OENOVIEW : BRINGING REMOTE SENSING TO WINE QUALITY

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ABSTRACT

Oenoview is born in 2006 from the partnership between Infoterra, an EADS Astrium company specialized in earth observation and the Institut Coopératif du Vin, a French wine and vine institute. Oenoview is an operating precision viticulture service, dedicated to vine monitoring, harvest optimisation and input management. Launched in France in 2009 on a commercial scale, this service is now used by clients as different as large wine coops in the Mediterranean region and famous “chateaux’s” in the Bordeaux region.

The Oenoview service provides the vine grower and vine consultant with a bundle of maps and recommendations during summer. These products are designed to support decision making processes along the year, more especially at the most critical stage of the vine growing process, the harvest. High resolution satellite images are processed by Infoterra’s processing chain to produce maps representing the vines vigour level. These maps, based on biophysical parameters provided by Infoterra proprietary software Overland^{TM} are analysed and interpreted by ICV consultants to support vine growers in their decision making.

The aim of this tool currently used by our clients is to create differential quality lots for the harvest. These lots will follow different wine making processes to produce different base wines that can then be assembled to achieve the targeted quality.
Since 2009, clients have started to use Oenoview maps as a basis for differential applications on crop inputs and report a saving of 30 % compared to their normal practice.

This service is able to deal with a wide range of on-demand remote sensing data. The development of an innovative processing chain and the mobilisation of a dedicated team enables Oenoview to deliver a high standard service to growers. This operational oriented development strategy was essential to ensure the service to be able to be provided abroad with local partners.

Keywords: Precision viticulture, Vineyard, Remote sensing …

INTRODUCTION

French agriculture appears to be a privileged context for the application of precision agriculture tools. During the emergence of site-specific management concepts, in 1996, the major European space company EADS Astrium, the French technical agronomic institutes (Arvalis for cereals, Cetiom for oil seed rape and ITB for sugar-beet) and French agronomic research institute (INRA) started a research partnership on remote-sensing based precision agriculture. As a result, after many years of research efforts (1996-2000) and worldwide ground validation (2000-2001), the Farmstar service was successfully launched in 2002.

Farmstar is a remote sensing based decision-support tool for precision agriculture (Coquil and Bordes, 2005). It aims at providing the farmer with cropping recommendations at both field and within-field scales. After 7 years of commercial campaigns, Farmstar is now the leader remote sensing management tool for agriculture in France, with over 10 000 farms and 410 000 hectares.

Infoterra, with this strong experience of an operational service looked for partners in other fields of agriculture to expend this type of service to other crops.

In 2006, the Institut Coopératif du Vin (ICV) from Montpellier tried to develop decision-support tool to help the vine growers in a better management of their crops and identified Infoterra as a key partner in this project.

From this partnership between Infoterra and the ICV group, was born Oenoview, an operational service based on remote sensing to guide and help the vine grower to take production decisions during the growing season.

The objectives of this paper are (i) to present the Oenoview service, and (ii) to present the different constraints and specificities of proposing a commercial precision viticulture oriented solution at a national or international scale.

MATERIAL AND METHODS

Principle

Oenoview is based on the analysis of remotely sensed data. The approach of our system involves two steps. The first step is the production of biophysical parameters, essentially the Green Cover Fraction (GCV) without any field measurements. After geometric correction, biophysical parameters of the crop canopy are extracted from reflectance data using a Crop Canopy Reflectance Model (CCRM).

The second part is to build, based on the GCV maps and according to the targets and limits of the grower, strategic recommendations to help him manage the different aspects of his production.

The CCRM involves a generic model of the leaf reflectance (PROSPECT, Jacquemoud and Baret, 1990), coupled with a canopy reflectance model (SAIL, Verhoef, 1984). An atmospheric correction is added using the MODTRAN model. More details can be found in Poilvé and Aubert (1998) and Blondlot *et al.* (2005). As a result, different parameters can be extracted with this method. However, regarding vineyards, one parameter is the most interesting: the Green Cover Fraction (GCV).
This part of the process is a key point because it allows us to obtain very well calibrated and very robust relations between reflectance and biophysical parameters of the crops (Blondlot et al., 2005). Those steps are led within a fully automated software named Overland™ (©Infoterra, 2008).

