LEOWorks 4: The new ESA open-source image processing and GIS software for Education and training

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Abstract

LEOWorks is an Open Source image processing and Geographical Information Systems (GIS) software for educational purposes. It introduces Earth Observation techniques to users from secondary school to university level. LEOWorks bridges the gap between: a) the theory, data and overall content of the ESA Eduspace website for secondary schools and b) the practical implementation of case studies in the classroom, letting students discover and experiment with satellite imagery and related geospatial information. LEOWorks 4 is a significantly superior product with respect to the previous version, providing not only many more processing possibilities, but also flexibility and potential for further development.

Keywords: ESA Eduspace, LEOWorks, software, GIS, image processing, education

1. INTRODUCTION

While many software applications exist for practical remote sensing, most are intended for experts and focus on one particular application area, such as radar or optical image processing or Geographic Information Systems (GIS). LEOWorks meets the requirement for an educational tool that provides beginners to remote sensing the opportunity to master the key techniques of Earth Observation, encompassing image processing (optical, thermal and radar) and GIS.

Funded by Romania, through the European Space Agency (ESA) (url1) Plan for European Cooperating States (PECS), the LEOWorks ("Learning with Earth Observation") software is an image processing and GIS software for educational purposes. Together with the related case studies, it serves as a major complement to the ESA Eduspace website (url2), but can also be used autonomously. LEOWorks is a didactical tool, with extensive help pages and an all-inclusive tutorial. It allows students to inspect, process and analyse satellite images, combine them with other geospatial information and investigate various real-world phenomena. As such, it is compatible with data collected by several Earth Observation missions and can read most standard image formats (e.g. jpg, tif, bmp, png).

LEOWorks began as a simple didactical image processing software, including only the most basic functions for viewing and processing imagery. Progressively, the software has expanded, in line with increasing availability of satellite imagery and processing algorithms. LEOWorks is able to perform basic and advanced processing operations, such as geometric correction, pan-sharpening and image classification. Several tools are available, such as GIS

functionalities that enable the displaying, drawing and managing of information layers as points, lines and polygons, on top of images.

2. UPGRADE TO LEOWorks 4

The first versions of LEOWorks were based on IDL, which limited the possibilities for further development. It was hence decided that next version (version 4) would be open source and based on Java. The main reason to rebuild LEOWorks from version 3 was to make it platform independent, avoiding recurrent high licence fees. Additionally, much higher flexibility and a more efficient use of the limited computing resources, typically occurring in schools (and universities), would become possible. Furthermore, this rebuilding would allow significant enhancements to the software, by exploiting existing material, primarily from ESA professional toolboxes such as BEAM and NEST.

For the past few years, on behalf of ESA, Advanced Studies and Research Center (ASRC, Romania) has been developing the upgrade of LEOWorks from version 3 (Dransfeld et al., 2009) to version 4 (Fig. 1, url3). This progress has resulted in a beta version of LEOWorks 4 published on Eduspace in March 2013 (Fig. 2, url4), while a final version will be released under a General Public License (GPL) within 2014. Compared to LEOWorks 3 (developed in IDL), much has changed, since the user interface has been updated, not only to have the "look and feel" of contemporary software, but also to resemble the interface of BEAM and NEST. The new LEOWorks version, developed in Java, is platform independent, performing equally well on all families of operating systems (e.g. Windows, Mac OS, Linux) and including modern GIS functionalities, in an overall user-friendly environment.

Figure 1. LEOWorks version 3 (left) and the new version 4 (right).

