TOPOGRAPHIC AND THEMATIC MAPPING FROM MULTI-RESOLUTION SATELLITE IMAGES

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(1) Abstract

(2) Introduction. In the Nasca desert plain, there are well known structures called geoglyphs. For about 40 years of her life, Maria Reiche (1903-1998) from Dresden investigated these structures. In 1994 the "Maria Reiche" Association was founded in Dresden for extension and continual science workflow in the Nasca region. Within the framework of this association, several expeditions to Peru were realized. In 1995 the Nasca project was initiated at the University of Applied Sciences in Dresden. The Nasca project's goals are: storage and preservation of the world cultural heritage in digital form, presentation of data and resulting information, creating of digital thematic maps. Peruvian law from 1995 saves the world-known Nasca geoglyphos area; this area is on the list of UNECSO world heritage; however, other areas are saved only on national or local level and their condition is in some cases very bad. The origin and reason of geoglyphs are not well known. Major theories speak about calendar and astronomical purposes, marking of subterranean water resources, movement and communication, ceremonial and religious signification, work therapy, artistic expression and extraterrestrial influence.

(3) Objectives. The area of interest is very large and not easily accessible; for this reason, aerial photogrammetric methods and satellite remote sensing for mapping of geoglyphs were used. There are aerial black and white photos (1:10,000) of two photo flight missions in May 1997 and May 1998 from this area; however, the quality of these photos is not very high and the access to them is not easy. From the 2000, there is possibility to use a satellite data with resolution of 1m, from 2003 with 65cm, from 2008 with 50cm; the progress in hardware and satellite segment such as processing and data access is very fast. In the year 2004 and 2008 two expeditions were realised as an international actions with participants from Germany (HTW Dresden) and Czech Republic (Technical University in Prague). Continuous documentation and mapping of all area by digital image methods has been planed. The measurement of necessary control points for aerial images (about 150 images) and satellite images (Ikonos and QuickBird) by precise GPS instruments was important aim of these expeditions. Satellite images were processed to maps. All the information is processed and stored in Nasca GIS (HTW Dresden) and on the other hand, specialised map server has been created at the CTU in Prague.

(4) Methodology. First of all seven separate satellite images from the Ikonos satellite with the help of the field-measured Ground Control Points were processed to the satellite image mosaic. For about 40 photogrammetrical control points and 30 control points for satellite images were measured in the Pampa Nasca. The field measurement was made by use of GPS Leica1200. A radiometric and histogram correction was necessary in order to homogenize the different colours of images. This base satellite mosaic was created on HTW Dresden in 2003, but the satellite image mosaic can only be used as an overview of the whole area. For details satellite maps in a scale 1:5,000 were created and completed with some vectors from Nasca GIS (major geoglyphs). Later the images from the QuickBird satellite with resolution of about 65cm were added. It is necessary to say that the fine line structures and some geoglyphs are not visible on satellite images. The reason is simple: some geoglyphs consists of lines only about 15cm wide, but the global view of the Nasca area is an advantage. Some special photographic flights were undertaken with a Cessna airplane (2004 and 2008) and helicopter (2005). Only digital cameras were used for the main geoglyphs documentation (Nikon D100, Canon 20D). These images have to be rectified (oblique photo axes), but the resolution is better then satellite images (depend on zoom and flight height, approximately about 5-10cm/pixel). Nowadays, local photo mosaics are created from aerial oblique photos; these mosaics are located to rectified satellite image-maps from QuickBird satellite. There is a problem with original paper maps from Nasca area. Local maps are not sufficient, quality of contour lines is low in mountain area; only old U.S. maps from 1964 were found and used with adequate quality. But in many cases the situation today is different. From this reason, we create own maps based on satellite images for local area.

(5) Results. Multi resolution spectral and panchromatic images were used. For digital elevation model (DEM) Aster satellite stereo data sets were used – two scenes from Pacific Ocean to Cordilleras (about 60x120km, resolution 15m). Necessary control points were localised on maps, photos or image sketches made from satellite images and these points were later measured by Trimble GeoExplorer XP GPS instruments. The base station and rover configuration was used with post processing accuracy of about 50-100cm in position. The quality of this DEM is not very high, but sufficient for creating of hypsography (in scale 1:50 000 the 15m is only 0.3mm). After DEM creating, multispectral image data processing by using geologically oriented hyperspectral process was used for processing of thematic maps. More valuable parts of Nasca area covered by geoglyphos were documented by using other satellite data such as QuickBird and processed to maps as vectorised features. Second aspect is displaying all of these outputs (own created maps, DEM, mosaics…) on web. Easy, fast and well-arranged access is necessary. The map server, based in our case (CTU in Prague) on UMN MapServer, is used.

