COMPUTING PARTIAL AND FULL STACK OF SEISMIC GATHERS – PROGRAM stack

Contents

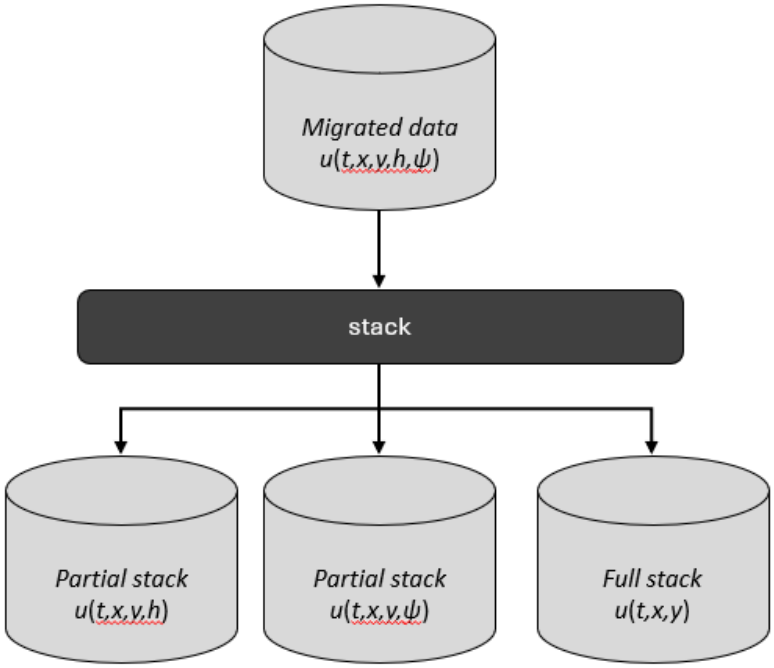
Overview

Stacking seismic traces provides a means of not only improving the signal-to-noise ratio over that provided by any single trace but also reduces the volume of the data to be interpreted. The invention of the common depth point (CDP) method and stacking is attributed to Harry Mayne (Proubasta, 1985). In its earliest and simplest implementation, seismic traces are collected into common depth (more accurately, common reflection point) gathers and subjected to a normal moveout correction to (ideally) align the reflectors. In 2025, it is more common to prestack migrate the seismic data (thereby correcting for velocity) and then stacking the migrated gathers. For 3D data, the traces within a gather may be labeled by their offset and azimuth, forming a 5D volume (t,x,y,h,ψ). For impedance inversion it is common to convert the offset axis h to one of incidence angle, θ). 3D data can also be binned into offset-vector tiles which are numbered in a snail-like ordering starting from the zero-offset trace.

Partial stacking refers to combining the information content of a subset of the available seismic traces for a given CRP. In migration, multiple traces with irregular source-receiver offsets and azimuths are combined into a finite number of offset and azimuth bins, whereby the resulting bins provide a migrated gather. These migrated 5D gathers can be fully stacked to generate a "stacked" trace in a 3D volume or partially stacked along either the h or ψ axis to form a partial stack to form a 4D (t,x,y,h) or (t,x,y,ψ) volume. A given (t,x,y,ψ) volume is commonly called an angle-limited stack.

Program stack provides three types of stacking – (1) the mean of the input traces, (2) the median of the input traces, and (3) the alpha-trimmed mean of the input traces.

Computation flow chart



The flow chart is simple. In this example, a migrated 5D volume is stacked over (left) azimuths, (center) offsets, or (right) azimuths and offsets to generate either a partial or full stack.

