

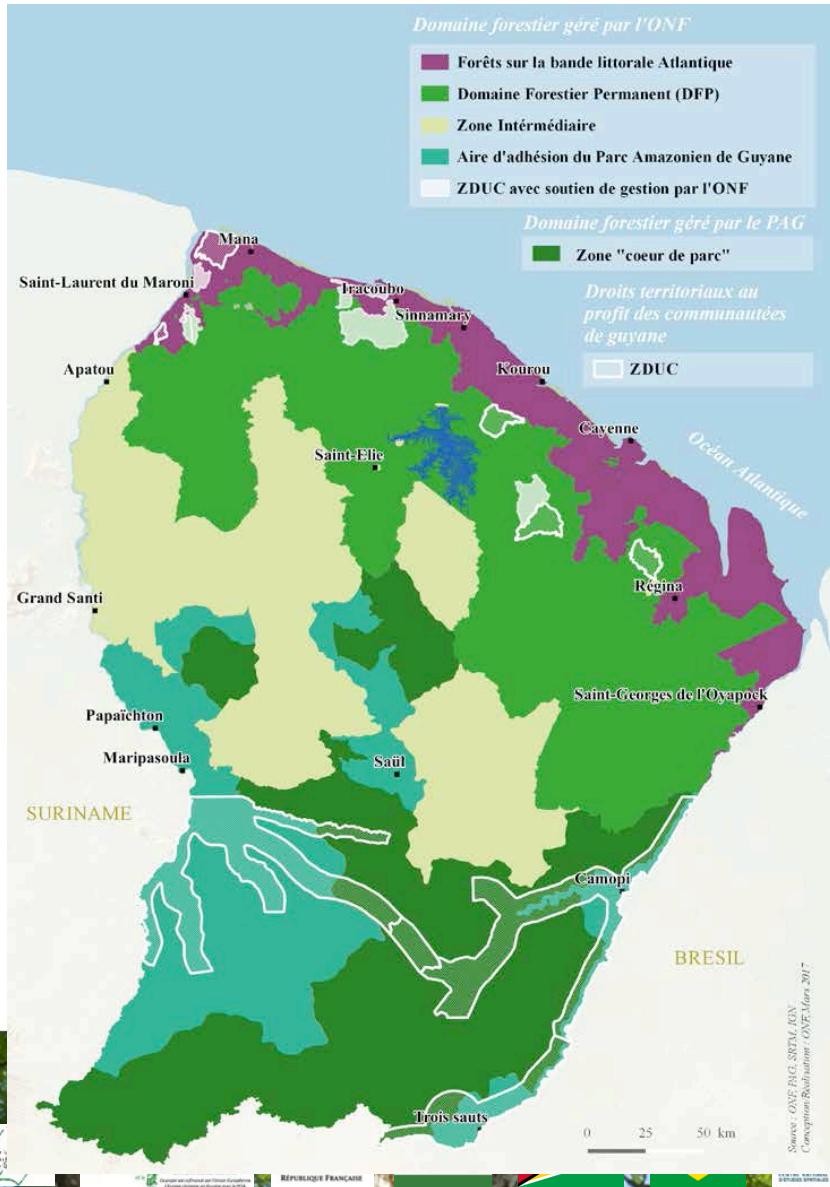
SUSTAINABLE FOREST MANAGEMENT AND RIL IMPLEMENTATION IN FRENCH GUIANA

CURRENT APPLICATIONS AND PERSPECTIVES OF REMOTE SENSING



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Pôle RDI
ONF DT Guyane

Context and stakes



F.Guiana total area : 8.4 M ha
Forest cover ~96%

Area managed by ONF : ~ 6 M ha

A sustainable and multifunctional management

- Conservation of ecological functions**
- Sustainable economic valorization of forests**
 - Supply wood sector, eco-touristic development, support to traditional uses of forest products by local communities ...
 - Reduced Impact Logging and PEFC Certification
- Unite F. Guianese society around forest**
- Knowledge acquisition and technical progress**



Context and stakes

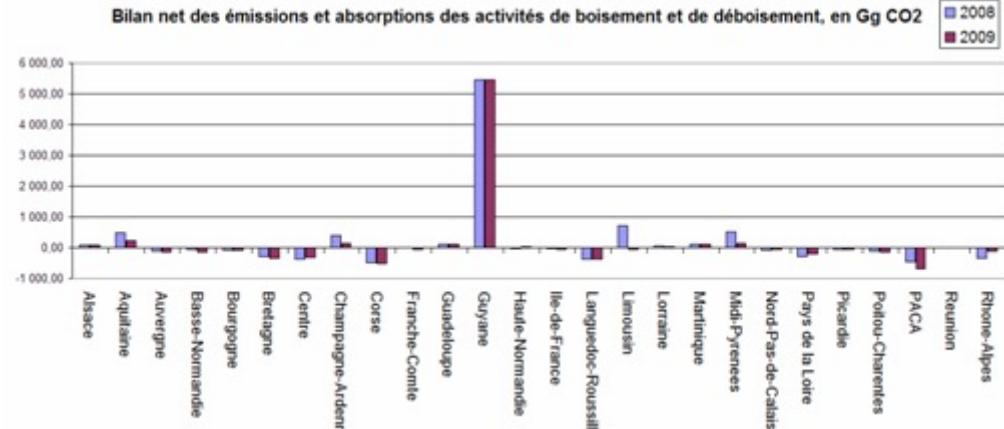
A mega biodiversity worldly recognized for its high stake

An important carbon stake

Aboveground carbon stock in F.Guiana forests = stock of France métropole forests

A vast territory hardly accessible

Limited road network – Fieldwork hard and costly



émissions de GES dues aux déboisements et des absorptions de GES dues aux boisements et reboisements, données par Région pour les années 2008 et 2009, (source : CITEPA/ MEDDTL inventaire CCNUCC)

A strong demand from wood sector to increase production

Timber wood & development of fuel wood



Forest domain well preserved but integrity under some pressures

Illegal gold mining – Illegal land occupation

Climate changes impacts



A knowledge about forests and their ecology still lacunar

Still no National Forest Inventory implemented



Global frame of sustainable management

Economic valorization of natural forests under essential rules

- Maintain biodiversity and ecological functions
- Maintain carbon stock
- Maintain natural renewal capacity
 - Preservation of areas with high environmental value and covering the diversity of ecosystems
 - Mitigation of impacts : Planning & Reduced Impact Logging (RIL)
 - Careful planning and RIL practices to limit impacts and optimize stock reconstitution, biomass and commercial (logging and skidtrails densities, cutting cycle, species sensitivity, seasonality, ...) → importance of geographic analyses

