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A Vegetation Classification of the Opunohu Valley (Moorea Island - French Polynesia) Based on a Relative Canopy-Height Class Set Using AirSAR and MASTER Data

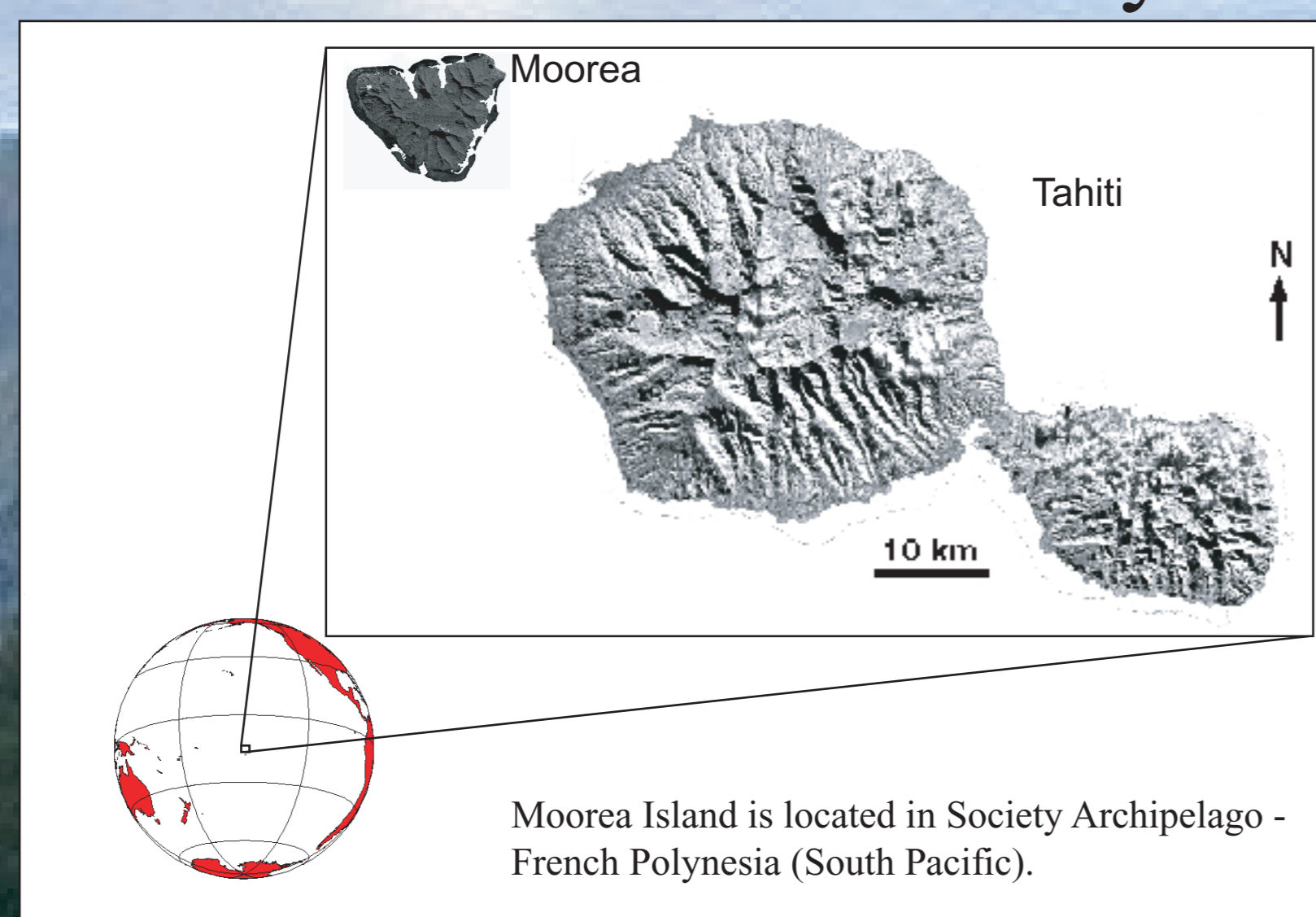
Abstract

This poster addresses the vegetation mapping and land use of Opunohu Valley (Moorea Island - French Polynesia) using JPL-AirSAR and MASTER (MODIS/ASTER simulator) images acquired during the PACRIM2 mission (Aug. 2000).

These sensors are different but can be considered as complementary since MASTER is a 20 meters ground resolution multispectral imaging scanner with 50 channels distributed in the visible-shortwave infrared, mid infrared and thermal infrared, and AirSAR is a C-band (TOPSAR) and L-band (POLARSAR), 5meters ground resolution radar sensor.

