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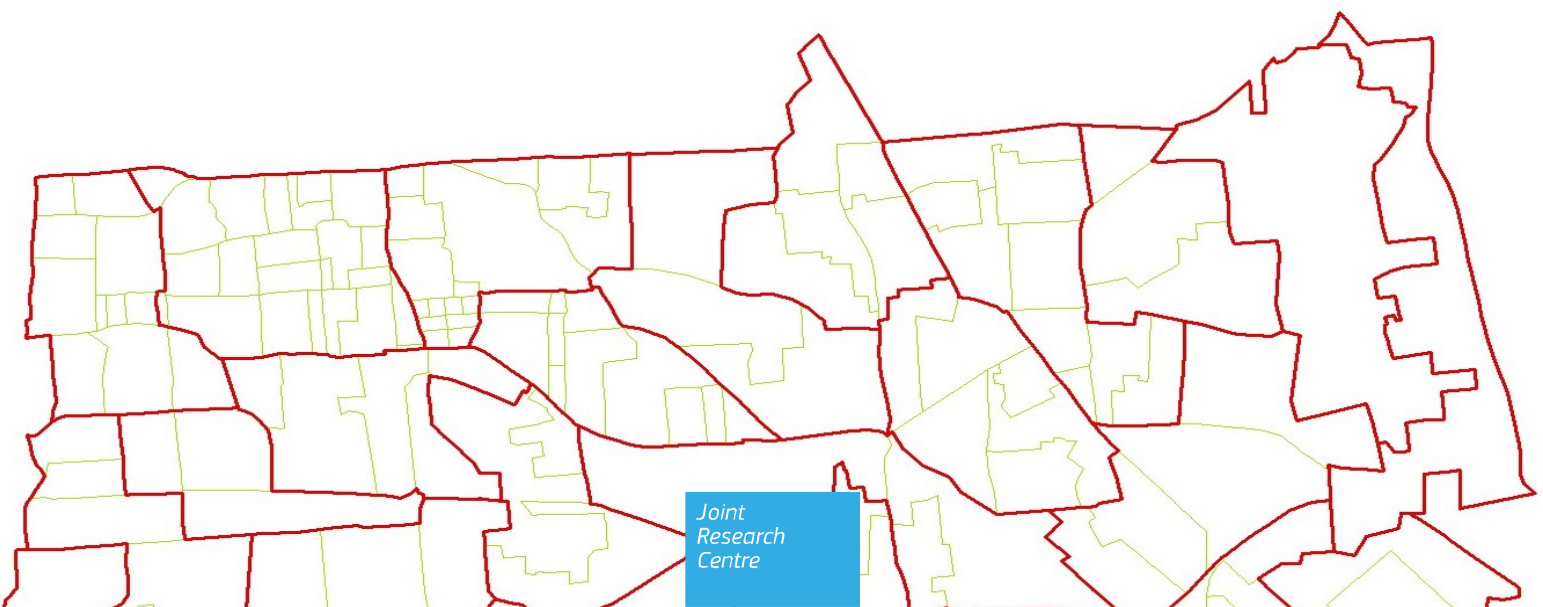
JRC SCIENTIFIC INFORMATION SYSTEMS AND DATABASES REPORT

GHS-SmartDissolve User Guide

*Documentation
Version 2*

Schiavina, M.; Melchiorri, M.; Freire, S.

2020



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JRC122055

PDF	ISBN 978-92-76-22750-2	doi:10.2760/572177
Print	ISBN 978-92-76-22749-6	doi:10.2760/610544

Luxembourg: Publications Office of the European Union, 2020

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How to cite this report: Schiavina, M.; Melchiorri, M.; Freire, S., *GHS-SmartDissolve User Guide*, Publications Office of the European Union, Luxembourg: 2020, ISBN 978-92-76-22750-2, doi:10.2760/572177, JRC122055.

Contents

Authors..... 2

Abstract..... 3

1 Introduction..... 4

2 Installation..... 5

 2.1 System requirements..... 5

 2.2 Installation procedure..... 5

 2.2.1 Install GHS-SmartDissolve ArcGIS toolbox (with internet access)..... 5

 2.2.1.1 Install GHS-SmartDissolve ArcGIS toolbox (with limited internet access)..... 8

 2.2.1.2 Remove GHS-SmartDissolve ArcGIS toolbox..... 8

3 The toolbox user interface..... 9

 3.1 Run the toolbox..... 12

4 Standalone executable..... 14

 4.1 Syntax for GHS-SmartDissolve command line tool..... 14

5 Input and Output..... 17

 5.1 Input..... 17

 5.2 Output..... 17

6 Conclusion..... 18

References..... 19

List of boxes..... 20

List of figures..... 21

List of tables..... 22

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Abstract

The GHS-SmartDissolve Tool– version 2 is an information system developed in the framework of the Global Human Settlement Layer (GHSL) to conduct smart and flexible aggregation of adjacent and complex polygons storing quantitative data.

