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This document provides an overview of the Interactive Age Scale Graphical User Interface (GUI). The Interactive Age Scale GUI was designed with the goal of determining the interannual age-depth scale for ice core records by way of annual layer counting. Specifically, the GUI allows the user to:

1. plot and observe an array of chemical species (up to five at one time; either smoothed or raw) as a depth-series along an ice/firn column,
2. rapidly change the x-y domain of all chemical species plotted for better visualization,
3. interactively add in "tie points" corresponding to a prescribed decimal year, with the capability of moving those tie points (graphically) left or right along the ice column, and finally
4. interpolate ages between tie points to produce an improved age-depth scale for that ice core.

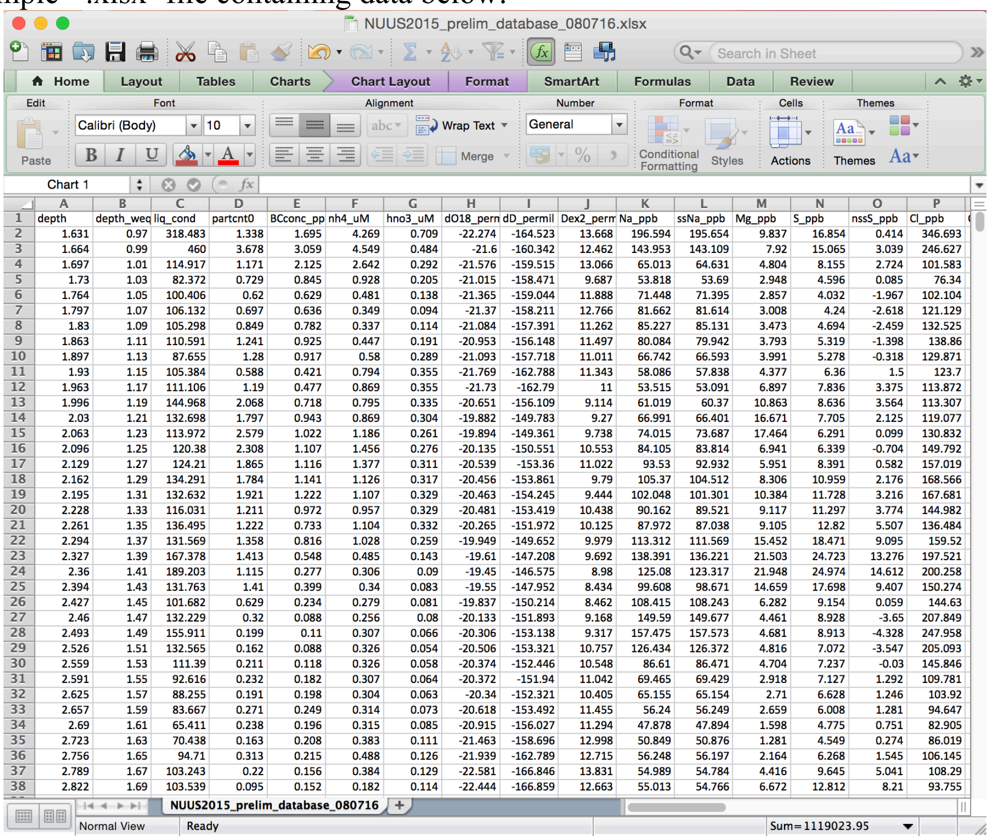
Additionally, the GUI allows the users to overlay predefined "absolute" tie points (i.e., ages defined using, e.g., volcanic or radiogenic markers) as a visual "road map" for higher resolution dating. Please follow the instructions below for implementation of the GUI:

Glossary:

1. Setting up the GUI

Two files are required to run the GUI: "interactive_age_scale_GUI.fig" and "interactive_age_scale_GUI.m". The GUI incorporates files containing ice-core chemistry (required), as well as any predetermined "absolute" tie points (optional). To incorporate these data into the GUI, the data files must be placed in the same folder on the user's computer as the two aforementioned files, and must be in ".xlsx" format (Microsoft Excel). If the user's computer platform cannot support ".xlsx" files (as opposed to, e.g., ".xls"), the user must change '*.xlsx' in ~lines 464 and 629 of "interactive_age_scale_GUI.m" to the desired format.

