GEOSAT: Sub-metric EO Biomass Estimation Model

Carolina de Castro, Rafael Sousa, César Fernández, Maria Elena Calleja, Lucía García, Rubén Niño, Silvia Fraile | GEOSAT

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WHO WE ARE: GEOSAT

Owns & Operates **2** satellites

12+ years of experience

+ 6bn sqkm imagery archive

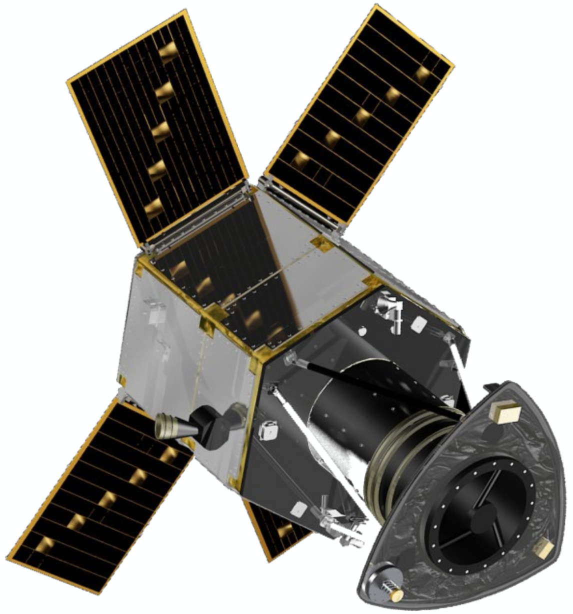
Global operations

Rapid tasking & delivery

Machine Learning and **Analytics**

European provider of **Very High-Resolution imagery (TPM)**

GEOSAT2 SATELLITE



12 km swath

2 days of revisit

5-bands
- ✓PAN
- ✓R, G, B
- ✓NIR

Optical / Agile Satellite

Very High Resolution

Copernicus data offer

Geosat-2	VHR1	VHR2
Band	**Pan, VNIR**	VNIR
Resolution	**0.75 m**	3 m
Pansharpened	**Yes**	/
Panchromatic	**Yes**	/
Multispectral	**Yes**	Yes
Bundle	**Yes**	Yes

BIOMASS AND CARBON PRODUCTS

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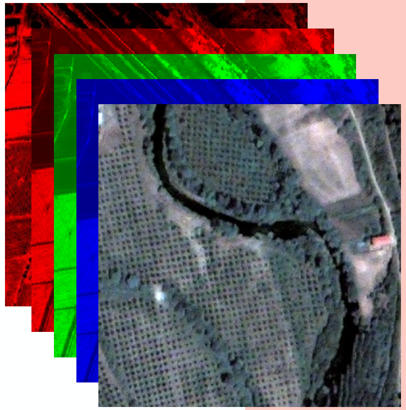
<u>European Green Deal</u> and the <u>Zero pollution Action Plan for 2050</u>
OBJ: Achieve climate neutrality.
MEDIA: satellite information is recognized as a crucial tool to measure, monitor and verify carbon storage.
HOW: Quantifying above-ground biomass and estimating carbon sequestration based on earth observation and in-situ field measurements.

