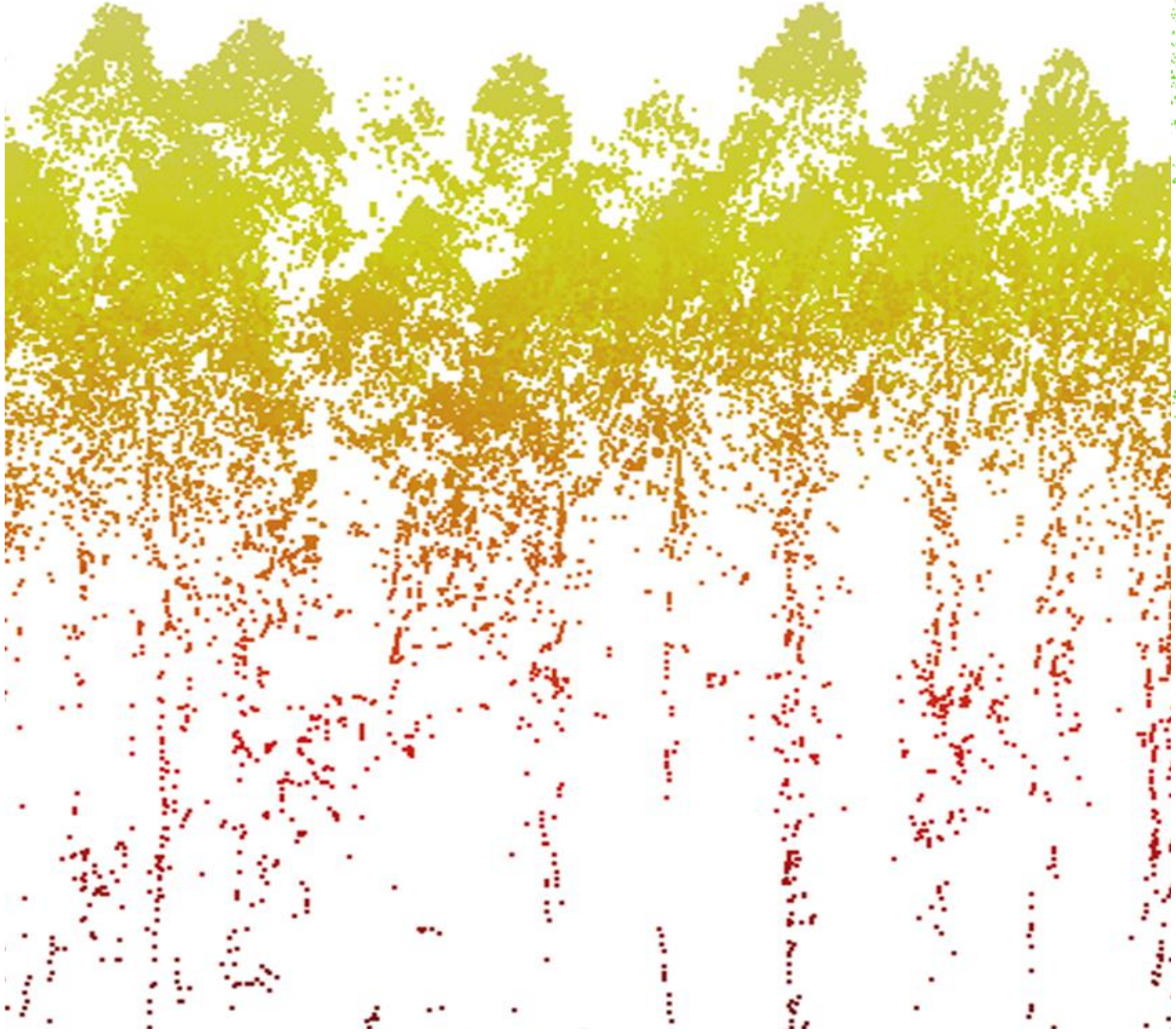
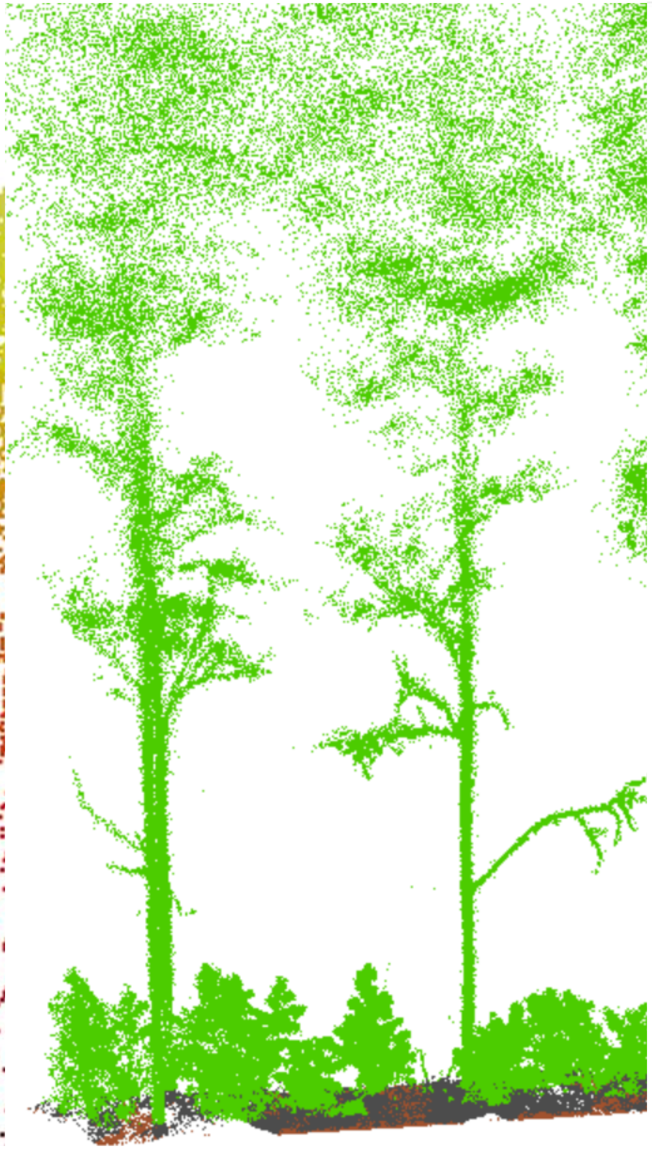
LiDAR – Aplicações Florestais





LiDAR – Aplicações Florestais

Sumário

1. O que é LiDAR? Para que server?

2. Benefícios da tecnologia LiDAR para o manejo de recursos florestais
   Inventário Florestal com LiDAR
      estado da arte com dados ALS (airborne laser scanning)
   Mensuração Florestal com LiDAR
      escaneamentos TLS / MLS (terrestrial / mobile laser scanning)

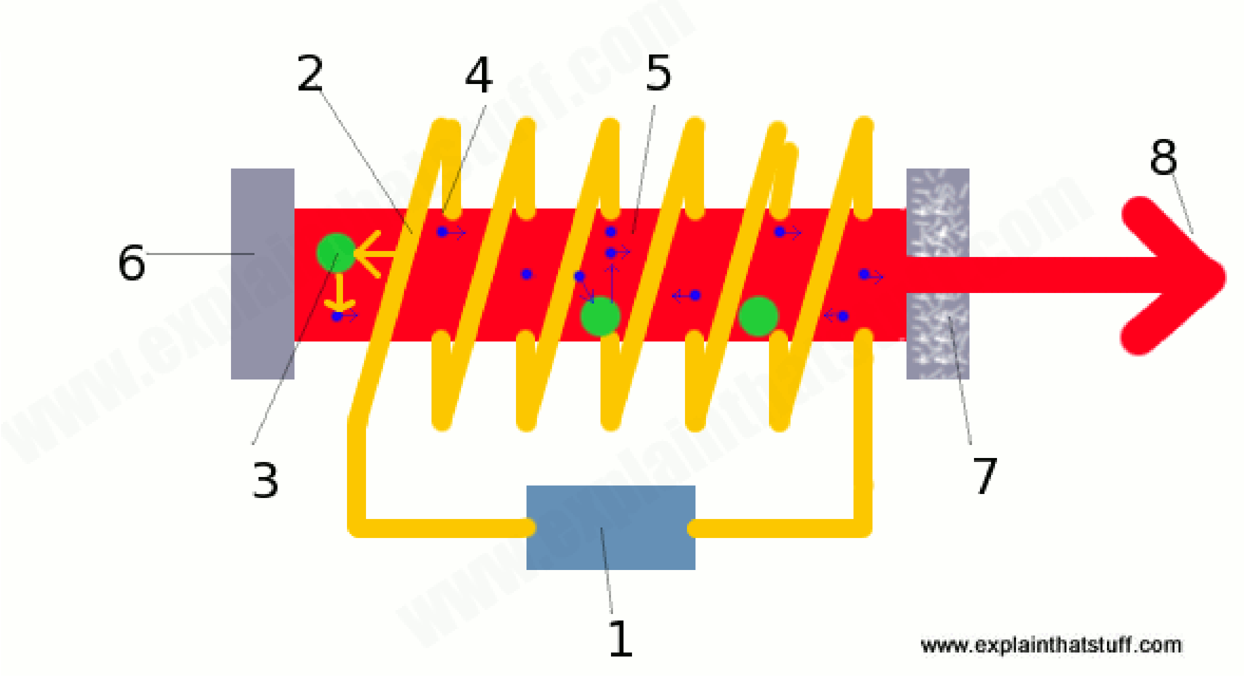
3. Avanços nas aplicações florestais
   mochila LiDAR para mensuração florestal
   quadrilaser um protótipo móvel de mensuração LiDAR
   LiDAR para monitoramento da restauração de áreas degradadas
   LiDAR + sensores multiespectrais + Inteligência Artificial

LiDAR – o que é?

Antes precisamos lembrar o que é laser:

(light amplification by stimulated emission of radiation)

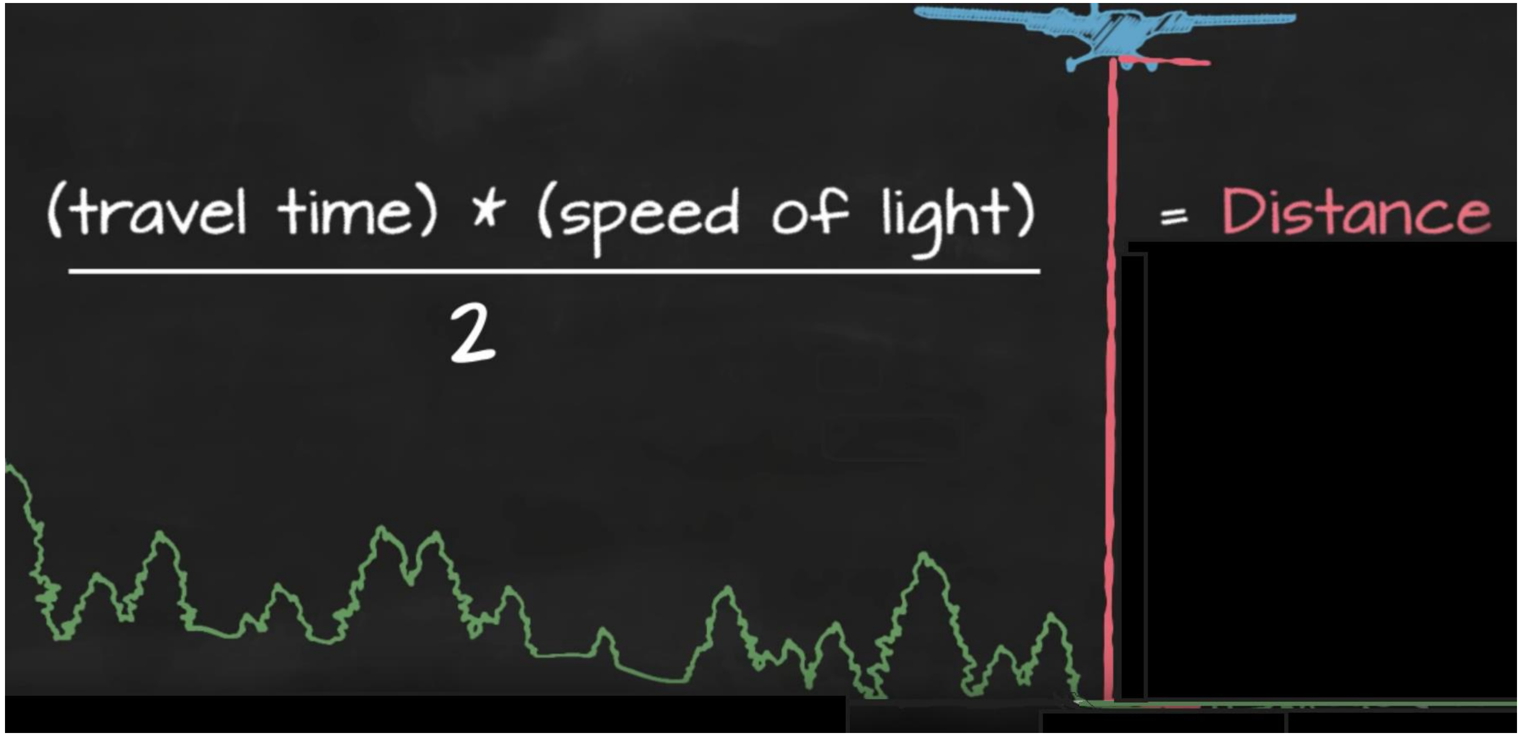
1. Alta tensão faz tubo fosforescente piscar.



LiDAR – o que é?

LiDAR – Light Detection And Ranging

Tecnologia que possibilita o cálculo de distâncias baseado na cronometragem do tempo de viagem dos fótons de luz emitidos por um **laser**

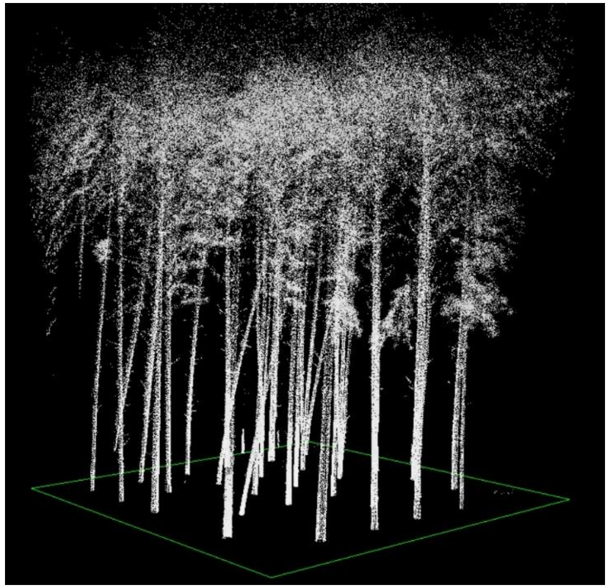


Levantamentos LiDAR segundo a plataforma de acoplamento

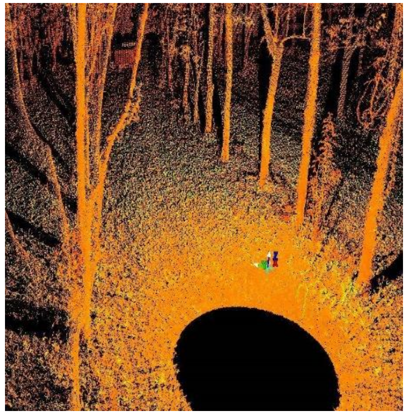
TLS *(aerrestrial laser scanning)*

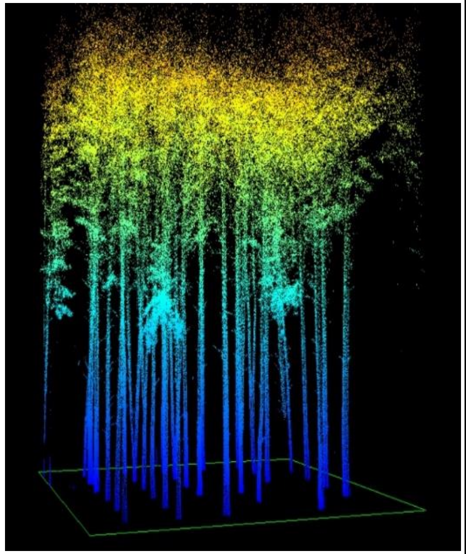
escaneamento terrestre

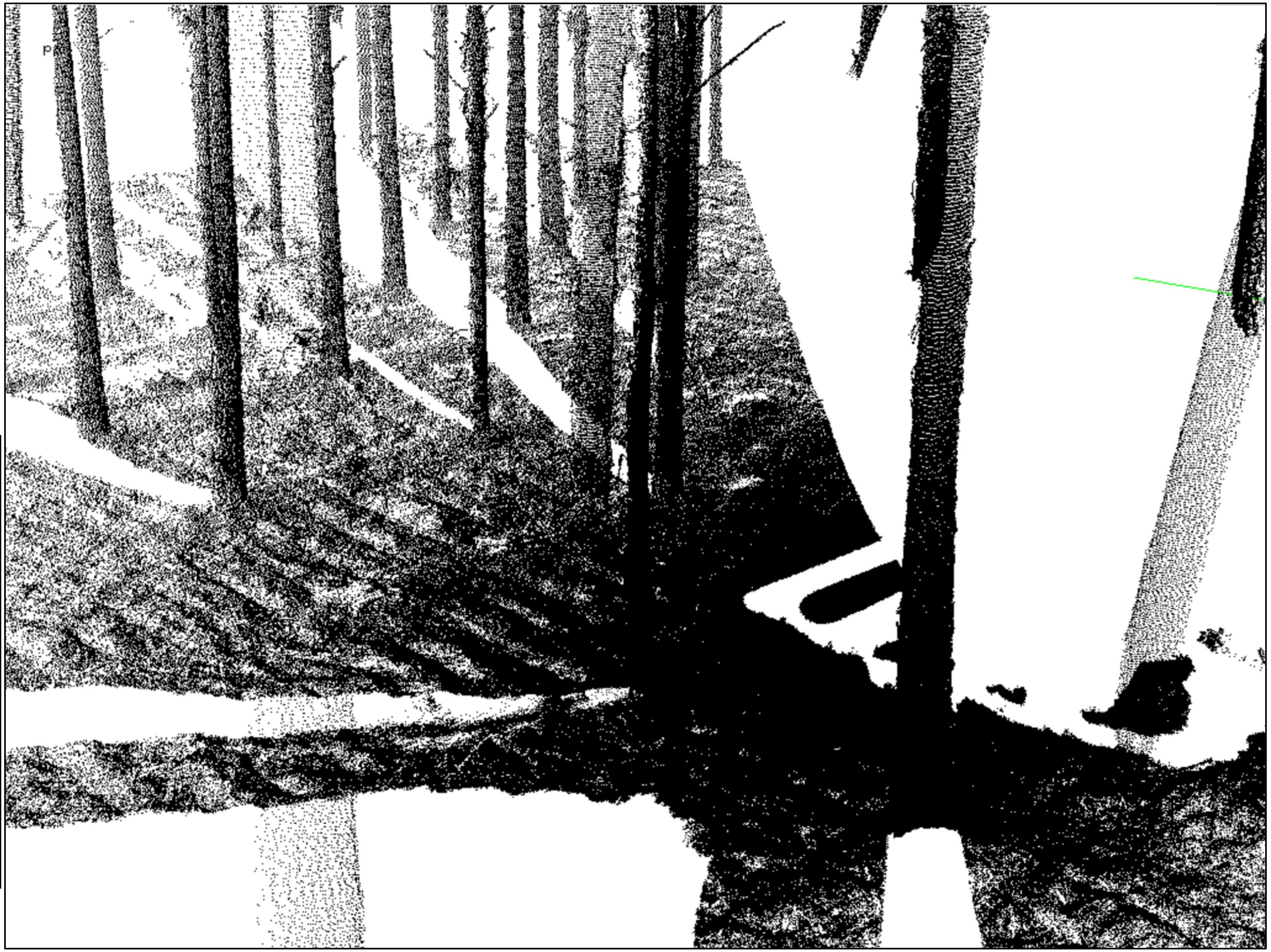
posicionamento fixo



LiDAR – o que é?







LiDAR – o que é?

Levantamentos LiDAR segundo a plataforma de acoplamento

TLS *(aerrestrial laser scanning)*

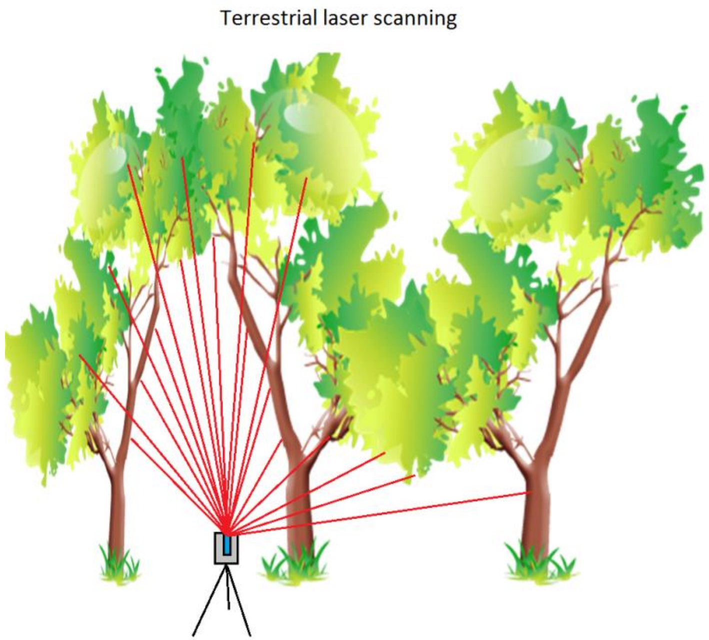
escaneamento terrestre

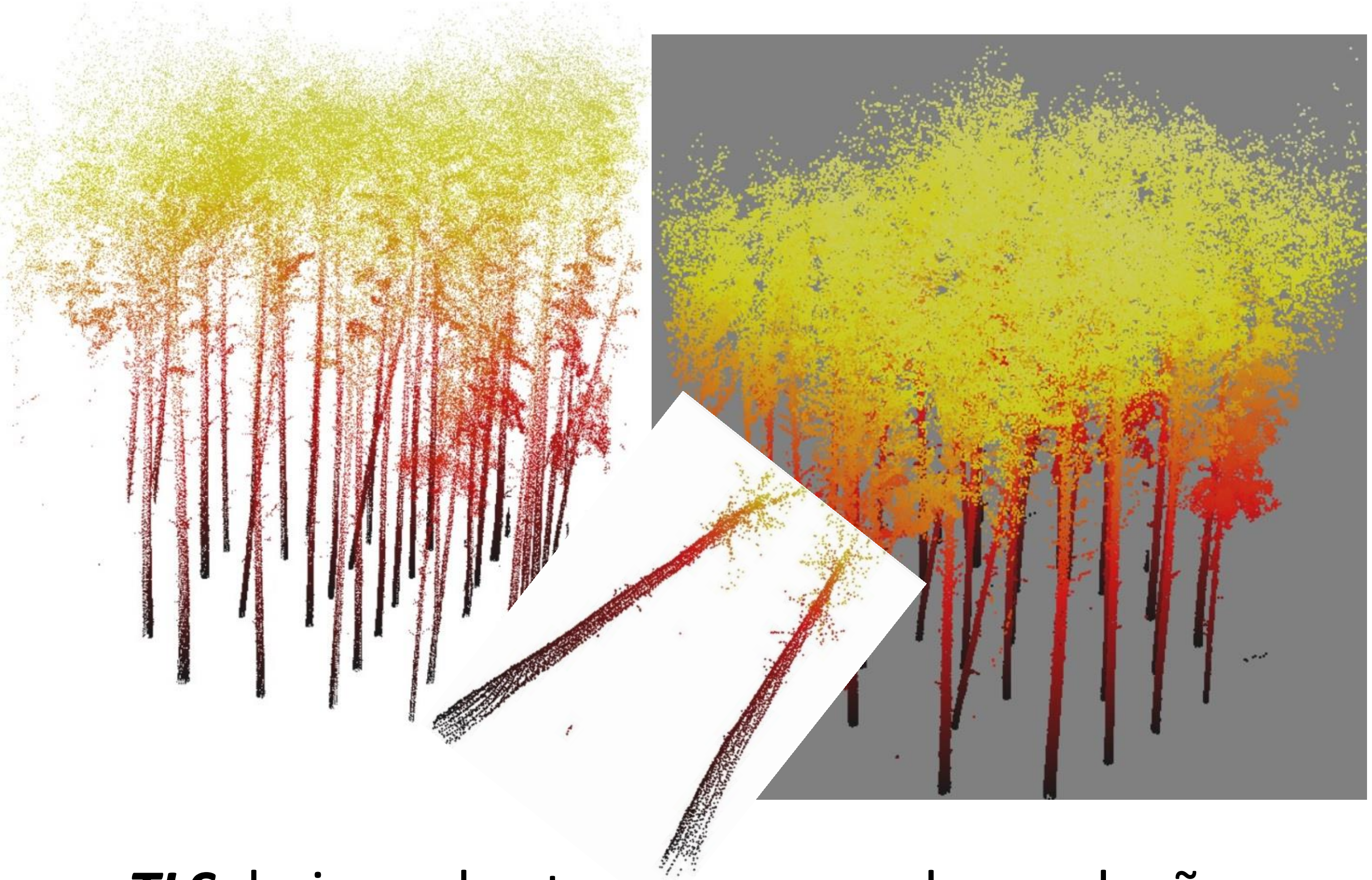
móvel

Levantamentos LiDAR segundo a plataforma de acoplamento

TLS *(aerrestrial laser scanning)*
escaneamento terrestre

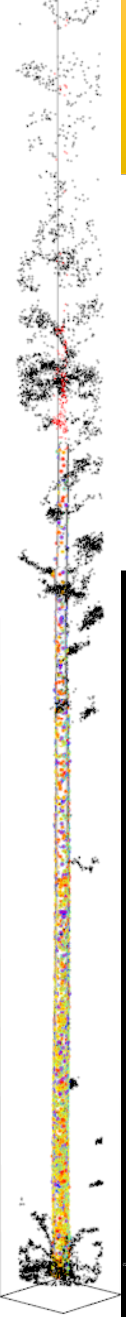
móvel

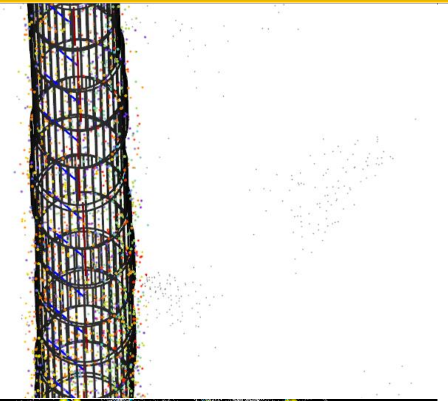


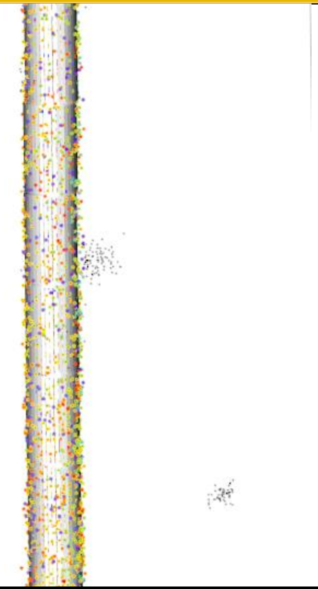


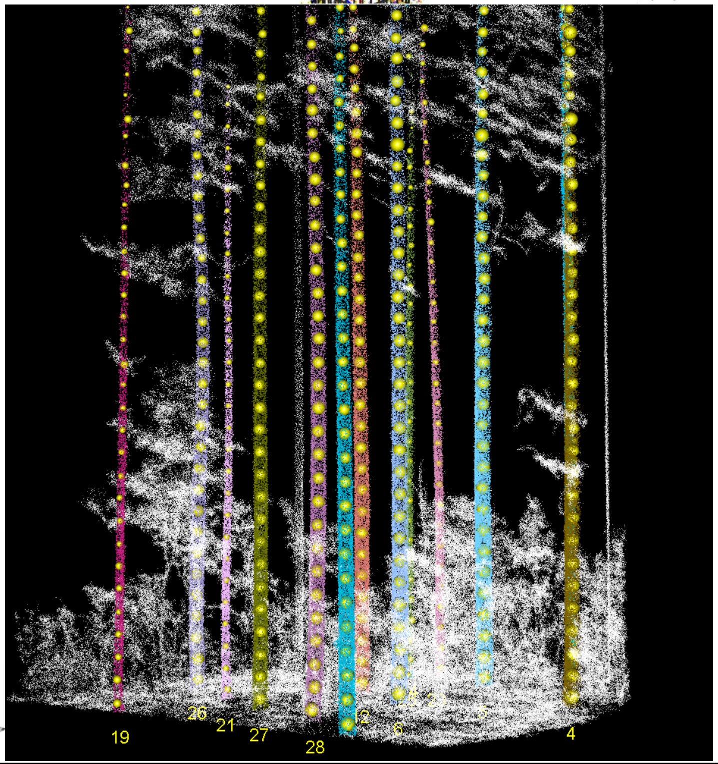
TLS: baixa cobertura com grande resolução

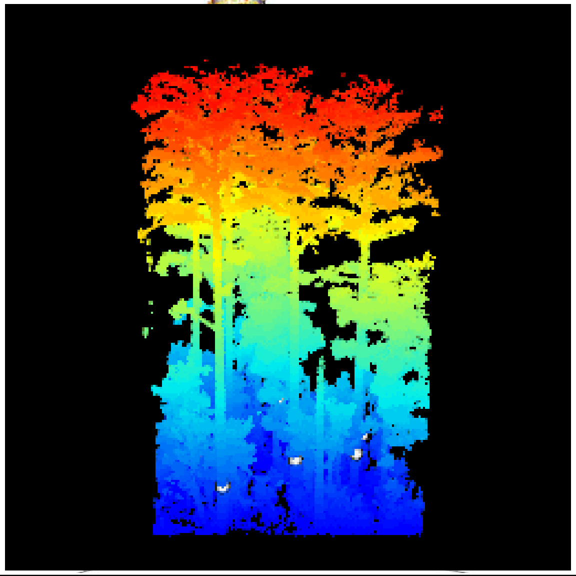
LiDAR – o que é?

