CORONA satellite imagery, preserving an account of the earth’s surface from 40 years ago, is a most important archaeological survey tool and we have often sung its praises. Here the authors use new procedures to extend the competence and revelations of CORONA even further. Stereo pairs derived from images taken from fore and aft of the satellite give three dimensional images of landscapes and even individual sites. Techniques of modelling and rectification restore the sites to their original shape without recourse to survey on the ground – in many cases no longer possible since the sites have been buried, inundated or erased. The ingenuity shown here indicates that results from CORONA are only going to get better.

Keywords: Near East, west Asia, CRM, research surveys, satellite survey, CORONA, landscape survey, site survey, tell settlements, hollow ways

Introduction

Since its declassification in 1996, CORONA satellite imagery has proved to be an invaluable resource in archaeology. These images, from the United States’ first programme of intelligence satellites that operated from 1959-1972, are especially useful in the Near East, where historic high-resolution aerial photography is unavailable or simply non-existent. The power of these images to aid in the recognition of archaeological sites and ancient landscape features such as roads, canals and field systems is now clearly demonstrated (Beck et al. 2007; Casana 2003; 2007; Challis et al. 2002-2004; 2006; Fowler 2004; Hritz 2005; Kennedy 1998; Kouchoukos 2001; Philip et al. 2002; 2005; Pournelle 2003; Ur 2003; 2005; Wilkinson 2003). Furthermore, because the landscape of the Near East has been so dramatically transformed in recent years, CORONA images are even better suited for archaeology than expensive, commercially available, high-resolution satellite imagery such as QuickBird or IKONOS. In the past three decades, dam projects, vast irrigation schemes, industrial development and an urban population explosion have obscured or destroyed
countless archaeological sites and other ancient cultural features. CORONA thus preserves a picture of an archaeological landscape which, by and large, no longer exists.

Despite widespread interest in CORONA as an archaeological tool and the many ways it has been deployed in research projects, there has been far less attention paid to the possibilities of using CORONA in stereo, both for three-dimensional viewing of archaeological landscapes and for extraction of digital topographic data. The final two generations of CORONA images, the KH-4A and KH-4B series, were taken in stereo utilising forward and aft panoramic cameras, but the relatively complex image geometry and the lack of most required metadata regarding image acquisition (Schenk *et al.* 2003; Sohn *et al.* 2004) have largely prevented researchers from employing these stereo capabilities. Yet three-dimensional analysis of CORONA imagery has enormous potential for archaeological research in the Near East and elsewhere. A significant percentage of archaeological sites in the region are mounded tells, exhibiting topographic relief of up to 40m in height, and many other ancient landscape features such as canals or roadways also have topographic expression. The ability to recognise and map such features directly from historic satellite imagery could transform the efficiency of archaeological surveys, enable us to generate detailed topographic maps of individual sites and features, and allow us to reconstruct lost landscapes in three-dimensions.

Several researchers have recently begun to develop means for three-dimensional analyses using CORONA imagery. Altmaier and Kany (2002) were the first to publish a space forward intersection-based method for digital elevation model (DEM) extraction from small segments of CORONA images. When applied in a mountainous region of Morocco, their method succeeded in producing a fairly accurate 17m DEM. A Belgian team of archaeologists working in the Altai Mountains of south-central Siberia utilised this method for the extraction of DEMs (Gheyle *et al.* 2004; Goossens *et al.* 2006), but the ephemeral nature of archaeological sites in the region as compared to the Near East render CORONA a less valuable tool. In studies of the middle Orontes river valley in western Syria, Galiatsatos and co-authors (2005; Galiatsatos 2004) have also employed CORONA-derived DEMs in archaeological analyses. The team had good results using stereo images for archaeological prospection for the production of regional topographic maps, although individual tell sites remained difficult to recognise and map in product DEMs (Galiatsatos 2004: 244-5). Furthermore, all of the above projects depended on the acquisition of ground control points (GPCs) from differential GPS (DGPS) surveys of study regions or from modern, orthorectified high-resolution satellite imagery such as IKONOS or QuickBird. These methods add enormously to the expense and effort required to generate three dimensional CORONA data because they require that researchers either go to study areas with expensive GPS equipment or purchase high-resolution imagery, and probably both.

