Simplified User Manual for *SlugPen* and *SlugHeat:*

Software for parsing and processing data collected by a heat-flow measurement system

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This is a simplified manual for using the programs SlugHeat and SlugPen together to parse data from multiple heat-flow probe penetrations using SlugPen and determine heat flow using SlugHeat. For a more detailed tutorial, see `*SlugPen full tutorial*` and `*SlugHeat full tutorial*`

First, run *SlugPen* to parse raw data from an entire deployment into individual penetration files

(1) Launch *SlugPen*

When you have ensured all necessary functions and sub-directories are in your current working directory or in your MATLAB path, you can launch the program.

In MATLAB command window:

```
>> SlugPen
```

The command window to the left of the program can be used to correct data, store metadata, and control the program. To right, all raw data recorded by the heat-flow probe is loaded in (Figure 1).

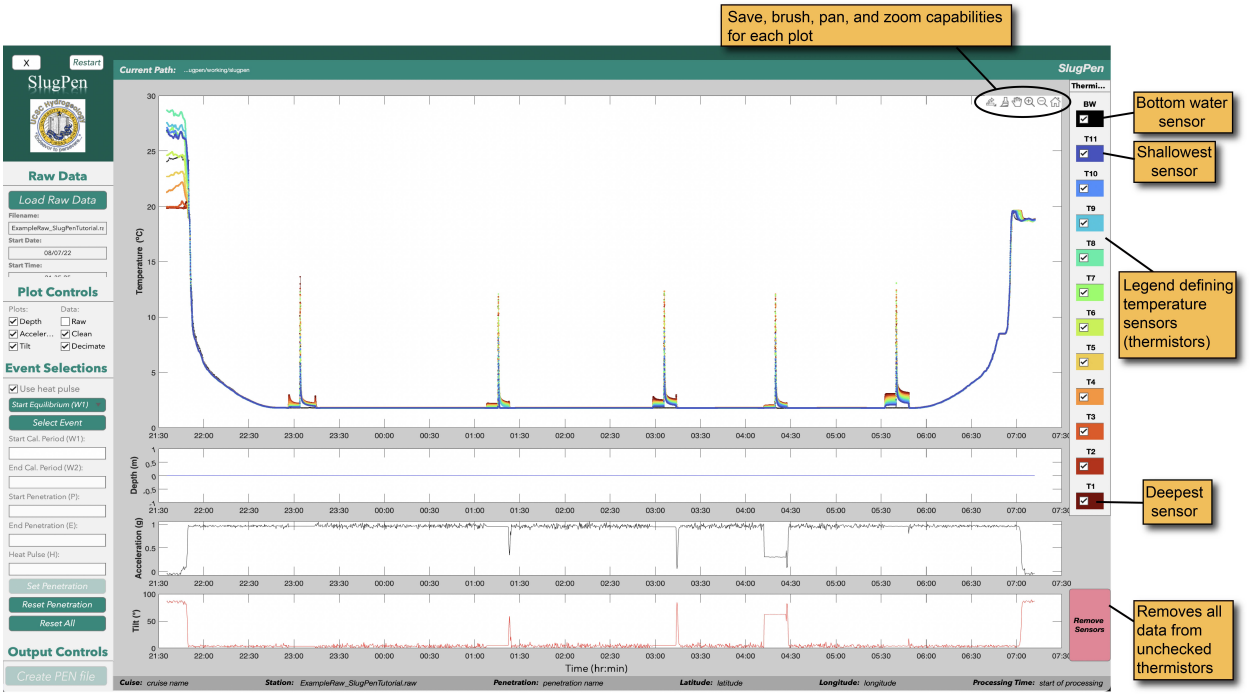

Figure 1: *SlugPen* example raw data loaded in and plotted

(2) Select timing of events:

Use the command window to left to select timing of important events during a penetration. A cross pointer will hover over the axes to allow you to manually select the following:

- Sensor calibration time
- Start and end of penetration
- Firing of the heat pulse

