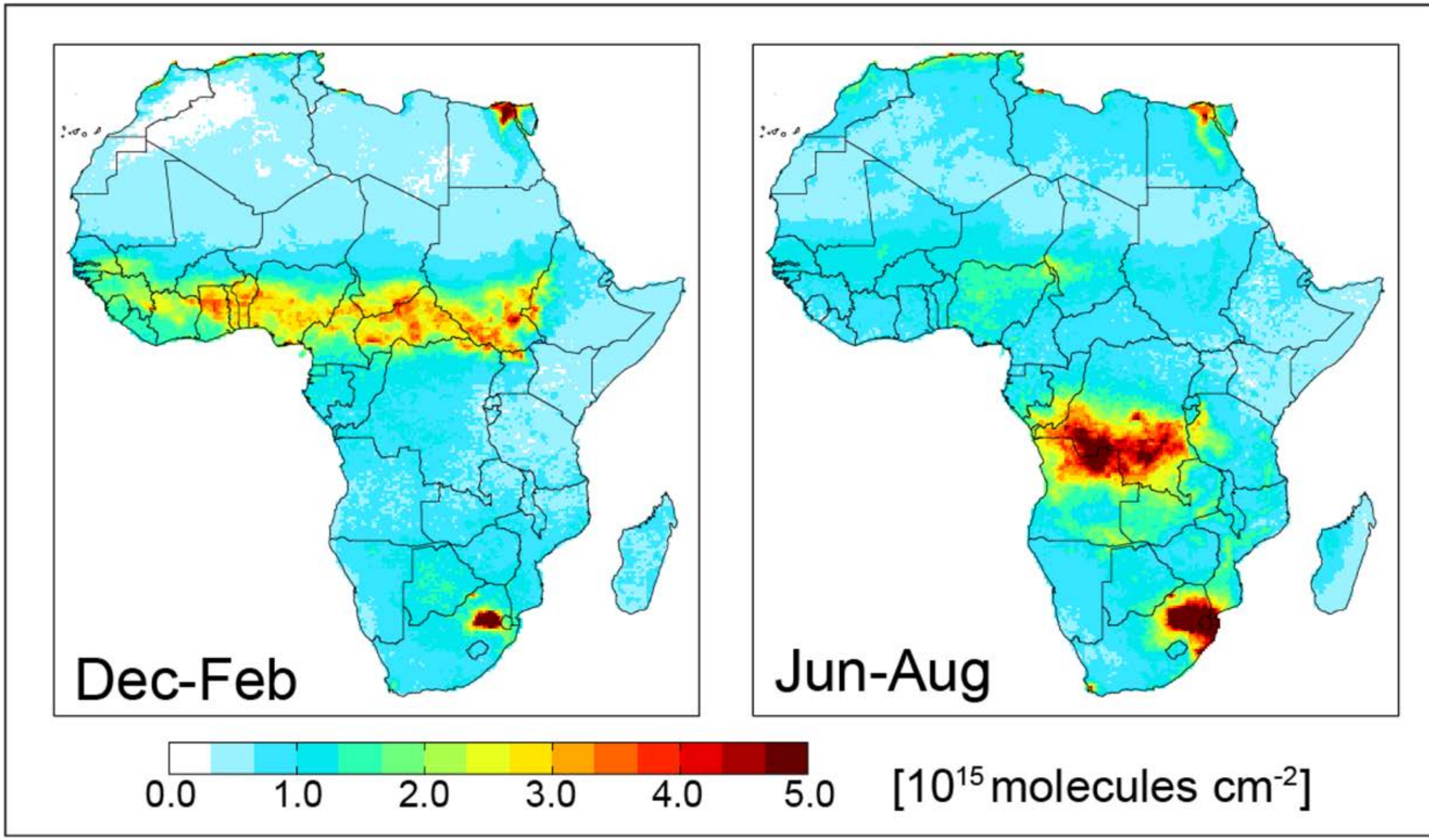
Air pollution in Africa and the impact on health

Eloise Marais
with Alfred Bockarie (PhD student),
R. F. Silvern, L. J. Mickley, A. Vodonos, J. Scwhartz

UNIVERSITY OF LEICESTER

Air Pollution in Africa

Seasonal mean tropospheric NO_2 column densities for 2006-2007

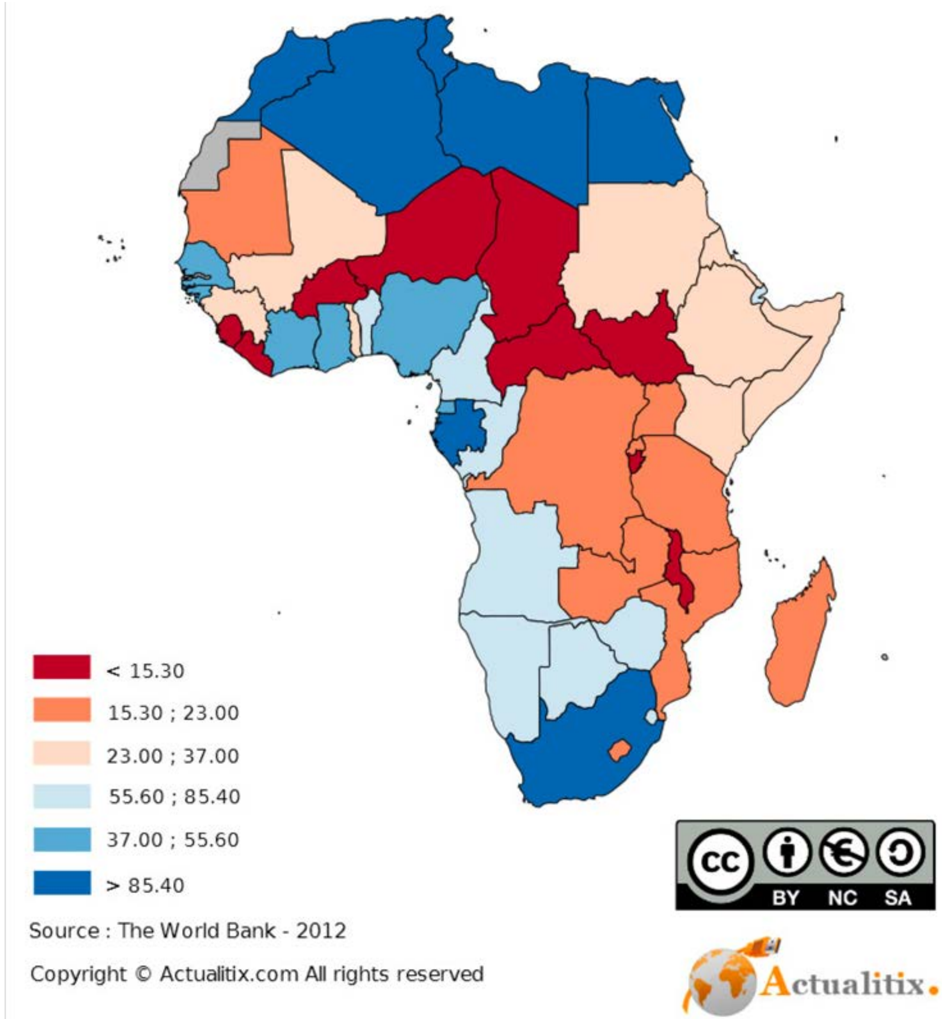


[Adapted from Marais and Chance, 2015]

Anthropogenic sources dominated by **diffuse, inefficient combustion**

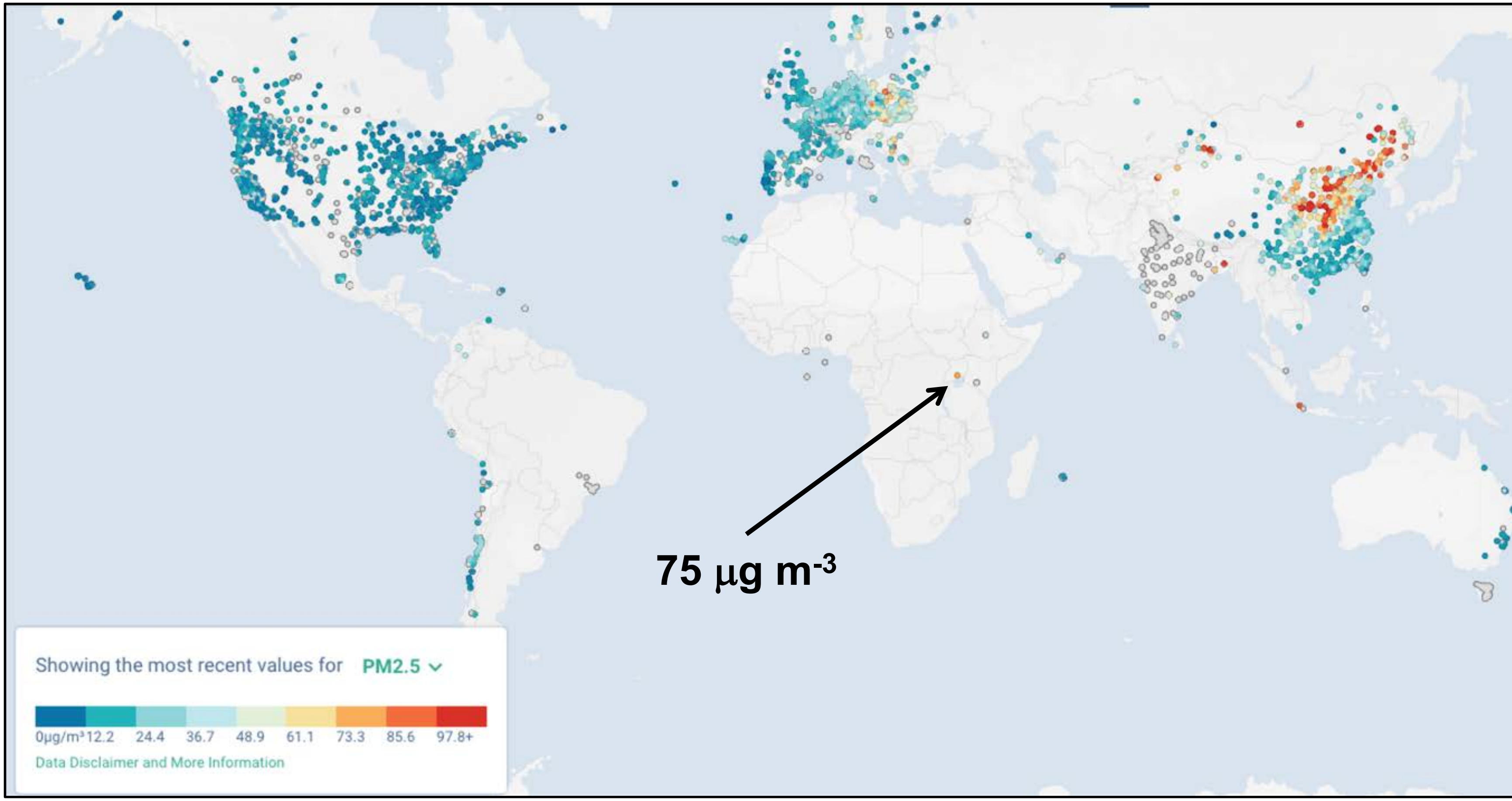
Limited Access to On-Grid Electricity

Access to Electricity (% of population)



