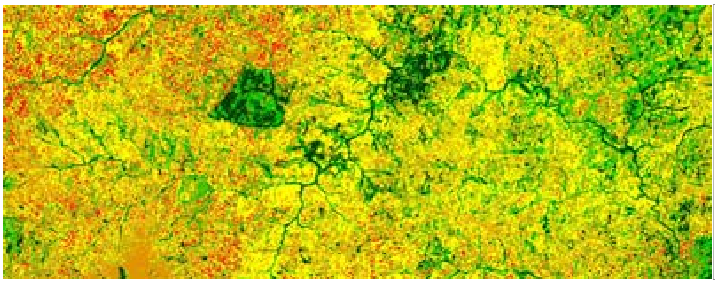
GROUND DATA PROCESSING & PRODUCTION OF THE LEVEL 1 HIGH RESOLUTION MAPS



VALERI 2005

Donga site
(grassland)

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CONTENTS

1. Introduction

This report describes the production of high resolution, level 1, biophysical variable maps for the Donga site in June 2005. Level 1 map corresponds to the map derived from the determination of a transfer function between reflectance values of the satellite image acquired during or around the ground campaign and biophysical variable measurements (hemispherical images).

Unfortunately, no high spatial resolution satellite image during or around the ground campaign was available for this site. Therefore, the biophysical variable maps are not produced from transfer functions using reflectance values of the high spatial resolution satellite image and ground measurements. More simple transfer functions are derived from a land cover map from 2005 which is based on a series of SPOT images provided by SPOT Image in the framework of the AMMA-API project.

For each Elementary Sampling Unit (ESU), the hemispherical images are processed using the CAN-EYE software (Version 4.2) developed at INRA-CSE. The derived biophysical variable maps are:

• four Leaf Area Index (LAI) are considered: effective LAI (LAIeff) and true LAI (LAItrue) derived from the measurement of the gap fraction as a function of the view zenith angle; effective LAI57 (LAI57eff) and true LAI57 (LAI57true) derived from the gap fraction at 57.5°, which is independent on leaf inclination. Effective LAI and effective LAI57 do not take into account clumping effect. LAItrue and LAI57true are derived using the method proposed by Lang and Xiang[1] (1986);

• cover fraction (fCover): it is the percentage of soil covered by vegetation. To improve the spatial sampling, fCover is computed over 0 to 10° zenith angle;

• fAPAR: it is the fraction of Absorbed Photosynthetically Active Radiation (PAR = 400-700nm). fAPAR is defined either instantaneously (for a given solar position) or integrated all over the day. Following a study based on radiative transfer model simulations, it has been shown that the root mean square error between instantaneous fAPAR computed every 30 minutes and the daily fAPAR is the lowest for instantaneous fAPAR at 10h00 AM (solar time, RMSE = 0.021). Therefore, the derivation of fAPAR from CAN-EYE corresponds to the instantaneous black sky fAPAR at 10h00 AM.

The Donga site corresponds to a mosaic of agricultural fields and natural vegetation including patches of wooded savannah and forests (generally gallery forests). The ground measurements were carried out the 20th and 21st of June 2005. The Donga site is 15 x 40 km with coordinates described in Table 1. The large size of this site as compared to the usual VALERI site size (3 x 3 km) is due to the fact that the measurements achieved will be used for other purpose than just validation within the AMMA framework:

	UTM 31, North WGS-84 (units = meters)		Geographic Lat/Lon WGS-84 (units = degrees)	
	Easting	Northing	Lat.	Lon.
Upper left corner	346000.0000	1088000.0000	9.83959444	1.59565000
Lower right corner	386020.0000	1072480.0000	9.70056187	1.96098514
Center	366010.0000	1080240.0000	9.77013132	1.77835012

Table 1. Description of the site coordinates.

2. Available data

2.1. Land cover map

The land cover map of 2005 (Figure 1) is derived from "a series of SPOT images provided by SPOT Image, following an agreement between SPOT Image and INSU (Institut National des Sciences de l'Univers) in the framework of the AMMA-API project". The projection is UTM 31, North, WGS-84. Spatial sampling is 20 m.

Six classes characterize the land cover (Figure 1). Note that 63% of the Donga site is covered by fallows:

- class 1 (brown): bare soil/urban (9%)
- class 2 (red): crops (6.6%)
- class 3 (yellow): young fallow/herbaceous (38%)

[1] Lang, A.R.G. and Xiang, Y., 1986. Estimation of leaf area index from transmission of direct sunlight in discontinuous canopies. Agric. For. Meteorol., 37: 229-243.

- class 4 (khaki): old fallow/shrub savanna (25.3%)
- class 5 (light green): wooded savanna (12.9%)
- class 6 (dark green): dense forest/gallery forest (8.2%)

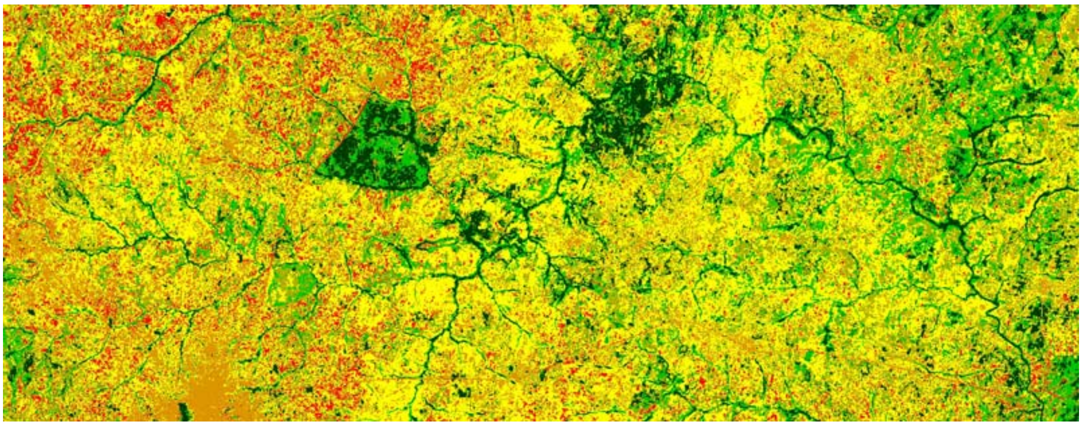

Figure 1. Land cover map, Donga site, 2005.

