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The Sound Speed package is part of the HydrOffice framework. HydrOffice is a research development environment for ocean mapping. It provides a collection of hydro-packages, each of them dealing with a specific issue of the field. The main goal is to speed up both algorithms testing and research-to-operation (R2O).

The Sound Speed package provides both a library and an application with functionalities to manage sound speed profiles, and to provide pre-processing ocean mapping tools to help bridge the gap between sound speed profiling instrumentation and multibeam echosounder acquisition systems.

It has been developing with the aim to merge together functionalities present in several applications that process sound speed profiles (SSP) for underwater acoustic systems:

- **Velocipy**, an application originally developed at the NOAA Coast Survey Development Laboratory (CSDL) as part of the Pydro environment.
- **SVP Editor**, an application originally developed at the Center for Coastal and Ocean Mapping (CCOM, UNH) for the MAC project (Multibeam Advisory Committee) under the NSF grant 1150574.
- **SSP Manager**, an application developed at the Center for Coastal and Ocean Mapping (CCOM, UNH) as part of the HydrOffice framework under NOAA grants NA10NOS4000073 and NA15NOS4000200.

In the integration of all these implementations to the current package several improvements have been introduced to enhance code maintainability (e.g., Python 3 support) and to store the collected data for further processing and analysis.

The current development of Sound Speed Manager is partially supported by:

- NOAA grant NA15NOS4000200, and
- NSF grant 1150574.
1.1 Operation modes

Currently, the hydro-package can operate in two mutually exclusive operation modes:

1. **Operator Mode**
   - This represents the primary mode, and it is used to convert data from different source formats, to graphically edit them, and to export/send the resulting profiles for use by underwater acoustic systems. Optional steps are the augmentation with measurements from a reference cast (to either improve salinity modeling or extrapolate the cast to the required depth), either manually specifying a loaded profile as reference cast, or deriving the reference from oceanographic models (currently, WOA09, WOA13 and RTOFS) as described in Appendix A - Oceanographic Atlases.

2. **Synthetic Profile Server Mode**
   - The Synthetic Profile Server Mode was developed to deliver WOA/RTOFS-derived synthetic SSPs to one or more network clients in a continuous manner, enabling opportunistic mapping while underway. Given the uncertainty of such an approach, this mode is expected to only be used in transit, capturing the current position and using it as input to lookup into the selected oceanographic model.

1.2 Currently implemented features

- Import of several commonly used sensor/file formats:
  - AML (.csv)
  - AOML AMVER-SEAS XBT (.txt)
  - CARIS (.svp)
  - Castaway (.csv)
  - Digibar Pro (.txt), and S (.csv)
  - ELAC Hydrostar (.sva)
  - Hypack (.vel)
  - Idronaut (.txt)
  - ISS Fugro (.svp, .v*, .d*)
  - Kongsberg Maritime (.asvp)
  - Rolls-Royce Moving Vessel Profiler (MVP) (.asvp, .calc, .m1, .s12)
  - Oceancience Underway CTD (.asc)
  - SAIIV (.txt)
  - Sea&Sun (.tob)
  - Seabird (.csv)
  - Sippican XBT, XSV, and XCTD (.EDF)
  - Sonardyne (.pro)
  - Turo XBT (.nc)
  - University of New Brunswick (.unb)
  - Valeport Midas, MiniSVP, Monitor, RapidSVT, and SWiFT (.000, .txt, .vp2)
• Network reception of data from:
  – Kongsberg Maritime SIS
  – Kongsberg Maritime K-Controller (*experimental*)
  – Sippican systems
  – Moving Vessel Profiler (MVP) systems
• Data visualization and interactive graphical inspection (e.g., outlier removal, point additions) of sound speed, temperature and salinity profiles
• Use of the World Ocean Atlas of 2009/2013 (WOA09/13) and Real-Time Ocean Forecast System (RTOFS) for tasks such as:
  – Salinity augmentation for Sippican XBT probes
  – Temperature/salinity augmentation for Sippican XSV probes and SVP sensors
  – Vertical extrapolation of measured profiles
  – Creation of synthetic sound speed profiles from the model of choice
• Augmentation of sound speed profile surface layer with measured surface sound speed (from Kongsberg SIS or manually)
• Designation of a reference profile, for example from a deep CTD, for use in tasks such as:
  – Salinity augmentation for Sippican XBT probes
  – Temperature/salinity augmentation for Sippican XSV probes and SVP sensors
  – Vertical extrapolation of measured profiles
• Export of several file formats:
  – Caris (.svp) (V2, multiple casts supported)
  – Comma separated values (.csv)
  – ELAC Hydrostar (.sva)
  – Hypack (.vel)
  – iXBlue (.txt)
  – Kongsberg Maritime (.asvp and .abs)
  – NCEI (.nc)
  – QPS (.bsvp)
  – Sonardyne (.pro)
  – University of New Brunswick (.unb)
• Network transmission of processed casts to data acquisition systems (see Appendix B - Connection Settings):
  – Kongsberg Maritime SIS
  – Kongsberg Maritime K-Controller (*experimental*)
  – QPS QINSy
  – Reson PDS2000
  – Hypack
• Persistent storage of collected SSP data in a SQLite database

1.2. Currently implemented features
1.3 Compared Functionalities

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Sound Speed Manager</th>
<th>Velocipy</th>
<th>SSP Manager</th>
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<tr>
<td>Input of Kongsberg format</td>
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<td></td>
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<tr>
<td>Input of OceanScience format</td>
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<td>x</td>
<td></td>
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<tr>
<td>Input of Seacat serial data</td>
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<td>x</td>
<td></td>
</tr>
<tr>
<td>Output of NCEI format</td>
<td>^</td>
<td>x</td>
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<tr>
<td>Output of QPS format</td>
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<tr>
<td>Support of WOA13 atlas</td>
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<td></td>
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<tr>
<td>Data filtering/smoothing</td>
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<tr>
<td>DQA analysis</td>
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<tr>
<td>Calculation of profile statistics</td>
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<tr>
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<td>Input of SAIV format</td>
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<td>Input of Turo format</td>
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<tr>
<td>Input of Valeport format</td>
<td>^</td>
<td>-</td>
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<tr>
<td>Output of Elac format</td>
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<td>x</td>
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<td>Output of iXBlue format</td>
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<td>Retrieval of current SIS profile</td>
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<tr>
<td>Retrieval/View/Use of SIS data</td>
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<td>SIS data view</td>
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</tr>
<tr>
<td>Output of Kongsberg format</td>
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<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Input of AML format</td>
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<tr>
<td>Input of AOML format</td>
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<td>Input of Caris format</td>
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<td>Input of ELAC format</td>
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<tr>
<td>Automated processing steps</td>
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<td>Data management for multiple projects</td>
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<td></td>
</tr>
<tr>
<td>Surface sound speed monitoring</td>
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<td></td>
<td></td>
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<tr>
<td>Cast timing based on past data</td>
<td>x</td>
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</table>

Symbols: x = New functionality; - = Basic functionality; ^ = Improved functionality
2.1 Installation

2.1.1 Installation using the Pydro distribution

If you are on Windows, you can easily install Sound Speed Manager as part of the NOAA Office of Coast Survey Pydro distribution.

Pydro is a suite of software tools used to support hydrography. It is (almost exclusively) built from open source components as well as public domain custom developed software. Pydro is maintained by Hydrographic Systems and Technology Branch (HSTB) to support NOAA operations (aiding Office of Coast Survey fleet) and is made available for public use.

You can download the latest Pydro installer from here.

2.1.2 Installation as stand-alone Python package

If you decide to install the package in a Python environment, the dependencies are:

- basemap
- gdal
- gsw (version == 3.0.6)
- matplotlib
- pillow
- netCDF4
- numpy
- scipy
- pyproj
• pyserial
• PySide2 (only for the application)

If you want to install the last stable version (from PyPI):
• pip install hyo2.soundspeed

Or, if you prefer the bleeding edge code:
• pip install https://github.com/hydroffice/hyo2_soundspeed/archive/master.zip

### 2.1.3 Supplemental Data Space Requirements

Approximately 500 MB of additional disk space is required for the WOA09 db set optionally required (but warmly suggested) by this hydro-package. If not available, the package will attempt to download it.

Alternatively, it is also possible to manually download, unpack the WOA09 data set at any path that SSM can have access to, and modify the configuration file to point to the correct path (see Possible Configurations).

By default, SSM looks for databases at:
• “C:/Documents and Settings/<username>/Application Data/HydrOffice/Sound Speed/atlases/[woa09 or woa13]” (Windows XP), or
• “C:/Users/<username>/AppData/Local/HydrOffice/Sound Speed/atlases/[woa09 or woa13]” (newer Windows OS)

Among other improvements, the WOA13 db provides a much better spatial resolution, but this comes with a much larger data size (~18 GB).

