Avoid the Unmanageable, Manage the Unavoidable

Eight Interdisciplinary Lectures on Climate Change

Charles F. Kennel

Monday Evenings, 5:30-7 pm, Martin Johnson House

Scripps Institution of Oceanography, University of California San Diego

Nov17: What we can do right away and what we still will have to adapt to

The failure of the climate negotiations, the inertia of the of the global energy system

Slowing climate change by working with short-lived climate pollutants

Why we cannot avoid 2 degC warming at mid-century

Coping with Climate Change
In the Next Half-Century

C.F. Kennel, V. Ramanathan, and D. Victor,
***Proceedings American Philosophical Society*, *156, 4*, 398-415,**
Dec. 2012 issue, Online April, 2013

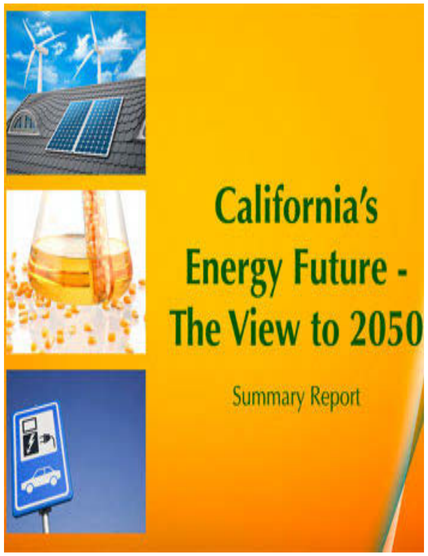
Challenges of CO_2 Mitigation

What would California have to do by 2050 to put its emissions on the path to CO_2 stabilization?

Can the world agree to start moving down a California-like path to stabilization?

If the world could agree, how rapidly could today's global energy system accomplish the task?

If the world stopped emitting *all* CO_2, how soon would our costs of adaptation decrease?

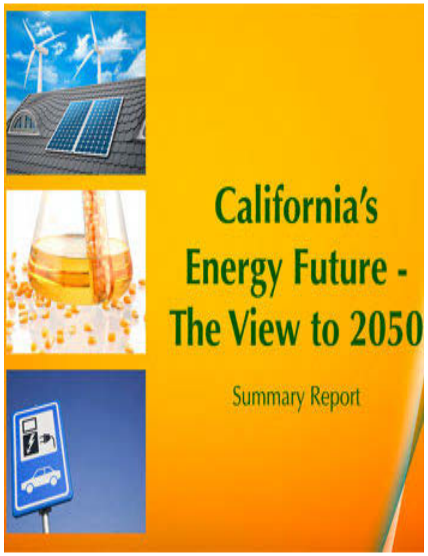


California's Path to CO2 Stabilization

California Council on Science and Technology
May 2011

CO2 emissions 80% below 1990 by 2050

Mandated by California executive order, legislation (AB 32),
Confirmed by ballot initiative
Given expected population growth, *per capita* emissions,
emissions need to decline by nearly 90%
Total emissions would otherwise double with "business as usual"



No Magic Bullet

No Single Technology Suffices

California Council on Science and Technology
May 2011

Aggressive deployment of known technologies

- 30 new nuclear plants, 1 per year after 2020
- New building standards by 2015, every building retrofitted by 2050, 80% improvement
- Redesigned transport systems
- 58 mpg fleet average for liquid fuels, 87 mpgge including electrical vehicles
- Low carbon liquid fuels, *viz.*, algal bio-fuels, etc

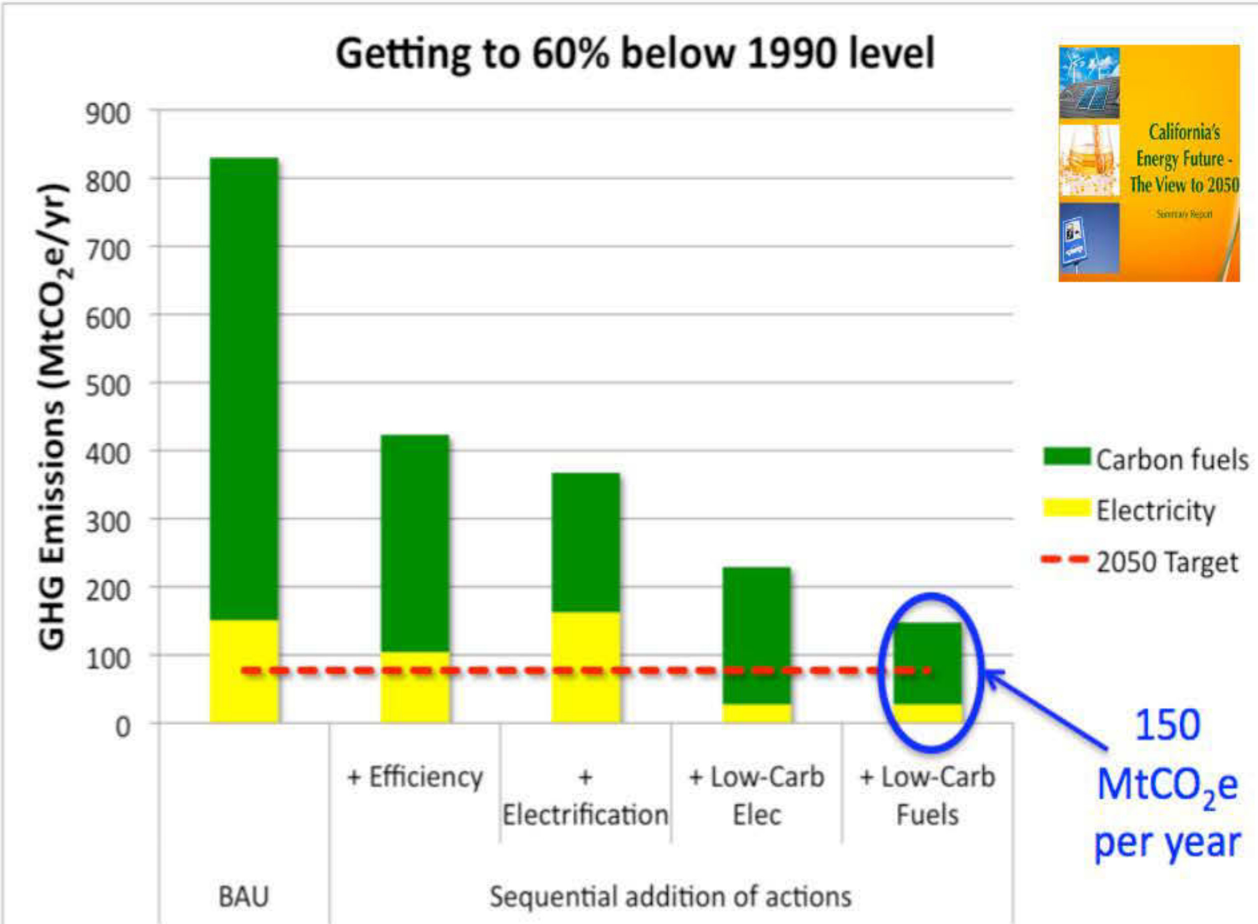
Transfer power use to zero-emission electrical system

- Electricity consumption would double
- 60% of light duty vehicles electrical
- Smart power transmission grids (zero emission load balancing)
- California has enough geothermal, wind, and solar capacity

No undue social resistance

Good, Bad, Important, and Hopeful News

Promise of technological innovation there but not evaluated



Good News: ¾ of the job could be done with existing technologies

Bad News: Deployment of these technologies politically and socially difficult

Important News: Working to lessen social and economic resistance to deployment could be decisive

Hopeful news: Entrepreneurs are betting that new technologies will help

Can the world agree on California-like goals?

20 years of UNFCCC negotiations have not produced meaningful results

David Victor, *Global Warming Gridlock*, Cambridge U. Press, 2011

Robert O. Keohane and David Victor, The International Politics of Energy, 97-104, *Daedalus, Winter Issue, 2013*

UN Climate negotiations, like those for trade, are not designed for speed

- Energy, like trade, is central to each country's economy and society
- Multiplicity of issues (Montreal Protocol attacked a single issue)
- Domestic constituencies must be catered to before entering negotiations
- Different readiness, plus different technical capacities
- Enthusiastic (Europe, Japan) and reluctant (America, China) countries
- Consensus among 193 countries extraordinarily difficult to achieve
- Slow, fitful, incremental advances at best, success requires persistence over decades

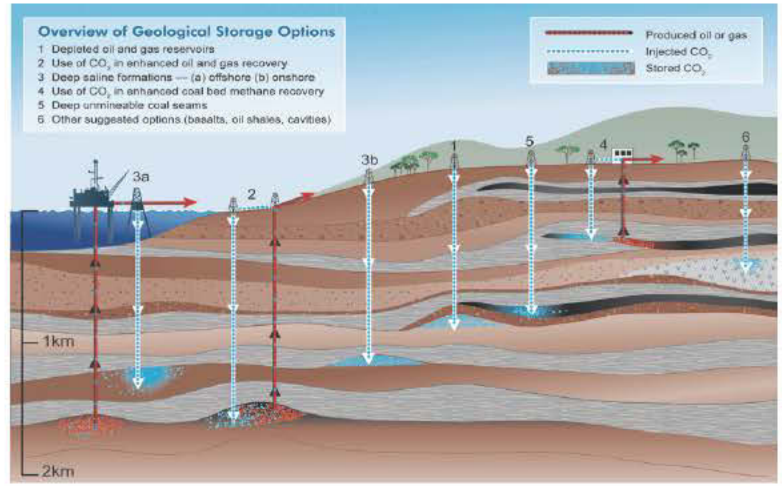
Coalitions of the Willing

Efforts where global consensus not required *can* make progress
A "regime complex" better suited to structure of climate problem

Lael-Aria, Alternative Architecture for Climate Change,
European Journal of Legal Studies, 4, no. 1, 2011

Decades To Restructure The Global Energy System

Even if the world could agree



Replacement cycle for energy infrastructure is 30-50 years

Energy decision-making complex and slow

- Nuclear power: accidents, waste, and proliferation
- Biofuels: competition with land use, agriculture, and for water
- Wind and solar compete for land and require new transmission infrastructure (zero emission load following)
- NIMBY

Coal remains the principal energy source of the most rapidly growing economies

- Inexpensive, secure, and widely distributed resource
- 120 years world-wide proven reserves
- China and India accounted for 95% of the increase in coal consumption between 2000 and 2011 (IEA, 2013)
- Clean coal technologies used only by most advanced power companies
- No demonstration of carbon, capture, and storage technologies

Low-carbon alternatives require subsidies, are politically, economically fragile

D.G. Victor and R.K. Morse, "Living with Coal", *Boston Review*, Sept-.Oct., 2009