Varies from >85% for South Africa to <15% for Chad/Niger/Malawi

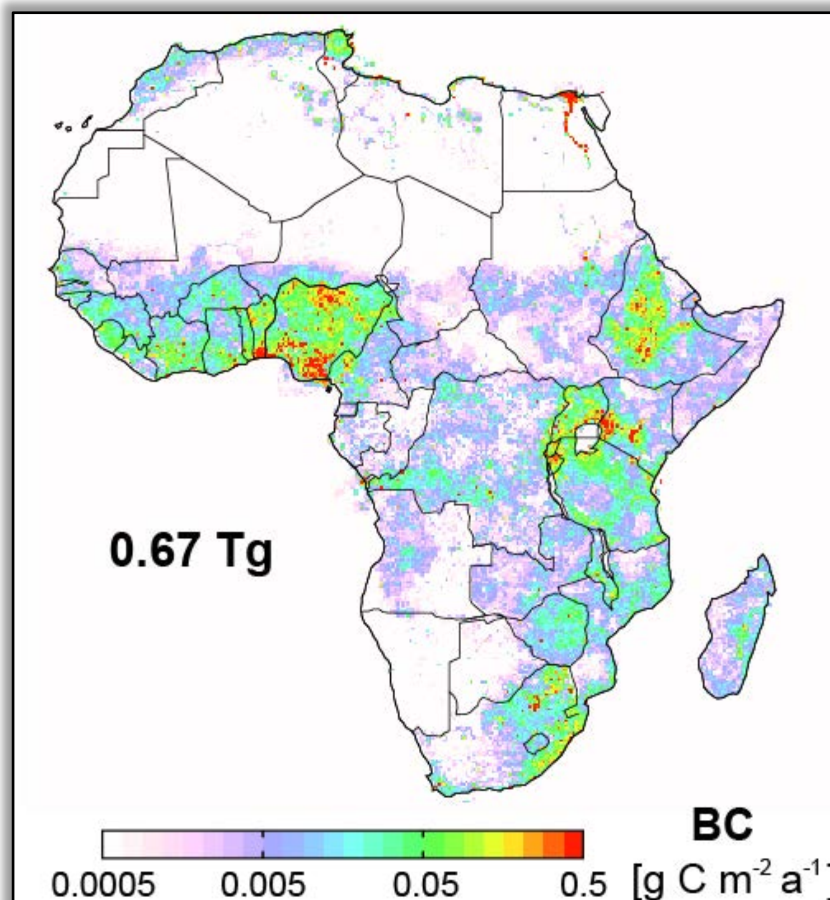
Severely Limited Surface Measurements



[OpenAQ, Accessed 18 February 2019]

Diffuse and Inefficient Combustion Emissions (DICE-Africa)

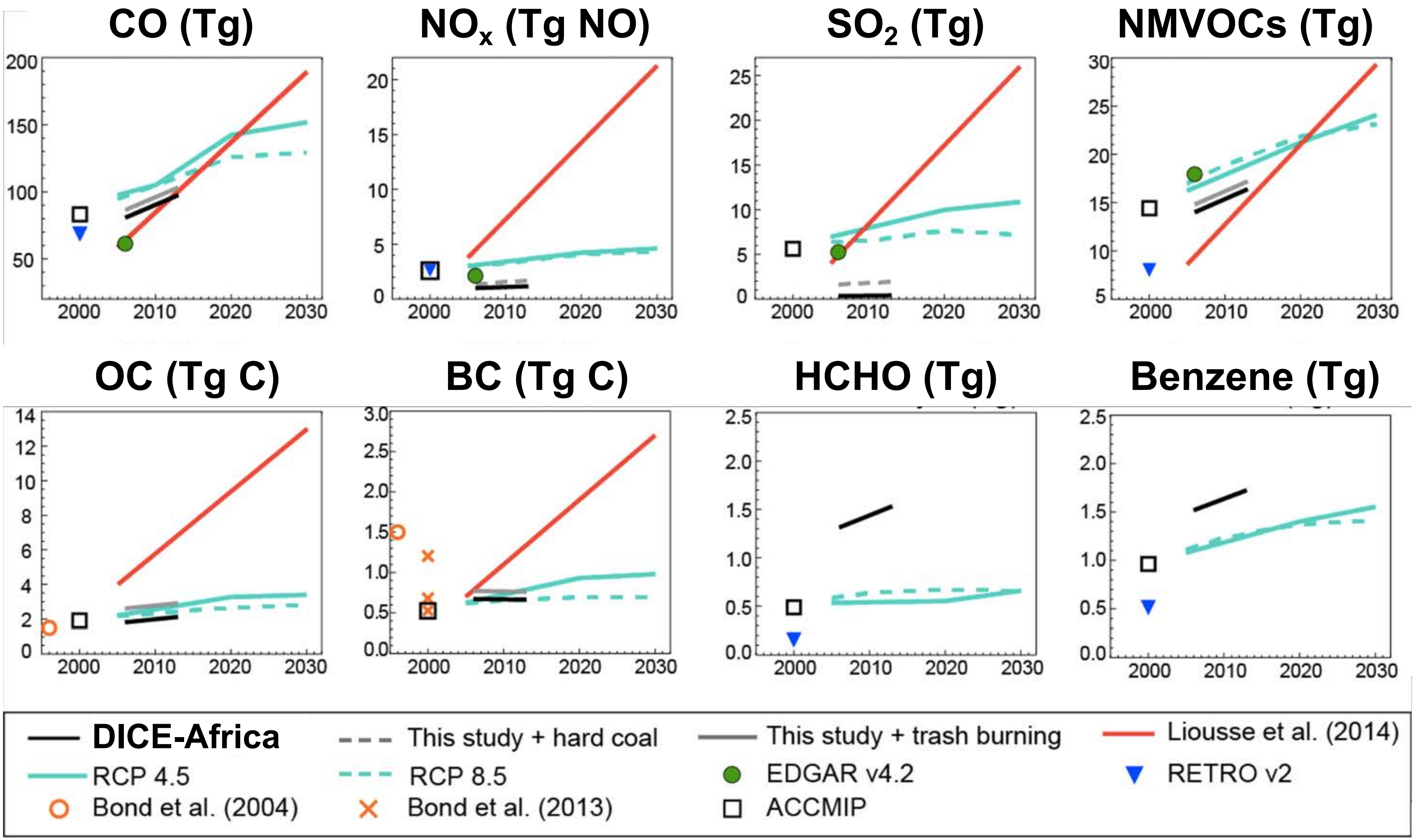
Black Carbon



[Marais and Wiedinmyer, 2016]

DICE and open fire emissions similar for many pollutants

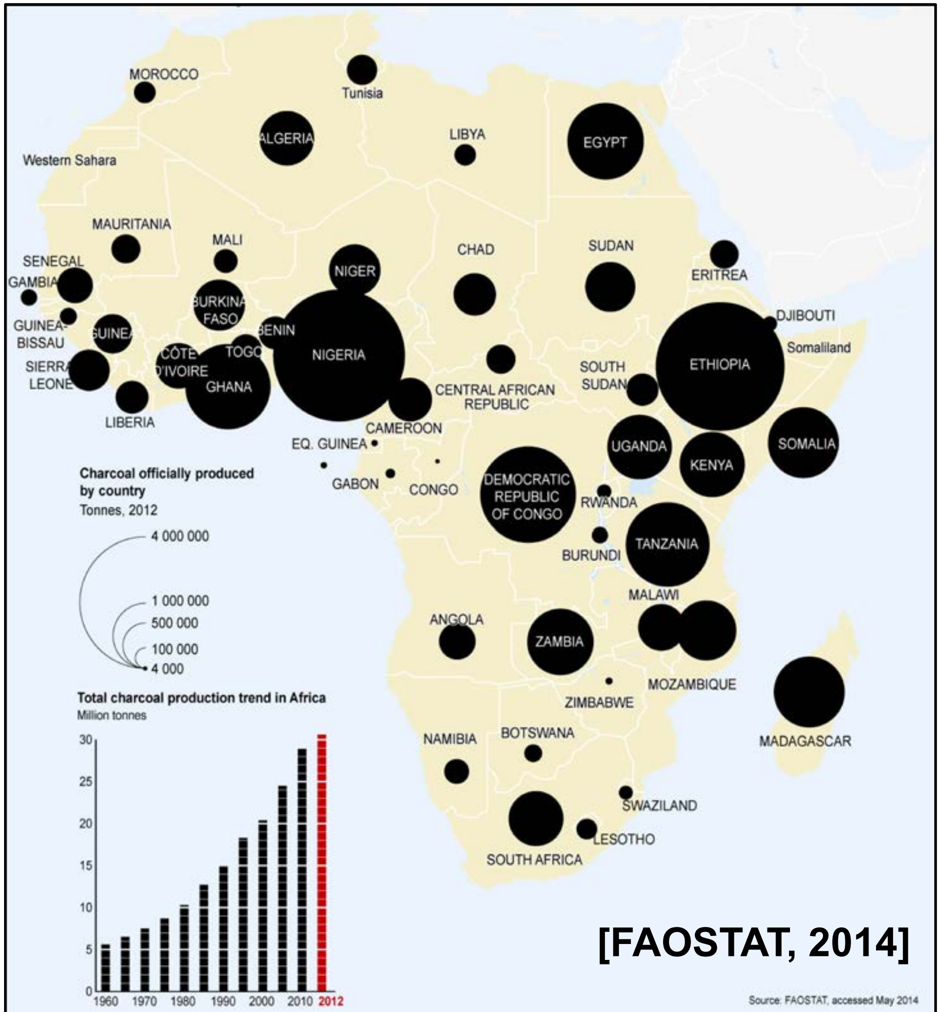
Emissions Trends and Projections for Africa



Wide range of emissions trends and projections. Which is correct?