Output file naming convention

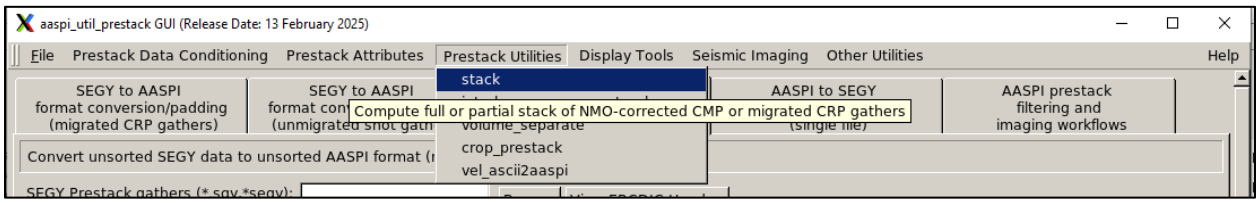
Program **stack** will always generate the following output files:

Output file description	File name syntax
Program log information	stack_unique_project_name_suffix.log
Program error information	stack_unique_project_name_suffix.err
Output surface file name	d_stack_unique_project_name_suffix.H or d_partial_stack_unique_project_name_suffix.H

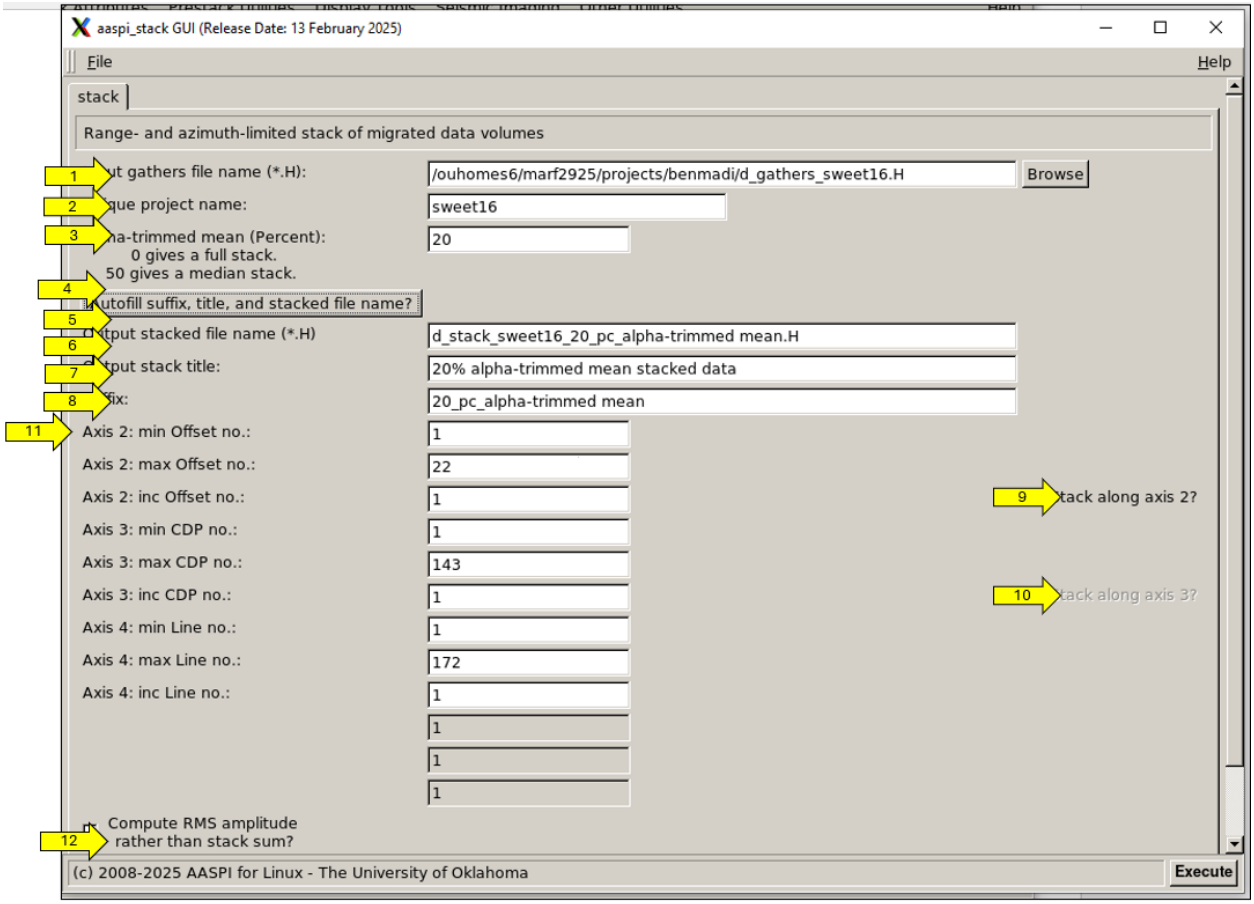
where the values in red are defined by the program GUI and the values in blue are related to the input file names. Errors, much of the input information, a description of intermediate variables, and any software trace-back errors will be contained in the **.log* file. More common errors and program completion messages will appear in the **.err* file and appear in a pop-up window upon program completion or termination.

