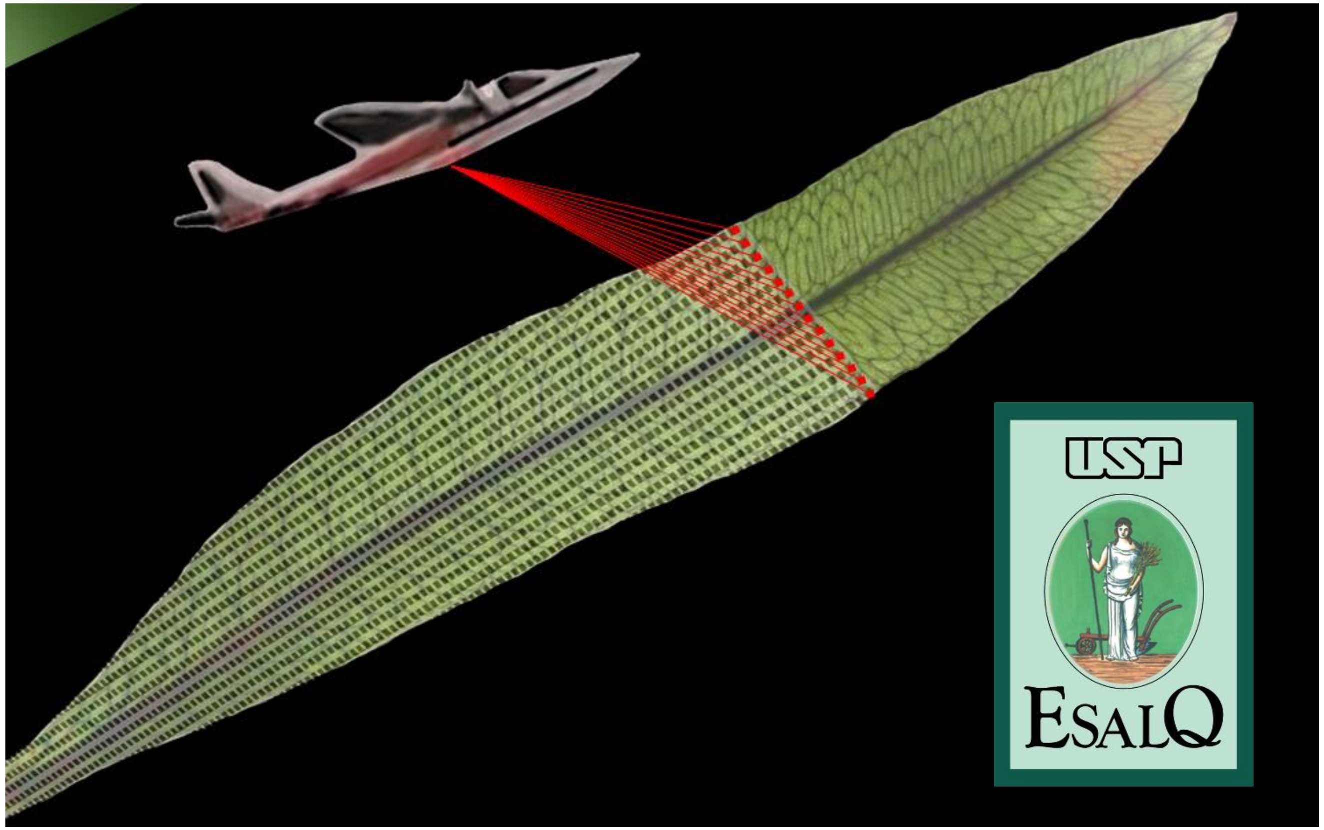
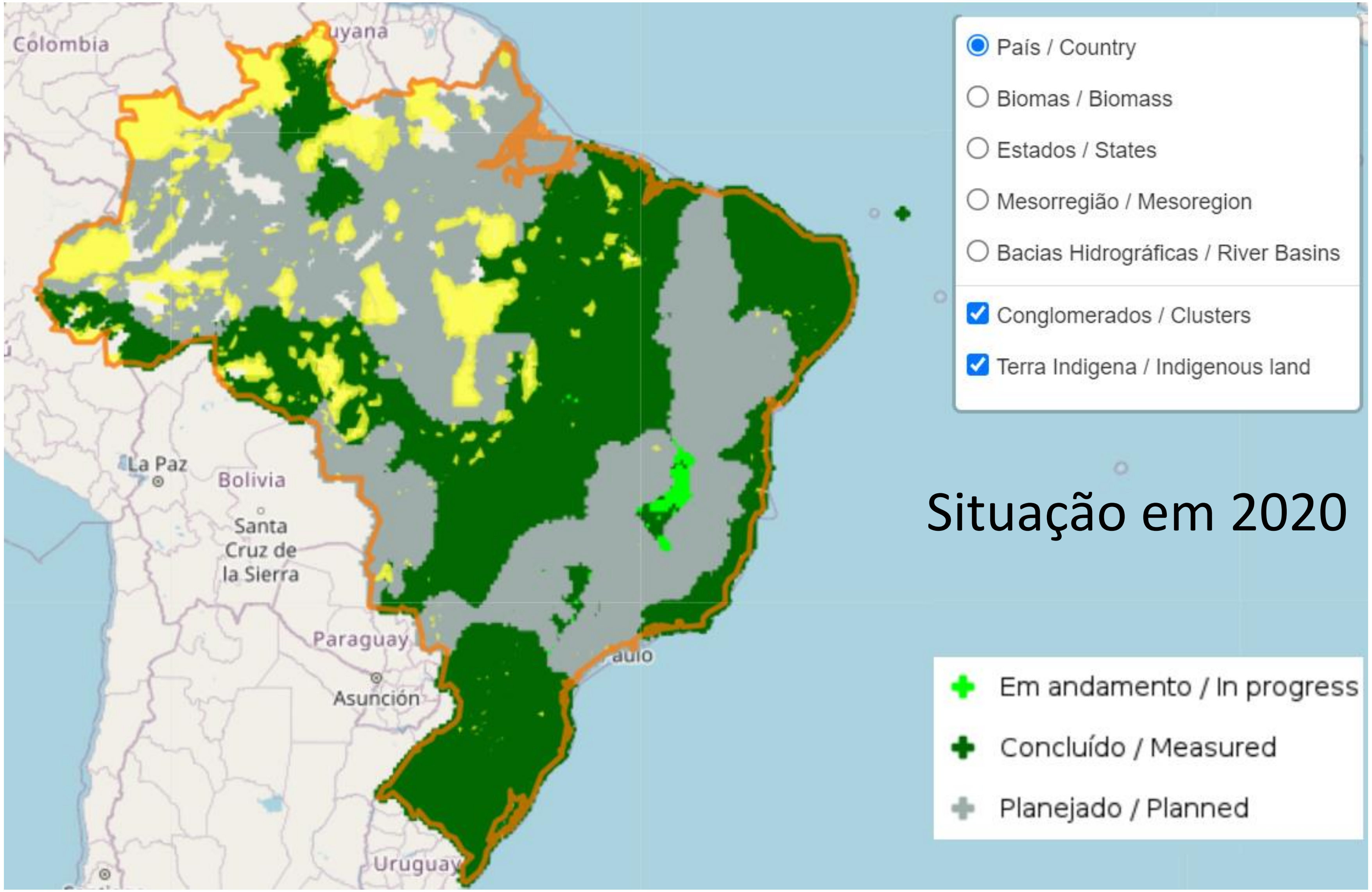


LiDAR – APLICAÇÕES FLORESTAIS

Luiz Carlos Estraviz Rodriguez

LCF0586 – Gestão de Recursos Florestais

Imaginem-se tendo que fazer o Inventário Florestal Nacional Brasileiro

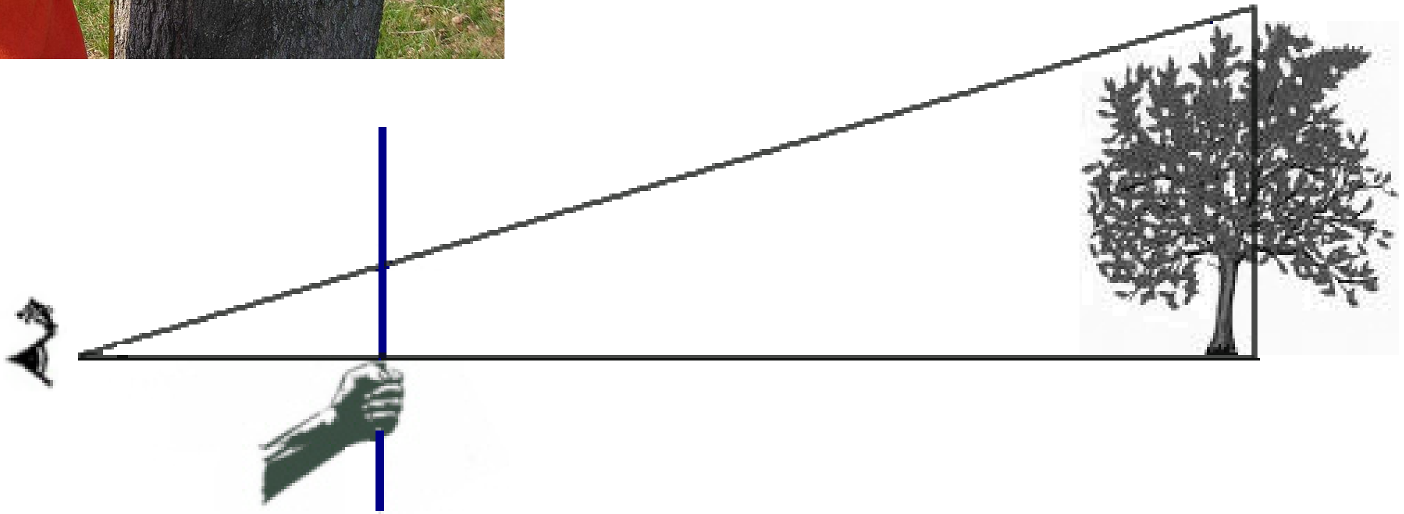


Situação em 2020

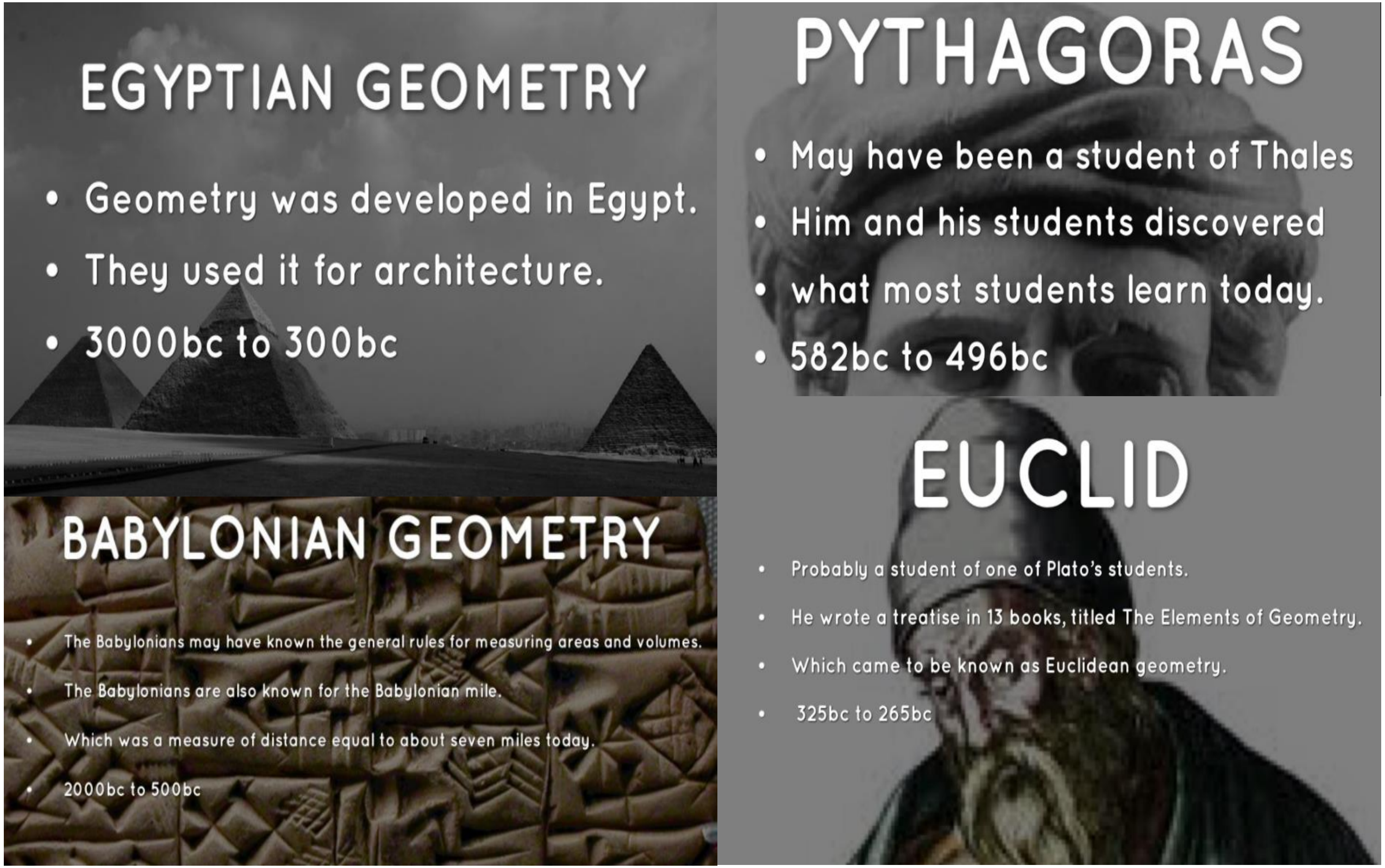
Fonte: https://sistemas.florestal.gov.br/mapas/geifn/

... ou o inventário de extensas florestas plantadas

... usando princípios rudimentares de medição



... e trigonometria elementar



Inovação

forLiDAR

GET-LiDAR

Grupo de Estudos em Tecnologias LiDAR

As novas tecnologias 3D para inventário e monitoramento florestal podem:

reduzir custos
gerar estimativas mais precisas
aumentar a segurança no campo
ser ergonomicamente mais adequadas

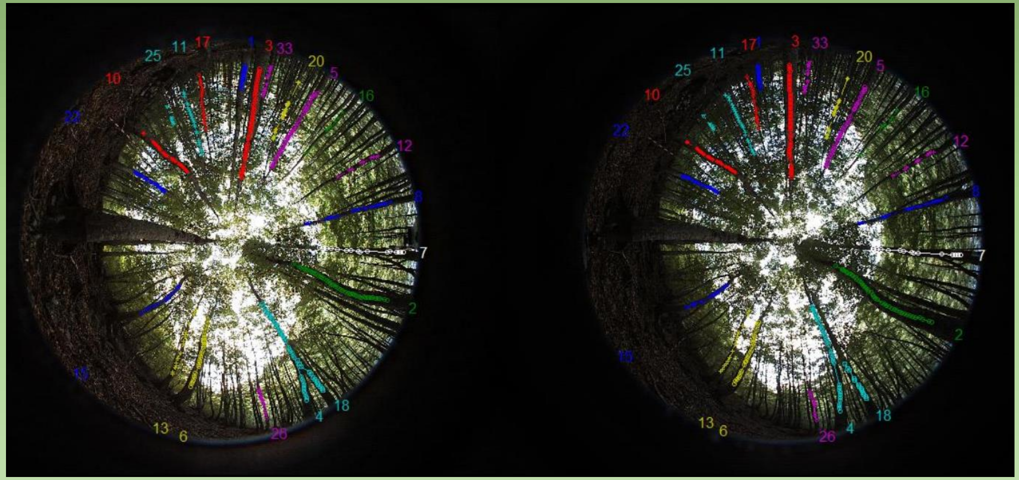
Tecnologias promissoras

Visão Artificial
Visão computacional
Percepção visual

Baseado em princípios de "structure from motion" (SfM)
processo de estimação de estruturas tridimensionais a partir de uma sequência de imagens bidimensionais que podem se integrar a sinais locais de movimento

