OUTLINE

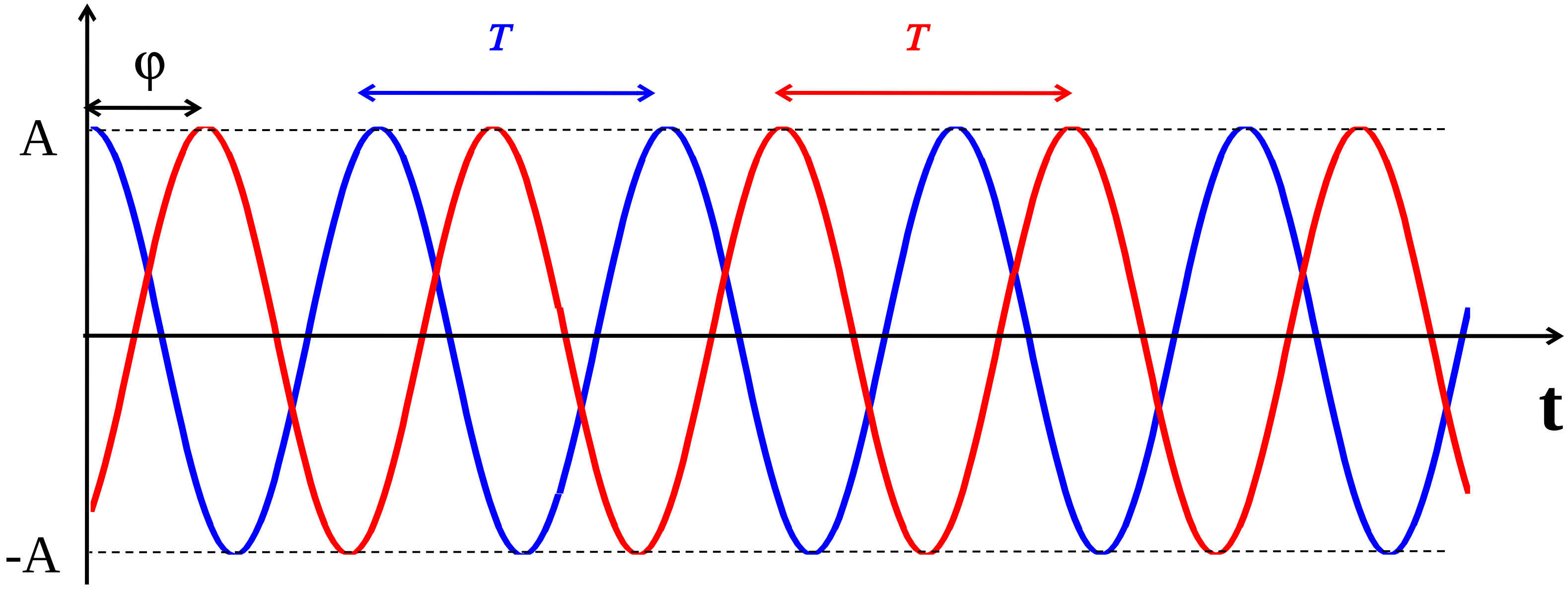
I. Radar imaging - Spatial resolution
II. Polarization - Polarimetry
III. Radar response sensitivity
IV. Relief effects
V. Speckle and Filtering

Université Gustave Eiffel

LaSTI
Laboratoire des Sciences et Technologies de l'Information Géographique

Electromagnetic coherent wave

Coherent wave: ***temporal*** behaviour



$$y(t) = A\cos\left(\frac{2\pi}{T}t\right)$$

$$y(t) = A\cos\left(\frac{2\pi}{T}t - \varphi\right)$$

$$T = \frac{1}{f_0}$$

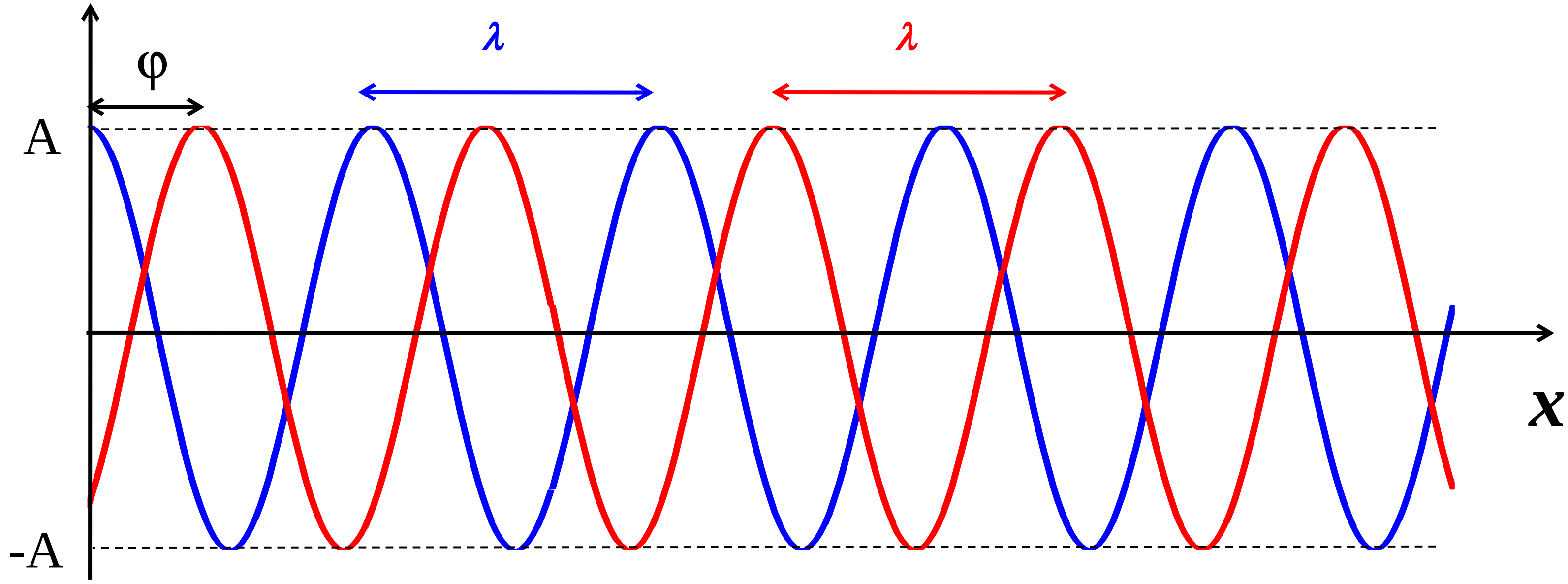
A: amplitude

T: time period

φ: phase shift

Electromagnetic coherent wave

Coherent wave: ***spatial*** behaviour



$$y(x) = A\cos\left(\frac{2\pi}{T}x\right)$$

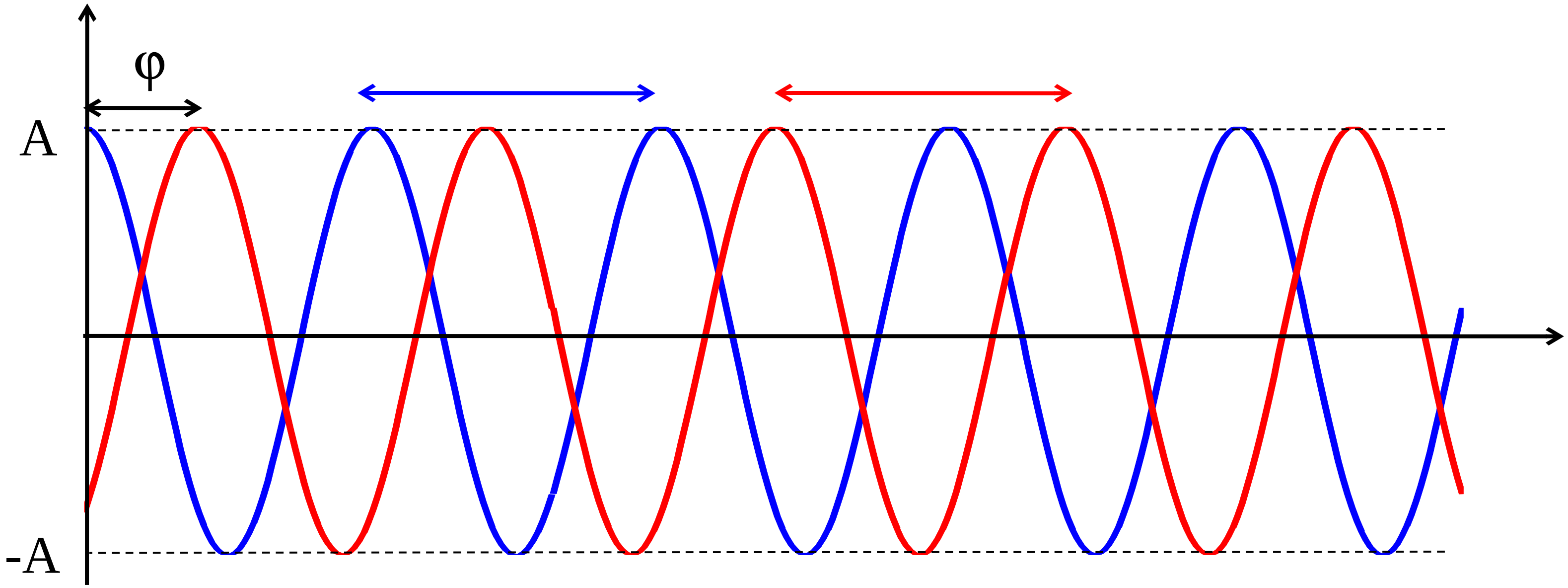
$$y(x) = A\cos\left(\frac{2\pi}{T}x - \varphi\right)$$

$$\lambda = cT = \frac{c}{f_0}$$

A: amplitude
λ: spatial period = wavelength
φ: phase shift
c: light celerity = 3.10^8 m/s

