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science for global insight

Key aerosol and methane emission sources and mitigation opportunities in the Arctic included in the recent GAINS global scenarios

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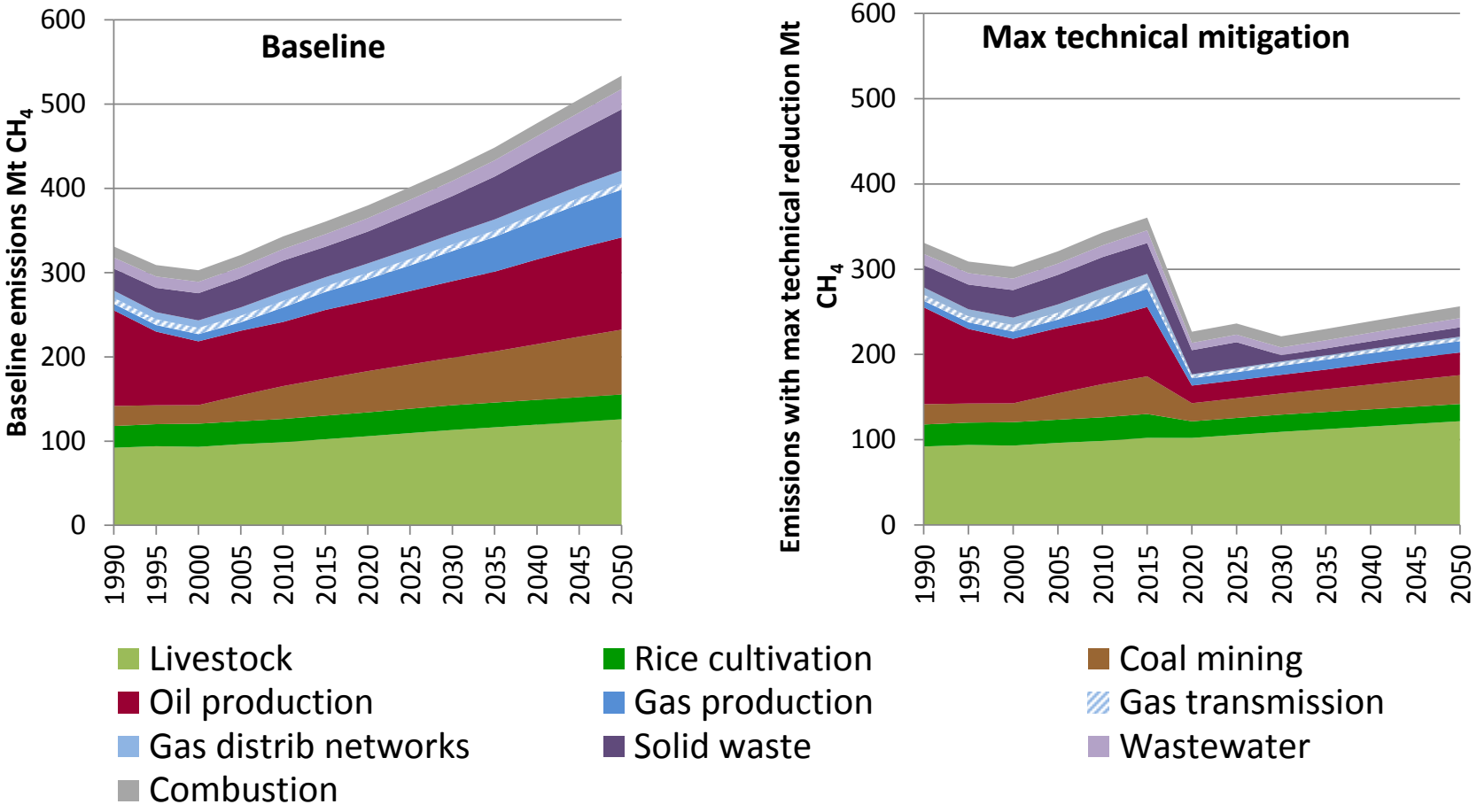
ECLIPSE v5 – new global air pollutants and methane scenarios developed with GAINS

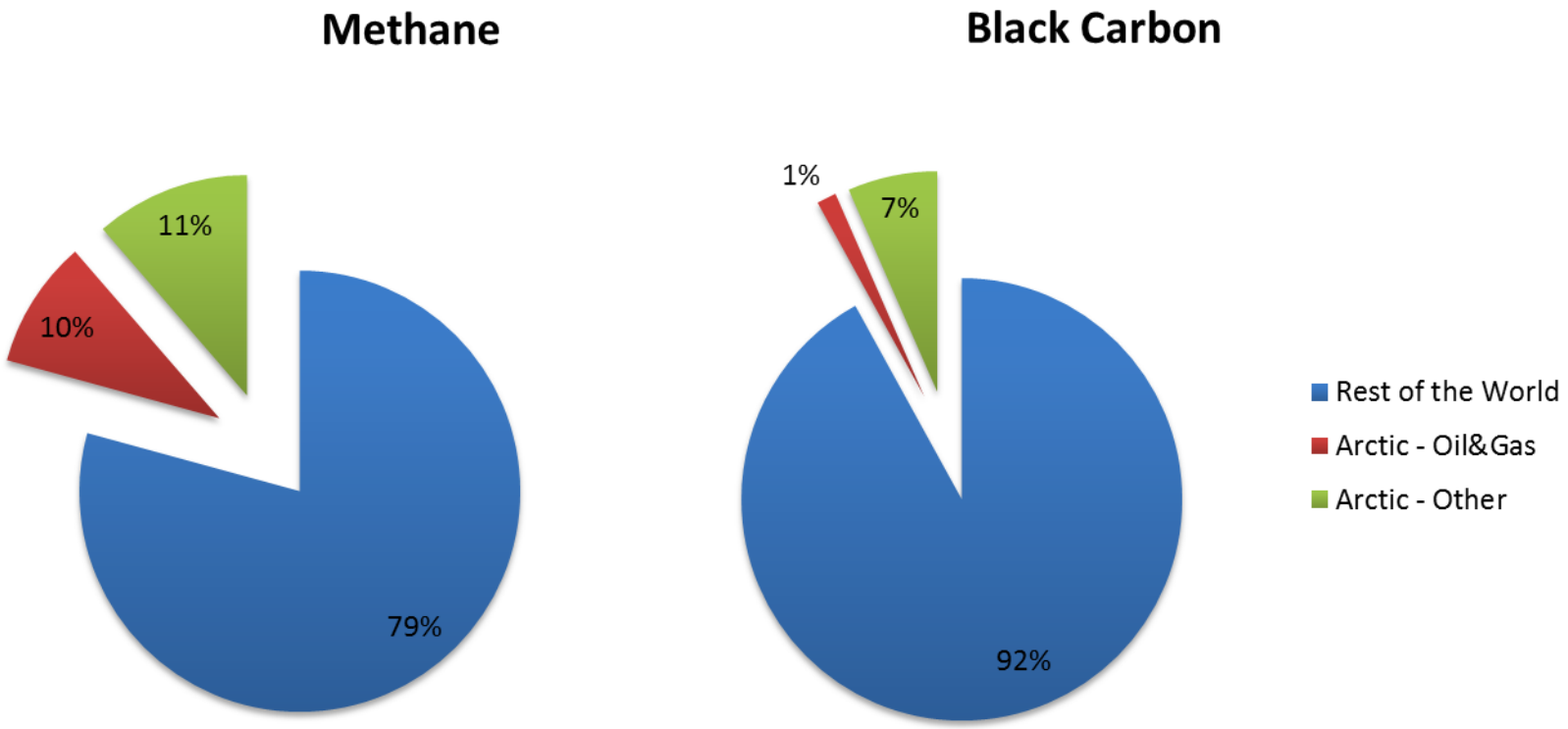
- Developed with the IIASA GAINS model; 165 regions, period 1990-2050;
- Revision of historic data for 1990-2010
- Two baselines drawing on the IEA/OECD projections until 2050 (Energy Technology Perspectives, 2012):
  - 6^{o}C scenario – consistent (until 2035) with the WEO, 2011
  - 2^{o}C mitigation scenario – comparable to the WEO 450ppm.
- Agriculture development based on the FAO (2012)
- Shipping baseline includes IMO agreements; low sulfur fuels
- For Europe: review of NEC Directive results included
- For China: 11th 5-year plan in the baseline; 12th 5-year plan scenario under development
- Improved spatial (0.5^{o}x0.5^{o}) distribution – updated proxies;
- Annual and monthly distribution of emissions
- A number of 'new' sources included: shale gas, gas flaring, wick lamps, diesel generators, high emitting vehicles
- Beyond baseline also 'no further control beyond 2015', 'SLCP mitigation', and 'maximum feasible reduction' cases under development

