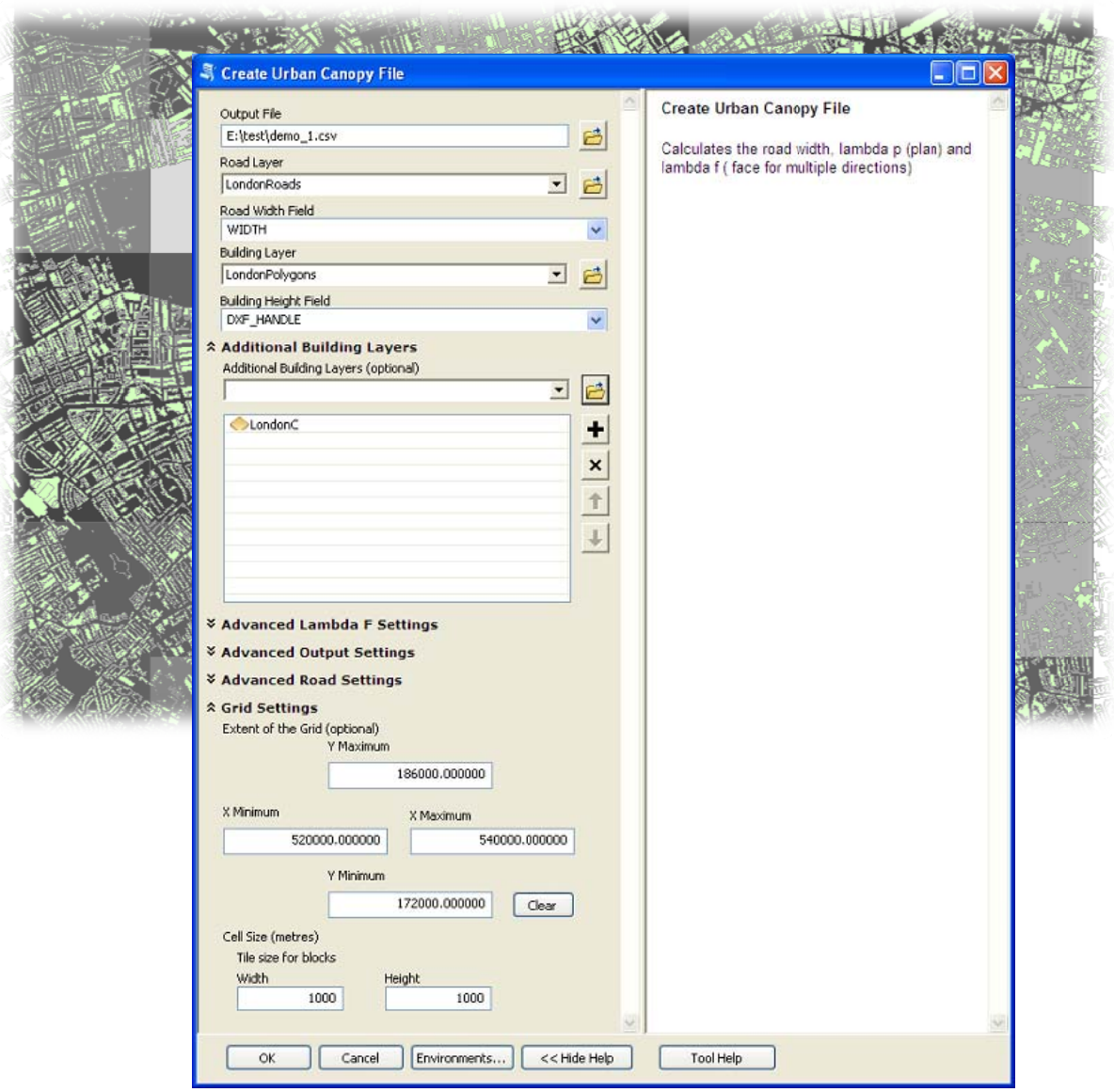
Urban Canopy Tool



User Guide CERC

ADMS

Urban Canopy Tool

User Guide

Version 2.0

June 2014

Cambridge Environmental Research Consultants Ltd.
3, King's Parade
Cambridge
CB2 1SJ
UK

Telephone: +44 (0)1223 357773
Facsimile: +44 (0)1223 357492
Email: help@cerc.co.uk
Website: www.cerc.co.uk

Contents

SECTION 1 Introduction

1.1 About the Urban Canopy Tool

The Urban Canopy Tool creates Urban Canopy files for use with the ADMS-Urban Urban Canopy flow module. The Urban Canopy Tool runs inside ArcGIS and uses building and road datasets to calculate the Urban Canopy values.

1.2 Features

The Urban Canopy Tool can be used to:

- Calculate average road widths in grid cells
- Calculate average building heights in grid cells
- Calculate λ_{P0} values (a measure of building coverage at ground level) in grid cells
- Calculate λ_F values (a measure of building fascias for multiple directions) in grid cells
- Generate input files for the ADMS-Urban Urban Canopy flow module
- View urban canopy results graphically

1.3 Requirements

The Urban Canopy Tool requires the following:

- A copy of ESRI ArcGIS (Version 10.1 or later)

1.4 About this user guide

This *Urban Canopy Tool User Guide* is a manual describing how to use the Urban Canopy Tool.

