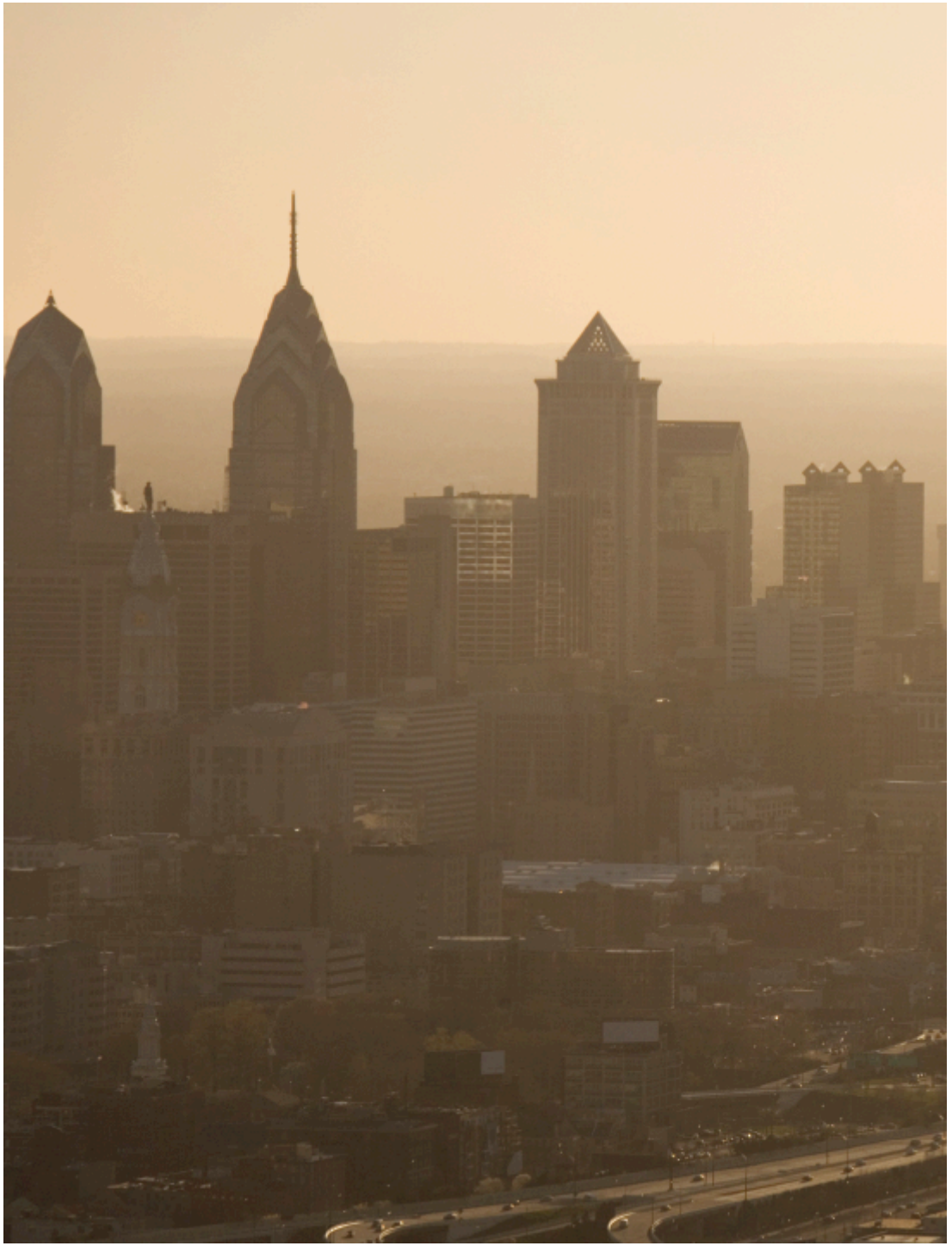