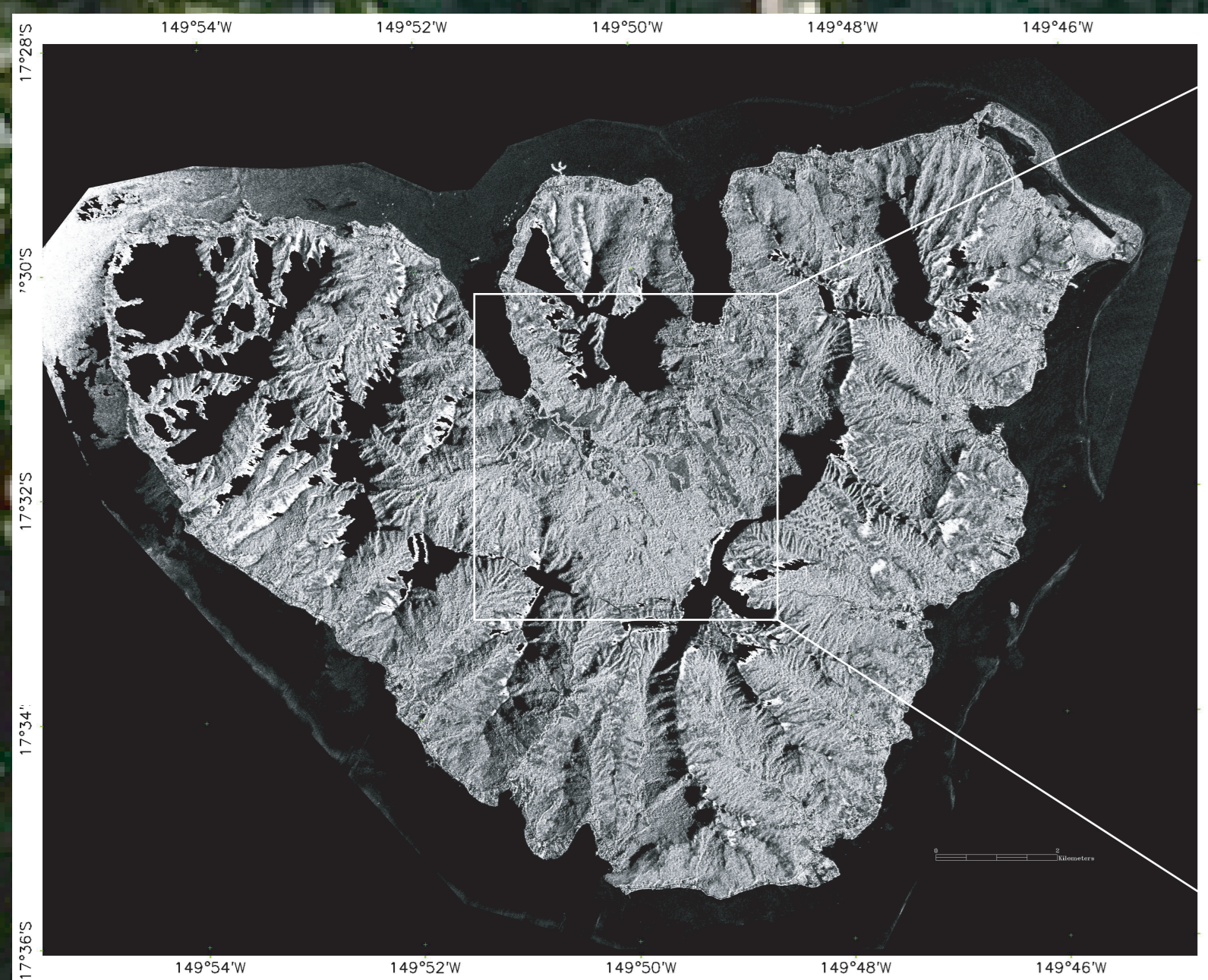
Our main application field deals with the complex and fragile vegetation cover of south pacific volcanic islands. We presently focus on Opunohu Valley because of its highly representative diversity of vegetation and land cover (found in other polynesian volcanic islands), including different types of forests, coconut fields, grass fields, fern lands, urban zones, agricultural areas, etc... Moreover this area is particularly interesting because of its flat topography reducing the slope effect on the radar backscattering signal.

