- PDRMIP -

Precipitation Driver Response Model Intercomparison Project

Rapid adjustments of black carbon dependency on the vertical profile

G. Myhre, B. Samset, Ø. Hodnebrog, R.J. Kramer, C.J. Smith, P. Forster, B. Soden, C.W. Stjern, T. Andrews, O. Boucher, G. Faluvegi, M. Kasoar, A. Kirkevåg, J-F. Lamarque, D. Olivié, T. Richardson, D. Shindell, P. Stier, T. Takemura, A. Voulgarakis, D. Watson-Parris

- Is rapid adjustments important for BC?
- Is there a strong warming from BC?

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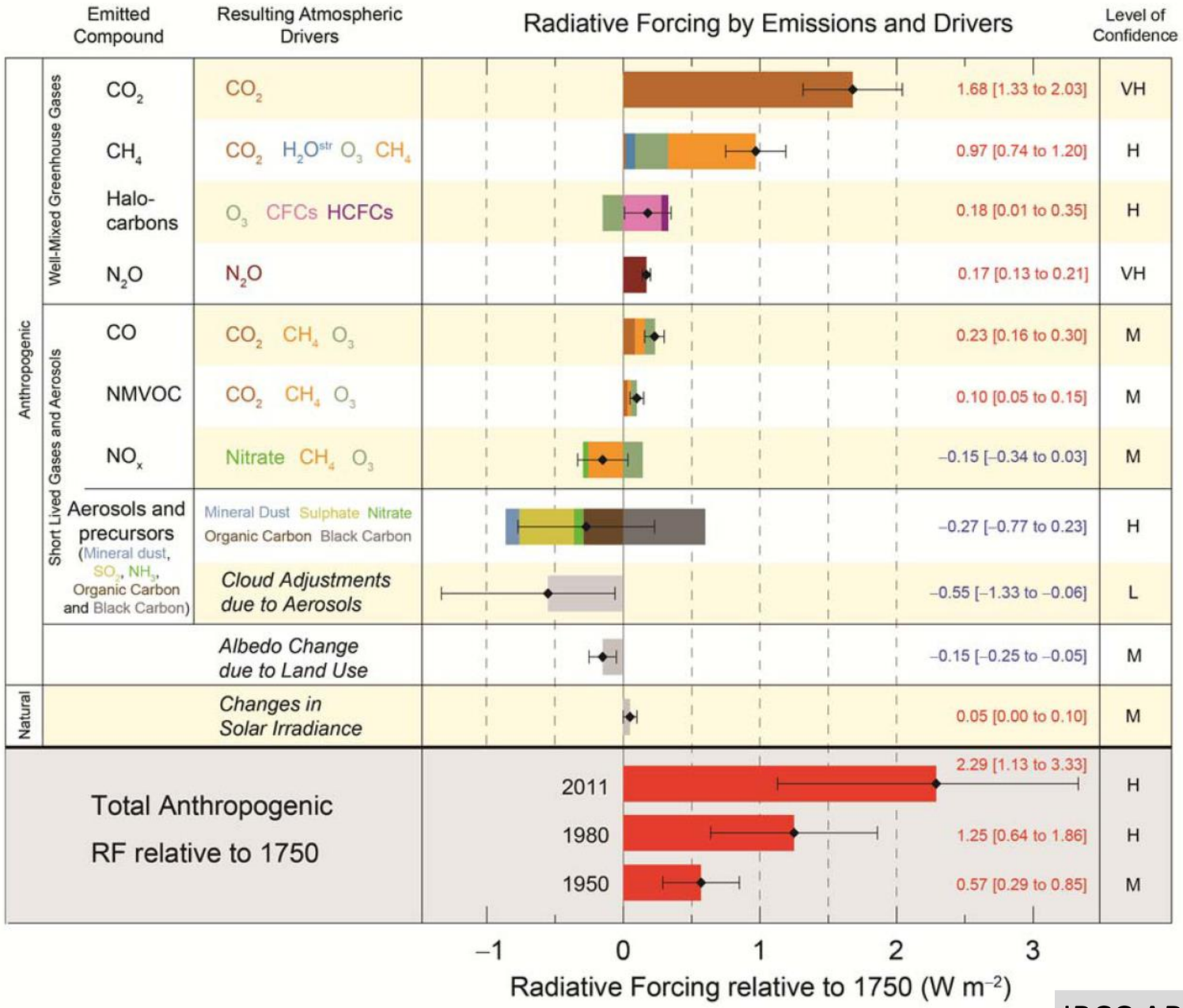
AeroCom

October 2018



Change in energy flux caused by natural or anthropogenic drivers of climate change (in W m^{-2})

