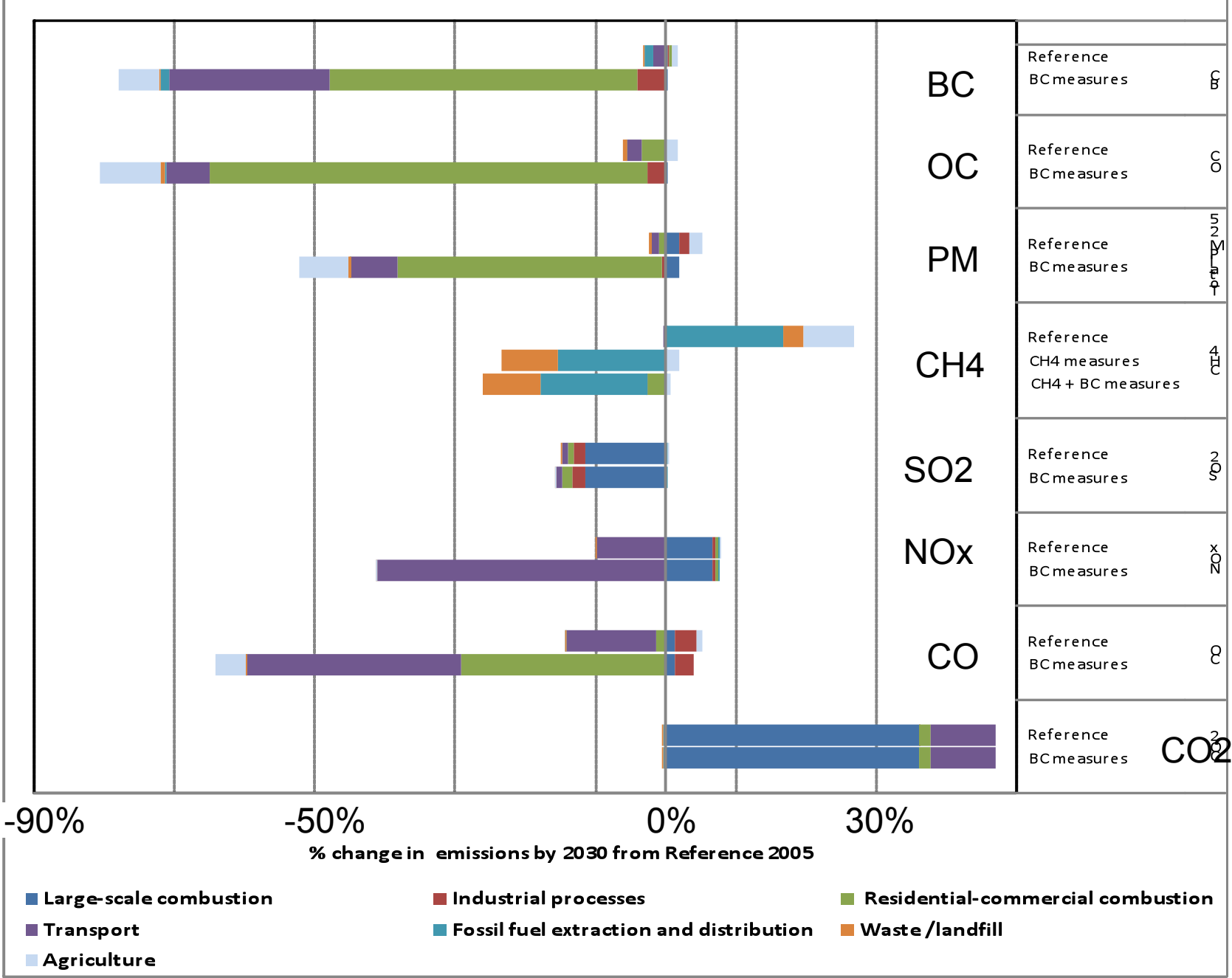# Impacts of the packages of measures on emissions

Scenario	Description[1]
Reference	Based on energy and fuel projections of the International Energy Agency (IEA) World Energy Outlook 2009 and incorporating all presently agreed on policies affecting emissions
CH_4 measures	Reference scenario plus the CH_4 measures
BC measures	Reference scenario plus the BC measures (the BC measures affect many pollutants, especially BC, OC, and CO)
CH_4 + BC measures	Reference scenario plus the CH_4 and BC measures
CO_2 measures	Emissions modelled using the assumptions of the IEA World Energy Outlook 2009 450 ppm CO_2e scenario and the IIASA GAINS database. Includes CO_2 measures only. The CO_2 measures affect other emissions, especially SO_2.[2]
CO_2 + CH_4 + BC measures	CO2 measures plus the additional CH_4 and BC measures

