User manual for GassDem GUI

GassDem (Gassmann Differential effective medium) GUI is designed for an anisotropic elastic solid A with variable amounts of liquid B with a shape specified by an ellipsoid of arbitrary orientation with semi-axes of variable lengths parallel to X, Y, Z described in Mainprice's (1997) "Modelling the anisotropic seismic properties of partially molten rocks found at Mid-Ocean Ridges", Tectonophysics 279, 161-179.

GassDem GUI and analytical schemes are described in the paper of Kim, E., Kim, Y., and Mainprice, D. (2019), "GassDem: A MATLAB program for modeling the anisotropic seismic properties of porous medium using differential effective medium theory and Gassmann's poroelastic relationship", Computers and Geosciences.

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EUNYOUNG KIM

Seoul National University, Seoul, Republic of Korea

e-mail: brilliant@snu.ac.kr

1. Information

GassDem graphical user interface (GUI) is designed using the MATLAB (R2016b) App Designer in Mac OS X for calculating the elastic stiffness tensor of the porous effective medium with fluid inclusions based on the differential effective medium (DEM) theory and Gassmann's (1951) poroelastic relationship. Using the elastic stiffness tensor from GassDem, seismic velocities in the direction of reference axes and the inverse of maximum quality factor (Q_{max}^{-1}) can be calculated. This manual provides guidelines on how to use GassDem GUI.

2. Using GassDem GUI

There are two ways to open GassDem GUI in MATLAB.

- From the Current Folder browser, double-click GassDem.mlapp.
- From the Command Window browser, type 'GassDem'.

It consists of four main tabs;

- Effective Medium
- Inclusion Shape and Orientation
- DEM Analysis
- Help

The Help tab consists of four sub-tabs; About GassDem, Inputs, Outputs and Codes.

A default data set (Figures 1-7) is an example for users to replicate DEM modeling, which is described in the main text. A background medium is antigorite-bearing olivine that is 'Model SC3' of Morales et al. (2018). The inclusion phase is liquid basalt (melt).

- Background medium: Antigorite-bearing olivine that is 1.63% crack porosity model of 78% antigorite and 22% olivine with spherical grains, having two types of the crack, one normal to the Z-axis and another normal to the Y-axis, with shapes X:Y:Z = 10:10:1 and X:Y:Z = 10:1:10, respectively (Kern et al., 2015; Morales et al., 2018).
- Inclusion: Liquid basalt (melt) whose bulk modulus (Kf) for elastic stiffness tensor is derived from the compressibility (Bf = 1/Kf) data at 1200°C of Murase and McBirney (1973).

2.1. Effective Medium tab

The user can construct a two-component system of A and B for DEM calculation (Figure 1). Phases A and B are set as host medium and inclusion (e.g., fluid), respectively.

1) Specify name, elastic constants file (*.txt) and density (g/cm^3) of two phases.

   Note that elastic stiffness matrix should be Voigt matrix in GPa. Elastic stiffness matrix of a background medium can be calculated using the SC approximation or other methods, or even taken from laboratory measurements.

2) Type full paths of the input files directory that includes elastic constants files.

3) Type full paths of the GassDem directory that includes GassDem codes.

   Note that the file separator character is a backslash (\) on Windows platforms, whereas it is a forward slash (/) on UNIX platforms (https://www.mathworks.com/help/matlab/ref/fullfile.html). For example,

   - C:\Users\EKim\Documents\GassDem\ (Windows)
   - /Users/ekim/Documents/GassDem/ (UNIX).

4) Specify fluid properties of compressibility (1/GPa), viscosity (Pa·s), *P*-wave velocity (*Vp*; km/s) and density (g/cm^3) required for Gassmann's relationship and attenuation estimation.

   Note that fluid compressibility (or 1/bulk modulus) should be consistent with bulk modulus of fluid inclusion provided as elastic stiffness tensor in step 1).

5) Specify maximum % error for Green's Tensor (e.g., 0.1).