This paper presents initial results of our efforts to utilise the stereo capabilities of CORONA imagery in analyses of the rich and complex archaeological landscape of the Near East. Case studies of individual sites and larger regions are drawn from several areas of the northern Levant, including the Islahiye Plain of southern Turkey, the Ghab Basin of western Syria, and the middle Euphrates river valley of northern Syria (Figure 1). We outline our methods for viewing CORONA imagery in stereo, the extraction of high-resolution digital elevation data, and ortho-rectification of images using only freely available base imagery and...
Method

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Figure 1. Location map illustrating regions and sites discussed in the text.

topographic data sources, eliminating the need for costly high-resolution satellite data or hard to acquire DGPS-derived ground control points. In our approach, we follow Altmaier and Kany (2002) in modelling small sections (sub-images) of the scanned film (no larger than 35 × 35mm) as frame images. Although this procedure does not fully address the distortions inherent in panoramic cameras on moving platforms, simple and readily available photogrammetric resection and intersection software can be used to model the full three-dimensional aspects of the stereo collections and enable quick and easy construction of good quality DEMs and orthorectified images. Our relatively straightforward methods produce robust results that offer powerful new perspectives on individual sites, larger archaeological features, and the landscapes in which they are situated. The ease with which these methods can be applied and the low cost of doing so opens the possibility for the application of these techniques across large regions and in areas with little or no modern ground control.

CORONA image preparation: problems and methods

Stereo viewing, DEM extraction and orthorectification of CORONA imagery are possible when the same area of the ground surface was photographed on overlapping images. The KH-4B missions, which provide the best spatial resolution (1.83m at nadir [Schenk et al. 2003; Sohn et al. 2004; United States Geologic Survey 1996]), carried two panoramic cameras, one angled approximately 15 degrees aft and the other 15 degrees forward of the direction of satellite motion. The resulting 30 degree convergent images allow stereo viewing in the direction of satellite motion (generally N-S) as well as from ‘side’-lapping images taken from different passes of the satellite. Before proceeding with analysis, it is essential to acquire the best quality digital images of an individual study area. Countless ground and atmospheric conditions can affect the relative visibility of archaeological features,
Stereo analysis, DEM extraction and orthorectification of CORONA satellite imagery

and much past research has suffered from use of less than optimal CORONA missions or scanning techniques. Beginning in 2005, the US Geological Survey began distributing high-resolution (7 micron) images scanned directly from the original film strips, providing much crisper images than the contact prints researchers previously utilised. Our experience suggests that these new scanned images provide superior spatial resolution than any image sold as a contact print and are thus the preferred format for analysis of CORONA imagery.

Once imagery has been selected, the first step in three dimensional analyses is to determine the orientation of the images to the ground, which is challenging due to high levels of spatial distortion found in raw CORONA images. KH-4B missions utilised a panoramic camera that is well suited for the acquisition of large ground areas because the long focal length lens (609.608mm), necessary for high-resolution, can be packaged inside a small camera body while maintaining a very large field of view (70 degrees) (Figure 2a). However, these cameras imaged a 'bow-tie' shaped area of the ground that was then compressed into a rectangular image frame. Furthermore, as the full 70 degree arc of the film platen was exposed, about $\frac{1}{2}$ second elapsed during which time the satellite moved forward approximately 4km (Sohn et al. 2004), causing another source of image distortion that was only partially mitigated by a forward motion compensator. When forward satellite motion and scan time is taken into account, the footprints of the cameras take the shape of two, slightly skewed 'bow ties' (Figure 2b). Thus, prior to any geometric correction, forward and aft images contain spatial distortions in opposite directions, making stereo viewing of raw images all but impossible outside a narrow strip in the centre of the images, as illustrated at the site of Zincirli in southern Turkey (Figure 3).

Image distortions contained in panoramic CORONA images would best be corrected using a rigorous model (e.g. Schenk et al. 2003; Sohn et al. 2004) that recognises both the position and orientation of the camera changes for each column of the sub-image. Because such models are not yet available in commercial photogrammetry packages, we follow Altmaier and Kany (2002) in employing a simpler and more common photogrammetric frame model, which results in an acceptable level of error. Due to the long focal length of CORONA panoramic cameras, a small sub-image may be treated as a frame camera exposed at a single instant in time. Figure 2a shows three possible sub-images formed from the scan, each with a different orientation to the ground. The errors induced by this assumption may be easily estimated and reach only about 5 pixels (0-15m on the ground) if the sub-image does not exceed 5000 $\times$ 5000 pixels (when scanned at 7 microns). Sub-images of this size or smaller may be oriented to the ground via a method known as space-resection and subsequently used to generate a DEM using standard forward space-intersection procedures available in most softcopy photogrammetry packages.