Emission reductions in 2030 by the 16 Measures compared to the reference

% change in emissions by 2030 from Reference 2005

- Large-scale combustion
- Industrial processes
- Residential-commercial combustion
- Transport
- Fossil fuel extraction and distribution
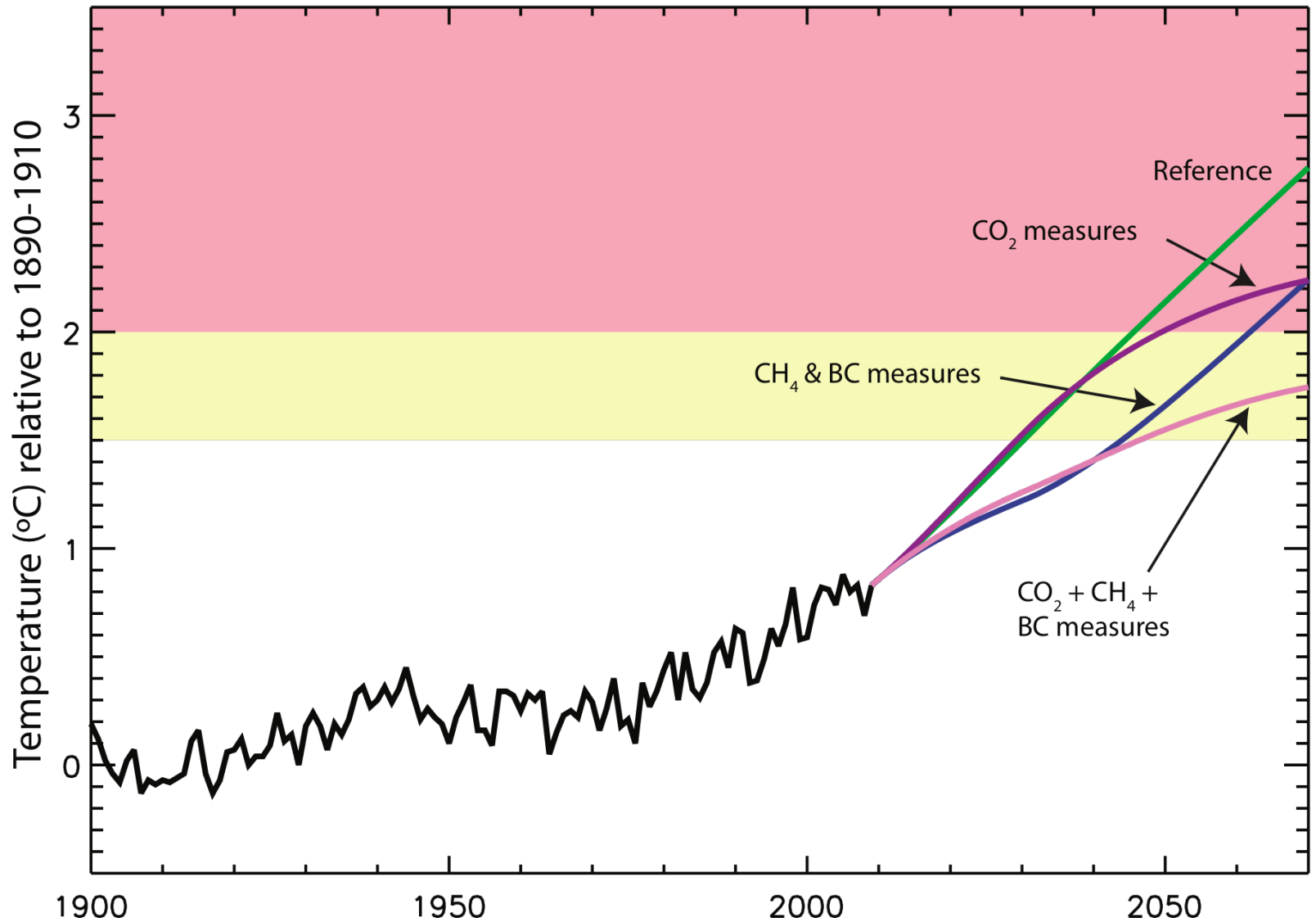- Waste /landfill
- Agriculture

Methane and BC measures vs CO_2 measures

- Emissions reductions from the methane and BC measures were almost identical when the measures were applied to the reference scenario or to the CO_2 measures scenario

- CO_2 measures target power plants and large industry

- Methane and BC measures largely target other sectors

- Even for transportation, which emits substantial CO_2 and BC/OC/CO, diesel particulate filters impact the latter but not CO_2

- Emissions would be more related in a world with very substantial shifts to low carbon (e.g. electric cars/public transport) or with certain regulatory/behavioral changes not examined (e.g. fuel economy)

Modelling temperature change using the GCMs

1. Use of two GCMs on the emissions data, NASA-GISS and ECHAM, to determine the relative impact of these measures compared with the total anthropogenic forcing, and

2. estimate the forcing due to the measures using the central value and range from our assessment of the published literature, both observational and model based, for the total anthropogenic forcing.

3. Determine temperature response to all substances that influence radiative forcing using relatively simple analytic estimate

Result for Global Temperature Change (hybrid of results from GISS and ECHAM models and assessment of literature) added to the historical record