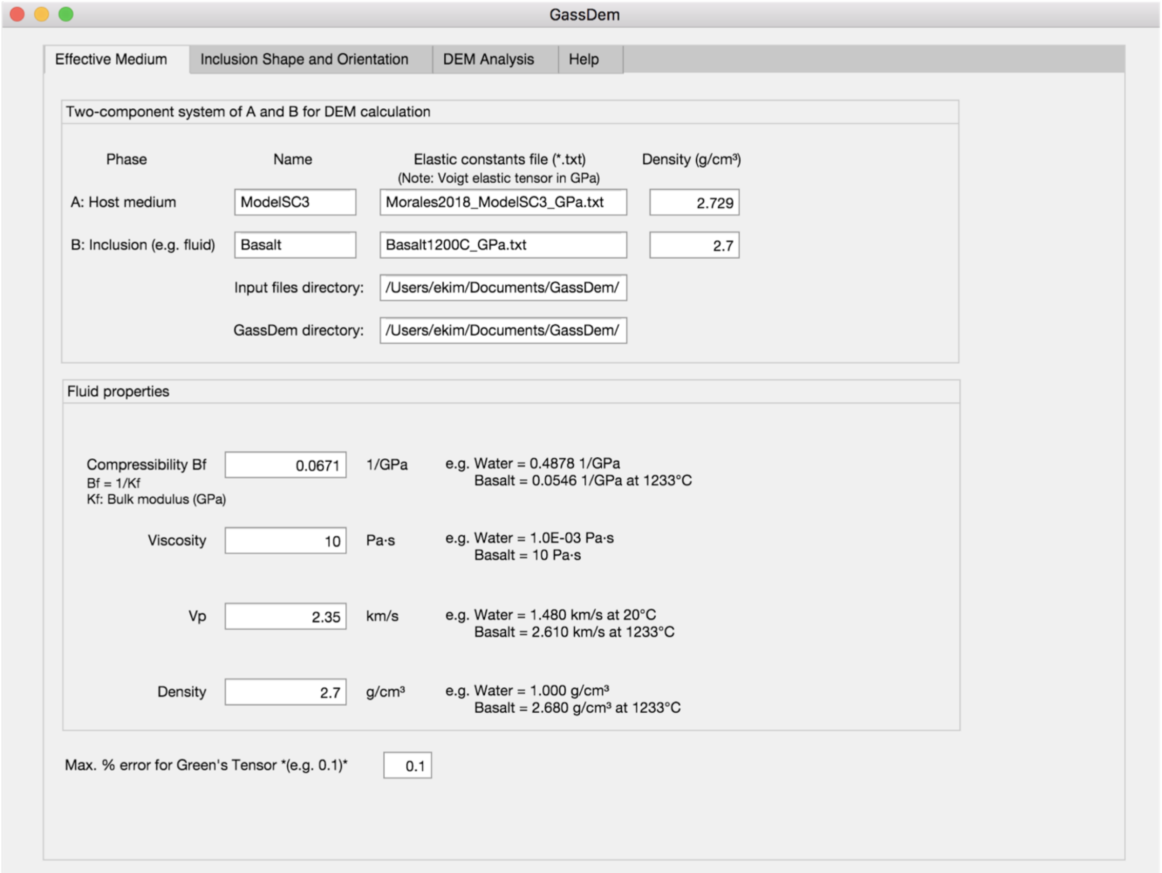

Figure 1. Effective Medium tab of GassDem GUI. A two-component system of A and B can be constructed for DEM calculation. Fluid properties of compressibility (1/GPa), viscosity (Pa·s), *Vp* (km/s) and density (g/cm^3) are required for Gassmann's poroelastic relationship and attenuation estimation.

2.2. Inclusion Shape and Orientation tab

The user can select inclusion shape and define orientation of inclusion semi-axes (Figure 2).