A Focus on Charcoal Production

Charcoal Production in Africa



[FAOSTAT, 2014]

6-9% per year increase in production

Major export in Somalia fueling civil unrest there

Improved representation of charcoal emissions

Production (RURAL)

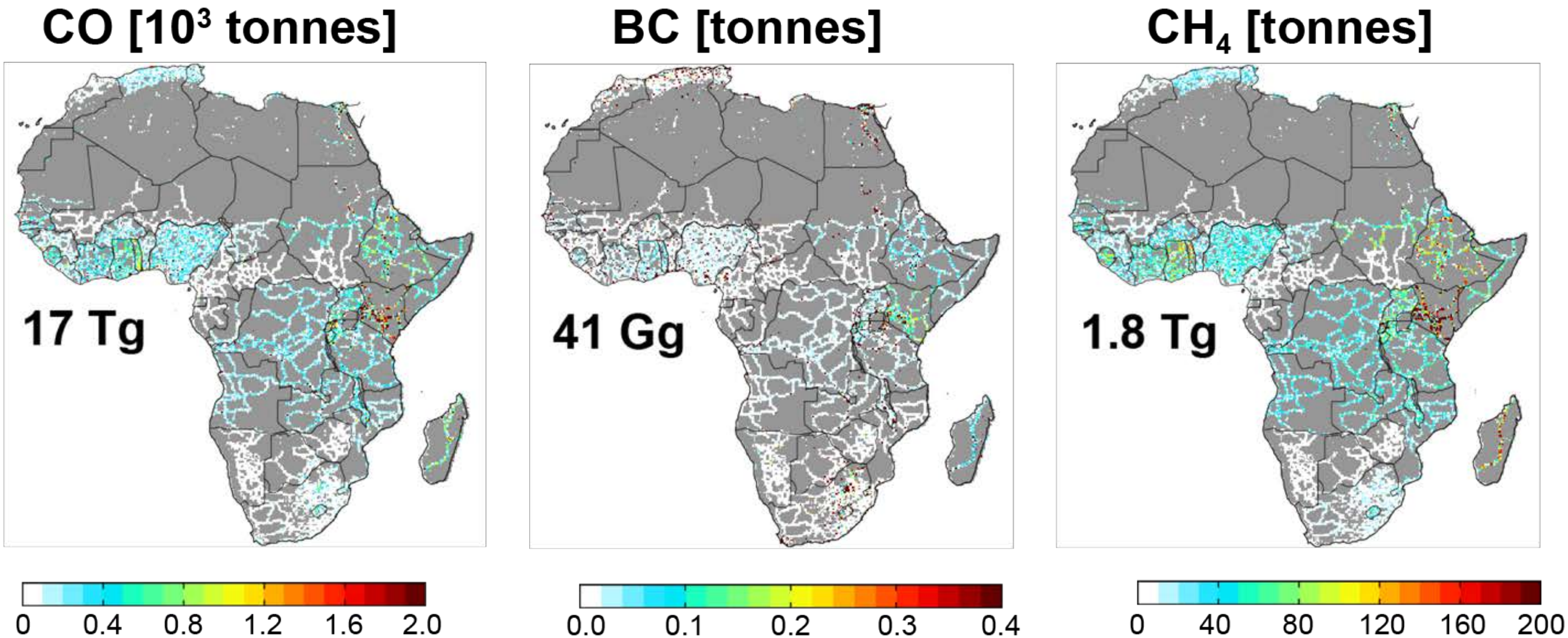
Transport

Use (URBAN)

Including burning plastic

Improved representation of charcoal emissions

Pollutant emissions from charcoal production, use and transport

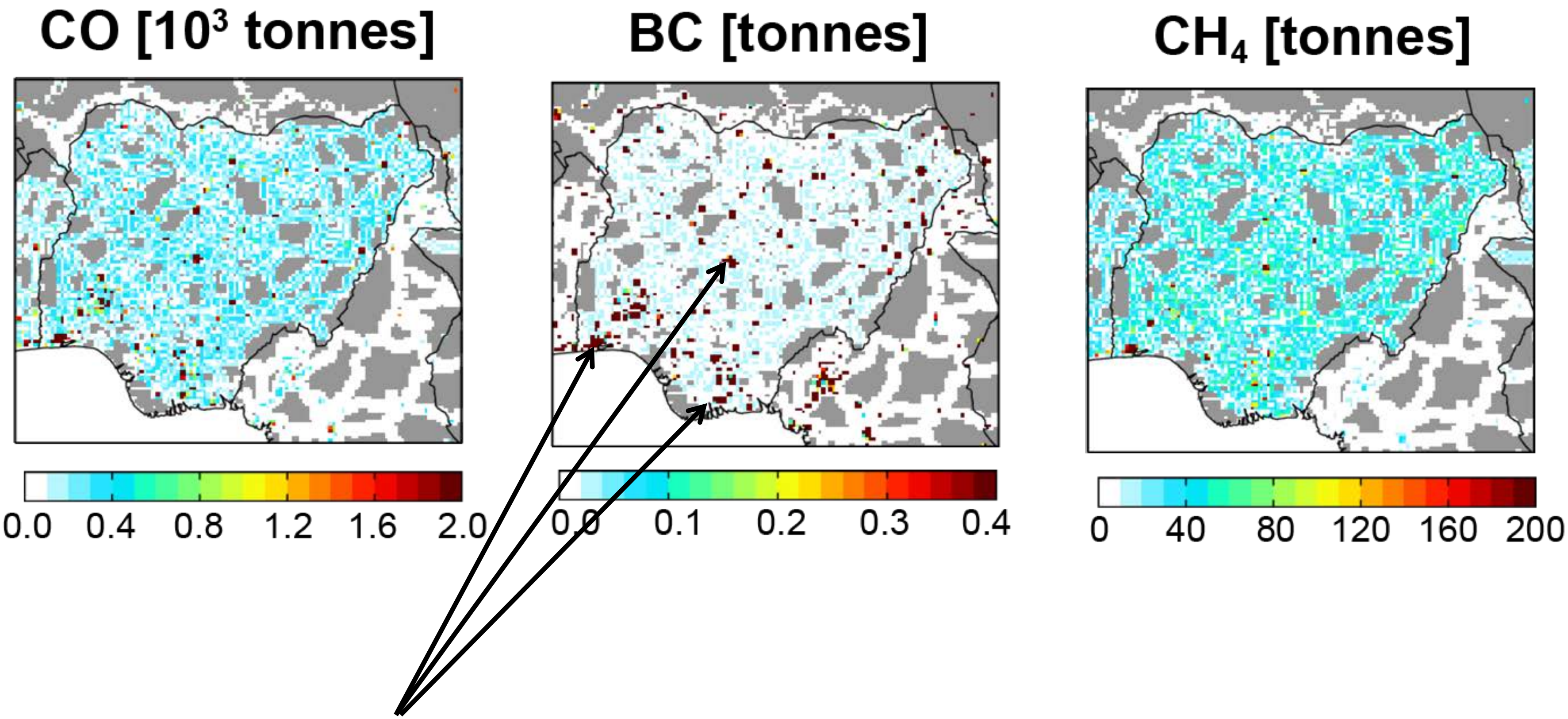


Annual biomass burning emissions in Africa:

440 Tg CO; **2.6 Tg BC**; **15 Tg CH_4** [Y. Shi et al., 2015]

Improved representation of charcoal emissions

Zoom in to Nigeria (largest charcoal producer in Africa)



Hot spots in urban centres

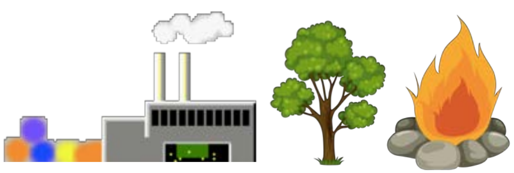
Question we'd like to answer with this inventory:

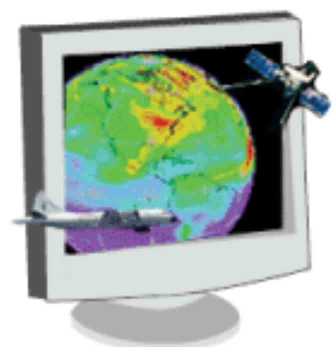
Is charcoal production in Africa sustainable?

