Adding Methane to the Natural Debt: a Combined Index of Responsibility

Kirk R. Smith and Jamesine V. Rogers*
Environmental Health Sciences
University of California, Berkeley

Copenhagen Climate Congress
March 10-12, 2009

***Current Address: California Air Resources Board, Sacramento**

Allocating Responsibility for Global Warming: The Natural Debt Index

Smith, KR. AMBIO, 20(2): 95, 1991

Cumulative Depleted Historical Emissions:

Surviving historical emissions as reduced by natural depletion mechanisms

What remains in the atmosphere today from emissions in the past

Paying off a significant fraction of the natural debt may not be easy, but it should not be dismissed out of hand. It may well be the only way to reach a world in which basic needs are met for all of humanity in a sustainable fashion.

No matter what the feasibility of paying off all past debts, the basic point remains the same. Since the present economic status of most countries has been achieved partly by incurring natural debts, it seems only fair to allocate responsibility for whatever needs to be done by using indices that reflect an expectation that nations should pay back the debt in the same proportion as it was borrowed.

Why “Natural Debt”

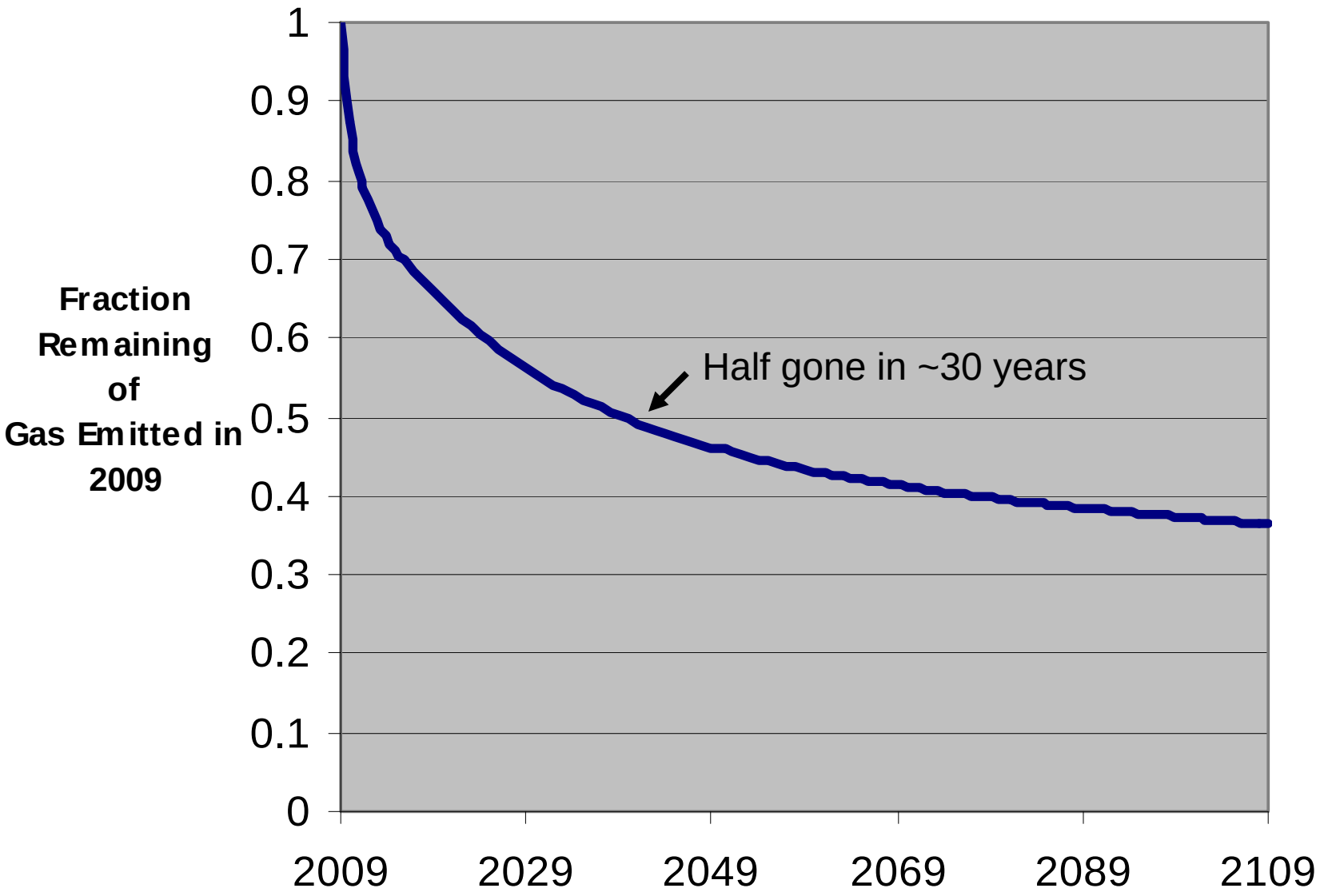
- Borrowing **national** financial capacity from the future – **national** debt
- Borrowing **natural** assimilative capacity from the future – **natural** debt
- One example: emitting GHGs into the atmosphere faster than they are assimilated
- Has been called atmospheric, ecological, and carbon debt

Math of GHG Decay (AR4)

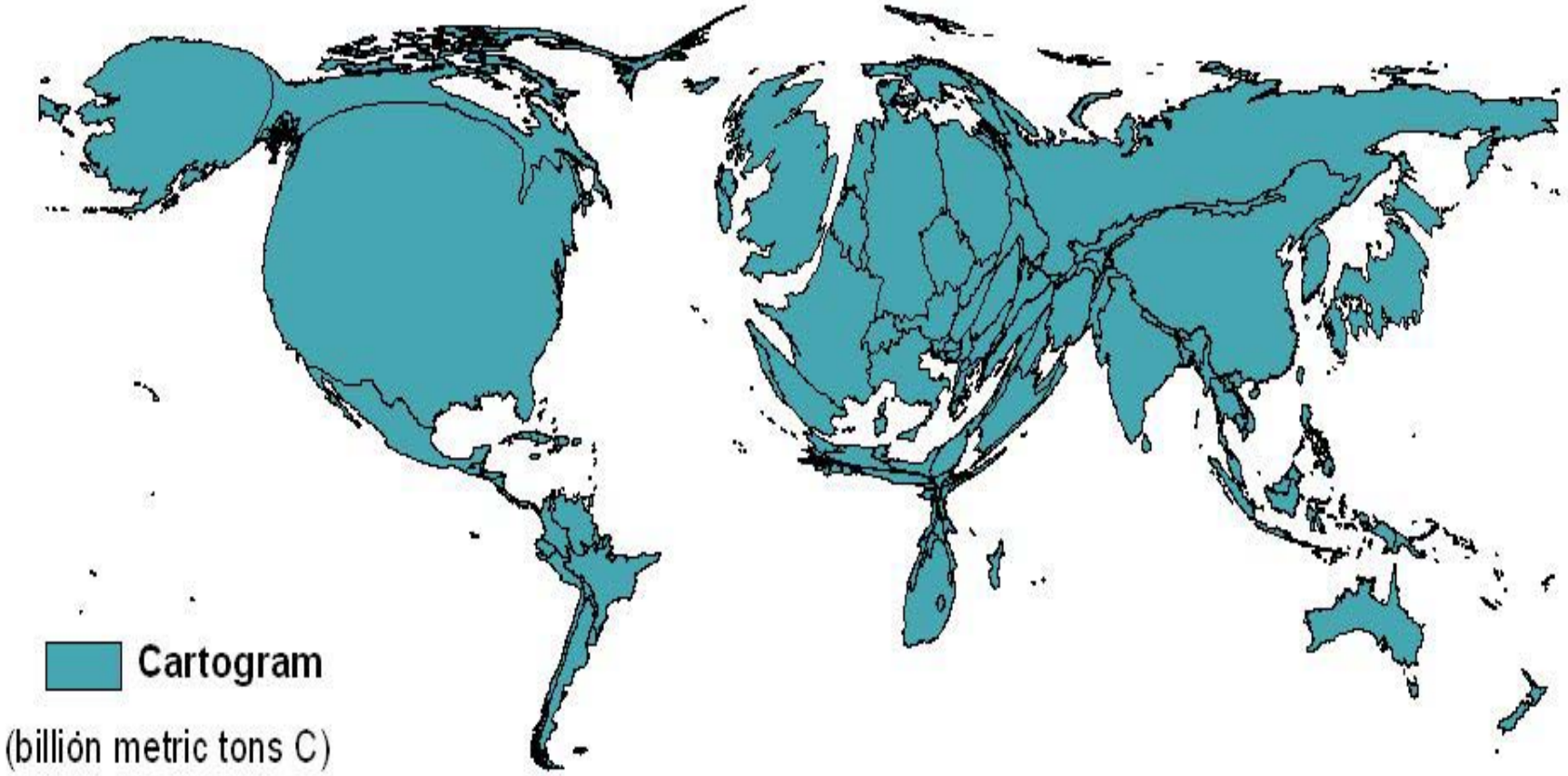
- CO_2 goes into four compartments (updated Bern Model):
  - 19% of total with a lifetime* of 1.2 years
  - 34% at 18.5 y
  - 26% at 173 y
  - 21% with a lifetime of “many thousand years”