Temperature (°C) relative to 1890-1910

Reference

CO_2 measures

CH_4 & BC measures

$CO_2 + CH_4 +$ BC measures

3

2

1

0

1900   1950   2000   2050

Further detail for Global Temperature Change from the hybrid of results from NASA-GISS and ECHAM models (vs 1890-1910 mean)
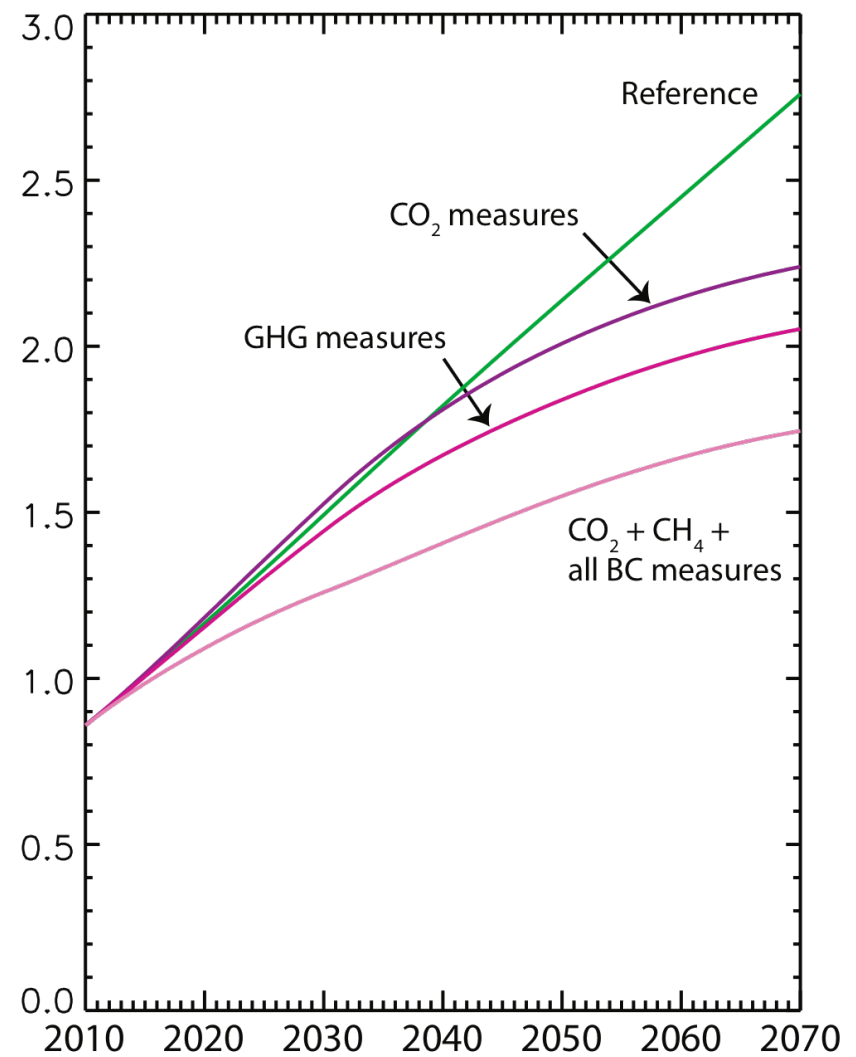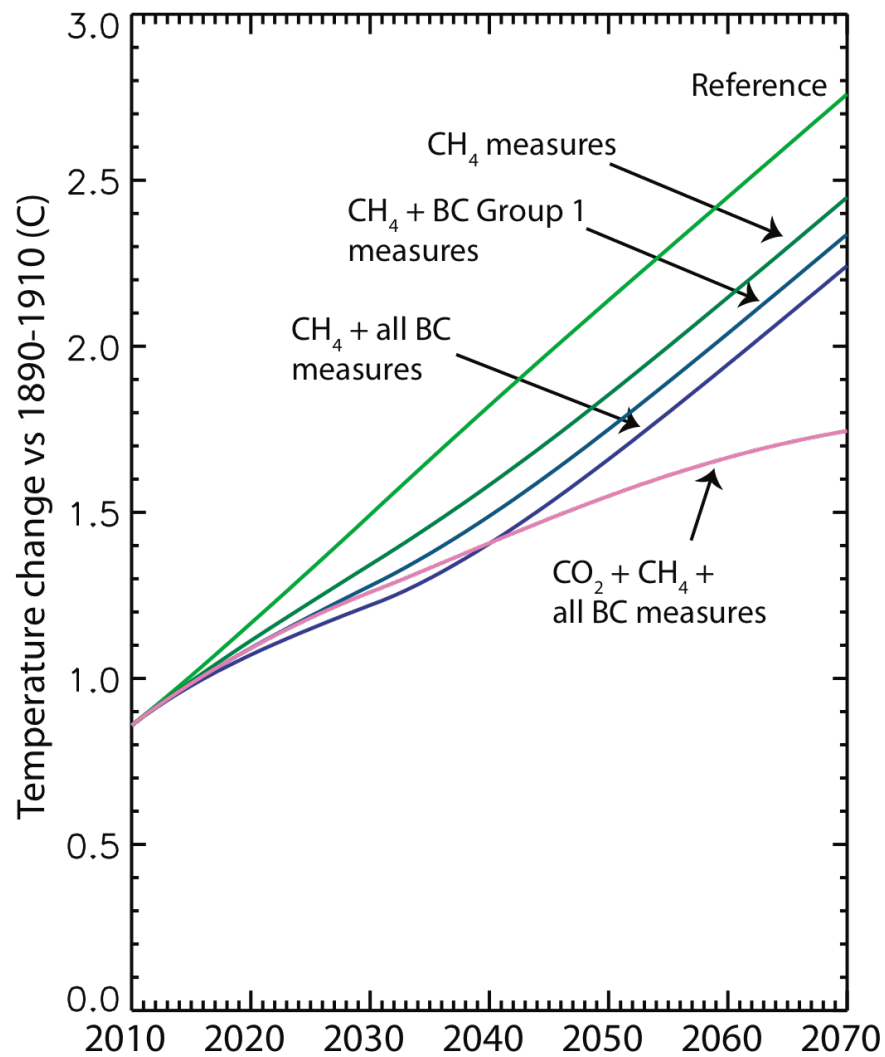
Global and Regional Temperature Change Relative to the Reference Scenario (hybrid modelling of GISS, ECHAM informed by the literature)
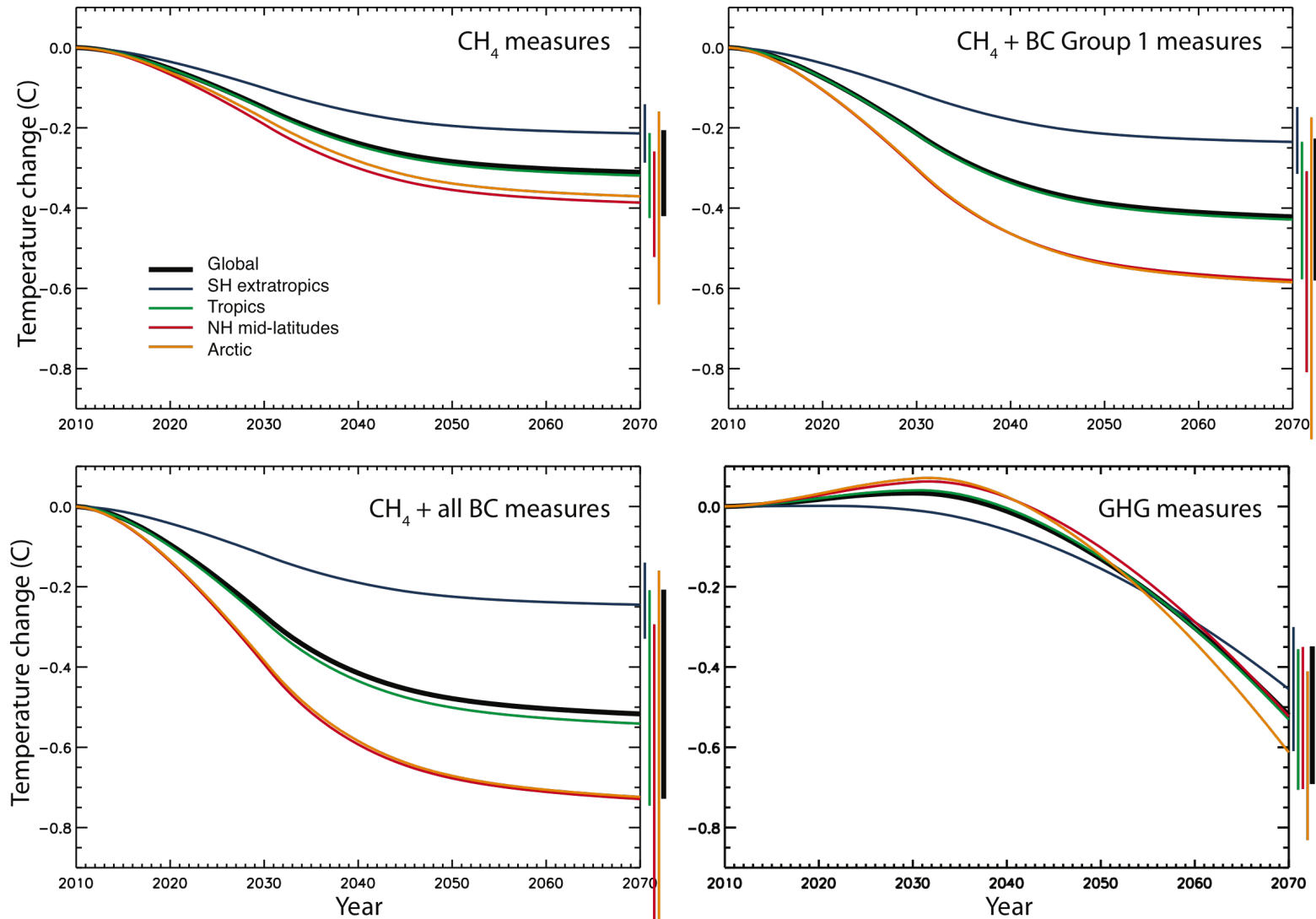
Bars on the right side of each plot give the temperature range at 2070 based on uncertainty in radiative forcing and climate sensitivity.

