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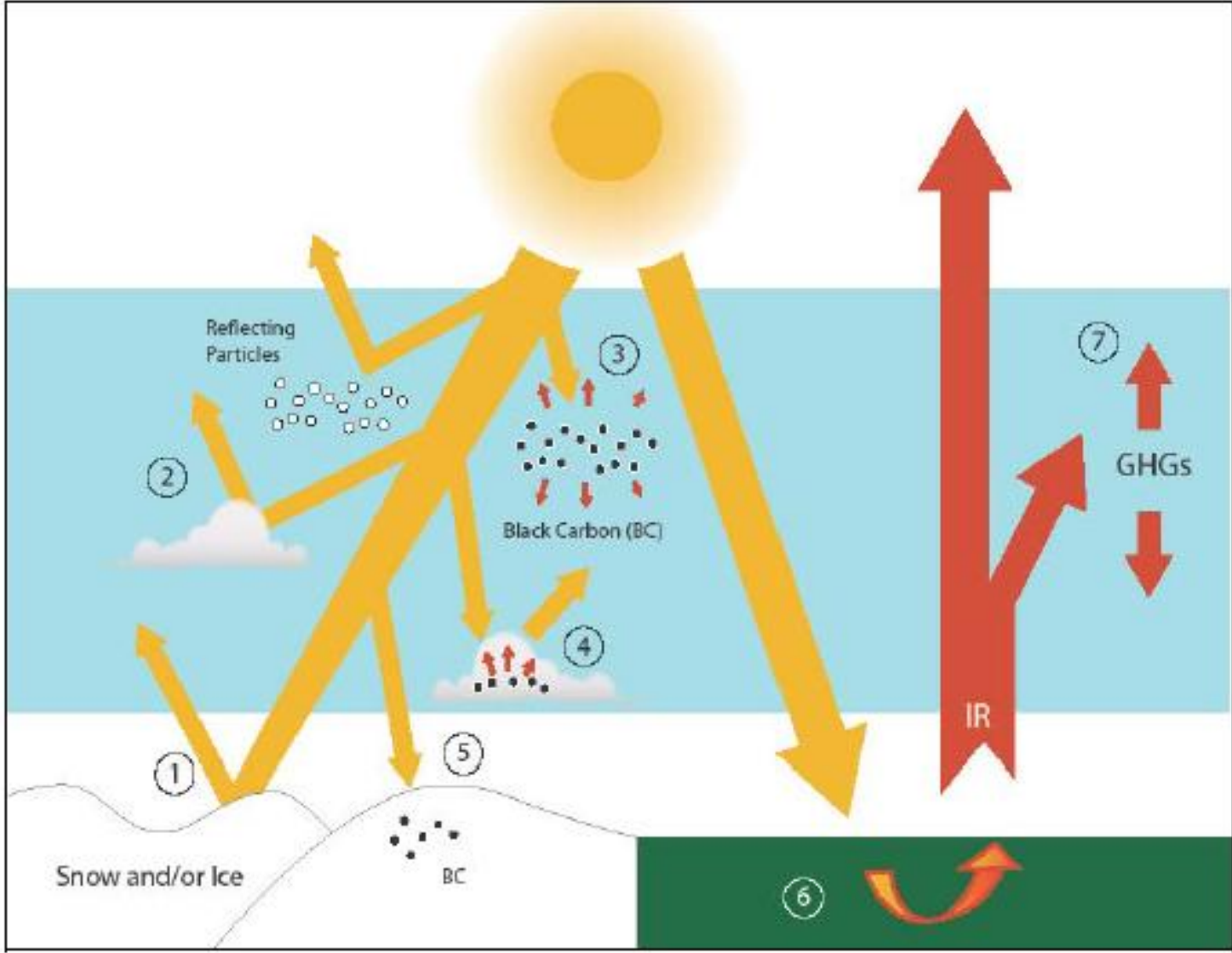
University of London

Black carbon and short-lived climate pollutants

Prof. Martin Williams
King's College London

London Air Quality Network Seminar, KCL, 28 June 2012

Climate impact of BC compared with other GHGs








What is Black Carbon?

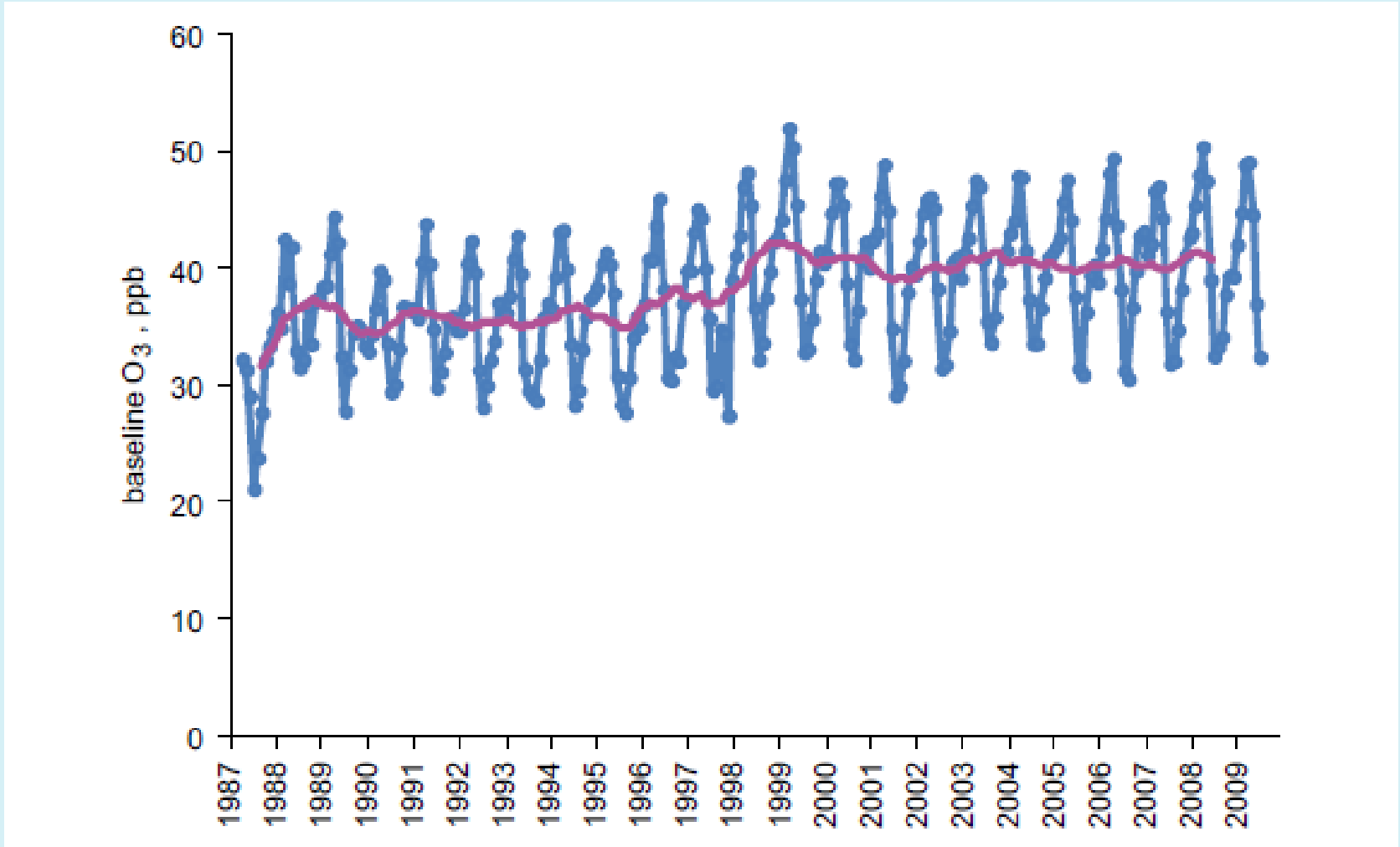
BC can be defined as the carbonaceous component of PM that absorbs all wavelengths of solar radiation. It is commonly referred to as “soot”. Per unit of mass in the atmosphere, BC can absorb a million times more energy than carbon dioxide (CO₂).



