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science for global insight

THE WORLD BANK
INTERNATIONAL CRYOSPHERE CLIMATE INITIATIVE

On Thin Ice
Mitigation measures

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GAINS model (http://gains.iiasa.ac.at)

Day of the Cryosphere:
Climate Change Today in Polar and Mountain Regions
Warsaw, 17 November 2013

Approach

From Baseline scenario towards RF mitigation and climate impacts

1. Develop emission projections for all substances
   (IEA 2009 World Energy Outlook Baseline and 450ppm, GAINS model technology db)
2. Determine future RF by sector and gas
   (Literature GWP values)
3. Rank mitigation measures by their net impact on warming of their CH_4/BC/OC/CO/SO_2/NMVOC/NO_x emission changes
   (GAINS technology db)
4. Choose a set of efficient measures
   (representing ~90% of potential)
5. Estimate climate impacts and co-benefits of the selected set of measures

UNEP/WMO, 2011

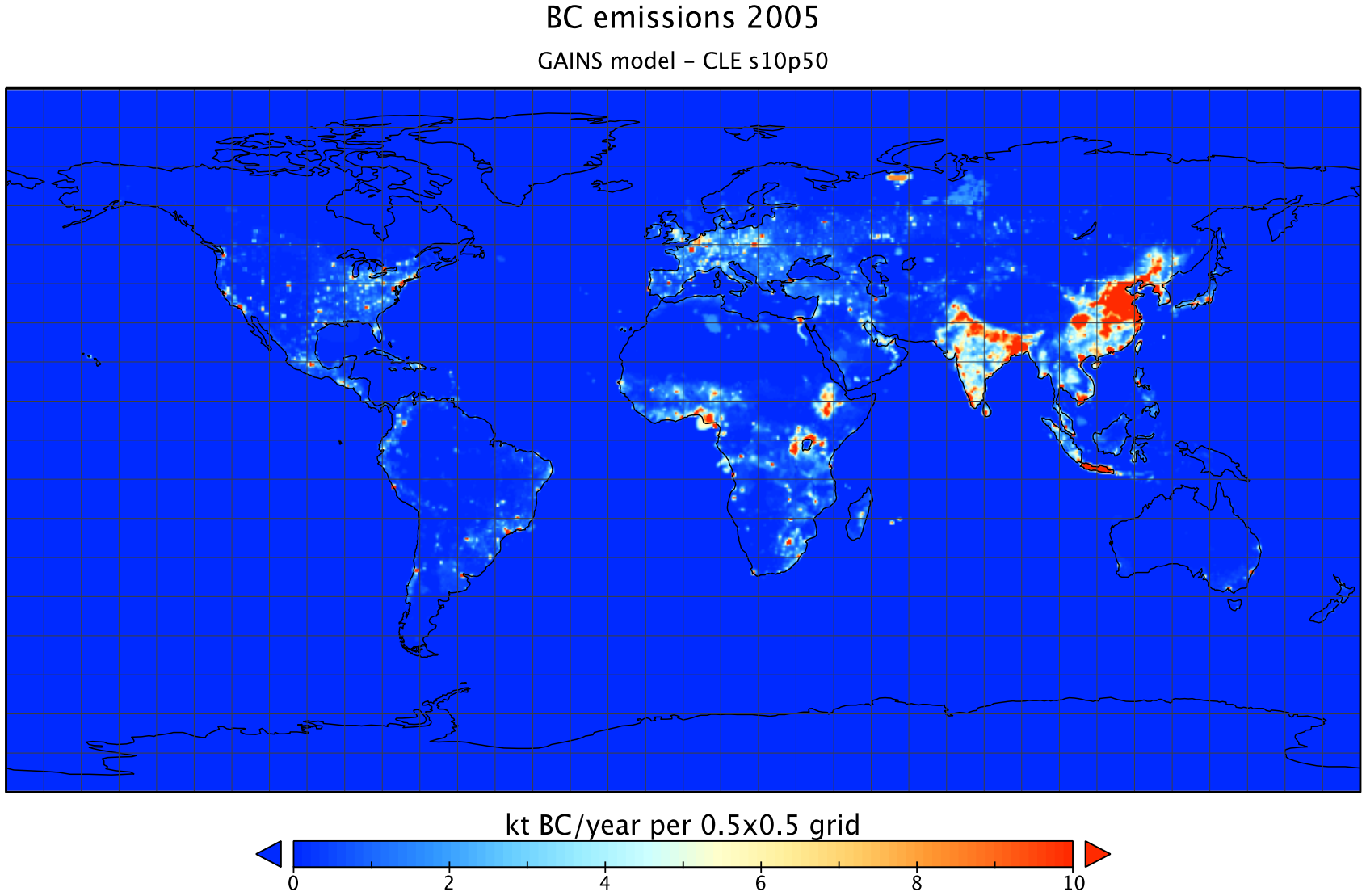
4. Update and extend set of measures

5. Analyse climate impact (3 models) and co-benefits of each single BC measure

6. Focus on cryosphere

WB/ICCI, 2013

Change in spatial distribution of BC emissions between 2005 and 2030; *GAINS current legislation; Klimont et al. (in preparation)*



