23 October 2018
Copernicus Global Land User Conference
Toulouse (France)

Testing Copernicus Products to estimate forest carbon

SESSION: GLOBAL TOWARDS HIGH RESOLUTION

Copernicus Global Land
Providing bio-geophysical products of global land surface

Copernicus
Europe's eyes on Earth

agresta

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GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

IN LUMINE SAPIENTIA
UNIVERSITAS ALMERIENSIS

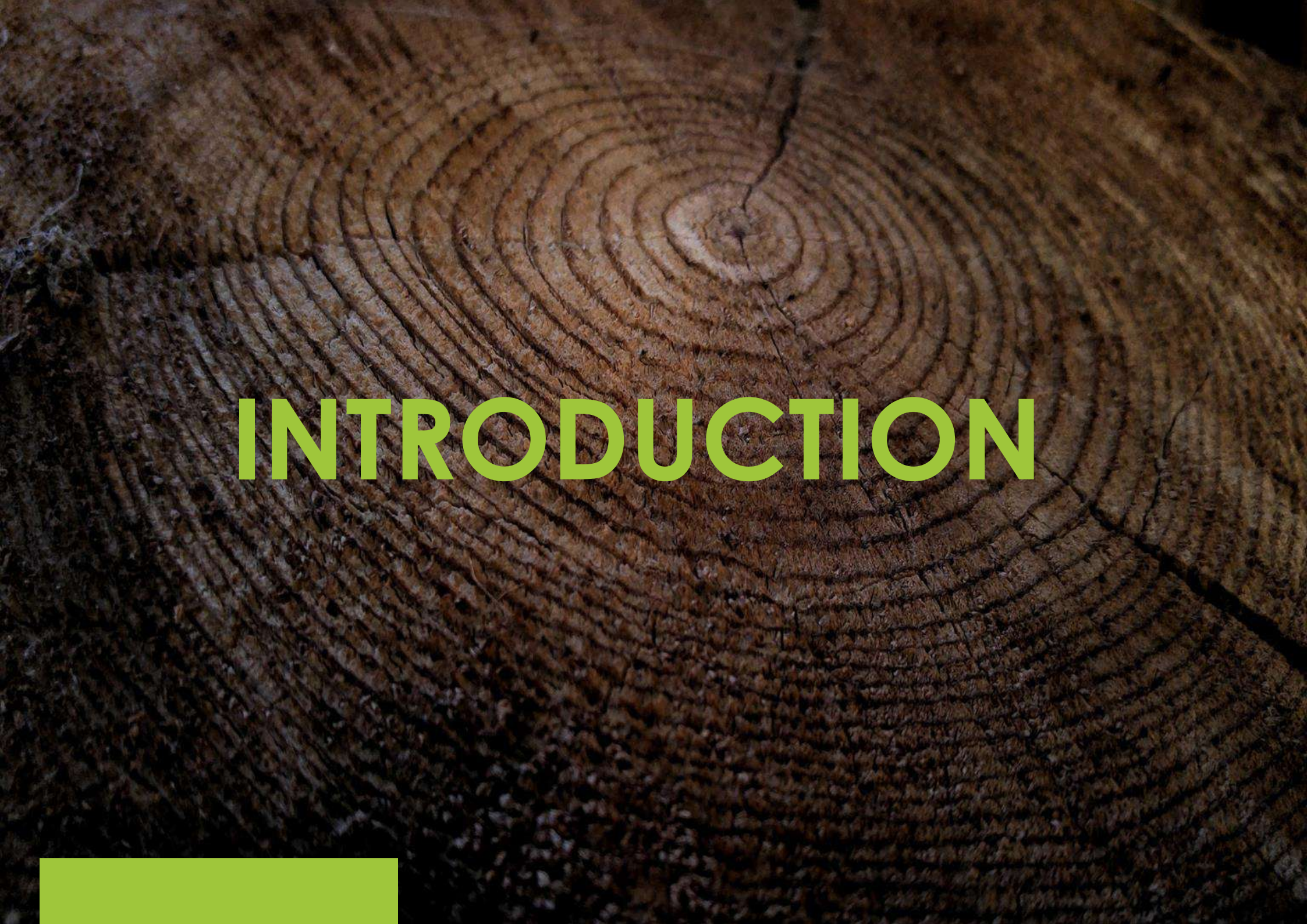
Introduction

Materials and methods

Results

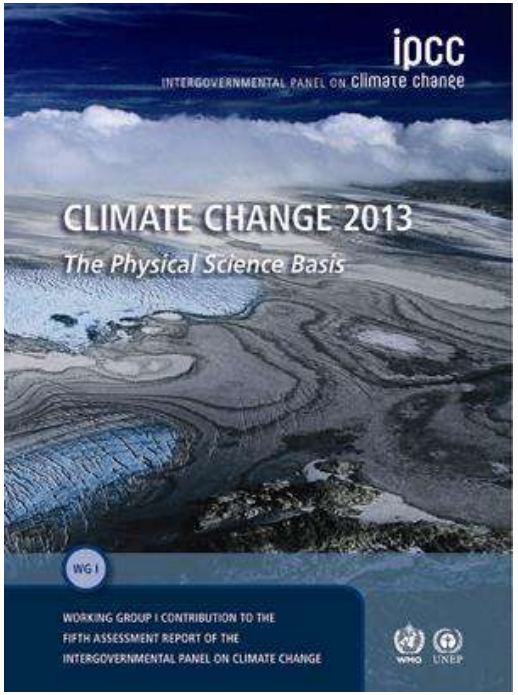
Discussion and conclusions

Future step


INTRODUCTION

Introduction

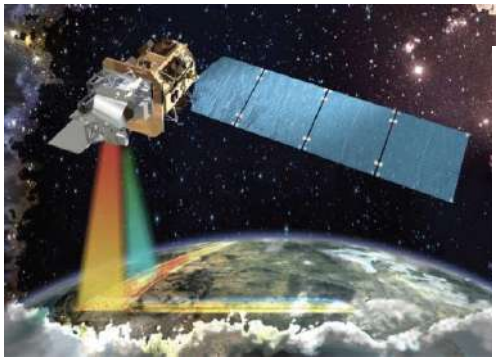
- Threatened by global change
- 2 ° C Global Temperature Target
- Potential carbon sinks: Forest at national scale