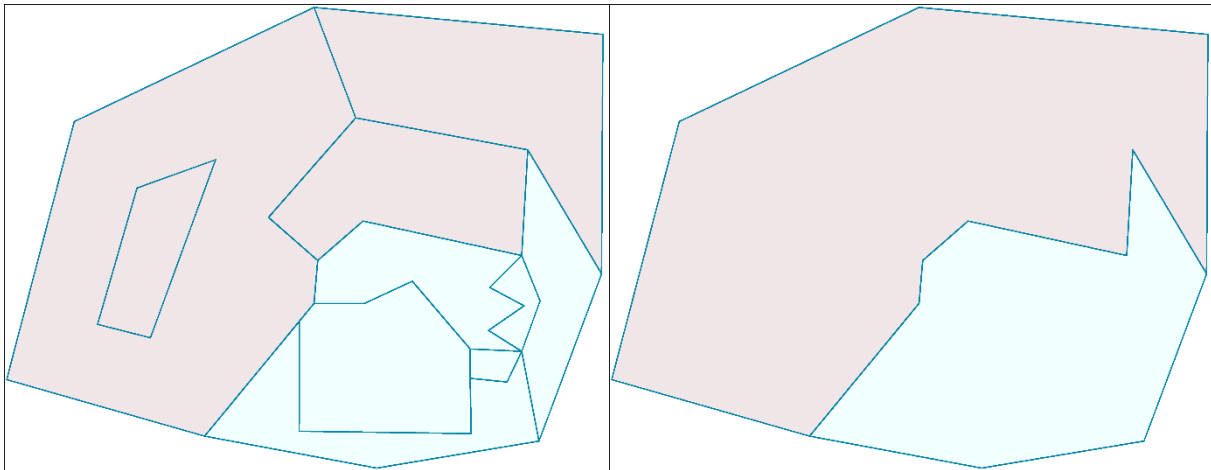
GHS-SmartDissolve is a tool that handles minimum mapping unit, resolution mismatch between layers, or spatial uncertainty problems in GIS. This tool automatically dissolves polygons below a threshold area or a threshold attribute value, updating fields' values to meet a minimum target area or a minimum attribute value. This flexible framework allows to select the ordering of polygon analysis, different dissolve rules, and different field updating operations. The GHS-SmartDissolve is available as toolbox for ArcGIS 10.X.

This document contains the description of the GHS-SmartDissolve Tool use, with details and description of the different settings and output. The GHS-SmartDissolve, as all GHSL Tools, is issued with an end-user licence agreement, included in the download package.

1 Introduction

The 'dissolve' spatial operation is one of the most common and useful procedures applied in Geographic Information Systems (GIS) (Davis 2001). In available dissolve tools, the aggregation is based on polygons sharing the same category or code (i.e. boundaries are removed between adjacent polygons that have the same value for a specified attribute, Figure 1).

Figure 1 Dissolve spatial operation. Two groups of polygons sharing a common attribute (reds and blues) are dissolved and interior geometry is removed



However, many spatial analyses require more flexible and sophisticated options enabling aggregation of adjacent polygons storing quantitative data, such as reaching defined target areas (surface) or attribute values thresholds (e.g. minimum population values), while correctly treating multi-part features and accurately handling variables of dissolved polygons.

The GHS-SmarDissolve is a tool developed to meet such requirements (Schiavina and Freire 2017): it handles minimum mapping unit, resolution mismatch between layers, minimum field value unit or spatial uncertainty problems in GISc.

The tool works with two alternative objectives:

- Minimum area
- Minimum attribute value (for count attribute fields)

By targeting a minimum area the algorithm dissolves all polygons below the threshold with adjacent polygons until the minimum surface requirement is met (or there are no other adjacent polygons); by targeting a minimum attribute value the algorithm dissolves all polygons having a lower attribute value with adjacent polygons – summing the field values –until the minimum attribute value is reached (or there are no other adjacent polygons).

The tool can follow different options based on:

- ordering of the polygon analysis and processing (i.e. from the smallest to the largest attribute value or area, vice versa; order of IDs; or selecting seeds);
- dissolve rules for selecting adjacent polygon to be dissolved with (i.e. smallest or largest attribute value or area; least or most dense attribute value; maximum-border-share, minimum total perimeter or maximum resulting compactness);
- field updating operations (i.e. sum, min, max, mean, or standard deviation for count fields; text concatenation for string field; last or first for any type of fields).

The algorithm correctly processes multi-part polygons and polygons with intersections (with some limitations, no common perimeter can be calculated, see section 5).

The tool is developed using MATLAB and is available as a toolbox for ArcGIS software (Esri) and as Windows command line executable.

2 Installation

2.1 System requirements

The “GHS-SmartDissolve” is graphical tool developed in MATLAB and created as ArcGIS software (Esri) toolbox. It has been developed in ArcGIS 10.6 environment and tested for back compatibility in ArcGIS 10.3. The main algorithm runs through a MATLAB compiled code, therefore the MATLAB Runtime is required. Its system requirements are listed below (Table 1). It is possible to run the MATLAB compiled executable as a standalone command line tool (see section 4).

Table 1 System requirements

Requirements	Operating system	Processor	RAM	Disk space
Minimum	Windows 7	Any Intel or AMD x86-64 processor	4 GB	90 Mb (+ 700 Mb for Matlab Runtime)
Recommended	Windows 10	Any Intel or AMD x86-64 processor	8 GB	90 Mb (+ 700 Mb for Matlab Runtime)

2.2 Installation procedure

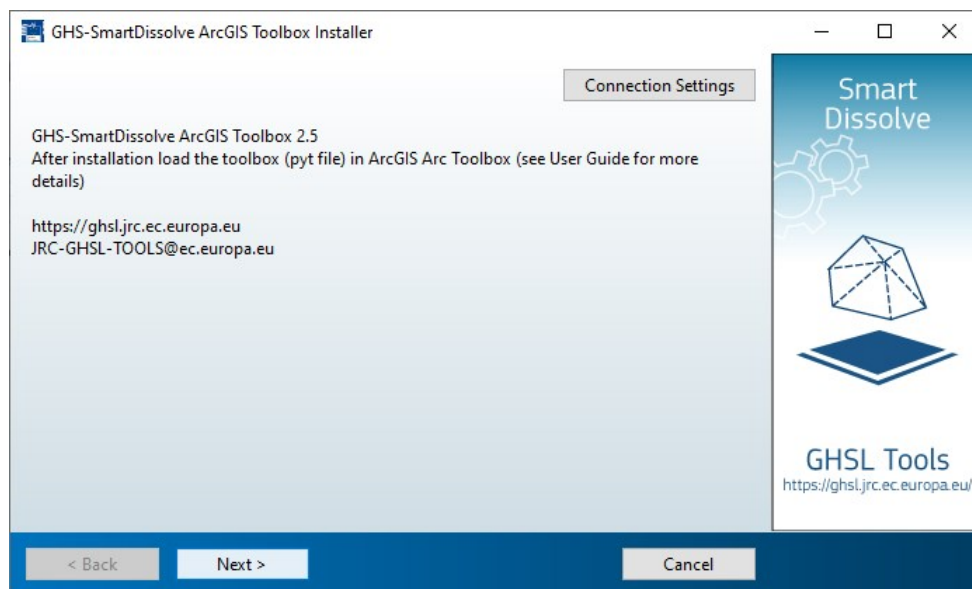
2.2.1 Install GHS-SmartDissolve ArcGIS toolbox (with internet access)