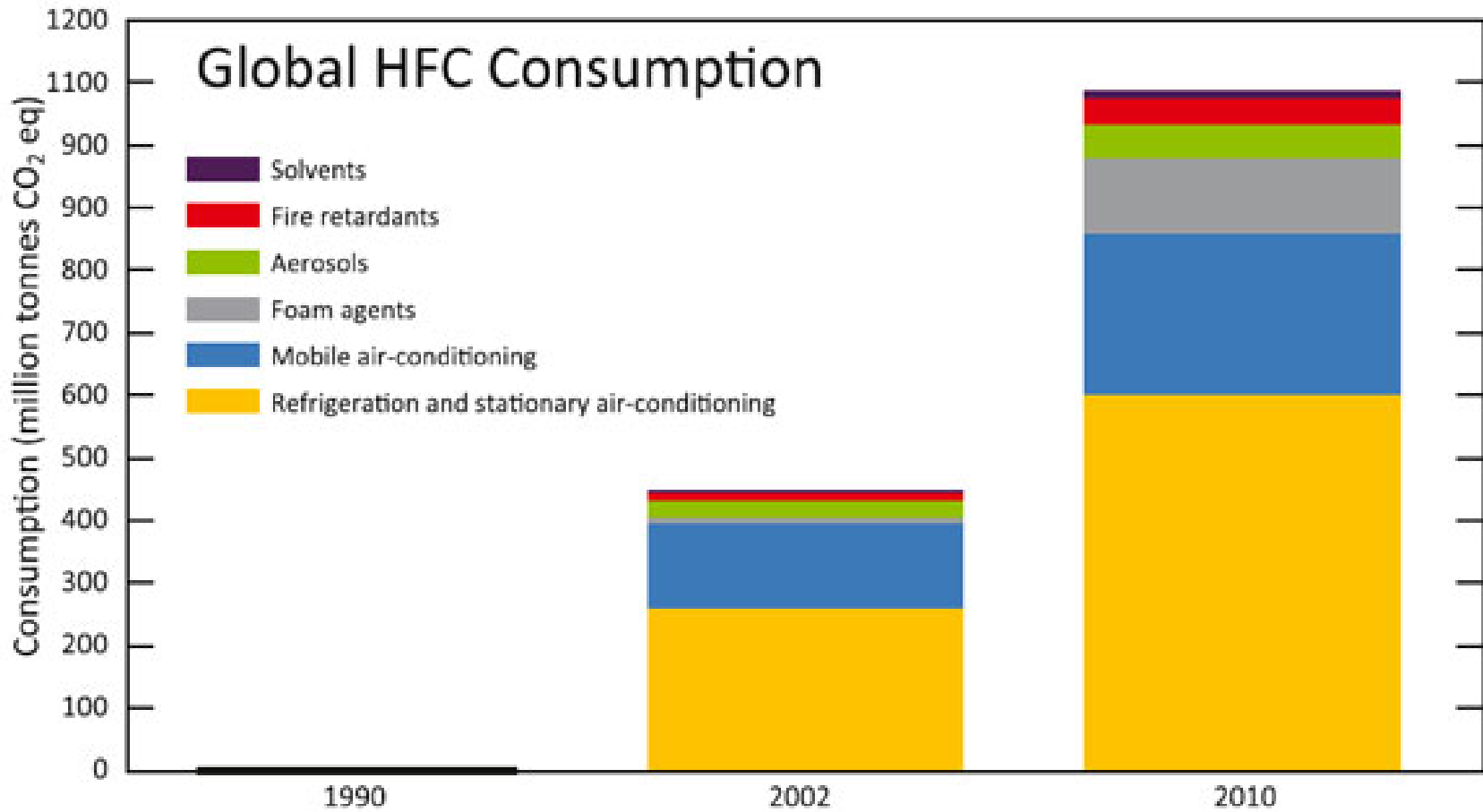
Radiative effects of different particles

Particle	Type	Radiative properties*
	Black carbon ^a	Absorbing (all solar wavelengths)
	Brown (or yellow) carbon ^b	Absorbing (UV and some visible)
	Non-absorbing carbon ^b	Scattering
	Nitrate ^c	Scattering
	Sulfate ^c	Scattering

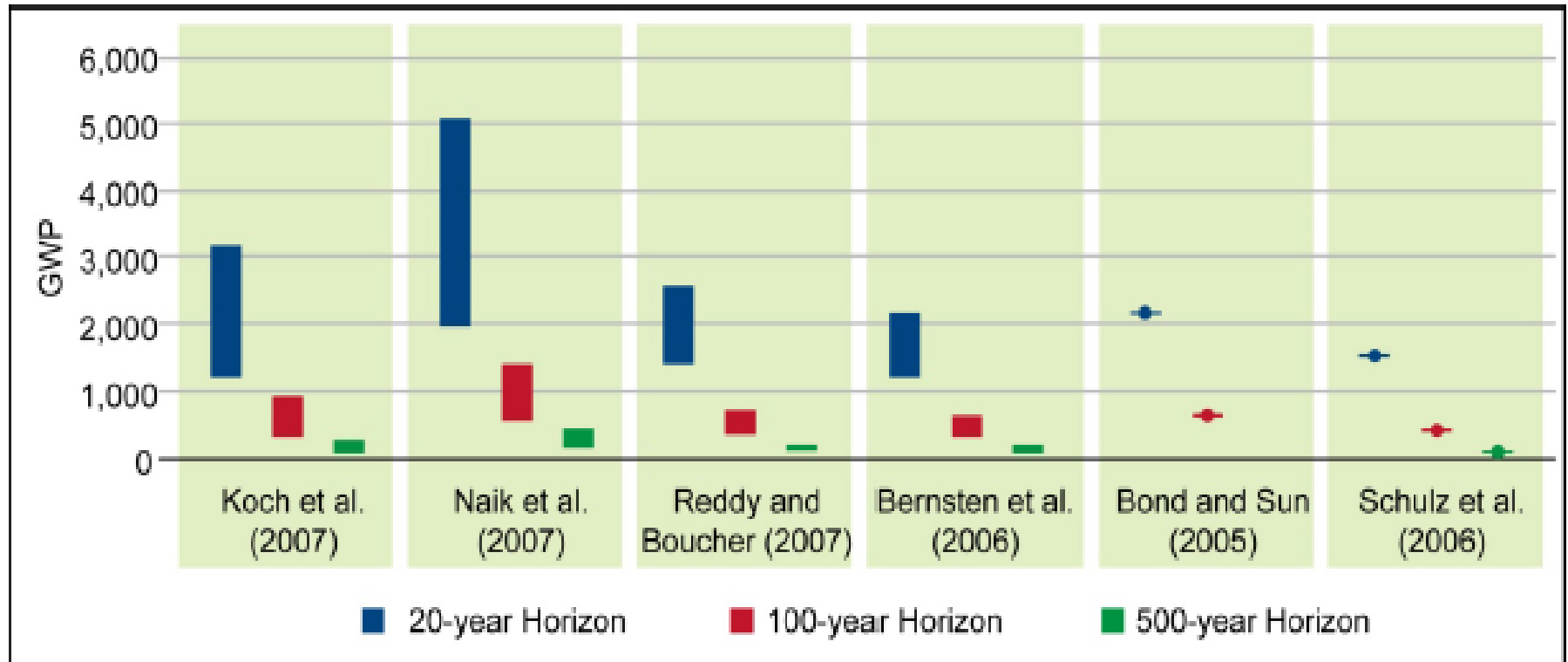
Ozone: Monthly mean baseline ozone at Mace Head, Ireland



HFCs

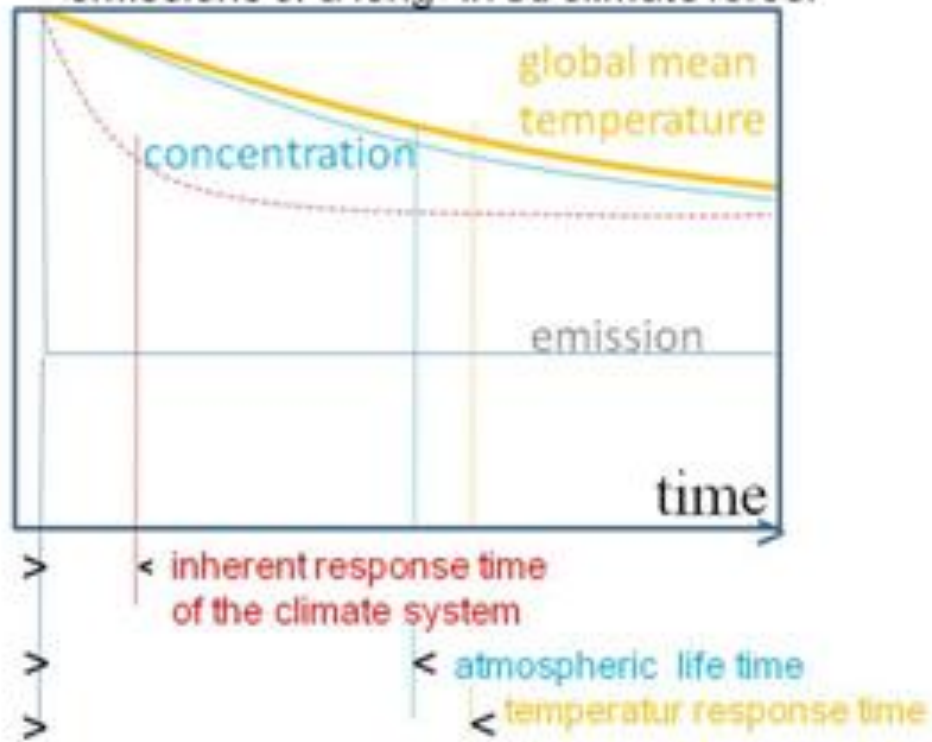


Ranges of GWP Estimates for BC ($\text{CO}_2 = 1$)

