CartoDEM

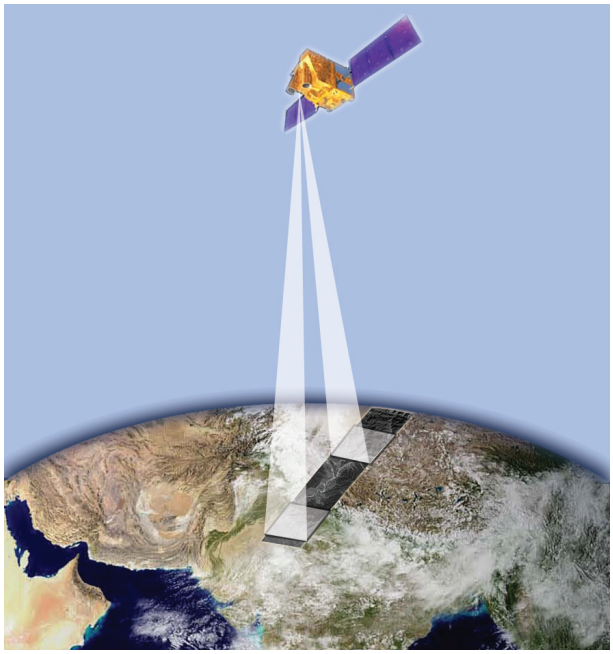
a national digital elevation model from Cartosat-1 stereo data

nrsc
National Remote Sensing Centre
Indian Space Research Organisation
Hyderabad
www.nrsc.gov.in

Introduction

Indian Space Research Organisation (ISRO) has launched Cartosat-1 on May 5, 2005 with prime objective of delivering high-resolution satellite data of 2.5 m in-track stereo. One of its mission goals is to generate a Digital Elevation Model (DEM) and corresponding ortho-image for the entire country to facilitate large scale mapping and terrain modelling applications. Cartosat-1 has completed five years of its operation successfully and has acquired images over India and across the globe.

Along Track Stereo Viewing



Payload Specifications

S No	Parameter		Specifications
01	Swath	Fore	29.42 km
		Aft	26.24 km
02	IGFOV	Fore	2.452 m (Across track)
		Aft	2.187 m (Across track)
03	Ground sample distance		2.54 m (Along track)
04	Spectral band		0.5 - 0.85 microns
05	Quantisation		10 bits (1024)
06	Number of detectors		12 k
07	Pixel size		7X7 micron
08	Integration time		0.336 ms
09	Focal length		1945 mm
10	Data rate per Camera		336 mbps
11	Data compression ratio		3.22:1(nominal)
12	Type of compression		JPEG

Cartosat-1 completes 5 years of in-orbit operation

Payload

Cartosat-1 satellite has two panchromatic cameras with 2.5 m spatial resolution, to acquire two images simultaneously, one forward looking (Fore) at +26 degrees and another rear looking (Aft) -5 degrees for near instantaneous stereo data. The time difference between the acquisitions of the same scene by two cameras is about 52 seconds. The spacecraft body is steerable to compensate the earth rotation effect and to force both Fore and Aft cameras to look at the same ground strip when operated in stereo mode. Simultaneous stereo pair acquisitions are of great advantage since the radiometric parameters of the images will be identical. The stereo pairs have a swath of 26 km and a fixed B/H ratio of 0.62. The spacecraft also has a facility to provide various pitch-biases to vary the look angle conditions of the stereo pair. The satellite covers the same area in a specified interval of 126 days. The roll and tilt capability of Cartosat-1 can be used to increase the viewing frequency, which varies with latitude. The revisit capability at equator is 5 days.

CartoDEM

CartoDEM is generated using Augmented Stereo Strip Triangulation (ASST) - indigenously developed software by Space Application Centre, ISRO. The seamless CartoDEM generation is an automatic process and makes use of limited Ground Control Points (GCPs) in long stereo strip pairs using dense feature matching, Triangulated Irregular Network (TIN) modeling and automatic long strip mosaicing.

