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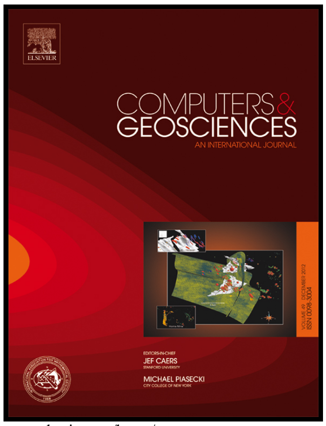

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Fast Computation of Bare Soil Surface Roughness on a Fermi GPU

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Abstract. Surface roughness is an important factor in bare soil microwave radiation for the observation of the Earth. Correlation length and standard deviation of surface height are the two statistical parameters that describe surface roughness. However, when the number of data points is large, the calculation of surface roughness parameters becomes time-consuming. Therefore, it is desired to have a high-performance computing facility to execute this task. A Graphics Processing Unit (GPU) provides hundreds of computing cores along with a high memory bandwidth. To carry out a parallel implementation of the algorithms, Compute Unified Device Architecture (CUDA) provides researchers with an easy way to execute multiple threads in parallel on GPUs. In this paper, we propose a GPU-based parallel computing method for 2D surface roughness estimation. We use an NVIDIA GeForce GTX 590 graphics card to run the CUDA implementation. The experimental input data is collected by our in-house surface roughness tester which is designed based on the laser triangulation principle, giving sample data points of up to 52,040. According to the experimental results, the serial CPU version of the implementation takes 5,422 seconds whereas our GPU implementation takes only 47 seconds, resulting a significant 115x speedup.

Keywords: bare soil surface roughness; correlation length; graphics processing unit (GPU);

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1 Introduction

Surface roughness is a description of the randomness or irregularity of the microtopography of a terrain. The standard deviation of surface height (σ) and the surface correlation length (l) describe the statistical variation of a surface height relative to a reference surface for a random component. Measurement of surface roughness is one of the key topics in soil erosion research in the sense that is an important parameter in order to determine soil hydrological characteristics and soil properties. While observing the earth using a microwave radiometer, surface roughness represents a key factor to analyze (Zheng, et al., 2010; Mittal, et al., 2010; Hong, 2010). Several research instances can be found in literature on determining surface roughness parameters. Seppke (Seppke, et al., 2010], and Wang (Wang, et al., 2011) utilized satellite images for inversion of soil roughness parameters, got σ=0.3~3cm, cl=3~35cm. Oh (Oh, et al., 2007) and Thomas (Thomas, 2003) developed a retrieval method of soil moisture and surface roughness from backscatter measurements of vegetation canopy. Moreover, Tang (Tang, et al., 2009) applied a digital image processing method to obtain roughness parameters of triangular prisms, the measurement results showed that roughness less than 0.35mm over an area of 60cm×60cm could be recognized. The contact method was also employed by Rosario (Rosario, et al., 2008) and Šařec (Šařec, et al., 2007) to measure the surface roughness parameters for different soils. Moreover, some authors of the current papers presented some surface roughness testing apparatus and the corresponding testing methods (Li, et al., 2012) that features rapid testing speed and high testing precision, requires no manual work and obtains three-dimensional parameters for the surface. By a single scan, a total number of data points in 500mm×600mm range of 40,000~100,000 can be obtained. However, calculations of the correlation length and