GEOS-Chem: Chemical Transport Model

GEOS-Chem

Emissions
(natural/human)





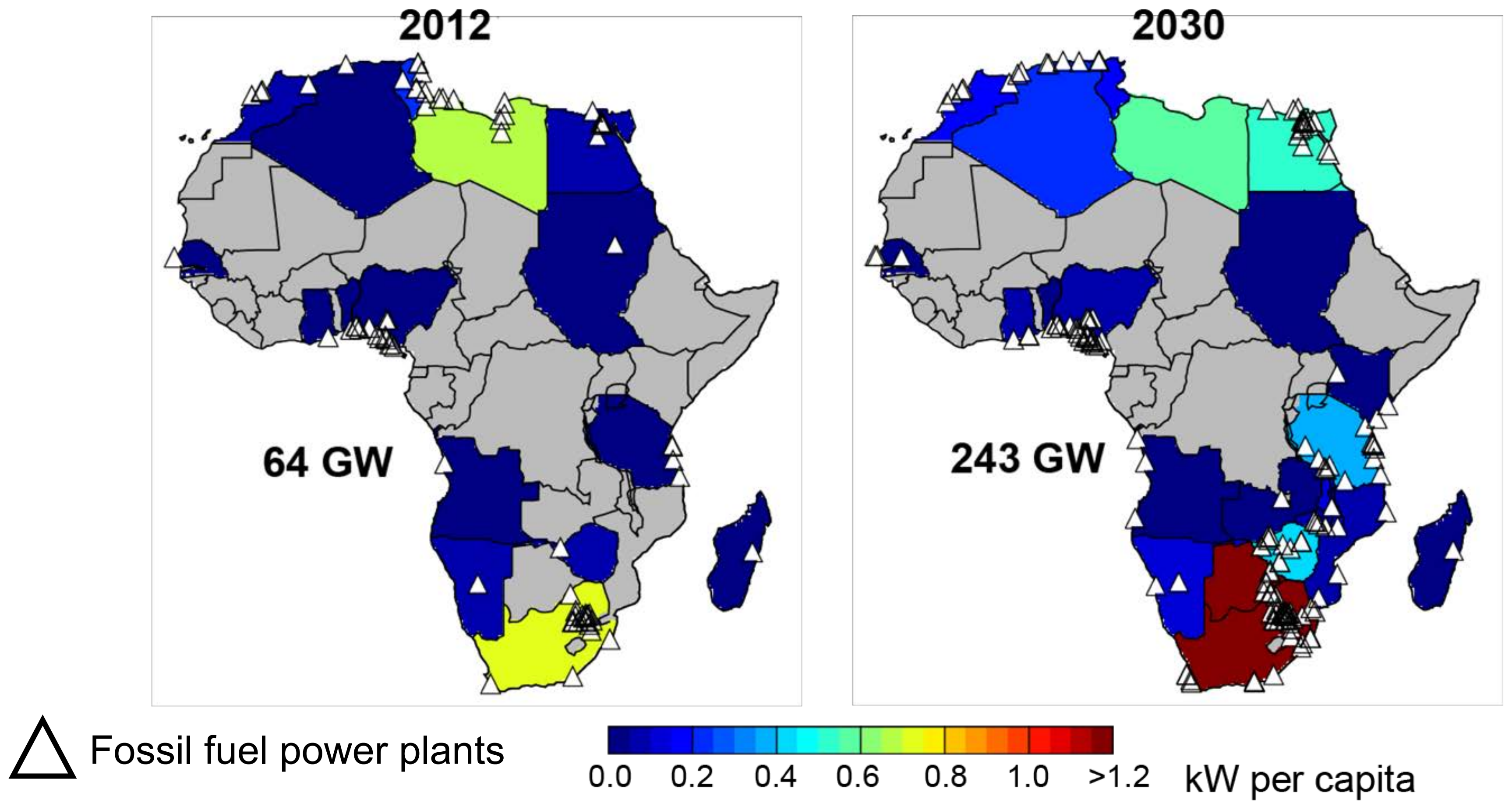
Offline assimilated
meteorology
(NASA GMAO)

Chemistry
Transport
Dry/wet deposition

3D global/regional atmospheric concentrations

Future Fossil Fuel Impact on Health

Per capita generating capacity



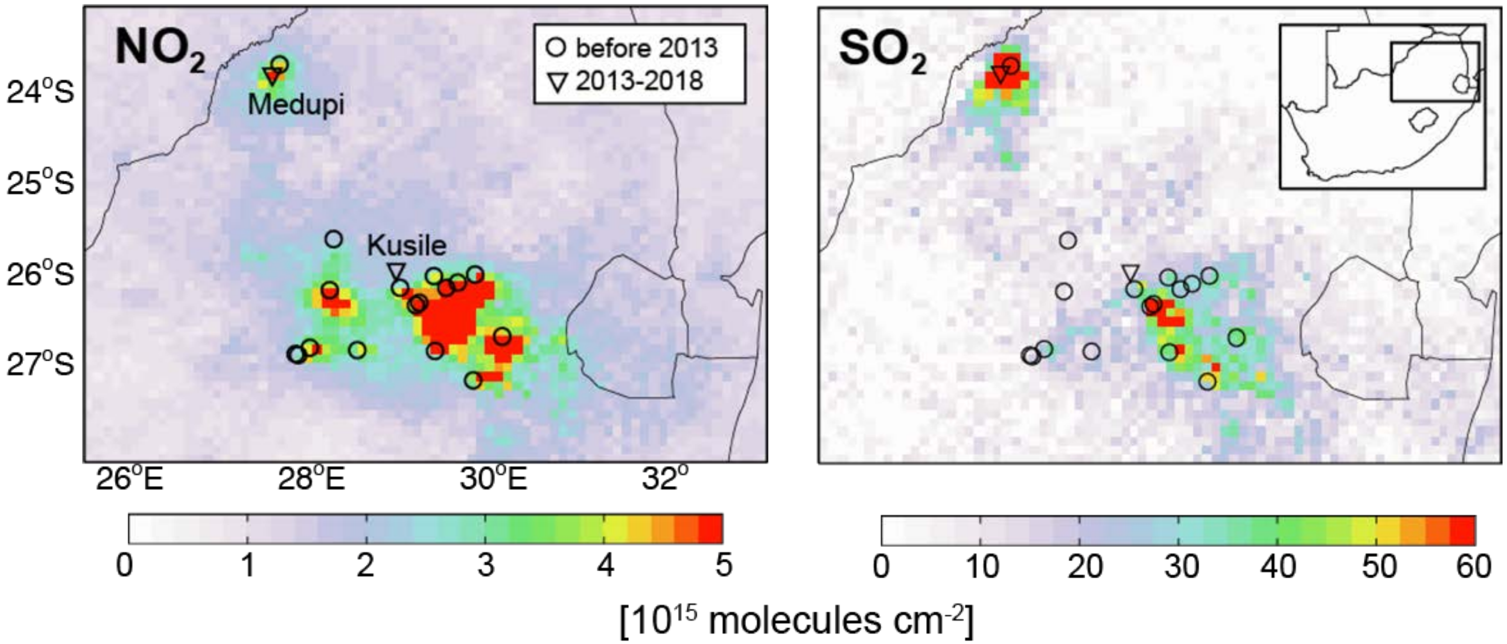
Generating capacity to increase by almost 300%
(mostly North and southern Africa)

The Wallace Foundation®

Already Evidence of AQ Degradation

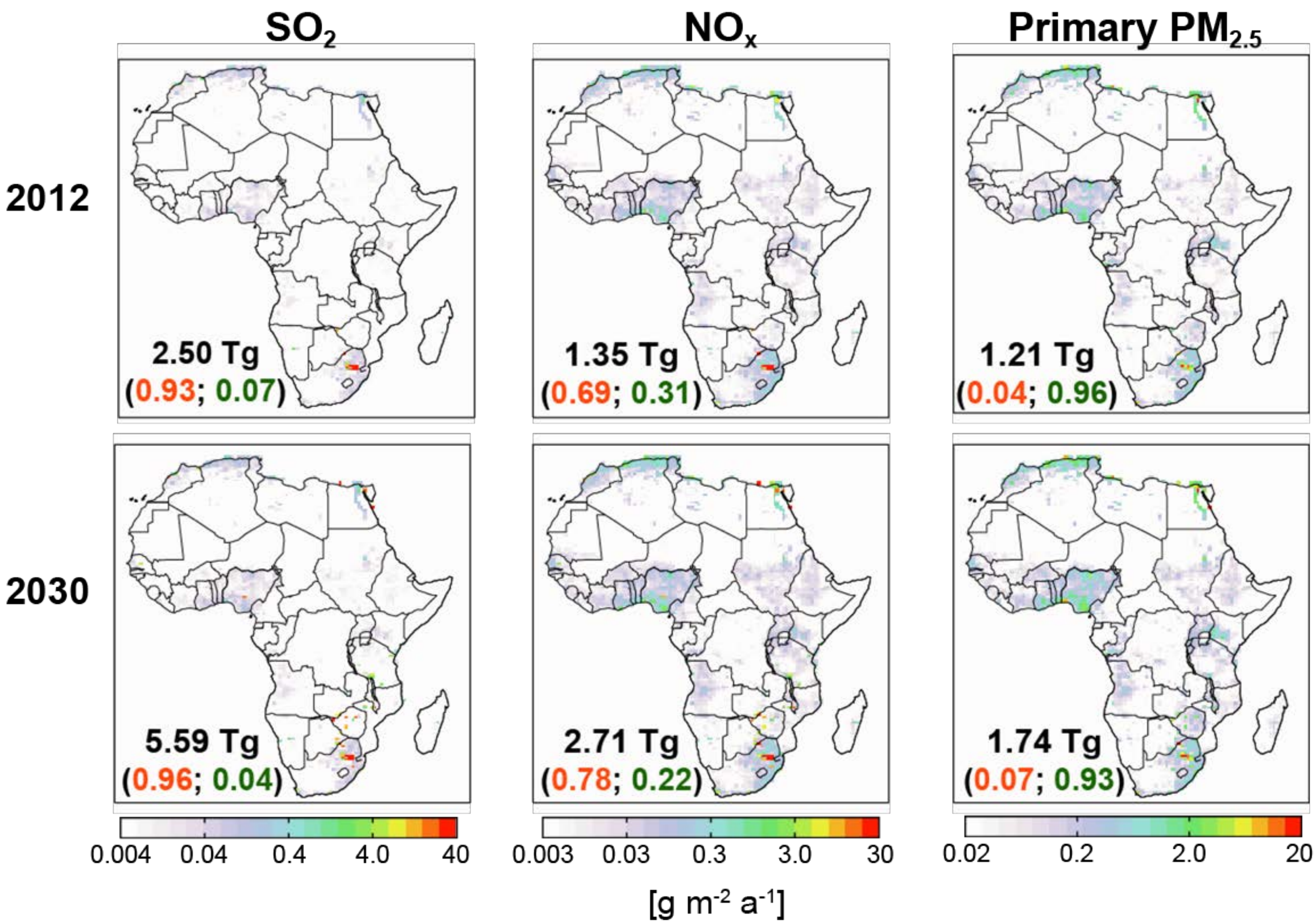
Earth observations of NO_2 from the high-resolution TROPOMI instrument

TROPOMI NO_2 and SO_2 at 0.1º x 0.1º for December 2018



Satellite observations support air quality degradation at the location of the new Medupi power plant

