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WM-NET ZERO



Impacts of net zero policies on air quality in a metropolitan area of the UK: Towards WHO air quality guidelines

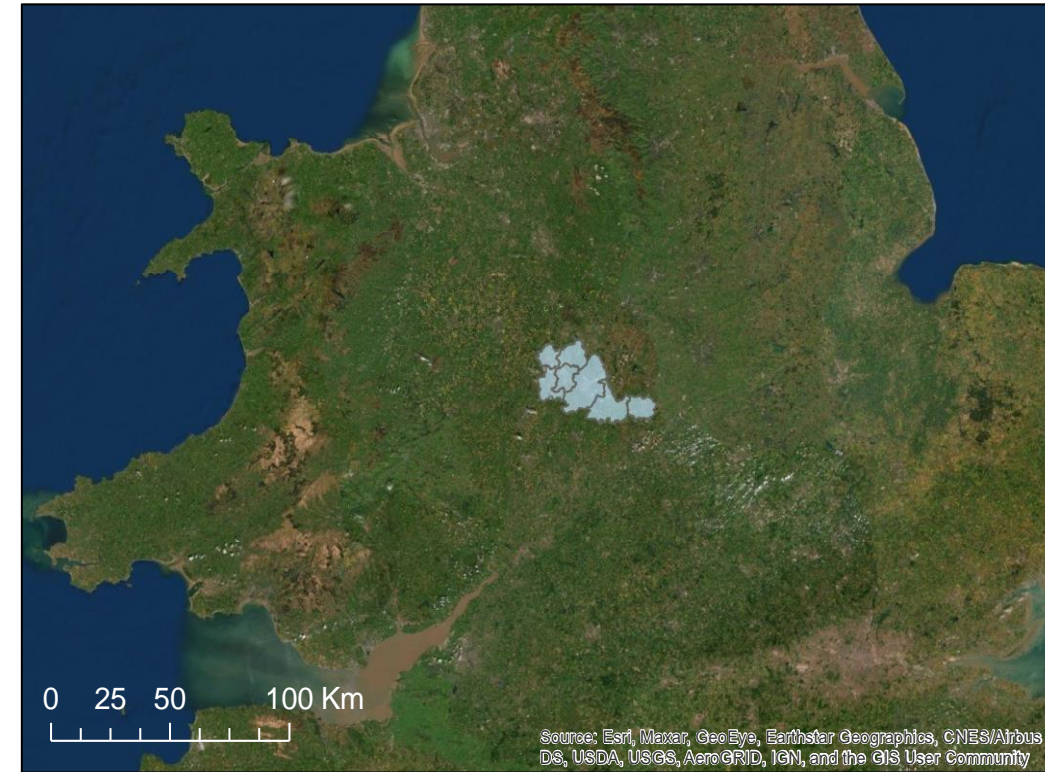


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Overview

- Introduction to WM-Air and WM-Net Zero
- Baseline model configuration
 - Road traffic emissions
 - Industrial and gridded emissions
 - Spatial splitting
- Baseline model evaluation
- Baseline model outputs
- Modelling scenarios: Clean Air / Net Zero Co-Benefits



Introduction to WM-Air and WM-Net Zero

- **WM-Air:** *Clean Air Science for the West Midlands (PI: Prof Bloss)*
- **Impact**-focused programme to support improvement of **air quality** and associated **health, environmental** and **economic** benefits in the West Midlands
- 5 year, £5m programme funded by UK NERC and led by University of Birmingham

- **WM-Net Zero:** *A Health-centred Systems Approach towards Net-Zero: Transforming regional climate mitigation policies (PI: Prof Shi)*
- Aim to transform regional **Net-Zero** policy solutions by adopting a **health-centred** systems approach.
- 3 year, £2m programme funded by Wellcome Trust and led by University of Birmingham

- West Midlands Combined Authority area
Birmingham, Coventry, Dudley, Sandwell,
Solihull, Walsall, Wolverhampton