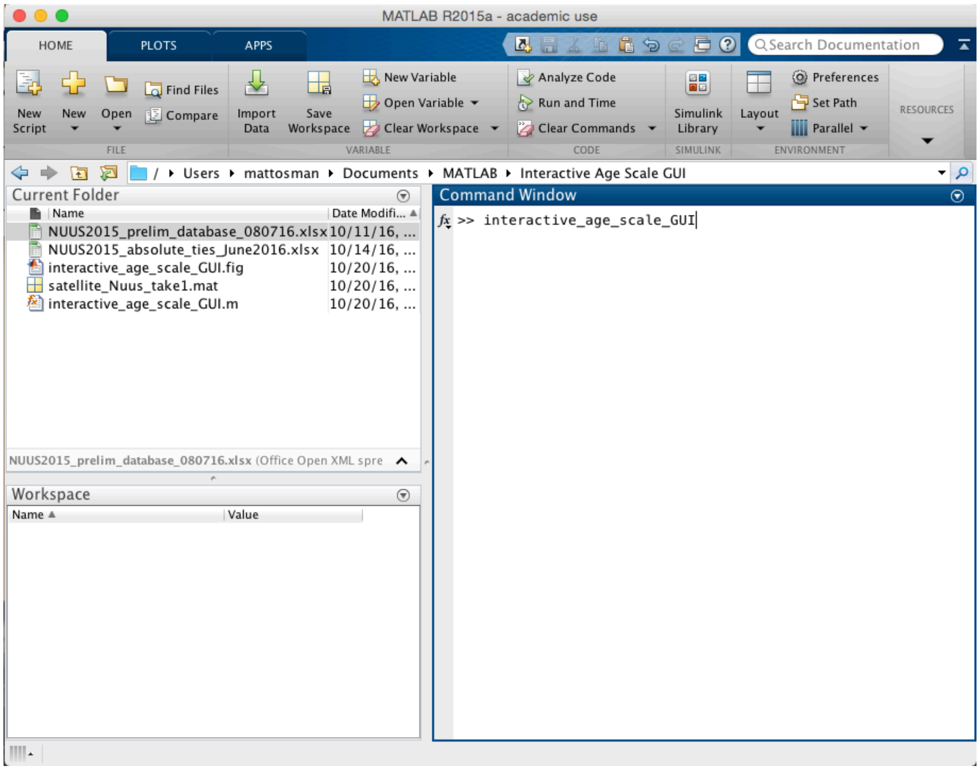
To be successfully loaded by the GUI, the Excel documents must contain the column headings (i.e., the variable names) in the first row, and the data for those respective columns immediately below, as in the example '.xlsx' file containing data below:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	depth	depth_weq	liq_cond	partcnt0	BCconc_pp	nh4_uM	hno3_uM	dO18_perm	dD_permil	Dex2_perm	Na_ppb	ssNa_ppb	Mg_ppb	S_ppb	nssS_ppb	Cl_ppb
2	1.631	0.97	318.483	1.338	1.695	4.269	0.709	-22.274	-164.523	13.668	196.594	195.654	9.837	16.854	0.414	346.693
3	1.664	0.99	460	3.678	3.059	4.549	0.484	-21.6	-160.342	12.462	143.953	143.109	7.92	15.065	3.039	246.627
4	1.697	1.01	114.917	1.171	2.125	2.642	0.292	-21.576	-159.515	13.066	65.013	64.631	4.804	8.155	2.724	101.583
5	1.73	1.03	82.372	0.729	0.845	0.928	0.205	-21.015	-158.471	9.687	53.818	53.69	2.948	4.596	0.085	76.34
6	1.764	1.05	100.406	0.62	0.629	0.481	0.138	-21.365	-159.044	11.888	71.448	71.395	2.857	4.032	-1.967	102.104
7	1.797	1.07	106.132	0.697	0.636	0.349	0.094	-21.37	-158.211	12.766	81.662	81.614	3.008	4.24	-2.618	121.129
8	1.83	1.09	105.298	0.849	0.782	0.337	0.114	-21.084	-157.391	11.262	85.227	85.131	3.473	4.694	-2.459	132.525
9	1.863	1.11	110.591	1.241	0.925	0.447	0.191	-20.953	-156.148	11.497	80.084	79.942	3.793	5.319	-1.398	138.86
10	1.897	1.13	87.655	1.28	0.917	0.58	0.289	-21.093	-157.718	11.011	66.742	66.593	3.991	5.278	-0.318	129.871
11	1.93	1.15	105.384	0.588	0.421	0.794	0.355	-21.769	-162.788	11.343	58.086	57.838	4.377	6.36	1.5	123.7
12	1.963	1.17	111.106	1.19	0.477	0.869	0.355	-21.73	-162.79	11	53.515	53.091	6.897	7.836	3.375	113.872
13	1.996	1.19	144.968	2.068	0.718	0.795	0.335	-20.651	-156.109	9.114	61.019	60.37	10.863	8.636	3.564	113.307
14	2.03	1.21	132.698	1.797	0.943	0.869	0.304	-19.882	-149.783	9.27	66.991	66.401	16.671	7.705	2.125	119.077
15	2.063	1.23	113.972	2.579	1.022	1.186	0.261	-19.894	-149.361	9.738	74.015	73.687	17.464	6.291	0.099	130.832
16	2.096	1.25	120.38	2.308	1.107	1.456	0.276	-20.135	-150.551	10.553	84.105	83.814	6.941	6.339	-0.704	149.792
17	2.129	1.27	124.21	1.865	1.116	1.377	0.311	-20.539	-153.36	11.022	93.53	92.932	5.951	8.391	0.582	157.019
18	2.162	1.29	134.291	1.784	1.141	1.126	0.317	-20.456	-153.861	9.79	105.37	104.512	8.306	10.959	2.176	168.566
19	2.195	1.31	132.632	1.921	1.222	1.107	0.329	-20.463	-154.245	9.444	102.048	101.301	10.384	11.728	3.216	167.681
20	2.228	1.33	116.031	1.211	0.972	0.957	0.329	-20.481	-153.419	10.438	90.162	89.521	9.117	11.297	3.774	144.982
21	2.261	1.35	136.495	1.222	0.733	1.104	0.332	-20.265	-151.972	10.125	87.972	87.038	9.105	12.82	5.507	136.484
22	2.294	1.37	131.569	1.358	0.816	1.028	0.259	-19.949	-149.652	9.979	113.312	111.569	15.452	18.471	9.095	159.52
23	2.327	1.39	167.378	1.413	0.548	0.485	0.143	-19.61	-147.208	9.692	138.391	136.221	21.503	24.723	13.276	197.521
24	2.36	1.41	189.203	1.115	0.277	0.306	0.09	-19.45	-146.575	8.98	125.08	123.317	21.948	24.974	14.612	200.258
25	2.394	1.43	131.763	1.41	0.399	0.34	0.083	-19.55	-147.952	8.434	99.608	98.671	14.659	17.698	9.407	150.274
26	2.427	1.45	101.682	0.629	0.234	0.279	0.081	-19.837	-150.214	8.462	108.415	108.243	6.282	9.154	0.059	144.63
27	2.46	1.47	132.229	0.32	0.088	0.256	0.08	-20.133	-151.893	9.168	149.59	149.677	4.461	8.928	-3.65	207.849
28	2.493	1.49	155.911	0.199	0.11	0.307	0.066	-20.306	-153.138	9.317	157.475	157.573	4.681	8.913	-4.328	247.958
29	2.526	1.51	132.565	0.162	0.088	0.326	0.054	-20.506	-153.321	10.757	126.434	126.372	4.816	7.072	-3.547	205.093
30	2.559	1.53	111.39	0.211	0.118	0.326	0.058	-20.374	-152.446	10.548	86.61	86.471	4.704	7.237	-0.03	145.846
31	2.591	1.55	92.616	0.232	0.182	0.307	0.064	-20.372	-151.94	11.042	69.465	69.429	2.918	7.127	1.292	109.781
32	2.625	1.57	88.255	0.191	0.198	0.304	0.063	-20.34	-152.321	10.405	65.155	65.154	2.71	6.628	1.246	103.92
33	2.657	1.59	83.667	0.271	0.249	0.314	0.073	-20.618	-153.492	11.455	56.24	56.249	2.659	6.008	1.281	94.647
34	2.69	1.61	65.411	0.238	0.196	0.315	0.085	-20.915	-156.027	11.294	47.878	47.894	1.598	4.775	0.751	82.905
35	2.723	1.63	70.438	0.163	0.208	0.383	0.111	-21.463	-158.696	12.998	50.849	50.876	1.281	4.549	0.274	86.019
36	2.756	1.65	94.71	0.313	0.215	0.488	0.126	-21.939	-162.789	12.715	56.248	56.197	2.164	6.268	1.545	106.145
37	2.789	1.67	103.243	0.22	0.156	0.384	0.129	-22.581	-166.846	13.831	54.989	54.784	4.416	9.645	5.041	108.29
38	2.822	1.69	103.539	0.095	0.152	0.182	0.114	-22.444	-166.859	12.663	55.013	54.766	6.672	12.812	8.21	93.755

