Tropical forest characterization

Using spatial and temporal patterns of optical remote sensing data

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Mapping canopy & forest structure

- Field plots:
  - Approached via indirect estimates (DBH);
  - Limited representativity;
  - Variation at different scales.
- Pixelwise/synchronous optical:
  - Saturation for high biomass levels (>250 t/ha, also for radar);
  - Permanent cloud/haze conditions
- Airborne LiDAR:
  - Cost/complexity

Spatial signatures

- Where is AGB mostly located in a rain forest?
  - **trunks of larger individuals**

- What is most likely to be correlated to wood stock?
  - **crown sizes, tree heights.**
  - NOT: fPAR, mean reflectance, etc.!!!

- Potential of **VHR spaceborne imagery** (Quickbird, Ikonos, etc.) but operational methodologies to be tested.

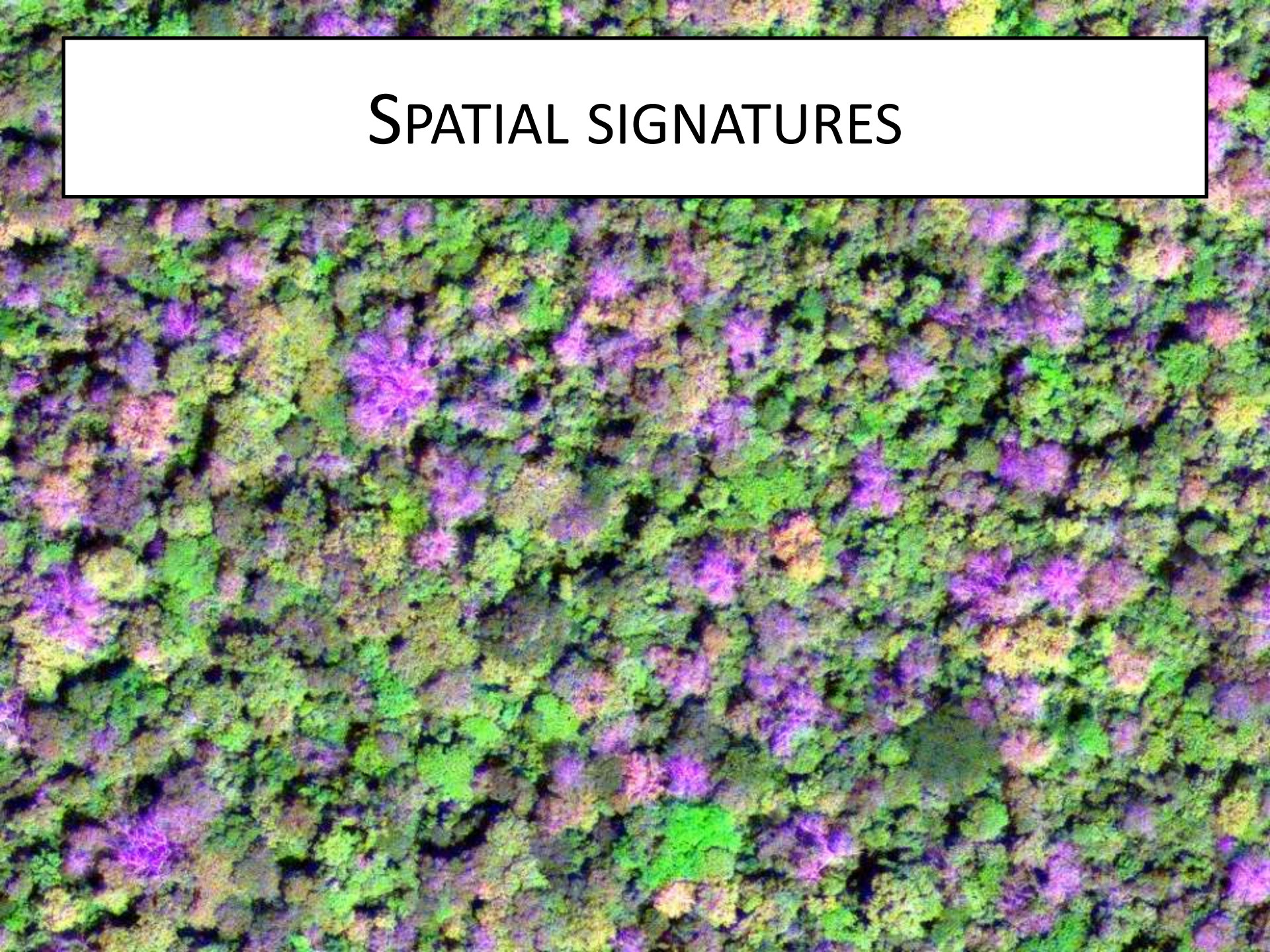
Temporal signatures

- Main forest gradients (in Africa) linked to canopy phenology variations (Schnell 1974)

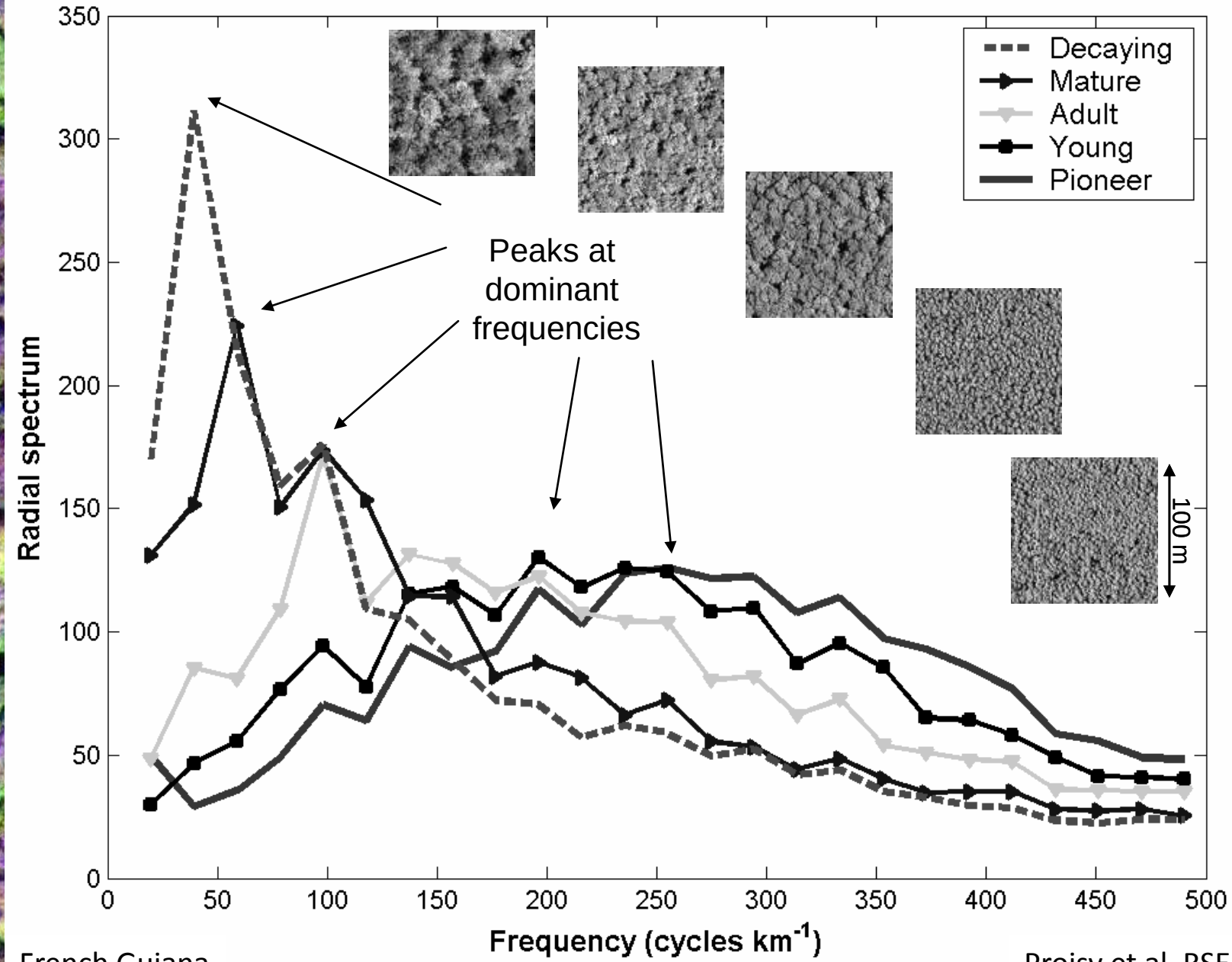
- MODIS product (daily temporal resolution, 250m):
  - Promizing results in the Amazon for phenology quantification (Bradley, GCB 2011).
  - But what's captured? Leaf fall or leaf flush?

