UNEP/WMO Integrated Assessment of Black Carbon and Tropospheric Ozone

Main Findings

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Background

- Black carbon, BC, and tropospheric ozone,O_3, are **harmful air pollutants that also contribute to global and regional climate change.**

- Together with methane, an important precursor to ozone, these are termed **'Short-Lived Climate Forcers'** due to short residence time in atmosphere compared to CO_2.

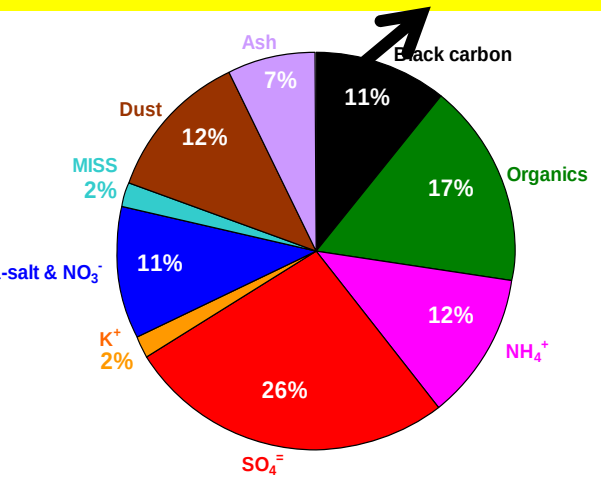
- Control of black carbon particles and tropospheric ozone have **immediate and multiple benefits for human well-being.**

Black Carbon

- carbon-containing **particulate matter (PM)**
- absorbs light, affects health as PM
- results **from inefficient and incomplete combustion**
- emitted together with CO_2, CO, organic particulate matter (OC), other $PM_{2.5}$, SO_2 , NO_X

*Greenhouse Forcing = 3 W/m**2 Brown Cloud Masking= -1.5 (+-50%) W/m**2*

Traps sunlight and heats the air



~10%
of global BC emissions

~50%

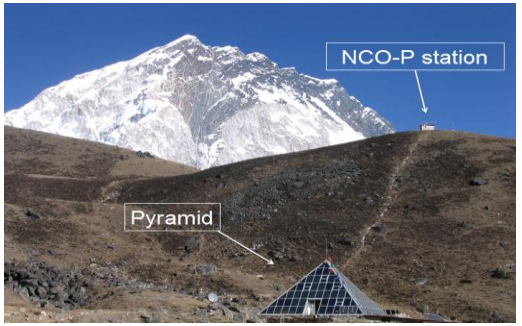
Reflects sunlight and cool

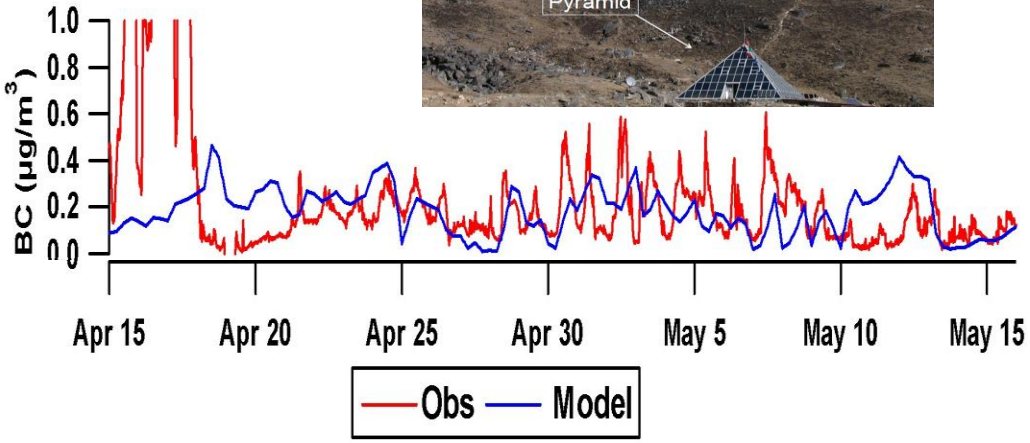
~60% of the *total* BC emissions is amenable to control

