Now, Soon, or Never

An Introduction to Temporal Dilemmas in Climate Mitigation: BC&OC and Methane

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Haagen-Smit Symposium 2009
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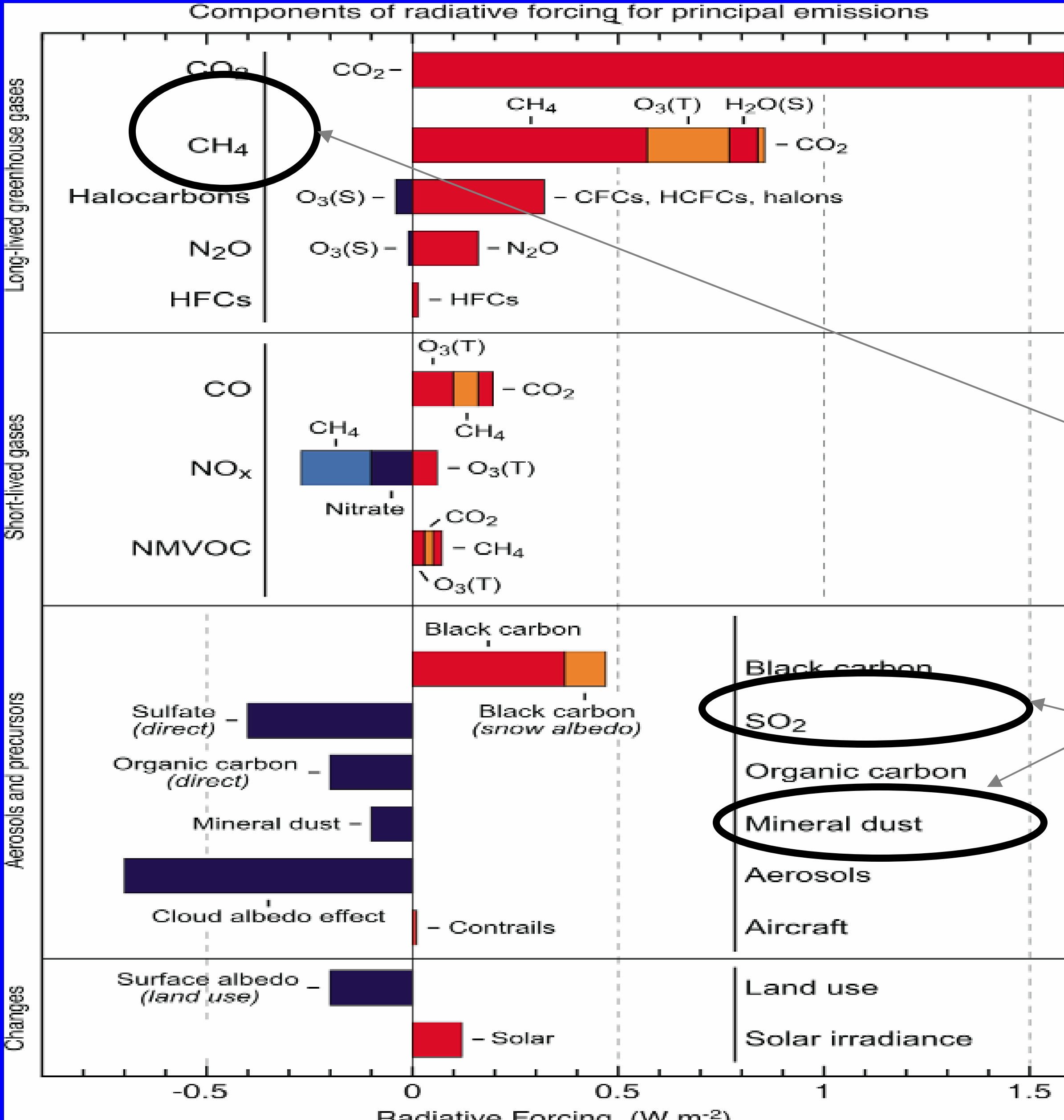


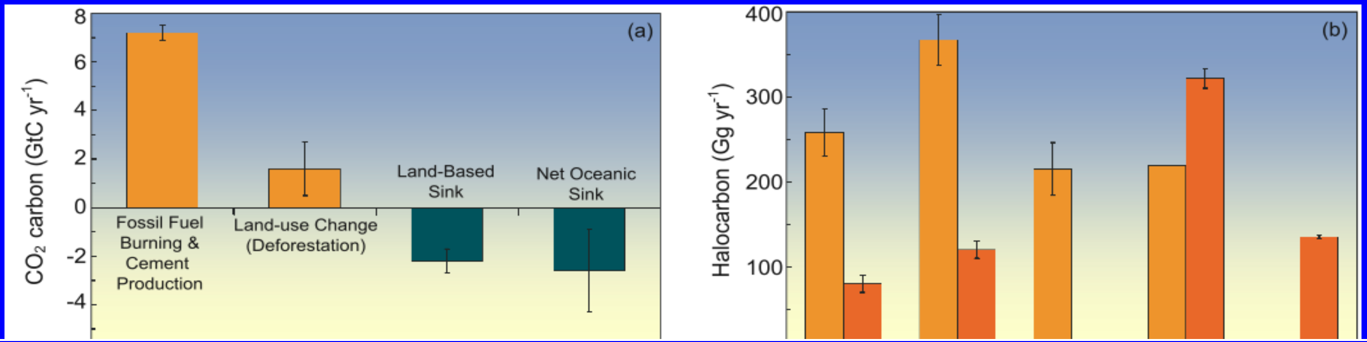
Warming in 2005 from emissions since 1750

Focus here is on these shorter-lived CAPs – Climate Active Pollutants

First BC&OC

Then CH4

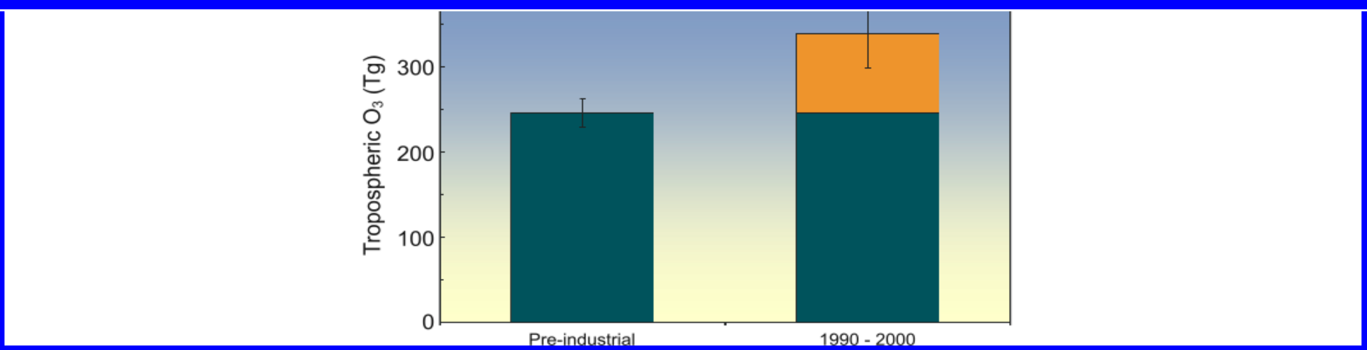
IPCC, 2007



Inventories for CO2, CH4, and N2O

Carefully parsed into “natural and “human-caused” as well as “pre-industrial and post-industrial”

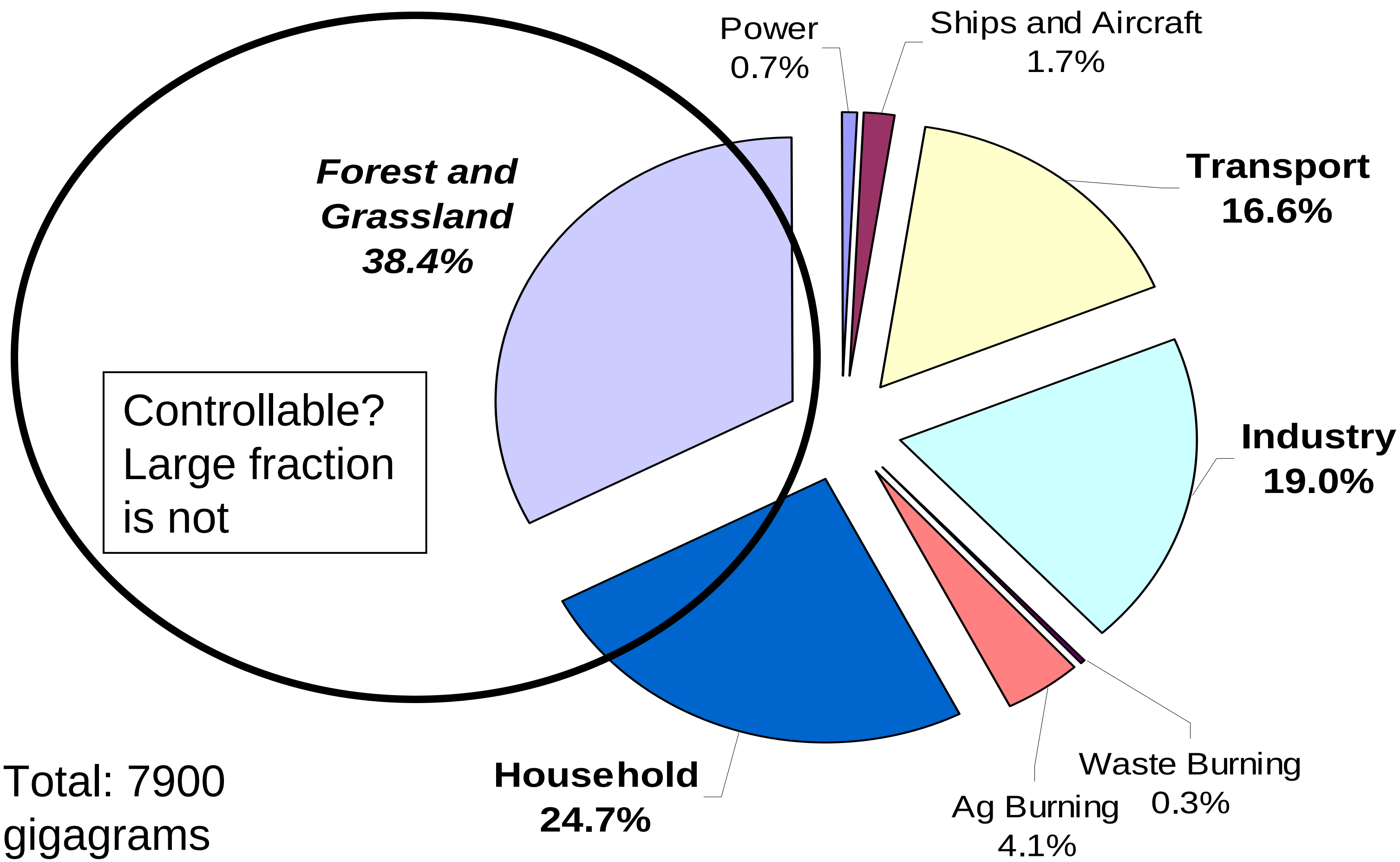
Not done yet for BC, OC, Ozone-precursors, etc.



