

SUSTAINED DATA ACCESS AND TOOLS AS KEY INGREDIENTS TO STRENGTHENING EO CAPACITIES: EXAMPLES FROM LAND APPLICATION PERSPECTIVE

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Abstract

Sustainably managing agriculture and forests is key for development, in particular in Africa, and for facing global challenges such as climate change or food security, but requires reliable information. As Earth Observation (EO) satellite data can contribute to these information needs, more and more institutes integrate this technology into their daily work. Facing ever-growing and evolving EO data sources (e.g. new satellites and sensors) and access technology (both online and via EUMETCast satellite broadcast), their applications require software tools to particularly facilitate (i) the exchange of data between the analysis tools, so users can take advantage of each tool's strengths, and (ii) the processing and analysis of time series.

A first example is the Land Surface Analysis Satellite Application Facility (LSA-SAF), that entered the second part of the Continuous Development and Operations Phase (CDOP-2), under the lead of the Portuguese Institute for Sea and Atmosphere (IPMA), in 2011. VITO, joining the LSA-SAF network for the first time and building on previous experiences (e.g. <http://www.metops10.vito.be>), aims to contribute by producing and delivering operational, 10-daily vegetation indicators based on MetOp-AVHRR. Furthermore, a software tool is developed to aid exploitation of LSA-SAF products, provisionally called "MSG Toolbox".

A second example is the AGRICAB project, that receives funding from the European Union's 7th Framework Programme for Research (FP7) and aims to build a comprehensive framework for strengthening capacities in the use of EO for agriculture and forestry management in Africa. This framework starts from sustained access to relevant satellite data (e.g. CBERS-3, DEIMOS) and derived products, such as those from the European Copernicus Global Land service, the 15 year time series of SPOT-VEGETATION (and its transition to PROBA-V) and Meteosat Second Generation (e.g. rainfall estimates). It combines local and EO data with tools and training into applications on crop monitoring, area statistics and yield forecasting, livestock insurance and modelling, forest and fire management, all fitted to the needs of stakeholders in the African focus countries.

BACKGROUND

Today, more and more applications and services are developed that integrate Earth Observation (EO) techniques, as well for monitoring and early warning as modelling and forecasting. Such integrated applications increasingly require combinations of (i) several EO satellites and sensors and (ii) EO data with *in situ* measurements for calibration and validation and local data sources (e.g. national crop statistics).

To properly integrate the EO data sources requires free, open and above all reliable access thereto. At the same time, the data are produced in many different locations around the world, with ever increasing volume (e.g. number and size of available products). They are delivered to users via dissemination channels, such as traditional web or FTP sites, that need to keep up with this evolution.

Last but not least, users rightfully expect the provided data and products to be easier to retrieve, manage and prepare, in order to leave more time for their actual analysis or modelling. Evolving or new software tools and web services try to meet this need. It is thus clear that sustained EO data access and software tools must go hand in hand, in order to rise up to these increasing challenges, while respecting and building on existing capacities and experiences.

EXAMPLES FROM LAND SURFACE ANALYSIS SAF

About the LSA-SAF

The Land Surface Analysis Satellite Application Facility (LSA-SAF) is part of the network of eight Satellite Application Facilities (SAF) coordinated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Each SAF can thereby be considered as a consortium of organizations, brought together into a single centre of excellence to generate and disseminate EO products on a specific thematic area (land, climate, etc.), complementing and integrated with the core ground segment of EUMETSAT itself.

In June 2011, the SAFs entered into their second Continuous Development & Operations Phase (CDOP-2). In this phase, the LSA-SAF continues to be led by the Portuguese Institute for Sea and Atmosphere (IPMA). The Flemish Institute for Technological Research, VITO, in Belgium, joining the LSA-SAF for the first time, aims to contribute by producing and delivering operational, 10-daily vegetation indicators based on MetOp-AVHRR and a software tool to facilitate the exploitation of available LSA-SAF products, provisionally called the “MSG Toolbox”, with co-funding from the Belgian Science Policy Office. Other members of LSA-SAF team include Meteo-France, the Belgian Royal Meteorological Institute, the University of Valencia in Spain, King’s College in London, the Karlsruhe Institute of Technology and Instituto Dom Luiz of the University of Lisbon.

