GFOI

Global Forest Observations Initiative

Baseline Global Acquisition Strategy For Satellite Data

2015 Implementation Report

for the

Global Forest Observations Initiative

Version 1.0
March 2016

CEOS

GEO

Committee on Earth Observations (CEOS)

Ad-hoc Space Data Coordination Group (SDCG)

Global Baseline Data Acquisition Strategy for the Global Forest Observations Initiative (GFOI)

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Version 1.0

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1 Background and Scope

This document constitutes the CEOS SDCG 2015 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).

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. 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 2014 and 2016. In 2015, 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 2015 comprises USGS/NASA Landsat-7 and Landsat-8 and the European COPERNICUS satellite Sentinel-1A and -2A. Sentinel-2A, launched on 23 June 2015, ended its commissioning phase in October 2015. The satellite is currently in its ramp-up phase until mid 2016, and already contributing to GFOI core data streams.

2 Space Data Availability

2.1 Core Data Streams in 2015

The Landsat-7 and -8 and Sentinel-1A were the only *Core data streams* in full operations in 2015, with Sentinel-1 in full operational use from June 2015. 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 for GFOI concentrated on frequent observations in heavily clouded areas and started global coverage 2 – 4 times a year. Sentinel-2 was launched on 23 June 2015, ended its commissioning phase in October 2016 and is currently in its ramp-up phase providing routinely data since 3 December 2015.

2015 Landsat Data availability

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 439 (91.6% of 479 opportunities), while at the same time reducing the number of times the sensor needs to be power cycled. 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.

For mid-latitude (57 degrees North and South) scenes (rows 21 through 104) all Landsat 8 scenes not pre-empted by manoeuvres 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.

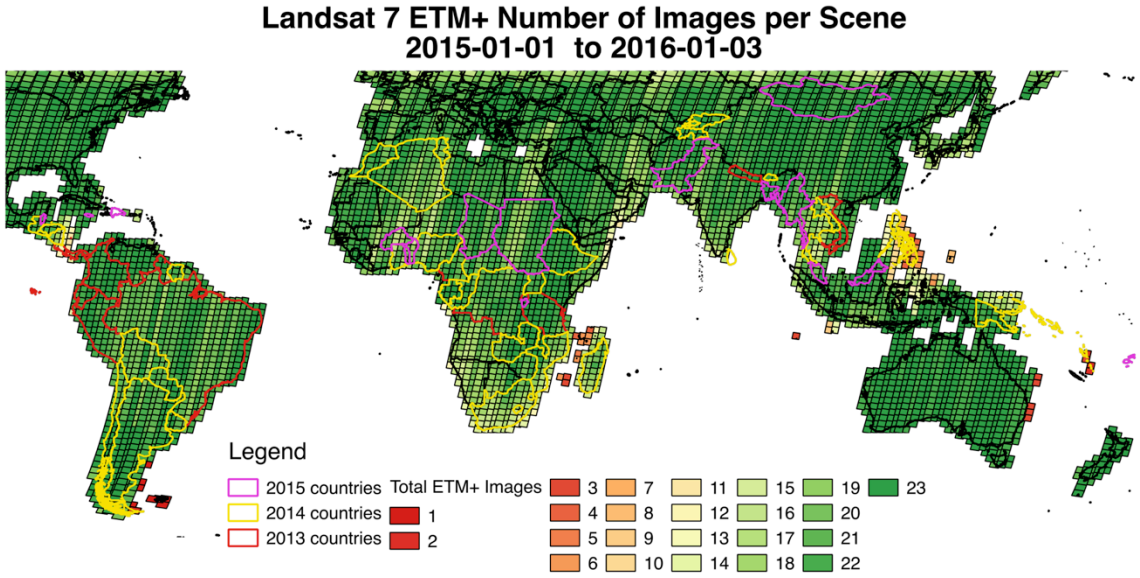

Figure 2.1. Landsat 7 acquired 91.6% of the day-lit land opportunities over tropical and temperate zone countries in 2015.

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. Over the continental land masses in 2015 over 40 images (23 with Landsat 8 and 21 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.

