C_AssesSeg – concurrent computing version of AssesSeg: a benchmark between the new and previous version

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Extraction of information from passive satellite data

In the last decade, passive satellite data were analyzed by means of different approaches that can be classified into two big categories:

- **Pixel-based**;
- **(Geographic) object-based image analysis (OBIA)**.

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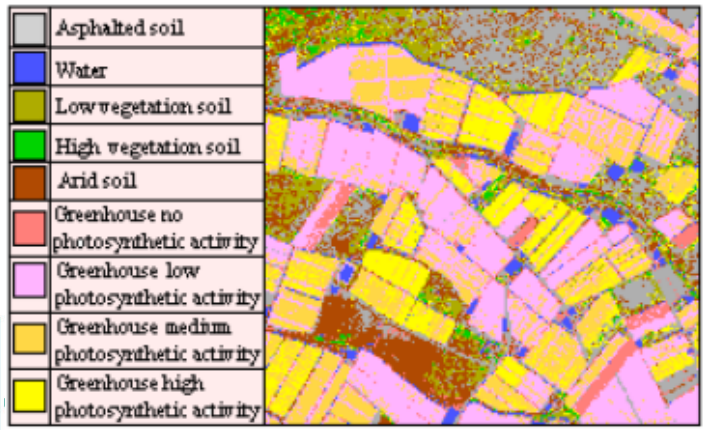
Extraction of information from passive satellite data

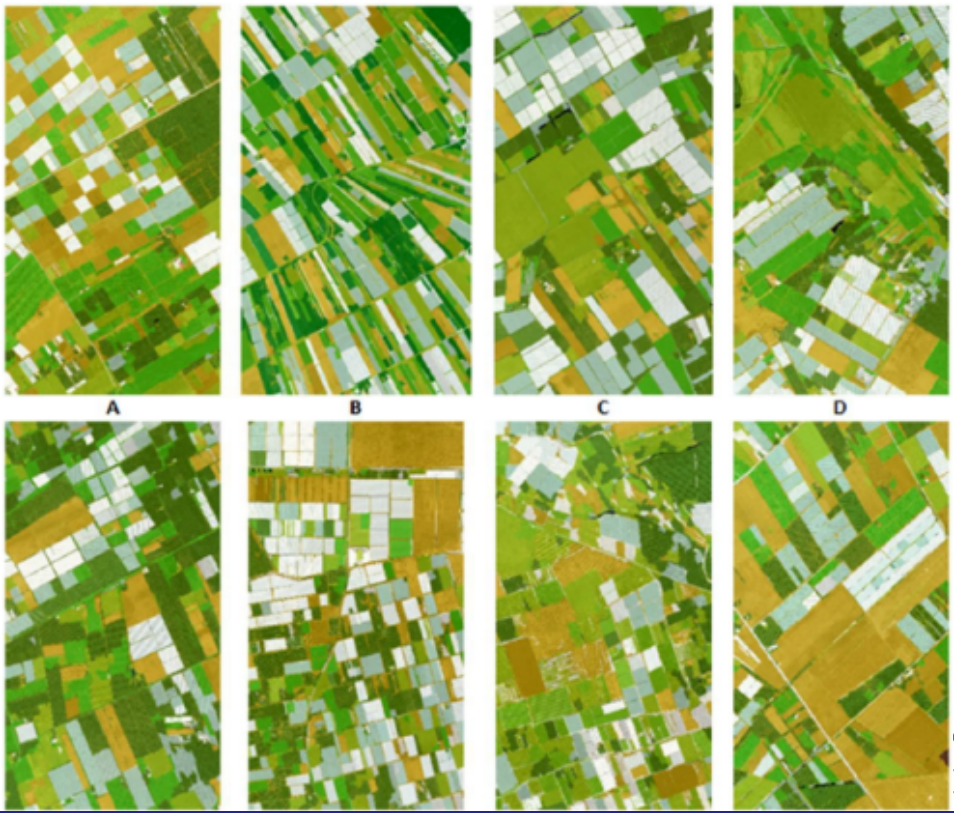
- The pixel-based approach was increasingly criticized since the late nineties (Blaschke et al. 2014), although it was the dominant approach with passive remotely sensed data.
- For objects composed of many pixels, could be more relevant the analysis of their spatial patterns than the classic statistical analysis of single pixels