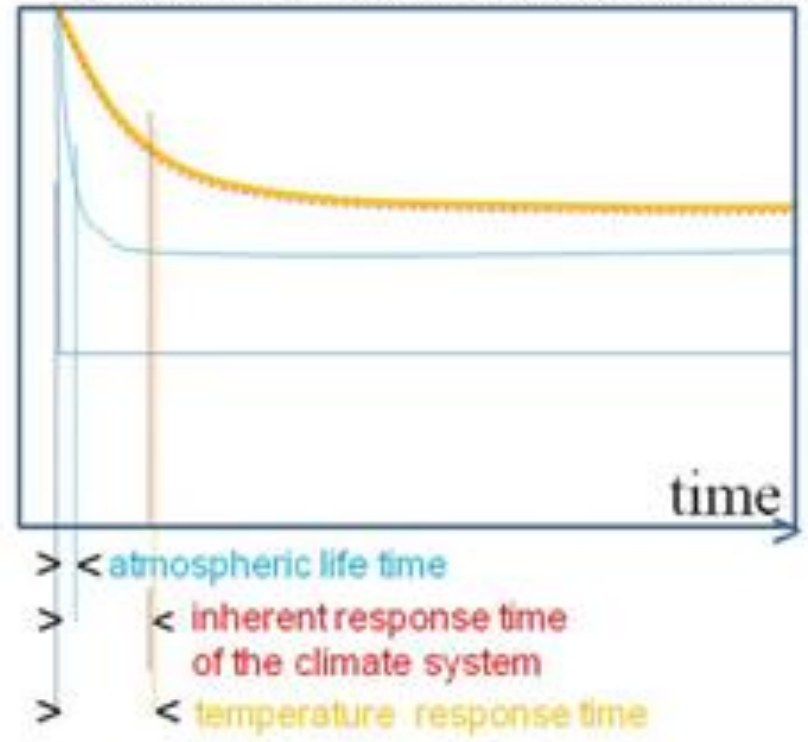


Global temperature response to LLGHG and SLCHF reductions

a) long term response to a reduction of emissions of a long-lived climate forcer



b) near term response to a reduction of emissions of a short-lived climate forcer



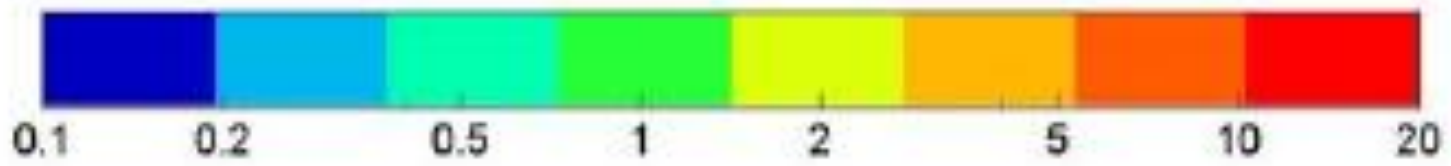
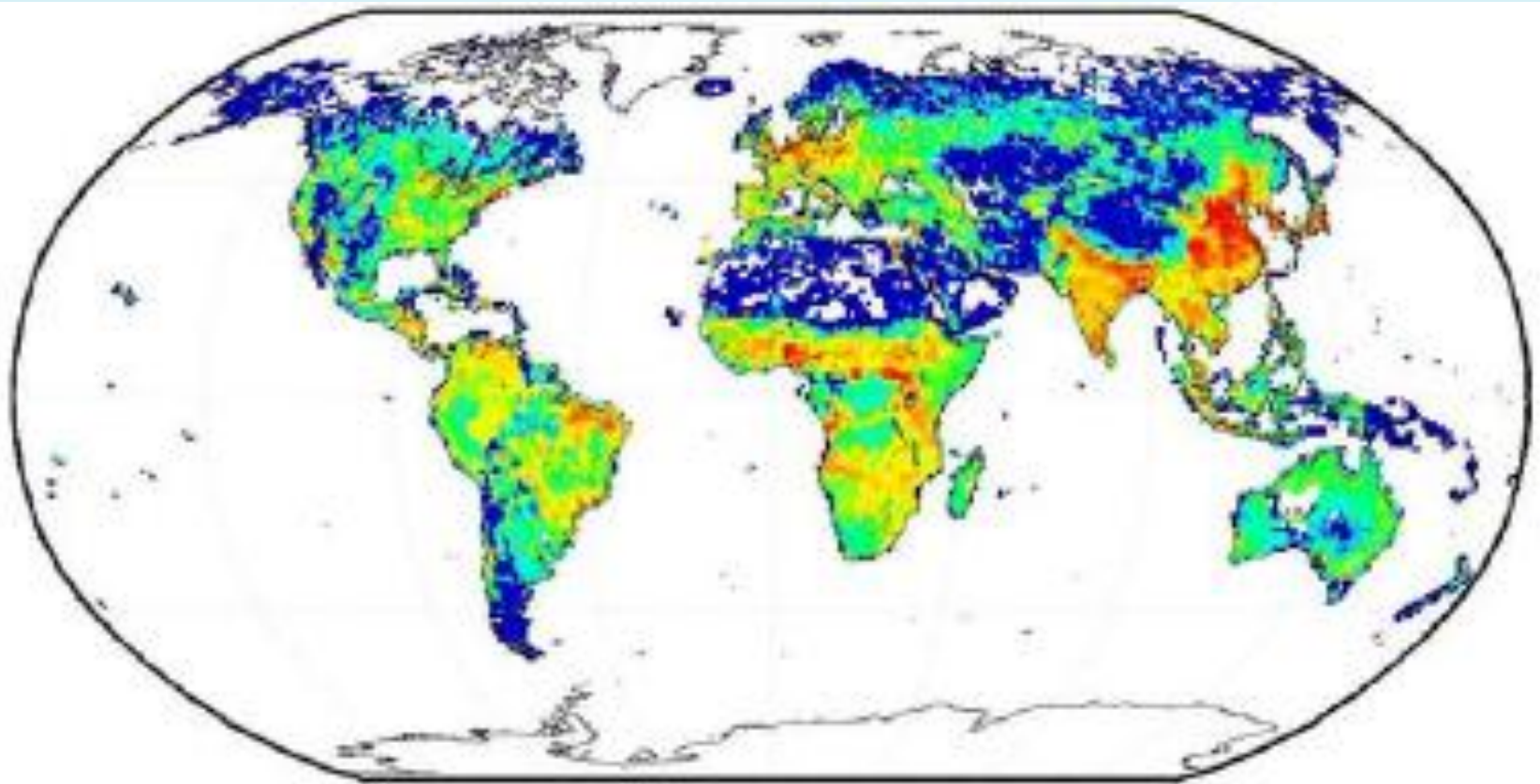
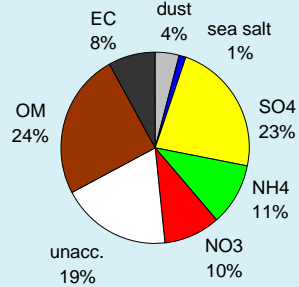


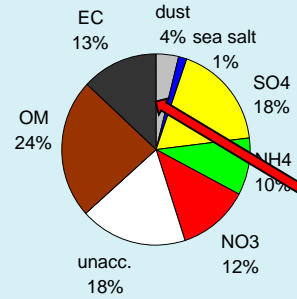
Figure B. BC Emissions, 2000, Gg (T. Bond)

PM2.5 composition in world regions

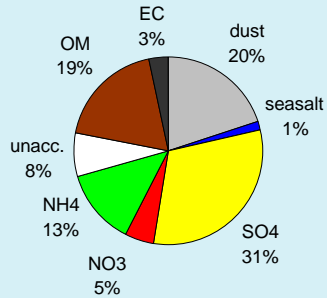
Central Europe , regional background (PM2.5=11 µg/m³)



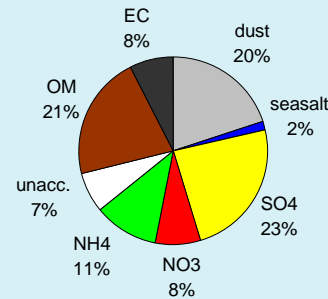
Central Europe , urban background (PM2.5=20 µg/m³)



Eastern USA, regional background (PM2.5=10 µg/m³)

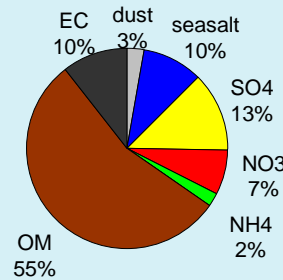
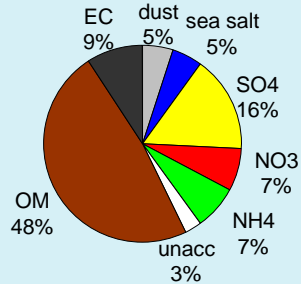


Eastern USA, urban background (PM2.5=14 µg/m³)