Electromagnetic coherent wave

Coherent wave: ***spatial*** and ***temporal*** behaviour

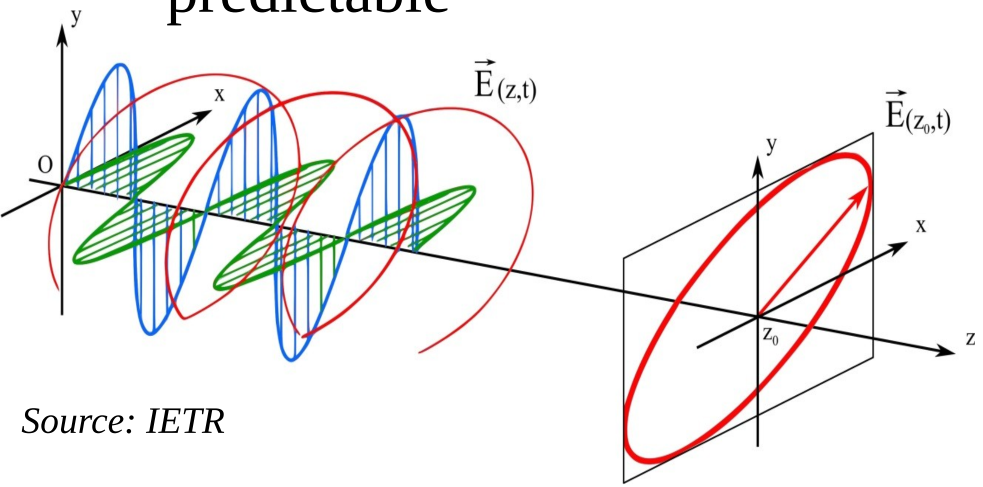


$$\psi(x,t) = A\cos\left(2\pi f_0 t - \frac{4\pi}{\lambda}x + \varphi\right)$$

Polarization

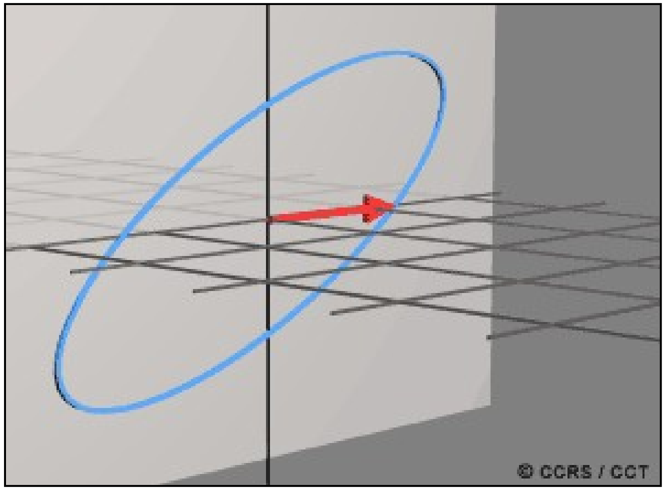
Important characteristics of coherent EMW:

Electromagnetic field evolution is predictable



Source: IETR

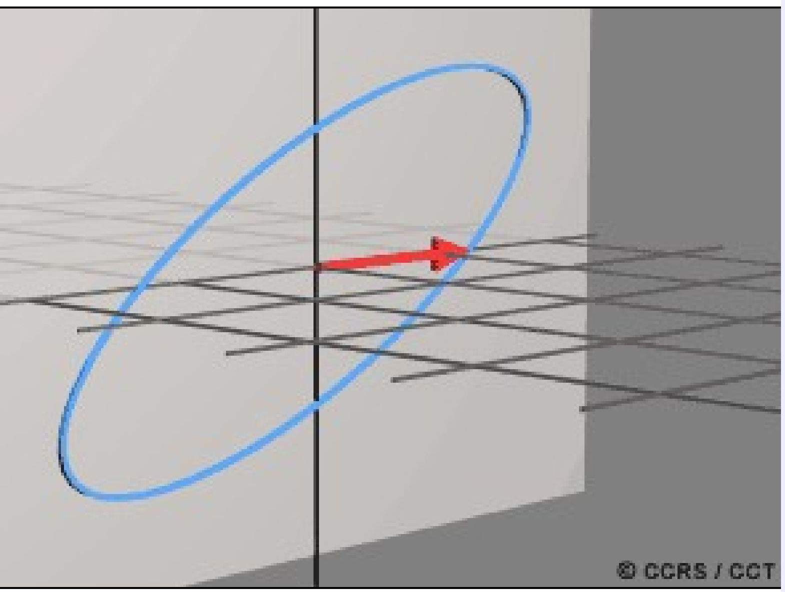
Most general: ***Elliptical*** *polarization*

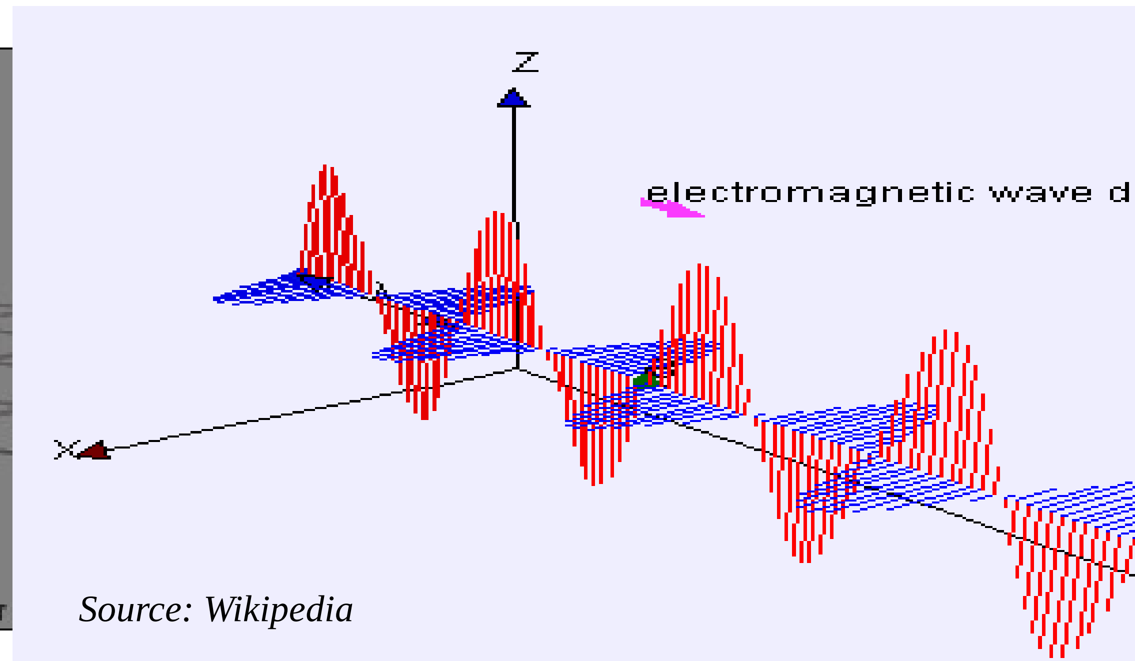


Polarization

Most general:
Elliptical *polarization*

Common radar sensor:
Linear *polarization*





Source: Wikipedia

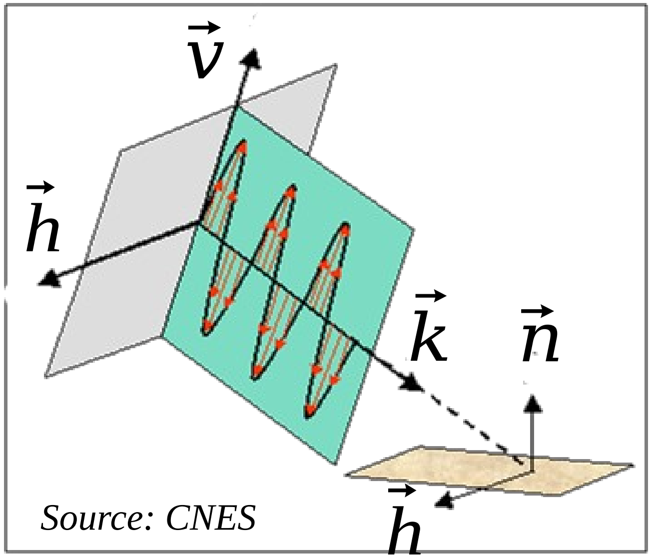
Polarization

Radar :