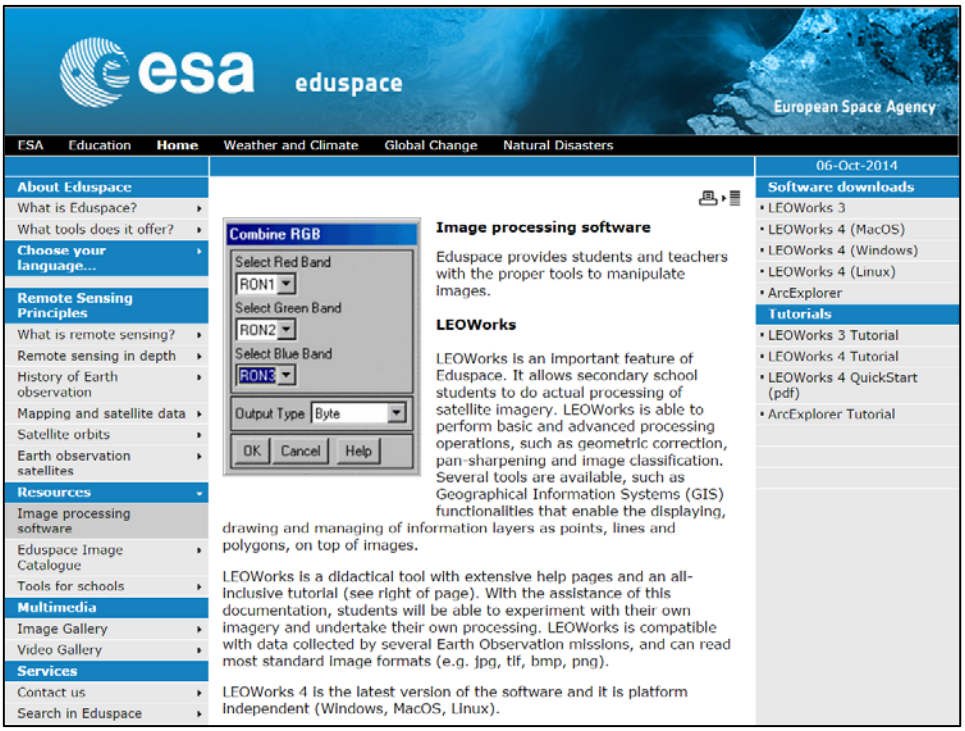

Figure 2. LEOWorks on the ESA Eduspace website (url 4).

3. FEATURES AND FUNCTIONALITIES

LEOWorks 4 is mainly targeted to secondary education, by providing students and teachers with an educational tool, which allows them to process Earth Observation data, in order to derive and assimilate useful information on real-world topics, in a controlled (education-wise) environment. Nevertheless, depending on the background and level of students, LEOWorks 4 also serves as an ideal hands-on tool for beginners in Remote Sensing/Earth Observation, GIS or related disciplines at university level. Finally, as the software in developed in Java, it is also flexible enough to allow addition of modules for advanced processing.

Some of the major features and functionalities of LEOWorks 4 include:

- Raster support for a large number of formats
- Importing of GPS (GPX format) files
- Displaying images in grayscale and/or RGB
- Image enhancement techniques (e.g. contrast manipulation, filtering)
- Image registration/georeferencing
- Performing measurements on imagery
- Unsupervised and supervised image classification
- Creating, editing, displaying and querying vector data (GIS manager)
- Animation of multi-temporal images
- Map creation

LEOWorks version 4 has significant improvements over version 3. Version 4 contains more import routines for both raster and vector file formats. Improvements in data visualisation include: more intuitive zooming and panning functions; better metadata visualisation; the possibility to link multiple viewers of geocoded imagery; and to overlay multiple layers (raster and vector) in the same viewer. An improved animation tool enables visualisations of times series, or images of multiple spectral regions, and save the output to a movie file. A sophisticated new map creation function provides the possibility to produce maps, such as temperature calibrated thermal infrared images, or classified images, complete with a legend, grid, title, scale bar and north arrow. Better image enhancement functions include more sophisticated and more didactic histogram manipulation tools. A wide range of new and improved analysis tools include a powerful band arithmetic function, which enables the application of user defined formulas taking as input the image bands of multiple files. This is complemented by a range of predefined filters for applications such as edge detection, image enhancement and averaging. Various classification functions provide users with a choice of algorithms for both supervised (minimum distance, maximum likelihood and parallelepiped) and unsupervised (ISODATA) classification. The visualisation and comparison of the spectral signatures of selected pixels is possible through a spectral analysis tool, and profile plots can be drawn to compare pixel values of various bands for different line segments. Images can be geocoded, either by taking as a reference a geocoded image of the same area, or by manually inputting map coordinates. Other tools include pan-sharpening; subset and mosaic.