Extraction of information from passive satellite data

Greenhouses Pixel-based classification on a QuickBird MS image



Greenhouses Object-based classification by Tarantino and Figorito (2012)



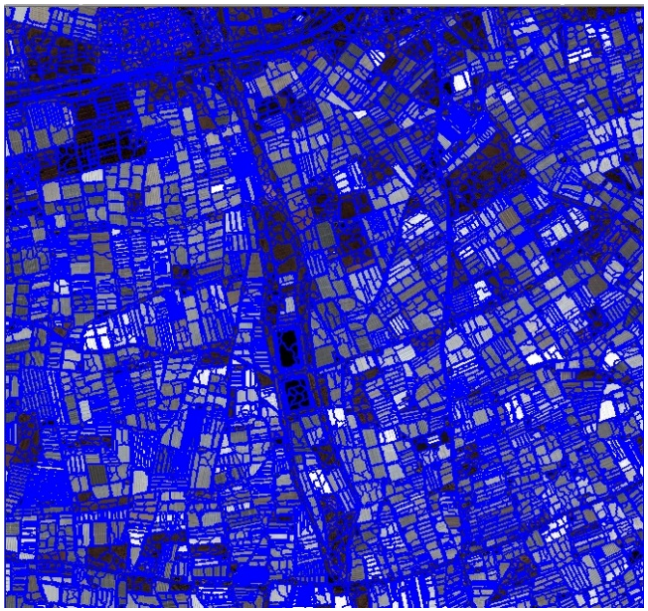
OBIA workflow: Segmentation

The Multiresolution Segmentation (MRS) is controlled by four factors:

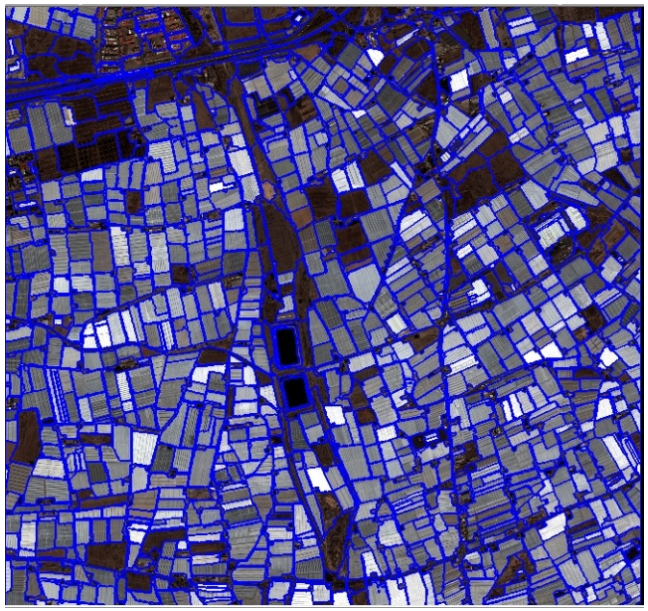
- **The Scale parameter (SP);**
- **Shape (SH);**
- **Compactness (CP);**
- **The layer (bands) of information used.**

OBIA workflow: Segmentation

SP=15, SH=0.3, CP=0.5, 8 MS bands



SP=50, SH=0.3, CP=0.5, 8 MS bands



Novelli et al., 2017. AssesSeg - A command line tool to quantify digital image segmentation quality: a test carried out in southern Spain from Satellite imagery. Remote Sensing.

