Methane Natural Debt
and
Impacts on India's Workers
Of Extreme Climate Change

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Health Impacts, Adaptation, and Co-Benefits

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Centre for Science and Environment
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Allocating Responsibility for Global Warming: The Natural Debt Index

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

Cumulative Depleted Historical Emissions:

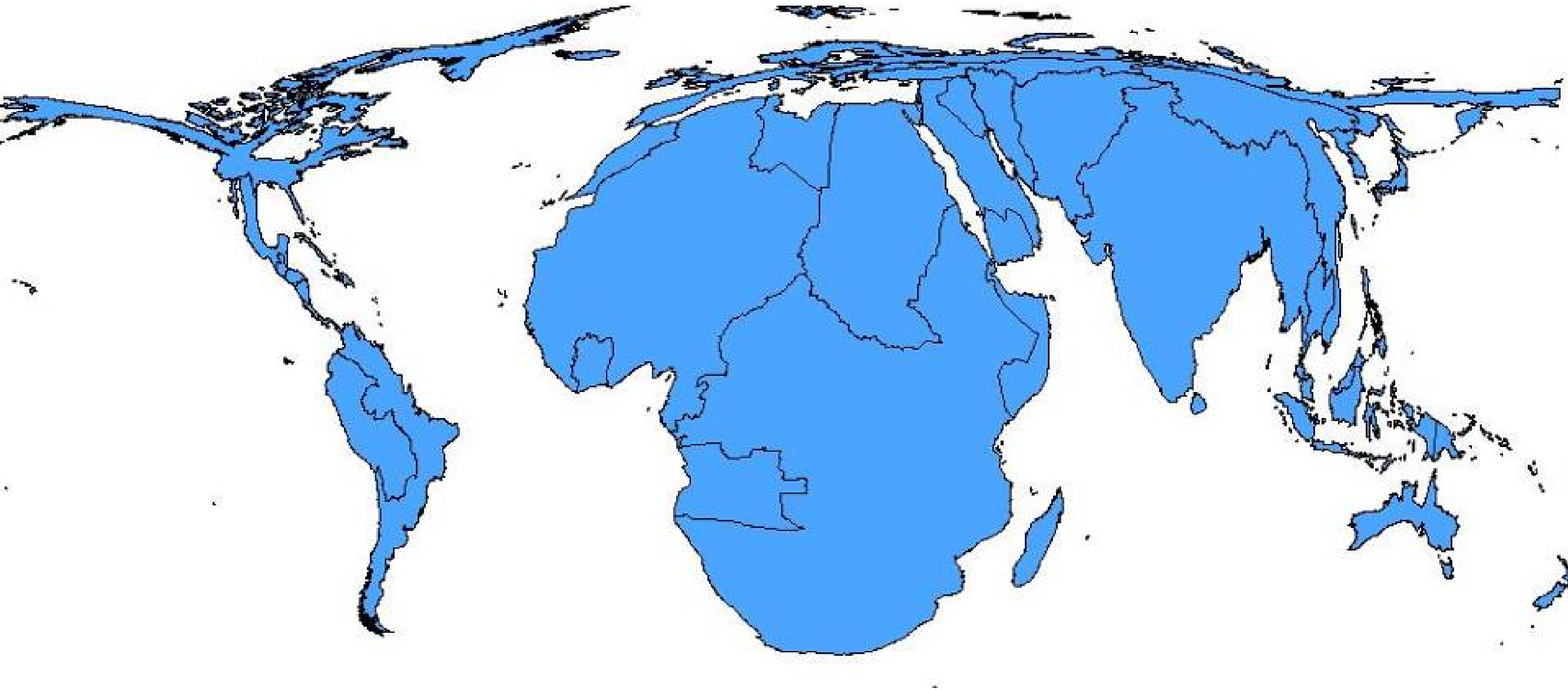
Surviving historical emissions as reduced by natural depletion mechanisms

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.

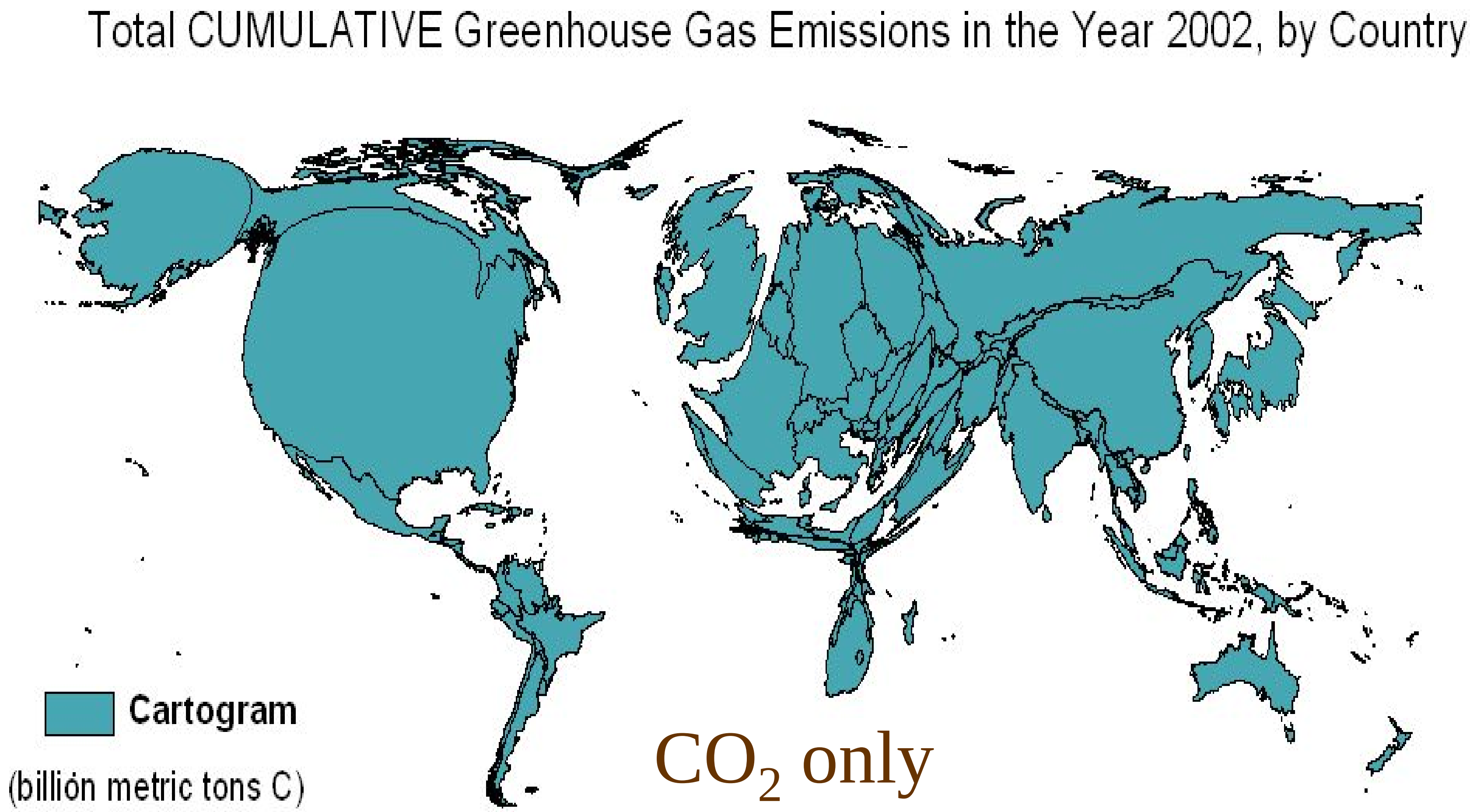
No matter what the feasibility of paying off all past debts, the basic point remains the same. Since the present economic status of most countries has been achieved partly by incurring natural debts, it seems only fair to allocate responsibility for whatever needs to be done by using indices that reflect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

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.