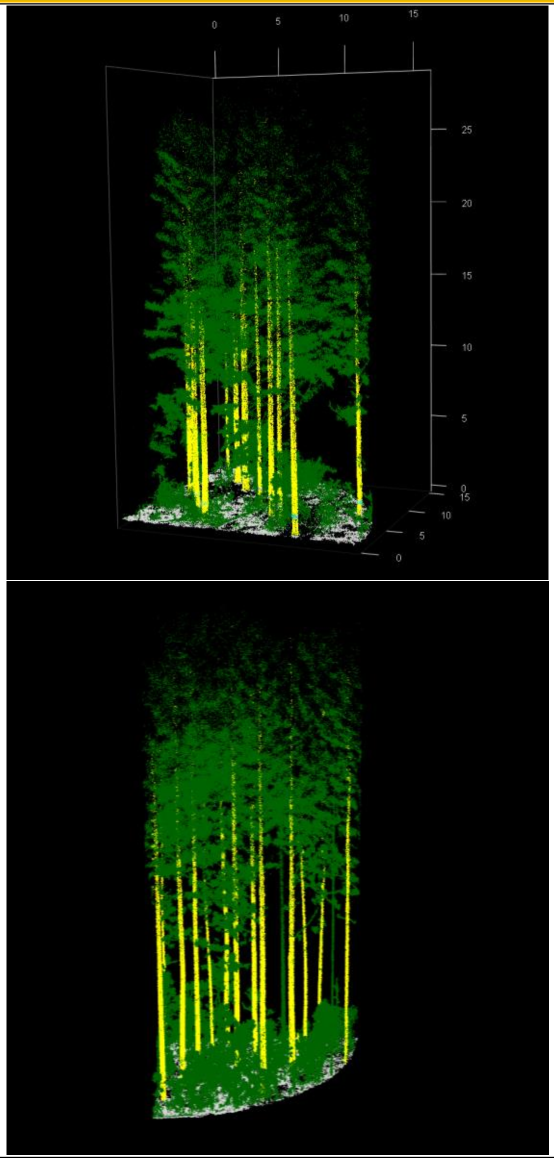


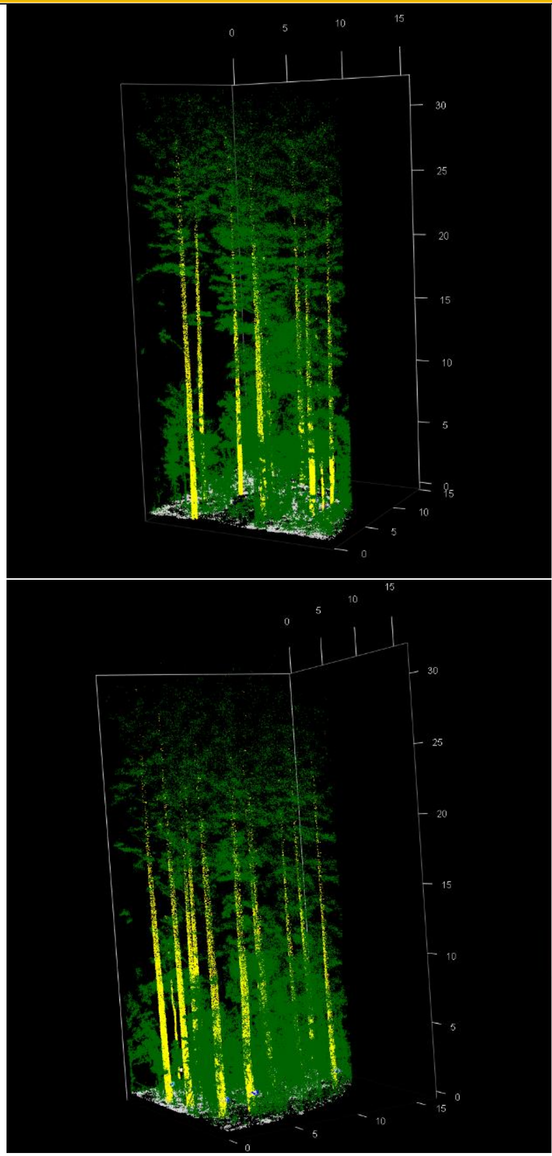












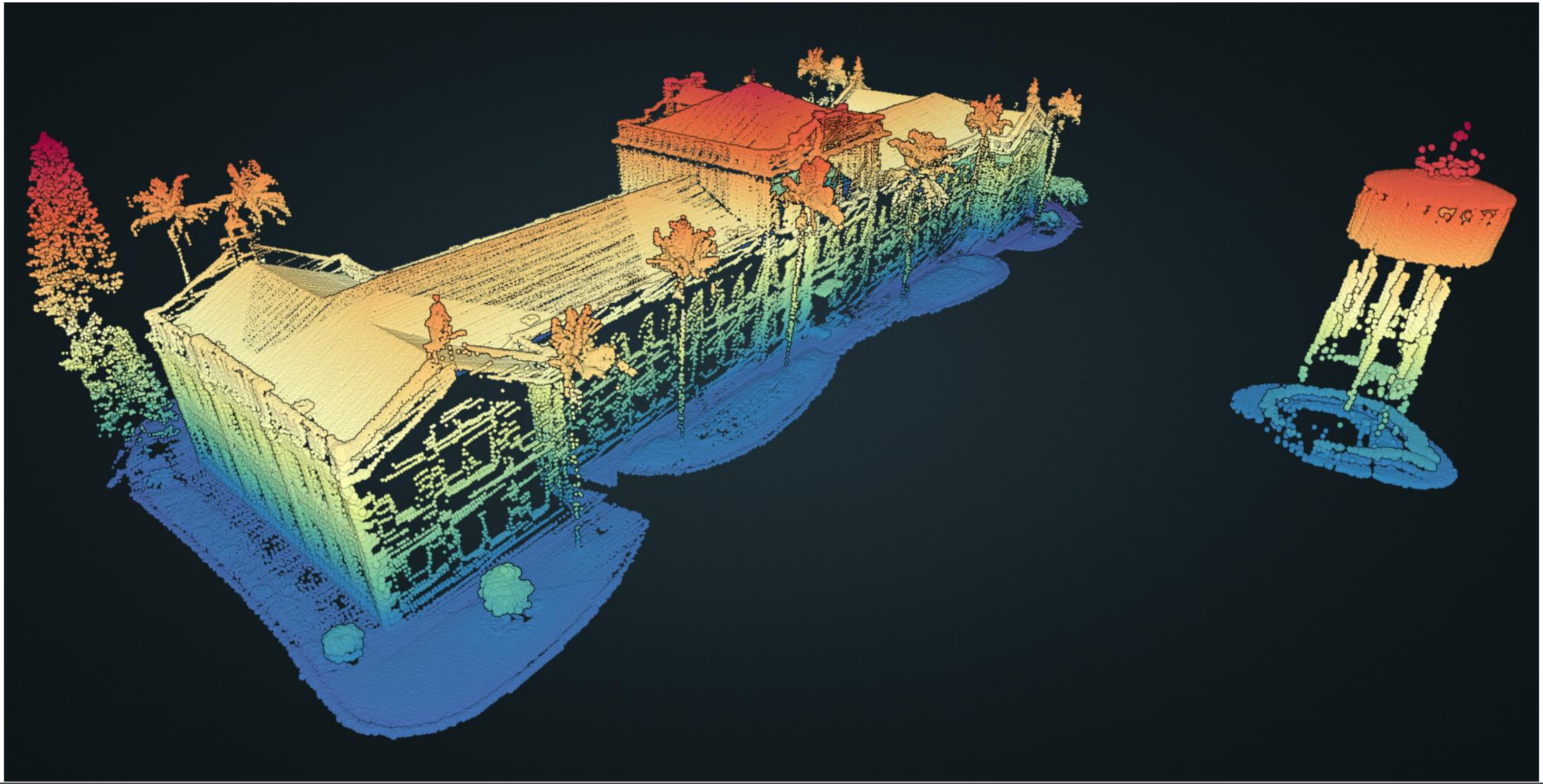
Levantamentos LiDAR segundo a plataforma de acoplamento

ALS *(airborne laser scanning)*

escaneamento aeroembarcado

não tripulado

Levantamentos LiDAR segundo a plataforma de acoplamento

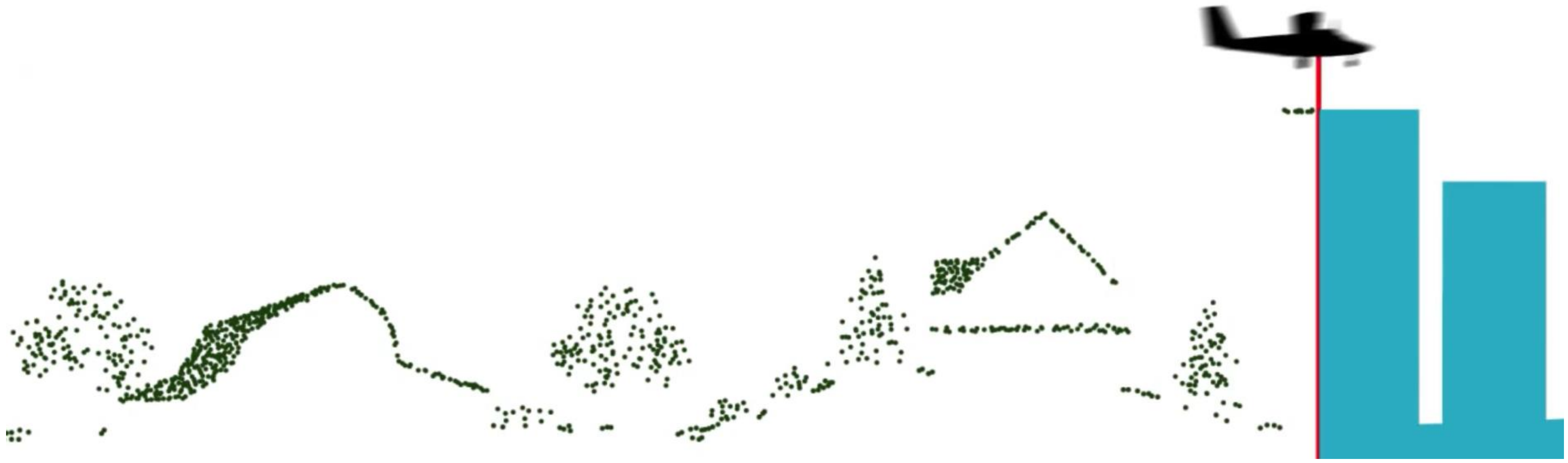


Levantamentos LiDAR segundo a plataforma de acoplamento

ALS (*airborne laser scanning*)

escaneamento aeroembarcado

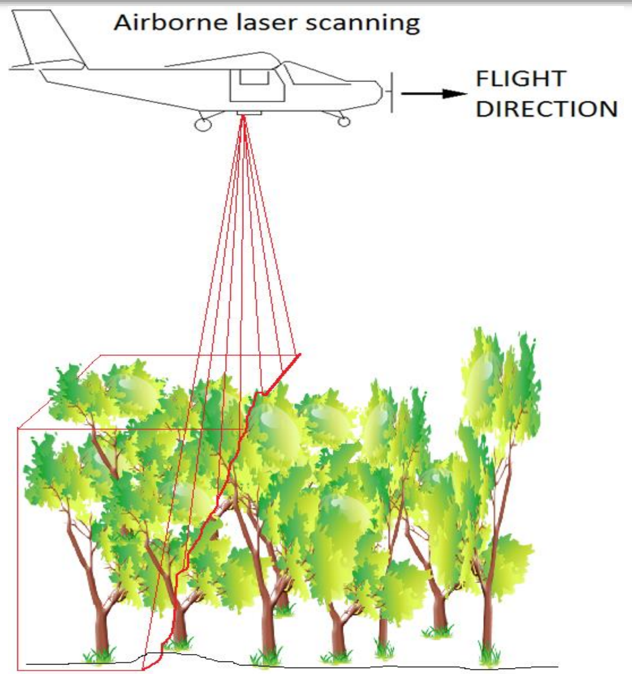
tripulado

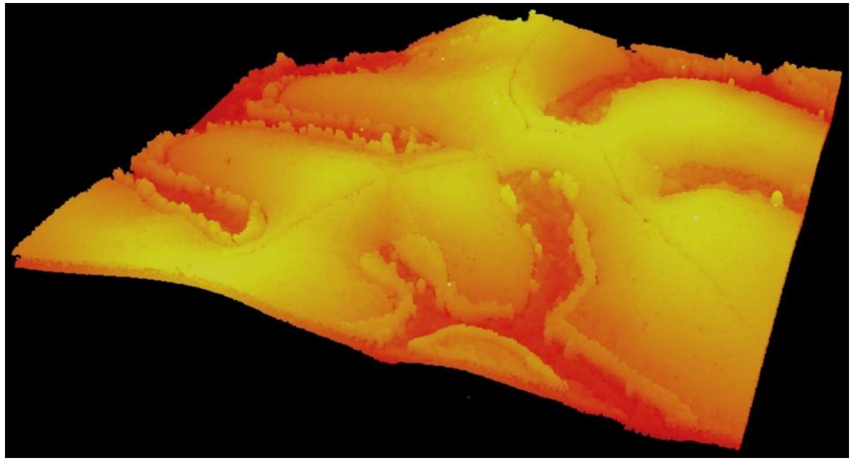


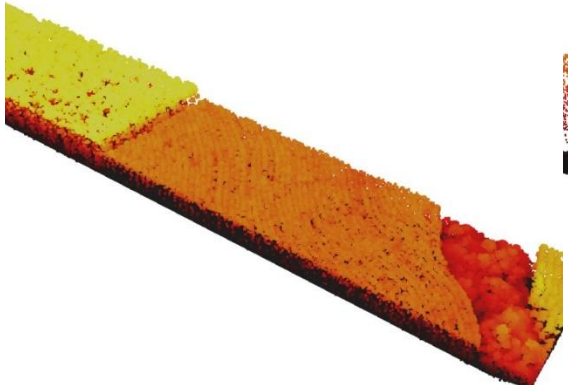
Levantamentos LiDAR segundo a plataforma de acoplamento

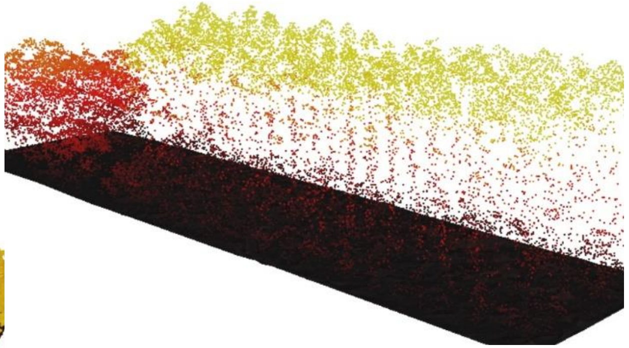
ALS (*airborne laser scanning*)
escaneamento aeroembarcado

tripulado





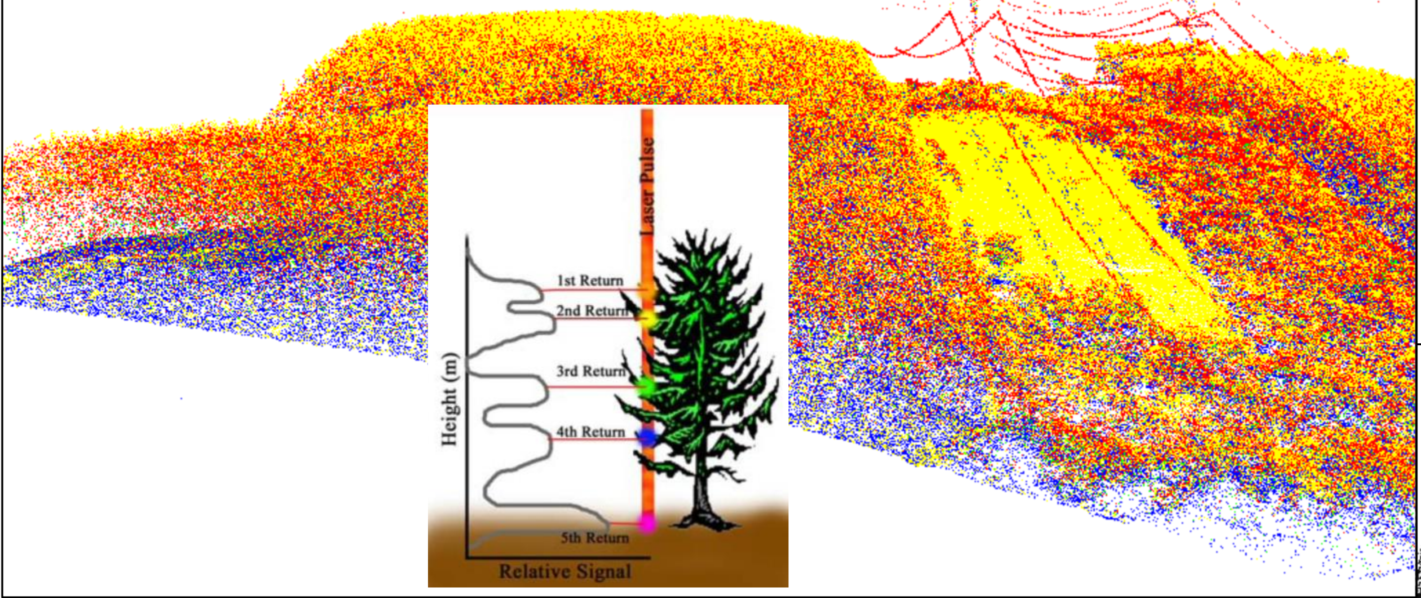




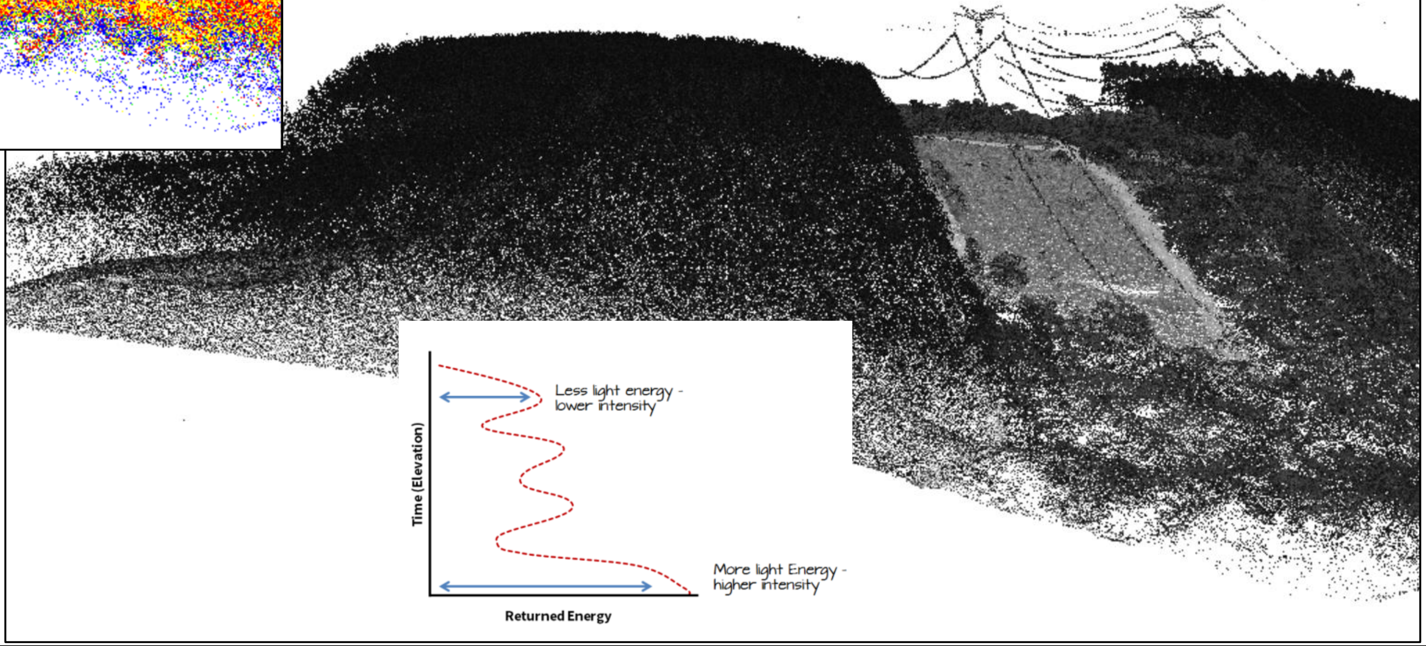
ALS: ampla cobertura cam baixa resolusão

LiDAR – o que é?

Retornos de um pulso



Intensidade de um Retorno



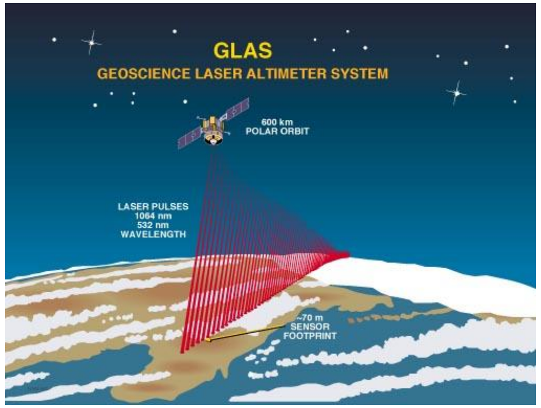
Levantamentos LiDAR segundo a plataforma de acoplamento

SLS (*spaceborne laser scanning*)

escaneamento espacial

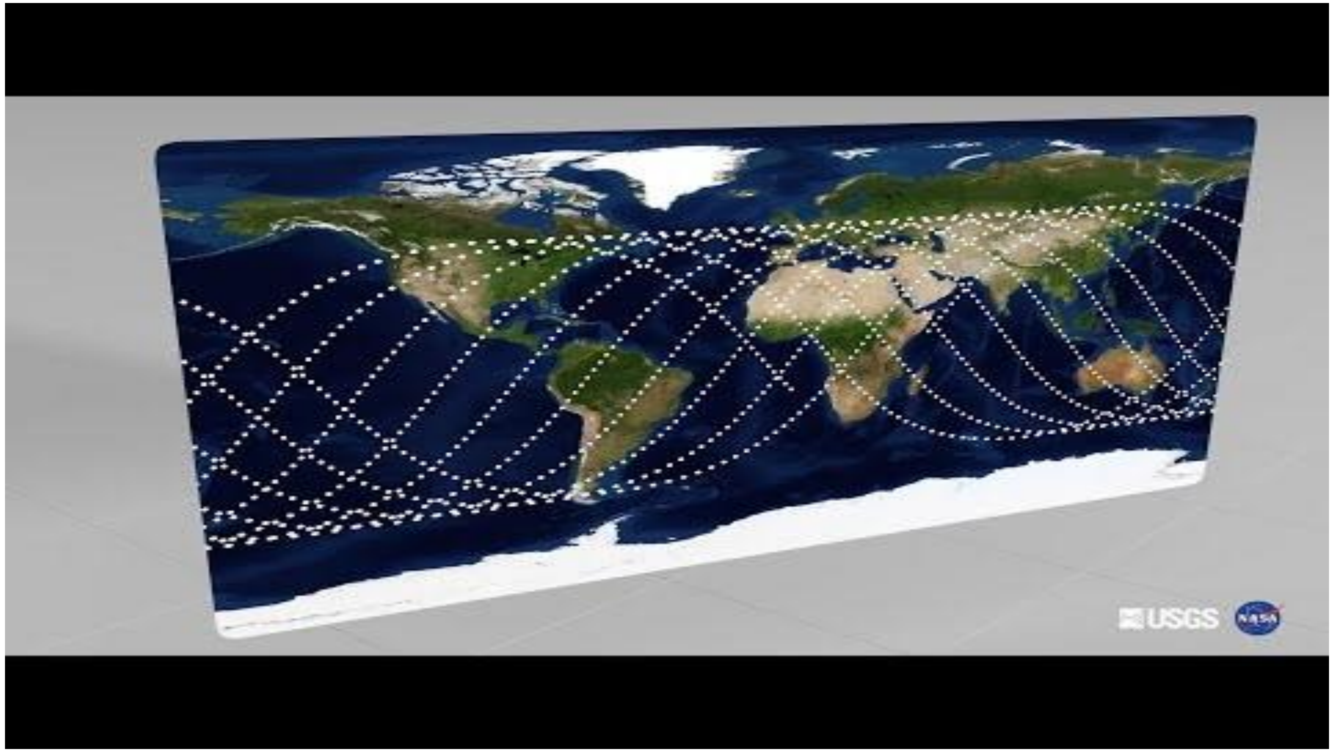
satélites ou estações orbitais

https://nsidc.org/data/icesat/icesat_spots_santa_rosa.html

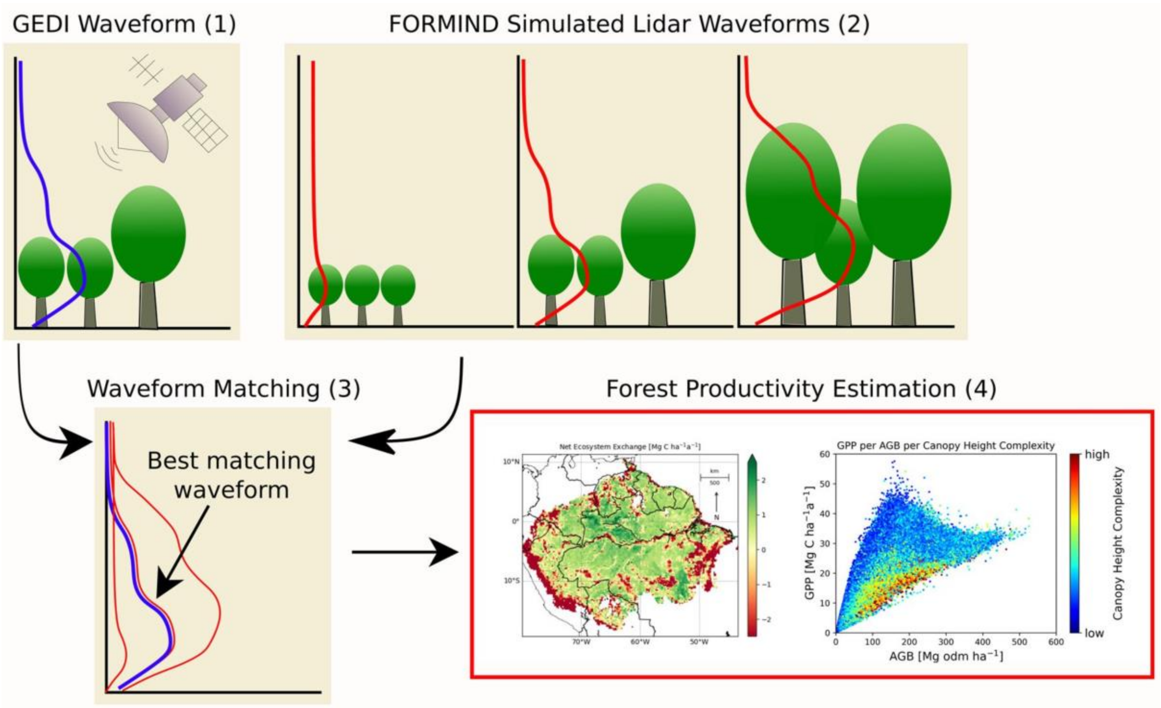


ICESat / GLAS (2003-2010)
Ice, **C**loud, and land **E**levation
Geoscience **L**aser **A**ltimeter **S**ystem

LiDAR – o que é?



https://youtu.be/wxgrxvAKpTo



https://twitter.com/FORMIND_de
https://formind.org/team/

LiDAR – para que serve?

Inspiração / Justificativa

“A gestão florestal depende de informação de qualidade e de técnicas de monitoramento eficientes e eficazes”

- Conservação das florestas em todos os biomas
- Detecção de mudanças e de sinais de degradação
- Inventário de recursos florestais

Novas tecnologias – medições remotas

Mapeamento florestal 3D – inventário florestal

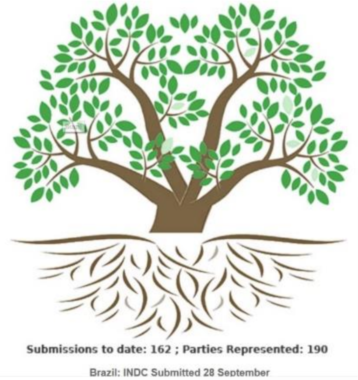
Investigação científica – métodos LiDAR precisam evoluir

Biometría florestal – novos desafios

LiDAR – para que serve?

