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Comparative Study of Cartosat-DEM and SRTM-DEM on Elevation Data and Terrain Elements

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Abstract The three dimensional space is represented by Digital Elevation Models (DEMs) in a discrete form. DEM plays an important role in characterizing the topography and to derive the watershed boundaries thereby to study the landscape with in the watershed. Over a decade, DEMs from satellite imageries like ASTER, SRTM, IKONOS, Cartosat etc. are becoming popular with wide applications. However, issue of accuracy of DEMs generated from the satellite imageries is the major concern of remote sensing researcher's. The main purpose of this study is to compare the accuracy of DEM generated from two different satellite sources, 1) Optical based sensory satellite data – Cartosat-DEM. 2) Microwave based sensory satellite data – SRTM-DEM. The study was conducted over Southpennar watershed which has gradually undulating topography. The comparative study was done under two categories; they are through elevation data and terrain derivatives. The study reveals that in gradually undulating terrain, elevation values of Cartosat-DEM are lower than SRTM-DEM. whereas the stream parameter values of Cartosat-DEM are higher than SRTM-DEM. In visual analysis the contours obtained from Cartosat-DEM and SRTM-DEM aligns with each other irrespective of the resolution.
Keywords *Cartosat-DEM; SRTM-DEM; Accuracy; Elevation; Terrain Derivatives*

1. Introduction

The most common and the simplest form of terrain representation in 3D are the Digital Elevation Models (DEMs). The satellite based DEMs can be assessed by comparing the elevation data generated from them with elevation data obtained from topographic maps. The assessments can also be done by comparing DEM's elevation data with the elevation data's obtained from Global Positioning Systems (GPS) or with Differential Global Positioning Systems (DGPS). However it's very expensive to procure DGPS data's. The accuracy of DEMs produced from satellite is found to be ±5 and ±20 m RMSE (Root Mean Square Error) [1]. From past few years many researchers have done a series of local and global assessments of these elevation products. Evaluation of ASTER GDEM of 20 sites in 16 countries was conducted. Comparison was made between DEM to DEM and Ground Control Points (GCPs) to DEM. Detailed visual analysis was also conducted between the derivatives [2]. For qualitative assessment between SRTM–DEM and ASTER–DEM vertical and horizontal components were estimated. Two different study areas were considered of different topography, elevation distributions were compared using Skewness and kurtosis in each study area. For obtaining the degree of relation between two DEMs, Scatter plots were used. The results show a good correlation of elevation data between them [3]. Cartosat and SRTM DEMs are two post processed datasets which were used for range of applications due to their global coverage. In this study, Cartosat-DEM and C-band SRTM were compared for Southpennar watershed region. For any hydrological processes, relative accuracy is sufficient but elevation data's were also assessed to complement the Cartosat-DEM

2. Study Area

Study area is located in the Survey of India Toposheet Nos. 57K/1, 57K/3 and D43R15, lies between North Latitude of $13^{0}58^{'}29^{''}$ to $14^{0}58^{'}29^{''}$ and East Longitude of $77^{0}12^{'}31^{''}$ to $78^{0}12^{'}31^{''}$. Southpennar is a part of upper Ponnaiyar sub catchment between Cauvery and Krishna basin, partially covered in Chikballapur, Sidlagatta and Chintamani taluks of Chikballapur District, Karnataka. The study area is one of the watersheds of Southpennar river system which originates at Nandhi hills of Chickballapur district, Karnataka, India.

3. Data

Data from following sources was acquired;

1) Cartosat - DEM (downloaded from Bhuvan - geoportal of ISRO)
2) SRTM - DEM (downloaded from the USGS web site: www.usgs.org)

3.1. Cartosat-DEM

Cartosat-1 launched by ISRO on 5th May 2005, provides stereo data for entire India. Under Space based Information Support for Decentralized Planning (SIS-DP) project. Dem (1 arc Sec) were generated country wide using digital photogrammetric techniques [4]. To generate seamless DEMs, photogrammetric blocks were formed and with minimal break-lines, DEMs were edited across the scenes. Automatic process of seamless DEM data generation is done by making use of Ground Control Points through dense feature matching, Triangulated Irregular Network modelling and automated strip mosaicing [5]. Quality verification process is done by panning and draped visualization to demarcate distortions [6]. Further validation is done for height accuracy for stereo pairs overlapping portions.