Space resection requires the input of at least three full GCPs (with XYZ values) as well as the scan resolution, camera focal length and average flying height. Previous projects have acquired GPCs from DGPS surveys of study areas in which coordinates of features visible on CORONA are recorded in the field, or from identification of such features on orthorectified QuickBird or IKONOS imagery. However, our research shows that space resection of CORONA sub-images can be successfully accomplished using a variety of freely available imagery and topographic data. In our work, we have relied on orthorectified 10m SPOT satellite data from the early 1990s, freely distributed by the National Geospatial
Figure 2. (A) A diagram showing how image acquisition is accomplished in CORONA panoramic cameras using a curved film platen. Small portions of the film strip may be sectioned into sub-images and treated as a frame camera; (B) ground areas covered by forward and aft cameras of KH-4B missions. Note the scale change across the width of the film, with higher resolution at nadir positions and lower resolution at the extremes of the scan. At the edges of the scans, the view of the ground is highly oblique.
Intelligence Agency (at: http://geoengine.nga.mil/), which provides adequate if less than optimal resolution for acquiring GPCs. Figure 4 illustrates a means of measuring GPCs through the identification of common points visible in both the SPOT and CORONA data, in this case, at the intersection of two major canals in the Ghab Basin. SPOT imagery provides the X and Y values for geometric correction while the same geographic location can then be found on 90m SRTM topographic data to provide a Z value.

Because of the various assumptions in the simplified mathematical model and the relative imprecision of the control points, it is important to measure a relatively large number of GCPs (greater than 20) that are distributed evenly across the CORONA images spatially and topographically. Once the space resection of the images is complete, it is possible to proceed with stereo viewing, DEM extraction and orthorectification, each of which is discussed in separate sections below. All images have been prepared using Leica’s Photogrammetry Suite and ERDAS Imagine Stereo Analyst, while three-dimensional renderings are produced in the ArcGIS module, ArcScene.

**Viewing CORONA in stereo**

The vertical perspective that CORONA affords has always helped investigators better understand archaeological sites by examining the spatial relationships of features that are sometimes difficult to recognise on the ground. Viewing these data in three dimensions enables even greater insight into the morphology of sites and the distribution of features around them. Pairs of images, or in our case, sub-images, may be viewed stereoscopically if they are taken from sufficiently different viewpoints (i.e. if the baseline between the images is long enough) and if the convergence angle is not too large. The parallax induced by the baseline separation allows a stereo-view in which humans can perceive parallactic changes as small as 1 arc-second (Wolf & Dewitt 2000: 150, 327-45). Stereo viewing is therefore possible in overlapping forward and aft images discussed herein or in areas of overlap between adjacent images. Since parallactic changes in these images correspond to depth changes in the terrain, stereo-viewing allows very precise qualitative views of terrain relief.
Once space resection of CORONA sub-images is complete, it is possible to view the images in stereo as anaglyphs or as traditional stereo pairs using a variety of software packages, including ArcGIS, ERDAS Imagine and others. Stereo viewing offers archaeologists a powerful means of viewing CORONA imagery, enabling mounded archaeological sites to be easily differentiated from other surface disturbances and the relationship between cultural features and local topography to be readily recognised. Examples from the middle Euphrates valley in Syria (Figure 5) and the Islahiye Plain in Turkey (Figure 6), demonstrate the potential of the technique in Near Eastern archaeology. These images have been produced as anaglyphs (Figures 5-6), which require the use of red-blue glasses for viewing. Red-blue glasses are available free of charge from numerous online distributors (e.g. www.rainbowsymphony.com). These same images have also been formatted as traditional stereo pairs for readers with access to a stereoscope (Figure 7).