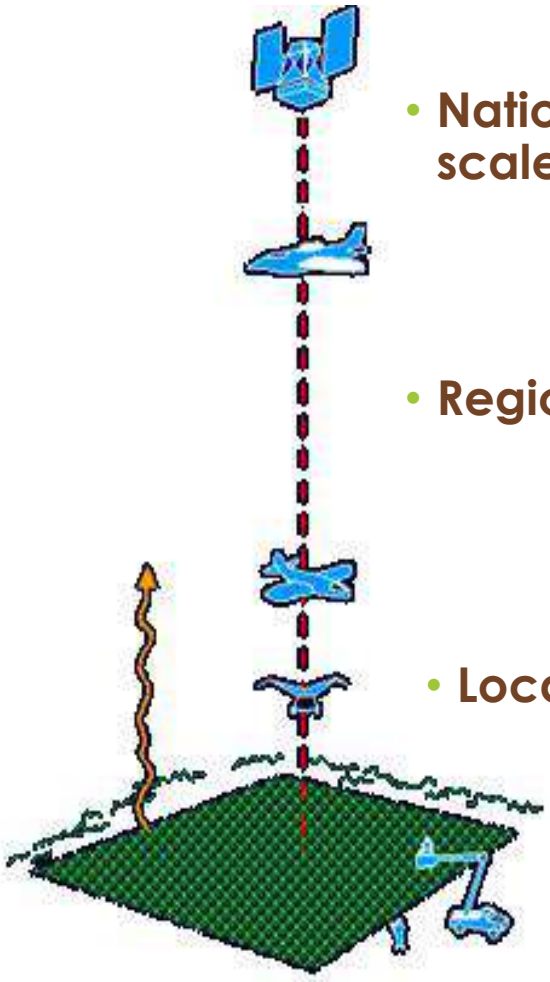


COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

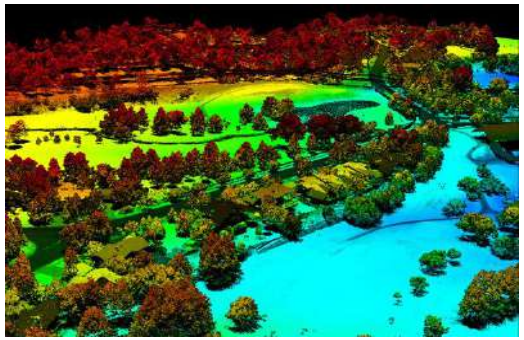
Introduction

The issue of scale in remote sensing





- National/Global scale
- Regional scale
- Local scale



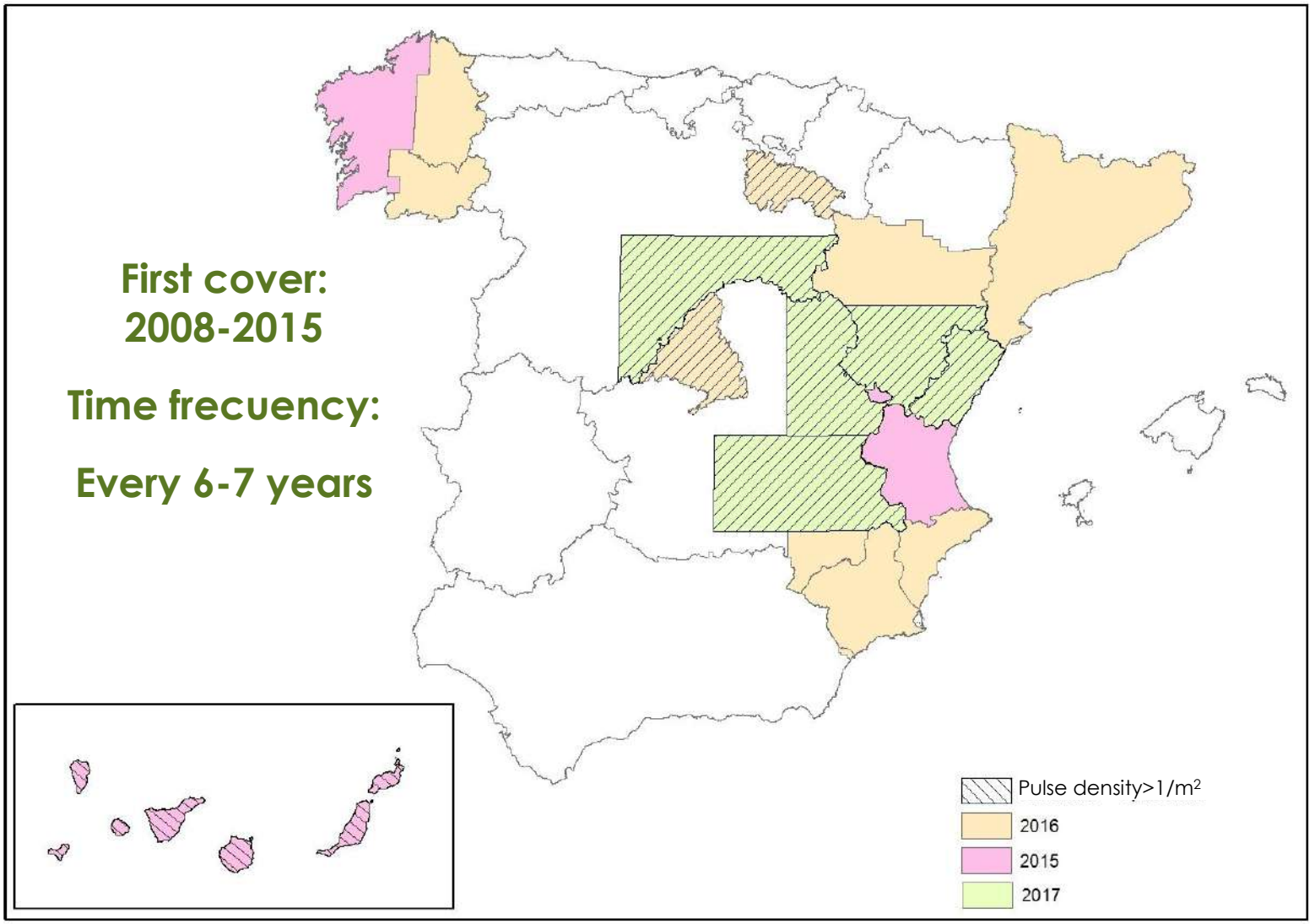
Introduction

LiDAR Images availability : Second cover of National Plan for Aviation Ortho (PNOA) 2016

First cover:
2008-2015

Time frecuency:

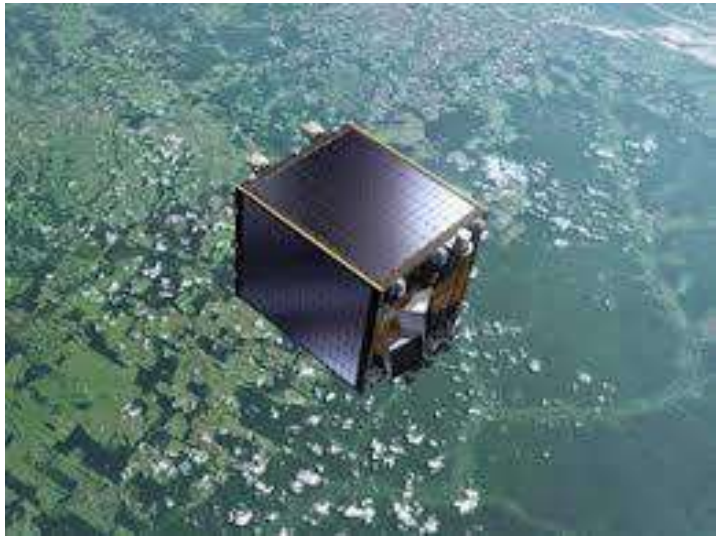
Every 6-7 years



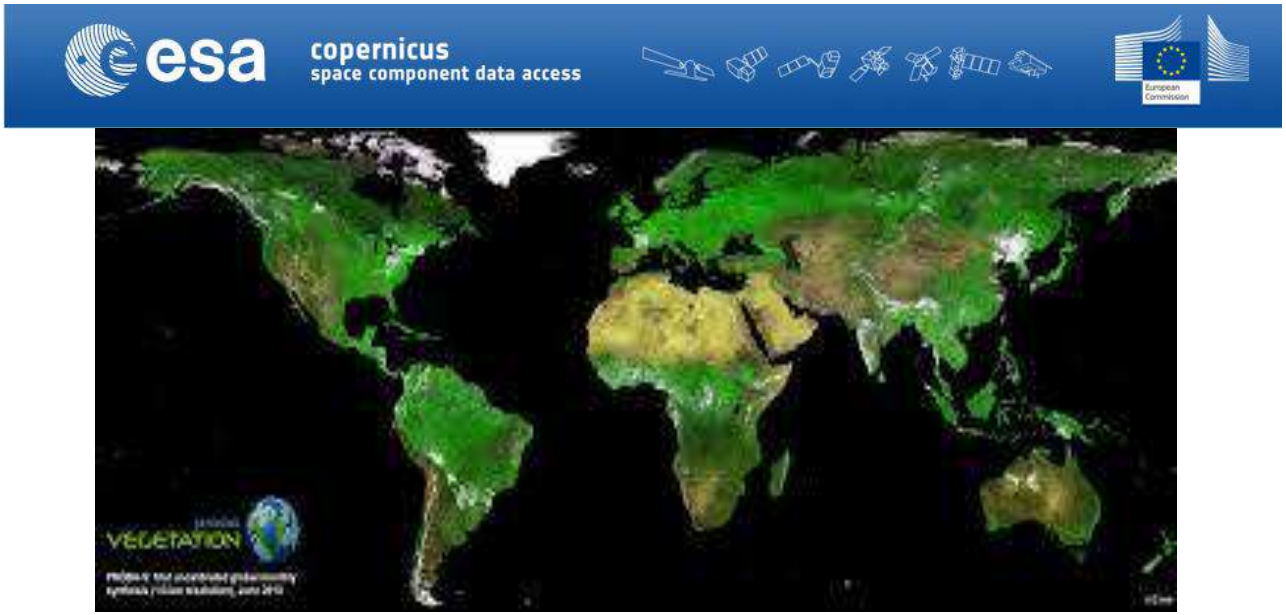
- Pulse density:
  0.5 pulse/m^2
- Mean vertical accuracy:
  20 cm

Introduction

Copernicus Global Land Service: Providing bio-geophysical products of global land surface in near-real time. Vegetation products of 300 m pixel resolution each 10 –day period



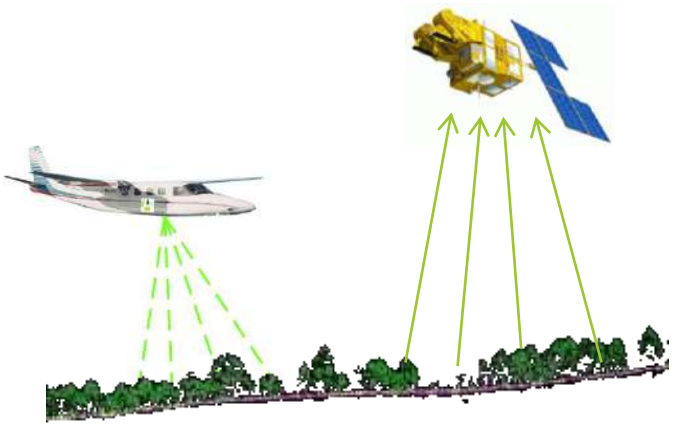
PROBA-V ESA Mission (2014)



Introduction

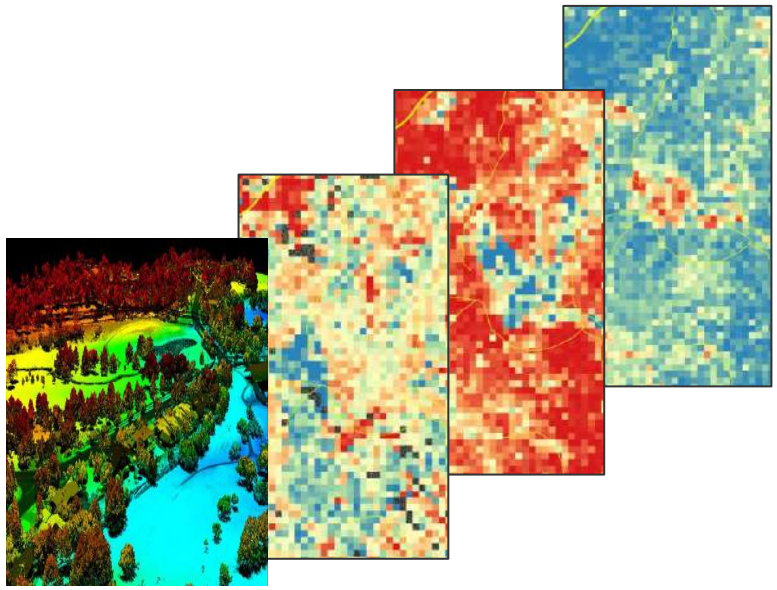
What if we combine them?