CO2 Mitigation, A Thankless Task

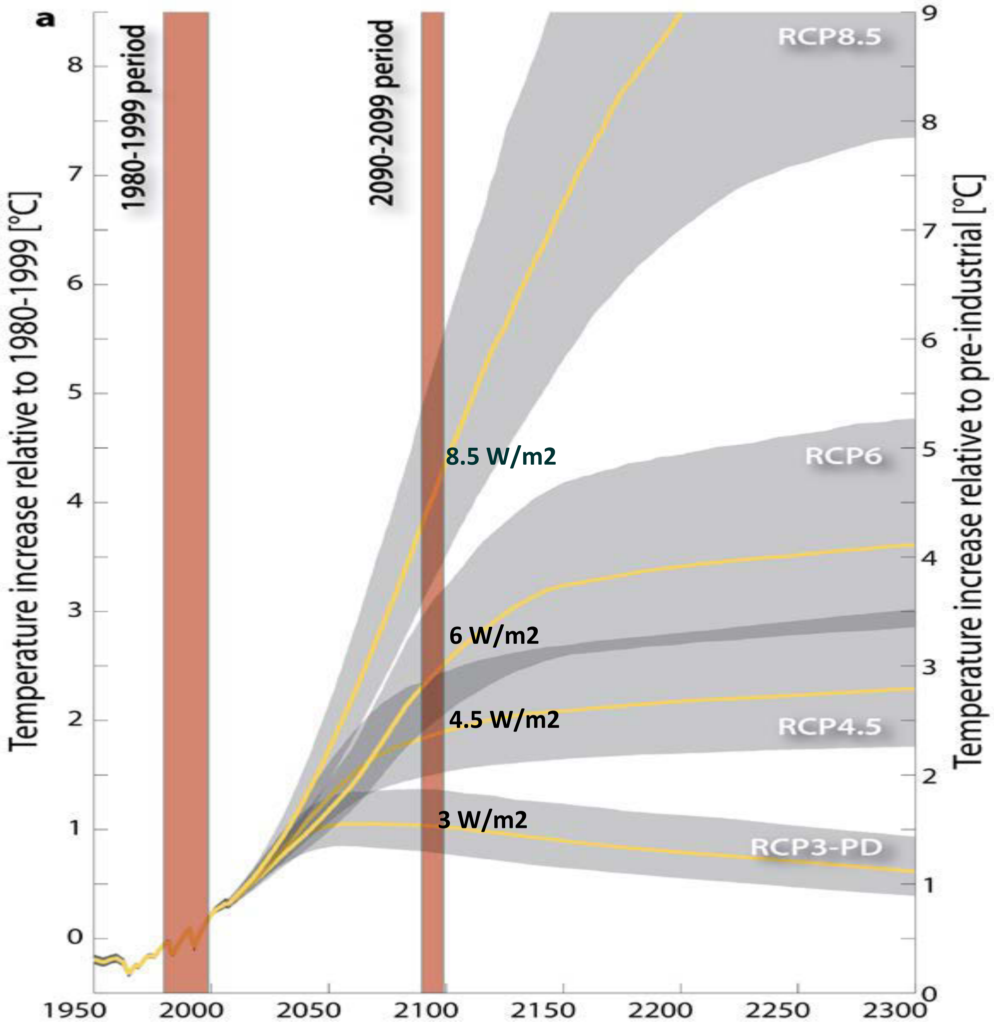
It would be easier if incentives and goals were better aligned but they are not.

Even if we stopped all CO_2 emissions, the global temperature would remain constant for centuries. We would stop piling additional risk on future generations, but we would not reduce our own exposure to adaptation risk. The lack of short-term reward has got to be a fundamental reason for the political gridlock on climate. It also means that climate change is at best a secondary benefit of investments in energy.

S. Solomon, G. K. Plattner, R. Knutti, P. Friedlingstein, *Proc. Natl. Acad. Sci. U.S.A.* 106, 1704, 2009
Damon Matthews and Susan Solomon, Irreversible Does Not Mean Unavoidable, *Science, 310,* 438, 2013

The New Climate Driver Democracy

All drivers are equal but some are more equal than others



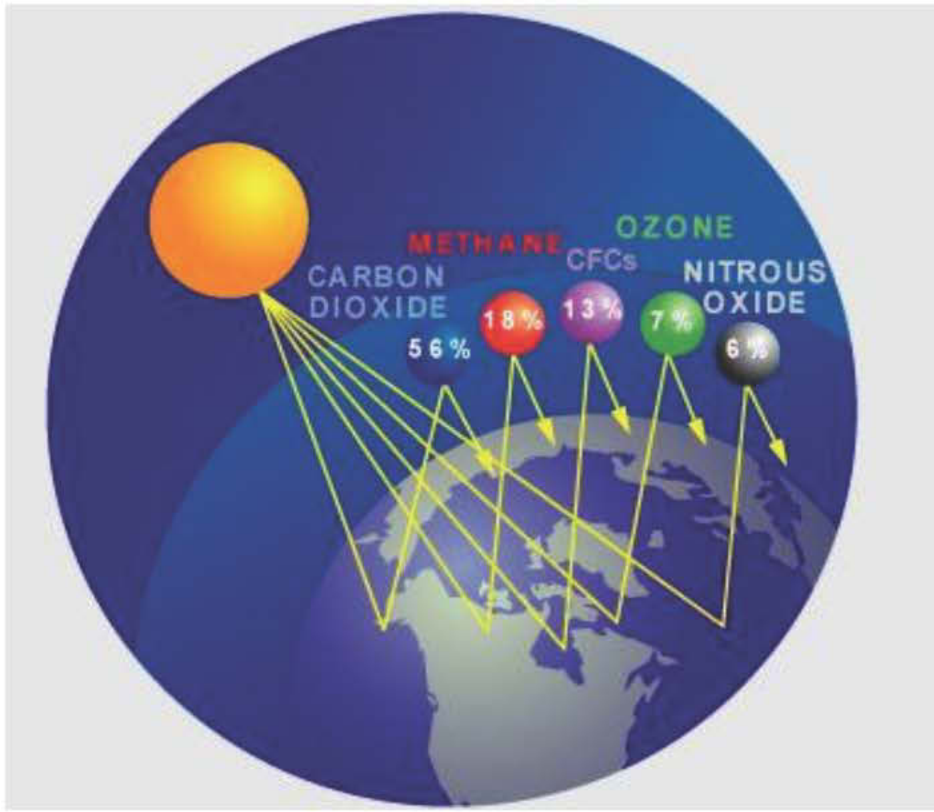
Source: Rogelj, Meinshausen et al. 2012

IPCC AR5 2014 Representative Concentration Pathways

The representative pathways can be generated by any combination of heating and cooling agents. This allows a more nuanced mitigation strategy. As opposed to CO2s indifference to space and time, every other driver will have a characteristic pattern in both space and time. Paradoxes may be resolved and opportunities found by looking there. There are many things we can do that will help.

The Other Greenhouse Gases

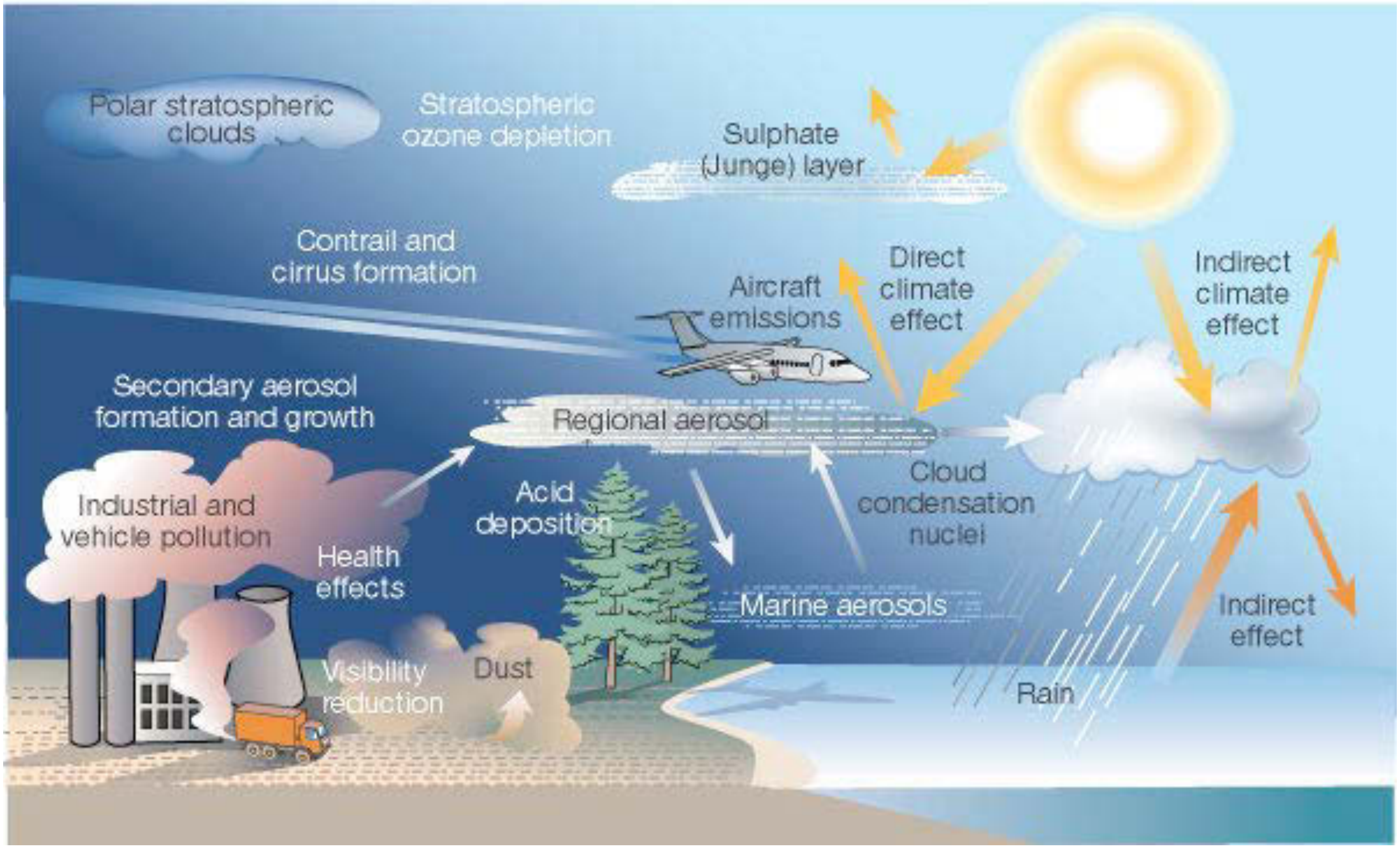
Ramanathan and Feng, PNAS, 2008; Ramanathan and Xu, PNAS, 2010; Forster, et al, IPCC WG1, 2007



CO2 (1.65 W/m2) and non-CO2 GHGs (1.35 W/m2) are almost equally effective in warming the atmosphere. Together, they are adding 3 W/m2 of infrared radiant energy flow to the earth's surface. According to energy balance, +3 W/m2 should be producing 2.4C warming above pre-industrial levels but 0.8C is observed. Something counteracts GHG warming.