Moorea Island - French Polynesia

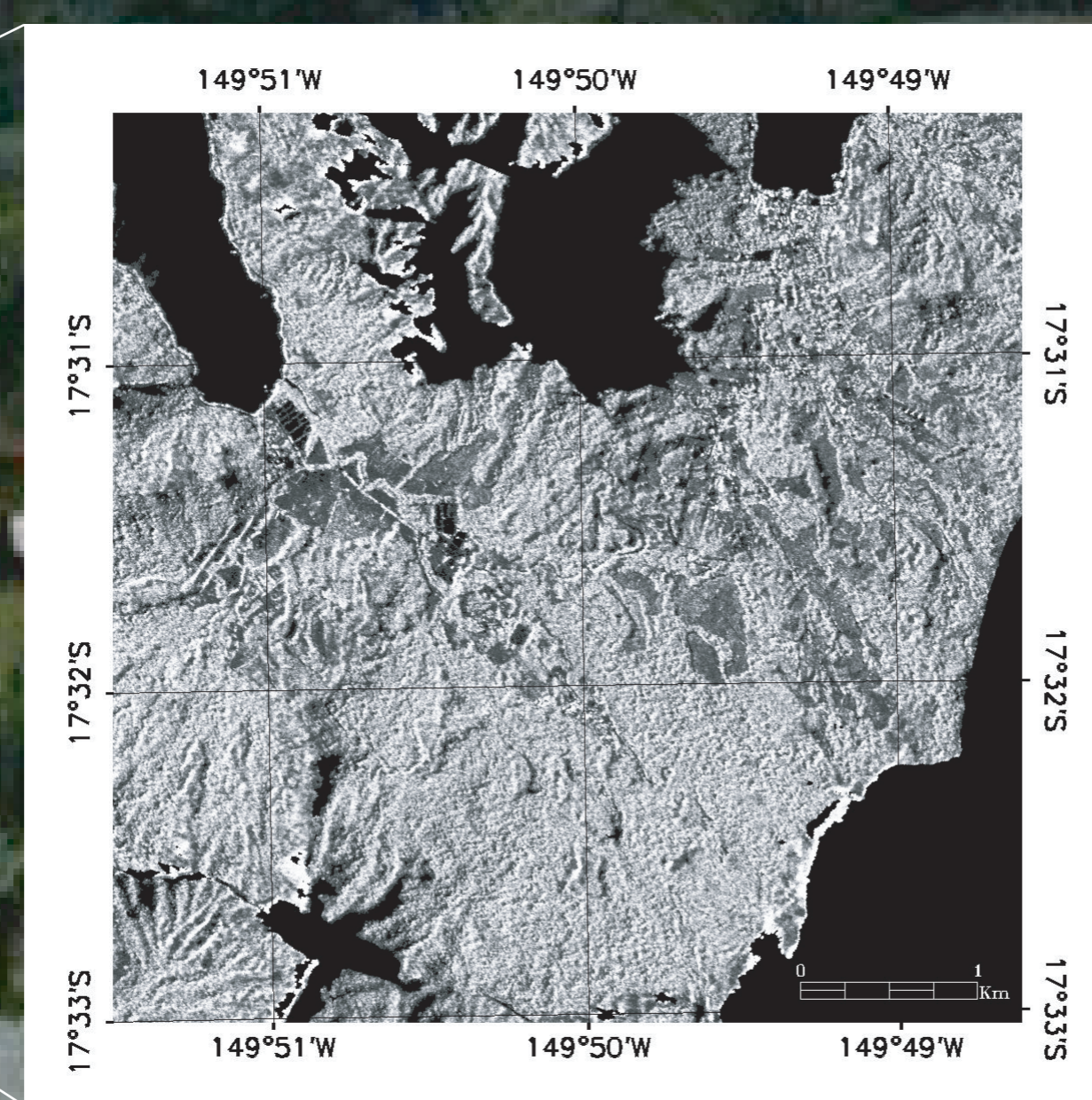


Location of Moorea Island in French Polynesia.

Opunohu Valley Study Zone



AirSAR L-TP Moorea Island



AirSAR L-TP Opunohu Valley

PACRIM II Mission Data

The JPL-NASA PACRIM2 mission over French Polynesia (August 2000), gives a complete data set from MODIS/ASTER and AirSAR sensors.

MODIS/ASTER (MASTER): multispectral imaging scanner

- 50 channels distributed in the visible-shortwave infrared, mid infrared and thermal infrared (*only 32 bands usable in Moorea Data Set*)
- 20m ground resolution (*after geometric correction*)