2. Running the GUI

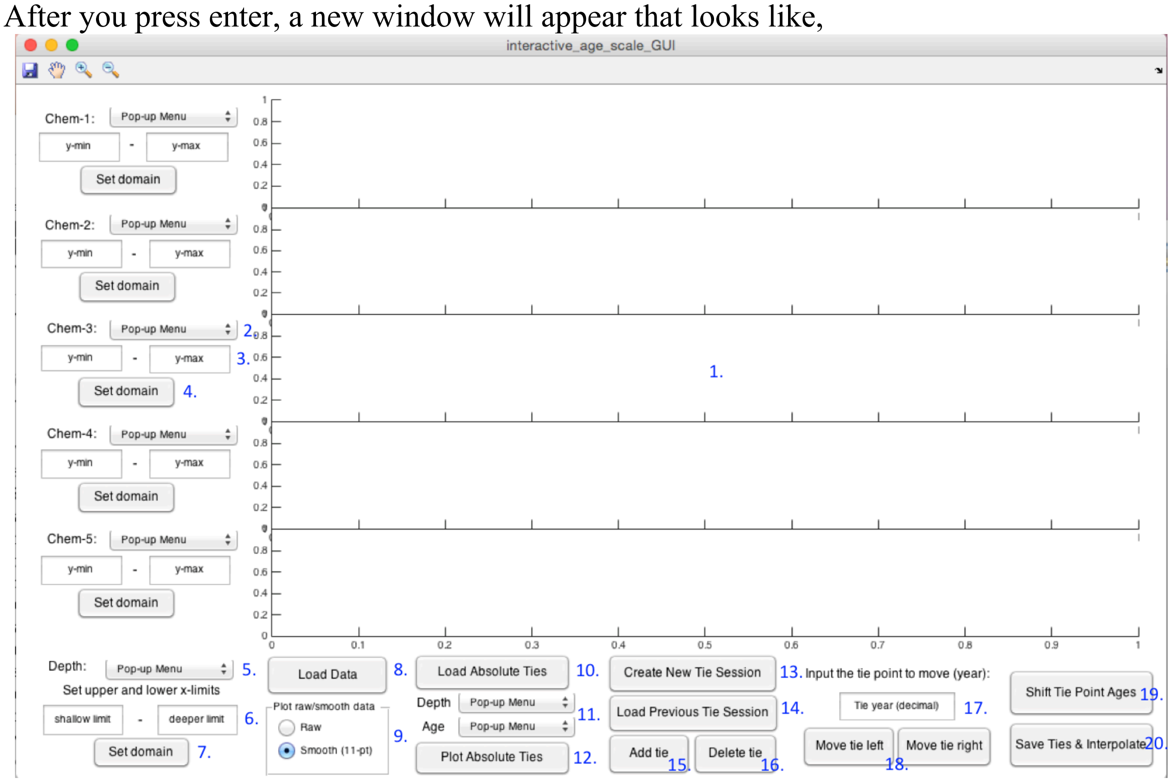
Open MATLAB. Set the "Current Folder" to the folder that contains "interactive_age_scale_GUI.fig" and "interactive_age_scale_GUI.m", and your data series (e.g., in figure below, data = "NUUS2015_prelim_database_080716.xlsx" and absolute ties = NUUS2015_absolute_ties_June2016.xlsx". In the MATLAB Command Window, type in "interactive_age_scale_GUI" and press Enter.



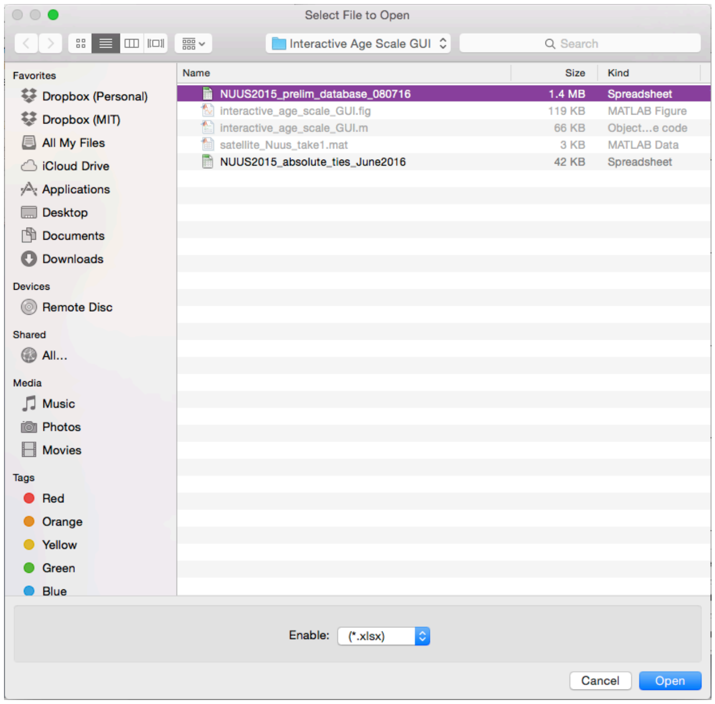
3. Managing the GUI interface

3.1 Loading + plotting data

After you press enter, a new window will appear that looks like,



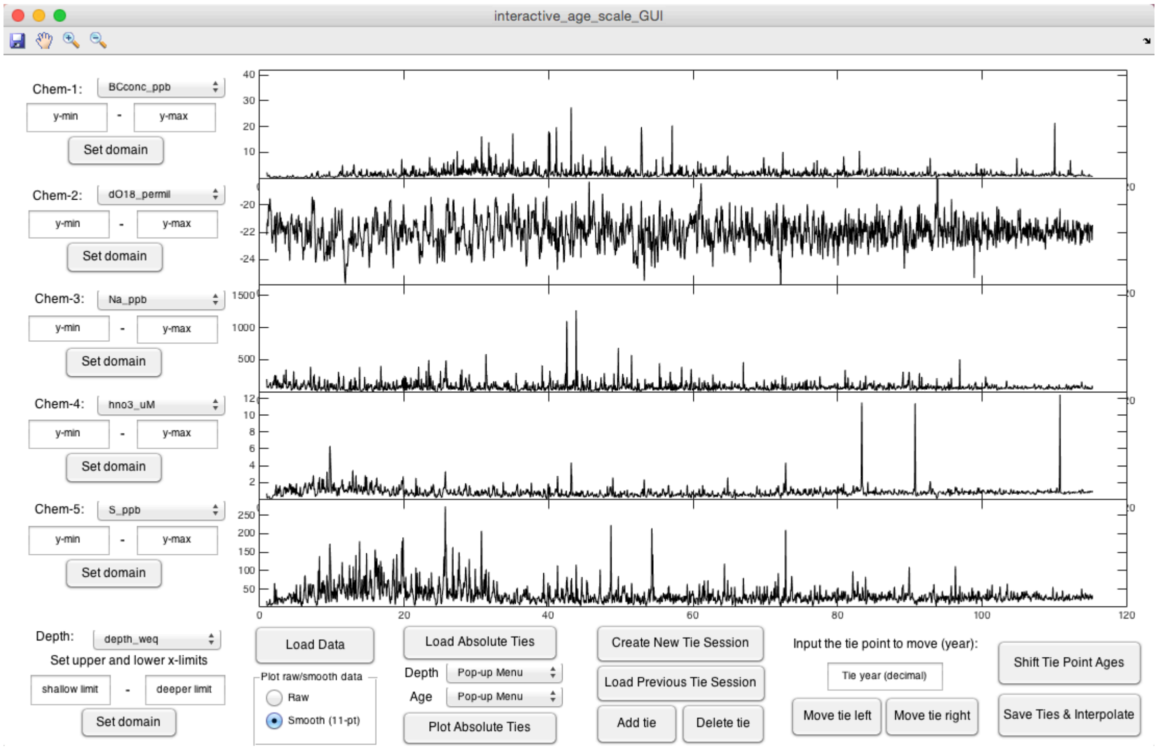
Note the blue numbers in the figure above; these will each be defined and referred to subsequently. To begin, the user must press "Load Data" (8.), and a window will pop-up showing the "Current Folder". Only the options in MATLAB's "Current Folder" ending in ".xlsx" are highlighted – choose the file that contains the ice core chemical data-series – in this example, we have chosen the file "NUUS2015_prelim_database_080716.xlsx" to open.



