INITIAL BEDROCK AND SOIL DEPTH

Comparing differently derived soil depth and bedrock strength inputs for landscape evolution modelling of the Bergantes catchment (Spain).

FACSIMILE

Field And Computer SIMulation In Landscape Evolution

Introduction

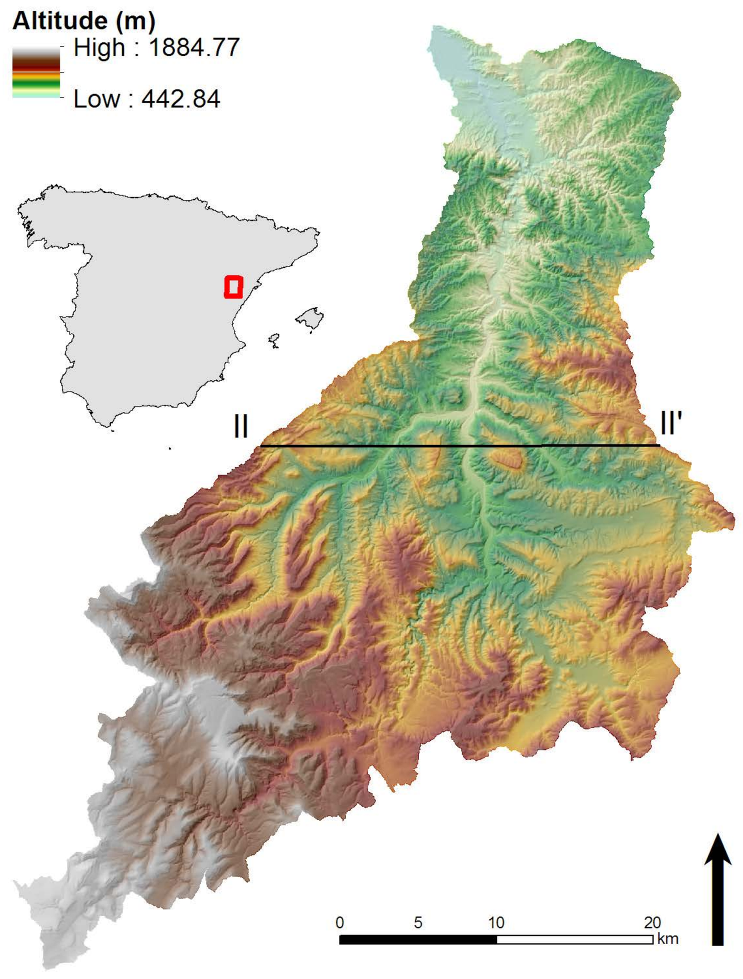

Fig. 1: The Bergantes catchment location showing the 30m DEM with crosssection.

Depth to bedrock is an important initial condition for landscape evolution models as it governs the magnitude of erodibility and sediment availability. This comprises estimation of soil depth, thickness of recent alluvial deposits, slope material and unconsolidated bedrock, that in turn are derived from geology, climate and landscape position. For this aim, relatively simple 30m gridded bedrock depth maps are constructed using increasinlgy complex information from the 30m DEM derivatives and the IGME geology map (**Fig. 2**) on these three factors.

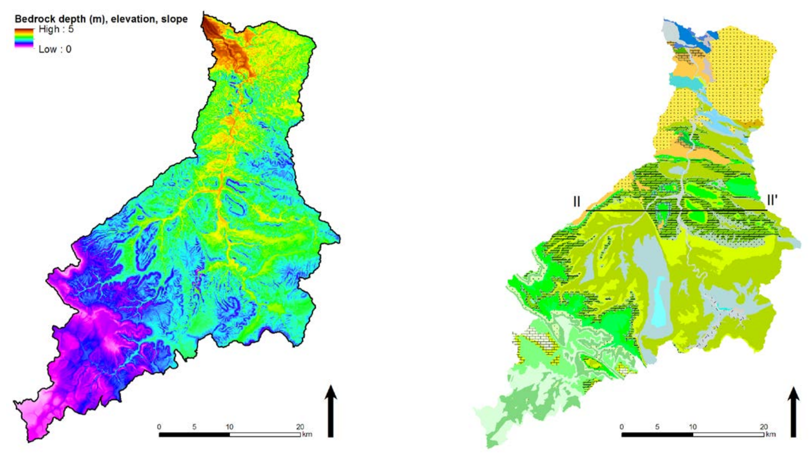

Fig. 2. Left: simple elevation slope based soil depth maps used for initial model runs. Right: geological map.