2.2. Hemispherical images

The hemispherical images are processed using the CAN-EYE software (Version 4.2) to derive the biophysical variables. Figure 2 and Figure 3 show the distribution of the several variables over the 97 sampled ESUs. The hemispherical images are acquired from above the understorey and from below the canopy (trees). Biophysical variables correspond thus to the whole canopy, combining understorey (downward) and overstorey (upward) measurements. The two sets of acquisition are processed separately to derive LAI (effective and true), LAI57 (effective and true), fCover, and fAPAR. The ESU biophysical variable is then computed as:

- LAIeff, LAI57eff, LAItrue, LAI57true: LAI(above) + LAI(below).
- fCover: 1-(1-fCover(above))*(1-fCover(below)). This assumes independency between the gaps inside the understorey and those inside the trees which is not true at all the scales but it is the only way to get the total fCover. However, for the local scales considered, this might be true as a first order approximation.
- fAPAR: 1-(1-fAPAR(below))*(1-fAPAR(above)), since 1-fAPAR can be considered equivalent to a gap fraction. Here again, the same independency between the two layers has to be assumed.

Note that LAI (effective and true) derived from directional gap fraction and LAI derived from gap fraction at 57.5° (effective and true) are consistent (Figure 2 and Figure 3). Effective LAI (LAIeff, LAI57eff) varies from 0.01 to 3.92, while true LAI (LAItrue, LAI57true) varies from 0.01 to 7.51. The site is thus heterogeneous (Figure 2) in terms of LAI. LAIeff and LAI57eff are lower than LAItrue and LAI57true, due to the clumping observed for several ESUs. The relationship between fAPAR and LAI is in agreement with what is expected (Beer-Lambert law) while the fCover-LAI relationship is more noisy (Figure 3).

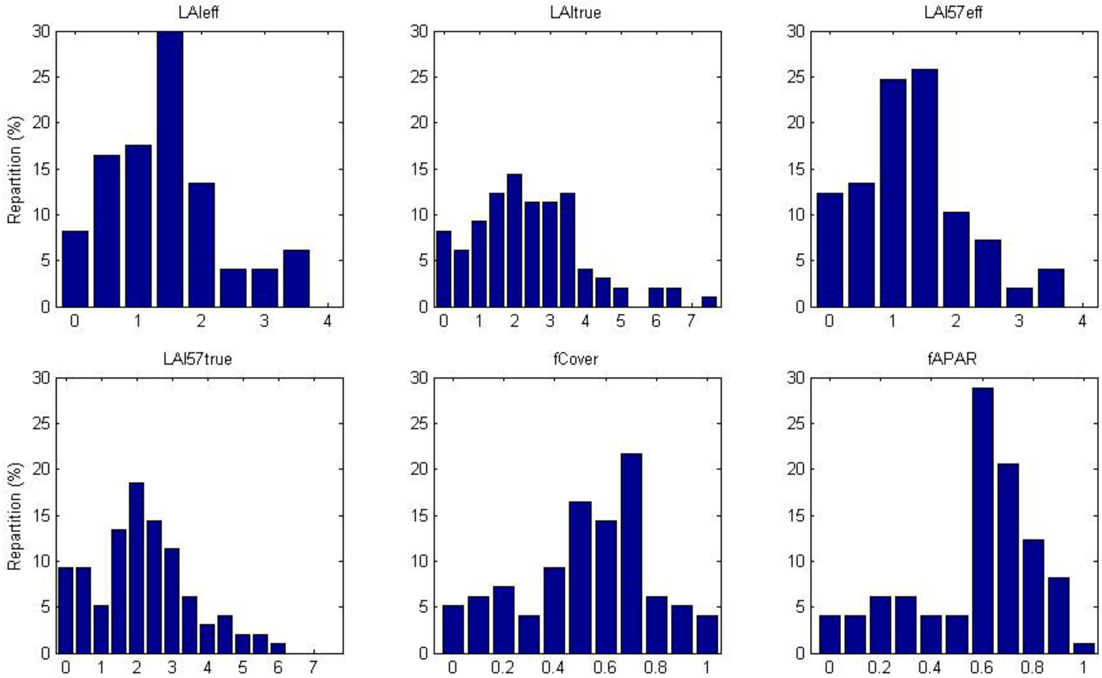

Figure 2. Distribution of the measured biophysical variables over the ESUs.

