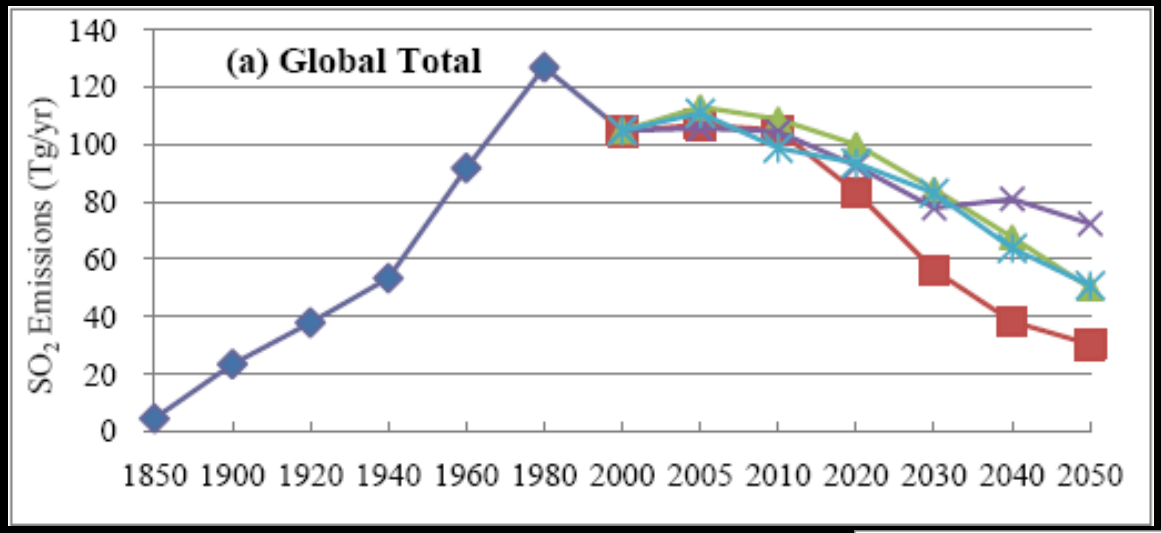
Global SO_2 Emission For 2007

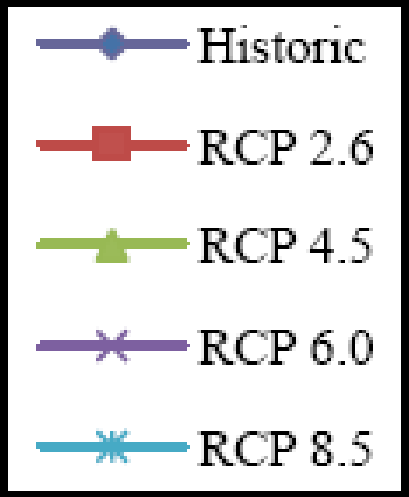
– A new emission inventory

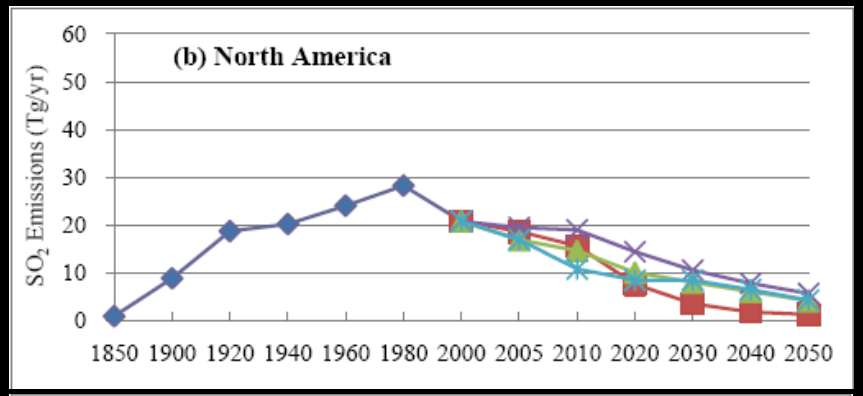
城市与环境学院

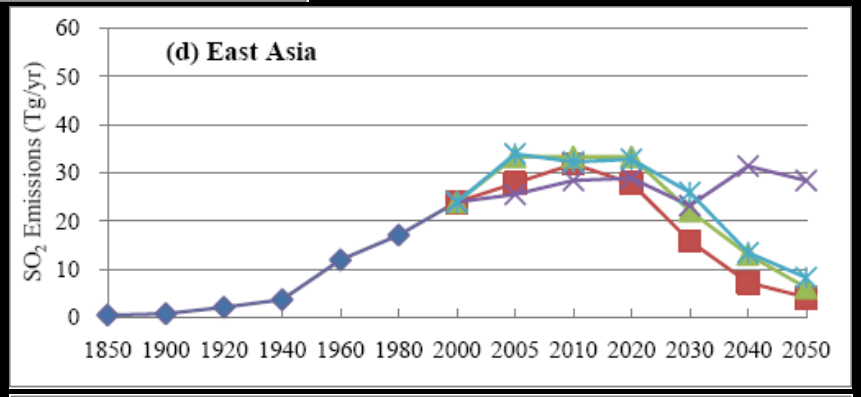
College of Urban and Environmental Sciences
Peking University

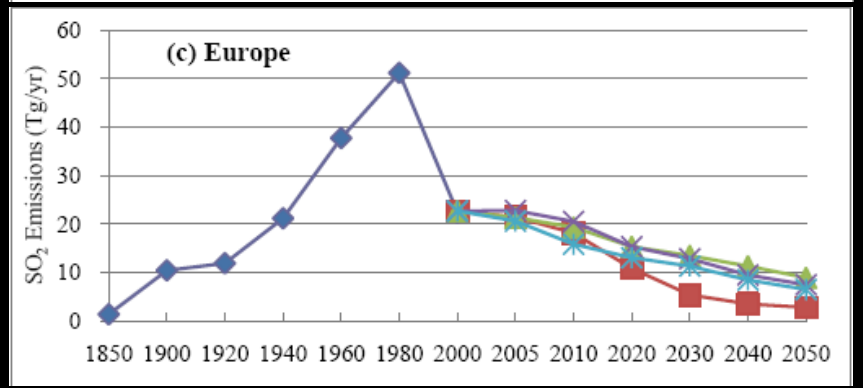
IPCC – AR4

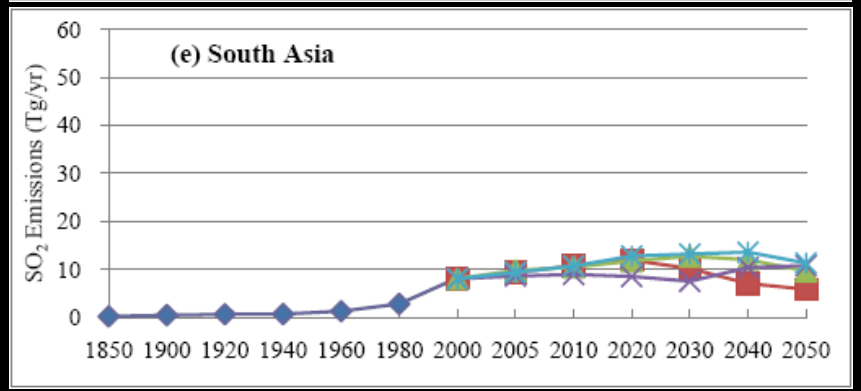

(a) Global Total
SO_2 Emissions (Tg/yr)
140
120
100
80
60
40
20
0
1850 1900 1920 1940 1960 1980 2000 2005 2010 2020 2030 2040 2050