*Lifetime refers to the time to reach 1/e (37%) of the original amount

Natural CO2 Depletion - 100 years

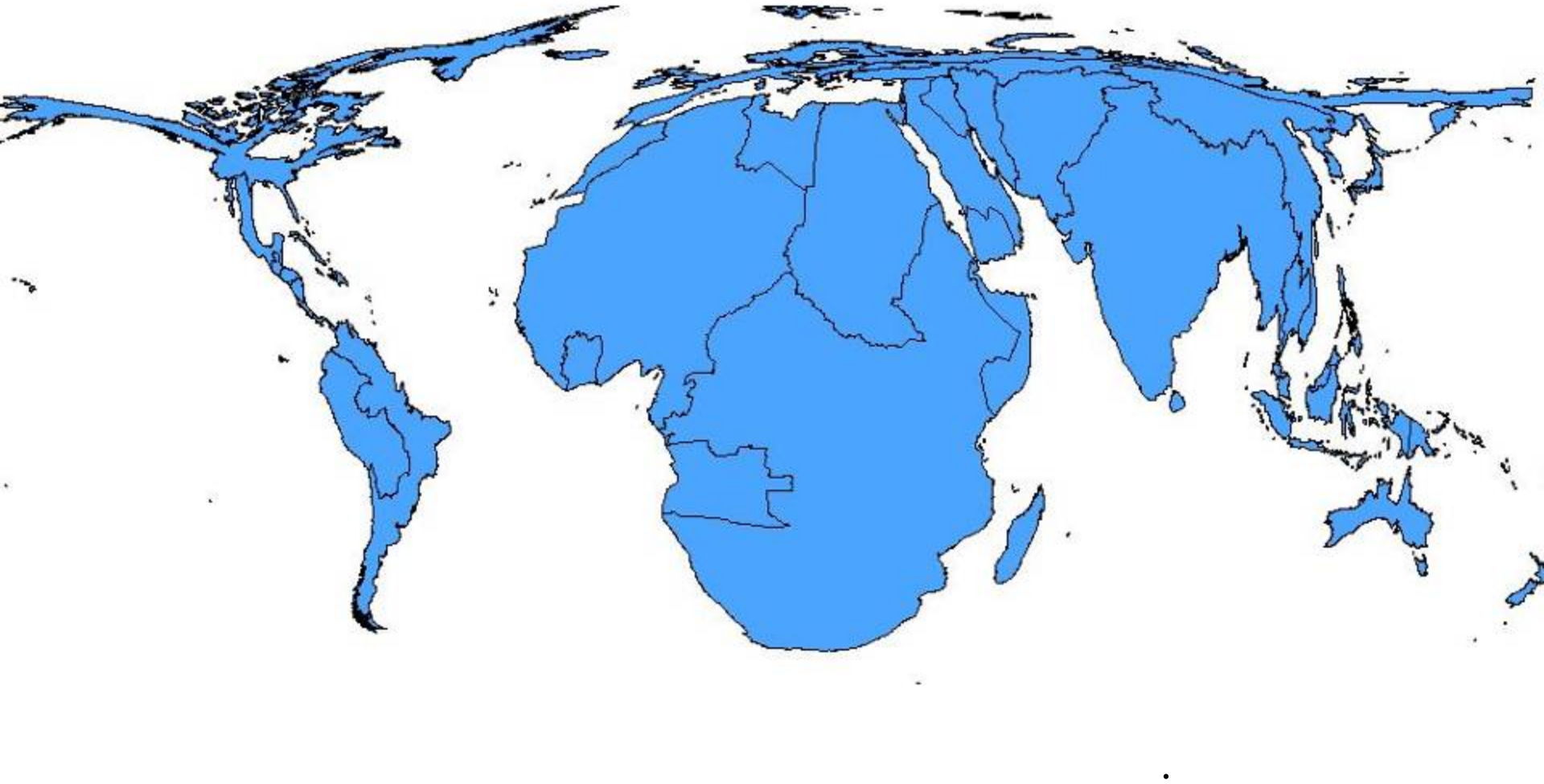


Total CUMULATIVE Greenhouse Gas Emissions in the Year 2002, by Country



Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

Cartogram of Climate-related Mortality (per million pop) yr. 2000



Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

Criticisms of Natural (Ecological) Debt for use in Responsibility Metrics

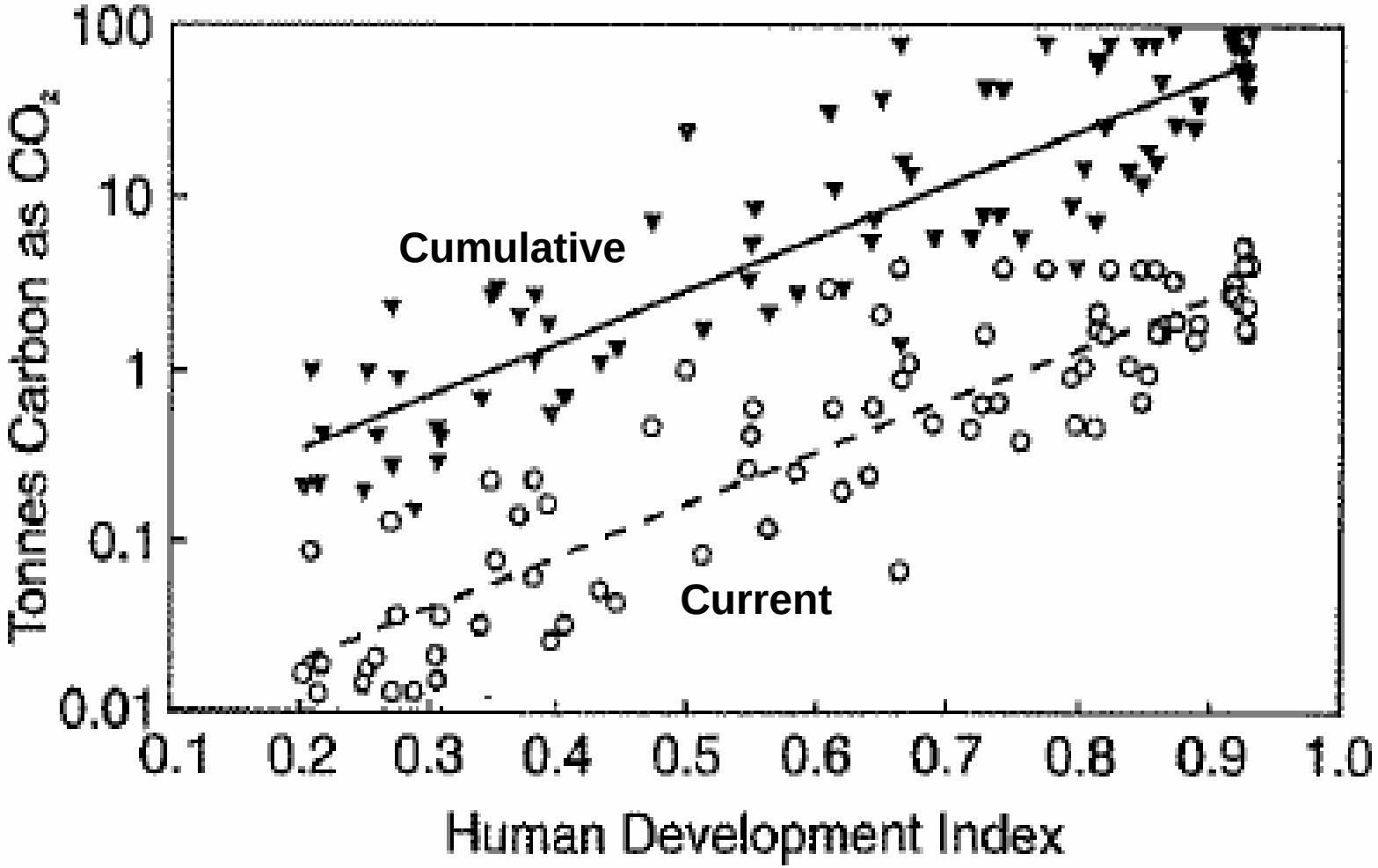
- Unfair
- Conceptually incomplete
- Data too uncertain
- Too insensitive for policy

Not fair – ancestors did not know.

- If we accept the benefits from past activities, we should accept the debts
- If we do not require responsibility for past activities, we reward ignorance and jeopardize the future
- In line with “polluter pays” principle
- Not blame, but accounting

Conceptual and Data Uncertainty

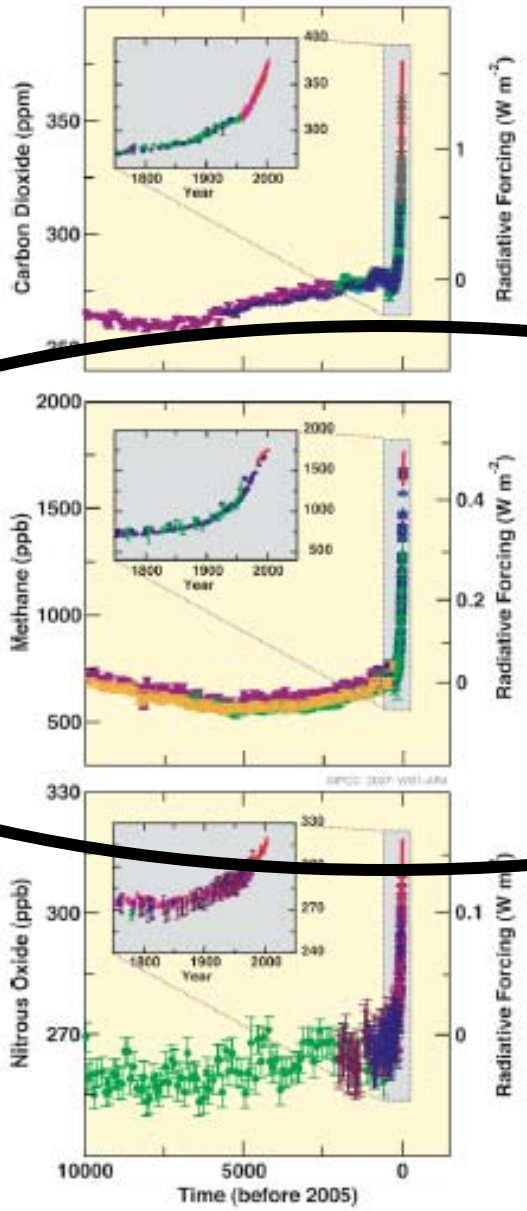
- Conceptual difficulties
  - Biosphere emissions – what is baseline?
  - Political boundaries have changed
- Basic data uncertain earlier than mid-20th century
  - Particularly for emissions from sources other than fossil fuels
- Not needed – current emissions give same answer


Tonnes Carbon as CO_2
100
10
1
0.1
0.01
Cumulative
Current
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Human Development Index

“International” Natural Debt – from ~1950

- Beginning of Era of Global Responsibility
- Nearly all major international organizations began at this time
  - UN, WHO, IBRD, UNICEF, IMF, etc.
  - Most major bilateral aid agencies
  - Oxfam, CARE, etc., the major international NGOs
- Most (not all) post-colonial political boundaries were established or soon to be
- International data tracking became established in systematic way

