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A Comparison of U.S. Geological Survey Seamless Elevation Models with Shuttle Radar Topography Mission Data

Dean Gesch*, Jason Williams*, Wayne Miller
U.S. Geological Survey
EROS Data Center
47914 252nd Street, Sioux Falls, SD 57198
Phone: 605-594-2705, Fax: 605-594-6567
Email: jason@usgs.gov

Abstract – **Elevation models produced from Shuttle Radar Topography Mission (SRTM) data will be the most comprehensive, consistently processed, highest resolution topographic dataset ever produced for the Earth's land surface. Many applications that currently use elevation data will benefit from the increased availability of data with higher accuracy, quality, and resolution, especially in poorly mapped areas of the globe. SRTM data will be produced as seamless data, thereby avoiding many of the problems inherent in existing multi-source topographic databases. Serving as precursors to SRTM datasets, the U.S. Geological Survey (USGS) has produced and is distributing seamless elevation datasets that facilitate scientific use of elevation data over large areas. GTOPO30 is a global elevation model with a 30 arc-second resolution (approximately 1-kilometer). The National Elevation Dataset (NED) covers the United States at a resolution of 1 arc-second (approximately 30-meters). Due to their seamless format and broad area coverage, both GTOPO30 and NED represent an advance in the usability of elevation data, but each still includes artifacts from the highly variable source data used to produce them. The consistent source data and processing approach for SRTM data will result in elevation products that will be a significant addition to the current availability of seamless datasets, specifically for many areas outside the U.S. One application that demonstrates some advantages that may be realized with SRTM data is delineation of land surface drainage features (watersheds and stream channels). Seamless distribution of elevation data in which a user interactively specifies the area of interest and order parameters via a map server is already being successfully demonstrated with existing USGS datasets. Such an approach for distributing SRTM data is ideal for a dataset that undoubtedly will be of very high interest to the spatial data user community.**

I. Introduction

Elevation data produced from the Shuttle Radar Topography Mission (SRTM) will mark a significant advance in the availability of basic earth science data, especially for areas outside the United States where suitable topographic information for many applications is often lacking. Besides the significant increase in spatial resolution and vertical accuracy over many existing elevation datasets, the consistent source and processing for SRTM data are key characteristics that will benefit the user community. Extensive information on SRTM data collection and processing is available on the SRTM web site (www.jpl.nasa.gov/srtm/). SRTM data will be produced as "seamless" data, thereby avoiding many of the problems inherent in existing multi-source topographic databases. Seamless datasets have distinct advantages over tile-based datasets: processing has been performed so that the user sees data with a consistent resolution, projection, datum, format, and, in the best case, accuracy. The clear advantage with seamless data is that users have access to "application-ready" products, and thus they realize significant savings in the effort required to collect and assemble the base data needed for their applications.

II. Existing Seamless Datasets

Serving as precursors to SRTM data, several seamless elevation datasets currently exist, and they offer numerous advantages over traditional, tile-based, multi-source, multi-format elevation data sources. The U.S. Geological Survey (USGS) has produced and is distributing seamless elevation datasets that facilitate scientific use of elevation data over large areas.

A. GTOPO30

GTOPO30 is a global elevation model with a 30-arc-second resolution (approximately 1 kilometer) [1]. At the time of its release in early-1997, GTOPO30 represented a significant improvement in the availability of global elevation data. Previously, the best global elevation model had a resolution of 5-arc-minutes (approximately 10 kilometers). Currently, GTOPO30 still is the highest resolution global elevation dataset.

GTOPO30 was derived from the "best available" sources of digital topographic information. However, none of these sources covered the globe entirely, so eight different sources of variable quality and resolution were used. Although processing was performed during assembly of GTOPO30 to minimize the elevation differences in transition areas between data sources, changes in the topographic detail are

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still evident. Additionally, production artifacts present in some of the full resolution source data are visible even in the reduced resolution representation of GTOPO30. Fig. 1 shows an example of both the change in topographic detail at the boundary between different source data and the residual production artifacts, in this case a striping pattern.