Historic
RCP 2.6
RCP 4.5
RCP 6.0
RCP 8.5

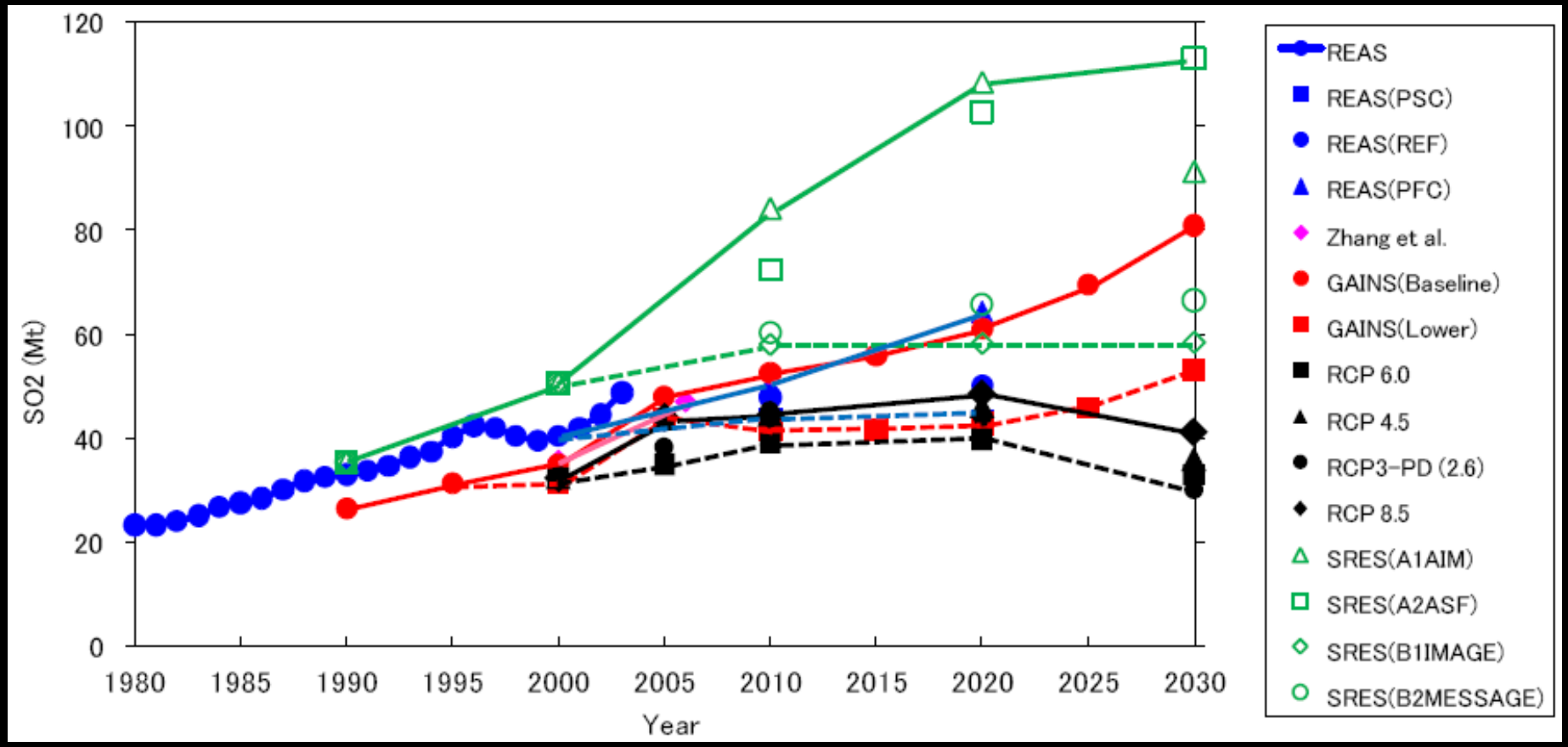

(b) North America
SO_2 Emissions (Tg/yr)
60
50
40
30
20
10
0
1850 1900 1920 1940 1960 1980 2000 2005 2010 2020 2030 2040 2050


(d) East Asia
SO_2 Emissions (Tg/yr)
60
50
40
30
20
10
0
1850 1900 1920 1940 1960 1980 2000 2005 2010 2020 2030 2040 2050


(c) Europe
SO_2 Emissions (Tg/yr)
60
50
40
30
20
10
0
1850 1900 1920 1940 1960 1980 2000 2005 2010 2020 2030 2040 2050


(e) South Asia
SO_2 Emissions (Tg/yr)
60
50
40
30
20
10
0
1850 1900 1920 1940 1960 1980 2000 2005 2010 2020 2030 2040 2050

Asia - literitures



Smith et al., 2011 - ACP

	Coal			Petroleum		
Category	S Content	Driver	Total	S Content	Driver	Total
I. Recent-Country-Inventory	±10%	±5%	±11%	±20%	±5%	±21%
II. Older Inventory	±15%	±10%	±18%	±25%	±10%	±27%
IIa. OECD (pre inventory)	±20%	±15%	±25%	±40%	±15%	±43%
III. Other Countries	±20%	±20%	±28%	±40%	±20%	±45%
IV. Int Shipping	±20%	±20%	±28%			
IV. Int Shipping (earlier)	±30%	±30%	±42%			

	Smelting			Other Process, Biomass		
Category	S Content	Driver	Total	S Content	Driver	Total
I. Recent-Country-Inventory	±10%	±10%	±14%	±20%	±10%	±22%
II. Older Inventory	±20%	±15%	±25%	±35%	±15%	±38%
IIa. OECD (pre inventory)	±20%	±15%	±25%	±50%	±15%	±52%
III. Other Countries	±30%	±20%	±36%	±50%	±20%	±54%

Uncertainty values by country category.

Smith et al., 2011 - ACP

Uncertainty as fraction of source

	1900 - 2005			
	Max	Min	1900	2005
Coal	19%	12%	17%	19%
Petroleum	29%	16%	28%	18%
Smelting	20%	15%	20%	18%
Other Process	29%	13%	29%	19%
Shipping	42%	28%	42%	28%
Biomass	36%	26%	26%	34%
Total	14%	8%	14%	11%

Uncertainty as fraction of emissions from each source in 1900, 2005, and the maximum and minimum over this period.

(EDGAR v4.1 – Smith 2011)

Regional Difference	1970	1975	1980	1985	1990	1995	2000	2005
USA, Europe, Japan	-9,093	-2,210	4,609	-192	-559	2,809	1,101	-924
China + FSU	5,799	9,002	12,335	8,119	11,279	6,645	3,395	4,541
Rest of World	968	1,523	2,668	2,517	2,812	3,676	4,208	6,756
Int. Shipping	-1,603	-1,640	-1,654	-1,154	-1,844	-2,717	-3,014	-4,206
Total	-3,928	6,675	17,958	9,291	11,688	10,413	5,691	6,167
Diff as %	-3%	5%	14%	7%	9%	9%	5%	5%

Sectoral Differences	1970	1975	1980	1985	1990	1995	2000	2005
Energy & Fuel Proc	-2,944	2,037	6,213	2,109	7,277	8,521	5,066	4,761
Smelting	-806	-773	-384	-451	-104	-54	-485	-502
Other Process	-1,893	-998	-414	-165	-174	-1,015	-911	-375
Industry-Comb	5,312	8,711	13,472	9,282	8,043	8,139	7,716	9,660
Transport	-1,572	-1,075	-164	87	-739	-349	-35	-451
Domestic	-556	297	739	-571	-933	-2,274	-2,817	-2,884
International Shipping	-1,603	-1,640	-1,654	-1,154	-1,844	-2,717	-3,014	-4,206
Total	-4,060	6,562	17,811	9,138	11,529	10,253	5,521	6,003

A bottom-up inventory

For Coal combustion:

$$\text{Emission}_i = \sum_{j.k} \left[\text{FuelUse}_{ijk} \times \text{SulfurContent}_i \times (1 - f_{\text{ash,i}}) \times (1 - f_{\text{control,i}}) \right]$$

For other sources:

$$\text{Emission}_i = \sum_{j,k} \left[\text{FuelUse}_{ijk} \times EF_{jk} \right]$$

Sectors, sources ...