Insure whole domain global integrity

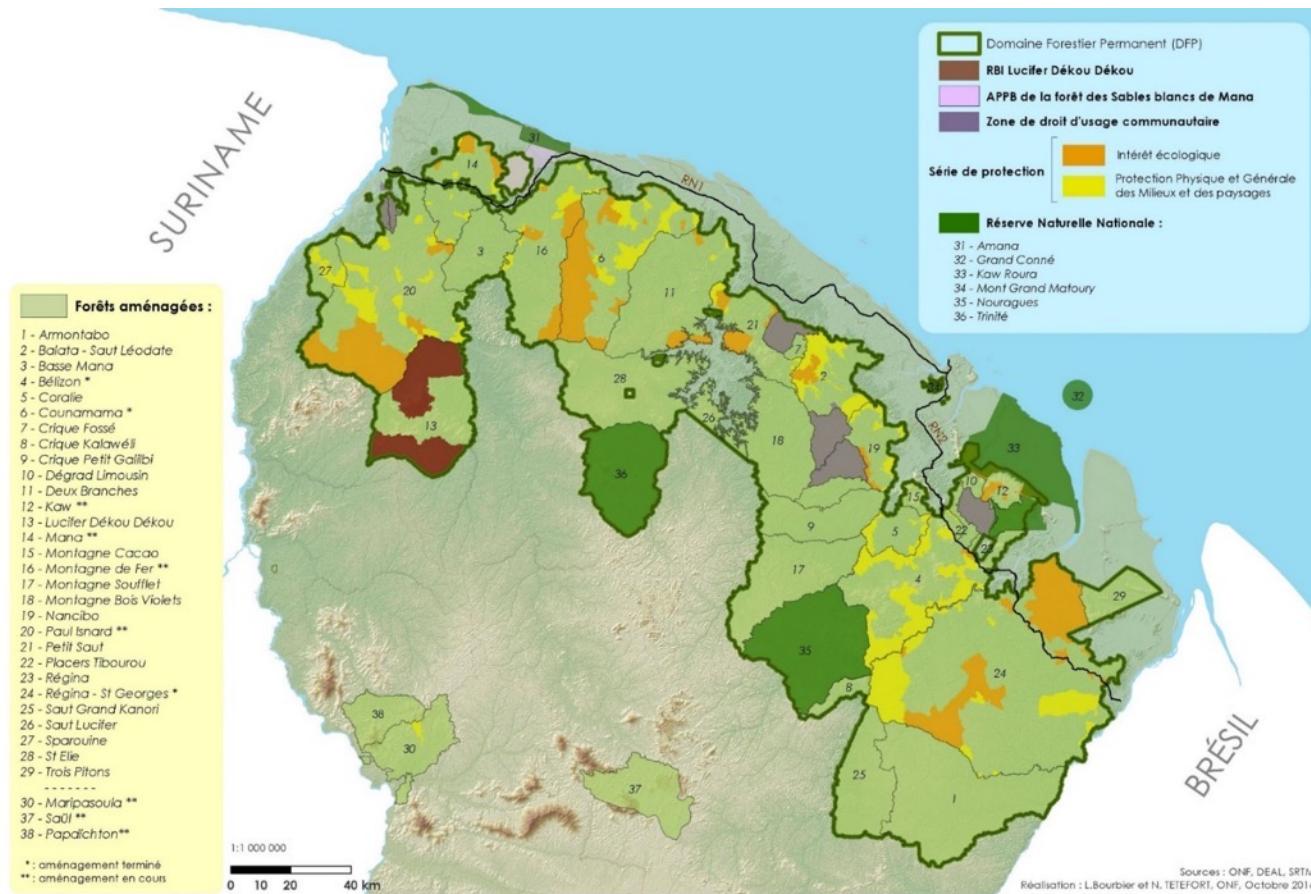
- Surveillance & Monitoring systems
 - Monitoring the good implementation of logging activities
 - Control of illegal and legal (other) activities
 - Long-term scale monitoring (human activities but also natural dynamics ...)



Global frame of sustainable management

Management plans & long/middle term planning

- **Zoning** : protection areas / wood production areas
- **Planning** : evaluation of commercial volumes, timing and costs of operations (road construction, field inventory, ...)



Remote sensing for Management & Planning

Data & Analyses compromises



Spatial units	Planning Level	Satellite Sentinel, SPOT , SRTM, ..	Aerial Lidar OrthoRGBPIR	Field Inventory
DFP	Regional directive			
Forest	Management plan			
Road unit	Operational program (PRMV)			
Plot	Logging			

Spatial scale / Surfaces

Resolution & Precision

Costs of data acquisition

Remote sensing for Management & Planning

Data & Analyses compromises



Spatial scale / Surface ↑

Resolution & Precision ↓

Spatial units	Planning Level	Satellite Sentinel, SPOT , SRTM, ..	Aerial Lidar OrthoRGBPIR	Field Inventory
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Plot	Logging			

Stepwise processes
and interrelations btw data

Costs of data acquisition



Remote sensing for Management & Planning

Data & Analyses

Management plan (&PRMV)

Satellite imagery & SRTM

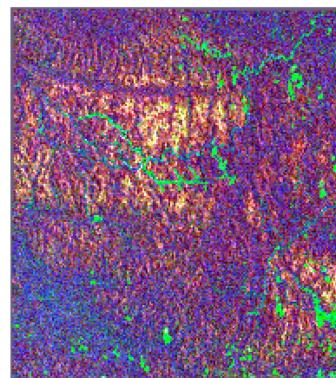


Biodiversity / Ecosystem services



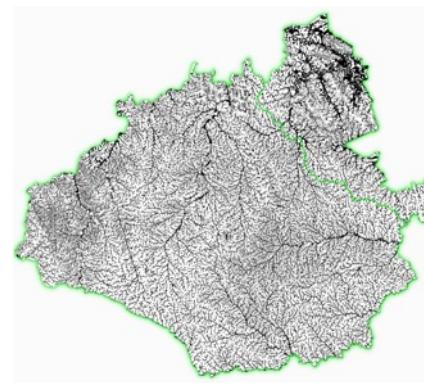
Forest habitats
Soils ...
SRTM30m

Commercial ressource



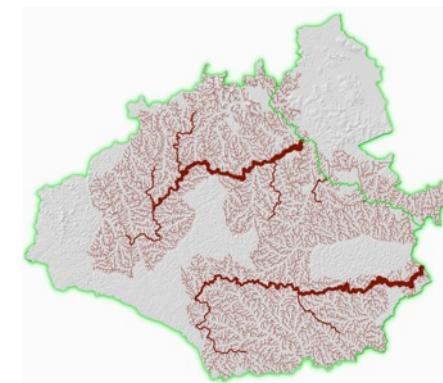
Low height stands /
Particular habitats
Pléiades
SPOT6/7
(*Lidar ICESat/GLAS*)

Exploitability



Terrain &
hydro
constraints
SRTM30m

Road conception



Wood volume going
through theoretical
network
SRTM30m



Remote sensing for Management & Planning

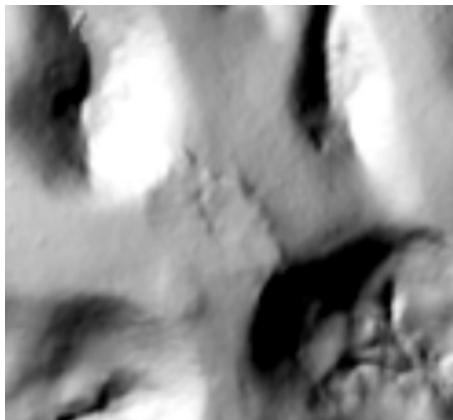
Data & Analyses

PRMV & Logging

Airborne Lidar



Biodiversity /
Ecosystem services



Particular
habitats

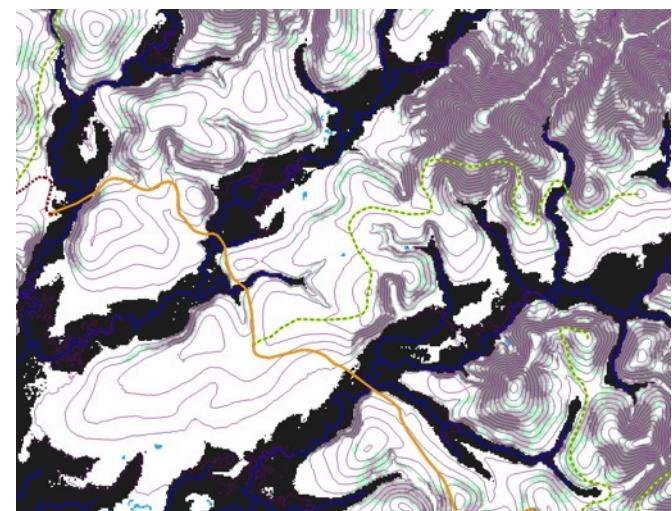
Commercial
ressource



Canopy height,
Field Inventory

Exploitability

Road
conception



Terrain, hydro ...