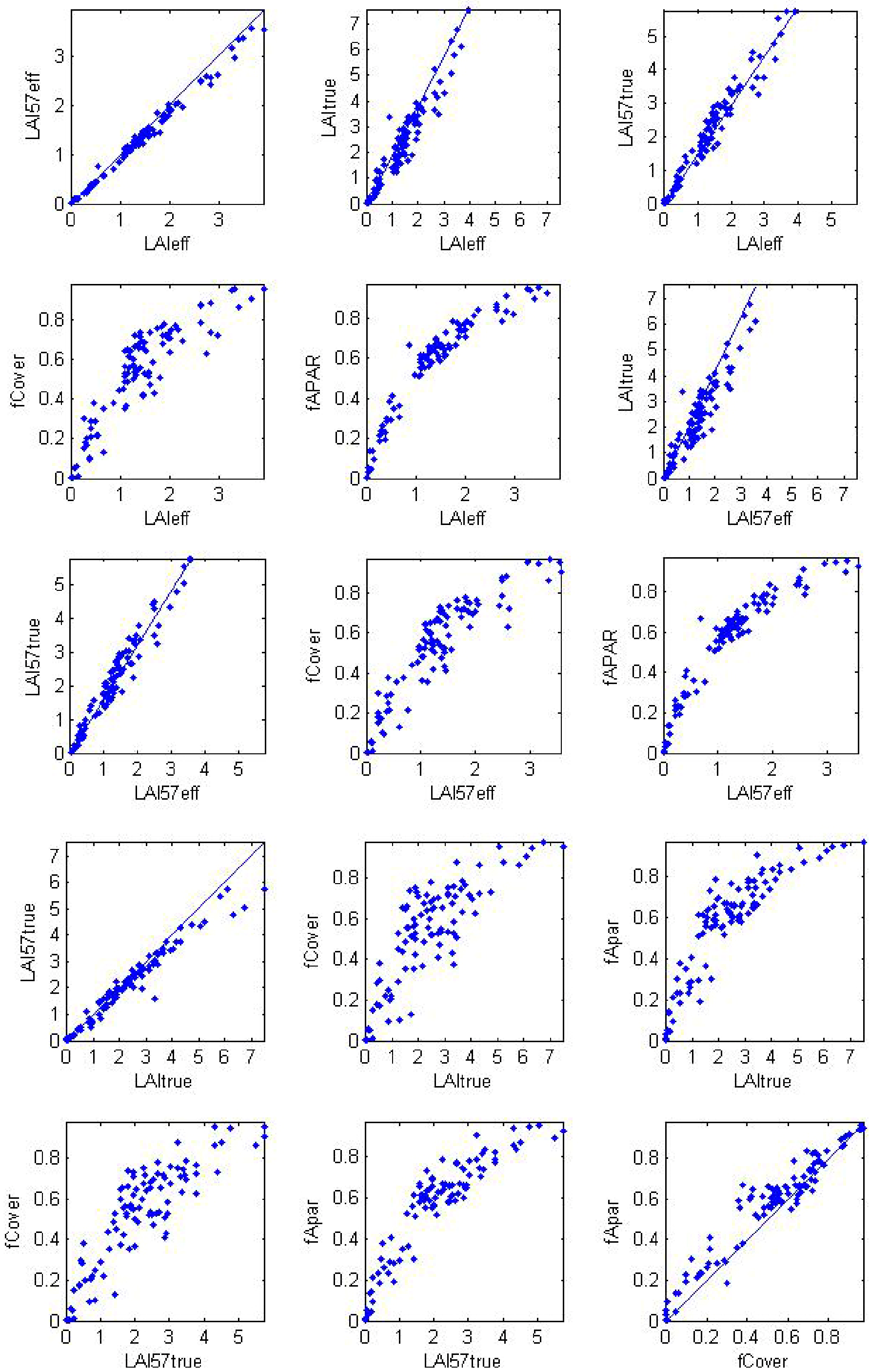

Figure 3. Relationships between the different biophysical variables.

2.3. Sampling strategy

2.3.1. Principles

The sampling of each ESU (for information: a transect in GPS file is composed of *x* ESUs) is based at least on twelve elementary images from above the understorey and from below the canopy. Figure 4 shows the distribution of the 97 ESUs over the site (15 x 40 km).

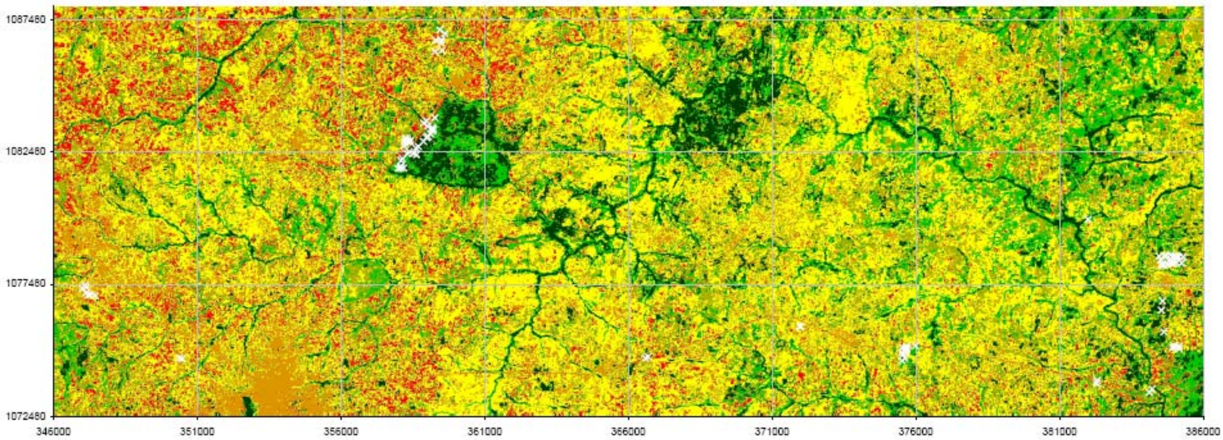

Figure 4. Distribution of the ESUs around the Donga site.

2.3.2. Development of transfer functions

In the framework of the VALERI project, two transfer functions are used to produce the biophysical variable maps. If no available satellite image, the transfer function consists only in attributing the average value of the biophysical variable measured on the ESUs belonging to the considered class to each pixel of the land cover map belonging to the class. For this site, three transfer functions were considered, depending on the confidence put in the land cover map used.