JPL-AirSAR: XT11 mode

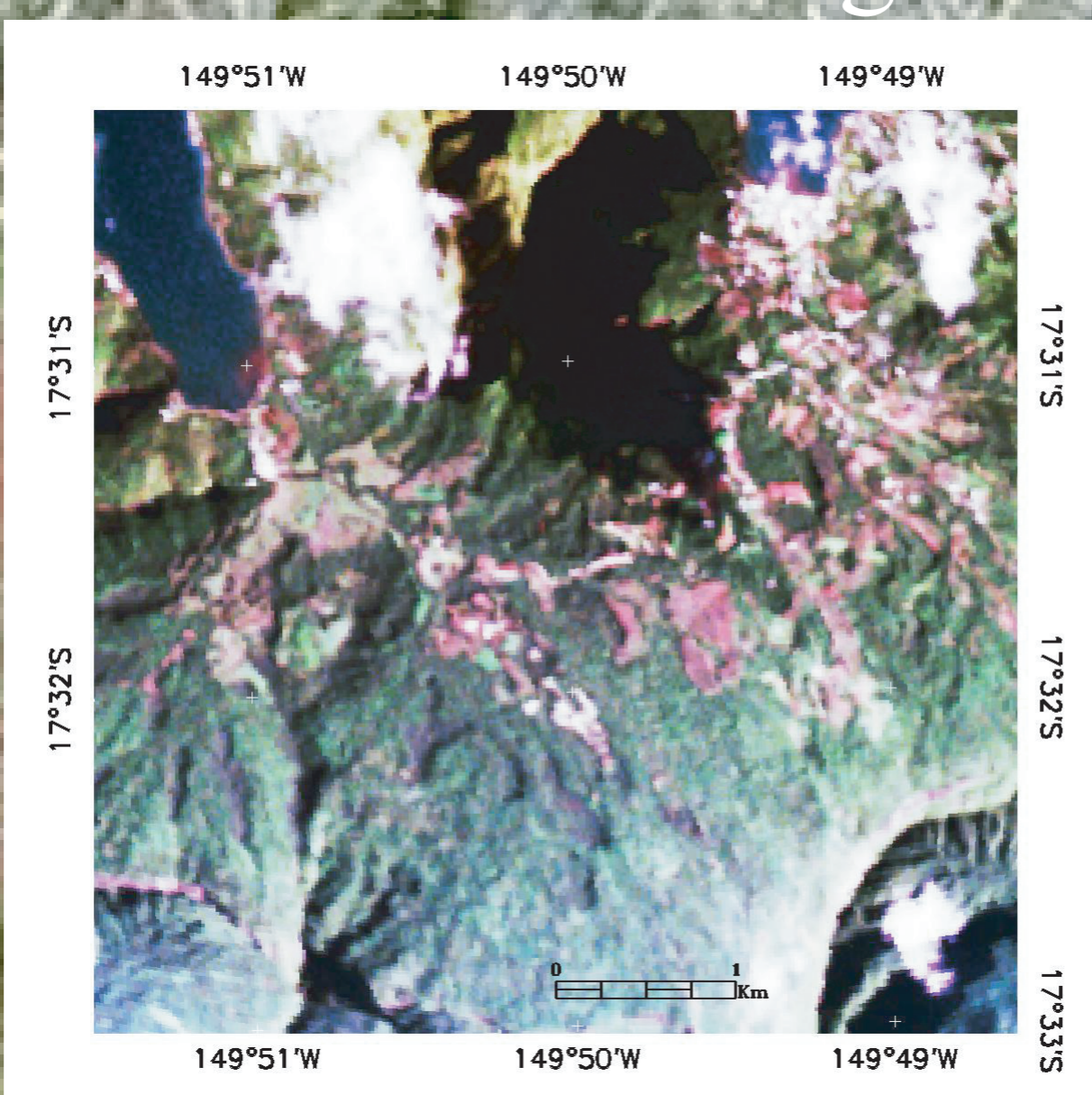
- C-band single-baseline interferometry in VV polarization (TOPSAR)
- L-band Polarimetry (POLARSAR)
- P-band Polarimetry (*unavailable for Moorea Island Data Set*)
- 40MHz Bandwidth thus the pixel size is 5m ground-range resolution.

TOPSAR C-band (5.6cm)		POLARSAR L-band (25cm)	
VV polarization	HH polarization		
Correlation	VV polarization		
Incidence angle	HV polarization		
DEM	Total Power		

Aerial Photographs

A set of aerial photographs (courtesy of French Polynesia Territory) from October 16th, 2002 completes the Data Set available for this study.

