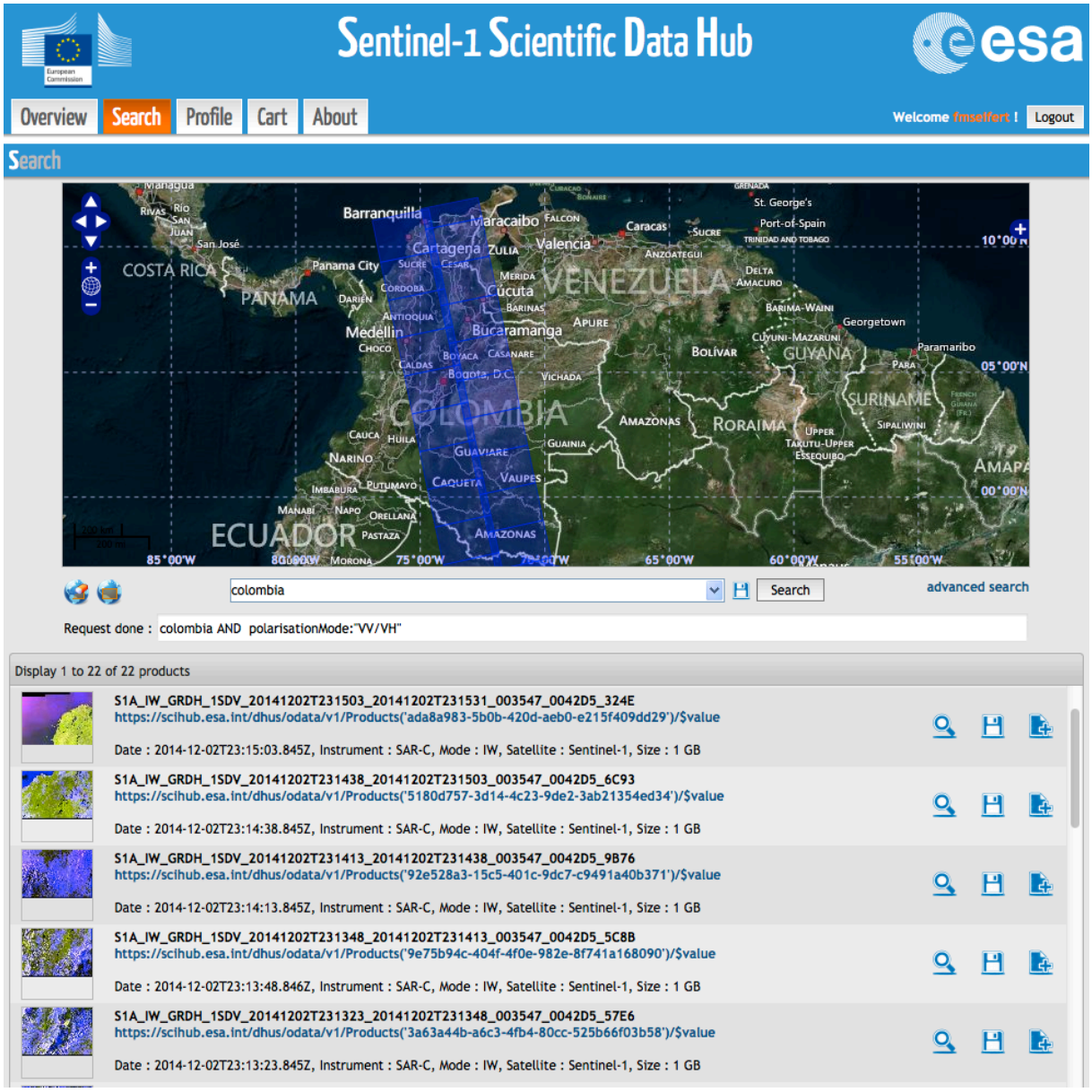

Figure 2.6 Sentinel Scientific Data Hub: dual pol acquisitions over Columbia

Dedicated areas in 11 countries were covered by 4486 Sentinel-1 scenes during the operations ramp-up phase, out of that 587 in dual pol (Table 2.1). The Congo basin is only scarcely covered as it lies on the same orbits as Europe, which is the COPERNICUS priority area. Relatively few dual pol acquisitions have been recorded during ramp-up phase related to the reduced workload of the system. An increase of dual-pol acquisitions is expected when Sentinel-1A is entering its operational phase after its first yearly Routine Operations Review in June 2015.