2.3.2.1. Evaluation considering the land cover map as the actual one

This first evaluation is working on the assumption that the land cover map classification at high spatial resolution (20 m) is a good approximation of the actual one at the date of ground measurements. Figure 5 shows the comparison of the class distribution between the land cover map (left) and that derived from ground observations over the sampled ESUs: the distribution of the classes on the land cover map is different from that of the ESUs. Classes 2, 3 and 4 are under-represented while classes 1, 5 and 6 appear to be over-sampled.

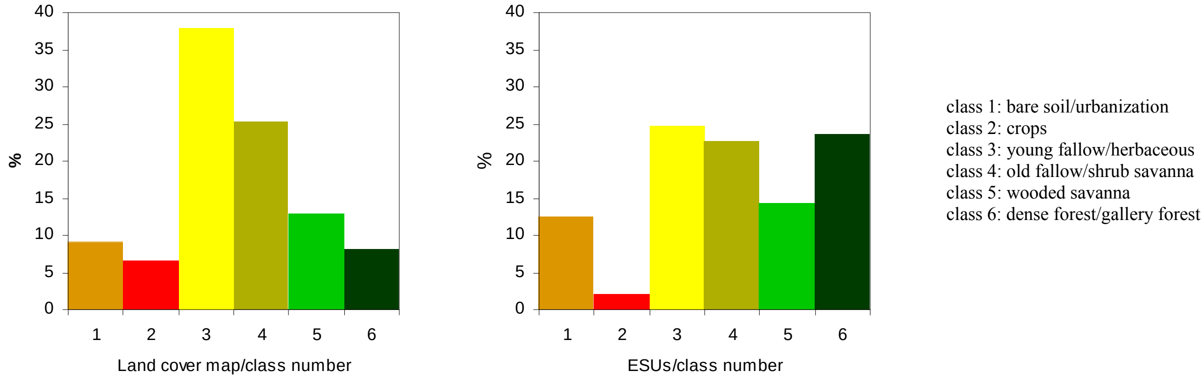

Figure 5. Comparison of the class distribution over the whole site and that corresponding to the sampled ESUS.

If this transfer function is applied, this gives the following biophysical variable values (Table 2):

	Classes	LAIeff	LAItrue	LAI57eff	LAI57true	fCover	fAPAR
1	bare soil/urban	1	1,5	0,9	1,5	0,48	0,49
2	crops	2,2	3,9	2,1	3,2	0,75	0,77
3	young fallow/herbaceous	1,1	1,7	1,1	1,6	0,44	0,49
4	old fallow/shrub savanna	1	1,6	0,9	1,6	0,41	0,47
5	wooded savanna	1,7	3,3	1,6	2,8	0,63	0,68
6	dense forest/gallery forest	2,1	3,5	1,9	3,2	0,66	0,72

Table 2. Values of the biophysical variables measured on each class averaged over all the corresponding ESUs. Attribution of the class is based on the land cover map.

For classes 1 and 2, the biophysical variable values appear over-estimated according to our knowledge of the actual surface state (bare soil, crops with little vegetative development). Here, the ESUs are attributed to a class of the land cover map within take account the local observations during the measurement campaign.

As each ESU is described in the GPS file, ESUs can be attributed to one of the classes used in the land cover map (annex). Results (table 2) can be compared to the average values of the biophysical variables of ESUs belonging to a class from ground classification (Table 3). Note that the values of class 5 (wooded savanna) are higher than the values of class 6 (dense forest/gallery forest).

	Classes	LAIeff	LAItrue	LAI57eff	LAI57true	fCover	fAPAR
1	bare soil/urban	0,1	0,3	0,1	0,2	0,02	0,07
2	crops	0,5	1,0	0,4	0,8	0,24	0,31
3	young fallow/herbaceous	1,4	2,0	1,4	2,0	0,61	0,64
4	old fallow/shrub savanna	1,4	2,5	1,3	2,3	0,52	0,60
5	wooded savanna	2,7	5,1	2,5	4,3	0,78	0,82
6	dense forest/gallery forest	2,1	3,6	1,9	3,3	0,71	0,75

Table 3. Values of the biophysical variables for each class averaged over all the corresponding ESUs. Attribution of the class is based on ground observations over the ESUs.

As the two methods of computing the average biophysical variables values do not provide similar results, a confusion matrix is performed to compare the land cover map with ground observations over the ESUs.

2.3.2.2. Using confusion matrix

The following confusion matrix (Table 4) highlights the occurrences of the land cover map and the ground classification:

		classes	Classification/land cover map						Total ESUs	ESUs
			1	2	3	4	5	6		
			bare soil/ urban	crops	young fallow/ herbaceous	old fallow/ shrub savanna	wooded savanna	dense forest/ gallery forest		
Classification/ground observations	1	bare soil/ urban	**0**	0	2	1	1	1	5	E11, E44, E58, E67, T28
	2	crops	3	**0**	9	7	0	0	19	E1, E6, E43, E54, E63, T1, T2, T3, T4, T6, T9, T11, T14, T15, T20, T25, T26, T29, T33
	3	young fallow/ herbaceous	7	1	**9**	8	1	1	27	E2, E3, E4, E5, E8, E9, E40, E42, E46, E48, E50, E51, E53, E57, E59, E65, E66, T5, T10, T16, T17, T18, T19, T24, T27, T30, T31
	4	old fallow/ shrub savanna	2	0	4	**3**	5	5	19	E7, E10, E12, E13, E14, E15, E16, E17, E41, E52, E55, E60, E62, E64, T7, T8, T21, T22, T32
	5	wooded savanna	0	0	0	0	**2**	5	7	E19, E21, E37, E38, E39, E56, T34
	6	dense forest/ gallery forest	0	1	0	3	5	**11**	20	E18, E20, E22, E23, E24, E25, E26, E27, E28, E29, E30, E32, E33, E34, E35, E36, E61, T12, T13, T23
		Total pixels	12	2	24	22	14	23	97	

