# *The elevation error of DEMs caused by grid size*

Lei Wang
College of Urban and Environment
Northwest University
Xi'an, China
montez@nwu.edu.cn

Yong qing Long
College of Urban and Environment
Northwest University
Xi'an, China
sjzxlyq@126.com

*Abstract*—**Based on the DEM generated by the full digital photogrammetry and field measurements in Yaojiawangou watershed, Suide, Shaanxi Province, the relationship between the elevation error of GRID DEMs and grid size is discussed. The influence of grid size on the elevation error of DEMs is shown as follows: the elevation on a grid is overestimated in down-slope direction, while underestimated in up-slope direction. As a result, the value of elevation error on a grid is decided by the slope gradient, while the complication of distribution of elevation error is decided by the size of grid. The analysis of elevation error calculated from the DEMs series generated by sampling directly shows that the RMSE and the maximum error of elevation increase with the grid size in the way that is a quadratic function. The maximum error on a grid far exceeds the 2 times of RMSE. Consequently, the grid size of DEMs should be as small as possible according to the precision in the application of DEMs.**

## INTRODUCTION

As well known, the grid size of DEMs influence the result of terrain analysis seriously [1-6]. However, the way and the extent of the influence are still not clear. In fact, most the changes of terrain parameters along with grid size, such like slope gradient, could be attributed to the changes of grid height along with grid size when the algorithm of those parameters are taken in account carefully. As the most basic attribute of DEMs which is a kind of model to simulate the surface of ground, the heights on the grid themselves don't change once the DEMs were created. However, the change of gird size or sampling interval alter the scope represented by one grid height if one grid is regarded as a flatten surface. Therefore, the error of elevation on one grid will change with grid size. According to the analysis mentioned above, the reason of the change of elevation error could be explained; however, the quantities and the distribution of elevation error caused by grid size should be discussed further. This paper aims to this problem to quantifies the elevation error on one grid and summary the spatial pattern of the elevation error based on the DEM which has a fine grid size and was generated by the full digital photogrammetry and field measurements in Yaojiawangou watershed, Suide, Shaanxi Province.

## BASIC METHOD

### *A. Data extraction*

Use the full digital photogrammetry to create a DEM with 1 meter grid size as the reference data in study area. And then, base on this data; use the method of direct sampling to obtain a DEMs series which have the same vertical precision with varying grid size.

### *B. Elevation error calculation*

Use the DEMs with different grid size in the DEMs series one by one to minus the 1 meter DEM which is taken as "true" value. The result could be thought as the elevation error of the DEMs on every grid

## BASIC RESULT AND DISCUSSION

### *A. Data extraction*

Fig.1 shows that the RMSE of Elevation increases with the grid size increasing in the way that is a quadratic function which is very similar with linear relationship. While Fig. 2 describe the relationship between the range of elevation error on one grid and the grid size. It is consistent with the result showed in Fig. 1.

According to the result showed in Fig. 1 and Fig. 2, the RMSE of elevation and the range caused by gird size could be estimated, Although the RMSE of elevation caused by grid size coincident with the specification in the standards CH/T9008.2-2010 and CH/T9009.2-2010[7-8], the maximum error far exceed the 2 times of RMSE which is specification in the standard. In fact, the mean of maximum error on grids is in 2 times of RMSE. The area with big maximum error usually occurs in the part with large slope gradient on the surface.

Fig. 3 shows the relationship among the RMSE , the scale ratio of grid size and the original grid size. The relationship could be represented with the formula as follow:

$$RMSE=0.2386m+0.0826d-0.0137m^2-0.002d^2+0.1738md$$

Where the *m* is the scale ratio and the *d* is the original grid size.

This relationship indicates that the result of Fig. 1 is correct no matter how big the sampling interval is. For instance, if the DEM with 5 meters grid size is taken as the original data and is thought as "true" value, the RMSE of elevation of DEM also increase with the increasing of grid size in a way of quadratic function which is similar with the result of Fig. 1.

