



**MIT** JOINT PROGRAM ON THE  
SCIENCE AND POLICY  
of **GLOBAL CHANGE**



清华大学能源环境经济研究所  
INSTITUTE of ENERGY, ENVIRONMENT and ECONOMY  
TSINGHUA UNIVERSITY

## BC from Transportation: How much now, and future?

Energy Modeling  
Forum – Snowmass  
2015 SLCF Session

Valerie J. Karplus

July 21-22, 2015

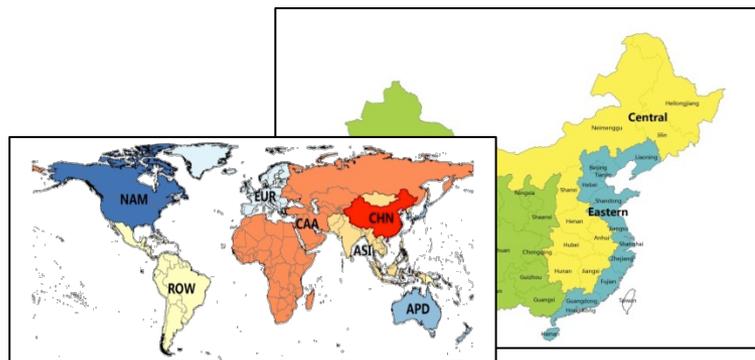
TSINGHUA-MIT  
CHINA ENERGY &  
CLIMATE PROJECT  
能源与气候变化研究项目

# Program of research: Transition in large, complex energy systems

## Characterizing micro dynamics and relationship to macro outcomes



[www.steel-plant.cn/](http://www.steel-plant.cn/)



TSINGHUA - MIT  
CHINA ENERGY & CLIMATE PROJECT

### Observe reality

Firm & household surveys

Case studies & econometric analysis

→ Quantify implementation challenges

### Simulate impacts

Models: Global & China regional  
Capture regional heterogeneity  
Evaluate policy change

#### CECP Team ongoing research:\*

- China carbon policy & emissions trading system design
- Transportation choices & energy
- Urbanization & energy
- Wind energy integration
- Impacts on air pollution & health

### Inform decisions

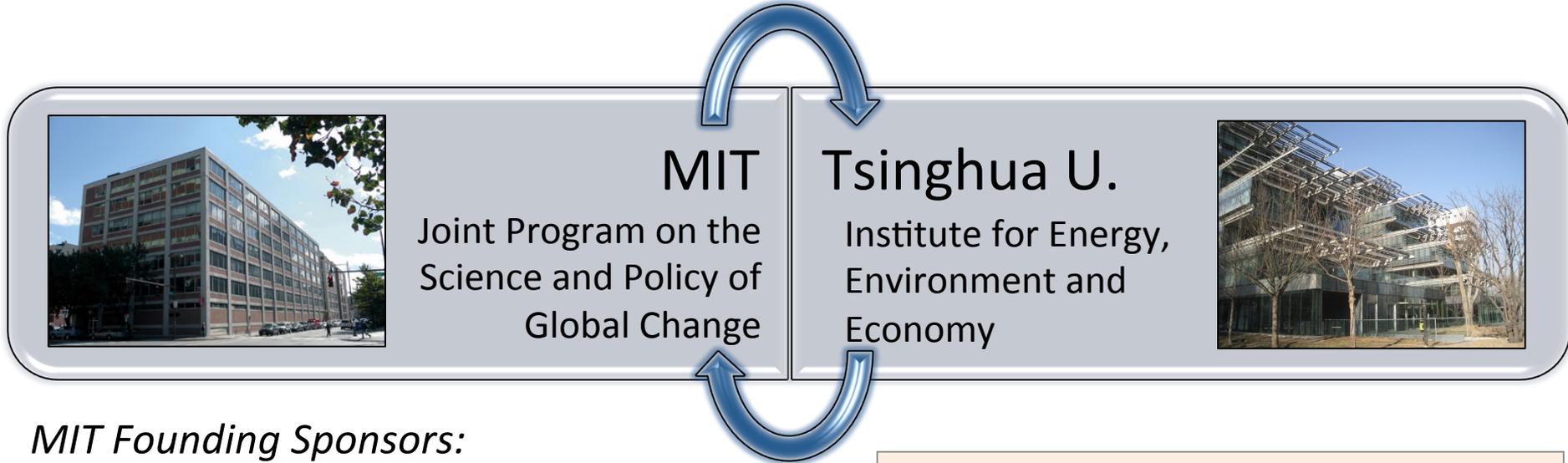
China & other emerging countries  
Policy / management

#### Outreach:

- Policy communication
- Annual Stakeholders Meeting in Beijing

# Our Team: Tsinghua-MIT China Energy and Climate Project

A collaborative research effort to develop new tools and analysis for supporting strong climate and energy decisions in China.



## MIT Founding Sponsors:



## Tsinghua Sponsors:

**RioTinto** NDRC MOST NEA

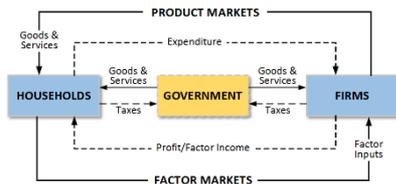


## Sustaining Sponsors:



- 12 team members (6 students)
- Closely integrated research team
- Separate funding at MIT & Tsinghua
- Offices in Cambridge & Beijing

# CECP has developed the Regional Emissions Air Quality Climate and Health (REACH) modeling framework to analyze the impacts of China's energy and environmental policies



*Policy Scenarios*

**1 Energy-Economic Model**  
China Regional Energy Model (C-REM)

**2 Projected Emissions**  
REAS emissions inventory:  $\text{NO}_x$ ,  $\text{SO}_2$ , VOC, BC, OC, CO,  $\text{NH}_3$ ,  $\text{CO}_2$

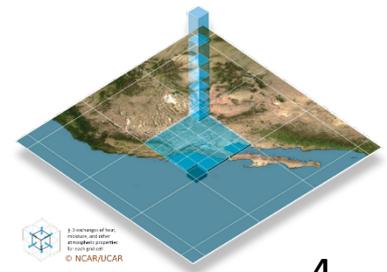
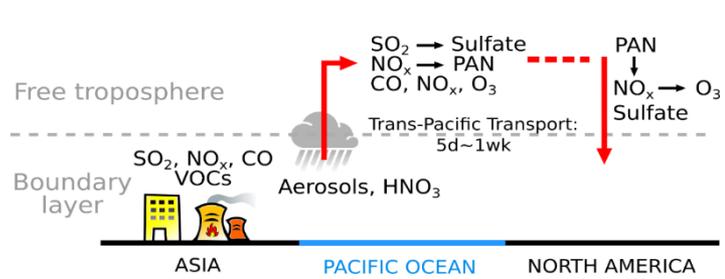
**3 Atmos. Chemistry model**

- GEOS-Chem
- WRF-Chem

*Air Quality*

**4 Health Effects**  
Uses latest estimates from Chinese sources

*We are applying this framework to analyze the impact of economy-wide and transportation-specific policies.*