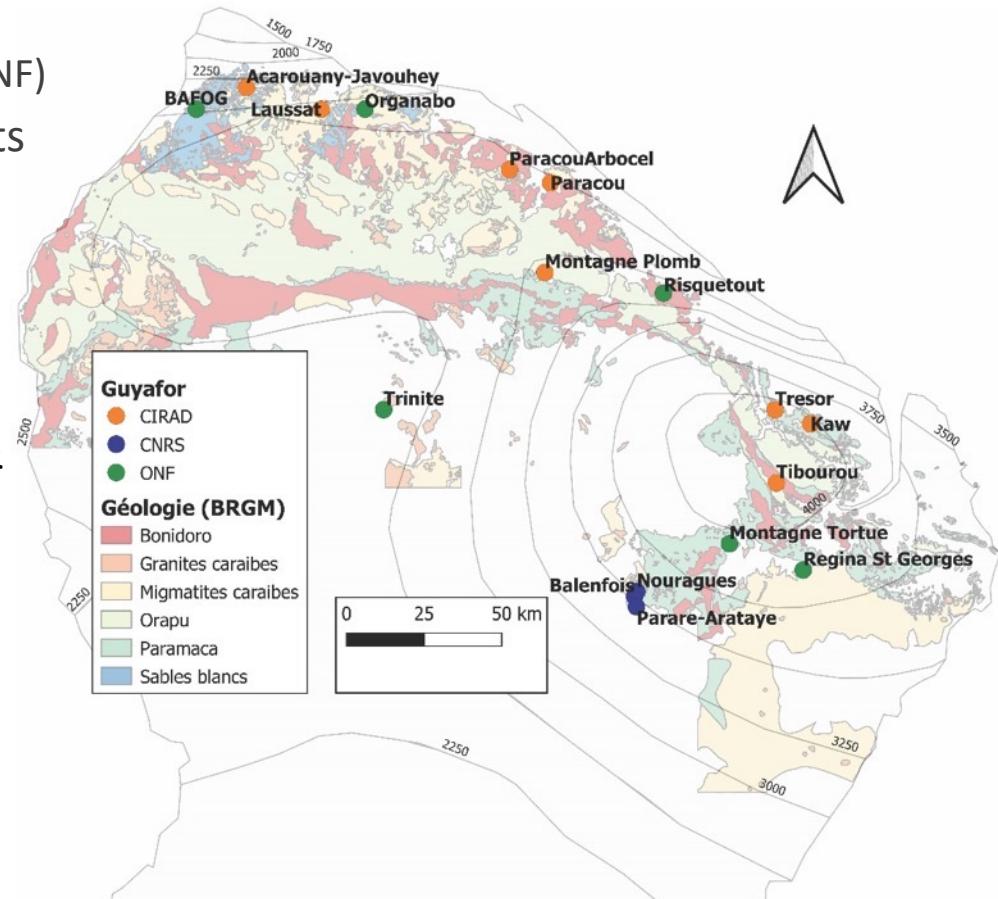
Remote sensing for Management & Planning

Necessity of field data

- GUYAFOR Network (CIRAD, CNRS, ONF)
 - Network of permanent forest plots
 - 16 sites
 - 250 ha

→ Long term monitoring
 Forest dynamics, trajectories, carbon &
 climate change impacts ...

Local & global models



Remote sensing for Management & Planning

Necessity of field data

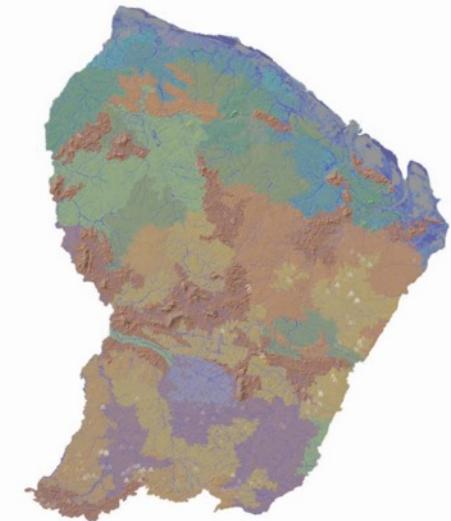
- ‘HABITATS’ project & inventories
 - Geomorphology approach
 - Standardized protocol
 - Species, diameters, palm trees, soils...
 - Implemented for biodiversity, biomass and commercial resource estimations

→ ‘One-shot’ inventories

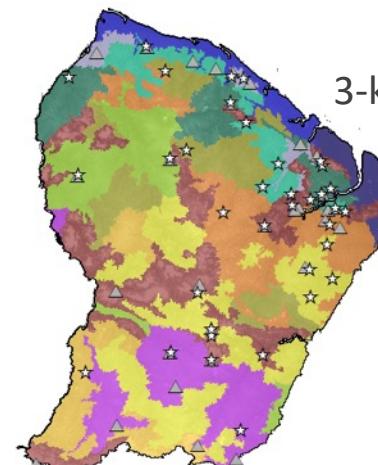
Broader spatial extent

Finer characterization of global and local variations

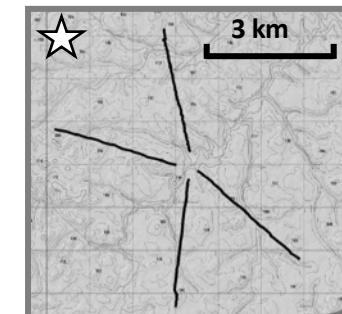
...