222 countries

7 sectors:
power plants, industrial, residential, domestic transportation, biomass, international aviation and international shipping

64 combustion sources

0.1×0.1 degree

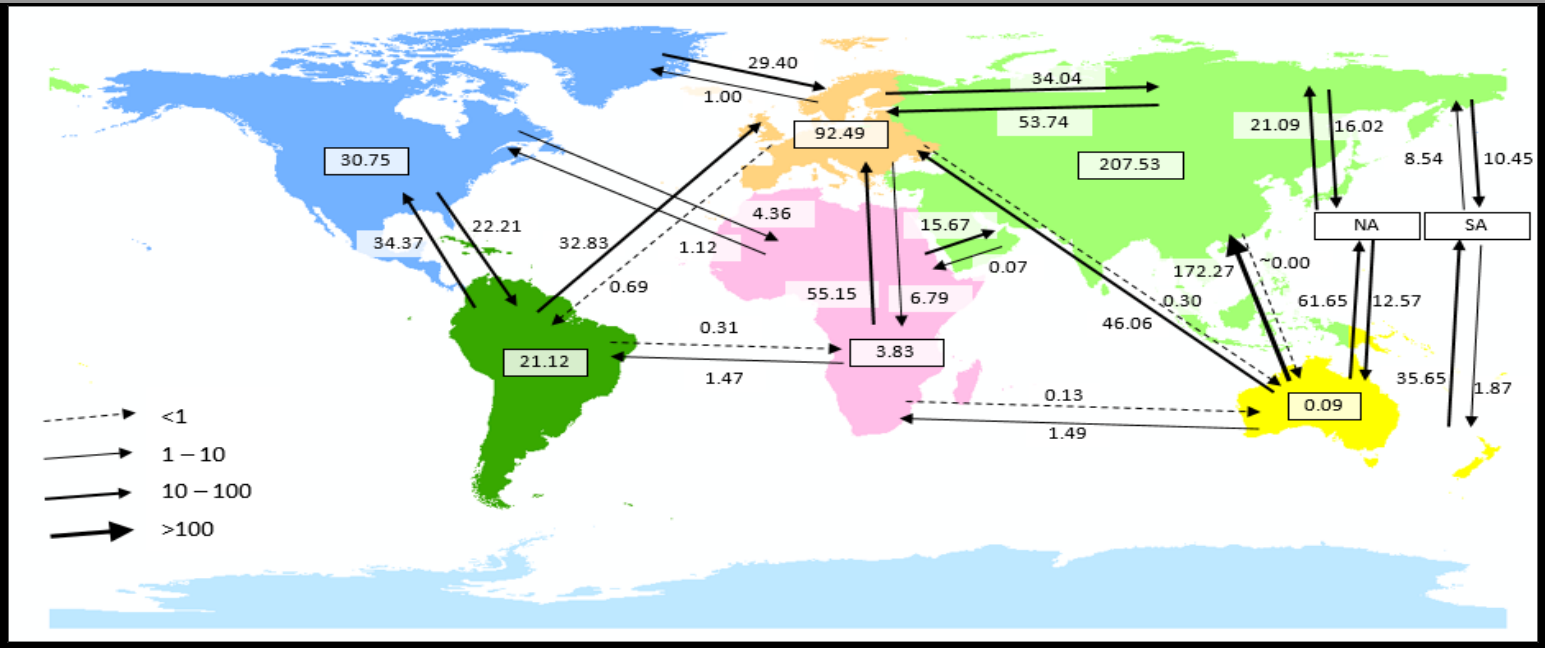
Data

Activity data: PKU-Fuel 2007

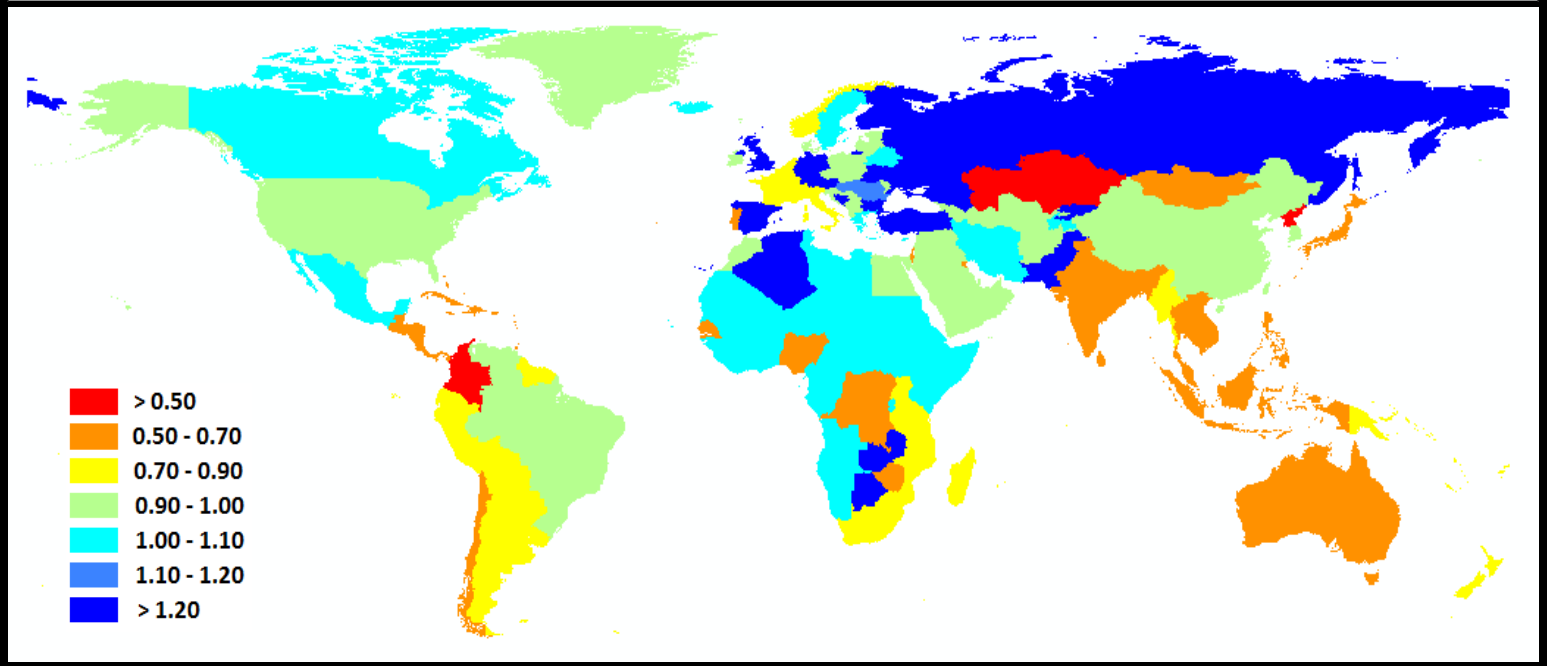
Emission factors: Geometric mean of collected EFs (for non-coal sources)