# Modeling transportation (BC) emissions in China: Five learnings

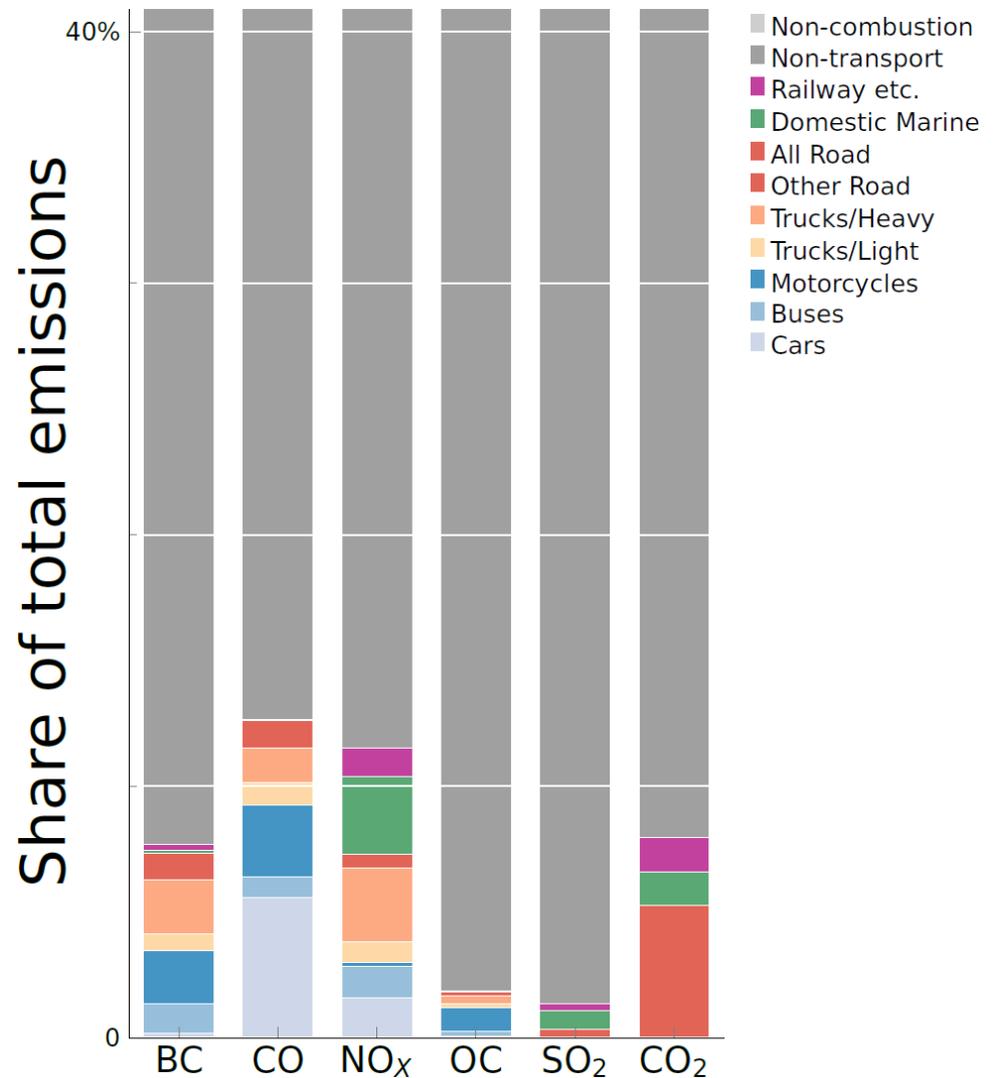
1. Transportation contributes modestly to total BC (and other) emissions in China—with big regional variation.
2. Huge measurement uncertainty in underlying inventories.
3. Huge uncertainty in future trends: vehicles vs. public transport vs. car sharing / e-Commerce freight / economic situation
4. Models often do not capture important dynamics in transition economies that affect household (transport) BC sources.
5. Good policy on the books is not the problem – main problem is implementation.

# 1) Emissions from transportation in China – 2007

Transportation is a small but important share of total air pollution and CO<sub>2</sub> emissions.

- *Is expected to grow significantly in the future.*
- *Is highly concentrated in urban centers.*
- *Accounting issues—e.g. some “industrial” use may be transport.*