Natural and Anthropogenic Aerosols

Millions of Small Volcanoes



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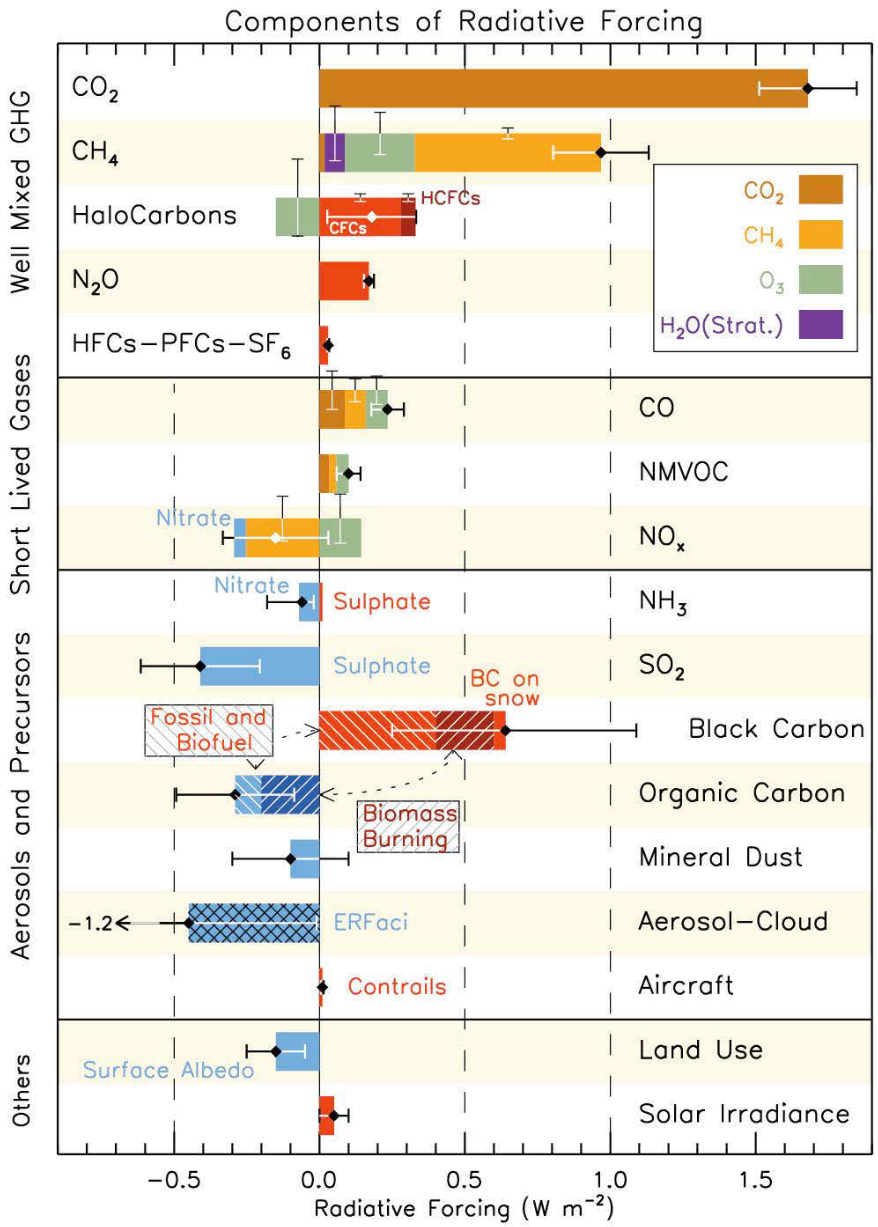
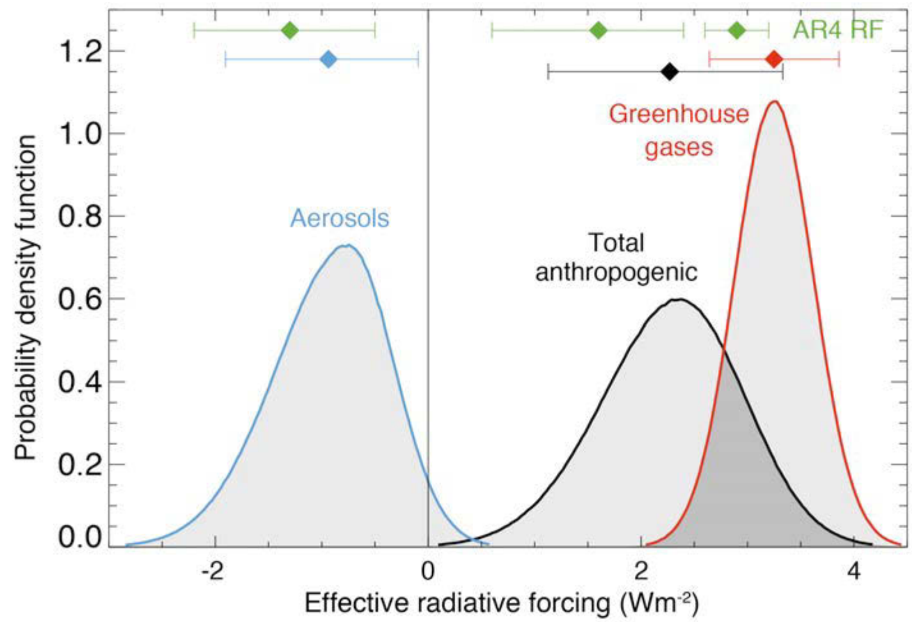
Charles E. Kolb, Atmospheric chemistry: Iodine's air of importance, *Nature, 417*, 597-598(6 June 2002) doi:10.1038/417597a

Human Drivers of Climate Change

Jekyll and Hyde

Both warming and cooling
Net increase since 1750
is 2.3 W/m2

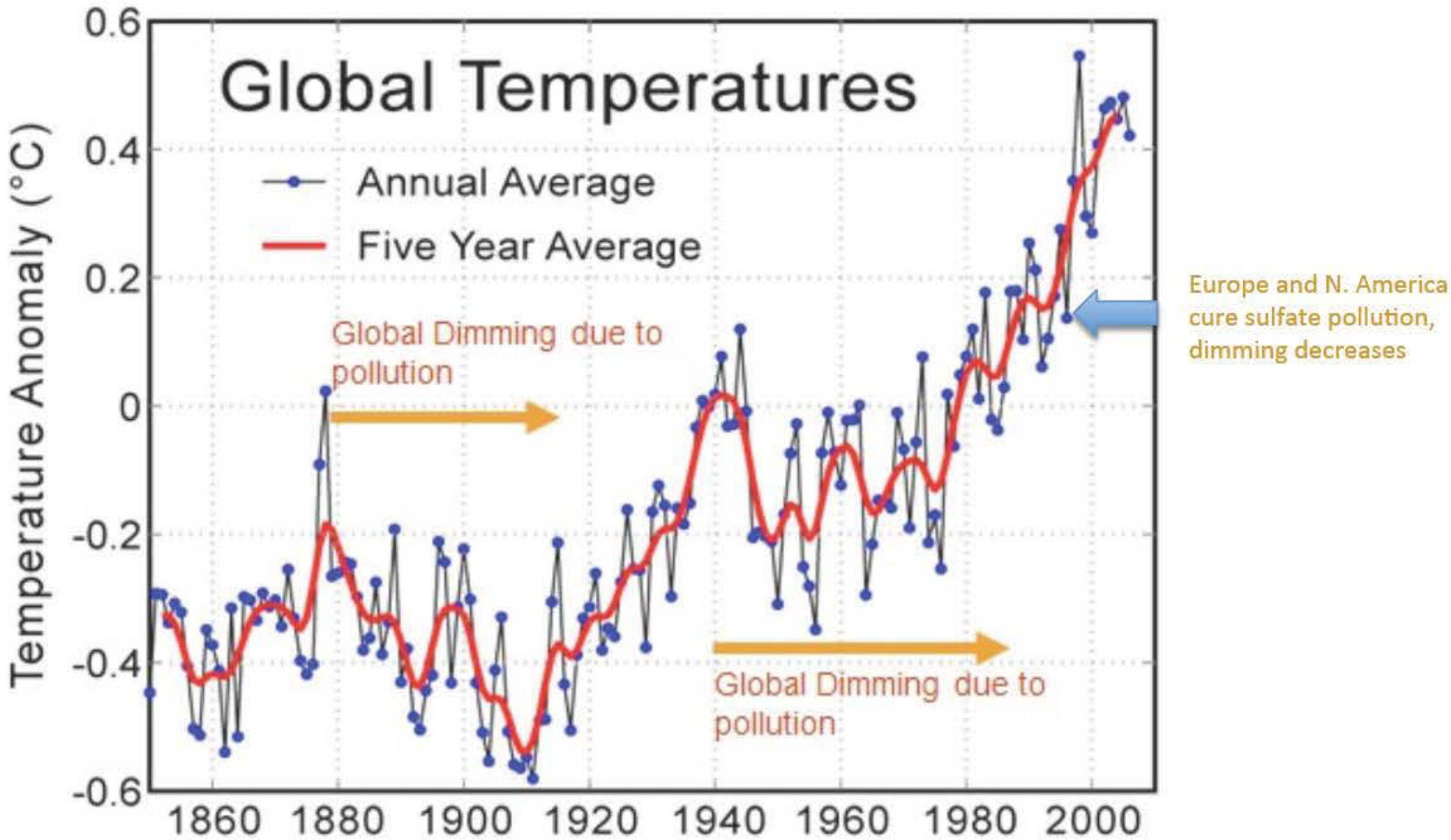




IPCC AR5, Working Group I, 2013
Figures 8.16 and 8.17

Mid-20th Century Warming Hiatus

Likely due to dimming created by N. American and European air pollution



"Surface solar radiation *likely* underwent widespread decadal changes after 1950, with decreases ('dimming') until the 1980s and subsequent increases ('brightening') observed at many land-based sites."

IPCC AR5, 2013

Global Dimming

Sulfate-Organic-Nitrate aerosols in the lower atmosphere are reflecting visible sunlight back into space, making the atmosphere less bright

At the surface, there is competition between aerosol cooling in visible light and greenhouse warming in the infrared

Estimated net effect of today's cooling aerosol's is -2.1 W/m2

- Sulfates, Organics, Nitrates (SON) pollution

Without this SON cooling, the global temperature increase would be 1.9C

- About 2.5 times what is observed (0.8C)
- Oceans have sequestered heat and + 0.5C will be released later
- Land use albedo changes are cooling, -0.2 W/m2

Ramanathan and Carmichael, *Nature Geoscience*, 2008


Reducing aerosol pollution "unmasks"
embedded greenhouse warming
Suppose by magic, pollution cooling were to disappear. Even if our present GHG concentrations *never* increased, we would end up +1.9C warmer than now, with another +0.5C to come later from the oceans.
We are already committed to this path.
Ramanathan and Feng, PNAS, 2008

Offsetting greenhouse warming by tolerating harm to public health and agriculture is not sustainable

Urban air pollution can be controlled in 25 years: London, Los Angeles, Mexico City, Sao Paolo…
Populations in India and China, today's largest sources, are demanding that it be done.
Estimates of warming should assume that cooling pollution will be much reduced by mid-century


Can we make the path to 2050 safer?
What other options do we have to reduce the rate of warming?
How much adaptation risk can be deferred by slowing warming?
What is the minimum warming we should prepare for now?

