

**3D Seismic Attributes to Define Structure and
Stratigraphy – A Hands-On Short Course
Part 1: Software Installation**

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Introduction

These notes were first compiled and used for a two-day hands-on attribute short course on machine learning for the 2019 CSEG Doodletrain and builds upon experiences gained from an earlier hands-on short course on attribute computation and interpretation prepared for the 2015 AAPG Midcontinent Section Conference, and improved for subsequent courses for the OKC Geological Society continuing education program and for AAPG Student Expos held on the OU campus in 2016, 2017, 2018, and 2019. Our hypothesis is that learning, and seismic interpretation in particular, is best achieved by doing. While it is common to have hands-on access to commercial software in a software-provider or internal company short courses, short courses provided by professional societies are much more difficult. With few exceptions, it is difficult to obtain a sufficient number of software licenses. Adding further complexity, control of such software licenses almost always requires excellent wi-fi communication with a license server. Finally, even if we were to obtain licenses to a given software package, a professional society class will have participants who may use as many as six different packages in their workplaces. To address these challenges, we will use a university-written software package that focuses primarily on seismic attributes, seismic data conditioning, and image enhancement. Most, but not all, of these capabilities are now available in commercial software packages such as Kingdom, Petrel, GeoTeric, GeoModeling, OpenDtect, and DecisionSpace. While we are quite proud of our developments, we do not claim that they are better than their corresponding commercial implementations. Such subjective appraisals are for you, the interpreter, to make.

This guide will help you go through the software usage portion of the course with step-by-step instructions and screenshots.

We hope you enjoy the course. Any question or comment, please feel free to bother any of us at the following email addresses: kmarfurt@ou.edu, thang.N.Ha-1@ou.edu, davidlubo@ou.edu, and gmachado@ou.edu.

The AASPI Software

The AASPI software we will use in this class was developed by faculty, staff, and students at the University of Oklahoma over the past decade as part of the industry-supported “Attribute-Assisted Seismic Processing and Interpretation” consortium. A great deal of documentation and published papers can be found on our web site <http://mcee.ou.edu/aaspi/>. As part of this course, you are invited to download a copy of the software that runs on Windows. Since you will only be able to give you a taste of how attributes help in visualizing the seismic expression of structure and stratigraphy, this software will remain active until July 31, 2018, giving you an opportunity to apply these techniques to more proprietary data at your workplace.

The AASPI software is parallelized, running over multiple processors, including those on physically distinct compute nodes using the Message Passing Interface, or “MPI”. The software runs on laptops running windows with just one or two processors and on supercomputer clusters running Linux with thousands of processors (useful for very large marine data volumes), including supercomputers using batch submission systems such as PBS, LSF, and SLURM.

AASPI Software Installation

If you have not installed AASPI into your system, then this is the first thing you want to do. Otherwise, simply skip to the next section. The installation package is located on the hand-out USB drive. You can also download it from:

http://mcee.ou.edu/aaspi/upload/files/AAPG_Student_Expo_Short_Course/

Then please follow the instructions provided in the file *Installation_Guide_AASPI_For_Windows_2015-08-30.pdf* located in the same folder.

Here is a brief summary of the installation process:

AASPI requires Visual Studio C++ 2013 64-bit Runtime Libraries (vcredist_x64_2013.exe) to be installed in your system. That file is located in the “Prerequisite for AASPI Installation” folder.

If you have downloaded the zip package, please extract it. The extracted files will be called **AASPI.msi** and **setup.exe**. Then right click on **setup.exe** and choose “run as administrator”. You will need administrator privilege to install AASPI. Once the installation process is finished, please restart your computer.

If, for some reason, you don’t have administrator privileges on your system, you need to get help from your administrator. Without such privileges, you won’t be able to run any MPI-related

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program although you should be able to do format conversions, crop, and display the data volumes (simple processes that do not use MPI).

Starting AASPI and converting from SEGY to AASPI format

To start AASPI, double click on the AASPI shortcut on your desktop (1A) (Yes, the logo is indeed a snake grasping the letter π). A directory browser will pop up (1B), allowing you to change the working directory of AASPI (i.e. the directory into which the AASPI output files will be written). Navigate to the desired directory and click OK. The **aaspi_util** window will pop up.

