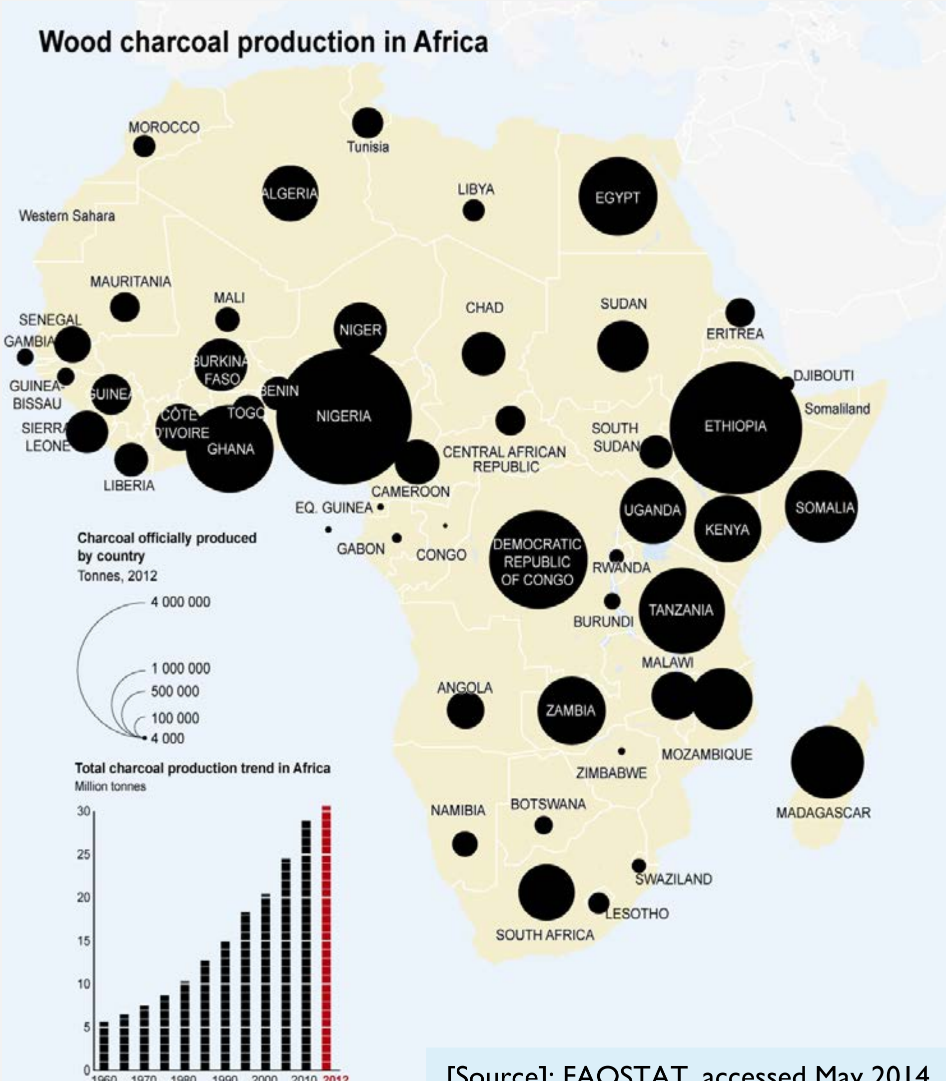
Air Quality and Climate Impact of the Charcoal Supply Chain in Africa

[a]A.S. Bockarie, [b]E.A. Marais, [a]A.R. MacKenzie, [a]R. M. Harrison

[a] School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK
[b] Department of Physics and Astronomy, University of Leicester, Leicester, UK

Charcoal production in Africa



[Source]: FAOSTAT, accessed May 2014

[Source]: Global Cities Institute

By 2100, Africa will have 13 of the world's 20 largest megacities which suggests charcoal production will continue to increase

Charcoal supply chain

Kilns combustion efficiency < 20%

Large source of CO, NMVOCs, OC, CH_4

Unregulated and outdated diesel trucks. Source of SO_2

Large source of NO_x and BC

Includes burning of plastic to initiate combustion. Prevalent in slums. Source of HCl

