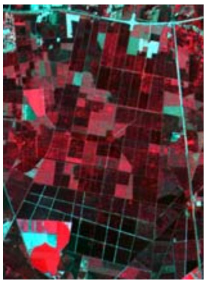
GROUND DATA PROCESSING & PRODUCTION OF THE LEVEL 1 HIGH RESOLUTION MAPS



VALERI 2000

Nezer site
(pine forest)

Philippe Rossello

June 2007

CONTENTS

1. Introduction

This report describes the production of the high resolution, level 1, biophysical variable maps for the Nezer site in 2000 (see campaign report for more details about the site and the ground measurement campaign: annex or http://www.avignon.inra.fr/valeri). Level 1 map corresponds to the map derived from the determination of a transfer function between reflectance values of the SPOT image acquired during (or around) the ground campaign and biophysical variable measurements (LAI2000 in this case).

The derived biophysical variable maps are:

- Leaf Area Index (LAI): LAI corresponds to effective LAI derived from the description of the gap fraction as a function of the view zenith angle;
- cover fraction (fCover): it is the percentage of soil covered by vegetation between 0° and 7° view zenith angle.

The land cover is mainly composed of maritime pines (forest). The site is "nearly flat" (for more information, see annex or campaign report: http://www.avignon.inra.fr/valeri).

The site coordinates are described in Table 1:

	France Zone III sud, Nouvelle Triangulation Française IGN (units = meters)		Geographic Lat/Lon, WGS-84 (units = degrees)		UTM 30 North, WGS-84 (units = meters)	
	Easting	Northing	Lat.	Lon.	Easting	Northing
Upper left corner	327985.3300	263008.9000	44.61608792	-1.09179174	651397.3609	4942075.0969
Lower right corner	336025.3300	251968.9000	44.51978005	-0.98495945	660137.6256	4931581.1166
Center	332005.3300	257488.9000	44.56794674	-1.03833189	655767.4801	4936828.2008

Table 1. Description of the site coordinates: they correspond to SPOT image coordinates.

2. Available data

2.1. SPOT Image

The SPOT image was acquired the 20th July 2000 by HRVIR2 on SPOT4 while the ground measurements were carried out from 22th June 2005 to 8th August 2000. The initial projection is France Zone III sud, Nouvelle Triangulation Française IGN (please, refer to the campaign report for more details: annex or http://www.avignon.inra.fr/valeri). The image was geo-located by SPOT image (SPOTViewBasic product, precision 2B). The atmospheric correction[1] was performed by INRA CSE. Note that a SPOT image acquired the 1st August 2000 was available, but no data is available to perform an atmospheric correction. Moreover, the results of the multiple robust regression between ESUs reflectance (TOA) and the considered biophysical variable were not better.

Figure 1 shows the relationship between Red and near infrared (NIR) SPOT channels: the soil line is well marked and no saturated points are observed.

[1]Aerosol optical thickness: AOT_550 nm = 0.2156 (EUROFLUX/INRA); water vapor content (gcm-2,): 1.29 cm-1 (ARPEGE); ozone content (atmcm-1): 0.3 atm.cm (TOVS/NOAA); air Pressure: 1017 hPa (ARPEGE).

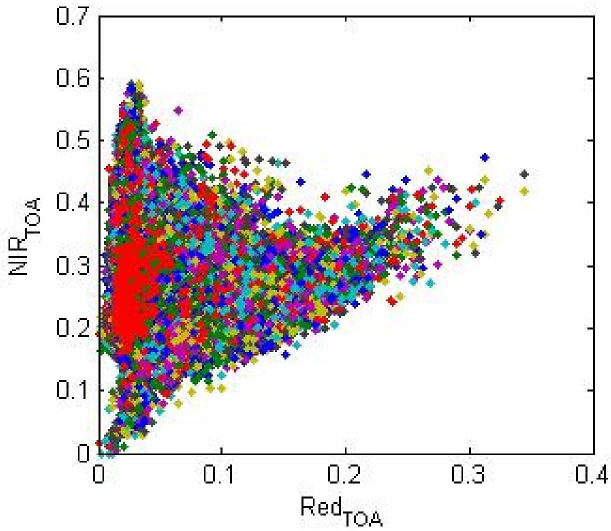


Figure 1. Red/NIR relationship on the SPOT image for Nezer, 2000.

2.2. LAI2000 measurements

For each Elementary Sampling Unit (ESU), the biophysical variables (LAI, fCover) were derived from LAI2000 instrument. **Although we are interested in the whole leaf area index[2] in the VALERI context, the understorey was not always taken into account at the time of the measurement campaign: only young stands and clear cutted areas both tree crowns and understorey** (please, refer to the campaign report for more details: annex or http://www.avignon.inra.fr/valeri). Therefore, the ESU biophysical variables that are used in the following were computed as:

- LAI = LAI_canopy or LAI = LAI_canopy + LAI_ground for young stands and clear cutted areas;
- fCover is the percentage of soil covered by vegetation at 7° view zenith angle (ground level).

Figure 2 shows the distribution of the different measured variables over the sampled ESUs. LAI varies from 0.68 to 3.34 and fCover from 0.08 to 0.87. This range shows a heterogeneous site in terms of LAI. To build the relationships between biophysical variables and SPOT data, the reflectance of a given forest ESU was considered as the average reflectance over the central pixel + the 8 surrounding pixels.

[2] LAI = LAI_canopy + LAI_ground

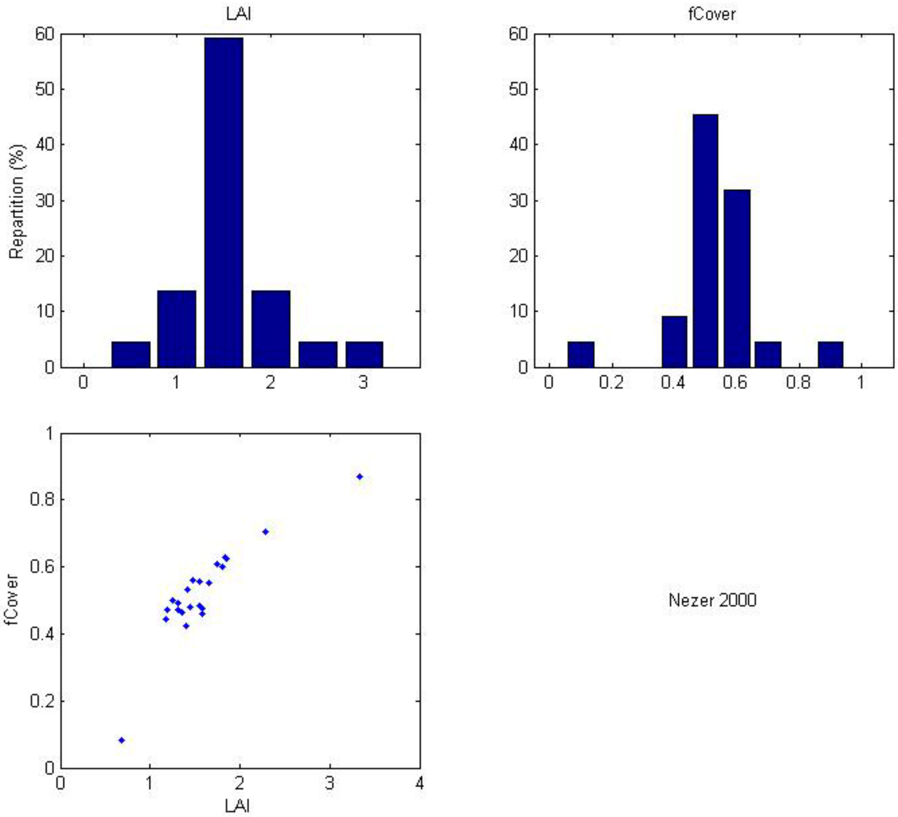


Figure 2. Distribution of the measured biophysical variables over the ESUs.

