VALERI
PRODUCING A HIGH RESOLUTION LAI MAP FOR VALERI 2001 INDONESIAN SITE: AEK LOBA

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1. Introduction

A general methodology (Weiss et al., 2001) was proposed to derive high resolution LAI maps for the different VALERI sites. However, the Indonesian site, Aek Loba (palm plantation) is specific since the SPOT image acquired on the site appears quite homogeneous (Figure 1) although the LAI measured at the ground varies between 3 and 4.5 (Figure 2). The site, as well as spatial sampling for LAI measurements performed with LAI2000 instrument, are described in Lelong et al. (2001). The processing of the SPOT image (no atmospheric correction) and LAI2000 data is described in Garrigues (2002) and Weiss (2002). Figure 2 shows that the ground spatial sampling is quite good when comparing the distribution of NDVI values over the ESUs (Elementary Sampling Units) with that of the NDVI values observed over the whole site. Low NDVI value are not represented in the sampling since it corresponds to field borders for which LAI is not 0 .

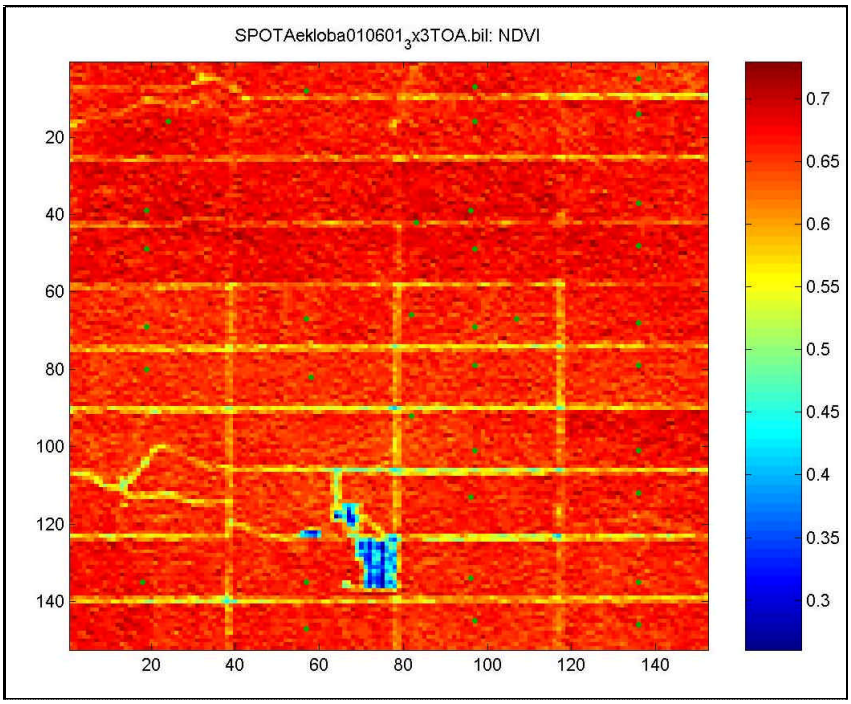

Figure 1. NDVI image of Aek Loba site (Image acquired the 1st June 2001). Green points correspond to ground measurements.