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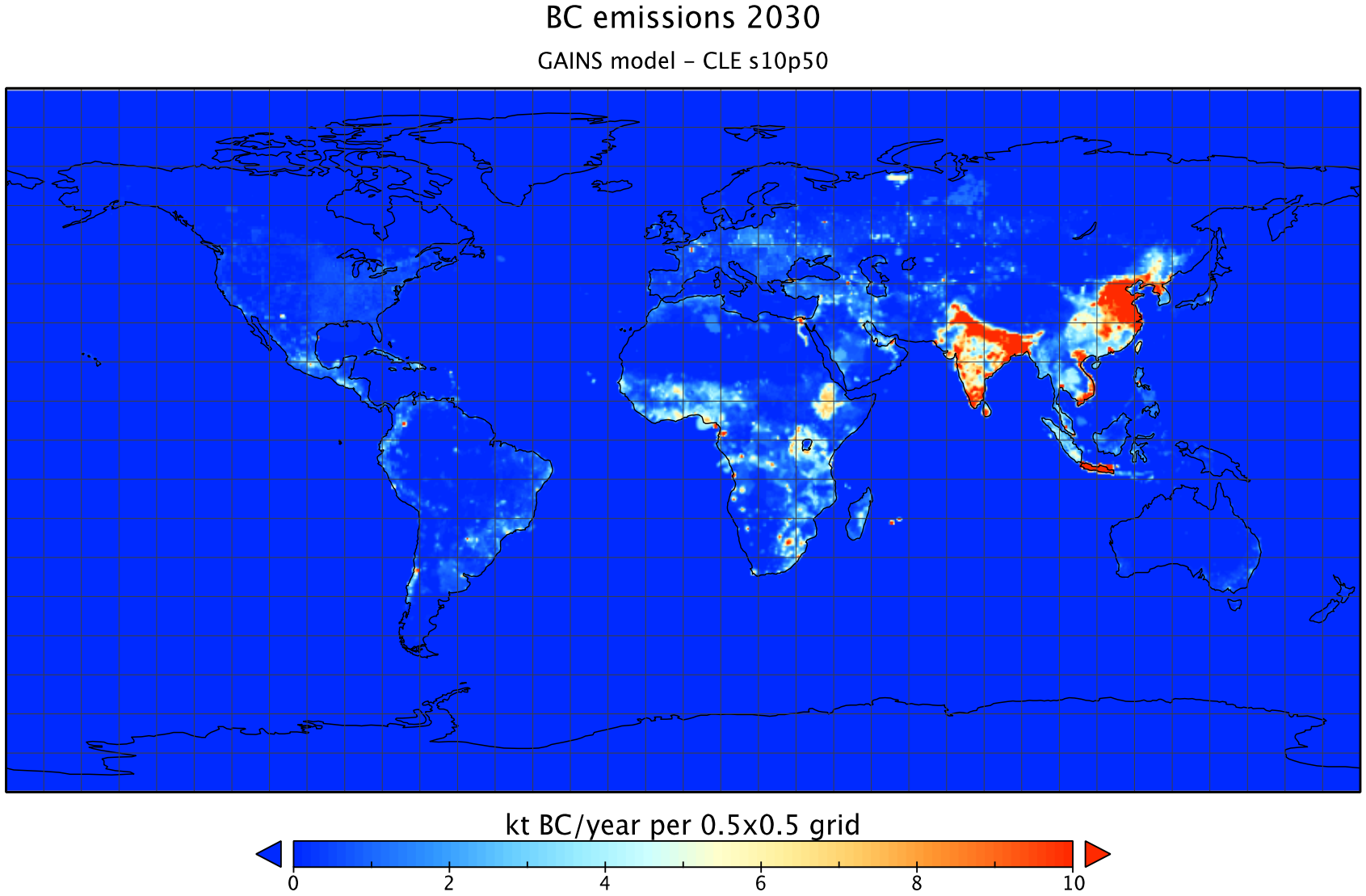


The **GAINS** multi-pollutant/multi-effect framework

(**G**reenhouse gas and **A**ir pollution **IN**teractions and **S**ynergies)

	PM (BC, OC)	SO_2	NO_x	VOC	NH_3	CO	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM (Loss in life expectancy)	√	√	√	√	√					
O_3 (Premature mortality)			√	√		√		√		
Vegetation damage: O_3			√	√		√		√		
Acidification		√								
Eutrophication			√		√					
Climate impacts: Long-term							+	+	+	+
Near-term forcing	+ / -	-	+ / -	+	-	+				
Black carbon deposition	+									