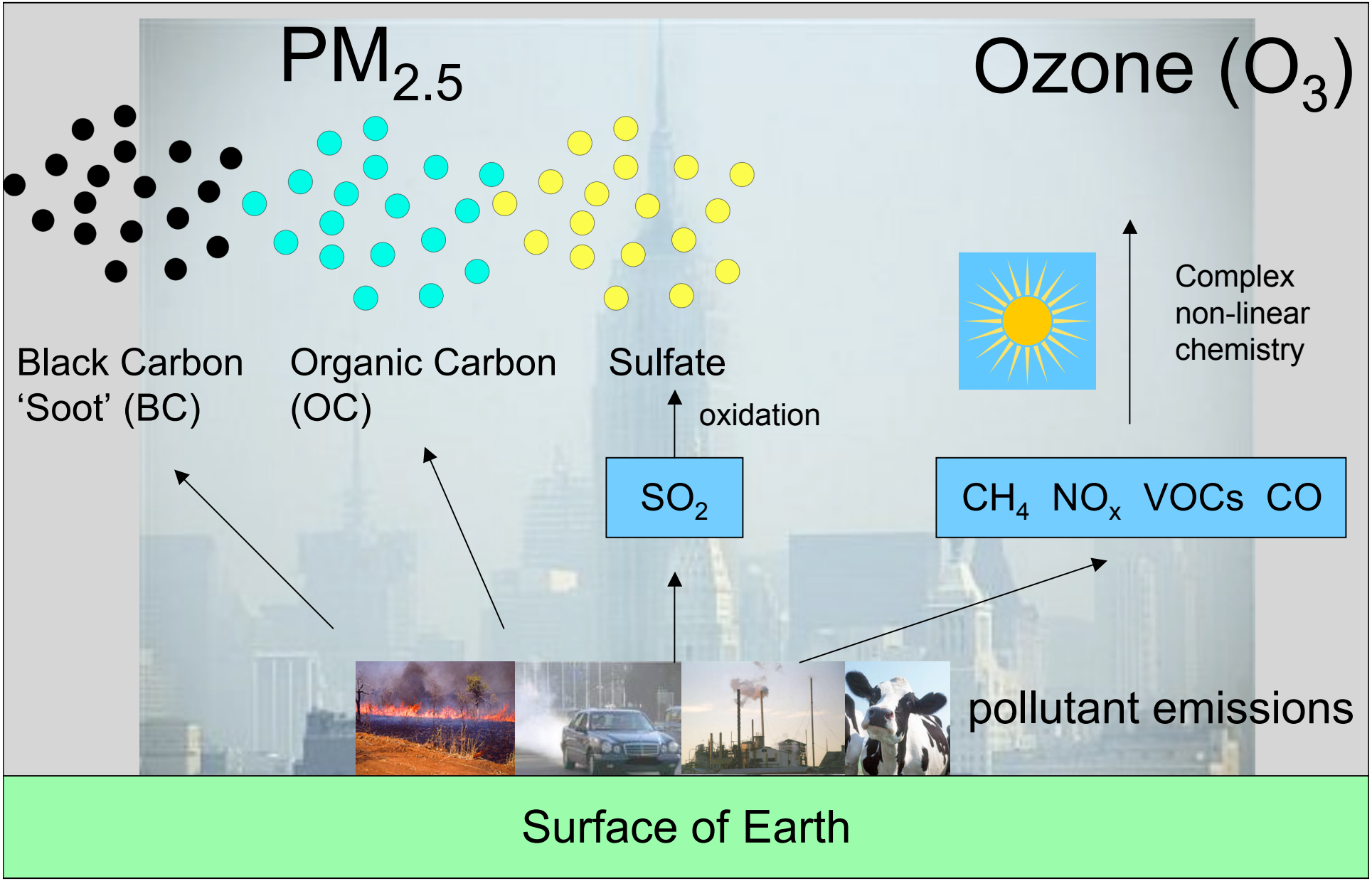