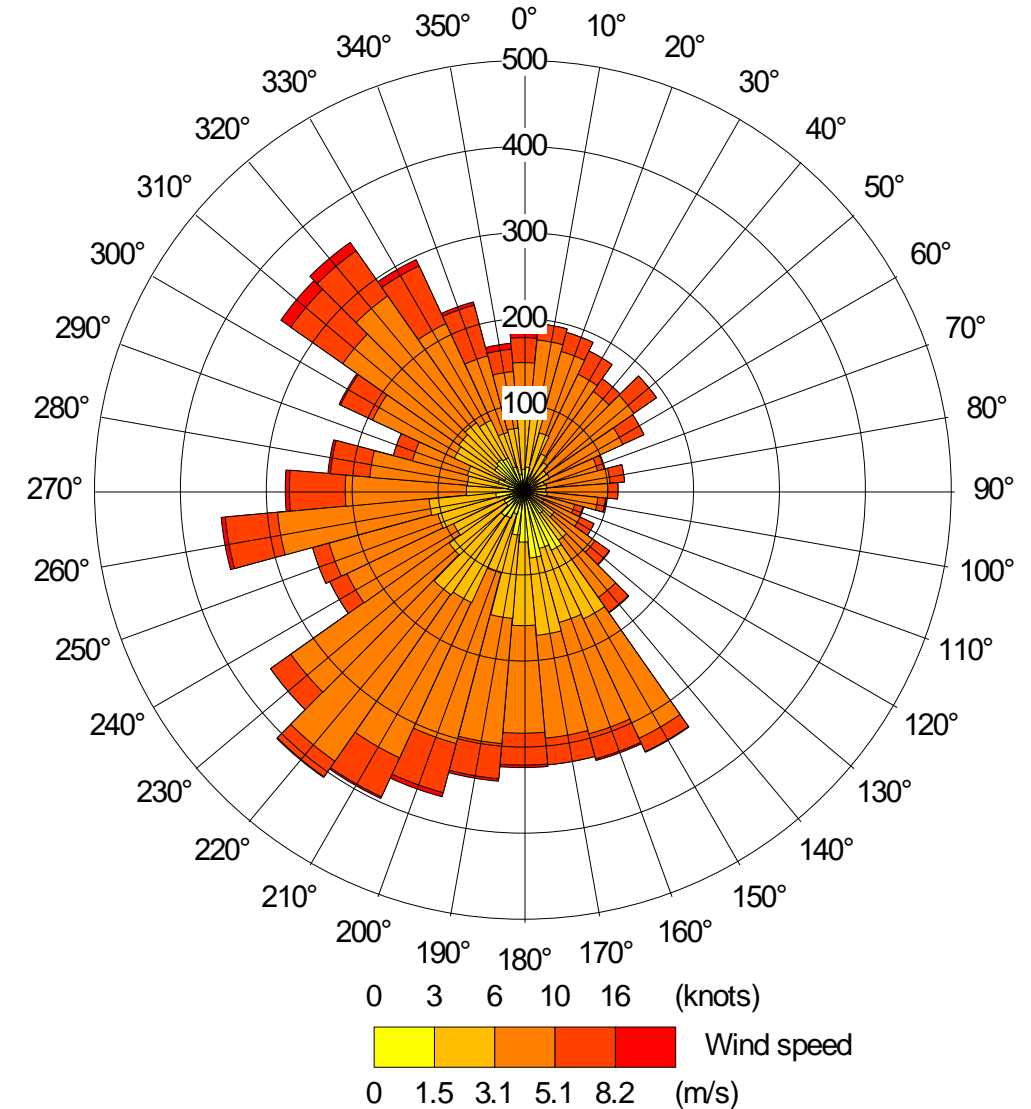


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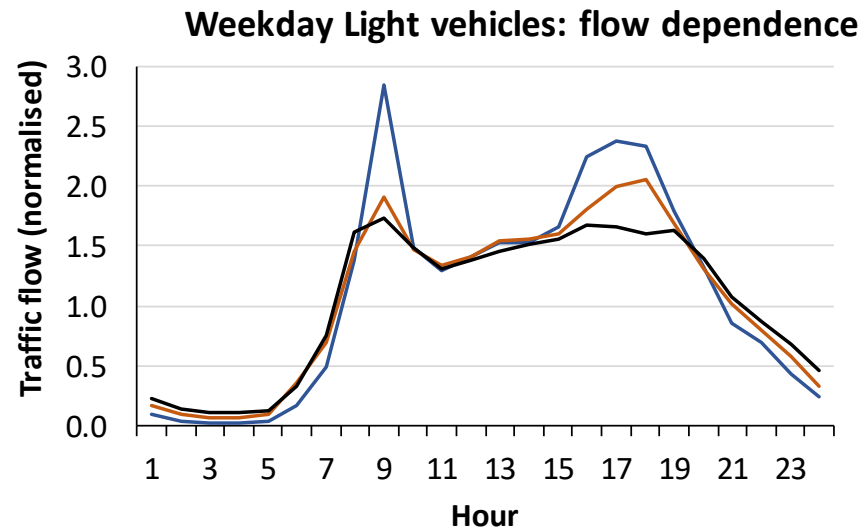
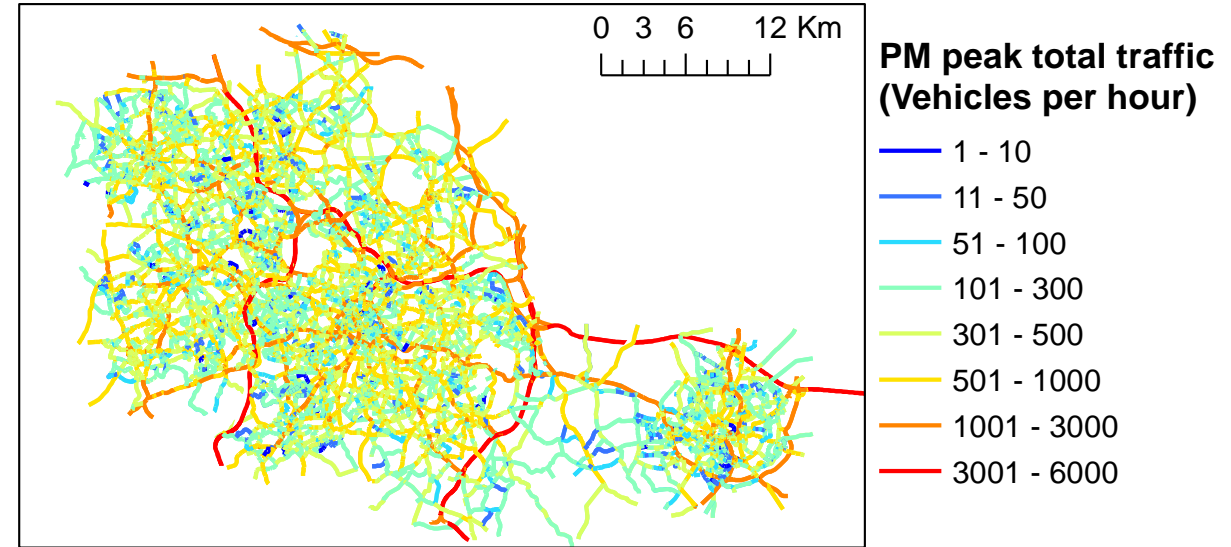
Baseline model configuration

- Model baseline year 2016 [now also 2019]
- Meteorology – measured data from Elmdon, obtained from BADC
- Background
 - Upwind measured data from rural sites
 - $PM_{2.5}$ tricky due to lack of rural measurement sites, scaled from Chilbolton
- Advanced canyon and urban canopy parameters calculated from explicit building footprints and heights