‘Win-win’ air quality measures with co-benefits on climate change

Radiative forcing from short-lived air pollutants:

- Warming: BC, O_3 precursors (CH_4, CO)
- Cooling: SO_2, OC
- Only little net effects: NO_x, NMVOC

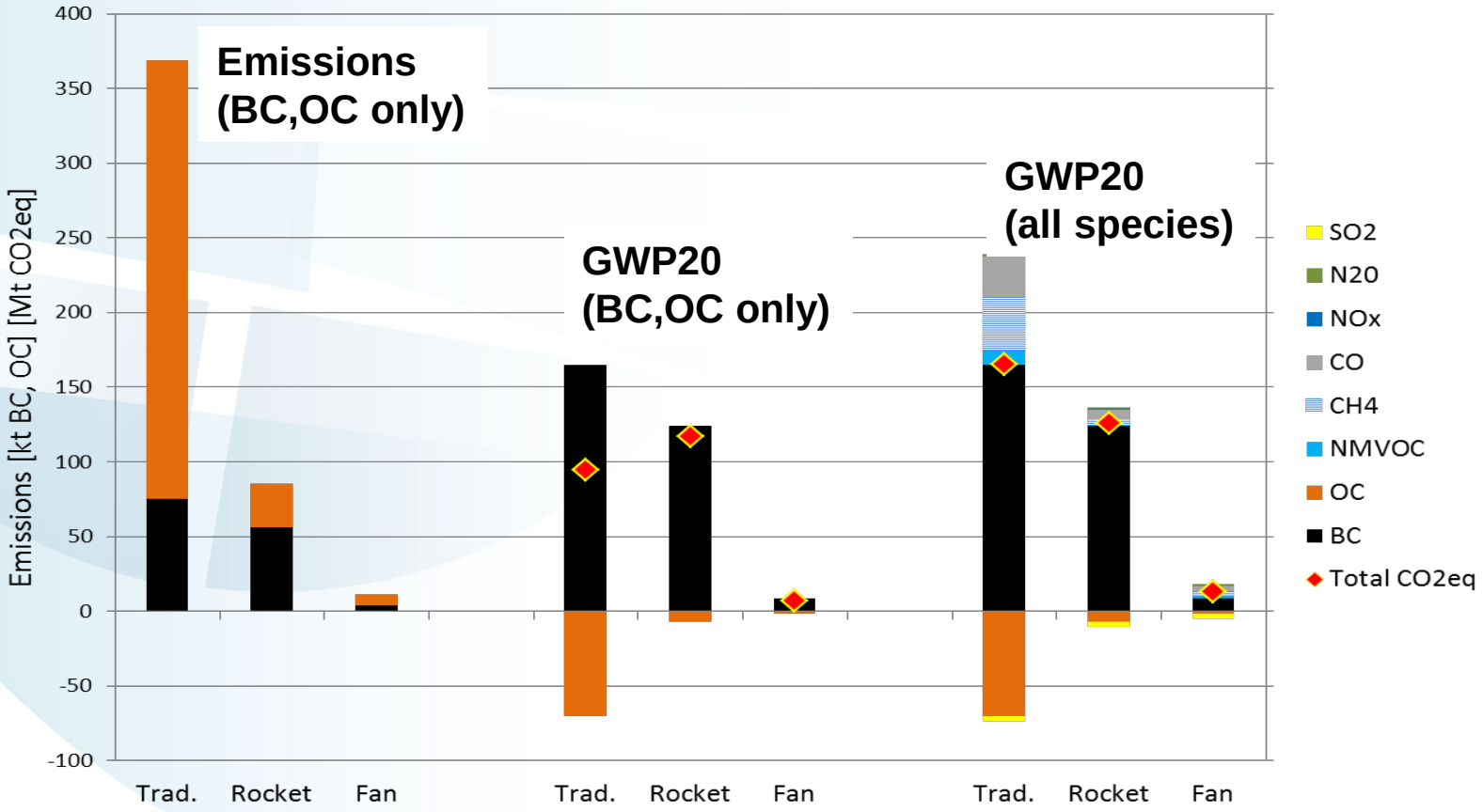
These substances are often co-emitted, and control measures affect several substances at the same time.

Which air quality measures would also reduce radiative forcing?

Selecting measures*

Importance of considering all pollutants

Example: *Fuelwood cooking stoves (fuel efficiency improvement considered); Klimont et al. (in preparation)*



* The GWP20 is used for demonstration purpose. While the choice of GWP (100 or 20 years) would not change the conclusion about the selected measures the shown here CO_{2eq} emissions were not used in the analysis, i.e., the emissions of various pollutants for specific measures were put directly into the climate model.