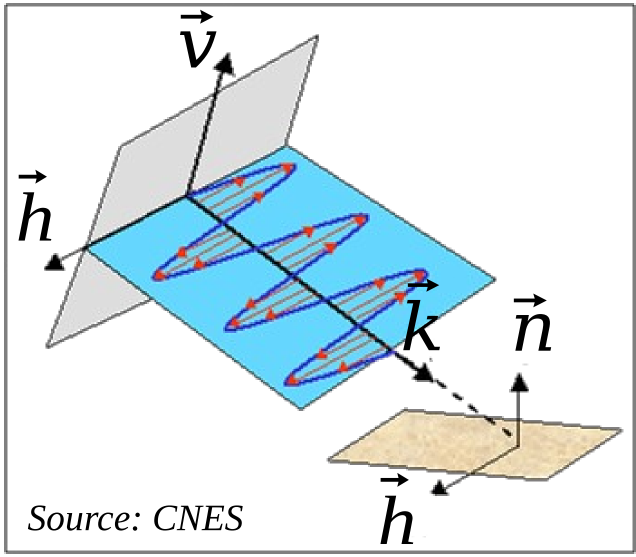
transmits a EMW in a give polarization

measures the backscattered wave contribution in a given polarization

Vertical *polarization*



Horizontal *polarization*



$(\vec{k}, \vec{n})$ ***incident plane***

$\vec{k}$: Direction illumination

$\vec{n}$: Normal to the observed surface

Polarization

Polarization characterisation of a radar acquisition:

VV — ERS, ASAR, Sentinel-1

reception emission

HH — JERS, RADARSAT, PALSAR

reception emission

HV — ASAR, PALSAR, Sentinel-1

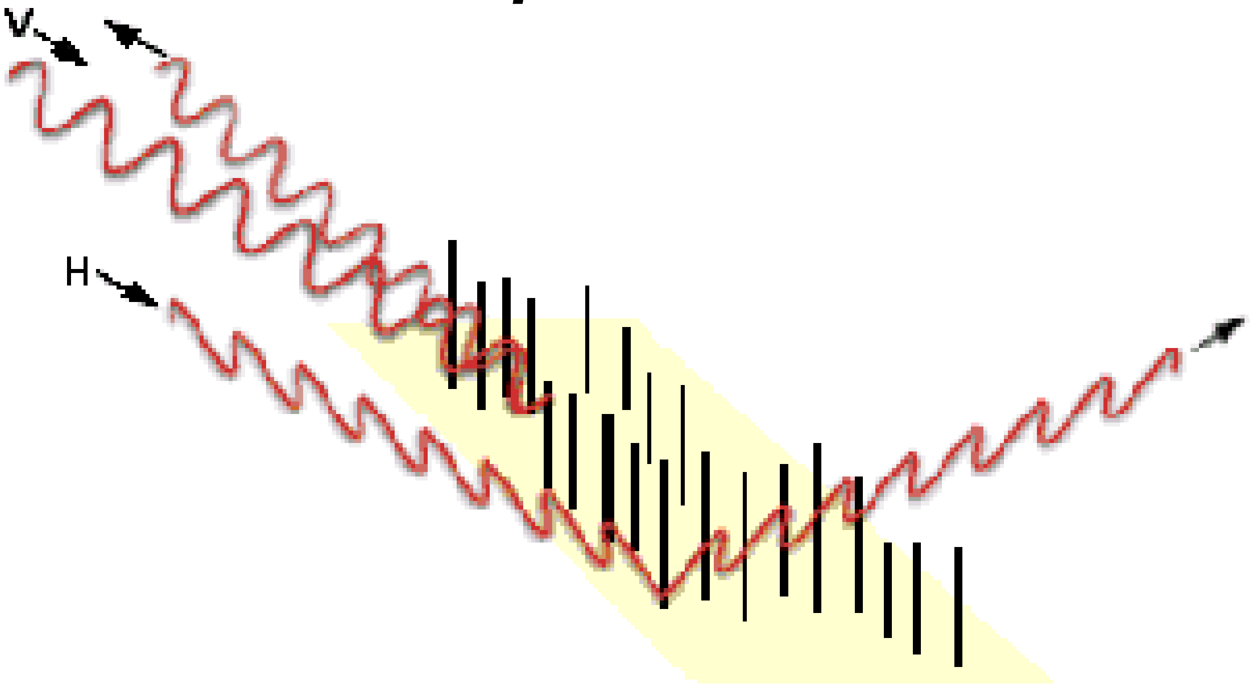
reception emission

VH — ASAR, PALSAR, Sentinel-1

reception emission

Polarization

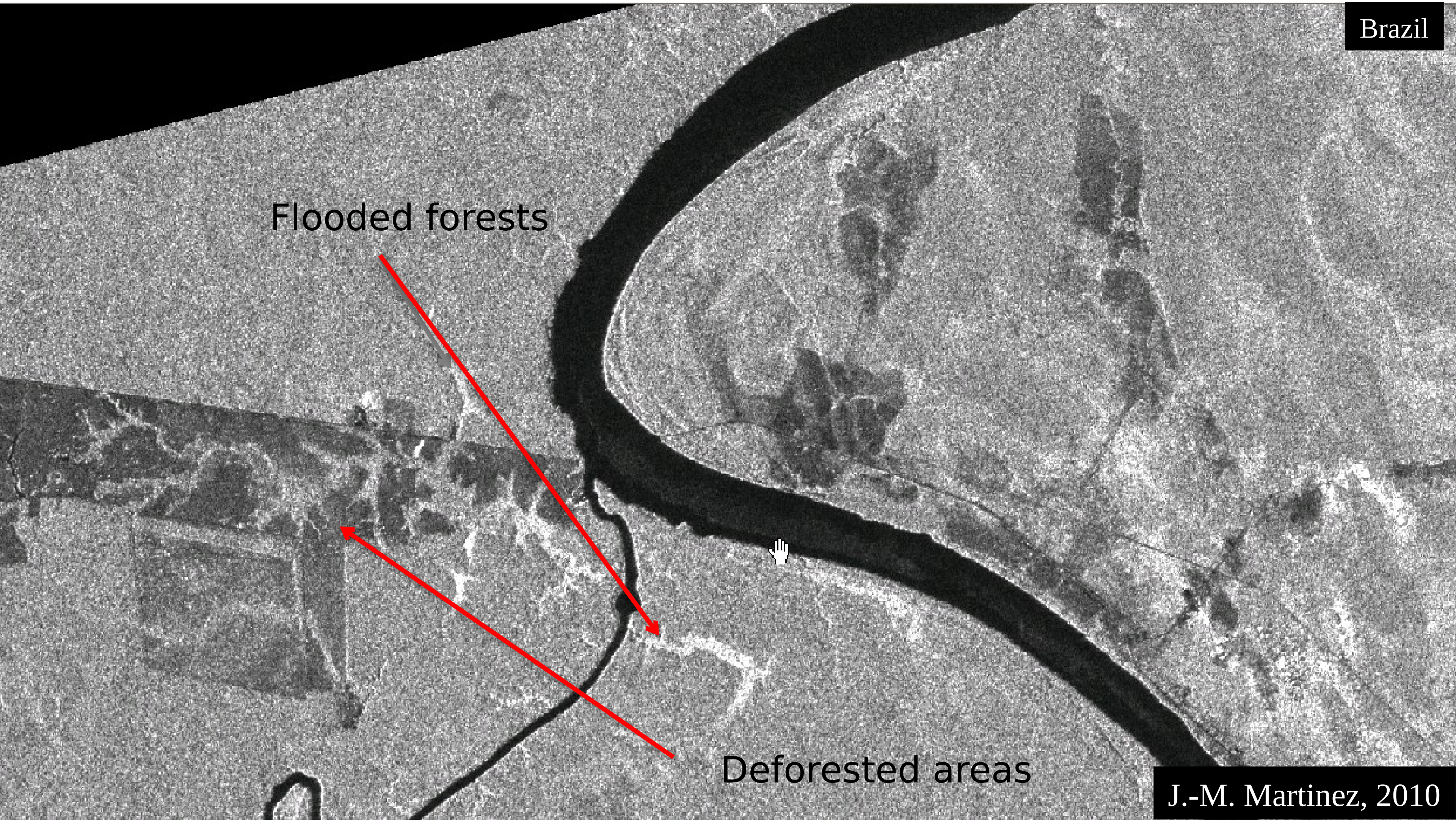
Surface with vertical structures



Polarization

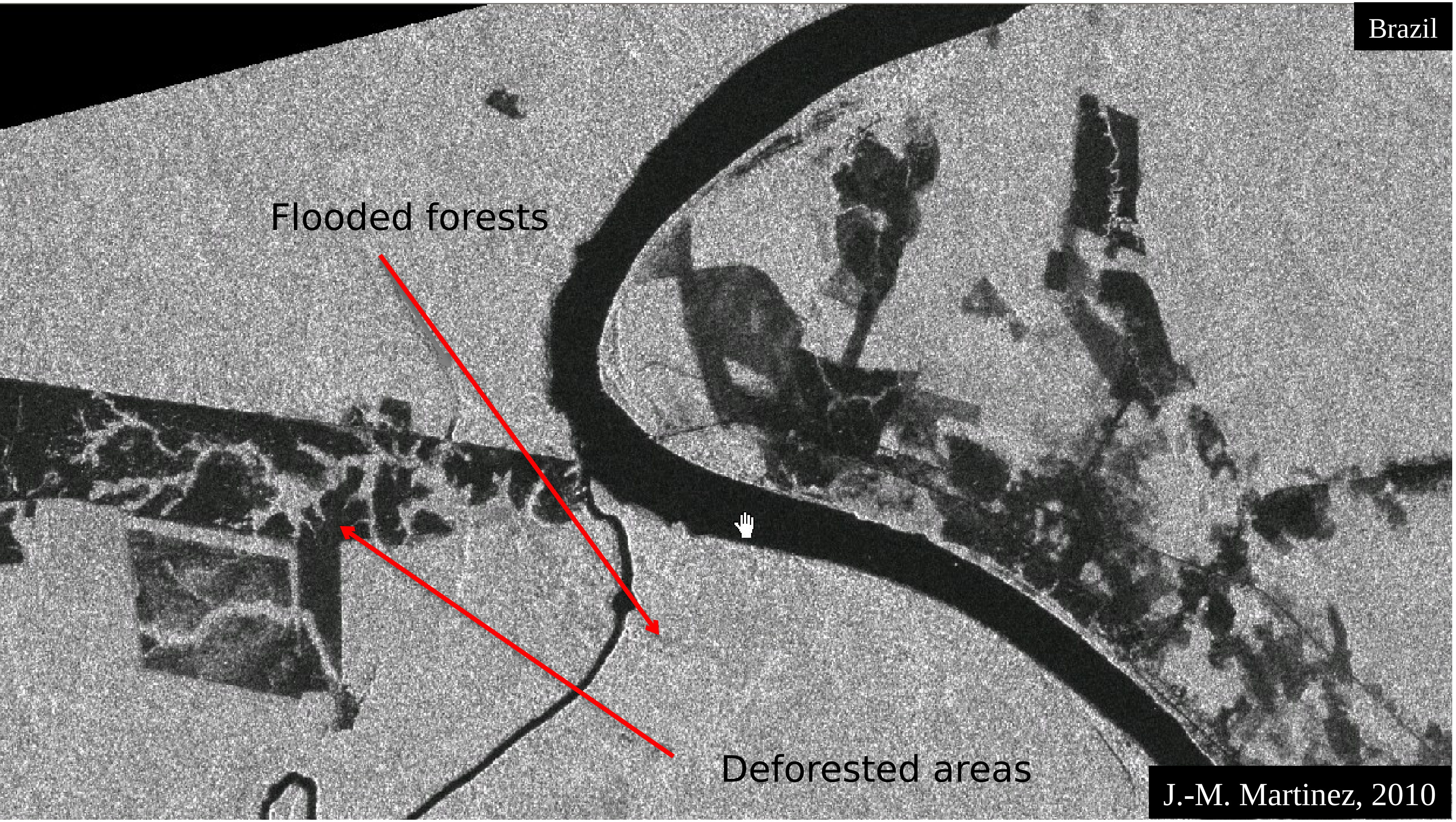
Microwave oven

Polarization



ALOS acquisition (λ = 24 cm)- Polarization ***HH***

Polarization

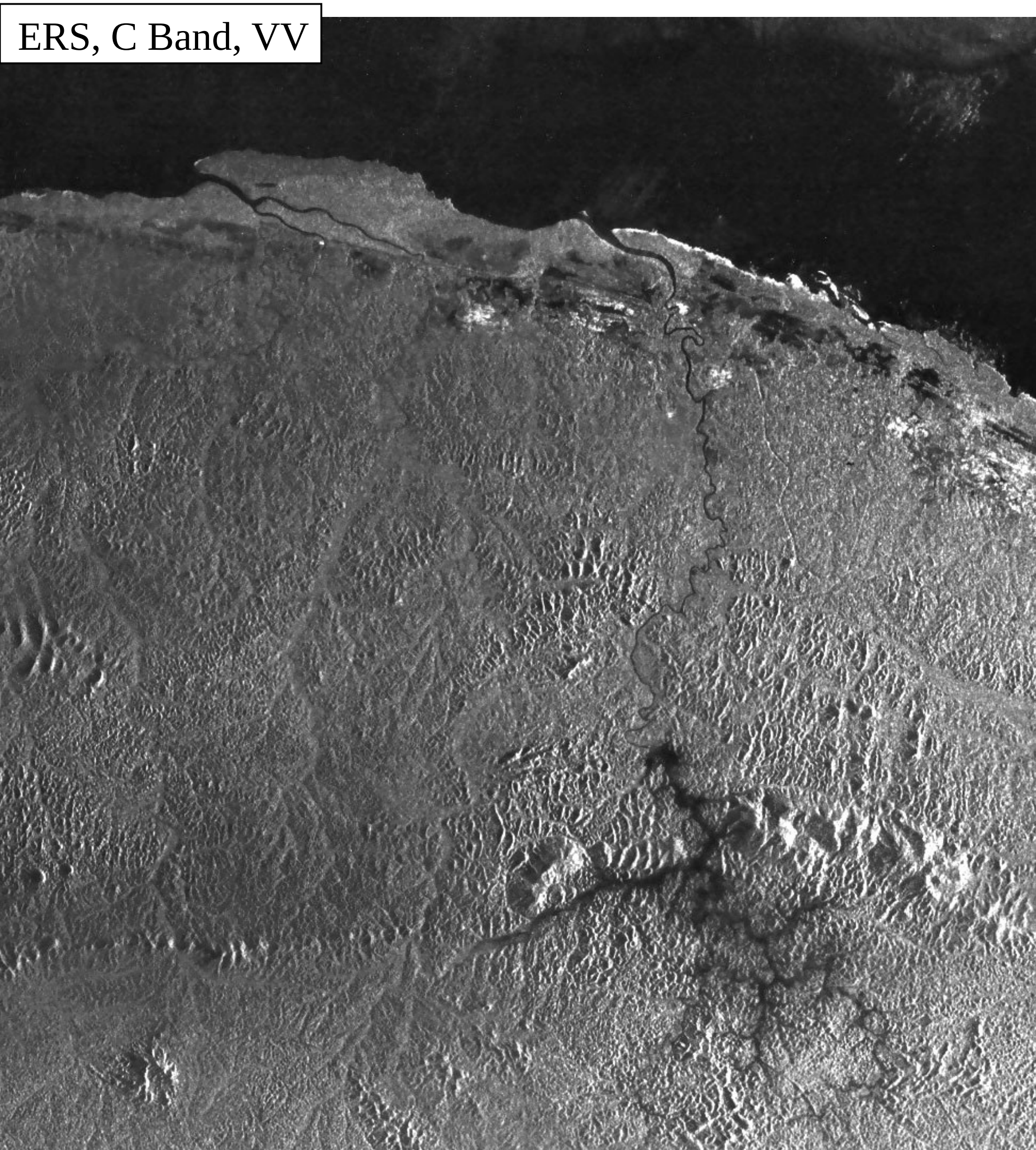


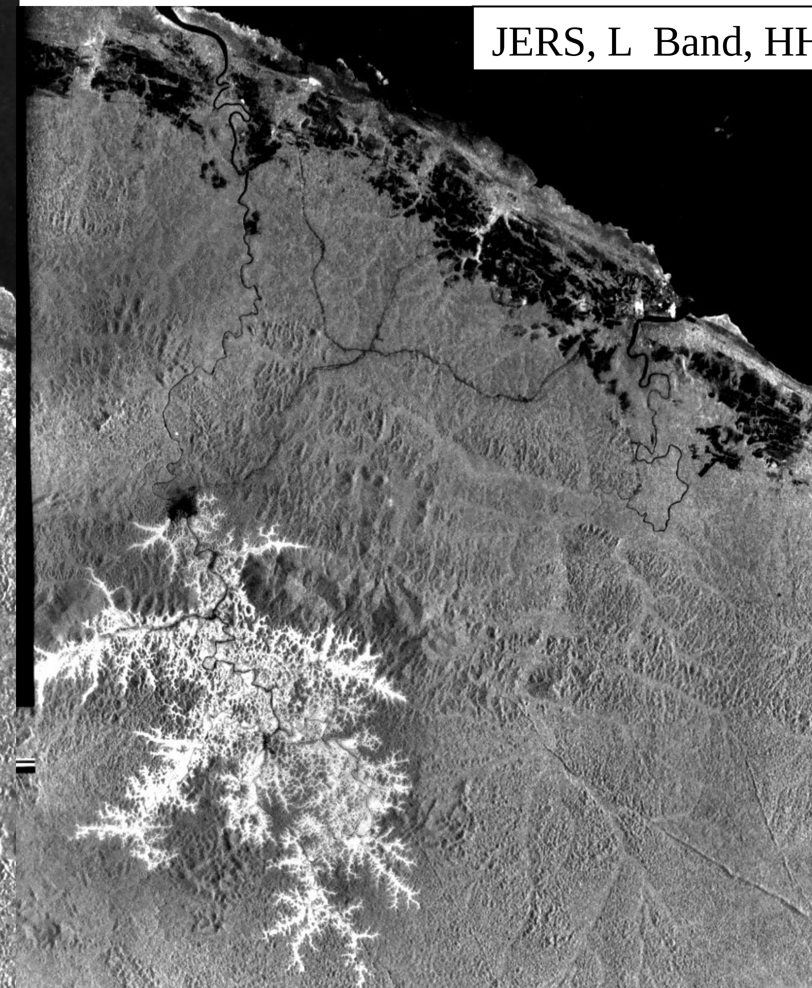
ALOS acquisition (λ = 24 cm)- Polarization ***HV***