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

GISS-PUCCINI, all measures   ECHAM-HAMMOZ, all measures
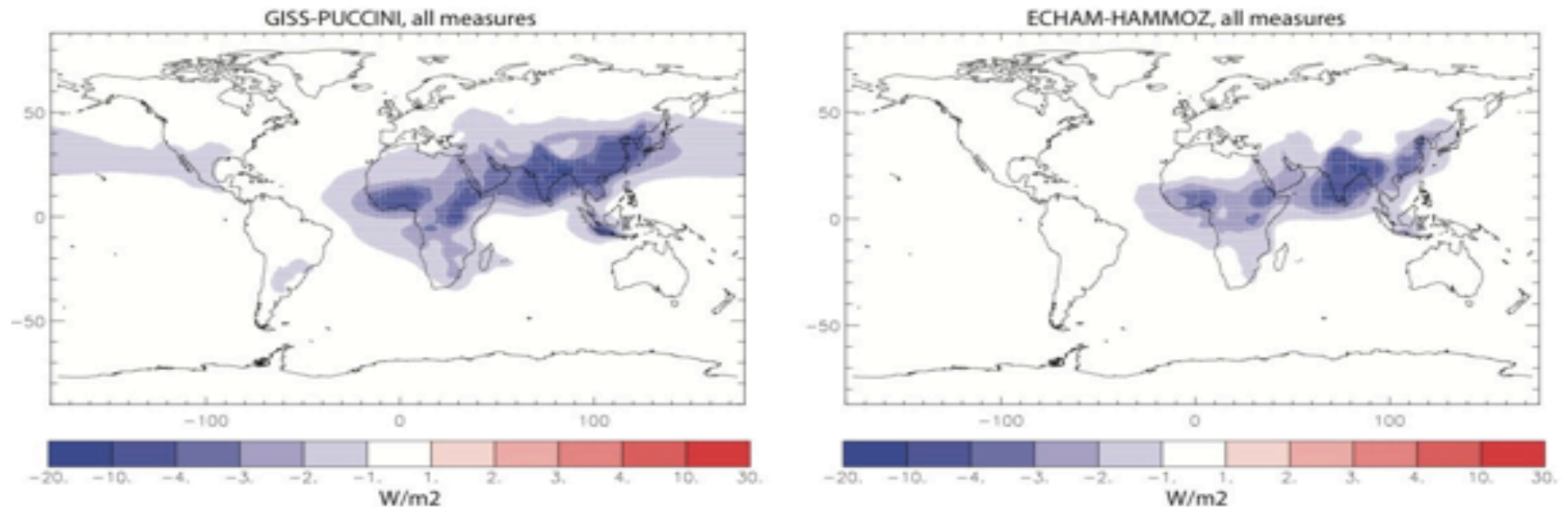
The implementation of the selected measures would have particularly large benefits in the Arctic, reducing warming there by 0.7 °C (range 0.2-1.3°C) by 2040 compared to the reference scenario. Mitigating ~2/3 of projected warming.

The carbon dioxide measures would deliver no reduction over the Arctic until after 2040.