Global CH_4 emissions and mitigation potentials



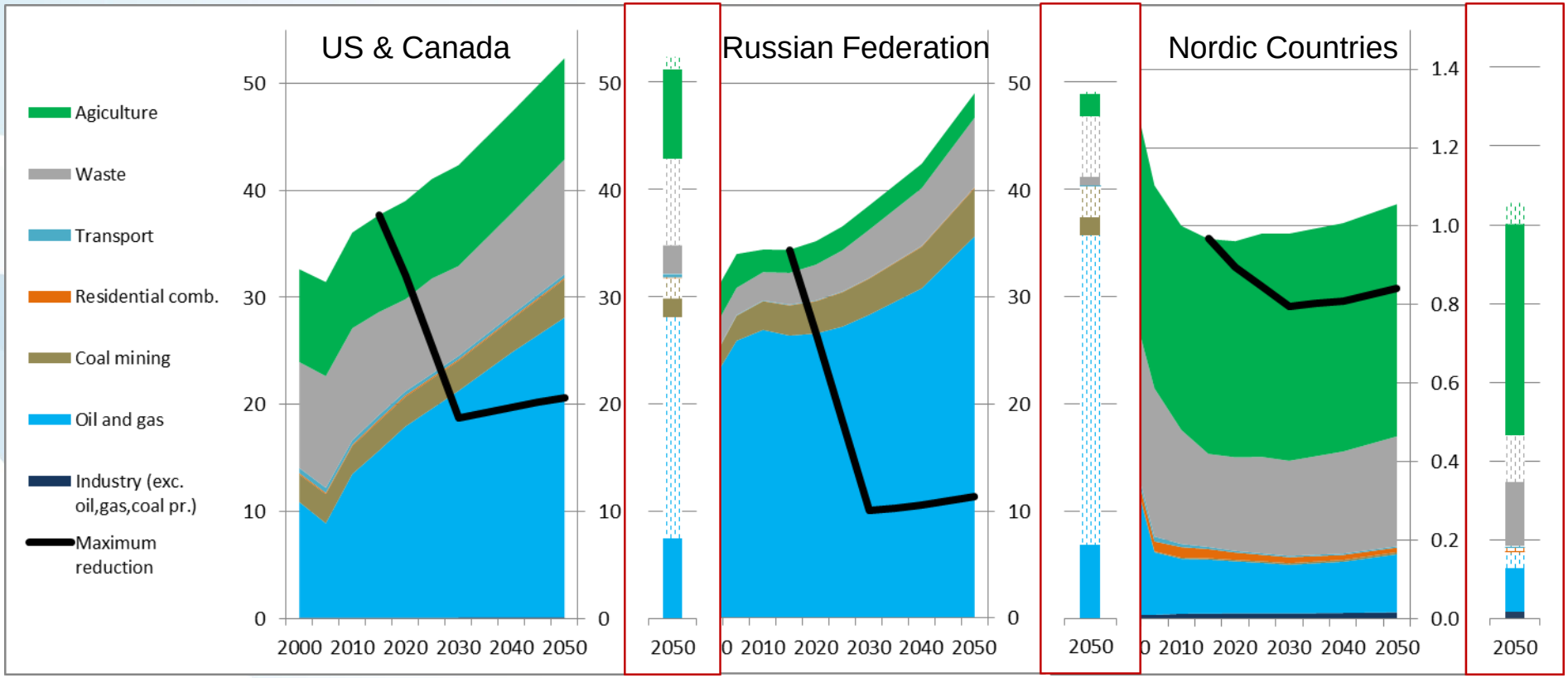
Source: GAINS model; ECLIPSE V5 scenario

Contribution of Arctic nations and its oil & gas industry to global anthropogenic emissions of methane and black carbon in 2005



Source: GAINS model; ECLIPSE V5 scenario

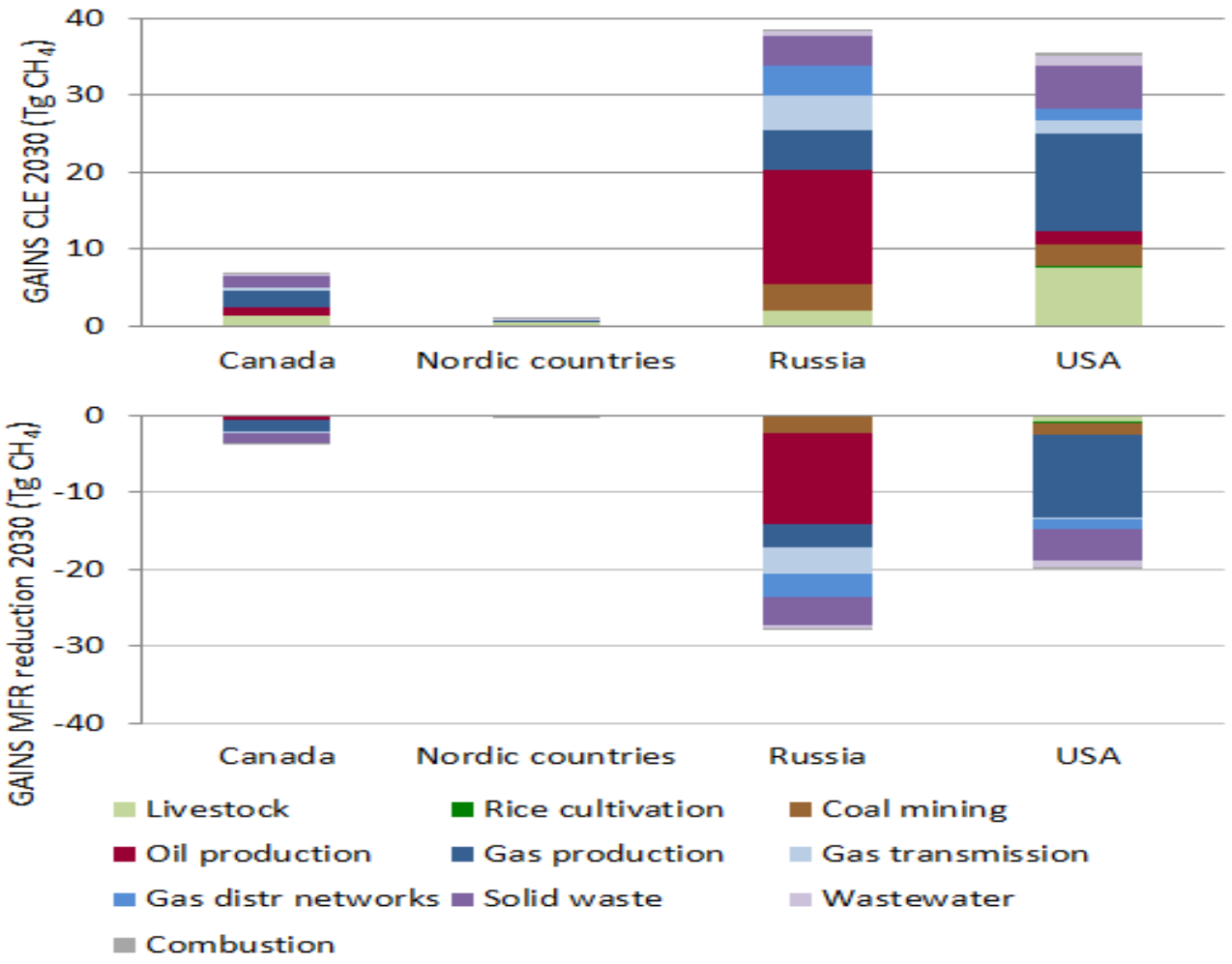
GAINS CH_4 baseline and mitigation potential for Arctic Council countries, *Mt CH_4*