IPCC AR5
Figure SPM.5

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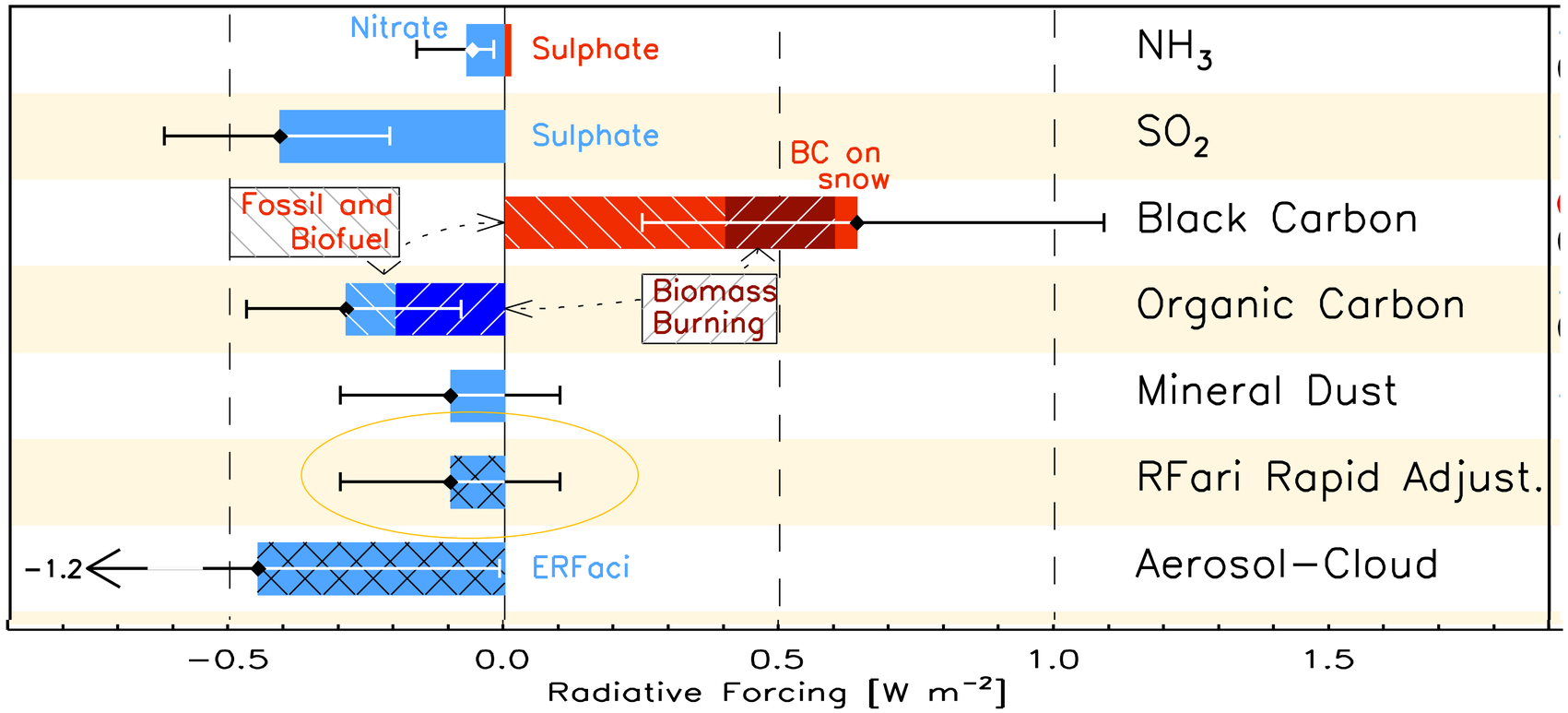
Semi-direct aerosol effect IPCC AR5



IPCC, AR5, Fig 7 Technical Summary

nature COMMUNICATIONS

ARTICLE

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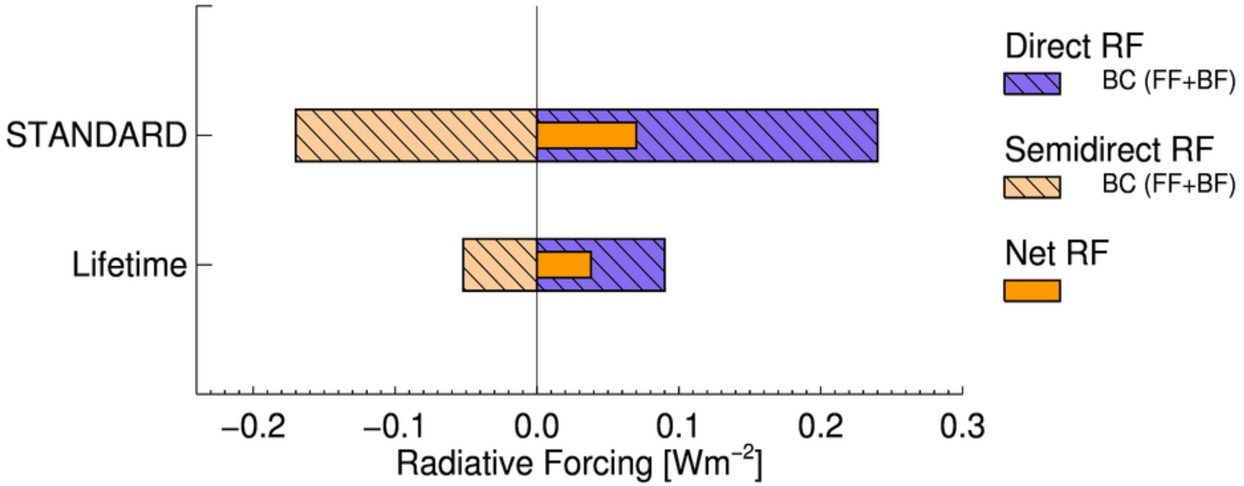
How shorter black carbon lifetime alters its climate effect

Øivind Hodnebrog[1], Gunnar Myhre[1] & Bjørn H. Samset[1]



Black carbon lifetime modified to have shorter lifetime

-Simulations performed with **STANDARD** BC lifetime and shorter BC **LIFETIME**

-Rapid adjustment **(**Semi-direct effect) is negative and reduces the total black carbon radiative forcing

-Model simulations indicate that the net of direct and semi-direct better constrained than their individual effect