**Source:** Kurokawa et al., (2013).  
REAS Emissions Inventory 2.1.

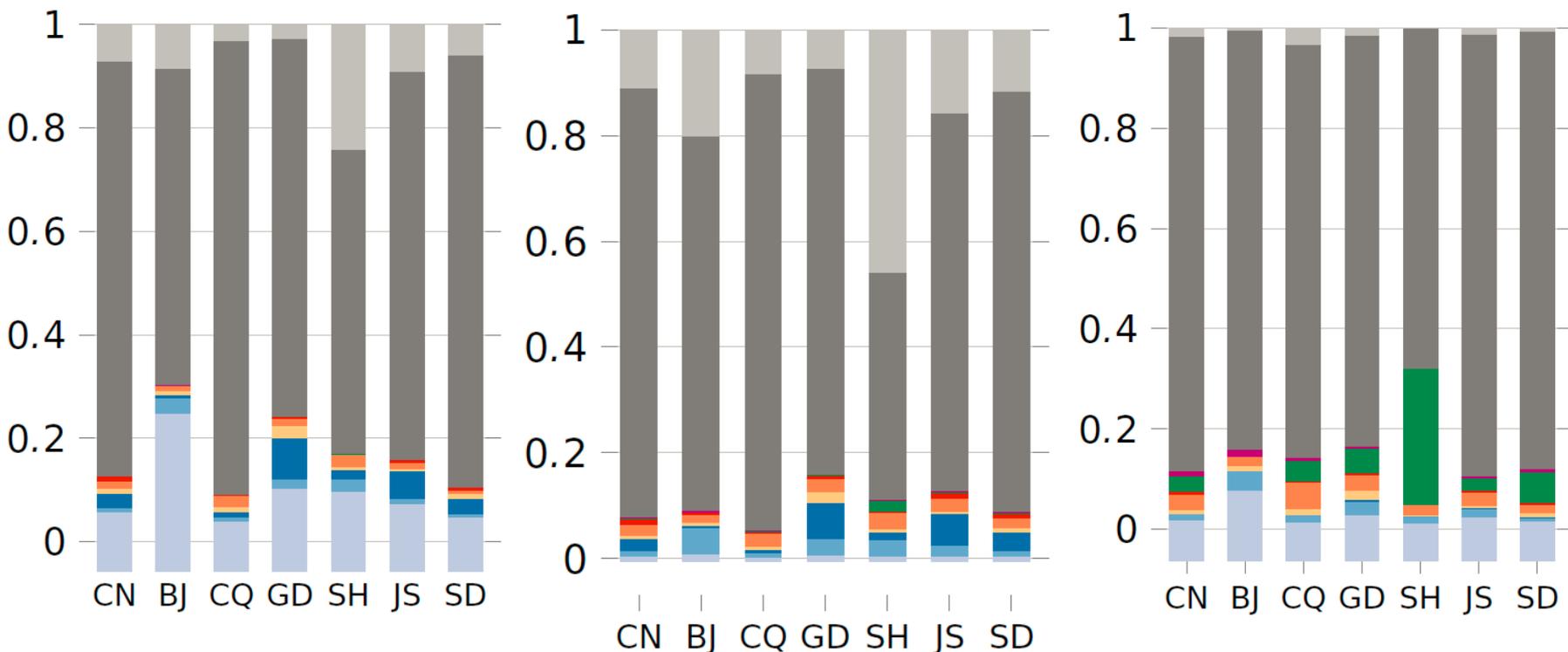


# Transportation accounts for a modest share of primary pollutant emissions (Tg) (2007)

CO

BC

NO<sub>x</sub>



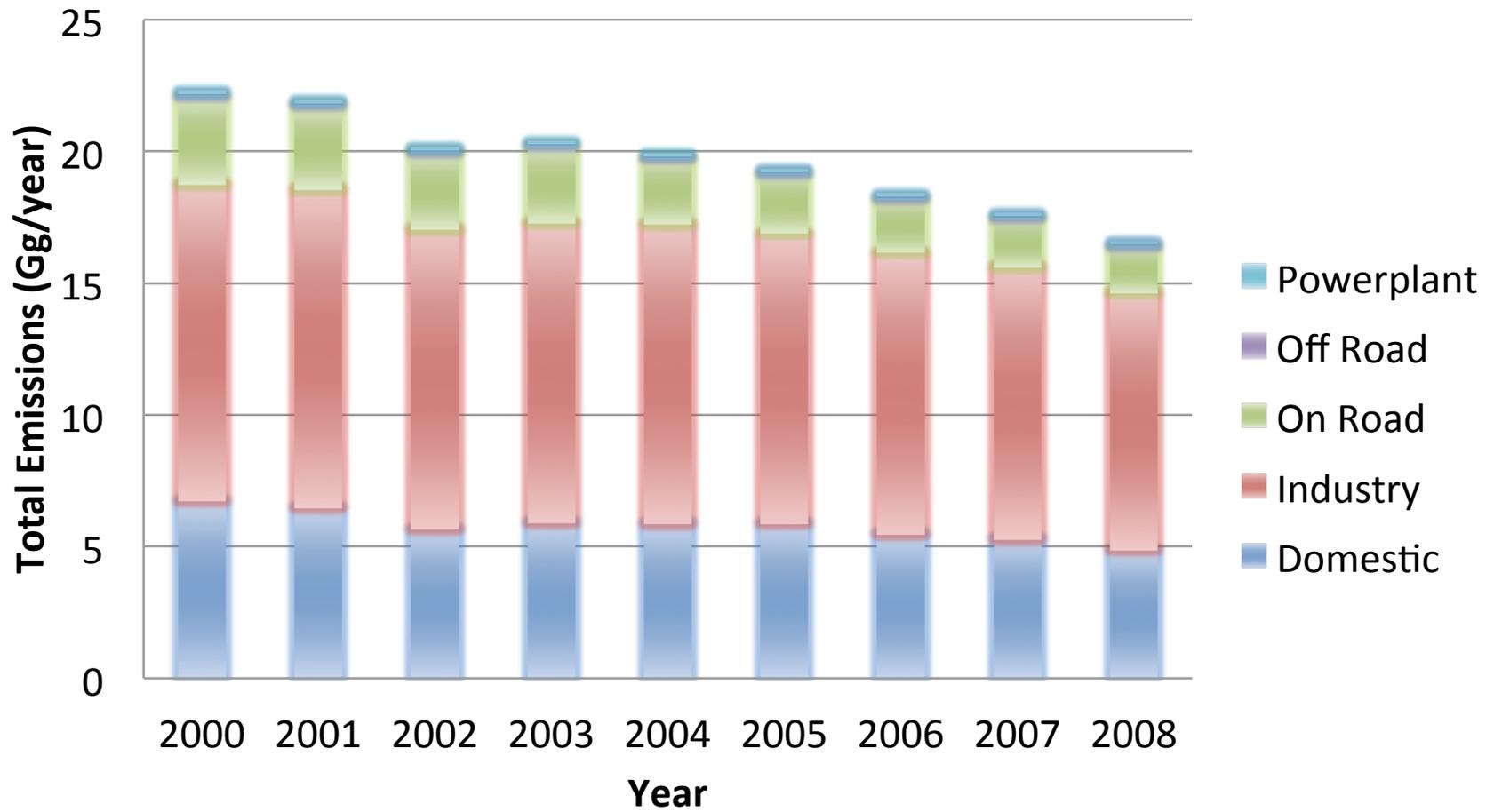
Non-combustion Sources
  Non-transport Combustion
  Railway etc.
  All Road (SO<sub>2</sub> only)
  Trucks/Heavy
  Motorcycles
  Cars
  Domestic Marine
  Other Road
  Trucks/Light
  Buses

Source: Kurokawa et al., (2013). REAS Emissions Inventory 2.1.

Not shown: OC and SO<sub>2</sub> – transportation is a very small share of both totals.

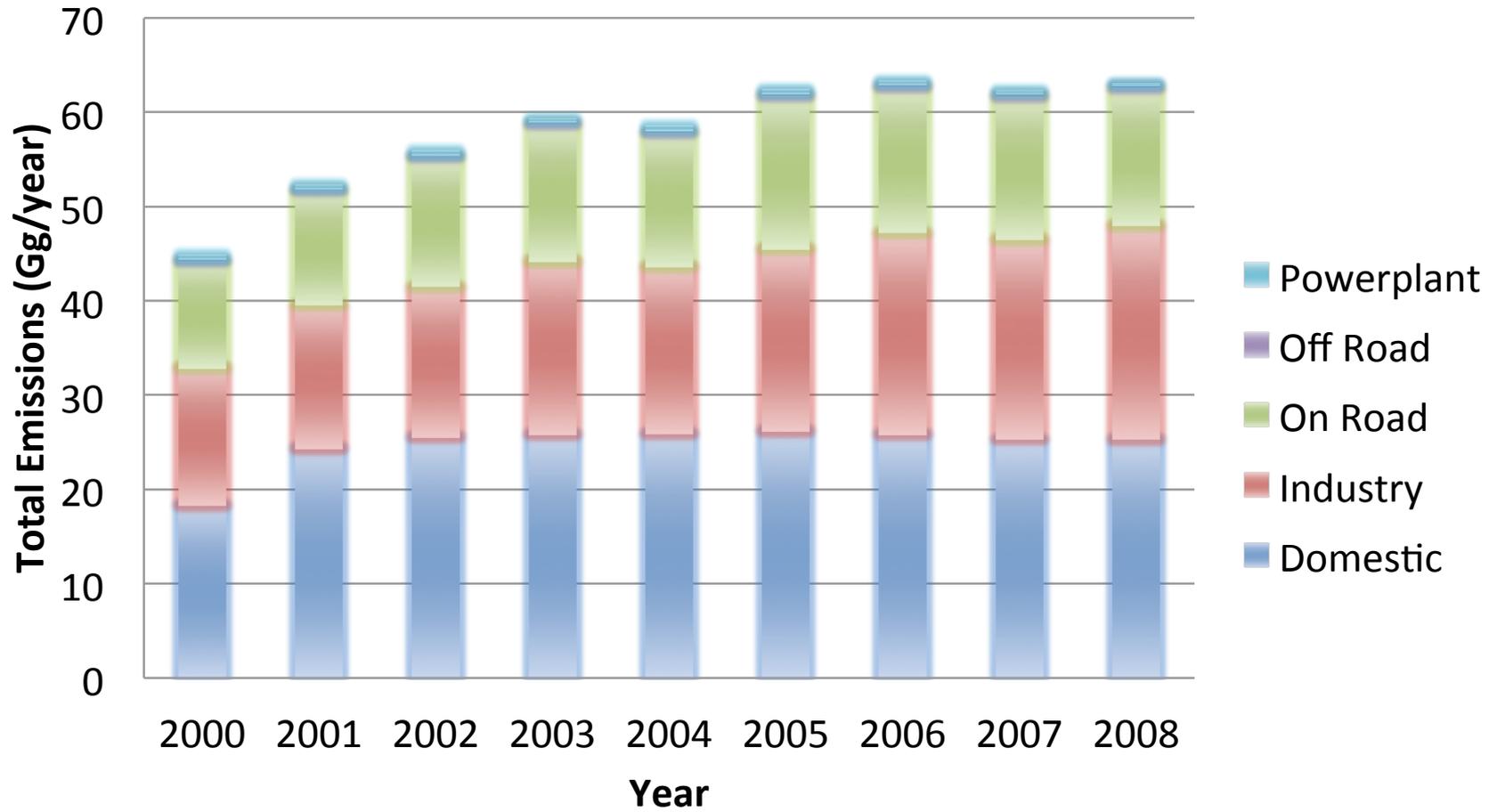
# Comparing trends in provinces across China (1)

