Ricardo
Energy & Environment

NOx to NO2 sector removal tool
Technical Note

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Report for Scottish Government

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DRAFT

Please keep until final version for audit purposes

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Scottish Government

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1   Introduction

Background maps are produced for the UK at 1 km resolution for NOx, split by source sectors. When removing sectors from the background NO_x concentrations to avoid double counting in the modelling process, it is necessary to adjust the NO_2 concentrations in proportion to the reductions in NO_x as a result of removing the specific source sector(s).

The "NO$_2$ Adjustment for NO$_x$ Sector Removal Tool" [1] recalculates the NO_2 concentrations depending on the NO$_x$ sector removed. The current tool is not compatible with the Scottish Background maps hosted on the Air Quality in Scotland website[2]. This is a result of the different calibration of the reference year background between the maps hosted by DEFRA website and those on the Air Quality in Scotland website.

Ricardo Energy and Environment have created a Scotland specific tool, hosted on the SAQD (Scottish Air Quality Database) website. This tool has been integrated within the current background mapping function on the website and uses new drop-down options within the web page. This tool calculates the background map concentrations after sector removal behind-the-scenes through use of R (a language and environment for statistical computing). The website tool has advantages over the current DEFRA Excel-based tool including simpler and integrated usage, and minimises the chance of user error due to the automatic calculation of the sector removal.

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[1] Available on the DEFRA website**:** https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector
[2] www.scottishairquality.co.uk

2 Methodology

The method carried out 'behind the scenes' within the NO$_2$ sector removal tool code is described below. With each step, a demonstrative example is shown, contained within the coloured boxes. The tool exposed on the website will simple for users to interact with and will take the form of a number of drop-down menus – a separate guidance note is hosted on the website to provide instructions to Local Authorities using the tool.

1) User inputs will be obtained from the website (in the form of selection from a drop-down menu) describing:
   - The year of background map required (same options as current background map website)
   - The local authority area of interest for the background mapping (same options as current background map website)
   - The sectors to remove from the background concentrations (options: *All road, Motorway, Trunk Roads, Primary A Roads, Minor Roads, Industry, Domestic, Aircraft, Rail, Other, Point,* or *Rural*). The user will be able to select multiple pollution sources to exclude from the maps.
   - The background source contributions to be removed: Inside the cell, Outside the cell, or Both Inside and Outside the cell
   - Should a shapefile be created from the background maps (options: *Yes,* or *No*)

   These selections are the only input required from the user in the NO$_2$ sector removal tool. Steps 2 to 6 are automatically carried out by the tool behind the scenes.

Example:

Year: *2020*

Area: *City of Edinburgh Council*

Sectors to remove: *Point*

Make shapefile: *Yes*

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2) A URL is generated using the user requested area and year to allow download of the background NO$_x$ and NO$_2$ concentrations files (in .csv format) from the Scottish Air Quality Database website (http://www.scottishairquality.co.uk/data/mapping?view=data).

Example:

The URL generated to download the NO$_x$ background map:

http://www.scottishairquality.co.uk/data/mapping.php?bkgrd-la=370&bkgrd-pollutant=nox&bkgrd-year=2020&view=data&submit=Download+CSV

The URL generated to download the NO$_2$ background map:

http://www.scottishairquality.co.uk/data/mapping.php?bkgrd-la=370&bkgrd-pollutant=no2&bkgrd-year=2020&view=data&submit=Download+CSV

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3) A total NO$_x$ concentration is calculated after removal of the sources requested by the user for each of the locations described in the downloaded background NO$_x$ concentration file. Steps 3 to 5 are carried out for all background map coordinate locations, generating specific concentration information for each 1 km grid cell.

Example:

Point sources were requested to be removed by the user. The total of the concentrations without emissions is calculated for each coordinate in the background maps. The remainder of this example case is for a single coordinate for ease of description.

Source	NO_x Concentration ($\mu g/m^3$)
Motorway	2.3
Trunk Roads	0.1
Primary A Roads	1.1
Minor Roads	1.4
Industry	0.6
Domestic	1.4
Aircraft	0.2
Rail	0.9
Other	1.9
Point	0.4
Rural	3.0
Total NO_x (All sources)	13.3
Total NO_x (without Point)	12.9

4) The fraction of the background NO_x concentration (all sources) attributed to the total NO_x after sector removal is then calculated.

Example:

For the same coordinate described above:

Fraction contribution = NO_x without point / total NO_x = 12.9 / 13.3 = 0.97

5) The background NO_2 concentrations after removal of the requested sources is calculated by multiplying the total background NO_2 concentration by the fraction calculated in step 4 above.

Example:

The background NO_2 concentration at the coordinate (from the downloaded NO_2 background map) = 9.2

Therefore, the NO_2 concentration excluding Point sources:

Total NO_2 * fraction = 9.2 * 0.97 = 8.9 $\mu g/m^3$

6) A csv file is created for the user to download containing the NO_x background concentrations, and corresponding background NO_2 and scaled background NO_2 concentrations for the local authority requested.

