XXIV ISPRS CONGRESS
NICE – JUNE 6-11, 2022

ASSESSMENT OF STEREO-EXTRACTED DSM FROM WORLDVIEW-3 OVER DIFFERENT LAND COVERS DEPENDING ON THE IMAGING GEOMETRY

Manuel A. Aguilar, Rafael Jiménez-Lao and Fernando J. Aguilar

University of Almería. Department of Engineering, CIAIMBITAL. Almería (Spain)
maguilar@ual.es
rjl020@ual.es
faguilar@ual.es

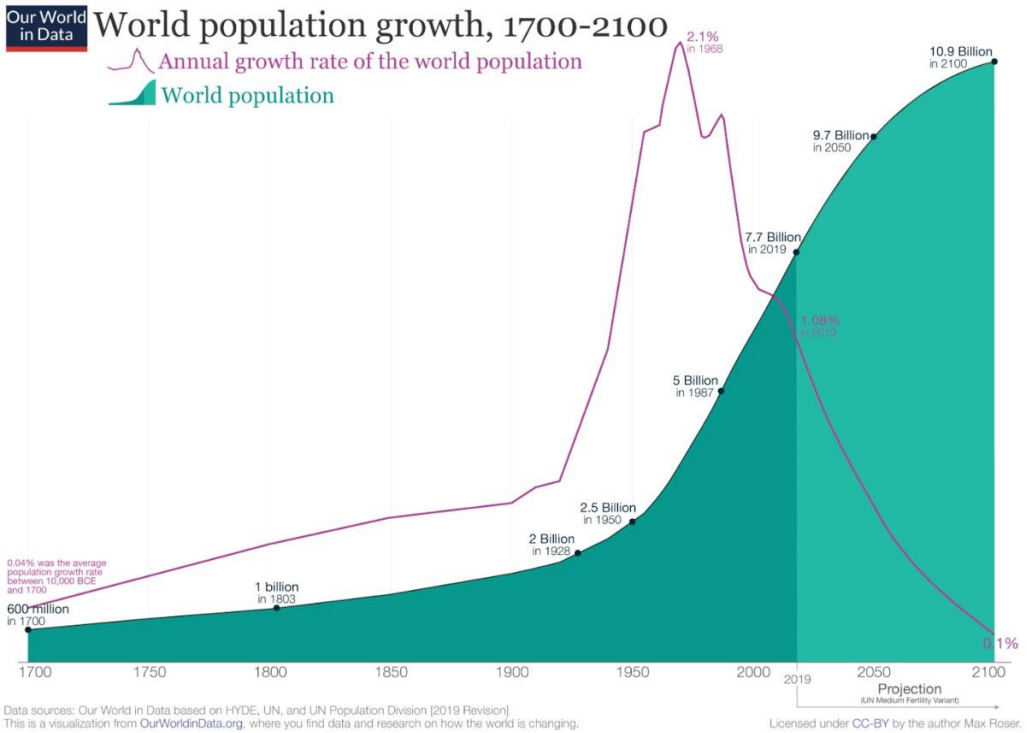
"MAPPING GREENHOUSES AND IDENTIFICATION OF PROTECTED HORTICULTURAL CROPS THROUGH OBJECT-BASED IMAGE ANALYSIS AND SATELLITE IMAGERY TIME SERIES (Sentinel-GH)" **RTI2018-095403-B-I00**

https://w3.ual.es/Proyectos/SentinelGH/

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

EUROPEAN UNION
European Regional Development Fund

1.- Introduction. Why?



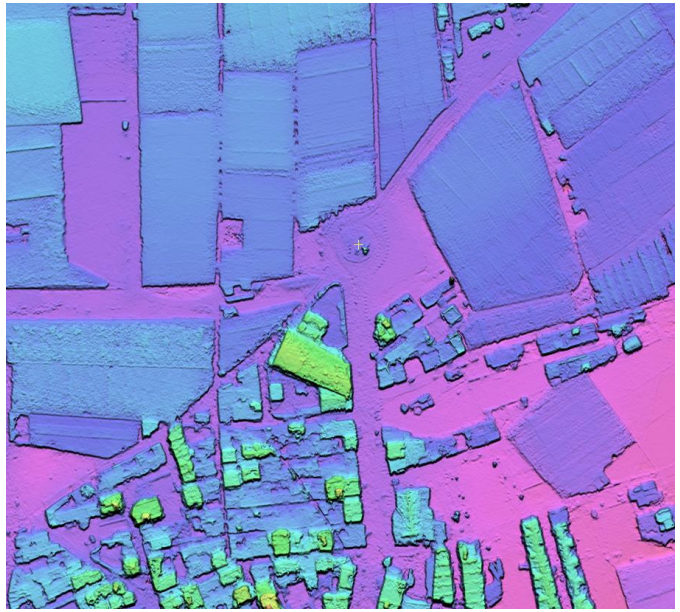
The real world → Spatial data sets → Produced geoinformation → Human decisión-making

Satellite imagery

Orthoimages
DSMs
Classification maps

Planning & management

1.- Introduction. DSM extraction and goal



DSM quality (accuracy and completeness) depends on GSD, viewing geometry and sun position.