AGU PUBLICATIONS

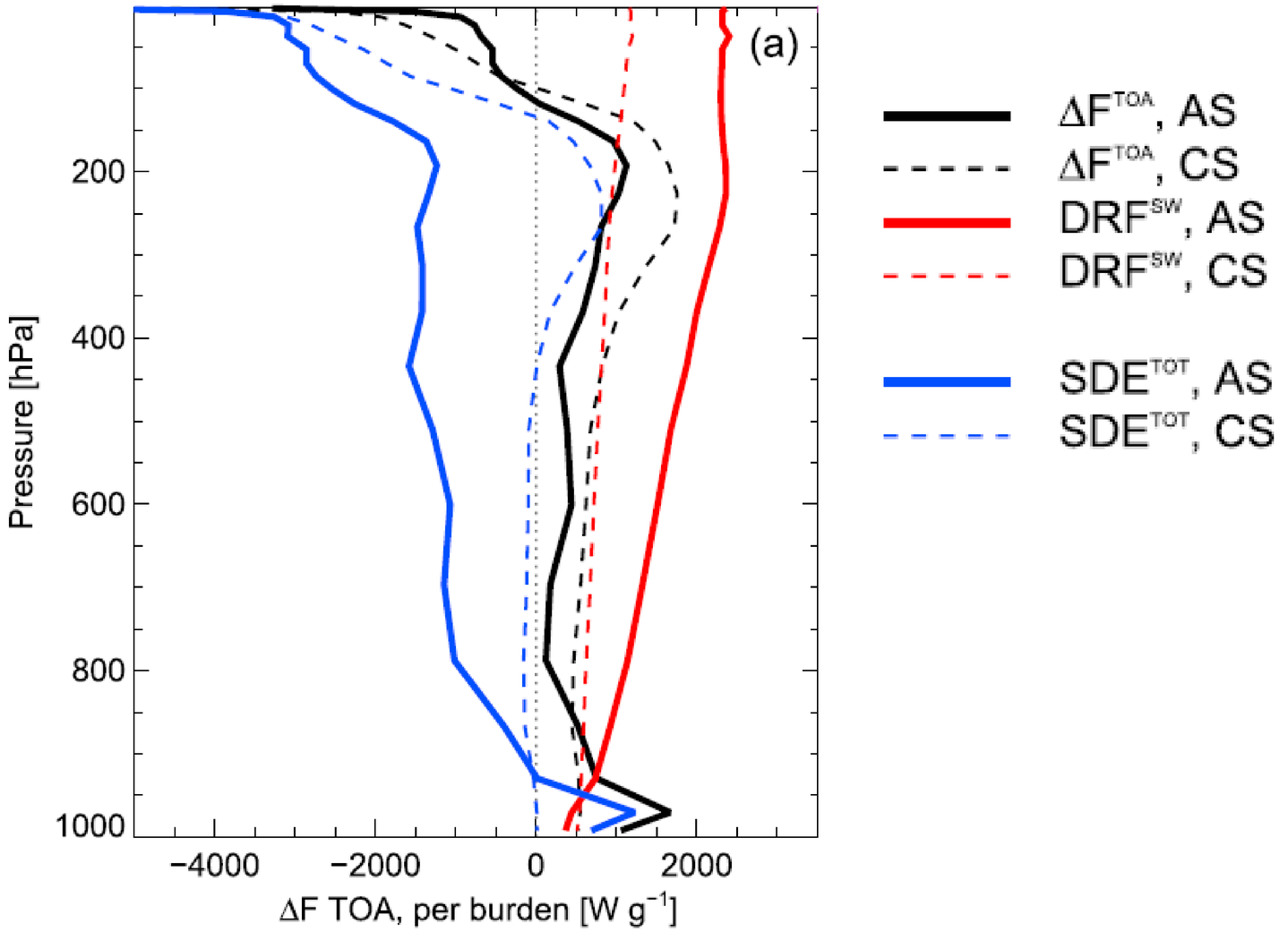
JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE
10.1002/2014JD022849

