Digital Elevation Model (DEM) Product Comparison Guide

Overview

Digital elevation models (DEMs) are quantitative measurements of Earth's elevation provided as georeferenced arrays. DEMs provide a three-dimensional view of Earth's topography and can be used to derive additional attributes such as slope, aspect, and curvature. Two common techniques used to remotely sense Earth's elevation and generate DEMs include (1) using a nadir-viewing and backward-viewing band from an optical sensor and (2) using a Synthetic Aperture Radar (SAR) sensor. The National Aeronautics and Space Administration's (NASA) Land Processes Distributed Active Archive Center (LP DAAC) processes, archives, and distributes several DEM data products that were generated from both optical and SAR sensors. This guide will discuss global DEM data products distributed by the LP DAAC, all of which are available at no cost to the public and provide background information as well as known observations to consider when choosing a suitable global DEM for the user's needs.

DEM Data Products

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is an optical instrument aboard the NASA Terra platform, which was launched on December 18, 1999, with data available from 2000 to the present. It consists of three sub-system instruments, visible and near infrared (VNIR), shortwave infrared (SWIR), and thermal infrared (TIR). The VNIR sub-system instrument acquires images in three bands, and the third band includes nadir- and backward-viewing telescopes that allow for creation of DEMs.

The ASTER DEM (AST14DEM), an on-demand higher level data product, relies on the VNIR nadir- and backward-viewing telescopes to create a stereo pair, which can be processed to generate DEMs. These products are mapped to the Universal Transverse Mercator (UTM) coordinate system with an accuracy of 25 meters root mean square error (RMSE) or less in xyz dimensions.

ASTER Global DEM (ASTGTM) version 3 was publicly released by LP DAAC in August 2019. ASTER GDEM V3 was generated using over 1.88 million Level 1A Terra ASTER scenes acquired between March 1, 2000, and November 30, 2013. All cloud masked scenes as well as non-cloud masked scenes were stacked and screened to remove abnormal data. For regions with limited scenes, other existing reference DEMs were used to correct residual artifacts. The ASTER Global Water Bodies Database (ASTWBD) data product, a near global raster dataset of water body surface, is a by-product of ASTGTM generated to correct elevation values of water body surfaces.

Shuttle Radar Topography Mission (SRTM)

The Shuttle Radar Topography Mission (SRTM) is a joint effort between NASA, the National Geospatial-Intelligence Agency (NGA), the German Aerospace Center, and the Italian Space Agency. Data derived from SRTM are based on interferometric observations from C-band and X-band synthetic aperture radar (SAR) antennas aboard space shuttle *Endeavour*. The mission flew February 11–21, 2000, imaging the Earth's surface between 60°N and 56°S; this accounts for 80% of the Earth's landmass. The spectral coverage for SAR operates at a much longer wavelength than optical sensors. C-band operates at 5.6 cm wavelength while X-band operates at 3.1 cm. Because radar operates at a longer wavelength, smaller particles such as cloud droplets are transmitted and not reflected. Additionally, C-band was used to provide mapping coverage as mandated by the mission, while X-band with higher signal-to-noise ratio was used to validate C radar processing and quality control.

SRTM DEM data products include global 1 and 3 arc second tiled data, swath and combined image data products, as well as SRTM water body data that identifies land and water classes.

NASA Global DEM

The NASADEM data products were publicly released by LP DAAC in February 2020. Interferometric SAR data from SRTM were reprocessed with an optimized hybrid processing technique in producing the data products. The data rely on multiple radar images to create interferograms with 2-dimensional phase arrays that result in greater elevation accuracy. Because of inherent characteristics of interferometric data, it needs to be wrapped and unwrapped so the data are quantifiable. NASADEM relied on the latest unwrapping techniques and auxiliary data that were not available during the original processing of SRTM data. The optimized technique minimized data voids and extended spatial coverage of the SRTM. Additional voids were filled with a variety of sources including ASTER GDEM, Advanced Land Observing Satellite (ALOS) Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), USGS National Elevation Dataset (NED), and Canada and Alaska DEMs. Vertical and tilt adjustments were applied based on ground control points and laser profiles from the Ice, Cloud and Land Elevation Satellite (ICESat) mission. This application improved the vertical accuracy, swath consistency, and uniformity within the swath mosaic.

Global DEM Specifications

	Terra ASTER	**SRTM**	**NASADEM**
Launch date	December 18, 1999	February 11, 2000	
Platform	Terra	Space Shuttle *Endeavour*	
Instrument type	Optical Sensor	Radar Sensor	
Datum	WGS84	WGS84/EGM96	
Spatial coverage	83°N - 83°S	60°N - 56°S	
Spatial resolution (meters)	30 m	30 m and 90 m[1]	

Acquisition period	March 1, 2000 – November 30, 2013	February 11 – 21, 2000	
Resampling method	Average of qualified input pixels[2]	Bi-cubic Interpolation	Nearest Neighbor, Bilinear Interpolation
Wavelength	0.52 – 0.86 um	C-Radar, 5.6 cm; X-Radar, 3.1 cm	

[1] Only SRTM is available at 90m.
[2] Complete details are available via ASTER GDEM V3 User Guide.

Known Observations

- Although both SRTM and NASADEM provide the same spatial coverage that extends between 60°N - 56°S, there is a noticeable difference. NASADEM relied on the latest hybrid unwrapping technique; therefore, previous data voids near the peripheral region of the spatial extent have been filled.
- ASTER GDEM V3 provides global spatial coverage; however, there are noticeable data voids over Greenland and Antarctica.
- SRTM contains more data voids over mountainous regions than the ASTER GDEM.
- Because ASTER GDEM V3 and SRTM/NASADEM are derived from two different instruments, there are inherent differences. One noticeable difference is ASTER GDEM V3 images might contain cloud coverage since ASTER is an optical sensor while SRTM and NASADEM are able to penetrate clouds because they rely on synthetic aperture radar.
- There are limited NASADEM data around the anti-meridian (180° longitude) region.