Evaluating TauDEM Delineated Stream Networks Against the National Hydrography Dataset

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CI-WATER A Utah-Wyoming Cyberinfrastructure Water Modeling Collaboration
http://ci-water.org/

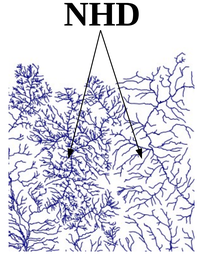
EPSCoR EPS 1135483
Paper# H23E-1310

Abstract

TauDEM is a computer program for delineating stream networks and watershed boundaries from Digital Elevation Model (DEM) raster data. To evaluate the quality of TauDEM output we have compared a TauDEM delineated stream network generated from a 10 meter USGS National Elevation Dataset (NED) DEM against the stream network of the USGS National Hydrography Dataset (NHD) using Hausdorff distance as a similarity metric.

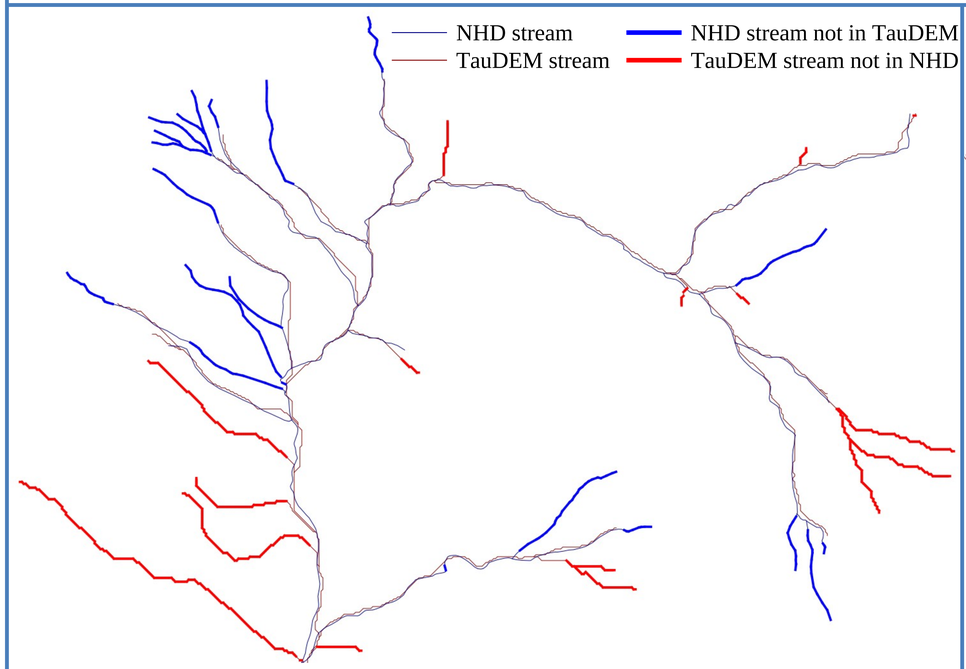
In general, the quality of the TauDEM output is very good, but we found three areas of difficulty. First, TauDEM uses only collecting area to determine the initiation points of streams. It was not possible by varying this single parameter to match the stream initiation points in NHD over the entire stream network. Second, The TauDEM stream network showed increased errors in areas of low slope. Third, TauDEM could not identify human created channels smaller than the resolution of the DEM.