Download the online installer of GHS SmartDissolve ArcGIS toolbox from the GHSL website (Tools section):

<https://ghsl.jrc.ec.europa.eu/tools.php>

Run the installer executable (it requires Administrator rights).

Figure 2 Windows installer



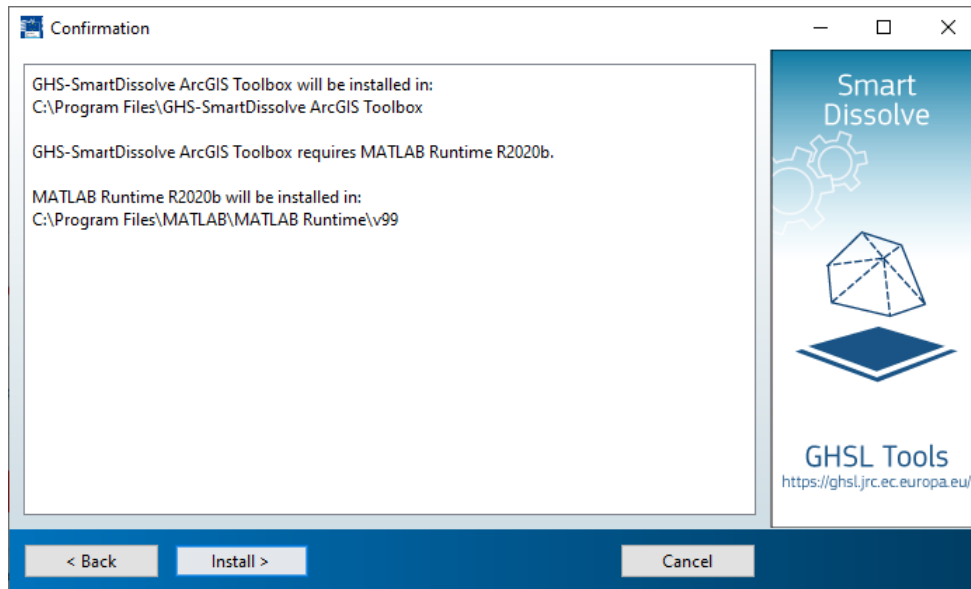
In case of failure of the installation process, due to connection issues, we suggest to proceed following the offline installation procedure (see section 2.2.1.1).

If needed, the installer will also automatically download MATLAB Runtime from MathWorks® website during application installation.

If needed, set your connection settings (i.e. proxy setup) using the specific button and click “next”. In the following steps choose where to store the tool itself and the MATLAB Runtime libraries.

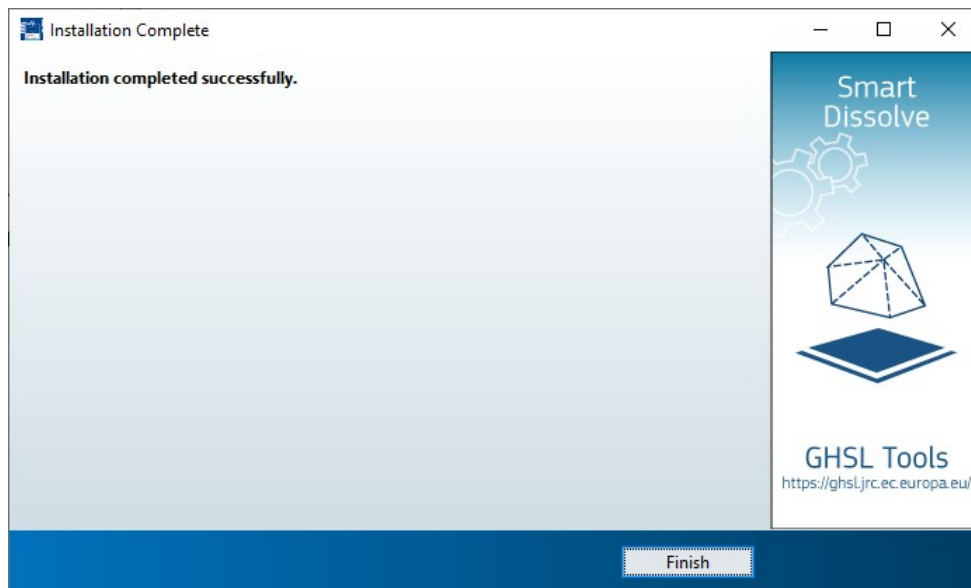
Default values can be used, as shown in the following screenshot:

Figure 3 Default installation values



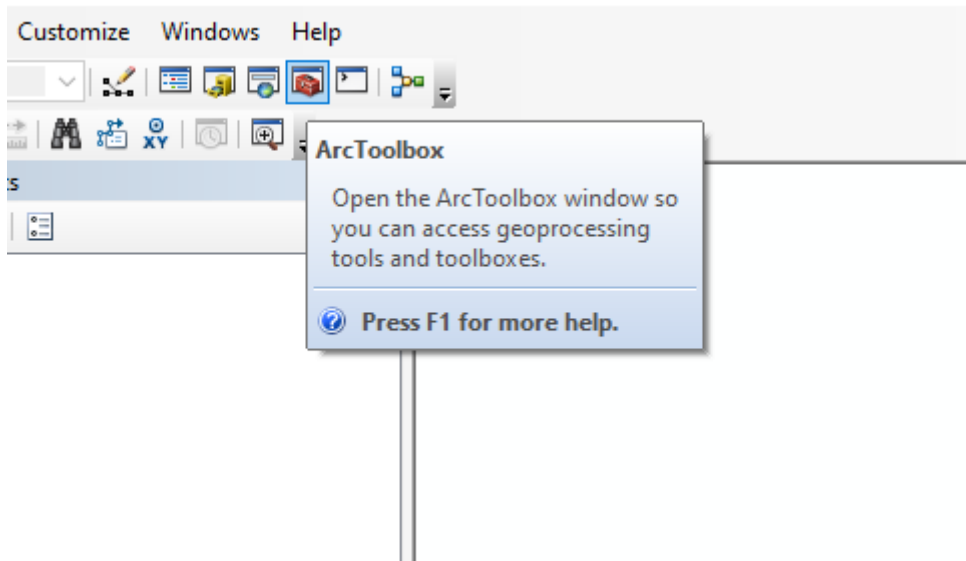
Once started, the installer downloads all needed files and libraries and shows the following message after successful installation.

Figure 4 Installation Complete



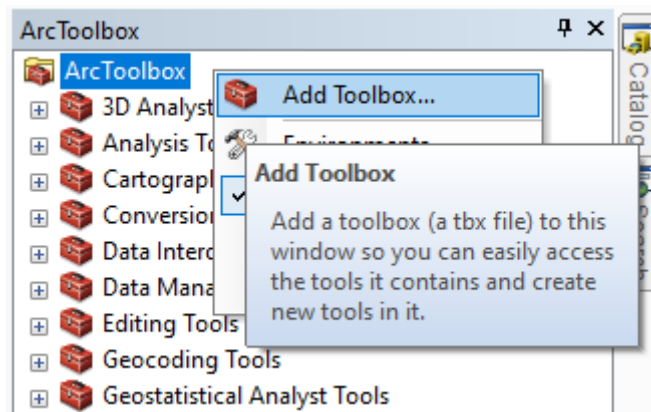
After installation open ArcGIS and from the Tools panel open the ArcToolbox window:

Figure 5 Show ArcToolbox window



From the ArcToolbox window right click, press Add Toolbox

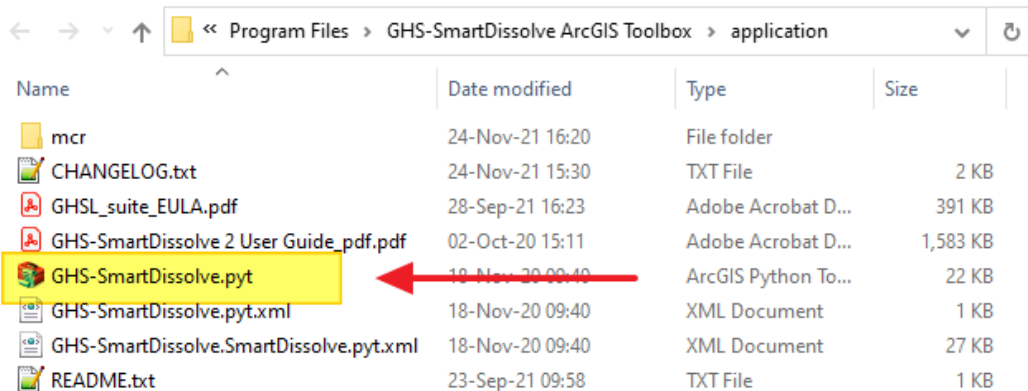
Figure 6 Add toolbox to ArcGIS



Then and select the GHS-SmartDissolve.pyt file; by default it will be available in the Windows Start menu and at the path:

C:\Program Files\GHS-SmartDissolve ArcGIS Toolbox\application

Figure 7 The toolbox pyt file to import in ArcGIS



Once added the toolbox will be listed under GHS Tools section.

2.2.1.1 Install GHS-SmartDissolve ArcGIS toolbox (with limited internet access)

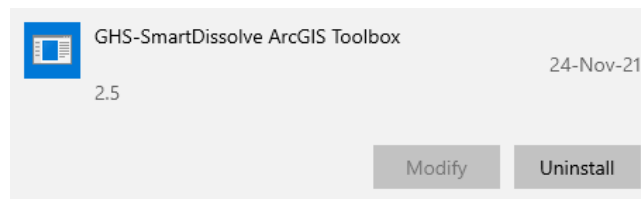
The tool can be installed also when no Internet access or limited access (i.e. firewall or proxy limitations) is available by downloading the offline installer version from the GHSL website (Tools section).

This solution is provided to overcome potential issues during the connection to MathWorks® repositories. This zip includes MATLAB Runtime within the installer so that it can be installed without connecting to the MathWorks® website.

2.2.1.2 Remove GHS-SmartDissolve ArcGIS toolbox

To uninstall GHS-SmartDissolve navigate to “settings -> Apps” and uninstall from there:

Figure 8 Uninstall ArcGIS toolbox from Windows Settings



MATLAB Runtime can also be uninstalled in the same way if not necessary for other applications.

3 The toolbox user interface

The toolbox user interface (Figure 9) has 15 editable items disposed in a logical order described in Table 2. The user should start to fill them from top to bottom, but that's not mandatory.