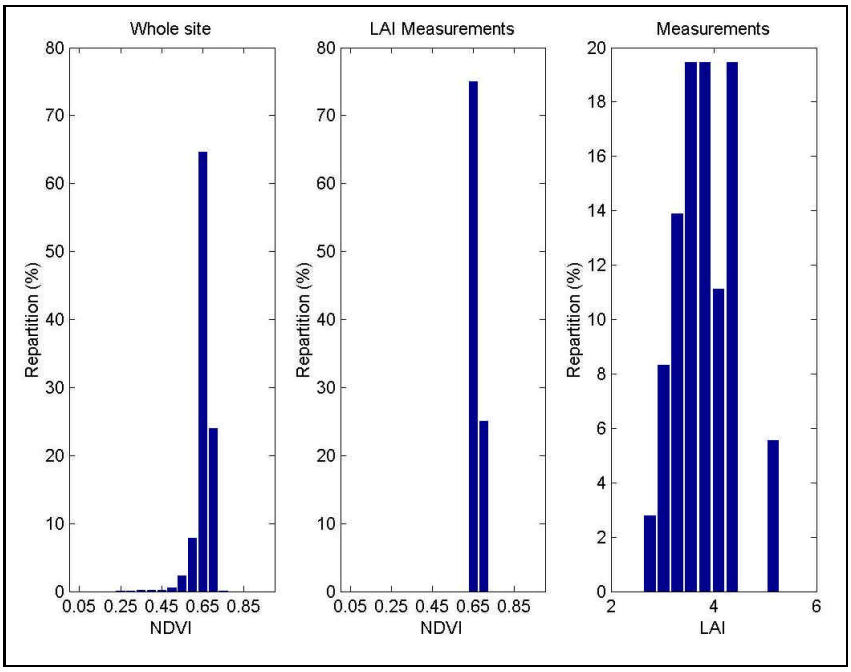

Figure 2. Distribution of NDVI values. over the whole site(left), and (center over the ESUs. The figure on the right corresponds to the distribution of LAI values as observed over the ESUs.

2. Determining a relationship between the image and ground measurements

Figure 3 shows that there is no apparent relationship between NDVI and LAI measured over the ESUs. The image shows very little variation of NDVI (mainly between 0.64 and 0.7). Therefore, it is not possible to develop a robust relationship between SPOT reflectance and ground measurements. In order to derive a LAI map from the SPOT data and the ground measurements performed over the ESUs, several approaches were investigated.

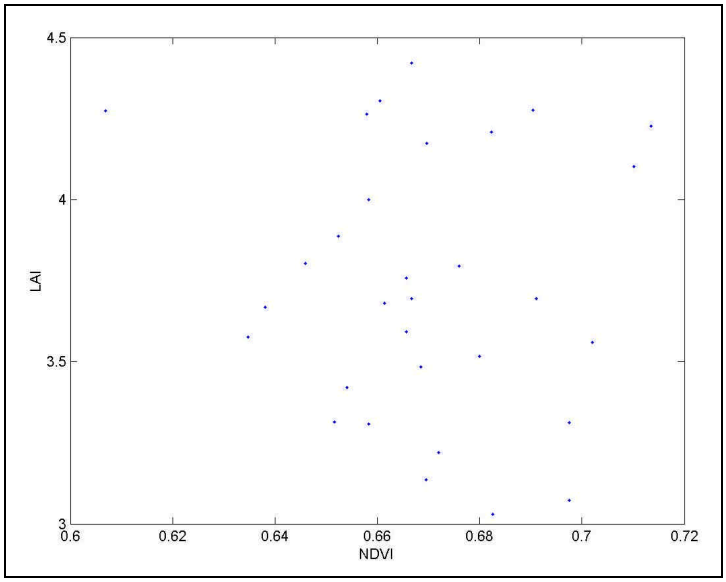

Figure 3. NDVI-LAI relationship on Aek Loba site

2.1. Image classification

The first idea was to perform a classification over the SPOT image. As the fields appear quite homogeneous (Figure 1), we decided to classify the image and attribute LAI value field per field (Figure 4). We first noticed that the NDVI repartition is quite similar from one field to another. Therefore, a field classification performed over the mean and standard deviation values of field NDVI could not lead to satisfying results.

We then tried to classify the image using the red and near infrared reflectance averaged over each field. Fields were visually delimited by the operator. The two variables were normalized by their mean value so that they have similar weights in the unsupervised classification process. We used the "kmeans" method, and chose 5 classes after several trials (Figure 5).