Invoking the surface_driven_data_registration GUI

To convert an AASCI-format surface to AASPI-format, click the *Prestack Utilities* tab in the **aaspi_util_prestack**



The following GUI appears:



The first step is to (1) choose the AASPI-format (*.H) *Input gathers file name* that will be stacked. As with all AASPI programs, also (2) supply a *Unique project name*. The next step is to (3) choose the value of *alpha* that will be used in computing the alpha-trimmed mean as described in the gray box below. If you choose (4) *Autofill suffix, title, and stacked file name?* the (5) *Output stacked file name (*.H), Output stack title,* and (7) *Suffix* will be automatically generated from the value of alpha, and whether you perform a partial stack by choosing only one of (9) *Stack along axis 2* or (10) *Stack along axis 3*. For 5d gathers, choosing only one of options (9) and (10) will

result in a partial stacked 4D output volume. In this latter case the *Output stacked file name* will be gin with the string *d_partial_stack*. If you perform a full stack for either 4D or 5D input the *Output stacked file name* will begin with the string *d_stack.* The option (11) limiting the offset axis provides the ability to generate an offset or azimuth range-limited stack. For 5D gathers a similar option is provided to provide an azimuth-limited stack.

Theory: The alpha-trimmed mean

There are several ways of computing a stacked trace from *J* input traces:

The mean trace
The mean trace is the simplest, where the mean μ of *J* samples d_j is defined as:

$$\mu = \frac{1}{J}\sum_{j=1}^{J} d_j \ . \tag{1}$$

The mean is a smoothing filter that will smooth out but not remove erroneous spikes into the output.

The median trace
The first step of the median filter is to sort the data vector, **d**, into a new vector **u** where $u_k \le u_{k+1}$:

$$\mathbf{u} = \mathrm{sort}\left\{d_1, d_2, \ldots, d_j, \ldots, d_{J-1}, d_J\right\}. \tag{2}$$

Then the median, *m*, is defined as:

$$m = u_{(J+1)/2} \ . \tag{3}$$

The median filter will reject erroneously high and low spikes in the gather..

The α-trimmed mean trace
The α-trimmed filter is an extension of the median filter. First, the algorithm sorts the data in ascending order as in equation 2. Then one defines a fraction (usually defined as a percentage) of the data that falls within the range

$$0 \le \alpha \le \frac{1}{2} \ . \tag{4}$$

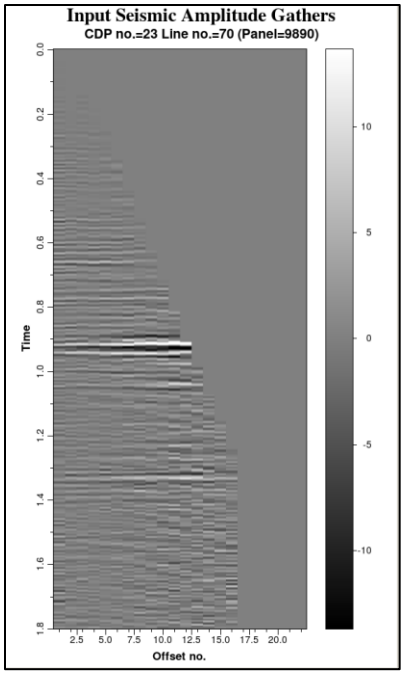
The filter rejects αJ "outliers" on each end of the data vector and computes the mean of the values of u_j with indices $1+\alpha J \le j \le J-\alpha)(J-1)$:

$$u_{\alpha-trim} = \frac{1}{J - 2\alpha(J-1)} \sum_{j=1+\alpha(J-1)}^{J-\alpha(J-1)} u_j \ . \tag{5}$$