AR4 7.1, Figure 1

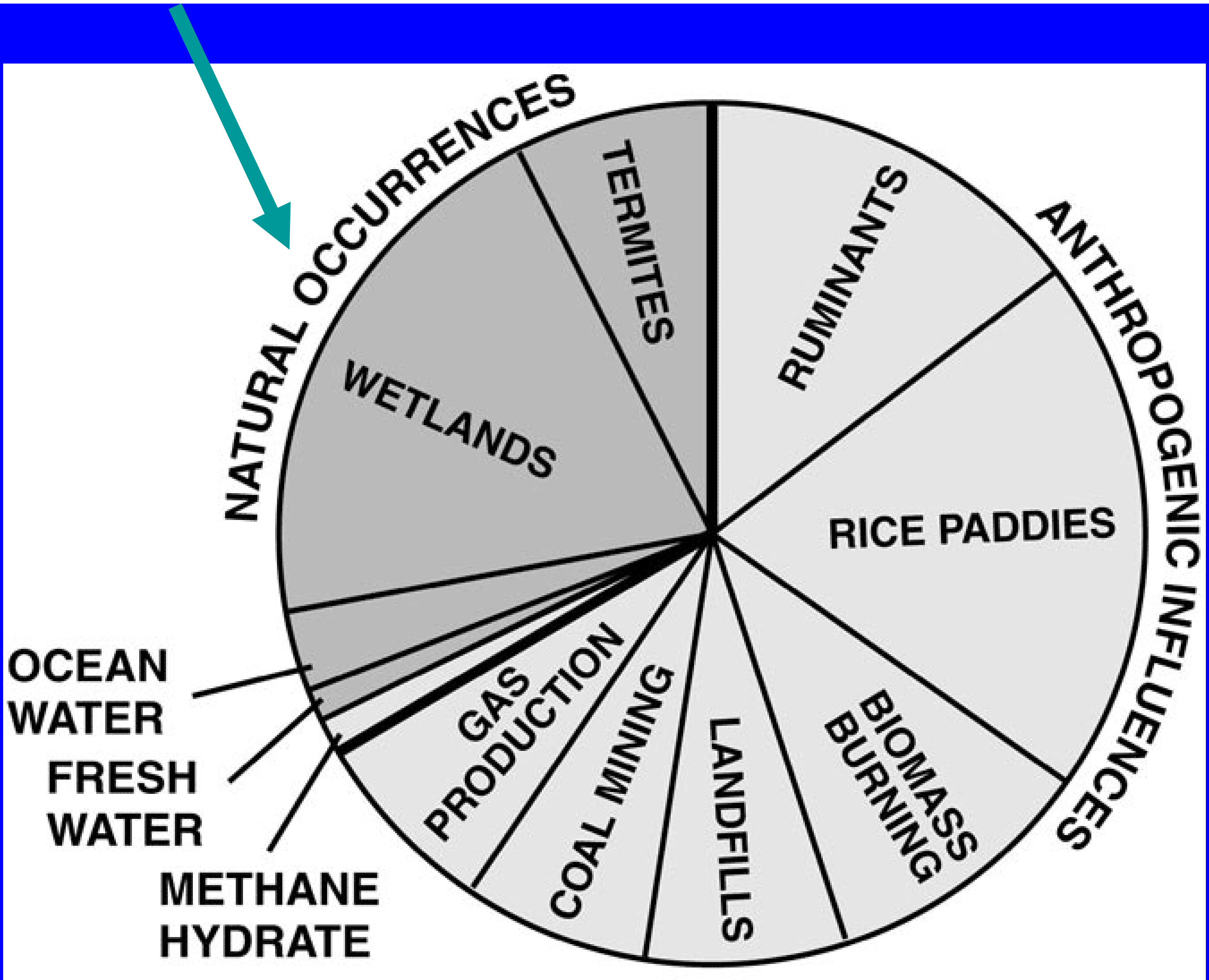
Total Black Carbon Emissions in 2000

Source: T Bond Database, V 7.1.1 Feb 2009
Plus Bond et al., 2004



Total: 7900
gigagrams

One-third of emissions from natural sources – not put into anthropogenic group



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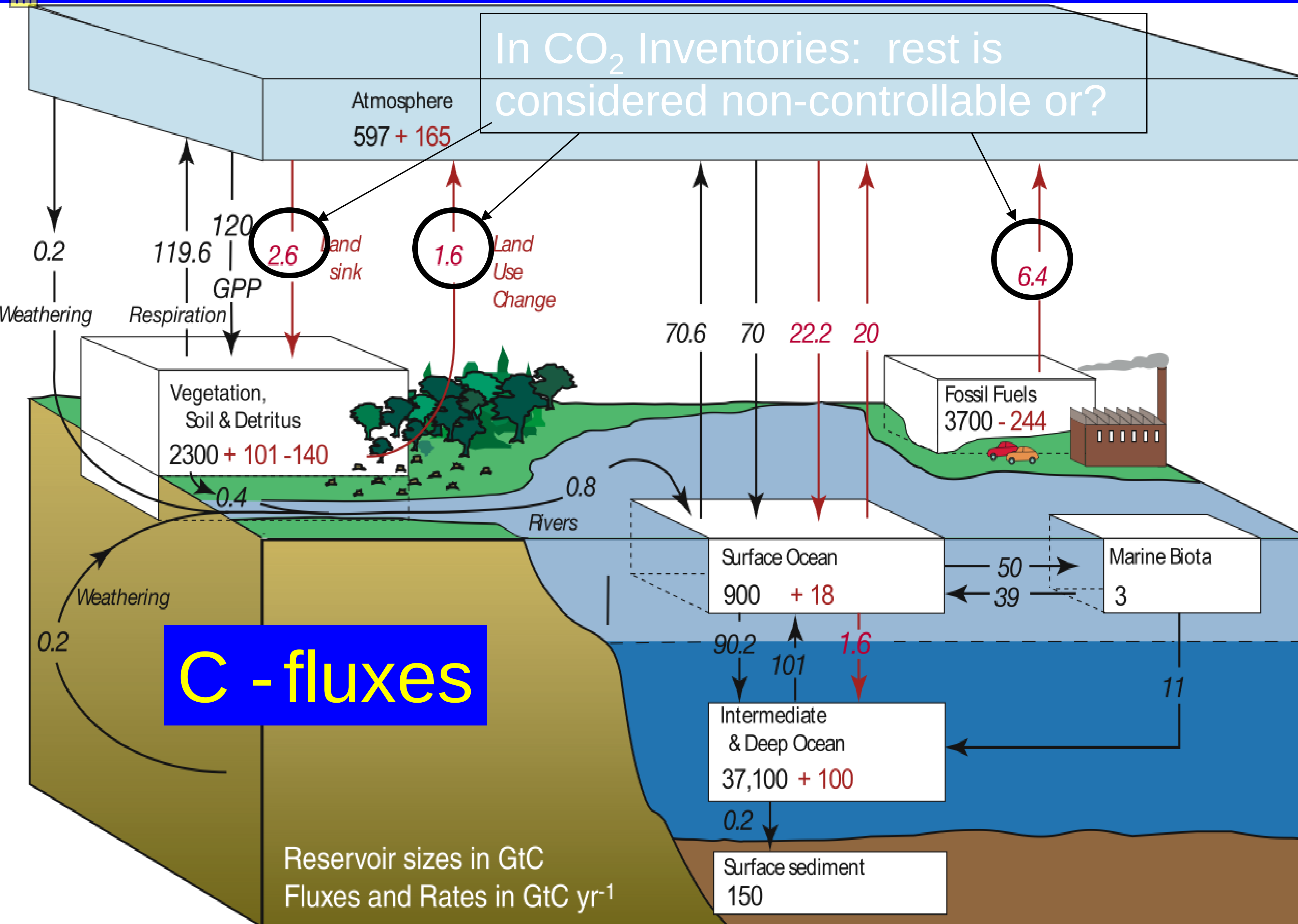
C - fluxes

In CO_2 Inventories: rest is considered non-controllable or?

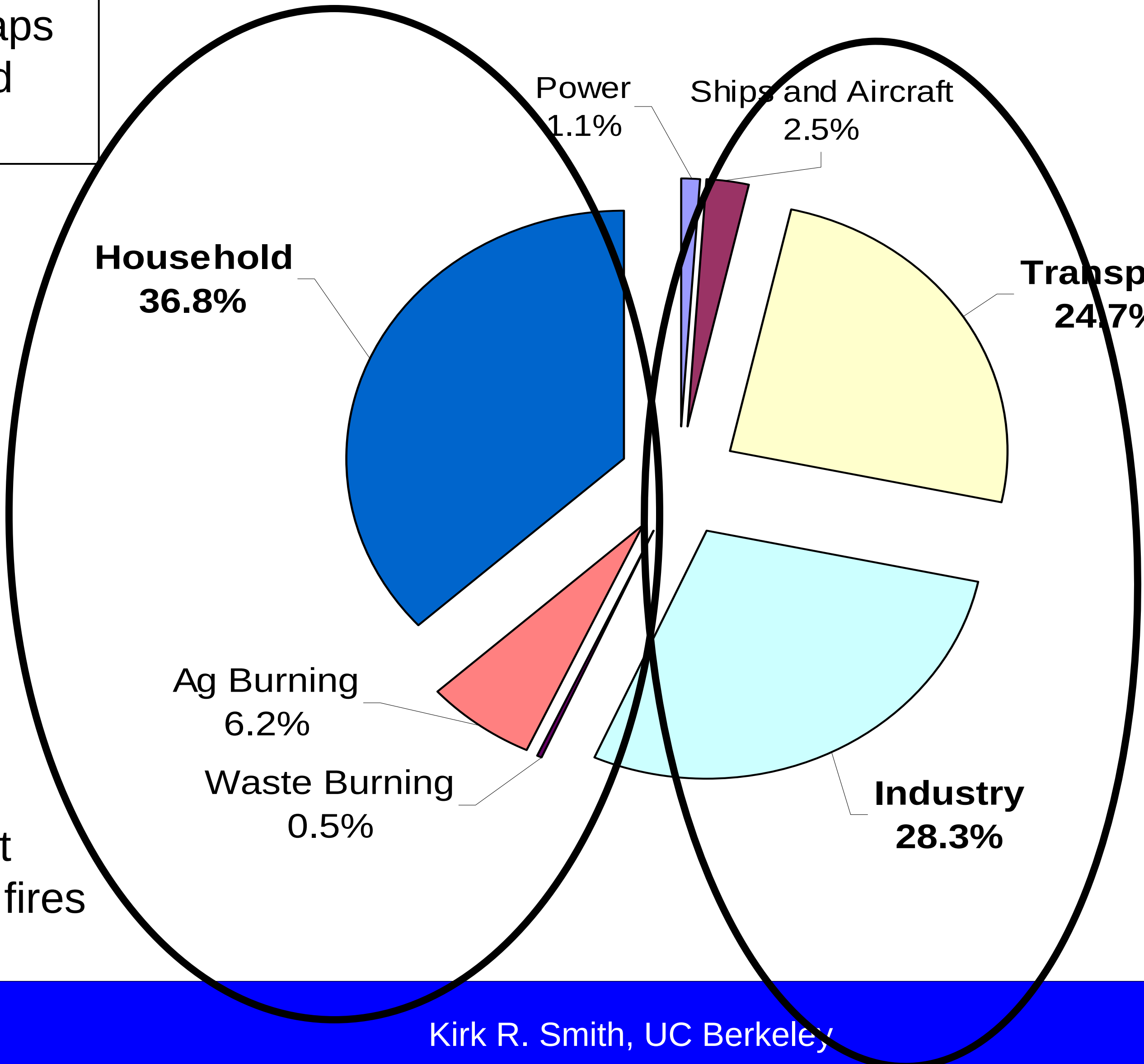


Controllable Black Carbon Emissions in 2000

Source: T Bond Database, V 7.1.1 Feb 2009

Pre-industrial but perhaps increased since

Total: 5300 gigagrams



Unequivocably Post-1750

~36% of total BC

~57% of controllable

No forest or grass fires

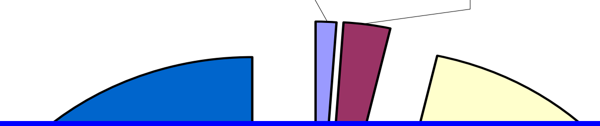
Really three categories

- Natural – not amendable to human interventions (e.g., some wildfires)
- Pre-industrial, but still amendable to human interventions (e.g. household biomass fuel burning)
- Post-industrial (e.g., essentially all fossil fuel use)

Controllable Black Carbon Emissions in 2000

Source: T Bond Database, V 7.1.1 Feb 2009

Total 5300 gigagrams



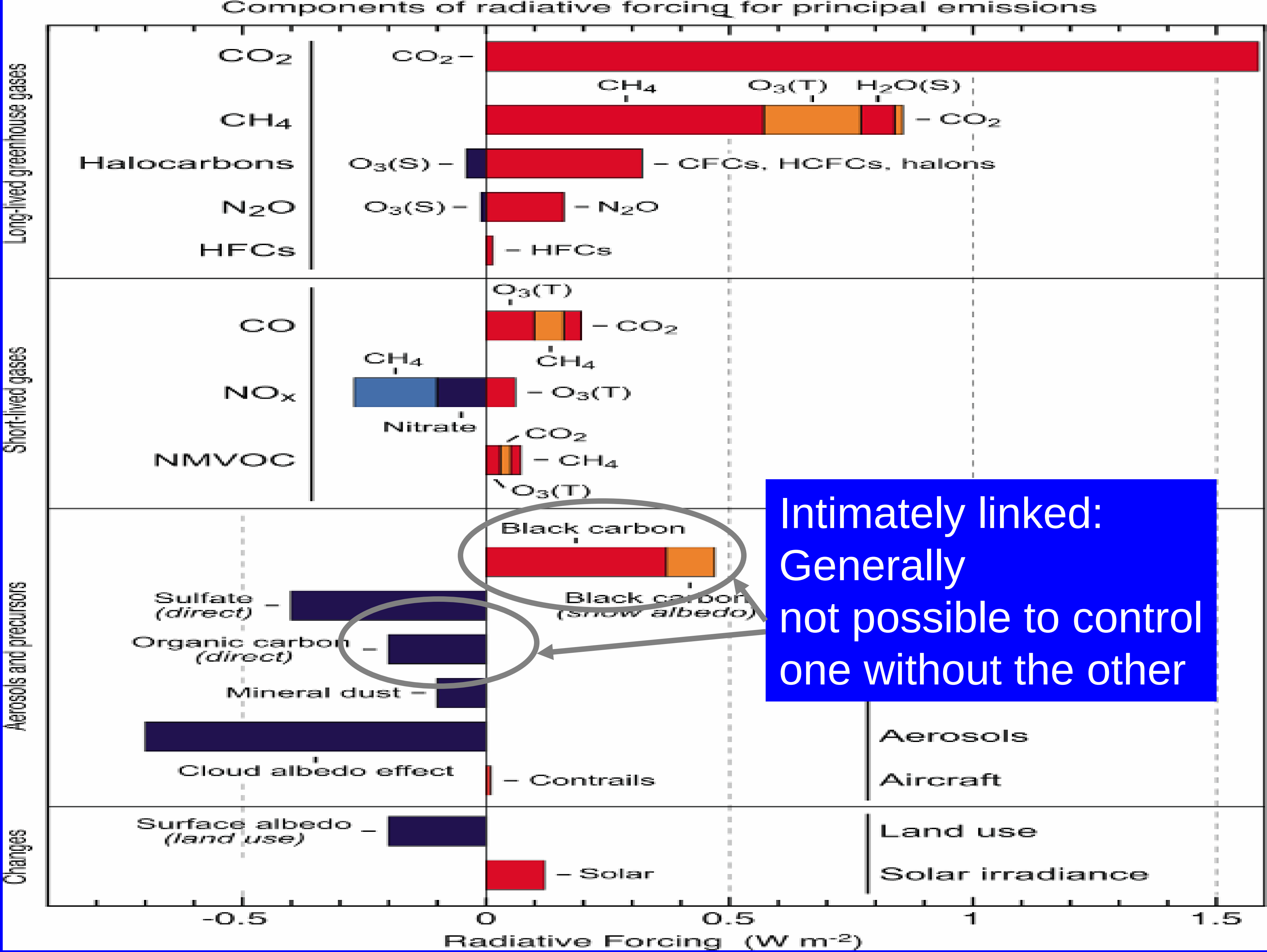
If total is 0.9 W/m² (Ramanathan & Carmichael, 2008)

--Controllable portion is ~ 0.6 W/m²

--Post-1750 portion is ~ 0.34 W/m²

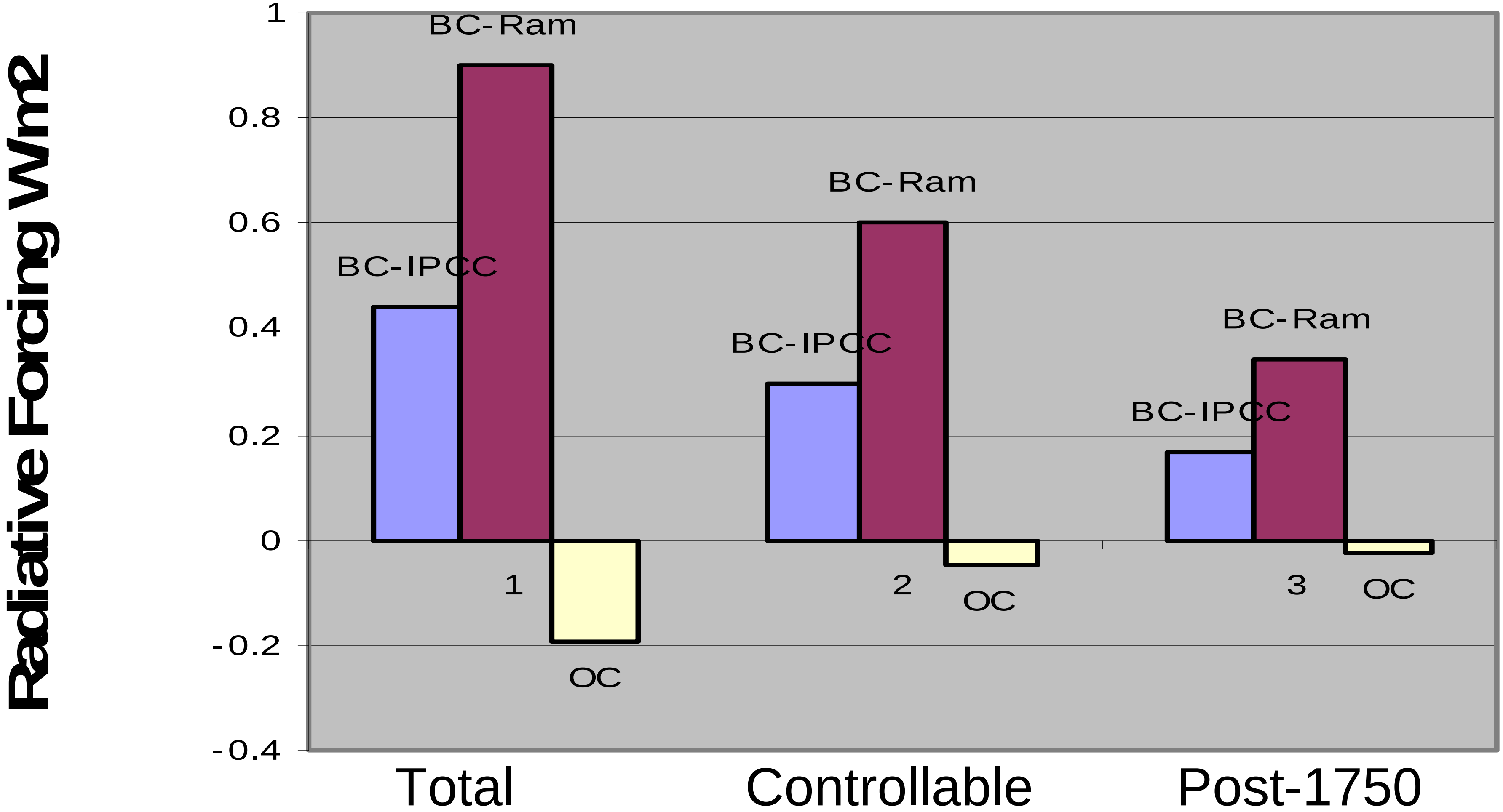
But then, the OC emissions need to be parsed into these categories also

