Add-on MSF calculations for LI6800

This is a self-developed add-on for LI6800 by plantphysiologist.com. The add-on includes calculations of gas exchange parameters accounting for small fluxes as presented by Márquez, Stuart-Williams, and Farquhar (2021) (MSF). The incorporation of the add-on is via the configuration function included in the tab “Start up” of the LI6800. The add-on was developed for the LI6800’s software version 2.0.04 but was tested in the version 1.5.02 as well. The add-on does not replace the previous calculations performed by the LI6800 but adds a set of columns and rows to the data file including the new calculations and parameters.

Installation

1. Download the configuration file “Configuration MSFGasEx”.
2. Add the add-on file into the config folder (From the console using a thumb-drive in the “Start up/Configuration” section or via an Ethernet connection).
3. Load the configuration from the console in “Start up/Configuration”.

What’s in the add-on?

The configuration add-on includes three main features to be added when loading it onto the LI6800: **calculations** using MSF theory in the option UsrDef; reconfiguring the **graphs** in the tab measurements to use the new variables in the option Graphs; and the **grids** in the tab measurements to use the new variables in the option Grids. The user can load all three of them or only the calculations (UsrDef).

*Notice that if UsrDef is not load, the options Graphs and Grids will not work properly.

Calculations:

The configuration will add two new row constants and ten new columns to the log file. The two row constants are the ratio of water vapour diffusivity in air over the CO_2 diffusivity in air (D_{wa}/D_{ca}); and the ratios of this to diffusivities for the boundary layer ((D_{wa}/D_{ca})^(2/3)) according to Cowan (1972). The default values for these constants are 1.6 and 1.37 respectively (Figure 1). These constants affect the calculation of the ten new columns only. The constants can be modified from the console in the tab “Constants” option “User:”.

8	UserDefCc	Dwa/Dca	(Dwa/Dca)^(2/3)	
9		1.6	1.37	

Figure 1 Rows with the constants Dwa/Dca and (Dwa/Dca)^(2/3).

The ten new columns include two new constants and eight new calculations (Figure 2). The two constants are total cuticular conductance to water (g_{cw}) and the ratio of cuticular conductance to CO_2 over cuticular conductance to water (Beta: β), with default values of 10 mmol m^{-2} s^{-1} and 0.04 respectively. The calculated new variables are transpiration through the stomatal pores (E_s), transpiration through the cuticle (E_c), mole fraction of water vapour inside the leaf (w_i), mole fraction of vapour water at the surface of the leaf (w_s), recalculation of the stomatal conductance (g_{sw_c}), mole fraction of CO_2 at the surface of the leaf (C_s), mole fraction of CO_2 inside the leaf (C_{i_c}) and air saturation deficit (ASD).

G	H	I	J	K	L	M	N	O	P
UserDefCon	UserDefCon	UserDefVar	UserDefVar	UserDefVar	UserDefVar	UserDefVar	UserDefVar	UserDefVar	UserDefVar
gcw	Beta	Es	Ec	wi	ws	gsw_c	Cs	Ci_c	ASD
mmol m-2 s-1	--	mol m-2 s-1	mol m-2 s-1	mmol mol-1	mmol mol-1	mol m-2 s-1	µmol mol-1	µmol mol-1	kPa

Figure 2 Ten new column in the data log file.

The procedure starts by calculating w_s using information from the LI6800 for total transpiration (E), boundary layer conductance to water (g_{bw}) and mole fraction of vapour water in the chamber (w_a),

$$w_s = \frac{\frac{E}{2g_{bw}}\left(1-\frac{w_a}{2}\right)+w_a}{1+\frac{E}{4g_{bw}}},$$

and w_i is estimated using the values of saturated vapour pressure inside the leaf (SVP_{leaf}) and the atmospheric pressure plus the overpressure within the chamber ($P_a+\Delta P_{ch}$),

$$w_i = \frac{SVP_{leaf}}{P_a + \Delta P_{ch}}.$$

Then, E_c and E_s are calculated as

$$E_c = g_{cw}(w_i - w_s),$$

and

$$E_s = E - E_c.$$

Then C_s is calculated using the assimilation rate (A), the mole fraction of CO_2 in the chamber (C_a), E and g_{bw},

$$C_s = \frac{2\frac{g_{bw}}{\left(D_{wa}/D_{ca}\right)^{2/3}}C_a - A - C_a\frac{E}{2}}{2\frac{g_{bw}}{\left(D_{wa}/D_{ca}\right)^{2/3}}+\frac{E}{2}}.$$

The stomatal conductance to water (g_{sw_c}) and the mole fraction of CO_2 inside the leaf (C_{i_c}) are recalculated as

$$g_{sw\_c} = \frac{E_s - E_s\frac{w_i - w_s}{2}}{w_i - w_s}$$

and

$$C_{i\_c} = \frac{C_s\left(\frac{g_{sw\_c}}{D_{wa}/D_{ca}} + \beta g_{cw} - \frac{E_s}{2}\right) - A}{\frac{g_{sw\_c}}{D_{wa}/D_{ca}} + \beta g_{cw} + \frac{E_s}{2}}.$$

Finally, the calculation of air saturation deficit is calculated as

$$ASD = SVP_{ch} - VP_{ch}.$$

Graphs

After loading the add-on configuration for graphs, the eight graphs (A to H) in the tab “Measurements” will be displayed as follows: Graph A has the assimilation rate (A) and the recalculated stomatal conductance to water (g_{sw_c}) against time; Graph B contains the recalculated CO_2 concentration inside the leaf (C_{i_c}) and total transpiration (E) against time; Graph C has the CO_2 concentration in the reference and sample against time; Graph D has the vapour water concentration in the reference and sample against time (Figure 3); Graph E shows the logged values (obs) of total transpiration (E) and assimilation rate (A); Graph F presents the logged values (obs) of recalculated CO_2 concentration inside the leaf (C_{i_c}) and recalculated stomatal conductance to water (g_{sw_c}); Graph G shows the new and old calculations of CO_2 concentration inside the leaf and stomatal conductance to water against time; Graph H contains the logs of assimilation rate and g_{sw_c} against the recalculated CO_2 concentration inside the leaf (C_{i_c}) (Figure 4).