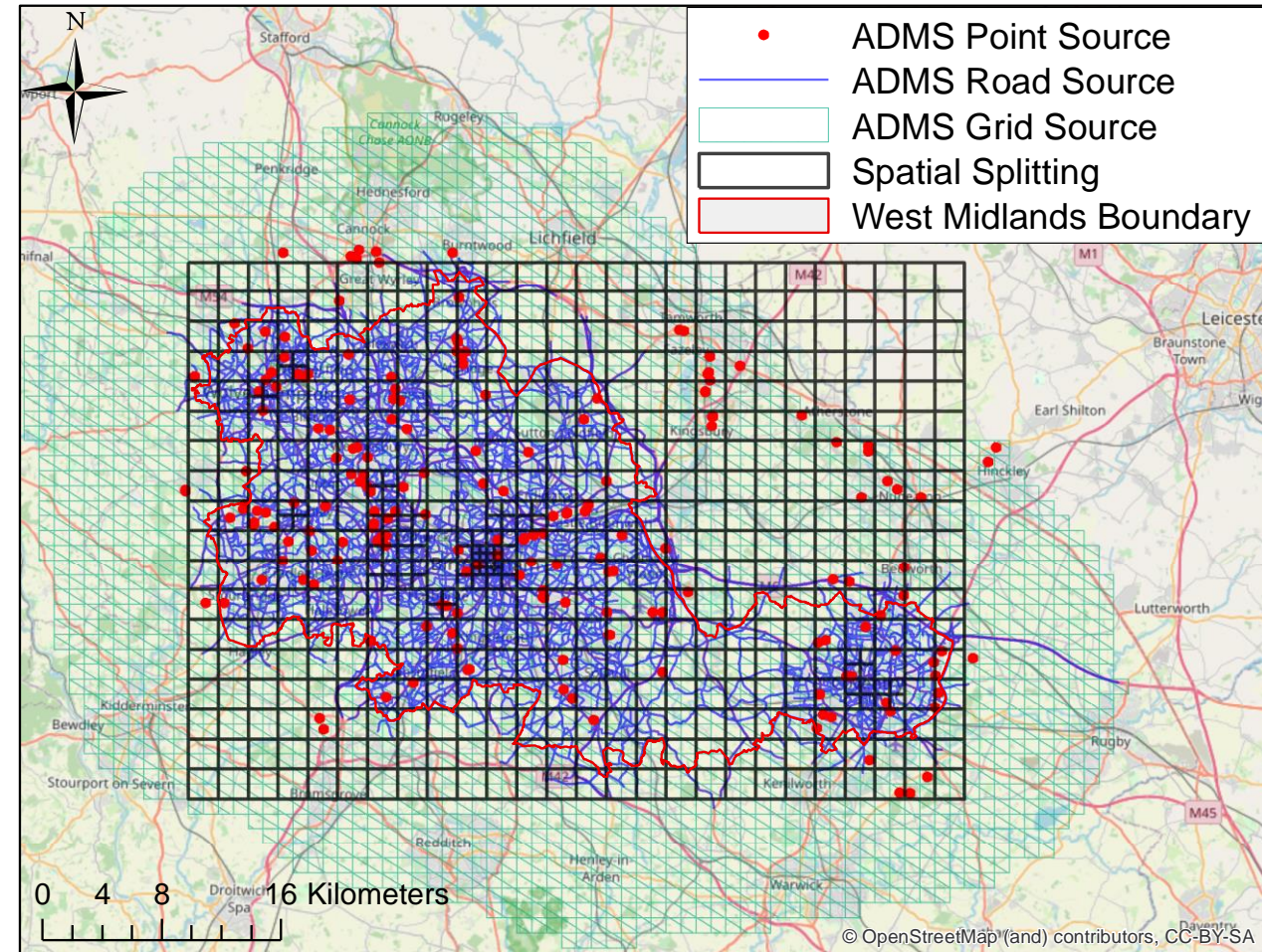
Baseline model configuration: road traffic emissions

- Traffic models
 - TfWM PRISM
 - Birmingham City Council SATURN
 - HGV proportion recalculated based on traffic count data from WMCA
- Bus flow data from Remix
 - Annual time-table data for 526 routes
- Traffic emission factor adjustments based on remote sensing measurements
- Time-varying emissions profiles:
 - Weekday, Saturday and Sunday profiles normalised for roads with light, medium and heavy traffic flow



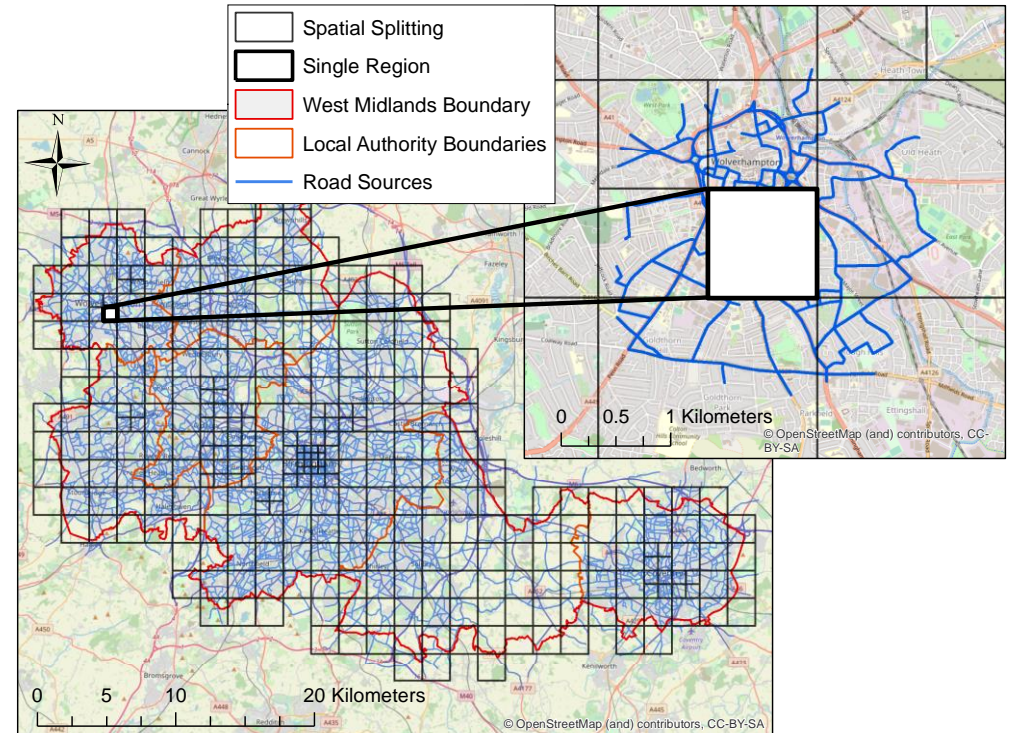
Baseline model configuration: Industrial and gridded emissions

- Industrial emissions
 - NAEI emission rates, updated with BCC (Airviro) locations and stack properties
- Gridded emissions
 - NAEI
 - 1 km × 1 km resolution
 - 11 SNAP sectors
 - Modified sector 7 (Road Transport) based on explicit road adjustments