COP 21
Paris
Nov/2015

COP 22
Marrakech
Nov/2016



FEDERATIVE REPUBLIC OF BRAZIL
INTENDED NATIONALLY DETERMINED CONTRIBUTION
TOWARDS ACHIEVING THE OBJECTIVE OF THE
UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

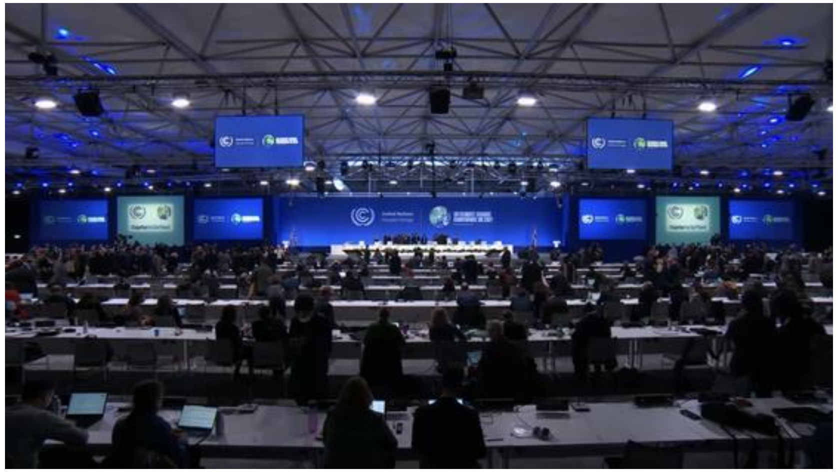
Contribution: Brazil intends to commit to reduce greenhouse gas emissions by 37% below 2005 levels in 2025.

Subsequent indicative contribution: reduce greenhouse gas emissions by 43% below 2005 levels in 2030.

ii) in land use change and forests:

- strengthening and enforcing the implementation of the Forest Code, at federal, state and municipal levels;
- strengthening policies and measures with a view to achieve, in the Brazilian Amazonia, zero illegal deforestation by 2030 and compensating for greenhouse gas emissions from legal suppression of vegetation by 2030;
- restoring and reforesting 12 million hectares of forests by 2030, for multiple purposes;
- enhancing sustainable native forest management systems, through georeferencing and tracking systems applicable to native forest management, with a view to curbing illegal and unsustainable practices;

LiDAR – para que serve?



https://unfccc.int/news/cop26-pivotal-progress-made-on-sustainable-forest-management-and-conservation

COP 26
Glasgow
Nov/2021

THE ROAD TO COP26

World leaders, including China's Xi and Brazil's Bolsonaro, pledge to end deforestation by 2030

PUBLISHED TUE, NOV 2 2021-4:07 AM EDT | UPDATED TUE, NOV 2 2021-6:30 AM EDT

A deforested area in the Amazon rainforest in the state of Para, Brazil, on October 14, 2014.
Raphael Alves | AFP | Getty Images

https://www.cnbc.com/2021/11/02/cop26-china-brazil-among-nations-pledging-to-end-deforestation-by-2030.html

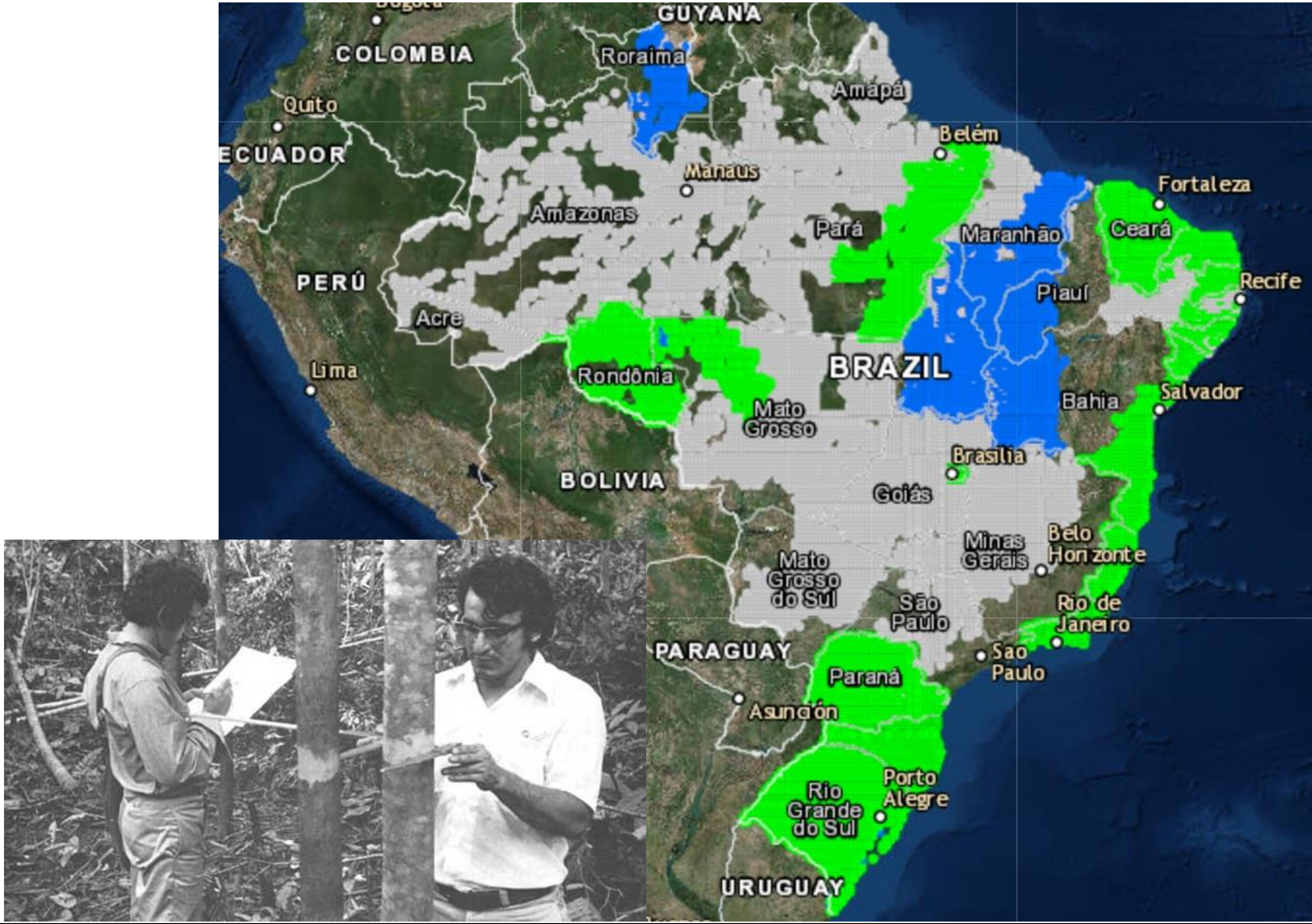
12 países prometem fornecer US $ 12 bilhões para financiamento climático relacionado a florestas entre 2021 e 2025.

Essas promessas atenderão a uma maior colaboração para deter e reverter a perda florestal e degradação da terra até 2030.

LiDAR – para que serve?

Medição de parcelas de campo

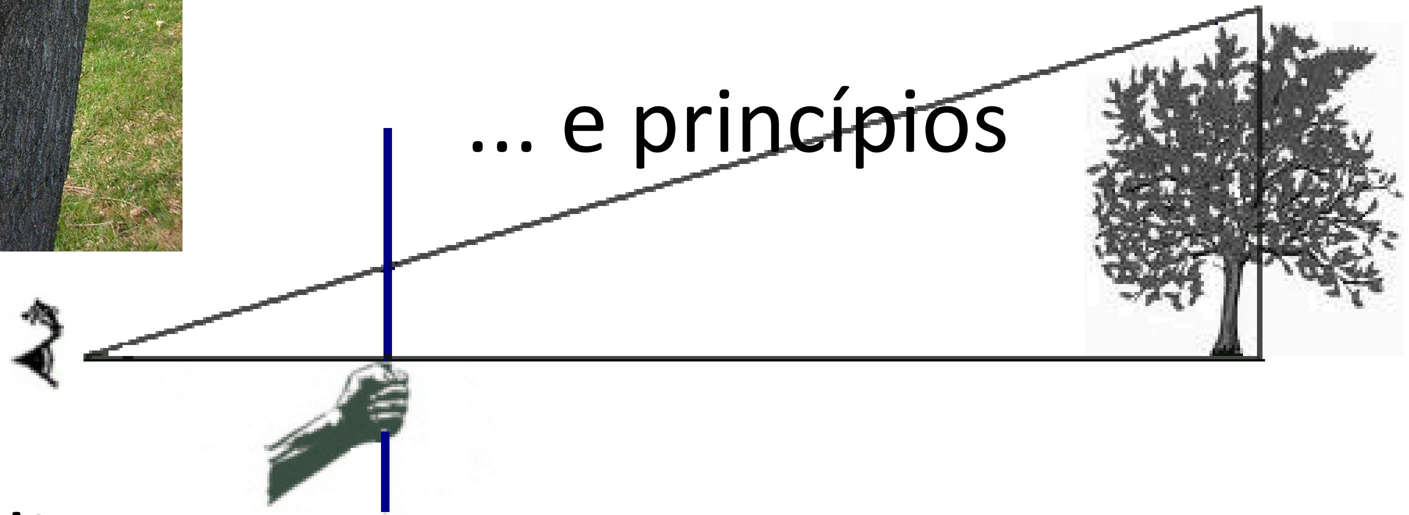
Inventário Florestal Nacional



LiDAR – para que serve?

Procedimentos

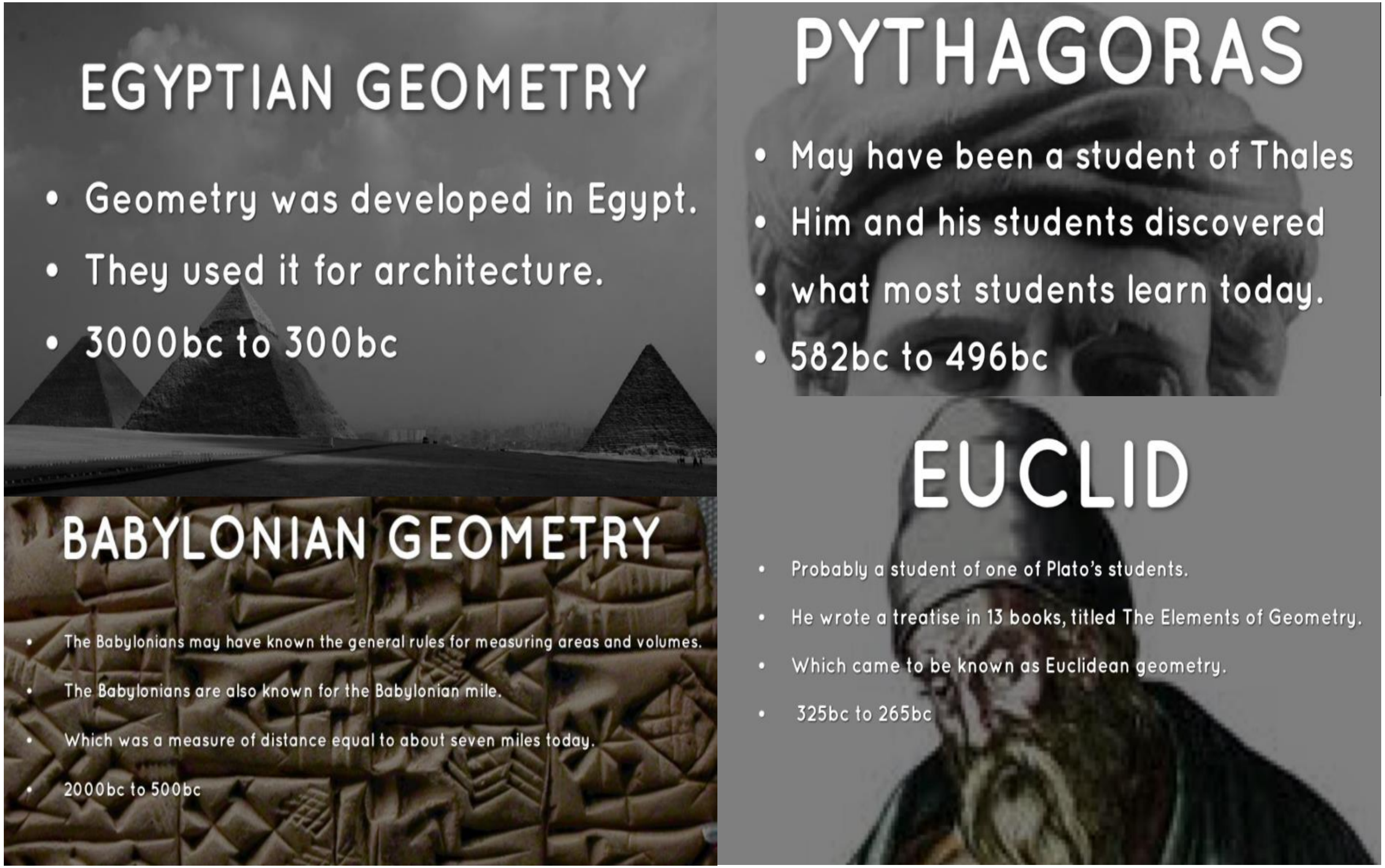
... e princípios



... relativamente rudimentares

LiDAR – para que serve?

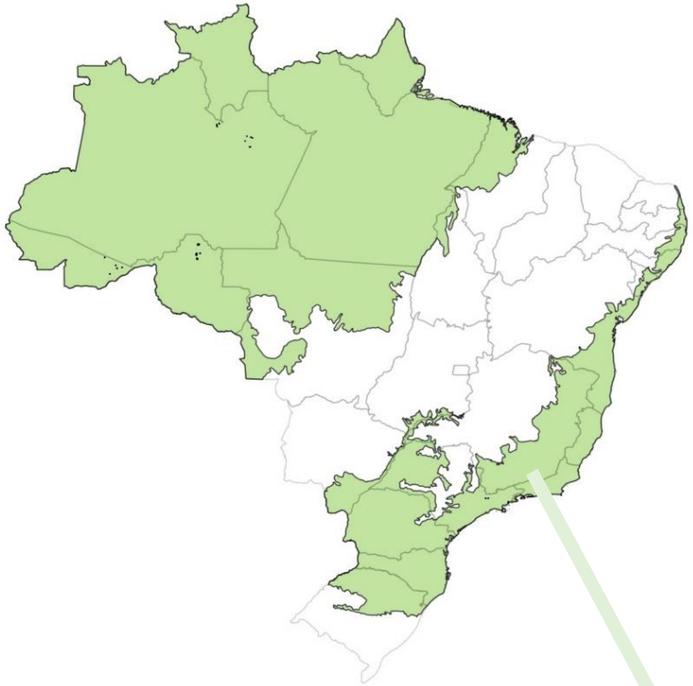
baseados em simples e sólidos conceitos



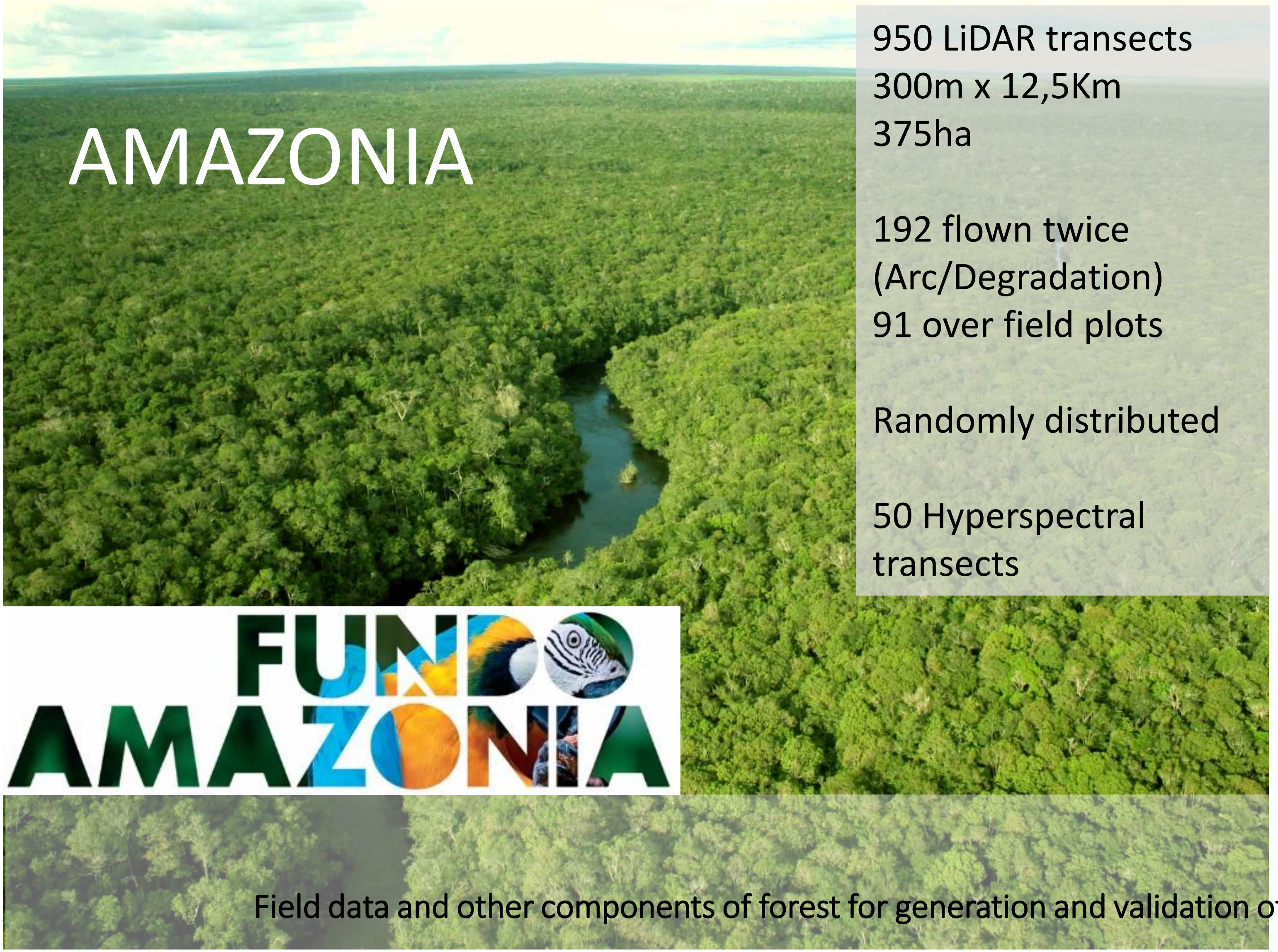
LiDAR – para que serve?

... que podem ser melhorados com novas tecnologias

LiDAR – para que serve?



LiDAR – para que serve?



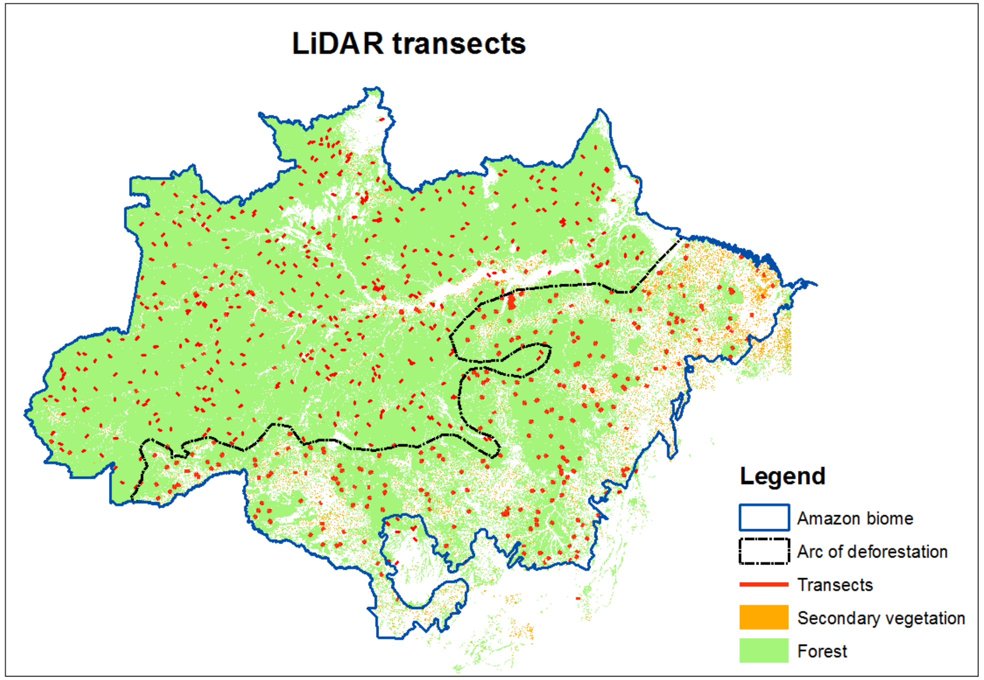
AMAZONIA

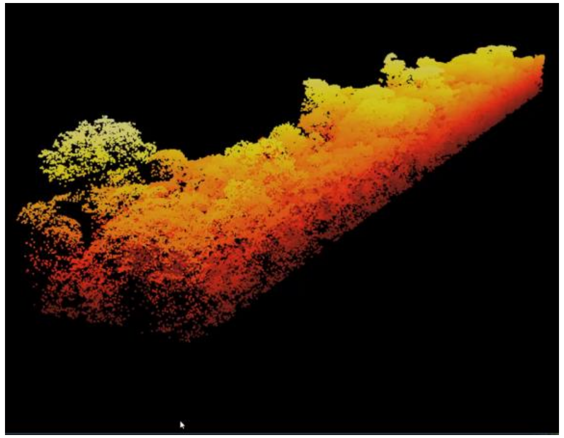
950 LiDAR transects
300m x 12,5Km
375ha

192 flown twice
(Arc/Degradation)
91 over field plots

Randomly distributed

50 Hyperspectral
transects





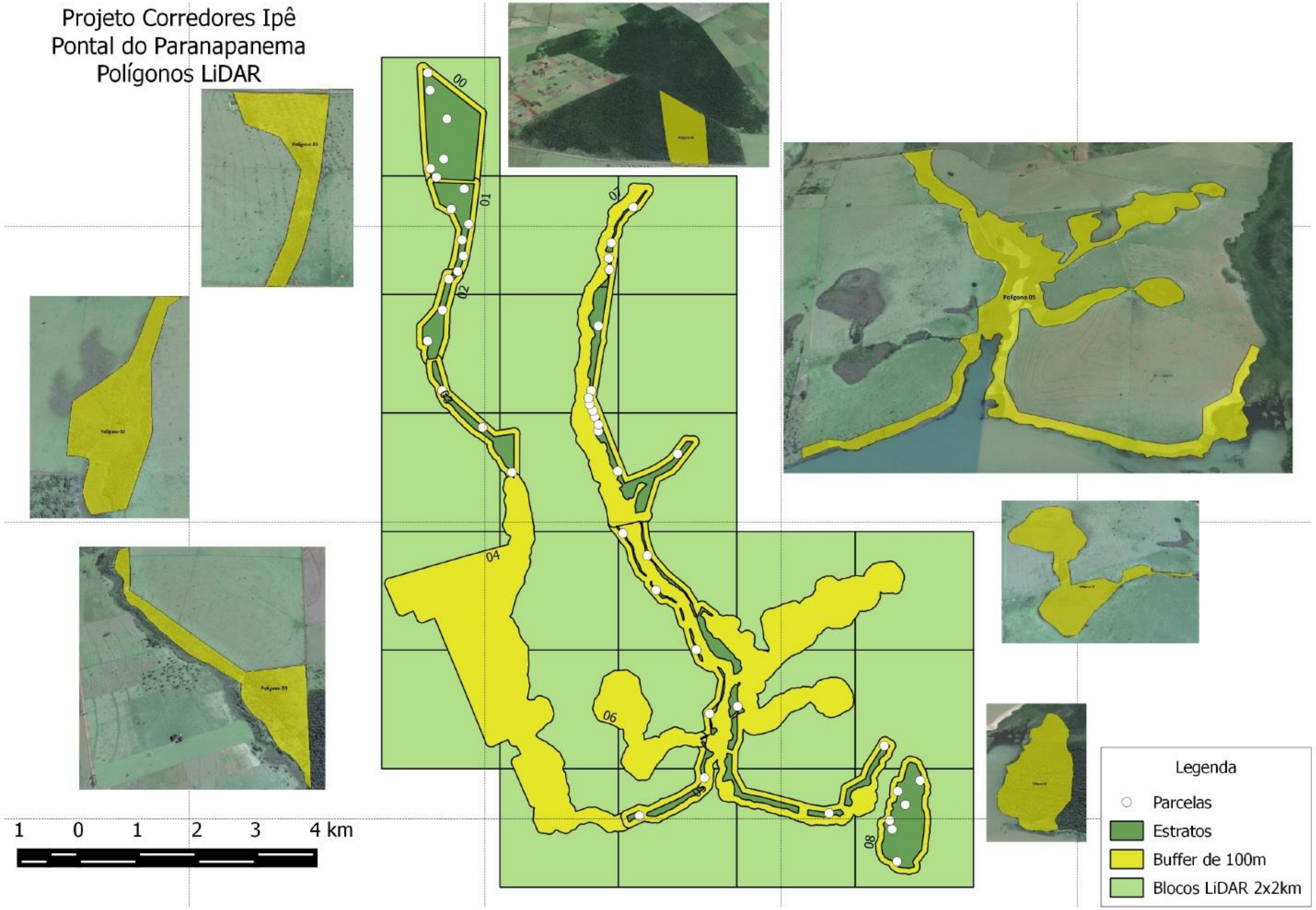
EBA Project

Field data and other components of forest for generation and validation of Amazonian biomass map

LiDAR – para que serve?

Monitoramento da restauração de corredores ecológicos

(zonas ripários)

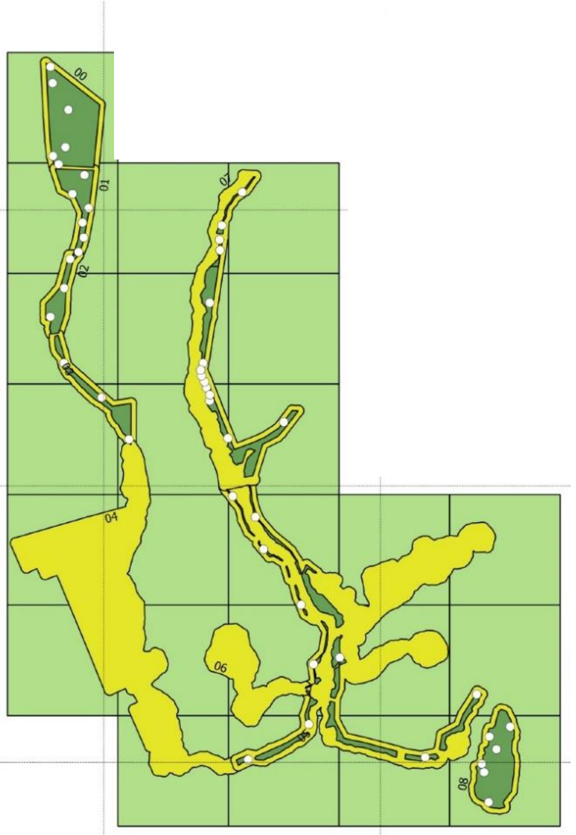


LiDAR – para que serve?

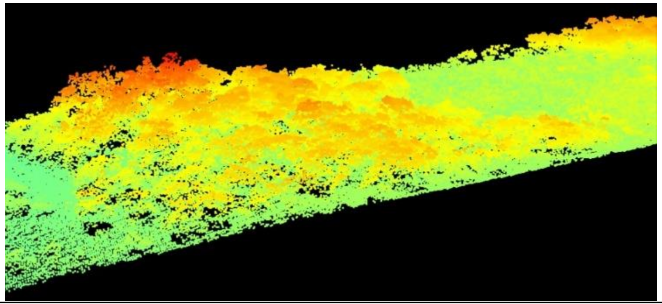
Medição de parcelas de campo

Parcelas de monitoramento em projetos de restauração

LiDAR – para que serve?