## Beijing: Black Carbon Emissions



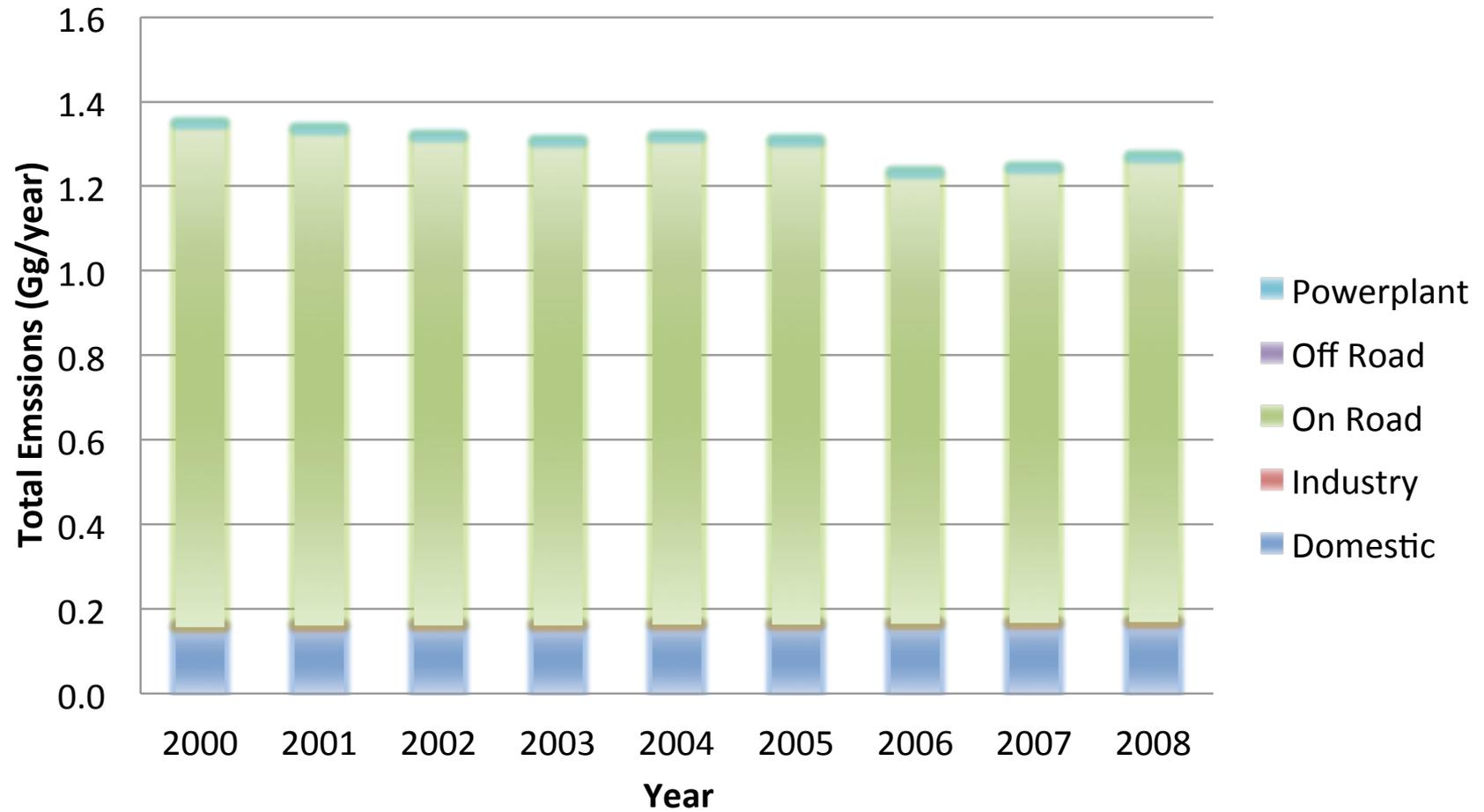
# Comparing trends in provinces across China (2)

