Assessing the quality of ASTER DEMs for Hydrological Applications
(Case Study: Cheshmehkhan Catchment in the northeastern of Iran)

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Abstract—Digital Elevation Model (DEM) data have been used to derive hydrological features which serve as inputs to various models. Currently, elevation data are available from several Major sources and at different spatial resolutions. This paper shows the quality and accuracy of drainage network analysis resulted from ASTER DEMs. Hydrology tools in the ArcGIS package was used to extract drainage networks from a grid DEM for cheshmehkhan catchment in the northeastern of Iran. Extracted networks compared with the one derived from aerial photographs and high resolution satellite Images as real ground. Results showed both the DEMs and current GIS algorithms have basic imperfections. However, drainage morphometry analysis based on extracted rivers from DEM are similar of Natural network in the raster format and for whole catchment area but there are many large differences when we used the vector datasets for Analyzing in separate land features. The best threshold values for Extraction of rivers from ASTER DEMS are 25 cells for head waters in the mountain areas, 50-100 for pediments, 100-250 for Alluvial fans and 500 for plain domains.

Keywords—DEM, River network extraction, raster and vector data, threshold values, Geomorphology

I. INTRODUCTION

Digital Elevation Models are elevation data that collect by remote sensing methods. These data have been used vastly in Geomorphology, Hydrology, Geology and other studies. Currently, elevation data are available from several Major sources with low to high spatial resolutions (table 1).

Because of the General availability of DEMs, Scientists have been increasingly using DEMS for various applications, such as river network delineation, flood modeling and hazard mapping [4]. Many algorithms have been developed to derive basic topographic characteristics or features from DEMs, such algorithms include extracting drainage networks [1] and delineating watersheds [2]. Basic geomorphic or topographic attributes extracted from DEMs often serve as inputs to other Models. Thus, DEMS and related algorithms provide the foundations of scientific in queries related to environment and topography. The degree of quality and accuracy of DEMS and the nature of algorithms are basic questions for above Analysis. Therefore in this paper we examined the quality and accuracy of ASTER DEMs by Comparison of Extracted river networks resulted from a ASTER DEM with the one derived from high resolution aerial photographs and satellite Images.

II. METHOD AND MATERIALS

The method employed to evaluation of degree adjustment between the drainage network extracted automatically from a DEM and the network delineation from photographs and satellite Images comprises three steps:

A. River delineation from aerial photographs and satellite Images

The river network of the study area was drawn from IRS pan satellite Image (2004) and photo interpretation of 1:20000 scale aerial photographs (1970) combined with field work. The criterion used to define first – order channels was they have channel morphology and a length of over 50m. River network has been digitized by ArcGIS sketch tools after geometric transformation of image and aerial photographs in UTM coordinate system.

B. Extraction of network from ASTER DEM by GIS

The extraction of network from ASTER DEM by GIS

The extraction of drainage network of the study area carried out from an ASTER DEM, in raster format with a 30m*30m grid cell size, which was provided by Japanese scanner has been installed on the Terra satellite in 1999. Hydrological tools in ArcGIS software, version 9.3 (ESRI 2008) was used to extract drainage channels. The automated

<table>
<thead>
<tr>
<th>DEM Creation Method</th>
<th>DEM Type</th>
<th>Nominal Resolution (m)</th>
<th>Relative-Vertical Resolution (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spaceborne Photogrammetry</td>
<td>Terra/ASTER</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SPOT 5</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Ikonos</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>HRSRC</td>
<td>90</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>HRSRC</td>
<td>30</td>
<td>0.2</td>
</tr>
<tr>
<td>Spaceborne iSAR</td>
<td>SRTM-C-band (11/02/2000)</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>ERS TanDEM (est 1998-1999)</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Terra/ASAR</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Terra/ASAR</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Airborne</td>
<td>IF SAR (Next MAP)</td>
<td>1=5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>LIDAR</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>Other</td>
<td>MODIA</td>
<td>400 (DEM)</td>
<td>0.3H (point value)</td>
</tr>
</tbody>
</table>
method for delineating streams followed a series of steps (figure 4) starting with a filled DEM.

