

Pléiades and its users thematic commissioning

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Abstract. The Pléiades system is made of two "small satellites" (mass of one ton) offering a spatial resolution at nadir of 0.7 meters and a field of view of 20 kilometers. ORFEO, the Pléiades Accompaniment Program, was set up by CNES, the French Space Agency, to prepare, accompany and promote the use and the exploitation of the images acquired by this very high resolution optical sensor, especially in public sector. It was initiated in 2004 and will last until April 2014. The objectives of this program are 1) to assess the thematic capability of the Pléiades system to produce the various services required by end-users for distinct domains (defence, risks, cartography, hydrology, forestry, agriculture . . .) and 2) to develop efficient tools to facilitate image information extraction by end-users. This paper presents the first results of the last phase of the ORFEO program : the Pléiades Users Thematic commissioning.

Keywords. Pléiades, earth observation, optical, satellite, space applications, thematic commissioning.

1. Introduction

The Pléiades project [1] was undertaken, under the leadership of the French Space Agency (CNES), as part of an intergovernmental agreement setting out the objectives and general principles of cooperation between France and Italy in the field of Earth observation. Signed on 29 January 2001 in Turin, the agreement makes particular provision for the building of a dual-purpose observation system, ORFEO, with submetric resolution, including an optical component, Pléiades, developed by France and a radar component, Cosmo-SkyMed, developed by Italy.

Cooperation agreements relating to Pléiades have also been signed with Austria, Belgium, Spain and Sweden. In return, they have been granted a right to programming requests and access to the system archive, proportional to their contribution to development according to schemes similar to those used for the Spot family.

The purpose of Pléiades is to deliver optical images of sub-metric resolution to two categories of customers (Defense and civilian users), while meeting the stringent requirements of each one: those of Defense in terms of priority (50 high priority images are allocated each day) and confidentiality of requests, and those of civilian users in terms of acquisition capability and coverage. The Dual System is specified to fulfill a broad spectrum of applications, in the field of cartography, agriculture and forestry, geology and hydrology, marine applications, Earth science, resource management, land use, law enforcement and risk management according to scientific, institutional and commercial customers.

Given the dual nature of this system, two types of access are defined to schedule the satellites' tasks:

- The Defense channel used by Ministry of Defense beneficiaries for High Priority Defense programming requests.

- The Civil channel used by civilian users. It is operated by a civilian Operator.

The civilian data distribution is delegated to Astrium Geo-Information Services (ex Spot Image) through a Public Service Delegation: 40% of the resources of the system are reserved for institu-

tional users of the cooperative countries for no-commercial activities. CNES has granted an exclusive license to the Civilian Operator allowing him to process, distribute and commercialize the data and products on the worldwide market [2].

2. Key Missions Performances

The Pléiades system consists of a constellation of two optical satellites (visible and near-infrared range) each weighing a ton, positioned on a quasi-circular, Sun-synchronous orbit of 695 km altitude, at a local hour at descending node of 10:30 am.

The first Pléiades satellite was launched by a Soyuz rocket on the 17th December 2011, from the European spaceport at Kourou in French Guiana. The second satellite was launched less than one year later on December 2nd 2012.

Worldwide coverage and a daily accessibility to any point on the globe are requested, and fulfilled by the use of both satellites simultaneously in orbit and 180° phase shifted. This concept is necessary for two reasons:

- To ensure the accessibility and prompt imaging required by Defense and Civil Security missions.
- To ensure the coverage capability required for mapping and land planning needs.

The Pléiades system offers:

- daily access to any point on the globe (with its two satellites)
- a panchromatic channel with a 70 cm vertical viewing resolution.
- four spectral bands (blue, green, red and near-infrared) with a 2.8 m resolution.
- field of view of 20 km in vertical viewing.
- acquisition capacity, in a single pass, of mosaic of images.
- virtually instantaneous acquisition capacity for stereoscopic pairs (and even triplets).
- cloud-free image coverage of 2,500,000 km² per year.

In addition it offers very precise image location enabling optimal use of data in Geographic Information Systems (GISs).

This section should describe in detail the study material, procedures and methods used.

3. Thematic Commissioning Phase

The Thematic part of the ORFEO accompaniment program covers a large range of applications, and aims at specifying and validating products and services required by users. An in-depth work of user needs assessments in eight domains (sea and coastline, risks and humanitarian aid, cartography and urban planning, geophysical hazards, hydrology, forestry, agriculture and defence) has given rise to a large number of feasibility studies from 2006 to 2011. Since 2006, more than 40 studies have been led by scientists and thematic experts from French and Belgium institutions, in close link with public end-users such as Ministry of Internal Affairs, Ministry of Ecology, French national cartographic institute, etc. Such studies, generally based on student internship, have been performed with imagery support provided by CNES both in optical domain (WorldView-2, Formosat, Quick-Bird, Ikonos, GeoEye-1, Kompsat, aerial images) and radar domain (TerraSAR-X, COSMO-SkyMed, aerial images).