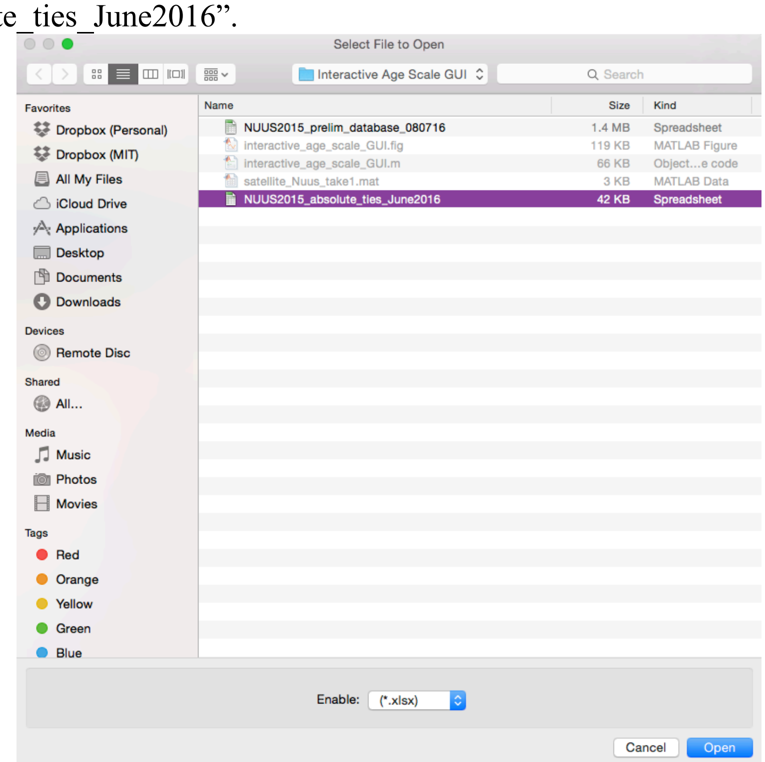
Depending on the size of the file, the user may now have to wait for the data to be read-in – in the file used in this example (which is large; containing >100,000 data points), the wait time is ~10 seconds (Mac OS-X 10.10.13).

Once the data is successfully read into the GUI, the Chem-X (where X = 1, 2, 3, 4, or 5) and Depth pop-up menus (2.) should display the variable names (the column headings in the .xlsx file), if Step 1 was successfully implemented. Choose the variables in Chem-X and Depth; all Chem-X variables are plotted against the same Depth variable. Upon choosing the variables, the GUI will automatically plot the variables in the corresponding graphical regions (1.) – this again may take time for the computer to read, in the current example-case ~10-60 seconds.

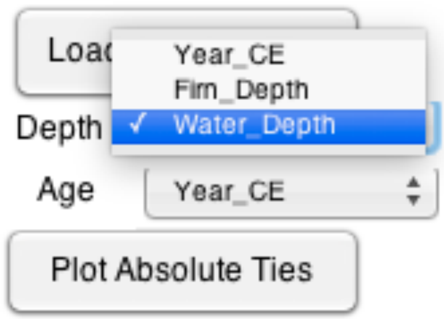
In the below figure, from top to bottom, black carbon, $d^{18}O$, Na^{+}, HNO_3, and S, are plotted against depth in units of meters of water equivalent. Here, the data is plotted as a smoothed (11-pt) series (9.); now that the data is loaded, at any point the user can choose the "Raw" button, and the data will be replotted as the raw data series – this again may take ~seconds while the data is rerouted through the GUI.



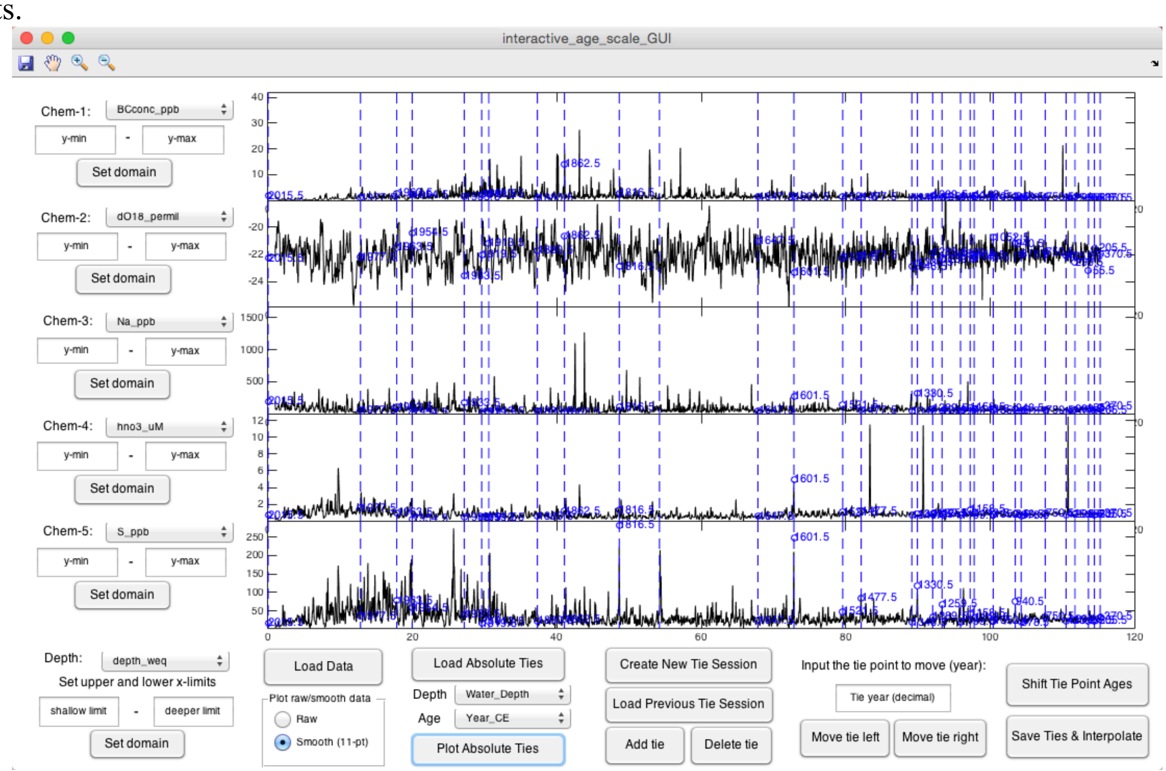
Next (*note this section is optional*), to better orient ourselves to the approximate age-depth scale of the data, we will **plot the absolute-dated ties**. Choose "Load Absolute Ties" (10.), and again a pop-up screen will ask you to choose your data from options ending in ".xlsx". Here, we choose "NUUS2015_absolute_ties_June2016".