1) Select a sphere or an ellipsoid for inclusion shape.
2) If an ellipsoid is selected, specify semi-axes lengths (e.g., A1:A2:A3 = 5:5:1). If a sphere is selected, semi-axes lengths are set to be A1:A2:A3 = 1:1:1.
3) Select the orientation of shape ellipsoid semi-axes to be parallel to elastic tensor axes or parallel to user-defined orientation (shape preferred orientation, SPO).

4) If an orientation is selected to be parallel to elastic tensor axes, ellipsoid semi-axes (A) are parallel to elastic tensor axes (X). For example, it is set that A1//X1, A2//X2, and A3//X3 for olivine with the principle axes X1 = [100], X2 = [010], and X3 = [001].

5) If an orientation is selected to be parallel to user-defined orientation, specify azimuth (°) and inclination (°) for A1 and A3.

Note A1 should be 90° to A3, which can be checked by pushing the Check button.

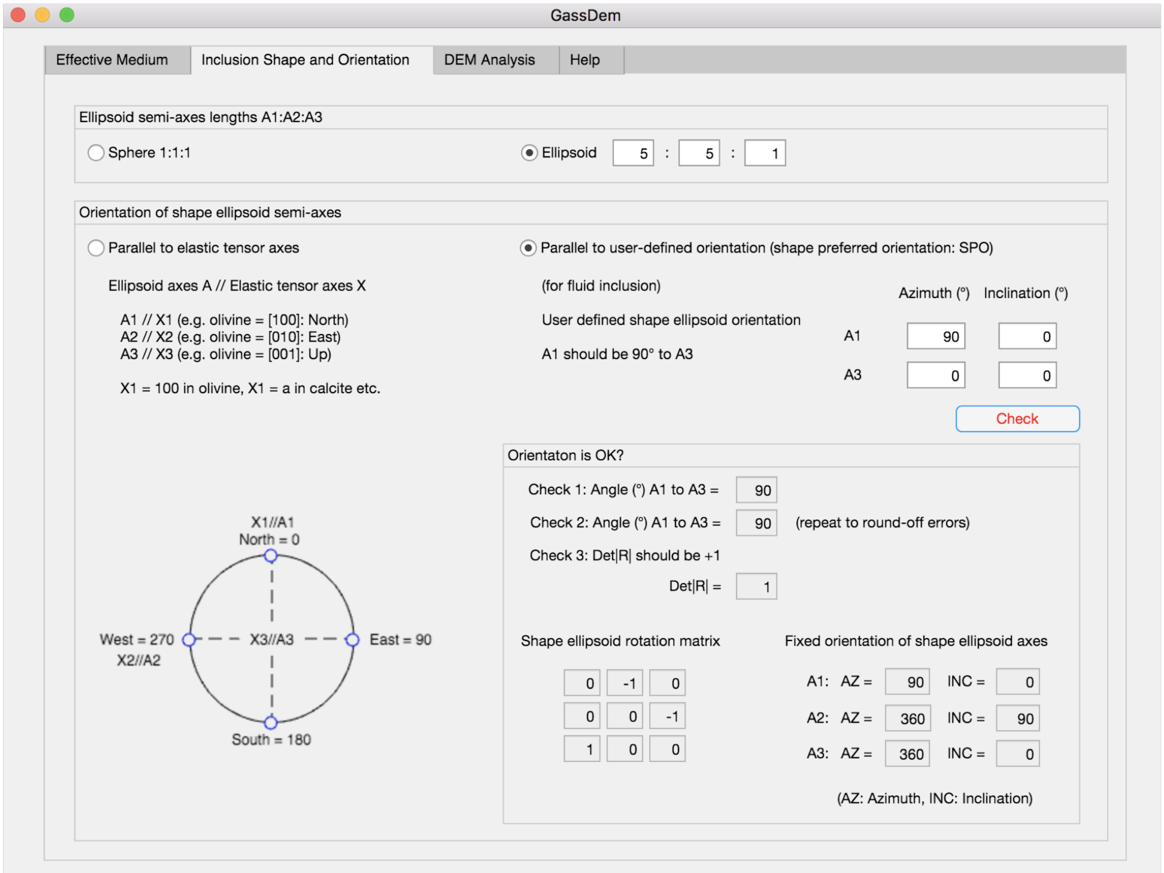

Figure 2. Inclusion Shape and Orientation tab of GassDem GUI. Ellipsoid semi-axes lengths and orientation of inclusion can be defined.