The Climate Threat We Can Beat

What it is and how we can deal with it

David Victor, Charles F. Kennel, and V. Ramanathan
University of California San Diego
http://ssi.ucsd.edu/gwi/

Foreign Affairs, 91,3,112-121, April-May, 2012

IR/PS

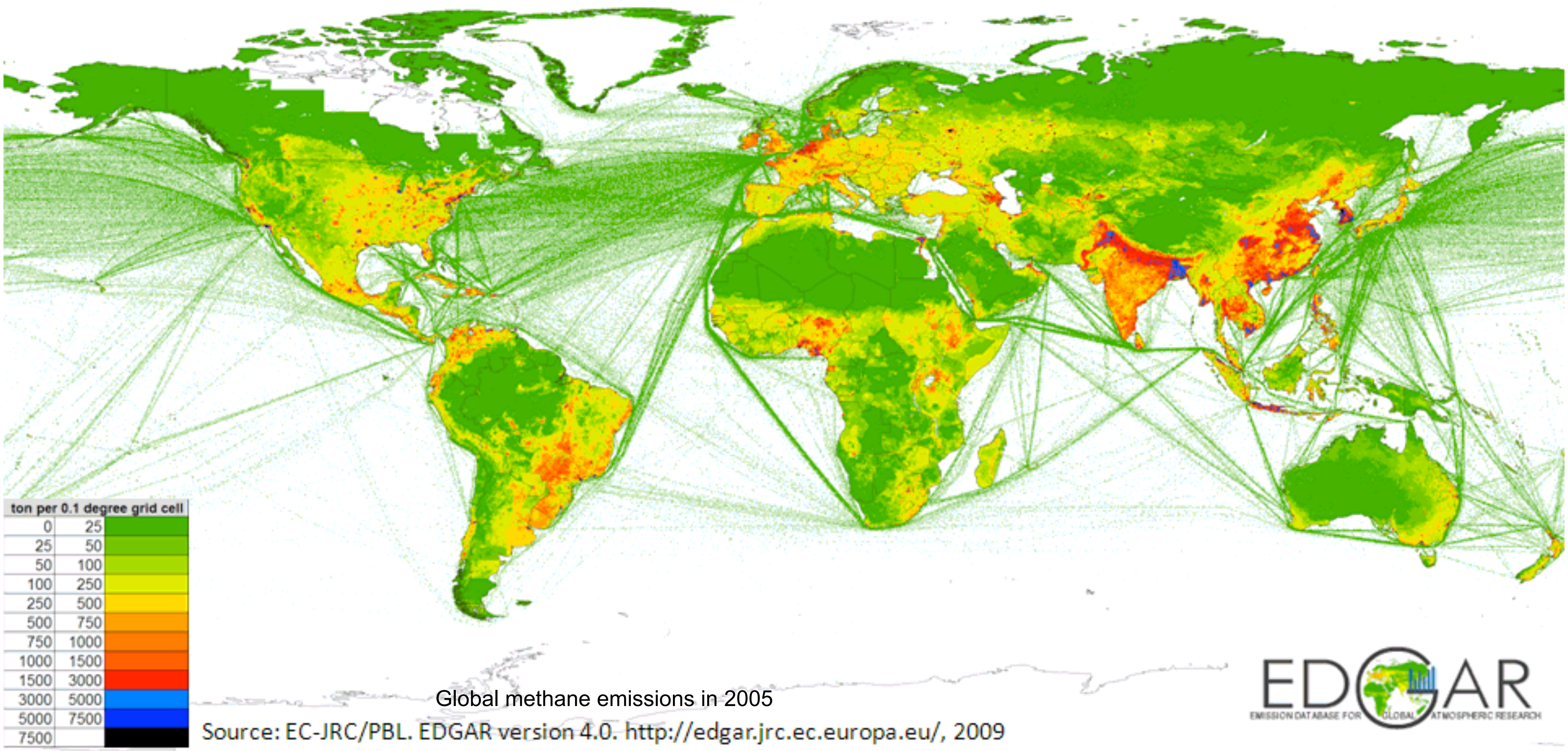
UC San Diego
Local Impact, National Influence, Global Reach

SCRIPPS INSTITUTION OF OCEANOGRAPHY UCSD
1903 · CENTENNIAL · 2003

Sustainability Solutions Institute
UC San Diego

We *can* take the edge off climate change

Warming rate between now and 2050 could be cut meaningfully by acting on short-lived climate pollutants

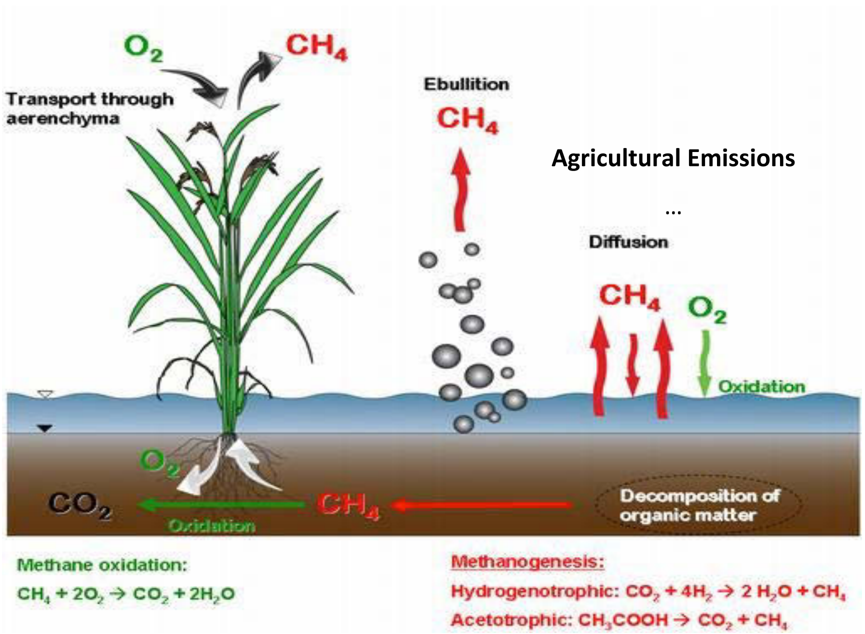


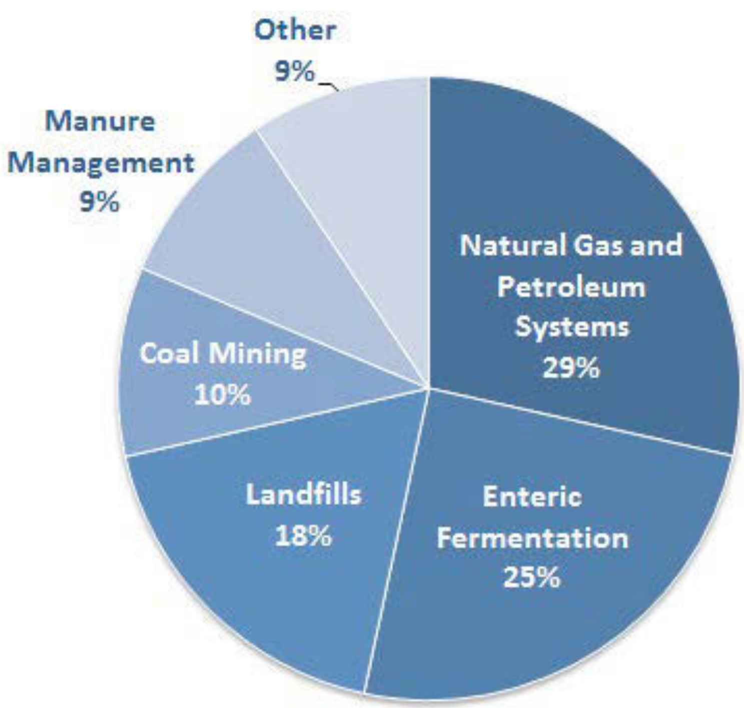
Global methane emissions in 2005

Source: EC-JRC/PBL. EDGAR version 4.0. http://edgar.jrc.ec.europa.eu/, 2009

Shindell, *et. al.* (2012) identified 14 actionable measures for methane and black carbon that could reduce warming in 2050 by 0.5 degC

Hu, et.al, 2013, found that SLCP mitigation could reduce 2100 sea level rise by 22-40%





US Emission Sources
EPA

Methane

Atmospheric methane is at highest level in past 650,000 years

Human activities account for 50-65% of global CH4 budget

23 times more potent per molecule than carbon dioxide

Drives 18% of greenhouse warming, 0.48 Watts/m2 (2005)

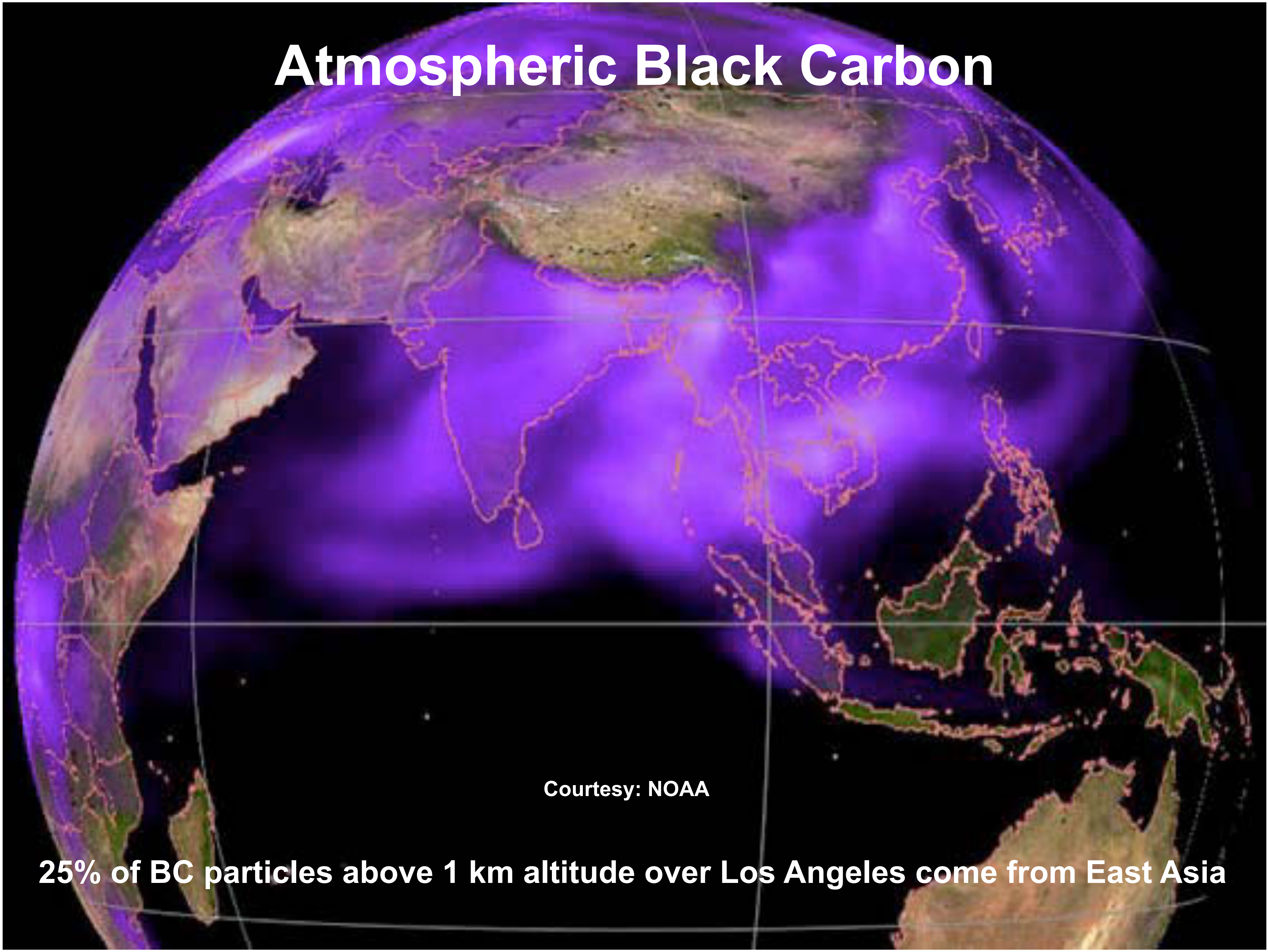
Microbes in anaerobic environments release methane to the atmosphere

