Ambient NO_x pollution in Accra, Ghana: Spatiotemporal patterns and role of meteorology

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Multi-country and multi-institution effort

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PATHWAYS TO EQUITABLE HEALTHY CITIES

Solomon Baah; Josephine Bedford-Moses; James Nimo

INTEGRI PROCEDAMUS

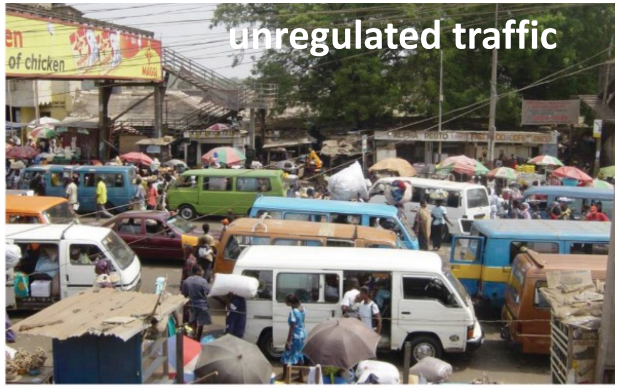
UNIVERSITY OF GHANA

Contributing Pathways team members:

- **Imperial College London** (Majid Ezzati; James Bennett; Frank Kelly; Ben Barratt)
- **University of Ghana** (Samuel Agyei-Mensah; Ernest Agyemang; Allison Hughes; George Owusu)
- **University of British Columbia** (Michael Brauer)
- **McGill University** (Jill Baumgartner)

Urban air pollution in Sub-Saharan Africa

- Air pollution in SSA cities is a huge public health issue:
- Diverse combustion and non-combustion sources
- Regional influences from Sahara Desert during the Harmattan season
- Lack of monitoring network for pollutants, especially NO_x

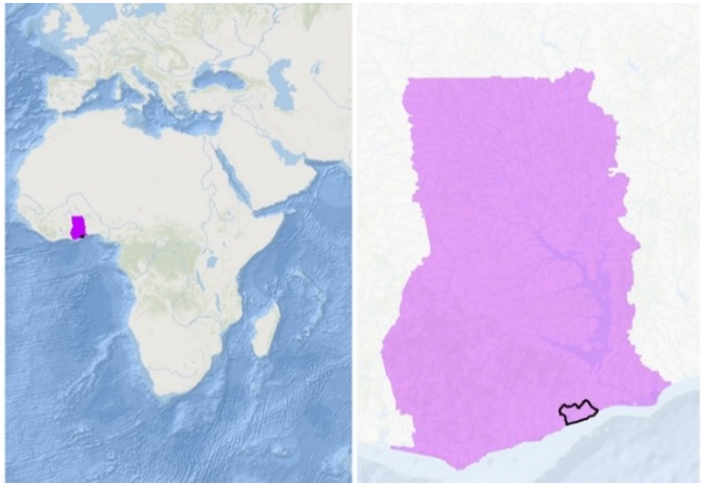


Urban and economic expansion in Accra

- Accra, capital city of Ghana, expand remarkably in the last two decades
  - Population increased ~3 times since 2000
  - Vehicle numbers increased ~6 times since 2005
- Household biomass use as fuel dropping but remain high (~50%)
- Unclear whether relative influence of biomass vs traffic is changing

Study design

- Location: Greater Accra Metro (GAMA)
- Sampling time: July 2019 – June 2020
- Sampling method:
  - Passive Ogawa sampler
- 150 monitoring sites:
  - Fixed sites (year-long, n=10) for temporal patterns
  - Rotating sites (week-long, n=140) for spatial pattern
    - Commercial/Business/Industrial (CBI) (Traffic)
    - High density residential (HD) (Traffic and biomass burning
    - Medium/Low density residential (LD)
    - Peri-urban background (UB)



