GIS-Based Automated Landform Classification for Analysis of Archaeological Sites

Authors: D. Becker[1,3], M. de Andrés-Herrero[2,3], C. Willmes[1], G. Bareth[1], G.-C. Weniger[2,3],
Institute of Geography[1], University of Cologne - Institute of Prehistoric Archaeology[2], University of Cologne - Neanderthal Museum[3], Mettmann

1. Introduction & Context

One of the main objectives of the Collaborative Research Centre 806 (CRC 806) is to capture the complex nature of chronology, regional structure, climatic, environmental and socio-cultural contexts in Europe during the last 190.000 years by interdisciplinary research.

This poster presents the first results of an attempt to classify archaeological sites by landform analysis of the landscape.

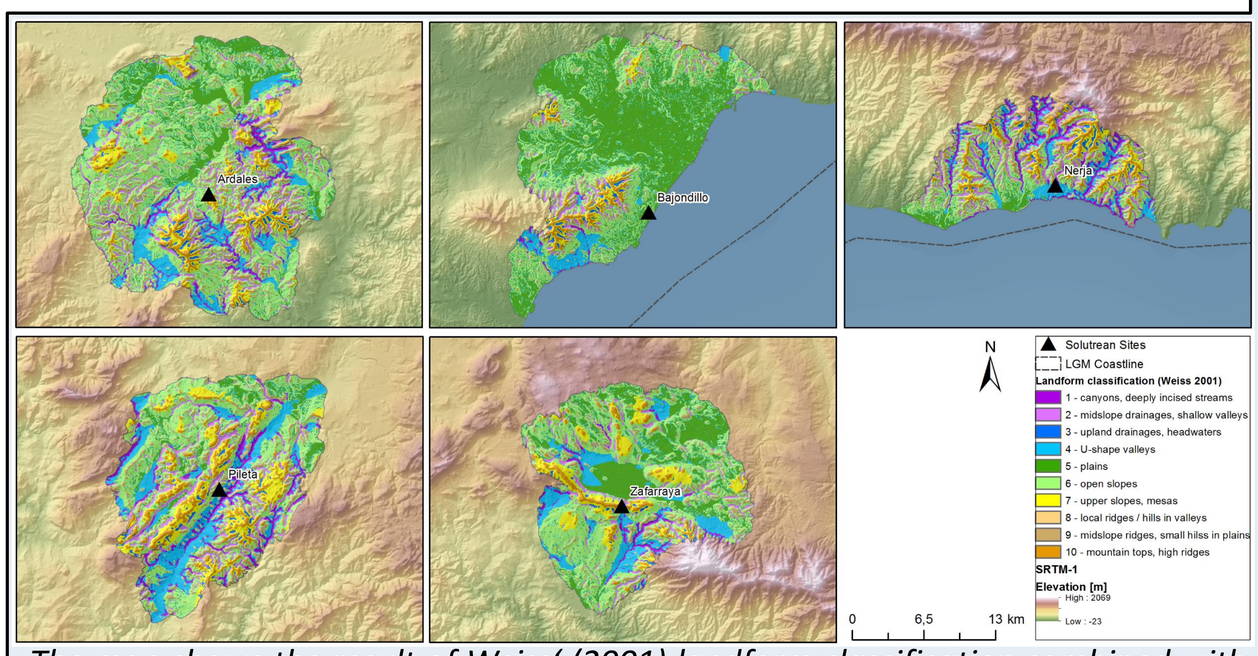
2. Topographic Position Index and Landform Classification

Part of our work is the modelling of DEM-derived site catchments. To make further use of the modelled catchments, it is possible to classify the relief to be able to compare the sites environment quantitatively. To achieve that goal, we applied the landform classification approach from Weiss (2001) to the study area in Andalusia (Spain) to compare the results for various Solutrean sites.

The approach is based on the **Topographic Position Index** (TPI):

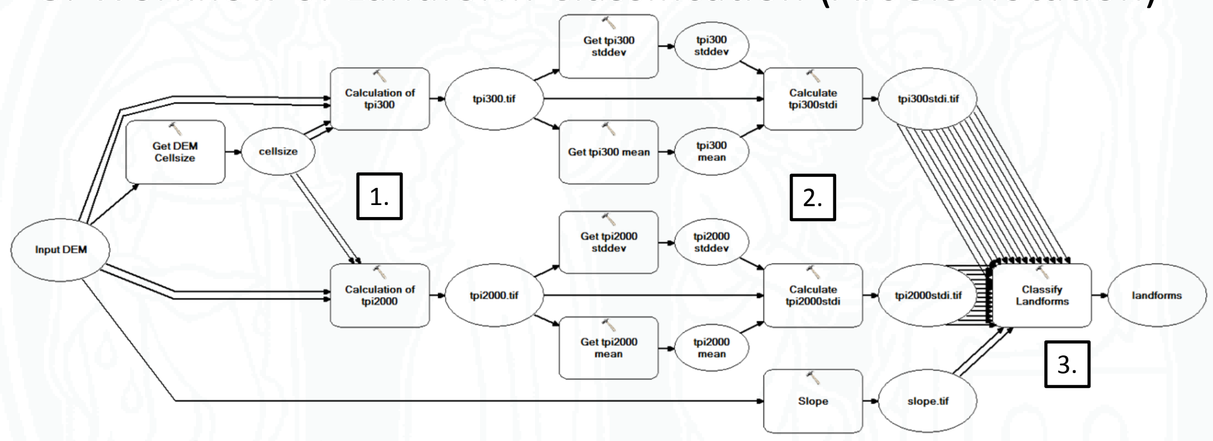
- TPI compares the elevation of each cell in a DEM to the mean elevation of a specified neighbourhood around that cell.
- Positive or negative TPI values represent surroundings that are higher or lower than their surroundings, respectively.
- In combination with slope, TPI can be utilized to classify the landscape into **landforms** or slope positions, based on a DEM only.