Simula a forma como percebemos a tridimensionalidade das coisas que inclui mover-nos em volta ou fazer as coisas se moverem

Estereoscopia com lentes hemisféricas

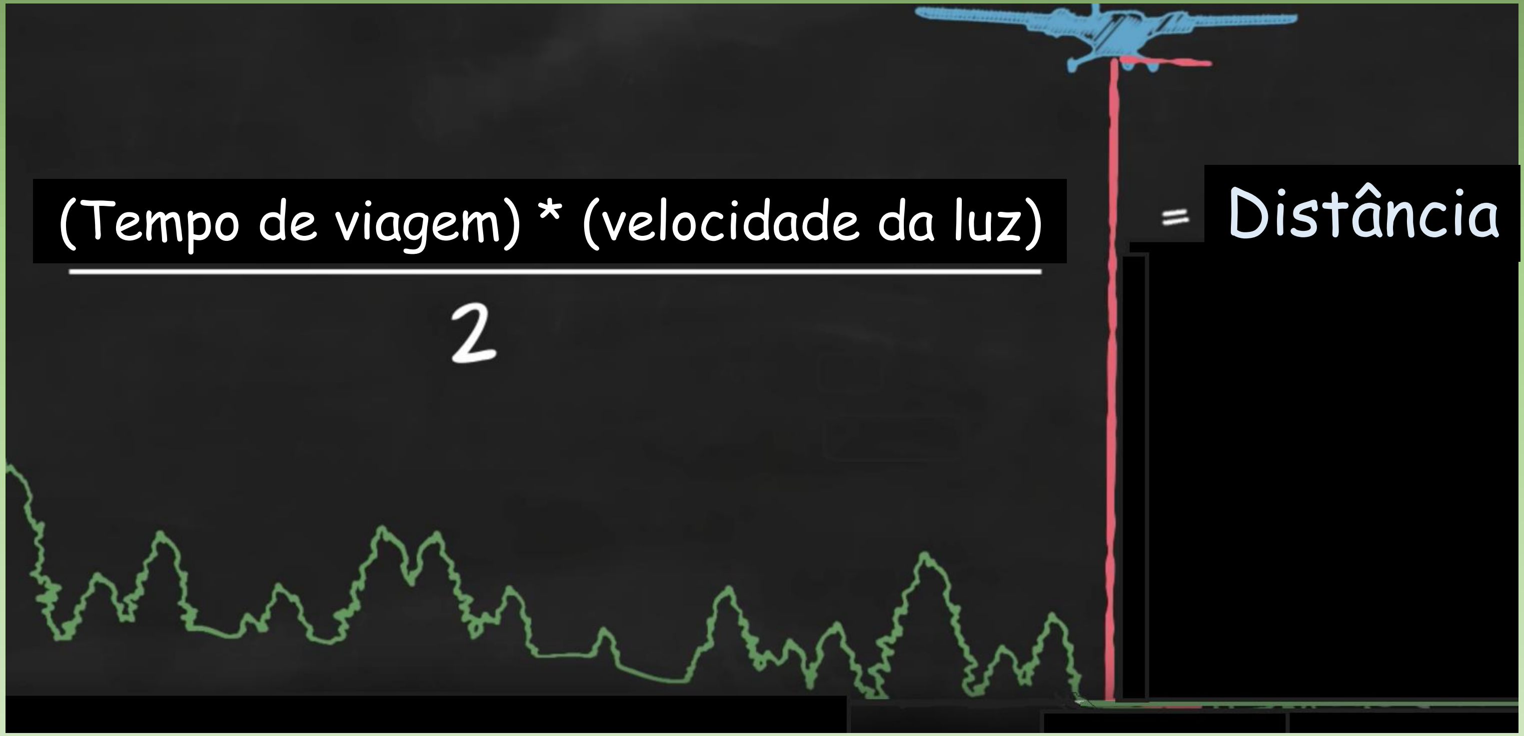


LiDAR

O que é LiDAR?

LiDAR – Light Detection And Ranging

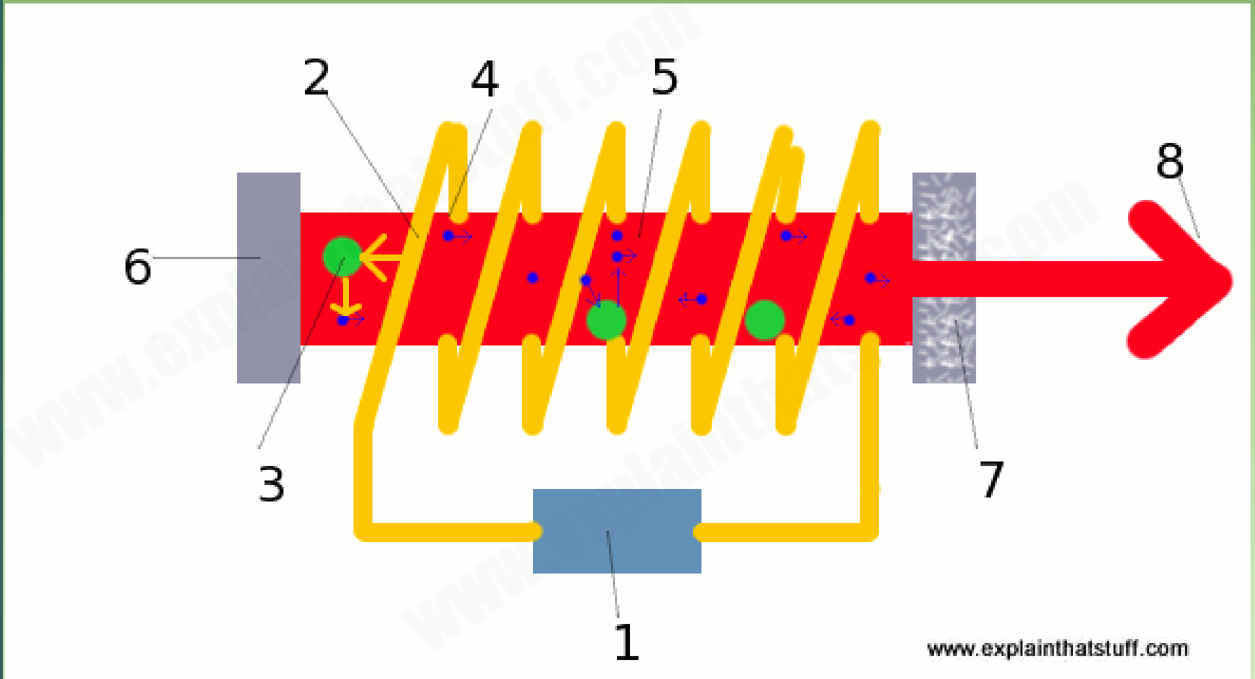
Tecnologia que possibilita o cálculo de distâncias baseado na cronometragem do tempo de viagem dos fótons de luz emitidos por um **laser**



O que é laser?

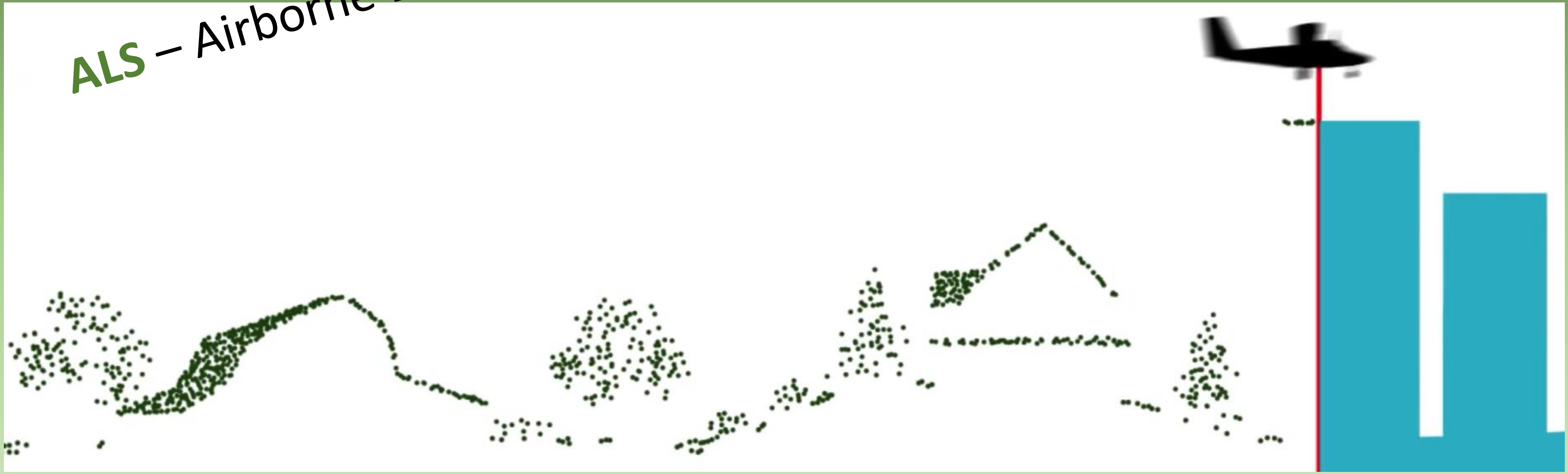
laser - light amplification by stimulated emission of radiation