- Need to bridge the resolution gap (field → MODIS)

Spatial signatures

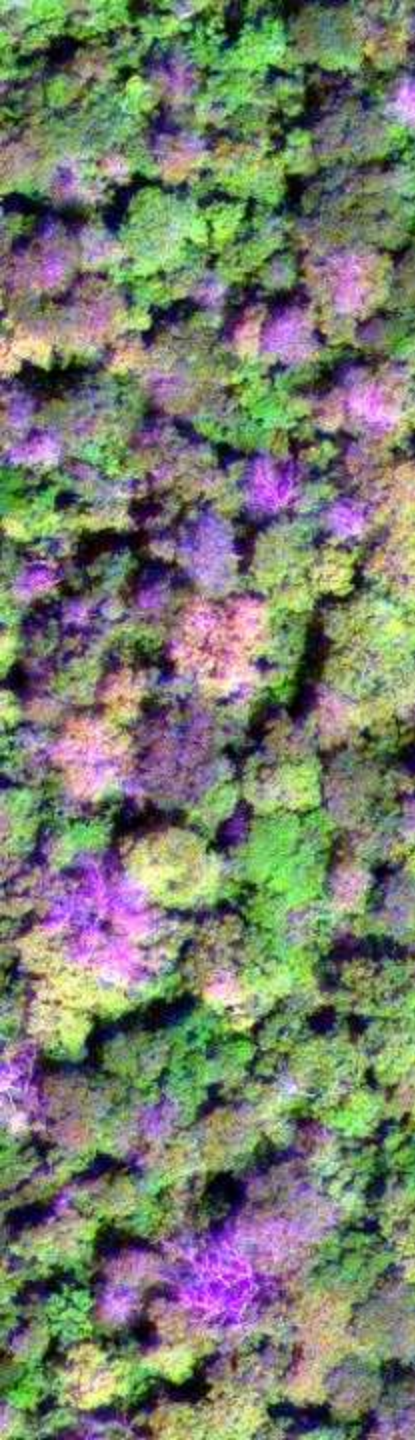


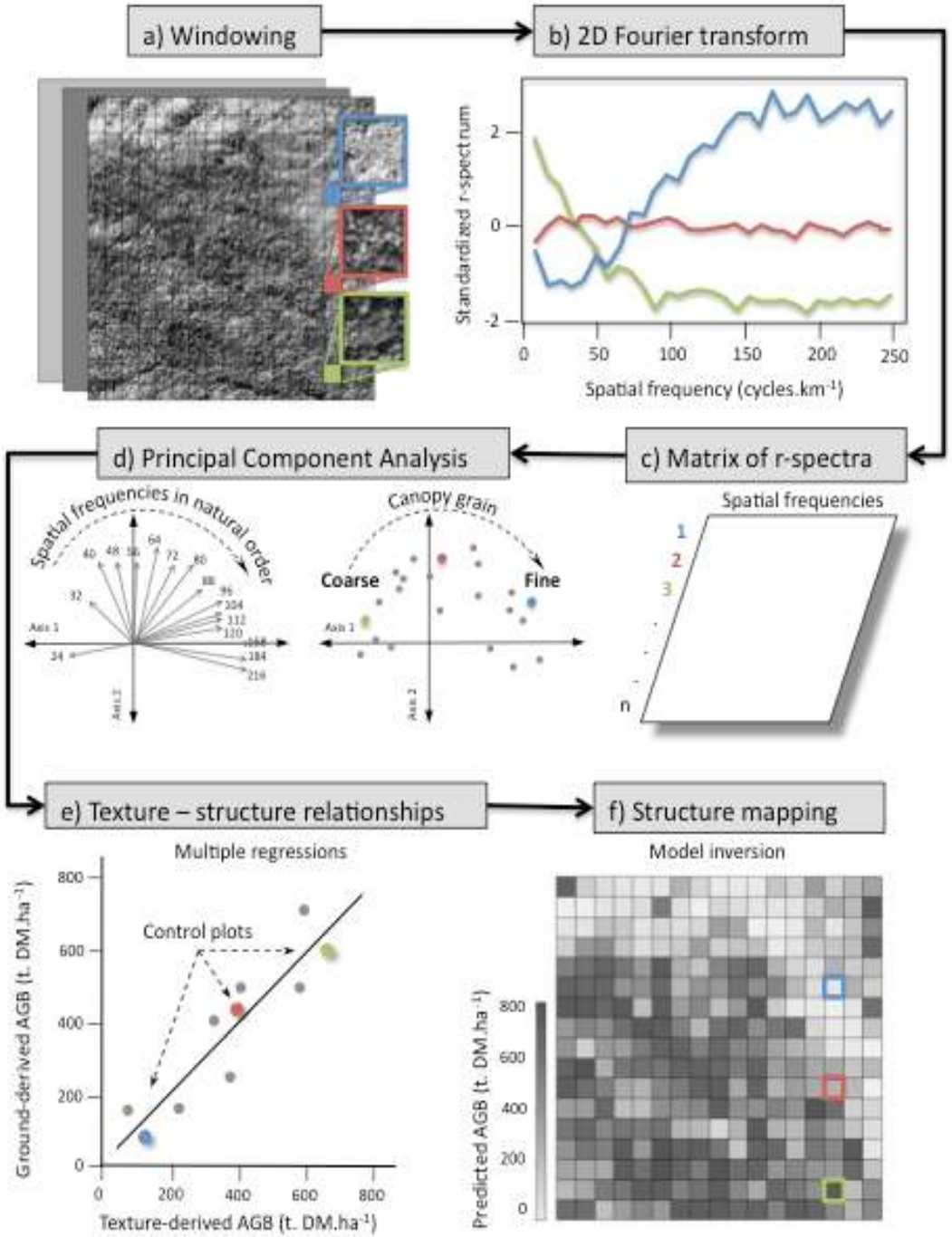
Fourier periodograms: quantification of image texture

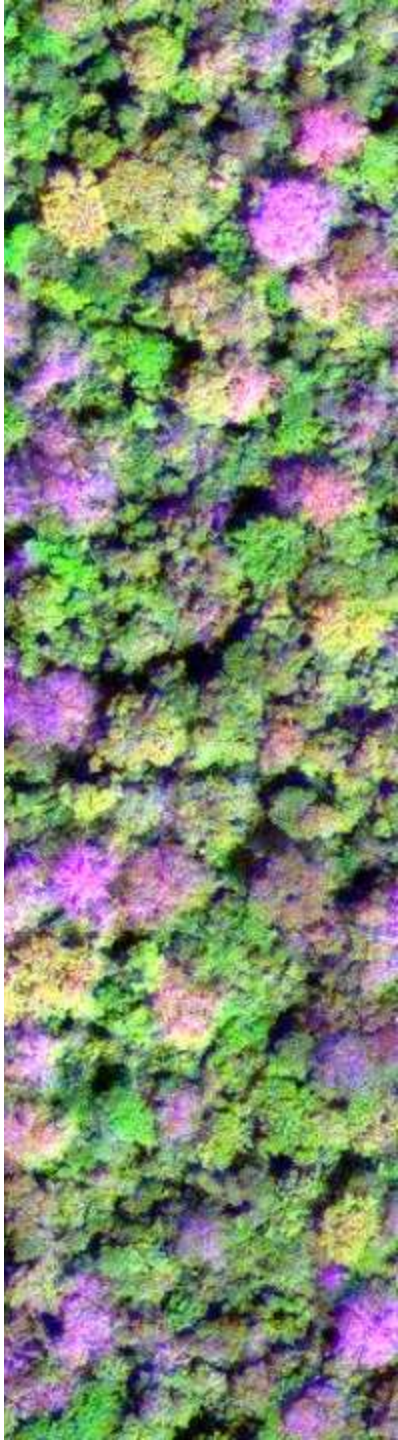


French Guiana

Proisy et al. RSE (2007)




a) Windowing
b) 2D Fourier transform
Standardized r-spectrum
Spatial frequency (cycles.km-1)
c) Matrix of r-spectra
Spatial frequencies
d) Principal Component Analysis
Spatial frequencies in natural order
Canopy grain
Coarse
Fine
Axis 1
Axis 2
e) Texture – structure relationships
Multiple regressions
Control plots
Ground-derived AGB (t. DM.ha-1)
Texture-derived AGB (t. DM.ha-1)
f) Structure mapping
Model inversion
Predicted AGB (t. DM.ha-1)



