Two global maps of anthropogenic CO_2 emission derived with a database of large point sources

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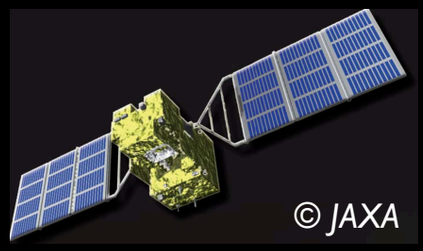
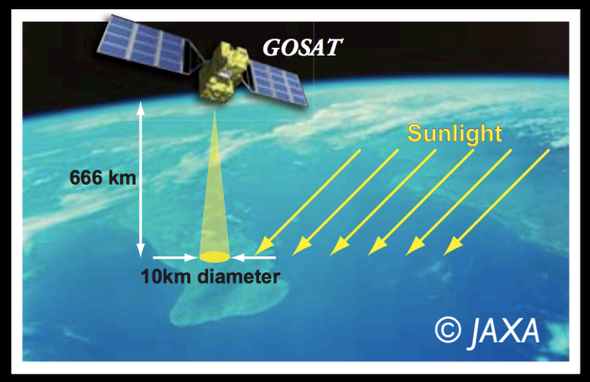
Greenhouse gases GOSAT PROJECT Observing SATellite

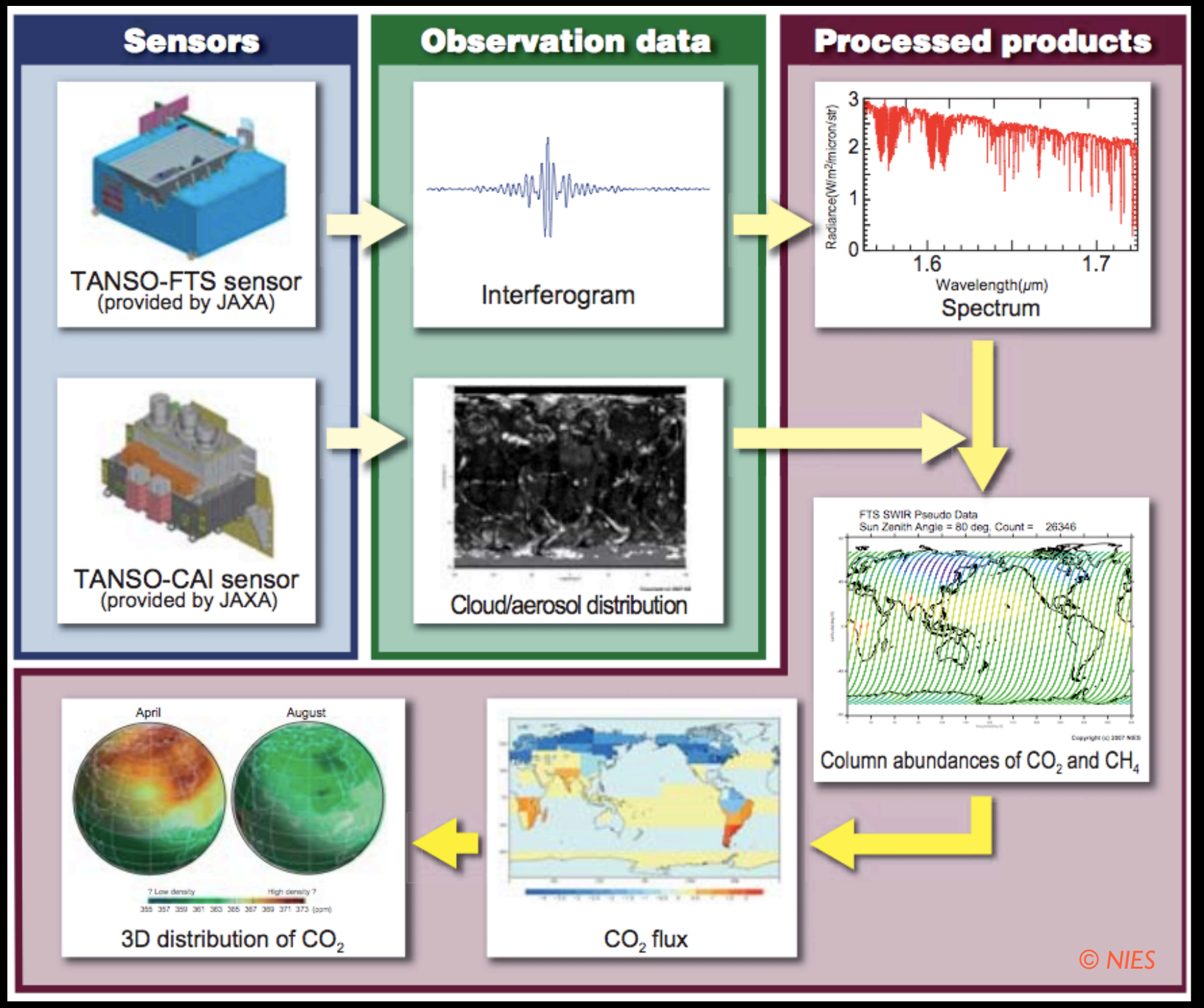
Fossil fuel CO_2 emission data

- *Useful tool for monitoring/controlling emission*
- *Input data for atmospheric modeling*
- *Serve as a reference in inverse estimation*

Greenhouse gases Observing SATellite







Outline of GOSAT data processing

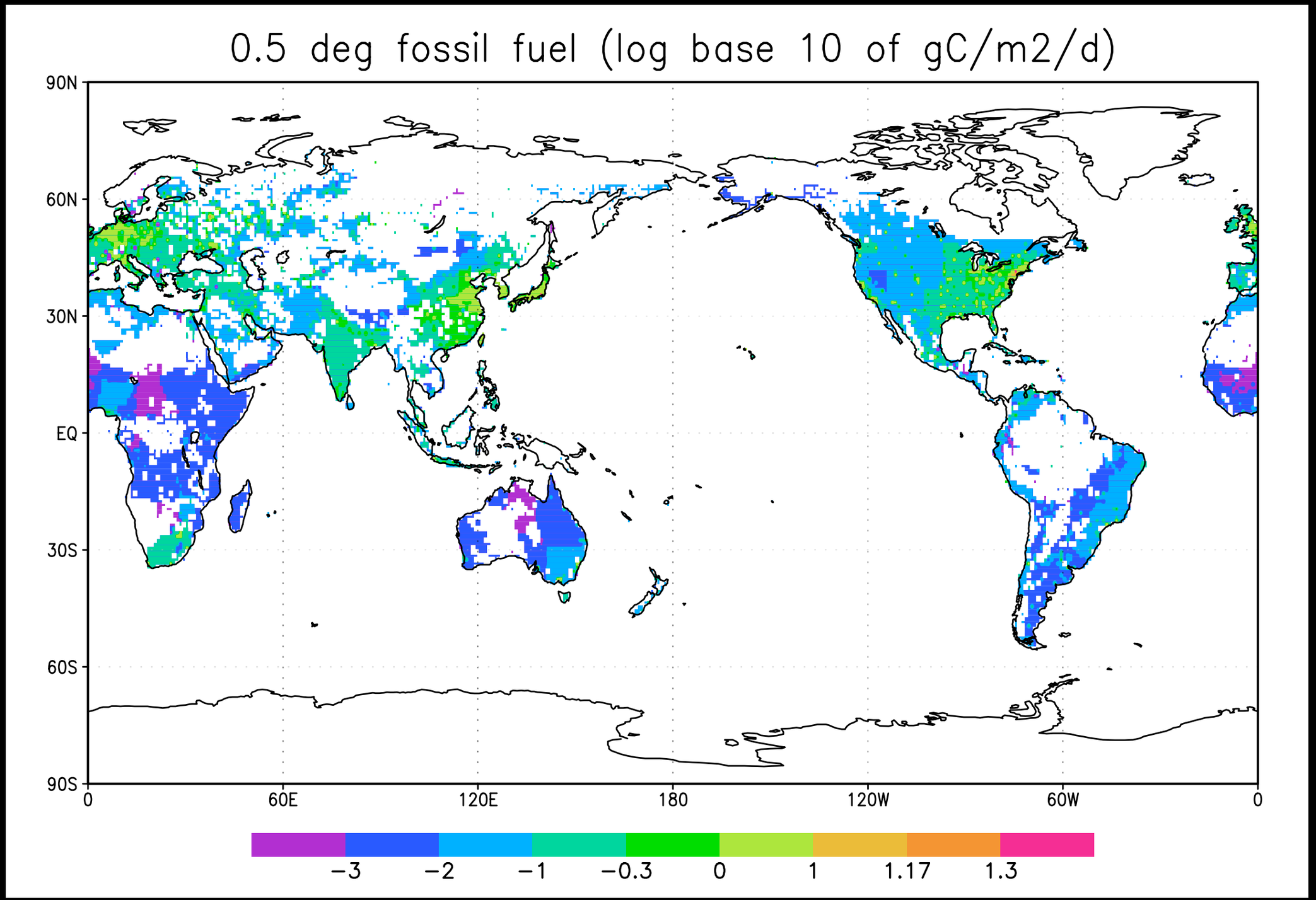
Fossil fuel CO_2 emission data

- *Useful tool for monitoring/controlling emission*
- *Input data for atmospheric modeling*
- *Serve as a reference in inverse estimation*

Fossil fuel CO_2 map

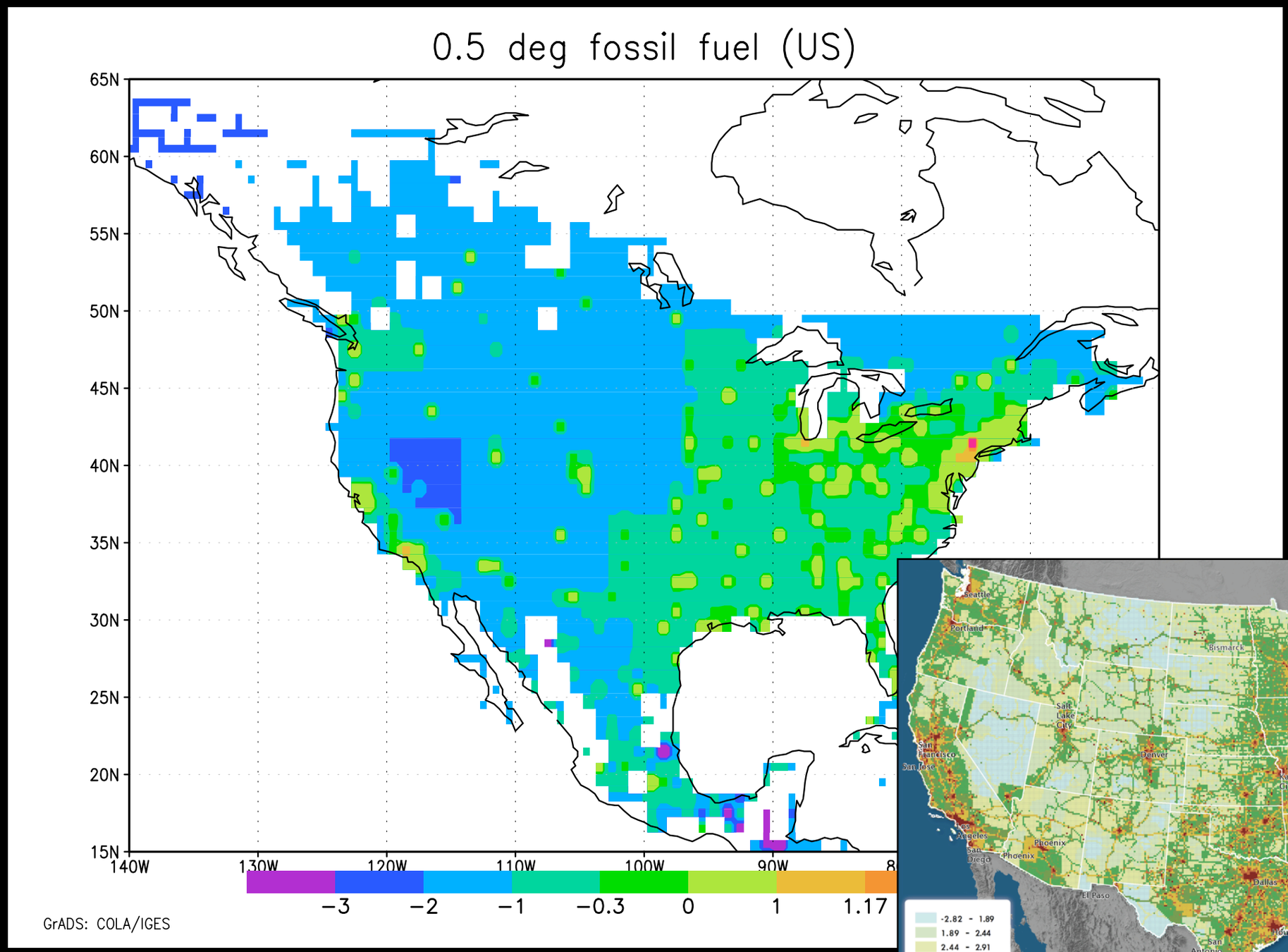
- *Derived from global energy statistics*
- *Population may explain emission distribution*
- *Typical spatial resolution is one degree*
- *No annual change*
- *No seasonality*

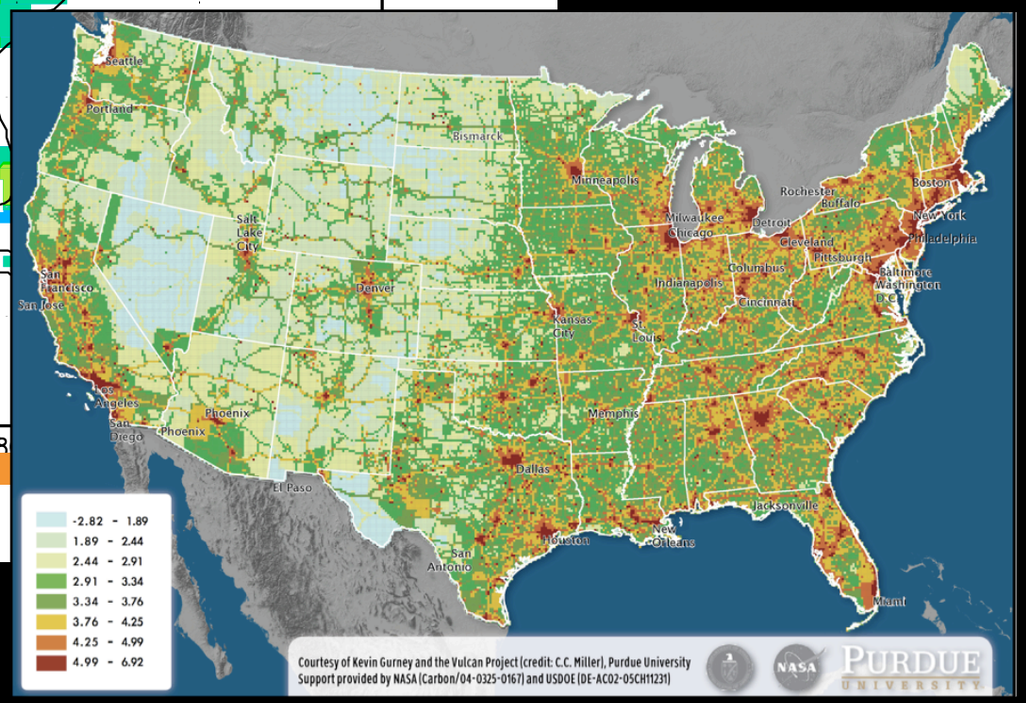
Input for global inversion



0.5 deg map, original CDIAC data was 1 deg data (Law et al. 2006)

North America

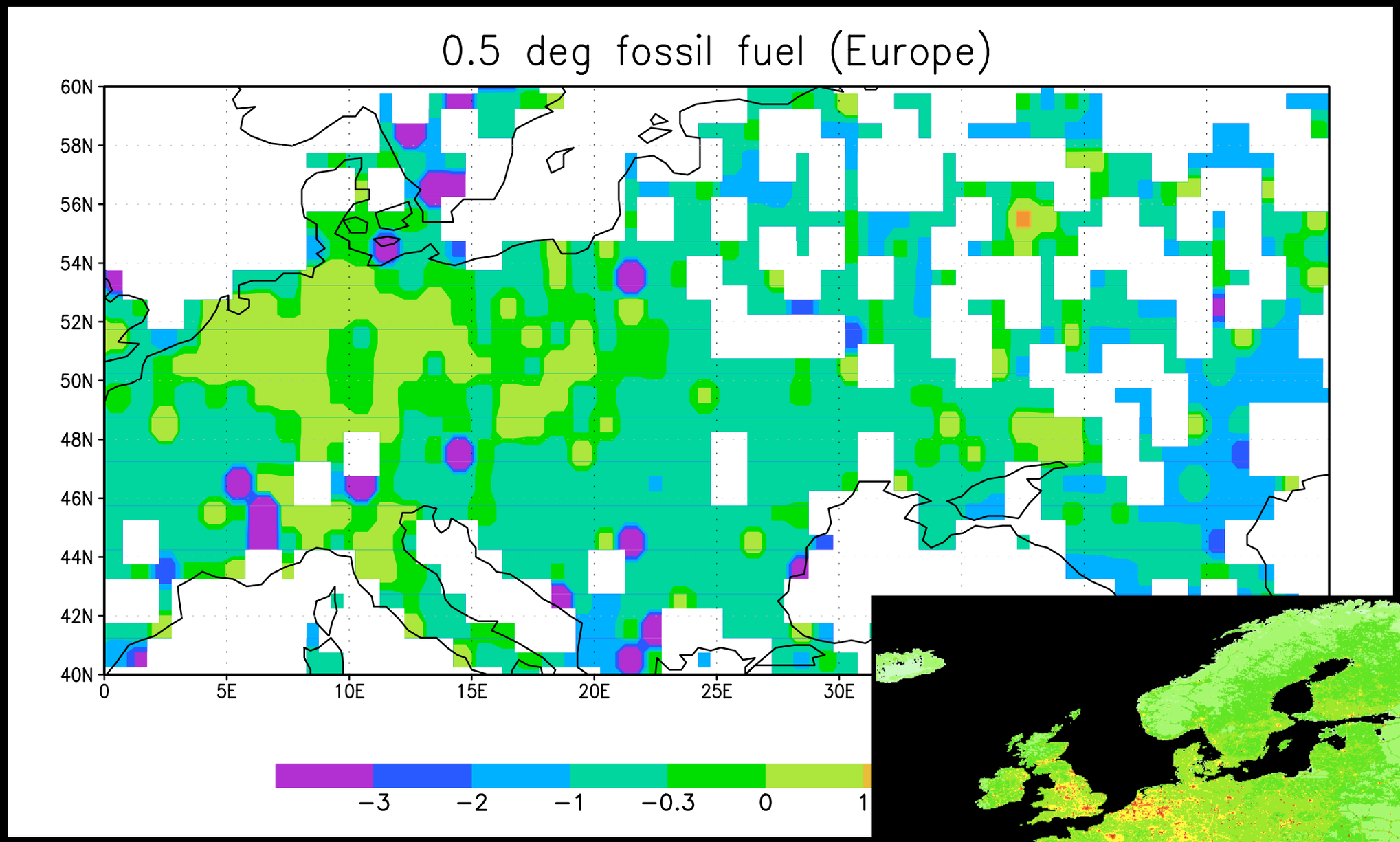


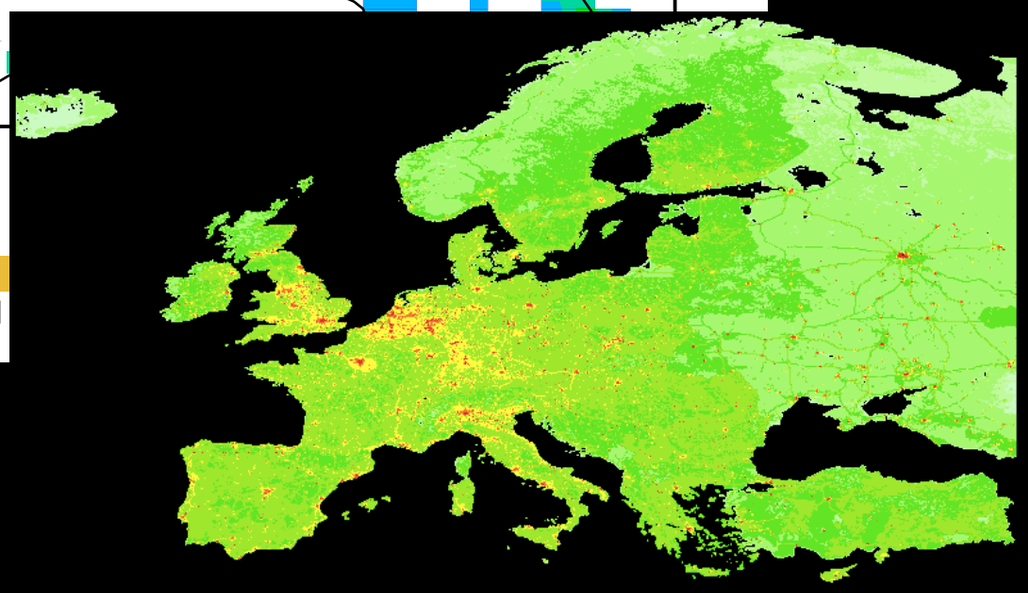


Unit: Log base 10 of gC/m²/d

Vulcan project (Gurney et al. 2008)