1. Alta tensão faz tubo fosforescente piscar.



O emissor laser pode estar em um avião

ALS – Airborne Laser Scanning

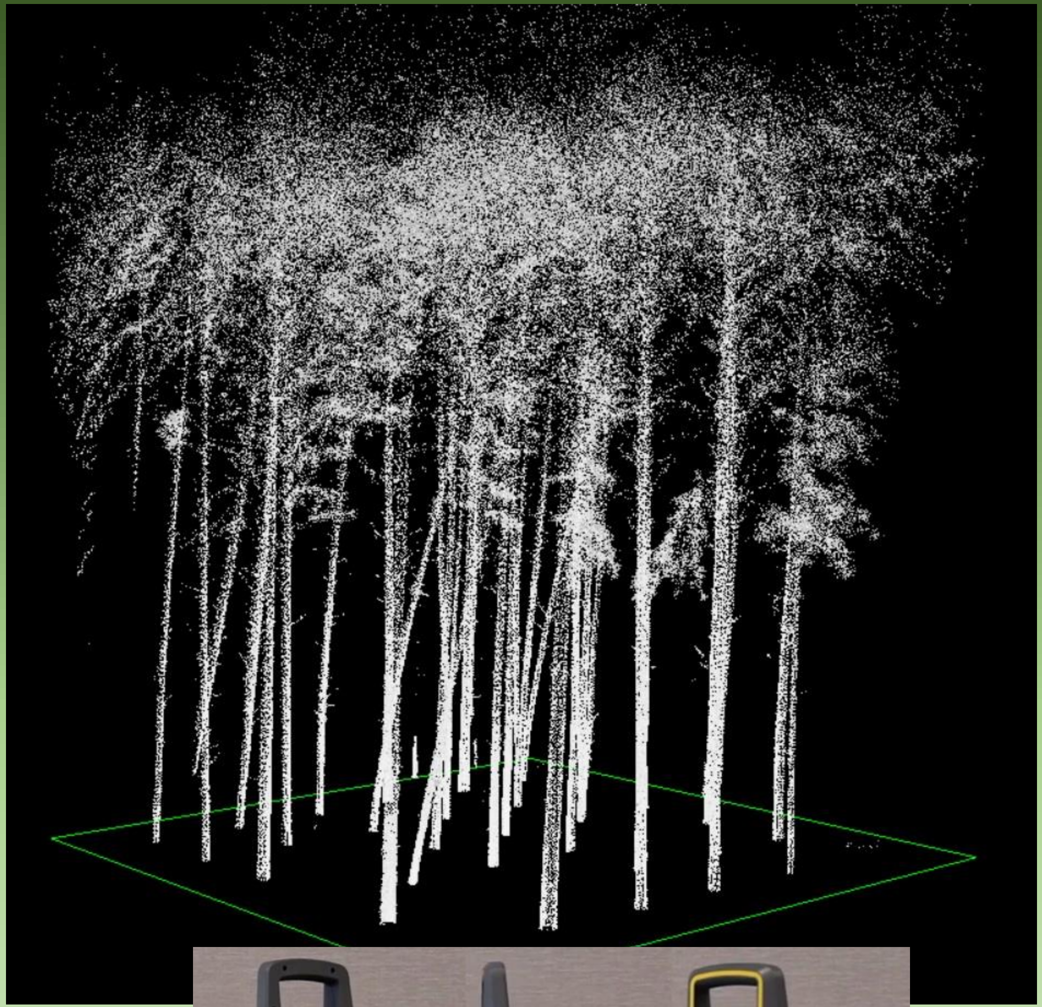


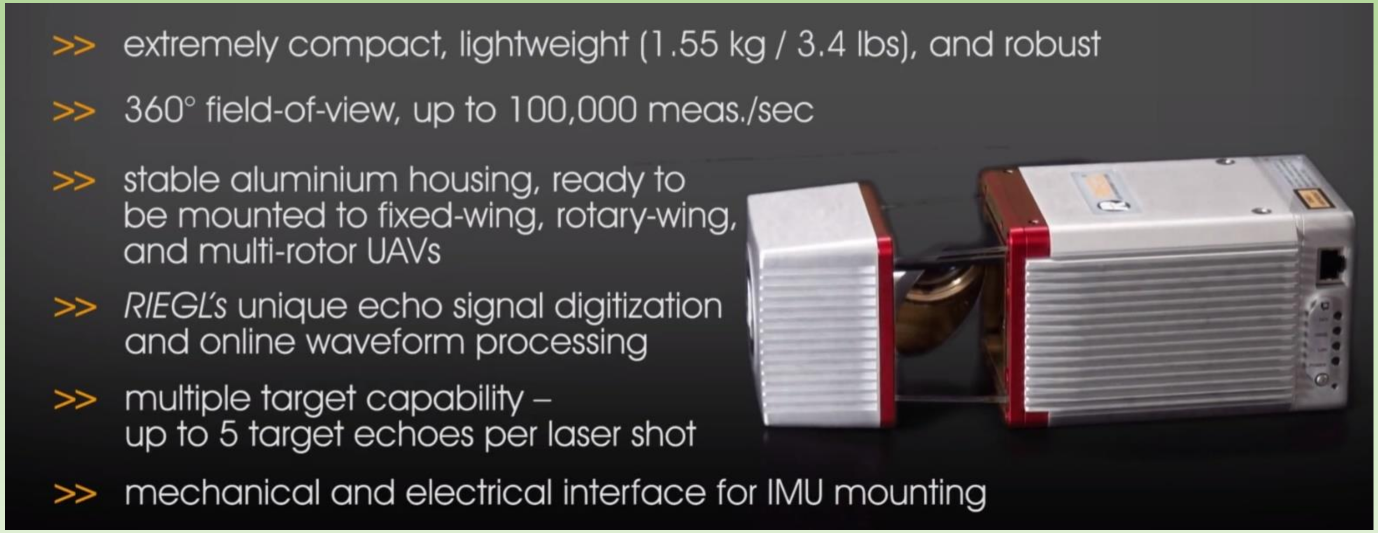
O emissor laser pode estar no chão

www.faro.com

TLS – Terrestrial Laser Scanning

www.rigel.com



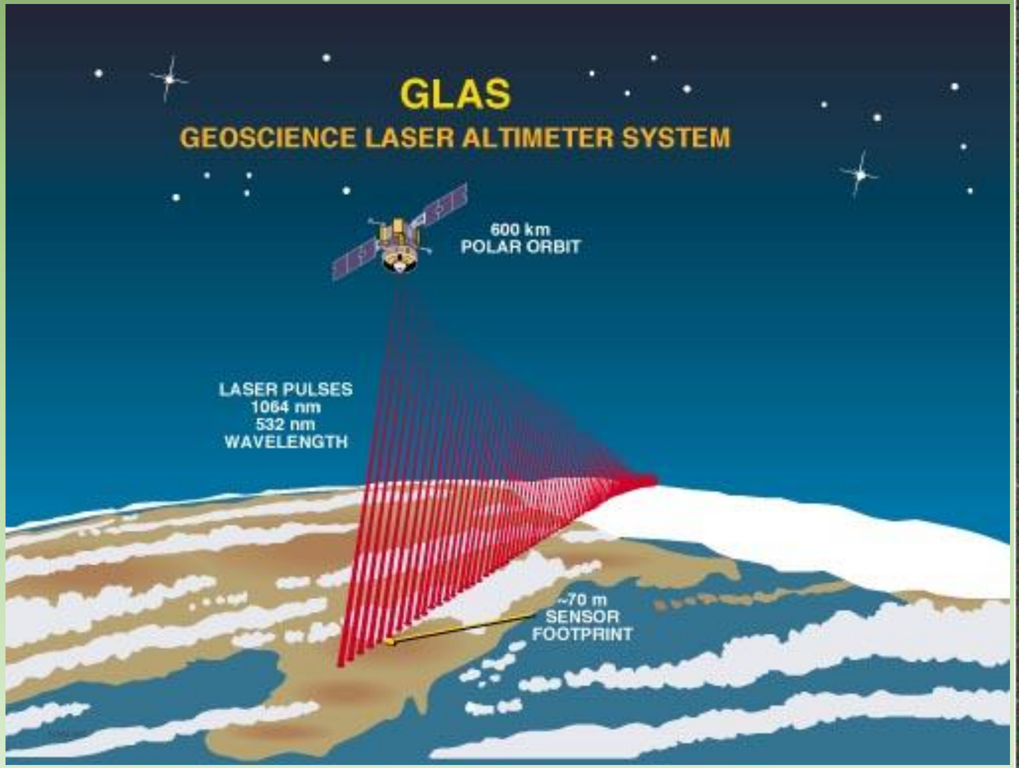


www.riegl.com/products/unmanned-scanning/riegl-minivux-1uav

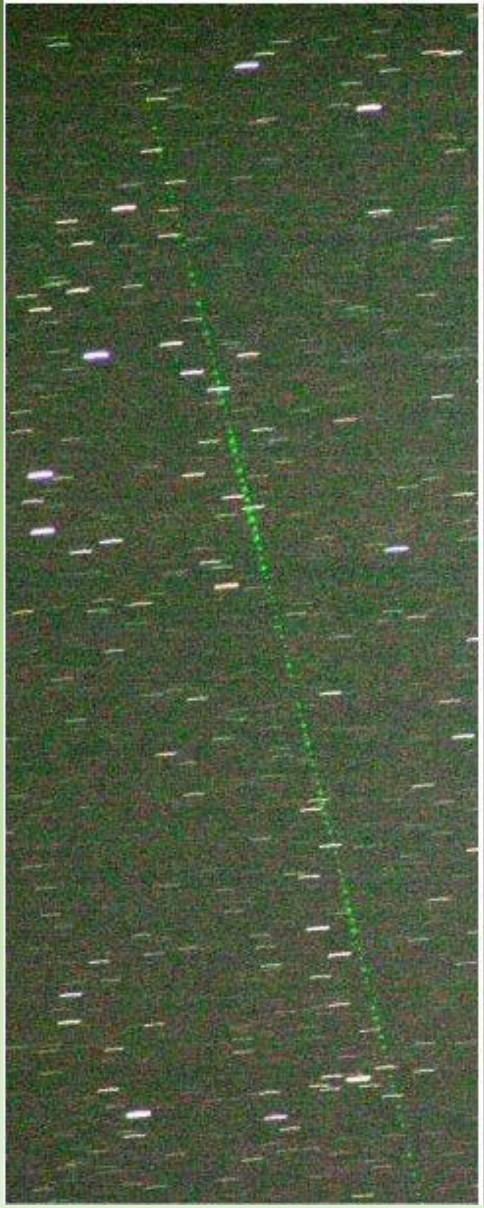
O emissor laser pode estar no espaço

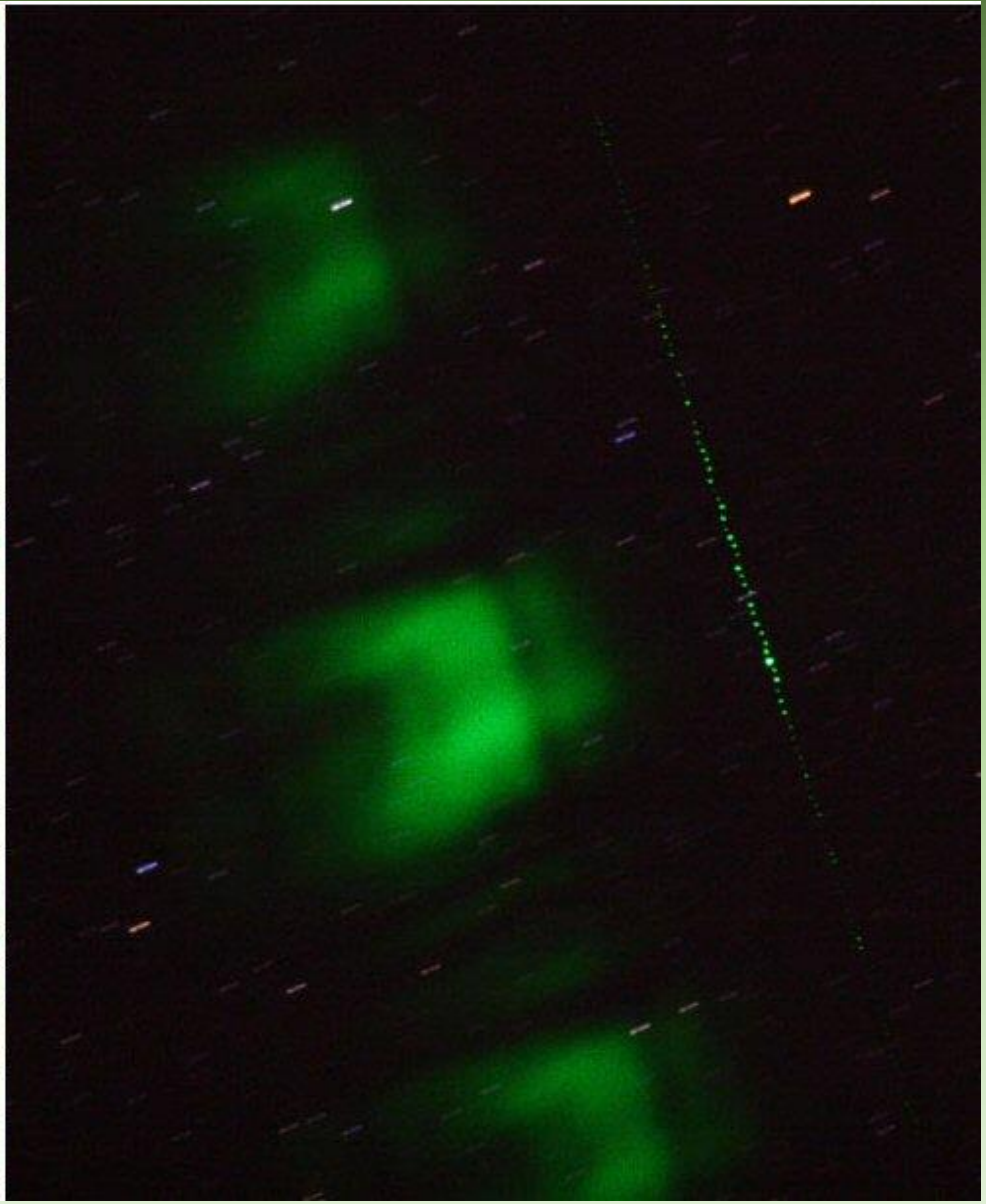
https://nsidc.org/data/icesat/icesat_spots_santa_rosa.html