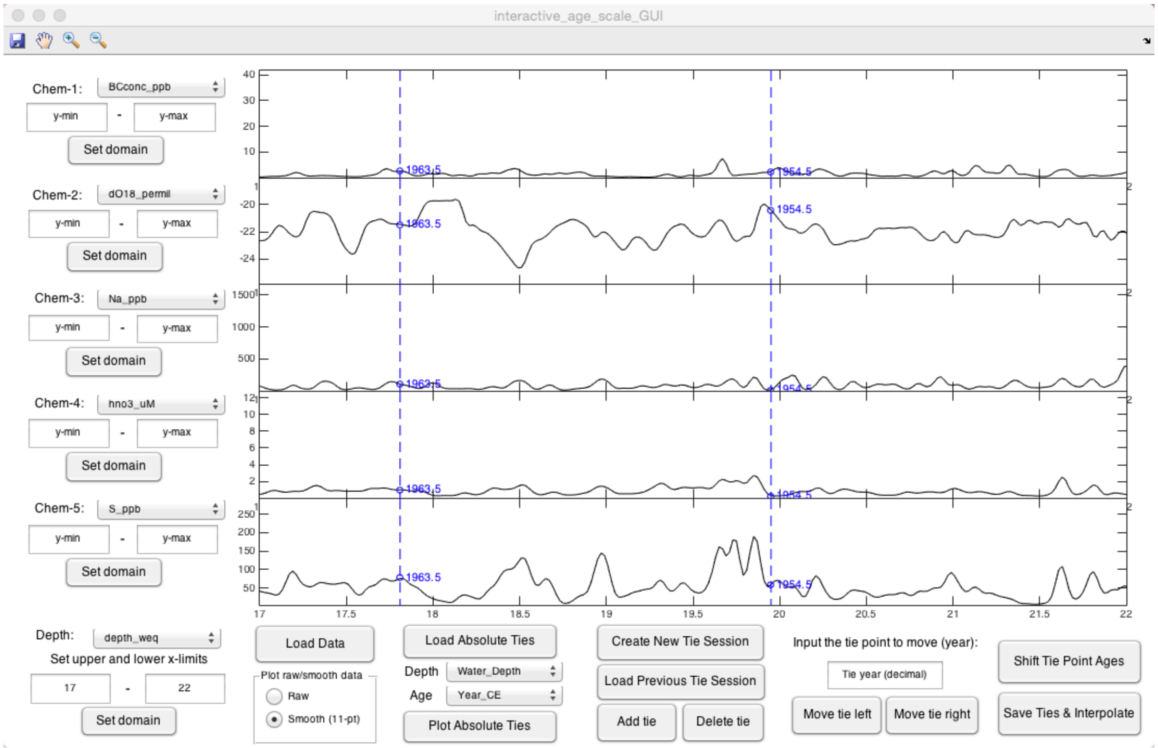
Both of the Absolute Tie pop-up menus (11.) will indicate new variables once the data is successfully loaded. Since the chemical data was plotted on the x-axis on units of meters of water equivalent, "Water_Depth" is chosen (see figure below; *reminder*: make sure the x-axes of the chemical data and the ties are using in the same units!)



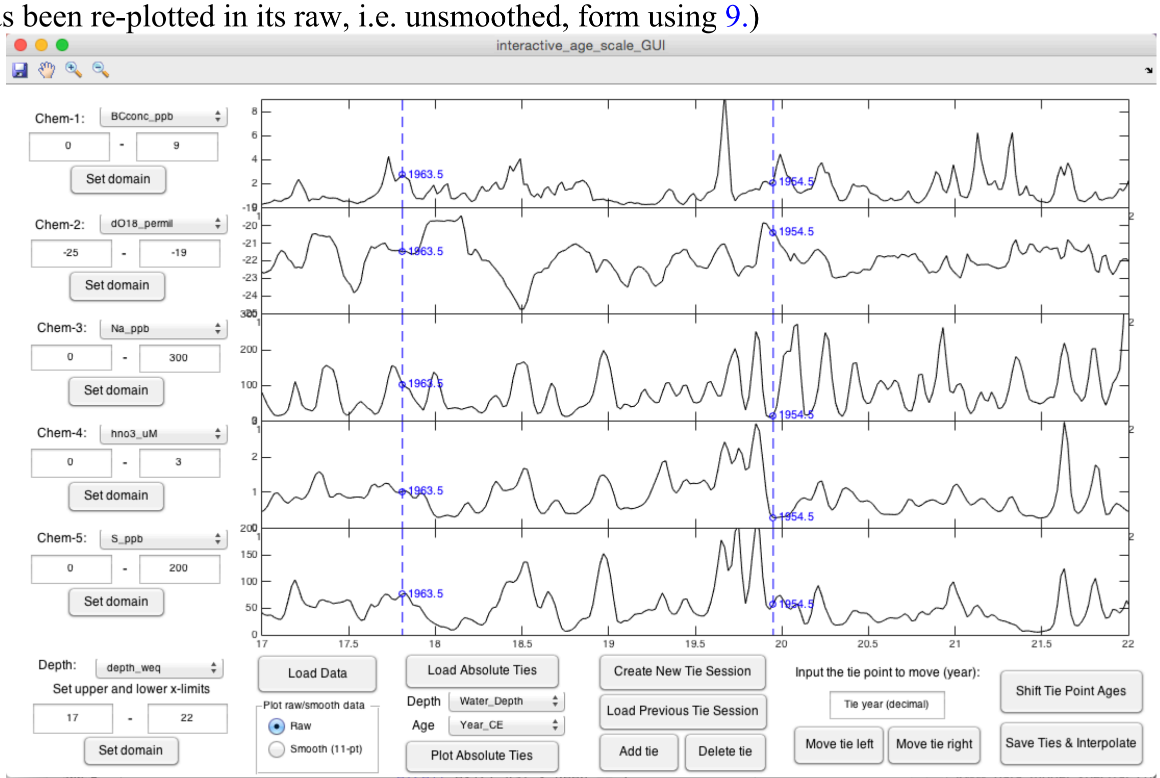
Press "Plot Absolute Ties" (12.), and vertical blue tie-lines will appear for all absolute-dated tie-points, with the decimal year of the tie noted next to the corresponding data point (see below) in all five plots.



With the arbitrary goal of prescribing annual dates between the two absolute tie points situated at ~18-20 m w.eq. depth (above plot), we first observe that the depth-series as it is plotted above is too large and unwieldy to date this section efficiently. To adjust the domain of the plotted series, we set the Shallow and Deeper limits of the x-limits (6.) as 17 and 22, and press "Set Domain (7.). The GUI adjusts the depth-interval of all 5 plots.



Similarly, at this depth-interval interannual chemical variability is hard to discern for some species (notably, black carbon, Na^+, HNO_3) due to inadequate y-axis limits. As was done for the x-limits, the y-limits are each adjusted accordingly (defined using 3. and implemented after pressing 4.); the specific limits used for all 5 species in this example can be seen below. (Note in the figure below the data has been re-plotted in its raw, i.e. unsmoothed, form using 9.)