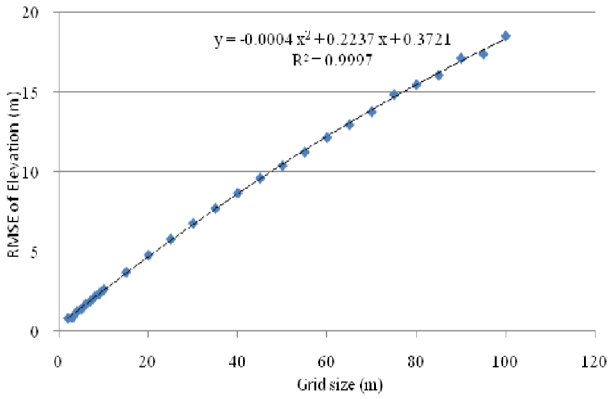


Fig.ure 1. The relationship between the RMSE of Elevation and grid size

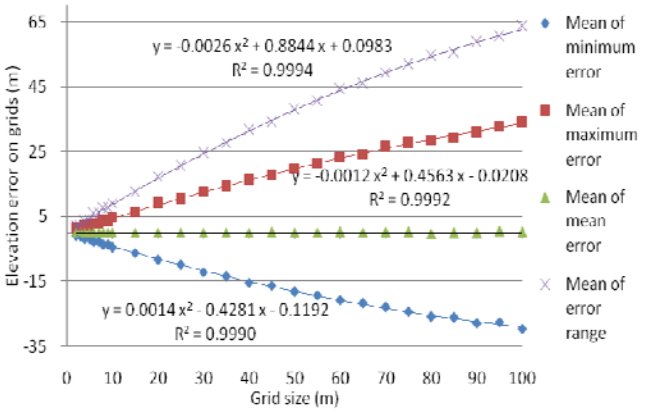


Figure 2. The relationship between the mean range of error on the grid and the grid size

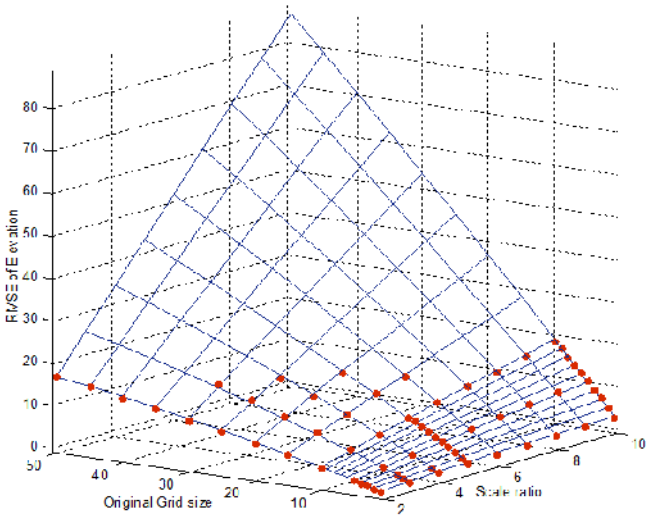


Figure 3 The relationship among the RMSE , the scale ratio of grid size and original grid size

## BASIC CONCLUSION

The result mentioned above explained that the elevation error of DEMs cause by grid size could be estimated once the grid size and the complication of terrain are specified. RMSE can only express the global accuracy of DEMs while the local accuracy in the complicated topography areas usually far exceeds the RMSE. In fact, the terrain parameters extracted from DEMs in these areas often influence the final conclusion of terrain analysis. The result of this paper could estimate the elevation error of DEMs caused by the grid size, and could help to make the right choice of grid size according to the precision in the application of DEMs.

## REFERENCES

[1] Horritt M. S.,Bates P. D. Effects of spatial resolution on a raster based model of flood flow. Journal of Hydrology, 2001, 253(1-4): 239-249.

[2] Thompson James A., Bell Jay C.,Butler Charles A. Digital elevation model resolution: effects on terrain attribute calculation and quantitative soil-landscape modeling[J]. Geoderma, 2001, 100(1-2): 67-89.

[3] Wu Wei, Fan Yan, Wang Zhengyin, et al. Assessing effects of digital elevation model resolutions on soil-landscape correlations in a hilly area[J]. Agriculture, Ecosystems & Environment, 2008, 126(3-4): 209-216.

[4] Liu Xuejun and Zhang Ping. Effective Scale of Slope and Aspect Derived from Grid-based Digital Elevation Mode. Geomatics and Information Science of Wuhan University, 2008, 33(12): 1254-1258.

[5] Wu XianFeng, Liu Changming, Wang zhonggen, et al. Effect of horizontal resolution of raster DEM on drainage basin characteristics. Joural of Natural Resources, 2003, 18(02): 148-154.

[6] Sørensen Rasmus,Seibert Jan. Effects of DEM resolution on the calculation of topographical indices: TWI and its components[J]. Journal of Hydrology, 2007, 347(1-2): 79-89.

[7] CH/T9008.2-2010 Digital products of fundamental geographic information 1:500 1:1000 1:2000 digital elevation models[s]. Beijing: Surveying and Mapping Press,2010.

[8] CH/T9009.2-2010 Digital products of fundamental geographic information 1:5000 1:10000 1:25000 1:50000 1:100000 digital elevation models[s]. Beijing: Surveying and Mapping Press,2010.