Combining LiDAR data with optical remote sensing images



High-accuracy LiDAR data at local scale

High temporal resolution at global scale




Materials and methods

Materials and methods

Study area: Region of Murcia

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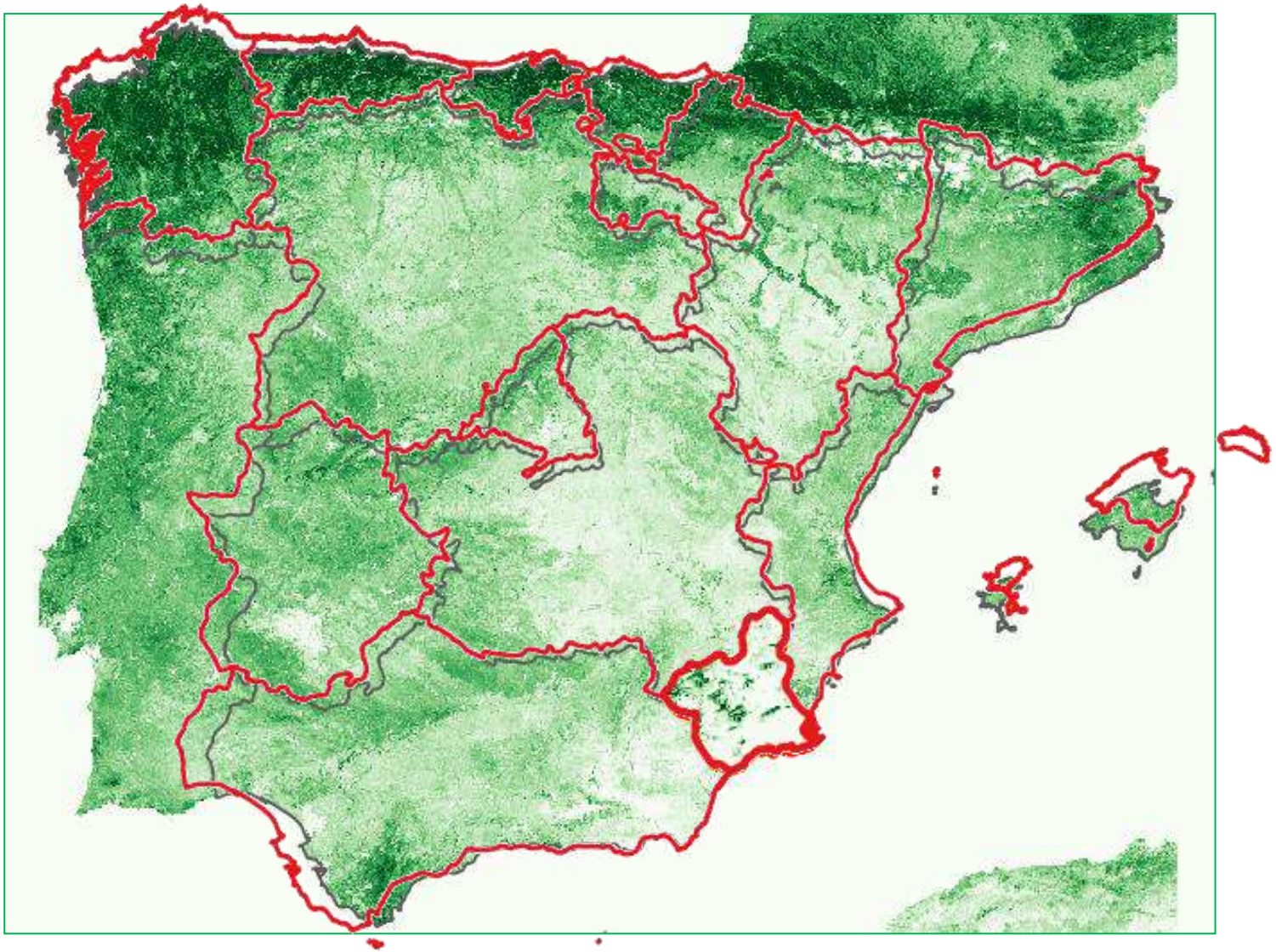