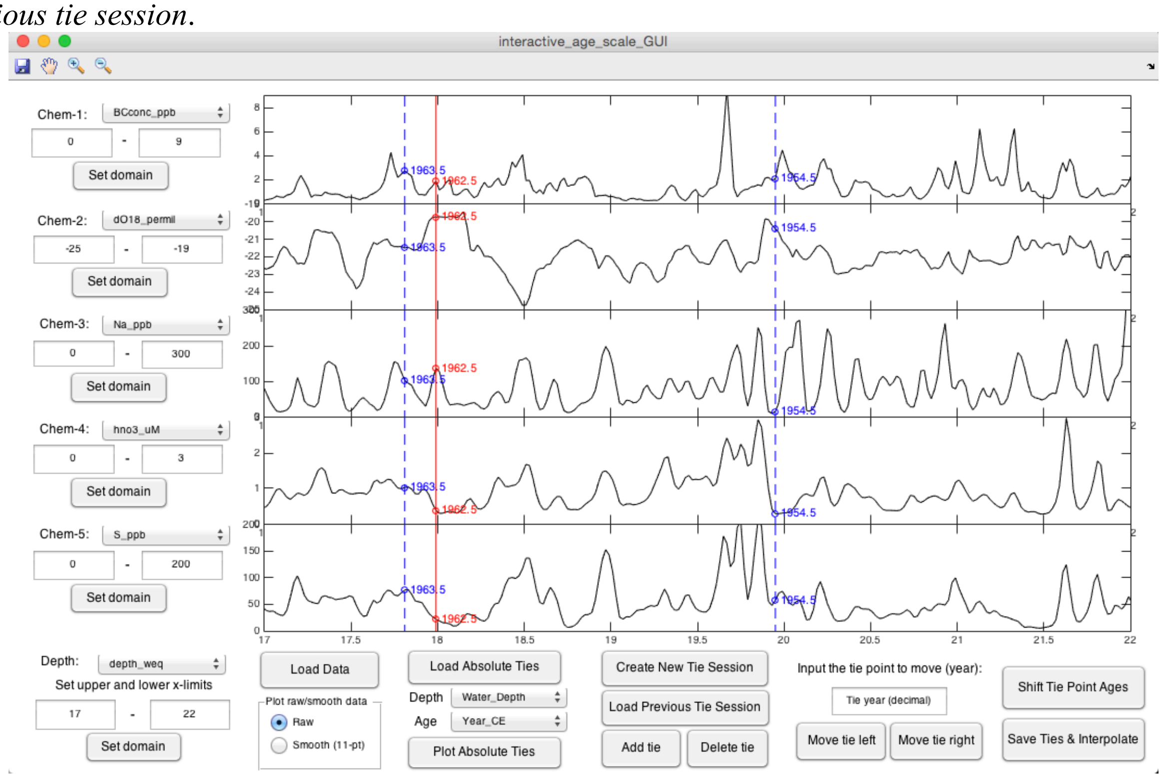


3.2 Creating, deleting, and moving ties

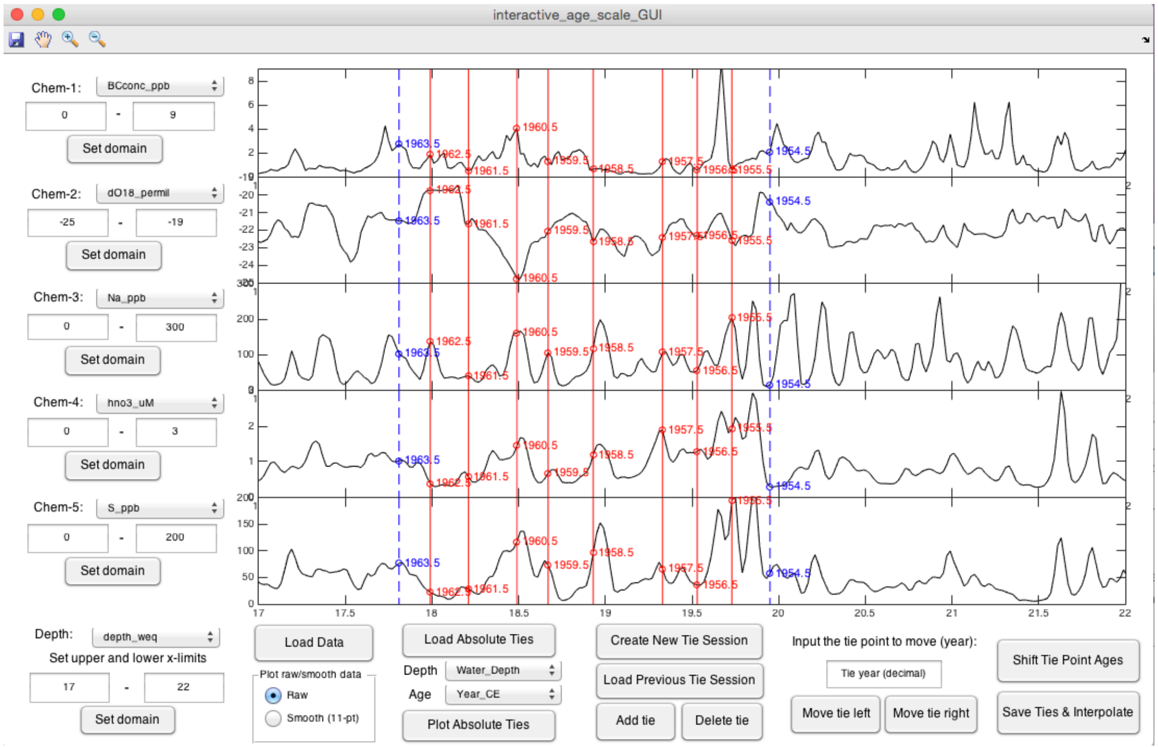
Now that the chemistry data is properly displayed, we see that the absolute ties at ~18 and 20 m w.eq. correspond to the years 1963.5 and 1954.5 (tritium bomb horizons), respectively. Our goal is to assign annual tie points for each year in between these two absolute markers.

Let's "Create a New Tie Session" by pressing the so-named button (13.) – a confirmation window should briefly appear saying this was successful (*IMPORTANT* – if the user has already began a session and "Create a New Tie Session" is pressed, any ties that were created without being saved will be lost; see below for instructions on saving).

In this example, we will work our way downcore (younger to older) from 1963.5 to 1954.5; to create a new tie, press the button "Add Annual Tie" (15.). A popup window will appear asking you to input a tie year. Input the decimal year 1962.5 and press "Ok". The cursor will now become crosshairs; hover your mouse over the graphs until you find a spot that you believe to be the most likely location of 1962.5, and click. A vertical red line with the prescribed year will appear over the data-point nearest to the point clicked. *Please note that new ties can be added only after creating a new tie session or loading a previous tie session*.



Now we can do the same, one year at a time (note that any decimal year could be input – it does not require intervals of 1 year!), until all annual ties are defined within the two absolute ties points (blue), as shown below (*disclaimer – the assigned tie points in the examples above and below are not claimed to be the *actual* age-tie!).



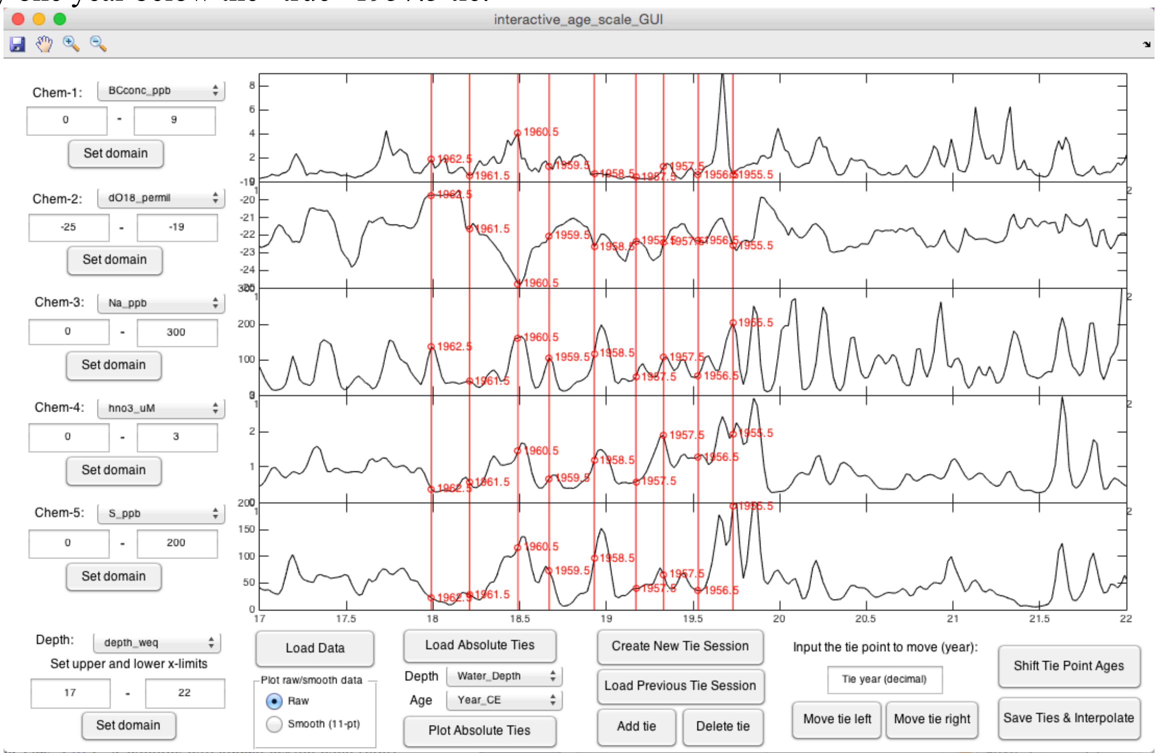
Now, let's say for whatever reason the user wants to **delete a point**. To do so, the user must press "Delete Tie" (16.), which will turn the cursor into a crosshair pointer again. The user must then click (on any one of the graphs) near the point that he/she wants to delete, and a pop-up window will appear confirming whether (you) wish to delete that tie-point. Pressing "Ok" confirms the deletion, and the tie will disappear from the plots. The tie point is not deleted if "Cancel" is pressed.

