Supporting Information for:

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

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

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

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

(S1),

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 for each grid cell (in % change in mortality per 1 $\mu g$ m$^{-3}$ PM$_{2.5}$) determined as the area under the curve shown in Figure S1 between the hazard risk ($\beta_{i,j}$) at the PM$_{2.5}$ for 2012 and for 2030:

$$\bar{\beta}_{i,j}(PM_{2.5}) = \int_{PM_{2.5}(2012)}^{PM_{2.5}(2030)} \beta_{i,j}(PM_{2.5})$$

(S2).

The relationship shown in Figure S1 was determined from a meta-analysis of the association between long-term exposure to PM$_{2.5}$ and mortality from 53 cohort studies. The relationship is non-linear, so percent change in mortality decreases with increase in PM$_{2.5}$. The meta-analysis approach yields greater sensitivity to a unit change in PM$_{2.5}$ than the Global Exposure Mortality Model (GEMM), detailed in Burnett et al., for PM$_{2.5} > 10 \mu g$ m$^{-3}$; opposite for PM$_{2.5} < 10 \mu g$ m$^{-3}$ (Vodonos et al.). Mortality estimates from GEMM are at least double that obtained with the Integrated Exposure–Response (IER) function used in Global Burden of Disease studies.
Figure S1. The shape of the concentration-response curve used in this work. The plot shows the relationship between percent change in mortality per unit change in PM$_{2.5}$ and PM$_{2.5}$ concentration. Shading shows the 95% confidence interval. Blue hash marks indicate mean PM$_{2.5}$ for each cohort used to generate the model.
**Figure S2.** Evaluation of GEOS-Chem (red) and satellite-derived (black) PM$_{2.5}$ against surface observations. Points are annual mean PM$_{2.5}$ for 2012. Regional monitoring network PM$_{2.5}$ is the quality screened South African Air Quality Information System (SAAQIS) data from Garland et al. GEOS-Chem and satellite-derived data are the 0.5° × 0.667° grids coincident with the monitoring sites. Figure S4 shows the spatial distribution of the monitoring network. The reduced major axis (RMA) regression fits (solid lines) and statistics are shown for GEOS-Chem (red) and satellite (black) data. The dashed grey line is the 1:1 line.
Figure S3. Evaluation of GEOS-Chem PM$_{2.5}$ in 2012 with the satellite-derived PM$_{2.5}$ data (see manuscript for details). Data are annual means compared on the same 0.5° × 0.667° grid for the African continent. The line is the RMA regression fit and inset numbers are regression statistics and the Pearson’s correlation coefficient.
Figure S4. Spatial distribution of annual mean PM$_{2.5}$ in the Highveld of South Africa. Circles are quality screened measurements from the South African air quality monitoring network given in Garland et al. Background is GEOS-Chem. Triangles show locations of power plants operating in 2012. Inset map shows the Highveld domain sampled.
Figure S5. Satellite observations of NO$_2$ and SO$_2$ over the South African Highveld. Maps are NO$_2$ tropospheric (left) and SO$_2$ total (right) column densities from the Sentinel-5P (S5P) TROPOMI instrument averaged during May-September 2018 and gridded to 0.1° × 0.1°. Symbols indicate locations of power plants operational in 2012 (open circles) and added since (upside-down triangles). Inset map shows the Highveld domain sampled. TROPOMI level 2 reprocessed NO$_2$ (v1.02) and SO$_2$ (v1.05) data were obtained from the S5P data hub (https://s5phub.copernicus.eu/dhus/#/home; last accessed 13 August 2019).
Figure S6. Impact of future fossil fuel emissions on surface ozone. GEOS-Chem annual 24-hour mean surface ozone concentrations in 2012 (left) and the change in modeled ozone in 2030 relative to 2012 (right) due to an increase in fossil fuel emissions from power plants and transport.
References


