

The burgeoning charcoal industry in Africa and its influence on air quality and climate

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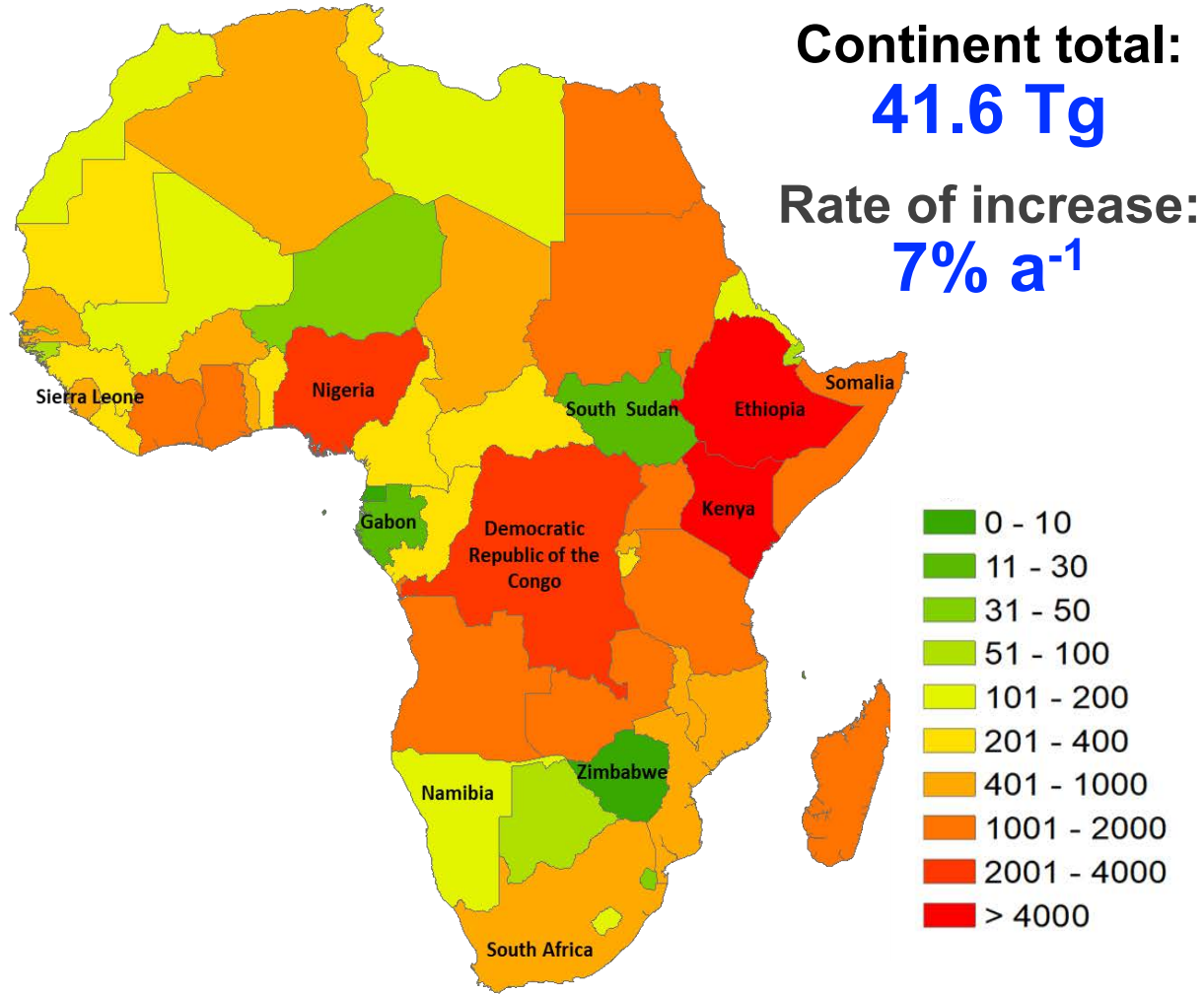
