stRat stat manual – Sept. 2019 – v.01

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Stratigraphic sections are one of the main tools used by sedimentologists, stratigraphers, and basin analysists communicate the nature of the sedimentary record to others. Stratigraphic sections are used to describe bedding thickness, bed boundary, grain size, sedimentary structures (physical and biogenic), facies, and larger lithosomes in a graphical/visual form. They're typically composed of an x-axis that is used to describe the grain size of the sediment and the y-axis is used to describe the thickness of the drawn interval. The scale of an individual stratigraphic section ranges from meters (Fig. 1) to thousands of meters (i.e., entire basin fill). As such, the use of stratigraphic sections vary from detailed description of individual beds to the description of multiple sedimentary systems.

Figure 1-Conglomerate-dominated submarine channel deposit filling an incision into proximal-overbank deposit (left). Stratigraphic section through the same interval (right). DeCourcy Formation, Mayne Island, British Columbia, Canada.

Stratigraphic sections are employed in both academic and applied fields of sedimentary geology, with thousands of kilometers of stratigraphic sections housed in peer-reviewed publications and in private databases. The analysis of stratigraphic sections is largely done through visual comparison of the recorded data (e.g., bed thickness, facies proportion, correlation to well log response). Although there are multiple examples of software to create stratigraphic sections (e.g., SedLog, SedMob), there are few programs that are designed to analyze and explore the data recorded in stratigraphic sections (e.g., MatStrat). Additionally, as investigators look to implement machine learning approaches for the prediction of sedimentary characteristics (e.g., facies occurrence, permeability, and net:gross) bridges between the hand-drawn stratigraphic sections and data types used in prediction algorithms are needed.

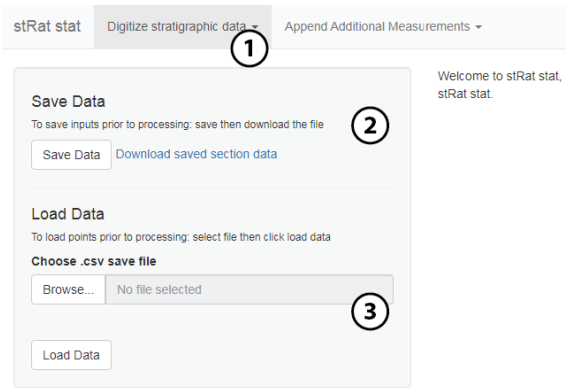
stRat stat is an R-based application that allows for users to discretize a graphical/visual stratigraphic section in to a numerical data format. Users are able to import an image of a stratigraphic section, digitize on bed boundaries, grain size divisions, sedimentary structures, facies, and two levels of stratigraphic hierarchy (i.e., elements and element sets). Additionally, users are able to pair both discrete measurements (e.g., core measurements) and continuous measurements (e.g., petrophysical logs) to the section and summarize these data by bed, facies, element, or element set. The output is a large datatable that where each row contains information of a certain thickness of the stratigraphic section. This datatable is downloadable in .csv format of for the later manipulation and visualization of the data in other platforms (e.g., Excel, python, etc.).