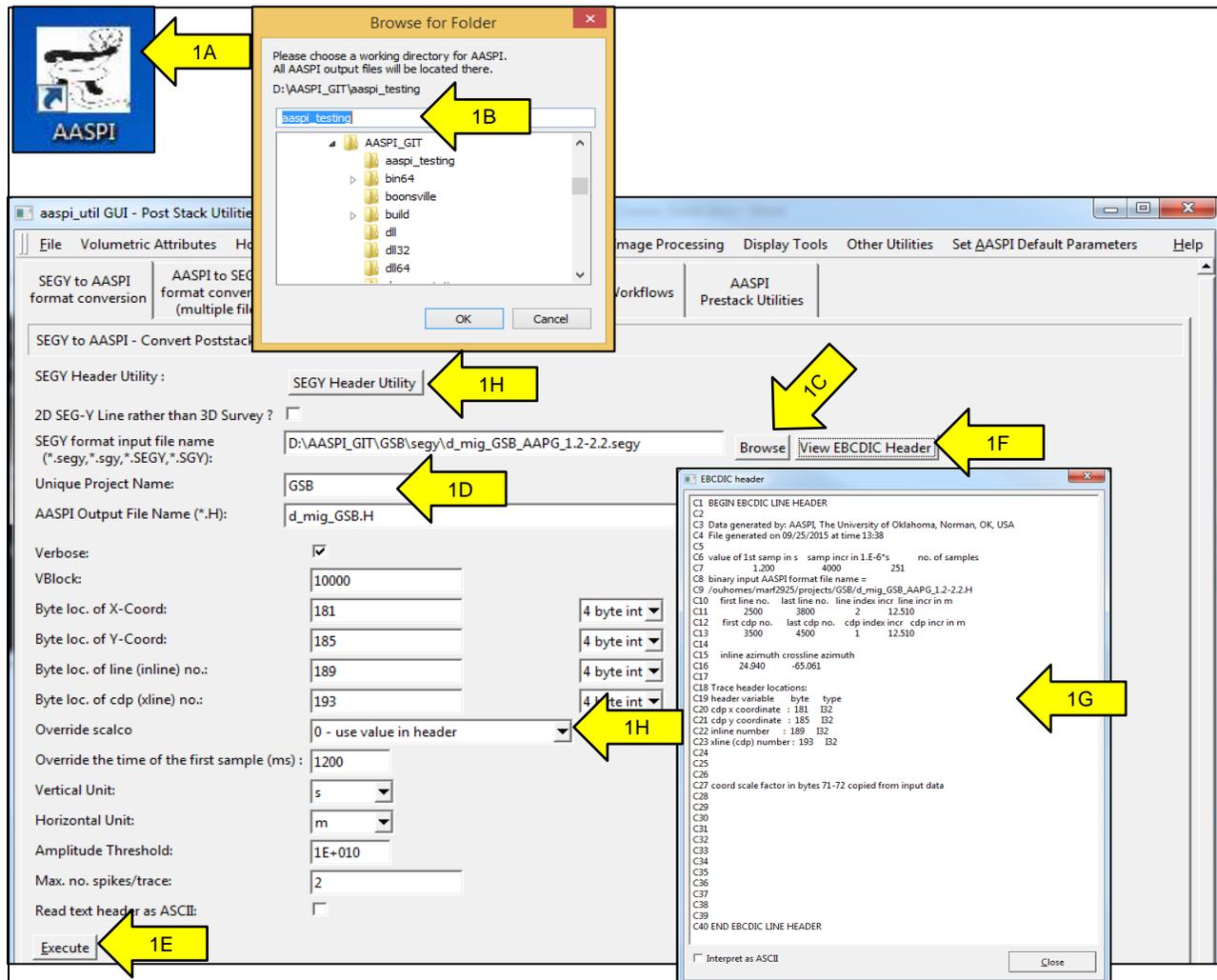
To begin, you need to convert SEGY-format data to AASPI-format data. We think of the Society of Exploration Geophysics SEGY format as not so much a standard, but as a suggestion. Many companies were acquiring 3D seismic data and writing 3D interpretation software years before the 3D standard was adopted in 2002. The AASPI software uses a format that is compatible with those written by the Stanford Exploration Project (using the SEP format) and research teams at UT-Austin and Colorado School of Mines (using the Madagascar format). Our format only differs in that we carry around more headers (such as mute zones) and the explicit orientation of the survey. Headers are necessary to honor no-permit zones and load the data into commercial workstations. Orientations calibrate the computation of vector dip, as well as flexure and fault strike and azimuths to be measured from North.

The first tab of **aaspi_util** defines this format conversion. Browse to your SEGY file (1C) and specify a unique project name, as well as the output AASPI-format file (preferably with a *.H extension) (1D). If you are using the New Zealand Great South Basin (GSB dataset), enter the project name to be “GSB”, “class”, or whatever you wish. Our practice is to name the migrated data something like d_mig_GSB.H, where “d” indicates that the file contains seismic data, the “mig” that it is migrated, the “GSB” that it is the GSB or Great South Basin survey, and the “.H” that it is an ascii survey “header” (following the SEP convention). The only *required* part of this naming convention is the *.H at the end, since the GUIs will search for data files with this ending. Next you need to know where the headers are located on your data. For the GSB data volume, these will be the default 2002 SEGY standard locations, so you can simply click the *Execute* button (1E). You will see data being read (twice!) in the black window. In the first pass it breaks the data into the “SEP” four-file format: an ASCII-format *.H history file, an ASCII-format *.H@@ file containing a map of the trace headers, an IEEE binary format *.H@ file containing the seismic (or attribute) floating point samples, and finally, an IEEE binary format *.H@@@ file containing the (typically integer) header values. As complicated (and annoying) as this may seem, this “broken file” format is common to most larger processing centers. In this way, sorting the data requires only reading and sorting the small header files which can remain in computer memory, in contrast to reading multiple times through the large SEGY format file containing headers and data together.