Mitigation potential by 2050

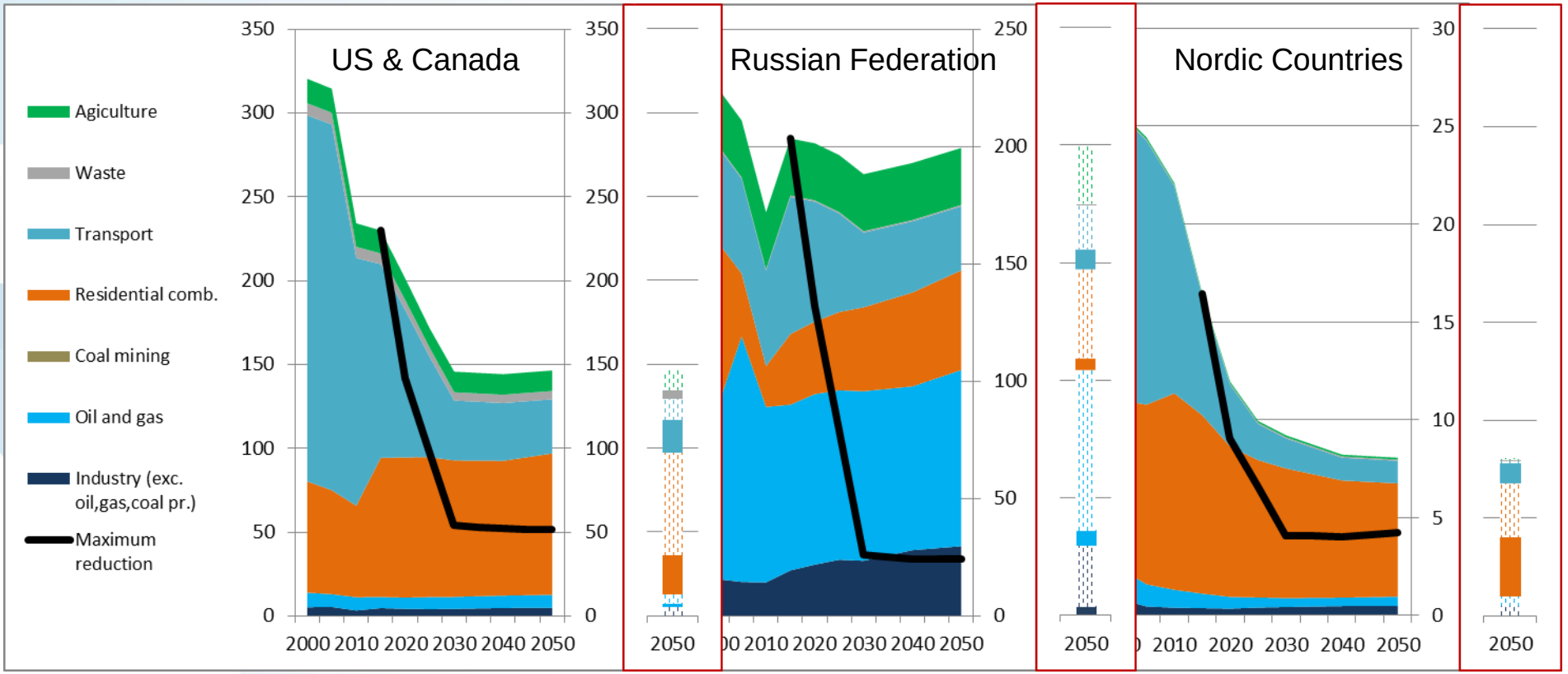
Source: GAINS model; ECLIPSE V5 scenario

Methane emissions in Arctic Council countries 2030
ECLIPSE v.5 scenario (IEA-ETP, 2012) and mitigation potential



Source: GAINS model; ECLIPSE V5 scenario

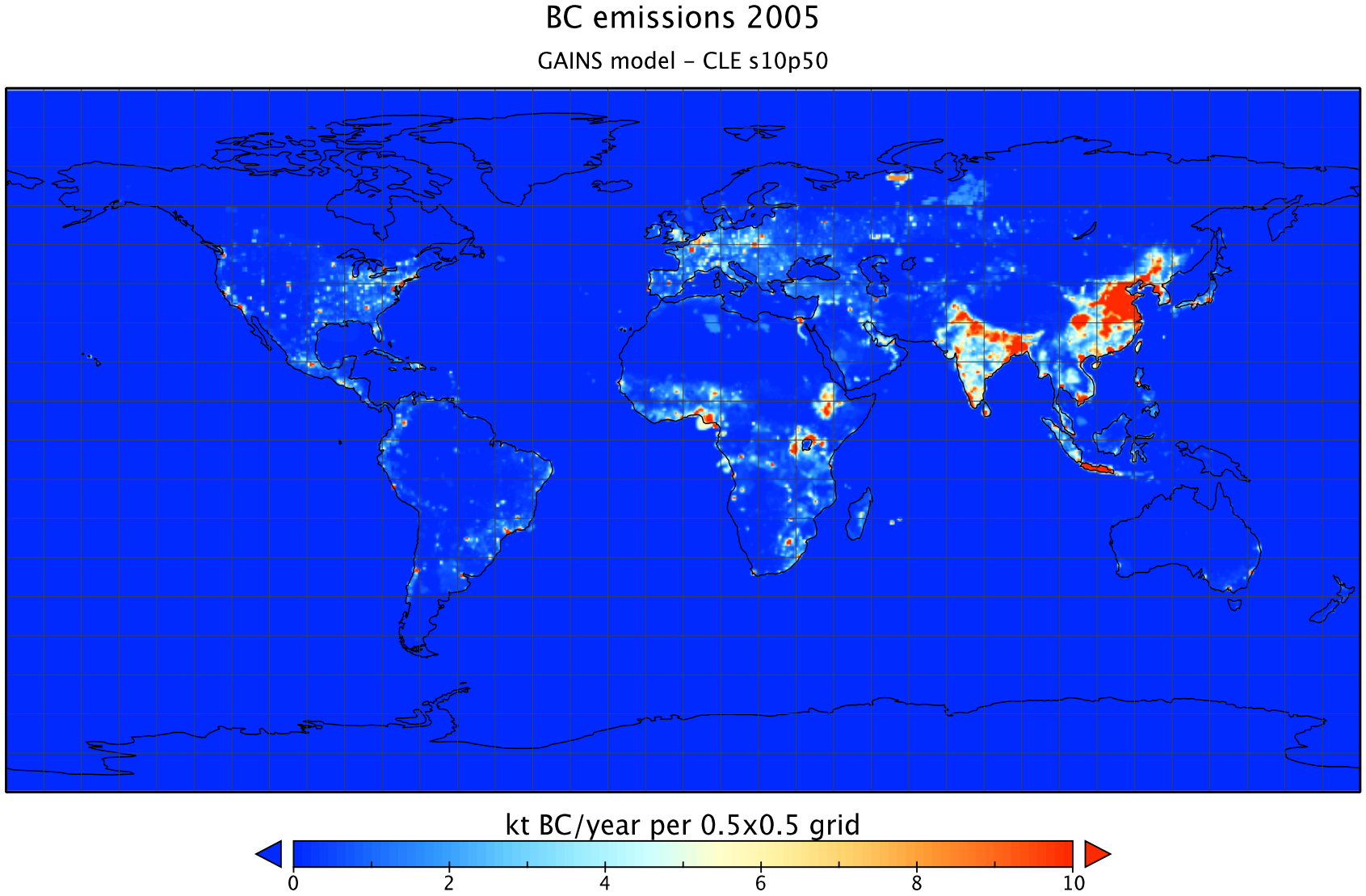
GAINS BC baseline and mitigation potential for Arctic Council countries, *kt BC*



