

Analytical_EngineINTERFACE–A macro for automatically processing data in an Excel application

Excel-based analytical engines have been developed frequently for specific, limited purposes. Analyzing larger data sets or a breadth of conditions can be difficult because of design limitations in the analytical engine. Sometimes altering array operations is not straightforward. More frequently, misguided application of password protection hinders simple modifications or one must use an unaltered version of a published workbook. The workbook MonthETtoEngine.xlsx is an example of an analytical engine for computing ET rates from meteorological data and is password protected (Figure 1).

The screenshot shows the 'MonthETtoEngine.xlsx' workbook. At the top, there are input fields for 'Enter a Year Number' (2006), 'Station Name' (Davis), 'Station Number' (6), 'Latitude' (38.5 deg), and 'Elevation' (18.5 m). To the right, 'albedo = 0.23' and 'BPress = 101.1 de' are displayed. Below these, a yellow banner reads 'Enter data in only one of the columns below' with a 'priority >>' indicator and columns 5, 4, 3, 2, 1. The main data table has columns: Month, PM ETr (mm d⁻¹), HS ETo (mm d⁻¹), PM ETo (mm d⁻¹), Cc (%), nN (0-1), n (<24), R_n (MJ m⁻²d⁻¹), R_s (MJ m⁻²d⁻¹), T_x (°C), T_n (°C), U₂ (m s⁻¹), and T_d (°C). The data rows show values for months 1 through 12. Red dashed boxes highlight the 'Analytical-engine output range' (columns 2-4) and the 'Analytical-engine input range' (columns 8-12).

Month	PM ETr mm d ⁻¹	HS ETo mm d ⁻¹	PM ETo mm d ⁻¹	Cc %	nN 0-1	n <24	R _n MJ m ⁻² d ⁻¹	R _s MJ m ⁻² d ⁻¹	T _x °C	T _n °C	U ₂ m s ⁻¹	T _d °C
1	1.2	1.0	0.8					5.6	10.9	3.1	2.2	4.6
2	1.9	1.6	1.4					8.9	13.7	4.3	2.3	5.6
3	2.9	2.5	2.2					13.6	16.2	5.1	2.3	6.2
4	4.6	3.7	3.4					18.4	19.5	6.7	2.6	5.9
5	5.7	4.6	4.3					21.8	22.5	8.9	2.6	7.9
6	6.9	5.5	5.3					24.6	25.7	10.9	2.6	9.2
7	7.1	5.8	5.4					24.8	28.1	11.7	2.3	10.9
8	8.0	5.8	5.9					24.7	30.9	12.5	2.4	10.9
9	6.8	4.6	4.9					19.9	29.3	11.5	2.3	9.7
10	5.1	3.0	3.5					14.1	25.0	9.1	2.3	7.2
11	2.9	1.6	1.9					8.9	17.5	5.1	2.3	5.0
12	1.6	1.1	1.1					6.2	12.2	2.6	2.6	4.1

Figure 1.— Example of input and output ranges in an analytical engine for computing ET rates

The EngineINTERFACE.v3.xlsm workbook automates the process of analyzing data sets larger than the input of an analytical engine. Larger data sets can be analyzed without modification by analyzing subsets of data and tabling analytical-engine results from these subsets. Automation makes this approach tractable and avoids potential errors from manual execution of this approach. Larger ranges of input data and output results are specified in an auxiliary workbook (Figure 2).

	A	B	C	D	E	F	G	H	I	J	K
1		INPUT						OUTPUT			
2		R_s	T_x	T_n	U_2	T_d		PM ET _r	HS ET _o	PM ET _o	
3		MJ m ⁻² d ⁻¹	°C	°C	m s ⁻¹	°C		mm d ⁻¹	mm d ⁻¹	mm d ⁻¹	
4	2006	6.5	12.7	3.6	2.6	5.4					
5		10.4	16.0	5.0	2.7	6.6					
6		15.9	19.0	6.0	2.7	7.2					
7		21.5	22.8	7.8	3.0	6.9					
8		25.5				9.2					
9		28.8				10.8					
10		29.0				12.7					
11		26.0	32.5	13.2	2.5	11.5					
12		20.9	30.8	12.1	2.4	10.2					
13		14.8	26.3	9.6	2.4	7.6					
14		9.4	18.4	5.4	2.4	5.3					
15		6.5	12.8	2.7	2.7	4.3					
16	2007	6.2	12.1	3.4	2.5	5.1					
17		9.9	15.2	4.8	2.6	6.3					
18		15.1	18.1	5.7	2.6	6.8					
19		20.4	21.7	7.4	2.9	6.6					
20		24.2	25.0	9.9	2.9	8.7					
21		27.4	28.6	12.1	2.9	10.3					
22		27.6	31.3	13.0	2.6	12.1					
23		24.7	30.9	12.5	2.4	10.9					
24		19.9	29.3	11.5	2.3	9.7					
25		14.1	25.0	9.1	2.3	7.2					
26		8.9	17.5	5.1	2.3	5.0					
27		6.2	12.2	2.6	2.6	4.1					
28		5.6	10.9	3.1	2.2	4.6					
29		8.9	13.7	4.3	2.3	5.6					
30		13.6	16.2	5.1	2.3	6.2					
31		18.4	19.5	6.7	2.6	5.9					
32		21.8	22.5	8.9	2.6	7.9					
33		24.6	25.7	10.9	2.6	9.2					
34		24.8	28.1	11.7	2.3	10.9					