Holy Smoke:

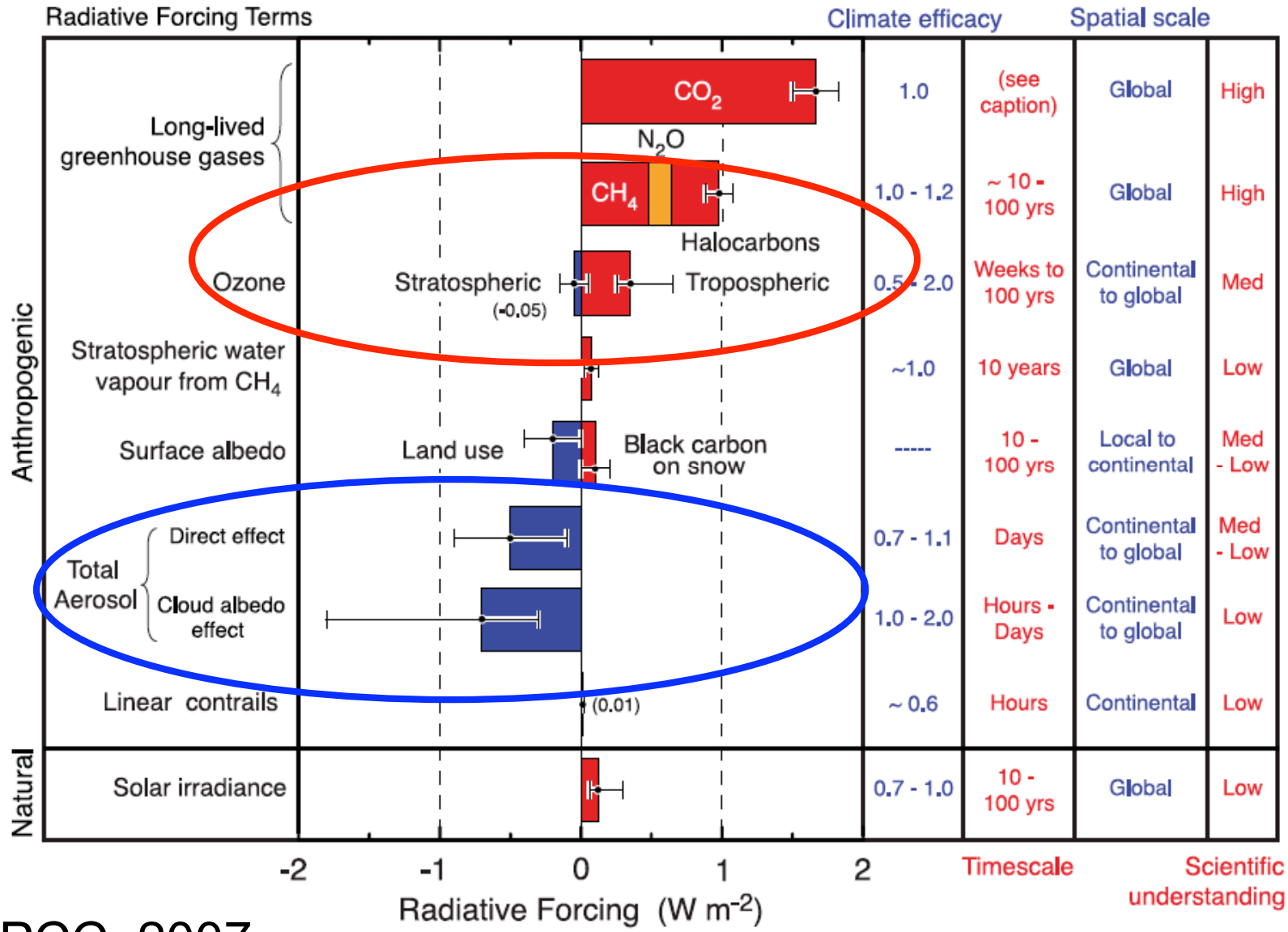
immediate global warming mitigation via smog control

Nadine Unger
Columbia University

WHAT IS SMOG?


$PM_{2.5}$
Ozone (O_3)
Black Carbon 'Soot' (BC)
Organic Carbon (OC)
Sulfate
oxidation
SO_2
Complex non-linear chemistry
CH_4 NO_x VOCs CO
pollutant emissions
Surface of Earth