year



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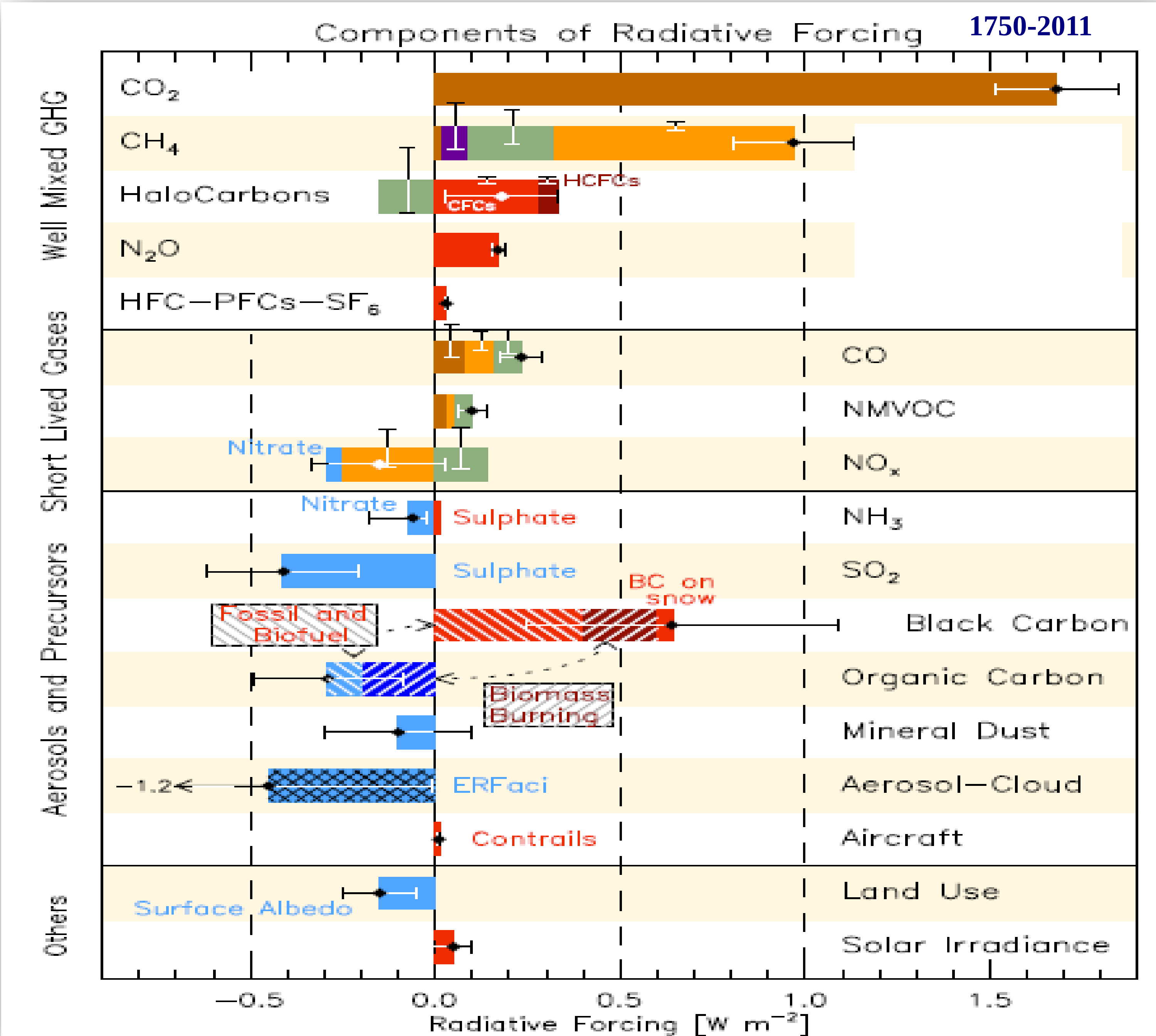
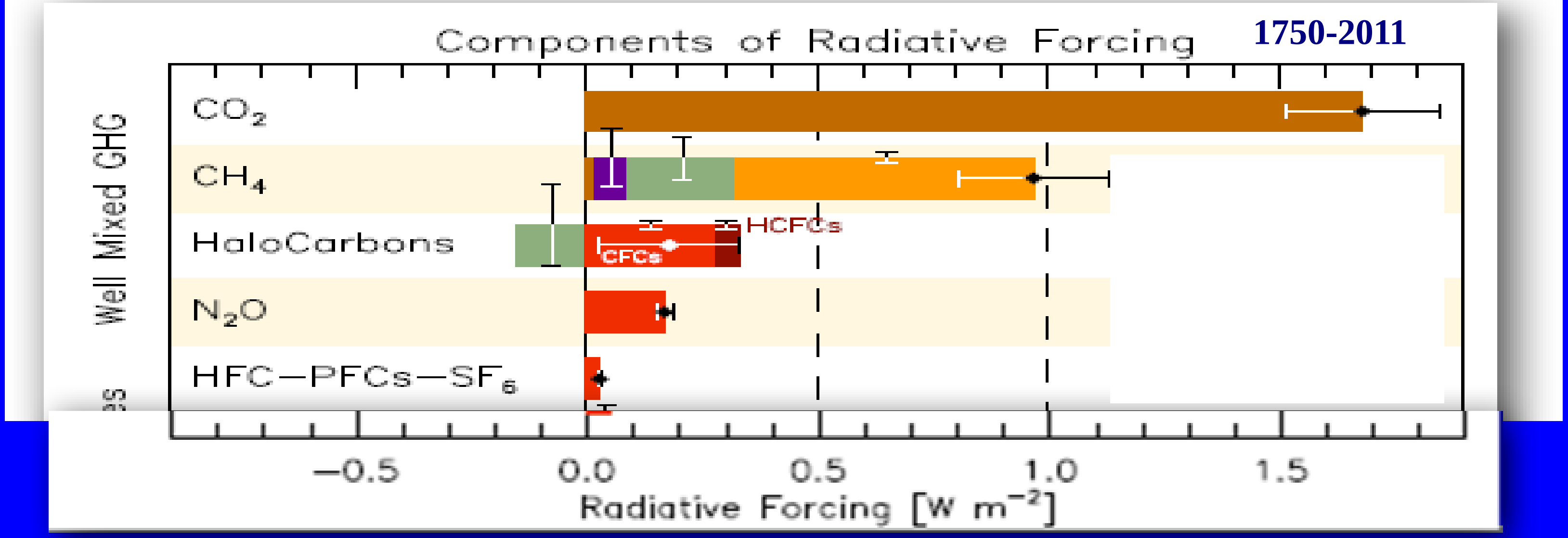