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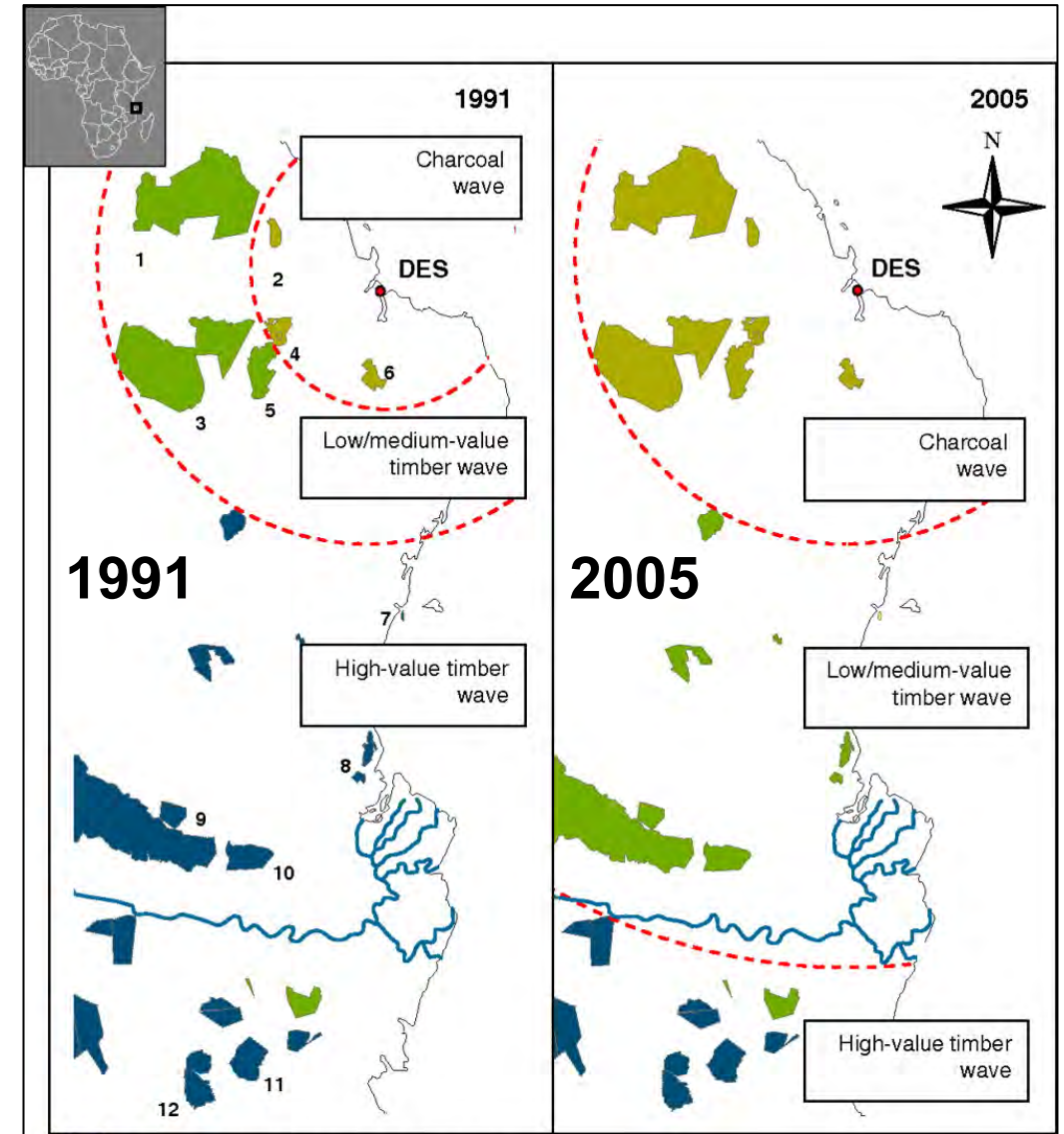
The Burgeoning Charcoal Industry in Africa