Fig. 3: river on bedrock adjacent to unconsolidated materials.

FACSIMILE

Over the past decade the FACSIMILE working group (Field And Computer Simulation In Landscape Evolution), founded by Maddy, Veldkamp and Wainwright, has been working on the synergy between numerical modelling and field-based approaches. The past few years the FACSIMILE working group has been focusing their attention to one single catchment: the Bergantes river, a tributary of the Guadalope river, that drains the south-east part of the Ebro basin (Northeast Spain, **Fig. 1, 3**). Various experts in the fields of computer simulation, palaeohydrology, geochronology, geomorphology and sedimentology work together in an attempt to improve the synergy and understanding of the Late Quaternary landscape evolution of the Bergantes catchment over the past 140 Ka with a multidisciplinary approach.

Methods and Results

Using slope, elevation and landforms based on Topographic Position Index (TPI)[i] from SAGA-GIS (**Fig 4**), relations between landforms and soil depth are listed (**Table 1**). Soildepth is linearly scaled with elevation and slope. **Below:** TPI landform factors lead to a slope-landform based soil depth map. Because soil depth in the Bergantes varies with climatic periods[ii], a subdivision between two initial climates is made: 1) Warm, moist, with developed soils and incised streams and 2) cold, dry, with thin soils on slopes and thick deposits in streams. A factor three more available soil material in the warm moist scenario occurs, whilst in the cold dry scenario, most unconsolidated material occurs in streams **(Fig 5, 6).**

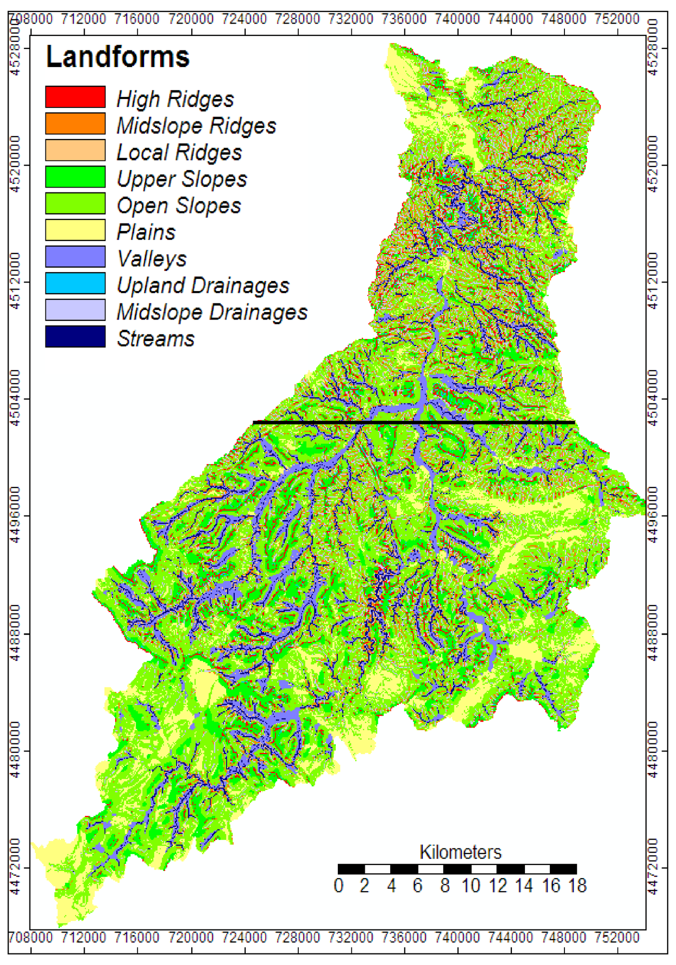

Fig. 4: TPI based landform classification.