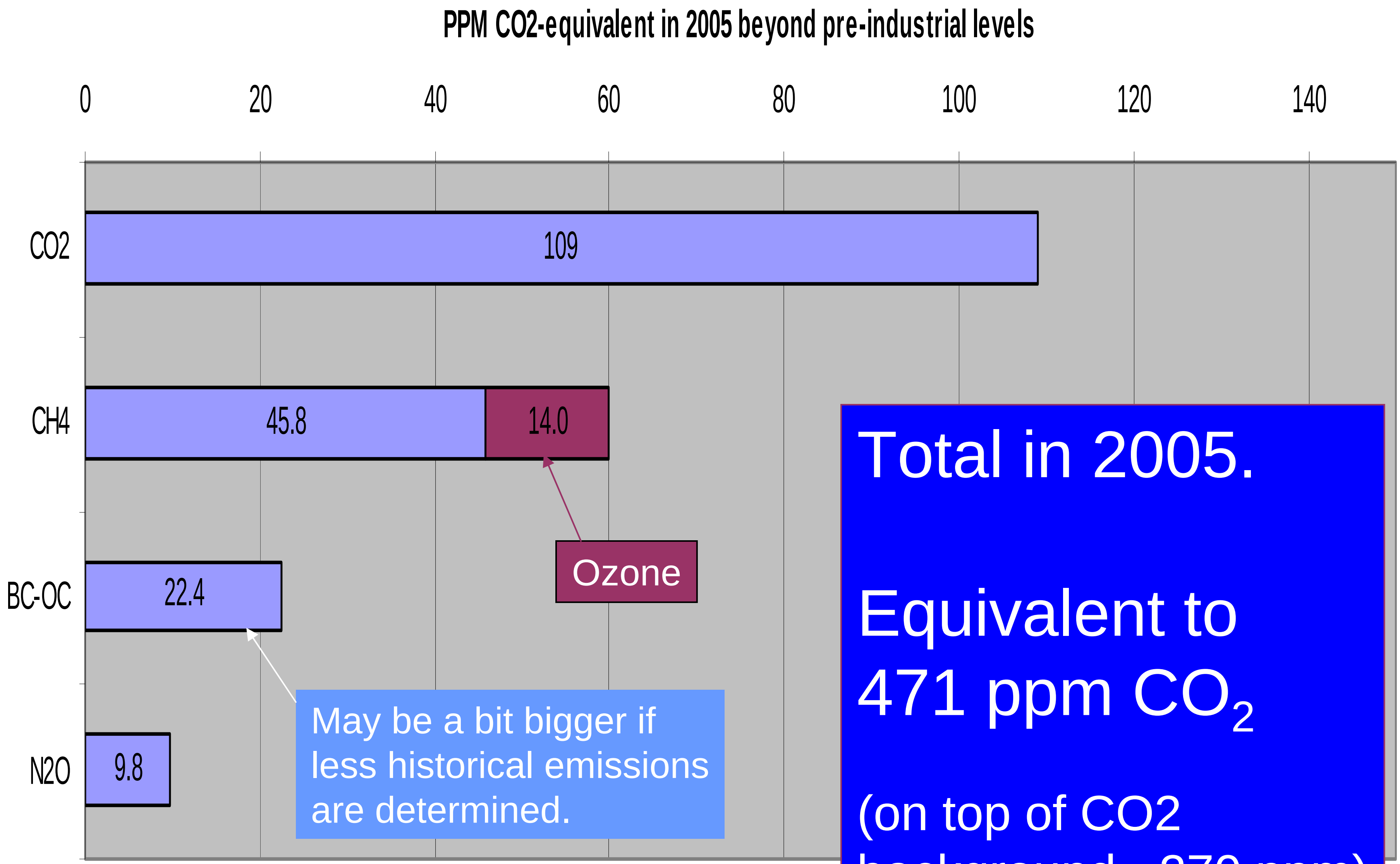
grassland fires



Intimately linked: Generally not possible to control one without the other

BC-OC Comparisons ~2005 Forcing
Total, Controllable, and Post-1750





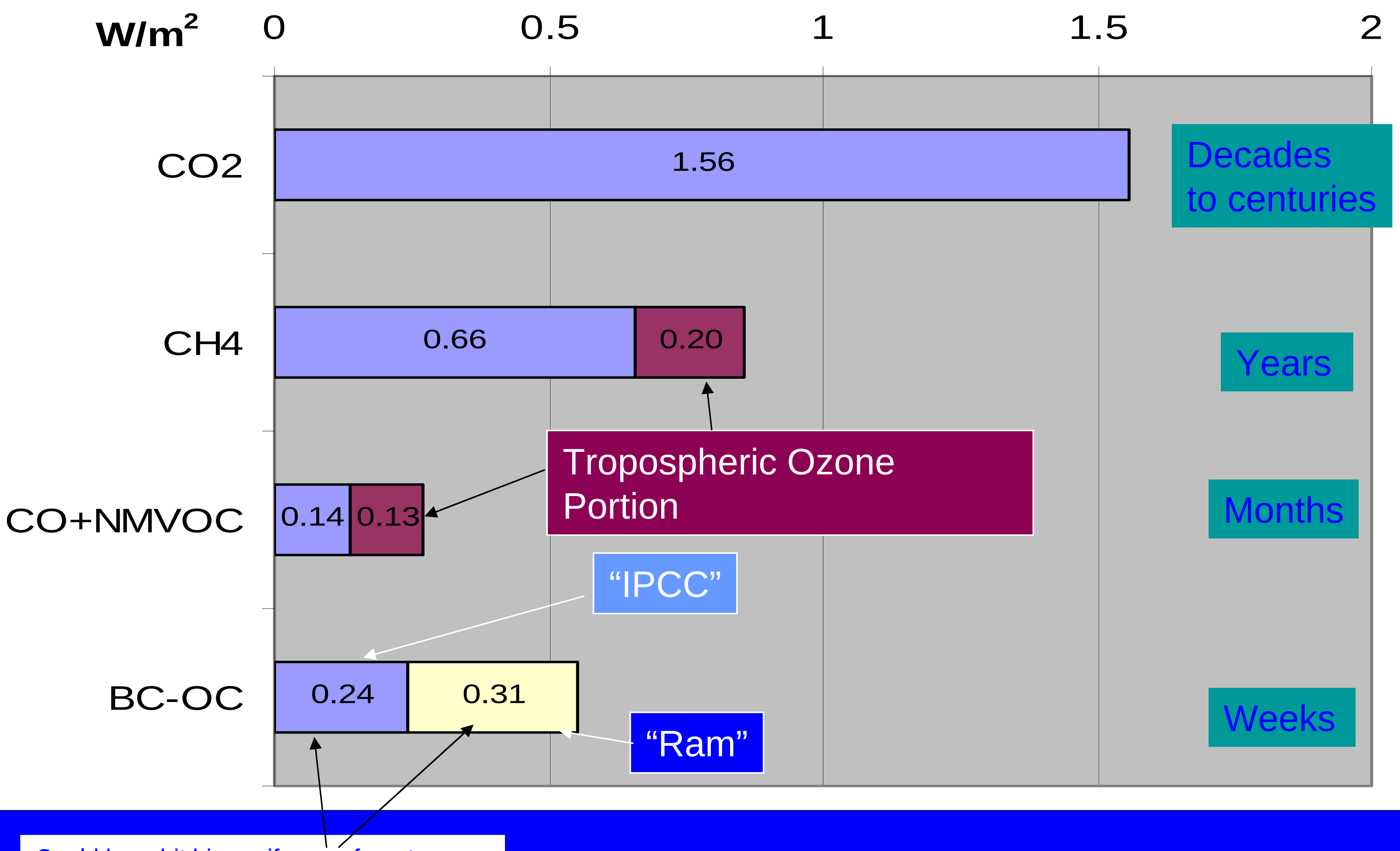
Total in 2005.

Equivalent to 471 ppm CO_2

(on top of CO2 background ~270 ppm)

Recommended Accounting

Controllable PIC Emissions Plus CO_2 Radiation Forcing in 2005



Could be a bit bigger if some forest and grass fires are seen to be controllable

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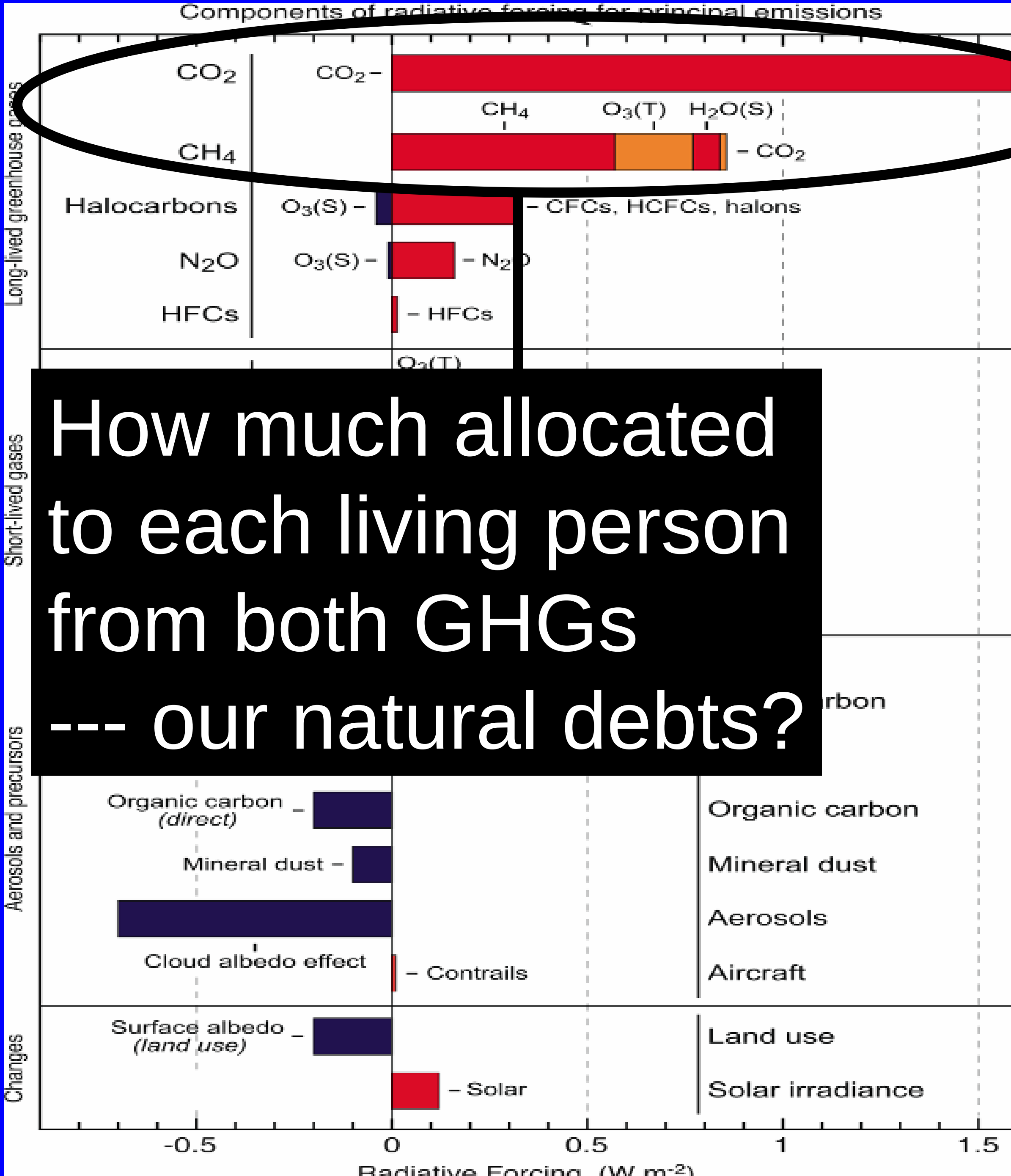


How much allocated to each living person from both GHGs --- our natural debts?