GTOPO30 is currently being updated based on new source data that have become available since the original model was assembled. About 50% of the globe will be updated based on higher quality source data. Although these new data sources will reduce the differences in topographic detail across some source data transition zones, many of the artifacts will remain where new source data were not available

B. The National Elevation Dataset

The National Elevation Dataset (NED) is a seamless elevation model covering the United States at a 1-arc-second resolution (approximately 30 meters). NED is assembled from approximately 57,000 individual map-based digital elevation model (DEM) files. These source DEMs have been produced by the USGS for over 20 years, and they vary in resolution, accuracy, and data quality. The assembly of NED is analogous to GTOPO30 in that the source data are not consistent across the dataset. Also, as with GTOPO30, the assembly process for NED includes procedures to remove production artifacts where necessary and to minimize elevation discrepancies at transitions between differing source data types. For the most part, the assembly procedures have been successful in significantly improving the U.S. elevation data available to users, yet some artifacts still remain in the seamless NED (Fig. 2).

An important aspect of NED is that it is in a continual update cycle. Except for Alaska coverage, NED is now

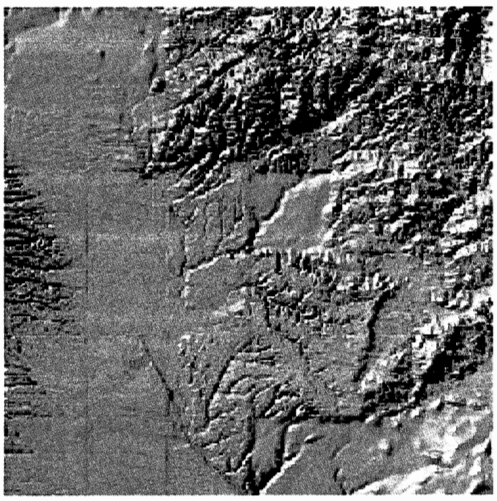

Fig. 1. Example of artifacts present in GTOPO30.

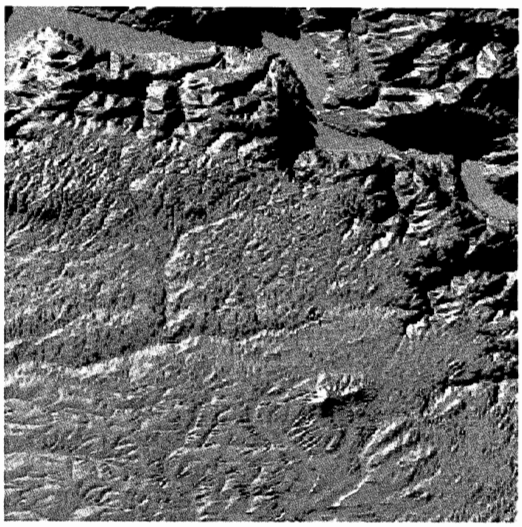

Fig 2. Example of residual artifacts present in NED.

assembled completely from 10-meter and 30-meter resolution source DEMs. New map-based DEM tiles, especially at 10-meter resolution, are being produced by the USGS and cooperating agencies, and they are incorporated into NED as they become available. Currently, an updated version of NED is released every two months, which includes all new source DEMs that became available since the previous release. However, even with ongoing source DEM production, which in most cases is replacing the oldest, least accurate 30-meter data, a majority of NED is still derived from source data requiring artifact removal and/or edge matching.

III. Advantages of SRTM Data

A. Seamless Production

Unlike existing seamless elevation datasets, SRTM elevation models are being produced from a consistent source. Also, the SRTM data production system has been designed to output consistently processed data over very large areas. Prior to mosaicking, processing is being done on as large a unit as possible, the entire length of a data take swath (60 kilometers wide by 450 to 18,000 kilometers in length). With the seamless data concept built in from the start, the SRTM production system should produce data that are not just seamless in format, but also data that have fewer artifacts than other seamless datasets assembled from varied sources. SRTM data will have the additional advantage of accuracy that is well characterized and reported for the entire dataset, a feature that is often lacking in large datasets derived from multiple sources.