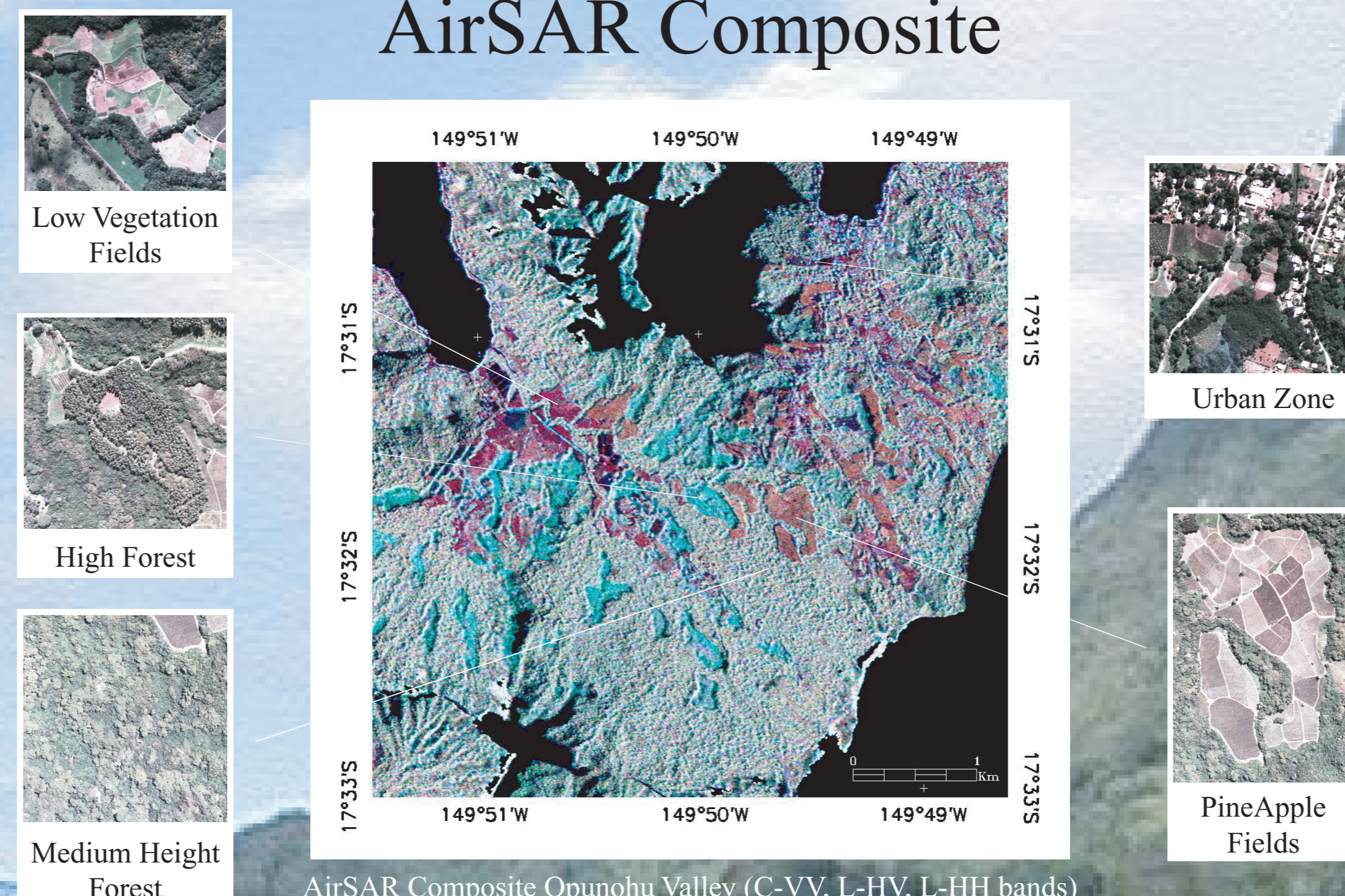
MASTER Image



MASTER Image of Opunohu Valley (5,3,2 bands)

Benoît Stoll (1)(3), Johann Thomas (2), Patrick Capolsini (1)

AirSAR Composite



AirSAR Composite Opunohu Valley (C-VV, L-HV, L-HH bands)

Class Set Definition

A 4 classes set has first been defined on a relative vegetation density since radar backscattering signal can be representative of the volume of vegetation and its crown complexity.

· High density vegetation · Medium density vegetation · Low density vegetation · No vegetation

A RGB composite (*respectively C-VV, L-HV, L-HH bands used as Red, Green, and Blue*) has been processed to visually discriminate the above classes. An histogram equalization contrast stretch must be applied to normalize the mean power of the various bands (*C-band (TOPSAR) or L-band (POLARSAR)*) and polarizations (*VV, HV or HH*).

The colors in the resulting RGB composite image reflects the above class properties, i.e. a low vegetation field will be represented in red, dark green will represent a high density of vegetation, etc...

A 5 class set is defined visually from this RGB Composite (the no-backscattering area are excluded by masking):

High Forest	Pinus, Falcata, etc..
Medium Forest	Purau, Bamboo, Mango Tree, etc...
Pineapple Field	
Low Vegetation	Low grass fields, etc..
Urban Zone	Local houses, garden, roads, trees, etc..

