



JORNADAS URUGUAYAS DE gvSIG



JORNADAS DE TECNOLOGÍAS LIBRES DE  
INFORMACIÓN GEOGRÁFICA Y DATOS ABIERTOS

# Fotogrametría con drones

Servicio de Geomática – Intendencia de Montevideo

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# Agenda

- Normativa nacional
- Vehículos Aéreos No Tripulados (VANT, Dron, RPA)
  - Tipos y características principales
- Usos y productos principales
- Software
  - Planificación de vuelo
  - Software de procesamiento
  - Explotación de los productos

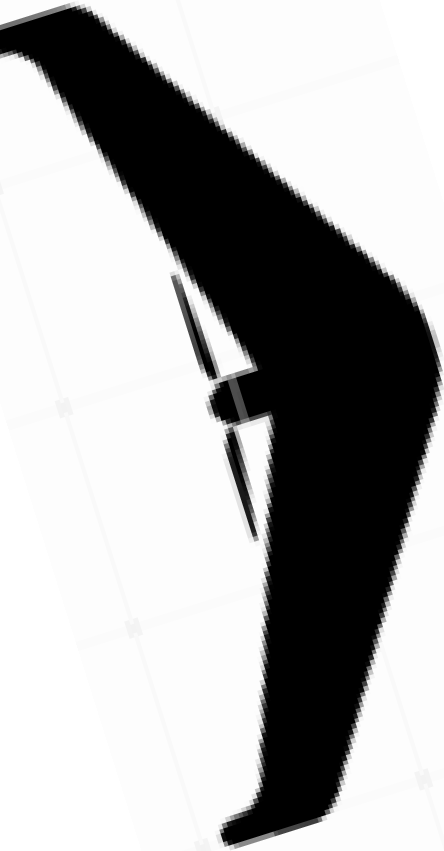
## Normativa nacional

**DINACIA** - Dirección Nacional de Aviación Civil e Infraestructura Aeronáutica

**Requisitos:** dependen del porte, así como del uso que se le vaya a dar (recreativo/deportivo o de trabajo).

- Registrar el Dron en la DINACIA (Res. 291/014)
- Permiso de trabajo aéreo
- Seguro de Responsabilidad Civil
- Permiso piloto
- Aprobar pruebas teórica y práctica
- Carné de salud al día

# Tipos de Drones y sus características



**Ala Fija**

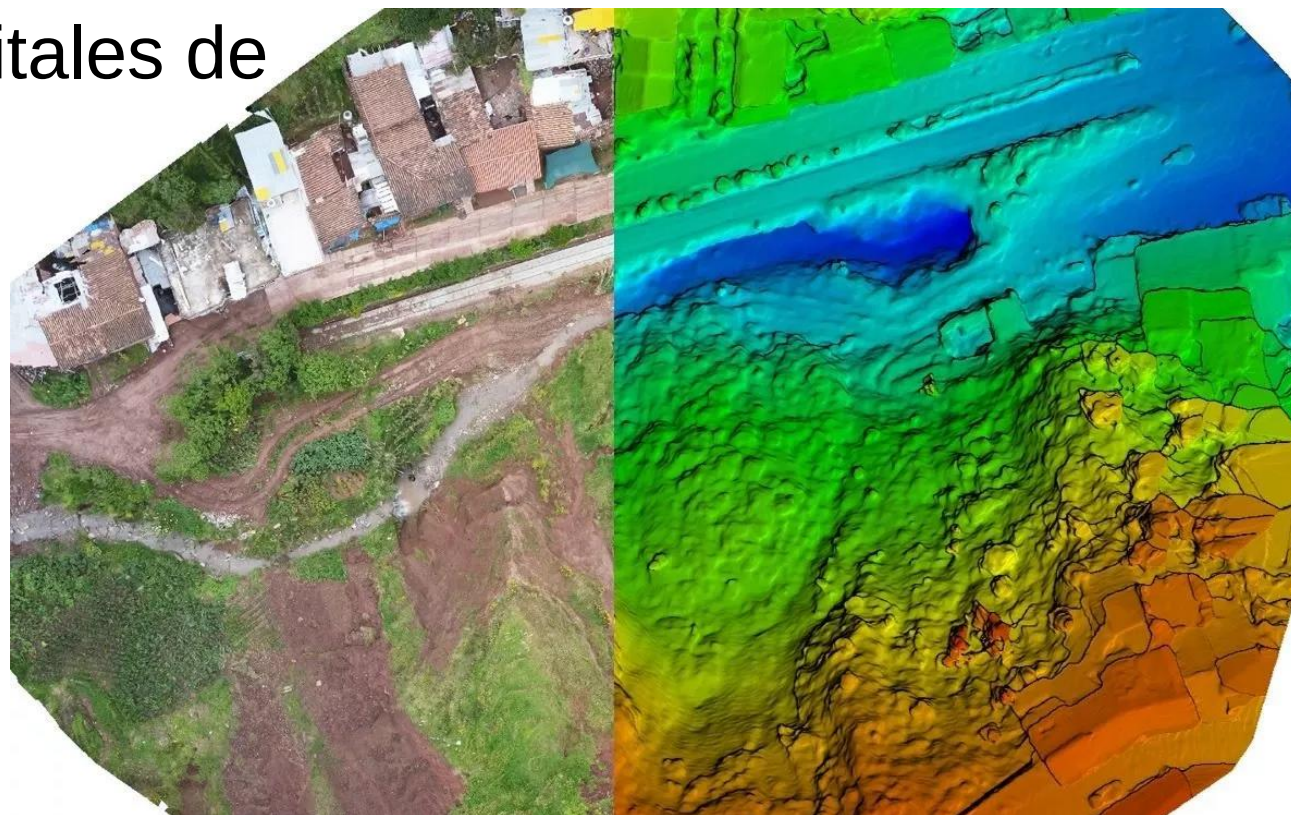
- Forma de despegue y aterrizaje
- Área de cobertura
- Duración de la batería
- Vuelo estático



**Multirotor**

# Productos principales 2D

- Ortofotoplanos
- Modelos digitales de elevaciones





3D

## Productos principales

- Nubes de puntos
- Modelos en 3D renderizados



50 m – 1 cm pixel  
76 m – 1,5 cm pixel  
120 m – 2,5 cm pixel

# Planificación de vuelo

- Software propietario/costo
  - Ejemplo: AiProFlight de Aibotix
- Software gratuito
  - Pix4Dcapture
  - DroneDeploy