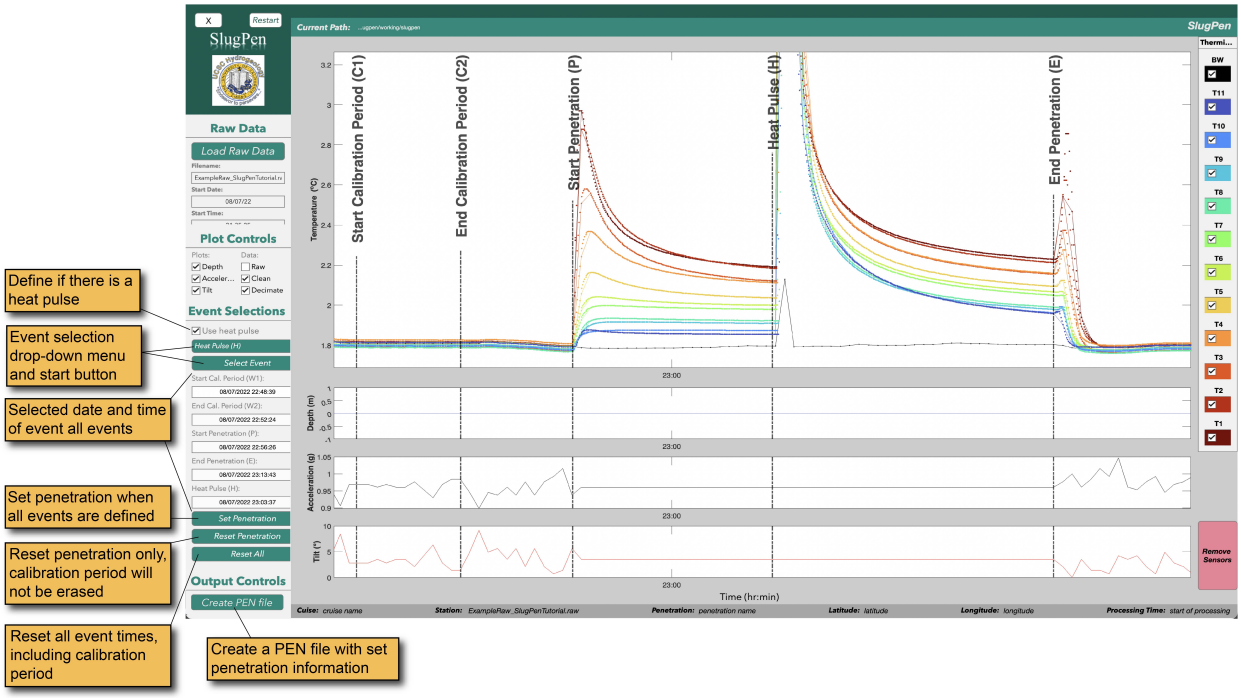

Figure 2: *SlugPen* selection of a single penetration, including all significant events: start of calibration period, end of calibration period, start of penetration, heat pulse firing, and end of penetration.

(3) Create PEN, TAP, and MAT files

Press the *Create PEN file* button to save penetration data to files that can be used as input files for loading data into the processing software, SlugHeat. A MAT file will created that stores all MATLAB variables needed to processing the penetration. Two text files will be created, including a PEN file (stores temperature data) and a TAP file (stores tilt and depth data).

Next, run *SlugHeat* to process data from an individual penetration to determine heat flow.

(1) Launch *SlugHeat*

When you have ensured all necessary functions and sub-directories are in your current working directory or in your MATLAB path, you can launch the program.

In MATLAB command window:

```
>> SlugHeat
```

(2) Set up for processing

- The command window to the left of the program can be used to correct data, store metadata, and control the program. To right, all raw data recorded by the heat-flow probe is loaded in (Figure 3 **(box 1)**).
- The input parameters for data processing and calibration of temperature sensors must be defined. To see default parameters and modify as needed, use the *Input Parameters* box on the command window (Figure 3 **(box 2)**. To change these input parameters, either (a) manually change using *Manually set input parameters* button or (b) load in a new PAR file created from processing previous penetration in SlugHeat using *Choose another PAR file* button.