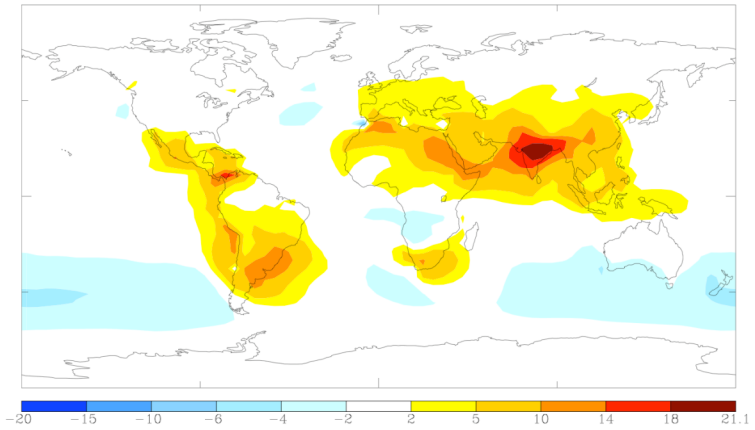
RADIATIVE FORCING OF CLIMATE BETWEEN 1750 - 2005



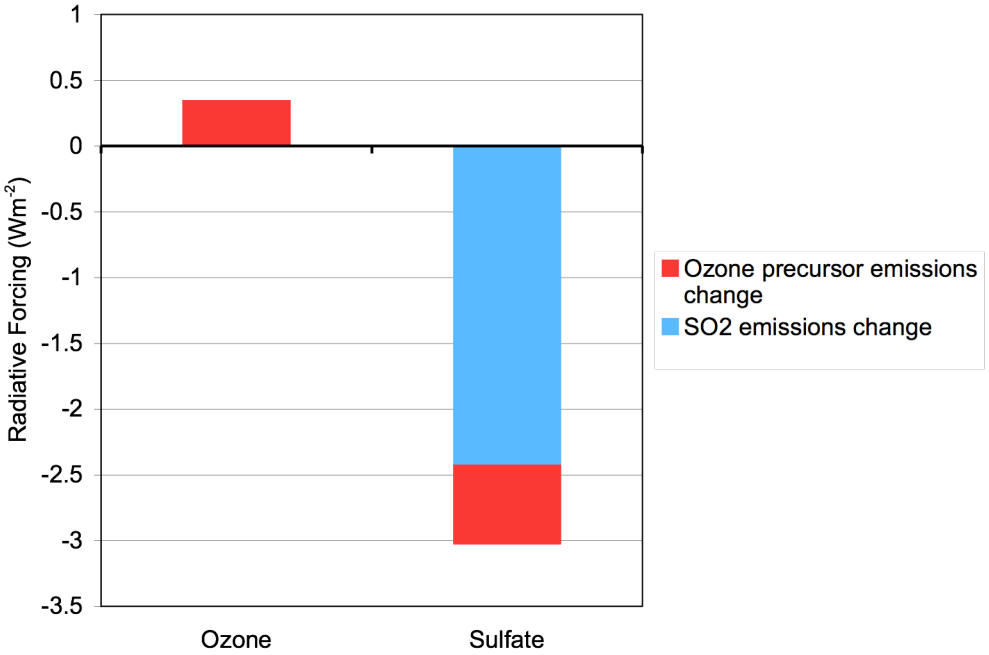
IPCC, 2007

OZONE PRECURSORS IMPOSE INDIRECT RADIATIVE FORCING VIA SULFATE AEROSOL

Surface sulfate amount due to O_3 precursor emissions changes PD to 2030 (%)



India and China



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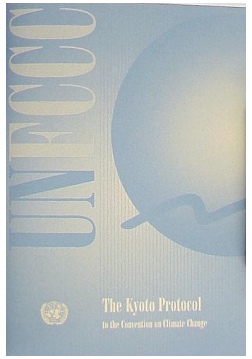
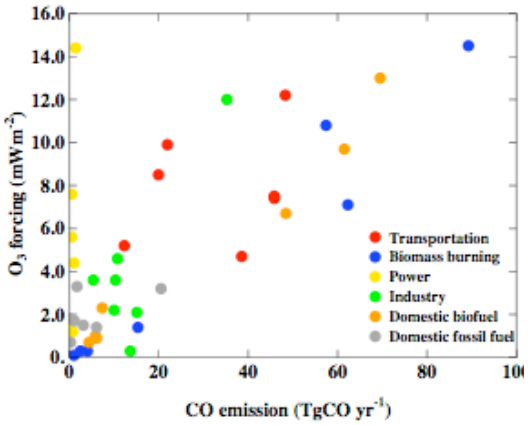
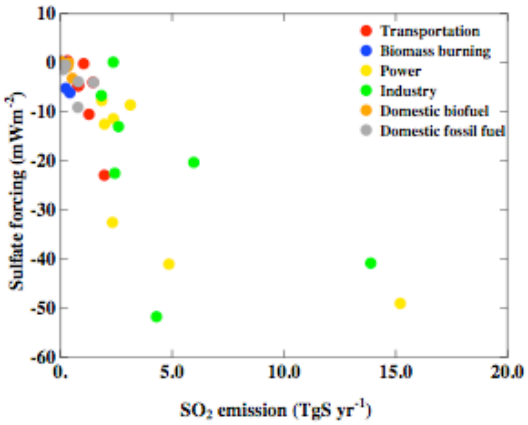
Net negative RF from O_3 precursor change = + 0.35 (O_3) - 0.61 (sulfate) = - 0.26 Wm^{-2}

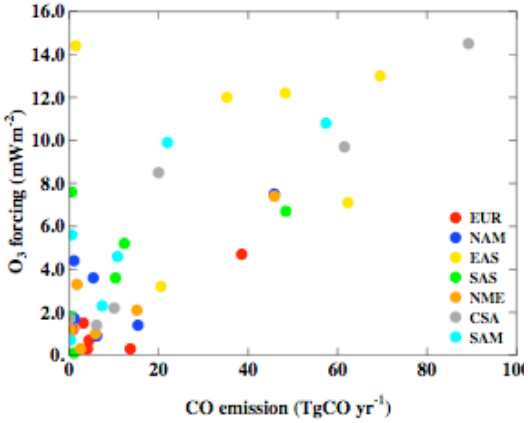
[Unger et al., *Proc. Natl. Acad. Sci.*, 2006]