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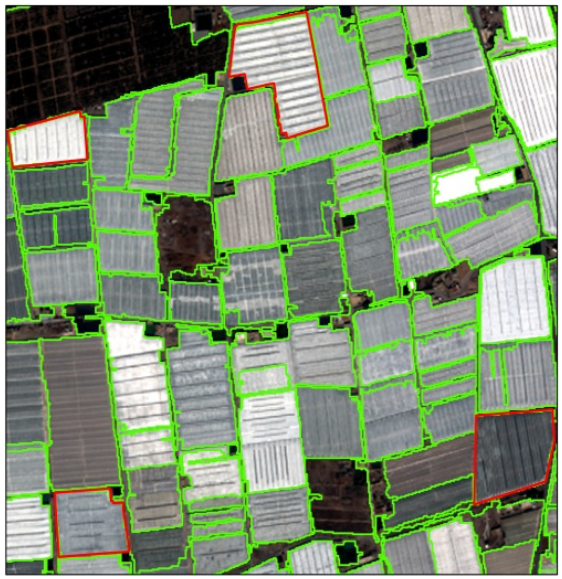
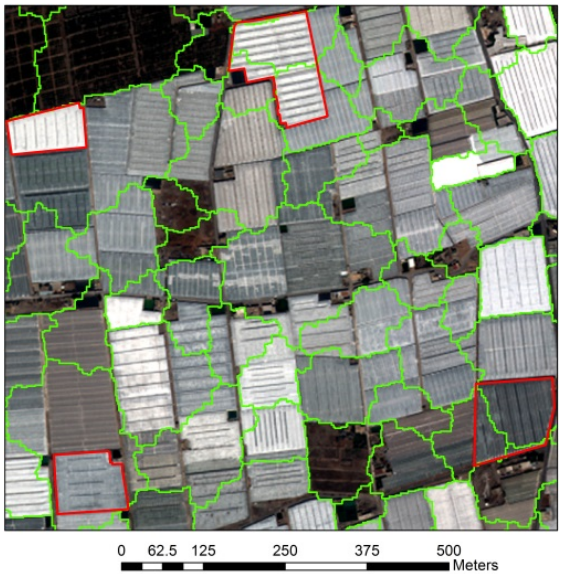
OBIA workflow: Segmentation

SP=50, **SH=0.1**, CP=0.5, 8 MS bands



SP=50, **SH=0.9**, CP=0.5, 8 MS bands



Novelli et al., 2017. AssesSeg - A command line tool to quantify digital image segmentation quality: a test carried out in southern Spain from Satellite imagery. Remote Sensing.

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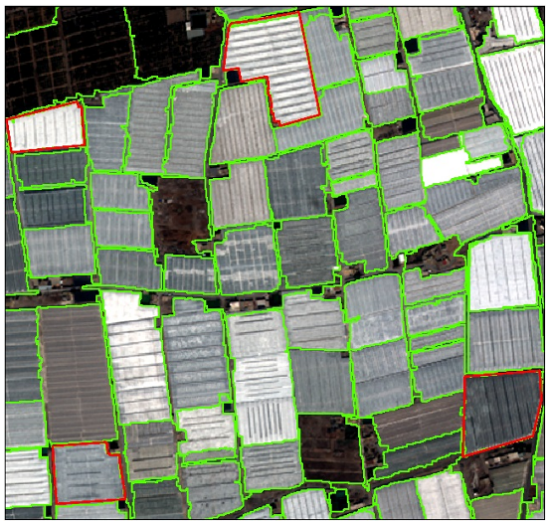
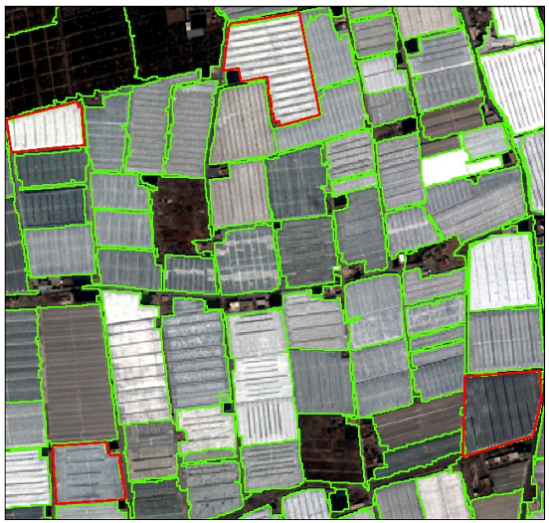
What is the best segmentation?

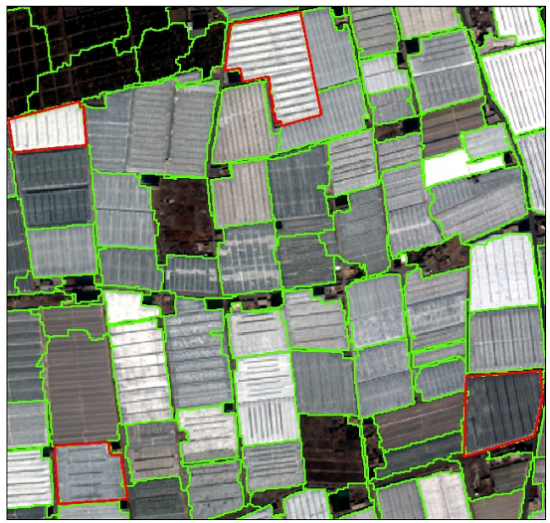
SP=50, **SH=0.1**,
CP=0.5, 8 MS bands



SP=53, **SH=0.3**,
CP=0.5, 8 MS bands



SP=47, **SH=0.5**,
CP=0.5, 8 MS bands



Novelli et al., 2017. AssesSeg - A command line tool to quantify digital image segmentation quality: a test carried out in southern Spain from Satellite imagery. Remote Sensing.