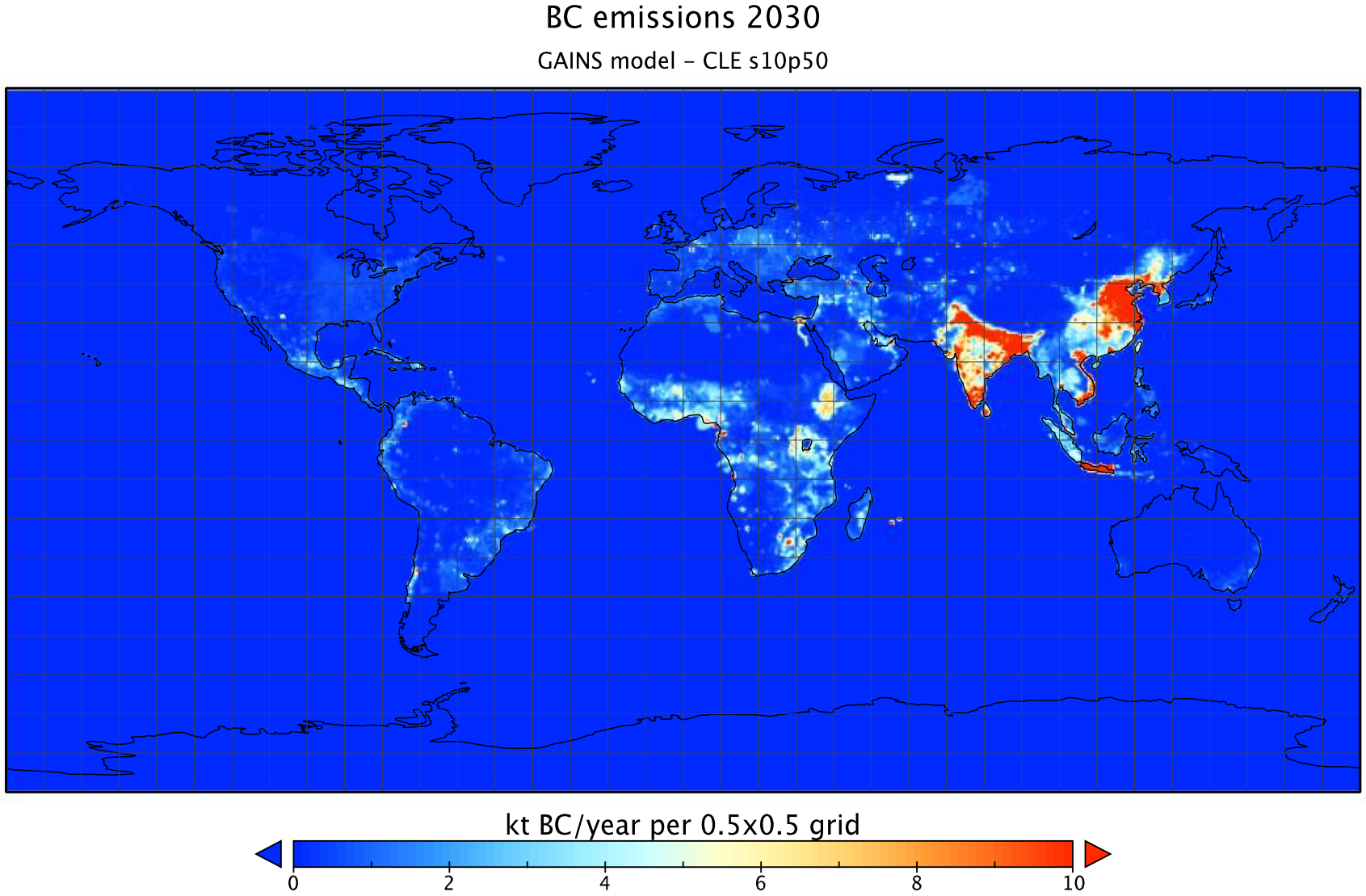
Mitigation potential by 2050

Source: GAINS model; ECLIPSE V5 scenario

Change in spatial distribution of BC emissions between 2005 and 2030; *GAINS (ECLIPSE V4a) current legislation*

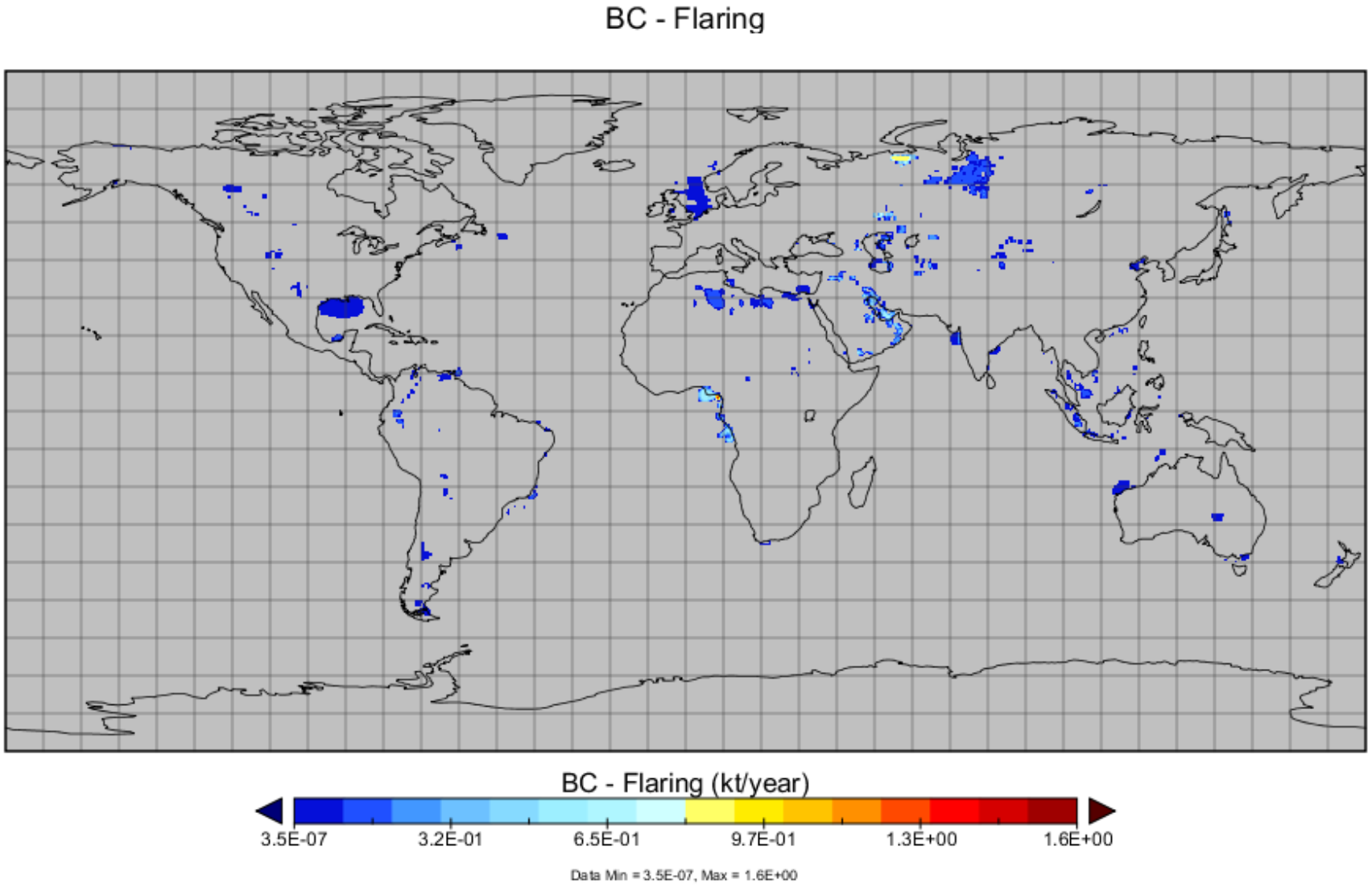


Change in spatial distribution of BC emissions between 2005 and 2030; *GAINS (ECLIPSE V4a) current legislation*



