Comparison of SRTM Data with other DEM sources in Hydrological Researches

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Abstract: The Shuttle Radar Topography Mission (SRTM) delivered a digital terrain model of better spatial resolution and accuracy than traditional free global DEM datasets at near-global coverage and made a wide range of detailed hydrologic applications feasible. In this study, the SRTM data is compared with the digitalized topographic contour DEM in hydrological analysis over the QingJiang catchment in HuBei province of China and a void patching method of SRTM for hydrological research is proposed. Drainage networks and catchment boundaries are generated with TOPAZ from both DEM datasets. The result shows that the voids in the raw SRTM dataset should be a big problem to hydrological analysis and the voids need to be treated carefully. The proposed void patching method can avoid the overestimation elevation values in drainage networks and make SRTM data more suitable to hydrological analysis.

Key Words: SRTM, DEM, hydrology, QingJiang

1. INTRODUCTION

Digital elevation models (DEMs) are becoming more and more important in hydrological modeling and in water resources management because they can provide many hydrological relevant parameters, such as drainage networks and catchment boundaries. In practice, DEMs are often derived from stereo-photos or satellite imagery such as stereoscopic SPOT image and from digitalized topographic contour. Not only the procedures are time-consuming and costly, but also the resolution, quality, and availability of these derived DEMs are highly variable, leading to tremendous problems for research over large regions. Although various free global datasets of topography, such as GTOPO30, have been widely used for many years and played an important role in hydrological researches especially for macro-scale application, the lower spatial resolution prevented their abilities in modeling more detailed earth surface processes.

The Shuttle Radar Topography Mission (SRTM) was a joint venture of NASA's Jet Propulsion Laboratory (JPL), National Imaging & Mapping Agency (NIMA), the German and Italian Space Agencies. Using the Spaceborne Imaging Radar (SIR-C) and X-Band Synthetic Aperture Radar (X-SAR) hardware that flew twice on Space Shuttle Endeavour, the mission collected 12 terabytes of data cover the entire globe (latitudes 60N to 60S) in February 2000 in about 10 days. The DEMs currently distributed by the USGS were derived from interferometric analysis of the C band signal and were processed by NASA. The data were gridded with a resolution of 1 arc-second by 1 arc-second (SRTM-1) that has been made available to the public only for North America. A resample version with resolution of 3 arc-second by 3 arc-second (SRTM-3) is freely for the whole global with the accuracy is given as ±16 meters. This giant leap forward in spatial resolution for DEMs with global coverage is likely to change the way in which related research can be performed and applied, bringing local catchment scale hydrological modeling into the realm of global applicability[1,2,3].

While the data coverage of SRTM is global, some regions are missing data because of a lack of contrast in the radar image, presence of water, or excessive atmospheric interference. These data holes are especially concentrated along rivers, in lakes, and in steep regions (often on hillsides with a similar aspect due to shadowing). This non-random distribution of holes, ranging from 1 pixel to regions of 500 km^2, impedes the potential use of SRTM data, and has been the subject of a number of algorithms for "filling-in" the holes through various spatial analysis techniques. These include spatial filters, iterative hole filling, and interpolation techniques, many of which are still under development and testing[4].

The object of this work is to access the quality of SRTM in the hydrological research through the comparison of SRTM with the digitalized topographic contour DEM data, especially focusing on the effect of voids in the SRTM dataset.

2. MATERIALS AND METHODS

2.1 Data Acquirement and Preprocessing

The QingJiang catchment, which is one of the main sub-catchment of Yangtse Rive Basin, is located at HuBei province of China. The length of main stream is about 423 kilometers and the area of whole catchment is about 17,000km^2.

In order to perform the hydrological analysis of SRTM data, the first step is to obtain the SRTM DEM data covering the whole catchment. In this study，the SRTM data were downloaded from ftp://edcsgs9.cr.usgs.gov/pub/data/srtm/. Six datasets including N29E108.hgt, N29E109.hgt, N30E108.hgt, N30E109.hgt, N30E110.hgt and N30E111.hgt covering the whole QingJiang catchment were prepared for the following analysis.