Medição de parcelas de regeneração

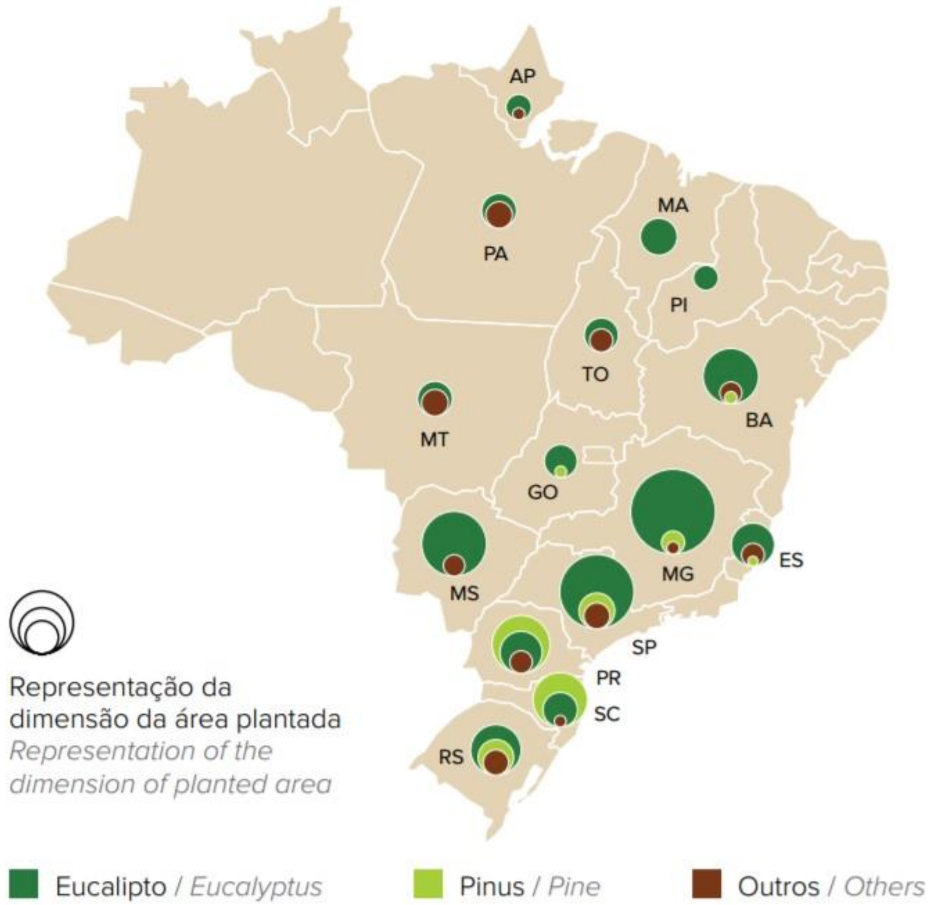


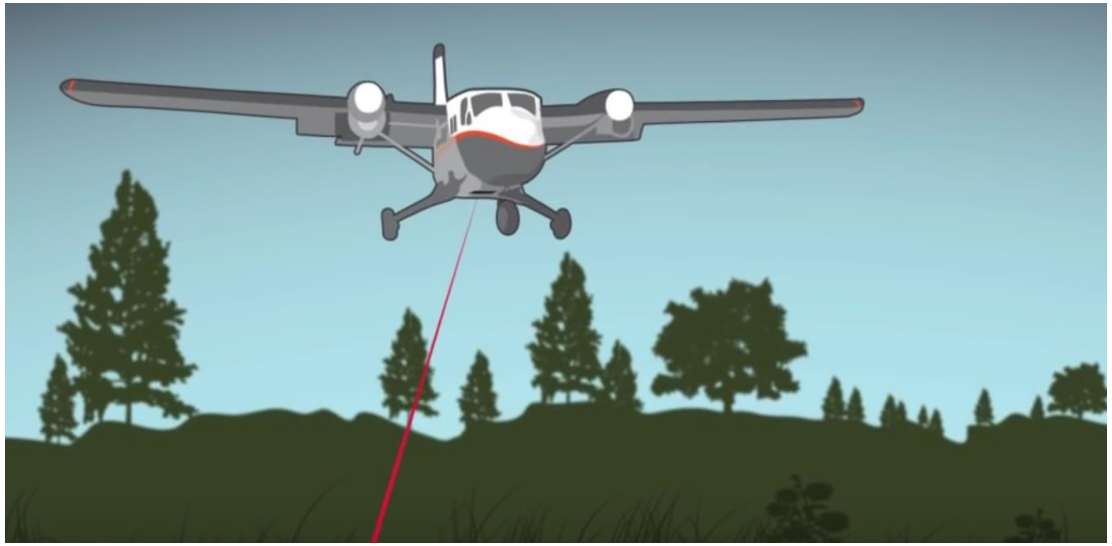
LiDAR – para que serve?

Medição de parcelas de campo

Inventário em plantios industriais

LiDAR – para que serve?



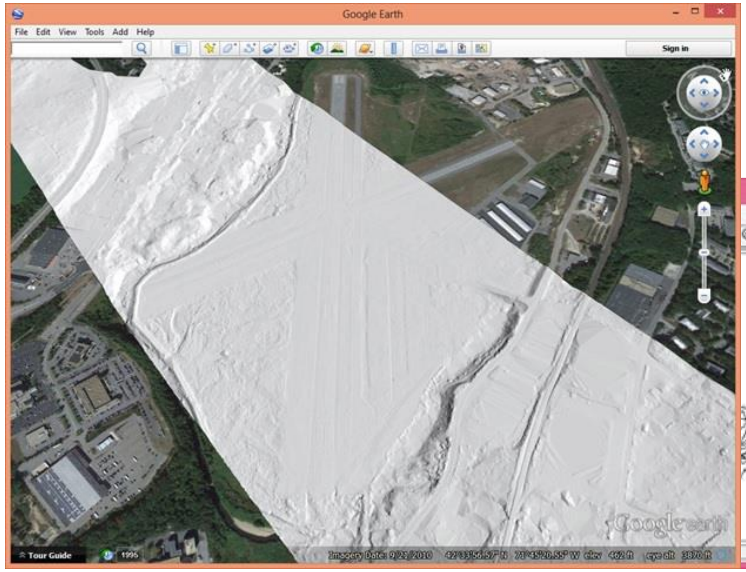


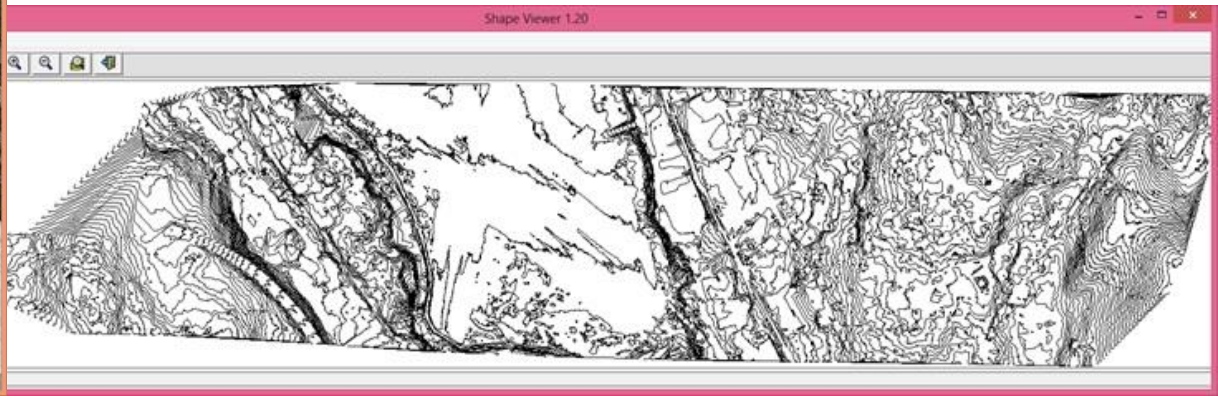
ALS

5 a 15 US$/ha

Produtos:

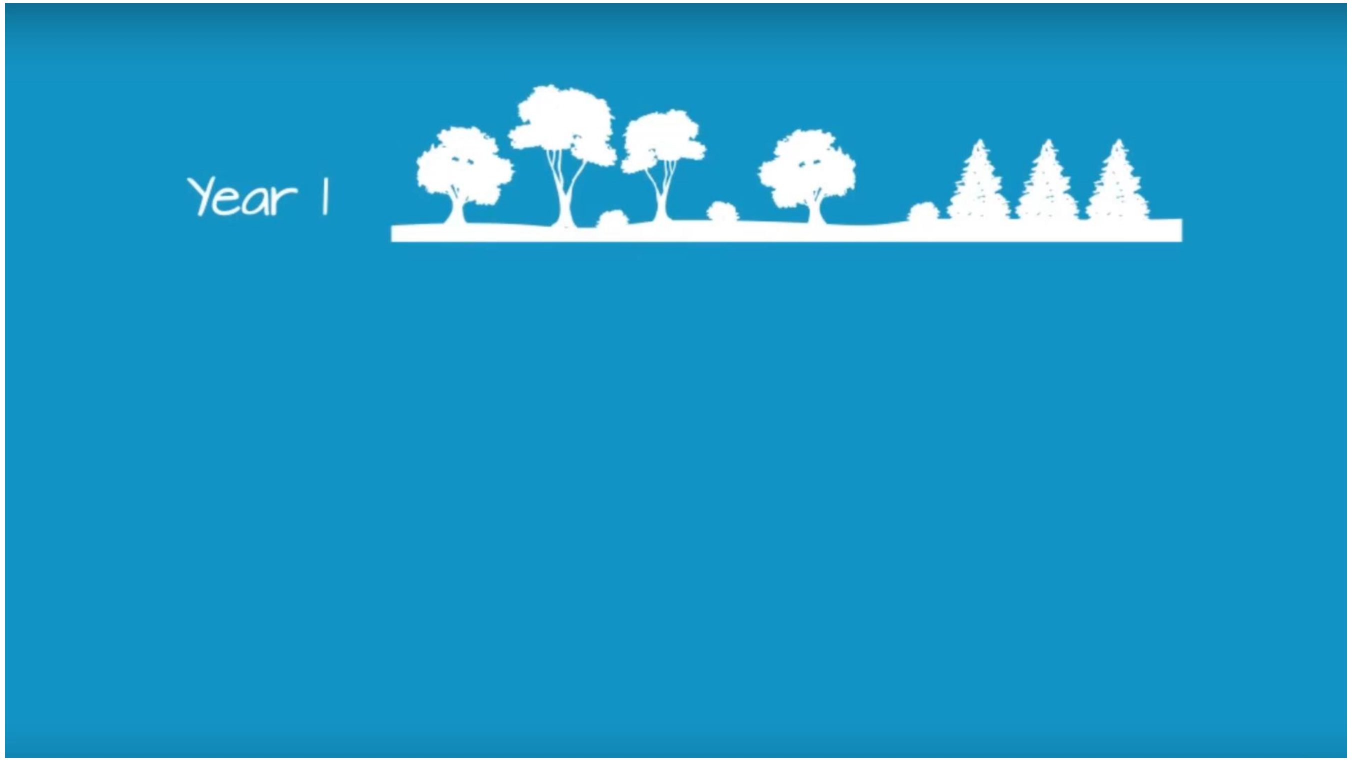
MDT e MDS

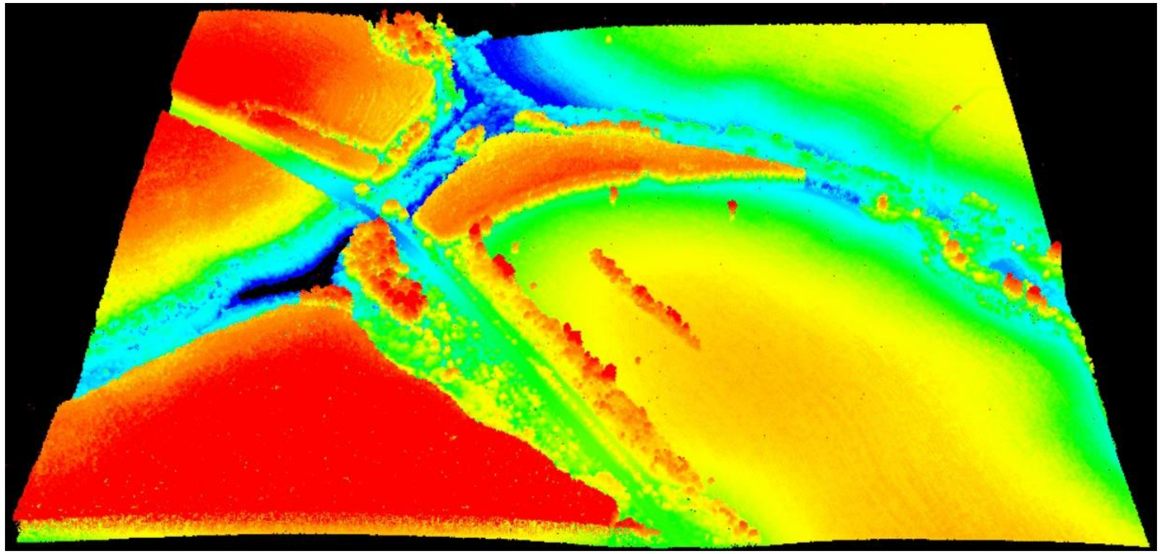




LiDAR – para que serve?

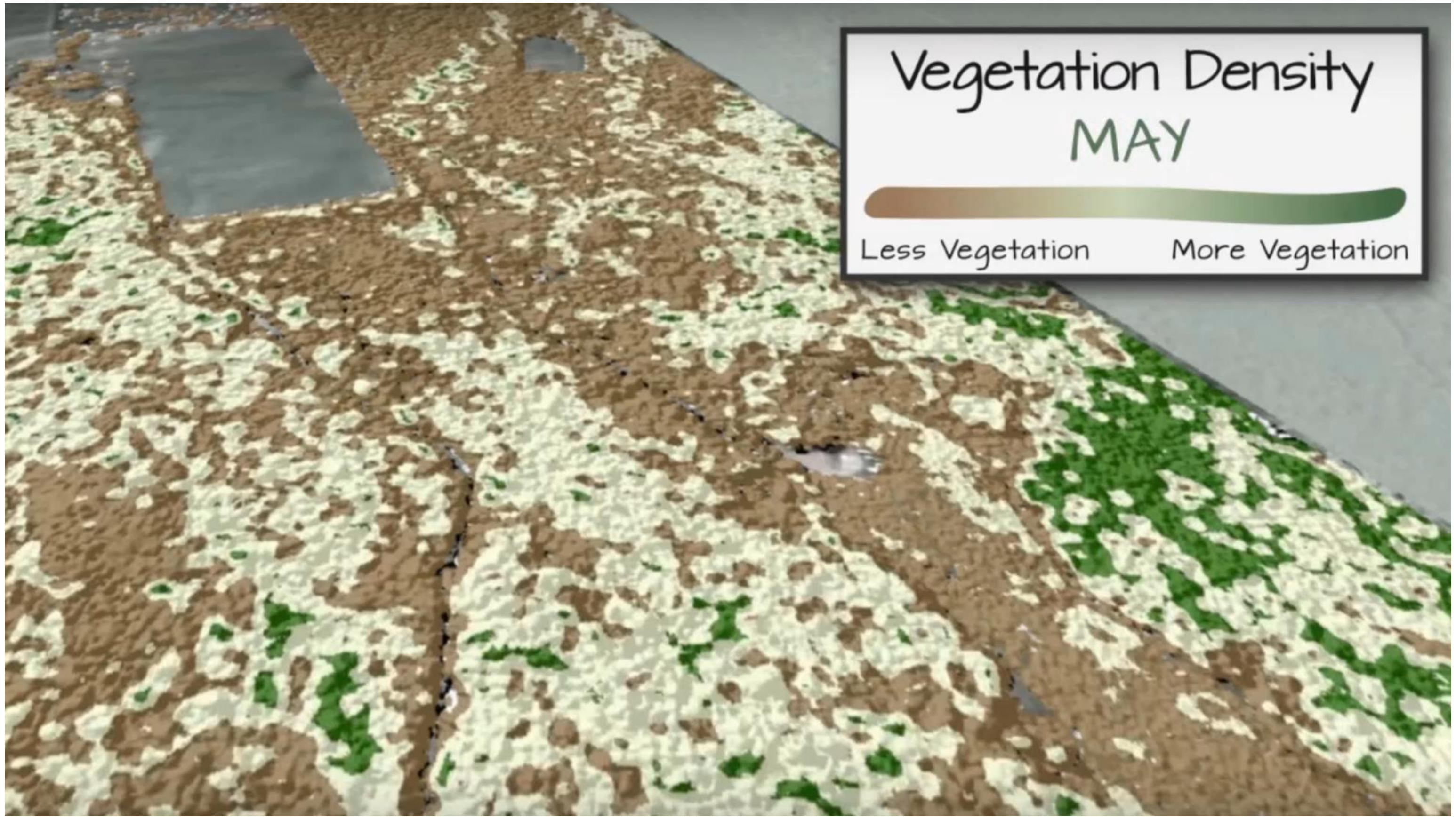
Informação multi temporal





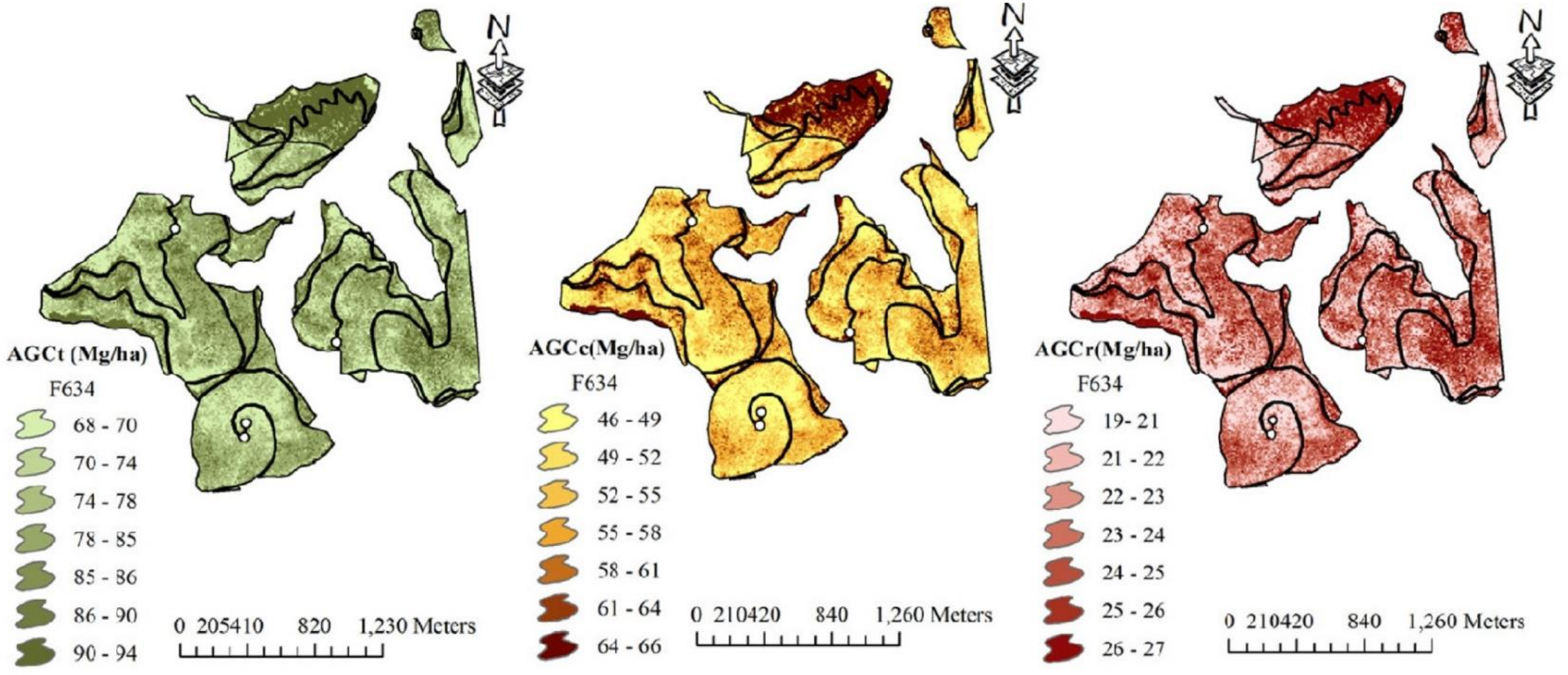
LiDAR – para que serve?

Densidade da cobertura vegetal



LiDAR – para que serve?

Mapas de carbono estocado

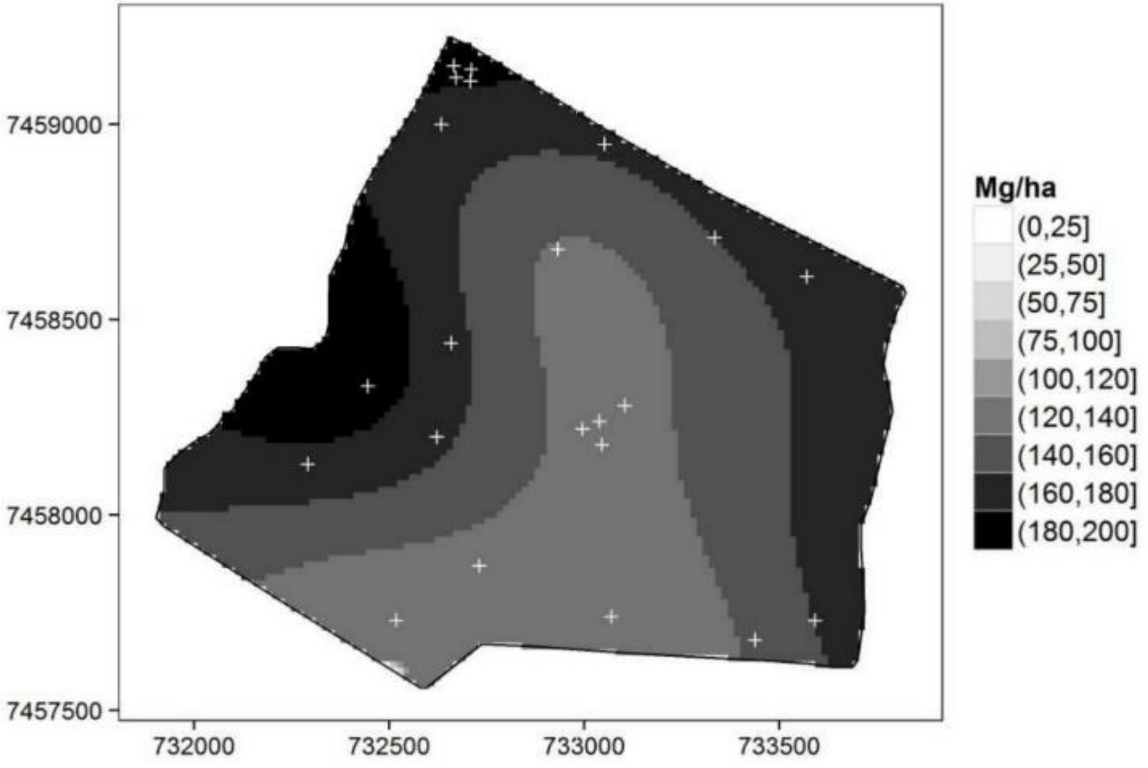


Predicted AGC stocks (AGCt, AGCc and AGCr) for *Eucalyptus* plantations located in F184, F166, F948 and

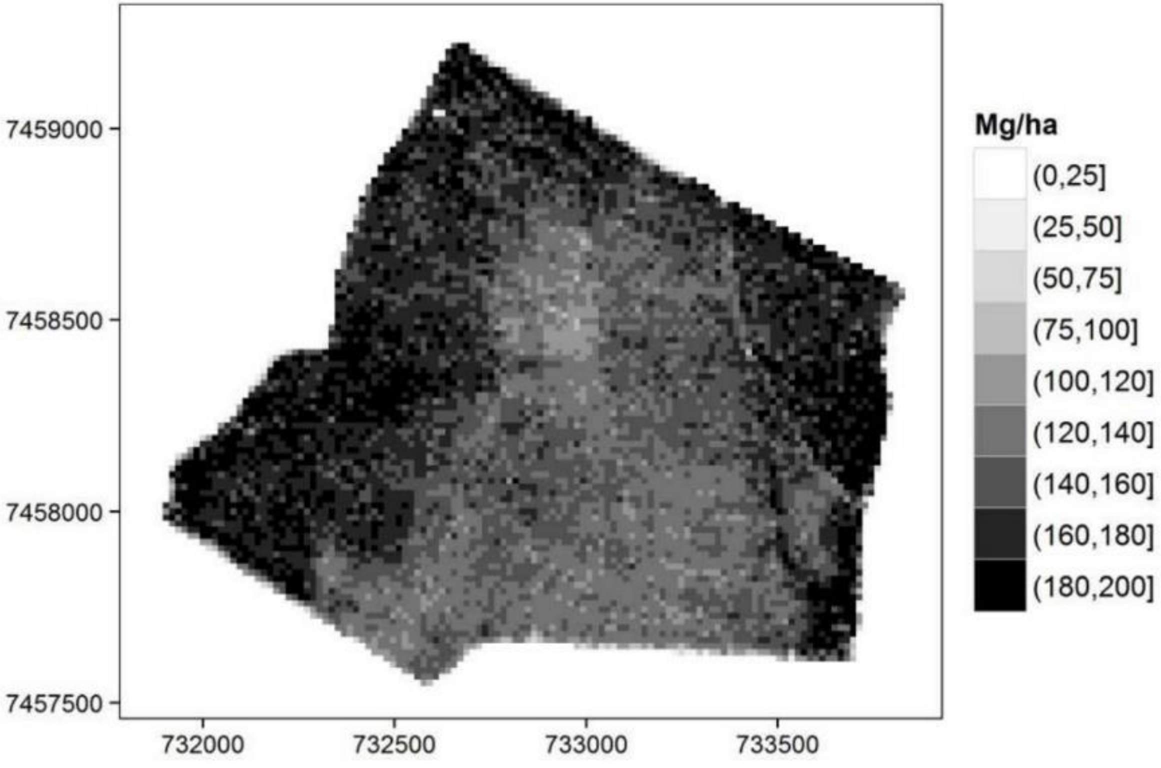
LiDAR – para que serve?

Mapas de carbono estocado

Convencional

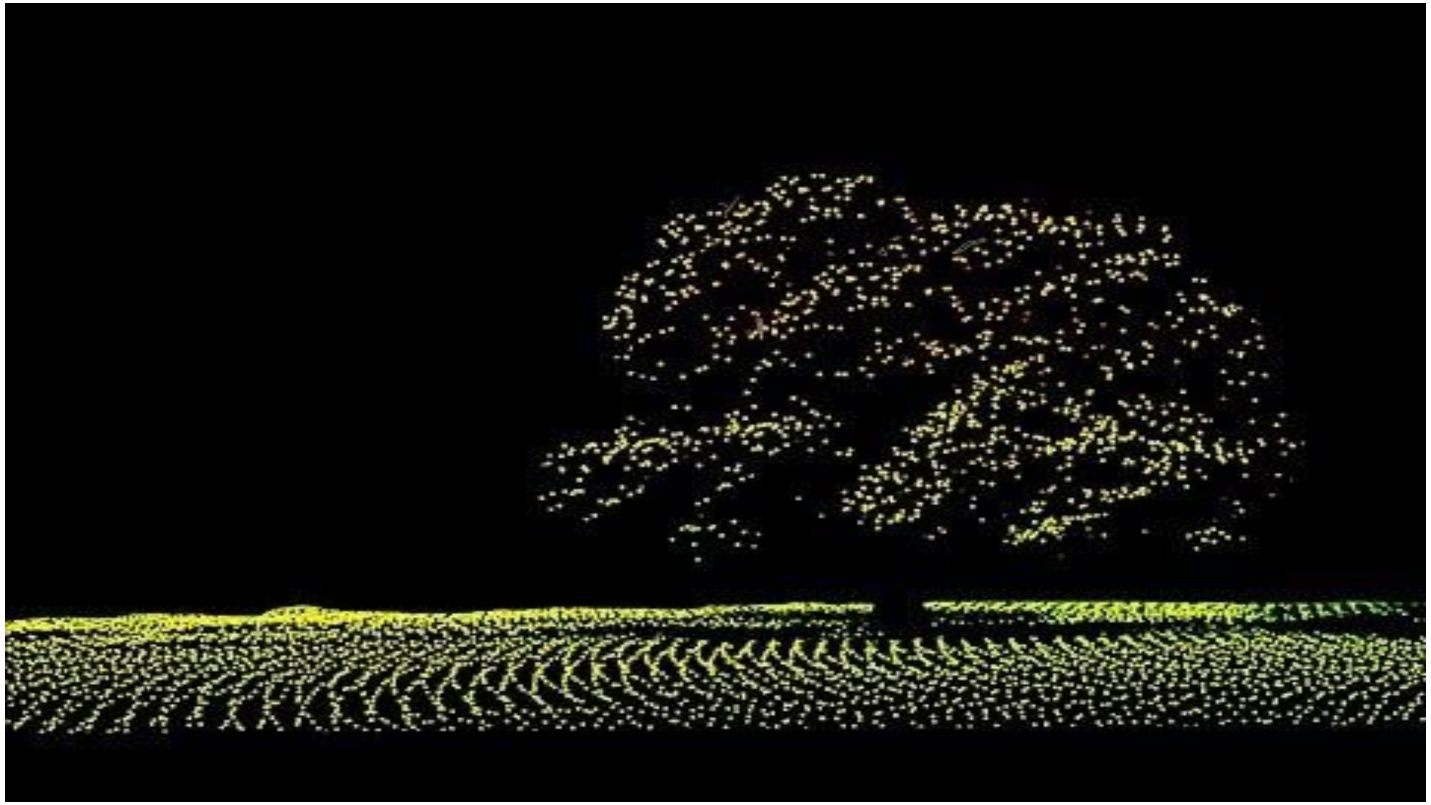


LiDAR



LiDAR – para que serve?

