

Technical Report No. SRH-2013-XX

Development of Software Tools for Efficient Processing of Bathymetry and Discharge Data Final Report, Science & Technology Proposal ID 3937



U.S. Department of the Interior Bureau of Reclamation

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION Technical Service Center, Denver, Colorado Sedimentation and River Hydraulics Group, 86-68240

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Development of Software Tools for Efficient Processing of Bathymetry and Discharge Data

Final Report, Science & Technology Proposal ID 3937

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Executive Summary

Details regarding the development and guidelines for application of a software tool, HydroProc, for processing bathymetry data are described. The computational backbone of HydroProc is comprised of several freely available geodetic source codes that have been modified and integrated under a single user interface. The software is designed to process data collected using a Sontek M9 ADCP (Acoustic Doppler Current Profiler) and HydroSurveyor software package with Trimble R8 GPS receiver. The goal of the project is to provide a seamless and efficient means for producing point-based bottom bathymetry from data collected using the ADCP with GPS information. The HydroProc methods are generally extendable to variations in equipment, data collection procedures, and end-user needs.

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Introduction

Bathymetric surveys are increasingly becoming an integral part of the hydraulic studies that the Bureau of Reclamation is performing for its clients on a regular basis. Detailed bathymetry data is useful in estimating zones of sediment aggradation and degradation in rivers and reservoirs (with implications to reservoir sustainability), tracking channel and bar migration, and for setup and calibration of numerical models.

Reclamation needs to collect depth and velocity data in rivers for numerous habitat and sedimentation investigations. Numerical models of river hydraulics, sediment transport, and vegetation growth and mortality are used to predict river conditions over a range of flows. These models depend on accurate channel bathymetry and flow velocity data.

Using modern acoustic depth-sounding instruments and GPS equipment mounted to a floating raft, a small team of hydraulic engineers can map the bathymetry of 50 or more river miles in a matter of days. The newest generation of acoustic Doppler current profilers (e.g., Sontek RiverSurveyor ADCP) have up to five acoustic beams acquiring spatially distributed samples of water depth, thus greatly increasing the resolution and quality of the data without any increased man-hours in the field.

After the field data-acquisition process is complete, post-processing and integration of data is necessary in order to glean physically-relevant information. The process of relating ADCP data to data from the GPS receiver is unnecessarily time-consuming. This process is commonly performed using GIS tools, and requires approximately a day of processing time per day of field data-acquisition for typical bathymetric studies.

The purpose of the software developed herein (HydroProc) is to improve the efficiency of operation by partially automating the task of post-processing and integration of GPS information.

Workflow

Data Collection Software and Hardware

The HydroProc tool is designed to handle data collected using the Sontek M9 ADCP with the Sontek HydroSurveyor software package. The HydroSurveyor software package was introduced in 2013 and designed specifically for collection of bathymetric, water column velocity profile, and acoustic bottom tracking data as part of a hydrographic survey. HydroSurveyor is offered as an alternative or upgrade from the RiverSurveyor software package. For the purpose of bathymetric surveying, the HydroSurveyor software offers benefits over the RiverSurveyor software; for these reasons, the HydroProc post-processing tool was designed specifically to interface with the HydroSurveyor data export. In the future, the HydroProc tool may be extended to complement the RiverSurveyor data export as well.

GPS Configuration

GPS positioning is provided with the Trimble R8 system. The GPS hardware can be operated either in "generic GPS" or "auxiliary GPS" configuration, as defined by the HydroSurveyor data collection software. There are implications to the data processing workflow within the HydroProc tool depending on which GPS configuration is implemented during the data collection process. According to Dave Velasco of Sontek, "auxiliary GPS" is the preferred configuration, although there is uncertainty as to why that is the case. Using "auxiliary GPS" configuration, the setup of the cables connecting the ADCP and GPS hardware is cleaner. However, when using the "generic GPS" configuration, a NMEA log file for each data collection session is produced, which contains geodetic information that can be useful in processing data. In "auxiliary GPS" configuration, a NMEA log file is not recorded, which puts some additional constraints on data processing using the HydroProc tool.

HydroSurveyor Data Export

After data acquisition is complete, the input dataset for the HydroProc tool can generated using the "Export Soundings" utility within the HydroSurveyor software. Soundings can be exported from within the soundings data layer by clicking the "Export Soundings" button in the expandable drop-down menu (see image below). It is important that soundings are exported as elevations, not depths. This can be controlled by verifying that the "Fixed Altitude" option is not selected in the "Project Settings" tab within the "Config" menu (see image below).



Exporting soundings within Sontek HydroSurveyor Software

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Verifying that "Fixed Altitude" is not selected prior to Soundings Export

HydroProc Code Development

User Interface

The HydroProc user interface and driver is written in the Matlab language and compiled into a PC-executable using the Matlab Compiler. This allows the tool to be used on computers without a full Matlab installation. It is necessary to run the MCR (Matlab Compiler Runtime) installer which provides the underlying Matlab engine to run the executable.

NGS INTG

The INTG (<u>INT</u>erpolate <u>G</u>eoid) tool was developed by Dan Roman of NGS for interpolating geoid height given a user specified position and geoid model. Interpolation is performed using either spline or bilinear interpolation. Gridded data model files (*.bin) are direct access, unformatted, binary format, and must be located within the search directory. The gridded data files are available for download from the NGS website, and are specific to each geoid model (e.g., Geoid09 vs. Geoid12A).

The INTG code was written in C/C++ language. Integration into HydroProc was performed by building a Matlab gateway routine and compiling the code into a MEX (Matlab Executable) file. This allows the INTG program to be called as a function at the Matlab command line or in script.

HydroProc is using INTG version 3.17, which is the latest release as of the time of writing this document.

The INTG source code can be found here:

http://www.ngs.noaa.gov/GEOID/GEOID12A/GEOID12A_data.shtml

The INTG readme file (specific to GEOID12A) can be found here:

http://www.ngs.noaa.gov/GEOID/GEOID12A/g2012Arme.txt

NGS HTDP

The HTDP (<u>H</u>orizontal <u>Time-D</u>ependent <u>P</u>ositioning) tool was developed by Richard Snay and Christopher Pearson of the NGS for transforming positional coordinates across time and between spatial reference frames.

The HTDP code was written in the FORTRAN fixed-format style language. Integration into HydroProc was performed by building a Matlab gateway routine and compiling the code into a MEX (Matlab Executable) file. This allows the HTDP program to be called as a function at the Matlab command line or in script.

HydroProc is using HTDP version 3.2.3, which is the latest release of the time of writing this document.

The HTDP source code, User's Guide, and revision log can be found here:

http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp.shtml

NGA F477

The F477 tool was developed by Richard Rapp of Ohio State University in collaboration with NGA/NASA. The program calculates geoid undulation at a user specified location using the EGM96 geo-potential model. The undulation is relative to the WGS84(G873) ellipsoid.

The F477 source code was written in the FORTRAN fixed format style language. Integration into HydroProc was performed by building a Matlab gateway routine and compiling the code into a MEX (Matlab Executable) file. This allows the F477 program to be called as a function at the Matlab command line or in script.

The F477 program was developed in December 1996.

The F477 source code, User Instructions, and EGM96 Coefficients files can be found here:

http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/egm96.html

Future Work

It is likely that future work will be required to maintain the HydroProc capabilities while updates to ADCP and GPS hardware and software progress.

Bathymetry mapping utilizes rapidly changing technology and it will be important for users to remain current in order to maintain efficient workflow, particularly as data requirements increase in routine project work.