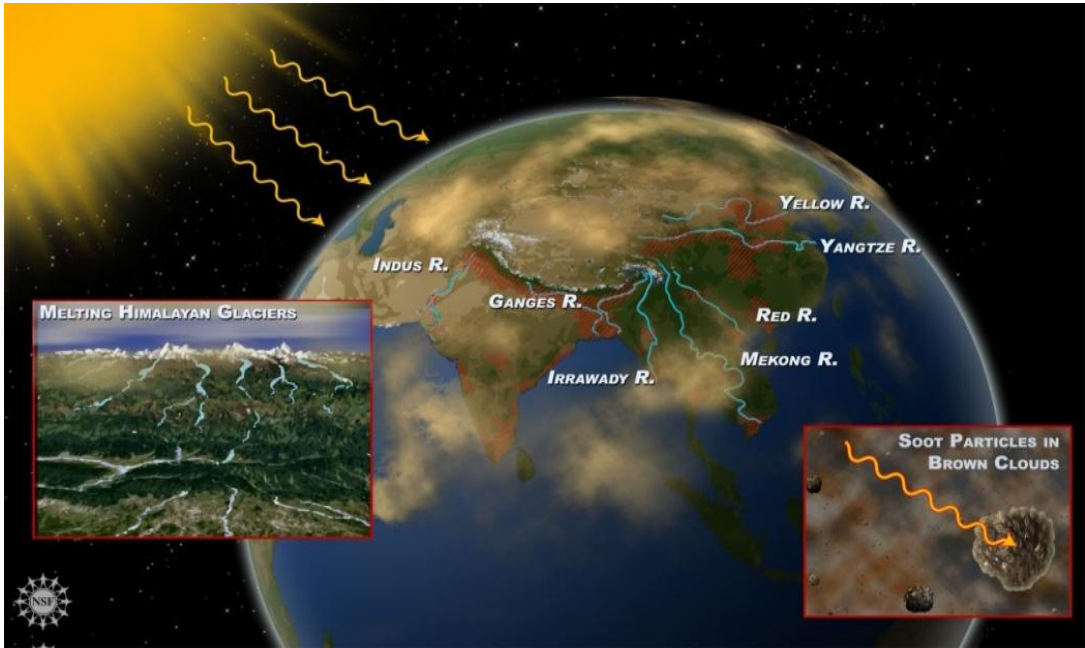
Figure Source: V. Ramanathan, and G. Carmichael, Nature Geoscience, 2008

BC Transport and Deposition have Large Impacts at High Latitudes/Altitudes

NCO-P web-cam images of Khumbu valley







S. Fuzzi and team, Project ABC

Tropospheric Ozone

stratosphere

troposphere

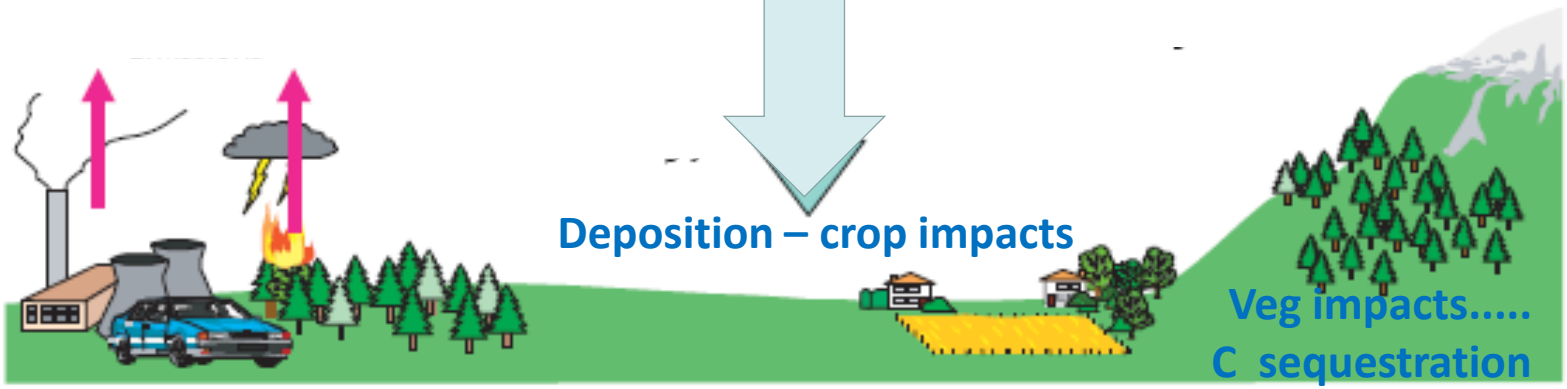
stratospheric O_3

8 – 15 km

chemical production

chemical destruction

CH_4 CO VOCs NO_x → O_3 + PM



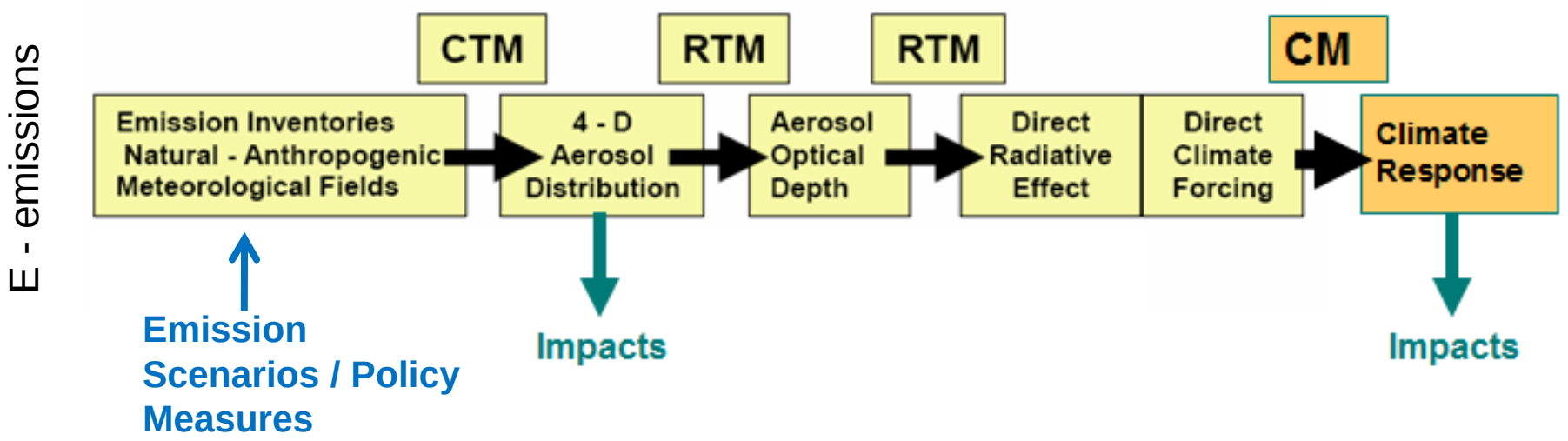
cattle
gas leaks
mining
biofuels
fossil fuels