Landscape analysis: Euphrates valley, Syria

Figure 5 presents an anaglyph and a stereo pair of the middle Euphrates river valley in Syria. Today this area is largely submerged below Lake Assad, a reservoir formed following the construction of the Tabqa Dam in the late 1970s. The very high topographic relief of the
Figure 5. (Top) stereo anaglyph, requiring red-blue glasses for viewing, showing the middle Euphrates valley in Syria, now submerged by Lake Assad (Mission #1105-1, acquired 4 November 1968); (bottom) line drawing showing the location of archaeological sites.
Figure 6. (Top) stereo anaglyph, requiring red-blue glasses for viewing, showing the Islahiye Plain, Turkey. Archaeological sites (1-2) appear as mounded features while lacustrine features (3) are topographically flat (Mission #1105-1, acquired 4 November 1968); (bottom) line drawing showing the location of archaeological sites and other features.
older terraces into which the Euphrates river has incised appear with stunning clarity on these images. On the northern bank of the river, the large site of Tell Hadidi (1) is clearly visible and marks the extent of the modern lake. In the valley below, all archaeological sites are now submerged. Archaeological and geomorphological surveys of the region prior to its being flooded suggest that many sites in the Euphrates floodplain were probably eroded by
the river or buried beneath aggrading sediments, while sites like Tell Hadidi that are situated on the high terrace above the river were well preserved (Wilkinson 2005: 19-24). There are nonetheless small portions of the floodplain that have been less impacted by fluvial processes, resulting in relict patches where archaeological sites are better preserved. In the valley bottom, just to the south-east of Tell Hadidi, one such site, Shams ed-Din, appears as a high central tell surrounded by a crescent-shaped area of lower mounded features (2). Surveys suggest that the site is predominantly Early-Middle Bronze Age (c. 3000-1750 BC), demonstrating that this portion of the floodplain has been preserved since at least 3000 BC (ibid.: 249-50). Figure 5 is just one example of the ability of stereo viewing of CORONA imagery to aid in interpreting archaeological landscapes by enabling researchers to view sites in relation to the surrounding topography and to other physical landscape features.

Archaeological site prospection: Islahiye region, southern Turkey

One of the most promising applications for stereo analysis using CORONA imagery is in the prospection for and recognition of mounded archaeological sites in unexplored regions. While many sites appear with great clarity on CORONA imagery, a large percentage of sites are either not apparent or difficult to distinguish from other features such as depressions, patches of unusual vegetation, soil disturbance or geologic features. However, because when viewed in stereo CORONA substantially exaggerates topographic relief, subtly mounded sites appear with greater clarity than they do even in the field.

Figure 6 provides an anaglyph and stereo pair of a small area in the Islahiye Plain that has not been intensively surveyed for archaeological remains. Alkim (1969) recorded many of the largest sites in the region, but as is common with low-intensity surveys, many smaller sites were probably not discovered. In Figure 6, two small, round mounded features (1-2) are visible that are slightly lighter in colour than the surrounding agricultural plain, just to the south and west of the large limestone hill at the bottom centre of the image. The size, shape and location of these features strongly suggest that they are small archaeological sites, and a visit to the area during the 2007 season at nearby Zincirli confirmed this fact. While these features appear prominently in stereo, in traditional 2D CORONA images they would be difficult to distinguish from other light-coloured patches, such as the lacustrine feature (3) indicated on the line drawing. Stereo analysis thus constitutes a powerful site prospection tool because it enables us to differentiate mounded features from flat or depressed areas, as well as from other non-cultural surface anomalies, and thus greatly improves the efficiency of imagery-based surveys.

Digital Elevation Model extraction

Stereo images have been utilised by cartographers as the primary means of generating regional-scale topographic data for more than a century, but significant technical difficulties discussed above have prevented the use of these techniques for CORONA. More quantitative methods for extracting relief from overlapping images can be accomplished by either manually extracting heights of visible features or automatically extracting heights via image correlation. We have followed a similar method to that of Altmaier and Kany (2002) (i.e.
treating small sub-images as frame images), but with some improvements to address the specific needs of archaeological research, particularly in improving image matching through manually inputting tie points around specific areas of interest.

Once two overlapping CORONA sub-images are oriented with respect to the ground, the three-dimensional ground coordinates of any feature that can be identified in both images may be computed via forward space-intersection (Wolf & Dewitt 2000: 150, 327-45). This may be accomplished manually, with the user selecting each feature of interest in both images (the pair of image points defining each feature are known as tie-points). Modern methods of DEM generation via soft-copy photogrammetry, use image correlation to automate the tie point selection. In one implementation of this process, the user instructs the computer to select every \( n \)th pixel in the left image, find the matching point in the right image and compute its ground XYZ coordinates. The known orientation of the images restricts this search along what is known as an epipolar line. A rough knowledge of possible elevation values (taken from the minimum and maximum SRTM elevations in our case) further limits the search to a segment of this line. Because this process relies on the uniqueness of the surrounding image content to find good matches, reducing the search space is important.