(6) Conclusions. By this project, satellite and aerial image data with different geometrical and spectral resolution were used for basic mapping and documentation of historical valuable parts of landscape with world – known geoglyphos. The aim of this project is creating the thematic maps collection and their displaying on web by using map server.

1. Introduction

In the Nasca desert plain, there are well known structures called geoglyphs investigated by Maria Reiche (1903-1998) from Dresden of about 40 years. In 1994 the "Maria Reiche" Association was founded in Dresden to extend and continue research in the Nasca region. Under the auspices of this association several expeditions to Peru were organized. In 1995 a Nasca project was initiated at the University of Applied Sciences (HTW) in Dresden. The Nasca project's goals are, as follows: storage and preservation of the world cultural heritage in digital form, presentation of data and resulting information and creation of digital thematic maps. The world-known Nasca geoglyphs have been protected by Peruvian law since 1995 and this area is on the UNECSO list world heritage sites; however, other areas are protected only at national or local level and their physical condition is, in some cases, very poor. The origin and reason why the geoglyphs were created are not well known. Major theories refer to calendar and astronomical purposes, marking of subterranean water resources, movement and communication, ceremonial and religious purposes, work therapy, artistic expression and extraterrestrial influence.

2. Objectives of the project

The area of interest is very large and not easily accessible; for this reason, aerial photogrammetric surveying and satellite remote sensing for mapping of the geoglyphs were used. Aerial black and white photos (1:10,000) from photo flight missions in May 1997 and May 1998 of this area are available; however, their quality is not very high and access to them not easy. Since years 2000, 2003 and 2008 satellite data have been on disposal with a resolution of 1m, 65cm and 50cm, respectively. Progress in hardware and satellite segments such as processing and data access is very fast. In 2004 and 2008, two international expeditions were launched with participants from Germany (HTW Dresden) and the Czech Republic (Czech Technical University in Prague). Continuous documentation and mapping of the whole area by digital imaging methods have been planned. An important aim of these expeditions was measurement of necessary control points (about 150) for aerial images and satellite images (Ikonos and QuickBird) by precise GPS instruments. All information is processed and stored in the Nasca GIS (HTW Dresden); a specialised map server exists at the CTU in Prague.

3. Using of satellite and aerial images

First of all, seven separate satellite images from the Ikonos satellite were processed to a satellite image mosaic using the field measured Ground Control Points. For about 40 photogrammetric control points and 30 control points for satellite images were measured especially in the Pampa Nasca. The field measurements were made by GPS Leica1200. In order to homogenize the image colours difference a radiometric and histogram correction was necessary. This basic satellite mosaic was created at HTW Dresden in 2003, but it can be used as an overall view of the whole area only. For

details, satellite maps on a scale 1:5,000 were made and completed with some vectors from the "Nasca GIS" (major geoglyphs). Later, images from the QuickBird satellite with a resolution of about 65cm were added. It is to be said that on the satellite images, the fine line structures and some geoglyphs are not visible. The reason is simple: some geoglyphs consist of only about 15cm wide lines, but the global view of the Nasca area is an advantage. Some special photo survey flights were undertaken with a Cessna airplane (2004 and 2008) and a helicopter (2005). Only digital cameras for the main geoglyphs documentation (Nikon D100, Canon 20D) were used. These images have to be rectified (oblique photo axes), but they offer better resolution than the satellite images; the resolution depends on zoom and flight height and reaches approximately about 5-10cm/pixel. At present, local photo mosaics are created from aerial oblique photos; these mosaics are located to rectified satellite image-maps from the QuickBird satellite. The original paper maps from the Nasca area cause many problems. Local maps are not sufficient, the quality of contour lines is low in mountainous areas and only old U.S. maps from 1964 were found and used with adequate quality. However, in many cases the present situation is different. For this reason, we create our own maps for local areas based on satellite images.