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

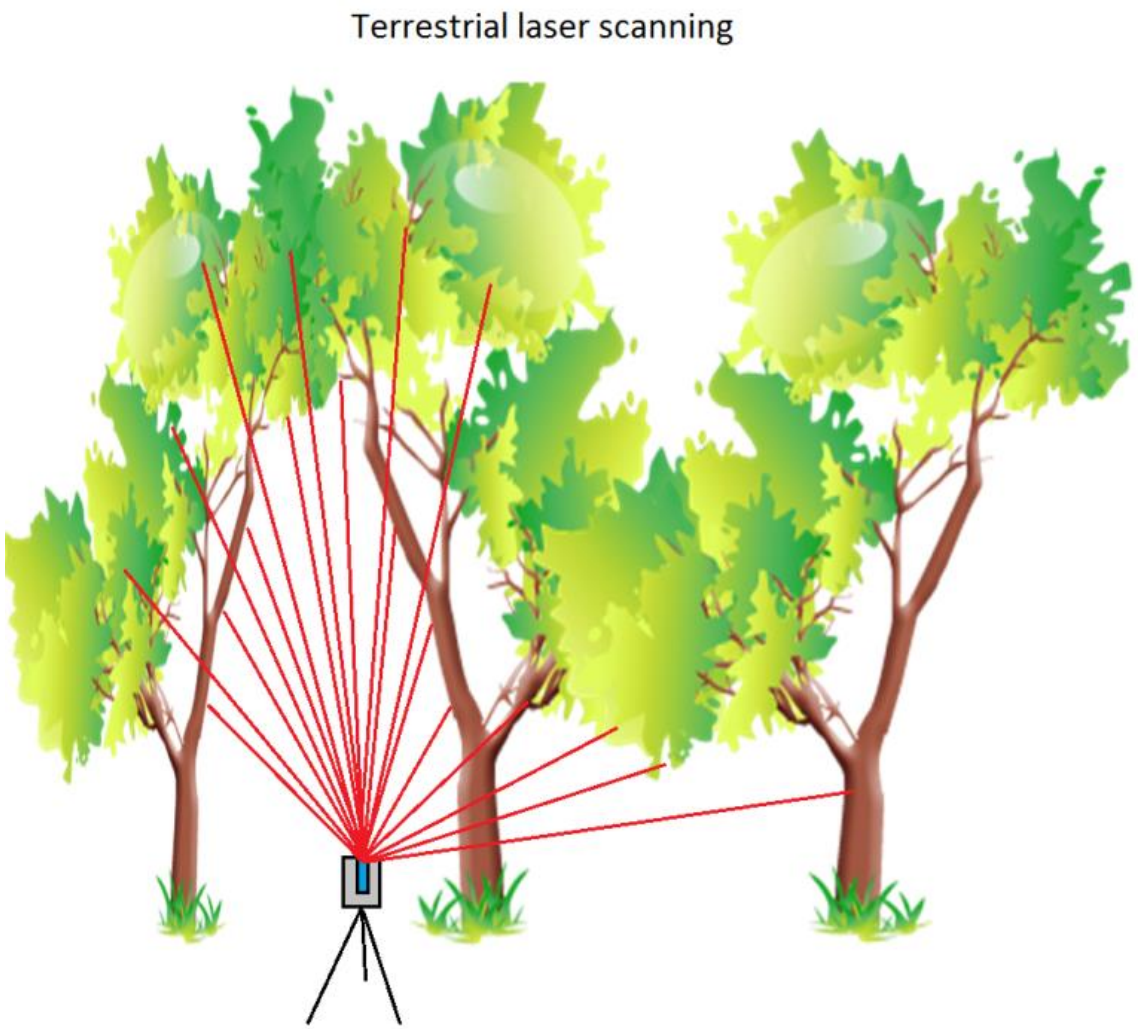


www.csr.utexas.edu/glas/



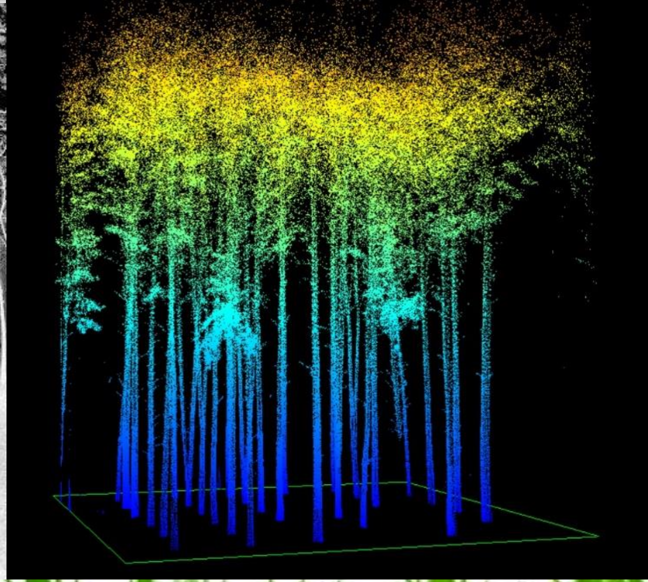


Inventário Florestal com LiDAR TLS

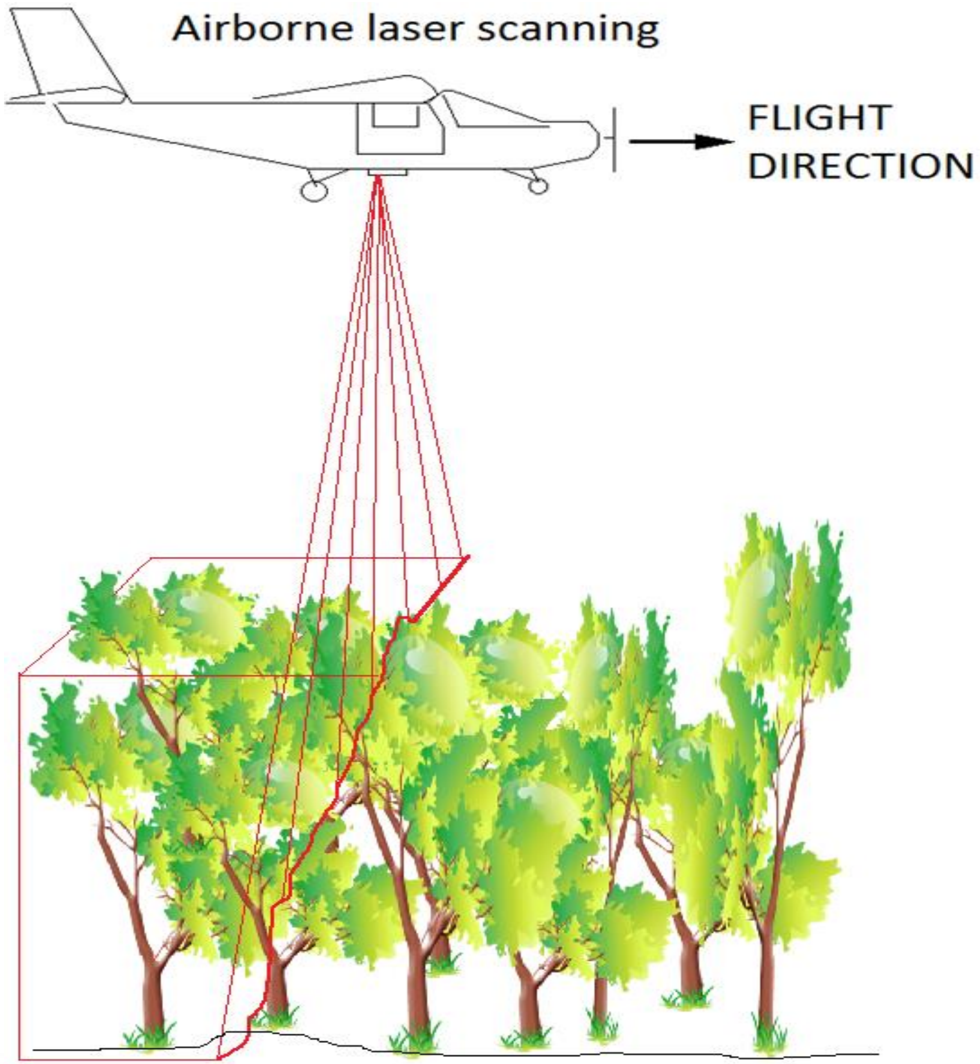


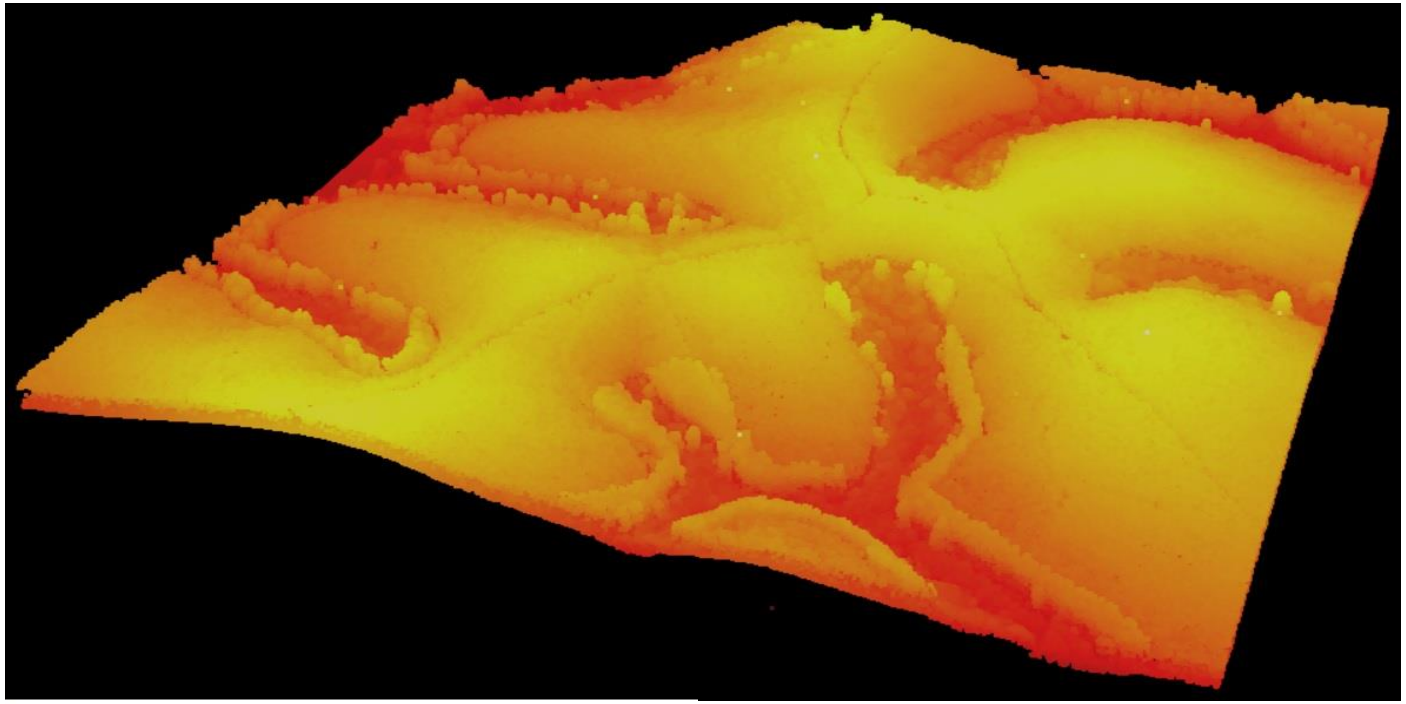
TLS: menor cobertura com maior resolução
modelagem 3D, reconstrução de elementos da paisagem

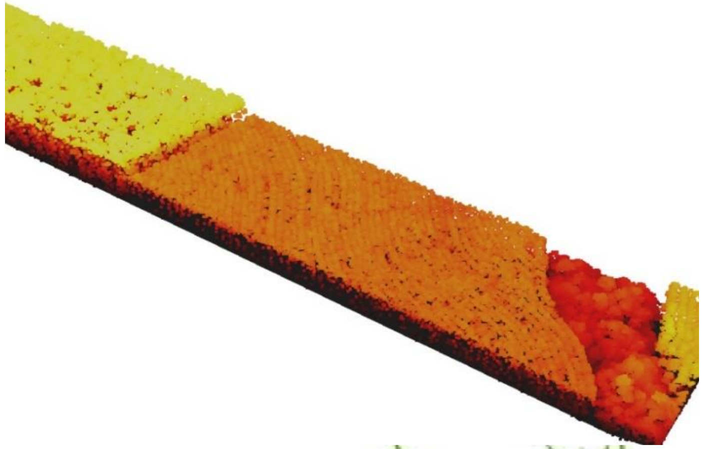
Inventário Florestal com LiDAR TLS

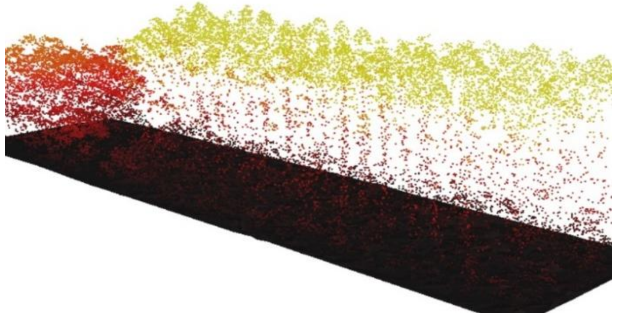


Inventário Florestal com LiDAR ALS









ALS: ampla cobertura com baixa resolução espacial

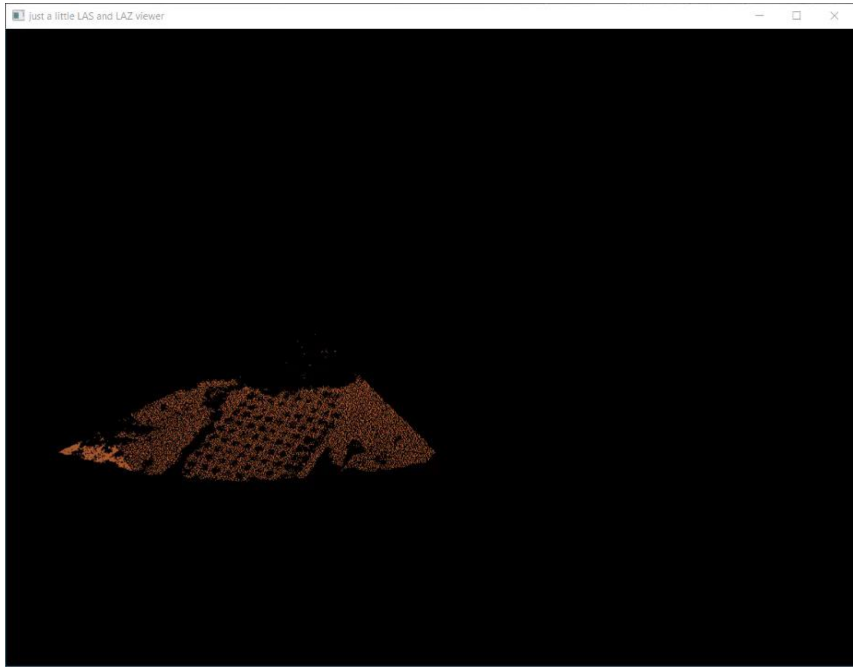
Inventário Florestal com LiDAR ALS

Checar especificações → Reparar Nuvem -> LAZ → Requadricular com buffers → Classificar solo e medir alturas → Classificar vegetação e prédios → Classificar ruído → ...

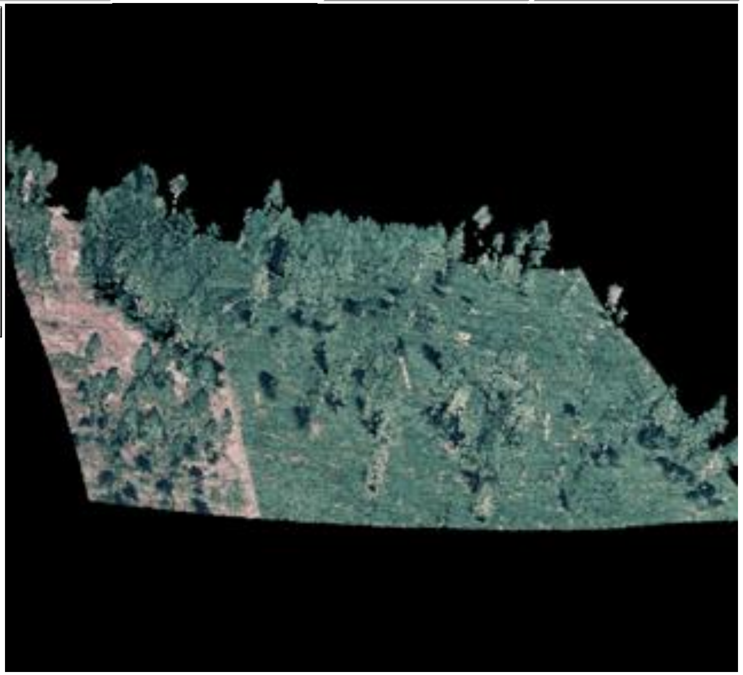
... → Criar quadriculas limpas → Criar nuvem para cada talhão → Produzir mapas DTM DSM → Normalizar quadriculas → Calcular métricas LiDAR → **Inferir e produzir mapas**

Inventário Florestal com LiDAR ALS

Checagem de especificações



LAStools



Outros sistemas úteis:

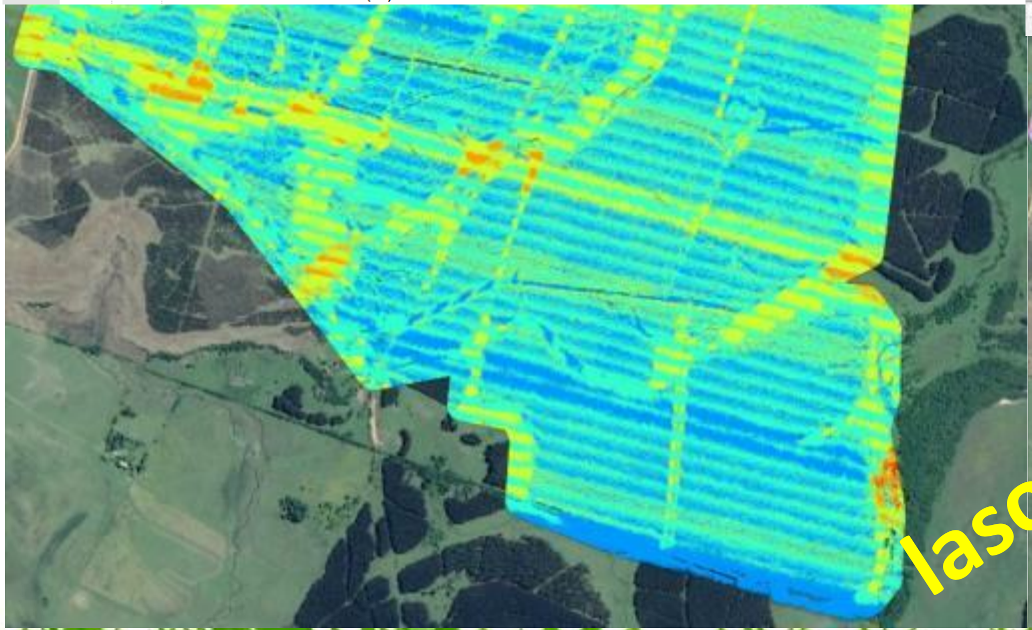
- LIS Desktop
- SAGA GIS
- MCC-LiDAR

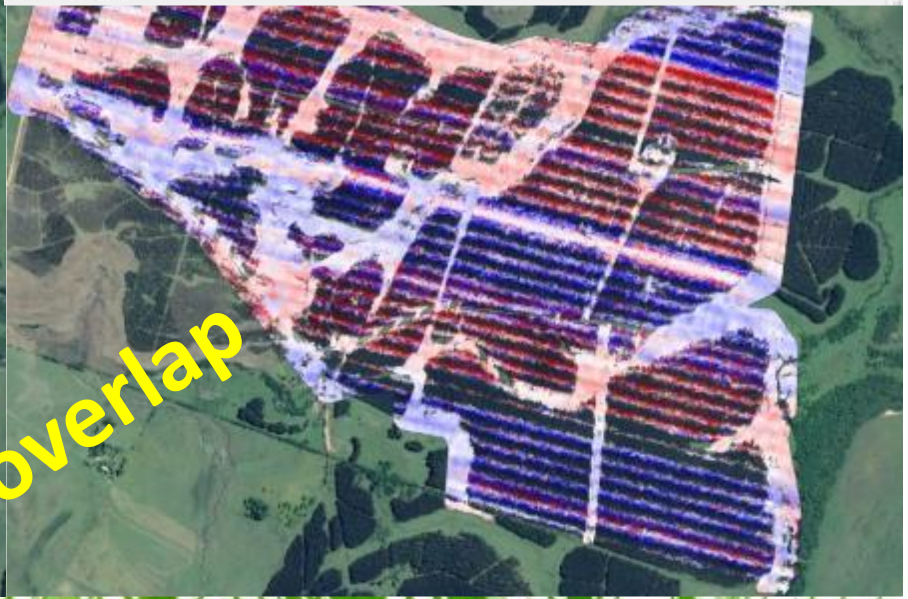
Inventário Florestal com LiDAR ALS

Checagem de especificações

lasinfo

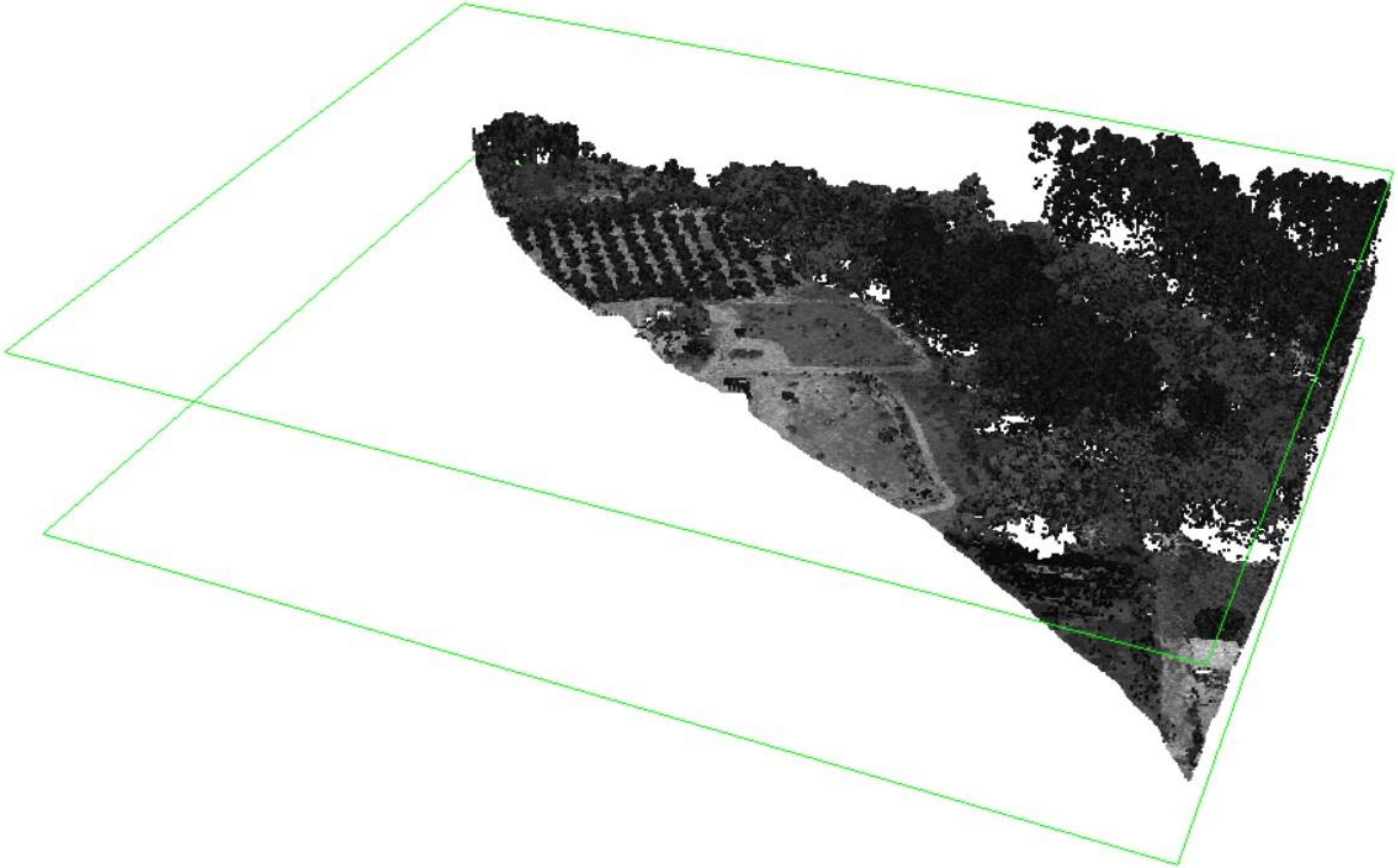
```
reporting all LAS header entries:
...
  system identifier:          'LAStools (c) by rapidlasso GmbH'
  generating software:        'lasmerge (version 161114)'
  file creation day/year:     315/2016
  header size:                227
  offset to point data:       227
...
  number of point records:    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)
```





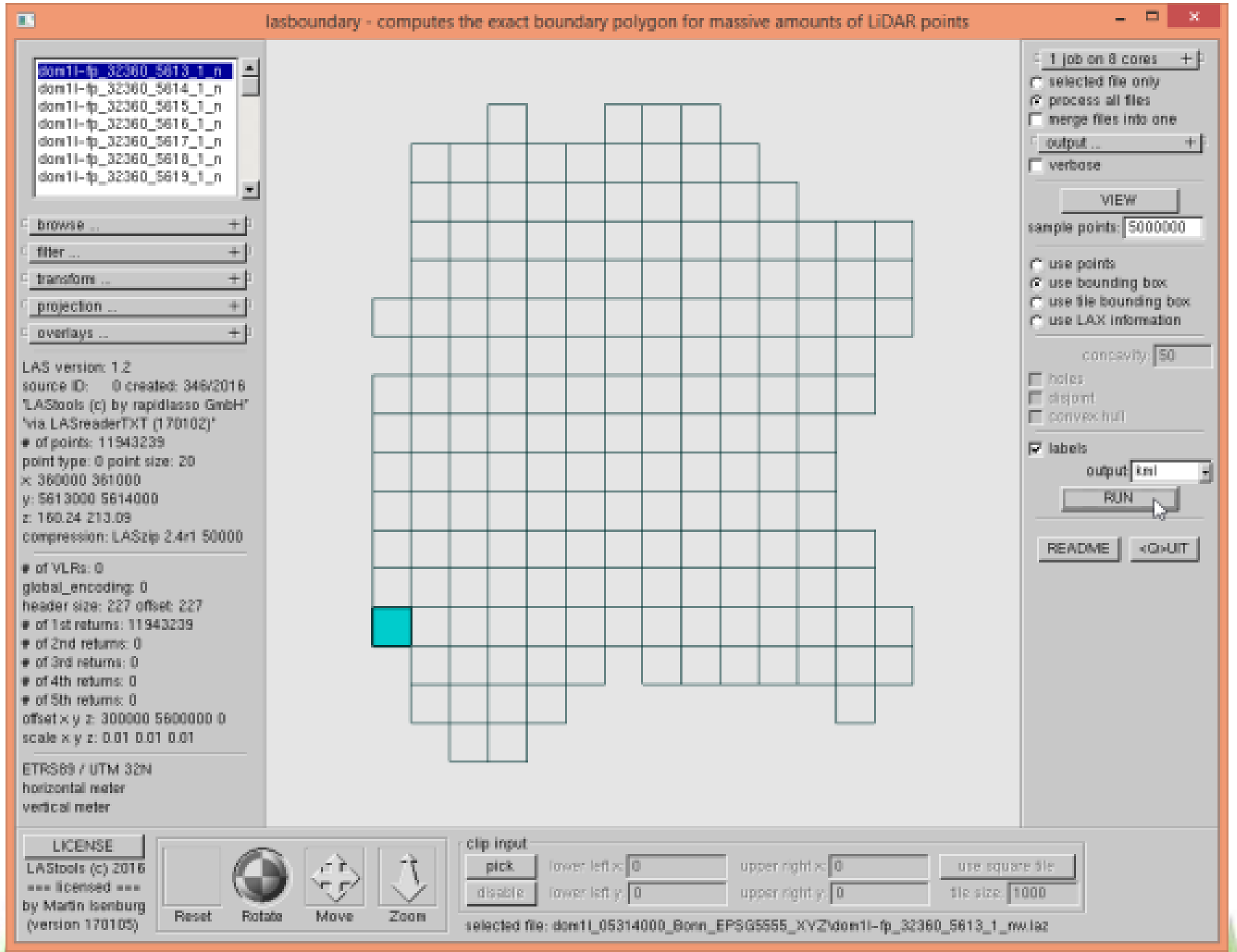
Inventário Florestal com LiDAR ALS

Reparar



Inventário Florestal com LiDAR ALS

Requadricular

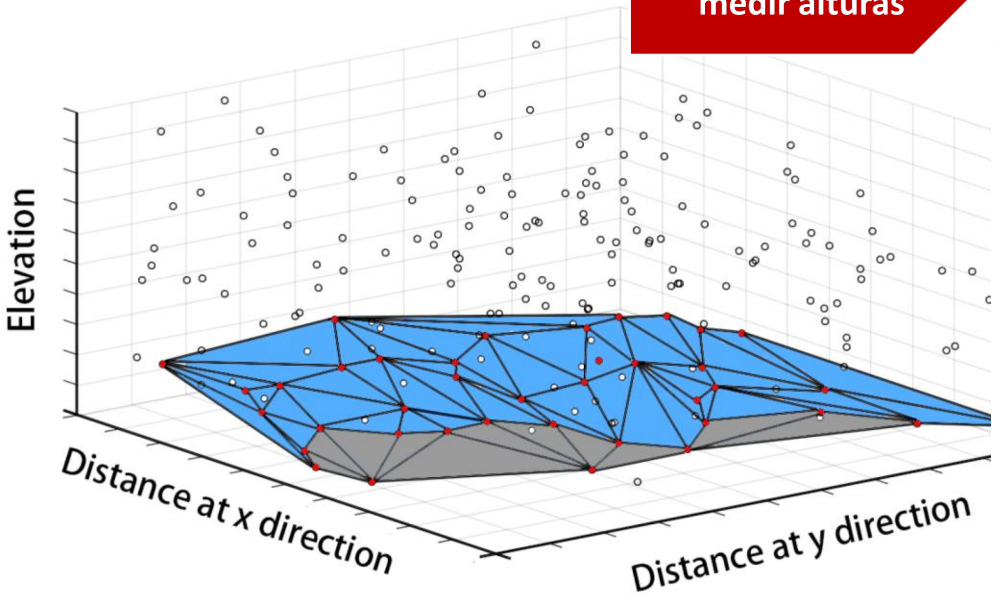


lastile

-tile_size 500
-buffer 30

Inventário Florestal com LiDAR ALS

Definir solo e medir alturas



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

Inventário Florestal com LiDAR **ALS**

Definir solo e medir alturas

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

www.mdpi.com/journal/sensors

sensors

MDPI

Kraus and Pfeifer (FUSION)

*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***

Review

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

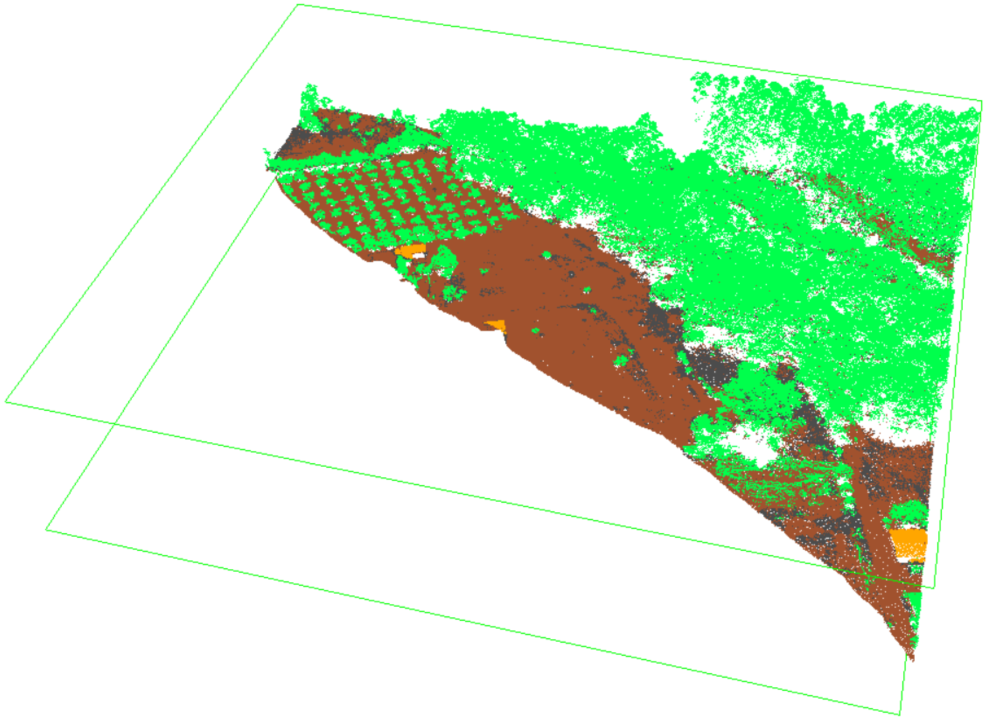
Ziyue Chen [1,*], Bingbo Gao [2] and Bernard D