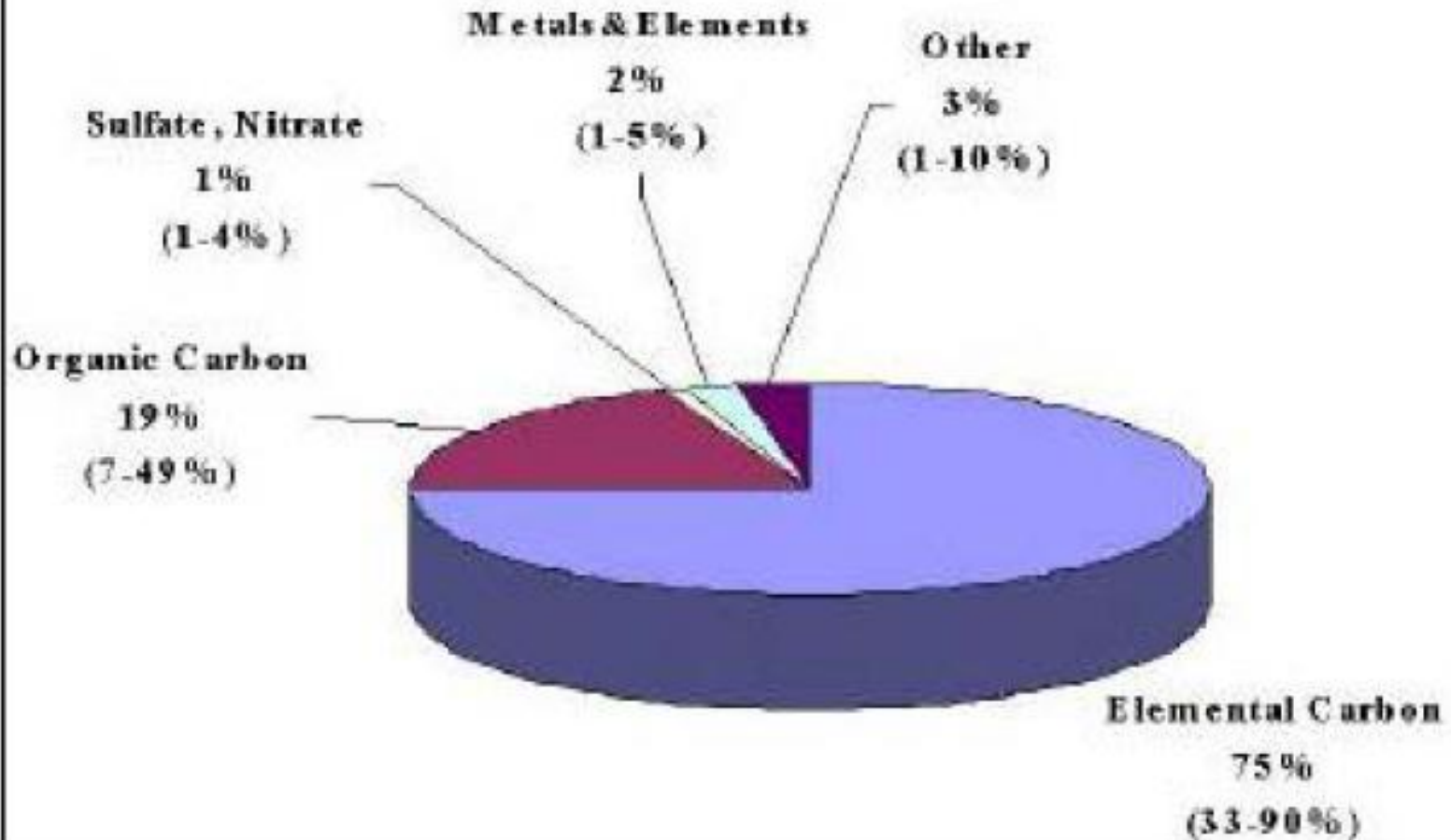


Black carbon

Northern India, regional background (PM2.5=87 µg/m³) Eastern India, urban background (PM2.5=122 µg/m³)



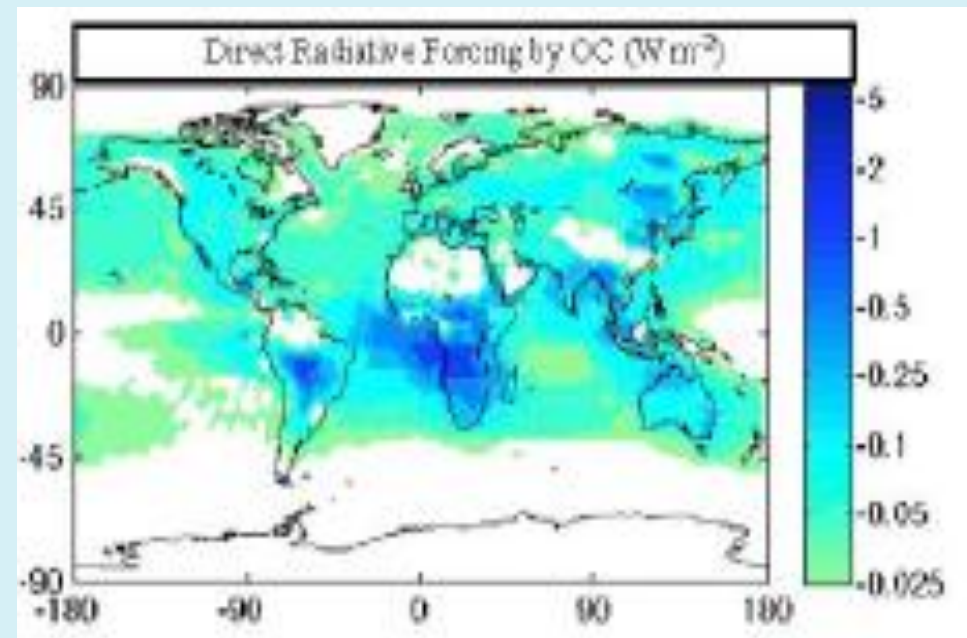
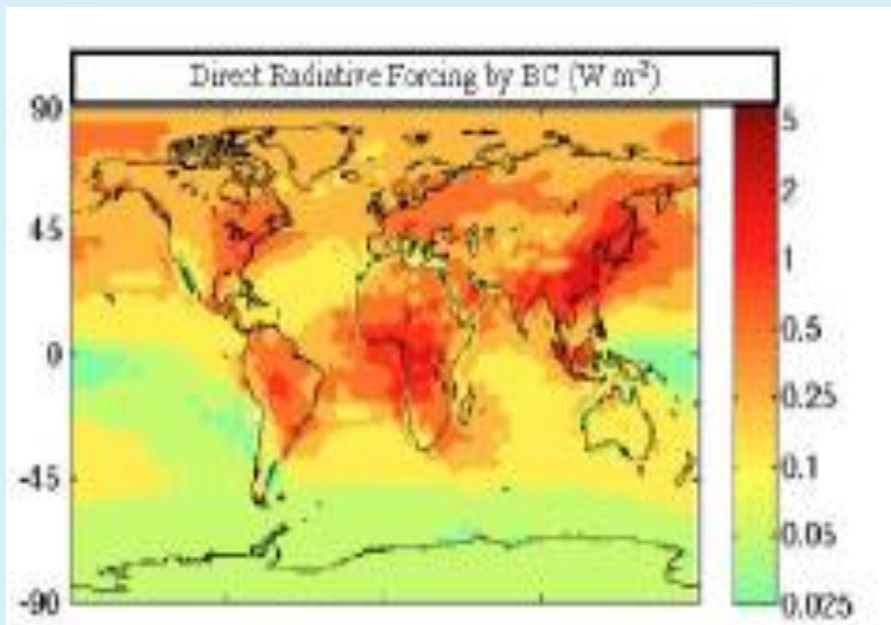
Diesel PM_{2.5} Chemical Composition



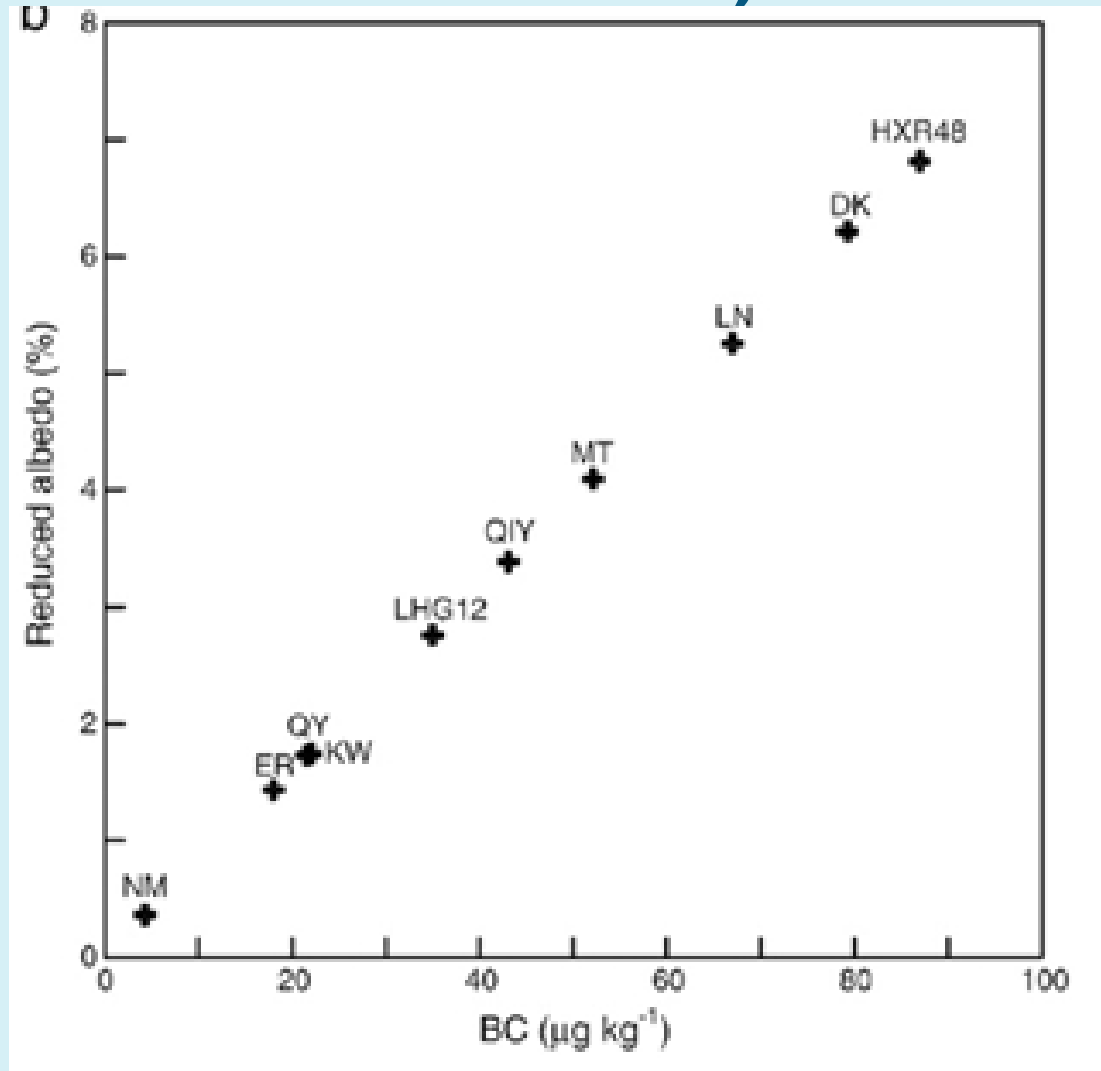
Source: Diesel Health Assessment Document, 2002, from US EPA BC Report 2011

