

## The Vegetation Programme

Julien Béclard

Under human pressure, many changes are taking place in the resources and the environment of Earth. An increasing global population fuels the need for food, natural resources and land. Consequently, the need for maintaining a capacity to observe and understand the Earth system and the biophysical processes has become a key element for the sustainable management of the planet's natural resources. The SPOT-Vegetation instruments have significantly contributed to reach this goal.

### The SPOT heritage

In 1977, France proposed to develop a series of Earth observation satellites aimed at taking images of the Earth in different light bands: SPOT. These high-resolution satellites were designed to improve the knowledge and the management of Earth's resources by gathering data regarding agriculture, water resources, renewable and non-renewable fuels and contribute to a better understanding of the oceans, climate and erosion<sup>1</sup>.

Initially, Spot was suggested by France in February 1977 as a European project but was supported only by two countries, Belgium and Sweden. Consequently, the French government decided to adopt Spot as a national project and offered Belgium and Sweden to join on a bilateral basis (contributing 4% each). In order to market the images Spot could take from every spot of the Earth, CNES set up the first satellite-based Earth resources company, "SPOT Image", based in Toulouse. CNES was a 39% shareholder along with other sponsors from Belgium, Sweden and Italy<sup>2</sup>.

Spot-1 was launched with Ariane 2 in February 1986. This first satellite was joined by Spot-2 in January 1990 followed by Spot-3 in September 1993. In 1998, Spot-4 was launched with Ariane 4 when Spot-3 went out of action. This new satellite contained major technical developments and carried

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<sup>1</sup> HARVEY Brian, *Europe's space programme: To Ariane and beyond*, Springer, 2003, p.71.

<sup>2</sup> Ibidem.

additional experiments for the observing of the ozone layer and radio-positioning. CNES managed to convince the European Union (EU) of the necessity of making available in Europe a global monitoring instrument devoted to the vegetation cover. Jointly developed by France, the EU, Belgium, Italy and Sweden, this new instrument dedicated to the daily measurement of the Earth vegetation cover was Spot-4's main improvement. This instrument was regarded as a workhorse of global monitoring: *"It gives a basic dataset you can trust, really designed around dedicated measurements, oriented to understanding the state of the vegetation cover of the world on a day in-day out basis"*<sup>3</sup>.

## The Vegetation instrument

First on Spot-4 (1998) and then on Spot-5 (2002), the Vegetation instrument provides measurements that have proven to be most helpful in monitoring land surfaces' parameters with a frequency of approximately once a day on a regional and global basis and a medium spatial resolution of one kilometre. Designed to react to the colour signature of plant cover (blue, red, near-infrared and mid-infrared wavebands), its images identify trends and patterns in various key ecosystems of the world such as in crop production, forestry, flooding, desertification, habitat mapping for biodiversity etc.

The key features of this programme are:

- low resolution data (1000m)
- daily revisiting of the entire earth land surface
- use of spectral bands related to vegetation canopy features
- preparation of series of products from raw data to temporal synthesis
- timeliness of the data delivery
- attention to data quality<sup>4</sup>

At the organizational level, Vegetation consists of a satellite-borne sensor and of a ground segment. The later is based on a main centralised architecture subdivided in different systems: a receiving station in Kiruna (Sweden), a quality monitoring centre in Toulouse (France), a processing and archiving image centre in Mol (Belgium) and a distribution organisation acting as the commercial interface with all users (1998-2007: SPOT Image; 2007-today: VITO)<sup>5</sup>. The SPOT-Vegetation programme is also advised by an International Users Committee (IUC), an independent body consisting of Vegetation users, that delivers feedback and recommendations. The IUC is one of the main features essentially attached to the overall Vegetation effort. Since the beginning, it has been assumed that, in order to run a significant programme for scientific interest, the future users inevitably had to be involved: *"Having the users involved in this way gives credibility to our recommendations and shows the interest*

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<sup>3</sup> "Meet the Proba-V team: Jean-Paul Malingreau, Chair of the Vegetation International Users Committee", European Space Agency, 2 May 2013, [http://www.esa.int/Our\\_Activities/Technology/Meet\\_the\\_Proba-V\\_team\\_Jean-Paul\\_Malingreau\\_chair\\_of\\_the\\_Vegetation\\_International\\_Users\\_Committee](http://www.esa.int/Our_Activities/Technology/Meet_the_Proba-V_team_Jean-Paul_Malingreau_chair_of_the_Vegetation_International_Users_Committee)

<sup>4</sup> MALINGREAU J.P, BARTHOLOME E., DEFOURNY P., "Securing a European presence in Global Biosphere Monitoring: The role of the Proba-V program", *Note to the attention of the Belgian Authorities prepared by the International Users Committee of the Proba-V satellite*, Brussels, September 2012, p.4

<sup>5</sup> "Vegetation overview", [www.vgt.vito.be/userguide/book\\_1/1/11/e11a.htm](http://www.vgt.vito.be/userguide/book_1/1/11/e11a.htm)

being taken from all over the world”<sup>6</sup>.

