A Simple Class-Set Based Vegetation Classification of a South Pacific Volcanic Island (Moorea Island, French Polynesia) using Both AirSAR and MASTER Data

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***Abstract*—This paper addresses the vegetation mapping and land use of Opunohu Valley (Moorea Island - French Polynesia) using JPL-AirSAR and MASTER (MODIS/ASTER simulator) images. We first define an original set of classes based on the relative canopy-height of vegetation, out of a well-suited RGB SAR-composite image that visually discriminates our vegetation classes. An interesting "pineapple fields" class (an important economic resource in Moorea island) proves to discriminate particularly from the height-related "Low Vegetation" class. Two supervised maximum likelihood classification maps have been processed on both the AirSAR and the MASTER images, using aerial photographs as a ground truth training set. The vegetal species included in each class as well as the classification results are discussed. Comparison of the MASTER and AirSAR based classification results leads us to propose a fusion of AirSAR and MASTER classification maps keeping the best of both worlds in order to improve the overall accuracy of the AirSAR classification.**

Keywords: vegetation mapping, JPL-AirSAR, MASTER, Classification, AirSAR/MASTER Fusion.

I. INTRODUCTION

The JPL-NASA PACRIM2 mission [1] occurred in August 2000, providing a complete set of data from both MODIS/ASTER and AirSAR sensors on the main French Polynesian islands and atolls.

This study addresses the vegetation mapping [2] of South Pacific Volcanic Islands [3] using this complementary data set.

Moorea Island is located in the Society Archipelago (French Polynesia), South Pacific (149°5'W, 17°32'S).

We presently focus on Opunohu Valley (the main caldera of Moorea Island) (Fig. 1) because of its highly representative diversity of vegetation [4] and land cover (found in other Polynesian high islands), including different types of forests, coconut fields, grass fields, fern lands, urban zones, agricultural areas, etc.

II. MATERIALS AND METHODS

A. Image Data

- MODIS/ASTER (MASTER) [5] is a multi-spectral imaging scanner with 50 channels distributed in the visible-shortwave infrared, mid infrared and thermal infrared. After geometric correction the pixel size is 20 meters.
- JPL-AirSAR: The data set on Moorea island is made out of two scenes, in XTI1 mode: C-band single-baseline Interferometry in VV polarization (TOPSAR) and L-band Polarimetry (POLSAR), (P-band Polarimetry is lacking). The 40MHz Bandwidth was used therefore the pixel size is 5m.

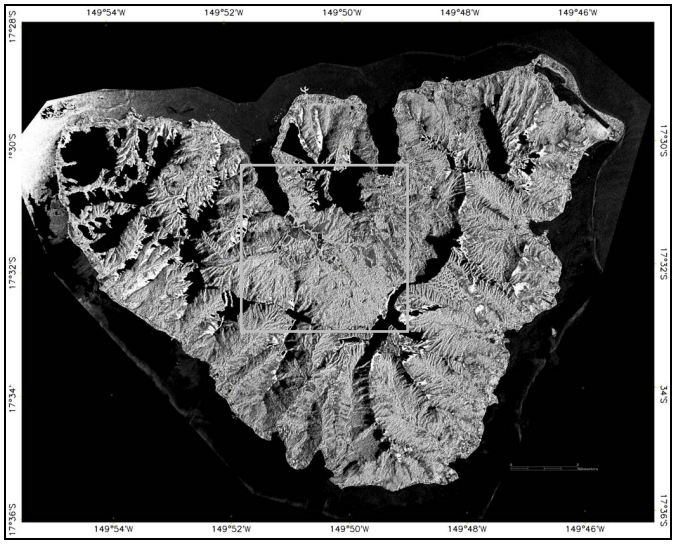

Figure 1. Moorea Island JPL-AirSAR image (L-band Total Power) and Opunohu Valley area