increase of precursor emissions by man has **more than doubled** the concentration of tropospheric ozone since pre-industrial times!

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

Analysis Chain - Linking Emissions to SLCFs Distributions and Subsequent Radiative/Climate Impacts



Emission Control Measures in the Analysis

IIASA ranked mitigation measures by the net GWP of their emission changes (considering CO, CH_4, BC, OC, SO_2, NO_X, nmVOCs, and CO_2), 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+)
- Eliminate high emitting vehicles
- Coal briquettes replacing coal in residential stoves
- Pellet stoves & boilers replacing residential wood burning in industrialized countries
- Clean-burning cookstoves in developing countries OR replace biomass with other fuel
- Modern brick kilns
- Modern coke ovens
- Ban of open burning of agricultural waste

Policy Packages Used in the Assessment

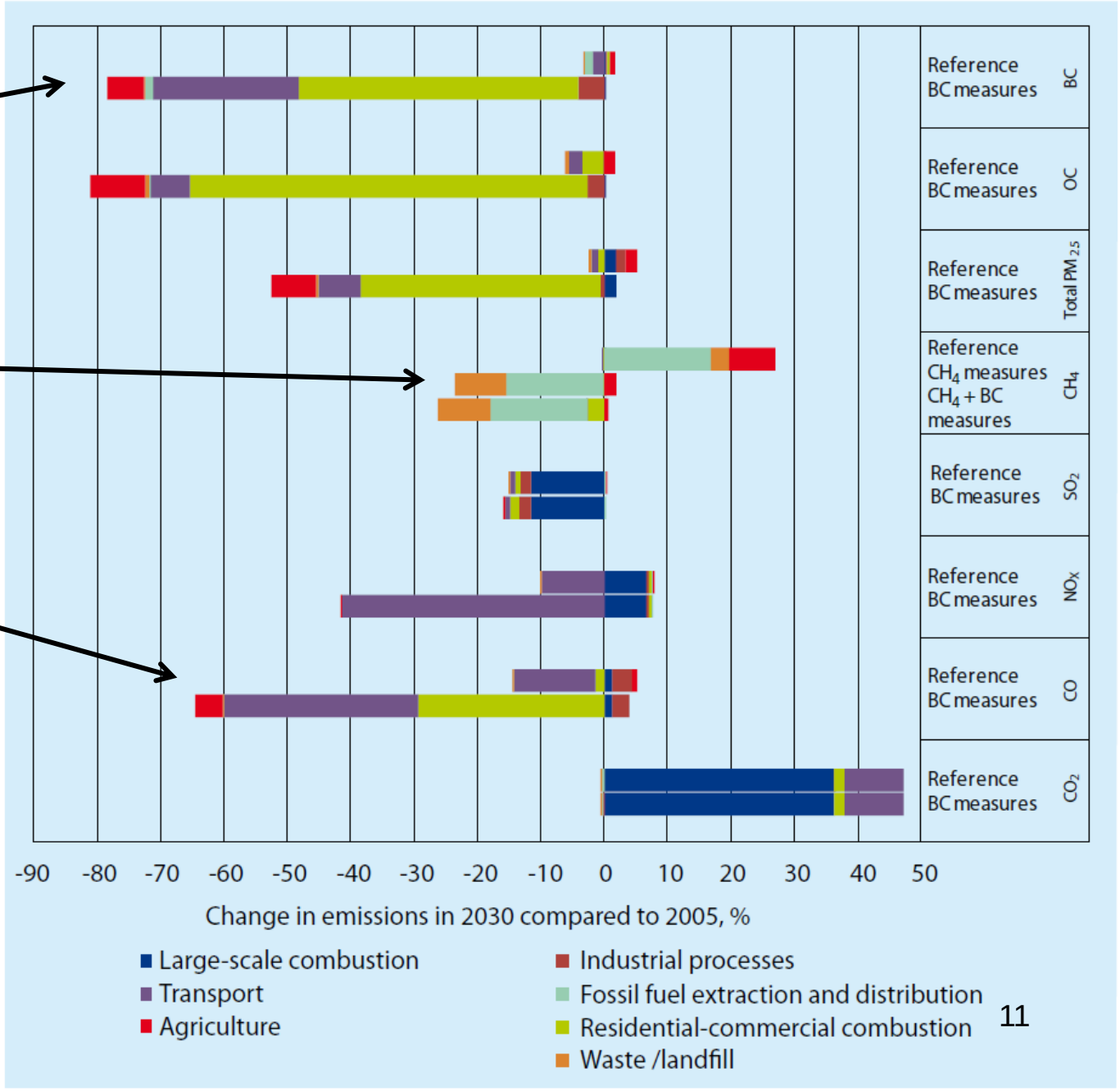
Scenario	Description
Reference	Based on energy and fuel projections of the (IEA) *World Energy Outlook 2009* and incorporating all presently agreed policies affecting emissions
CO_2 Measures	Emissions modelled using the assumptions of the IEA **450**ppm Scenario and the IIASA GAINS database. Includes CO_2 measures only.
CH_4 Measures	Reference scenario plus the CH4 measures
BC Measures	Reference scenario plus the BC measures (also affects other pollutants, especially BC, OC, and CO)

