A review of ADP processing software

A REVIEW OF ADP PROCESSING SOFTWARE

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ABSTRACT

Data processing is an essential part of Acoustic Doppler Profiler (ADP) surveys, which have become the standard tool in assessing flow characteristics at tidal power development sites. In most cases, further processing beyond the capabilities of the manufacturer provided software tools is required. These additional tasks are often implemented by every user in mathematical toolboxes like MATLAB, Octave or Python. This requires the transfer of the data from one system to another and thus increases the possibility of errors. The application of dedicated tools for visualisation of flow or geographic data is also often beneficial and a wide range of tools are freely available, though again problems arise from the necessity of transferring the data. Furthermore, almost exclusively PCs are supported directly by the ADP manufacturers, whereas small computing solutions like tablet computers, often running Android or Linux operating systems, seem better suited for online monitoring or data acquisition in field conditions. While many manufacturers offer support for developers, any solution is limited to a single device of a single manufacturer. A common data format for all ADP data would allow development of applications and quicker distribution of new post processing methodologies across the industry.

1. INTRODUCTION

Acoustic Doppler Profilers (ADP) have become the standard tool in flow profile measurements in oceanographic research and marine and off-shore engineering. For the growing tidal industry, power outputs, and thus economics, are extremely important. The power output of a device is proportional to the cube of the inflow velocity, so accurate assessment of the flow is of paramount importance. Accurate velocity predictions rely on accurate measurements and data interpretation. In addition to the correct functioning of the hardware, results of ADP surveys depend heavily on the post processing applied. The more complex the deployment type, the more complicated the post-processing technique. The most complex, commonly employed, ADP deployment method is probably a vessel mounted survey. This type of work will thus mainly be used in this paper to highlight problems in the post processing of ADPs.

2. VESSEL MOUNTED SURVEYS

Vessel mounted surveys are undertaken to obtain a spatial distribution of the flow regime. For example, a developer might want to know what the distribution of the depth-averaged velocity is in an available area, to choose the best position for turbine deployment. During vessel mounted surveys an ADP is deployed on a boat and coupled with a GPS system. The ADP is mounted downward facing on the boat and used to measure the flow velocity relative to the boat. Many models also offer a possibility to obtain the depth and velocity relative to the ground (Bottom Tracking). Most ADPs are sold with internal magnetic compasses and pitch/roll sensors, so that the correct position of the data relative to the ADP can be calculated [1].

In order to get an accurate position and velocity value relative to the ground the position and velocity over ground of the vessel must be accounted for. The position, velocity, heading, sinkage, heel and trim of the boat must, therefore, be recorded at the same time. The internal ADP compass and pitch/roll sensor can be used for this. Alternatively differential GPS or the boats' navigational equipment like a gyrocompass can be used. To refer the data to chart datum, the water level must also be available for the duration of the survey.

Post processing the data includes, as a minimum, transferring data from beam to device and then Earth coordinates, correcting for the boats' motion and compensating for changes in tidal range. These transformations can be expressed as matrix operations and implemented efficiently. Although the amount of data collected could be large the computational burden is rather small, especially for today's computer hardware. The end result is typically a set of locations given as coordinates, with the three-dimensional velocity distribution over the depth.

3. PROCESSING AND PRESENTATION

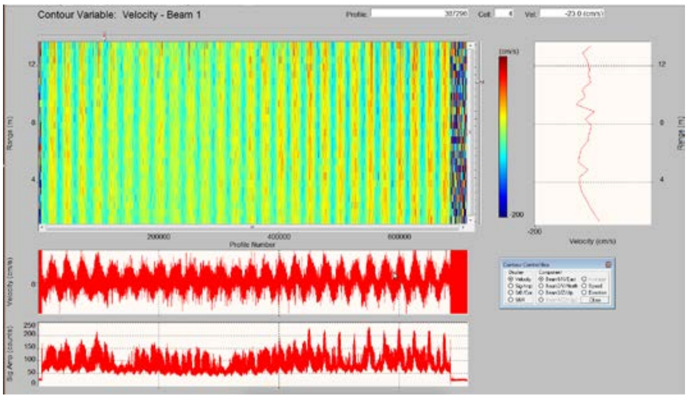
3.1 DISPLAYING VESSEL MOUNTED DATA USING MANUFACTURERS SOFTWARE

Most ADP manufacturers provide simple post processing software with their devices. Typical functionality comprises a graph displaying the boats' position, heading, pitch and roll as line graphs. The velocity data is usually presented as a filled contour plot, where velocity or similar data is shown as coloured maps over time and depth. Figure 1 shows typical representations of measured velocities over time in software provided from three different device manufacturers, Sontek [2], Nortek [3] and Teledyne RDI [4].