Europe

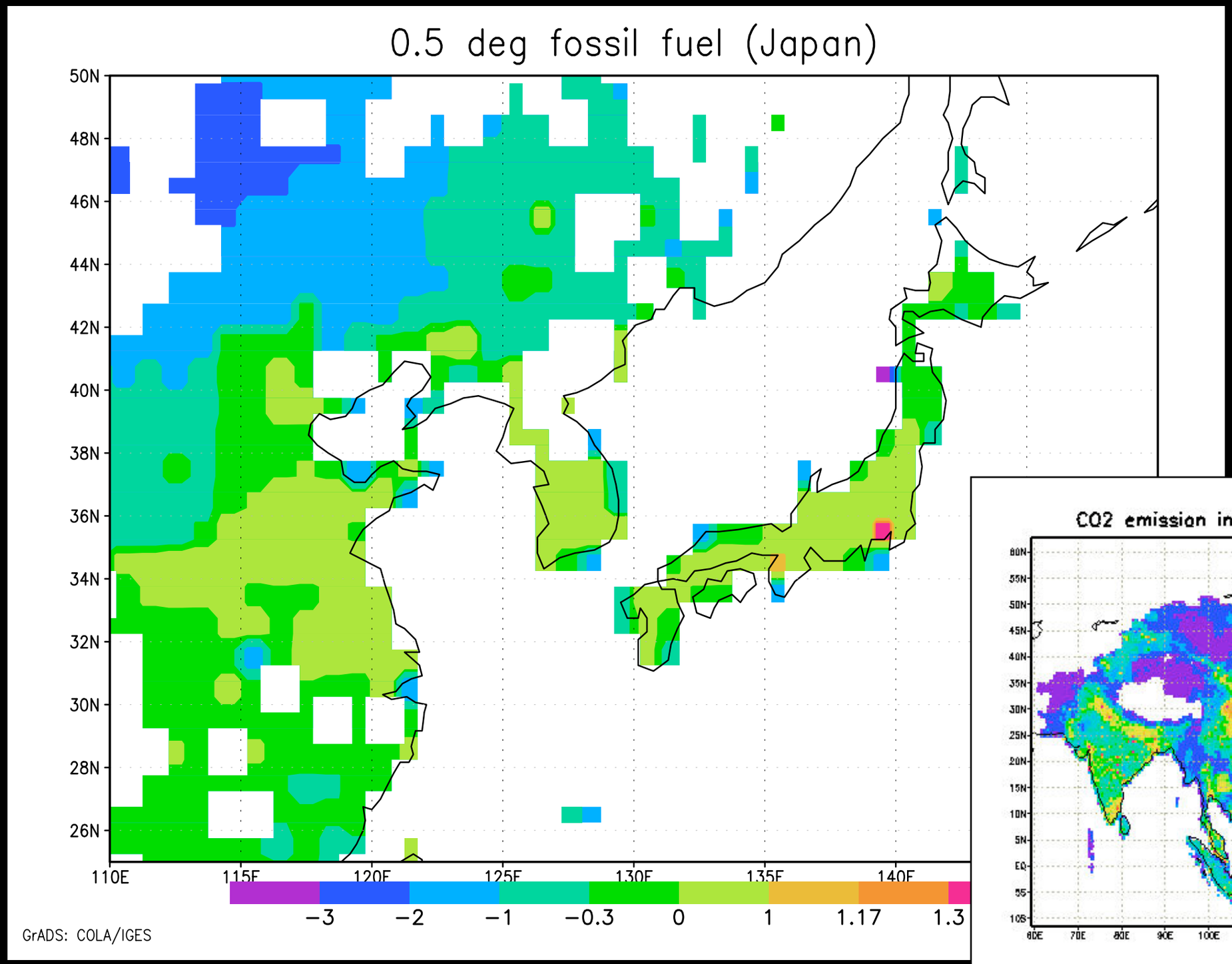




Unit: Log base 10 of gC/m²/d

Thiruchittampalam et al. 2009, in prep

East Asia



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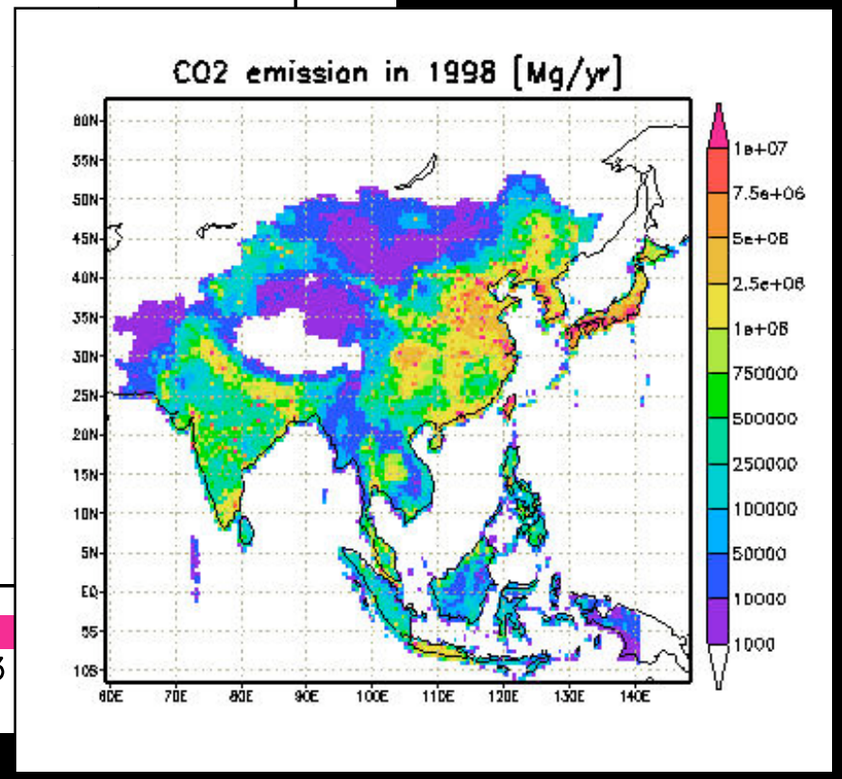


REAS (Ohara et al. 2008, ACP)

Fossil fuel CO_2 map

- *Derived from global energy statistics*
- *Population may explain emission distribution*
- *Typical spatial resolution is one degree*
- *No annual change*
- *No seasonality*

Need to be upgraded for high-resolution study!

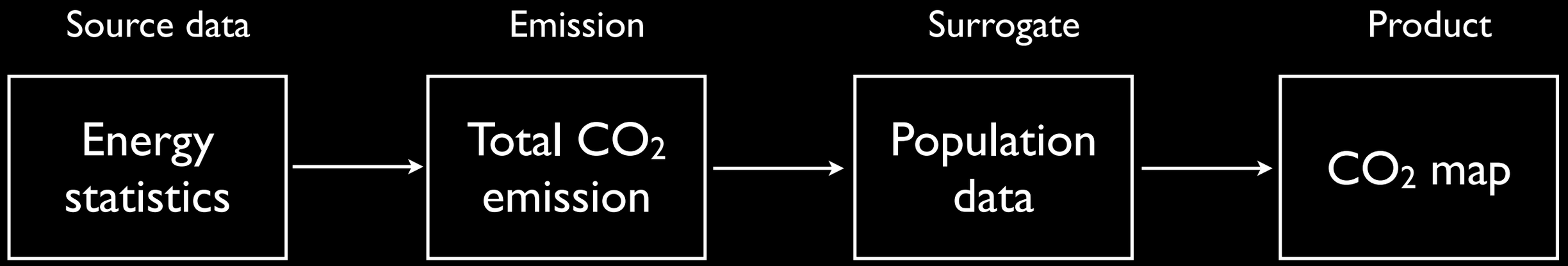
Our goals

We prepared fossil flux data of ...

- *Spatial resolution: global 5 x 5 km*
- *Temporal resolution: Monthly*
- *Year coverage: 27 years (1980-2007)*

for inverse estimation of CO_2 flux using GOSAT observational data

Mapping algorithm



Issues on high-resolution mapping

✓ *How to deal with various types of sources?*

- Point, line and other sources should be considered

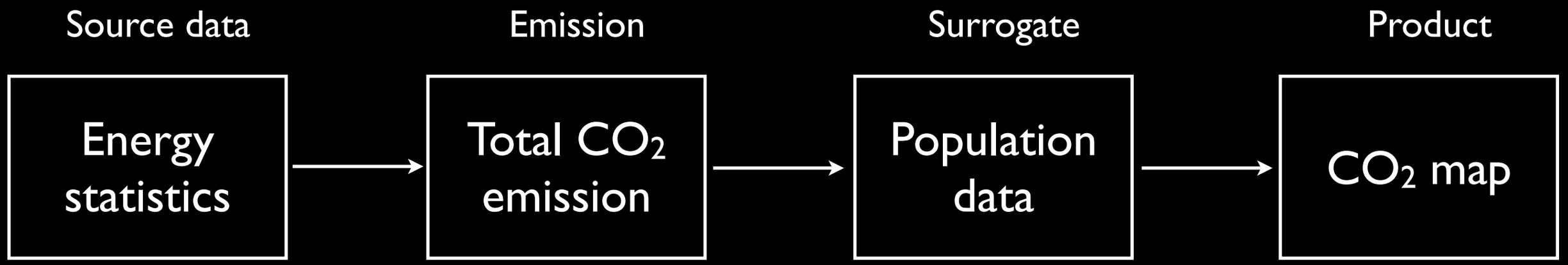
✓ *Do population statistics work well as a surrogate?*

- Not certain if applied to high-resolution mapping

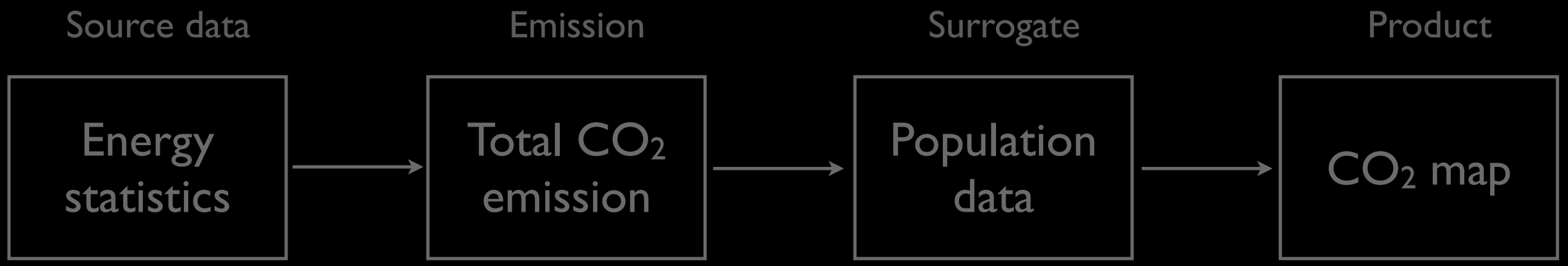
✓ *How to account for temporal change of flux?*

- Need to parameterize since no data is available

Global mapping algorithm



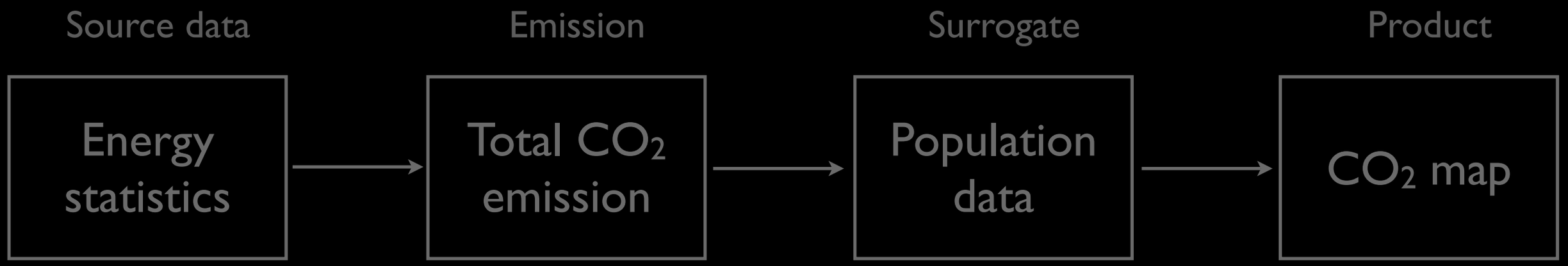
Our mapping algorithm



Energy statistics

Source data

Our mapping algorithm

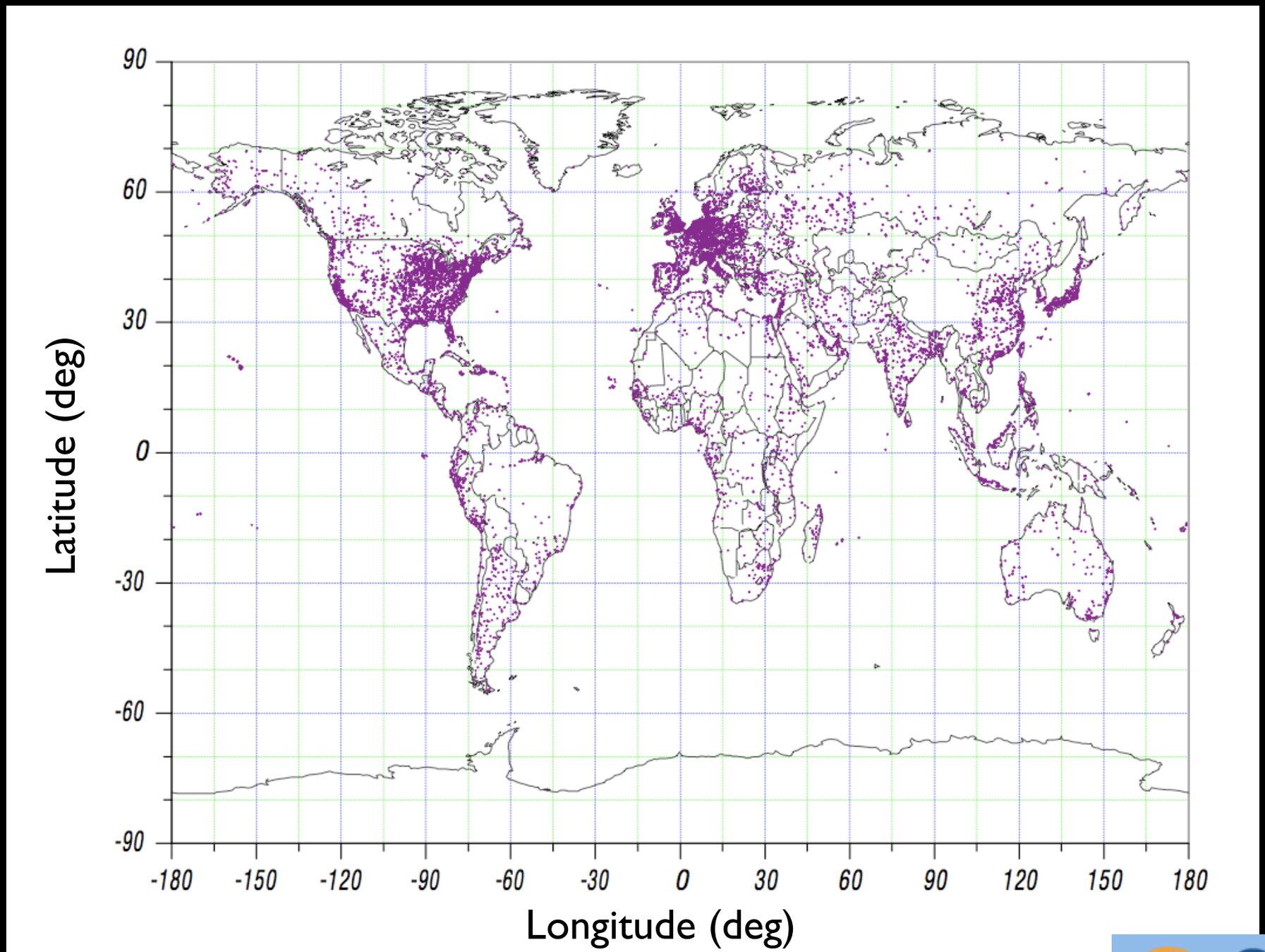


Energy statistics

DB of point source

Source data

Point source database: CARMA

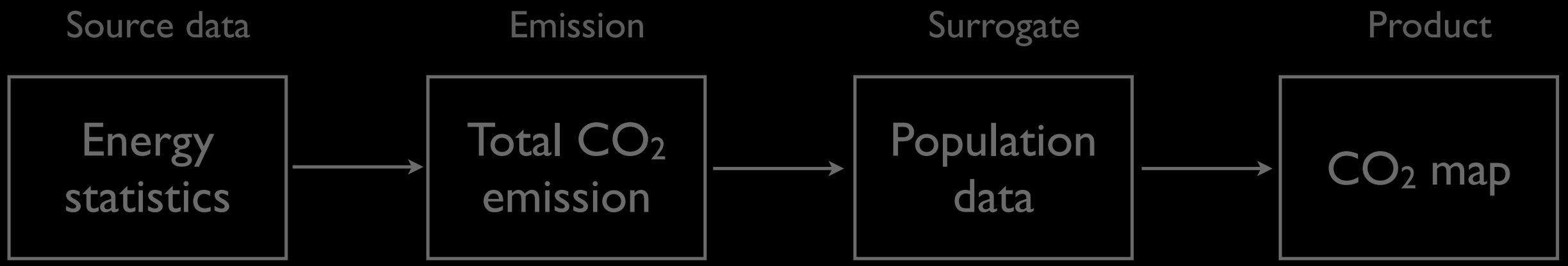


Plot for 2007, over 17000 power plants are mapped.