The third and last phase of the ORFEO program, the Pléiades Users Thematic Commissioning (PUTC) phase, started in March 2012. This phase is a direct follow-up of ORFEO program objectives and philosophy, aiming at supporting and encouraging institutional use of Pleiades, performing research, R&D and demonstration projects required by institutional actors. Free opensource image handling and processing tools set up in the ORFEO methodological part will be provided, if

needed, for easier access to data. Such activities are performed in complementary and in synergy with Astrium GEO-Information Services marketing activities, aiming at developing Pléiades market among commercial users and at setting up certified and qualified commercial services.

The most promising studies since 2006 are being assessed with Pléiades imagery, in the eight domains of interest. Several key issues such as response to crisis, urban planning, human pressure on coastlines, watershed cartography, forest management are thoroughly studied. The parameters taken into account for the selection of the thematic studies were:

- projects ready for operational applications (e.g. monitoring large gathering/summits, updating databases . . .)
- projects still in demonstration but very mature (e.g. coastline detection and characterization, scrublands detection for fire prevention . . .)
- projects of interest for institutional actors whatever their technical maturity is: research, Research & Development, demonstration (e.g. Green and Blue corridors, biodiversity, roof reconstruction . . .)
- projects for operational demonstration capacity acquisition (eg IGN studies: department global coverage, MNT-Lidar assessment. . .).

Major disasters and emergency events are covered with Pléiades imagery for Civil Protection needs. Since the beginning of 2013, Pléiades is fully operational in the International Charter “space and major disasters” process [3]. The PUTC philosophy remains in the association of institutional users in the related projects. Indeed, studies in close interaction with public sector which answer to the requirements of the Ministry of Ecology specified in the *Plan d'Applications Satellitaires* but also to other Ministries Requirements (Internal Affairs, Agriculture).

The importance of a collaborative work between the different thematic working groups has been privileged in order to maximize the efficiency for the key thematic studies (i.e. Green and Blue Corridors) and to gather the data acquisition over multi-thematic sites. About 70 geographical sites related to almost 130 thematic studies have been selected in the framework of PUTC. More than 500 Pléiades acquisitions have been requested by users.

A specific seminar will be held in April 2014 in Toulouse (France) to present the results of this large panel of public sector driven studies. Main French ministries (Ecology, Internal Affairs, Agriculture and Forestry . . .) and European bodies such as GMES project will be involved.

4. First results

4.1. State of the art

From its start in March 2012, the PUTC allowed the acquisition of more than 150 , From its start in march 2012, the PUTC allowed the acquisition of more than 150 Pléiades images with a total surface of 40000 km². About 150 000 km² are planned to be imaged by Pléiades for PUTC until the end of 2013.

69 geographic sites around the world have been selected; their sizes vary from 100 km² up to 3500 km².

In the framework of the PUTC, more than 60 scientists or institutional teams are provided with the Pléiades images. Most of them are French but there are also some Belgian partners. As images are bought under DSP licence, institutional partners from France, Belgium, Spain, Sweden and Austria can access those images for free, thanks to their affiliation to ORFEO program.

Most of the selected studies have already started and first results are already available in various thematic applications such as sea and coastline [4] [5], environmental monitoring [6] [7], risks [8] [9] [10], cartography [11], DSM processing from stereoscopic acquisitions [12], forest monitoring [13].

Two examples are highlighted in the following paragraphs.

4.2. Demonstration of operational performances

The aim of the PUTC is not only the demonstration of potentialities of VHR data for specific thematic applications, but also the capacity of Pléiades acquisitions in an operational context. Due to its high agility and high performance of the guidance algorithms, the satellite is capable of targeting image along any ground direction within 47° of vertical viewing position, and even more, with very low maneuvers durations between two consecutive images. This agility has been tested and validated during the in-flight commissioning of both satellites, but was also proved in the context of a specific PUTC case.

In the framework of a thesis, a study on the characterization of canopy has been initiated with the Institut de Recherche pour le Développement (IRD) and the Institut Agronomique néo-Calédonien (IAC). Fifteen targets, characterizing the new Caledonian forest, have been selected in the middle part of New Caledonia, an island located in the southwest Pacific. Pléiades acquisitions on those sites will be combined with ground measurements. On the 5th of May 2013, Pléiades 1A was able to acquire images on eleven of the targets in the same single pass. Because of the presence of clouds, only eight images have been validated, but this shows the capacity of Pléiades for imaging several targets in a same path. This is really of interest for such scientific studies with images acquired in the same atmospheric conditions, and so, with analysis consistent with each other.



Figure 1. 11 targets (surfaces varying from 100 km² up to 400 km²) have been acquired by Pléiades 1A on a single pass on the 5th of May 2013.

