DOES LACK OF TOPOGRAPHIC MAPS LIMIT GEO-SPATIAL HYDROLOGY ANALYSYS?

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ABSTRACT

Watershed boundaries and flow paths within the watershed are the most important factors required in watershed analysis. Most often the derivation of watershed boundaries and stream network and flow paths is based on topographical maps but spatial variation of flow direction is not clearly understandable using this method. Water resources projects currently use 1: 50, 000-scale ground survey or aerial photography-based topographical maps to derive watershed boundary and stream network. In basins, where these maps are not available or not accessible it creates a real barrier to watershed geo-spatial analysis. Such situations require the use of global datasets, like GTOPO30. Global data sets like ETOPO5, GTOPO30 are the only data sets, which can be used to derive basin boundaries and stream network and other terrain variations like slope aspects and flow direction and flow accumulation of the watershed in the absence of topographic maps. Approximately 1-km grid-based GTOPO 30 data sets can derive better outputs for larger basins, but they fail in flat areas like the Karkheh basin in Iran and the Amudarya in Uzbekistan. A new window in geo-spatial hydrology has opened after the launching of the space-borne satellite stereo pair of the Terra ASTER sensor. ASTER data sets are available at very low cost for most areas of the world and global coverage is expected within the next four years. The DEM generated from ASTER data has a reasonably good accuracy, which can be used effectively for hydrology application, even in small basins.

This paper demonstrates the use of stereo pairs in the generation of ASTER DEMs, the application of ASTER DEM for watershed boundary delineation, sub-watershed delineation and explores the possibility of understanding the drainage flow paths in irrigation command areas. All the ASTER derived products were compared with GTOPO and 1:50,000-based topographic map products and this comparison showed that ASTER stereo pairs can derive very good data sets for all the basins with good spatial variation, which are equal in quality to 1:50,000 scale maps-based products.

1 Introduction

Spatial variation of terrain parameters plays a key role in basin-scale water resources analysis. Defining the domain boundary with reasonable accuracy is the first step in modern basin analysis. All other collected information depends on the demarcation of the domain boundary. It will help reduce an enormous amount of repetitive preparatory work in the analysis of spatial and temporal datasets for basins. When the basin is a big one like the Nile or a small basin like the Ruhuna basin in Sri Lanka, there are thousands of basin boundaries derived by different authorities based on their studies. People waste most of their allocated project time to discuss the correctness of their basin boundary instead of carrying out real analytical work. As a matter of fact this cannot be criticized, since there is no single "right" method of basin boundary derivation. Most water resources projects still use manual delineation of watershed boundary because it is easy. But this can yield different boundaries since manual interpolation is used for boundary delineation. Use of digitized contour maps creates a
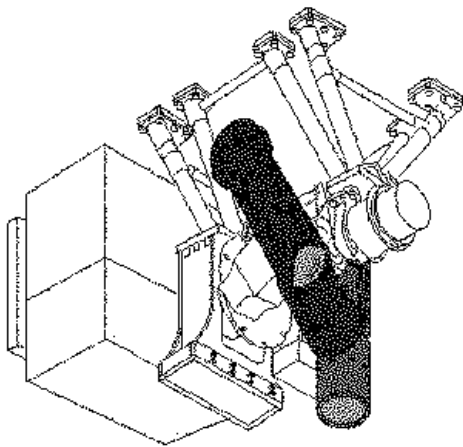
Figure 1 ASTER sensor stereo Geometry

Figure 2: ASTER Stereo Geometry

better result when compared to manual delineation. Digitized contour maps create a reasonably accurate boundary based on the digitized contours and interpolation algorithm. The advantage of the stereo pairs is that they can create a DEM , which has an array of spatially distributed elevation values for the coverage of the stereo scene. In theory this can yield a good basin boundary based on the spatial resolution of the image.

A new window has opened in geo-spatial hydrology, after the launching of the space-borne satellite stereo pair of the Terra Advanced Spaceborn Thermal Emission and Reflection Radiometer (ASTER) sensor. ASTER data sets are available at very low cost for most areas of the world and global coverage is expected within the next four years. The DEM generated from ASTER data has a reasonably good accuracy, which can be used effectively for hydrology applications even in small basins.

This paper demonstrates the use of ASTER 3N and 3B stereo pairs in the generation of ASTER DEM, application of ASTER DEM for watershed boundary delineation, sub-watershed delineation and explores the possibility of understanding the drainage flow paths in irrigation command areas.

Available optical sensors for DEM generation
ASTER, IKNOS, IRS, SPOT
InSAR DEM capability
ERS, JERS, RADARSAT