Figure 2.— Example of data-source and output-table ranges in an auxiliary workbook that supplies data to the analytical engine and tables computed-ET rates.

The EngineINTERFACE.v3.xlsm workbook consists of a single control on one page that launches the **Specify Ranges** form (Figure 3). The form allows necessary ranges to be specified interactively, activate workbooks, and specify accumulation of results along rows or columns. Usage of the **Specify Ranges** form is annotated and summarized on the single page with the “Process data through engine” button.

EngineINTERFACE.v3.xlsm Workbook

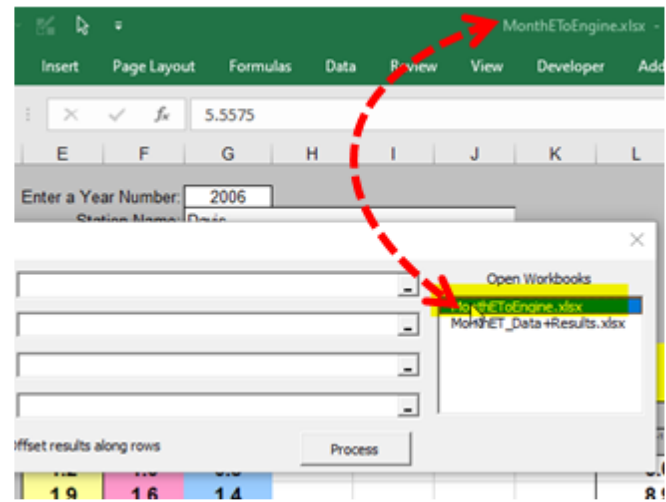
The workbook consists of a single control on one page, M, and most interaction is through the **Specify Ranges** form (Figure 4). The form allows necessary ranges to be specified interactively, activate workbooks, and specify accumulation of results along rows or columns.

Figure 4.—Specify Ranges form for processing data through an analytical engine.



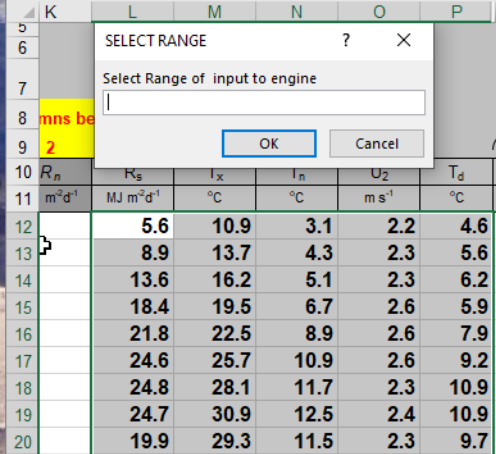
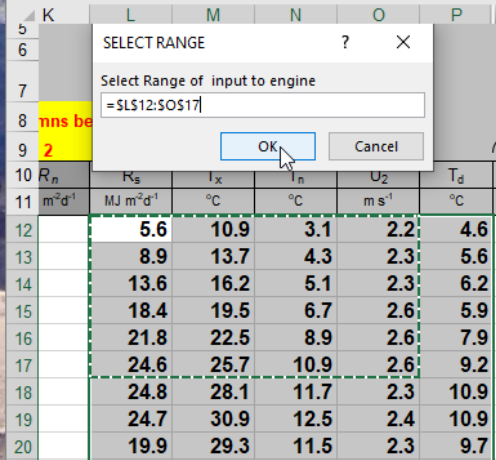
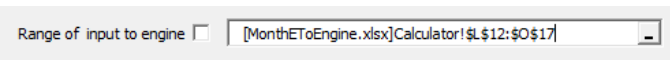
Launch form

Click “Process data through engine” button in upper, left corner to launch form.	
Specify Ranges form will appear and EngineINTERFACE.v3.xlsm Workbook will disappear.	
<p>All open workbooks other than EngineINTERFACE.v3.xlsm are listed on the right side of the form.</p> <p>Double-click on a workbook name to activate a workbook where ranges will be specified.</p> <p>Macro will report error and stop if less than 2 or greater than 6 other workbooks are open.</p>	

Double-clicking another workbook name in the list activates the other workbook.