Para um aprofundamento no uso do LiDAR em Ecologia:
National Ecological Observatory Network (**NEON**): www.neonscience.org
Videos: *www.youtube.com/user/NEONBetaEDU*



LiDAR no manejo de recursos florestais

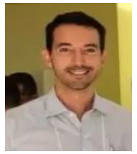
Grupo de Estudos em Tecnologias LiDAR (GetLiDAR) – Pós-Graduados ESALQ

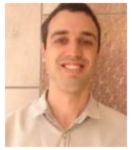


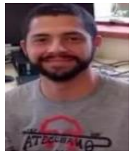
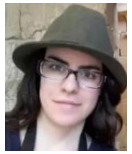
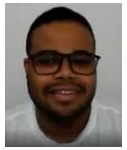


2009 2013 2014 2015 2016 2017 2018 2019 2020 2021



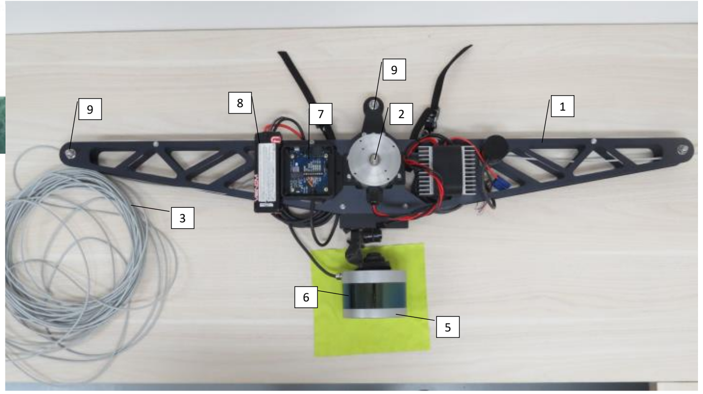


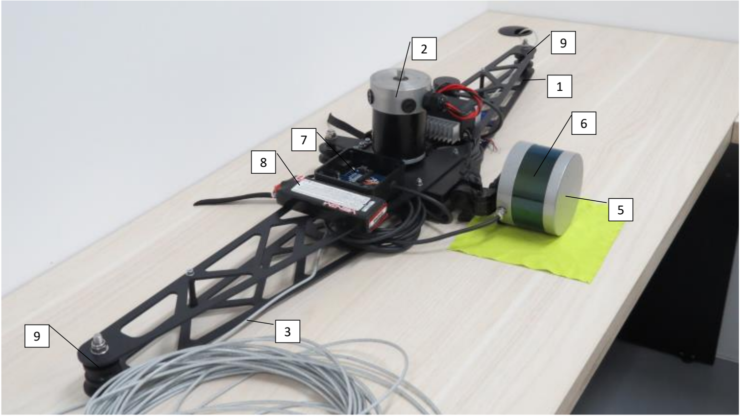





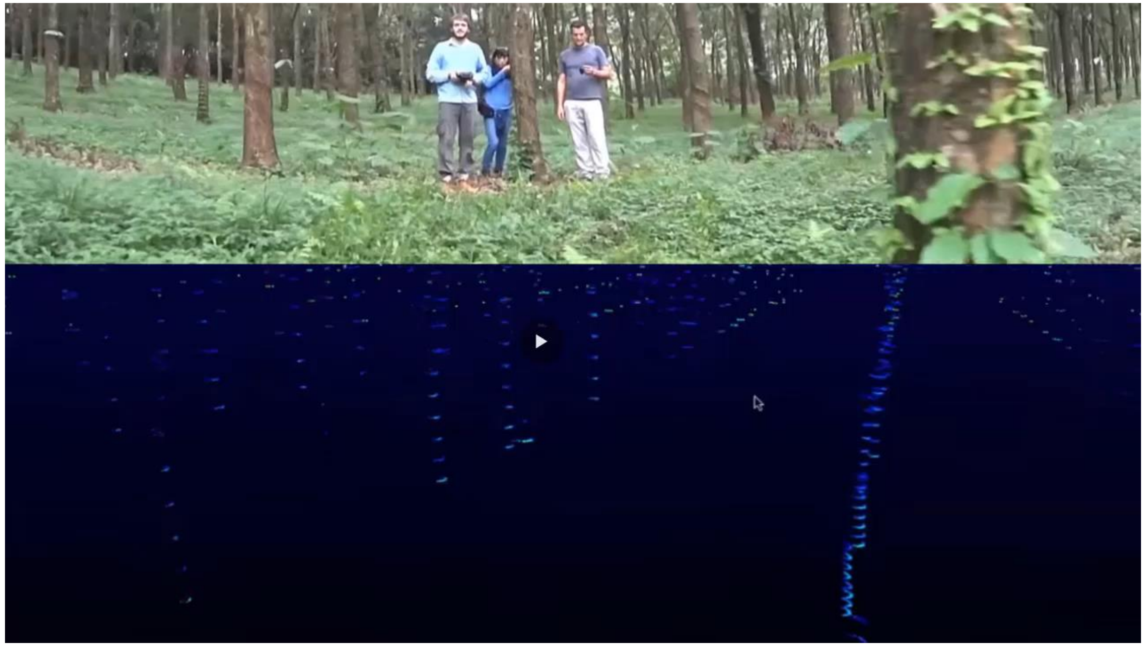

	Nativas	Plantadas	Restauração	Urbanas
LiDAR – ALS	✓	✓	✓	✓
LiDAR – TLS	✓	✓	✓	✓
Fotogrametria SfM	✓	✓	✓	✓
Estereoscopia	✓	✓	✓	✓

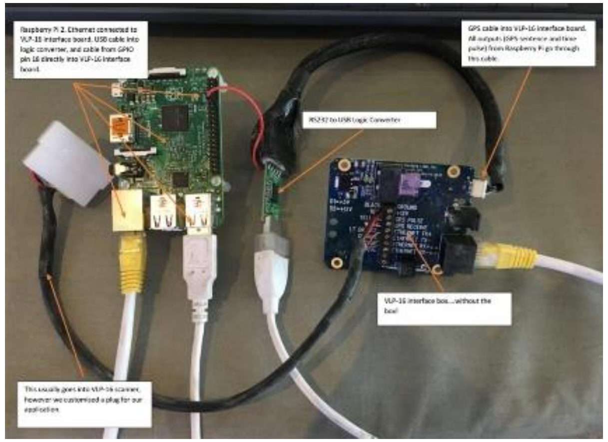
LiDAR no manejo de recursos florestais

Startups









LiDAR no manejo de recursos florestais

Startups

Forlidar

Home Soluções Tecnologias Parcerias Blog Na Mídia Contato

Precisão, Rapidez e Segurança

Tecnologias LiDAR AgroFlorestal

Desenvolvemos soluções para o inventário florestal e monitoramento da produção agrícola a partir da reconstrução do ambiente em 3D.

Saiba Mais

Análise de dados LiDAR ALS para fins florestais

LiDAR no manejo de recursos florestais

Conferir especificações → Arrumar as Nuvens -> LAZ → Quadricular com buffers → Classificar solo e determinar as alturas dos pontos → Classificar vegetação e prédios → Classificar ruído → …

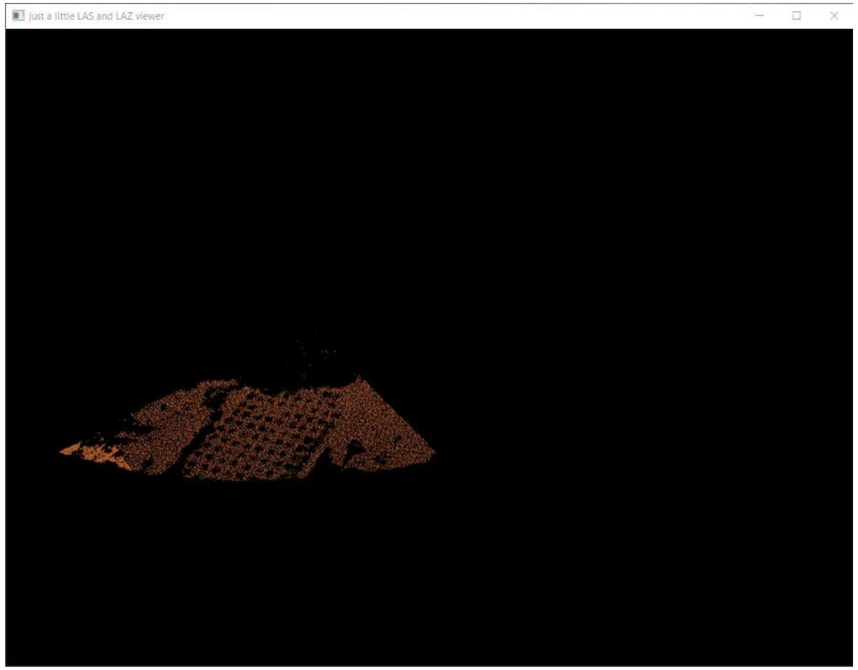
- **Conferir especificações**: **lasview**, **lasinfo**, **lasoverlap**, **lasvalidate**
- **Arrumar as Nuvens -> LAZ**: **las2las**
  - -epsg
  - -rescale
  - -set_classification
- **Quadricular com buffers**: **lastile**
  - -tile_size 500
  - -buffer 30
- **Classificar solo e determinar as alturas dos pontos**: **lasground**
  - -compute_height
- **Classificar vegetação e prédios**: **lasclassify**
  - -step 3
  - -ground_offset 0.5
- **Classificar ruído**: **lasnoise**
  - -ignore_class 2
  - -step 2
  - -isolated 3
  - -classify_as 1

… → Criar quadrículas limpas → Criar nuvem para cada área área interesse → Produzir mapas DTM DSM → Normalizar quadrículas → Calcular métricas LiDAR → **Inferir e produzir mapas**

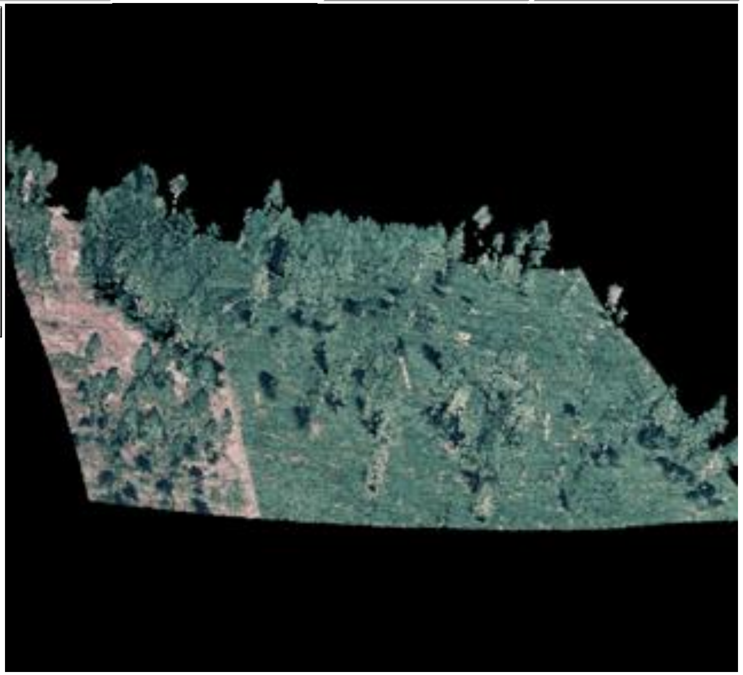
- **Criar quadrículas limpas**: **lastile**
  - -drop_class 1
  - -remove_buffer
- **Criar nuvem para cada área área interesse**: **lasclip**
  - -merged
  - -poly
  - -split
- **Produzir mapas DTM DSM**: **blast2dem**
  - -keep_class 2
  - -keep_class 2 5
- **Normalizar quadrículas**: **lasheight**
  - -replace_z
  - -set_user_data 0
- **Calcular métricas LiDAR**: **lascanopy**
  - -drop_class 1
  - -step 20
  - -centroids
  - -height_cutoff 0.5
  - -cover_cutoff 0.5

LiDAR no manejo de recursos florestais

Conferir especificações



LAStools



Outros sistemas úteis:

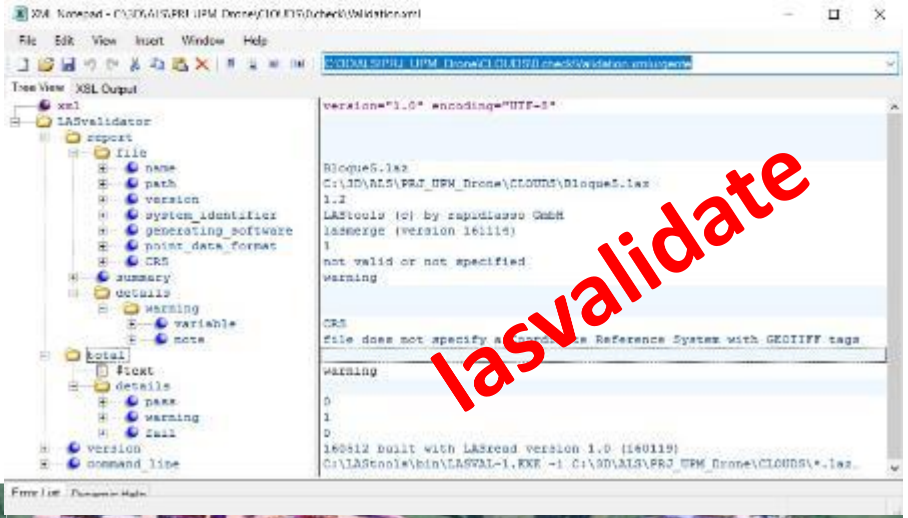
- LidR
- LIS Desktop
- SAGA GIS
- MCC-LiDAR

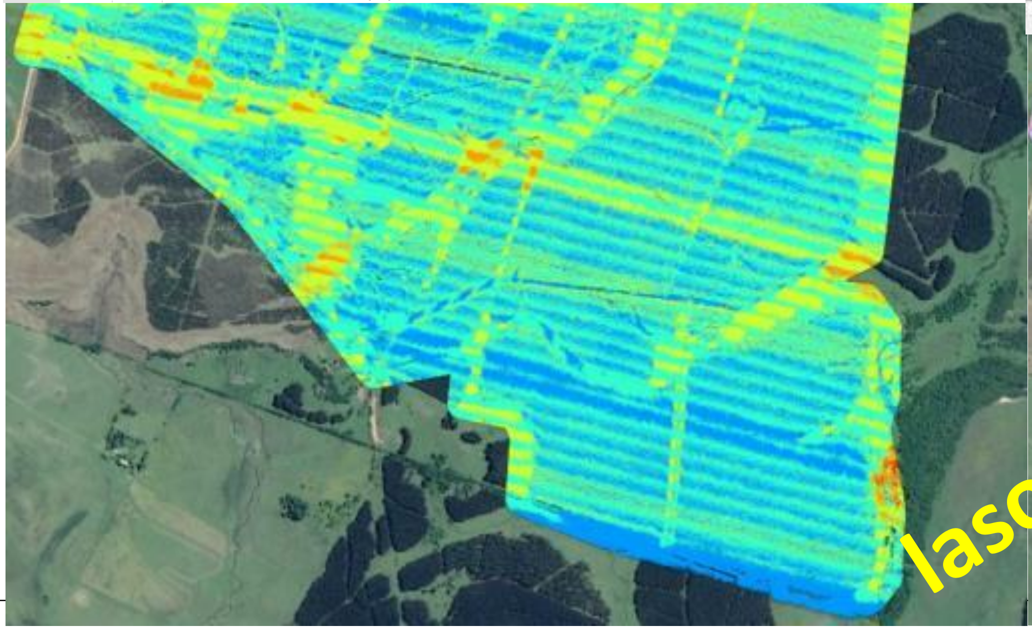
LiDAR no manejo de recursos florestais

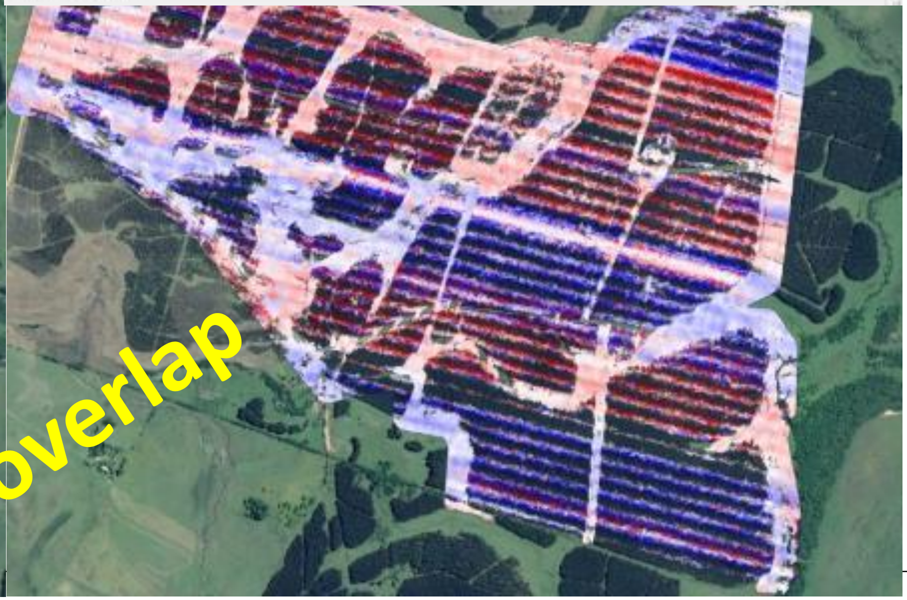
Conferir especificações

```
reporting all LAS header entries:
...
  system identifier:            'LAStools (c) by rapidlasso GmbH'
  generating software:          'lasmerge (version 161114)'
  file creation day/year:       315/2016
  header size:                  227
  offset to point data:         227
...
  number of point records:      441270594
...
covered area in square units/kilounits: 3991672/3.99
point density: all returns 110.55 last only 99.68 (per square units)
      spacing: all returns 0.10 last only 0.10 (in units)
overview over number of returns of given pulse: 355001767 86268827 0 0 0 0 0
histogram of classification of points:
       121911915  never classified (0)
        14668361  ground (2)
       304305141  high vegetation (5)
          366835  building (6)
           18342  noise (7)
```

lasinfo







LiDAR no manejo de recursos florestais

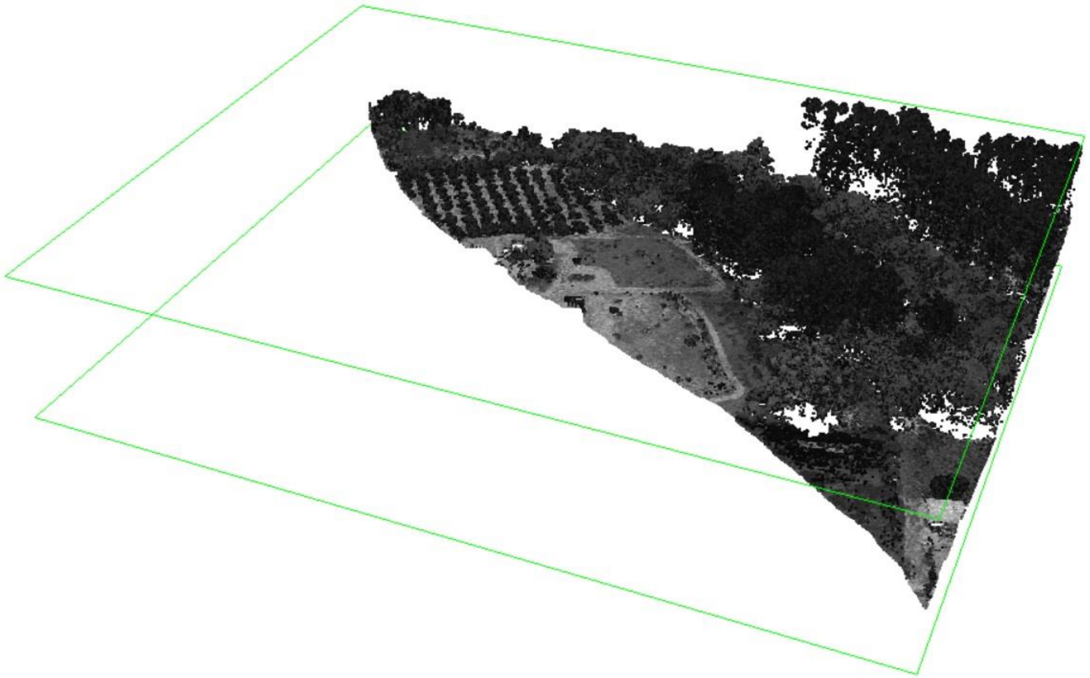
Arrumar nuvens

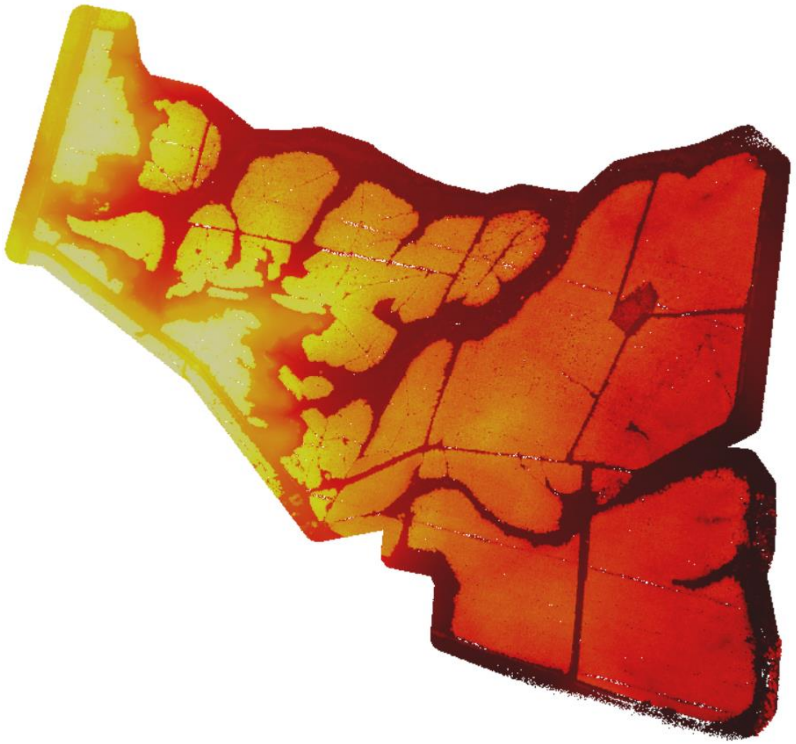
LAS version: 1.2
source ID: 0 created: 315/2016
'LAStools (c) by rapidlasso GmbH'
'las2las (version 170628)'
# of points: 441270588
point type: 1 point size: 28
x: 485424.95 488197
y: 6402583.94 6405189.54
z: 77.54 170.62
compression: LASzip 3.0r1 50000

# of VLRs: 0
global_encoding: 0
header size: 227 offset: 227
# of 1st returns: 398394041
# of 2nd returns: 42876547
# of 3rd returns: 0
# of 4th returns: 0
# of 5th returns: 0
offset x y z: 400000 6400000 0
scale x y z: 0.01 0.01 0.01

WGS 84 / UTM 21S
horizontal meter
vertical meter

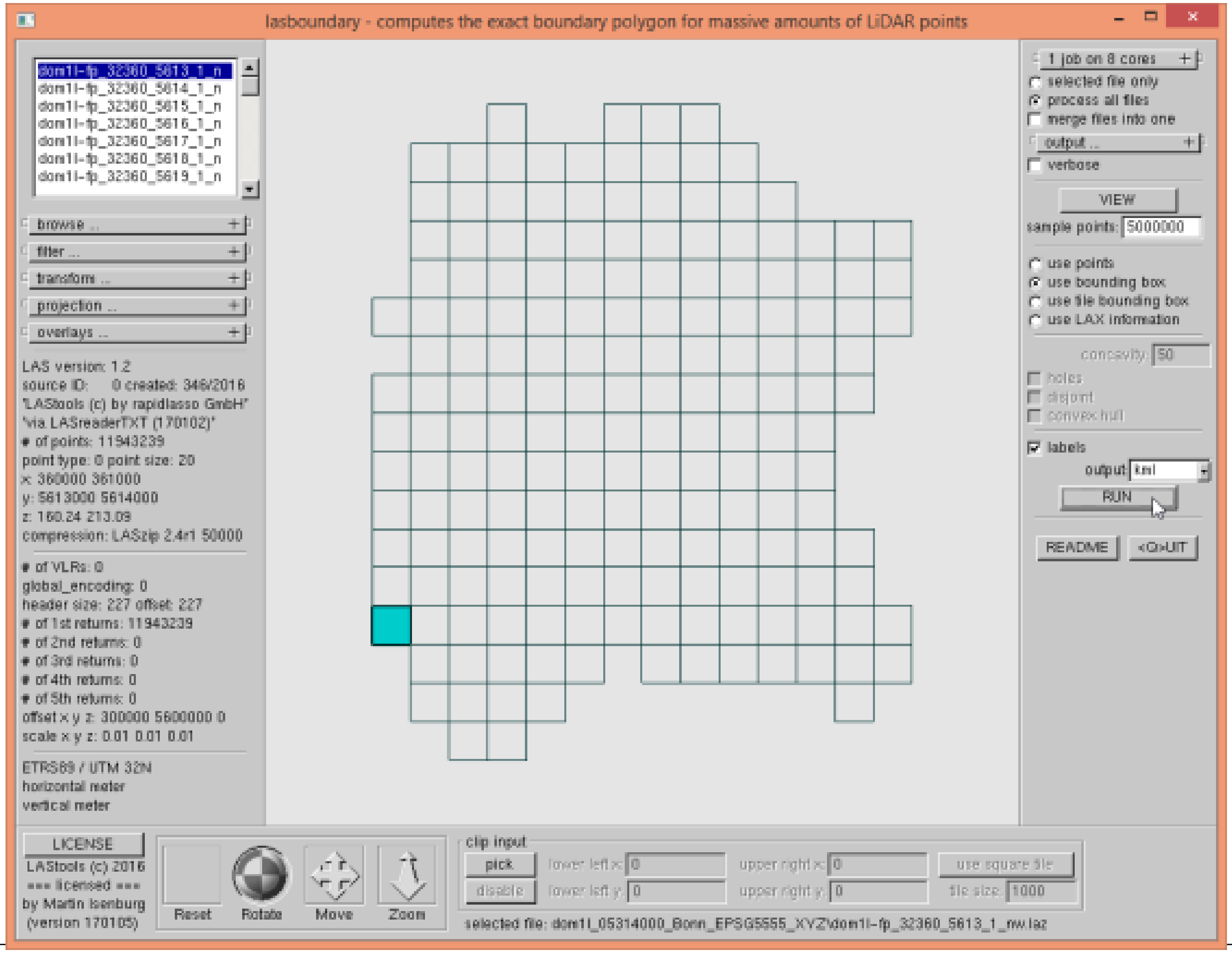
LICENSE
LAStools (c) 2017
=== licensed ===
by Martin Isenburg
(version 170628)





LiDAR no manejo de recursos florestais

Quadricular

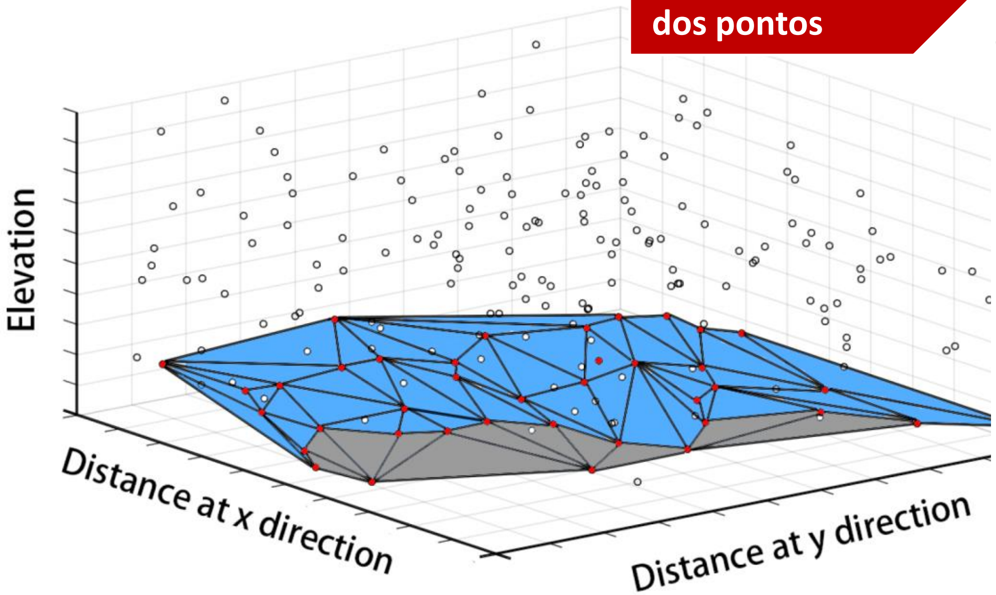


lastile

-tile_size 500
-buffer 30

LiDAR no manejo de recursos florestais

Definir solo e determinar alturas dos pontos



ELSEVIER

ISPRS Journal of Photogrammetry & Remote Sensing 53 (1998) 193–203

PHOTOGRAMMETRY & REMOTE SENSING

Determination of terrain models in wooded areas with airborne laser scanner data

K. Kraus *, N. Pfeifer

Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Gusshausstr. 27–29, 1040 Vienna, Austria

International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B4. Amsterdam 2000.

