Modeling process chain of SPOT images for resources uncertainty to monitor change in forest cover

Aimé Richard Hajalalaina[*1, 2], Dominique Hérvé[3], Eric Delaitre[4], Thérèse Libourel[4, 5]

[1]Centre Universitaire de Formation Professionnalisante, Université de Fianarantsoa, Madagascar
[2]Laboratoire de Recherche Appliquée Multidisciplinaire, Université de Fianarantsoa, Madagascar
[3]Institut de Recherche pour le Développement (IRD UMR 220), BP 64501, Montpellier, France
[4]Espace DEV, 500 rue JF Breton, Montpellier, France
[5]LIRMM, 161 rue Ada Université de Montpellier II, Montpellier, France

*Corresponding author: arhajalalaina@yahoo.fr

Abstract. In this paper, process chain and knowledge-based models of SPOT satellite images are proposed to help scientists, working in the field of the environment and in particular of the forest, to solve uncertainty of spatial resources (data, process) to monitor the change in forest cover which usually results of deforestation. Indeed, deforestation mobilizes all research, various methods of satellite image processing on forest dynamics are proposed. The SPOT images available, at present, are voluminous and heterogeneous in terms of spatial, radiometric and temporal resolutions (sensors HRV, HRVIR, HRG, NAOMI). The use of these SPOT images may solve uncertainty of data. In addition, phenomena such as deforestation require the analysis of time series of satellite images and the development of automated and reusable processing chains for monitoring change of forest cover. We propose to formalize these processing chains from modeling an abstract and concrete models based on existing standards in terms of interoperability (International Standard Organisation ISO and OGC Open Geospatial Consortium). The use of these standards solves uncertainty of process. These processing chains modelled will be capitalized, and diffusible in operational environments. Our modeling approach uses work-context concepts. These concepts need organization of human resources, data, and process in order to establish a knowledge-based connecting the two latter. This knowledge-based will be used to solve uncertainty of SPOT images resources for monitoring change in forest cover.

Keywords: forest cover, resources uncertainty, modeling, knowledge base, processing chain, satellite image, SPOT, work-context.

I INTRODUCTION

Our concerns are on the application of computer science in the field of environment remote sensing. Specialists in remote sensing produce hypotheses which they validate from experimental protocols. Now, remote sensing and computer experts work together to automatize these protocols in processing chains. This automatization poses many problems due, on the one hand, to the volumes of satellite images coming from different sensors and, in the other hand, to the proliferation of more or less complex image processing methods required by environment remote sensing.

In this context, it is necessary to put in place systems which help to store and manage important image-streams as well as their processing, by taking into account their various origins (different sensors, different spatial, spectral and temporal resolutions). The restitution and the exchange of these pieces of information are a real challenge in terms of

interoperability. This later has an advantage in reducing the uncertainty of image-processing methods through the capitalization and the mutualization of experiments between remote sensing specialists.

A lot of research-work, which represent high accuracy of classification, has been published on the study of forest cover using SPOT images, namely Hajalalaina et al. (2013), Souza et al. (2005)., Achard et al. (2002), Kimes et al. (1999), which has contributes to improving the knowledge on forest dynamics. But a data and processing formalization is necessary to ensure much larger spread of the research results to the scientific community. It helps to resolve the problem of uncertainty in the SPOT-image processing methods on the study of forest cover.

The formalization of data and processing is realized in a work-context acquired by the MDWeb platform put into practice by Desconnets et al. (2007). This platform proposes a view of human resource organization. It allows the plateform administrator to reference the future users from predefined roles and rights, and to reference the ressources (data/processings) within a metadata-base.

We propose to use this of this formalization to coordinate the collection of SPOT images and their processing, necessary for monitoring forest-cover. The objective is to capitalize, harmonize and spread the resources which allow a better understanding of forest dynamics at different spatial and temporal resolutions. It is part if several achievable actions within different period of time. The first one is the formalization of SPOT image processing to ensure their sharing, their re-use and their interoperability. The second one, which is a medium-term objective, is setting-up of a platform for the sharing a mutualization of experiments on SPOT image processing methods on the study of forest cover.

First, we have collected the current norms and formalization of spatial data and processing, then proposed work-context models for the formalization of SPOT image processing chains for monitoring of forest-cover.