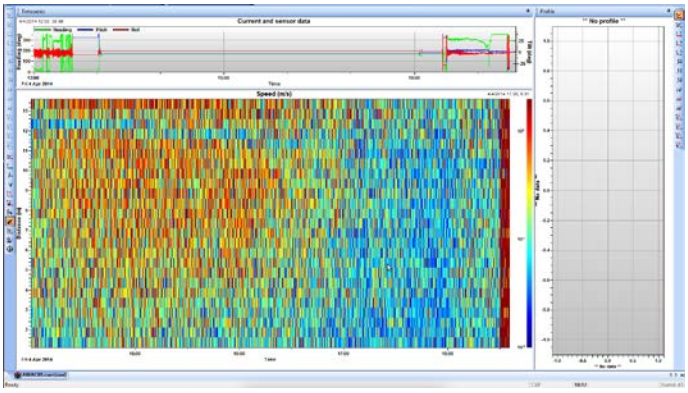
The images produced by each of the software programs are similar and represent very similar information. The variation of the velocity with time and relative position can, therefore, be inferred from each of the different manufacturers.

There are, however, some issues for consideration. For example, the number of transformations required, i.e. from beam to Earth coordinates, and data sources involved, such as a coupled GPS, make the processing prone to errors. It is generally recommended that data should only be made available together with documentation of the applied transformations, filtering or data replacement used in further processing steps [5]. Some, but unfortunately not all, software tools provided by device manufacturers write an extra configuration file together with the new result files if data is reprocessed with different settings. This configuration file can be used to determine variations to the configuration, for example, if extreme pitching has occurred which could affect the data collected.

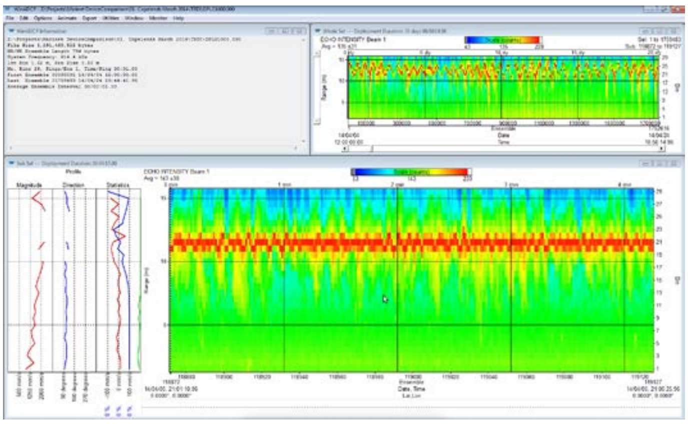
These manufacturer software packages are good for visualising these standard metrics of a survey, but even for simpler ADP deployments, data is frequently post processed further. Besides filtering, calculating depth-averaged values and comparing different datasets, methods to evaluate turbulent properties, for example, are commonly applied. Most of these tasks are not difficult to implement, especially in mathematical toolboxes like MATLAB, Octave or Python, but often cannot be performed in the post processing software provided by the manufactures.



Sontek ViewADP



Nortek Storm



Teledyne RD Instruments Inc. WinADCP

Figure 1: Sontek ViewADP (top), Nortek Storm (middle) and Teledyne RD Instruments, Inc. WinADCP (bottom) contour plots of velocity and line graphs of ancillary data.

3.2 DATA EXCHANGE

The data recorded can be output in various file formats, depending on the manufacturer. These files can contain information on the configuration of the device, the velocities recorded (in different coordinate systems) and the position and time of the recorded data. All of this information can be used in post-processing systems using other software packages.