Charcoal Production in 2014 [Gg]



Data are from the UN (<http://data.un.org/Explorer.aspx>)

[Bockarie et al., 2020]



[Ahrends et al., 2010]

Contributes Outdoor and Indoor Air Pollution

... during charcoal production with earth kilns



$PM_{2.5} > 100 \mu g m^{-3}$

[\[https://www.smallstarter.com/\]](https://www.smallstarter.com/)



[\[https://blog.worldagroforestry.org/\]](https://blog.worldagroforestry.org/)

... and during charcoal use for cooking



$PM_{2.5} > 400 \mu g m^{-3}$

[\[https://www.economist.com/\]](https://www.economist.com/)



[\[https://envirofit.org/\]](https://envirofit.org/)

WHO guideline:
 $10 \mu g m^{-3}$

Mapping Charcoal Industry Activities (Fuel Use)

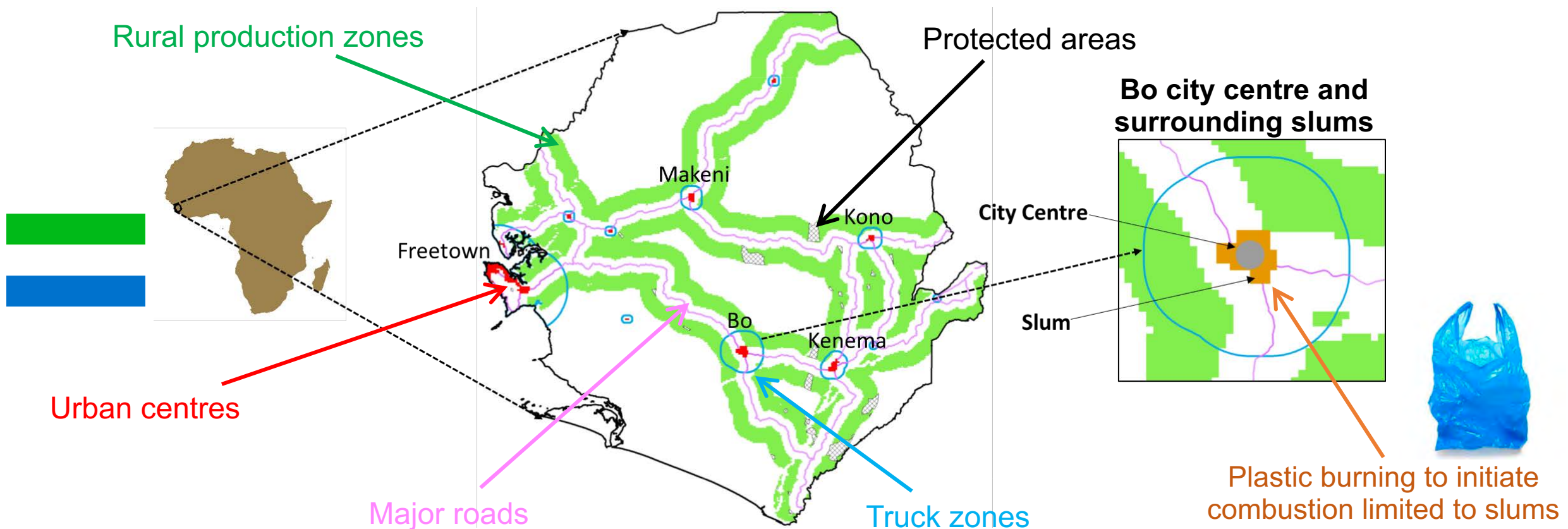
Produce



Transport

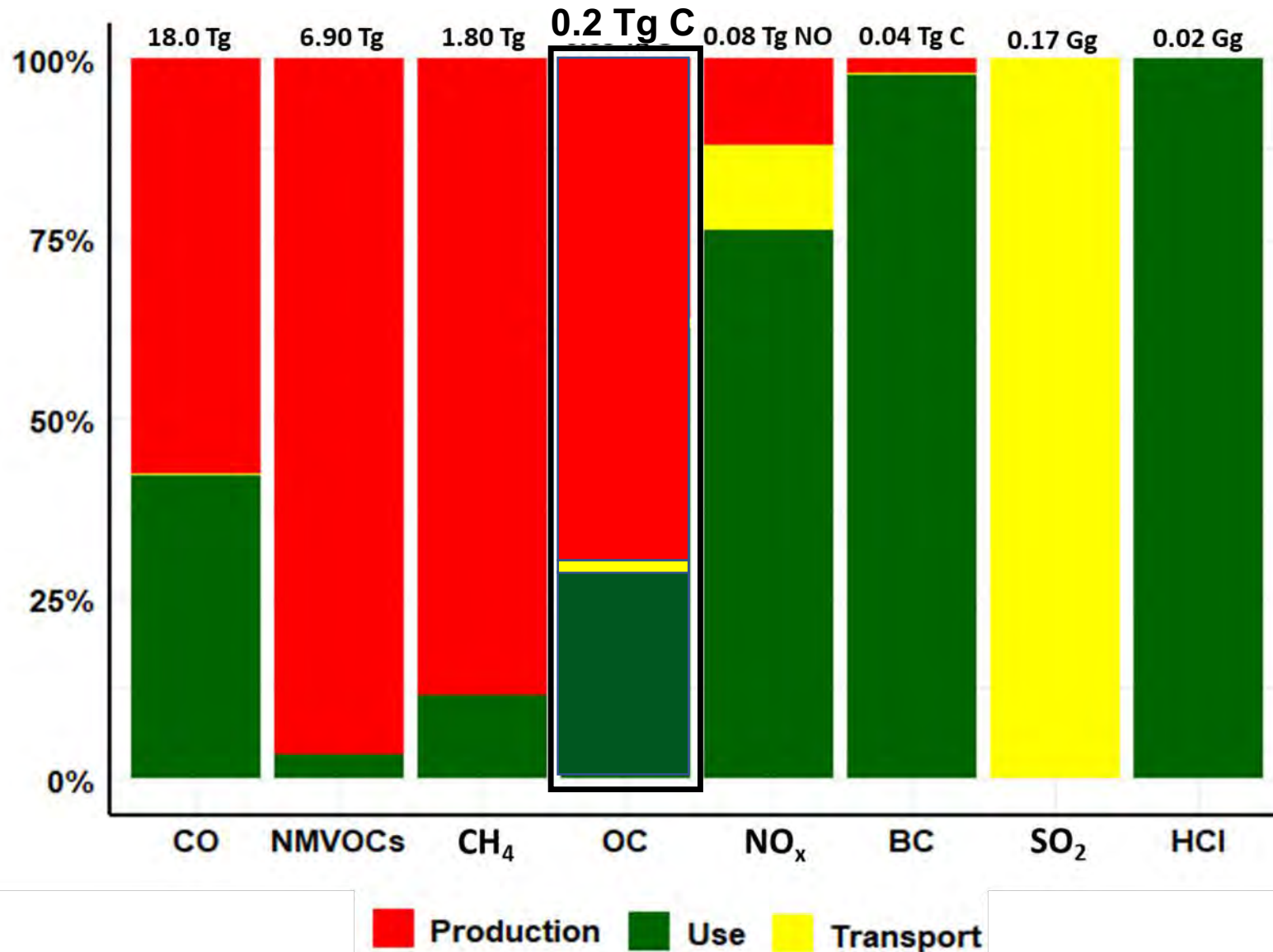


Use



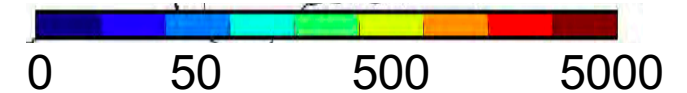
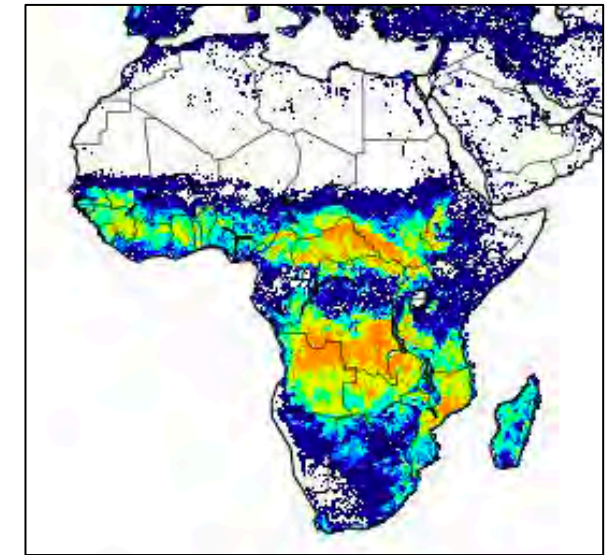
Charcoal Activities and Pollutant Emissions

Total and Relative Emissions



Comparison to Open Fires

Inventory (GFED4) carbon emissions
[g C m⁻² year⁻¹]



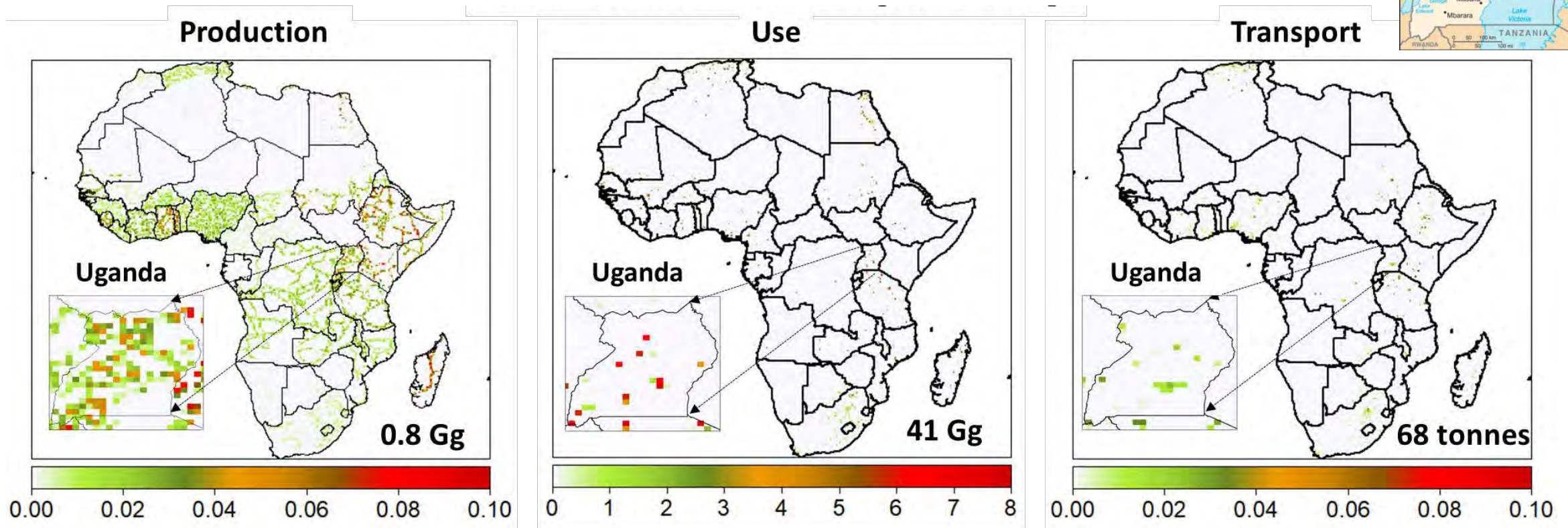
<https://daac.ornl.gov/>

CH₄: 4.6 Tg
BC: 0.81 Tg C
CO: 136 Tg
OC: 5.6 Tg C

Spatial Distribution of Emissions

Apply reported emission factors of air pollutants to mapped activities

Black carbon emissions at $0.1^\circ \times 0.1^\circ$ grid for 2014 [tonnes per year]