Effect of Measures on Emissions Projected in 2030 Relative to 2005

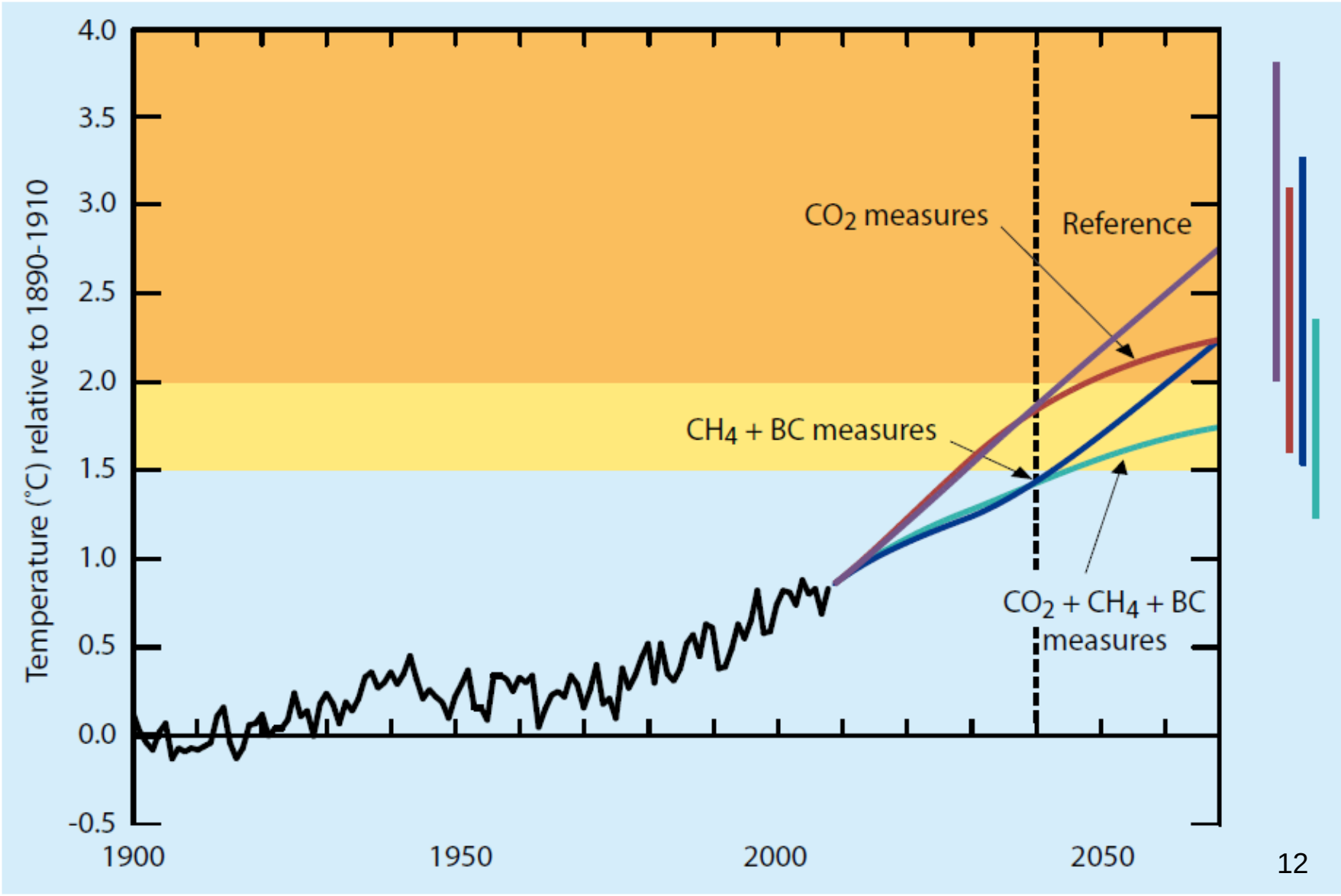
9 BC measures reduce ~80% of BC

Reference: CH_4 increases
7 CH_4 measures reduce ~25% of CH_4 (2005); or ~ 40% relative to 2030

