

## ***Interactive comment on “Effect of DEM resolution on SWAT outputs of runoff, sediment and nutrients” by S. Lin et al.***

**S. Lin et al.**

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Dear Prof. Grimaldi,

Thank you very much for your inspiring comments. The objective of this work is to evaluate the sensitivities of SWAT outputs to DEM resolution and DEM data source (i.e. DLG5m, ASTER30m and SRTM90m). With regards to “SWAT output analysis or ArcSWAT output analysis?” This question reminds us that we should discuss the SWAT outputs and ArcSWAT outputs separately. The former is the sequent effect of the latter, which is directly affected by resolution and plays more significant role in the SWAT resolution uncertainty. As you mentioned, terrain topographic attributes (e.g., mean slope) might not decrease with coarser DEM resolution. This is on the contrary of many

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previous studies including this one. Therefore, we will discuss in more details about the method used in the ArcSWAT watershed delineation. What is more, your method, PEM4PIT (Grimaldi et al., 2007), for DEM pit correction worth further investigation to tackle the DEM resolution uncertainty in hydrological models including SWAT.

The following are responses to your comments. We are looking forward to having more comments/critics/suggestions from you.

Sincerely,

The authors

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The manuscript describes an interesting comparison of SWAT model application on DEMs with several resolutions. The topic is important and the manuscript is well written. The present comment is on the DEM preprocessing method used to extract morphometric terrain characteristics considered in the manuscript. Authors refer to ArcSWAT2.3.4 (Di Luzio et al. 2004) but it is not clear which is exactly the approach used to extract the drainage network: -flow direction method used;

-pit filling method used;

-flat area treatment method used.

RE:\*\*\*\*\*

The article (Di Luzio et al. 2004) is not exactly about ArcSWAT2.3.4, but AVSWAT version 1.0, which is the elder version of ArcSWAT2.3.4. I have already written to Dr. Di Luzio talking about the latest method used to extract morphometric terrain characteristics. He has not reply to my e-mail so far. However, we still can refer the methods used in ArcSWAT2.3.4 from the article (Di Luzio et al. 2004), assuming that no significant methodological differences between ArcSWAT2.3.4 and AVSWAT version 1.0.

"The Watershed Delineation module of the AVSWAT framework relies on a user pro-

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vided DEM in raster-grid format for deriving the hydrologic extent (watershed boundary) of the SWAT model application and also for the calculation of several geomorphological parameters of the whole watershed and the constituent segments. The initial basic steps of this module include the application of some elementary raster functions provided by ArcView along with its Spatial Analyst extension and the derived Hydrology Extension (Kopp 1998) for delineating streams from a raster digital elevation model. The standard methodology, which is based on the eight-pour point algorithm with steepest descent, is implemented (Jenson and Domingue 1988) along with the preprocessing procedure of filling the sink holes.”—Paragraph 2, Page 118, Di Luzio et al. 2004

Based on this paragraph, 1) the flow direction method used, 2) the pit filling method used and 3) the flat area treatment method used should be the standard one using in ArcGIS (Jenson & Domingue 1988)

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This could be an important point because if ArcSWAT2.3.4 is based on the common routines included in ArcGIS, these latter are overcame by other ones present in literature (see the references at the end of this document).

The problem is that applying the bilinear interpolation for DEM resampling several new pits could be generated and some new flat areas could appear. Consequently the slope, for instance, could be affected by the pre-processing procedure. A simple example is showed in the following.

Given a watershed DEM at 20 meter of resolution (Rigo Basin, an Italian watershed, 84Km<sup>2</sup>) and resampled with bilinear interpolation at 90m, two pre-processing procedures are applied: A)the standard one using ArcGIS (D8, pit filling, flat areas with Jenson & Domingue 1988); B)an advanced one (described in Grimaldi et al. in press).

Threshold area used for the drainage network extraction: 8Km<sup>2</sup>

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The results of this simple test are:

----- MSSP- - MSAP -----

DEM 20m.....8,08%...3,45%

DEM 90m.....6,06%...3,81%

MSSP: Mean slope of the drainage network extracted with standard procedure

MSAP: Mean slope of the drainage network extracted with advanced procedure

It is clear that resampling to 90 meter new pits will be created and in any case a large amount of flat areas are present in the drainage network. So apparently the paper evaluates SWAT model performances using cells of different size but practically the results and conclusions could be meaningful affected by ArcSWAT2.3.4 approach.

References related to this document:

GRIMALDI S., PETROSELLI A., ALONSO G., NARDI F., "Flow time estimation with variable hillslope velocity in ungauged basins" in press to Advances in Water Resources

GRIMALDI S., NARDI F., DI BENEDETTO F., ISTANBULLUOGLU E., BRAS R.L. (2007) "A physically-based method for removing pits in digital elevation models" Advances in Water Resources, Volume 30, Issue 10, pages 2151-2158.

JENSON, S. K. & DOMINGUE, J. O. (1988) Extracting topographic structure from digital elevation models. Photogramm. Eng. Remote Sensing 54, 1593–1600.

NARDI F., S. GRIMALDI, M. SANTINI, A. PETROSELLI AND L. UBERTINI (2008) "Hydrogeomorphic properties of simulated drainage patterns using digital elevation models: the flat area issue" Hydrological Science Journal, 53(6).

SANTINI M., GRIMALDI S., RULLI M.C., PETROSELLI A., NARDI F., (2009) "PreProcessing algorithms and landslide modeling on remotely sensed DEMs" Geomorphol-

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ogy, vol. 113, pages 110-125.

RE:\*\*\*\*\*

Thank you very much for sharing your results with us. As indicated in your published papers (listed above), we believe that the method used in ArcSWAT2.3.4 could cause more flats and reduce the mean slope. Your DEM correction method, PEM4PIT (Grimaldi et al., 2007), is very interesting. It should be an better approach to improve the accuracy of DEM-based hydrological models. We will do more study using your approach of DEM correction. Discussion relevant to this topic will be provided in the revised version.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 4411, 2010.

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