TPI Landform (Weiss, 2001)	Landform factor	Warm, moist Bedrock factor	Cold, Dry Bedrock factor
Streams, canyons	0	0.1	1
Midslope drainages	1	0.8	0.5
Upland drainage	2	0.9	0.5
valley (U-formed)	3	2	2
Plains	4	2	0.2
Open slopes	5	1	0.1
Upper slopes	6	1	0.1
Local ridges	7	0.3	0
Midslope Ridges	8	0.3	0
High ridges	9	0.3	0

Table 1: bedrock depth factors

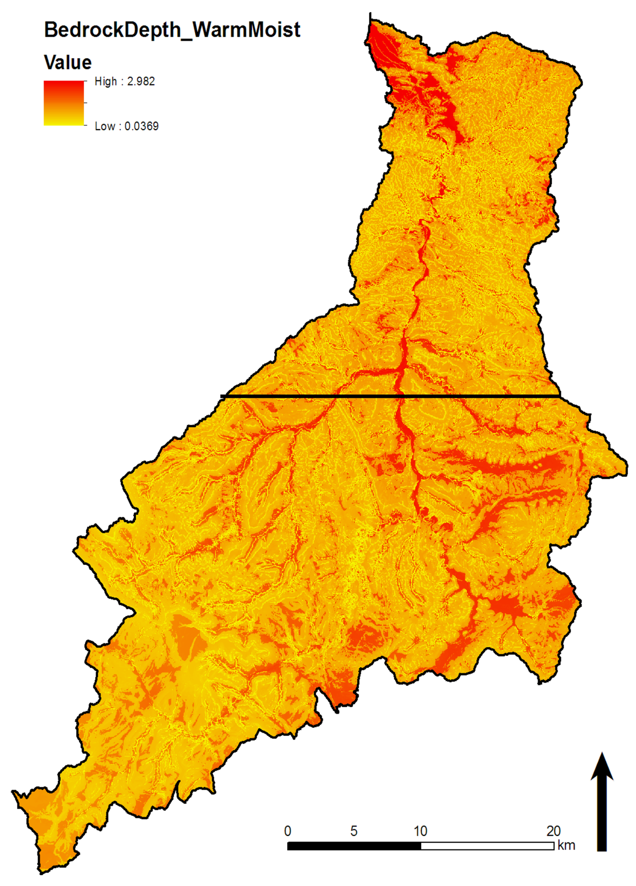

Fig. 5: bedrock depth (m) under warm, moist conditions

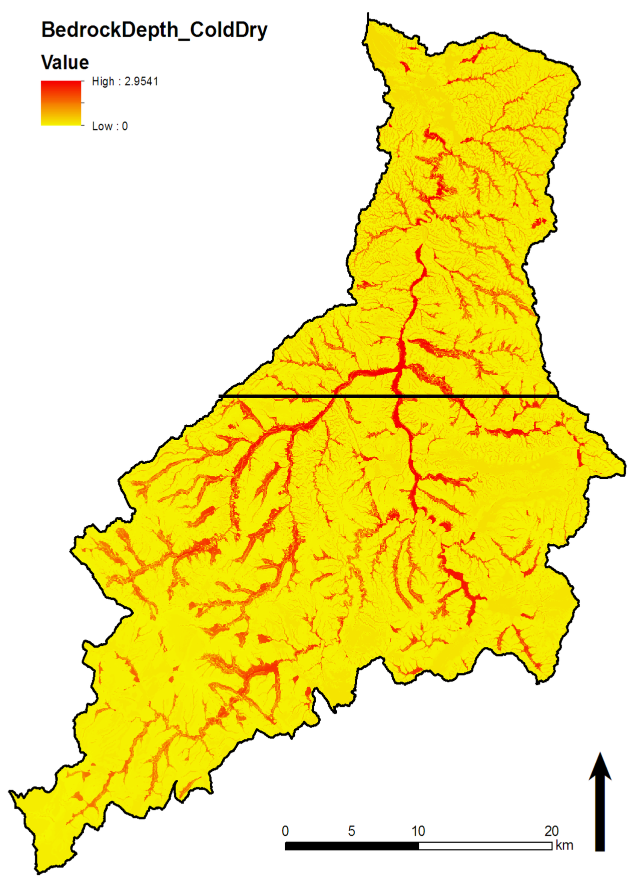

Fig. 6: bedrock depth (m) under cold, dry conditions

SoilGrids comparison

The Soilgrids project[iii] produced global 250m gridded bedrock depth maps. For the finer resolution modelling demands of the Bergantes catchment, their depths and patterns do not resemble