To make this manual simpler to use, certain conventions have been followed with regard to layout and style.

- Urban Canopy Tool interface controls are shown in Arial font, e.g. click on Generate Report.
- Keyboard inputs are shown in **bold**, e.g. press **Enter**.
- Directory and file names are shown in *italics*, e.g. **.nc*.
- Table and figure references are shown in **bold**, e.g. see **Figure 3.1**

SECTION 2 Using the Urban Canopy Tool

2.1 Installing the Urban Canopy Tool

To install the Urban Canopy Tool, copy the contents of the install directory to a directory with full privileges on your machine. From the Start menu, open ArcCatalog. Open the ArcToolbox window (on the toolbar), right-click on the ArcToolbox window (see **Figure 1**) and select Add Toolbox...

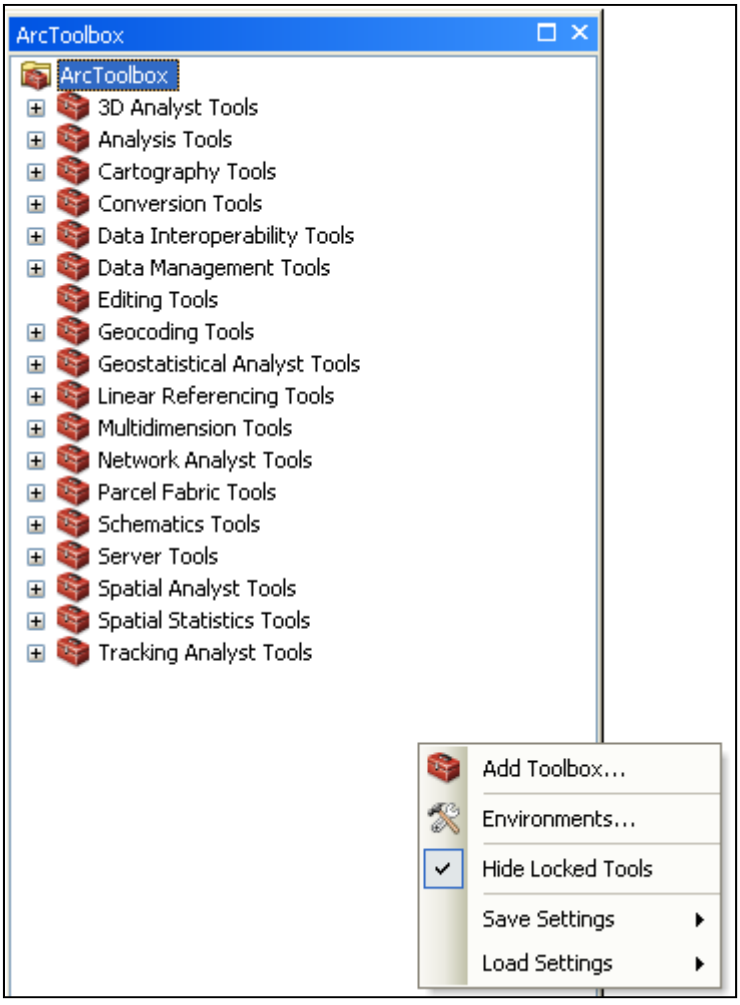


Figure 1 - The ArcToolbox

Navigate to the folder containing the Urban Canopy files and select UrbanCanopy.pyt. The Urban Canopy Tools toolbox should now appear in the ArcToolbox in ArcCatalog and also in ArcMap, as shown in **Figure 2** below. The toolbox contains one tool, Create Urban Canopy File.

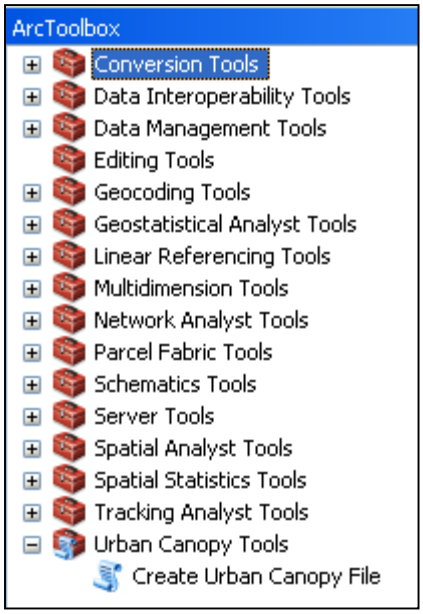


Figure 2 - The Urban Canopy Tools toolbox

2.2 Running the Urban Canopy Tool

Once the Urban Canopy toolbox has been added to the ArcGIS' ArcToolbox window (refer to Section 2.1 Installing the Urban Canopy Tool), the Urban Canopy Tool can be used by clicking on the Urban Canopy Tools toolbox to reveal the individual tools, and clicking on the Create Urban Canopy File tool.