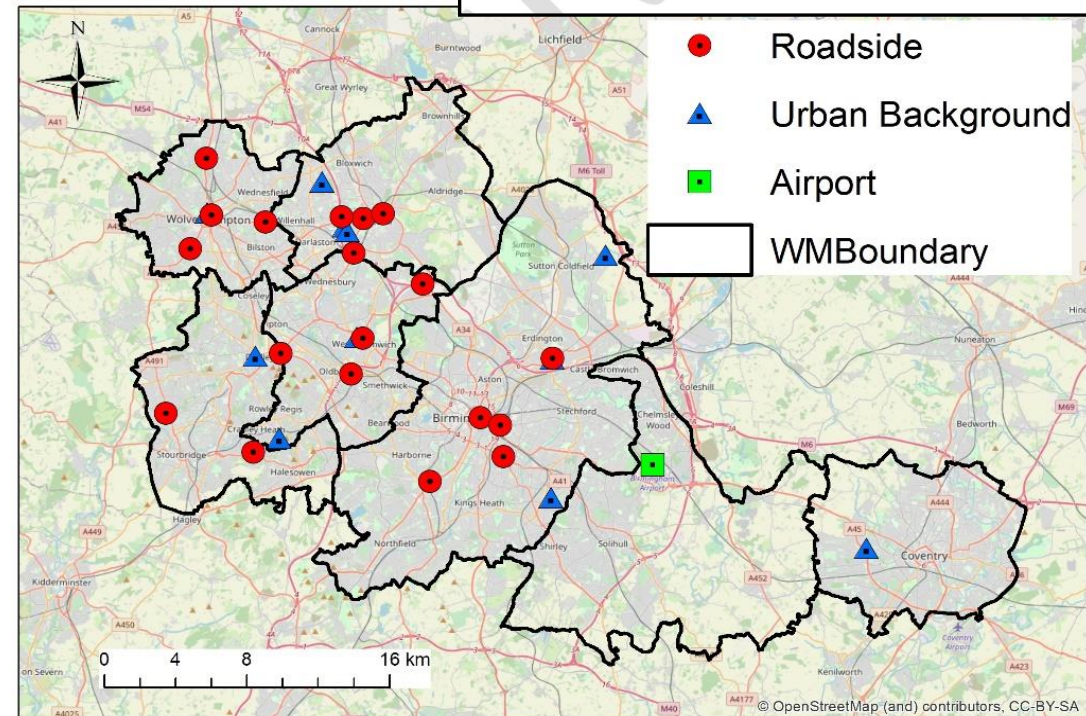
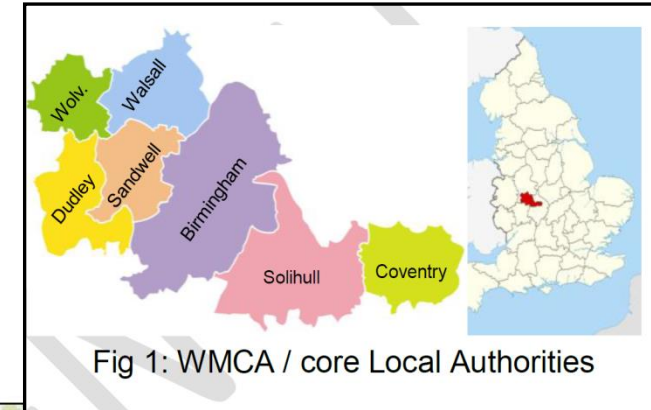
Baseline model configuration: Spatial splitting

- Tasking farming: Domain splitting into 540 smaller sub domains
- Each sub domain with a size of 2 km × 2 km, 1 km × 1 km or 500 m × 500 m (city centre areas).
- A buffer zone of 750 m for road sources.
- Run time for a typical annual simulation: 35h.



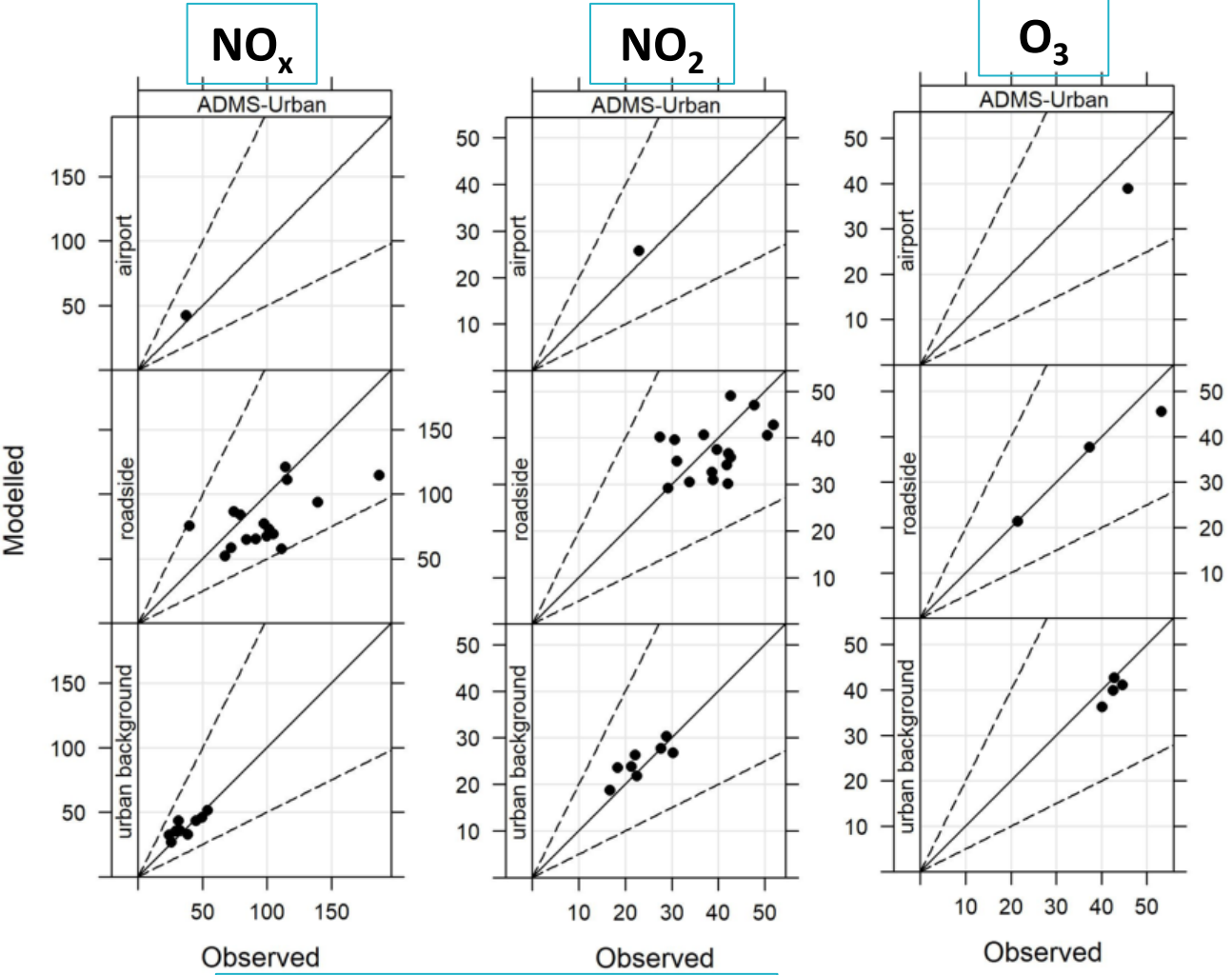
Baseline model evaluation

- Site types:
 - 19 roadside
 - 12 urban background
 - 1 airport
- Temporal data capture:
 - Mostly hourly
 - Some daily (PM)
 - Poor data capture at some sites (6 sites less than 50%)
- No monitors in Solihull (apart from airport)