catchment patterns well. A map showing the probability of the occurrence of an R horizon (bedrock) within 2 meter resembles catchment patterns best and is converted to a depth to bedrock map **(Fig 7).**

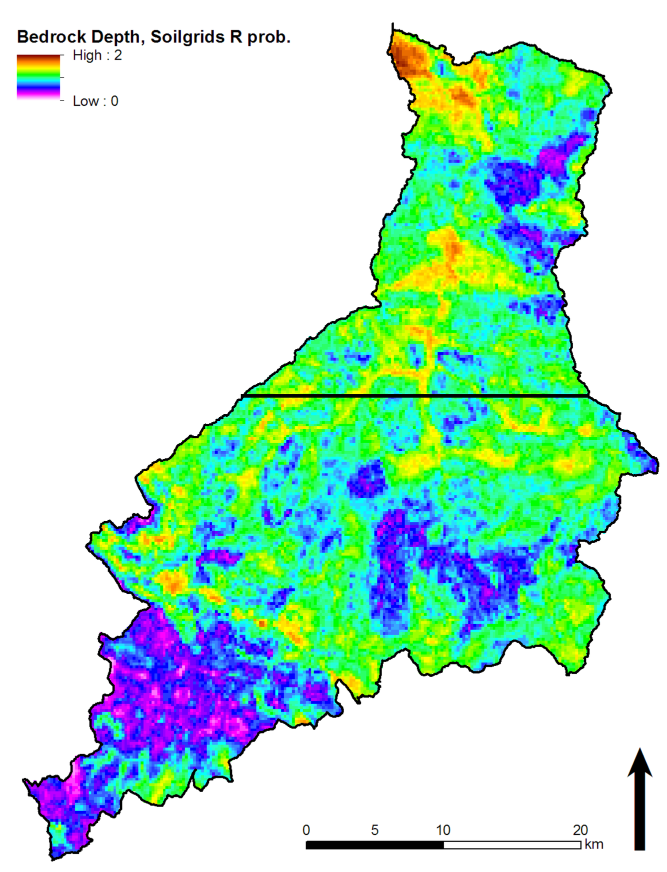

Fig. 7: bedrock depth (m) derived from Soilgrids R probability map pattern

Evaluation

The increased amount of detail of the 30m DEM compared with the coarser Soilgrids data seems valid, given the complex relief and geological subsurface in the catchment. The Facsimile-Bergantes products are better in producing heterogeneous bedrock depth pattern witnessed in the field. Bedrock depths of Crossection II **(Fig. 8)** resemble local relief variation and valley infillings with increasing complexity.