The generated DEM and ortho images of each Cartosat-1 segment are cut into tiles of 7.5'x7.5' extents. The entire Indian region is covered by approximately 500 Cartosat-1 segments with a total number of around 20,000 tile pairs. Every tile is subjected to quality verification process through panning and 2.5D draped visualization to identify and demarcate distortions in Quality Verification (QV) system for further improvement. The automatic generation of DEM has inherent problems like water-body irregularities, hill-top distortions, plain-area sinks and residual mosaics; and these are corrected in the Tile Editing (TE) system. Qualified CartoDEM tiles are formatted and archived systematically in database Dissemination System (DS).

CartoDEM Specifications

Parameters	Specifications
Image Format	Geo-Tiff
Data Type (DEM)	Signed short (2 bytes)
Data Type (Ortho-image)	Unsigned short (2 bytes)
Datum (planimetric and height)	WGS84
Projection	Geographic
Ortho Image Resolution	1/12 arc sec ~ 2.5 m
Posting	1/3 arc sec ~ 10 m
DEM type	Digital Surface Model
Absolute accuracy (Planimetric)	15m (CEP 90)
Absolute accuracy (Vertical)	8 m (LE 90)
Relative accuracy (Vertical)	> 5 m (LE 90)
Ellipsoidal height Units	Meters
Tile Extents (Size)	7.5'x7.5'
Generating Agency	NRSC / ISRO
Copyright	NRSC / ISRO

Systems of CartoDEM

CartoDEM is realised in a project mode, by a team of ISRO scientists from SAC, NRSC, RRSC and EOS, through the following indigenously developed software systems.

- DEM Generation System
- Quality Verification System
- Tile Editing System
- Dissemination System

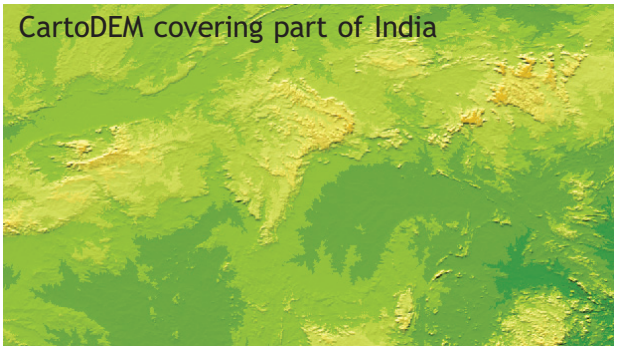
CartoDEM generation system is highly sensitive to subtle height variations due to high density of mass points and which does not necessitate introduction of break lines. The quality evaluation studies reveal that the achieved height accuracy is better than the specifications in plain and undulating terrains.

CartoDEM Applications

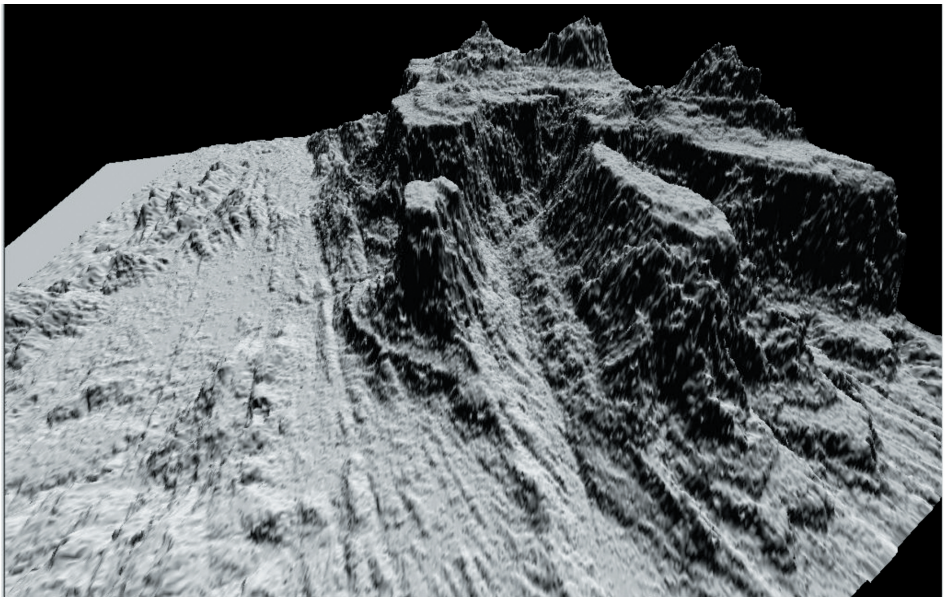
CartoDEM products are extremely useful in contour generation; drainage network analysis; quantitative analysis of run-off and soil erosion; volume-area calculations; design of hydraulic structures; design of new road, rail and pipeline alignments; watershed planning; urban utility planning; landslide zonation; river configuration studies and flood proofing; and fly through visualization; etc.