Figure 9 ArcGIS toolbox window

The screenshot shows the GHS-SmartDissolve toolbox window with the following configuration:

- Input Features:** [Empty field]
- Output Feature:** [Empty field]
- Target:** Area
- Order Rule:** ID
- Threshold Area:** 1 Square Meters
- Target Field:** [Empty field]
- Threshold Value:** 1
- Seeds Field:** [Empty field]
- Seeds Values (optional):** [Empty field]
- Seeds Table:**

Seeds	Threshold Value	Unit (only for Area Target)
- Dissolve Rule:** MinValue
- Update Fields (optional):** [Empty field]
- Field Table:**

Field	Statistic Type
- Target Upper Bound (Percentage of Threshold Value or Area) (optional):** [Empty field]
- Bound Adjacency Field (optional):** [Empty field]
- Minimum Perimeter Share (Percentage) (optional):** [Empty field]
- Multicore (optional):**

Buttons at the bottom: OK, Cancel, Environments..., Show Help >>

Table 2 Toolbox items description

Item	Description		
Input Features	Select and load the polygon Feature layer to dissolve (shp or gdb)		
Output Feature	Select the Output Feature layer (shp or gdb)		
Target	Specify Target Typology	<i>Area</i>	Target a minimum area threshold
		<i>Field</i>	Target a minimum attribute value threshold
Order Rule	Select the order of polygon analysis and processing	<i>ID</i>	Follow IDs order
		<i>MinMax</i>	From minimum area/attribute value to maximum
		<i>MaxMin</i>	From maximum area/attribute value to minimum
		<i>Seeds</i>	Select specific polygons as seeds for the dissolve procedure. Only these polygons will be analysed and processed to meet the area/attribute requirement.
Threshold Area	Set the minimum area requirement Disabled when "Target" is set to <i>Field</i> or when "Order Rule" is set to <i>Seeds</i>		
Target Field	Select the attribute field to be used as target Disabled when "Target" is set to <i>Area</i> or when "Order Rule" is set to <i>Seeds</i>		
Threshold Value	Set the minimum attribute value requirement Disabled when "Target" is set to <i>Area</i> or when "Order Rule" is set to <i>Seeds</i>		
Seeds Field	Select the attribute field to be used as id for seeds polygons Disabled when "Order Rule" is not set to <i>Seeds</i>		
Seeds Values	Specify seeds polygons and their specific thresholds	Seeds	Field values of selected polygons as seeds
		Threshold Value	Set the minimum area/attribute value requirement for each seed
		Unit	Set the unit of measure for area thresholds Only when "Target" is set to <i>Area</i>
Dissolve Rule	Select the dissolve rule to prioritize adjacent polygons	<i>MinValue</i>	Minimum area/attribute value
		<i>MaxValue</i>	Maximum area/attribute value
		<i>MinDensity</i>	Minimum density of attribute value Only when "Target" is set to <i>Field</i>
		<i>MaxDensity</i>	Maximum density of attribute value Only when "Target" is set to <i>Field</i>
		<i>MaxBorder</i>	Maximum shared border length
		<i>MinPerimeter</i>	Minimum dissolved perimeter
		<i>MaxCompactness</i>	Maximum dissolved compactness (Area/Perimeter)

Update Fields	Specify the fields to be updated during dissolve and the statistics to be applied	Field	Field names to be updated	
		Statistic Type	<i>Sum</i>	Calculate the sum of count values
			<i>Min</i>	Keep minimum count value
			<i>Max</i>	Keep maximum count value
			<i>St Dev</i>	Calculate the standard deviation of all count values
			<i>Mean</i>	Calculate the average count value
			<i>Concatenate</i>	Concatenate all values as string
			<i>First</i>	Keep first value
<i>Last</i>	Keep last value			
Target Upper Bound	Percentage of area/attribute value not to be exceeded during dissolve e.g. Threshold = 200; Target Upper Bound = 20; Adjacent polygons resulting in a total area/attribute value > 240 are excluded			
Bound Adjacency Field	Select field to bound adjacency only in groups of polygons sharing the same value for the given field			
Minimum Perimeter Share	Minimum percentage of shared border for both polygons i.e. two adjacent polygons must have the minimum perimeter share with each other to be dissolved			
Multicore	Use all available machine cores. By default is deactivated (single core).			

3.1 Run the toolbox

Before running the toolbox all required inputs and parameters must be filled. The toolbox performs internal checks to ensure the values are correct. In case of doubt, the help section contains a short description about each field.

Figure 10 Toolbox setup with all inputs and parameters

The screenshot shows the GHS-SmartDissolve toolbox window with the following settings:

- Input Features:** Poly_sample
- Output Feature:** c:\Poly_sample_SD.shp
- Target:** Field
- Order Rule:** MinMax
- Threshold Area:** 1 Square Meters
- Target Field:** P1
- Threshold Value:** 500
- Seeds Field:** SEZ2011
- Seeds Values (optional):** (empty)
- Seeds Table:**

