CHARACTERIZATION OF ENVISAT MULTIPOLARIZATION SAR DATA WITH BIDIMENSIONAL STATISTICS.

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1. INTRODUCTION

The actual SAR sensors provide multipolarization images in simultaneous or delayed modes. The use of such images is becoming more and more usual but there are many different methods to characterize differences ou similarities between images of the same area. On the other hand, multicore 64 bits computers with gigabytes of random access memory offer nowadays great ressources for high computing algorithms. This provides a new interest in using two dimensioned statistics on 16 bits SAR images.

The purpose of this work is about evaluating the interest between studying directs dual polarization statistical indices and the use of statistical indices build from two images with different polarizations. There are many statistics that characterized the real amplitude of radar images [1]. Among them, the maximum sample frequency of the histogram of the backscatter amplitude (i.e the most present pixel value) is related to all the others, for a uniform texture model, by the K-law [2]. This measure is useful to the characterization of urban texture [3] as well as natural texture. That is why we study here this maximum of frequency computed from the bidimensional histogram and compare it to the same two statistical indices extracted separately from both polarizations.

As a result, we show differences in accuracy in a natural context by applying those works to a natural context with forest and mangrove maping and to a human-made context by characterizing urban density. Those results are computed from ENVISAT ASAR data in HH and VV polarizations near Libreville, Gabon.

2. CONTEXT

The use of multipolarization images offers great major advances in the automatical interpretation of SAR images, especially with applications where differences in the physical nature of the land cover allow a prediction of the appearance of images [4]. We stand here a point of view a little bit different because we are trying to find and evaluate criteria of similarity or difference between images to find derivated indices that can be used as input into classification algorithms without a priori on the physical construction of the signal.

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There are two ways of computing statistical combined studies of two radar images : the first one is to compute statistical measurements on each image, the second one is to compute conjoint statistics directly. In the case of linear measurement like mean for example, the two ways give the same result but, for non linear measurement like maximum probability, for example, the second approach can give different informations [5]. To show the interest of the joint study of two polarizations, we consider the difference between computed maximum amplitude frequency on each image and the coordinates of the value of the greatest frequency in the bidimensional histogram. This statistical measurement makes sens only on uniform textured areas so, we computed our value using a small window on each pixel image. With an appropriate coding, this provides a new image that we call indice.

The SAR images issued from the ENVISAT satellite mode are delivered with their amplitude coded in a 16 bits range. That is why the use of two-dimensional histograms for studying this kind of image needs plenty of computing time and memory. This can explain why there is not a lot of studies conducted in this area either with multi-temporal or multi-polarization images. But, when using local bidimensional histogram, the amount of memory needed decreases significantly.

3. METHODOLOGY TESTING AND COMPUTATION OF THE MAXIMUM FREQUENCIES.

To compare the amount of information of each indice produced by the method described above, we do the following calculations :

– First, we compute the maximum of frequency over a sliding window on each image by calculating the histogram and finding its maximum. Those values are coded into two images, f_h and f_v, where each pixel value is replaced by the maximum frequency value.
– Then, we compute bidimensional histogram over a sliding window and find its maximum. The two coordinates of this maximum is coded into two images fb_h and fb_v.
– From these four images, we derivated an image of module (fb_m) and an image of angle (fb_a) between the line joining the origin of the histogram to the maximum point and the line define by $fb_h = 0$.

Calculation of these indices from the bidimensional histogram in 16 bits image is theoretically expensive in calculation time but it can be easily optimized. To reduce the amount of required memory, we first compute two images of maximum values computed in a sliding window, so we can allocate small arrays for histogram. Secondly, to reduce the computing time, we compute the bidimensional histogram line by line and the value of the next pixel on the line is computed by adding and removing a column of pixels. With those two precautions, producing these indices can be done in about ten minutes in a simple macbook for extractions (3800x5500) of two ENVISAT images.

To quantify the respective contributions of these images, we performed two types of tests : one to quantify the global interest of images computed with the bidimensional histogram, and the other to determine the ability of those statistical indices for intra-class discrimination like urban density study.

– We do a supervised classification with a gaussian markov random field modeling where the input data are the two single images of statistical indices f_h and f_v. In a second step, we compute the same classification based on bidimensional histogram derived. We do this for a learning set with sea, mangrove forest and urban plots. Then, we compute the confusion matrix between human interpretation and computed results for the two sets of input. This gives us an appreciation of the overall contribution of each image fb_1, fb_2, fb_m and f_a.
– In order to obtain more detailled informations on this last image, we compute for some statistical indices the mean and the standard deviation on the human extract classification.This allows us to

quantify the ability of these statistical indices to discriminate different urban or forest densities.

The results of this test are shown on Libreville aera in Gabon, for a couple of ENVISAT ASAR HH and VV images acquired in 2005.