Figure 1. Conceptual work flow for drainage network Delineation [5]

C. Comparison Between two Drainage Networks

Obviously both networks contain errors. For our comparison we took the extracted networks from aerial photographs and images to be real stream channels. This is partly because more detailed scale of the aerial photos and satellite images guarantees a good reference map with which to compare the network obtained from the DEM. The comparison process has been done in both raster and vector formats. These comparisons are included morphometric characteristics as river frequency, stream length, stream density and drainage ratio as well as the spatial pattern of the drainage lines, which was evaluated by visual analysis and calculating the degree of coincidence between two networks.

III. STUDY AREA

The study area is a subbasin of Madarsu river located in the northeastern of Iran (Figure 2), drains an area of 520 km². The catchment is situated upstream of the Madarsu basin, and it is overall terrain presents distinct variability with elevation varying from 960 to 2440 m. the basin is been divided to 4 geomorphologic units, mountain, pediment, alluvial fans and aggraded plain.

IV. RESULTS

A. Comparison of stream attributes

Visual study and numerical results highlight only a network Map which is derived in 25 thresholds value is near to the real network map (Geo). We recognized decreasing of river orders and cell frequencies in higher threshold values. The comparison of the cell and river frequencies show good agreement for all stream orders but there are large differences for 4, 5 and sixth-order streams. The differences have been measured 77, 73 and 76 percents for 4, 5 and sixth-order rivers respectively (table II).it means the distribution of first-order rivers have a big difference with natural drainage patterns. Thus, we have done the comparison analyzing in the separate geomorphologic units of mountain, pediment, alluvial fans and plain (figure 3).

B. Comparison of stream Spatial patterns

The comparison of the spatial patterns of the two drainage networks (Figure 10) reveals poor agreement. It has been measured only 31.75 percent for whole catchment area and all rivers but between 15-20 percent for first to fourth river order and lower than 10 percent for other orders. The maximum of overly degree has been found on the pediment area for fourth-order streams. It means the DEM resolution
of 30*30 meters is not enough to locate the rivers in accurate locations.

Figure 4. Drainage networks extracted from aerial photos and satellite images (A), DEM with Threshold of 500 (B), threshold of 200 (C), Threshold of 100 (D), Threshold of 50 (E), and threshold of 25 (F).

<table>
<thead>
<tr>
<th>Stream Order</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAP</strong></td>
<td>Geo</td>
<td>4779</td>
<td>1187</td>
<td>337</td>
<td>137</td>
<td>31</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>DEM</td>
<td>5348</td>
<td>1443</td>
<td>437</td>
<td>415</td>
<td>116</td>
<td>46</td>
<td>1</td>
</tr>
<tr>
<td><strong>Difference amount (%)</strong></td>
<td>11</td>
<td>18</td>
<td>23</td>
<td>77</td>
<td>73</td>
<td>76</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td><strong>Drainage ratio calculated from Geo</strong></td>
<td>--</td>
<td>4.02</td>
<td>3.52</td>
<td>2.4</td>
<td>4.1</td>
<td>2.8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Drainage ratio calculated from DEM</strong></td>
<td>--</td>
<td>3.7</td>
<td>3.3</td>
<td>1.05</td>
<td>3.57</td>
<td>2.5</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
C. Comparison of Drainage Density

The Drainage density calculated for whole basin area shows good agreement between rivers which extracted by different methods. Obviously differences appear in separate Geomorphologic units as we can see completely incorrect results for alluvial fan and plain sectors for rivers delineated from DEM (Figure 11). The best agreement of drainage density is been recognized for pediment where the surface slope is moderate.
V. CONCLUSION

ASTER DEMS have enough resolution for extracting of first and second-order rivers in mountain areas with 25 thresholds values. The morphometric analysis based on extracted networks from ASTER DEMs give incorrect results through alluvial fan and plain areas but there is a good agreement for river length in the mountain and pediment sectors. 30*30 in resolution of ASTER DEMs is not enough to derive river networks in the alluvial fan and plain sectors. It is possible to increase the threshold values for network extraction on the alluvial fan and plain sectors (250 for alluvial fans and 500 for plain area). Therefore we suggest that automated river extraction from DEMs can be improved by dividing the basin into geomorphological units and using a different threshold in each unit. The best method for river extraction can be using the high resolution of aerial photograph and satellite images; however it takes a long time than the automated method.

REFERENCES