Spatial distribution of emissions from gas flaring in GAINS

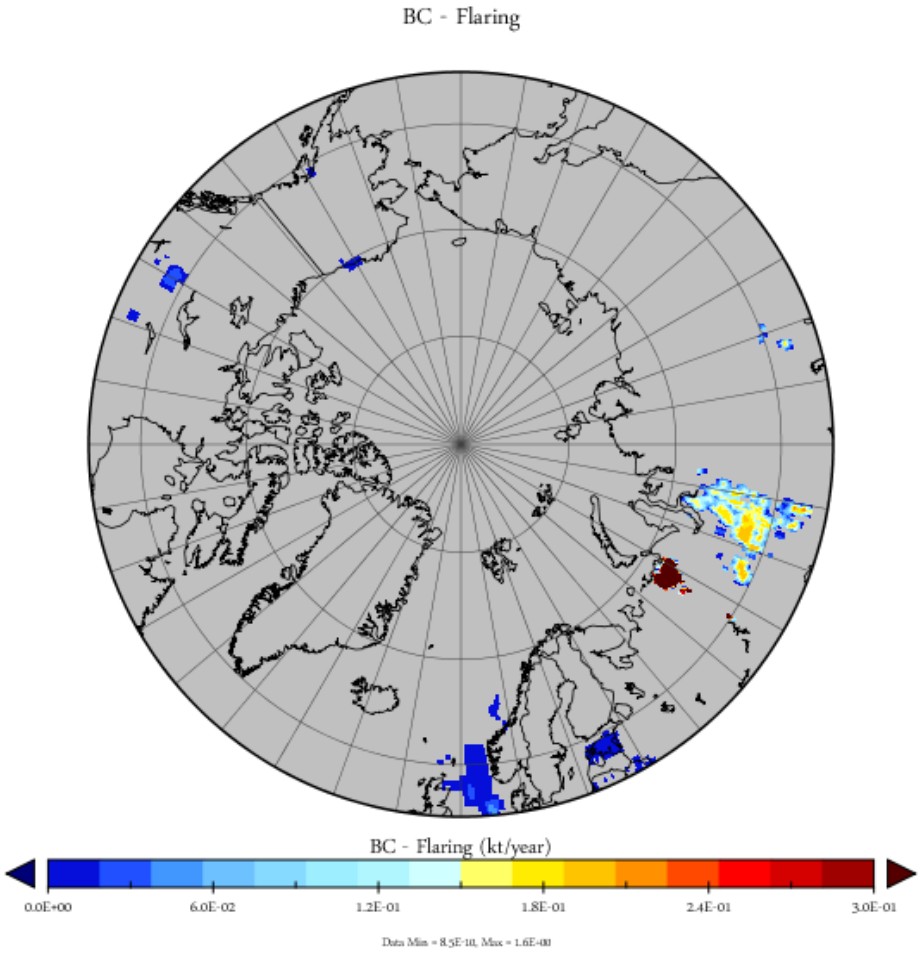
Location of flares: *Interpretation of GGFR work (World Bank, NOAA, NASA)*
Emission estimates: *GAINS model using flaring volumes from Elvidge et al, 2009*

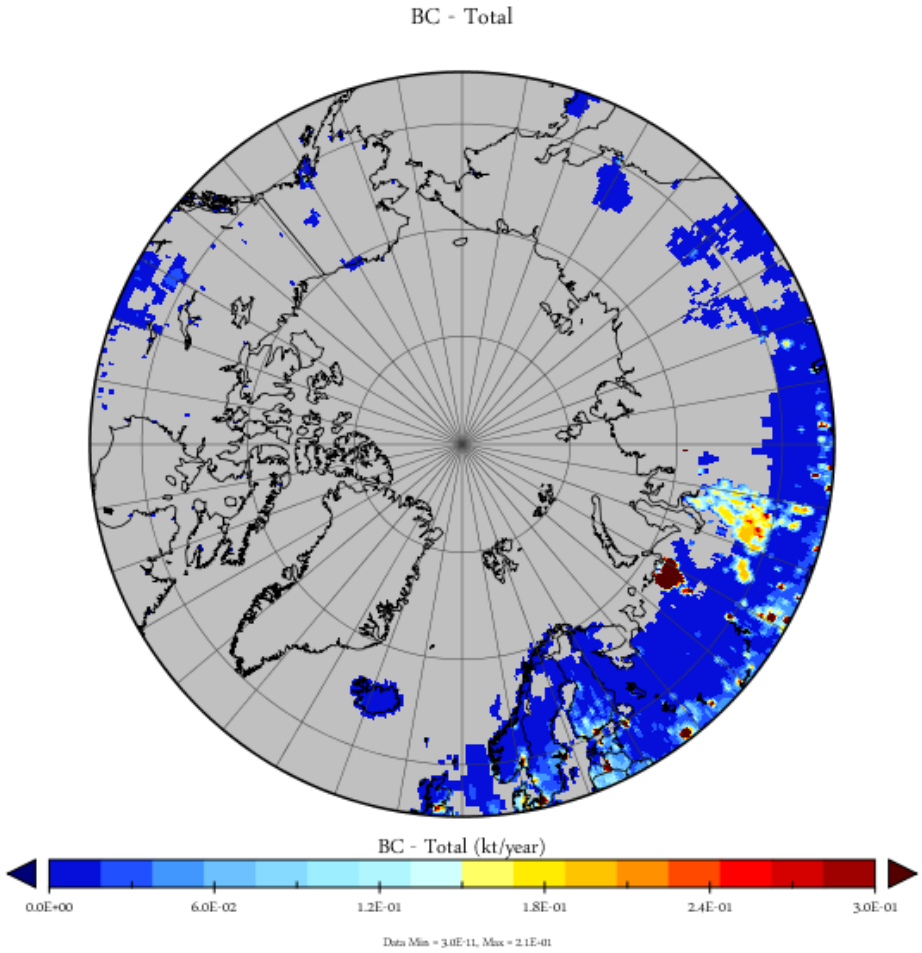


BC emissions 55ºN

Importance of flaring

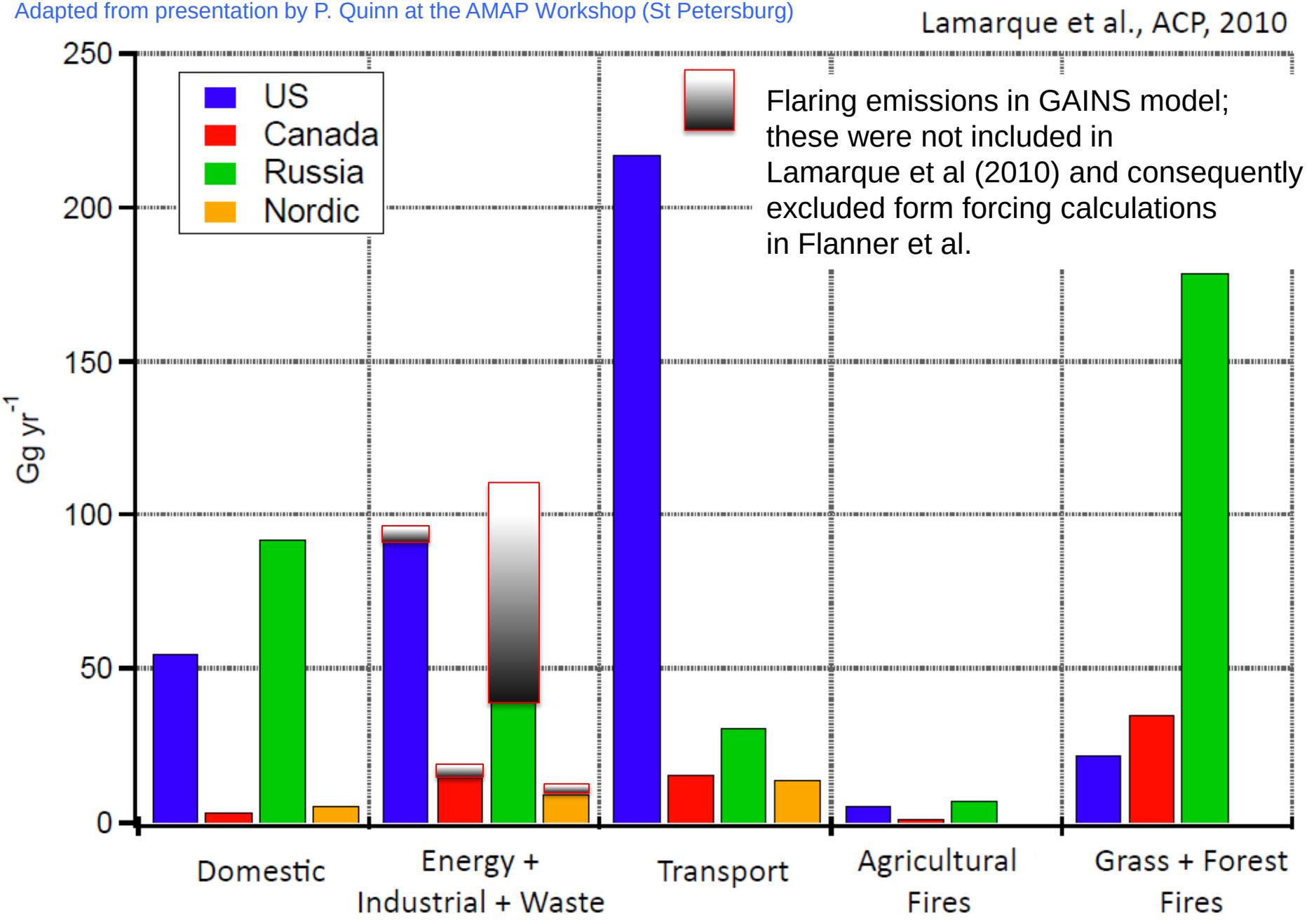
Source: *GAINS model (estimate for 2005), gas flaring volumes and distribution (Elvidge et al, 2009; GGFR)*