Polarization

Monitoring of the Petit Saut Dam, French Guiana. Flooding beginning: 1994

Polarization

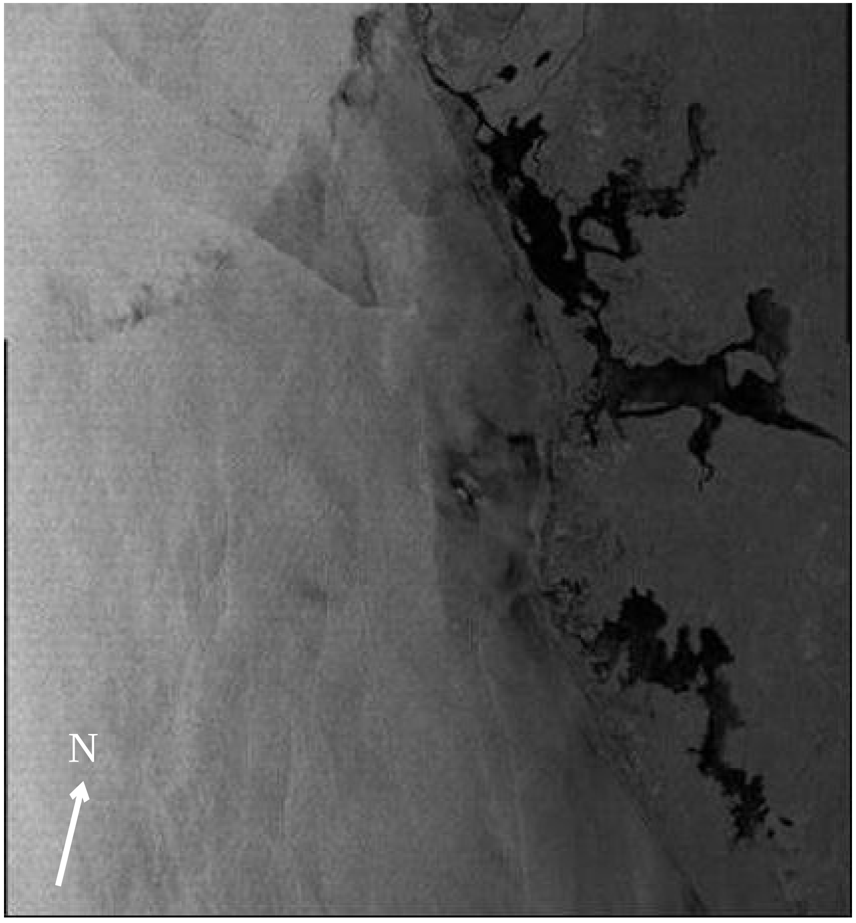




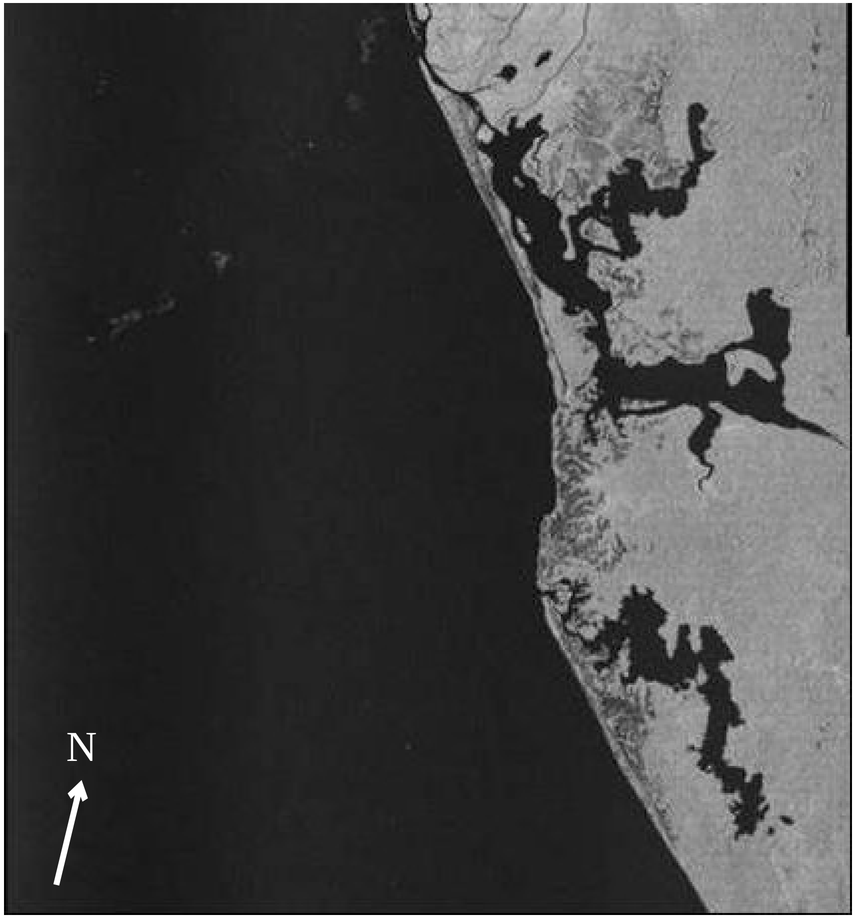
Polarization

ASAR acquisition
Gaboon

VV

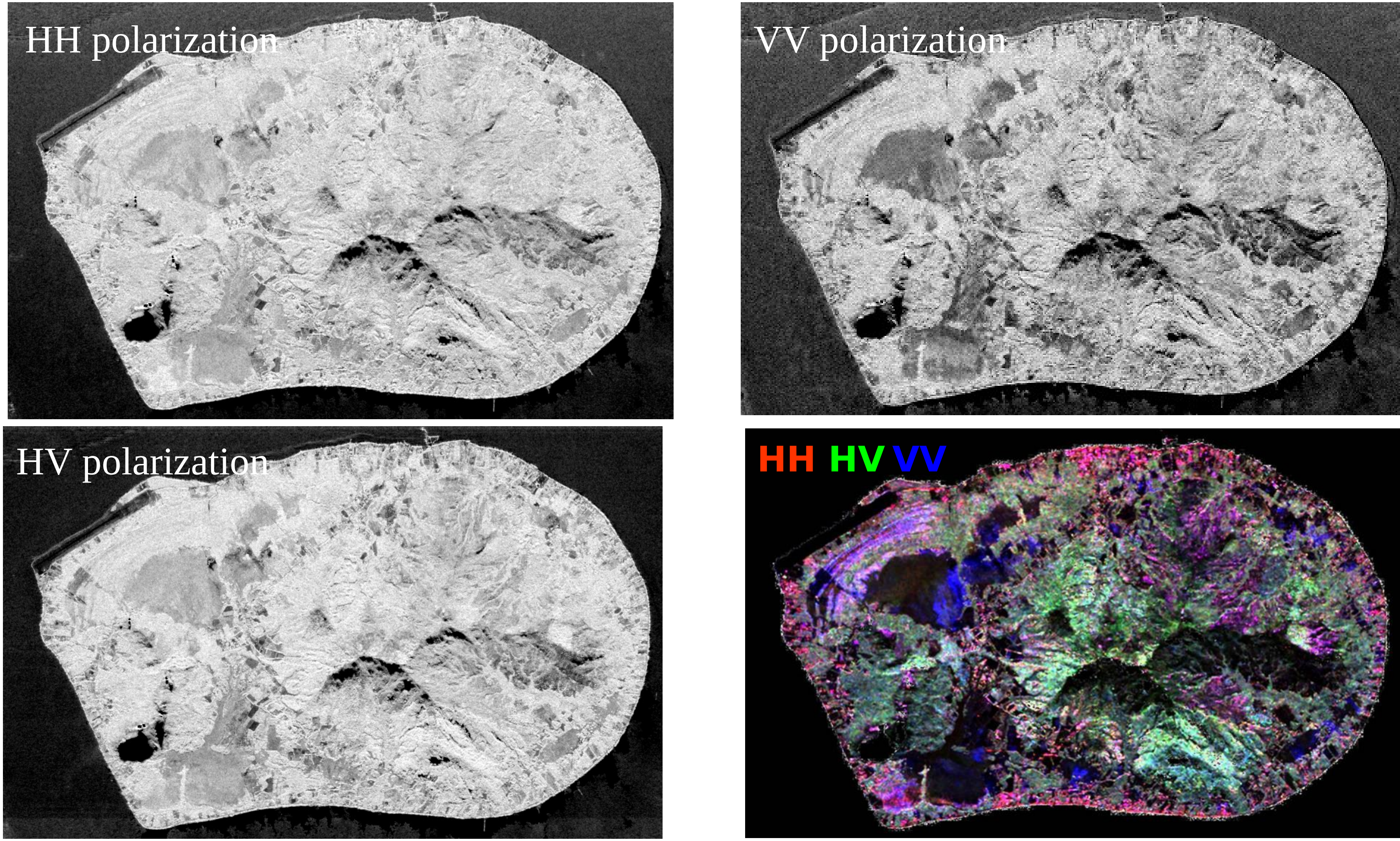


HV



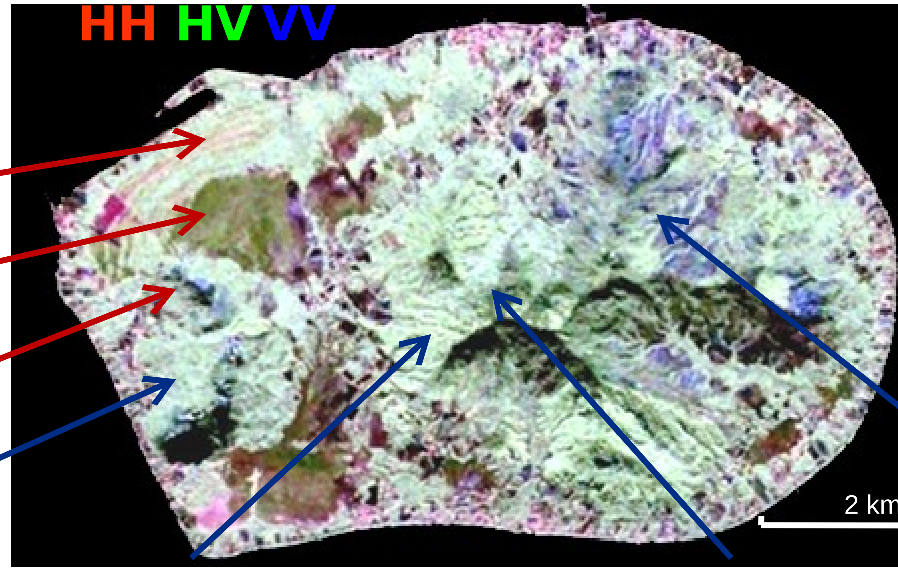
Polarization

Tubuai Island, vegetation discrimination, L Band



Radar polarimetry for Forest types cartography

Tubuai Island, French ¨Polynesia



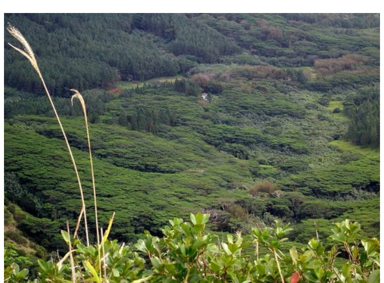
AIRSAR data
L band (λ = 24 cm)
Aug. 2000