Atmospheric Greenhouse gas concentrations



Anthropogenic Sources

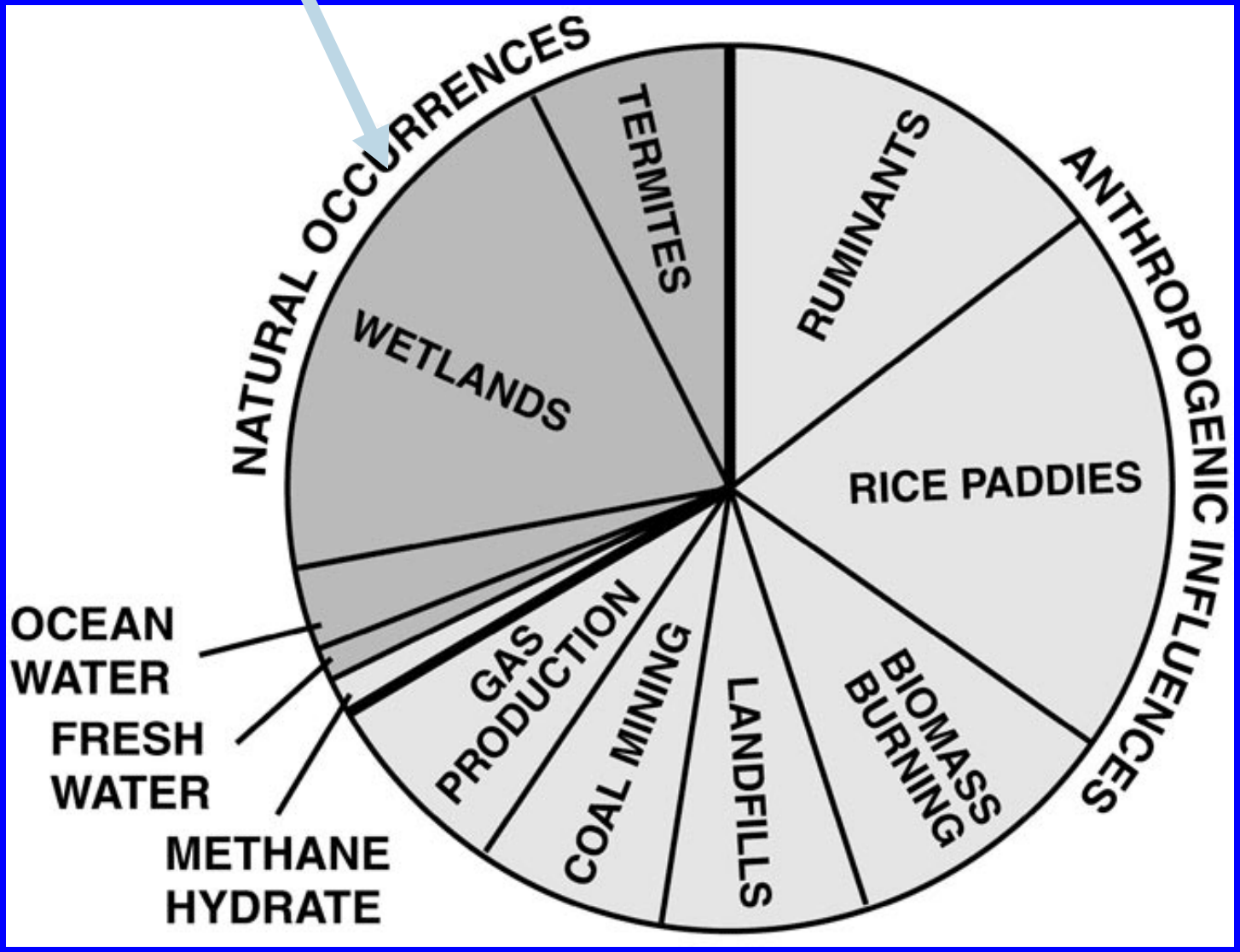
CO_2
Fossil fuels
Land use change
Cement manufacturing

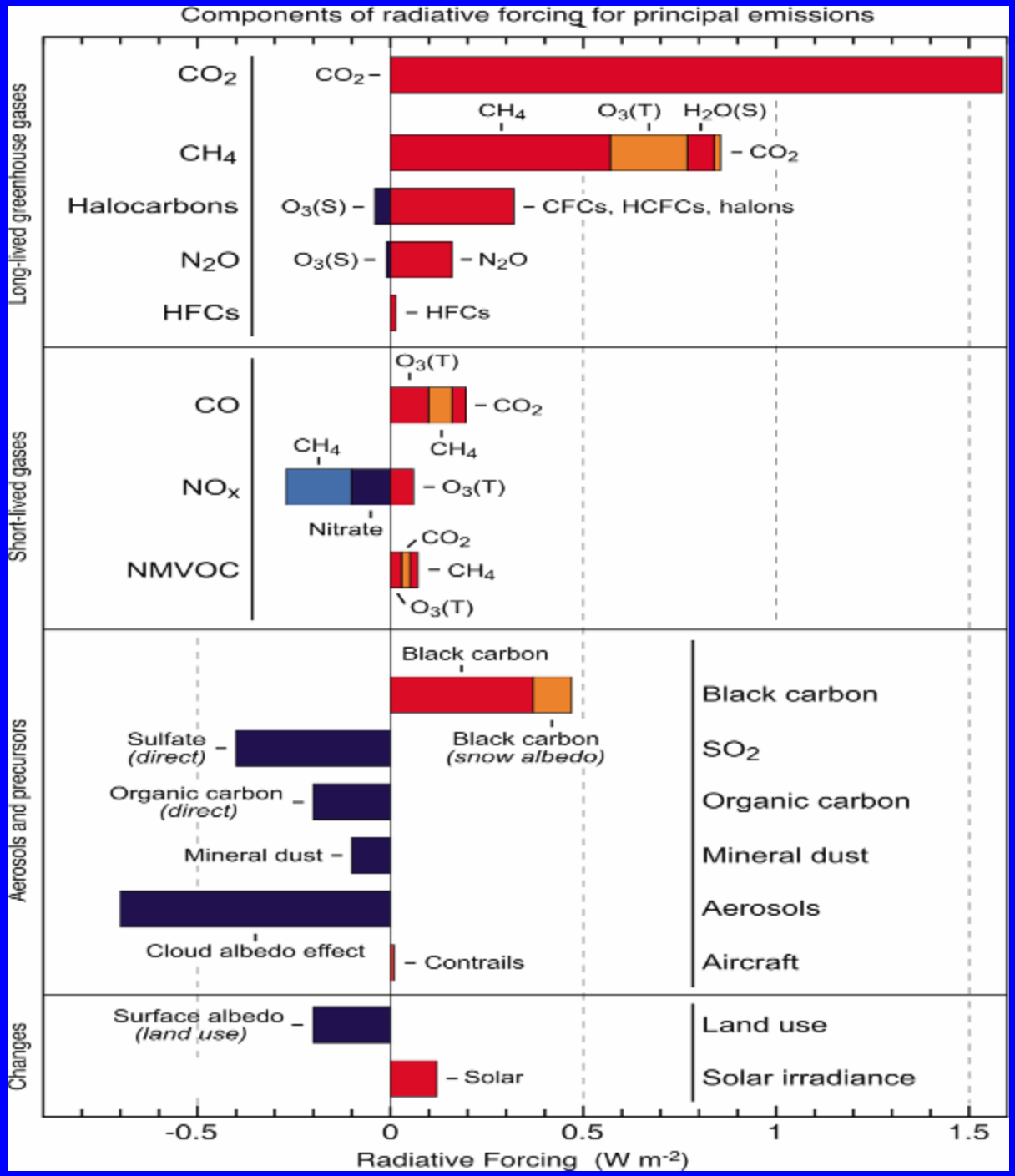
Methane
Landfills
Rice
Livestock
Waste management
Fossil recovery

N_2O
Fertilizer
Planted N-fixers
Combustion

Figure SPM.1
IPCC 2007

Only one-third of methane emissions from natural sources





Warming in 2005 from emissions since 1750

Methane more than half of total from CO_2

IPCC, 2007

Methane and Global Warming

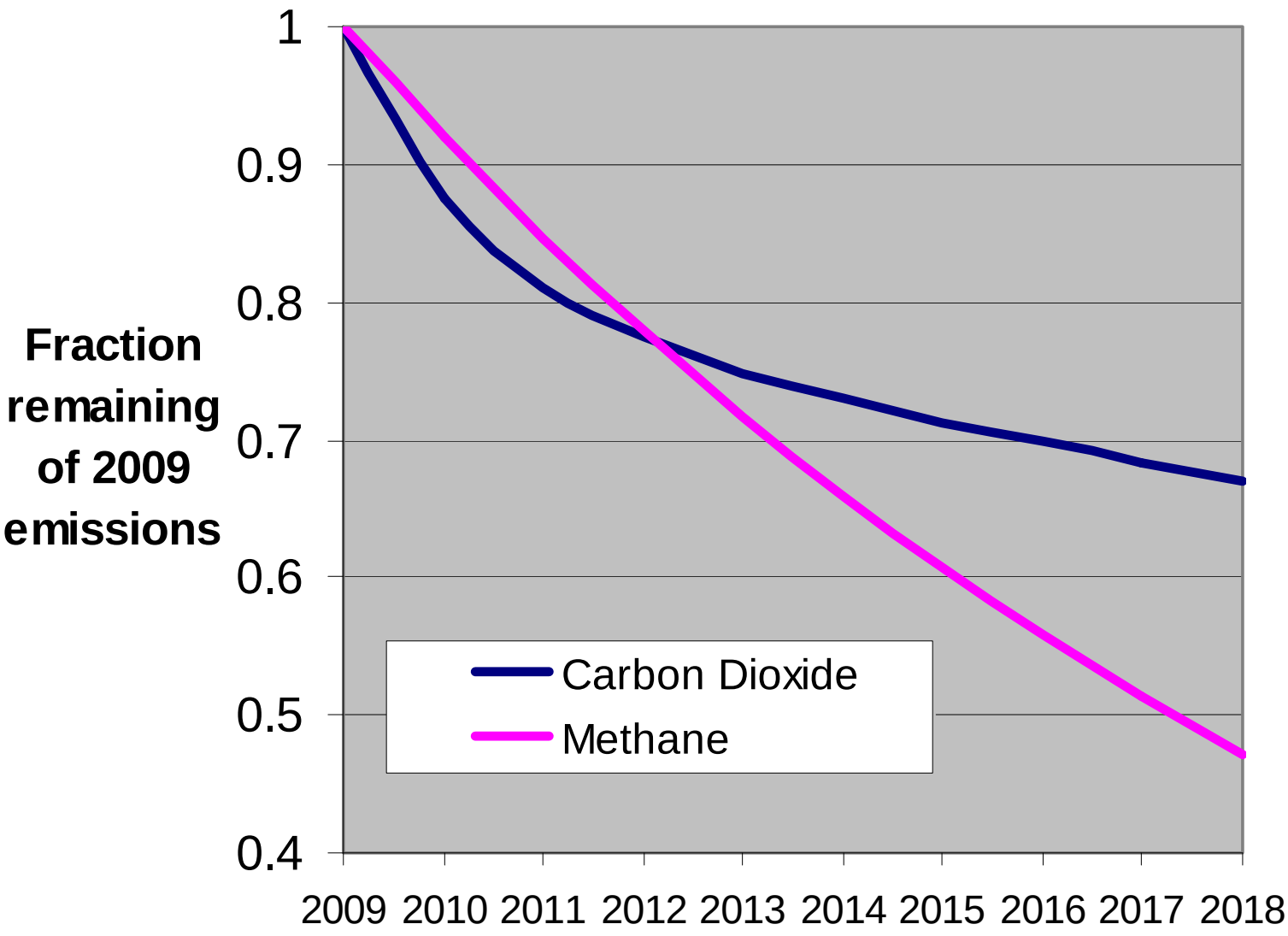
- A much more powerful greenhouse gas (GHG) than CO_2
- Partly due to its direct effect, but also because it creates ozone (O_3), another powerful GHG
- Nearly 100 times more per ton than CO_2 at any one time (73x from direct effects)
- Methane has thus contributed a significant amount to global warming, more than half that of CO_2
- But has a much shorter atmospheric lifetime compared to CO_2, although still long enough (12 years) to be globally mixed
- Thus changes in emission rates affect global levels much sooner than those for CO2

Math of GHG Decay (AR4)

