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Effect of sampling classification patterns on SOC variability in the red soil region, China

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ABSTRACT

Field sampling remains a vital step for assessing the spatial distribution of various soil properties. In regional soil surveys, unclassified grid-based mode (Grid), soil type-based mode (SoTy), land-use pattern-based mode (Lu), and land-use pattern–soil type-based mode (Lu–SoTy) are all used popularly in allocating sampling points. However, few studies have identified which mode is most effective for sampling point allocation in SOC studies. This study on the effectiveness of sampling modes was conducted in Yujiang County, Jiangxi Province, China, where red soil prevails on hills. A total of 561 soil samples were collected on the basis of 2 km × 2 km grids. Then the collected samples were classified according to the four aforementioned modes respectively where SOC spatial variability data was compared and assessed. The coefficient of variation (CV) of SOC from the classification of Grid was 47%. Mean CVs from the classification of SoTy were 46%, 38%, and 34% at the soil great group, subgroup, and family categories respectively. The mean CV of SOC from the classification of Lu was 42%, and the mean CVs from the classification of Lu–SoTy were 41%, 37%, and 31% at soil great group, subgroup, and family categories, respectively. The mean CVs of SOC from the three latter classification modes were all lower than that from the classification of Grid. The widest decrease in CV was found in the classification of the Lu–SoTy case. A decrease in the mean CV of SOC indicates a decrease in the uncertainty of sampling point allocation for getting SOC spatial distribution. For soil survey in China's hilly red soil areas with complicated soil types and diversified land-use patterns at a county scale, the most effective way to assess the spatial distribution of SOC is to allocate sampling points based on Lu–SoTy.

1. Introduction

Soil organic carbon (SOC) influences not only soil fertility and crop production (Maia et al., 2010; Lal, 2004; Ruth and Lennartz, 2008; Shi et al., 2009) but also global carbon cycles (Post and Kwon, 2000; Wu et al., 2009). Spatial SOC variability is also influenced by soil forming factors and land-use patterns (Lugato et al., 2010; Gao et al., 2009). Increased SOC variability causes decreased sampling representativeness and increased sample size is needed for revealing true SOC distribution (Conant and Paustian, 2002). Previous studies have indicated that SOC variability changes with soil sample classification modes (Davis et al., 2004; Tan et al., 2004). Hence, a study on SOC variability under various sample classification modes at the regional level is important for effective sample point allocation in a soil survey.

Field sampling and laboratory analysis remain the most important way for assessing the spatial distribution of various soil properties at the regional scale. However, several sampling modes exist, such as the unclassified grid-based mode (Grid), soil type-based mode (SoTy), land use-based mode (Lu) and land-use pattern–soil type-based mode (Lu–SoTy). In recent years, allocating sampling point based on Grid has been used by more and more researchers in studies of SOC spatial distribution and evolution (Kravchenko, 2003; Bellamy et al., 2005; Kerry and Oliver, 2007). The grid sizes vary with study purposes and requirements, and range from m^2 to km^2. For example, Bellamy et al. (2005) collected 5662 soil profiles on the basis of 5 km × 5 km grids to calculate SOC content change rates from 1978 to 2000 in England and Wales. Sumfleth and Duttmann (2008) succeeded in predicting the spatial distribution of soil carbon in a 10 km^2 area in Jiangxi Province, China, by collecting 212 soil samples on the basis of 150 m × 150 m grids in combination with landform and remote sensing data. Gallardo and Parama (2007)

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studied SOC variability in two plant communities in northwest Spain, by collecting 389 soil samples on the basis of grids varying from 0.25 m × 0.25 m to 2 m × 2 m. Scientists have been paying much attention to the studies on soil types and related SOC variability. Most studies show that SOC variability is heavily impacted by soil types (Grossman et al., 1998; Zhang et al., 2008b). Consequently, use of the SoTy for sampling point allocation was adopted widely for actual applications. With the help of spectral technology, Sankey et al. (2008) succeeded in spatially predicting SOC in grasslands with an area of about 300 km^2 in Montana, USA, by collecting 106 soil samples with soil type-based sampling. Land-use patterns have been directly changed by human activities and SOC variability changes greatly with land-use patterns (Rezaei and Gilkes, 2005; Jiao et al., 2010). Consequently, allocating sampling point on the basis of Lu can be adopted. Wei et al. (2008) studied soil carbon content and its spatial distribution using both classic and geo-statistics. They collected 292 soil samples from the plow layer of Mollisols in a typical micro-catchment of 992 ha in Northeast China, and found the spatial distribution of SOC was closely related to land-use patterns. In consideration of both soil type and land-use pattern on SOC variability, some scientists have adopted a combined mode sampling for their studies. For example, Huang et al. (2007) reported spatial and temporal variability of soil organic matter in Rugao County (1593 km^2), Jiangsu Province, China by collecting 342 soil samples considering both soil type and land-use pattern. Similarly, Chai et al. (2008) made a comparison of precision among soil organic matter predictions using different spatial predictive methods by collecting 201 soil samples in Pinggu County, Beijing, China.

