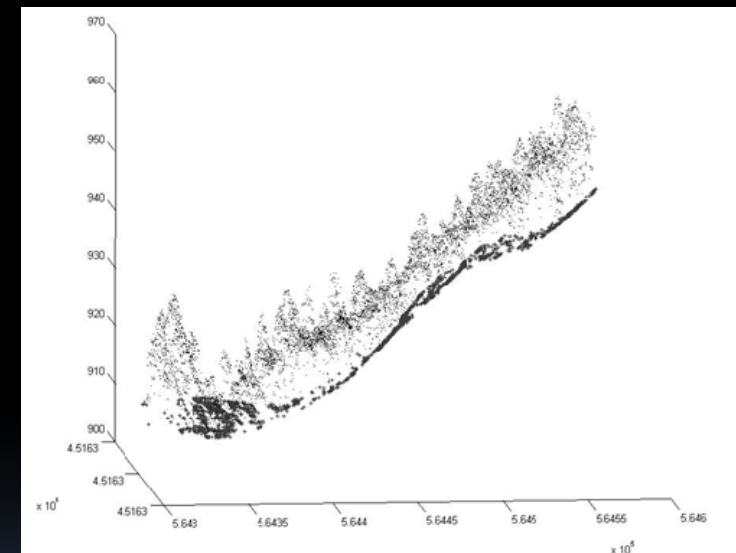
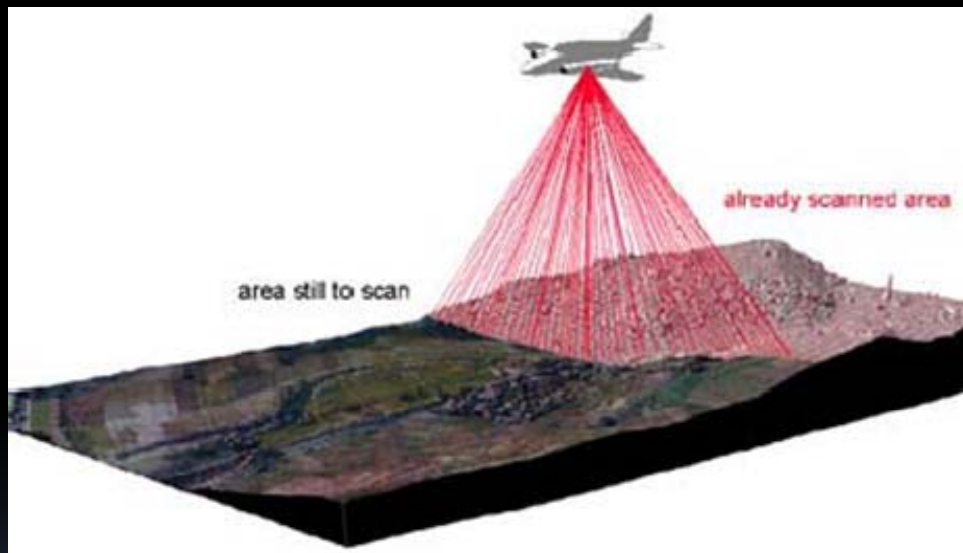


INTRODUCCIÓN A LA TECNOLOGÍA LiDAR

XV CONGRESO NACIONAL TECNOLOGÍAS DE LA INFORMACIÓN GEOGRÁFICA
Tecnologías de la Información Geográfica en el Contexto de Cambio Global



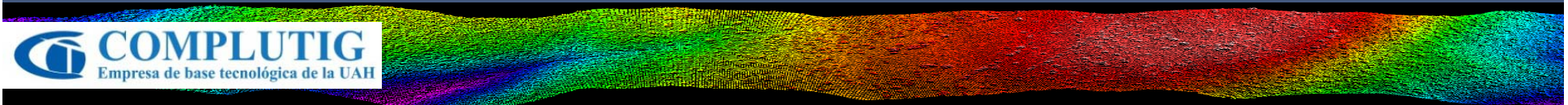
Mariano García Alonso (mariano.garcia@uah.es)



INTRODUCCIÓN AL LiDAR

- ✓ Introducción a la tecnología LiDAR. Principios básicos
- ✓ Componentes de un sistema LiDAR
- ✓ Especificaciones del sistema
- ✓ Clasificación de los sistemas LiDAR
- ✓ Datos proporcionados por los sistemas LiDAR
- ✓ Precisión de los datos LiDAR
- ✓ Recursos disponibles

- ✓ LiDAR: Light Detection And Ranging.
 - ✓ Laser scanning
 - ✓ Airborne Laser Scanning (ALS)
 - ✓ LaDAR (Laser Detection and Ranging)
- ✓ Rápido desarrollo desde mediados de 1990s.
 - ✓ Sistemas experimentales. Perfiles (Institute for Photogrammetry, University Stuttgart, Special research group)



Instrument development

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2 kHz

Up to ~200 kHz

1000 m max. AGL height

Up to 4500 m max. AGL height

$\pm 20^\circ$ scan angle

Up to $\pm 32^\circ$ scan angle

First or last return

Multiple returns to full waveform

4-5 m point spacing

8-16 bit intensity values

< 1m point spacing

Lidar Market: Status and growth Trends

(presented at the International Lidar Mapping Forum 28 January 2009.
Tina Cary, Ph.D, Cary and Associates)

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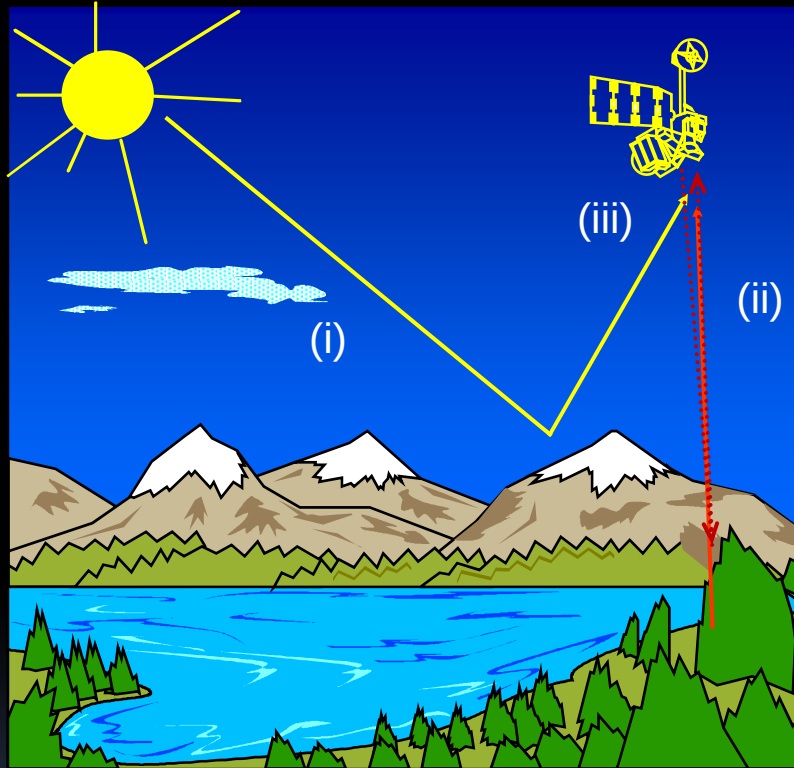
Region	LiDAR systems
North America	51 ALS operated by 29 commercial companies and 3 universities
Europe	30 ALS operated by 19 commercial companies and 1 university
Rest of the world	29 ALS operated by 18 commercial companies
Bathymetric LiDAR	10 systems operated by 3 commercial companies and 7 government organizations

global market for lidar services at **\$160 million per year**, with **North America** being the largest market at **\$64 million**, **Rest of World** next at **\$52 million**, and **Europe** accounting for **\$44 million**