Range Selection, direct

Range selection controlled with checkbox on left and text input box on right.	
Unchecked example starts, Click drop-down button on right side of text input box.	
Range selection form replaces Specify Ranges form after clicking button.	
<p>Range is specified directly in workbook with mouse.</p> <p>Range L12:O17 was selected.</p>	
Range L12:O17 with workbook and sheet names are added to text input box.	

Range Selection, UPPER, LEFT

Checked example starts,
Click drop-down button on right side
of text input box.

UPPER, LEFT cell of input to engine ☒

WHOLE BLOCK selection

Upper, left cell in range of interest is
specified, cell **L12**.

Selection is extended across columns
to rightmost edge and across rows to
lowermost edges of data block.

	K	L	M	N	O	P
5						
6						
7						
8						
9						
10						
11	R_n	$\text{MJ m}^{-2}\text{d}^{-1}$	T_x	T_n	U_2	T_d
			$^{\circ}\text{C}$	$^{\circ}\text{C}$	m s^{-1}	$^{\circ}\text{C}$
12		5.6	10.9	3.1	2.2	4.6
13		8.9	13.7	4.3	2.3	5.6
14		13.6	16.2	5.1	2.3	6.2
15		18.4	19.5	6.7	2.6	5.9
16		21.8	22.5	8.9	2.6	7.9
17		24.6	25.7	10.9	2.6	9.2
18		24.8	28.1	11.7	2.3	10.9
19		24.7	30.9	12.5	2.4	10.9
20		19.9	29.3	11.5	2.3	9.7
21		14.1	25.0	9.1	2.3	7.2
22		8.9	17.5	5.1	2.3	5.0
23		6.2	12.2	2.6	2.6	4.1

Range **L12:P23** with workbook and
sheet names are added to text input
box.

UPPER, LEFT cell of input to engine ☒

WHOLE COLUMN selection

Select upper, left cell and extend
across rows in column of interest,
range **L12:L16** in this example.

Selection is extended across rows to
lowermost edges of data column.

	K	L	M	N	O	P
7						
8						
9						
10						
11	R_n	$\text{MJ m}^{-2}\text{d}^{-1}$				T_d
						$^{\circ}\text{C}$
12		5.6	10.9	3.1	2.2	4.6
13		8.9	13.7	4.3	2.3	5.6
14		13.6	16.2	5.1	2.3	6.2
15		18.4	19.5	6.7	2.6	5.9
16		21.8	22.5	8.9	2.6	7.9
17		24.6	25.7	10.9	2.6	9.2
18		24.8	28.1	11.7	2.3	10.9
19		24.7	30.9	12.5	2.4	10.9
20		19.9	29.3	11.5	2.3	9.7
21		14.1	25.0	9.1	2.3	7.2
22		8.9	17.5	5.1	2.3	5.0
23		6.2	12.2	2.6	2.6	4.1

Range **L12:L23** with workbook and
sheet names are added to text input
box.

WHOLE ROW selection

Select upper, left cell and extend across columns in row of interest, range **L12:N12** in this example.

Selection is extended across columns to rightmost edge of data row.

The screenshot shows an Excel spreadsheet with a 'SELECT RANGE' dialog box open. The dialog box has a title bar with a question mark and a close button. It contains the text 'Select UPPER, LEFT cell of input to engine' and a formula bar with '= \$L\$12:\$N\$12'. There are 'OK' and 'Cancel' buttons. In the background, a data table is visible with columns L through P and rows 12 through 21. Row 12 is highlighted in yellow, and the range L12:N12 is selected. The table contains numerical data, and the first column (K) contains labels: 'columns', '2', 'R_n', and 'MJ m⁻² d⁻¹'. The last column (P) contains labels: 'T_d' and '°C'.