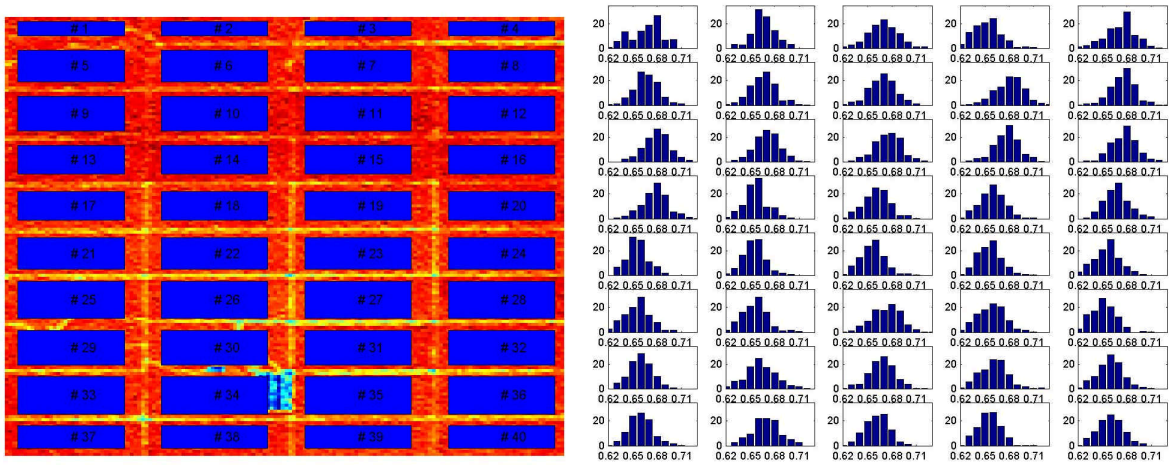

Figure 4. Left: Aek Loba field numbers. Right: NDVI dstribution per field.