If you are loading your own dataset, you may wish to examine the header information by clicking on (1F) “View EBCDIC header” button. This will display the text-format “line header” in your SEGY file (1G). There are several fundamental header values you need in order to load SEGY data, including the X and Y coordinates of each migrated trace, the line (or inline) number, the CDP (or crossline) number, the computer TYPE of those values (e.g. 4-byte integer vs. floating point IBM...), the coordinate scale factor, the time of the first sample, and the time and distance units.

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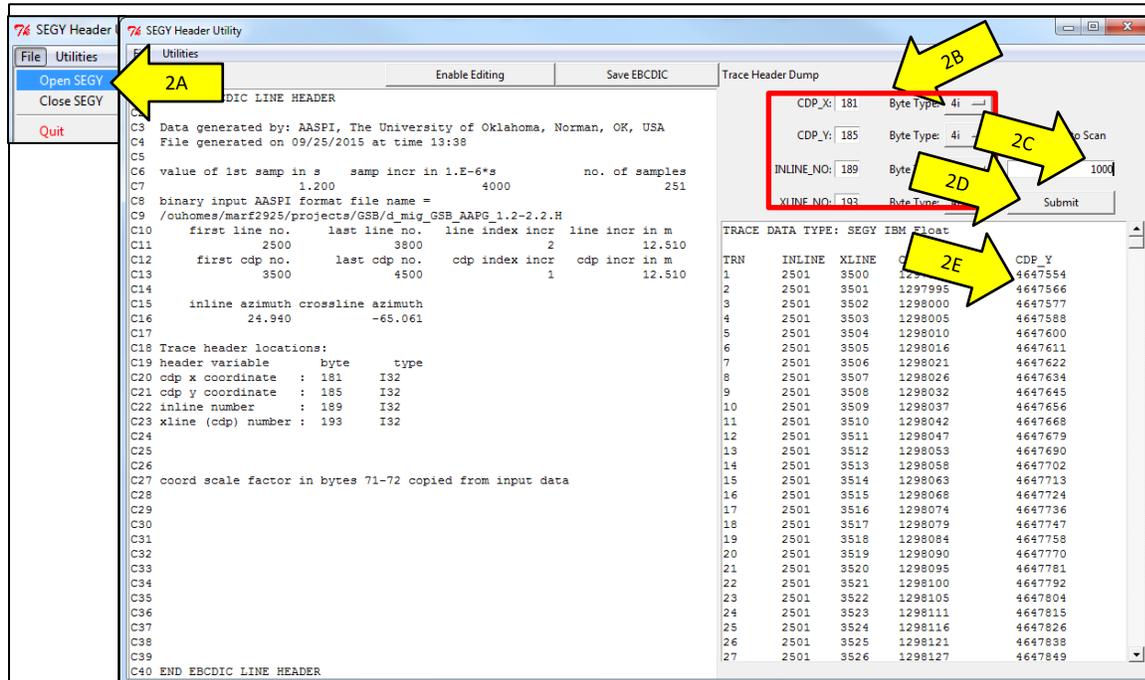
With the exception of the byte locations, most of these variables are well defined. However, be aware that it is common for commercial interpretation software to scale the x and y locations to the correct world coordinates, but when exporting to *not* change the SEG-Y coordinate scaling value, resulting in bin sizes that may be 10 or 100 times too large. If this happens, you will need to override the *scalco* value (1H).