Global vegetation indicators from MetOp-AVHRR

Building on previous experiences (Eerens et al, 2009 and <http://www.metops10.vito.be>), VITO regularly produces 10-daily synthesis of vegetation indicators, in particular the Normalized Difference Vegetation Index (NDVI, see *Figure 1*) based on data from the AVHRR sensor on board the first generation of MetOp satellites. These vegetation indicators are freely and openly available and currently migrating towards the second MetOp satellite.

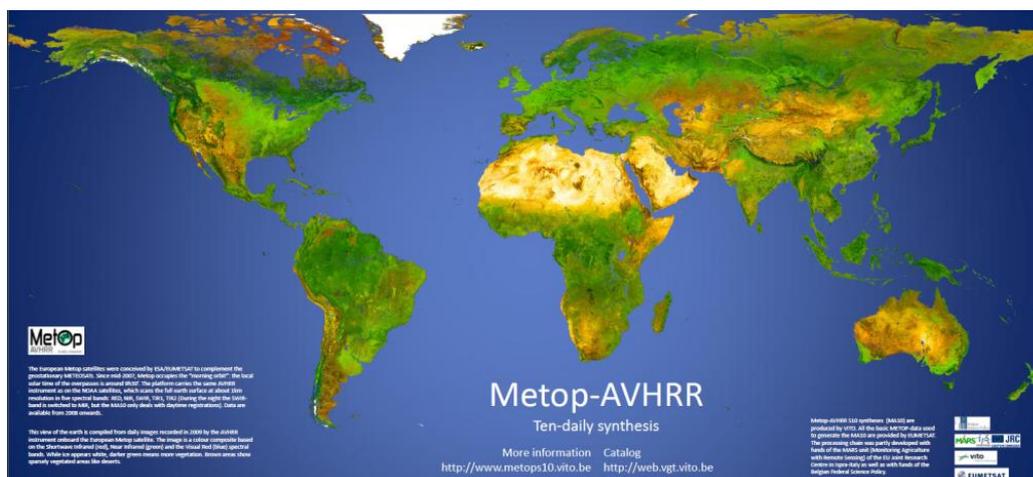


Figure 1 Example of MetOp AVHRR 10-daily NDVI synthesis

A new toolbox to facilitate the use of LSA-SAF products

Users of LSA-SAF products, in particular in environment and agriculture sectors, have requested to facilitate the use of the products in their GIS and Remote Sensing processing and analysis systems, as shown in the recommendations of the 9th EUMETSAT User Forum in Africa. The generic and flexible Hierarchical Data Format (HDF) used, but also the raw geolocation according to the Meteosat Second Generation (MSG) disc, were particularly noted as barriers to be lowered. Even with the advent of time-integrated (daily, 10-daily, monthly) composites directly produced by LSA-SAF, and the CDOP-2 phase promising archive back-processing, users today still face the use of many products at 15 min, 30 min or hourly time steps and corresponding data volumes.

This inspired the development of a new software tool, provisionally called “MSG Toolbox”, starting off by documenting user requirements and comparing existing software solutions. The following solutions were mainly considered: (i) the operational MSG processing chain (Roerink et al, 2012) that VITO runs on behalf of the European Commission’s Joint Research Centre, in particular the unit dealing with agriculture monitoring using remote sensing (MARS unit, <http://mars.jrc.ec.europa.eu/>), (ii) VITO’s VGTEExtract utility for easing the integration of SPOT-VEGETATION data into GIS and Remote Sensing software, (iii) the GEONETCast Toolbox extension to ILWIS developed by the University of Twente, faculty of Geo-information Science and Earth Observation (ITC) and 52 North (<http://52north.org/communities/earth-observation>) and (iv) the ‘georeferencer’ utility developed by R. Da Silva from IPMA (<https://github.com/ricardogsilva/LSASAF-georeferencer>). Other solutions were briefly explored as well.

This toolbox is still being developed and tested. *Figure 2* shows one of several processing workflows included in the design of the toolbox and performing the main output: the production of daily composites (minimum, maximum, average) from input LSA-SAF products with sub-daily (e.g. 15 min) frequency.