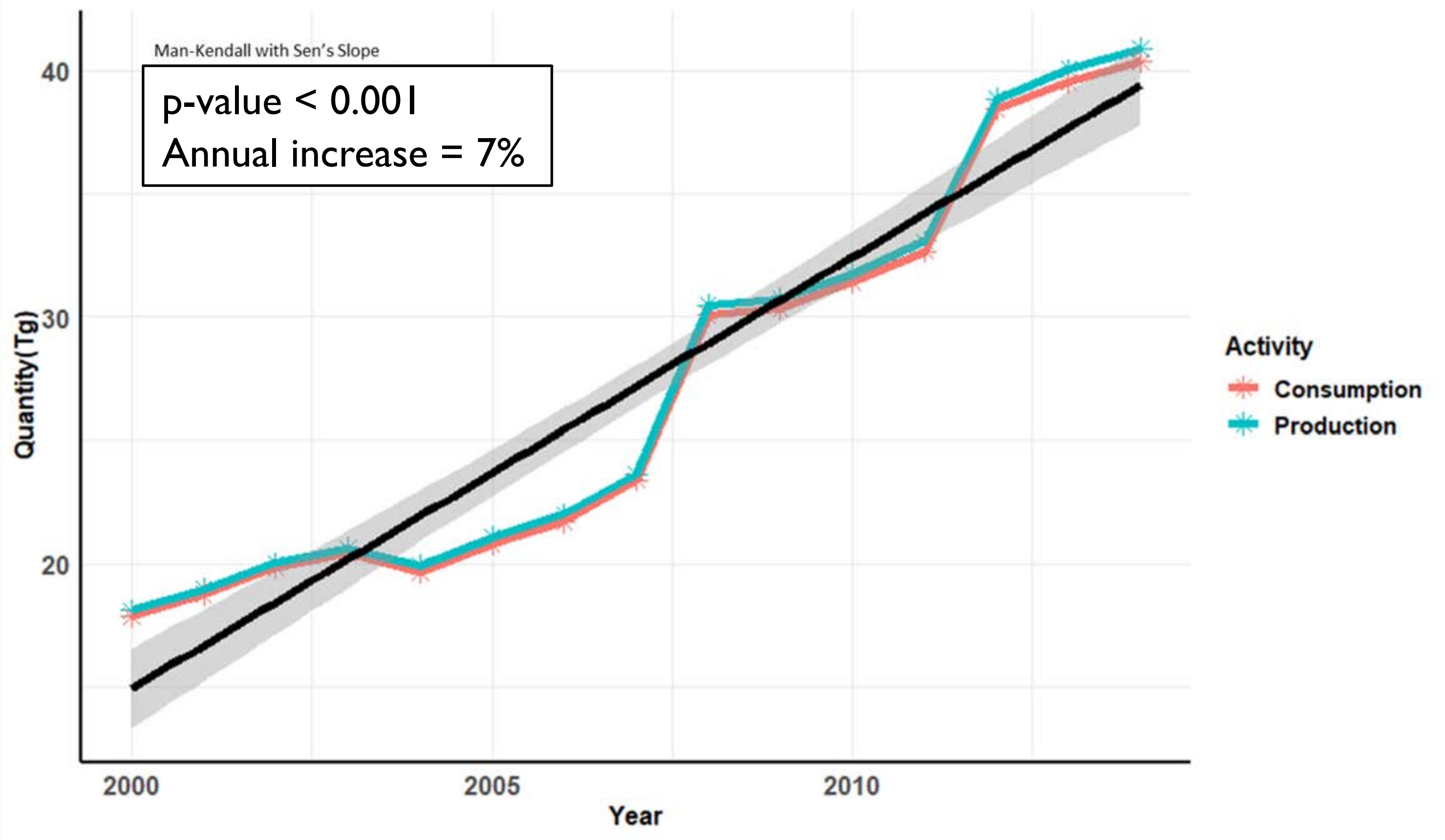
Production in rural areas

Rural to urban transport

Use in densely populated urban centres

Charcoal production and use are sources of primary aerosols and precursors of secondary aerosols and ozone

Charcoal production and use trends in Africa (2000 – 2014)



YEAR	CHARCOAL PRODUCTION [Tg]
2014	41.7
2030	82.7

[Data source]: United Nations energy statistics database (UN, 2017)

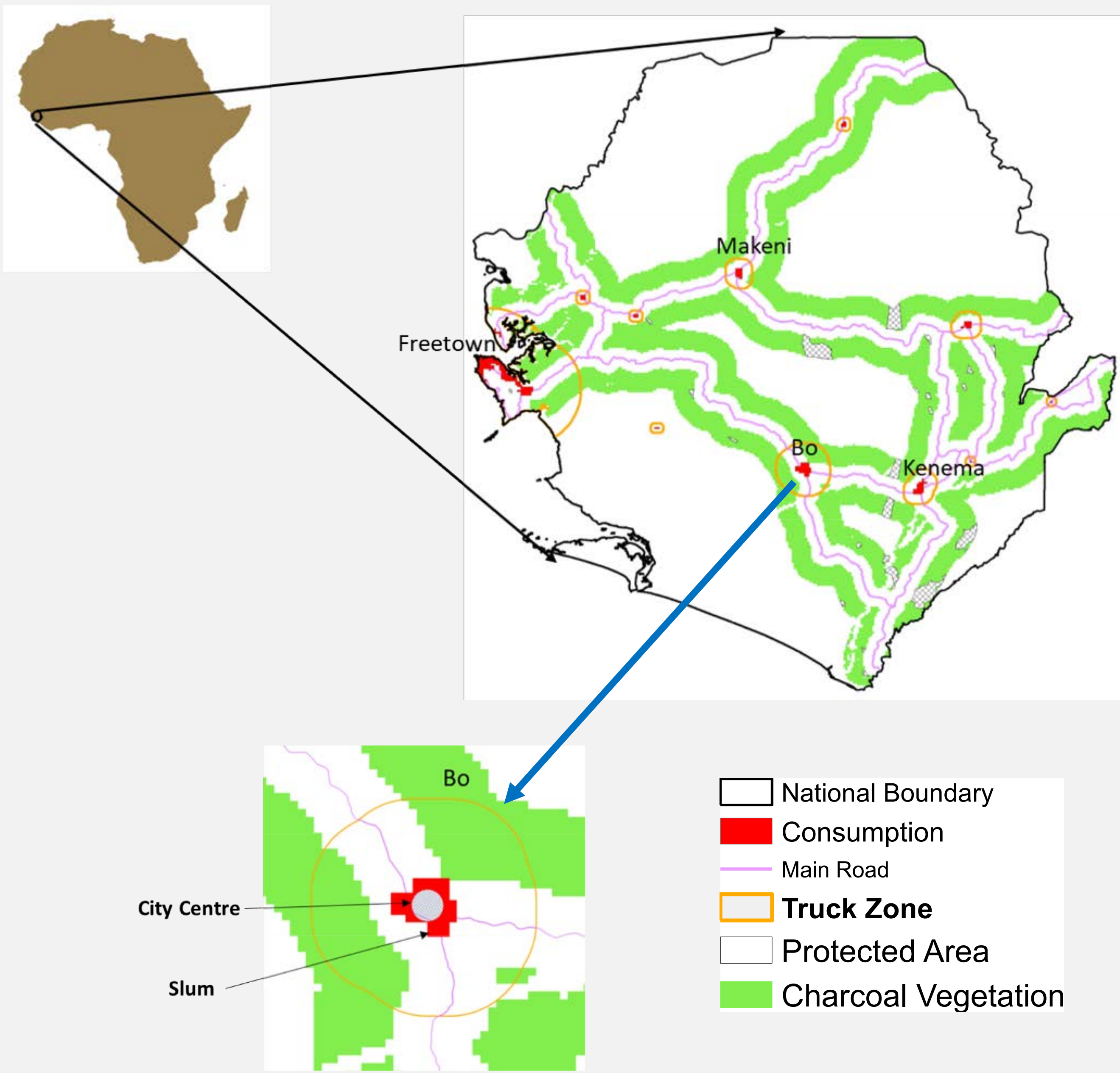
From 2014 to 2030 charcoal production will double in Africa due to urbanization

Developing emission inventory

Emission = Activity Data x Emission Factor

We develop country level emissions of air pollutants from the charcoal supply chain in Africa in 2014

Mapping emission activity locations



Production :
5-15 km from main roads.

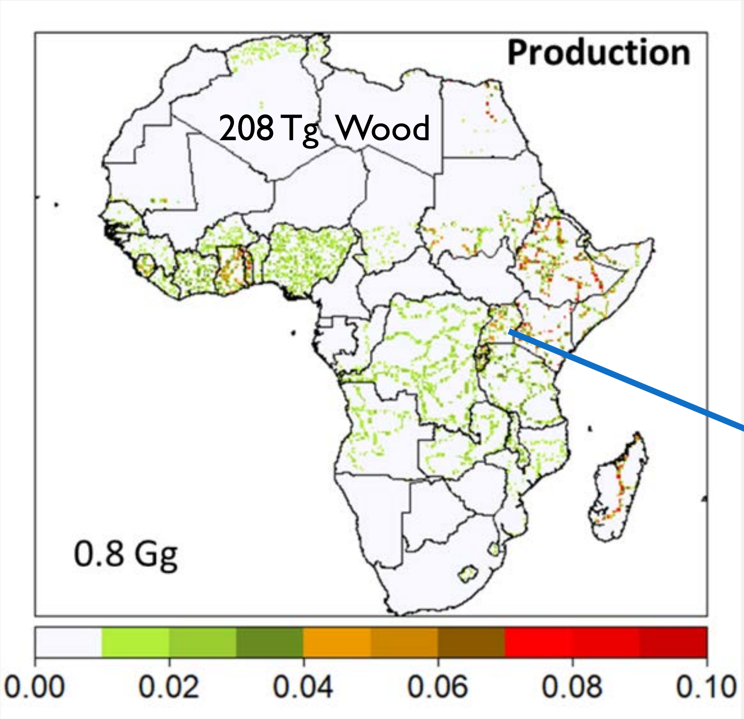
Consumption:
Urban extent determined using road network data

Plastic burning limited to slums.