2.3. Sampling strategy

2.3.1. Principles

The sampling strategy is defined in the campaign report: http://www.avignon.inra.fr/valeri. Figure 3 shows that the 23 ESUs are evenly distributed over the site (8 x 11 km), even if the number of sampled ESUs is insufficient compared with the size of Nezer site: only 23 ESUs whereas the size of study area is 8 x 11 km. Therefore, the representativeness of the ESUs is not optimal at the scale of the site (§2.3.4). The sampling of the forest was privileged to the detriment of the bare soil and the open fields. Note that the sampling strategy was reviewed in 2001 and 2002. Indeed, this first campaign in 2000 made possible to improve the following sampling strategies.

The processing of the ground data has shown that:

- considering that SPOT geo-location and GPS measurements are associated to errors, we found that processed LAI for ESUs E72, E181 and E191 did not correspond to the SPOT pixels in terms of reflectance as compared to the knowledge of the land use: it has been shifted by 1 or 2 pixels;
- E582b was located on a small plot with a strong heterogeneity on the borders and it was very close to E582a. This ESU was eliminated.

Finally, the 22 ESUs have been kept for the computation of the transfer function.

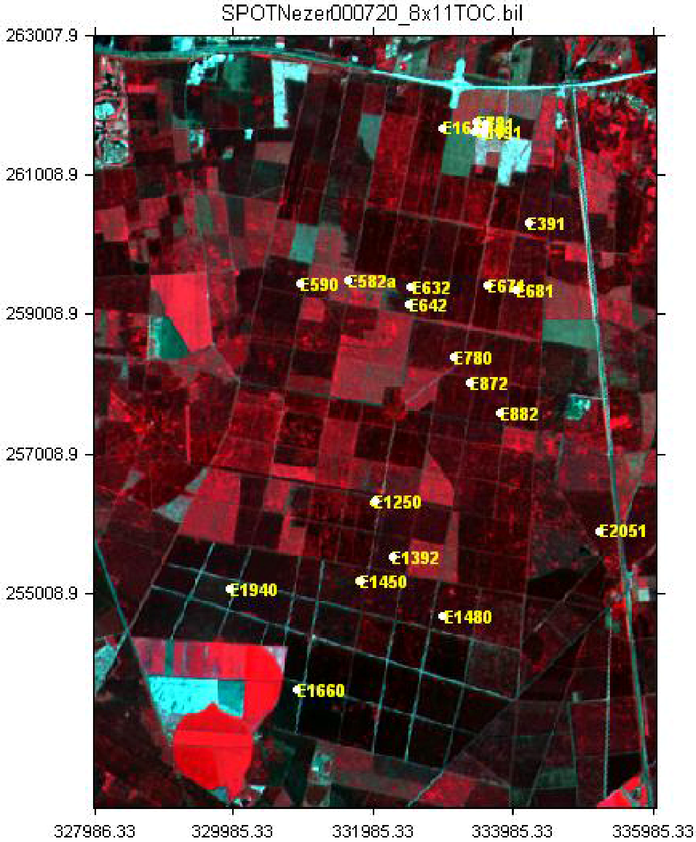


Figure 3. Distribution of the ESUs around the Nezer site.

2.3.2. Evaluation based on NDVI values

The sampling strategy was evaluated using the SPOT image by comparing the NDVI distribution over the site with the NDVI distribution over the ESUs (Figure 4). As the number of pixels is drastically different for the ESU and whole site (WS = 220000 in case of a 8 x 11 km SPOT image at 20 m resolution), it is not statistically consistent to directly compare the two NDVI histograms. Therefore, the proposed technique consists in comparing the NDVI cumulative frequency of the two distributions by a Monte-Carlo procedure which aims at comparing the actual frequency to randomly shifted sampling patterns. It consists in:

1. computing the cumulative frequency of the N pixel NDVI that correspond to the exact ESU locations;
2. then, applying a unique random translation to the sampling design (modulo the size of the image);
3. computing the cumulative frequency of NDVI on the randomly shifted sampling design;
4. repeating steps 2 and 3, 199 times with 199 different random translation vectors.

This provides a total population of $N = 199 + 1$(actual) cumulative frequency on which a statistical test at acceptance probability $1 - \alpha = 95\%$ is applied: for a given NDVI level, if the actual ESU density function is between two limits defined by the $N\alpha / 2 = 5$ highest and lowest values of the 200 cumulative frequencies, the hypothesis assuming that WS and ESU NDVI distributions are equivalent is accepted, otherwise it is rejected.

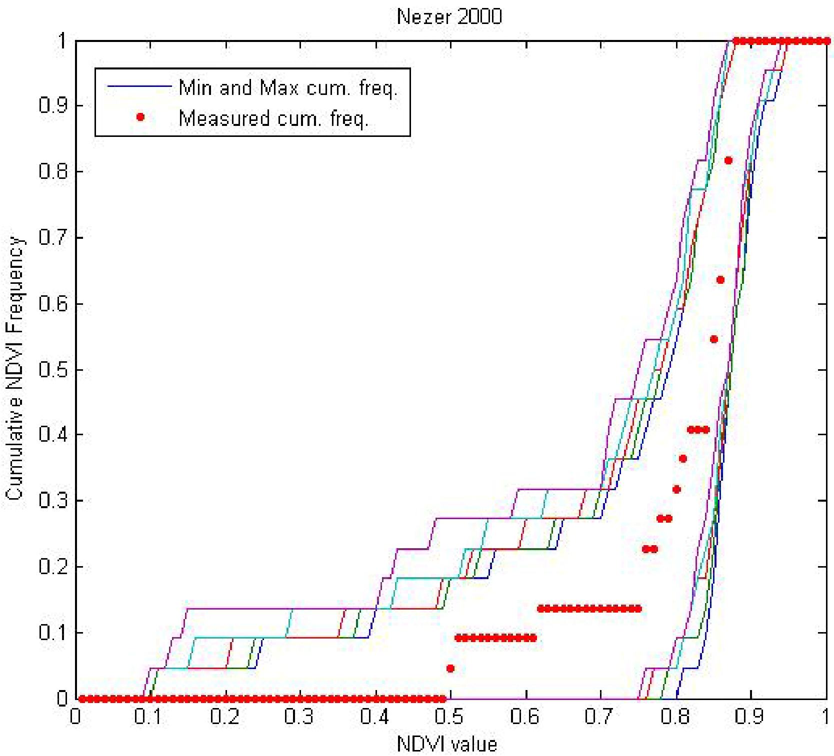


Figure 4. Comparison of the ESU NDVI distribution and the NDVI distribution over the whole image.

Figure 4 shows that the NDVI distribution of the 22 ESUs is good as compared to the NDVI distribution over the whole site since the 'ESU' curve is inside the 'boundary curves'. Note that NDVIs lower than 0.50 (bare soil, crops, paths, clear cutted areas…) and higher than 0.88 have not been sampled although they are present in the image. The site is heterogeneous in terms of NDVI values.

2.3.3. Evaluation based on classification

A non supervised classification based on the k_means method (Matlab statistics toolbox) was applied to the reflectance of the SPOT image to distinguish if different behaviours on the image for the biophysical variable-reflectance relationship exist.

A number of 3 classes was chosen (Figure 5). The distribution of the classes on the image and on the ESUs is rather similar: classes 1 and 3 are under-represented while class 2 appears to be over-sampled.