4. Digital elevation model

Multi-resolution spectral and panchromatic images were used. For digital elevation model (DEM) Aster/Terra satellite stereo data sets (two scenes) were used – from the Pacific Ocean reaching as far as Cordilleras (about 60x120km, resolution 15m). The necessary control points were localised on maps, photos or image sketches made from satellite images, and these points were later measured by Trimble GeoExplorer XP GPS instruments. The base station and rover configuration were used with a post-processing absolute accuracy of about 50-100cm in position. The quality of this DEM is not sufficient for detailed mapping in big scales, but good for creating hypsography (on plans in scale 1:50 000 the 15m pixel is only 0.3mm). For satellite data processing, 21 or 20 control points were used on Aster scene 1 or Aster scene 2, respectively (residual on control points is about 0.5 pixel). All coordinates are in Peruvian system PSAD56.

Easting WGS84	Northing WGS84	Elevation WGS84	Name	Point	Easting PSAD56	Northing PSAD56	Elevation PSAD56
9/2008 Trimble XP	9/2008 Trimble XP	9/2008 Trimble XP					
494300,39 8/2004 Leica 1200	8368679,09 8/2004 Leica 1200	569,23 8/2004 Leica 1200	qq37a	08-qq37a	494524,39	8369042,74	537,71
494300,335	8368678,768	568,969	qq37a		494524,33 ΔE	8369042,41 ΔN	537,44 ΔH
					-0,06	-0,33	-0,27

Table1. Example of control points measurement: GPS Trimble XP and Leica 1200

We finished one own DEM from Nasca area based on ASTER satellite data beginning 2009; however, in June 2009 NASA and Japan released a new digital topographic map of Earth. The map was produced with detailed measurements from NASA's Terra spacecraft. The new global digital elevation model of Earth was created from nearly 1.3 million individual stereo-pair images collected by ASTER, instrument aboard Terra. NASA and Japan's Ministry of Economy, Trade and Industry (METI), developed the data set. It is available online to users everywhere at no cost. Previously, the most complete topographic set of data publicly available was from NASA's Shuttle Radar Topography Mission. That mission mapped 80 percent of Earth's landmass, between 60° north latitude and 57° south. The new ASTER data expands coverage to 99%, from 83° north latitude and 83° south. Each elevation measurement point in the new data is 30m apart (two pixels in original images with pixel resolution 15m). ASTER GDEM (Global Digital Elevation Model) is developed based on a grid of 1 x 1 degree in latitude and longitude and requires no scene selection or mosaicking. The ASTER GDEM covers land surfaces between 83°N and 83°S and is comprised of 22,600 1°-by-1° tiles. Tiles that contain at least 0.01% land area are included. The ASTER GDEM is in Geographic Tagged Image File Format (GeoTIFF) with geographic lat/long coordinates and a 1 arc-second (30 m) grid. It is referenced to the WGS84/EGM96 geoid. Pre-production estimated (but not guaranteed) accuracies for this global product were 20 m at 95% confidence for vertical data and 30 m at 95% confidence for horizontal data. The original data of ASTER GDEM is the property of METI and NASA.Data users can download the Aster global digital elevation model at:
http://www.gdem.aster.ersdac.or.jp

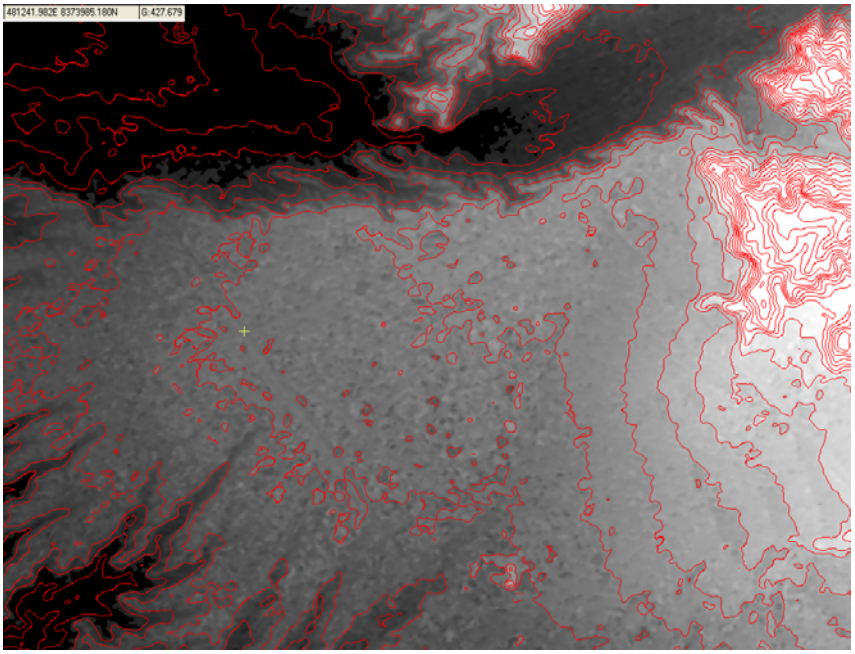

Figure 1. DEM with contour lines (step 25m) created by using software Geomatica 10.03 OrthoEngine (CTU in Prague)