Coal: S contents, S retention in ash, S reduction ratio

Int. trading of hard coal and adjusted S content

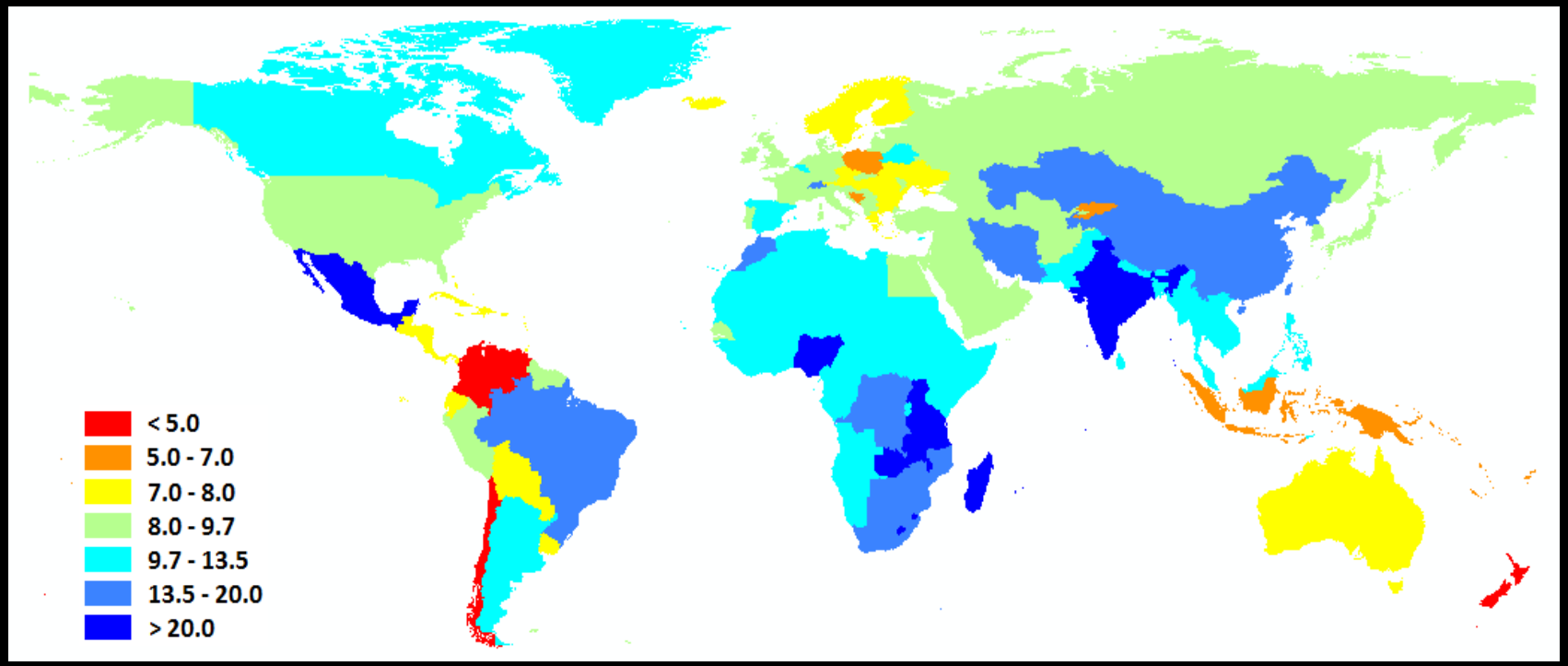


Unit: Tg (IEA)



Unit: %

Ash retention ratio (Unit: %)



Name	S %	ash %	Name	S %	ash %
China	1.00	13.90	Indonesia	0.54	6.22
India	0.54	23.70	Brazil	0.97	15.13
Japan	0.64	9.04	Canada	1.08	10.39
Russia	1.26	8.72	South Africa	0.83	17.63
United States	1.00	8.87	United Kingdom	1.24	9.43
Australia	0.50	7.61	New Zealand	0.75	4.39

Reduction ratio (from Smith et al., 2005)

$$f_{control} = \frac{f_{\max}}{1 + Exp\{-\frac{c}{\tau}\left(GDP_{cap} - GDP_0(t)\right)\}}$$

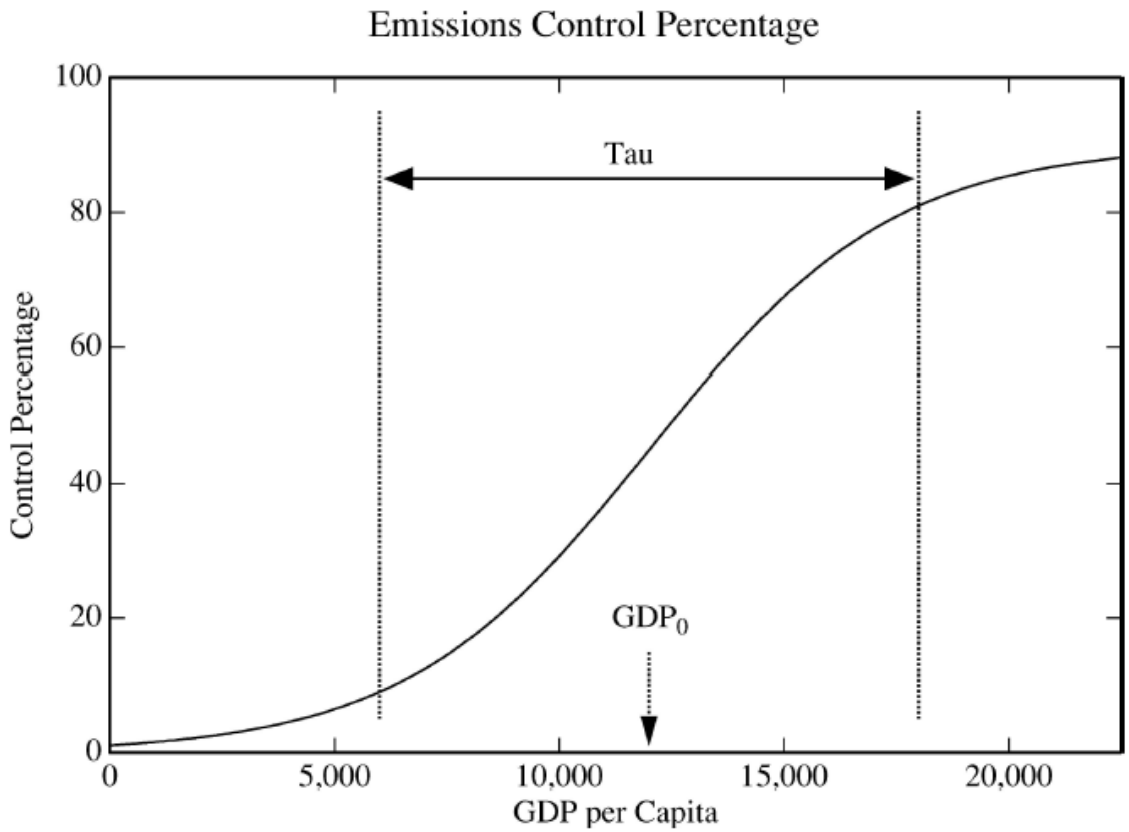


Figure 4. Example logistic curve used to describe future emission controls, with $GDPCap_0$ = \$12,000; τ = \$12,000; and f_{max} = 90% (see text).