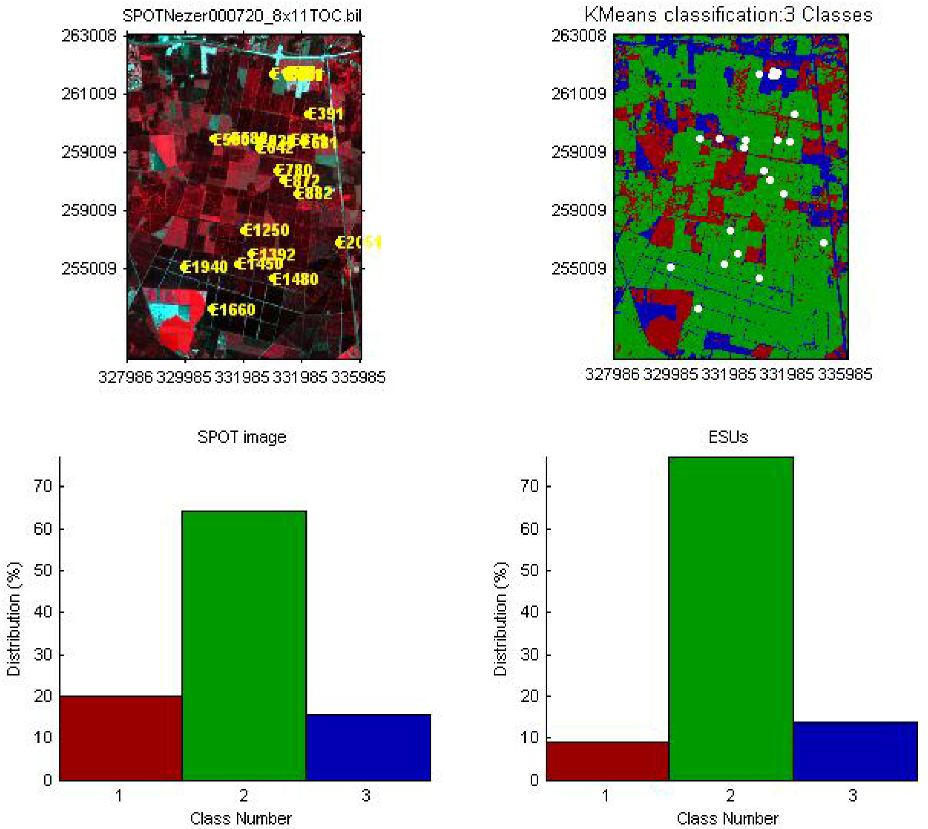


Figure 5. Classification of the SPOT image. Comparison of the class distribution between the SPOT image and sampled ESUs.

Figure 6 shows the different relationships observed between the biophysical variables and the corresponding NDVI on the ESUs, as a function of the SPOT classes determined from non supervised classification.

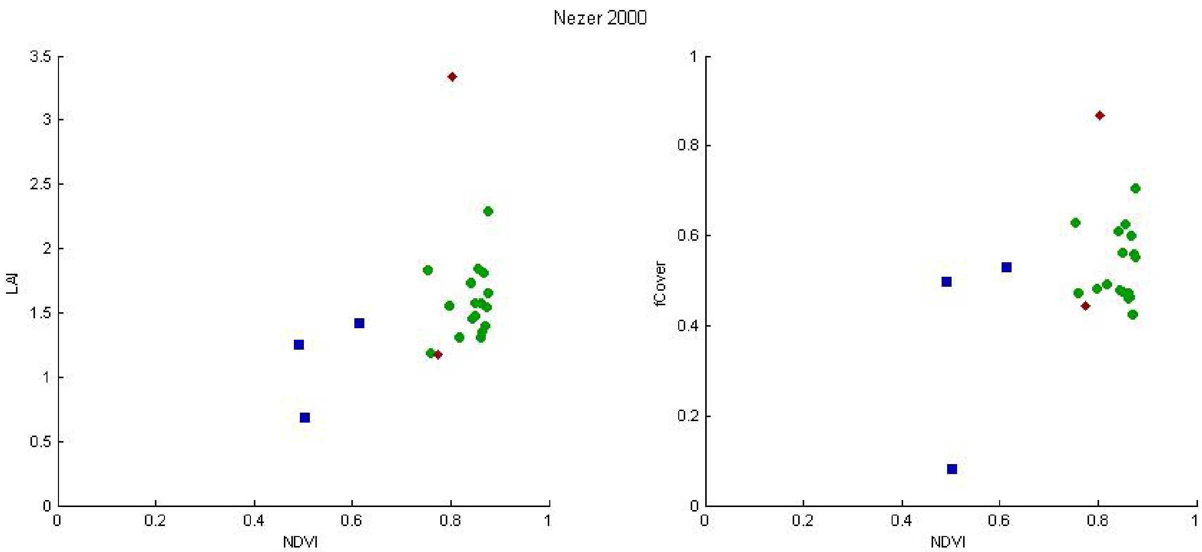


Figure 6. NDVI-Biophysical Variable relationships as a function of SPOT classes

The relationships between the biophysical variables and NDVI is not very good. As the understorey is not taken account[3] (except for young stands and clear cutted areas), the biophysical variable values are certainly underestimated in forest (class 2). The behaviour of classes 1 and 3 is also in question. Several NDVI values are

[3] Please, read campaign report for more details: annex or http://www.avignon.inra.fr/valeri

relatively high while biophysical variable values are low (E181, E582a). Note also that only two or three ESUs represent the classes 1 and 3. The sampling is mainly performed in forest. However, a single transfer functions was generated (§3.2.1).

2.3.4. Using convex hulls

A test based on the convex hulls was also carried out to characterize the representativeness of ESUs. Whereas the evaluation based on NDVI values uses two bands (red and NIR), this test uses the four bands of the SPOT image. A flag image, is computing over the reflectances (Figure 7). The result on convex-hulls can be interpreted as:

- pixels inside the 'strict convex-hull': a convex-hull is computed using all the SPOT reflectance corresponding to the ESUs belonging to the class. These pixels are well represented by the ground sampling and therefore, when applying a transfer function the degree of confidence in the results will be quite high, since the transfer function will be used as an interpolator;
- pixels inside the 'large convex-hull': a convex-hull is computed using all the reflectance combination (±5% in relative value) corresponding to the ESUs. For these pixels, the degree of confidence in the obtained results will be quite good, since the transfer function is used as an extrapolator (but not far from interpolator);
- pixels outside the two convex-hulls: this means that for these pixels, the transfer function will behave as an extrapolator which makes the results less reliable. However, having a priori information on the site may help to evaluate the extrapolation capacities of the transfer function.

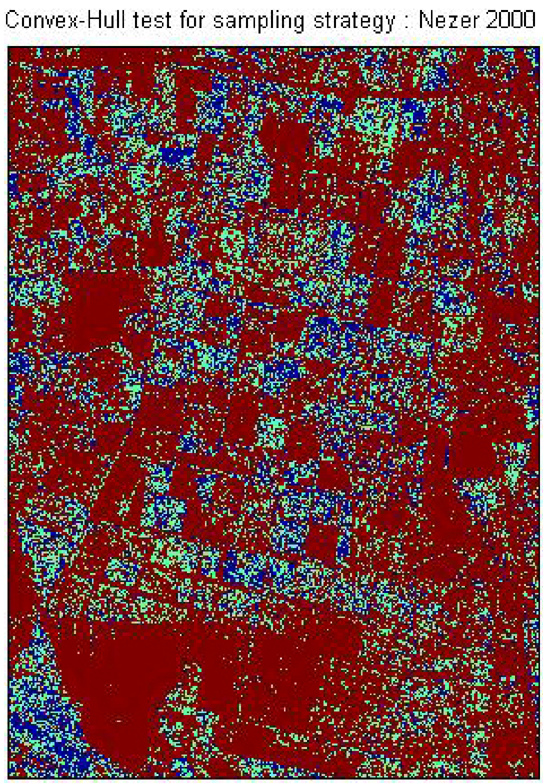


Figure 7. Evaluation of the sampling based on the convex hulls. The map is shown at the bottom: blue and light blue correspond to the pixels belonging to the 'strict' and 'large' convex hulls and red to the pixels for which the transfer function is extrapolating.

This map shows that the representativeness of the ESUs is not satisfactory since many pixels are outside the two convex-hulls. They correspond to bare soil, roads, agricultural fields, forest… The following ranges of NDVI values were not sampled: <0.50, between 0.52 and 0.61, between 0.63 and 0.70 and >0.88. The sampling is thus insufficient even if the evaluation based on NDVI values is good (§2.3.2).

