SHORT TERM SCIENTIFIC MISSION

Spatial and temporal variability in hydrological and sediment modelling in a Mediterranean catchment

STSM Applicant:

Josep Fortesa Bernat. PhD student. Mediterranean Ecogeomorphological and Hydrological Connectivity Research Team Department of Geography, University of the Balearic Islands, E-07122 Palma, Mallorca, Balearic Islands and Institute of Agro-Environmental and Water Economy Research –INAGEA, University of the Balearic Islands. Carretera de Valldemossa km 7.5. 07122, Palma, Spain.

Host:

Dr. José Andrés López Tarazón. Marie Curie Intra-European Fellow (PIEF-GA-2013-622468, Seventh EU Framework Programme) Institute of Earth and Environmental Science University of Potsdam Karl-Liebknecht-Str. 24-25 14476 Potsdam-Golm, Germany

COST STSM Reference Number: COST-STSM-ES1306-35743

Period: 13/01/2017 – 17/03/2017

COST ACTION: ES1306

STSM type: Regular (from Spain to Germany)

1. Introduction

The analysis of the type and strength of spatial linkages operating in a catchment allows us to quantify and model the sediment cascade (flux) and whether it is connected or disconnected over various timeframes (Bracken et al., 2015). A nested-catchment approach is a way to tackle the evaluation of the effect of the catchment area on sediment transport in a particular river system. This integrated catchment perspective allows data to be collected at both the micro and macro scale and is thus essential because it is able to integrate the relevant hydrological and geomorphological processes at different temporal and spatial scales.

When catchments are located in transition climatic regions (e.g., Mediterranean environments), it is very difficult to study their hydro-sedimentary response because of the intrinsic conditions of that specific climate. Mediterranean fluvial systems are then characterized by large (often extreme) temporal and spatial variability in rainfall, and hence in discharge; depending on the degree of their flow permanence, they can be classified from perennial (continuous flow) to intermittent/temporary (seasonal flow) (Oueslati et al., 2015). With such huge variability in many hydrological (and geomorphological) processes in Mediterranean catchments, the establishment of general rules that explain or predict how rainfall generates runoff, erosion and sediment transport represents a challenge (García-Ruiz, et al., 2000; Lorente et al., 2000).

2. Purpose of the STSM

In this Short Term Scientific Mission the objective was parametrize the *WASA-SED* (Water Availability in Semi-Arid environments-SEDiments) model for continuous simulation of water and sediment fluxes in a representative Mediterranean catchment. This task was carry out as follows:

a) Generation and application of statistical analysis of precipitation, discharge and suspended sediment data.
b) Integration of different characteristics of the catchment; i.e, relief, soil, land uses, lithology and soil and water conservation structures.

c) Learning of the programming language of the models and in the definition and application of news scripts and sub-routines.

3. Study area

Es Fangar catchment drains an area of 3.4 km^2, a headwater tributary of the Sant Miquel River. It is a mountainous catchment (151 km^2) located in the north-west part of Mallorca (Fig. 1). The lithology is mainly composed of marl and marl-limestone of medium-upper Jurassic and Cretaceous in the bottom valleys and massive calcareous and dolomite of lower Jurassic and dolomite and marls of Triassic (Rhaetian) in the upper parts of the catchment.