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Assess Segmentation (AssesSeg) tool

First step: Reference Polygons (RP). **Only 30 RP per class were used in previous segmentation quality studies** (Witharana and Civco, 2014, Liu et al., 2012).

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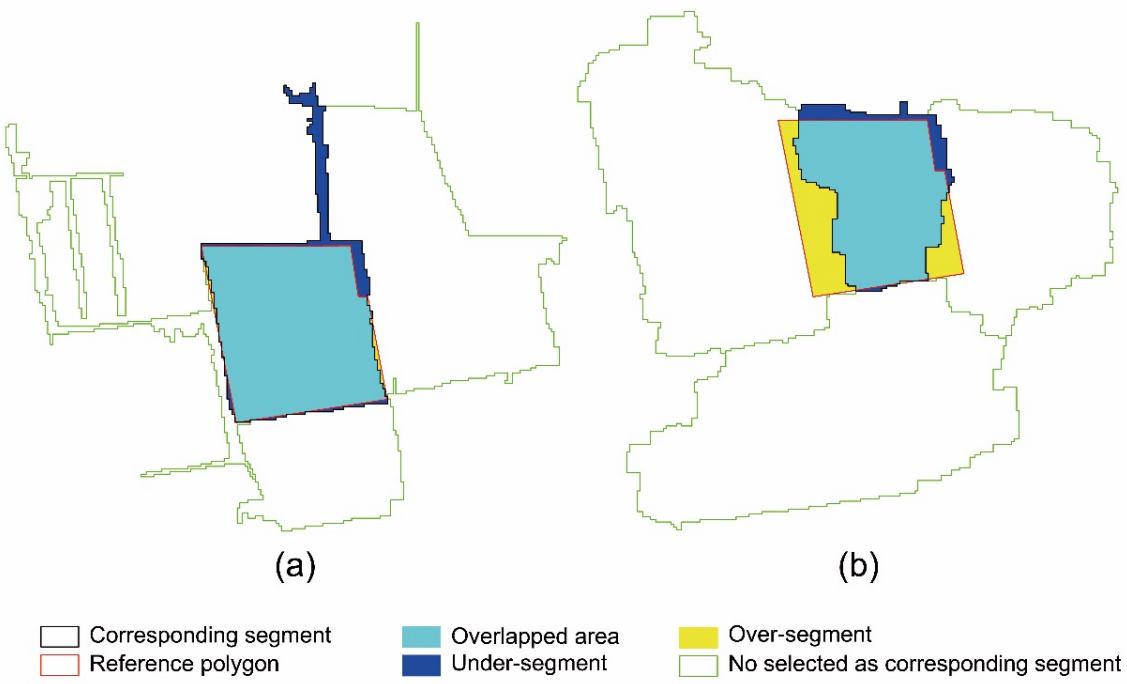
Assess Segmentation (AssesSeg) tool



It is based on a modified version of ED2 supervised discrepancy measure proposed by Liu et al. (2012). It tries to optimize in a two dimensional Euclidean space both the **geometrical discrepancy** (by mean of the potential segmentation error, **PSE**) and also the arithmetic discrepancy between image objects and reference polygons (by using the number-of-segmentation ratio, **NSR**)

$$\mathbf{ED2} = \sqrt{(\mathbf{PSE})^2 + (\mathbf{NSR})^2}$$

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Assess Segmentation (AssesSeg) tool

- **AssesSeg.exe** is a standalone command line tool that implements the **ED2** rules;
- AssesSeg deals only with the **ESRI polygon shapefile** (it does not depend on the segmentation software);
- **Its source code was written in Python 2.7** given the large availability of open source optimization, data analysis, control, and numerical analysis libraries (e.g., NumPy and SciPy).
- **AssesSeg.exe** output is an **Excel file (.xlsx)** with detailed records for each processed segmentation file.