**Note:** If a previous version of the application was installed, Sound Speed Manager will try to localize past installations of WOA databases (WOA09 or WOA13).

### 2.2 Setup

#### 2.2.1 Possible Configurations

Given its specific aim, Sound Speed Manager is usually installed to run in one of two configurations:

**On the machine used for sound speed profile acquisition**

This represents a quite common choice since many of the operations accomplished in the software are typically done immediately after acquisition of a cast.

If the machine is on the same network as the multibeam acquisition workstation, the processed profile can be directly delivered via network.

When this is not possible, the package can export the processed data to files that can then be manually uploaded to the multibeam workstation.
On the multibeam acquisition workstation

This configuration is particularly useful when it is anticipated that the software will run in Server Mode. In fact, it is important that multibeam watch standers are able to monitor the server, and to disable it in the event that a measured profile is to be uploaded.

2.2.2 Upgrading

It is possible to copy configuration settings from a previous installation. When a new installation is performed, the user is prompted (see Fig. 2.2) to select existing configuration settings (if any).

![Fig. 2.2: Select the desired setup and click on the OK button to copy an existing setup.](image)

2.2.3 Application Settings

In the Sound Speed release data folder, you can find a configuration file: setup.db.

This SQLite database file has to be modified to reflect the chosen software deployment and environment-specific configuration settings (e.g., the SIS IP address and ports).

Use the Setup tab to view the available configuration options in the database. If you want to modify them, click on the ‘Lock/Unlock’ button (Fig. 2.3).

**Warning:** If you want to use the RTOFS data, Internet (and the port 9090) must be accessible from the machine in use.

2.2.4 NOAA Tools Flag

For NOAA field, it is recommended to turn on the NOAA tools flag in the General Settings tab.

Currently, the NOAA Tools flag is mainly used for NCEI format output. When NOAA tools flag is on:

- In the Setup tab, the default institution is not editable.
- In the Metadata dialog, the vessel name is not editable
- During NCEI files exporting, the NOAA-specific project naming format is enforced.

2.2.5 Sound Speed Manager - SIS v4 interaction

As with any communication between any software, whether it is on the same computer or between different computers on a network, some setup is required. For SIS and Sound Speed Manager, all communication is done across User Datagram Protocol (UDP). UDP on the same windows-based computer requires port numbers; UDP across a
Fig. 2.3: When unlocking, you will be asked to confirm that you want to modify the setup.
network requires both IP addresses on the network and port numbers from each computer. The easiest way to find this information for a given computer is by typing “ipconfig” into a windows command prompt, and note the IPv4 Address.

In order for Sound Speed Manager to automatically interact with Kongsberg SIS, some initial configuration are required on the SIS side to make it to broadcast a specific subset of datagrams that can then be interpreted by the SSP hydro-package (identification codes in parentheses):

- **Position** (‘P’, 80, 0x50): for retrieving current date and position
- **Sound Speed Profile** (‘U’, 85, 0x55): checking whether a SSP transmission was successful
- **XYZ88** (‘X’, 88, 0x58): to retrieve:
  - The surface sound speed (used in beam forming and steering) and the transducer draft (both used when augmenting SSPs with the measured surface sound speed value).
  - The depth (to estimate the approximate water depth). This is used in the sound speed, temperature and salinity plots to help the user appreciate the minimal depth to which the profiles should be extended.

Fig. 2.4: Kongsberg SIS v4 can be configured to broadcast datagrams in three different ways as discussed in Methods A, B, and C.

**Method A: Sound Speed Manager and SIS v4 Installed on the same Computer**

This method is usually used for the case where Sound Speed Manager and SIS are installed on the same machine. However, this method may not be suitable if this mechanism is already in use by another program. In such a case, the DataDistrib.exe program explored in Method C: Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager should be attempted.

The configuration for this method is actually quite simple:

- Open SIS, do not “Ping”
- Under the Installation Parameters Tearoff, in PU Communication Setup, Output Setup
  - Choose **User Defined** from the **UDP Host Port** dropdown menu
  - Note the Port Address (the Display Port Address is used during the Sound Speed Manager Setup)
  - Select the following datagrams: Depth, Position, and Sound Speed Profile
  - Click the **OK** button on the top left of the Installation Parameter Tearoff and close the window

---

2.2. Setup
• Access the *Installation Parameters* dialog (see Fig. 2.5) from the *View* menu by choosing *Tear off* and then *Installation Parameters*

![Installation Parameters dialog](image)

**Fig. 2.5:** *SIS Installation parameters* dialog, with key settings in red for *Method A: Sound Speed Manager and SIS v4 Installed on the same Computer.*

• On the main SIS screen, start *Pinging*

• Open Sound Speed Manager, and open the *Setup Tab*, and unlock settings editing
  
  − Under *Output*, you can leave the client list set to default, or create a new client with IP = 127.0.0.1, port = 4001, and protocol = SIS (see Fig. 2.6). These settings will tell Sound Speed Manager that SIS is on the same computer, and to send the CTD cast data to port 4001 (KM default).

  • Under *Listeners*, in the *Listen port*, enter the Port Address noted from the *User Defined UDP Host Port* in SIS. This will allow SIS to send a received CTD cast message to Sound Speed Manager, and well as real time data including time, position, surface sound speed, and average depth (see Fig. 2.7).

**Note:** The surface sound speed and depth will only update if the echosounder is pinging (since the surface sound speed information can only be extracted when *Sound Speed Manager* receives the depth datagram).

You will now be able to send a sound speed profile from Sound Speed Manager to SIS and receive a receipt message (see Fig. 2.8), and see the SIS-received information displayed in the status bar.

**Note:** The value of the *User Defined UDP* port in *SIS* cannot be modified.
Fig. 2.6: Sound Speed Manager Setup Output dialog, with key settings in red for Method A: Sound Speed Manager and SIS v4 Installed on the same Computer.
Fig. 2.7: *Sound Speed Manager Setup Listeners* dialog, with the *Listen Port* setting and incoming SIS data highlighted in red for *Method A: Sound Speed Manager and SIS v4 Installed on the same Computer*.

Fig. 2.8: *Sound Speed Manager SIS Receipt* dialog.
Method B: Sound Speed Manager and SIS v4 Installed on Separate Computers within a Network

This method is more general, and it can be used for data transmission to other computers on the network (by specifying IP address and port, as well as transmission rate).

- In SIS, from the Tools menu, choose Custom... and then Datagram Distribution (see Fig. 2.9).

![Request datagrams from EM dialog](image)

Fig. 2.9: Request Datagrams from EM dialog, with key settings in red for Method B: Sound Speed Manager and SIS v4 Installed on Separate Computers within a Network.

- Choose the datagram from the drop down menu, starting with Position (P).
- Type in the IP address (e.g. 192.168.0.100) of the remote machine where Sound Speed Manager is installed, immediately followed by a colon (:), then the port number (e.g. 16103) that the data should be delivered to on the remote machine: e.g., Entire address: 192.168.0.100:16103.
- Click the Subscribe button.
- Repeat Steps 2-4 for the SVP (U) and the XYZ88 (X) datagrams.
- With Sound Speed Manager open, go to the Setup Tab, and unlock setting editing (see Fig. 2.10).
  - In Output, create a new Client. Enter the SIS computer IP Address, use default port “4001”, and protocol “SIS”. Sound Speed Manager will send your cast from the acquisition computer, to this SIS connection.

Note: Local test should be removed from the Client list if you add an additional Client. Otherwise, this will cause a
failed receipt message.

Fig. 2.10: Sound Speed Manager Setup Output dialog, with key settings in red for Method B: Sound Speed Manager and SIS v4 Installed on Separate Computers within a Network.

- Under Listeners, in the Listen port, enter the Port Address noted from Request datagrams from EM and the Enter the Listen port number (e.g. 16103). This is where Sound Speed Manager will be receiving messages from (see Fig. 2.11).

Note: The surface sound speed and depth will only update if the echosounder is pinging (since the surface sound speed information can only be extracted when Sound Speed Manager receives the depth datagram).

You will now be able to send a sound speed profile from Sound Speed Manager to SIS and receive a receipt message (see Fig. 2.12), and see the SIS-received information displayed in the status bar.

Note: SIS needs to be restarted for the changes to take effect. Furthermore, since the software does not seem to validate user inputs, mistakes made cannot be easily discovered and undone (unsubscribe).

Method C: Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager

This method is required when multiple software packages need to receive data from SIS v4, and it represents an extension of the previous two methods. Methods A and B are not required in addition to Method C. SIS v4 uses a
Fig. 2.11: Sound Speed Manager Setup Listeners dialog, with the Listen Port setting and incoming SIS data highlighted in red for Method B: Sound Speed Manager and SIS v4 Installed on Separate Computers within a Network.