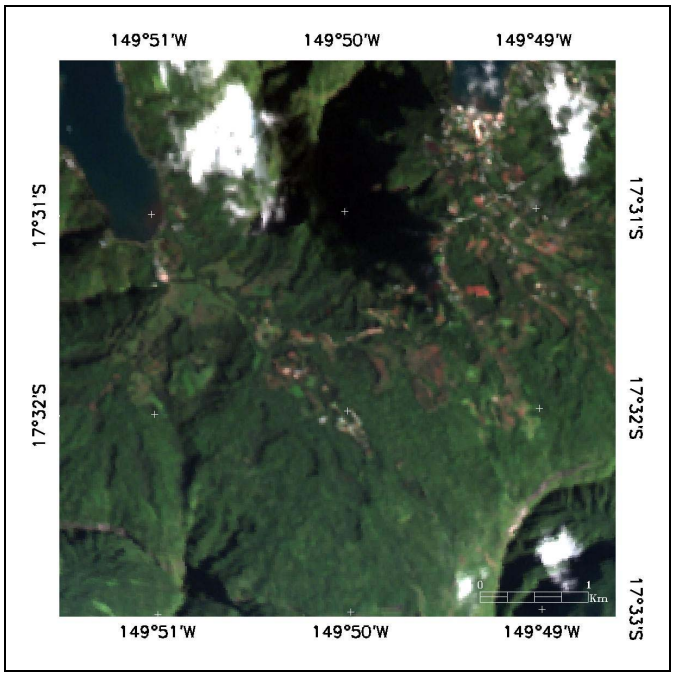

Figure 2. Opunohu Valley MASTER image (5,3,2 bands)

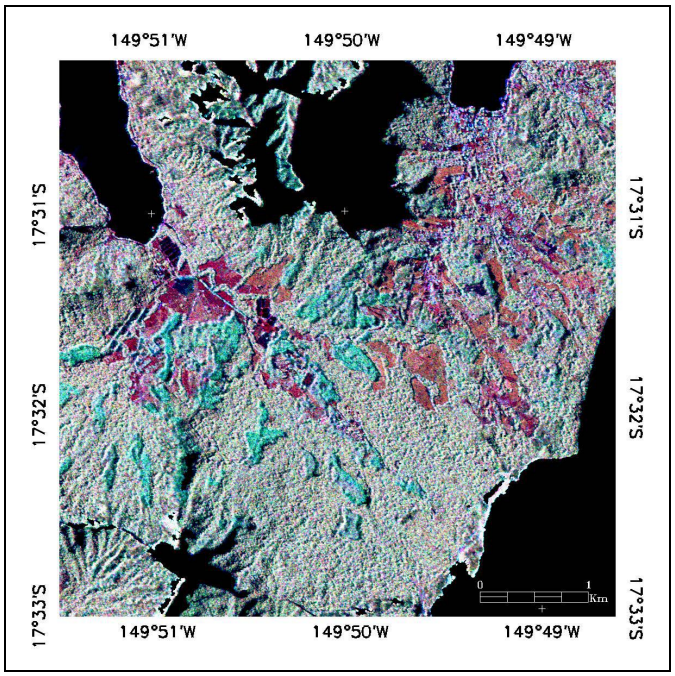

Figure 3. Opunohu Valley JPL-AirSAR RGB Composite

B. *Image Processing*

A geometric correction of the MASTER Data (Fig. 2) has been processed (AirSAR Data are already corrected by JPL), to match the AirSAR geometry. A geo-referencement step gives a common ground reference for both images.

A mosaic of the AirSAR data has been performed to provide a complete image of Moorea Island.

AirSAR Data mask is based on the radar shadows and water area while the MASTER Data mask includes both shadows and cloudy areas. A common mask is created including the masked areas of both images in order to compare the classification results.

The final Opunohu Valley study area is 1024*1024 pixels.

C. *Classes Definition*

A class set has been defined on a relative vegetation density since radar backscattering signal is representative of structural properties of the vegetation (volume, crown complexity).

We define a RGB composite (Fig. 3) with respectively C-VV, L-HV, L-HH bands used as Red, Green and Blue.

The colors in the resulting RGB composite image outline the vegetation properties (Fig. 4). For example a low vegetation area will be represented in red, and dark green will represent a high density of vegetation. We can visually discriminate 5 different classes.