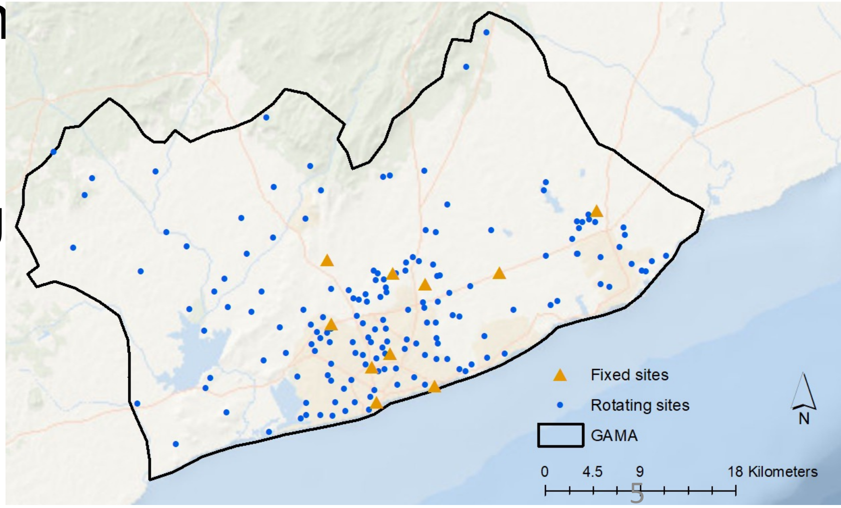
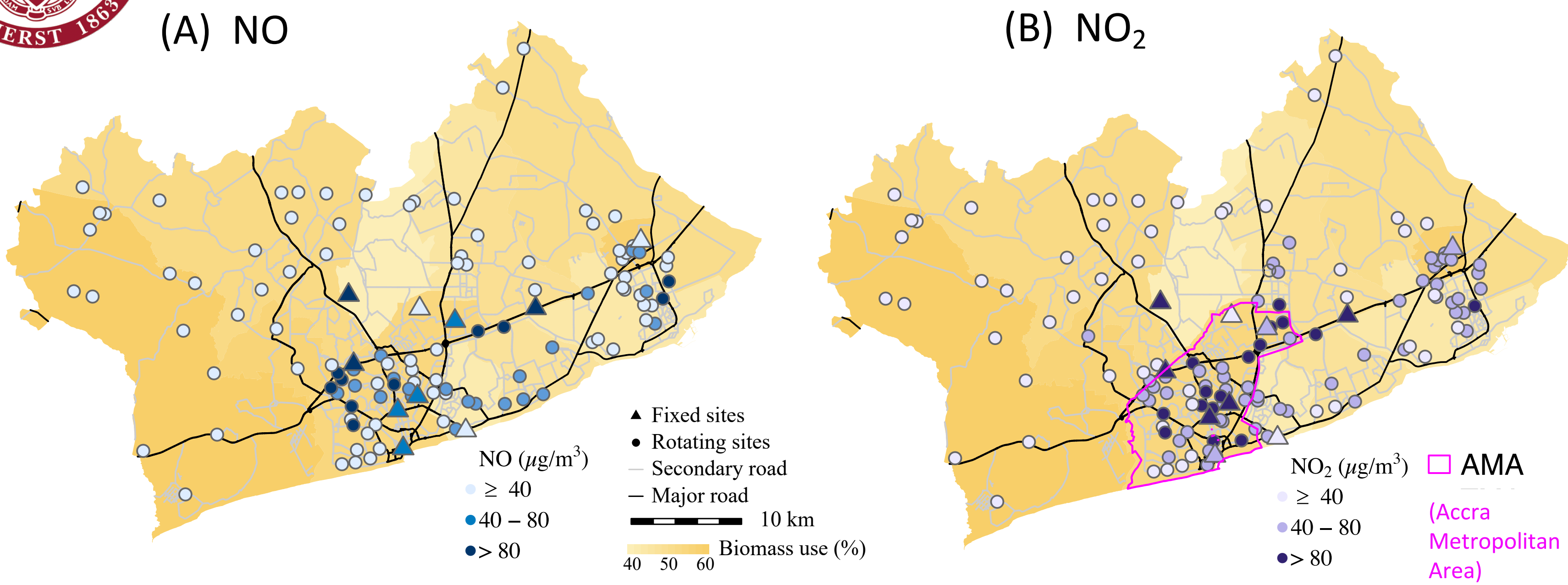
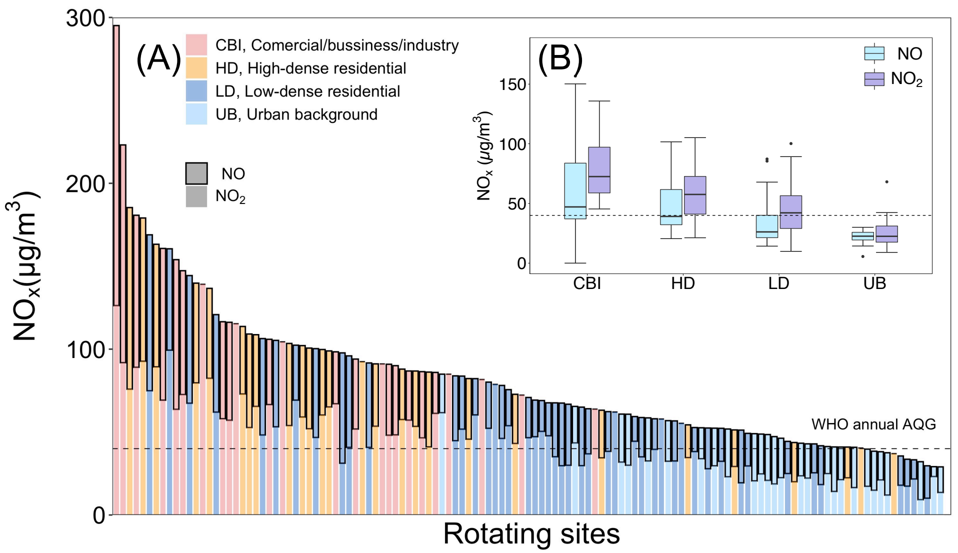


