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Invited review

Assessment of multiple and interacting modes of soil loss in the karst critical zone, Southwest China (SWC)

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ABSTRACT

In Southwest China (SWC) soil loss is becoming a serious threat to the sustainable development of resources and the health of the environment. A large number of studies have been conducted to investigate the causes (e.g. environmental factors and human activities) and impacts (e.g. karst rocky desertification) of soil loss. However, the following are some important problems related to soil loss in the karst of SWC: 1) although soil loss is caused by chemical weathering, gravity and water interaction in karst, the mechanisms by which soil loss takes place in the SWC and their interaction are still not clear; 2) subsurface soil loss varies under different geological and hydrological conditions, and there is still no consensus on the common the ratio between surface soil erosion and underground soil loss; 3) traditional methods for soil loss risk assessment are difficult to apply over the whole of SWC; and 4) a large number of studies have been published only in Chinese and remain inaccessible to the international science community. Therefore, a review paper is needed to address this gap and introduce the contributions of Chinese researchers to soil loss in karst. This paper proposes a novel modelling approach for the grouped soil loss styles and presents a comprehensive discussion for the mechanism, causes, and risk assessment of the various soil loss styles in SWC karst.

Contents

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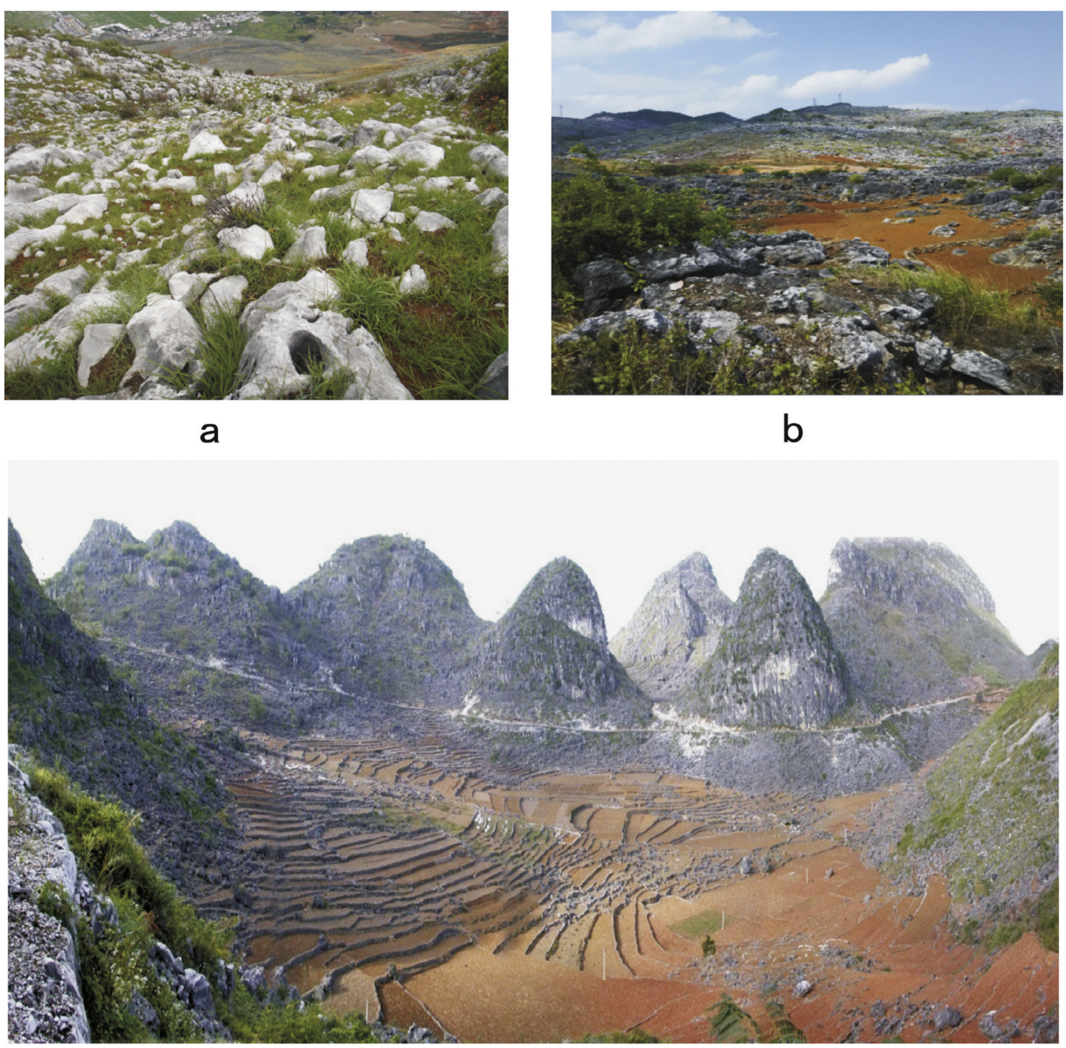
1. Introduction