Textural ordination: principal axes of variation

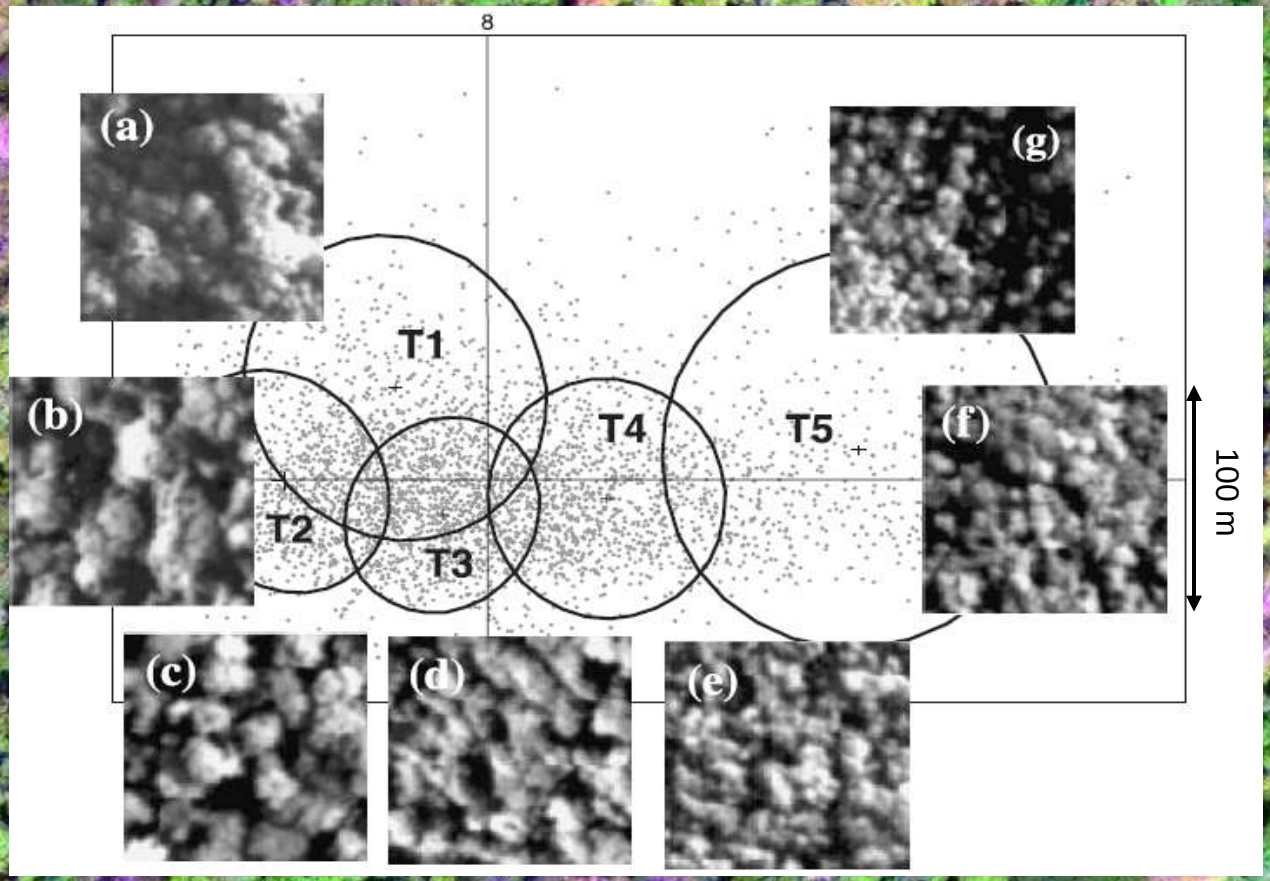
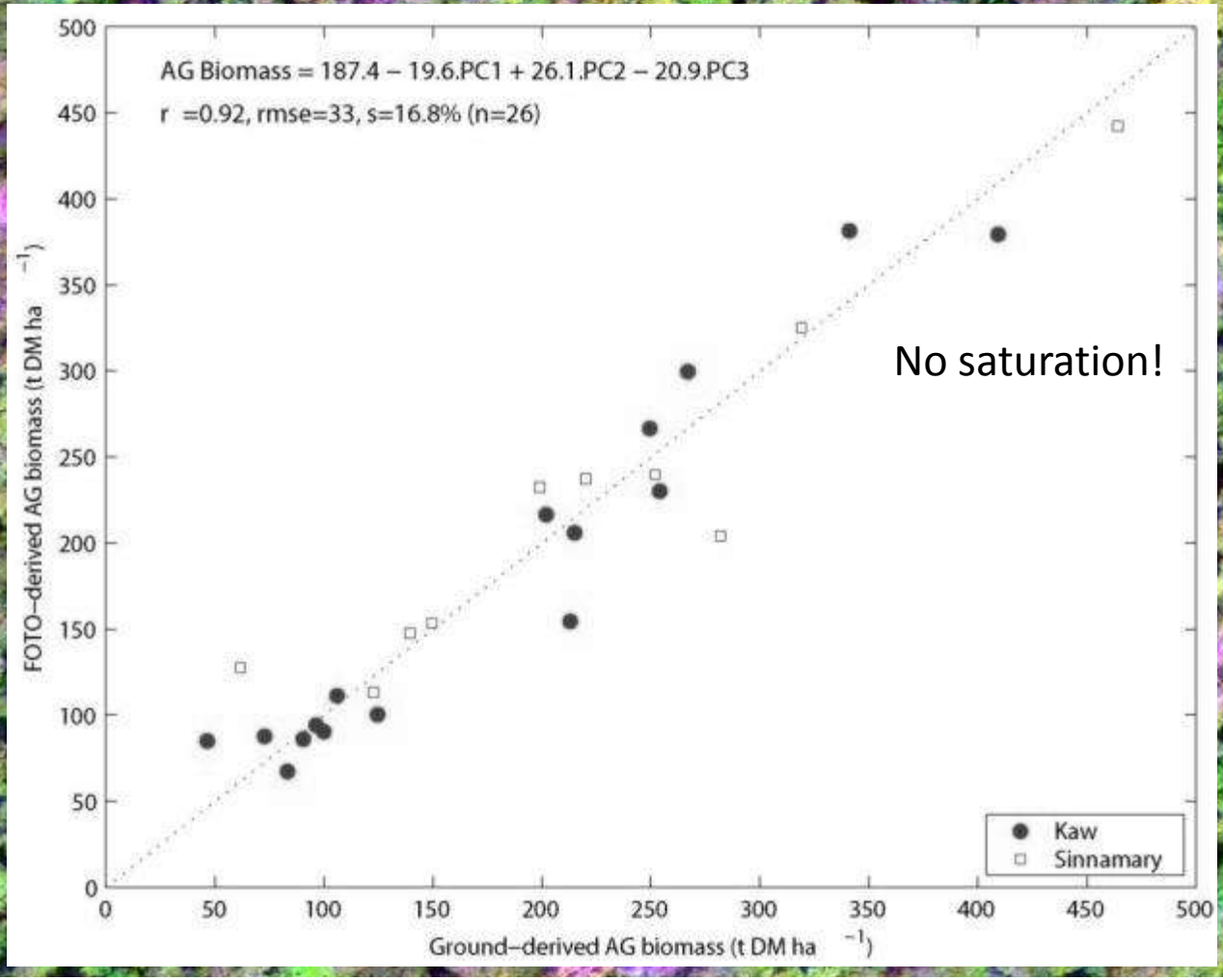


FOTO analysis on aerial photographs in French Guiana

Couteron et al. J Appl Ecol (2005)

Relationships with forest parameters

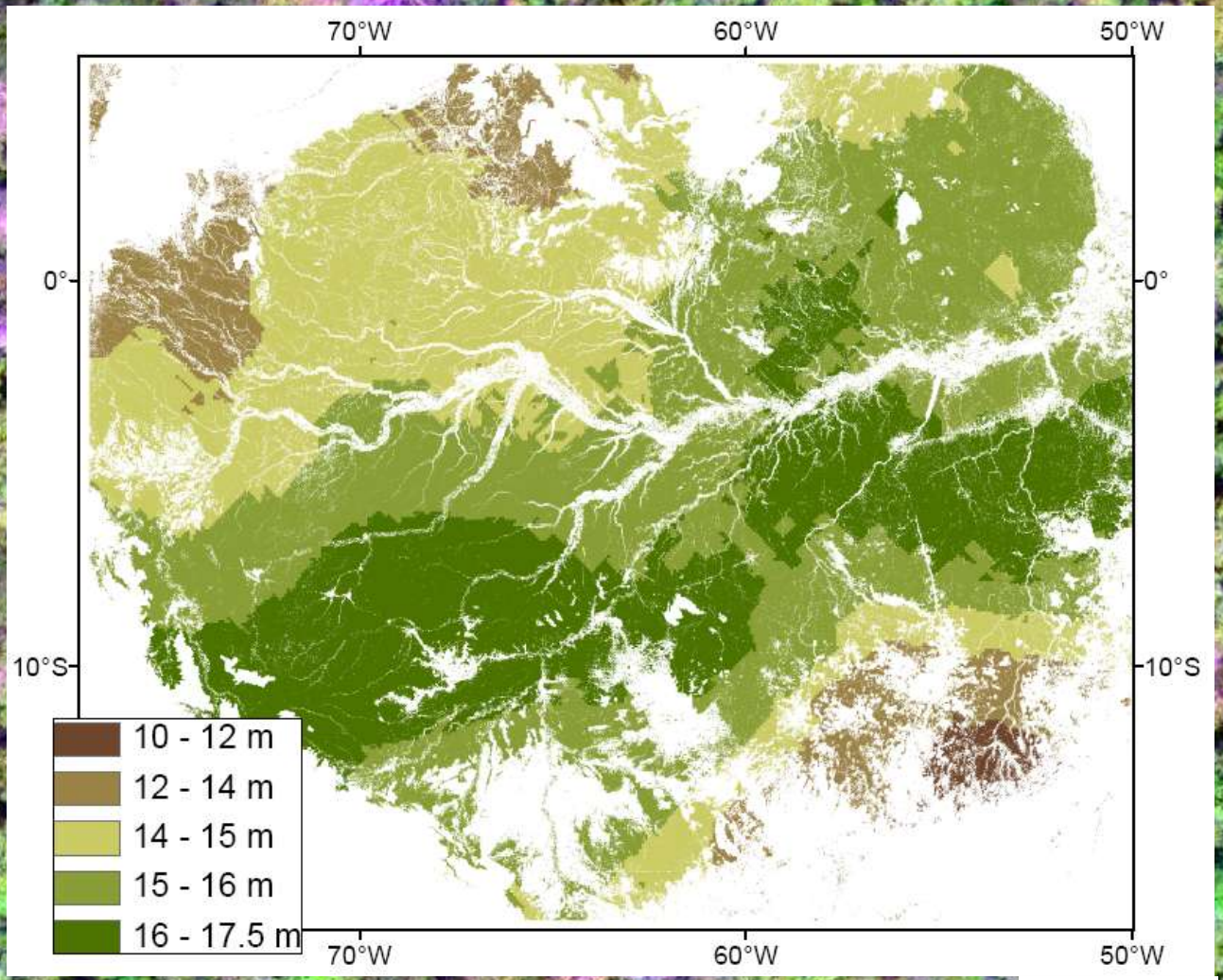


Biomass prediction using Ikonos imagery in mangrove stands; French Guiana

Proisy et al. RSE (2007)