The user is advised (though not required) to load the required roads and building shapefiles into ArcGIS before running the tool. The input layers must be shapefiles, not (for example) geodatabase layers. All input shapefiles must be in the same coordinate system. This must be a projected coordinate system with units of metres.

Also the input layers must not have been created from ArcGIS's "Make Feature Layer" tool with the "Use Ratio Policy" option.

2.3 Create Urban Canopy File Tool

The main screen, shown in **Figure 3**, appears on starting the processor. Each of the features and buttons are described below.

In the Create Urban Canopy File main screen, click on Show Help >> *to display information relating to each input.*

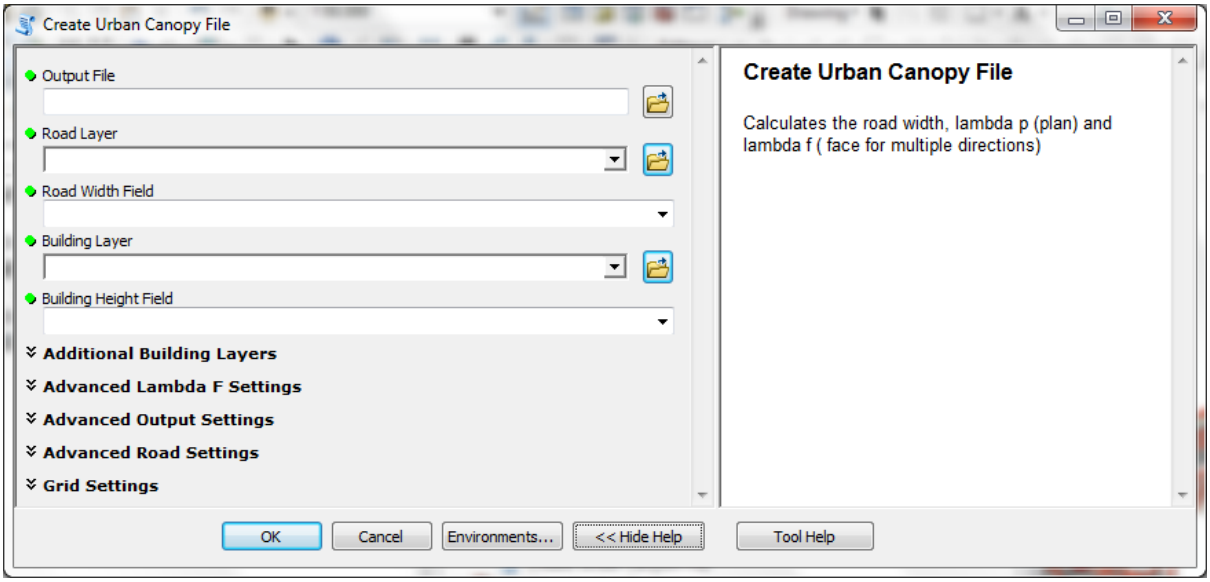


Figure 3 – The main screen

2.3.1 Output File

The Output File is the location and name for the Urban Canopy *.csv* file created by this process. The path can be set by clicking Browse , navigating to the required directory, typing the filename in the File name textbox and clicking Save.

2.3.2 Road Layer

The Road Layer is the shapefile containing the road geometry and the road width information for each road feature. The road layer can be selected by using the dropdown, if the layer is already loaded in ArcGIS, or the Browse button to navigate to and select the shapefile.

The Road Layer shapefile must use a coordinate system with units of metres.

2.3.3 Road Width Field

The Road Width field is the field in the Road Layer that stores the road width information for each road feature. The road width should be stored in metres.

Note: If using Urban Canyon canyon width data rather than actual road width data, this field should be 'c_width_l'.

2.3.4 Building Layer

The Building Layer is the shapefile containing the building geometry and building height information for each building feature. The building layer can be selected by using the dropdown, if the layer is already loaded in ArcGIS, or by using the Browse button to navigate to and select the shapefile.

The Primary Building Layer shapefile must use a coordinate system with units of metres.

2.3.5 Building Height Field

The Building Height field is the field in the Building Layer that stores the building height information for each road feature. The Building Height should be the height above ground level and should be in metres.

2.3.6 Additional Building Layers

The Additional Building Layers section enables users to provide extra building layers. Additional building layers may be required if the building data is provided in tiles, or if there are multiple layers for different building types.