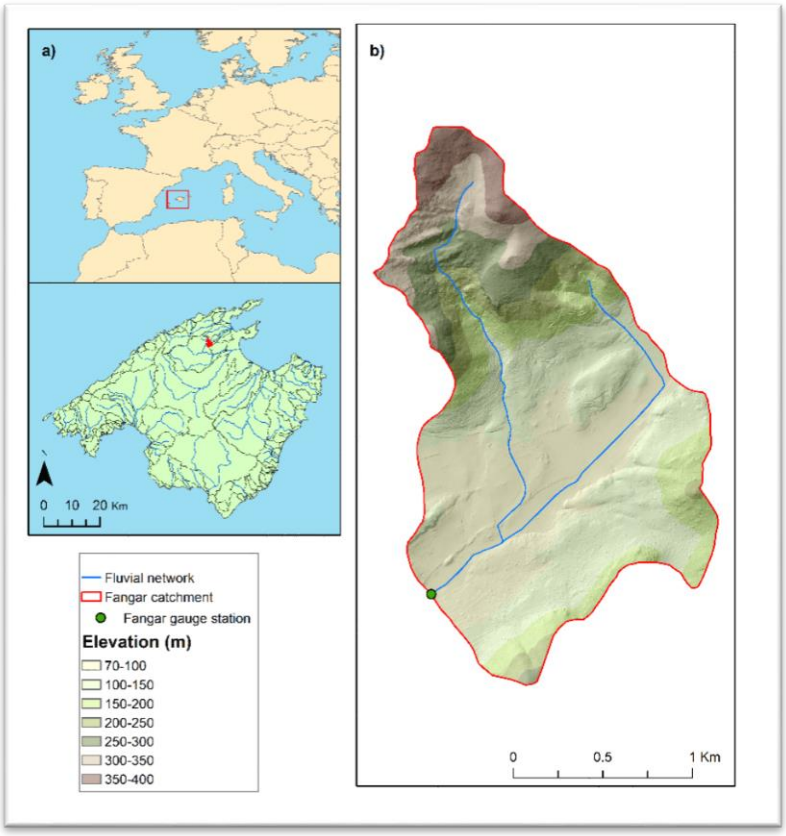

Figure 1. Es Fangar catchment location

The minimum elevation of the catchment is 72 m.s.n.m, where a gauging station is located, and the maximum elevation is 404 m.s.n.m. The mean slope of Es Fangar catchment is 25.5%. The length of the main channel is 3.1 km with and average slope of 22.4%. The river network is natural in the mountainous areas, but in the bottom valley it is transformed through artificial channels for providing larger areas to the agricultural activities. Applying the Emberger method (Guijarro, 1986), Es Fangar's climate is classified as temperate sub-humid. The catchment has an average annual rainfall of 826.4 mm. Land uses are agricultural (47%), forest (36.5%) and shrubland (16.5%). Due to the agricultural activity in the catchment, traditional soil conservation structures cover 9% of the area.

4. Description of the work carried out during the STSM

During the stay in the Institute for Earth and Environmental Sciences of the University of Potsdam the work carried out were:

- Calibration of the recording systems with the previous field measurements data collected from pressure (*Druck PDCR-1830-3*) and turbidity (*Campbell Scientific CS451-L*) sensors.
- Generation of stage-discharge and sediment rating curves.
- Generation and treatment of time series at 15 minutes and 1 hour step for precipitation, discharge and suspended sediment.
- LiDAR processing for the generation of high-resolution Digital Elevation Model (i.e., 1 m cell size).
- Identification of abandoned soil and water conservation structure from de high-resolution Digital Elevation Model.
- Introduction through initial exercise to the programming language and application of scripts with *R* software.
- Generation of geographic information maps (Fig. 2) for the different characteristics of the catchment (i.e., relief, soils, land uses and lithology) through GRASS.