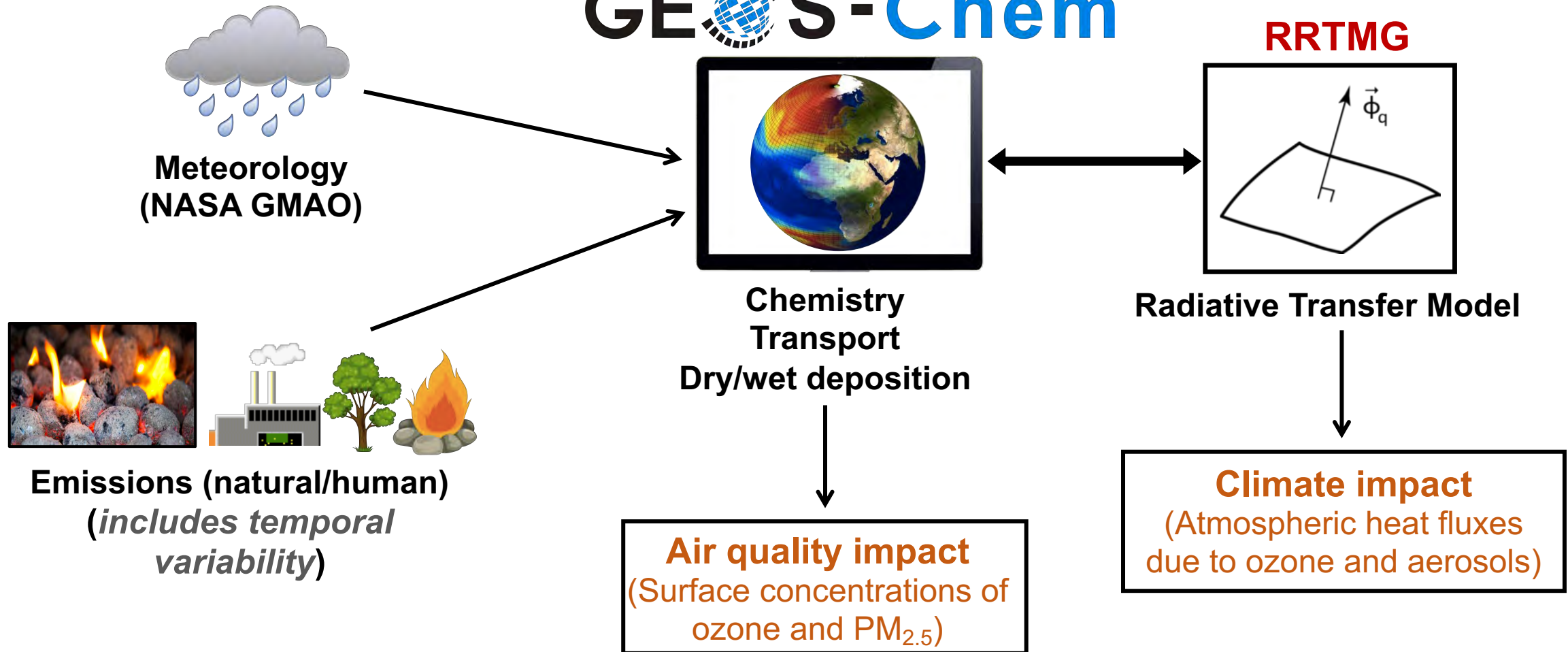


Emissions on a trajectory to **double** by 2030

Quantify Impact on Air Quality and Short-Term Climate

Coupled 3D atmospheric chemistry and radiative transfer models