DEM GENERATION FROM LASER SCANNER DATA USING ADAPTIVE TIN MODELS

Peter Axelsson
Digpro AB
Ynglingagatan 14
113 47 Stockholm, Sweden

ESALQ

LiDAR no manejo de recursos florestais

Definir solo e determinar alturas dos pontos

Sensors 2017, *17*, 150; doi:10.3390/s17010150

www.mdpi.com/journal/sensors

sensors

Kraus and Pfeifer (FUSION)

MDPI

Review

State-of-the-Art: DTM Generation Using Airborne LIDAR Data

Ziyue Chen [1,*], Bingbo Gao [2] and Bernard D

1 College of Global Change and Earth System S
Beijing 100875, China
2 Beijing Research Center for Information Tech
Forestry Sciences, Beijing 100097, China; gaob
3 Department of Geography, University of Cam
* Correspondence: zychen@bnu.edu.cn; Tel.: +8

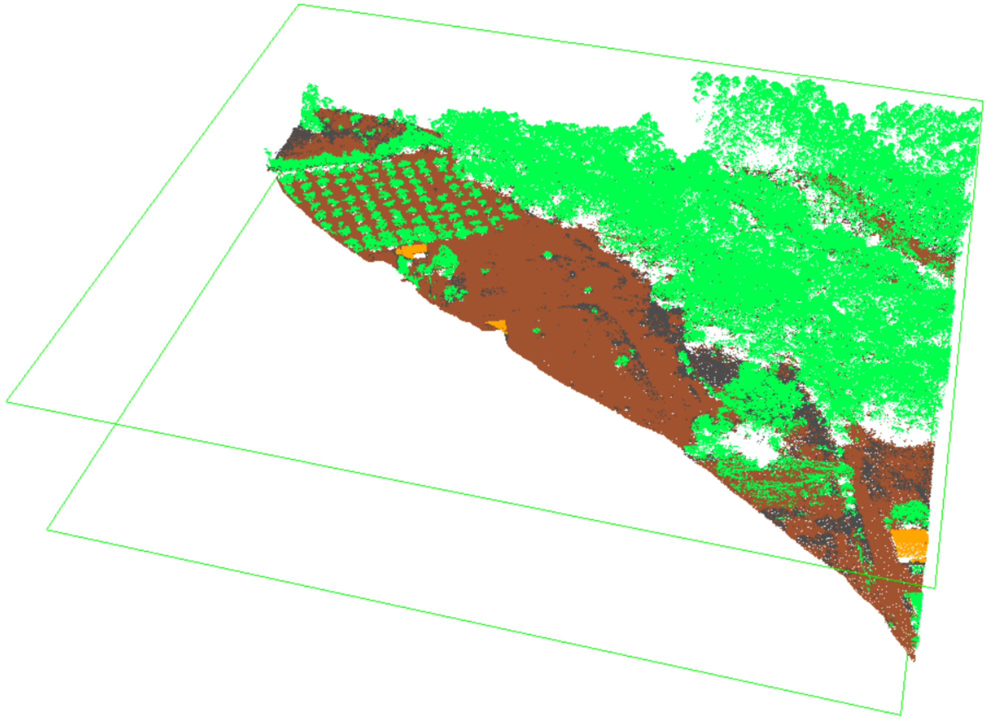
The most widely used Lidar processing software ***TerraScan**** *was designed based on the* ***Axelsson's*** *TIN-model … and the reliability and accuracy of this method has been proved by a large body of studies.*

** também usado no* ***LAStools***

Filtering Methods	Suitable for	Not Suitable for	Memory Storage Demands	Computational Efficiency [2]
Surface-based	Forested areas	Rough and steep terrains	High	Middle
Morphology-based	Steepterrains [1], Terrains with small objects	Terrains with various objects	Low	High
TIN-based	Steep terrains	Urban areas, Discontinuous terrains	Middle	Middle
Segmentation-based	Urban areas, Terrains with various objects	Rough and steep terrains, Dense forests	NA [3]	NA [4]
Statistical analysis	Generally flat terrains	Terrains with various objects	Low	Low
Multi-scale comparison	Urban areas	Rough and steep terrains	Middle	Low

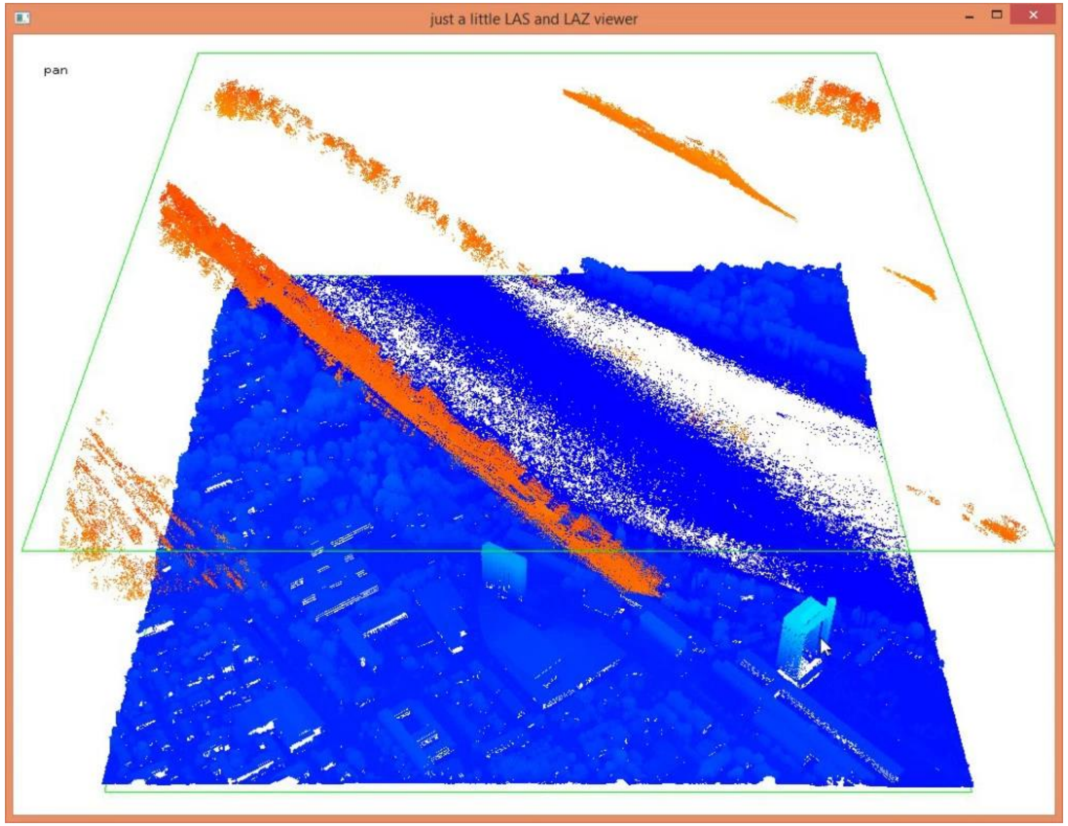
LiDAR no manejo de recursos florestais

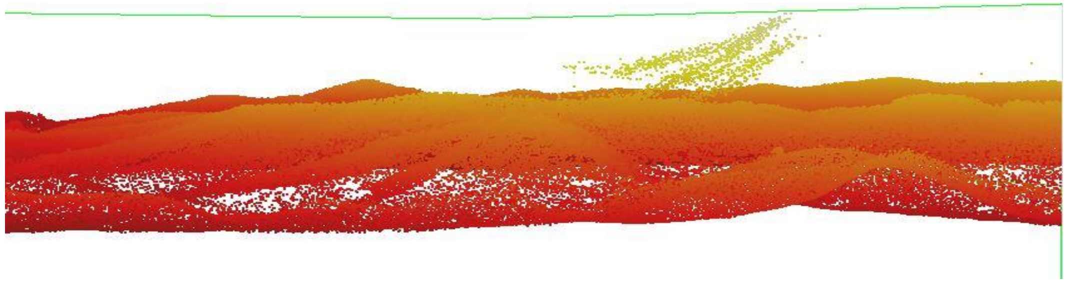
Classificar vegetação e prédios



LiDAR no manejo de recursos florestais

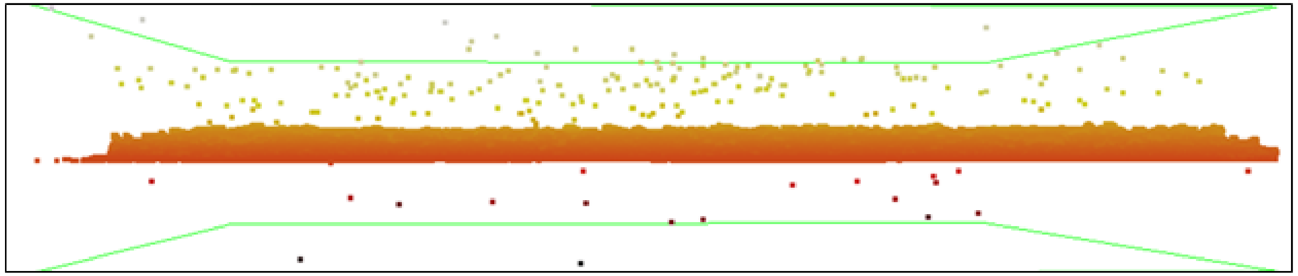
Classificar ruído

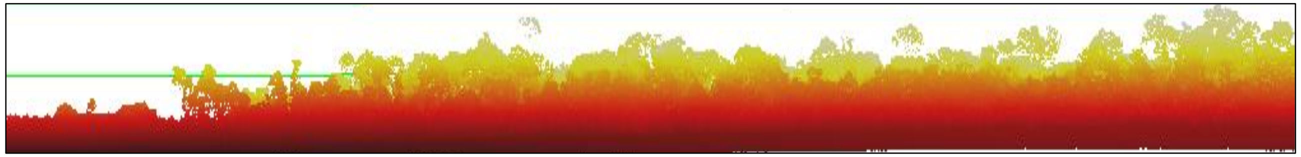


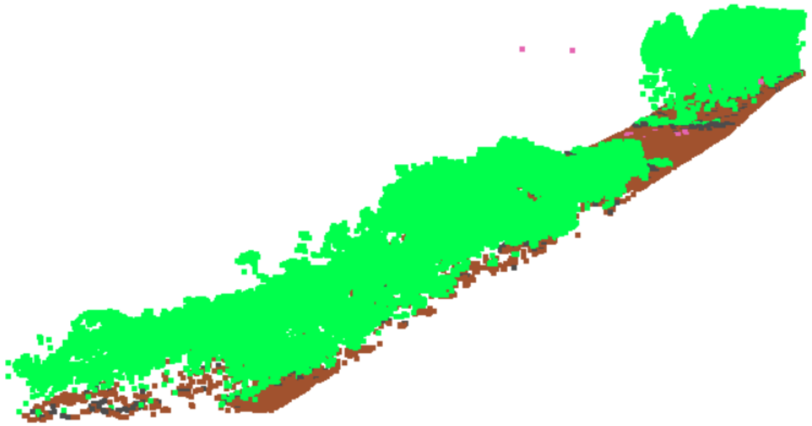


LiDAR no manejo de recursos florestais

Quadrículas limpas



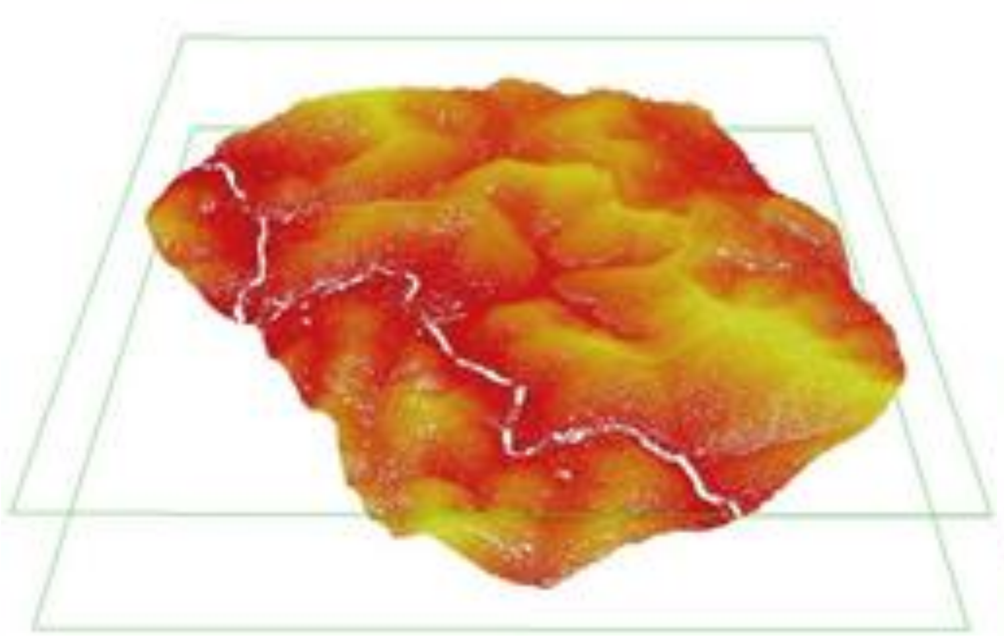


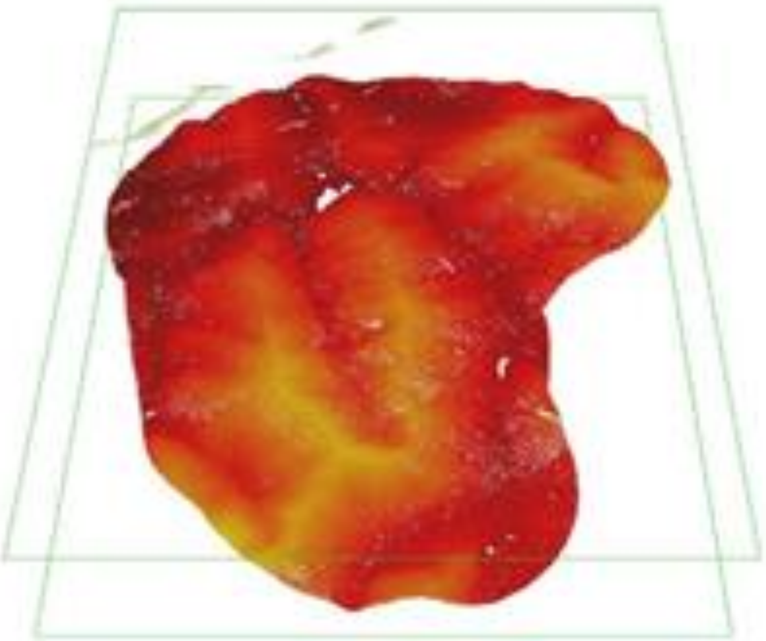


```
LASrun = LAStool('lasnoise', inDir,
          '-cores', cores,
          '-ignore_class 2',
          '-step 4',
          '-isolated 5',
          '-odir', outDir,
          '-odix _d',
          '-olaz -v')
```

LiDAR no manejo de recursos florestais

Criar nuvem para cada área de interesse





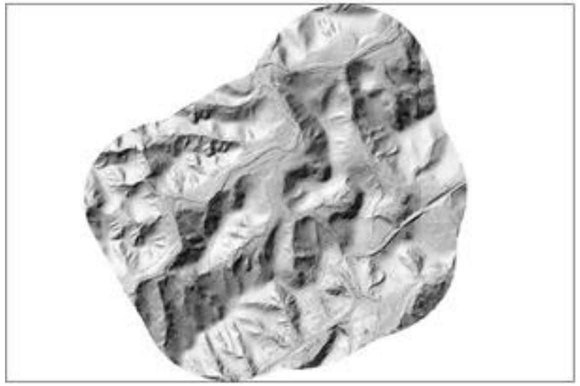
```
LASrun = LAStool('lasclip', inDir,
          '-merged',
          '-poly', inShp,
          '-split CUADRO',
          '-odir', outDir,
          '-olaz',
          '-v')
```

LiDAR no manejo de recursos florestais

Produzir mapas DTM e DSM

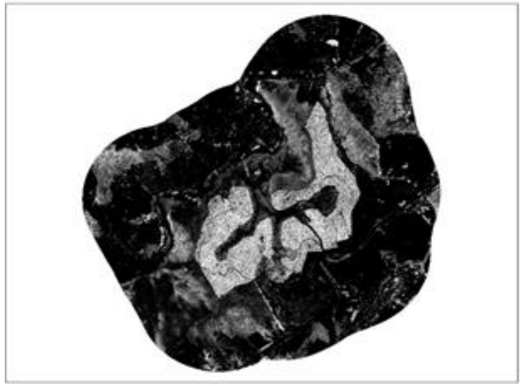
DTM (elevación del terreno)

```
LASrun = LAStool('blast2dem', inDir,
            '-keep_class 2',
            '-step 1',
            '-elevation',
            '-hillshade',
            '-odir', outDir,
            '-odix _dtm',
            '-opng -v')
```



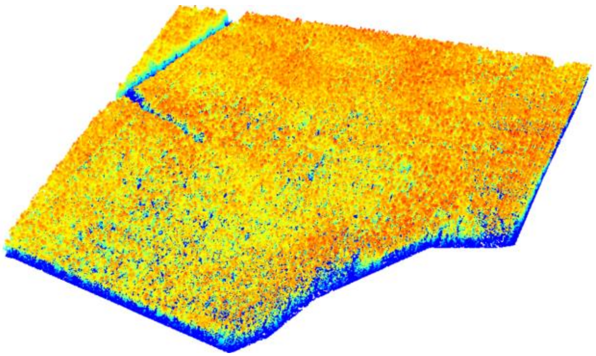
DSM (elevación del terreno + vegetación)

```
LASrun = LAStool('blast2dem', inDir,
            '-keep_class 2 5',
            '-step 1',
            '-elevation',
            '-hillshade',
            '-odir', outDir,
            '-odix _dsm',
            '-opng -v')
```



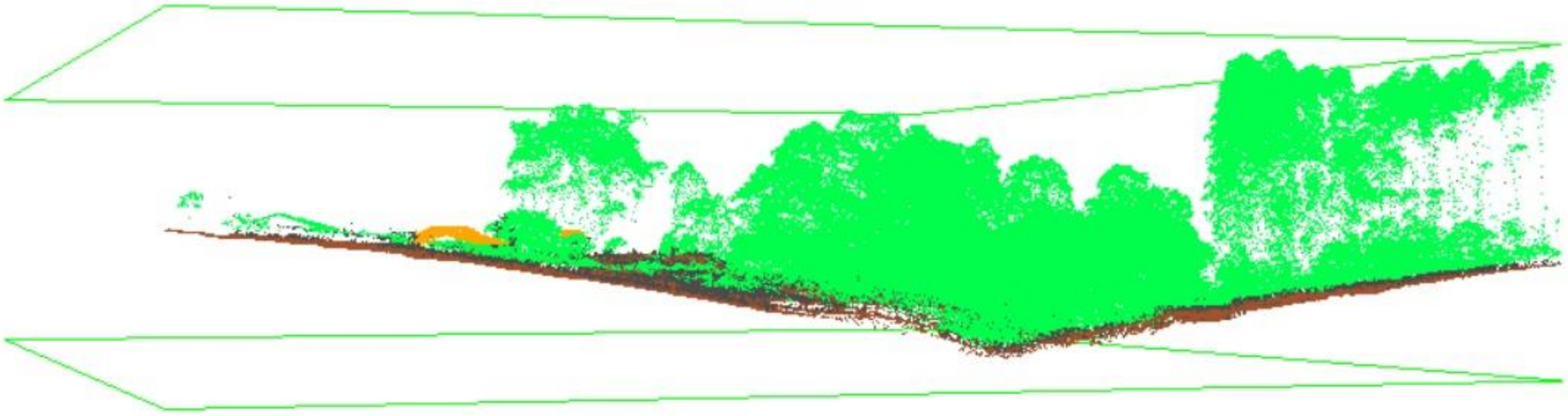
DEM (elevación solo de la vegetación)

```
LASrun = LAStool('lasgrid', inDir,
            '-user_data',
            '-step 1',
            '-false',
            '-odir', outDir,
            '-odix _dem',
            '-opng -v')
```

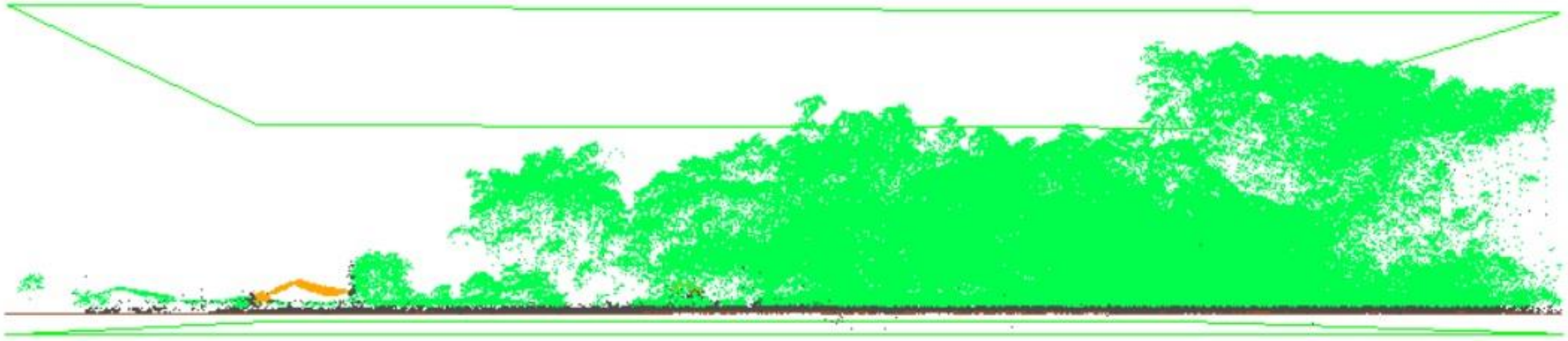


LiDAR no manejo de recursos florestais

Normalizar quadrículas

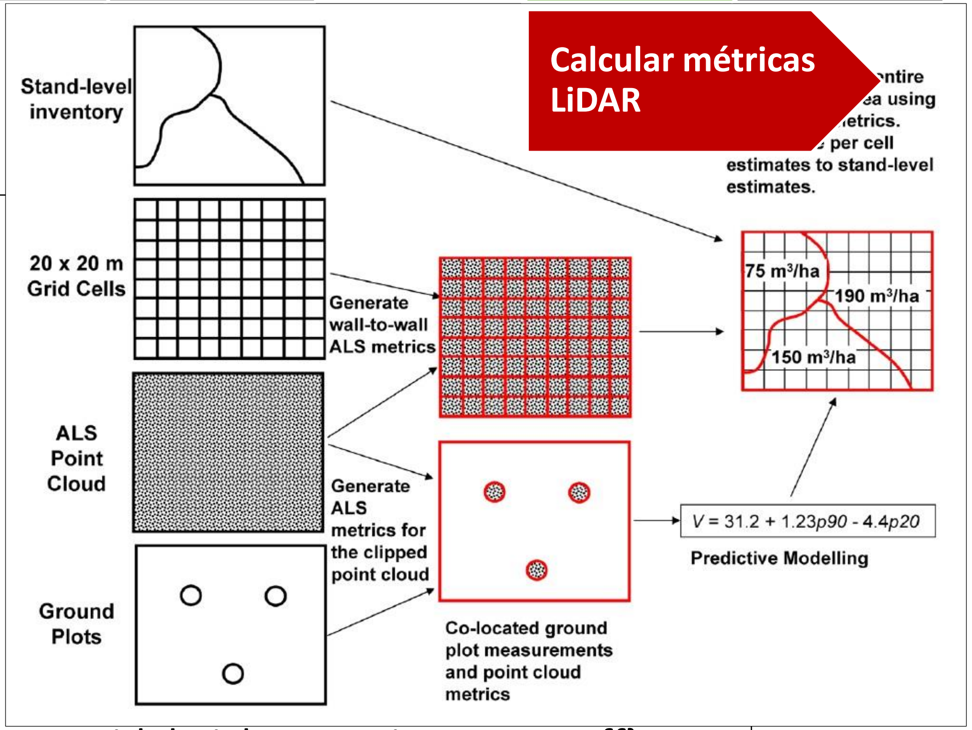


```
LASrun = LAStool('lasheight', inDir,
              '-cores', cores,
              '-replace_z',
              '-set_user_data 0',
              '-odir', outDir,
              '-odix _n',
              '-olaz -v')
```



Calcular métricas LiDAR

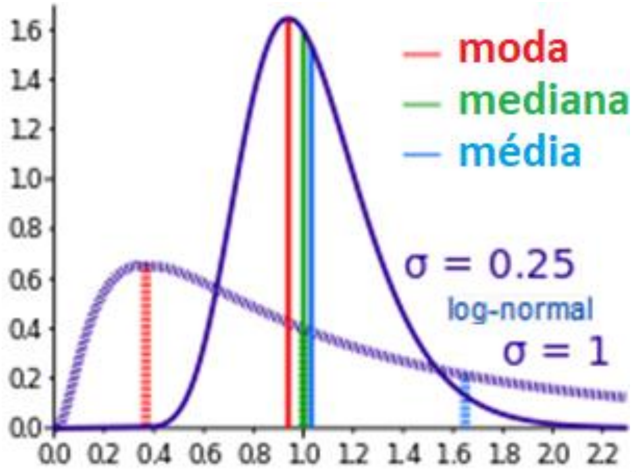
Métricas para o grid da área de estudo

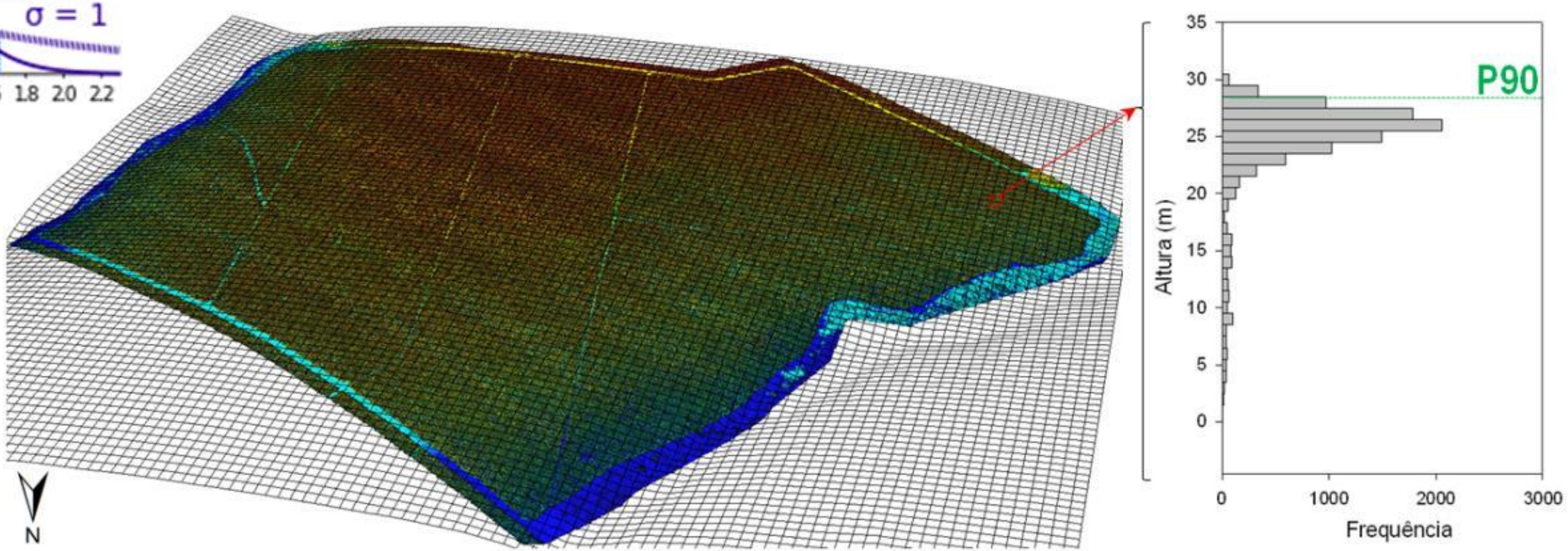



```
LASrun = LAStool('lascanopy', inDir,
            '-merged',
            '-keep_z 0.0 40.0 -drop_class 1',
            '-step ', cell_size,
            '-grid_ll 10 10',
            '-height_cutoff 0.5',
            '-cover_cutoff  1.3',
            '-max -avg -std -ske -kur -qav',
            '-cov',  # canopy cover (%) first returns above the cover cutoff / all first returns
            '-dns',  # (%) all returns above the cover cutoff   / all returns
            '-b 25 50 75', # points in the lower 25% "voxel" / "points in the voxel" {voxel: column with height = maximum - cutoff}
            '-c 0.5 1.3 10.0 20.0 35.0', # amount of points whose heights fall into the intervals
            '-d 0.5 1.3 10.0 20.0 35.0', # (%) points with heights into the intervals / total
            '-p 10 30 70 90',       # percentiles 10, 30, 70 and 90
            '-odir', outDir,
            '-o AtClip2016.asc',
            '-oasc -v')
```

LiDAR no manejo de recursos florestais

Calcular métricas LiDAR





LiDAR no manejo de recursos florestais

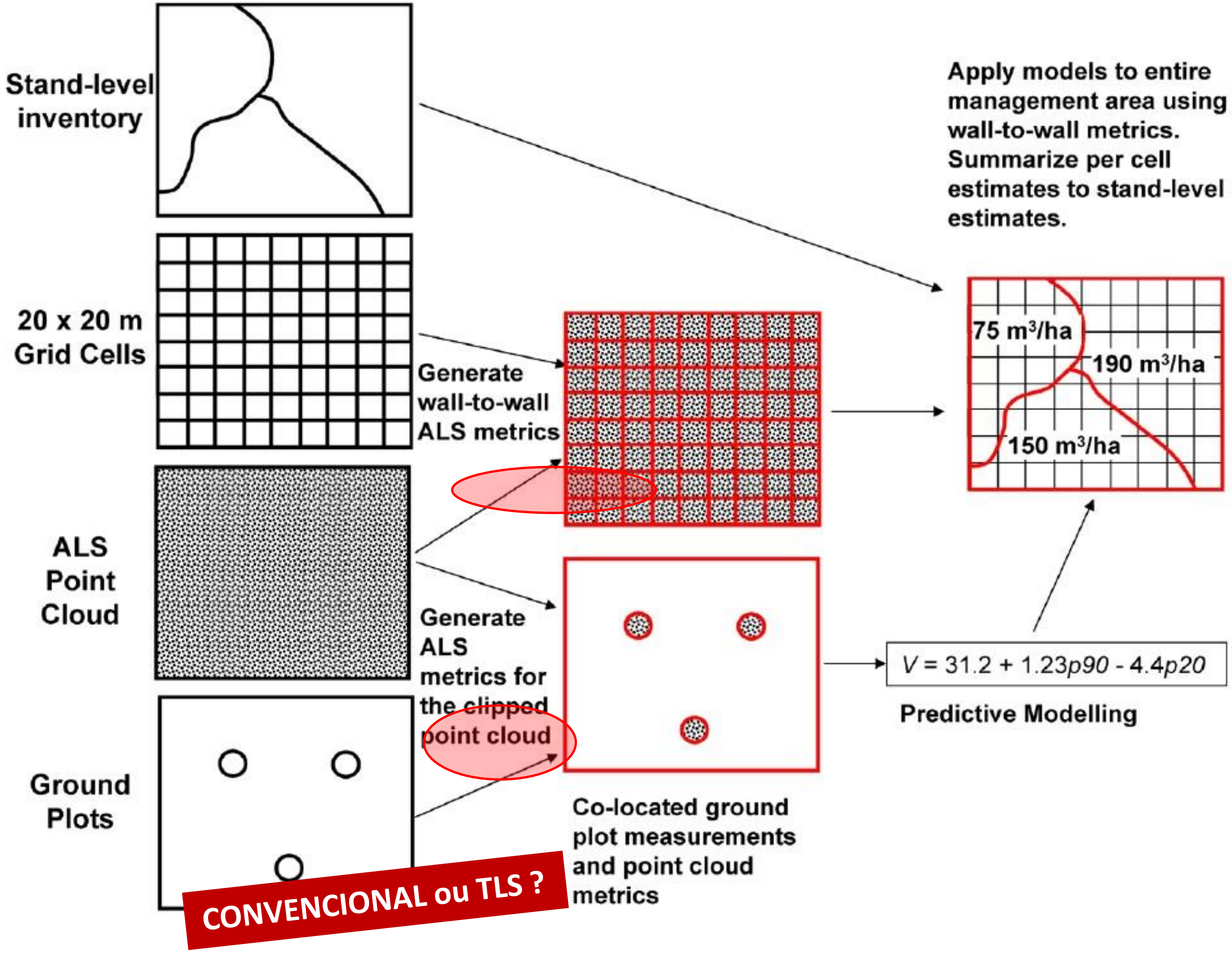
Calcular métricas LiDAR

Métricas de altura e cobertura de copa derivadas do LiDAR.