CARMA
Carbon Monitoring for Action

Visit http://carma.org/

Our mapping algorithm



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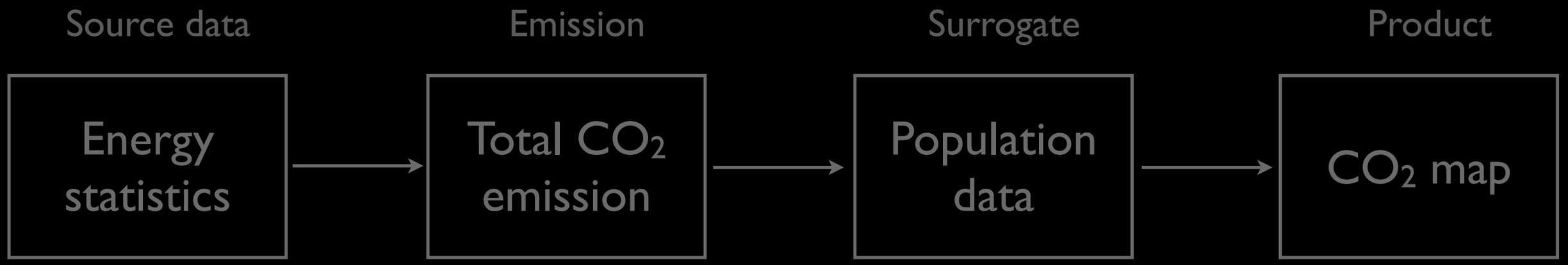

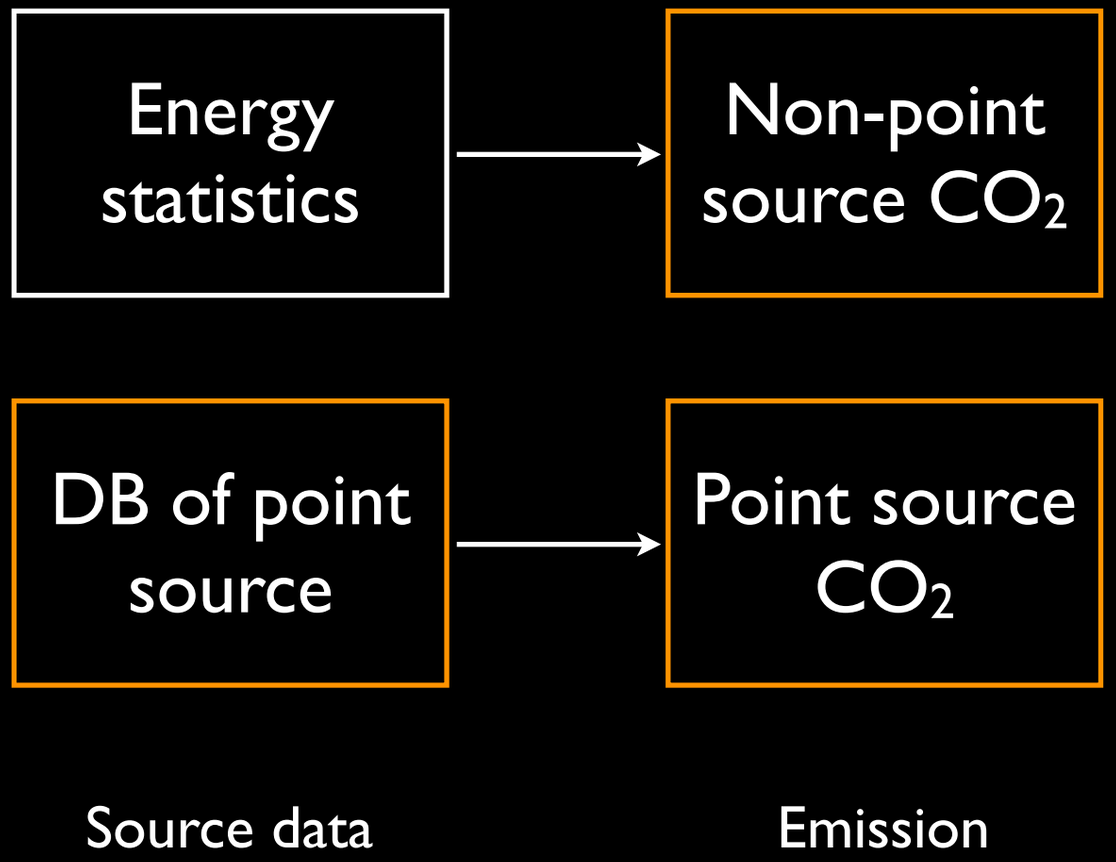

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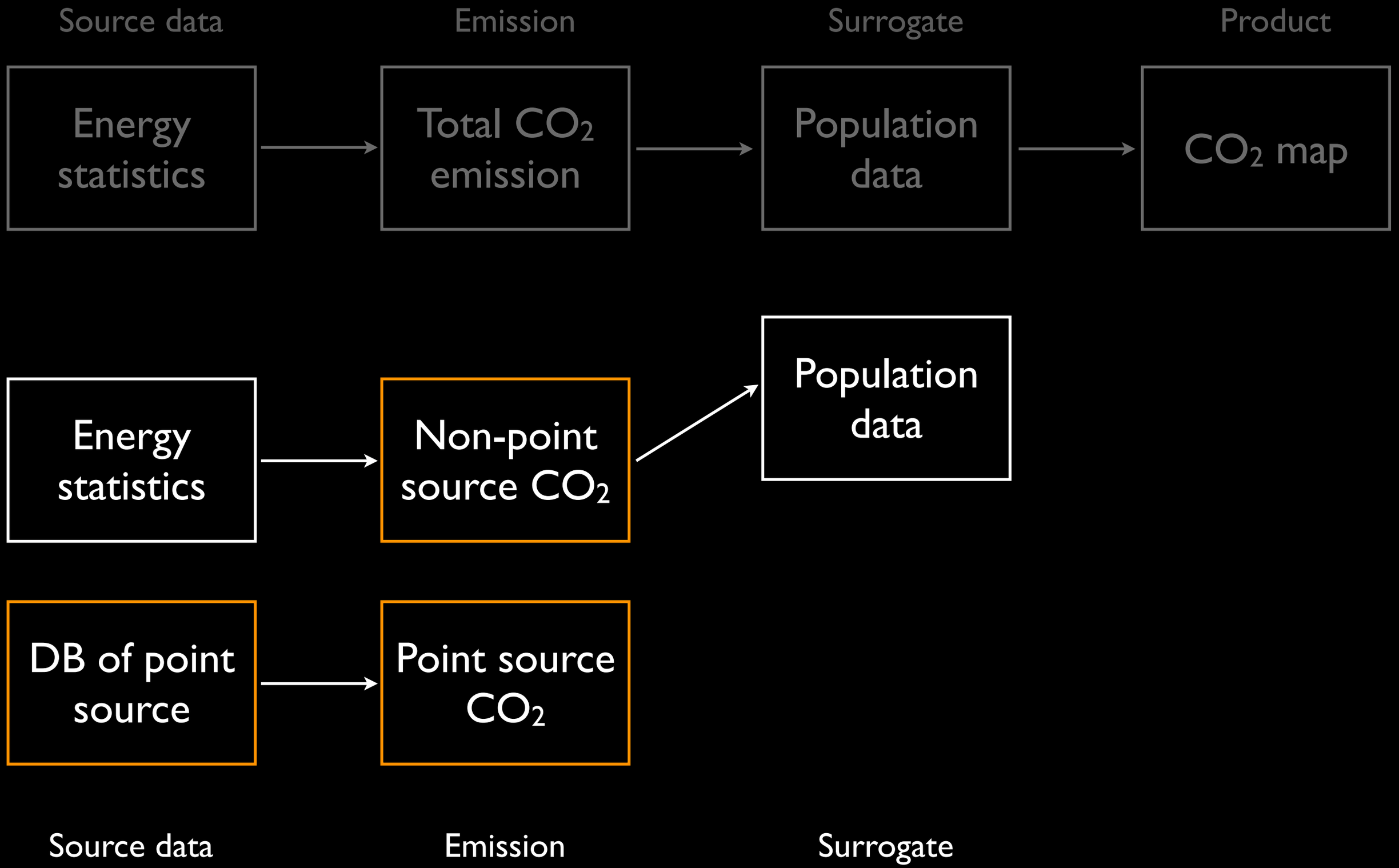
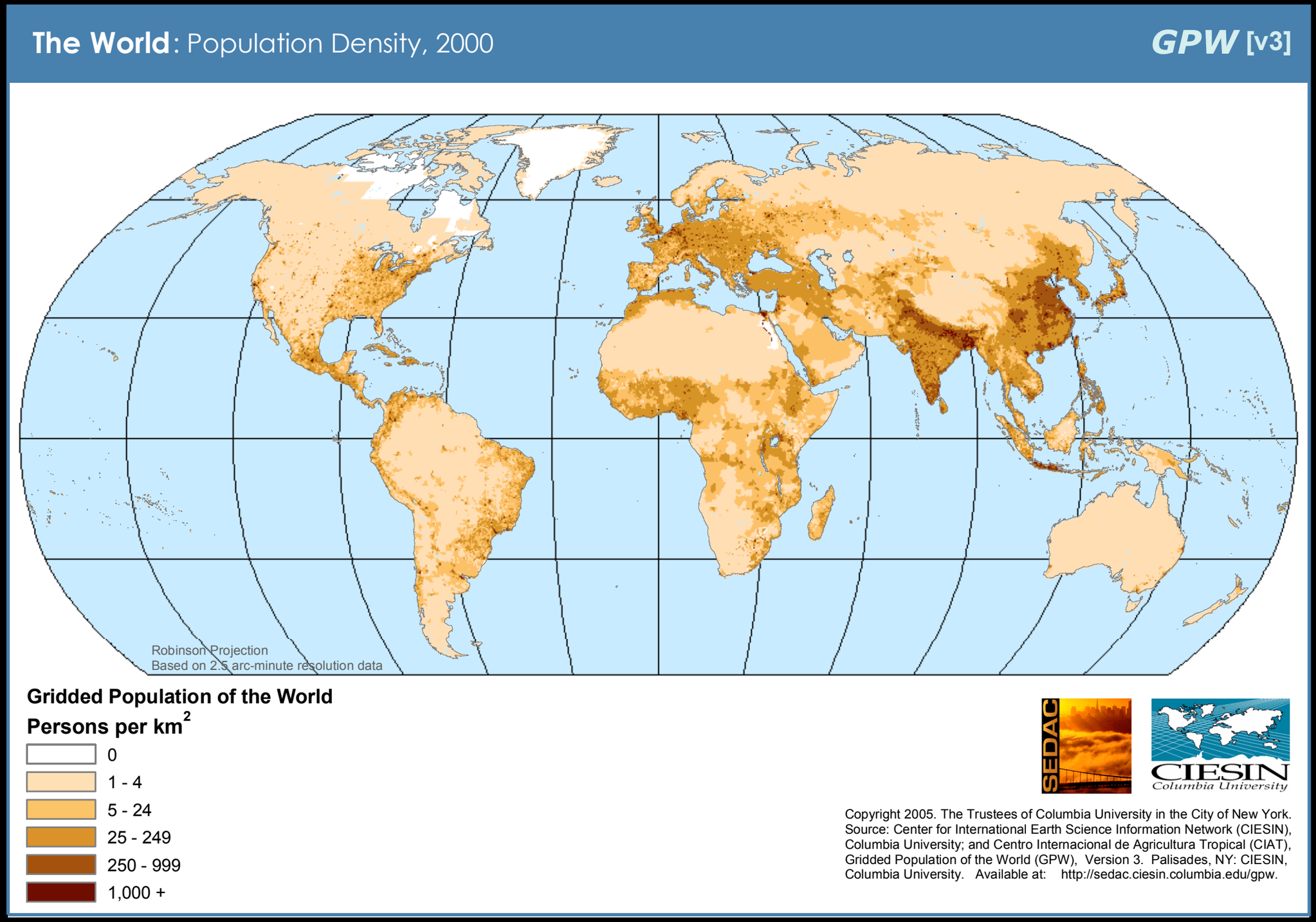
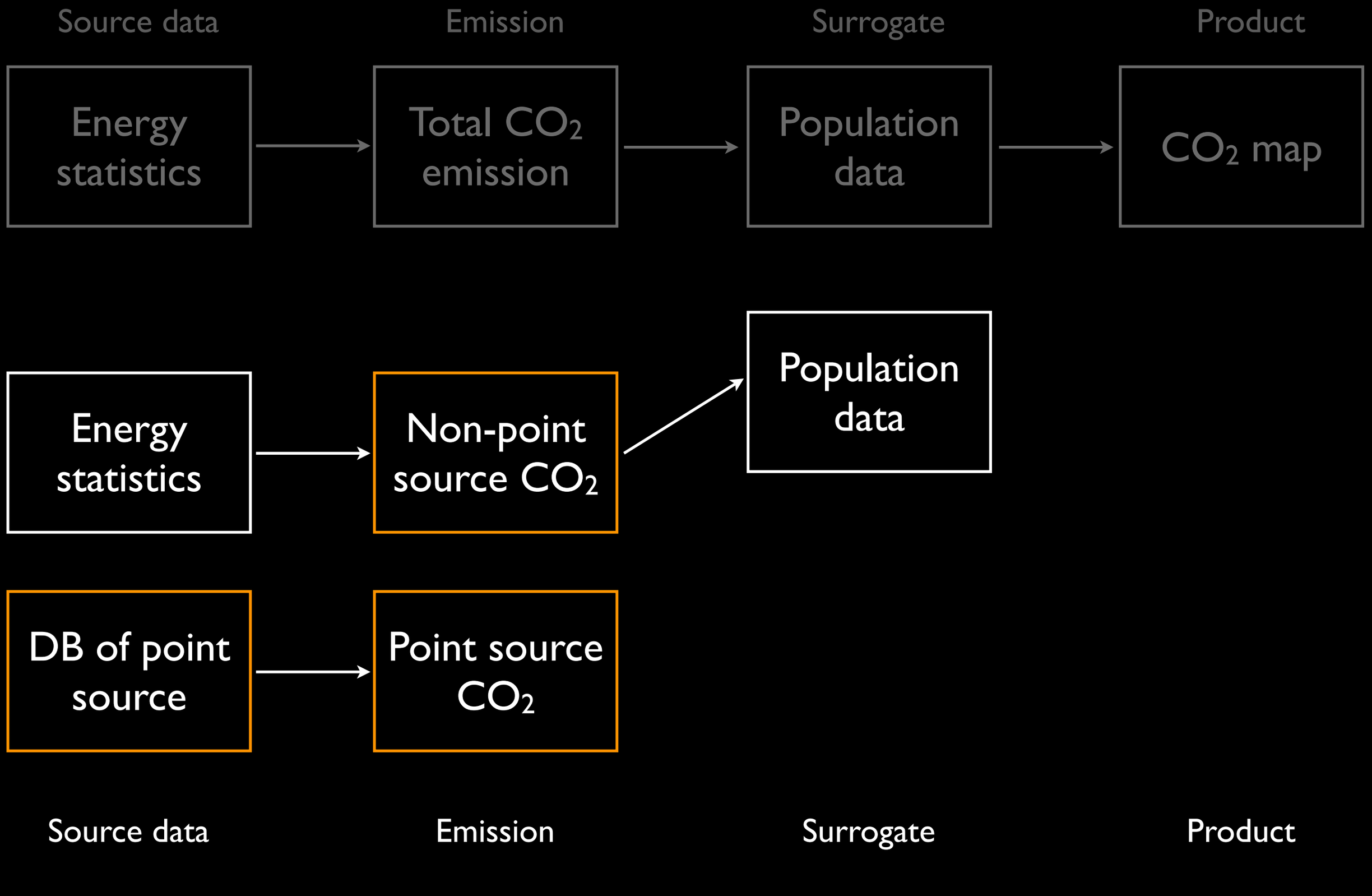


Population data: GWPv3

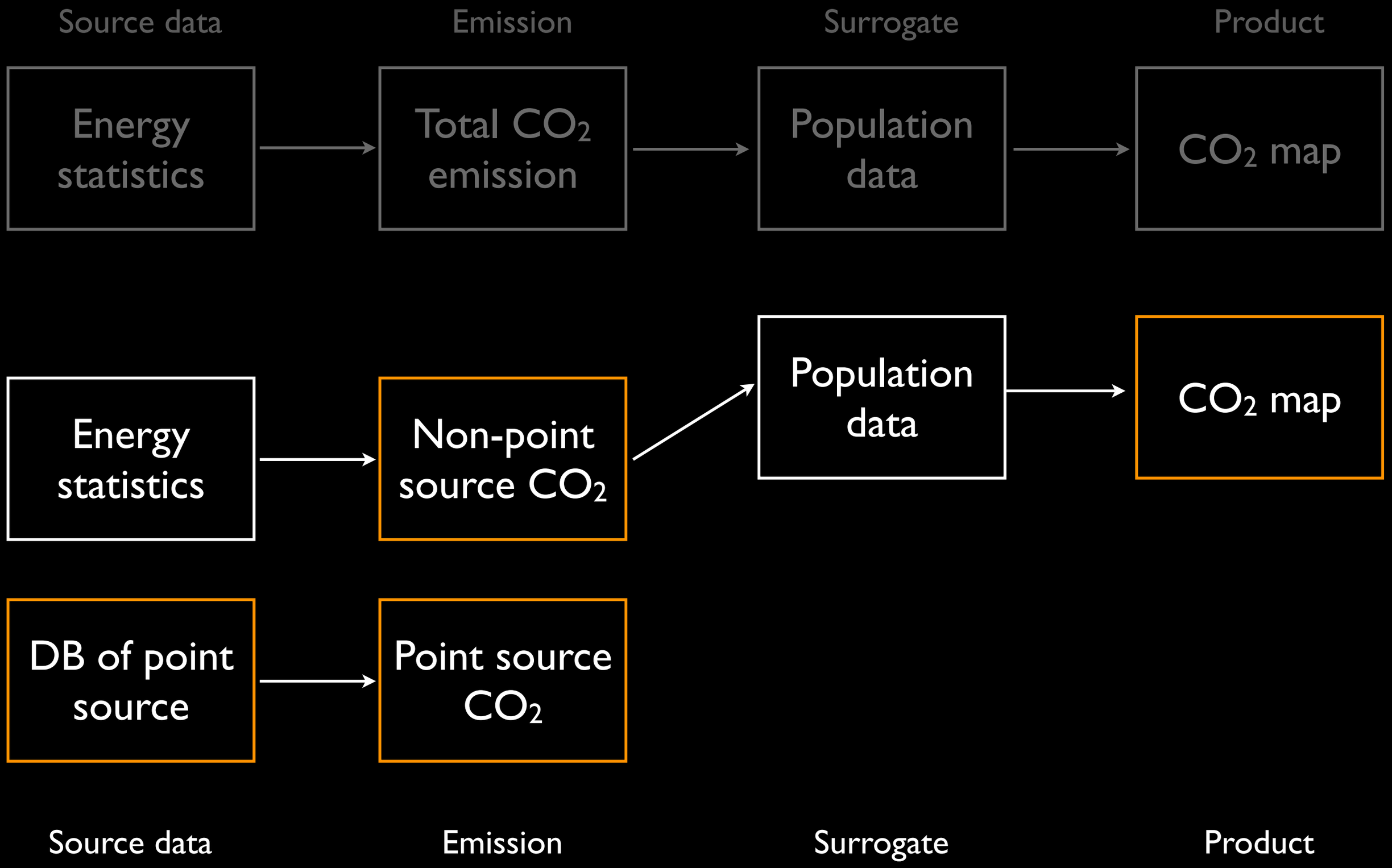


A global population map, a common surrogate for emission mapping

Our mapping algorithm



Our mapping algorithm



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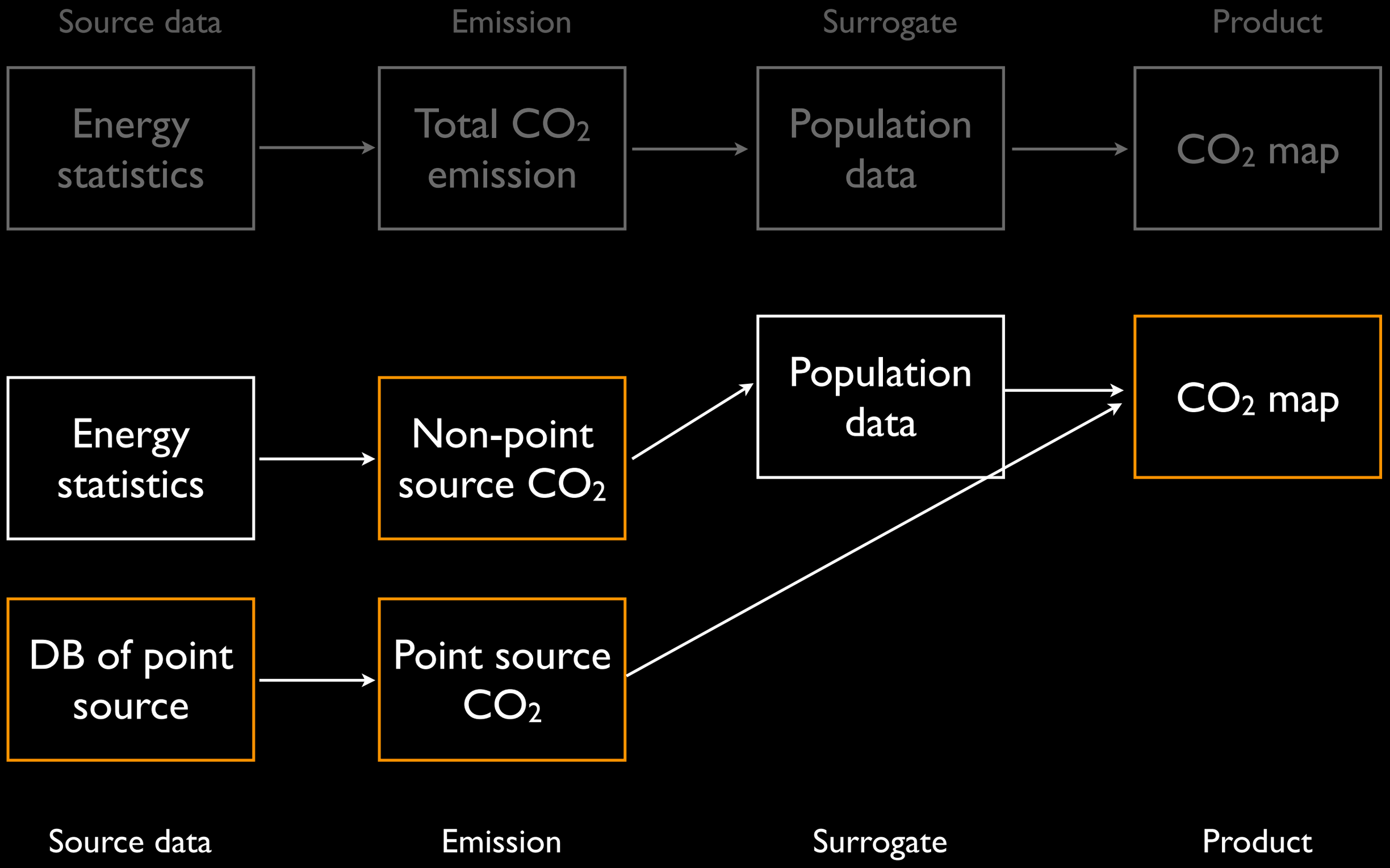