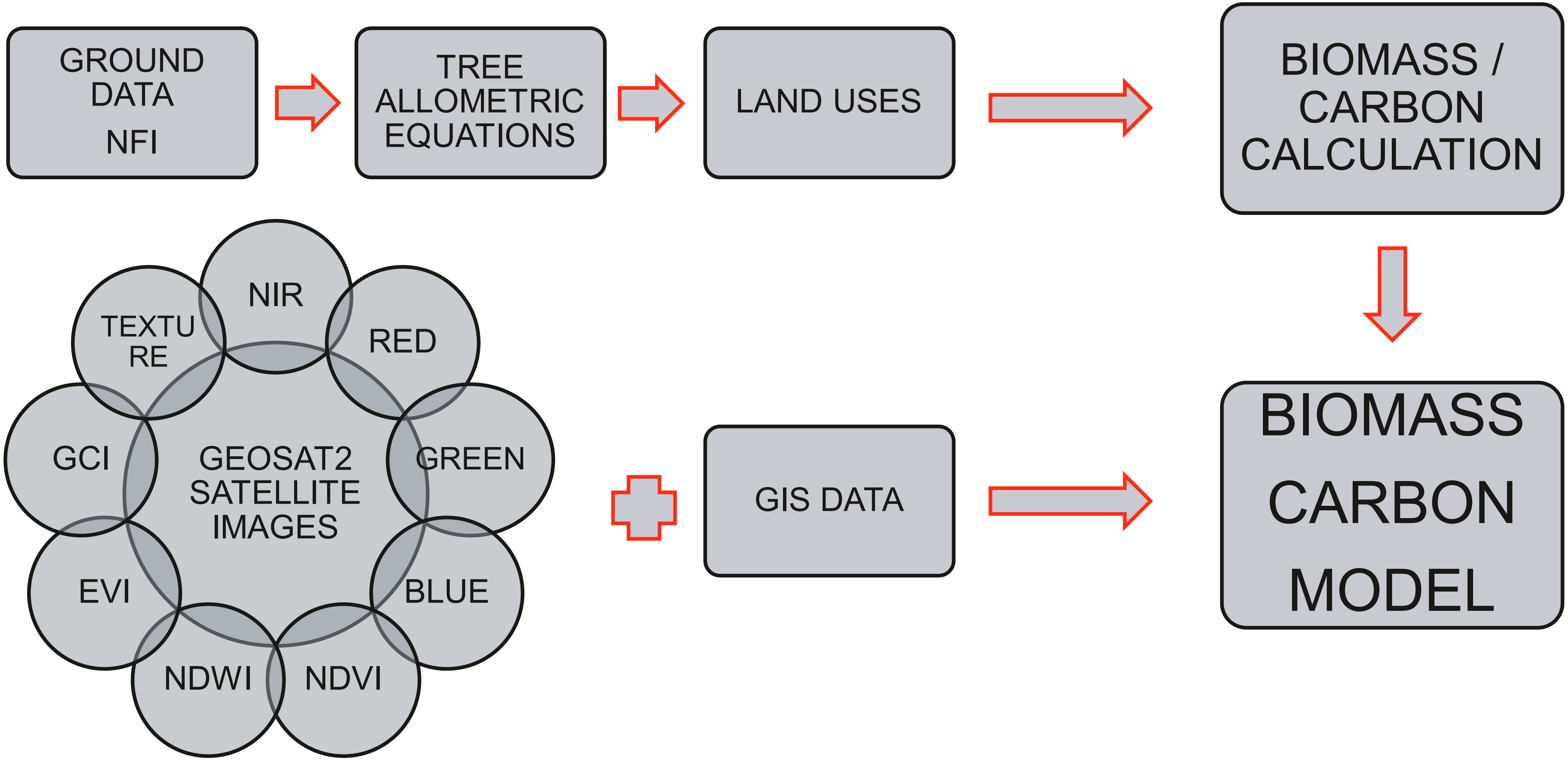


EO data
GEOSAT2

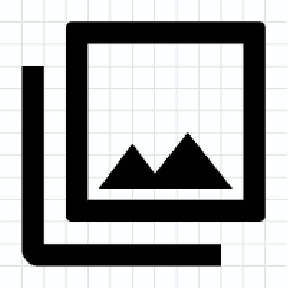
- Forest inventories: species georreferenced data
- Forest maps: land used, may be principal tree specie..
- Land use, land-use change and forestry (lulucf)

Biomass (tn/ha)
CO2 (tn/ha)