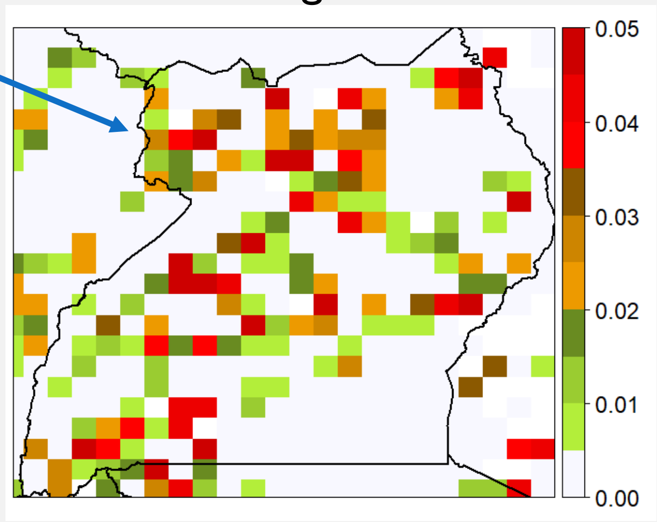
Trucks:
Mapped around urban centres proportional to population

Spatial distribution of pollutants from charcoal production in 2014

Black Carbon Emission [tonnes a^{-1}]



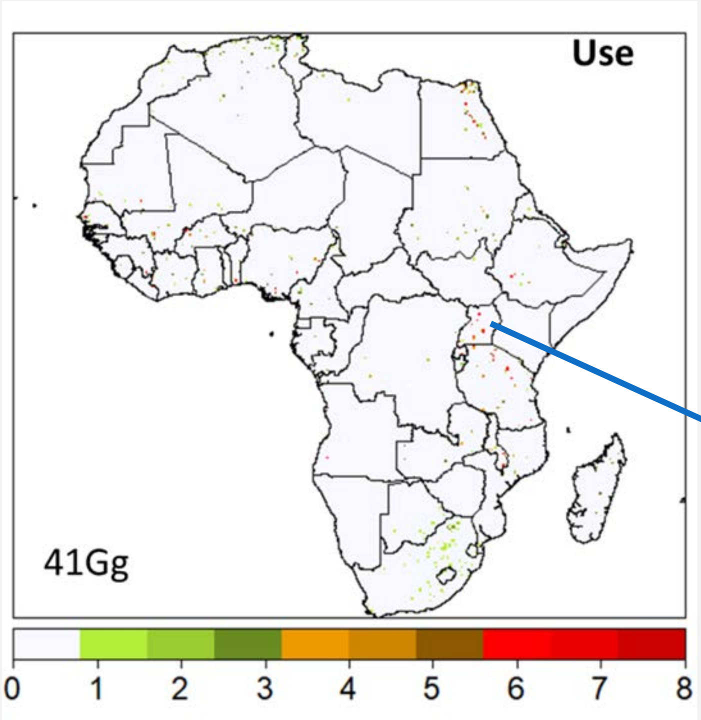
Uganda



Emission from the charcoal production are highest in East and West Africa

Spatial distribution of pollutants from charcoal use in 2014

Emission of Black Carbon



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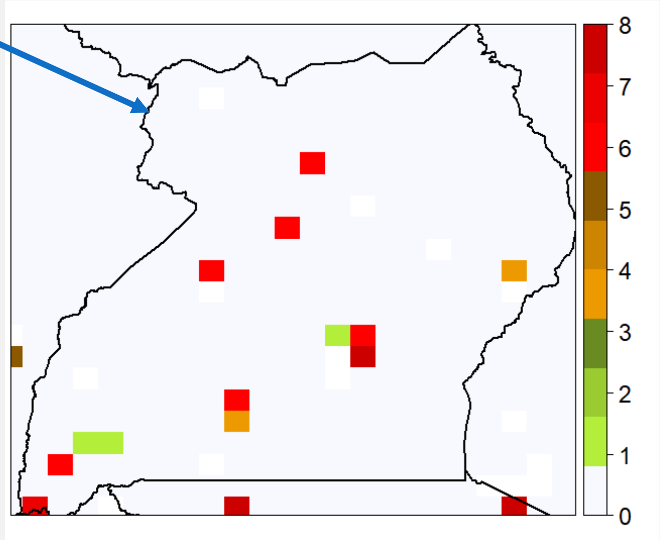
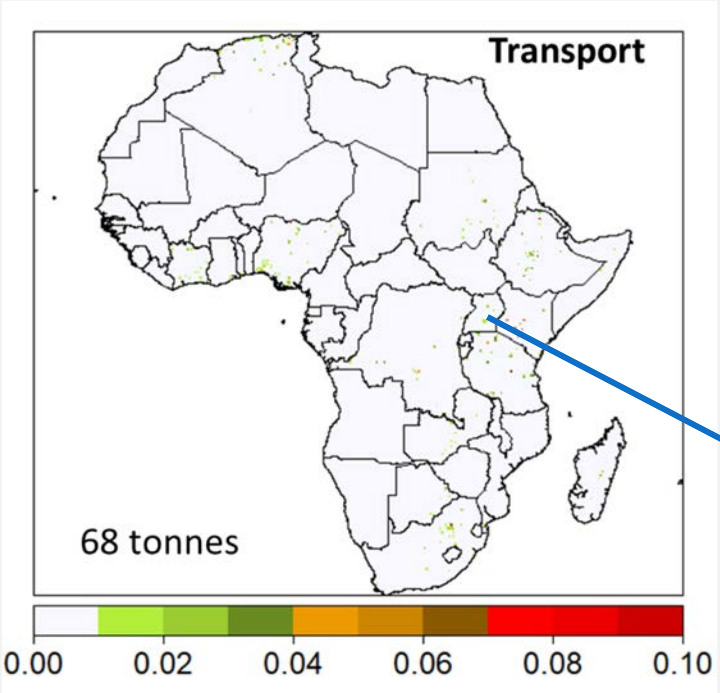