TABLE I. VEGETATION CLASS SET

High Forest (HF)	Low Vegetation (LV)	Urban Zone (UZ)
Medium Forest (MF)	Pineapple Field (PF)	UnClassified

(Colors and class names suitable for the following classification maps)

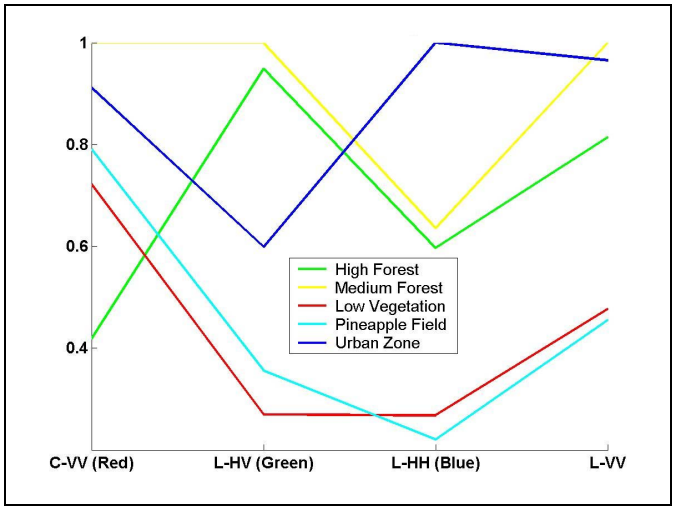

Figure 4. AirSAR Classes Mean Signature (Normalized)

TABLE II. FILTERED IMAGE ROI SEPARABILITY INDEX (JEFFRIES MATUSITAAS)

Low Vegetation	Pineapple Field	1.25635474
High Forest	Medium Forest	1.75250398
Medium Forest	Urban Zone	1.86430262
High Forest	Urban Zone	1.90294545
Low Vegetation	Urban Zone	1.90301543
Pineapple Field	Urban Zone	1.91280686
Medium Forest	Pineapple Field	1.98632083
Low Vegetation	Medium Forest	1.98817265
Low Vegetation	High Forest	1.99698506
High Forest	Pineapple Field	1.99796923

