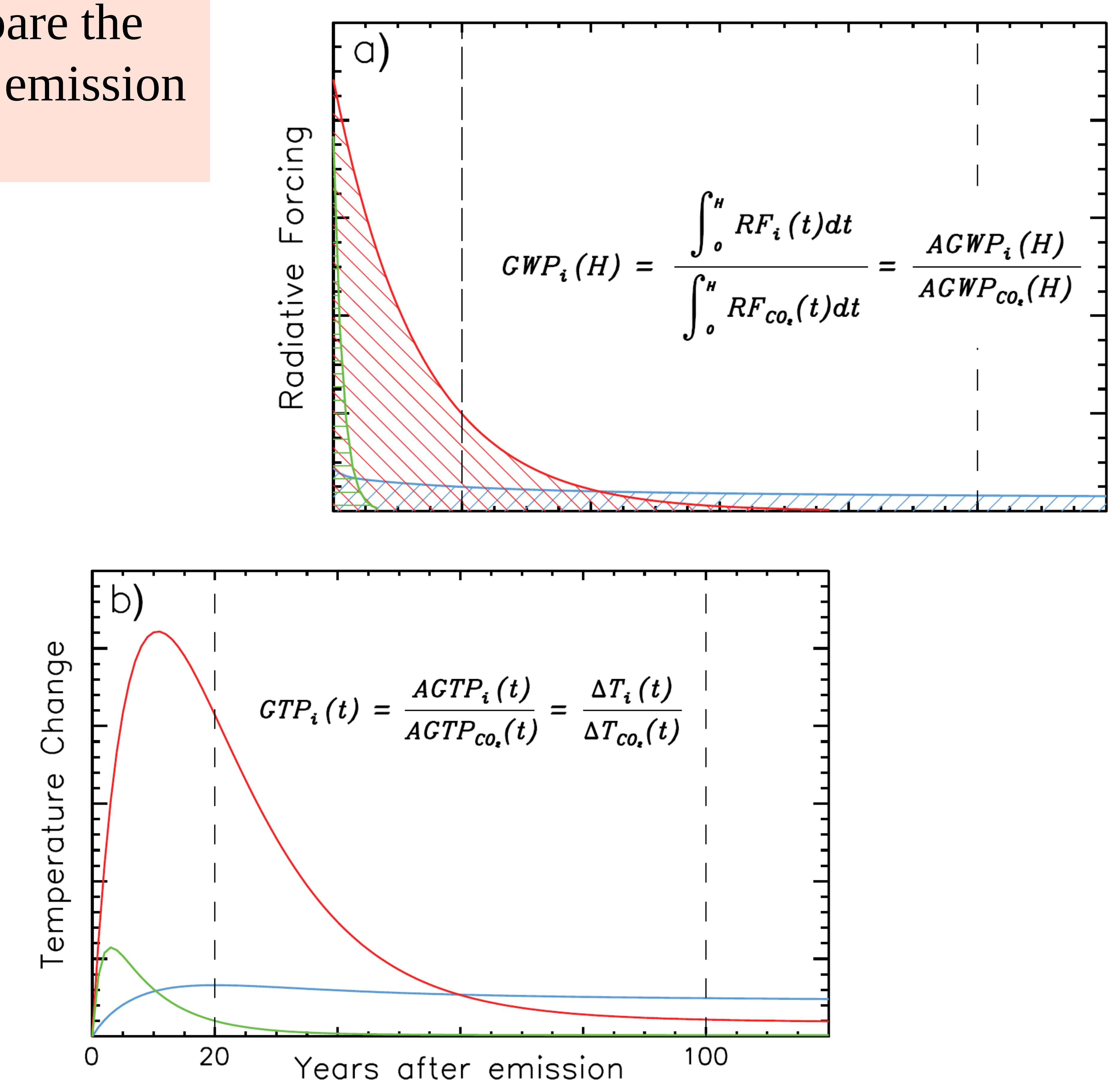
°CICERO

How climate metrics work: climate impacts of methane and black carbon and relevance for metrics development

Marianne T. Lund, Center for International Climate Reserach
CCAC Scientific Advisory Panel Experts Workshop
March 16-17, Ottawa, Canada

The basics: How climate metrics work

Emission metrics:
Simple means to compare the climate impacts of the emission of different species.



IPCC 2013 WG1 Ch.8

Numerous metrics, numerous applications:

- Climate agreements
- Emission trading
- Climate policy assessments
- Trade-offs in policy making
- Design and operation (e.g. aircraft)
- Information about properties of components and uncertainties
- Scientific studies