Black carbon from charcoal use is higher due to higher emission factor

Spatial distribution of pollutants from charcoal transport in 2014

Emission of Black Carbon



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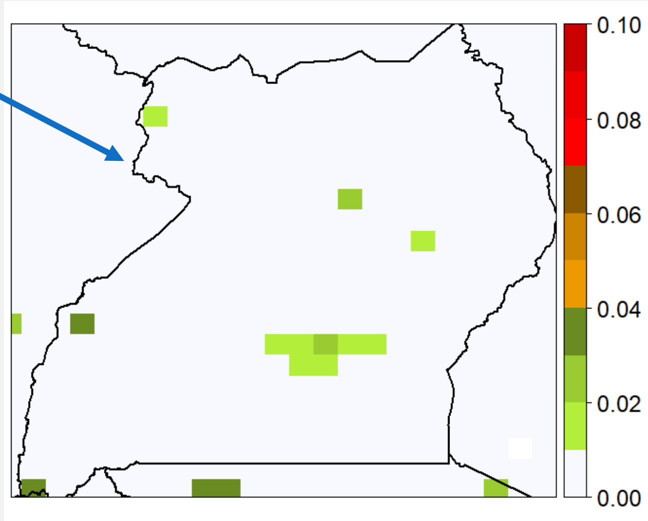
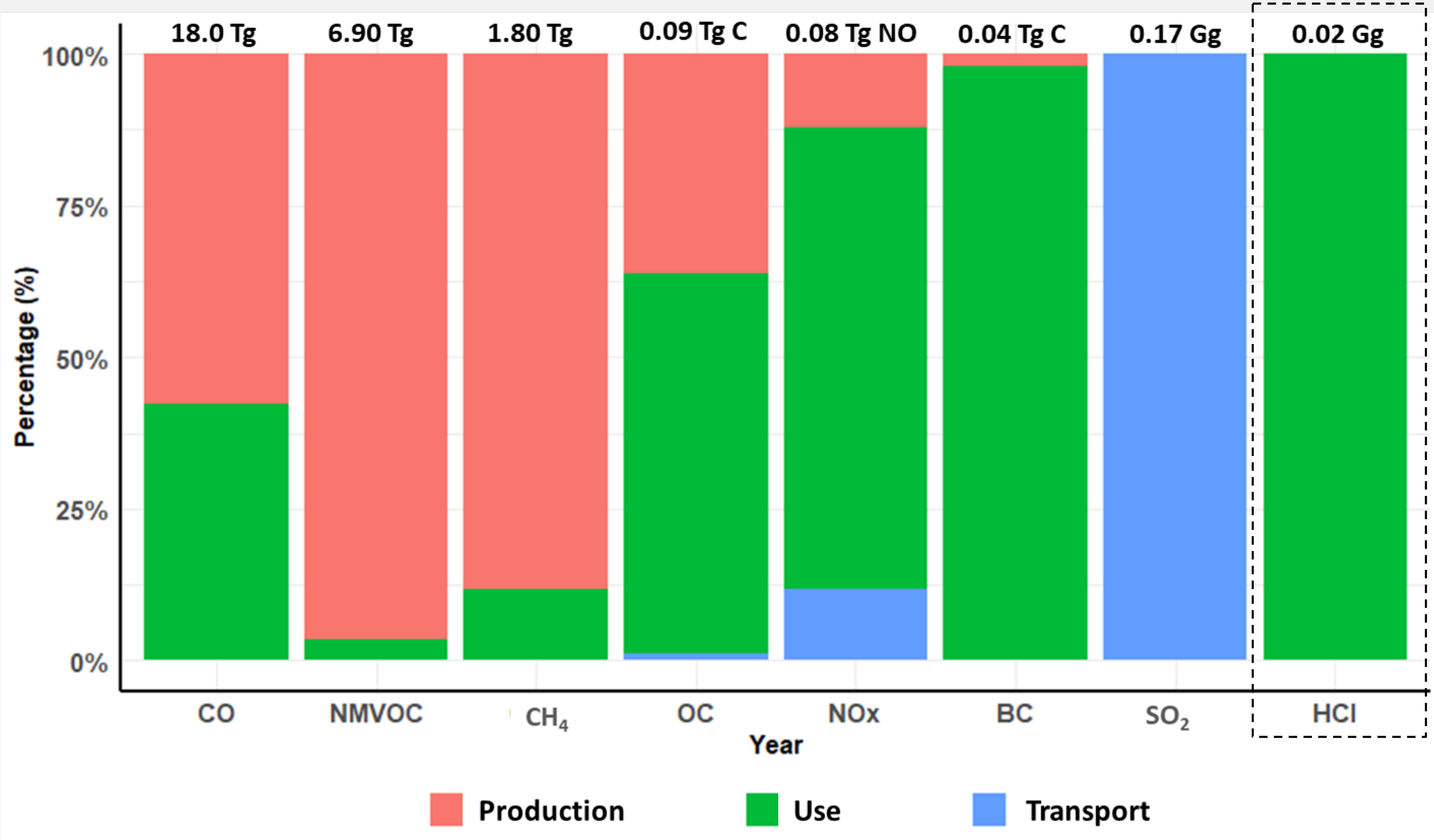


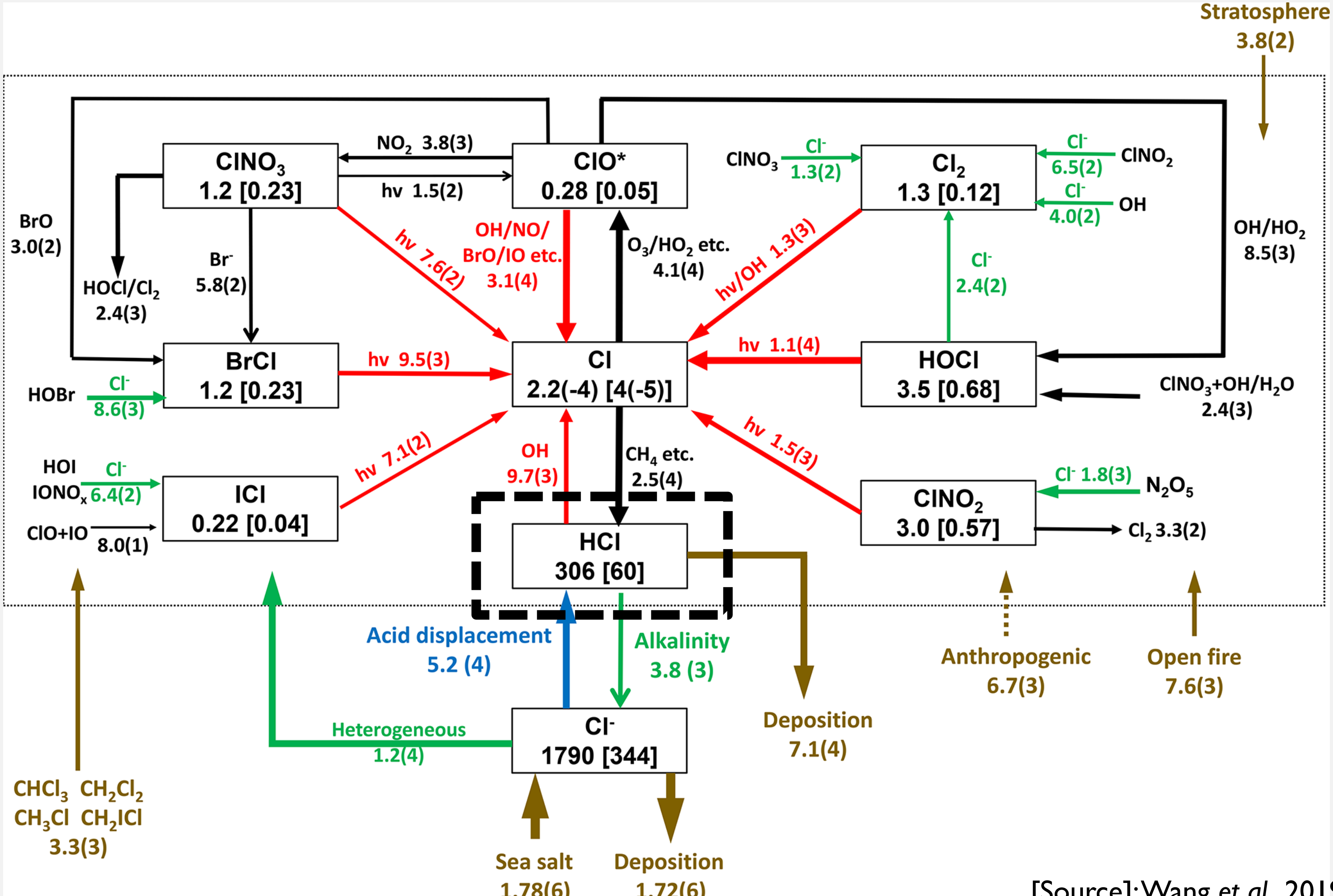
Emission from the charcoal transport is least from the supply chain