Main human sources are landfills, cattle, rice paddies, and industrial releases

Methane interacts with lower atmosphere pollution to create harmful ozone

Miller, *et al*, Anthropogenic Emissions of Methane in the United States, PNAS 2013

Atmospheric Black Carbon



Courtesy: NOAA

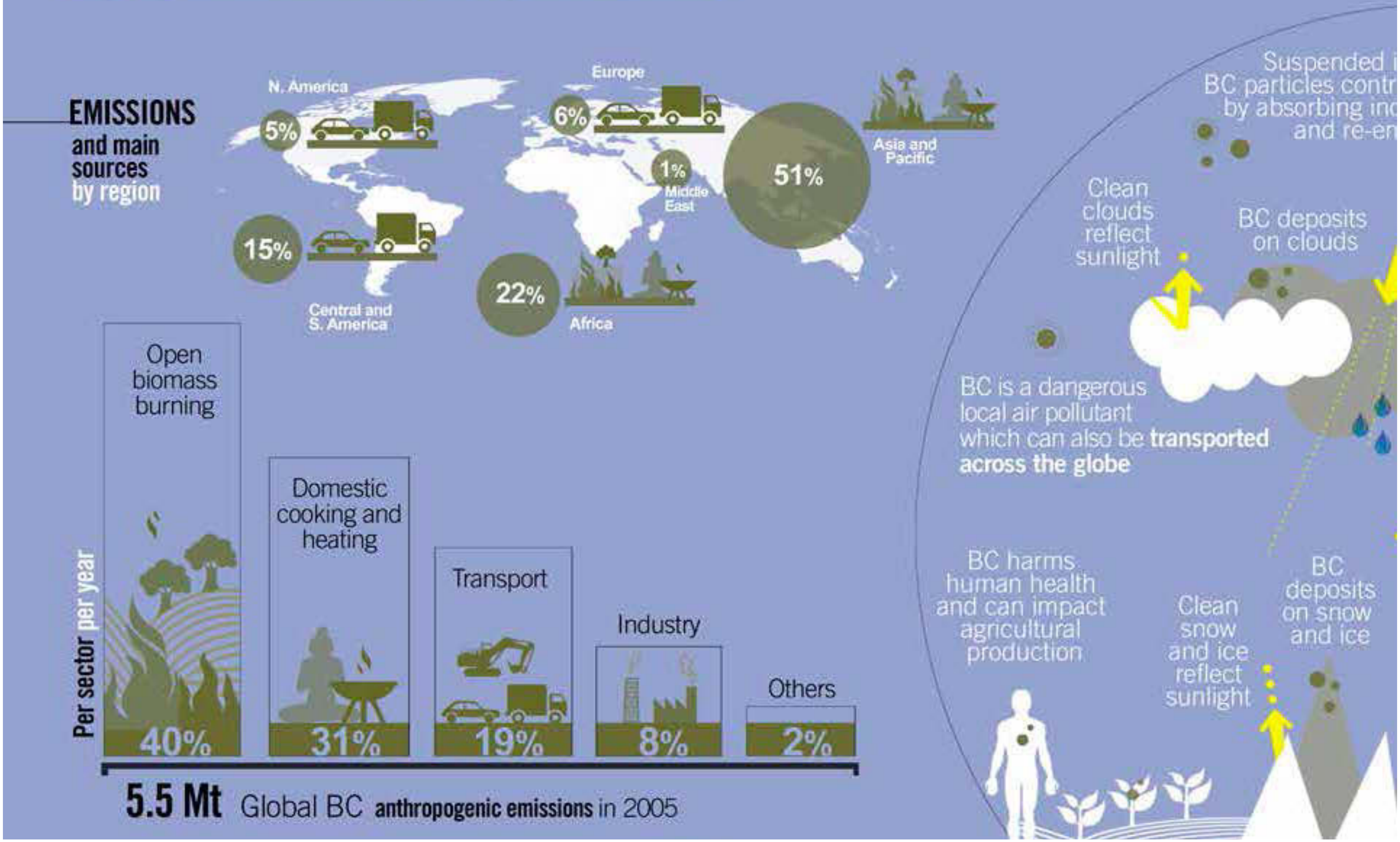
25% of BC particles above 1 km altitude over Los Angeles come from East Asia

Black Carbon (BC)

Black carbon aerosols are emitted from incomplete combustion of fossil fuel and biomass. They are powerful climate forcers and dangerous air pollutants.

LIFETIME IN ATMOSPHERE: days

CURRE RADIATIV FORCIN: 0.64 W



Black Carbon
0.6-1.1 W/m2

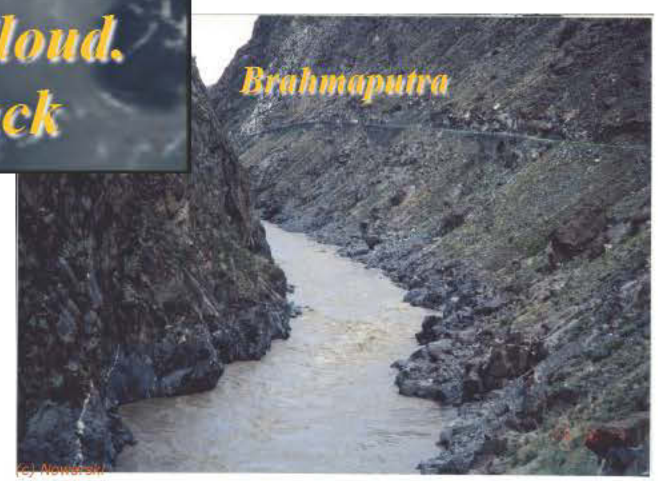
23% of China's population

Win for Asia
Public health
Agriculture
Snow melt and river flow

Win for the World
Reduced warming rate
More time to adapt

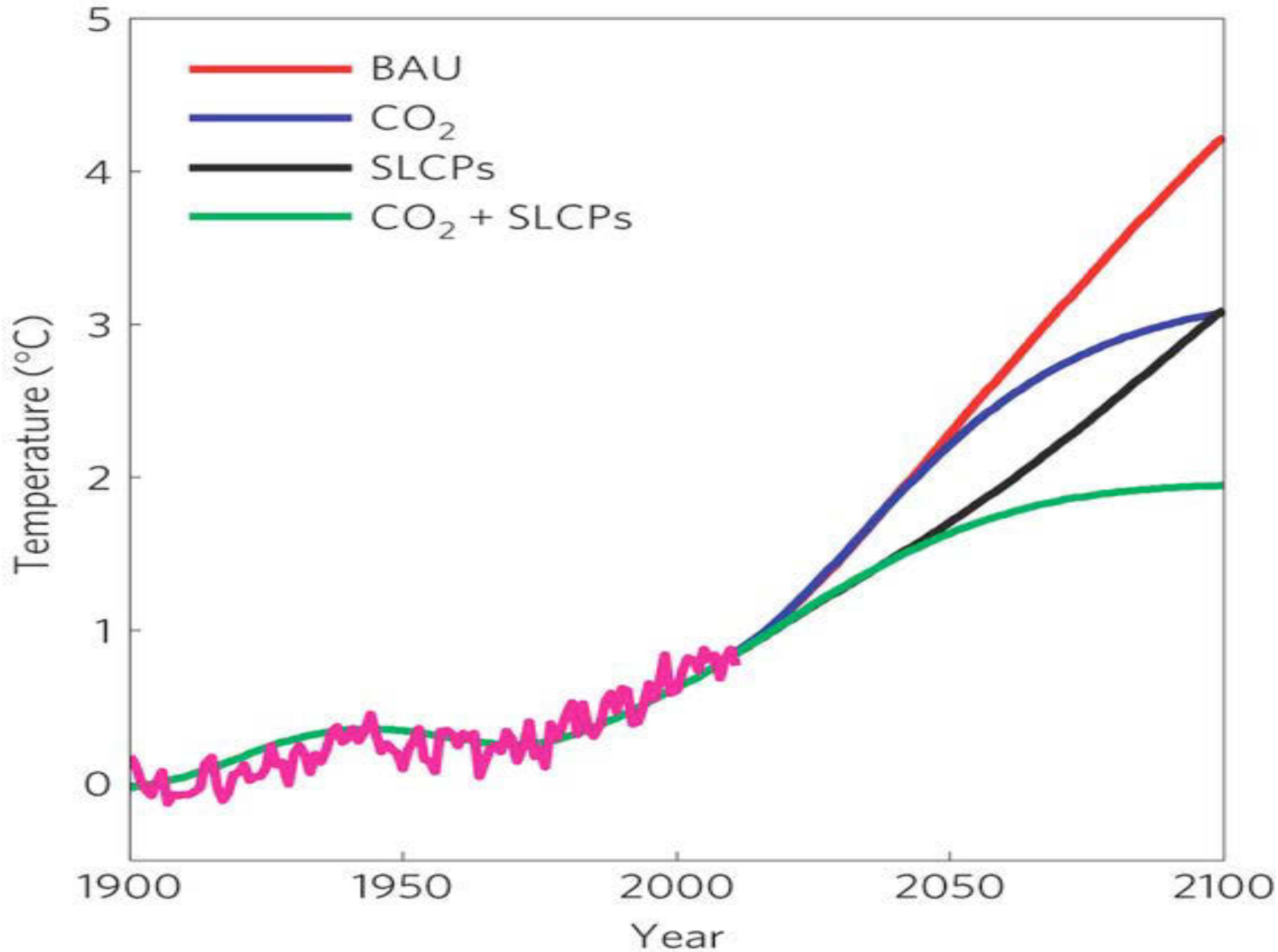
70% of summer flow from snowmelt

Most important warming agent after CO2



A Second Front

Short-term reward: Warming in 2050 reduced by 0.5C
Long-term benefit: Sea level rise in 2100 reduced by 20-40%



Hu, Ramanathan, *et al*, Mitigation of short-lived climate pollutants slows sea-level rise, Nature Climate Change 3, 730–734 (2013)

Short-Lived Climate Pollutants.