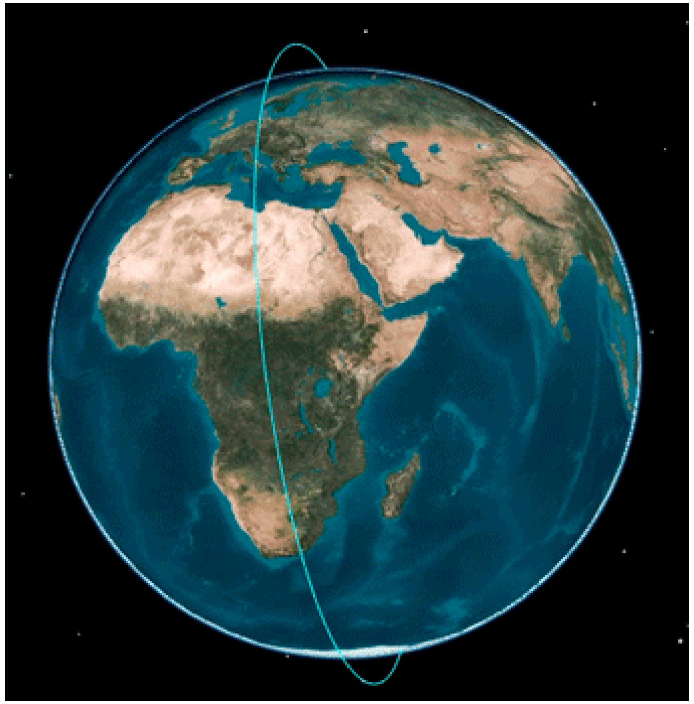
WORKFLOW


GROUND DATA
NFI
TREE ALLOMETRIC EQUATIONS
LAND USES
BIOMASS / CARBON CALCULATION
NIR
TEXTU RE
RED
GCI
GEOSAT2 SATELLITE IMAGES
GREEN
EVI
BLUE
NDWI
NDVI
GIS DATA
BIOMASS CARBON MODEL