Wall-to-wall Map of forest habitats



3-km Transects

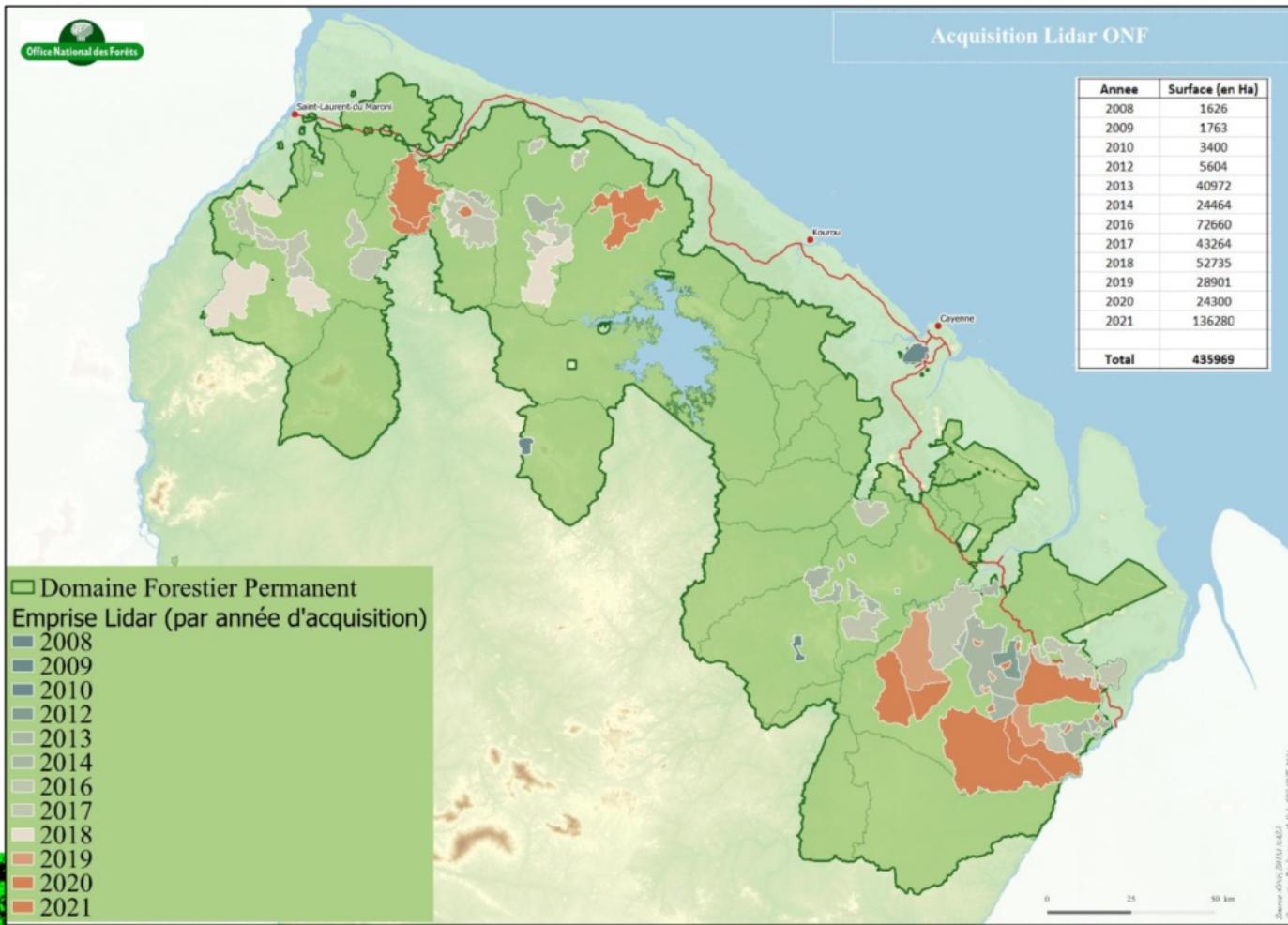


Remote sensing for Management & Planning



Airborne Lidar acquisitions

- ~ 435 000 ha ALS acquisitions over Permanent Forest Domain since 2008



Remote sensing for Management & Planning

Biodiversity, Ecosystem Services and commercial resource

- Caracterization of forest stands and mapping
- Identification of particular habitats (high ecological value)
- Species distribution (flora and fauna)
- Carbon stocks
- Impacts of climate change
- ...

➤ Tools, methods and research topics :

- Field plots and inventories (GUYAFOR network, HABITAT inventories)
- Remote sensing data / field models and extrapolation

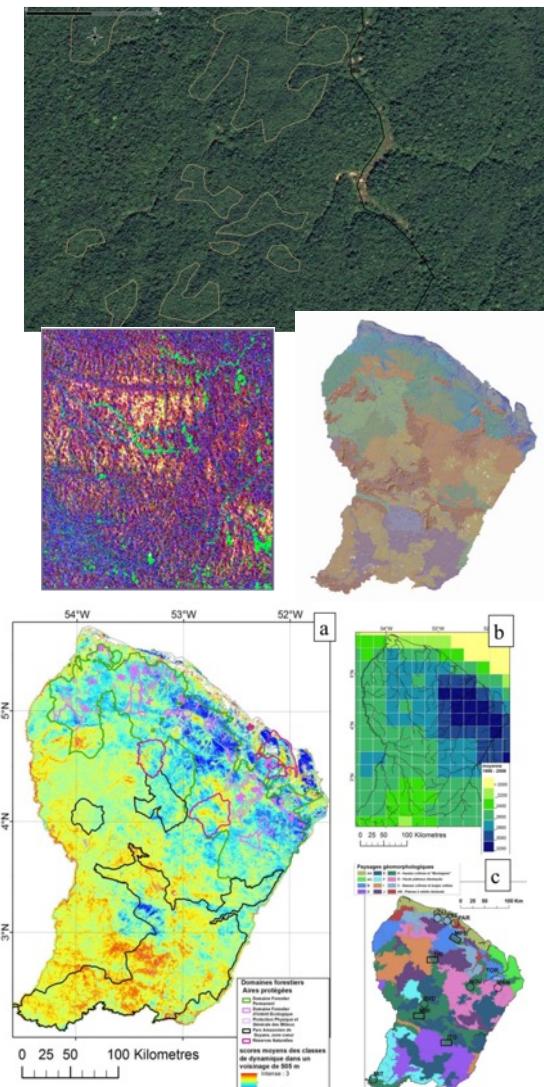


Fig. 12. a) carte des dynamiques forestières et dispositifs de gestion-conservation; b) pluviométrique TRMM 1998-2008 ; c) paysages géomorphologiques (Guitet *et al.* 2013)

RS for biodiversity, ES and commercial resource

DYNFORDIV - (IRD UMR AMAP – PAG – ONF)

Regional map of forests dynamics

Landsat / Lidar

→ Strategy for location of conservation areas and differentiated management of North / South forests

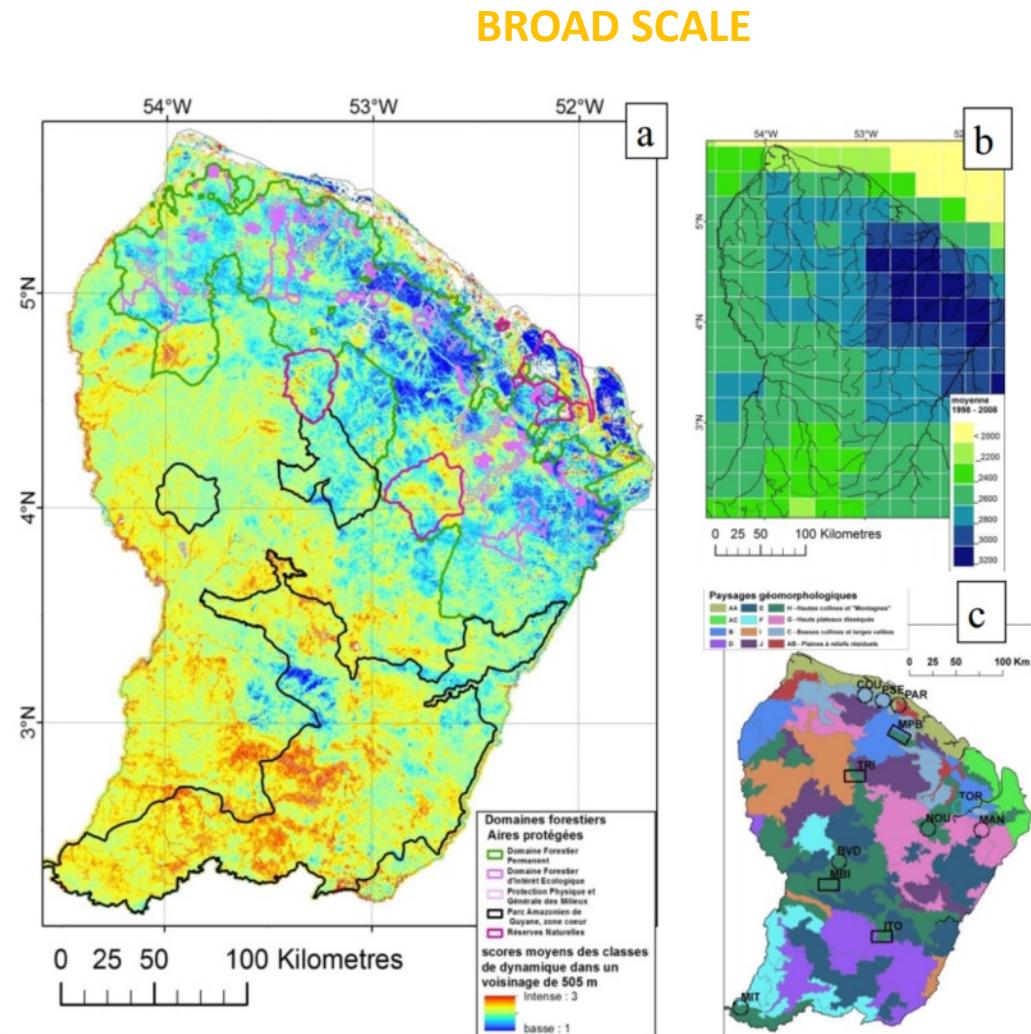


Fig. 12. a) carte des dynamiques forestières et dispositifs de gestion-conservation; b) pluviométrie TRMM 1998-2008 ; c) paysages géomorphologiques (Guitet *et al.* 2013)