Large scale application

maps of apparent crown size and canopy heterogeneity

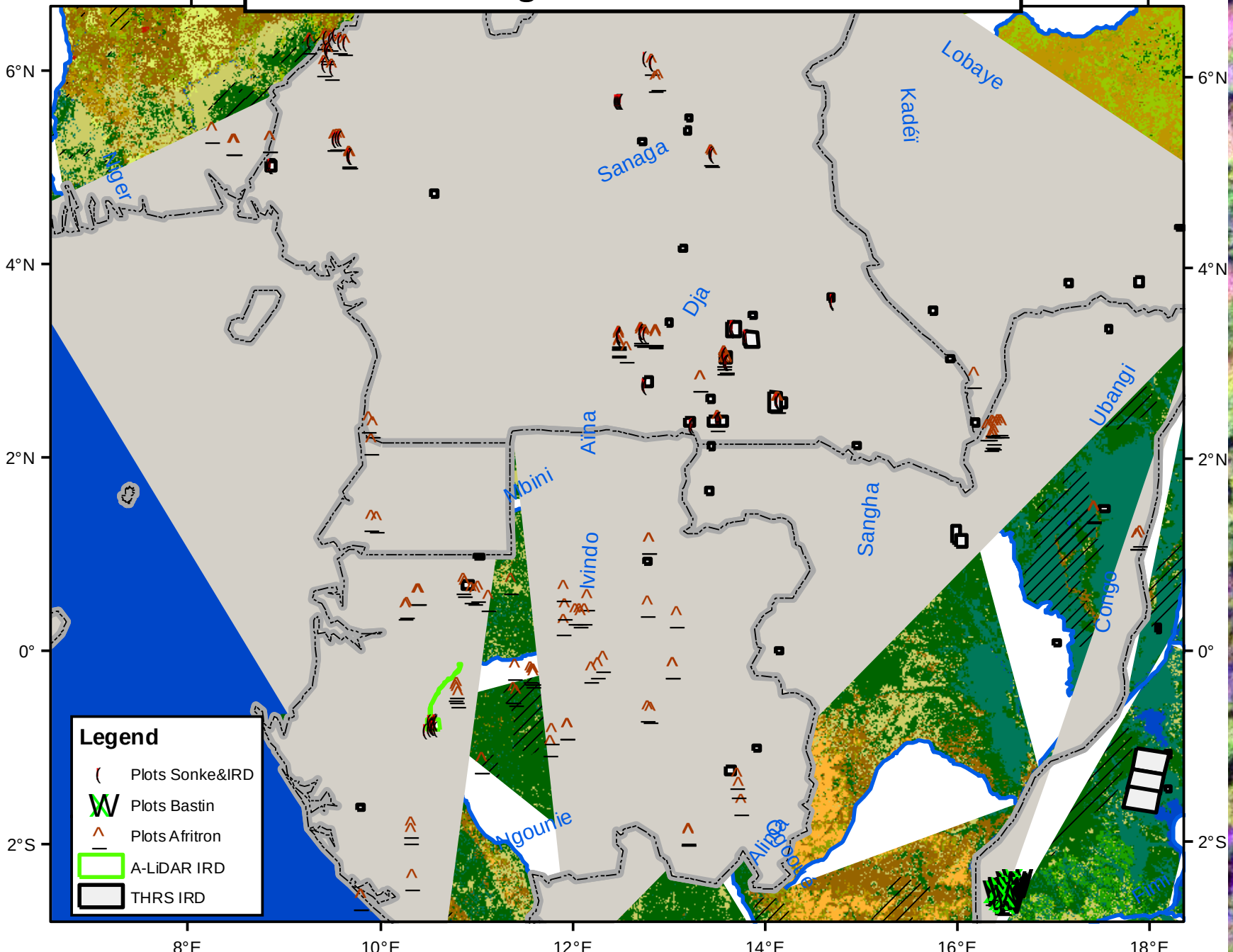


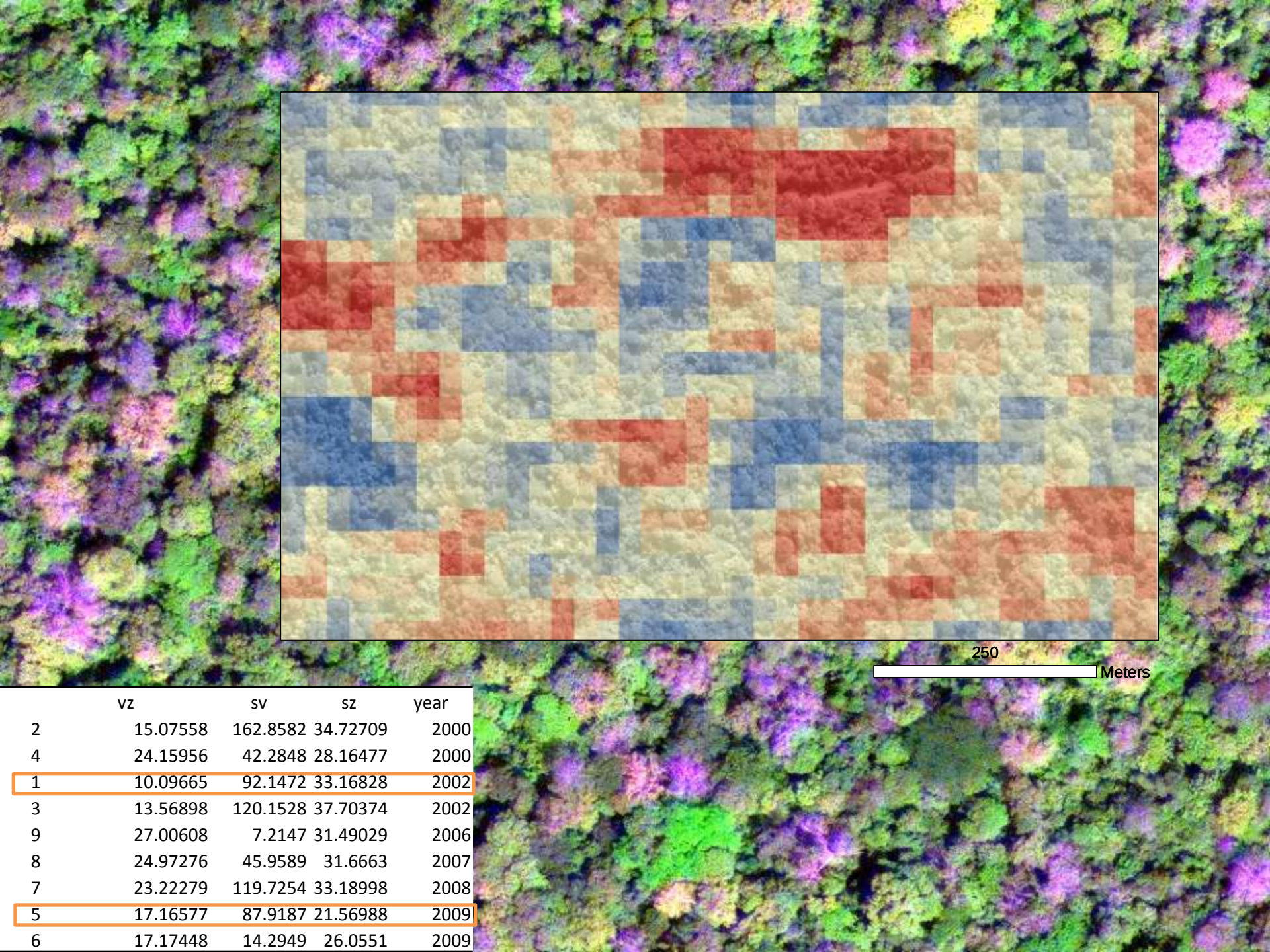
Amazonia

Fondation Wiener Anspach

Barbier et al. GEB (2010)