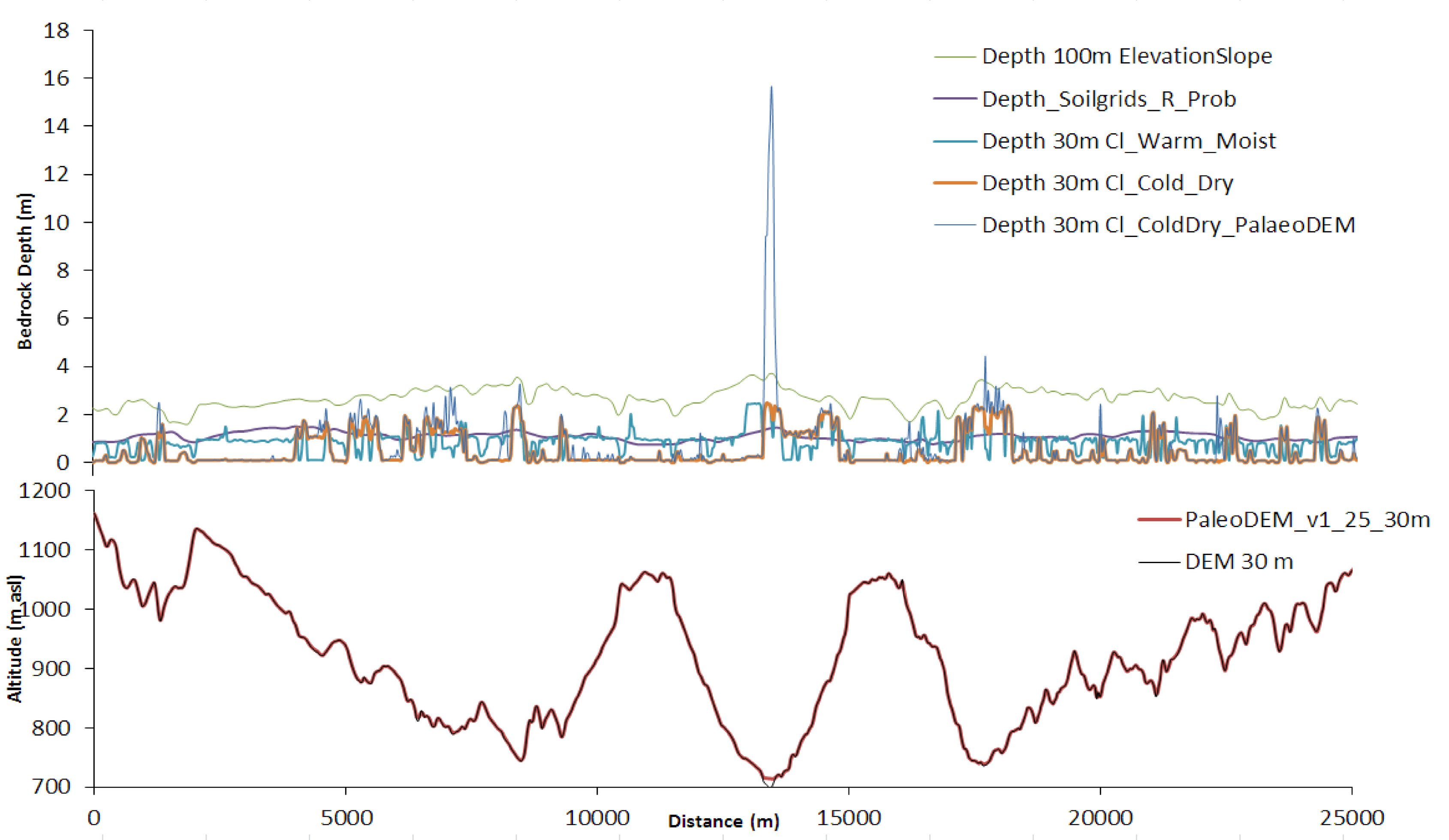

Fig. 8: crossection II-II'. Top: bedrock depth of different maps. Bottom: DEM and Palaeodem crossection.