2.2 Other Core and Contributing Data Streams

The phasing of the strategy applies to coordination of the necessary satellite data acquisitions consistent with national reporting requirements. The strategy is:

- working to ensure continuity of coverage of the Forest Carbon Tracking (FCT) National Demonstrator countries and adds as a priority those countries that are seeking active participation in GFOI and have engaged in related capacity building activities;
- dependent on the launch of the core data streams anticipated between 2013 and 2016 and generally consistent with their acquisition capacities; these are:
    - INPE/CRESDA CBERS-4 (7 December 2014);
    - ESA Sentinel-1B (spring 2016);
    - ESA Sentinel-2A and -2B (23 June 2015, summer 2016);
    - CONAE/ASI SAOCOM-1A and -1B (2015, 2016)

Other CEOS agencies' related missions, such as optical high-resolution missions, (e.g. RapidEye and the SPOT series), and radar missions (e.g. ALOS-2, Radarsat-2, TerraSAR-X and TanDEM-X) can supplement the core missions for persistently cloudy areas in addition to supporting validation and technical studies.

3 National Data Requirements and Availability

The requirements for the baseline global data acquisition strategy can be anticipated to evolve continuously as the policy, methodological and reporting framework evolves. The acquisition plans and data access policies will also evolve as the provider space agency and user national data evolve.

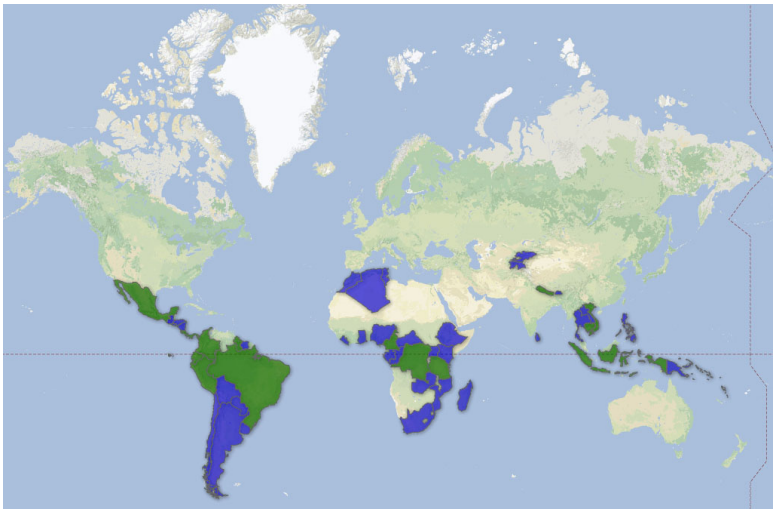

Figure 3.2 – 2013 (Green): 2014 (Blue)

Year	Country	Number of scenes	2013			2014		
			Total number of images	Number of scenes with less then 20% cloud cover	Number of scenes with less then 60% cloud cover	Total number of images	Number of scenes with less then 20% cloud cover	Number of scenes with less then 60% cloud cover
2013	Brazil	392	13128	390	392	16984	391	392
	Cambodia	17	463	17	17	663	17	17
	Cameroon	37	949	35	37	1548	35	37
	Colombia	71	2174	63	71	3074	61	71
	Costa Rica	9	208	8	9	309	9	9
	Democratic Republic of the Congo	119	3564	119	119	5055	118	119
	Ecuador	22	688	17	22	845	12	22
	Guyana	18	554	14	18	799	17	18
	Indonesia	220	6939	209	220	9278	218	220
	Mexico	156	5023	155	156	6789	156	156
	Nepal	19	618	19	19	809	19	19
	Panama	13	329	12	13	519	12	13
	Peru	77	2470	75	77	3315	73	77
	United Republic of Tanzania	49	1689	49	49	2153	49	49
	Viet Nam	41	1122	41	41	1632	41	41
	Total	1260	39918	1223	1260	53772	1228	1260

Table 3.1–CEOS GFOI 2013 countries. Reported are the total number of Landsat images; the number of scenes (Landsat WRS-2 path/rows); the number of scenes where the lowest cloud cover image has less than 20% cloud cover; and the number of scenes where the lowest cloud cover image has less than 60% cloud cover.