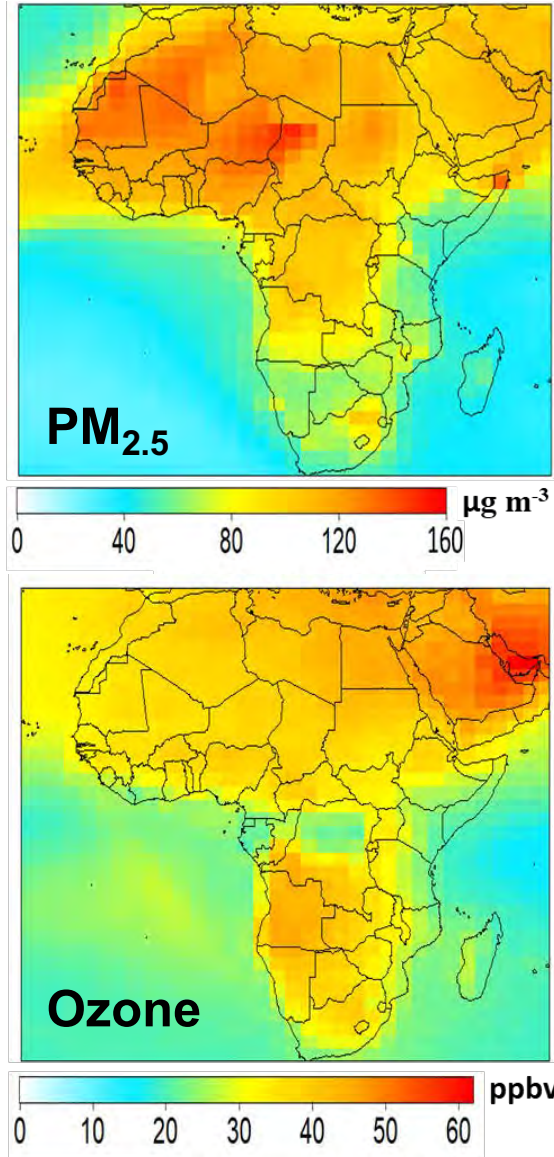
GEOS-Chem



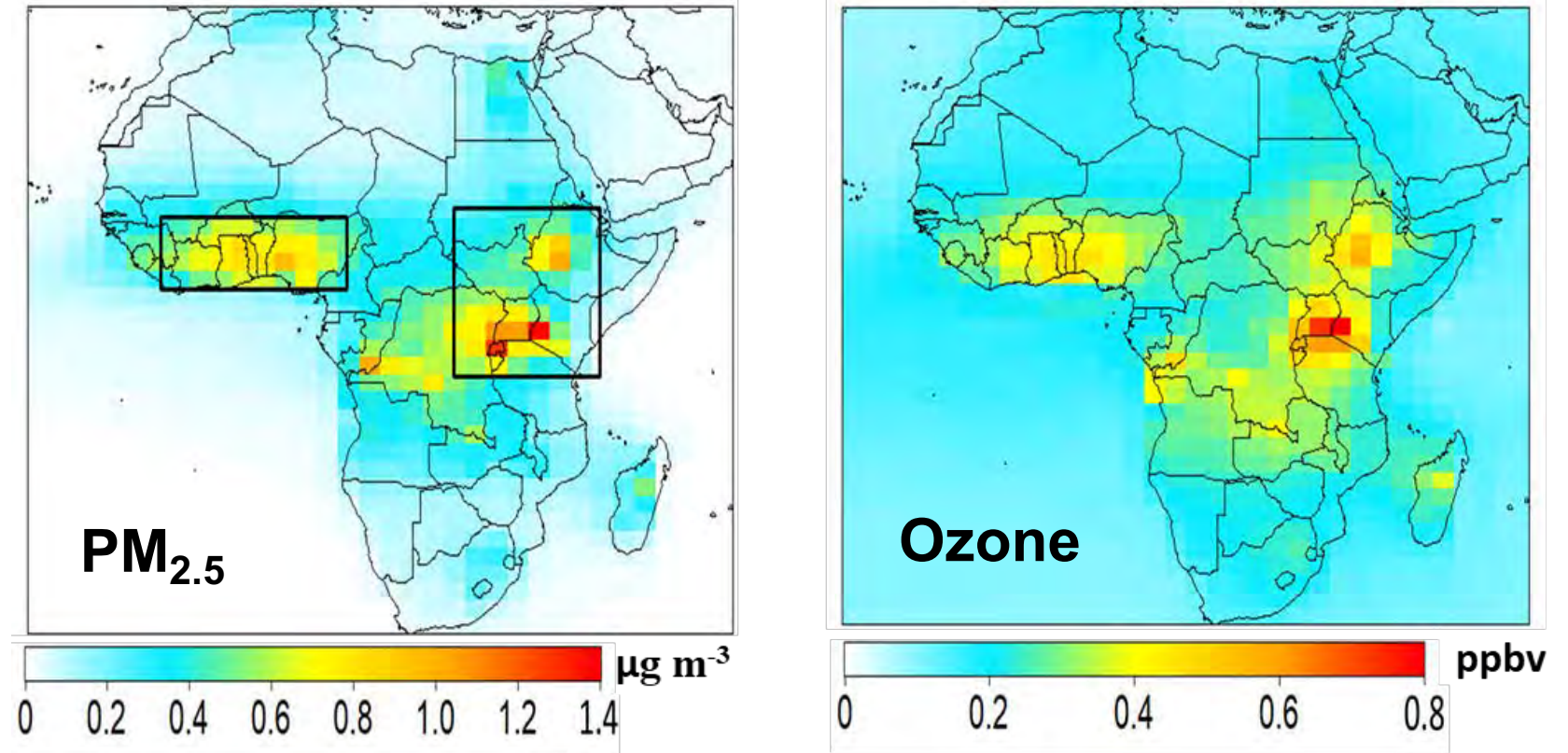
To find out more about GEOS-Chem: <http://acmg.seas.harvard.edu/geos/index.html>