Anomalously High Stream Density in NHD



Methodology

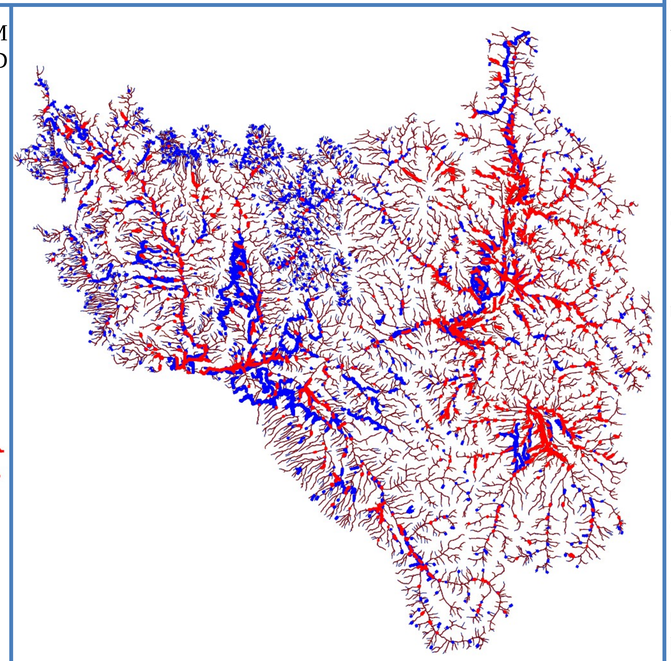
- Comparison of two stream network datasets of Hydrologic Unit Code (HUC) 14010001
  1) USGS National Hydrography Dataset (NHD)[5]
  2) Generated by TauDEM software[4] from USGS National Elevation Dataset (NED) Digital Elevation Model (DEM) 1/3 arc second resolution (~10 meters)[6]
- For the purpose of evaluating the quality of the stream network generated by TauDEM software
- Hausdorff distance metric[3,8] used to find locations on each stream network not within 50 meters of a location on the other stream network



Stream Initiation Point Disagreement

The vast majority of disagreements between NHD and TauDEM are of a single type where they disagree not on the location of a stream's course, but on its initiation point, or whether a particular side branch counts as a stream or not. In TauDEM there is a single parameter, collecting area, that determines the initiation points of all streams. All DEM cells with a collecting area above a specified threshold are considered streams. We found that there was no setting of the threshold that caused TauDEM to match NHD on the initiation points of most streams.

One possible cause of this is if the initiation point of a stream is affected by factors independent of collecting area such as soil type or rainfall rate. However, another possible cause is inconsistency in the NHD. The NHD exhibits some areas of anomalously high stream density. The NHD data were compiled from multiple sources[7]. The anomalously high stream density suggests some of those sources may have had different stream initiation point criteria. There is also research suggesting that NHD underestimates the drainage density of hydrologically meaningful streams[1]. Because of these issues NHD may not be a good source to be taken as ground truth of stream initiation points. Further work will need to be done to validate the accuracy of the stream initiation points generated by TauDEM.



Increased Errors in Areas of Low Slope

Errors other than stream initiation point disagreement tend to be clustered in areas of low slope. We believe this is caused by limited relative vertical accuracy in the source DEM. A study[2] on the vertical accuracy of 1 arc second (~30 meter) NED DEMs determined a mean relative vertical accuracy of 1.64 meters, which implies a mean slope accuracy of 2.73 percent.

The study noted that, “As the NED is continually upgraded based on new acquisitions of high-resolution data, the overall vertical accuracy should improve.” The more recent 1/3 arc second dataset may have better accuracy than this, but no similar study has been done on that data. Our experience was that at around one percent slopes and below the quality of the TauDEM output was seriously degraded. This would make sense if that is the slope accuracy of the source DEM.

Conclusion

There are three primary causes of disagreement between NHD and TauDEM stream networks.

First, they disagree on stream initiation points. When both have a stream they generally agree on the location of the stream, but they often disagree on where the stream initiates, or whether a particular side branch counts as a stream. There is some evidence that NHD may not be an ideal definitive source for the hydrologically meaningful initiation points of streams.

Second, TauDEM has more errors in areas of low slope. We believe this is caused by the limitation of the relative vertical accuracy of the DEM, and is not an inherent problem with TauDEM.

Third, TauDEM cannot identify human created channels smaller than the resolution of the DEM. These channels often do not follow natural slopes precisely because they were created to redirect where water will go.

The second and third difficulties point to the utility of LiDAR and other high-accuracy, high-resolution measurements when generating DEMs for hydrologic modeling of channels.

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