3. Determination of the transfer function for the two biophysical variables: LAI, fCover

3.1. The transfer function considered

Two types of transfer functions are usually tested in the frame of the VALERI project:

- AVE: if the number of ESUs belonging to the class is too low. The transfer function consists only in attributing the average value of the biophysical variable measured on the class to each pixel of the SPOT image belonging to the class;

- REG: if the number of ESUs is sufficient, multiple robust regression between ESUs reflectance (or Simple Ratio) and the considered biophysical variable can be applied: we used the 'robustfit' function from the Matlab statistics toolbox. It uses an iteratively re-weighted least squares algorithm, with the weights at each iteration computed by applying the bisquare function to the residuals from the previous iteration. This algorithm provides lower weight to ESUs that do not fit well. The results are less sensitive to outliers in the data as compared with ordinary least squares regression. At the end of the processing, three errors are computed: classical root mean square error (RMSE), weighted RMSE (using the weights attributed to each ESU) and cross-validation RMSE (leave-one-out method).

For all the classes, the 'REG' function is tested using either the reflectance or the logarithm of the reflectance for any band combination as well as the simple ratio or NDVI. As the method has poor extrapolation capacities, a flag image, based on the convex hulls is computing over reflectances.

3.2. Results

3.2.1. Choice of the method

For all the ESUs, a single transfer function was computed. Figure 8 shows the results obtained for all the possible band combinations using either the reflectance (ρ) or the logarithm of the reflectance (log(ρ)): the results using the reflectance were selected for LAI and fCover since they are better.

The Red*NIR ('+' or RN) combination is added to all the band combinations (except NDVI and SR). Please read the document (http://www.avignon.inra.fr/valeri/table_methods/new_linear.pdf): "A method to improve the relation between the biophysical variables".

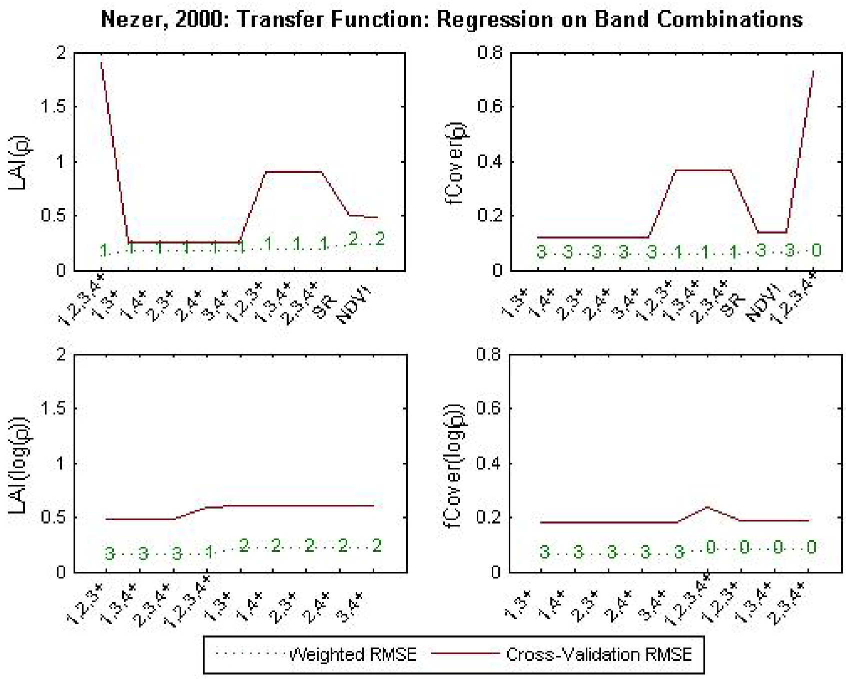


Figure 8. Transfer function: test of multiple regression applied on different band combinations. Band combinations are given in abscissa. The estimated biophysical variable is given in ordinate. Top graphs correspond to regression made on reflectance (ρ): the weighted root mean square error (RMSE) is presented in green along with the cross-validation RMSE in red. The numbers indicate the number of data used for the robust regression with a weight lower than 0.7 that could be considered as outliers. Bottom graphs correspond to regression made on the logarithm of the reflectance.

3.2.2. Choice of the band combination

For LAI, the XS3, XS4, RN (Figure 9 and Figure 10) combination on reflectance was selected since it provides a good compromise between the cross-validation RMSE (lowest value), the RMSE (among the lowest values) and the weighted RMSE. Note that one weight is lower than 0.7. The following band combinations provide the same results: [XS1, XS3, RN]; [XS1, XS4, RN]; [XS2, XS3, RN]; [XS2, XS4, RN].

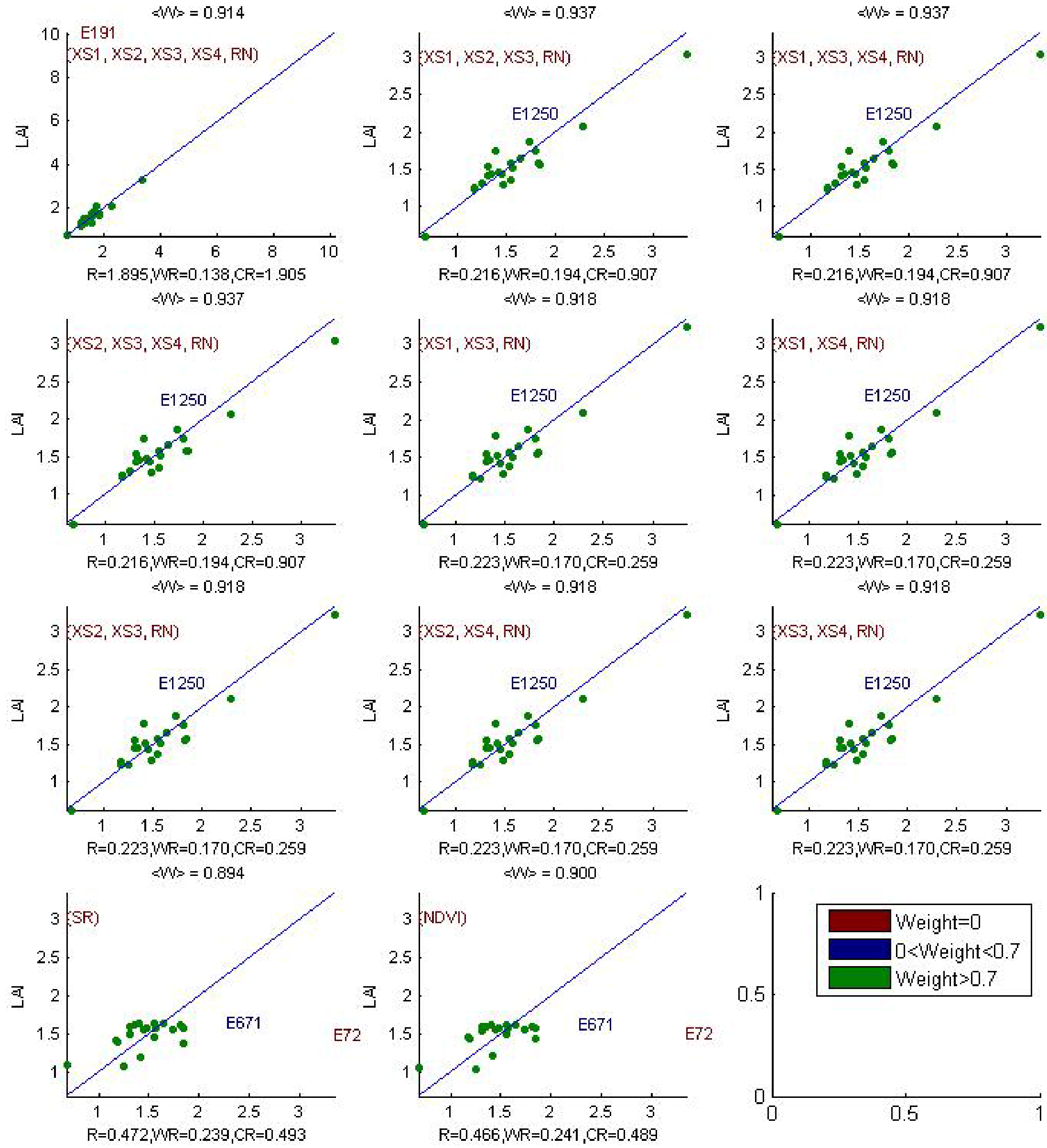


Figure 9. Leaf Area Index: results for regression on reflectance using different band combinations. R is the root mean square error computed between LAIeff and estimated LAIeff. WR is the weighted root mean square error and CR is the cross validation root mean square error.