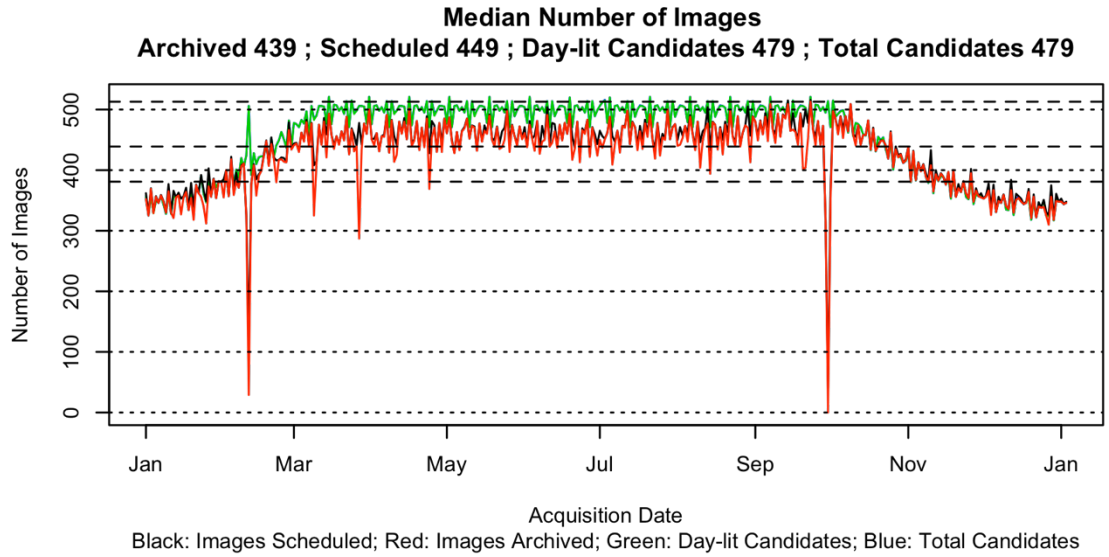

Figure 2.2. Landsat 7 acquired 439 images per day in 2015.

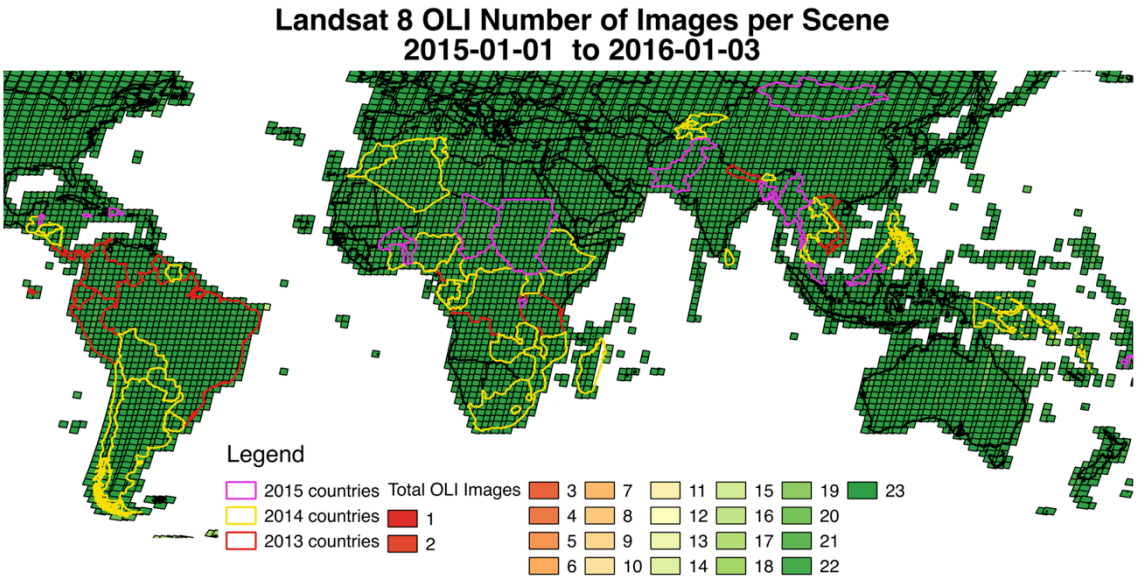

Figure 2.3. Landsat 8 acquired over 96.5% of all candidate images in 2015

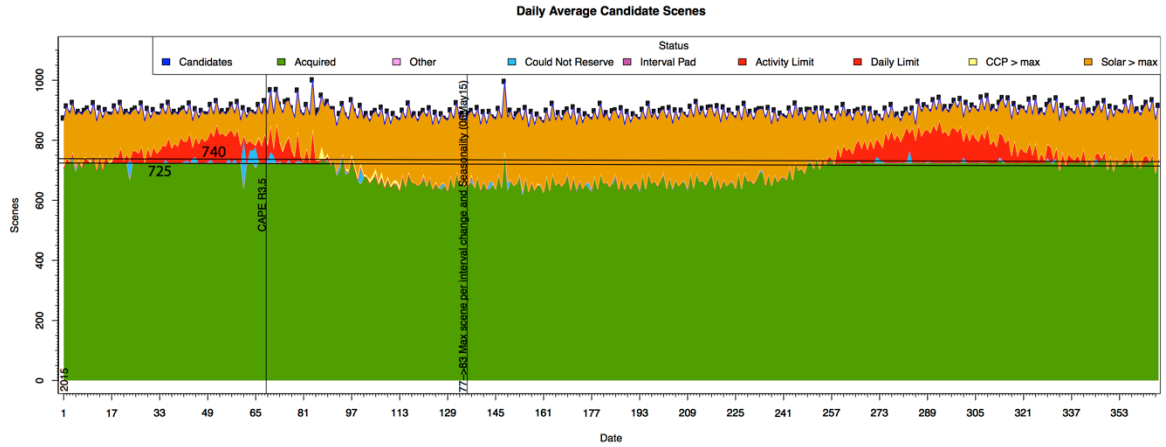

Figure 2.4. Landsat 8 acquired 702 images/day in 2015. Most rejected scenes are over water and Antarctica.

An 8-day revisit time is not sufficient to create annual cloud-free mosaics in regions with persistent cloud cover (Figure 2.5 & Table 2.1). 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. In the GFOI countries the best cloud cover for 26 scenes was over 20 per cent.

