

1 Supporting Information for:

2 **Air Quality and Health Impact of Future Fossil Fuel Use for Electricity Generation and**
3 **Transport in Africa**

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16 Contains: 9 pages (including cover page); description of the attributable fraction calculation; 3
17 tables (SI spreadsheet); and 6 figures.

18 Description of Attributable Fraction Calculation

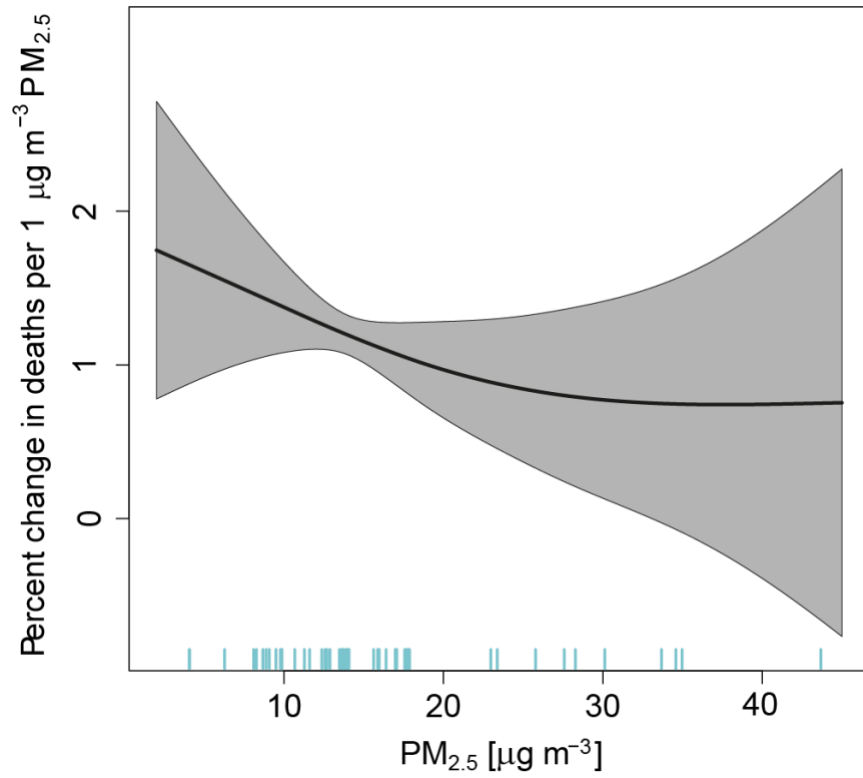
19 The fraction of baseline deaths attributable to exposure to PM_{2.5} in each country in Africa for
20 people > 14 years, the attributable fraction (AF) (Equation (2)), is calculated in each GEOS-
21 Chem gridbox (*i,j*) as follows:

$$23 \quad AF_{i,j} = \frac{\left[\exp(\bar{\beta}_{i,j} \times \Delta x_{i,j}) - 1 \right]}{\exp(\bar{\beta}_{i,j} \times \Delta x_{i,j})} \quad (S1),$$

24
25 where $\Delta x_{i,j}$ is the increase in PM_{2.5} from 2012 to 2030, and $\bar{\beta}_{i,j}$ is the mean estimate of mortality
26 for each grid cell (in % change in mortality per 1 $\mu\text{g m}^{-3}$ PM_{2.5}) determined as the area under the
27 curve shown in Figure S1 between the hazard risk ($\beta_{i,j}$) at the PM_{2.5} for 2012 and for 2030:

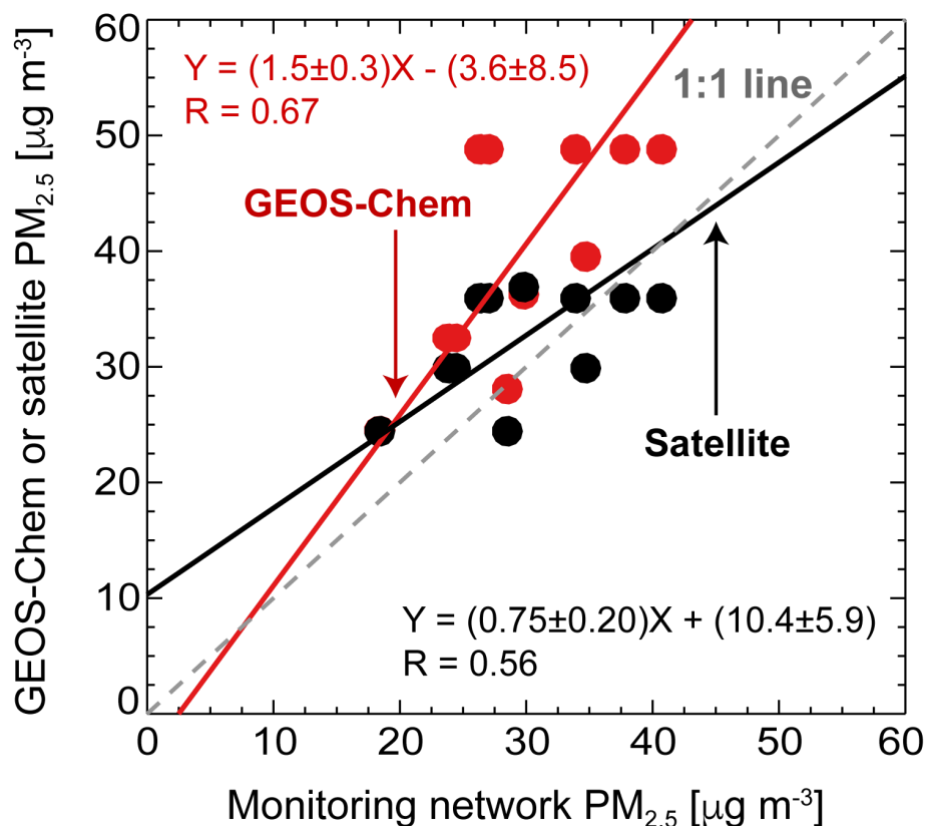
$$29 \quad \bar{\beta}_{i,j}(\text{PM}_{2.5}) = \int_{\text{PM}_{2.5}(2012)}^{\text{PM}_{2.5}(2030)} \beta_{i,j}(\text{PM}_{2.5}) \quad (S2).$$

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31 The relationship shown in Figure S1 was determined from a meta-analysis of the association
32 between long-term exposure to PM_{2.5} and mortality from 53 cohort studies¹. The relationship is
33 non-linear, so percent change in mortality decreases with increase in PM_{2.5}. The meta-analysis
34 approach yields greater sensitivity to a unit change in PM_{2.5} than the Global Exposure Mortality
35 Model (GEMM), detailed in Burnett et al.², for PM_{2.5} > 10 $\mu\text{g m}^{-3}$; opposite for PM_{2.5} < 10 $\mu\text{g m}^{-3}$
36 (Vodonos et al.³). Mortality estimates from GEMM are at least double that obtained with the
37 Integrated Exposure–Response (IER) function used in Global Burden of Disease studies².



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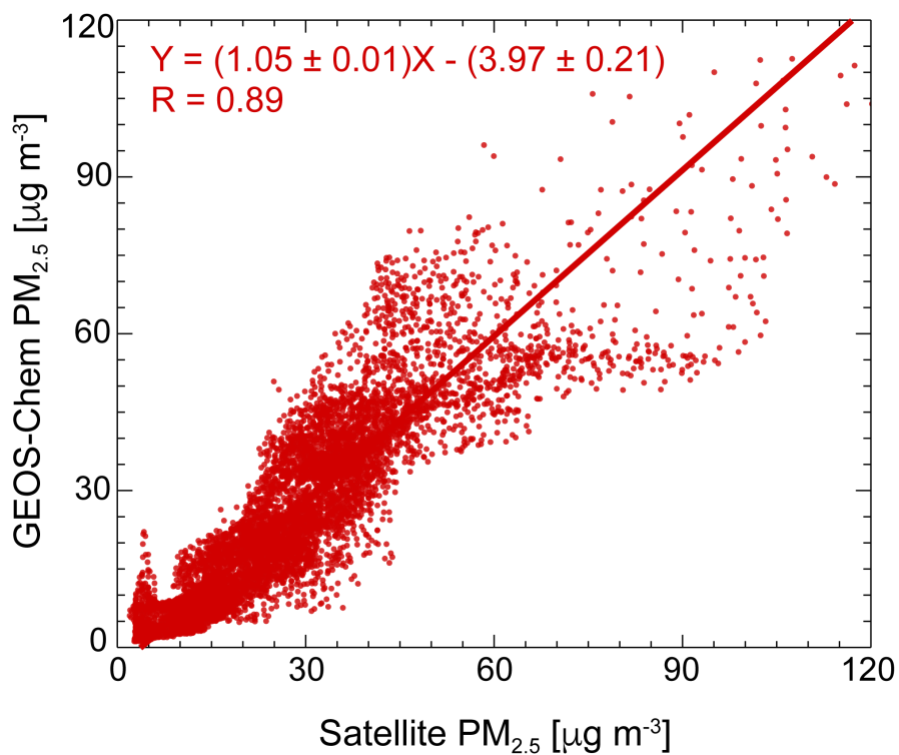
39 **Figure S1.** The shape of the concentration-response curve used in this work. The plot shows the
40 relationship between percent change in mortality per unit change in $PM_{2.5}$ and $PM_{2.5}$
41 concentration. Shading shows the 95% confidence interval. Blue hash marks indicate mean $PM_{2.5}$
42 for each cohort used to generate the model.