This simple class set is based on the relative-height of the vegetation except for the Urban Zone and the Pineapple Field classes.

Ground Truth missions helped defining precisely the components of each class:

-The High Forest class includes essentially the *Pinus Caribaea* and *Falcata (Paraserianthes Falcataria)* culminating way above the Medium Forest, which is the main type of forest in volcanic islands including "Purau" (*Hibiscus Tiliaceus*), Bamboo, Fern lands, Mango Trees and etc...

-The Pineapple Fields class discriminates from the height-related Low Vegetation class, the other crop area seems to be classified in Medium Forest or Low Vegetation depending on their quantity of vegetation.

-The Urban Zone is a collection of heteroclit objects, local houses, garden, roads, trees, etc...

-High Forest class should include the "Mape" (Tahitian Chestnuts, *inocarpus fagiferus*) forest but this trees grow in river beds and the canopy doesn't culminate the medium forest and therefore is classified as Medium Forest, moreover, the "Aito" (*Casuarina Equisetifolia*) trees should be classified in medium forest class (because of its canopy height) but its relative height is important compared to the surrounding Low Vegetation so it's mostly classified as High Forest.

The Region of Interests are then defined using aerial photographs, each clearly identified zone is delineated for the Supervised Algorithm learning process.

Preprocessing and Classification

Geometric correction

AirSAR Data are already corrected by NASA JPL-office, but MASTER data need a geometric correction to match the AirSAR images geometry, after this process the pixel size is 20 meters.

Georeferencing, Mosaic and Masks

Both images were georeferenced using an IGN Map in order to have a common ground reference, a mosaic step was then processed for the AirSAR Data (two scenes). The AirSAR mask was based on the radar shadows while the MASTER image mask includes the clouds and shadows area. A common mask including both AirSAR and MASTER masks helps compare the classification results.

Filtering and Region Of Interest Separability

A speckle reduction was processed on AirSAR Data, Several ENVI[®] filtering techniques were tested using ENVI[®] ROI Separability Index (*Jeffries-Matusita*) as a comparison criteria for Speckle filters. The Lee filtering (*preserves image sharpness and detail while suppressing noise*) with 10x10 pixels window shows best results on our AirSAR image and ROI definition.

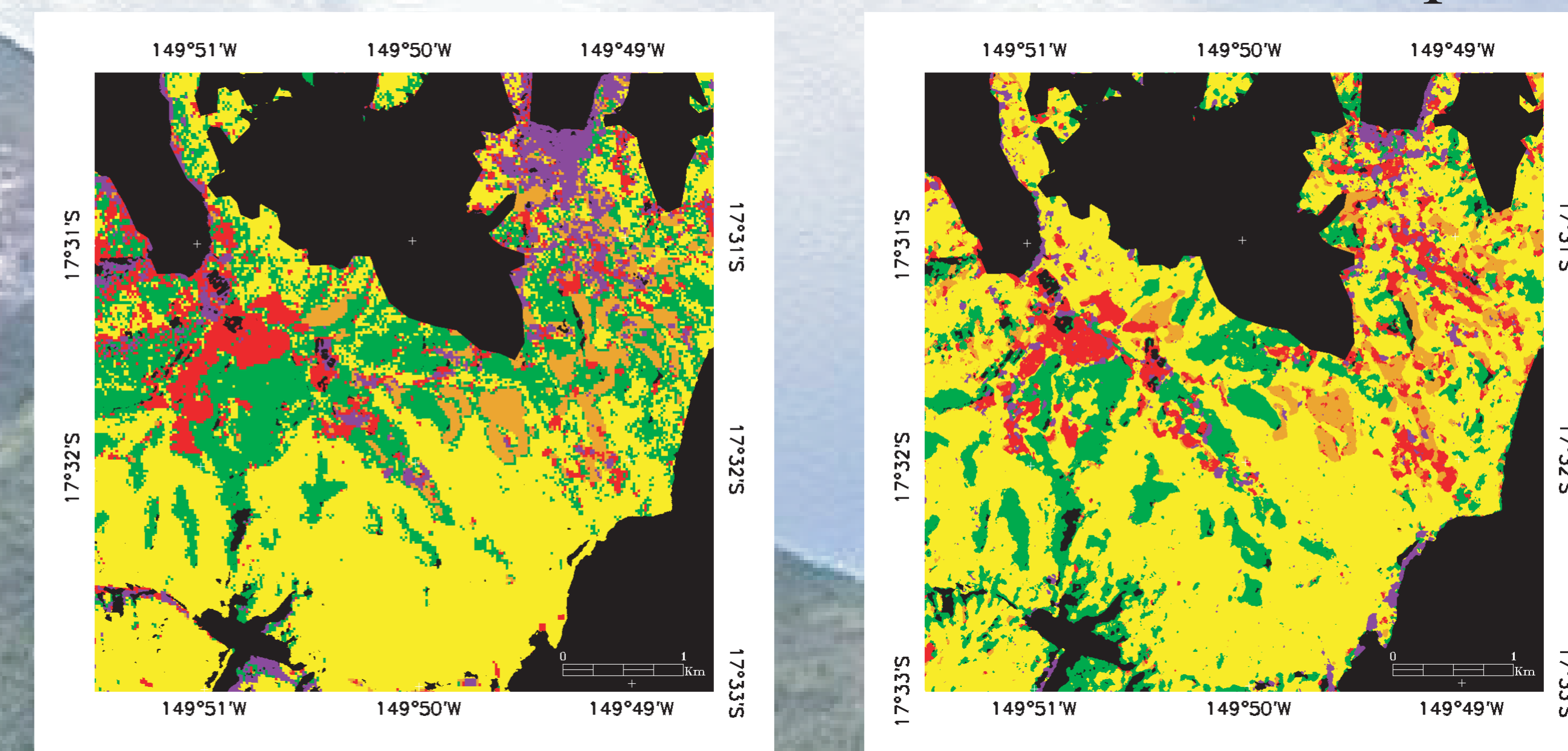
Low Vegetation	Pineapple Field	1.25635474
High Forest	Medium Forest	1.75250398
Medium Forest	Urban Zone	1.86430262
High Forest	Urban Zone	1.90294545
Low Vegetation	Urban Zone	1.90301543
Pineapple Field	Urban Zone	1.91280686
Medium Forest	Pineapple Field	1.98632083
Low Vegetation	Medium Forest	1.98817265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