CartoDEM Coverage

More than 80% of the country is covered by CartoDEM and work is in progress to complete remaining parts of the country. The users can browse pictures of DEM and corresponding ortho-images at NRSC website.

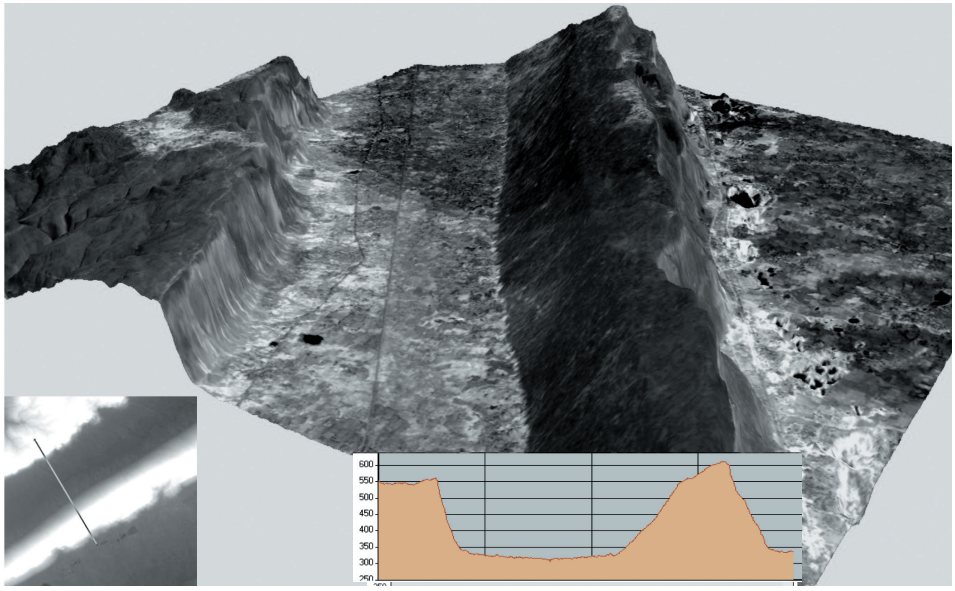


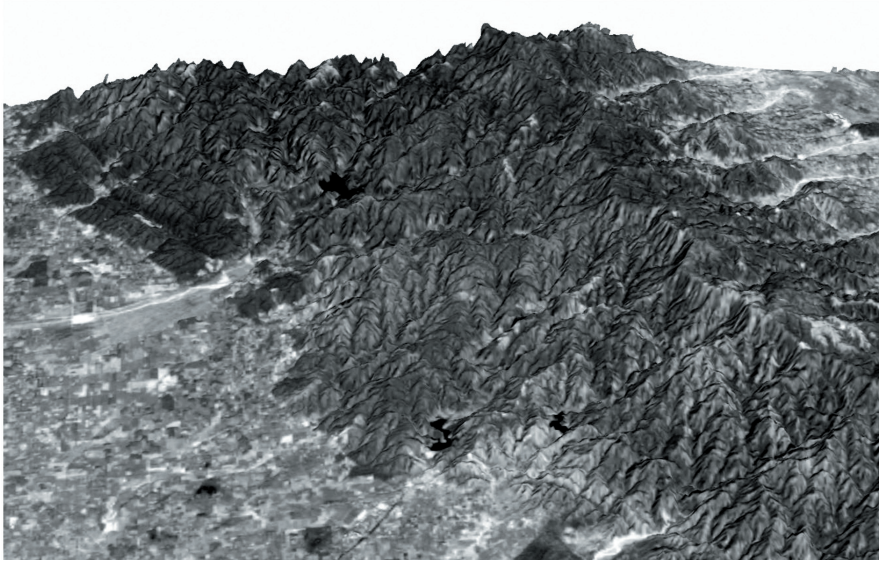
Perspective views generated using CartoDEM



This image corresponds to Trimbakeswar surroundings, Nasik district, Maharashtra, where the River Godavari originates. The area is dominated by plateae top, mesa, butte and with steep escarpment slope.