Total and Charcoal Industry Surface PM_{2.5} and Ozone

PM_{2.5} and Ozone from
All Sources



PM_{2.5} and Ozone from the Charcoal Industry



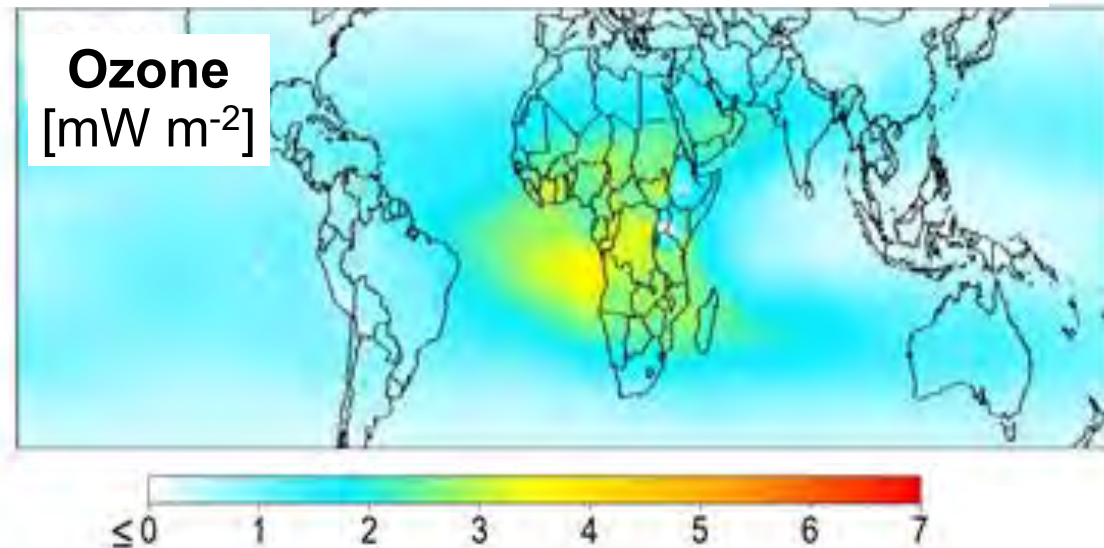
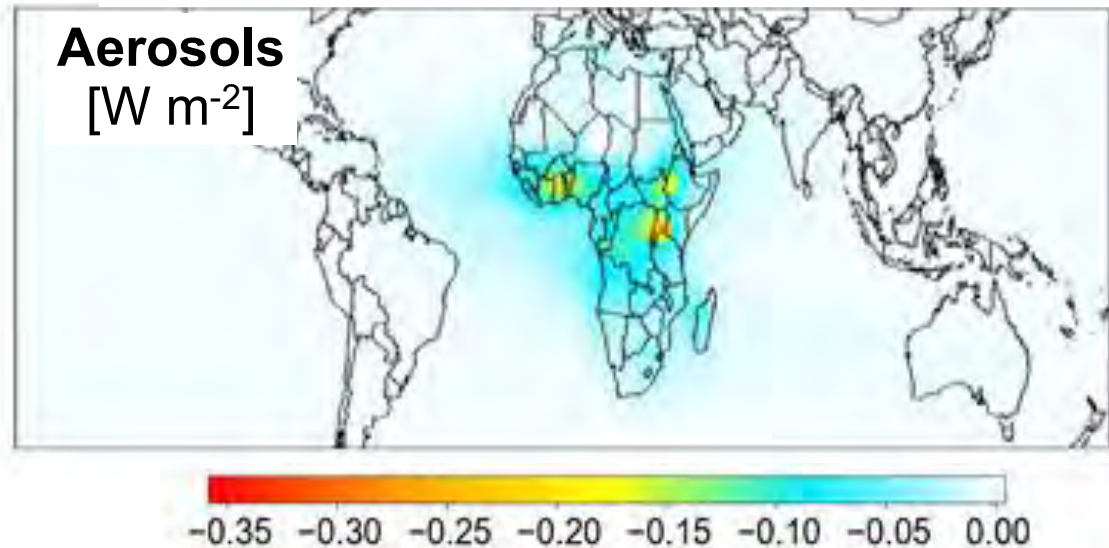
Peaks in urban areas in East, West and Central Africa, as expected from spatial distribution of emissions

PM_{2.5} > 0.8 $\mu\text{g m}^{-3}$ in East Africa has serious health implications

Increase in surface ozone is small (at most 0.8 ppbv)

Total and Charcoal Industry Surface PM_{2.5} and Ozone

Top-of-atmosphere direct all-sky radiative forcing



Shortwave cooling

Due mostly to scattering by organic aerosols

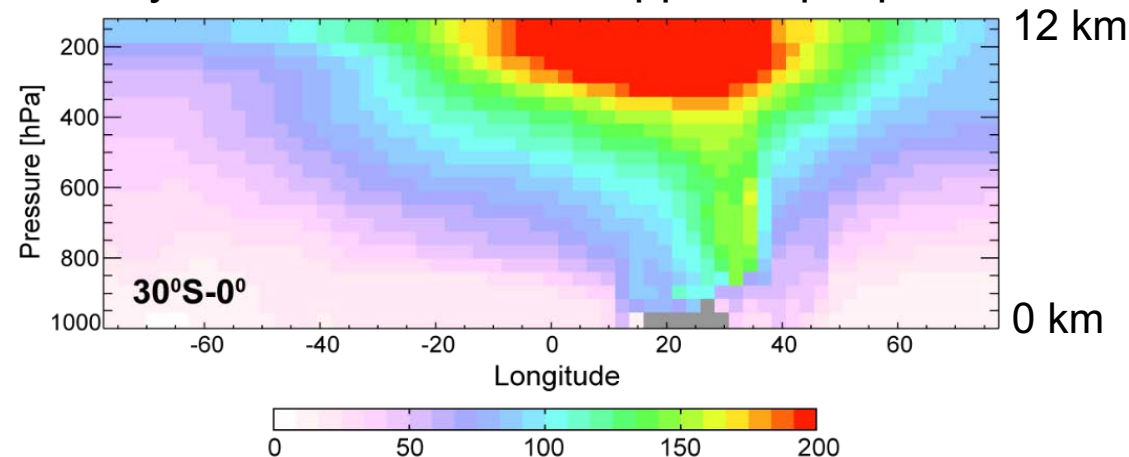
Localized effect, peaking in dense urban areas

Continent mean: **-30 mW m⁻²**

Greater response than 10% reduction in biomass burning emissions of -4 mW m⁻² [Naik et al., 2007]