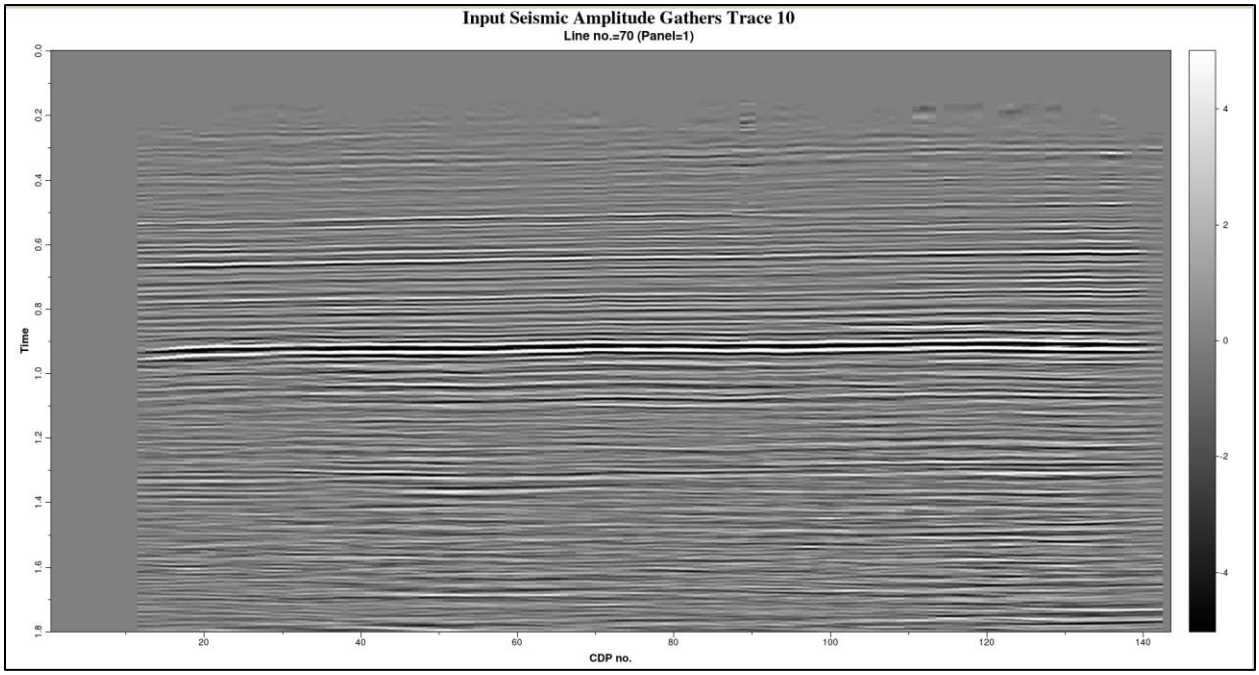
The alpha-trimmed mean filter thus rejects spikes in the data and smooths the remaining values.