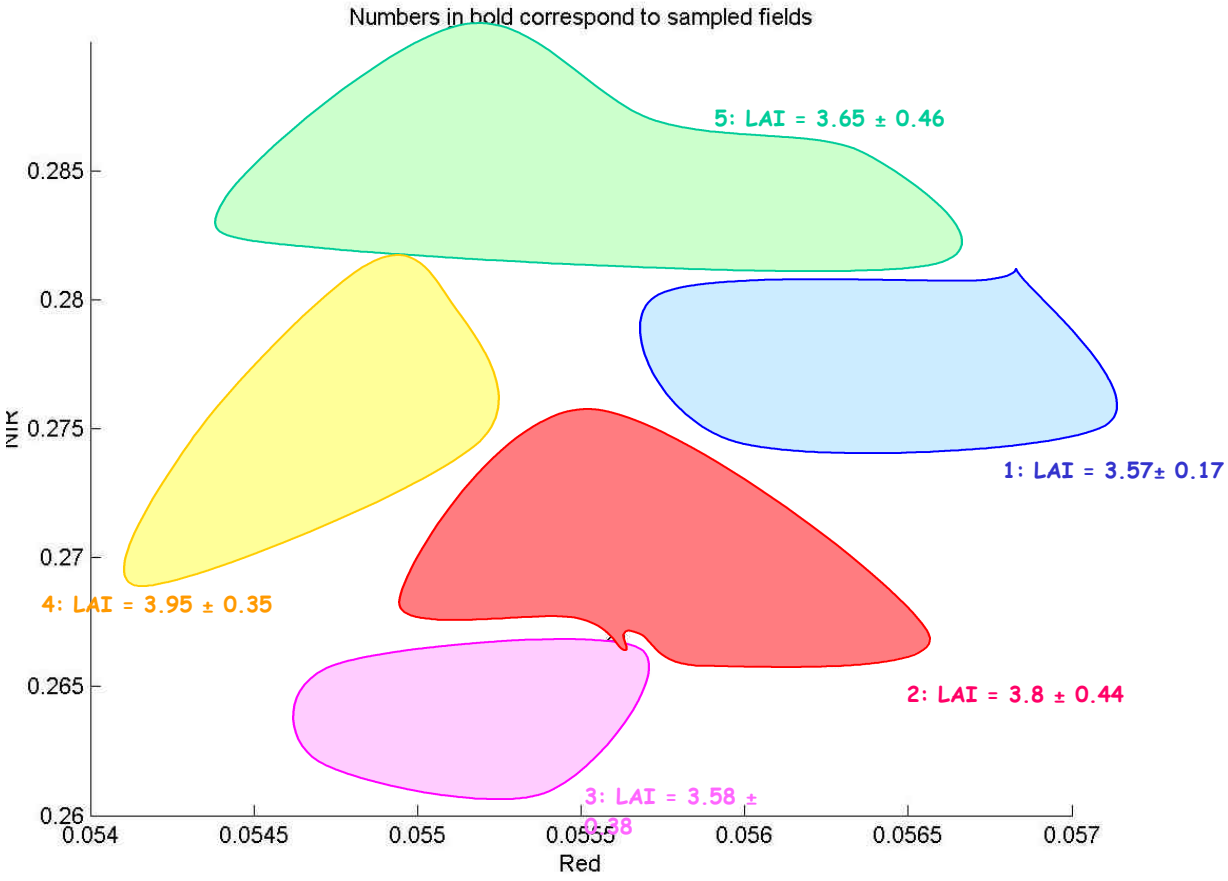

Figure 5. Results of the "kmeans" classification on the average Red and NIR field reflectance.

Classification results are still not fully satisfying since classes 1 and 3 show the same average LAI with little standard deviation, for two different levels of both red and near infrared reflectance. Moreover, for class 5, only the NIR level is discriminating. On the other hand, there is still a problem to estimate the LAI of field borders.

As the NDVI value is quite high (more than 0.5), it seems that there is always some vegetation on pixels corresponding to the borders of the field, which is confirmed by Figure 6. We therefore chose to use another method based on a linear relationship between LAI and NIR reflectance.

Figure 6. Tracks delimitating the fields in Aek Loba (from Lelong et al. (2001))

2.2. NIR linear method

Using the Near Infrared Band band, a linear relationship with the LAI was assumed, which make sense since the LAI levels reached are not very high (maximum at 4.5). Two points were thus required to estimate the slope and intercept of this linear relationship: the first point corresponds to NIR reflectance for bare soil (LAI=0) and the second one is the average measured LAI and corresponding average NDVI values as observed over the ESUs.
As no bare soil was present on the VALERI 3*3km² site, we used a larger part of the image (12kmx8km). By plotting the red against the near infrared band, we were able to determine the soil line (Baret et al., 1993), and therefore to provide a NIR reflectance equal to 0.18 for very low LAIs approximated to bare soil (Figure 8).

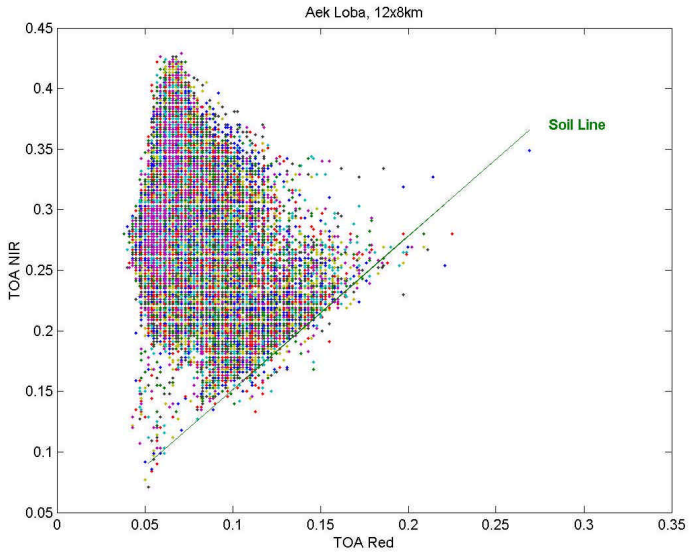

Figure 7. Red and NIR top of atmosphere reflectance on the 8x12km Aek Loba site. Soil line is shown in green.

Figure 8 shows the corresponding linear regression that will be applied to the whole image. The root mean square error between estimated LAI with this regression and measured LAI is 0.54, which is quite satisfying as compared to the accuracy of the LAI2000 measurements that doesn't take into account clumping effect or the presence of non green elements such as trunks and branches.