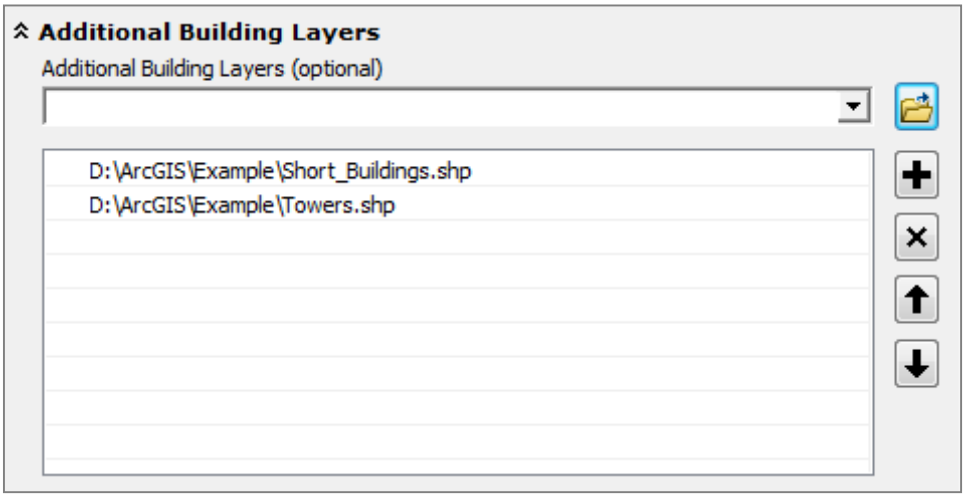


Figure 4 - The Additional Building Layers section

2.3.6.1 Additional Building Layers

Additional building layers can be selected by using the dropdown, if the layers are already loaded in ArcGIS, or by using the Browse button to navigate to and select the shapefile. Layers can be removed from the list by using the button to the right of the list.

The Additional Building Layers shapefile(s) must be in the same coordinate system as the main Building Layer (refer to Section 2.3.4) and must have the same name for the Building Height field.

2.3.7 Advanced Lambda F Settings

The Advanced Lambda F Settings section enables users to specify additional sectors for λ_F (LambdaF) calculations. By default, λ_F will be calculated for 0 degrees (sector: 315 to 45 degrees), 90 degrees (sector: 45 to 135 degrees), 180 degrees (sector: 135 to 225 degrees) and 270 degrees (225 to 315 degrees). The angles are measured clockwise from North (the positive y-axis direction).

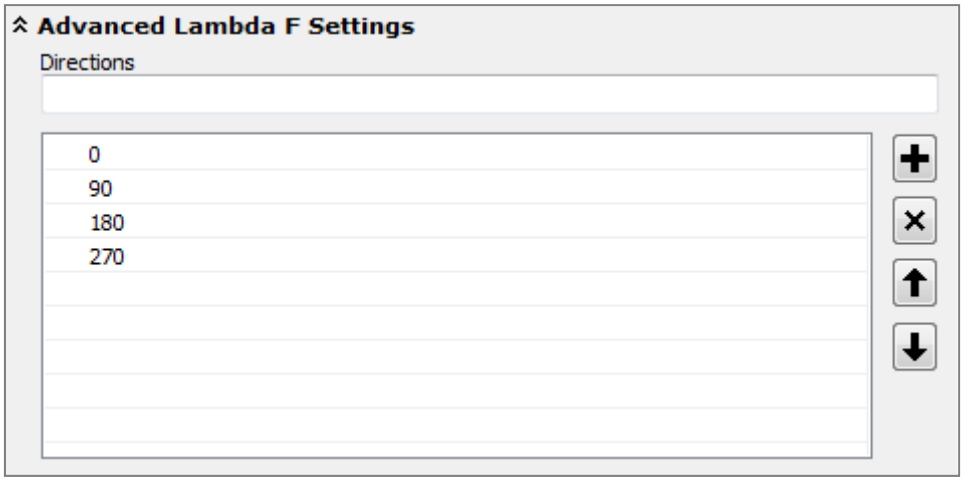


Figure 5 - The Advanced Lambda F Settings section

2.3.7.1 Directions

The user can add to the list of directions by typing the angle in degrees (from 0 to 359) and pressing the button. To remove a direction the user can select the direction from the list and press the button. In the Urban Canopy File the directions will be in order of increasing angles.

The direction defines the central angle of each sector. The directions must be whole numbers.

2.3.8 Advanced Output Settings

The Advanced Output Settings section provides the option to view the output in additional formats, as well as the Urban Canopy file.

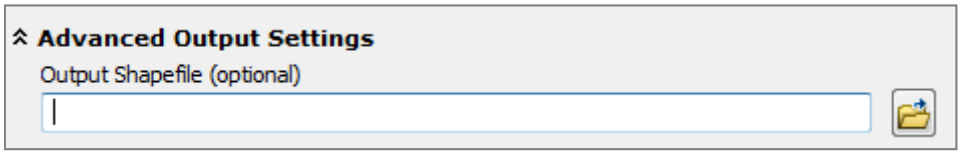


Figure 6 - The Advanced Output Settings section

2.3.8.1 Output Shapefile

The user can select the location and name for a shapefile to view the output data on the map. To choose this option, click Browse , navigate to the required directory, type the required filename in the File name textbox and click Save. The shapefile will be automatically added to the current map when the process ends.