Table 4. Comparison between the classification of the land cover map and the ground observations

Results show that the two classifications are not consistent. For examples, class 1 in the land cover map is characterized by 12 ESUs belonging to class 2 (3 ESUs), class 3 (7) and class 4 (2); class 4 in the land cover map is characterized by 22 ESUs belonging to five different classes: class 1 (1 ESU), class 2 (7), class (8), class 4 (3) and class 6 (3)… Moreover, class 2 is only represented by 2 ESUs which are not crops!

2.3.2.3. Using weighted values

In order to estimate biophysical variables while taking into account possible errors in the land cover classification expressed by the confusion matrix (Table 4), the average values of biophysical variables estimated from local measurements were weighted by the probabilities in Table 4, according to:

Confusion matrix: occurrences (%)		Classification/land cover map (j)						Average value of the biophysical variables of ESUs belonging to a class*					
	Classes	1	2	3	4	5	6	LAIeff	LAItrue	LAI57 eff	LAI57true	fCover	fAPA R
Classification/ ground observations (i)	1	0	0	8,3	4,5	7,1	4,3	0,1	0,3	0,1	0,2	0,02	0,07
	2	25	0	37,5	31,8	0	0	0,5	1,0	0,4	0,8	0,24	0,31
	3	58,3	50	37,5	36,4	7,1	4,3	1,4	2,0	1,4	2,0	0,61	0,64
	4	16,7	0	16,7	13,6	35,7	21,7	1,4	2,5	1,3	2,3	0,52	0,60
	5	0	0	0	0	14,3	21,7	2,7	5,1	2,5	4,3	0,78	0,82
	6	0	50	0	13,6	35,7	47,8	2,1	3,6	1,9	3,3	0,71	0,75
Weighted values**	LAIeff	1,2	1,8	1	1,2	1,7	2						
	LAItrue	1,8	2,8	1,6	1,9	3,1	3,5						
	LAI57eff	1,1	1,6	0,9	1,1	1,6	1,8						
	LAI57true	1,8	2,7	1,5	1,8	2,8	3,1						
	fCover	0,5	0,66	0,41	0,47	0,6	0,65						
	fAPAR	0,55	0,69	0,46	0,52	0,65	0,7						

*From ground classification, average value of the biophysical variables of ESUs belonging to a class

**Weighted values of biophysical variables (Var_j)

$$Var_j = (\sum_i \alpha_{ij} . Var(i)) / 100$$

Table 5. Weighted values of biophysical variables for each class

For classes 3 to 6, the weighted values appear consistent, but they over-estimate actual LAI values for classes 1 and 2 (Table 5). The solution which consists in attributing the weighted values to all the classes of the land cover map is thus not very pertinent.

2.3.3. Summary

The several evaluations at high spatial resolution show that the results are not consistent, even if the weighted values are close to the average values of the biophysical variable measured on the class to each pixel of the land cover map belonging to the class (§2.3.2). The results are compared in Table 6:

		LAIeff			LAItrue			LAI57eff			LAI57true			fCover			fAPAR		
	Methods / classes	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1	bare soil/urban	1,0	0,1	1,2	1,5	0,3	1,8	0,9	0,1	1,1	1,5	0,2	1,8	0,48	0,02	0,50	0,49	0,07	0,55
2	crops	2,2	0,5	1,8	3,9	1,0	2,8	2,1	0,4	1,6	3,2	0,8	2,7	0,75	0,24	0,66	0,77	0,31	0,69
3	young fallow/ herbaceous	1,1	1,4	1,0	1,7	2,0	1,6	1,1	1,4	0,9	1,6	2,0	1,5	0,44	0,61	0,41	0,49	0,64	0,46
4	old fallow/ shrub savanna	1,0	1,4	1,2	1,6	2,5	1,9	0,9	1,3	1,1	1,6	2,3	1,8	0,41	0,52	0,47	0,47	0,60	0,52
5	wooded savanna	1,7	2,7	1,7	3,3	5,1	3,1	1,6	2,5	1,6	2,8	4,3	2,8	0,63	0,78	0,60	0,68	0,82	0,65
6	dense forest/ gallery forest	2,1	2,1	2,0	3,5	3,6	3,5	1,9	1,9	1,8	3,2	3,3	3,1	0,66	0,71	0,65	0,72	0,75	0,70

(a) average value of the biophysical variable measured on the class to each pixel of the land cover map belonging to the class (§2.3.2.1)
(b) average values of the biophysical variables of ESUs belonging to a class from ground classification (§2.3.2.1)
(c) weighted values of biophysical variables on each class (§2.3.2.3)

Table 6. Biophysical variable estimations on each class averaged over the whole site at high spatial resolution

In order to reduce the estimation errors, the production of medium resolution biophysical variable maps is proposed.

3. Evaluation of the transfer function for the 6 biophysical variables: LAIeff, LAItrue, LAI57eff, LAI57true, fCover, fAPAR

3.1. The transfer functions considered

From biophysical variable estimations on each class (Table 6) and land cover map, high spatial resolution maps are performed. For each biophysical variable, three high resolution maps are thus produced (methods described in §2.3.3). Then, medium resolution biophysical variable maps (1 km) are computed by aggregating over 1 km² high spatial resolution pixels. Each pixel at medium resolution make up of 2500 pixels at high spatial resolution and its value is equal to the average of all the pixels at 20 m resolution whatever their class.

