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Transferring Google Earth Observations to GIS-software: Example from Gully Erosion Study

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Abstract

High-resolution images available on Google Earth are increasingly being consulted in geographic studies. However, most studies limit themselves to visualizations or on-screen measurements. Google Earth allows users to create points, lines and polygons on-screen, which can be saved as KML files. Here, the use of R statistics freeware is proposed to easily convert these files to the shapefile format [or '.shp file format'], which can be loaded into GIS-software (ESRI ArcGIS 9 in our example). The geospatial data integration in GIS strongly increases the analysis possibilities.

Key Words

Geographic study; Geospatial Data Integration; Google Earth

1. Introduction

The free access to high-resolution satellite imagery through digital globes like Google Earth greatly benefits geographic studies. Indeed, such platforms allow 3D-visualizations or on-screen measurements that can facilitate fieldwork and its planning, and to some extent, even replace it (Smith and Pain 2009). As a result, the number of studies that use digital earth imagery to visualize, map or analyse landforms is increasing. For example, Google Earth images were used to visualize and inspect dunes in Chad (Warren *et al.* 2007), karst phenomena in Slovenia (Podobnikar *et al.* 2009), and glacial landscapes in Tibet (Heyman *et al.* 2008). Qualitative observations are frequently complemented by quantifying landforms on-screen, like measuring dune size in Peru (Hesse 2009), pre-landslide topography in Taiwan (Tsou *et al.* 2011), or treeline elevation in Ethiopia (Jacob *et al.* 2011). Very few studies, however, transferred their data (i.e. points, lines, polygons) into a conventional Geographic Information System (GIS) in order to allow advanced analysis of geographic features (e.g., Frankl 2012). Some even prefer to georeference images from Google Earth in CAD software (Iglesias *et al.* 2009).

In contrast to the limited use of digital globes in geographical studies, the number of scripts which allow to transfer Google Earth observations into GIS-environments is increasing, which is well-illustrated by the number of hits when searching the World Wide Web for "convert KML to SHP". Hengl (2011) points out the great visualization capabilities of Google Earth outmatching any GIS. They provide many examples of exporting vector maps from GIS to KML and Google Earth, which is the reverse order as the one in the presented study.

The objective of this paper is to enhance the use of digital earth images and tools in geographic studies, by presenting a simple methodology which uses freeware to transfer data layers created in Google Earth into ESRI® ArcGIS 9. The example given addresses the analysis of gully erosion in Northern Ethiopia.

2. Methodology

In the catchment of May Ba'ati (13°39' N, 39°13' E, Northern Ethiopia), gully networks were mapped in Google Earth from the DigitalGlobe images (resolution of 0.60 m) of 2006, based on the visual analysis of the images. In addition, the catchment was delineated and ground control points were selected, corresponding to distinctive features (placemarks) on the images, such as rock outcrops, the junction of stone bunds, pounds, footpaths, etc. Creating points, lines and polygon was done with the tools in the Add-menu, by numbering them from 1 to 70. In order to transfer the vector data created in Google Earth into ArcGIS, the R freeware was used to convert KML files into shapefiles. First, the points, lines and polygons were saved as KML files from Google Earth into a designated folder on the computer. Second, the R freeware (version 2.14.0; R Core Team, 2012) was downloaded from <http://www.r-project.org/> and installed. The *rgdal*-library was unpacked from the Packages menu. To convert the KML files to shapefiles, a script was used that allows the user to convert all the files at once:

```
library(rgdal)
for (i in n:m)
```

```

{
a = paste("Folder location of the KML files",i,"KML",sep="")
b = paste(i,"KML",sep="")
import<-readOGR(a,b)
c = paste(i,sep="")
writeOGR(obj=import,dsn="Folder location for the shapefiles", driver = "ESRI
Shapefile",layer=c)
}

```

By running this script for features n to m (in our example $n = 1$ and $m = 70$), .shapefiles were written to the designated folder. The shapefiles could then be loaded into ESRI ArcGIS 9 and further analysed in combination with existing datasets of gully networks derived from aerial photographs of 1963, 1974 and 1994.