Fig. 2.12: Sound Speed Manager SIS Receipt dialog.
standalone program, named `DataDistrib.exe`, bundled with SIS and usually installed in “C:/Program Files/Kongsberg Maritime/SIS/bin” (together with a configuration file “DataDistrib.ini” with all the subscriptions).

The `Data Distribution - MDM 400`, which is automatically bundled with SIS and usually installed in “C:\Program Files\Kongsberg Maritime\SIS\bin”, is required when multiple software package need to receive data from SIS. It is suggested to add the `DataDistrib.exe` to the Startup menu of the computer, in Windows OS (so that it is automatically started). However, common back sides of this method is that the executable can be accidentally closed (stopping the data distribution to this package), or it can accidentally runs twice corrupting the configuration file (to prevent this, it could be made “read only”).

Because `Sound Speed Manager`, `SIS`, and `Data Distribution - MDM 400` are on different computers within a network, we have to know the IP Addresses of each computer. The easiest way to find this information for a given computer is by typing “ipconfig” into a windows command prompt, and note the IPv4 Address. With this information, we can tell Sound Speed Manager where to send our sound speed profile.

The setup of this method is summarized as follows:

- In Sound Speed Manager, Setup, Output, unlock settings editing, and add a new Client.
  - Give the Client a name, enter the SIS computer IP Address, use default port “4001”, and protocol “SIS”. Sound Speed Manager will send your cast from the acquisition computer, to this SIS connection (see Fig. 2.13). Note: Local test should be removed from the Client list if you add an additional Client. This will caused a failed receipt message.

![Sound Speed Manager Setup Output dialog](image)

**Fig. 2.13: Sound Speed Manager Setup Output dialog, with key settings in red for Method C: Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager.**

- In SIS, Installation parameters, PU Communication Setup, Output Setup, UDP Host Port drop down, select User Defined (note this Port address).
This address is used in *Data Distribution - MDM 400* as the source port (where the data is coming from) (see Fig. 2.14).

![Fig. 2.14: SIS Installation Parameters dialog, with key settings in red for Method C: Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager.](image)

- In *Data Distribution - MDM 400*, messages will be sent from your “User Defined” UDP Host Port (noted in previous step) to any number of *Destination Ports* of your choosing.
  - First, enter the “User Defined” UDP Host Port (from the previous step) in the “Source Port” column. The information for the “Destination: Port” column includes: the IP Address for the computer where Sound Speed Manager is located, followed by a “:” and the port number, which can be any port not already in use (e.g. 192.168.0.100: 16103). Note this port number; it will be used in the Sound Speed Manager setup.

- In Sound Speed Manager, Setup, Listeners, unlock settings editing.
  - Enter the Listen port number (the Destination Port number from Data Distribution - MDM 400). This is where Sound Speed Manager will be receiving messages from.

For an example using Method C, see Fig. 2.17 for a complete diagram. Here the “User Defined” Port Address “16103” found in SIS’s Installation Parameters, is enter in the “Source Port” column in Data Distribution - MDM 400. The IP Address of the computer with Sound Speed Manager is entered in Data Distribution - MDM 400’s “Destination: Port” column, followed by an open port number, here “16103”. This same port number is entered into Sound Speed Manager’s Listeners tab, in the “Listen port:” dialog.

You will now be able to send a sound speed profile from Sound Speed Manager to SIS and receive a receipt message (see Fig. 2.18), and see the SIS-received information displayed in the status bar.

### 2.2.6 Sound Speed Manager - SIS v5 interaction

The support of SIS v5 and K-Controller is currently *experimental*. 
This method describes the case where Sound Speed Manager and K-Controller are installed on the same machine. First, retrieve the multicast address/port from the K-Controller’s Output Setup (see Fig. 2.19).

Open in editing mode the Sound Speed Manager’s Setup Tab, then set the retrieved multicast address/port in the Listeners sub-tab (see Fig. 2.20).

Then, switch to the Input sub-tab (see Fig. 2.21) and select the True value for the Listen SIS5 field.

The previous steps are required to make Sound Speed Manager able to listen the K-Controller.

In order to be able to transmit to K-Controller, you need to add a client in the Output sub-tab (see Fig. 2.22) using the following settings:

- IP: 127.0.0.1
- port: 14002
- protocol: KCTRL

Now restart Sound Speed Manager. If a K-Controller-controlled sonar is pinging, you should start to see the parsed information in the status bar (see Fig. 2.21).
Fig. 2.16: *Sound Speed Manager Setup Listeners* dialog, with the *Listen Port* setting and incoming SIS data highlighted in red for *Method C: Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager*. 
Fig. 2.17: Complete Method C Diagram, with key information and connections highlighted in orange for Method C:
Managing Multiple Software Connections to SIS v4, Including Sound Speed Manager.
Fig. 2.18: Sound Speed Manager SIS Receipt dialog.

Fig. 2.19: KController’s Output Setup dialog.
Fig. 2.20: *Listeners* tab in the Sound Speed Manager’s *Setup*. 
Fig. 2.21: *Input* tab in the Sound Speed Manager's *Setup*. 
Fig. 2.22: Output tab in the Sound Speed Manager’s Setup.
### 2.3 Supported Formats

<table>
<thead>
<tr>
<th>Format</th>
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<th>Write</th>
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<tbody>
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### 2.4 How to use

#### 2.4.1 Operator Mode

**Data Editor Tab**

**Data import**

From the Editor tab, select Import data (Fig. 2.23) and choose the desired import file type (Fig. 2.24).

This will launch a file selection dialog (Fig. 2.25) with the expected file extension set as a filter, e.g. .edf for Sippican files.

---

1 For details on how to browse the content of a generated NCEI file, see Appendix C - Exploring Profiles in NCEI format.

2 The QPS bsvp format is only supported by old versions of some QPS applications (e.g., FMGT and FMMW).
Fig. 2.23: Click on the *Import data* button in the *Editor* tab to start the import process.

Fig. 2.24: Click on the desired import file type.
Fig. 2.25: Browse to the desired data file.
Note: A number of sample data files can be downloaded from the data folder in the project repository.

After the selection of the desired file, the window shows panels with the sound speed, temperature and salinity profiles drawn in solid blue (left to right, respectively, in Fig. 2.26).

![Sound Speed Manager](image)

**Fig. 2.26:** *Sound Speed Manager* showing the three main plots: sound speed, temperature, and salinity.

During the import stage, the geographic position and date in the input file are used to query WOA or RTOFS atlases (if available) to obtain mean sound speed, temperature and salinity profiles (to provide a context during data editing), which are drawn in dashed colours. Thus, it is important that the cast positional metadata are correct for this lookup operation.

Furthermore, the position is also required by some formats to compute the pressure to depth conversion (since this has a latitudinal dependence). Since some file formats do not support recording of geographic position (e.g., Valeport .000) the user must enter these manually during import (if the SIS position datagram is not available).

All the available processing steps can be accessed from the *Process* menu. A selection of these steps is present in the toolbar for ease their access in operation. This selection can be customized through the *Button Visibility* dialog (Fig. 2.27) accessible using *Process/Change Buttons Visibility*.

**Interactive data editing**

The mouse interactive mode is set using the plotting toolbar at the bottom (Fig. 2.28) or by directly right-clicking on the plots once a cast is loaded. Currently available inspection modes are:
Fig. 2.27: The Button Visibility dialog.

- **Reset view**: to visualize the full profile
- **Pan**: to move the area visualized in the plot
- **Scale**: to modify the horizontal and vertical scales of the plots
- **Zoom in**: to zoom in to a selected area
- **Zoom out**: to zoom out from a selected area
- **Flag**: mark spurious measurements for removal from any plot panel through a left-click drag motion over the bad data points. The flagged points will be drawn in red.
- **Unflag**: reclaiming previously flagged data, using the same left-click and drag motion as Flag.
- **Insert**: manually adding points to the profiles can be useful to create a more realistic cast extension. This is particularly useful when the measured temperature and/or salinity values deviate from WOA/RTOFS or the reference profile near the bottom of the profile.

Zooming back out to the full view is accomplished by choosing Reset view from the plotting toolbar (or by directly right-clicking on the plot and selecting Reset view). The Hide flagged option in the plotting toolbar will toggle the display of flagged points.

**Metadata editing**

Several information related to the cast are collected during the import and the processing of a cast. Metadata can be viewed by clicking the Metadata button on the tool bar (Fig. 2.29).

It is also possible to manually edit several of the metadata entries (Fig. 2.30) and to force the visualization of the Profile metadata tool at the import time (Fig. 2.31).
Fig. 2.28: Interactive data editing of a loaded profile.