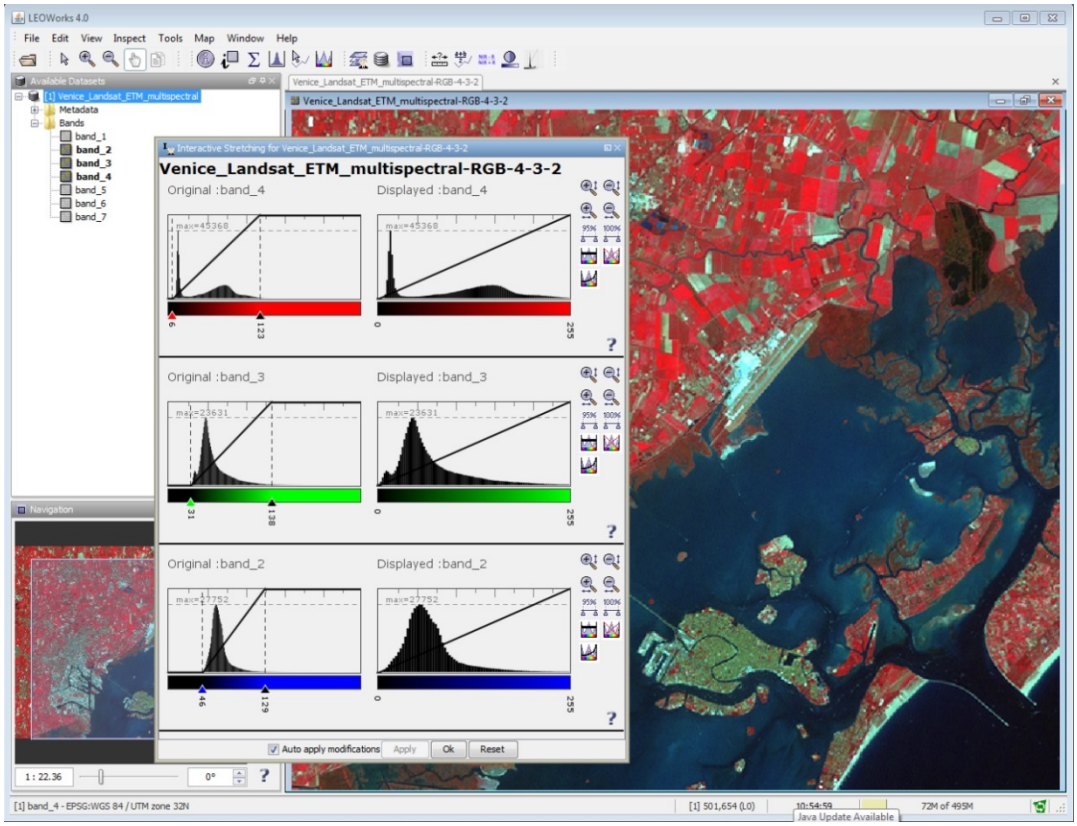

Figure 3. Snapshots of LEOWorks 4.0 interface and functionalities: Interactive stretching to enhance a false colour composite of a Landsat satellite image over Venice.