7 different classes:

- bare soils
- swamps
- Fernlands

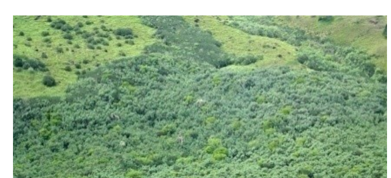
4 forets species

- Purau



- Pines

- Falcata



- Guava

Polarization

in visible domain also!

Polarization

in visible domain also!

Vertical

Horizontal

Rees, 2012

Radar images interpretation rules

Intensity (or Amplitude) Images

	smooth	rough
Surface scattering (bare soils)		
VV > HH	low	high
HV ~ 0		

Volume scattering (Dense forest)

HH, VV high

HV high

Double reflexion (urban areas, flooded vegetation)

HH > VV

Wild areas (urban areas, disorderly rocks)

VV ~ HH ~ HV

Radar images interpretation rules

Intensity (or Amplitude) Images

VV polarization

For bare surfaces (roughness / moisture)

vegetation with vertical structures (*i.e.* rice crops)

HV polarization

For Forest/Non forest discrimnation

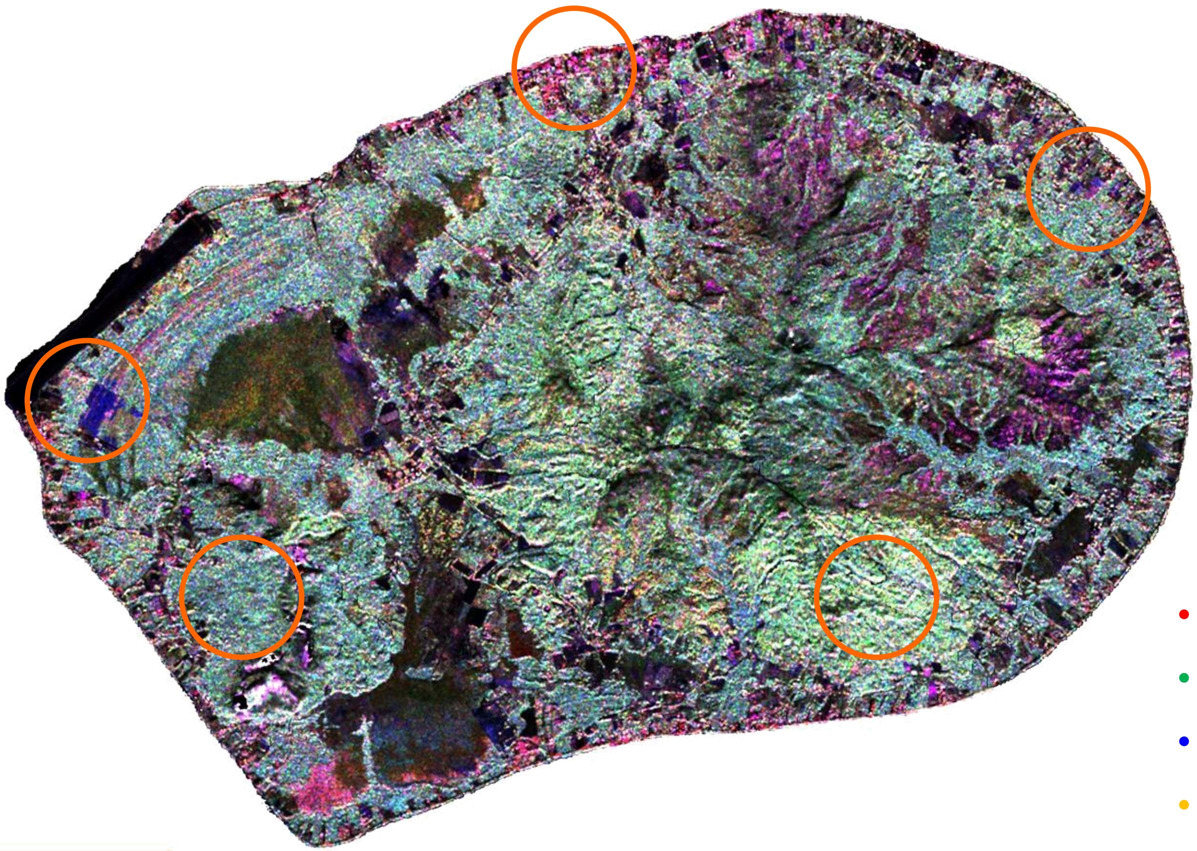
HH polarization

For flooded/Non flooded vegetation

Urban areas

Radar images interpretation rules

Intensity Image



HH HV VV

Tubuai Island

AISAR data, L Band

- ***Double bounds***
- ***Dense vegetation***
- **Bare soil**
- **Pinus** et **Falcata**

Purau

POLARISATIONS DIVERSITY ≠ POLARIMETRY

INTENSITY Images (different polarization):

HH, HV, VV *(ASAR)*

Fully Polarimetric Data: INTENSITY + PHASE

HH, HV, VV *(PALSAR, RADARSAT-2)*

Partial Polarimetric Data: INTENSITY + PHASE

HH, HV

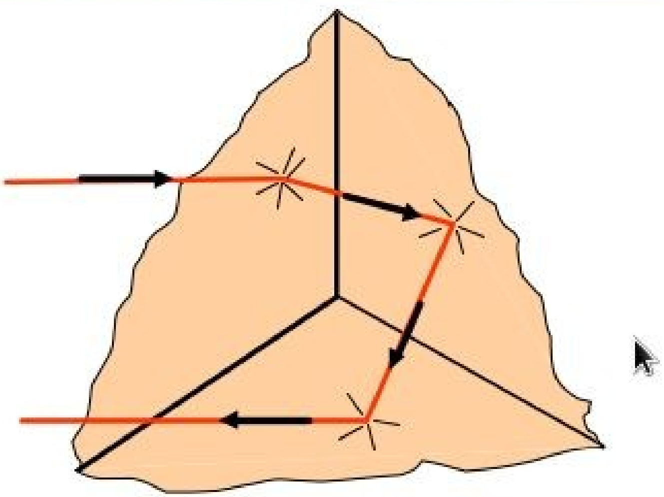
VV, HV

HH, VV *(PALSAR, RADARSAT-2)*

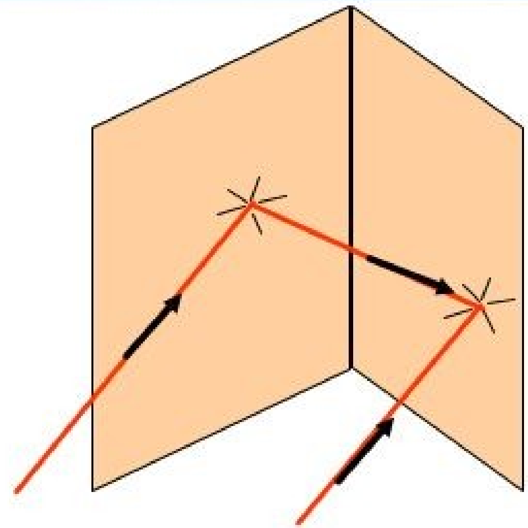
Radar images interpretation rules

Polarimetric Data: Amplitude + Phase Images

Behavior of the differential phases



Odd number of reflexions:
Ex: Trihedral target type
$\phi_{HH}-\phi_{VV} \approx 0°$