Data sources

Remotely-sensed data

The processing chain is build around the Overland™ environment, which was developed to be a multisensor system. The processing chain is therefore able to ingest images from different sensors. As a result, Oenoview uses images from the SPOT 5, FORMOSAT 2 sensors and airborne multispectral images in specific cases (Tbl. 1).

Sensors	Nb. of spectral bands	Ground resolution (m) using a pan-sharpening method.	Sensor swath (km)	Access capabilities
SPOT 5	4	2,5	3 × 2 × 60	1-2 days
FORMOSAT2	4	2	24	Daily *(within satellite corridors)*

Tbl. 1Characteristics of the main sensors available under Overland™ and used by Oenoview.

The choice of the resolution has been a very important issue in this project. A lot of projects done in the past on vineyards used a very high resolution, around 20 to 50 cm. But after the first year of experimentation we chose to use a high resolution, which is between 2 and 2, 5 m. This is for two main reasons:

- This resolution allows us to mask the row effect and shows more clearly the homogeneous zones that can be operationally managed. This is crucial because we want the service to be used in real conditions.

- This resolution induces a cost reduction and allows the service to be affordable by a large number of growers and to have a positive return on investments for them even on medium range wines.

Ground and background data

In order to produce recommendations, field information is needed at each step of the product generation. To configure the biophysical model within Overland™, the single information that is needed is the crop type and the phase of the crop cycle (common information to all fields of the same crop within a given region).

To build the final recommendation, more information is required. As explained later, the Oenoview products are used to manage crop inputs and harvest qualities. Both types of recommendation need ground and background information.
By ground information we mean, vine density, presence of grass between the rows, vine trellising system, type of variety (red or white), varieties... This gives the consultant a good interpretation of the vegetation development shown on the maps because, for instance, a same vegetation development can be due to a large number of leaves on the vine or grass on the ground.

By background information we mean all the information about the target of the grower in terms of wine quality, wine type, winemaking process used, size and number of tanks available to manage different lots...

Technical challenges

Oenoview aims at providing vine growers with technical recommendations based on remote sensing data at a large scale as it addresses potentially the whole world market. The commercial scale of the service induces very specific constraints.

Data collection

If the type of image source is not a problem for the processing chain, a point has to be stressed: the very strong need of pictures at a precise time of the year.
In this case the capacity of the image provider to insure the availability of pictures during a precise period of time is crucial. In the case of Oenoview, a strong partnership between Infoterra and the Spot Image group plays a key role. Spot Image being able to task the satellites on specific zones during a precise period of time can provide Infoterra with high resolution (both spatial and spectral) images at the period required by the specific crop development of the year. Nevertheless, if the data acquisitions in the northern zones of France in winter, dedicated to wheat monitoring are sometime hard to get, summer images of vineyards are far less dependent on weather conditions.

As specified above, ground and background data are also needed to complete the recommendations. This data collection is for the moment based on an email system but this is certainly a point to improve as the service will expend on a larger scale. Like any decision support tool, we know that the quality of the input information is a key factor in the quality of the output product.

Date of acquisition.

Besides spatial resolution, date of data acquisition is a very important parameter to set. As on other crops, the first target was to give the grower information at the right period to take the best decision possible. In the vineyard the most strategic operation is obviously the harvest. It was therefore decided to create recommendations that would be used for the harvest management. As we always want to keep an operational approach in the project, we had to take into account the logistics needed to prepare the harvest. As this operation requires a large amount of human resources for sampling, organising the team etc., the product had to be delivered as early as possible in order to give the vineyard manager time to organise his work. With this target and knowing that the spatial distribution of the plant growth will change throughout the season and the question to answer was: how early can we produce a map that accurately represents the in-field variation at harvest time. After many trials, the conclusion was that a picture taken between 20 days before veraison and veraison shows, with very good accuracy, what should be the spatial structure of the difference, in plant growth, at harvest.