Mapping the gully networks in May Ba'ati was also done in the field in July-August 2008. This was done using an accurate GPS (Trimble GEO XH 2005 series) with planimetric and altimetric accuracies at submeter level. The locations of the control points created in Google Earth were also recorded in the field with the Trimble GPS. These recordings could thus serve to assess the planimetric and altimetric accuracy of the Google Earth image. Google Earth uses the NASA Shuttle Radar Topography Mission data (SRTM, <http://srtm.csi.cgiar.org>) for the altimetry. In order to understand the spatial variability in the altimetric accuracy, the relation with the local slope gradient was analyzed. The slope gradient map was prepared at 100 m resolution from a Digital Elevation Model (5 m resolution; Root mean Square Error in x , y and z being: 9.8, 5.2 and 4.3 m; Frankl, 2012) based on the photogrammetric restitution of aerial photographs of the area.

3. System Requirements

The R software can run on the following operating systems: Linux, MacOS X or Windows. Installation details can be found on the FAQ-page on <http://www.r-project.org/>.

Installation procedures and system requirements for Google Earth can be found on <http://support.google.com/earth/>; and for ESRI ArcGIS on <http://www.esri.com/software/arcgis>.

4. Results and Discussion

Table 1 presents the planimetric and altimetric accuracy which is provided by the DigitalGlobe images on Google Earth calculated from the 15 ground control points. The average planimetric error was 4.8 ± 2.7 m and the average altimetric error was 4.4 ± 3.5 m. This is better than what is provided by a handheld GPS (e.g. Garmin GPSMap60, XYZ-error typically < 10-15 m). Analyzing the relation between the altimetric accuracy and local slope gradient did only show a weak and insignificant association (Pearson $R = 0.24$, $p = 0.2$). The variability in altimetric accuracy can thus not be explained by the proximity of steep slopes or escarpments (Table 1).

Table 1. Accuracy of the planimetry and altimetry provided by Google Earth and relation between the altimetric error and the local slope gradient.

Point	Planimetric error (m)	Altimetric error (m)	Local slope gradient (%)
1	4.43	3.04	13
2	4.53	3.77	48
3	2.47	1.83	23
4	4.11	4.18	40
5	5.26	7.49	38
6	11.81	0.27	16
7	3.33	4.88	21
8	7.94	4.6	7
9	3.33	1.05	4
10	0.26	10.7	48
11	7.13	2.64	14
12	4.46	10.82	19
13	5.14	0.65	57
14	3.04	8.69	28
15	4.16	2.03	13
Average	4.76	4.44	Pearson $R=$
Standard Deviation	2.66	3.47	0.24 $p = 0.2$ (1-tailed)

Mapping the gully networks within the May Ba’ati catchment was done within one hour on the DigitalGlobe image consulted in Google Earth. The gully networks were in total 11,185 m long, which is less than the 12,096 m of total gully length that were identified in the field. The over-estimation, or features that were mapped as a gully in Google Earth, which in fact are no gullies in the field, was 93 m, or <1% of the network. The under-estimation, or gullies that are present in the field but that were not mapped in Google Earth, was 1004 m, or 8.3% of the network. Overall, mapping gullies from Google Earth could be done accurately, which can be viewed as optimal given that the researchers had good knowledge of gully erosion, including field experience in Ethiopia. Mapping errors especially occurred 1) at gully heads, 2) in zones where the contrast between the bare soil surface and the gully channel was low, 3) where gullies interfered with footpaths, and 4) where the gully channel was narrow (i.e. < 0.5-1 m) and/or stabilized (Figure 1).