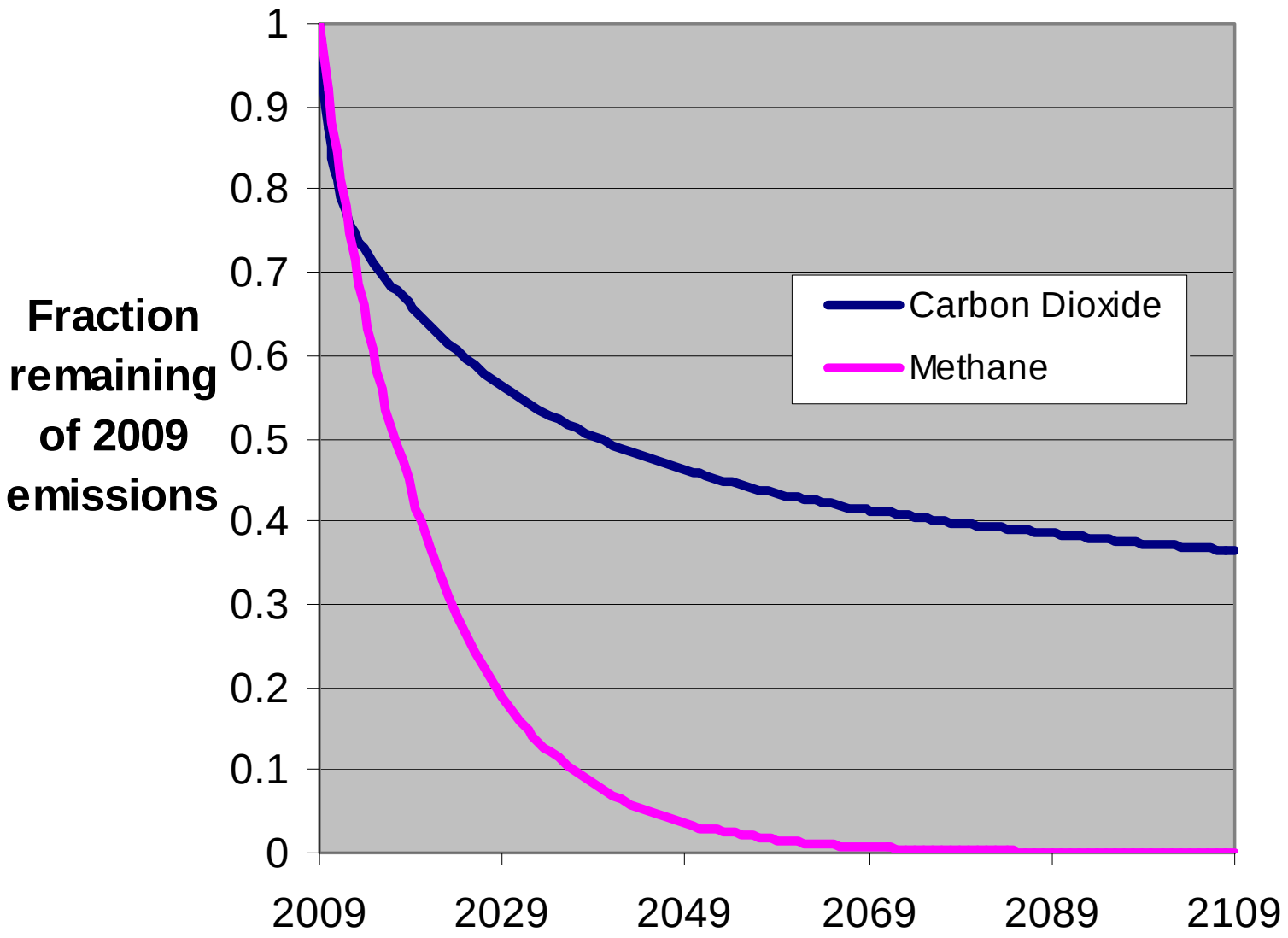
- CO_2 goes into four compartments:
  - 19% of total with a lifetime* of 1.2 years
  - 34% at 18.5 y
  - 26% at 173 y
  - 21% with a lifetime of “many thousand years”
- Methane has a 12 y lifetime,
  - but contributes to ozone, a GHG
  - and eventually oxidizes to CO_2

*Lifetime refers to the time to reach 1/e (37%) of the original amount

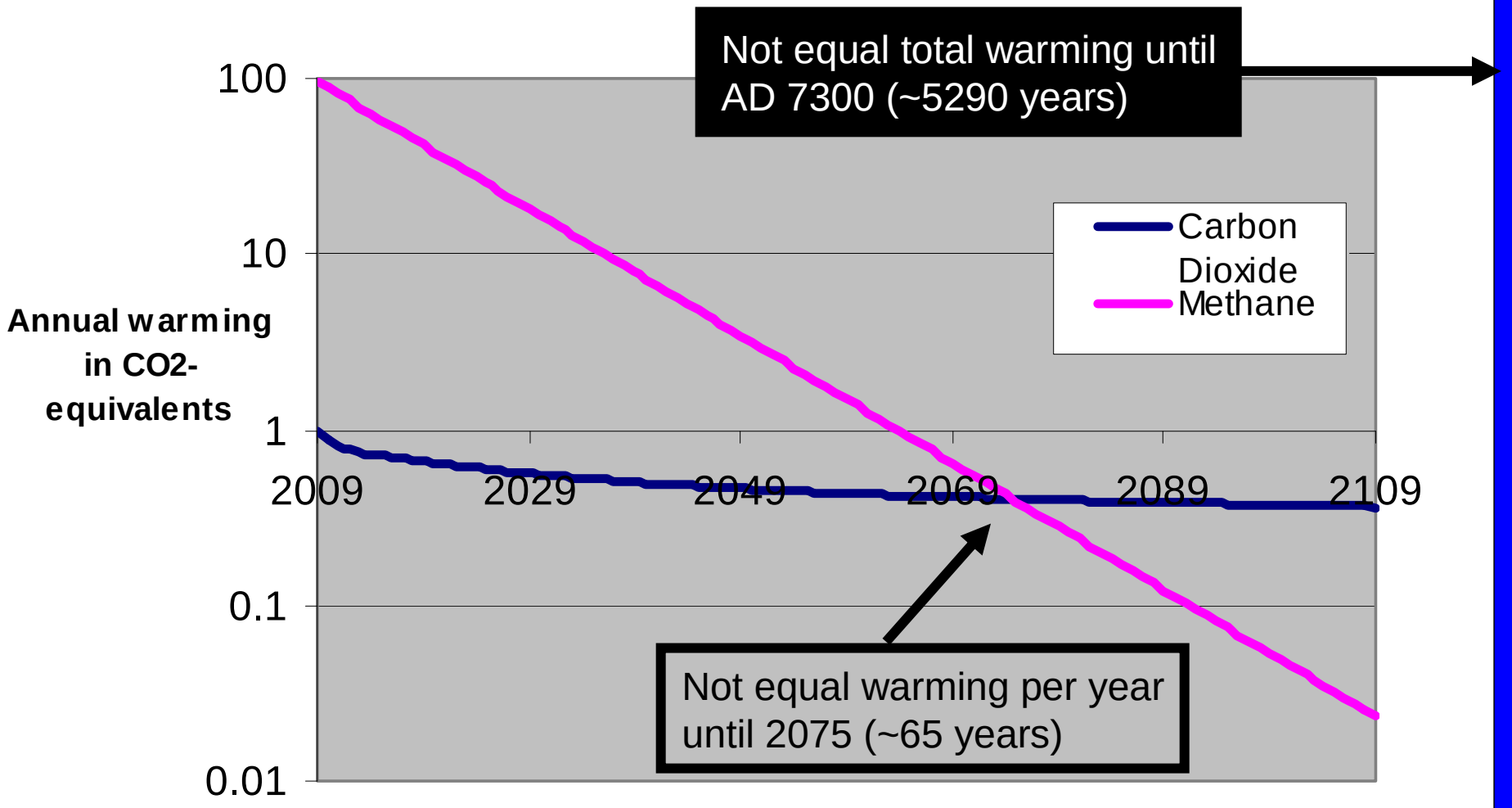
Natural CO2 and CH4 Depletion - first 10 years

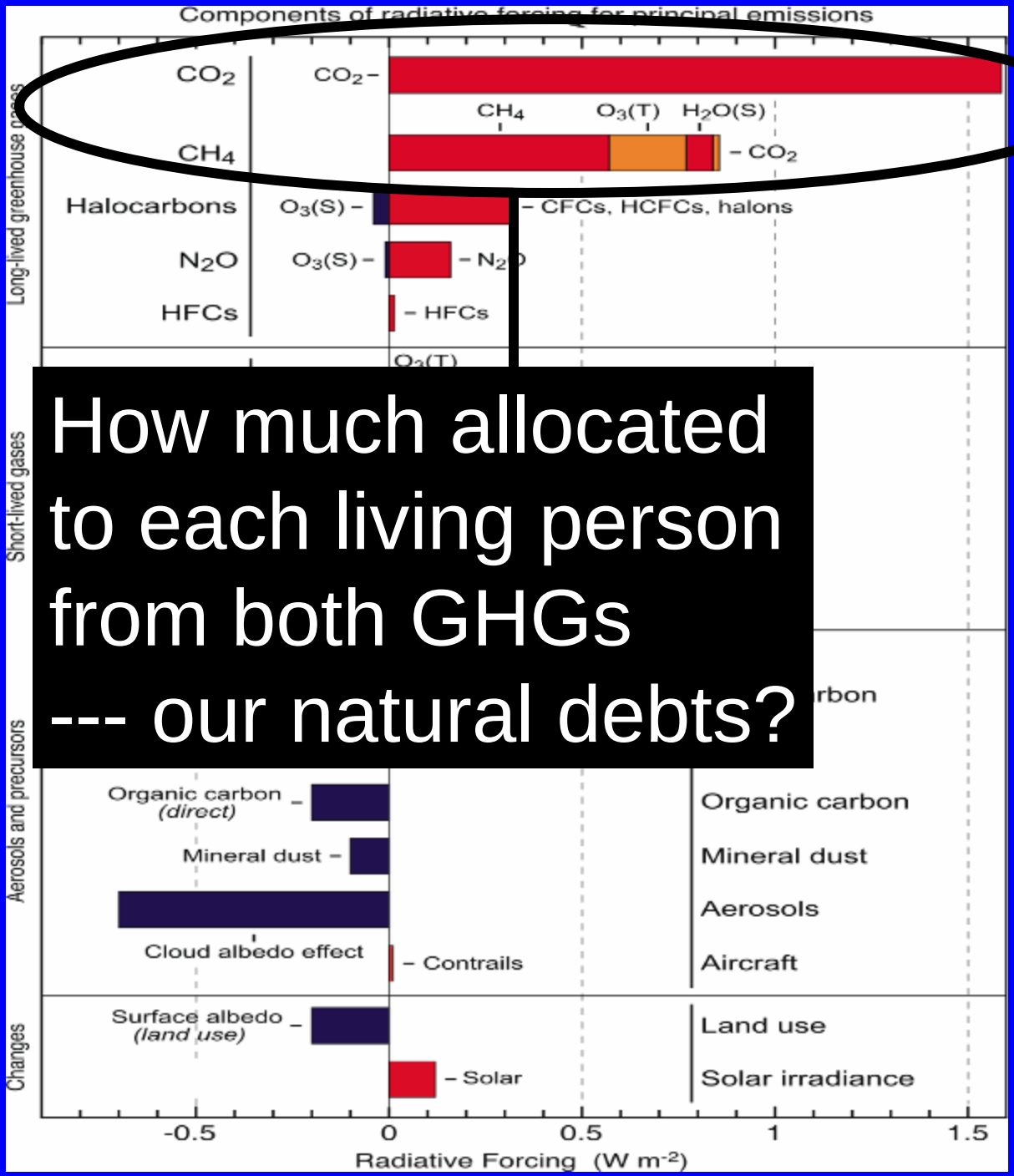


Natural CO2 and CH4 Depeletion - 100 years



Comparative warming over time from CO2 and CH4 emitted in 2009 (one ton of each)
100 years





How much allocated to each living person from both GHGs --- our natural debts?

