UNIVERSITY OF CAMBRIDGE
Department of Chemistry

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Minimal climate impacts from short-lived climate forcers following emission reductions related to the COVID-19 pandemic

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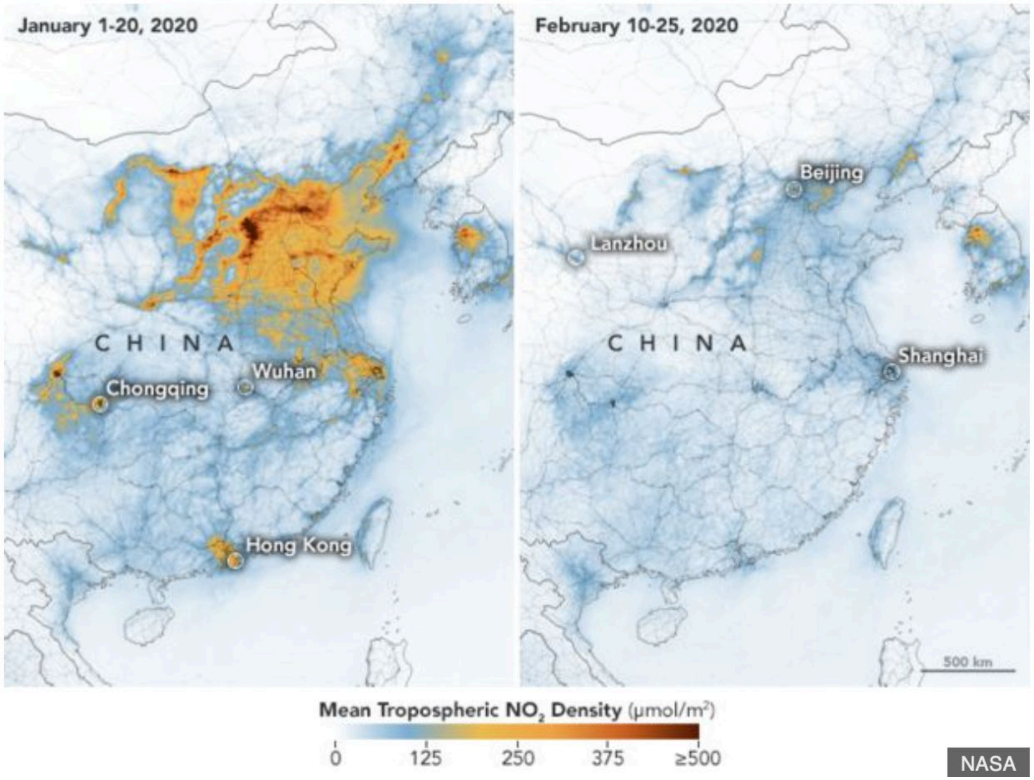
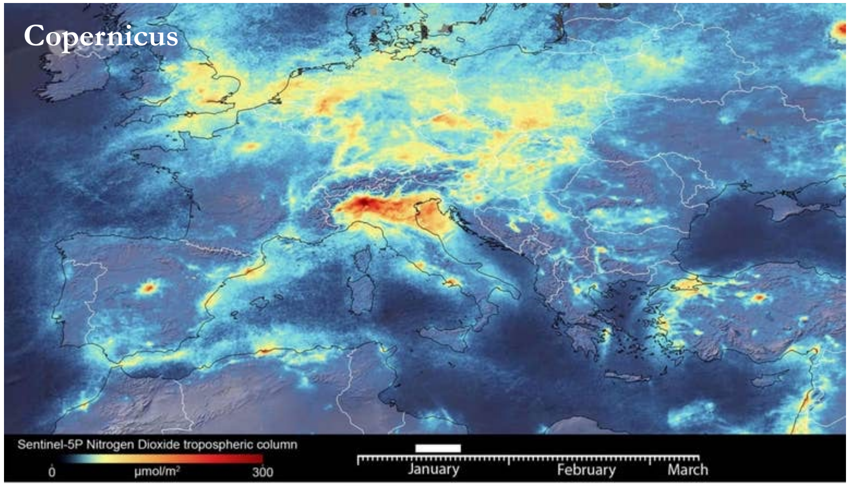
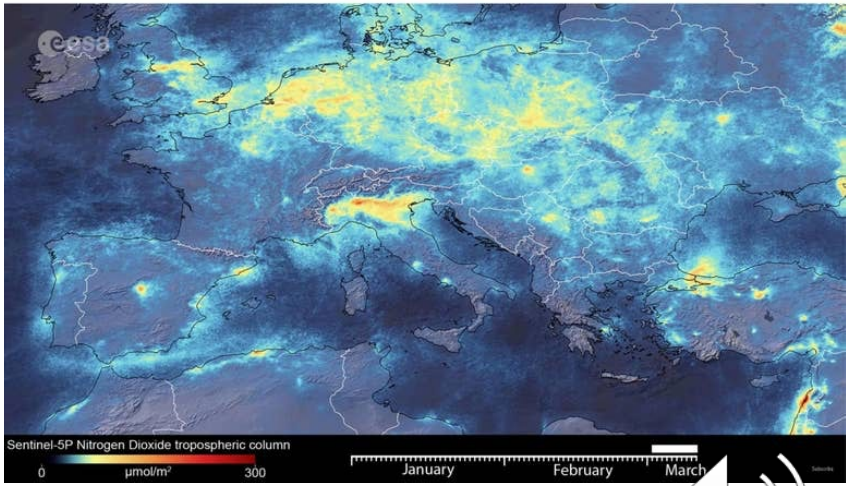
Weber et al (2020) Geophysical Research Letters