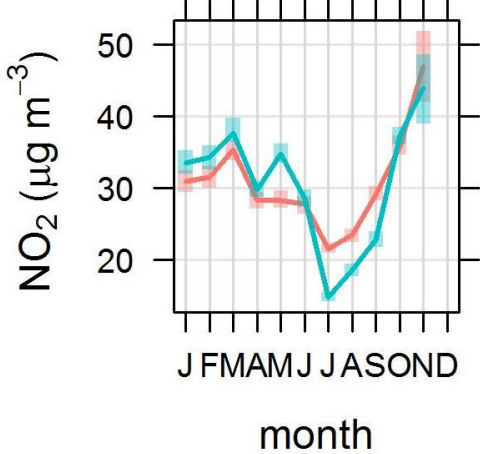
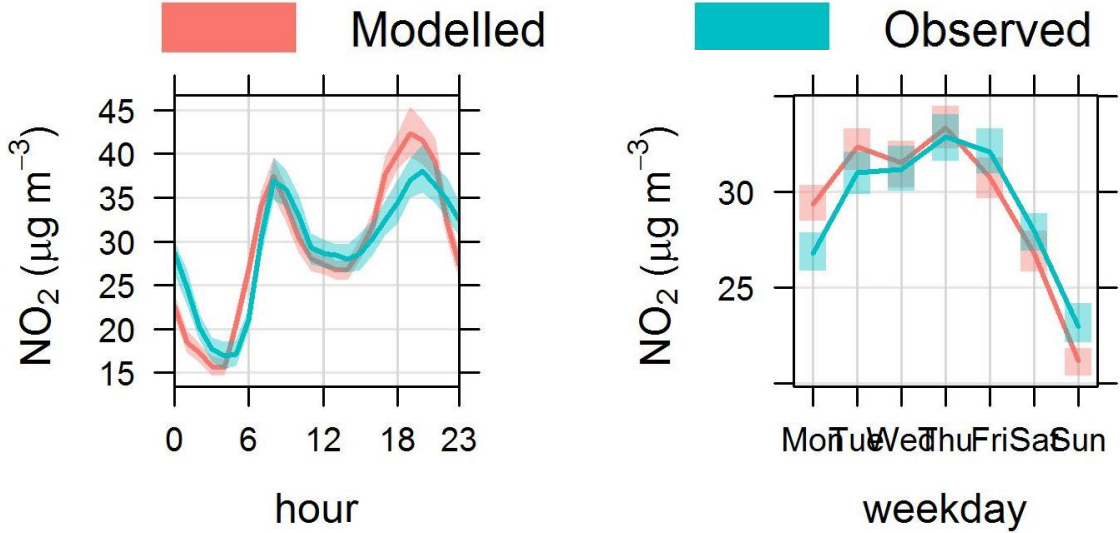
Baseline model evaluation

- Model Evaluation Toolkit used for wide-ranging evaluation



Annual Average $\mu\text{g}/\text{m}^3$

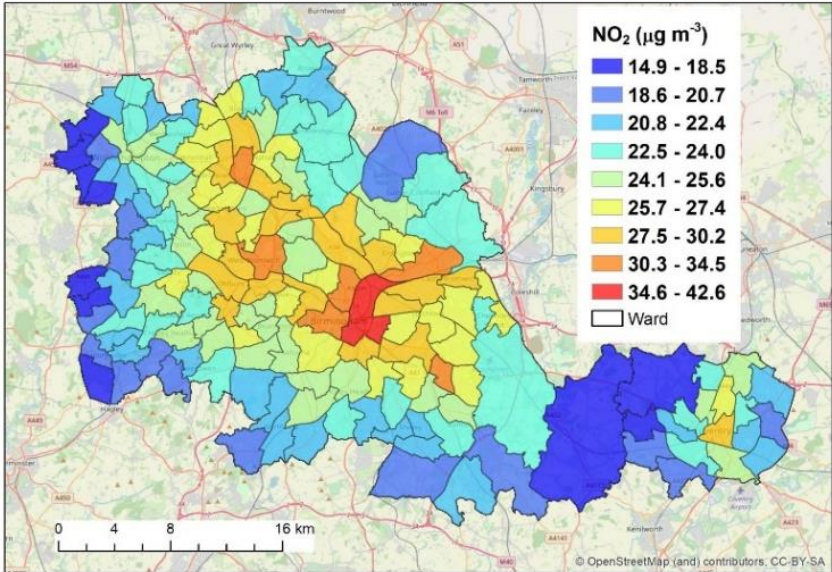
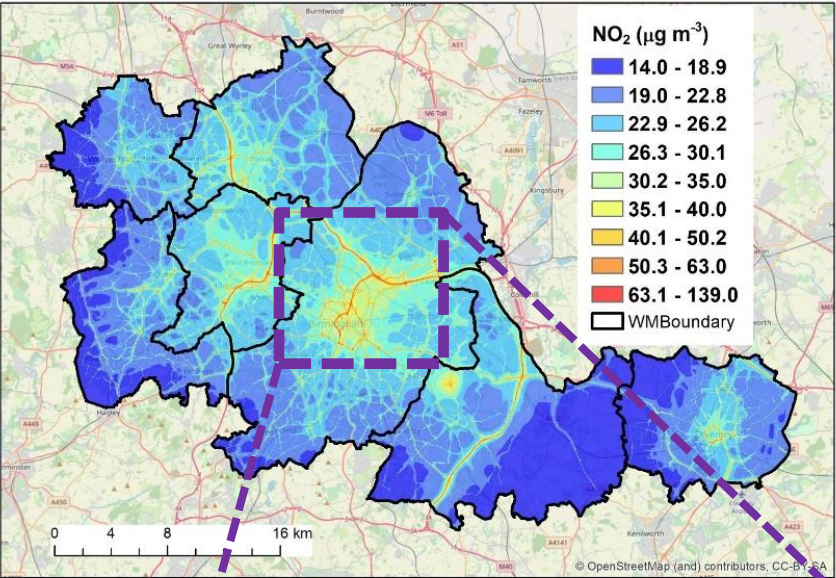
Bristol Road (Roadside)