Adding the data into ESRI ArcGIS 9 allowed to analyse the 2006 gully network derived from Google Earth in relation to the networks mapped from aerial photographs of 1963, 1974 and 1994 (Frankl, 2012). As shown on Figure 2, the drainage density increased over the studied period: 1.20 km per km² in 1963, to 1.62 km per km² in 1974, 2.70 km per km² in 1994 and 3.02 km per km² in 2006. A visual analysis of the different layers representing the gully

networks in the studied periods revealed that the increase in network density occurred in the upper-part of the catchment by fast headcut retreat.

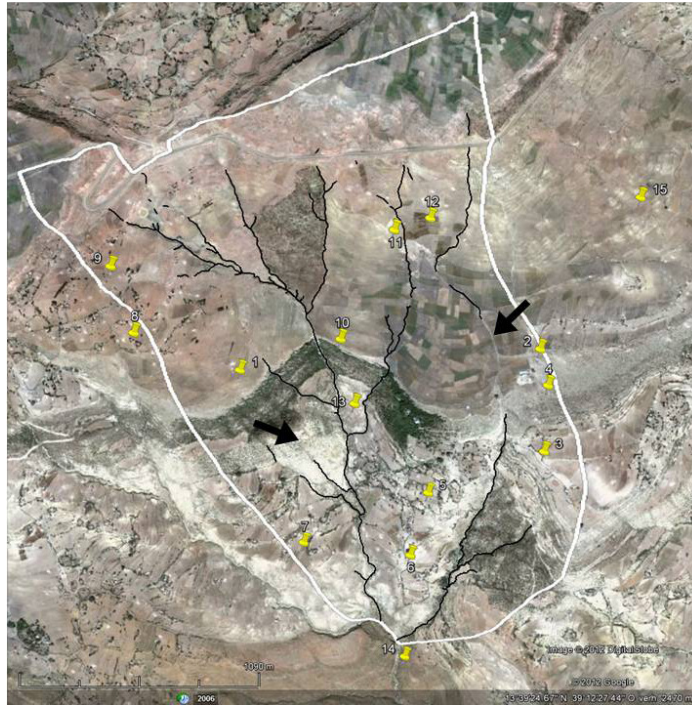


Figure 1. Within one hour, the gully network (black lines) was mapped using Google Earth imagery. Zones where the identification of gullies was difficult are indicated with arrows. Placemarks represent the ground control points.

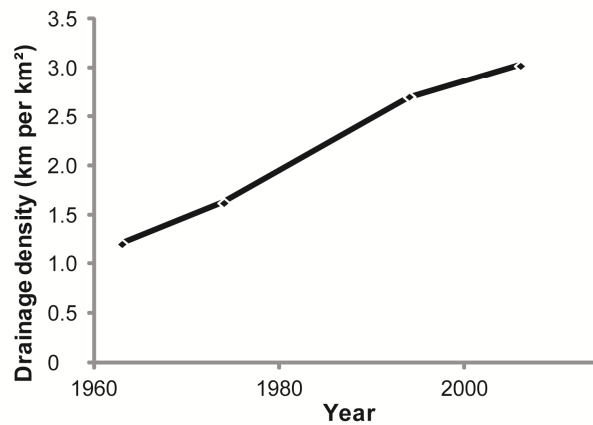


Figure 2. Evolution of gully drainage density over time. Transferring the observations from Google Earth into ESRI ArcGIS 9 (a conventional GIS-environment) allows the thorough study of network changes and to relate them to observations made on other data-layers.

5. Conclusion

High-resolution satellite images, like DigitalGlobe (0.6 m resolution), which can be consulted in Google Earth, allow users to rapidly investigate geographic features at good planimetric and altimetric accuracies, higher than that of common handheld GPS (that is in general in the order of < 10-15 m). High-resolution images consulted through Google Earth can thus strongly facilitate data collection, substitute field investigations, and optimize time use, especially in difficult to access, such as mountain areas. With the possibility to convert the KML format to the shapefile format, points, lines and polygons created in Google Earth can be transferred into a conventional GIS-environment (in our example, ESRI ArcGIS 9). In the GIS-environment, the geospatial data integration allows the analysis of the studied features.

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