Components of Radiative Forcing
1750-2011
Well Mixed GHG
Short Lived Gases
Aerosols and Precursors
Others
CO2
CH4
HaloCarbons
HCFCs
CFCs
N2O
HFC–PFCs–SF6
CO
NMVOC
Nitrate
NOx
Nitrate
Sulphate
NH3
Sulphate
SO2
BC on snow
Fossil and Biofuel
Black Carbon
Organic Carbon
Biomass Burning
Mineral Dust
–1.2
ERFaci
Aerosol–Cloud
Contrails
Aircraft
Surface Albedo
Land Use
Solar Irradiance
–0.5
0.0
0.5
1.0
1.5
Radiative Forcing [W m–2]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CO2
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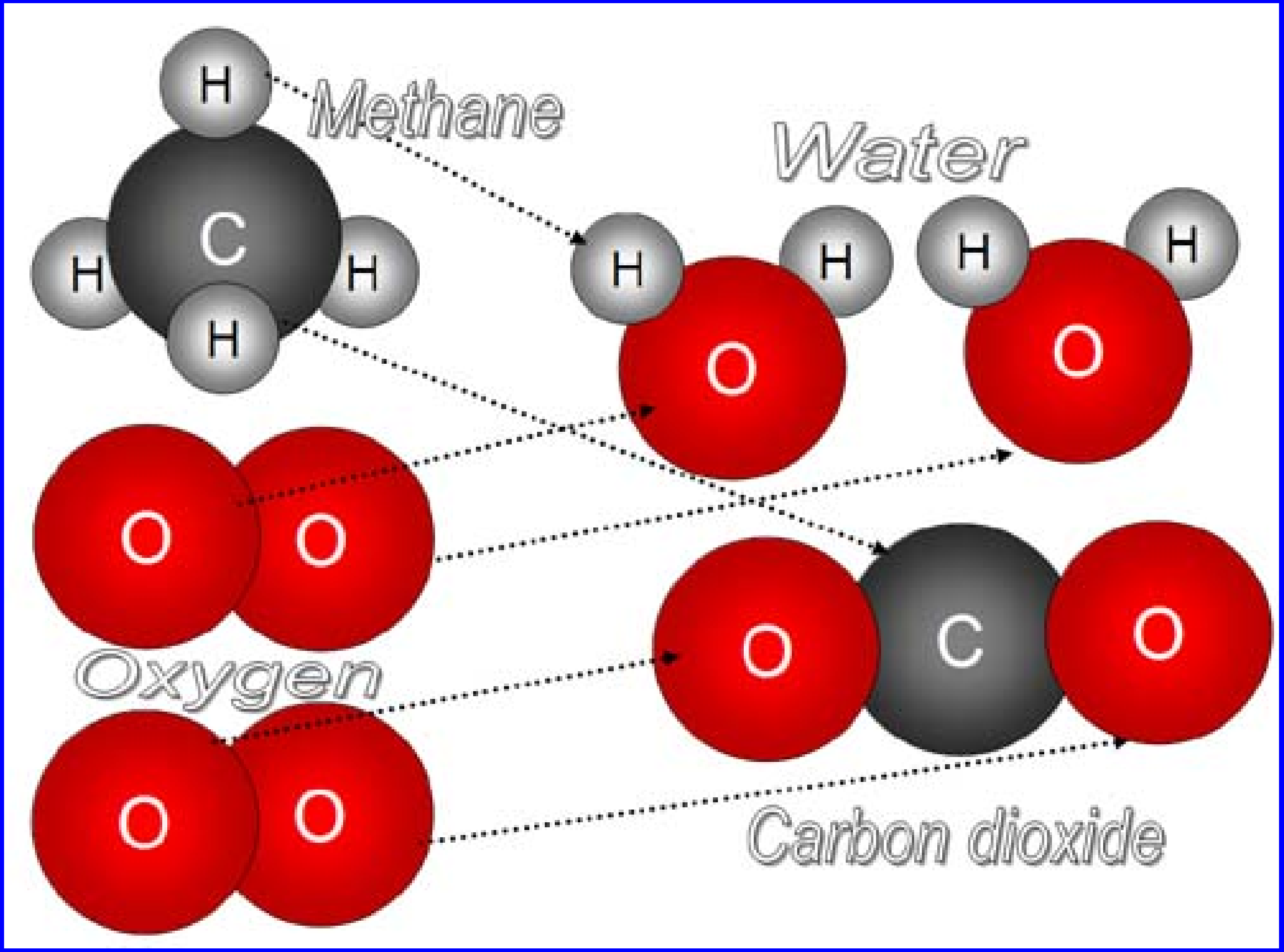
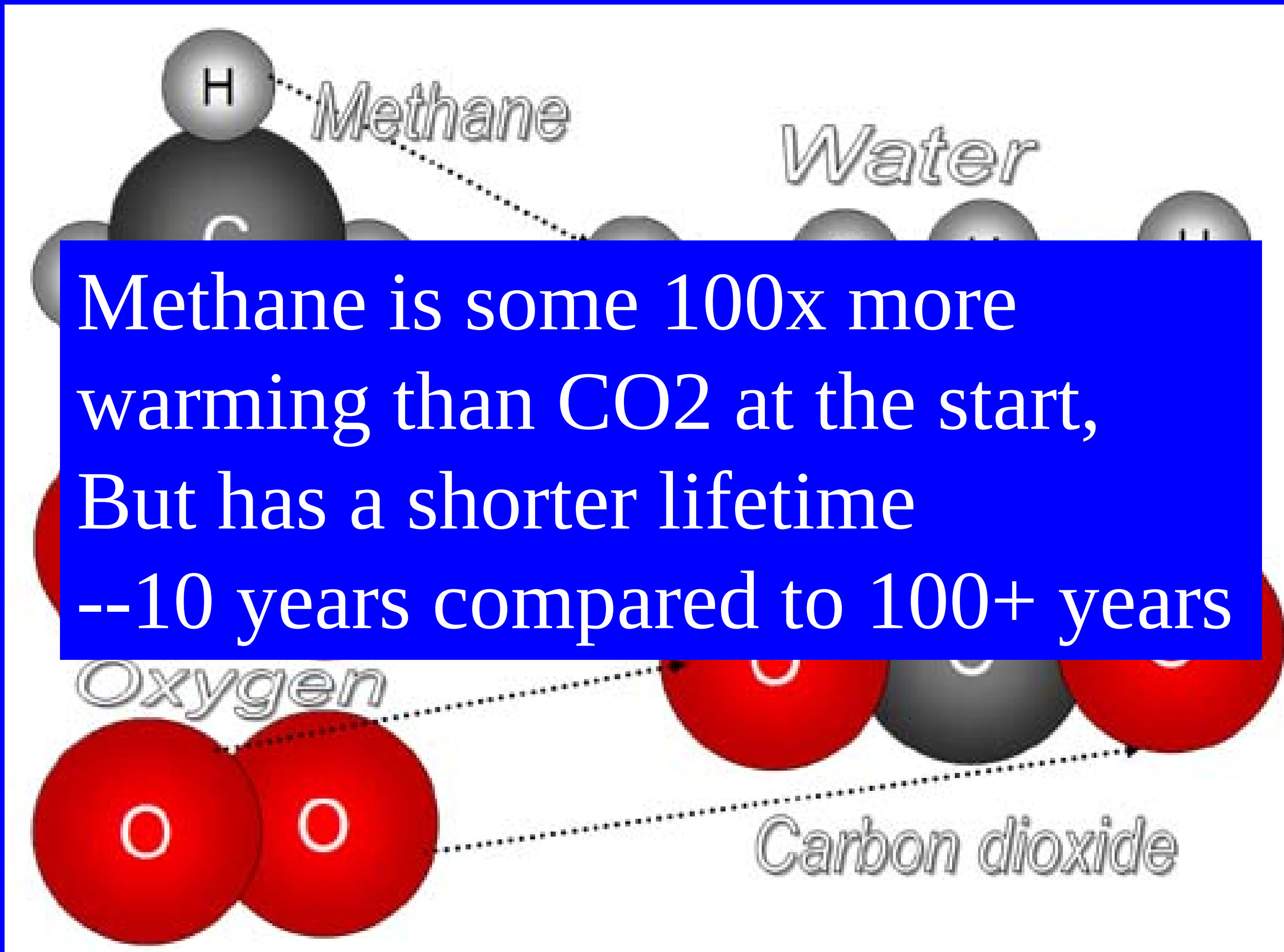
Radiative Forcing [W m−2]

WG1, AR5

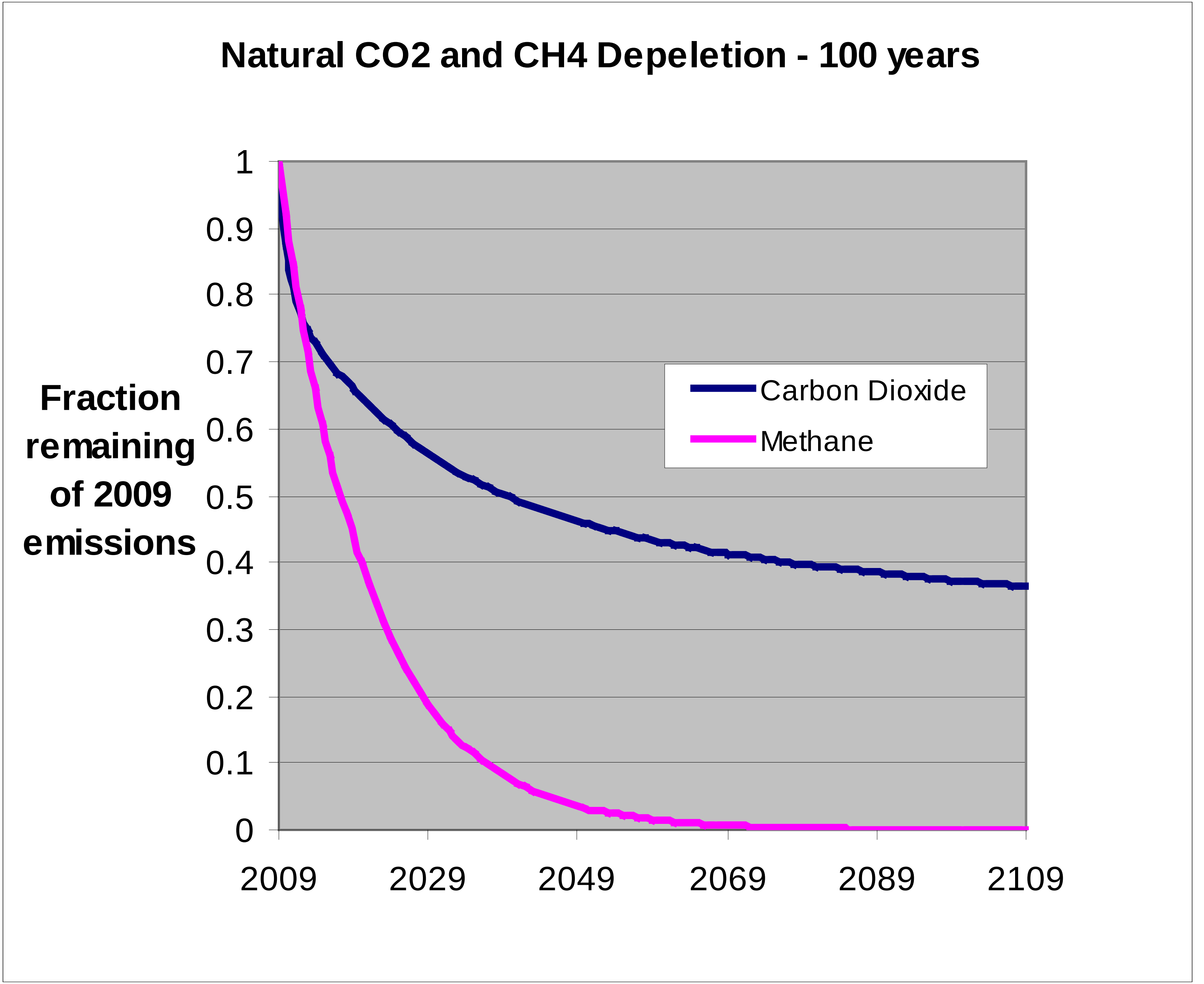
The Methane Story: CH_4



The Methane Story: CH_4



Methane is some 100x more warming than CO2 at the start,
But has a shorter lifetime
--10 years compared to 100+ years