Example:

The image below shows the additional information added to the NOx background map csv file after running the NO$_2$ sector tool:

AA	AB	AC	AD
Total_excluding_sectors	Fraction_of_total_from_sectors	Total_NO2_20	ScaledNO2
12.827486	0.972751994	9.218904	8.967707252
14.500297	0.97528064	10.28808	10.03376524
16.71744	0.97790829	11.57968	11.32386506
18.646614	0.979535495	12.73602	12.47538366

7) A log file (in .txt format) detailing the user selected inputs (as described in step 1 above) along with the date/time of the request made on the website is additionally created.

Example:

The log file generated is shown in the image below:

```
NO2 sector removal tool
Ricardo Energy and Environment

Tool available from www.scottishairquality.co.uk
Date of sector request: 2018-03-16 12:49:40
User selected year: 2020
User selected area: City_of_Edinburgh_Council
User selected sources to be excluded: Point

Tool description:
    1) The NOx and NO2 background maps for the year and area selected by the user loaded into memory
    2) The sectors requested for removal by the user were removed from the NOx data
  For each location in the background maps:
    3) The total NOx concentrations after sector removal were calculated
    4) The total NOx after sector removal as a percentage of total NOx when all sources included was
    calculated
    5) This percentage was used to scale the background concentrations of NO2
```

8) If the user requested a shapefile to be generated, this will also be created for the user to download. The shapefile contains all the same information contained within the csv file created in step 6 above, however is geospatially referenced and can be loaded into a GIS system.

Example:

The image below shows the shapefile created as a result of the NOx to NO$_2$ sector removal tool. This can be loaded into a GIS, and in the example below the points are colour coded by the NO$_2$ concentration ($\mu g/m^3$) after point source removal.
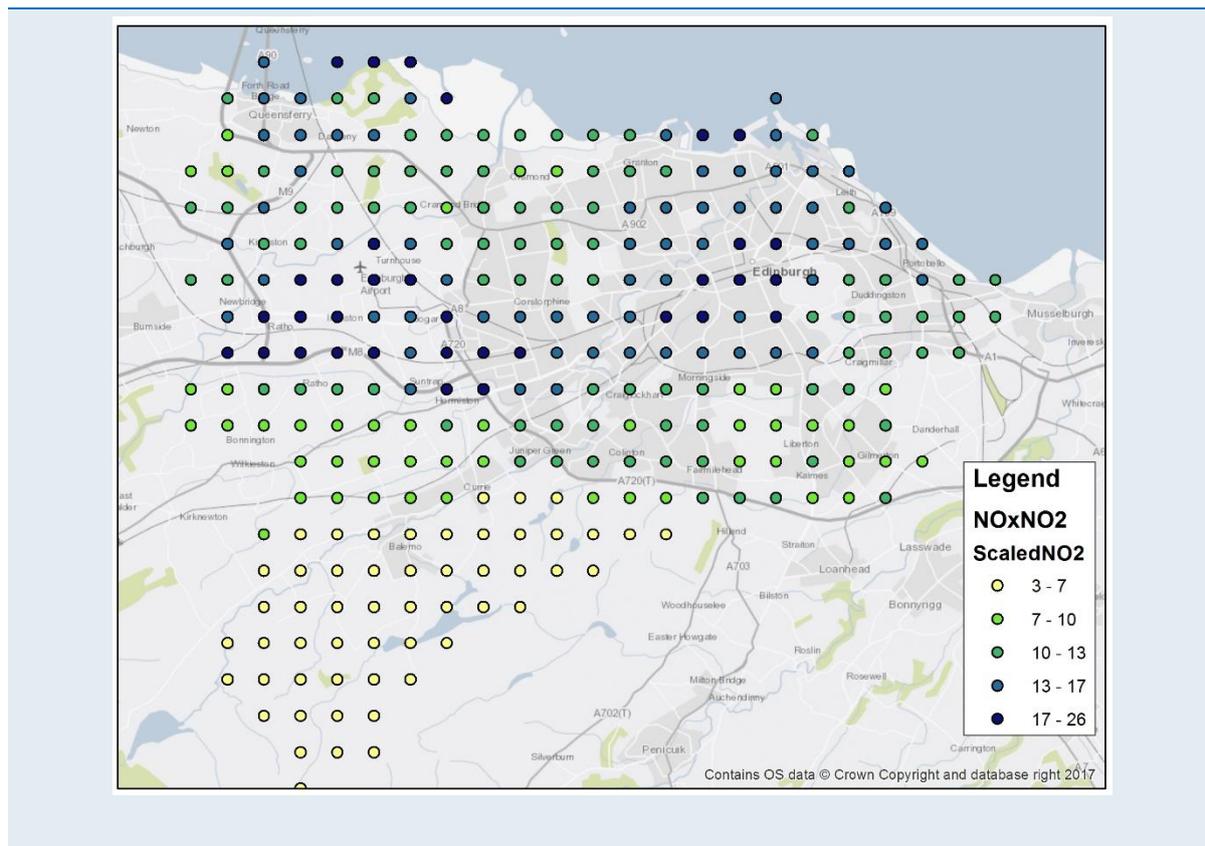
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