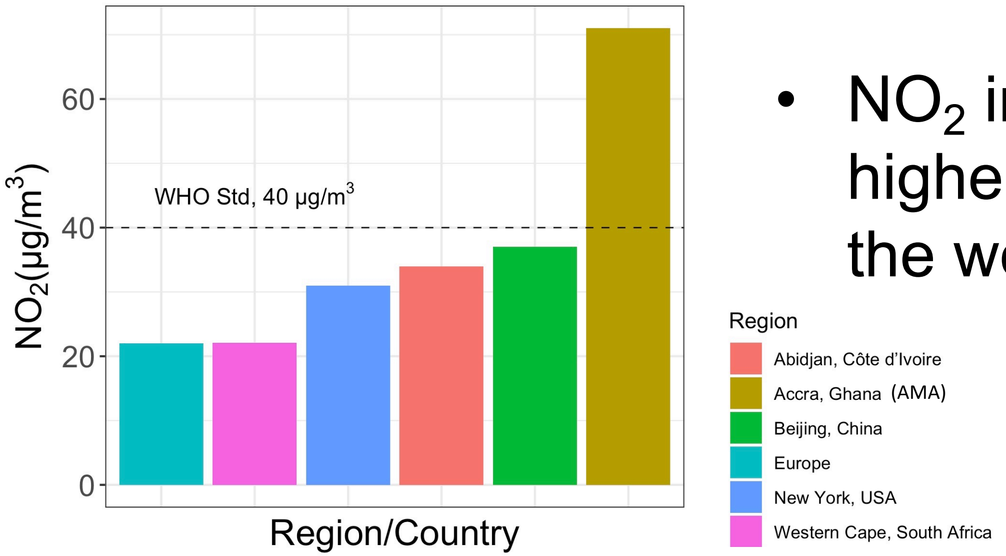
Figure from Clark *et al.*, 2020, BMJ Open

Important spatial variation in NOx



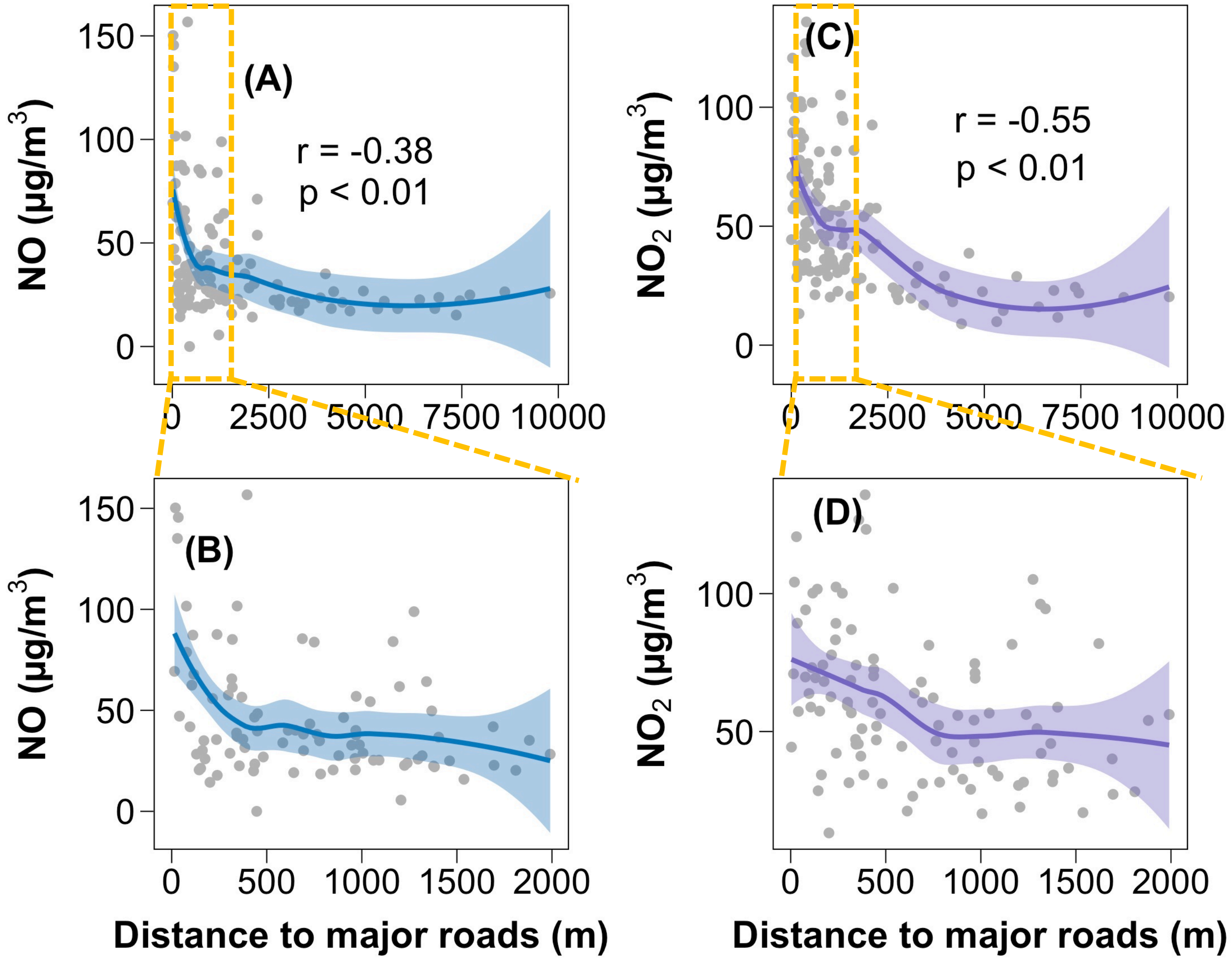
- GAMA average conc:
  - NO: 38 μg/m³
  - NO_2: 48 μg/m³
- ~60% sites exceed WHO guideline for NO_2
- CBI > HD > LD >UB
- NO_2 in AMA is much higher than the rest of the world