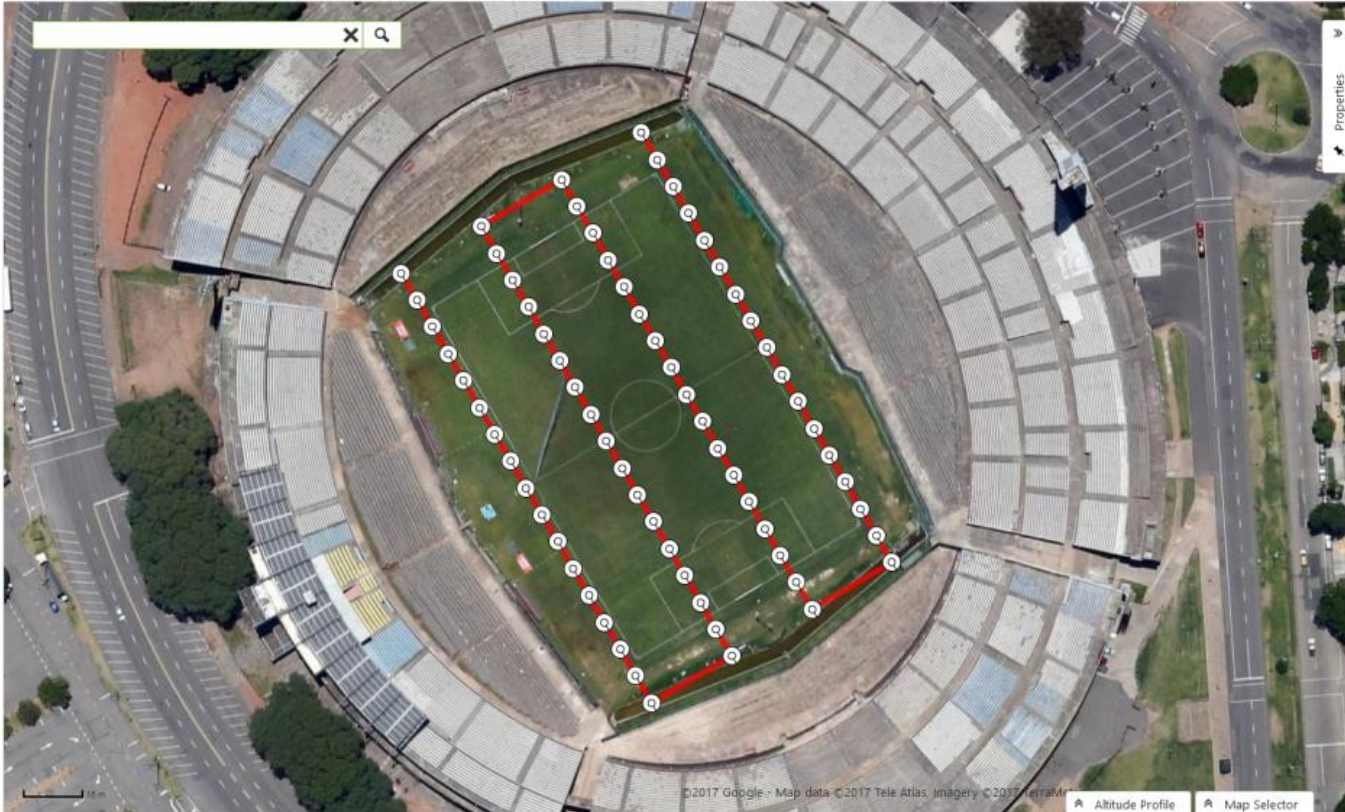
## AiProFlight

AIBOTIX AIROFLIGHT - PRUEBA

START PAGE PROJECT EDITOR LOG MANAGER UNIT CONFIGURATION ABOUT

Review 2.0.0.37

Properties



| No. | Type | Name | Latitude    | Longitude   | Altitude |
|-----|------|------|-------------|-------------|----------|
| 1   | WP   | WP1  | -34.8941750 | -56.1535100 | 50.85    |
| 2   | WP   | WP2  | -34.8942375 | -56.1534656 | 50.85    |
| 3   | WP   | WP3  | -34.8942999 | -56.1534212 | 50.85    |
| 4   | WP   | WP4  | -34.8943624 | -56.1533768 | 50.85    |
| 5   | WP   | WP5  | -34.8944249 | -56.1533324 | 50.85    |
| 6   | WP   | WP6  | -34.8944873 | -56.1532879 | 50.85    |
| 7   | WP   | WP7  | -34.8945498 | -56.1532435 | 50.85    |
| 8   | WP   | WP8  | -34.8946122 | -56.1531991 | 50.85    |
| 9   | WP   | WP9  | -34.8946747 | -56.1531547 | 50.85    |
| 10  | WP   | WP10 | -34.8947371 | -56.1531103 | 50.85    |
| 11  | WP   | WP11 | -34.8947996 | -56.1530659 | 50.85    |
| 12  | WP   | WP12 | -34.8948621 | -56.1530215 | 50.85    |
| 13  | WP   | WP13 | -34.8949245 | -56.1529771 | 50.85    |

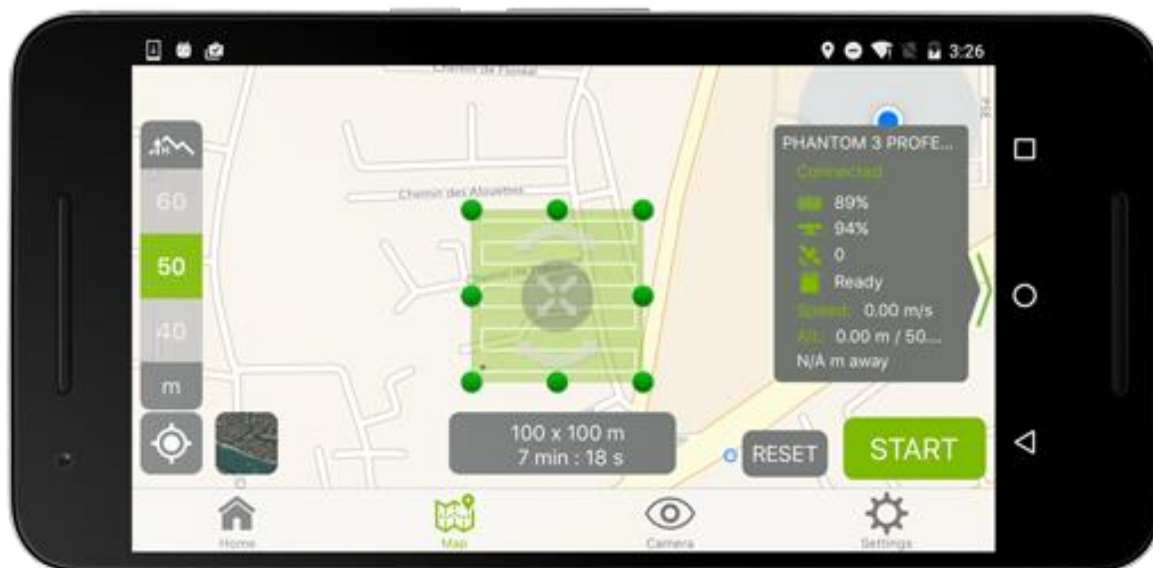
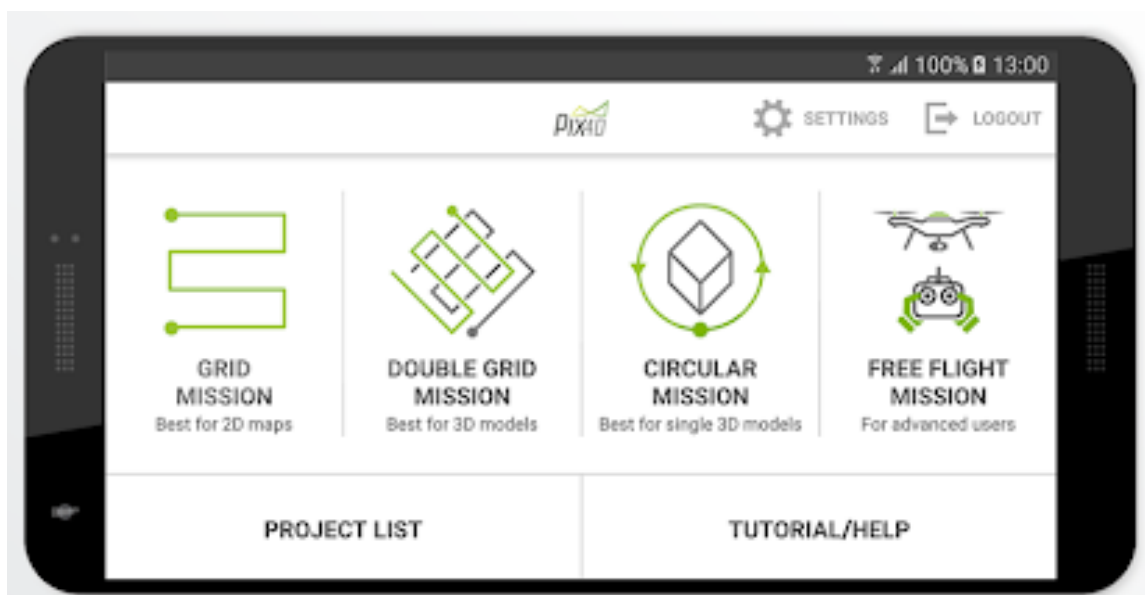
Waypoints Points of Interest

Altitude Profile Map Selector

586.09 m 00:06:30 #68 #0 0.00 m 00:00:00 #0 #0

50 m de altura - 1 cm pixel - 2 Há - 68 fotos







Dashboard

Plan Name  
Mlociny

4:49  
Minutes

4  
Hectares

1.9  
cm / px

1  
Battery

Altitude  
45 m

Flight Direction  
180°

Available Offline  
Downloading basemap, 0% done.

Advanced

Don't own a drone? [Test the simulator](#)

Planning

Advanced

Sidelap  
70%

Frontlap  
60%

Max Flight Speed  
15 m/s

Starting Waypoint  
19

Automatic Camera Settings

Orbit at End of Mission

# Software de procesamiento

| Programa                 | Plataforma             | Licencia                                              |
|--------------------------|------------------------|-------------------------------------------------------|
| <b>Visual SFM</b>        | Linux, OSX, Windows    | Libre y gratuito                                      |
| Open MVS                 | Linux, OSX, Windows    | Libre y gratuito                                      |
| MicMac                   | Linux, OSX, Windows    | Libre y gratuito                                      |
| <b>Opendronemap</b>      | Linux                  | Libre<br>ODM gratis<br>webODM 47\$-97\$ por única vez |
| <b>Pix4Dmapper</b>       | Windows, OSX, Online   | 291\$-350\$ /mes                                      |
| <b>AgiSoft PhotoScan</b> | Linux, OSX, Windows    | Standard 179\$ - Pro 3.499\$                          |
| PhotoModeler             | Windows                | Standard 49\$ - Scanner 149\$ - UAS 199\$ /mes        |
| Dron2Map (ArcGis)        | Windows                | 1.500\$ /usuario /año                                 |
| DroneDeploy              | Online                 | Pro 83\$ - Business 249\$ /mes                        |
| <b>DroneMapper</b>       | Linux, Windows, Online | RAPID gratis<br>Remote 499\$ - Expert 1.999\$         |