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45 **Figure S2.** Evaluation of GEOS-Chem (red) and satellite-derived (black) PM_{2.5} against surface
 46 observations. Points are annual mean PM_{2.5} for 2012. Regional monitoring network PM_{2.5} is the
 47 quality screened South African Air Quality Information System (SAAQIS) data from Garland et
 48 al.⁴ GEOS-Chem and satellite-derived data are the 0.5° × 0.667° grids coincident with the
 49 monitoring sites. Figure S4 shows the spatial distribution of the monitoring network. The
 50 reduced major axis (RMA) regression fits (solid lines) and statistics are shown for GEOS-Chem
 51 (red) and satellite (black) data. The dashed grey line is the 1:1 line.

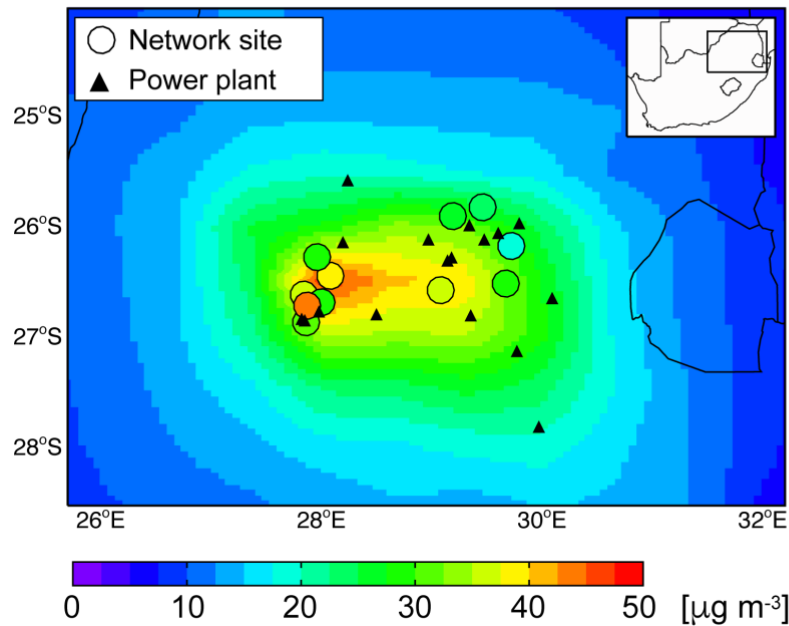


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54 **Figure S3.** Evaluation of GEOS-Chem PM_{2.5} in 2012 with the satellite-derived PM_{2.5} data (see
55 manuscript for details). Data are annual means compared on the same $0.5^\circ \times 0.667^\circ$ grid for the
56 African continent. The line is the RMA regression fit and inset numbers are regression statistics
57 and the Pearson's correlation coefficient.

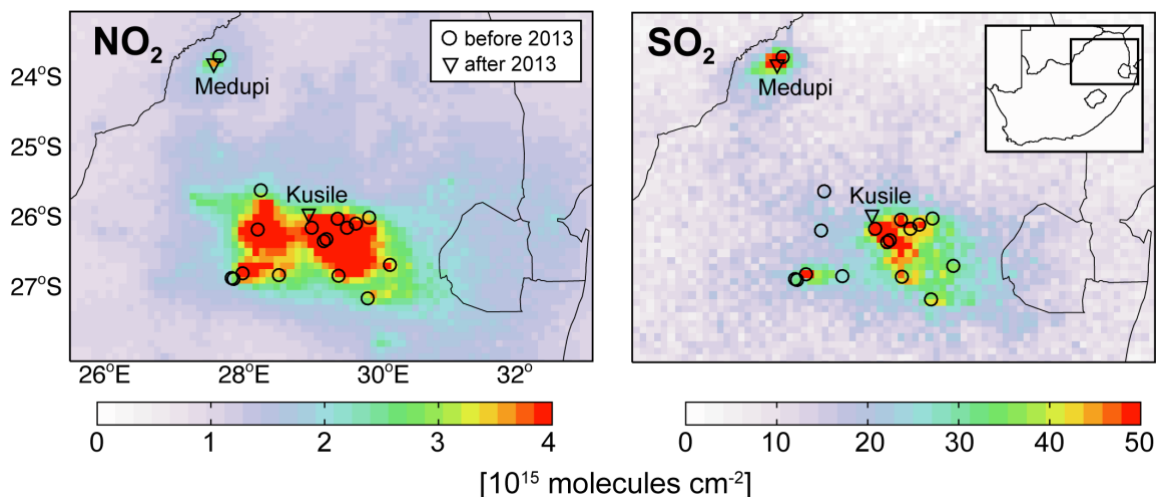
PM_{2.5} in the Highveld of South Africa