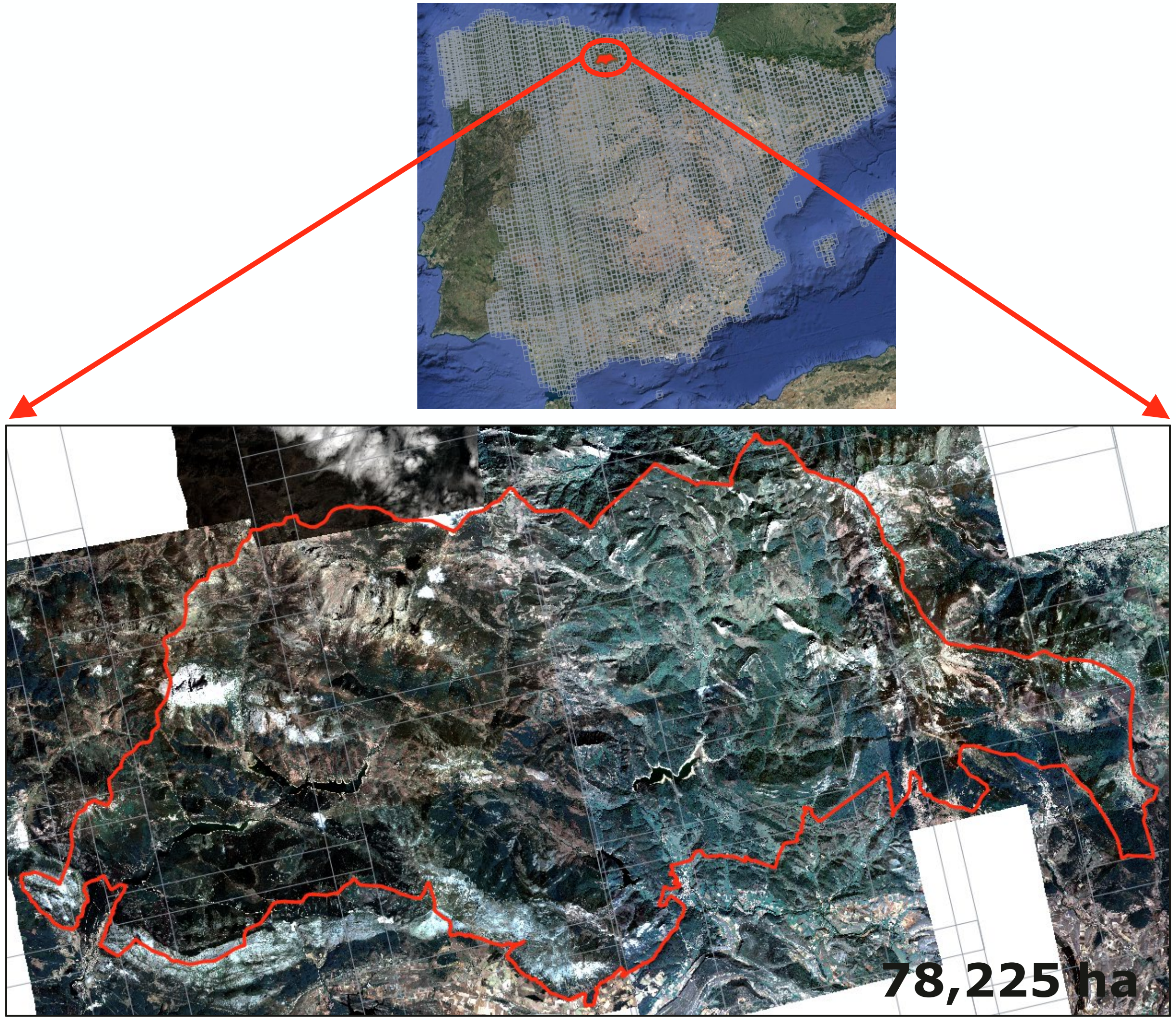
GEOSAT2 SATELLITE IMAGES: COVERAGE OF SPAIN



+ 3 years acquiring
+ 7,000 images / year
+ 500,000 km2 / year



AOI: Atlantic Forest



BIOMASS / CARBON CALCULATION

AOI GROUND DATA: NFI

Province	Plot	CoorX	CoorY
34	95	359892	4746794
34	95	359892	4746794
34	95	359892	4746794
34	95	359892	4746794

IFN DB

ALLOMETRIC EQUATIONS

```
    elif species == 'Pinus nigra':
        return ((0.0403*(d**1.838)*(ht**0.945))+(0.228*(d-32.5)**2)+(0.0521*
(d**2))+
                (0.0720*(d**2))+(0.0189*(d**2.445)))
    elif species == 'Pinus pinaster':
        return ((0.0278*(d**2.115)*(ht**0.618))+(0.000381*(d**3.141))+(0.0129*
(d**2.320))+(0.00444*(d**2.804)))
    elif species == 'Pinus pinea':
        return ((0.0224 * (d** 1.923) * (ht ** 1.0193)) + (0.247 * (d - 22.5)
** 2) +
                (0.0525 * d ** 2) + (21.927 + (0.0707 * d) - 2.827 * ht) +
(0.117 * d** 2))
    elif species == 'Pinus radiata':
        return exp(4.623+2.002*log10(d))*1.04*10**(-3)
    elif species == 'Pinus sylvestris':
        return  ((0.0154 * (d ** 2) * ht) + (0.540 * (d- 37.5) ** 2 - 0.0119 *
(d - 37.5) ** 2 * ht) +
                 (0.0295 * (d ** 2.742) * (ht ** -0.899)) + (0.530 * (d **
2.199) * (ht ** -1.153)) + (0.130 * d ** 2))
    elif species == 'Pinus uncinata':
        return  ((0.0203 * d ** 2 * ht) + (0.0379 * d ** 2) + ((2.740 * d) -
(2.641 * ht) + (0.193 * d ** 2)))
    elif species == 'Populus alba':
        return  ((0.0130 * d ** 2 * ht) + (0.538 * (d - 22.5) ** 2 - 0.0130 *
(d - 22.5) ** 2 * ht) +
                                (0.0385 * d ** 2) + (0.0774 * d ** 2 -
0.00198 * d ** 2 * ht) + (0.122 * d ** 2))
    elif species == 'Populus nigra':
        return  ((0.0130 * d ** 2 * ht) + (0.538 * (d - 22.5) ** 2 - 0.0130 *
(d - 22.5) ** 2 * ht) + (0.0385 * d ** 2) +
                 (0.0774 * d ** 2 - 0.00198 * d ** 2 * ht) + (0.122 * d ** 2))
    elif species == 'Populus tremula':
        return  ((0.0130 * d ** 2 * ht) + (0.538 * (d - 22.5) ** 2 - 0.0130 *
(d - 22.5) ** 2 * ht) +
                 (0.0385 * d ** 2) + (0.0774 * d ** 2 - 0.00198 * d ** 2 * ht)
+ (0.122 * d ** 2))
    elif species == 'Populus x canadensis': return ((0.0130 * d ** 2 * ht) +
(0.538 * (d - 22.5) ** 2 - 0.0130 * (d - 22.5) ** 2 * ht) +
                                (0.0385 * d ** 2) + (0.0774 * d ** 2 -
0.00198 * d ** 2 * ht) + (0.122 * d ** 2))
    elif species == 'Prunus avium': return  (-1.86827 + 0.21461*d**2 +
0.01283*d**2*(ht) + 0.0138*(ht)**2*d-0.06311*(ht)**2)
```