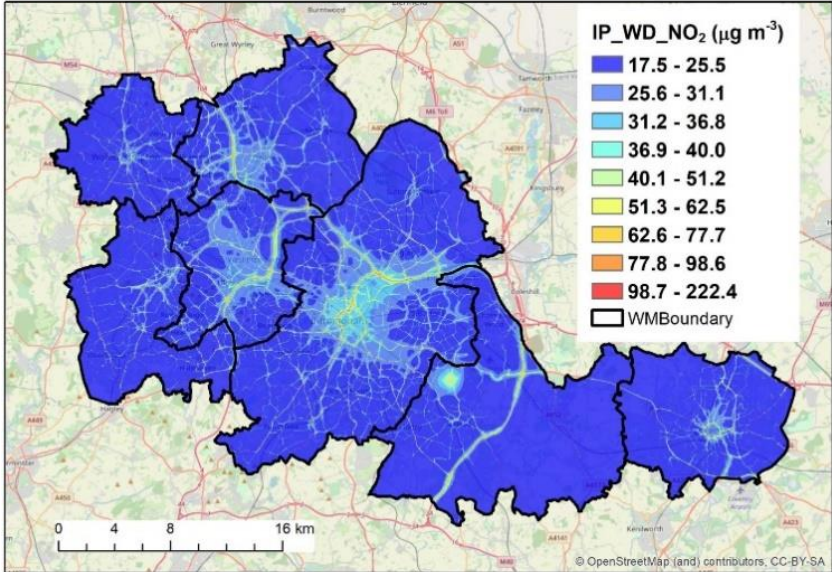
Baseline model outputs

- ‘Raw’ high resolution concentration contours
- Spatially aggregated to Lower-level Super Output Areas (LSOA) and Wards [approach-dependent]
- Averaged over different diurnal subsets eg. weekday peaks

Weekday inter-peak



Wards



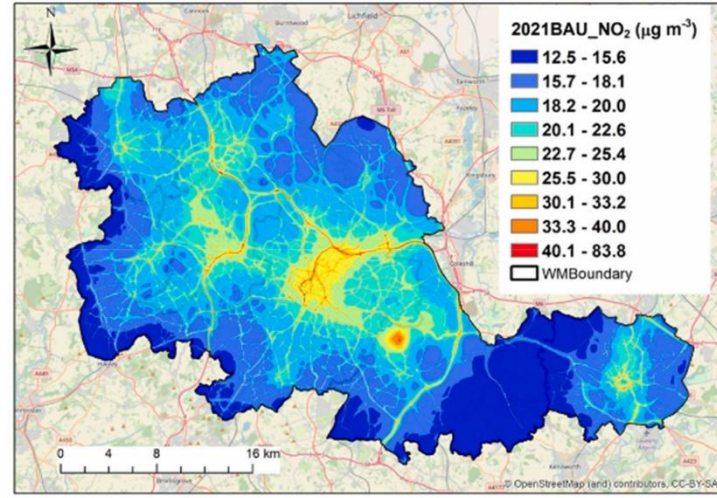
Modelling scenarios: Clean Air / Net Zero Co-Benefits

- **2021 BAU** Business-as-usual: NB no covid impacts on activity (updated from the baseline model)
- **2030 BAU** Business-as-usual: Anticipated emissions reductions in line with NECD commitments / 2019 Clean Air Strategy
<https://www.eea.europa.eu/data-and-maps/data/necd-policies-and-measures-database>
- **2030 Net Zero** Emission reductions estimated in line with the UK Net Zero Strategy, derived from CO₂ changes (as appropriate to sector/activity); CO₂ emission changes as evaluated by the **Climate Change Committee**
- **2030 “EV”** Transport-sector only changes in line with the above
(24% car; 9% HGV; 25% bus/Coach=EV)

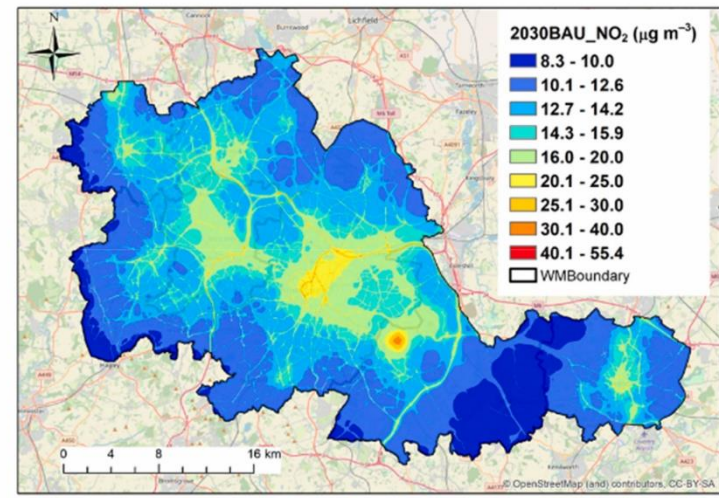
...these are all really quite substantial approximations...