## A large community of users

For 15 years, SPOT-Vegetation 1 and 2 have delivered on a daily basis reliable images of the entire terrestrial surface on a daily basis. SPOT-Vegetation images are available from 1998 to present. Some of the products are free and some carry a cost<sup>7</sup>.

As a result, a large SPOT-Vegetation community of operational users – both institutional and commercial – requesting data in near-real time, has been established: “Over the years, more than 50.000 gigapixels of data have been distributed to 14.000 users. The scientific community (...) was not left out. From 2001 on, archived data could be downloaded for free, fueling many international research projects and resulting in an avalanche of scientific publications”<sup>8</sup>. The Vegetation data are used in numerous operational services by European (JRC, VITO) and non-European users (FAO, USGS, Agrhymet, OSS, national agricultural administrations in Africa)<sup>9</sup>.

When an ever-growing number of users rely on the images for monitoring agriculture and the influence of human activities and climate factors on the environment, continuity in the observation of vegetation is definitely of value. When the French announced they would not be able to continue the Vegetation series on Spot, a major time gap in the data continuity had to be avoided since the ESA Sentinel 3 satellites would not be operational in due time: “the thousands of users of SPOT Vegetation images were in danger of being bereft of data”<sup>10</sup>. The Vegetation IUC managed to get Belgium interested in developing something on its own on the very different technical basis of small satellites<sup>11</sup>.

## Proba-V – The “gapfiller”

On 7 May 2013, Proba-V(egétation), the latest in ESA’s Proba series of minisatellites (less than a cubic metre in volume), was launched from the Guiana Space Centre aboard the Vega rocket. A full Belgian consortium under the authority of ESA has designed Proba-V. QinetiQ Space nv is the prime contractor, OIP developed the instrument which is a grouping of three small TMA telescopes, while the user segment (data processing and distribution) is benefiting from knowledge gained by

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<sup>6</sup> “Meet the Proba-V team”, *loc. cit.*

<sup>7</sup> “Satellite Pour l’Observation de la Terre Vegetation (SPOT Vegetation)”, *Landscape Toolbox*, [http://wiki.landscapetoolbox.org/doku.php/remote\\_sensor\\_types:spot\\_vegetation](http://wiki.landscapetoolbox.org/doku.php/remote_sensor_types:spot_vegetation)

<sup>8</sup> “From past to future”, *Probing Vegetation Conference*, Antwerp, 4-5 July 2013, <http://probing.vegetation.be/node/5>

<sup>9</sup> European Space Agency, *European Earth Watch Programme – Programme Proposal for a n Element “Proba-V Exploitation Phase”*, Paris, May 2012, ESA/PB-EO-EO(2012)25 rev.1, p.11.

<sup>10</sup> COURARD Philippe, « Opening speech at the opening session of the Probing Vegetation Conference », 4 juillet 2013, <http://www.courard.belgium.be/fr/opening-speech-philippe-courard-opening-session-probing-vegetation-conference>

<sup>11</sup> “Meet the Proba-V team”, *loc. cit.*

VITO in the management of Vegetation data<sup>12</sup>.

Proba-V is a Spot-like Earth observation mission that has been designed in order to provide a seamless transition and keep the data flowing between the end of Vegetation 2 instrument operations and the launch and operations of Sentinel 3. Similarly to Vegetation, the instrument maps land cover and vegetation growth across the majority of planet Earth on a daily basis: complete coverage of high latitudes each day, with 90% of equatorial regions also acquired within that day. Within two days, the entire planet's land is imaged<sup>13</sup>.

Compared to the instrument previously flown aboard Spot-4 and Spot-5 satellites, Proba-V's Vegetation instrument provides a significantly shrunk design and harnesses subsequent technological advances. The spatial resolution has been improved: in addition to the existing 1km products, products with a resolution of 350m will be generated, with 100m resolution available within its central field of view<sup>14</sup>. Two kinds of product shall continue to be offered by Proba-V. On the one hand, "Vegetation Primary" products for scientific applications necessitating extremely precise physical measurements. On the other hand, "Vegetation Synthesis" products that ensure coverage of landmasses worldwide on a daily or 10-day basis<sup>15</sup>.

### Upcoming key issues

Originally, Proba-V had been imagined by ESA as a simple "gapfiller" dedicated to providing continuity in global measurements of the Earth's vegetation conditions by shrinking any possible gap between the end of SPOT-Vegetation and the beginning of similar observing by GMES Sentinel-3, whose first satellite is due for launch in 2014-15, with a second satellite to provide global coverage by 2016-17.

Europe and the world are nowadays facing critical challenges that necessitate preserving the capability to closely observe the Earth system and its several processes. In this regard, it seems that the recent developments of Sentinel 3 now encourage moving towards a reinforcement of the role of the dedicated Proba-V satellite programme beyond the "gapfiller" concept.