Contribution of the charcoal activities to pollutant emission



Most of the ozone precursors are emitted during charcoal production whilst most of the directly emitted particles are from charcoal use

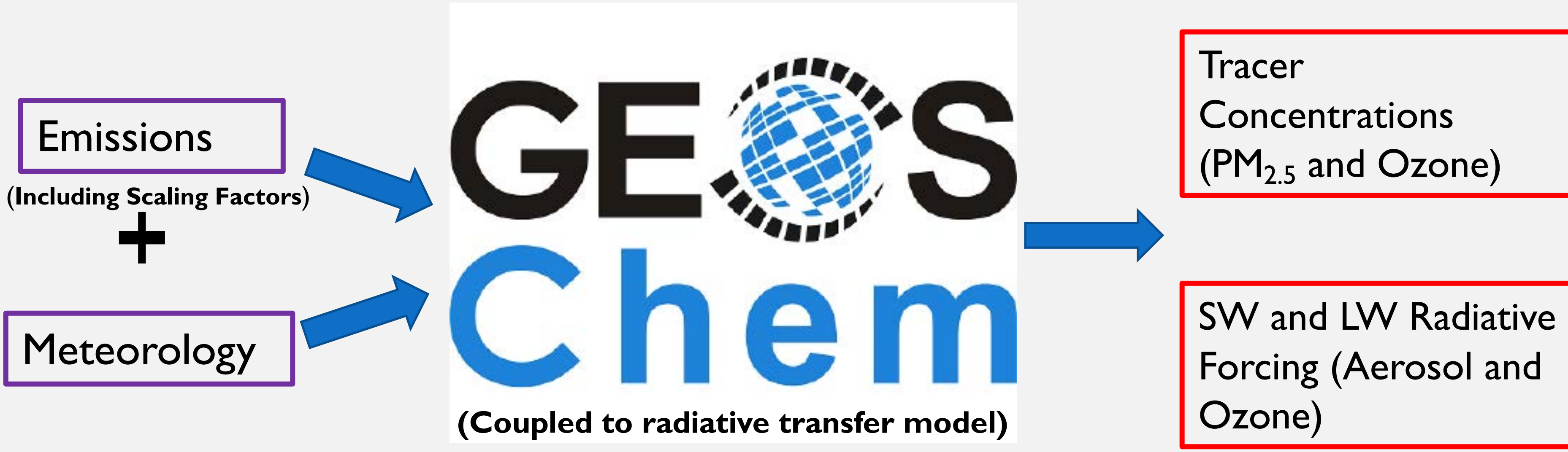
Global cycling of tropospheric chlorine



[Source]: Wang *et al.*, 2019

HCl from charcoal use contributes to the chlorine budget of the troposphere and reduces the oxidative capacity of the atmosphere

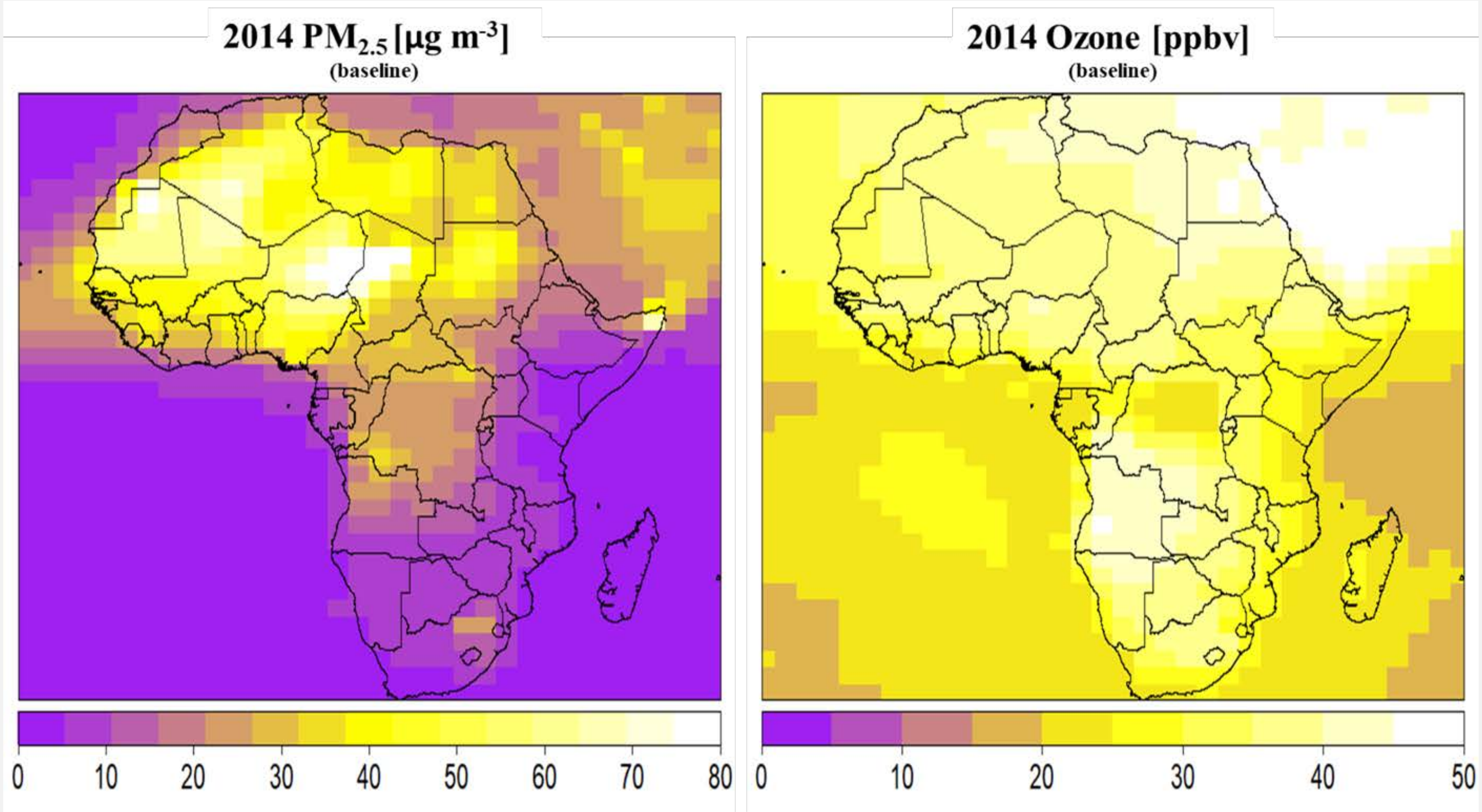
Chemical transport modelling (CTM)