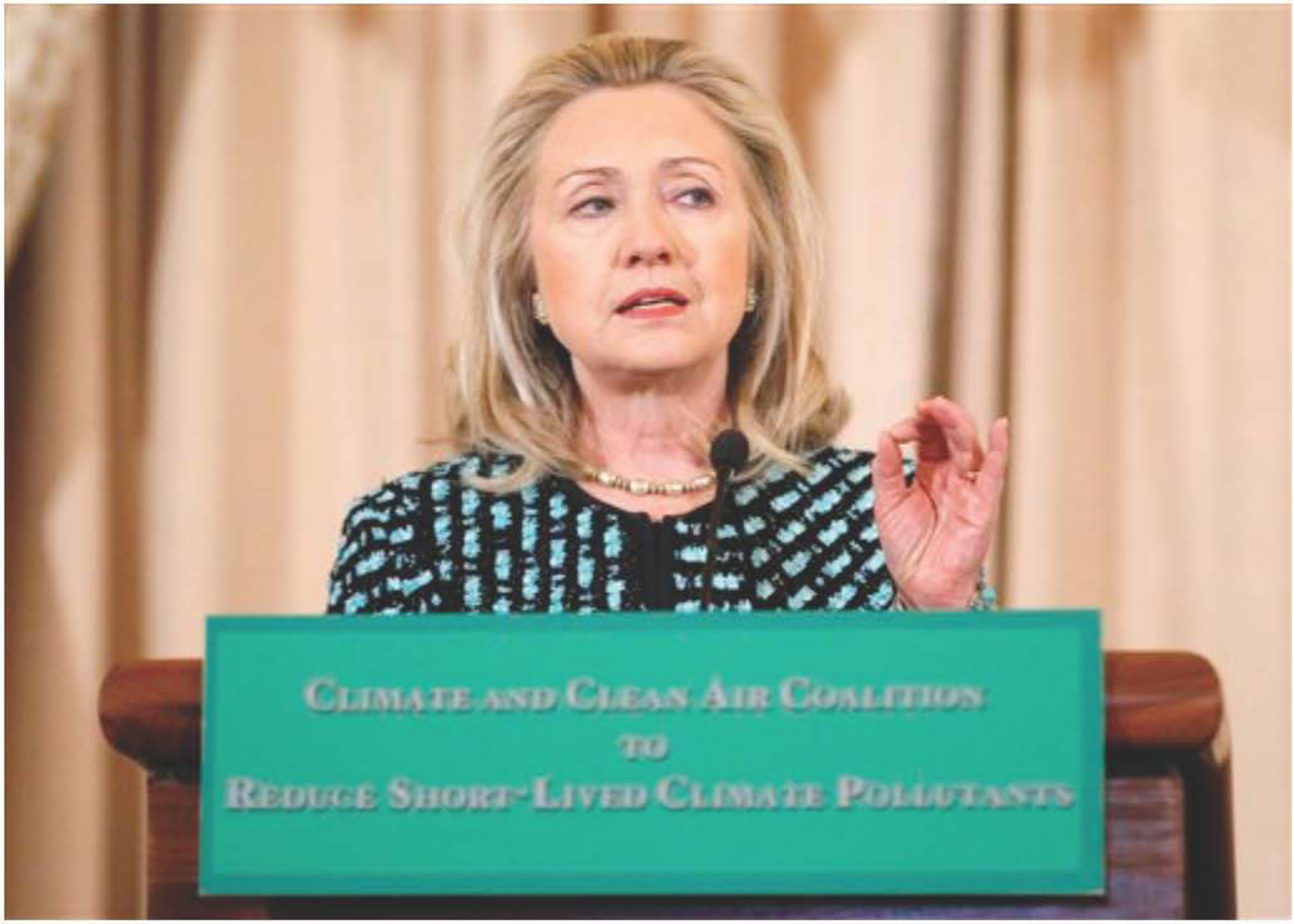
Incentives are aligned. The biggest polluters have the biggest reasons to attack the problem. Because SLCPs have short lifetimes, politicians can see progress in their terms in office. They can claim a win-win. They can take credit for improving human welfare while also slowing climate change.

The politics are simpler. You do not have to wait for a global consensus to emerge. Those most afflicted can take immediate action.

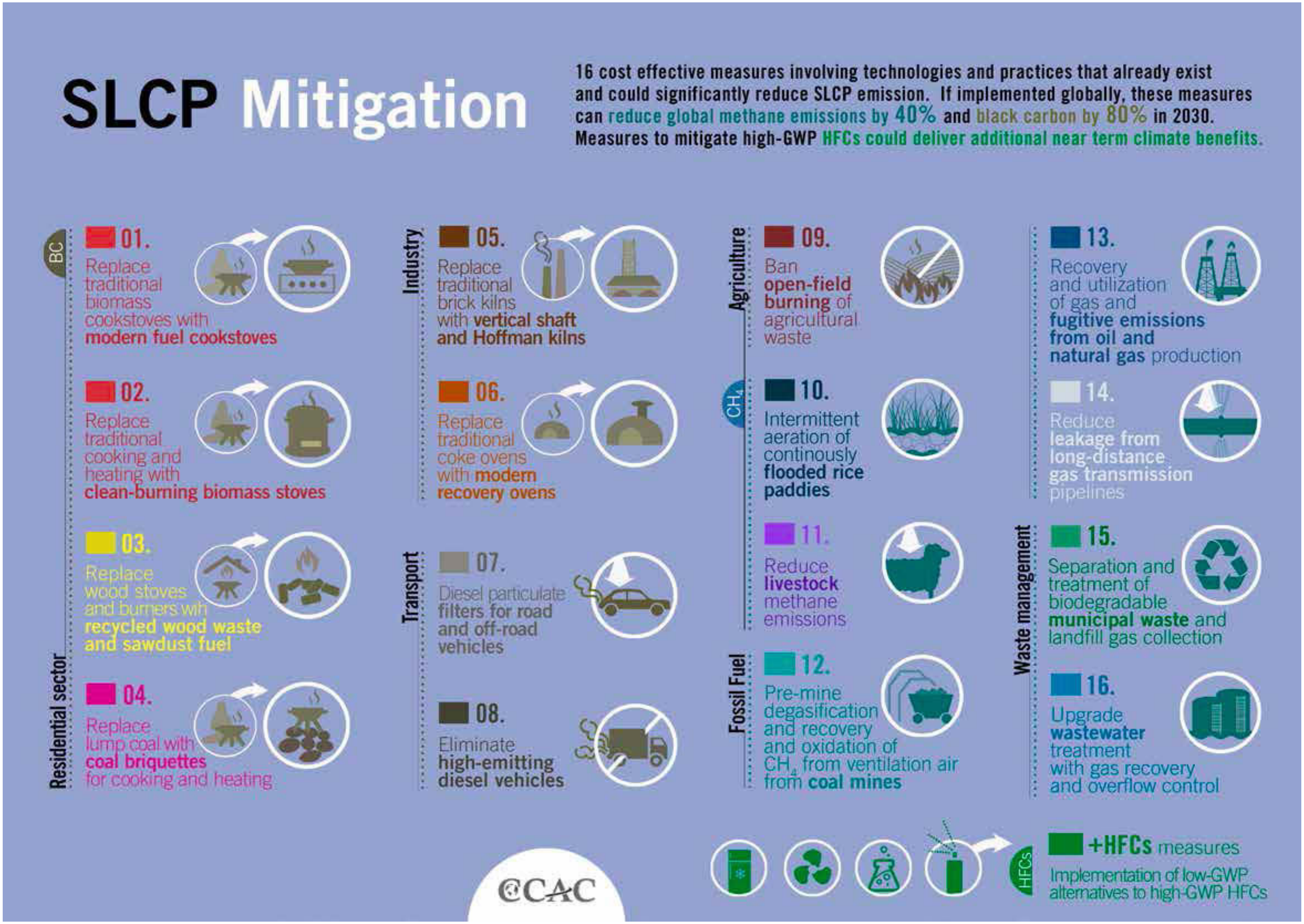
Management is simpler. SLCPs can be managed by local pollution control agencies, who already have many of the tools to do the job. The global role is to provide technical support.

Climate and Clean Air Coalition

Washington, DC, Feb 16, 2012



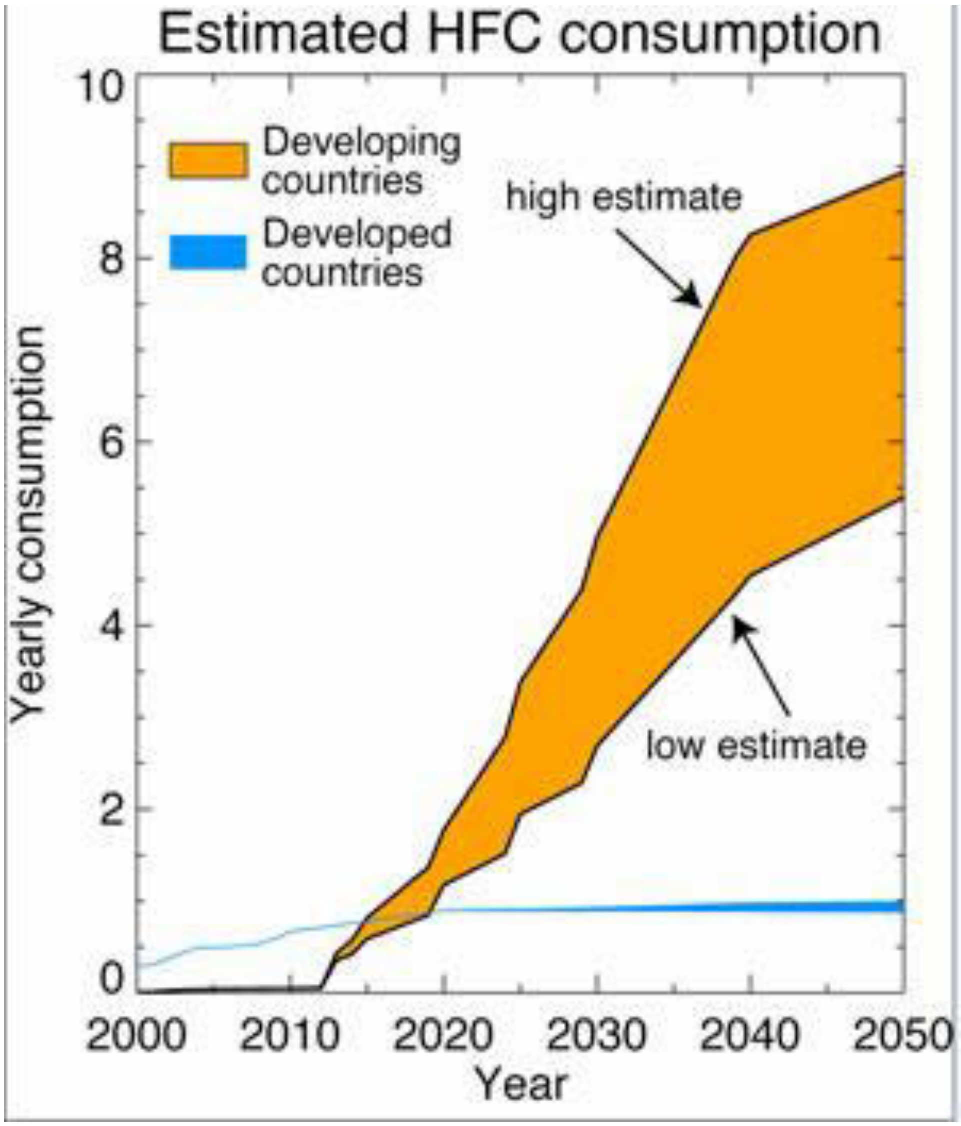
Bangla Desh, Canada, Ghana, Mexico, Sweden, United States, Colombia, Japan, Nigeria, Norway, The European Commission, the UN Environmental Programme, …