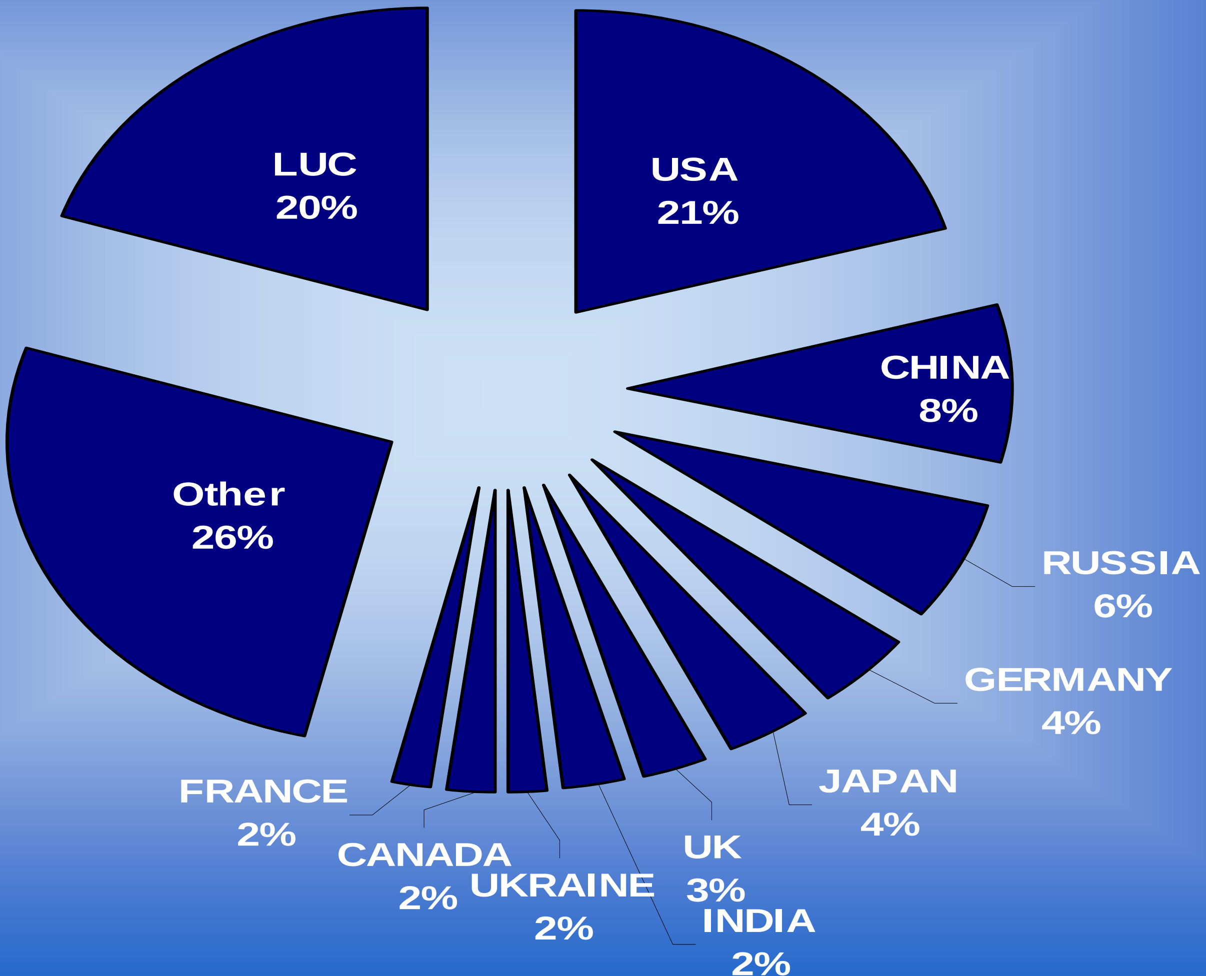
Warming in 2005 from emissions since 1750

More than half due to methane

IPCC, 2007

Distribution of Global Natural Debt Among Top 10 Nations
CO2 only in 2005

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



Brazil: 0.8%

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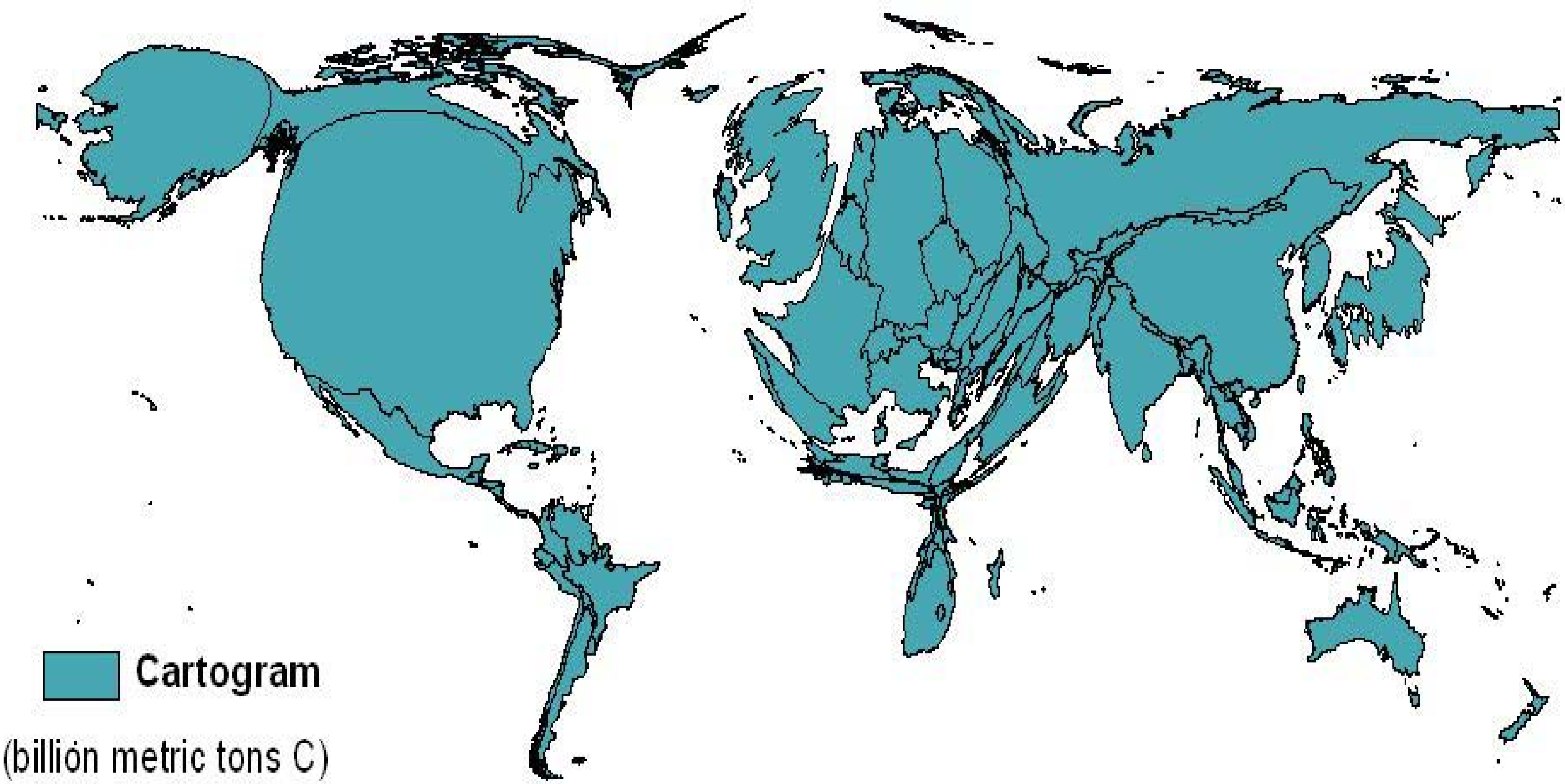
Smith and Rogers, in preparation

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.

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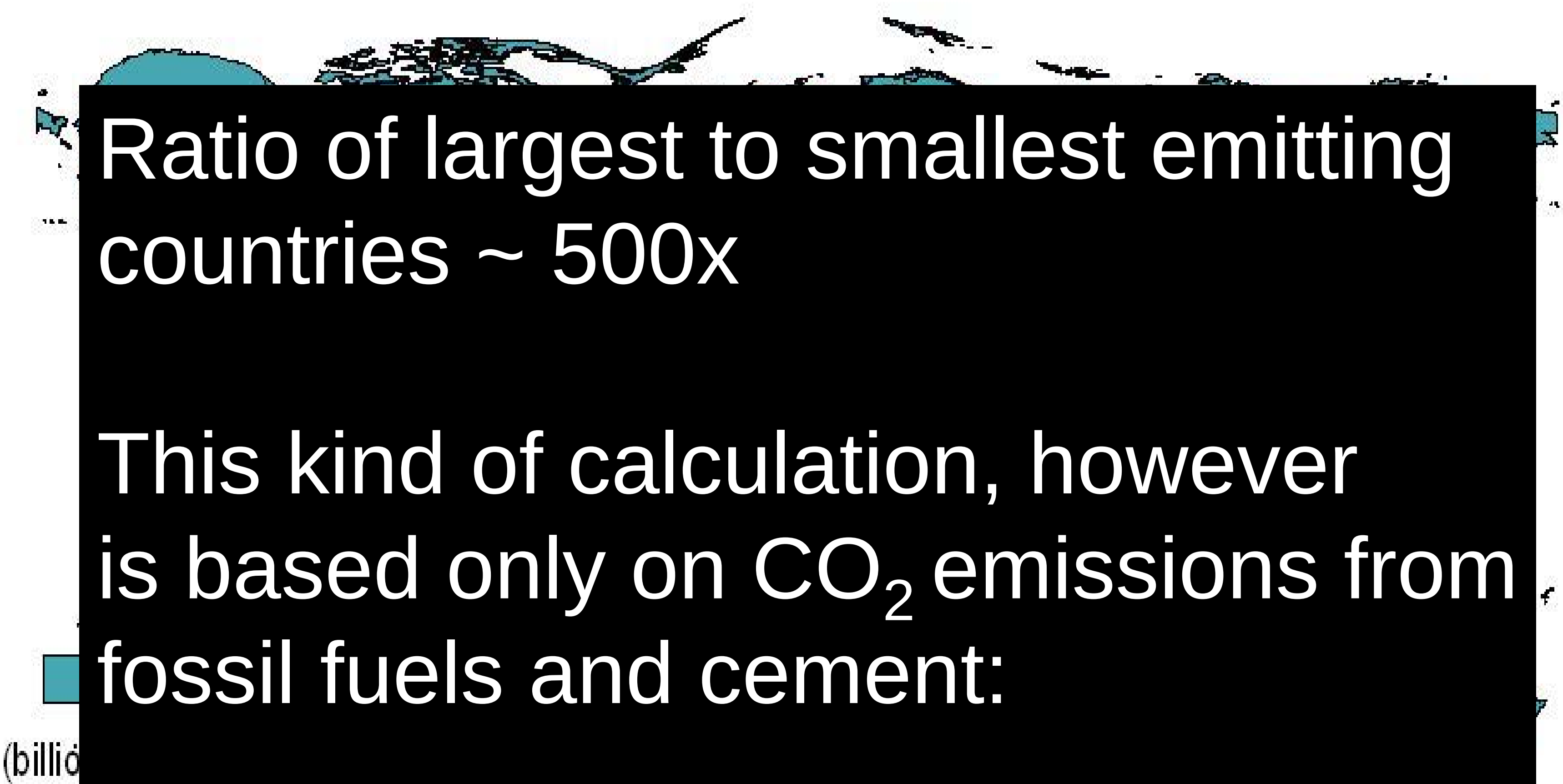
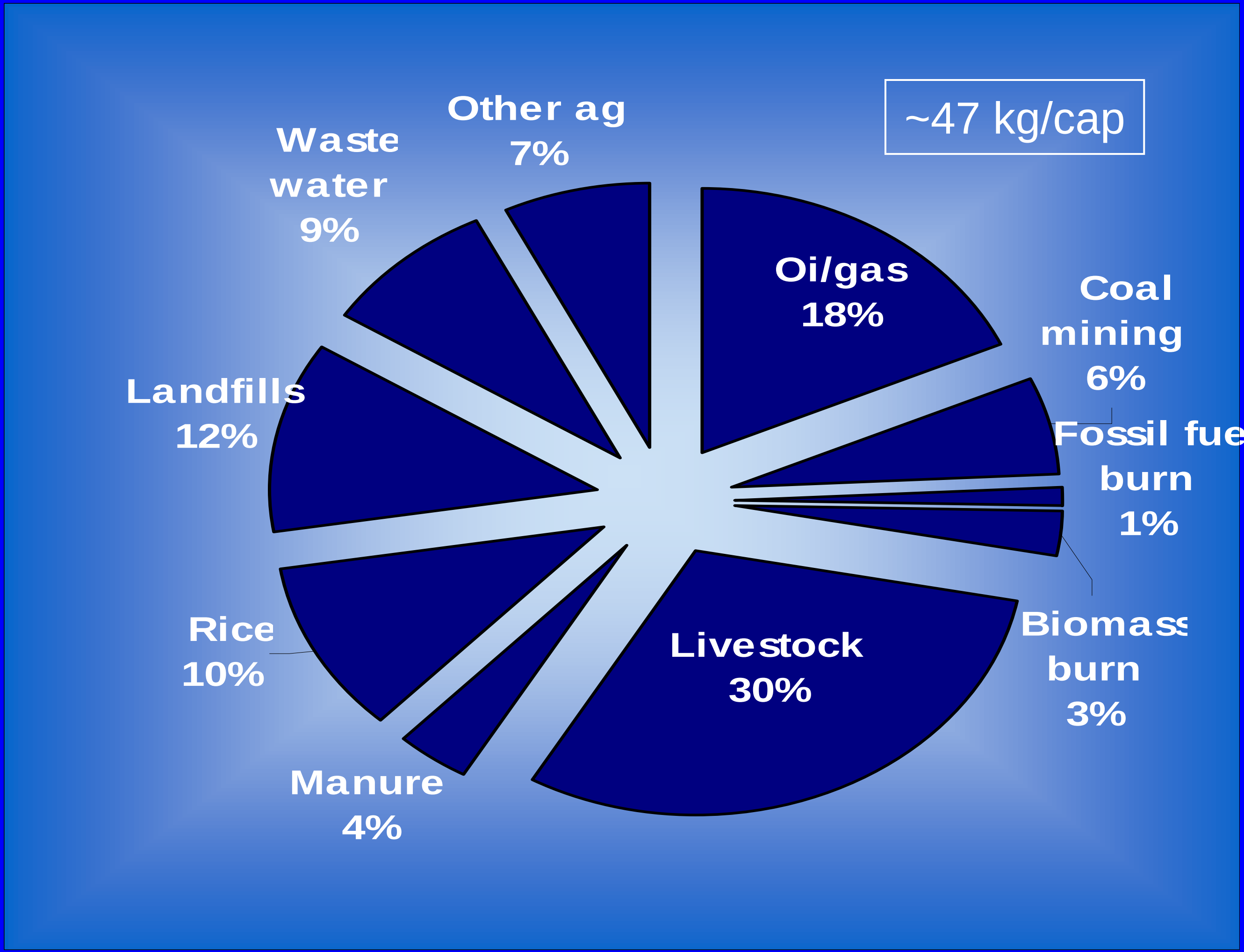