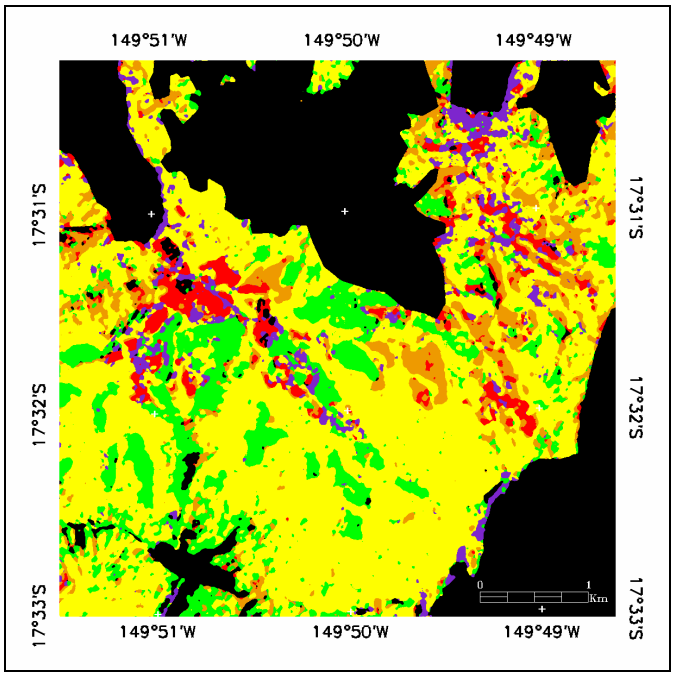

Figure 5. Opunohu Valley AirSAR Classification Map

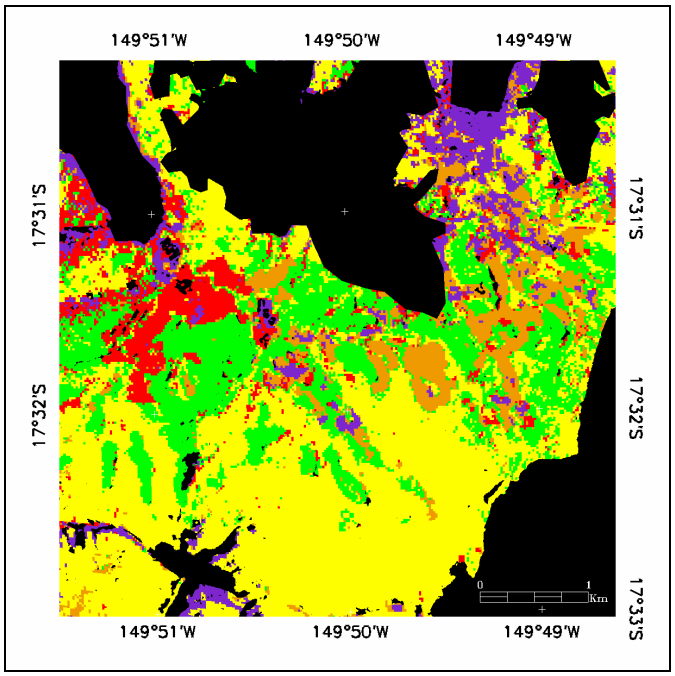

Figure 6. Opunohu Valley MASTER Classification Map

Regions of Interest (ROI) are defined using aerial photographs. Each clearly identified zone is randomly used for the Supervised Algorithm learning process or the Post Classification results control.

A Speckle reduction is processed on AirSAR Data. The ROI Separability index (TABLE. II) is used as a maximization criteria for Speckle filters optimization. The Lee filter gives good results on AirSAR image and our ROI set.

D. Classification

A standard Maximum-Likehood Supervised classification algorithm is used on both images. AirSAR classification (Fig. 5) is performed on C-VV, L-HH, L-HV and L-VV bands. MASTER image is classified (Fig. 6) using the same learning ROI on the whole band set (except the noisy bands).

III. RESULT AND DISCUSSION

A ground truth mission helps define precisely the composition of each class:

The "High Forest" class includes essentially the *Pinus Caribeae* and *Paraserianthes Falcataria* forests, which culminate above the "Medium Forest" (main forest in volcanic islands [6]). It includes *Hibiscus Tiliaceus* (Purau), Bamboo, Fern lands, Mango Trees etc... The "Pineapple Field" class discriminates from the height-related "Low Vegetation" class, while the other crop areas don't discriminate from their height-related class. The "Urban Zone" is a collection of heteroclite objects, local houses, gardens, roads, trees, etc...

A first comparison of the MASTER and AirSAR classification maps (TABLE III) shows that the MASTER map under-estimates the "Medium Forest" while over-estimating the "High Forest", "Low Vegetation" and "Urban Zone" classes.

TABLE III. AIRSAR AND MASTER CLASSIFICATION MAPS RESULTS

Classes	AirSAR	MASTER	Diff.
HF	(11,64%)	(15,67%)	4,03%
MF	(40,74%)	(33,01%)	-7,73%
PF	(7,63%)	(7,18%)	-0,45%
LV	(3,90%)	(6,18%)	2,28%
UZ	(3,69%)	(5,65%)	1,96%
Unclass.	(32,40%)	(32,31%)	-0,09%

The "Urban Zone" seems to be better estimated with MASTER (TABLE. V) because of its 20 meters ground resolution aggregating all the heteroclite objects of this class.

A fusion of both classification maps has been processed to keep the "Urban Zone" class estimated from MASTER and estimate the vegetation classes from the AirSAR 5 meters ground resolution image. The overall accuracy (TABLE. VI) of the resulting classification map (Fig. 7) is thus increased compared to the AirSAR classification map (TABLE. IV).

IV. CONCLUSIONS

Two classification maps were produced from MASTER and AirSAR images based on a relative canopy-height class set plus a particular class representing the Pineapple Fields. The "Urban Zone" class heterogeneity leads to different results considering the AirSAR or MASTER Data. MASTER seems to give better results because of its low ground resolution, which helps considering the Urban Zone as a collection of heteroclite objects. An AirSAR/MASTER classification fusion is then processed to improve the Overall Accuracy of the AirSAR classification map, keeping its high ground resolution for further classifications with a higher number of classes.