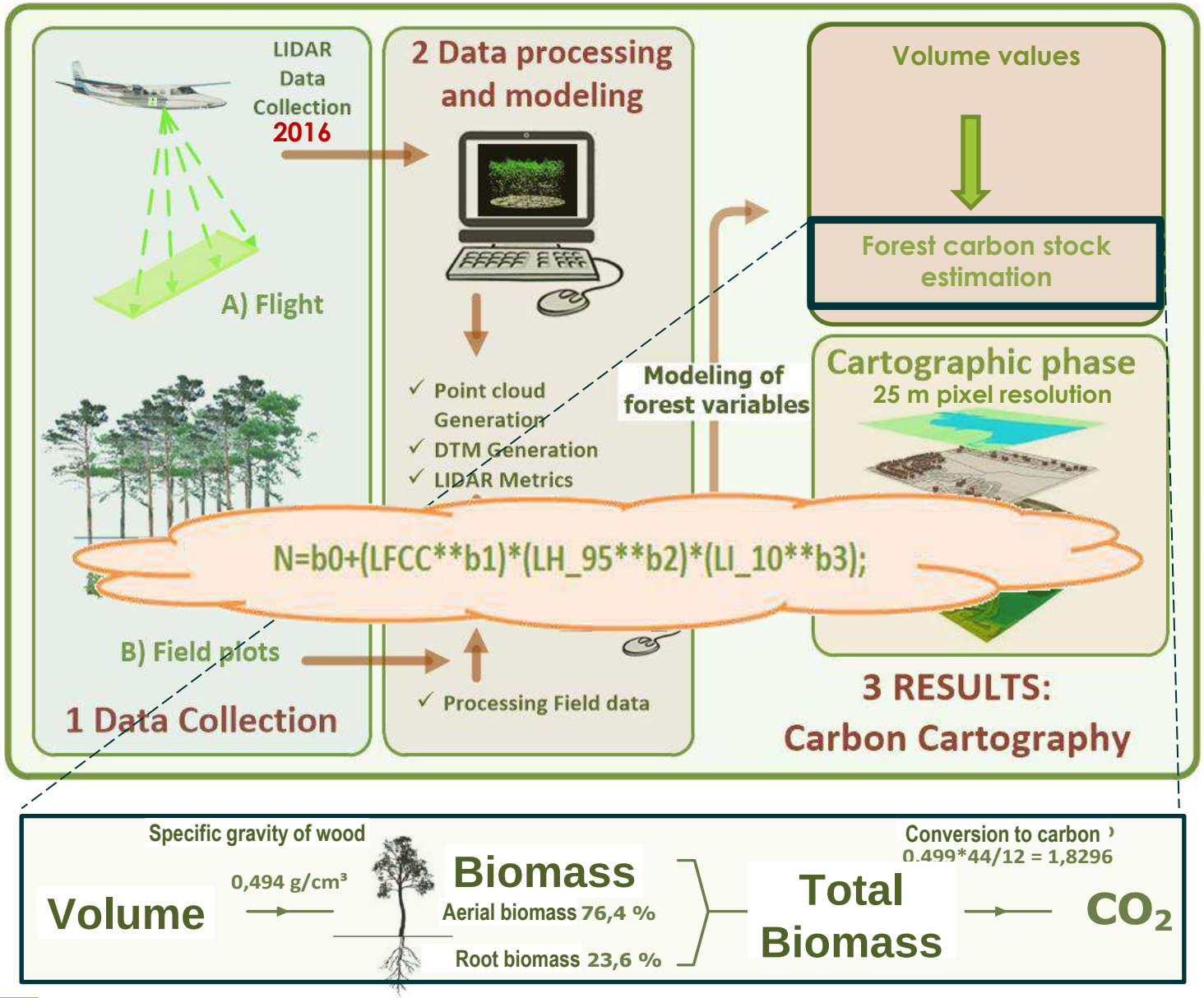
Materials and methods

Study area: Region of Murcia

Materials and methods

SOURCE DATA

✓ LiDAR data (PNOA2016) → Aboveground forest carbon map

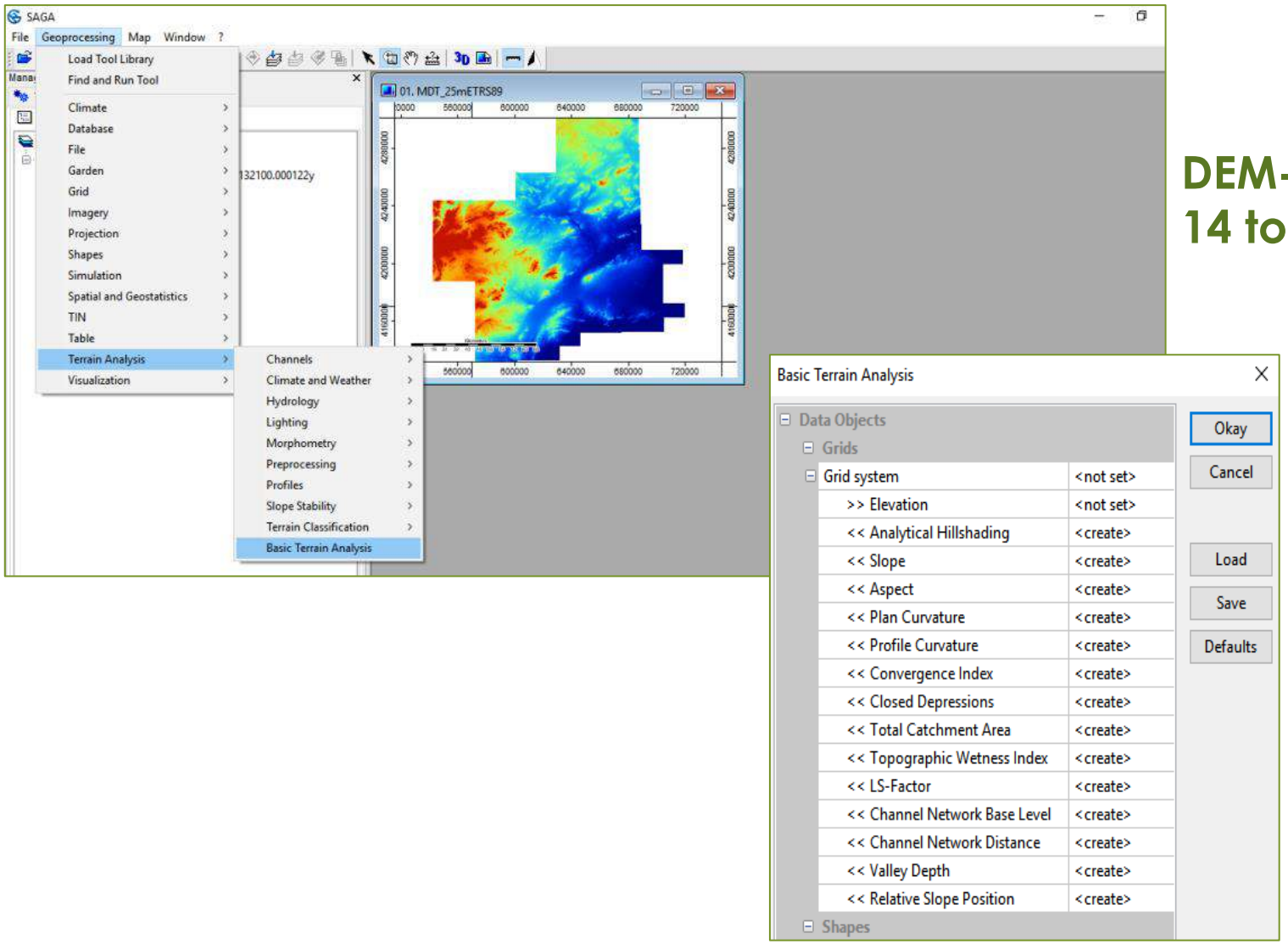

LIDAR
Data
Collection
2016
A) Flight
B) Field plots
1 Data Collection
2 Data processing
and modeling
✓ Point cloud
Generation
✓ DTM Generation
✓ LIDAR Metrics
✓ Processing Field data
Modeling of
forest variables
N=b0+(LFCC**b1)*(LH_95**b2)*(LI_10**b3);
Volume values
Forest carbon stock
estimation
Cartographic phase
25 m pixel resolution
3 RESULTS:
Carbon Cartography
Specific gravity of wood
Volume
0,494 g/cm³
Biomass
Aerial biomass 76,4 %
Root biomass 23,6 %
Total
Biomass
Conversion to carbon
0.499*44/12 = 1,8296
CO2

Materials and methods

SOURCE DATA

- ✓ LiDAR data (PNOA2016) → Aboveground forest carbon map
- ✓ DEM 25-m pixel resolution from «Spanish National Geographic Institute» (CNIG):
  - 14 terrain variables (SAGA GIS software)

Materials and methods
Source data



DEM-SAGA GIS ⇨
14 topographic variables

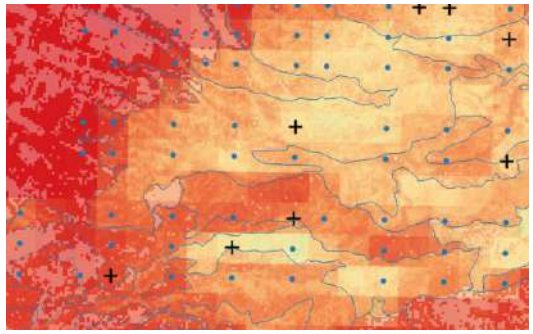
Materials and methods

SOURCE DATA

- ✓ LiDAR data (PNOA2016) → Aboveground forest carbon map
- ✓ DEM 25-m pixel resolution from «Spanish National Geographic Institute» (CNIG):
  - 14 terrain variables (SAGA GIS software)
- ✓ Forest Map of Murcia (1:25000) (MAPAMA): GIS Cover linked to a detailed forest database.
- ✓ Copernicus Global Land Service. Vegetation products 300 m:
  - NDVI , LAI, FAPAR, FCOVER

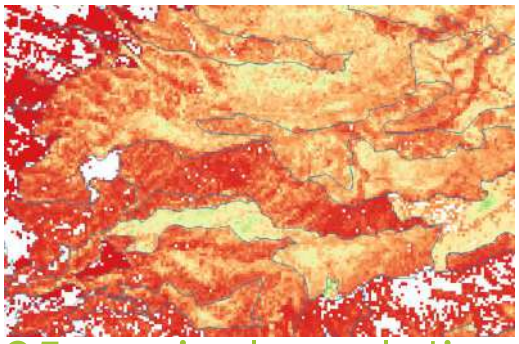
Materials and methods
Source data

Methodological scheme



300 m pixel resolution

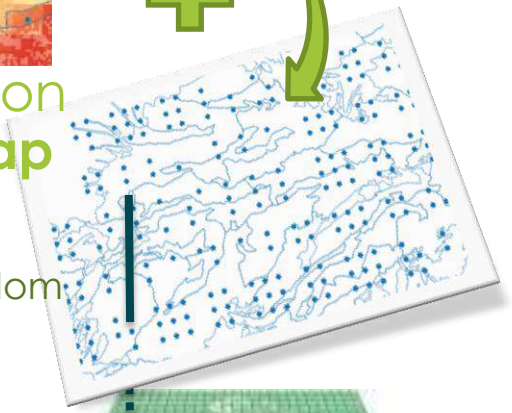
LiDAR carbon map

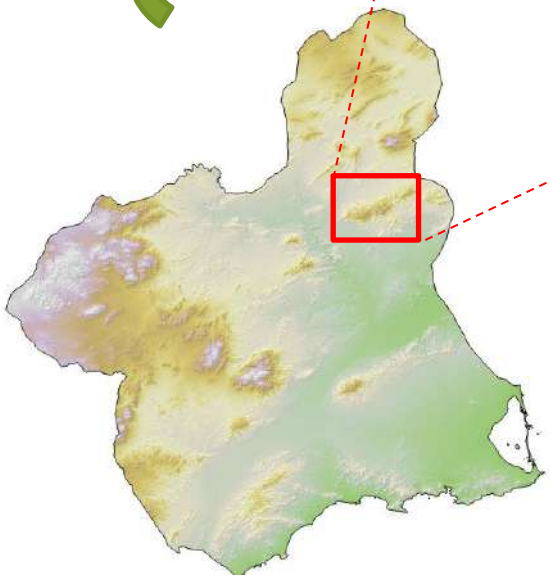


25 m pixel resolution

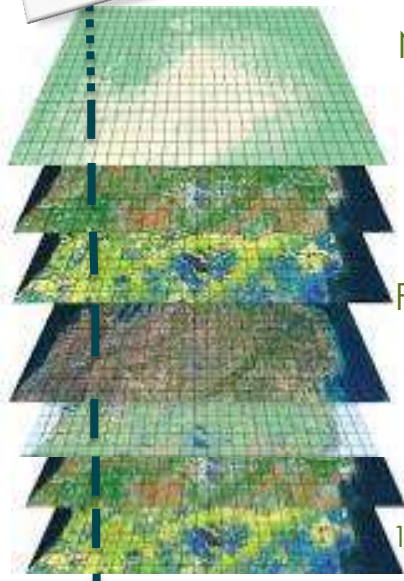
Train data set

Test data set (3,000 random points)





	Carbon_Mur300	FAPAR_160510	FAPAR_160520	FAPAR_160531	FAPAR_161010	FAPAR_161020
125069	54.245749958	0.33600003	0.33200002	0.31600001	0.32400000	0.33200002
125070	35.312420866	0.32000002	0.31200001	0.30400002	0.31600001	0.33600003
125805	35.577684141	0.28000000	0.28400001	0.27200001	0.31200001	0.34000000
125807	45.450012740	0.34400001	0.33200002	0.30800003	0.32400000	0.34000000
125808	38.286589771	0.34000000	0.33600003	0.32400000	0.34000000	0.36400002
125809	33.944698758	0.28400001	0.29200003	0.30000001	0.31600001	0.32000002
125810	29.381473173	0.25600001	0.25600001	0.23600002	0.17200001	0.18000001
125811	4.879452941	0.24000001	0.22400001	0.19200000	0.08800001	0.08800001
126540	35.708285305	0.30000001	0.28000000	0.24800001	0.28000000	0.29200003
126541	33.383498357	0.30400002	0.28800002	0.27600002	0.30000001	0.32000002
126542	30.456027013	0.29200003	0.28000000	0.27200001	0.30000001	0.30800003
126543	41.383917295	0.33200002	0.31200001	0.30400002	0.33200002	0.35600001



NDVI

LAI

FAPAR

FCOVER

DEM

14 terrain data

Methodological scheme

Carbon spatial predictive model

- **Three stages**:
  - 1. Predictor variable selection
  - 2. Spatial interpolation (QRF)
  - 3. Estimation of uncertainty
- **1. Variables selection**
  - Linear models (stepwise)
  - Variance inflation factor (VIF)
  - Variable Selection Using Random Forests (VSURF -R package)