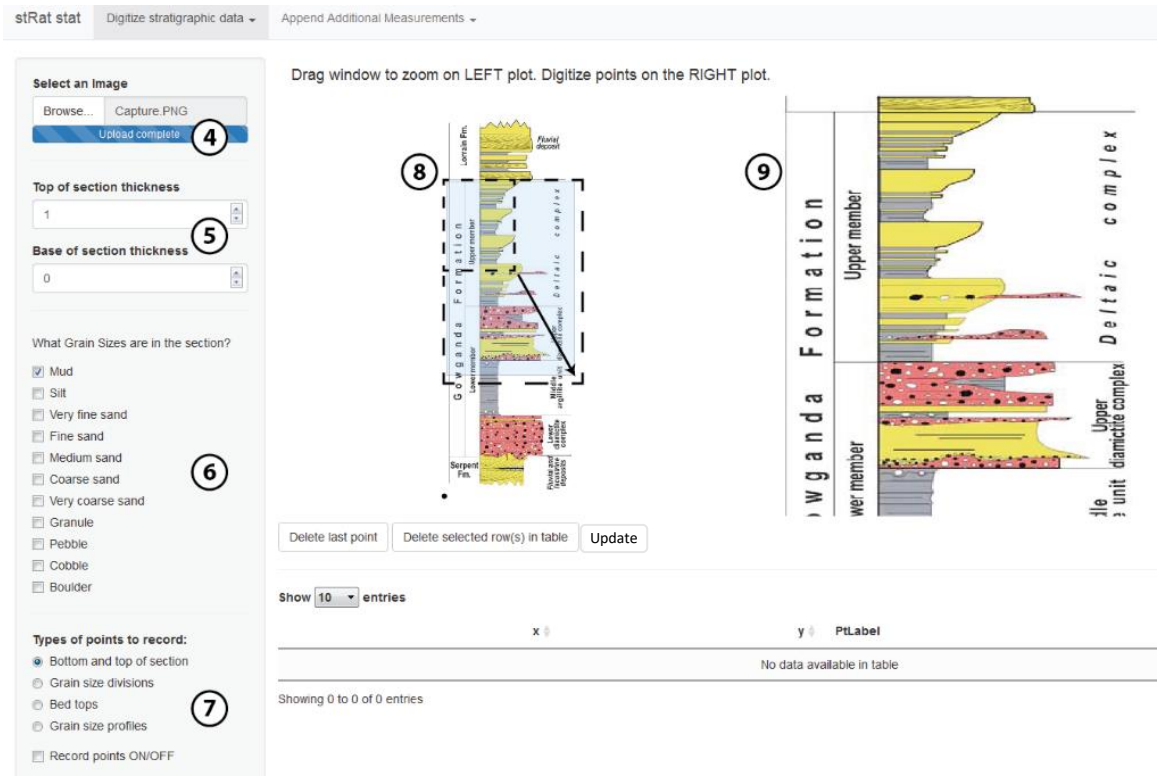
Important note, this tool was designed by D. Coutts to learn R. As such, there are likely mistakes, inelegant solutions, and shortcomings within the code. If you have any suggestions please contact D.Coutts at dannycoutts@gmail.com or interact via GitHub. Additionally, D.Coutts would like to publish stRat stat in a formal academic journal (JOSS, Computers and Geoscience, etc.), so co-authorship is welcome to streamline the code and provide insight into software publication.

The first panel of stRat stat hosts save and load options. If creating new data, click the “Digitize stratigraphic data” drop down (1) and navigate to “Digitize beds and grain sizes”.

If saving digitized data (2), click “Save Data” to compile all currently picked points into a save file, and then click “Download saved section data” to download it.

If loading a previously saved file (3), browse to the location the click “Load data”.





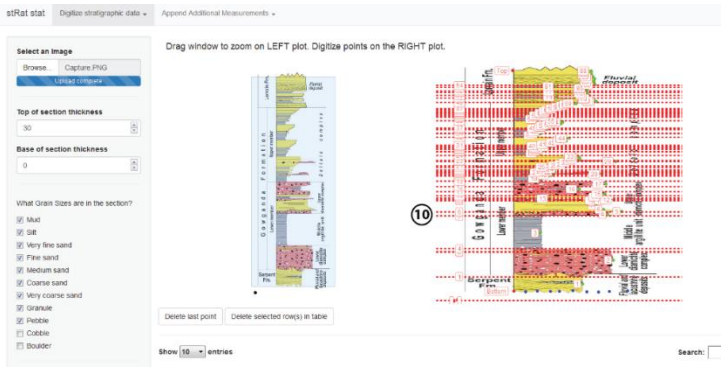
The first panel is where the majority of digitization is done. First upload a stratigraphic section in .png, or .jpg format (4) by browsing to the file location and selecting the file. For stRat stat to work effectively file sizes should be <1mb for the image. This will hopefully be improved in future versions and more high-resolution images can be imported. The thickness at the top and bottom are input numerically (5). The grain size division present in the stratigraphic section are selected in a checkbox list (6).

(7) Four types of data points are digitized on this panel: 1) top and bottom locations of the section, 2) grain sizes division along the bottom or top of the section, 3) the location of bed tops, and 4) the grain size profile of the section. Check the bottom box to turn on the ability to digitize points on the right hand image.

(8) The left-hand plot is used to zoom and navigate the view of the right hand image. To zoom drag a window on the portion of the stratigraphic section you would like to view. Click to digitize points on the right-hand image (9).