Tie points often need to be adjusted, for example, to test whether a better alignment with multiple chemistry profiles exists, or if the user's cursor aim was simply a little off when applying the tie. To **move a tie point left or right** along the graph, the user must input the decimal year of the tie he/she wishes to move (17.), and then press either "Move tie left" or "Move tie right" (18.); the tie point closest to (though ideally matching) the input value (17.) will move left or right (one data point per click) correspondingly on the graphs.

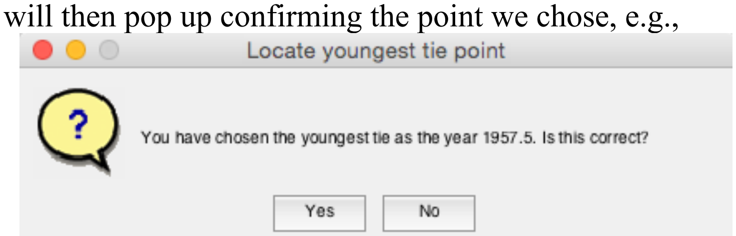
3.3 Shifting the age of a group tie points

When dating any record, you may find from time to time a need to adjust the defined age of a large number of previously created tie points. For example, such a need may arise if it is determined that an annual tie point was either erroneously included or not included during annual layer counting, or a given year was double counted as two consecutive annual layers. In each of these cases, the true age scale would be wrongly offset by one year for all subsequent annual tie points defined in the downcore direction. Rather than having to delete and correct each of these downcore ties one at a time, the GUI provides the user the option to **shift the age of a group of consecutive ties** (19.) by some user-defined constant all in one step.

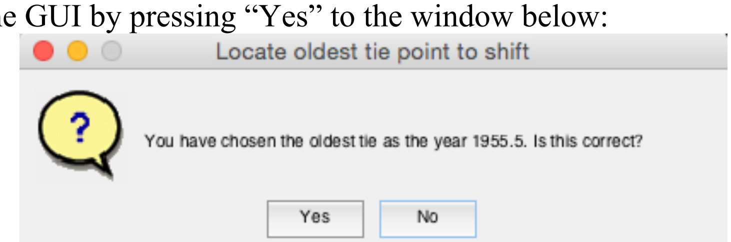
For example suppose in our example above that it is later decided the absolute tie for 1954.5 (the blue tie) is in fact wrong, and that we have in fact missed an annual layer in between our previously defined ties for 1958.5 and 1957.5. Thus, we add in the “true” tie for 1957.5 in between the tie for 1958.5 and the previously defined 1957.5 tie (at ~19.2 m w.eq.), thus leaving us with an age scale that is offset by one year below the “true” 1957.5 tie:



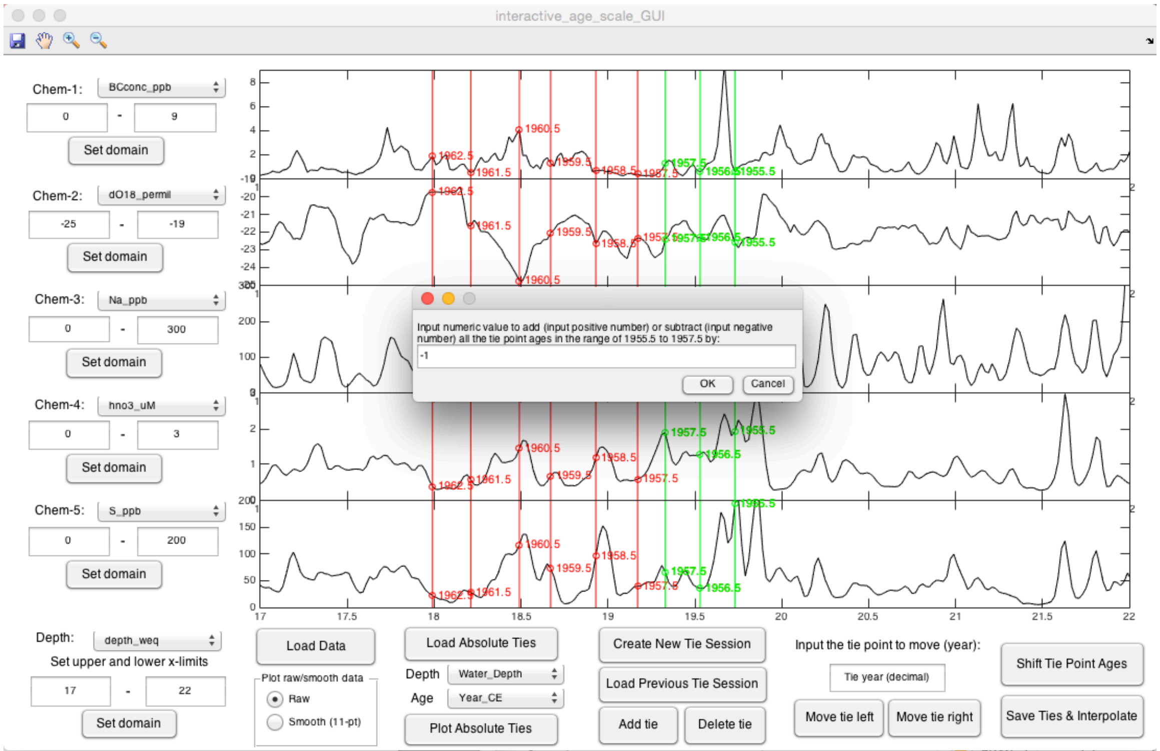
To correct this, we must simply subtract one year from all subsequent tie points (i.e., all tie points below the “true” 1957.5 at ~19.2 m). Press “Shift Tie Point Ages” (19.), and a window will pop up requesting us to locate the youngest tie in the group of points we wishes to shift the age of. The cursor will turn into a crosshair point, allowing the user to identify this point by clicking on it (in any of the 5 graphs). Upon clicking, a window will then pop up confirming the point we chose, e.g.,