2.3.9 Advanced Road Settings

The Advanced Road Settings section provides the ability to use road width data for each side of the carriageway, such as the results of the Street Canyon Tool calculations.

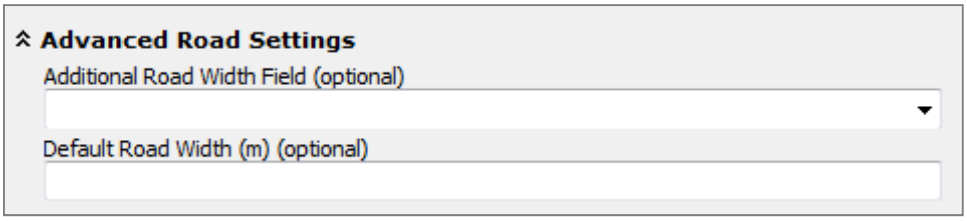


Figure 7 - The Advanced Road Settings section

The Urban Canopy canyon widths provide the widths from the road centreline to the buildings on each side of the road, not the width of the carriageway itself.

2.3.9.1 Additional Road Width Field

To use this field, the Road Width parameter (refer to Section 2.3.3) should be the field containing the width of the carriageway left of the road centreline, and this parameter should be the field containing the width right of the road centreline.

If using Urban Canopy canyon widths, the additional road width field should be named 'c_width_r'.

2.3.9.2 Default Road Width

For datasets that may include roads with unknown widths, this setting can be used to specify a default width for those roads.

2.3.10 Grid Settings

The Grid Settings section allows the user to define the extents of the output grid and the size of each grid cell.

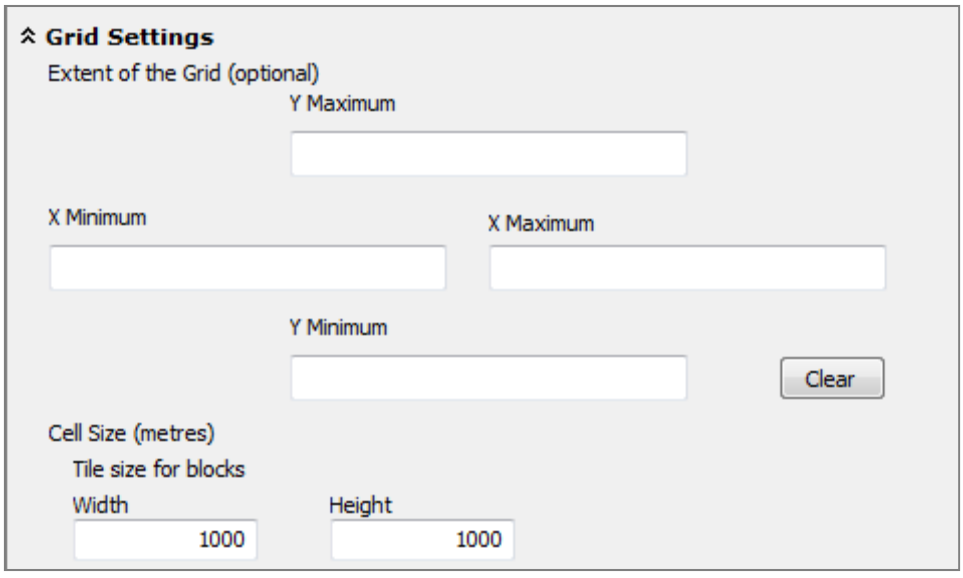


Figure 8 – The Grid Settings section

2.3.10.1 Extent of the Grid

By default the extent is derived from the extents of the Road Layer, with limiting coordinates rounded to start at a suitable location, e.g. a grid with 1000 x 1000 m cells will default to start on a (xxx000, yyy000) origin.

Pressing Clear will revert the extent back to the extent of the Road Layer.

2.3.10.2 Cell Size

By default the results will be for 1 x 1 km squares, but using this setting the user can define different cell sizes. The values are in metres.

2.3.11 Running the Tool

Clicking OK will run the tool. The ArcMap window will display scrolling text at the bottom right, indicating that the tool is running.

2.4 Monitoring Progress

In ArcMap, under the Geoprocessing menu, open the Results window. The top entry in the Current Session will be the tool in progress. The Inputs menu gives details of the tool inputs selected. The Messages menu displays progress messages from the tool. It is possible to cancel the tool run, by right-clicking on the tool in progress and clicking Cancel.