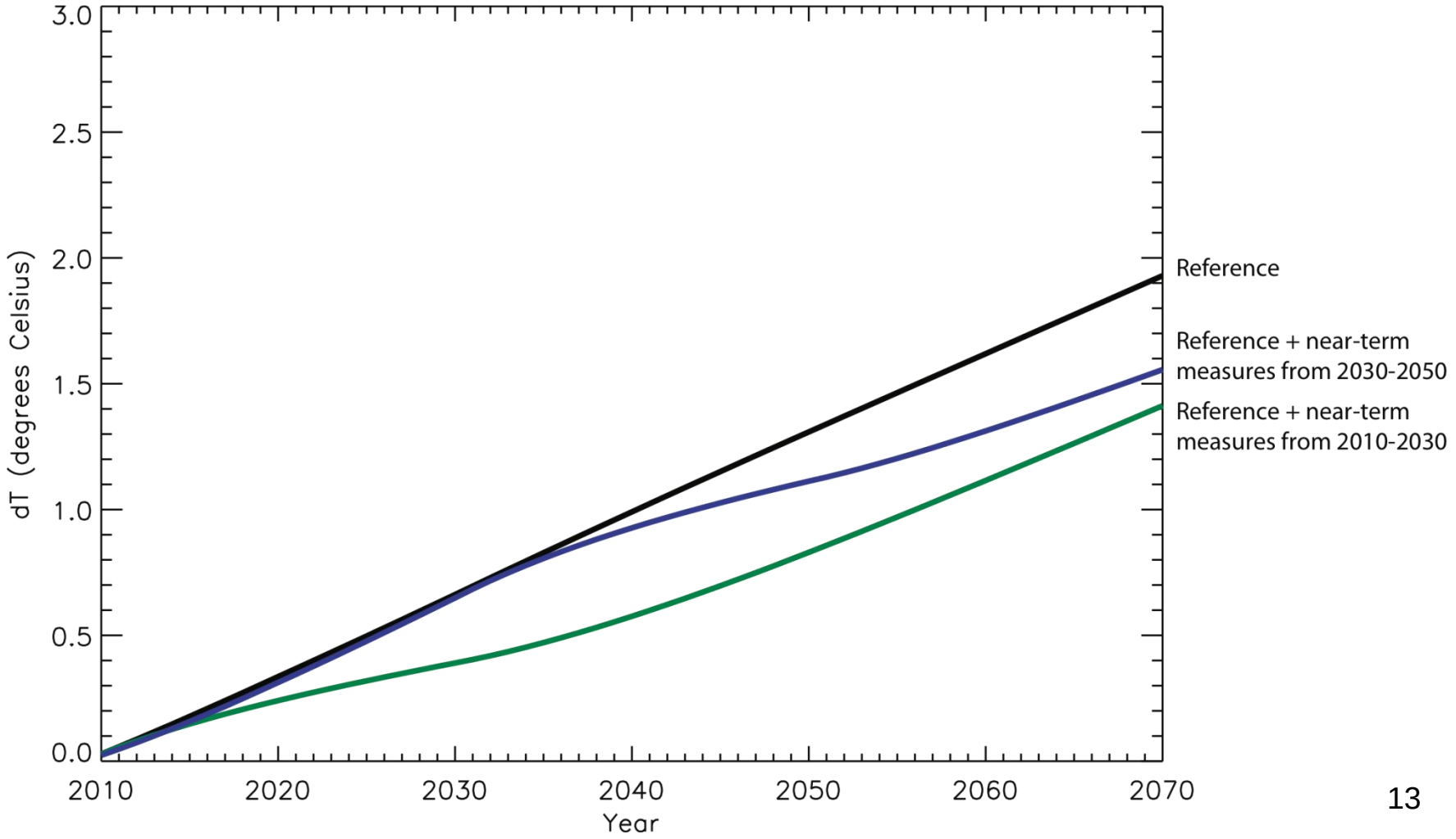
BC measures reduce CO



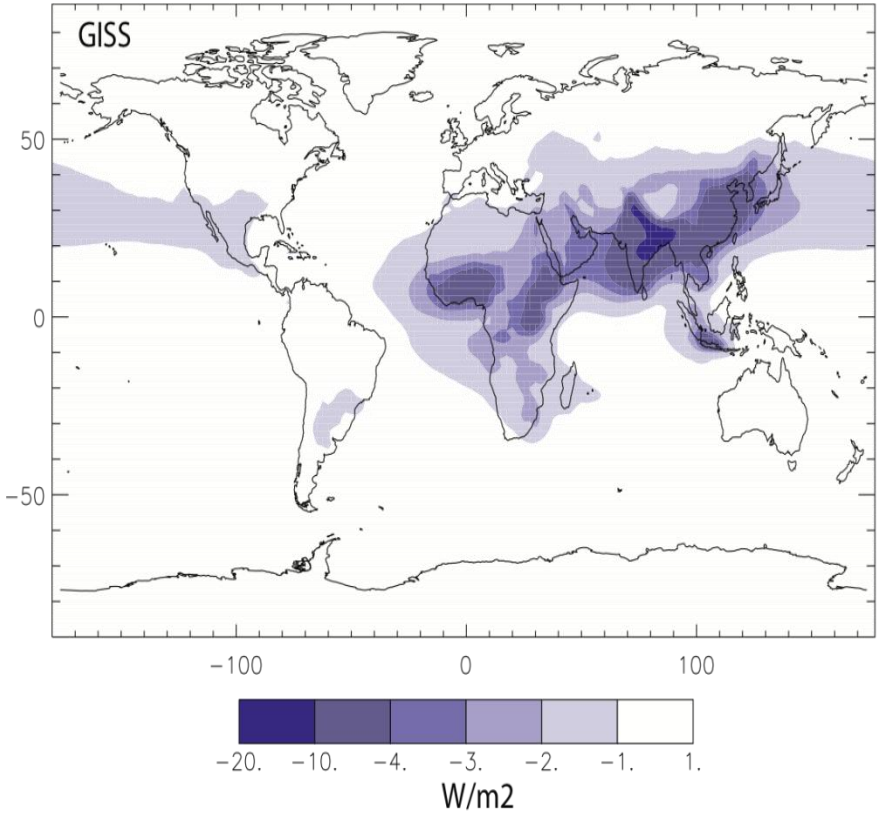
Result for Global Temperature Change: CO_2 and SLCF Measures are Complementary Strategies