II RESOURCE FORMALIZATION

The formalization corresponds with the description of the resources used by respecting the norms and standards which are in force. They are in the size of metadata. Various formalizations respecting the norms in force deal with syntactic and semantic aspects for the metadata. This definition and the application of these norms help to resolve the heterogeneity of the resource used. Dublin Core in BNF (2008) and ISO 19115 (2003) are the two norms which are valid and most used for the formalization of georeferenced data, like SPOT image, while ISO 19119 (2005) allows us to describe their processing. The formalization of processing chains use notion of work-context. The work-context is closely linked to the field of expertise. It can then be envisaged that it is built, through consensus, by experts in the area. Every scientist (the final user) will have at their disposal this context which they can develop or enrich in their turn. The construction of any work-context corresponds with the progressive on gradual organization of useful data and processing references, following three steps: human resource organization, data organization, and processing organization according to Libourel et al. (2010). Moreover even if this approach has not been standardized yet, it uses a relatively simple graphic symbolic language, called Simple Workflow Model (SWM) suggested by Lin et al. (2008), which allows the user scientists to handle easy appropriation concepts in a simple language.

The work-context of SPOT images in field of monitoring forest-cover is made up of three models bellow: human resource organization (figure 1) which manages the description of the platform users as well as that of their different roles and access rights, data organization (figure

2) which manages the description of SPOT image category according to sensors, processing organization (figure 2), which manages the description of SPOT images processing categories, work-context knowledge-base (figure 3) and the abstract model of processing chain of SPOT images to monitor change in forest cover (figure 4). This abstract model can be implemented by designing concrete model by using Orfeo Toolbox (2015) image processing.