To speed up digitization, the right-hand plot will only updated when the window selected on the left-hand plot is changed, or when the “Update” button is clicked.

When all four data types are digitized on the image it may appear very busy (10); however, by zooming in on the right-hand image, points can be picked easily. For later steps (e.g., sedimentary structures, and facies) only the required digitized data will be displayed.

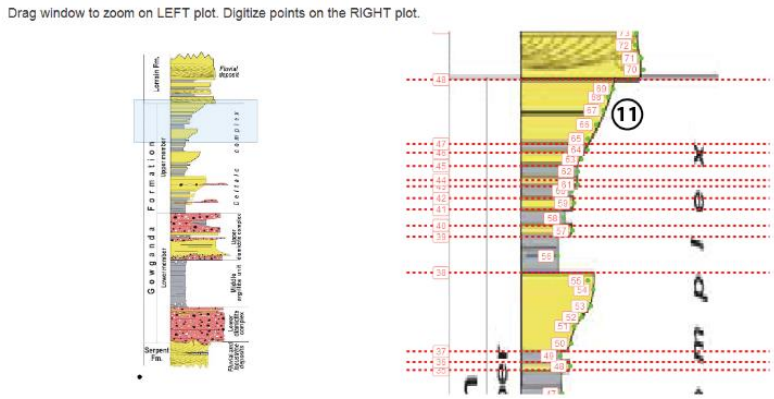


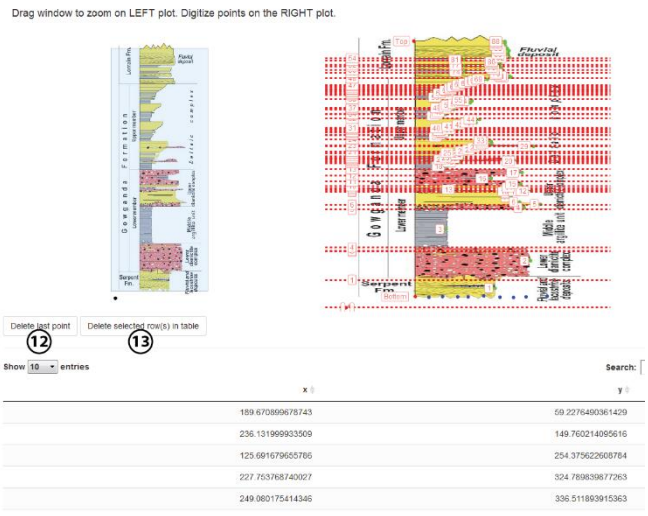
When picking grain size points:

If zero points are picked between bed boundaries, the interval will be treated as there is no data/covered interval/lost core.

If a single grain size point is picked between bed boundaries, there will be a uniform/single grain size populated for the bed.

If two or more grain size points are picked between bed boundaries (11), the points will be interpolated, and uniform grain sizes will be populated below the first point in the bed and above the last point in the bed.