Ratio of largest to smallest emitting countries ~ 500x

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



Expected to grow at ~1.5% per year

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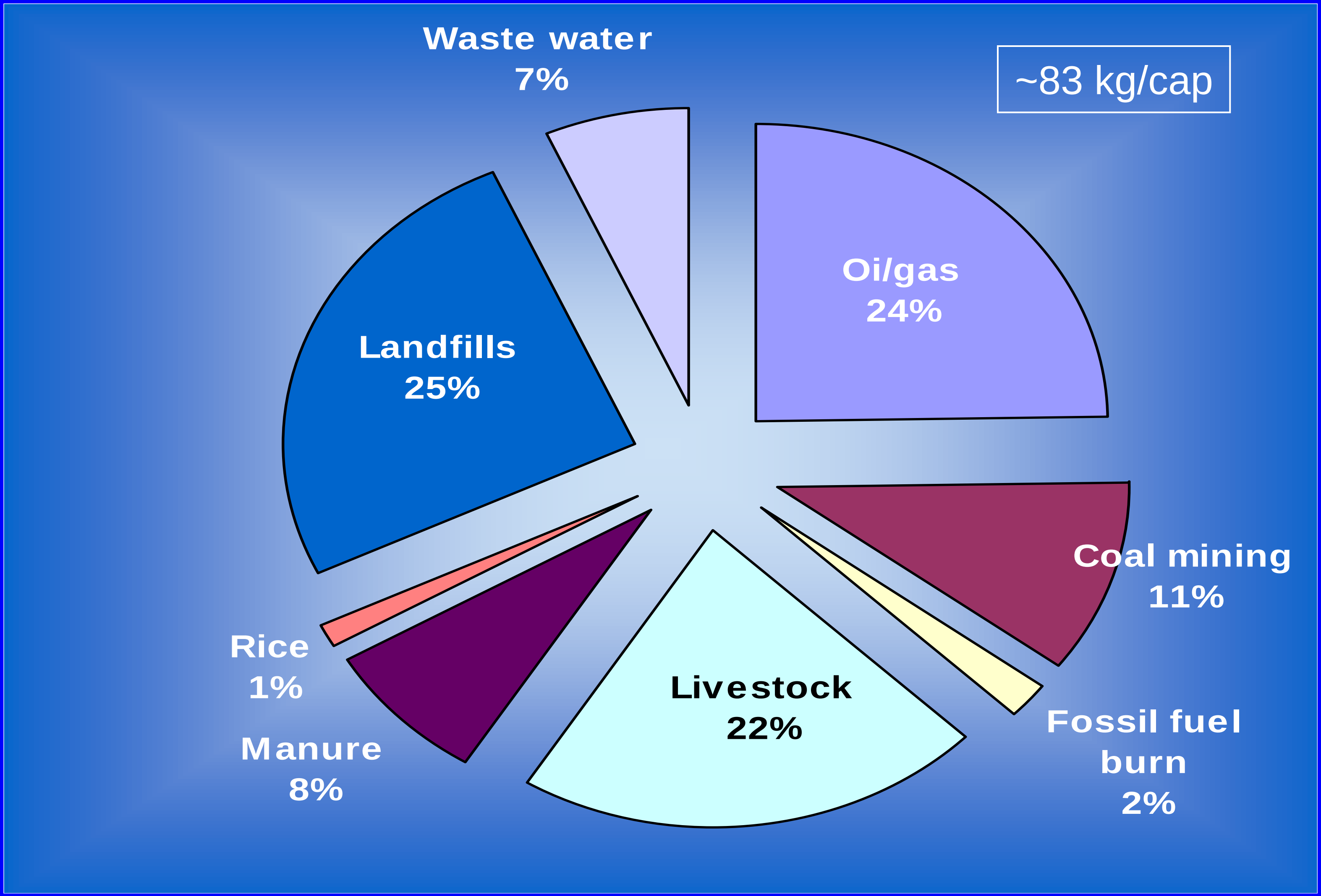
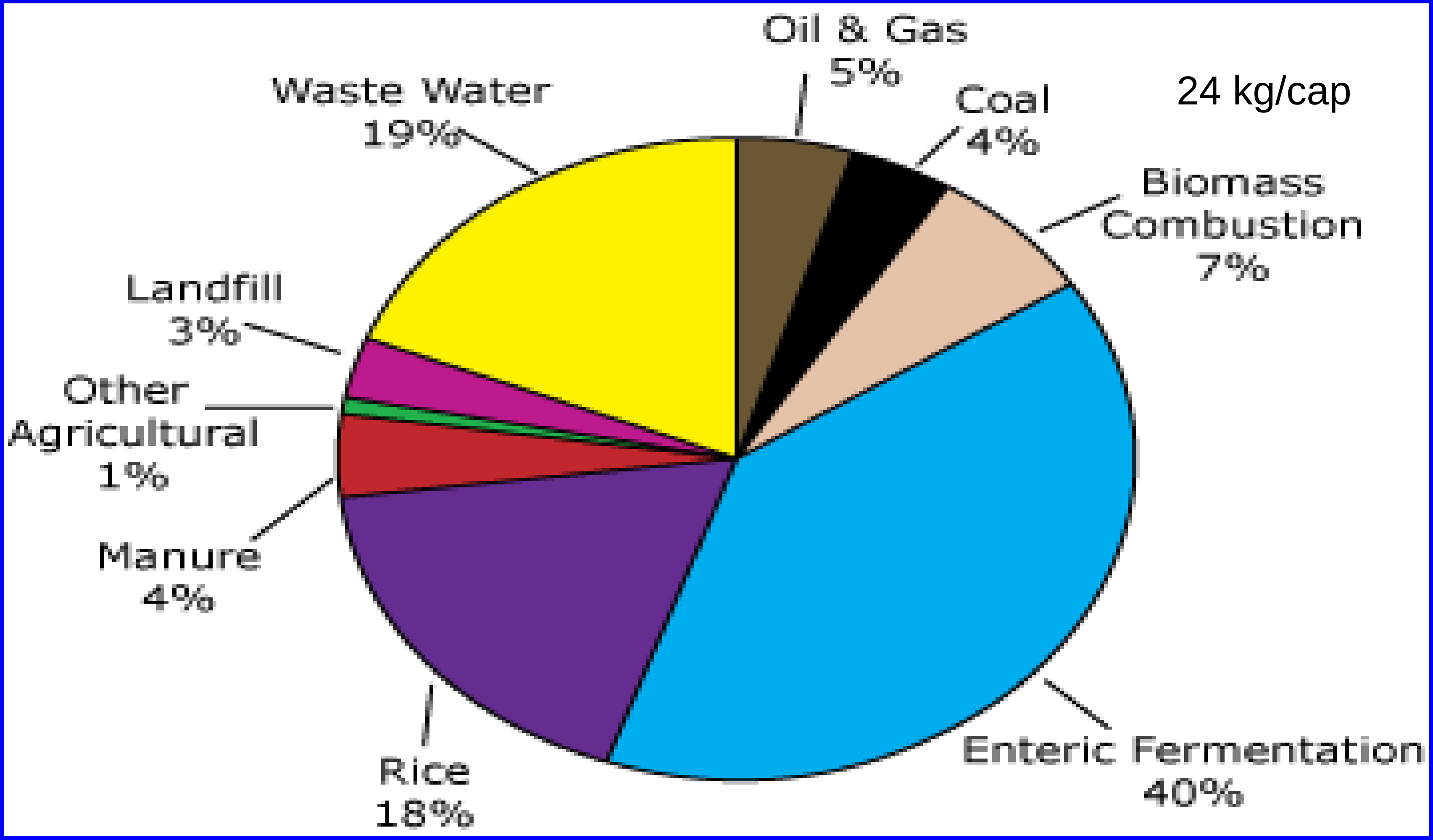
USEPA, 2006

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



USEPA
2006

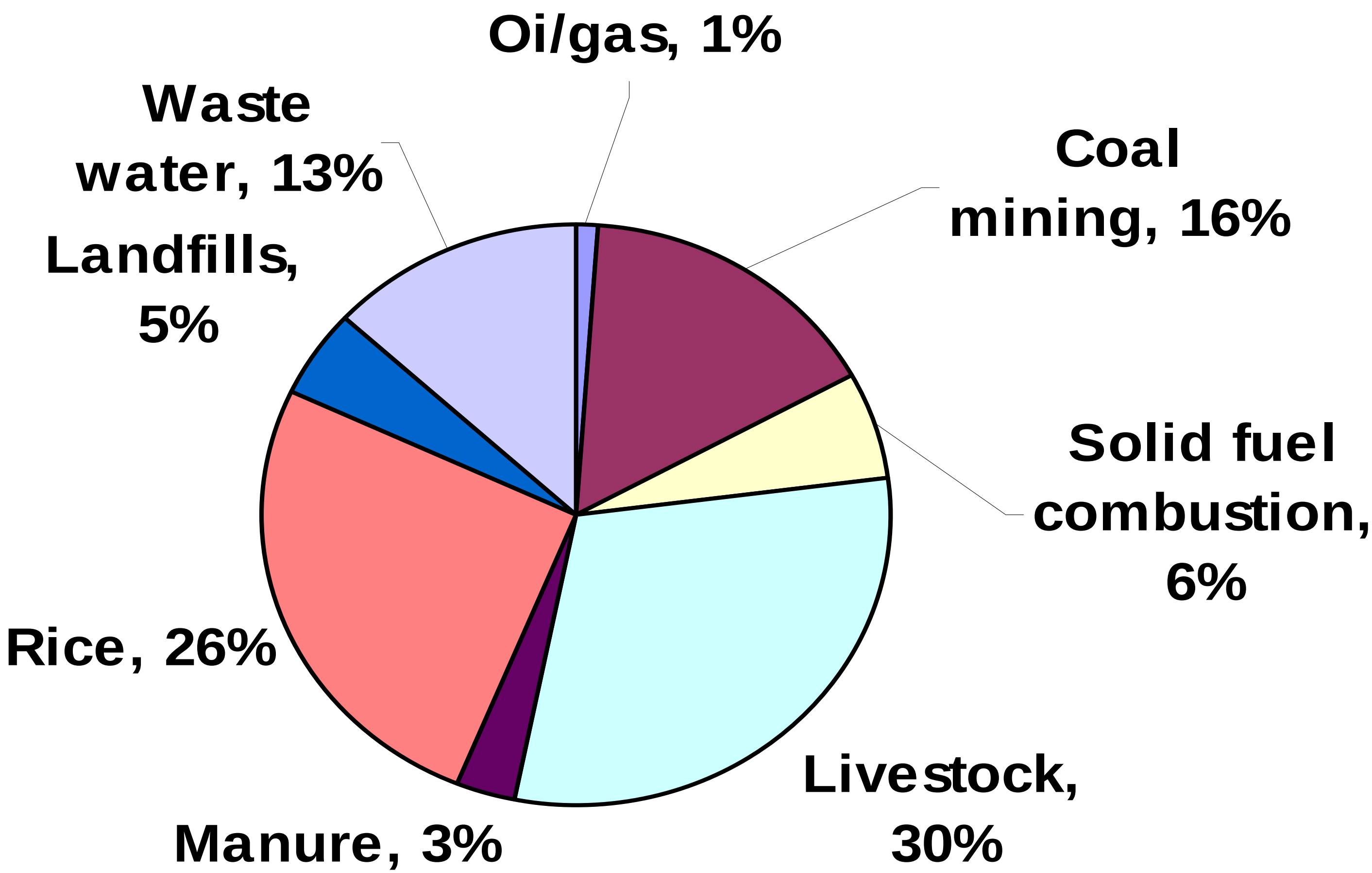
Methane Emissions from India in 2005
26.1 Mt (9% of world)



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

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

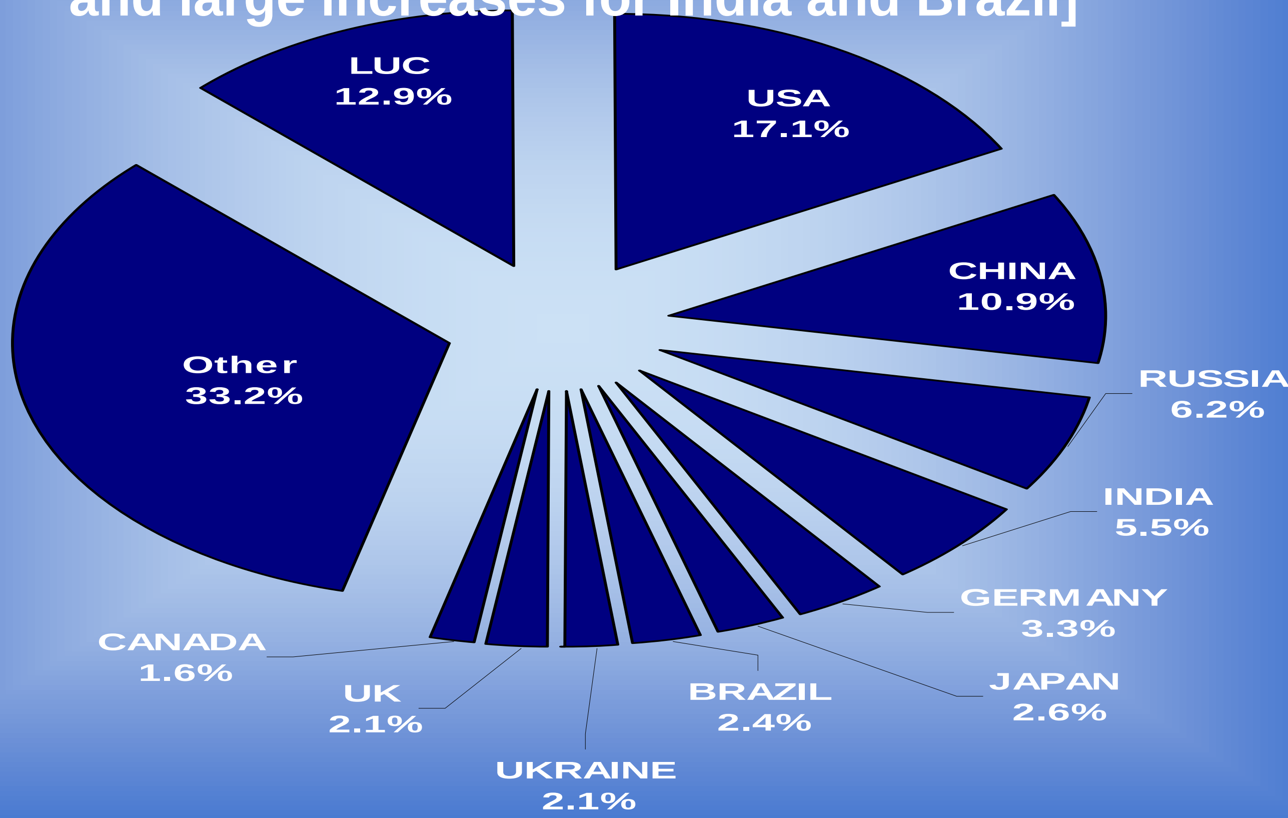
31 kg/capita



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]



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

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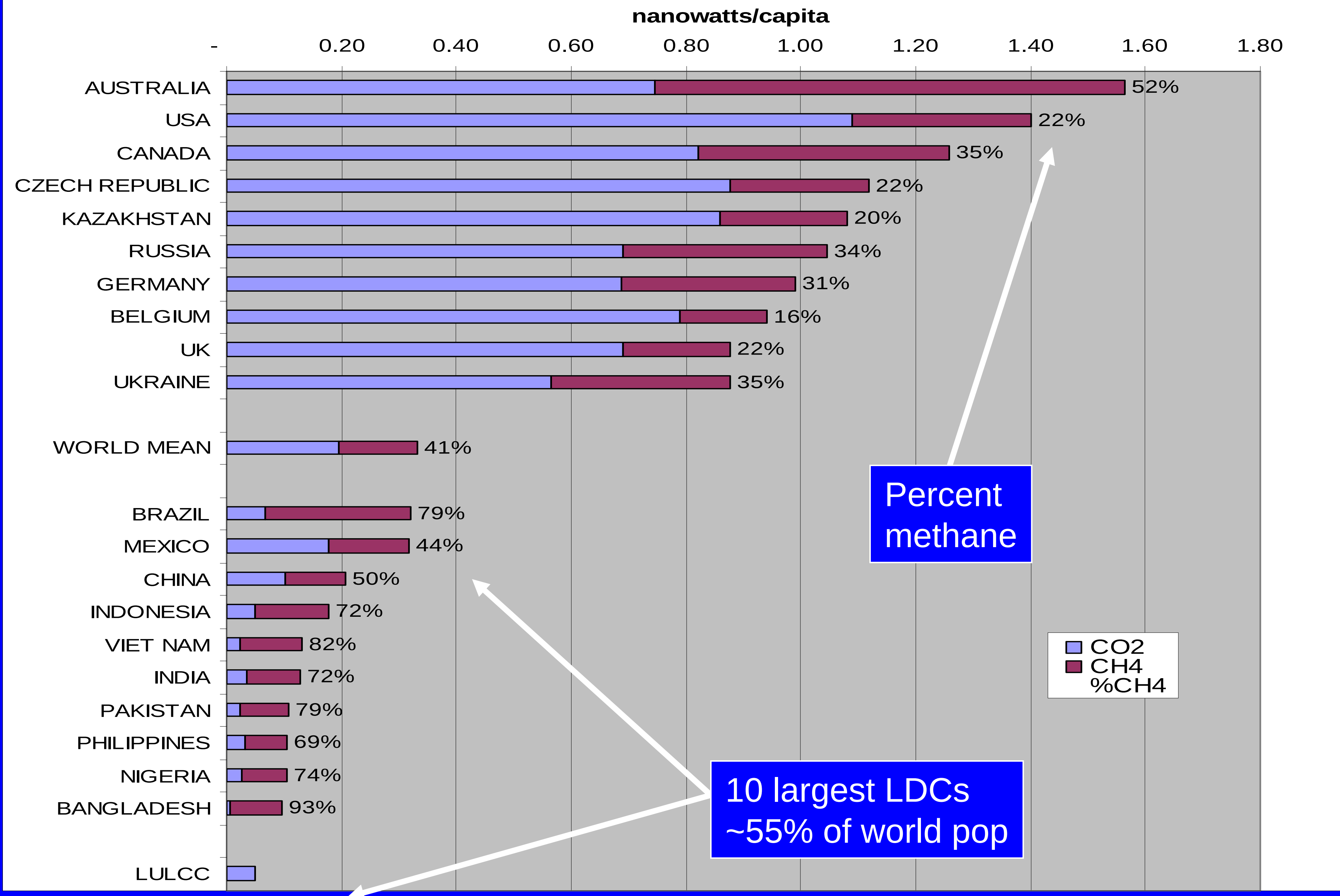
Smith and Rogers, in preparation