In addition, we use a simple **slope reclassification** (Burke 2008, García 2013) to compare the results of both classification.



The map shows the result of Weiss' (2001) landform classification combined with slope-derived site catchments (corresponding to 4 hours walking time), based on the SRTM-1 DEM for 5 five Solutrean sites in Andalusia, Spain.

3. Workflow of Landform Classification (ArcGIS notation)



1. Calculation of tpi300 and tpi2000 raster

```
tpi300 = (Input_DEM - FocalStatistics(Input_DEM, NbrAnnulus((300/cellsize)-5, 300/cellsize, CELL), MEAN, DATA)) + 0.5

tpi2000 = (Input_DEM - FocalStatistics(Input_DEM, NbrAnnulus((2000/cellsize)-5, 2000/cellsize, CELL), MEAN, DATA)) + 0.5
```

2. Calculation of standardized TPI rasters tpi300stdi and tpi2000stdi

```
tpi300_stdi = (((tpi300 - tpi300_mean)/tpi300_stddev)*100)+0.5

tpi2000_stdi = (((tpi2000 - tpi2000_mean)/tpi2000_stddev)*100)+0.5
```

3. tpi300stdi, tpi2000stdi and slope rasters are used to derive the landform classes (1-10)

```
Con ((tpi300_stdi >  -100) & (tpi300_stdi  <   100) & (tpi2000_stdi > -100) & (tpi2000_stdi < 100) & (slope_deg <= 5), 5,
Con ((tpi300_stdi >  -100) & (tpi300_stdi  <   100) & (tpi2000_stdi > -100) & (tpi2000_stdi < 100) & (slope_deg >= 6), 6,
Con ((tpi300_stdi >  -100) & (tpi300_stdi  <   100) & (tpi2000_stdi >= 100), 7,
Con ((tpi300_stdi >  -100) & (tpi300_stdi  <   100) & (tpi2000_stdi <= 100), 4,
Con ((tpi300_stdi <=  100) & (tpi2000_stdi >  -100) & (tpi2000_stdi < 100) , 2,
Con ((tpi300_stdi >=  100) & (tpi2000_stdi >  -100) & (tpi2000_stdi < 100) , 9,
Con ((tpi300_stdi <= -100) & (tpi2000_stdi >=  100), 3,
Con ((tpi300_stdi <= -100) & (tpi2000_stdi <= -100), 1,
Con ((tpi300_stdi >=  100) & (tpi2000_stdi >=  100),10,
Con ((tpi300_stdi >=  100) & (tpi2000_stdi <= -100), 8,
))))))))))
```

based on Weiss (2001)

4. Results

For the results see the map and figures 1 and 2.

- The method of TPI-based landform classification leads to results that should be useful to show quantitative differences and similarities between archaeological sites.
- It is possible to point out distinct characteristics for the environment of different sites, especially when data and the map are considered in combination.
- In the much simpler approach of Burke (2008), slope is classified in 4 categories (0-5% - flat or nearly flat; 5-15% - gently sloping ground; 15-30% - steeply sloping ground; >30% - very steeply sloping to mountainous). In comparison, the landform classification leads to more differentiated results, which we hope to be more meaningful.
- TPI-based landform classification and the slope classification show no obvious discrepancy, which is a good sign.