The relationship between the biophysical variable values estimated from the methods [a] and [c] over the whole Donga site are very close while the relationships between [a] and [b] or [b] and [c] (§2.3.3) are less consistent because of the biophysical variable values from [a] and [c] are under-represented. Figure 6 shows the relationships of LAIeff values from different evaluation methods. All the LAIeff values from [a] and [b] are higher than 1 while method [b] provides low biophysical variable values.

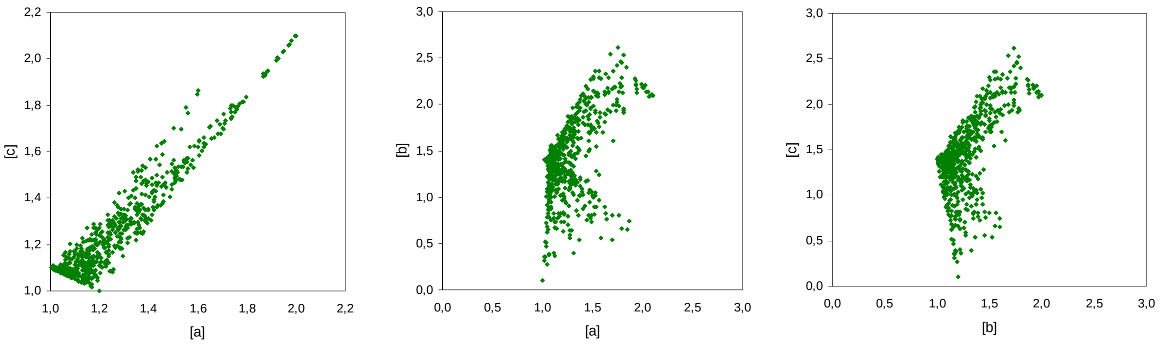

Figure 6. Relationships between LAIeff values estimated from three evaluation methods. High spatial resolution pixels are aggregated at 1 km² resolution. Results over the whole Donga site

3.2. Results

3.2.1. Choice of the method

As the biophysical variables are over-estimated from methods [a] and [c] on classes “bare soil/urban” and “crops”, the values estimated from method [b] are respectively applied to classes 1 and 2 of land cover map. For others classes, the weighted values are selected (§2.3.3). This method [d] takes better account the low biophysical variable values (bare soil/urban and crops). Figure 7 shows the relationships of LAIeff values between [a] and [d], [b] and [d], [c] and [d] at medium spatial resolution:

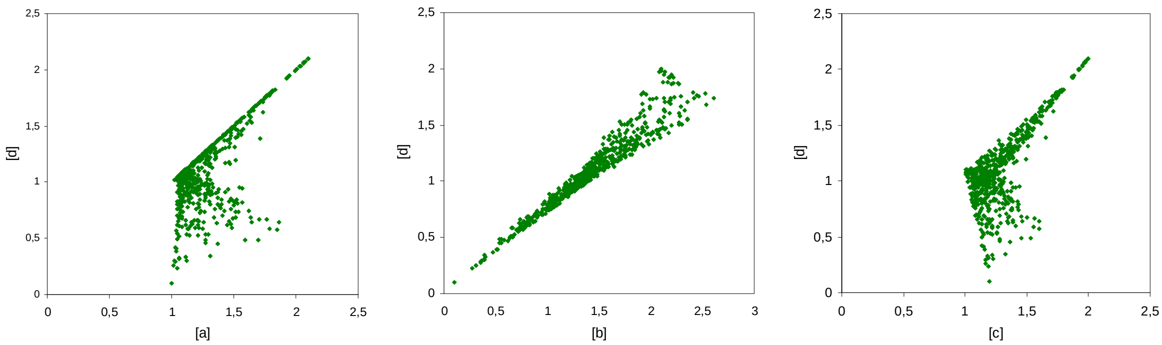

Figure 7. Relationships between LAIeff values estimated from [a] and [d], [b] and [d], [c] and [d]

Finally, a single transfer function (method [d]) is computed for all the classes. The high resolution biophysical variable maps are produced from data described in Table 7:

	classes	LAIeff	LAItrue	LAI57eff	LAI57true	fCover	fAPAR
1	bare soil/urban	0,1	0,3	0,1	0,2	0,02	0,07
2	crops	0,5	1,0	0,4	0,8	0,24	0,31
3	young fallow/ herbaceous	1,0	1,6	0,9	1,5	0,41	0,46
4	old fallow/ shrub savanna	1,2	1,9	1,1	1,8	0,47	0,52
5	wooded savanna	1,7	3,1	1,6	2,8	0,60	0,65
6	dense forest/ gallery forest	2,0	3,5	1,8	3,1	0,65	0,70

Table 7. Biophysical variable values applied to land cover map

3.2.2. Medium resolution biophysical variable maps

Figure 8 presents the medium resolution biophysical variable maps obtained with the transfer functions described in §3.2.1. The maps obtained for the six variables are consistent, showing similar patterns: low LAIeff values where low fCover or fAPAR are observed and conversely… The difference between effective LAI and true LAI is significant (see the average values in Figure 8). This was expected when looking the LAIeff/LAItrue relationship, showing that for high LAI the difference between the two can be significant.