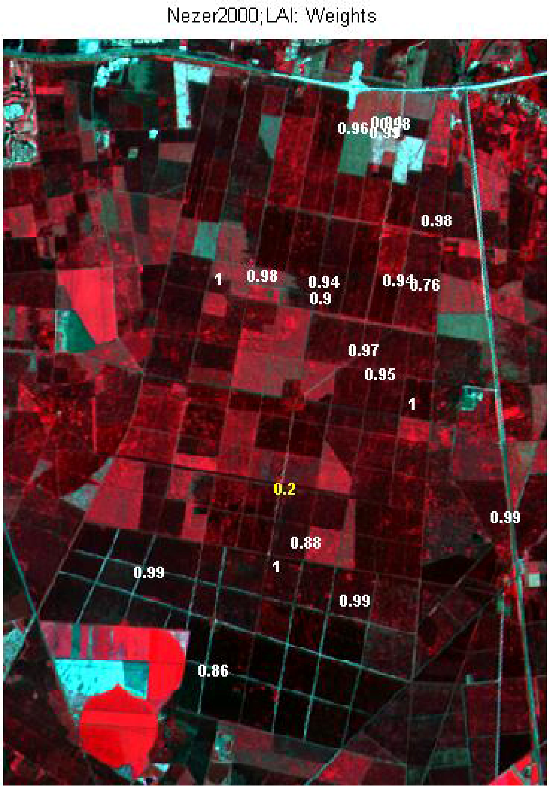


Figure 10. Weights associated to each ESU for the determination of LAI transfer function.

For fCover, the XS3, XS4, RN (Figure 11 and Figure 12) combination on reflectance was selected since it provides the best results. Note that two weights are lower than 0.7 and one weight is equal to zero. The following band combinations provide the same results: [XS1, XS3, RN]; [XS1, XS4, RN]; [XS2, XS3, RN]; [XS2, XS4, RN].

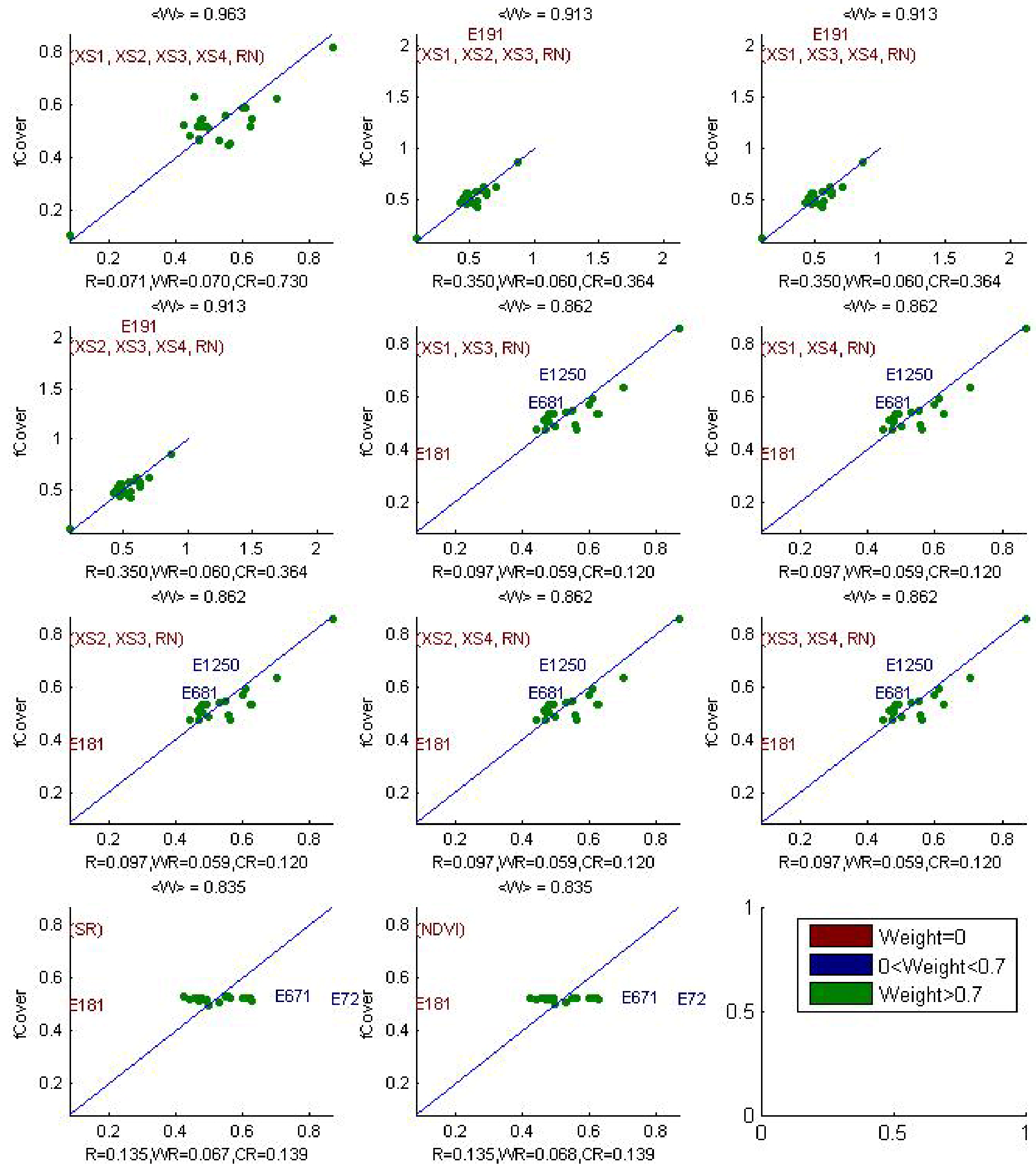


Figure 11. fCover: results for regression on reflectance using different band combinations. R is the root mean square error computed between LAItrue and estimated LAItrue. WR is the weighted root mean square error and CR is the cross validation root mean square error.

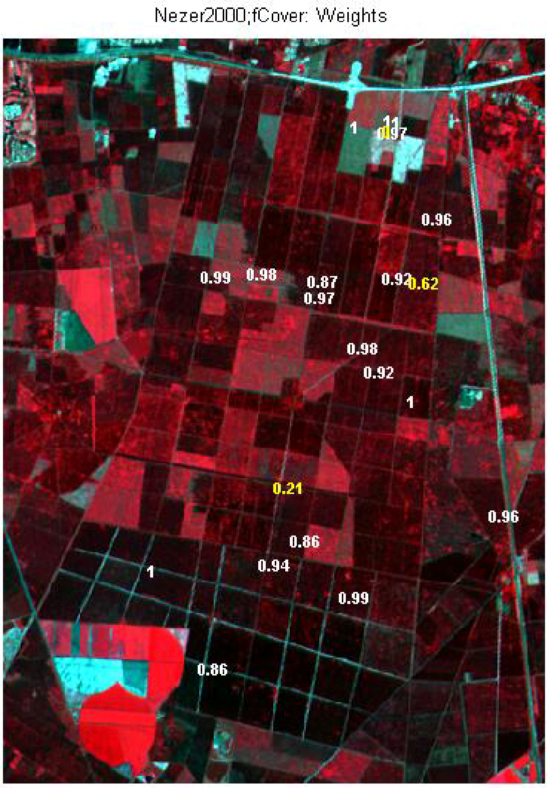


Figure 12. Weights associated to each ESU for the determination of fCover transfer function.

