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Preface

Scales and erosion

Soil erosion – the entrainment, transport and deposition of soil particles – is an important phenomenon to understand; the quantity of soil loss determines the long term on-site sustainability of agricultural production (Crosson, 1997; Pimentel et al., 1995; Stocking, 2003) , and has potentially important off-site impacts on water quality (Bilotta and Brazier, 2008), flooding, river morphology and even coastal development (Syvitski et al., 2009; Vericat and Batalla, 2006; Woodward, 1995). The fundamental mechanisms of the soil erosion process have been studied at the laboratory scale, plot scale (Cerdà, 1997; Cerdà and Jurgensen, 2011; Turnbull et al., 2010), the small catchment scale (Bilotta et al., 2009) and river basin scale through sediment yield and budgeting work (Birkenshaw and Bathurst, 2006; Trimble, 1999). Subsequently, soil erosion models have developed alongside and directly from this empirical work; from data-based models such as the USLE (Wischmeier and Smith, 1978), to 'physics or process-based' models such as EUROSEM (Morgan et al., 1998) and WEPP (Nearing et al., 1989). Model development has helped to structure our understanding of the fundamental factors that control soil erosion processes at the plot and field scale. Despite these advances, however, our understanding of and ability to predict erosion and sediment yield at the same plot, field and also larger catchment scales remains poor. Sediment yield has been shown to both increase and decrease as a function of drainage area (de Vente and Poesen, 2005; de Vente et al., 2007; Osterkamp and Toy, 1997); the lack of a simple relationship demonstrates complex and scale-dependant process domination throughout a catchment, and emphasises our uncertainty and poor conceptual basis for predicting plot to catchment scale erosion rates and sediment yields (Cammeraat, 2002; Parsons et al., 2006b).

Empirically based methods of regression (Walling, 1983), or 'semi-quantitative models' (de Vente and Poesen, 2005; de Vente et al., 2006) have been employed to predict catchment sediment yield; the latter seeking to predict sediment yields from distributed catchment properties and expert assessments. Whilst these models may provide an initial evaluation of the key catchment properties that contribute towards sediment yield, they often do not provide distributed output to evaluate sediment sources for potential erosion mitigation or indeed to evaluate the quality of predictions in spatial terms. In addition, there is a potential conceptual flaw in predicting sediment yield over a given time period using current catchment characteristics to parameterize model structures (drainage density, evidence of landslides for example) that may be (and is highly likely to be) dynamic over the time period of measured sediment yield or erosion.

Application of physically based soil erosion models at the catchment scale has remained difficult owing to large data requirements, the need for high-resolution representation of spatially distributed parameters and the consequently high computational requirements (Brazier et al., 2005; Evans and Brazier, 2005). In addition, changing process domination and process complexity at larger scales is not represented in most soil erosion models (de Vente et al., 2008; Merritt et al., 2003; Wainwright et al., 2008) which are typically formulated on smaller scale empirical observations, despite the recognition of the role of scale in controlling dominant process by authors such as Kirkby et al. (1996). Thus, without explicit consideration of the role of scale in controlling erosion rates, understanding of soil erosion and prediction at larger scales cannot simply be applied over increasing catchment areas (de Vente and Poesen, 2005; Parsons et al., 2006a).

Consequently, there is a need to develop scale explicit understanding of erosion to overcome existing conceptual and methodological flaws in our modelling methods currently applied to understand the process of erosion, transport and deposition at the catchment scale. These models need to be based on a sound understanding and representation of the physical system, and provide useful information to guide further scientific work and/or erosion mitigation. The rest of this special issue, therefore, contains a number of papers that address the problem of scale in soil erosion studies. The papers describe efforts to improve fundamental understanding of the effects of scale on soil erosion observations, improvements in the representation of scale in existing erosion models, upscaling of erosion predictions to catchment or watershed scales. Bagarello et al. (2013–this issue) developed a new expression of the slope factor in the Sparacia experimental Area where the empirical research is transferred into theoretical research. Experimental research based on direct measurements are also developed by García Estrigana et al. (2013–this issue) in order to determine the effect of scale and legumes on soil erosion processes under semiarid climatic conditions. The study of the scale effect on soil erosion processes needs the contribution of different methods to understand the redistribution of sediments, as has been illustrated by Gaspar et al. (2013–this issue) at hillslope scales. Research at catchment scales (González Hidalgo et al., 2013–this issue) and on the high magnitude, low frequency rainfall events will shed light into the effect of temporal scale on soil erosion. The connection of surface wash within the slope, along the slopes and within the watershed is being researched by López-Vicente under different land-use scenarios that control soil loss. Nunes et al. (2013–this issue) demonstrate the value of models to understand soil erosion rates under climate change. Measurements in the field such as the above mentioned were carried out by Sadeghi et al. (2013–this issue) under arid conditions at watershed scales, and Taboada Castro et al. (2013–this issue). These authors studied the connection between slopes and streams, which contribute to a better understanding of the soil erosion processes and rates at different scales. Other authors studied the sediment delivery and the connectivity (López Vicente et al., 2013–this issue; Tetzlaff, 2013–this issue).

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In conclusion, this special issue presents current work on the effects of scale on soil erosion and how our understanding of scale can be incorporated into the improvement of erosion monitoring and prediction. Comments and discussion are welcomed to build on the research presented herein and ensure that the problem of scale in erosion studies is addressed explicitly in future soil erosion research.

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Artemi Cerdà
Soil Erosion and Degradation Research Group (SEDER), Departament de Geografia, Universitat de València, Blasco Ibàñez, 28, 46010-Valencia, Spain
Corresponding author. Tel.: +34 9 6 3864882; fax: +34 9 6 3983054.
E-mail address: artemio.cerda@uv.es.

Richard Brazier
Geography, College of Life and Environmental Sciences, University of Exeter, Amory Building, Rennes Drive, Exeter, Devon, EX4 4RJ, UK

Mark Nearing
USDA-ARS Southwest Watershed Research Center, 2000 E Allen Rd. Tucson, AZ, USA

Joris de Vente
Estación Experimental de Zonas Áridas, Consejo Superior de Investigaciones Científicas (EEZA-CSIC), Desertification and Geoecology Department, Ctra. de Sacramento s/n, 04120, La Cañada de San Urbano, Almeria, Spain