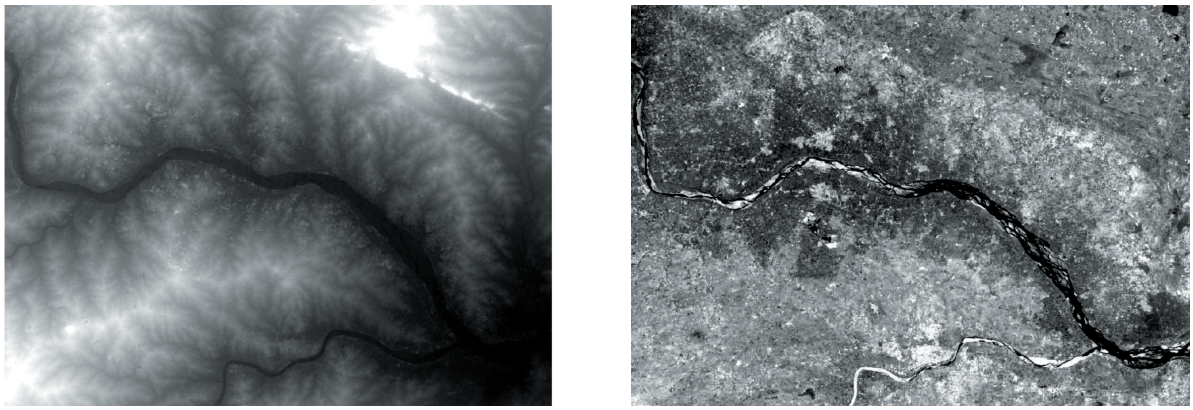
This image (ortho-image draped over DEM) corresponds to Maihar area in Madhya Pradesh and depicts broad valley with hogback and cuesta. The profile indicates a terrain variation of 300 m.