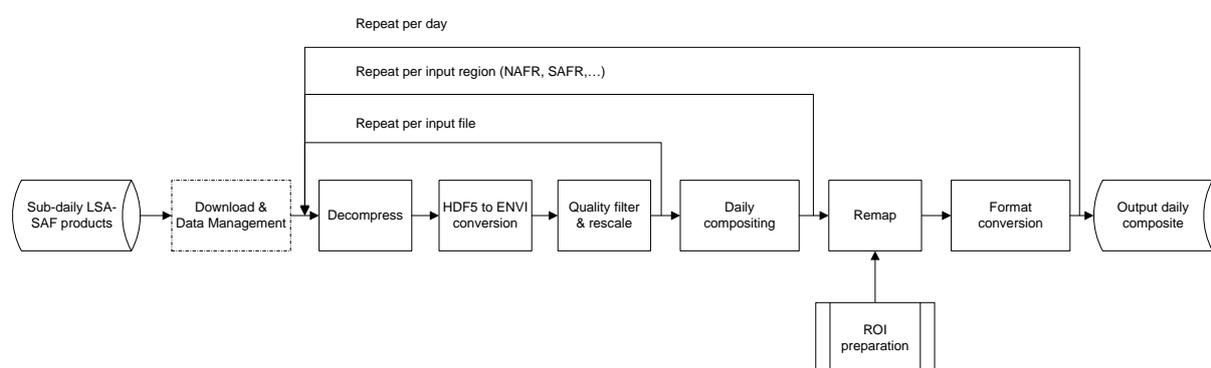


Figure 2 Example of high level processing flow in the MSG toolbox design

Variations of the above workflow were added to produce 10-daily, monthly and yearly composites and to consider also input LSA-SAF products with daily frequency such as the so-called VEGA suite (Leaf Area Index, Fraction of Vegetation Cover, etc.). In fact, the toolbox is supporting the use of all operationally available LSA-SAF products as input.

After the retrieval and management of input products, considered as preparation steps run outside of and prior to the toolbox, the toolbox will automatically de-compress the LSA-SAF input products and convert them to the internal work format (ENVI). Subsequently, a rescaling is performed and the data values are – optionally – filtered on quality using the bitwise quality flag and error margin layers where these are provided in the input product. The next step is the computation of daily minimum, maximum or average composites that further allows a configurable tolerance for data gaps and time shift (e.g. starting from 6h UTC rather than 0h).

The secondary flow, called Region Of Interest (ROI) Preparation in the above image, separately produces and manages re-usable geolocation grids and land-sea mask, used for remapping the daily composites to geographic lat/lon.

This remapping can be configured to balance between speed and precision, but also to mask out the edges of the MSG disc, where the effective resolution is much coarser than at nadir.

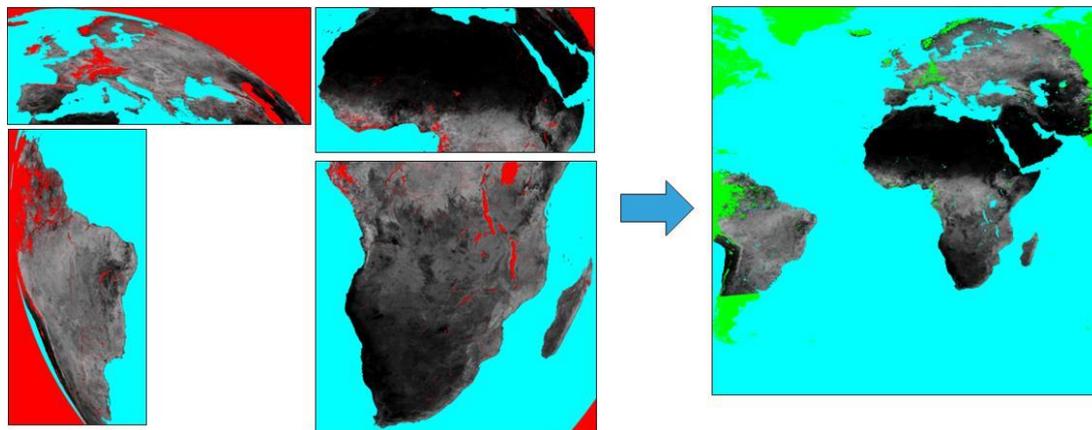


Figure 3 Example of remapping the fAPAR data of 27 May 2013, provided in four input regions (left), to geographic lat/lon with land-sea masking

Finally, the results are converted to a limited set of commonly used file formats, including GeoTiff, to facilitate further analysis.