Data costs

Grown from a research and development stage to an industrial sized service means that the service has to be economically sustainable. To insure the economical balance, the main costs must be identified. In our case, the need of very high resolution multispectral images within a specific period of time is the most significant cost of the service. To take into account this fact, a pricing strategy has been built to encourage the growers to concentrate the subscribed fields within a single zone in order to increase the concentration in a specific picture. As the two satellites used have different footprints (3000 km2 or 570 km2), the choice of the satellite is also a way to optimise the cost of the images.

Organisation of the service

Operational structure of the service

The Oenoview service is operated in France by two partners, Infoterra and the ICV group. Infoterra is in charge of the remote sensing processing, operational production and user logistic support during the campaign. ICV group is in charge of the recommendation building and support to the client. As shown in the figure below the final distribution is operated either by the ICV group on its zone of operation either by local distributors.

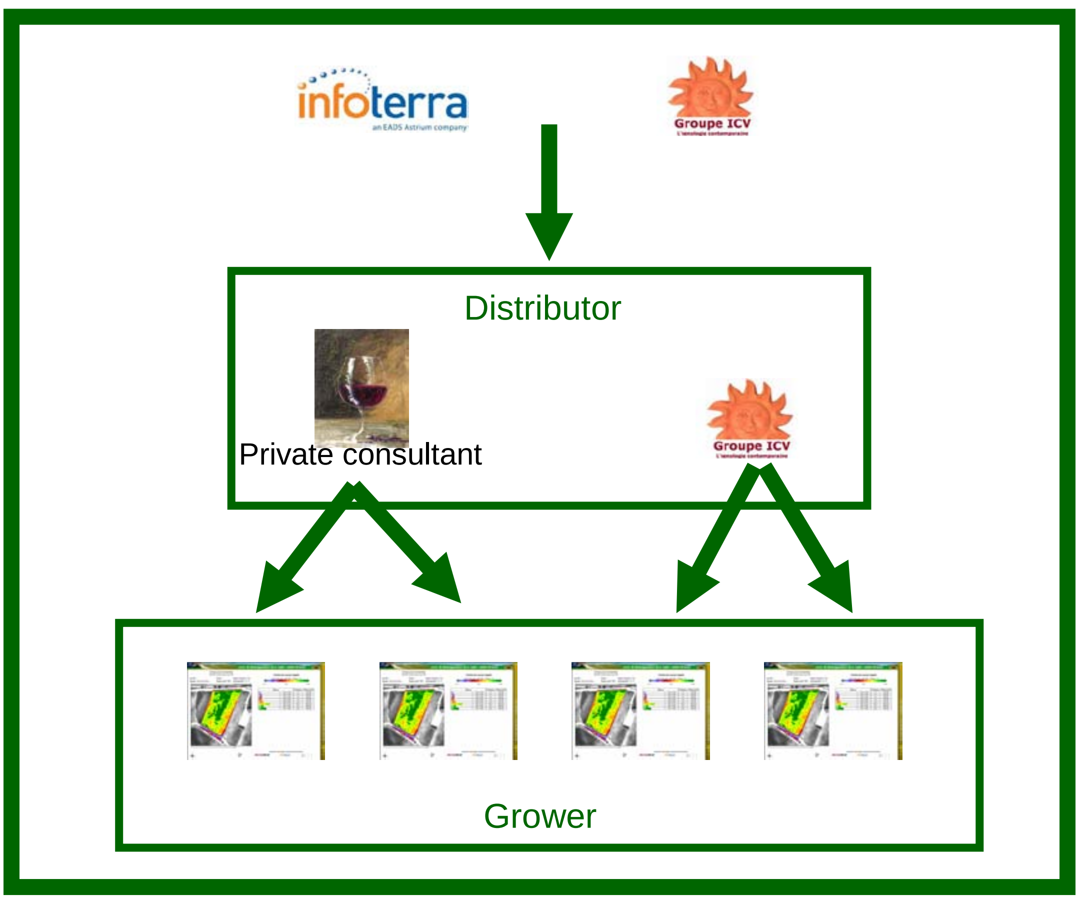

Fig. 2 The distribution concept.