## Visual SFM

- Genera nubes de puntos
- No genera ortofoto
- Admite carga de puntos de apoyo
- Depende de otros algoritmos (SIFT, GCP, Bundle Adjustment, CMVS, PMVS2, etc.)
- Sin herramientas de medición
- Sin límite de cantidad de imágenes
- Documentación

```
Task Viewer
Run dense reconstruction, begin...
#####
Undistorting 21 images in model #0
param_undistortion_thread_num = 0
NOTE: using 12 threads...
#09: DSC00550 -> 00000007.jpg, 6.686 sec
#06: DSC00538 -> 00000012.jpg, 6.724 sec
#03: DSC00536 -> 00000015.jpg, 6.775 sec
#00: DSC00544 -> 00000000.jpg, 6.820 sec
#02: DSC00548 -> 00000004.jpg, 6.838 sec
#10: DSC00541 -> 00000009.jpg, 6.902 sec
#05: DSC00539 -> 00000011.jpg, 6.939 sec
#07: DSC00531 -> 00000014.jpg, 6.952 sec
#08: DSC00549 -> 00000006.jpg, 6.957 sec
#11: DSC00540 -> 00000010.jpg, 6.966 sec
#01: DSC00545 -> 00000002.jpg, 7.356 sec
#04: DSC00543 -> 00000005.jpg, 7.356 sec
#09: DSC00551 -> 00000008.jpg, 5.691 sec
#10: DSC00529 -> 00000020.jpg, 5.484 sec
#03: DSC00535 -> 00000016.jpg, 5.682 sec
#02: DSC00534 -> 00000018.jpg, 5.759 sec
#06: DSC00537 -> 00000013.jpg, 5.920 sec
#00: DSC00546 -> 00000001.jpg, 5.900 sec
#01: DSC00547 -> 00000003.jpg, 5.549 sec
#03: DSC00530 -> 00000017.jpg, 5.239 sec
#02: DSC00533 -> 00000019.jpg, 5.210 sec

-----
Running Yasutaka Furukawa's CMVS/PMVS tool...
cmvs C:\Users\Geomatica\Documents\DescargaSW\
\pruebaVisualSFM.cmv\00\ 50 12
Yasutaka Furukawa's CMVS cannot be located!
Please go download or compile them and
place them where VisualSFM is or in your PATH

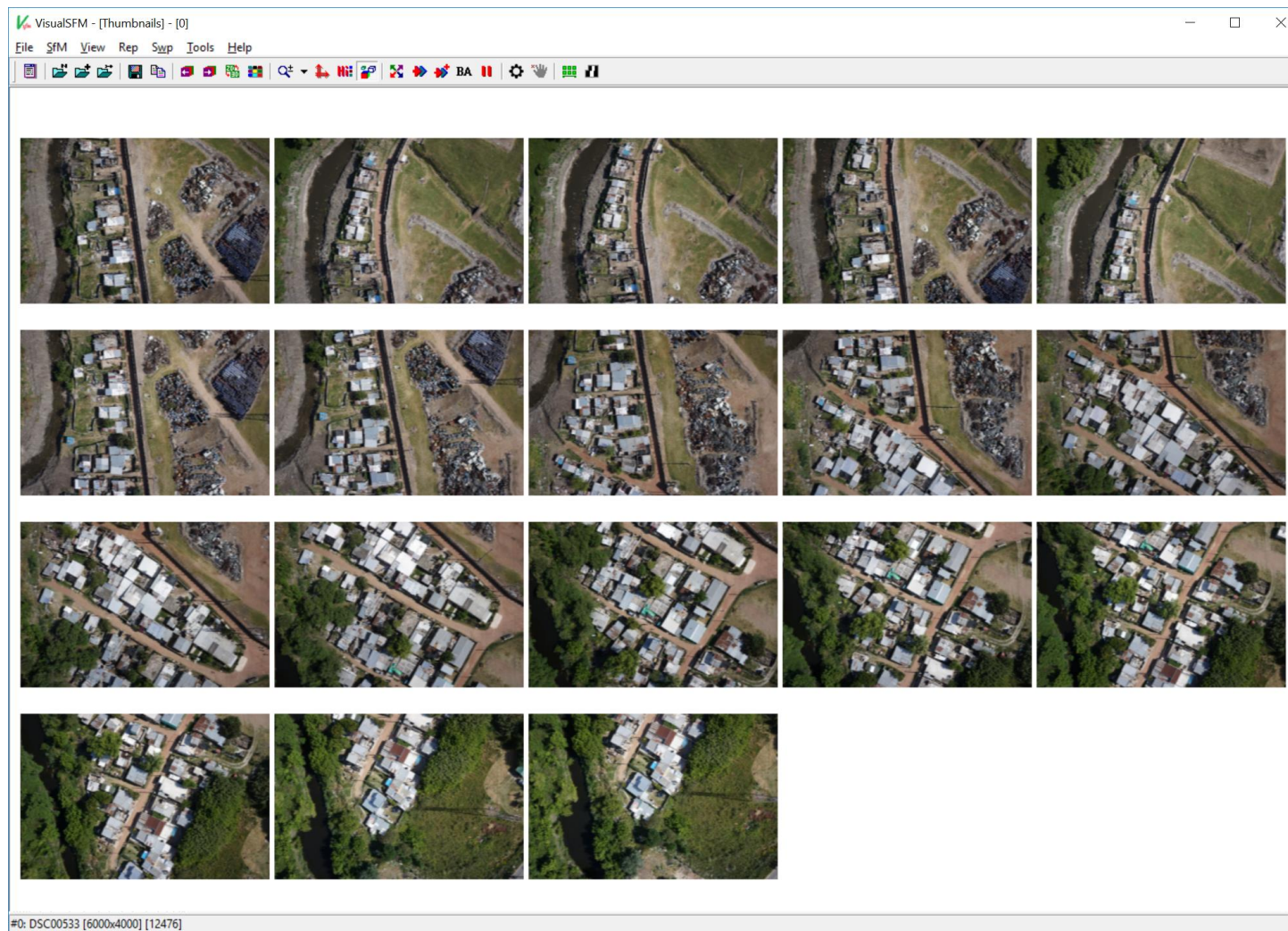
-----
Run dense reconstruction, finished
Totally 18.000 seconds used
```



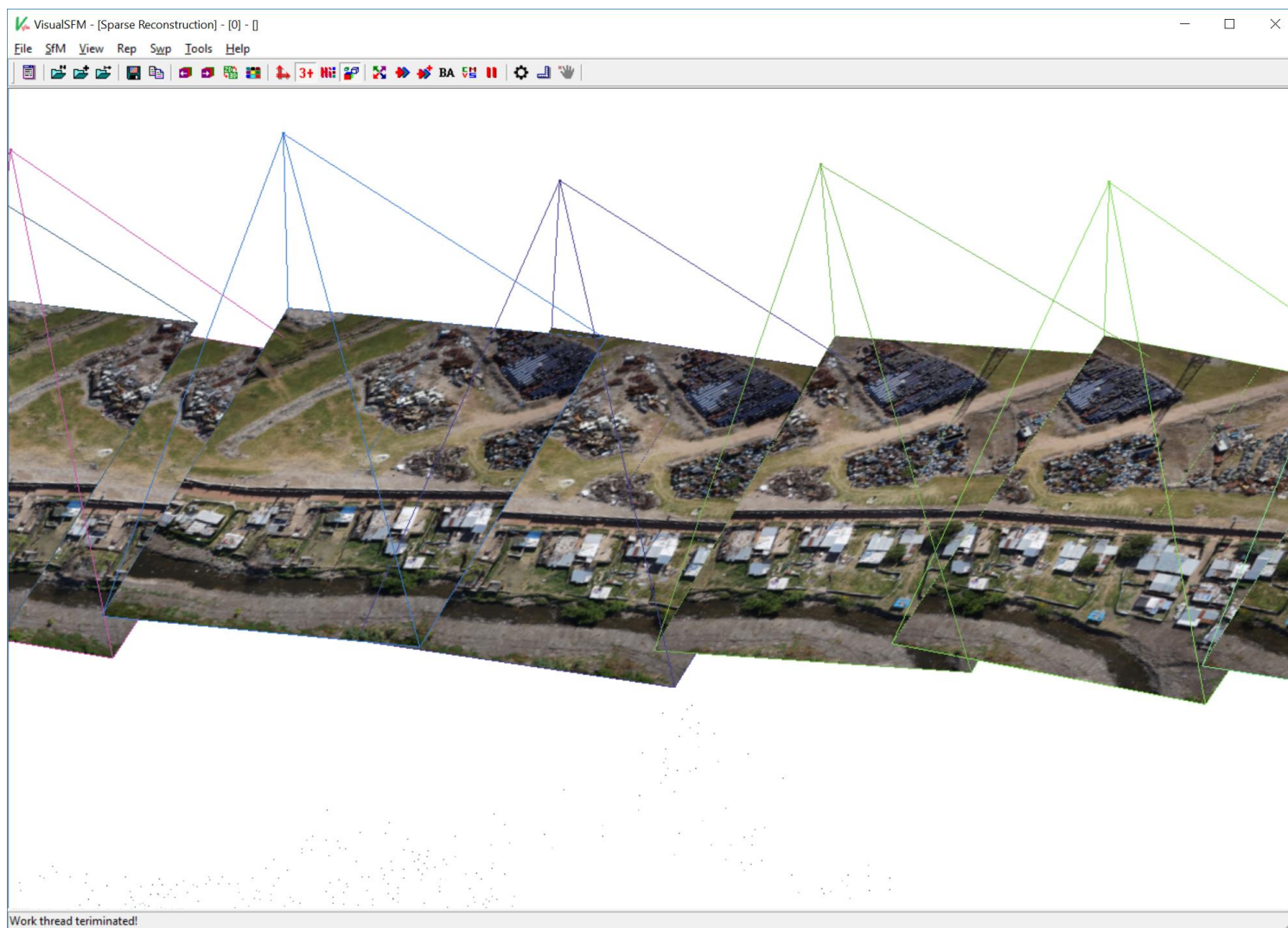
# Visual SFM: pasos típicos



# Paso 1. Añadir imágenes



## Paso 2. Alinear imágenes





# Paso 3. Crear nube dispersa

VisualSFM - [Sparse Reconstruction] - [0] - []

File
SfM
View
Rep
Swp
Tools
Help

Thread started at 12:47:10; Press X to refresh timing.

Task Viewer

21 modeled; 0 reused; 21 EXIF;  
4MB(3) used to store feature location.