Warming in 2005 from emissions since 1750

More than half due to methane

IPCC, 2007

Natural Debt Methodology

- Obtain annual national emissions data for 1950-2004 for 80 most populous nations, fill in data gaps -94% of global pop
- Calculate undepleted national emissions remaining in 2004 from each year
- Sum undepleted national emissions for 1950-2004 by nation
- Apply ratios of national to global natural debt (CO_2 and CH_4) to amount of radiative forcing in 2004 due to CO_2 and CH_4

Emissions Data Sources

- Carbon dioxide emissions
  - CO2 emissions from consumption of fossil fuels, gas flaring and cement production
  - Carbon Dioxide Information Analysis Center (Oak Ridge National Laboratory)
  - UNFCCC Annex I country reports
- Methane emissions
  - CH4 emissions from combustion of fossil fuels and biofuels, waste, agriculture and others (industrial processes and temperate and tropical forest fires)
  - Emission Database for Global Atmospheric Research (Netherlands Organization for Applied Scientific Research and National Institute of Public Health and Environment)
  - UNFCCC Annex I country reports

Filling in the Gaps – CO2

- For nations gaining independence before 1950 and missing data, extrapolated data from trends
- For nations gaining independence after 1950 and missing data:
  - Calculated ratio of nation's population (2004) to total population of all nations (2004) under governance of same entity historically (back to 1950)
  - Applied ratio to entity's emissions
  - *Pakistan emissions in year x = (East-West Pakistan emissions in year x) * [(2004 popn Pakistan) / (2004 popn Bangladesh + 2004 popn Pakistan)]*
- For Annex I nations, UNFCCC data (1990-2004)

Filling in the Gaps – CH4

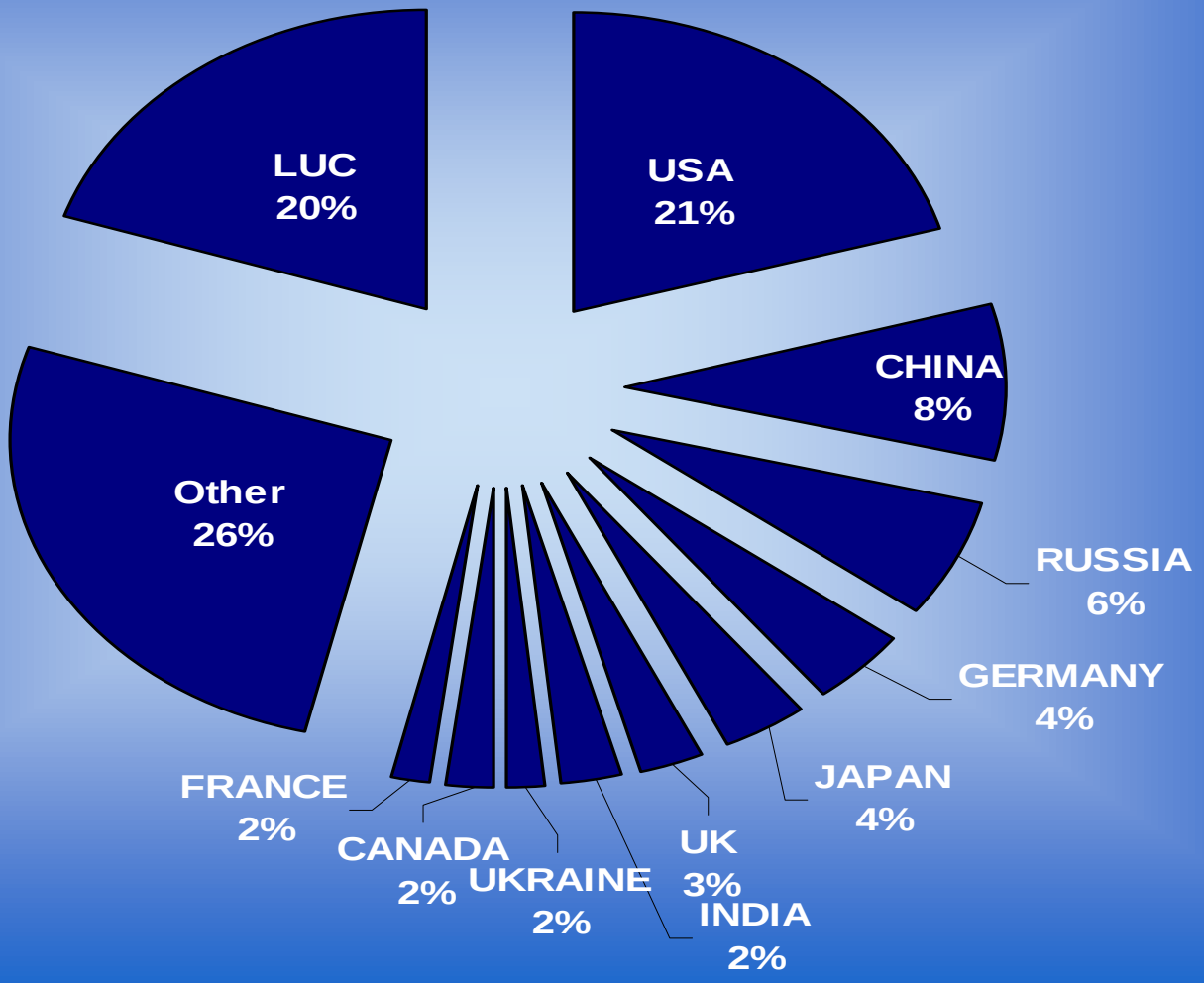
- Linear interpolation between years with emissions data (1970-2000, 5 year intervals)
- For pre-1970 and post-2000 emissions:
  - Calculated per capita emissions by nation in 1970 and 2000
  - Apply to national population in 1950 and 2004, respectively
  - Interpolated emissions linearly for 1950-1970 and 2000-2004
- For Annex I nations, UNFCCC data (1990-2004)

Undepleted Emissions

- Apply Bern model to national CO2 emissions:
  - *Undepleted CO2 from year x, remaining in 2004 = (Emissions in year x) * (0.186*exp(-y/1.186)) + (0.338*exp(-y/18.51)) + (0.259*exp(-y/172.9)) + 0.217*
- Apply CH4 lifetime (IPCC TAR) to national CH4 emissions:
  - *Undepleted CH4 from year x, remaining in 2004 = (Emissions in year x) * (exp(-y/12))*
- Note: Y is the number of years difference between 2004 and year x