Category	LiDAR metric	Acronym
	Maximum Height	h_{max}
	Mean height	h_{mean}
	Standard deviation of mean height	h_{sd}
	Coefficient of variation of height	h_{cv}
	Mode of height	h_{mod}
	5th percentile of height	H5
	10th percentile of height	h10
	20th percentile of height	h20
	25th percentile of height	h25
Height	30th percentile of height	h30
	40th percentile of height	h40
	50th percentile of height	h50
	60th percentile of height	h60
	70th percentile of height	h70
	75th percentile of height	h75
	80th percentile of height	h80
	90th percentile of height	h90
	95th percentile of height	h95
	99th percentile of height	h99
Cover	Percentage of first returns above 2 m	C_{dens}

LiDAR no manejo de recursos florestais

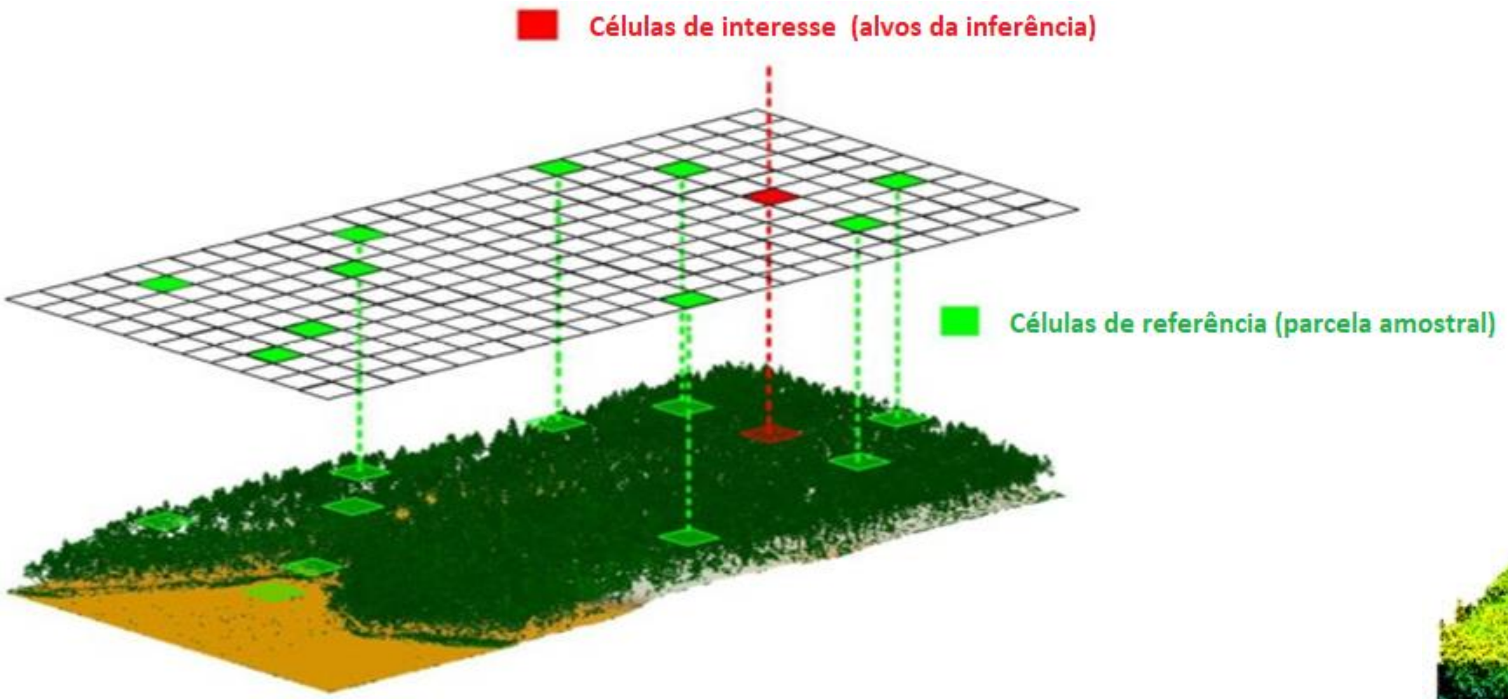
Inferir e produzir mapas



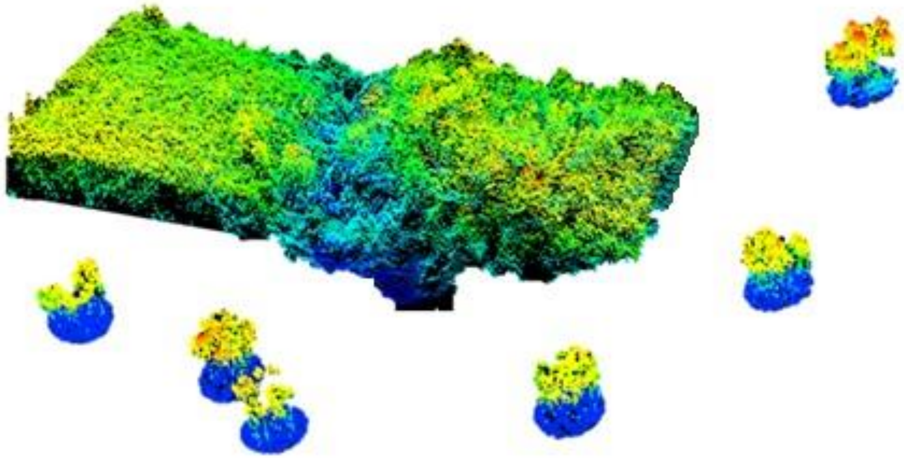
Joanne C. White; Michael A. Wulder; Andrés Varhola; Mikko Vastaranta; Nicholas C. Coops; Bruce D. Cook; Doug Pitt and Murray Woods.
A best practices guide for generating forest inventory attributes from airborne laser scanning data using an area-based approach (Version 2.0) Natural Resources, Canadian Forest Service, Canadian Wood Fibre Centre. Information Report FI-X-010, 2013.

LiDAR no manejo de recursos florestais

Inferir e producir mapas



CONVENCIONAL ou TLS ?



LiDAR no manejo de recursos florestais

Calcular métricas LiDAR

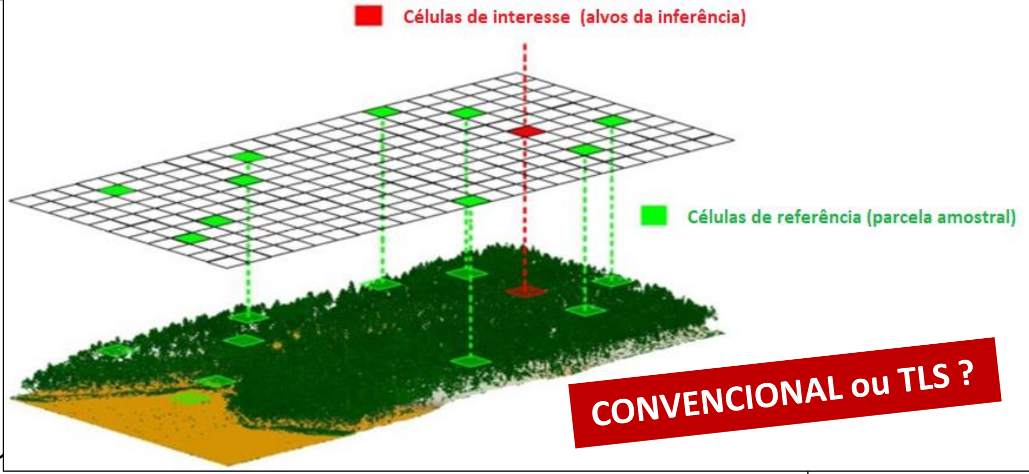
Métricas para as parcelas

1

```
LASrun = LAStool('lasclip', inDir,
                 '-merged',
                 '-poly', inShp,
                 '-split Plot',
                 '-odir', outDir,
                 '-olaz -v')
```

2

```
LASrun = LAStool('lascanopy', inDir,
                 '-keep_z 0.0 40.0',
                 '-drop_class 1',
                 '-files_are_plots',
                 '-names',
                 '-height_cutoff 0.5',   # for Pxx,Bxx, MAX, AVG, STD, SKE, KUR, QAV
                 '-cover_cutoff  1.3',   # for COV and DNS
                 '-max -avg -std -ske -kur -qav',
                 '-cov',  # canopy cover (%) first returns above the cover cutoff / all first retu
                 '-dns',  # (%) all returns above the cover cutoff   / all returns
                 '-b 25 50 75', # points in the lower 25% "voxel" / "points in the voxel" {voxel: column with height = maximum - cutoff}
                 '-c 0.5 1.3 10.0 20.0 35.0', # amount of points whose heights fall into the intervals
                 '-d 0.5 1.3 10.0 20.0 35.0', # (%) points with heights into the intervals / total
                 '-p 10 30 70 90',       # percentiles 10, 30, 70 and 90
                 '-odir', outDir,
                 '-o Atlas2016B_PlotMetrics.csv',
                 '-oasc -v')
```



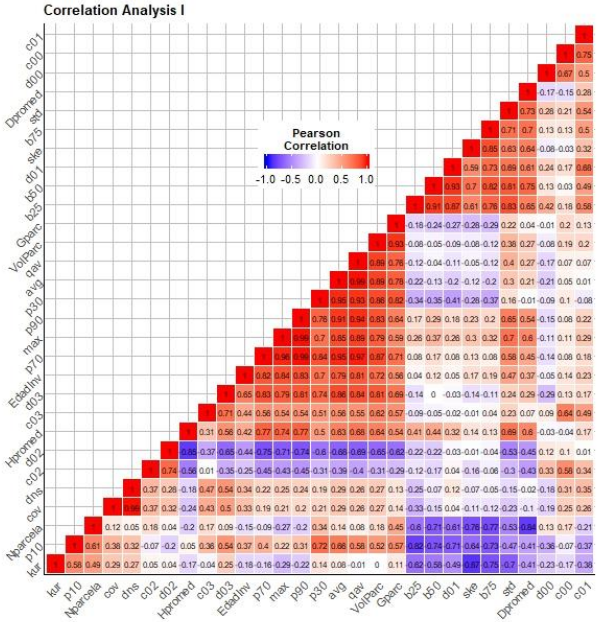
Geração de métricas LiDAR para as parcelas disponíveis (página anterior):

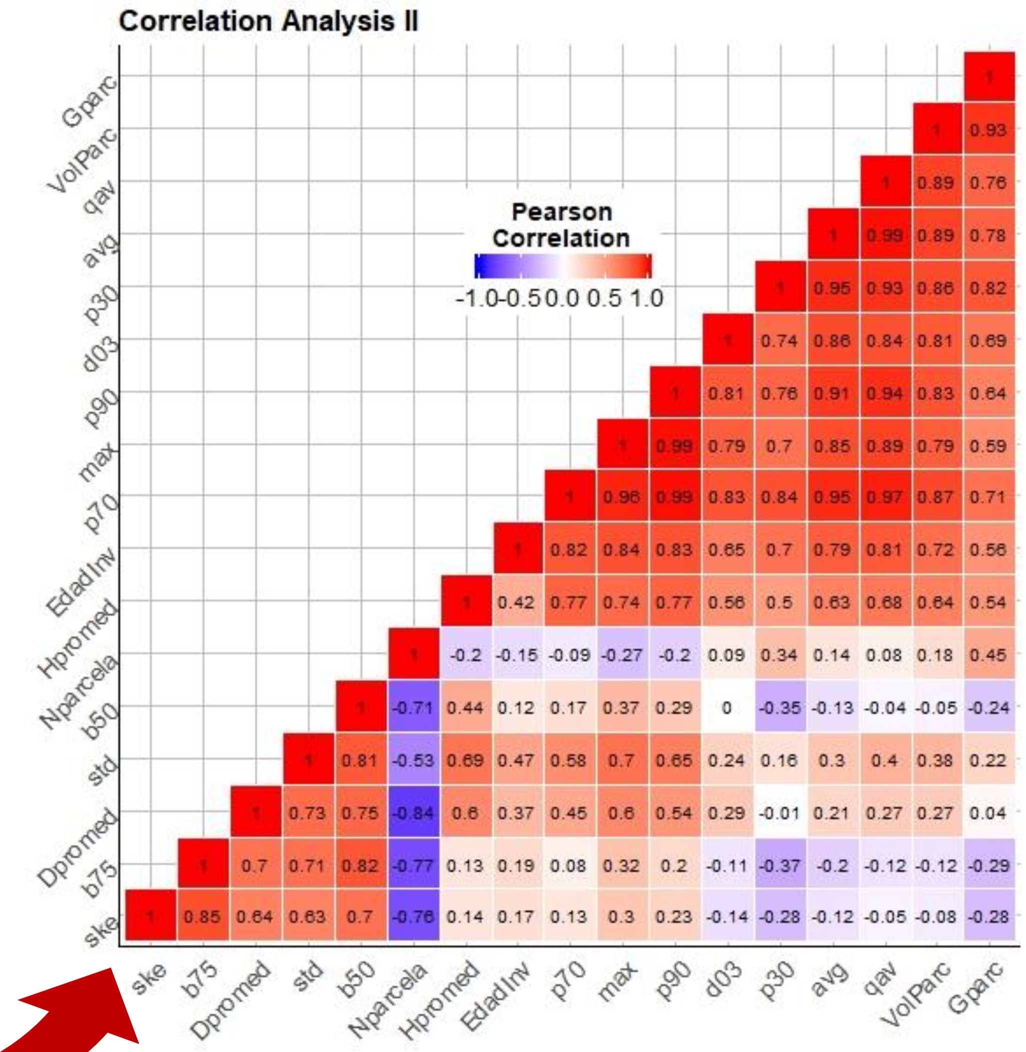
file_name	max	avg	qav	std	ske	kur	p10	p30	p70	p90	b25	b50	b75	c00	c01	c02	c03	d00	d01	d02	d03	cov	dns
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot742.laz	29.23	17.96	372.84	7.1	-0.49	1.96	7.45	13.03	23.13	26.06	10.4	34.9	62.4	3	301	394	770	0.1	13.2	17.2	33.7	69.2	64.1
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot758.laz	31.4	23.82	591.49	4.92	-1.9	7.82	18.17	22.87	26.58	28.51	2	7.3	37.8	31	218	1002	8611	0.2	1.7	7.7	66.4	85.3	75.8
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot769.laz	31.28	22.44	538.82	5.96	-1.46	5.1	14.54	21.36	26.02	28.27	4.7	12.4	47.4	0	65	208	888	0	2.8	9	38.4	48.9	50.2
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot776.laz	23.09	18.56	355.19	3.28	-3.52	18.64	16.36	18.22	20.02	21	2.5	2.5	18.7	5	11	402	183	0.4	0.8	30.3	13.8	52.3	44.9
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot777.laz	24.64	18.57	370.7	5.1	-1.96	6.3	11.05	18.68	21.22	22.47	6.4	11	29.1	20	173	741	1212	0.4	3.5	15	24.6	47.6	43.1
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot778.laz	23.31	18.22	349.43	4.19	-2.51	9.71	15.02	18	20.3	21.47	4.7	6.3	24.4	7	51	602	396	0.2	1.7	20.4	13.4	40.7	35.6
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot779.laz	31.85	22.8	558.15	6.21	-1.75	5.86	15.01	21.81	26.46	28.29	6.1	10.9	45.7	31	491	806	5497	0.3	5.1	8.4	57.4	76.3	70.9
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot783.laz	24.81	17.83	345.95	5.28	-1.67	5.17	9.52	17.43	20.86	22.33	6.6	13.6	38.7	8	78	358	345	0.3	2.9	13.5	13	33.2	29.4
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot785.laz	22.49	16.32	282.8	4.06	-1.97	6.68	10.74	16.17	18.32	19.77	5.2	10.5	43.6	19	312	2851	263	0.4	6.1	55.3	5.1	76.5	66.5
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot793.laz	29.71	19.34	407.1	5.76	-0.93	3.62	11.52	17.38	22.79	25.8	6.2	19.9	65.8	2	90	486	667	0.1	4.6	24.6	33.7	74.2	62.8
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot798.laz	30.61	21.64	504.43	6.02	-1.61	5.34	12.68	21.09	25	27.16	6.3	11.9	47.6	13	161	385	1587	0.3	4.2	10	41.1	63.9	55.2
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot800.laz	23.36	18.03	339.22	3.76	-2.08	7.98	14.29	17.39	20.16	21.32	2.9	6.5	33.9	3	69	846	471	0.1	2	24.9	13.9	49.7	40.9
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot801.laz	26.76	20.67	449.46	4.7	-2.21	8.14	15.49	20.43	22.97	24.68	4	7.6	26.3	4	95	351	1382	0.1	2.5	9.2	36	53.9	47.7
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot825.laz	22.97	17.43	321.09	4.17	-1.75	6.26	12.6	16.61	20.08	21.1	3.3	8.2	36.5	2	39	383	190	0.1	1.4	13.8	6.9	24.5	22.1
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot827.laz	22.09	17.97	327.56	2.13	-1.16	7.28	15.55	16.97	19.28	20.39	0.1	0.3	24.8	0	5	1169	233	0	0.2	57	11.4	82.8	68.6
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot828.laz	24.09	19.27	378.26	2.6	-1.92	11.24	16.48	18.36	20.72	21.99	0.8	1.5	27.4	1	20	1300	992	0	0.6	39.8	30.3	83.5	70.7
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot830.laz	22.73	18.23	342.72	3.21	-3.1	15.11	16.32	17.65	19.7	20.89	2.4	4.2	21	32	217	5008	1639	0.3	2.3	52.6	17.2	82.6	72.2
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot831.laz	25.61	20.9	442.69	2.41	-3.25	22.53	19.01	20.27	21.97	23.3	0.6	1.4	14.1	1	21	558	1769	0	0.6	16.6	52.6	82.2	69.8
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot833.laz	33.5	26.12	720.95	6.21	-2.12	7.28	17.01	26.29	29.33	31.04	3.7	9.9	20.4	7	89	157	1682	0.2	2.8	5	53.5	73.4	61.3
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot839.laz	24.56	21.2	452.78	1.86	-4.07	39.62	19.41	20.5	22.06	23.08	0.4	0.4	2.8	0	8	330	1327	0	0.3	14	56.4	81.3	70.8
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot840.laz	31.46	25.07	644.24	3.98	-2.34	12.32	21.24	24.08	26.96	29.05	1	3.3	24.3	4	16	74	1441	0.1	0.5	2.5	47.8	59.8	50.8
C:/3D/ALS/PRJ_UPM3/CLOUDS/2016/ATLAS/B.plotsDrone/Plot841.laz	32.1	25.5	679.88	5.46	-2.36	8.82	20.33	25.39	28.4	29.67	3.1	7.5	21.2	4	115	197	2911	0.1	2.1	3.6	52.7	71.4	58.4

Correlacionar métricas e medições de campo disponíveis:

Year	Plot	Area_Parce	Cuadro	Ciclo	Rotacion	EdadInv	VolParc	Hpromed	Dpromed	Gparc	Nparcela	Vol_Ha	G_Ha	N_Ha
2017	Plot742	314.159265	Q004	1	2	9	5.926481	24.918182	24.722727	0.5931	11	148.162013	18.878959	350.140875
2017	Plot758	314.159265	Q243e	1	1	10	9.21805	22.711765	18.066176	1.022215	34	230.45125	32.538114	1082.253613
2017	Plot769	314.159265	Q002	1	2	10	7.486739	24.526316	22.994737	0.862467	19	187.168487	27.453177	604.788784
2017	Plot776	314.159265	L138a	2	1	9	6.078294	20.838095	15.72619	0.850238	42	151.957346	27.063916	1336.901522
2017	Plot777	314.159265	L138	2	1	9	6.996427	22.697297	17.248649	0.921093	37	174.910672	29.319301	1177.746579
2017	Plot778	314.159265	L138a	2	1	9	5.152684	20.618182	15.927273	0.703725	33	128.817109	22.400262	1050.422624
2017	Plot779	314.159265	L135	1	1	11	9.71079	22.677419	20.532258	1.152852	31	242.769757	36.696419	986.760647
2017	Plot783	314.159265	L137	2	1	8	6.285326	22.695652	20.445652	0.780389	23	157.133157	24.840553	732.112738
2017	Plot785	314.159265	L137a	1	2	9	5.497792	18.142857	16.305357	0.659613	28	137.444805	20.996134	891.267681
2017	Plot793	314.159265	L135	1	1	11	7.15954	19.842105	22.068421	0.823232	19	178.98851	26.204288	604.788784
2017	Plot798	314.159265	L173	2	1	10	8.115064	22.057895	22.263158	0.839578	19	202.876589	26.724598	604.788784
2017	Plot800	314.159265	L136	1	1	8	6.205506	20.295	15.7475	0.845087	40	155.137656	26.899955	1273.239545
2017	Plot801	314.159265	L165	2	1	9	9.314354	22.924324	19.140541	1.157487	37	232.858858	36.843956	1177.746579
2017	Plot825	314.159265	L134a	1	1	9	5.928427	20.946154	18.757692	0.756834	26	148.210679	24.090774	827.605704
2017	Plot827	314.159265	L150	1	2	9	5.599261	17.52	17.746	0.664683	25	139.981528	21.157517	795.774715
2017	Plot828	314.159265	L150	1	2	9	6.49908	18.860606	16.313636	0.778576	33	162.47699	24.782844	1050.422624
2017	Plot830	314.159265	L152	1	2	9	6.477614	19.044737	15.436842	0.799919	38	161.94036	25.462213	1209.577567
2017	Plot831	314.159265	L151	2	1	9	6.950582	19.965909	15.478409	0.887655	44	173.764562	28.254936	1400.563499
2017	Plot833	314.159265	L157	2	1	11	9.530566	23.925	17.608333	1.055508	36	238.264153	33.597863	1145.91559
2017	Plot839	314.159265	L151	2	1	9	7.796942	21.878788	18.543939	0.925697	33	194.923547	29.465851	1050.422624
2017	Plot840	314.159265	L156	2	1	11	8.655438	23.273333	18.545	0.950892	30	216.385939	30.267832	954.929659
2017	Plot841	314.159265	L156	2	1	11	11.540235	25.314286	20.072857	1.251743	35	288.505871	39.844217	1114.084602