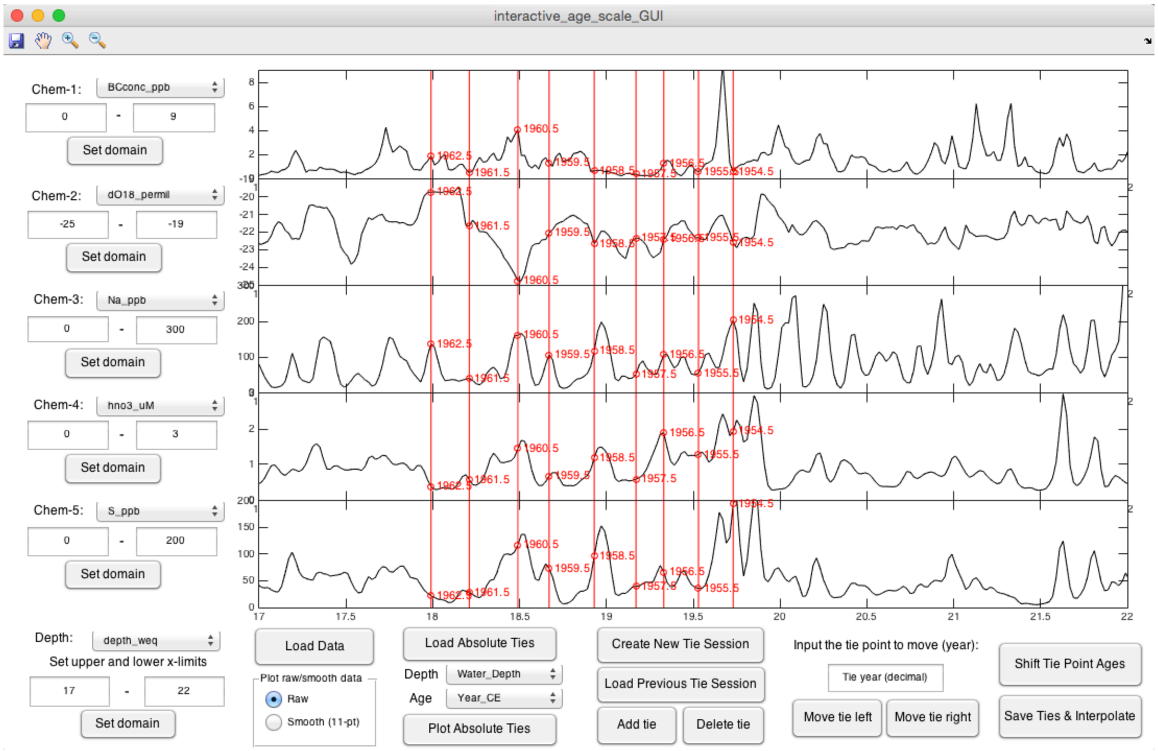
Since this is correct (and we are confident that, in this case, we have not clicked on the shallower, or “true”, 1957.5 tie point), we click “Yes”, and a new window pops up asking us to click on the oldest tie point in the group of tie points we wish to shift the age of. We use the cursor to click on 1955.5, and again confirm this with the GUI by pressing “Yes” to the window below:



Upon pressing yes, the GUI will plot the group of tie points we aim to shift the age of in green. Simultaneously, an input-dialogue box pops up requesting us to input the numeric value we wish to adjust the points now plotted in green. In this case, we wish to accommodate the inclusion of the "true" 1957.5 tie point by subtracting one year from all subsequent tie points, so we input "-1", and press "OK":

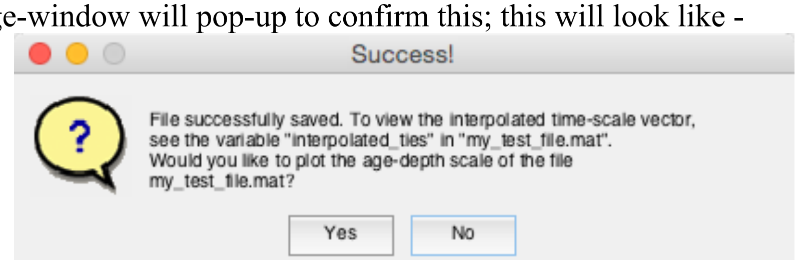


If the age shift is successful, a pop up window will pop up confirming this, and the ages of the tie points on all the plots are subsequently adjusted.



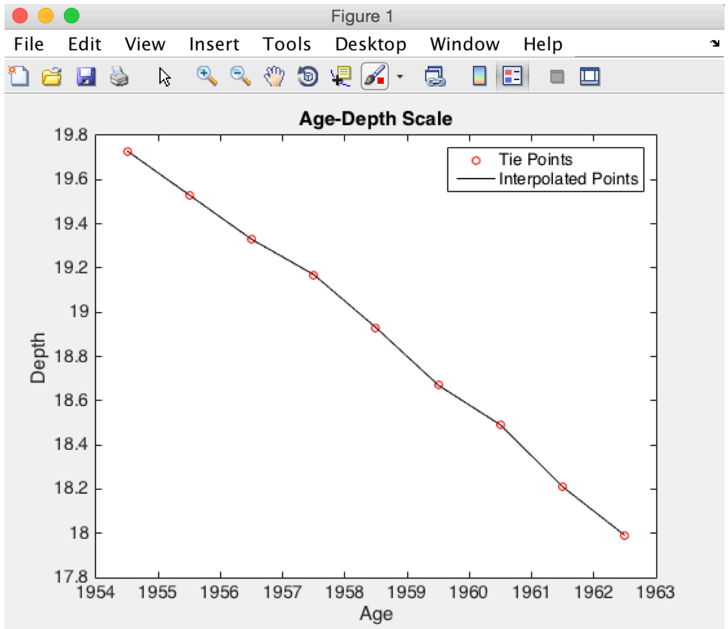
3.4 Saving tie sessions

To save any tie points created, press "Save Ties" (20.). A window will appear asking what (you) wish to save the filename as. Since this is a ".mat" file, do not leave spaces in the file name (i.e., in this example, we didn't save this file as , "my test file", but rather as "my_test_file"). If the file save was successful, a message-window will pop-up to confirm this; this will look like -



And *remember*, save frequently! To resave the same file, the user will need to retype the same file name upon each save (i.e., "my_test_file").

As the text in the above figure indicates, upon saving the file the corresponding age-depth scale will be automatically calculated by linearly interpolating between the user-defined tie-points. This age-depth scale will always be output as the variable "interpolated_ties". Note that only tie points that the user created [i.e., the red ties] – not the predefined absolute ties [i.e., blue ties] – will be interpolated between ties; the user must overlay their own ties to any predefined absolute ties. As also indicated in the figure above, there is also an option to plot the age-depth scale you just created. To do so, press yes, and a graph that looks similar to the plot below will appear.



To retrieve the calculated age-depth scale from "my_test_file", double click on the file, "my_test_file.mat" in MATLAB's "Current Folder", and the variable "interpolated_ties" will be displayed in the "Workspace" on MATLAB. Double click on the variable (interpolated_ties) in the Workspace, and the data will appear.

3.5 Loading old tie sessions

Let's say that the user exited out of the GUI, only to return a week later wishing to pick up where he/she left off on dating the record. After opening the GUI and loading the chemistry data (Step 3.1), the only required step to begin is to press "Load Previous Tie Session" (14.) – upon doing so, a pop-up window will appear asking the user to load any files of the ".mat" format. Choose the previously saved file, "my_test_file.mat"; the tie points defined in Section 3.2 will again be plotted, ready to be revised + adjusted.