China includes approximately 3.44 million km^2 of karst areas (buried, covered, and exposed carbonate rock areas), approximately 15.6% of the 22 million km^2 of karst areas in the world (Jiang et al., 2014a). The exposed/outcropped carbonate rock regions in Southwest China (SWC), with an area of approximately 0.53 million km^2 (Jiang et al., 2014a), include Guizhou (116,100 km^2, with 61.17% of the region's total land area), Yunnan (108,200 km^2, 30.07%), Guangxi (82,100 km^2, 34.73%), Chongqing (30,100 km^2, 36.84%), Hunan (63,600 km^2, 30.07%), Hubei (51,800 km^2, 27.91%), Sichuan (70,300 km^2, 14.61%) and Guangdong (10,200 km^2, 5.84%) (Cao et al., 2011). In SWC, karst geomorphic types at macroscopic scale can be grouped into medium-high mountain karst, karst fault basin, karst plateau, karst trough valley, karst gorge, karst peak cluster, karst peak forest and karst undulating hill (Cao et al., 2008). Unfortunately, the phenomenon of karst rocky desertification (KRD) occurs in all karst geomorphic types. KRD is one type of severe soil loss in karst area (Wang et al., 2004; Jiang et al., 2014a) and has occurred in various countries and regions, including the European Mediterranean and Dinaric Karst regions of the Balkan Peninsula, and Southwest China on a large scale, and alarmingly, even in tropical rainforests such as those on Haiti and Barbados (Jiang et al., 2014a). KRD refers to the processes that collectively transform an area previously covered by vegetation and soil into a barren, rocky landscape (Yuan, 1997). Fig. 1 shows the characteristic landforms of KRD in karst regions in SWC.

In recent decades, the area of KRD in SWC has increased rapidly. From 1987 to 2005, the total area of KRD in SWC was 9.12×10^4 km^2 in 1987, 11.35×10^4 km^2 in 1999, and 12.96×10^4 km^2 in 2005. Hence, KRD has become a severe threat to the sustainable development of resources and the environment in SWC (Peng and Wang, 2012; Wang et al., 2016). To control the increase in KRD and restore the environment in SWC, a large number of studies have been conducted to investigate the causes and impacts of soil loss, including environmental processes and human activities, local geology, hydrology, ecology and land cover conditions, climate and inappropriate land management practices (Wang et al., 2004; Jiang et al., 2009, 2014a; Peng et al., 2011, 2013; Huang et al., 2016; Wang et al., 2016). The style of soil loss in karstic environments is one of the most important issues (Yuan, 1997; Li et al., 2002; Zheng and Wang, 2002; Wan et al., 2004; Lv et al., 2007; Kheir et al., 2008). The soil loss styles in karst are different from those in non-karst areas (Zhang et al., 2007a). Following the development of a conduit system in the karst subsurface, soil can be eroded underground or transported via pore fissures, funnels and sinkholes. Hence, soil can disappear from the surface without a long-distance physical transportation (Yuan, 1997; Li et al., 2002) or be removed and deposited at underground fissures and caves (Zhang et al., 2007b; Dai et al., 2015). Based on the different karstification of the subsurface, soil loss styles in karst



a b

c

Fig. 1. The severe karst rocky desertification in karst fault basin (a), karst plateau (b) and karst peak cluster (c) landforms.