Radiative forcing from BC and OC

-both are *regional*



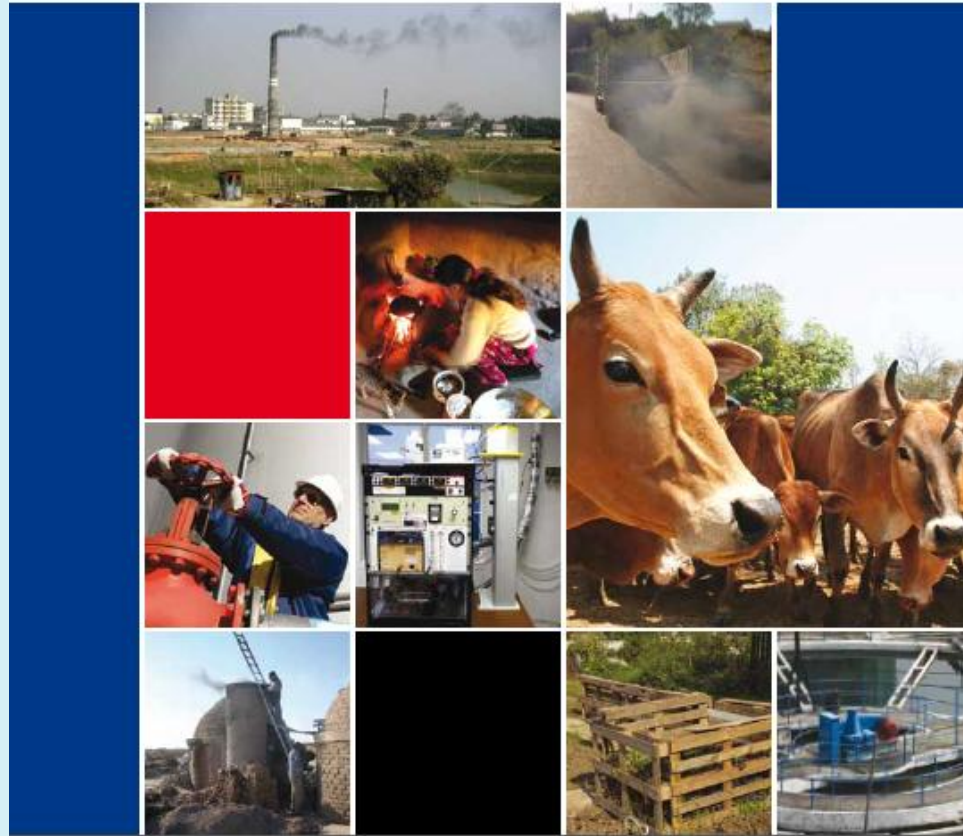
Effect of BC on albedo of Asian glaciers (Ming et al 2009)





Integrated Assessment of Black Carbon and Tropospheric Ozone

Summary for Decision Makers



Assessment Objectives

- To **review the scientific literature** on black carbon (BC), tropospheric ozone and its precursors and assess the state of knowledge of their influence on climate and impacts as air pollutants
- To assess the extent by which carefully identified **measures using existing technology** to address BC and ozone can help protect near-term global and regional climate change
- Determine the **co-benefits** of the selected measures on **health and crops**
- Identify how the selected measures can be widely implemented with reference to **case studies**



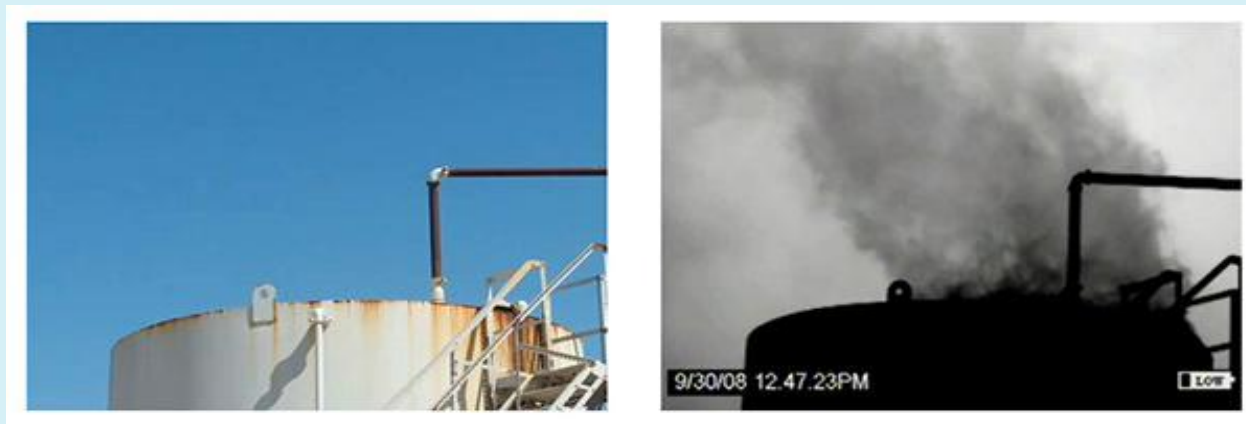
Emission Control Measures in the Analysis

•IIASA ranked mitigation measures by the net GWP of their emission changes (considering CO, CH₄, BC, OC, SO₂, NO_x, nmVOCs, and CO₂), picked the top measures

‘Methane measures’

- extraction and long-distance transport of fossil fuels (~25%)
- waste management; municipal, landfills & wastewater (~10%)
- agriculture; livestock manure & intermittent rice aeration (~5%)

(% reduction in 2030 relative to reference)



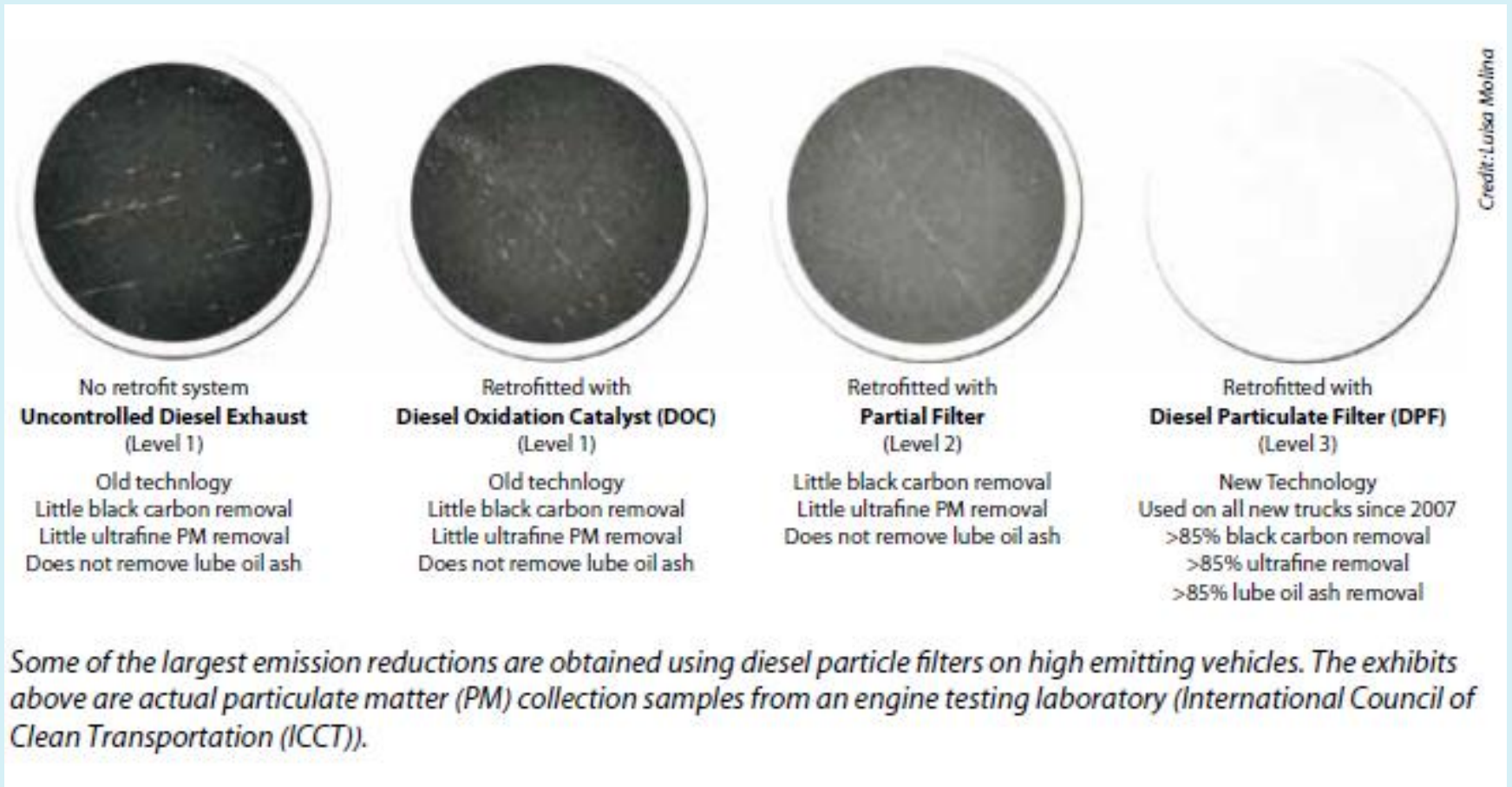
Black Carbon Measures

‘BC Measures’ that reduce emissions of black carbon and co-emissions (e.g. OC, CO)