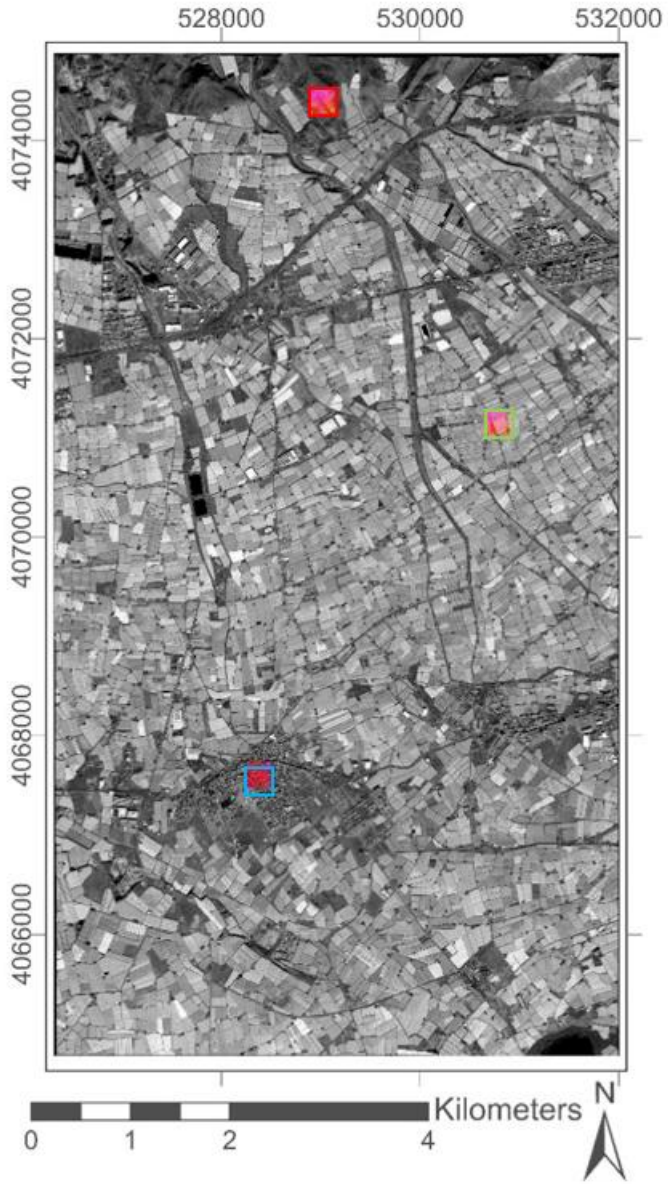
WorldView-3 (2014): 0.31 m PAN GSD, by DigitalGlobe (Maxar).

Cartosat-3 (2019): 0.28 m PAN GSD, by Indian Space Research Organisation (ISRO).

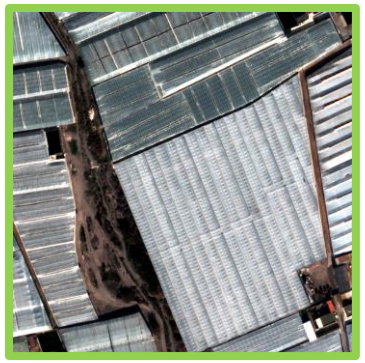
Pleiades Neo (2021-2022): Constellation of four identical satellites, 0.30 m PAN GSD, by Airbus Defence and Space (Airbus DS).

WorldView Legion (2022): Constellation of six identical satellites, 0.30 m PAN GSD, by Maxar.