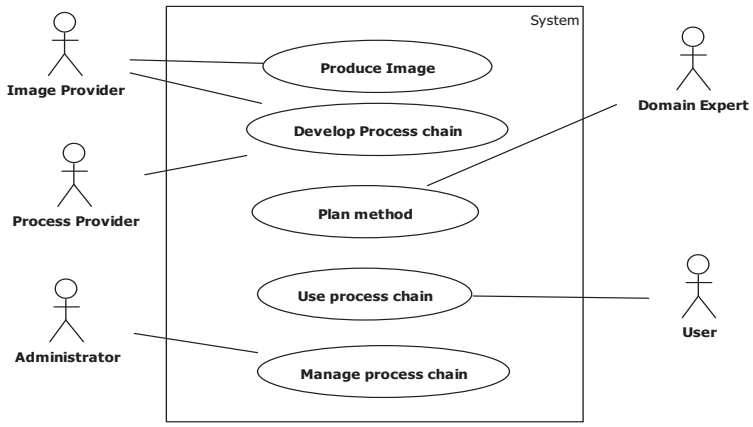

Figure 1 : Human resource organization model

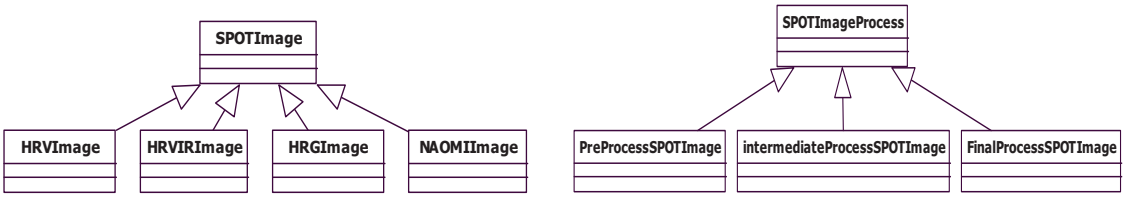

Figure 2: SPOT images organization and their processing models

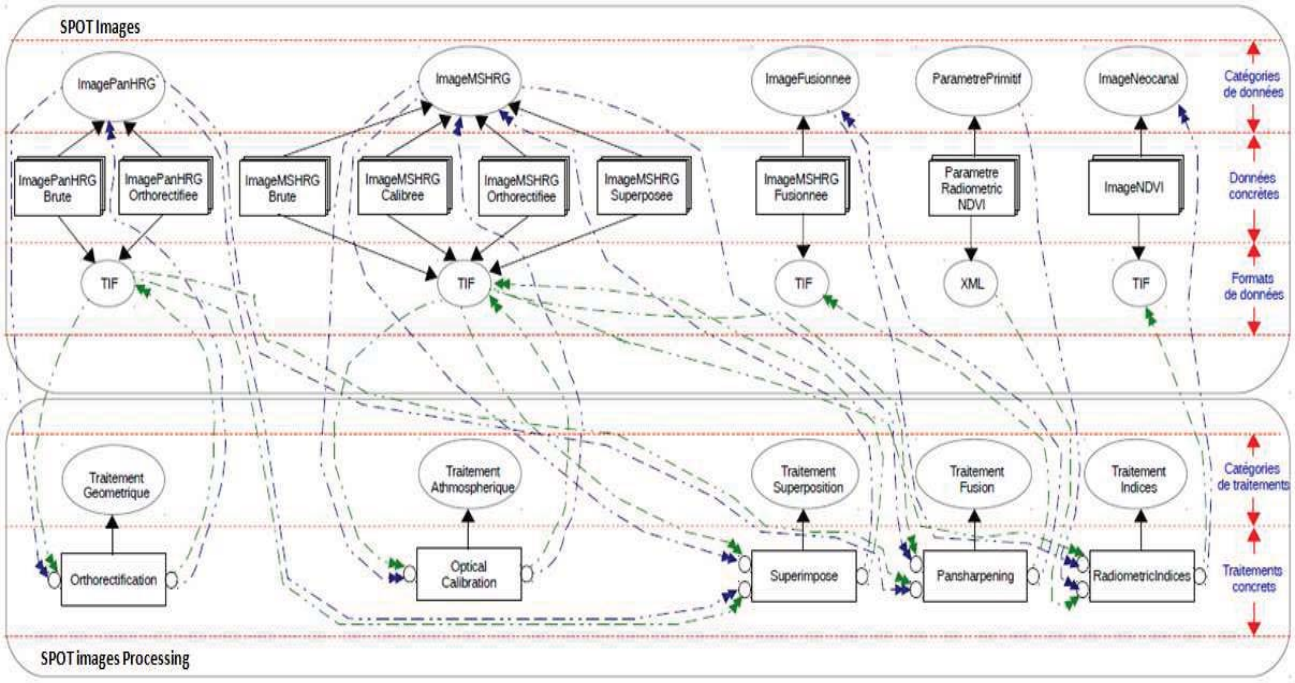

Figure 3: Extract of Work-context knowledge-base of SPOT images model

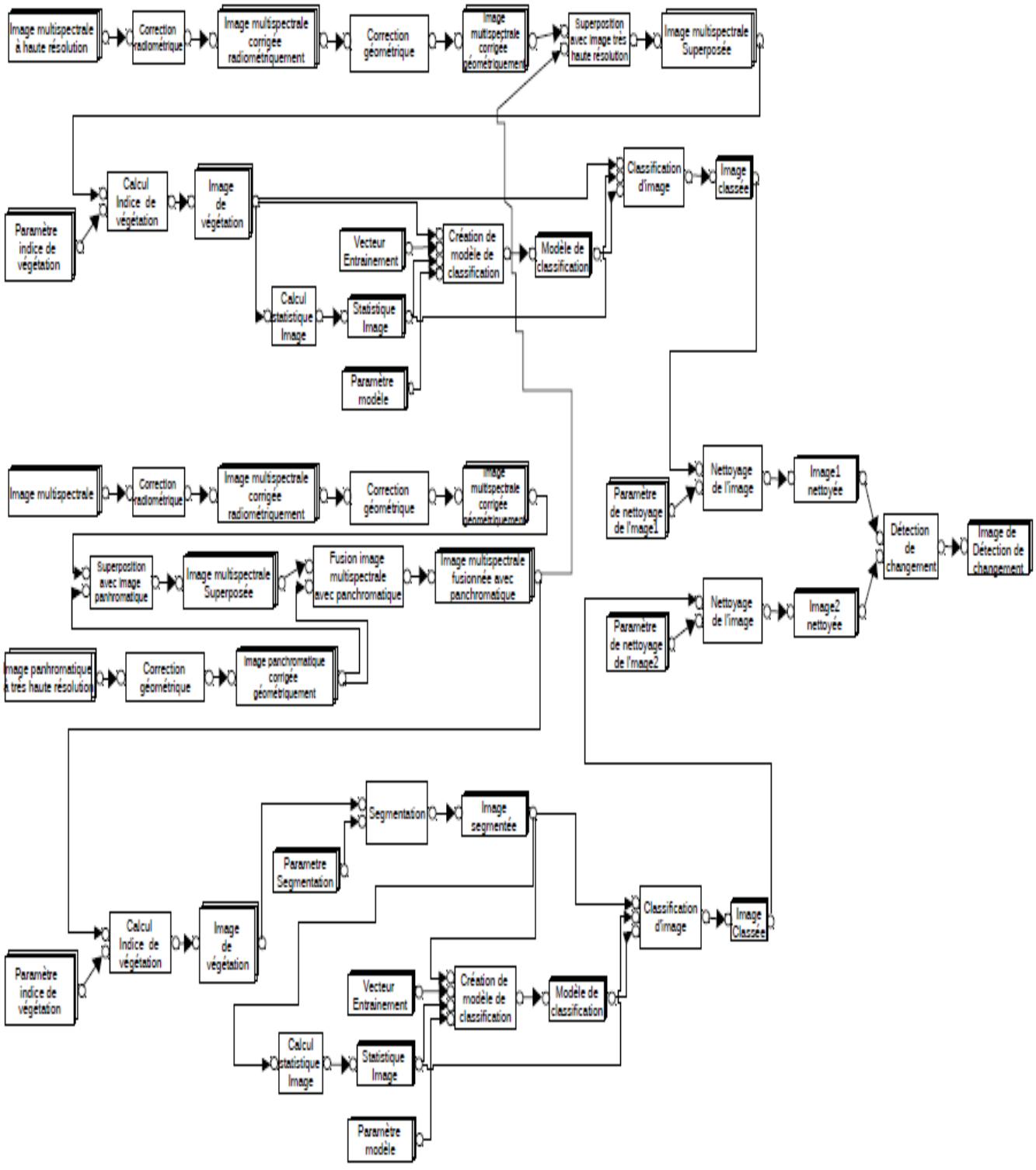

Figure 4: Abstract model of multi-resolution and multi-temporal SPOT images processing chain to monitoring change in forest cover

III ASSESSMENT OF PROCESSING CHAINS MODELS OF SPOT IMAGES

The manual processing chains of SPOT images will always remain a tough intellectual process. As a matter of fact, this type of chain requires the help of a remote sensing expert all along the realization process. In addition, new images entering the chain require the re-start of

the process from the beginning till the end. This makes their re-use difficult for users who are not specialists in the field and it does not make it possible to capitalize the experts' knowledge to assist the occasional users in the valorization of new images. We can say that the manual processing chains are not adapted to the SPOT images actualizing critical phenomena like the monitoring of forest cover.

Faced with this advantages of the manual processing chains, it interest of our proposals on formalizing processing chains lies in the automatization of different processing on SPOT satellite images.

Processing chain re-use: Once processing chain is formalized, its execution (implementation) is carried out automatically by taking into account new images. This is what makes the chain re-usable and also makes several repetitions of the processing possible without expert assistance for using the new images to carry out their analyses corresponding to their needs. Those properties are actually adapted to the monitoring of the forest cover, in view of changing and evolving character of SPOT images. It presents a major interest for capitalizing the experiments on SPOT images processing methods in order to overcome the problems of uncertainty in the processing of forest cover evolution.