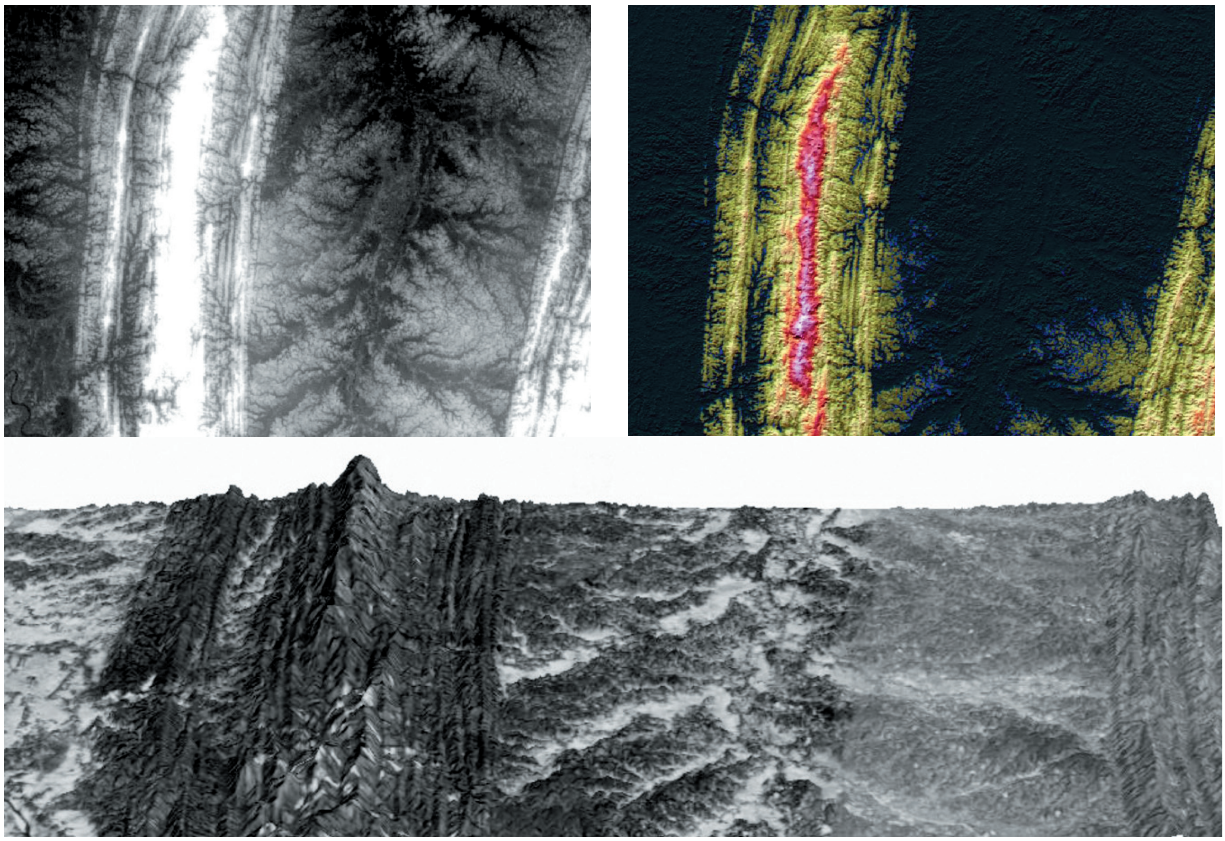


This image corresponding to part of Hoshiarpur district of Punjab, depicts highly dissected denudational hill with piedmont slope. The well defined drainage pattern is captured by CartoDEM without introduction of break lines.

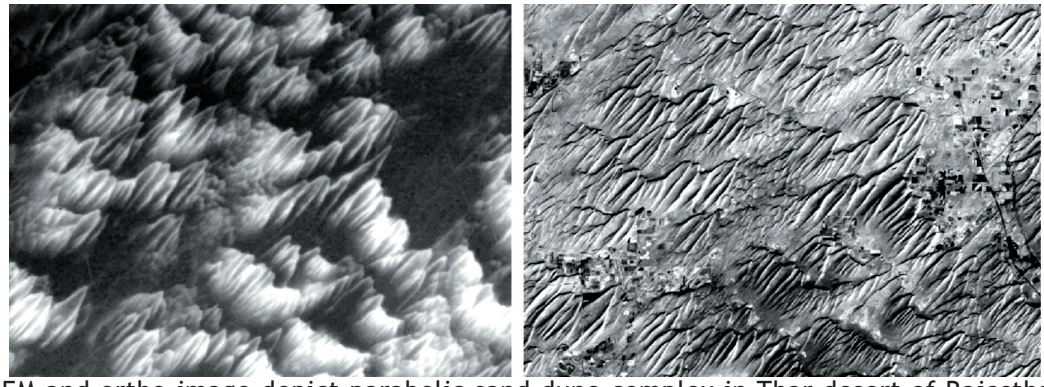
Sample Images of CartoDEM



DEM & ortho-image pair corresponds to Cauvery river basin in Tamil Nadu.
High drainage density is observed in a relatively plain area (height variation of ~ 70 m).