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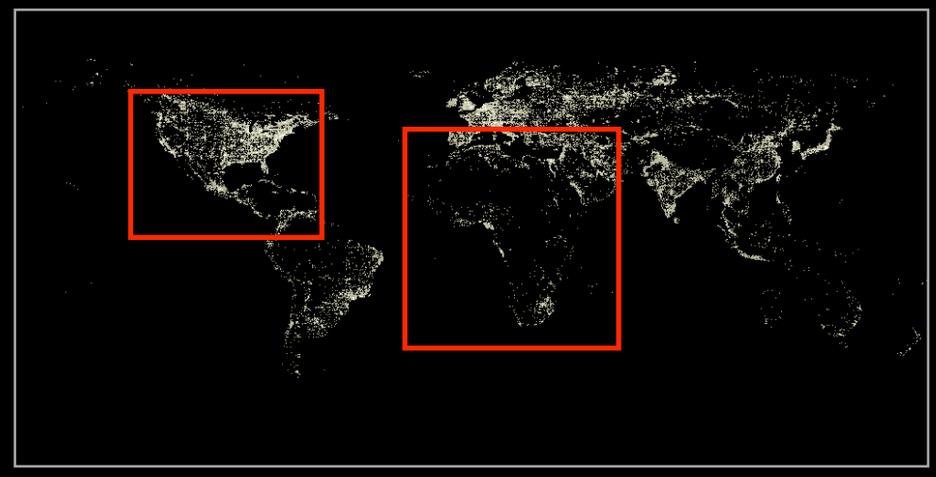
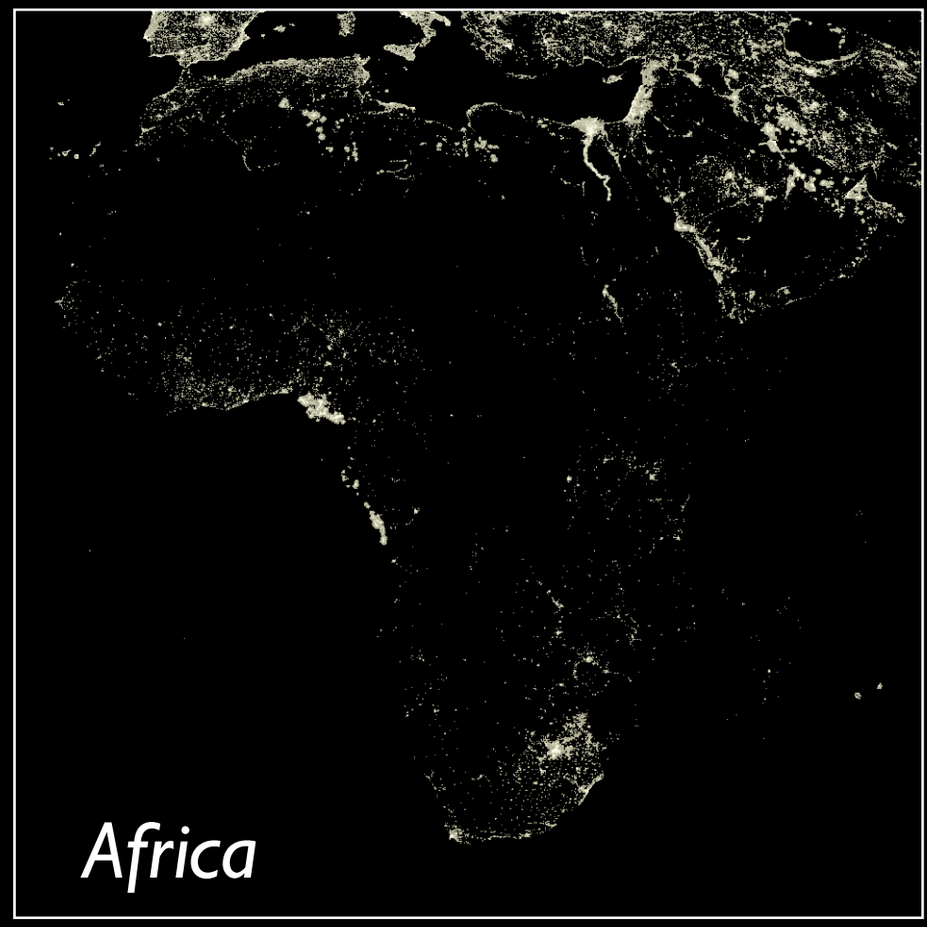
Nighttime lights data: DMSP-OLS

North America





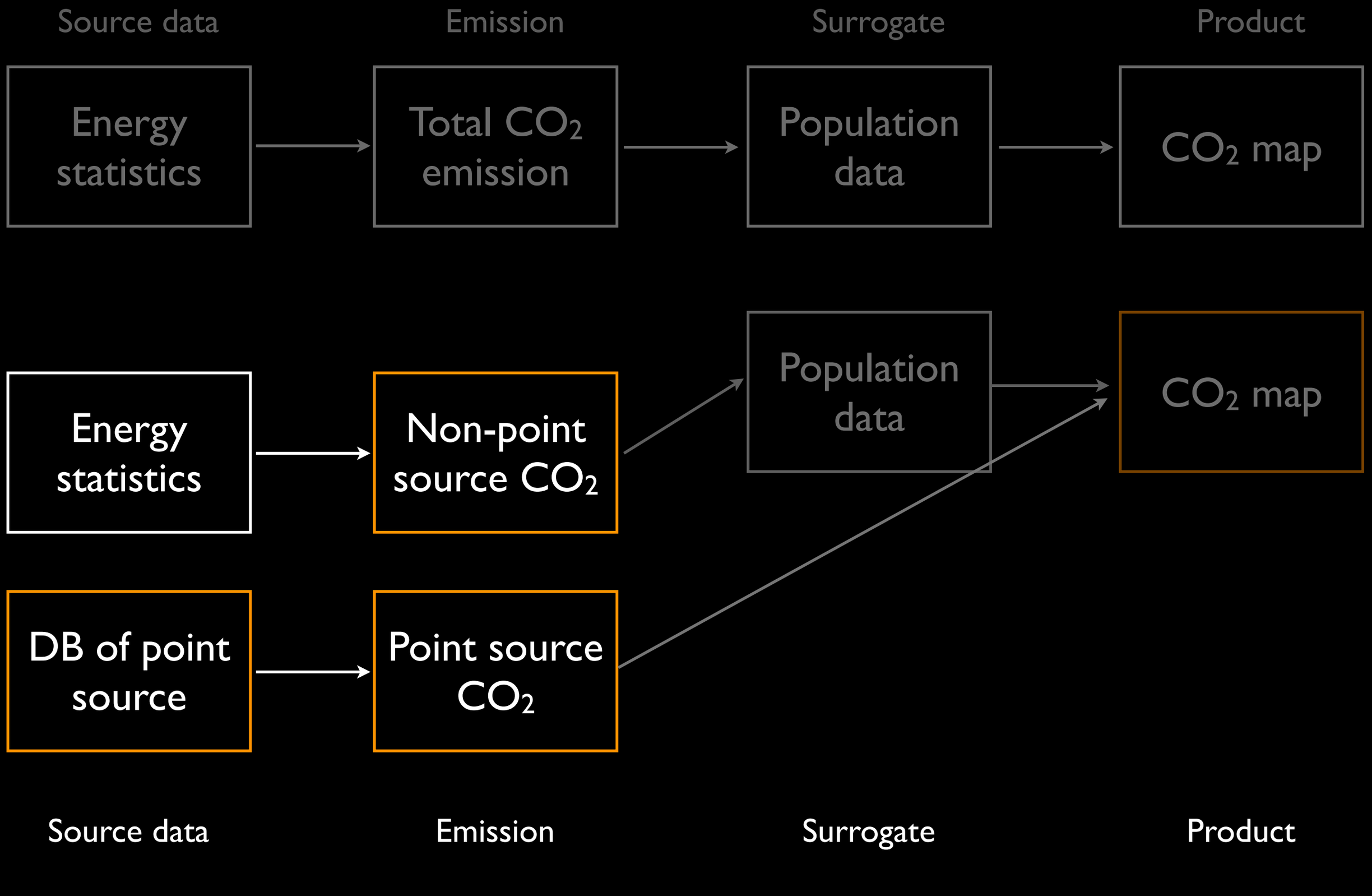
Africa

Data provided by:

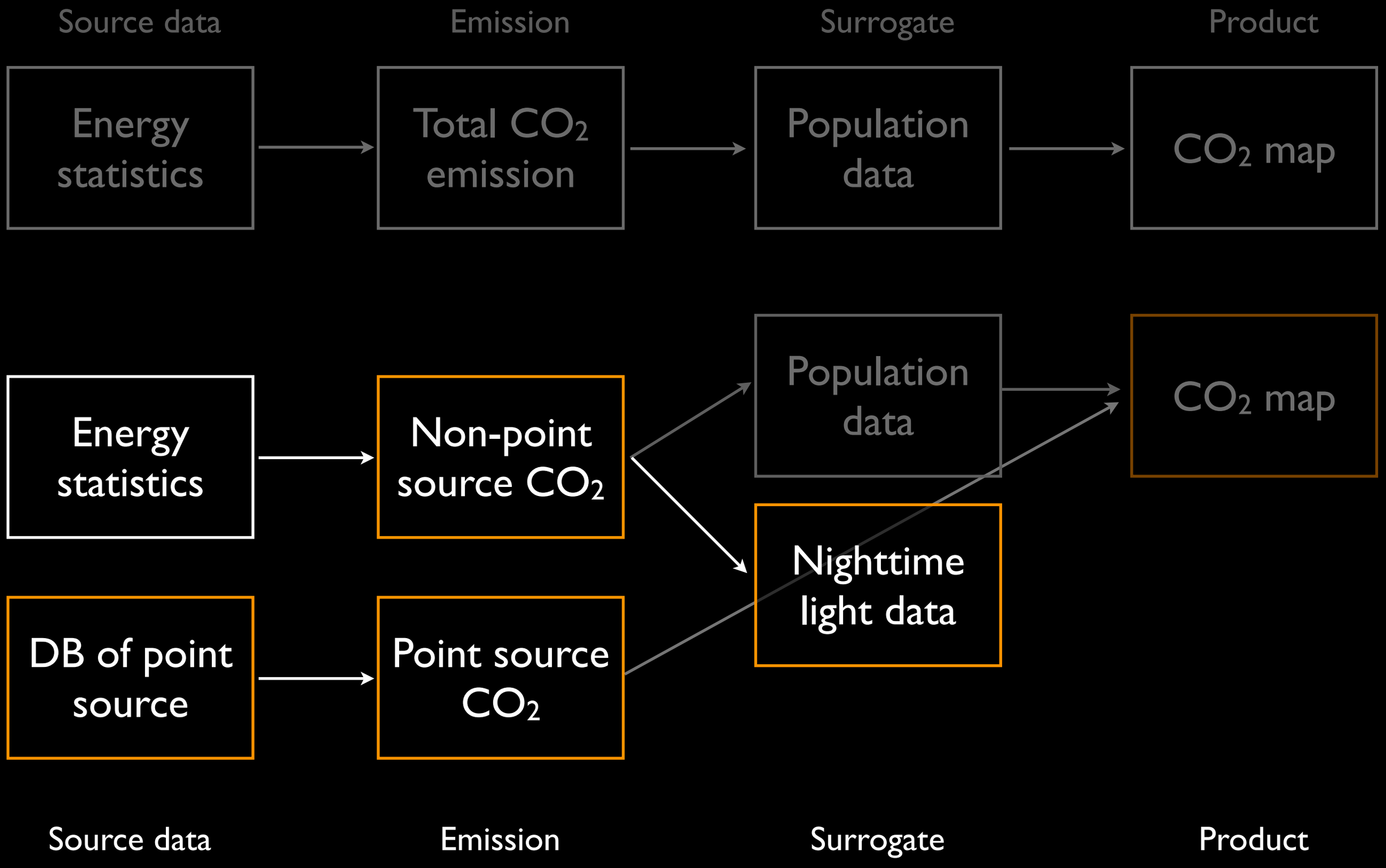
National Geophysical Data Center (NGDC)
NOAA Satellite and Information Service

Composite maps for 2003, lights indicate human settlements and gas flares

Our mapping algorithm



Our mapping algorithm



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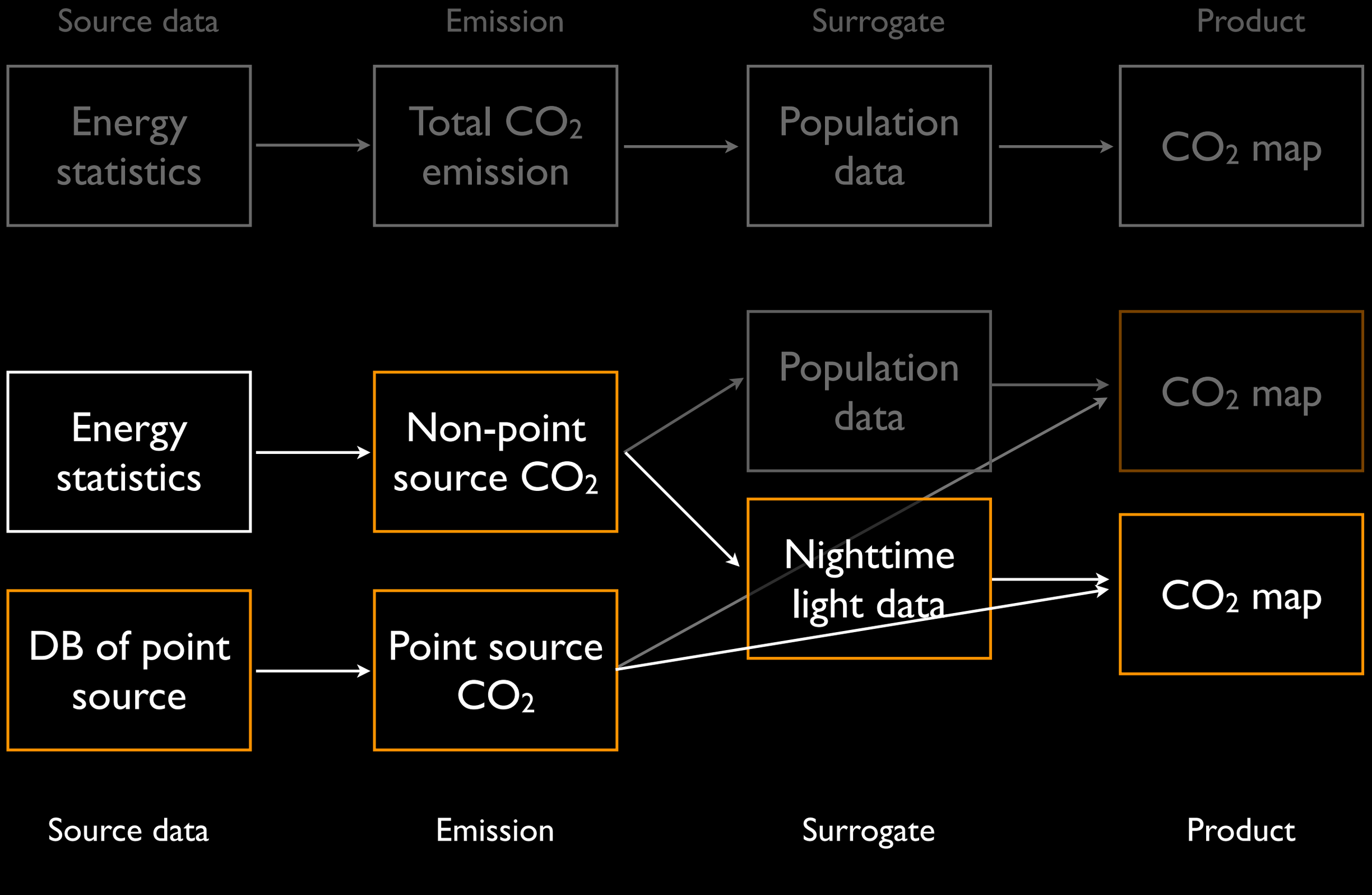
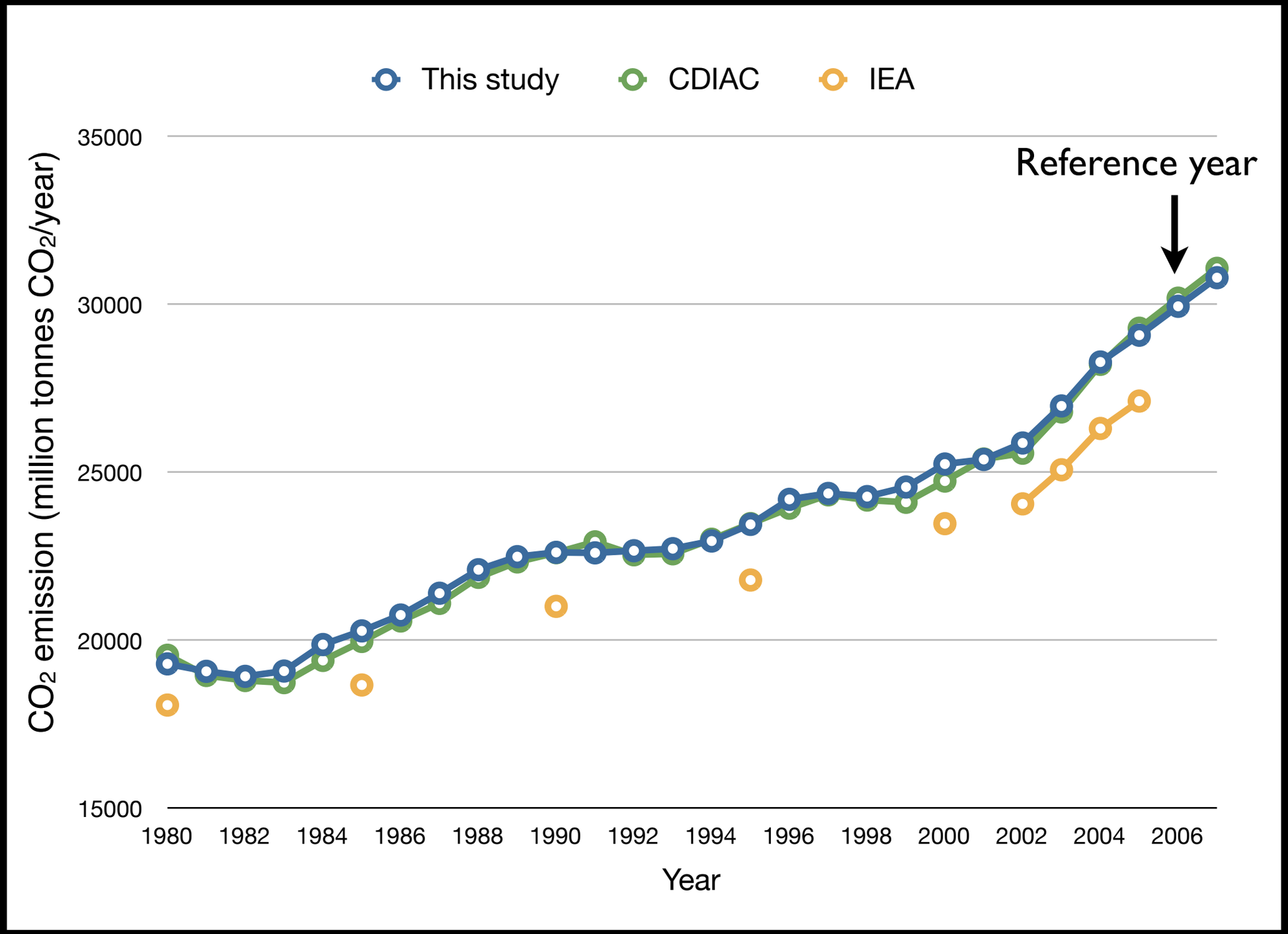