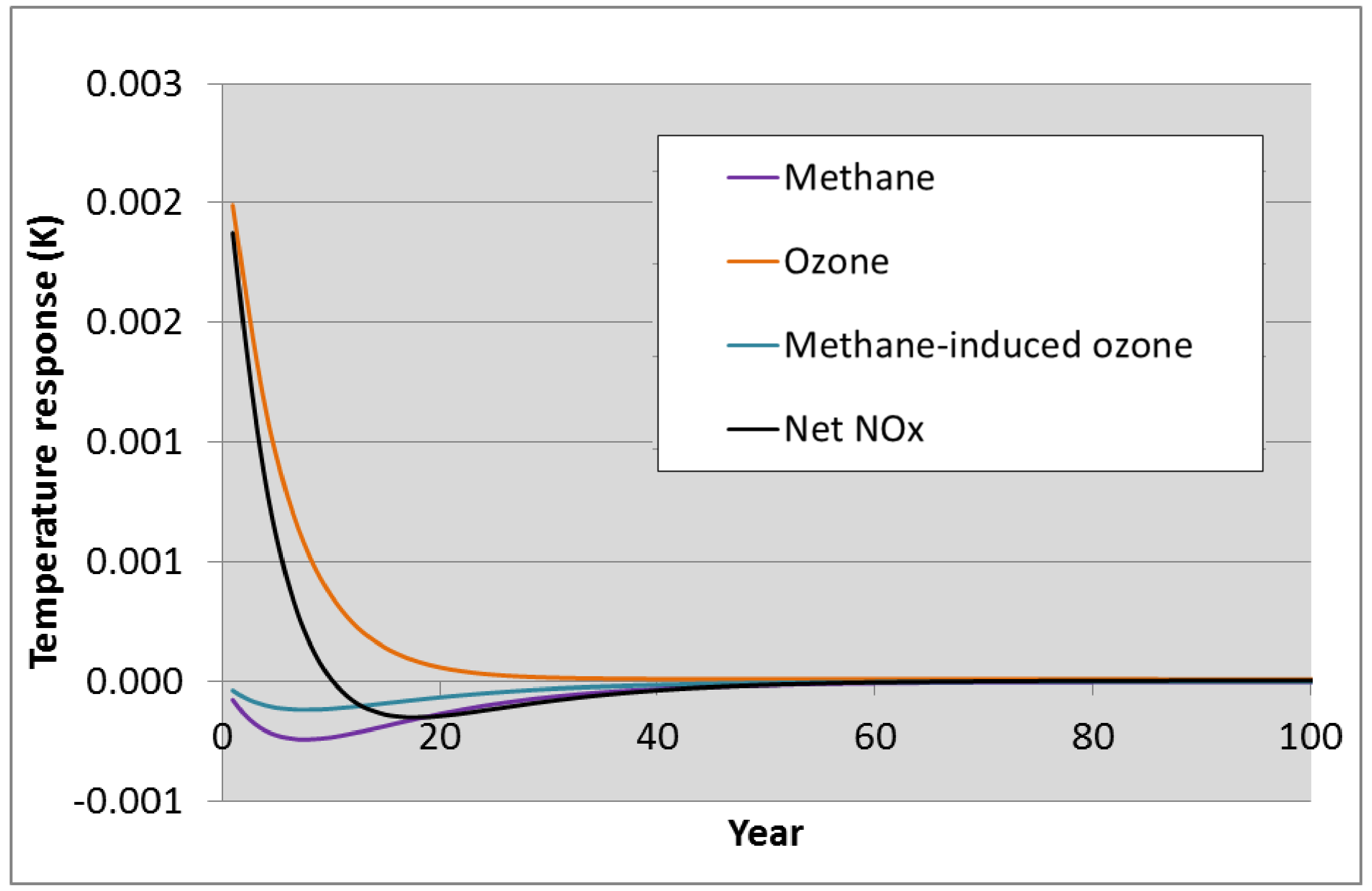
Overview talk by Keith Shine…

The basics: How climate metrics work

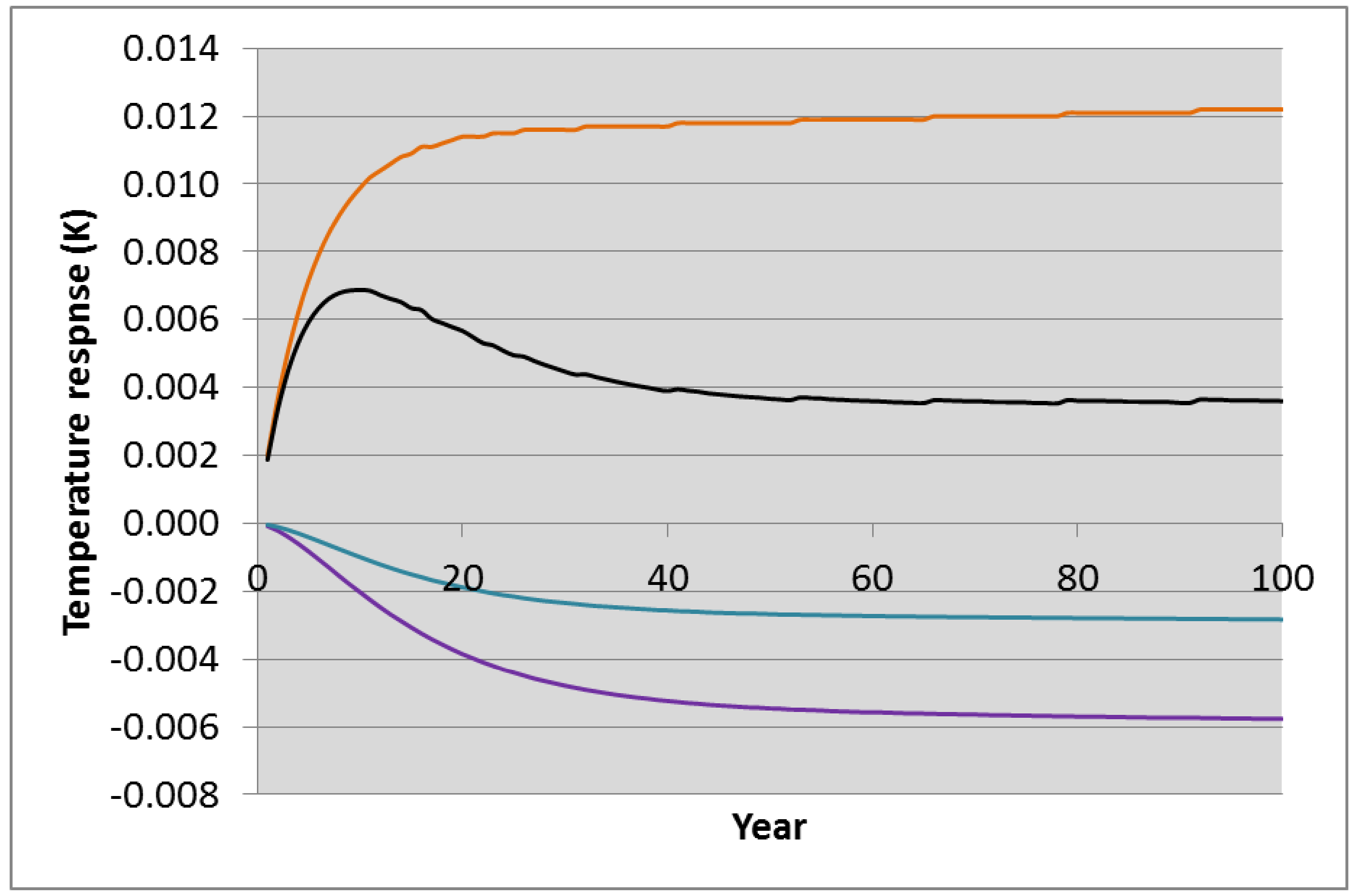
Pulse based metrics + convolution → impact of any emission scenario

Temperature response aviation NOx emissions

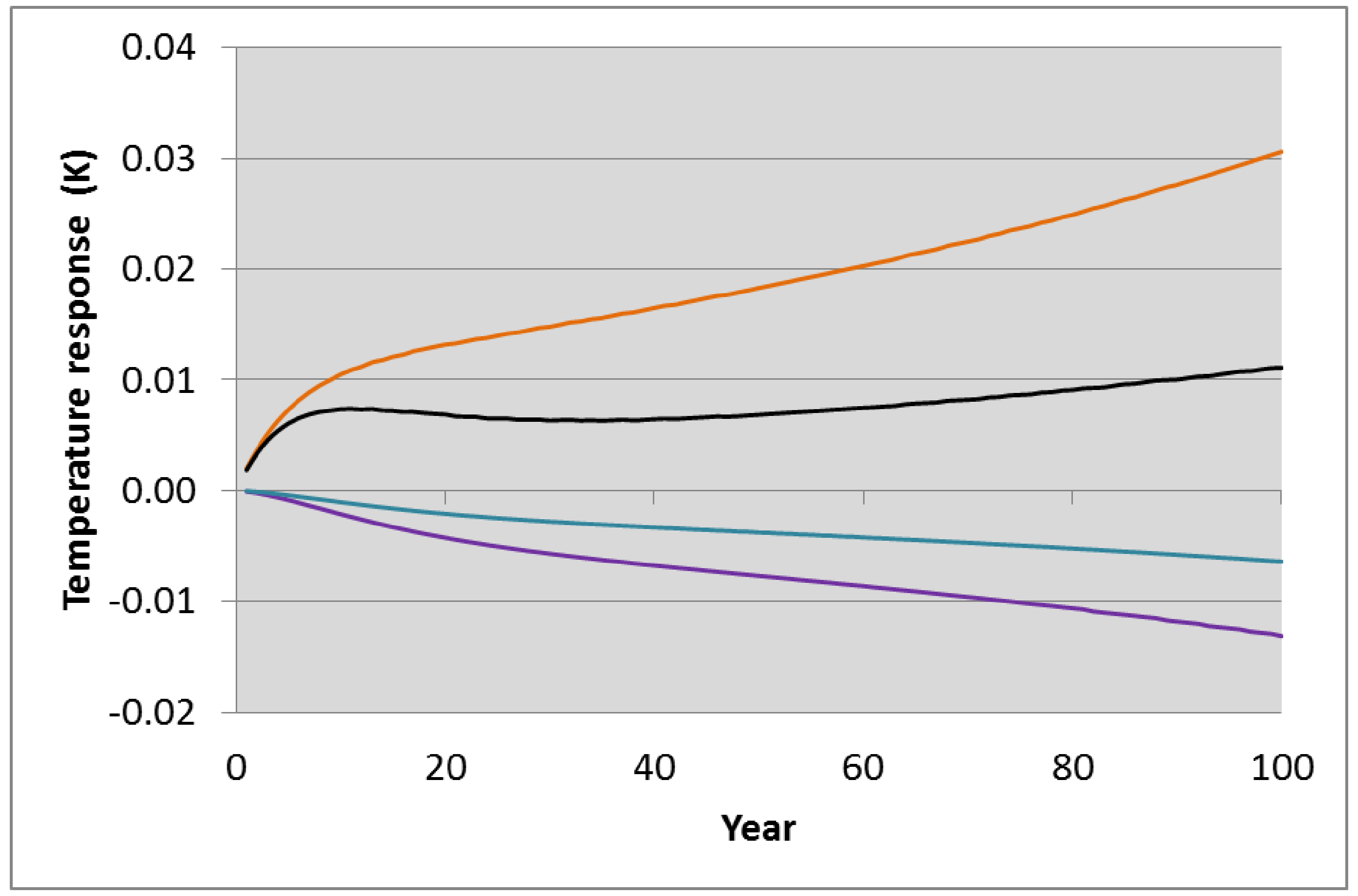
Pulse emissions



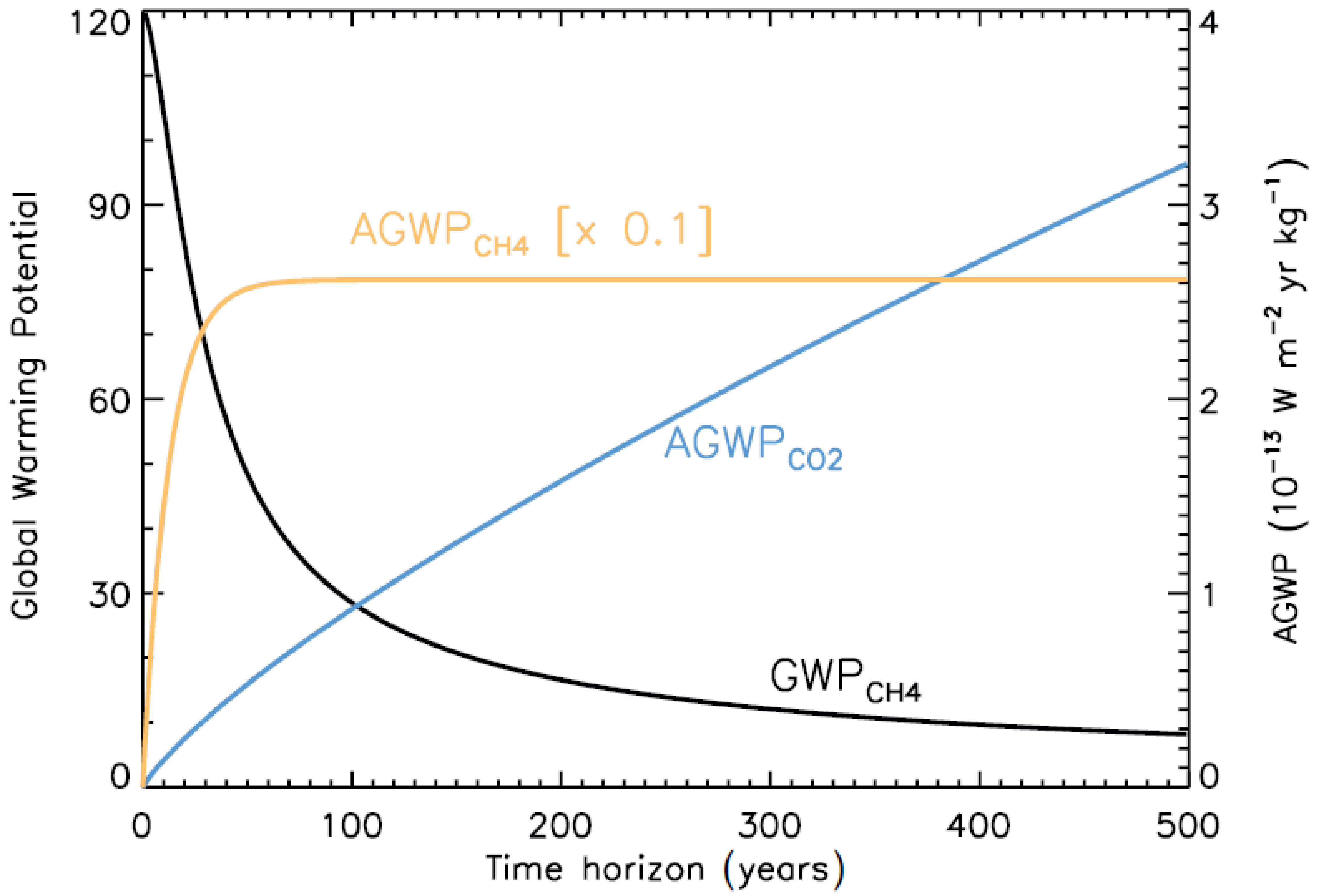
Sustained emissions



1% per year increase



Short lifetime of BC and CH4 – the reference gas determines the behaviour of the normalized metric over time



IPCC 2013 WG1 Ch.8

Should/can we use metrics to trade between short-lived and long-lived species?