3.2. SRTM-DEM

The high – resolution topographic database for the entire earth is Shuttle Radar Topography Mission (SRTM) by the collaborative effort of National Aeronautics and Space Administration. SRTM launched February 2003, carries Space borne Imaging Radar-C (SIR-C) hardware. Data points are collected in 3 arc-seconds spacing referred as SRTM3. Speckle, the error source in synthetic aperture radar data is overcome through averaging.

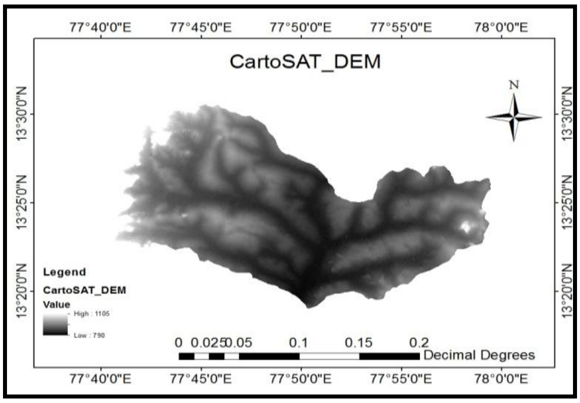

Figure 1: Cartosat-DEM Image

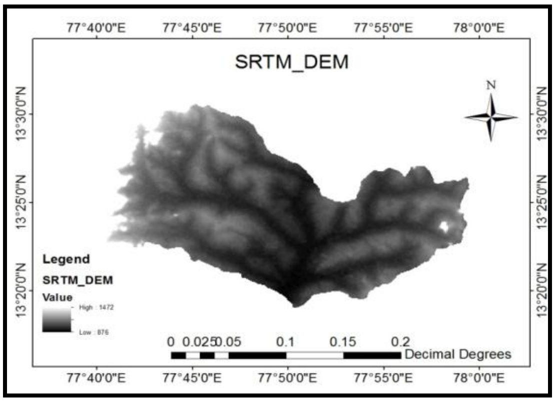

Figure 2: SRTM-DEM Image

4. Methodology

For comparing the accuracy of Cartosat-DEM (Figure 1) and SRTM – DEM (Figure 2) through elevation data, sub watershed maps were generated (Figure 3) from both the DEMs in ArcGIS-10. For generating the sub watershed maps, pour point of each 4th order streams were identified in the flow accumulation raster and the sub watersheds were delineated using watershed tool. Areas of sub watershed generated from different DEMs can be compared. Maximum elevation point and minimum elevation point of each sub watershed were identified. The elevation values of those points were identified from both the DEMs. These elevation points from SRTM- DEM and Cartosat -DEM were compared by finding the variances and standard deviations.

For comparing the accuracy of Cartosat-DEM and SRTM - DEM through terrain derivatives, first drainage maps were generated for both the DEMs in ArcGIS-10 individually. For generating the drainage maps, spatial analyst tools were used. Raster calculator tool was used to create and execute a single map algebra expression using python syntax in a calculator interface that will create a raster output. From the drainage map, stream length, mean stream length, stream length ratio and bifurcation ratio were calculated.

