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FEATURE

Elevation-Derived Hydrography: The USGS's rich new hydrological features dataset

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The US Geological Survey (USGS) is the main source of publicly available elevation data in the United States. One of the USGS's major programs, the 3D Hydrography Program (3DHP), includes Elevation-Derived Hydrography (EDH), a detailed water features dataset that is derived from elevation data such as Digital Elevation Models (DEMs). EDH fills the need for hydrography data that align with elevation data, which is important for analysis such as flood modeling. It is difficult to use hydrographic and elevation data together if they do not align—for example, a hydrographic features dataset produced from imagery might indicate a different location for a river's edge than an elevation dataset over the same area. Because EDH data consist of hydrological features derived from an elevation dataset, the two datasets will align, enabling more accurate analysis and hydro modeling.

This new dataset promises to be a very useful tool for a wide range of natural resource applications. In fact, the USGS posted a *Hydrography Requirements and Benefits Study* (Dewberry 2016), which indicated that the value of the benefits provided by hydrographic data could exceed US$1 billion annually in the United States. These benefits are broken down by "business uses," which include river and stream flow management, water quality, coastal zone management, and many others. Amongst the public and private hydrographic data users who participated in this study, with regards to hydrographic data integration, "the top five requirements for integration with other datasets were elevation, stream flow, wetlands, soils, and land cover, with integration with elevation data being the top requirement." EDH data are therefore an important tool that can help meet the needs of many hydrological data users by offering this valuable integration of hydrological and elevation data.

WHAT IS ELEVATION-DERIVED HYDROGRAPHY?

The EDH dataset currently available in select areas of the United States provides detailed information on water features, including not only location and size, but also direction of water flow and connectivity. These data enable hydrological modeling, which is not possible without direction or flow; static hydro feature data are less useful, as they only enable viewing the location of water features. By accounting for network connectivity, EDH data enable more robust analysis. Additionally, EDH data offer improved accuracy for hydro feature location by referencing elevation data. One of the common ways the resolution of EDH data is defined is through the Hydrologic Unit Classification (HUC) level. The higher the HUC number, the smaller the minimum watershed area and therefore the higher the resolution of the resultant EDH data. These data are provided in several formats, including the following:

- National Hydrography Dataset (NHD) vector data, which include water linework (e.g., rivers);
- Watershed Boundary Dataset (WBD) vector data, which include nested catchment areas and enable users to examine water feature network connectivity; and
- Hydro-Enforced DEMs, which provide accurate modeling of the Earth's surface due to the integration of spatially aligned water and elevation data—these are useful for any analysis/modeling involving the Earth's surface, such as water runoff or erosion analysis.

HOW IS ELEVATION-DERIVED HYDROGRAPHY MADE?

As with other elevation-related products, there is no single definitive approach to create EDH data. Geospatial software provider Esri (Redlands, California) has hydrography workflows and solutions available for their software users; geospatial data provider Surdex (Chesterfield, Missouri) used one of Esri's workflows as a starting point and modified as needed—for example, based on the ruggedness of the terrain, tolerances were set to generate specified lengths of derived hydrography ensuring features were limited to main tributaries. Surdex's adapted workflow is outlined below:

1. Prepare source 3DEP data. For example, ensure proper projection, process hydrographic polygons, and create required centerlines.
2. Develop derived stream features. This is completed using a hydrography model—with ArcHydro, for example (figure 1). The DEM is processed to fill sinks and create flow direction and flow accumulation rasters, which are used to derive the initial hydrography lines.
3. Classify 3DEP surface using geomorphic indicators. These indicators include depression, valley, footslope, hollow, slope, spur, shoulder, ridge, summit, and flat. This results in a continuous surface classified by geomorphons (figure 2).
4. Perform cartographic refinement. Use data sources such as geomorphon index, contours, hillshade, and imagery to confirm and refine hydro feature locations (figure 3).
5. Apply topological rules and build hydrography network. Ensure proper connectivity and incorporate junction nodes, directionality, etc.
6. Complete attribute/schema review. Conflate attributes from existing NHD data, if applicable, and confirm that feature codes and domains align with the latest NHD hydrography schema.

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Figure 1
Progression of developing derived stream features from a Digital Elevation Model (left to right).

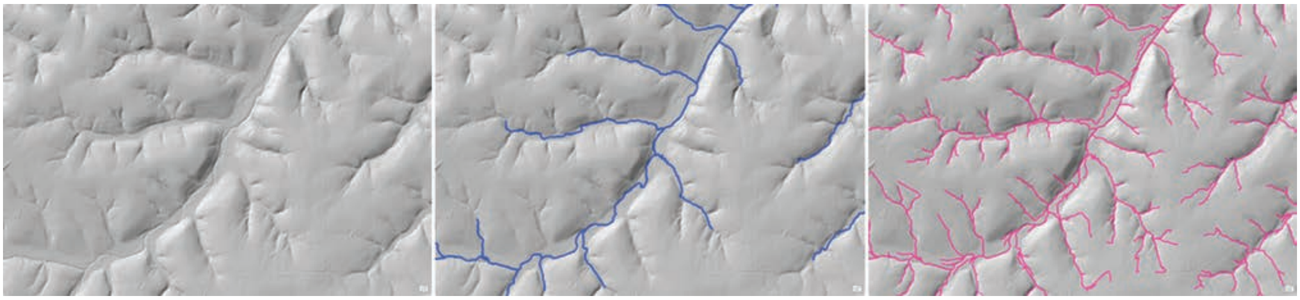


Figure 2
Geomorphon index data overlaid on hillshade data for Elevation-Derived Hydrography production.