PPP-based GDP per cap

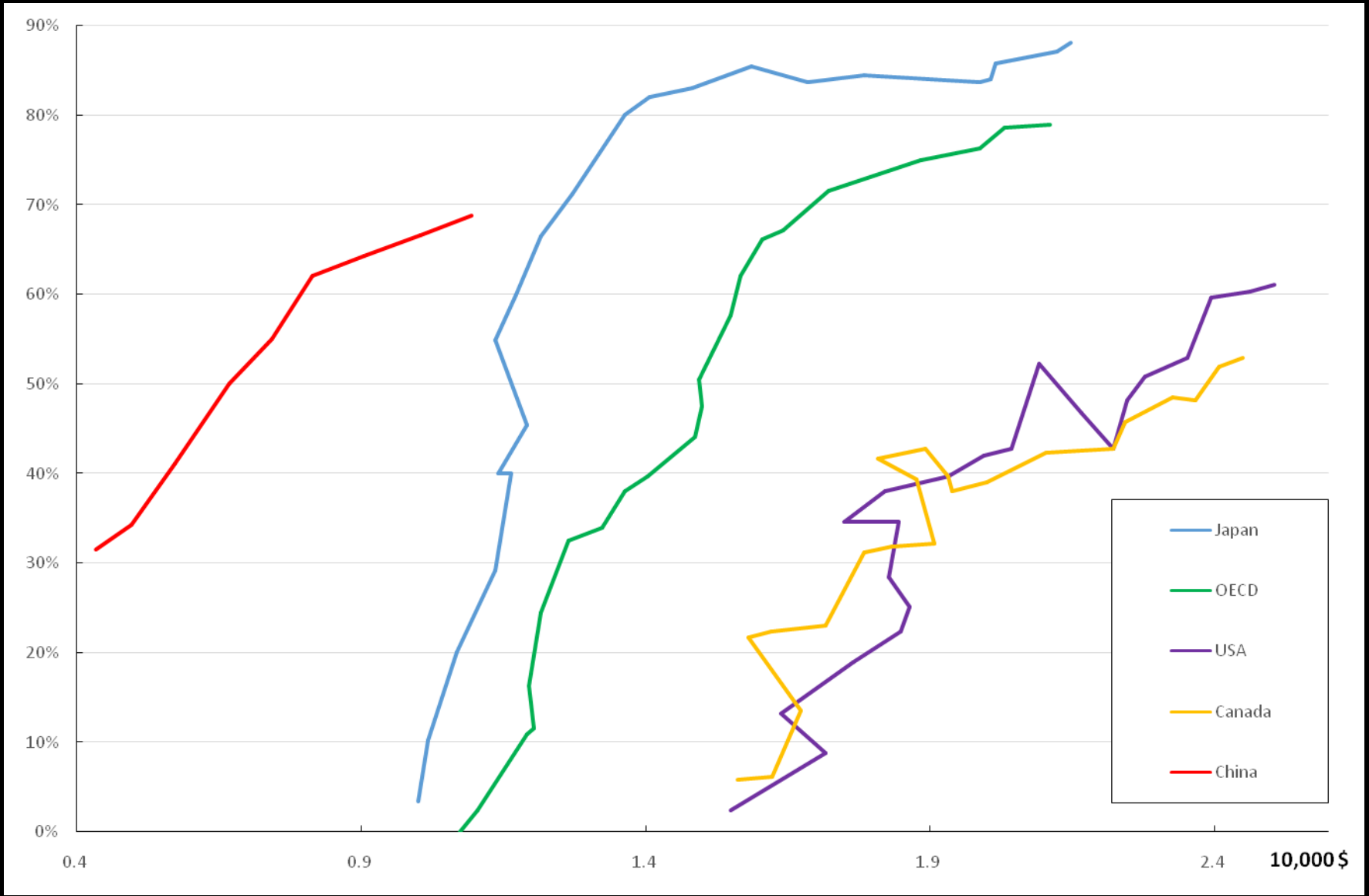
exponential logistic curve

Affluence & controls

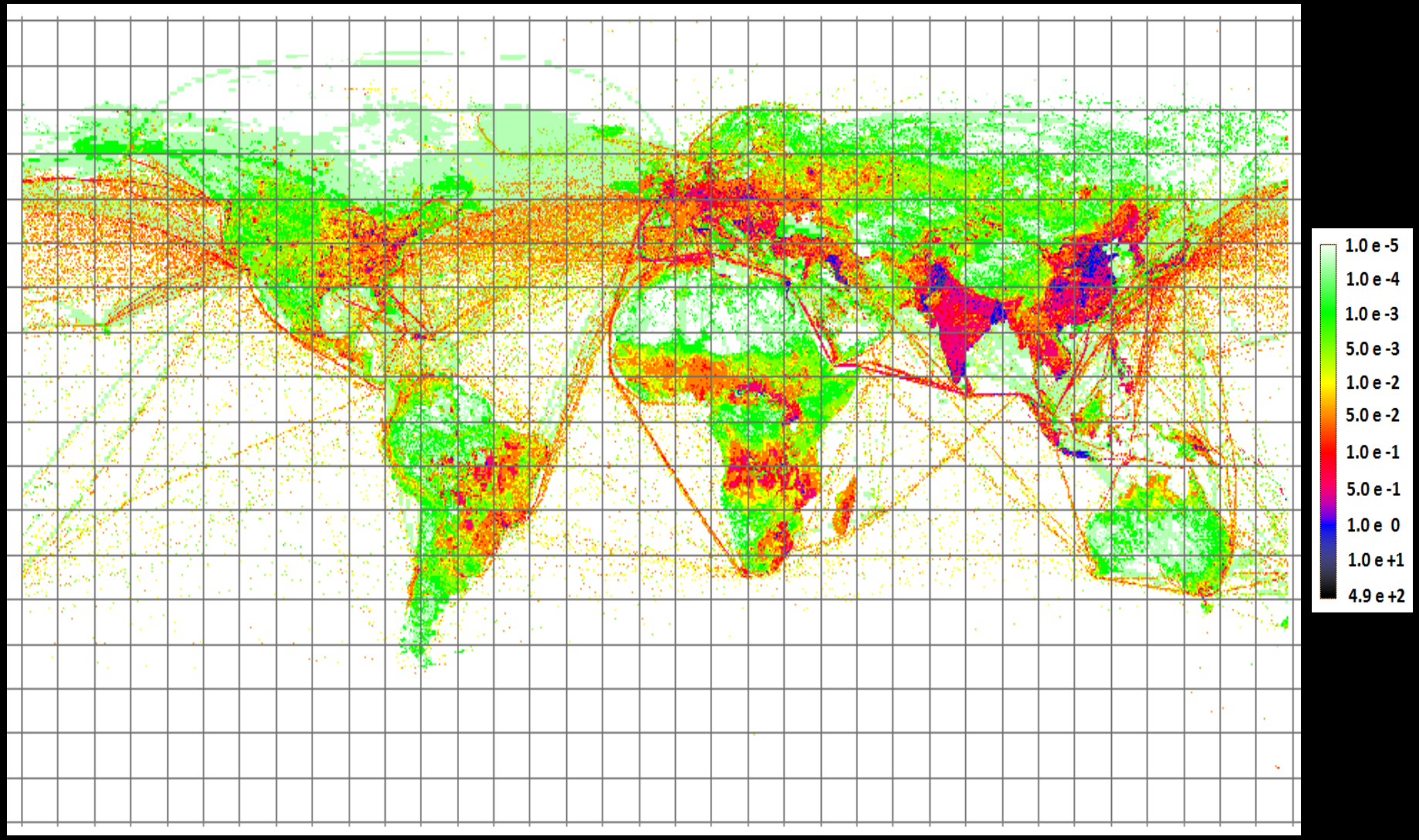
GDP_0 & Tech. Diffusion

τ & environ. pressure