Natural CO2 and CH4 Depeletion - 100 years
Fraction remaining of 2009 emissions
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2009
2029
2049
2069
2089
2109
Carbon Dioxide
Methane

Joint CO_2 and CH_4 accountability for global warming

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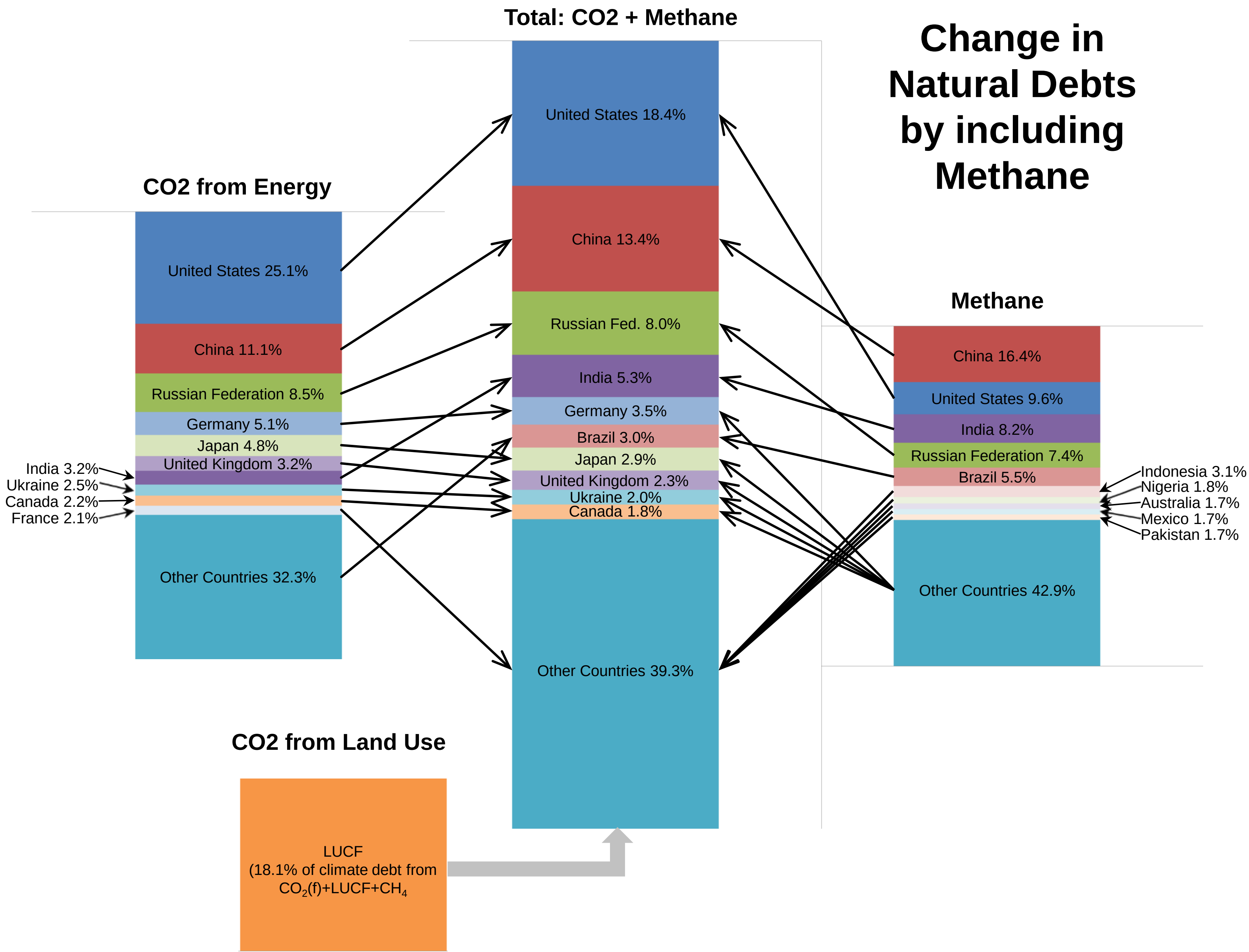
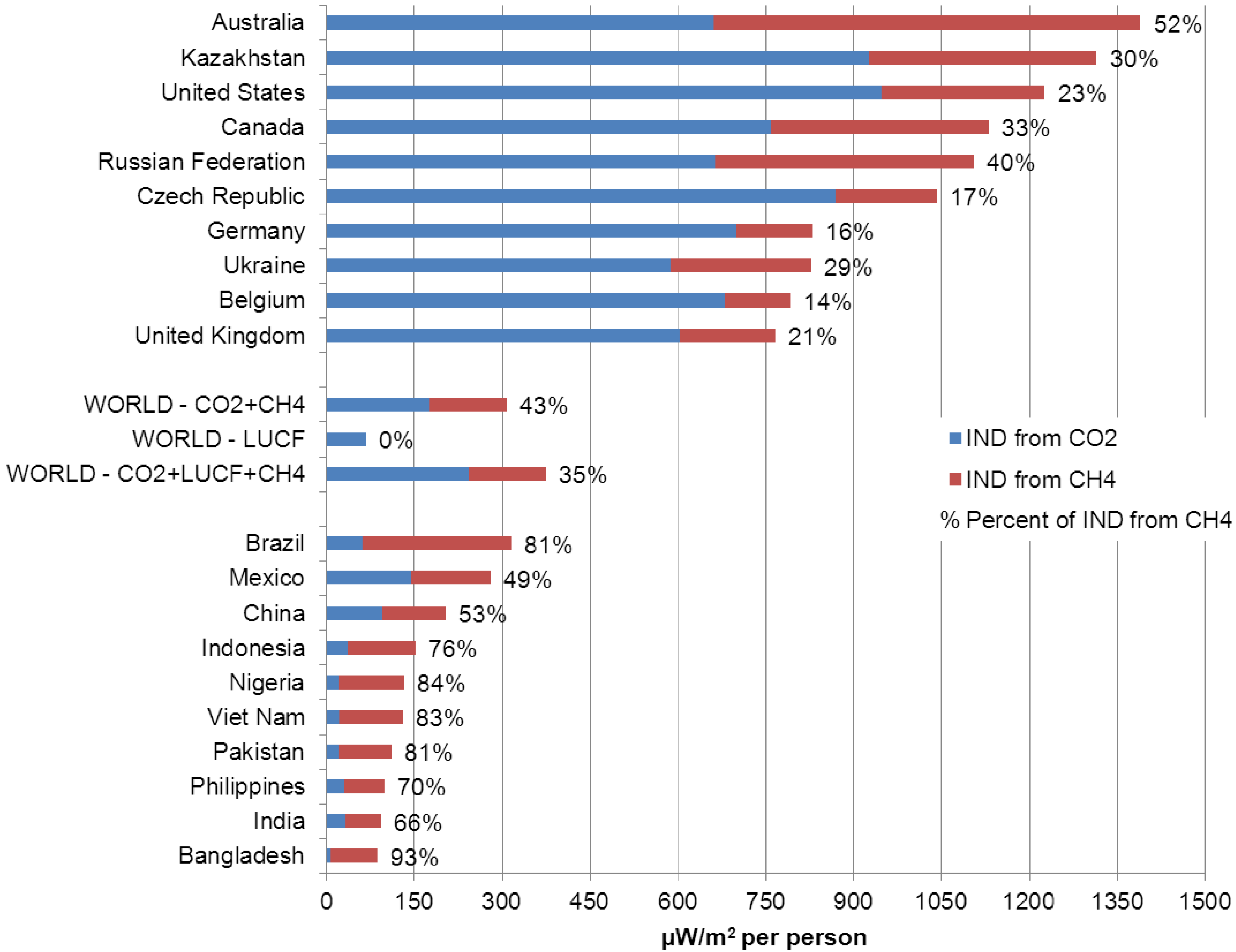
Proceedings of the (US) National Academy of Sciences, July 2013



Change in Natural Debts by including Methane
Total: CO2 + Methane
United States 18.4%
China 13.4%
Russian Fed. 8.0%
India 5.3%
Germany 3.5%
Brazil 3.0%
Japan 2.9%
United Kingdom 2.3%
Ukraine 2.0%
Canada 1.8%
Other Countries 39.3%
CO2 from Energy
United States 25.1%
China 11.1%
Russian Federation 8.5%
Germany 5.1%
Japan 4.8%
United Kingdom 3.2%
India 3.2%
Ukraine 2.5%
Canada 2.2%
France 2.1%
Other Countries 32.3%
Methane
China 16.4%
United States 9.6%
India 8.2%
Russian Federation 7.4%
Brazil 5.5%
Indonesia 3.1%
Nigeria 1.8%
Australia 1.7%
Mexico 1.7%
Pakistan 1.7%
Other Countries 42.9%
CO2 from Land Use
LUCF
(18.1% of climate debt from CO_2(f)+LUCF+CH_4