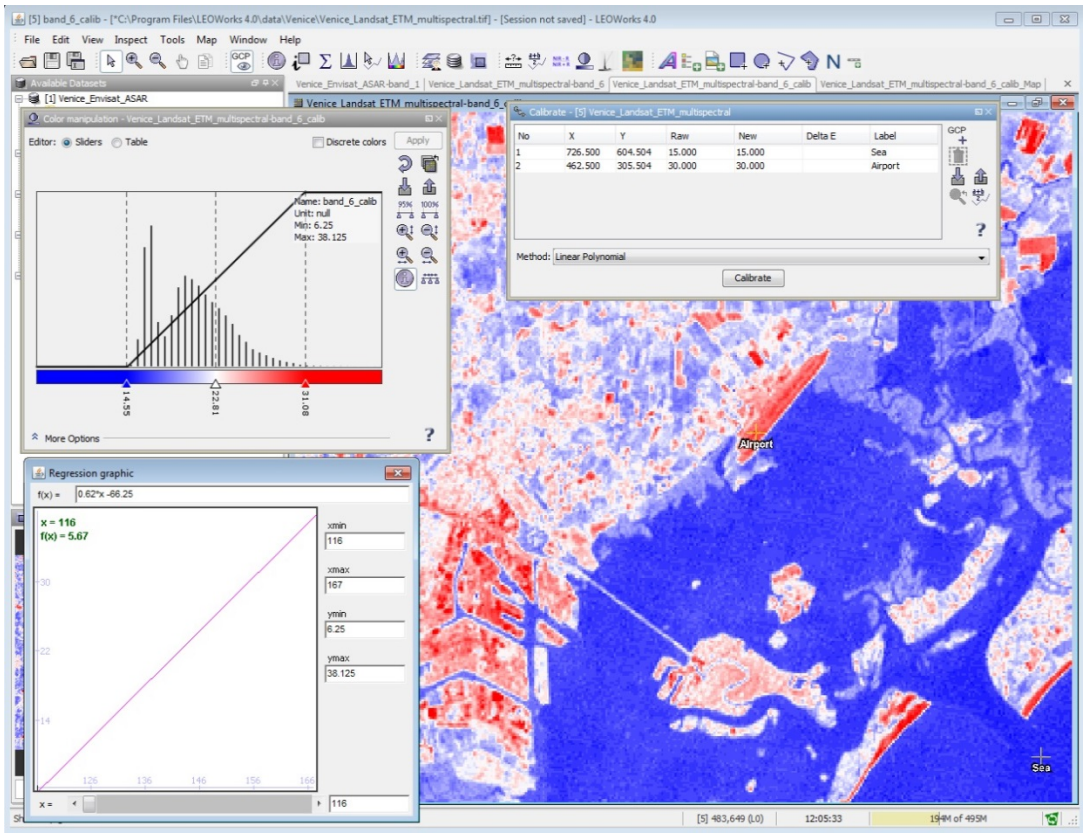

Figure 4. Snapshots of LEOWorks 4.0 interface and functionalities: Calibrated temperature image of Venice.

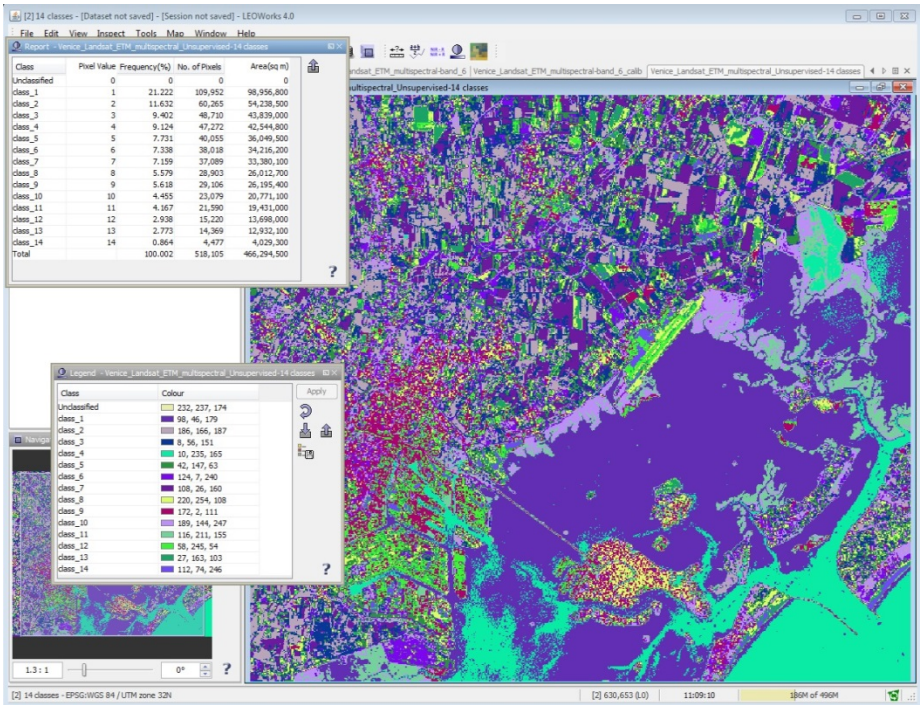

Figure 5. Snapshots of LEOWorks 4.0 interface and functionalities: Classified image of Venice.

The GIS functionality of LEOWorks 4 provides far more options for vector data analysis than was possible in LEOWorks 3. More vector file formats (including GPS points) can be imported and exported by LEOWorks 4. Better visualisation of vectors is possible with more options to change the symbology, colour and weight of polygons, lines and points. With LEOWorks 4 it is possible to perform queries on vector attributes. Selected attributes can be displayed and overlain on imagery, with choices to modify the font characteristics of text. Vector and attribute creation is far more intuitive in LEOWorks 4 (Fig. 6).