RS for biodiversity, ES and commercial resource

FINE SCALE

Photo-interpretation of optical imagery

VHR Optical satellite imagery

SPOT6/7 & Pléiades



Ce travail a bénéficié d'une aide de l'Etat gérée par l'Agence Nationale de la Recherche au titre du Programme Investissements d'Avenir pour le projet EQUIPEX GEOSUD portant la référence ANR-10-EQPX-20

Images Pléiades et SPOT7 fournies par la station SEAS-Guyane, © CNES 2015,
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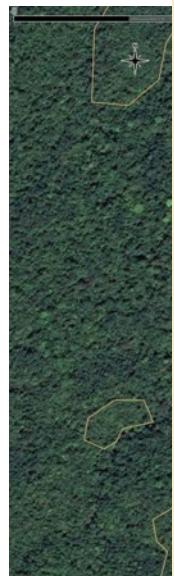
RS for biodiversity, ES and commercial resource

FINE SCALE

Photo-interpretation of optical imagery

VHR Opt
SPOT6/7

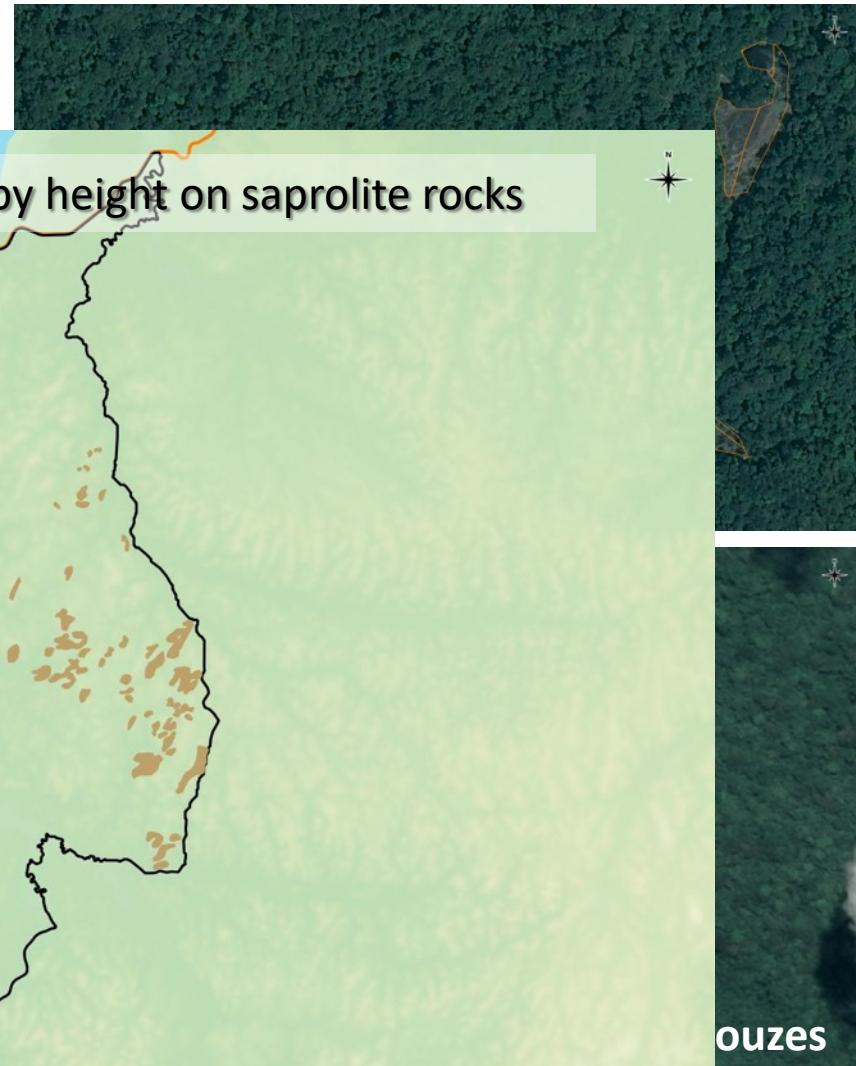
Sparouine Forest – Stands of low canopy height on saprolite rocks



Ce travail
Rech
GEO

0

10 km



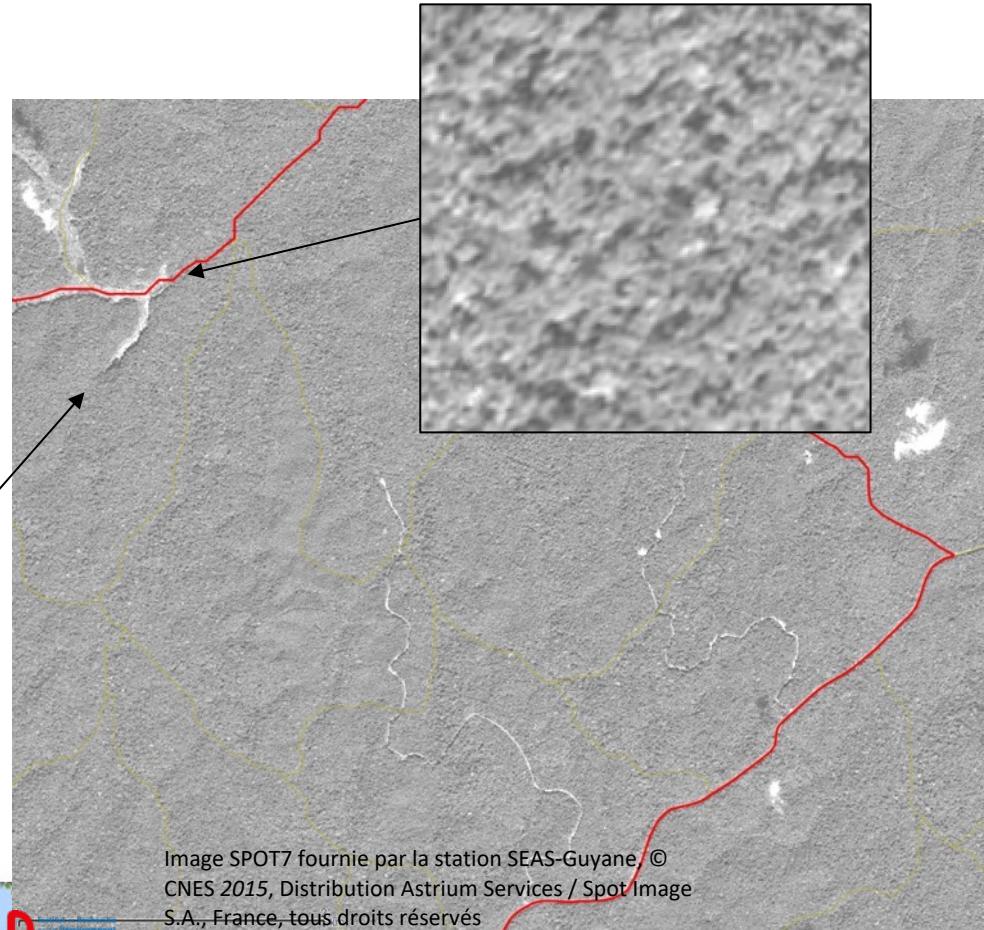
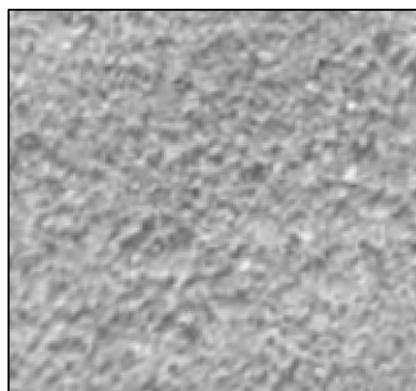
RS for biodiversity, ES and commercial resource