LAND USES

LULUCF: 111, 121 & 131

PREDICTORS: GEOSAT2 SATELLITE IMAGES + GIS DATA

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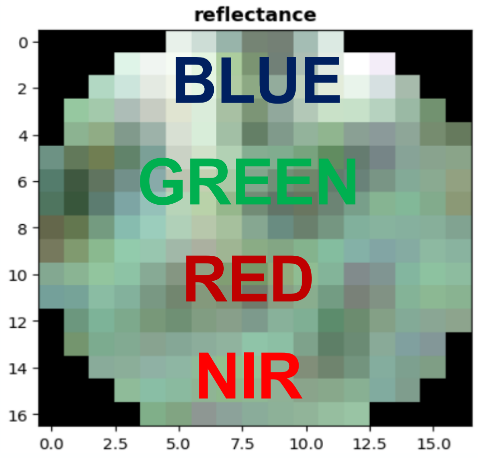
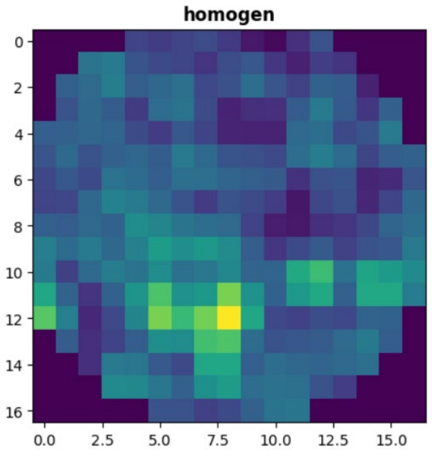
D2-PSH-L1C RADIANCES