---

Compute remaining photos, finished  
Totally 0.000 seconds used

---

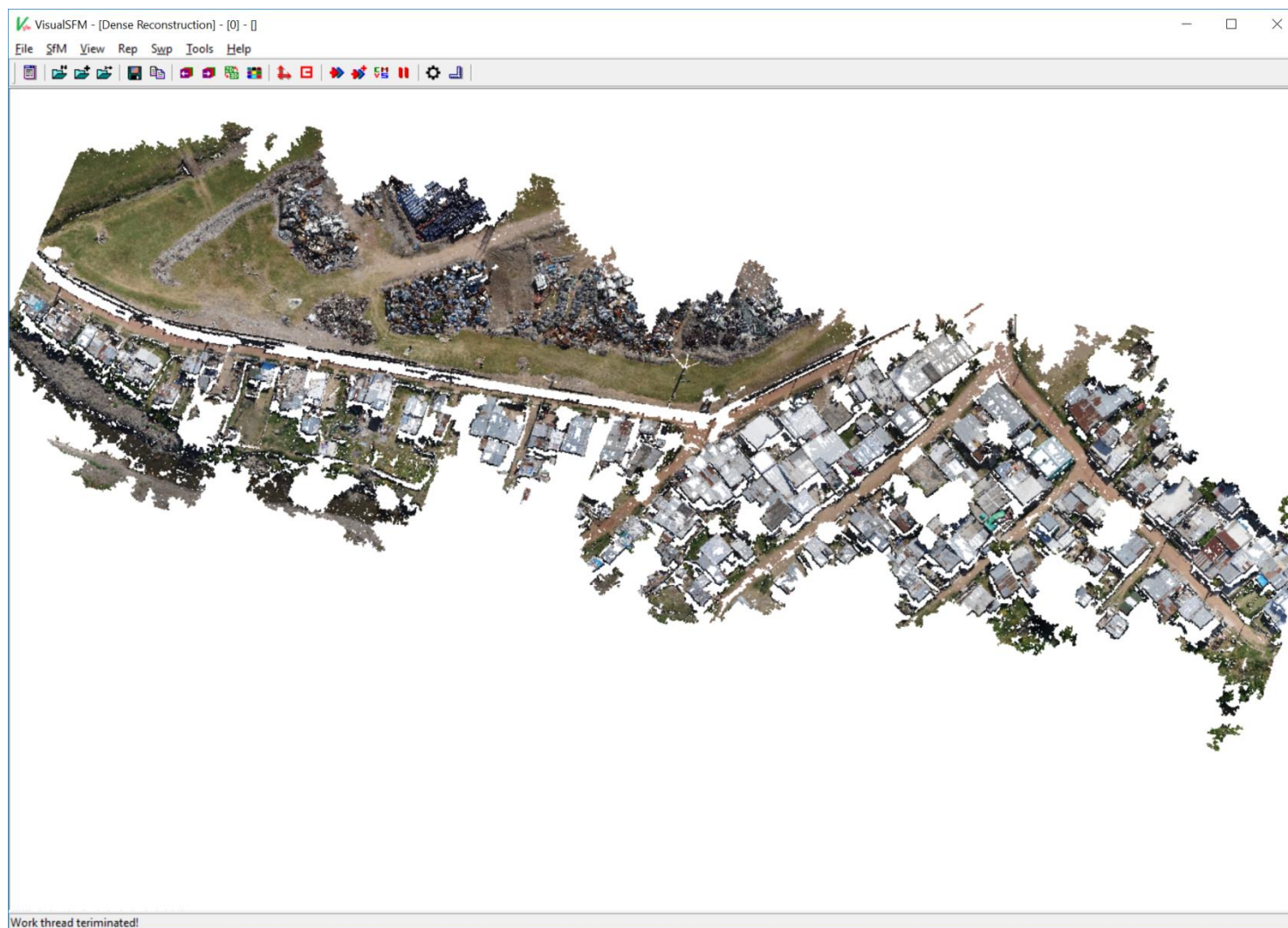
Run dense reconstruction, begin...  
#####  
Undistorting 21 images in model #0  
param\_undistortion\_thread\_num = 0  
NOTE: using 12 threads...  
#06: DSC00536 -> 00000015.jpg, 6.648 sec  
#05: DSC00549 -> 00000006.jpg, 6.783 sec  
#02: DSC00547 -> 00000003.jpg, 6.803 sec  
#11: DSC00538 -> 00000012.jpg, 6.836 sec  
#04: DSC00548 -> 00000004.jpg, 6.964 sec  
#07: DSC00550 -> 00000007.jpg, 6.969 sec  
#01: DSC00545 -> 00000002.jpg, 6.977 sec  
#03: DSC00537 -> 00000013.jpg, 6.983 sec  
#00: DSC00544 -> 00000000.jpg, 6.985 sec  
#10: DSC00540 -> 00000010.jpg, 7.042 sec  
#08: DSC00531 -> 00000014.jpg, 7.437 sec  
#09: DSC00541 -> 00000009.jpg, 7.453 sec  
#02: DSC00533 -> 00000019.jpg, 5.539 sec  
#04: DSC00543 -> 00000005.jpg, 5.479 sec  
#00: DSC00546 -> 00000001.jpg, 5.540 sec  
#06: DSC00535 -> 00000016.jpg, 5.899 sec  
#05: DSC00530 -> 00000017.jpg, 5.766 sec  
#07: DSC00551 -> 00000008.jpg, 5.607 sec  
#10: DSC00539 -> 00000011.jpg, 5.597 sec  
#02: DSC00529 -> 00000020.jpg, 5.391 sec  
#05: DSC00534 -> 00000018.jpg, 5.240 sec

---

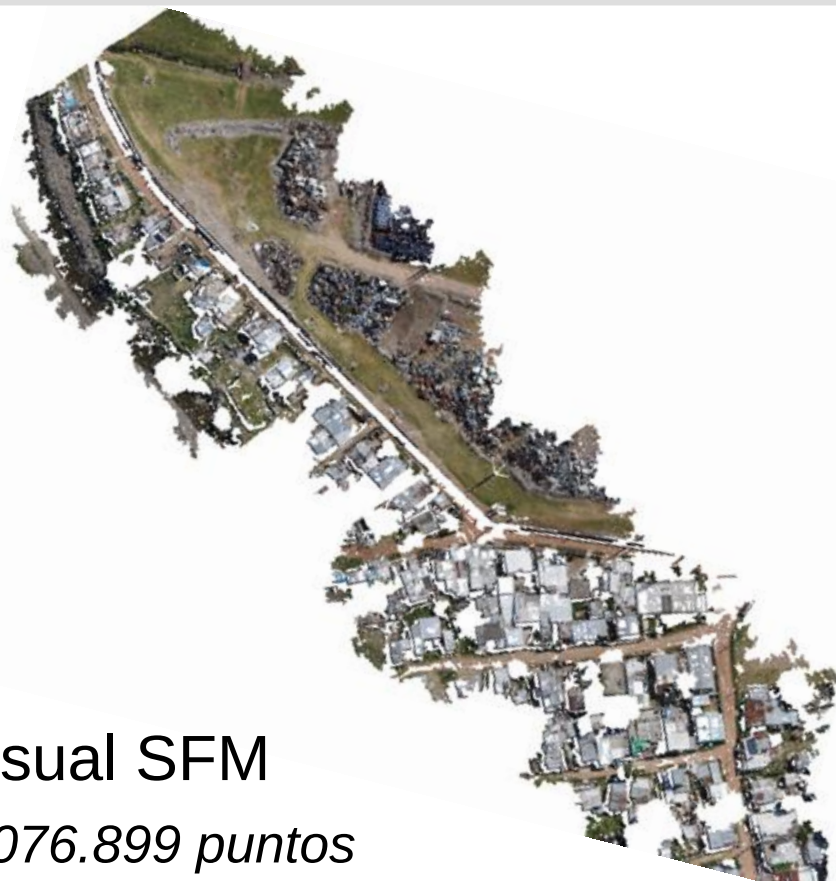
Runing Yasutaka Furukawa's CMVS/PMVS tool...  
cmvs C:\Users\Geomatica\Documents\DescargaSW  
\prueba\VisualSFM.nvm.cmvs\00\ 50 12  
genOption C:\Users\Geomatica\Documents\DescargaSW  
\prueba\VisualSFM.nvm.cmvs\00\ 1 2 0.700000 7 3 12  
1 cluster is generated for pmvs reconstruction.  
pmvs2 C:\Users\Geomatica\Documents\DescargaSW  
\prueba\VisualSFM.nvm.cmvs\00\ option-0000  
This may take a little more time, wating...