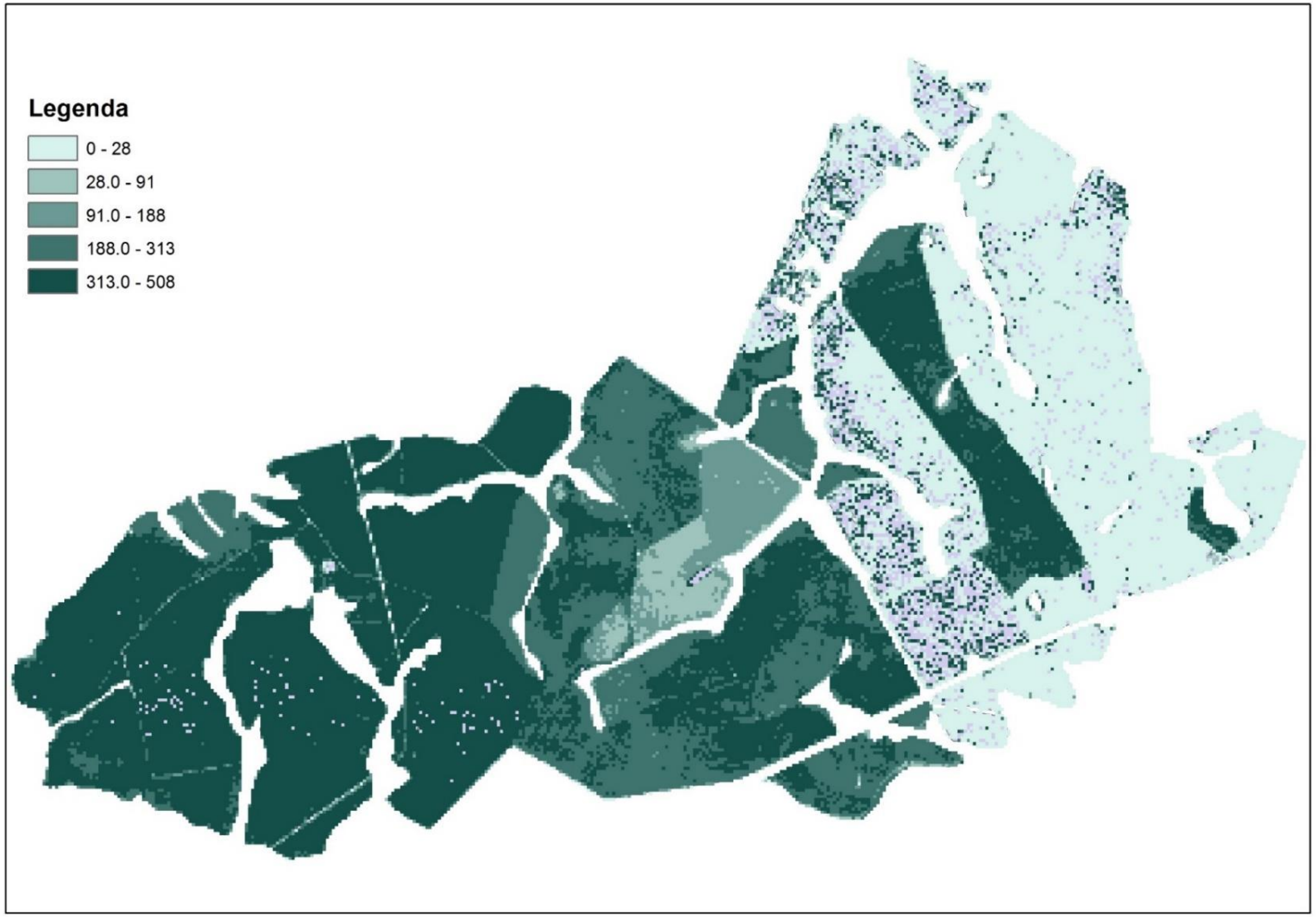
Buscando as melhores correlações





LiDAR no manejo de recursos florestais

Inferir e produzir mapas



Análise de dados LiDAR TLS para fins florestais

Inovação

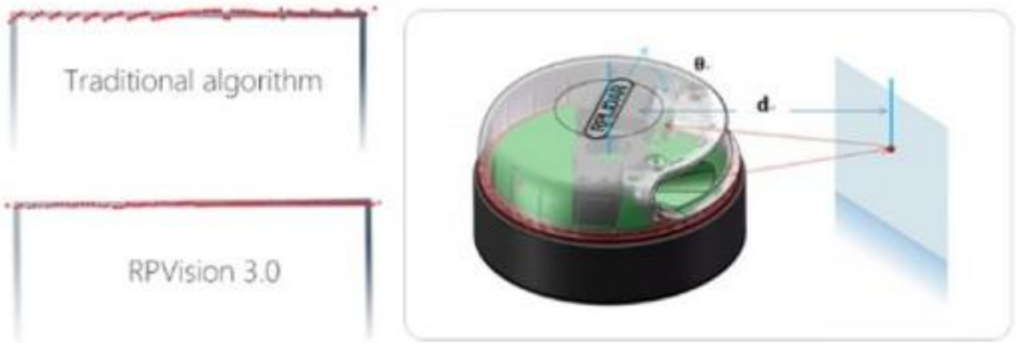
ForLiDAR

Criação de um equipamento TLS

- móvel
- portátil
- barato
- preciso
- de operação segura
- ergonômico

Sensores portáteis

Sensores portáteis



LiDAR no manejo de recursos florestais

LiDAR no manejo de recursos florestais

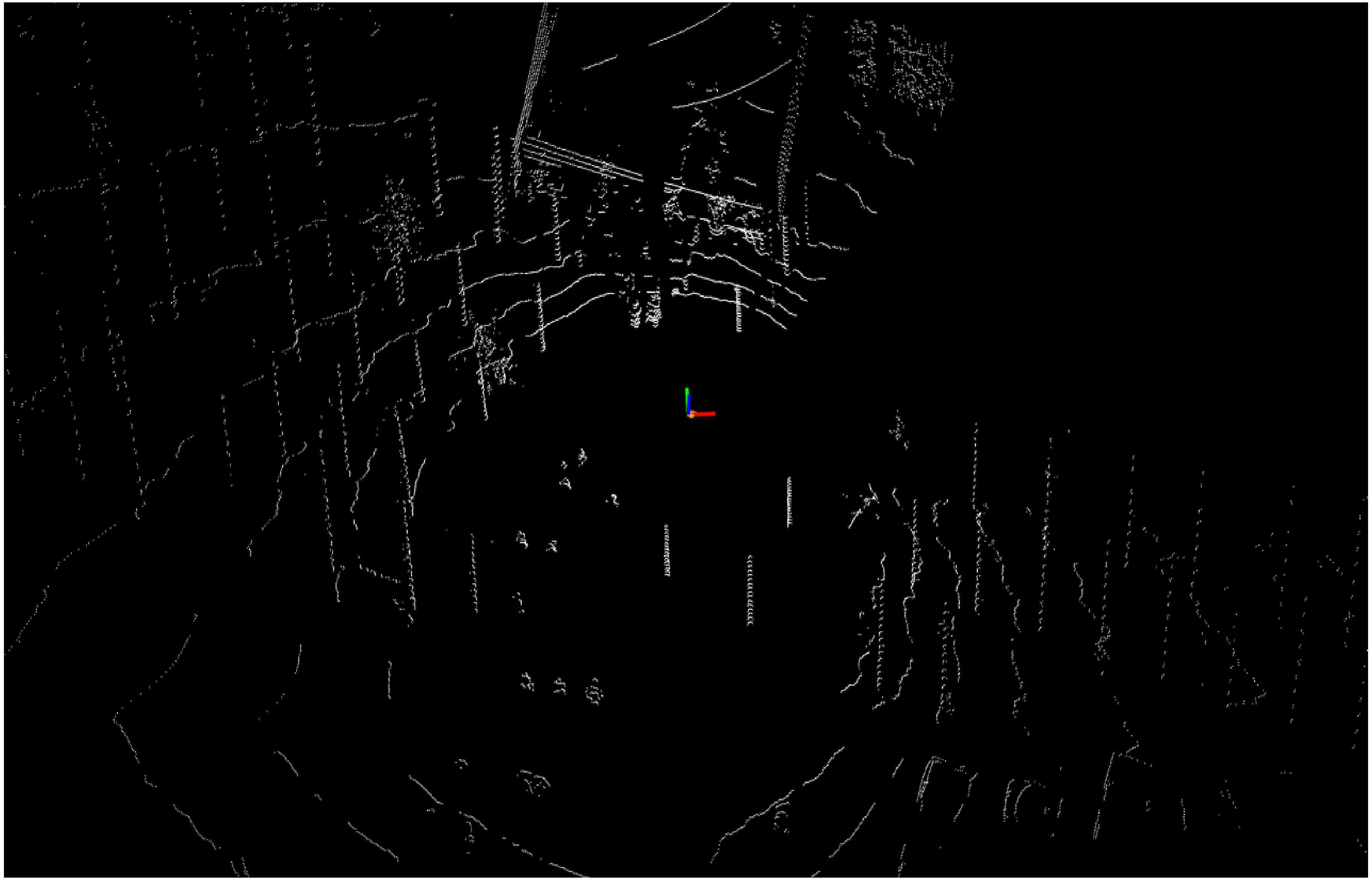
LiDAR no manejo de recursos florestais

LiDAR no manejo de recursos florestais

Backpack

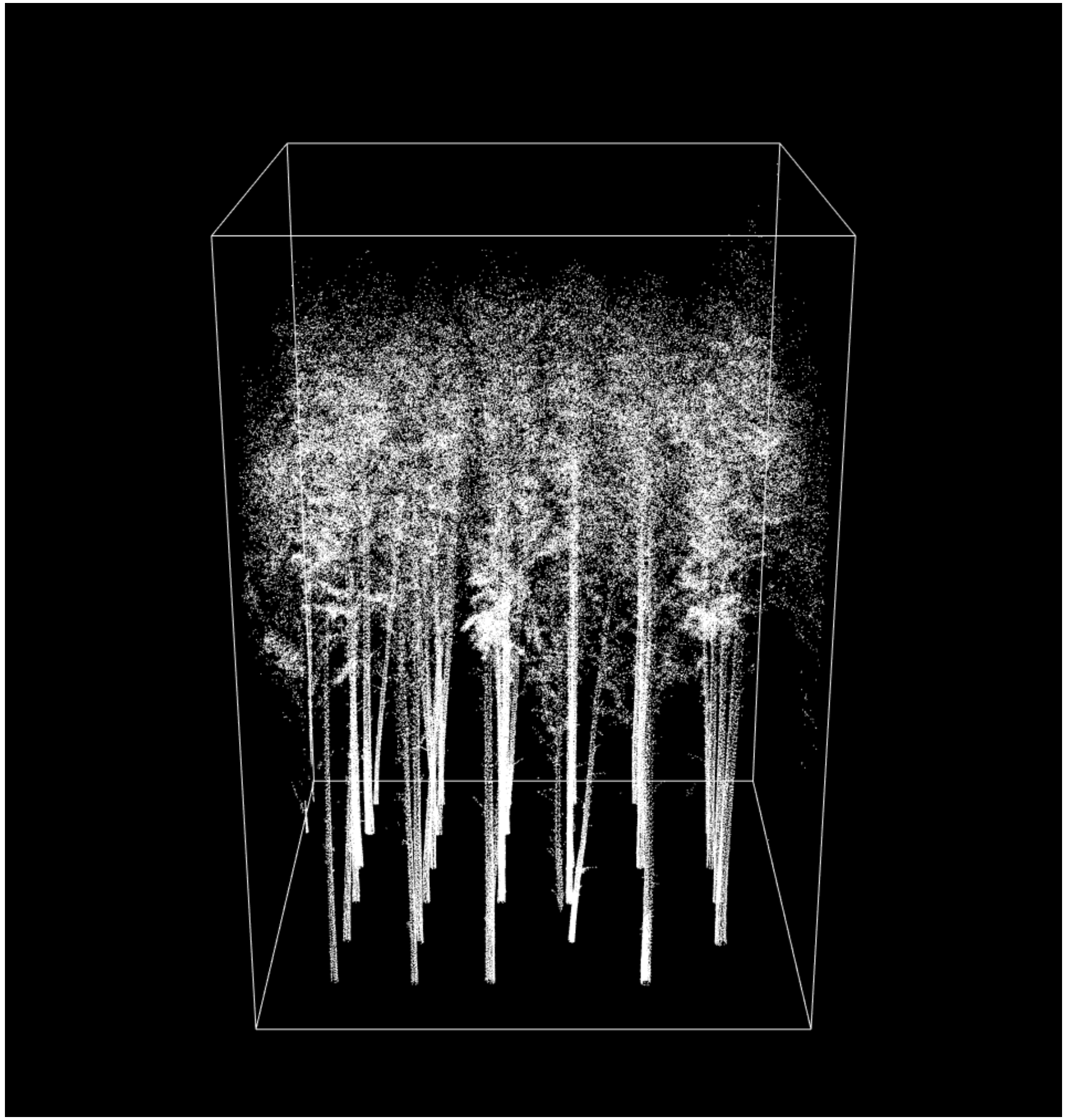
Forlidar

LiDAR no manejo de recursos florestais

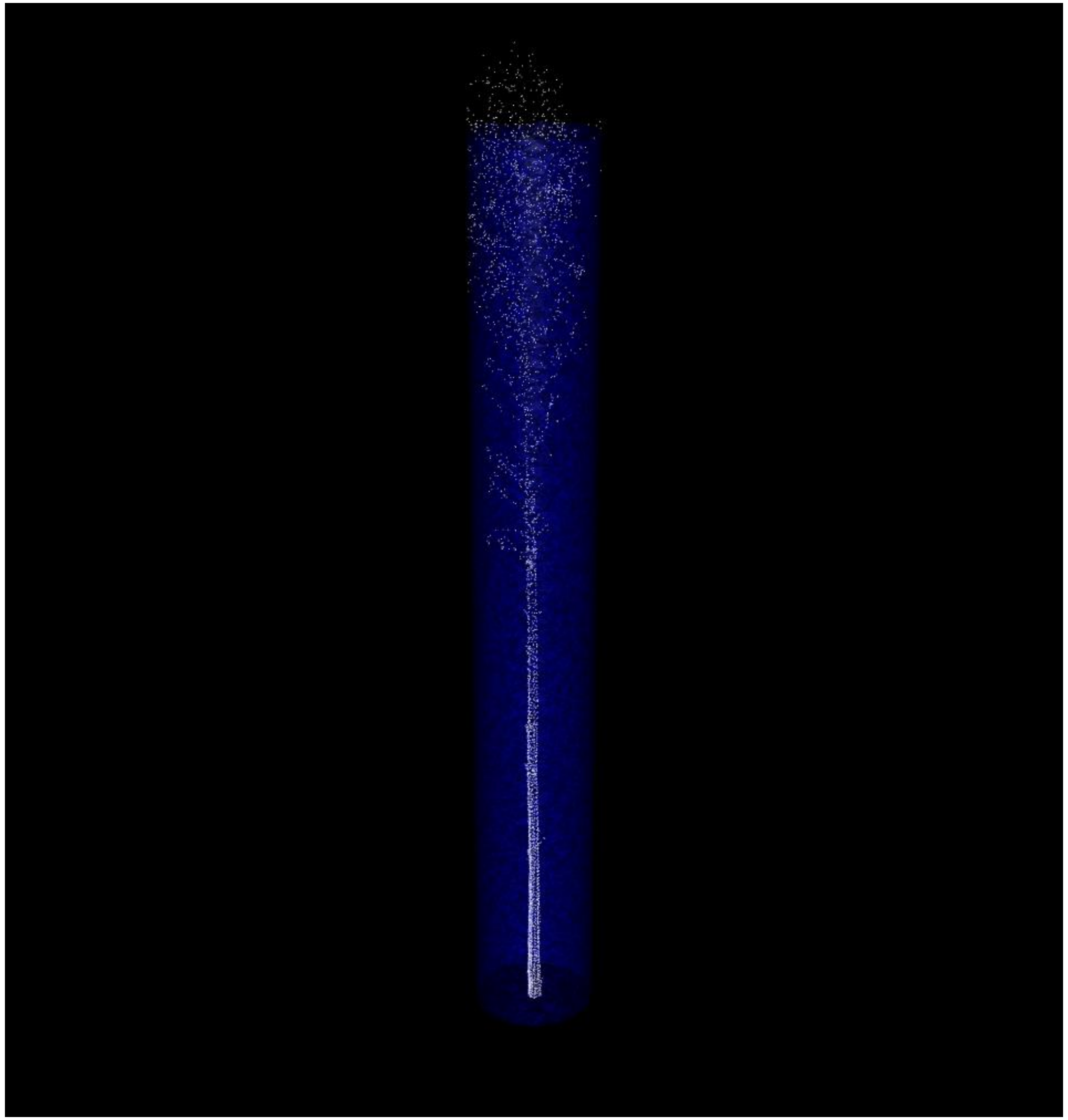


LiDAR no manejo de recursos florestais

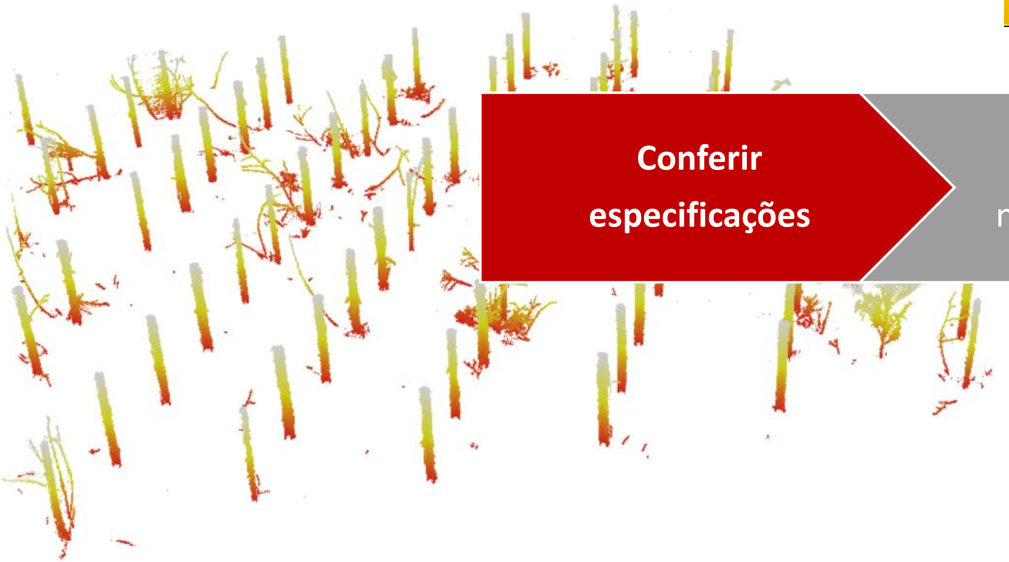
LiDAR no manejo de recursos florestais



LiDAR no manejo de recursos florestais



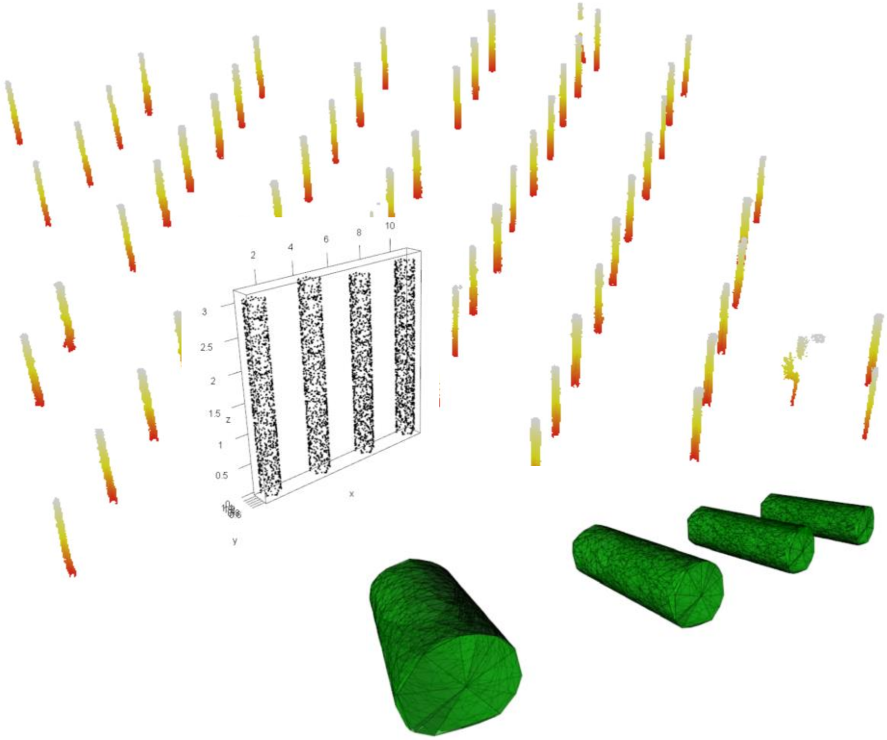
LiDAR no manejo de recursos florestais



Conferir especificações → Arrumar nuvens -> LAZ → Classificar solo e determinar alturas dos pontos → Classificar pontos da vegetação → Classificar ruído …

… Criar nuvem para cada parcela → Normalizar parcelas → Isolar árvores, calcular volumes e métricas LiDAR → **Inferir e pro modelo**

TLStrees



LiDAR no manejo de recursos florestais

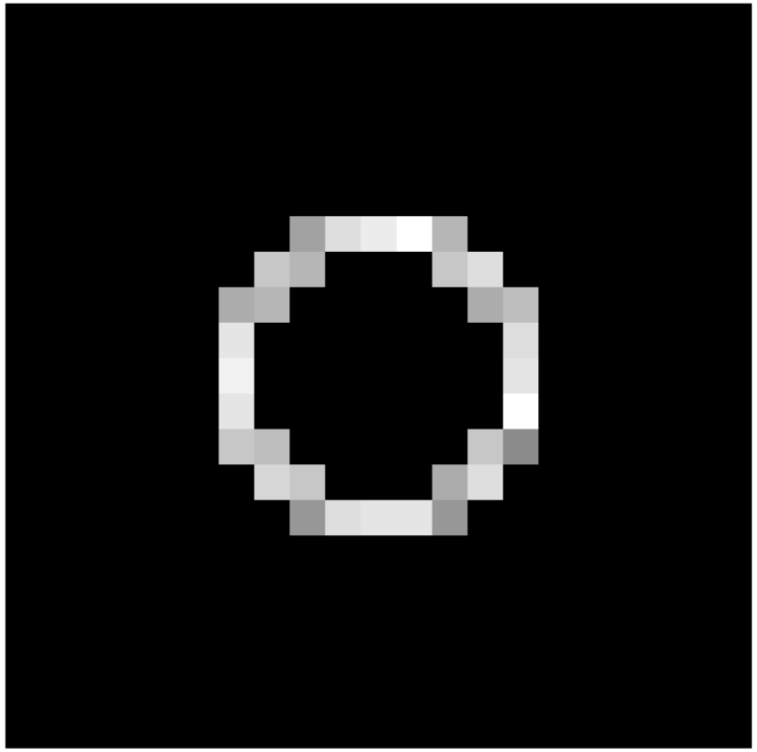
- Algoritmo de duas etapas
  - *Pré-filtragem*
    - Remoção de ruído e isolamento prospectivo de troncos
  - *Ajuste fino*
    - Isolamento preciso de troncos por meio de ajuste de círculos/cilindros

Pré-filtragem

Hough transformation and RANSAC circle fit
adapted from Olofsson et. al. (2014)

Hough transformation

- adapted from Olofsson et. al. (2014)
- iterative method
- looks for specific 2D shapes on raster layers
- counts *votes* on each pixel



LiDAR no manejo de recursos florestais

Pré-filtragem

Ajuste fino

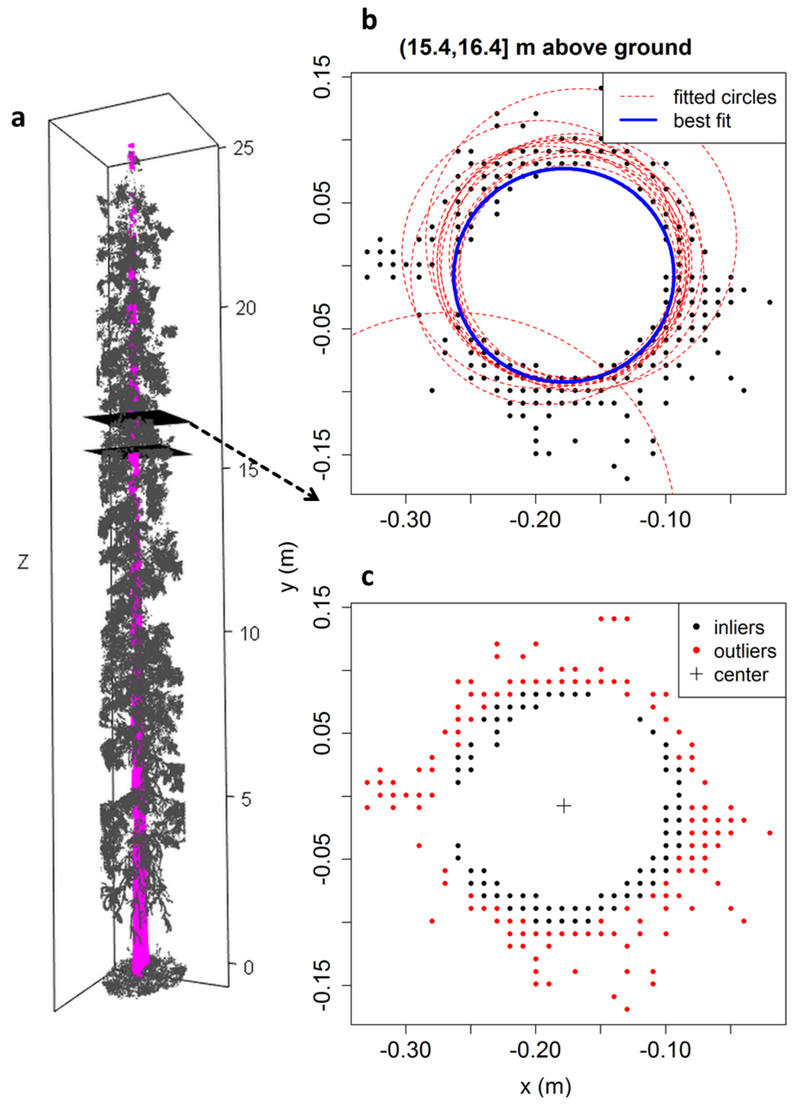
Hough transformation and **RANSAC circle fit**

adapted from Olofsson et. al. (2014)

- **RAN**dom **SA**mple **C**onsensus
- probability that all observations from a random sample belong to a model

$$N = \frac{log(1-P)}{log(1-p^n)}$$

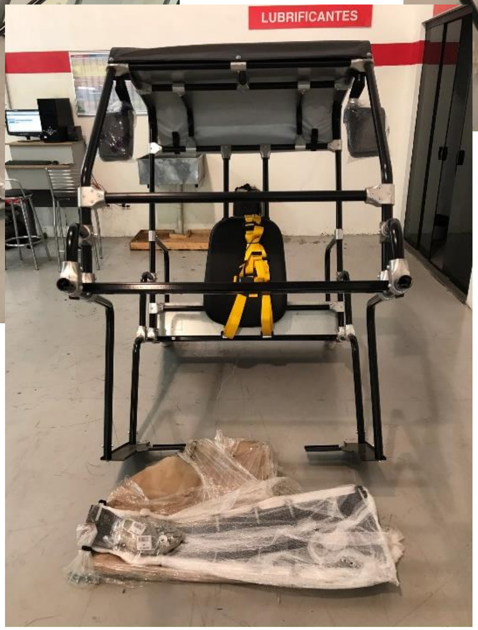
N = number of iterations
P = confidence level
p = proportion of *inliers* in the dataset
n = size of random sample



Ajuste fino

LiDAR – avanços e desafios

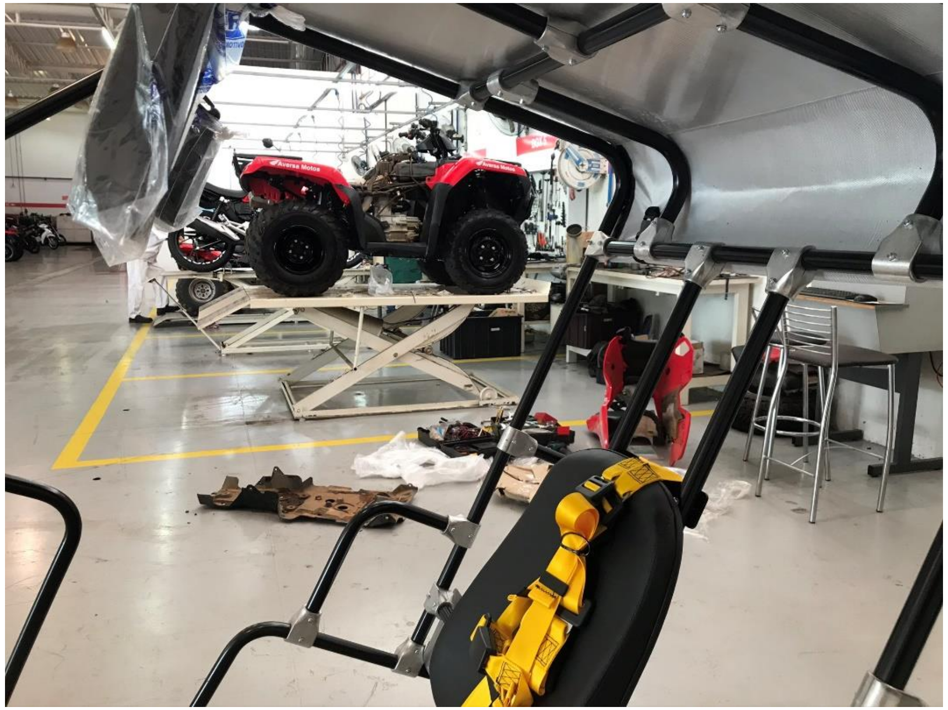
Novas plataformas: *quadrilaser*



Forlidar

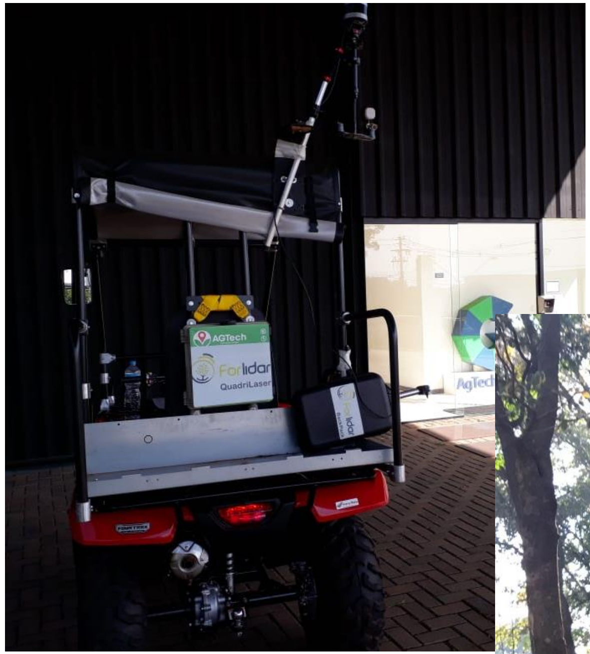
AGTech
agrotecnologia

LiDAR – avanços e desafios



Forlidar

LiDAR – avanços e desafios



Forlidar

LiDAR – avanços e desafios

Forlidar

LiDAR – avanços e desafios

Capacitação em Oficinas e Eventos

Startup ForLiDAR

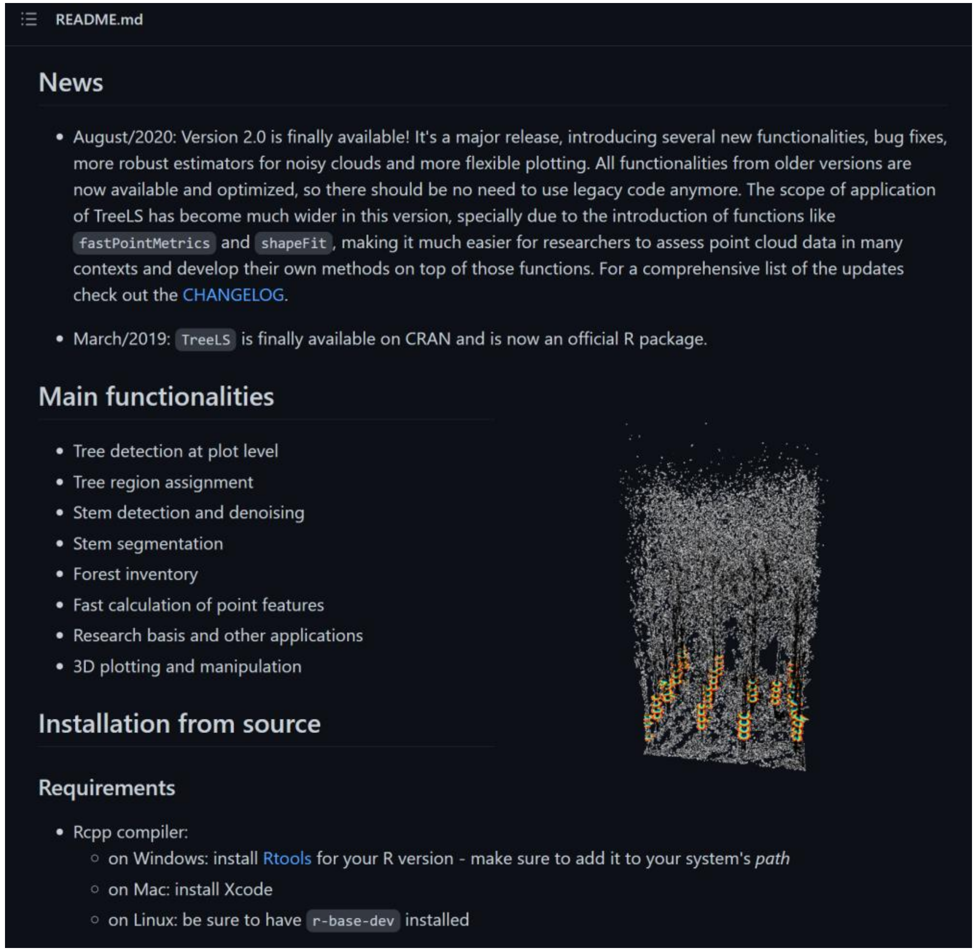
https://github.com/tiagodc/TreeLS

Tiago de Conto
Department of Geographycal Sciences
University of Maryland
https://geog.umd.edu/gradprofile/de-conto/tiago

Mobile Laser Scanning - towards a new standard for forest inventory

Parte 1: https://youtu.be/6xSKATE8amg

Parte 2: https://youtu.be/XKhRn8NzOPw



README.md

News

- August/2020: Version 2.0 is finally available! It's a major release, introducing several new functionalities, bug fixes, more robust estimators for noisy clouds and more flexible plotting. All functionalities from older versions are now available and optimized, so there should be no need to use legacy code anymore. The scope of application of TreeLS has become much wider in this version, specially due to the introduction of functions like `fastPointMetrics` and `shapeFit`, making it much easier for researchers to assess point cloud data in many contexts and develop their own methods on top of those functions. For a comprehensive list of the updates check out the CHANGELOG.
- March/2019: `TreeLS` is finally available on CRAN and is now an official R package.

Main functionalities

- Tree detection at plot level
- Tree region assignment
- Stem detection and denoising
- Stem segmentation
- Forest inventory
- Fast calculation of point features
- Research basis and other applications
- 3D plotting and manipulation

Installation from source

Requirements

- Rcpp compiler:
  - on Windows: install Rtools for your R version - make sure to add it to your system's *path*
  - on Mac: install Xcode
  - on Linux: be sure to have `r-base-dev` installed

LiDAR – avanços e desafios

Próximos passos:

Desenvolvimento de indicadores de monitoramento da restauração florestal com LiDAR e imagens multiespectrais de alta resolução

Clayton Bittencourt Junior (dissertação de mestrado 2021)

Detecção de padrões em nuvens de pontos LiDAR a partir de algoritmos baseados em inteligência artificial

Obrigado!

lcer@usp.br