EXAMPLES FROM AFRICAN CAPACITY BUILDING IN THE AGRICAB PROJECT

About the AGRICAB project

The collaborative research project entitled “A framework for enhancing EO capacity for agriculture and forest management in Africa, as a contribution to GEOSS”, or AGRICAB in short, receives funding from the European Union’s 7th Framework Programme for Research (FP7). The project aims to bring together the necessary international organizations and capacities (e.g. satellite data providers, researchers, capacity builders, operational practitioners and decision makers), with the aim of building a sustainable and comprehensive framework for strengthening the African capacities.

Contributing to the global Group on Earth Observation’s System of Systems (GEOSS), this framework has the following objectives: (i) To assure sustained provision & availability of EO satellite data and further facilitate their exploitation through free software, (ii) To develop integrated applications with monitoring and predictive models on crop production, livestock and forest (incl. fire) systems in five focus countries and (iii) To stimulate the wider uptake of these Earth Observation techniques at wider scales, such as UN agencies, African Union policies (incl. the New Partnership for Africa’s Development – NEPAD), higher education (MSc and PhD studies) and the global GEO network.

To achieve these objectives, the project particularly builds on the existing capacities in Africa, by e.g. working closely with national stakeholders, and a rich heritage from previous projects such as “GEONETCast for and by Developing Countries” (FP7-DevCoCast) and the ESA-funded “Global Monitoring for Food Security” (GMFS). The AGRICAB project is implemented by 17 partner institutes across 12 countries in Africa, Europe and South America (<http://www.agricab.info>), between Oct 2011 and March 2015.

Strengthening existing EO capacities, starting from access to a multitude of data sources

As shown in the below, high level overview, the strengthening of the existing African capacities is aligned to the end-to-end application or service flows (see *Figure 4*, left to right, green blocks are not covered in full detail). These applications clearly involve several combinations of passive and active remote sensing data, from optical and radar sensors, as well as in situ measurements for calibration and validation and local ancillary data. All of these need to be efficiently accessed, managed and prepared for the qualitative and quantitative analysis. The reliable access to the various data sources constitutes an important foundation for all the applications, yet is only the first step.

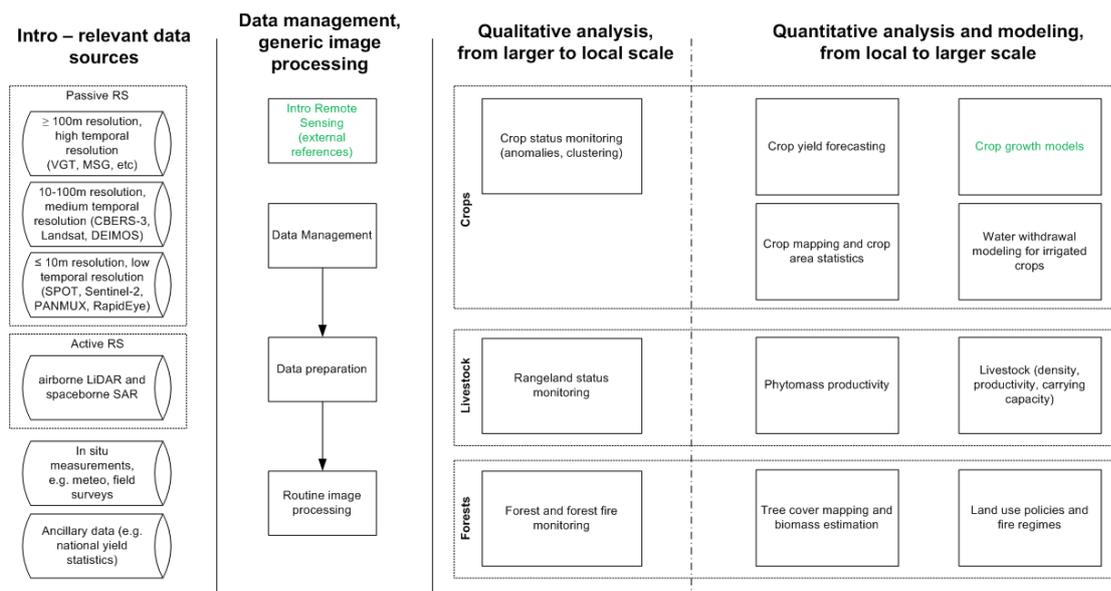


Figure 4 Overview of AGRICAB's capacity building activities, with end-to-end applications from left to right