Interoperability of processing chains: The formalized chain can therefore, a priori, be implemented in a distributed environment of Grid or Cloud type. Thus, it would then now be interesting to display these chains in a distributed manner in order to profit from this possible interoperability. As a matter of fact, in the contexts of forest cover monitoring, the distributed dimension will bring about an important advantage to this approach for it allow to divide up the experiments and spread on the whole set of the system to put in place, the contribution of separate elements to the knowledge-bases of work-context. In addition, normalized exchange protocols allow distributed requests which can be interesting for simultaneous research of SPOT image processing methods used in monitoring forest cover, which makes it possible to fills up the gaps on the uncertainty of SPOT image processing methods.

Cataloging processing chains: Making catalogs is the first step that will lead to an exchange or a spread of resources. Often the catalog is the origin of the initiatives for the rapprochement between the actors who wish to share their SPOT image processing chains for the monitoring of forest-cover. We would like to stress that it does not answer a move to share the processing chains but the one to share the metadata. We take profit from this possibility that the processing chains modeled and formalized in this way can be included into a catalog.

Processing chain exchange: We can take profit from the processing chain exchange by taking into account the different human resources which are proposed for monitoring change in forest cover. As a matter of fact, in contract to the spread which can be made through a downloading website, the exchange of SPOT image processing chains generally requires an interaction between the actors involved. This encounter is often initiated for legal reasons in order to draw up an exchange convention that respects the objectives of each party, or each of the parties. The notion of exchange is sometimes mixed with that of partnership, much broader. A partnership is a process of strategy cooperation between at least to actors and whose objective is to achieve a goal through the common use of material, intellectual, human, financial means. It often has a political dimension. The exchange of processing chains is interesting in setting up a process concerning the physical realization of one of the aspects of partnerships between the different actors. We stress that the notion of exchange implies a bilateral relation (the producer versus the receiver) which focuses on a flow while the notion of sharing also allows considering all the related aspects, in particular the appropriation and sharing of the knowledge which can result the exchange.