5. Comparisons

5.1. Elevation Values

DEM is considered to be an effective tool for analysis of terrain attributes with the help of ArcGIS. The maximum and minimum elevation points were identified in each subwatershed and the values are obtained in ArcGIS platform from Cartosat-DEM and SRTM_DEM. The total area of watershed obtained from Carto-DEM shows a higher value of 333.65 Km^2 compared to SRTM-DEM of 333.61 Km^2. Difference in area is found to be more in subwatershed 2 and 3. The Statistic parameters such as variance and standard deviation were found between the elevation values of two DEMs under each subwatershed. It’s found that standard deviation of maximum elevation points in subwatershed 2 and 3 were 111.02 and 125.16 (Table 1). High variation is found only in these two subwatersheds. Low value of 3.54 is found in subwatershed 1. Subwatershed 2 and 3 has steep terrain.

***Table 1:** Elevation Statistics of Cartosat-DEM and SRTM-DEM*

Sub Watershed	Cartosat-DEM Area (Km^2)	SRTM-DEM Area (Km^2)	Cartosat-DEM Elevation(m)		SRTM-DEM Elevation(m)		Difference in Elevation		Standard Deviation	
			Max	Min	Max	Min	Max	Min	Max	Min
1	41.68	39.74	954	848	949	897	-5	49	3.54	34.65
2	23.6	28.29	866	817	1023	921	157	104	111.02	73.54
3	45.73	43.21	959	795	1136	881	177	86	125.16	60.81
4	25.55	25.63	851	795	947	889	96	94	67.88	66.47
5	26.79	27.25	830	794	927	889	97	95	68.59	67.18
6	23.02	22.8	846	797	920	882	74	85	52.33	60.10
7	24.05	24.52	856	820	933	909	77	89	54.45	62.93
8	36.89	36.26	850	820	938	884	88	64	62.23	45.25
9	14.56	14.24	842	807	927	881	85	74	60.10	52.33
10	18.75	18.56	838	809	896	883	58	74	41.01	52.33
11	19.06	18.73	839	798	920	882	81	84	57.28	59.40
12	26.99	27.32	811	797	940	900	129	103	91.22	72.83
13	6.98	7.06	849	813	881	879	32	66	22.63	46.67

5.2. Terrain Elements

Drainage maps were generated with the same threshold from Cartosat-DEM and SRTM-DEM (Figure 4) for comparing the streams. Topological corrections were made and Morphometric parameters were calculated. From both the DEMs highest order of 6th order streams were found. The number of streams and the length of the streams are less in SRTM-DEM compared to Cartosat-DEM. Drainage density calculated from total stream length per unit drainage area was found to be 1.423 from Cartosat-DEM and 1.529 from SRTM- DEM (Table 2) for the study area. Stream frequency (the ratio of number of stream segments of all orders per unit drainage area) for the study area is found to be 1.77 per Km^2 from Cartosat-DEM and 1.909 per Km^2 from SRTM-DEM. Bifurcation ratio (the ratio between stream numbers of given order to its next higher order) was found to be 3.81 from Cartosat-DEM and 3.55 from SRTM-DEM for the study area.