Emissions of BC by Sector and Region within the Arctic Council Nations

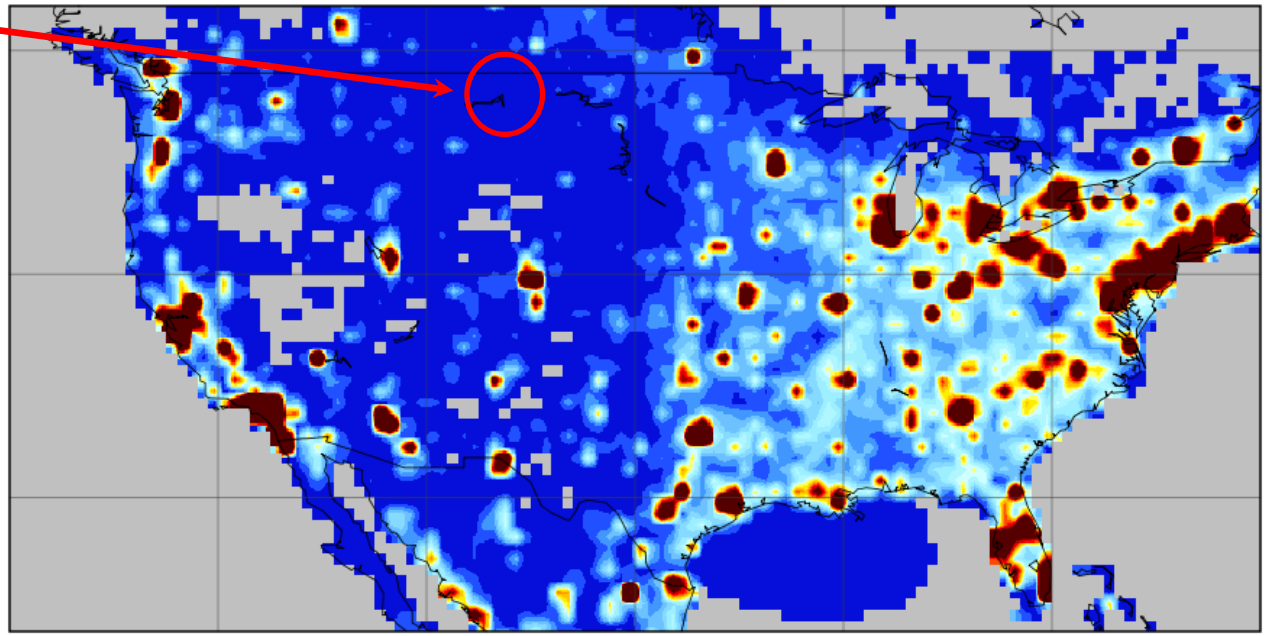
Adapted from presentation by P. Quinn at the AMAP Workshop (St Petersburg)



Missing source areas;

Example NOAA-NASA 'night-light' image of US against GAINS BC estimates for the same area

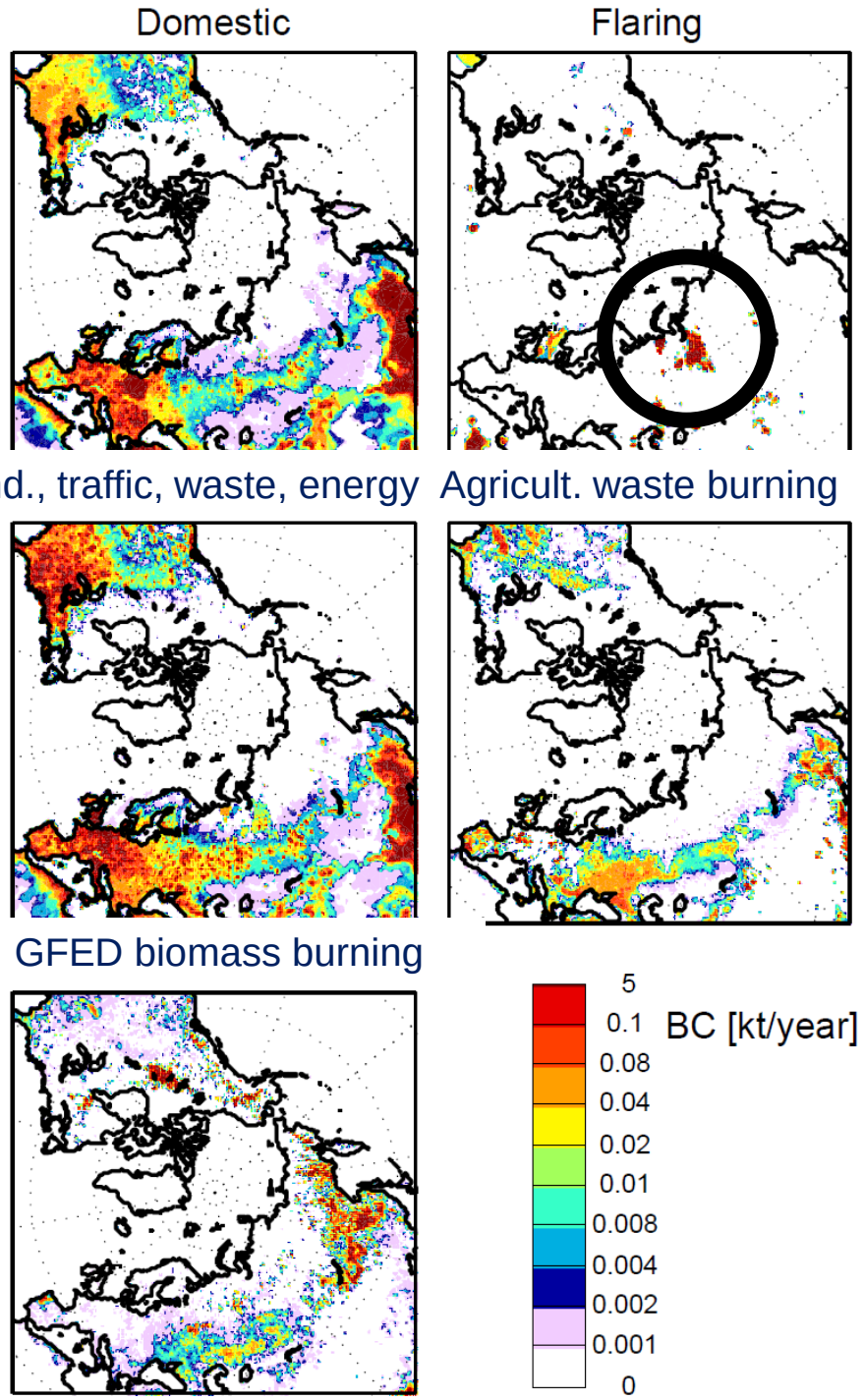
North Dakota flaring
Missing in GAINS?