Fig. 2.29: Button to access the Metadata widget.
Fig. 2.30: The Profile metadata tool.
Fig. 2.31: When the “Show at Import” button is flagged like in the figure, the *Profile metadata* tool is automatically displayed when a new profile is imported.
Sound Speed Manager, Release 2019.2.4

Data filtering/smoothing

If required, the profile data can be automatically filtered and smoothed using the Filter/Smooth Data button (Fig. 2.32).

![Filter/Smooth Data button](image)

Fig. 2.32: The Filter/Smooth Data button in the Editor toolbar.

Data augmentation

Sound speed data can be augmented with WOA/RTOFS/reference salinity and/or temperature. If a reference cast has been set, then the reference cast will be used to augment salinity and/or temperature profiles instead of the WOA/RTOFS profiles.

XBT probes

XBT probes measure the temperature of water as they drop to the seafloor. Since the speed of sound in water is strongly affected by water temperature, this measurement can be used to estimate the sound speed profile. Since salinity can also influence the speed of sound in water, the accuracy of the sound speed estimate can be improved through better approximation of the water’s salinity. This approximation can be as simple as assuming that the salinity is constant over all depths or it could be as sophisticated as using an independent salinity depth profile from an alternate sensor such as a CTD or perhaps from an oceanographic model.

The package follows this second approach. The salinity profile is specified by selecting Retrieve salinity (Fig. 2.33) from the Editor toolbar (the option is only active when an XBT cast is loaded). With this command, the dashed WOA or RTOFS salinity profile is used to augment the XBT temperature measurement. Since the vertical resolution of the WOA/RTOFS grids is coarse compared to the typical sampling interval of the measured data, the salinity estimates are linearly interpolated to the depths associated with each of the temperature observations in the measured XBT profile.

![Retrieve salinity button](image)

Fig. 2.33: The Retrieve salinity button in the Editor toolbar.

The salinity plot (right-most of the three panels) will update with a salinity profile and the sound speed plot (left-most panel) is updated with sound speed (recalculated using the new salinity estimates). Sound speed values are calculated using the UNESCO equation (Fofonoff and Millard, 1983).

2.4. How to use 33
XSV probes

In the case of an XSV file, the user can decide to augment the measured sound speed with WOA/RTOFS temperature and salinity through the XSV load temperature/salinity option under the Process menu (Fig. 2.34). The option is only active when an XSV cast is loaded.

![Sound Speed Manager interface showing Retrieve Temperature/Salinity option](image)

Fig. 2.34: The Retrieve temperature/salinity button in the Editor toolbar.

**Note:** In this mode, the sound speed is NOT recalculated, the temperature and salinity are meant merely for SIS to compute transmission loss corrections for improved backscatter normalization. Thus, the application disallows the Retrieve salinity button in the Editor toolbar for XSV profiles.

Manual user insertions

There are two methods to add points, after having selected the Insert mode in the right-click menu or in the plotting toolbar:

1. **Adding sound speed points in the sound speed plot.** This method adds points to the sound speed profile only and it holds the current temperature and salinity gradients constant (i.e., it makes no attempt to update the temperature/salinity profiles for the chosen sound speed). Thus, this method is well suited for output formats or transmission protocols in which the temperature/salinity values are not used.

2. **Adding salinity and temperature points.** This method adds salinity and temperature points in their respective plots and then calculates the resulting sound speed based on the temperature/salinity plots. A first click in the salinity plot sets both the point depth and salinity. A second click in the temperature plot sets the temperature for the point depth selected in the prior step. The package will automatically calculate the sound speed based off the temperature/salinity points previously selected. The click order can be reversed (i.e., a first click in temperature sets the depth and temperature).

Multipoint extensions are achieved through repeating the above sequence. If a deep extension that exceeds the view limits is required, use the pan utility to adjust the view limits.

Applying surface sound speed

If configured to receive data from SIS, the surface sound speed and transducer draft from the depth datagram broadcast can be used to create a surface layer of thickness equal to the transducer draft and of sound speed equal to the value used in beam forming (this is based on the assumption that the value comes from the surface sound speed probe). This operation can be achieved by selecting Retrieve Surface Sound Speed from the Editor toolbar (Fig. 2.35).

If neither the surface sound speed or transducer draft values are available from a SIS data broadcast, the software will prompt the user to input values for both.
The intent of this feature is to keep the sound speed profile and sound speed sensor values similar such that the numerical display monitors in SIS do not warn against sound speed discrepancies between the two measurements. It should be noted that this is done internally in SIS during their ray tracing operations, regardless of this external processing stage: “transducer depth sound speed is used as the initial entry in the sound speed profile used in the ray tracing calculations” (Kongsberg, 2012).

Using this package method, keeps the system from warning against discrepancies based on:

- The uncertainty in XBT temperature measurements ($\pm 0.1^\circ C$, roughly equivalent to $\pm 0.4$ m/s)
- Inadequate choice of salinity in the Sippican acquisition system
- Deviations of true salinity from the mean surface salinity in the WOA/RTOFS.

**Profile extension using WOA/RTOFS atlases or a reference cast**

Profile extension can be applied by selecting *Extend profile* from the *Editor* toolbar (Fig. 2.36). This operation will extend the observed cast in depth as much as possible using the WOA/RTOFS profile. After that, the three plot panels will be updated. If necessary, users should edit any discontinuities between the cast in depth and the extension in the vicinity of the maximum observation depth.

The extension will only go as deep as 5,500 m as this is the deepest depth layer that the WOA/RTOFS atlases support (more details on such an operation are provided in Appendix A - Oceanographic Atlases).

However, when files are transmitted to SIS or exported in .asvp format, the software extends the profile to 12,000 m depth to meet SIS input criteria (thus, there is no need for the user do this manually). Similar to data augmentation for XBT probes and for XSV probes, when a reference cast is set, this will be used to extend the cast instead of WOA/RTOFS atlases data.

**Automated processing**

To streamline the processing of new sound speed profiles, it is also possible to automate a number of steps in the workflow. The *Automated Processing Setup* dialog (Fig. 2.37) can be accessed under Process/Automate Processing.

**Output creation**

The profile accepted by SIS has a limited number of samples, thus the collected profile often requires the application of a thinning algorithm when exporting in Kongsberg format. The thinning is obtained by iteratively running a custom version of the Douglas-Peucker algorithm.

In addition, a *Preview thinning* method is provided to inspect the result of such an algorithm before the actual transmission.

---

2.4. How to use
Fig. 2.36: The *Extend profile* button in the *Editor* toolbar.
Fig. 2.37: The Automated Processing Setup dialog.
Data export

Any file that is loaded into the package can be exported by accessing the Export data from the Editor toolbar (Fig. 2.38).

Several formats are currently supported, so the user must select the format of interest and then choose Export selected formats to actually perform the export. To inspect the content of a profile exported in the NCEI format, see Appendix C - Exploring Profiles in NCEI format.

The export function will prompt the user for an output prefix prior to export.

Data transmission

Data transmission is triggered by selecting the Transmit data from the Editor toolbar (Fig. 2.39).

The recipients of such a transmission are configured in the configuration file (see Possible Configurations).

Data storage

Each time that a profile is exported or transmitted, it is also automatically stored in the current active database. It is also possible to force the storage of a profile using Process/Save to Database.

Database Tab

The package provides functionalities to permanently store, delete and retrieve the sound speed profiles. Any time that a profile is exported or transmitted, its data content is stored in the database. A profile can also be stored in the database by using Save to database in the Editor toolbar (Fig. 2.40).
Fig. 2.40: The *Save to database* menu entry in the *Process* menu.
In particular, each profile contains three types of stored data:

1. The raw data (which makes it possible to redo the processing from scratch).
2. The processed samples (with flags to identify the different sources of data).
3. An optional SIS profile (that represents the result of the thinning process required by Kongsberg SIS).

Once stored in the database, the Database tab provides analysis functions and tools to manage the collected profiles (Fig. 2.41).

Fig. 2.41: The Database tab provides access to the collected profiles and related tools.

**Context menu**

The context menu provides access to different tools based on the number of selected profiles:

- Single-profile selection (Fig. 2.42).
- Pair-profile selection (Fig. 2.43).
- Multi-profile selection (Fig. 2.46).

**Project and Profiles groups**

The Project group provides functionalities to:

- Create a new project (New project button).
Fig. 2.42: The single-selection context menu provides functionalities specific to a single profile.
Fig. 2.43: The pair-selection context menu provides functionalities like ray-tracing comparison (Fig. 2.44) and bias plots (Fig. 2.45).
Fig. 2.44: The ray-tracing comparison between the pair of selected profiles.