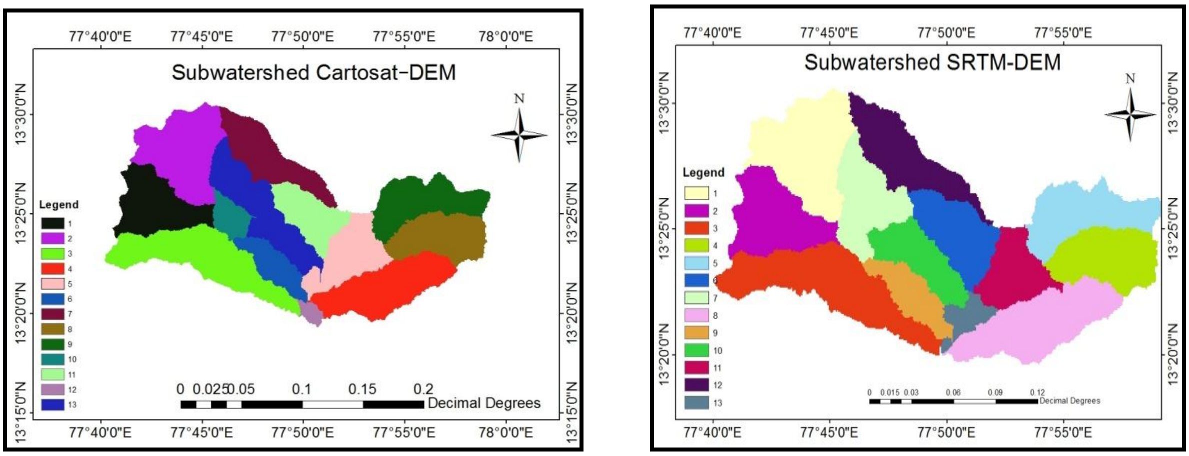

***Figure 3:** Subwatershed Map from Cartosat-DEM and SRTM-DEM*

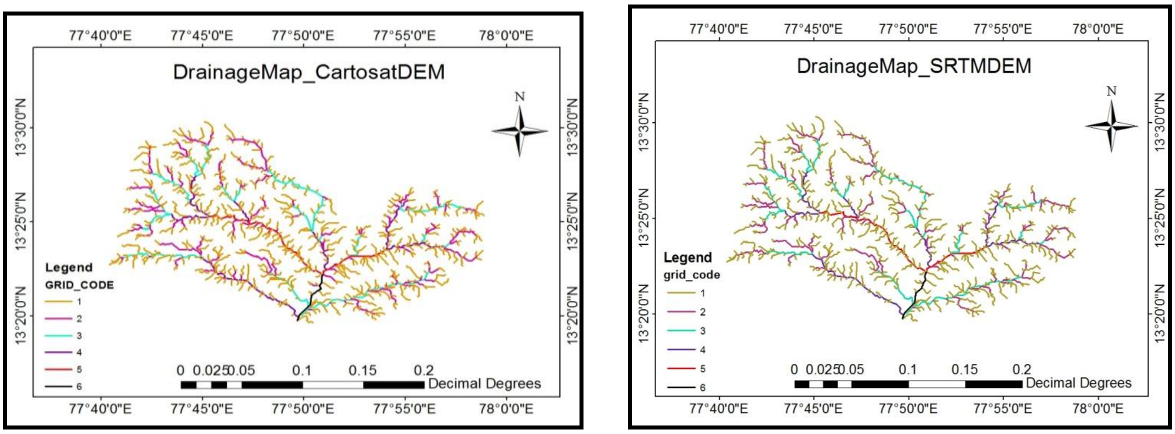

Figure 4: *Drainage Map Derived from Cartosat-DEM and SRTM-DEM*

Table 2: *Parameters Derived from Drainage Map of Cartosat-DEM and SRTM-DEM*

Stream Order	Cartosat-DEM				SRTM- DEM			
	Stream Number	Stream Length (Km)	Mean Stream Length (Km)	Bifurcation Ratio	Stream Number	Stream Length (Km)	Mean Stream Length (Km)	Bifurcation Ratio
1	556	342.89	0.62	4.41	474	291.2	0.61	3.92
2	126	97.62	0.77	6.30	121	96.56	0.79	3.78
3	20	71.17	3.56	2.86	32	62.78	1.96	4.57
4	7	36	5.14	3.50	7	35.98	5.14	3.50
5	2	18.9	9.45	2.00	2	18.84	9.42	2.00
6	1	4.9	4.90		1	4.83	4.83	
	712	571.48		3.81	637	510.22		3.55

6. Visual Analysis with Contours

Contour-based visual analyses were done for the assessment of Cartosat-1 DEM. Using ArcGIS 10m interval contours are generated for the study area from both the DEM’s and draped on top of the respective DEMs as shown in Figure 5. Both the SRTM - DEM and Cartosat – DEM derived contours were superimposed over the Cartosat – DEM (Figure 6). It was found that contours obtained from two different sources align with each other.