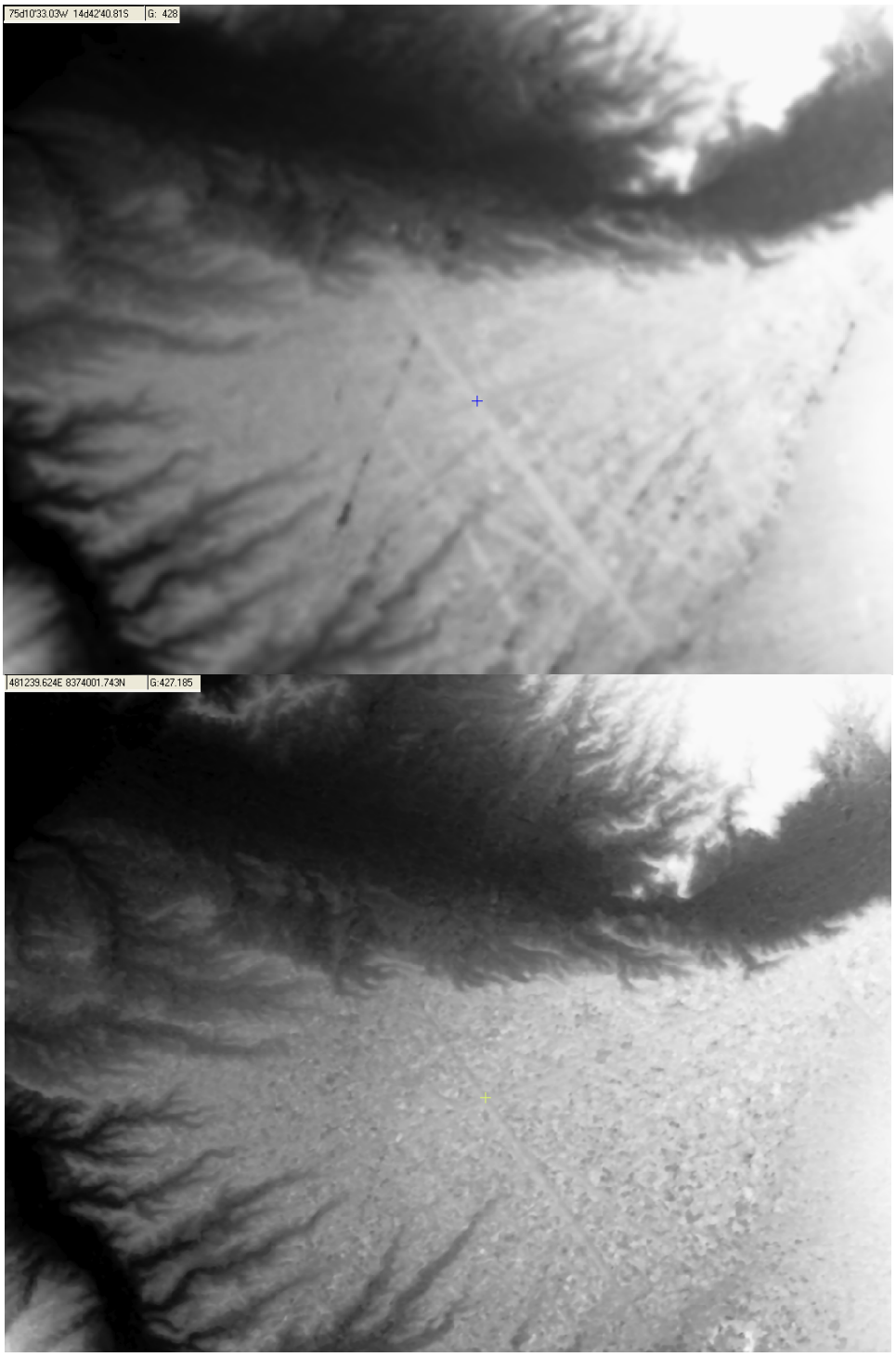

Figure 2. Comparison of GDEM ("ASTER GDEM is a product of METI and NASA") for Nasca geoglyhs main region and DEM created on CTU in Prague (second image); the height at the signed point (marked with small cross in the middle of image) is almost the same (!) 428m and 427,185m – by pixel resolution of 15m very good result.