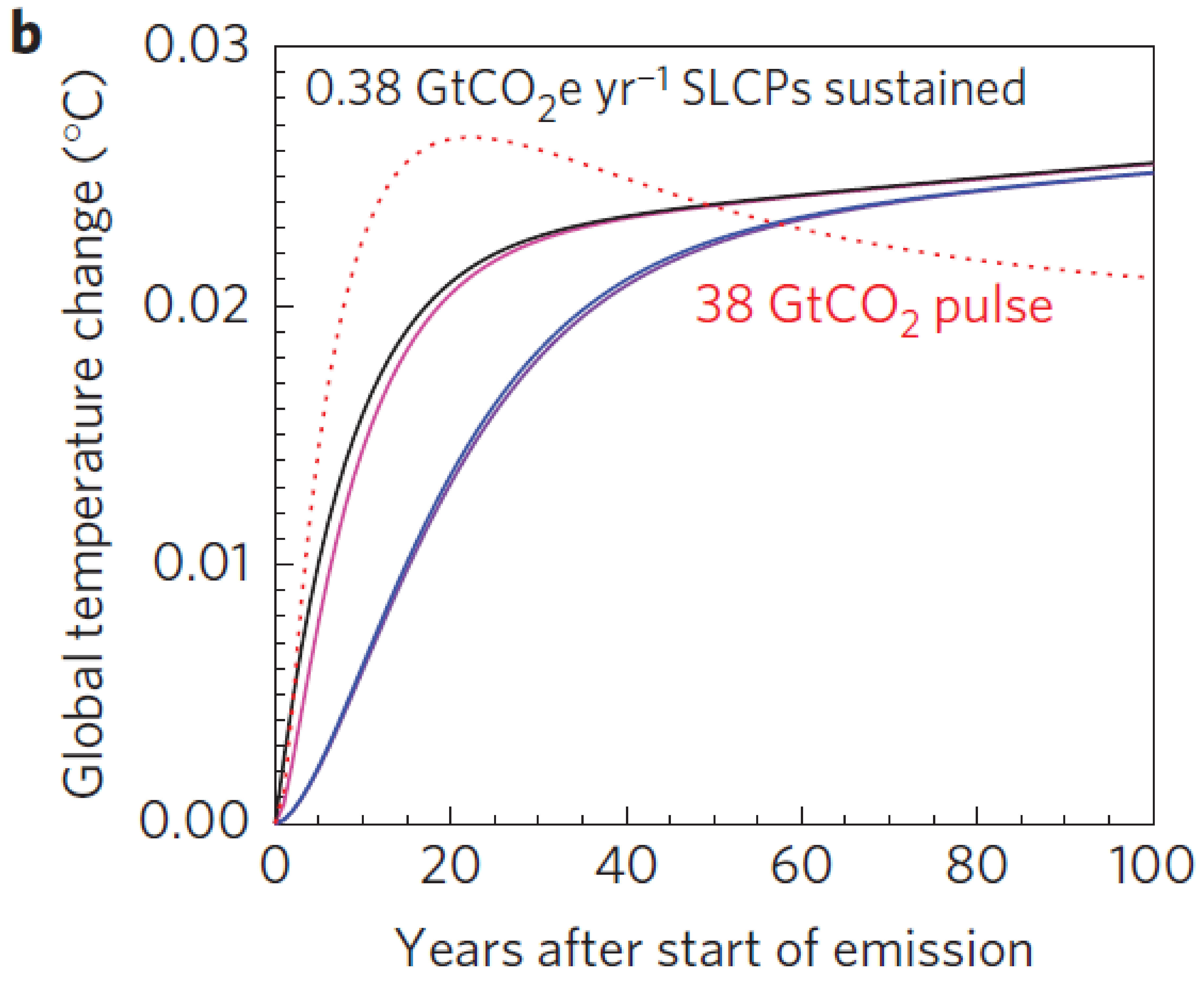
nature climate change

LETTERS

PUBLISHED ONLINE: 2 MAY 2016 | DOI: 10.1038/NCLIMATE2998

New use of global warming potentials to compare cumulative and short-lived climate pollutants

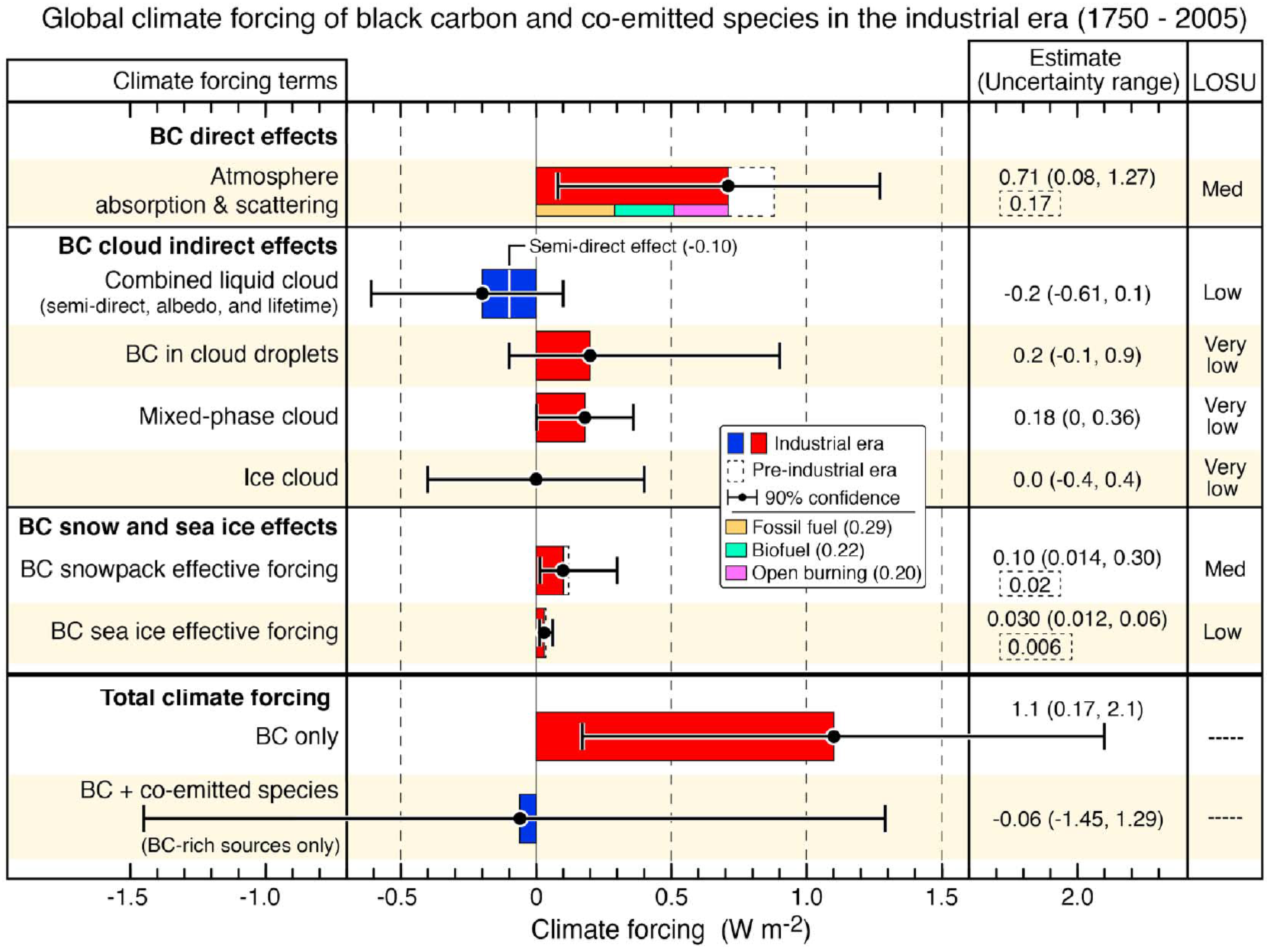
Myles R. Allen[1,2*], Jan S. Fuglestvedt[3], Keith P. Shine[4], Andy Reisinger[5], Raymond T. Pierrehumbert[2] and Piers M. Forster[6]



"The GWP100 can be used to approximately equate a one-off pulse emission of a cummulative pollutant and an indefinitely sustained change in the rate of emission of an SLCP. "