FIGURE 1: LANDFORM PERCENTAGES IN 4 HOUR WALKING TIME SITE CATCHMENTS

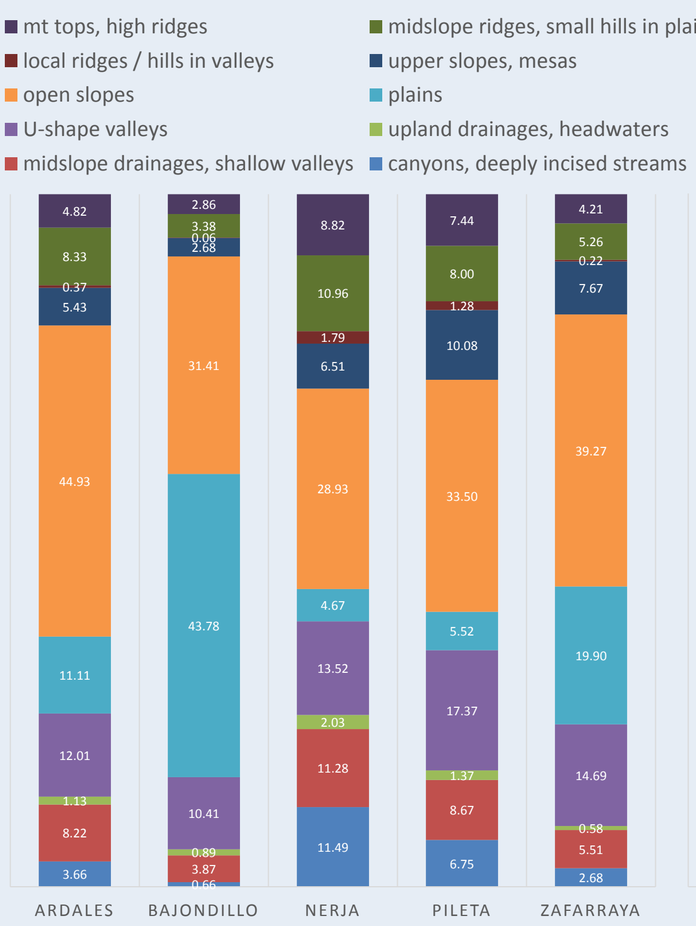
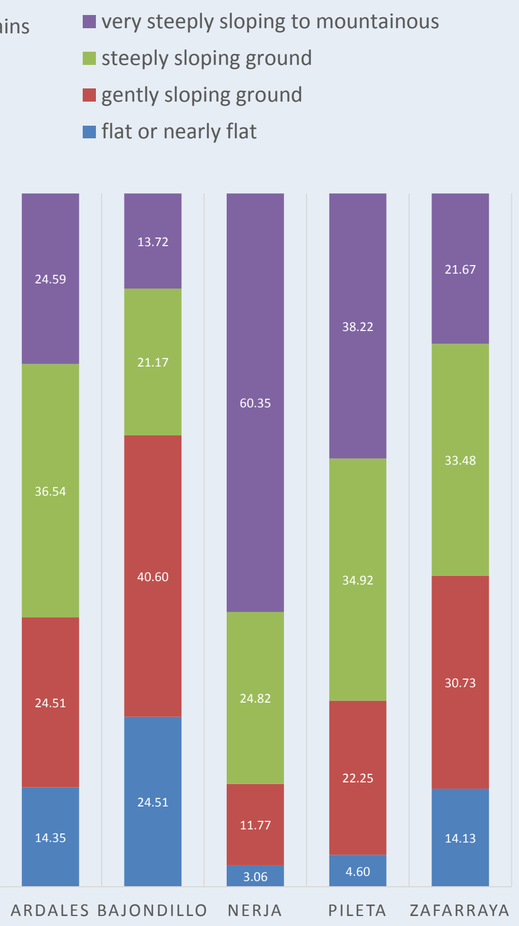


FIGURE 2: SLOPE CLASS PERCENTAGES IN 4 HOUR SITE CATCHMENTS



5. Discussion and Outlook

The method of TPI-based landform classification from Weiss (2001) is a straightforward approach to classify the relief. Since the TPI is scale dependent (although this is addressed by the standardization of the TPI raster), it is not assured that the method works well in every landscape. For example, De Reu et al. (2013) found that DEV (deviation from mean elevation) worked better in the heterogenous landscape of northwestern Belgium. Further, other methods of geomorphometric landform classifications that consider curvature, slope and aspect should be looked into, as possible alternatives.

We assembled a tool for ArcGIS to automate the process of TPI-based landform classification (see section 3). The next step would be to combine it with our tool for slope-based site catchment modelling to accelerate the steps of clipping the data to the modelled site catchments and calculating the percentages of the class values.

Other landscape features like aspect or viewshed analysis could be utilized to characterize sites, but further thoughts must go into actual classification of archaeological sites with the help of these values. Good results of relief classification could also be useful for ecological niche modelling of prey species during the Pleistocene.

References

Barka, I., Vladovic, J., Malis, F., 2011. Landform classification and it's application in predicive mapping of soil and forest units.
Burke, A., Ebert, D., Cardille, J., Dauth, D., 2008. Paleoethology as a tool for the development of archaeological models of land-use: the Crimean Middle Palaeolithic. Journal of Archaeological Science.
CRC806, 2014. CRC 806 - Our Way to Europe. http://www.sfb806.uni-koeln.de/
De Reu, J., Bourgeois, J., Bats, M., 2013. Application of the topographic position index to heterogeneous landscapes. Geomorphology.
García, A., 2013. GIS-based methodology for Palaeolithic site location preferences analysis. A case study from Late Palaeolithic Cantabria (Northern Iberian Peninsula). Journal of Archaeolocical Science.
Tagil, S., Jenness, J., 2008. GIS-Based Automated Landform Classification and Topographic, Landcover and Geologic Attributes of Landforms Around Yazoren Polje, Turkey. http://scialert.net/fulltext/?doi=jas.2008.910.921
Vita-Finzi, C., Higgs, E., 1970. Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis. Proceedings of the Prehistoric Society 36, 1–37.
Weiss, A.D., 2001. Topographic Position and Landform Analysis. ESRI User Conference.