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Sensores Pasivos

- (i) Reflexión
- (ii) Emisión

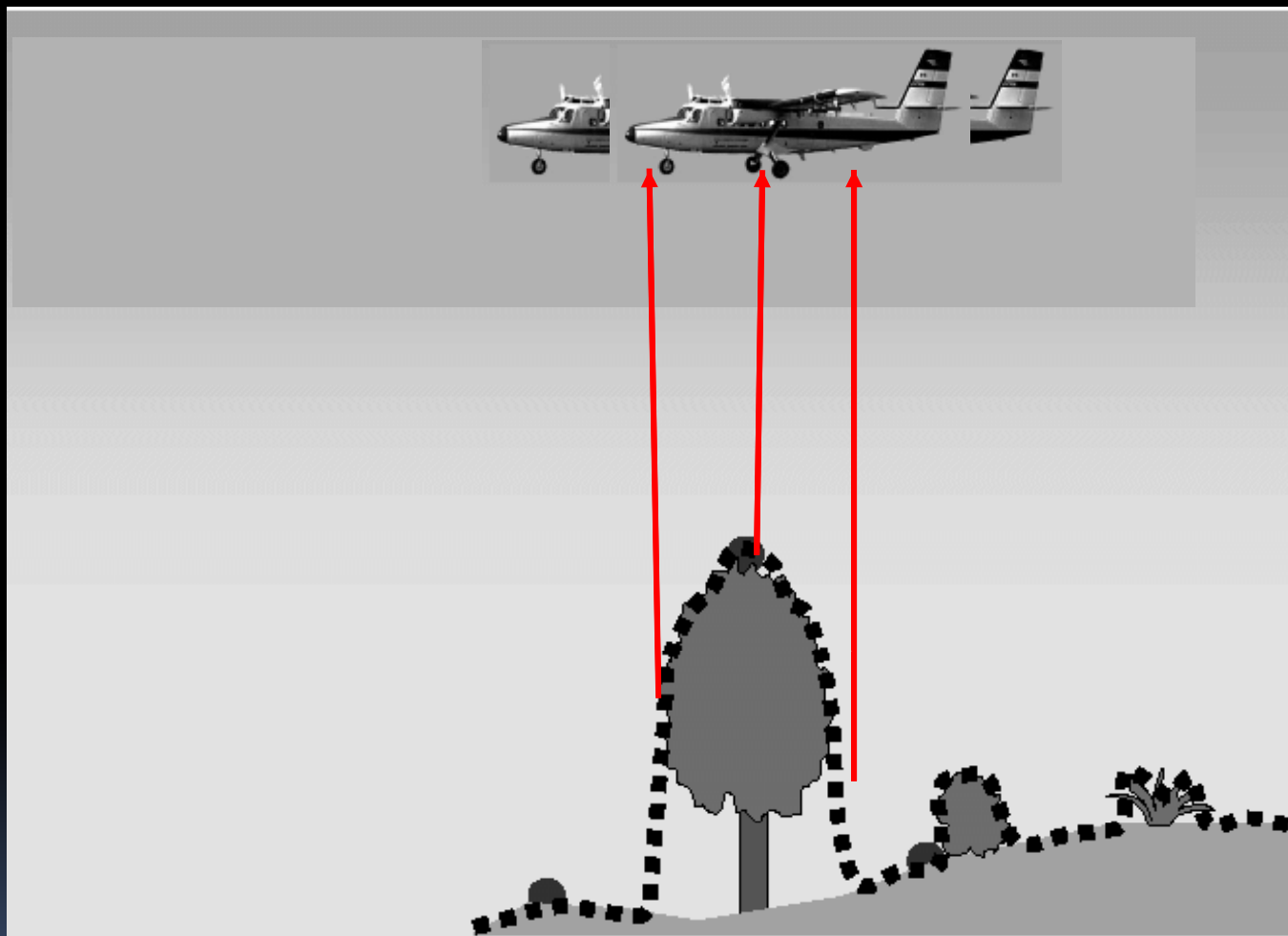
Sensores Activos

- (iii) Emisión-Reflexión

Chuvieco, 2002

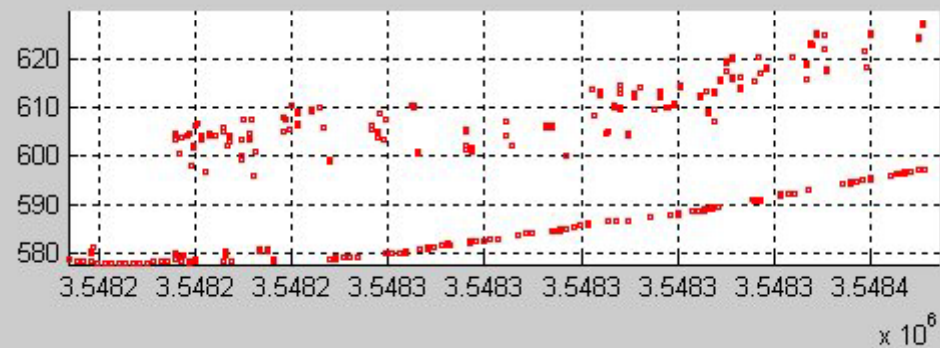
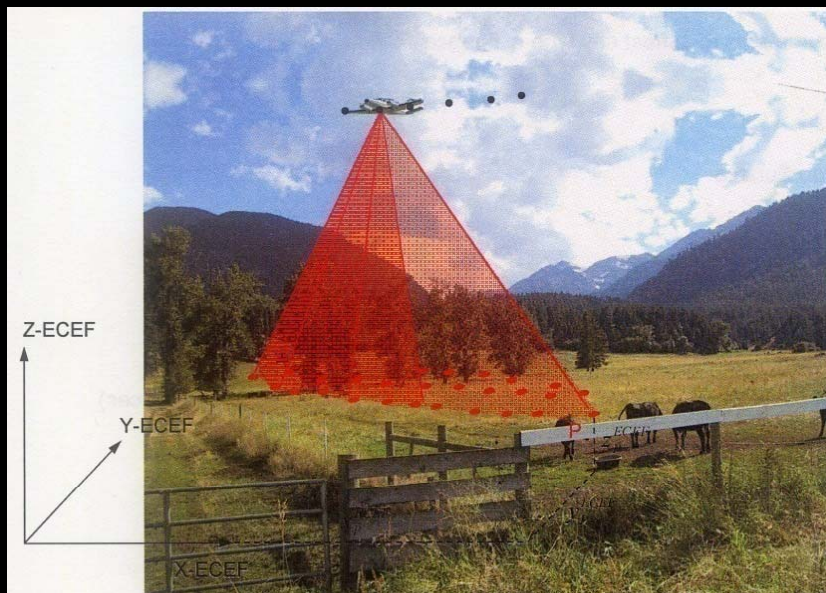
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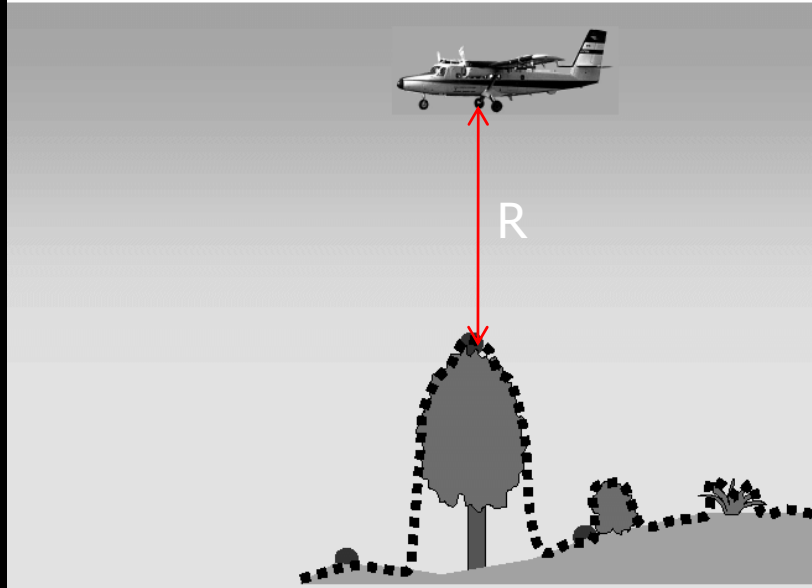


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Principio de funcionamiento. Medida de distancia

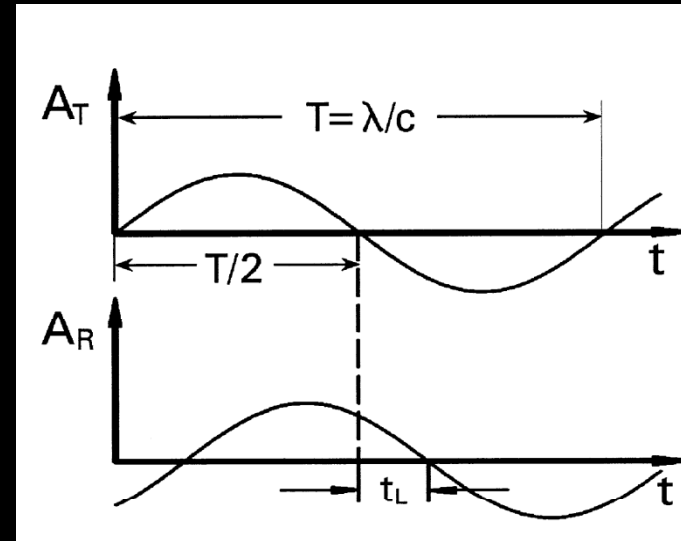


$$R = c \cdot t / 2$$

- ✓ R: distancia sensor-objeto (range)
- ✓ c: velocidad de la luz ($300.000 \text{ km s}^{-1}$)
- ✓ t= tiempo transcurrido entre la emisión del pulso y la recepción del retorno

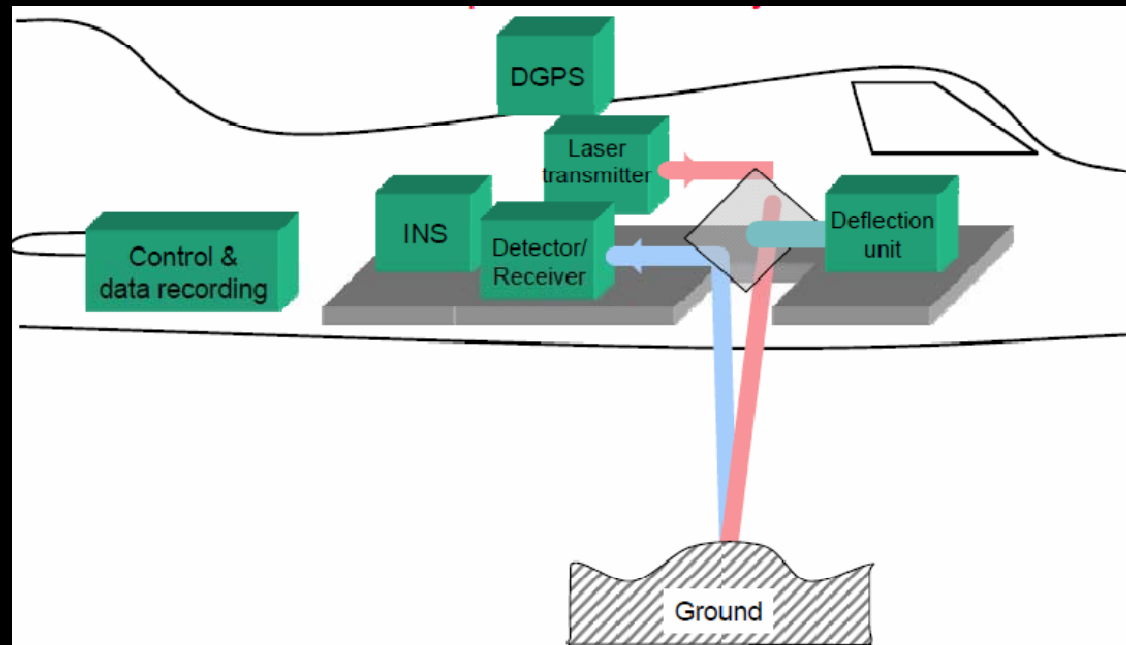
Principio de funcionamiento. Medida de distancia

Diferencia de fase



$$R = \frac{1}{4\pi} \frac{c}{f} \phi$$

- ✓ R: distancia sensor-objeto (range)
- ✓ c: velocidad de la luz (300.000 km s⁻¹)
- ✓ f= frecuencia (Hz)
- ✓ ϕ = diferencia de fase entre la señal emitida y la recibida (rad)



(Fuente: Baltsavias:International SchoolonLIDARTechnology, IIT Kanpur, India, 31 March - 4 April 2008)

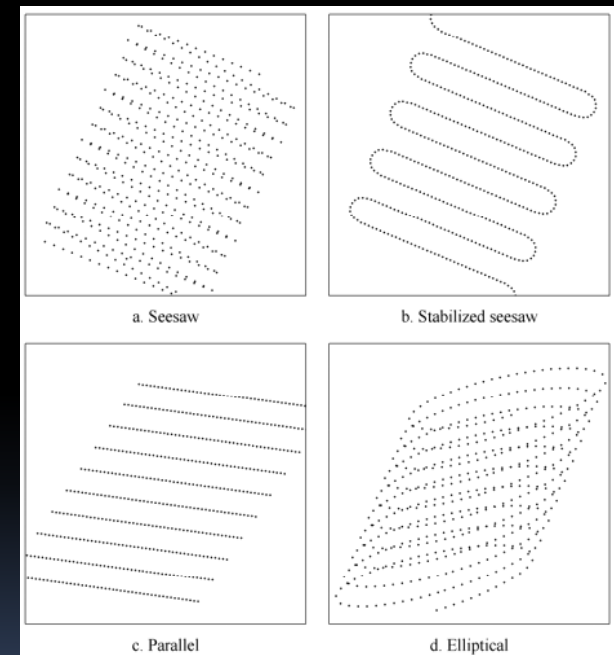
- ✓ Unidad de medida de distancia
- ✓ Scanner
- ✓ Sistema GPS (posicionamiento diferencial)
- ✓ Inertial Measurement Unit
- ✓ Unidad de control, seguimiento y registro

[illegible]

Ejemplo adquisición de datos de un sistema aeroportado



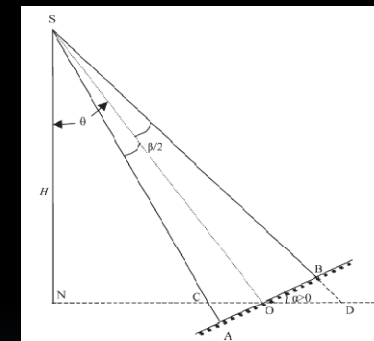
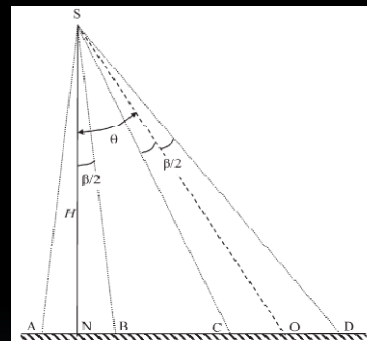
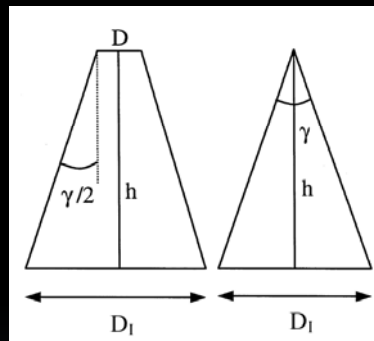
- ✓ Pueden determinar los costes de adquisición e incluso la viabilidad del proyecto
- ✓ Frecuencia de emisión de pulsos:
 - Número de pulsos emitidos por segundo.
 - ≥ 150 kHz.
 - Mayor altura de vuelo y velocidad $\rightarrow$ ↓ Tiempo de vuelo y costes
- ✓ Patrón de escaneo:
 - Función del *espejo*
- ✓ Frecuencia de escaneo:
 - Número de líneas por segundo
- ✓ Ángulo de escaneo:
 - Determina el FOV
- ✓ Divergencia del rayo:
 - Incremento del diámetro del rayo con la distancia



✓ Pueden determinar los costes de adquisición e incluso la viabilidad del proyecto

✓ Diámetro de la huella:

- IFOV
- Área muestreada por el láser.
- f (altura de vuelo, ángulo escaneo, divergencia del rayo, geometría objeto)



✓ Distancia entre huellas:

- Junto con el diámetro de la huella determina la resolución

✓ Configuración de registro:

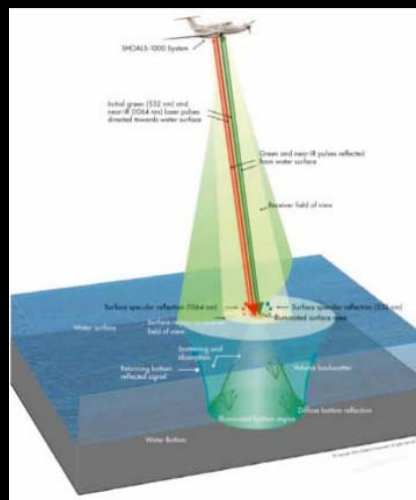
- Determina cómo se graban la energía recibida

✓ Criterios

✓ Superficie a medir



$\lambda=(700-1550 \text{ nm})$



$\lambda_1=(700-1300 \text{ nm})$
 $\lambda_2=(500-600 \text{ nm})$

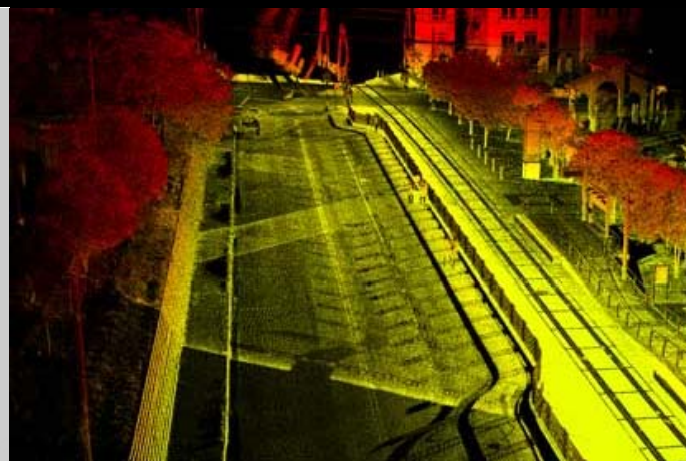
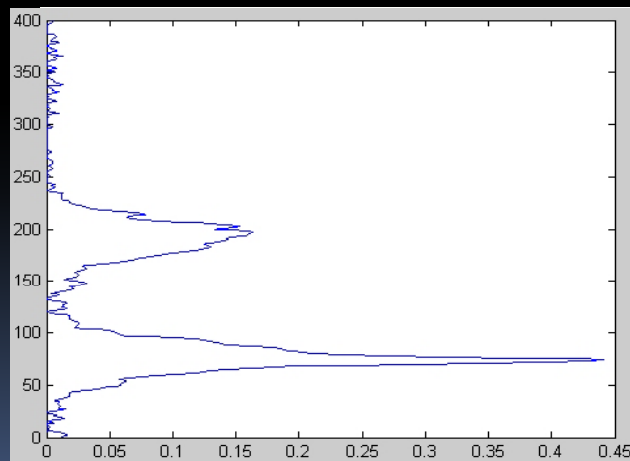


✓ Criterios

✓Plataforma

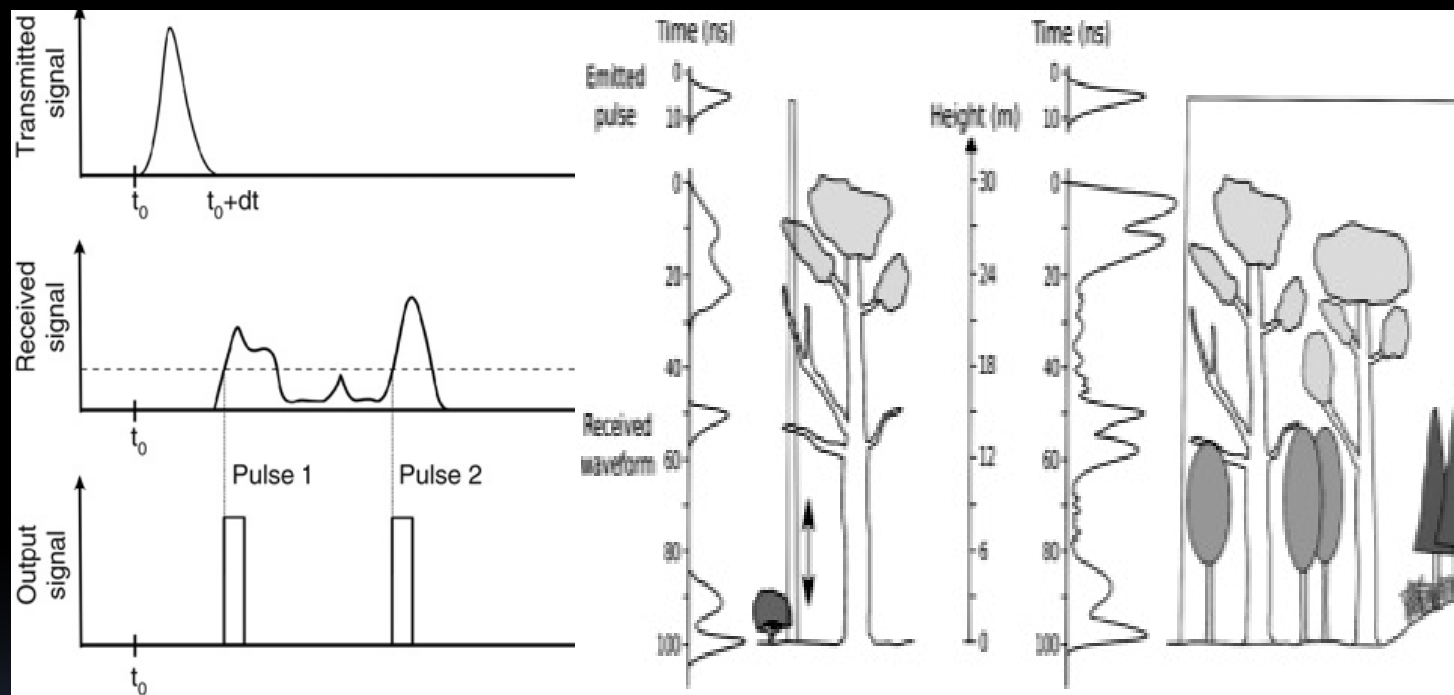
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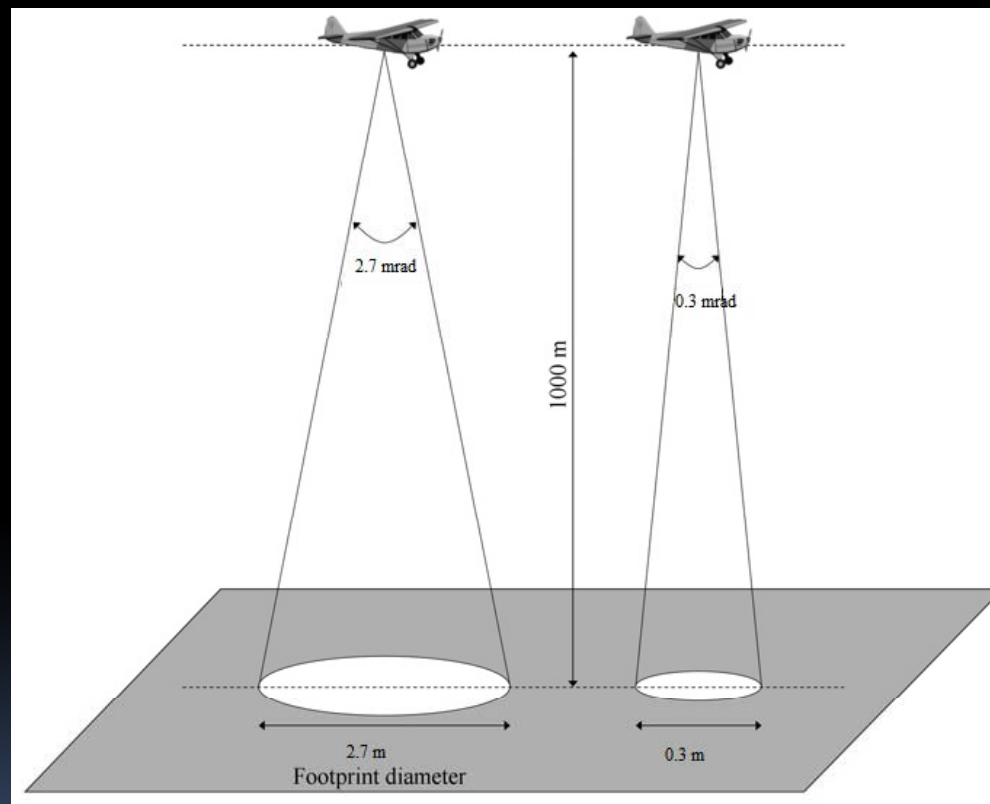
✓ Criterios

✓ Capacidad de registro



✓ Criterios

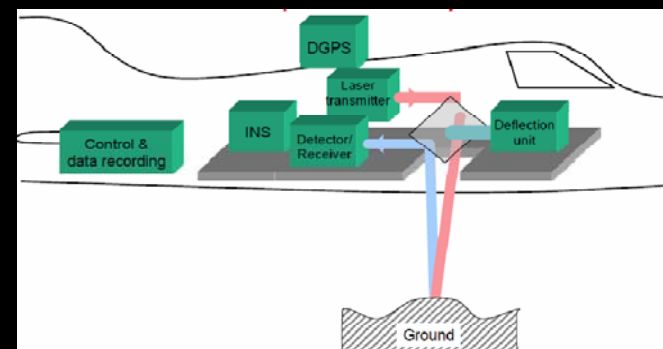
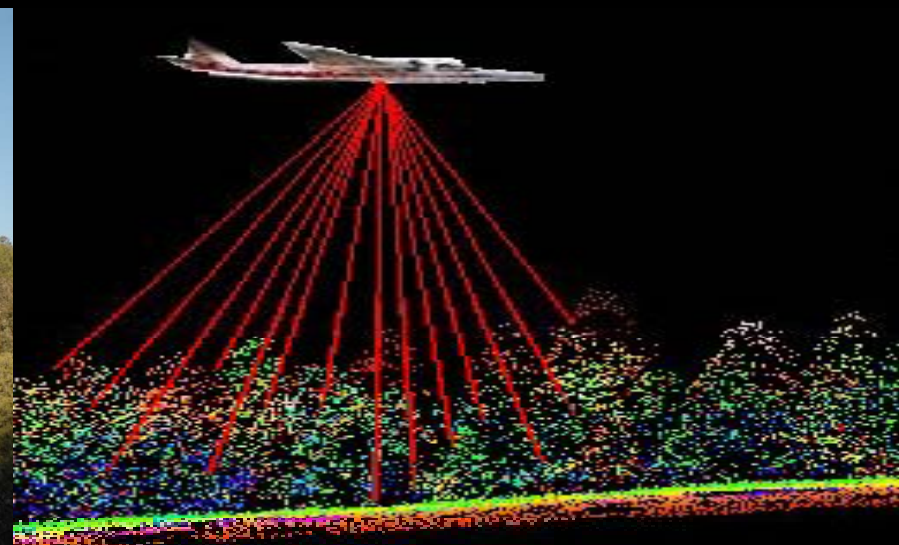
✓Tamaño de huella



✓ Datos LiDAR

Datos

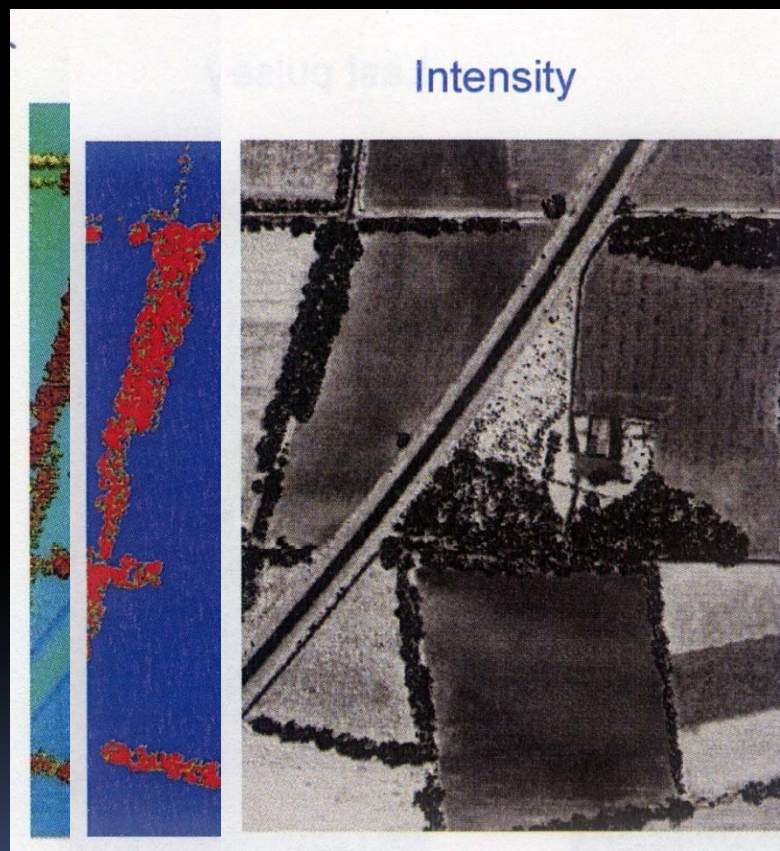
proporcionados

[illegible]