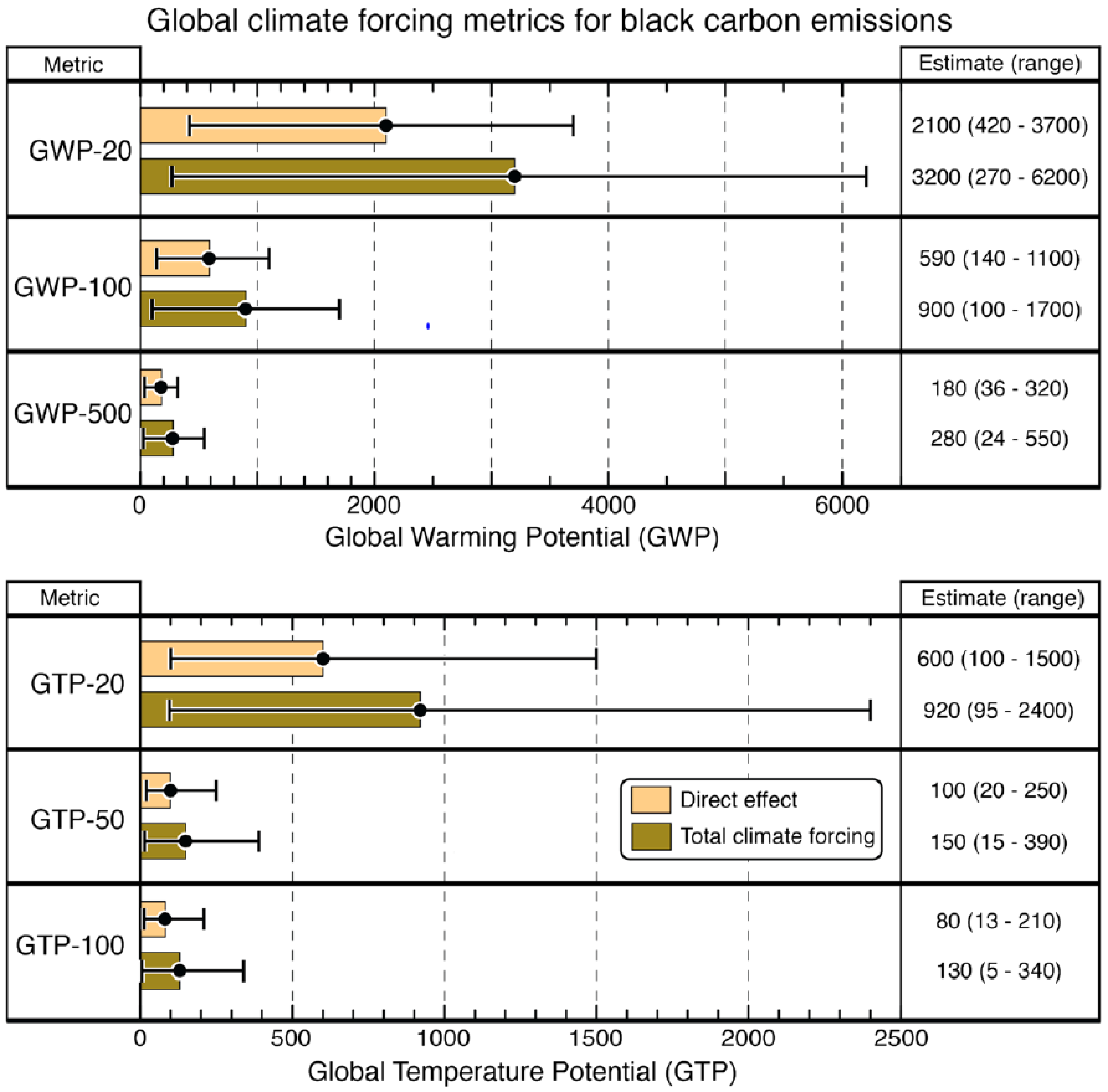
Uncertain radiative forcing translates to large range in metric values

Radiative forcing



Bond et al. 2013 (JGR)

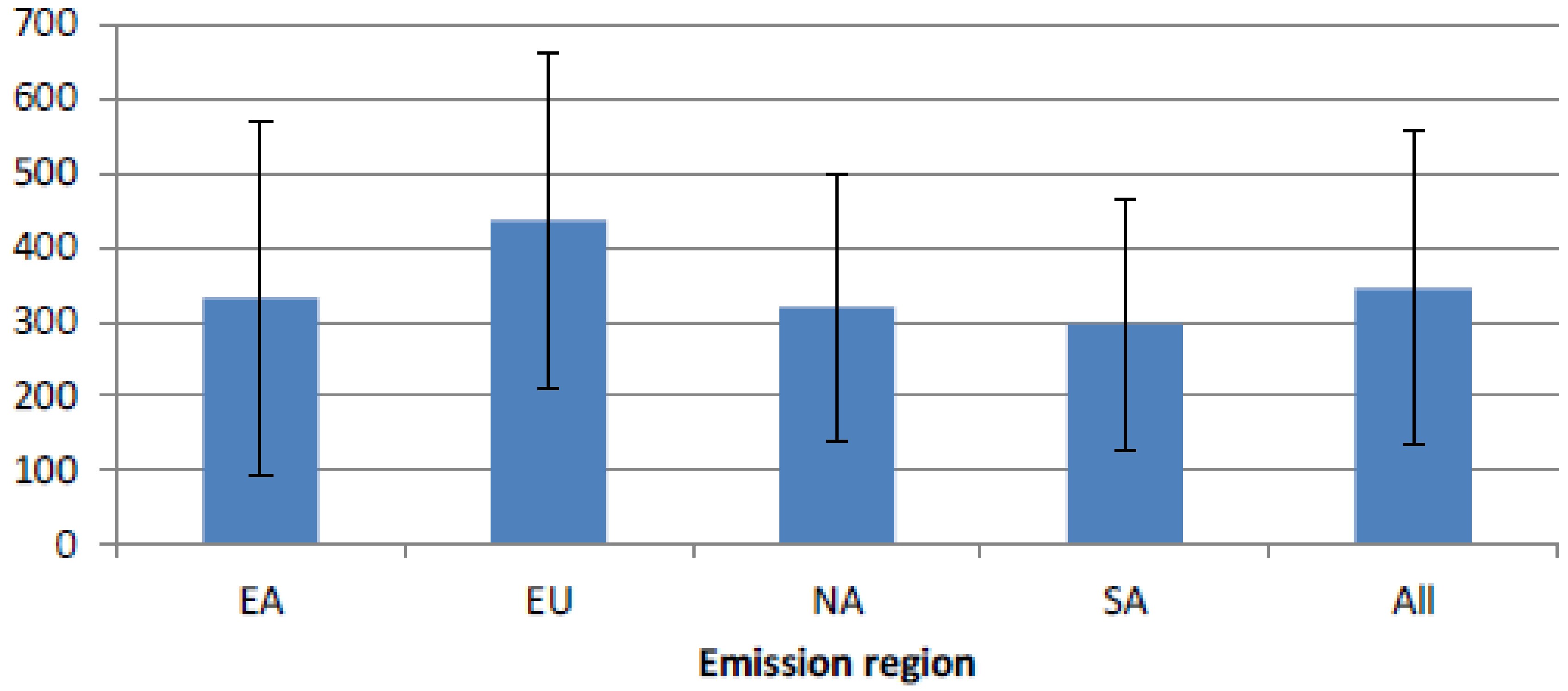
Emission metrics



°CICERO

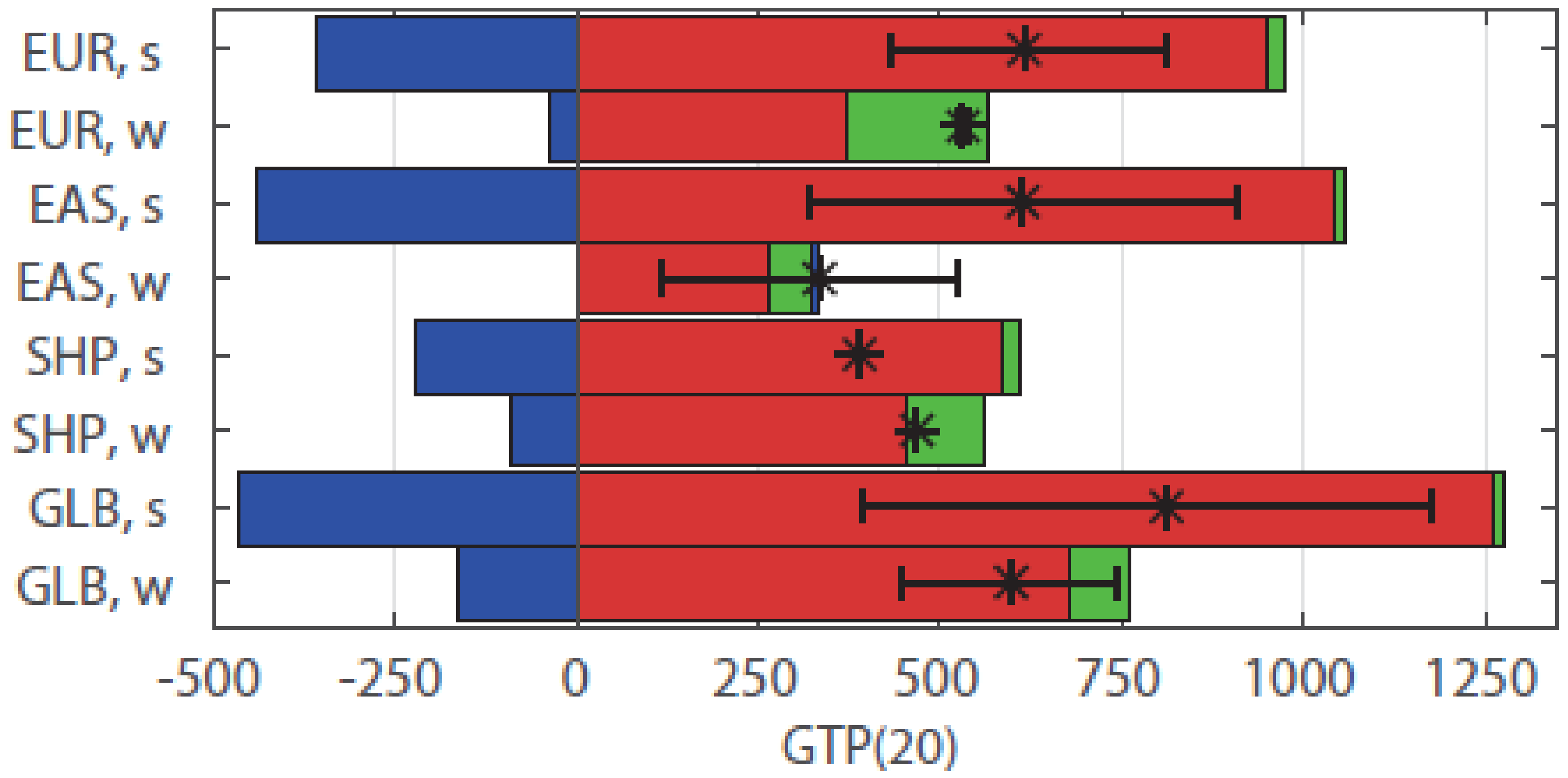
Metric values for global impact depend on the region and timing of the emissions due to the short lifetime of BC