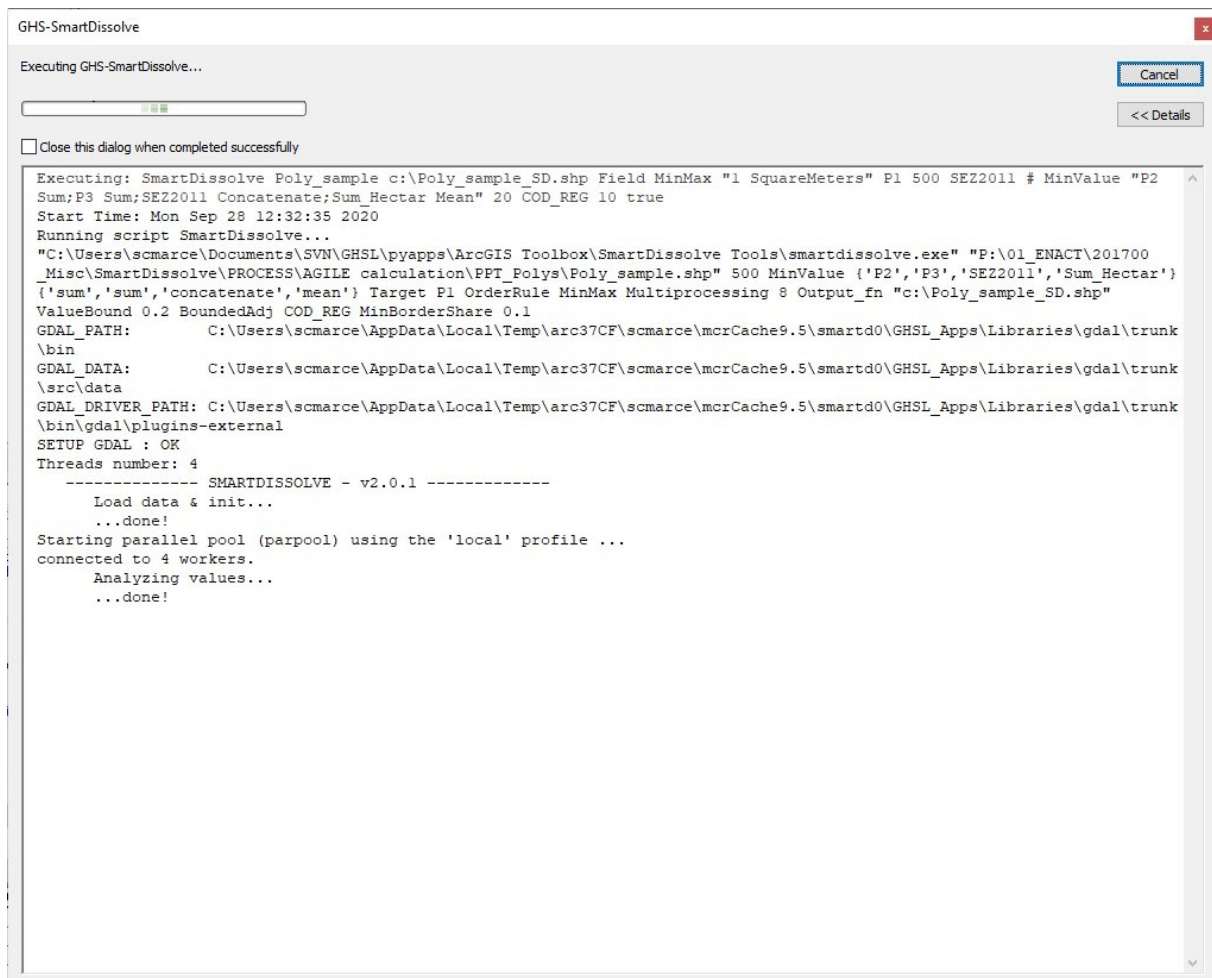
Seeds	Threshold Value	Unit (only for Area Target)
- Dissolve Rule:** MinValue
- Update Fields (optional):** (empty)
- Field and Statistic Type Table:**

Field	Statistic Type
P2	Sum
P3	Sum
SEZ2011	Concatenate
Sum_Hectar	Mean
- Target Upper Bound (Percentage of Threshold Value or Area) (optional):** 20
- Bound Adjacency Field (optional):** COD_REG
- Minimum Perimeter Share (Percentage) (optional):** 10
- Multicore (optional):**

Buttons at the bottom: OK, Cancel, Environments..., Show Help >>

If no error messages appear while selecting the input data and the parameters, the user can hit OK and start the computation. The user can follow the run progress by checking the computation logs.

Figure 11 Toolbox running



Once the process is completed the windows can be closed and the results can be loaded in ArcGIS or any other GIS to be inspected.

4 Standalone executable

The tool is developed as user-friendly ArcGIS toolbox but could also be used as a standalone command line tool. By using the MATLAB compiled core executable it is possible to run the tool without loading it into ArcGIS.

4.1 Syntax for GHS-SmartDissolve command line tool

There are three possible syntaxes from command (drive name “X” is not a requirement):

— The minimal syntax:

```
X:\SmartDissolvePath\> smartdissolve.exe InputFeatures Threshold DissolveRule
```

— The complete syntax:

```
X:\SmartDissolvePath\> smartdissolve.exe InputFeatures Threshold DissolveRule  
Fields Rules
```

— The option syntax:

```
X:\SmartDissolvePath\> smartdissolve.exe InputFeatures Threshold DissolveRule  
Fields Rules option optionvalues
```

Table 3 lists all parameters, while Table 4 lists all options and their possible values.

smartdissolve.exe InputFeatures Threshold DissolveRule

The minimal syntax dissolves the polygons of the shapefile at the path *InputFeatures*, with area smaller than the area defined as *Threshold* expressed in square metre, following the dissolve rule specified with *DissolveRule*.

Example:

```
X:\SmartDissolvePath\> smartdissolve.exe "C:\Poly_sample.shp" 500 MinValue
```

Output:

```
C:\Poly_sample_dissolved.shp
```

All polygons below 500 square metres are dissolved with adjacent polygons prioritizing the smallest, until the resulting polygon reaches at least 500 square metres. The output will not retain any attribute of the input layer.

smartdissolve.exe InputFeatures Threshold DissolveRule Fields Rules

The complete syntax dissolves the polygons of the shapefile at the path *InputFeatures*, with area smaller than the area defined as *Threshold* expressed in square metre, following the dissolve rule specified with *DissolveRule*. The fields listed in *Field* will be updated according to the rules listed in *Rules* (the two list must have the same length).