3D Chemical transport model driven by reanalysis meteorology
Grid Resolution: 2° x 2.5° (200 - 250 km)

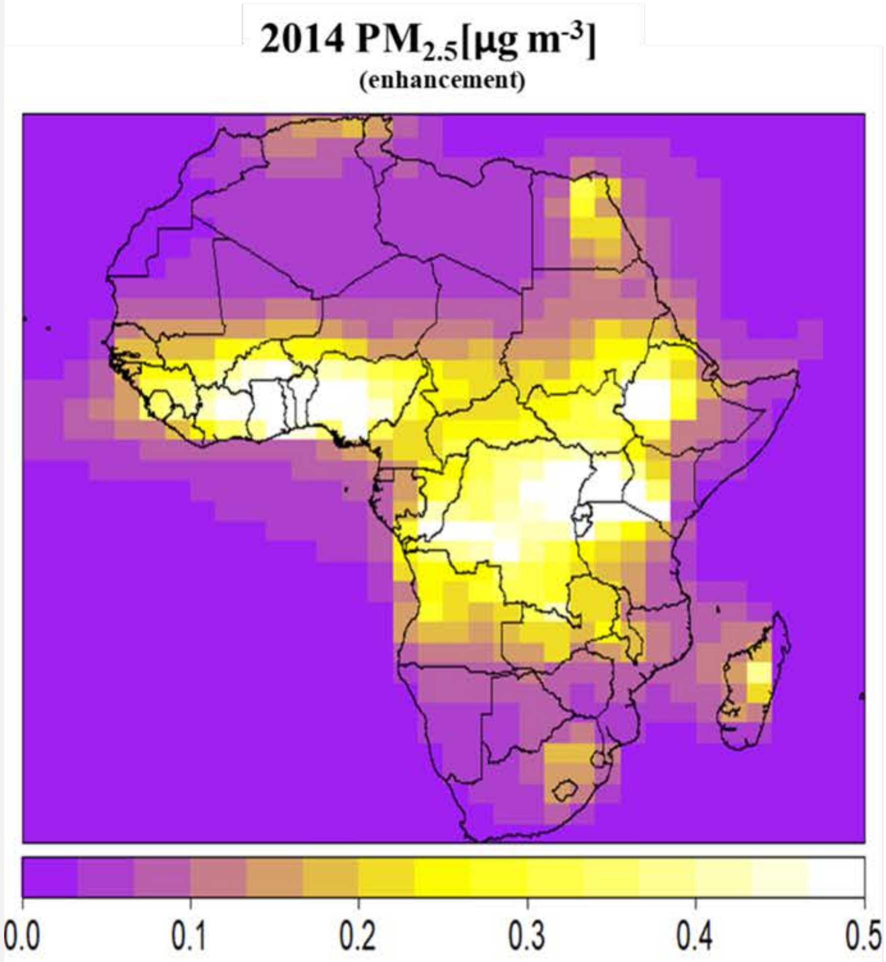
CTM provides comprehensive representation of the atmosphere

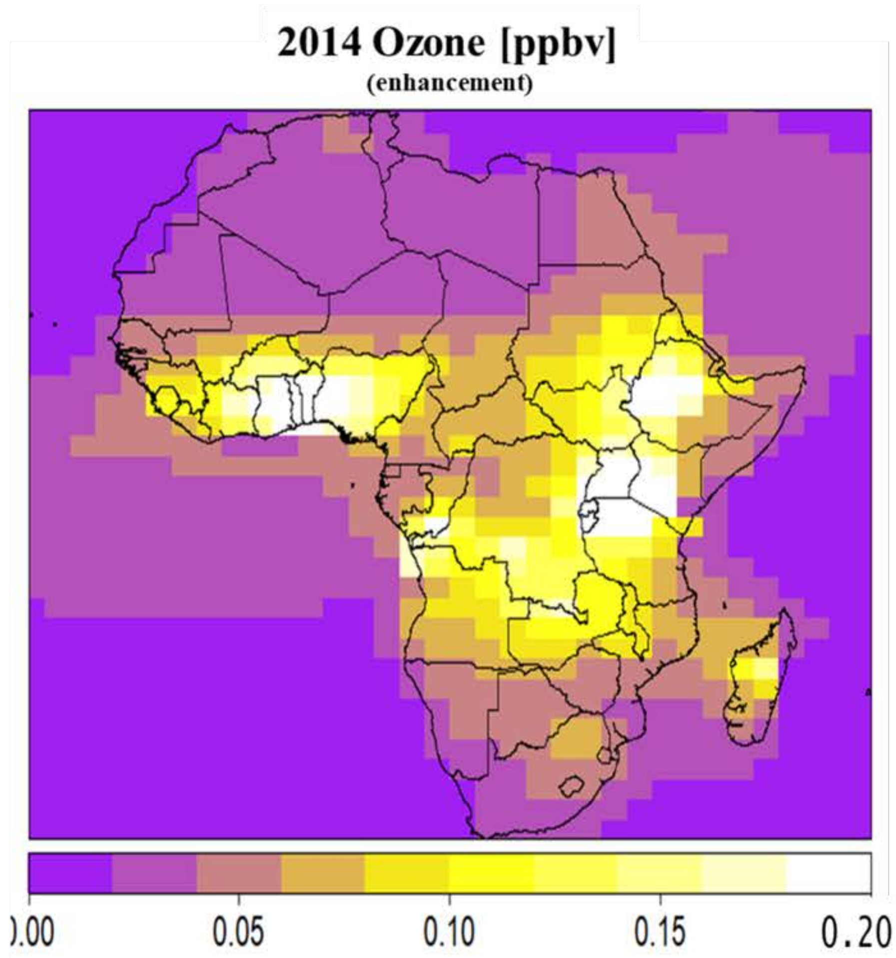
GEOS-Chem baseline surface $PM_{2.5}$ and ozone