Data set

- *Energy statistics: BP energy review 2008 by BP plc*
- *Point source DB: CARMA (base year of 2007)*
- *Population data: GPWv3 (base year of 2005) with national boundary data for 2000*
- *Nighttime lights: DMSP stable lights 94-95*

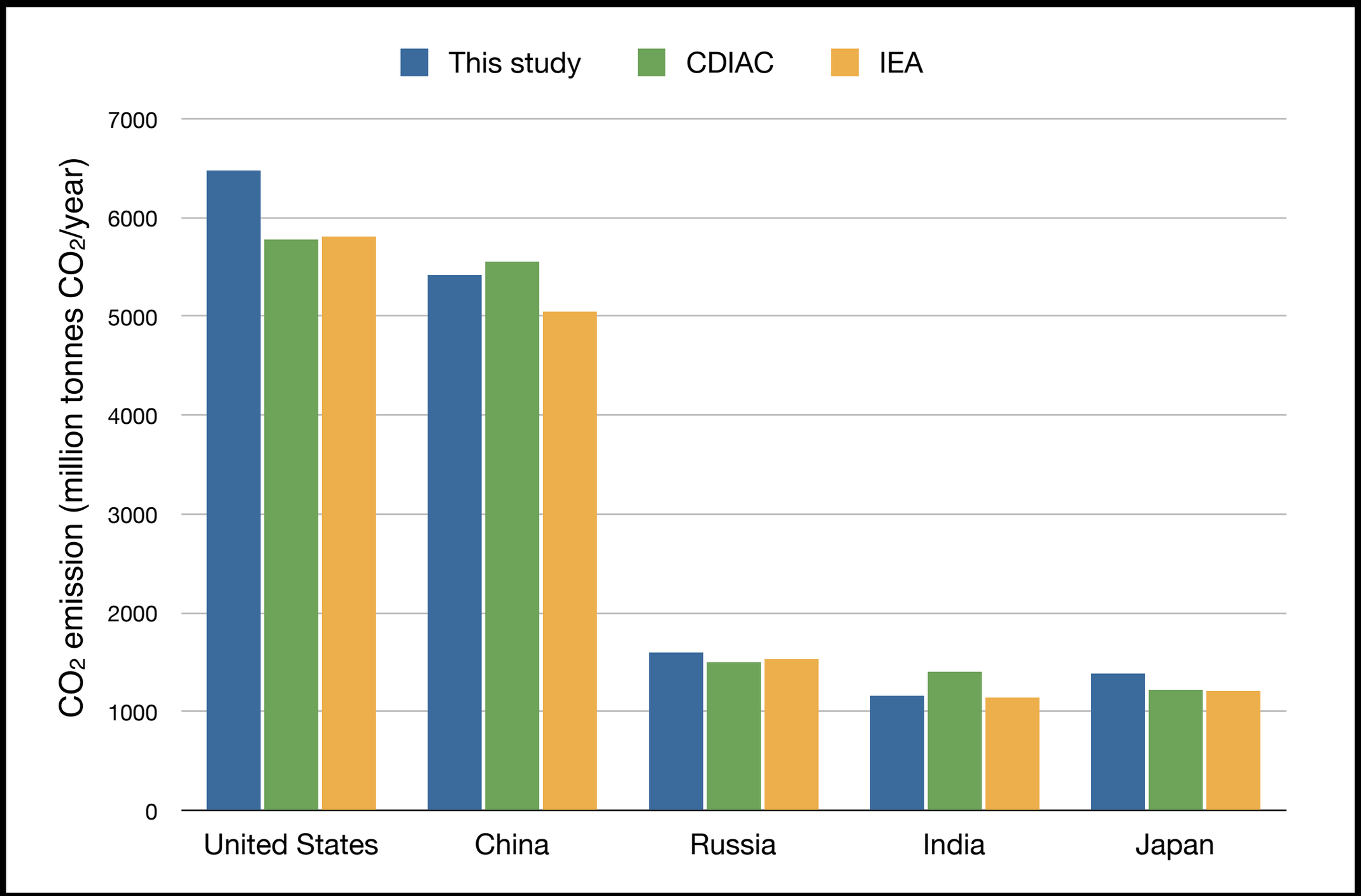
Using these data, maps for the base year ('06) were created

Global total estimates



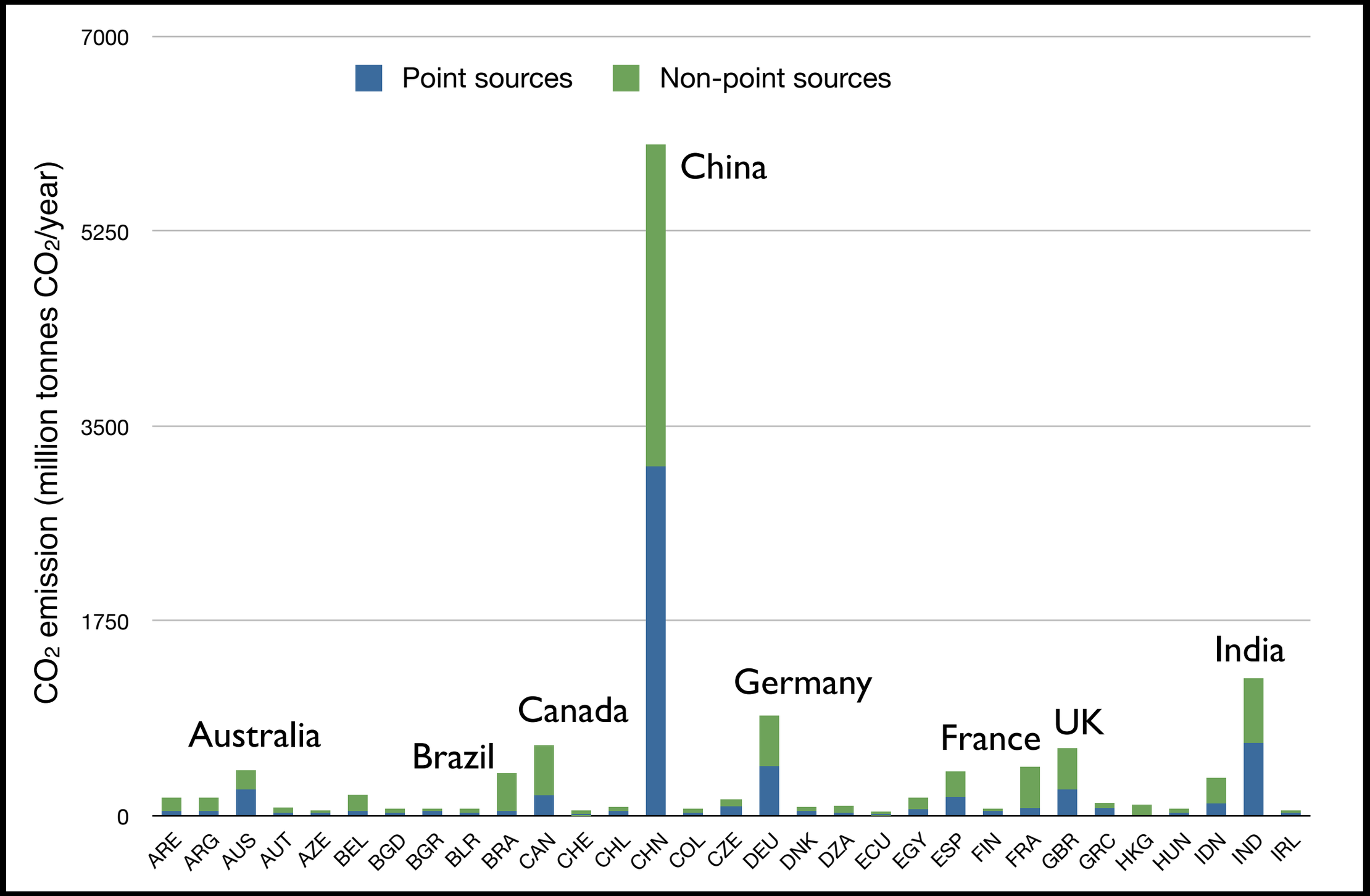
Good agreement with CDIAC, the difference from IEA is within acceptable level

National emissions



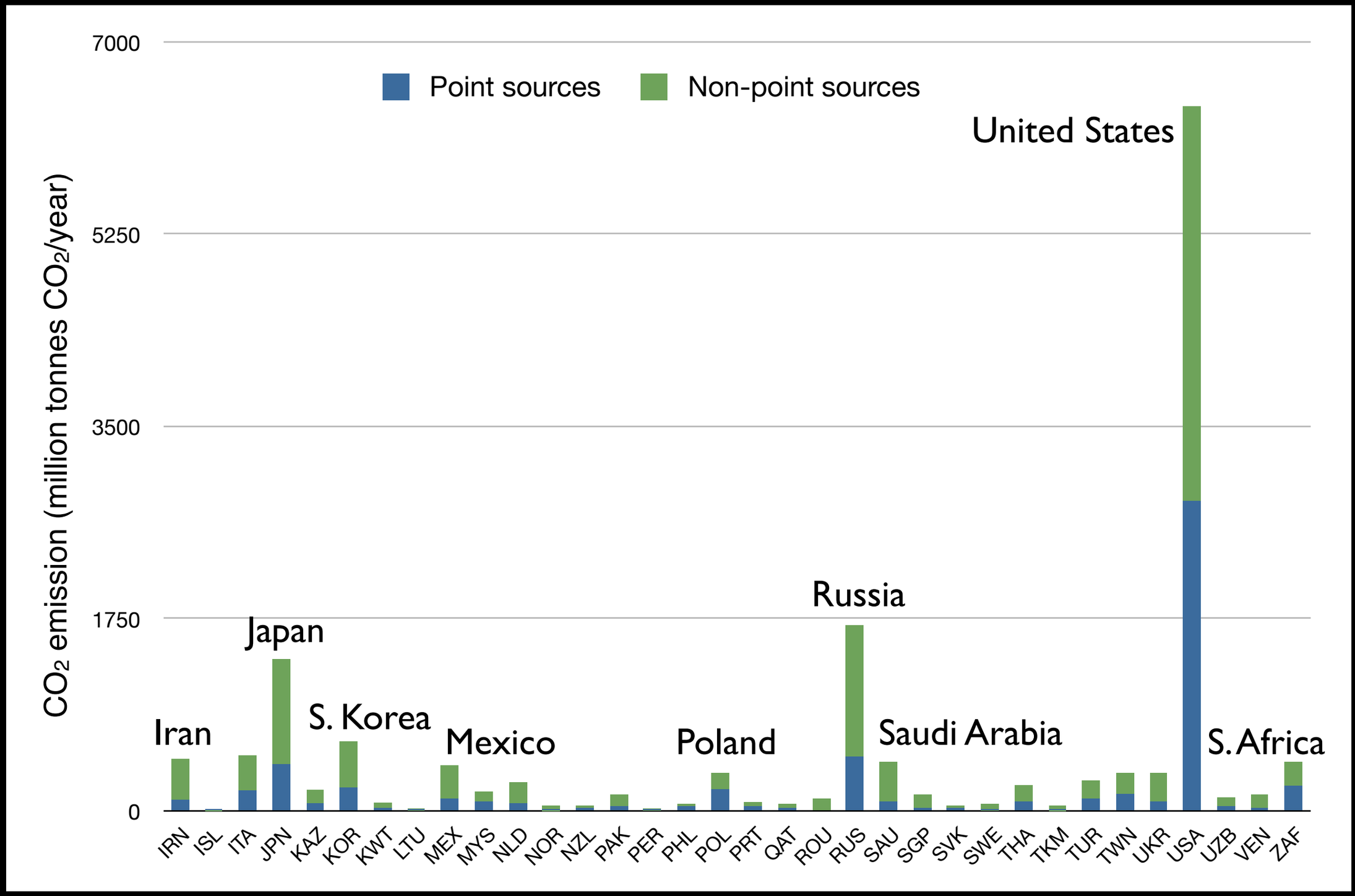
Reasonable agreement to other estimations obtained

Point vs. Non-point sources



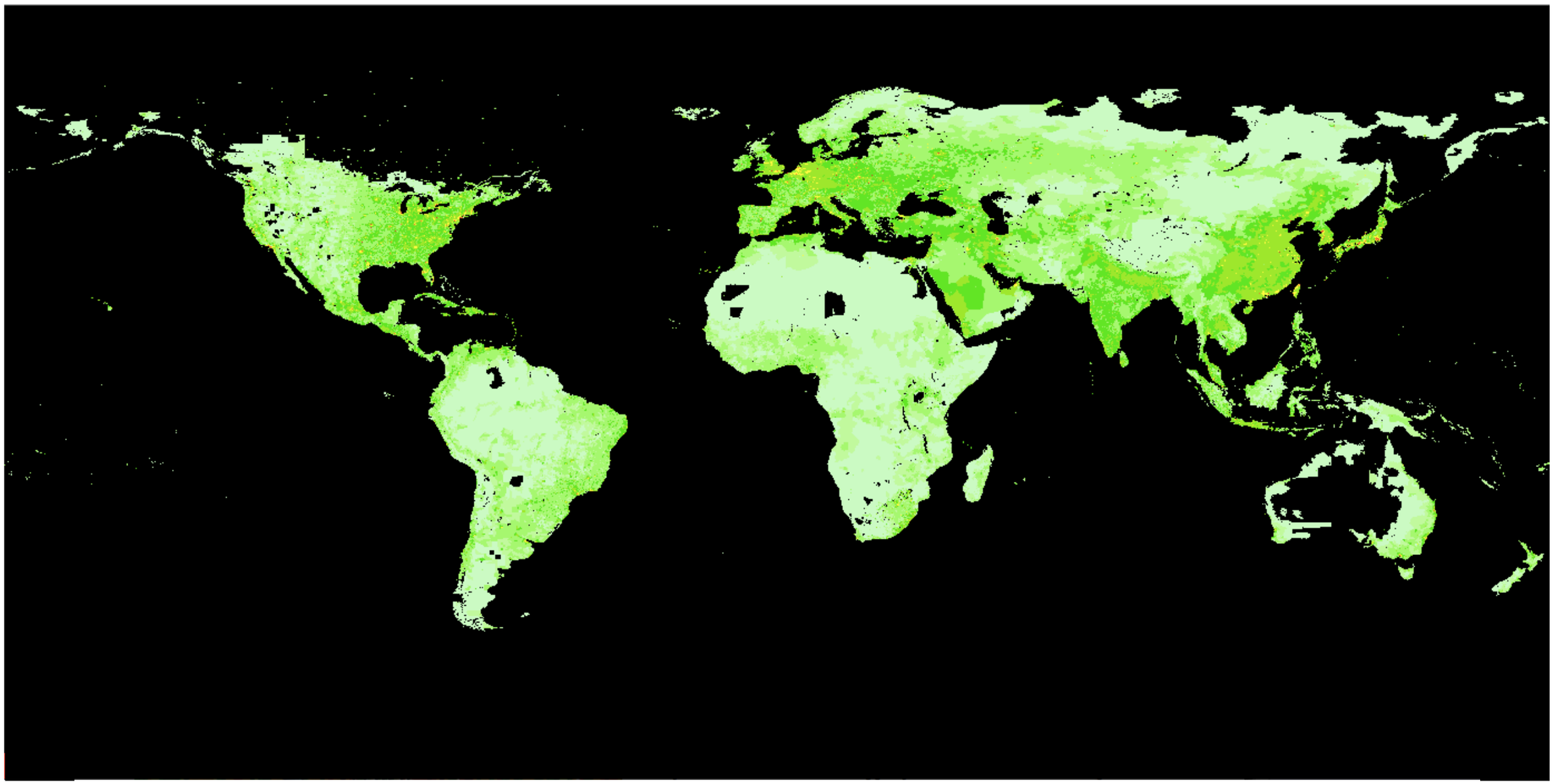
Emissions from point sources account for significant portions of total emissions