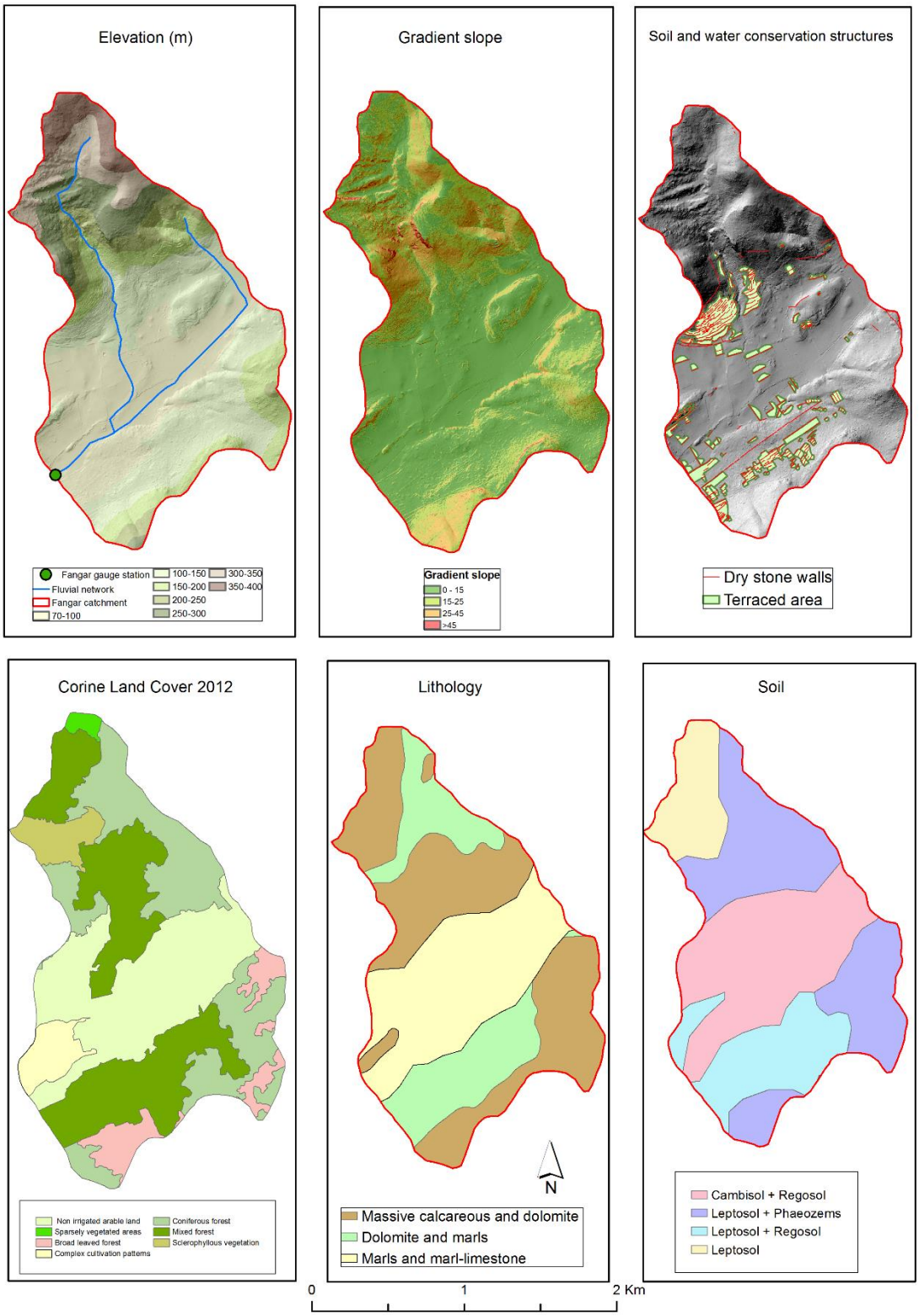

Figure 2. Elevation, slope, terraces, land uses, lithology and soil maps of Fangar catchment

- Installation of the R-LUMP package: loading and running the characteristics of the catchment with GRASS – R LUMP package.

- Designed a work plan for the next step in WASA-SED: application and validation of the hydrologic and sediment modelling. Generation of past and future scenarios affected by global change (i.e., land use, climate change).
- Participation at the Symposium on Global Changes Effects on Floods (Potsdam, 6-8 March) with the presentation of a poster entitled "*Assessing hydrological modelling in a Mediterranean temporary river at event scale*".
- Preparation and discussion of scientific papers related to hydrological variability, dynamics, water budgets and yields, and hydrological responses of the Sant Miquel River catchment.

5. Description of the main results obtained

The main result of this Short Term Scientific Mission is the spatial representation of landscape characteristic through the Landscape Unit Mapping Program (LUMP) and the parameterisation of Es Fangar catchment. This main outcome was achieved accomplishing these another results:

- Data inputs generation for the calibration of the WASA-SED model: a data-base composed for rainfall, discharge and suspended sediment during 4 hydrological years were obtained at 15 minutes and 1 hour step (linked to Working Group 2: Measuring approaches). Then, these datasets will allow us to apply WASA-SED model for continuous simulation of water and sediment fluxes response under different scenarios (linked to Working Group 3: Modelling).

- Spatial representation of landscape characteristics. The sub-catchments were divided into landscape units under similar characteristics as terrain, hydrologic network, lithology, soils, reservoir and vegetation associations. Then, for each factor, parameters were obtained as an input data requirement for WASA-SED. Terrain and river parameters were obtained from de high-resolution digital elevation model, but the other factors parameters were adjusted from different authors (Williams, 1995;

Morgan, 1995; Verdu et al., 2000; Breuer at al., 2003; de la Rosa et al., 2004; Atronico et al., 2005; Bevan and Conolloy, 2011; CLC, 2012; Panagos et al., 2015a; Panagos et al., 2015b).

6. Description about how the results contribute to the Action aims

The work carried out in this STSM, related with the Working Group 3 (Modelling Connectivity), will allow us to predict runoff generation and suspended sediment transport (Medeiros et al., 2010; Mueller et al., 2010), both factors closely related with soil erosion processes. This task was developed testing a new hydrometric dataset which was measured and recorded (linked to Working Group 2: Measuring approaches) in the hydrometric network. These datasets were applied for WASA-SED model (linked to Working Group 3: Modelling). Once the catchment is parameterized, the application of the WASA-SED model will be useful for continuous simulation of water and sediment fluxes response under different global change scenarios (past, current, future). Additionally, under the current scenario of land-use changes in many European countries, especially in the Mediterranean region, together with the very intensive use of the natural resources, the present and future work will produce a better knowledge in generate future scenarios of soil losses and in the impact of land management (Working Group 5: Sustainable land and water management) techniques in Mediterranean environments of the European Union.

7. Confirmation by the host institution of the successful execution of the STSM

Dr. José Andrés López-Tarazón, Marie Cuire Intra-European Fellow at the Institut für Geoökologie, Universität Potsdam, certifies that:

Josep Fortesa Bernat has carried out a Short-Term Scientific Mission within the framework of the Connecteur-Connecting European Connectivity Research – COST Action ES1306.