Satellite NO_x

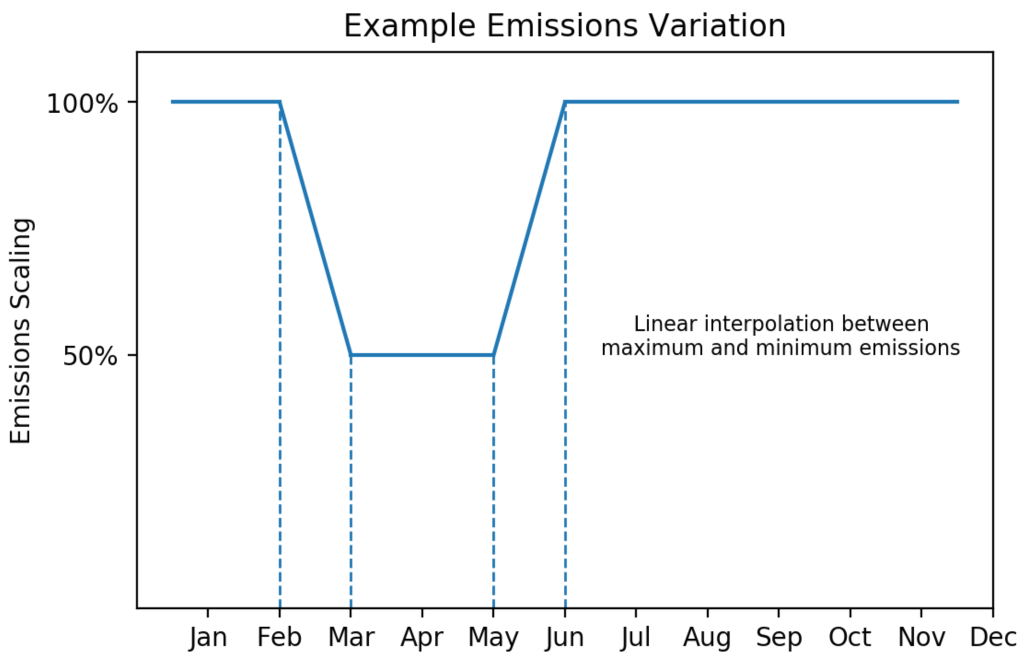






Experiment Setup

- United Kingdom Chemistry and Aerosol Model (UKCA) - 1.9° x 1.25° grid, 85 vertical levels up to 85 km, fully interactive chemistry (STRAT-TROP)
- Reduce non-CO_2 emissions from **surface transport, industry and aircraft** (chiefly NO, SO_2, BC)
- Runs nudged to 2012-2014 meteorology - horizontal winds and temperatures don't respond to forcings