Impact of the Measures on Health and Crop yields

1. **Two GCMs using emissions:** GISS and ECHAM

2. Models give **$PM_{2.5}$ and ozone concentrations** for health and crop yield impact assessment

3. Dose-response relationships from literature used to evaluate impacts over the whole world (downscaling for PM2.5)

Global Impacts of Additional Emissions Controls on Methane and Products of Incomplete Combustion
1: CH_4 measures, 2: CH_4+BC Group 1 measures, 3: CH_4+ all BC measures
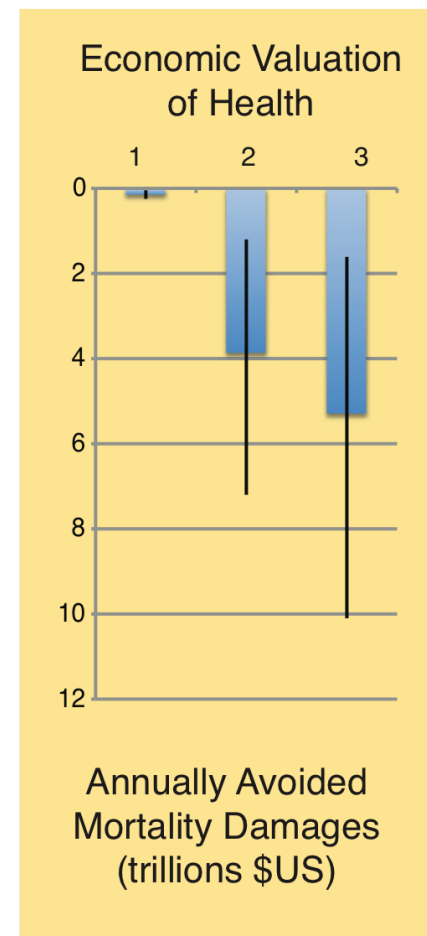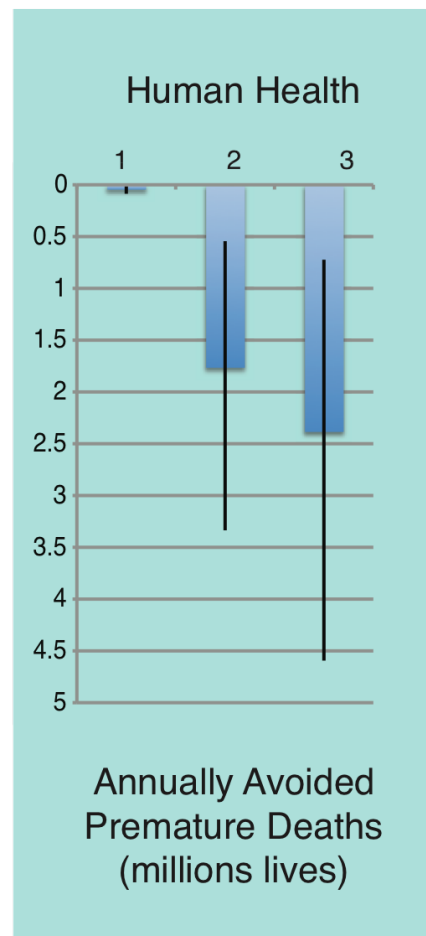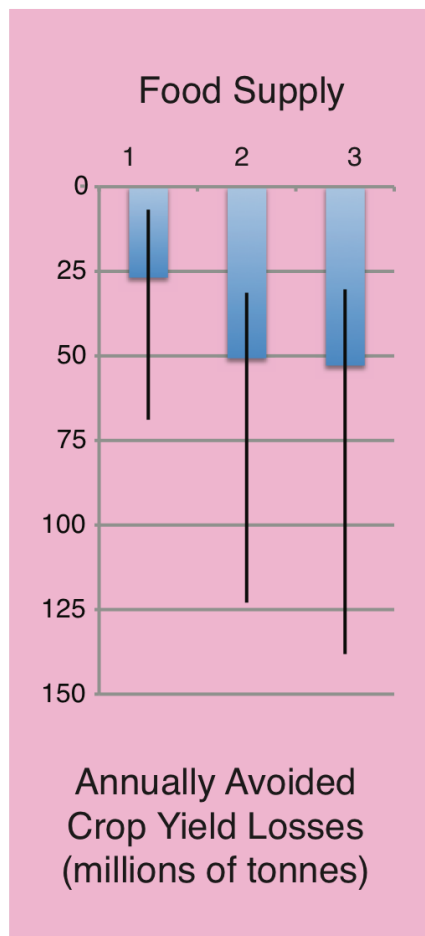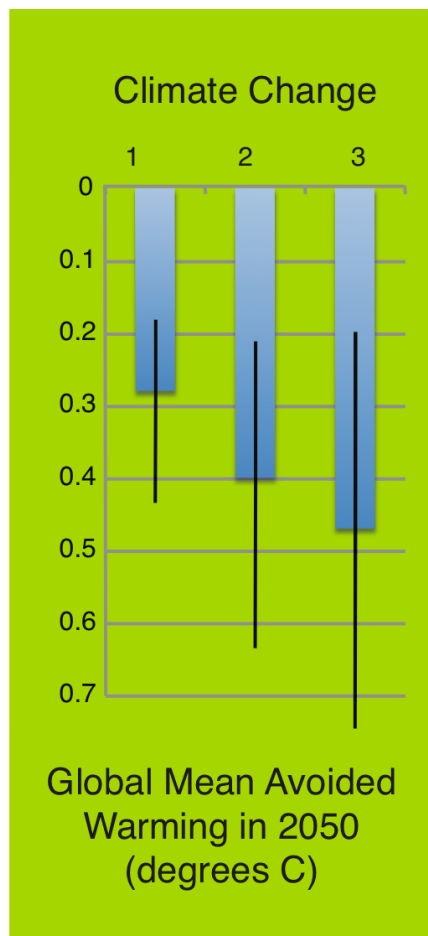
Regional Impacts: Changes in climate, agriculture and health