Following, the results of the transfer function (Table 2):

Variable	Band Combination	RMSE	Weighted RMSE	Cross-valid RMSE
LAI	4.4889 - 223.4194(XS3) + 29.8664(XS4) + 405.8838(RN)	0.223	0.170	0.259
fCover	1.1002 - 44.2618(XS3) + 7.1087(XS4) + 77.781(RN)	0.097	0.059	0.120

RN = Red*NIR

Table 2. Transfer function applied to the whole site for the different biophysical variables, and corresponding errors

3.3. Applying the transfer function to the Nezer SPOT image extraction

Figure 13 presents the biophysical variable maps obtained with the transfer function described in Table 2 for the classes 1, 2 and 3. The maps obtained for the two variables are consistent, showing similar patterns: low LAI values where low fCover are observed and conversely… Note that estimated LAI values were higher than 25. As the NDVI values corresponding to ground measurements on the Nezer site were between 0.50 and 0.88, the multi-linear regression is valid only for NDVI ranging between these two values. The extrapolation capacity of this relationship may not be good in certain conditions. Indeed, when applying the relationship on pixels in the image (at the scale of the site: 351 pixels, 0.15%), the regression provides unrealistic results such as extremely high values of LAI. We have no indication in the image and no knowledge of the ground cover which could explain bad regression results. The maximum measured LAI was attributed to these pixels (LAI = 3.5).

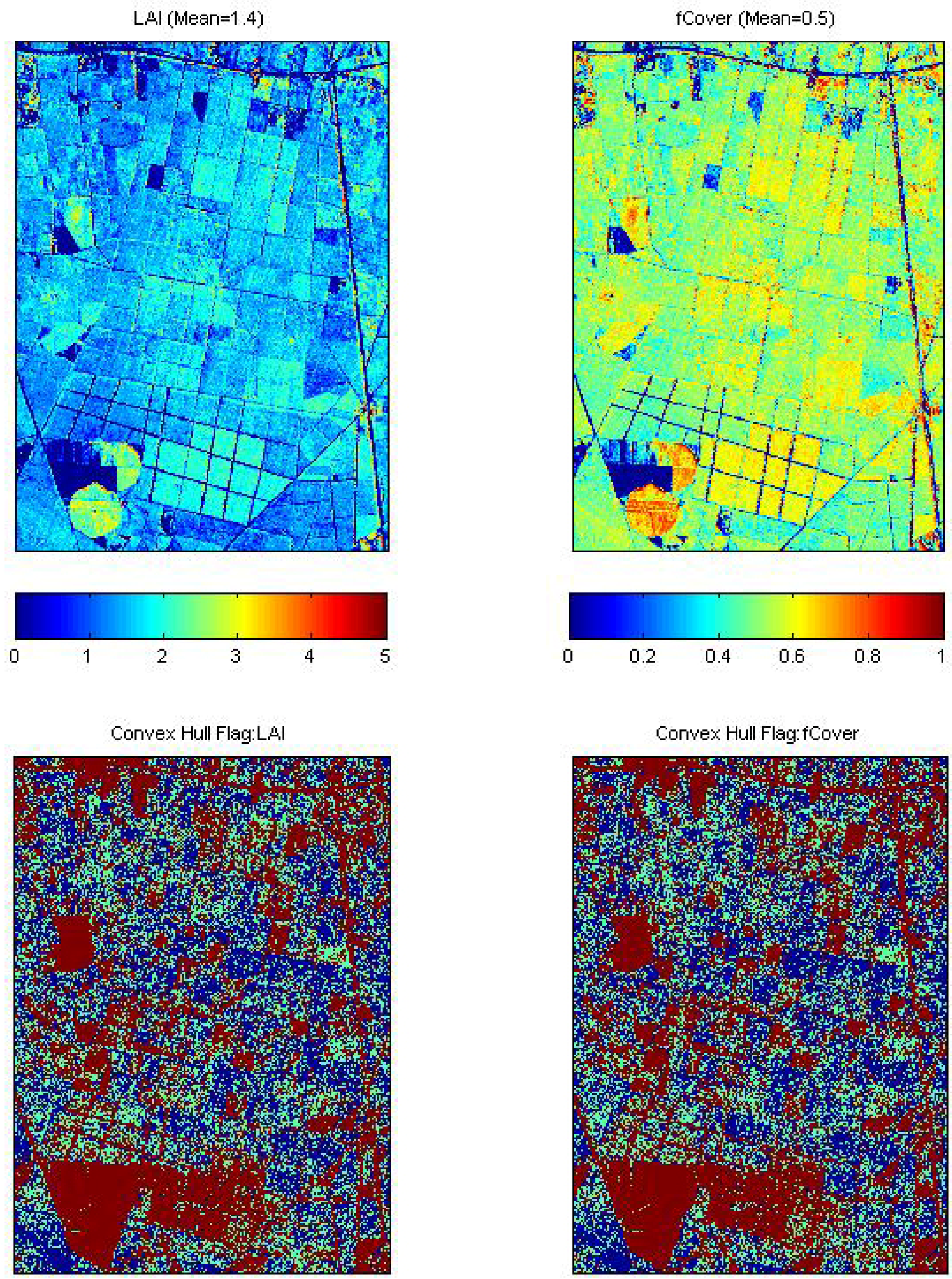


Figure 13. High resolution biophysical variable maps applied on the Nezer site (top). Associated Flags are shown at the bottom: blue and light blue correspond to the pixels belonging to the 'strict' and 'large' convex hulls, red to the pixels for which the transfer function is extrapolating.

The flag maps are comparable between LAI and fCover. The extrapolation corresponds to bare soil, roads, agricultural fields, but also forest areas… The representativeness of the land cover is in question (§2.3.2 and §2.3.4).

4. Conclusion

The 'REG' method is applied to the classes 1, 2 and 3 by using 22 ESUs. Note that the number of sampled ESUs is insufficient compared with the size of Nezer site. The representativeness of the land cover of the different ESUs is not optimal even if the evaluation based on classification or NDVI values is good. However, the results of the robust regression are satisfactory and the maps obtained for the biophysical variables are consistent. The flag associated to each map show that the extrapolation is mainly related to the problems of representativeness of the land cover. For all the variables, the regression coefficients are computed by relating the variable itself to reflectance (§3.2.1).

The biophysical variable maps are available in France Zone III Sud (datum: Nouvelle Triangulation Française).

5. Acknowledgements

We want to thank: Jean-Louis **Roujean**, Wim **Van Leeuwen**, Roselyne **Lacaze**, Laurent **Franchisteguy** and Karine **Belin** (Météo France, CNRM, Toulouse), Dominique **Guyon**, Gaston **Courrier**, Didier **Garrigou**, Jean-Pierre **Lagouarde**, Jean-Marc **Bonnefond**, Vincent **Rivalland**, Jérôme **Lejot**, Anne-Marie **Bouchon** (INRA Bioclimatologie, Bordeaux) for the organisation and participation to the campaign.

ANNEX

VALERI-2000 campaign in Nezer site (France)

17 July - 10 August 2000

Dominique GUYON

Participants :

► Dominique Guyon, Gaston Courrier, Didier Garrigou, Jean Pierre Lagouarde, Jean Marc Bonnefond, Vincent Rivalland, Jérôme Lejot, Anne Marie Bouchon (INRA Bioclimatologie, Bordeaux).

► Jean Louis Roujean, Wim Van Leeuwen, Roselyne Lacaze, Laurent Franchisteguy et Karine Belin (Météo France, CNRM, Toulouse).

1. INTRODUCTION

The VALERI-2000 campaign took place from 17 July to 10 August 2000 in the test site called NEZER. The objectives are to obtain LAI and cover fraction estimates at low spatial resolution (1km² for instance) for validating large swath satellite products.