Percent cloud cover	<=10	>10 & <=20	>20 & <=30	>30 & <=40	>40 & <=50	>50
Number of Scenes	4375	121	22	4	0	0

Table 2.1. Distribution of best cloud cover for 2015 for GFOI countries.

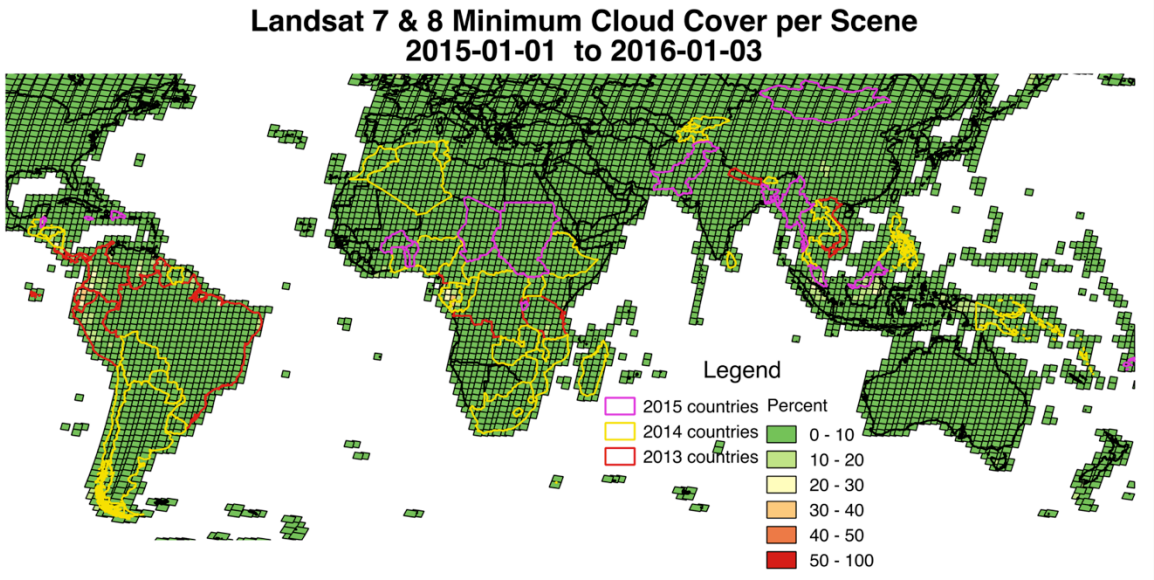

Figure 2.5. Minimum cloud cover for each scene for Landsat 7 & 8 during 2015.

The combination of Landsat-7 and -8 provided global coverage in 2015. 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.

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 on 22 April 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 until it reached full operational status in June 2015. It acquired a significant number of intervals over GFOI priority areas such as tropical regions with high cloud coverage and areas with a high risk of illegal logging (Figure 2.6). Interferometric Wide Swath (IW) in dual polarisation is the preferred mode for forestry applications.

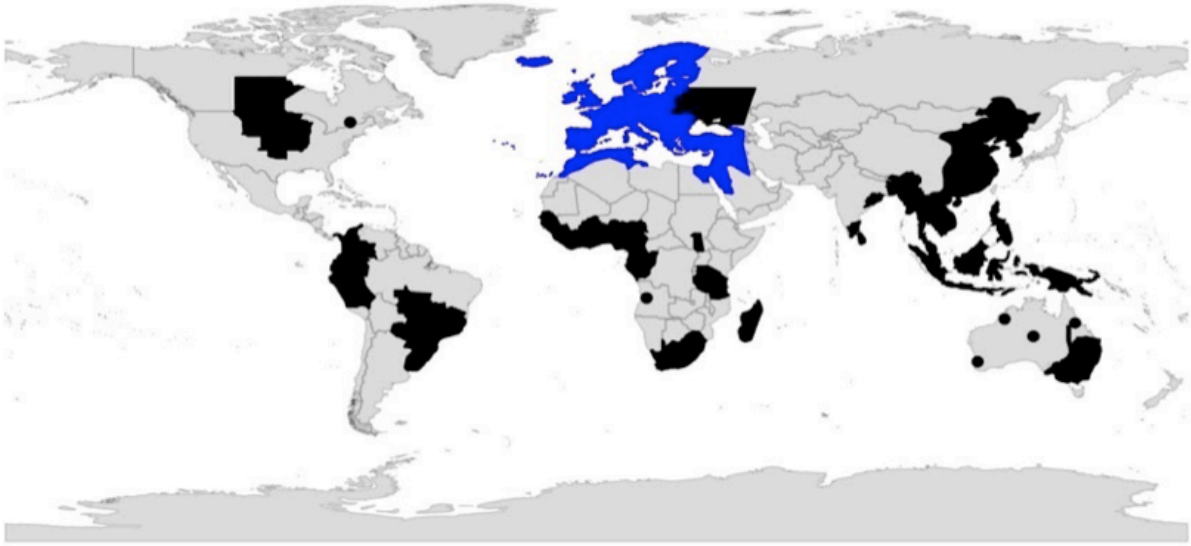

Figure 2.6 Sentinel-1 priority area for forestry and agriculture: Acquisitions over Europe (blue) as prime Copernicus service area are in IW mode, in dual polarisation (VV+VH), every 12 days ascending and descending. Acquisitions over the black areas are in IW mode in dual polarisation (VV+VH) every 12 days in one pass. Repeat passes over SE Asia are every 24 days whereas the Andes and Tanzania are covered with lower frequency.