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60 **Figure S4.** Spatial distribution of annual mean PM_{2.5} in the Highveld of South Africa. Circles are
61 quality screened measurements from the South African air quality monitoring network given in
62 Garland et al.⁴ Background is GEOS-Chem. Triangles show locations of power plants operating
63 in 2012. Inset map shows the Highveld domain sampled.



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66 **Figure S5.** Satellite observations of NO₂ and SO₂ over the South African Highveld. Maps are

67 NO₂ tropospheric (left) and SO₂ total (right) column densities from the Sentinel-5P (S5P)

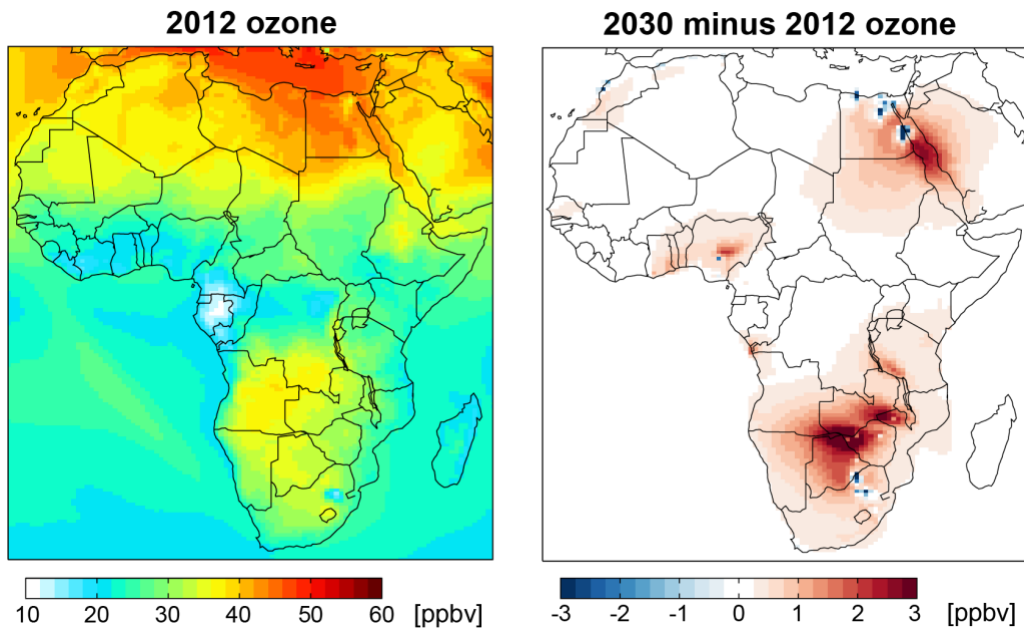
68 TROPOMI instrument averaged during May-September 2018 and gridded to 0.1° × 0.1°.

69 Symbols indicate locations of power plants operational in 2012 (open circles) and added since

70 (upside-down triangles). Inset map shows the Highveld domain sampled. TROPOMI level 2

71 reprocessed NO₂ (v1.02)⁵ and SO₂ (v1.05)⁶ data were obtained from the S5P data hub

72 (<https://s5phub.copernicus.eu/dhus/#/home>; last accessed 13 August 2019).



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75 **Figure S6.** Impact of future fossil fuel emissions on surface ozone. GEOS-Chem annual 24-hour

76 mean surface ozone concentrations in 2012 (left) and the change in modeled ozone in 2030

77 relative to 2012 (right) due to an increase in fossil fuel emissions from power plants and

78 transport.

79 **References**

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105 [Sulphur-Dioxide-Readme.pdf](http://www.tropomi.eu/sites/default/files/files/publicSentinel-5P-Sulphur-Dioxide-Readme.pdf) (accessed on 15 February 2019).
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