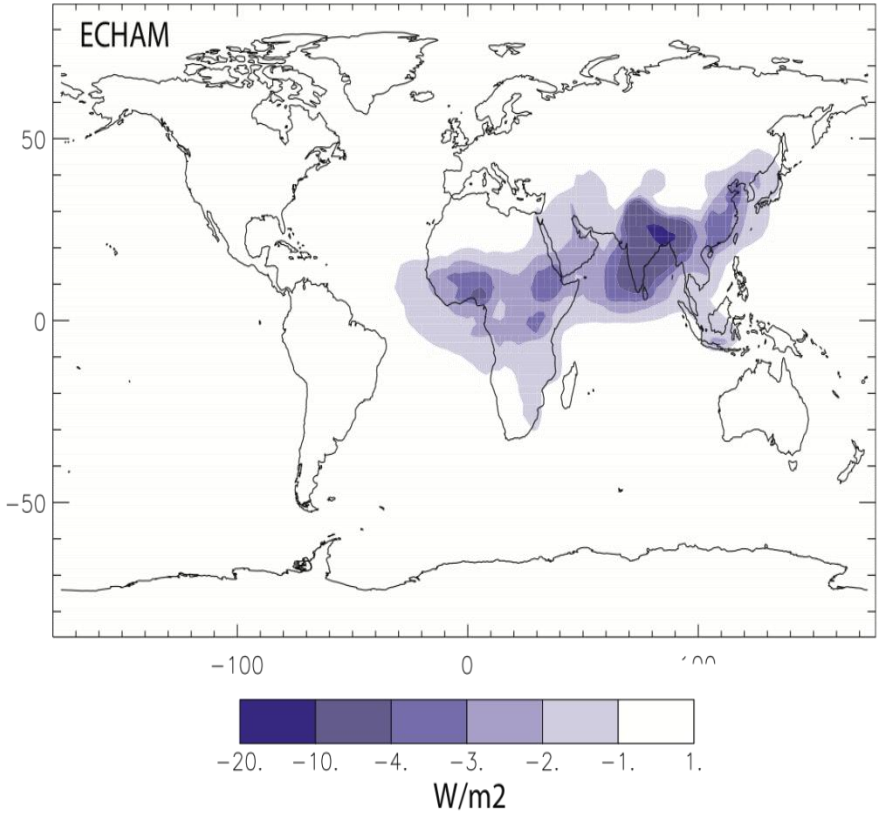


Climate Impact of Measures: Starting Now vs Delayed



Regional Climate Changes: Change in atmospheric forcing at 2030 relative to the reference case in the GISS & ECHEM models.