Subscription phase

In this first period, all the data needed for the production has to be collected. The information is: the geographical reference of the field and the metadata associated to each particular field. This phase is crucial; as the quality of the database build during this period strongly influences the quality of the final recommendations.
Crops monitored in vines have very small sized field. In Farmstar the average cereal field is around 10 ha, in Oenoview, the average size of fields is around 1 ha. This stresses again the importance of the quality of the geo-database put in place before the campaign. Any mistake in the field delineation has strong consequences on the final product.

In order to help the grower to have a good geo-database of his fields, Infoterra can provide a 2,5m colour mosaics that can be used in any GIS available on the market.

RESULTS AND DISCUSSION

After this short presentation of the scientific principles, data used and operational constraints, we will present how the service has been designed to be successful.

The Oenoview service

As explain earlier, Oenoview is a decision support tool; it uses remote sensing based maps representing the vine vigour joined to expert recommendations. This service can be used by two types of use in two different ways. The first type of use is to work within the field in order to have different practices in different sub-field areas. The second type of use is to work at the inter-field level, to group different fields together in order to make homogeneous lots.

In-field products.

The product is, as explained before, representations of the vine status at an optimal growth stage, which is in our case, between berry touch and veraison.

The document is always built with the same principle. On the left part, a map represents the geographic distribution of the information within the field (in our case GCV). Above the map, general information on the fields are displayed (name, acreage, variety) but also two very important values, that are the average GCV and the heterogeneity index. On the right part, a table presents the values according to the different colours (absolute value of the parameter, % of area covered by this value and total acreage covered by this value).

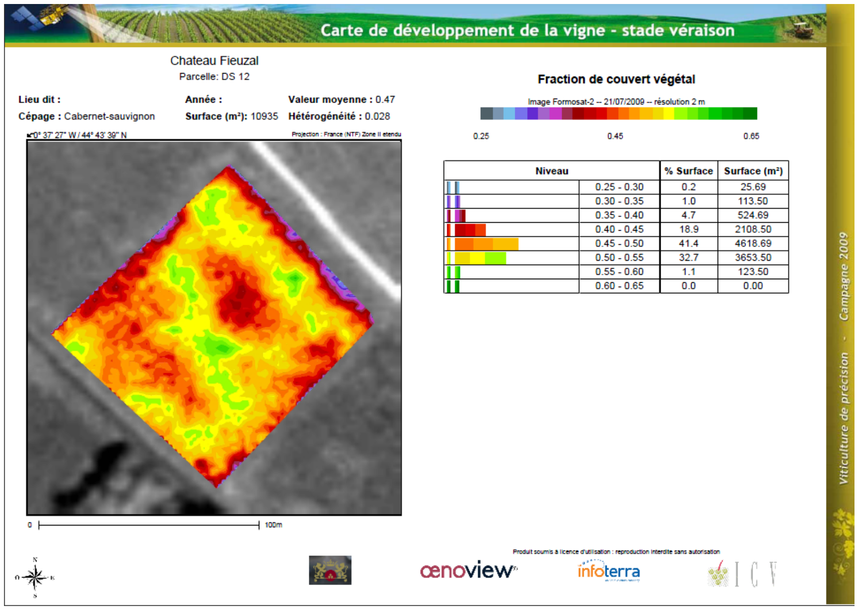

Fig. 3 An example of in-field product

This type of product is currently used in three domains, input management, pruning/trimming etc. and finally harvests management.

On the input management side, the maps representing the vine vigour are currently used to adapt the pesticide dosage according to the leaf area and to adapt the fertilisation rate according to the need of the plants, leading to a possible reduction by 30 % of some inputs in heterogeneous vineyards.

During the winter and the spring following the service, the grower can decide to try and reduce the level of heterogeneity of his field working with differential practices in different management sub-field zones. Trimming, for example can be augmented in a very vigorous zone of a specific field.