Classification

A standard Maximum-Likelihood Supervised classification algorithm was processed on the filtered data. We performed this algorithm on the C-VV, L-HH, L-HV, L-VV bands.

MASTER image was classified, using the same M-L algorithm and the same learning ROI on the 32 bands (*18 bands were corrupted during the acquisition*)

MASTER and AirSAR Classification Maps



Classification map of Opunohu Valley (MASTER Data)

Classification map of Opunohu Valley (AirSAR Data)

Classification Analysis

MASTER Classification Results				AirSAR Classification Results				Diff.
High Forest	164 323 pixels	(15,67%)	High Forest	122 104 pixels	(11,64%)	-4,03%		
Medium Forest	346 165 pixels	(33,01%)	Medium Forest	427 148 pixels	(40,74%)	7,72%		
Pineapple Field	75 272 pixels	(7,18%)	Pineapple Field	79 965 pixels	(7,63%)	0,45%		
Low Vegetation	64 768 pixels	(6,18%)	Low Vegetation	40 903 pixels	(3,90%)	-2,28%		
Urban Zone	59 267 pixels	(5,65%)	Urban Zone	38 722 pixels	(3,69%)	-1,96%		
Unclassified	338 781 pixels	(32,31%)	Unclassified	339 734 pixels	(32,40%)	0,09%		

MASTER based classification map under-estimates the Medium Forest while over-estimating the High Forest and Low Vegetation classes.

Producer Accuracy	Urban Zone	Medium Forest	High Forest	Pineapple Field	Low Vegetation
MASTER	81,44%	75,21%	70,83%	98,28%	80,07%
AirSAR	51,33%	91,45%	72,29%	86,86%	71,25%

The Urban Zone seems to be better estimated with MASTER because of its 20meters ground resolution including all the heteroclit objects of this class.