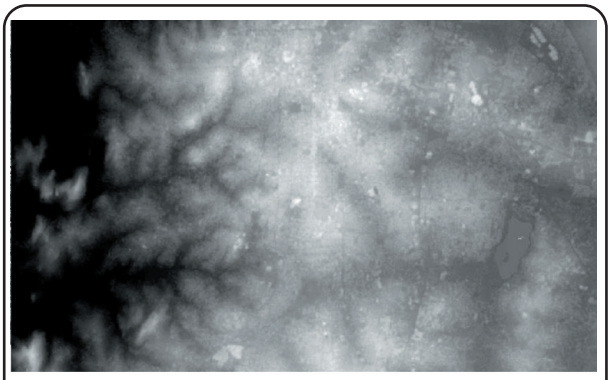


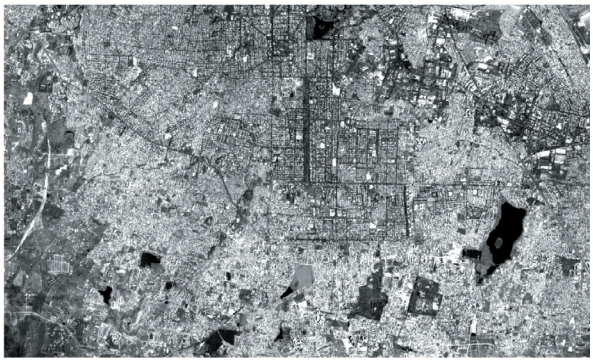
DEM, painted relief and perspective image corresponds to Dharmanagar in Tripura state depicts number of parallel anticlinal hills with synclinal valley & large drainage network in the valley area.



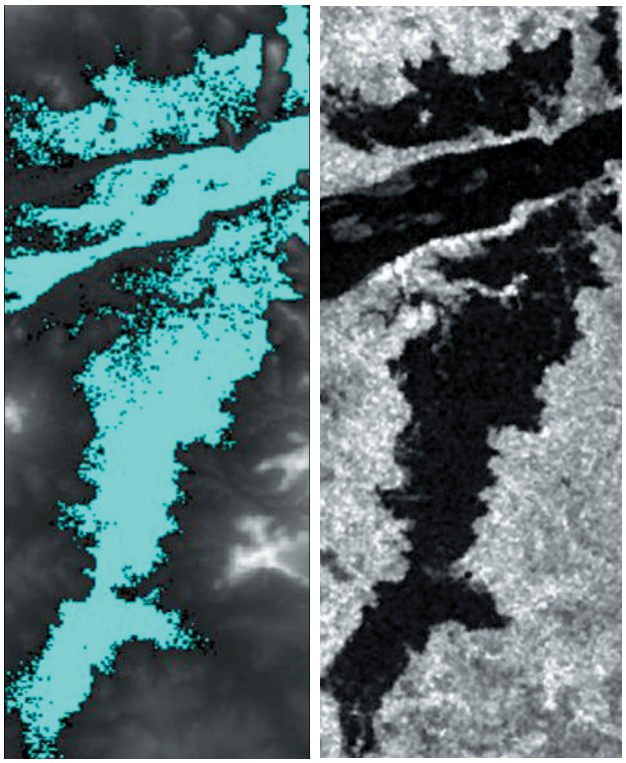
DEM and ortho-image depict parabolic sand dune complex in Thar desert of Rajasthan.
Minute variations in height of sand dunes is captured by CartoDEM in desertic terrain.

CARTODEM Applications

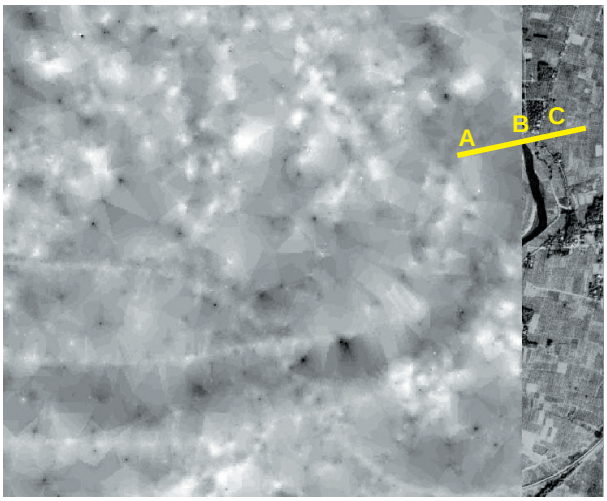


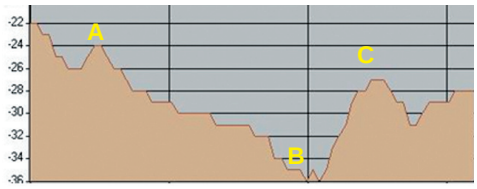


The DEM and ortho-image corresponds to part of Banaglore city, Karnataka. The drainage pattern and overland flow dirctions are clearly depicted in CartoDEM and highly useful for planning storm drainage in dense urban areas.