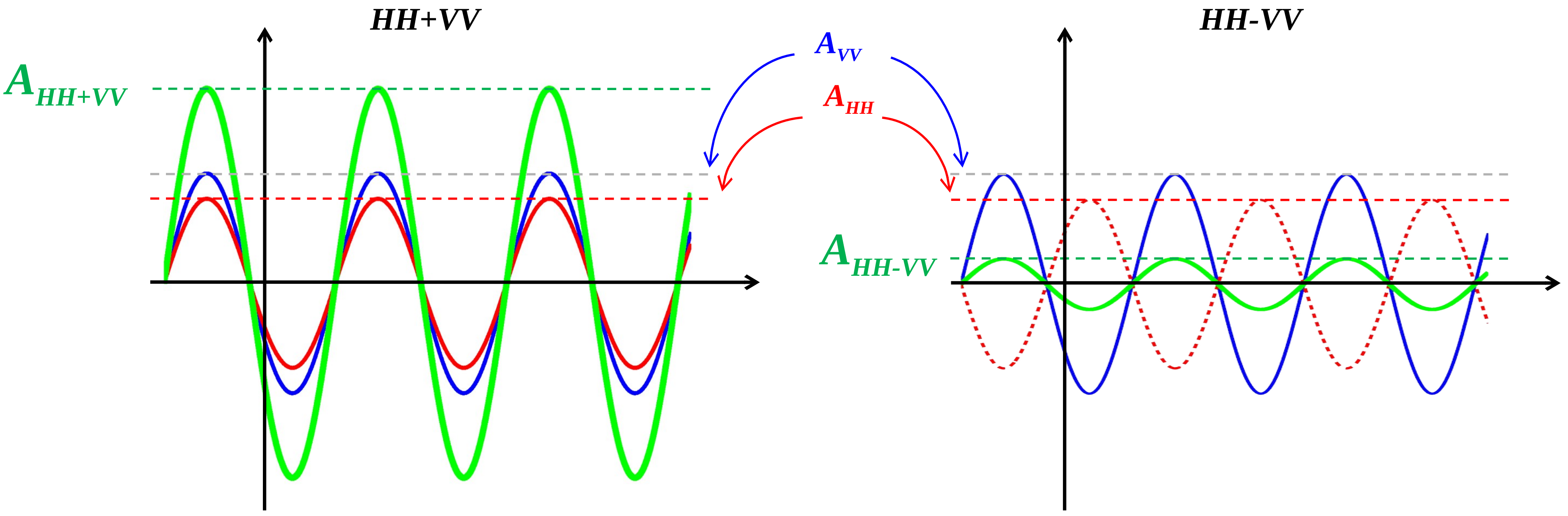
Even number of reflexions:
Ex: dihedral target type
$\phi_{HH}-\phi_{VV} \approx 180°$

Radar images interpretation rules

Polarimetric Data: Amplitude + Phase

$VV = A_{VV} \cos(\phi_{VV})$ $HH = A_{HH} \cos(\phi_{HH})$

***Surface Scattering**: $\phi_{VV} = \phi_{HH}$*

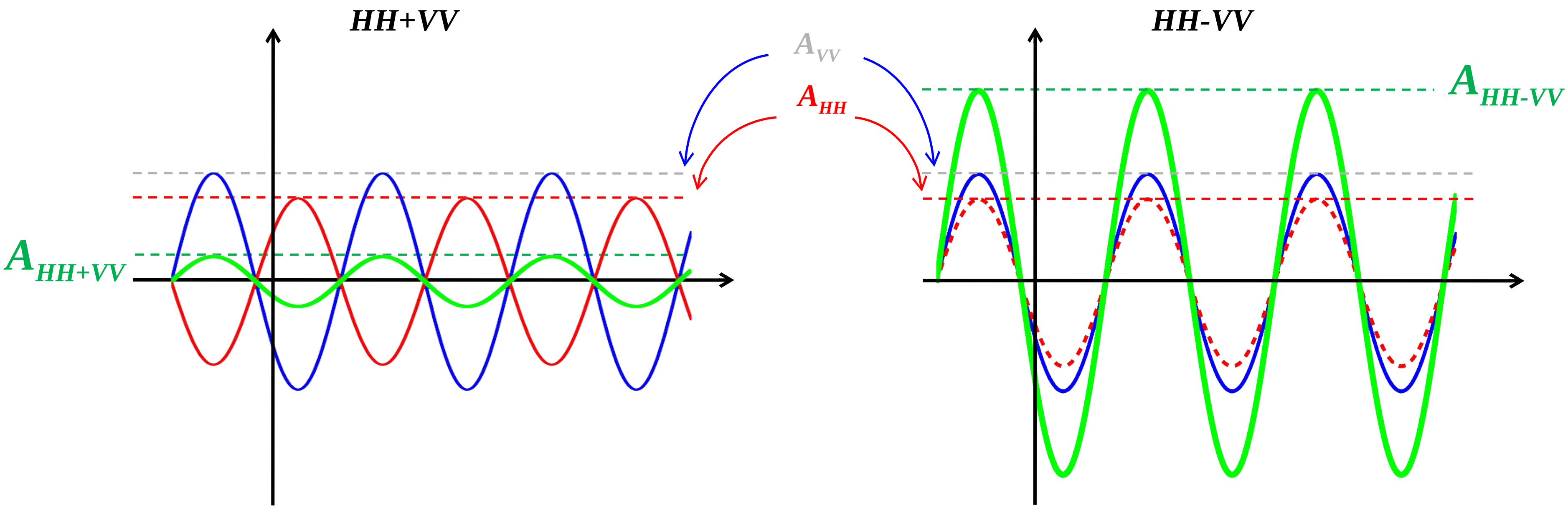


Radar images interpretation rules

Polarimetric Data: Amplitude + Phase Images

$VV = A_{VV} \cos(\phi_{VV})$ $HH = A_{HH} \cos(\phi_{HH})$

Double bounds: $\phi_{VV} - \phi_{HH} = \pi$



Radar images interpretation rules

Polarimetric Data: Amplitude + Phase Images

Surface scattering (bare soils)

Amplitude

VV* > *HH

HV ~ 0

Phase difference

$\phi_{VV} - \phi_{HH} = 0$

|HH+VV| high

Volume scattering (Dense forest)

HH, VV high

HV high

Double reflexion (urban areas, flooded vegetation)

HH > VV

$\phi_{VV} - \phi_{HH} = \pi$

|HH-VV| high

Wild areas (dense habitat, screes,…)

VV ~ HH ~ HV

Radar images interpretation rules

Polarimetric Data: Amplitude + Phase Images

|***HH+VV***|

Bare surfaces

HV polarization

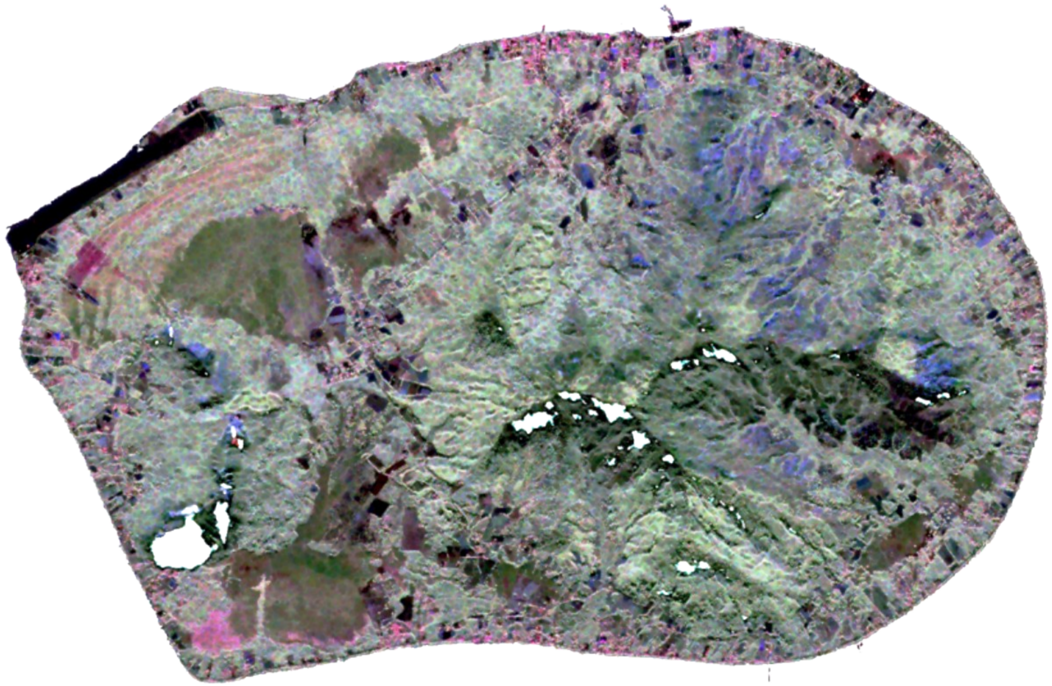
For Forest/Non forest discrimnation

|***HH-VV***|

For urban areas and flooded vegetation

Radar images interpretation rules

Polarimetric Image: *Pauli Representation*



Tubuai Island

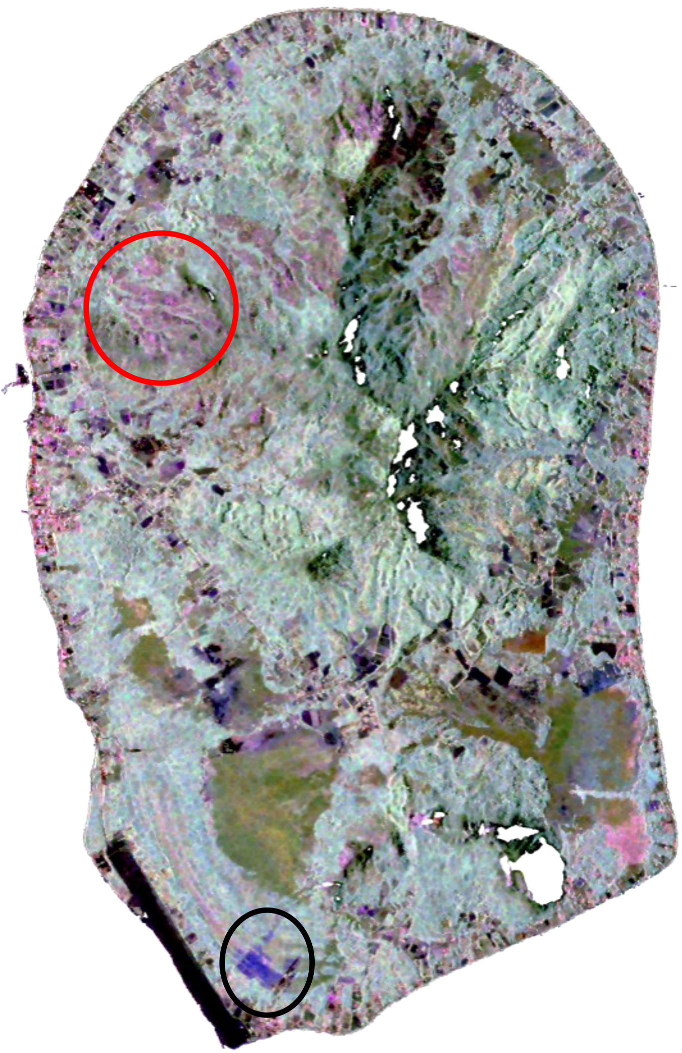
AISAR data, L Band

- ***Double bounds***
- ***Dense vegetation***
- **Bare soil**
- **Pinus** et **Falcata**