The downloaded SRTM data have many voids which make the raw SRTM DEM not suitable for hydrological analysis and these data holes must be filled in at first. Martin[4] describes the filling-in methods and software dealing with these data failures in detail. After comparing the results of these methods, the patching method with free lower resolution global DEM dataset is chosen in this study for it is suitable for the whole global and the result seems relative well. All of the data voids in the SRTM datasets are patched with the DTED0 data at the aid of free BLACKED software.

Several other processing steps need to be performed to these void-free SRTM data before the hydrological analysis. The first is mosaicking the six SRTM DEM files to one file covering the whole area, the second is reprojecting the mosaicked SRTM data to UTM projection system (the spatial resolution is set to be 90m) for the geographic reference system of raw SRTM data is not suitable to hydrological analysis.

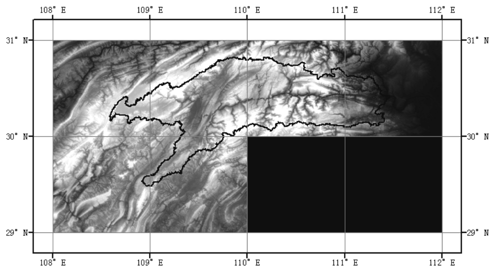


Fig1. SRTM DEM data covering the whole catchment

Moreover, another DEM dataset is derived from the 1:250,000 digitalized topographic contour with the interval of 100m. This DEM dataset called TopoDEM in this paper is also reprojected to UTM system and the spatial resolution is set the same as SRTM DEM (90m) in order to perform the comparison between these two DEM datasets.

2.2 Hydrological Analysis Model

At present, there are many tools could be used in hydrological analysis, such as the hydro model of ESRI, RiverTools of RSI and TOPAZ (TOpographic PArameteriZation) software. The TOPAZ model was chosen in this study for the ease with which it can be applied to DEMs, and its use of well-established techniques for deriving topographic variables and parameters[5].

TOPAZ processes a grid DEM to extract many topographic and hydrological variables that are physically meaningful to watershed runoff processes. TOPAZ consists of several modules which perform the processing of grid DEMs to identify topographic features, measure topographic parameters, define surface drainage, subdivide watersheds along drainage divides, quantify the drainage network and parameterize sub-catchments.

TOPAZ first modifies the input DEM to remove depressions and flat areas to eliminate indefinite downslope drainages and uses the common D8 method to determine the direction of overland flow at each cell of a DEM. Then the main watershed boundary is determined from flow direction data and once this boundary is determined, the drainage network for the basin under study is derived with two user specified parameters, critical source area (CSA) and minimum source channel length (MSCL). Other processing generates spatial landscape information and parameters (e.g. slope; aspect; etc.) and provides raster reformatting to allow the display of raster output as images using GIS.

3. RESULTS AND DISCUSSION

SRTM DEM and the TopoDEM are both used to derive the drainage networks and catchment boundaries with the TOPAZ software. After many calibration runs, the CSA and MSCL are set to be 50km^2 and 4km. The derived drainage networks and catchment boundaries are shown in fig2a and fig2b respectively.

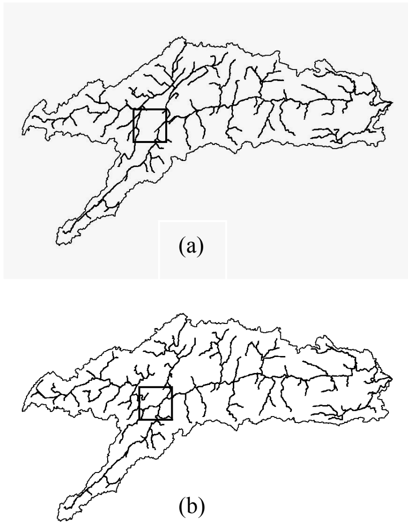
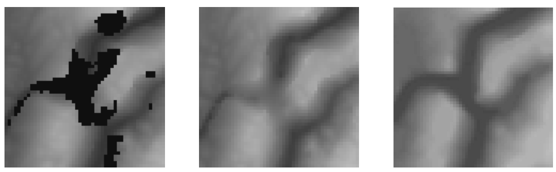