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

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

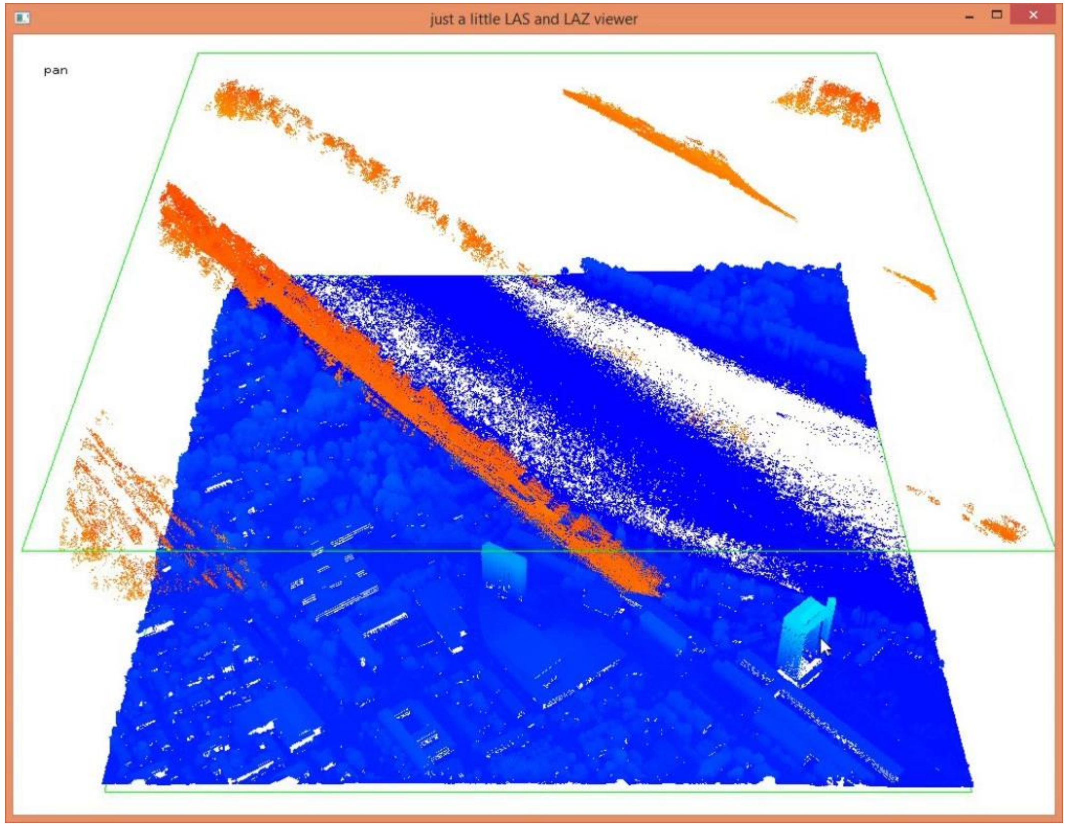
Inventário Florestal com LiDAR ALS

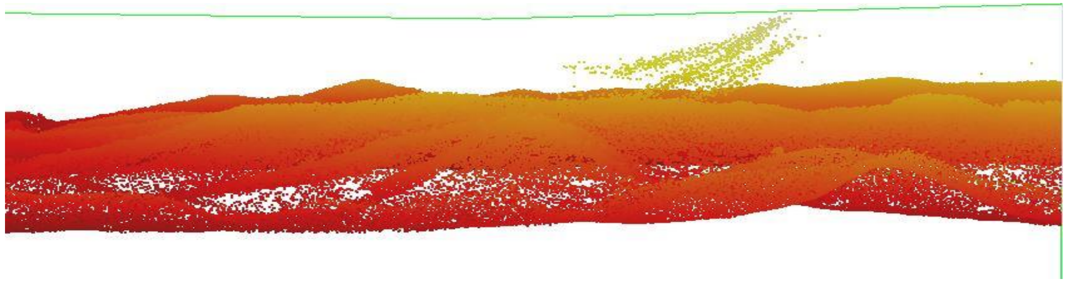
Classificar vegetação e prédios



Inventário Florestal com LiDAR ALS

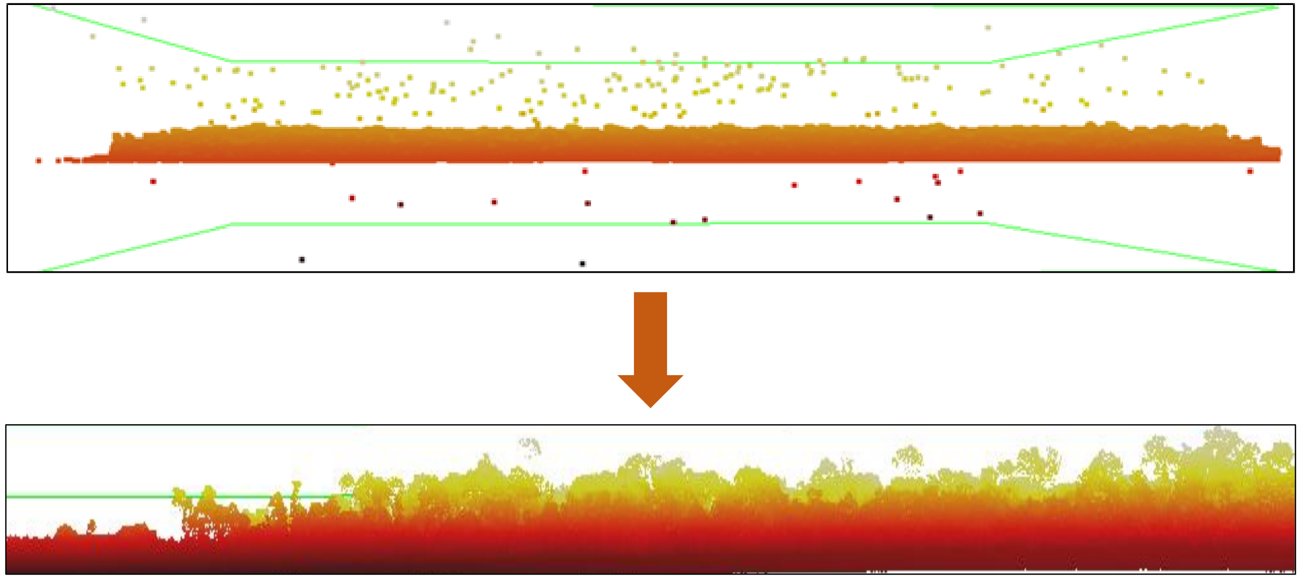
Classificar ruído





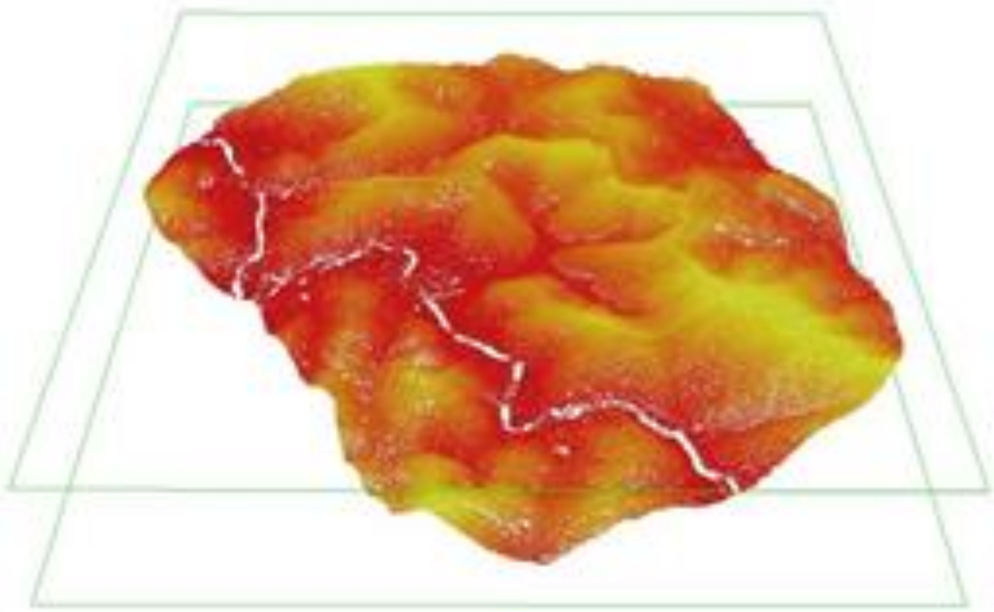
Inventário Florestal com LiDAR ALS

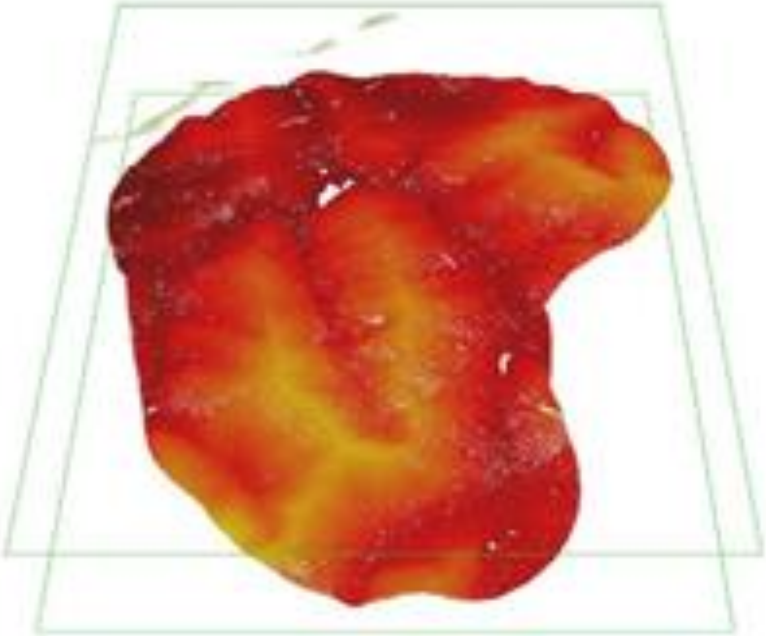
Quadrículas limpas



Inventário Florestal com LiDAR ALS

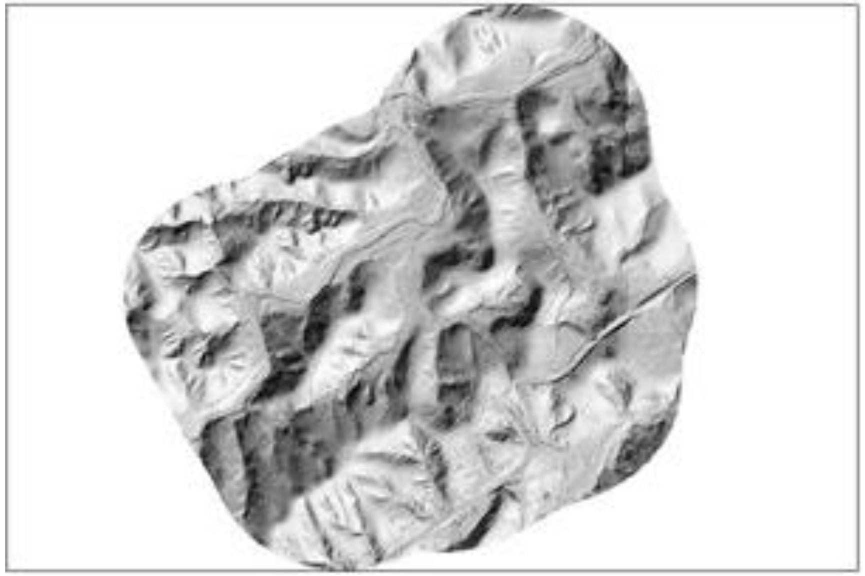
Criar nuvem para cada talhão

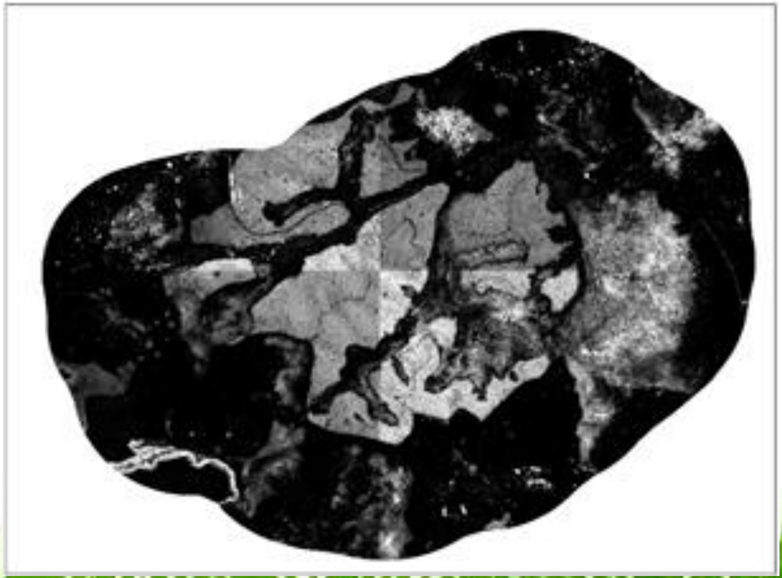




Inventário Florestal com LiDAR ALS

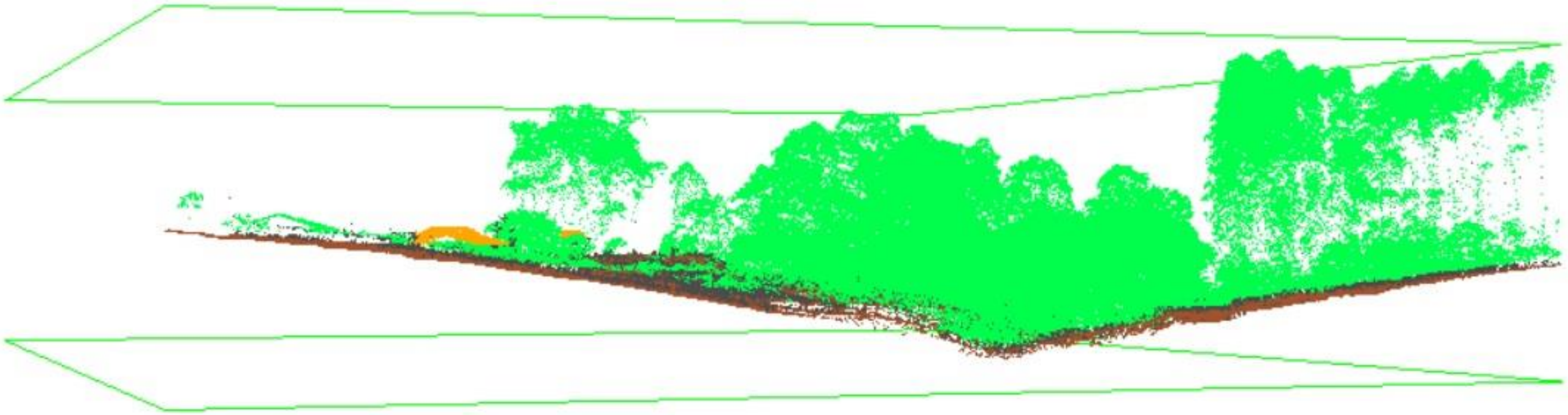
Produzir mapas DTM e DSM

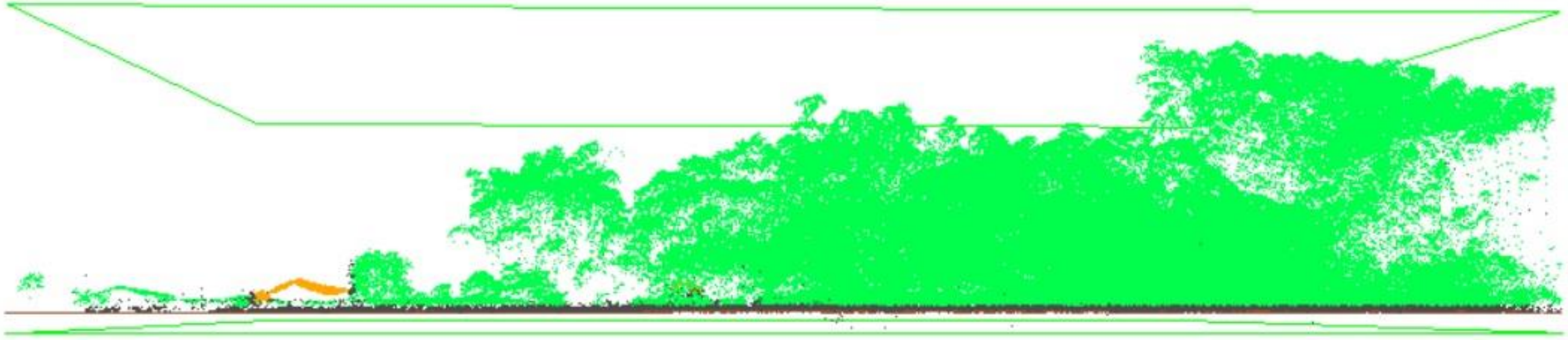


Inventário Florestal com LiDAR ALS

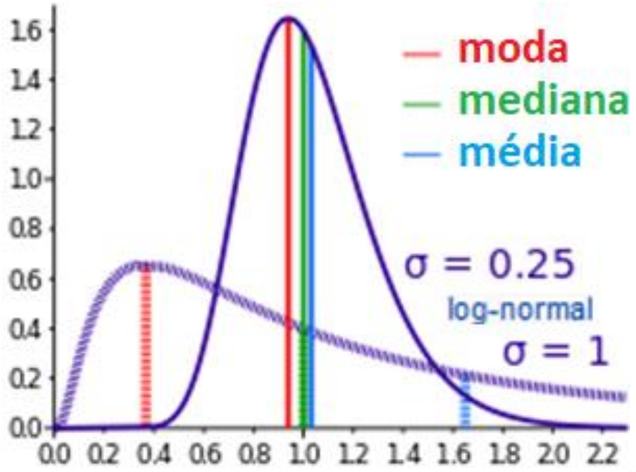
Normalizar quadrículas

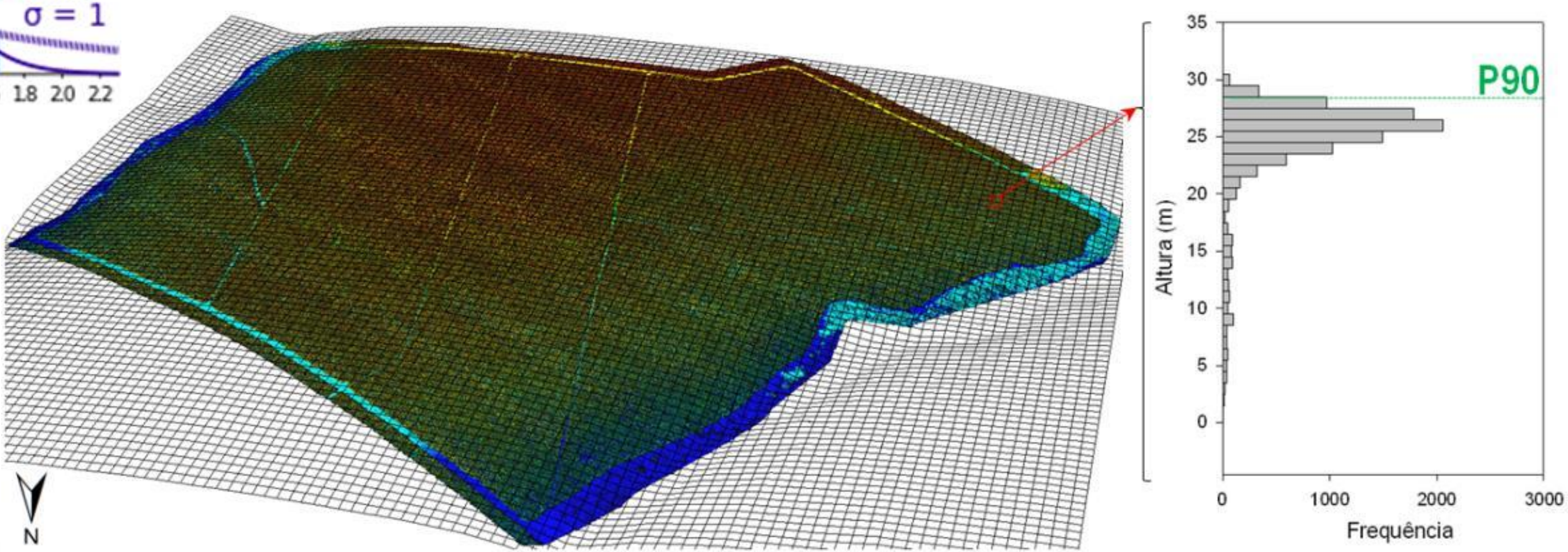




Inventário Florestal com LiDAR **ALS**

Calcular métricas LiDAR





Inventário Florestal com LiDAR ALS

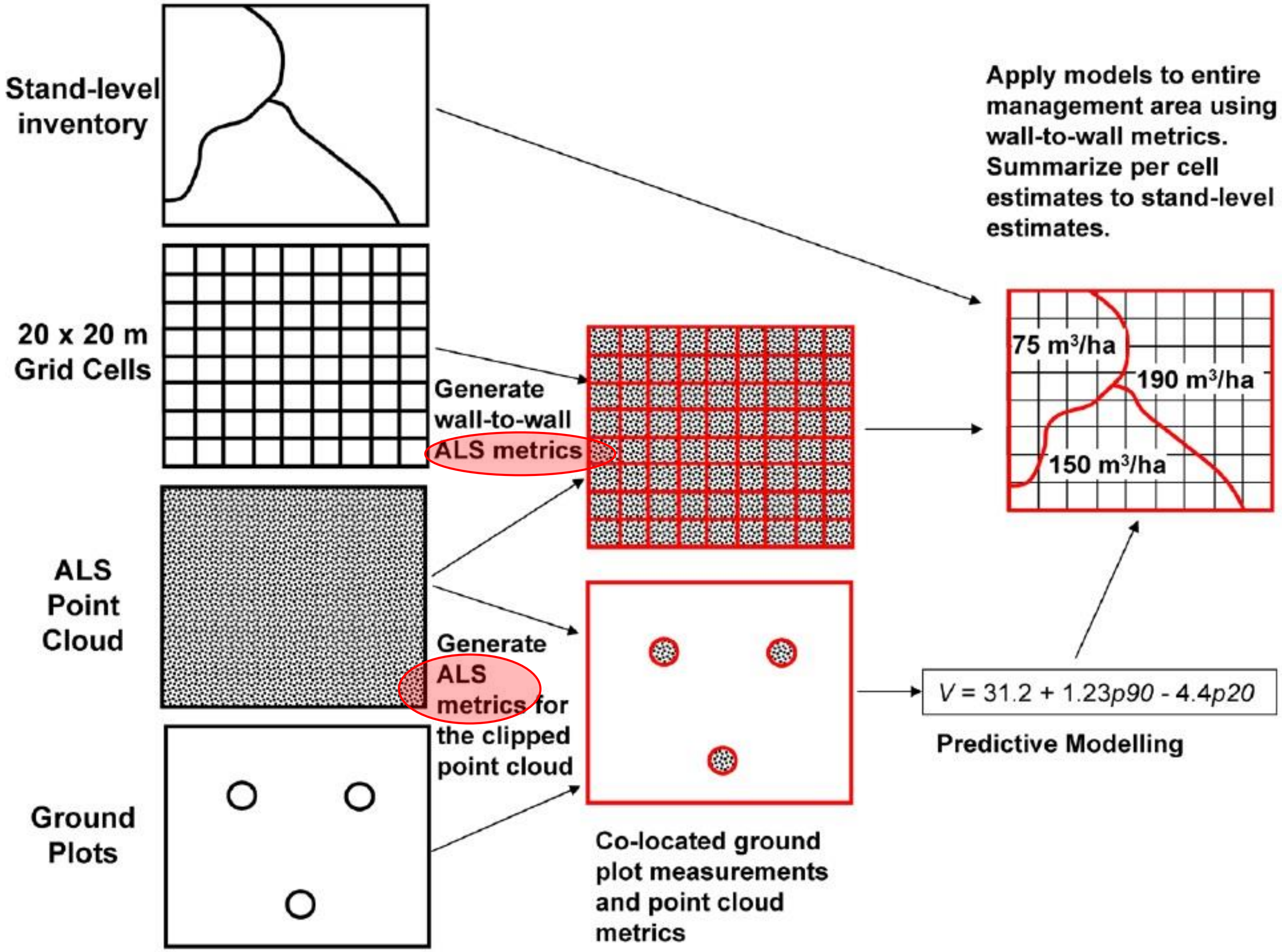
Calcular métricas LiDAR