Year	Country	Number of scenes	2013			2014		
			Total number of images	Number of scenes with less then 20% cloud cover	Number of scenes with less then 60% cloud cover	Total number of images	Number of scenes with less then 20% cloud cover	Number of scenes with less then 60% cloud cover
2014	Bolivia (Plurinational State)	60	2066	60	60	2620	60	60
	Congo	25	714	22	25	1094	24	25
	Nigeria	46	1105	46	46	1736	46	46
	Papua New Guinea	66	1613	66	59	2400	65	66
	Paraguay	29	1006	29	29	1260	29	29
	Zambia	43	1367	43	43	1815	43	43
	Philippines	52	1335	52	52	1509	52	52
	Solomon Islands	23	330	23	23	459	23	23
	Sri Lanka	10	250	10	10	270	10	10
	Argentina	187	6358	187	187	8107	186	187
	Bhutan	12	403	12	12	543	12	12
	Chile	100	3300	100	100	4279	99	100
	Ghana	19	518	19	19	723	19	19
	Lao People's Democr. Rep.	25	715	25	25	1028	25	25
	Mozambique	53	1707	53	53	2237	53	53
	Thailand	46	1162	46	46	1789	46	46
	Central African Republic	47	1163	47	47	1958	47	47
	El Salvador	4	118	4	4	175	4	4
	Ethiopia	69	2141	69	69	3003	69	69
	Gabon	21	601	16	21	885	19	21
	Guatemala	11	337	11	11	488	11	11
	Honduras	13	359	13	13	531	13	13
	Kenya	33	1085	31	33	1452	33	33
	Liberia	10	240	10	10	405	10	10
	Madagascar	39	1156	39	39	1423	39	39
	Nicaragua	11	312	9	11	431	11	11
	Suriname	11	368	11	11	496	11	11
	Uganda	20	734	20	20	864	20	20
	Vanuatu	11	122	11	11	217	11	11
	Algeria	128	3785	128	128	5160	128	128
	Kyrgyzstan	26	931	26	26	1140	26	26
	Morocco	54	1579	54	54	2185	54	54
	South Africa	89	2597	89	89	3458	89	89
	Tajikistan	21	749	21	21	917	21	21
	Tunisia	23	726	23	23	966	23	23
	Uruguay	17	628	17	17	729	17	17
	Total	1454	43680	1442	1447	58752	1448	1454

Table 3.2– CEOS GFOI 2014 countries. Reported are the total number of images; the number of scenes (Landsat WRS-2 path/rows); the number of scenes where the lowest cloud cover image has less than 20% cloud cover; and the number of scenes where the lowest cloud cover image has less than 60% cloud cover.

4 Conclusions

Landsat-7 and -8 acquired operational data for all of 2014. Landsat-8 revisited each location 18 times and Landsat-7 revisited each location 23 times. Sentinel-1A acquired within an operational ramp-up acquisition strategy during 2014. About 4500 scenes were acquired over dedicated GFOI areas to support the R&D necessary to advance investigations in the use of Sentinel-1 for forest monitoring and the investigate inoperability methodologies for working with inventory systems using both optical and radar data.

Ninety per cent of the Landsat images in a best available image mosaic of the 2013 and 2014 GFOI countries have less than 10% cloud cover. Thirty-two out of 2216 path/rows have best available images with greater than 20% cloud cover. The worst image has 43% cloud cover. Most scenes should be able to be completely sampled with two images, although for the worst cases more images will be needed. Except in a very few path/rows more than 20 images are available from which to sample. In the worst case, Colombia has two path/rows with only 10 or 11 images available. Over 20% of the path/rows in Guyana and Ecuador have cloud cover worse than 20%. Seasonal mosaics would be difficult to produce in most countries.

As a global mission with a long-term acquisition plan, the continued expansion of GFOI toward a global mandate can be met within the current Landsat LTAPs. Improvements in the LTAP suggested through the GFOI country analysis contributed to the improved global long-term acquisition plan for Landsat. About 112,524 scenes were acquired in 2014 over the 51 countries involved in GFOI. Of the 2714 scenes, 2676 scenes had images with cloud cover assessments of 20% or better. Conversely the best cloud cover assessment for 38 scenes was greater than 20% cloud cover. For these scenes radar data could be investigated as an alternative. For regions, such as the persistently northwest portion of South America, non-core optical data would provide additional opportunities for cloud free data.

5 References

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