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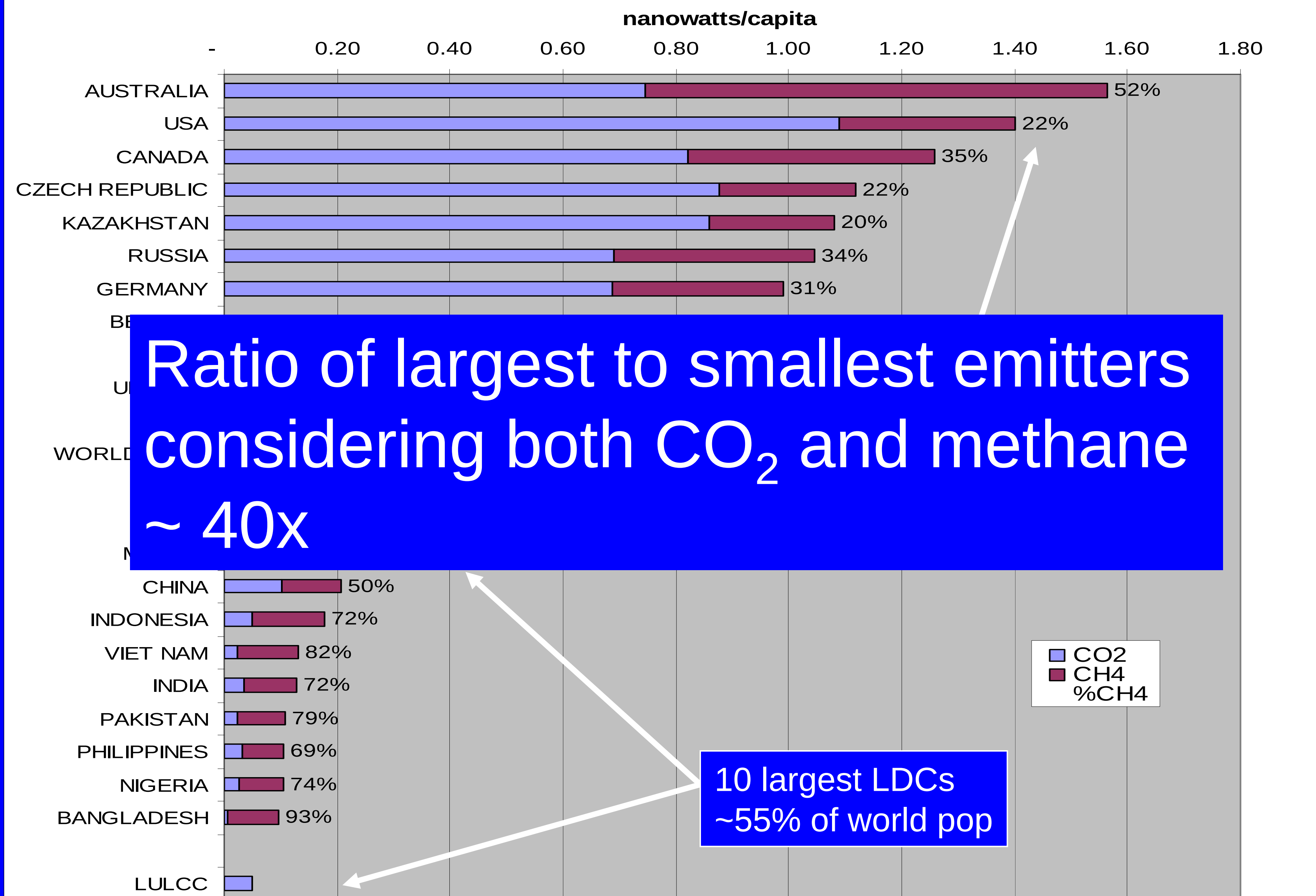
Smith and Rogers, In preparation



Ratio of largest to smallest emitters considering both CO_2 and methane ~ 40x

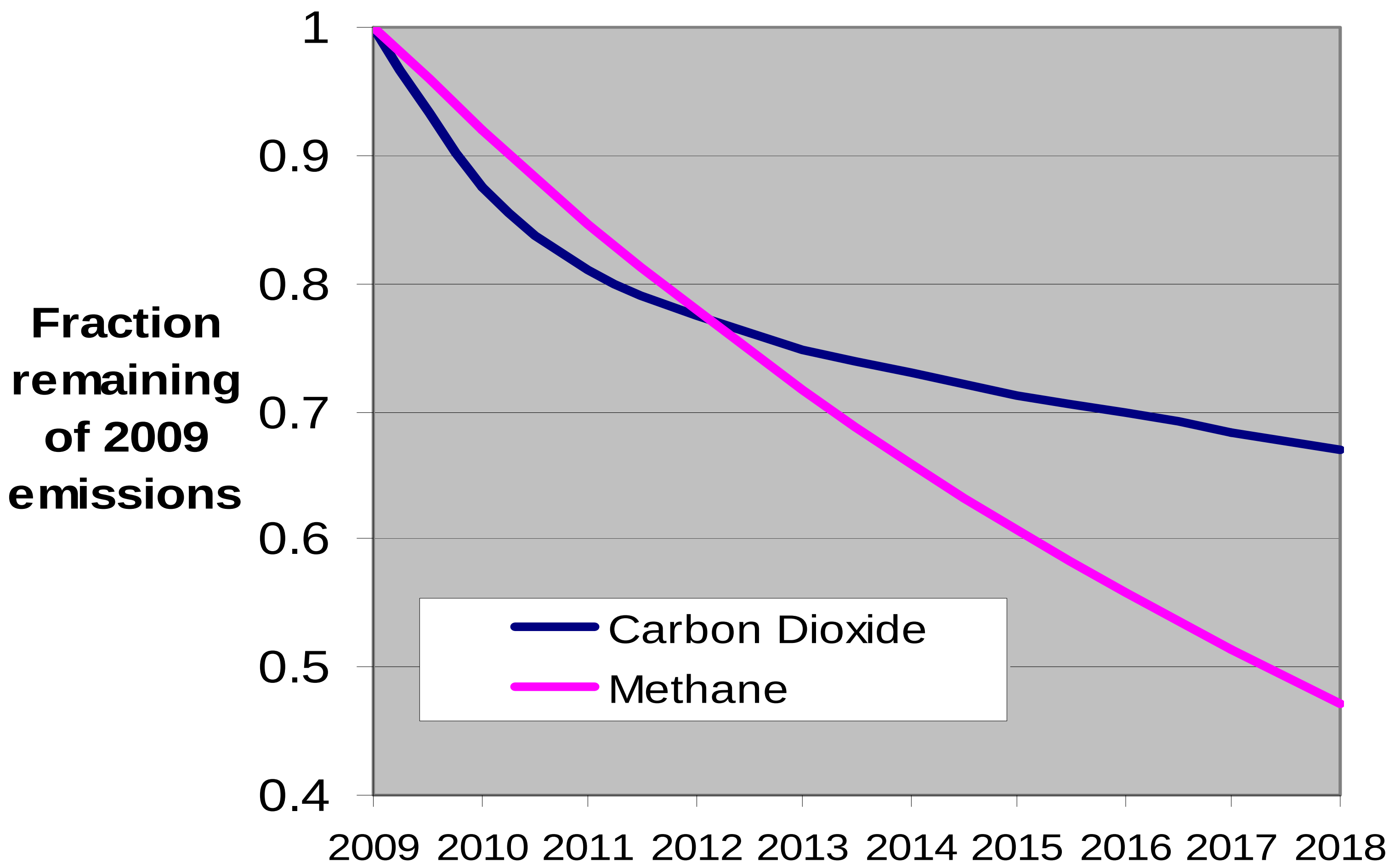
Smith and Rogers, In preparation

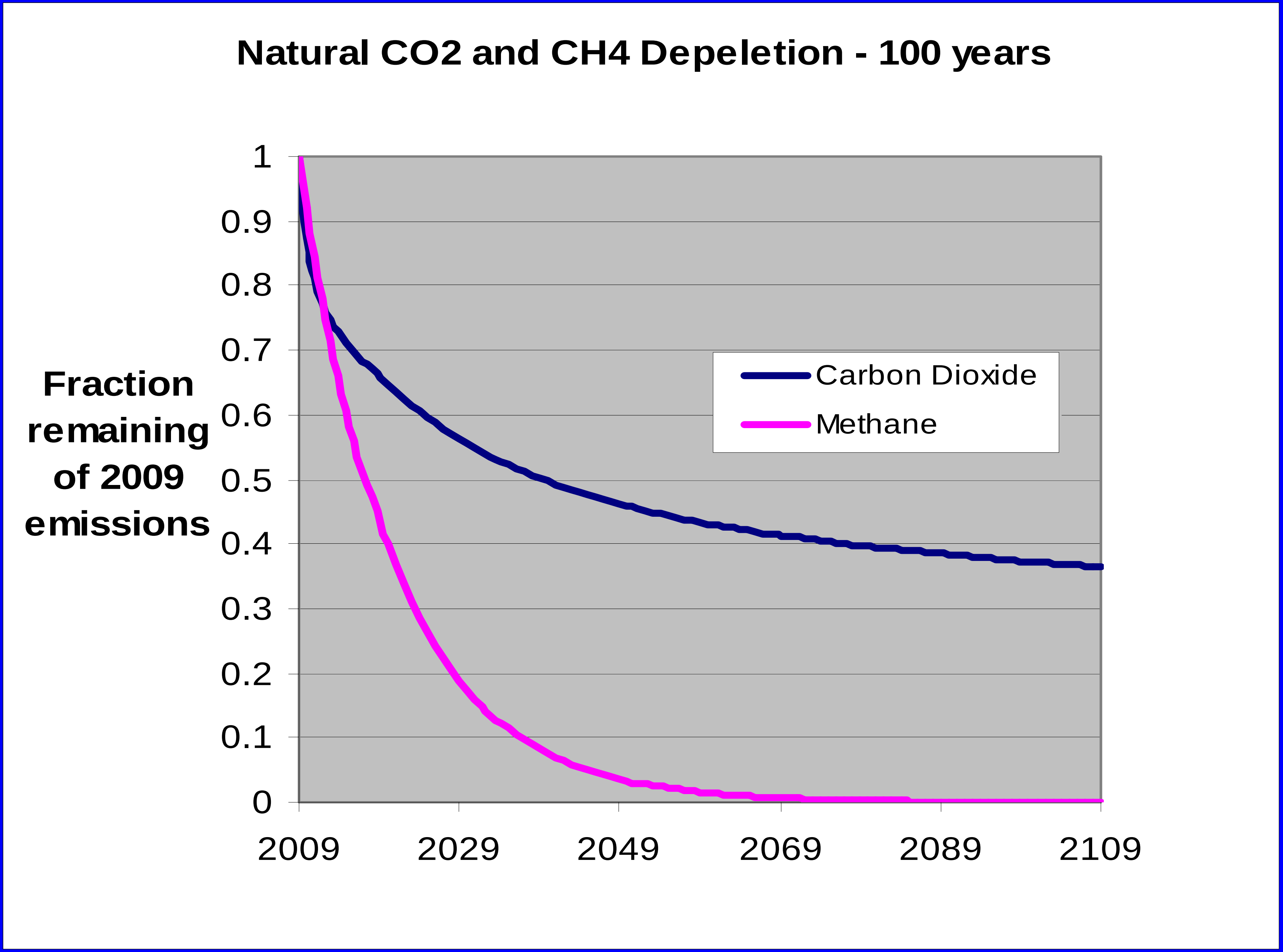
Math of GHG Decay (AR4)

- 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





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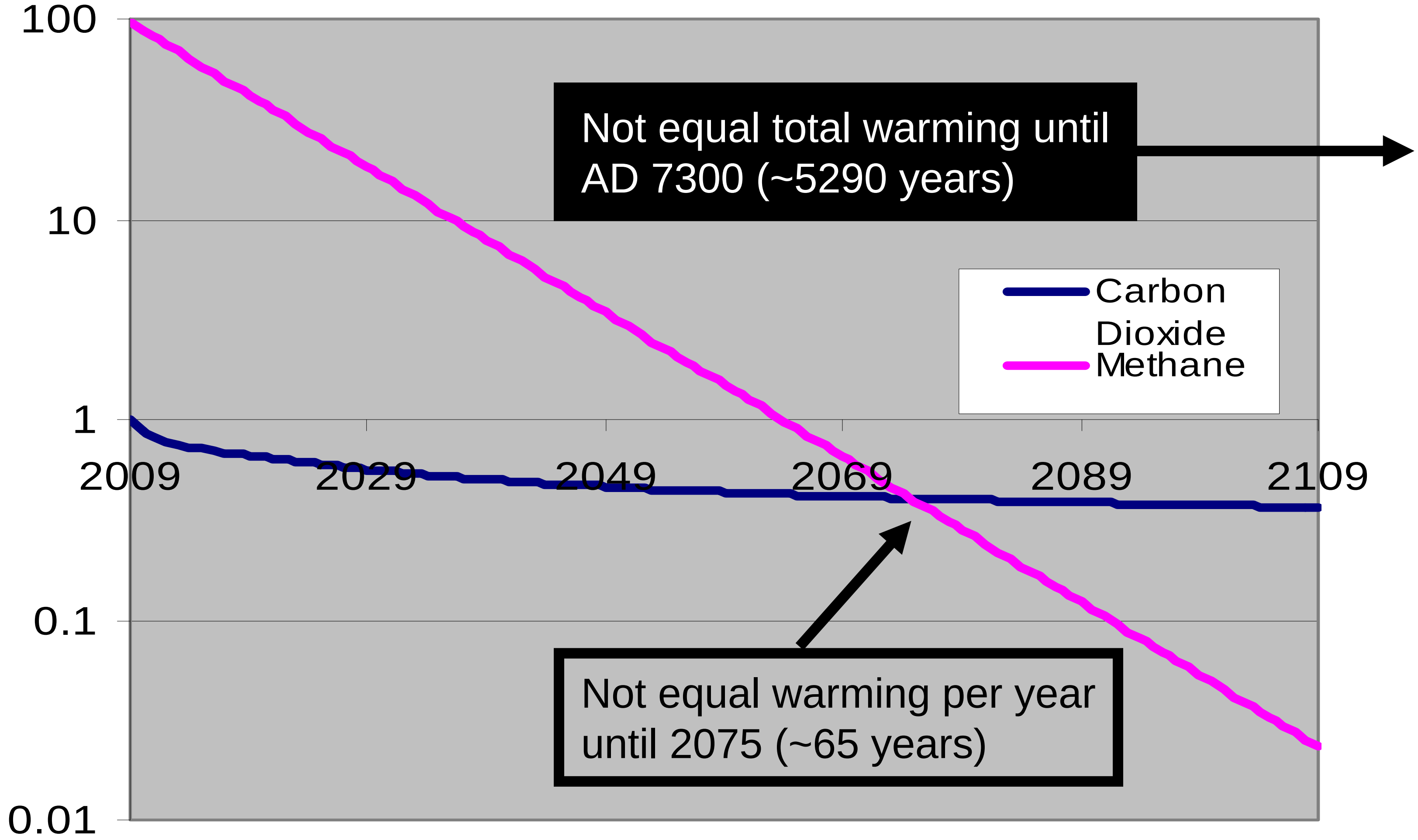
Relative Warming from CO2 and CH4 emitted in 2009 (one ton of each)

