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Supplement of

Radiative impact of improved global parameterisations of oceanic dry deposition of ozone and lightning-generated NO_x

Ashok K. Luhar et al.

Correspondence to: Ashok K. Luhar (ashok.luhar@csiro.au)

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S1. Estimation of the direct energy dissipated from lightning

A rough estimate of the amount of direct energy dissipated from lightning can be made as follows.

We assume a mean energy release of 0.67 GJ per intracloud (IC) lightning flash and 6.7 GJ per cloud-to-ground (CG) lightning flash (Price et al., 1997), with 24% of the total global flashes being CG (Price and Rind, 1993; Luhar et al., 2021).

The global climatologically averaged lightning flash frequency calculated based on the Optical Transient Detector (OTD) / Lightning Imaging Sensor (LIS) satellite lightning flash data (Cecil et al., 2014) is 46.26 flashes s^{-1} (Luhar et al., 2021).

Taking the surface area of the Earth as 5.1×10^{14} m^2, the globally averaged flash density, therefore, is $= 46.26/(5.1 \times 10^{14}) = 9.07 \times 10^{-14}$ flashes m^{-2} s^{-1}.

Thus, the globally averaged energy release is $= (0.24 \times 6.7 + 0.76 \times 0.67)9.07 \times 10^{-14} = 19.2 \times 10^{-14}$ GJ m^{-2} s^{-1}. This is equal to 19.2×10^{-5} W m^{-2} or ~ 0.2 mW m^{-2}.

S2. Modelled radiative flux differences

Table S1 presents changes in the modelled all-sky net downward total TOA radiative flux (ΔR^{N}_{TOA}), net downward TOA longwave radiative flux (ΔL^{N}_{TOA}), net downward TOA shortwave radiative flux (ΔS^{N}_{TOA}), and incoming longwave ($\Delta L{\downarrow}_S$) and shortwave ($\Delta S{\downarrow}_S$) radiative fluxes at the surface, with respect to the base model run. Table S2 is the same except for clear-sky conditions.

Table S1: Changes in the modelled all-sky net downward total TOA radiative flux (ΔR^{N}_{TOA}), net downward TOA longwave radiative flux (ΔL^{N}_{TOA}), net downward TOA shortwave radiative flux (ΔS^{N}_{TOA}), and incoming longwave ($\Delta L{\downarrow}_S$) and shortwave ($\Delta S{\downarrow}_S$) radiative fluxes at the surface, with respect to the base model run. Values (mW m^{-2}) are averages over 2006–2010.

Region	Parameter	Model difference from base run (mW m^{-2})				
		1 (dep.)	2 (dep. + LNO_x)	3 (dep. + scaled LNO_x)	4 (dep. + LNO_x + no CH_4)	5 (dep. + no LNO_x)
Globe	ΔR^{N}_{TOA}	4.4	86.3	70.9	107.0	-190.8
	ΔL^{N}_{TOA}	-2.5	74.0	54.8	101.2	-184.3
	ΔS^{N}_{TOA}	6.9	12.3	16.1	5.8	-6.5
	$\Delta L{\downarrow}_S$	9.0	93.1	69.7	92.3	-199.2
	$\Delta S{\downarrow}_S$	7.8	-72.1	-44.6	-75.6	204.9
Tropics	ΔR^{N}_{TOA}	13.7	133.4	113.0	163.2	-264.8
	ΔL^{N}_{TOA}	1.2	115.8	82.7	149.3	-266.2
	ΔS^{N}_{TOA}	12.5	17.6	30.3	13.9	1.4
	$\Delta L{\downarrow}_S$	4.7	131.0	90.5	135.1	-283.7
	$\Delta S{\downarrow}_S$	17.7	-95.3	-49.5	-98.4	266.3
Extra-tropics	ΔR^{N}_{TOA}	-5.5	37.4	27.1	48.6	-114.1
	ΔL^{N}_{TOA}	-6.5	30.5	25.8	51.1	-99.4
	ΔS^{N}_{TOA}	1.0	6.9	1.3	-2.5	-14.7
	$\Delta L{\downarrow}_S$	13.4	53.8	48.2	47.9	-111.4
	$\Delta S{\downarrow}_S$	-2.4	-47.9	-39.5	-51.9	141.1
Northern Hemisphere	ΔR^{N}_{TOA}	7.9	112.2	76.8	124.0	-277.0
	ΔL^{N}_{TOA}	-4.7	66.6	26.8	93.9	-165.5
	ΔS^{N}_{TOA}	12.6	45.6	50.0	30.1	-111.5
	$\Delta L{\downarrow}_S$	5.9	88.0	64.0	82.3	-190.4
	$\Delta S{\downarrow}_S$	13.5	-37.9	-4.4	-43.3	90.0
Southern Hemisphere	ΔR^{N}_{TOA}	0.7	60.9	65.1	90.4	-106.5
	ΔL^{N}_{TOA}	-0.5	81.1	82.2	108.2	-202.8
	ΔS^{N}_{TOA}	1.2	-20.2	-17.1	-17.8	96.3
	$\Delta L{\downarrow}_S$	12.0	98.1	75.4	102.2	-207.7
	$\Delta S{\downarrow}_S$	2.2	-105.6	-83.9	-107.3	317.2
Land	ΔR^{N}_{TOA}	0.2	89.9	81.8	99.7	-281.4
	ΔL^{N}_{TOA}	-1.6	52.8	59.3	78.6	-185.5
	ΔS^{N}_{TOA}	1.8	37.1	22.5	21.1	-95.9
	$\Delta L{\downarrow}_S$	16.1	104.4	87.5	93.7	-252.7
	$\Delta S{\downarrow}_S$	0.7	-40.6	-35.3	-47.1	124.3