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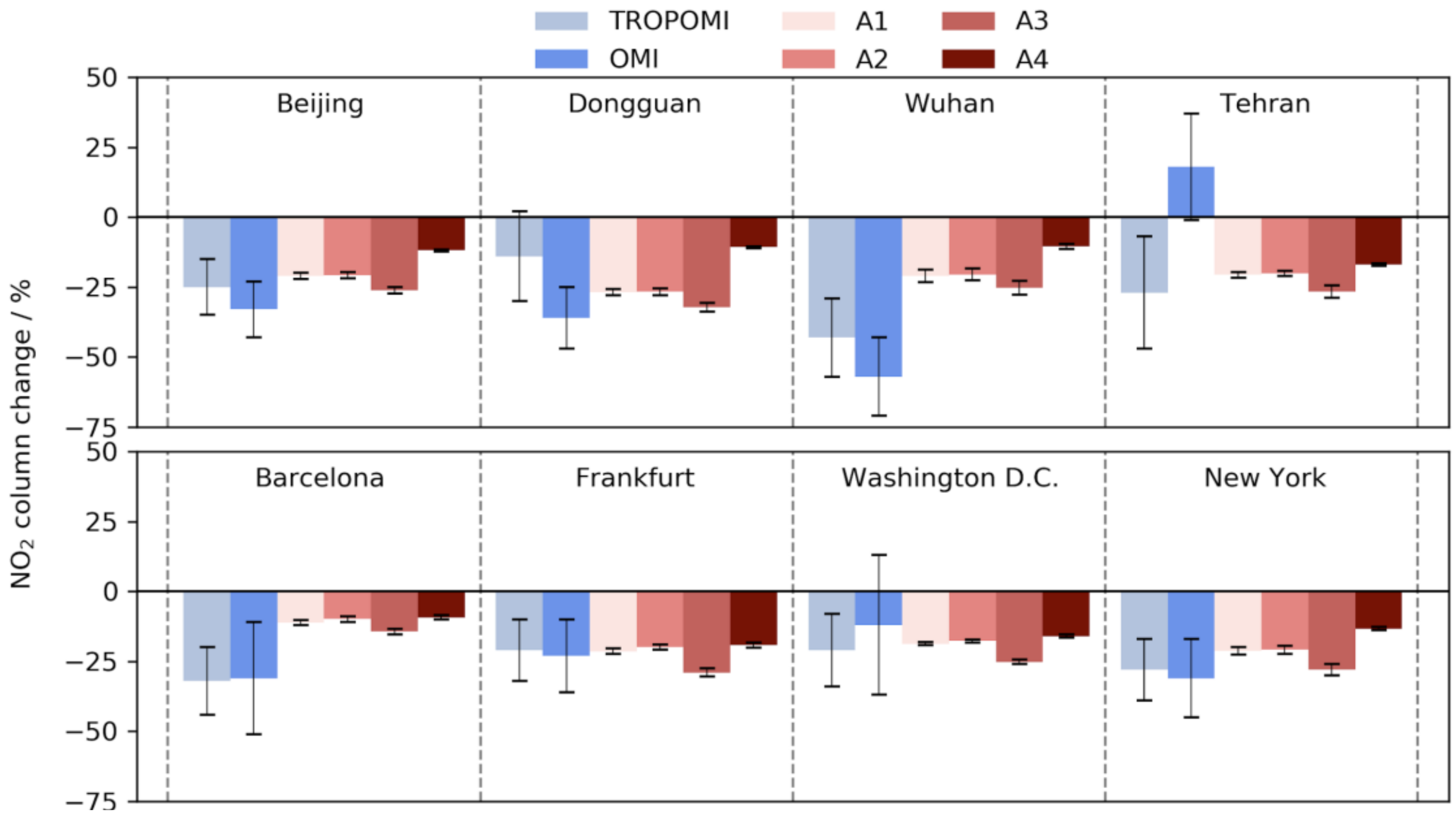
Scenarios

Scenario	Transport	Aircraft	Industry	Global NO	Global SO_2	Global BC*
Control	No reduction	No reduction	No reduction	No reduction	No reduction	No reduction
A1	-50%	-50%	-25%	-16%	-9%	-12%
A2	-50%	-25%	-25%	-16%	-9%	-12%
A3	-75%	-50%	-25%	-22%	-9%	-16%
A4	-50%	-50%	-	-13%	-1%	-9%