Distribution of Global Natural Debt Among Top 10 Nations

CO2 only in 2005

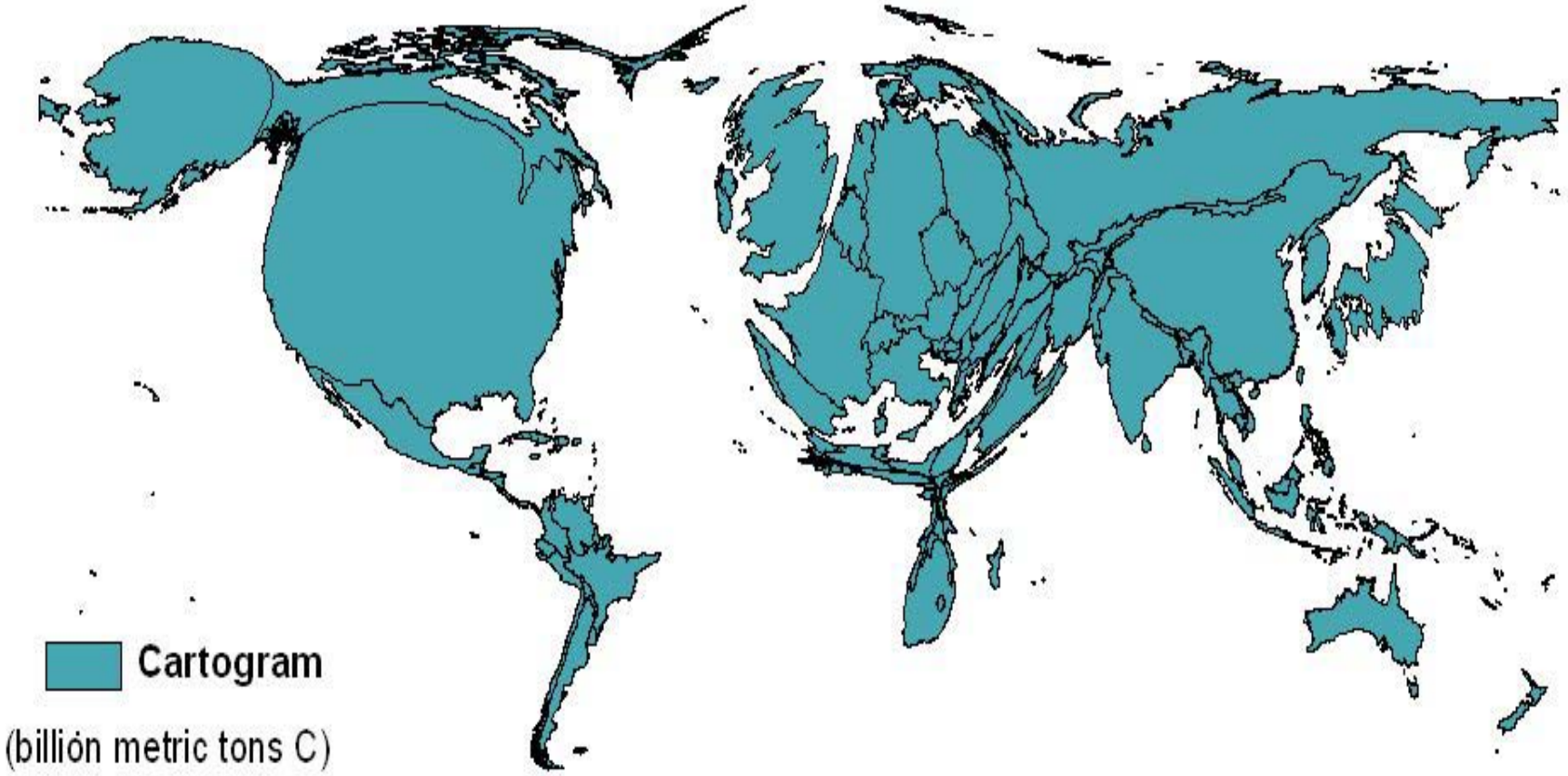


Brazil: 0.8%

Nb. Land-use change emissions not are parsed out by country

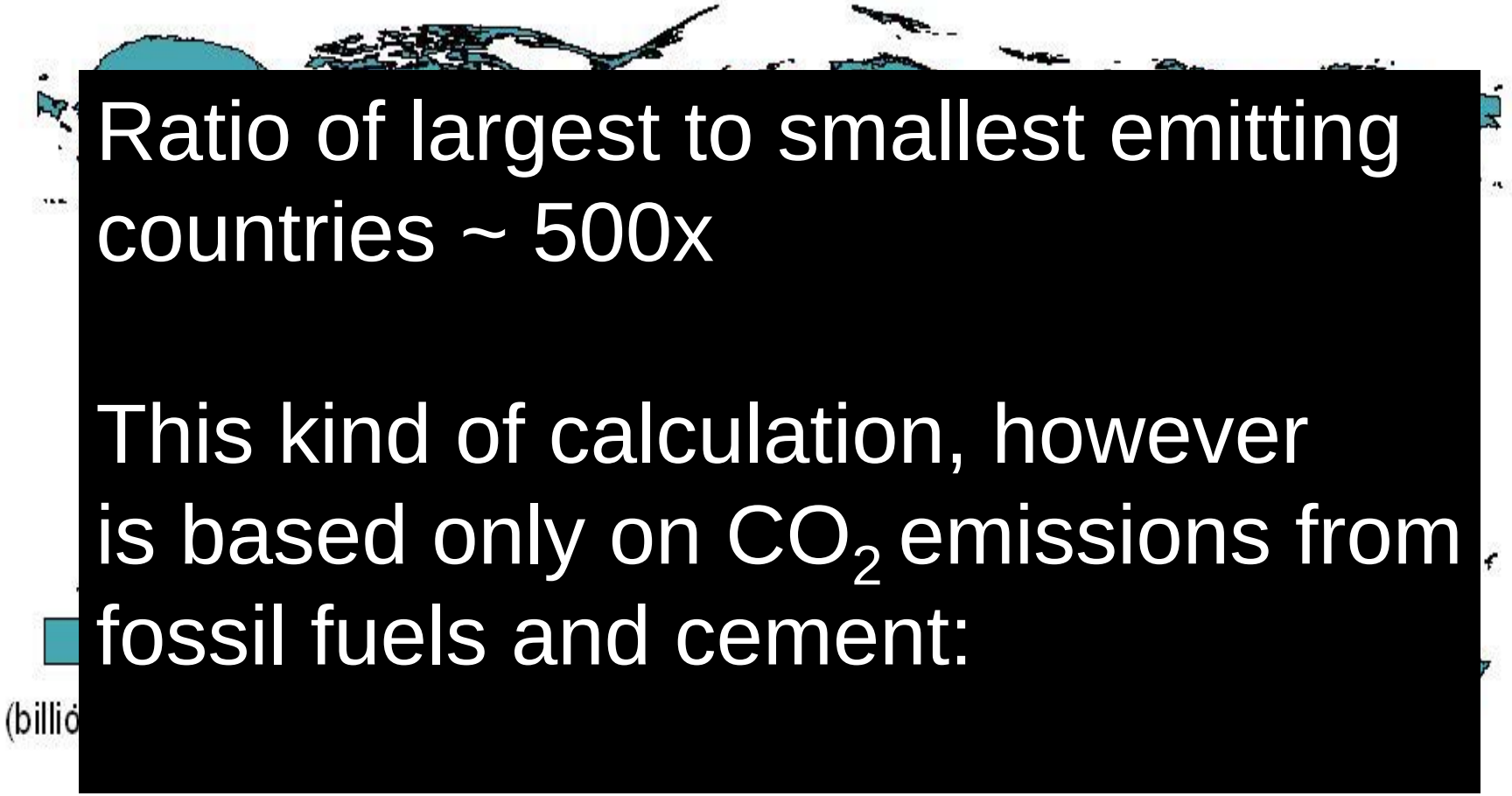
Smith and Rogers, in preparation

National Natural Debts:
Cumulative CO_2 emissions, depleted by natural processes



Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

National Natural Debts:
Cumulative CO_2 emissions, depleted by natural processes



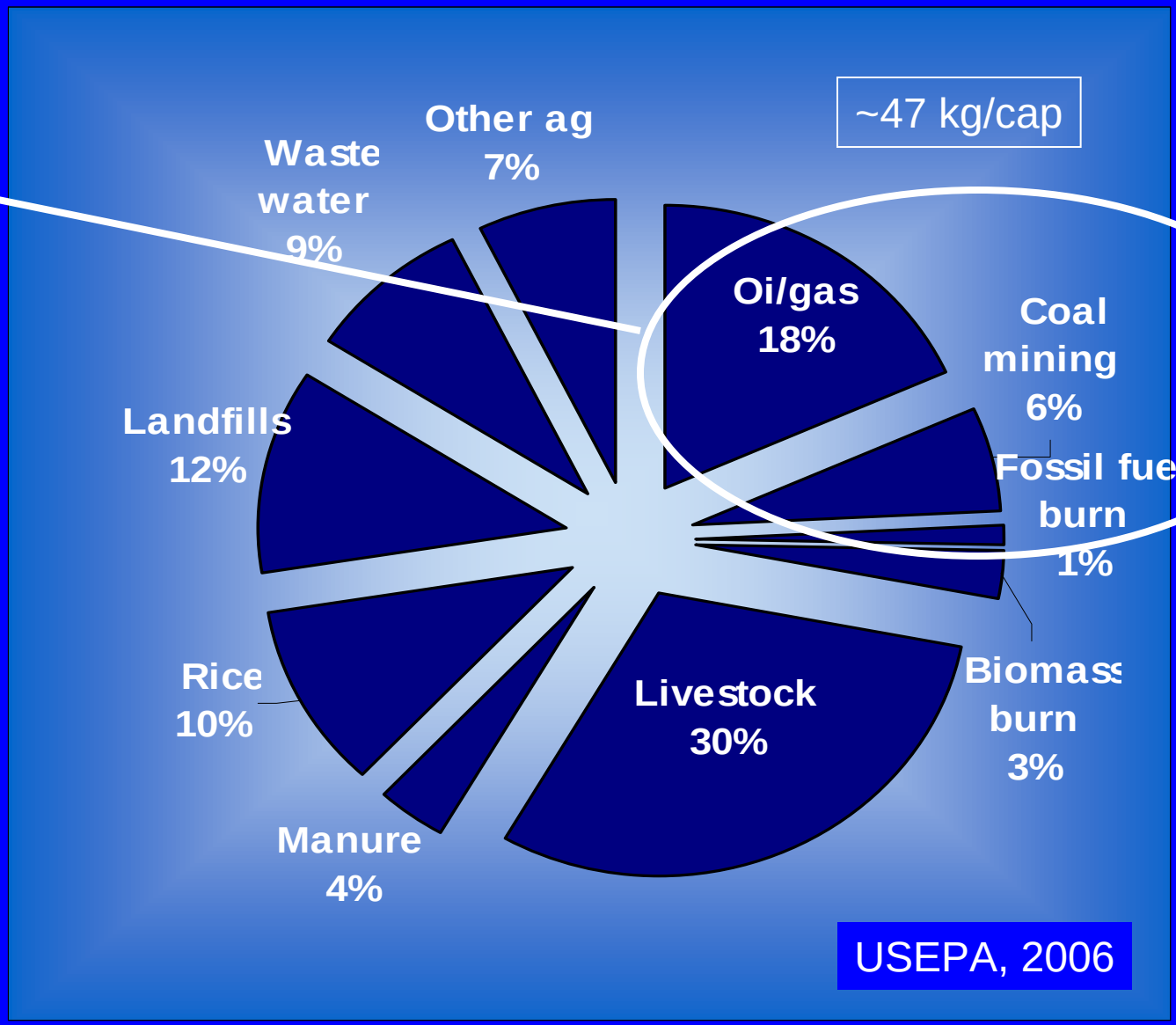
Ratio of largest to smallest emitting countries ~ 500x

This kind of calculation, however is based only on CO_2 emissions from fossil fuels and cement:

Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

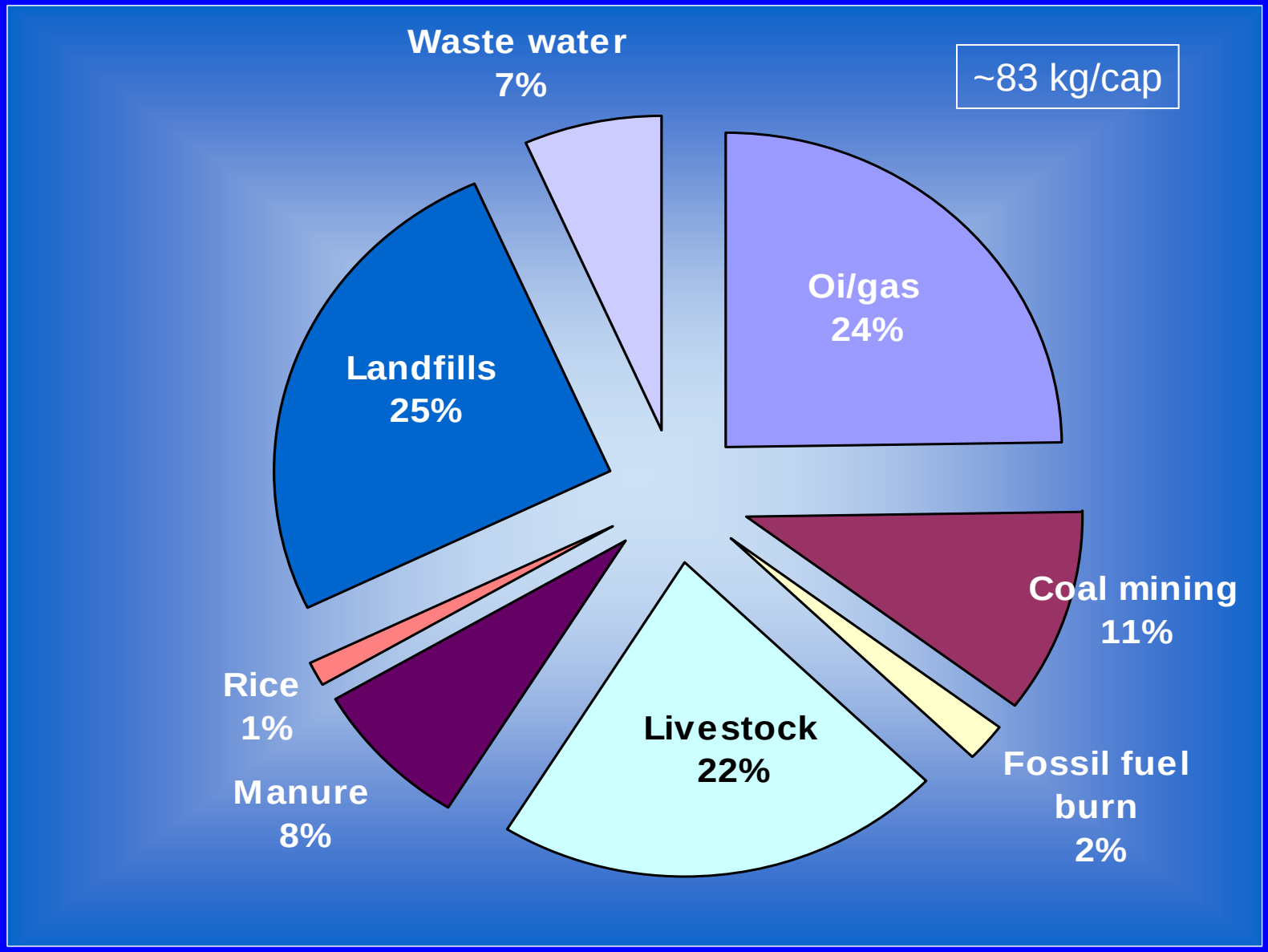
Global Anthropogenic Methane Emissions ~2005
Total ~ 305 million tons