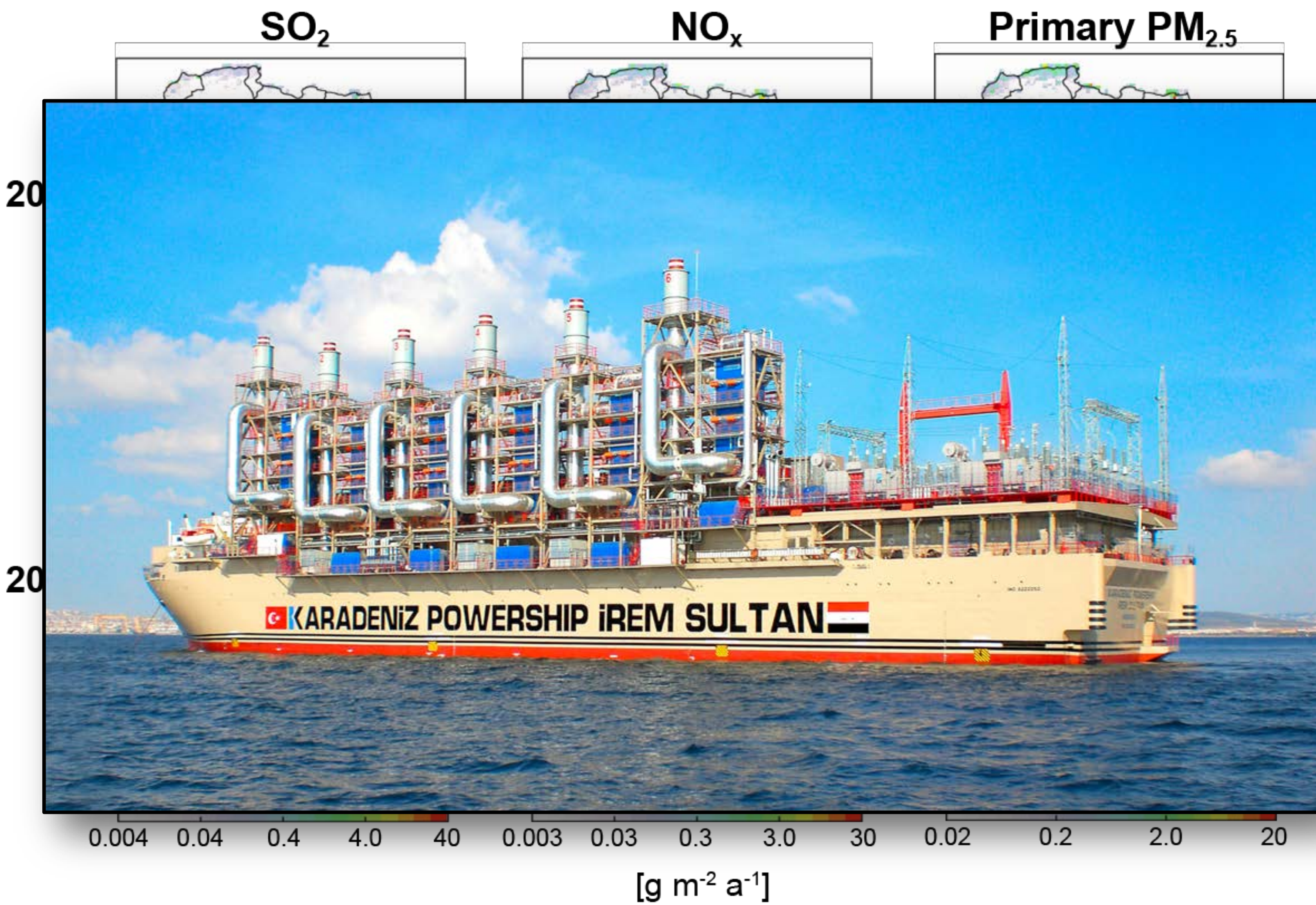
Emissions from current and future fossil fuels in Africa



Black: total continent emissions

Fractional contribution from power plants (red) and vehicles (green)

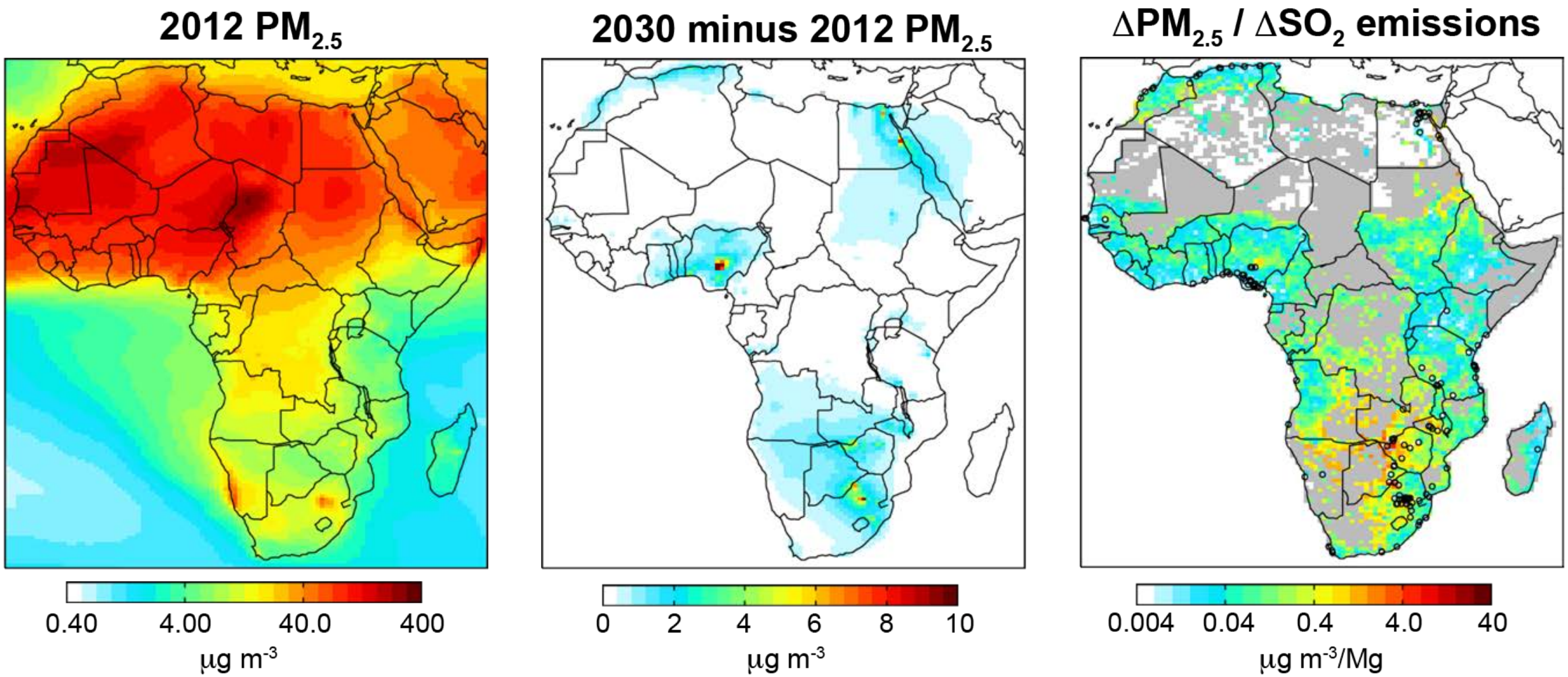
Emissions from current and future fossil fuels in Africa



Black: total continent emissions

Fractional contribution from power plants (red) and vehicles (green)

$PM_{2.5}$ from fossil fuels

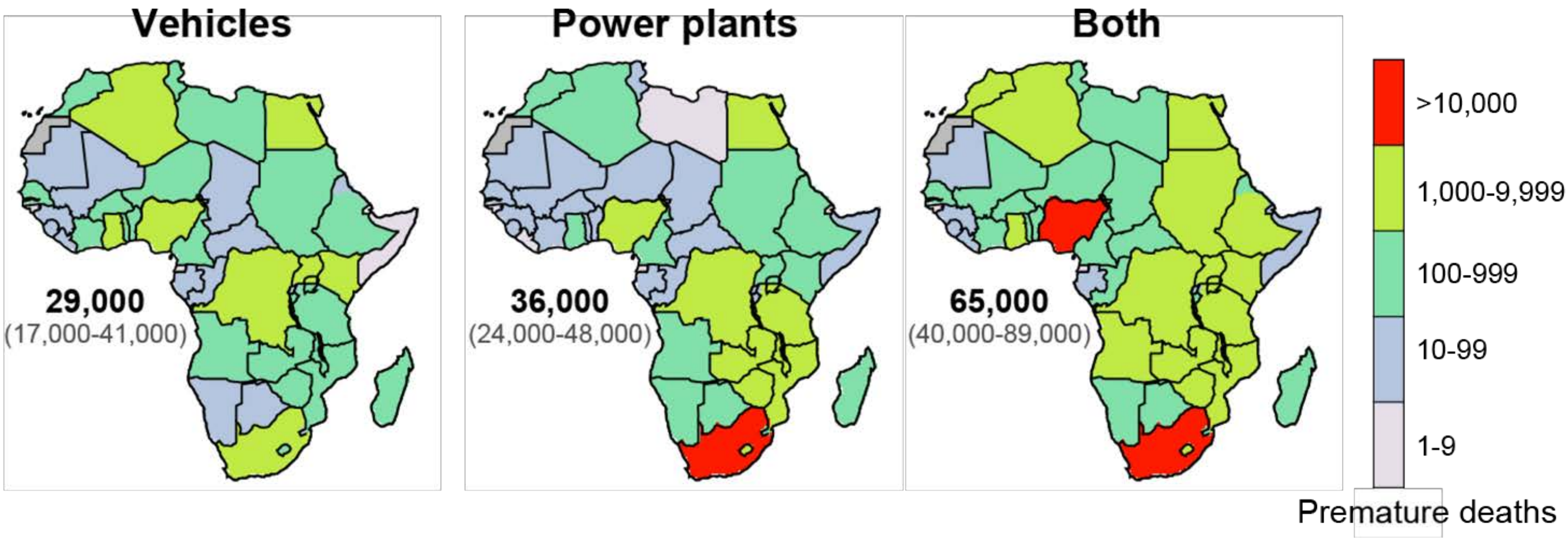


Absolute contribution dominated by dust

>10 μg m^{-3} increase in locations in Nigeria, Egypt and South Africa

Greatest sensitivity of $PM_{2.5}$ to SO_2 emissions is downwind of the source

The Impact on Health



Total premature deaths in Africa: 65,000

Equal contribution from vehicles and power plants, as increase in vehicles and population coincide (urban centres)