Wang et al., *under review*

Traffic is the most important source



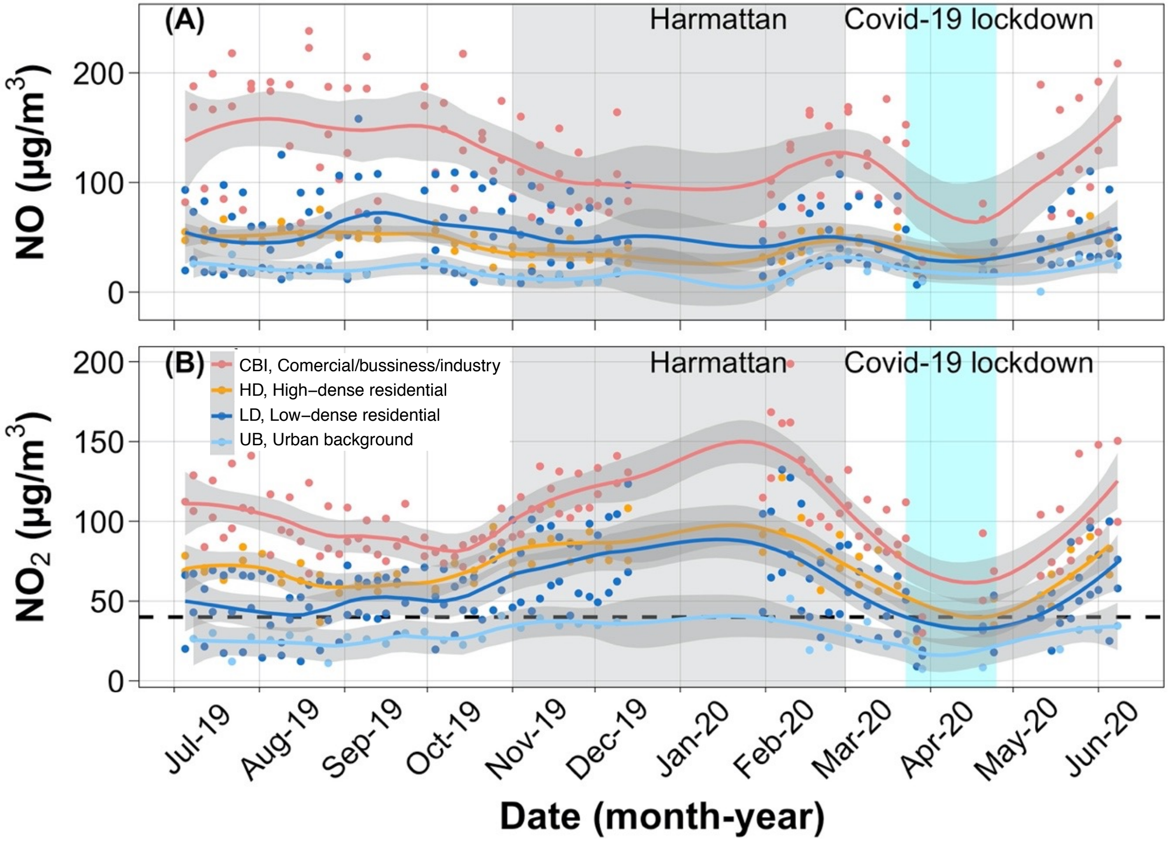
Conc. ≤ 500 vs. >500 m:

- NO: 60 vs. 33 µg/m^3, $p < 0.01$;
- NO_2: 68 vs. 41 µg/m^3, $p < 0.01$

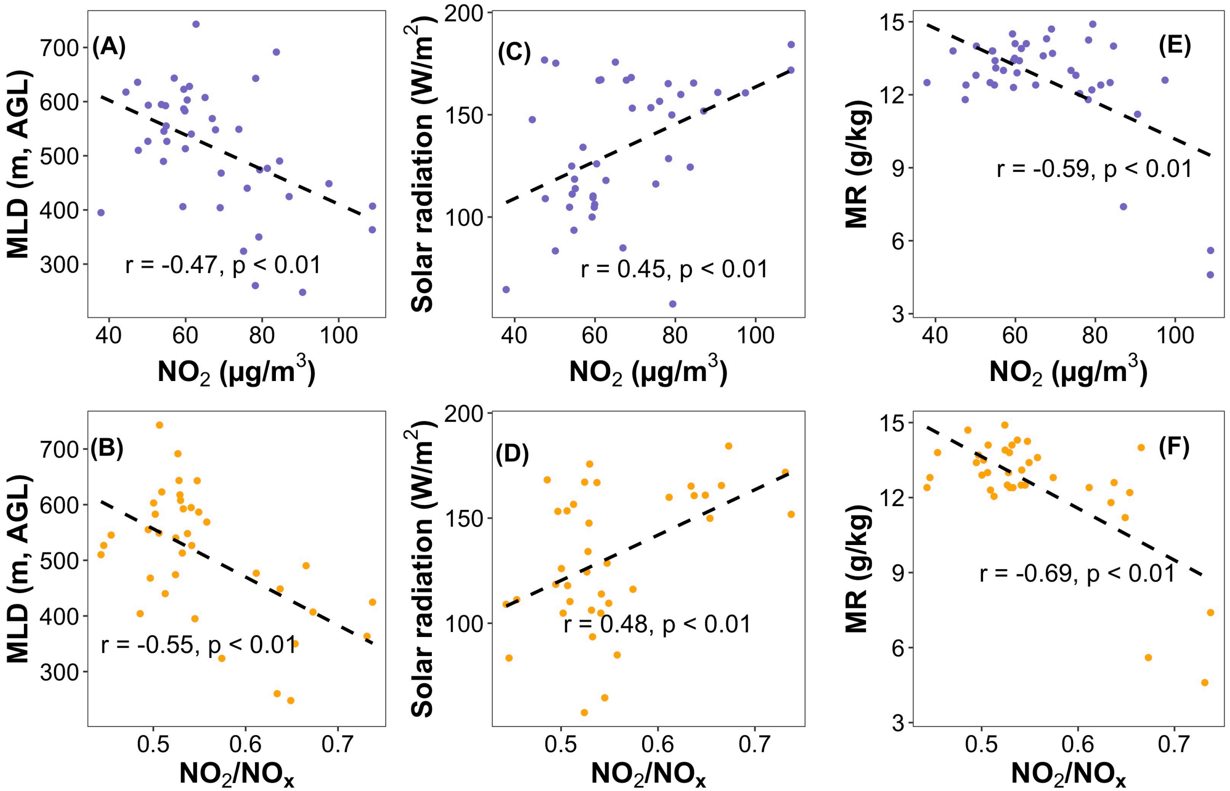
Wang et al., *under review*

Temporal variation

- NO – primary emission, little change
- NO_2 – increased significantly during the Harmattan