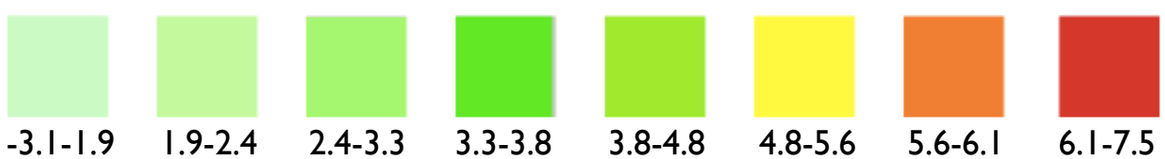
Point vs. Non-point sources



Emissions from point sources account for significant portions of total emissions

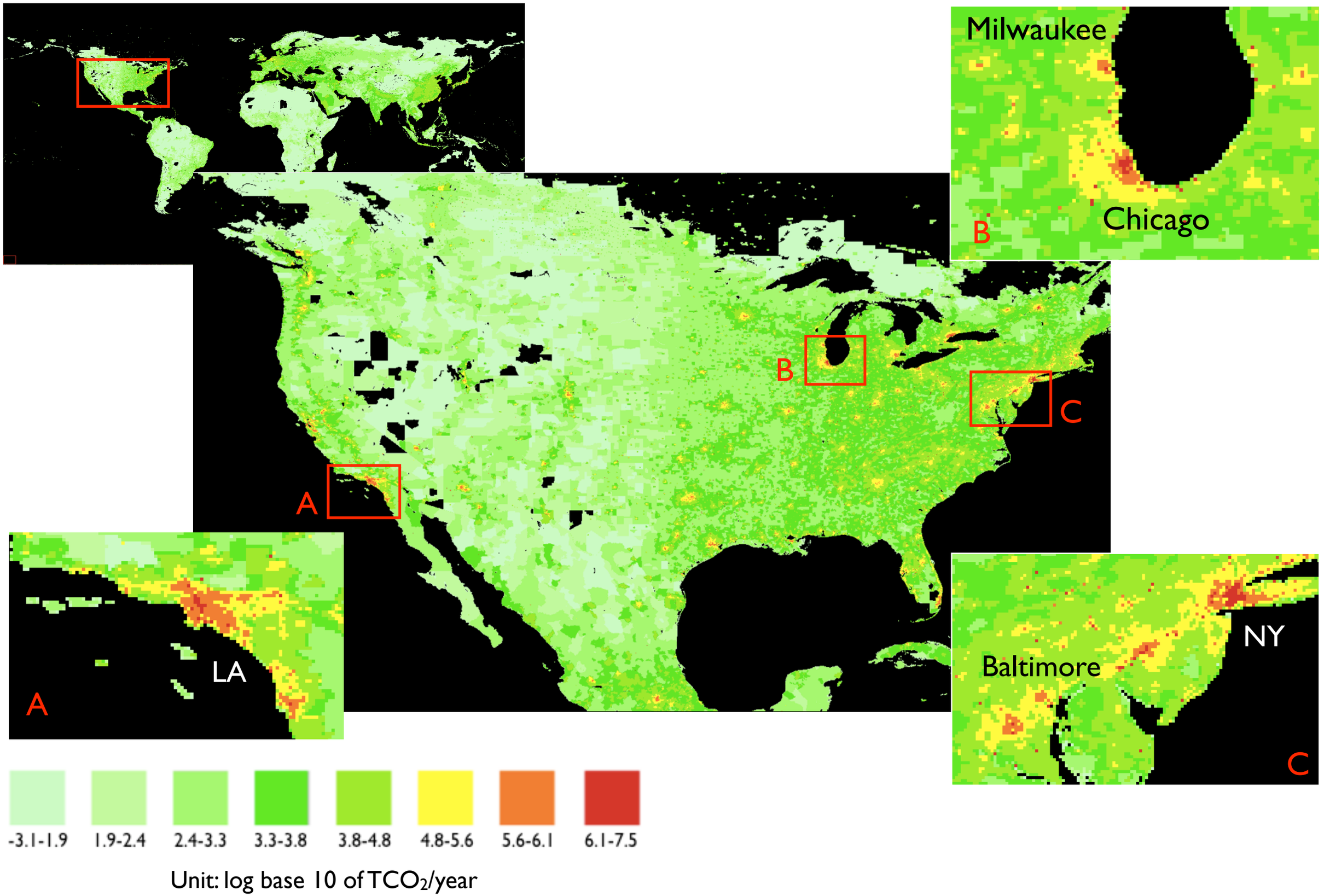
Population-based map



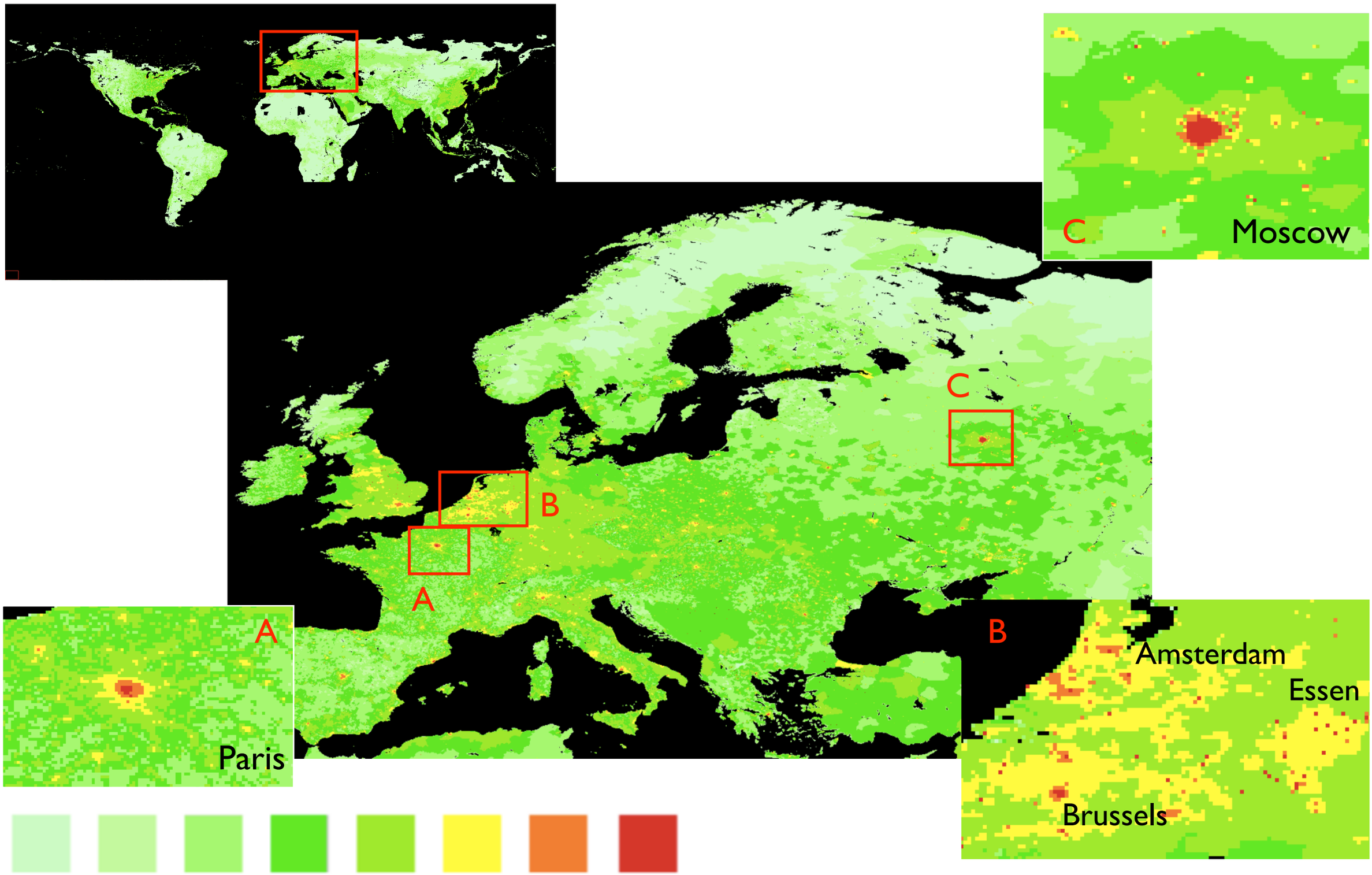


Unit: log base 10 of TCO_2/year

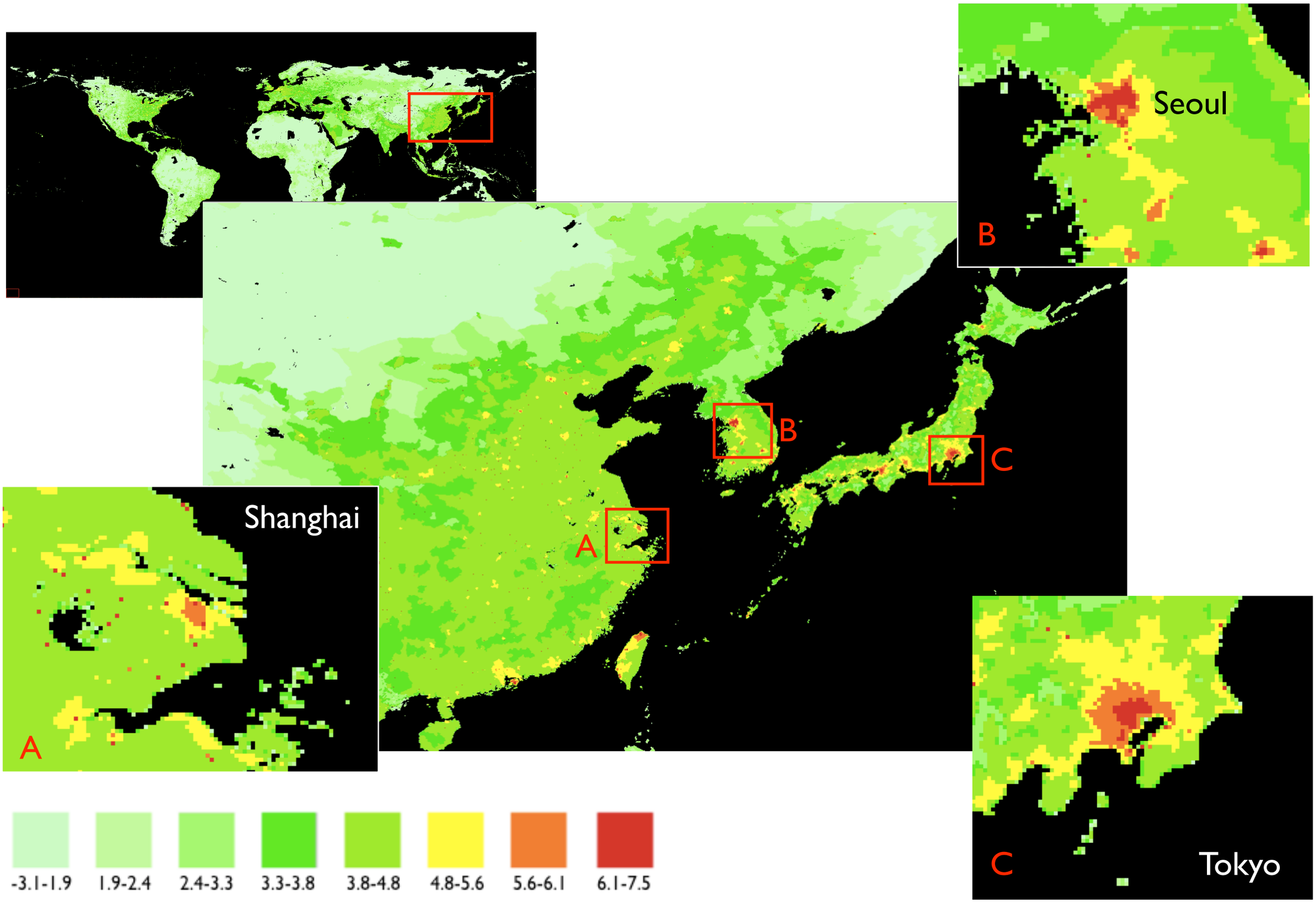
North America



Europe

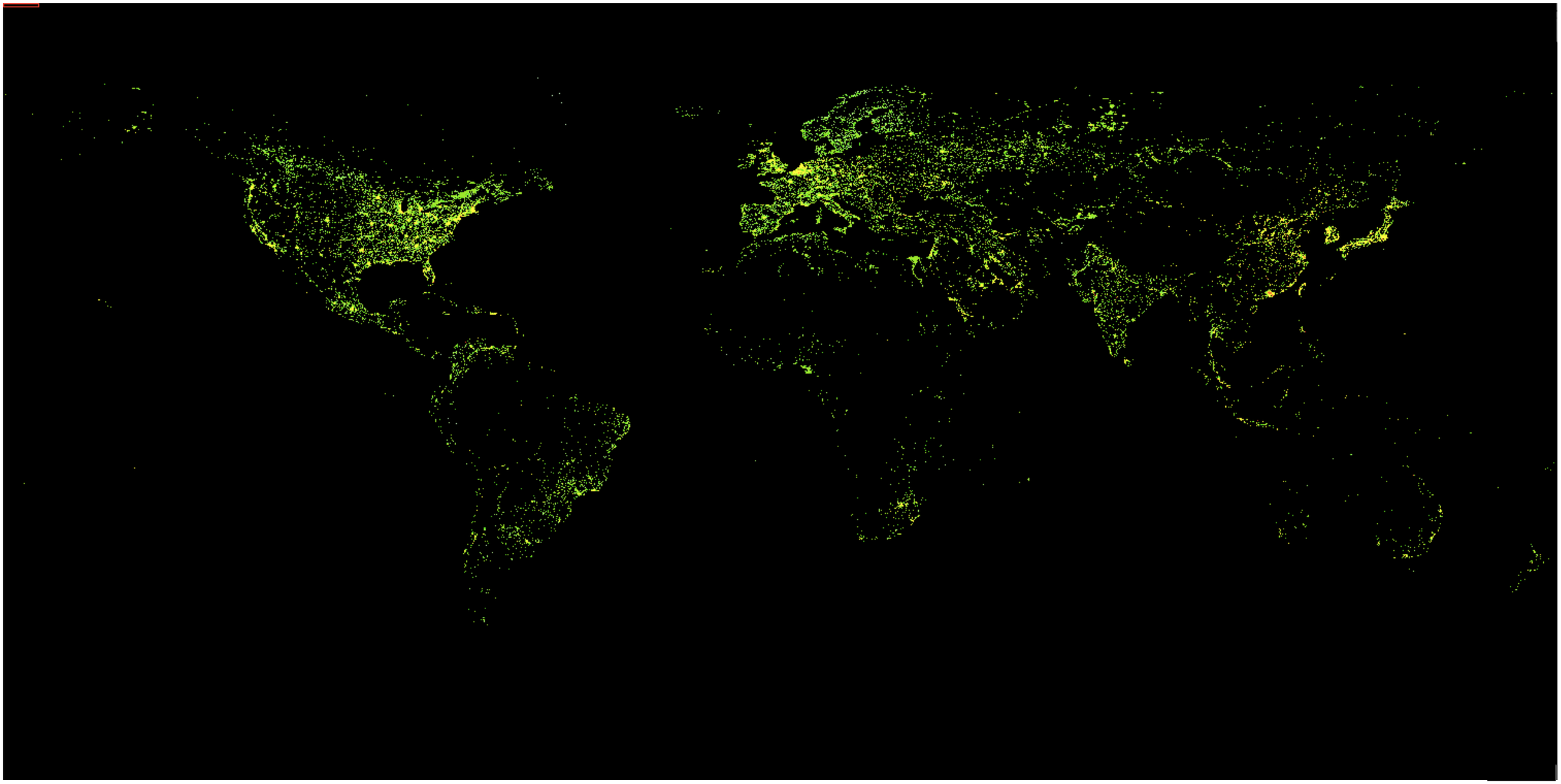

A
B
C
Paris
Amsterdam
Essen
Brussels
Moscow
-3.1-1.9
1.9-2.4
2.4-3.3
3.3-3.8
3.8-4.8
4.8-5.6
5.6-6.1
6.1-7.5
Unit: log base 10 of TCO2/year