Fig. 2.45: The plots show the vertical and the horizontal bias using the pair of selected profiles.
Fig. 2.46: The multi-selection context menu provides functionalities that apply to multiple profiles (e.g., editing common metadata fields for multiple profiles).
• Rename an existing project (Rename project button).
• Switch among existing projects (Switch project button).
• Import data from an existing database to the current project (Import data button).
• Open the folder that contains the project databases (Open folder button).

From the Profiles group, it is possible to import (Import profiles button) or export (Export profiles button) multiple profiles.

Using the Make plots and Export info buttons (Fig. 2.47), you may:

• Export the profile metadata in several geographic formats: csv, kml, shapefile (e.g., Fig. 2.48), and
• Create maps (Fig. 2.49) and plots (Fig. 2.50 and Fig. 2.51).

![Fig. 2.47: The Make plots and Export info buttons in the Profiles group creates plots/maps and exports the metadata for all the profiles in the database.](image)

### Additional Functionalities

#### Retrieve Profiles from Various Sources

It is possible to retrieve a profile from a number of sources. This can be done by selecting one of the options listed under Retrieve from in the Input data dialog (Fig. 2.52). Database specific instructions for creating a profile are detailed in the sections below.

### 2.4. How to use
Fig. 2.48: Loading result of the exported metadata (kml format) in Google Earth.
Fig. 2.49: Example of a map created from a stored SSP data set.
Fig. 2.50: Example of a daily plot that can be created from a stored SSP data set.

**Project Database**

The *Input data* dialog can be used to recall a profile from the project database. Clicking the *Project DB* button will open a dialog with a drop-down menu containing all the profiles in the current project database. After selecting a profile, it can be edited, and the resulting cast can be eventually sent as described in *Data transmission*.

**Request profile from SIS4/SIS5**

The *Input data* in the *Editor* toolbar can also be used to retrieve the cast currently being used by *SIS* and use it to create a new profile.

This is only possible if the package is receiving data transmissions from *SIS*. If it is not, the package will request a cast and will wait a few seconds until it times out on the request. During this wait period, the package will be unresponsive to further user interaction.

If a profile is received, it will be given the name `YYYYMMDD_HHMMSS_SIS` with the date/time in the filename based on the cast time recorded by *SIS*.

There are a number of shortcomings regarding the Kongsberg datagram format for sound speed profiles:

- It does not preserve the latitude/longitude of the observed cast. You will be prompted to enter the position of the cast when you request the cast from *SIS*. It is up to you to determine the position as accurately as you require it to be, perhaps by consulting CTD/XBT logs.

- The observation time associated with the cast is known to be incorrect in the *SIS* sound speed profile datagram format so it is not necessarily straightforward to use the observation time to look up the navigation.
Fig. 2.51: Example of aggregate plot to study the sound speed variability during a selected time span.

Fig. 2.52: The Input data button in the Editor toolbar.
Temperature and salinity are not included in the datagram, even if they are provided to SIS when the associated cast was originally uploaded (they are preserved internally in SIS, however).

These shortcomings are overcome through the use of the “W” datagram in SIS, however, it is not currently possible to dynamically request this datagram from SIS (though it is possible to have SIS broadcast it as discussed in the section Method B: Sound Speed Manager and SIS v4 Installed on Separate Computers within a Network).

Note: SIS5 functionality is currently unavailable.

Seabird CTD

Clicking Seabird CTD in the Retrieve from section of the Input data dialog opens a dialog that allows for direct interaction with a SeaCAT instrument.

Oceanographic and Regional Atlases

It is possible to upload a single WOA, RTOFS, or any of the supported RegOFS models listed in Appendix A - Oceanographic Atlases. This can be done by selecting the button under Request from that matches the desired model service.

This will trigger a series of question dialogs about timestamp and position to apply a spatio-temporal search. The user can decide to use the SIS timestamp/position input (when available) or manually set these inputs. After, a surface sound speed can be applied, and finally the resulting cast can be sent as described in Data transmission.

The new cast will be given the filename YYYYMMDD_HHMMSS_MODEL where the date/time of the filename is based on the query time of the cast and MODEL corresponds to the model descriptor described in Appendix A - Oceanographic Atlases.

Using a reference cast

There are several scenarios where a CTD profile can be used as a reference cast by this package:

- To support XBT measurements by providing a salinity profile measurement in place of using an assumed constant salinity
- To augment SVP/XSV casts with temperature and salinity profiles to improve seafloor backscatter attenuation corrections
- Since CTD casts typically sample much deeper than most XBT probes, to provide an improved vertical extrapolation to the XBT cast.

To establish a reference cast, the desired cast is imported using the same mechanism described in Data import. After that the profile is verified, edited and perhaps extended further in depth using an oceanographic database, it is set as the reference profile by selecting “Reference cast” in the Editor toolbar (Fig. 2.53).

Once a profile is set as the reference cast, the reference profile is drawn in orange. This cast is retained in memory as the currently loaded cast to allow for additional operations, such as exporting or transmission to a sounder. The reference profile can be cleared from memory at any time via the Clear reference cast option under the Reference cast menu (Fig. 2.54). Further extensions and augmentations will then use WOA/RTOFS.

The reference cast can be reimported into memory by choosing Reload reference cast as current profile from the Reference cast menu. This will load a copy of the reference cast into memory for further manipulation. If desired, the edited version can then be set as the new reference cast and will replace the previous version. Prior to setting a cast
as the reference cast, it is advisable to store it in database such that future sessions do not need to repeat any reference cast processing.

**Refraction monitor**

*Note: This plugin is currently disabled.*

An experimental feature has been set up to allow the user to establish the impact of their currently loaded sound speed profile on the refraction correction by plotting swath data with the new sound speed profile applied prior to sending the profile to the multibeam echosounder.

This provides a preview of the effect of the new sound speed profile allowing appropriate action if the results are not as expected without introducing artifacts into the multibeam data stream.

**Network data reception**

The package is configurable to listen on specified ports for UDP input of sound speed cast data. Currently supported systems are MVP and Sippican. See *Appendix B - Connection Settings* for more on how to configure these systems. The port numbers associated with various data sources can be changed in the setup.db file using the Setup tab.

Upon reception of a network cast, the display panels will be colored red to indicate that operator intervention is required in order to further process the data and deliver it to the multibeam acquisition system. Once the cast has been processed and delivered, the statusbar color-coding will return to the normal background.

If the Server mode happened to have been running at the moment of reception, it will be stopped and the received cast will be displayed as described above.
2.4.2 Synthetic Profile Server Mode

The Synthetic Profile Server mode is meant for transits during which perhaps one XBT per day might be thrown. For much of the world oceans, using the WOA is a reasonable substitute for in situ measurements (Beaudoin et al., 2011). Given that transit data are usually a lower priority, this mode supports continuous underway logging of multibeam data that are refraction corrected, using the mean temperature and salinity profiles provided by oceanographic models. This mode should not be used if SSPs are going to be collected on a regular basis.

![Synthetic Profile Server](image)

Fig. 2.55: The Synthetic Profile Server tab provides the controls to manage the Server mode.

A preliminary requirement to run the Server Mode is that position and surface sound speed are received from SIS. This can be checked by looking in the status bar.

When this mode is active, all the user’s manual functionalities becomes unavailable until the Server mode is stopped. The last sent profile is displayed in the view panel and all three plot panels are colored green. The mode can be stopped by selecting Stop under the Server menu (Fig. 2.55). Closing the application will also stop the server. To guard against accidentally overwriting a profile that was uploaded by the operator after the server was started, this mode verifies with SIS that nothing has been uploaded since the last synthetic cast was delivered.

If the package finds that a profile has been uploaded, either by another program or a person, it will stop serving WOA data to SIS and will notify the user.
Serving to multiple clients

For installations with multiple clients, the server will deliver the cast sequentially to all clients. Failure on transmission to one client will not interfere with other clients. Once a client is deemed “dead”, i.e., no reception confirmation is received, no further attempts to send to the client are made even if a “dead” client comes back to life (a restart is required). If all clients are deemed dead, then the server stops and notifies the user.

Note:  
SIS will accept and rebroadcast SVP datagrams even if it is not pinging. Thus, to make a client appearing “dead” to the server, you must shutdown SIS.

2.4.3 Survey Data Monitor

The Survey Data Monitor (Fig. 2.56) has two main functionalities:

- Monitoring the survey data being collected (*SIS required*).
- Estimation of the time of the next cast (always available, but SIS information are used if present).

![Survey Data Monitor tab](image)

Fig. 2.56: Survey Data Monitor tab.