The letter of confirmation by the host institution of the STSM is attached in a separate file.

8. Authorization to post the report at the Action website

I, Josep Fortesa Bernat, consent to post this report on the COST Action ES1306 website.

REFERENCES

Antronico, L., Coscarelli, R., Terranova, O.,. (2005). Surface erosion assessment in two Calabrian basins (southern Italy). In: Batalla, R.J., Garcia, C. (Eds.), *Geomorphological Processes and Human Impacts in River Basins*. IAHS, pp. 16–22.

Bevan, A., & Conolly, J. (2011). Terraced fields and Mediterranean landscape structure: an analytical case study from Antikythera, Greece. *Ecological Modelling*, *222*(7), 1303-1314.

Bracken LJ, Turnbull L, Wainwright J, Bogaart P. (2015). Sediment connectivity: a framework for understanding sediment transfer at multiple scales. *Earth Surface Processes and Landforms* 40:177–188.

Breuer, L., Eckhardt, K., Frede, H.-G. (2003). Plant parameter values for models in temperate climates. *Ecological Modelling* 169, 237–293.

Copernicus Land Monitoring Services, Pan-European: Corine Land Cover. (2012). Source: http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012/view.

De la Rosa, D., Mayol, F., Diaz-Pereira, E., Fernandez, M., de la Rosa Jr., D.,. (2004). A land evaluation decision support system (MicroLEIS DSS) for agricultural soil protection with special reference to the Mediterranean region. *Environmental Modelling and Software* 19, 929–942

García-Ruiz JM, Martí-Bono C, Arnáez J, Beguería S, Lorente-Grima A, Seeger M. (2000). Las cuencas experimentales de Arnás y San Salvador en el Pirineo Central Español: escorrentía y transporte de sedimento. *Cuadernos de Investigación Geográfica* 26:23–40.

Lorente A, Martí-Bono C, Beguería S, Arnáez J, García-Ruiz JM. (2000). La exportación de sedimento en suspensión en una cuenca de campos abandonados. Pirineo Central Español. *Cuaternario y Geomorfología* 14(1-2):21–34.

Medeiros PH, Güntner A, Francke T, Mamede GL, Carlos de Araújo J. (2010). Modelling spatio-temporal patterns of sediment yield and connectivity in a semi-arid catchment with the WASA-SED model. *Hydrological Sciences Journal–Journal des Sciences Hydrologiques 55*(4): 636-648.

Morgan, R.P.C. (1995). Soil Erosion and Conservation Longman Group, UK Limited

Mueller EN, Güntner A, Francke T, Mamede G. (2010). Modelling sediment export, retention and reservoir sedimentation in drylands with the WASA-SED model. *Geoscientific Model Development* 3(1): 275-291.

Munro, R. N., Deckers, J., Haile, M., Grove, A. T., Poesen, J., & Nyssen, J. (2008). Soil landscapes, land cover change and erosion features of the Central Plateau region of Tigrai, Ethiopia: Photo-monitoring with an interval of 30 years. *Catena*, *75*(1), 55-64.

Oueslati O, De Girolamo AM, Abouabdillah A, Kjeldsen T, Lo Porto A. 2015. Classifying the flow regimes of Mediterranean streams using a multivariate analysis. *Hydrological Processes* 29:4666–4682.

Panagos, P., Meusburger, K., Ballabio, C., Borrelli, P., & Alewell, C. (2014). Soil erodibility in Europe: A high-resolution dataset based on LUCAS. *Science of the total environment*, *479*, 189-200.

Panagos, P. Borrelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L., Alewell, C. (2015a) The new assessment of soil loss by water erosion in Europe. *Environmental Science & Policy*, 54, 438-447.

Panagos, P., Ballabio, C., Borrelli, P., Meusburger, K., Klik, A., Rousseva, S., ... & Aalto, J. (2015b). Rainfall erosivity in Europe. *Science of the Total Environment*, *511*, 801-814.

Ranzi, R., Le, T. H., & Rulli, M. C. (2012). A RUSLE approach to model suspended sediment load in the Lo river (Vietnam): Effects of reservoirs and land use changes. *Journal of Hydrology*, *422*, 17-29.

Verdu, J.M., Batalla, R.J., Poch, R.M. (2000). Dinamica erosiva y aplicabilidad de modelos fisicos de erosion en una cuenca de montana mediterranea (Ribera Salada, Cuenca del Segre, Lleida, Espana). *Pirineos* 155, 37–57.

Williams, J.R. (1995). The EPIC model. In: Singh, V.P. (Ed.), Computer Models of Watershed Hydrology. *Water Resources Publications*, Highlands Ranch, CO, pp. 909–1000.