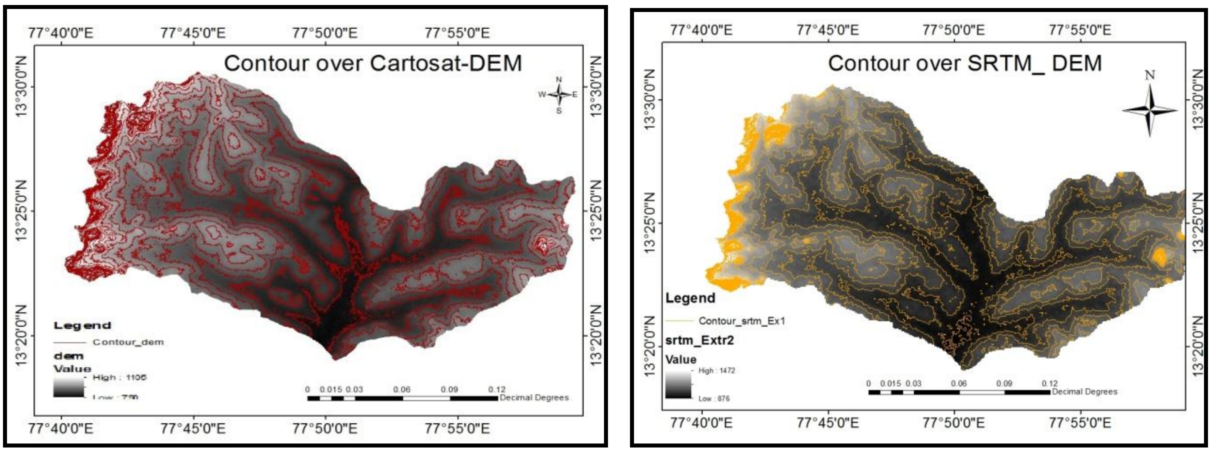

Figure 5: *Contour Map over the Respective DEM Images*

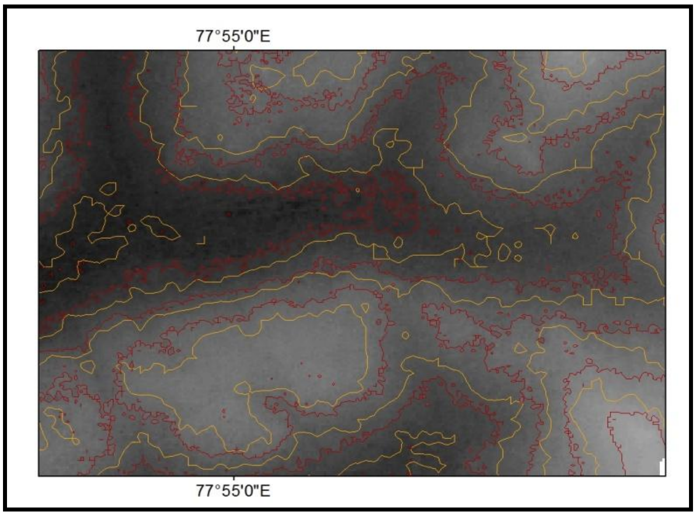

Figure 6: *Cartosat-DEM and SRTM-DEM Derived Contours Superimposed Over Cartosat-DEM*

7. Conclusion

This study analysis and compares the statics of many elevation data and terrain attributes generated from Cartosat–DEM and SRTM–DEM. With the help of ArcGIS terrain attributes obtained from different DEMs are displayed in attribute databases. For all type of terrain the drainage map from higher resolution DEM produces a most realistic stream layer. This results in consistent stream order and drainage density. Cartosat-DEM with 10m resolution shows virtually the same as that of SRTM-DEM data with 30m resolution. In the study of terrain elements Cartosat-DEM are more accurate than SRTM-DEM. SRTM-DEM shows higher elevation values compared to Cartosat-DEM in all the sub watersheds. The study reveals that the resolution of DEM has greater impact on the drainage map analysis and the statistical values become lower when resolution of DEM changes from fine to coarse.

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