Table 2.2 shows Sentinel-1 acquisitions over the three major tropical forested areas in 2015.

	Overall IW Acquisitions	VV / HV Acquisitions
Tropical Latin America	19,500	5,320
Tropical Africa	16,000	8,580
South East Asia	15,500	6,820

Table 2.2. Sentinel-1 acquisitions in forested tropical zones in 2015.

In two GFOI key areas Sumatra (1002 VV/VH out of 1836 acquisitions) and in Colombia (339 VV/VH acquisitions out of 3323) dedicated campaigns were conducted. The low percentage in Colombia is related to the very frequent single pol acquisitions for the tectonic user community in that area.

An observation scenario for one cycle (cycle 66) is shown in figure 2.7, whereas 2.8 shows the actual acquisitions during that cycle.

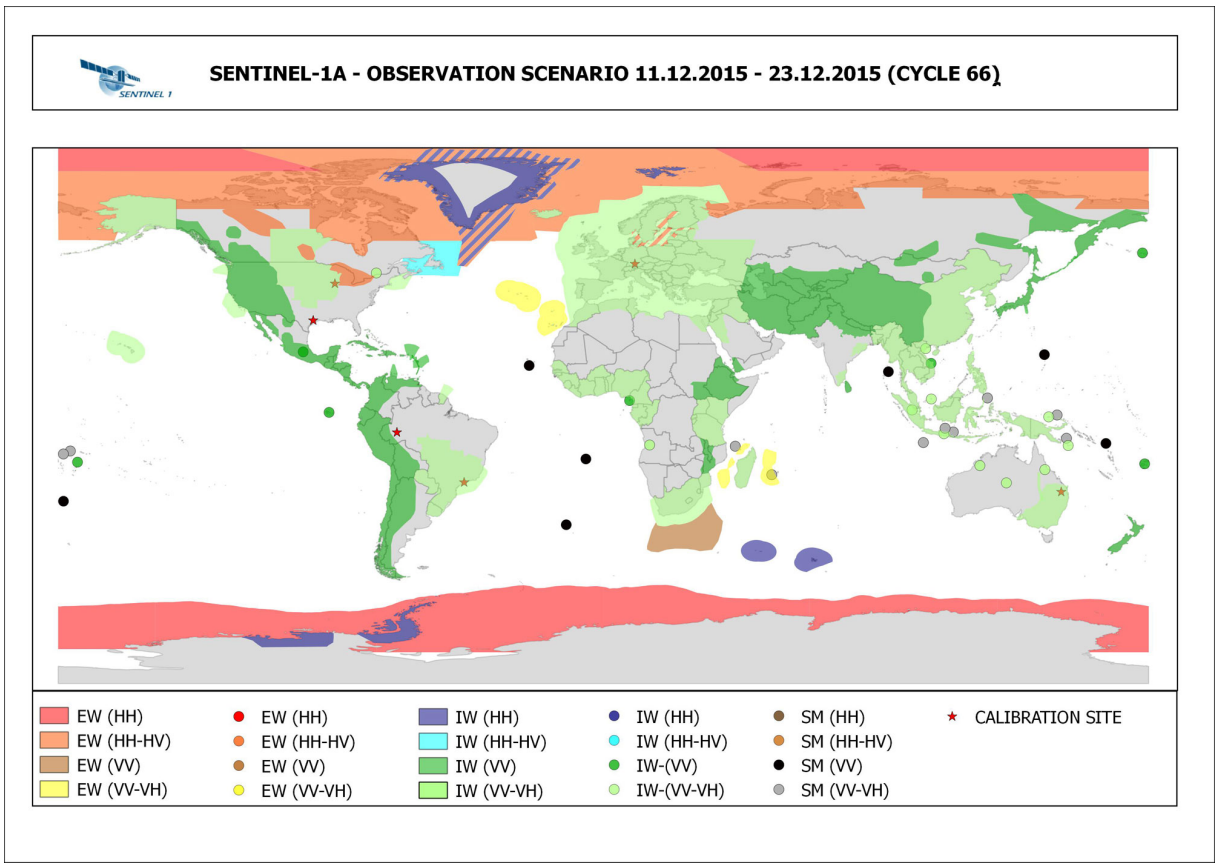

Figure 2.7 Sentinel-1A observation scenario - 10 days (cycle 66)