Natural Debt Per Capita



Multiple Benefits of Reducing Methane

Methane is the chief cause of widespread ozone pollution which damages human health, crops, and ecosystems

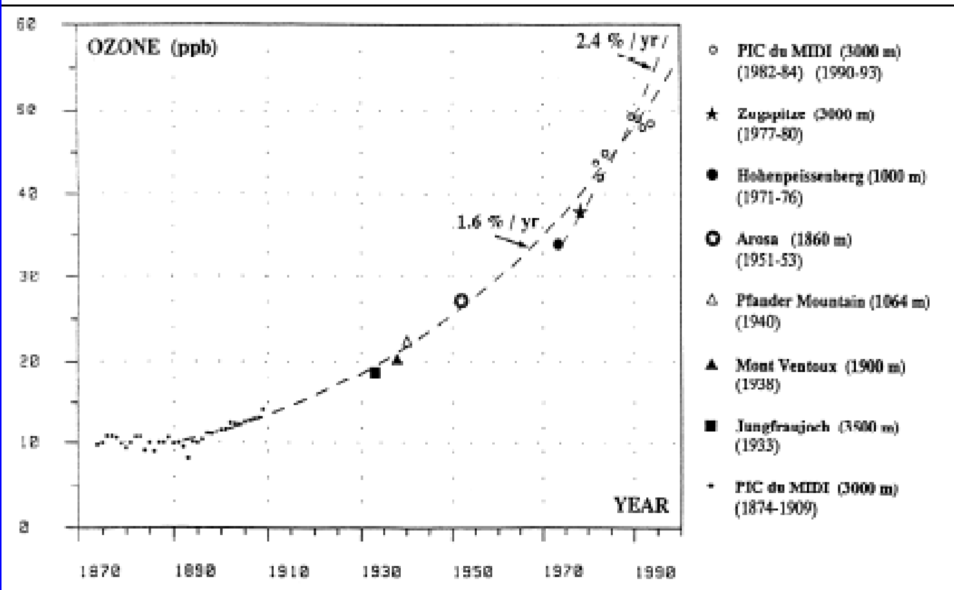
Reducing ~20% of anthropogenic methane emissions will:

- **Be possible at a net cost-savings.**
- **Reduce 8-hr. average ozone globally by ~1 ppb.**
- **Reduce global radiative forcing by ~0.14 W m^{-2}.**
- **Provide ~2% of global natural gas production.**
- **Prevent ~30,000 premature deaths globally in 2030, ~370,000 from 2010-2030.**

Mauzerall, 2007

Background Ozone is Growing …

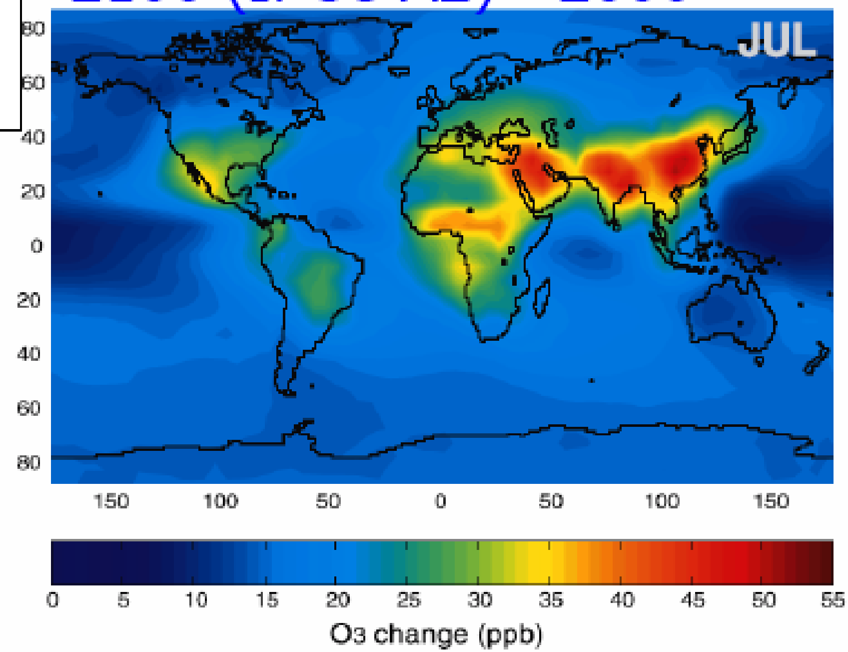
… and Will Continue to Grow!



Historic and future increases in background ozone are due mainly to increased methane and NO_X emissions (Wang *et al.*, 1998; Prather et al., 2003).

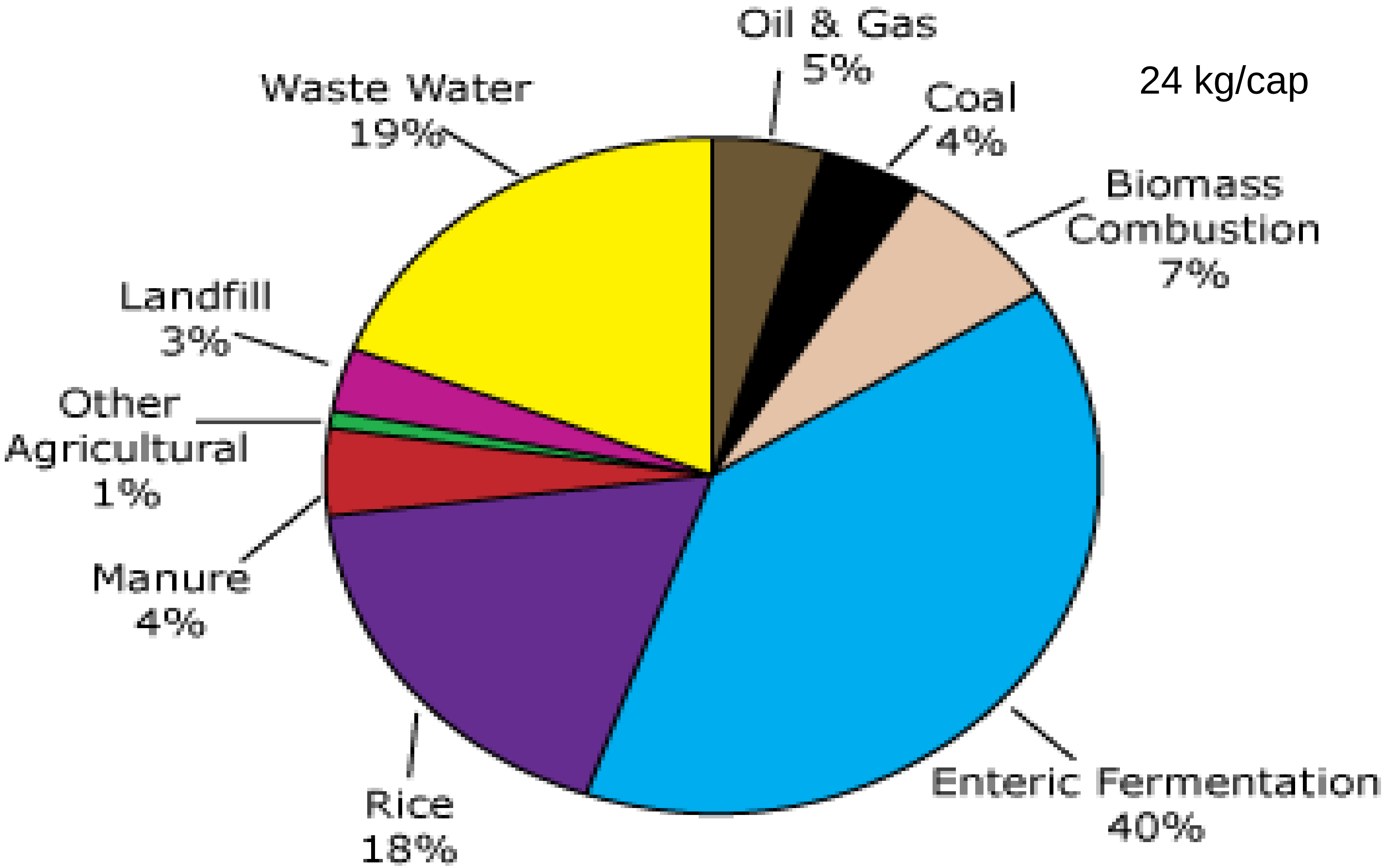
Ozone trend at European mountain sites, 1870-1990 (Marenco et al., 1994).