We achieved the best results when choosing a 10m DEM post spacing (about every fifth pixel) but found it difficult to achieve good matches, and thus good elevations, in homogenous areas and areas exhibiting repetitive patterns. However, we were able to significantly improve the matching by manually measuring tie points in areas of special interest. These tie points can be distributed around the base and the peak of a mounded tell site, for example. The tie-points reduced the search space by providing better elevation estimates in the local area.

Mapping landscapes: Lower Orontes river valley, western Syria

Figure 8 illustrates a 10m DEM produced from a stereo pair of CORONA covering Ghab Basin in western Syria. As is clear on the product DEM, areas of higher topographic relief are generally easier for the software to model, as in the lofty Jebel Anasryiah range on the left of the image. In the low-lying Orontes river floodplain at the centre of the image, there are some occasional mistakes in the image matching process, resulting in high spikes or low troughs. These problems can be corrected by carefully going through individual problem areas and removing bad tie points or adding additional ones. But even in its raw state, the data provide a very high-resolution DEM across most of the terrain and have the ability to reveal mounded archaeological sites. Several such sites are visible on the image, indicated at A-D. Results of this analysis are thus a significant improvement on those attained by Galiatsatos (2004; Galiatsatos et al. 2005), and far superior to the use of SRTM for the same purpose, as described by Menze and co-authors (2006), where even the largest tells are scarcely visible and smaller sites not at all.

These detailed topographic data have a wide range of archaeological applications, being far higher resolution than most publicly available digital elevation data. They can serve as base-maps for planning regional archaeological surveys, aid in the interpretation of the topographic setting of archaeological sites and help recognise cultural landscape features that have topographic expression, such as relict canals. These data also preserve a picture of
topographic variation in areas that are now inundated, as in the case of the Euphrates valley discussed above, or which are otherwise obscured by modern development.

**Mapping sites: Tell Qarqur, western Syria**

Some data generated from CORONA are even of high enough spatial resolution to produce detailed topographic maps of individual archaeological sites. Figure 9 compares DEMs of Tell Qarqur, a large mounded site in western Syria (Dornemann 2003), as produced from: (a) stereo CORONA imagery, (b) a two-week total station mapping project and (c) 90m SRTM data. Clearly, the total-station produced DEM provides the greatest detail, but the CORONA-based map of the site is a fairly close approximation, whereas the site is apparent as only a few pixels in SRTM data. The image matching around the site was improved by the input of more than 50 additional tie points across the site. It is also possible using various software tools to manually map either topographic contours or three-dimensional block features using a stereo view of the imagery. Better pixel matching tools that may be developed in the future would significantly improve results of automated DEM extraction from CORONA imagery.

The ability to produce detailed topographic maps of individual sites like the one illustrated in Figure 9a has enormous possibilities for archaeology in the Near East and elsewhere. We can, for example, now quickly produce topographic maps of all mounded sites within archaeological survey areas, something that would have been cost and time prohibitive in the past. Sites that have been destroyed by urban or agricultural development, inundated by dam projects, or damaged by bulldozing and looting can also be reconstructed.
Orthorectification Tell Hadidi ‘hollow ways’

Orthorectification is a process by which image distortions caused by topography and image orientation are geometrically corrected by the incorporation of a terrain model. One of the primary benefits of the production of DEMs from CORONA sub-image stereo pairs is the ability to use these data to orthorectify the images themselves, producing geometrically
corrected images with much less spatial distortion than other methods, particularly in areas of high topographic relief. Moreover, an orthorectified sub-image may then be ‘draped’ over the extracted DEM.

Several researchers have recognised the utility of analysing CORONA imagery that has been draped over a digital terrain model as in the case of the Neo-Assyrian canals of northern Mesopotamia (Ur 2005) or the distribution of sites along the Syrian Euphrates (Challis et al. 2006). These studies show how three-dimensional views of the landscape enable us to recognise the relationship of archaeological sites and features to local topography more effectively. The method described here improves on these efforts, because the underlying topographic data is of much higher resolution than the 90m SRTM data generally used by researchers and because the orthorectification of CORONA against these data produces a much closer match between topography and image.