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AssesSeg related works:

- Novelli, A., Aguilar, M. A., Nemmaoui, A., Aguilar, F. J., Tarantino, E. (2016). **Performance evaluation of object based greenhouse detection from Sentinel-2 MSI and Landsat 8 OLI data: A case study from Almeria (Spain)**. International Journal of Applied Earth Observation and Geoinformation, 52, 403-411.;
- Novelli, A., Aguilar, M. A., Aguilar, F. J., Nemmaoui, A., Tarantino, E. (2017). **AssesSeg—a command line tool to quantify image segmentation quality: a test carried out in Southern Spain from satellite imagery**. Remote Sensing, 9(1), 40.
- Aguilar, M. A., Novelli, A., Nemamoui, A., Aguilar, F. J., Lorca, A. G., González-Yebra, O. (2017, June). **Optimizing Multiresolution Segmentation for Extracting Plastic Greenhouses from WorldView-3 Imagery**. In International Conference on Intelligent Interactive Multimedia Systems and Services (pp. 31-40). Springer, Cham.

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C_AssessSeg (concurrent computing version of AssesSeg):

- Although **the first version** of the software was packaged for 64-bit systems, the computing algorithm **was not designed to exploit multi-core CPU computation capabilities**;
- In the new version of AssesSeg, **C_AssesSeg**, the function designed to compute the ED2 **was rewritten to exploit the Python multiprocessing package**;
- **By exploiting the multiprocessing package C_AssesSeg implements the capability to split the working load among a prefixed number of processes (set by the user)**;

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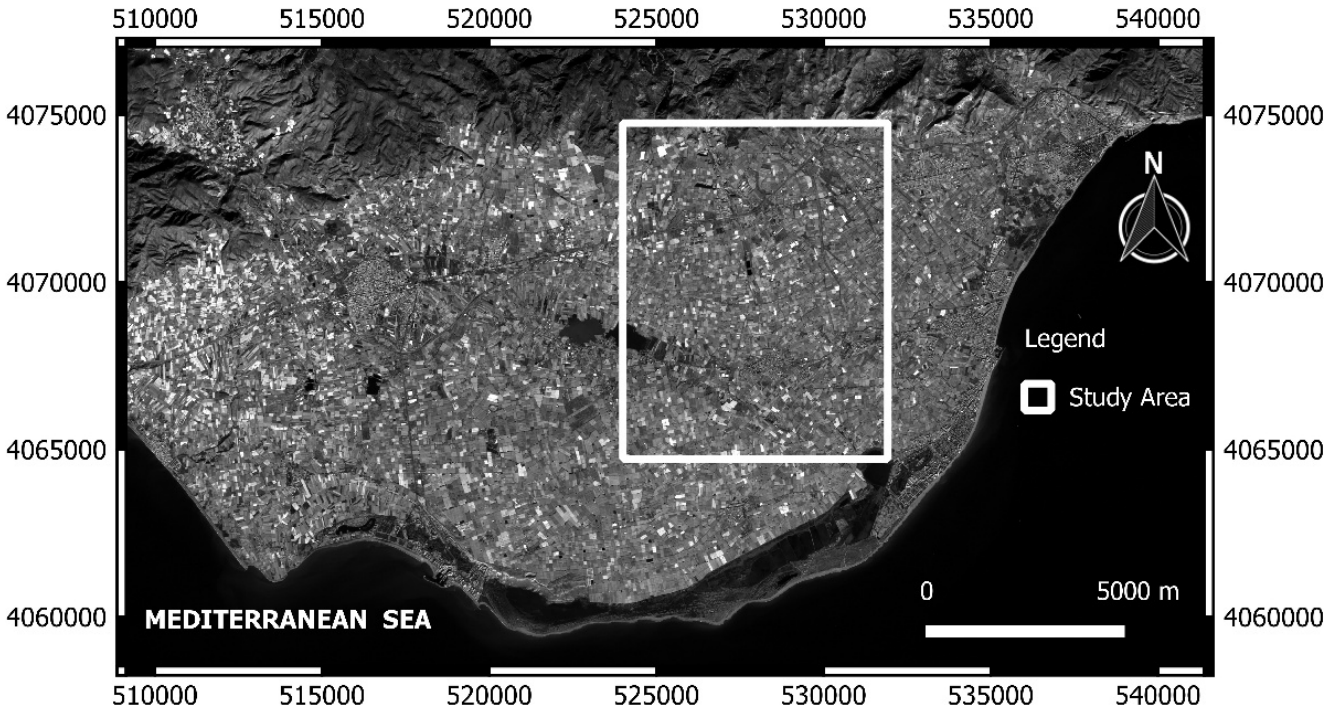
Study Area