Selected set of measures

CH_4 measures

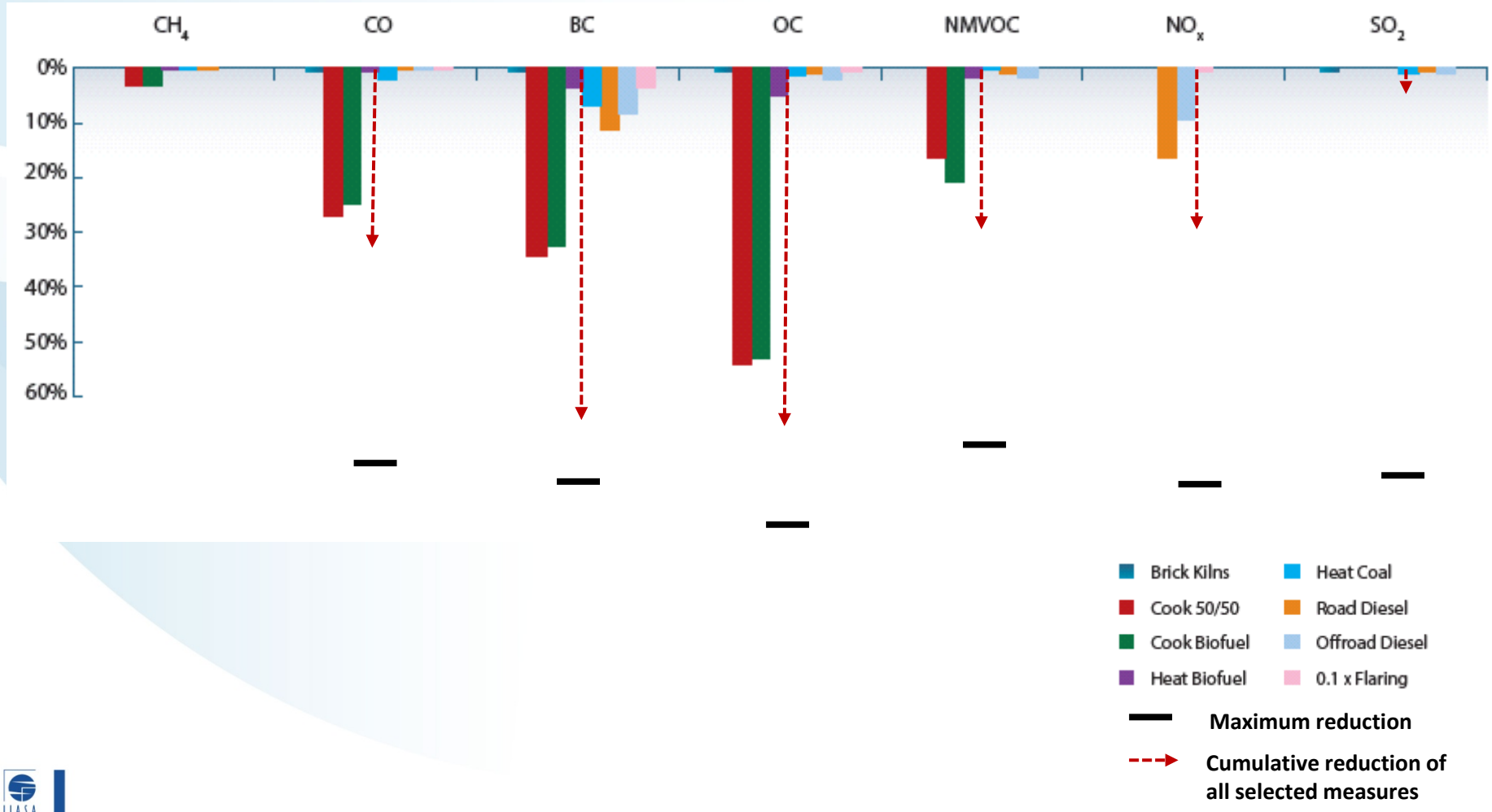
1. Recovery of coal mine gas
2. Production of crude oil and natural gas
3. Gas leakages at pipelines and distribution networks
4. Waste recycling
5. Wastewater treatment
6. Farm-scale anaerobic digestion
7. Aeration of rice paddies

Black Carbon measures

1. Diesel particle filters
2. Improved biomass cookstoves
3. Biogas/LPG cookstoves
4. Briquettes for coal stoves
5. Pellet stoves and boilers
6. Reduction of flaring
7. 50% reduction of biomass burning
8. 90% reduction of open burning in Eurasia