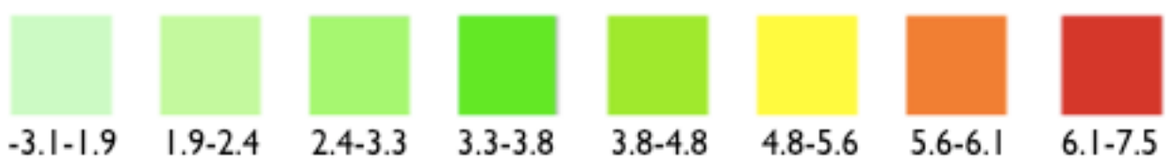
East Asia



Unit: log base 10 of TCO_2/year

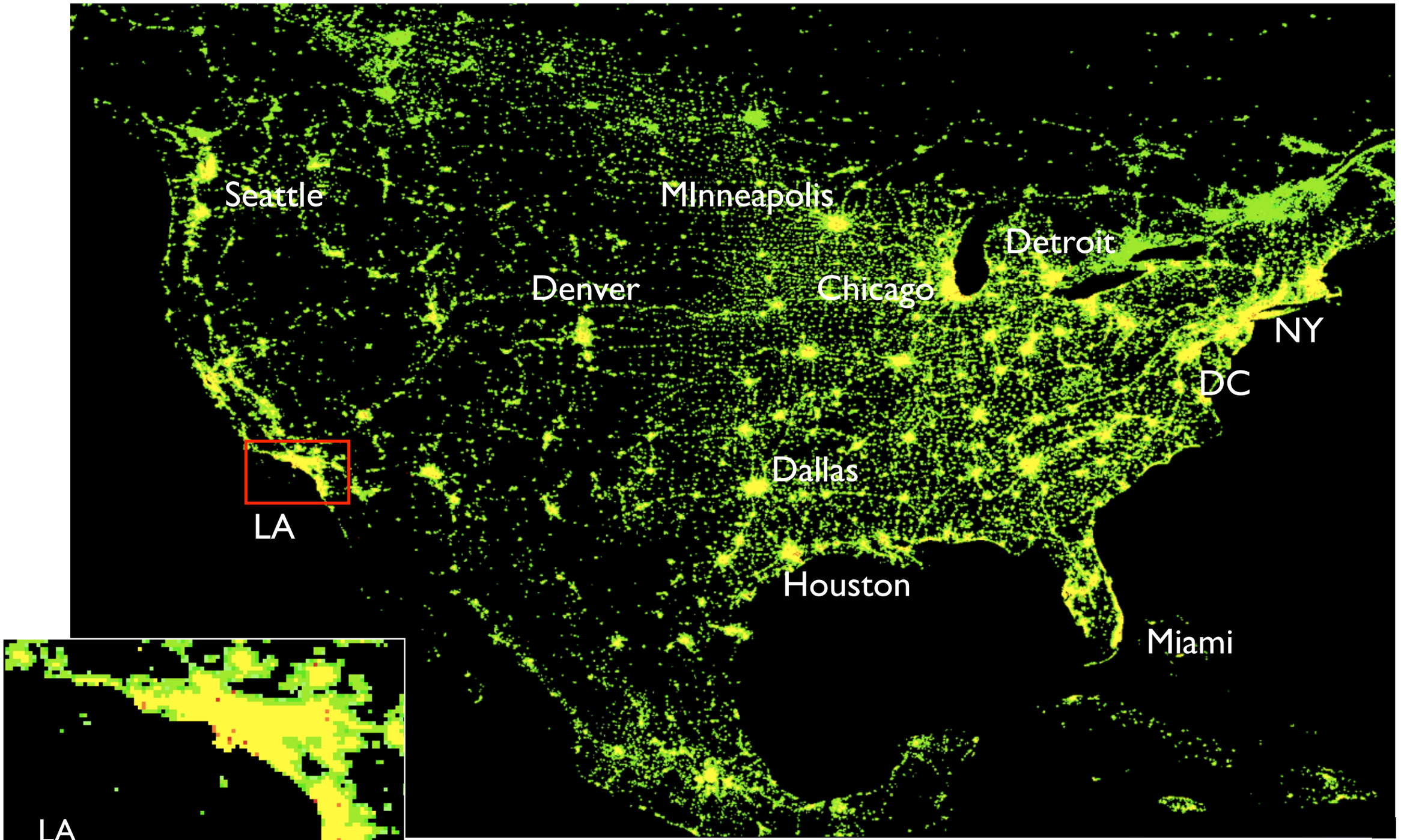
Nighttime lights-based map



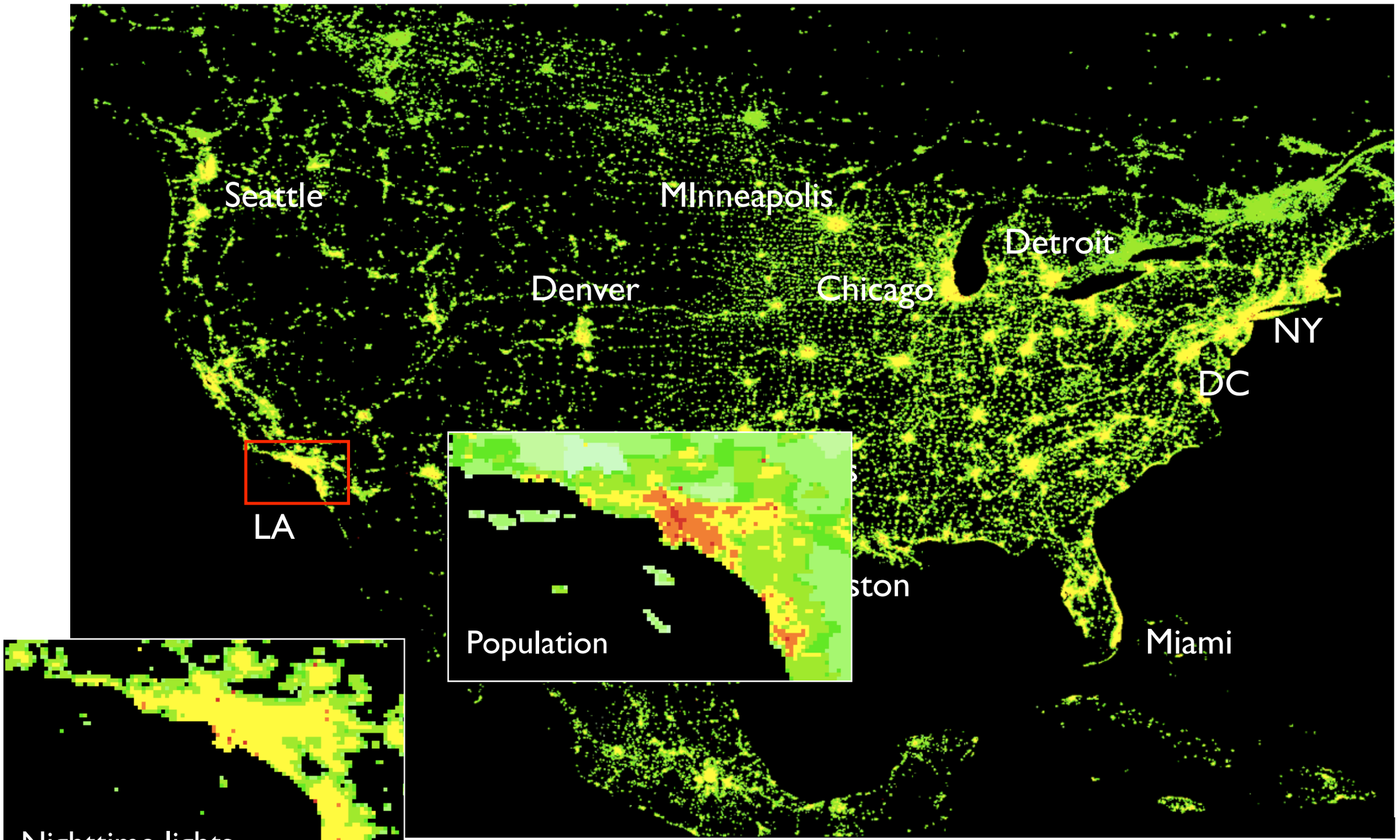


Unit: log base 10 of TCO_2/year

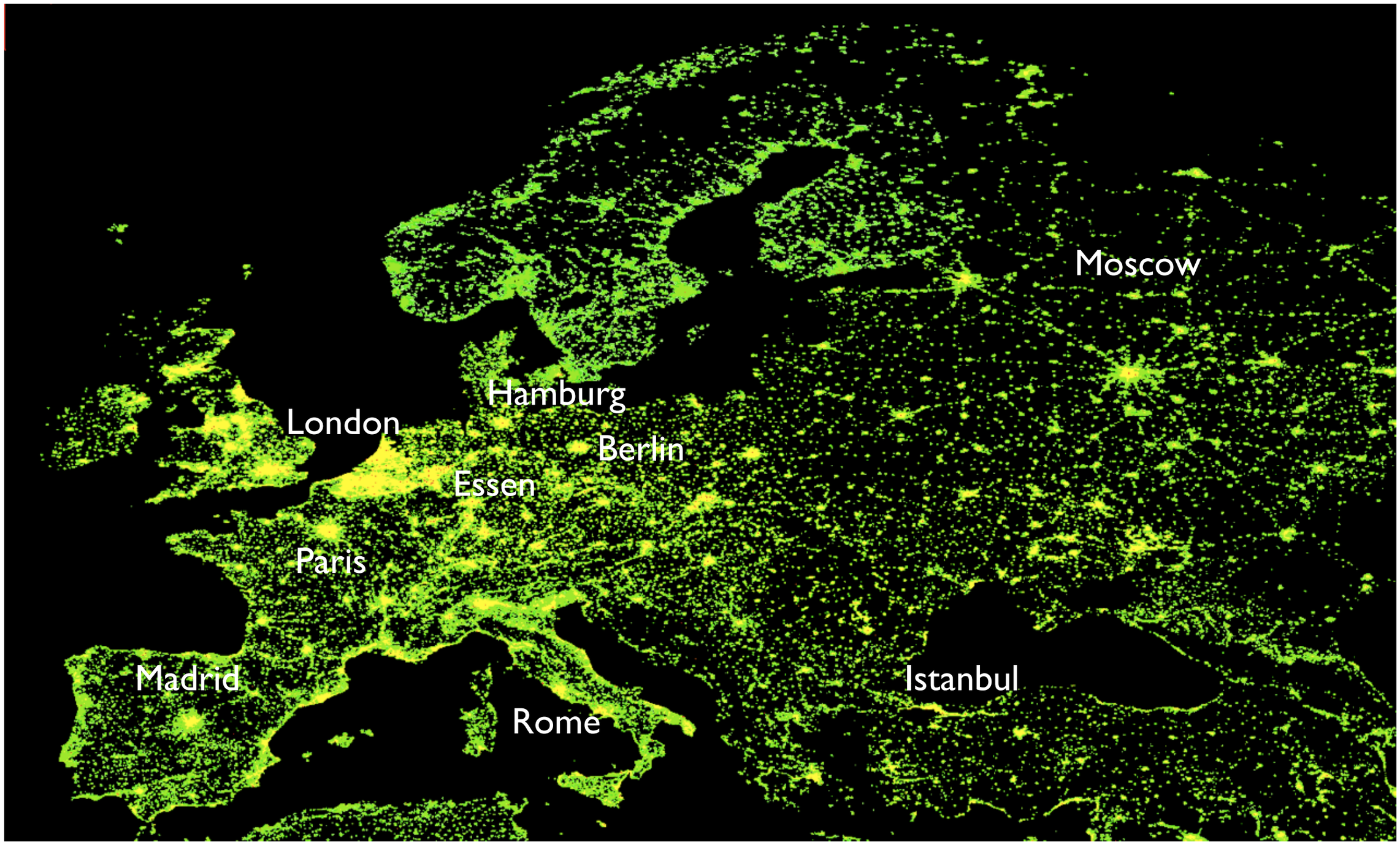
North America



North America



Europe


Moscow
Hamburg
London
Berlin
Essen
Paris
Madrid
Istanbul
Rome
-3.1-1.9
1.9-2.4
2.4-3.3
3.3-3.8
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6.1-7.5
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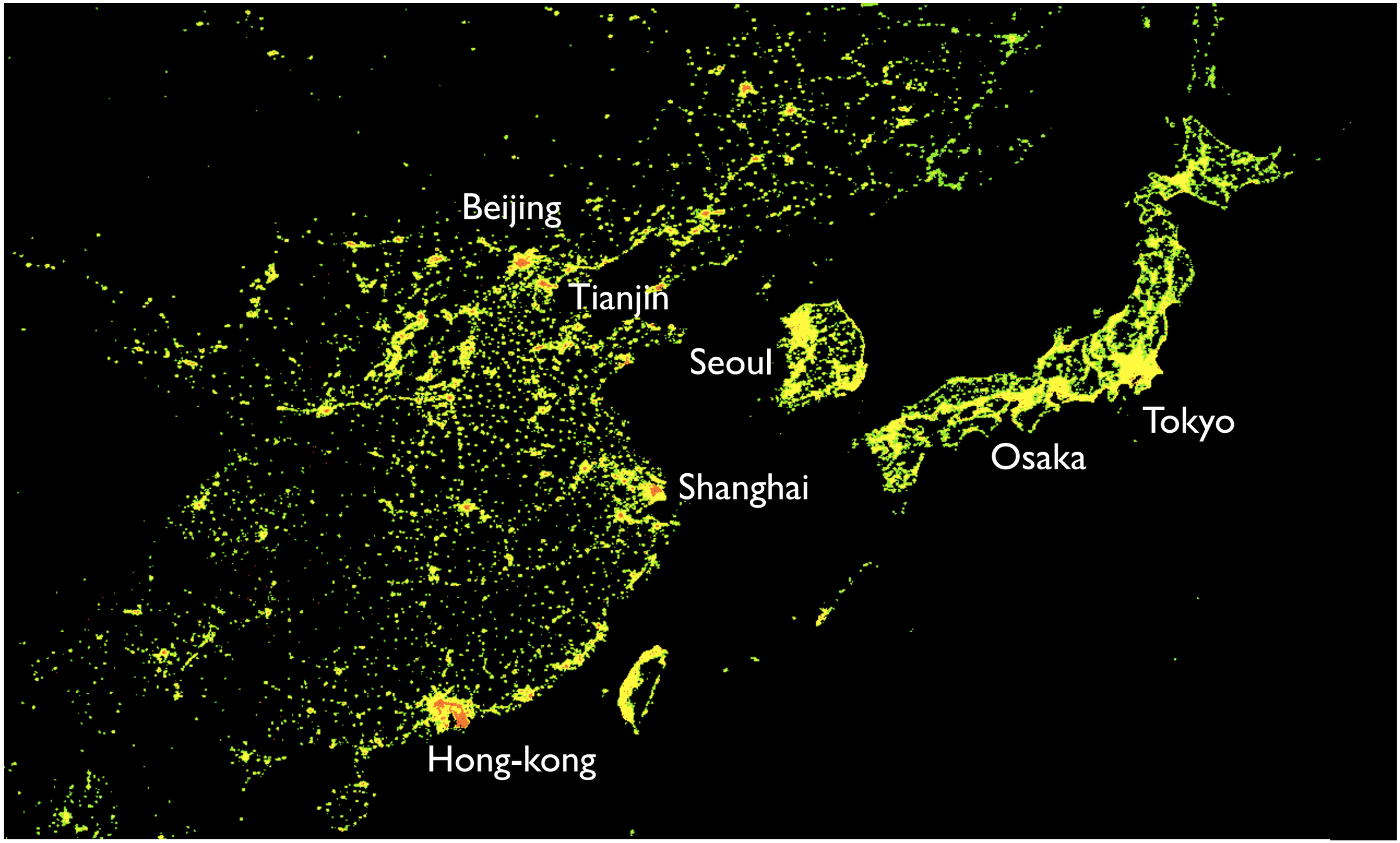
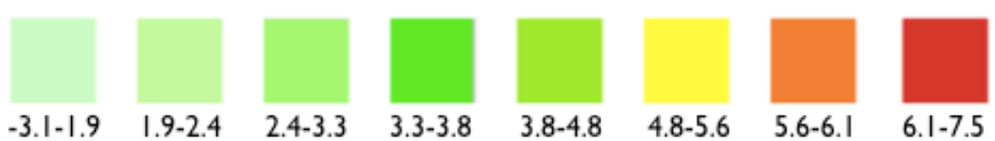
East Asia





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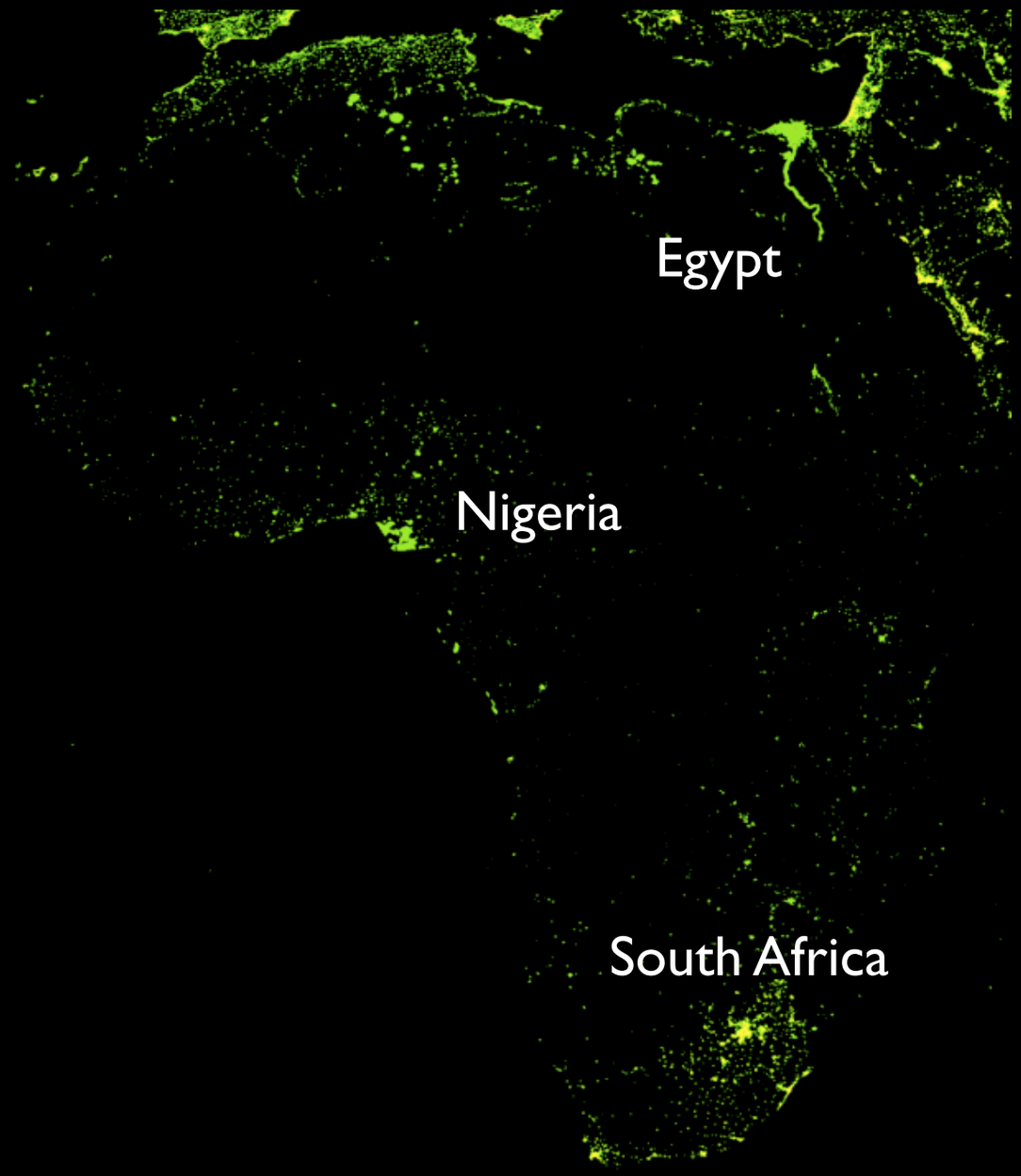
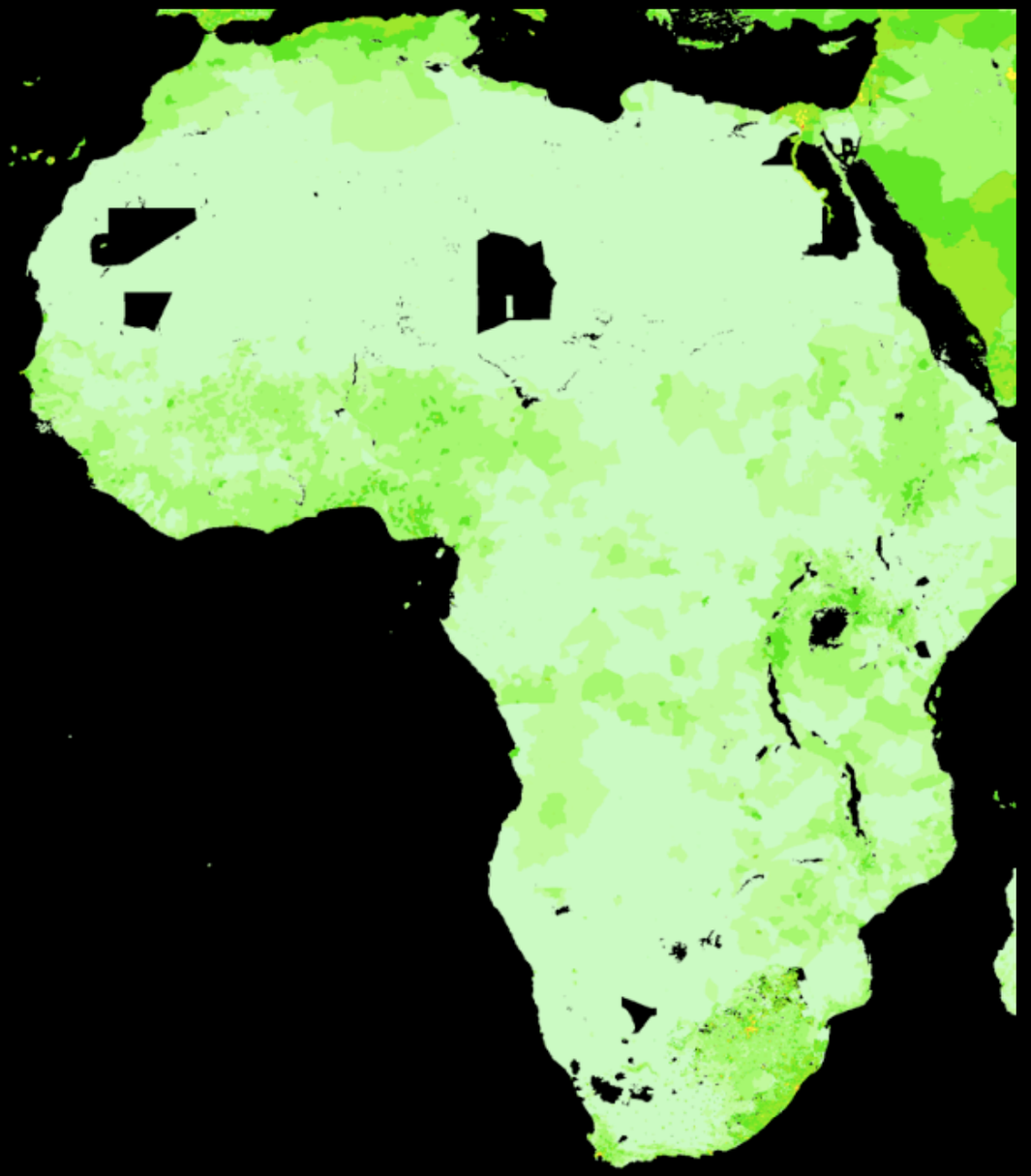
Africa