The Spanish study area depicted by means of the Red band of a Sentinel-2 image. Coordinate system: ETRS89 UTM Zone 30N



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test dataset

- 400 polygons, representing individual greenhouses, were manually digitized over the whole study area.

The dataset for the benchmark: **Landsat-8 (L8)**, **Sentinel-2** (S2), **WorldView-2 (WV2)**, **WorldView-3 (WV3)** Multi Spectral (MS – original digital number), WV3 Panchromatic (PAN – original digital number) and WV3 MS-ATCOR (atmospherically corrected reflectance values).

Dataset	Number of segmentation files (*.shp)	Size [MB]
L8	111	396 MB
S2	111	291 MB
WV2	294	7340 MB
WV3 MS	247	20225 MB
WV3 MS-ATCOR	259	11551 MB
WV3 PAN	35	11236 MB

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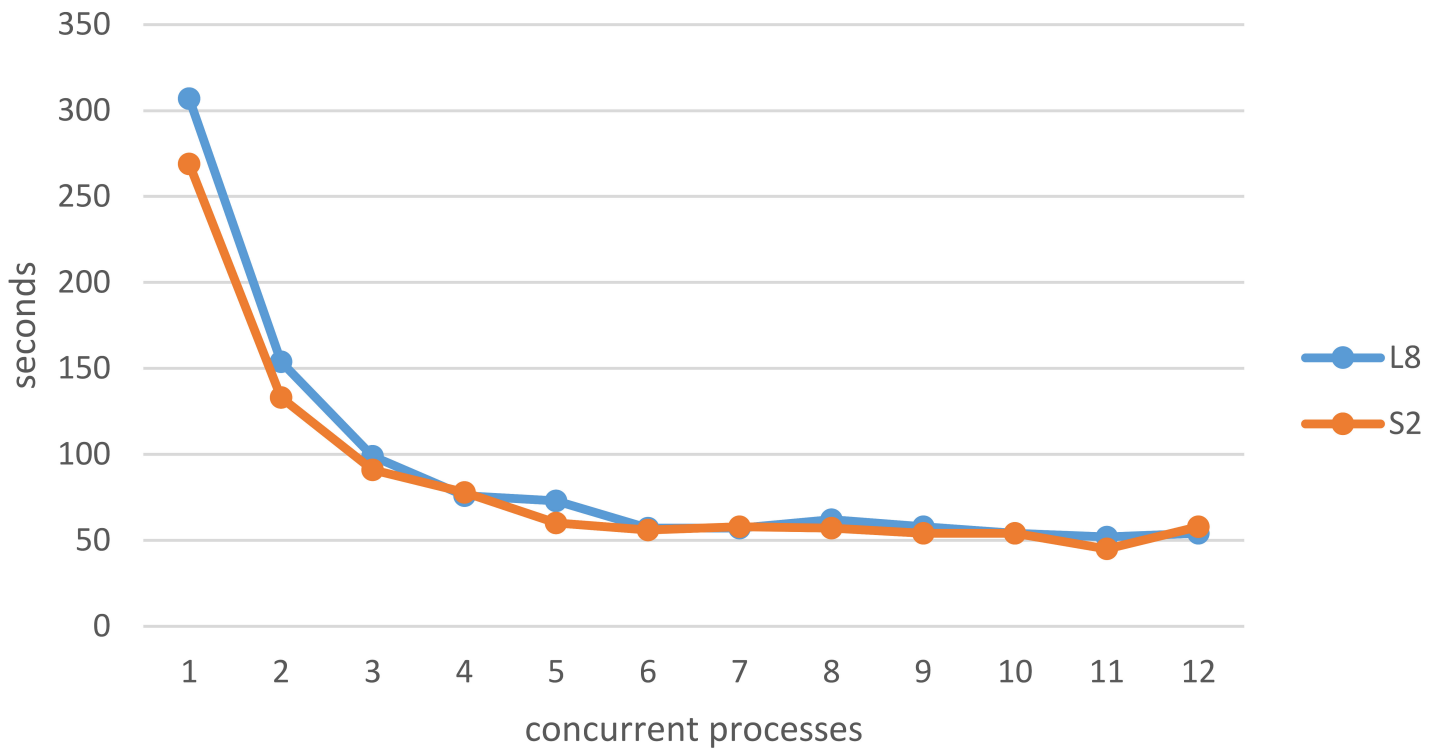
Hardware and Experimental Design

