Tutorial of ray tracing software fastTracer

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How to run FastTracer?

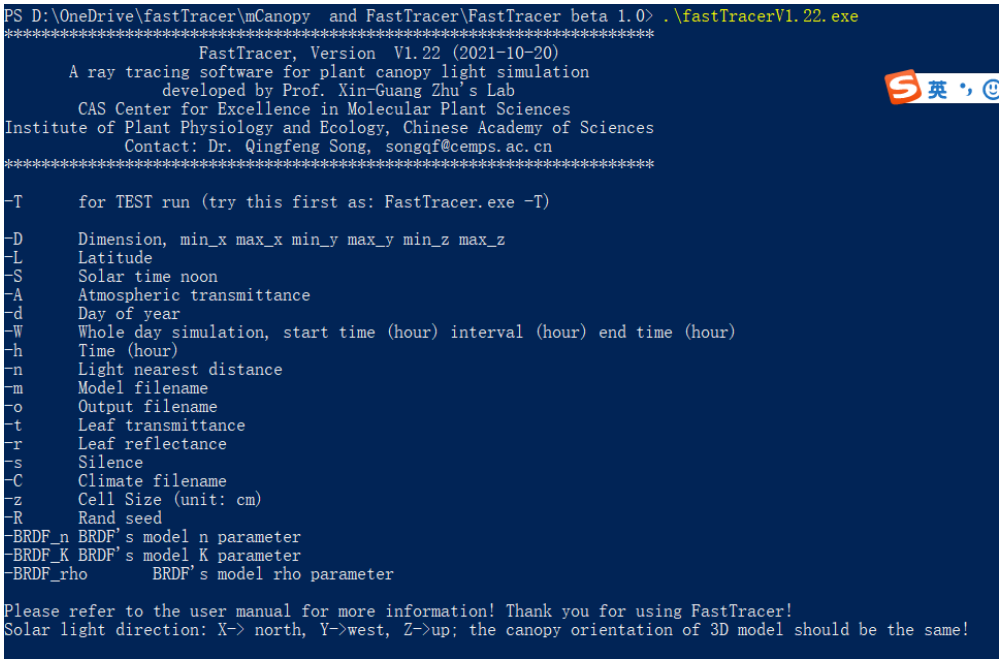
FastTracer is a command line software run on a Windows 8 or Windows 10 platform.

Use PowerShell to run the command lines.

Command line 1：

```
.\fastTracer1.0.exe
```

Run the software with no parameter, it will output the following info:



Command line 2：

```
.\fastTracer1.0.exe -T
```

This is a test run. It will do ray tracing simulation with default parameters and the output file is "outputFile.txt", you can open it or copy the data to Excel.

Command line 3：

```
.\fastTracer1.0.exe -D -10 20 -5 30 0 100 -L 21
```

Run the software with parameter input "-D" followed with 6 values `-10 20 -5 30 0 100`, This means the simulation boundary is that X extension is from -10 to 20， Y extension is from -

5 to 30，Z extension is from 0 to 100.

The parameter of "-L" followed with a value 21, showing that the latitude is set to be 21 degrees.

As above, the user can set any parameter when run the software：

运行命令（4）：

```
.\fastTracer1.0.exe -D -10 20 -5 30 0 100 -L 21 -S 12 -A 0.5 -d 249 -W 7 1 17 -n 0.1 -m modelFile.txt -o outputTESTFile.txt -t 0.075 -r 0.075 -s 1 -C weather2015-246-286.txt
```

Attention! all the parameter settings only work for the current run and are not saved.

Table 1. FastTracer parameter table

Symbol	Name	Value number	Description
-D	Dimension	6	6 values includes minimal X、maximal X、min Y、max Y、min Z and max Z
-L	Latitude	1	Used for calculating the solar ray direction
-S	Solar time noon	1	Used for adjusting the local time
-A	Atmosphere transmittance	1	Use to calculate the ratio of direct light and diffuse light
-d	Day of year	1	Used for calculating the light direction
-W	Whole day simulation	3	3 values are begin time, time interval and end time
-h	Hour	1	Use for one time point simulation. Attention, do not use together with -W
-n	Light nearest distance	1	The distance between rays
-m	Model file	1	3D canopy model, the data format is listed as following.
-o	Output file	1	3D model with PPFD
-t	Leaf transmittance	1	Leaf transmittance
-r	Leaf reflectance	1	Leaf reflectance
-s	Silence	1	0 for printing information to screen. 1 for silence.
-C	Climate file	1	Climate data file, data format is shown in following.

Data format of the 3D Model

Column 1-5 is for IDs. (if no id, use 0)

Column 6-14 is for triangle three points (P1, P2, P3) coordinates, x1,y1,z1,x2,y2,z2,x3,y3,z3, P1(x1,y1,z1), P2(x2,y2,z2) and P3(x3,y3,z3) are the three points for one triangle. Right hand law to present the upper surface of the triangle.

Column 15-17 is for other leaf level traits, 15 is leaf nitrogen content (not used for ray tracing), 16 is the leaf transmittance, 17 is the leaf reflectance. (range: 0-1, eg. 0.05 means 5% transmittance)

Data format of the Output file

Column 1 to 17 is the same as input file. Column 18 is triangle area, 19 and following is PPFD.

Data format of the Climate file

Column 1 is year, 2 is day of the year, 3 is hour, 4 is air temperature (not use for ray tracing), 5 is relative humidity (not use for ray tracing), 6 is total (direct + diffuse) PPFD and 7 is diffuse PPFD.

FastTracer software reference：

- Song Q, Zhang G, Zhu X-G. 2013. Optimal crop canopy architecture to maximise canopy photosynthetic CO_2 uptake under elevated CO_2- a theoretical study using a mechanistic model of canopy photosynthesis. *Functional Plant Biology* 40, 109–124.

FastTracer application reference：

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- Wang Y, Song Q, Jaiswal D, P. de Souza A, Long SP, Zhu X-G. 2017. Development of a three-dimensional ray-tracing model of sugarcane canopy photosynthesis and its application in assessing impacts of varied row spacing. *Bioenergy Research* 10, 626–634.
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