Wang et al., *under review*

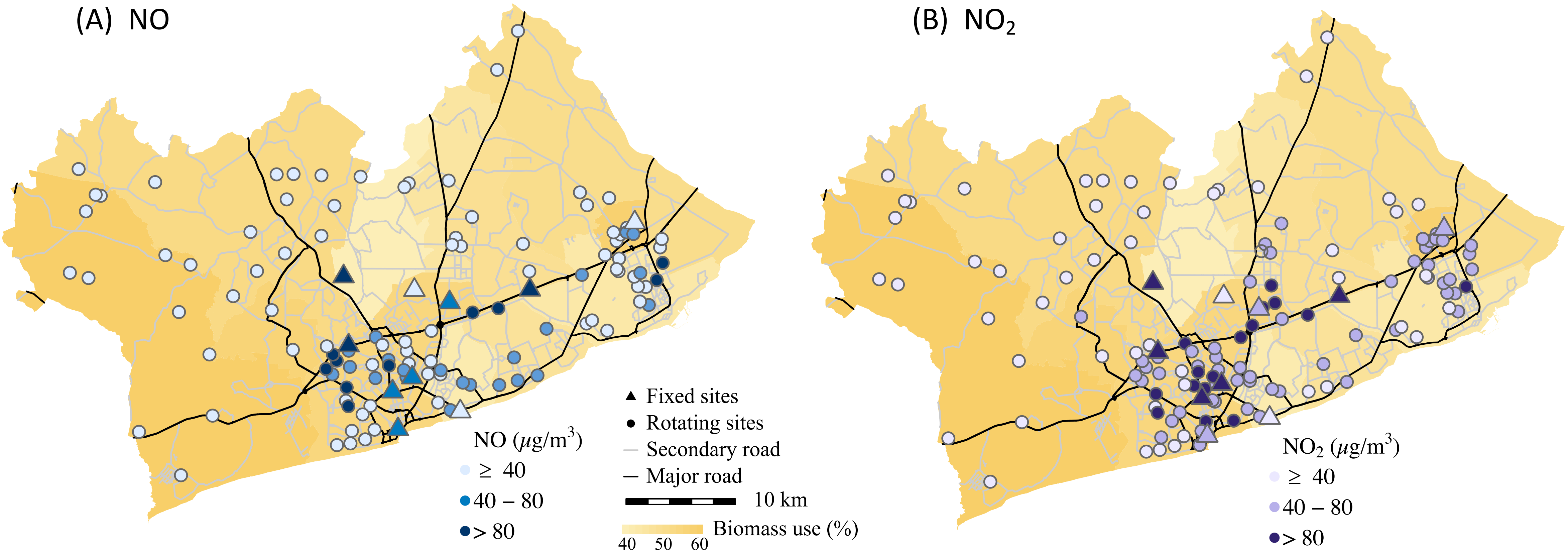


- Local pollution level was likely enhanced due to lowering of the mixing layer depth
- Secondary formation of NO_2 was likely promoted by higher solar radiation and drier air

MLD: mixing layer depth; MR: water vapor mixing ratio

Measured data as input for LUR models

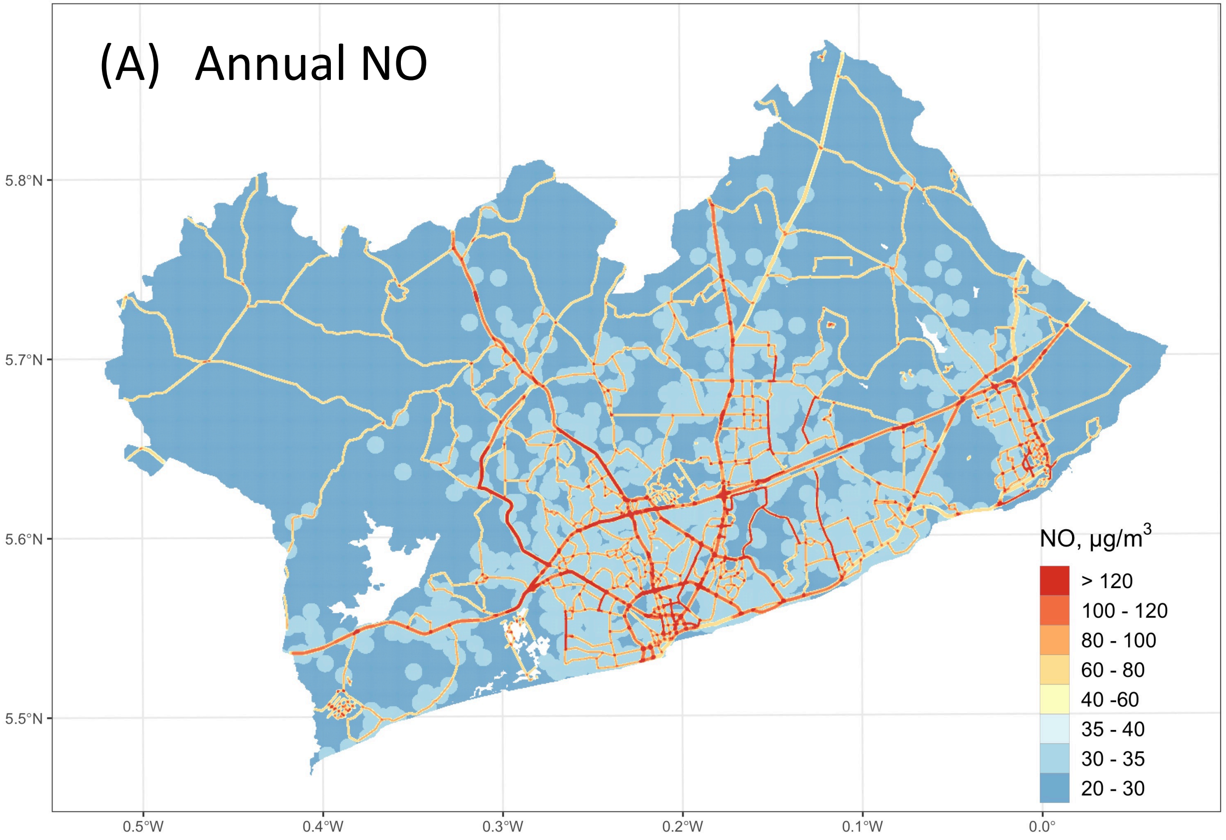
- Spatial predictors: Land use factors
  - Total length of maj/sec roads; NDVI; bar presence
- Temporal predictors: Weekly meteorological factors
  - RH; wind speed; solar radiation