2.- Study site and datasets



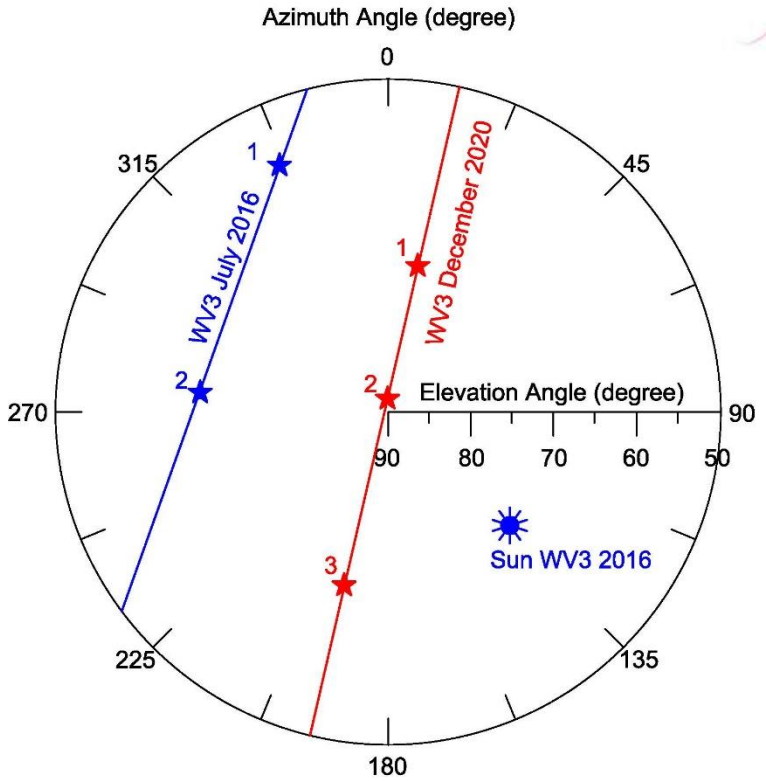
Bare soil



Greenhouse

Urban

WV3 2020 (3) and WV3 2016 (2)



WV3 December 2020
1-2: convergence angle 15.35°
2-3: convergence angle 22.54°
1-3: convergence angle 37.89°

WV3 July 2016
1-2: 32.1°

3.- Methodology

DSM Extraction from VHR Satellite Stereo Pairs

i. Three WV3 stereo pairs (1-2, 2-3 and 1-3) used independently to extract three DSMs.

ii. Sensor orientation of WV3 images was carried out using RFM refined with a zero-order polynomial adjustment (RPC0), using seven accurate GCPs (OrthoEngine, Geomatica v. 2018).

iii. Hierarchical SGM (Hirschmüller, 2008), without interpolation, implemented in OrthoEngine. 0.3 m resolution.