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4.3. Interest of Pléiades data for mapping green corridors in urban area

A comparison study of extraction of vegetation layer has been performed on an urban area (Toulouse, France). Figure 2-a shows the area of interest as seen by aerial view in 2011. Two © Google Street View extracts precise the presence or not of trees in the streets. Figure 2-b describes the vegetation layer extracted from the aerial view with an over-estimation of vegetation in straight or shadowed streets. SPOT 5 data (2.5m resolution) under-estimates the vegetation in Figure 2-c, as Pléiades image (Figure 2-d) seems to better estimate the vegetation surface than other aerial and SPOT5 data. It is important to emphasize that, in the middle part of the target, the aerial data detect

vegetation as Pléiades do not. The aerial data were performed in 2011 when Pléiades data were acquired in May 2012.

This example shows that VHR data are not only crucial for the vegetation detection in urban areas (HR – VHR comparison), but it is also really important to have up-to-date information (2011 – 2012 comparison in this case).

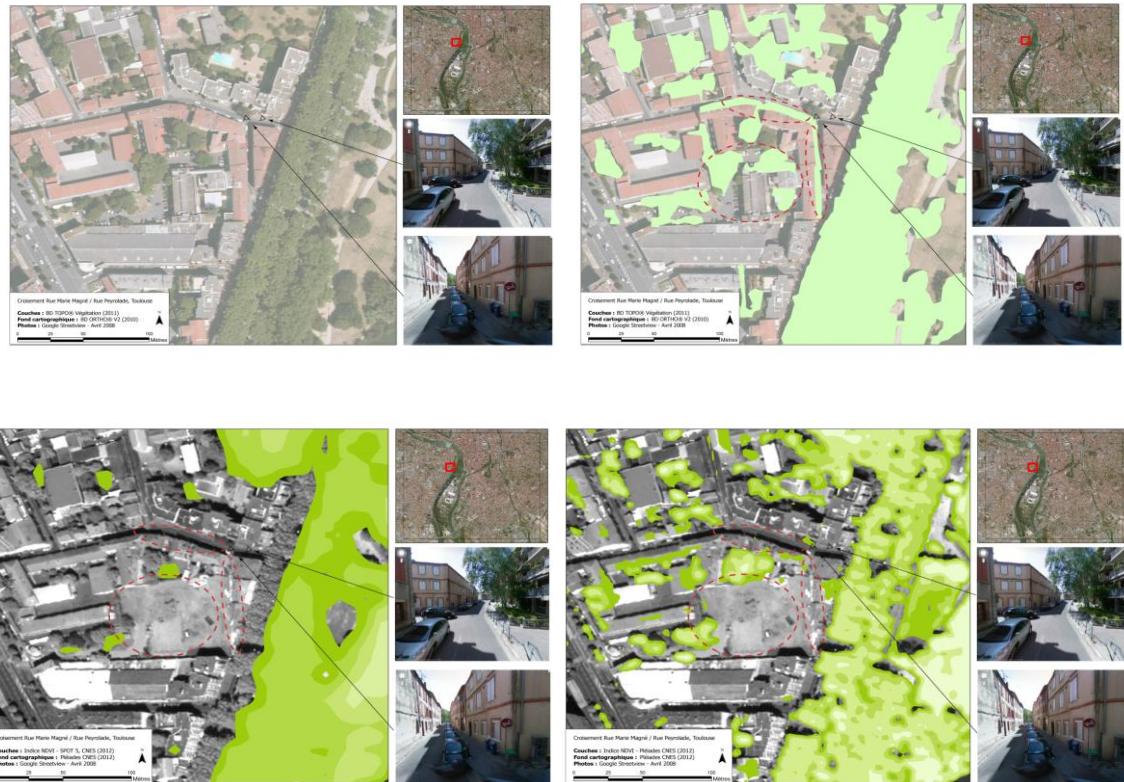


Figure 2. (a) top left (b) top right (c) bottom left (d) bottom right
Comparison of vegetation layer seen by (b) aerial view – 2011, (c) SPOT 5 – 2012 and (d) Pléiades - 2012

5. Conclusions

The Pléiades Users Thematic Commissioning is starting its second year, and first results seem really promising.

Meanwhile, other key challenges have to be tackled by ORFEO team, both thematic and methodological.

First, the large number of studies should demonstrate and concretely assess the benefit of sub-metric optical data for a large range of public sector users.

Second, the Orfeo Tool-Box Open source library, OTB applications and Monteverdi, should bring a real benefit to a large numbers of users (from c++ developers to end-users), to use, manipulate and process these huge and incredibly rich images.

Last, the ORFEO program should significantly and concretely demonstrate that Pléiades imagery is of great technical benefit for both public and commercial sectors.

The final objective to reach is to show that such imagery can be efficiently integrated into operational processes, in order that decision makers include this new type of data into their usual tools.

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