The AGRICAB project has already undertaken many training workshops (see Jacobs et al., 2013), ranging from advanced training for the project partners, to dedicated training for the national experts in the focus countries and international workshops on data access and related free data management and image processing software. The workshops were particularly linking with existing international initiatives and networks. The participants selected for the data access workshops for instance ensured involvement of the SADC Thema component of the European Development Fund (EDF) supported “African Monitoring of Environment for Sustainable Development” (AMESD) in southern Africa, the “Action Contre la Faim” NGO network in the west and the OSFAC forest observatory for central African countries, to name a few.

These first international workshops included in particular data access via the EUMETCast satellite broadcast, the regional component of the global GEONETCast infrastructure that is operated by EUMETSAT. The routine data reception via GEONETCast receiving stations, such as the those set up at the Sahara and Sahel Observatory (OSS) in Tunisia (*Figure 5, left*), the Tsavo national park in Kenya or for the training in Burkina Faso (*Figure 5, right*), complements traditional internet-based solutions via web sites and FTP.



Figure 5 Low cost GEONETCast receiving station at OSS, Tunisia (*left*) and for training in Burkina Faso, subsequently transferred to 2iE, a local higher education institute (*right*)

Evolving EO data sources

The data provision efforts that underpin the capacity enhancement and application development efforts, of course need to keep up with the evolution in satellites and sensors, as well as related data production and delivery services. The launch of the Belgian PROBA-V satellite to continue the 15 year time series of SPOT-VEGETATION basic and derived products, in May 2013, and the upcoming launch of the third Chinese-Brazilian Earth Resources Satellite (CBERS-3), planned in Nov 2013, are examples thereof.

January 2013 however also saw the start of the Global component of the Land service of the European Copernicus programme, the main European EO programme (formerly known as Global Monitoring for Environment and Security or GMES). While this “Global Land” service focuses on operational data production and delivery of core (i.e. broadly usable) EO products (see *Table 1*), the collaboration with AGRICAB is expected to help to ensure sustainability beyond the FP7 research context, and a smoother transition to products derived from PROBA-V. Whereas AGRICAB in turn can embed parts of its African network or Community of Practice to the global network of the Copernicus service.

Variable	Temporal Coverage	Temporal resolution	Spatial coverage	Spatial resolution	Sensor	Time-liness
LAI / FAPAR / FCOVER	1999 – present	10 days	Global	1km	SPOTVGT	3 days
NDVI / VCI / VPI	1999 – present	10 days	Global	1km	SPOT/VGT	3 days
Dry Matter Productivity	2009 – present	10 days	Global	1km	SPOT/VGT	3 days
Burnt Area	1998 – present	1 day	Global	1km	SPOT/VGT	3 days
TOC Reflectance	2013 – present	10 days	Global	1km	SPOT/VGT	3 days
Surface Albedo	1999 – present	10 days	Global	1km	SPOT/VGT	3 days
Land Surface Temperature	2009 – present	1 hour	Global	0.05°	Combination of Geostationary	1 day
Soil Water Index	2007 – present	1 day	Global	0.1°	MetOp / ASCAT	1 day
Water bodies	1999 – present	10 days	Global*	1km	SPOT/VGT	3 days

Table 1 Product portfolio from Global component of Copernicus Land service (source: Copernicus land service), showing vegetation (top four), radiation (TOC Reflectance and Albedo) and water-related products

In addition to the upcoming free CBERS and other commercial EO data, such as DEIMOS images over specific study areas, AGRICAB supports the use of free Landsat imagery and their distribution via GEONETCast, through for instance a limited-scale demonstration in a training workshop in Kenya and requesting routine delivery of Landsat for the covered study areas.