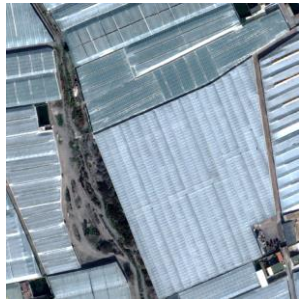
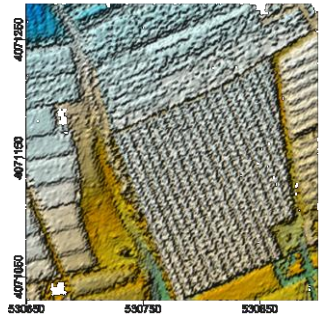
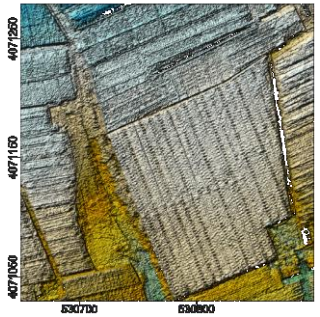
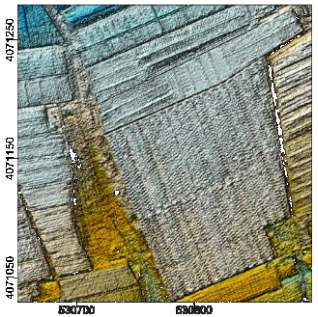
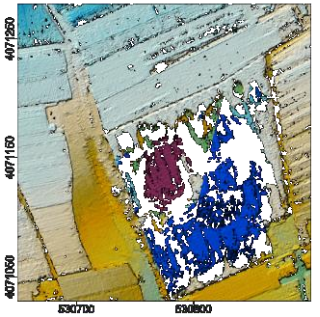
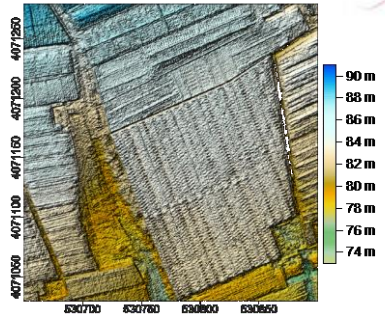
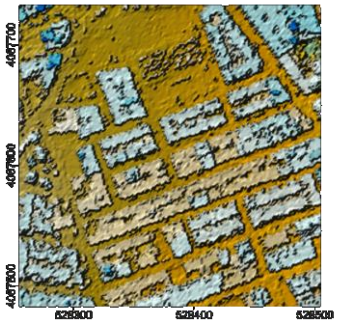
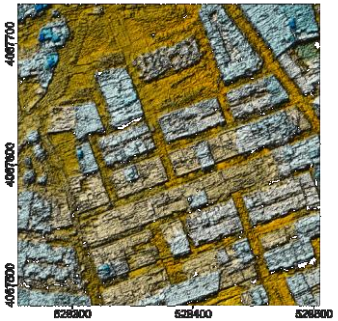
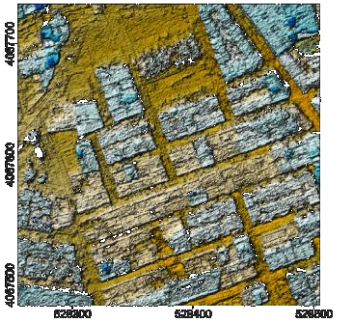
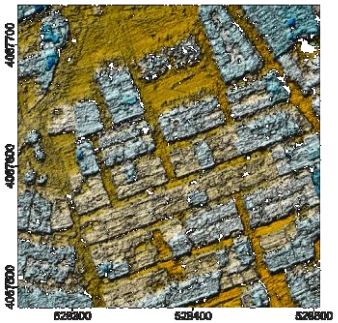
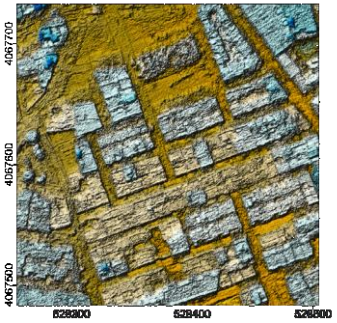
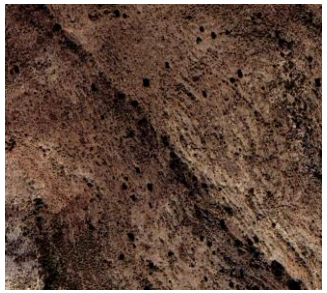
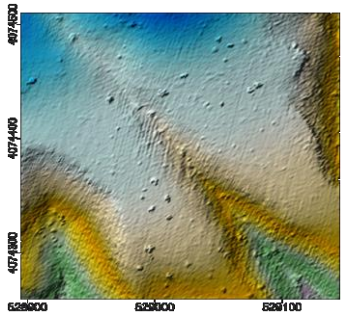
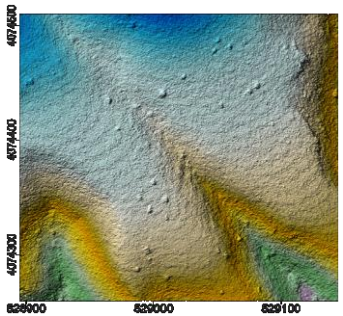
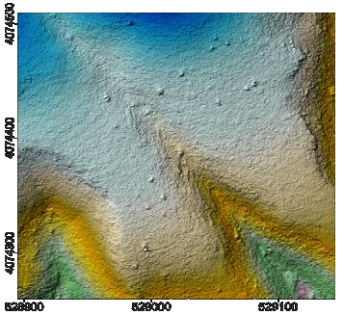
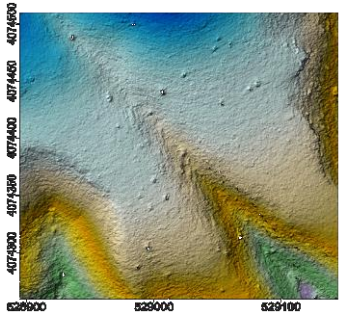
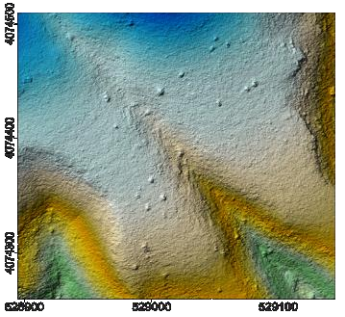
iv. A fused DSM (MultiView DSM) using the score channels was computed (Mandanici et al., 2019). The score channel in our case only presented values of 0, 99, 100 and 101. We only averaged those elevations that presented values of 99 or more in the score channel.