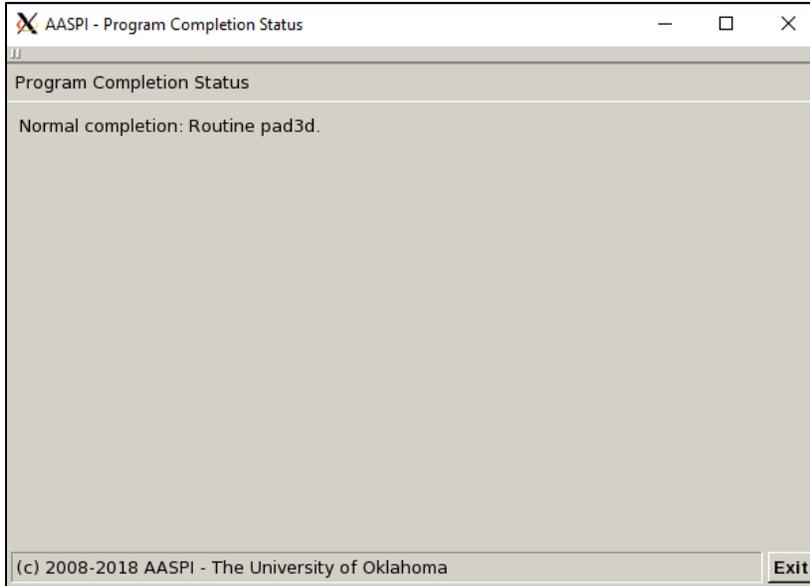
Another way to determine the header information is to use the SEG-Y header utility (1H). This utility allows you not only to view the ASCII header of your SEG-Y file, but also scan through headers of a number of traces in the dataset. Click Open SEG-Y (2A) and navigate to your SEG-Y file. If you have the byte locations of inline number, crossline number, and x and y coordinates, fill them in (2B). Usually you don't need more than 1000 traces to be scanned (2C). After that, click Submit (2D), and you will see the header values (2E) in order to check if the header byte location is correct. If there is no information in the ASCII header, or if those information are inaccurate, it will take some hit-and-miss guesses before you find the correct header byte locations. Common location for line no. locations are 189, 5, 9, and 17, for cdp no. locations 193,

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17, 21, for cdp x locations 181, 73, 81, and for cdp y locations 185, 77, and 85. Yes, this is why most larger companies have exploration technologists who load the data for you. As before, click *Execute*. Good luck!



The conversion is a two-step process. The first step converts the (generally unpadding) SEG-Y-format file to an unpadding AASPI-format file. The second step determines the geometry from the headers and defines the smallest rectangular survey to encompass the data. These padding traces are assigned a trace-id value of "3" for "padding". Live traces have a trace-id value of "1" while dead traces have a trace-id value of "2". Often, the SEG-Y file will have the trace-id set to "0", or simply undefined. In this case, the conversion program examines the trace and sets it have a trace-id=1 if non-zero data are found. Starting and ending mutes are also computed for each trace to honor no-permit zones. After completion, you should see a pop-up window that looks like this:



indicating that it completed normally. Yes, other messages are possible!

Data Loading Pitfalls

Pitfalls in loading data exported from interpretation workstation 8- and 16-bit formats

For very large data volumes where the goal is to keep as much of the data in computer memory as possible, it is common practice to store data in an interpretation workstation in either 8-bit or 16-bit format. 8-bit format stores the data as scaled integers ranging between ± 127 . Although acceptable for visualization and picking, 8-bit format can be problematic for subsequent attribute generation even within the same interpretation software package, whereby large anomalous amplitudes may get clipped, resulting in “corners” in the seismic waveform and high-frequency attribute artifacts. We advise interpreters to always compute their attributes from the original 32-bit volume.

16-bit format stores the data as scaled integers ranging between ± 32767 and is in general less problematic. However, many software packages do not preserve header information include no-permit areas and mutes. In the AASPI software, we recompute these headers by searching for zero-value samples. Unfortunately, values that were zero on the original 32-bit data are often no longer zero on a 16-bit format volume exported to 32-bit. Rather, the data are assigned to some small non-zero value approximately six orders of magnitude less than the RMS amplitude of the seismic data. If this occurs, the mutes and dead traces will not be flagged, resulting in many sharp amplitude discontinuities. Such discontinuities then express themselves as high amplitude dip, coherence and curvature artifacts. We address this issue in the AASPI software by allowing the user to define a statistical zero.

IBM vs. IEEE and big-endian vs. little-endian formats

Since the big mainframe processor of the 1960s and 70s was IBM, the SEG Y defined IBM hexadecimal floating-point format as part of the SEG Y standard. Since that time, the standard has been generalized to accept the (currently) more common IEEE format. SEG Y line header bytes 3225-3226 provide a location to define the data format, but sometimes this number is absent or incorrectly entered. If your data look like seismic data but the values are ridiculously large ($>1.0E30$), you probably have a format error.

IBM and Solaris operating systems dominated seismic processing in the 1980s and 90s, such that big-endian byte format was the rule such that the SEG Y rev 1 standard is big-endian. Today, most folks use Windows and Linux. Windows PCs use little-endian. Our Dell hardware Linux clusters also use little-endian. If you write a MATLAB code and naively construct a SEG Y-type data volume, but you write the data as IEEE little-endian, no commercial software will be able to read it.