In terms of the studies on SOC spatial distribution and evolution, it is very popular to allocate sampling points in the modes of Grid, SoTy, Lu, and Lu–SoTy. However, no research has assessed the effectiveness of these modes and identified which is preferable. The present study was initiated in Yujiang County which is located in the red soil hilly region in Southern China, with complicated soil types and diversified land-use patterns. The objective of this study was to explore which soil sampling point allocation model was superior for the red soil hilly region in Southern China at the regional scale on the basis of comparison among mean coefficient of variability (CV) of SOC derived from different classification modes.

2. Materials and methods

2.1. Study area

Covering an area of 927 km^2, Yujiang County (116°41′–117°09′E, 28°04′–28°37′N) is a transition from the northeastern hills and mountains to the Boyang Lake Plain in Jiangxi Province, China (Fig. 1). Situated in a subtropical, humid monsoon climate zone, the county has a warm climate, abundant heat and sunshine, plentiful rainfall, and a long frost-free period. The mean annual temperature is 17.6 °C and mean annual precipitation is 1758 mm. Hills and plains cover 78% and 22% of the county, respectively (Li et al., 2006). Low hills are the dominant landform, though high hills are found in the county's north and south extremes. Paddy fields, dry farmland, and forestland are the major land-use patterns accounting for 39%, 13%, and 38% of the county in 2005, respectively (China Land-use Data Base from Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences). Red soil (Acrisols, WRB) and paddy soil (Anthrosols, WRB) are the dominant soil types, and jointly account for >90% of the county's total area, though fluvo-aquic soil (Cambisols, WRB) (Shi et al., 2010) is also distributed across the study area. Parent materials include red sandstone, Quaternary red clay, shale and alluvium (Soil Survey Office of Yujiang County, 1986). The major crops of the area are rice, peanut, sweet potato, sesame, and rape.

2.2. Soil sampling and laboratory analysis

Considering land-use pattern and soil type, soil sampling was conducted in 2 km × 2 km square grids. Sampling point number in a single grid depends on the complexity of the land-use pattern in the grid. Only one point was allocated in a grid where a single land-use pattern is dominant. Two points were allocated in a grid where two major land-use patterns were almost equally distributed, one for each pattern. Three points were allocated in seldom grids where three land-use patterns were almost equally found, one for each pattern. All samples were collected from the surface layer (0–20 cm). Sampling locations for each point were georeferenced by GPS, and related data for each point, such as

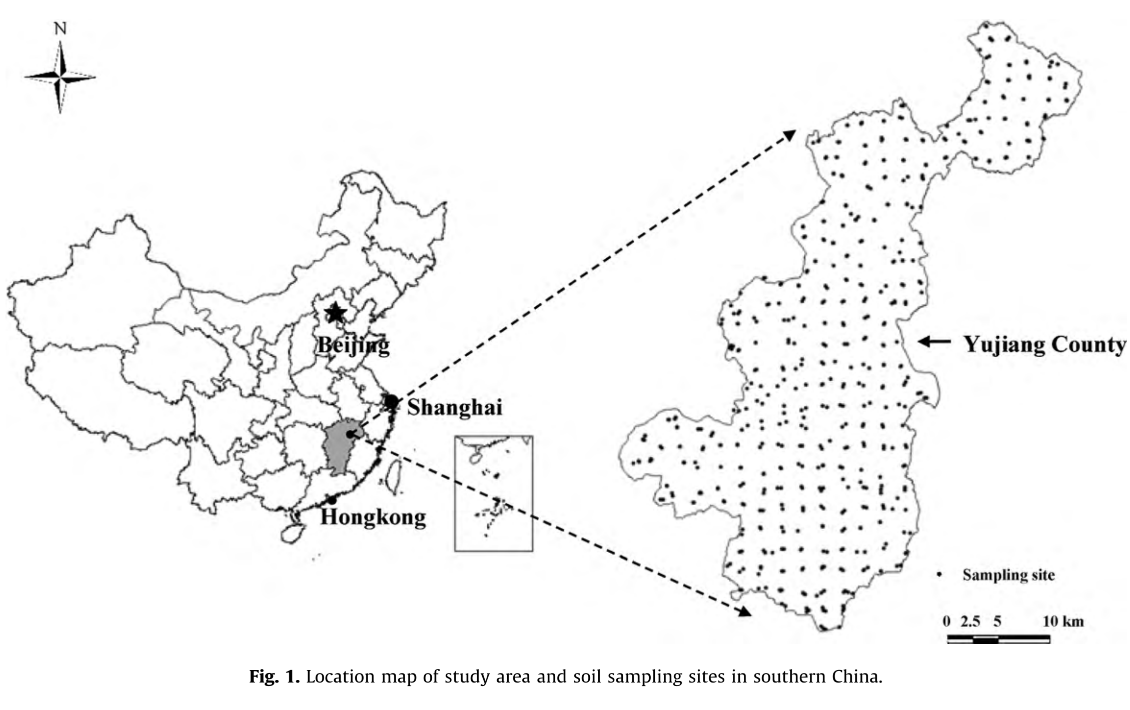

Fig. 1. Location map of study area and soil sampling sites in southern China.