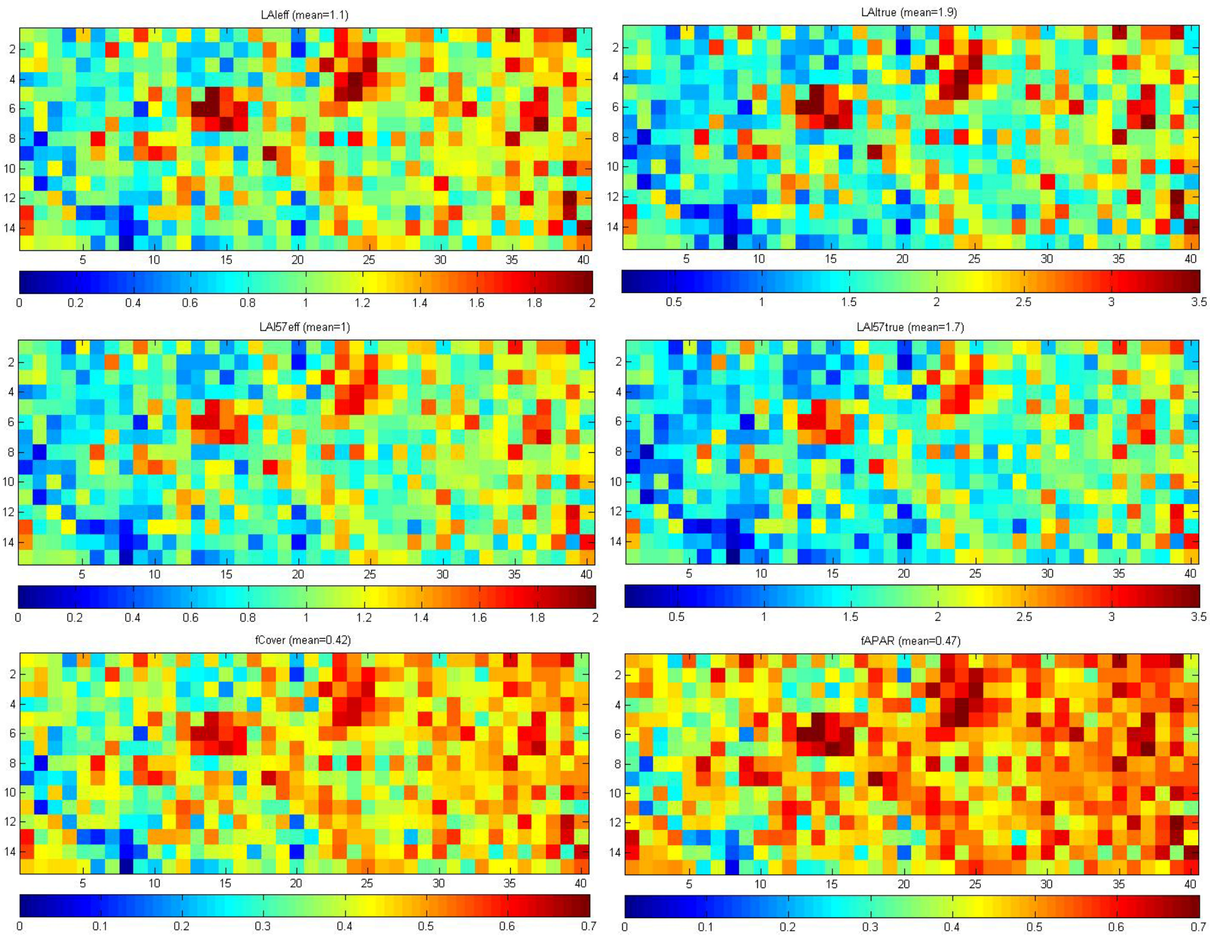

Figure 8. Medium resolution biophysical variable maps

4. Conclusion

Unfortunately, no satellite high spatial resolution image during or around the ground campaign was available. Therefore, the biophysical variable maps are not produced from transfer functions using reflectance values of the high spatial resolution satellite image and ground measurements. More simple transfer functions are derived from a land cover map which is derived itself from a series of SPOT images.

The transfer functions developed over 97 ESUs consist in attributing (§3.2.1):

• classes 1 and 2: the average value of the biophysical variable measured on the class to each pixel of the land cover map belonging to the class;

• classes 3, 4, 5 and 6: the weighted value of biophysical variable measured on the class of the land cover map.

From high resolution maps, medium resolution biophysical variable maps are produced in order to reduce the estimation errors. Note that the Donga site is heterogeneous in terms of LAI.

Biophysical variable maps are available in UTM, 31 North, projection coordinates (Datum: WGS-84), at high spatial resolution. However, the high spatial resolution maps should not be used directly, and spatial aggregation is necessary. We thus provide also 1 km aggregated maps.

5. Acknowledgements

We thank **Christophe Peugeot** (IRD) for his participation to the field experiment and **Isabella Zin** (LTHE) who has provided the land cover map (AMMA-API project).

Annex. Classification of ESUs according to ground observations and land cover map