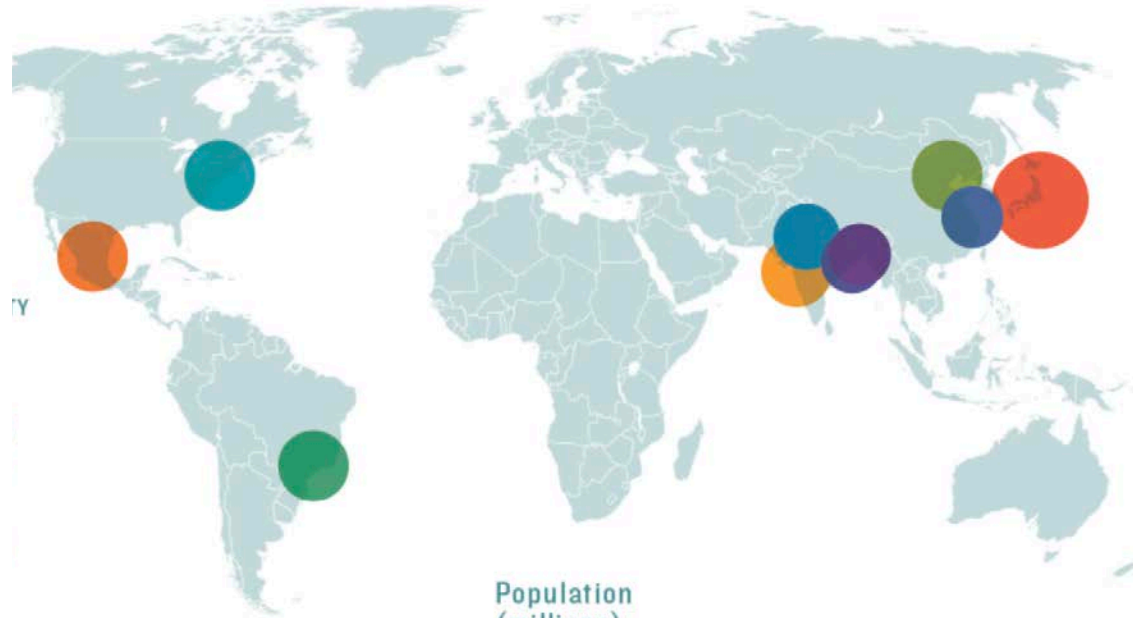
Long- and short-wave heating

Mostly due to ozone in the upper troposphere



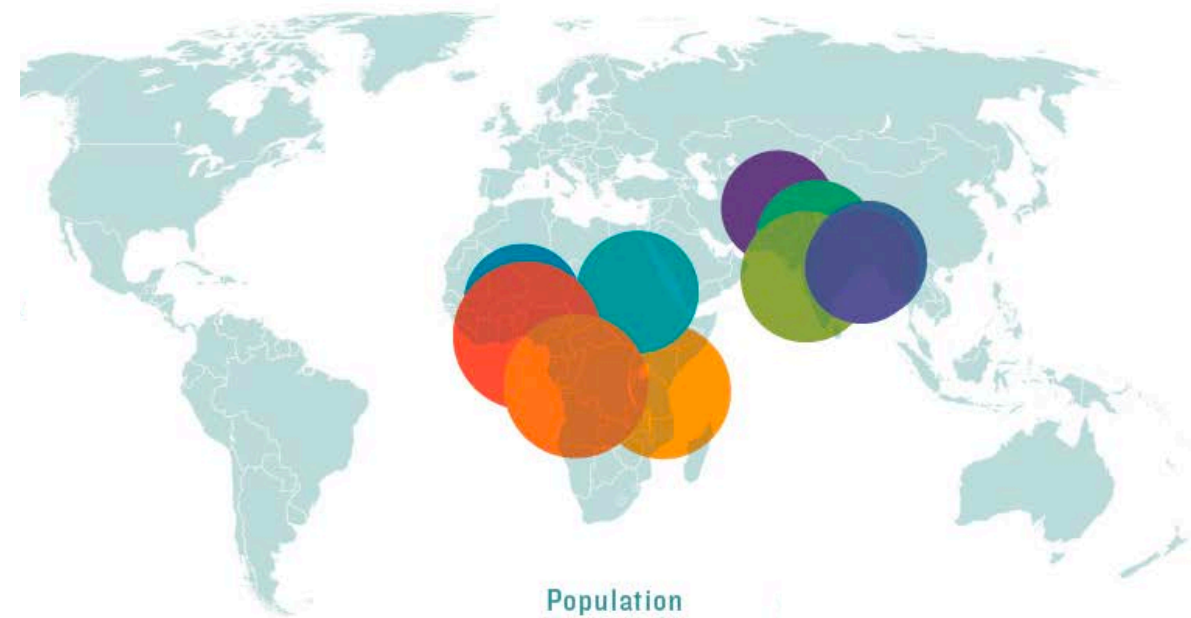
By 2100 The Largest Cities in the World Will be in

2010 Africa 2100



Population
(millions)

36.1	TOKYO
20.1	MEXICO CITY
20.1	MUMBAI
19.6	BEIJING
19.6	SÃO PAULO
19.4	NEW YORK
17.0	DELHI
15.8	SHANGHAI
15.6	KOLKATA
14.8	DHAKA



Population
(millions)

88.3	LAGOS
83.5	KINSHASA
73.7	DAR ES SALAAM
67.2	MUMBAI
57.3	DELHI
56.6	KHARTOUM
56.1	NIAMEY
54.2	DHAKA
52.4	KOLKATA
50.3	KABUL

**Rapid urbanization without
energy alternatives:
Charcoal production will
double by 2030**

Image source: <http://edge.ensia.com/here-come-the-megacities/>

Data source: <https://journals.sagepub.com/doi/pdf/10.1177/0956247816663557>

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Questions?

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