5. Data processing and map server

After obtaining DEM (hypsometry), multispectral image data processing by the geologically oriented hyperspectral process was used for thematic maps producing (Aster/Terra satellite multispectral data with a variable resolution from 15m to 80m). More valuable parts of the Nasca area covered by geoglyphs were documented by using other satellite data such as QuickBird or Ikonos (geometric resolution 0.65m panchromatic / 2.4 multispectral or 1m/4m, respectively) and processed to maps as vectorised features. The orthorectification process was used. Another aspect is displaying all of these outputs (own created maps, DEM, mosaics) at the web. The map server based in our case at CTU in Prague uses the UMN MapServer.

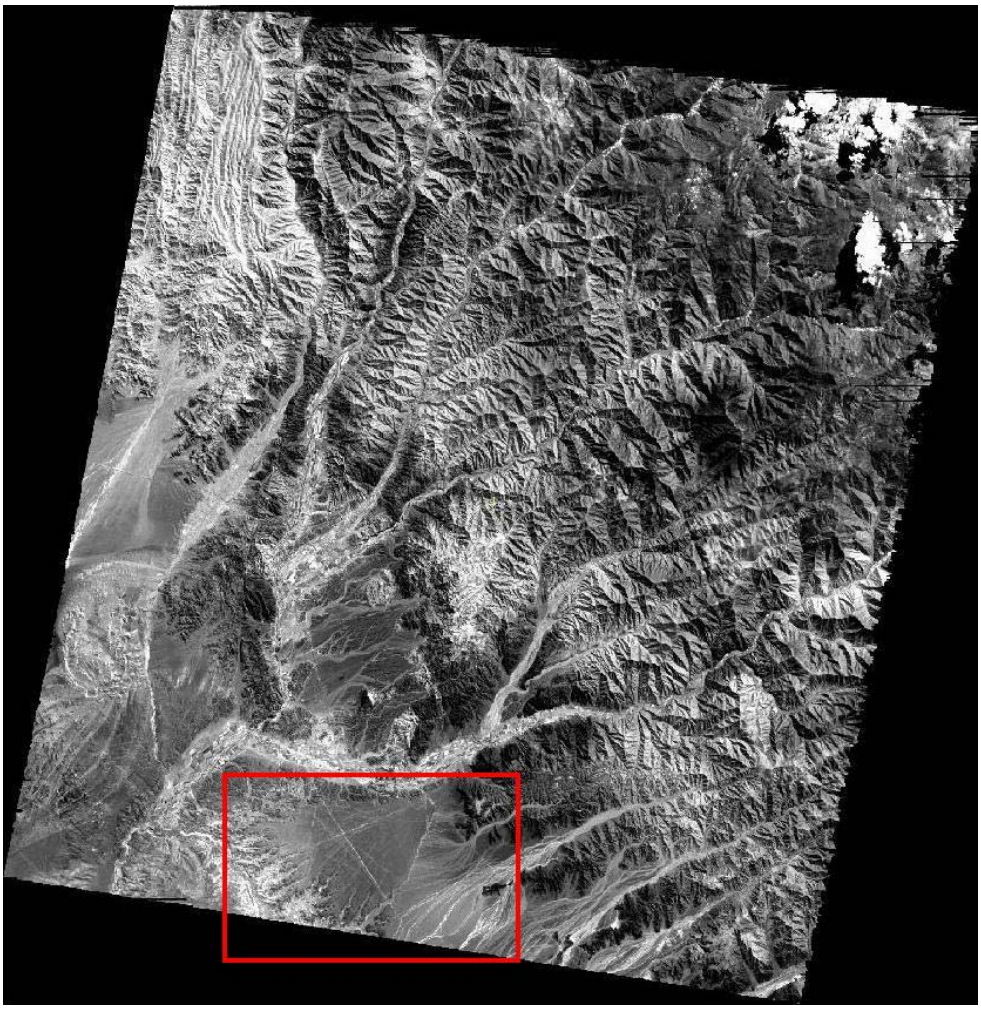

Figure 3. Orthophoto of Nasca main geoglyphs region created from ASTER data (CTU in Prague). Central part of "Pampa del Calendario" with main geoglyphs (here marked by red rectangle) is shown on next figure (QuickBird, 2005)