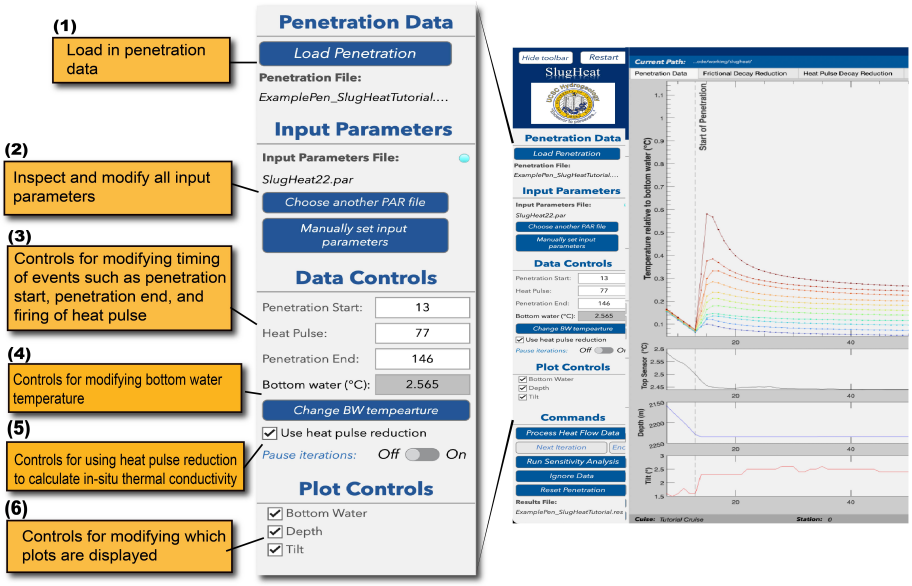

Figure 3: *SlugHeat* controls for modifying data, input parameters, and plot display before processing. Yellow boxes indicate notable pre-processing data and display controls. Example penetration used: `ExamplePen_SlugHeatTutorial`

Once loaded, all temperature, tilt, and depth data will be automatically plotted to the *Penetration Data* tab:

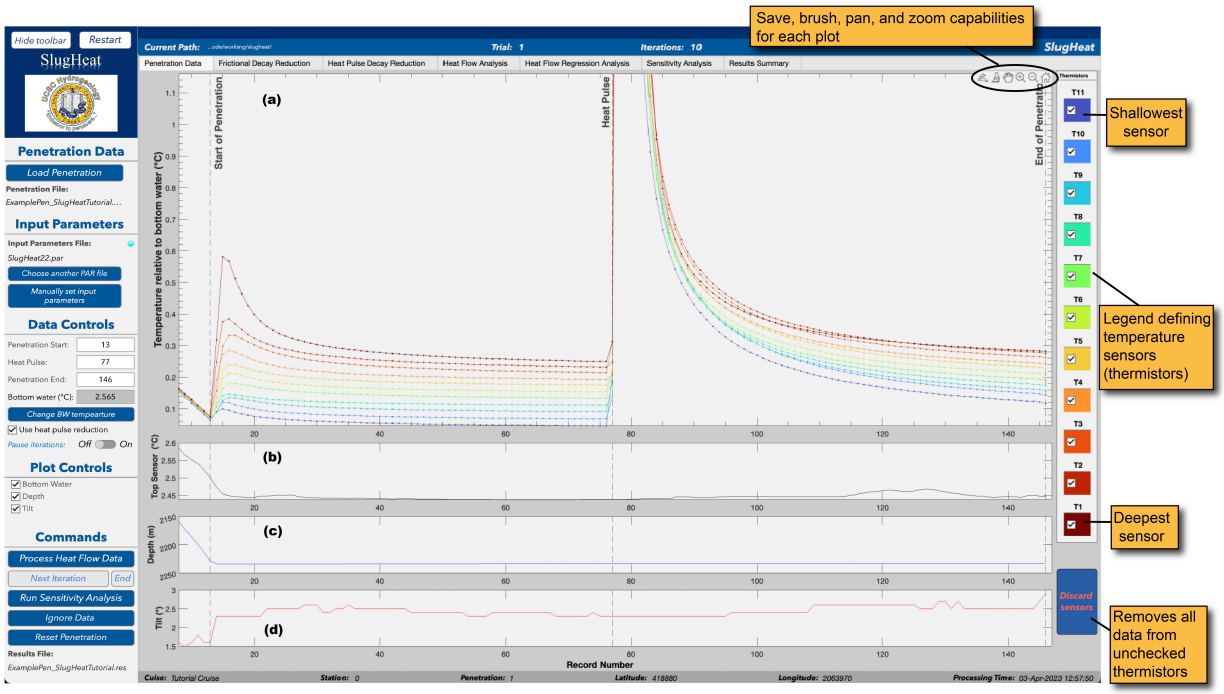

Figure 4: *SlugHeat* example *Penetration Data* tab

(3) Process for heat flow

When input parameters and data have been checked and modified as needed, the data can be processed to determine heat flow.