2.Methodology
DEM Generation using optical images -ASTER
Along track and Across track stereo Geometry
The ASTER sensor creates an extra track of the image by capturing a backward locking image (3B) in addition to the existing third nadir looking image (3N). The two telescopes mounted on the ASTER sensor allows
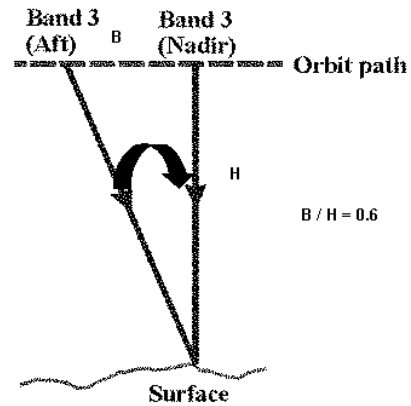
simultaneously (64 seconds lag) capture of the ground target with appropriate parallax and Base height ratio (B/H) of 0.6. This creates a stereo along track geometry which ensures atmospheric condition as well as illumination of ground coverage identify at its best possible way between two image geometry. Optical sensors with stereo capability like SPOT and IRS PAN use across track stereo geometry, which capture its stereo pairs from two different orbits, which can affect the success of the DEM due to the temporal variations of the stereo pairs. Since there is no temporal changes in along track ASTER stereo pairs (64-second lag between two scenes can be considered as negligible) which contribute to achieve better correlation between stereo pairs at the stage of image correlation.

DEM Generation procedure
The DEM generation procedure required the stereo pairs to be registered to the same ground using Ground Control Points (GCP) or tie points (TP) or using both. At this stage TP will do the relative orientation of the stereo pairs where as absolute orientation can be done using GCP. In our study 30 tie points and 5 GCP points were used to accomplish the orientation. Once two images are registered along track position difference can be assumed due to the parallax. Measured parallax difference on pixel-by-pixel basis can be converted to elevations using satellite orbital data. It is necessary to correlate 4980X4200 pixels in one image that of its conjugate. Figure 3 shows the selected tie point and GCPs, which were used for the model, the correlation algorithm based on the relationship between pixels in 3N image and that of its conjugate 3B image.

The coefficient of the mathematical model converts the 3B image in to and "EPIPOLAR "image which is conjugate to the left hand image (3N)." The Epipolar image 3B is re-projected to minimize the cross track offset relative to the reference image. The offset in
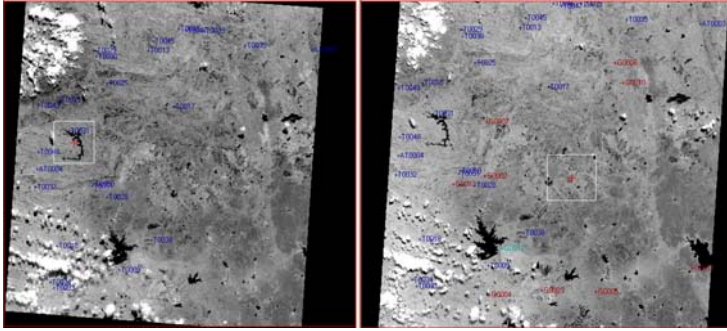
Figure 3: ASTER 3N and 3B Bands and selected GCP and TP.

Figure 4: Result Anaglyph image

image to image registration between 3N and 3B images are due to the along track differences. So parallax offset is assumed to be topographic relief. So the elevation information contains in the Epipolar pairs used for both DEM generation and 3D visualization using anaglyph.

The result anaglyph is shown in figure 4.
The Anaglyph stereo mode can be considered as the intermediate step to check the correctness of the resulting DEM. If 3D effect works well when it is viewed using red and blue glasses and the scenes are not distorted with curved edge as if it were heavily warped, the resulted Epipolar is in a good condition for DEM generation.

3 Discussion and Conclusion.

ASTER stereo pairs can be used for DEM derivation and the resulting elevation data are comparable with 1:50,000 base map data. According to our analysis it showed the 0.85 RMS value when compared with 1:50,000 based spot elevations in noise-free image coverage.
ASTER DEM based watershed boundaries produce a very good result when compared to 1:50,000 contour-based map data.
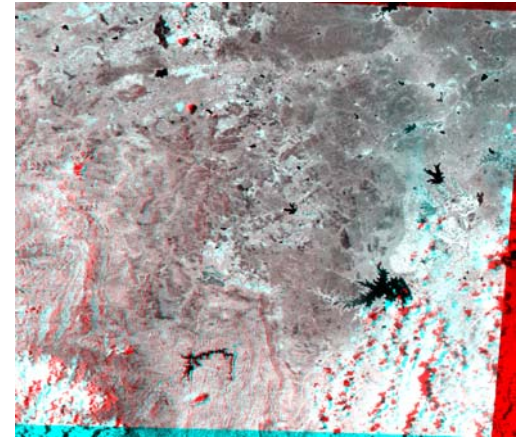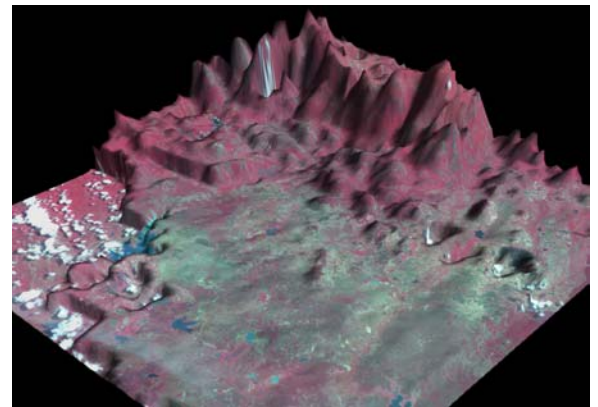

Figure 5: 3d view of the DEM

Figure 6: ASTER DEM derived watersheds