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Appendix

Computation of Spatially Varying Morphometric Parameters

The approach to be followed consists in dividing the raster grey scale image representing the urban DEM into a grid and then performing a morphometric analysis on each grid cell of dimension Δx and Δy. We recall that for an urban area of horizontal dimensions s_x and s_y, the scale factor is $\beta = s_x/p_x = s_y/p_y$ m/pixel, where p_x and p_y are the image dimensions in pixels.

As mentioned, the grid itself can be either regular or irregular and can be constituted of either rectangular or square grid cells. Consider for example a regular grid of m-rows and n-columns. In this case, the user only has to specify the grid steps Δx and Δy (in length units). Consequently, the quantity ($\beta^{-1}\Delta x$ x $\beta^{-1}\Delta y$) will represent the number of matrix elements contained in each grid cell, namely a sub-matrix M_{ij}, with i = 1, 2 ,.., m and j = 1, 2,.., n. The total number of sub-matrices (i.e. grid cells) is of course m x n. To extrapolate the m x n sub-matrices, the algorithm simply creates the following m x 2 matrix B and n x 2 matrix C:

$$\mathrm{B} = (1 + (i-1)\beta^{-1}\Delta y \ , \ \ i\beta^{-1}\Delta y)_{i=1,\dots,m} \tag{A.1}$$

$$\mathrm{C} = (1 + (j-1)\beta^{-1}\Delta x \ , \ \ j\beta^{-1}\Delta x)_{i=1,\dots,n} \tag{A.2}$$

Here, for a given i and j , the couple of elements (B_{i1}, B_{i2}) specifies the range of rows in the image matrix to be retained in the sub-matrix output M_{ij}, while (C_{j1}, C_{j2}) specifies the correspondent range of columns. At this point, the algorithm computes the morphometric parameters for each sub-matrix, M_{ij}, by implementing the standard morphometric analysis discussed previously.

Note that the procedure is the same for the case of irregular grid, the only difference being that Δx and Δy will be user-defined vectors (rather than scalars). An example of this case was given in Section 3 (Test 3).

Vectors B and C used to extrapolate the sub-matrices M_{ij} for Test2 and Test 3 are reported in **Table A1** and **Table A2**, respectively. Results of the morphometric analysis carried out on each sub-matrix for both tests are also given (**Tables A3-A4**).

Table A1. Vectors B and C used to extrapolate the sub-matrices M_{ij} for Test2. For instance, given i=1 and j=4, the sub-matrix M_{14} is identified by (B_{11}, B_{12}) = (1, 2605) and (C_{41}, C_{42}) = (1353, 1950) and corresponds to an area of dimensions $\Delta x = \beta$ [(1950-1353)pixels] ≈ 239 m and Δy =1050 m.

I	(B_{i1}, B_{i2})	*J*	(C_{j1}, C_{j2})
1	(1, 2605)	1	(1, 416)
2			(417, 1015)
3			(1016, 1352)
4			(1353, 1950)
5			(1951, 2222)
6			(2223, 2528)
7			(2529, 2777)
8			(2777, 3126)

Table A2. Same as Table 2 but for Test3.

I	(B_{i1}, B_{i2})	*J*	(C_{j1}, C_{j2})
1	(1, 624)	1	(1, 416)
2	(625, 1308)	2	(417, 1015)
3	(1309, 2175)	3	(1016, 1352)
4	(2176, 2605)	4	(1353, 1950)
		5	(1951, 2222)
		6	(2223, 2528)
		7	(2529, 2777)
		8	(2777, 3126)

Table A3. Results of the morphometric analysis obtained for Test2.

Mij	$\overline{H}$ (m)	λ_p	λ_f (θ)	z_d (m)	z_0 (m)
M_{11}	19	0.14	0.03	6	0.27
M_{12}	15	0.22	0.02	6	0.06
M_{13}	37	0.36	0.17	23	1.5
M_{14}	34	0.32	0.27	20	2.79
M_{15}	24	0.34	0.22	15	1.39
M_{16}	22	0.25	0.14	11	1.45
M_{17}	8	0.16	0.04	3	0.19
M_{18}	16	0.05	0.01	2	0.02

Table A4. Results of the morphometric analysis obtained for Test3.

Mij	$\overline{H}$ (m)	λ_p	$\lambda_f(\theta)$	z_d (m)	z_0 (m)
M_{11}	0	0.00	0.00	0	0.00
M_{21}	6	0.12	0.02	2	0.04
M_{31}	25	0.3	0.07	14	0.47
M_{41}	5	0.05	0.01	1	<0.01
M_{12}	11	0.05	0.03	1	0.29
M_{22}	9	0	0	0.07	<0.01
M_{32}	17	0.52	0.04	13	0.01
M_{42}	6	0.21	0.01	3	<0.01
M_{13}	20	0.48	0.21	15	0.42
M_{23}	17	0.21	0.07	7	0.55
M_{33}	67	0.42	0.28	46	3.14
M_{43}	10	0.29	0.07	6	0.18
M_{14}	16	0.17	0.07	6	0.70
M_{24}	45	0.36	0.45	28	4.21
M_{34}	41	0.42	0.40	28	2.52
M_{44}	7	0.24	0.03	3	0.04
M_{15}	6	0.13	0.04	2	0.16
M_{25}	29	0.48	0.38	22	1.22
M_{35}	27	0.45	0.3	20	1.08
M_{45}	6	0.18	0.02	2	0.02
M_{16}	8	0.19	0.04	3	0.13
M_{26}	17	0.43	0.2	12	0.52
M_{36}	47	0.19	0.24	19	6.46
M_{46}	6	0.16	0.02	2	0.02
M_{17}	6	0.04	0.01	1	0.007
M_{27}	8	0.12	0.04	2	0.18
M_{37}	9	0.28	0.09	5	0.29
M_{47}	5	0.14	0.01	2	<0.01
M_{18}	0	0.00	0.00	0	0.00
M_{28}	36	0.06	0.02	5	0.22
M_{38}	8	0.06	0.01	1	0.02
M_{48}	5	0.10	0.01	1	<0.01