Reduction ratio & GDP for selected countries

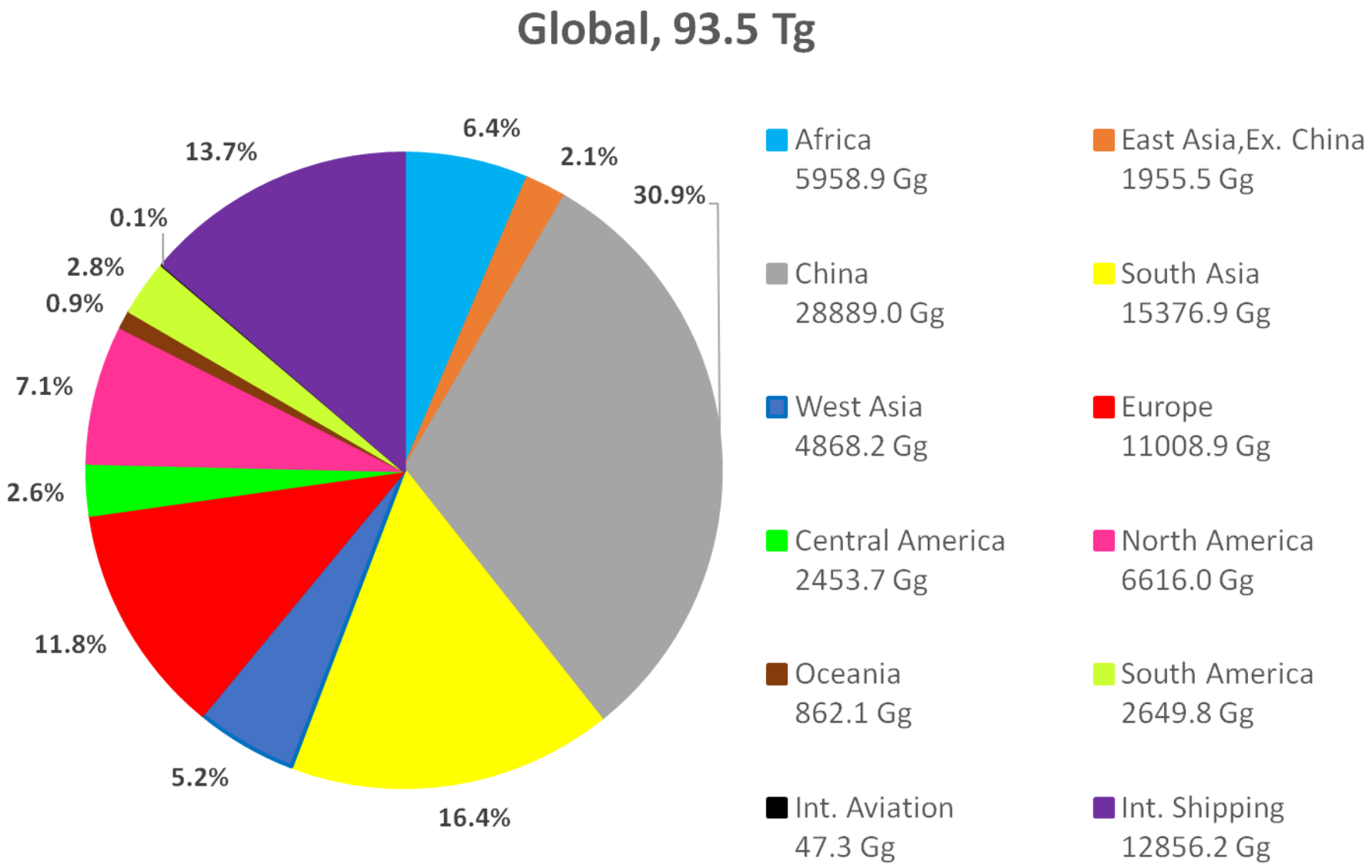


Gridmap of global SO_2 emission (2007)

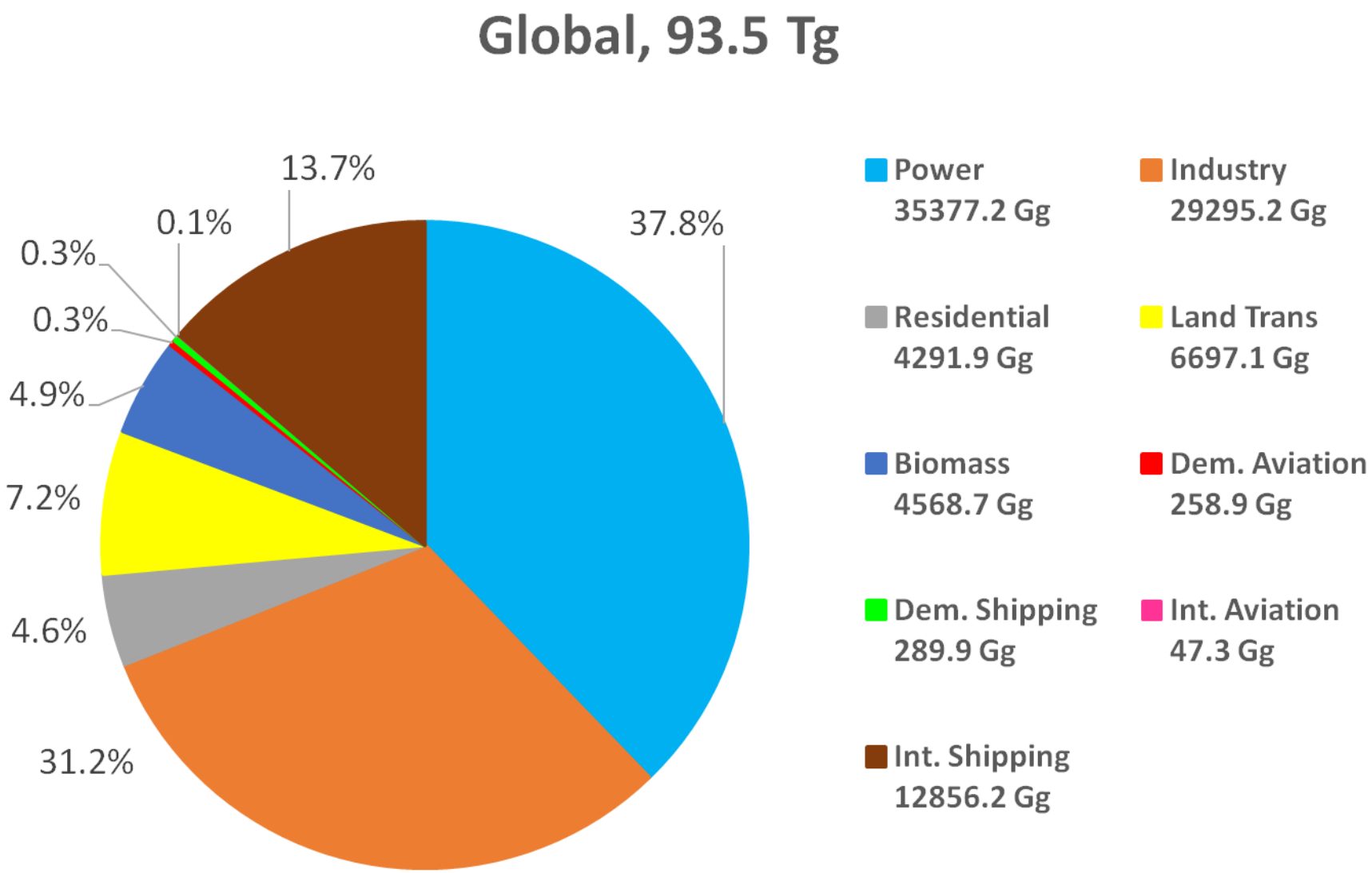


Total SO_2 emission in Gg per grid cell (0.1 × 0.1°)