## Paso 4. Crear nube densa



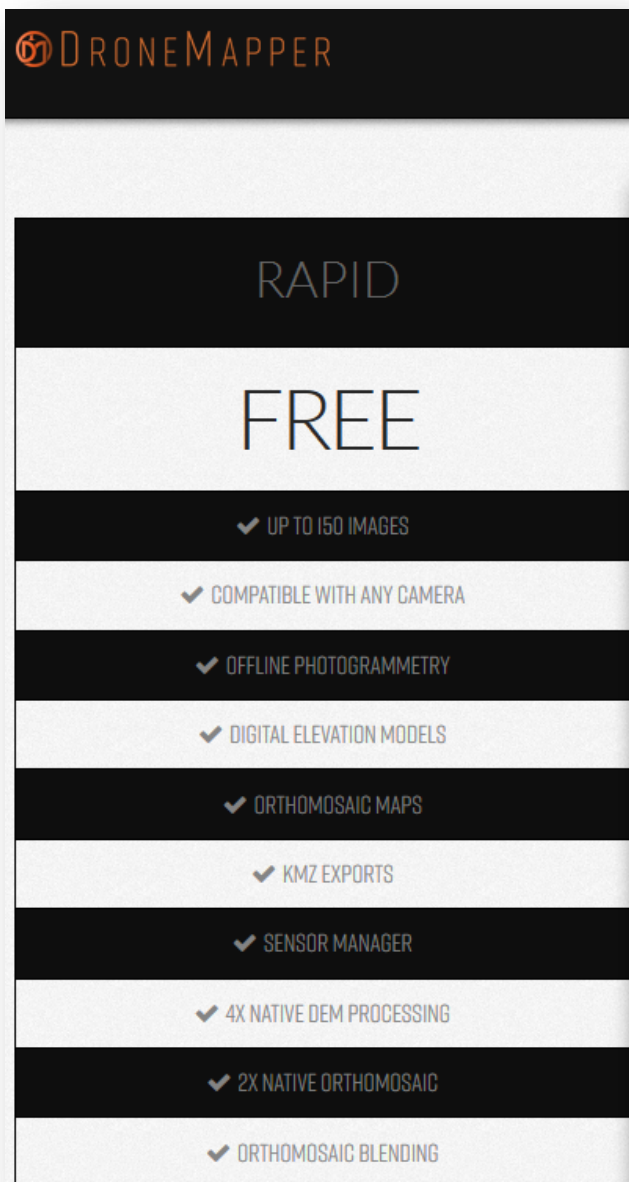
# Comparación Nubes de puntos



Visual SFM  
3.076.899 *puntos*



Agisoft  
34.577.216 *puntos*



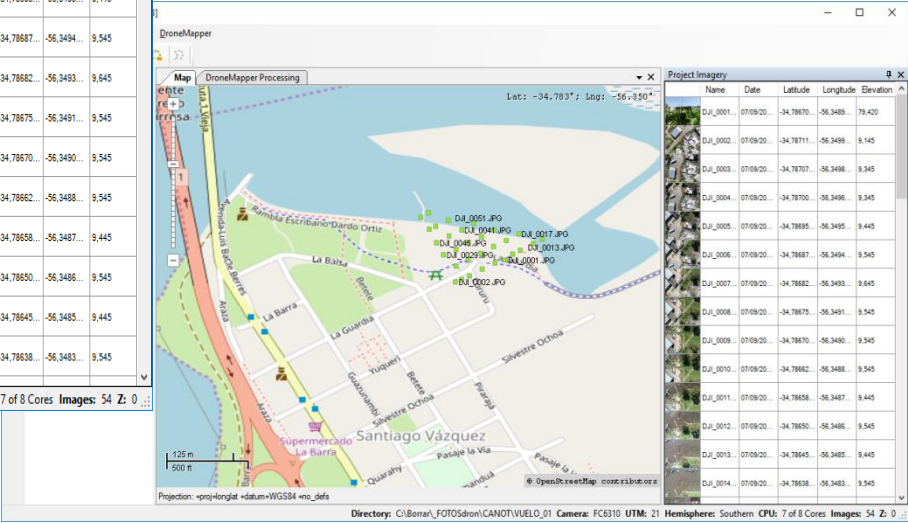
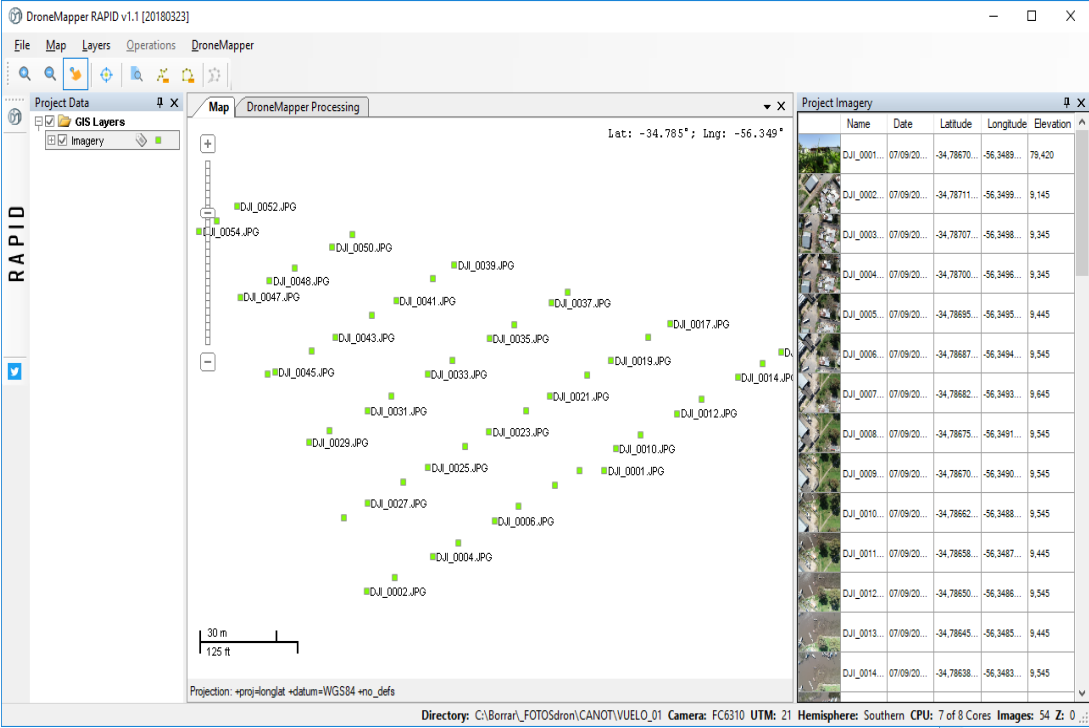
## DroneMapper RAPID

- Genera ortofoto y DEM
- No genera nubes de puntos
- No permite carga de puntos de apoyo
- Muy sencillo de instalar y usar (rápido)
- Herramientas de medición
- Máximo 150 imágenes
- Documentación



# DroneMapper RAPID: pasos típicos

- FILE → Open JPGs



# DroneMapper Processing: 1 PREVIEW

DroneMapper RAPID v1.1 [20180323]

File Map Layers Operations DroneMapper

Project Data

GIS Layers

Imagery

RAPID

DroneMapper Processing

1 2 3

00:00:06

PREVIEW

EXIF

FEATURES

ALIGN

GEO

TIME

NA

DIGITAL ELEVATION MODEL

DEM

GEO

0 cm/px

TIME

NA

ORTHOMOSAIC

ORTHO

GEO

0 cm/px

TIME

NA

Native GSD: 0 cm/px

Tasks Processing: 8

Overnight Mode

FEATURES

LOW

Project Imagery

| Name        | Date        | Latitude     | Longitude   | Elevation |
|-------------|-------------|--------------|-------------|-----------|
| DJI_0001... | 07/09/20... | -34,78670... | -56,3489... | 79,420    |
| DJI_0002... | 07/09/20... | -34,78711... | -56,3499... | 9,145     |
| DJI_0003... | 07/09/20... | -34,78707... | -56,3498... | 9,345     |
| DJI_0004... | 07/09/20... | -34,78700... | -56,3496... | 9,345     |
| DJI_0005... | 07/09/20... | -34,78695... | -56,3495... | 9,445     |
| DJI_0006... | 07/09/20... | -34,78687... | -56,3494... | 9,545     |
| DJI_0007... | 07/09/20... | -34,78682... | -56,3493... | 9,645     |
| DJI_0008... | 07/09/20... | -34,78675... | -56,3491... | 9,545     |
| DJI_0009... | 07/09/20... | -34,78670... | -56,3490... | 9,545     |
| DJI_0010... | 07/09/20... | -34,78662... | -56,3488... | 9,545     |
| DJI_0011... | 07/09/20... | -34,78658... | -56,3487... | 9,445     |
| DJI_0012... | 07/09/20... | -34,78650... | -56,3486... | 9,545     |
| DJI_0013... | 07/09/20... | -34,78645... | -56,3485... | 9,445     |
| DJI_0014... | 07/09/20... | -34,78638... | -56,3483... | 9,545     |

Directory: C:\Borrañ\FOTOSdron\CANOT\VUELO\_01 Camera: FC6310 UTM: 21 Hemisphere: Southern CPU: 7 of 8 Cores Images: 54 Z: 0

# Vista previa de la ortofoto

DroneMapper RAPID v1.1 [20180323]

File Map Layers Operations DroneMapper

Project Data

- GIS Layers
  - Imagery
  - Ortho-Preview

Map DroneMapper Processing

Lat: -34.785°; Lng: -56.349°

Projection: +proj=longlat +datum=WGS84 +no\_defs

Project Imagery

| Name        | Date        | Latitude     | Longitude   | Elevation |
|-------------|-------------|--------------|-------------|-----------|
| DJI_0001... | 07/09/20... | -34,78670... | -56,3489... | 79,420    |
| DJI_0002... | 07/09/20... | -34,78711... | -56,3499... | 9,145     |
| DJI_0003... | 07/09/20... | -34,78707... | -56,3498... | 9,345     |
| DJI_0004... | 07/09/20... | -34,78700... | -56,3496... | 9,345     |
| DJI_0005... | 07/09/20... | -34,78695... | -56,3495... | 9,445     |
| DJI_0006... | 07/09/20... | -34,78687... | -56,3494... | 9,545     |
| DJI_0007... | 07/09/20... | -34,78682... | -56,3493... | 9,645     |
| DJI_0008... | 07/09/20... | -34,78675... | -56,3491... | 9,545     |
| DJI_0009... | 07/09/20... | -34,78670... | -56,3490... | 9,545     |
| DJI_0010... | 07/09/20... | -34,78662... | -56,3488... | 9,545     |
| DJI_0011... | 07/09/20... | -34,78658... | -56,3487... | 9,445     |
| DJI_0012... | 07/09/20... | -34,78650... | -56,3486... | 9,545     |
| DJI_0013... | 07/09/20... | -34,78645... | -56,3485... | 9,445     |
| DJI_0014... | 07/09/20... | -34,78638... | -56,3483... | 9,545     |

Directory: C:\Borra\FOTOSdron\CANOT\VUELO\_01 Camera: FC6310 UTM: 21 Hemisphere: Southern CPU: 7 of 8 Cores Images: 54 Z: 0



# DroneMapper Processing: 2 DEM

DroneMapper RAPID v1.1 [20180323]

File Map Layers Operations DroneMapper

Project Data

GIS Layers

Imagery

Ortho-Preview

Map DroneMapper Processing

1 2 3

00:00:11

PREVIEW DIGITAL ELEVATION MODEL ORTHOMOSAIC

|          |          |      |         |       |         |
|----------|----------|------|---------|-------|---------|
| EXIF     |          | DEM  |         | ORTHO |         |
| FEATURES |          | GEO  |         | GEO   |         |
| ALIGN    |          |      |         |       |         |
| GEO      |          |      | 0 cm/px |       | 0 cm/px |
| TIME     | 00:10:24 | TIME | NA      | TIME  | NA      |