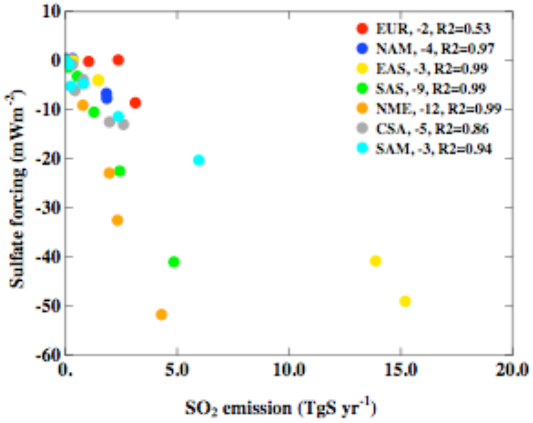
AIR POLLUTANTS ARE NOT INCLUDED IN CLIMATE POLICY INSTRUMENTS











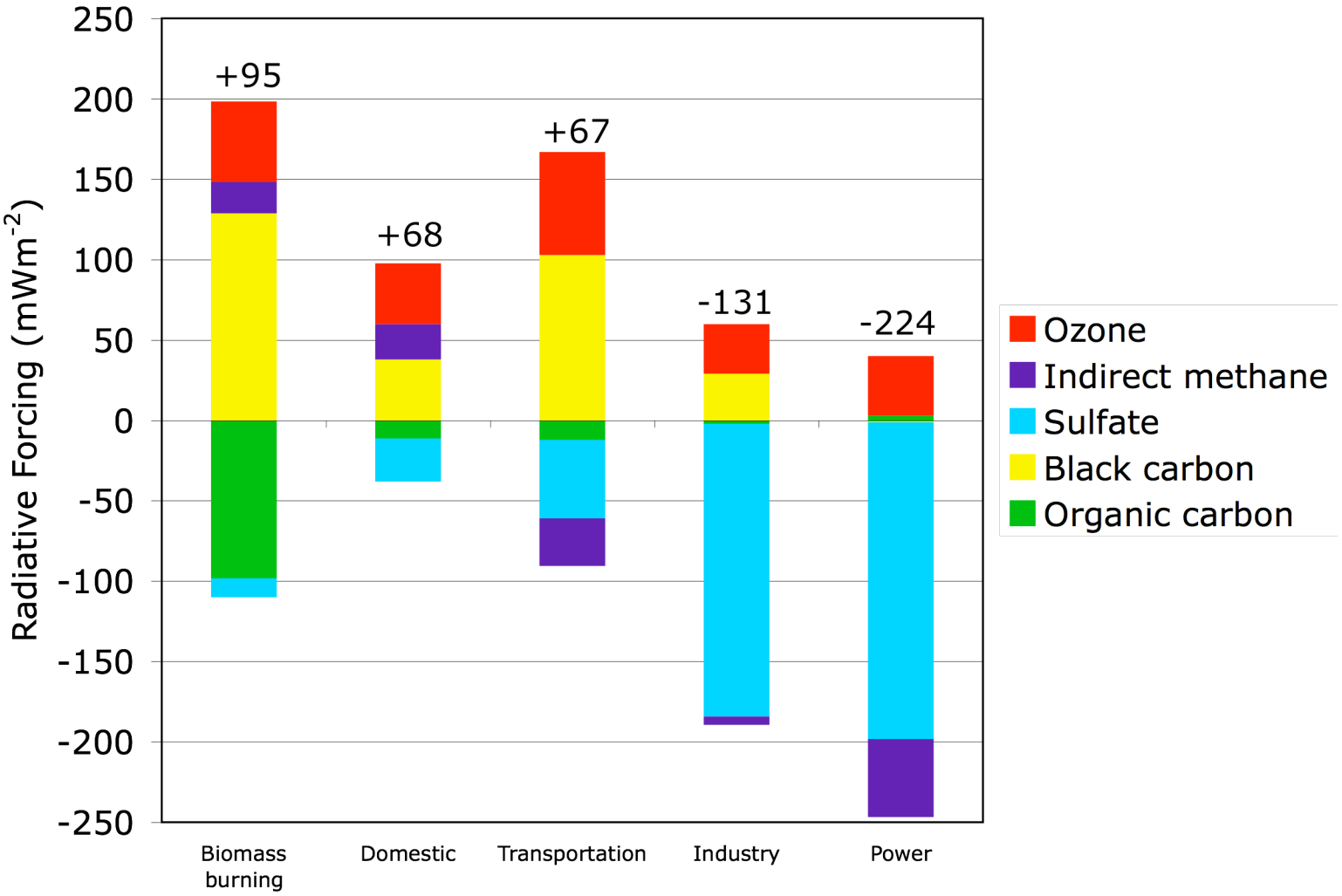
Emissions to RF Diagnostics

Ozone RF w.r.t. CO emissions:
Depends on sector
Biomass burning
Domestic biofuel
Independent of Region
+0.2 mWm^{-2}/TgCO

Sulfate RF w.r.t SO_2 emissions:
Depends on region
Independent of sector
-3 to -12 mWm^{-2}/TgS

[Unger et al., *J. Geophys. Res.*, 2008]