The site is located in the Landes forest which covers about 1 million hectares in the South West of France and where maritime pine (*Pinus pinaster* Ait.) is the dominant species.

The measurement period corresponds to the end of the growth of trees and of understorey vegetation i.e. to the phenological stage when the green LAI is almost maximal.

2. LOCATION AND DESCRIPTION OF THE TEST SITE

The test site is included into a 8km * 11km grid whose co-ordinates are given in table 1.

	Geographic co-ordinates (geodesic system: WGS84) Longitude ; Latitude	LAMBERT III co-ordinates (geodesic system: NTF) Easting ; Northing
Upper left corner	1°05.15' W ; 44°37.20' N	328000 m ; 3263000 m
Lower right corner	0°59.45' W ; 44°34.14' N	336000 m ; 3252000 m

Table 1: Co-ordinates of the 8x11km grid

The grid area is covered in major part by large and homogeneous (even-aged trees) stands of maritime pine which are intensively managed. The remainder consists mainly of small deciduous wood lands, mosaics of small-sized stands of deciduous species or pine, large agricultural fields, urban and industrial areas, and unmanaged heath lands (see the land use map in figure 1).

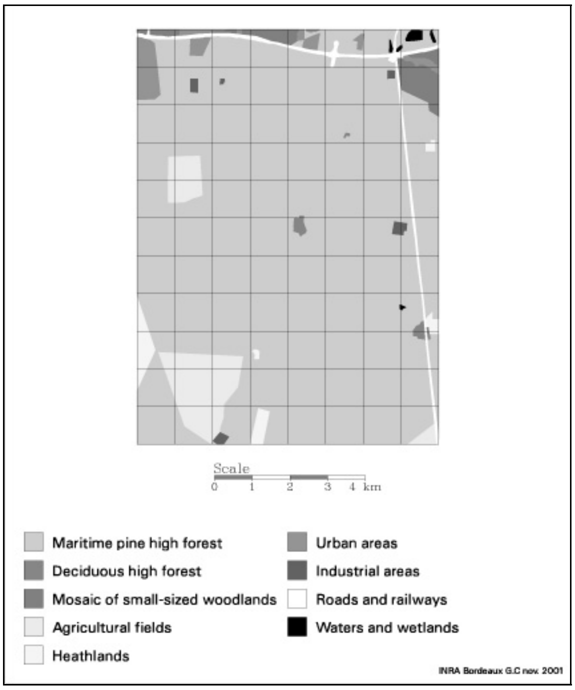


Figure 1: Land use map in 2000 (from aerial photographs and Spot images)

The Nezer site itself covers about 50 km² in the central part of the grid. It is a patchwork of large maritime pine stands whose mean size is about 500m x 500m and whose various stages of development are ranged from the sowing to the clear-cutting (at about 50 years). The forest structure is thus very heterogeneous at the scale of 1km²-units, where the proportion of surface not covered by trees, i.e. clear-cuts or young stands, ranges between 5% and 95% (Guyon et *al*., 2000).

The whole of maritime pine stands of the experimental site are described in geographic data base built by INRA (so-called INRA geographic data base), where age, some dendrometric characteristics and sylvicultural practices are given.

3. GROUND MEASUREMENTS OF LAI

- **Protocol of spatial sampling**

The big storm which occurred in December 1999 in France damaged many stands. Its consequences (windthrow, windbreakage, overgrowth of the understorey vegetation) have strongly constrained the sampling protocol and so did not make easy the ground measurements.

Information collected from the INRA geographic data base, aerial photographs at large scale (January 2000), SPOT images and ground observations about forest structure and accessibility is used then to optimise the spatial sampling.

- Selection and location of sampling plots

The sampled stands have been chosen in according of 5 criteria: (1) representativity of the distribution of age classes. The 5-to-15 years old stands are under-sampled because of their inaccessibility due to the overgrowth of the understorey. (2) size of the stand greater than 4 ha. The LAI estimation from LAI2000 instrument is indeed based on directional gap fraction measurements over a surface which can be very large. Its radius is roughly 3 times the canopy height. For instance the field of view of the sensor is about 120m for trees 20m high (3) regular spatial distribution in a grid of 1km² sub-areas (4) availability of forest data in the INRA database (5) accessibility.

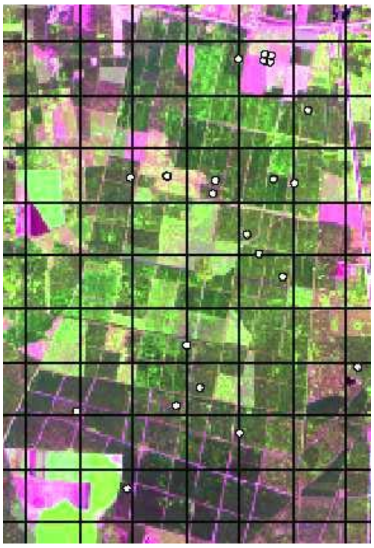


Figure 2: Location of sampling plots on the SPOT4 image (2000/08/01).
The scale is given by the 1km²-grid.

The geographical location of the centre of each plot is obtained from ground measurements of distance and from the INRA geographic database. It is given in LAMBERT3 map projection. We did not use GPS system.

- Plot size and location of measurement points within plot

Two protocols are defined in according to the age of the stand. The first corresponds to the clear-cuts and young stands with trees lower than undergrowth vegetation. The second corresponds to the other age classes. In the case of the oldest stands the LAI is measured only for trees storey after removal of the windfall trees and clearing of the understorey.

The sampling designs are conceived to limit bias due to the tree spatial distribution by rows (Table 2, Figures 3 and 4). The points location is not measured.

Age class	Plot			Measurement points within the plot			Strata
	size (m)	Distance to stand edge	number	sampling	Number	Repetition/ point	
Clear-cuts & Age < 5 years	20x20	≥40	6	Systematic(8 transects)	40	0	Understorey + trees
Age > 5 years	80*80	≥70	17	random	30	0	trees

Table 2: Plot size and sampling design within plots

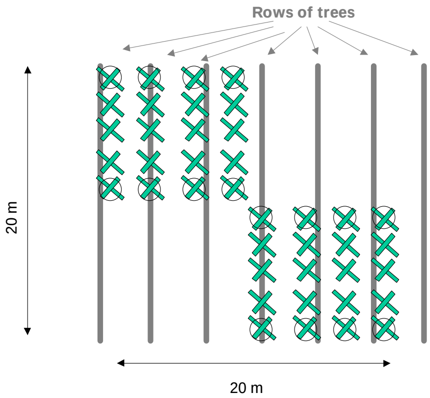


Figure 3: Sampling design (green crosses) within plot for young stands and clear-cuts.

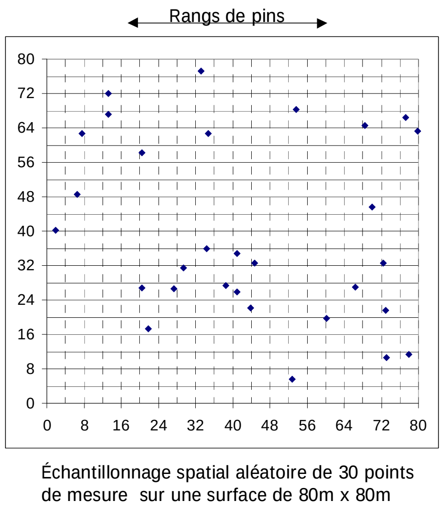


Figure 4: Sampling design within plot for stands older than 5 years.

- **Methods of measurement**

We have used LAI-2000 analysers (LI-COR Inc.) which provide gap fraction measurements in 5 classes of viewing direction. The zenith angles of each class are on average equal to 7, 23, 38, 53 and 68°.

Measurements are made in diffuse radiation conditions: clear sky at sunset or at sunrise when the sun is outside the field of view of the sensor (sun zenith angle >74°). They have been carried out between the 22th July and the 8th August.