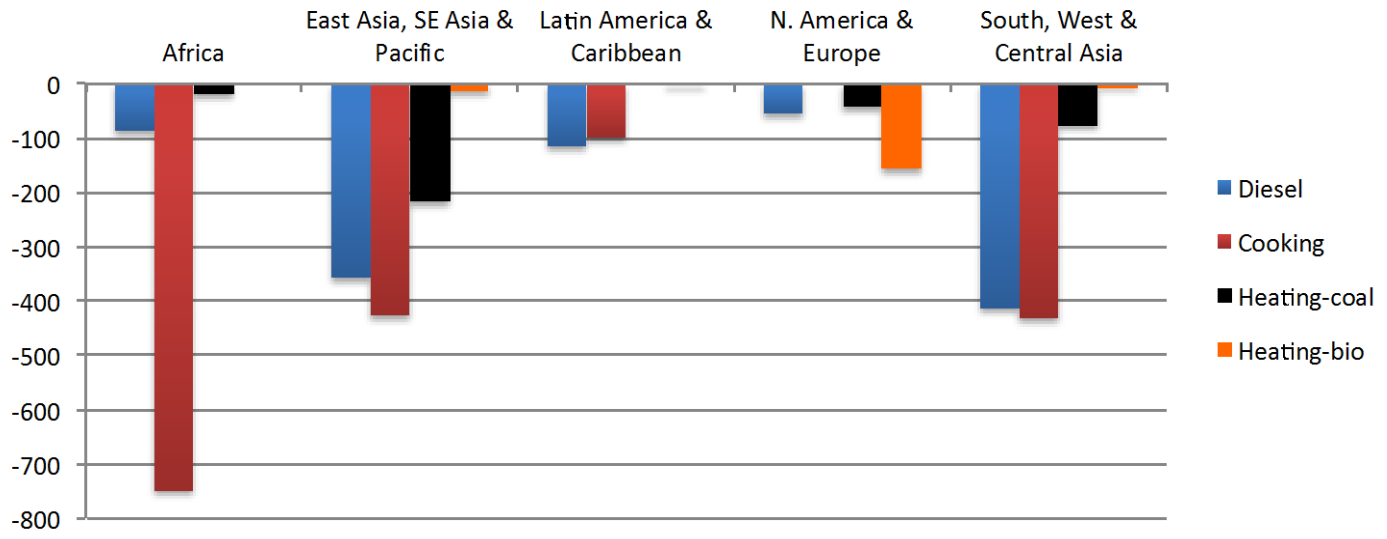
Impact of BC measures

Change in 2030 anthropogenic emissions relative to the reference emissions of each compound

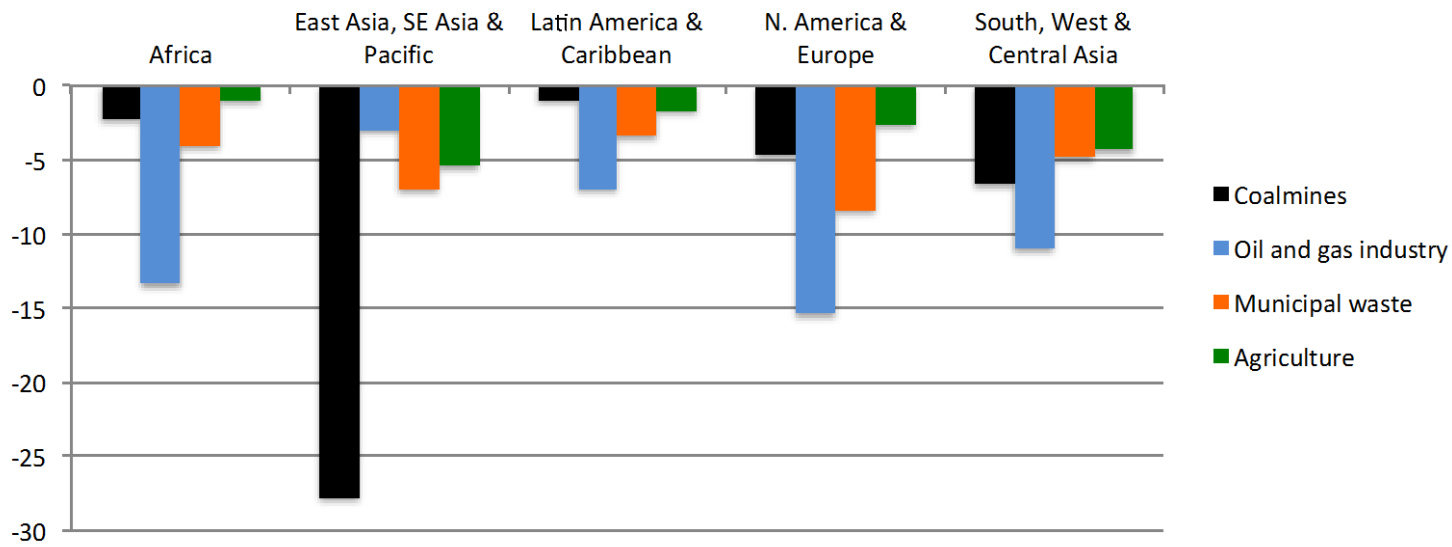


Regional distribution of mitigation by key measures

BC [kt]