Spread of processing chains: More modest on the level of interactions, the objectives on the spread are not a challenge for the capacities of appropriation of processing chains by the actors with who the producer will have little or even no interaction. It can be pointed out here that there is a marked opposition with the co-production objective which, instead of relying on work groups, prefers to spread the produced processing chains without any discussion. It's the logic of the action of the researchers who wish to make their processing chains accessible to a great number of people.

Mutualization of processing chains: The interest in the formalization of chain-processing is to encourage the multualization of experience experiments between the researchers and is justified by various reasons. The reason is first of all to avoid useless duplication of efforts in the constitution of chain processing, avoiding at the same time redundancy of the result fragmentation which comes out. Considering the compartmentalization related to the multiplication of autonomous and non-coordinated chain-processing, the formalization of these chains represents an adequate solution to these defects.

Finally, our proposals on the formalization of processing chains constitute necessary conditions for the mutualization of experiments for monitoring forest cover. In fact, the mutualization of data implies formalizing the production and spread supervision modalities, according to an interoperable mode of a piece of information ready for use and whose quality is checked, for reason of common usage. By renforcing the cooperation between producer and users of processing chains, the mutualization also favours the exchange of experience and good practice through networking.

Processing-chain sharing: At last, it can be said that our proposals on the processing-chain formalization facilitate the sharing of experiments to monitoring change in forest cover. As a matter of fact, the data sharing aims at providing the community of experiment-users with coherent formats and structures, which will enable them to fulfill their missions better and produce their experimentations according to common and pre-defined requirements. Conversely, this interoperability and the improvement of processing-chain availability can contribute to reinforcing the relationships between the producer and user organizations and therefore can help to fill up some gaps on the use of SPOT satellite images for the monitoring of forest cover.

Experiment-sharing platform: Starting from the advantages offered by over proposals on the modelling and formalization of SPOT image processing chains for the monitoring of forest cover we are going to present other advantages which come out. We can state that the formalization of processing chains can be valued by the setting-up of a platform for sharing, mutualization re-use and the spread of experiments on the valuation of SPOT images for the monitoring of forest-cover.

The knowledge on the SPOT image processing methods for the monitoring of forest-cover are modelled then formalized in the form of processing-chains. The knowledge acquired on SPOT image-processing has to be made available to the actors. This capitalization is conceived so that everyone's experiment does not remain continued to individual level, but serves the collective in a move for knowledge sharing allowing to reduce the uncertainty in concerned field. The preservation and transmission of experiments and knowledge through formalized processing-chains facilities the implementation of new experiment protocols using SPOT images. More other, the capitalization and valuation of experiments using processing-chains is part of knowledge management. It means that the starting point is strong hypothesis that all experience or knowledge can by organized, referenced, enriched on supports which are adapted and exchanged as knowledge that other people can make their own. This puts the stress on the re-use, interoperability and sharing, the re-use, the spread of processing-chains to

valve the new SPOT images available as well as the new innovating methods for the monitoring of forest-cover.

The interests in formalizing processing-chains can be valued by the proposal on setting up a platform while allows the sharing, the mutualisation the spread, the naming of SPOT image processing-chains through catalogs for the monitoring of forest-cover. In addition, the existing platforms at the world level propose functionality for knowledge management following this view; we have proposed platforms for sharing SPOT images to deal with the uncertainty due to the lack of image of this type.

Knowledge management consists in grousing, sharing, and updating knowledge. It requires not only setting up mechanisms and procedures for uniting, organizing, presenting and spreading SPOT image processing-chains which are modelled and partners, but also proceeding to the assessments of these operation-results.

We have demonstrated how to produce SPOT image processing-chains which are reusable, sharable, spreadable, interoperable, and mutualizable. The step which can follow is implementation of a platform for sharing experiments. In view the interest the valorisation of our proposals, we can draw up a deduction that the solutions we found represent a help in the formalization of SPOT image processing-chains to capitalize the knowledge of the monitoring of the evolution of forest-cover.

IV CONCLUSION AND PERPECTIVES

This article shows the possibility for sharing and mutualizing the experiments or existing SPOT image-processing to deal with the uncertainly of the monitoring of forest-cover using the technique of remote sensing. The proposal on resource modelling and formalization for their sharing is one of the efficient techniques for resolve the problems of heterogeneity of SPOT image-processing. In fact the experiments or the processing methods of these images used for the monitoring of forest-cover will be re-usable for non-remote-sensing-expert-users. This decreases the uncertainly of the use of SPOT image processing in the forest area.