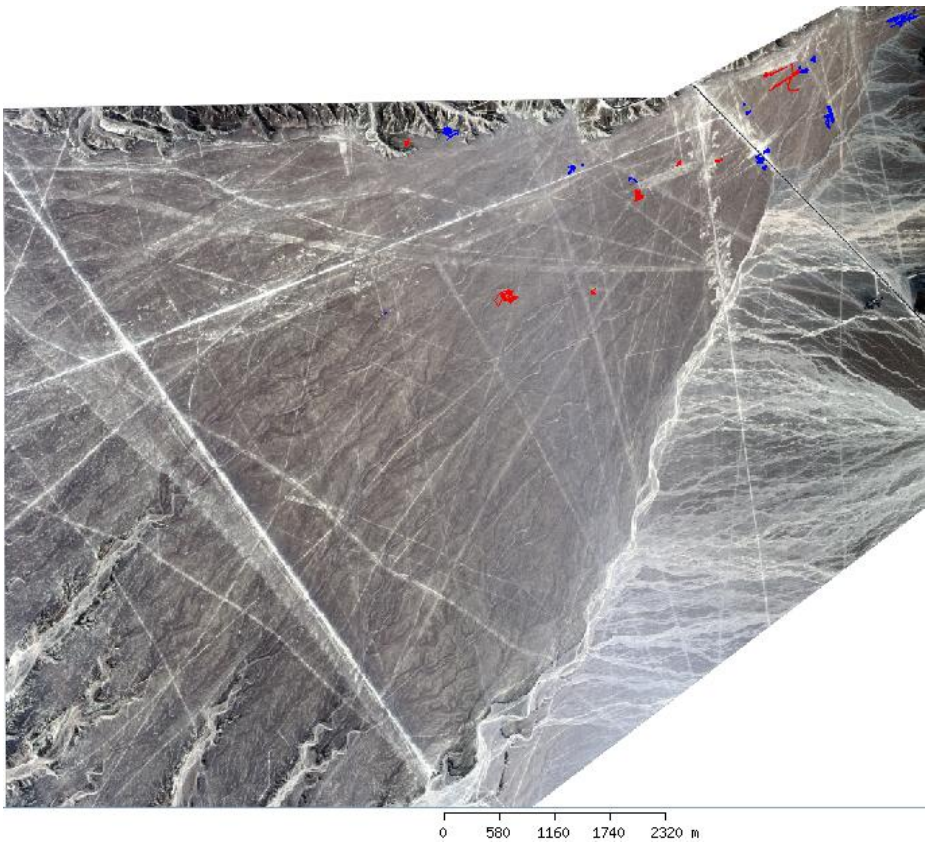

Figure 4. "Pampa del Calendario" with main geoglyphs (QuickBird, 2005)