## Guangdong: Black Carbon Emission

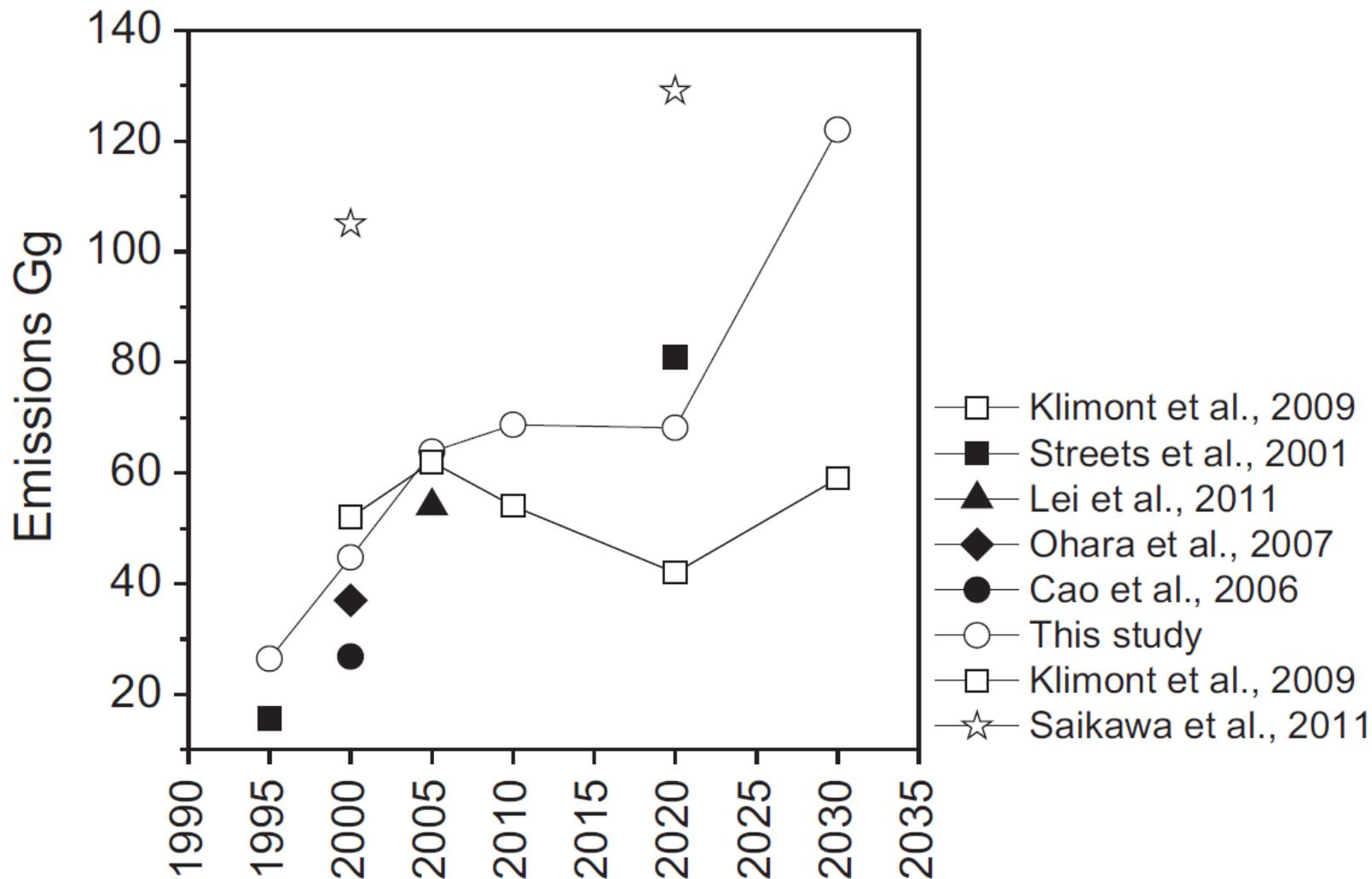


# Contrast to developed regions, even within Asia

## Hong Kong: Black Carbon Emissions



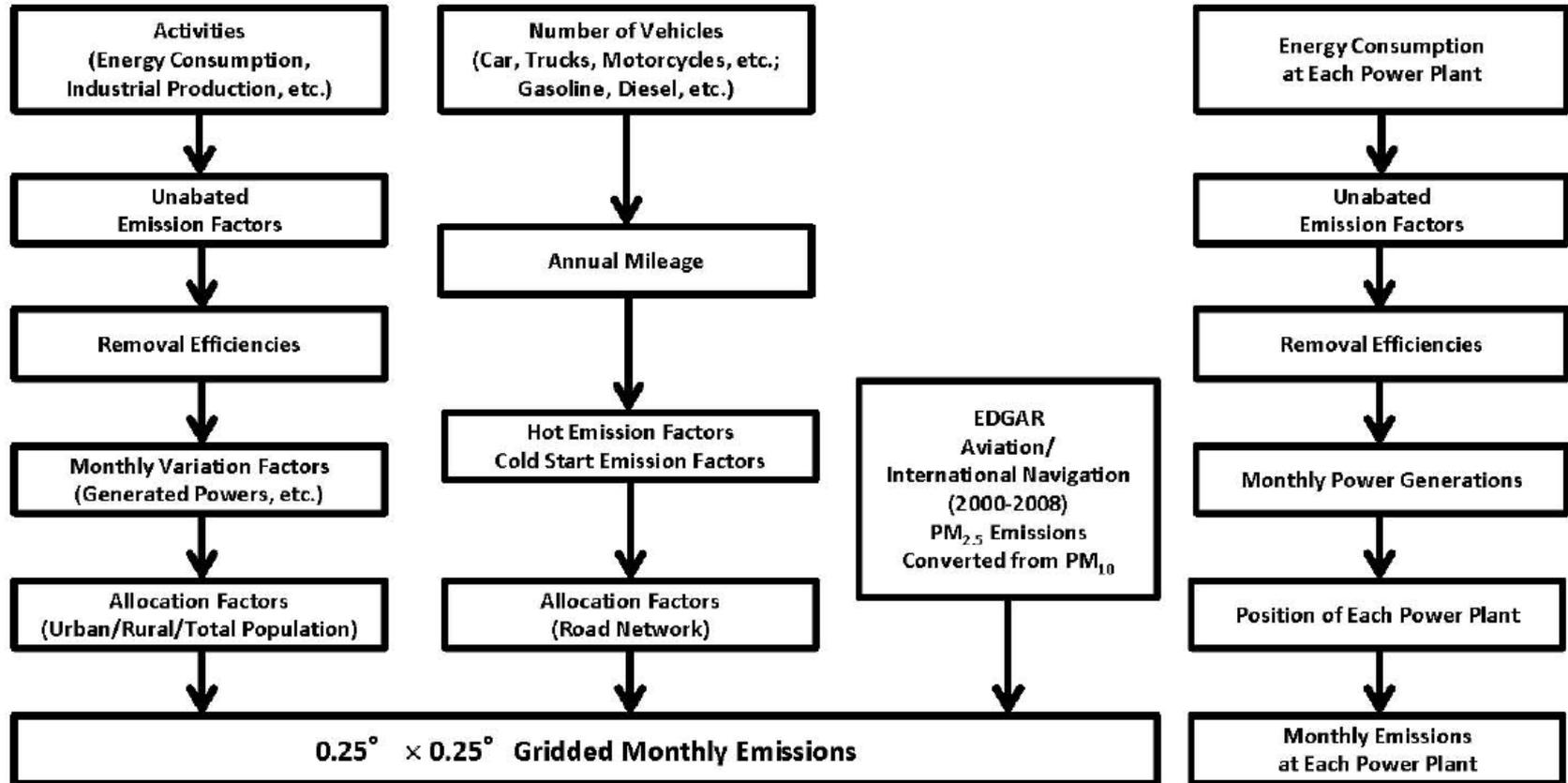
## 2) BC emissions – comparing studies



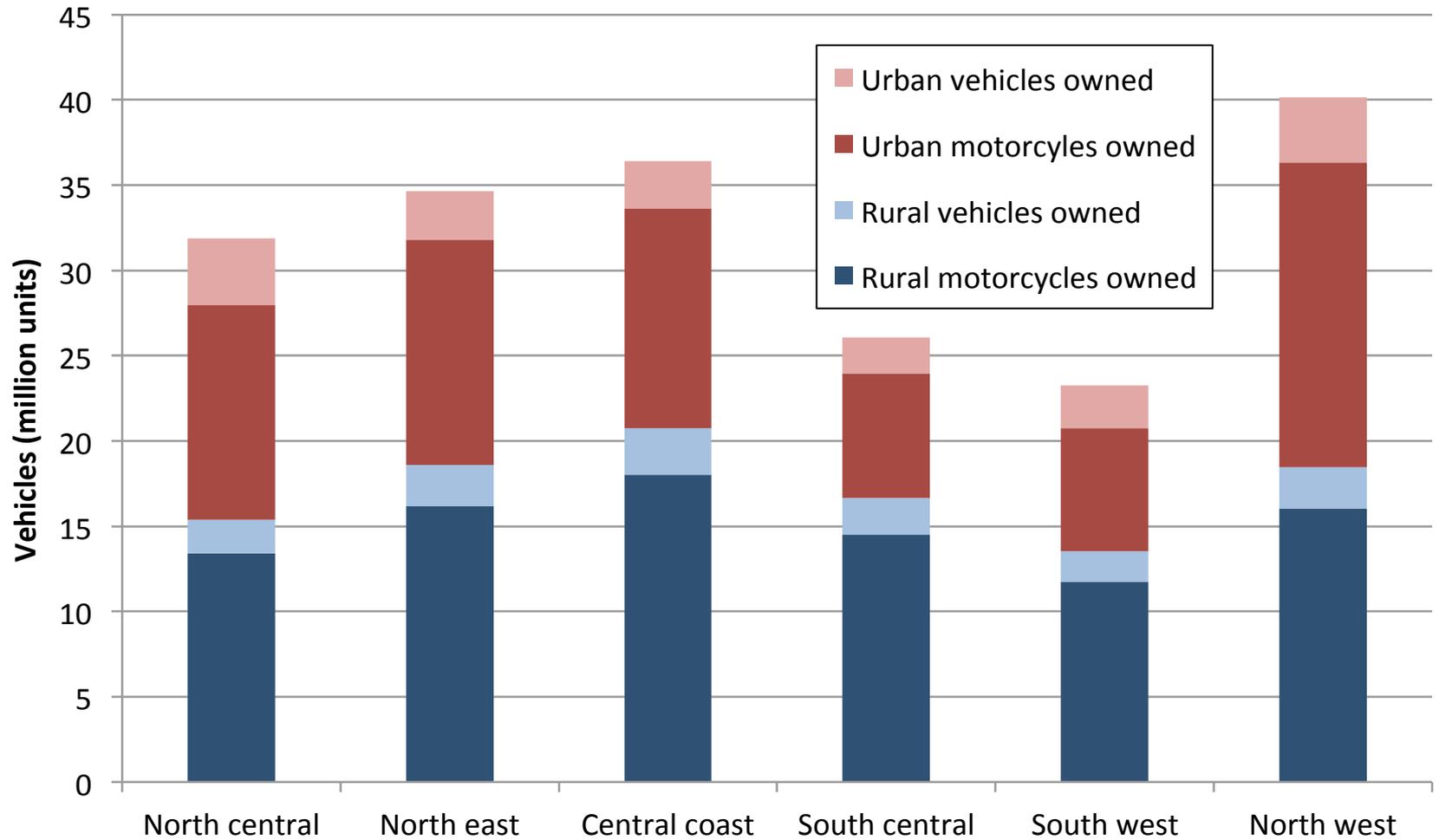
# REAS Inventory Development

## Regional Emission inventory in ASia

(a) Stationary and Mobile Sources