While they are regarded as the pillar of global monitoring in the European Space Agency instruments, the Sentinel 3 pair of satellites have been conceived with priority to the monitoring of oceans at low resolution: "*Sentinel 3 is therefore not specifically dedicated to vegetation monitoring (...) complete land coverage will be secured each 3 days. In order to secure a coverage of land masses on a daily base, two Sentinel 3 (a and b) will be needed*"<sup>16</sup>. Since the first Sentinel-3 satellite is

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<sup>12</sup> VITO, "The Proba-V project", 2013, <http://proba-v.vgt.vito.be>

<sup>13</sup> European Space Agency, "V for Vegetation", 2013, [http://www.esa.int/Our\\_Activities/Technology/Proba\\_Missions/V\\_for\\_Vegetation](http://www.esa.int/Our_Activities/Technology/Proba_Missions/V_for_Vegetation)

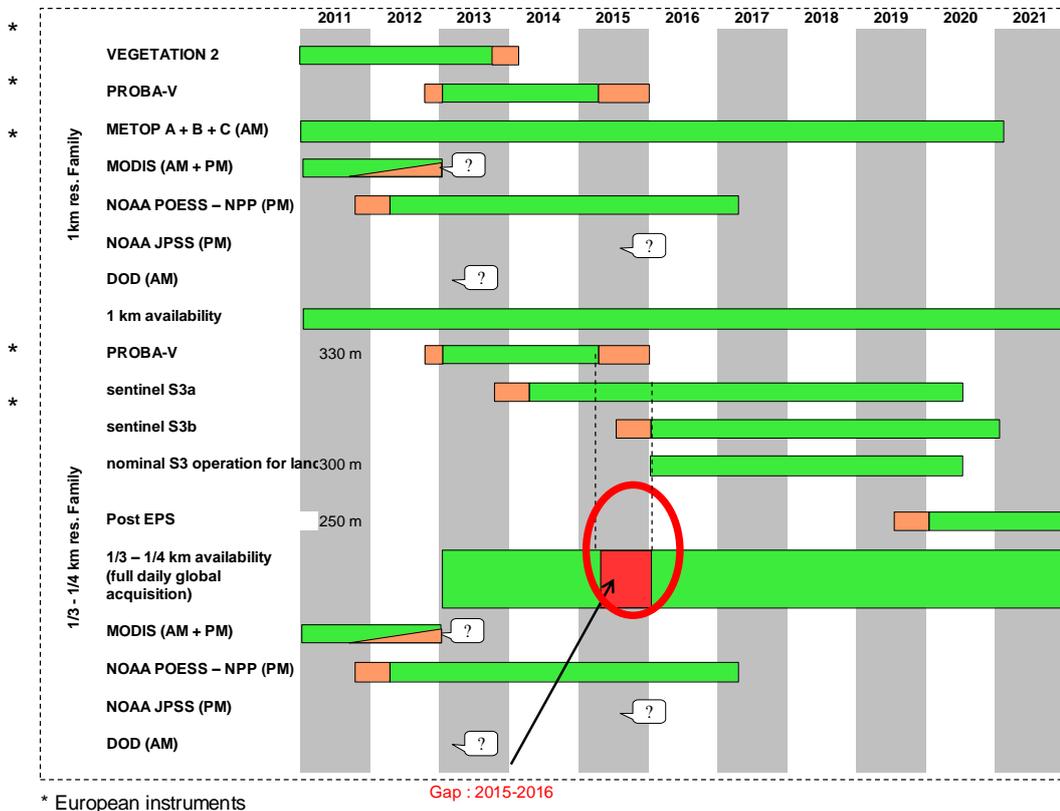
<sup>14</sup> European Space Agency, "Proba-V minisatellite tracking global vegetation growth", 2013, <http://esamultimedia.esa.int/multimedia/publications/BR-310/offline/download.pdf>

<sup>15</sup> European Space Agency, *European Earth Watch Programme*, op. cit. p.5

<sup>16</sup> MALINGREAU J.-P., BARTHOLOME E., DEFOURNY P., op. cit. pp.4-5

expected to be ready for launch between 2014 and 2015, and the second is not programmed with much certitude (2016), Europe is expected to have no Earth observing facilities providing accurate monitoring (resolution of 300m, daily) of vegetation during the years 2015-2016:

Figure 1 : Data availability for global vegetation monitoring<sup>17</sup>



While this expected gap is a new threat for the various users that rely on data availability for global vegetation monitoring, some observers are also turning the long term continuity and quality in global measurements of the Earth’s vegetation conditions into a strategic issue for the European Union: “It might be possible to buy similar data on the open market, but there are other aspects of the question. Isn’t it worth having some autonomy in observing Earth? The way things are evolving in terms of use of resources and environmental impacts, it might be a strategic mistake to become dependant on other people for such critical data on resources”<sup>18</sup>.

The IUC is now supporting a successor mission for a series of Proba-V satellites dedicated to securing day-in day-out vegetation coverage measurements on a relatively cheap basis all the way to 2020<sup>19</sup>. Furthermore, it is assumed that any new Proba-V programme would be cheaper because of the economy of scale obtained by building a recurring programme, strongly pushing for innovation bound up with small satellites.

<sup>17</sup> Ibid., p.6.

<sup>18</sup> Meet the Proba-V team”, loc. cit.

<sup>19</sup> Ibidem