Datos adquiridos por sistemas LiDAR

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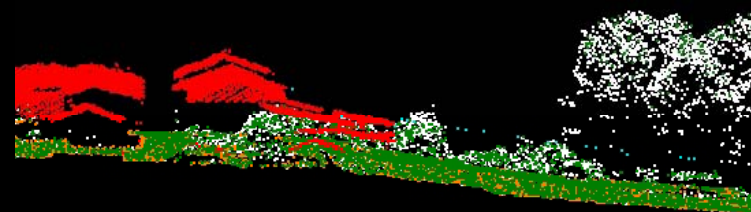
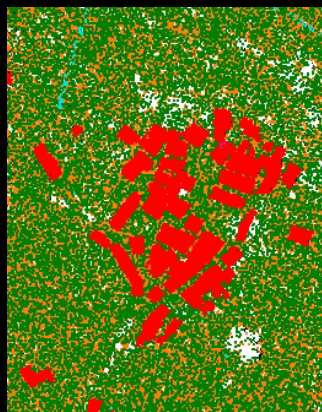


Datos adquiridos por sistemas LiDAR

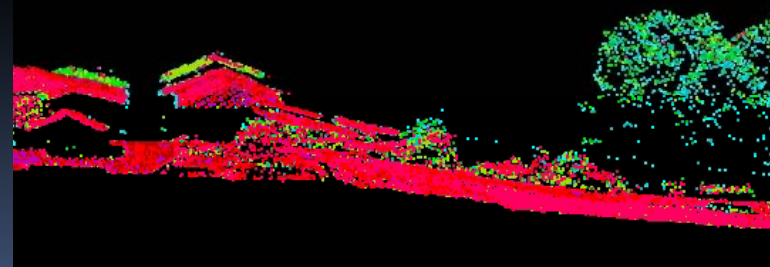
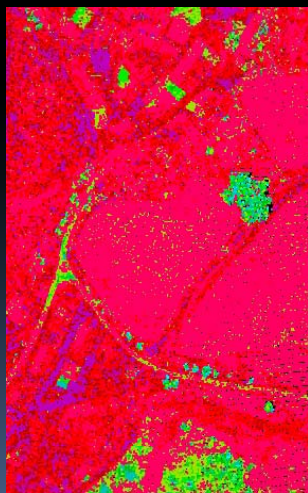
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Classified returns



Intensity data



Datos adquiridos por sistemas LiDAR

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Intensidad

$$P_r = \frac{\rho \eta_{atm}^2 D_r^2 D_{tar}^2}{4R^4 \gamma^2} P_s \quad (\text{Baltsavias, 1999})$$

Intensidad depende:

- ✓ Propiedades del sistema
- ✓ Ángulo de incidencia
- ✓ Distancia
- ✓ Reflectividad del objeto

Intensidad varía entre campañas, regiones o incluso a lo largo de una misma línea de vuelo

Problema: los sistemas comerciales no proporcionan información sobre el algoritmo empleado para detectar los retornos.

Datos adquiridos por sistemas LiDAR

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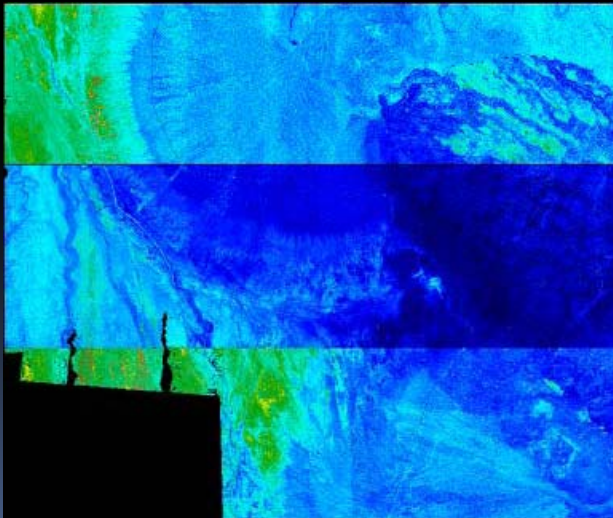
Calibración de los datos de intensidad ¿?

1.- Range dependency removal

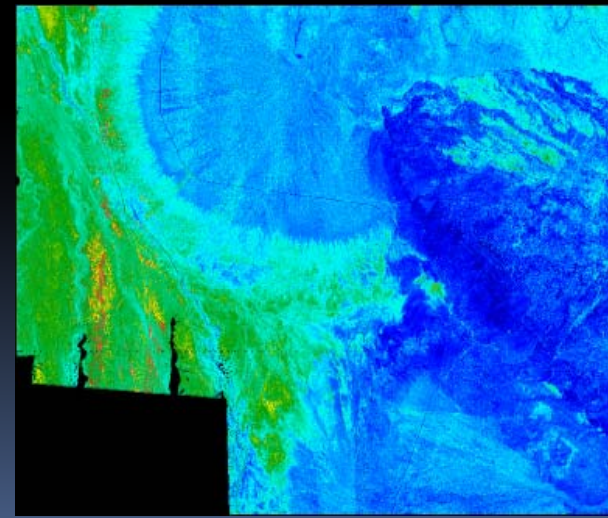
Datos normalizados a una distancia estándar definida por el usuario

$$I_{norm} = \frac{R^2}{R_s^2} I_{raw}$$

Before Normalization



After Normalization



Intensidad. Calibración

Se han propuesto otro método más elaborados

Höfle and Pfeifer (2007)

Utiliza dos aproximaciones

1.- Empírica.

- Asume que la intensidad es proporcional a la reflectividad del terreno y depende de la altura de vuelo via una función monótona.

Es necesario volar con distintas alturas de vuelo sobre las áreas (target) de referencia

Solo se pueden emplear retornos únicos como targets de referencia

2.- Teórica.

$$\rho_{\text{diffuse}}(R_s, \alpha) \propto I \frac{R^2}{R_s^2} 10^{2Ra/10000} \frac{1}{\cos\alpha}$$

Intensidad. Calibración

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Before Correction



Data-driven correction



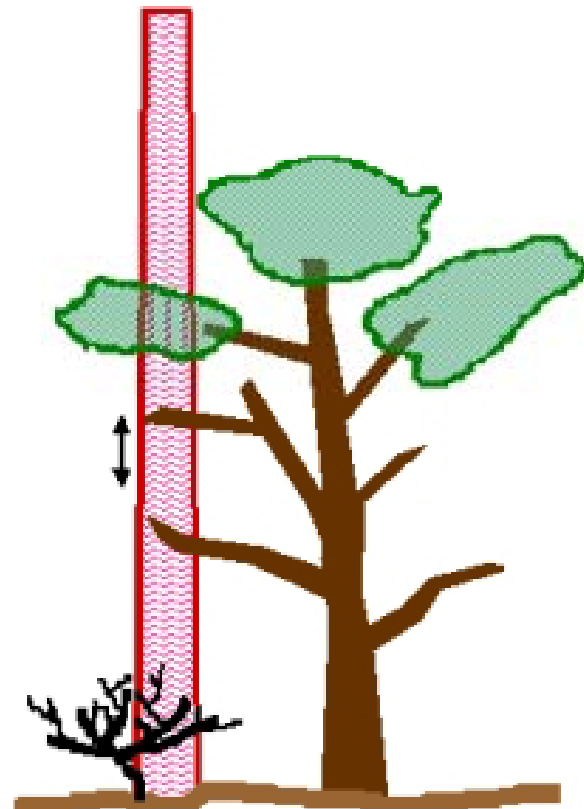
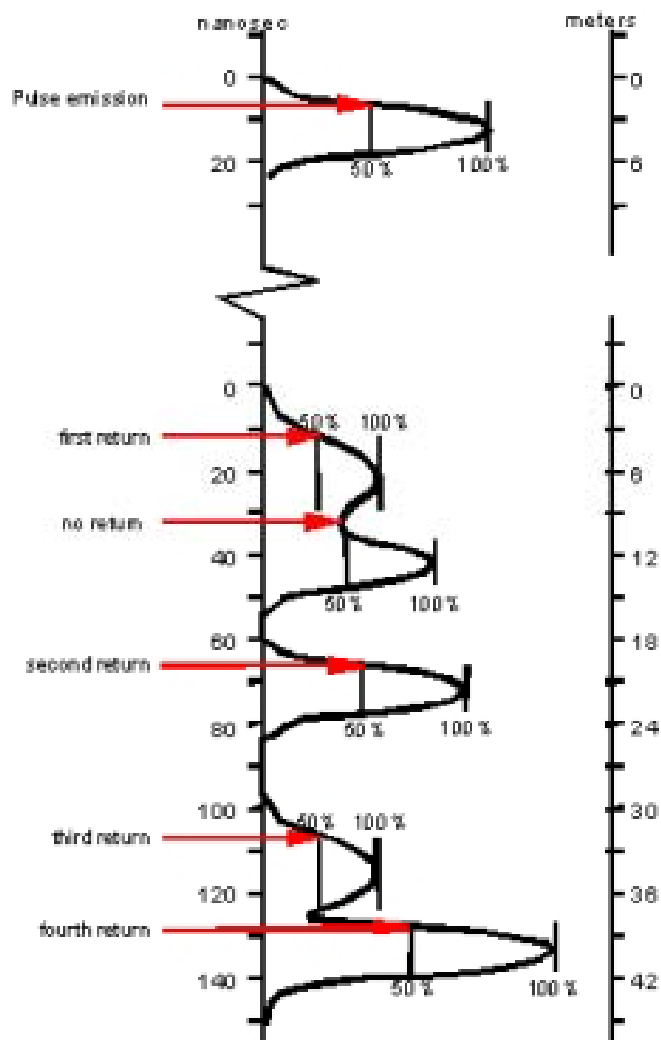
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Höfle and Pfeifer (2007)

Atributos de los datos LiDAR

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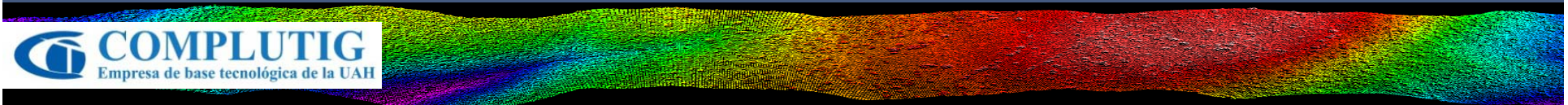
<https://www.e-education.psu.edu/lidar/book/export/html/1873>

Atributos de los datos LiDAR

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- ✓ Ángulo de escaneo:
 - ✓ Atributo del pulso → = todos los retornos asociados
- ✓ Tiempo GPS:
 - ✓ Instante de emisión del pulso.
 - ✓ Atributo heredado por todos los retornos asociados al pulso
- ✓ Final línea escaneo:
 - ✓ Atributo binario. Indica si el pulso corresponde al final.
 - ✓ Atributo heredado por todos los retornos
- ✓ Clasificación:
 - ✓ Clase a la que corresponde el retorno.
 - ✓ Opcional.



Formatos de los datos LIDAR

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Full waveform / **retornos discretos**

X, Y, Z, Intensidad

Primer y/o último retorno; múltiples retornos; ángulo escaneo; etc.