2.3. DEM Analysis tab

The user can make a file name and directory for DEM results (Figure 3).

1) Type file name that is used as a prefix to save outputs as text files (.txt) in the program.

   Note that file name should not contain a filename extension.

2) Type output directory to save outputs.

   Note that output directory can be any directory the user wants. If the directory does not exist in MATLAB's path, the program will make the directory and add it to MATLAB's path.

3) Specify maximum volume fraction of inclusion between 0 and 1for DEM processing.

4) Push the Calculate button. Then, the Current status panel shows the name of inclusion, volume increment step size (dVb) and total steps, and progress status (Processing or Completed).

5) In the Figure configuration panel, select structural direction X, Y or Z that are lineation, normal to the lineation in the foliation plane or normal to the foliation plane, respectively.

6) Select the shear wave direction as fast (Vs_1) or slow (Vs_2).

7) Specify limits of inclusion volume fraction, Vp, Vs and Q_{max}^{-1}.

8) Push the Plot button. Then, Vp, Vs and Q_{max}^{-1} are plotted as a function of inclusion volume fraction on the figures.

   Note that high and low frequency velocities are denoted as 'H' and 'L', respectively, in figure legends.

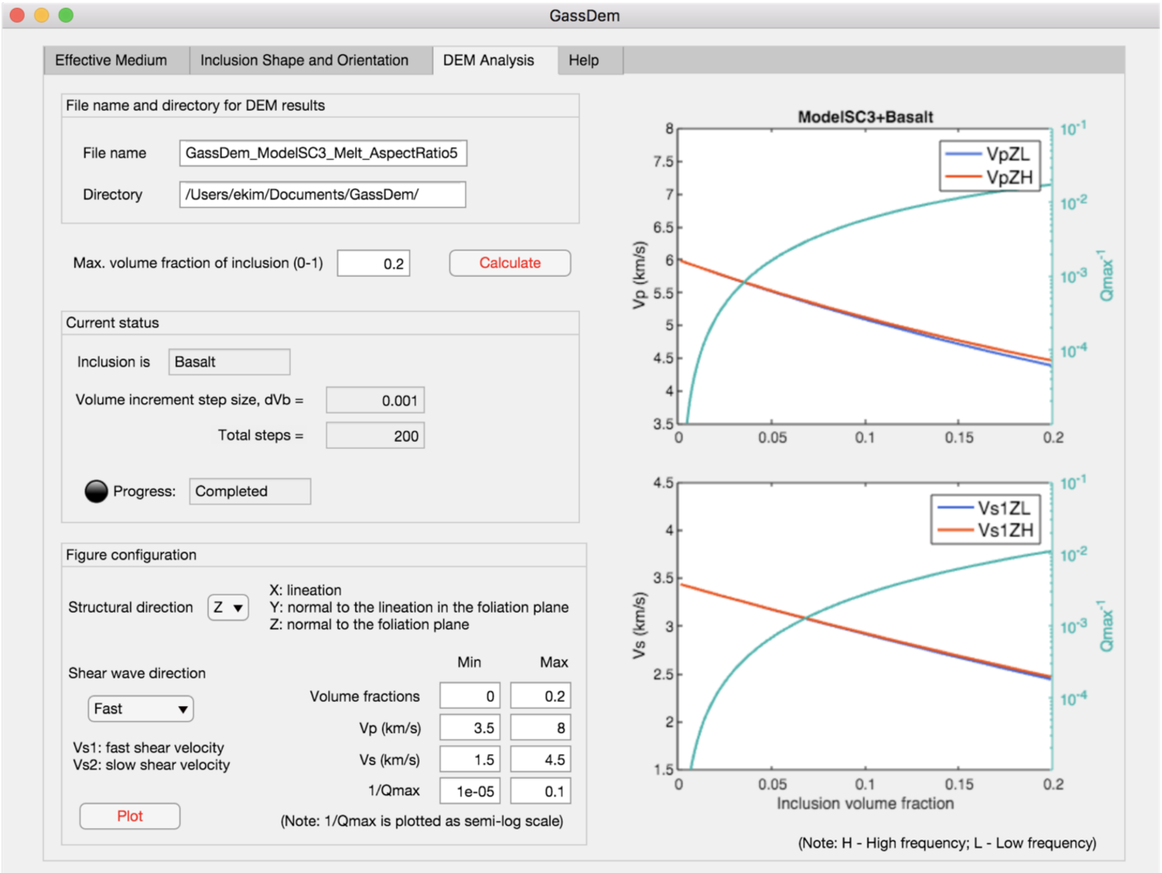

Figure 3. DEM Analysis tab of GassDem GUI. File name and directory for DEM results can be set. By specifying a maximum of inclusion volume fraction and pushing the Calculate button, DEM modeling is processed. Outputs are saved as text files (*.txt). By setting the Figure configuration panel, Vp, Vs and Q_{max}^{-1} are plotted for a given range of inclusion volume fraction.

2.4. Help tab

The user can refer to the Help tab for information about GassDem and several notes on inputs, outputs and codes (Figures 4-7).