BC GTP(20) by emission region

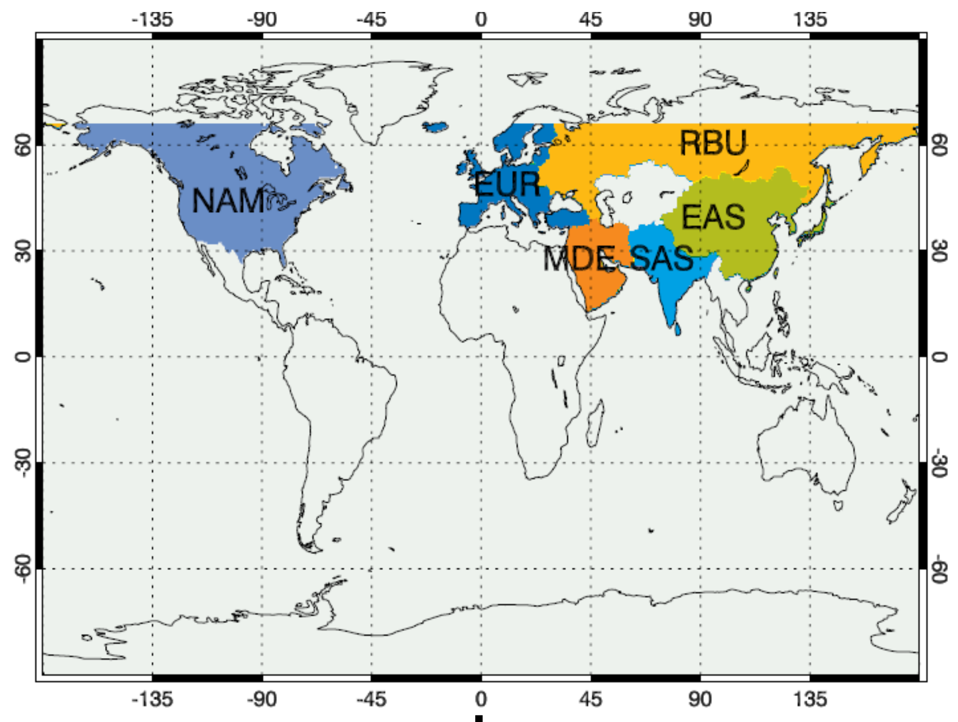


Collins et al. 2013 (ACP)

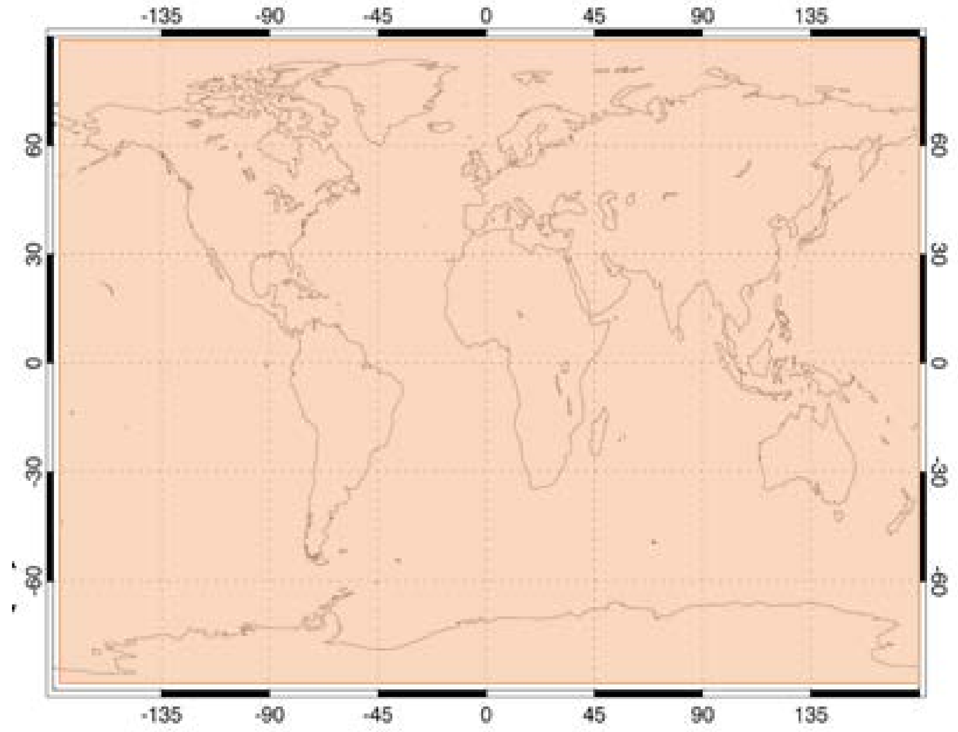
BC GTP(20) by emission region



Aamaas et al. 2016 (ACP)