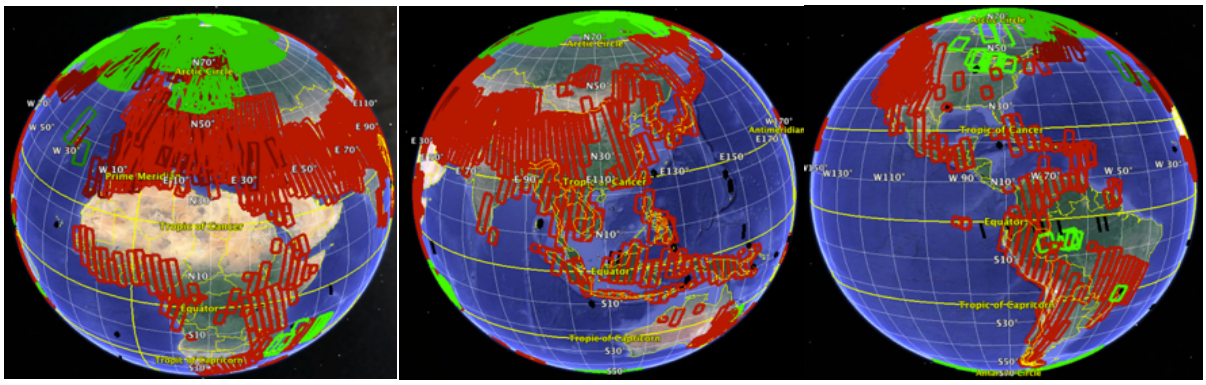

Figure 2.8: Sentinel-1 acquisitions in Africa, SE Asia and Central America during cycle 70 in December 2015

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 2 – 4 times a year following a zonal concept in a stable one pass IWS mode, VV-VH polarization. The revisit frequency for all zones increased in line with the gradual mission capacity increase. Overall more than 400 000 Sentinel-1 data products were available end of December 2015.