Example:

```
X:\SmartDissolvePath\> smartdissolve.exe "C:\Poly_sample.shp" 500 MaxBorder  
{ 'P2', 'P3', 'SEZ2011', 'Sum_Hectar' } { 'sum', 'sum', 'concatenate', 'mean' }
```

Output:

```
C:\Poly_sample_dissolved.shp
```

All polygons below 500 square metres are dissolved with adjacent polygons prioritizing the highest border shares, until the resulting polygon reaches at least 500 square metres. The four attributes 'P2', 'P3', 'SEZ2011' and 'Sum_Hectar' are updated using 'sum', 'sum', 'concatenate' and 'mean' statistics, respectively.

smartdissolve.exe InputFeatures Threshold DissolveRule fields rules option optionvalues

The option syntax dissolves the polygons of the shapefile at the path *InputFeatures*, with area or attribute value (according to *Target* option) smaller than the value defined as *Threshold* (if area, expressed in square metre), following the dissolve rule specified with *DissolveRule*. The fields listed in *Field* will be updated according to the rules listed in *Rules* (the two list must have the same length). In the optional syntax imposing no field to be updated should be explicitly expressed with a pair of empty curly brackets "{} {}". The option syntax uses additional options specified by one or more *option optionvalues* pair arguments (when option is not specified the tool uses the default option as specified in Table 4).

Example:

```
X:\SmartDissolvePath\> smartdissolve.exe "C:\Poly_sample.shp" [500,1000]
MaxCompactness {} {} Target P1 OrderRule Seeds SeedsField SEZ2011 SeedsValues
{6326,6322} Output_fn "C:\Poly_sample_SD.shp" ValueBound 0.2 BoundedAdj COD_REG
```

Output:

C:\Poly_sample_SD.shp

The two polygons with field 'SEZ2011' values 6326 and 6322 are dissolved with adjacent polygons prioritizing the maximum resulting compactness, until values of field 'P1' reaches at least 500 and 1000, respectively. Adjacent polygon list is filtered by imposing the same 'COD_REG' field value of seeds and a maximum resulting field 'P1' value not exceeding the 20% of the threshold (i.e. 510 and 1200 respectively).

Table 3 List and description of input parameters

Parameter	Description		
InputFeatures	Input shapefile full path and filename		
Threshold	The minimum area/attribute value requirement (if area, in square metres). <i>Target</i> option defines if threshold is set to area (default) or attribute field (see Table 4). If <i>OrderRule</i> option is <i>Seeds</i> , it could be a list in square brackets with a threshold value per seed (e.g. [500, 1000, 852]), with same length as <i>SeedsValue</i> option (see Table 4).		
DissolveRule	Set the dissolve rule to prioritize adjacent polygons	<i>MinValue</i>	Minimum area/attribute value
		<i>MaxValue</i>	Maximum area/attribute value
		<i>MinDensity</i>	Minimum density of attribute value
		<i>MaxDensity</i>	Maximum density of attribute value
		<i>MaxBorder</i>	Maximum shared border length
		<i>MinPerimeter</i>	Minimum dissolved perimeter
		<i>MaxCompactness</i>	Maximum dissolved compactness (Area/Perimeter)
Field	List of field names to be updated In option syntax, if empty use {}		
Rule	List of statistics to be calculated for each field listed in <i>Field</i> In option syntax if empty use {}	<i>Sum</i>	Calculate the sum of count values
		<i>Min</i>	Keep minimum count value
		<i>Max</i>	Keep maximum count value
		<i>St Dev</i>	Calculate the standard deviation of all count values
		<i>Mean</i>	Calculate the average count value
		<i>Concatenate</i>	Concatenate all values as string
		<i>First</i>	Keep first value
		<i>Last</i>	Keep last value

Table 4 List and description of options

Option	Description		
Target	Specify Target Typology	<i>Area</i>	Target a minimum area threshold (Default)
		<i>Field</i>	Target a minimum attribute value threshold
OrderRule	Set the order of polygon analysis and processing	<i>ID</i>	Follow IDs order (Default)
		<i>MinMax</i>	From minimum area/attribute value to maximum
		<i>MaxMin</i>	From maximum area/attribute value to minimum
		<i>Seeds</i>	Select specific polygons as seeds for the dissolve procedure. Only these polygons will be analysed and processed to meet the area/attribute requirement.
SeedsField	Attribute field to be used as id for seeds polygons. Default: empty		
SeedsValues	Field values of selected polygons as seeds. Default: empty		
ValueBound	Fraction of area/attribute value not to be exceeded during dissolve. Default: Infinite e.g. Threshold = 200; ValueBound = 0.2; Adjacent polygons resulting in a total area/attribute value > 240 are excluded		
BoundedAdj	Attribute field to bound adjacency only in groups of polygons sharing the same value for the given field. Default: empty		
MinBorderShare	Minimum border share for both polygons. Default: 0 i.e. two adjacent polygons must have the minimum perimeter share with each other to be dissolved		
Output_fn	Output shapefile full path and filename. Default: <InputFeatures>'_dissolved.shp'		
Multiprocessing	Number of cores the algorithm will use. Default: 1		

5 Input and Output

5.1 Input

The only input necessary to run the tool is a polygon vector file. The ArcGIS toolbox supports both shapefiles (.shp) and vector layers contained into a GeoDataBase (.gdb), while the standalone executable could only work with shapefiles (.shp). There are no particular constrains except having a correct geometry without errors.

Box 1 Polygons with intersections

Polygons with intersections are considered adjacent but no border share can be computed. Therefore all settings using border share (MinPerimeter, MaxBorder, MaxCompactness, dissolve rules; MinBorderShare constrain) are affected.