Finally, at harvest time, the in-field maps can be used to operate a differential harvest. This is the part of the service the most used today by our French growers. As physiologic and organoleptic characteristics of the grapes are linked to our GCV parameter, the grower often chooses to separate the harvest in different lots according to the map. It appears very clearly that zones with high GCV will have bigger berries, vegetal aroma, thicker berry skins and astringency (Fig. 4). On the other hand, in the zones with lower GCV, we will find smaller berries, more fruit aromas, thinner berry skins and far less astringent.

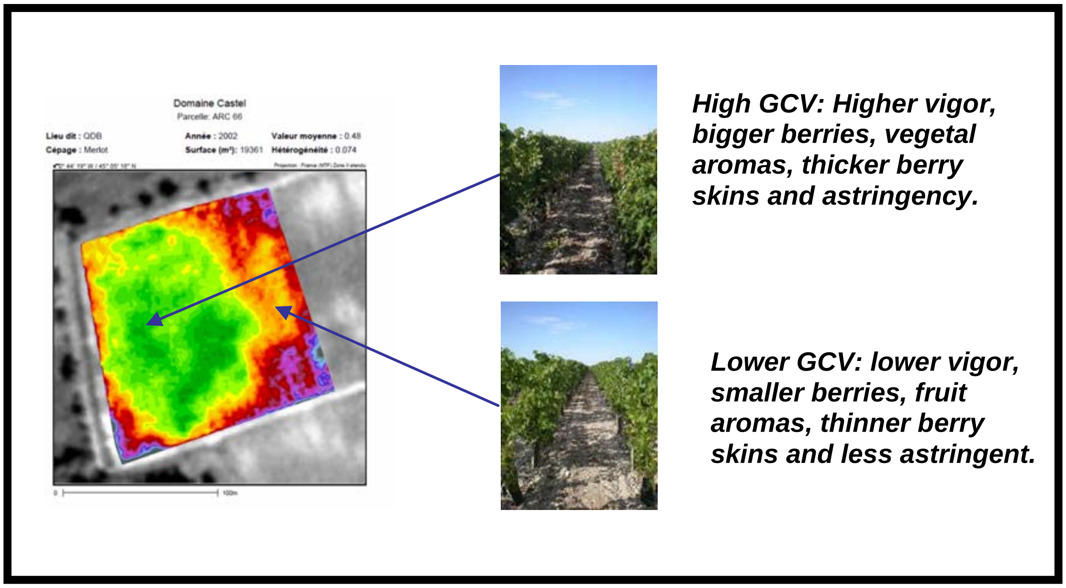

Fig. 4 Relationships between the GCV parameter and the grape characteristics

At present time, a lot of users separate the harvest in order to apply different vinification methods. Typically, they apply longer maceration to the low GCV lots. We have now non-experimental wines made this way by our clients showing very impressive differences.

Inter field and lot making.

Some of our clients have some different issues to solve in their business. These clients are often bigger and have to manage a large number of fields. Their problem is not to harvest parts of fields but to choose which fields can be mixed together in order to optimise the potential of the grapes available.

The starting point of this strategy is that the level of heterogeneity in the leaf development of a field will increase the uncertainty about the optimal harvest date. This is shown on the table below (Fig. 5) where we can see that the standard deviation in the sugar content of the lot 1 composed by “homogeneous” fields is far lower than in the lot 2 composed of “heterogeneous” field.

LOT1

	03/09/2007	CODEVIGNE	POIDS APPORT KG	DEGRE APPORT
TH08-030907		5785027	3621	14,1
		5785027	1454	14,3
		17063	5268	14,7
		17063	4404	14,6
		5065012	1400	14,7
		5850031	3529	13,5
		17039	3814	14,3
somme et moyenne			23489	14,3

LOT2

	03/09/2008	CODEVIGNE	POIDS APPORT KG	DEGRE APPORT
TH19-030907		1260022	3875	13
		1260022	2532	13
		4315028	580	15,1
		5850001	1749	14,7
		3250003	4149	14,7
		6530001	1240	14,1
		6530001	1380	13,7
		6915037	1280	14,3
somme et moyenne			16786	13,9

Fig. 5 Extract of at harvest analysis for lot comparison.