*cf. Evangeliou et al (2020) – European BC emissions reduced by ~20%

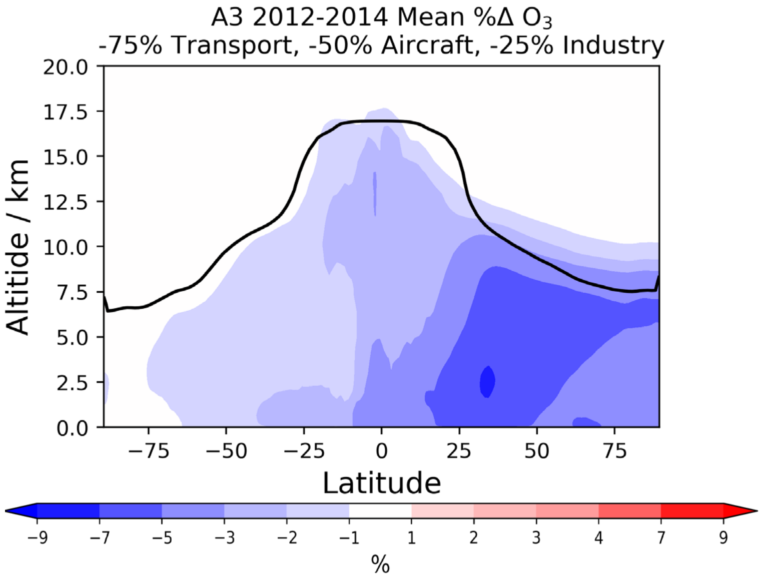
Model– Observation Comparisons



Observed reductions in NO_2 and increases in O_3 in China (Shi & Brasseur, 2020) also captured spatially by simulations