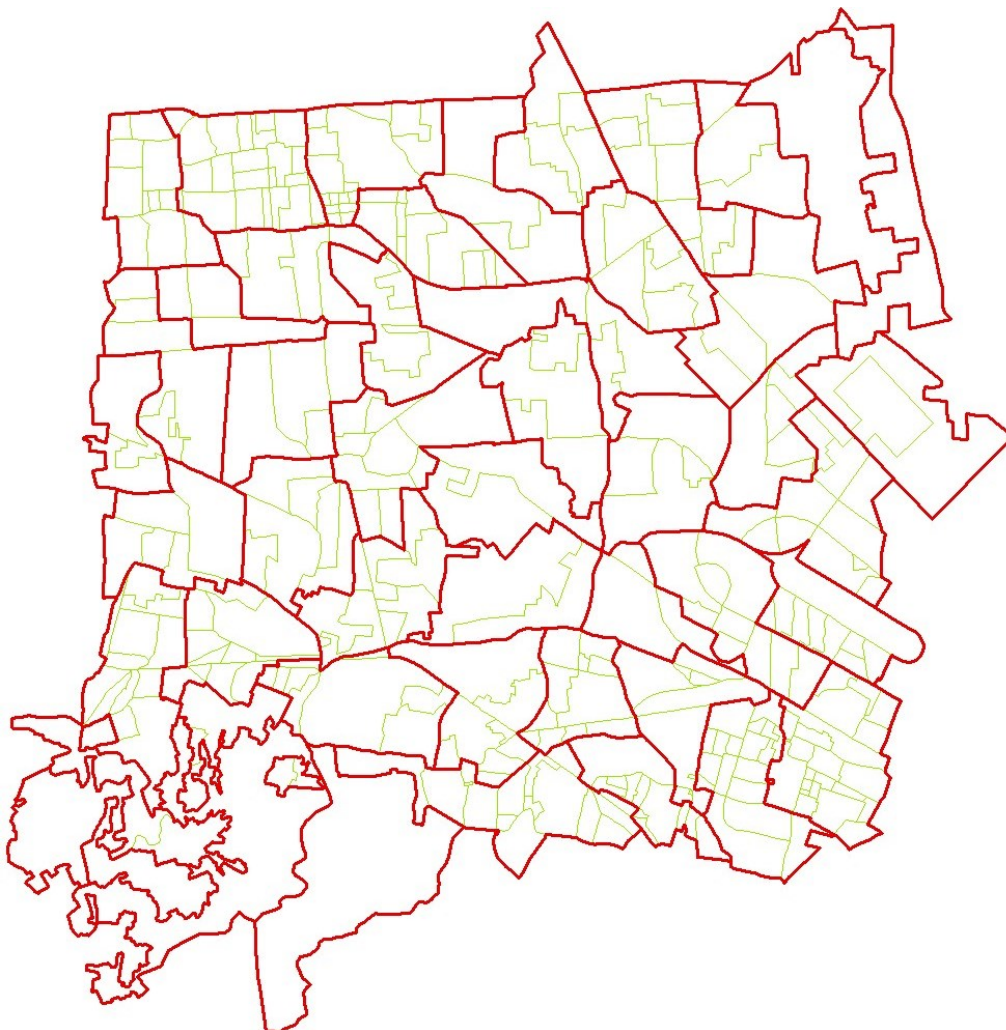
When the algorithm detects intersecting polygons, a warning message will be shown at the end of the execution.

Common GIS repair geometry tools could partially solve these issues.

5.2 Output

The GHS-SmartDissolve takes a polygon vector layer in input and exports another polygon vector layer as outputs (Figure 12), where polygons are dissolved according to the tool settings and attribute values are updated according to the selected rules (see section 2.2.1.1 and 4).

Figure 12 The input (green) and the output (red) polygon layers of GHS-SmartDissolve tool targeting a minimum polygon area using the *MaxCompactness* rule to dissolve polygons.



6 Conclusion

The GHS-SmartDissolve Tool 2 adds to the family of GHSL open and free tools to enact the “open input, open method, open output” paradigm of the Global Human Settlement Layer framework. With the GHS-SmartDissolve Tool presented in this report the user can enhance dissolve procedures by producing vector layers meeting minimum areal requirements or minimum attribute fields value to solve minimum mapping unit, resolution mismatch between layers, minimum field value unit or spatial uncertainty problems in GISc.

References

Davis, Bruce Ellsworth. 2001. *GIS: A Visual Approach*. 2nd ed. Albany, N.Y: Delmar Thomson Learning.

Schiavina, Marcello, and Sérgio Freire. 2017. 'Development of a New and Open Approach to Dissolve Polygons Storing Count Data Based on Areal Threshold'. In *Proc. of the 20th AGILE Conference on Geographic Information Science*, 6. Wageningen, the Netherlands, May 9-12.

List of boxes

Box 1 Polygons with intersections 17

List of figures

Figure 1 Dissolve spatial operation. Two groups of polygons sharing a common attribute (reds and blues) are dissolved and interior geometry is removed4

Figure 2 Windows installer.....5

Figure 3 Default installation values6

Figure 4 Installation Complete6

Figure 5 Show ArcToolbox window7

Figure 6 Add toolbox to ArcGIS7

Figure 7 The toolbox pyt file to import in ArcGIS.....7

Figure 8 Uninstall ArcGIS toolbox from Windows Settings.....8

Figure 9 ArcGIS toolbox window.....9

Figure 10 Toolbox setup with all inputs and parameters..... 12

Figure 11 Toolbox running 13

Figure 12 The input (green) and the output (red) polygon layers of GHS-SmartDissolve tool targeting a minimum polygon area using the *MaxCompactness* rule to dissolve polygons..... 17

List of tables

Table 1 System requirements5

Table 2 Toolbox items description..... 10

Table 3 List and description of input parameters 15

Table 4 List and description of options..... 16

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doi:10.2760/572177

ISBN 978-92-76-22750-2