Methods for Projecting CO_2 Emissions in Southeast Asia

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The Problem

- Developing Cities and Carbon Emissions
- Harms
    - Climate Change
    - Pollution
- Mapping CO_2 Emissions by city area
- CO_2 Emissions Projections

Methods

- Mapping CO_2 Emissions by Population and by Nighttime Lights
- Carbon Dioxide Prediction by Region
- Relation of Zipf’s Law and the Pareto Principle

Mapping CO_2 Emissions by Population and by Nighttime Lights

- Variance between the models
  - 0 ≤ |NTL - PPP| ≤ 250 ≤ max
- May need to use both to obtain limit per pixel

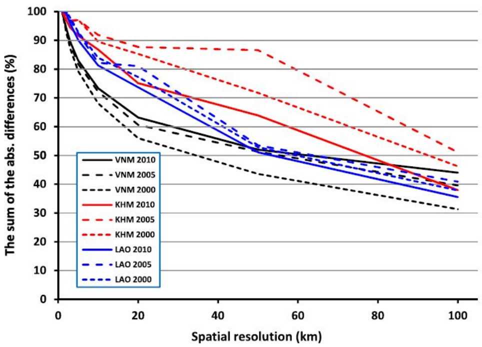


Figure 6. The level of disagreement between the two gridded CO_2 datasets by the spatial resolution (pixel size) in km versus the sum of the absolute differences at the spatial resolution divided by the sum of the absolute differences at 1 km, presented as a percentage.

(Gaughan et. al, 2019)

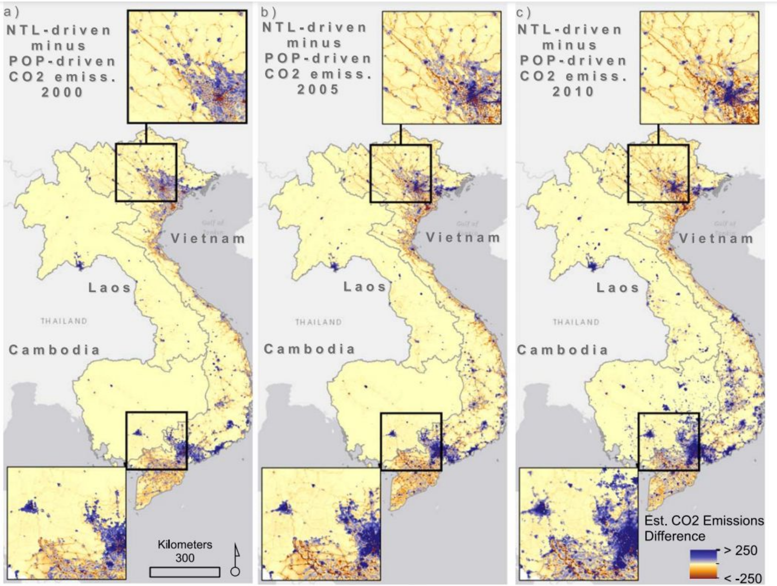
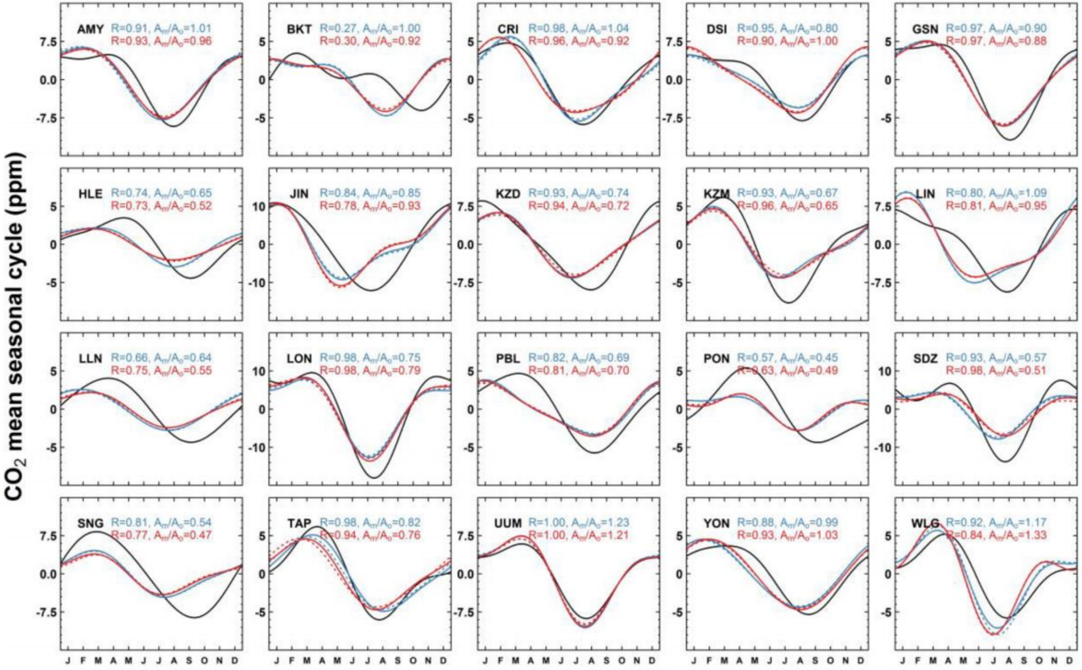