Methodological scheme

Carbon spatial predictive model

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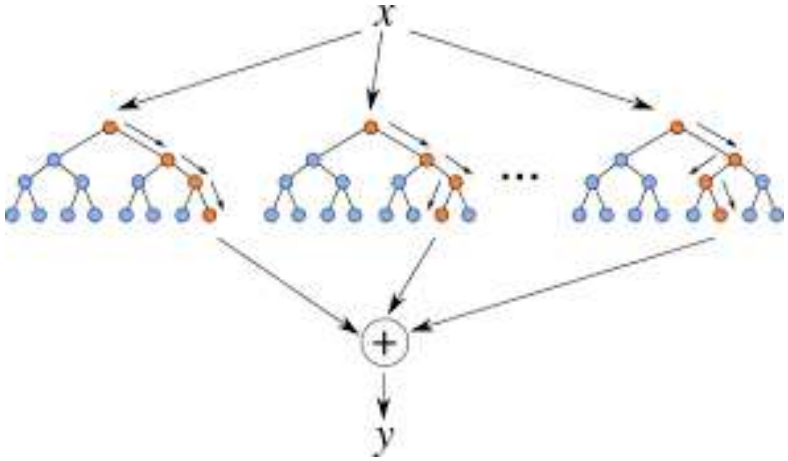
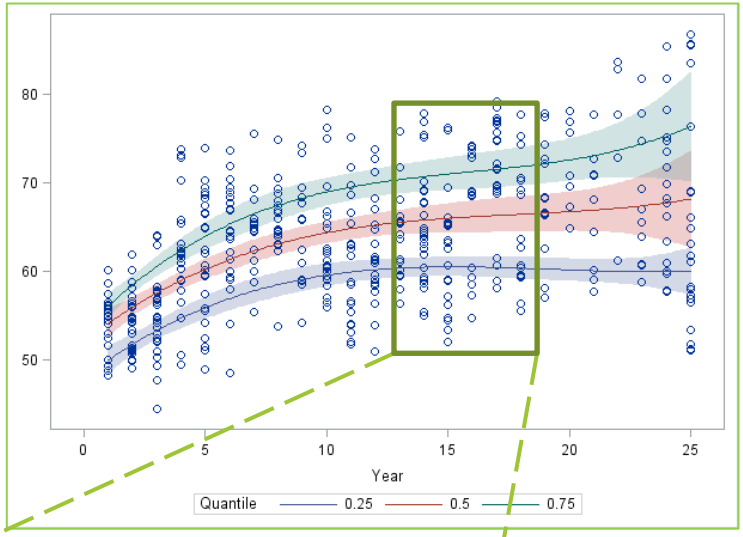
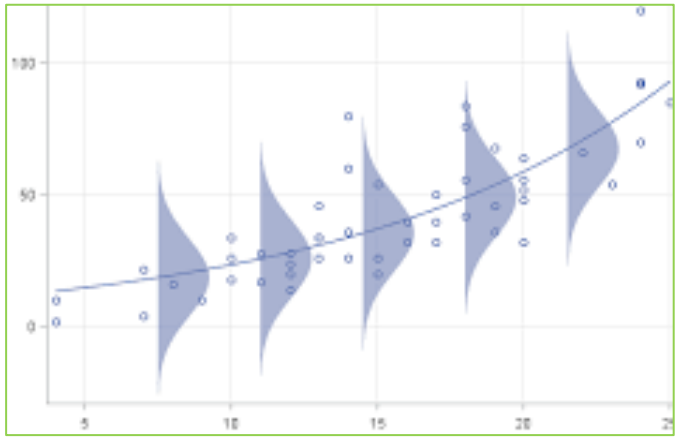
2. Spatial interpolation: Quantile Regression Forest (Meinshausen 2006)







3. Estimation of uncertainty


Results

Results

1. Selected variables:

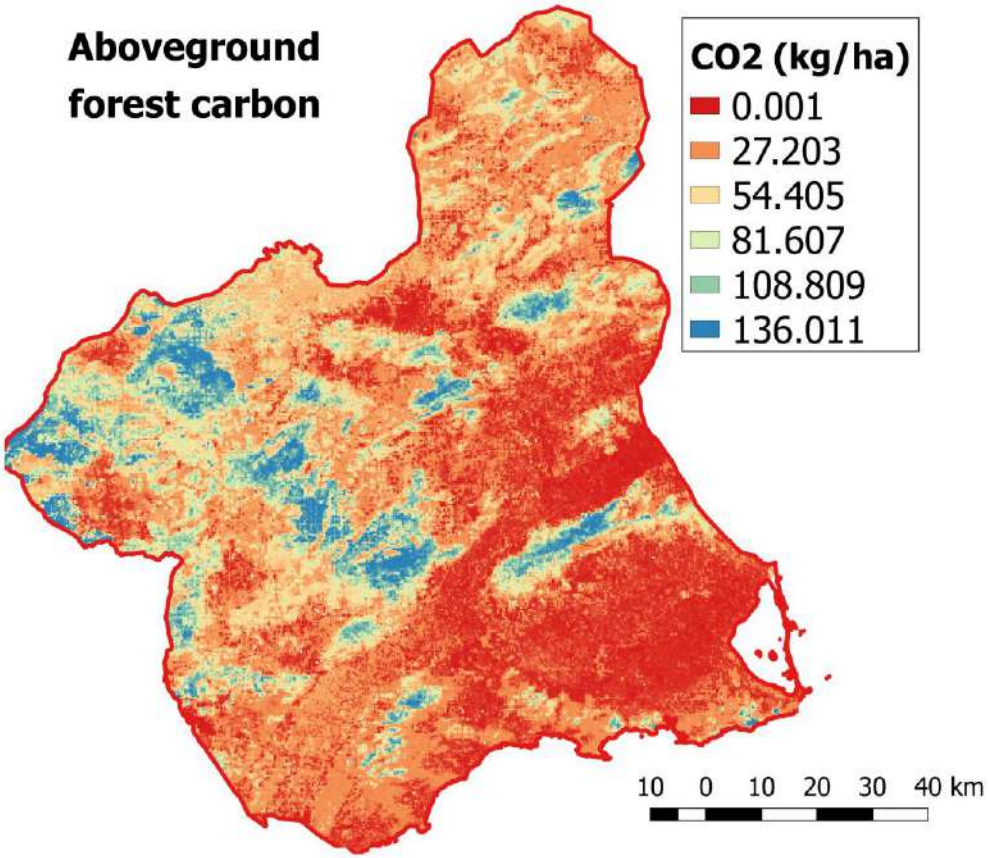
- Vegetation index: NDVI (2016/10/11 and 2016/05/21) and LAI (2016/10/10);
- Topographic variables: DEM, relative slope position and channel network base level.

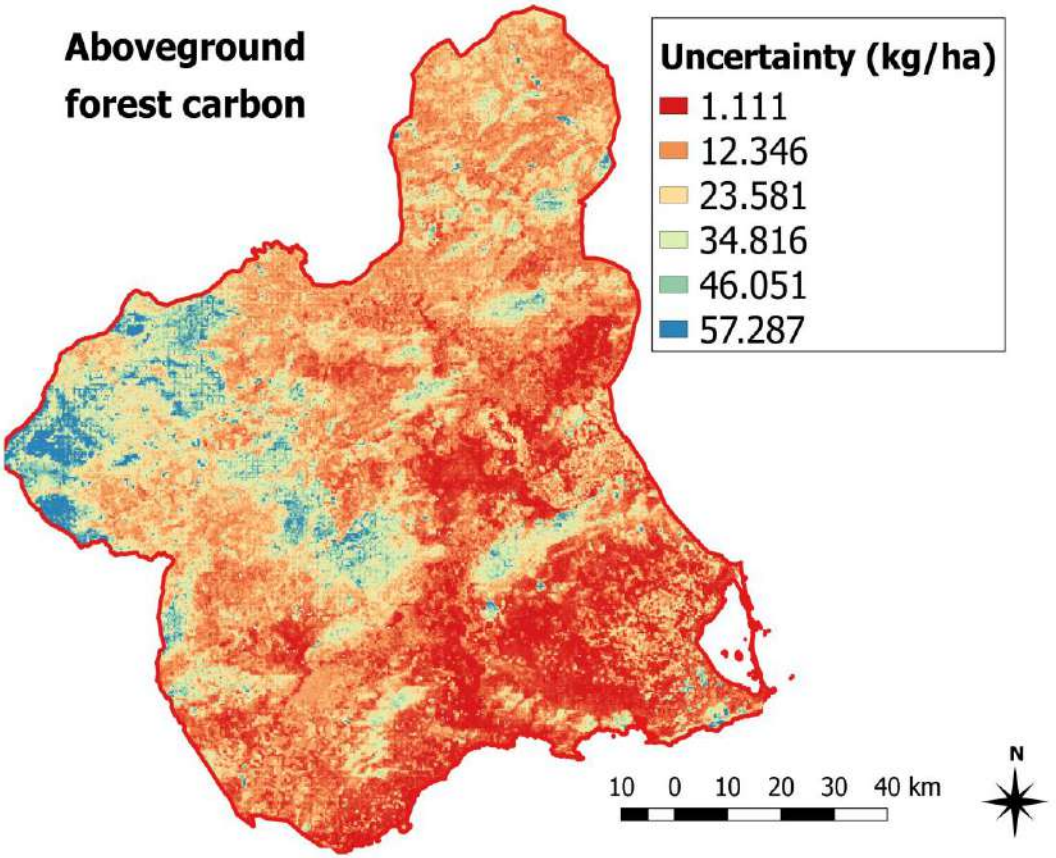
2. Spatial interpolation. Predictive model:

RMSE	R squared	Accuracy	RMSE val
24.45	0.69	0.70	25.38

Results

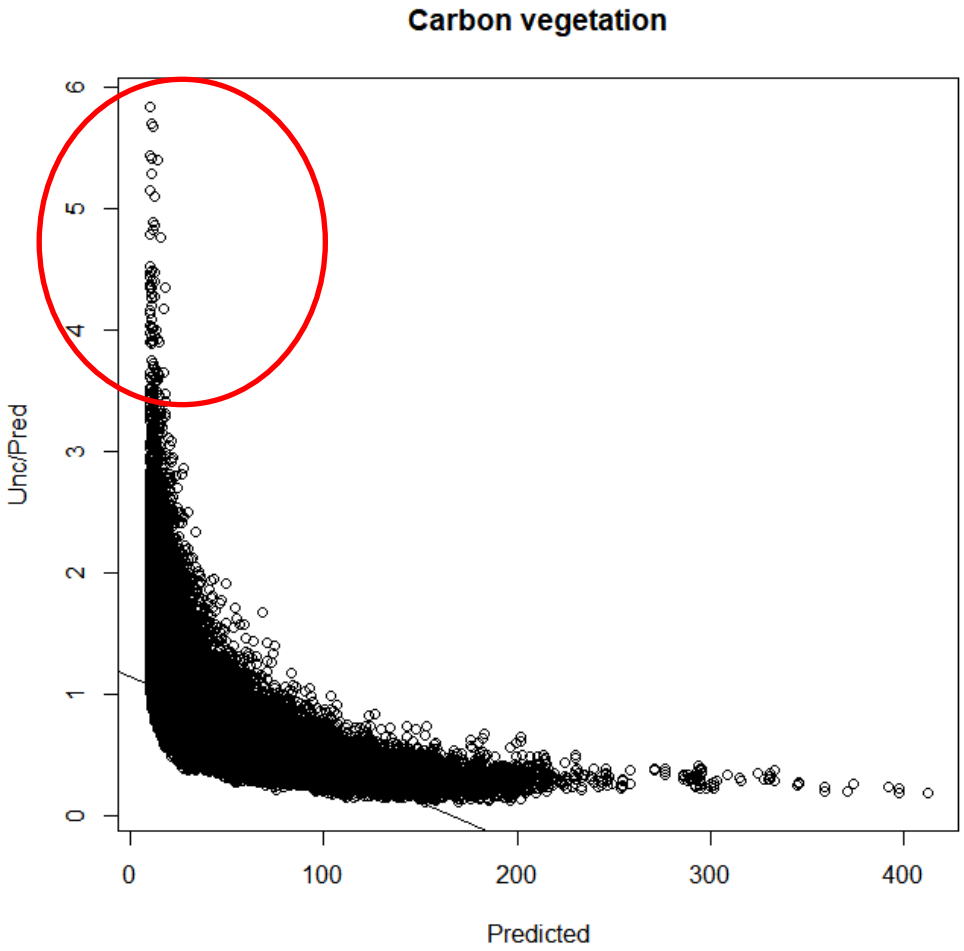
Spatial interpolation





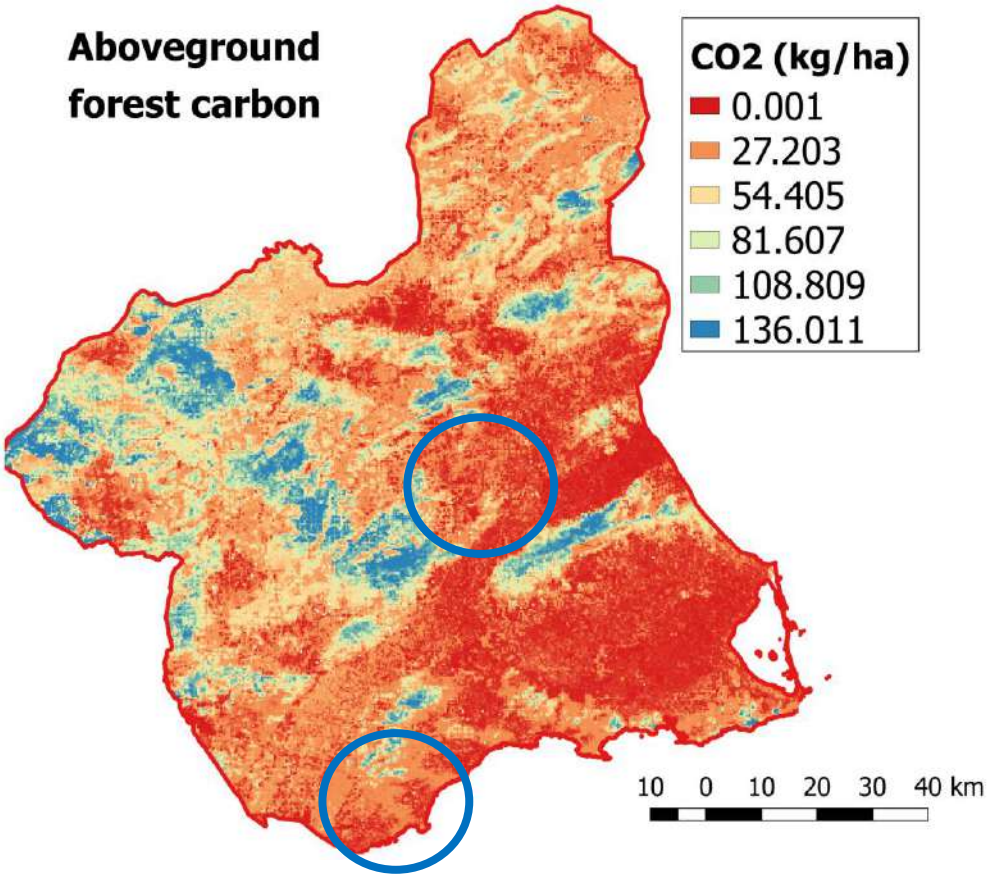
Results

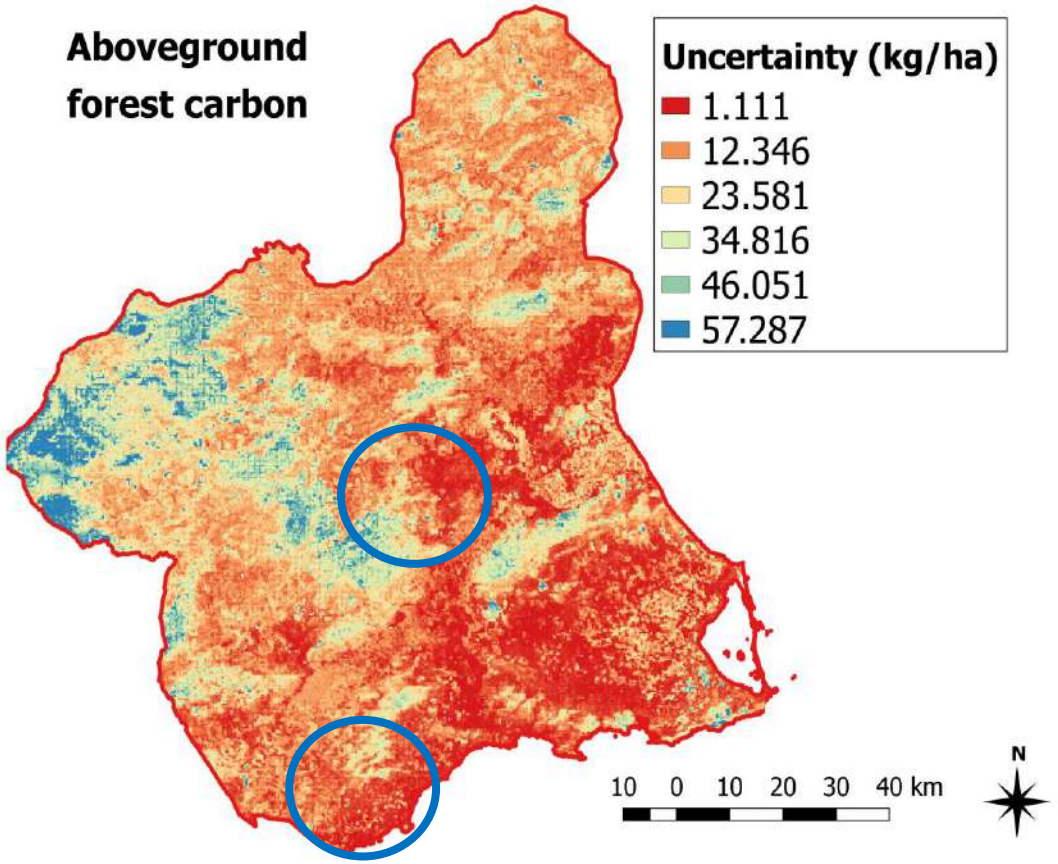
Associated uncertainty



Results

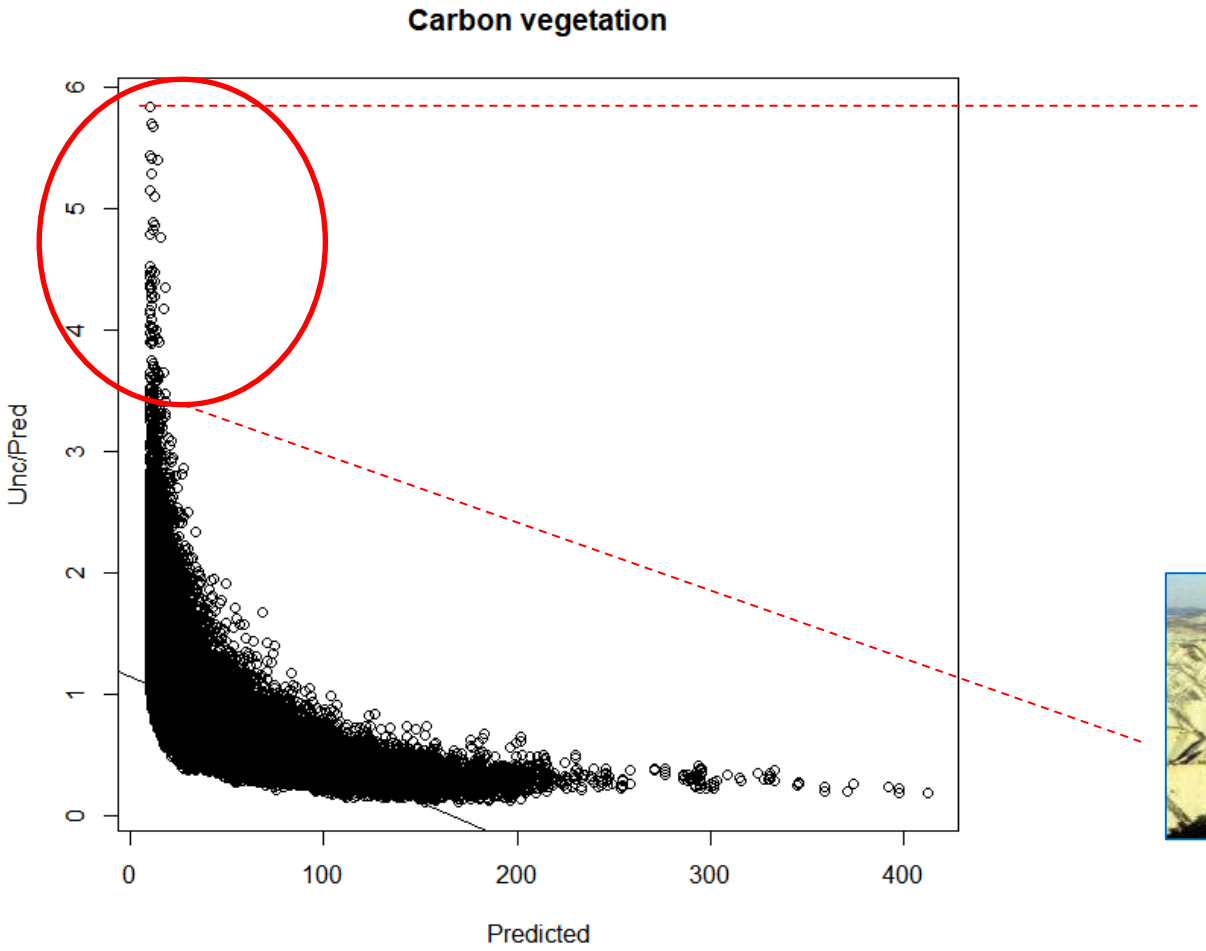
Spatial interpolation





Results

Associated uncertainty



Discussion and conclusions

Discussion and conclusions

- Close relationship between:

Aboveground forest carbon (LiDAR) ⟺ Vegetation characterization (Remote sensing)

Vegetation characterization (Remote sensing) → NDVI

(Mean seasonal profile in Mediterranean ecosystem: max in spring and autumn)

Vegetation characterization (Remote sensing) → LAI

(Thickness of the vegetation cover. Essential Climate Variable)

- Highest uncertainty associated with low predicted carbon values, it may be associated with the accuracy of the general allometric equation obtained from literature.
- Statistically-robust model; feasible and cost-effective approach for monitoring nationwide (moderate spatial resolution) and easily updated (high temporal availability)


Future step

Expectations

- Copernicus global products with high temporal and spatial resolution, applicable for global, national and regional scale for forest inventories, planning and management.

- According to our projects, implementation of products for quantification, assessment and monitoring at different scale approaches:
  - Afforestation /Deforestation
  - Fuel types
  - Burned areas
  - Changes detection in ecosystems

- Combination of different sensors:
  - Radar/optical
  - LiDAR/optical

Technology:
Field instrument

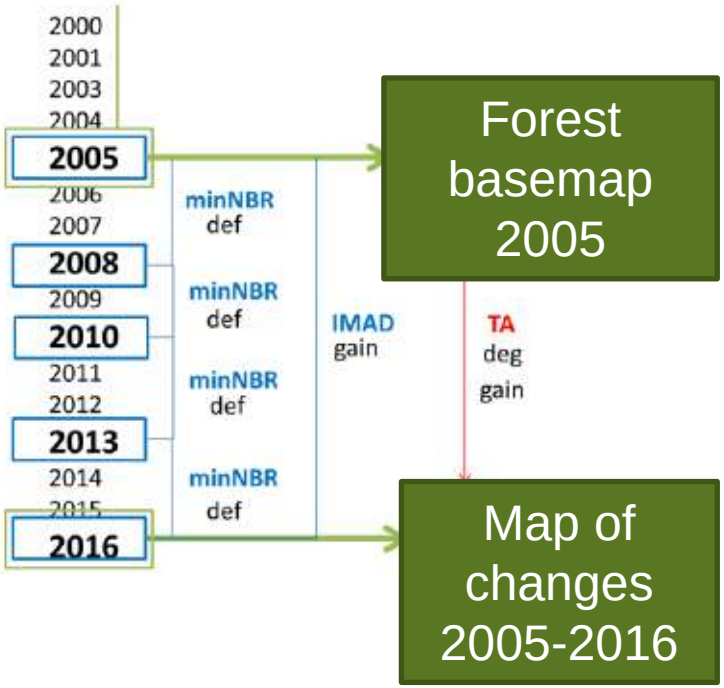
Applications

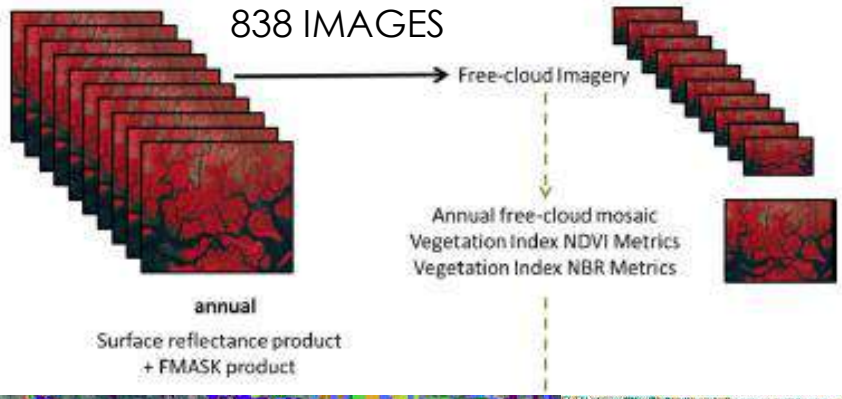
- ✓ Forest management:
  - Forest survey
  - Plots measurements
  - Timber volume assessment

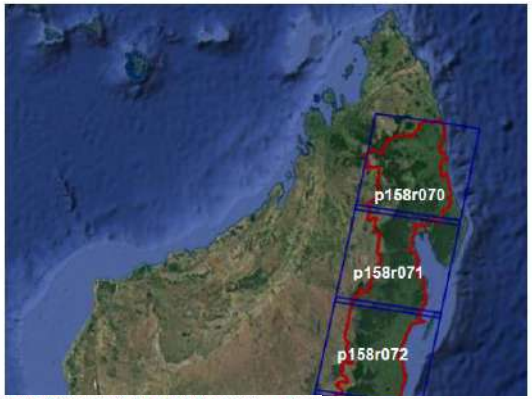
REDD+ PROGRAM: Madagascar

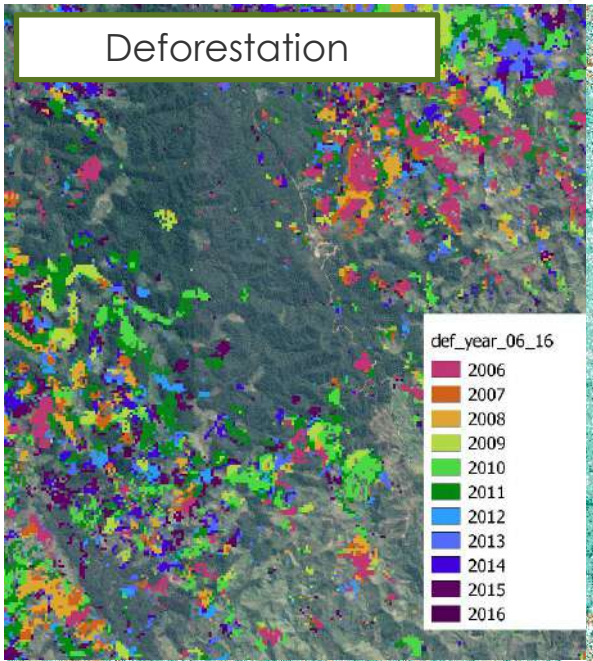
Carbon losses by **degradation and deforestation** vs.

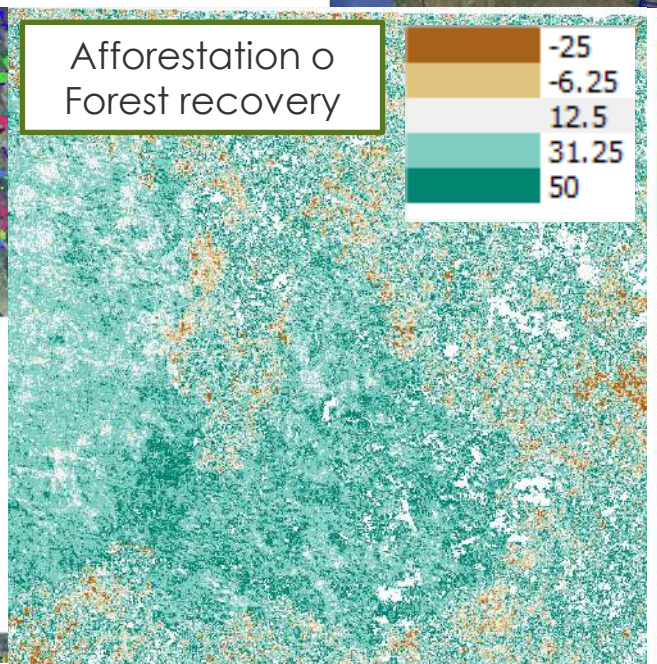
Carbon gains by **afforestation and forest recovery**

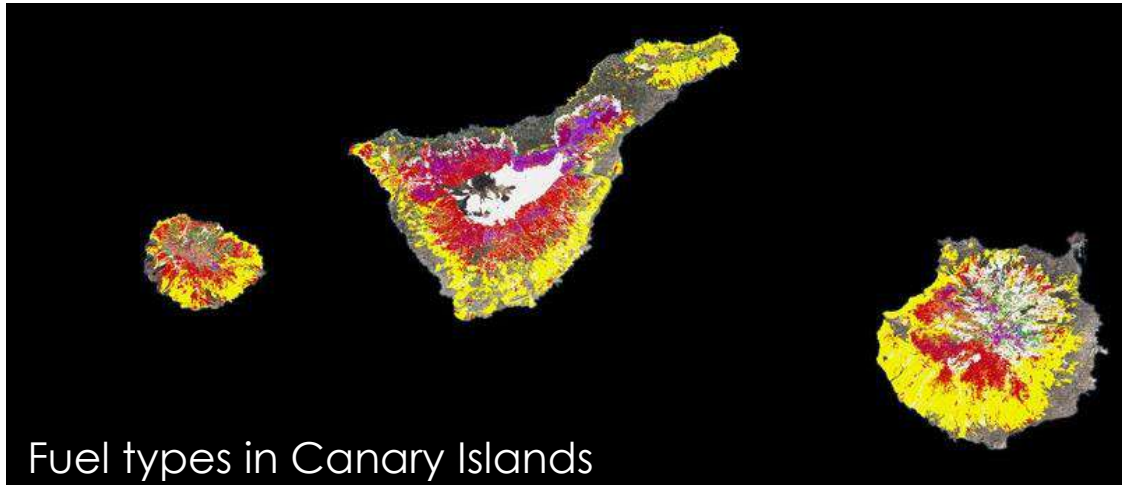












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Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Generation of high-resolution fuel model maps from discrete airborne laser scanner and Landsat-8 OLI: A low-cost and highly updated methodology for large areas