Displaying data using the AASPI QC Plotting tab

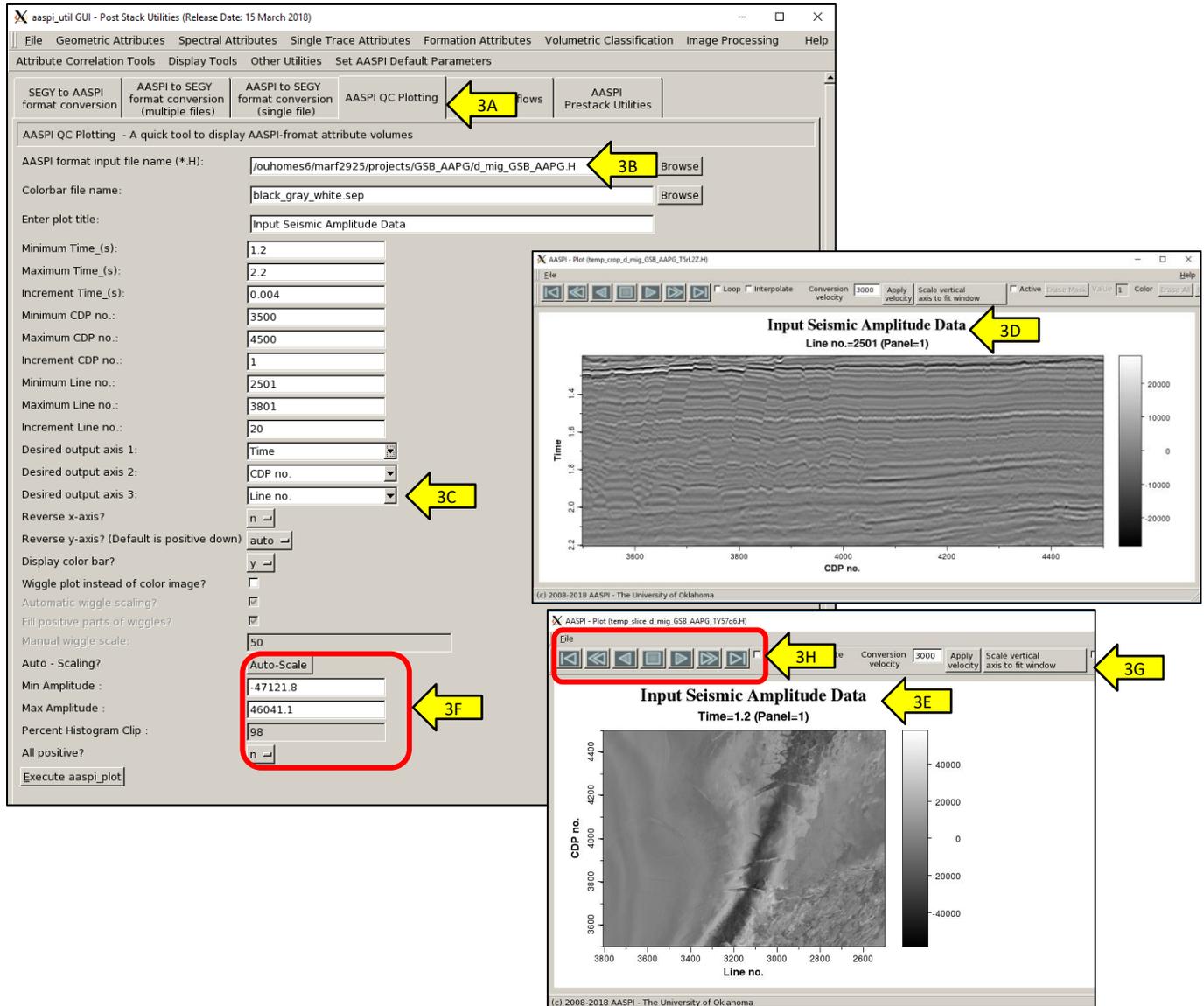
To display a dataset, click the AASPI QC Plotting tab (3A). Browse to find your dataset (3B). The default is set to display a vertical slice along an inline of the seismic or attribute data volume (3C) (i.e. the 3rd slowest moving axis is inline). If you want to change the view to time-slice mode, select the 3rd axis to be time (3C). Then the plot will display time-slices of the dataset (3E). Similarly, if the 3rd axis is cross-line, then each panel view is a cross-line view.

Also, by default, the scaling is set to be auto-scaling (3F), meaning the display color bar spans (in this case) 98% of the data, “clipping” the values below the 1 and above the 99 percentiles. The lower the clipping percentage, the more contrast the image exhibits. You can click on the *Auto scale* button to change it to fixed scale mode and manually modify the maximum and minimum values of your dataset to be used in color scaling.

The default display will size the image to approximate the true spatial dimensions. If the vertical axis is time, the software will look for a velocity value in the file name. Since we haven’t done that yet, it will pick a reasonable value of 10000 ft/s or 3000 m/s. For time or depth slices, the true bin size will be honored, and the data rotated to the nearest x-y orientation to the survey design. If you wish to stretch the image to fit the entire canvas, click on (3G) scale to fit window. Use the VCR buttons (3H) to move between panels to explore the volume.