Fossil methane ~25%



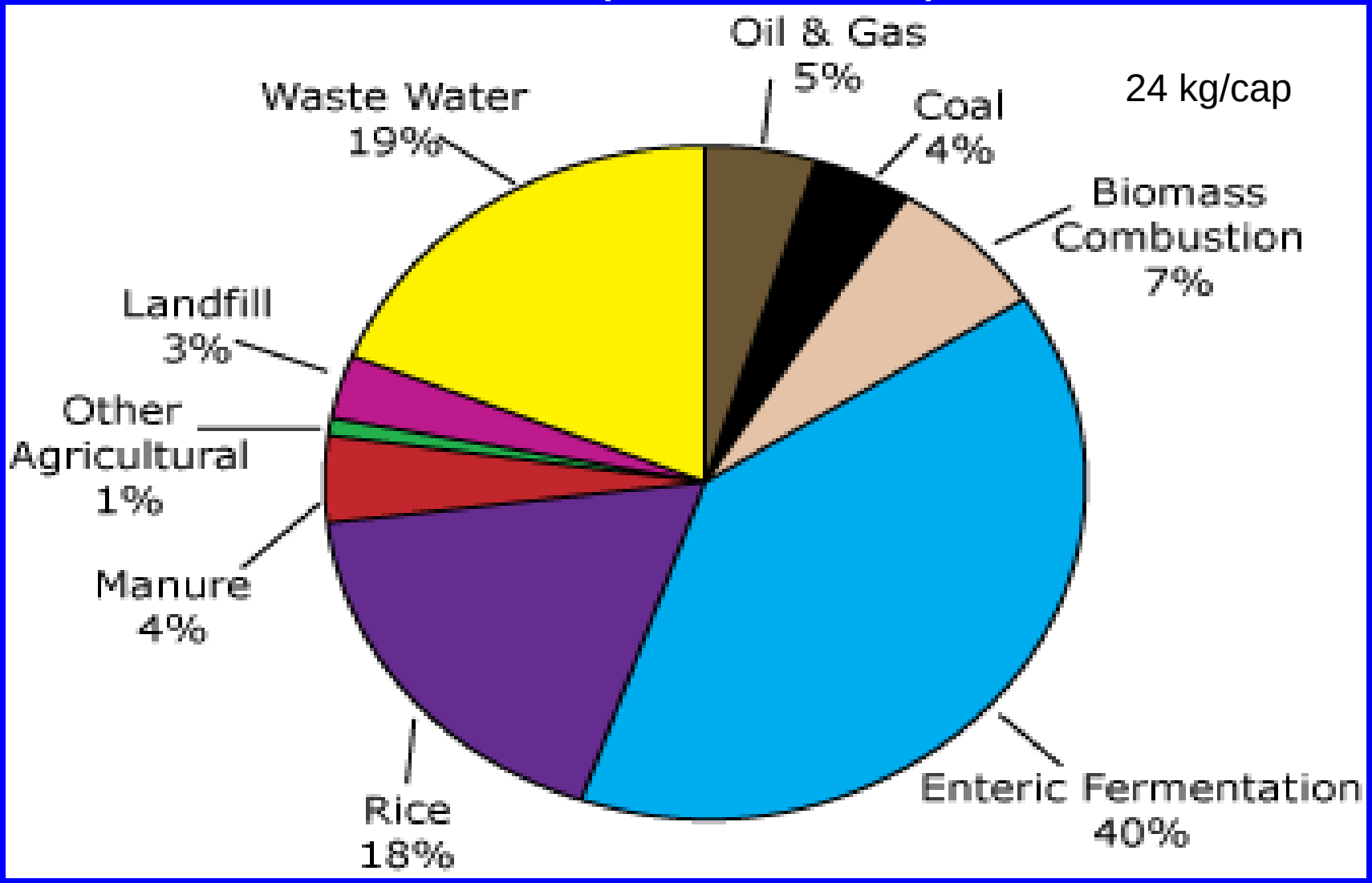
Expected to grow at ~1.5% per year

USA Anthropogenic Methane Emissions ~2005
25 million tons (8% of world)



USEPA
2006

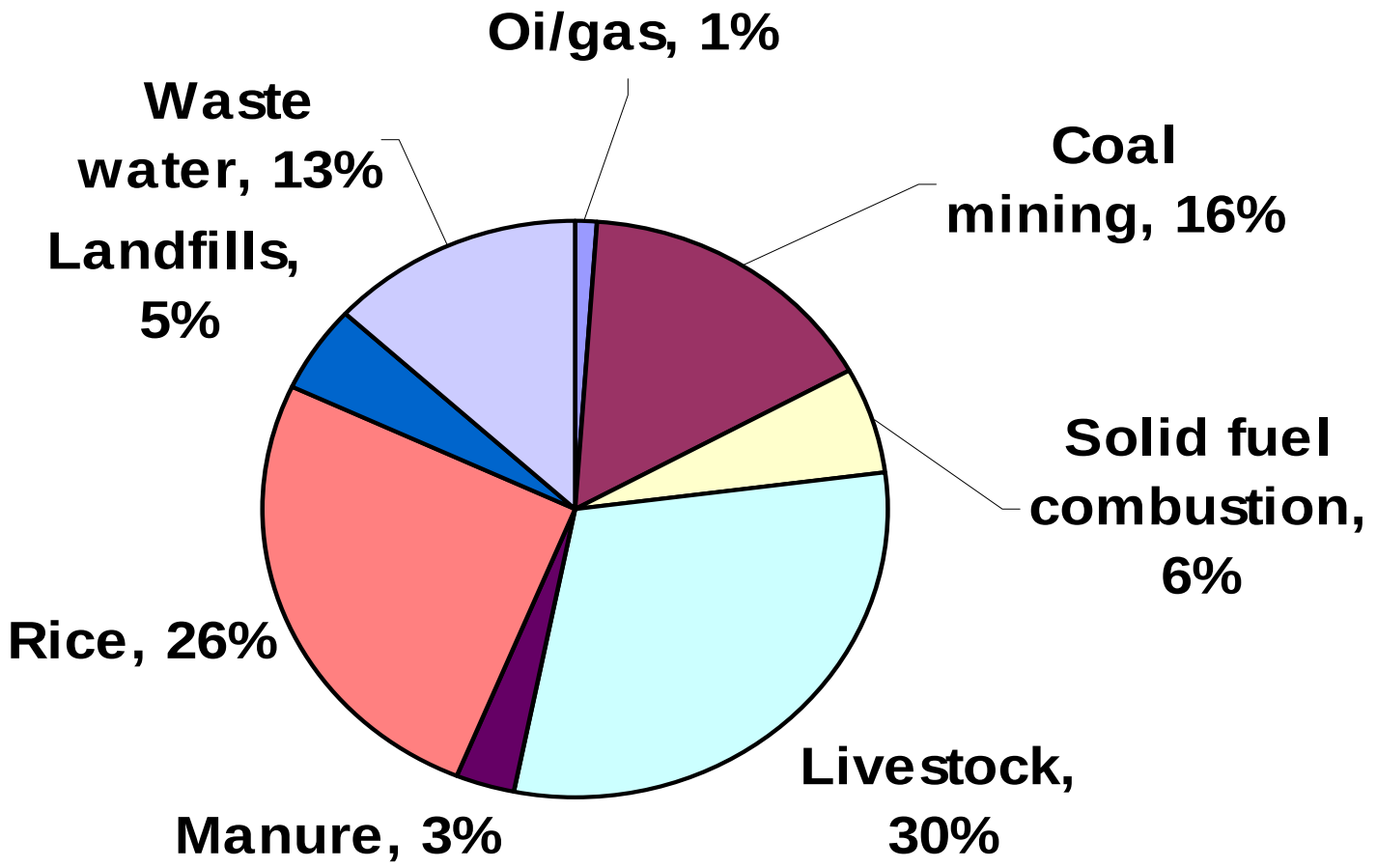
Methane Emissions from India in 2005
26.1 Mt (9% of world)



http://www.epa.gov/nonco2/econ-inv/international.html

Chinese Methane Emissions in 2005
41 MT (13% of world)