In Brief

The default configuration uses the CastTime algorithm to estimate the time suggested for the next cast. CastTime analysis is based on the two latest casts from the Sound Speed Manager database (see *Database Tab*).
Fig. 2.57: Example of analysis plot to display the error tolerance limits (in magenta on the right pane) used by CastTime to estimate the next cast time.
The background color in the Next-cast Info viewer (Fig. 2.56) identifies three possible estimation states (calculated in function of the maximum allowable error):

- *Steady* state (blue): the casting interval is the same as in the previous estimation.
- *Relax* state (green): the previous casting interval was increased.
- *Panic* state (red): the previous casting interval was reduced.

Independently by the current estimation state, the Next-cast Info viewer starts to blink when the suggested next-cast time was reached, and there have not been newer casts stored in the database.

In the following sections, more details on how to use the Survey Data Monitor usage are provided.

**Data Monitor toolbar**

The Data Monitor toolbar (Fig. 2.58) is used to start, pause, or stop the collection and the analysis of the survey data. When SIS interaction is active, additional data (i.e., dynamic transducer draft, sound speed at transducer, and average depth across the sonar swath) are collected.

The collected monitoring data are stored in a survey database (.mon).

![Fig. 2.58: In red, the Data Monitor toolbar controls to start, pause, or stop the data monitoring.](image)

The Options button in the Data Monitor toolbar (Fig. 2.58) provides access to the setup, organized as follows:

- **General** tab (Fig. 2.59).
- **CastTime** tab (Fig. 2.60).
- **ForeCast** tab (*currently disabled*).
- **Plots** tab (Fig. 2.61).

**Note:** A high number of samples selected in the Plots tab (Fig. 2.61) may reduce the reactivity of Sound Speed Manager.

**Data Manager toolbar**

The Data Manager toolbar (Fig. 2.62) provides functionalities to load previously collected data as well as to export such data in a few geospatial formats (Fig. 2.63).

It is also possible to import Kongsberg EM Series (.all) files.

When a GeoTiff output is selected, the surface sound speed values in the collected data points are rasterized in two kinds of files:

- Floating point GeoTiff, to be loaded in GIS applications (like QGis, Caris Hips&Sips, Esri ArcMap).
- Color-table Geotiff, supported by a large number of applications (e.g., Xylem HYPACK).
Fig. 2.59: In the General tab, you can select the estimator to be used (ForeCast is currently disabled). You can also change the default values adopted by the estimator in case that SIS data are not available. When the Plot analysis flag is set, additional plots are visualized at the time of next-cast estimation.
Fig. 2.60: This tab contains the *CastTime*-specific settings: the initial casting interval, the possible range of variability for the estimated casting interval, the angle at which to calculate the ray-tracing, and the factors used in the formula used to calculate the maximum allowable error.
Fig. 2.61: This tab is used to change the number of samples displayed in the plotters. This value does not affect the storing in the survey database (.mon). It is also possible to select the initial plotted area (e.g., CONUS).

Fig. 2.62: In magenta, the Data Manager toolbar controls to open the output folder, to load data, and to export in various formats.

Fig. 2.63: The dialog shows the available export data formats.
Data Views toolbar

The Data Views toolbar (Fig. 2.64) helps the user to customize the data visualization.

The Survey Data Monitor tool provides several plots and viewers that can be un-docked to ease their visualization while performing other tasks with Sound Speed Manager:

- General Info viewer.
- Surface Sound Speed Map plotter.
- Surface Sound Speed vs. Time plotter.
- Transducer Depth vs. Time plotter.
- Average Depth vs. Time plotter.
- Next-Cast Info viewer.

Each plotter has a navigation toolbar that provides basic functionalities like panning and zooming.

![Fig. 2.64: In magenta, the Data Views toolbar controls to toggle the visualization of viewers and plotters.](image)

The Next-Cast Info viewer (Fig. 2.65) displays textual information related to the latest analysis performed by the next-cast estimator (e.g., CastTime).

![Fig. 2.65: The Next-Cast Info viewer provides information on the analysis performed by the CastTime algorithm.](image)
2.4.4 List of references


Note: For some examples on how to use the library: https://github.com/hydroffice/hyo2_soundspeed/tree/master/examples

2.5 Appendix A - Oceanographic Atlases

2.5.1 World Ocean Atlas

The World Ocean Atlas is a 3-dimensional grid of mean temperature and salinity for the world’s oceans that is based upon a large set of archived oceanographic measurements in the World Ocean Database.

More information about the World Ocean Atlas 2009 (WOA09) can be found online

The WOA09 netCDF temperature and salinity grids used by the package can be accessed from http://www.nodc.noaa.gov/OC5/WOA09/netcdf_data.html

The files required are:

- temperature_annual_1deg.nc
- temperature_seasonal_1deg.nc
- temperature_monthly_1deg.nc
- salinity_annual_1deg.nc
- salinity_seasonal_1deg.nc
- salinity_monthly_1deg.nc

Basin and land/sea masks can be downloaded from: http://www.nodc.noaa.gov/OC5/WOA09/masks09.html

2.5.2 Global Real-Time Ocean Forecast System

The Global Real-Time Ocean Forecast System (RTOFS Global) is a 1/12°, 3-D oceanographic forecast model. More information can be found online at: http://polar.ncep.noaa.gov/global/

Daily forecast/nowcast grids can be downloaded via the URL listed above, but the file sizes for the daily forecast are prohibitive for use at sea. Instead, the package relies on the OpenDAP portal to download only small segments of the
nowcast grids for surrounding a specified query location. The downloaded subset is a 5x5 grid centered on the query location.

### 2.5.3 Regional Operational Forecast System

The NOAA Operational Forecast System (RegOFS) is a network of operational nowcast/forecast hydrodynamic models covering a number of coastal regions in the USA. Models are run 4 times a day and generate current and short-term (0 to 48 hour) forecast predictions of pertinent parameters such as water levels, currents, temperature, and salinity.

More information about RegOFS models can be found at: [https://tidesandcurrents.noaa.gov/models.html](https://tidesandcurrents.noaa.gov/models.html)

Daily forecast/nowcast grids can be downloaded via the URL: [https://opendap.co-ops.nos.noaa.gov/thredds/catalog.html](https://opendap.co-ops.nos.noaa.gov/thredds/catalog.html)

Similar to the RTOFS Global atlas, the package relies on the OpenDAP portal to download only small segments of the nowcast grids surrounding a specified query location.

Currently the package supports a limited number of the RegOFS models. The full list of models with related support is provided in the table below.

<table>
<thead>
<tr>
<th>Regional Operational Forecast System Model</th>
<th>Descriptor</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chesapeake Bay</td>
<td>CBOFS</td>
<td>X</td>
</tr>
<tr>
<td>Delaware Bay</td>
<td>DBOFS</td>
<td>X</td>
</tr>
<tr>
<td>Gulf of Maine</td>
<td>GoMOFS</td>
<td>X</td>
</tr>
<tr>
<td>New York and New Jersey</td>
<td>NYOFS</td>
<td></td>
</tr>
<tr>
<td>St. John’s River</td>
<td>SJROFS</td>
<td></td>
</tr>
<tr>
<td>Northern Gulf of Mexico</td>
<td>NGOFS</td>
<td>X</td>
</tr>
<tr>
<td>Tampa Bay</td>
<td>TBOFS</td>
<td>X</td>
</tr>
<tr>
<td>Lake Erie</td>
<td>LEOFS</td>
<td>X</td>
</tr>
<tr>
<td>Lake Huron</td>
<td>LHOFS</td>
<td></td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>LMOFS</td>
<td></td>
</tr>
<tr>
<td>Lake Ontario</td>
<td>LOOFS</td>
<td></td>
</tr>
<tr>
<td>Lake Superior</td>
<td>LSOFS</td>
<td></td>
</tr>
<tr>
<td>Columbia River Estuary</td>
<td>CREOFS</td>
<td>X</td>
</tr>
<tr>
<td>Sanfrancisco Bay</td>
<td>SFBOFS</td>
<td>X</td>
</tr>
</tbody>
</table>

### 2.5.4 Synthetic cast values derived from atlases

The cast extrapolation algorithm vertically extends temperature and salinity profiles as deep as possible using the estimates immediately local to the area of the cast in either WOA or OFS.

**WOA09-based profiles**

The World Ocean Atlas 2009 (WOA09) extension algorithm uses a nearest neighbor lookup in each of the 33 depth levels in the grids within a 3x3 grid node search box centered on the cast’s geographic position. This is roughly equivalent to a search radius of 1.5° or 90 nmi at the equator. Note that this grid node search box becomes rapidly narrower in the east-west direction with latitude. The nearest-neighbor geodetic distance is, however, correctly computed and the nearest neighbor will indeed be the geographically most proximal grid node; the only shortcoming is that the lookup will ignore potentially closer data in the east-west direction at high latitudes.