$PM_{2.5}$ is mostly from windblown dust in the north. Major sources of both $PM_{2.5}$ and ozone are open fires in the tropics and coal burning in South Africa

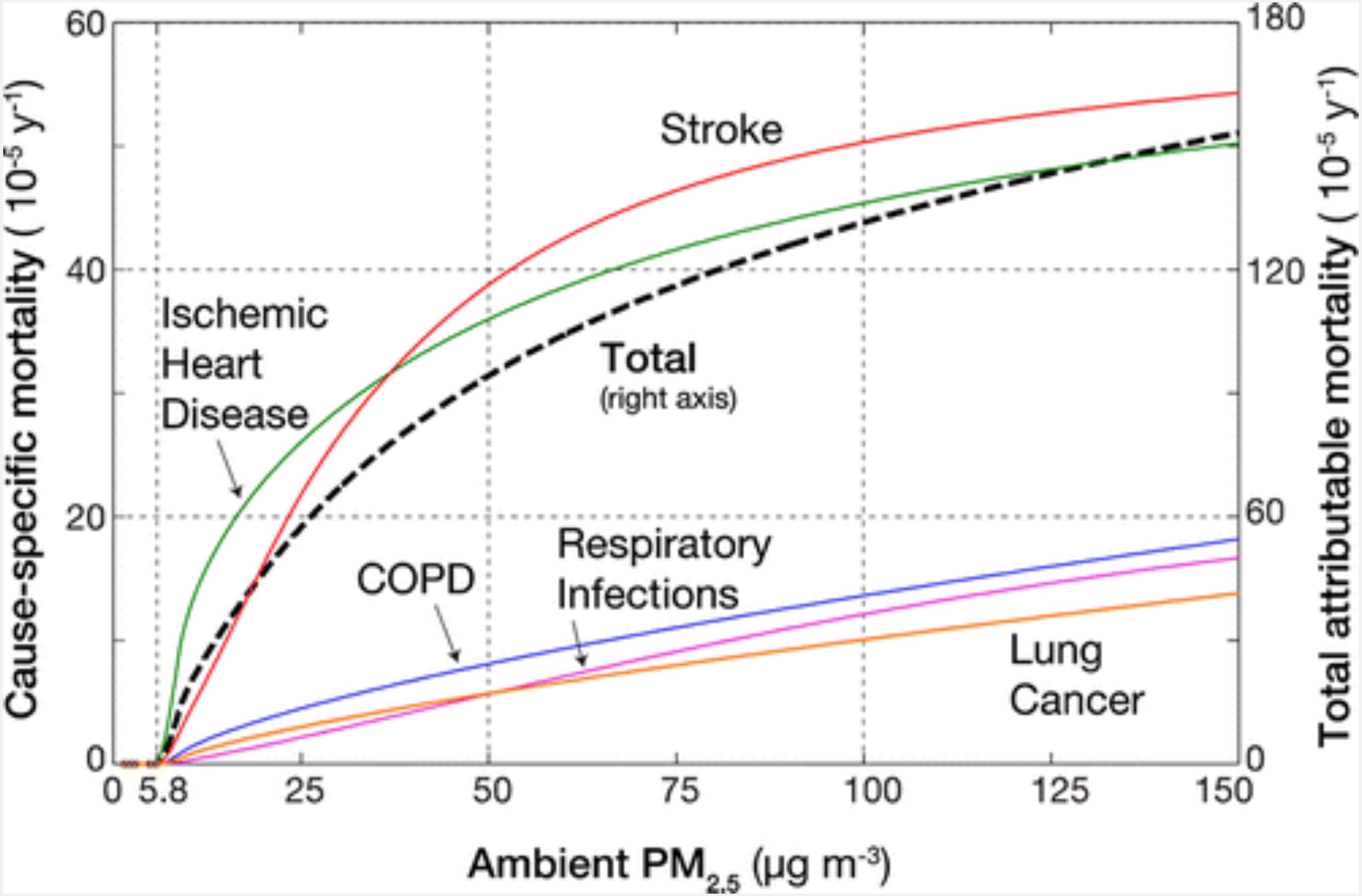
$PM_{2.5}$ and Ozone enhancement in 2014





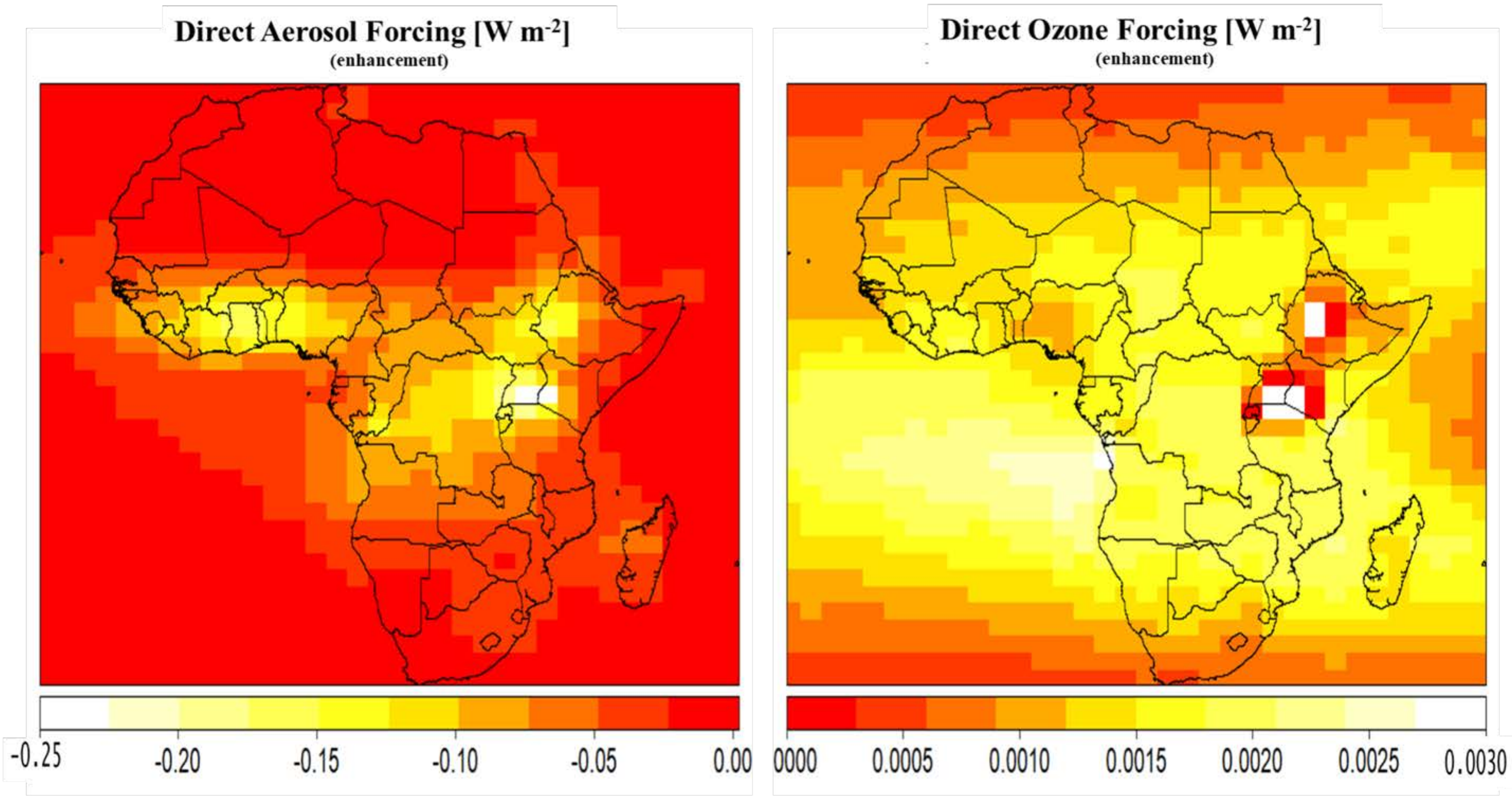
Surface enhancements are widespread across the tropics and subtropics, with peak, with peak values of 1.3 μg m^{-3} for $PM_{2.5}$ and 0.7 ppbv for ozone respectively.