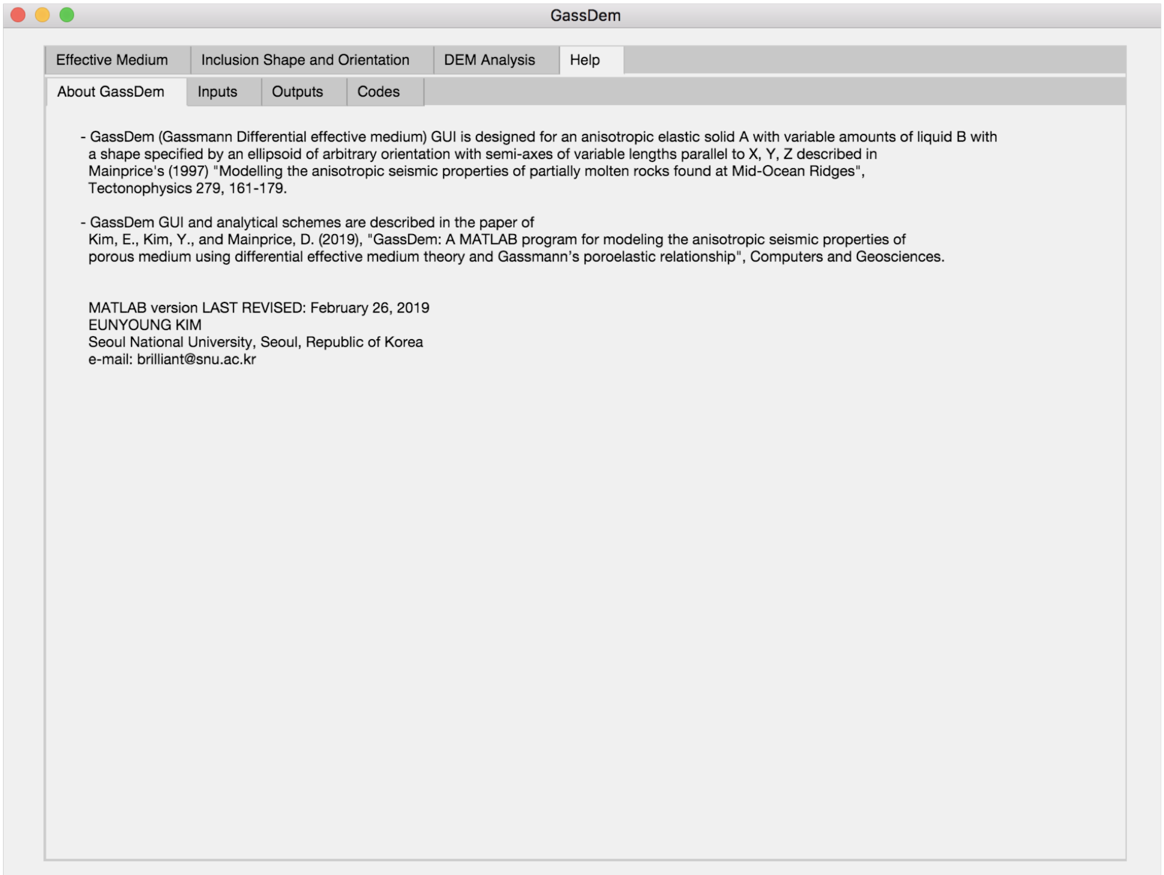

Figure 4. About GassDem sub-tab of the Help tab. The information of GassDem GUI, references and developer is described.