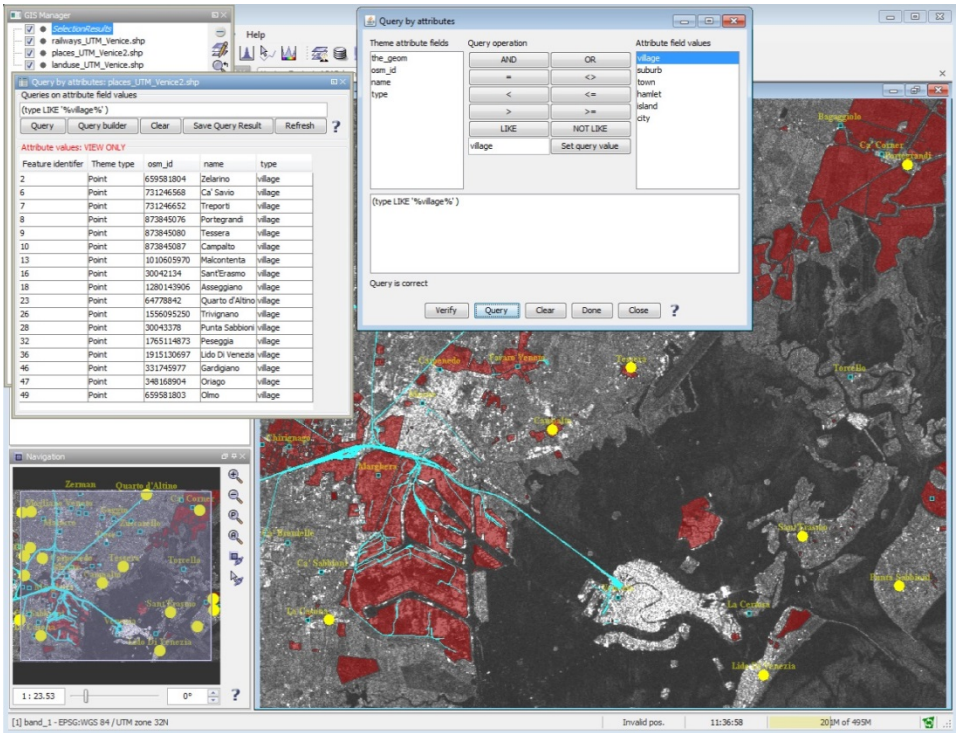

Figure 6. Snapshots of LEOWorks 4.0 interface and functionalities: Envisat/ASAR radar image of Venice with Open Street Map vectors overlain.

4. DISCUSSION AND FUTURE PROSPECTS

Hands-on training is important for learners, as it enables them to better understand the theory, phenomena, processes and their implications to the natural and anthropogenic environment. Satellite imagery and related geospatial data can be attractive tools for both teachers and students in this learning process. To this end, LEOWorks, in conjunction with the contents of the Eduspace case studies, is a dedicated resource for this kind of practical educational activities.

LEOWorks 4 shall remain the basic image processing and GIS educational software of Eduspace for the coming years. Future developments of the current version will include: more options for the map composer (e.g. additional choices for scale bar appearance and location on map); a new and improved mosaic tool; and improvements to GIS functionality (e.g. buffering). Additional updates shall mainly be focused on the compatibility with respect to the new image formats from new sensors (e.g. the Sentinels). Eventually, it is envisaged that the flexibility of version 4, shall considerably facilitate the transition to a newer version, whenever deemed necessary.

REFERENCES

Dransfeld, S., Lichtenegger, J., Brøgger Sørensen, P., Sarti, F., Serban, F., Kalogirou, V., Stewart, C. (2009). LEOWorks for teaching Earth observation – current state and future upgrades, Proceedings of the 2nd Workshop on Education and Training: From Research to Teaching in Schools and Universities, 16-17 June 2009, Chania, Greece, 4p.

Internet links:

url1: www.esa.int (European Space Agency)
url2: http://www.esa.int/SPECIALS/Eduspace_EN/ (ESA Eduspace)
url3: http://leoworks.asrc.ro/ (LEOWorks)
url4: http://www.esa.int/SPECIALS/Eduspace_EN/SEMHA60P0WF_0.html (LEOWorks on Eduspace)