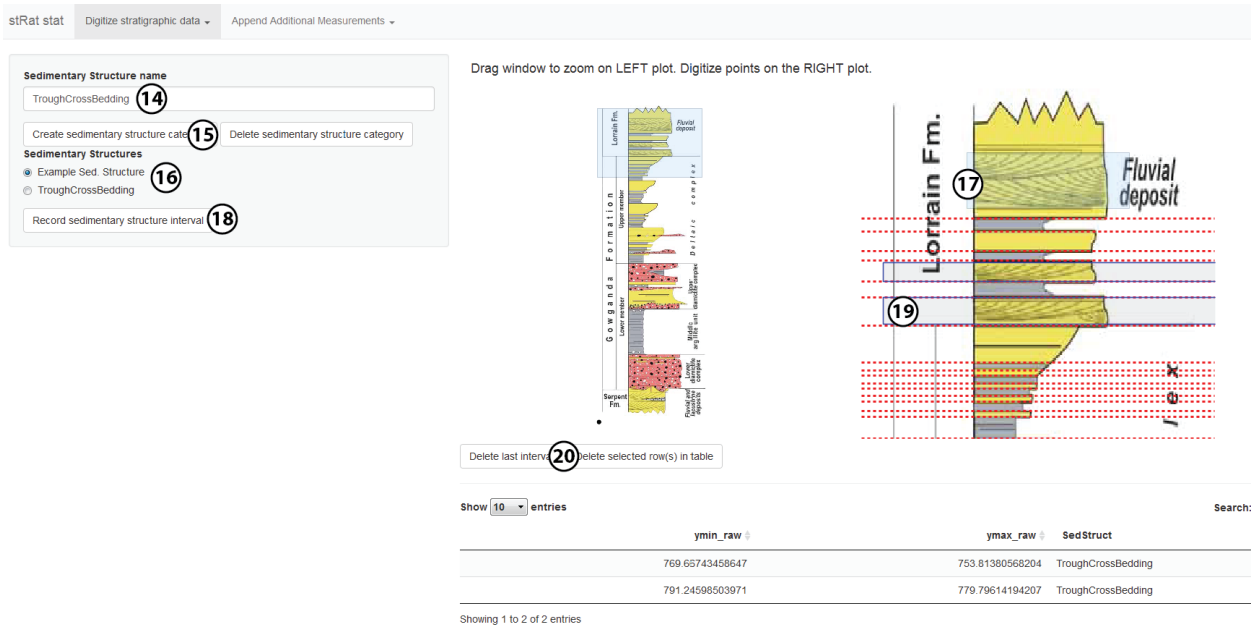




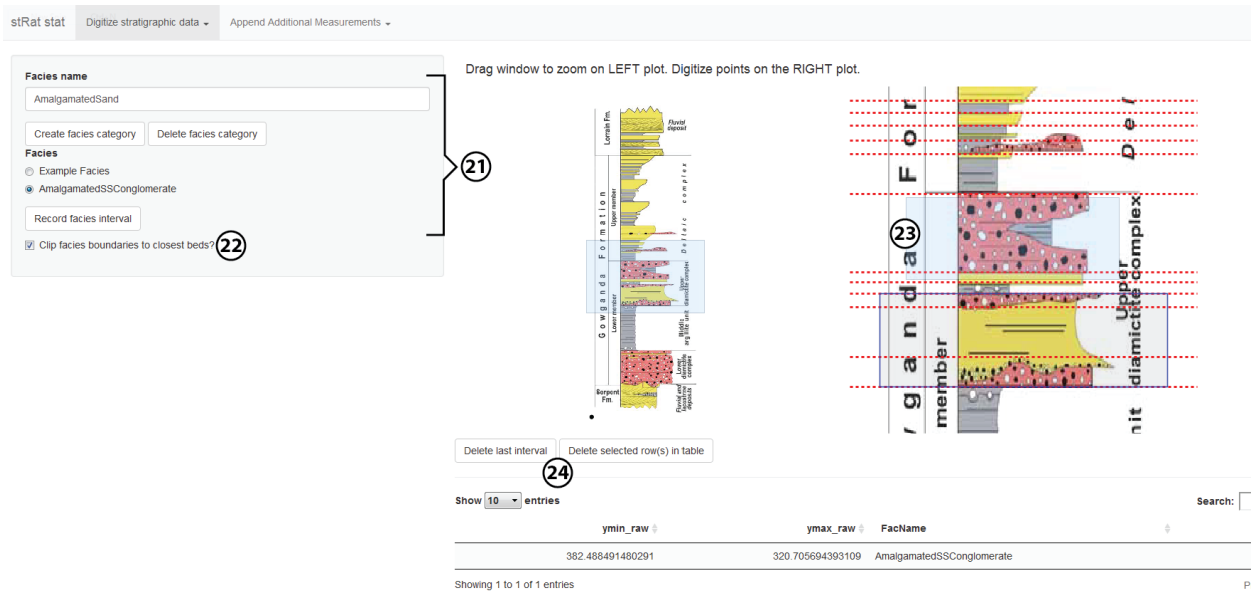
Logged points of each type will appear in a table below the plots of the sedimentary section, when the type of point is selected on the left (7). To delete logged points, the last point logged can be deleted by selecting the button (12).

To delete multiple points, multiple rows can selected in the table then deleted (13).

Points or intervals that are logged are numbered or labeled.