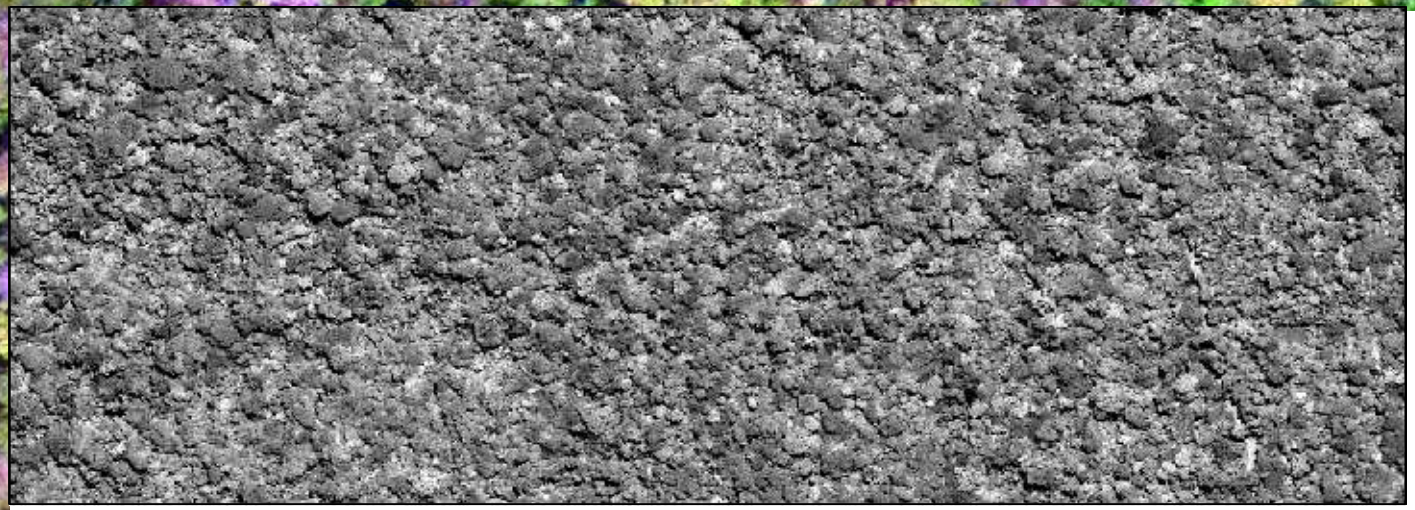
Towards a large scale calibration in Africa





	vz	sv	sz	year
2	15.07558	162.8582	34.72709	2000
4	24.15956	42.2848	28.16477	2000
1	10.09665	92.1472	33.16828	2002
3	13.56898	120.1528	37.70374	2002
9	27.00608	7.2147	31.49029	2006
8	24.97276	45.9589	31.6663	2007
7	23.22279	119.7254	33.18998	2008
5	17.16577	87.9187	21.56988	2009
6	17.17448	14.2949	26.0551	2009

Issue 1: Instrumental effects



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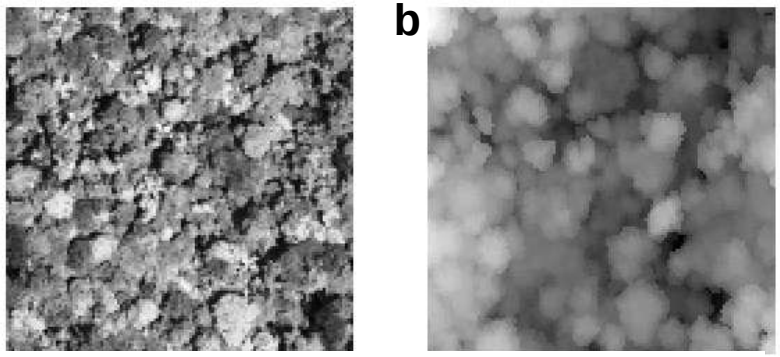
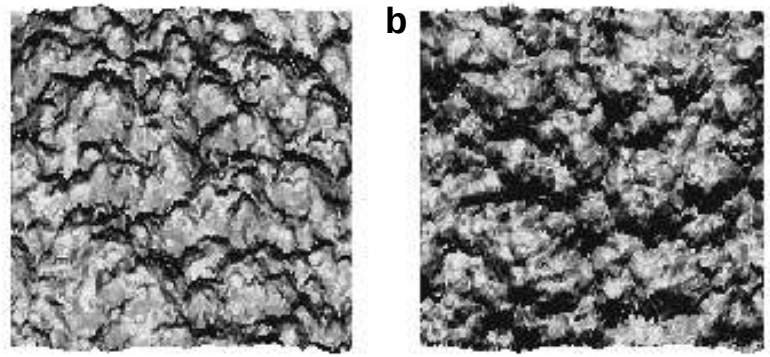
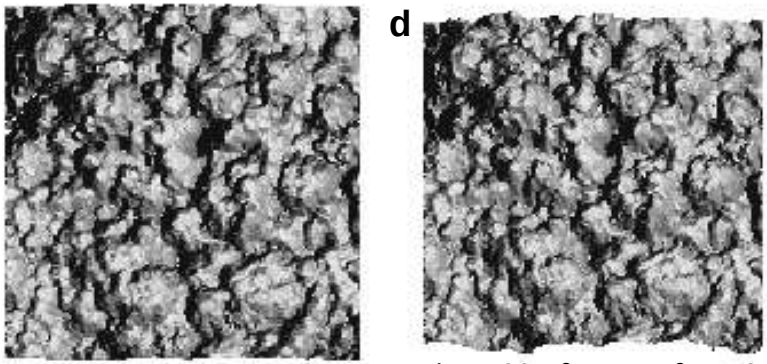


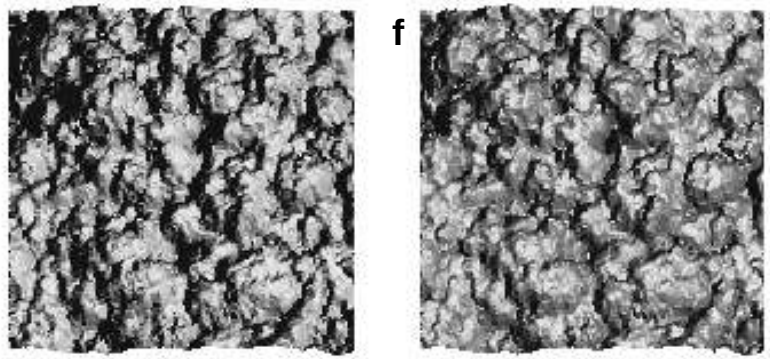
Ikonos VHR LiDAR



$\boldsymbol{\Phi_{s\text{-}v} = 0°}$; $\theta_V = 9°$; $\theta_S = 59°$ $\boldsymbol{\Phi_{s\text{-}v} = 180°}$; $\theta_V = 9°$; $\theta_S = 59°$



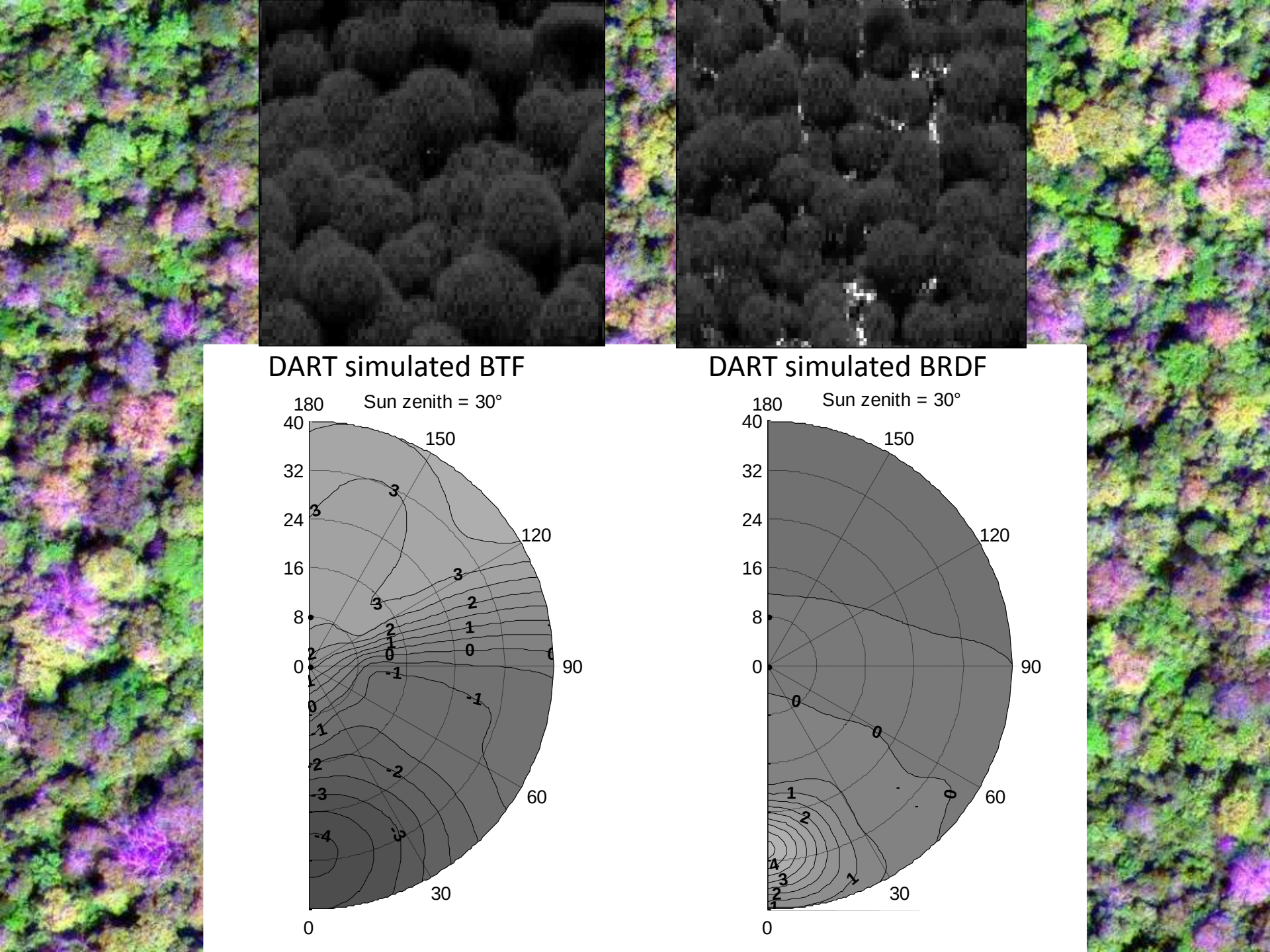
$\Phi_{s\text{-}v} = 80°$; $\boldsymbol{\theta_V = 3°}$; $\theta_S = 59°$ $\Phi_{s\text{-}v} = 80°$; $\boldsymbol{\theta_V = 15°}$; $\theta_S = 59°$