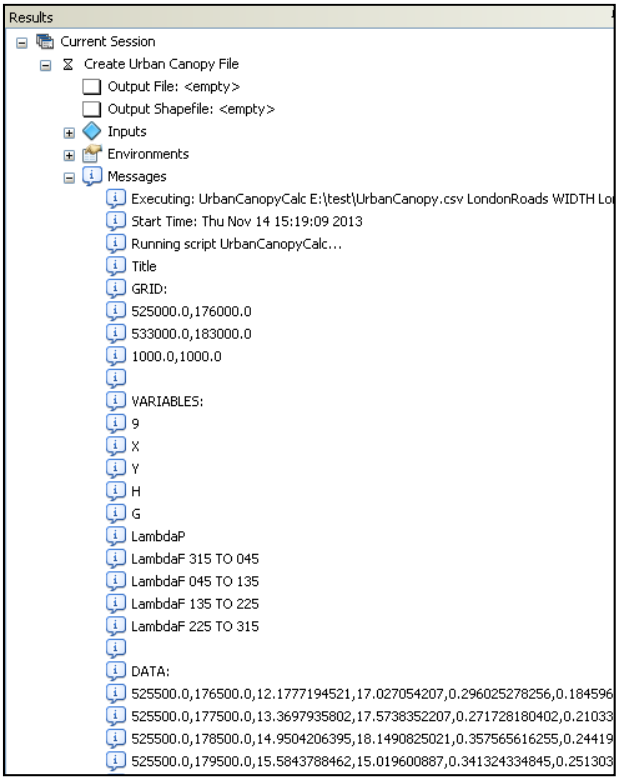


Figure 9 – The Results window in ArcGIS Geoprocessing

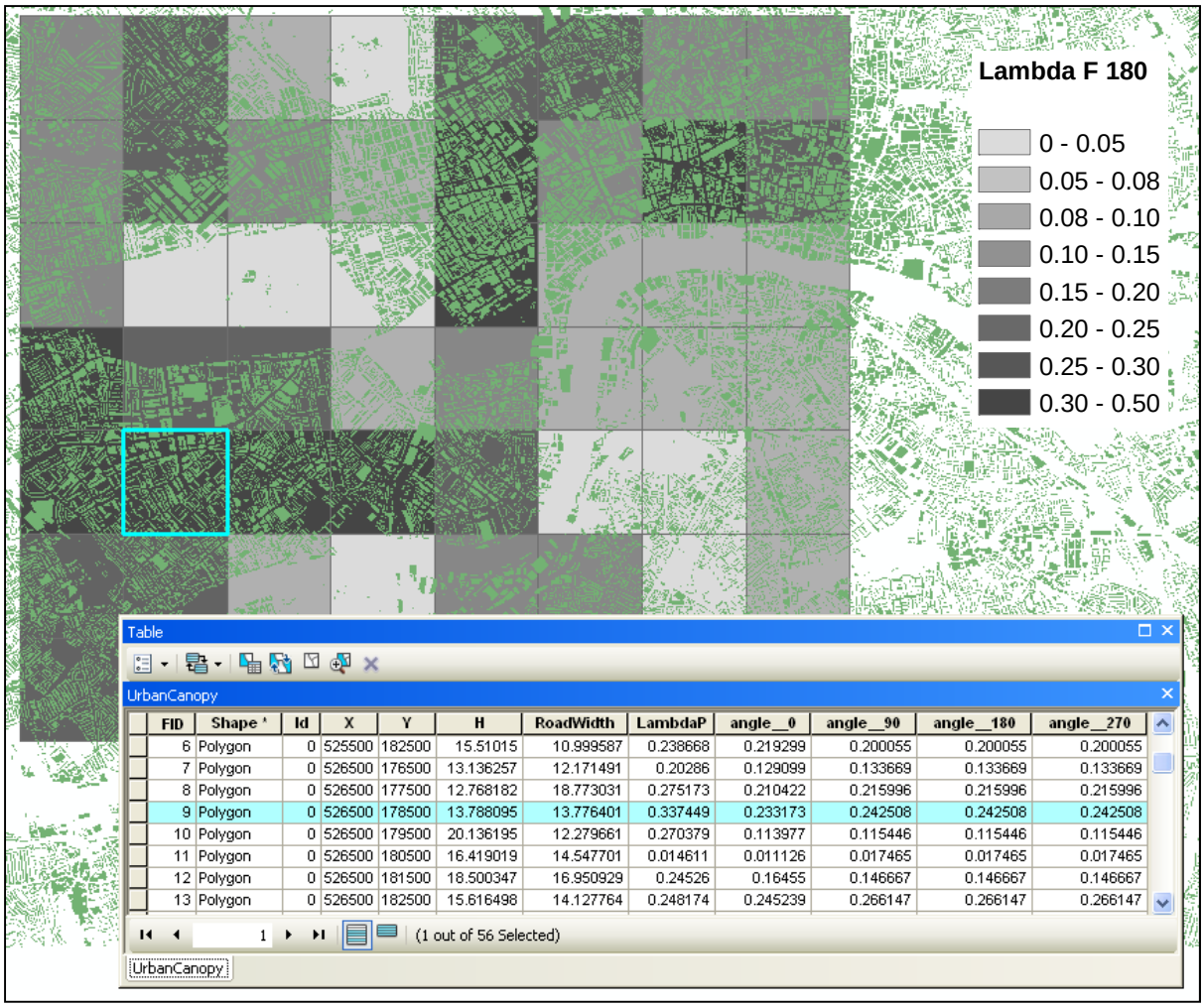
2.5 Viewing the results

The results will be available in the *.csv* file selected in Output File.