Our wok is limited to modelling, formalization and design of a resource-knowledge base related to the work-context. This latter has its advantage because if can be enriched by new recently-produced resources. It helps integrate new satellite images and recent processing methods for analysing forest cover.

Next, the perspective of this work is the integration of resources formalised in that way. This formalization makes the resources interoperable, which makes it possible to integrate the resources easily into the MDWeb tools for the sharing and mutualization and WPS (Web Processing Services), for the execution. For the execution of processing-chains via the web, we propose the web WPS Service server OGC standard (2012) since 2005.The specification of the WPS is in the form of a generic interface allowing describe and carry out or execute image processing chains of satellite images, according to Machet et al. (2008) and Eberle and Strobl (2012), which we produced in this work. The WPS is based on the http protocol and XML language. The processing-chains presented in this work will be converted into XML files, and will be integrated into WPS for execution.

References

Achard F., Eva H.D., Stibig H.-J., Mayaux P., Gallego J., Richards T., Malingreau, J.-P. (2002). Determination of deforestation rates of the world's humid tropical forests. Science 297:999-1002.

BnF, (2008). Guide d'utilisation du Dublin Core (DC) à la BnF : Dublin Core simple et Dublin Core qualifié, avec indications pour utiliser le profil d'application de TEL, Version 2.0. Bibliothèque nationale de France /Direction des Services et des Réseaux / Département de l'Information bibliographique et numérique, France.

Desconnets J-C., Libourel T., Clerc S., Granouillac B., (2007). Cataloguing for distribution of environnemental ressources. *10th AGILE, International Conference on Geographic Information Science,* Aalborg University, Danmark.

Eberle J. and Strobl C., (2012). WEB-Based Geoprocessing and Workflow Creation for Generating and Providing Remote Sensing Products. Geomatica, Vol.66(1), pp.13-26. Canadian Institute of Geomatics.

Hajalalaina A. R., Grizonnet M., Delaître E., Rakotondraompiana S., Hervé D., 2013. Discrimination des zones humides en forêt malgache, proposition d'une méthodologie multirésolution et multisource utilisant ORFEO ToolBox. *Revue Française de Photogrammétrie et de Télédétection*, n° 201, pp. 37-48.

ISO19115, (2003). Geographic Information Metadata, ISO 19115. International Organization for Standardization (ISO), Genève, Suisse.

ISO19119, (2005). Geographic Information Service, ISO 19119. International Organization for Standardization (ISO), Genève, Suisse.

Kimes D.S., Nelson R.F., Salas W.A. and Skole D.L., (1999). Mapping secondary tropical forest and forest age from SPOT HRV data. *in International Journal of Remote Sensing*, 20:3625–3640.

Libourel T., Lin Y., Mougenot I., Pierkot C., (2010). A platform dedicated to share and mutualize environmental applications. In J. Filipe, J. Cordeiro J. (eds.), *in Proceedings of the 12th international conference on enterprise systems. ICEIS, International Conference on Enterprise Systems, 12.*, Madere Funchal, 8-12 juin 2010. Setubal : SciTePress, p. 50-57.

Lin Y., Mougenot I., Libourel T. (2008). Un nouveau langage de workflow pour les sciences expérimentales. *In INFORSID'08 : Atelier ERTSI Evolution, Réutilisation et Traçabilité des Systèmes d'Information*, Fontainebleau, France.

Machet E., Kamhi M., Jacquin M., Le Page M., Dejoux J.-F. and Dedieu G., (2008). Web Processing Service pour le traitement des images satellites. *CESBIO, CNES, Toulouse, France.*

OGC. (2012). Web Processing Service 2.0 Standard Working Group. http://www.opengeospatial.org/projects/groups/wps2.0swg. Accessed: 2016-04-29

Orfeo ToolBox, (2015). The ORFEO Tool Box Software Guide Updated for OTB-5.2.1. https://www.orfeo-toolbox.org/packages/OTBSoftwareGuide.pdf. Accessed: 2016-04-29. Centre d'Etudes Spatiales (CNES), Toulouse, France

Souza C., Firestone L., Silva L.M.,, Roberts D., (2003). Mapping forest degradation in the Eastern Amazon from SPOT 4 through spectral mixture models. *in Remote Sensing of Environment*, 87:494–506.