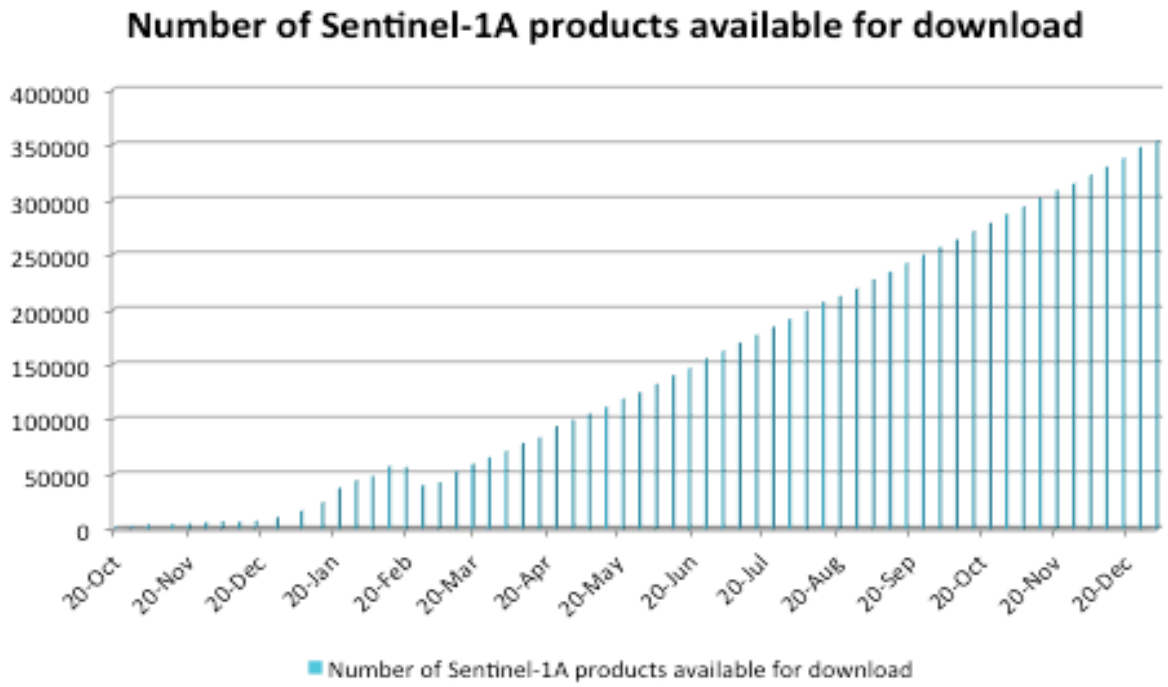

Figure 2.9 Sentinel-1 products available for download end 2015

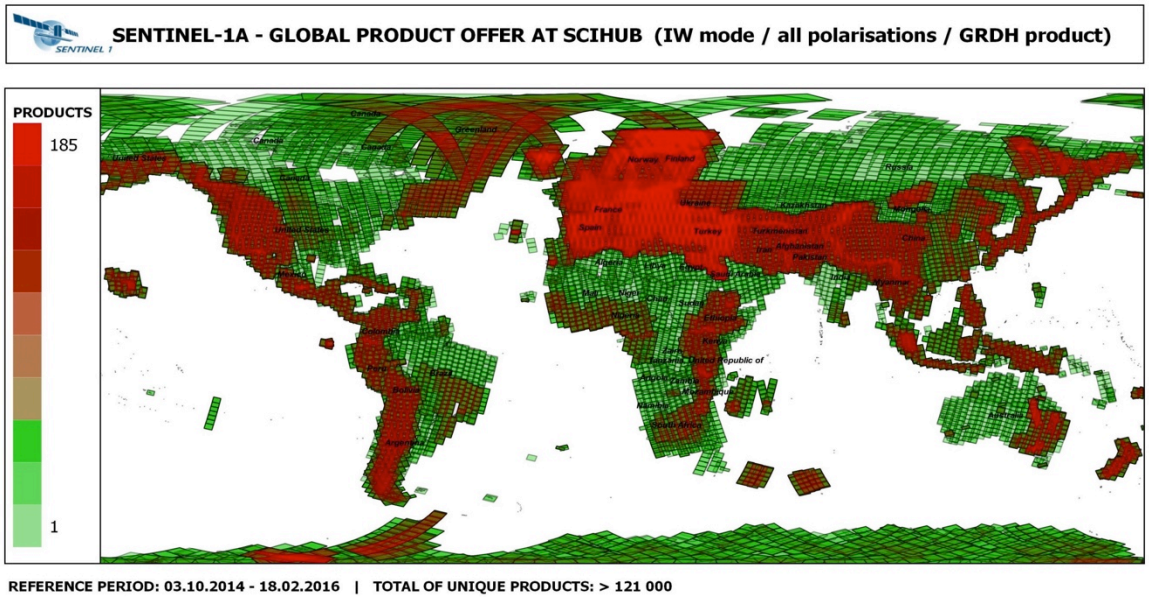

Figure 2.10 Global Product offer at SciHub

Sentinel-2

The Sentinel-2 mission comprises a constellation of two polar-orbiting satellites, operating a multispectral imager with 13 bands. Sentinel-2A was launched on 23 June 2015 and Sentinel-2B will follow end 2016. The commissioning phase of Sentinel-2A ended successfully in October 2016 and currently the mission is in its ramp-up phase: Europe and Africa are covered systematically every 10 days (each cycle), whereas North and South America, Asia and Oceania are covered every 30 days (once over 3 cycles). This will be progressively reduced over the coming months to reach 10 days in routine phase. The Sentinel-2 baseline observation scenario will systematically cover all land surfaces between 56° South latitude and 84° North latitude. Data from Sentinel-2 is provided routinely since 3 December 2015.

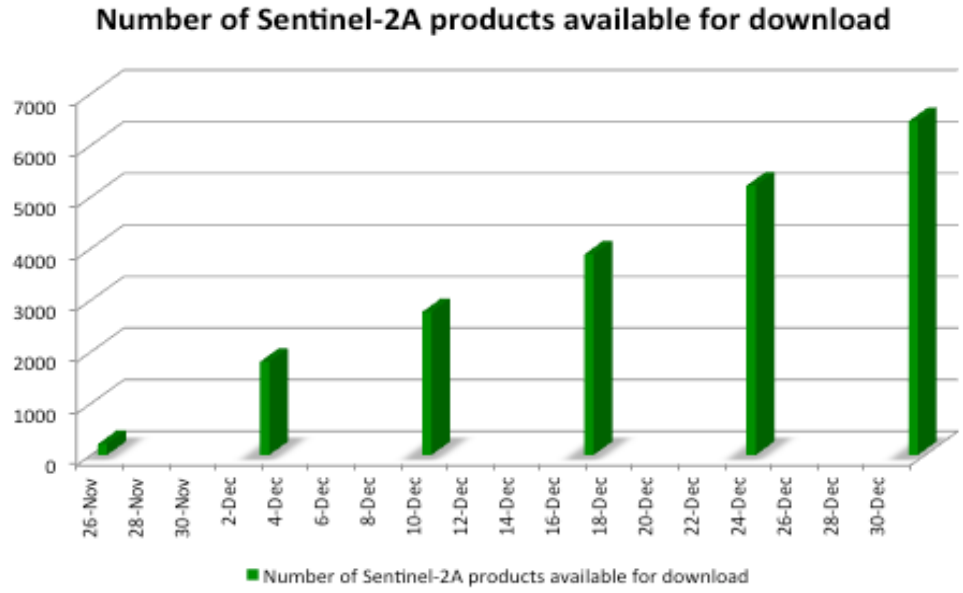

Figure 2.11 Sentinel-2 products for download in 2015

Sentinel Data Access

The Sentinel Scientific Data Hub at **http://scihub.copernicus.eu** provides free and open access to a rolling archive of Sentinel user products (Figure 2.6). The routine data flow opended for Sentinel-1 in October 2014 and for Sentinel-2 in December 2015. It provides an open source hub interface and offers the possibility to automatically download data via scripts. It maintains at least the latest 2 months of products, but currently no data were removed from the rolling archive.

The automatic and immediate self-registration is available to anyone. Sentinel 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 2 concurrent downloads per user is allowed in order to ensure a download capacity for all users.

Figure 2.12 and 2.13 show available Sentinel images over Colombia in 2015, 339 acquisitions of Sentinel-1 in VV-HV polarization and overall 3413 Sentinel-1 (red) and Sentinel-2 (green) products, respectively.