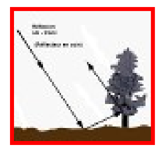
Purau

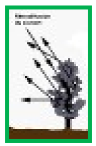
|HH-VV| |HV| |HH+VV|

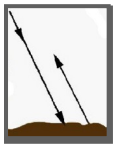
Radar images interpretation rules



HH HV VV

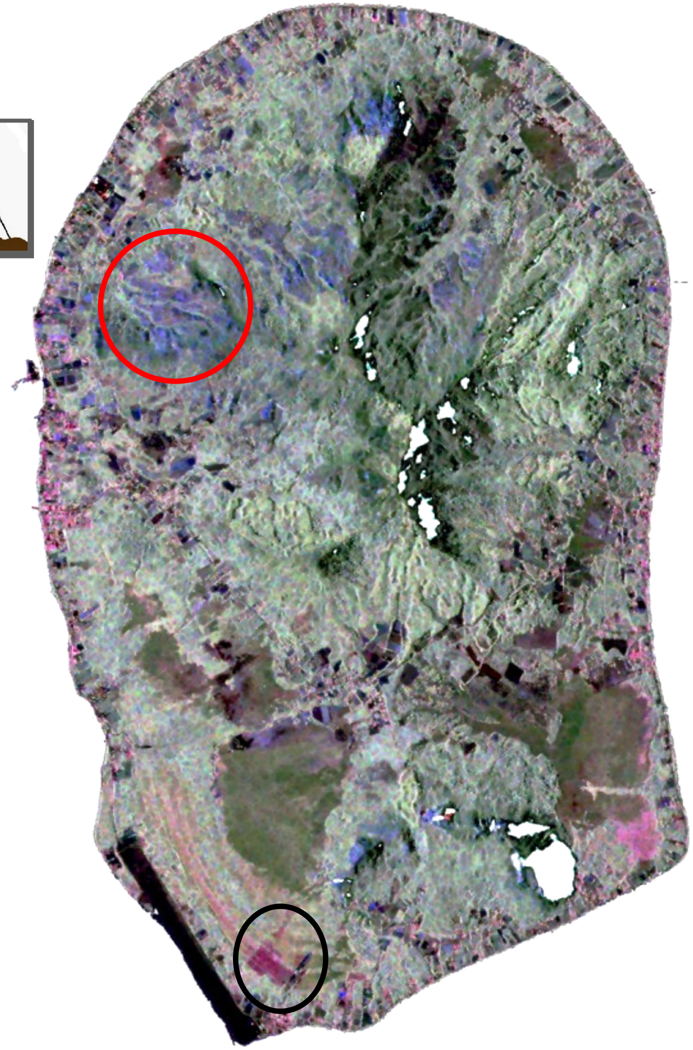






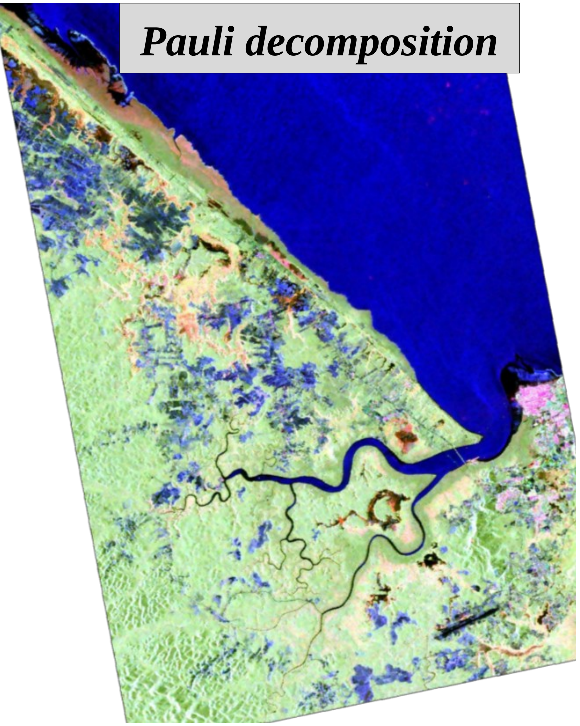
Quickbird

Pauli Representation

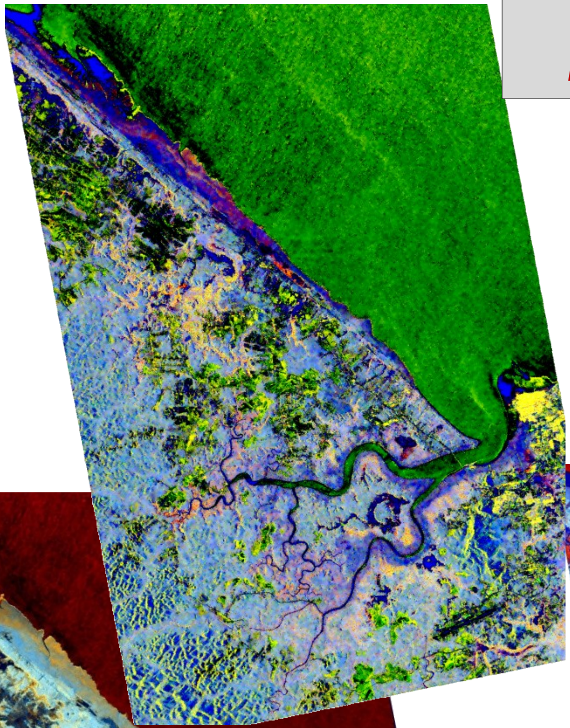


|HH-VV| |HV| |HH+VV|

Radar images interpretation rules

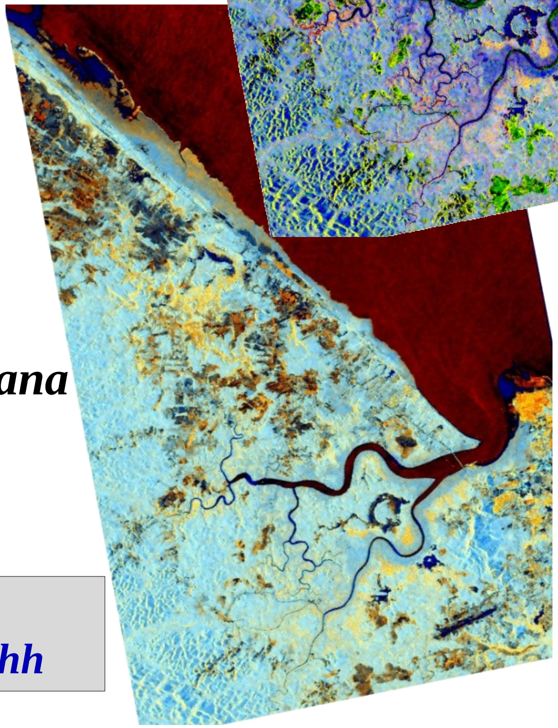


Pauli decomposition



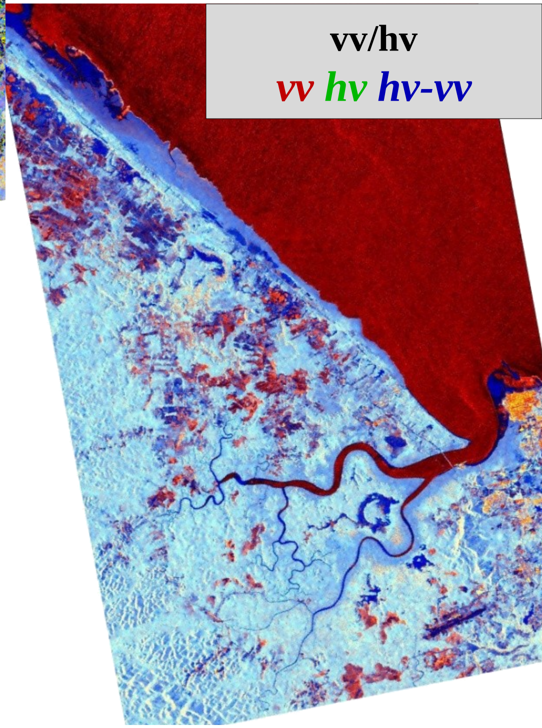
hh/vv

hh vv hh-vv



hh/hv

hh hv hv-hh



vv/hv

vv hv hv-vv

Natural Vegetation - French Guyana
PALSAR (L Band)