To log sedimentary structures, navigate to the "Digitize sedimentary structures and features" page. To create a sedimentary structure to log in an interval, type the name (e.g., TroughCrossBedding) in the field (14) and click "Create sedimentary structure" (15). After creating the structure, it will appear in the list (16). They can be deleted by clicking "Delete sedimentary structure category" button. To log the interval of the sedimentary structure, select the interval on the right-hand plot (17) and click "Record sedimentary structure interval (18). Once it is logged, it will appear as a blue box on the right-hand section (19). Options to delete (20) are the same as on the previous page, either deleting the last logged interval, or deleting row(s) from the table.



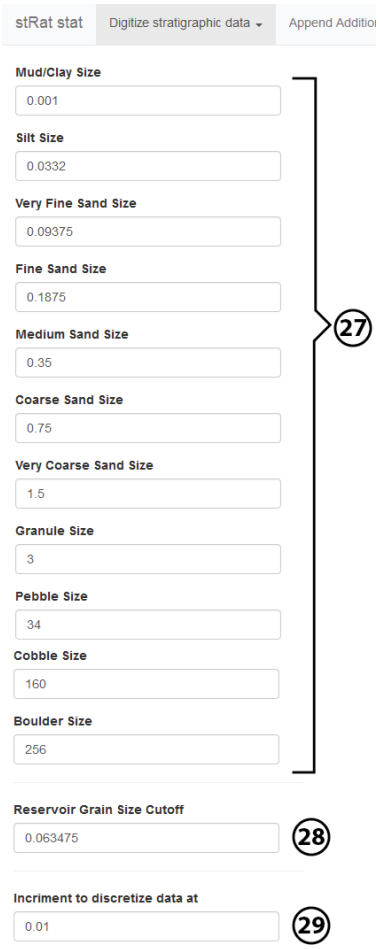
To log the facies, elements, and element sets (on separate pages), categories can be created, deleted, and selected similar to sedimentary structures (21). A feature for facies, elements, and element sets is clipping the selected interval to the nearest bed boundaries (22). If this check box is selected/checked, the interval selected (23) will be modified to have the same position as the nearest bed boundaries. If this check box is not selected/un-checked. The interval that is selected (23) will be logged exactly as it is on the right-hand plot. Recorded facies can be deleted as previously described (24).

After points are logged into stRat stat, there are options to provide user-specific numerical settings on the “Numerical settings” page.

The numerical values of each grain size division can be set to user-specific values (27). These values are the values that are at each logged point. If some grain size check boxes are un-checked (6), their sizes do not need to be changed.

Key reservoir grain size cutoffs (28) can be changed to case-specific values.

Lastly, the increment that the data/stratigraphic is discretized at can be modified (29). The increment should be half to one third of the thickness of the thinnest bed that is to be resolved.



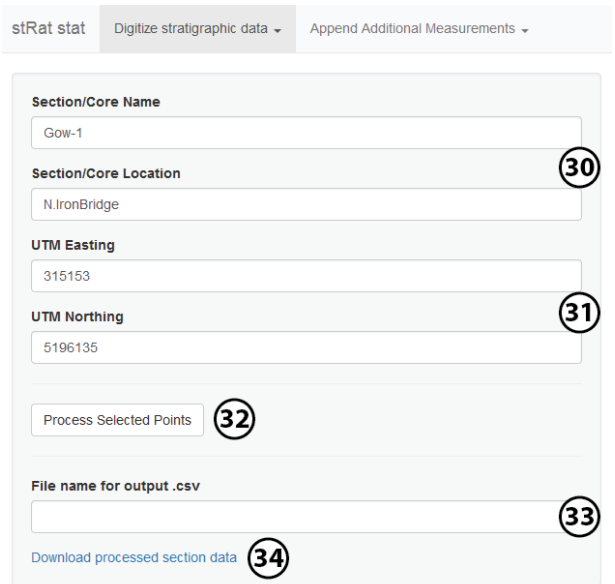
The last inputs allow for the name and location of the data to be input (30).

The UTM of the section can be input (31) to allow for spatial analysis of multiple stRat stat sections. Neither of these are required inputs.

If all inputs are correct the then the process can be run (32).

It should be note that the logged data should be saved (2) prior to running the discretization process.

Once run, the data can be downloaded (34) with the given name (33).

