Surface Energy budget in the Mixed Layer (seml)

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A. Introduction

This toolbox contains the functions and an example (inputs and outputs) to run "seml", a code that computes surface energy budgets, lake numbers, and stability.

Please, always keep in mind that this code is a 'research' code, and thus is always under development. Some of the calculations are straightforward, others require judgment. Some comments on the latter are included at the end of this document (section D).

The main code containing all the equations is "seml.m" and is called by a Graphical User Interface (GUI) function "seml_gui.m", which are located in:

…\functions\MAIN

The model needs:

(1) Lake temperature (raw data)
(2) Meteorological data
(3) Hypsographic curve of the lake (depth-surface area relationship)

The first ~140 lines in seml.m describes code changes, input and output variables, sub-functions, and helpful tips about sign convection and vector orientation.

B. Description of the folders

(1) **functions**: It contains all functions required to run seml (MAIN). NB. Set the path in Matlab to the folder and subfolders in this folder.

(2) **input_data**. It contains an example of input files to run seml: bathy (hypsographic curve); met (meteorological data); and T (lake temperature).

(3) **literature**: Here you will find useful papers to understand equations and calculations in this code.

(4) **results**: This is the output folder, where results of seml are saved.

C. How to run the code

1. **Prepare the input data** in the required format. Look in the folder "Input_data" to see an example of what is needed and how it must be saved.

2. **Set the current directory in Matlab to the folder called "results" (output folder)**, where you want to save the results (in a .mat format)

3. Type **seml_gui.m** in the command window and hit Return to run it (NOTE, this mfile calls the main code "seml.m")

4. A GUI window will appear. The GUI has boxes to click such that you provide the path to the bathymetric data, the temperature data, and the met data. The GUI also has boxes which you need to fill in to indicate the lake's name, elevation, latitude, wind sensor height, mean specific conductance in the water (280 μS/cm by default), factor to compute salinity from specific conductance (0.6 by default), type of temperature sensors (RBR or HOBO) to select the method to compute the mixed layer depth, and threshold values involved in the selected method.
   a. When loading the met.mat file, either you manually provide a mean attenuation coefficient here, or you include a time series of attenuation coefficients in the met.mat file.
   b. See section D to understand the implications of selecting RBR or HOBO sensors.
   c. Accept any error that may pop up while loading data.

5. **Click on "Run seml"** bottom of the GUI and stay in the folder where you are (output folder)

6. Seml will automatically **save the output**s as a file named "[NameOfTheLake].mat" into the "results" folder.

D. <u>Steps in which user judgment is required</u>

1. <u>Density calculations:</u> We compute density (RHO, kg m^3) as a function of temperature (T, ^oC) and salinity (Sal, g kg^{-1}), following Chen and Millero (1977). We compute salinity from specific conductance (SC) as, Sal (g kg^{-1}) = fsal * SC (mS cm^{-1}), where fsal depends on the ion content in the water. Users must sum the major ions and bicarbonate in the lake water to obtain actual values of salinity when SC measurements are available. Thus, the lake specific value of fsal will be accurately estimated. By default, we set fsal = 0.9.

2. <u>Mixed layer depth</u>: The goal in the computation is to find the depth of the actively mixing layer. This can be obtained readily using the function **ml_depth.m** when RBR loggers are used. This function will use the temperature difference approach, and dT = 0.2^{o}C (by default).

   Water temp pros (HOBO) do not have sufficient accuracy for the calculation. Hence, for it, we use the **mld_rueda.m** function which uses a density gradient approach. Users should look at their data and decide a good density gradient threshold. *By default, drhodz = 0.003 kg m^{-2}. However, this value is specific of each data set.* In addition, we encourage the users to **calibrate their temperature data to 0.05ºC** (if possible) and **inter-calibrate the time series based on times when the water column should be mixed.**

The user must choose the right type of temperature loggers in the GUI and temperature or density threshold to correctly compute the mixed layer depth.

3. Lake numbers: Seml computes Lake numbers as averages of the largest time interval. For example, this value is 5 min in our example case. However, Lake numbers need to be averaged for a period equal to ¼ the period of the dominant internal wave mode. Thus, if the period of the internal waves is 4 hours, the 5-minute data must be averaged to hourly. We do this using binave, and a binsize = 12 (i.e., there are 12 five minute samples in an hour). If the waves are wind forced with the wind period daily, we do six-hour averaging. By default, the code will average Lake numbers every 6 hours. Search for the 'binsize' variable in seml.m if a different period is required.