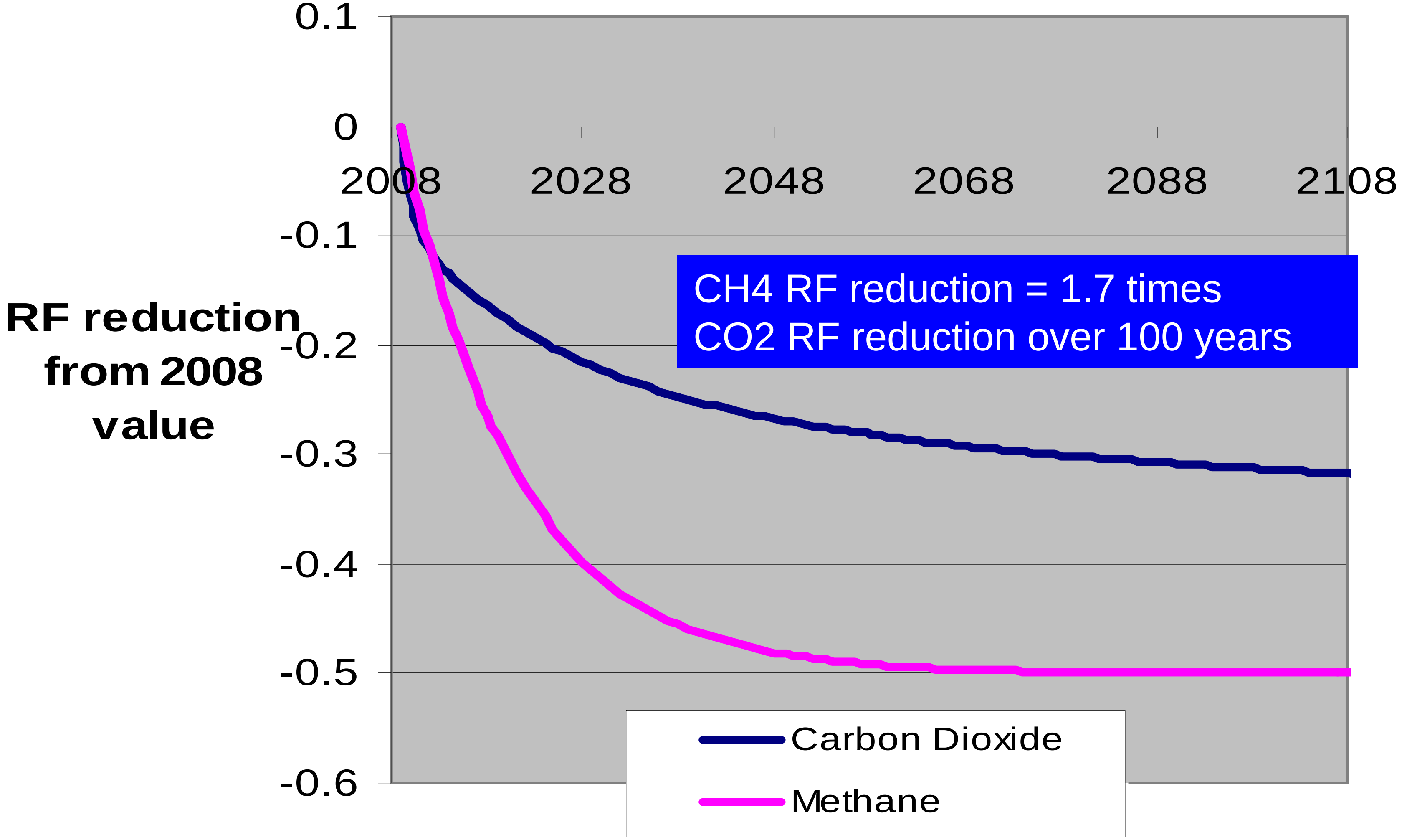


Hypothetical Choice of Interventions

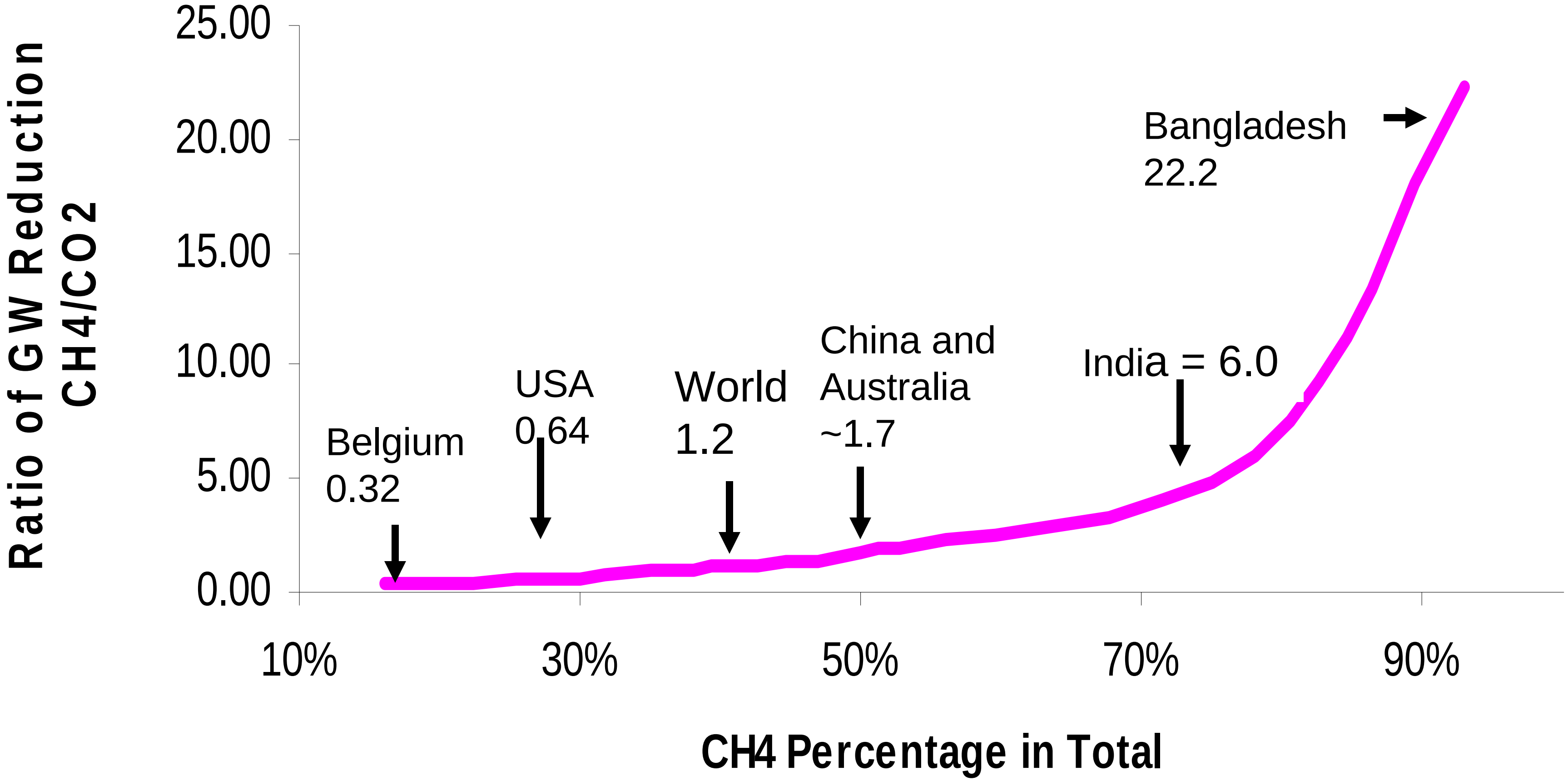
1. Stop emitting CH_4 today for rest of century
2. Stop emitting CO_2 today for rest of century

- Which will produce the biggest drop in integrated radiative forcing over a century?

Interventions for China and Australia Where CH4=CO2 in 2005



Amount of Warming Reduction in 100 Years: Comparison of CH4 and CO2

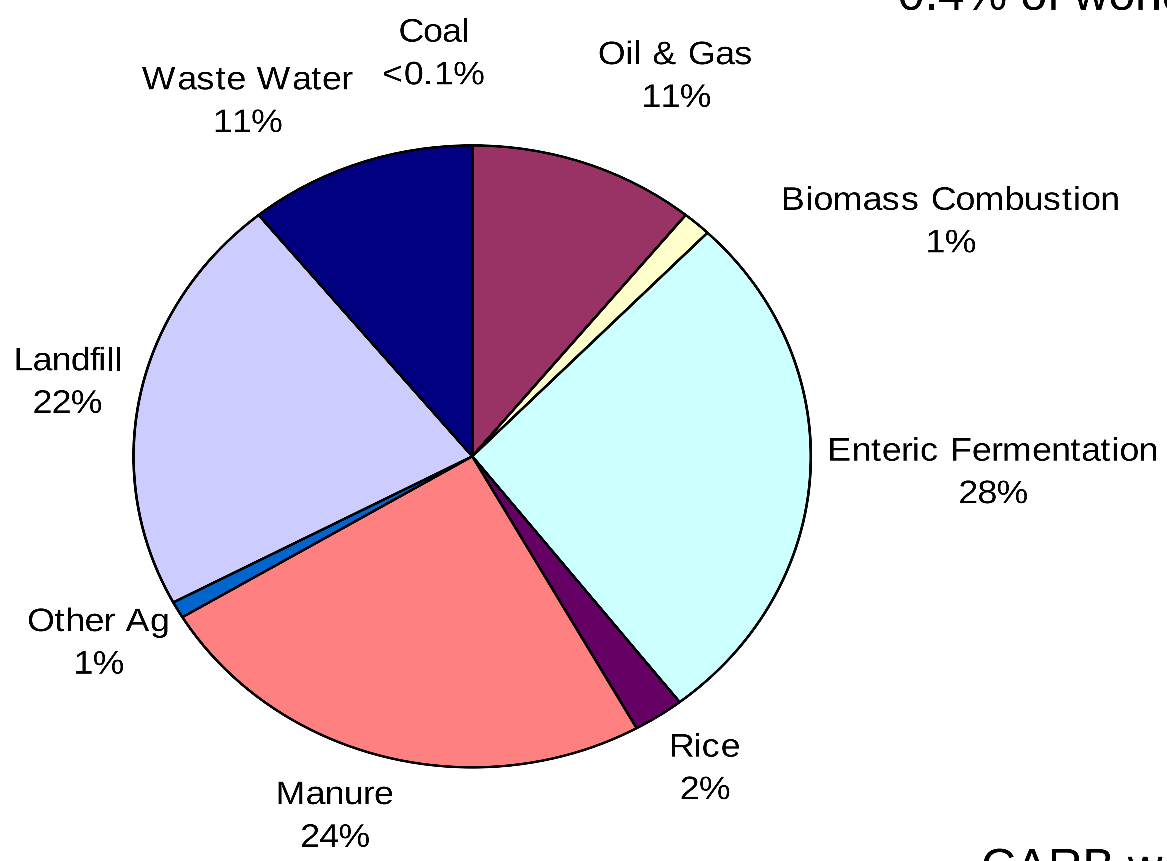


California Methane Emissions
2005 – 1.26 MT

CA = 35 kg/capita

USA = 83 kg/cap

0.4% of world



CARB website

THE ANTHROPOGENIC GREENHOUSE ERA
BEGAN THOUSANDS OF YEARS AGO

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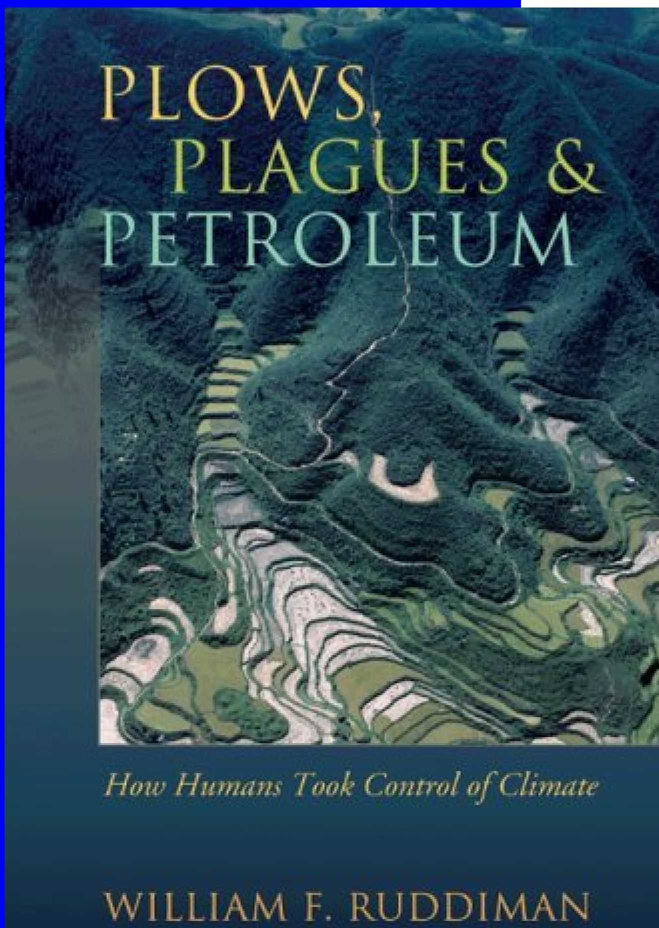
Climatic Change **61**: 261–293, 2003.