2100 (IPCC A2) - 2000



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

24 kg/cap



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

Methane Conclusions

- Methane holds a unique niche in climate change
  - High warming and large emissions: 2nd largest total impact after CO2
  - Relatively short-lived, but long-enough to be globally mixed – can be treated under existing frameworks
  - ~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, unlike those for black carbon
- Adding in shorter-lived climate-altering pollutants such as methane shifts the political landscape
  - More relative accountability for LDCs, but also
  - Controls in LDCs wield greater leverage for making an impact – opportunities are greater and response to them faster than in rich countries
  - More co-benefits – methane and all other SLCAPs have health impacts

What is possibly the largest economic impact of climate change as well as one of the major threats to health?

- Storms, floods, droughts, wildfires?
- Malaria, dengue, meningitis?
- Heat waves?
- Malnutrition?

Climate Vulnerability Monitor 2012, DARA

Estimates climate change impacts to 2030, US$ Billions

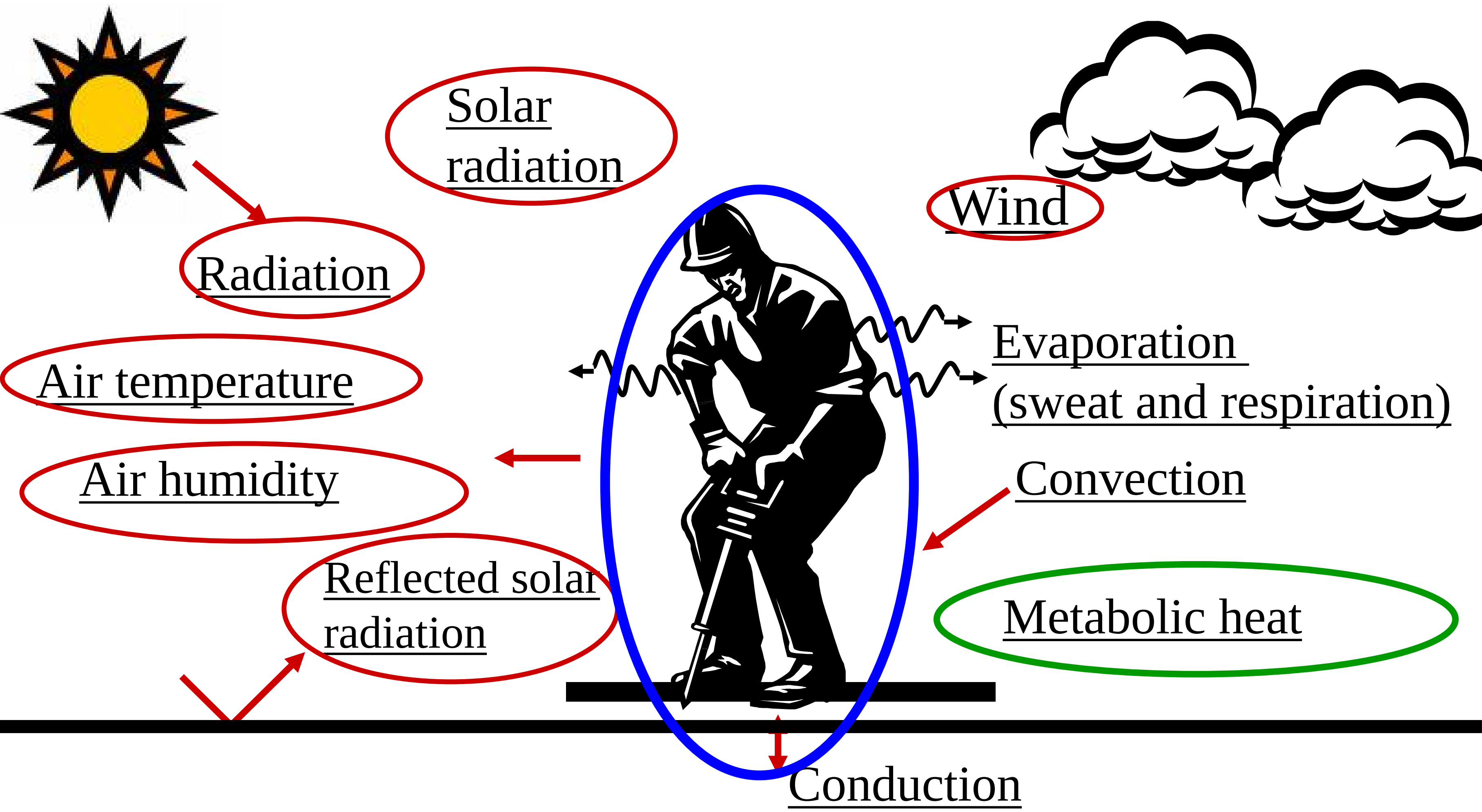
Impact component	Total global net cost; in brackets, % of total climate		Net cost in 2030 in specific country types		
	2010	**2030**	**Developing, low GHG emitters**	**Developing, high GHG emitters**	**Developed**
Total climate change costs	609 (100%)	4345 (100%)	1730(100%)	2292 (100%)	179 (100%)
Labor Productivity loss due to increased workplace heat	**311** (51%)	**2436** (56%)	1035(60%)	1364 (60%)	48 (27%)
Clinical Health impacts costs	23 (3.7%)	106 (2.4%)	84 (4.9%)	21 (0.9%)	0.002 (0.001%)

DARA Report, 2012

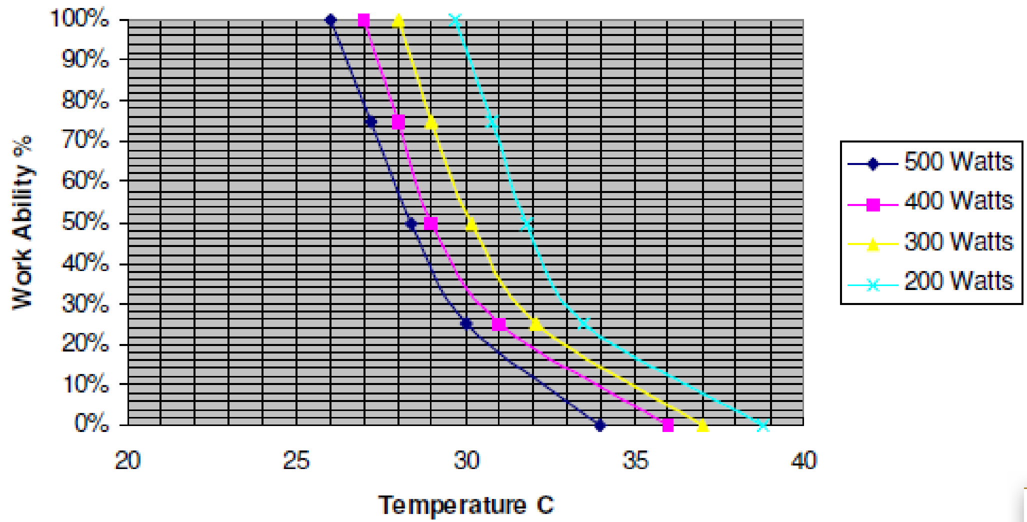
- Fractional increases in global temperature can translate into tens of additional hot days with each passing decade.
- (Loss of) labour productivity is estimated to result in the largest cost to the world economy of any effects analysed
- Trillions of US$ by 2030
- Not peer-reviewed and only one report, but indicates potential scale of the issue

Heat exchange of worker performing physical work in hot weather

Heat stress = Environmental + metabolic heat loads - heat loss



Work ability (%) as a function of WBGT (degr.C) at 4 work intensities (Watts), acclimatized



Wet Bulb Globe Temperature =

Function of

- temperature,
- humidity,
- wind speed, and
- radiative energy, e.g., sunlight

- Basic physics and human physiology from exposure chamber studies
- The science is 60 years old – US military research in the 1950s and much since
- **Refers to healthy workers – not the most vulnerable**