$\Phi_{s\text{-}v} = 80°$; $\theta_V = 9°$; $\boldsymbol{\theta_S = 47°}$ $\Phi_{s\text{-}v} = 80°$; $\theta_V = 9°$; $\boldsymbol{\theta_S = 71°}$

Typical examples of extreme configurations using hillshade effects on LiDAR surface models

Barbier et al. RSE (2010)

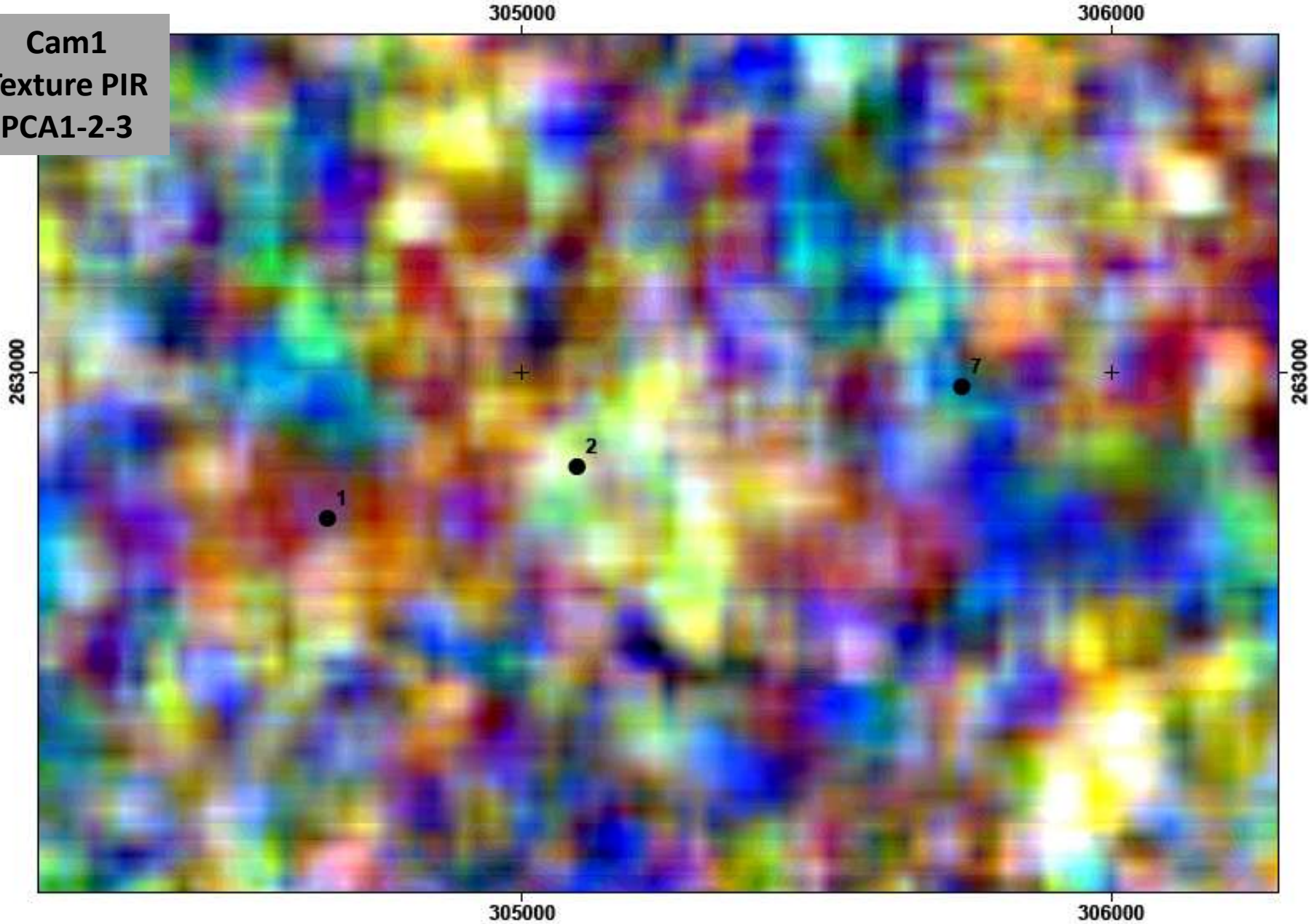

DART simulated BTF
Sun zenith = 30°
DART simulated BRDF
Sun zenith = 30°
180
150
120
90
60
30
0
40
32
24
16
8
0

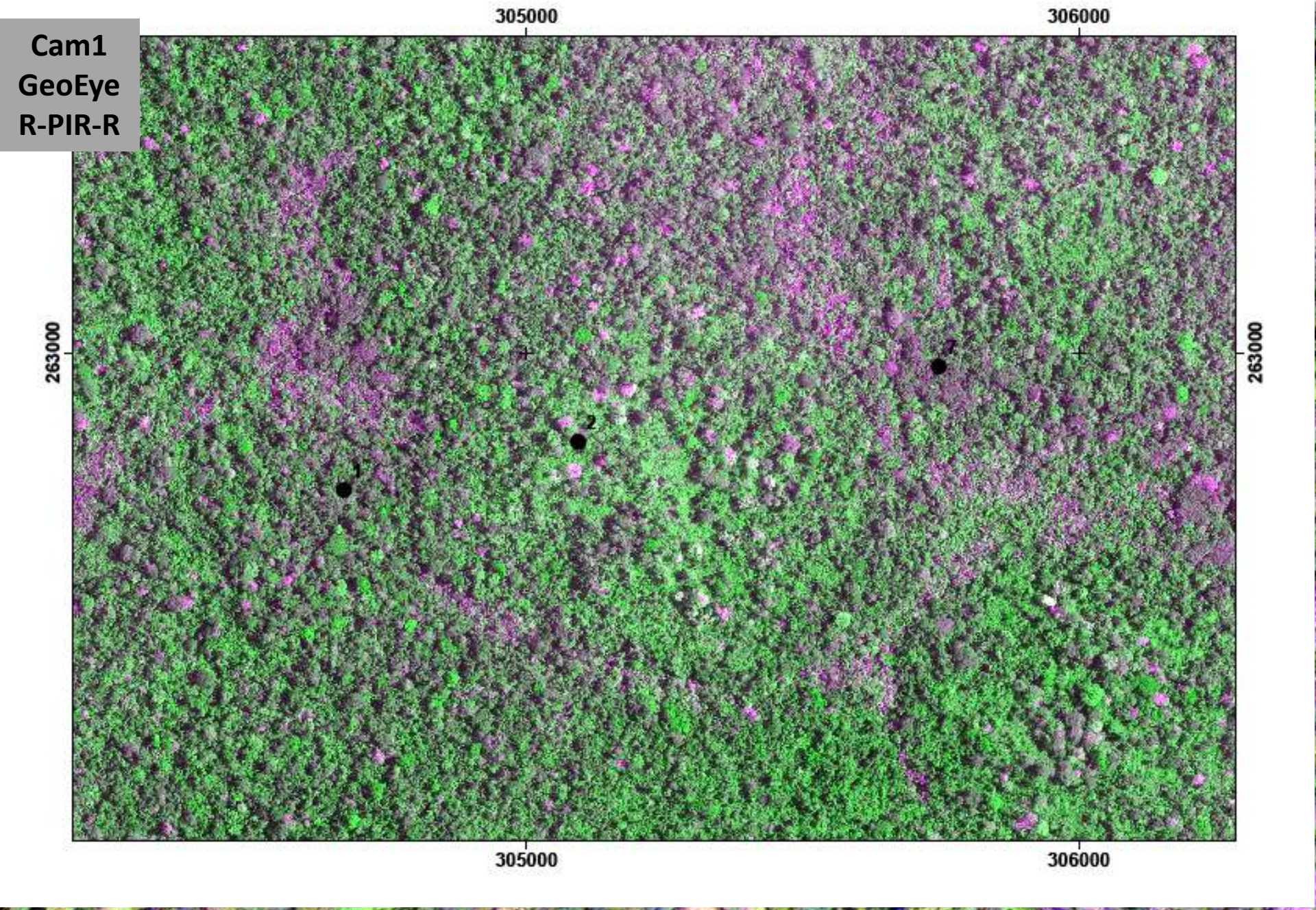
Issue 2: Structural variations

Photointerpretation of GeoEye Image (0.5 m)