Princeton U Press, 2006

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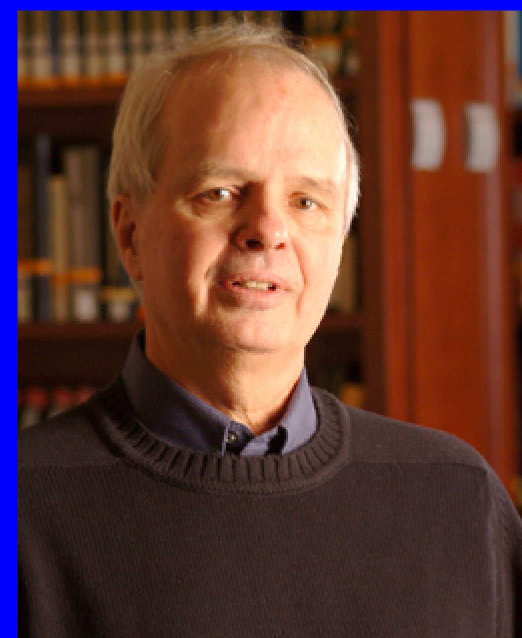

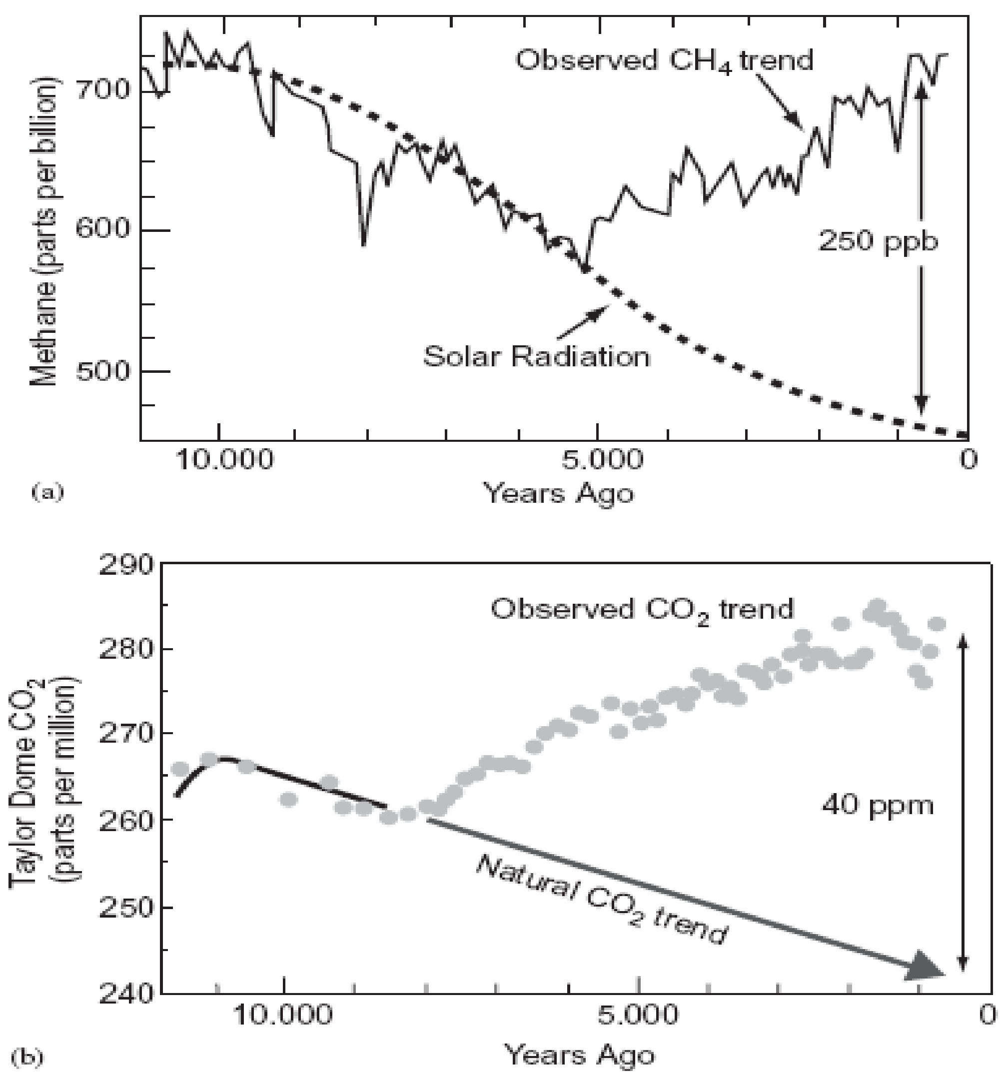

Fig. 1. Anthropogenic effects on (a) CH_4 and (b) CO_2 calculated as the difference between observed trends (Blunier et al., 1995; Indermuhle et al., 1999) and trends estimated from previous early interglacial intervals (Ruddiman, 2003).

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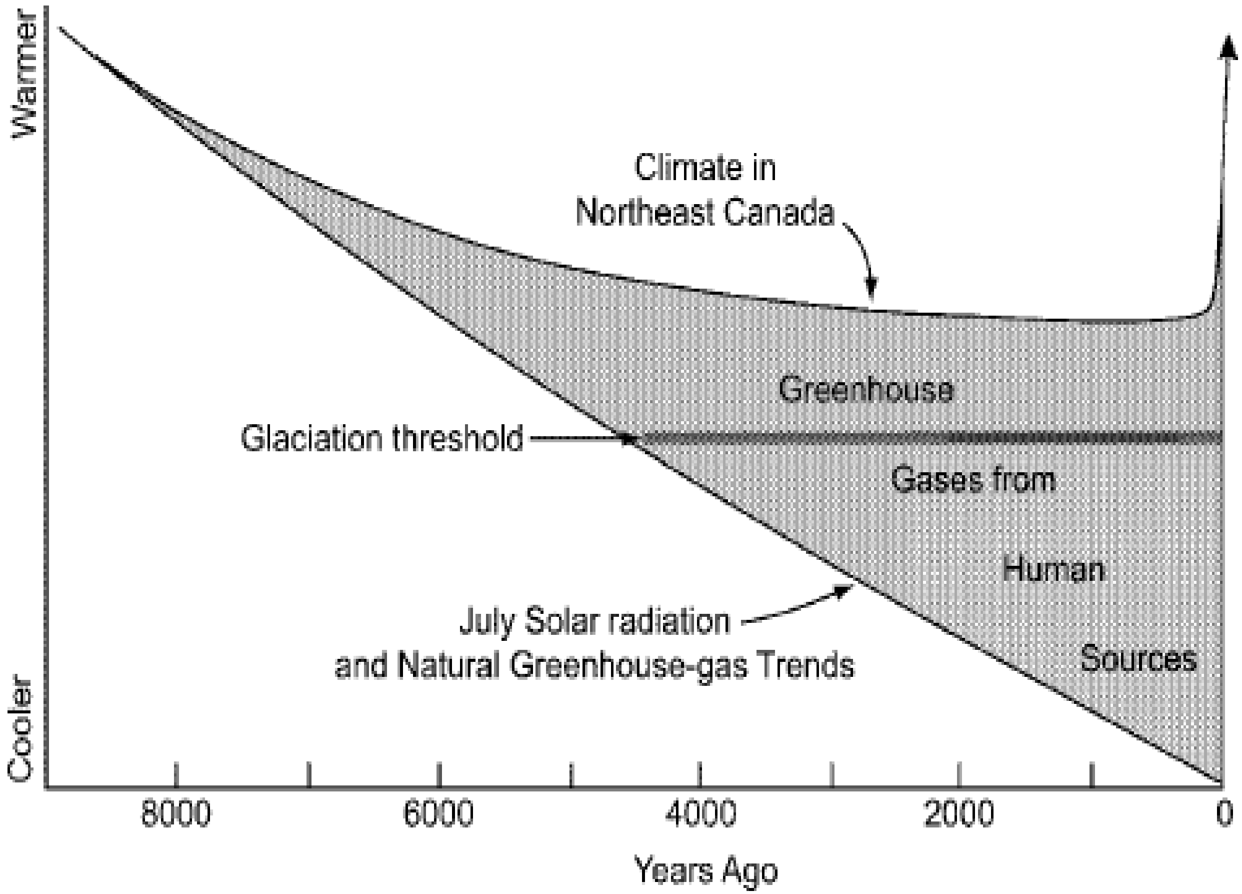
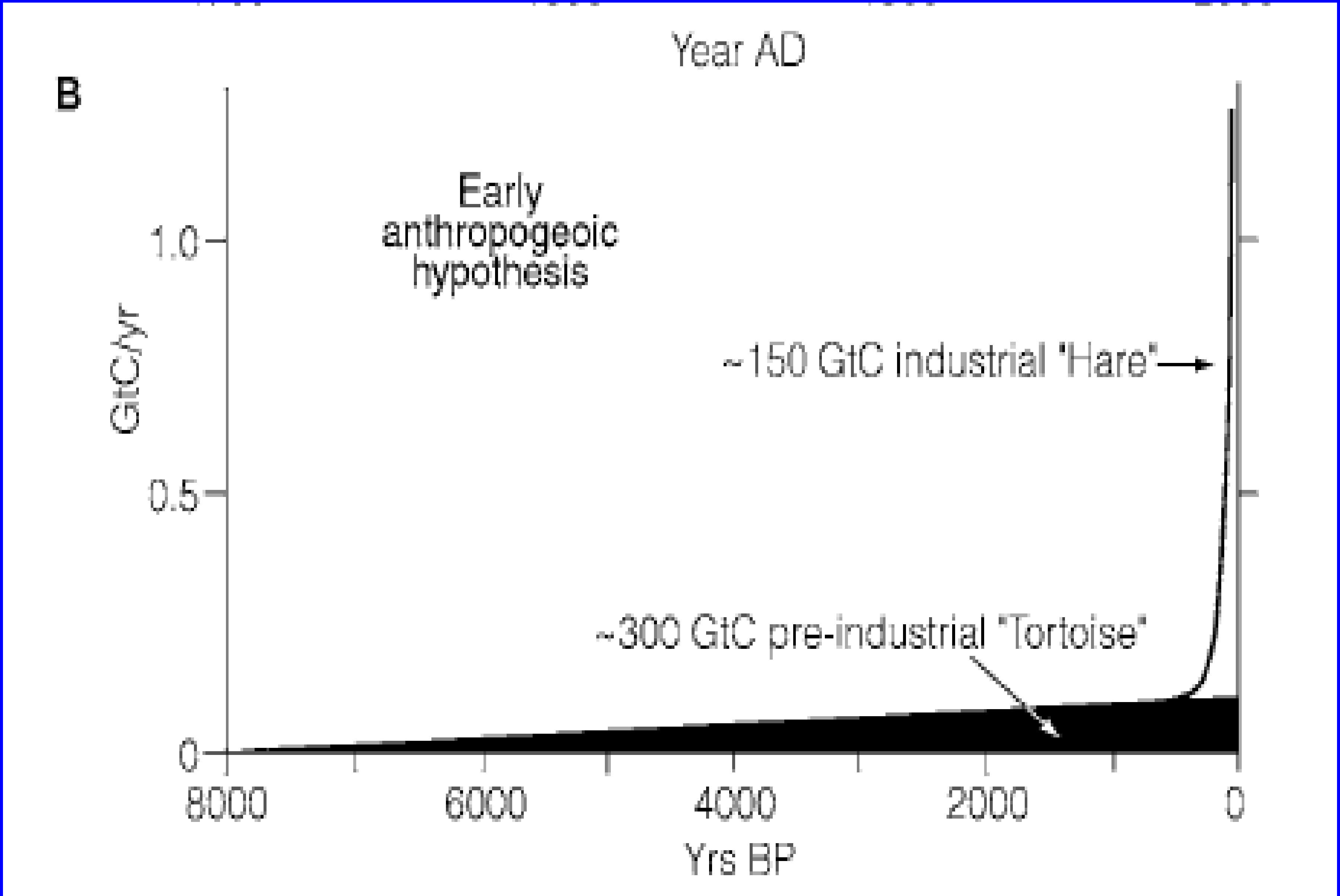


Figure 9. The natural summer cooling driven by Holocene insolation and greenhouse-gas trends should have produced a new glaciation by ~5000–4000 years ago. Early anthropogenic emissions of CO_2 and methane kept climate warm enough in northeastern Canada to prevent glaciation.

Ruddiman 2003



Ruddiman 2003

Historical Framework

- Human societies have been contributing to incipient climate change for several millennia.
- Reversing what would have been a natural decline in CO_2 and methane in this period
- Contributing substantial CO4 and CH4, but also BC-OC, VOC, and CO
- Excess GHGs are not just a feature of industrialization, but of human activates since at least the control of fire.
- However, the rate has risen dramatically after the industrial revolution, which also corresponded to great increases in population.

Laws of Carbon-thermodynamics

I. Keep all fossil and forest carbon out of the atmosphere

II. If you cannot do so, the least-damaging form to release is carbon dioxide because all other forms are worse for climate and health.

III. Even renewable (non-fossil) carbon is damaging for climate and health if not released as carbon dioxide.

Ranking of Carbon Emissions:
The Pharmaceutical Index

- Carbon dioxide is noxious if fossil or forest derived, but benign if from renewable sources
- Products of incomplete combustion (PIC) such as carbon monoxide and hydrocarbons are like CO_2 on caffeine – several times worse
- Methane from any source (fossil, biologic, or incomplete combustion) is like CO_2 on steroids – dozens of times worse.
- Black carbon in particles from incomplete combustion is like CO_2 on crack – hundreds of times worse.

Conclusions

- For good policy, need consistent frames to compare CAPs from an emissions (not atmospheric chemistry) standpoint
  - Controllable (may need to be revisited)
  - Post-industrial (how to deal with non-FF emissions not well developed)
- The metrics used to compare CAPs – Kyoto gases and 100-year time-horizons -- came out of the early 1990s when climate change seemed far off and less certain.
- Today, however, it seems to be neither, being demonstrateably upon us already
- More emphasis is thus needed to sustainably control shorter-lived CAPs because
  - These can achieve large reductions sooner in RF and,
  - Only their control can affect the rate of as well as the total warming
  - They also exert substantial human health and ecosystem impacts (cobenefits)

Conclusions, cont.

- Products of incomplete combustion -- BC, OC, CO, NMVOCs, however, are difficult to make policy for because
  - They so short lived as to not be globally mixed – difficult to treat in same framework as longer lived CAPs, such as CO2 and N2O
  - Their science is still quite uncertain, particularly for aerosols
  - Essentially all control measures affect multiple species at once
- Methane, however, holds a unique niche
  - High RF and large emissions: 2nd largest total impact after CO2
  - Relatively short-lived, but long-enough to be globally mixed – can be treated under existing framework
  - Two-thirds of its emissions are amenable to control measures using existing technology and policy tools, much at low cost
  - Interventions commonly target methane alone
- Adding in shorter-lived CAPs shifts the political landscape – more responsibility to LDCs in the case of methane, but also
  - Controls in LDCs wield greater leverage for making an impact – opportunities are greater and response to them faster than in rich ones

Publications and presentations available at

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

Thank you