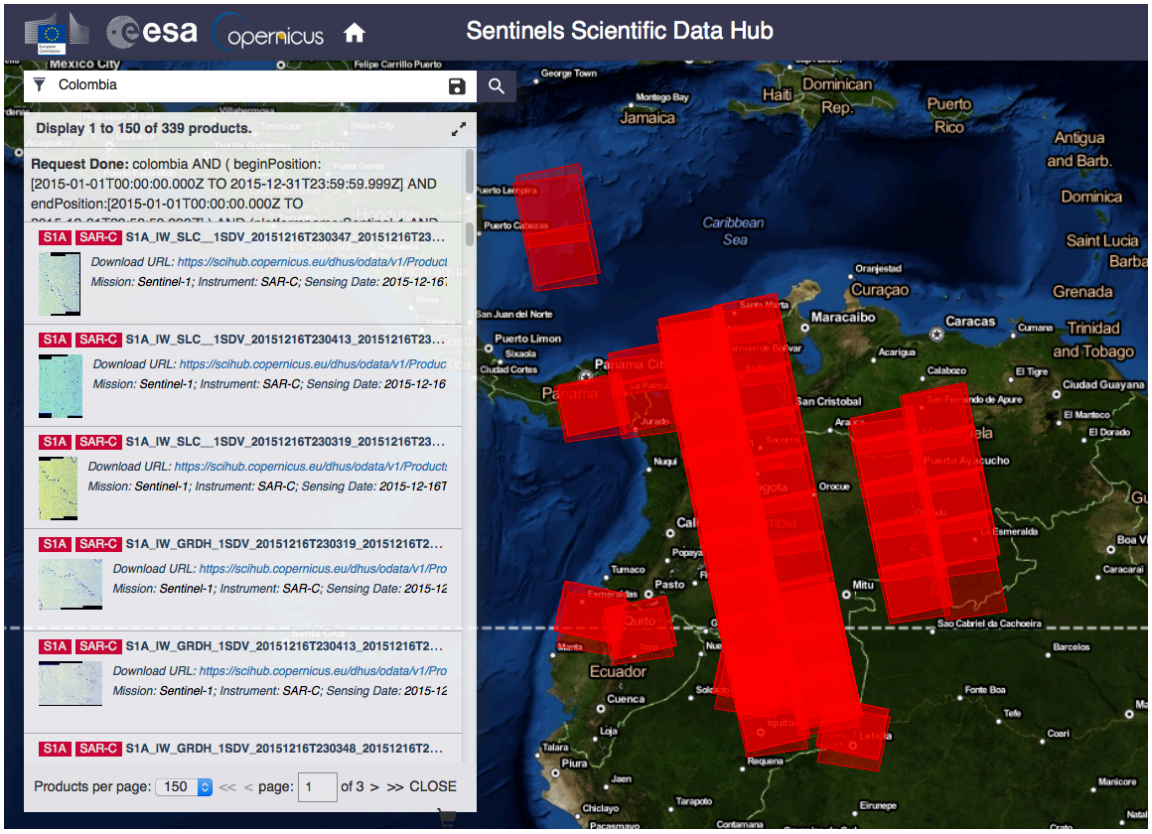

Figure 2.12 Sentinel Scientific Data Hub: 339 dual pol acquisitions over Columbia in 2015