	L	M	N	O	P
7					
8	columns				
9	2				
10	R _n				
11	MJ m ⁻² d ⁻¹				
12		5.6	10.9	3.1	2.2
13		8.9	13.7	4.3	2.3
14		13.6	16.2	5.1	2.3
15		18.4	19.5	6.7	2.6
16		21.8	22.5	8.9	2.6
17		24.6	25.7	10.9	2.6
18		24.8	28.1	11.7	2.3
19		24.7	30.9	12.5	2.4
20		19.9	29.3	11.5	2.3
21		14.1	25.0	9.1	2.3

Range **L12:P12** with workbook and sheet names are added to text input box.

[MonthEToEngine.xlsx]Calculator!\$L\$12:\$P\$12

Table Analytical-Engine Results

Analytical-engine results are either tabled by rows or columns as specified by the lowermost checkbox on the Specify Ranges form.

☒ Offset results along rows

or

☐ Offset results along columns

Analytical-engine results are tabled by rows and stacked vertically if checked.

Source ☒ "[MonthET_Data+Results.xlsx]IO"!\$B\$5:\$F\$35

Engine ☒ [MonthETtoEngine.xlsx]Calculator!\$L\$12:\$P\$23

Output ☒ [MonthETtoEngine.xlsx]Calculator!\$E\$12:\$G\$23

Table ☒ "[MonthET_Data+Results.xlsx]IO"!\$H\$5

☒ Offset results along rows

Process

2	H	I	J	K	L	M	N	O	P
3	OUTPUT								
4	PM ETr	HS ETo	PM ETo						
5	mm d ²	mm d ²	mm d ²						
6	1.5	1.2	1.0						
7	2.4	1.9	1.7						
8	3.7	2.9	2.7						
9	6.0	4.3	4.4						
10	7.4	5.4	5.5						
11	9.1	6.4	6.8						
12	9.5	6.9	7.1						
13	8.8	6.1	6.5						
14	7.5	4.8	5.3						
15	5.7	3.1	3.8						
16	3.1	1.7	2.1						
17	1.7	1.1	1.1						
18	1.3	1.1	0.9						
19	2.2	1.8	1.6						
20	3.4	2.8	2.5						
21	5.5	4.1	4.0						
22	6.8	5.1	5.1						
23	8.3	6.1	6.2						
24	8.6	6.5	6.5						
25	8.0	5.8	6.0						
26	6.8	4.6	4.9						
27	5.1	3.0	3.5						
28	2.9	1.6	1.9						
29	1.6	1.1	1.1						
30	1.2	1.0	0.8						
31	1.9	1.6	1.4						
32	2.9	2.5	2.2						
33	4.6	3.7	3.4						
34	5.7	4.6	4.3						
35	6.9	5.5	5.3						
36	7.1	5.8	5.4						

Analytical-engine results are tabled by columns and stacked horizontally if unchecked.

Source ☒ "[MonthET_Data+Results.xlsx]IO"!\$B\$5:\$F\$35

Engine ☒ [MonthETtoEngine.xlsx]Calculator!\$L\$12:\$P\$23

Output ☒ [MonthETtoEngine.xlsx]Calculator!\$E\$12:\$G\$23

Table ☒ "[MonthET_Data+Results.xlsx]IO"!\$H\$5

☐ Offset results along columns

Process

1	H	I	J	K	L	M	N	O	P
2	OUTPUT								
3	PM ETr	HS ETo	PM ETo						
4	mm d ²	mm d ²	mm d ²						
5	1.5	1.2	1.0	1.3	1.1	0.9	1.2	1.0	0.8
6	2.4	1.9	1.7	2.2	1.8	1.6	1.9	1.6	1.4
7	3.7	2.9	2.7	3.4	2.8	2.5	2.9	2.5	2.2
8	6.0	4.3	4.4	5.5	4.1	4.0	4.6	3.7	3.4
9	7.4	5.4	5.5	6.8	5.1	5.1	5.7	4.6	4.3
10	9.1	6.4	6.8	8.3	6.1	6.2	6.9	5.5	5.3
11	9.5	6.9	7.1	8.6	6.5	6.5	7.1	5.8	5.4
12	8.8	6.1	6.5	8.0	5.8	6.0			
13	7.5	4.8	5.3	6.8	4.6	4.9			
14	5.7	3.1	3.8	5.1	3.0	3.5			
15	3.1	1.7	2.1	2.9	1.6	1.9			
16	1.7	1.1	1.1	1.6	1.1	1.1			
17									
18									
19									
20									
21									
22									
23									
24									
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