Arrow lengths proportional to size of change

North America & Europe — Warming, Crop Yield Losses, Premature Mortalities

East/SE Asia & Pacific — Warming, Crop Yield Losses, Premature Mortalities
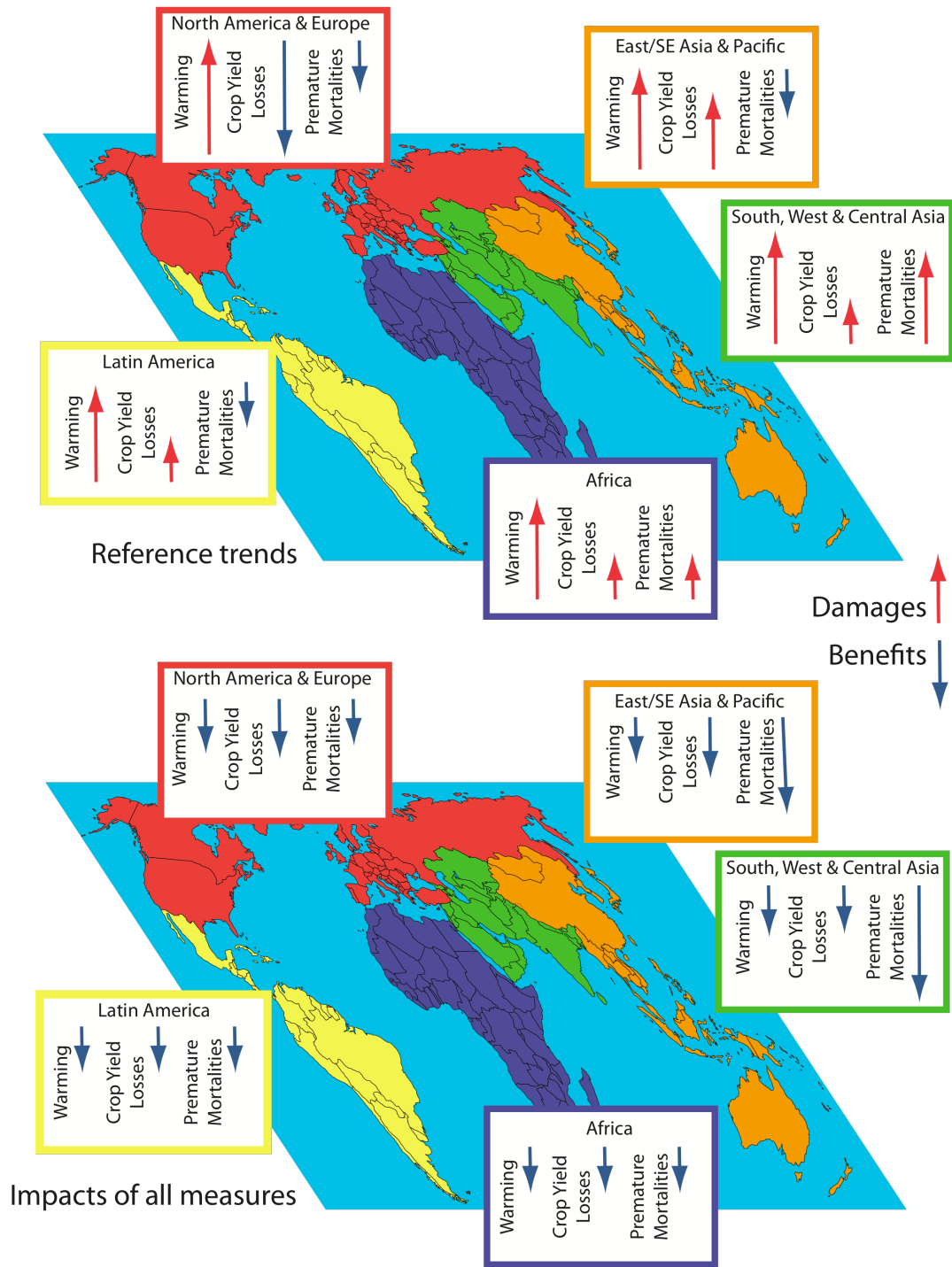
South, West & Central Asia — Warming, Crop Yield Losses, Premature Mortalities