	A	B	C	D	E	F	G	H	I
1	Title								
2	GRID:								
3	525000	176000							
4	533000	183000							
5	1000	1000							
6									
7	VARIABLES:								
8	9								
9	X								
10	Y								
11	H								
12	G								
13	LambdaP								
14	LambdaF 315 TO 045								
15	LambdaF 045 TO 135								
16	LambdaF 135 TO 225								
17	LambdaF 225 TO 315								
18									
19	DATA:								
20	525500	176500	12.17772	17.02705	0.296025	0.184596	0.205603	0.205603	0.205603
21	525500	177500	13.36979	17.57384	0.271728	0.210335	0.203093	0.203093	0.203093
22	525500	178500	14.95042	18.14908	0.357566	0.244193	0.233208	0.233208	0.233208
23	525500	179500	15.58438	15.0196	0.341324	0.251304	0.246332	0.246332	0.246332
24	525500	180500	15.29726	15.95154	0.238549	0.161516	0.204986	0.204986	0.204986
25	525500	181500	14.58357	17.76585	0.217493	0.162846	0.172254	0.172254	0.172254
26	525500	182500	15.51015	10.99959	0.238668	0.219299	0.200055	0.200055	0.200055
27	526500	176500	13.13626	12.17149	0.20286	0.129099	0.133669	0.133669	0.133669
28	526500	177500	12.76818	18.77303	0.275173	0.210422	0.215996	0.215996	0.215996
29	526500	178500	13.78809	13.7764	0.337449	0.233173	0.242508	0.242508	0.242508
30	526500	179500	20.13619	12.27966	0.270379	0.113977	0.115446	0.115446	0.115446
31	526500	180500	16.41902	14.5477	0.014611	0.011126	0.017465	0.017465	0.017465
32	526500	181500	18.50035	16.95093	0.24526	0.16455	0.146667	0.146667	0.146667

Figure 10 - Example Urban Canopy file viewed in Microsoft Excel

If the Advanced Output Settings option was selected, the results will be added to the current map in order to display the results. The results can also be viewed in tabular format by using the resulting layer's Open Attribute Table.



FID	Shape *	Id	X	Y	H	RoadWidth	LambdaP	angle__0	angle__90	angle__180	angle__270
6	Polygon	0	525500	182500	15.51015	10.999587	0.238668	0.219299	0.200055	0.200055	0.200055
7	Polygon	0	526500	176500	13.136257	12.171491	0.20286	0.129099	0.133669	0.133669	0.133669
8	Polygon	0	526500	177500	12.768182	18.773031	0.275173	0.210422	0.215996	0.215996	0.215996
9	Polygon	0	526500	178500	13.788095	13.776401	0.337449	0.233173	0.242508	0.242508	0.242508
10	Polygon	0	526500	179500	20.136195	12.279661	0.270379	0.113977	0.115446	0.115446	0.115446
11	Polygon	0	526500	180500	16.419019	14.547701	0.014611	0.011126	0.017465	0.017465	0.017465
12	Polygon	0	526500	181500	18.500347	16.950929	0.24526	0.16455	0.146667	0.146667	0.146667
13	Polygon	0	526500	182500	15.616498	14.127764	0.248174	0.245239	0.266147	0.266147	0.266147

Figure 11 - Example shapefile output

SECTION 3 Technical Summary

This section provides a technical summary of the Urban Canopy Tool. The inputs to the tool are described in Section 2.3 of this User Guide. The tool generates a **.csv* format file that can be used directly with the Urban Canopy flow module in ADMS-Urban. The file contains all of the required headers, together with averaged building parameter data, on a rectangular grid. A shape file can also be output from the tool, containing the same information, which can be viewed spatially in GIS software.

3.1 Characterisation of the urban area

In the ADMS-Urban Urban Canopy module, the urban velocity and turbulence profiles are defined based on surface roughness and displacement height. These parameters are calculated from two parameters, which characterise the urban area:

$$\lambda_P = \frac{\text{Building plan area}}{\text{Total lot area}}$$

and

$$\lambda_F = \frac{\text{Building frontal area}}{\text{Total lot area}}.$$

3.2 The Urban Canopy flow module data

The following neighbourhood-scale parameters are required by the ADMS-Urban Urban Canopy flow module, as described in **Table 1**.