Two methods are defined in according to the age of the trees:

- clear-cuts and young stands

Only one LAI-2000 system is used. The incoming illumination above the canopy is measured at the begin and at the end of each transect along trees rows (marked by circles in figure 3). The transmitted radiation below the canopy is measured at ground level under the understorey vegetation. The azimutal field of view of the sensor is reduced to 180° for hiding of the operator. The transects are covered with the sensor looking along the row.

- Stands older than 5 years

Two LAI-2000 systems are necessary. One is located in a large clear-cutted area and automatically records the incoming illumination above the canopy every 15 seconds. The other provides measurements below the pines canopy. Each sensor is horizontally set on a photographic tripod at shoulder height (about 1.5m). The azimutal sampling is total (360°). It is necessary to make measurement with uniform sky conditions, because the 2 sensors are often several kilometres apart. The method requires to calibrate the 2 sensors to each other.
We have used 3 analysers: only one (named VAL1) is used for remote measurements of incoming radiation, the 2 others (named VAL3 and UREFV) collect data below the canopy. Their calibration has been performed at the beginning of the VALERI experiment (17 and 24 July 2000) with clear sky conditions and for solar zenith angle greater than 82°. Results are given for each class of view zenith angle in figure 5.

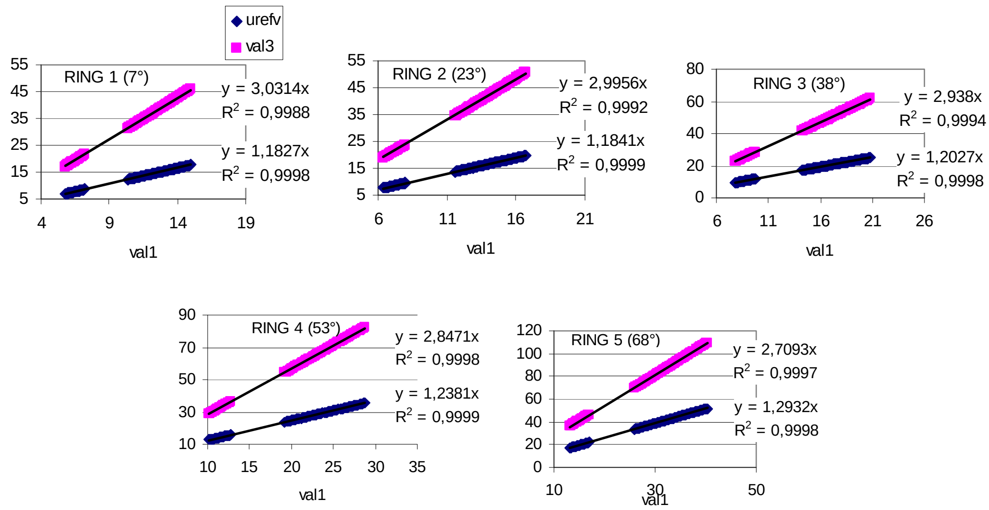


Figure 5: Inter-calibration of the 3 LAI-2000 sensors
VAL1 : serial number = PCH-0979
VAL3: serial number = PCH-1467
UREFV: serial number = PCH-0122

- **LAI estimation**

The LAI estimation from measurements of directional gap frequency assumes that the foliage is randomly distributed. We have ignored the clumping around stems and branches. The retrieved values correspond thus to the effective LAI. The computation is made with the C2000 software devoted to LAI2000 data processing.
The used radiation interception model and the inversion method are described in the report on VALERI-2000 campaign for Romilly site.

4. ATMOSPHERIC AND RADIATIVE FLUXES MEASUREMENTS

Various kinds of data have been measured at ground or collected for atmospheric correction of satellites data acquired during the campaign.

- Atmospheric transmission of direct sun radiation

Manual sunphotometer (CIMEL CE318) is used to estimate aerosol optical thickness with the Langley-Bouguer method (Wu et *al*., 1997). The atmospheric optical properties are measured at various wavelengths: 440, 670, 870, 936, 940 and 1020 nm. The instrument is set close by the BF2 instrument (see below).
Two types of measurements have been performed:

- for calibration of the Langley-Bouguer method: measurements are made from sunrise to sunset in conditions of clear sky and stable atmosphere. We have obtained satisfactory data sets for 3 days (days 202, 213, 222), except early in the morning because of haze or smoke plume coming from a neighbouring paper factory. The frequency of measurement depends on the sun zenith angle: from 2 minutes at beginning and at end of the day to 10 minutes at midday.

- for estimation of aerosols during acquisitions of SPOT satellites data : measurements are made between 10 to 12 UTH. Data have been recorded for 5 days.

- global and diffuse incoming radiation

An integrated sensor of photosynthetic active radiation (400-700nm) is set in a large clear-cutted area located in the central part of NEZER (331592m Easting, 3259485m Northing Lambert3). The instrument named BF2 (Delta-T Devices Ltd) is used to measure global and diffuse incoming radiation.

Measurements are recorded from 17 July to 10 August 2000 (figure 6). From 10 to 17 July the sampling frequency is equal to 10 minutes. After 17 July the measurements are made every 2s and averaged every 1 minute. In this case instantaneous data are not recorded.

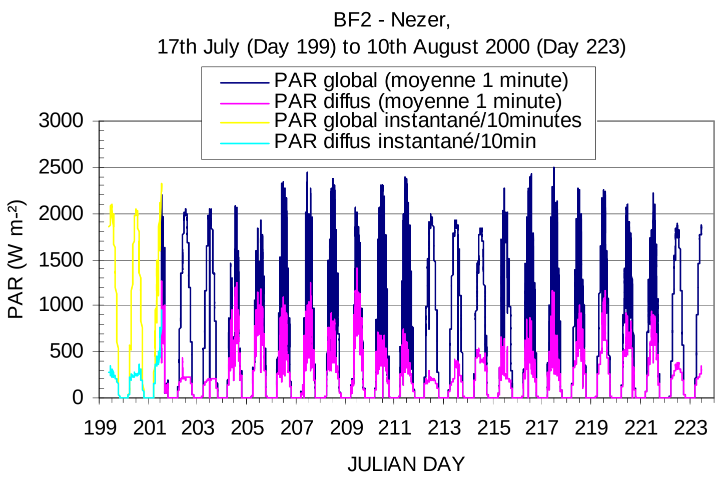


Figure 6: Incoming PAR measured from 17 July to 10 August 2000.

- Complementary atmospheric data are also provided by METEO-FRANCE: sea level pressure and vapour water content from the ARPEGE meteorological meso-scale model and ozone content from TOVS/NOAA measurements. They are complemented by ground-based measurements of sea level pressure on the EUROFLUX/INRA experimental site located at about 25km from Nezer.

5. SPOT IMAGES

Two SPOT4 multi-spectral images were acquired during the campaign: 20 July and 01 August 2000. They are georeferenced in the LAMBERT3 map projection from geometric corrections processed by SPOT IMAGE company.

We did not make any sun photometer measurement on the 1th August because of the variable weather.

6. DATA FILES DESCRIPTION

The data files are described in the file named *datafiles_description.txt*

7. CONCLUSION

The experiment lasted 3 weeks because of bad weather. Only 22 forest stands are been sampled in the 50km² study area. The main reasons of the low sampling are the following:

- LAI2000 measurements require uniform sky brightness. Blue sky conditions at the sunrise or at sunset were satisfactory for a little number of days. Conditions of uniform overcast sky have never been observed during any day of the period, except for rainy weather.
- dew or fog at morning have reduced the measurement capabilities.
- inaccessibility due to windstorm damages or high density of the understorey vegetation.

In the framework of VALERI the LAI2000 measurements should be performed at ground level, including both tree crowns and understorey. It is the case only for young stands and clear cutted areas. For the oldest stands data were acquired only for tree crowns, because of the presence of broken crowns or windfall trees on the ground or because of the difficulties to progress in the very tall and dense vegetation of the understorey.

For future VALERI experiments the sampling strategy should be reviewed. It is better that the size of plots and the number of measurement points per plot are not variable. The size of study area should be also reduced.

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