Quality assessment of the extracted DSMs

Vertical accuracy comparing with LiDAR data (standard deviation (SD), root mean square error in Z ($RMSE_Z$) and normalized median absolute deviation (NMAD))

Completeness: ratio between the number of correctly matched points and the maximum possible number of points corresponding to the 0.3 m DSM grid spacing.

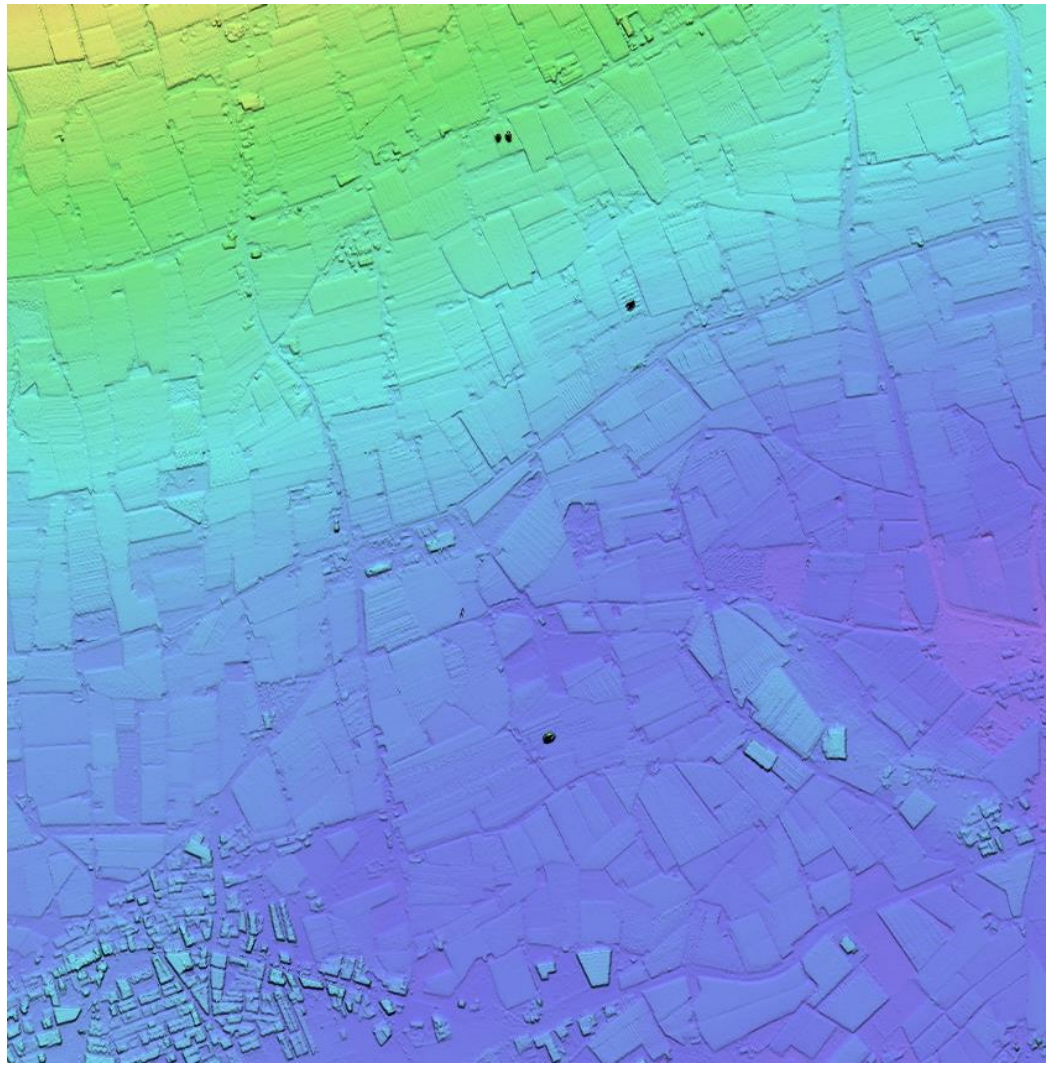
3.- Results. Completeness

			15.35°	22.54°	37.89°	
Greenhouse						
	Orthoimage	LiDAR	1-2 (98.21%)	2-3 (97.25%)	1-3 (75.49%)	Multi View (99.30%)
Urban						
	Orthoimage	LiDAR	1-2 (93.52%)	2-3 (87.17%)	1-3 (79.63%)	Multi View (99.17%)
Bare soil						
	Orthoimage	LiDAR	1-2 (99.98%)	2-3 (99.86%)	1-3 (99.03%)	Multi View (100%)