The AASPI format uses simple inline by inline data storage, rather than the more efficient (and unfortunately proprietary) brick storage used by commercial software. It therefore takes more time to display time slices.

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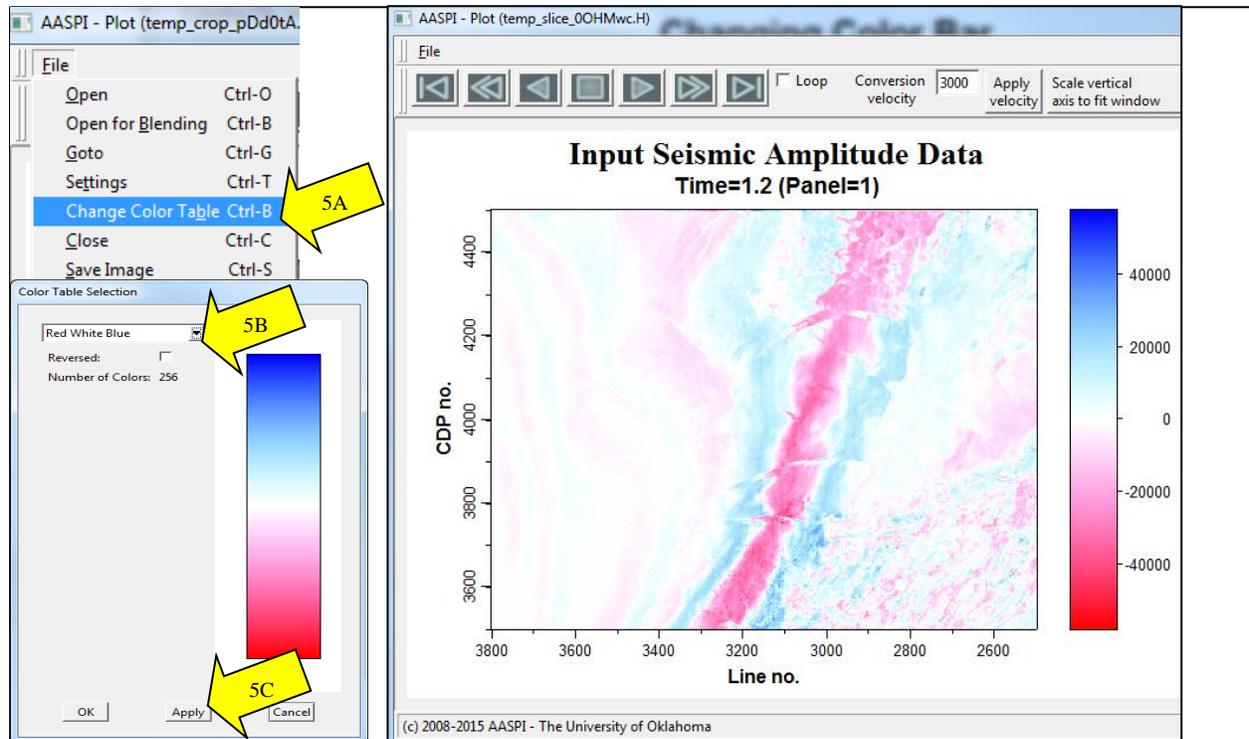


The AASPI QC Plotting GUI allows you to manually change plotting parameters after the data are displayed. Click on (4A) File → Settings to open the settings dialog. In the general tab (4B), you can specify whether to show a color bar, transpose an image, reverse the axes, or reverse a color bar. If you are comparing two data of the same type but with different ranges of values (for example, seismic amplitude reprocessed using a different workflow), it is better to turn off the color bar to maintain the exact size of the main plot area. In the Title/Labels tab (4C), you can change the title of the plot, as well as the axes labels and color bar label.

The data *Settings* tab (4D) is the most common one that you will use. This tab allows you to change from a statistical scaling mode using a percentage of the histogram to a fixed scale mode using minimum and maximum values (4E). These modes are mutually exclusive, so you can only use one of them at a time. Statistical scaling parameters are in box (4F), while fixed scaling