Changes in air quality for 2021 BAU vs 2030 BAU

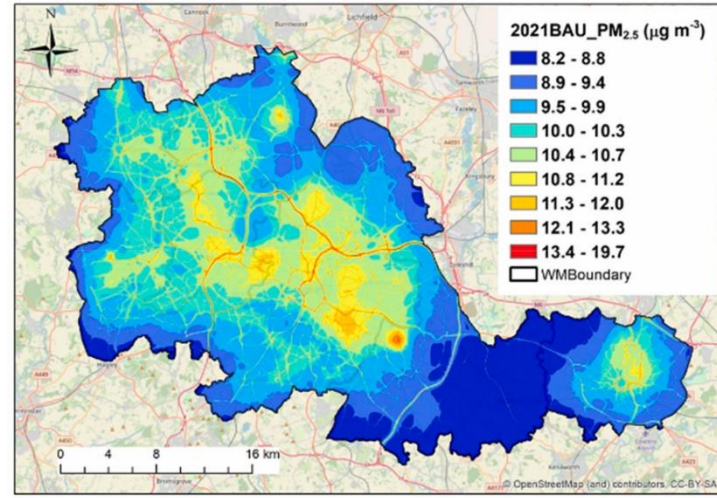
(a) NO₂ for 2021 BAU



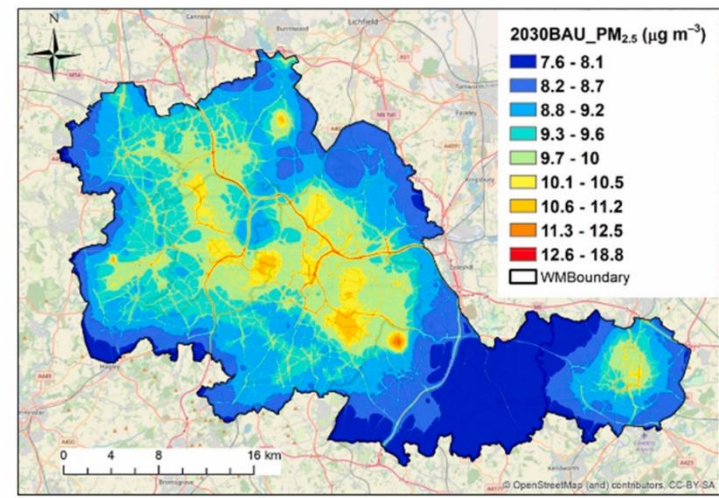
(b) NO₂ for 2030 BAU



(c) PM_{2.5} for 2021 BAU

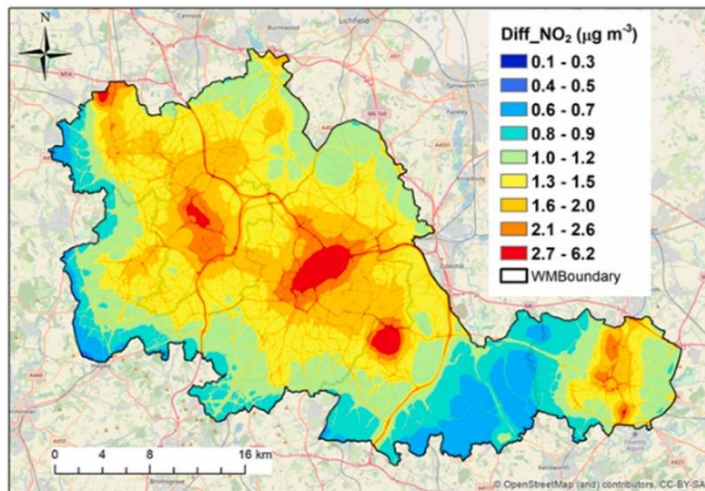


(d) PM_{2.5} for 2030 BAU

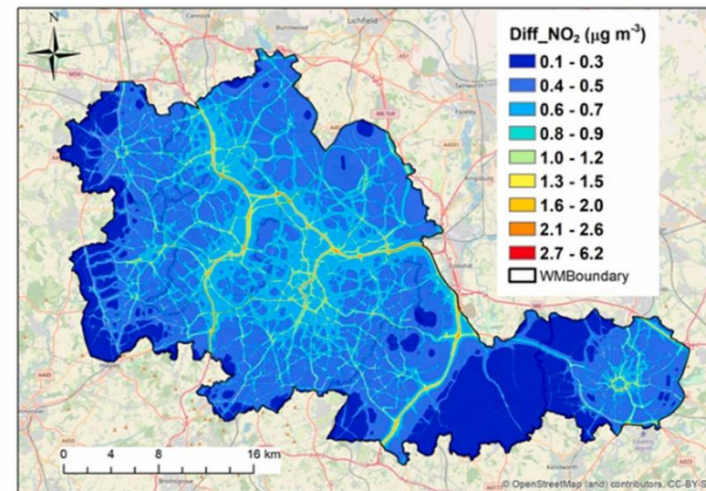


Assessing air quality co-benefits of net zero policies: NO_2

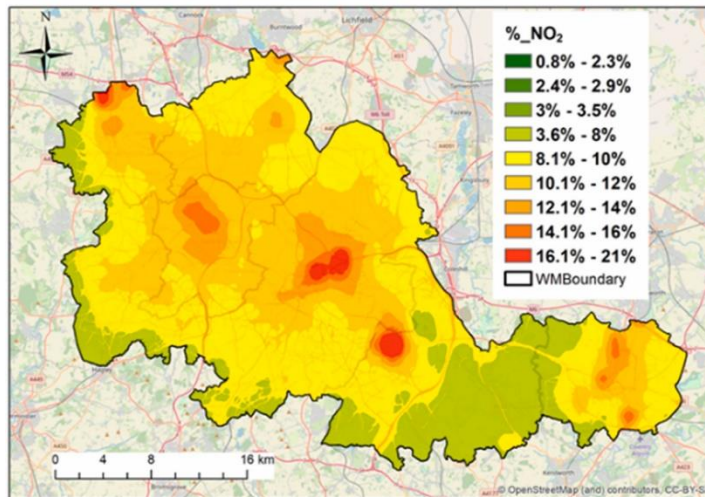
(a) 2030 BAU-2030 NZS



(b) 2030 BAU -2030 EV

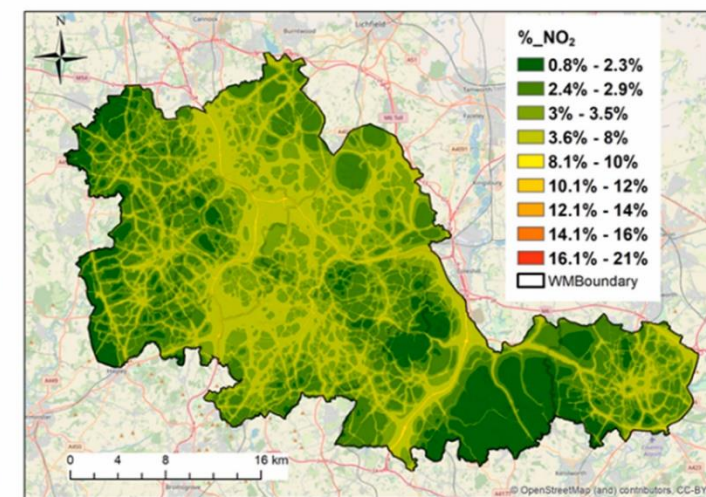


(c) (2030 BAU -2030 NZS)/2030 BAU



Net Zero Scenario

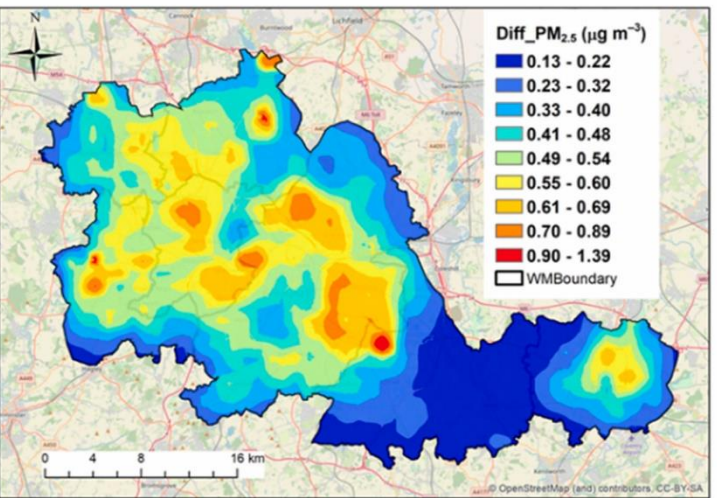
(d) (2030 BAU -2030 EV)/2030 BAU



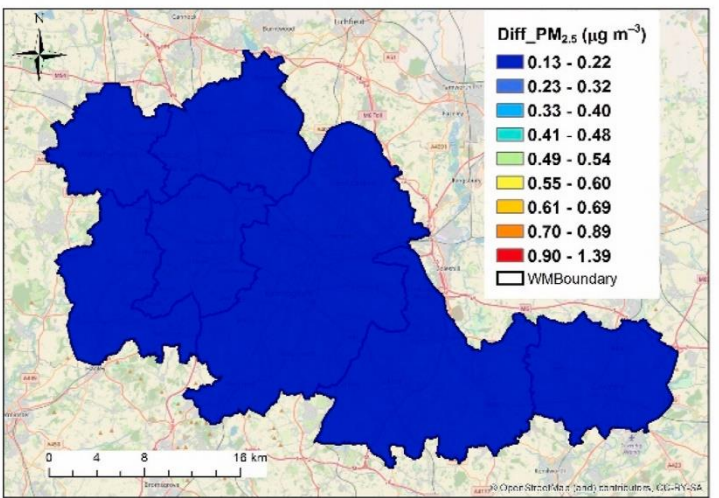
EV only Scenario

Assessing air quality co-benefits of net zero policies: PM_{2.5}

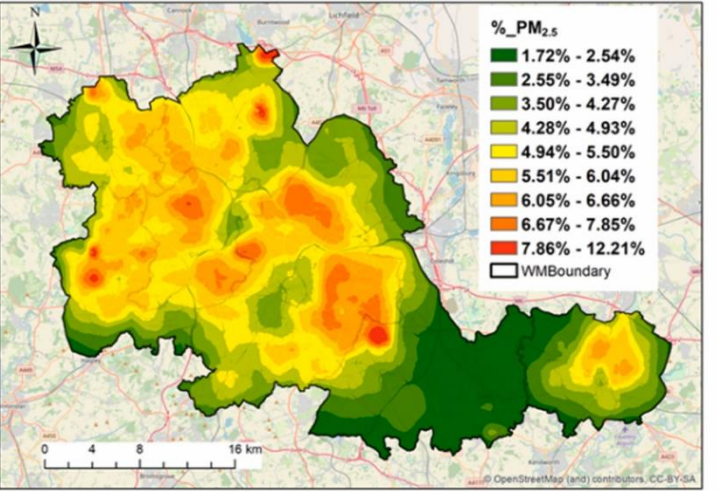
(a) 2030 BAU-2030 NZS



(b) 2030 BAU -2030 EV

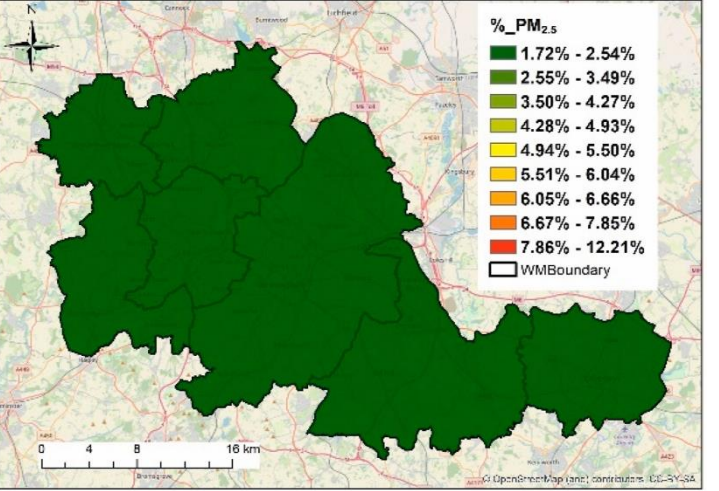


(c) (2030 BAU -2030 NZS)/2030 BAU



Net Zero Scenario

(d) (2030 BAU -2030 EV)/2030 BAU



EV only Scenario

Implications for “target” attainment / exposure

Target / Objective / Guideline	PM _{2.5} / $\mu\text{g m}^{-3}$	NO ₂ / $\mu\text{g m}^{-3}$
	(annual mean)	
1 Current binding DEFRA Air Quality Objective [England]*	25	40
2 WHO 2021 Air Quality Guideline	5	10
3 WHO 2021 Interim Targets	35 / 25 / 15 / 10	40 / 30 / 20