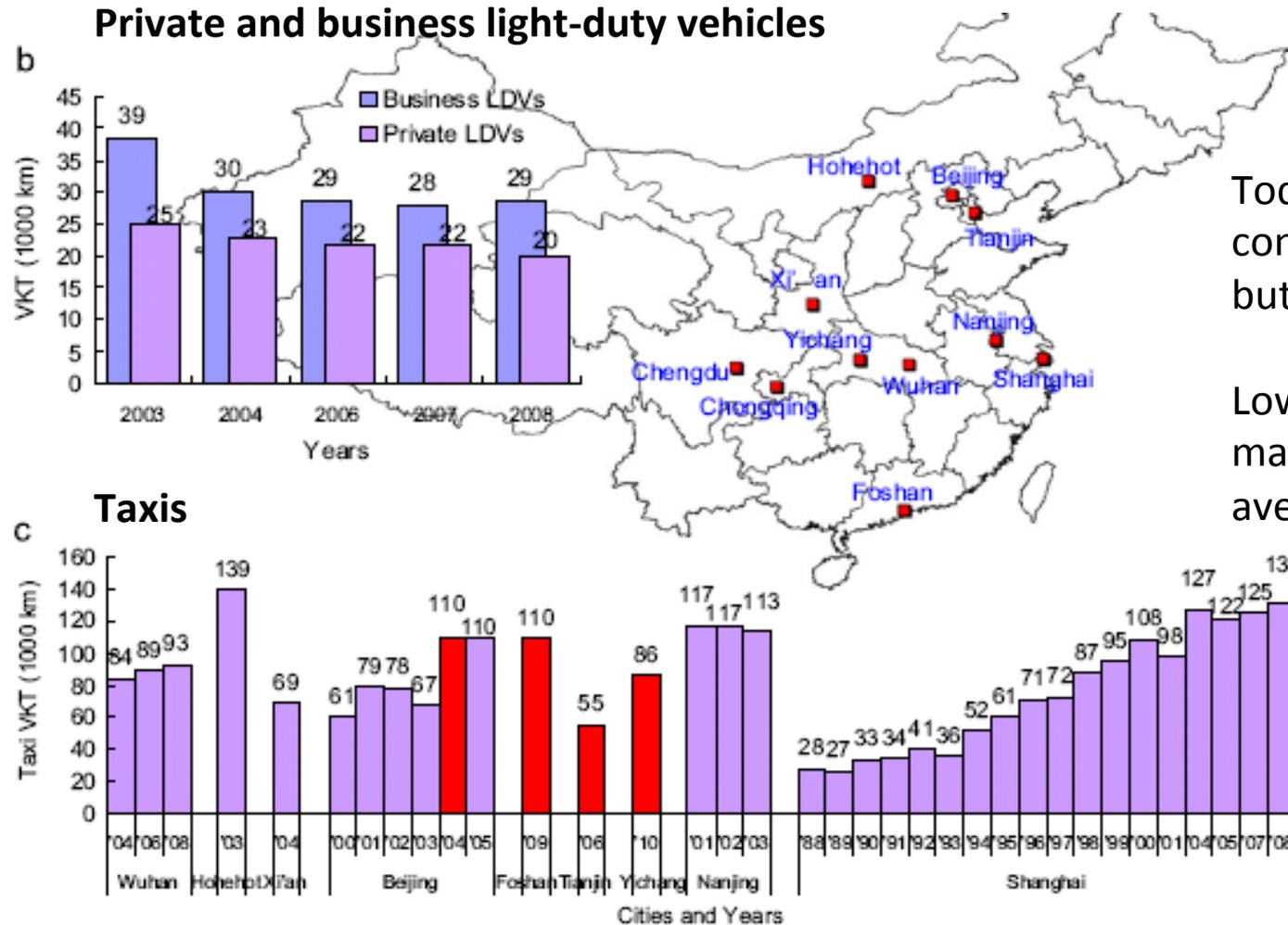


# Difference possibly due to inclusion of motorcycles / poor rural vehicle accounting / off-road vehicles



China Statistical Yearbook, 2011.

# Vehicle travel per year varies by vehicle and service type

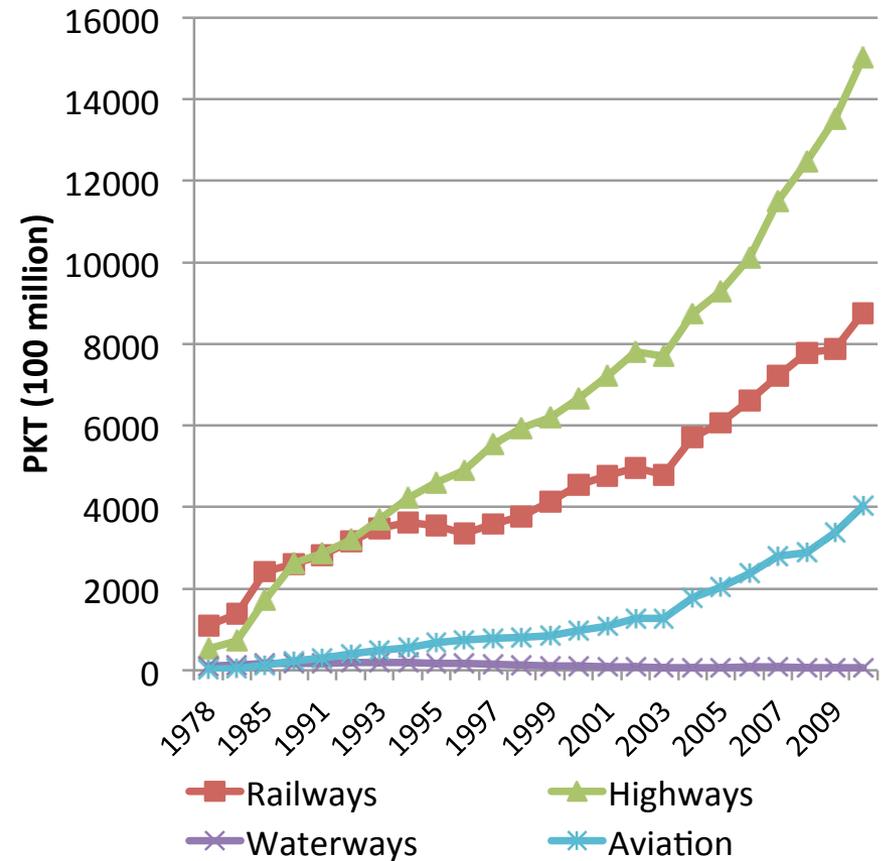
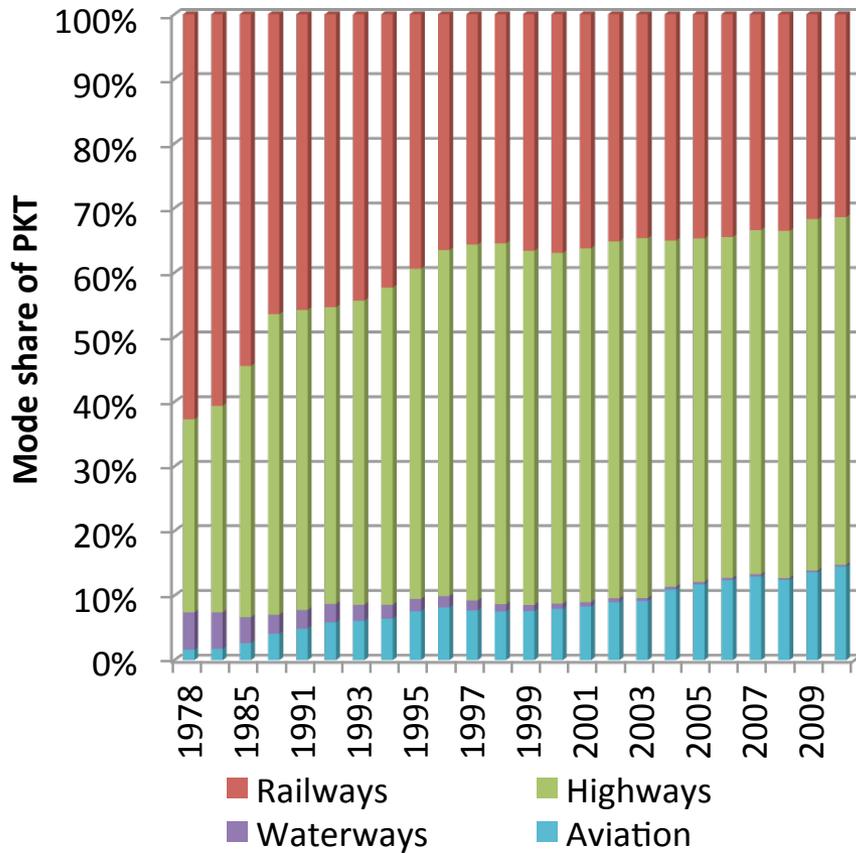


Today: Beijing wants consumers to buy cars, but not to drive them?