Initial bedrock depth

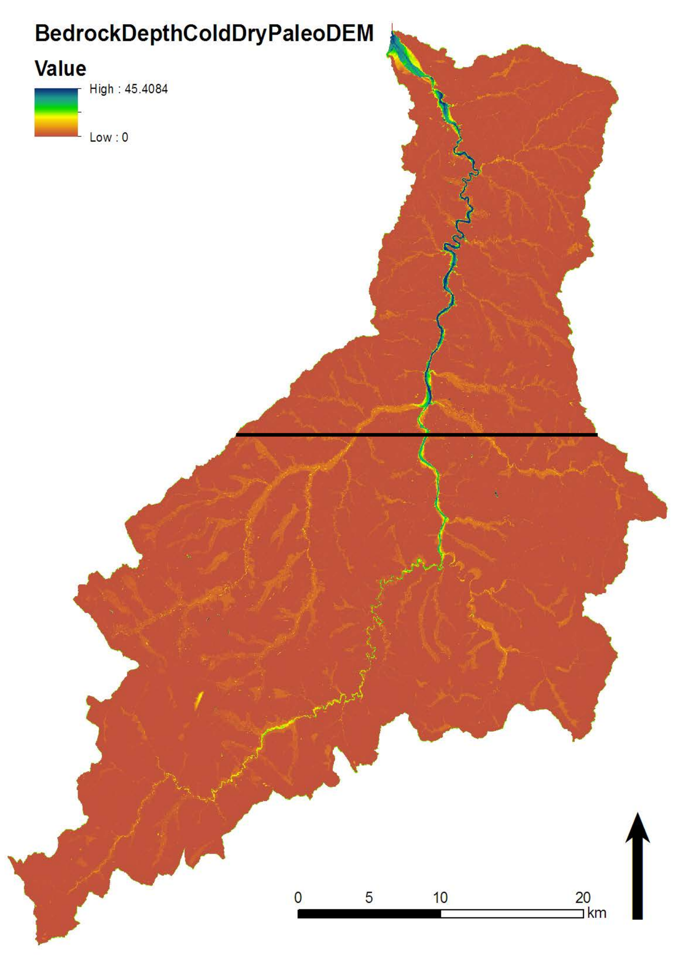

Fig. 9: bedrock depth for a cold, dry climate with thin soils and thick infillings in streams based on 130 ka paleoDEM

A bedrock depth input for Landscape evolution modelling should reflect the appropriate initial conditions at the time of the start of the model. Several terraces are recognized along the Bergantes[iii], two of which a palaeoDEM has already been created by members of the Facsimile group. A major terrace is dated to MIS 6, which resembles an infilled valley under cold, dry conditions[iii]. This may be a logical modelling start for the model runs. The difference between the modern and palaeoDEM reflects the minimum depth of unconsolidated Quaternary materials and is therefore added to the depth of the "Cold dry" bedrock depth scenario **(Fig 9).** Future work includes further integration of geological information to estimate erodibility values and field validation of the proposed maps. Initial modelling will comprise sensitivity and scenario modelling.

References: [i]Weiss, A. 2001. Topographic Position and Landforms Analysis. Poster presentation, ESRI User Conference, San Diego, CA. [ii]Shangguan, W., T. Hengl, J. Mendes de Jesus, H. Yuan, and Y. Dai (2017), Mapping the global depth to bedrock for land surface modeling, J. Adv. Model. Earth Syst., 9, 65–88. [iii]Whitfield, R.G., Macklin, M.G., Brewer, P.A., Lang, A., Mauz, B., Whitfield (née Maher), E., 2013. The nature, timing and controls of the Quaternary development of the Rio Bergantes, Ebro basin, northeast Spain. Geomorphology. 196, 106-121.

Wouter Van Gorp, Groningen Institute of Archaeology, University of Groningen, the Netherlands
Marco van de Wiel, Coventry University, Centre for Agroecology Water and Resilience, UK
Jeroen Schoorl, Soil Geography and Landscape, Wageningen University & Research, the Netherlands
Kim Cohen, Utrecht University, Dept. of Physical Geography, Utrecht, the Netherlands

Contact information:
Wouter van Gorp
Groningen Institute of Archaeology (GIA)
Room 121, Poststraat 6, 9712 ER Groningen
University of Groningen
W.van.gorp@rug.nl

university of groningen

WAGENINGEN UNIVERSITY & RESEARCH

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