Fig 2.The drainage network and catchment boundaries derived from DEM datasets. (a) SRTM DEM; (b) TopoDEM

After the comparison of these two results, it could be concluded that these two results are similar except some zones such as the area in the black rectangle. To explore this phenomenon, the raw SRTM DEM, the patched SRTM DEM and the TopoDEM in this rectangle area are compared in Fig3. It could be found that there are many overestimated elevation values in the patched SRTM data, which are voids in the raw SRTM data. These overestimated elevation values make the river network not successive any more.

Through the analysis of these three datasets, the conclusion could be made that for there are many voids in the raw SRTM data along the river and the elevation values beside the river change rapidly, the surrounding elevation values should make the patched elevation much higher than the real values, especially the elevation value in the drainage network. Although TOPAZ can effectively handle depressions and flat areas in the input DEM using an innovative combination of depression outlet breaching, depression-filling, and relief imposition, it still can not deal with these overestimated errors caused by the voids in the raw SRTM data and lead to the unsatisfied result [5,6].



(a) (b) (c)

Fig 3. The DEM data in the rectangle of fig2. (a) Raw SRTM data (black represent voids); (b) The patched SRTM data; (c) TopoDEM

For the voids always locate along rivers and in steep regions, the overestimated elevation values over drainage networks are ubiquitous in the patched SRTM DEM data. And for overestimated value error in DEM is difficult to be deal with in the hydrological analysis algorithms at present, these error values over the drainage network must be eliminated carefully before the DEM are imported into the hydrological analysis software.

In this study, a SRTM patching method at the aid of the digitalized drainage network from the map is proposed to eliminate the overestimated elevations over the drainage network.

At first, the digitalized drainage network overlays with the SRTM data and the SRTM pixels over the drainage network are masked. Then, the voids of the masked river pixels are patched with a simple method. Tracing from the outlet of the river to upstream, if the pixel has the elevation value then let it alone. In case the pixel is void, find two pixels which have elevation values at the upstream and downstream of this pixel along the drainage network and use the simple linear resample method to set the elevation value of this void. After all of the voids over the drainage network are patched, other voids in the SRTM data should be patched as the normal method mentioned above.

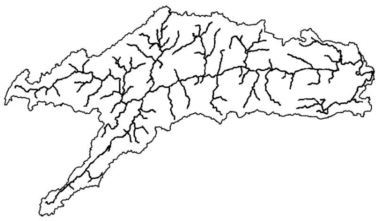


Fig 4. The drainage network and catchment boundary derived from SRTM DEM datasets with new patching method

Fig4 shows the network and catchment boundaries extracted with the SRTM data dealt with the new patching method and the result is evident better than the result of normal patched SRTM data.

4. CONCLUSION

SRTM is one of the most important DEM source could be obtained free for the nearly whole global area and should be a wonderful data to bring local catchment scale hydrological modeling into the realm of global applicability. However the voids in SRTM data make this dataset not suitable to many researches. The void filling method at present could handle this problem in some extend, however for hydrological analysis, these methods should overestimate the value in the river network and cause the hydrological analysis result unsatisfied. With the help of digitalized river network from the map, this problem could be overcome with the patching procedure proposed in this paper.

Although the SRTM data should be compared with more other DEM data sources and more analysis should be made to validate SRTM data at different area, especially the voids patching result. In general, for SRTM offers a consistent representation of topography on a near-global scale, it provides a promising new means to obtain important hydrological relevant parameters for hydrological researches.

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