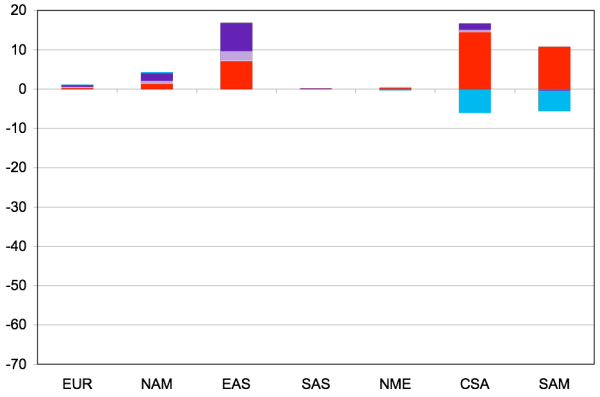
RADIATIVE FORCING BY ECONOMIC SECTOR AT 2030



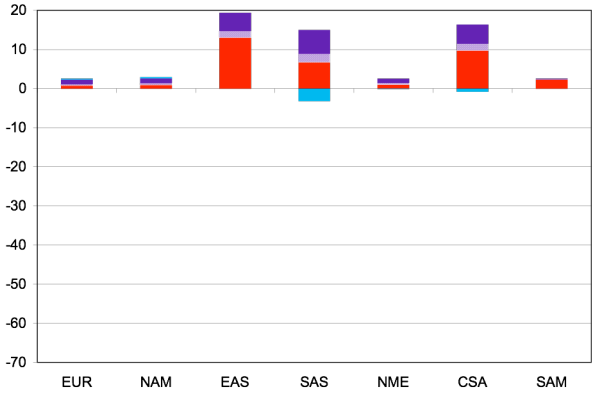
[Unger et al., *J. Geophys. Res.*, 2008]