Future updates to the WOA09 extraction algorithms will remedy this shortcoming. The search radius is set this large to enable the extension to at least estimate deeper temperature and salinity values in the case where the true depth at
the requested location is significantly larger than the coarse depth reported in the WOA09 grid for that location (the WOA09 grid depth will generally always be smaller than the true depth).

The search algorithm will not respect topographic boundaries and may extrapolate profiles using data from a neighboring oceanographic basin. Future versions of the algorithm will address this shortcoming as well, likely with the use of the basin mask file provided with the WOA09 data set.

**WOA13-based profiles**

WOA13 represents the ocean state variables of temperature and salinity with more detail and less uncertainty than WOA09 due to large increases in data holdings and better temporal and spatial coverage coupled with refined analysis and quality control techniques:

- Increased vertical resolution (3x in the upper ocean, 2x below 1500 m.)
- Increased spatial resolution (16x)
- Release of the decadal climatologies which were used to calculate the final 1955-2012 long-term climatological mean fields.

In the specific, the package uses the WOA13v2 release that was prepared to address both methodology concerns and, to a lesser extent, quality control concerns which have surfaced since the initial release of WOA13.

**RTOFS-based profiles**

The RTOFS extension algorithm differs in the size of the search area (5x5), roughly equivalent to a search radius of 0.2° or 12.5 nmi at the equator. All of the shortcomings of the WOA09 lookup described above also apply to the RTOFS lookup.

**RegOFS-based profiles**

The Regional Operational Forecast System Models follow an approach similar to the RTOFS-based profiles. However, the resulting search radius is function of the regular grid resolution at which each model output is published.

**Profile Finalization**

The final extrapolation to a depth of 12,000 m is done using the values measured by (Taira et al., 2005) in Challenger Deep. This could be improved by searching for the nearest neighbor grid node at the deepest level observed in the basin using the basin mask file.

**2.6 Appendix B - Connection Settings**

**2.6.1 Settings for data reception**

**Moving Vessel Profiler**

The MVP controller interface can be configured to transmit data via UDP using a variety of data format and transmission protocols (Figure – MVP Controller configuration dialog. Boxes A through C are required for transmission of cast information. Box D can be configured to transmit sensor data.).

The MVP computer IP address and the IP address of the machine running the SSM package can be configured in Box A. For newer versions of the MVP controller, it is recommended to choose the NAVO_ISS60 transmission protocol.
Fig. 2.66: Figure – MVP Controller configuration dialog. Boxes A through C are required for transmission of cast information. Box D can be configured to transmit sensor data.
as this will allow for large cast files to be transmitted in several packets without overflowing the UDP maximum packet size limitation (Box B). Older versions of the MVP controller software (up to version 2.35 to the best of our knowledge) do not support the NAVO_ISS60 protocol and the package must be configured to use the UNDEFINED protocol in the SSP package configuration file. The file format can be adjusted to accommodate a CTD with the S12 format or a sound speed sensor with the CALC or ASVP formats (Box C).

Note that the transmission protocol and file format must be configured in both the MVP controller interface and in the the Setup tab (in the Input tab, to activate the MVP listener and, in the Listeners sub-tab, for the communication settings).

Boxes D and E refer to raw instrument transmission settings that are configurable for future use. Since casts received from an MVP system do not have a filename embedded in the data stream, the Sound Speed package will name casts received using the following convention: YYYYMMDD_HHMMSS_MVP. The date/time stamp embedded in the filename will be the time of the cast.

**Note:** Once the MVP listener is activated, a “MVP” token will be visualized on the left side of the SSM’s status bar.

### Sippican

There does not currently exist any internal mechanism in the Sippican software to broadcast data via UDP, this capability has been included to accommodate vessels that use UDP network broadcasts to log data from various systems. The expected data format is the Sippican native .EDF file format.

Note that a single Sippican data file can sometimes exceed the maximum buffer size for UDP packet transmissions. If software is written to transmit Sippican data files via UDP, this limitation should be kept in mind. The Sound Speed package currently only accepts transfer of a single UDP packet thus transmission software may need to reduce the data by thinning the profile. Received profiles will use the filename embedded in the .EDF.

#### 2.6.2 Settings for data transmission

The Sound Speed package can be configured to transmit data to a number of systems by selecting the Transmit data button in the Editor tab.

For installations with multiple clients, the Sound Speed package will deliver the cast sequentially to all clients. Failure on transmission to one client will not interfere with other clients though it will slow down the transmission sequence through all clients for any clients who are timing out on confirmation of reception as the Sound Speed package will wait up to the ‘RX timeout’ value defined in the setup (default: 20 seconds) for confirmation.

**Note:** Server mode will only currently work with the SIS transmission protocol.

### Kongsberg SIS

SIS does not require additional configuration to receive sound speed files since it always listens on port 4001 for input sound speed data.

The following indications are useful for monitoring reception of sound speed profiles:

- The SSP profile filename will be updated in the Runtime parameters menu in the form: YYYYMMDD_HHMMSS_{asvp}. The date and time fields are populated based on the time stamp in the profile that was received from the SSP package. In the case of measured casts, this is the time of acquisition, as found in the input file. In the case of synthetic WOA profiles, the date/time is based on the time of transmission of the cast (using the computer clock where the SSP package is installed).
• SIS creates several files in the last location from which it loaded a sound speed profile.

• The SVP display window, if being viewed in SIS, will update with the new cast.

• In the event that a cast is rejected, SIS will launch a warning dialog to indicate that the cast it received was rejected.

Although SIS will always allow incoming sound speed transmissions, it has several restrictions that must be observed in order for the data to be accepted (see Kongsberg manual). As this particular transmission protocol is used by other acquisition systems, it is worth describing in detail what the Sound Speed package does to the cast data to satisfy the input criteria for SIS.

The transmission procedure used by the SSP package will format the temperature and salinity profiles into the Kongsberg Maritime format. Since the WOA09/RTOFS grids only extend to a maximum depth of 5,500 m, the profile undergoes a final extrapolation to a depth of 12,000 m to satisfy SIS input criteria, this is done with temperature and salinity values measured in the Mariana Trench by Taira et al. (2005).

Since SIS input profiles have a limit on the maximum allowable number of data points, the sound speed profile is thinned using a modified version of the Douglas-Peucker line reduction method as described by Beaudoin et al. (2011). The algorithm begins with a small tolerance and increases it linearly until the number of points in the profile falls below the maximum allowed by SIS.

By default, the cast header is formatted to instruct SIS to accept the profile for immediate application without launching the Kongsberg SVP Editor. This behavior can be changed through the configuration file by setting Auto apply profile to False (in the Setup tab). In this case, SIS will accept the cast but will then launch its own editor interface and user interaction will be required on the SIS computer in order to have the cast applied to the multibeam system.

Once the cast has been prepared for transmission, it is sent to SIS via UDP transmission over the network. If SIS receives the profile and accepts it, it will rebroadcast the SVP datagram. The Sound Speed package waits for this rebroadcast to ensure reception of the cast. The profile that was re-broadcasted from SIS is compared against that which was sent. If they match, then the transmission is considered successful. If there is a discrepancy, or if no rebroadcast profile is received, the user is notified that reception could not be confirmed. The lower left status bar notifies the user of the various stages of this verification process.

In deep water, the rebroadcast event may take several seconds to occur and the software will wait up to a user-defined amount of time (e.g., 20 seconds) for reception of the re-broadcasted SVP. All other package functionalities are suspended during this wait period.

### Hypack

The Sound Speed package can transmit data to HYPACK using HYPACK’s driver for Moving Vessel Profiler (MVP) systems (MVP.dll). Next figures provide a guidance on how to configure a Hypack project to receive data from SSP package.

### QINSy

QINSy accepts the same SVP transmission protocol as SIS, but a method to verify reception of the cast is not currently known thus the user should confirm reception in the acquisition system.

### PDS2000

PDS2000 accepts the same SVP transmission protocol as SIS, but a method to verify reception of the cast is not currently known thus the user must confirm reception in the acquisition system.
Choose “Project Manager” from the File menu to either create a new project or to open an existing project.

Fig. 2.67: Step 1: opening the project manager.
Choose an existing project and click “Open Project” below.

Or, click “New Project”, give it a name when prompted and then open it.

Fig. 2.68: Selecting or creating a Hypack project.

Once your project is open, add a device driver.

Fig. 2.69: Selecting the Add device button.
Fig. 2.70: Adding device drivers to a Hypack project.
Fig. 2.71: Adding the MVP device driver.
Fig. 2.72: Configuring the MVP driver. The network parameters of the driver are configured to use a UDP input protocol in a client role. The host IP address must match the address used by the computer running SSP and the reception port must match the port configuration chosen in the package configuration file. The “Write Port” is left as zero.
Fig. 2.73: Additional configuration of the MVP device driver.