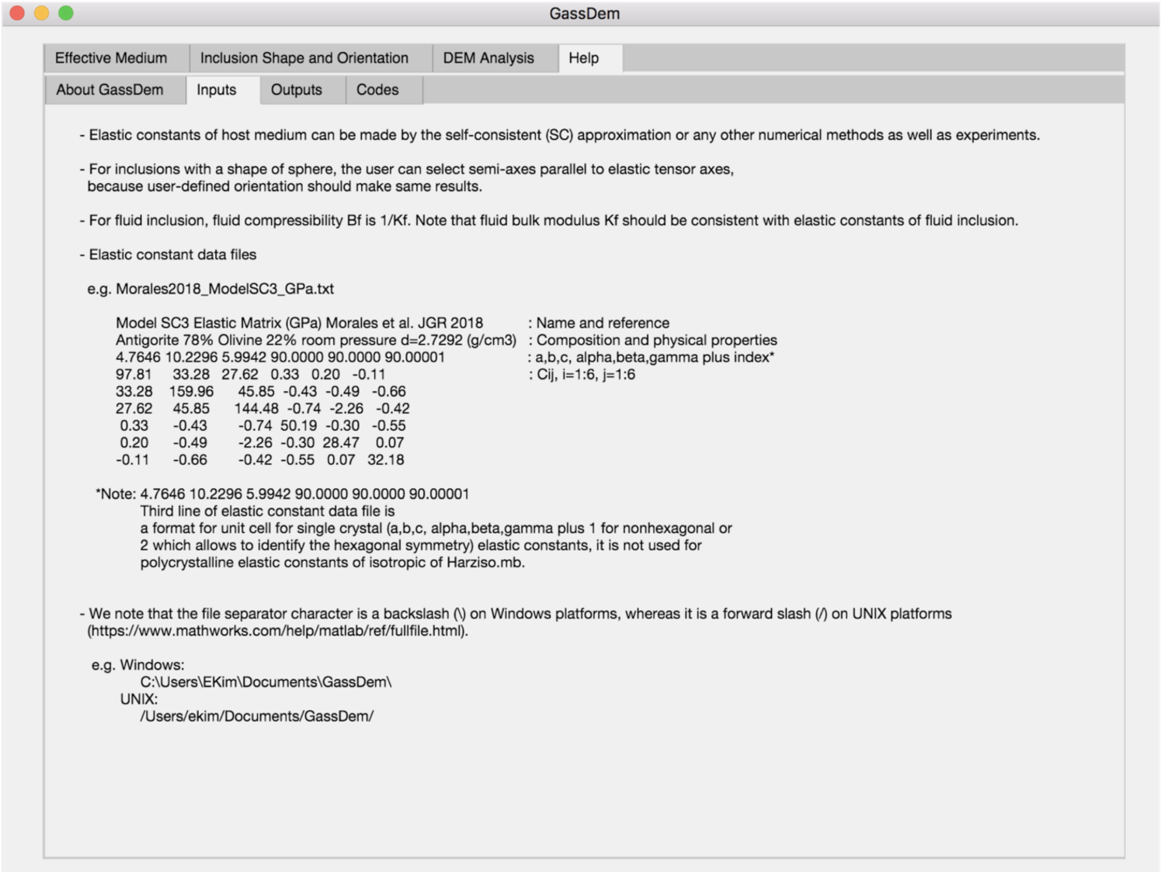

Figure 5. Inputs sub-tab of the Help tab. Notes on the input parameters are described.