SLCP Mitigation
16 cost effective measures involving technologies and practices that already exist and could significantly reduce SLCP emission. If implemented globally, these measures can reduce global methane emissions by 40% and black carbon by 80% in 2030. Measures to mitigate high-GWP HFCs could deliver additional near term climate benefits.
BC
Residential sector
01. Replace traditional biomass cookstoves with modern fuel cookstoves
02. Replace traditional cooking and heating with clean-burning biomass stoves
03. Replace wood stoves and burners with recycled wood waste and sawdust fuel
04. Replace lump coal with coal briquettes for cooking and heating
Industry
05. Replace traditional brick kilns with vertical shaft and Hoffman kilns
06. Replace traditional coke ovens with modern recovery ovens
Transport
07. Diesel particulate filters for road and off-road vehicles
08. Eliminate high-emitting diesel vehicles
CH_4
Agriculture
09. Ban open-field burning of agricultural waste
10. Intermittent aeration of continously flooded rice paddies
11. Reduce livestock methane emissions
Fossil Fuel
12. Pre-mine degasification and recovery and oxidation of CH_4 from ventilation air from coal mines
13. Recovery and utilization of gas and fugitive emissions from oil and natural gas production
14. Reduce leakage from long-distance gas transmission pipelines
Waste management
15. Separation and treatment of biodegradable municipal waste and landfill gas collection
16. Upgrade wastewater treatment with gas recovery and overflow control
HFCs
+HFCs measures
Implementation of low-GWP alternatives to high-GWP HFCs
CCAC

Fluorocarbons

10,000 times more potent per molecule than CO2



Since the Montreal Protocol (1988), 98% of 100 stratospheric ozone-destroying chlorofluorocarbons (CFCs) have been phased out. CFCs are also ultra-GHGs, and 0/6-1.6 Watts/m2 warming has been avoided, comparable to that from the CO2 added since 1988-an unexpected benefit. This is one of many suggestions to explain the recent hiatus in warming.

Hydrofluorocarbons, ultra-GHGs replacing CFCs in refrigeration, are the fastest growing climate forcing agent in many countries, growing globally at 10-15%/year. If this continues, the HFC warming potential would in 2050 be 20-25% of that from the CO2 emitted after 2000.

D. Zaelke, *Primer on Short-Lived Climate Pollutants,* Institute for Governance and Sustainable Development, 23 AprIl, 2013

“President Obama and Chinese President Xi Jinping agree to wind down production and use of hydrofluorocarbons, or HFCs”

Washington Post, June 8, 2013

The Case for Adaptation

What can we expect if we meet CO2 targets for stabilization, act on short-lived climate pollutants, but also reduce cooling air pollution?

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To stay below 2C, we have to begin reducing GHG emissions by 2015, but global GHG emissions are accelerating in 2013, and show no sign of moderating. Even if we try everything, we may not be able to keep warming in 2050 below 2C. We should prepare for at least 1.2C additional warming by 2050. Prudence suggests we prepare for more.

Ramanathan and Xu, The Copenhagen Accord For Limiting Global Warming PNAS, May 4, 2010

Mitigation and Adaptation Policy Balance

Many mitigation advocates disparage talk of adaptation

- Absolves emitters of their ethical responsibility to mitigate
- Admits we have lost the Carbon battle

Mitigation and Adaptation have different requirements

- Mitigation policy focuses on global deployments of greener energy technologies, macroeconomic and regulatory incentives, and similar measures of global reach
- Key adaptation decisions are about local infrastructure, and focus on specific regional issues of current urgency which are expected to grow in importance

Assessments for mitigation and adaptation have different audiences

- Present IPCC climate assessments are designed to support a small number of key mitigation decisions made by a comparative handful of central decision makers
- Regional assessments are required for hundreds of regions and millions of decision makers

Adaptation

Assess, Decide, Act

Think Globally, Assess Regionally, Act Locally

Kennel, C.F., "Think Globally, Assess Regionally, Act Locally", *Issues in Science in Technology, 25, 2,* 46-52, 2009, National Academies, ISSN: 0748-5492

Adaptive Management

Adaptive management is what you do when you know you have a problem but you don't know how it will unfold

How to Cope with An Uncertain Future

No magic solution

Assess, decide, and act-for the next 1000 years
- Doing what can be done ensures at least incremental progress
- Adapted to contemporary political and economic realities

Pay attention to every little thing
- Manage all the human drivers of climate change
- Mitigate *and* adapt

Keep in mind that "no one size fits all"
- Regions have different economic, political, and technical readiness
- Nations take action in different ways and at different rates

Don't delay or avoid decisions
- Directly involve decision makers
- Translate all new knowledge rapidly

Watch out for approaching tipping points
- Requires perpetual vigilance
- Have "insurance policies" and back-up plans

Build Enduring Institutions
- Global knowledge management and decision support

Think Globally, Assess *Regionally*, Act Locally

Regional impact assessments bridge the global and the local




Each physical, biological, and human system has a natural spatial configuration: analysis regions should be adapted to each system and then integrated into the larger picture

Assessments should relate changes in natural systems (watersheds, forests, weather patterns, mountain snows and glaciers, biomes, animal migration, …) to changes in human systems (agriculture, fisheries, public health, infrastructure, …)

The interactions of multiple environmental and social stresses increase the risks of systemic failure. These interactions are regionally and locally specific.

Risk management plans must be Regionally coherent and locally based

Regional adaptation planning needs global support but absolutely requires local knowledge

Think Globally, Assess Regionally, *Act Locally*

Communities are on the front lines of adaptation.
Emergency response to wide-spread disaster is local.

The balance of vulnerability and resilience is determined by locally specific interactions among social, technological, and natural systems

Each community has its own way of reaching decisions, its own cultural, political, and institutional structures

Adaptation strategies must take local politics and social acceptability into account

Motivating action requires communicating in culturally acceptable ways

Adaptation cannot be managed top-down

"Adaptation requires a system approach that links the physical and biological aspects of climate change to social response. It cannot be managed top-down. Integrated solutions should be sought through linked innovation in science, technology, policy, politics, institutions, and finance. It will have to be a distributed effort that is guided but not directed."

Kennel, Goldin, *et al,* "Creating an international framework for regional climate change impacts assessments and local action", Forum on Science and Technology in Science, Kyoto, October 2009 Special Adjunct Session on regional climate change

The Capacity Problem

Think Globally, Assess Regionally, Act Locally

The tools and institutions deployed to assess global climate change must now be adapted to the needs of millions of local decision-makers in hundreds of regions around the world.

How can the relatively small science, technology, and policy community develop the capacity to serve the needs of millions of decision-makers in thousands of communities with different cultural, economic, political, and environmental characteristics? And then integrate the mosaic of local issues into a global picture?

Kennel, Goldin, *et al,* Forum on Science and Technology in Science, Kyoto, 2009
Special Session on Regional Climate Change

Some Closing Thoughts

Until local adaptation costs are assessed locally, the benefits of mitigation cannot be computed

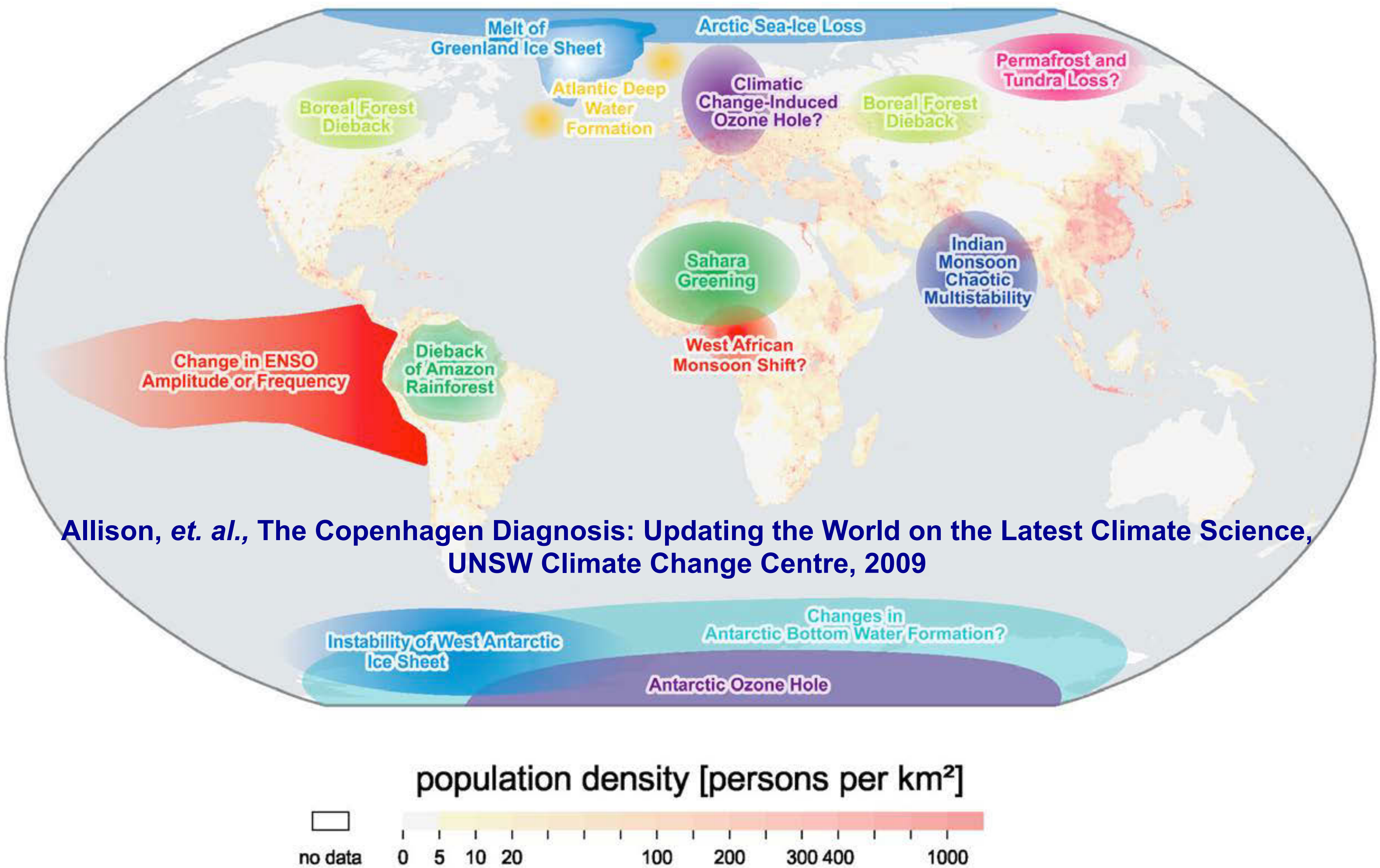
Communities will choose the solutions that are socially available to them

An international framework is needed to assure common reporting and archiving standards, provide commensurate financial estimates, prioritize resource allocations, and aggregate locally-derived adaptation costs on a global basis.