Supporting data access with free software solutions

At the international GEONETCast data access and image processing training workshops in Kenya and Burkina Faso in 2012, the project team put to the test its work on providing and integrating free software solutions. The emphasis in this work is two-fold: the first idea is link together the software from ITC / 52 North, VITO and Brazilian national space research institute (INPE), by facilitating the data exchange (import-export) between them. Such data exchanges make it easier for users to take advantage of the strengths of each software, by switching from one software to the next. Secondly, an important emphasis was put on the automated processing of large data sets, in particular time series.

This time series processing is exemplified by the use of the “Software for the Processing and Interpretation of Remotely Sensed Image Time Series”, SPIRITS, (Eerens et al., in press), initially developed by VITO for the European Commission’s Joint Research Centre. The newly developed small time series data conversion utility is a second example.

Emerging web services

Along with new satellites and sensors, new web-based data distributions platforms are rolled out. An example is the new VITO platform that was developed for PROBA-V data distribution, but will gradually become the single data portal for all VITO EO data.

But why stop at delivering EO data, knowing that the increasing volumes will be challenging? While often still in demonstration or prototype stages, emerging web services instead try to offer users tailored processing services, which run at the data centre that houses the large data sets, effectively preventing the transfer of large data volumes to the user.

A particularly interesting development here is the use of Big Data technologies such as Apache Hadoop, MapReduce or Rasdaman. These allow vast quantities of spatial data to be explored, viewed and queried almost on the fly and dynamically via web services. The below prototype (*Figure 6*) is for instance developed in the ESA funded “Enhanced Support Environment” (ESE) project, led by Spacebel. AGRICAB aims to build on the installation of this platform at VITO, by testing and fine-tuning it for agriculture and forestry management usage in Africa.

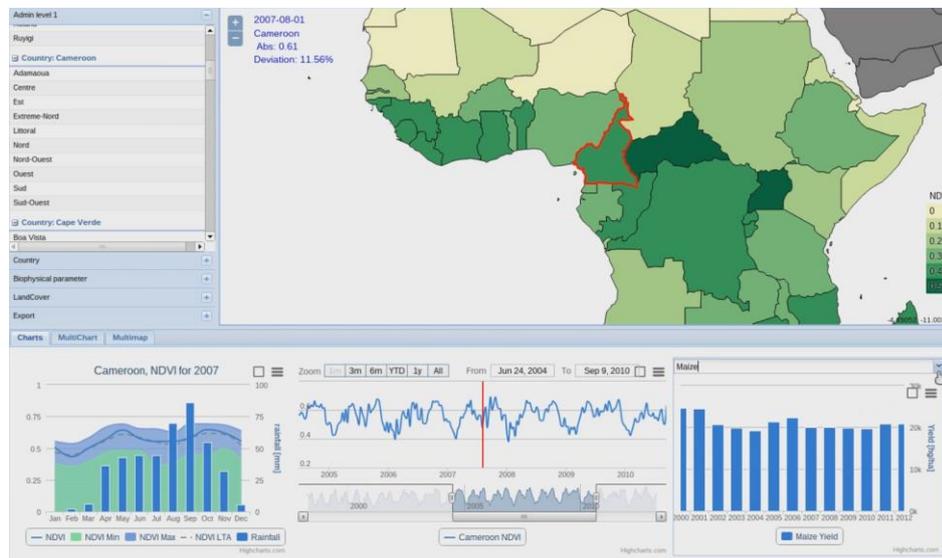


Figure 6 Example dynamic web viewer using Big Data technologies (source: ESE project)

The main challenge of the project: building national use cases on crop production, livestock and forestry systems

It is important to frame all of the above-mentioned EO data access efforts into the development of end-to-end applications. AGRICAB develops, at national level, applications on crop production systems, in particular agriculture statistics, agro-meteorological modelling and crop mapping & early warning, in Kenya, Mozambique and Senegal, and irrigated agriculture in Tunisia and its neighbours. On livestock systems, covering biomass monitoring, livestock insurance and modelling, use cases are developed in Niger, Senegal and Kenya. The use cases in Southern Africa in turn deal with providing maps and information on forest and fire systems, such as mapping tree cover or carbon storage in savannah and woodland areas.

In parallel to the technical work on data access, these use cases are being implemented with the first focused training efforts, by meeting with stakeholders to capture their needs (Tote et al., 2013) and organizing the first field missions.

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OTHER RELATED DOCUMENTS

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