The simulated flooded area using CartoDEM (left) and corresponding actural flood inundated area, in dark tone, in a micro-wave image (right) of Mahanadi river basin demonstrates the potential of CartoDEM for identifying flood depth.



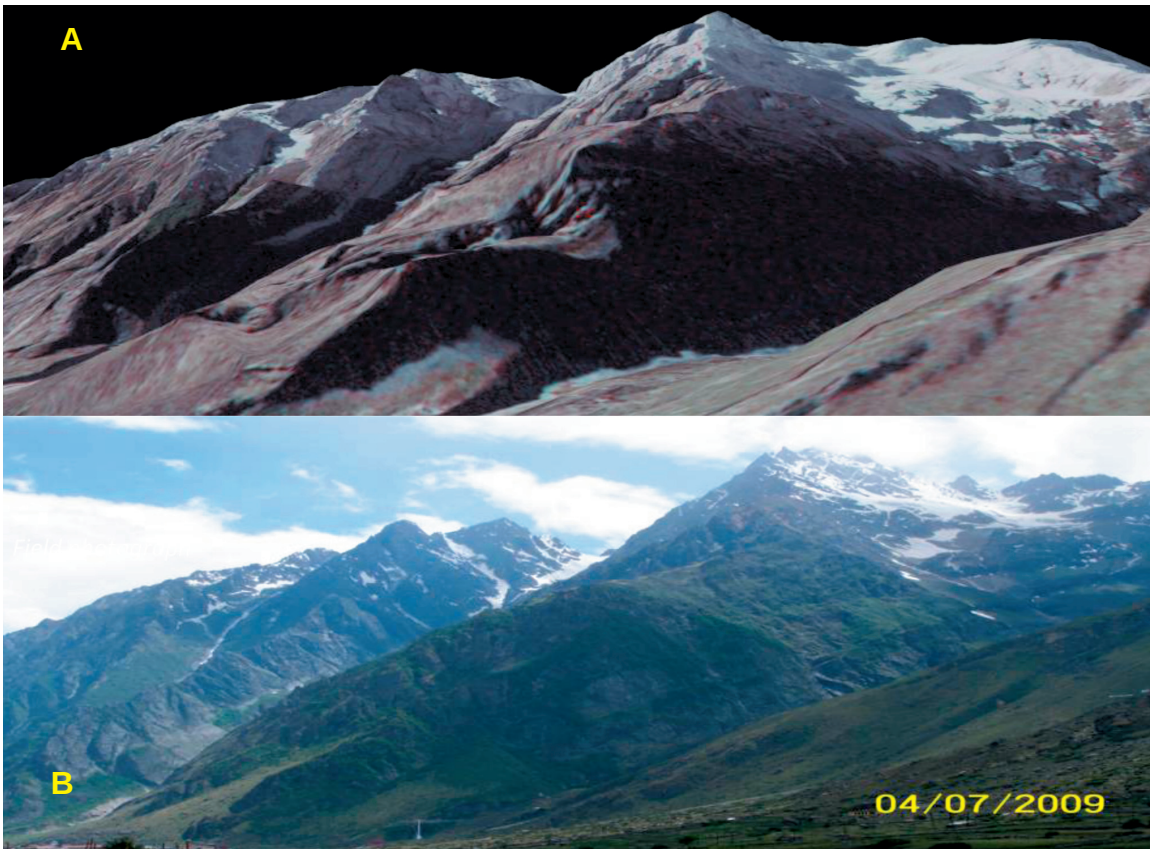


Point A: Left flood embankment
Point B: River
Point C: Right flood embankment

The DEM and ortho-image corresponds to part of Bihar. The DEM profile across the river in the flood plain clearly depicts subtle height variations (of 1 m) in slip-of-slope and undercut slope, which demonstrates the potentail of CartoDEM in flood management applications.