4a Proposed PM _{2.5} target for England** – to be achieved by 2040	10	
4b Proposed PM _{2.5} exposure reduction for England – of 35%, by 2040, relative to 2018		

Implications for exposure: 192 wards

- **PM_{2.5}** :

Scenario	No. Wards where mean PM _{2.5} >10 µg m ⁻³ **	(c) % Population [total 2.9m] in wards where mean PM _{2.5} >10 µg m ⁻³ **	No. Wards where mean PM _{2.5} > WHO AQG (5 µg m ⁻³) **
2021	104	57.2	192
2030 BAU	28	15.9	192
2030 Net Zero	0	0	192
2030 EV	26	14.7	192

- **NO₂** :

Scenario	No. Wards where: mean NO ₂ >40 (IT 1)	No. Wards where: mean NO ₂ >30 (IT 2)	No. Wards where: mean NO ₂ >20 (IT 3)	No. Wards where: mean NO ₂ >10 (AQG)
2021	0	0	78	192
2030 BAU	0	0	3	189
2030 Net Zero	0	0	0	174
2030 EV	0	0	2	187

Conclusions

Links for more information

- WM-Air ADMS-Urban baseline modelling paper:

[Zhong et al. 2021, mdpi.com/2073-4433/12/8/983](https://doi.org/10.3390/atmos12080983)

- Net Zero modelling scenario paper:

[Zhong et al. 2023, https://doi.org/10.1016/j.envres.2023.116704](https://doi.org/10.1016/j.envres.2023.116704)

- WM-Air website wm-air.org.uk
- ADMS-Urban and Comprehensive Output File Processor user guides www.cerc.co.uk/UserGuides
- **Regional – Local Model Coupling System [MAQS-Health]**

Thanks to :

- Colleagues at CERC
- WM LAs, WMCA & TfWM



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