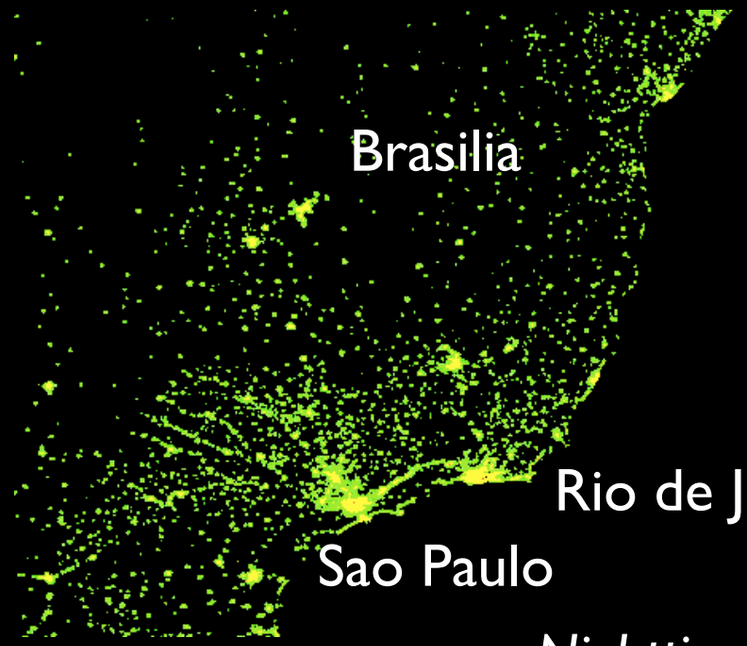


Nighttime light

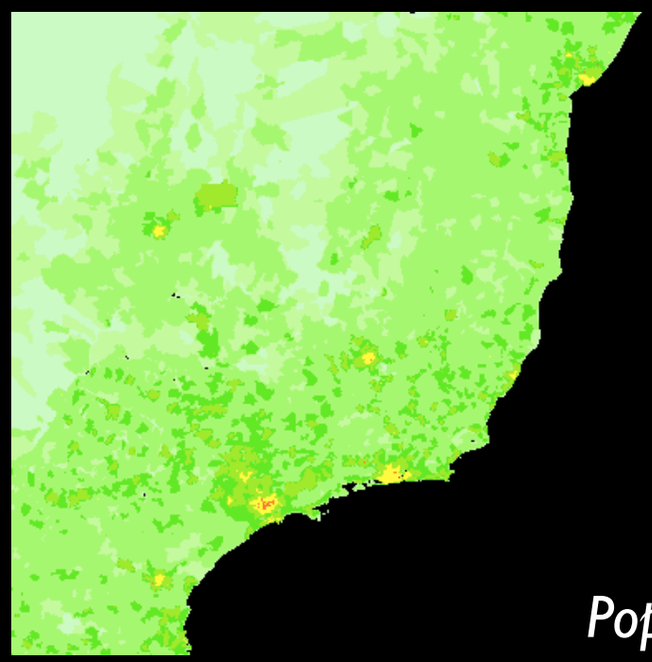


Population

Other regions

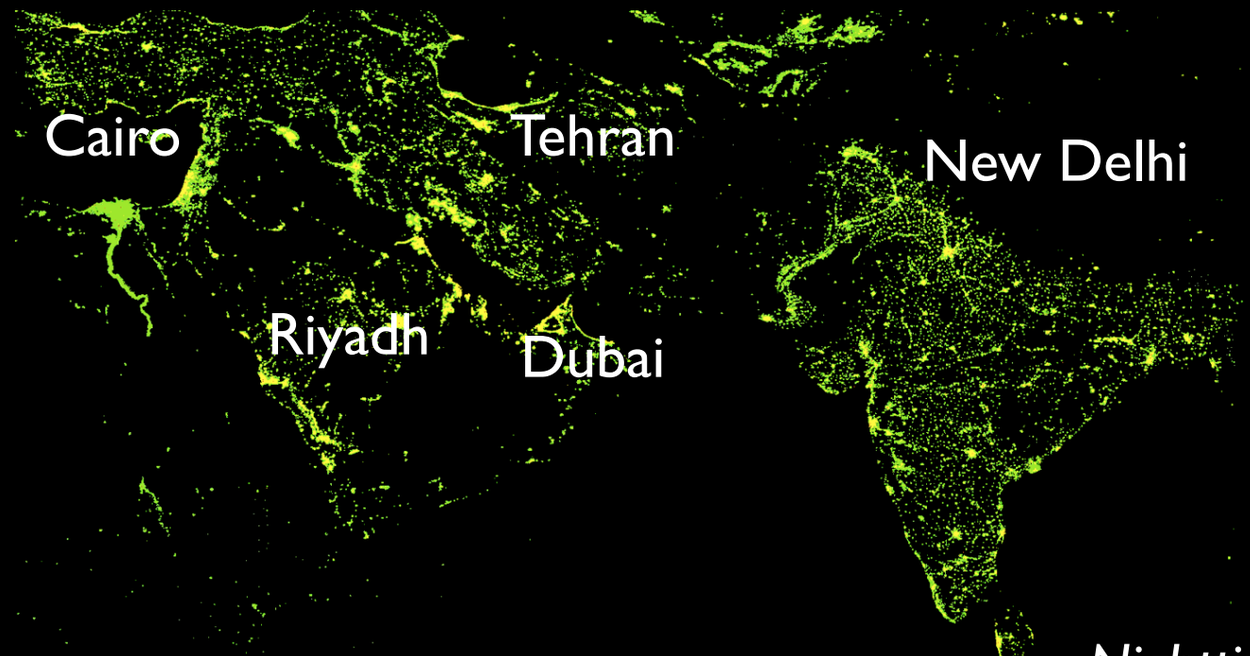


Nighttime light

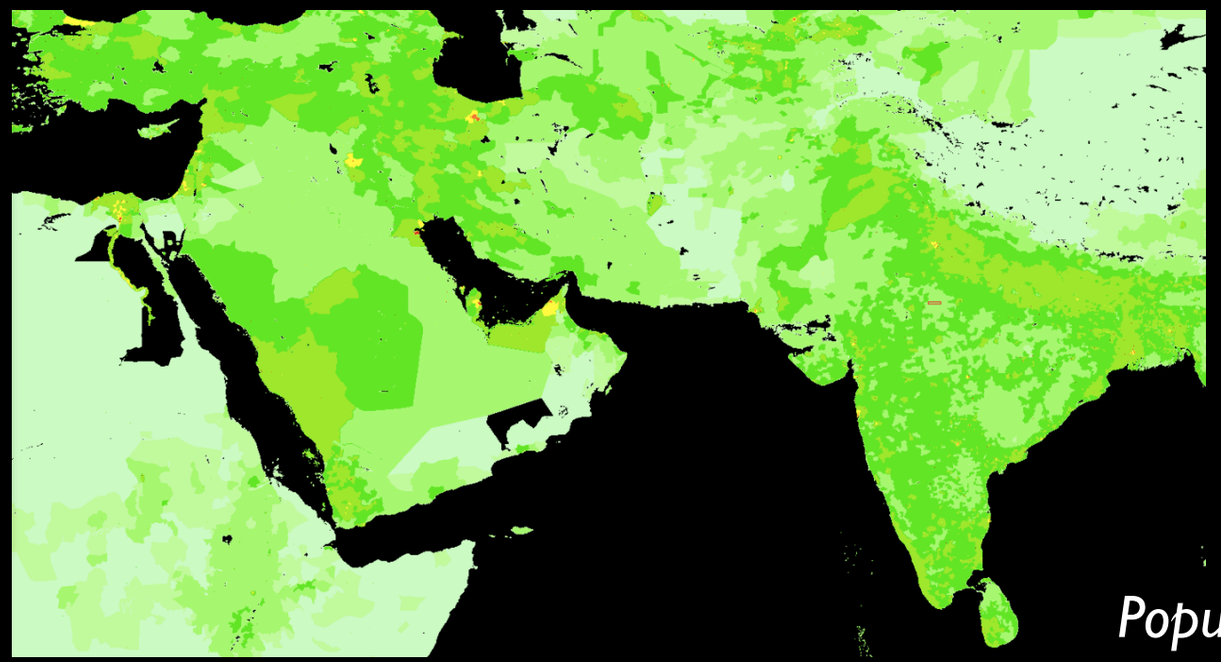


Population

S. America



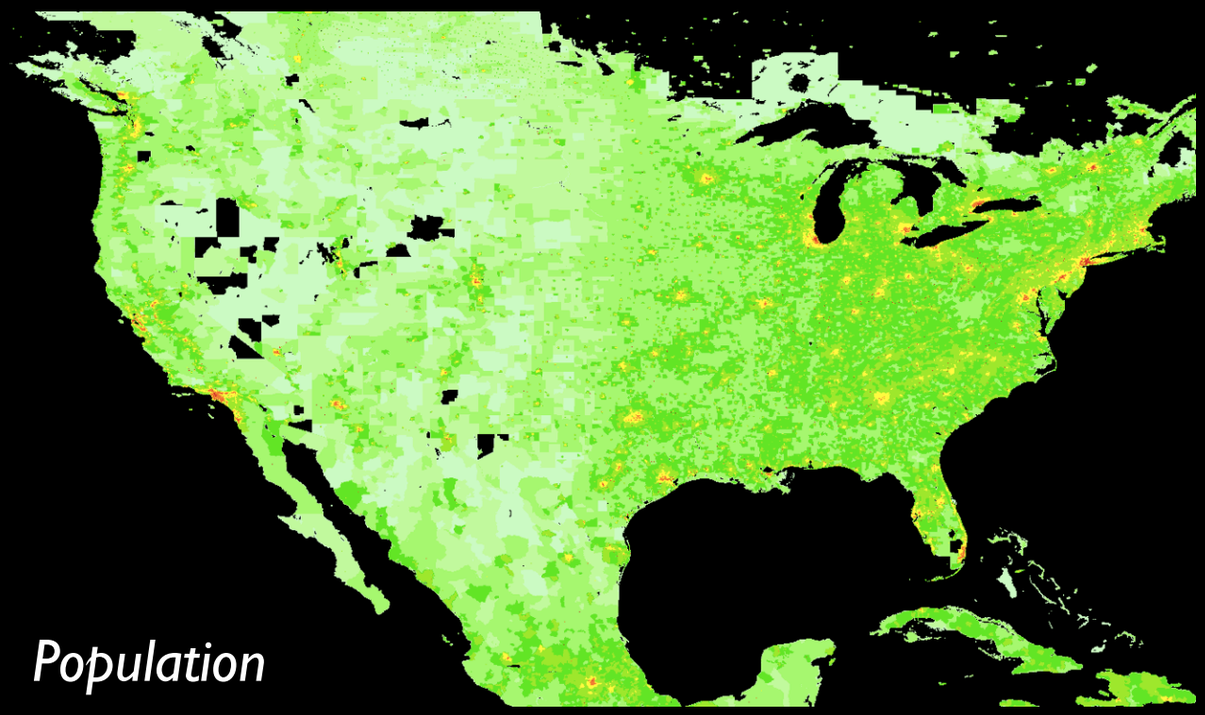
Nighttime light



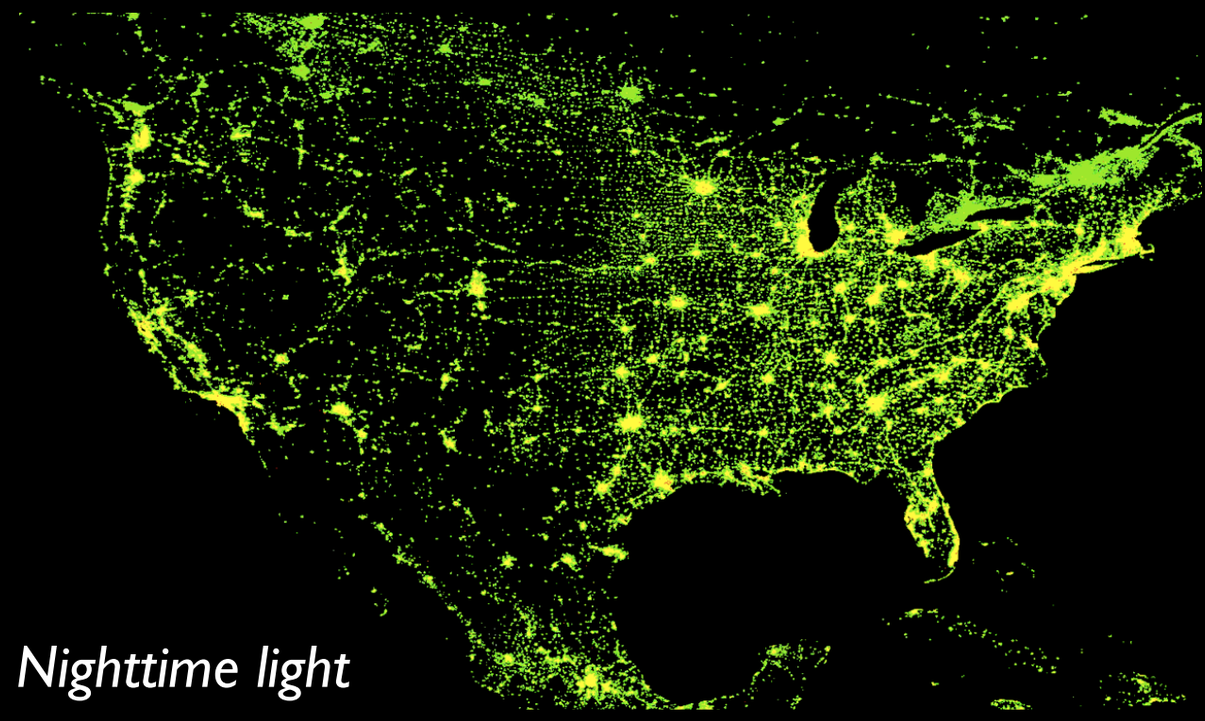
Population

Middle East and India

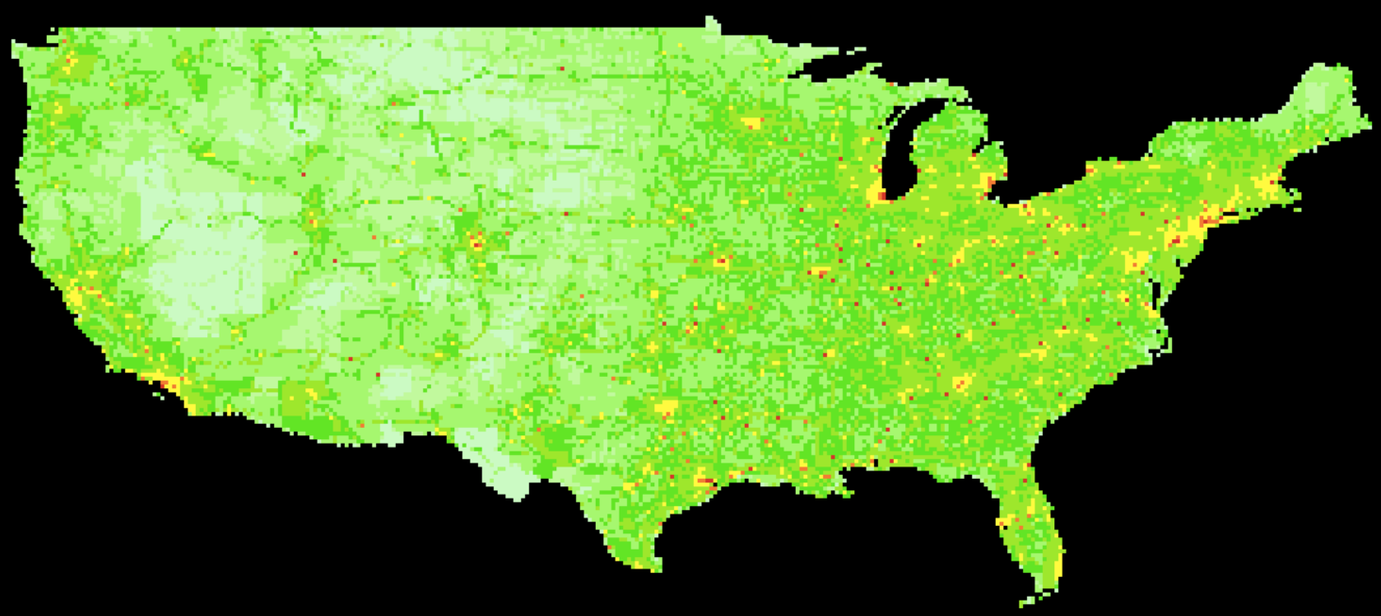
North America



Population



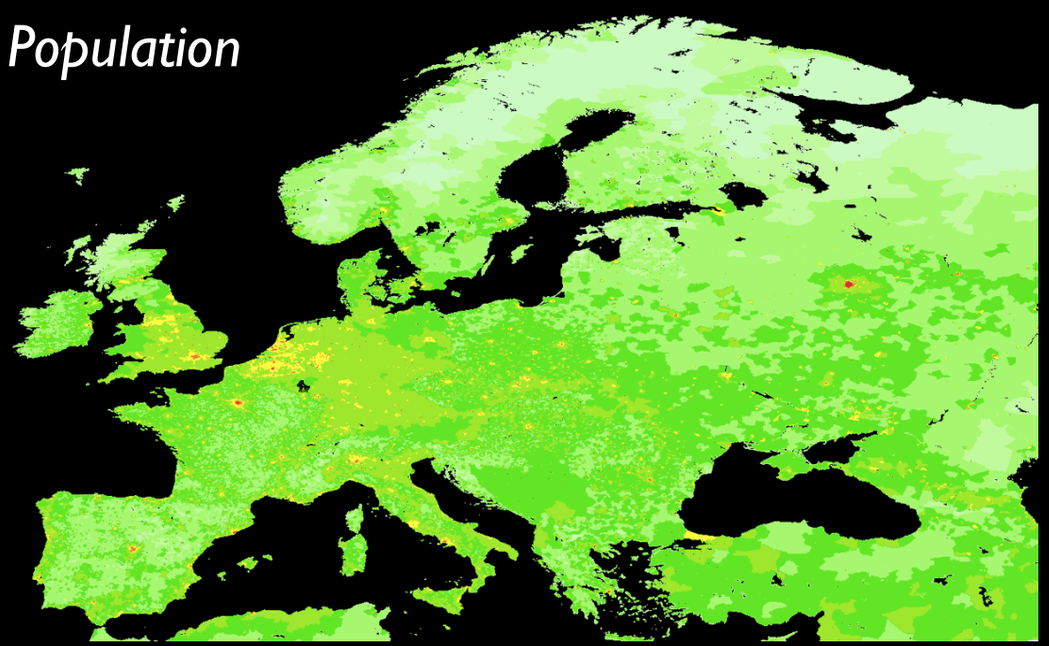
Nighttime light



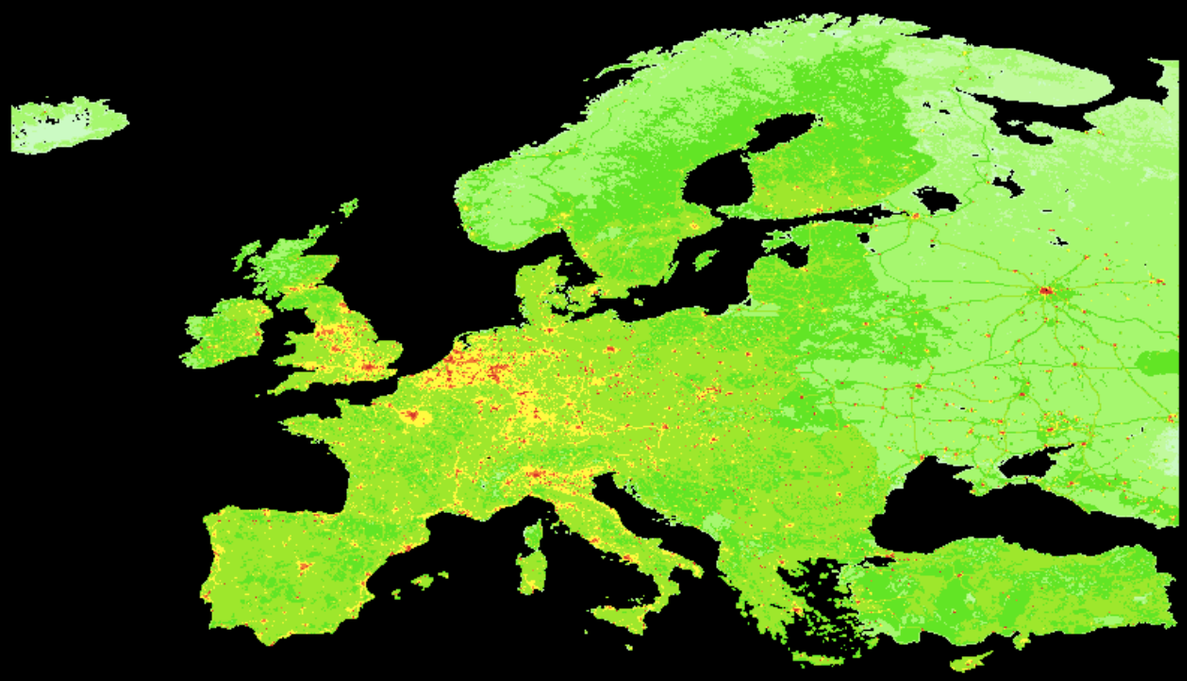
Vulcan project (Gurney et al. 2008)

Europe

Population



DMSP



Thiruchittampalam et al. 2009, in prep

Issues on high-resolution mapping

✓ *How to deal with various types of sources?*

- Point, line and other sources should be considered

✓ *Do population statistics work well as a surrogate?*

- Not certain if applied to high-resolution mapping

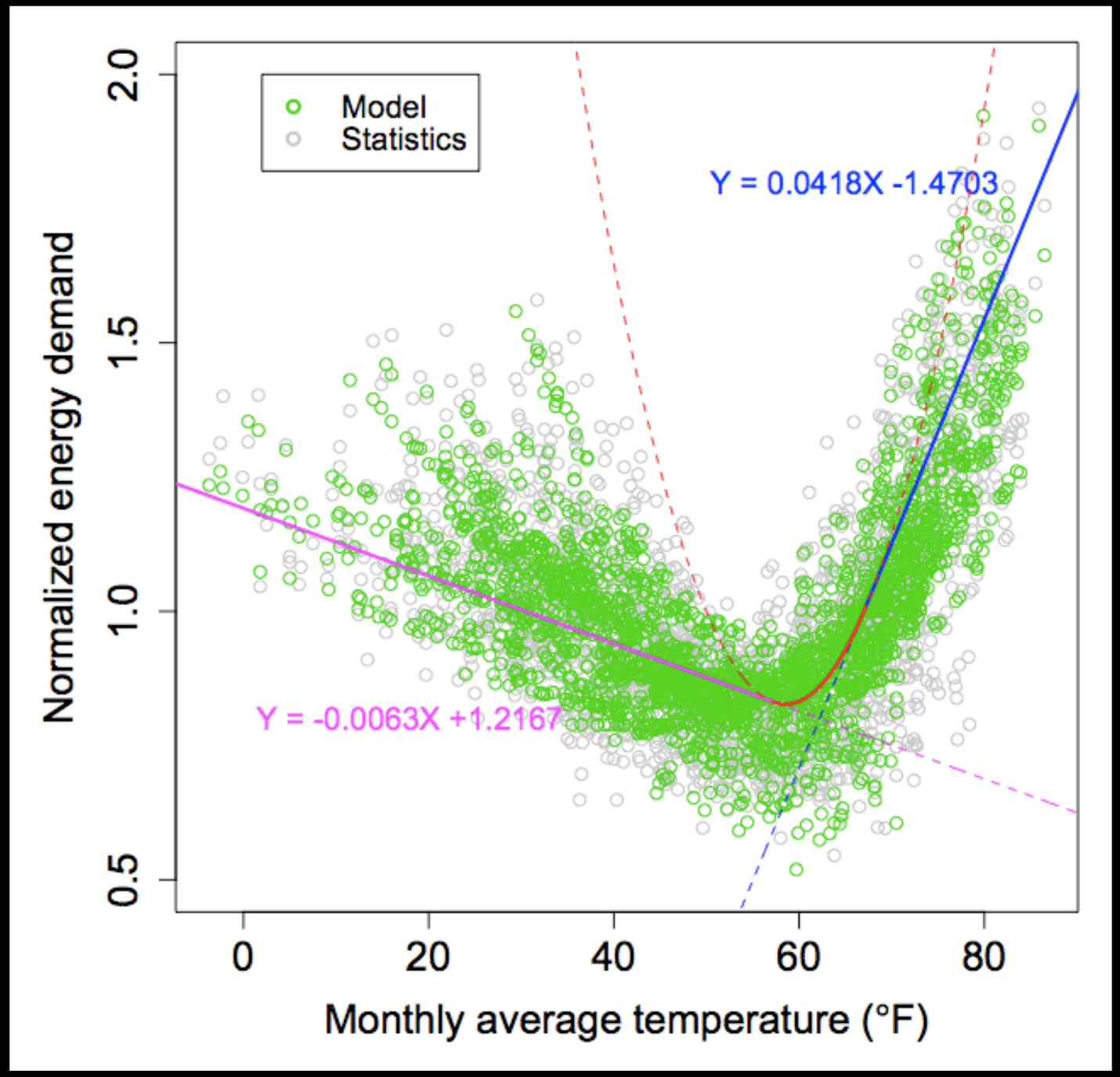
✓ *How to account for temporal change of flux?*

- Need to parameterize since no data is available

Parameterization of Seasonality

- *Derived a universal relationship between emission and temperature*
- *An energy demand model (Sailor & Vasireddy 2006) was employed*
- *The model was trained using US energy data*
- *A U-shaped global curve was obtained*
- *Annual emission was distributed to each month*

Temperature-Energy curve



Annual emission is distributed using a relationship shown above, monthly flux can be derived

Summary, Conclusion, and Future work

- *High-resolution global CO_2 maps were created*
- *Point sources were directly mapped*
- *Population and DMSP surrogates were used*
- *Good agreement with other works*
- *Seasonality was parameterized*
- *The maps will be applied to modeling studies*

Any question?

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