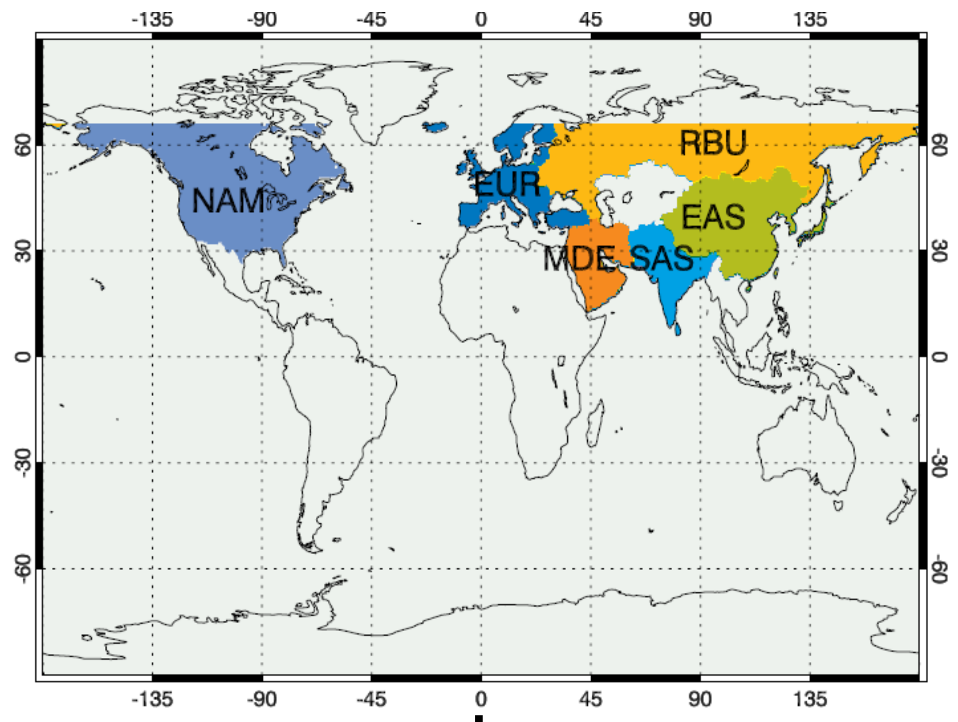


Regional emissions, global response

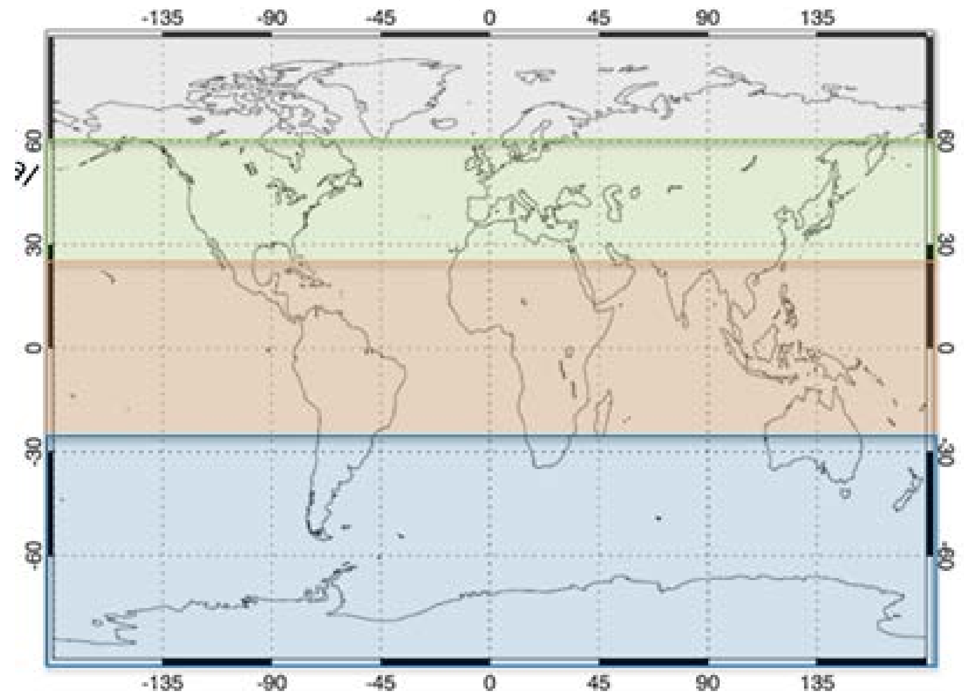


°CICERO

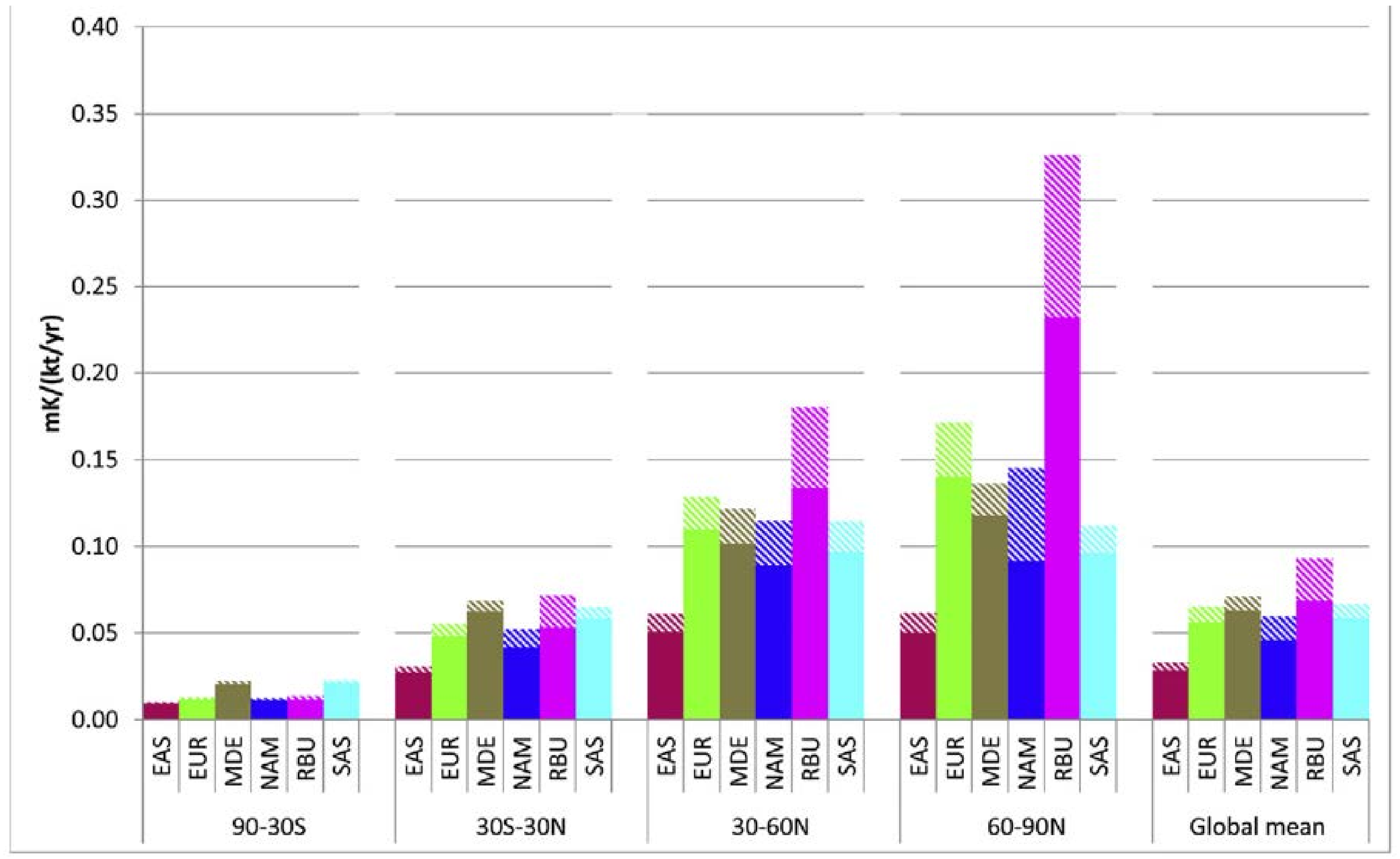
Large spatial variability in metrics hidden by global averaging