Latin America — Warming, Crop Yield Losses, Premature Mortalities

Africa — Warming, Crop Yield Losses, Premature Mortalities

Reference trends

Damages

Benefits

North America & Europe — Warming, Crop Yield Losses, Premature Mortalities

East/SE Asia & Pacific — Warming, Crop Yield Losses, Premature Mortalities

South, West & Central Asia — Warming, Crop Yield Losses, Premature Mortalities

Latin America — Warming, Crop Yield Losses, Premature Mortalities

Africa — Warming, Crop Yield Losses, Premature Mortalities

Impacts of all measures

Change in Number of Premature Deaths due to outdoor particulate under the Different Scenarios
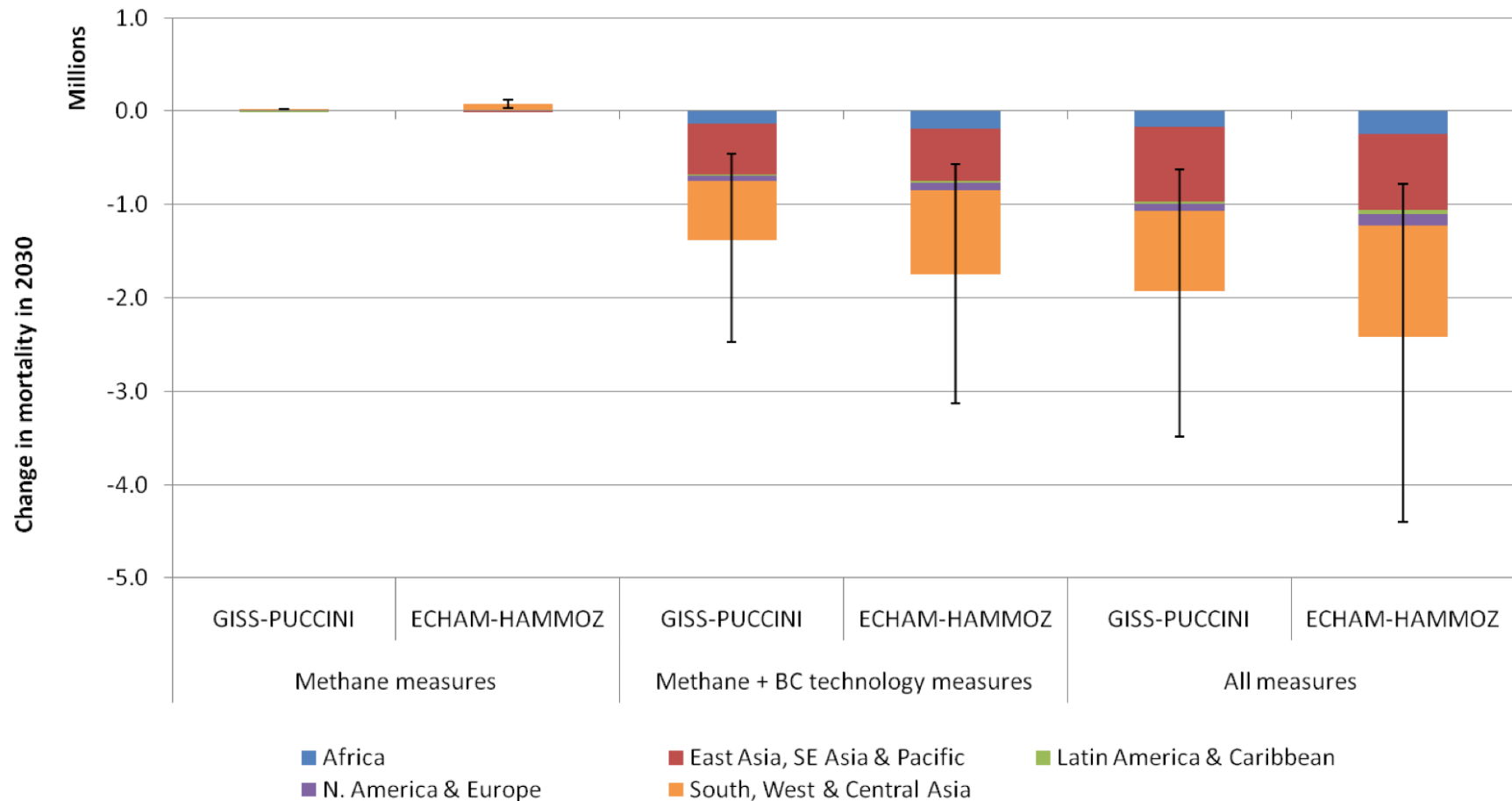
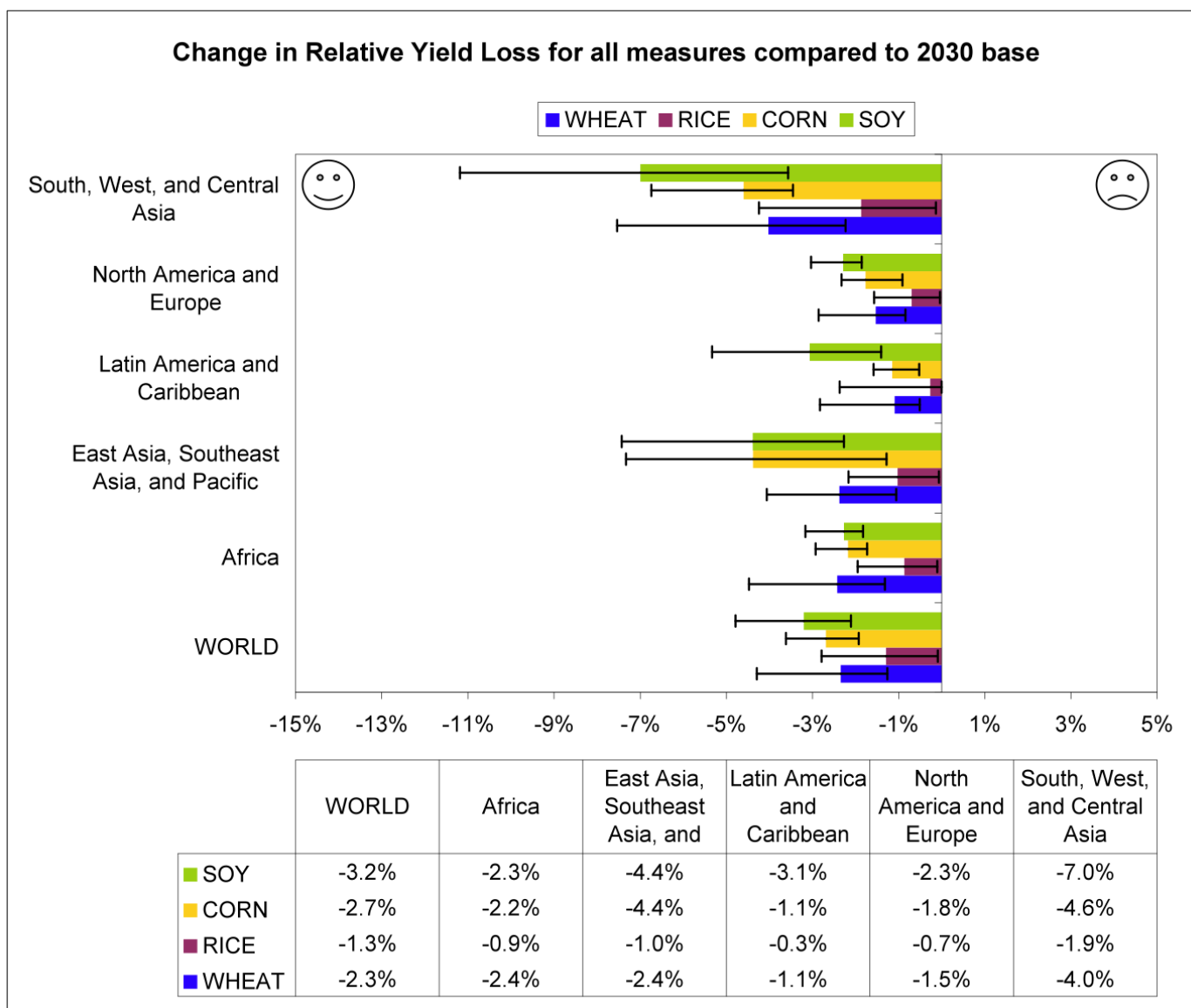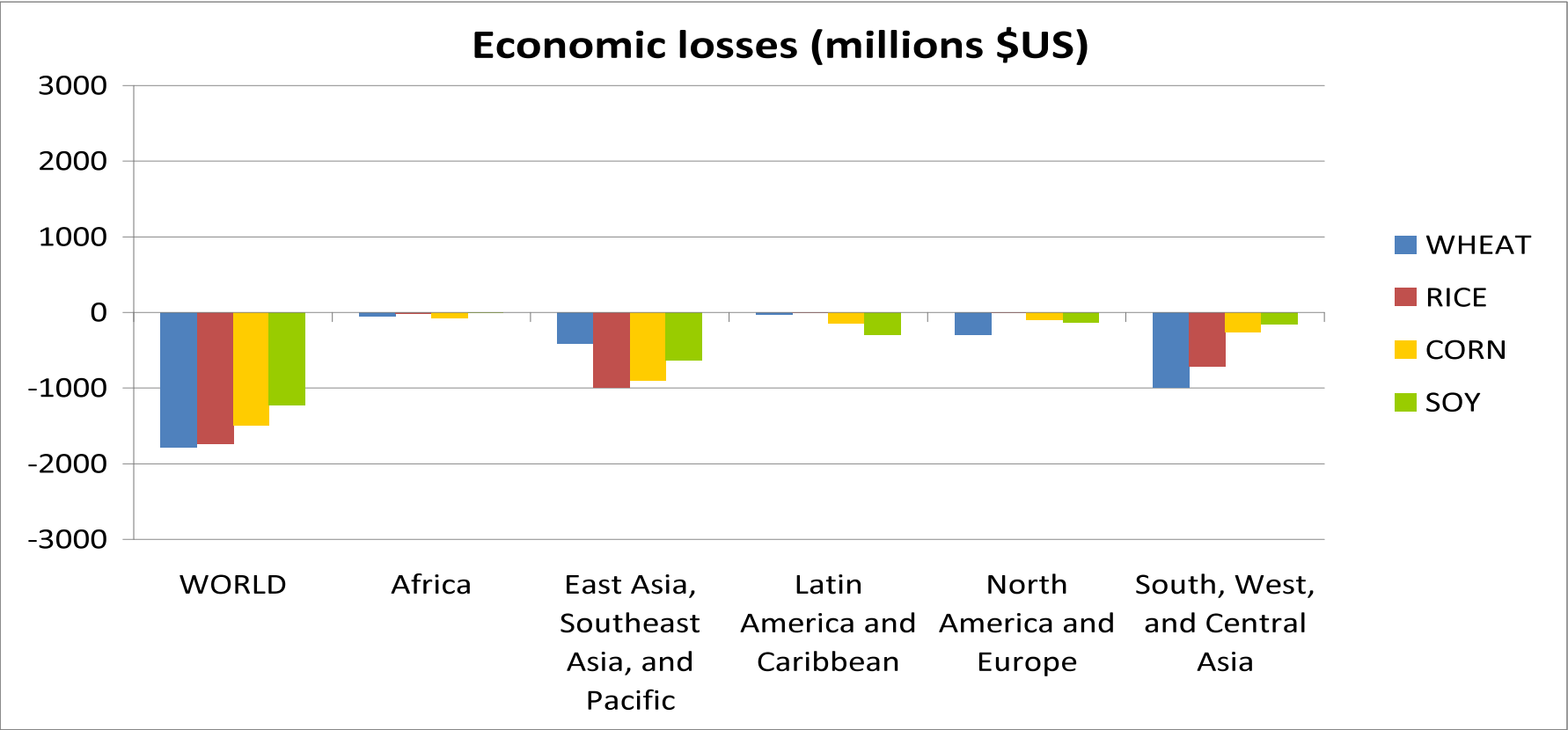Additional mortalities due to ozone exposure (~200,000) and indoor air (~350,000 in India and China alone)