- The computations were executed with a desktop workstation based on an Intel© Xeon© E-1620 v3. This CPU is characterized by 4 cores, 8 threads and 3.50 Ghz processor base frequency.
- The comparisons were made starting from the initial AssesSeg version (one only process) to 12 simultaneously concurrent AssesSeg processes initialized by the new proposed version.

Computing time for the L8 and S2 datasets



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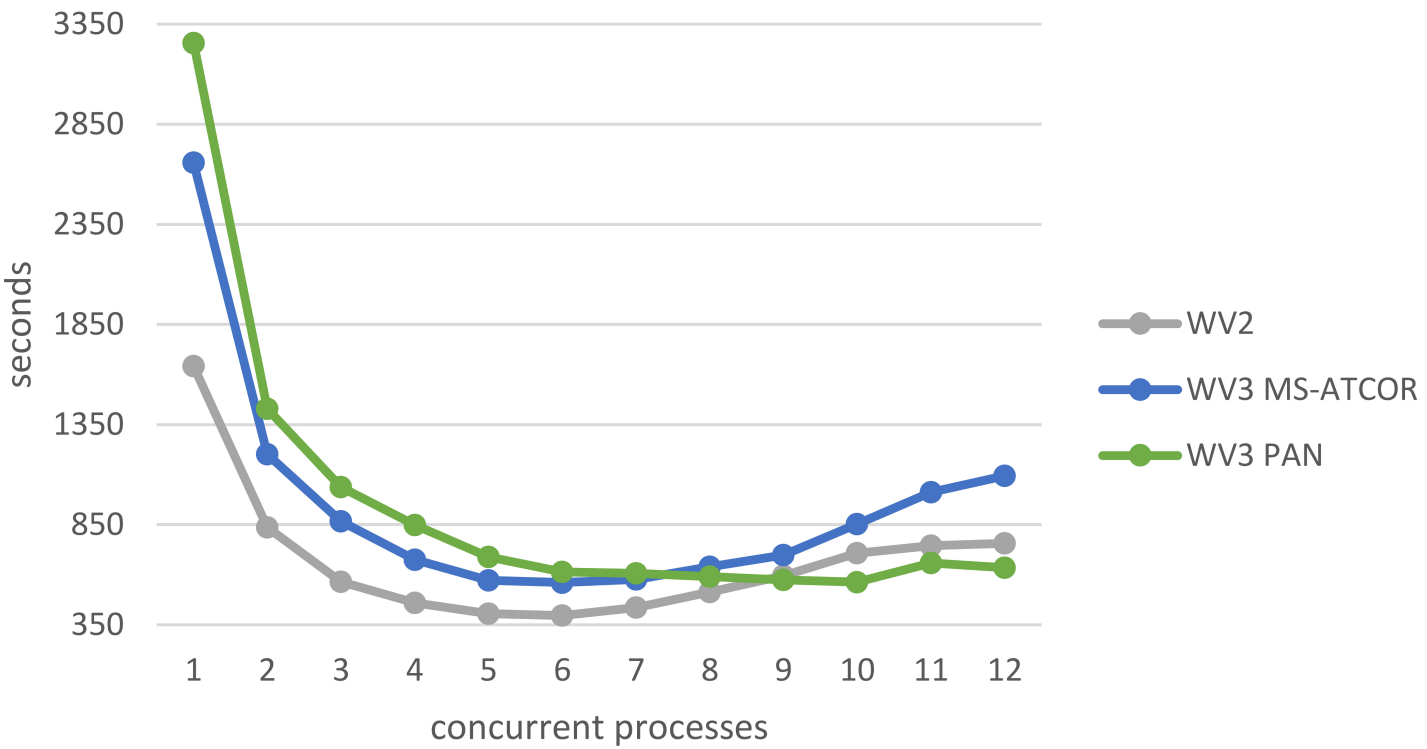
Computing time for the WV2, WV3 MS-ATCOR and WV3 datasets