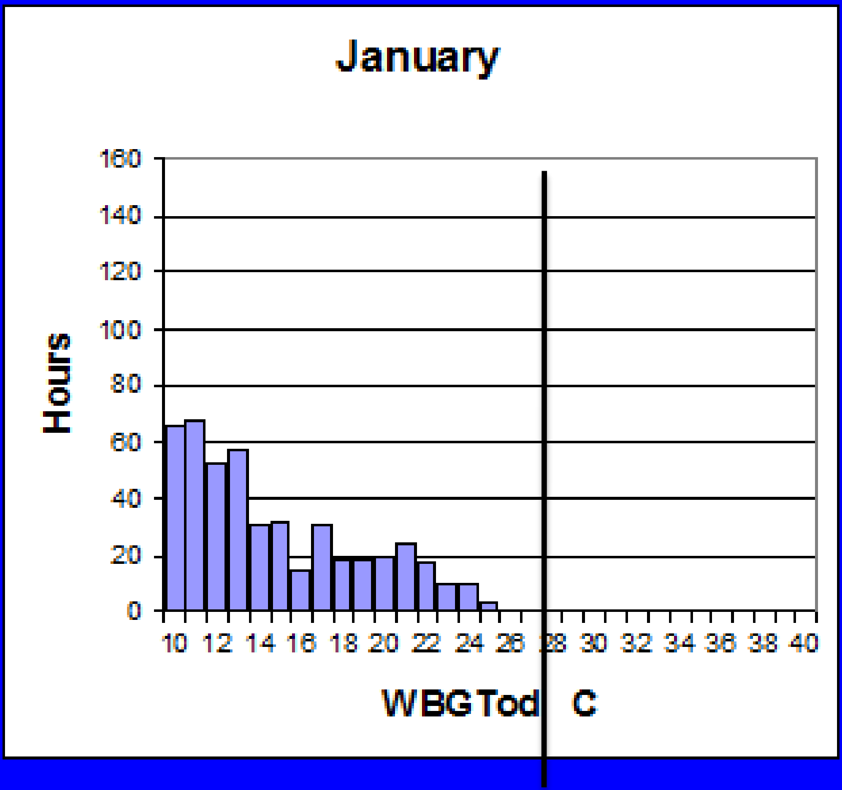
Effects of heat exposure

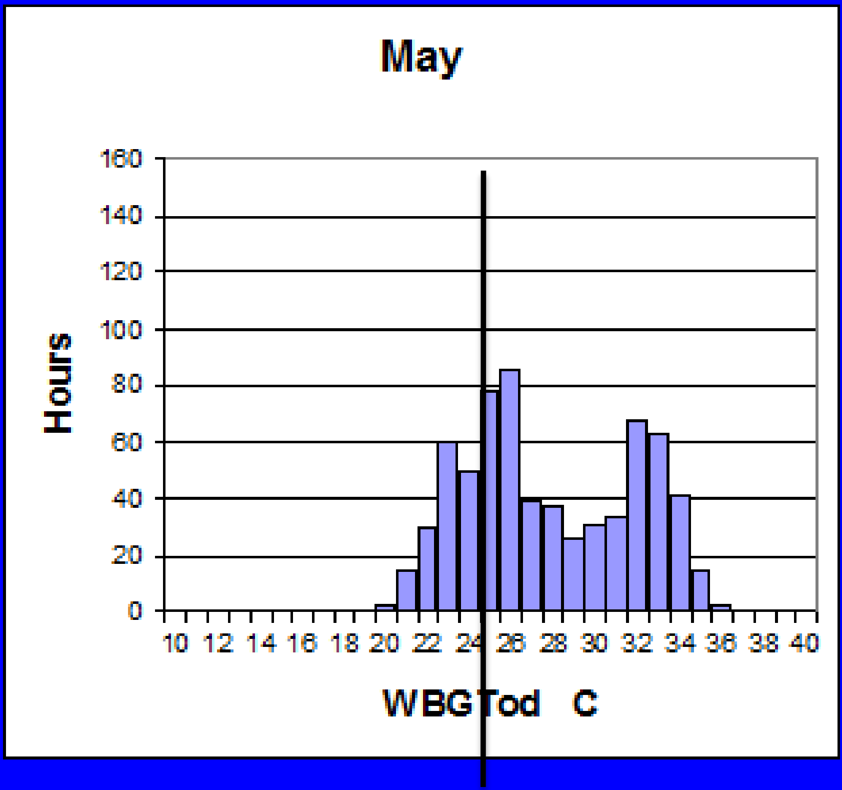
- Sweating, dehydration, salt loss
- Loss of ability to work intensively
- Loss of perceptual motor performance
- Increased accident risk

- Increased body temperature (>38 °C)
- Heat stroke
- Unconsciousness
- Death

Hourly heat exposure situation:

Heat index (WBGT) outdoors in Delhi, 1999. Hours each month at each WBGT level, January + May (coolest and hottest months). **WBGT = 26 ^{o}C cut-off point for work capacityimpact risk**