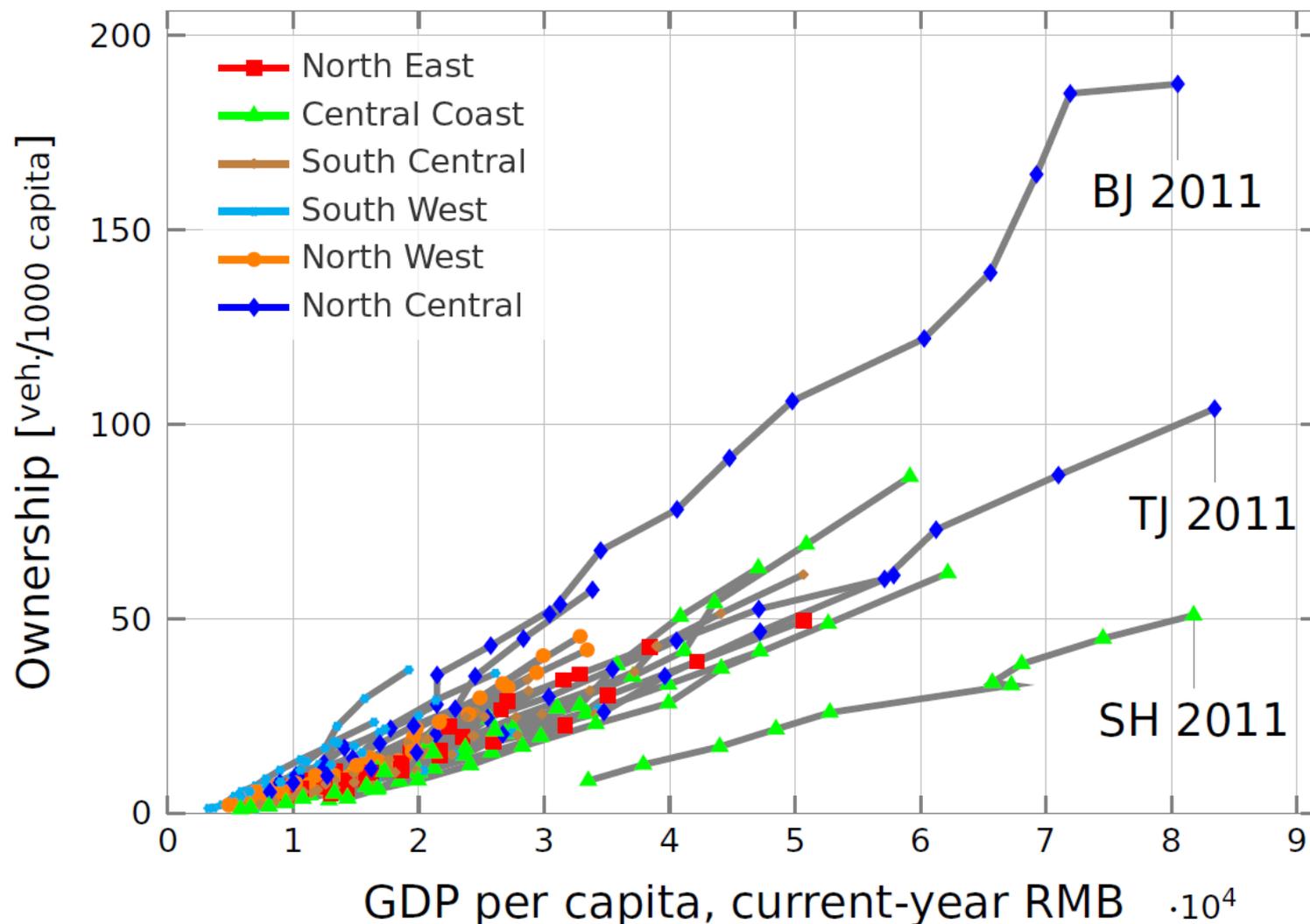
Low mileage in cities may bring down average going forward.

Source: Huo et al., 2012.

**3) 1978 mode share of rail has decreased, while vehicles and aviation mode shares increased. What will the future look like?**



# Will other cities look like Beijing or like Shanghai?

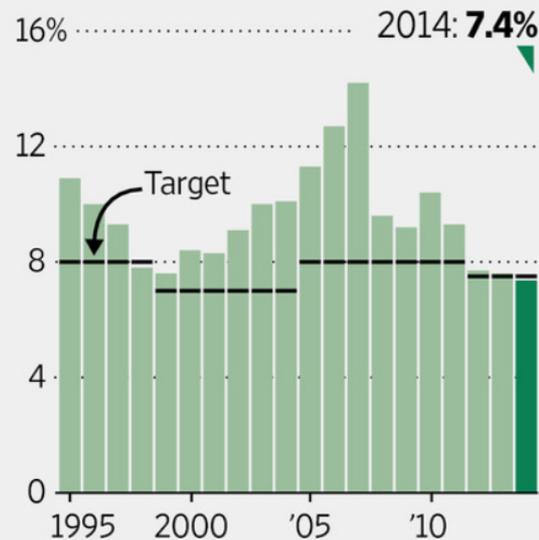


# The new normal?

## Downshifting

After decades of near double-digit growth, China's economy is slowing, weighed down by slumping real estate and weaker manufacturing.