Variable name in **.csv* file	Variable name in shapefile	Units	Description
X, Y	X, Y	m	Coordinates of a point in each grid cell of averaged data
H	H	m	The average height of the buildings in each grid cell. The average is weighted by plan area, so buildings with a larger plan area will have a larger influence on the average.
G	RoadWidth	m	The average road width in each grid cell
LambdaP	LambdaP	-	The ratio of horizontal area in the grid cell taken up by buildings to the total area, λ_P
LambdaF <*angle range*>	angle__ <*centre angle*>	-	The ratio of the cross-wind vertical area of buildings to the total area of the grid cell, for binned wind directions, λ_F

Table 1 – ADMS-Urban Urban Canopy module input parameters, which are output by the Urban Canopy Tool

3.3 Defining the Grid

Starting at the south-west corner (minimum *x* and *y* coordinates), the Urban Canopy Tool determines the first neighbourhood point at half the Cell Size in each direction from this corner. A rectangular grid is then defined at the Cell Size(s) defined by the user, up to the eastward and northward extents defined by the user. Each of the neighbourhood parameters is then determined by the model for each cell.

3.4 Calculating Road Width Averages

Within each cell, all of the road features in the Road Layer are identified. The average or neighbourhood-scale road width for the cell is calculated as the average value of the widths of all road features within that cell, weighted by the length of each road feature. If a road does not have width data included in the feature, the Default Road Width is used. If no road feature occurs within the cell, then the value of the road width, G, is set to 0. Where canyon widths are given, as values of the width from the centreline to the left and right of the road in two parts, these values are combined for each road feature before averaging.

3.5 Calculating Lambda Values

3.5.1 LambdaP

Within each cell, all of the building features in the Buildings Layer are identified. The value λ_P is calculated as the ratio of the horizontal area in the neighbourhood taken up by building features to the total area, calculated from the Cell Size.

3.5.2 LambdaF

Within each cell, all of the building features in the Buildings Layer are identified. The calculations are performed for each of the Directions provided by the user, which ADMS-Urban uses as the centre of a bin of wind directions. The vertical area for each building, for each Direction, is calculated from the product of the cross-wind extent of the building and its height. Buildings without a positive height are ignored.

When two or more buildings or buildings of varying height are found in the same location, the height and length of each part of the building(s) is apportioned into multiple segments. If one building feature completely contains a higher building, the tool assumes the overlapping feature represents part of one continuous building and that the actual height above ground level at each point is the maximum height (not the sum). The approach is illustrated in **Figure 12**.

Adjoining (touching) buildings are counted separately for λ_F, not merged. The tool does not treat internal building faces, it only takes into account the widest points of a building perpendicular to the wind direction. The tool does not support buildings data in which multiple buildings overlap without one building completely containing another.

The value of λ_F is then determined from the sum of the building vertical areas, divided by the total area of the cell, giving the ratio of the cross-wind vertical area to cell size.

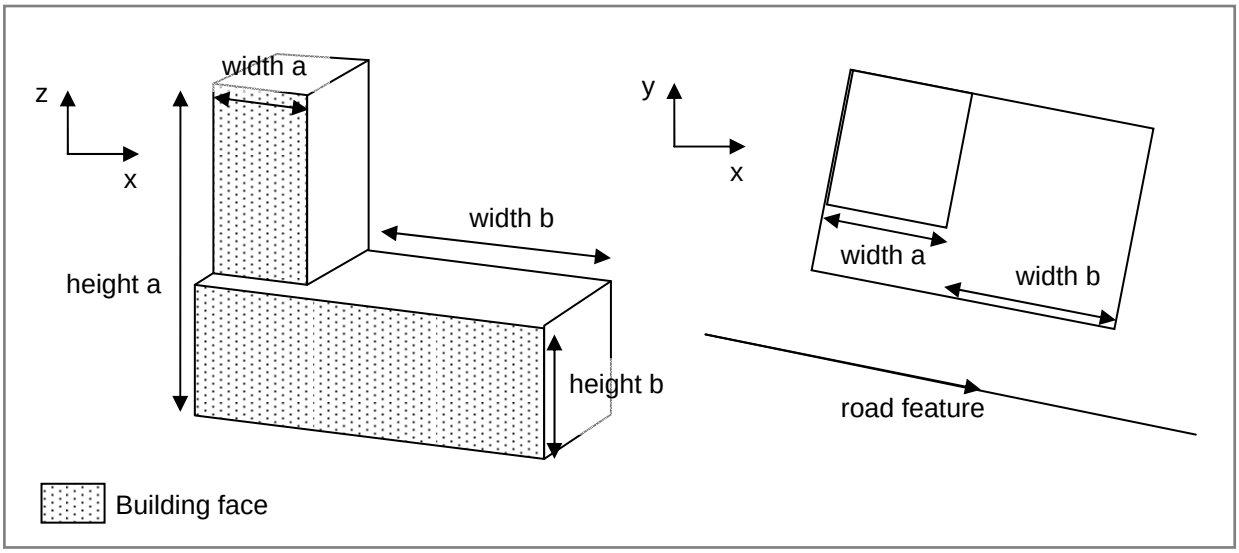


Figure 12 – Illustration of the approach taken with varying building height

CERC

Cambridge Environmental Research Consultants Ltd
3 King's Parade, Cambridge, CB2 1SJ, UK
Tel: +44 (0)1223 357 773, Fax: +44 (0)1223 357 492
Email: help@cerc.co.uk
Website: www.cerc.co.uk