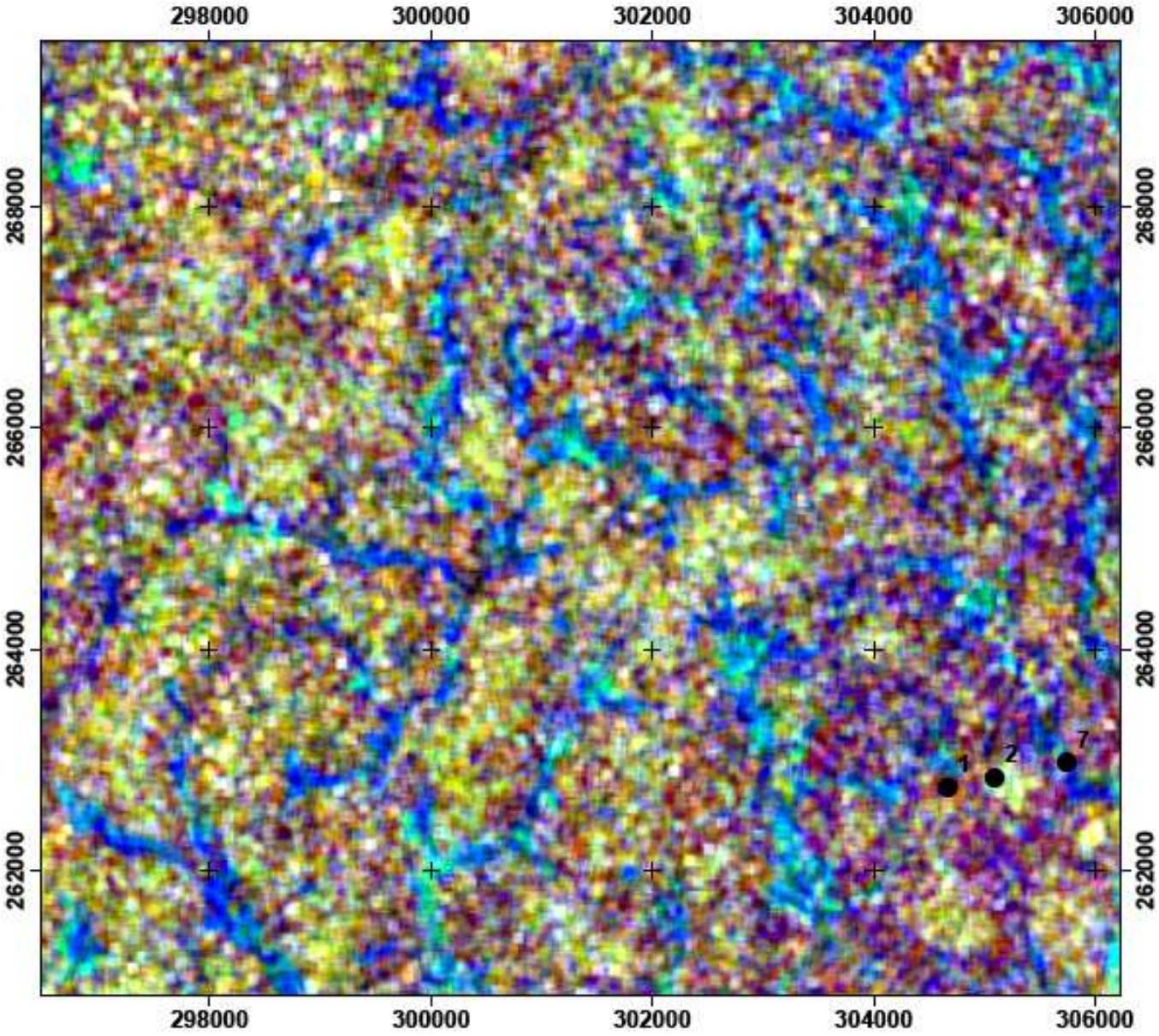
FM4 FM1 GDF2 YSF OF

Cam1
Texture PIR
PCA1-2-3

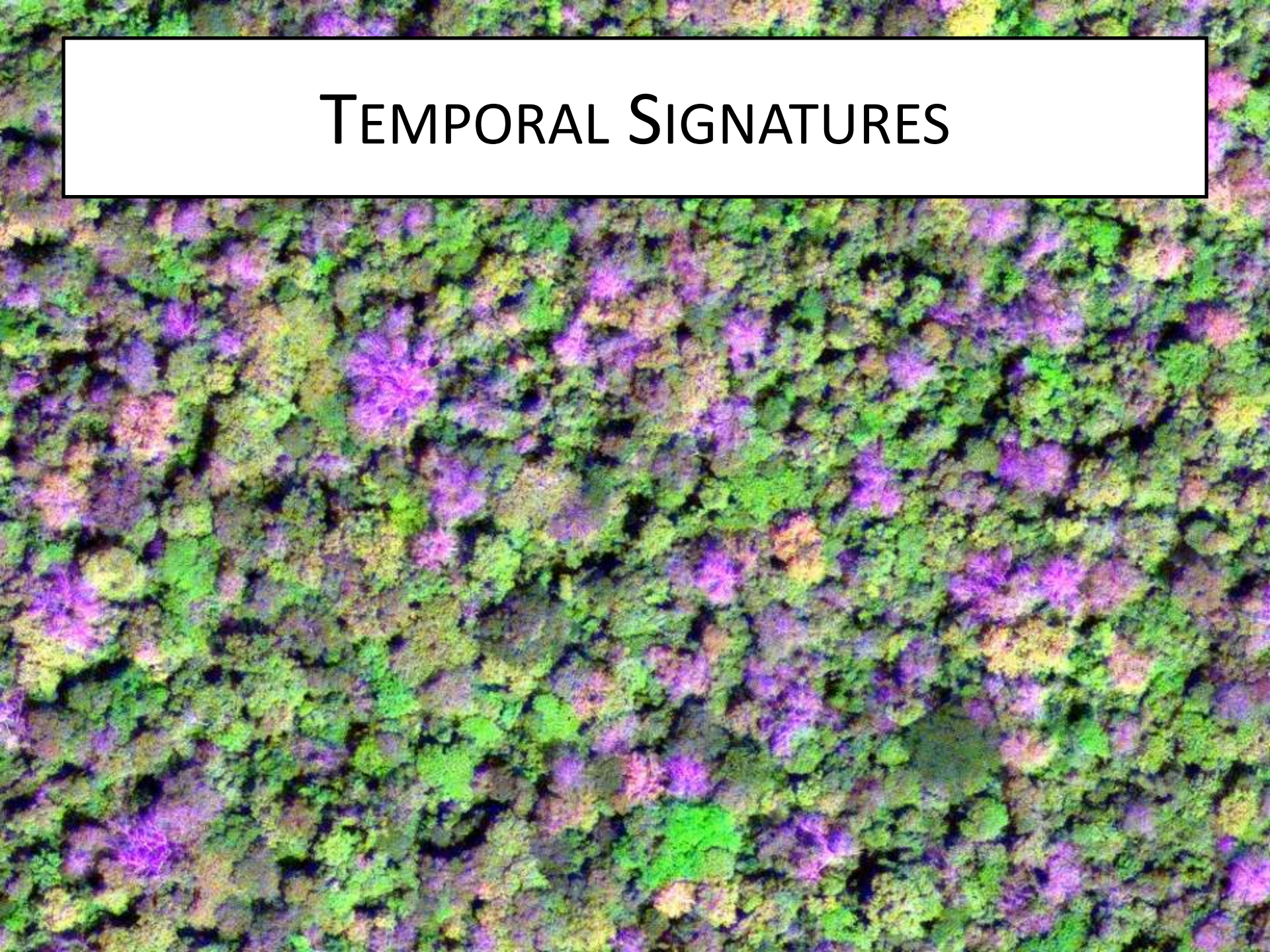



Cam1
GeoEye
R-PIR-R
305000
306000
263000
263000
1
2
7
305000
306000

Cam1
Texture PIR
PCA1-2-3



Temporal Signatures



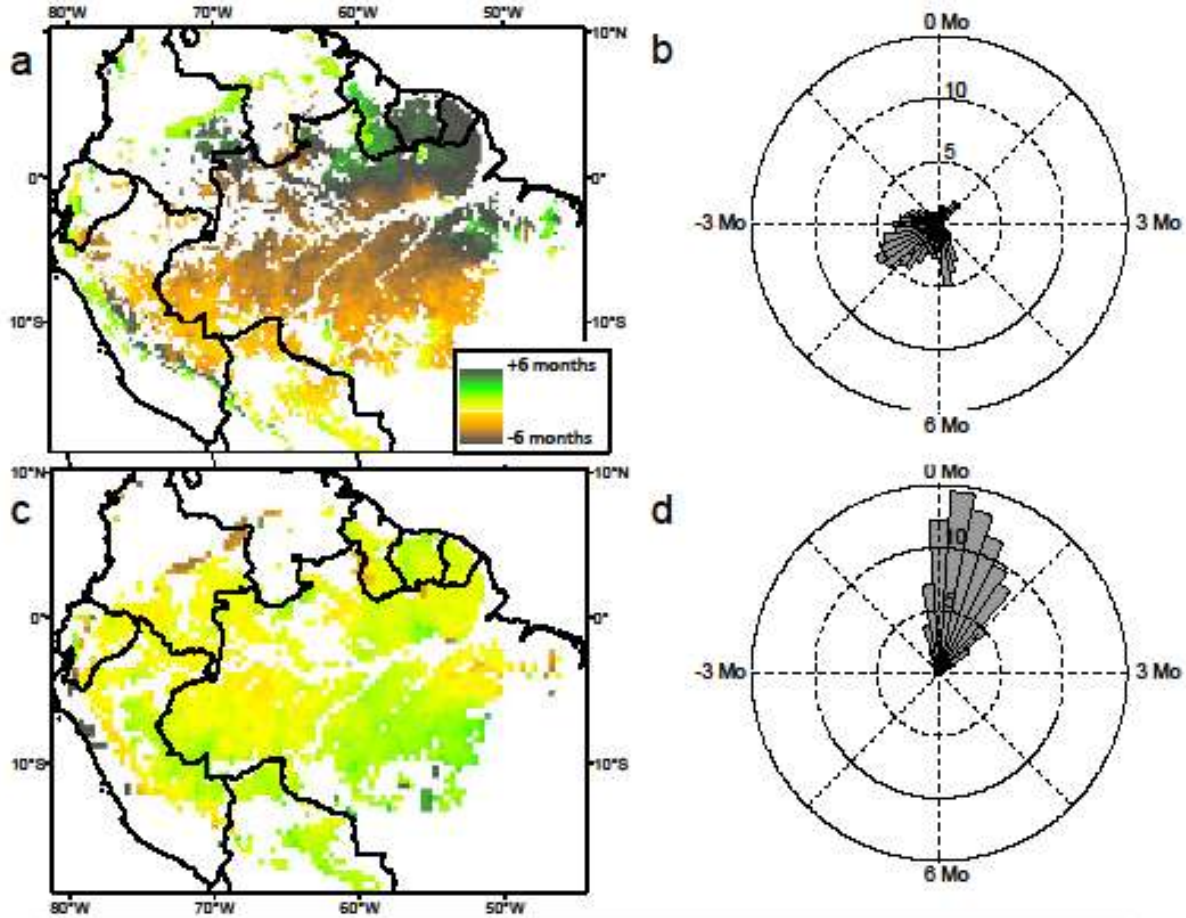


Figure 4. Maps and histograms (in %) of the seasonal phase shift between vegetation index (MODIS - EVI) and climate variables across Amazonia. (a, b) Seasonal phase shift with TRMM rainfall