Texture analyses on VHR optical imagery : FOTO method (IRD UMR AMAP – ONF)

MEDIUM SCALE

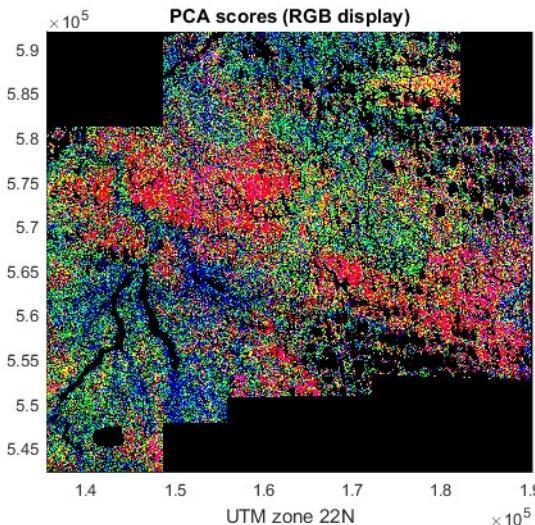
Relation between texture of VHR optical imagery and canopy height

SPOT6/7 - Lidar
Pléiades
...

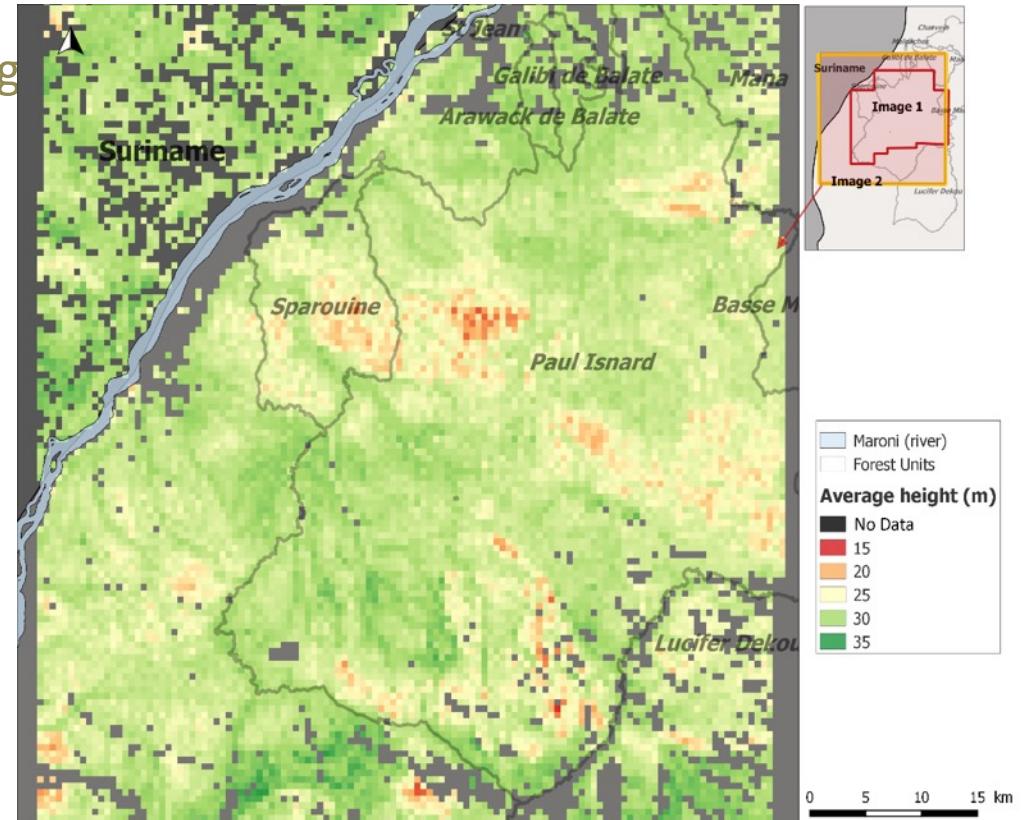
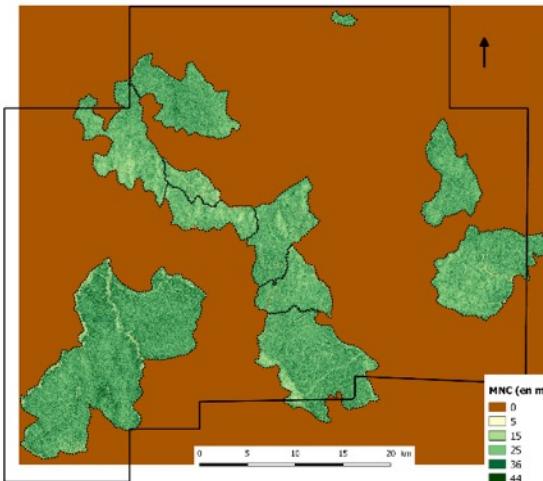


RS for biodiversity, ES and commercial resource

Texture



image



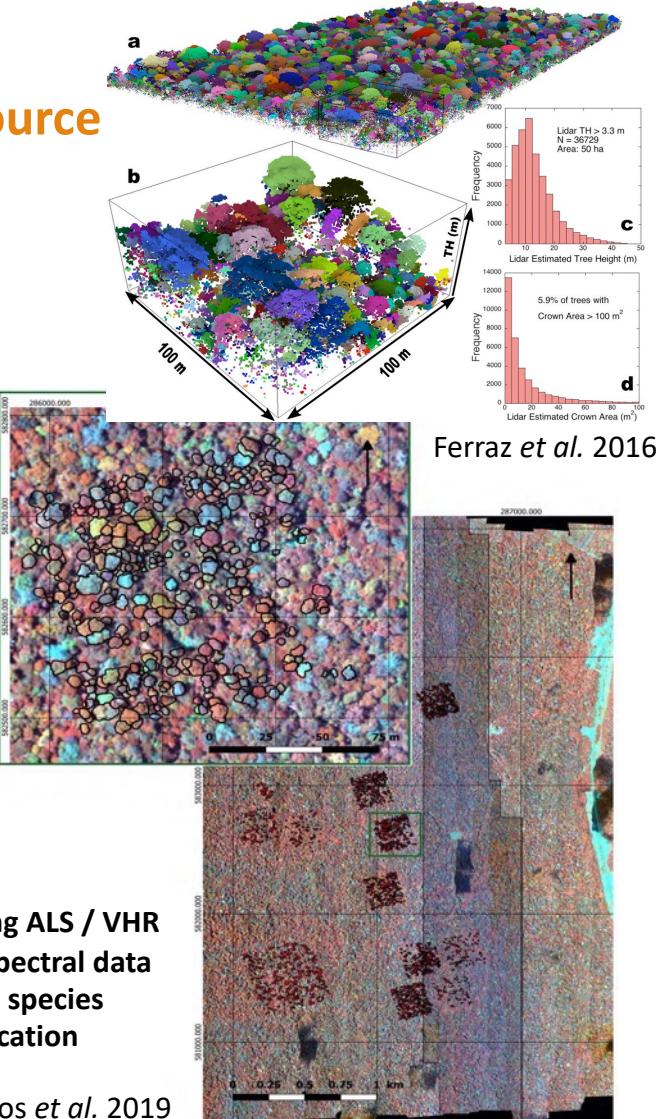
Generalization of canopy height using textural info from FOTO (SPOT6/7 panchromatic) and canopy height from ALS

Remote sensing for Management & Planning

Biodiversity, Ecosystem Services and commercial resource

- Identification of areas with low or high commercial resource potential
- Evaluation of commercial volumes at fine scales
- Identification of tree species using remote sensing
- ...