Changes in Crop Yields Under the Different Scenarios due to ozone concentration changes

Change in Relative Yield Loss for all measures compared to 2030 base

■ WHEAT ■ RICE ■ CORN ■ SOY

	WORLD	Africa	East Asia, Southeast Asia, and	Latin America and Caribbean	North America and Europe	South, West, and Central Asia
■ SOY	-3.2%	-2.3%	-4.4%	-3.1%	-2.3%	-7.0%
■ CORN	-2.7%	-2.2%	-4.4%	-1.1%	-1.8%	-4.6%
■ RICE	-1.3%	-0.9%	-1.0%	-0.3%	-0.7%	-1.9%
■ WHEAT	-2.3%	-2.4%	-2.4%	-1.1%	-1.5%	-4.0%

Example of valuation of agricultural gains for the BC technical measures

Economic losses (millions $US)

Policies to Implement the Measures

- **The identified measures are all currently in use in different regions around the world to achieve a variety of environment and development objectives.**

- **Much wider and more rapid implementation is required to achieve the full benefits identified in this Assessment**

- Accounting for near-term climate co-benefits could leverage additional action and funding on a wider international scale which would facilitate more rapid implementation of the measures.

- Many measures achieve cost savings over time. However, initial capital investment could be problematic in some countries, necessitating additional strategic support and investment.

Policies to Implement the Measures

- At national and sub-national scales many of the identified measures could be implemented under existing policies designed to address air quality and development concerns.

- Improved cooperation within and between regions would enhance widespread implementation and address transboundary climate and air quality issues.

- Additional efforts to scale up, replicate and expand the implementation of the selected measures would be required to achieve the benefits identified

- Such efforts could include capacity building, public-private financing, technology support, regional cooperation and agreements and community empowerment

Policies to Implement the Measures

- ## Methane case studies

  - Landfill biogas energy in Monterrey, Mexico
  - Recovery and flaring from oil and natural gas production in India
  - Livestock manure management in Brazil

- ## BC case studies

  - Diesel particle filters in Santiago, New York City, and London
  - Improved brick kilns in Vietnam and Mexico (Ciudad Juarez)