Long-Term Changes in Air Pollution in Cities

A focus on the UK and application to India

with Karn Vohra (PhD student),
Satellite Applications Catapult, Birmingham City Council, Defra

UK Sources: Cars and Wood Burners

In 2.5 million homes in the UK

INDEPENDENT

Environment

Each car in London costs NHS and society £8,000 due to air pollution, report finds

'We know the health impacts of air pollution, and now the economic case for cleaning up the air we breathe has been laid bare'

Josh Gabbatiss Science Correspondent | @josh_gabbatiss | Wednesday 6 June 2018 00:13 | 27 comments

Annual Emission Checks Exclude NO_x

Ministry of Transport (MOT) test

Petrol

n name: KwikFit
tion address: 291 - 295 Bearwood Road
Smethwick
Birmingham
B66 4DP
VIEA number: V100933

Date: 06/09/2018
Odometer:
VRN: FP54FLV
Tester: H.Khan
Fuel Type: Petrol
Time: 09:27:07
Make:
Model:
Engine Size: 1299 cc

MOT Exhaust Emissions Test Results

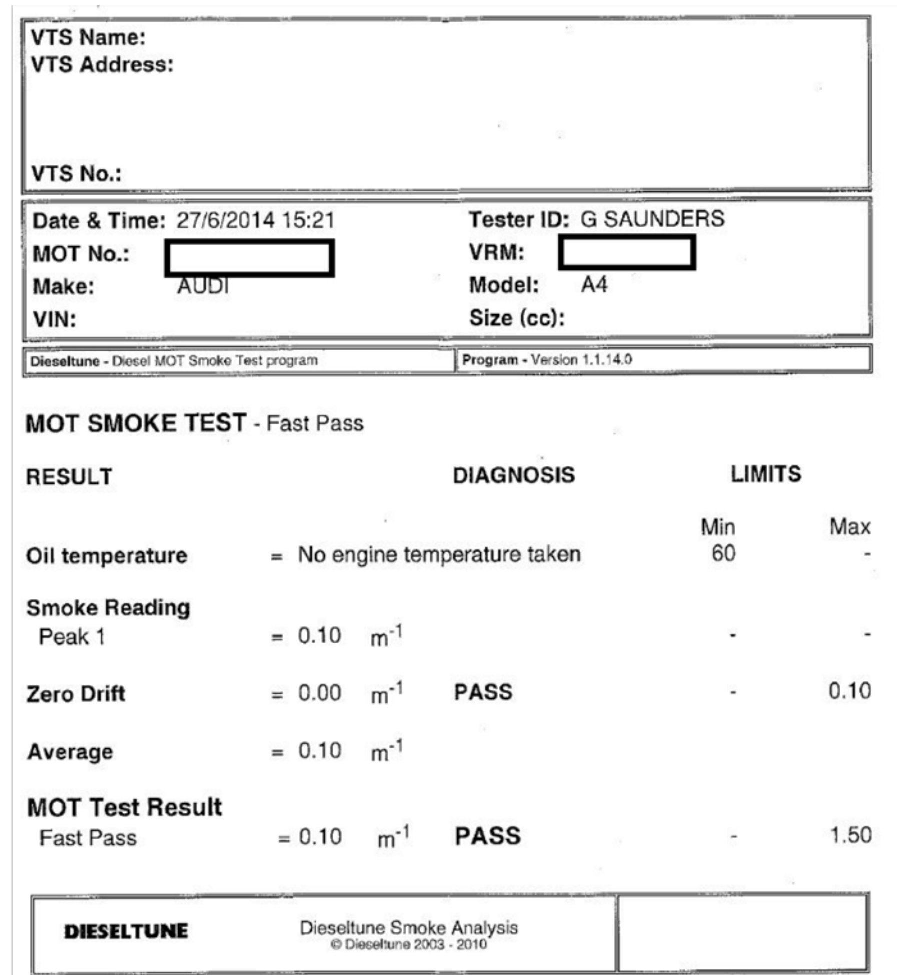
Basic Emission Test

Result			Diagnosis	Limits min	max
Fast Idle Test			Pass		
Engine Speed	= Manual Check		Pass	2500	3000
CO	= 0.01	% vol	Pass	-	0.20
HC	= 0	ppm	Pass	-	200
Lambda	= 1.003		Pass	0.970	1.030
Natural Idle Test			Pass		
Engine Speed	= Manual Check		Pass	450	1500
CO	= 0.00	% vol	Pass	-	0.30
OVERALL RESULT EXHAUST EMISSIONS TEST			Pass		

Engine oil temperature check:Temperature gauge showed warm engine
Engine speed measurement by-passed

Page 1 of 1

Diesel



VTS Name:
VTS Address:

VTS No.:

Date & Time: 27/6/2014 15:21 **Tester ID:** G SAUNDERS
MOT No.: **VRM:**
Make: AUDI **Model:** A4
VIN: **Size (cc):**

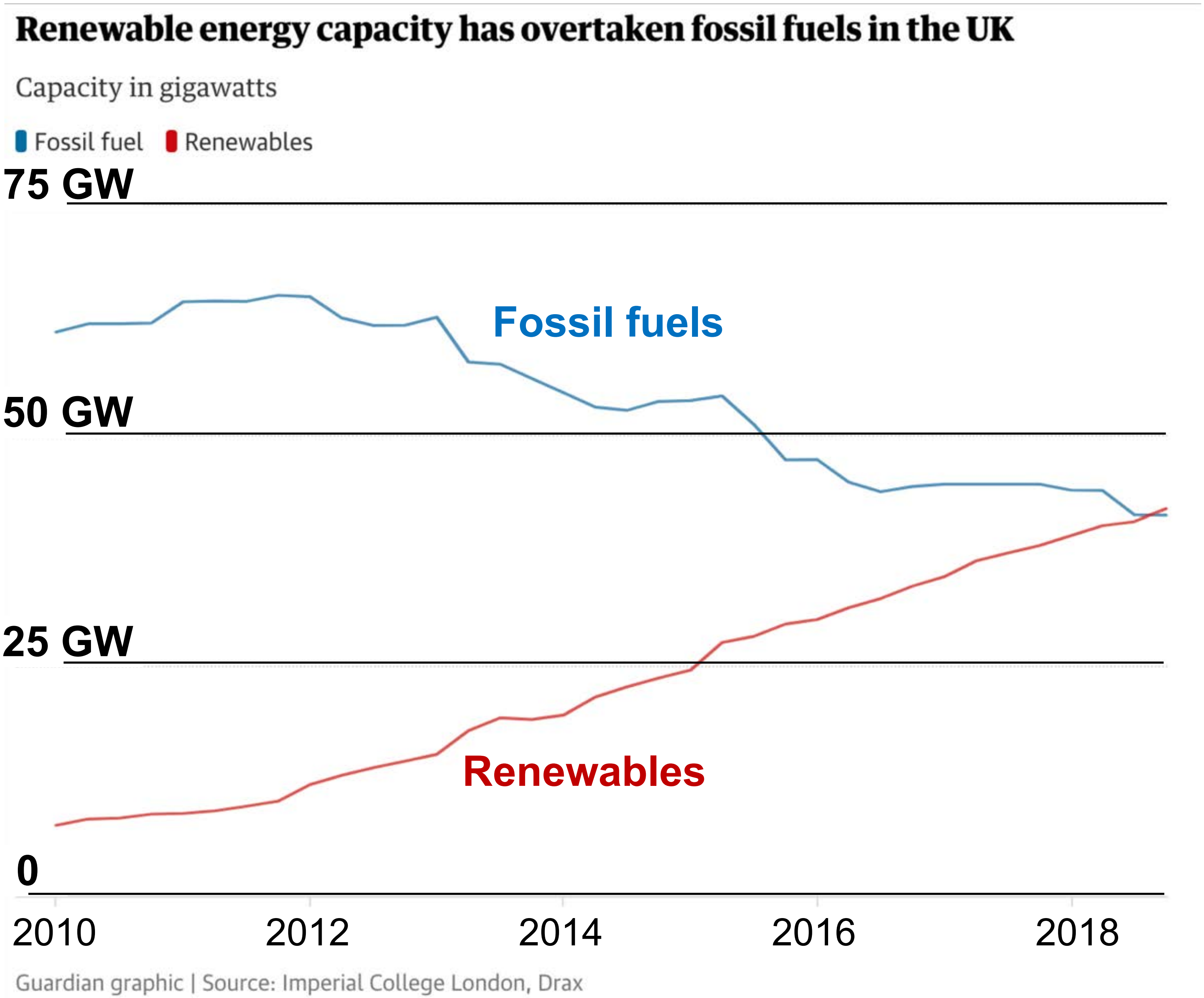
Dieseltune - Diesel MOT Smoke Test program | **Program** - Version 1.1.14.0

MOT SMOKE TEST - Fast Pass

RESULT			**DIAGNOSIS**	**LIMITS** Min	Max
Oil temperature	= No engine temperature taken			60	-
Smoke Reading Peak 1	= 0.10	m^{-1}		-	-
Zero Drift	= 0.00	m^{-1}	**PASS**	-	0.10
Average	= 0.10	m^{-1}			
MOT Test Result Fast Pass	= 0.10	m^{-1}	**PASS**	-	1.50