index. (c, d) Seasonal phase shift with GOES radiation (insolation) index. Areas in white are either non–forest or not significantly seasonal and/or correlated with the climate index.

(Bradley et al., GCB 2011)

- Field plots
- Literature
- THR

GeoEye

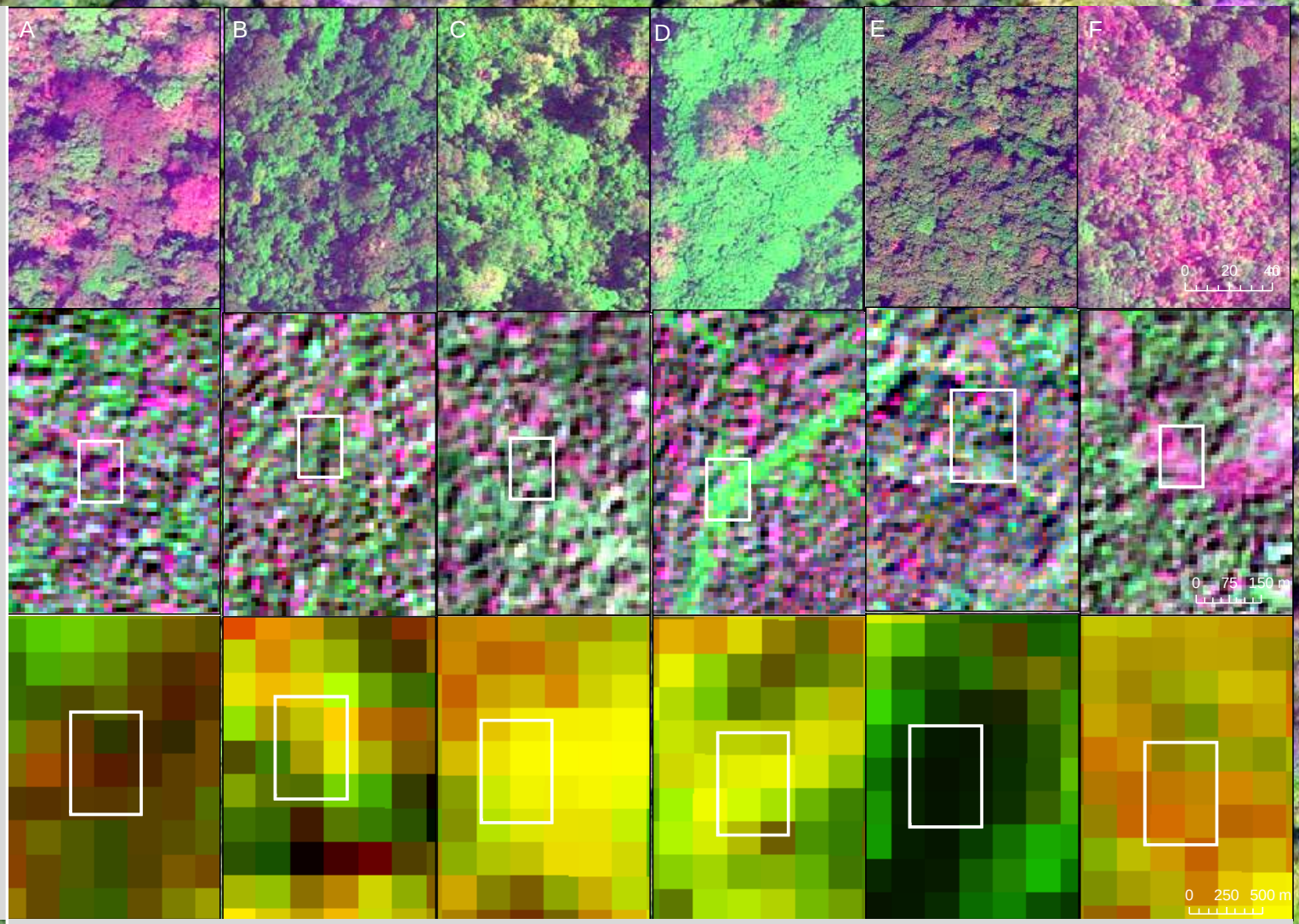
Discrimination of contrasted forest types

SPOT

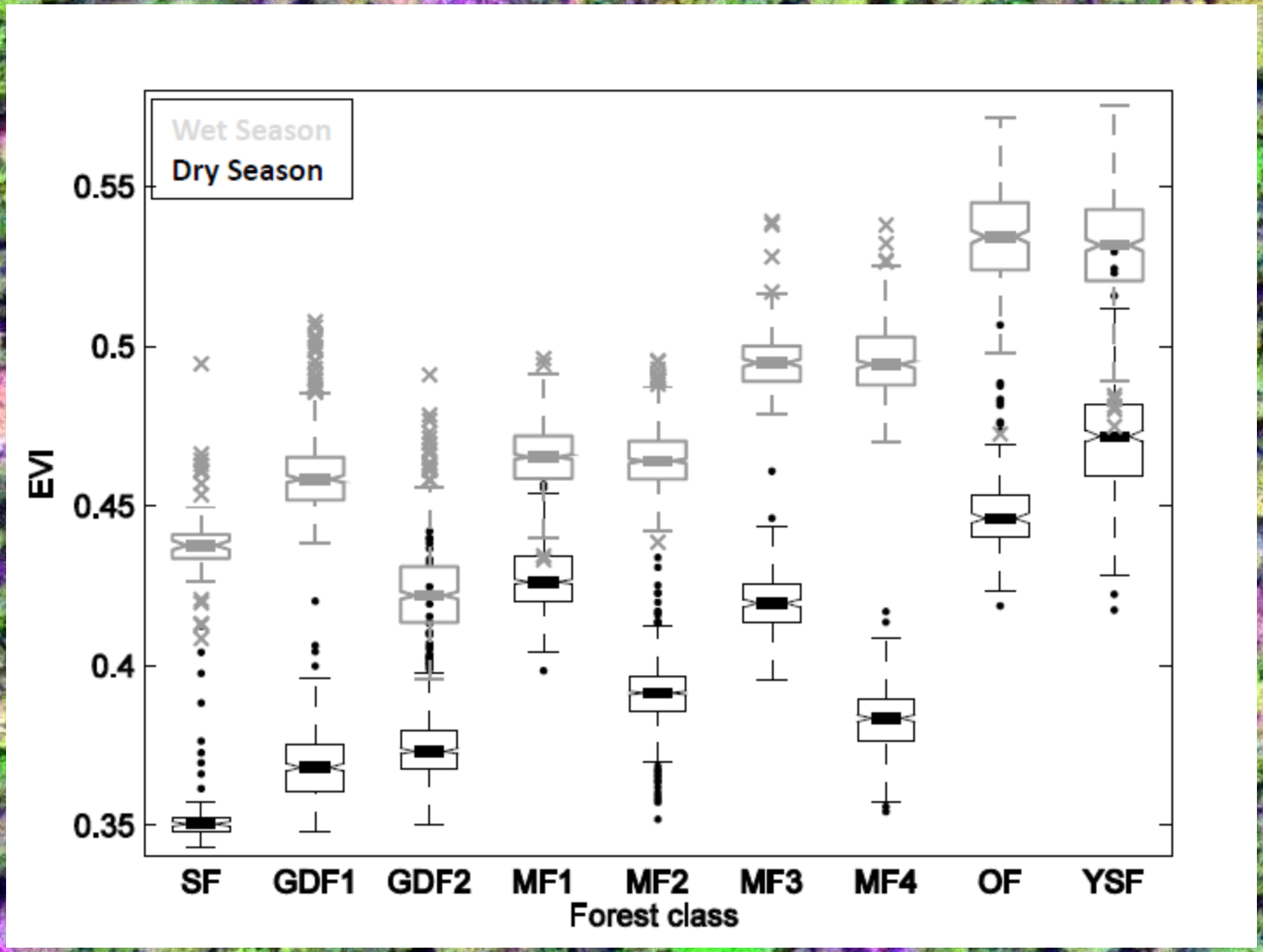
- ROI definition
- Deciduous %

MODIS

- Phenology
- Classification



Courtesy G. Viennois



Viennois et al. BGD 2013