Knowing this, the challenge now for the user, is to create lots from fields that can be mixed together. Due to the large number of fields (several hundreds to a thousand), and to the limited availability of human resources to scout the fields, remote sensing is a necessary tool to achieve this goal.

In order to address the user’s issues, a specific heterogeneity index was developed based on a statistical analysis (average and standard deviation) which also takes into account the spatial distribution of the GCV values in the field (Fig. 6). This index and the vigor are used to quickly sort the fields in three groups: homogeneous, heterogeneous and abnormal fields.

Using the geo-database built before the campaign and the GCV maps produced from the image processing, the heterogeneity index is generated for each field. Based on this data, the ICV experts create different lots of fields. The homogeneous and heterogeneous fields are sorted at the delivery in order to be grouped in separate tanks. After 3 years of experimentation at an industrial level in a cooperative winery of the Fitou area in France (Vignerons du Mont Tauch), it was shown that homogeneous vineyards with a medium vigor level of red varieties (Merlot, Grenache, Carignan) produced, with traditional maceration process, wines with fruity jammy aromas, and a good mouth feeling with smooth tannins. With the same wine process, heterogeneous vineyards or vineyards with excessively high or low vigor, would produce wines with rather fresh fruit and vegetal aromas, and a tendency to dryness and astringency. These grapes are more adapted to heating wine processes. The winery could organize the selection of 350 ha of vineyards –over 650 fields -, known as basic quality vineyards, meaning 50 % of Carignan vineyard of this sector, with Oenoview. The technical staff of the winery had formerly no time to visit these fields for field assessment. With Oenoview, the winery could organize the selection of each vineyard according to 2 wine processes, and improve the segmentation of wine quality according to market requirements.
The human resources can then focus on premium vineyards and improve the quality of bench marking using Oenoview GCV maps.

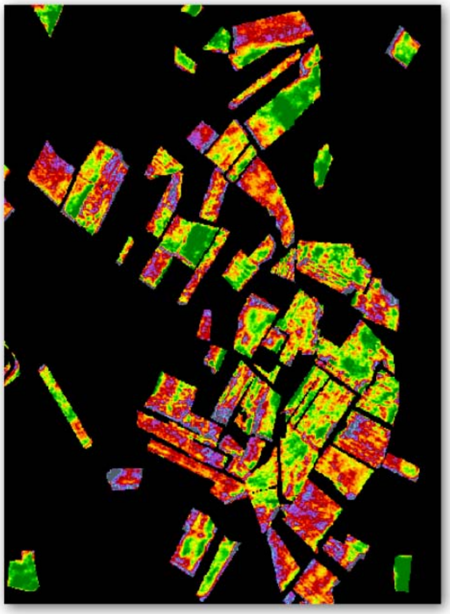

Fig. 6 Global view of field heterogeneity in term of vine vigor.

As a result, among the large quantity of fields available to produce standard wines, several of them are now identified as potentially usable to produce premium wine. Taking into account the price difference between a standard and a premium wine, the economical return in obvious.

Discussion

Environmental care and quality management: the double target.

In a global context of growing environmental issues, Oenoview should also be considered on the input management tool point of view.

Using the same tool, the grower has not only access to a tool allowing him to improve his wine quality and therefore his revenue but also by using the recommendations to optimize the vine inputs to reduce their costs and environmental footprint. It is interesting to stress that, in this case, the cost of the “quality management tool” and the cost of the “input optimisation” are not added but that the two targets are sharing the same cost.

User-oriented recommendations

In our case the first specific dimension of the service, is to be a truly decision support tool and a scientific remote sensing product. This objective has been developed in two ways. The first is to have a product "user oriented". The reflectance pictures, after processing, are converted into a packaged product with understandable parameters. In our case the link between the vine leaf development and the characteristics of the grapes is obvious for the growers, as they have been using this indicator for a long time. But now they are able to spatialize the data and obtain the equivalent of an important number of samples which are: one for each pixel, one every 4 sqm or one for every 2 to 4 individual vines. The second way is by the strong relationship with the ICV group that allows us to translate remote sensing data into agronomical values. This strong partnership is giving us a strong agronomical know-how and at the same time a link with the field reality that guaranties the accuracy of the recommendations.