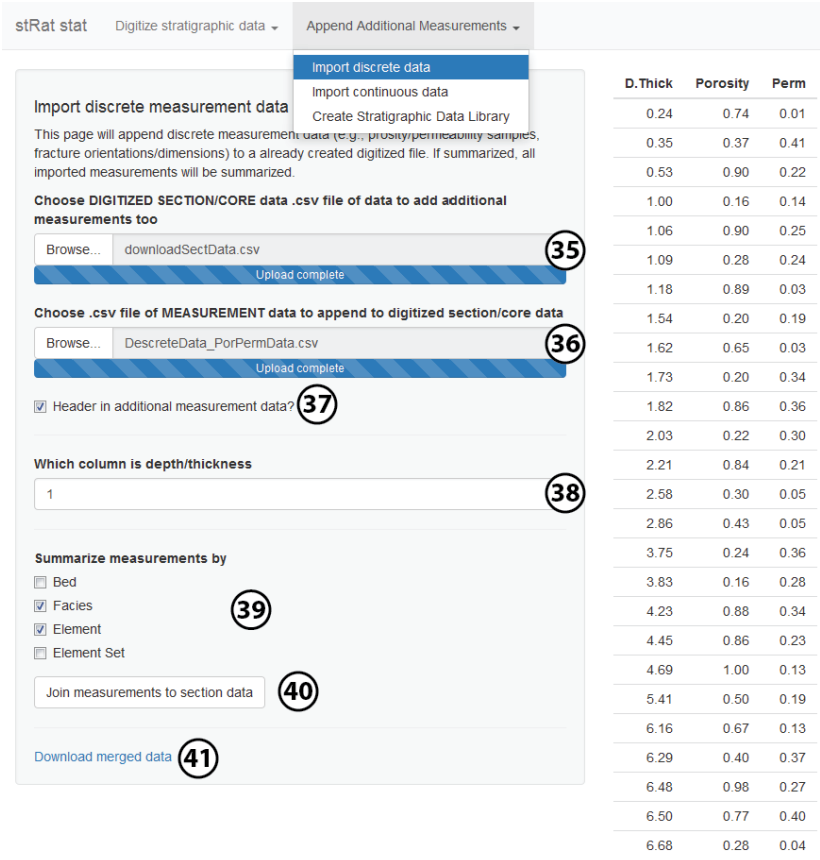


Once data is created through the digitization process it can be paired to additional data. Both discrete data (e.g., core analysis) or continuous data (e.g., well logs) can be paired to the data.

For both discrete and continuous data, this is done by selecting the digitized and downloaded section data .csv file (35) and a .csv file of the measurement data that is to be joined (36). Indicate whether the measurement data has a header or not (37) and which column hosts the thickness data (38).

Discrete data is rounded to the increment and matched to the stRat stat data. Continuous data is interpolated and then joined to the data. If the continuous data is a much finer scale (e.g., FMI logs) than the discretized data, then a rolling average will be applied to the data to find the mean of the discretized increment.

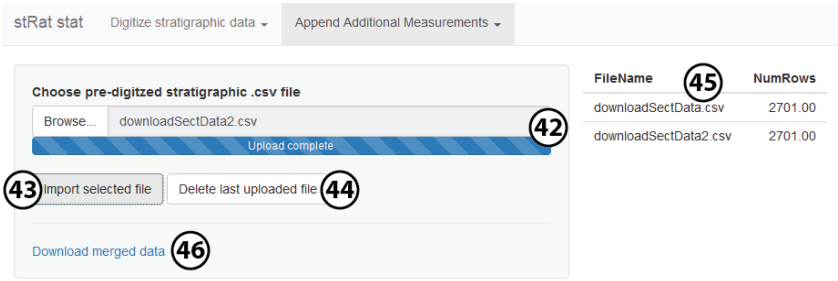
When the measurement data is loaded into stRat stat, it should appear in a table to the right.



The joined measurement data can be summarized by bed, facies, element, and element set (39).

Once the inputs are correct the process can be run (40) and then downloaded (41).

The final functions that stRat stat has is to create a large stratigraphic library from multiple stRat stat files. This is accomplished in the "Create Stratigraphic Data Library", where stRat stat files are simply appended together.



To do this, select files in the browser (42), then click "Import Selected File" (43). The last data file appended can be deleted (44). All appended datafiles will appear in a table to the right (45). The appended file can be downloaded (46) by clicking the "Download merged data". The appended datafile will have all columns of the input files and can be further manipulated/explored in multiple programs (e.g., R, Python, Excel, etc.) depending on the user's preferences.