TOWARDS THE USE OF DESIS FOR LANDSCAPE ARCHAEOLOGY: A CASE STUDY FROM KONYA, TURKEY

Daniele Cerra [1,*], Michele Massa [2], Stefan Auer [1]

[1] German Aerospace Center (DLR), Photogrammetry and Image Analysis Department - (daniele.cerra, stefan.auer)@dlr.de
[2] University of Chicago, Mansueto Institute - mmassa@uchicago.edu

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1. ABSTRACT

Over the last 30-40 years, archaeology has moved from being focused on excavation of individual sites, to analyse broader patterns in archaeological sites at regional level. This branch is called "landscape archaeology", and looks at the interaction among ancient human communities. Remote sensing played a key role in this area, but the use of spaceborne imaging spectrometers has been limited until recently due to the lack of state-of-the-art sensors. This paper presents the first assessment of the DLR Earth Observation Imaging Spectrometer (DESIS), mounted on the International Space Station, for the identification of archaeological sites through semi-automated detection of spectra associated with anthropogenic soils ("anthrosols") in the area of Konya, Turkey.

2. DATA AND CASE OF STUDY

The case study is Sarayönü (Turkey), a region near Konya that is covered by DESIS acquisitions and has received significant archaeological research. Surveys in the selected area have identified 15 mounded (tell) and flat settlements dateable between 4000 BCE-1300 CE, with several more believed to be present in the area. A clear DESIS image acquired over the site on the 19th of October 2018 has been selected and converted to bottom-of-atmosphere reflectance (Level 2A). In addition, a TanDEM-X digital elevation model (DEM) is added for the geometric description of the landscape.

3. ANTHROSOLS DETECTION

Anthrosols are anthropogenic soils present in areas inhabited for long periods of time. These are characterised by a high level of organic content, in particular phosphates, as a result of mixture of mudbrick clay with animal and human faeces, discarded rubbish, degraded wood and straw.

In order to detect anthrosols in the area, the DESIS image undergoes first a dimensionality reduction step: after a Principal Components Analysis (PCA) rotation, 8 Principal Components (PC) explaining at best the spectral variability in the area are selected. Results using Minimum Noise Fraction (MNF) yielded in this case inferior results. The known site richest in anthrosols around Konya is then manually selected as training area, and image elements exhibiting similar spectral features are located by thresholding the output of a simple Maximum Likelihood classifier, which gave better results with respect to the more common application of the Spectral Angle distance which exploits a larger number of spectral bands. Finally, an opening and closing morphological filtering is performed using a disk of radius 2 pixels, in order to remove noisy detection. The final result are 62 polygons derived from the identified image segments, which were individually checked by an expert and against a database of known archaeological sites. Results show that DESIS data can capture relevant spectral features related to anthrosols, as the analysis correctly detects known sites and flags previously unknown sites, among a limited amount of false positives.

DESIS Anthrosols Detections	N. of areas
Ancient	4
Modern	13
Previously Unknown	14
False Positives	31

Table 1. DESIS Anthrosols Detections.

Results presented in Table 1 and Fig. 1 show the encouraging results of this preliminary analysis. Here, anthrosols are differentiated as follows: "Ancient" represent known archaeological sites correctly retrieved by DESIS; "Modern" represents modern farms, which are not archaeologically relevant but exhibit similar spectral features due to the organic content of the soil; "Previously Unknown" is the most interesting category, as the expert who checked this area strongly believes they could be sites of archaeological interest. Finally, around 50% of the detected sites were false positives: still, the time needed for an expert to check a limited number of sites is greatly reduced with respect to looking for undiscovered sites without any prior knowledge.

4. CONCLUSIONS

While the newly identified sites will need to be confirmed in situ by archaeological survey, these results represent the first successful use of DESIS for semi-automated archaeological site recognition. The potential of this technique is its wide applicability to regions with similar landscape characteristics across the Near and Middle East, employing the identified anthrosol spectra in future iterations of the analysis over a wider study area, whenever additional DESIS images are successfully acquired.

In the future, we plan to combine the retrieved information with a DEM derived from the TanDEM-X mission, which will be employed to additionally locate tells (mounded sites) of archaeological interest, and deriving stronger indicators for the DESIS detections. Furthermore, the use of Sentinel-2 is envisaged in order to cover the Short Wave Infrared (SWIR) information, which is not included in DESIS range and is usually discriminative for the chraracterization of soils in general. Moreover, Sentinel-2 adds improved spatial resolution to the data fusion procedure and allows for the analysis of texture.