– **Press *Process Heat Flow Data* button** (Figure 5 **box 8**)

Processing penetration data includes iteratively determining equilibrium temperatures of the sediment and *in-situ* thermal conductivity of the sediment, which are subsequently used to determine heat flow.

Results will be displayed on the *Heat Flow Results* tab, which includes results for estimated equilibrium sediment temperatures, thermal conductivity, and heat flow:

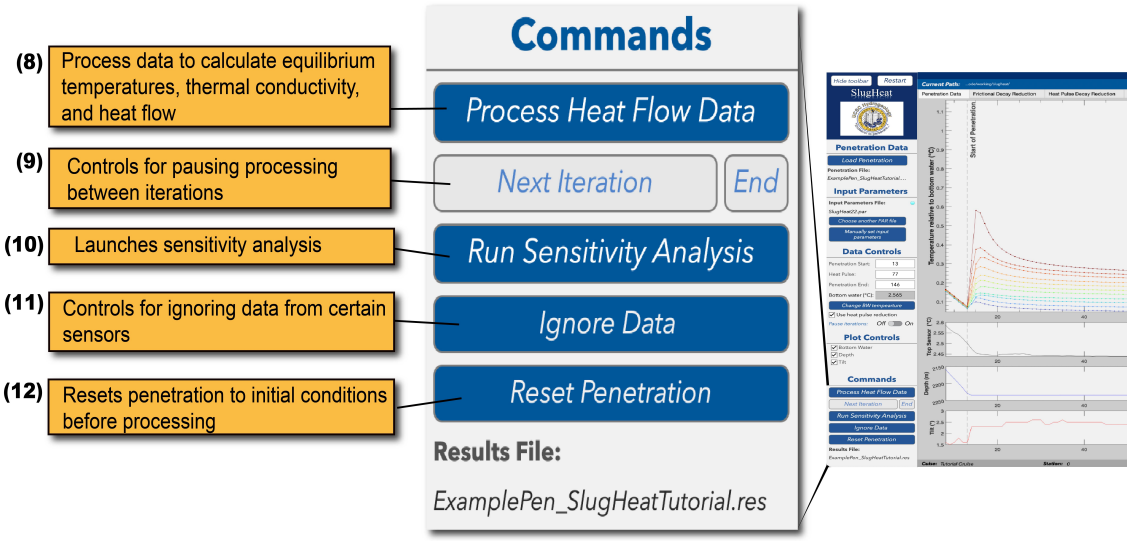

Figure 5: *SlugHeat* processing commands. Yellow boxes indicate notable processing data and display controls. Example penetration used: `ExamplePen_SlugHeatTutorial`