ECLIPSE BC emissions

Flaring emissions are 3% of global BC emissions

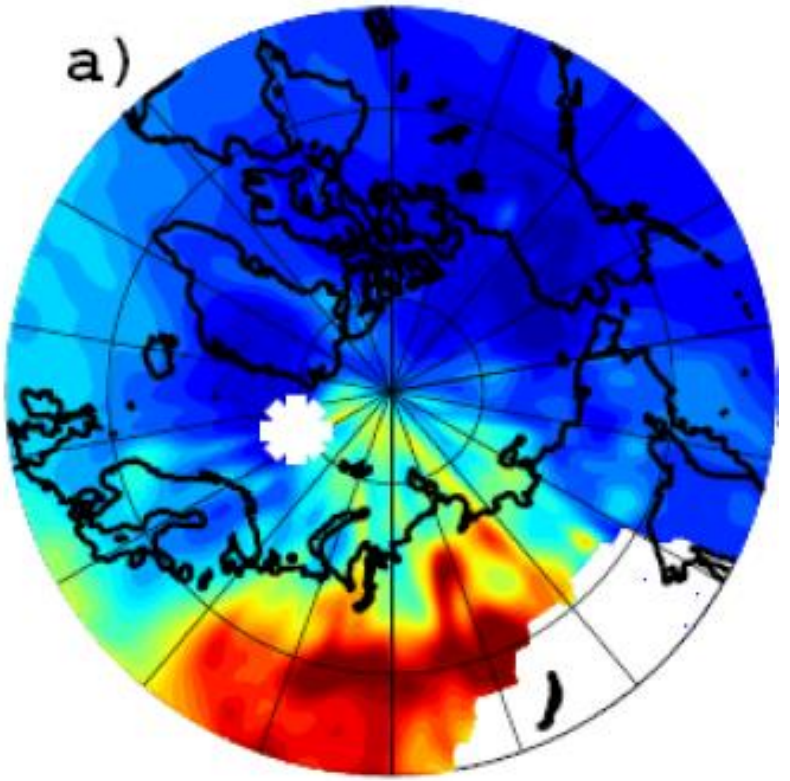
But constitute
1/3 of all emissions north of 60ºN, and
2/3 of all emissions north of 66ºN



Source: Stohl et al. (2013)

ECLIPSE BC emissions

Russian flaring located in region identified by Hirdman et al. (2010) as major source region for observed high concentrations of BC at Arctic stations (here: Zeppelin)



Source: Stohl et al. (2013)

Model simulations

Put emissions into Lagrangian particle dispersion model FLEXPART.

Ran FLEXPART forward for 3 years

Evaluated concentrations at several monitoring stations.

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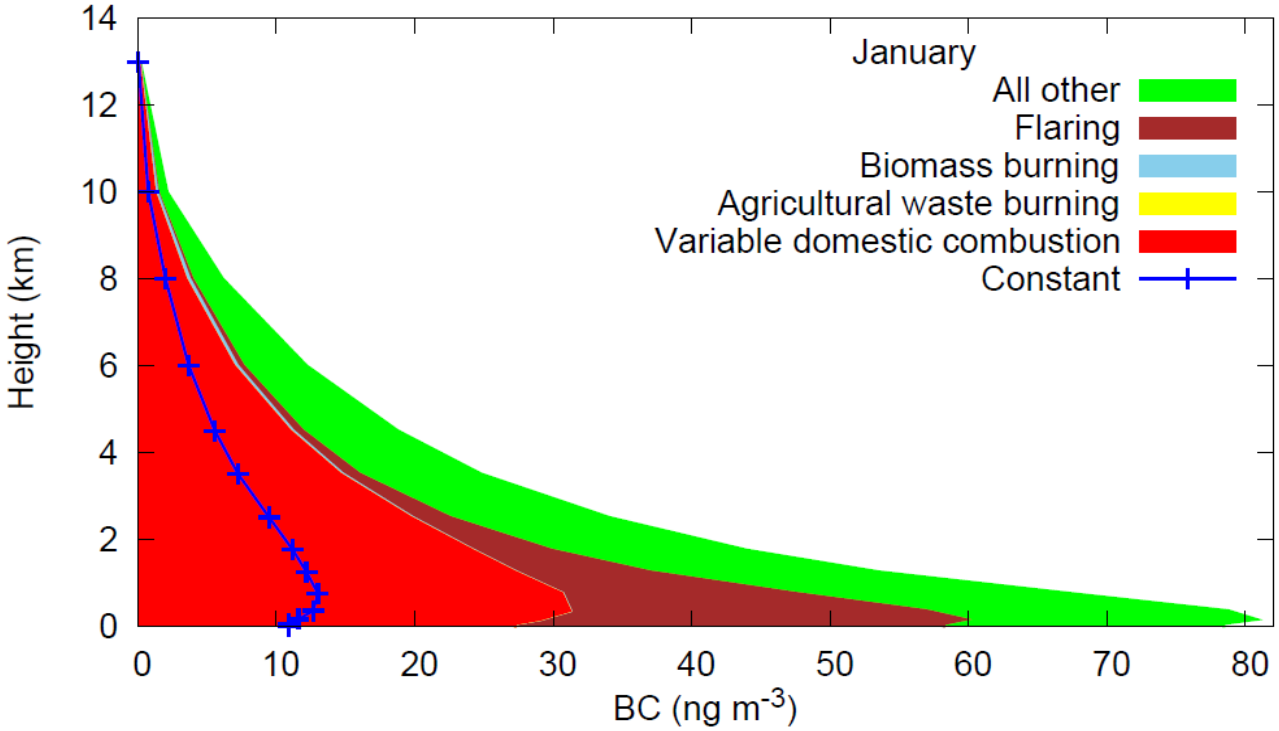
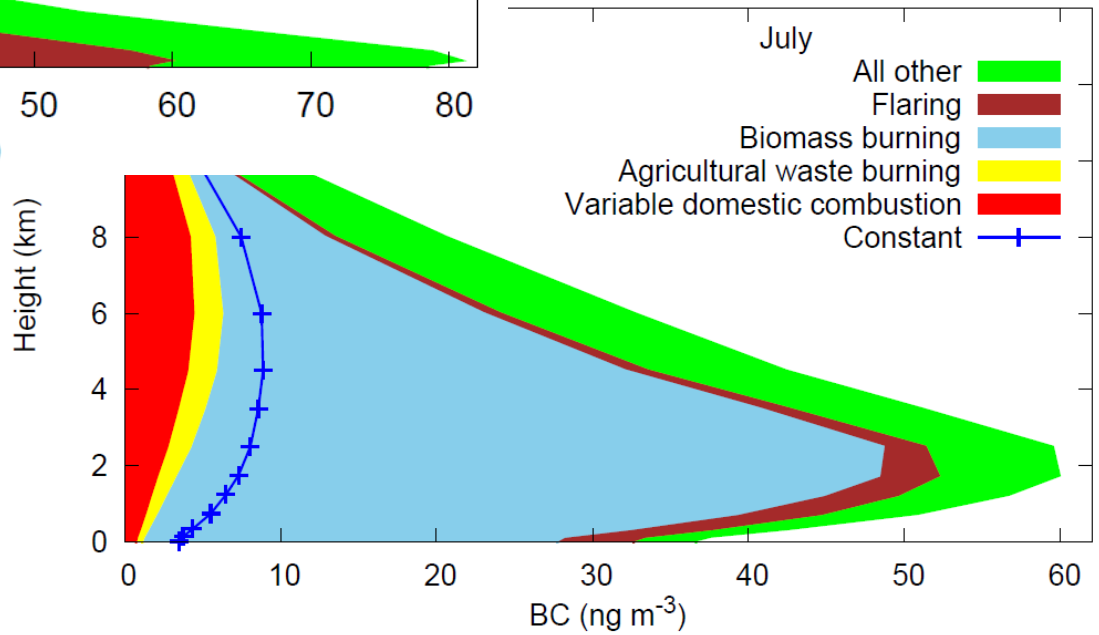
Vertical BC profiles from all sources