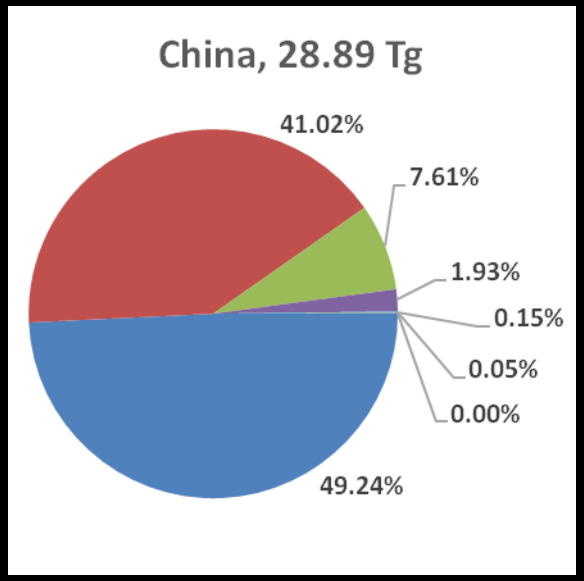
Regional SO_2 emission (2007)

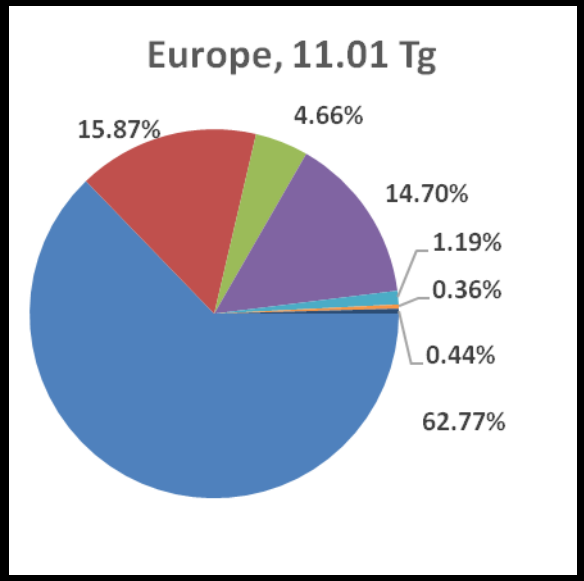


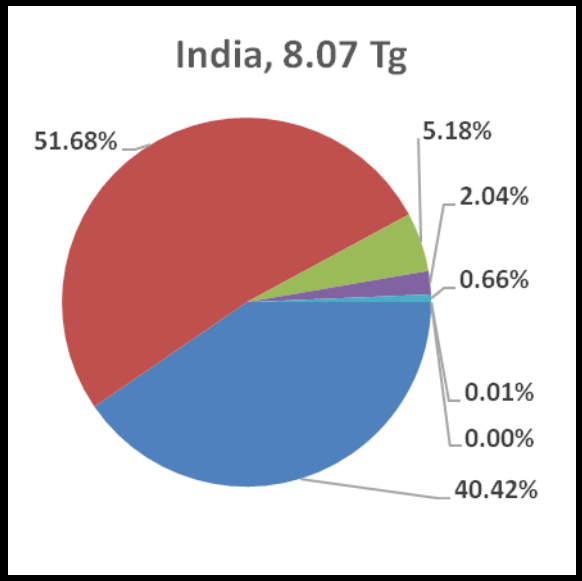
Global SO_2 emission by sectors(2007)

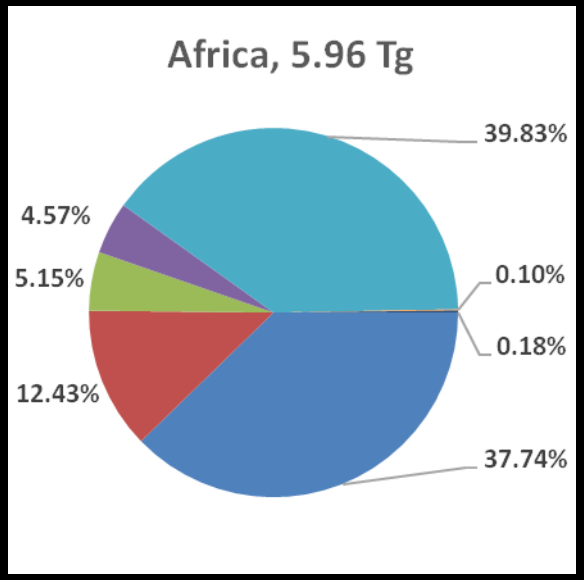


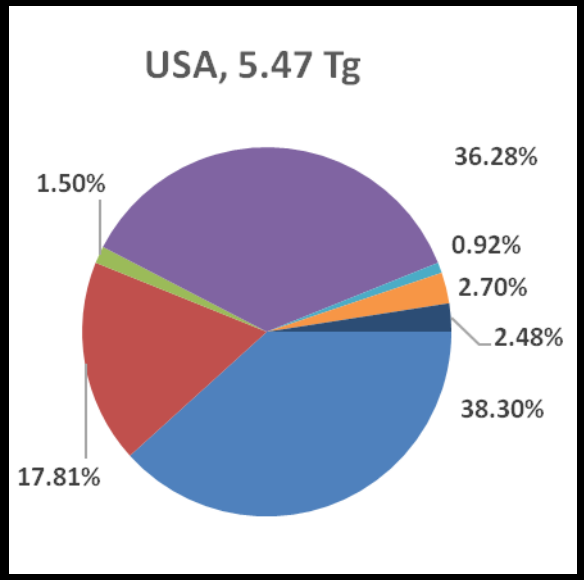
Inter-comparison of SO_2 emission (2007)