RADIATIVE FORCING BY REGIONAL ECONOMIC SECTOR

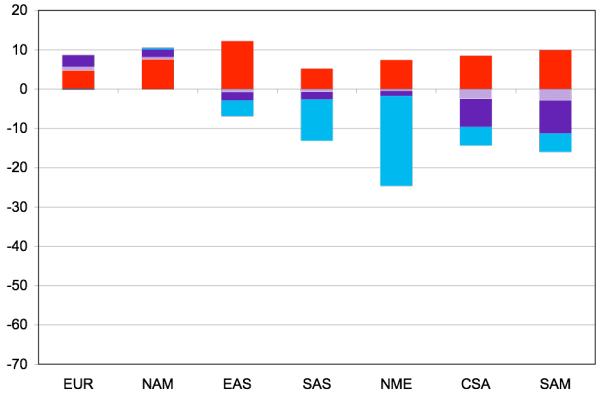
Biomass Burning



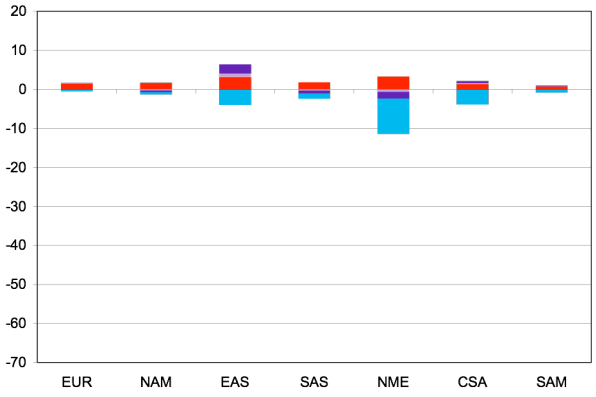
Domestic Biofuel



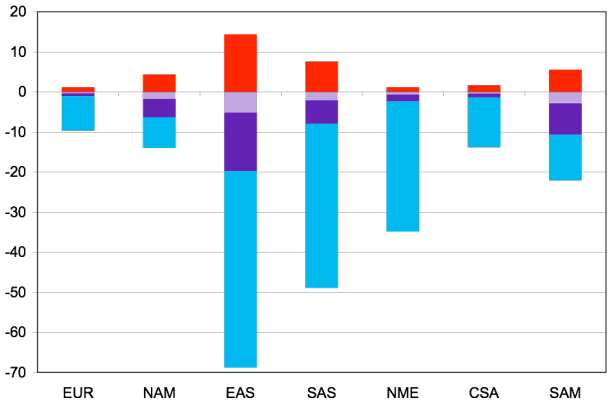
Transportation



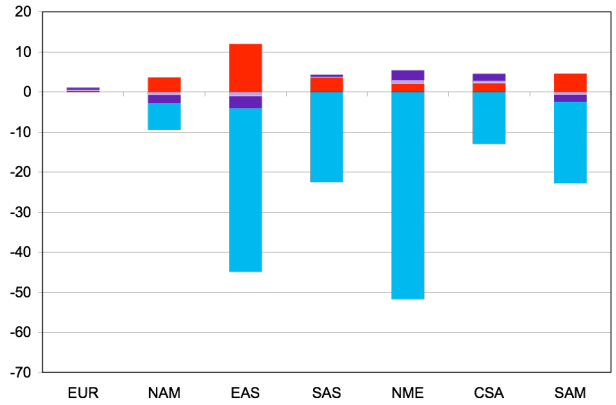
Domestic Fossil Fuel



Power



Industry



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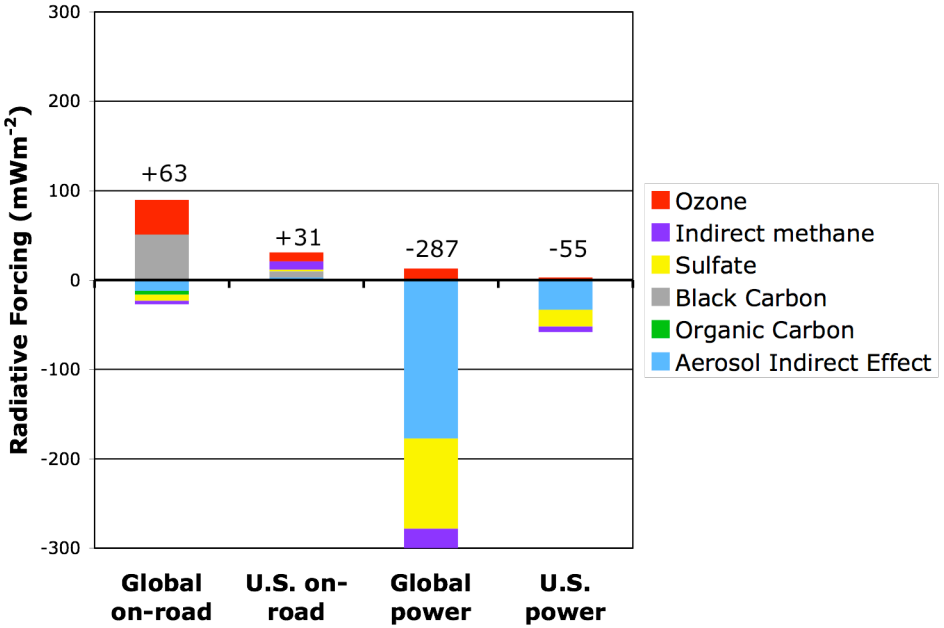
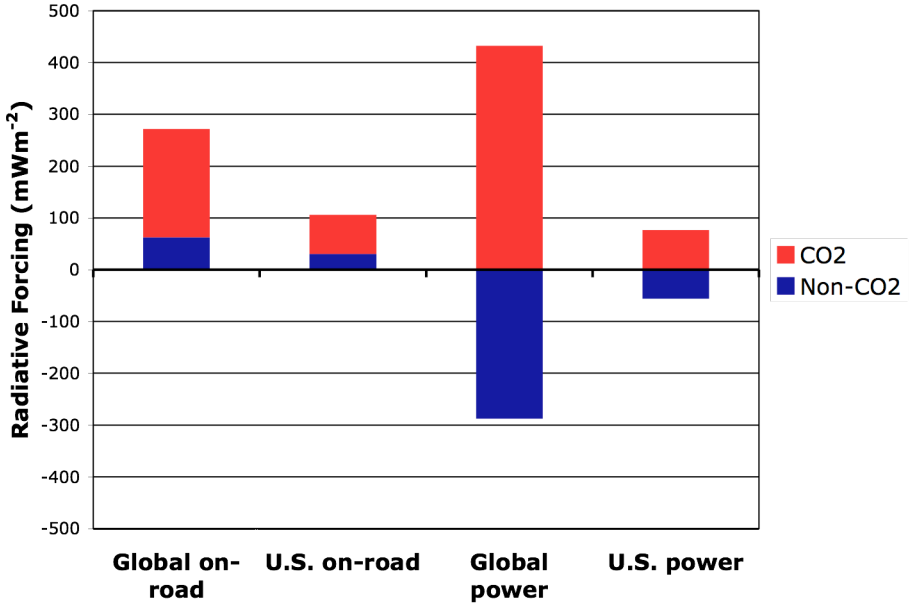
ozone(ST) ozone(LT) l-CH4 sulfate

[Unger et al., *J. Geophys. Res.*, 2008]