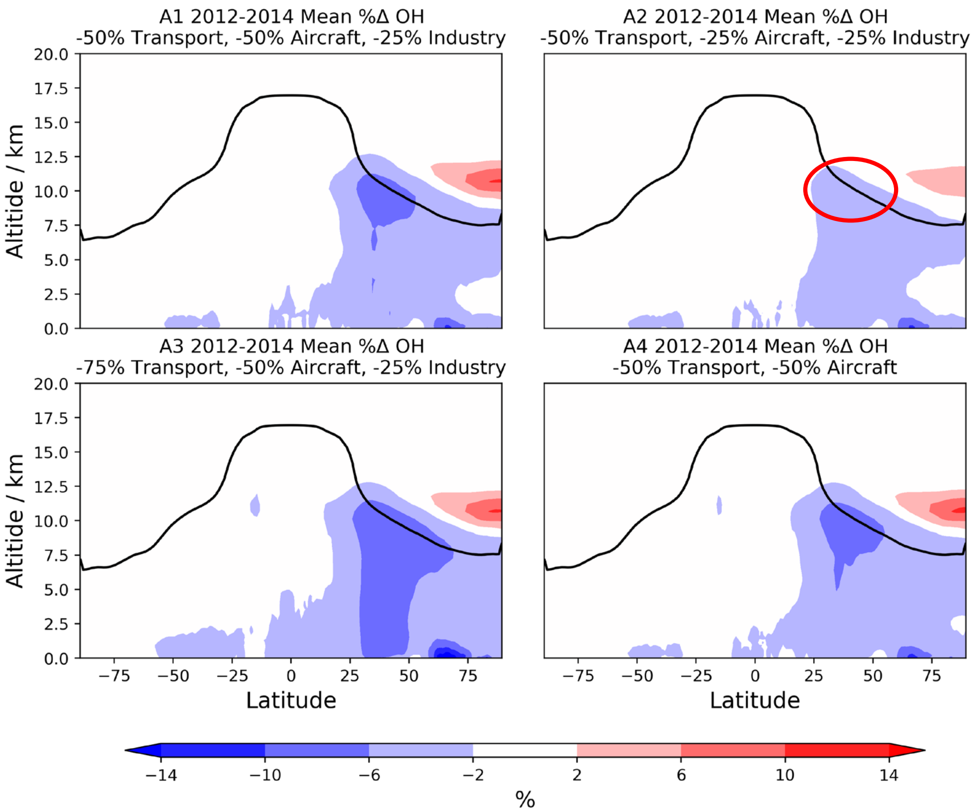
Oxidant Changes

2-3% decrease in tropospheric O_3 burden, localised decreases > 5%



1.6-3% decrease in tropospheric OH

regional impact of different sectors clear



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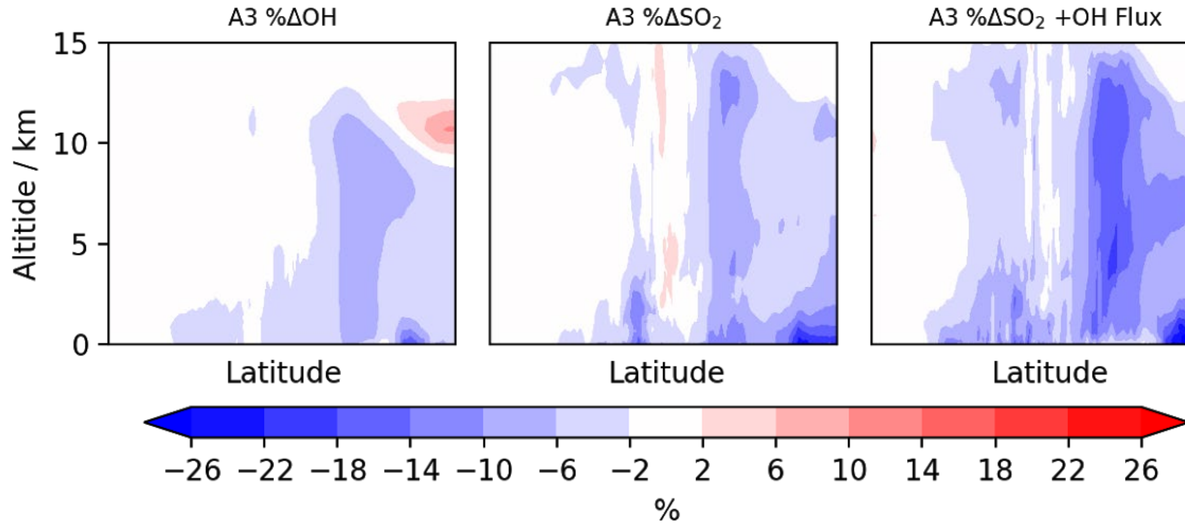
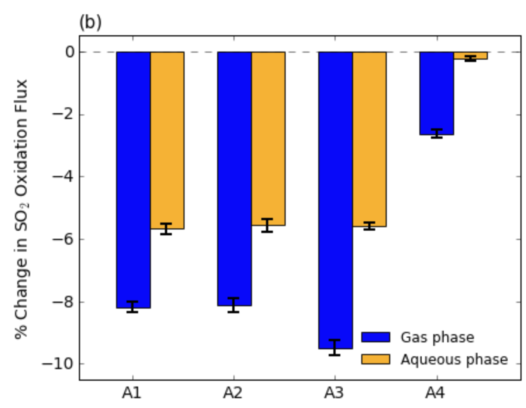
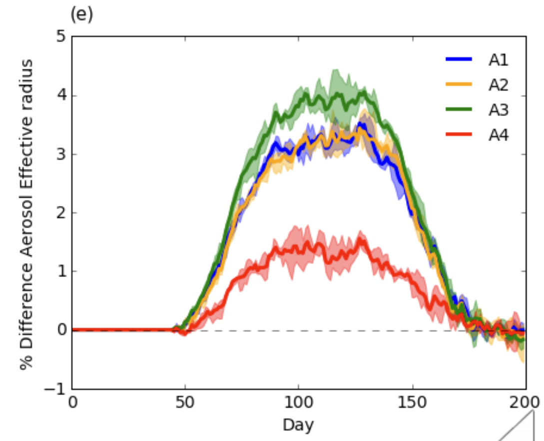
Oxidant – Aerosol Coupling