4. RESULTS

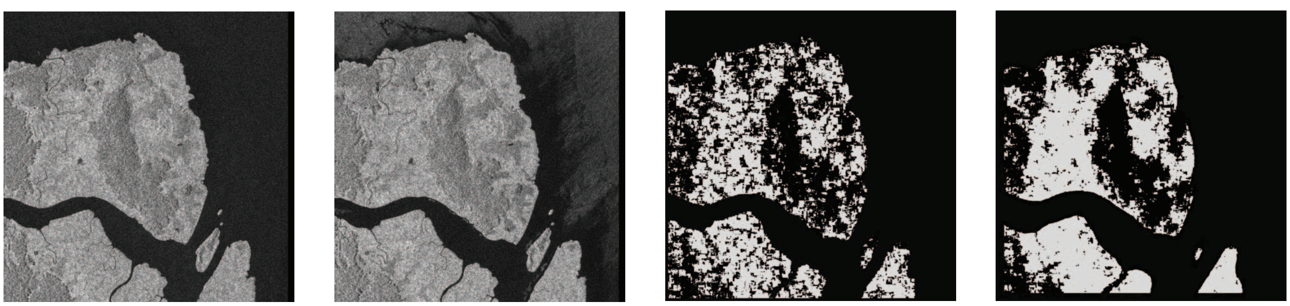
The results of the classifications presented here are deliberately not modified to allow the contributions of the indices appearing. They may be then filtered with classical techniques to obtain useful results. To produce this indice, we use a square sliding window of four hundred pixels.

On the figure 1, we can see our treatment results on a coastal area with mangrove and forest. The study of statistical indices shows that bidimensional derived images separate much more better class forest from mangroves than class indices calculated on a single image. This explains the increase in the quality of the classification that we observe between the images of figure 1.(c) and 1.(d).

On the figure 2, we show the results obtained on a part of the urban area of Libreville. On this figure, we find a great increasement in accuracy of the classification by the introduction of bidimensional histogram measurement. The table 1 shows the confusion matrix between the classification and the real map.

	sea	mangrove	forest	urban
Monodimensional indices (f_1, f_2)	98	40	65	66
Bidimensional indices $(f_1, f_2, fb_1, fb_2, ...)$	99	85	82	89

Table 1. Percentil of good detection in Libreville area vith envisat HH/VV images.



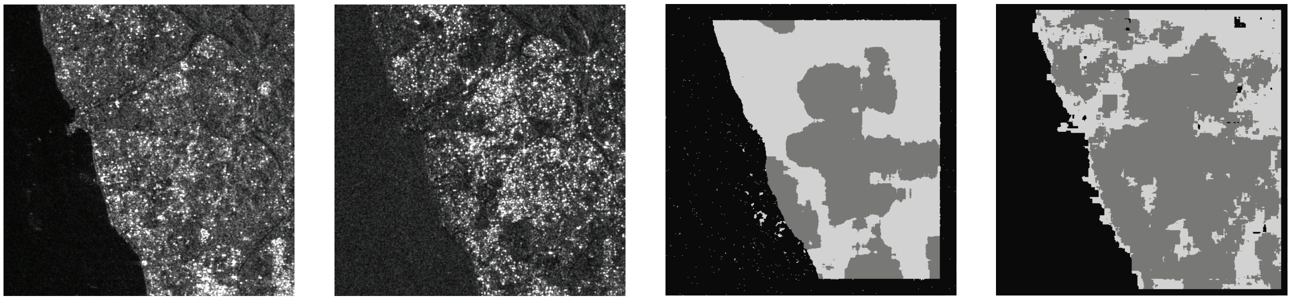
(a) Image HH (b) Image VV (c) result (f_1, f_2) (d) result (f_1, f_2, fb_1, fb_2)

Fig. 1. Example of results obtained for mangrove area. (a) ENVISAT HH image, (b) ENVISAT VV image, (c) classification in single (c) and conjoint (d) indice.

The means and standard deviations of (fb_1, fb_2) indices obtained in this region for our classes are shown in the tabular 2. They show that the discriminating aptitude of bidimensional indices is better than simple indice without removing possibilities of intra classe discrimination like study of urban density. We do not show results about angle fb_a measurements because they are too noisy for usual statistical measurements.

5. CONCLUSION

The main conclusions of this study are about the interest of using bidimensional indices calculation for dual polarization radar images. This work shows an original way of using this kind of images and we are



(a) Image HH (b) Image VV (c) result (f_1, f_2) (d) result (f_1, f_2, fb_1, fb_2)

Fig. 2. Example of results obtained for urban area. (a)

	sea	mangrove	forest	urban area
mean l (fb_h)	79	242	215	100
standard deviation l (fb_h)	34	224	172	190
mean l (fb_v)	264	263	234	114
standard deviation l (fb_v)	101	244	187	218
mean l (fb_m)	276	361	320	155
standard deviation l (fb_m)	104	328	250	287

Table 2. Conjoint maximum probability in ENVISAT HH and VV images.

working presently in three ways : one to extend this work on multisensor images, one to give a hierarchical classification method for forest mapping and one on finding a dual image indices like adaptative called ffmax described in [6] for single image case.

6. REFERENCES

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