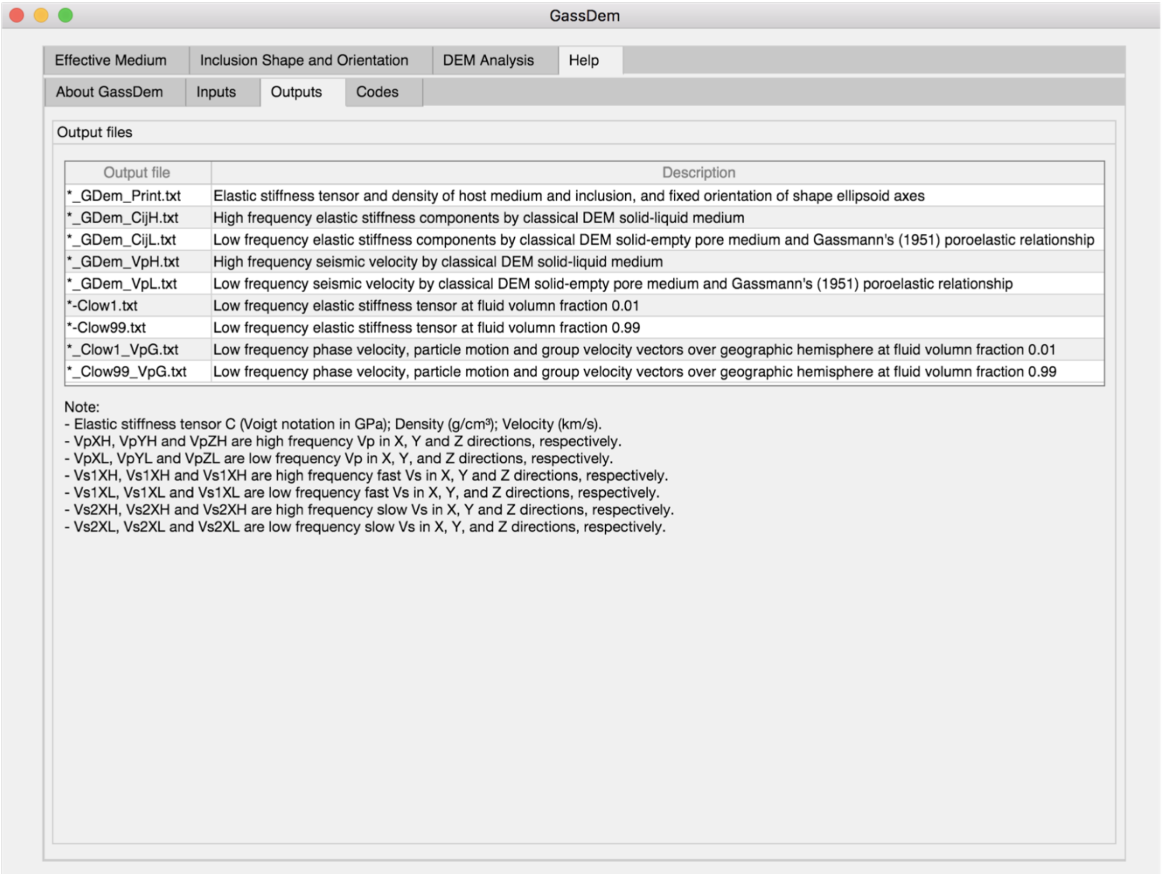

Figure 6. Outputs sub-tab of the Help tab. Notes on the output files are described.