Regional emissions, regional response

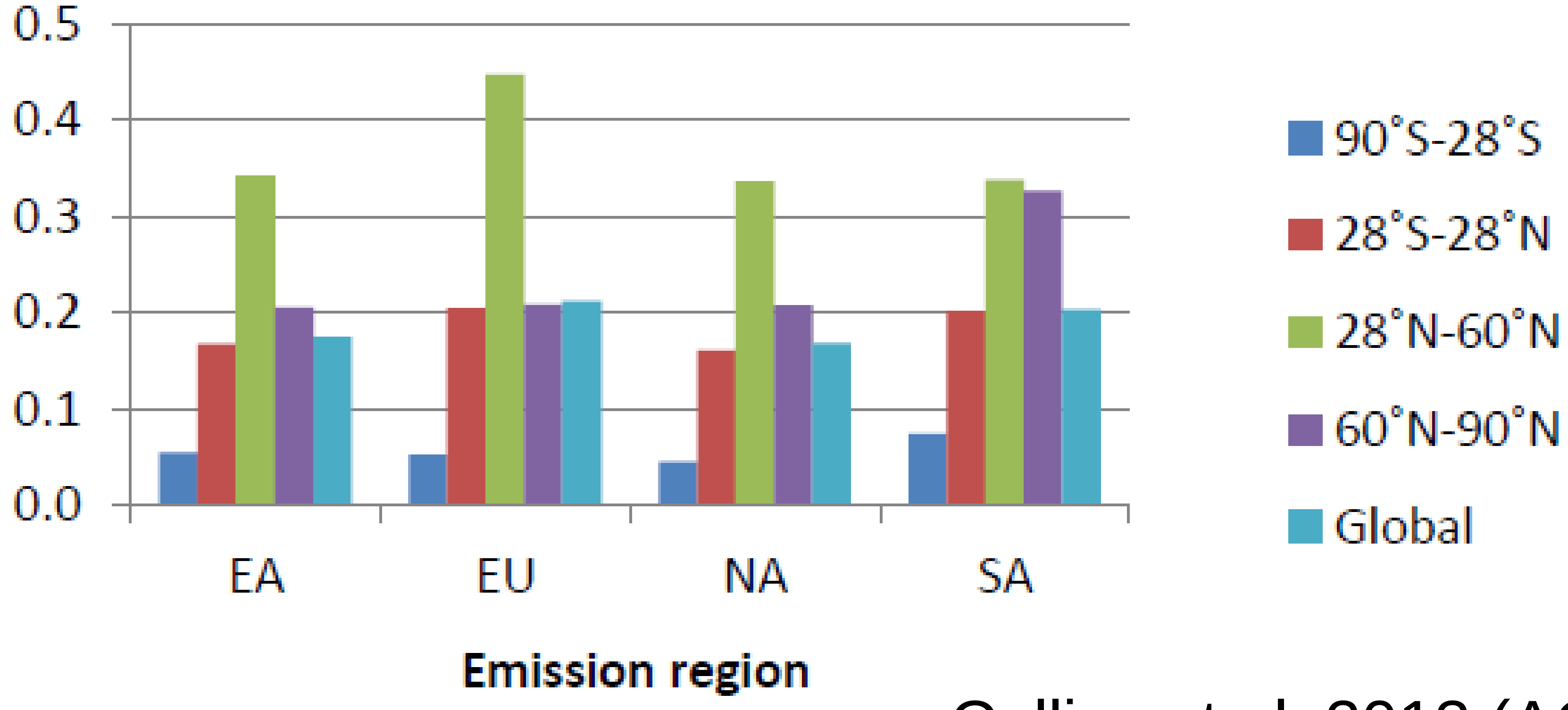


Regional temperature response to regional BC diesel emissions



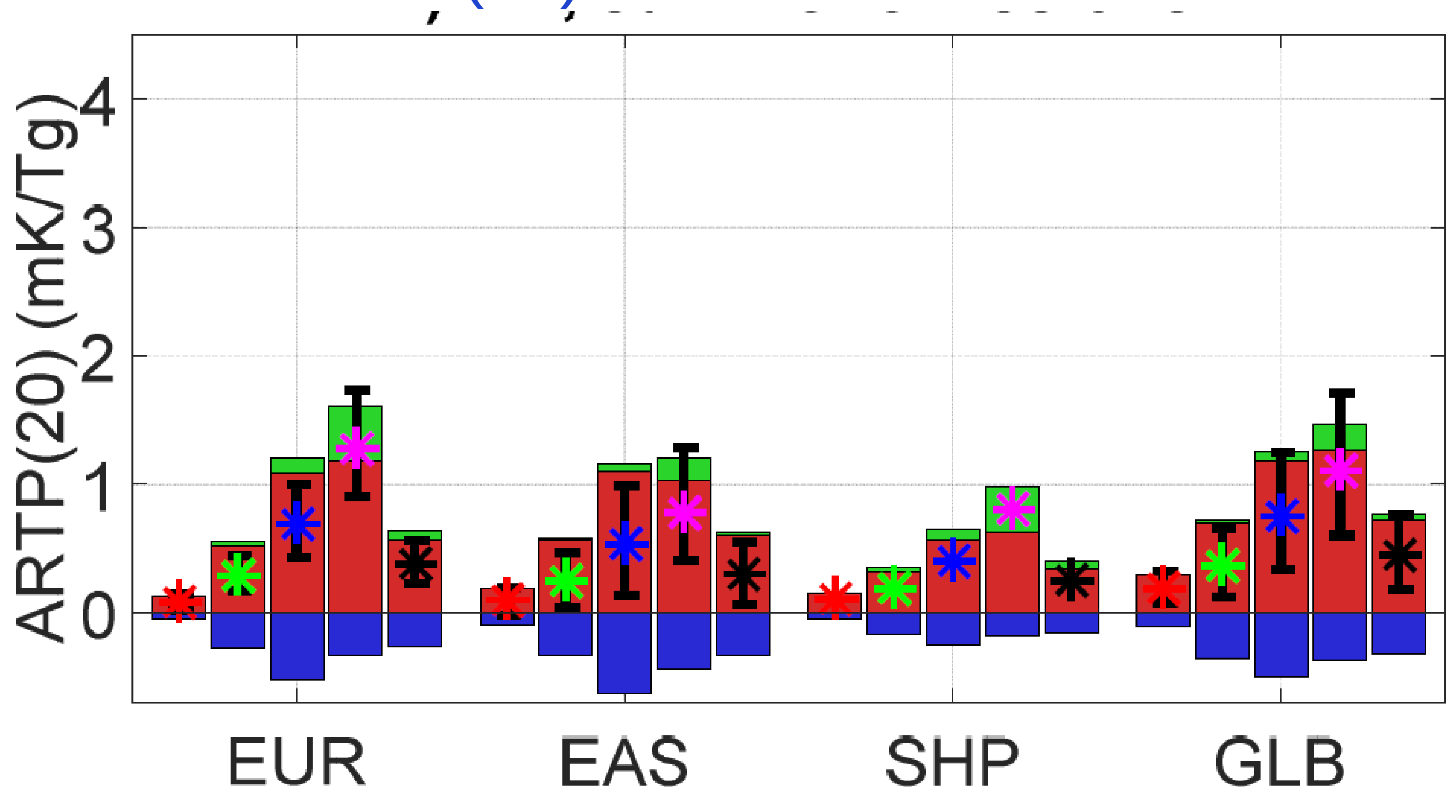
Lund et al. 2014 (Atm. Environ.)

ARTP(20) BC

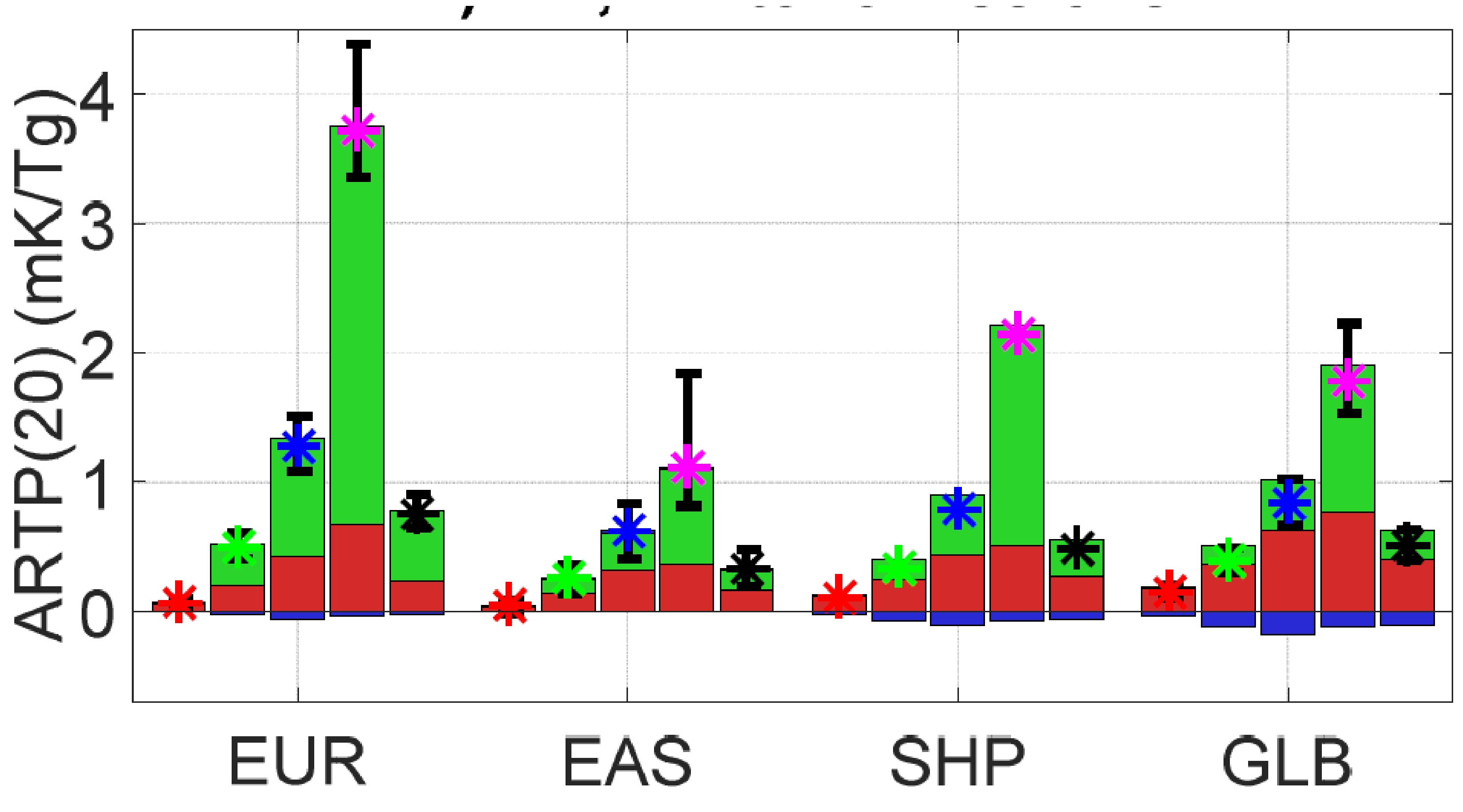


Collins et al. 2013 (ACP)

ARTP(20) BC summer emissions



ARTP(20) BC winter emissions

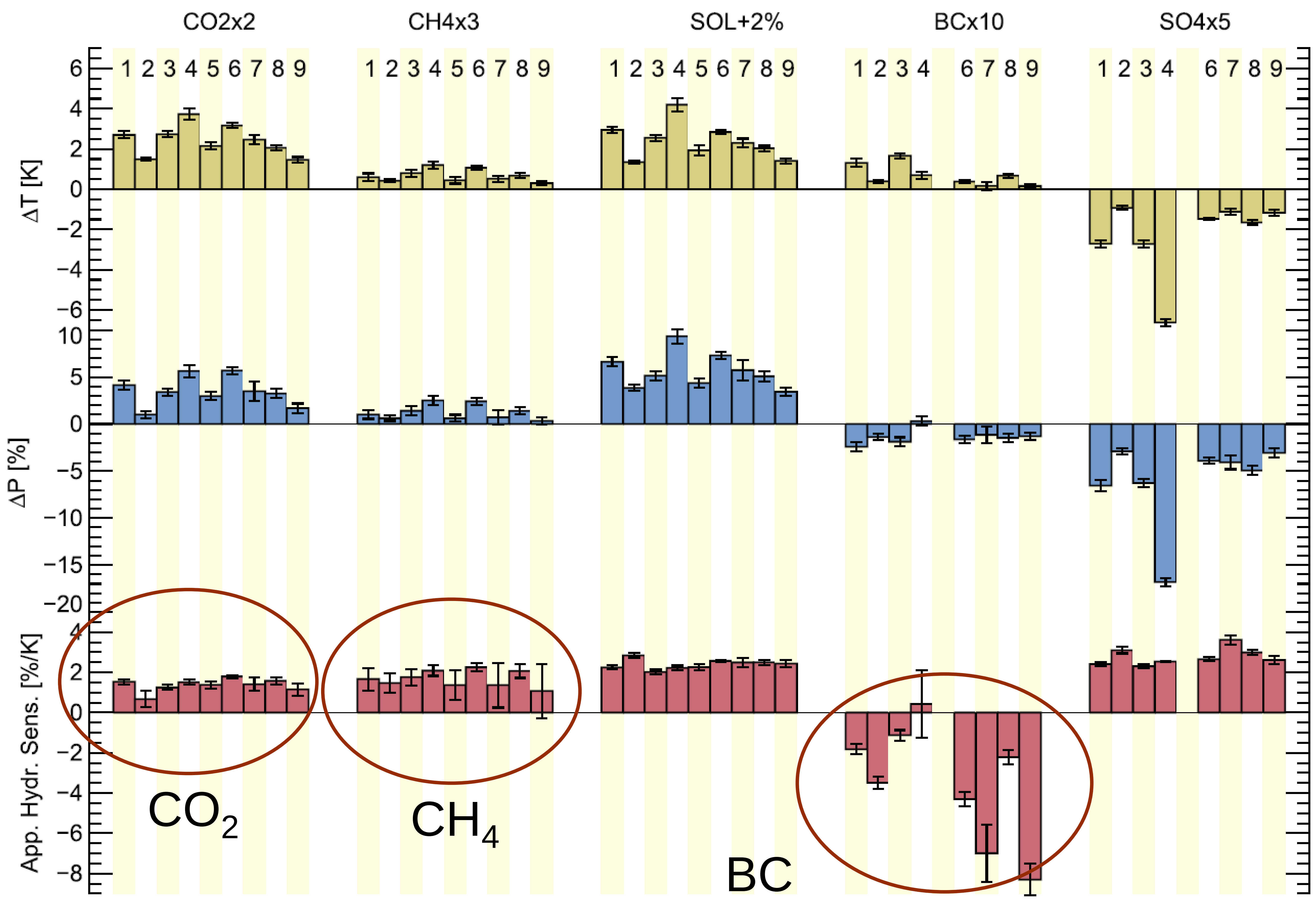


NB! Altitude matters!