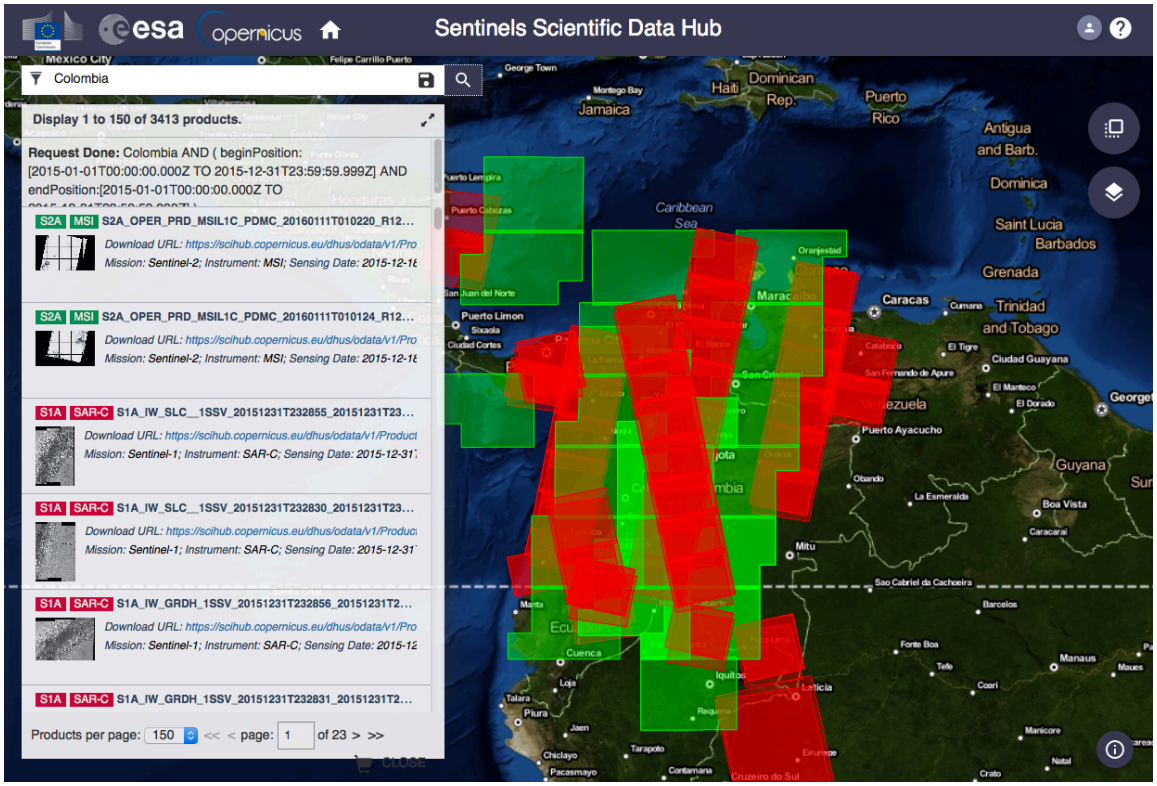

Figure 2.13 Sentinel Scientific Data Hub: all 3413 Sentinel-1 and -2 acquisitions over Columbia in 2015

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 those countries that are seeking active participation in GFOI and have engaged in related capacity building activities;
- expanding the coverage stepwise to a full global one in 2016;
- include other core data streams dependent on their launch and generally consistent with their acquisition capacities; these are:
    - ESA Sentinel-1B (22 April 2016);
    - ESA Sentinel-2B (end 2016);
    - CONAE/ASI SAOCOM-1A and -1B (2016+)

ALOS-2 / PALSAR-2 was launched on 24 May 2014 and is now operational. One of its objectives is global monitoring of tropical rain forest to identify carbon sinks. As for ALOS also for ALOS-2 annual global mosaics are made free of charge available by JAXA in 25 m resolution (Figure 2.14).

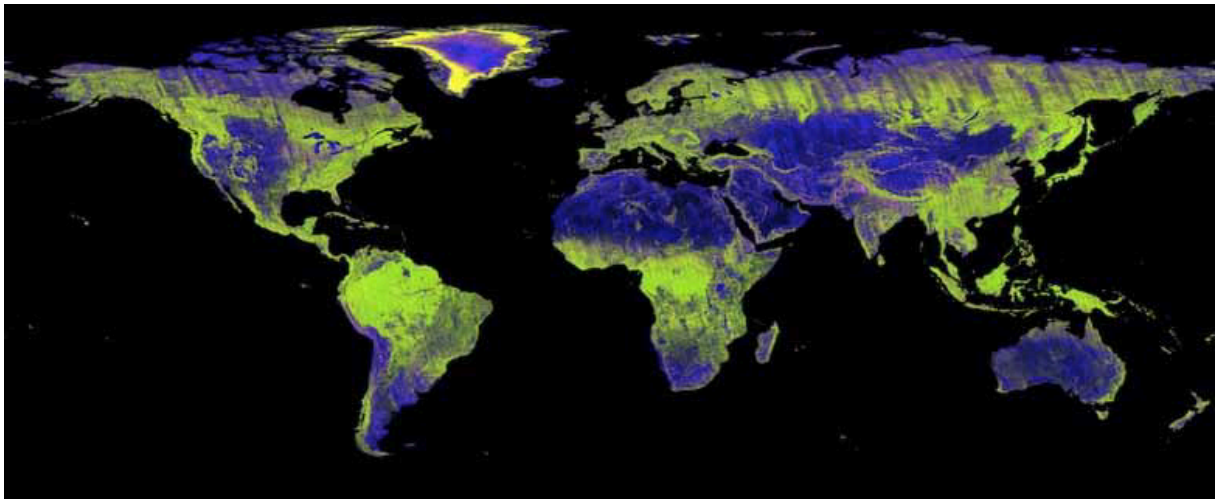

Figure 2.14 ALOS-2 PALSAR-2 Global Mosaic of 2015

CBERS-4 a joint mission from INPE/CRESDA was launched 7 December 2014. The satellite was decommissioned in July 2015, where geometric and radiometric commissioning of the instruments started in November 2015. With its four sensors on board it will contribute in the future to increase regional coverage.

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 Conclusions

Landsat 7 & 8 acquired operational data for all of 2015. All GFOI countries were revisited nearly every 8 days by Landsat with the exception of oceanic countries, which were revisited every 16 days. Sentinel-1A acquired within a ramp-up acquisition strategy until June 2015 and continued full operational according to its High Level Operational Plan for the rest of 2015.

Ninety-nine per cent of the Landsat images in a best available image mosaic of the 2013 - 2015 GFOI countries have less than 10% cloud cover. Twenty six out of 4522 path/rows have best available images with greater than 20% cloud cover. Cloud free annual mosaics should be possible for most scenes with two images, although for the worst cases more images will be needed. 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 and Sentinel-2 long term observation plans. Radar data like the annual ALOS-2 mosaics provide complementary information. For regions, such as the persistently northwest portion of South America, the Western Congo basin and South East Asia Sentinel-1 provide up to date information on recent forest disturbances. Non-core optical data would provide additional opportunities for cloud free data in those areas.

4 References

The CEOS Strategy for Space Data Coverage and Continuity in Support of the GEO Global Forest Observations Initiative (GFOI) and Forest Carbon Tracking (FCT) Task, v1.1 (2011); 25th CEOS Plenary, Lucca, Italy, 24 Oct 2011.

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