Climate response to externally mixed black carbon as a function of altitude

B. H. Samset[1] and G. Myhre[1]



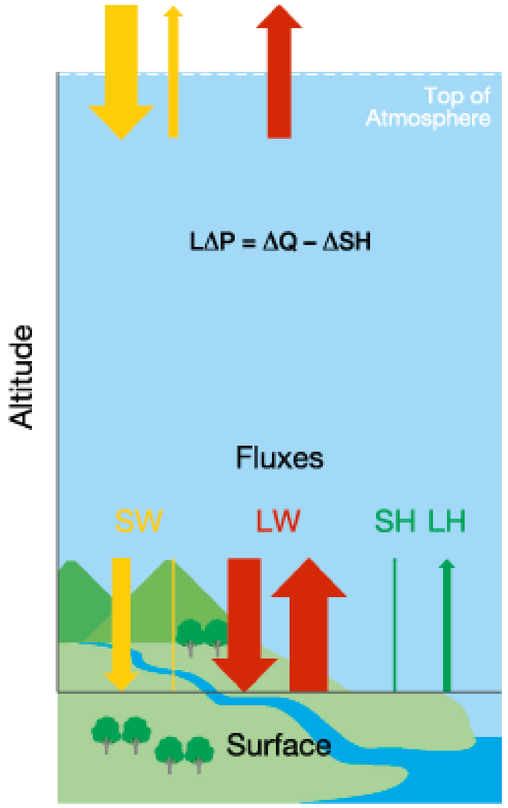


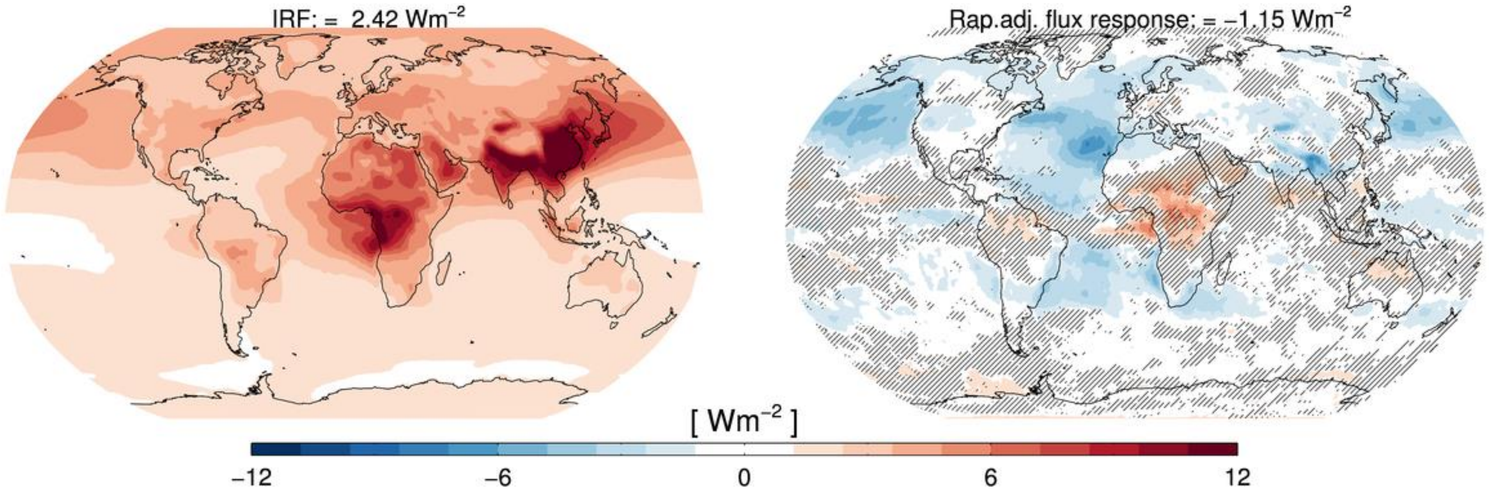
TABLE 1. PDRMIP core experiments. All experiments are performed with both fixed-SST (a minimum of 15 yr) and coupled model configurations (100 yr).

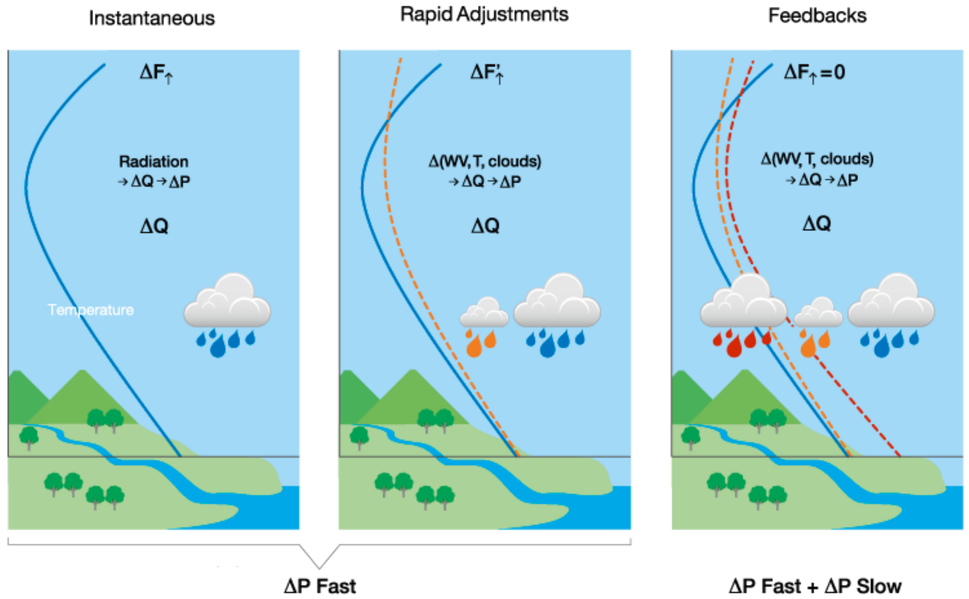
Name	Description
Base	Specified all anthropogenic and natural climate forcing agents at present-day abundances (preferred) or preindustrial abundances
CO_2 × 2	Doubling of the CO_2 concentration relative to base
CH_4 × 3	Tripling of the CH_4 concentration relative to base
Solar + 2%	Total solar irradiance is increased by 2%
Sul × 5	Increase in the anthropogenic sulfate concentration or emissions by 5 times relative to base
BC × 10	Increase in the anthropogenic BC concentration or emissions by 10 times relative to base

PDRMIP

A Precipitation Driver and Response Model Intercomparison Project—Protocol and Preliminary Results

G. Myhre, P. M. Forster, B. H. Samset, Ø. Hodnebrog, J. Sillmann, S. G. Aalbergsjø, T. Andrews, O. Boucher, G. Faluvegi, D. Fläschner, T. Iversen, M. Kasoar, V. Kharin, A. Kirkevåg, J.-F. Lamarque, D. Olivié, T. Richardson, D. Shindell, K. P. Shine, Camilla W. Stjern, T. Takemura, A. Voulgarakis, and F. Zwiers

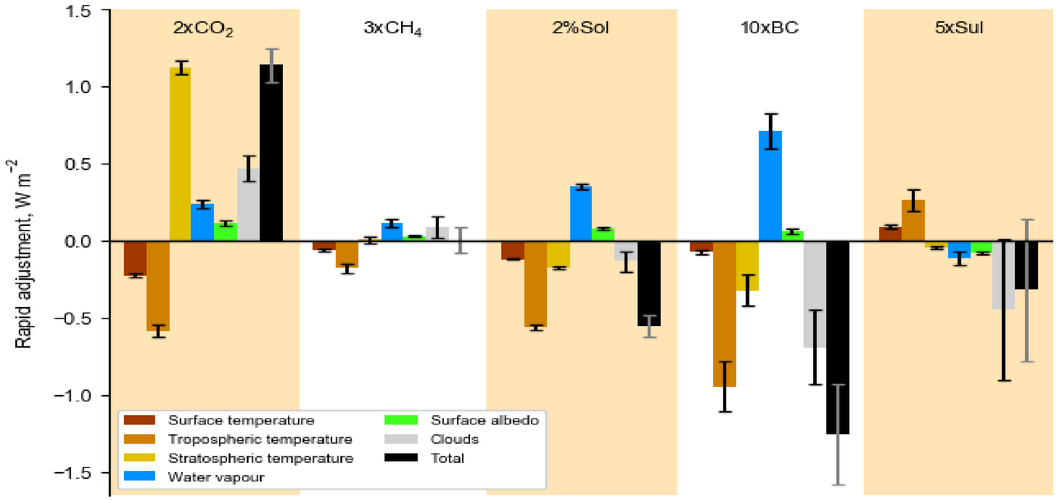




Journal of Geophysical Research: Atmospheres

Rapid Adjustments Cause Weak Surface Temperature Response to Increased Black Carbon Concentrations