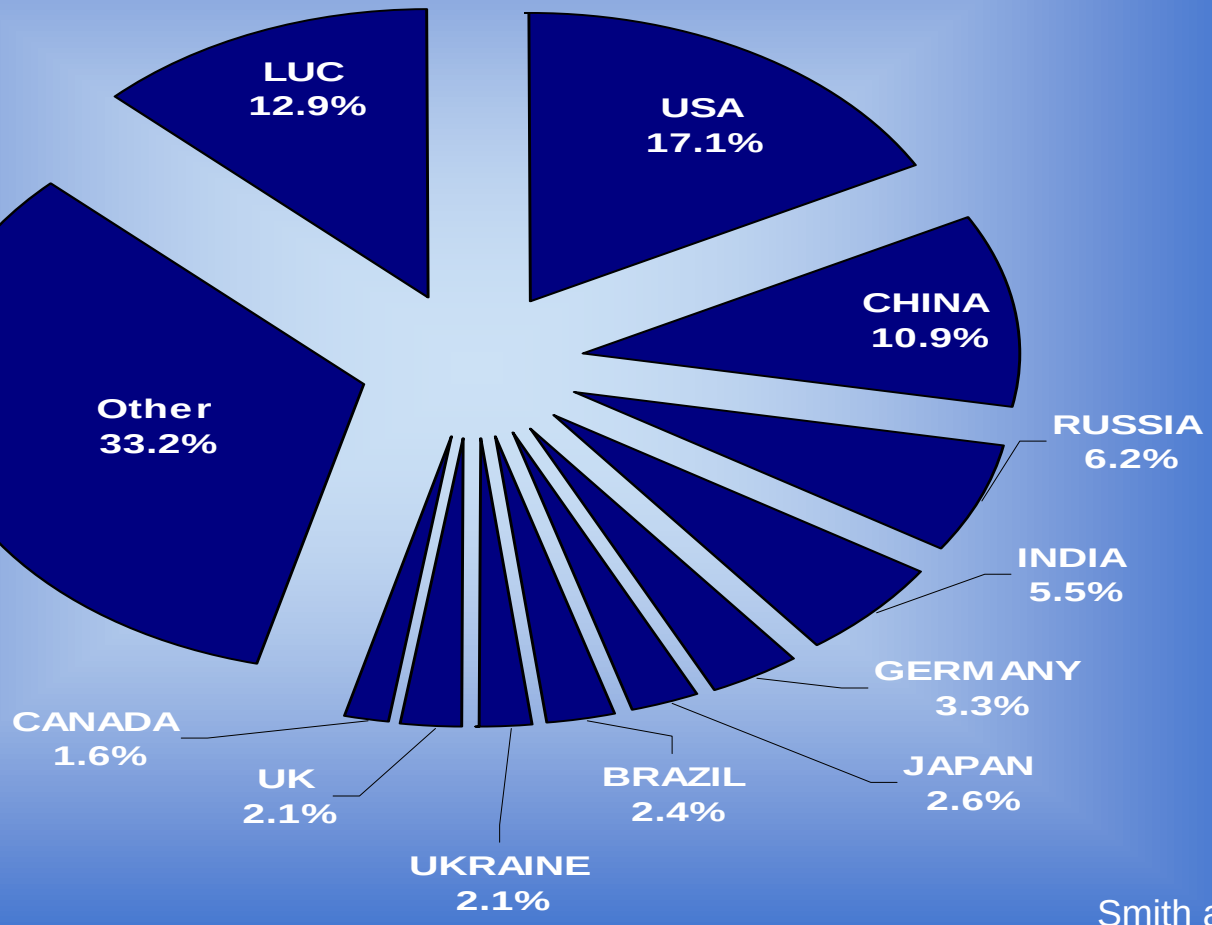
31 kg/capita



USEPA, 2006

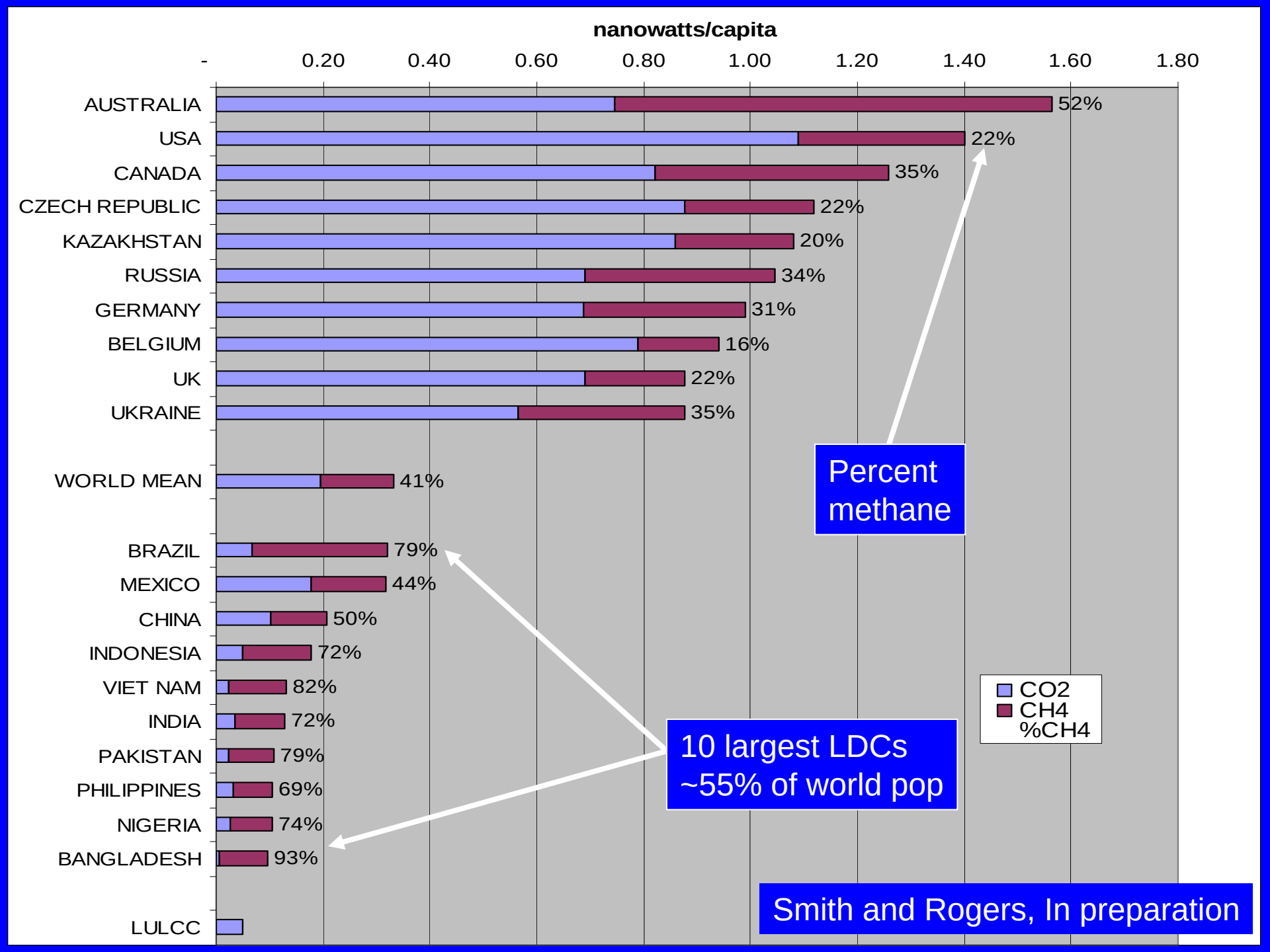
Distribution of Global Natural Debts in Top 10 Nations CH4 and CO2 in 2005

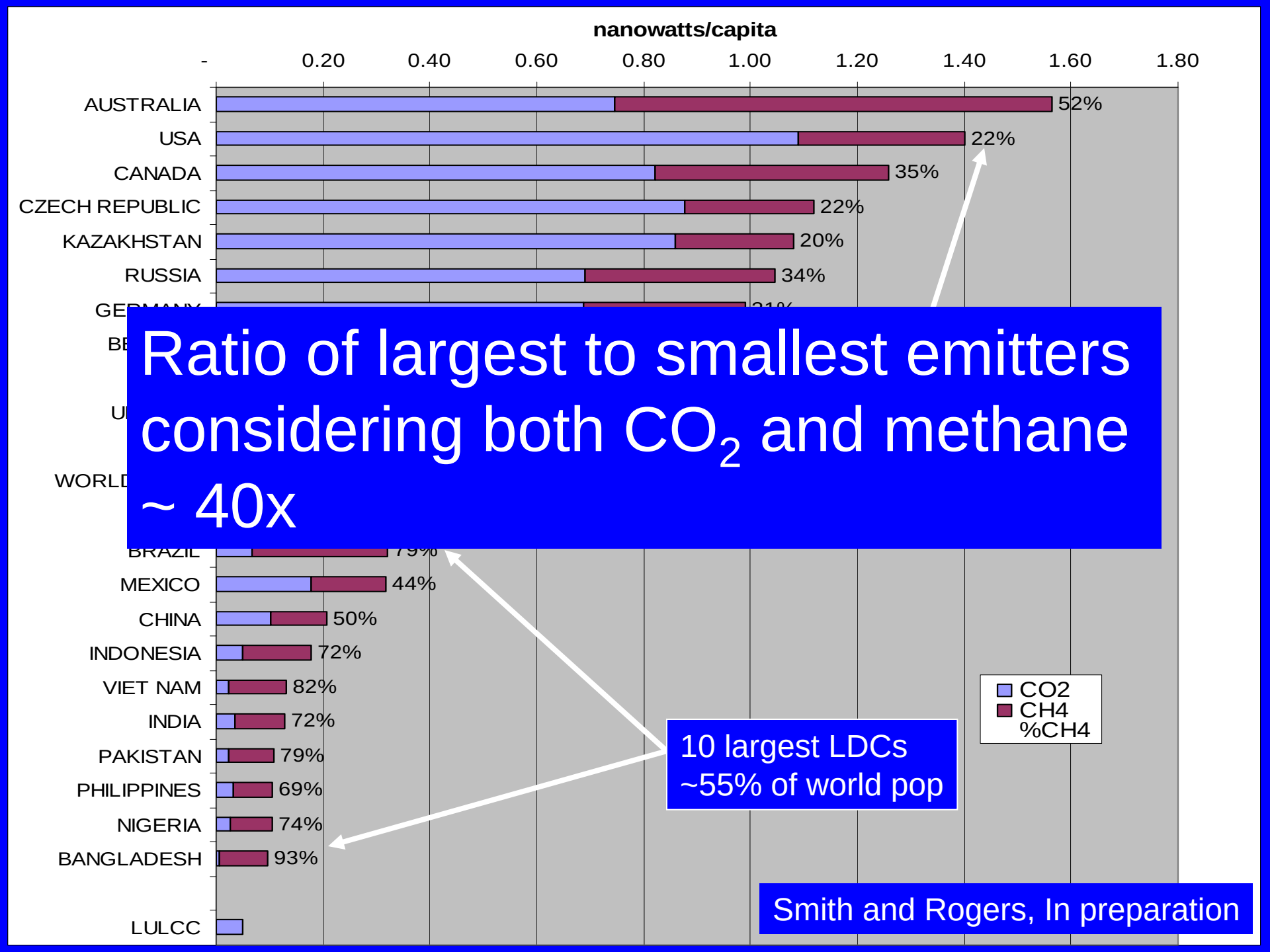
[compared to CO2 alone; note decrease for USA, increase for China, and large increases for India and Brazil]



Smith and Rogers, in preparation

Nb. National fossil fuel/cement emissions only for CO2, land-use change emissions are not parsed out by country


nanowatts/capita
-
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
AUSTRALIA
USA
CANADA
CZECH REPUBLIC
KAZAKHSTAN
RUSSIA
GERMANY
BELGIUM
UK
UKRAINE
WORLD MEAN
BRAZIL
MEXICO
CHINA
INDONESIA
VIET NAM
INDIA
PAKISTAN
PHILIPPINES
NIGERIA
BANGLADESH
LULCC
52%
22%
35%
22%
20%
34%
31%
16%
22%
35%
41%
79%
44%
50%
72%
82%
72%
79%
69%
74%
93%
Percent methane
10 largest LDCs ~55% of world pop
CO2
CH4
%CH4
Smith and Rogers, In preparation


nanowatts/capita
- 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80
AUSTRALIA 52%
USA 22%
CANADA 35%
CZECH REPUBLIC 22%
KAZAKHSTAN 20%
RUSSIA 34%
BRAZIL 79%
MEXICO 44%
CHINA 50%
INDONESIA 72%
VIET NAM 82%
INDIA 72%
PAKISTAN 79%
PHILIPPINES 69%
NIGERIA 74%
BANGLADESH 93%
LULCC
CO2
CH4
%CH4
Ratio of largest to smallest emitters considering both CO_2 and methane ~ 40x
10 largest LDCs ~55% of world pop
Smith and Rogers, In preparation

Summary

- The concept of “international” natural (or ecological) debt provides the basis for choosing the start date of historical emissions (1950)
- Including methane with CO2, changes the distribution of responsibility globally
  - Larger percent addition to debts of poor countries
  - Still major differences between rich and poor, but less so.
- The combined responsibility metric is more sensitive to policy measures than one with CO2 alone
  - Methane emission reductions will noticeable reduce debts in a few years, unlike those for CO2
  - Poor countries in this sense have greater potential for response than rich countries
- As climate change is becoming more apparent and urgent, the combined metric reflects actions that affect warming in the next decades, as well as maintaining watch over CO2

Publications and presentations available at

http://ehs.sph.berkeley.edu/krsmith/

Thank you