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}

Inventário Florestal com LiDAR ALS

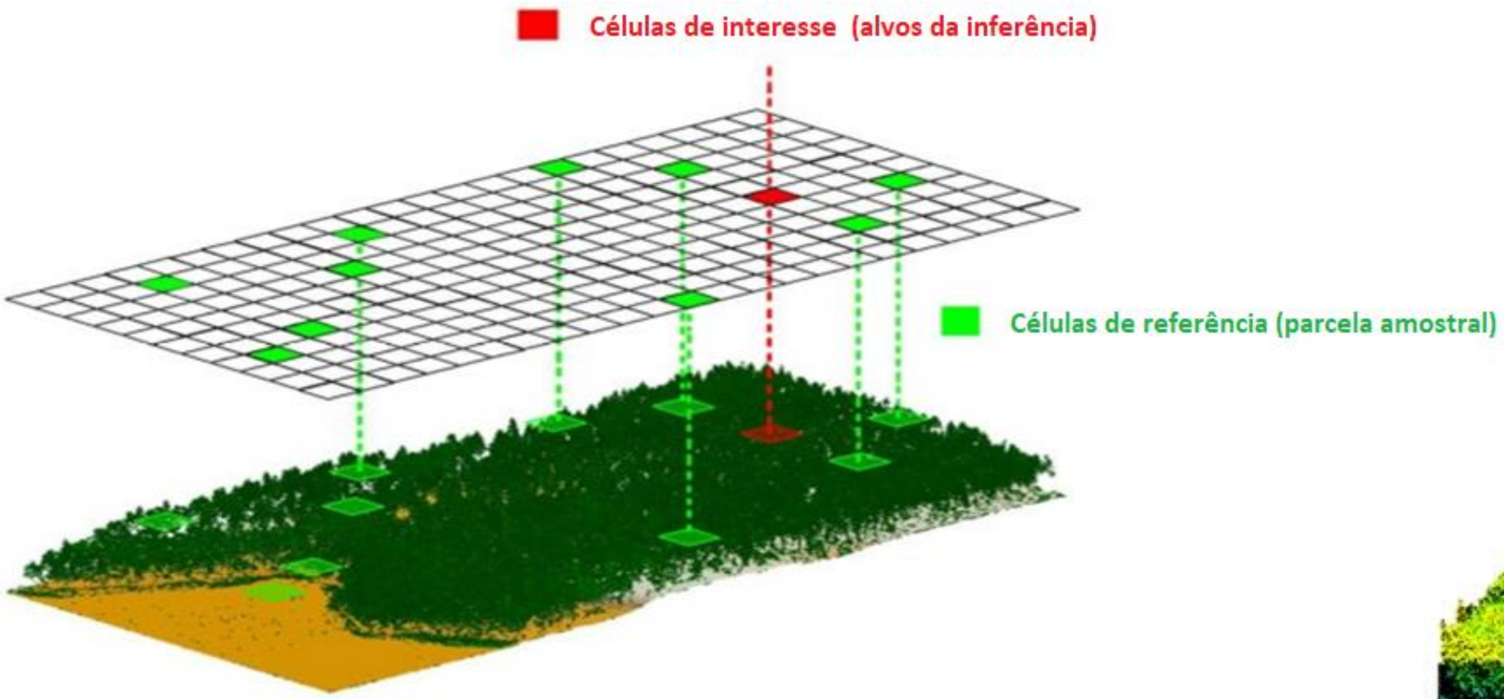
Inferir e produzir mapas

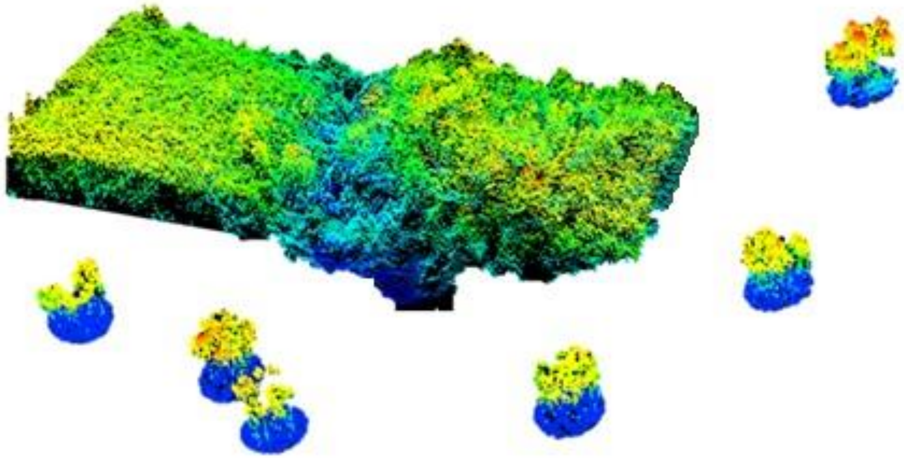


Joanne C. White; Michael A. Wulder; Andrés Varhola; Mikko Vastaranta; Nicholas C. Coops; Bruce D. Cook; Doug Pitt and Murray Woods. A best practices guide for generating forest inventory attributes from airborne laser scanning data using an area-based approach (Version 2.0) Natural Resources, Canadian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

Inventário Florestal com LiDAR ALS

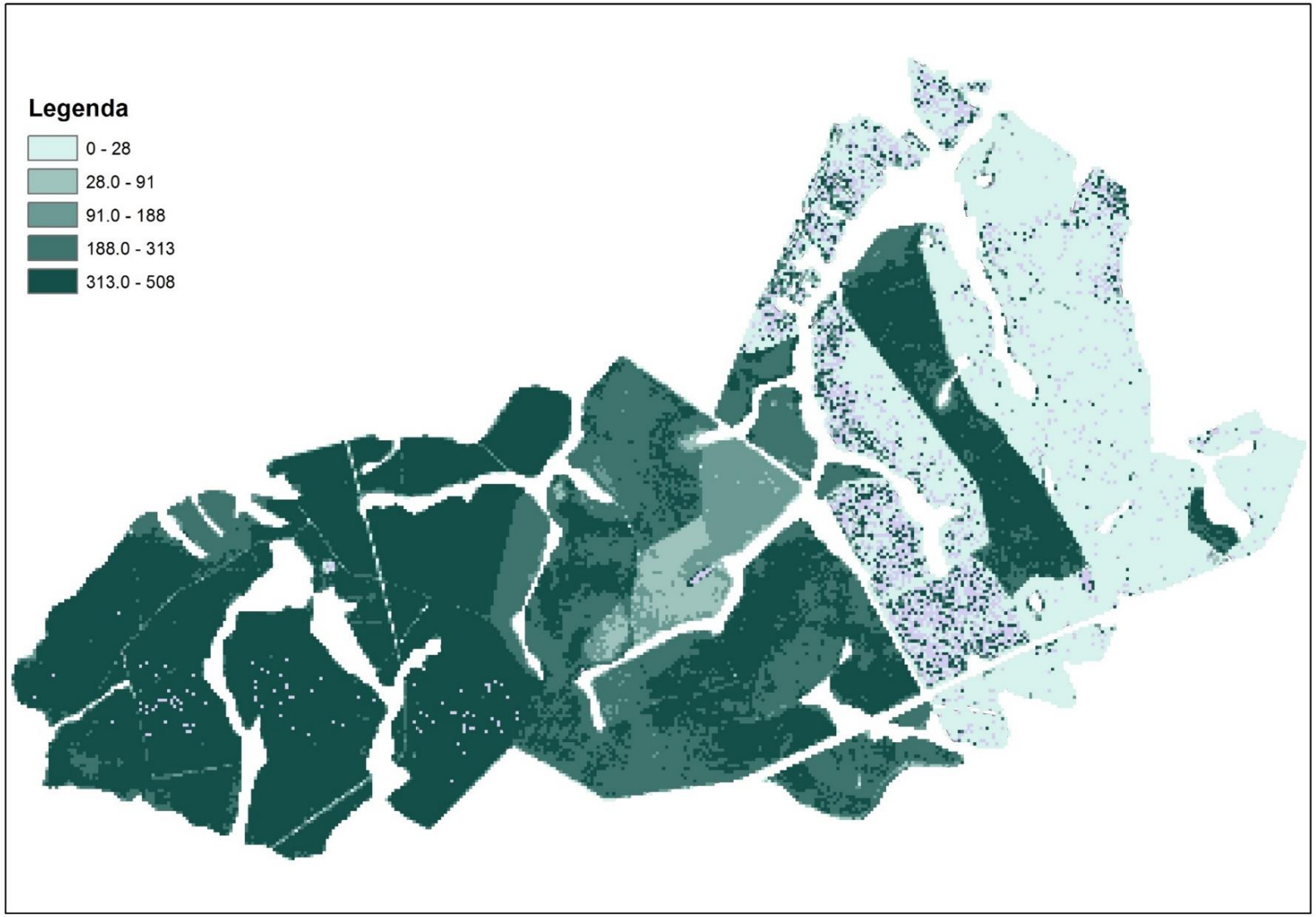
Inferir e produzir mapas





Inventário Florestal com LiDAR ALS

Inferir e produzir mapas



Inventário Florestal com LiDAR **ALS**

$$\bar{y} = \beta_0 + \beta_1 \, P90 + \varepsilon$$

$$S^2_{\bar{y}\,dl} = \frac{S^2_y}{n} \cdot \left(1 - \left(\frac{n' - n}{n'}\right) \cdot \rho^2\right)$$

$$\rho = \sqrt{R^2_{adj}}$$

$$S_{\bar{y}} = \pm\sqrt{S^2_{\bar{y}}}$$

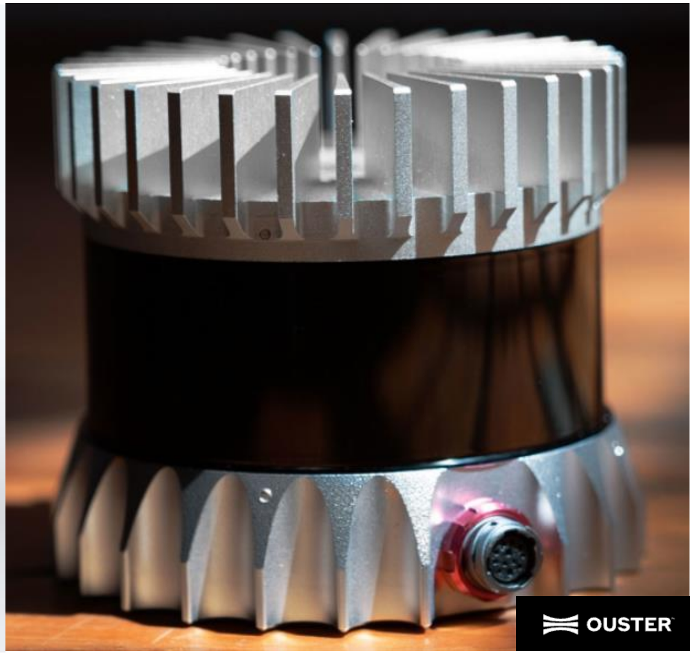
Inventário Florestal com LiDAR **TLS *(scanners de baixo custo)***