Camilla Weum Stjern[1], Bjørn Hallvard Samset[1], Gunnar Myhre[1], Piers M. Forster[2], Øivind Hodnebrog[1], Timothy Andrews[3], Olivier Boucher[4], Gregory Faluvegi[5,6], Trond Iversen[7], Matthew Kasoar[8], Viatcheslav Kharin[9], Alf Kirkevåg[7], Jean-François Lamarque[10], Dirk Olivié[7], Thomas Richardson[2], Dilshad Shawki[8], Drew Shindell[11], Christopher J. Smith[2], Toshihiko Takemura[12], and Apostolos Voulgarakis[8]



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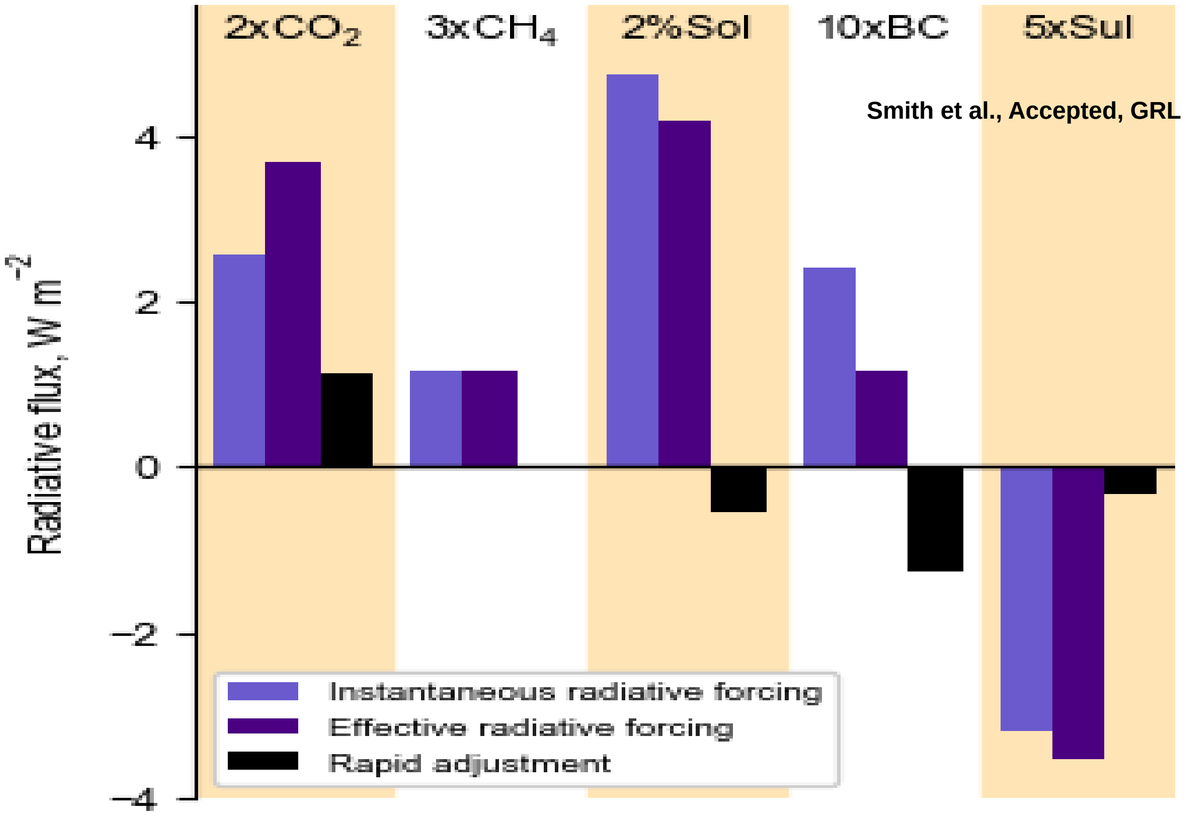
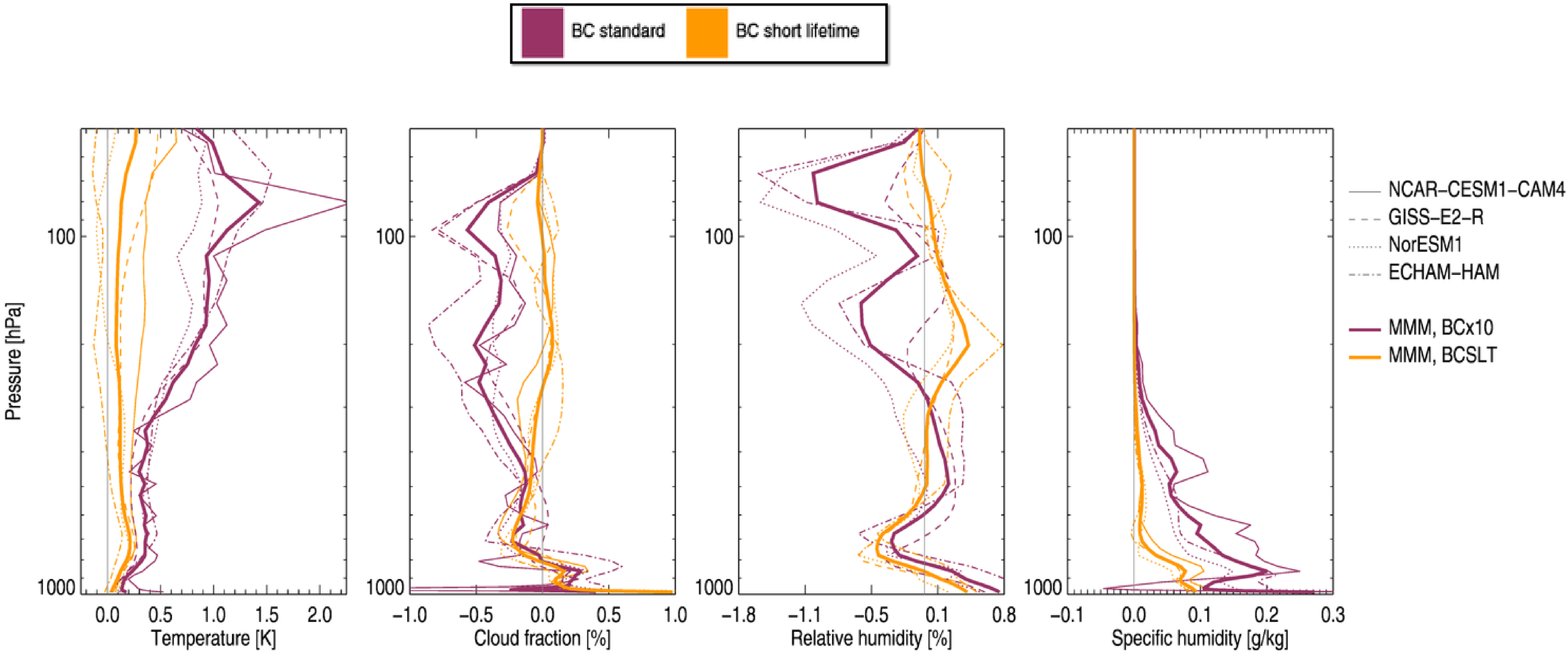
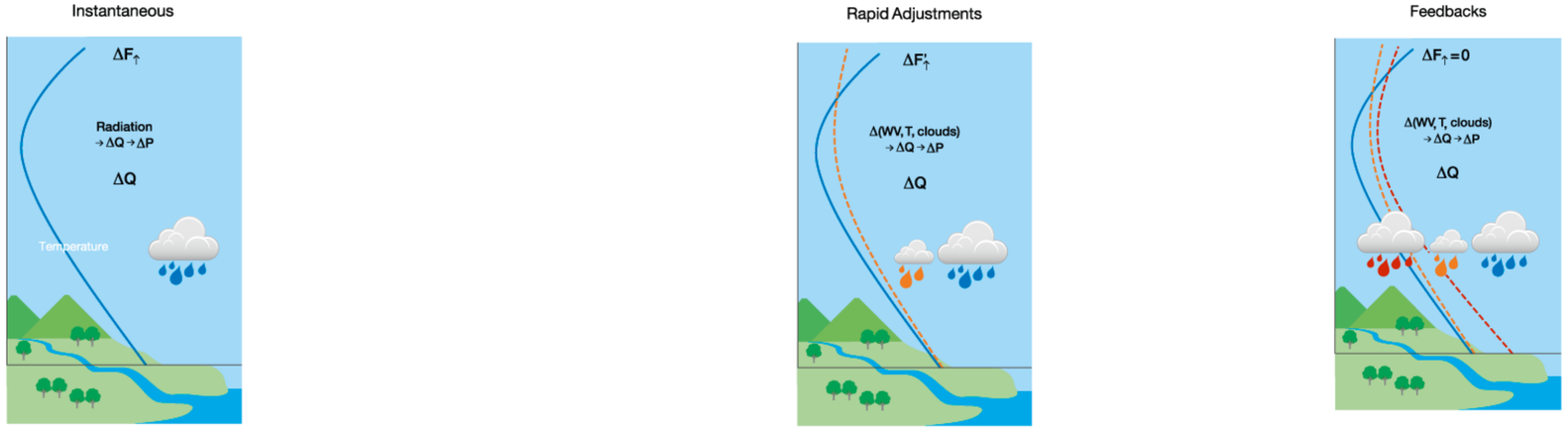
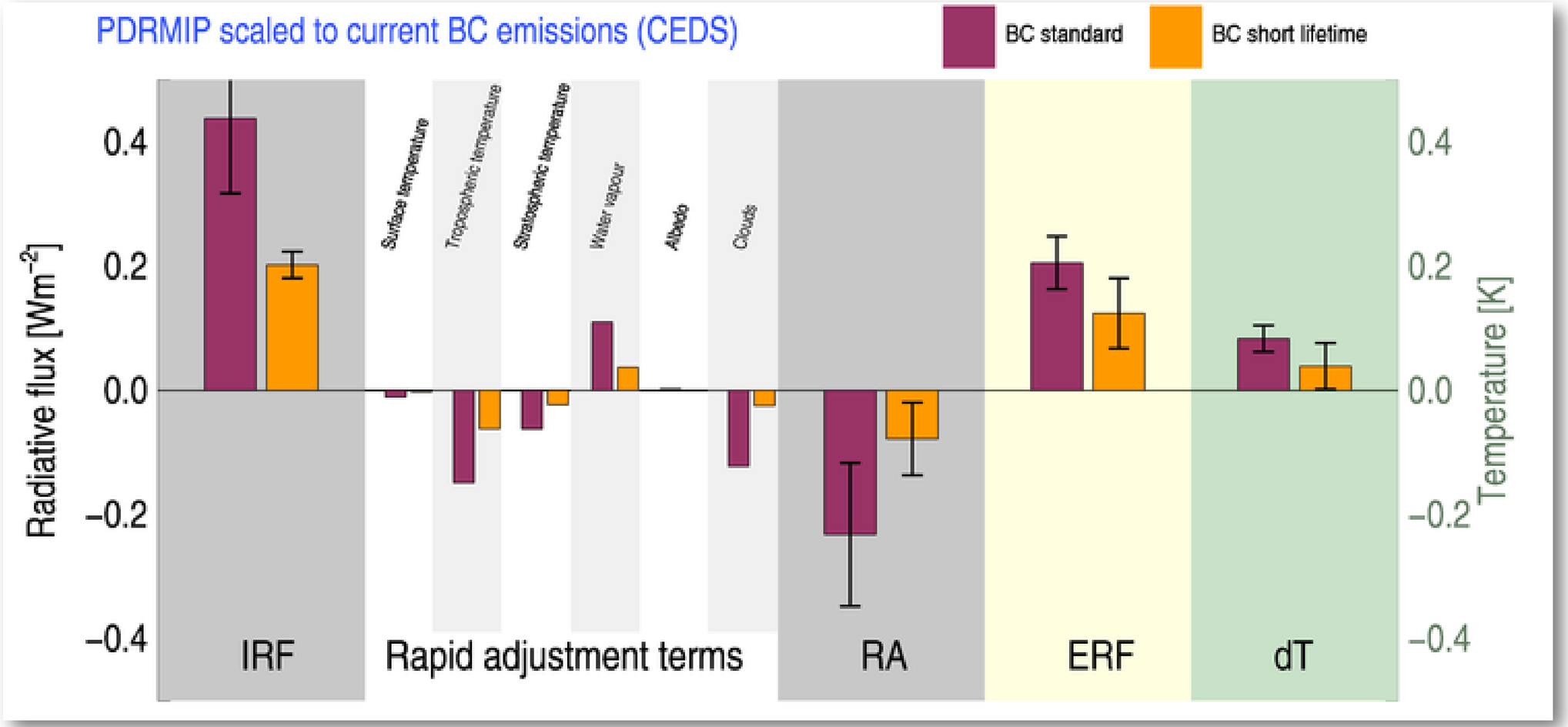