Change from a year earlier in annual real GDP growth



Source: National Bureau of Statistics

Change from a year earlier in property sales, by value

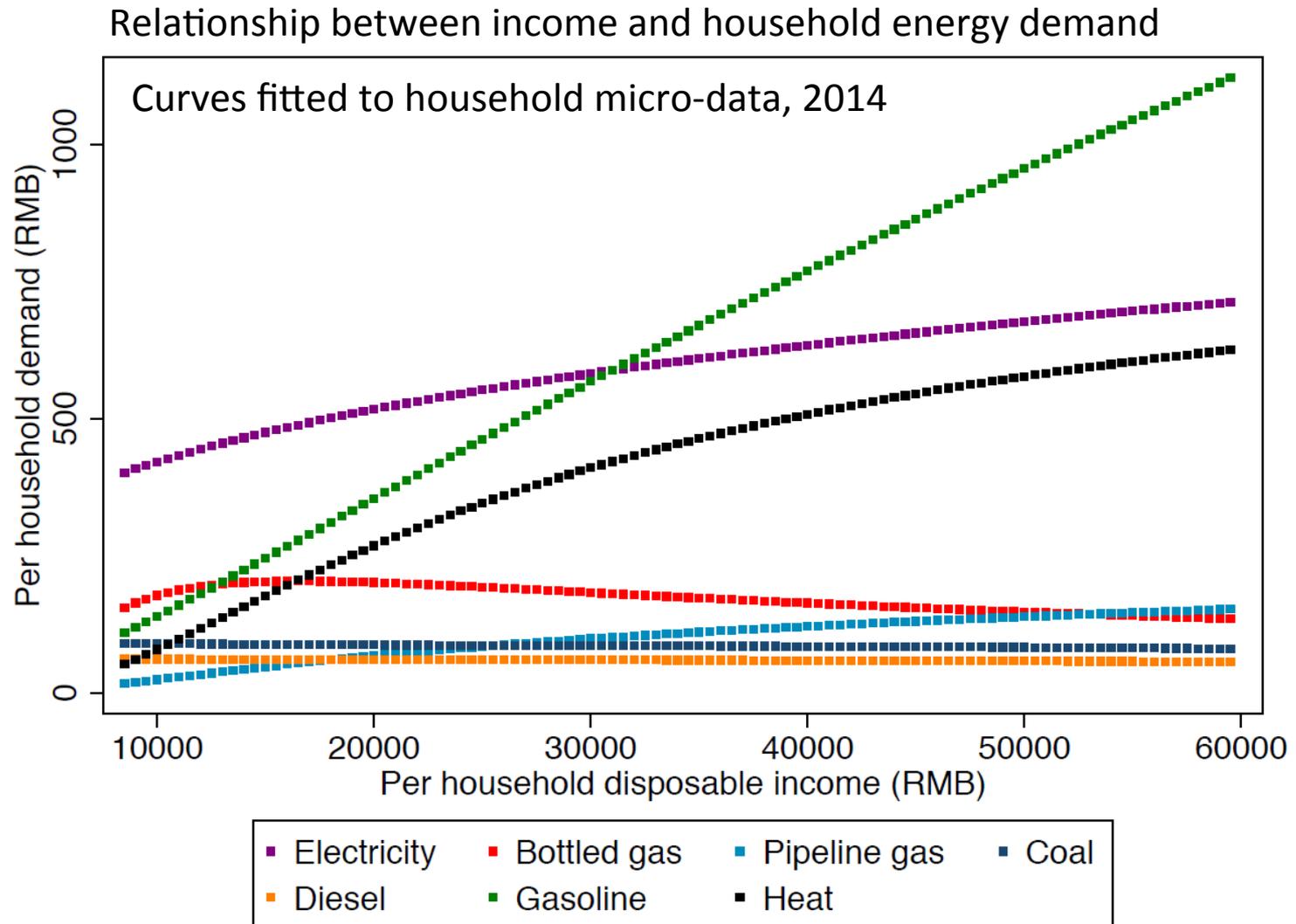


Change from a year earlier in industrial production



The Wall Street Journal

4) Models do not correctly capture the relationship between rising income and energy demand – income elasticities often far less than 1 and are not stable



## Departing from income elasticity = 1 makes a big difference...

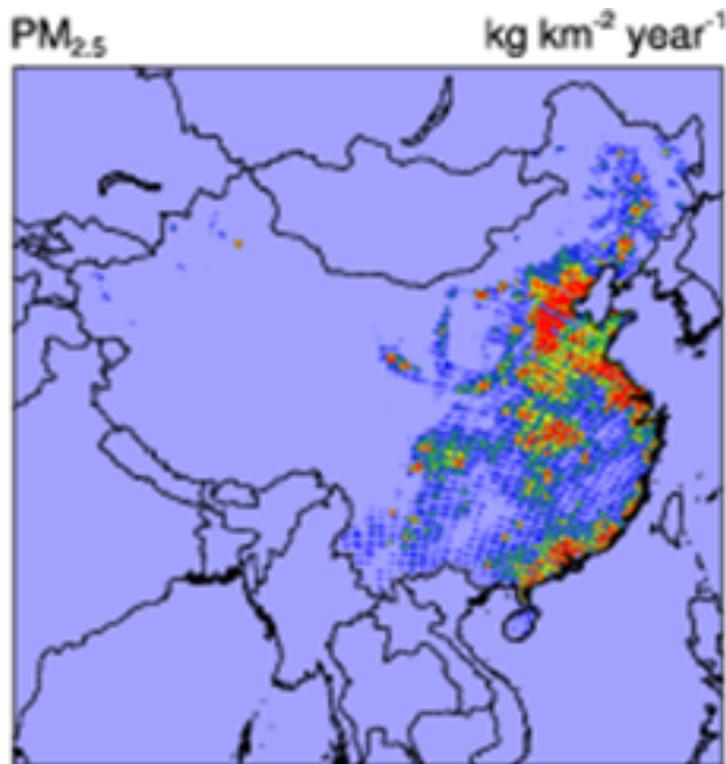
- In projection to 2030, CO<sub>2</sub> emissions due to household direct energy use is 65% lower when we account for income dependence of spending.
- Has the effect of lowering projected CO<sub>2</sub> emissions in 2030 by ~6%.
- Need to better understand drivers of fuel switching at the household level.
- Future work will examine impacts on BC and other air pollutants.

## 5) Policy on the books is not (the main) problem...

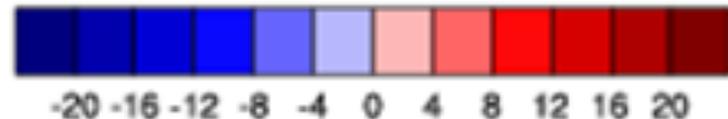
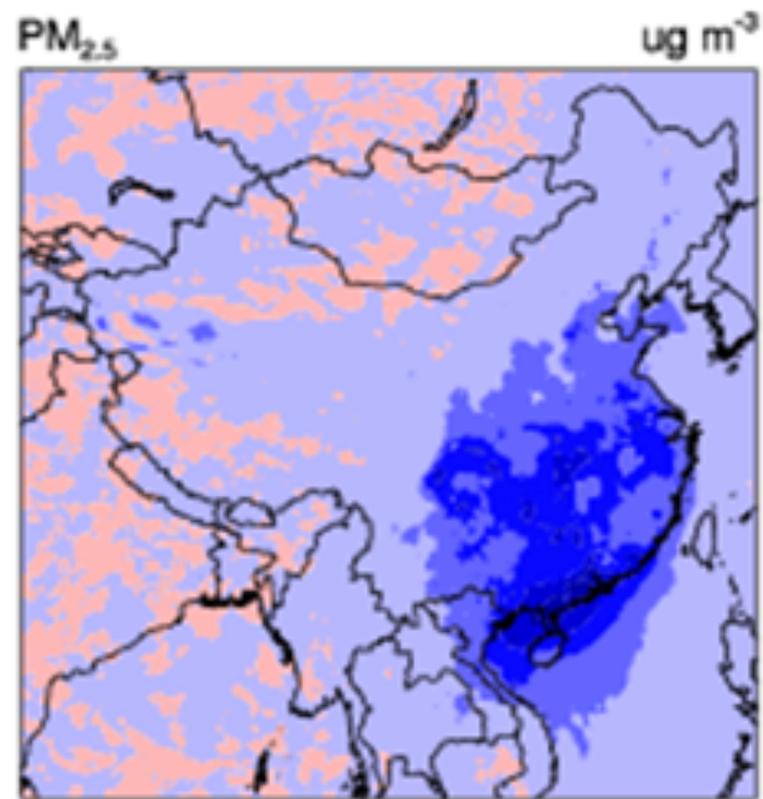
- Full implementation of China 3 standards has been very hard to achieve—will China 4, 5, or 6 be different?
- Vehicle standards implemented by Environment Ministry, but fuel standards controlled by Standardization Administration of China—committees to research standards represent oil company interests.
- Oil companies argued that they require financial support to make necessary changes—repeatedly delaying implementation—State Council intervened.
- *Our results suggest that full implementation of China 3 would make a big difference.*



Fully adopting China 3 standards nationwide by 2020 results in a reduction in  $PM_{2.5}$  ranging from 8-20  $\mu\text{g}/\text{m}^3$  across China



Reduction in emissions



Reduction in concentrations

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Thank you  
谢谢!



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