Sistemas auxiliares:

Computree

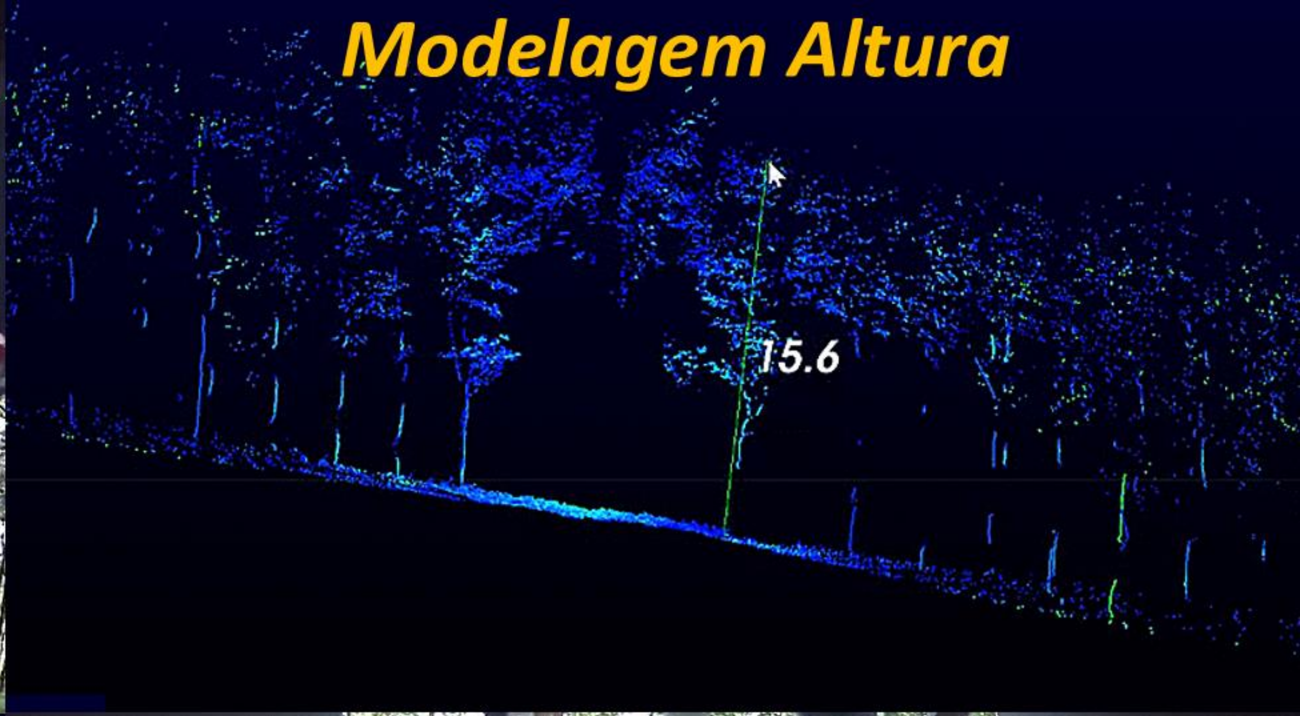
las2rings

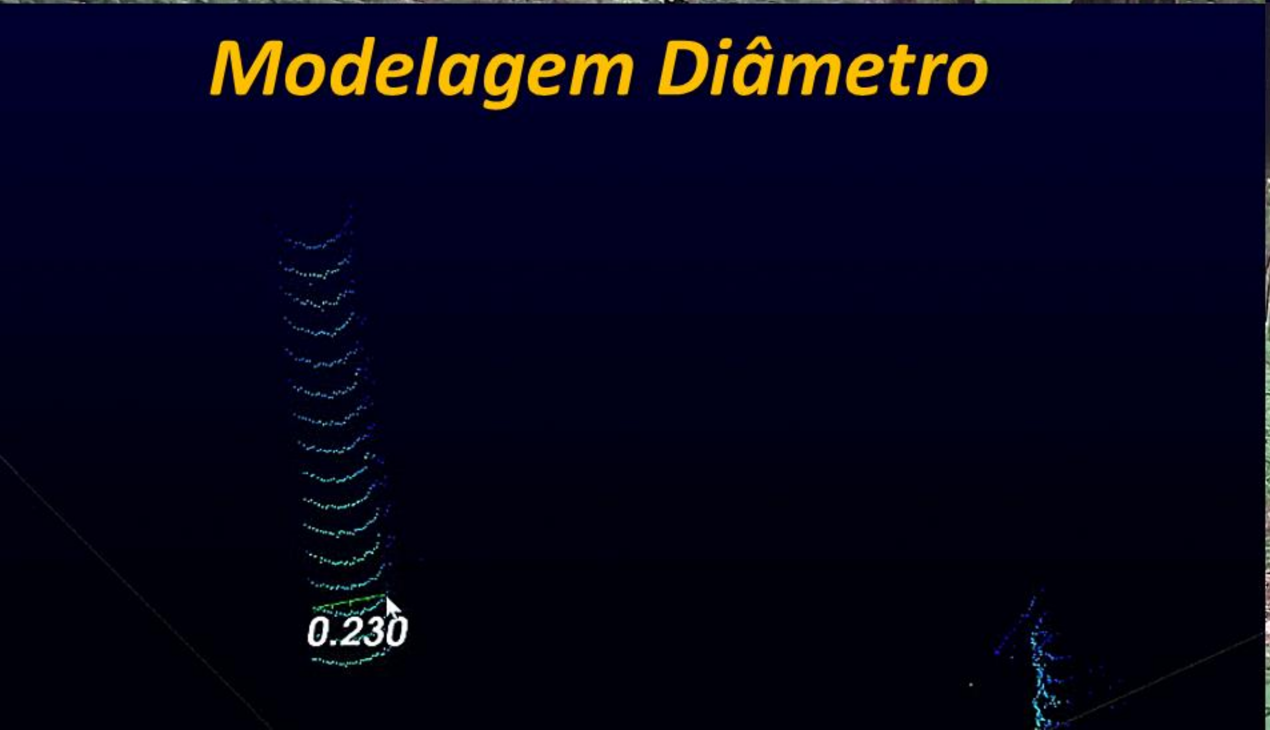
pcd2las



Inventário Florestal com LiDAR TLS *(scanners de baixo custo)*


Visão Lateral


Modelagem Altura
15.6

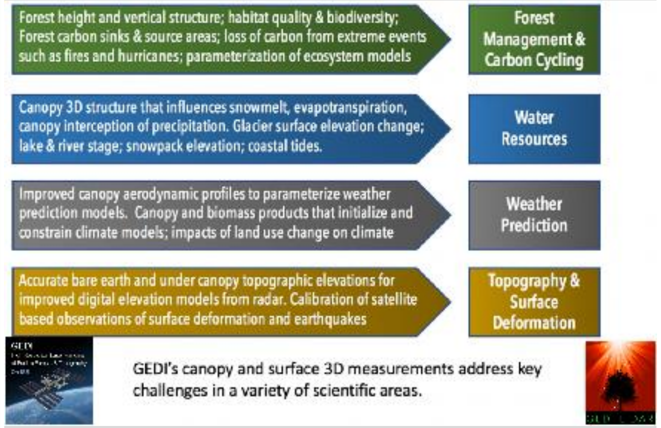
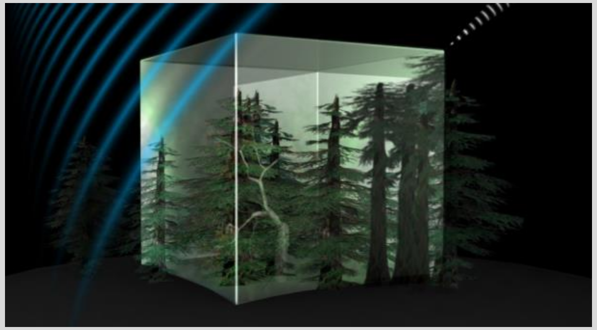

Modelagem Diâmetro
0.230


Visão Frontal
Google
DendroScan
Cableborne Laser Scanning

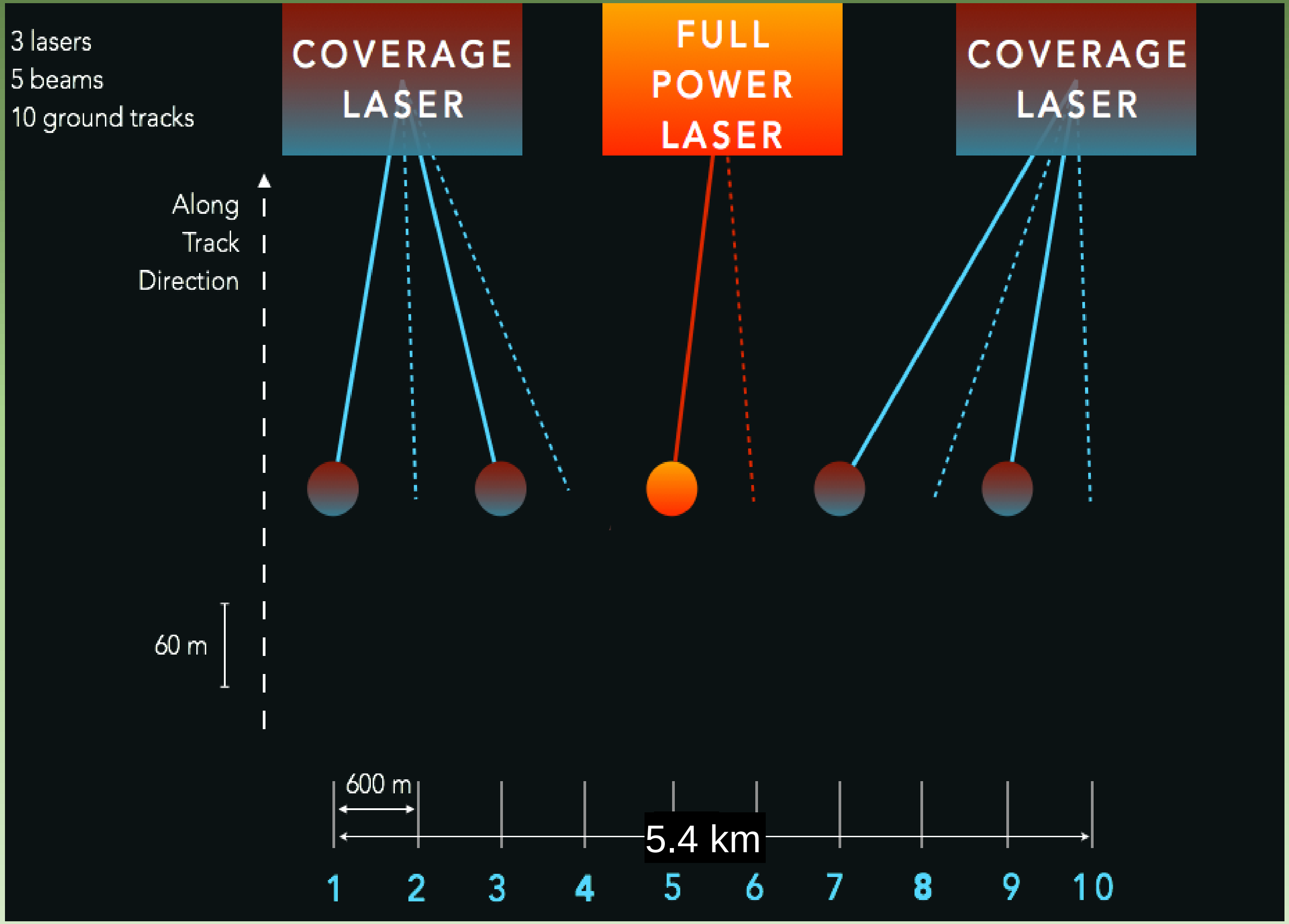
Inventário Florestal com LiDAR **TLS *(scanners de baixo custo)***

Uso de diferentes plataformas

públicos prestes a serem obtidos de plataformas espaciais

	GEDI	BIOMASS
Lançamento	Dezembro de 2018 (spaceX Dragon capsule)	Meados de 2020 (lançadores Vega, Antares ou PSLV)
Órbita	~420 km, inclinação 51.6º, período ~92 minutes	~660 km, sun-synchronous
Duração da missão	Dois anos	Cinco anos
Plataforma	A bordo da International Space Station	Estabilizada com dimensões (z, x, y) = (10, 12, 20) m
Instrumentos	Três lasers () 10 trilhas de escaneamento	Radar de abertura sintética banda P (435MHz) polarimétrico
Controle da missão	NASA Goddard Spaceflight Center (GSFC)	Centro de Operações da Agência Espacial Europeia (ESOC)
Colaboradores	Coordenado por Ralph Dubayah, da University of Maryland, congrega também pesquisadores de diversas outras instituições, incluindo Woods Hole Research Center, US Forest Service, Brown University, Agência Espacial Alemã (DLR), Agência Espacial Européia (ESA), Serviço Florestal Canadense, US Geological Survey, NASA Jet Propulsion Laboratory, UMass Boston, World Wildlife Fund e Conservation International.	Sob a gestão do diretor do Programa de Observação da Terra da Agência Espacial Europeia (ESA), Volker Liebig, a iniciativa é coordenada pelo Centro de Pesquisas e Tecnologias Espaciais (ESTEC) da ESA, com sede em Noordwijk Holanda. O projeto envolve cientistas de diferentes países da União Europeia, e o processamento de dados acontecerá no Centro de Observações da Terra da ESA (ESRIN), em Frascati Itália.
Principais características		 Measures biomass and carbon stored in tropical forests using a satellite in low Earth orbit equipped with a novel P-band-frequency sensor that features a 12-meter-diameter deployable antenna
Páginas web	http://science.nasa.gov/missions/gedi/ https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/iss-gedi	http://www.esa.int/Our_Activities/Observing_the_Earth/Ready_to_build_the_Biomass_forest_mission/ http://esamultimedia.esa.int/docs/EarthObservation/SP1324-1_BIOMASSr.pdf

GEDI – padrão de varredura



Obrigado pela atenção

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