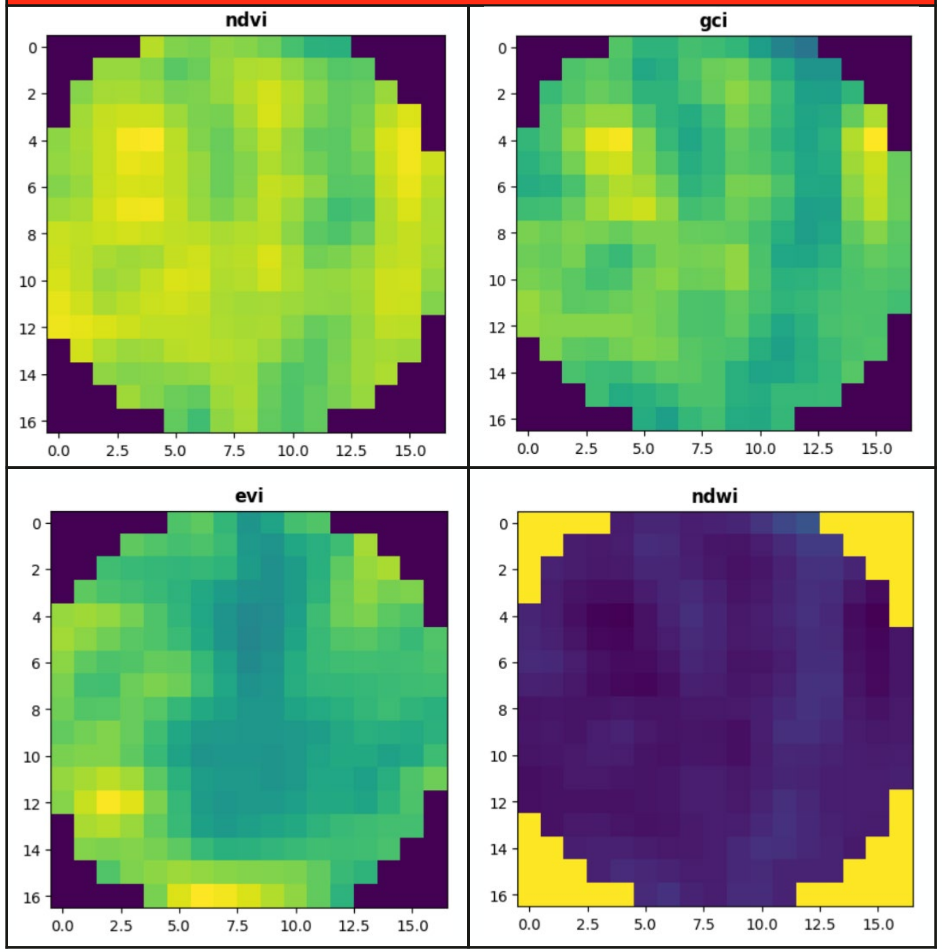
REFLECTANCES TOA

REFLECTANCES BOA





Vegetation INDEXES



GIS DATA

ORIENTATION
All winds
292.5 - 67.5
67.5 - 112.5
112.5 - 247.5
247.5 - 292.5

ALTITUD (m)
1.001 – 1.200
1.201 – 1.400
1.401 – 1.600
…….
2.801 – 3.000
> 3.001

BIOMASS / CARBON MODEL

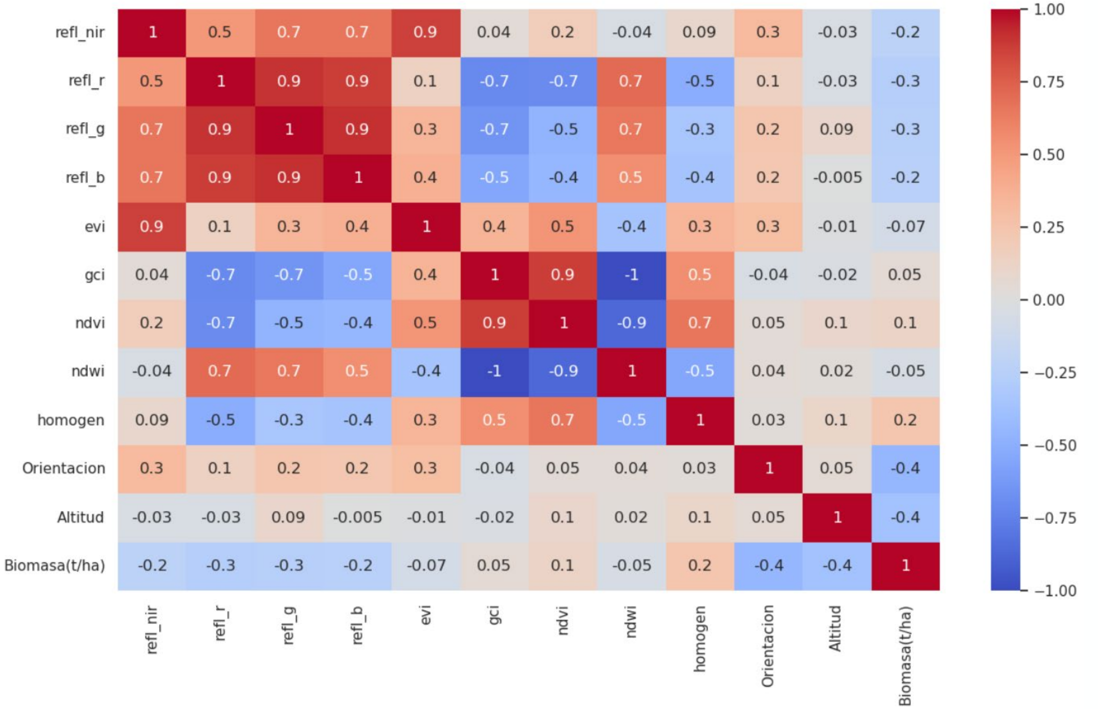
Model data

- **11 Variables X**
- **1 Variable Y– biomass (tn/ha)**
- **29 NFI Plots**

refl_nir	refl_r	refl_g	refl_b	evi	gci	ndvi	ndwi	homogen	Orientacion	Altitud	Biomasa(t/ha)
1966.0	284	279.0	134.0	0.830025	6.061885	0.747848	-0.751919	0.464093	2.0	6.0	219.670731
1433.0	194	194.0	51.0	0.634302	6.406426	0.762296	-0.762087	0.186378	4.0	7.0	28.680761
2471.0	306	312.0	146.0	1.024532	6.927735	0.780183	-0.775979	0.791667	2.0	8.0	89.657173
2446.0	389	385.0	208.0	0.971845	5.362102	0.725534	-0.728338	0.183491	2.0	7.0	136.501984