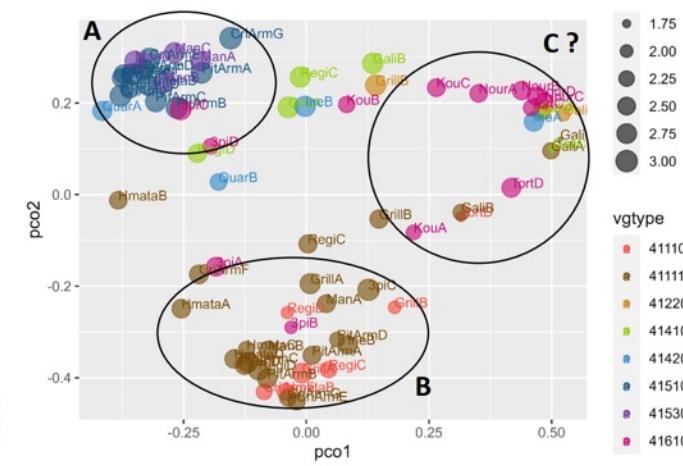
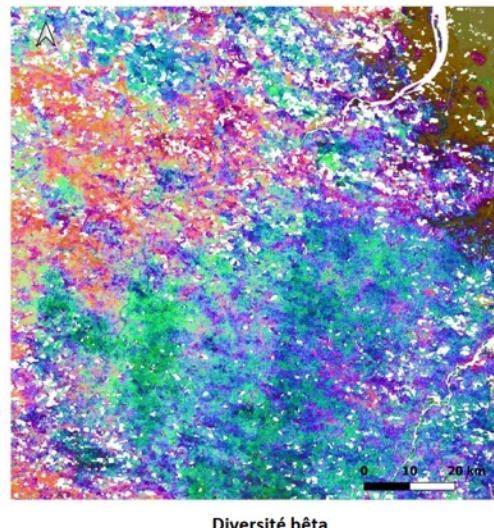
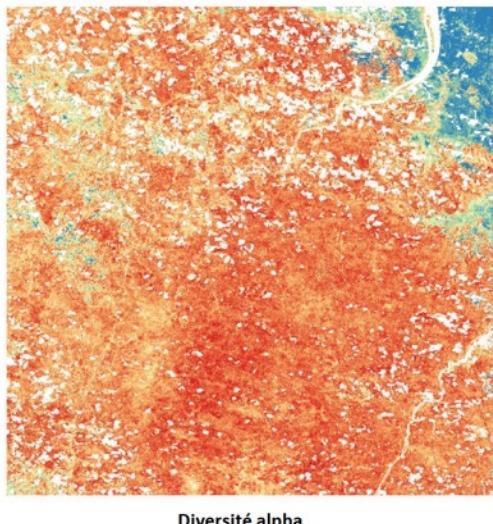
- Tools, methods and research topics :
- High and Very High Resolution satellite and aerial imagery
 - ALS Lidar data (CHM and 3D point clouds)
 - Hyperspectral imagery
 - ...



Remote sensing for Management & Planning

Biodiversity, Ecosystem Services and commercial resource

- PROGYSAT on-going work and perspectives :
 - Linking spectral diversity from Sentinel-2 to field inventory and species diversity (J.B. Féret & A. Defossez)
 - ? Extrapolate local and/or global maps of species, stands, ecological functions diversity ...
 - ? + monitoring over middle or long term temporal scales ...



A. Defossez



Surveillance & Monitoring systems



Observatory of mining activities (OAM)



Systematic surveillance - ~ the whole territory

1 : SENTINEL-2 Acquisition (*previously SPOT4/5 & Landsat*)

2 : 1/50 000^e spotting

3 : Identification / numerization at 1/5 000e

Current challenges : improve method with (semi)-automatic processing

- Détections optiques
- Surface exploitée (surf_expl)
- - 1 an
- + 1 an
- + de 10 ans

Donnée de synthèse orpaillage

- ▲ BARGE
- ▲ CAMPEMENT
- CHANTIER
- ◆ PUITS
- VILLAGE

Surveillance & Monitoring systems



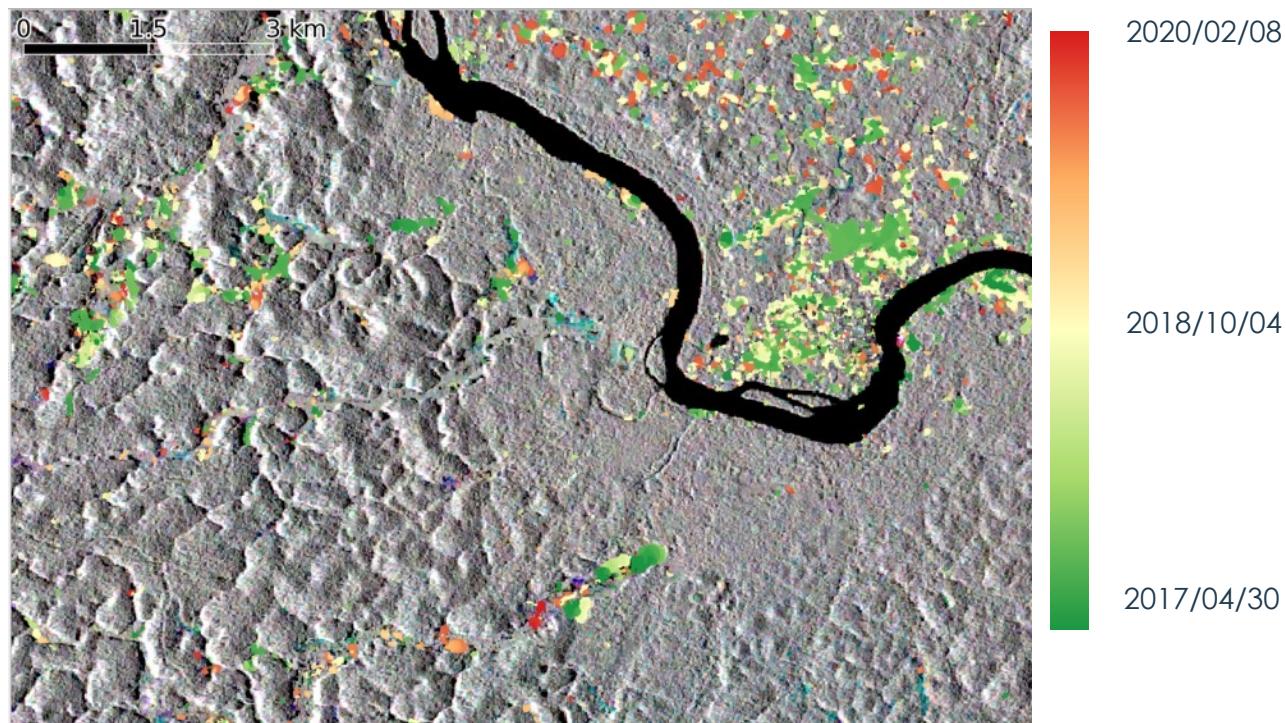
Sentinel-1 alert system for illegal cutting

Systematic surveillance - the whole territory

Fully automated process
Monthly map and stats

Current challenges :