Only then can a socially realistic cost-benefit ratio of mitigation be computed.

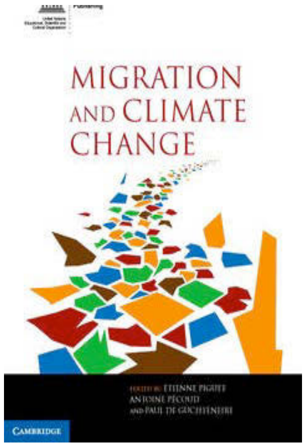
Tipping Points

When adaptive management can fail
Functionally irreversible restructuring of the climate system
Paleoclimate evidence suggests “slowing down” precedes abrupt transitions

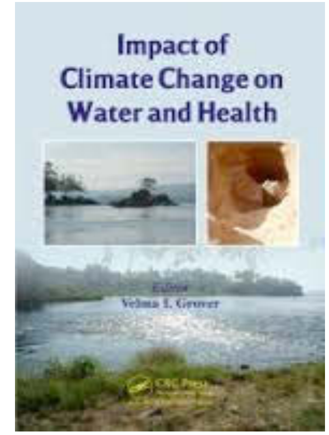


Allison, *et. al.,* The Copenhagen Diagnosis: Updating the World on the Latest Climate Science, UNSW Climate Change Centre, 2009

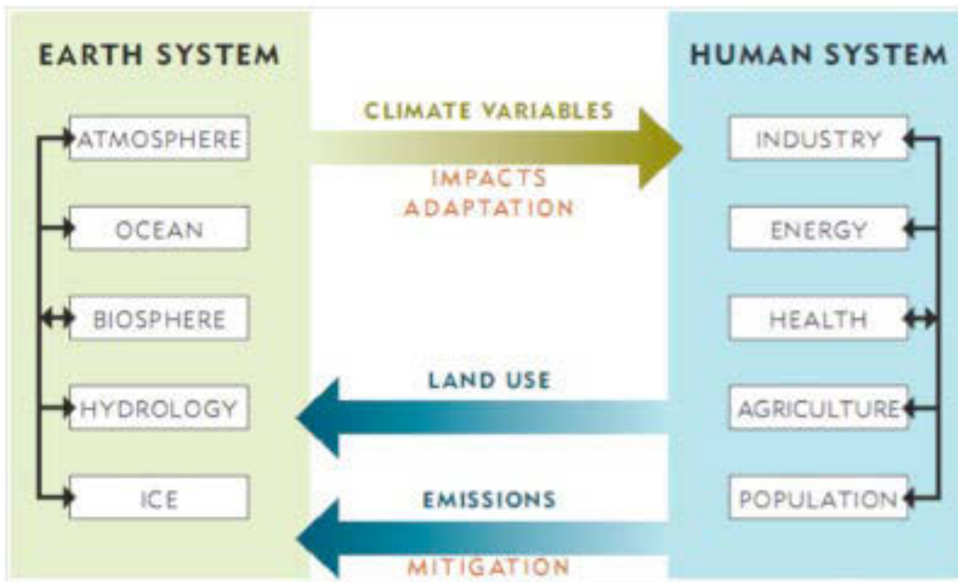
Dakos, *et al,* Slowing down as an early warning signal for abrupt climate change, PNAS vol. 105 no. 38 14308–14312, doi: 10.1073/pnas.0802430105

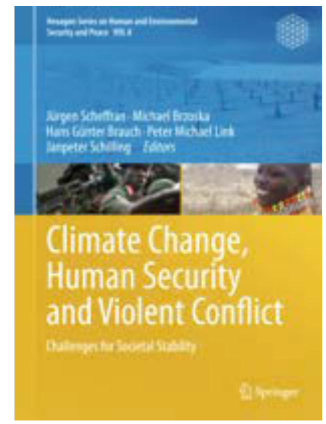


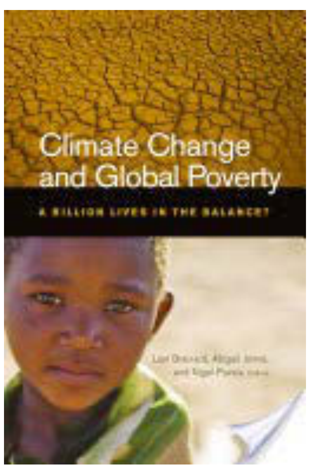
Socio-Economic Tipping Points



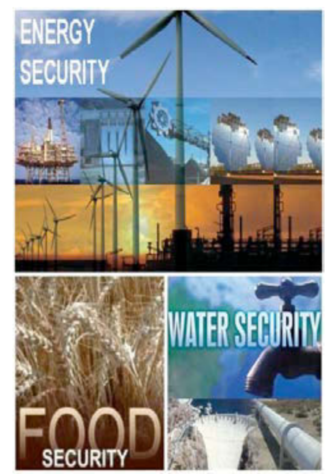
Irremediable social dislocations







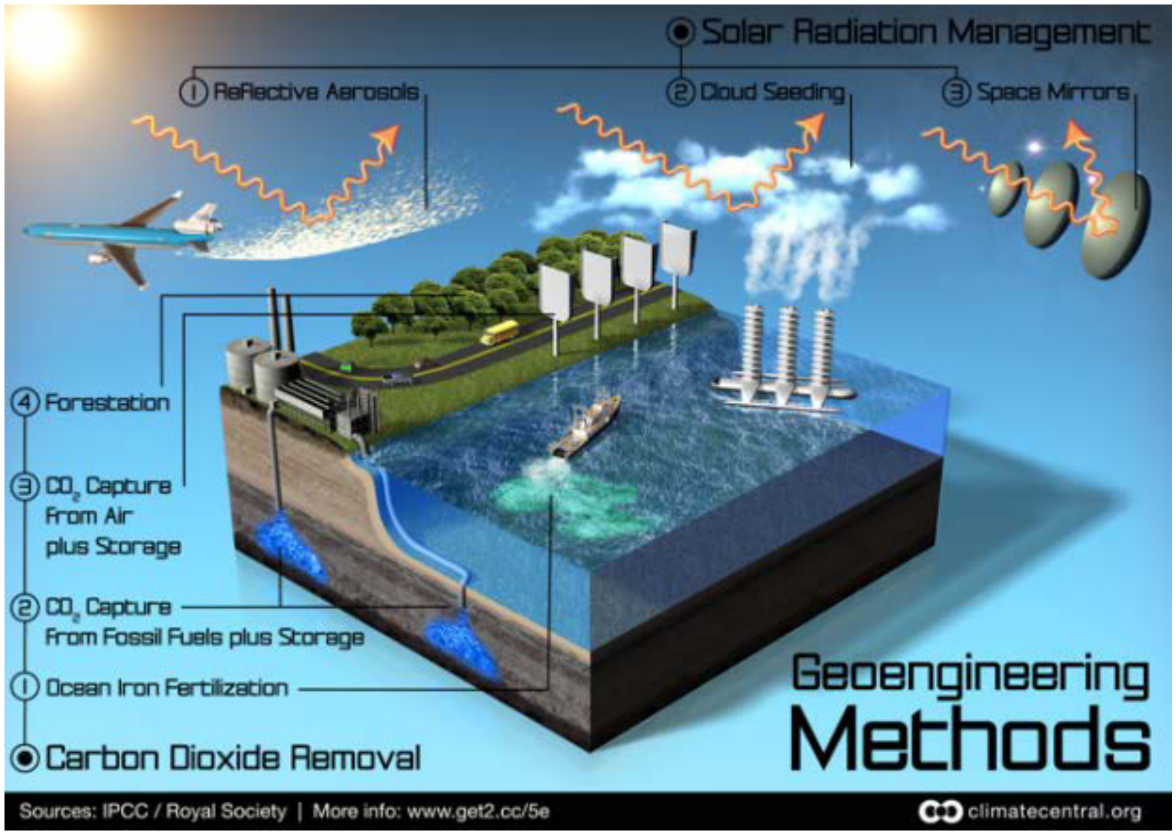
STERN review
ON THE ECONOMICS
OF CLIMATE CHANGE



An ongoing IPCC-like consolidation of knowledge is needed

Geoengineering

An insurance policy for intolerable risks



The outcomes from climate scenarios range from benign to catastrophic. It is very hard to forecast whether the climate will have a tipping point-a sudden irreversible change to a very different state. It is even harder to predict society's response to climate change, so we do not know at what point adaptation costs become unsustainable, tipping point or no.

Assess, Decide, Act

Both SLCP mitigation and adaptation require us to think globally, assess regionally, and act locally. Mitigation and adaptation work together at the regional and local levels.

We have been assessing globally since 1988, and thinking globally before that. We began to assess regionally in the 2000s. Assessments for cities have emerged in this decade, especially for sea level rise.

We know how to assess, we are beginning to understand what to decide, but there has not been much action.

A More Hopeful Dialogue

By acting on SLCPs and adaptation, we can refresh the stale climate dialogue centered on Carbon that has called forth profound opposition and led to global political gridlock.

We can buy time for the profound social and technical transformation needed to deal with Carbon. In the meantime, dealing with SLCPs and adaptation helps human health, reduces near term climate risks, and gives some hope that the world might be getting its climate change act together.

What would future generations say, knowing that we had useful things to do that we did not do? Would they think even the most ardent of us were not serious?

Most people do not live day in and day out with the images and data that fill the mental worlds of the scientists who study the earth. A very large majority of climate scientists may be convinced, but at today's 0.8C, climate change is not yet affecting most humans in socially compelling ways. Understanding what people may need to do to adapt could increase their support for climate change mitigation, especially if mitigation can reduce their adaptation risks in their lifetimes.