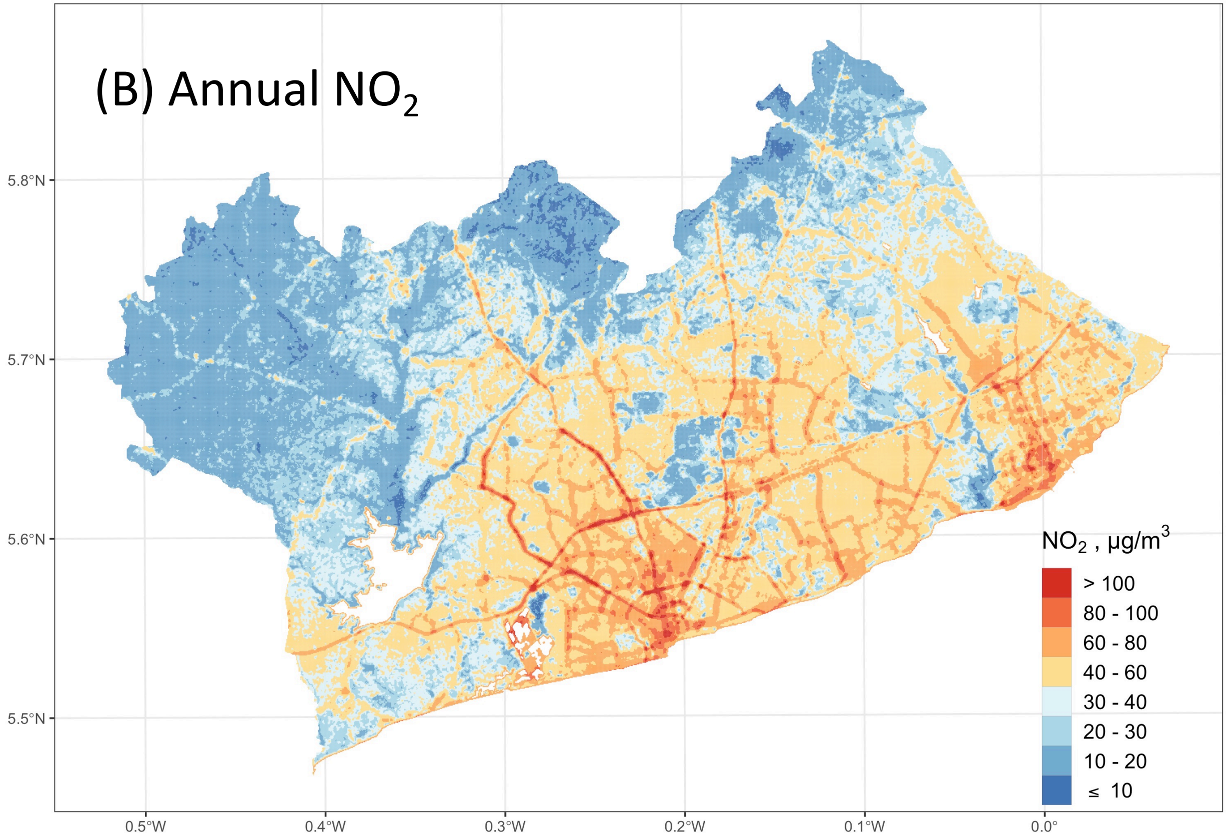


High spatial (50m) and fine temporal (weekly) LUR models of NO_2 and NO

NO: 34 (23): 24-514 μg/m^3

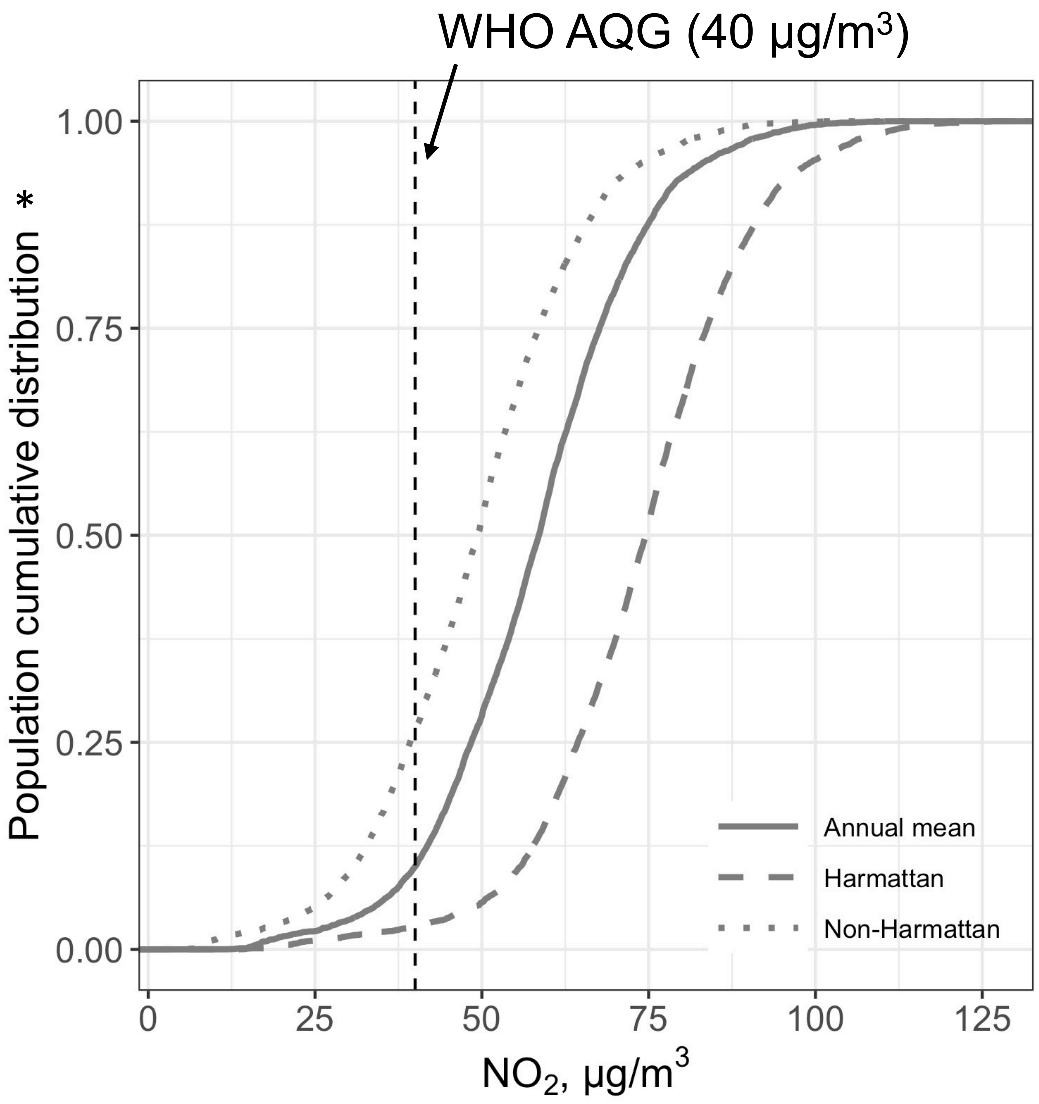
NO_2: 37 (19): 0.08 – 189 μg/m^3





Wang et al., *in prep*

NO_2 Population exposure estimates



- Annual: Over 88%
- Non-Harmattan: 75%
- Harmattan: Almost 99%

* population data: 2010 Ghana's Census

Wang et al., *in prep*

Summary

- NO_2 pollution is severe in GAMA – 60% of our sampling sites, and about 88% of the population exposed to levels exceeding the WHO annual guideline

- Traffic is the most important source of NO_x

- Local pollution level likely got enhanced due to meteorology changes during the Harmattan season

Policy Implications

- Although Ghana has been making big efforts in reducing air pollution:
  - Adoption of low sulfur content standard in diesel from 3000 ppm down to 50 ppm for all diesel fuel imports from July 2017, and
  - Adoption of Euro 4/IV vehicle emission standards from end of 2018

- Stronger enforcement is needed to meet the emission limits

- Stringent emission policies, especially during the dusty Harmattan season

Thanks for all your attentions!

Any questions?

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