Smith et al., Accepted, GRL


BC standard
BC short lifetime
Pressure [hPa]
100
1000
0.0
0.5
1.0
1.5
2.0
Temperature [K]
−1.0
−0.5
0.0
0.5
1.0
Cloud fraction [%]
−1.8
−1.1
−0.5
0.1
0.8
Relative humidity [%]
−0.1
0.0
0.1
0.2
0.3
Specific humidity [g/kg]
NCAR−CESM1−CAM4
GISS−E2−R
NorESM1
ECHAM−HAM
MMM, BCx10
MMM, BCSLT


Instantaneous
ΔF↑
Radiation
→ΔQ→ΔP
ΔQ
Temperature
Rapid Adjustments
ΔF↑
Δ(WV, T, clouds)
→ΔQ→ΔP
ΔQ
Feedbacks
ΔF↑=0
Δ(WV, T, clouds)
→ΔQ→ΔP
ΔQ


PDRMIP scaled to current BC emissions (CEDS)
BC standard
BC short lifetime
Radiative flux [Wm^{-2}]
Temperature [K]
0.4
0.2
0.0
−0.2
−0.4
Surface temperature
Tropospheric temperature
Stratospheric temperature
Water vapour
Albedo
Clouds
IRF
Rapid adjustment terms
RA
ERF
dT

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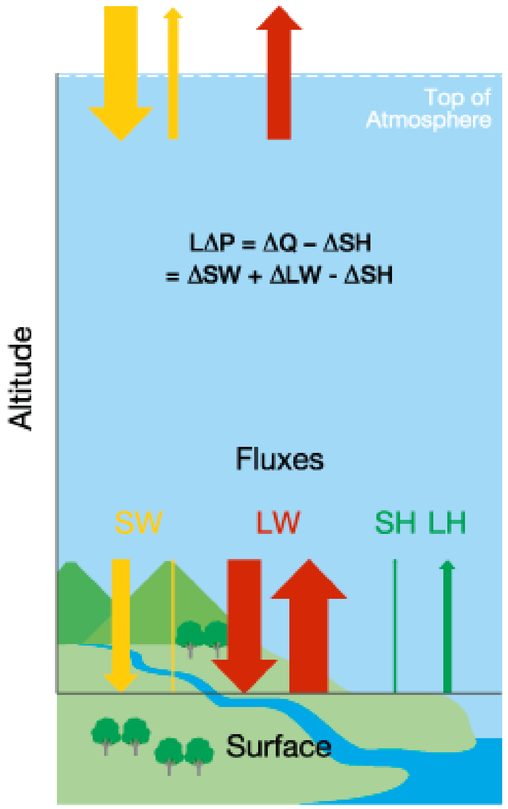
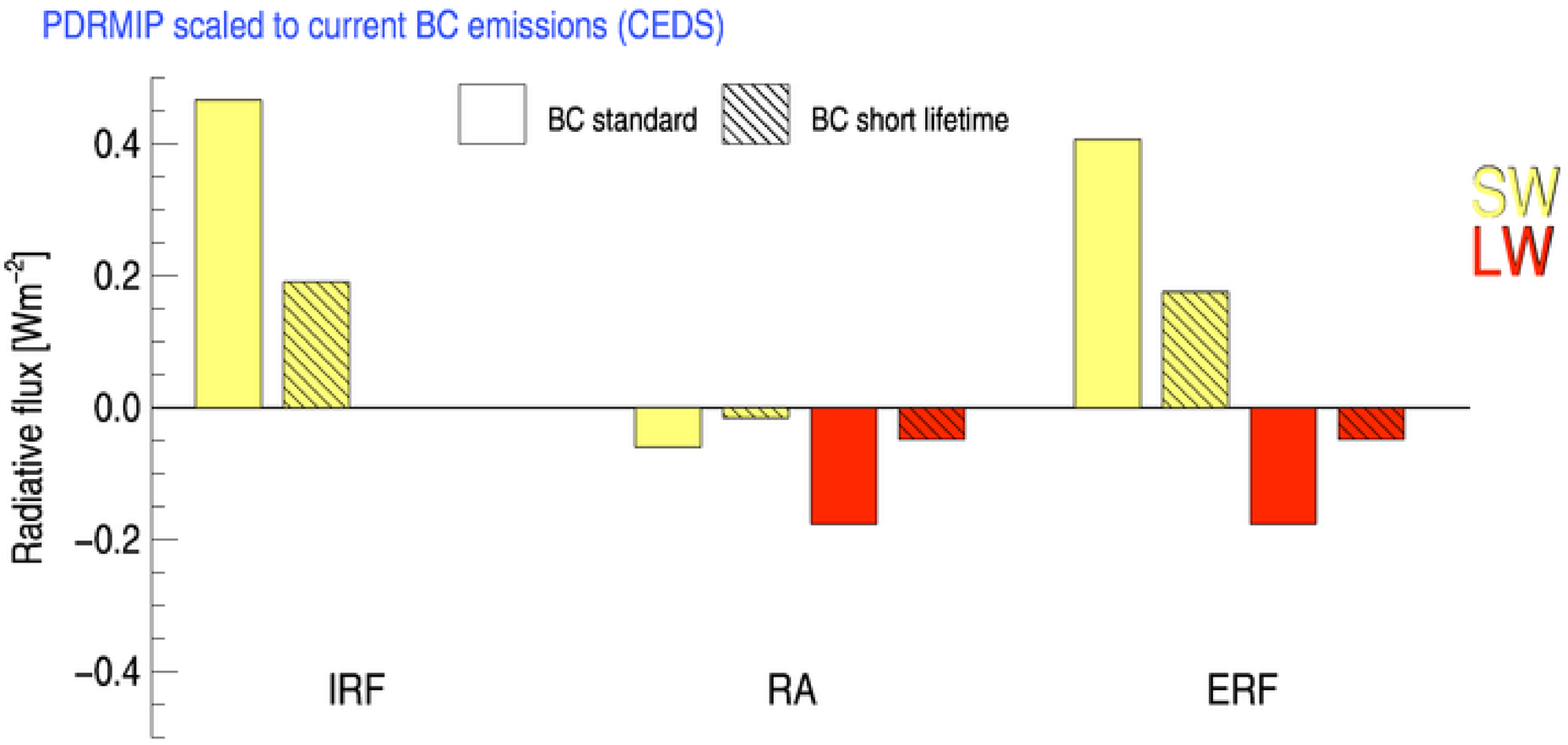