Example 1: Stacking simple 4D (t,x,y,h) gathers

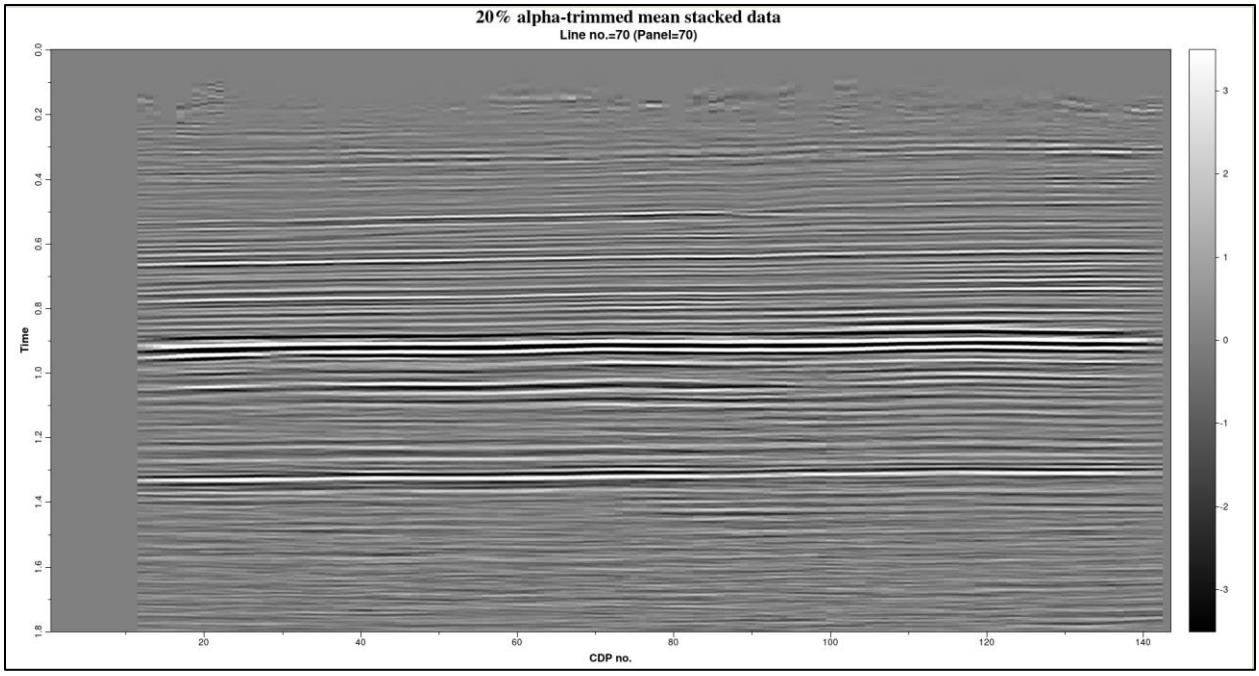
The following example is from a play in Central Oklahoma, USA. Using the AASPI program **aaspi_prestack_data_viewer**, I find a representative gather corresponding to inline 70 and CDP 23:



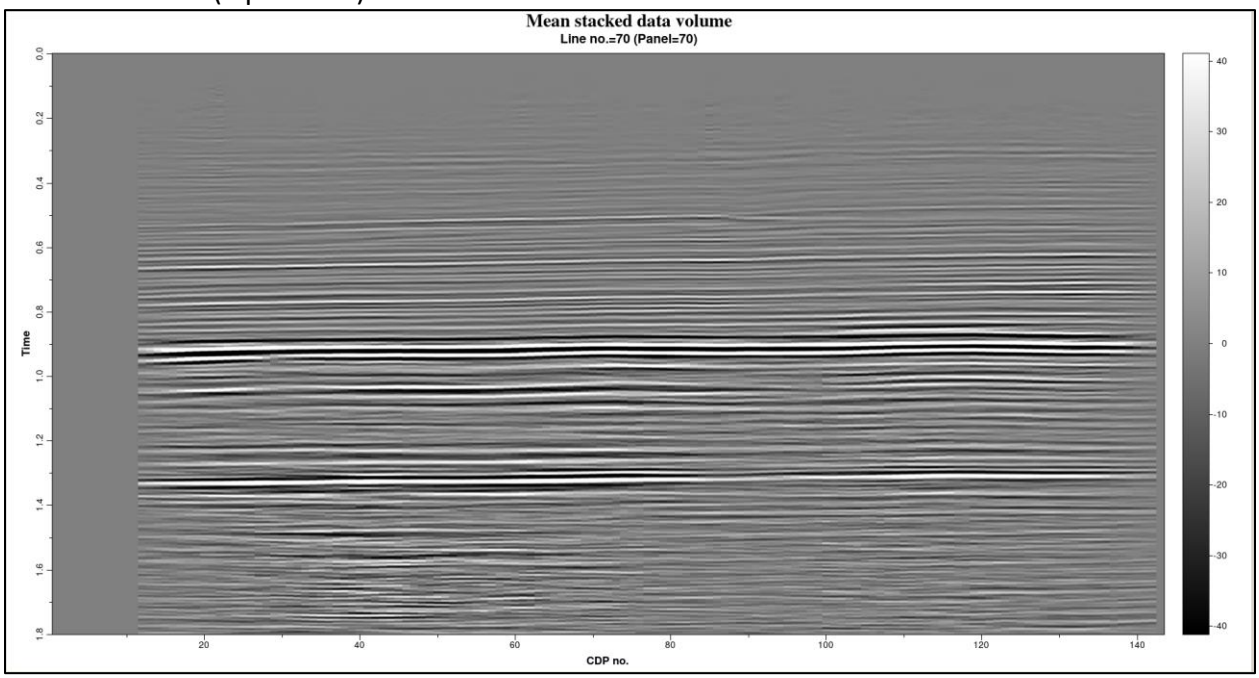
The corresponding common-offset gather along line 70 for trace index 10 looks like this:



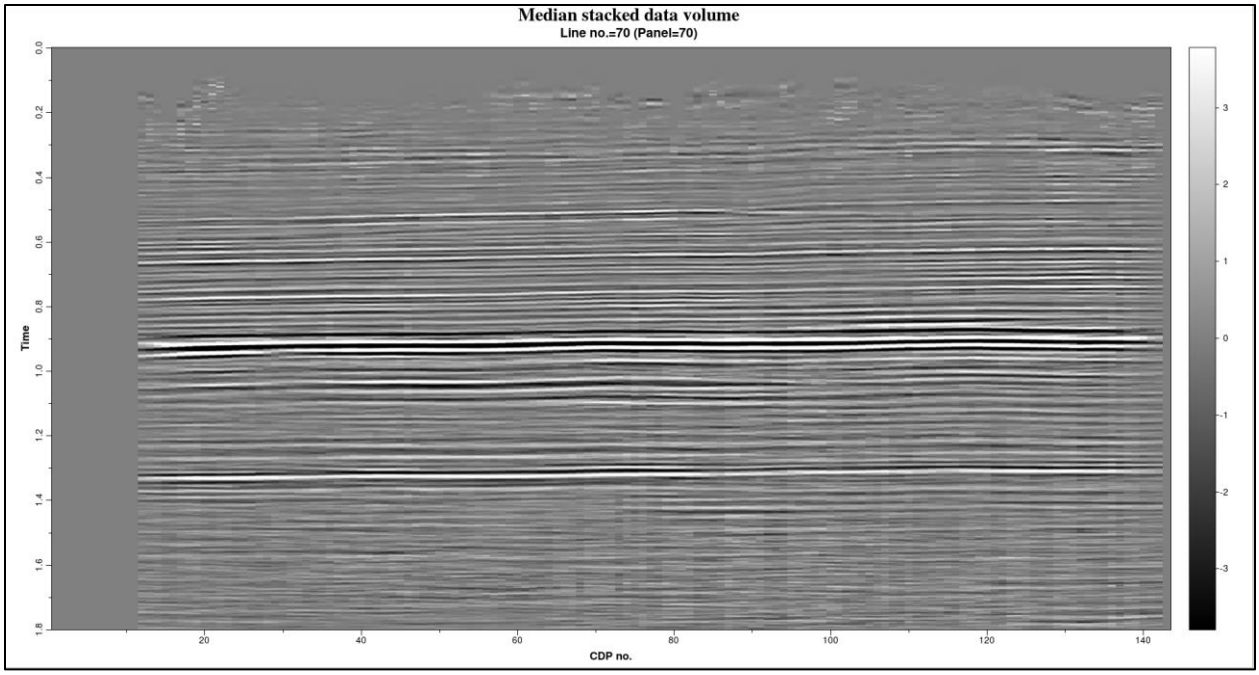
- The 20 percent alpha-trimmed mean stack of Line 70 looks like this:



The mean stack (alpha =0%) looks like this:



Finally, the median stack (alpha = 50%) looks like this:



References

Proubasta, D., 1985, Harry Mayne: The inventor of Comon Depth Point The Leading Edge, **4,** no. 7, 18-24.