- Diesel vehicles (particle filters+)
- Coal briquettes replacing coal in residential stoves
- Pellet stoves & boilers replacing residential wood burning in industrialized countries
- Clean-burning cookstoves in developing countries
- Modern brick kilns
- Modern coke ovens
- Ban of open burning of agricultural waste



Effect of DPFs on BC emissions



No retrofit system
Uncontrolled Diesel Exhaust
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash

Retrofitted with Diesel Oxidation Catalyst (DOC)
(Level 1)

Old technology
Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash

Retrofitted with Partial Filter
(Level 2)

Little black carbon removal
Little ultrafine PM removal
Does not remove lube oil ash

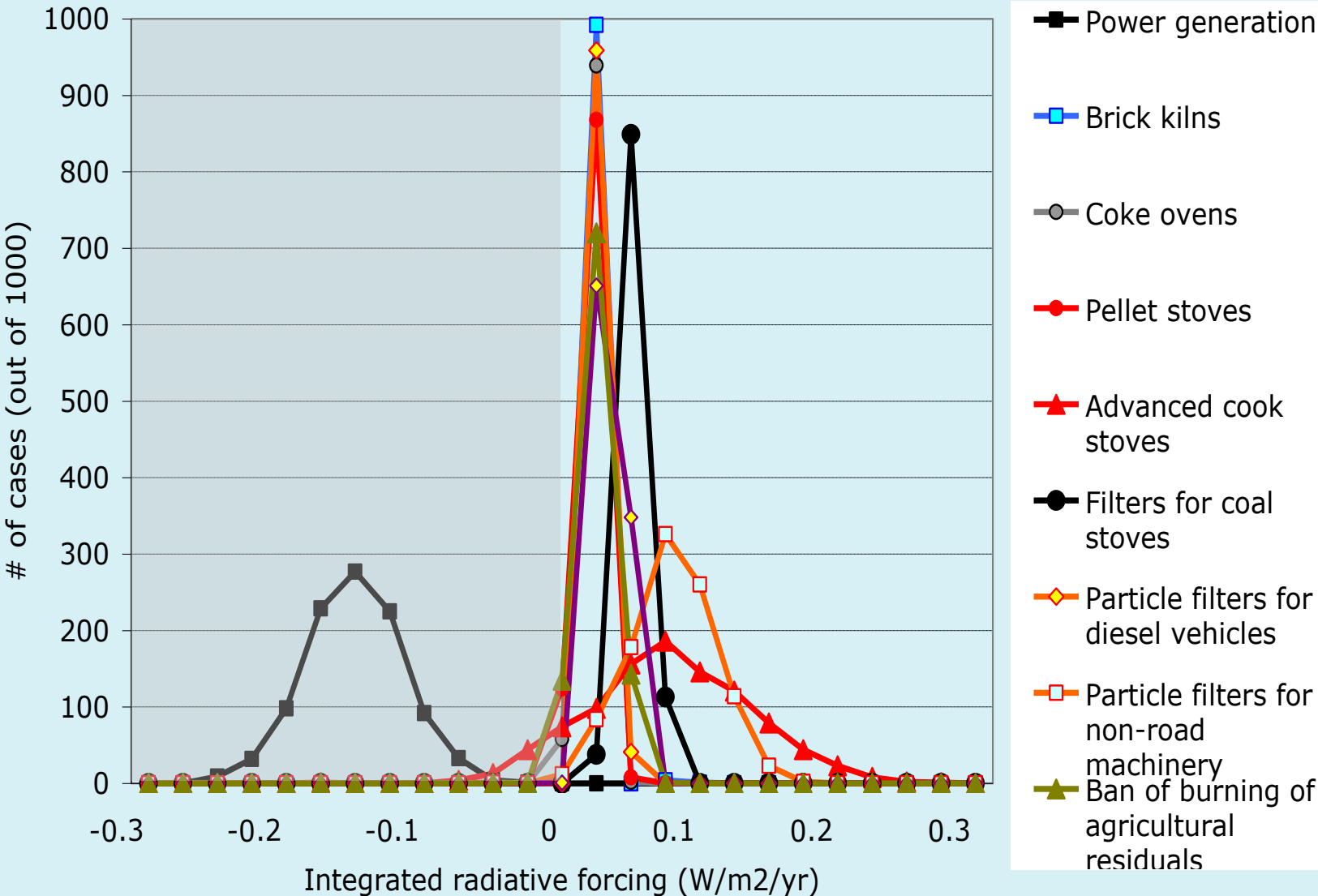
Retrofitted with Diesel Particulate Filter (DPF)
(Level 3)

New Technology
Used on all new trucks since 2007
>85% black carbon removal
>85% ultrafine removal
>85% lube oil ash removal

Some of the largest emission reductions are obtained using diesel particle filters on high emitting vehicles. The exhibits above are actual particulate matter (PM) collection samples from an engine testing laboratory (International Council of Clean Transportation (ICCT)).