3.3 DISPLAYING VESSEL MOUNTED DATA USING OTHER SOFTWARE

Vessel mounted surveys for tidal devices often have to be performed in confined waters, for example narrow bays with islands. These waters are characterised by large spatial gradients of flow velocities. Ideally any surveys would focus on areas of specific interest. The boat should therefore pass areas with high flow velocities or areas affected by large scale vortices more often.

The standard presentation of data as filled contour plots over time and depth is often not ideal for this type of data visualisation. Since the boat’s velocity over ground changes it can be difficult to understand the actual spatial distribution of the local flow.

The author often prefers to display vessel mounted data over a map containing additional data. Visualisations, in two or three dimensions, give a very good overview and enable the user to combine bathymetry and other geographic information with flow and vessel data. Several free and open source tools are available for these tasks.

The three-dimensional visualisations shown in Figure 2 were created in ParaView, an open source tool for scientific and flow visualisation. The visualisation process is straightforward and allows a wide range of data manipulation, extraction or filtering [6].

A second alternative is QGIS [7], an open source geographic information system available for various operating systems. It enables visualisation of data sources obtained in different coordinate reference systems, data manipulation and analysis. Adding additional functionality is possible through a Python interface or by developing plugins.

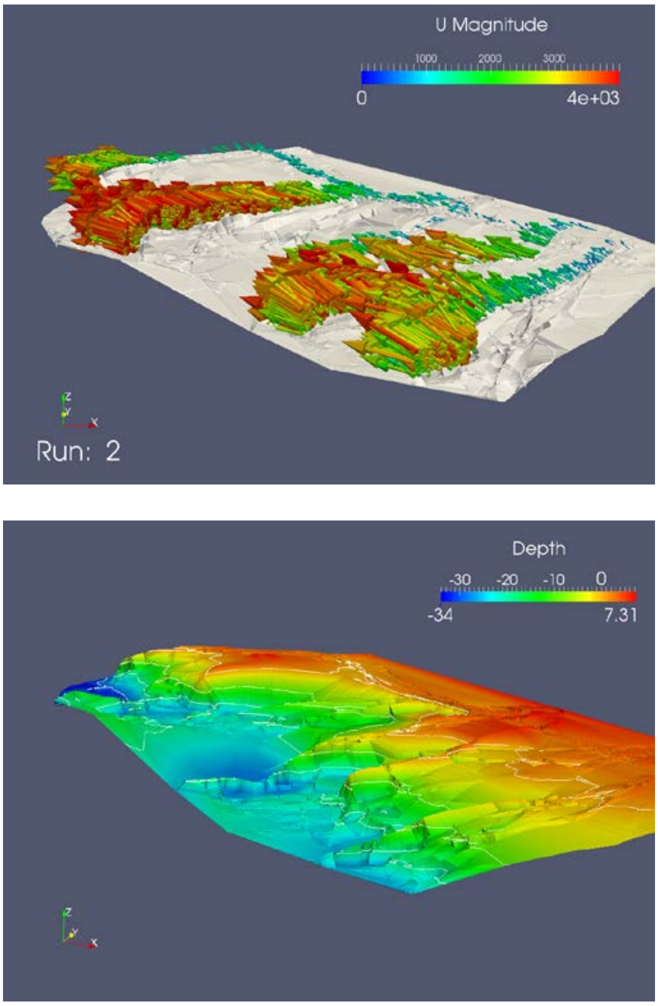


Figure 2: Three dimensional visualisation of velocity vectors over bathymetry (top). Bathymetry coloured according to depth with isolines representing 5m (bottom).