CH_4 [Mt]

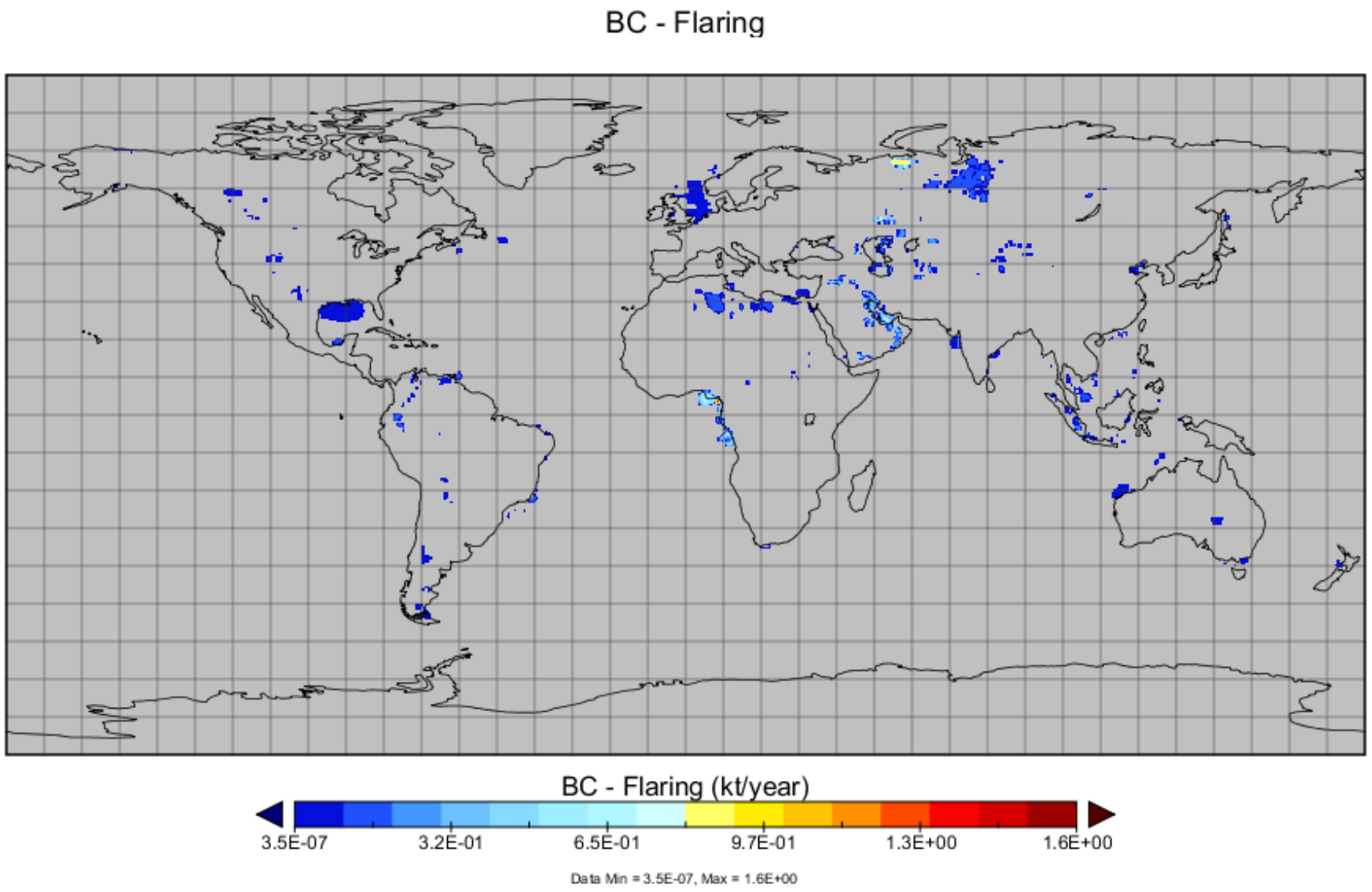


Opportunities

- There are several examples of successful implementation of mitigation measures for all key sources of SLCF
- A significant further reduction potential has been identified in the developed and developing world
- Small number of measures can address most of the available potential
- There is a variety of good reasons for their implementation
- Several measures have low implementation costs
- Implementation within two decades appears feasible
- Room for improvement – more potential?
  - Flaring, brick kilns, diesel generators, wick lamps…