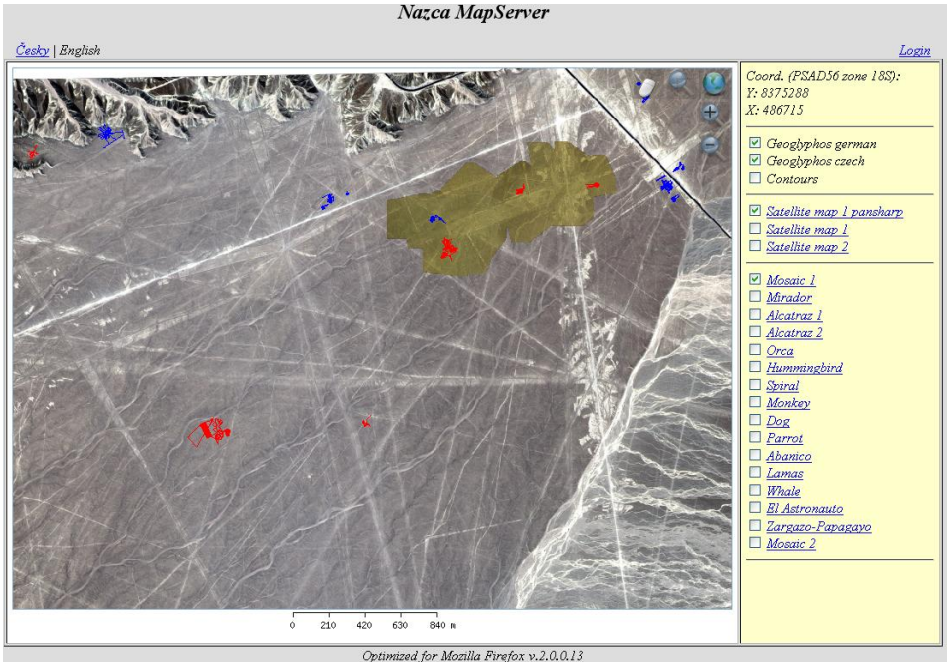

Figure 5. “Nasca Map Server” on CTU in Prague contains satellite images layers, aerial images mosaics, vector layers and DEM layer and contour lines layer

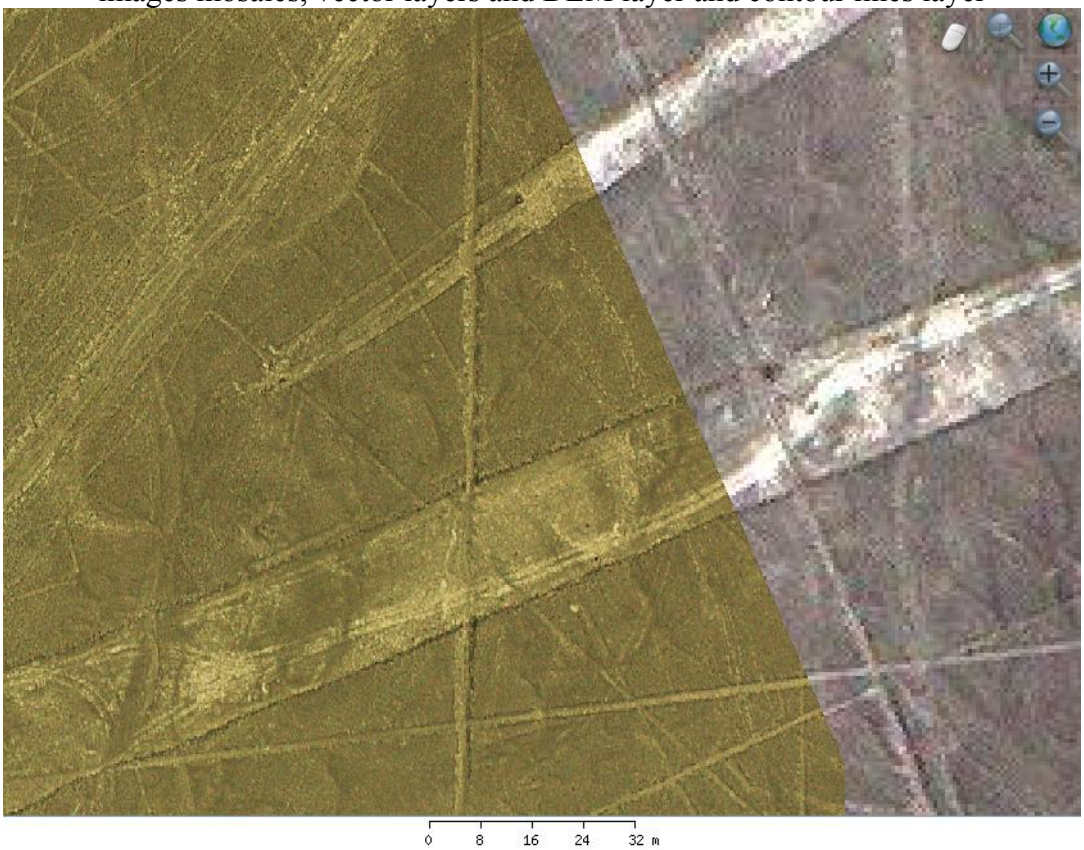

Figure 6. Comparison of aerial image mosaic and satellite pan-sharpened data (QuickBird, 2005)

Figure 7. A part of original panchromatic channel (QuickBird) with “Spine” geoglyph and the same geoglyph on aerial mosaic

6. Conclusion

This project uses satellite and aerial image data with different geometrical and spectral resolution for basic mapping and documenting of historically valuable parts of landscape with world – known geoglyphs. The aim of this project is creating a thematic maps collection and displaying them on the web by using a map server.

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