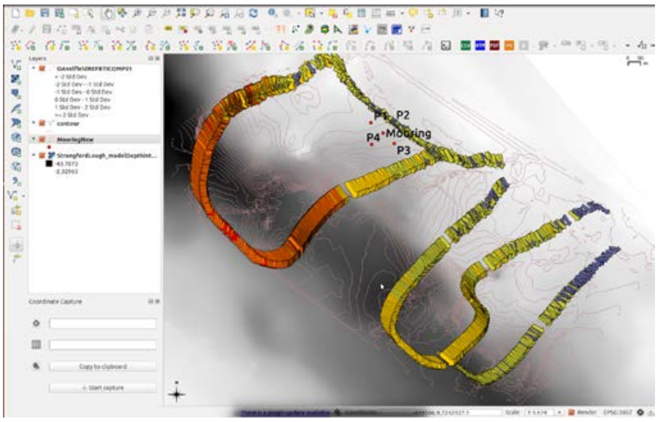


Figure 3: Visualisation of depth-averaged flow velocities as vectors over bathymetry data and mooring locations.

One other notable alternative is “UHDAS” (University of Hawaii Data Acquisition System). Together with CODAS (Common Ocean Data Access System) it provides a framework for vessel mounted surveys. Functions include: configuration of the ADPs; data processing and visualisation via Python; combination with a database structure to store data and processing steps in a standardised manner. It thus combines flexibility with safe, well documented data handling and the ability to automatically process datasets. UHDAS and CODAS currently only support the RDI OS38 and WH300 ADPs [8] however.

4. CONSIDERATIONS FOR DATA PROCESSING

The data transfer from the software provided by manufacturers to different formats can again introduce errors, affect the results and is not a trivial task.

All manufacturers seem to provide some way to export data to MATLAB or Octave in the *.mat or other readable text based formats.

In theory it should be possible to directly read the binary data from the instrument, which would also be the most efficient method. Nortek AS, for example, offers support for developing custom applications, with detailed information regarding data formats. They even provide ActiveX and Windows DLL's for clients, encouraging development of user specific tools [9].

In the authors’ experience, binary and ASCII data has sometimes changed after a firmware update of a device and is in some cases poorly documented. Some export functions do not provide the full data set, making it impossible for the next user to extract crucial information, for example which coordinate system the flow direction refers to. The transfer of data between the ADP software and any other environment is thus a possible point of failure for the analysis.

The Marine Research Group at Queen’s University Belfast owns and operates 5 different ADP models from three different manufacturers, with each device recording data in its own binary format. Comparison between different devices or usage of any device with custom applications requires careful adaptation or development of code. It should be noted that the cost in time or coding required to read the data (including error checking) is often more than the actual analysis, transformation and plotting/visualisation of results.

Another problematic aspect of the reliance on manufacturer software, especially for ADP applications in academic research, is the lacking ability to review the implemented processes and thus almost total dependency on manufacturer’s information.

5. OPERATING SYSTEMS

As previously mentioned, most processing steps can easily be performed today even with relative low end hardware. All ADPs known to the author communicate via the RS232 standard, which is supported by virtually any operating system.

Over recent years tablet computers have become increasingly popular for fieldwork due to their low price, long battery duration and water resistance. Nevertheless, at the time of writing only one company seems to offer software for tablets, and even this is limited to tablets running Windows 8. None of the manufacturers provide software for other operating systems, such as Android or Linux, although they dominate the market for smaller devices. This could provide flexible and low cost solutions.

6. THE ADVANTAGE OF A COMMON STANDARD

The lack of a common standard requires writing custom 'configuration' and 'reader' functions deflecting resources from the 'real' research of developing new processing methods or novel applications. It also complicates the development of applications or combinations with hardware.

In several industries missing or insufficient format specifications were recognized as a problem and have been addressed with a format specification. For example, the ISO norm ISO 10303-21 defines the "Standard for the Exchange of Product model data" (STEP). This format enables exchanging Computer Aided Design models between different software tools, giving the user the freedom to use the most suitable program to address his particular problem [10].

Another good example is the success of the National Marine Electronics Association (NMEA). The NMEA format enables the user to easily combine devices like GPS, gyrocompasses or other marine electronics into one network and exchange and process data.

7. CONCLUSIONS

This paper presented examples of typical applications of ADPs in the research of tidal power and highlights issues in the currently available processing tools and methodologies. Most issues raised are related to the lack of a common ADP data exchange format.

A standardised ADP data format could accelerate development of new post processing methodologies across the industry, facilitate collaboration, and improve the safety of data handling.

ACKNOWLEDGEMENTS

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