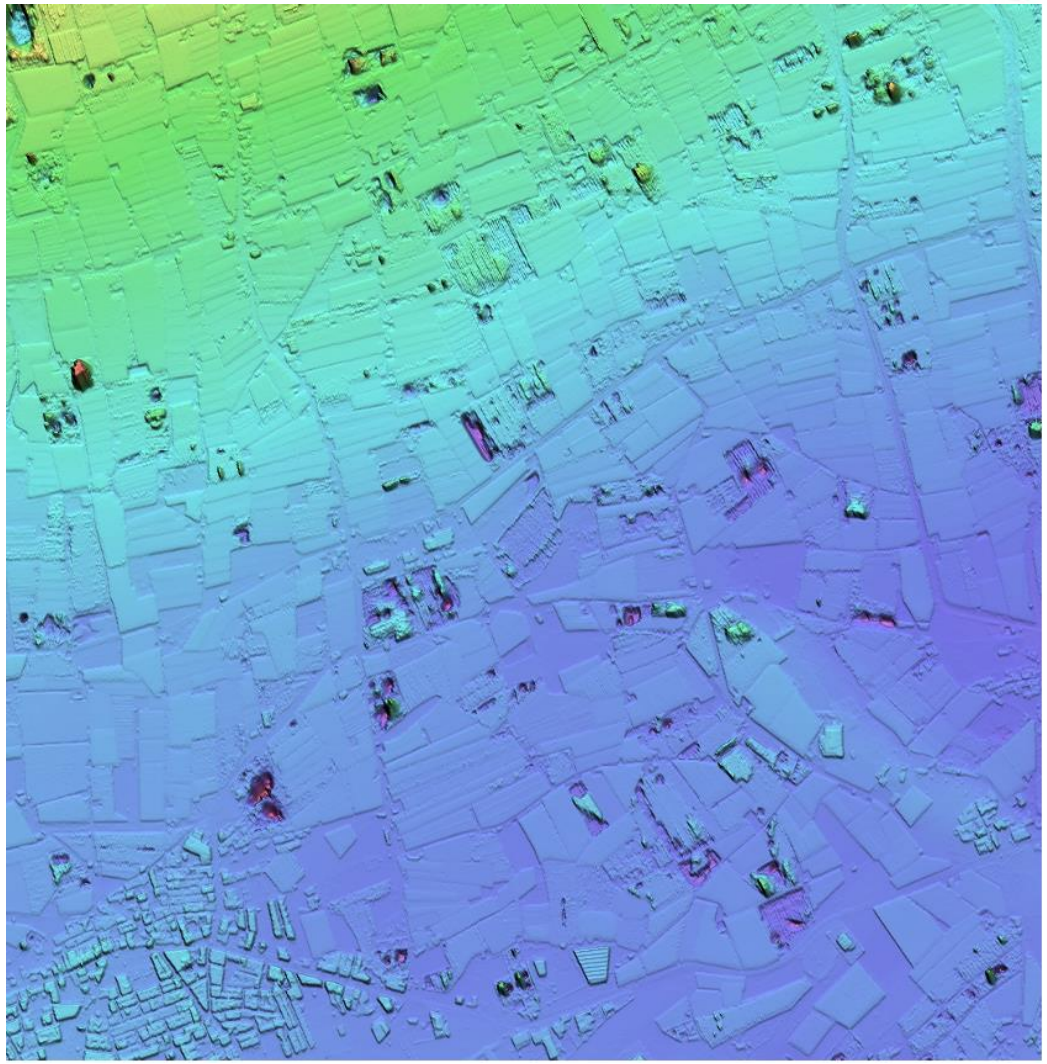
3.- Results. Vertical accuracy

Land Cover	DSM	NMAD (m)	SD (m)	$RMSE_z$ (m)
Bare Soil	1-2	0.202	0.231	0.231
	2-3	0.172	0.219	0.547
	1-3	0.160	0.212	0.357
	MV	**0.159**	**0.202**	**0.331**
Urban	1-2	0.713	1.304	1.304
	2-3	0.653	1.680	1.775
	1-3	0.653	1.649	1.703
	MV	**0.674**	**1.473**	**1.506**
Greenhouse	1-2	0.515	0.573	0.599
	2-3	0.518	0.574	0.691
	1-3	0.514	8.441	8.496
	MV	0.552	1.331	1.351
	MV (1-2, 2-3)	**0.493**	**0.551**	**0.561**