TRANSPORTATION VS. POWER GENERATION SECTORS
Non-CO_2 RADIATIVE FORCING



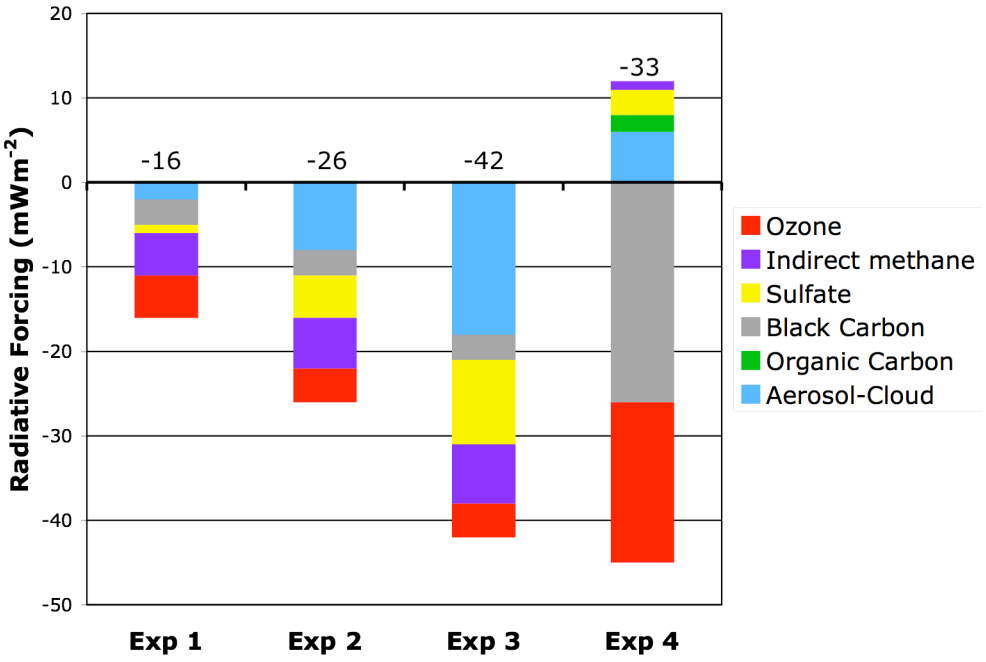


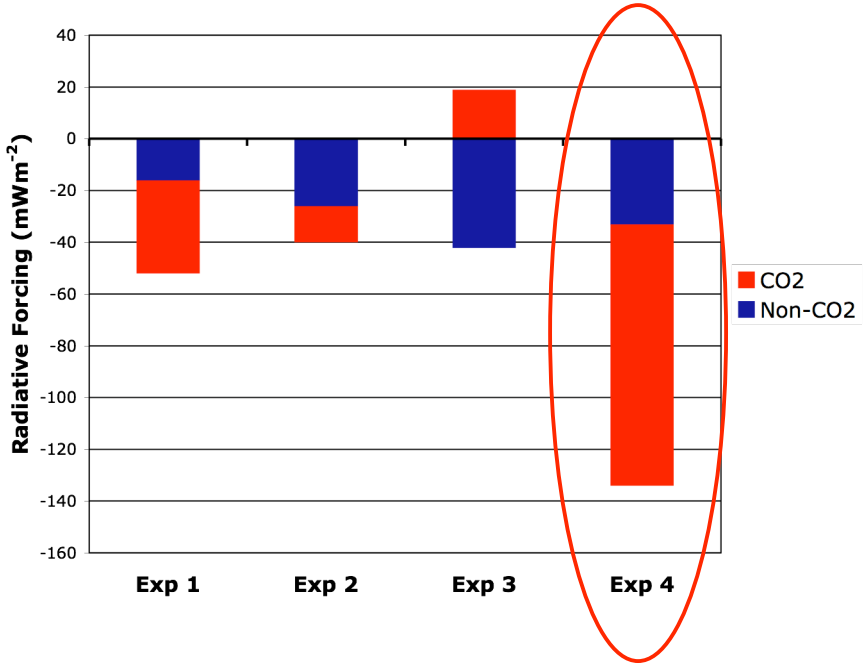
Net non-CO_2 air pollutant forcing:
- **enhances CO_2 forcing by 1/3 for transportation sector**
- **counteracts CO_2 forcing by 2/3 for power sector**

[Unger et al., in prep, 2008]

TRADE-OFFS BETWEEN TRANSPORTATION AND POWER IMPLICATIONS FOR U.S. PHEV FLEET

SIMULATIO N	Δ ON-ROAD TRANSPORTATION EMISSIONS	Δ POWER GENERATION EMISSIONS	HUMAN HEALTH IMPACTS	
			Δ MORTALITY (O_3)	Δ MORTALITY ($PM_{2.5}$)
Exp 1	-50% in U.S.	0 %	-1310	-1860
Exp 2	-50% in U.S.	+20% in U.S.	-1020	5150
Exp 3	-50% in U.S.	+50% in U.S.	-620	15650
Exp 4	-50% worldwid e	0 %	-	-





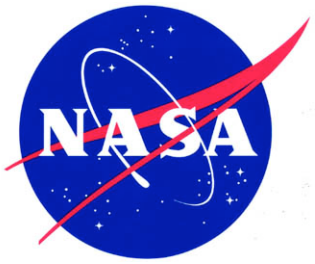
-140 mWm^{-2}

[Unger et al., in prep, 2008]

CONCLUSIONS

- Air quality and climate change problems are strongly interconnected
- Mitigation of global warming via controls on ozone and black carbon is a good strategy because
  - short lifetime + strong climate impact = rapid climate response
  - ancillary benefits to human health, agriculture and ecosystems
  - can buy some ‘climate time’
- Transportation is a key target sector in the U.S.

ACKNOWLEDGEMENTS



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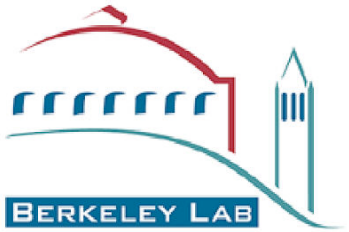

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David Streets