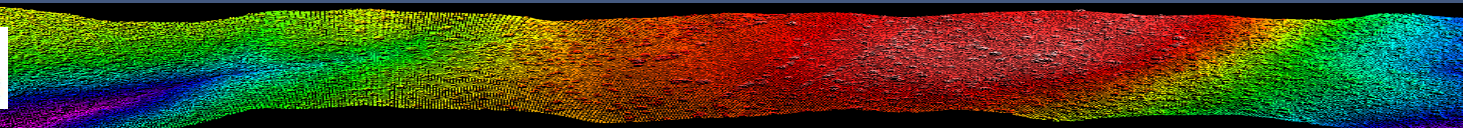
Variedad de formatos (propietarios, ASCII)

Inconvenientes:

Sistemas propietarios: difícil intercambio entre sistemas

Lectura e interpretación de los datos en formato ASCII puede ser muy lenta y el tamaño del archivo puede ser muy grande, incluso para cantidades de datos pequeña

La información bruta, así como cierta información específica de la adquisición de los datos es perdida.



Str_169.all - WordPad									
Archivo Edición Ver Insertar Formato Ayuda									
219791.262052	30569628.69	4529230.87	1225.35	109	30569628.68	4529230.88	1225.28	109	
219791.262082	30569628.23	4529231.75	1225.25	107	30569628.24	4529231.75	1225.29	107	
219791.262112	30569627.80	4529232.63	1225.31	108	30569627.80	4529232.63	1225.34	108	
219791.262142	30569627.37	4529233.51	1225.38	123	30569627.36	4529233.51	1225.32	123	
219791.262172	30569626.93	4529234.39	1225.41	120	30569626.92	4529234.39	1225.36	120	
219791.262202	30569626.49	4529235.27	1225.42	78	30569626.49	4529235.26	1225.47	78	
219791.262232	30569626.11	4529236.02	1225.46	80	30569626.12	4529236.02	1225.47	80	
219791.262262	30569625.67	4529236.90	1225.43	119	30569625.67	4529236.90	1225.49	119	
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GPS-time X,Y,Z & Intensity last return					X,Y,Z & Intensity 1 st return				
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219791.262472	30569622				30569622.66	4529242.93	1225.65	132	
219791.262502	30569622.14	4529243.94	1225.58	116	30569622.15	4529243.94	1225.60	116	
219791.262532	30569621.76	4529244.69	1225.59	137	30569621.77	4529244.69	1225.62	137	
219791.262562	30569621.33	4529245.57	1225.66	116	30569621.32	4529245.57	1225.63	116	
219791.262592	30569620.89	4529246.45	1225.68	124	30569620.88	4529246.45	1225.64	124	
219791.262622	30569620.43	4529247.34	1225.62	136	30569620.43	4529247.34	1225.62	136	
219791.262652	30569620.06	4529248.09	1225.64	125	30569620.05	4529248.09	1225.62	125	
219791.262682	30569619.66	4529248.85	1225.57	135	30569619.68	4529248.85	1225.66	135	
219791.262712	30569619.23	4529249.73	1225.67	118	30569619.24	4529249.73	1225.68	118	
219791.262742	30569618.73	4529250.74	1225.66	110	30569618.74	4529250.73	1225.74	110	
219791.262772	30569618.30	4529251.61	1225.80	126	30569618.30	4529251.61	1225.78	126	
219791.262802	30569617.85	4529252.50	1225.72	151	30569617.85	4529252.50	1225.76	151	
219791.262832	30569617.40	4529253.38	1225.71	143	30569617.41	4529253.38	1225.77	143	
219791.262862	30569616.95	4529254.27	1225.69	145	30569616.96	4529254.27	1225.73	145	

Huso UTM

Formatos de los datos LIDAR

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LASer (LAS) File Format Exchange

Formato público para el intercambio de datos LiDAR

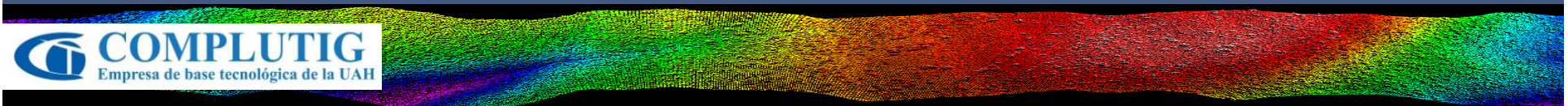
Formato de archivos binarios-- ASPRS

Última versión → permite almacenar datos full waveform

http://www.asprs.org/society/committees/standards/asprs_las_spec_v13.pdf

Actualmente, incluso software no específico para datos LiDAR software, puede leer archivos LAS

PCI GEOMATICS , ENVI, ERDAS, ArcGIS, GVSIG,...



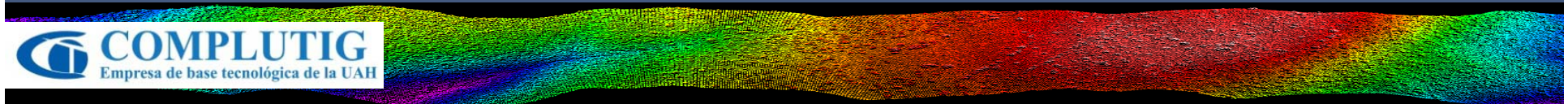
Formatos de los datos LIDAR

LAS format v1.3

POINT DATA RECORD FORMAT 0:

Table 4.9 - ASPRS Standard LIDAR Point Classes

	Classification Value (bits 0:4)	Meaning	
It	0	Created, never classified	ed
X	1	Unclassified ¹	
Y	2	Ground	
Z	3	Low Vegetation	
Ir	4	Medium Vegetation	
F	5	High Vegetation	
N	6	Building	
S	7	Low Point (noise)	
E	8	Model Key-point (mass point)	
(	9	Water	
s	10	Reserved for ASPRS Definition	
U	11	Reserved for ASPRS Definition	
F	12	Overlap Points ²	
s	13-31	Reserved for ASPRS Definition	



Precisión de las coordenadas

Fuentes de distorsión (Huising & Gomes Pereira, 1998; Maas, 2001):

- ✓ Sistema Laser (laser instrument+INS+GPS)
- ✓ Efectos atmosféricos (troposphere, atmospheric transmissivity)
- ✓ Características del objeto (*permeabilidad*, pendiente, ...)

Determinación de las distancias → Z

Espejo → X,Y

GPS/IMU → principal fuente de error (Maas, 2001)

10-20 cm en Z, hasta 50 cm en X,Y

Precisión de las coordenadas

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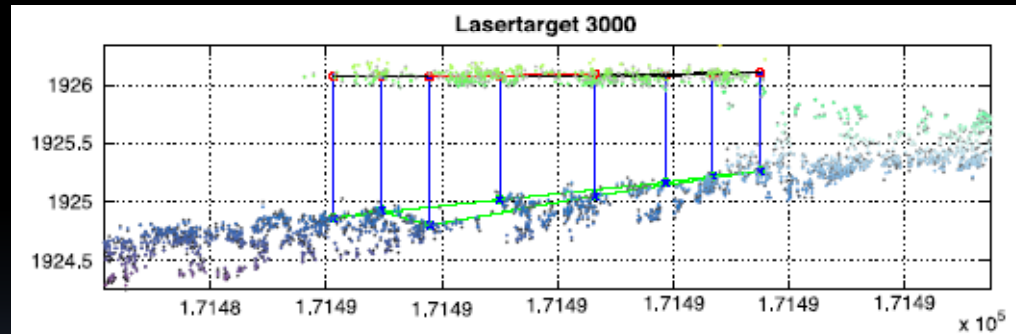
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Ejemplo determinación de la precisión:

Z error en torno a $\pm 15\text{cm}$ para una altura de vuelo de 1000 m.
Error horizontal (X,Y) en torno a 50cm (o 1/2000 la altura de vuelo).

(Amable, G. comunicación personal)



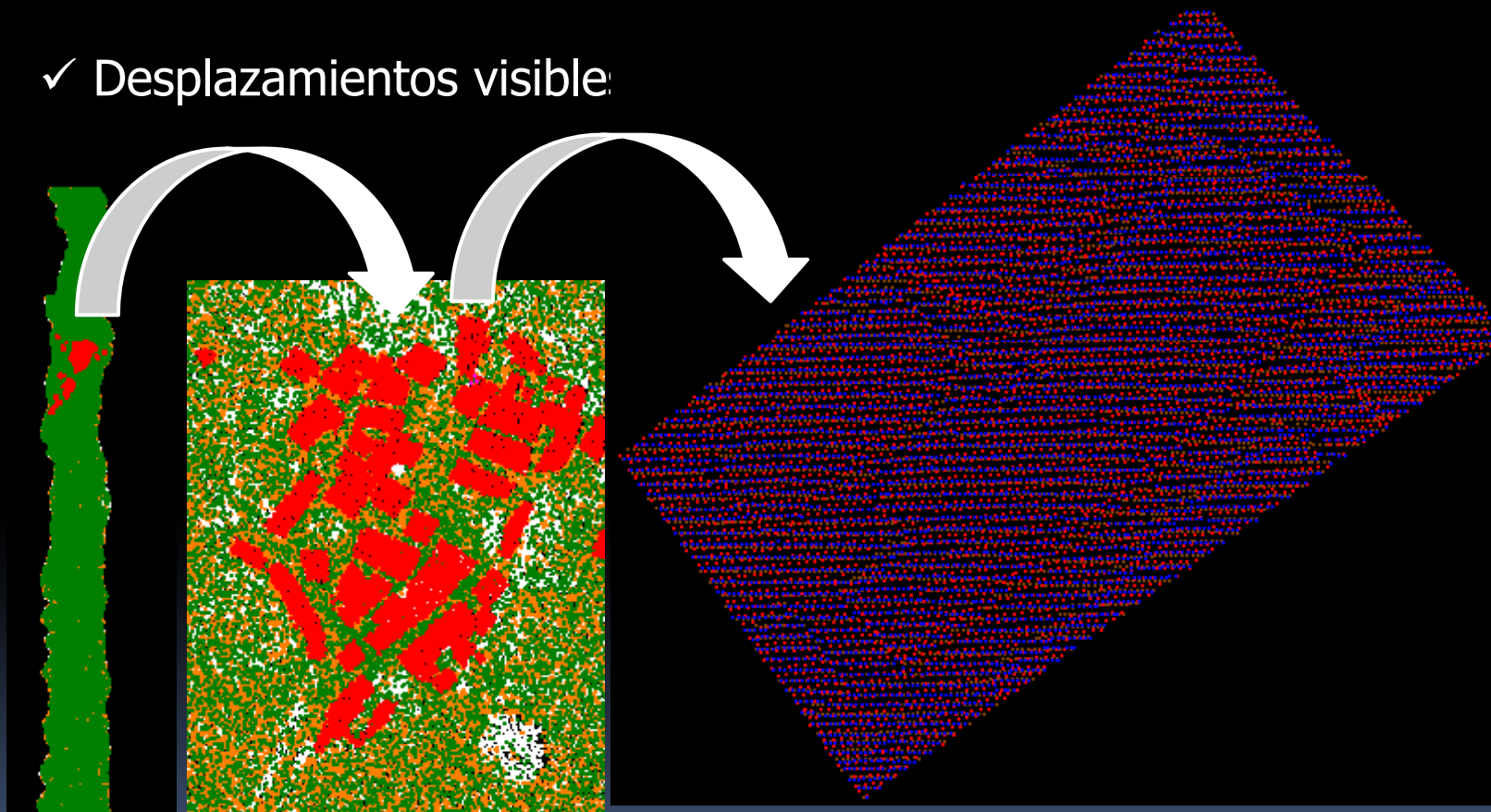
■ $3 \times 3 \text{ m}$

Morsdorf, 2004

Precisión de las coordenadas

¿Cómo quedan reflejados estos errores?:

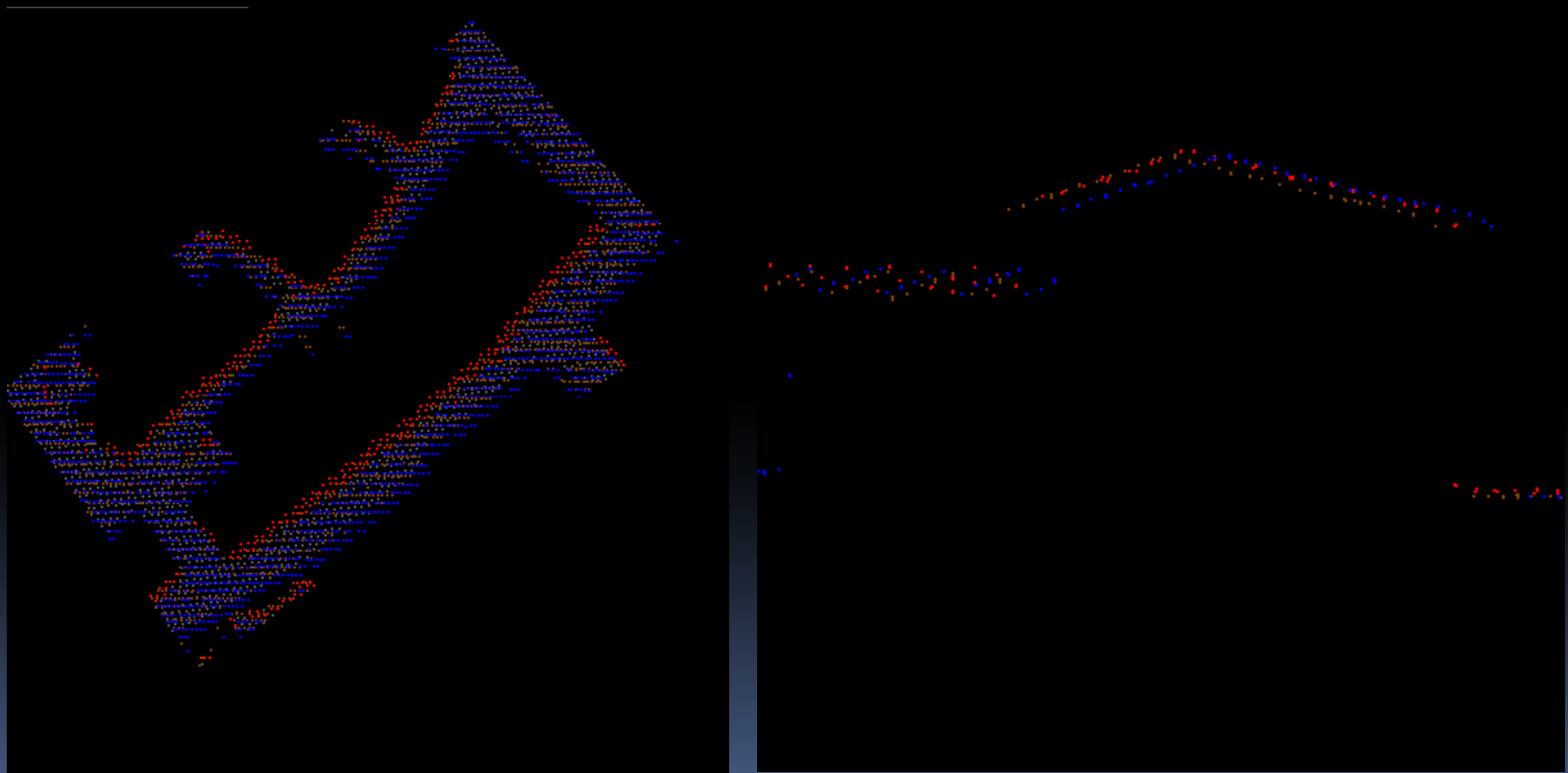
✓ Desplazamientos visibles



Precisión de las coordenadas

¿Cómo quedan reflejados estos errores?:

✓ Desplazamiento horizontal. Elementos artificiales



Precisión de las coordenadas

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Corrección de los desplazamientos:

Global: aplicación de métodos que permiten corregir en bloque los desplazamientos horizontales y verticales

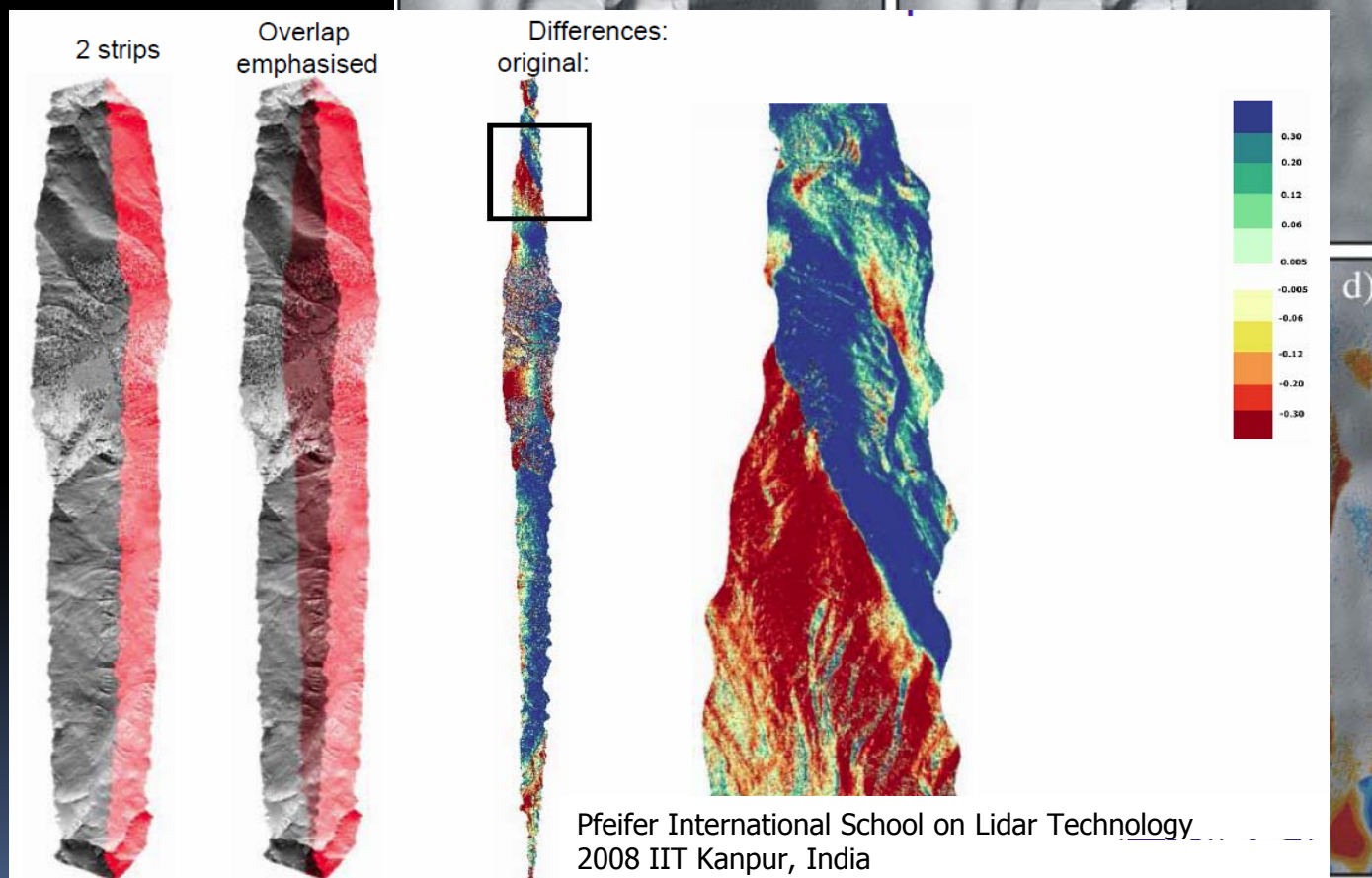
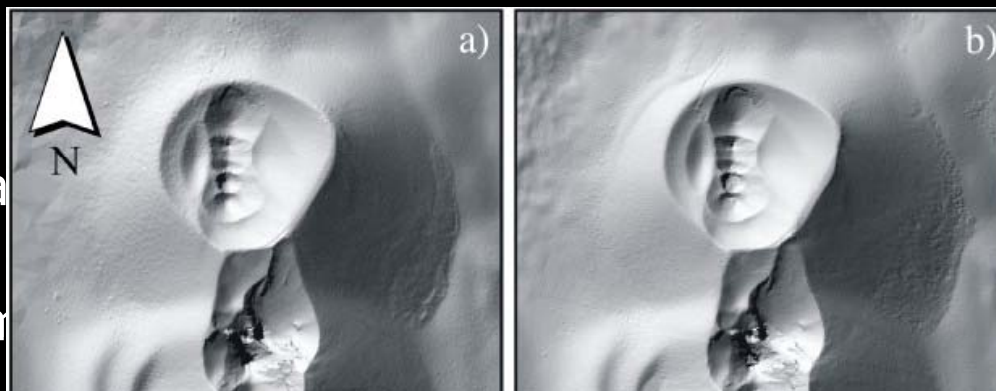
- ✓ Modelos que consideran diferencias entre puntos
 - ✓ Identificación de elementos que permite cuantificar las diferencias entre ambas pasadas.
- ✓ Modelos sensor

2- fases: corrección primero en Z y luego en X,Y.

Precisión de

¿Cómo queda

✓ Desplazam



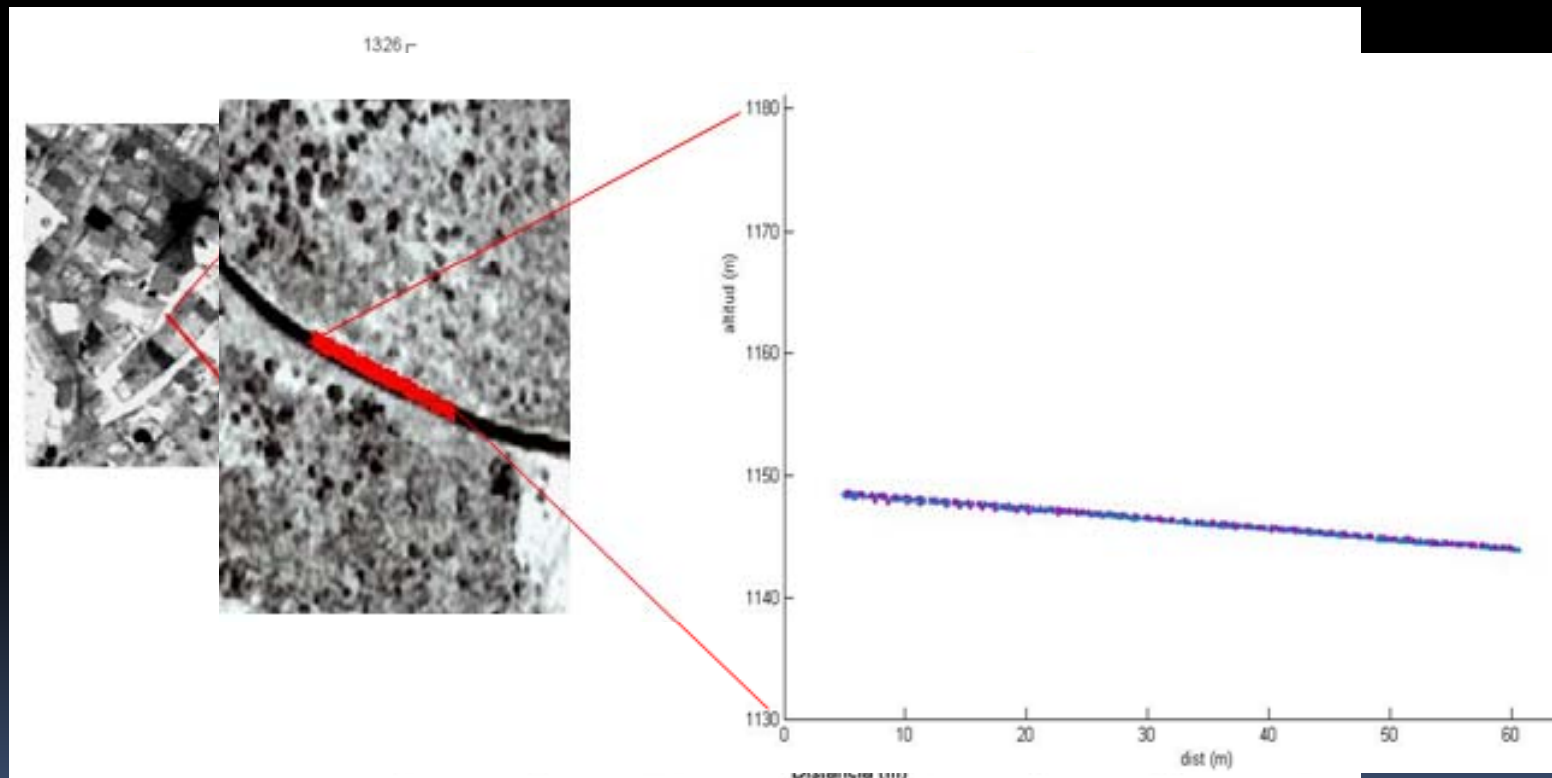
Pfeifer International School on Lidar Technology
2008 IIT Kanpur, India