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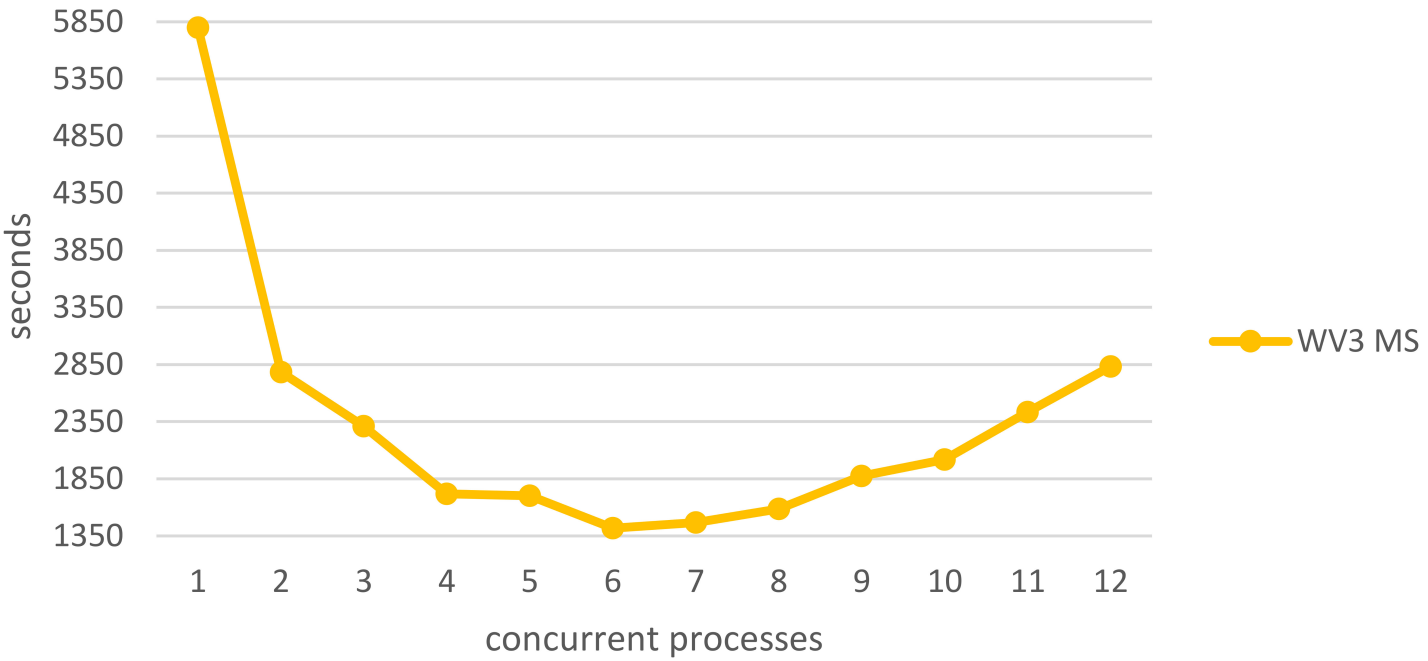
Computing time for the WV3 MS dataset



Discussion

- **Significant computing time decrease**.
- **The maximum time reduction ratio**, achieved for the L8, the S2, and the WV3 PAN datasets, **was almost equal to 6**.
- **All the six datasets feature a similar behavior up to 6 concurrent processes**, with a very high decreasing rate of computing time between 1 and 4 concurrent processes.
- The different behavior between the datasets could be linked to the Python function written to assign the working load to each concurrent process.

Conclusions

The aim of this work is to present the performances of the new version of the tool AssesSeg

- Thanks to the improvements introduced in this new version, the tool can exploit the modern multi-core CPU architectures capabilities;
- The results showed that, for some datasets, a number of concurrent processes greater than the number of CPU cores could lead to a very small computing time reduction;
- Future development will be characterized by the implementation of a graphical interface;

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Conclusions

- The new version and the previous one can be downloaded at: `https://www.ual.es/Proyectos/GreenhouseSat/index_archivos/links.htm`.

Acknowledgement

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Thank you for your kind attention

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