Figure 5. Per pixel differences in CO_2 emissions estimates produced using only nighttime light intensity, minus those produced using population estimates (per capita emissions). Units are expressed in tonne carbon/year/grid cell and results are separated by the years 2000 (a), 2005 (b), and 2010 (c).

Carbon Dioxide Prediction by Region

- BKT, PBL, DSI
  - Indonesia, Port Blair (India), Dongsha Island (South China Sea)
- BKT: R = 0.3
- PBL: R = 0.81
- DSI: R = 0.9



Observed v.s. Simulated Mean Seasonal CO2 Emissions Cycles for 39-layer models (Standard Prediction Model: Blue, China-India Prediction Model: Red) (Lin et al., 2018)

Relation of Zipf's Law and the Pareto Principle

- Internal v.s. External Complexity
- CO_2 Emissions to City Population Size

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- CO_2 Emissions to Number of Cities

Table 1. The numerical relation between the capacity dimension and the correlation dimension.

Pareto exponent (D_0)	Correlation dimension (D_2)	Zipf exponent (d_0)	Zipf's correlation exponent (d_2)
0.5	**0**	2	3
0.6	**0.2**	1.667	2.333
0.7	**0.4**	1.429	1.857
0.8	**0.6**	1.250	1.500
0.9	**0.8**	1.111	1.222
1	**1**	**1**	**1**
1.1	1.2	**0.909**	**0.818**
1.2	1.4	**0.833**	**0.667**
1.3	1.6	**0.769**	**0.538**
1.4	1.8	**0.714**	**0.429**
1.5	2	**0.667**	**0.333**
1.6	2.2	**0.625**	**0.250**
1.7	2.4	**0.588**	**0.176**
1.8	2.6	**0.556**	**0.111**
1.9	2.8	**0.526**	**0.053**
2	3	**0.500**	**0**

Note: The bold denotes the rational intervals of the scaling exponent values.
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$$P_k = P_1 k^{-d}$$

$$C(\lambda r) = \frac{1}{N^2}\int_{-\infty}^{\infty} s^{-D_0}(s-\lambda r)^{-D_0}\mathrm{d}s$$
$$= \frac{1}{N^2}\int_{-\infty}^{\infty} (\lambda y)^{-D_0}(\lambda y-\lambda r)^{-D_0}\mathrm{d}(\lambda y)$$
$$= \lambda^{1-2D_0}C(r)$$

(Chen, 2011)

Plan for Further Investigation

- Development of a predictive model: relationship between population and CO_2 increase
  - Zipf's Law and Pareto Principle
  - Obtain relationship between carbon emissions and population growth using NTL and PPP models as basis
- Find way to map of projected physical city population growth in Southeast Asia

References

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Lin, Xin, Ciais, Philippe, Bousquet, Philippe, Ramonet, Michel, Yin, Yi, Balkanski, Yves, . . . Zhou, Lingxi. (2018). Simulating CH 4 and CO 2 over South and East Asia using the zoomed chemistry transport model LMDz-INCA. Atmospheric Chemistry and Physics, 18(13), 9475-9497.

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