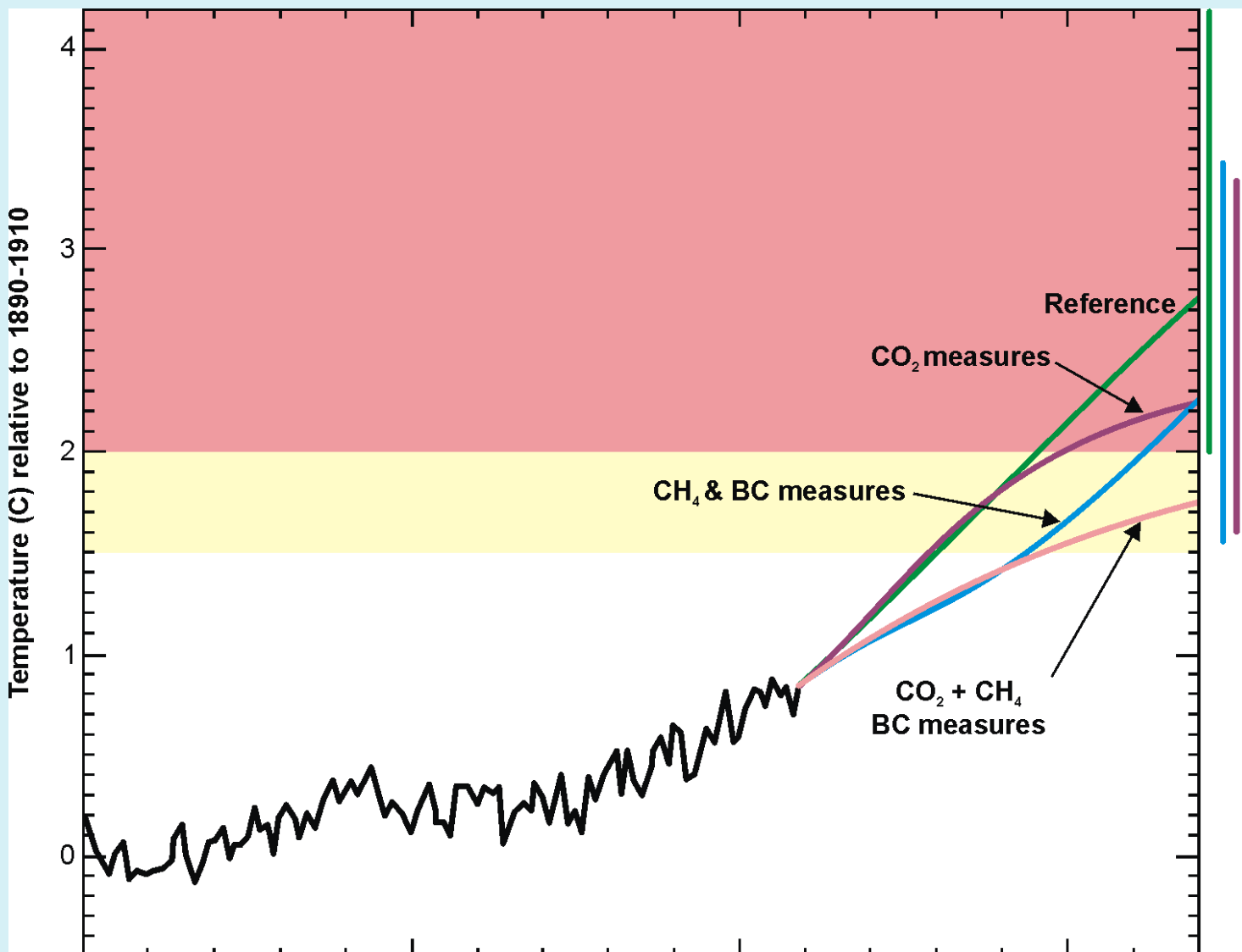
Credit: Luisa Molina

Uncertainty ranges on effects of BC measures

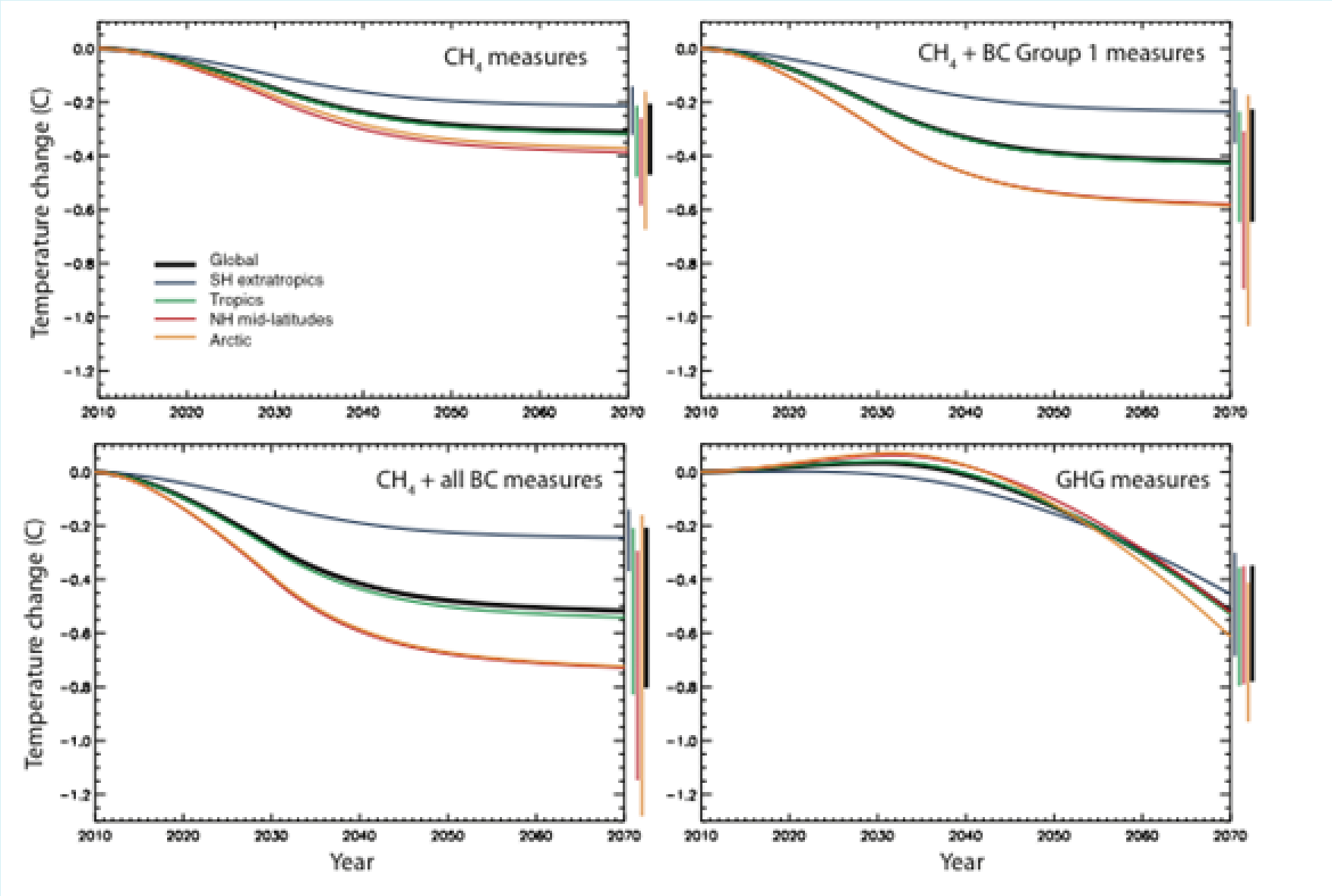


- Modelling using ECHAM5-HAMMOZ and GISS-PUCCINI climate impacts and concentrations
- Climate simulations with GISS-E2-S model + mixed-layer ocean
- FASST tool (JRC)
- Health impacts from long-term exposures to PM_{2.5} and ozone
- Crop impacts from ozone

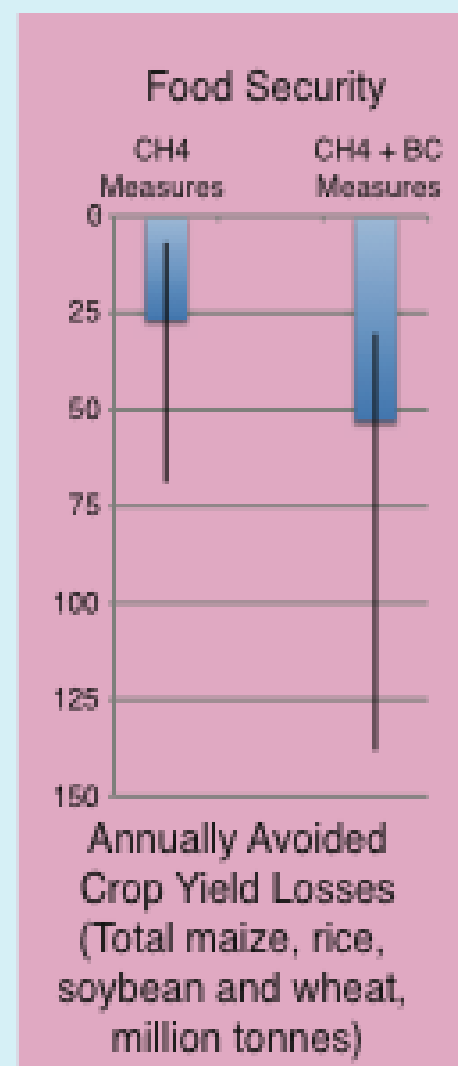
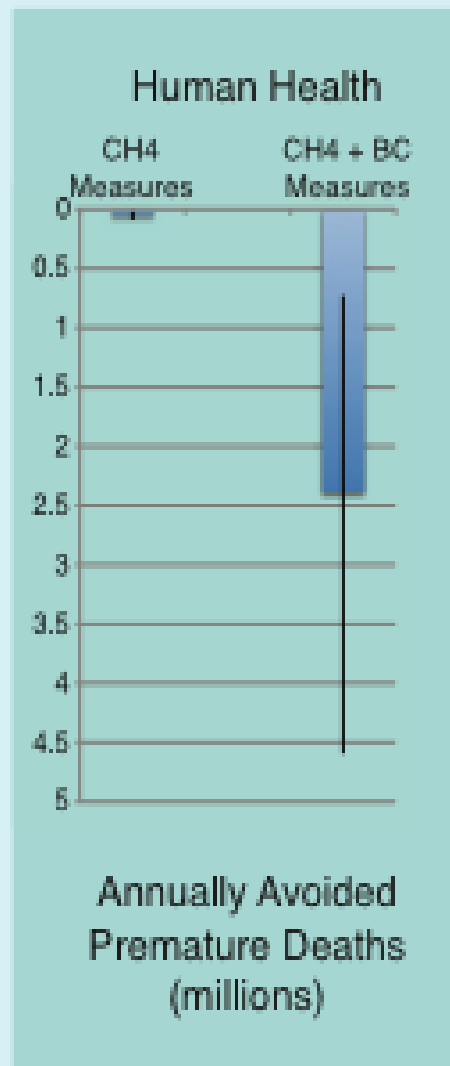
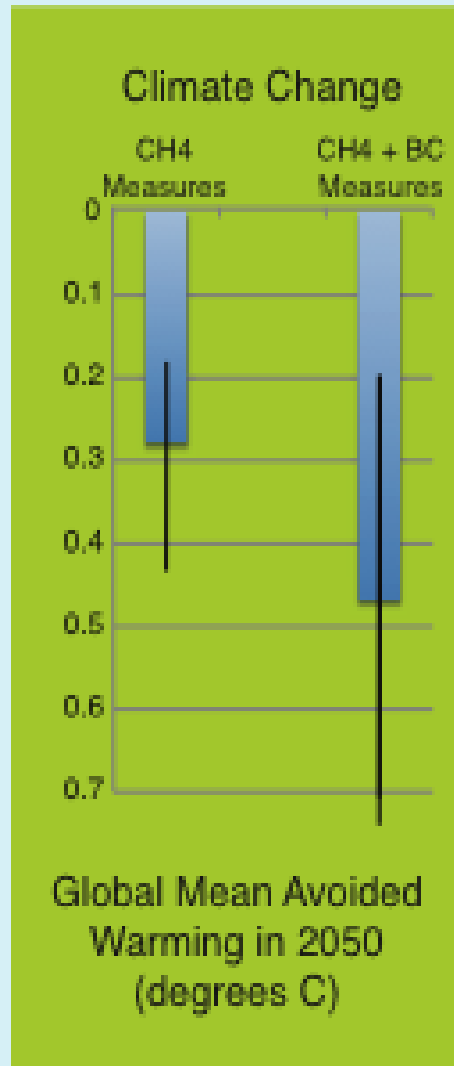
SLCF and CO₂ measures are complementary not mutually exclusive



Regional temperature impacts of SLCF measures



As well as climate benefits there are also major benefits for health and food security



Main policy messages of the UNEP/WMO Assessment

- There are important public health and food security benefits from tackling SLCFs as well as for climate
- SLCF abatement is complementary to measures on GHGs-both are needed
- Swift action is beneficial
- Abatement of SLCFs is feasible with existing technologies and policies
- ...BUT international governance is lacking

How would these scientific findings be translated into policies and action?