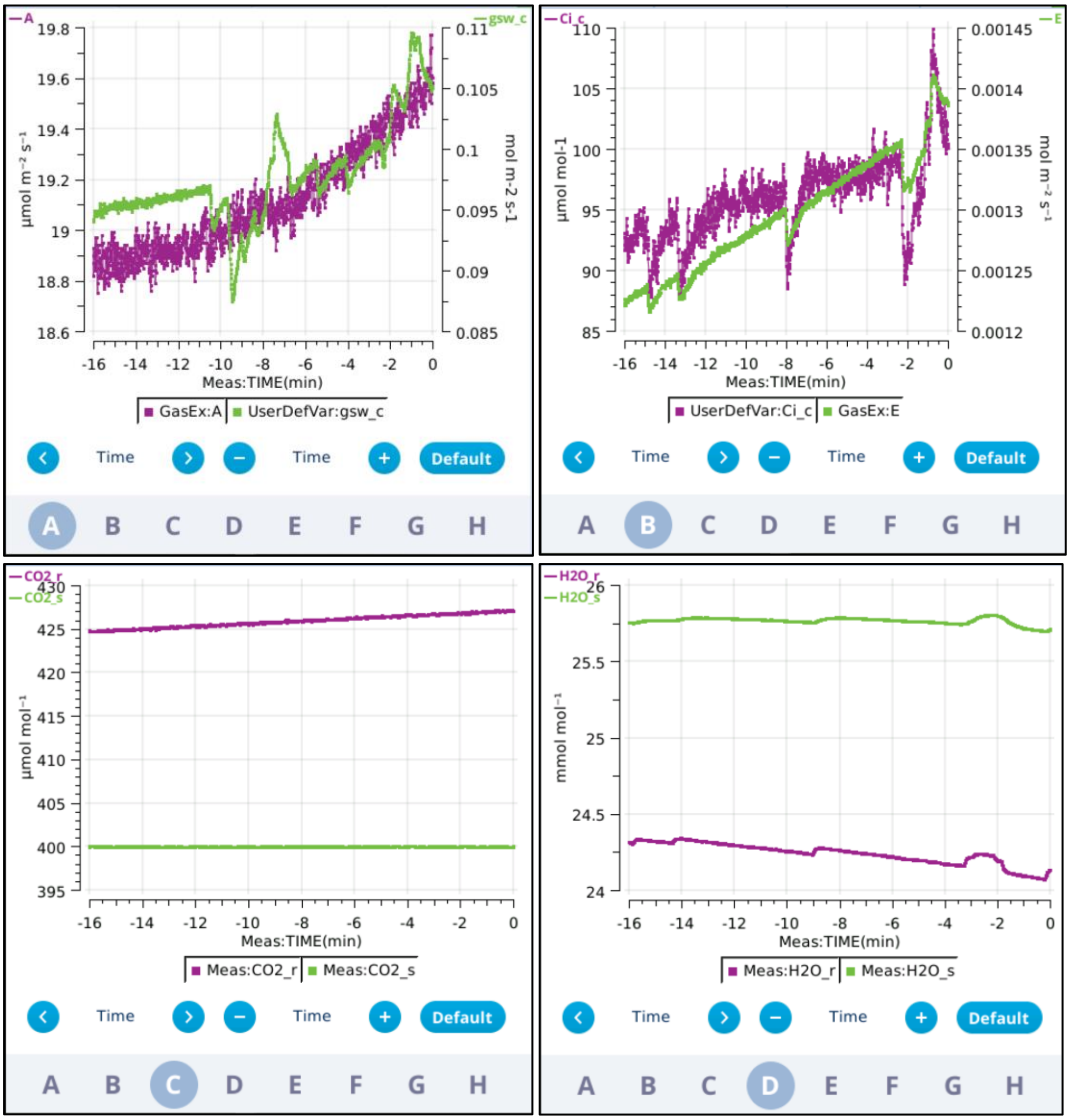

Figure 3 Configuration of the graphs A to D after loading the add-on.

Figure 4 Configuration of the graphs E to H after loading the add-on.

Grids

After loading the add-on configuration for grids, the first five grids in the tab "Measurements" will be displayed as shown in Figure 5.

Figure 5 Configuration of the grids 1 to 5 after loading the add-on.

References

Cowan, I.R. 1972. 'Mass and heat transfer in laminar boundary layers with particular reference to assimilation and transpiration in leaves', *Agricultural Meteorology*, 10: 311-29.

Márquez, D.A., Hilary Stuart-Williams, and G.D. Farquhar. 2021. 'An improved theory for calculating leaf gas exchange more precisely accounting for small fluxes', *Nature Plants*, 7: 317-26.