An operational service of precision viticulture

As a conclusion, Oenoview is now a stable and operationam tool used by clients using the service during their decision making process. The typology of the user is very wide and goes from the French cooperatives to the Medoc Grand cru. As we analyse the way the growers use the product today, we can say that we are only at the beginning and that the use of such a tool will take more and more place in the future of viticulture.

PERSPECTIVES

The commercial development of Oenoview was possible because of an important R&D program of the two companies, with a strong cooperation with agronomic research (Sup'Agro Montpellier, CEMAGREF and INRA in a collaborative research program, Vinnotec, supported by the French government, The European Union and the Languedoc-Roussillon region via Qualimed). This is a good illustration of the fundamental role that innovation has to play in the industrialisation of precision agriculture (McBratney *et al.*, 2005), and more generally in the scope of the application of new technologies to agriculture (Cox, 2002).

Oenoview is just reaching the industrialisation step, but the research and development process still goes on, and covers two different objectives. The first objective is to improve the existing services: improvement of the models of the architecture system in order to standardize the GCV values on discontinuous covers such as vineyards, which ever the row width or the row orientation or the trellising system, and the integration of new sensors within the processing chain (*e.g.* SENTINEL-2, Kompsat). The second objective is to propose new products. Actual users are now starting to work with these new tools and discover the potential of the use of remote sensing. There is a lot of demand for new products dedicated to specific issues (nitrogen management, disease monitoring, dead vines counting...). Besides, research effort focuses on making decision support methodologies adaptable to the industrial constraints of Oenoview, e.g. management zone delineation (Roudier *et al.*, 2007).

REFERENCES

Blondlot, A., Gate, P. and Poilvé, H. 2005. Providing operational nitrogen recommendations to farmers using satellite imagery. p. 345-352. *In* Precision Agriculture’05: Proceedings of the 5th European Conference on Precision Agriculture (Ed. J.V. Stafford). Uppsala, Sweden. Wageningen Academic Publishers, Netherlands.

Coquil, B. and Bordes, J.-P. 2005. Farmstar: an efficient decision support tool for near real time crop management from satellite images. p. 873-880 *In* Precision Agriculture’05: Proceedings of the 5th European Conference on Precision Agriculture (Ed. J.V. Stafford). Uppsala, Sweden. Wageningen Academic Publishers, Netherlands.

Cox, S. 2002. Information technology: the global key to precision agriculture and sustainability. Computers and Electronics in Agriculture. 36, p. 93-111.

Jacquemoud, S. and Baret, F. 1990. PROSPECT: A model of leaf optical properties spectra. Remote Sensing of Environment. 34, p. 75-91.

McBratney, A.B., Whelan, B., Ancev, T. and Bouma, J. 2005. Future directions of precision agriculture. Precision Agriculture. 6, p. 7-23.

Poilvé, H. and Aubert, P.H. 1998. Remote sensing for precision soil and crop management. *In* Proceedings of the International Fertilizer Society. No. 420, 20p., ISBN 0-85310-054-3.

Poilvé, H. and Coquil, B. 2003. Farmstar: a commercial remote sensing service to agriculture. *In* IGARSS’03: Proceedings of the IEEE International Geoscience and Remote Sensing Symposium. Toulouse, France.

Roudier, P., Tisseyre, B., Poilvé, H. and Roger, J-M. 2007. Management zone delineation based on remotely-sensed data. p. 625-632 *In* Precision Agriculture’07: Proceedings of the 6th European Conference on Precision Agriculture (Ed. J.V. Stafford). Skiathos, Greece. Wageningen Academic Publishers, Netherlands.

Verhoef, W. 1984. Light scattering by leaf layers with application to canopy reflectance modeling: the SAIL model. Remote Sensing of Environment. 16, p. 25-141.