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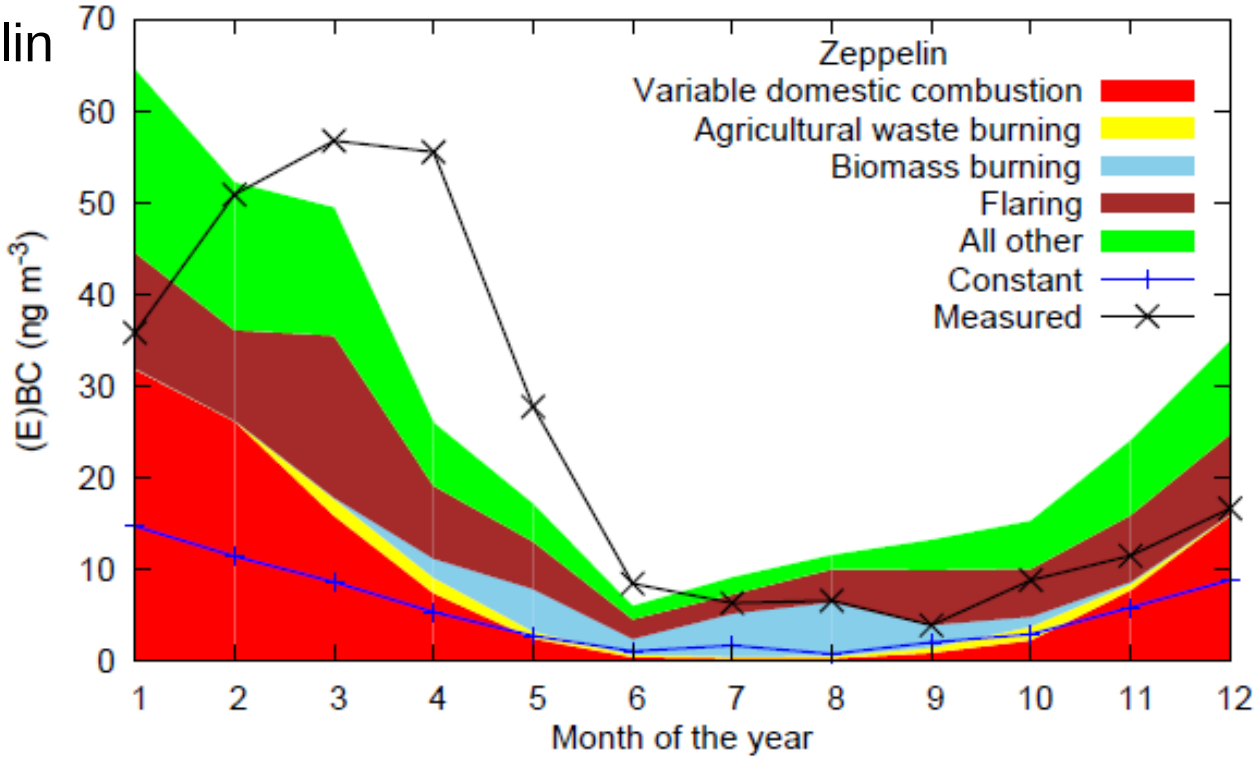
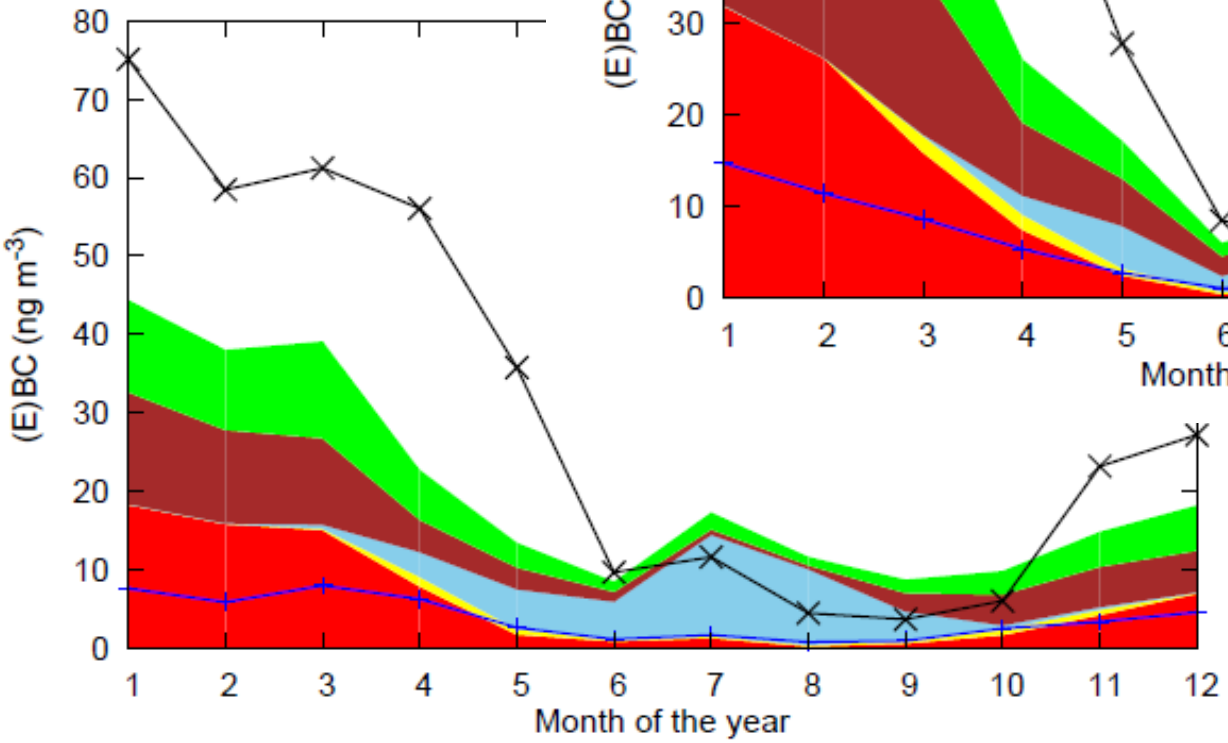
Source: Stohl et al. (2013)

Comparison of modeled and measured seasonality at Alert and Zeppelin stations

Zeppelin



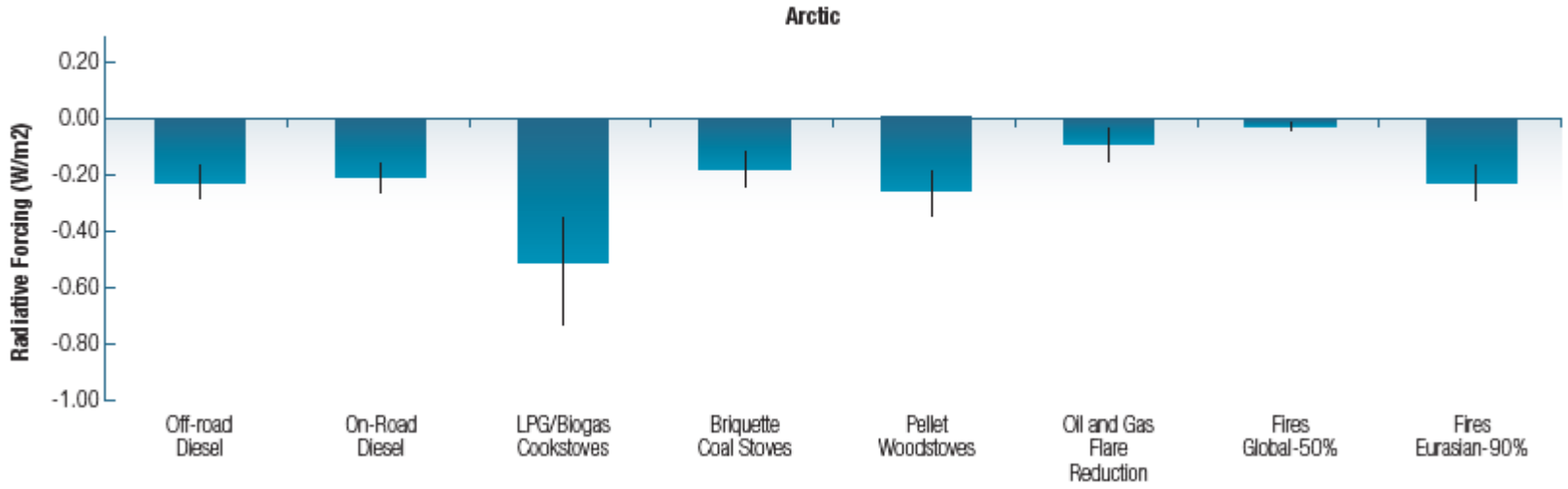
Alert



Source: Stohl et al. (2013)

Impact of selected global BC measures in radiative forcing for the Arctic

Figure 7: Average Radiative Forcing Estimates for the Arctic from Black Carbon Emissions Reductions.



Cryosphere/Climate Benefits:*

- Total decrease in radiative forcing, all measures: –1.7 W/m^2 (–0.9 to –2.5)
- Decrease from black carbon measures: –1.4 W/m^2 (–0.6 to –2.2)
- Decrease from methane measures: –0.32 W/m^2
- Annual avoided temperature increase from methane measures: 0.25–0.75 degrees (highest in Arctic Ocean/northern Siberia)

*Health** and Agricultural Benefits in Arctic Source Region:*

- Annual premature mortality avoided: 47,800
- Annual increase in staple crops: 10.2 million metric tons

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