DIESELTUNE Dieseltune Smoke Analysis
© Dieseltune 2003 - 2010

UK Renewables Surpass Fossil Fuels

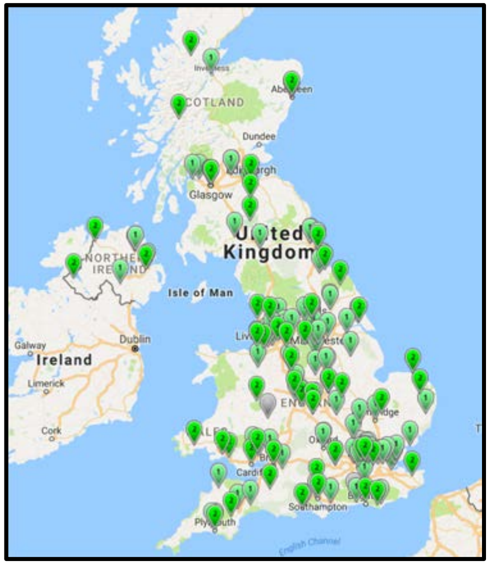


UK Air Quality Monitoring

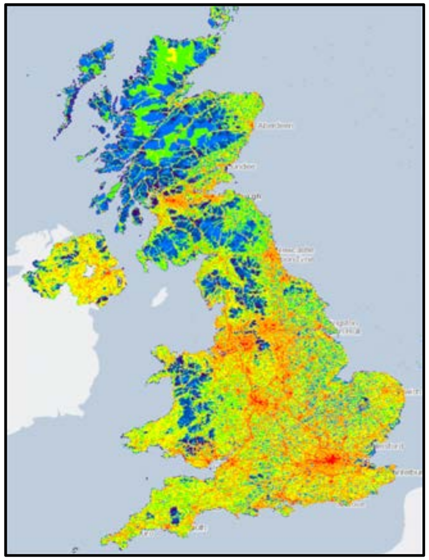
Current Approach:

- Surface monitoring network
- National Atmospheric Emission Inventory (NAEI)
- Air quality models
- Entities: Environment Agency, local city councils, universities, Environmental Consultants

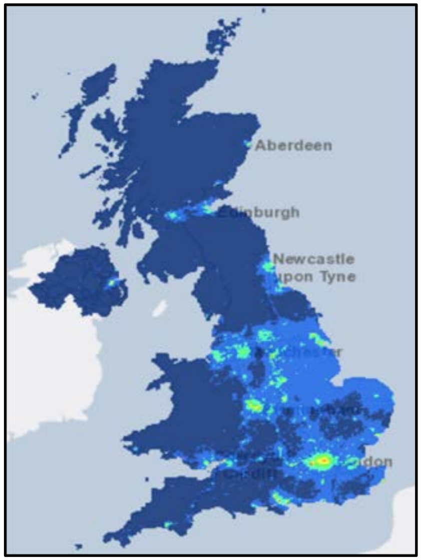
Network



Emissions



Models



UK Air Quality Monitoring

Shortcomings:

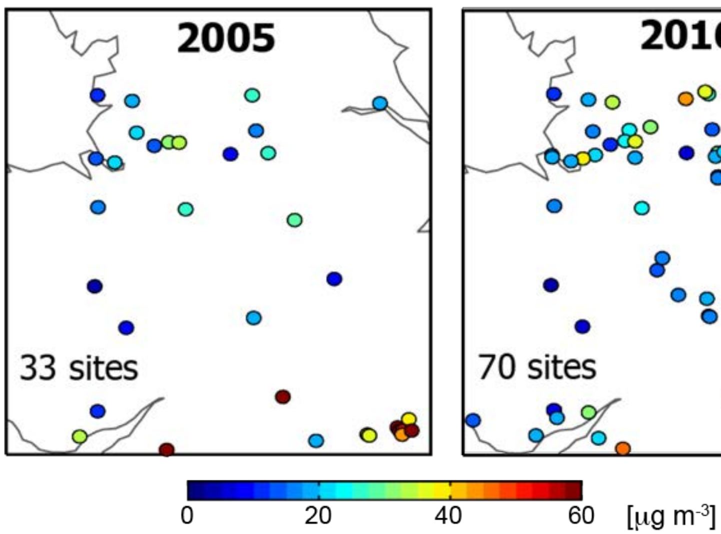
- **Austerity** (need to do more with less)
- **Costly** (£52k-£173k per monitor)
- **Large gaps** (space, time, frequency, pollutants)
- NAEI **inconsistent** from year-to-year
- **Limited validation** (large uncertainties)
- **Laborious**

Impacts efficacy of policy and leads to large fines (>£60M)

UK Air Quality Monitoring

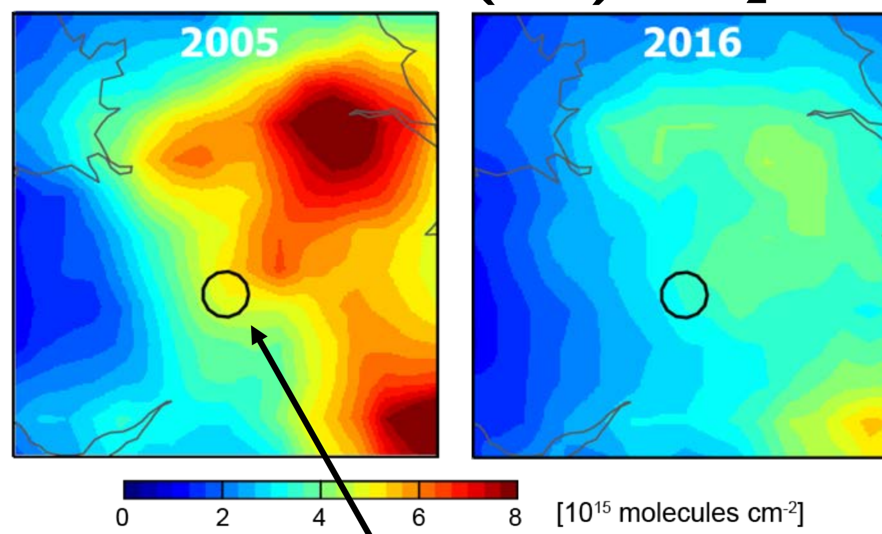
Earth observations are the only viable solution to address data gaps!

DEFRA (surface) NO_2



Excludes city council measurements

Aura OMI (EO) NO_2



Birmingham:

3% per year decline in NO_2

Demands advanced skills to use and interpret, limited in-house expertise

Tool for Recording and Assessing the City Environment

TRACE

A data transformation and interpretation service to integrate Earth observations in air quality policy

NERC SCIENCE OF THE ENVIRONMENT

EPSRC Engineering and Physical Sciences Research Council

CATAPULT Satellite Applications

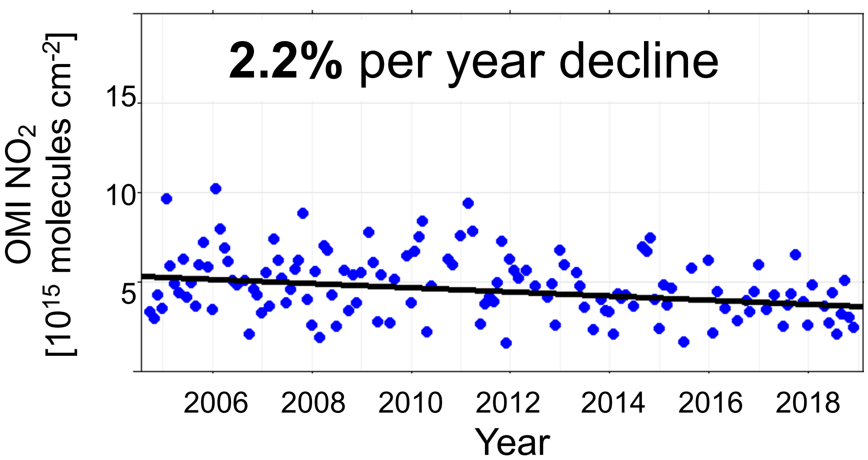
Birmingham City Council

defra Department for Environment Food and Rural Affairs

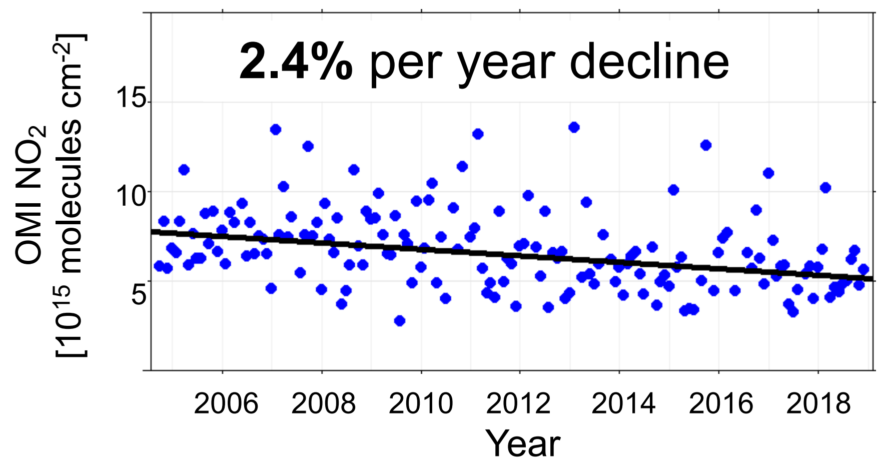
NO_2 trends for Cities in the UK

TRACE

Birmingham (2005-2018)



London (2005-2018)



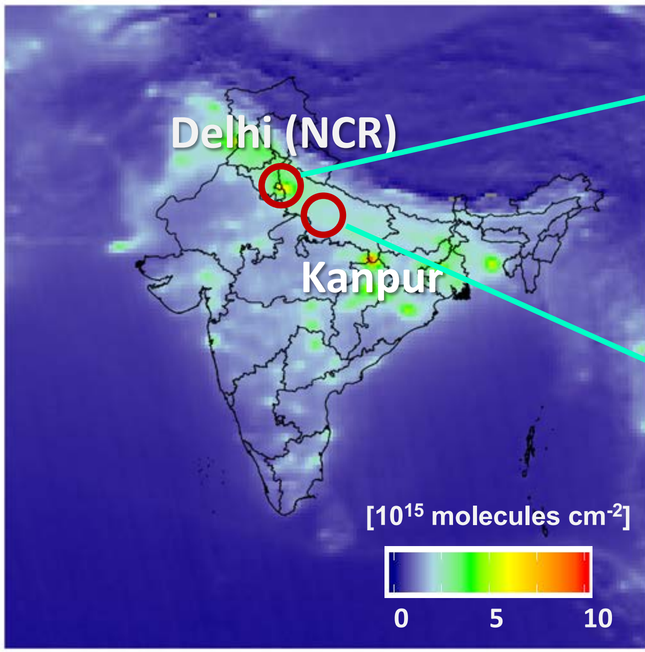
Decline from the London **surface network** is only **1.8% per year**