Feature selection

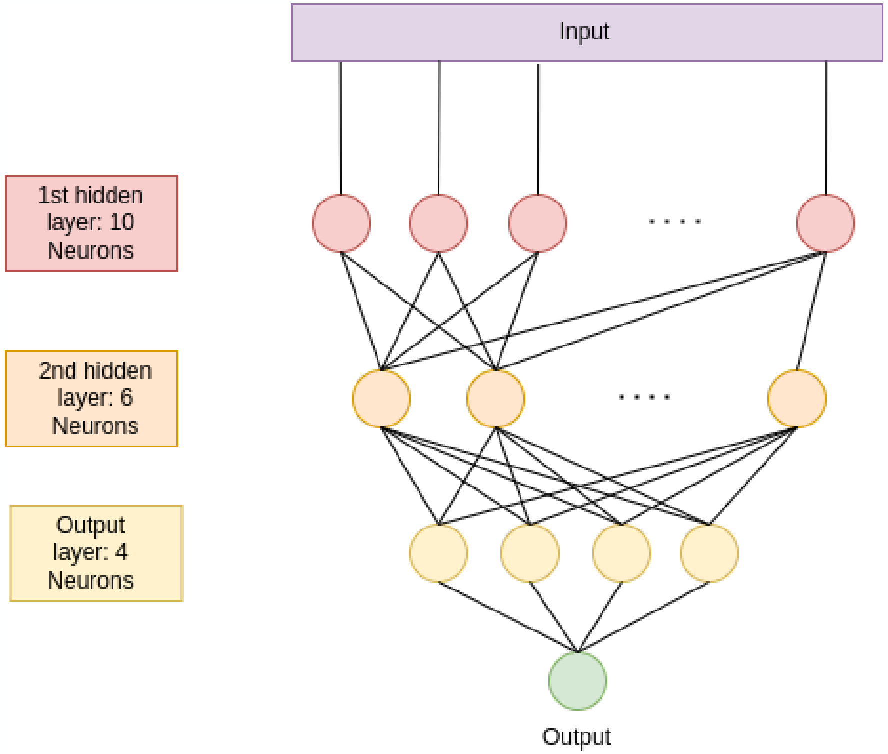
- Correlation matrix
- Sequential Backward Selection
- Sequential Forward Selection



Implemented regression models/algorithms

- LINEAR REGRESSION
- POLYNOMIAL REGRESSION
- MULTI-LAYER PERCEPTRON (MLP)
- RANDOM FOREST REGRESSOR
- XGBOOST

	MLP
RMSE	21.1628
MAE	11.1083



BIOMASS / CARBON MODEL

Expected errors and improvements

Expected Errors	Improvements
Model Overfit in small areas	Feed the model with “Atlantic Forest” data outside the AoI to increase variability
Non Forest tree biomass pixels in “Plot” areas	OBIA (Object Based Image Analisys)

Considerations

- It is not a Global Model
- Images used have different date and adquisition angle

Next Steps

- Evatuating Stratified to generalize, try Convolutional Neural Networks

PRODUCT RESULTS / MARKETS

GEOSAT Carbon Product not only monitor Forest and Vegetation, recognizing Forest Changes or Forest Health but also quantify the amount of carbon stored in forests.

GEOSAT Carbon Product has a 0.75 m resolution:

- suitable for private companies and local / regional governments, or more global areas with low data frequency.
- crucial for carbon offset projects.

GEOSAT Carbon Product can be visualized and better understood in platforms, to be designed ad-hoc.

LIMITS AND MARKET USES

Once GEOSAT has GEOSAT Carbon Product Generated….
WHAT?

- How are Carbon Products going to be validated?
- How is going to be the reliability of the data verified?
- How the participation in carbon markets is going to be facilitated?

Needs of uniform standards and clear international rules for the accounting and verification of carbon sinks.

THANK YOU!

carolina.decastro@geosat.space