Reduced oxidants further decrease aerosol production via SO_2 oxidation

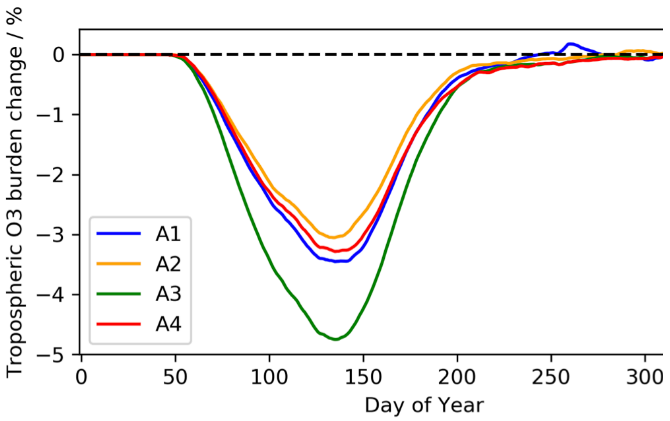


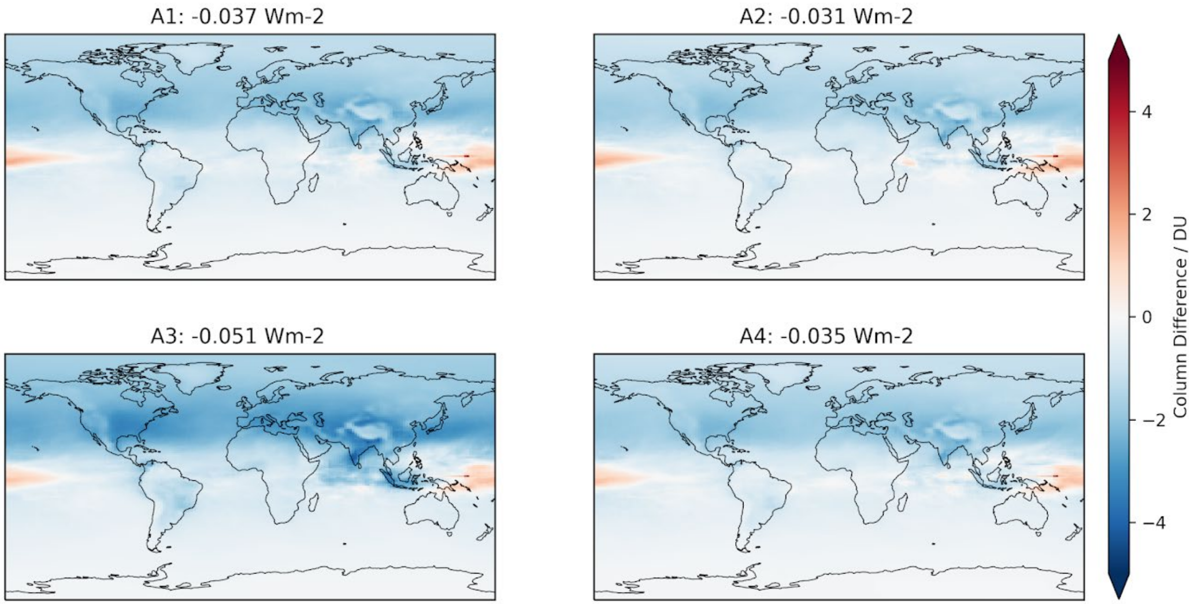
Unequal change to oxidation pathways – perturbs aerosol size distribution