Ravani et al., (2009)

Precisión de las coordenadas. Ejemplo corrección error planimétrico

Precisión nominal

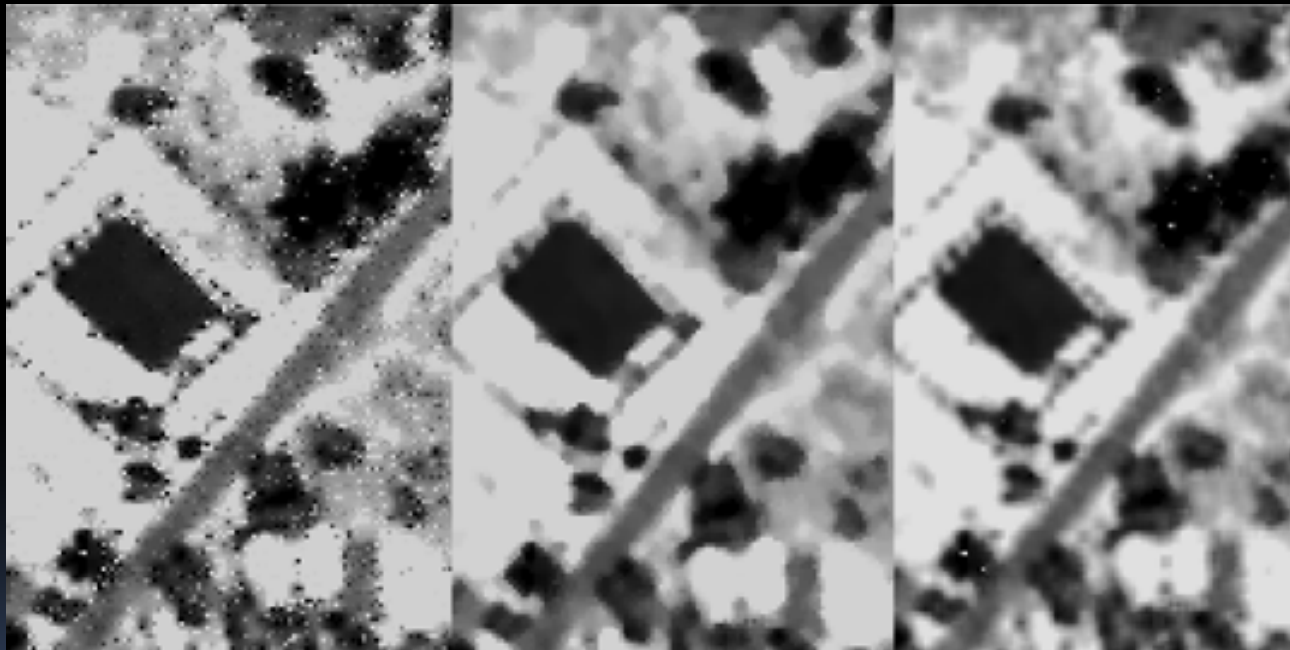
10-20 cm en Z, hasta 50 cm en X,Y



García et al. 2009 (Geofocus)

Precisión de las coordenadas. Ejemplo corrección error planimétrico

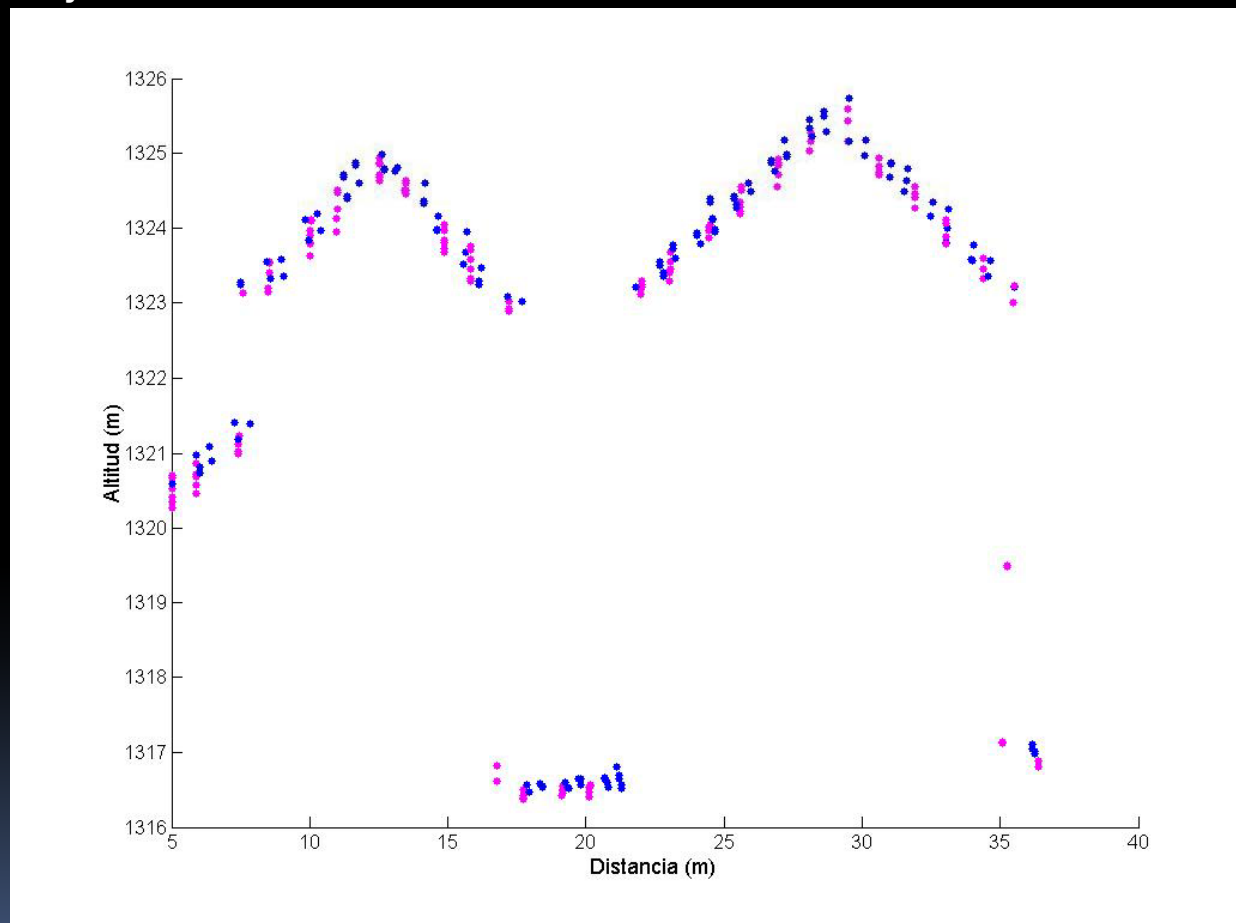
- ✓ Generación imágenes de intensidad a partir de los datos LiDAR
- ✓ Aplicación de técnicas de correlación de imágenes



García et al. 2009 (Geofocus)

Precisión de las coordenadas. Ejemplo corrección error planimétrico

Datos ajustados con una transformación afín 2-D



García et al. 2009 (Geofocus)

Recursos: software comerciales de procesamiento y visualizacion

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Terrasolid TerraScan TerraModeler

Merrick's Advanced Remote Sensing (MARS) Software

QT Modeler (Tinning and visualization)

ArcGIS and extensions

Interactive Data Language (IDL) for custom routines

GlobalMapper

Recursos disponibles

LAStools: [award-winning](#) software for rapid LiDAR processing

[download LAStools HERE](#)

now with GUIs and ArcGIS toolbox


L2Tools

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L2Tools

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L2Tools

 Like
 406


L2Tools

There are enormous amounts of uncompressed laser scanning points


L2Tools

Martin Isenburg
L2Tools


L2Tools

The BLAST extension can triangulate billions of [#L2Tools](#) points and raster them into one massive yet seamless DEM: [lnkd.in/B9GACQ](#)
 5 days ago · [reply](#) · [retweet](#) · [favorite](#)


L2Tools

The LASZip [#L2Tools](#) compressor and the [#L2Tools](#) format are featured on [@GeoDataPoint geodatapoint.com/articles/view/...@POBMag](#)
 12 days ago · [reply](#) · [retweet](#) · [favorite](#)


L2Tools

Ultra-efficient [#L2Tools](#) processing toolbox for ArcGIS 9.3 10.0 10.1. Download at [lastools.org/download/lasto... Pics at facebook.com/media/set/?set... #FertILC](#)


 Facebook social plugin

Join the conversation



bcal-lidar-tools

BCAL LIDAR Tools for processing and visualizing LIDAR data

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Project Information

 +3 Recommend this on Google

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Code license

[GNU GPL v3](#)

Labels

LIDAR, lidar, remotesensing, ENVI, GIS, geoscience, ALS, pointcloud, 3Dvisualizer, HeightFiltering, DEM, LAS

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[shrer_@isu.edu](#)

[2 committers](#)

Featured

 **Downloads**

[LIDARTools-14.1-envi5.zip](#)

[LIDARTools-14.2.zip](#)

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BCAL LIDAR Tools

BCAL LIDAR Tools are open-source tools developed by Idaho State University, [Ruess Center Aerospace Laboratory \(BCAL\)](#). These tools can be used for processing, analyzing and visualizing [LIDAR](#) data. They are written in [IDL](#) programming language. The tools can currently process LIDAR data up to [LAS 1.2 format](#).

Installation Instructions

- Follow the [installation instructions here](#). Version 2.x.x can be run with free [IDL Virtual Machine](#), and does not need ENVI software.

Using the Tools

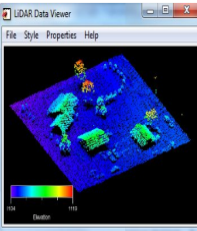
- Please visit [wiki pages](#) for further help on using the tools.
- Sample LIDAR Data: To download sample datasets, visit the [USGS CLICK](#) or [OpenTopography](#) websites.

Bug Report/Feature Request

- If you have found a bug or issue with the tools, or would like to request a new feature to be added to the tool, please submit an issue or feature request in the [issue tracking system](#).

Earlier versions

- BCAL LIDAR Tools were originally developed by David Streutker and are distributed through <http://bcal.geology.isu.edu/EnviTools.shtml>. BCAL LIDAR Tools have also been used by ITTVis to develop their own proprietary [LIDAR extension for ENVI](#).





[Home](#)
[About SPLib](#)
[Release page](#)
[FAQ](#)

The SPLib Documentation Wiki

These pages are for publicly documenting SPLib. If you would like to contribute please register.

What is SPLib?

SPLib is a set of open source tools used for processing large streaming data (e.g. LARs), including data captured from detectors and external platforms. The aim of the software is to provide you, the user, with the tools you need to process these data. The software you use for our work to LAR processing and we continue to grow. One of the key features which differentiates this software from other LAR software is the ability to process and store LAR waveform datasets alongside traditional detector stream data.

For more background on the software and its development see [here](#)

We are always looking to improve the software and its functionality so please email the mailing list if you think there are missing features or you run into problems.

Downloading SPLib

The latest released version of SPLib is available for download from sourceforge (<http://sourceforge.net/projects/splib/files>). This is the very latest development version of SPLib, it is available from the project's Bitbucket repository. It can be checked out using the following command:

```
git clone http://git.splib.org:20022/splib.git
```

Installation

To build and install SPLib the [CMake](#) system is used. However, with all the pre-requirements installed and provided by CMake, just give the following commands are required to build and install SPLib.

```
mkdir build
cd build
cmake ..
make
make install
```

For more general information see the general [installation guide](#) and see the platform specific information below.

Supported Platforms

Currently only x86 platforms are supported by this software. As these generally (x86 and x86_64) are the platforms on which the software has been developed and tested. Although, the build system and software (including packaging) should still support Windows. This has not been tested beyond some basic experimentation. You can try to compile and run software without this information or your experience would be interesting and we can try and provide that support as well. At the time it is hoped that testing and support will be supported to support Windows.