Aamaas et al. 2017 (ACPD)

Strong hydrological impacts of BC

Temperature (top), precipitation (middle) and hydrological sensitivity (bottom), PDRMIP multi-model mean



Samset et al. 2016 (JGR)

BC in the atmosphere causes surface dimming and changes the vertical temperature profile differently than the long-lived GHGs.

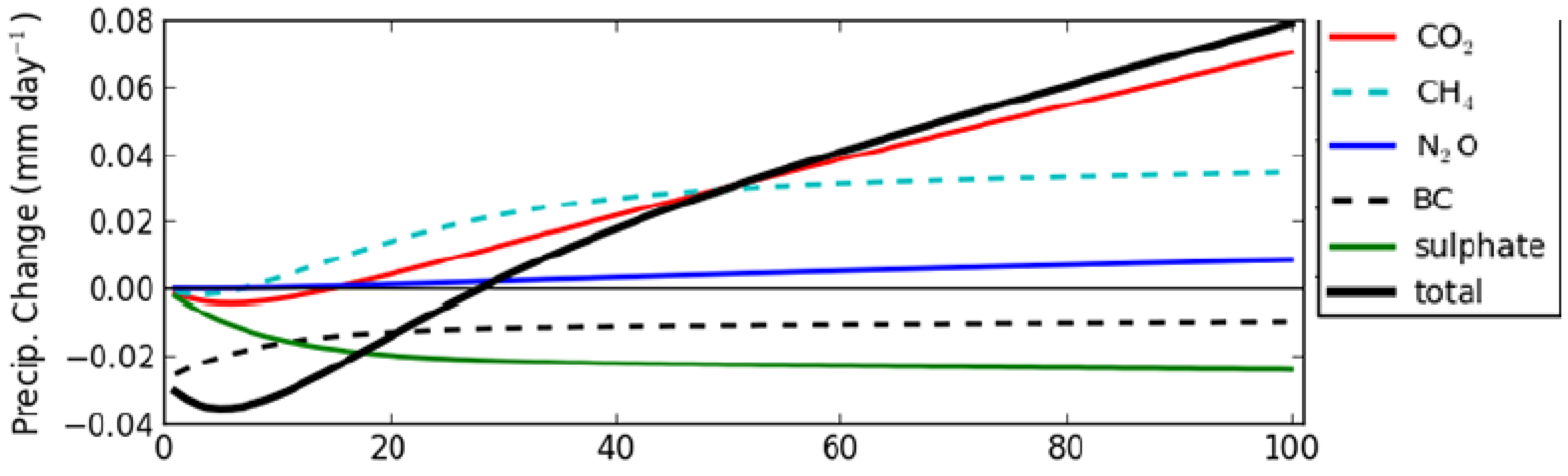
The various hydrological impacts caused by the dimming from BC are not captured in metrics that are based on global climate forcing or global mean surface temperature change.

Assessing hydrological impacts – Global Precipitation-change Potential

	$GPP_P(20)$	$GPP_P(100)$	$GPP_S(20)$	$GPP_S(100)$
CH_4	101	6.6	187	44.4
N_2O	370	303	486	367
Sulphate	−70	−8.2	−741	−94.0
Black Carbon	1200	141	−36 600, −87 400	−3740, −9250

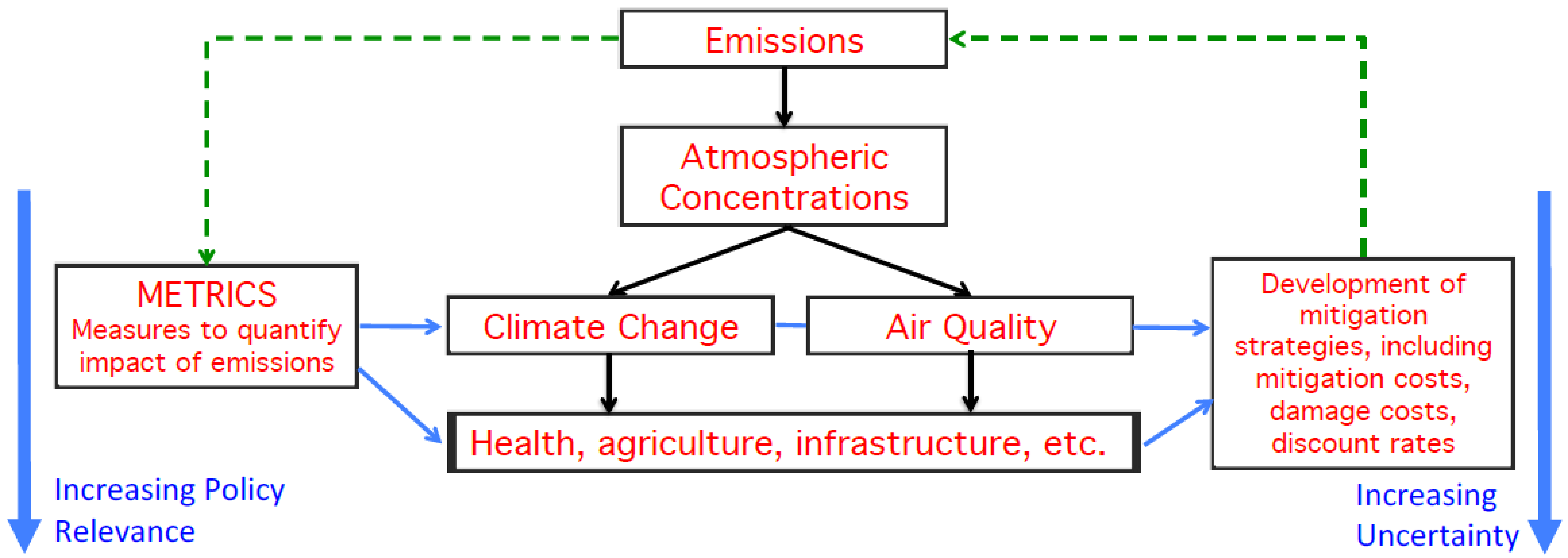
Shine et al. 2015 (ESD)

Precipitation change, sustained year 2008 emissions



°CICERO

Measuring societal impacts



Shindell et al. 2017 (Faraday Discussions)

Table 1. Social Costs of Carbon Dioxide and Methane ($ per tonne)

Discount rate	CO2	Biogenic CH4	Fossil CH4	CH4/CO2 Ratio: biogenic	CH4/CO2 Ratio: fossil
10%	7	1390	1400	198	199
5%	24	2400	2440	100	102
4%	38	2830	2910	75	76
3%	71	3520	3670	50	52
2.5%	102	4060	4270	40	42
DDR	92	3590	3780	39	41
1.4%	264	6270	6830	24	26

DDR is Declining Discount Rate, which is implemented here as 4*exp(−t/250); where t is year), based on the mean of results presented in [6].

Shindell 2015 (Climatic Change)

Table 2 Valuation of 2010 emissions (damages per ton in $2007 US)

Valuation; discount rate	CO_2	CH_4	N_2O	HFC-134a	BC	SO_2	CO	OC	NO_x	NH_3
Climate[a]; 5 %	10	490	2800	19,000	13,000	−900	42	−1800	−56	−240
Climate[a]; 3 %	32	910	9200	36,000	20,000	−1400	90	−2800	−220	−380
Climate[a]; 1.4 %	67	1400	19,000	56,000	30,000	−2100	160	−4200	−400	−560
Regional climate, aerosols; 5 %	0	0	0	0	19,000	3000	0	6100	90	820
Regional climate, aerosols; 3 %	0	0	0	0	26,000	4400	0	8700	350	1200
Regional climate, aerosols; 1.4 %	0	0	0	0	34,000	5900	0	12,000	600	1600
Additional climate-health[b]; 5 %	16	1600	8300	62,000	110,000	4500	140	9000	7	1200
Additional climate-health[b]; 3 %	45	2800	24,000	110,000	150,000	5700	260	11,000	30	1500
Additional climate-health[b]; 1.4 %	87	4000	47,000	160,000	190,000	6900	430	14,000	50	1900
Composition-health; 5 %	0	550	0	0	62,000	33,000	200	51,000	67,000	22,000
Composition-health; 3 %	0	670	0	0	62,000	33,000	240	51,000	67,000	22,000
Composition-health; 1.4 %	0	740	0	0	62,000	33,000	250	51,000	67,000	22,000
Median total; 5 %	27	2700	12,000	85,000	210,000	40,000	410	64,000	67,000	24,000
Median total; 3 %	84	4600	37,000	160,000	270,000	42,000	630	68,000	67,000	25,000
Median total; 1.4 %	150	6000	62,000	210,000	310,000	43,000	820	71,000	67,000	25,000
Median total; declining rate	110	4700	47,000	160,000	280,000	42,000	730	69,000	67,000	25,000

°CICERO

Suggested questions to guide discussions:

1. What are the arrays of available metrics for black carbon and methane for the group's theme (that is climate, health, agriculture and economics?

2. Which metrics would be best suited within the UNFCCC / NDC / SDGs context?

3. Which metrics would be best suited in the context of climate finance?

4. How can suggested metrics be used by the various policy communities, such as national or regional governments?

5. What are the challenges/barriers for uptake in using some of these metrics in the policy community?

°CICERO

Thank you

m.t.lund@cicero.oslo.no

cicero_klima
cicero.oslo.no
cicerosenterforklimaforskning