B. Increased Global Resolution

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An obvious advantage of SRTM is the significant increase in resolution and accuracy over existing global elevation data. For many areas outside the U.S., the best available elevation data are GTOPO30 data. When the 3-arc-second (approximately 100-meter) publicly releasable SRTM data become available for these areas, a 100-to-1 improvement will be realized: 100 SRTM elevation measurements (a 10-by-10 matrix) will cover the area currently represented by one GTOPO30 elevation value.

A common application of digital elevation data that will benefit from SRTM data is that of automatically deriving land surface drainage features, such as watersheds and stream networks, for use in distributed hydrologic models [2]. Fig. 3 depicts the James River headwaters area of North Dakota in the north central U.S. The watersheds and stream networks derived from 1-kilometer (GTOPO30) data, and 100-meter and 30-meter USGS elevation data (representing SRTM-like products) are displayed, along with the reference watershed area (delineated manually from topographic maps). It is clear that in a low relief area like this, the increased topographic detail provided by higher resolution elevation data is critical for accurate mapping of hydrologic features. SRTM data will provide the necessary detail for many non-U.S. areas where accurate hydrologic feature mapping is not currently possible based on existing data.

IV. SEAMLESS DATA DISTRIBUTION

A primary benefit of managing data covering large areas in a seamless format is that users can specify an area of interest without having to work with predefined tiles of data. The user realizes additional benefits when the seamless data are available electronically on the Internet, thereby greatly simplifying data ordering and access, reducing delivery time, and reducing data acquisition costs. The USGS is currently distributing its seamless elevation data in such a manner. GTOPO30 data may be downloaded free of charge from the dataset Web site (edcdaac.usgs.gov/gtopo30/gtopo30.html). Although GTOPO30 data are distributed as tiles, the tile coverage is large enough that the study area for many users will be contained in only one or several tiles. Also, due to the seamless nature of the global DEM, users can easily join adjacent tiles. Future plans for the updated version of GTOPO30 call for allowing download of user-specified areas as an alternative to predefined tiles.

NED products are also available through a Web-based seamless data distribution system. The system utilizes interactive map server technology to provide users the capability for viewing shaded relief images derived from NED. The map server includes numerous reference layers to help users define their study areas. The system also includes a geographic names capability wherein users can automatically pan and zoom to specific feature locations. The user enters their customer and order information interactively, and orders for products resulting in network compatible file sizes can be delivered electronically at no cost to the user. Orders for larger areas are produced on hard media for the cost of reproduction and shipped to the customer. The NED data distribution system is available on the NED Web site (gisdata.usgs.gov/ned/).

V. SUMMARY

Because they will be produced seamlessly, SRTM elevation models will offer improvements in the quality of large-area elevation datasets for much of the global land surface. Existing seamless datasets, GTOPO30 and NED, were assembled and formatted as seamless products, but the source data used for each were not originally produced to support easy integration into a seamless database design, thus extensive post-production processing was required to generate a seamless product. SRTM elevation data have the advantages of a singular type of source data, consistent processing, thoroughly characterized accuracy, and improved resolution (for many parts of the world). Elevation data users currently have online access to USGS seamless elevation products, and this is preparing the user community well for seamless distribution of SRTM data. The lessons learned by the USGS from its experience with current seamless datasets will be valuable as plans are developing for distribution of publicly available SRTM products.

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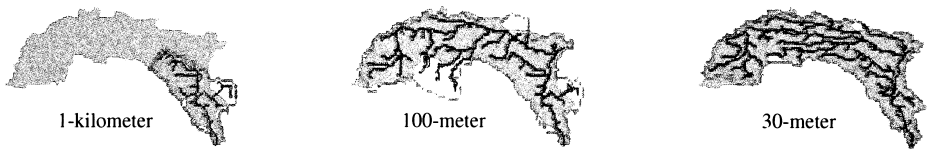

Fig. 3. Watersheds and stream networks (derived from different resolutions of elevation data) overlaid on the reference watershed area.

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