Native GSD: 1,75 cm/px

Tasks Processing: 2

Overnight Mode

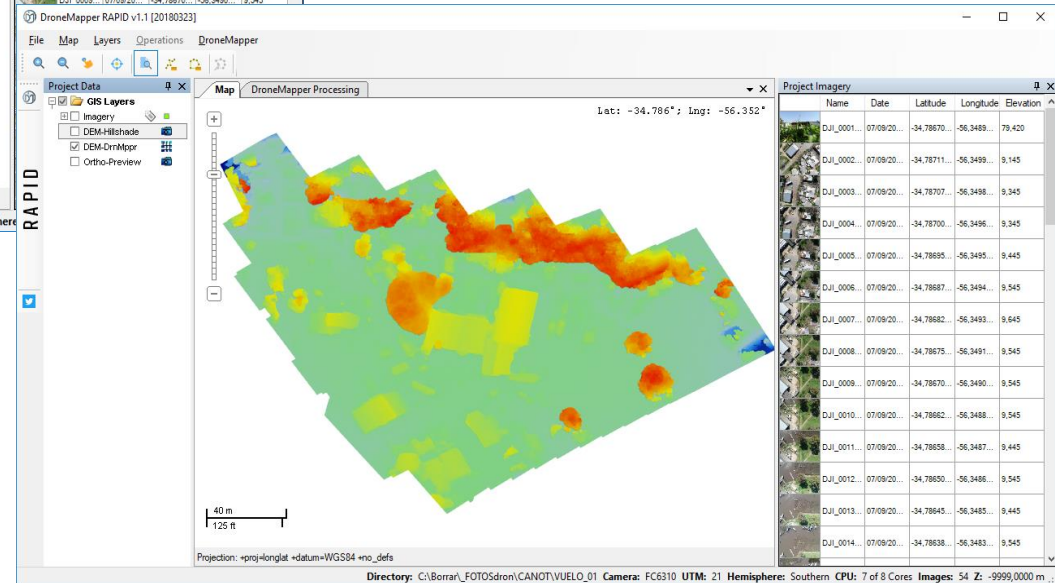
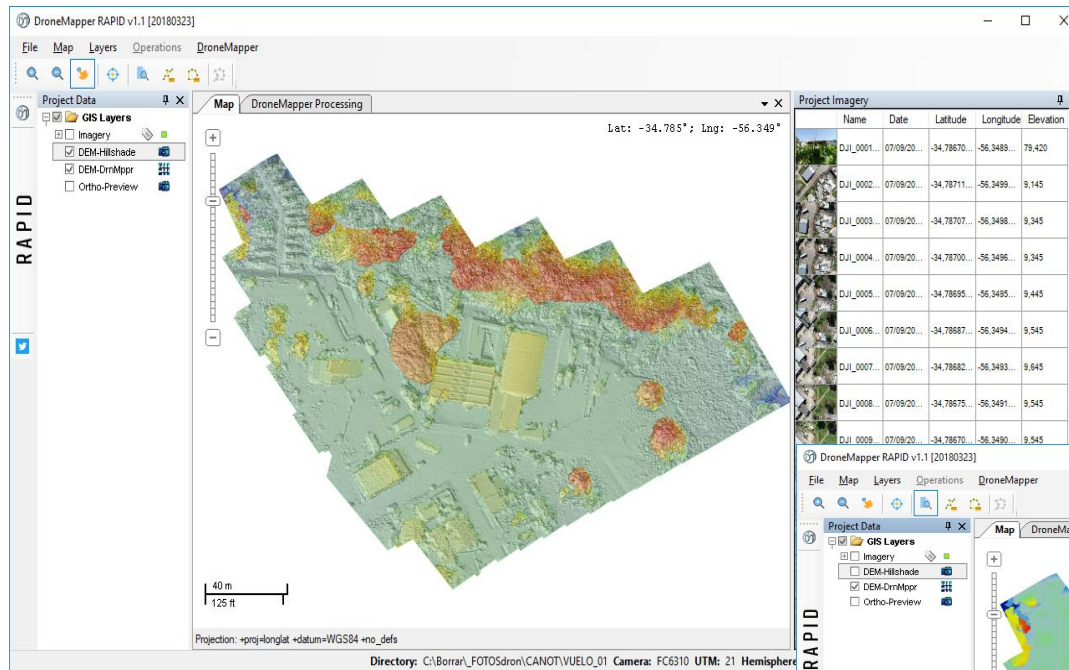
FEATURES LOW

Project Imagery

| Name        | Date        | Latitude     | Longitude   | Elevation |
|-------------|-------------|--------------|-------------|-----------|
| DJI_0001... | 07/09/20... | -34,78670... | -56,3489... | 79,420    |
| DJI_0002... | 07/09/20... | -34,78711... | -56,3499... | 9,145     |
| DJI_0003... | 07/09/20... | -34,78707... | -56,3498... | 9,345     |
| DJI_0004... | 07/09/20... | -34,78700... | -56,3496... | 9,345     |
| DJI_0005... | 07/09/20... | -34,78695... | -56,3495... | 9,445     |
| DJI_0006... | 07/09/20... | -34,78687... | -56,3494... | 9,545     |
| DJI_0007... | 07/09/20... | -34,78682... | -56,3493... | 9,645     |
| DJI_0008... | 07/09/20... | -34,78675... | -56,3491... | 9,545     |
| DJI_0009... | 07/09/20... | -34,78670... | -56,3490... | 9,545     |
| DJI_0010... | 07/09/20... | -34,78662... | -56,3488... | 9,545     |
| DJI_0011... | 07/09/20... | -34,78658... | -56,3487... | 9,445     |
| DJI_0012... | 07/09/20... | -34,78650... | -56,3486... | 9,545     |
| DJI_0013... | 07/09/20... | -34,78645... | -56,3485... | 9,445     |
| DJI_0014... | 07/09/20... | -34,78638... | -56,3483... | 9,545     |

Directory: C:\Borrar\FOTOSdron\CANOT\VUELO\_01 Camera: FC6310 UTM: 21 Hemisphere: Southern CPU: 7 of 8 Cores Images: 54 Z: 0

# Modelo Digital de Elevaciones



# DroneMapper Processing: 3 ORTHOMOSAIC

DroneMapper RAPID v1.1 [20180323]

File Map Layers Operations DroneMapper

Project Data

GIS Layers

- Imagery
- Ortho-DrnMppr
- DEM-Hillshade
- DEM-DrnMppr
- Ortho-Preview

Map DroneMapper Processing

1 2 3

00:00:00

PREVIEW DIGITAL ELEVATION MODEL ORTHOMOSAIC

|          | EXIF     | DEM                 | ORTHO               |
|----------|----------|---------------------|---------------------|
| FEATURES |          |                     |                     |
| ALIGN    |          |                     |                     |
| GEO      |          | 14,1641288415 cm/px | 7,08206442076 cm/px |
| TIME     | 00:10:24 | 00:06:58            | 00:00:24            |

Native GSD: 1.75 cm/px

Overnight Mode

FEATURES LOW

Tasks Processing: 0

Project Imagery

| Name        | Date        | Latitude     | Longitude   | Elevation |
|-------------|-------------|--------------|-------------|-----------|
| DJI_0001... | 07/09/20... | -34,78670... | -56,3489... | 79,420    |
| DJI_0002... | 07/09/20... | -34,78711... | -56,3499... | 9,145     |
| DJI_0003... | 07/09/20... | -34,78707... | -56,3498... | 9,345     |
| DJI_0004... | 07/09/20... | -34,78700... | -56,3496... | 9,345     |
| DJI_0005... | 07/09/20... | -34,78695... | -56,3495... | 9,445     |
| DJI_0006... | 07/09/20... | -34,78687... | -56,3494... | 9,545     |
| DJI_0007... | 07/09/20... | -34,78682... | -56,3493... | 9,645     |
| DJI_0008... | 07/09/20... | -34,78675... | -56,3491... | 9,545     |
| DJI_0009... | 07/09/20... | -34,78670... | -56,3490... | 9,545     |
| DJI_0010... | 07/09/20... | -34,78662... | -56,3488... | 9,545     |
| DJI_0011... | 07/09/20... | -34,78658... | -56,3487... | 9,445     |
| DJI_0012... | 07/09/20... | -34,78650... | -56,3486... | 9,545     |
| DJI_0013... | 07/09/20... | -34,78645... | -56,3485... | 9,445     |
| DJI_0014... | 07/09/20... | -34,78638... | -56,3483... | 9,545     |

Directory: C:\Borrar\FOTOSdron\CANOT\VUELO\_01 Camera: FC6310 UTM: 21 Hemisphere: Southern CPU: 7 of 8 Cores Images: 54 Z: -9999,0000 m



# Ortofoto

DroneMapper RAPID v1.1 [20180323]

File Map Layers Operations DroneMapper

Project Data

GIS Layers

- ☐ Imagery
- ☒ Ortho-DrmMppr
- ☐ DEM-Hillshade
- ☐ DEM-DrmMppr
- ☒ Ortho-Preview

Map DroneMapper Processing

Lat: -34.786°; Lng: -56.351°

Project Imagery

| Name        | Date        | Latitude     | Longitude   | Elevation |
|-------------|-------------|--------------|-------------|-----------|
| DJI_0001... | 07/09/20... | -34.78670... | -56.3489... | 79.420    |