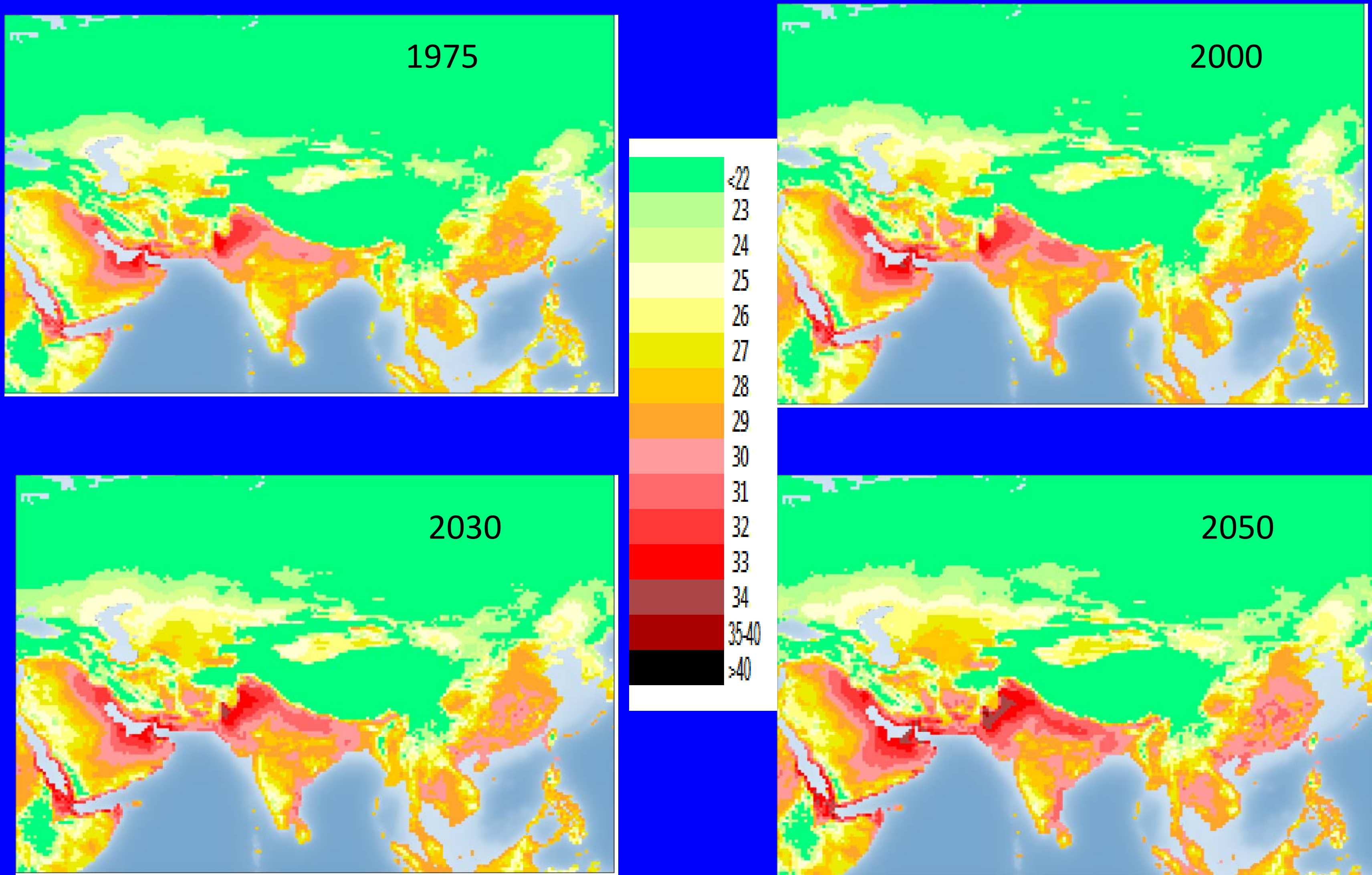




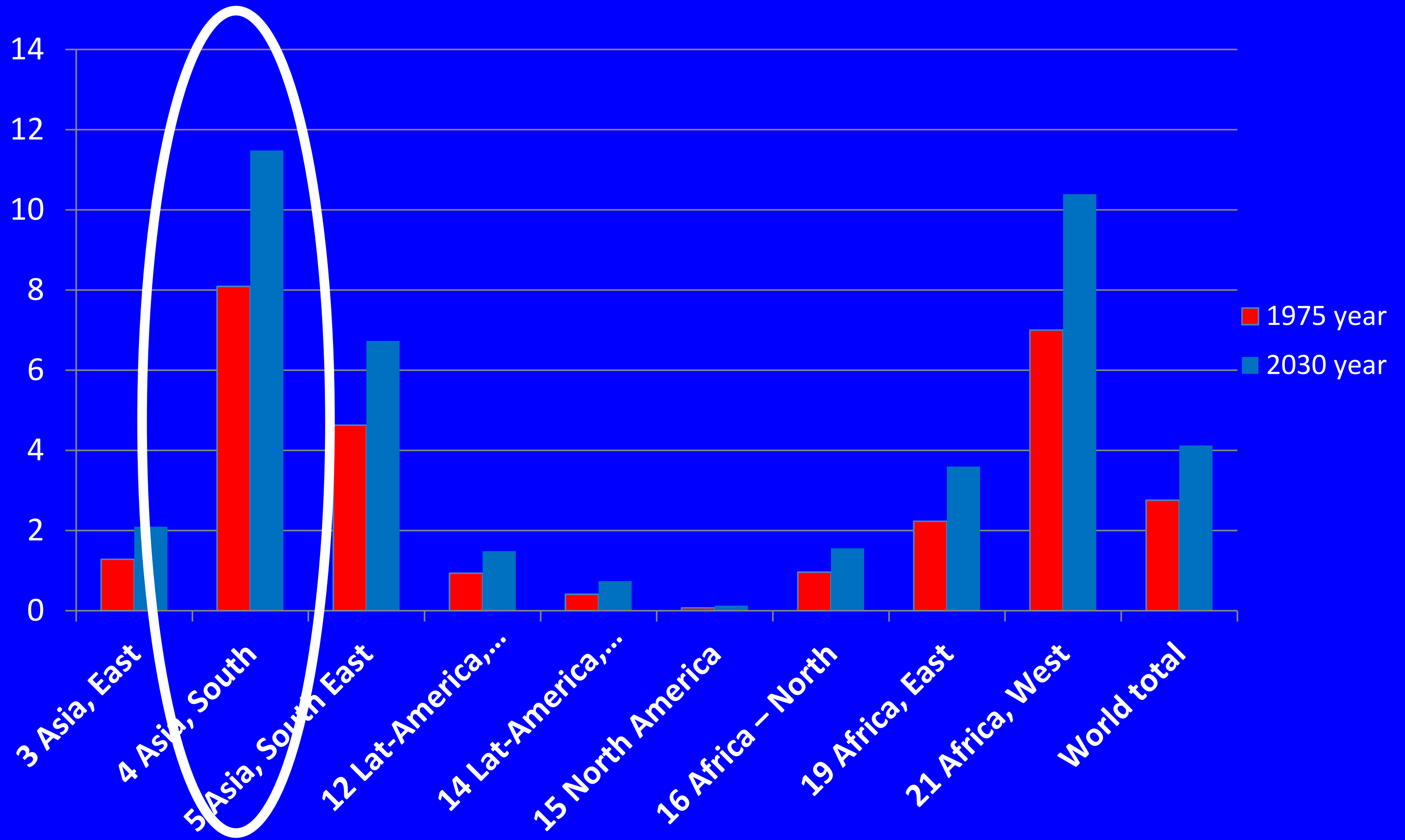
Hourly WBGT data for Summer 2013
Residential complex, Chennai

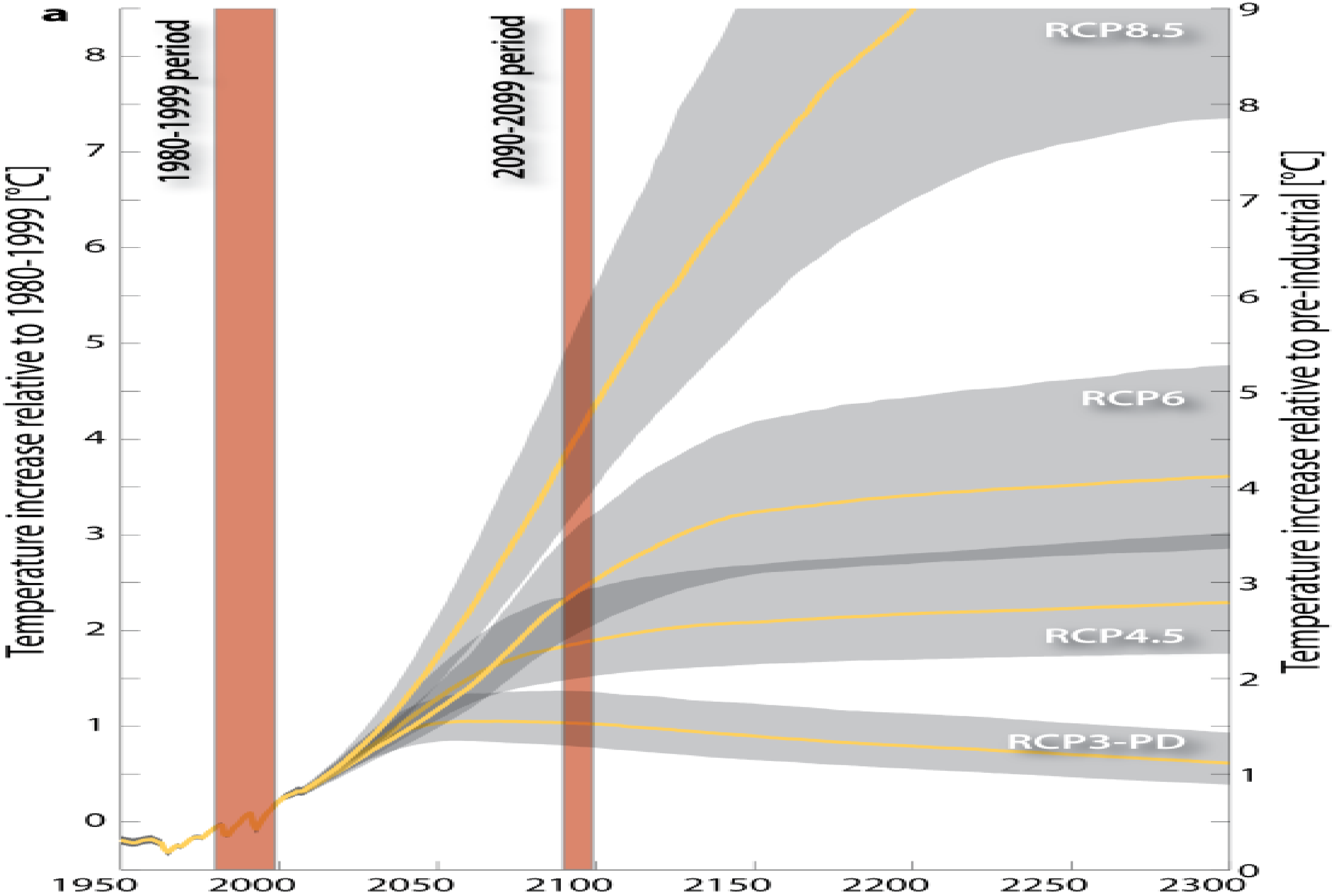
Date	Location	Work Category	WBGT (^0C)										Ambient temp(^0C)
			8:00-9:00	9:00-10.00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14.00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00	
21/05/2013	Ironing Room -G-Block	Heavy 500W	-	-	-	35.3	34.5	34.4	34.5	34.0	34.7	34.4	34.5
22/05/2013			34.2	34.3	34.7	35.1	35.7	36.0	35.0	35.4	35.7	35.1	35.1
23/05/2013			32.6	33.2	33.1	34.3	34.0	33.8	33.8	33.7	33.9	34.1	33.6
24/05/2013			34.3	34.0	34.7	34.8	35.4	34.6	35.8	35.7	35.3	34.8	34.9
25/05/2013			30.5	30.3	30.2	30.7	30.7	31.3	31.6	31.6	32.1	33.2	31.2
21/05/2013	Ironing Room -C-Block	Heavy 500W	-	-	-	34.1	34.3	33.9	32.7	32.7	33.0	33.6	33.5
22/05/2013			32.4	32.8	34.2	34.8	35.2	34.6	34.5	34.8	34.8	34.6	34.2
23/05/2013			31.5	32.8	32.5	32.8	33.2	34.5	34.6	34.6	35.0	35.5	33.7
24/05/2013			32.7	33.5	34.4	34.4	35.2	34.9	34.5	35.6	35.4	35.2	34.6
25/05/2013			31.1	30.9	32.3	32.8	33.3	33.5	34.1	34.6	35.5	35.5	33.3
21/05/2013	Ironing Room -D2-Block	Heavy 500W	-	-	-	34.2	34.0	33.2	33.6	34.4	34.8	34.8	34.1
22/05/2013			32.4	33.8	34.1	34.9	35.7	34.5	35.5	36.3	35.9	35.7	34.9
23/05/2013			31.5	34.6	34.5	34.7	35.6	35.2	35.1	36.4	35.8	36.7	35.0
24/05/2013			32.5	32.3	32.3	32.2	32.1	32.1	32.5	32.9	33.6	33.7	32.6
25/05/2013			30.4	30.4	30.7	35.1	33.0	31.6	31.7	31.6	34.8	34.6	32.7

July afternoon WBGT in 1975 and 2000 (based on recordings); 2030 and 2050 (based on models)



Work capacity loss (% of daylight hours) in 2030 based on regional climate change (average of 3 models), population in 2030 and estimated workforce distribution in 2030





__Draft__ IPCC Fifth Assessment

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Thank you