Concentration response curve



[Source]: Apte *et al.*, 2015

GEOS-Chem top of the atmosphere radiative forcing due aerosols and ozone from the charcoal supply chain



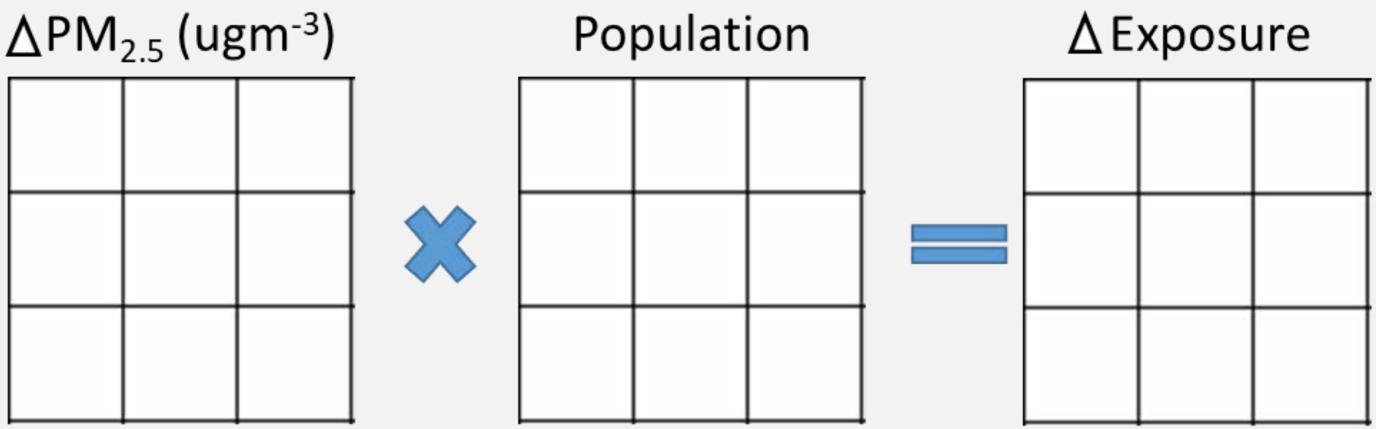
Aerosols exert a net cooling effect on the earth's climate, peaking in East Africa (-0.25 Wm^{-2}). Ozone forcing exerts a net warming effect on the earth's climate, peaking also in East Africa (2.7 mW m^{-2})

Conclusions

- Charcoal production is a considerable source of pollution in Africa (24% of open fire emissions in 2014)
- Charcoal enhances the poor air quality in Africa and contributes to warming and cooling of the atmosphere from the emission of aerosols and precursors of aerosol and ozone along its supply chain
- With an annual increase in charcoal production at 7% a^{-1}, it is quite clear that emissions will increase at the same rate in the coming decades and hence the effects on air quality and climate

Future Work

- **Assess the population weighted exposure to $PM_{2.5}$ from the charcoal value chain in 2014 and 2030**

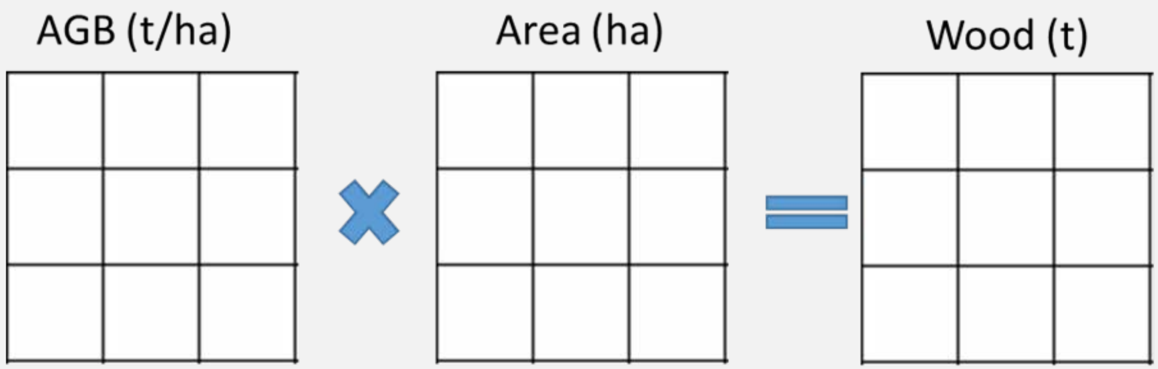


$$PWE = \sum_{i=1}^{n} pm_i \text{ x } pop_i \Big/ \sum_{i=1}^{n} pop_i$$

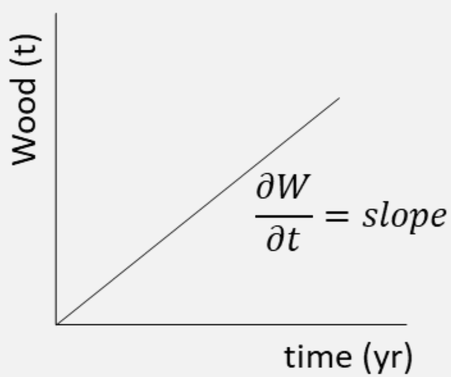
Future Work

- **Assess sustainability of the forest for charcoal production**

$$Time\ Taken = \frac{Total\ mass\ of\ wood\,(W_T)}{Rate\ of\ wood\ removal\ \left(\frac{\partial W}{\partial t}\right)}$$



$$W_T = \sum_{i=1}^{n} W_i$$

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CHARCOAL
BRIQUETTES


Thank
you