Figure 10a illustrates an orthorectified image of the Euphrates valley in Syria, now submerged below Lake Assad. In this case, the topographic features evident in the valley bottom would not be visible without the use of the CORONA-derived DEM because modern topographic data like the SRTM would show this area as a flat lake surface. The relationship of hills, river terraces and archaeological sites are all very apparent in this image, which has been exaggerated by 2x to enhance topographic contrasts.

Orthorectified, draped images like Figure 10a can be used to document and better interpret many archaeologically significant cultural landscape features, such as the so-called ‘hollow ways’, or ancient roads, found throughout much of eastern Syria and northern Iraq (Ur 2003; Van Liere & Lauffray 1954-55; Wilkinson 1993; 1994). Today hollow ways form shallow linear depressions that extend, often in radial patterns, outwards from archaeological sites for up to 5km. They have been interpreted as the remains of frequent human and animal foot traffic entering and leaving settlements, constrained by agricultural fields on either side, eventually forming a depression. While difficult to recognise on the ground, hollow ways are clearly visible in historic aerial photography and CORONA imagery, although the introduction of large irrigation schemes and mechanised ploughing has largely obscured them today. These roads, especially radial, spoke-like systems, are found almost exclusively surrounding third millennium BC (Early Bronze Age) settlements in the Jazireh, a semi-arid steppe in northern Mesopotamia. They have not been documented at third-millennium settlements in other regions of the Near East or around most sites of earlier or later date within the Jazireh. While the reasons for the restricted temporal and spatial distribution of hollow ways remains a subject of debate, they have been documented at several sites in the middle Euphrates including Tell es-Sweyhat and Tell Hadidi (Wilkinson 2005: 81-2), which is probably their westernmost attestation.

Figure 10b shows a close-up of the site of Tell Hadidi as it appears on an orthorectified CORONA image draped over the CORONA-produced DEM. Tell Hadidi is one of the largest sites in the region, with major settlement during the Early, Middle and Late Bronze Ages (3000-1200 BC), and was excavated by a salvage project during the 1970s (Dornemann 1988). The site is situated immediately adjacent to the Euphrates valley and is preserved as an elongate double mound, with a high citadel area perched on the western edge of the larger lower town. There are three major hollow ways visible at Tell Hadidi, extending northwards from the site. The fact that the image is draped over actual topography allows us to see that
Figure 10. (A) orthorectified CORONA image of the middle Euphrates river valley draped over a 10m CORONA-derived DEM; (B) close-up of Tell Hadidi, where three ancient roadways, or ‘hollow ways’, are visible extending north-east from the site.
each hollow way extends from the base of site, probably at a major gateway in a city wall, and then directly towards three drainages that provide access down to the Euphrates valley. Thus, these data reinforce the interpretation of Wilkinson (2005: 81-2) that the features were formed by persistent movement of shepherds bringing flocks between the city and the rich pasture areas found adjacent to the river.

**Conclusion**

This paper has sought to present a straightforward and inexpensive method for three-dimensional analyses of CORONA imagery, highlighting the enormous power of these techniques in regional and site-based archaeological studies in the Near East. We have successfully produced stereo views, 10m DEMs and orthorectified imagery utilising a simplified frame model for space resection of CORONA sub-images and ground control points derived entirely from freely available data sources. Our results show how these three-dimensional analyses of CORONA imagery can aid in archaeological site recognition, production of topographic maps of individual sites, assessing relationships among sites and other cultural or environmental features, and for the reconstruction and mapping of entire landscapes.

Methods discussed here are limited to use with small sub-images, which makes it difficult to employ them across large areas. A better approach would model the dynamic panoramic cameras more rigorously such that entire image strips could be treated at once, orthorectification would result in substantially smaller spatial errors and many images could be batch processed. While such a method is not currently possible with commercial photogrammetry software, we are currently working to recast a rigorous CORONA panoramic model using a Rational Functional Model into a form which can be more easily integrated with commercial packages. Once implemented, these methods will enable the techniques described herein to be deployed across large regions more efficiently and more accurately.

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Stereo analysis, DEM extraction and orthorectification of CORONA satellite imagery