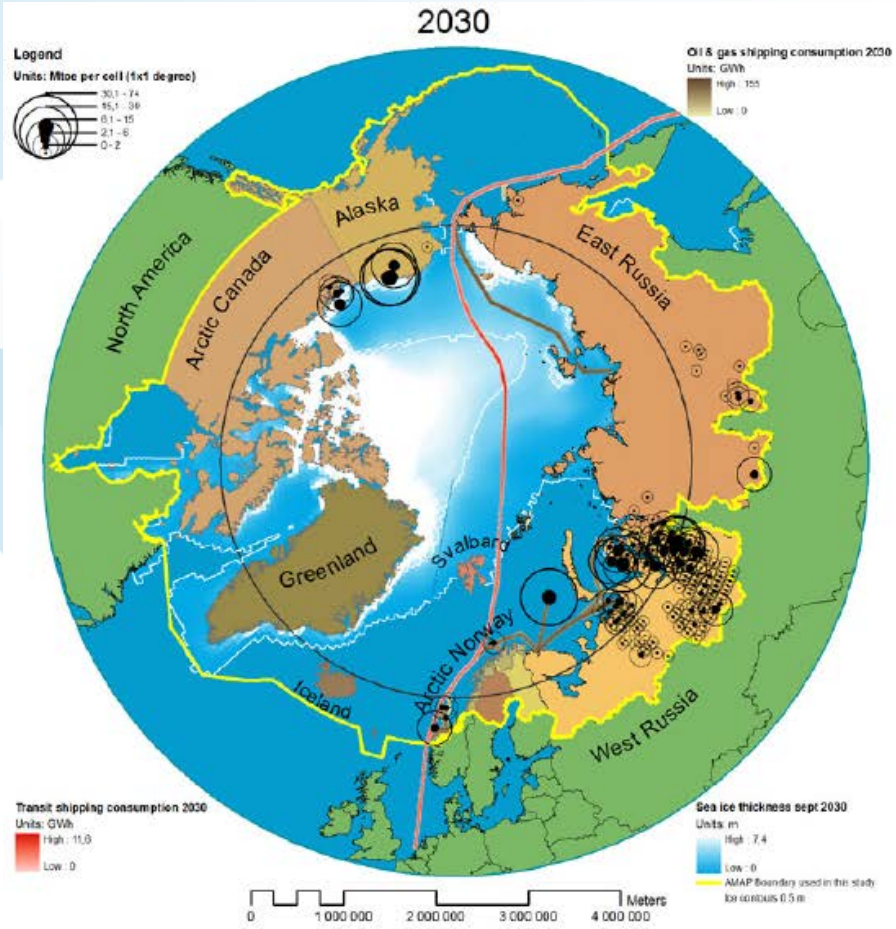
Spatial distribution of emissions from gas flaring in GAINS

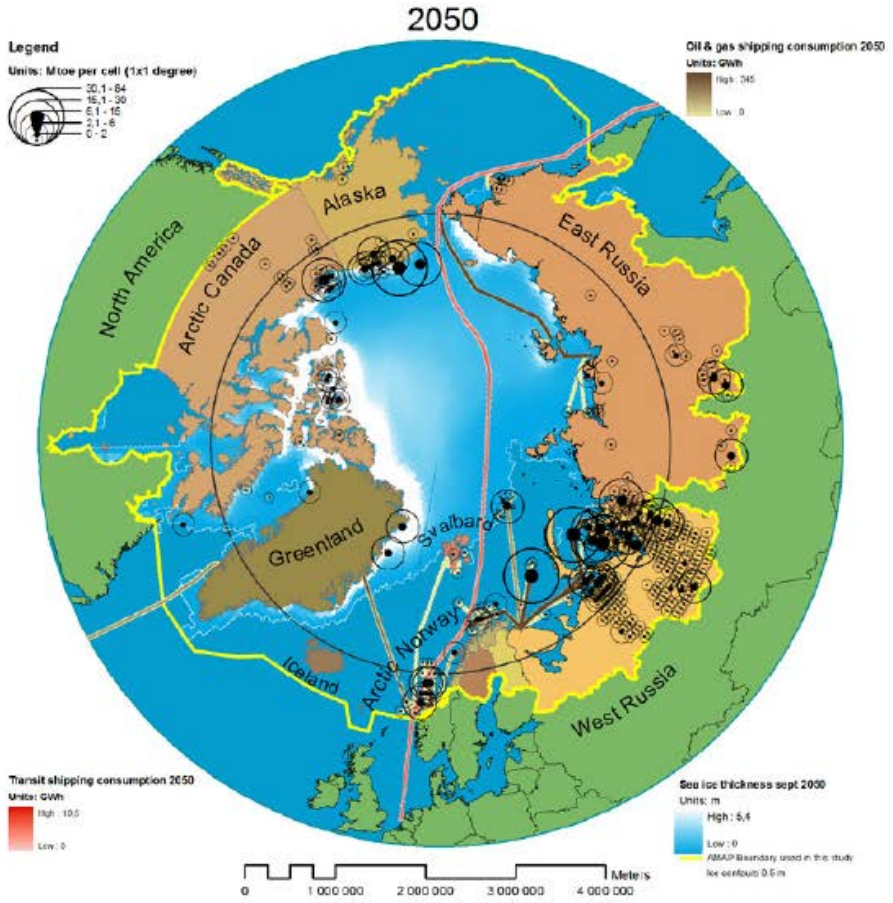
Location of flares: Source: *NASA, World Bank, GAINS model (Klimont et al., in preparation)*