Ozone and Methane Forcing

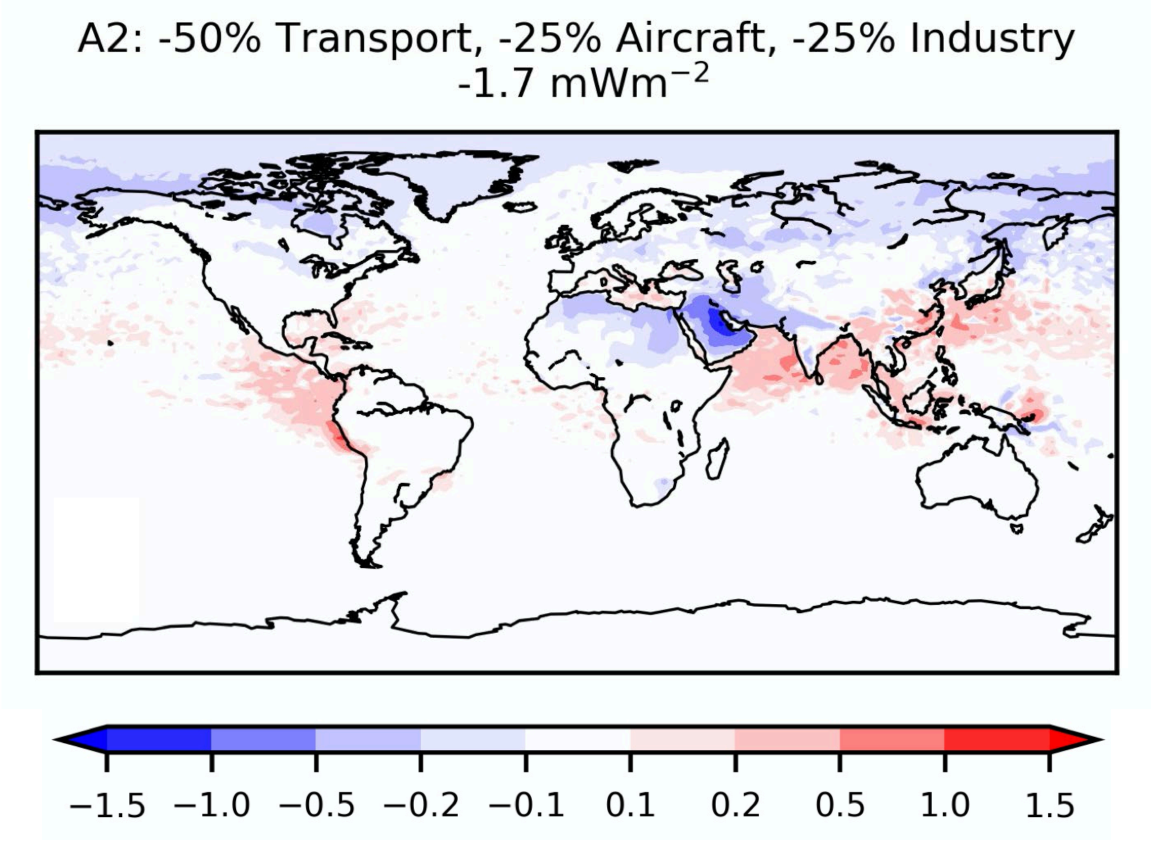




- Negative forcing from tropospheric ozone reduction calculated using Stevenson et al (2013)
- Methane lifetime increase by ~2-4% but minimal effect over course of 3-month perturbation (~2-4 ppb increase)