GDAL info: Ortho-DrmMppr

Driver: GTiff/GeoTIFF  
Files: C:\Borra\FOTOS\1\CANOT\VUELO\_01\DrMppr3D\Ortho-DmMppr.tif  
Size is 4577, 2931  
Coordinate System is:  
GEOGCS["WGS 84",  
DATUM["WGS\_1984",  
SPHEROID["WGS 84",6378137,298.257223563,  
AUTHORITY["EPSG","7030"]],  
AUTHORITY["EPSG","6326"]],  
PRIMEM["Greenwich",0],  
UNIT["degree",0.0174532925199433],  
AUTHORITY["EPSG","4326"]]  
Origin = (-56.351087051067765,-34.785347451001037)  
Pixel Size = (0.000000727129996,-0.000000727129996)  
Metadata:  
AREA\_OR\_POINT=Area  
Image Structure Metadata:  
INTERLEAVE=PIXEL  
Corner Coordinates:  
Upper Left (-56.3510871,-34.7853475) (56d21'3.91"W, 34d47'7.25"S)  
Lower Left (-56.3510871,-34.7874787) (56d21'3.91"W, 34d47'14.92"S)  
Upper Right (-56.3477590,-34.7853475) (56d20'51.93"W, 34d47'7.25"S)  
Lower Right (-56.3477590,-34.7874787) (56d20'51.93"W, 34d47'14.92"S)  
Center (-56.3494230,-34.7864131) (56d20'57.92"W, 34d47'11.09"S)  
Band 1 Block=4577x1 Type=Byte, ColorInterp=Red  
Mask Flags: PER\_DATASET ALPHA  
Band 2 Block=4577x1 Type=Byte, ColorInterp=Green  
Mask Flags: PER\_DATASET ALPHA  
Band 3 Block=4577x1 Type=Byte, ColorInterp=Blue  
Mask Flags: PER\_DATASET ALPHA

50 m  
125 ft

Projection: +proj=longlat +datum=WGS84 +no\_defs

Directory: C:\Borra\FOTOS\dron\CANOT\VUELO\_01 Camera: FC6310 UTM: 21 Hemisphere: Southern CPU: 7 of 8 Cores Images: 54 Z: -9999,000 m

# DroneMapper RAPID - Exporta a KMZ





# Comparación Ortofotos

DroneMapper

GeoTIF 51 Mb (8cm píxel)



Agisoft

JPG 25Mb (2cm píxel)