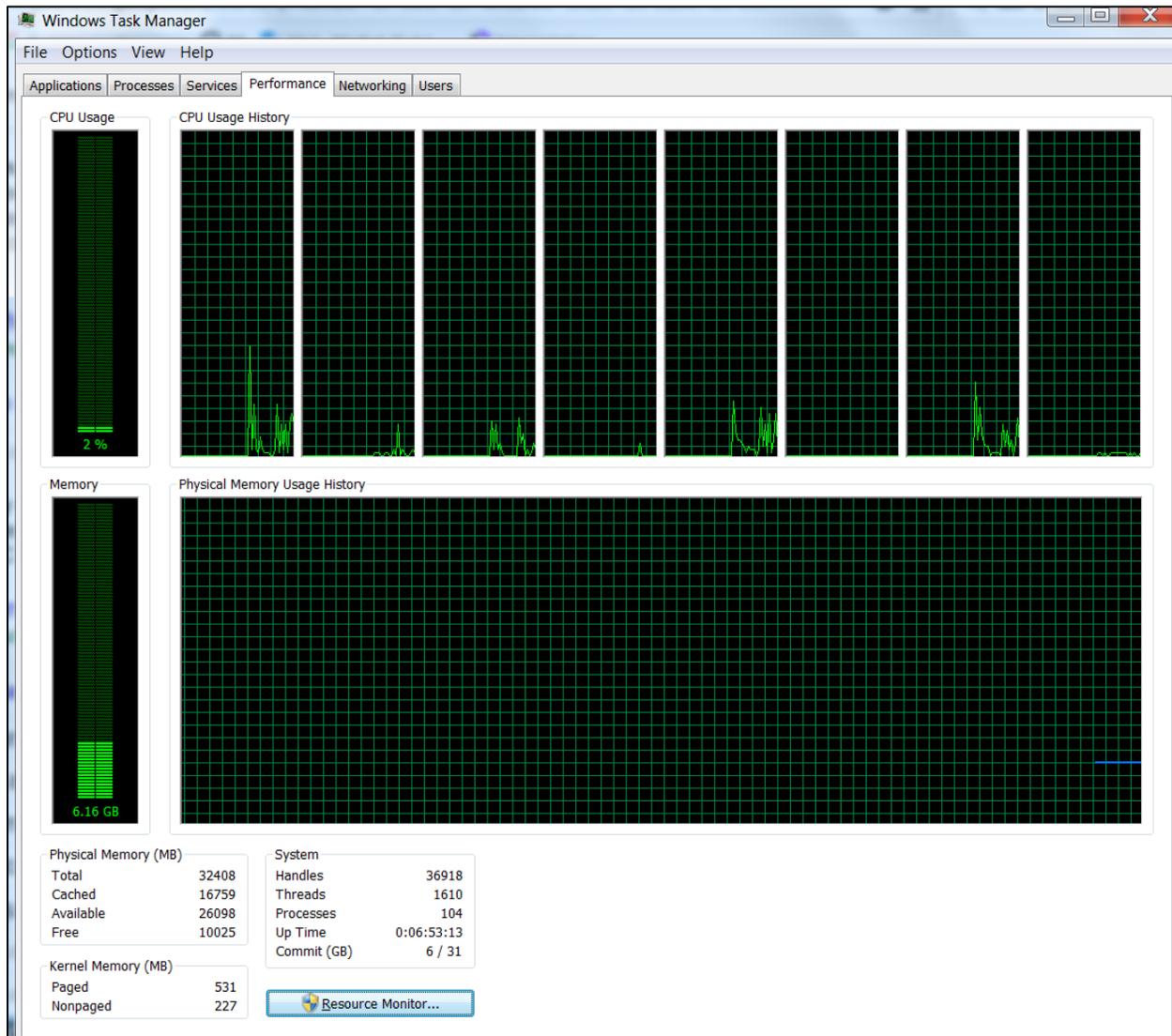
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parameters are in box (4G). If you want to change the color bar after the data are displayed, go to (5A) File → Change Color Table. The color bar dialog will pop up, allow you to change the color bar to your need (5B) and to reverse it if needed. Then click (5C) *Apply* (or OK) to see the change.