Aerosol DRE

Distinct regions of positive and negative forcing



IRF_{DRE} / Wm^{-2}

Net forcing is small

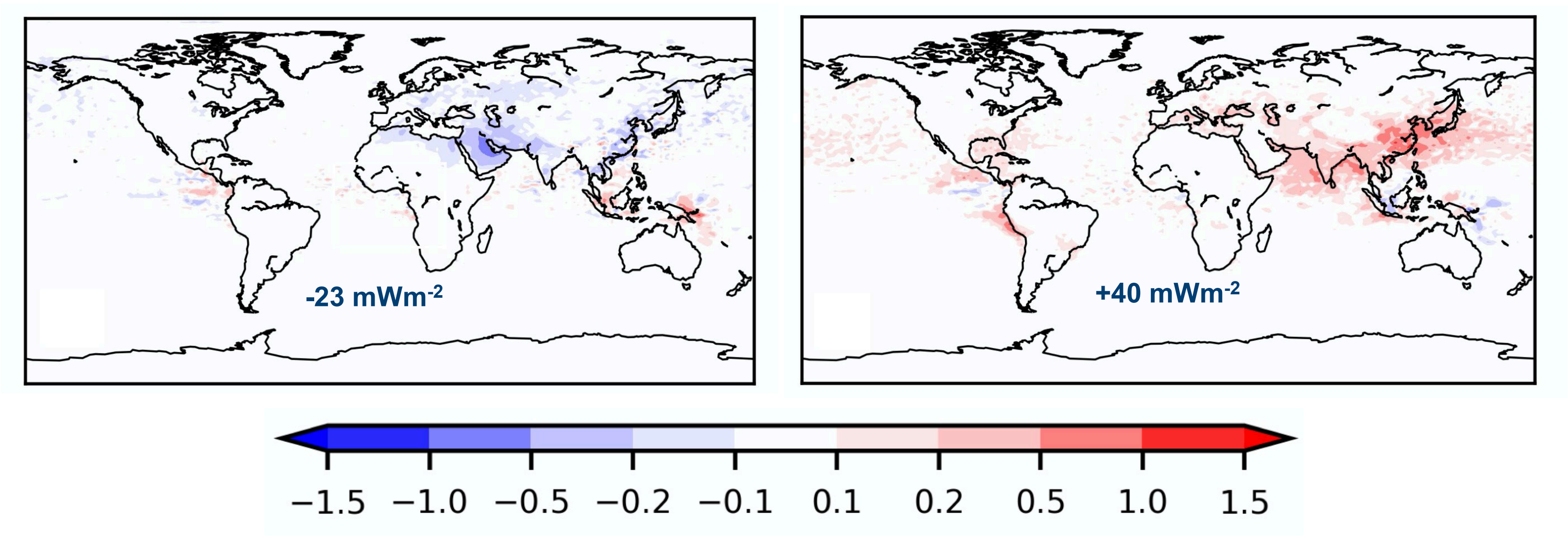
Opposing aerosol effects

A3-A1 → 25% reduction in surface transport

Cooling from reduced BC

A1-A4 → 25% reduction in industrial emissions transport

Warming from reduced sulphate aerosol



IRF_{DRE} / Wm^{-2}

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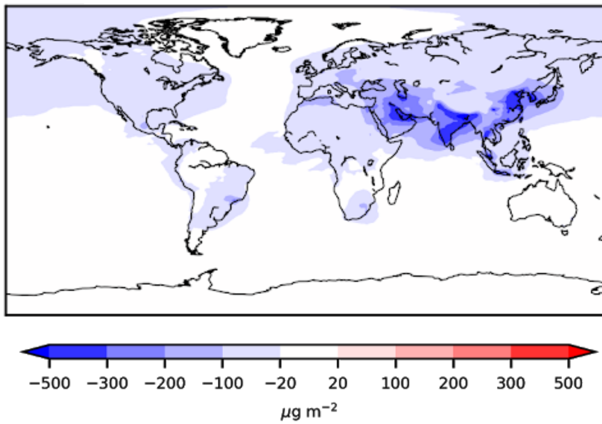
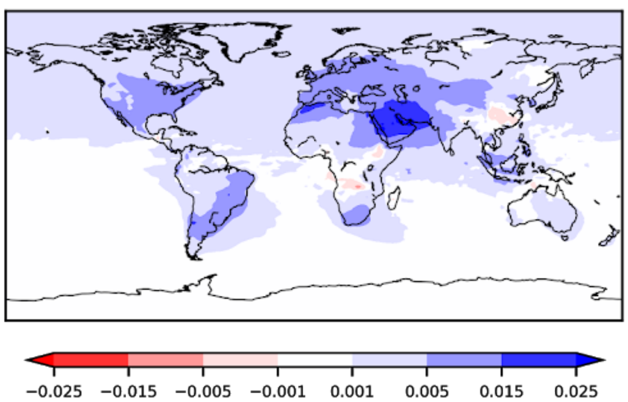
Aerosol Changes

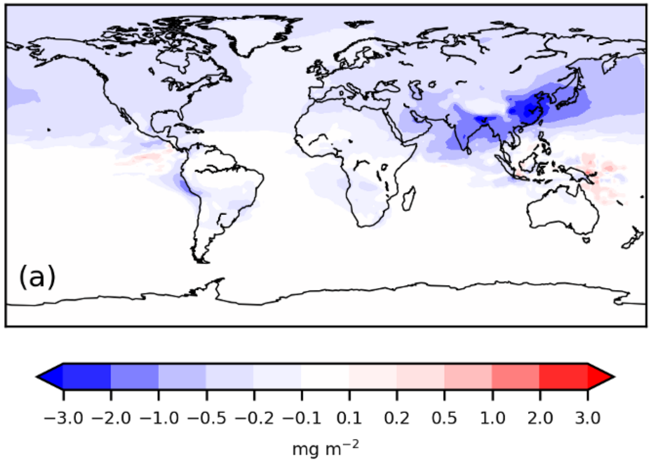
Change in BC column

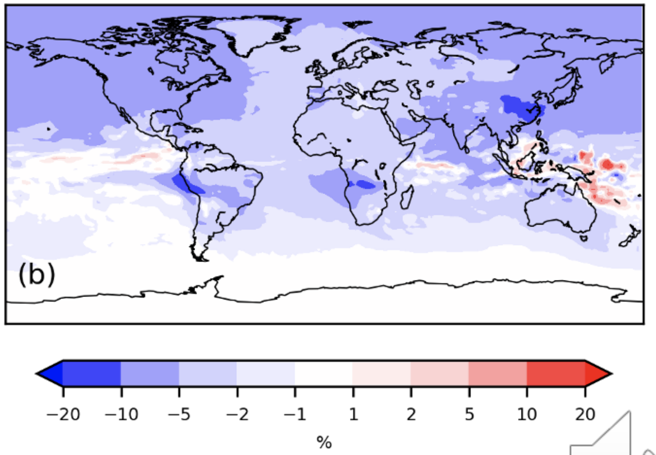


Change in SSA



Change in sulphate aerosol column





Aerosol and Ozone RF

RF / mWm^{-2}	A1	A2	A3	A4
Ozone	-37	-31	-51	-35
Aerosol IRF_{DRE}	-4	-2	-27	-44
Ozone and Aerosol RF	**-41**	**-33**	**-78**	**-69**

~3-6 ppm **temporary** drop in CO_2

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Conclusions

- **Climatic impact is small and temporary** - warming from reduced sulphate aerosol offset by cooling from reduced ozone and black carbon.

- **Reduced oxidative capacity** further reduced aerosol production and perturbed size distribution – important oxidant-aerosol coupling missed by simpler models.

- **Aerosol-cloud interactions** may yet prove to be important – further multi-model experiments with more ensemble members underway.