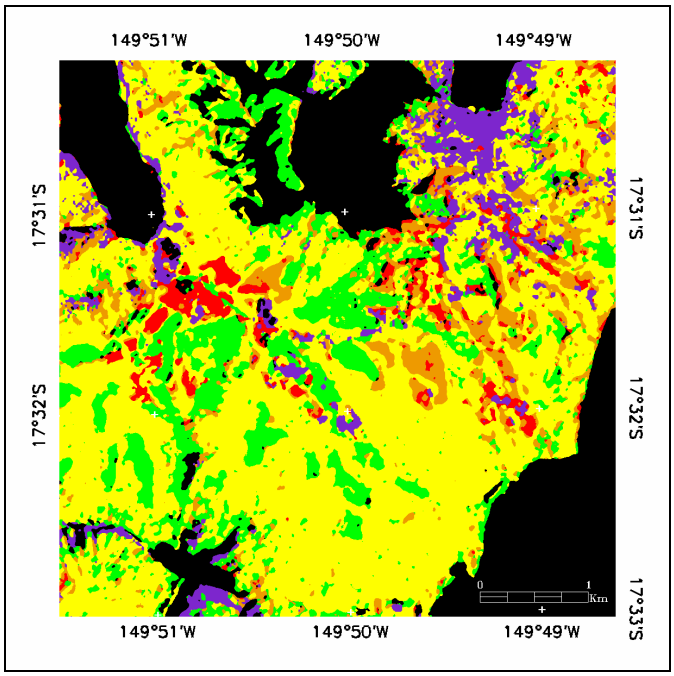

Figure 7. Opunohu Valley AirSAR/MASTER Classification Fusion Map

TABLE IV. AIRSAR CLASSIFICATION MAP CONFUSION MATRIX (PRODUCER ACCURACY)

Overall Accuracy			**77,86%**		
Kappa Coefficient			**0,7198**		
			Ground Truth		
Classes	**UZ**	**MF**	**HF**	**PF**	**LV**
Unclass.	11,70%	0,00%	6,32%	0,00%	0,00%
UZ	51,33%	0,92%	17,12%	1,72%	15,52%
MF	23,87%	91,45%	3,50%	3,97%	3,41%
HF	9,83%	5,74%	72,29%	0,00%	0,27%
PF	0,47%	1,88%	0,33%	86,86%	9,55%
LV	2,81%	0,00%	0,43%	7,45%	71,25%

TABLE V. MASTER CLASSIFICATION MAP CONFUSION MATRIX (PRODUCER ACCURACY)

Overall Accuracy			**80,20%**		
Kappa Coefficient			**0,7452**		
			Ground Truth		
Classes	**UZ**	**MF**	**HF**	**PF**	**LV**
Unclass.	11,70%	0,00%	6,32%	0,00%	0,00%
UZ	81,44%	0,00%	0,16%	1,20%	10,27%
MF	0,16%	75,21%	1,30%	0,00%	0,19%
HF	0,00%	22,06%	70,83%	0,52%	2,43%
PF	6,55%	0,00%	8,82%	98,28%	7,04%
LV	0,16%	2,73%	12,56%	0,00%	80,07%

TABLE VI. AIRSAR/MASTER CLASSIFICATION FUSION MAP CONFUSION MATRIX (PRODUCER ACCURACY)

Overall Accuracy			**86,64%**		
Kappa Coefficient			**0,8283**		
			Ground Truth		
Classes	**UZ**	**MF**	**HF**	**PF**	**LV**
Unclass.	0,31%	0,00%	5,92%	0,00%	0,00%
UZ	83,62%	0,00%	0,08%	1,01%	11,15%
MF	13,26%	95,71%	2,25%	5,43%	8,80%
HF	2,81%	2,48%	90,94%	0,00%	0,93%
PF	0,00%	1,81%	0,30%	89,25%	4,88%
LV	0,00%	0,00%	0,52%	4,31%	74,23%

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