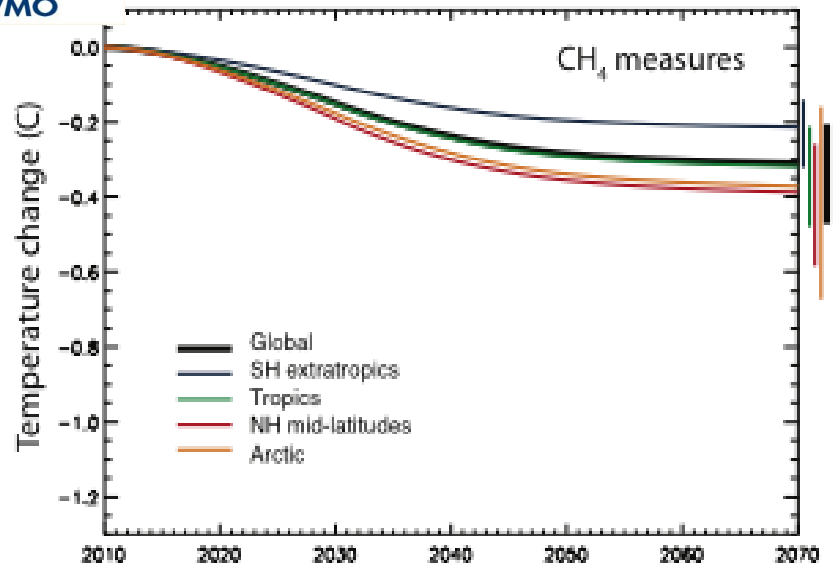




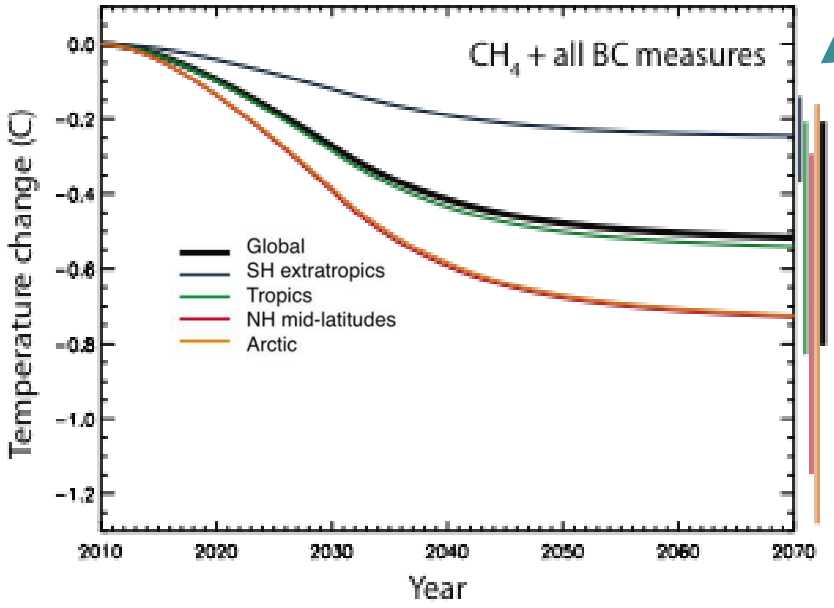
- Dark areas: where the biggest energy change to the atmosphere occurs

- This drives regional weather pattern changes

Global and Regional Temperature Change Relative to the Reference Scenario (hybrid modelling of GISS, ECHAM)



Methane measures:
Relatively uniform benefits, low uncertainty

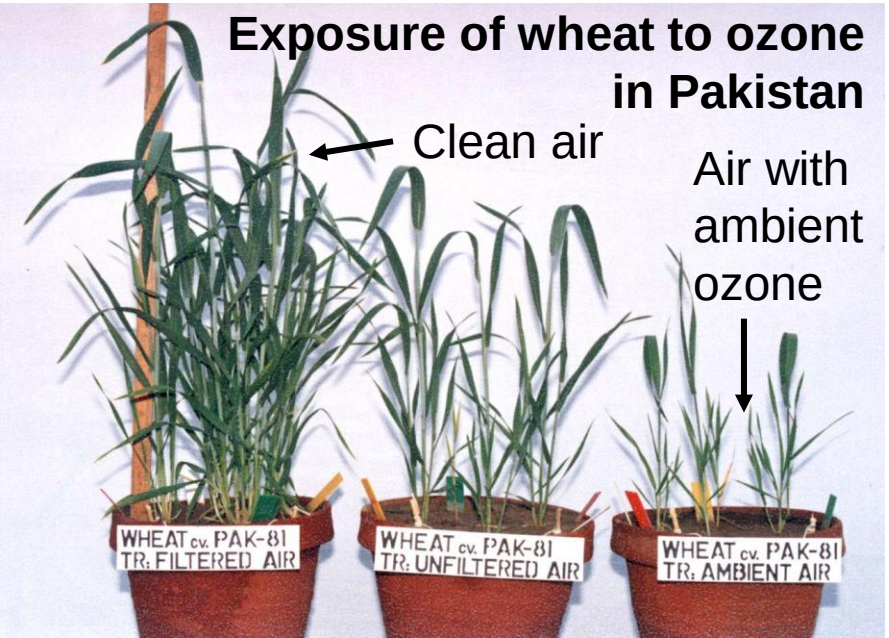


BC measures:
Larger benefits in North, greater uncertainty for temperature (large regional precipitation & glacial melting benefits)