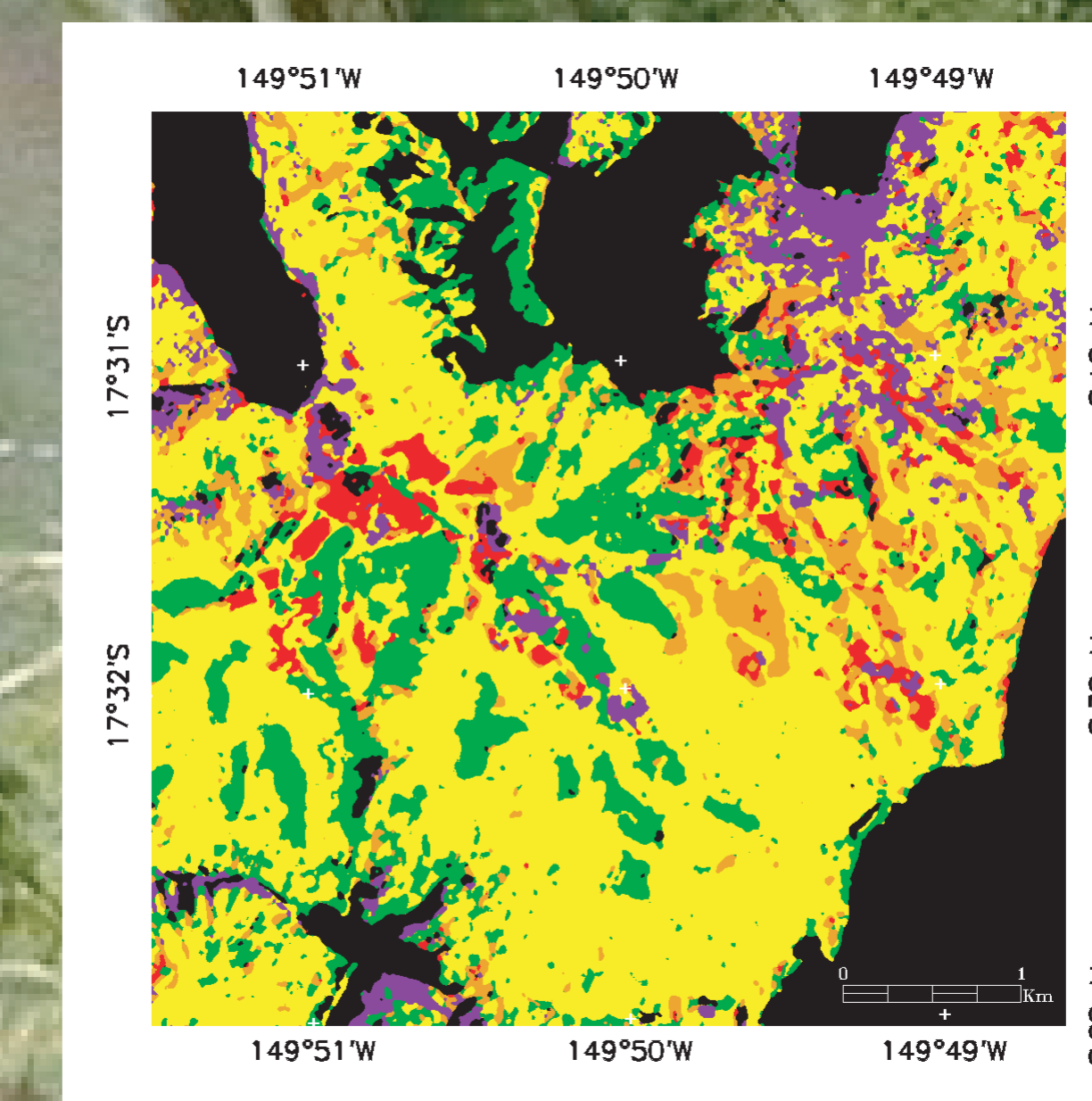
Producer Accuracy	Urban Zone	Medium Forest	High Forest	Pineapple Field	Low Vegetation
AirSAR Maj	52,11%	95,57%	75,28%	89,85%	74,29%
AirSAR 20m	69,42%	91,42%	74,33%	89,85%	75,22%

A majority analysis shows that all AirSAR classes (except Urban Zone) gets more accurate as the homogeneity of its classified area increases.

A degradation of AirSAR image down to 20m ground resolution improves the Urban Zone results compared to the original 5 meters image.

Producer Accuracy	Urban Zone	Medium Forest	High Forest	Pineapple Field	Low Vegetation
AirSAR/MASTER	81,44%	92,23%	88,96%	86,60%	71,89%
AirSAR/MASTER Maj	83,62%	95,71%	90,94%	89,25%	74,23%

A fusion step has been processed to keep the MASTER estimated Urban Zone class and estimate the vegetation classes using the AirSAR 5 meters ground resolution, the overall accuracy of the resulting classification map is increased.



Opunohu Valley Classification map (AirSAR + MASTER)

Conclusions

A simple relative canopy height class set has been defined using the AirSAR signal backscattering properties.

A particular Pineapple Field class proved to discriminate from the height-related Low Vegetation class (Pineapple is an important economic resource in Moorea Island).

Two classification maps were produced from MASTER and AirSAR images based on this class set including an Urban Zone which proved to be better classified on MASTER image while the vegetation based classes (Pineapple Field, Low Vegetation, High and Medium Forest) can be well classified on the AirSAR images.

A fusion between MASTER and AirSAR images has been processed using MASTER for classifying the Urban Zone and AirSAR for the Vegetation classes, this MASTER + AirSAR classification fusion improves the results (considering the overall accuracy).

This class set made from and for the AirSAR Data could be improved by adding the Polars P-band (lacking from the Moorea data set) and the use of the related DEM could add some interesting informations on the High Islands Vegetation.

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