Top of Atmosphere
LΔP = ΔQ – ΔSH
= ΔSW + ΔLW - ΔSH
Altitude
Fluxes
SW
LW
SH LH
Surface


PDRMIP scaled to current BC emissions (CEDS)
BC standard
BC short lifetime
Radiative flux [Wm^{-2}]
0.4
0.2
0.0
−0.2
−0.4
IRF
RA
ERF
SW
LW

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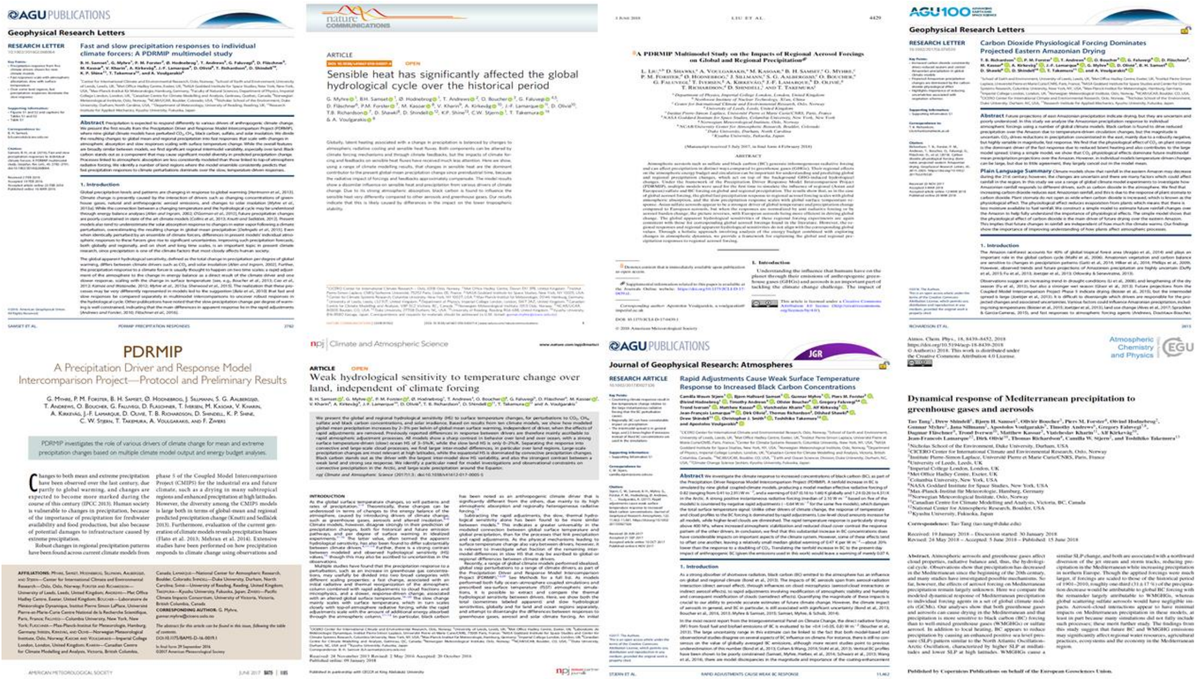
Summary

- The temperature response from atmospheric black carbon is weak.
- Either is rapid adjustments important to weakening the effective radiative forcing or is the instantaneous radiative forcing (direct aerosol effect) weak.
- Clouds are important for the rapid adjustment of BC, but non-cloud rapid adjustments are of similar magnitude



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