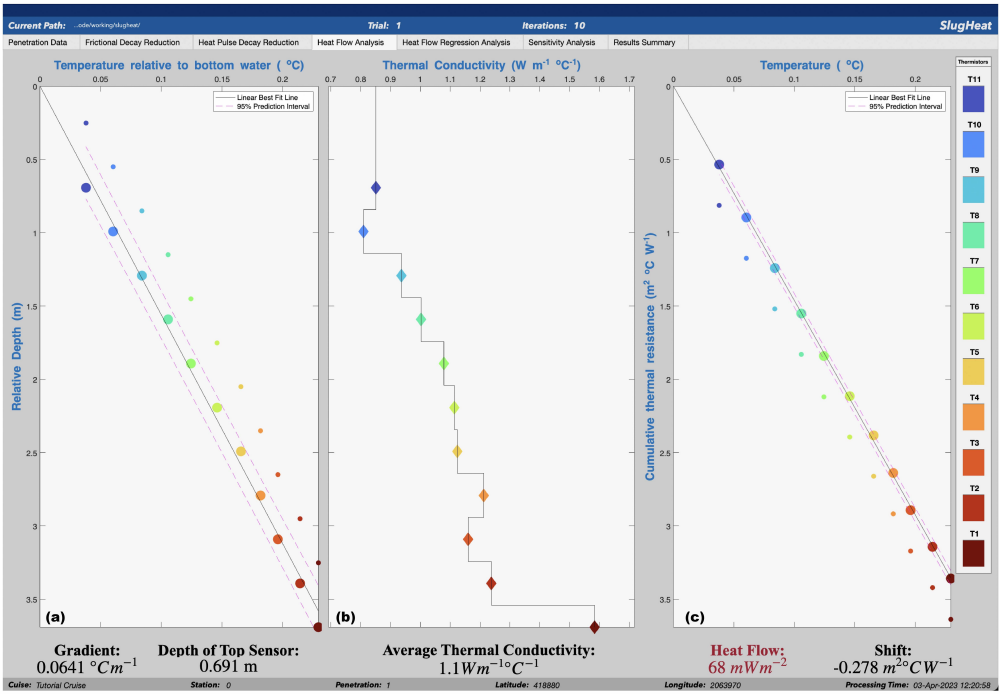

Figure 6: *SlugHeat* example *Heat Flow Analysis* tab for determining heat flow for a particular penetration.

(4) Determine error and uncertainty

There are several optional tools for determining error and uncertainty in heat flow estimations, including a heat flow regression analysis (*Heat Flow Regression* tab) and a heat flow sensitivity analysis (described below).

– To run sensitivity analysis, **press *Process Heat Flow Data* button** (Figure 5 **box**

10)

An auxiliary application is launched to create parameter distributions for sensitivity analysis:

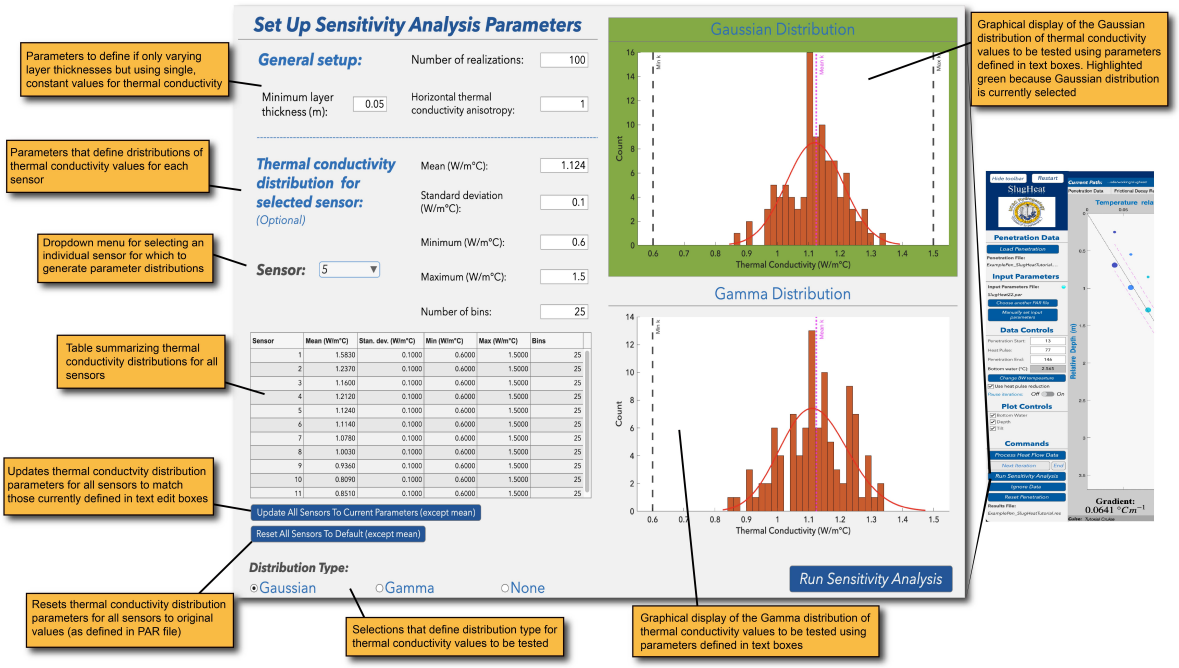

Figure 7: *SlugHeat* auxiliary application for defining parameters to be tested in a sensitivity analysis, including number of realizations to be run, minimum layer thickness, and thermal conductivity distributions.

All heat flow and error and uncertainty results are saved to a summary table (check *Results Summary* tab in GUI) and a text (RES) file in the */outputs* subfolder in your current directory. A new PAR file will also be generated defining the input parameters used, which can then be loaded in and used for subsequent penetrations, if desired.