3.- Results. DSMs comparison 2020 vs 2016

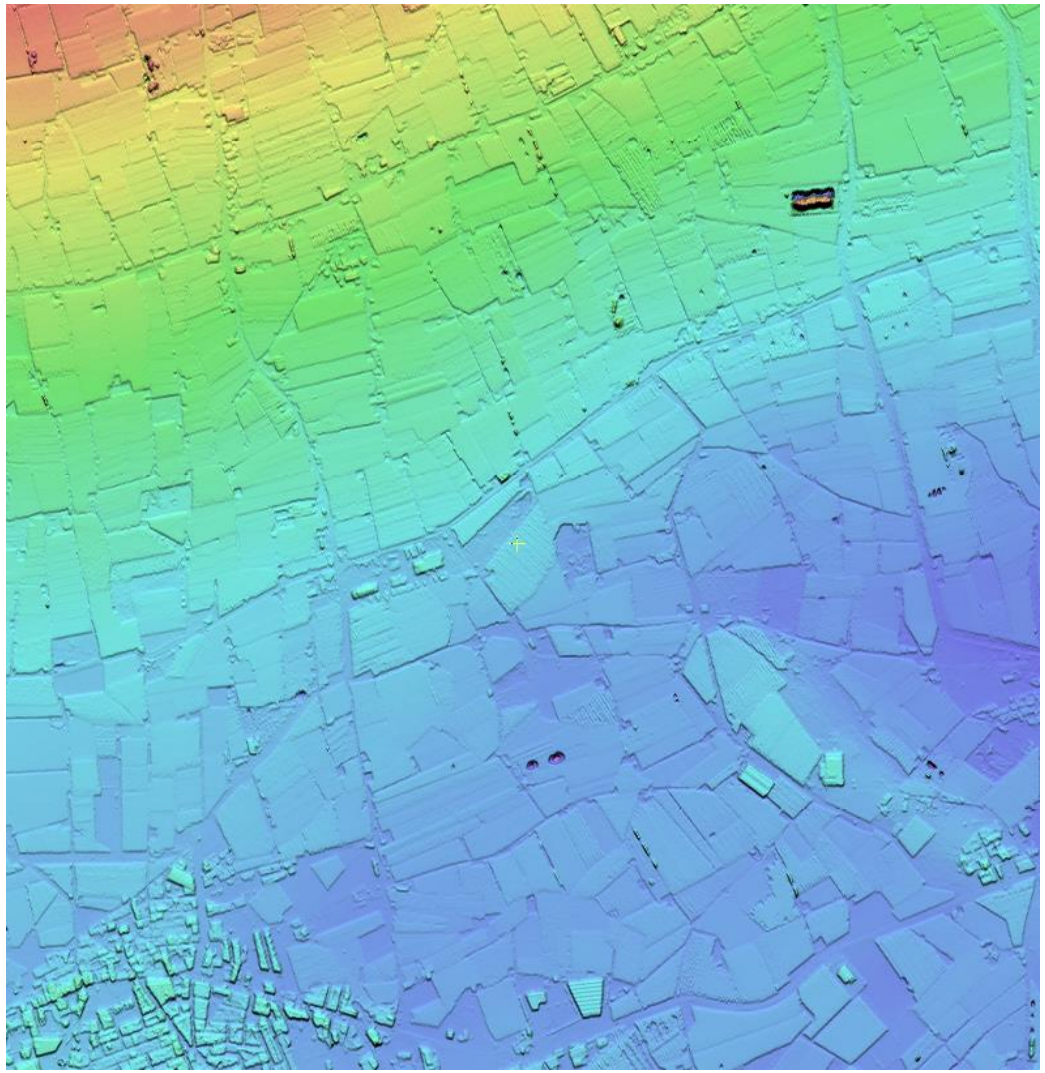


WV3 1-2 (December, 2020)
Sun elevation=28°; Convergence angle=15°

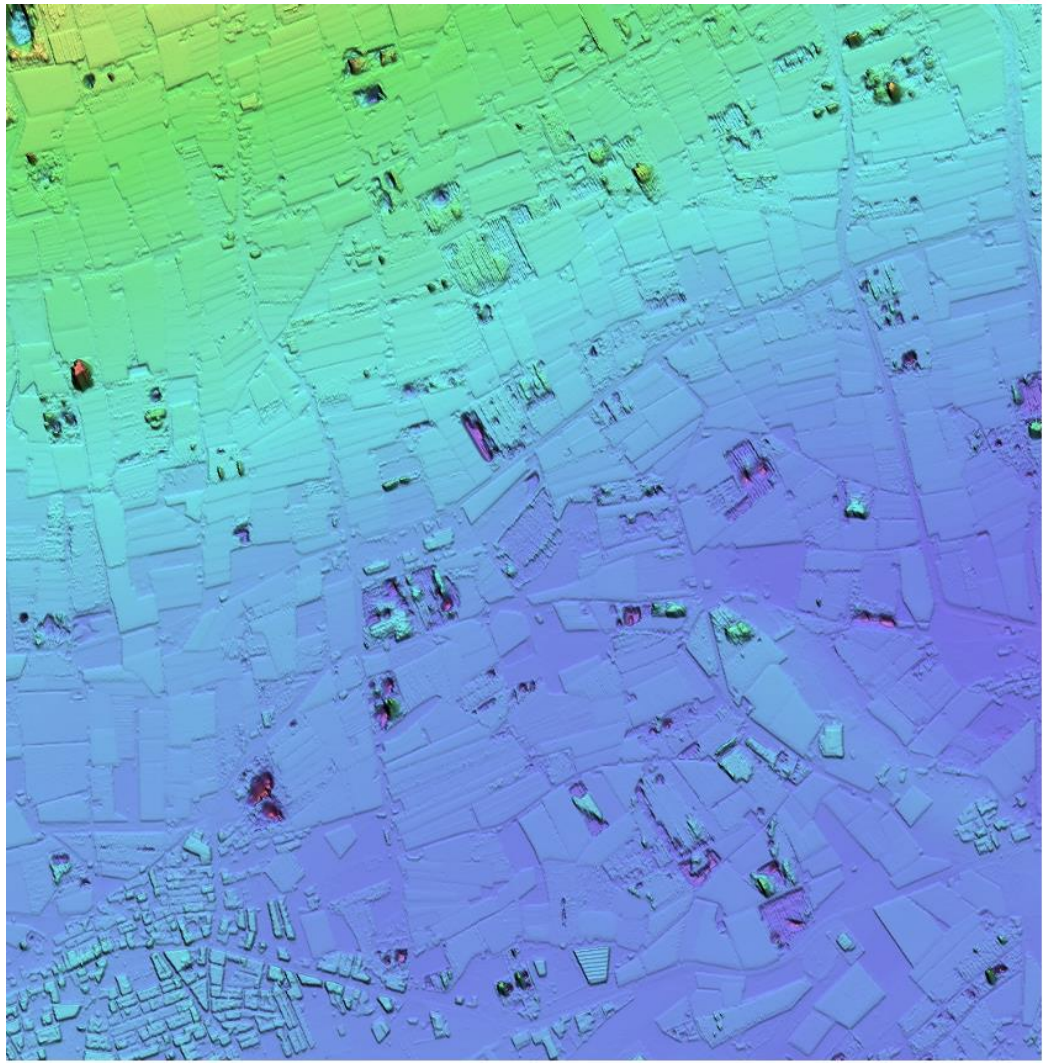


WV3 (July, 2016)
Sun elevation=70°; Convergence angle=32°

3.- Results. DSMs comparison 2020 vs 2016



WV3 1-3 (December, 2020)
Sun elevation=28°; Convergence angle=37°



WV3 (July, 2016)
Sun elevation=70°; Convergence angle=32°

4.- Conclusions.

i. The high spatial resolution of **WV3 stereo pairs** in PAN mode are very interesting to obtain accurate **DSM in very complex reliefs** such as **urban** or **plastic greenhouse** areas.

ii. The **completeness values decreased as convergence angles increased**. In fact, **convergence angles lower than 16°** is recommended when working on urban or greenhouse land covers.

iii. In **greenhouse** areas, the plastic cover can produce specular reflection of **sun light causing glint effects**. This fact seems to be related to the sun positions at the time of image acquisition. We recommended to use stereo pairs taken with a very **low sun elevation**.

iv. Bearing in mind the importance of the satellite viewing geometry and its relationship with the sun position in the greenhouse land cover, the use of **triplet** on this unique landscape (i.e., **more than one stereo pair**) can improve the DSM quality in terms of both vertical accuracy and, particularly, completeness.

Manuel A. Aguilar, Rafael Jiménez-Lao and Fernando J. Aguilar
University of Almería (Spain)
maguilar@ual.es, rjl020@ual.es, faguilar@ual.es