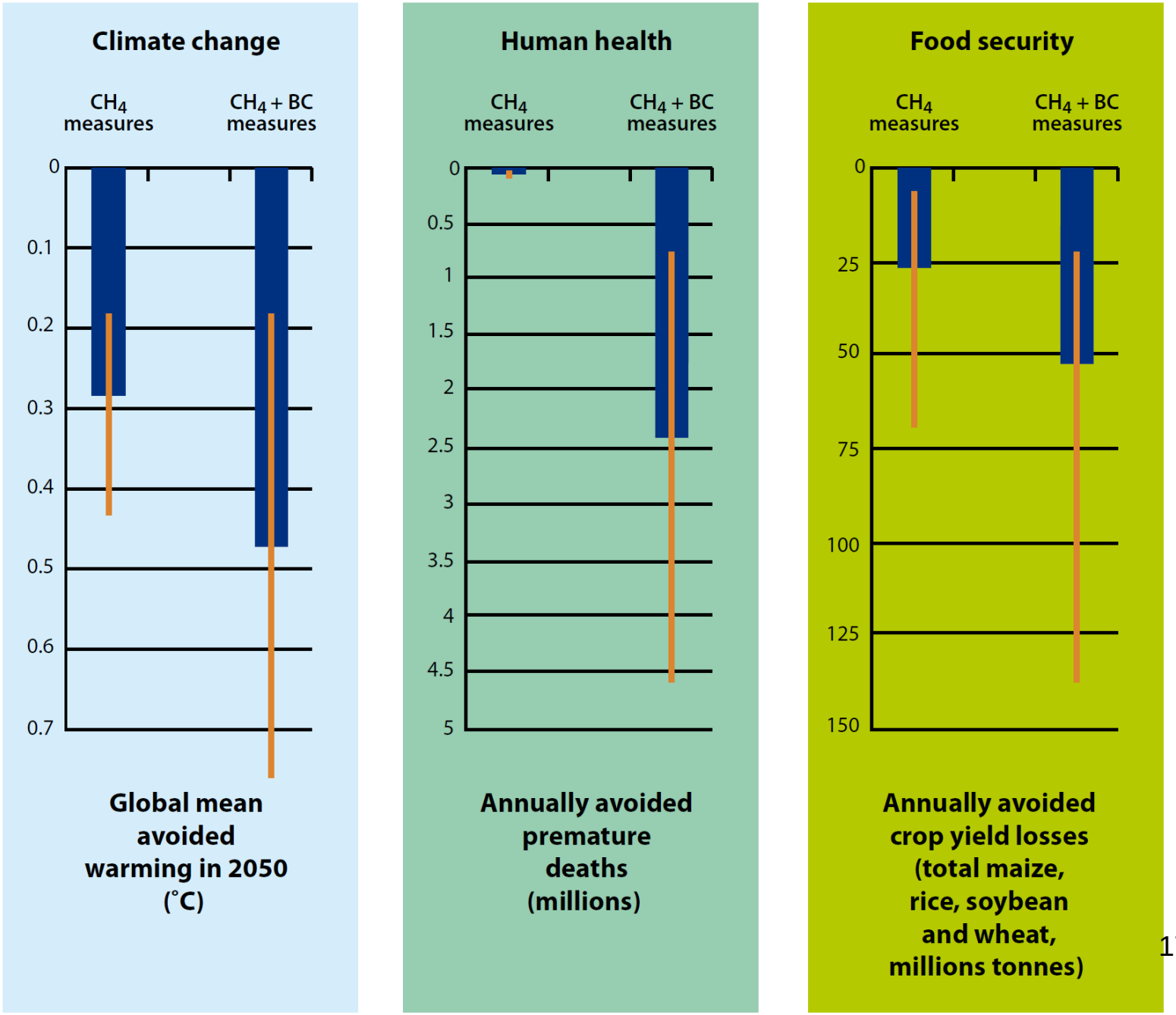
Reduced Arctic warming by 0.7°C by 2040 compared to the reference Scenario, with measures taken 2010---2030. **Mitigating ~2/3 of projected 1.2°C warming**

Impact of the Measures on Health and Crop Yields

- Models give **$PM_{2.5}$ and ozone concentrations** for health and crop yield impact assessment
- Concentration-response relationships from literature used to evaluate global impacts



Impact of the Measures on Health, Crop yields and Climate



Main Findings of the Assessment

16 identified measures, implemented by 2030, would **reduce global warming by 0.5ºC** (0.2-0.7ºC) in 2050 – half the warming projected by the Reference Scenario.

- Near-term measures would **improve the chance of not exceeding 2ºC target**, but only if CO_2 is also addressed, starting now (**complementary strategies**; **not alternatives**).
- Substantial regional climate benefits: e.g. in the **Arctic reduce warming by 0.7 ºC** (range 0.2-1.3ºC by 2040), for Himalayas and South Asian monsoon.
- Health and crop benefits are substantial – could **avoid 2.4 million premature deaths** (0.7-4.6 million) and **loss of 52 million tonnes** (30-140 million) of maize, rice, wheat and soybean, each year (plus indoor air pollution – chronic health).
- The identified **measures are all currently in use** in different regions around the world; much wider and more rapid implementation is required to achieve the full benefits.
- Many **measures achieve cost savings** over time. However, initial capital investment could be problematic, necessitating additional strategic support and investment.

‘An Integrated Assessment of Black Carbon and Tropospheric Ozone’

http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_SDM.pdf