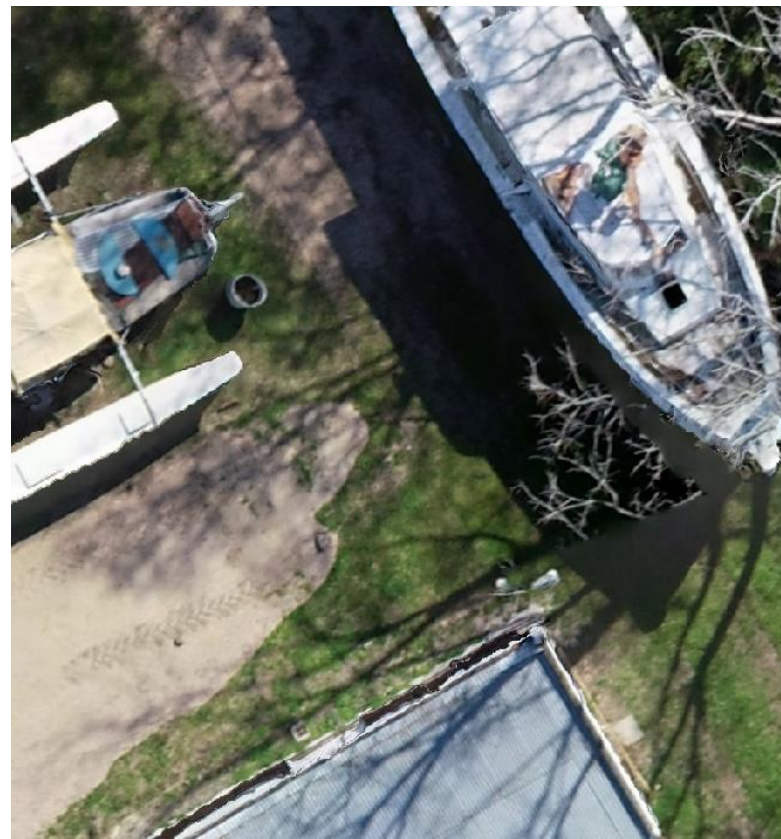


# Comparación Ortofotos

## DroneMapper



## Agisoft

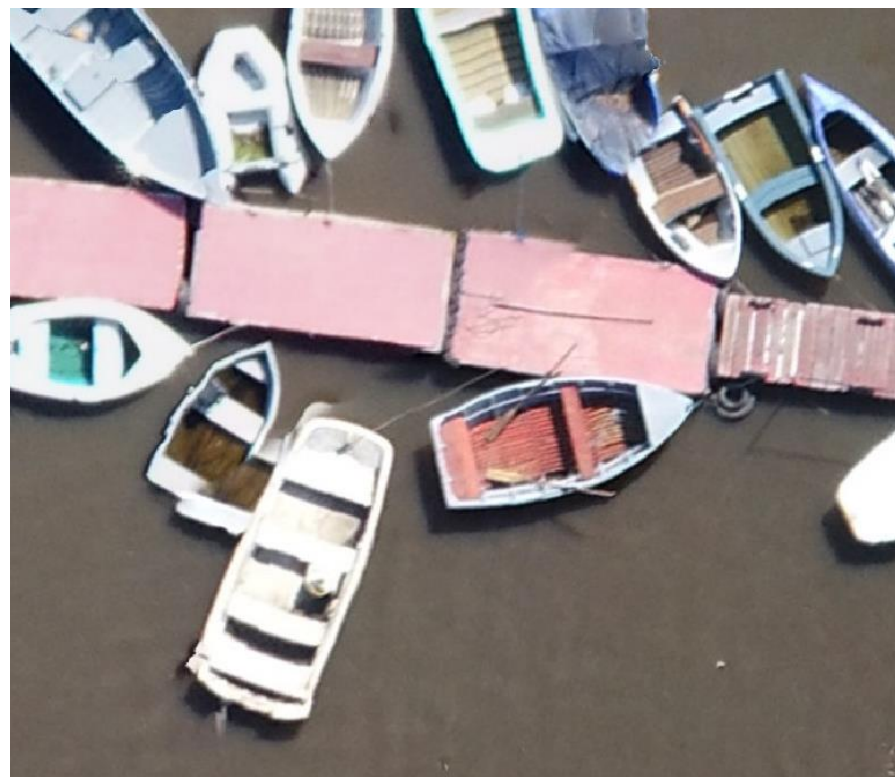


# Comparación Ortofotos

DroneMapper



Agisoft

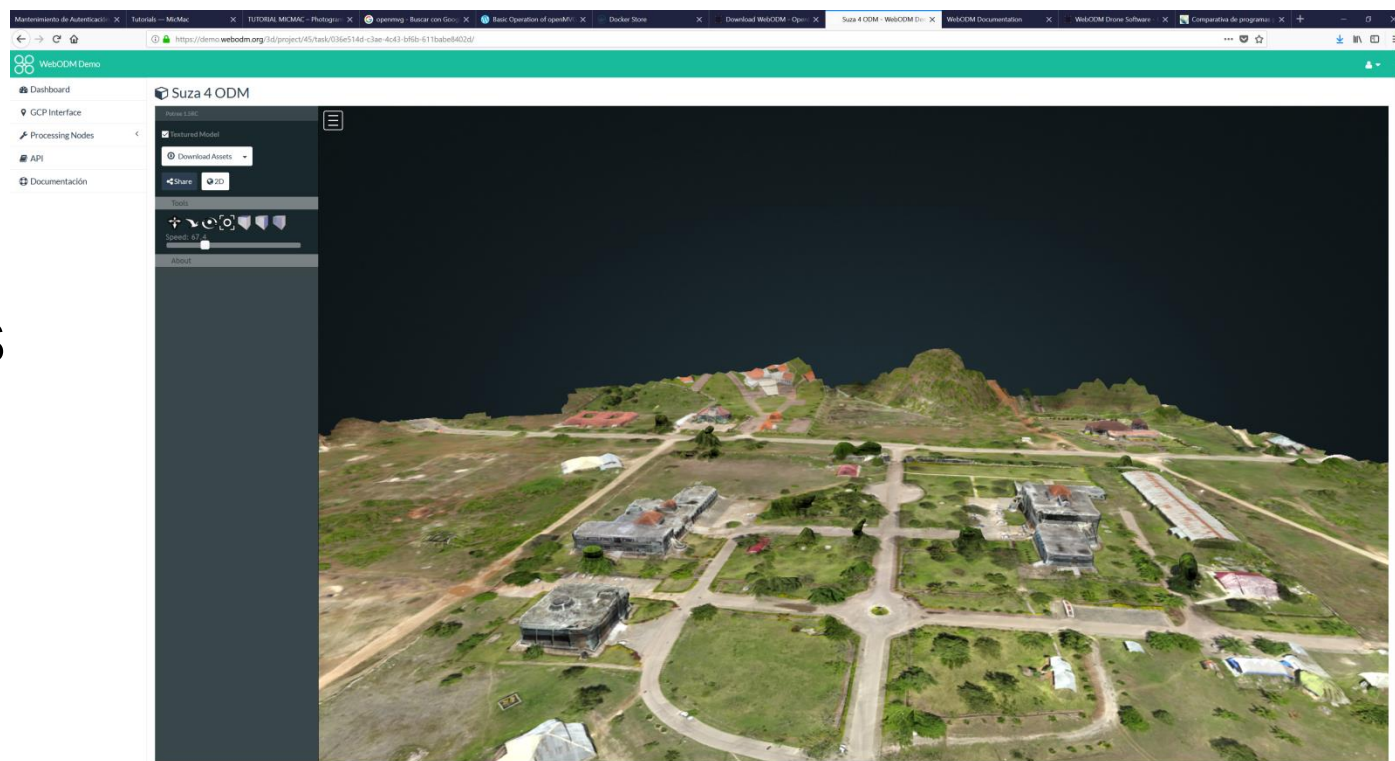




# Opendronemap

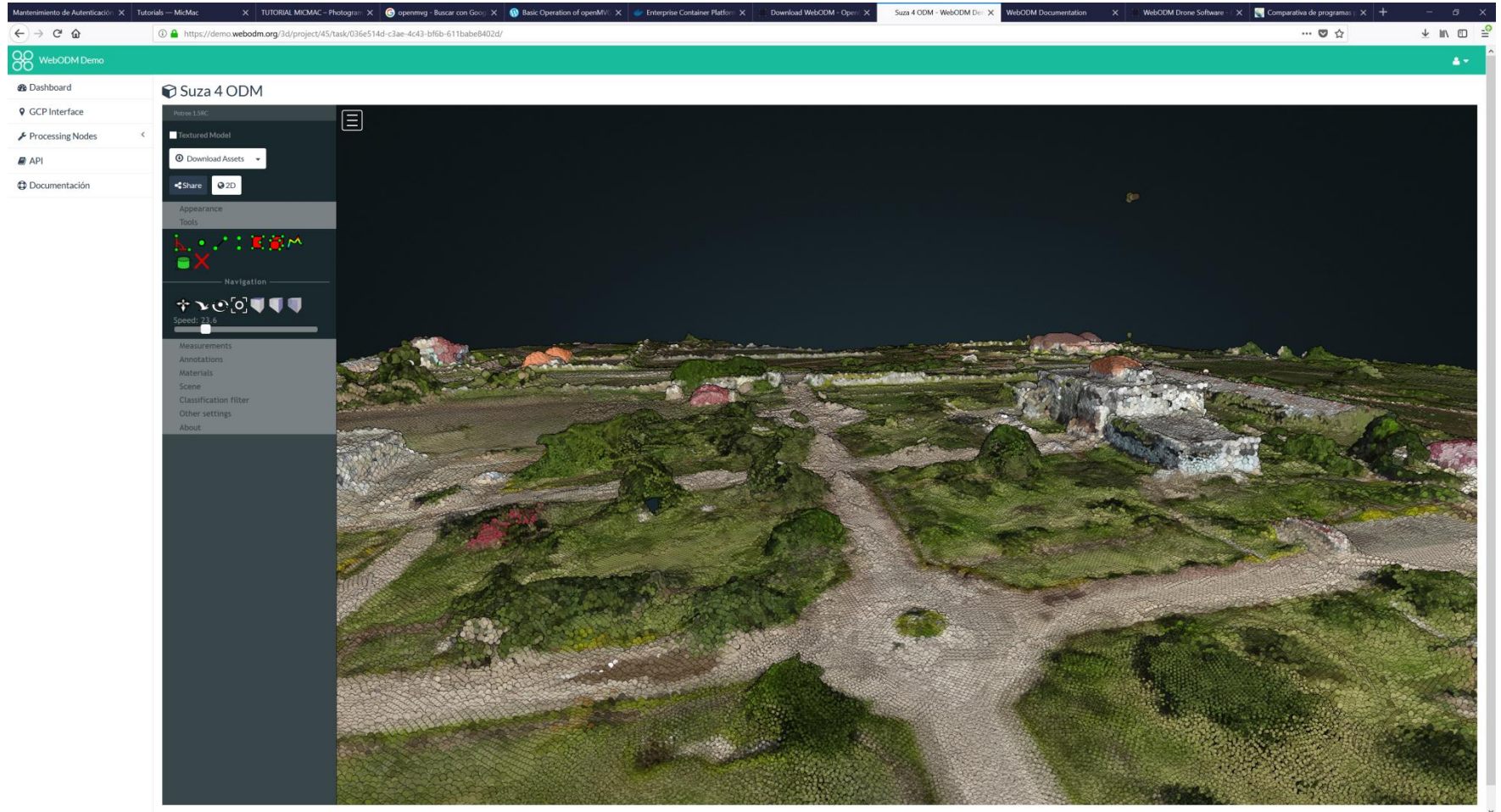
- **ODM**: línea de comandos
- **webODM**: interfaz gráfica (standard, server, portable)

Genera  
ortofotos,  
DEM, nubes  
de puntos,  
modelos 3D  
texturizados



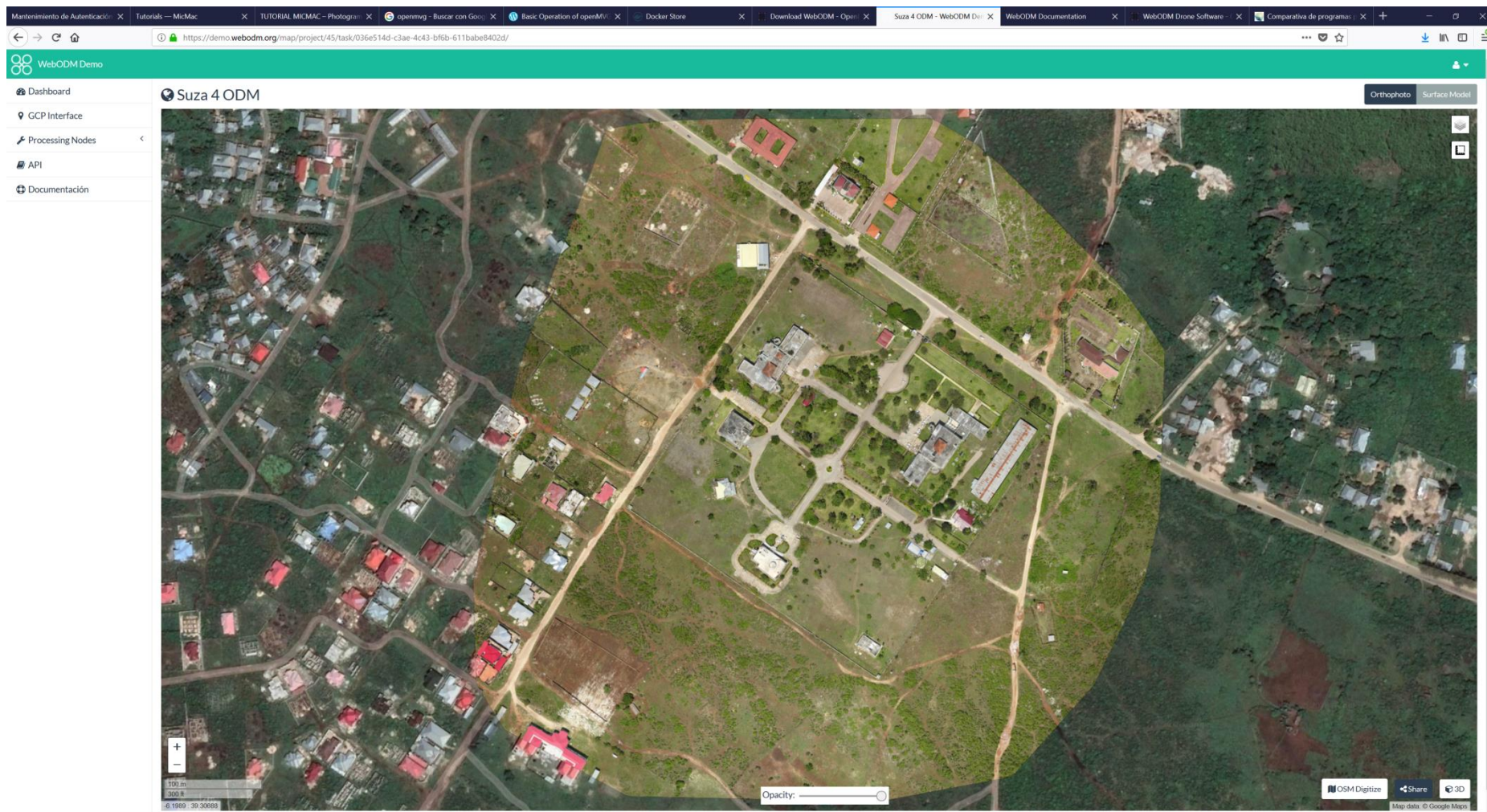


# WebODM: ejemplo Nube de puntos



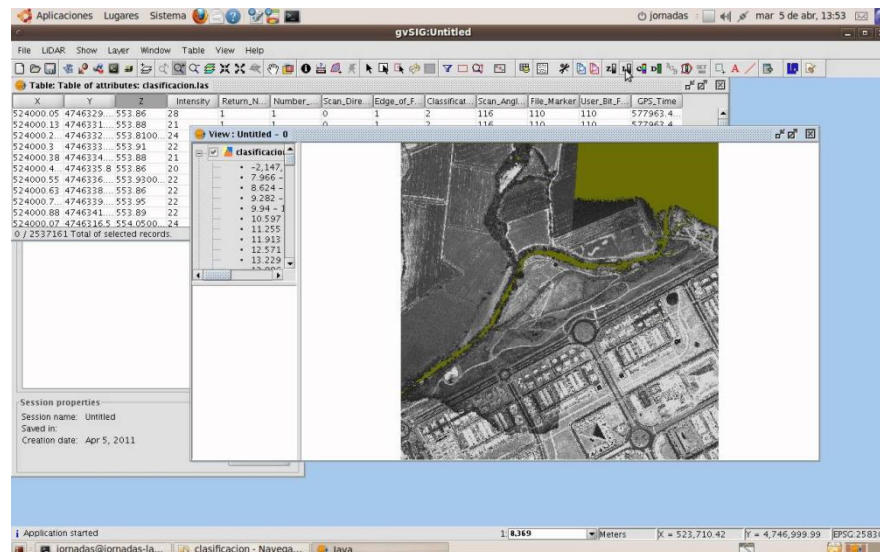


# WebODM: ejemplo ortofoto



# Software para explotación de productos

- Software de SIG:
  - gvSIG (Dielmo)
  - Qgis (LAStools)



- Específicos para Nubes de puntos:
  - Fugro Viewer
  - QTRReader
  - Cloud Compare





JORNADAS URUGUAYAS DE gvSIG



JORNADAS DE TECNOLOGÍAS LIBRES DE  
INFORMACIÓN GEOGRÁFICA Y DATOS ABIERTOS

**Preguntas... ¿?**  
**Muchas gracias**

**sig@imm.gub.uy**