Less steep than the estimated decline in NO_x emissions (3.9% a^{-1})

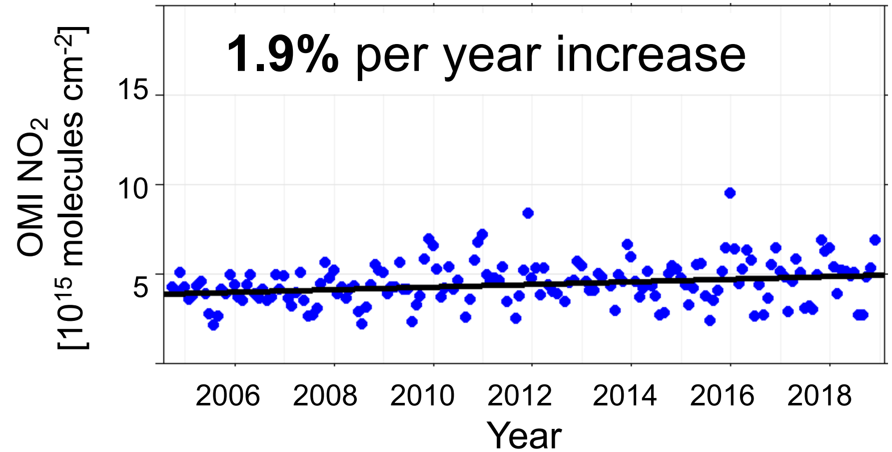
Steeper than published values (Pope et al., 2018):
2.2% a^{-1} for London; 1.6% a^{-1} for Birmingham

NO_2 trends for Cities in India

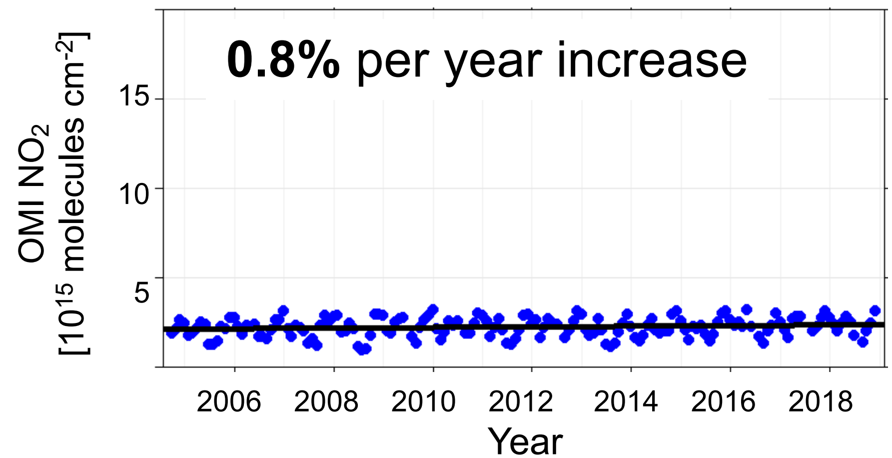
OMI NO_2 (2015-2018)



Delhi (2005-2018)



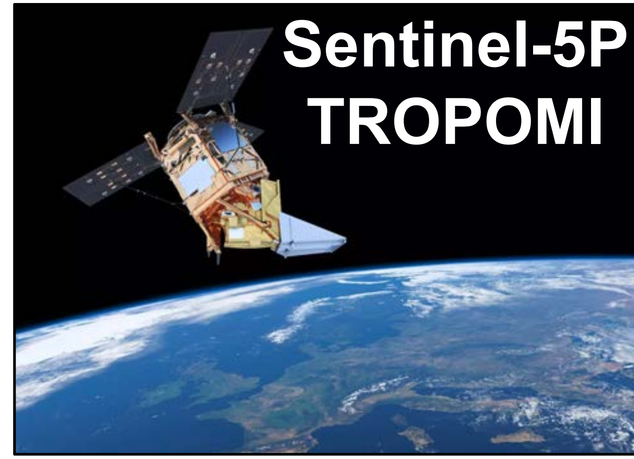
Kanpur (2005-2018)



No sign of influence of air quality policy enacted in 2015

Delhi NO_2 is now similar to London NO_2

Exploit high spatial resolution of TROPOMI

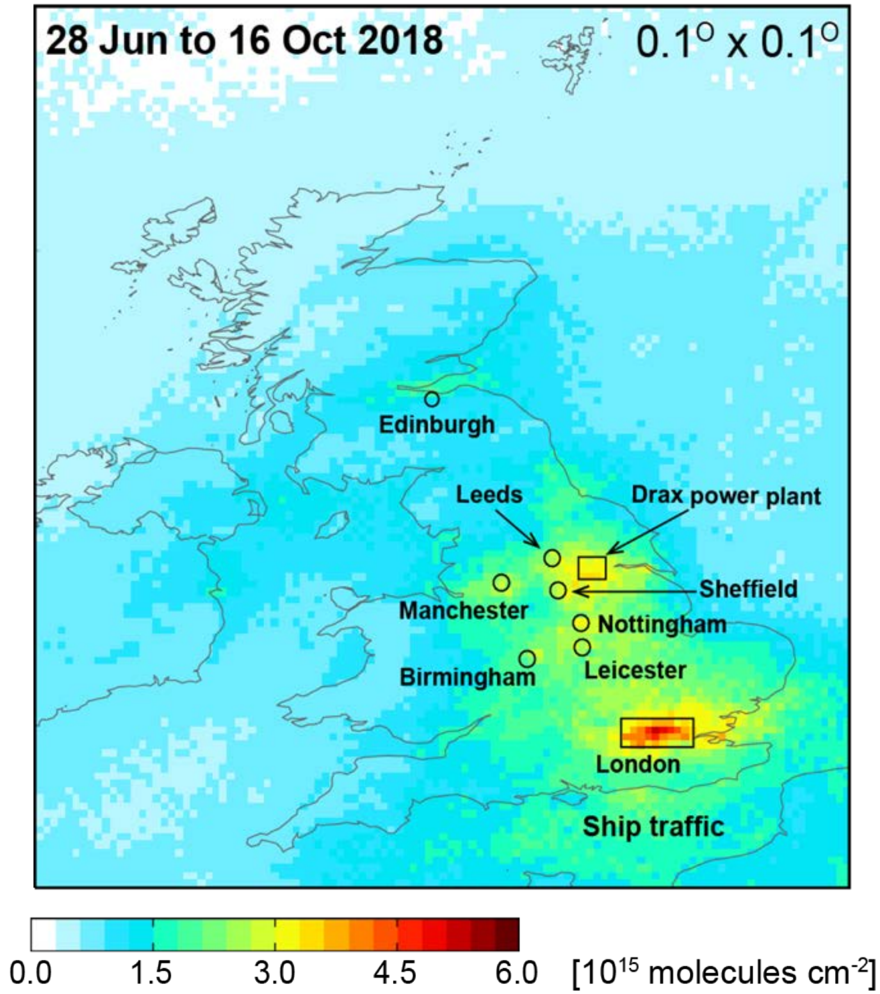


Overpass	13h30 LT	13h30 LT
Compounds	NO_2, O_3, HCHO, SO_2 CHOCHO, AI, AOD	Same as OMI + CH_4 and CO
Resolution	13 km × 24 km	7 km × 3.5 km

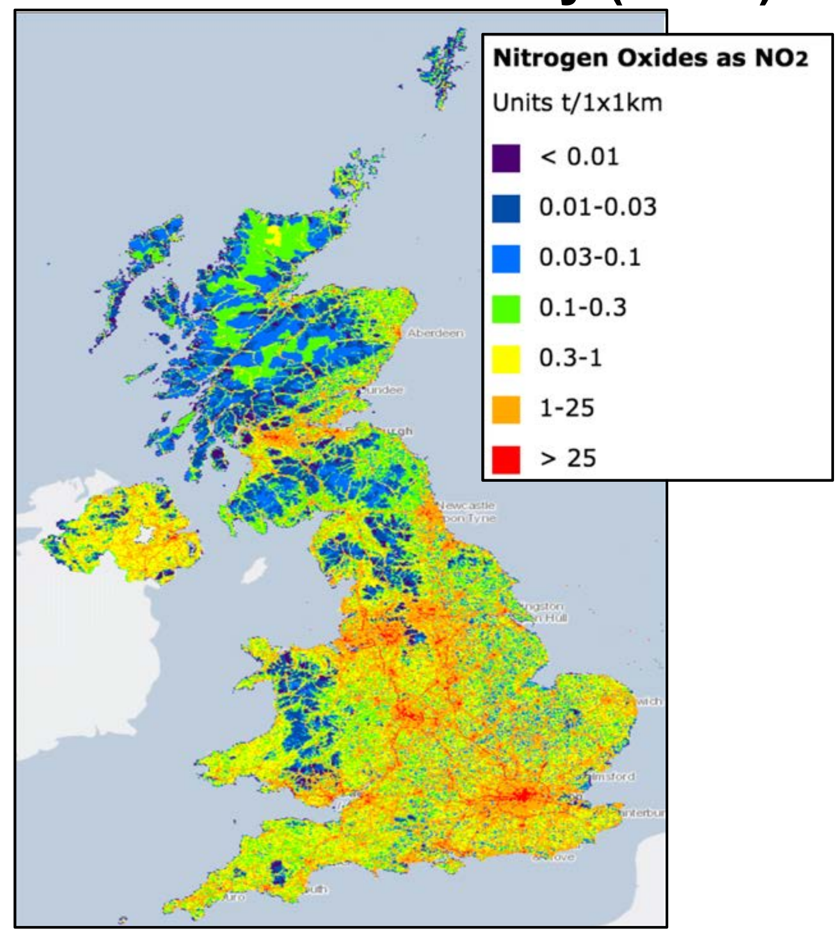
Constrain spatial variability of pollutants and evaluate high-resolution air quality monitoring tools (models and inventory)

Exploit high spatial resolution of TROPOMI

TROPOMI NO_2 over the UK



National Atmospheric Emission Inventory (NAEI)



Evaluate high-resolution emission inventory and air quality models

Acknowledgements

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EPSRC
Engineering and Physical Sciences Research Council