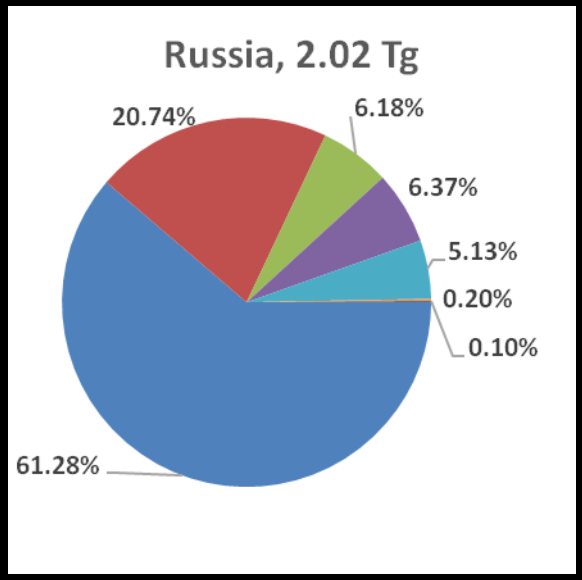






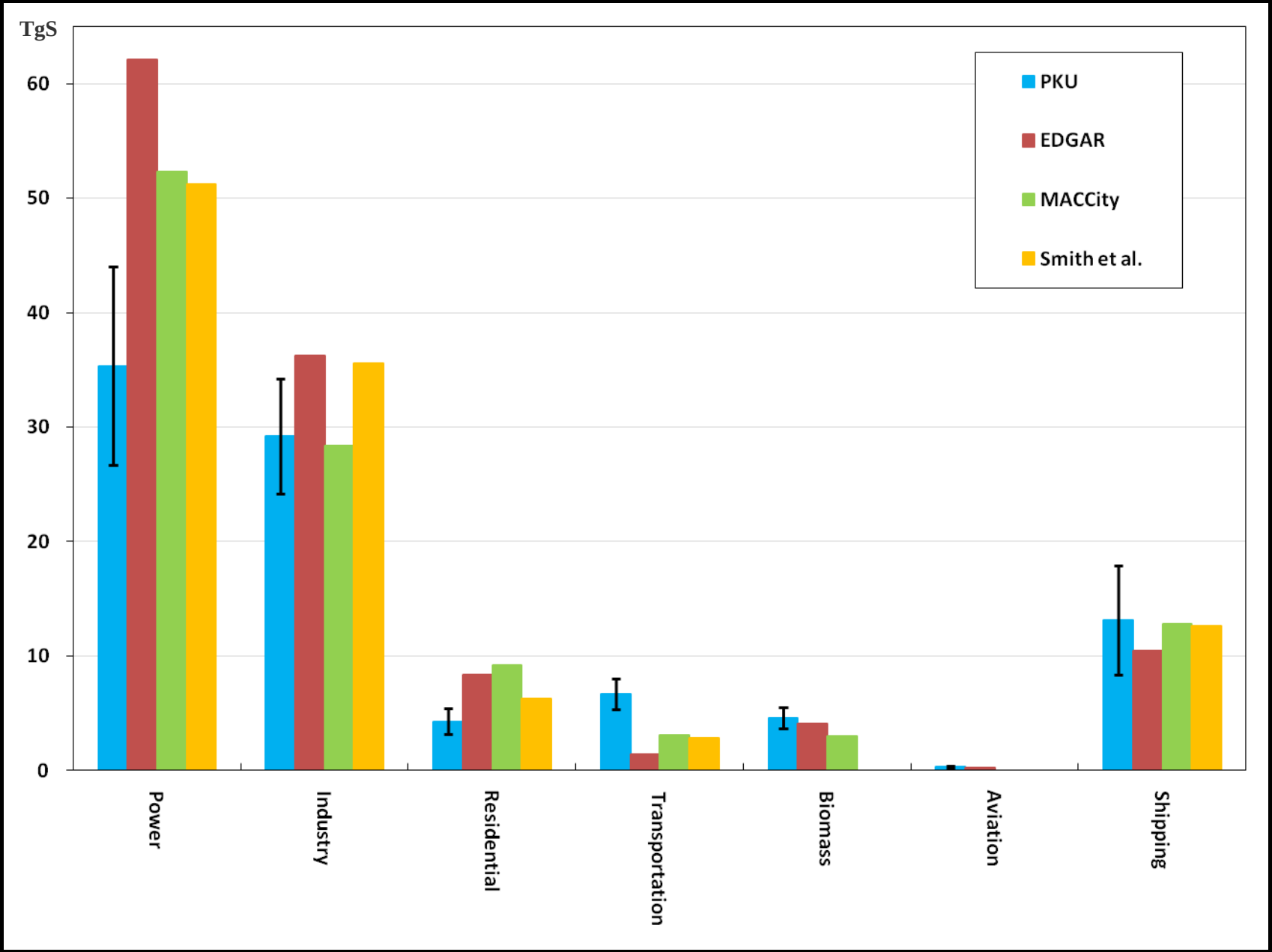




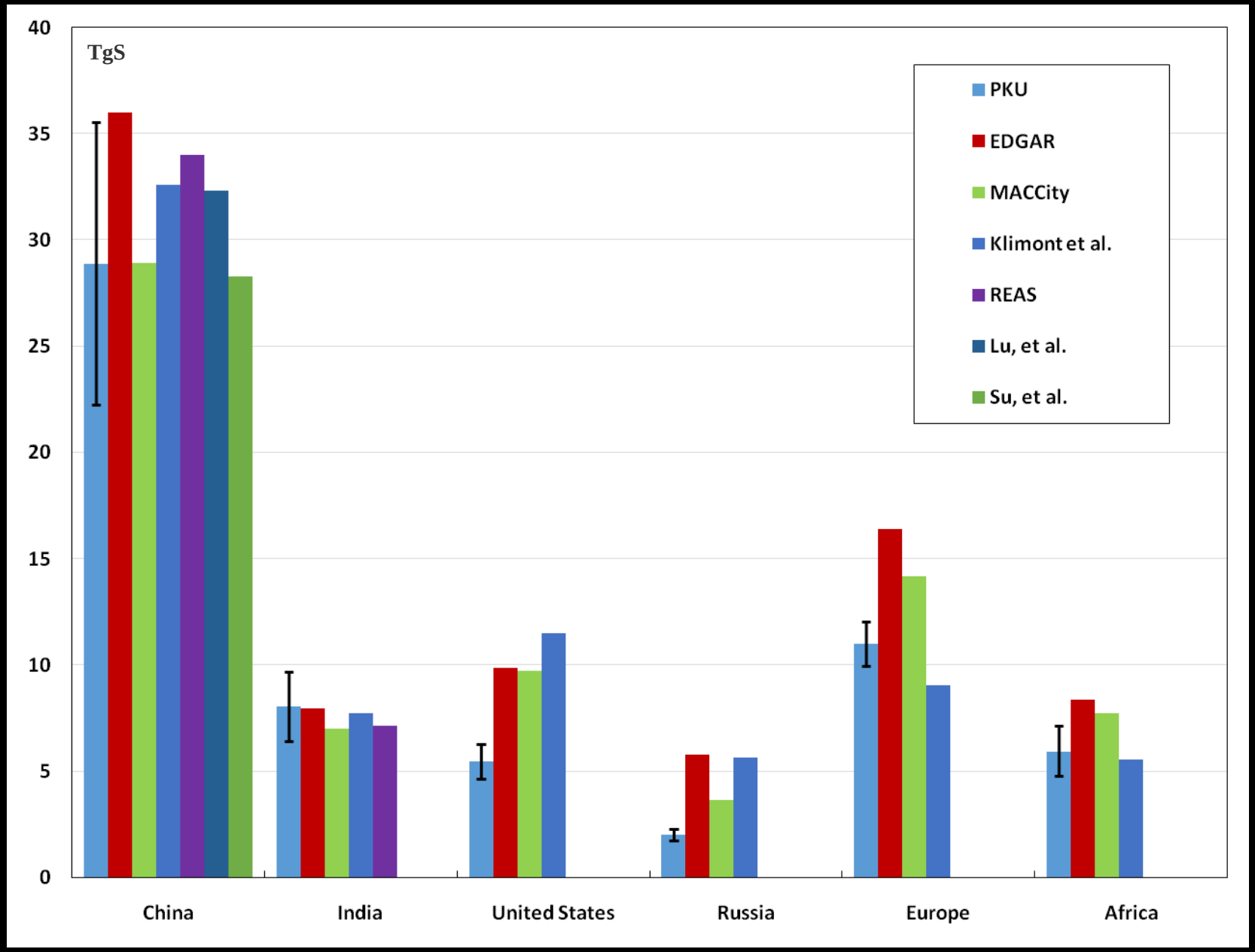


Power | Industry | Residential | Transportation | Biomass | Aviation | Ships

Comparison of inventories for 2007



Comparison of inventories for 2007



Uncertainty

Region	Total	
	Expected value (Gg)	95% confidence inverval
Africa	5958.9	15.6%
East Asia, Ex. China	1955.5	15.9%
China	28889.0	30.8%
South Asia	15376.9	19.0%
West Asia	4868.2	23.3%
Europe	11008.9	8.7%
Central America	2453.7	44.3%
North America	6616.0	21.5%
Oceania	862.1	15.3%
South America	2649.8	26.9%
International	12903.6	36.8%
Global	93542.5	11.8%

Sector	Total	
	Expected value (Gg)	95% confidence inverval
Power	35337.2	24.6%
Industrial	29195.2	17.3%
Residential	4291.9	26.8%
Land transportation	6697.1	19.7%
Biomass	4568.7	19.9%
Aviation	306.3	46.0%
Shipping	13146.2	36.2%
Global	93542.5	11.8%

Thanks for attention !