- Optional, but handy to verify in real-time that a cast was received.
- Make sure this is checked.
- Choose a base filename.
- Optional, but handy to for file management.
Fig. 2.74: Testing reception capabilities in Hypack. After having loaded a sample cast into SSP and send it, the profile should be visualized in Hypack (after clicking “Test” button).
Fig. 2.75: Select *Setup* from the QINSy console after loading your project. Refer to QINSy documentation for information regarding setting up a project.
Fig. 2.76: Edit your project database
Fig. 2.77: Right click the *Auxiliary Systems* icon and select *New System.*
Fig. 2.78: Configure the new system as shown above. Choose the same port number that SSP package will be sending casts to (this is configured in the __config__.db file).

Fig. 2.79: Choose Echosounder Settings from the Settings menu. This will allow you to configure the behavior of QINSy when it receives new sound speed profiles from SSP package.
Fig. 2.80: Leftclick the icon for the *SVP Editor* device.
Fig. 2.81: Choose appropriate options to control QINSy’s behavior when it receives casts from SSP package. For initial testing purposes, you should at least choose to be informed after a new update.

Fig. 2.82: With QINSy “online” and recording, send a test profile from SSP package. If you have chosen to be informed upon reception of a new cast, a message window will appear for acknowledgement.
Fig. 2.83: By choosing *Echosounder Settings* from the *Settings* menu again, you can verify that the cast was received.
Fig. 2.84: Adding an MVP driver to PDS2000.
Fig. 2.85: Configuring the MVP driver for PDS2000.
Fig. 2.86: Configuring an MVP driver for PDS2000. Be sure to scroll down in the list on the left side and choose the driver you added in the previous step before modifying the port number. The port number must match that which SSP package is sending data to (configured in the __config__.db file).
Fig. 2.87: After the driver is added, test the device to verify correct configuration of communication protocols.
Fig. 2.88: With the device driver open, send a test cast from SSP package. The data should appear in the Io port View window. Be sure that the correct device driver is selected from the top left list window.
Fig. 2.89: While running PDS2000 in acquisition mode, right click in the multibeam raw profile display and choose “Multibeam filters”. Choose “SVP Sensor” as the source of sound speed profiles to be used.
Fig. 2.90: While running PDS2000 in acquisition mode, you can verify reception in the Status displays and the “Raw Data” displays. Check the date, time, latitude, longitude against what you sent from SSP package.
2.7 Appendix C - Exploring Profiles in NCEI format

Among many other formats (see Supported Formats), Sound Speed Manager is able to export the loaded sound speed profiles in NCEI format.

The NCEI format requires to store the profile data and metadata in NetCDF format. As such, the content of this format can be explored using applications that are able to browse the content of NetCDF file such as HDF Compass and Panoply.

2.7.1 About HDF Compass

HDF Compass enables you to view HDF5 datasets, attributes, and groups. Simple line, image, and contour plots are supported as well. HDF Compass does not provide any editing functionality.

If you are using Sound Speed Manager with the Pydro distribution (see Installation using the Pydro distribution), you can easily access HDF Compass from Pydro Explorer (Fig. 2.91).

![Fig. 2.91: Pydro Explorer Sound Speed Menu.](image)

2.7.2 How to explore a NCEI (.nc) file with HDF Compass

After opening HDF Compass from Pydro Explorer, select File and Open (see Fig. 2.92).

The default file extension filter, HDF5 File contains the NCEI .nc file extension (see Fig. 2.93).

After opening the .nc file, HDF Compass allows the user to explore different data stored in the file. To view the file metadata, using the Window menu, reopen the file as HDF5 attributes (see Fig. 2.94).

Your .nc file attributes will open in a new window (see Fig. 2.95)
Fig. 2.92: HDF Compass Interface.

Fig. 2.93: HDF Compass Browse Dialog.
Fig. 2.94: HDF Compass HDF5 Window Menu.

Fig. 2.95: HDF Compass .nc file Attributes.
3.1 How to contribute

Every open source project lives from the generous help by contributors that sacrifice their time and this is no different.

3.1.1 Public Repositories

The source code is available on both GitHub and BitBucket. To propose changes to Sound Speed Manager, you can follow the common Fork & Pull Request workflow. If you are not familiar with such a workflow, a good starting point may be this short tutorial.

3.1.2 Coding Style

To make participation as pleasant as possible, this project adheres to the Code of Conduct by the Python Software Foundation. Here are a few hints and rules to get you started:

- Add yourself to the AUTHORS.txt file in an alphabetical fashion. Every contribution is valuable and shall be credited.
- If your change is noteworthy, add an entry to the changelog.
- No contribution is too small; please submit as many fixes for typos and grammar bloopers as you can!
- Don’t ever break backward compatibility.
- Always add tests and docs for your code. This is a hard rule; patches with missing tests or documentation won’t be merged. If a feature is not tested or documented, it does not exist.
- Obey PEP 8 and PEP 257.
- Write good commit messages.
- Ideally, collapse your commits, i.e. make your pull requests just one commit.

Note: If you have something great but aren’t sure whether it adheres – or even can adhere – to the rules above: please submit a pull request anyway! In the best case, we can mold it into something, in the worst case the pull request gets politely closed. There’s absolutely nothing to fear.

Thank you for considering to contribute! If you have any question or concerns, feel free to reach out to us (see Credits).
3.2 How to build the documentation

3.2.1 Requirements

The documentation is built using **sphinx**, so you need to have it:

- pip install sphinx sphinx-autobuild

To build the pdf manual on Ubuntu:

- sudo apt-get install texlive-full

3.2.2 First-time creation of documentation template

Just once for each project, you can create the documentation template as follows:

- mkdir docs
- cd docs
- sphinx-quickstart

3.2.3 Generate the documentation

To create the html

- make html

3.3 How to distribute

3.3.1 Preliminary steps

- First of all, run the full test suite and check that there are no failures.
- Verify the release version in the following files:
  - setup.cfg
  - setup.py
  - docs/conf.py
  - hydroffice/soundspeed/__init__.py
  - hydroffice/soundspeedmanager/__init__.py
  - hydroffice/soundspeedsettings/__init__.py
- Push any ‘release’ changes to GitHub/BitBucket

3.3.2 Update docs

- Build the new docs as html (make html) and as pdf (make latexpdf)
- Update the web site with the new html and pdf docs (urls too)
- Update the embedded pdf docs
3.3.3 Freeze the app

- Update the pyinstaller files under ‘freeze/’
- Freeze the application and test it on a ‘clean’ VM
- Upload the app on BitBucket
- Update the download link and the version on the SSM web page
- Update the latest file on the HydrOffice site

3.3.4 Final steps

- Push any ‘release’ changes to GitHub/BitBucket
- Create a ‘tag’ with the release
- Create a GitHub release
- Push the package on PyPI: ‘python setup.py build bdist_wheel upload -r pypi’
- Start to work on the next release :)

3.4 How to freeze

- pyinstaller --clean -y freeze\SoundSpeedManager.1file.spec
- pyinstaller --clean -y freeze\SoundSpeedManager.1folder.spec

3.5 Todo List

3.5.1 Sound Speed

- Increase GSW use

3.5.2 Manager

- Plot x-y for additional fields
- Display a ‘-’ close to tss, draft and bottom
- Rethink the Refraction Monitor

3.5.3 Atlases

- Add World Ocean Database 2013 (same data as WOA BUT preserved record of input data)
- Add World Ocean Atlas 2018
- Add HYCOM (near real time global prediction system)
- Add more NOAA OFS models
3.5.4 Research

- Planning tool: how many xbt?
- Real-time estimation of variability
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      (For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

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Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Library.

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This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to distribute the source code, even though third parties are not compelled to copy the source along with the object code.

5. A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a “work that uses the Library”. Such a work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

However, linking a “work that uses the Library” with the Library creates an executable that is a derivative of the Library (because it contains portions of the Library), rather than a “work that uses the library”. The executable is therefore covered by this License. Section 6 states terms for distribution of such executables.

When a “work that uses the Library” uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6. Any executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also combine or link a “work that uses the Library” with the Library to produce a work containing portions of the Library, and distribute that work under terms of your choice, provided that the terms permit modification of the work for the customer’s own use and reverse engineering for debugging such modifications.

You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

a ) Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable “work that uses the Library”, as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)

b ) Use a suitable shared library mechanism for linking with the Library. A suitable mechanism is one that

(1) uses at run time a copy of the library already present on the user’s computer system, rather than copying library functions into the executable, and
(2) will operate properly with a modified version of the library, if the user installs one, as long as the modified version is interface-compatible with the version that the work was made with.

c) Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in Subsection 6a, above, for a charge no more than the cost of performing this distribution.

d) If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.

e) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

For an executable, the required form of the “work that uses the Library” must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

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