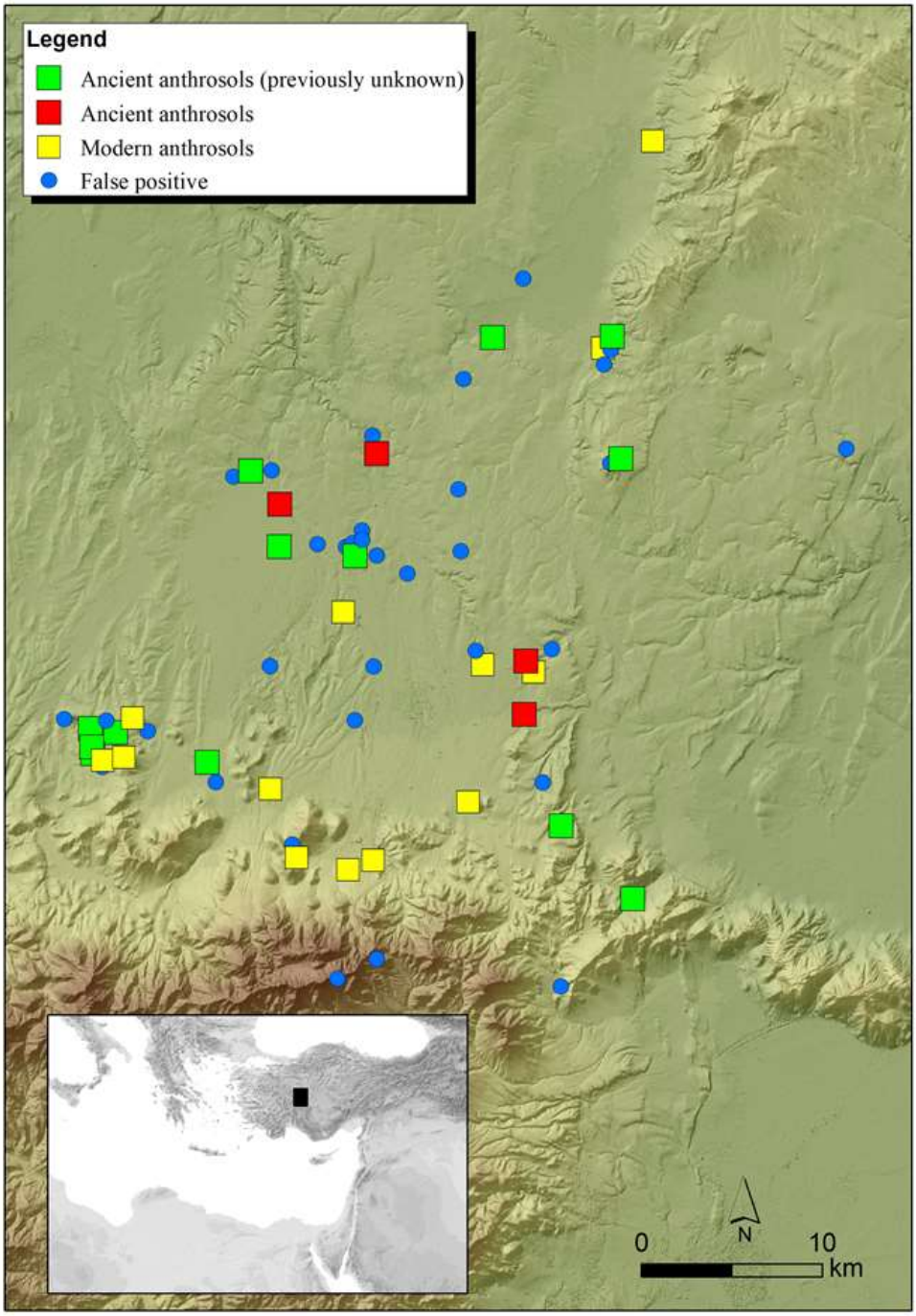

Figure 1. Detection of Anthrosols in Konya, Turkey from DESIS Data. The detections are overlaid on a Digital Elevantion Model derived from the TanDEM-X mission, which will be employed to additionally locate tells (mounded sites) of archaeological interest.