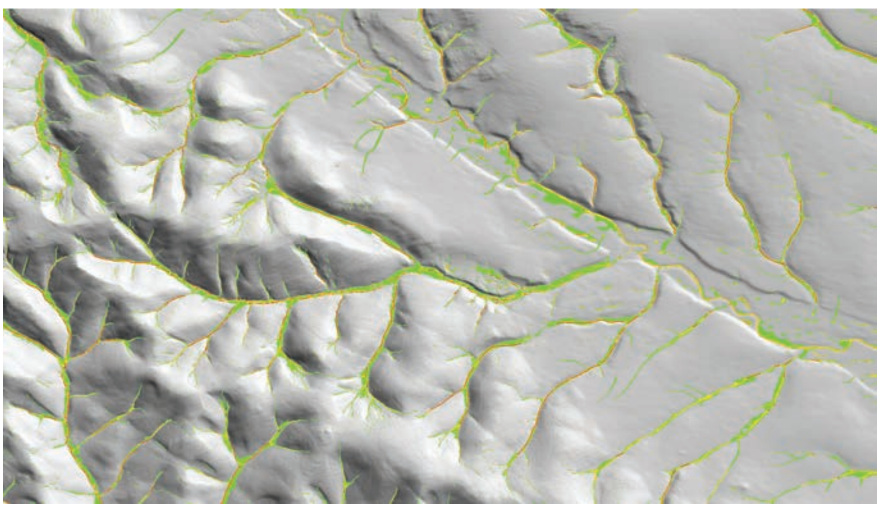
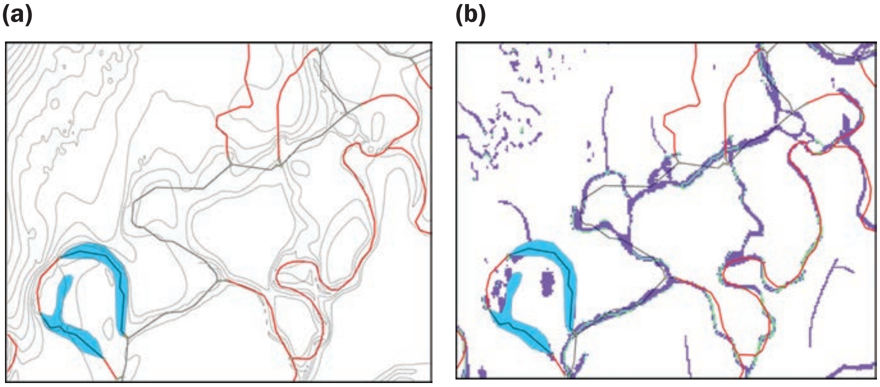


Figure 3
(a) Using contours and (b) geomorphon index to validate and refine stream location in Elevation-Derived Hydrography dataset.

(a) (b)



WHAT CAN I DO WITH ELEVATION-DERIVED HYDROGRAPHY DATA?

EDH data have a wide range of applications and are especially helpful for natural resources-related analyses and planning tasks across a variety of professions, such as forestry, conservation, hydrological engineering, and countless others. Users include federal and local government entities, as well as private sector firms. A few examples of EDH applications include:

- Flood forecasting and planning for oncoming weather events
- Water resource management (e.g., reservoirs and dams)
- Habitat modeling
- Waterway navigation

By using EDH data in place of older and less accurate hydrological data for these and other applications, data users can make more accurate and informed decisions in their field of work. Additionally, these data are publicly available at no cost, so anyone—including government entities as well as commercial enterprises and private individuals—can benefit from its use. Per the USGS Office of Communications and Publishing, integrating EDH data into currently available hydrographic data "will support applications such as flood forecasting to move from the neighborhood to the street level by making the data more detailed, accurate, and precise" (USGS Office of Communications and Publishing 2020).

EXAMPLE ELEVATION-DERIVED HYDROGRAPHY PROJECT

In the fall of 2021, the USGS issued a task order to the Merrick-Surdex Joint Venture (MSJV) for EDH data through a Geospatial Products and Services Contracts (GPSC3) agreement. This task order included the creation of EDH data, which were to be derived from existing QL5 Interferometric Synthetic Aperture Radar (IfSAR) data for an area of over 5,000 mi^2 in southwestern Alaska covering the Upper Nushagak River. Over the following few months, the MSJV worked closely with the USGS to train technical staff for proper data collection procedures, since this was one of the first EDH projects completed through a USGS GPSC contract. Deliverables included an updated HUC-12 hydrography network, updated watershed boundaries with pour points, as well as a Hydro-Enforced Digital Elevation Model. Significant changes were made to the existing watershed boundary data using high resolution data (IfSAR, new hydrological features and pour points); these updates resulted in more accurate watershed boundary data, which can be used to perform more reliable analyses (e.g., for natural resource management).

FINAL THOUGHTS

By increasing certainty in decision-making, EDH data have immense potential to improve a wide variety of water and land resource assessment and planning tasks. In the past, hydrological feature data were collected separately from elevation data (for example, from imagery). As a result, the two datasets could have instances of mismatch due to differences in the date of collection, scale, accuracy, and other variables. Integrating the two datasets required making assumptions about water feature locations in areas of misalignment, which could result in uncertainty regarding the integrated data and any subsequent analyses performed. With EDH data, because the hydrological feature data is derived *from* the elevation data, the two datasets can be integrated seamlessly without uncertainties caused by disparity between the datasets.

EDH data are a focal point in the USGS's 3DHP, "the first systematic remapping of the nation's hydrography since the original USGS 1:24,000-scale topographic mapping program was active" (USGS n.d.). The demand for this type of data is anticipated to increase significantly over the next few years as evidenced by the *Hydrography Requirements and Benefits Study* and the current and planned projects in the 3DHP, which can be viewed on the USGS's 3DHP web page.

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