Eva Marino [a,*], Pedro Ranz [a], José Luis Tomé [a], Miguel Ángel Noriega [a], Jessica Esteban [a], Javier Madrigal [b,c]

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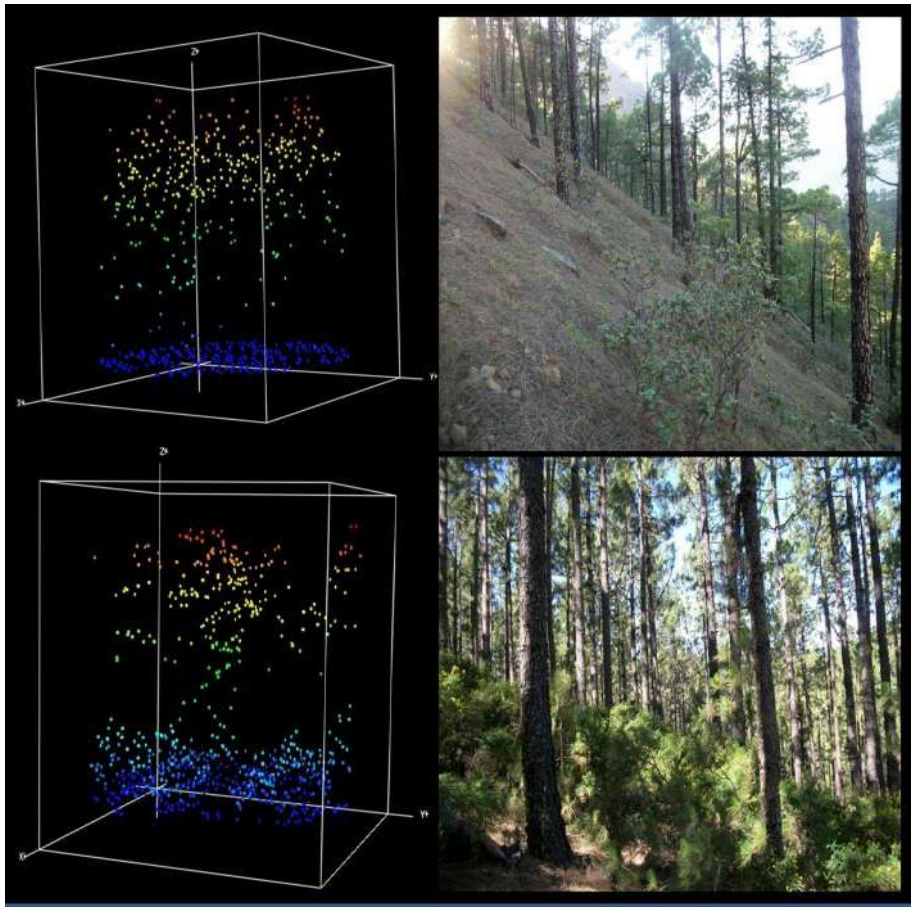
[b] INIA, Forest Research Centre, Department of Silviculture and Forest Management, Forest Fire Laboratory, Crta. A Coruña Km 7.5, 28040 Madrid, Spain
[c] Sustainable Forest Management Institute UVa-INIA, Crta. A Coruña Km 7.5, 28040 Madrid, Spain

FIRE FOREST

GEPRIF PROYECT (RTA-INIA)

«Integrated evaluation fire forest»



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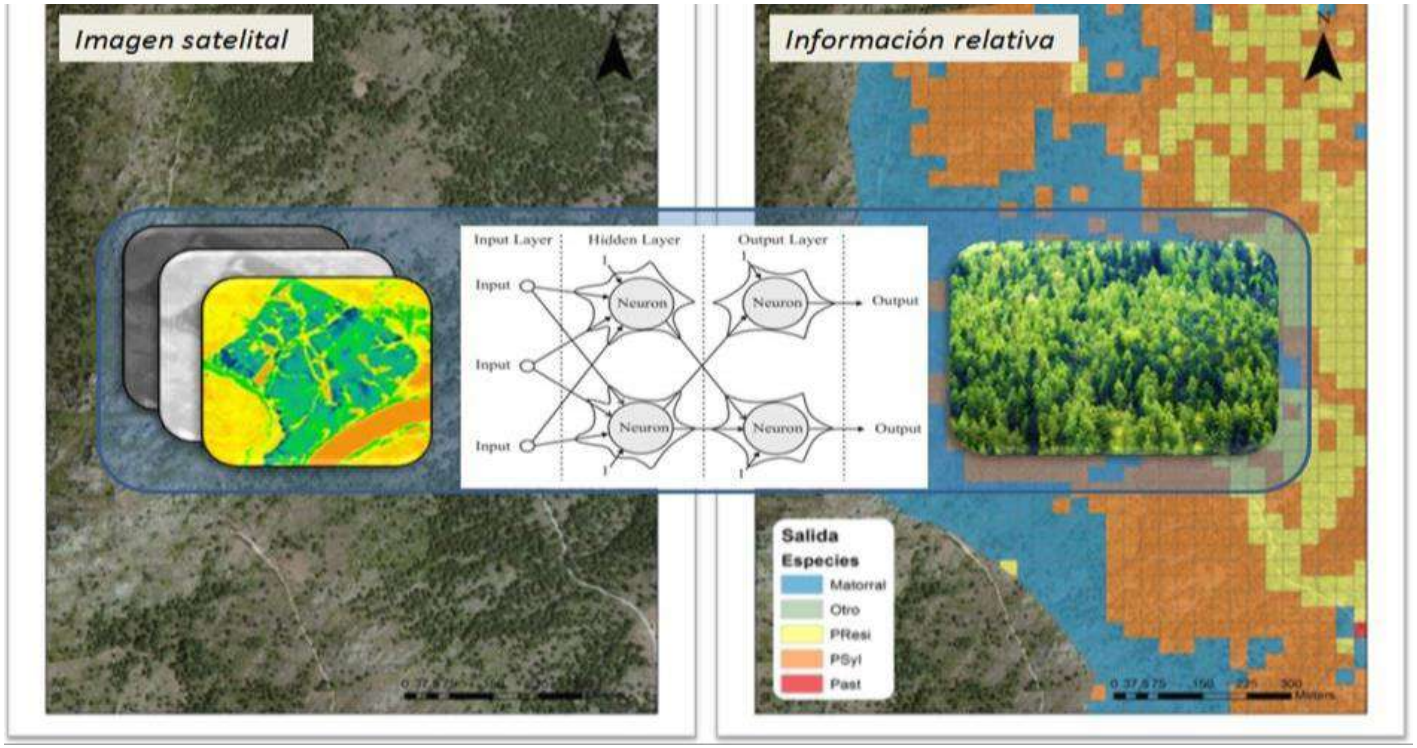
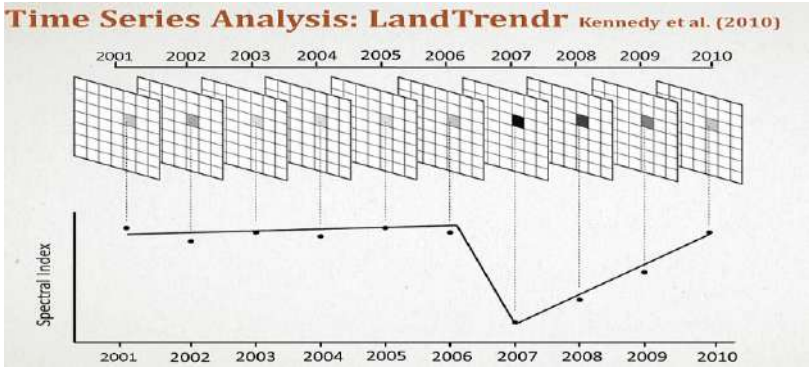
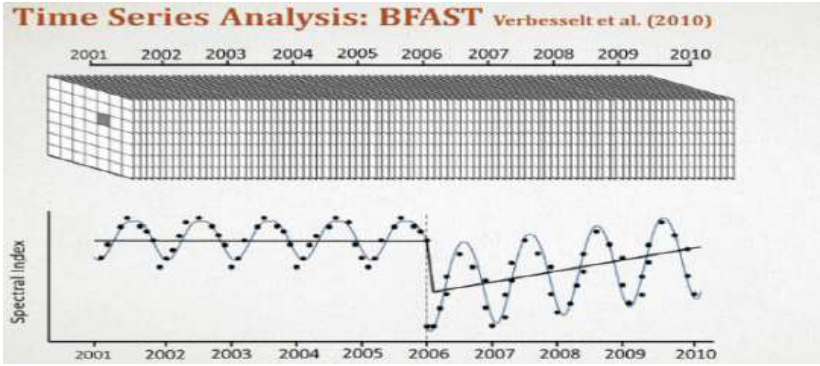
INIA Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

UNIVERSIDAD DE CÓRDOBA

Artificial neural networks (ANNs)







CARBON PROJECT

- Project: SUPPORT FOR THE JUSTIFICATION AND QUANTIFICATION OF GHG EMISSIONS FROM FOREST DEGRADATION AND GHG EMISSIONS FROM ENHANCEMENTS OF CARBON STOCKS OF A PROPOSED EMISSION REDUCTION PROGRAM IN MADAGASCAR
- Country: **Madagascar**
- January 2017 – in Process
- Partner: ONG FANC (Manondroala), Pôle Carto
- Client: Word Bank

Degraded mangroves

Collaborating centers networking

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Thank you very much for your attention

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