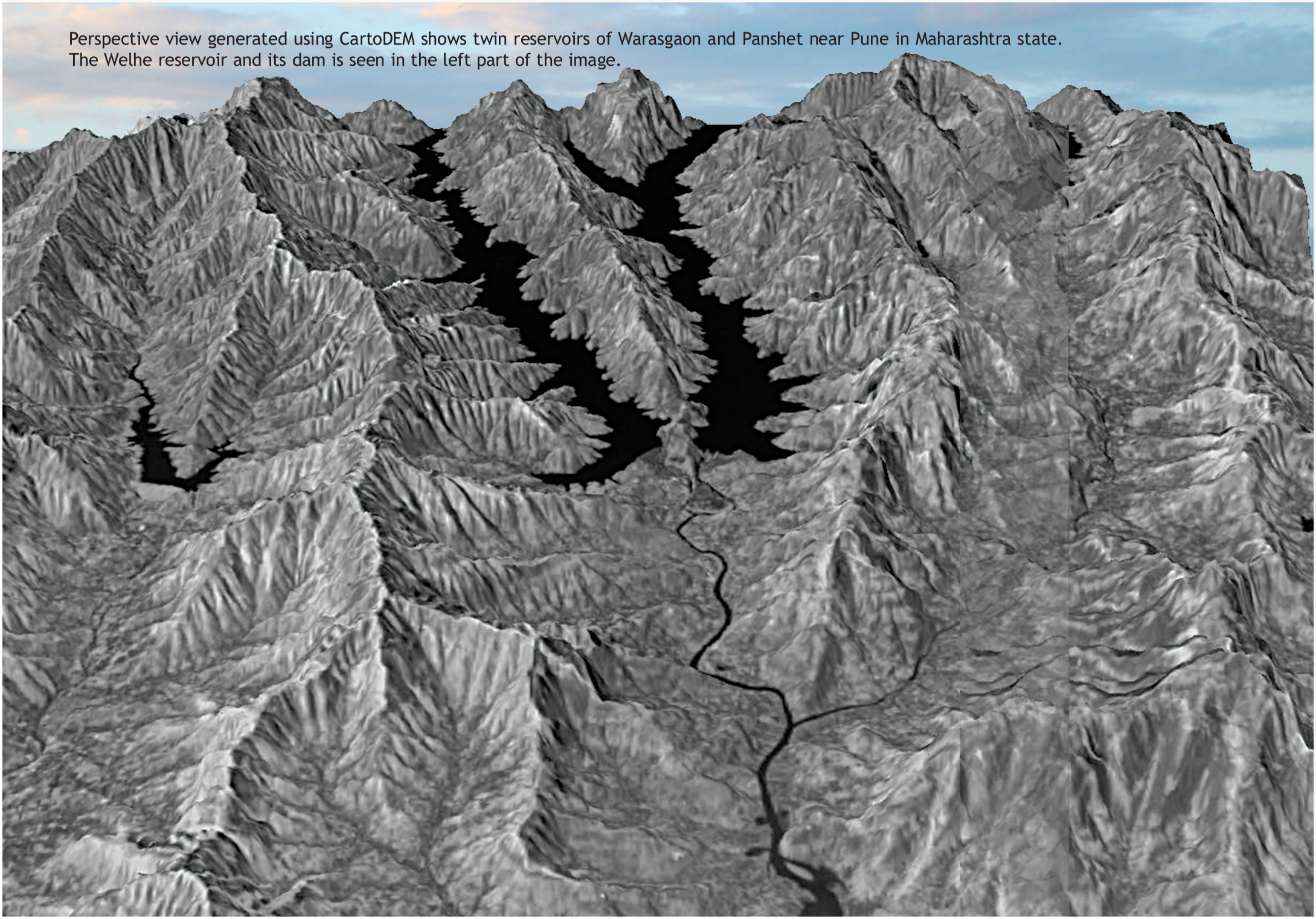
Realistic Perspective Views

A. Cartosat-1 ortho-image fused with LISS-IV draped over CartoDEM B. Corresponding field photo



Part of Narayan Parvat, Badrinath, Uttarakhand

Kurkuti village, Dhauliganga, Uttarakhand



Perspective view generated using CartoDEM shows twin reservoirs of Warasgaon and Panshet near Pune in Maharashtra state.
The Welhe reservoir and its dam is seen in the left part of the image.