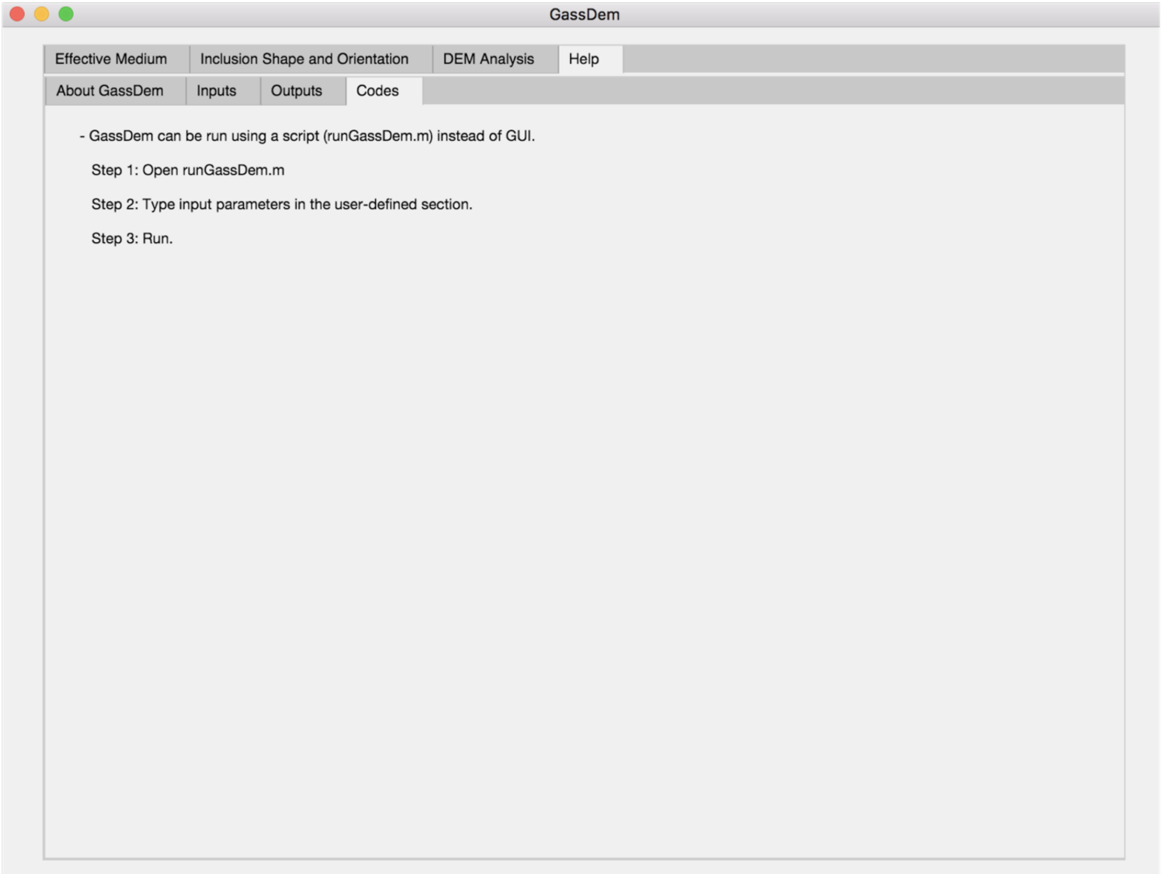

Figure 7. Codes sub-tab of the Help tab. A note on how to use the GassDem program using a script (runGassDem.m) instead of GUI is described.