Oil and gas production, energy consumption in transit and petroleum shipping and the September sea-ice extent in 2030 and 2050;

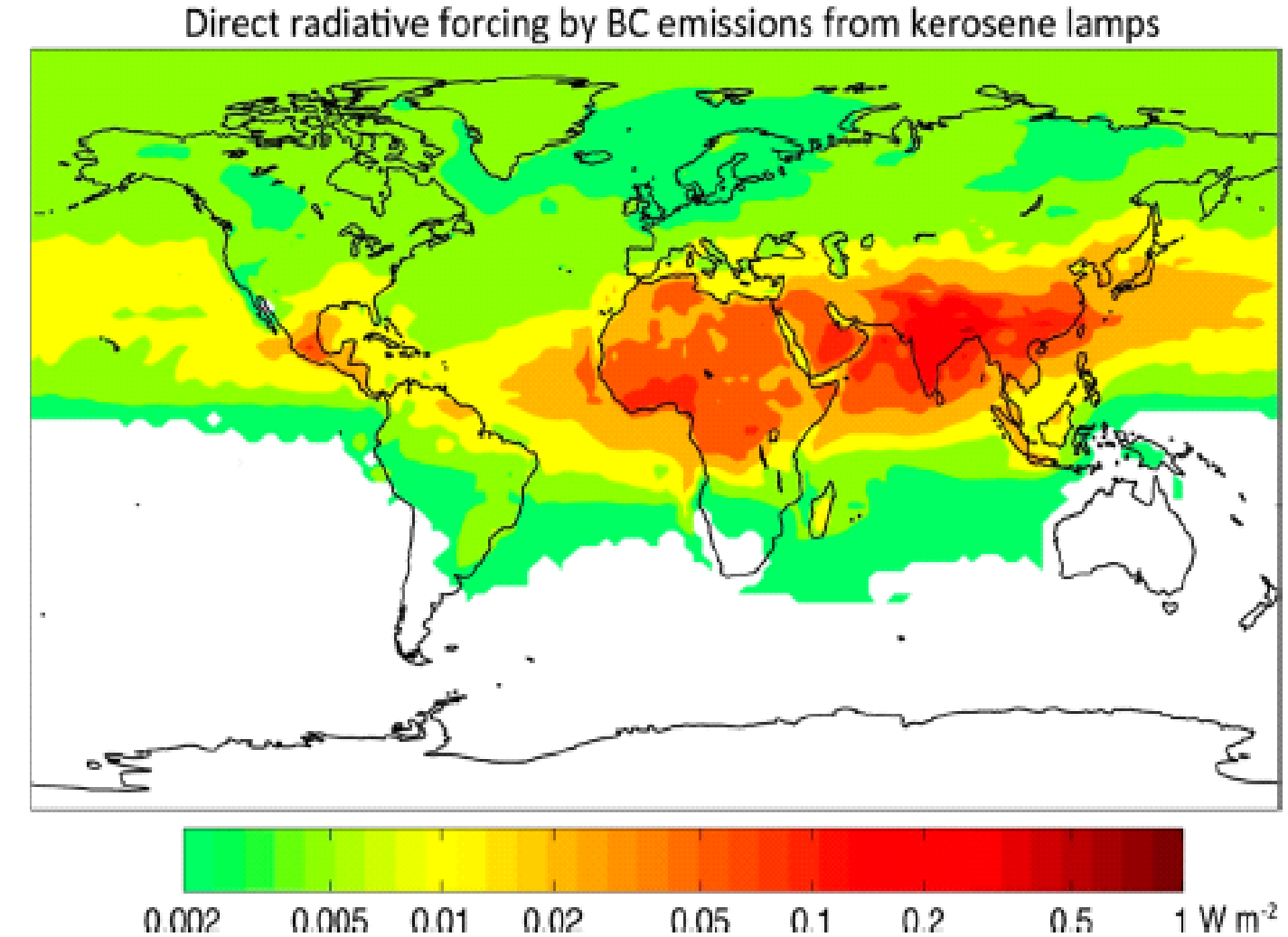
Source: Peters et al. (2011, ACP)





Direct BC radiative forcing from residential kerosene lighting (W/m^2);

Source: Lam et al. (2012, ES&T)



Challenges

- Developing technology matching region-specific expectations and challenges
- Successful implementation requires integration with other policies, e.g.,
  - Low sulfur diesel required for particle filters
  - Monitoring and maintenance programs
- Market forces alone are not likely to drive the change; additional regulation and incentives needed
- Identifying successful policy framework and financial schemes allowing for fast implementation