For detailed instructions on installing SPLib and to pre-requirements see all of the following pages:

- Linux
- Mac OS
- Solaris
- Windows


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OpenTopography

A Portal to High Resolution
Topographic Data and Tools

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- Metadata**

Resources

This section of OpenTopography provides links to various resources related to high-resolution topographic data. We hope this section of the site will grow into a useful knowledge base. If you can't find what you are looking for here, please contact us using this [form](#) or email us via info (at) opentopography.org

- Tools**

The [OpenTopography Tool Registry](#) provides a community populated list of software oriented towards the visualization, processing and management of high-resolution (bathy) topographic data.

[Offline - OpenTopography Open Source Software](#) Information on open source software developed by the OpenTopography team. At this time includes links to information and source code for the [Pumba25d](#) local [gnssing algorithm](#) for DEM generation from lidar point cloud data.
- Education & Training**

[Classroom Resources](#): Information for teachers on using LIDAR topography and the OpenTopography Portal in the classroom.

[Documents](#): Information prepared or compiled by the OpenTopography team and/or the LIDAR user community on technical aspects of LIDAR data and applications of these data.

[Links](#): Selected links to other sites related to topographic data and applications. Includes list of online sources of data, discussion forums and listserves, and organizations.

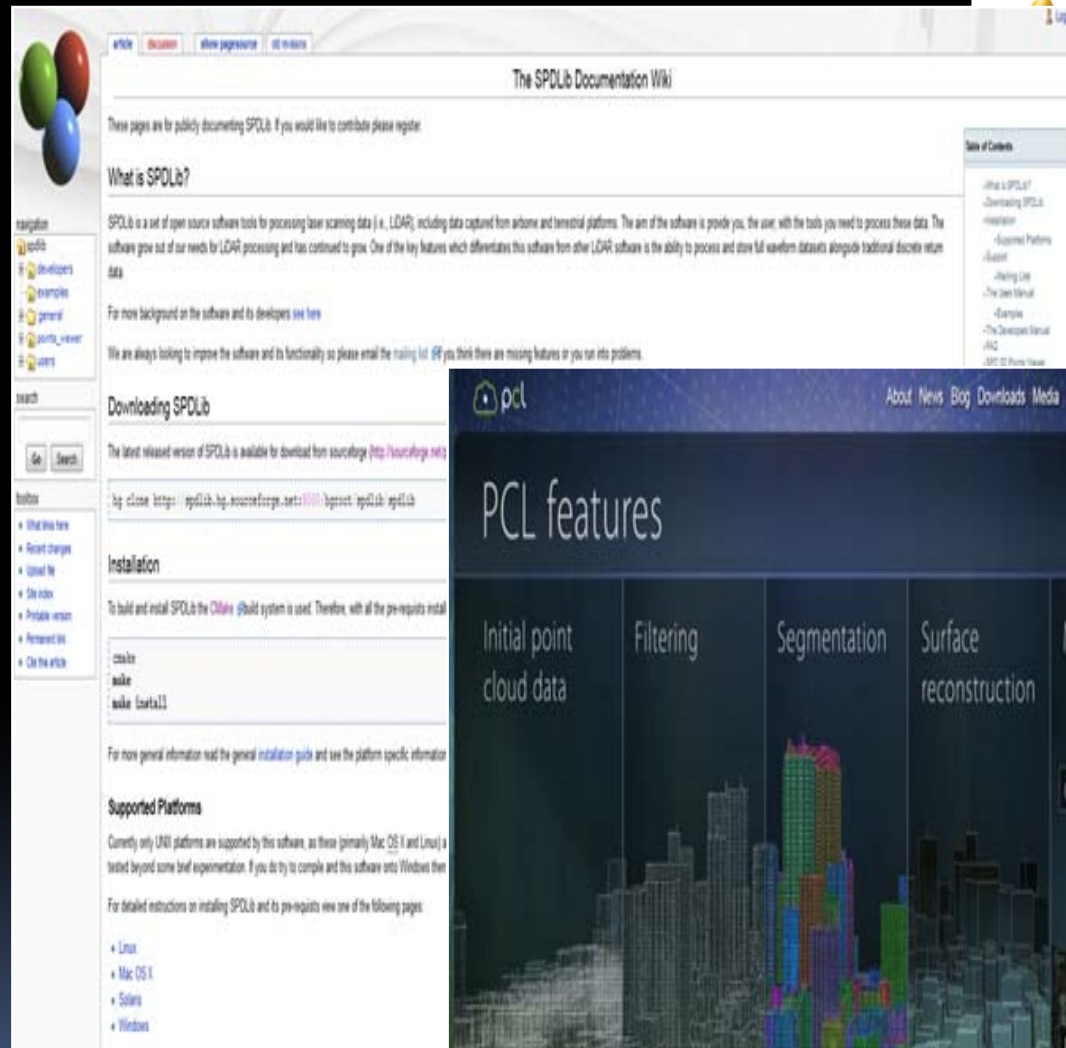
[Short Courses](#): Slides, exercise handouts, sample data, and documents compiled for short courses and workshops we have taught.

[Tutorials & Webex](#): Tutorials on the OpenTopography system, tools, and LIDAR technology.
- Dataset Metadata**

Metadata, associated files, and other supporting information for the datasets hosted by OpenTopography.

Sections: [Home](#) | [About](#) | [Data](#) | [Resources](#) | [Community](#) | [Support](#)

Recursos de libre distribucion



The SPDLib Documentation Wiki

These pages are for publicly documenting SPDLib. If you would like to contribute please register.

What is SPDLib?

SPDLib is a set of open source software tools for processing laser scanning data (i.e., LiDAR), including data captured from airborne and terrestrial platforms. The aim of the software is provide you, the user, with the tools you need to process these data. The software grew out of our needs for LiDAR processing and has continued to grow. One of the key features which differentiates this software from other LiDAR software is the ability to process and store full waveform datasets alongside traditional discrete return data.

For more background on the software and its developers [see here](#).

We are always looking to improve the software and its functionality so please email the mailing list [if](#) you think there are missing features or you run into problems.

Downloading SPDLib

The latest released version of SPDLib is available for download from sourceforge (<http://sourceforge.net>):

big clone: <http://spdlib.sourceforge.net:31222/viewsvn/spdlib-spdlib>

Installation

To build and install SPDLib the [CMake](#) build system is used. Therefore, with all the pre-requisites installed:

```
cmake
make
make install
```

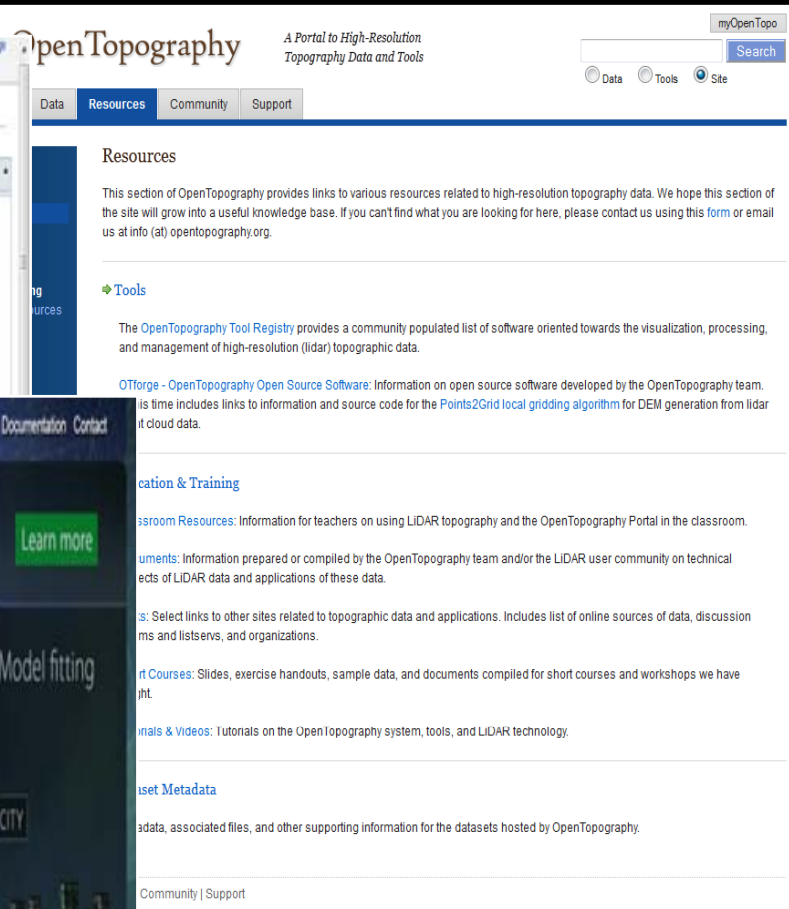
For more general information read the general [installation guide](#) and see the platform specific information.

Supported Platforms

Currently only UNIX platforms are supported by this software, as these (primarily Mac OS X and Linux) are tested beyond some brief experimentation. If you do try to compile and this software onto Windows then

For detailed instructions on installing SPDLib and its pre-requisites view one of the following pages:

- Linux
- Mac OS X
- Solaris
- Windows



OpenTopography

A Portal to High-Resolution Topography Data and Tools

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Resources

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Tools

The [OpenTopography Tool Registry](#) provides a community populated list of software oriented towards the visualization, processing, and management of high-resolution (lidar) topographic data.

OTforge - OpenTopography Open Source Software

Information on open source software developed by the OpenTopography team. This time includes links to information and source code for the [Points2Grid local gridding algorithm](#) for DEM generation from lidar it cloud data.

Education & Training

[Classroom Resources](#): Information for teachers on using LiDAR topography and the OpenTopography Portal in the classroom.

[Tutorials](#): Information prepared or compiled by the OpenTopography team and/or the LiDAR user community on technical aspects of LiDAR data and applications of these data.

[Links](#): Select links to other sites related to topographic data and applications. Includes list of online sources of data, discussion forums and listservs, and organizations.

Courses

[Slides](#): Slides, exercise handouts, sample data, and documents compiled for short courses and workshops we have given.

Tutorials & Videos

[Tutorials](#): Tutorials on the OpenTopography system, tools, and LiDAR technology.

Dataset Metadata

[Metadata](#): Metadata, associated files, and other supporting information for the datasets hosted by OpenTopography.

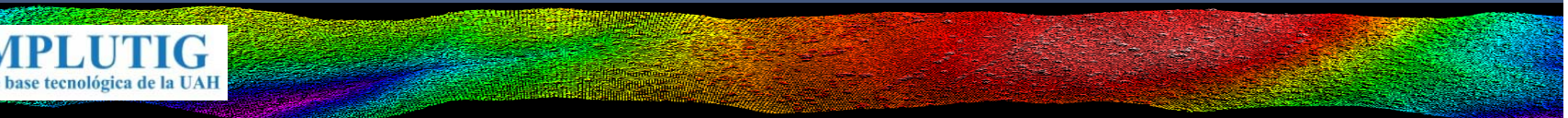
Community | Support

Recursos de libre distribucion

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- ✓ <http://www.airbornelasermapping.com/>
- ✓ <http://www.lidarmap.org/index.html>
- ✓ <http://www.fsl.orst.edu/~lefsky/>
- ✓ <http://www.asprs.org/society/committees/lidar/>
- ✓ <http://www.geo.unizh.ch/~morsdorf/>
- ✓ <http://lidar.cr.usgs.gov>



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✓ Research groups

- ✓ Dubayah – University of Maryland
- ✓ Lefsky – Colorado State University
- ✓ Hyppa - Helsinki University of Technology
- ✓ Naesset - Norwegian University of Life Sciences
- ✓ Homlgren – Swedish University of Agricultural Sciences
- ✓ Morsdorf- Universidad de Zurich
- ✓ Popescu – Universidad Texas A&M

✓ Journals

- ✓ Remote Sensing of Environment and other RS journals
- ✓ Scandinavian Journal of Forest Research, 19: 6, 2004
- ✓ Canadian Journal of Remote Sensing (CJRS). 2003. Special issue: LIDAR remote sensing of forest structure and terrain. Volume 29, No. 5
- ✓ ISPRS. 1999. Special issues on airborne laser scanning. *ISPRS Journal of Photogrammetry and Remote Sensing*, Vol. 54, No. 2 and 3

Thankyou
Merci.
Gracias
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