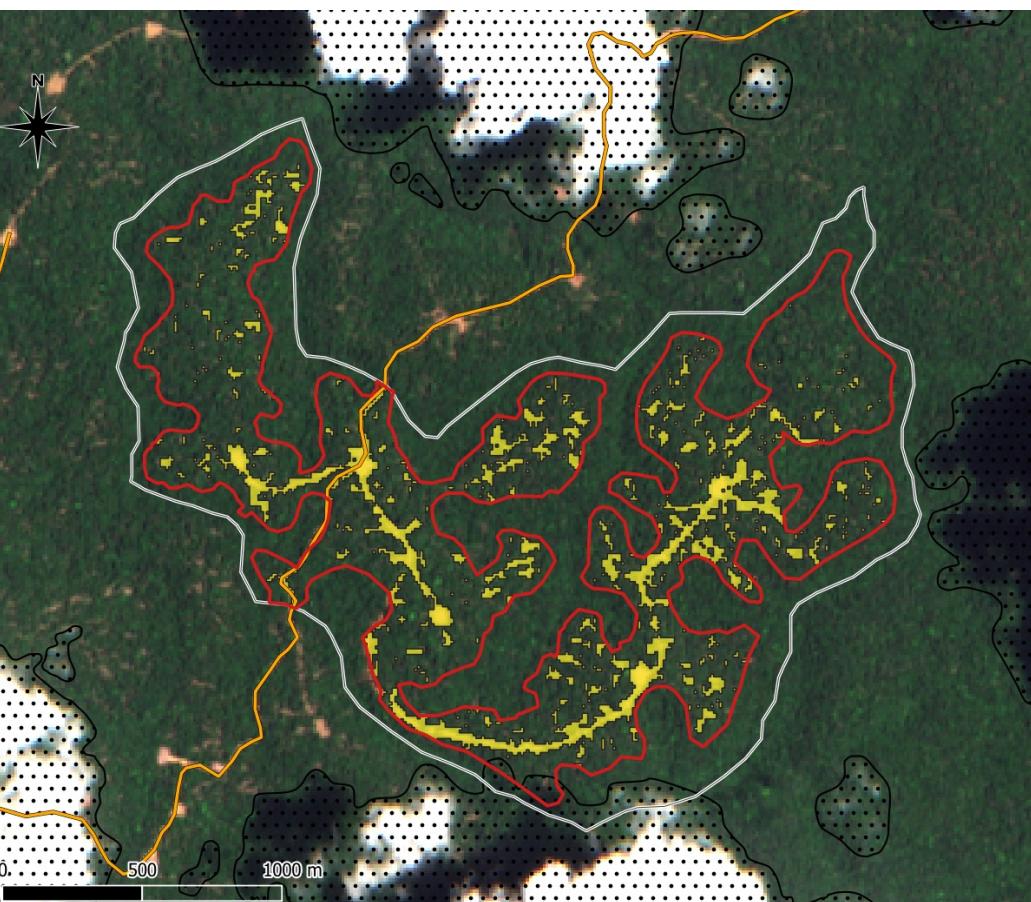
- Improve detection on small patches (< 1ha) and within strong relief
- Improve land cover basemap



ONF International - Lardeux 2021



Surveillance & Monitoring systems



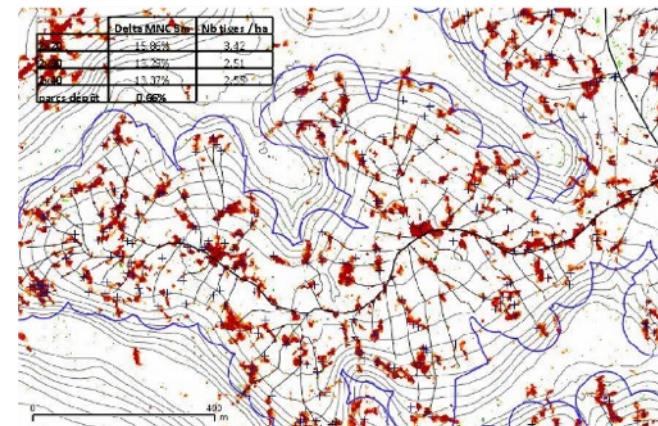
Logging impact monitoring with Sentinel-2 ...



... And with temporal ALS

Trouées liées à l'exploitation

△ MNC 2012 / 2013



Systematic - logged plots

Current challenges :

- Adaptation of method to S2 (previously SPOT4/5)
- Set-up automated selection & pre-process of S2 (clouds) scenes linked with spatio-temporal relevance

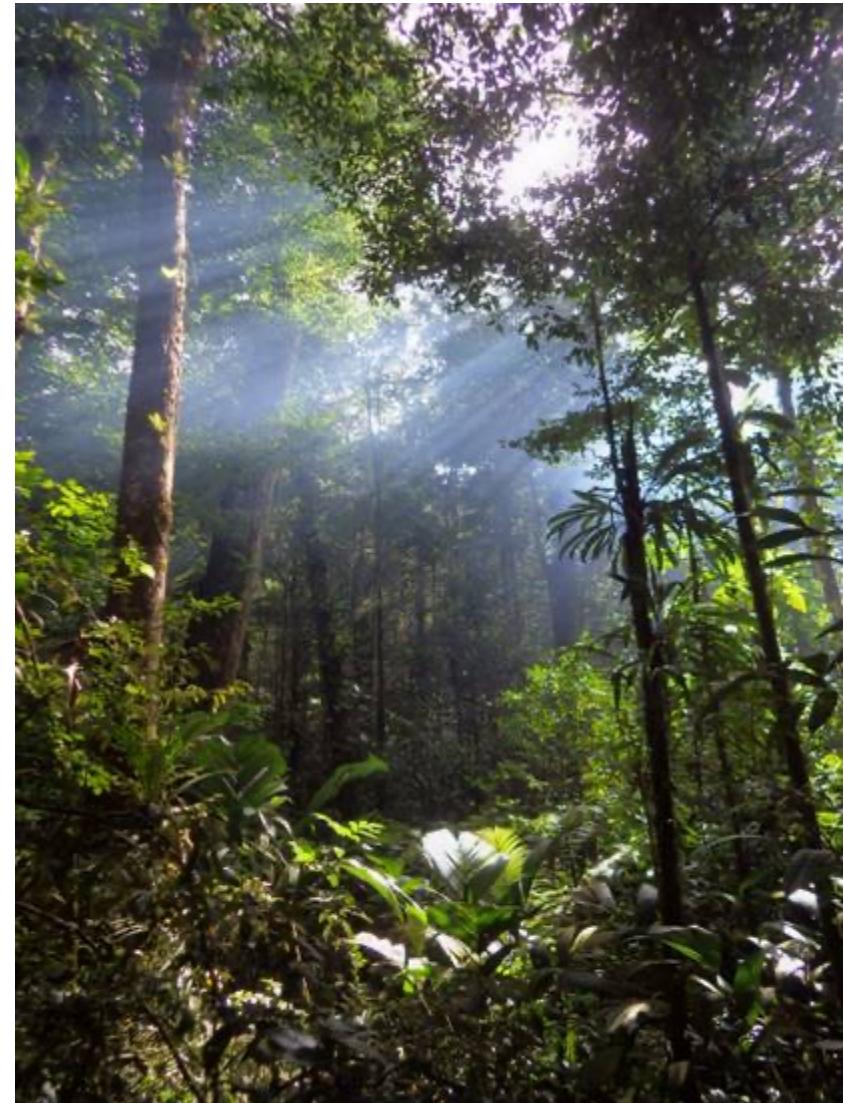
Monitoring systems

Remaining challenges

- Lack of global, comprehensive, forest monitoring system over the whole territory :
 - Absence of NFI and regular national forest reference data in French Guiana
 - Short-term monitoring systems compartmentalized and performed by managers
 - Long-term monitoring not fully addressed (currently restricted to permanent plots)
- Long-term monitoring to be improved with help of remote sensing technics :
 - Spatial and fine scale implementation
 - More adapted to local conditions of forests and to post-disturbance trajectories (degradation, deforestation, recovery ...)
 - Measurements / better evaluation of biomass, biodiversity and commercial resource evolutions over long temporal scales



Thank you for your attention



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