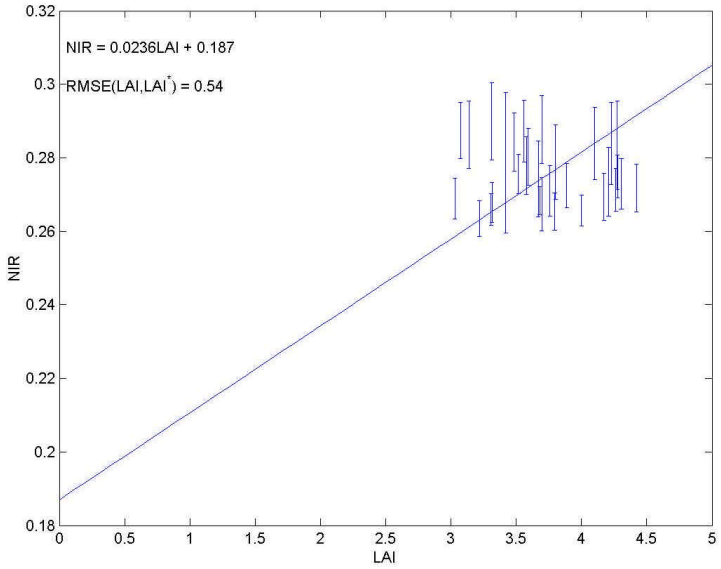

Figure 8. NIR-LAI linear regression for Aek Loba site. Error bars correspond to ± the standard deviation of NIR reflectance over the fields delimited in Figure 1.

3. Producing high resolution LAI map

Figure 9 shows the high resolution LAI map obtained by using the linear NIR-LAI relationship. As compared to ground measurements, it appears to be the most satisfying method to derive LAI map from the SPOT image since field classification would lead to no intra-field variation, and NDVI –LAI relationship is not convenient.

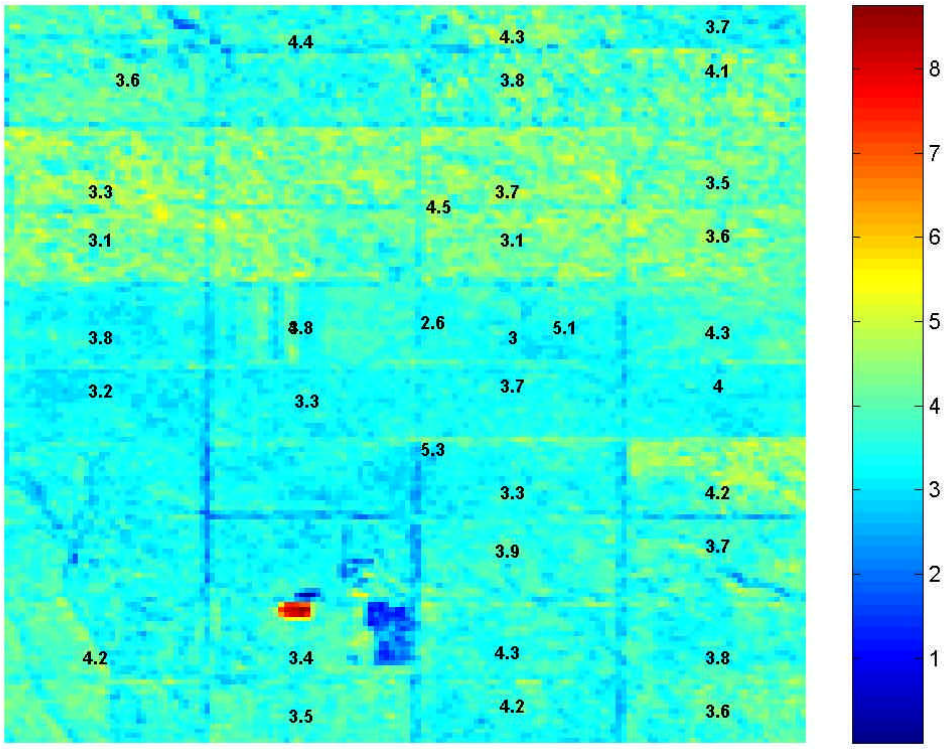

Figure 9. High Resolution LAI map obtained using the NIR-LAI linear regression. Figures in bold are centered on the pixel corresponding to ground measured LAI.

4. References

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