United States Environmental Protection Agency

Report to Congress on Black Carbon

Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010

AMAP Technical Report No. 4 (2011)



HFCs: A Critical Link in Protecting Climate and the Ozone Layer

A UNEP Synthesis Report

[ADVANCE COPY]



Near-term Climate Protection and Clean Air Benefits: Actions for Controlling Short-Lived Climate Forcers

A UNEP Synthesis Report

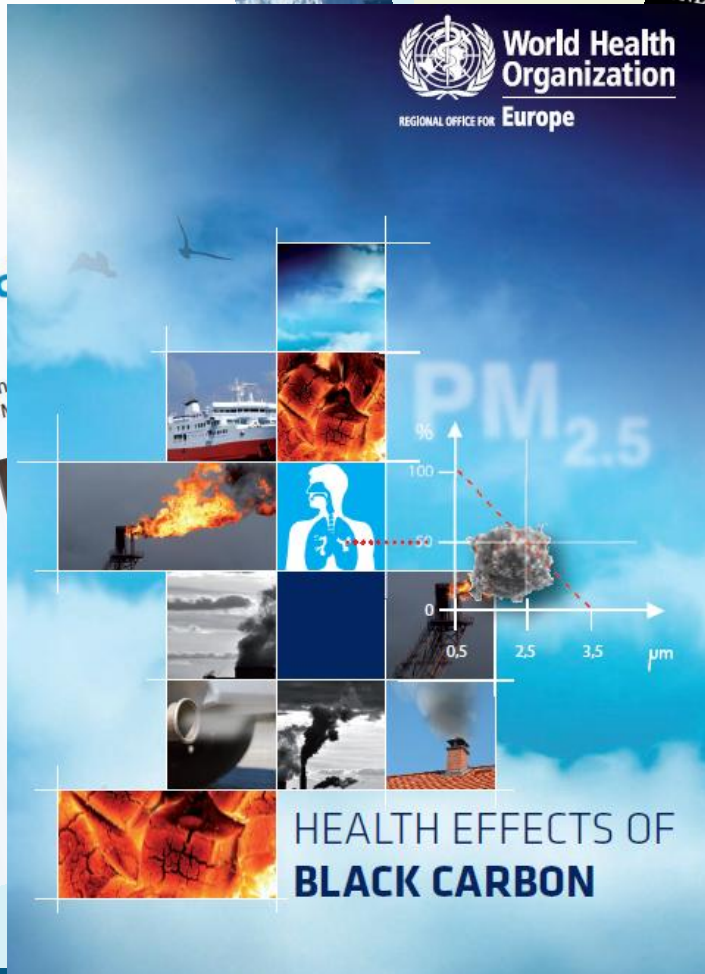


World Health Organization

REGIONAL OFFICE FOR Europe

The Impact of Black Carbon on Arctic Climate

P.K. Quinn, A. Stohl, A. Arneth, T. Berntsen, M. Flanner, K. Kupiainen, H. Lihavainen, M. Malm, H. Skov, and V. Vestreng



HEALTH EFFECTS OF BLACK CARBON

Climate and Clean Air Coalition launched in 2012 by US State Department



Five areas for first phase of action:

- **Heavy Duty Diesel Vehicles and Engines**
 - **Brick Production**
 - **Waste**
 - **HFC alternatives**
 - **Oil and Natural Gas production**
- **Members:** Bangladesh, Canada, Columbia, Ghana, Japan, Mexico, Norway, Sweden, USA, European Commission, UK, France, Germany, Italy, Russia

Brick Kiln Modernization Ciudad Juarez, Mexico



- Conventional brick kilns (left) burn waste wood, oil and tires in open-topped kilns
- New kilns (right) use same fuels but filters exhaust into underground channels, reducing emissions by 80% and using 50% less wood.

Cookstoves used around the world



Turbococina, El Salvador



LPG Cookstoves – Senegal



Oorja smokeless biomass stove, India



HELPS "ONIL" stove - Guatemala



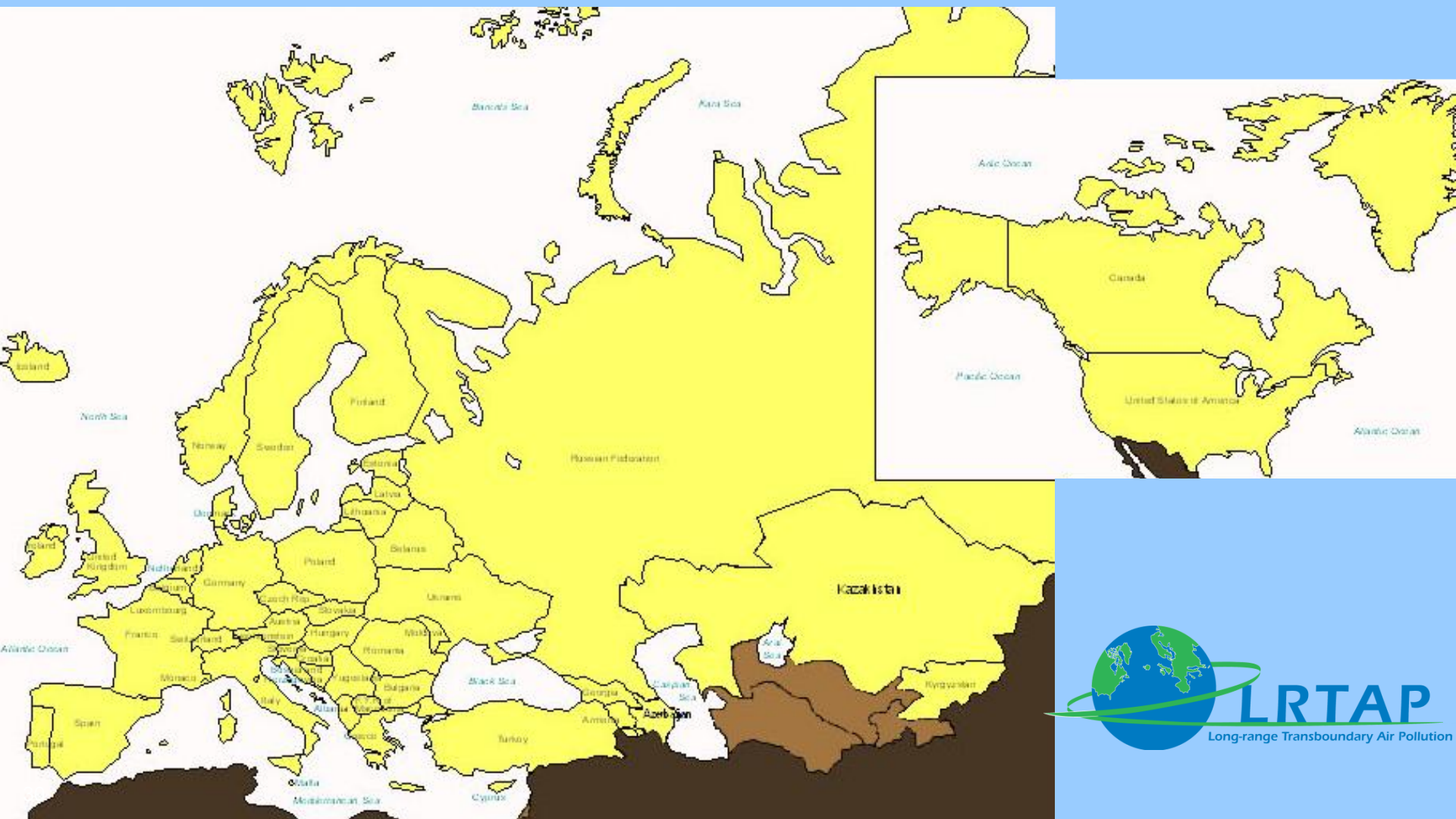
Solar cooker



Patsari stove in Mexico

CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

51 Parties in Europe, North America and Central Asia



Revised Gothenburg Protocol May 2012

- Sets national emissions targets for 2020 for PM_{2.5}
- Parties should :
 - ”in implementing measures to achieve their national targets for particulate matter, ***give priority, to the extent they consider appropriate, to emission reduction measures which also significantly reduce black carbon*** in order to provide benefits for human health and the environment and to help mitigation of near-term climate change.”
- “Each Party should, to the extent it considers appropriate, also ***develop and maintain inventories and projections for emissions of black carbon***, using guidelines adopted by the Executive Body.”

Revised Gothenburg Protocol

- The Parties shall encourage research, development, monitoring and cooperation related to:
 - The improvement of the ***scientific understanding of the potential co-benefits for climate change mitigation associated with potential reduction scenarios for air pollutants (such as methane, carbon monoxide and black carbon) which have near-term radiative forcing and other climate effects;***
 - The quantification and, where possible, economic evaluation of benefits for the environment, human health and the impacts on climate resulting from the reduction of emissions of sulphur, nitrogen oxides, ammonia, volatile organic compounds and particulate matter;

UK Options for Black Carbon reductions?

- Emission inventories are not well known
- Particularly the mix of BC(EC) and Organic Carbon in each source sector
- Policies on PM will reduce BC from most sources – transport (DPFs)
- Scope for speeding this up
 - *Retrofit incentives*
 - *Low Emission Zones for HGVs*
 - *Non-road Mobile Machinery (incl. Trains, ships/IMO)*
- BC from North Sea flaring? Arctic?