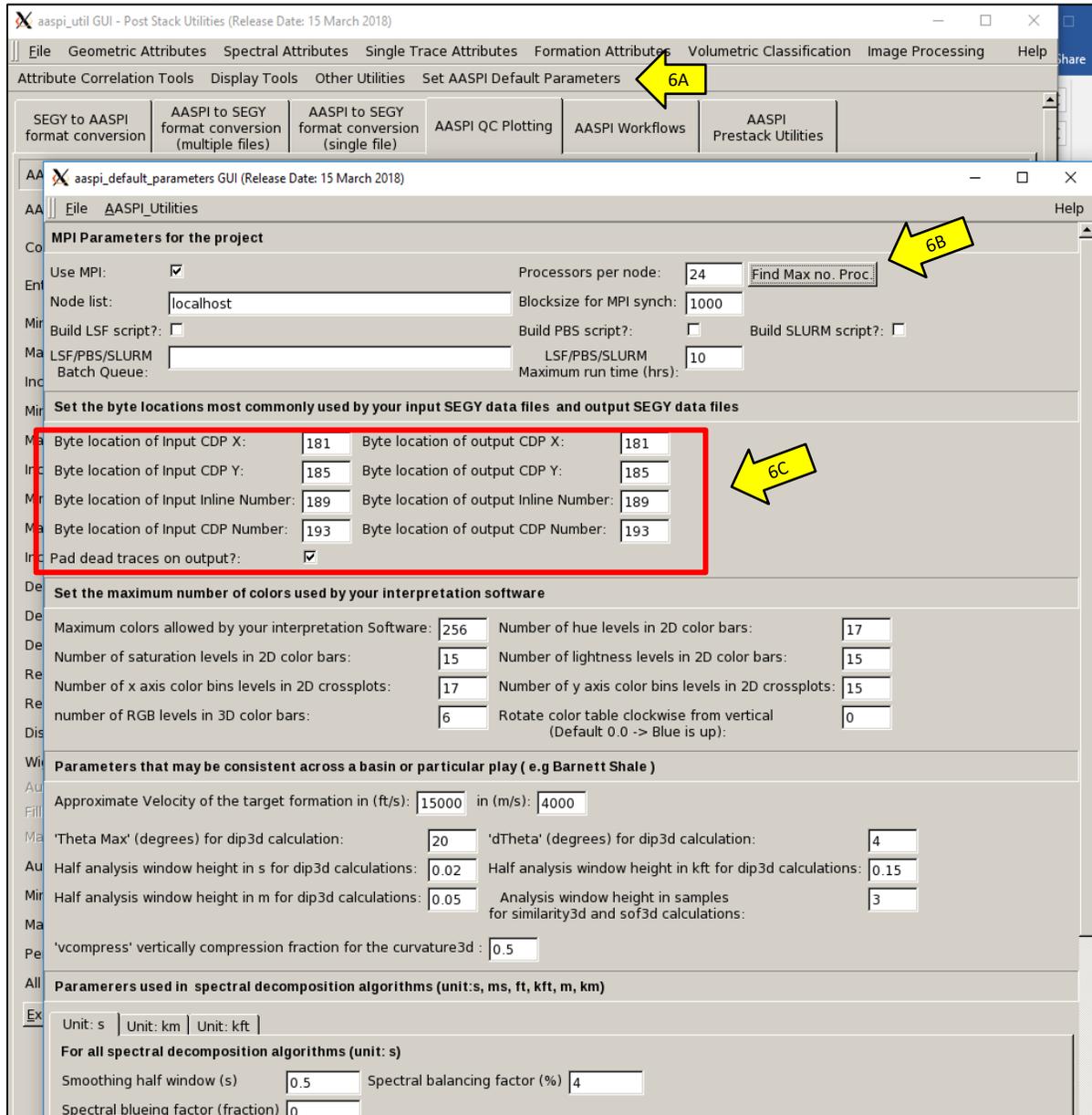
Setting up the AASPI default parameters

There are some parameters in AASPI that will occur repeatedly through multiple programs such that you will benefit by setting them up once and for all. To do so, click on (6A) Set AASPI default parameters. One of the most common parameter used in AASPI programs is the “Processors per node”. Since you are running on a laptop, you are running on only one node. The name of this node is “localhost”. The default is set to 2; however, most modern laptops have 4 or more processors (the product of sockets, cores, and threads, to be more precise). Desktop computers typically have 8-48 cores. It is highly recommended that you use the maximum available processors by clicking (6B) *Max processors no.* button. This will automatically determine the maximum number of processors your PC has. In Linux you can type “*lscpu*” on the command line. In Windows, type Ctrl-Shift-Escape and count the boxes; the image below shows eight boxes indicating my laptop has eight cores.



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Another important default parameters are the header byte locations (6C). If you are using your own dataset, the values are probably different from the defaults, so please change them to your need. This would make it faster and more consistent when you convert data from AASPI-format to SEG Y and vice versa. For example, if you are loading data into Petrel, set the output bytes for line no., cdp no., x, and y to be 5, 21, 73, and 77. In this manner you can use the defaults in Petrel when data loading.



Be sure to click “Save AASPI default parameters” at the bottom of menu:

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| For <code>spec_cmp</code> spectral decomposition (unit: s) | | | |
|--|-------------------------------------|---|-----------------------------------|
| Wavelet Type: | <input type="text" value="Ricker"/> | First tabled wavelet frequency (cycles/s) | <input type="text" value="2"/> |
| Last tabled wavelet frequency (cycles/s) | <input type="text" value="120"/> | Table increment (cycles/s) | <input type="text" value="0.5"/> |
| Fraction of max envelope peak | <input type="text" value="0.7"/> | Maximum number of iteration | <input type="text" value="20"/> |
| RMS amp of input data | <input type="text" value="0.01"/> | Min. convergence speed | <input type="text" value="0.01"/> |

(c) 2008-2018 AASPI for Linux - The University of Oklahoma **Save AASPI default parameters**