ESUs	Ground classification	ID	Land cover map	ID
E1	crops	2	bare soil/urbanization	1
E2	young fallow/herbaceous	3	young fallow/herbaceous	3
E3	young fallow/herbaceous	3	bare soil/urbanization	1
E4	young fallow/herbaceous	3	bare soil/urbanization	1
E5	young fallow/herbaceous	3	bare soil/urbanization	1
E6	crops	2	young fallow/herbaceous	3
E7	old fallow/shrub savanna	4	bare soil/urbanization	1
E8	young fallow/herbaceous	3	bare soil/urbanization	1
E9	young fallow/herbaceous	3	bare soil/urbanization , urbanisé	1
E10	old fallow/shrub savanna	4	bare soil/urbanization , urbanisé	1
E11	bare soil/urbanization	1	young fallow/herbaceous	3
E12	old fallow/shrub savanna	4	old fallow/shrub savanna	4
E13	old fallow/shrub savanna	4	young fallow/herbaceous	3
E14	old fallow/shrub savanna	4	old fallow/shrub savanna	4
E15	old fallow/shrub savanna	4	dense forest/gallery forest	6
E16	old fallow/shrub savanna	4	wooded savanna	5
E17	old fallow/shrub savanna	4	wooded savanna	5
E18	dense forest/gallery forest	6	wooded savanna	5
E19	wooded savanna	5	dense forest/gallery forest	6
E20	dense forest/gallery forest	6	wooded savanna	5
E21	wooded savanna	5	dense forest/gallery forest	6
E22	dense forest/gallery forest	6	dense forest/gallery forest	6
E23	dense forest/gallery forest	6	wooded savanna	5
E24	dense forest/gallery forest	6	dense forest/gallery forest	6
E25	dense forest/gallery forest	6	wooded savanna	5
E26	dense forest/gallery forest	6	dense forest/gallery forest	6
E27	dense forest/gallery forest	6	dense forest/gallery forest	6
E28	dense forest/gallery forest	6	dense forest/gallery forest	6
E29	dense forest/gallery forest	6	dense forest/gallery forest	6
E30	dense forest/gallery forest	6	dense forest/gallery forest	6
E32	dense forest/gallery forest	6	old fallow/shrub savanna	4
E33	dense forest/gallery forest	6	dense forest/gallery forest	6
E34	dense forest/gallery forest	6	wooded savanna	5
E35	dense forest/gallery forest	6	old fallow/shrub savanna	4
E36	dense forest/gallery forest	6	dense forest/gallery forest	6
E37	wooded savanna	5	wooded savanna	5
E38	wooded savanna	5	dense forest/gallery forest	6
E39	wooded savanna	5	dense forest/gallery forest	6
E40	young fallow/herbaceous	3	old fallow/shrub savanna	4
E41	old fallow/shrub savanna	4	dense forest/gallery forest	6
E42	young fallow/herbaceous	3	bare soil/urbanization	1
E43	crops	2	young fallow/herbaceous	3
E44	bare soil/urbanization	1	old fallow/shrub savanna	4
E46	young fallow/herbaceous	3	wooded savanna	5
E48	young fallow/herbaceous	3	crops	2
E50	young fallow/herbaceous	3	young fallow/herbaceous	3
E51	young fallow/herbaceous	3	old fallow/shrub savanna	4
E52	old fallow/shrub savanna	4	wooded savanna	5
E53	young fallow/herbaceous	3	young fallow/herbaceous	3
E54	crops	2	bare soil/urbanization	1
E55	old fallow/shrub savanna	4	young fallow/herbaceous	3
E56	wooded savanna	5	dense forest/gallery forest	6
E57	young fallow/herbaceous	3	young fallow/herbaceous	3
E58	bare soil/urbanization	1	young fallow/herbaceous	3
E59	young fallow/herbaceous	3	young fallow/herbaceous	3
E60	old fallow/shrub savanna	4	dense forest/gallery forest	6
E61	dense forest/gallery forest	6	old fallow/shrub savanna	4
E62	old fallow/shrub savanna	4	young fallow/herbaceous	3
E63	crops	2	young fallow/herbaceous	3
E64	old fallow/shrub savanna	4	old fallow/shrub savanna	4
E65	young fallow/herbaceous	3	young fallow/herbaceous	3
E66	young fallow/herbaceous	3	young fallow/herbaceous	3
E67	bare soil/urbanization	1	wooded savanna	5
T1	crops	2	young fallow/herbaceous	3
T2	crops	2	young fallow/herbaceous	3
T3	crops	2	young fallow/herbaceous	3
T4	crops	2	old fallow/shrub savanna	4
T5	young fallow/herbaceous	3	bare soil/urbanization	1
T6	crops	2	old fallow/shrub savanna	4
T7	old fallow/shrub savanna	4	wooded savanna	5
T8	old fallow/shrub savanna	4	wooded savanna	5
T9	crops	2	old fallow/shrub savanna	4
T10	young fallow/herbaceous	3	old fallow/shrub savanna	4
T11	crops	2	young fallow/herbaceous	3
T12	dense forest/gallery forest	6	crops	2
T13	dense forest/gallery forest	6	dense forest/gallery forest	6
T14	crops	2	old fallow/shrub savanna	4

(next)

ESUs	Ground classification	ID	Land cover map	ID
T15	crops	2	old fallow/shrub savanna	4
T16	young fallow/herbaceous	3	old fallow/shrub savanna	4
T17	young fallow/herbaceous	3	dense forest/gallery forest	6
T18	young fallow/herbaceous	3	old fallow/shrub savanna	4
T19	young fallow/herbaceous	3	young fallow/herbaceous	3
T20	crops	2	bare soil/urbanization	1
T21	old fallow/shrub savanna	4	young fallow/herbaceous	3
T22	old fallow/shrub savanna	4	dense forest/gallery forest	6
T23	dense forest/gallery forest	6	dense forest/gallery forest	6
T24	young fallow/herbaceous	3	old fallow/shrub savanna	4
T25	crops	2	old fallow/shrub savanna	4
T26	crops	2	young fallow/herbaceous	3
T27	young fallow/herbaceous	3	old fallow/shrub savanna	4
T28	bare soil/urbanization	1	dense forest/gallery forest	6
T29	crops	2	young fallow/herbaceous	3
T30	young fallow/herbaceous	3	young fallow/herbaceous	3
T31	young fallow/herbaceous	3	old fallow/shrub savanna	4
T32	old fallow/shrub savanna	4	dense forest/gallery forest	6
T33	crops	2	old fallow/shrub savanna	4
T34	wooded savanna	5	wooded savanna	5