Sea	ΔR^{N}_{TOA}	6.8	83.9	64.0	111.4	-134.7
	ΔL^{N}_{TOA}	-3.2	87.0	52.0	115.1	-183.7
	ΔS^{N}_{TOA}	10.0	-3.1	12.0	-3.7	49.0
	$\Delta L\downarrow_{S}$	4.6	86.1	58.7	91.5	-165.9
	$\Delta S\downarrow_{S}$	5.7	-82.0	-59.0	-74.2	283.7

Table S2: Changes in the modelled clear-sky net downward total TOA radiative flux (ΔR^N_{TOA}), net downward TOA longwave radiative flux (ΔL^N_{TOA}), net downward TOA shortwave radiative flux (ΔS^N_{TOA}), and incoming longwave ($\Delta L{\downarrow}_S$) and shortwave ($\Delta S{\downarrow}_S$) radiative fluxes at the surface, with respect to the base model run. Values (mW m^{-2}) are averages over 2006–2010.

Region	Parameter	Model difference from base run (mW m^{-2})				
		1 (dep.)	2 (dep. + LNO_x)	3 (dep. + scaled LNO_x)	4 (dep. + LNO_x + no CH_4)	5 (dep. + no LNO_x)
Globe	ΔR^N_{TOA}	-6.0	110.8	77.6	132.9	-276.5
	ΔL^N_{TOA}	-7.4	95.2	69.2	123.0	-245.2
	ΔS^N_{TOA}	1.4	15.6	8.4	9.9	-31.3
	$\Delta L{\downarrow}_S$	21.9	143.7	106.9	145.2	-287.3
	$\Delta S{\downarrow}_S$	-0.2	-70.0	-54.3	-72.8	177.4
Tropics	ΔR^N_{TOA}	-5.7	153.4	106.5	178.4	-354.7
	ΔL^N_{TOA}	-8.7	145.8	103.4	176.7	-357.4
	ΔS^N_{TOA}	3.0	7.6	3.1	1.7	2.7
	$\Delta L{\downarrow}_S$	13.2	178.9	125.1	186.5	-384.3
	$\Delta S{\downarrow}_S$	4.5	-106.0	-78.6	-111.8	263.8
Extra-tropics	ΔR^N_{TOA}	-6.3	66.6	47.5	85.6	-195.1
	ΔL^N_{TOA}	-6.2	42.6	33.5	67.2	-128.7
	ΔS^N_{TOA}	-0.1	24.0	14.0	18.4	-66.4
	$\Delta L{\downarrow}_S$	31.0	107.2	87.9	102.4	-186.5
	$\Delta S{\downarrow}_S$	-5.3	-32.8	-29.3	-32.3	87.6
Northern Hemisphere	ΔR^N_{TOA}	-8.1	109.9	62.4	124.1	-278.7
	ΔL^N_{TOA}	-8.7	85.3	52.4	111.5	-230.1
	ΔS^N_{TOA}	0.6	24.6	10.0	12.6	-48.6
	$\Delta L{\downarrow}_S$	17.8	128.6	96.1	128.5	-277.0
	$\Delta S{\downarrow}_S$	-1.6	-62.3	-50.4	-64.7	159.8
Southern Hemisphere	ΔR^N_{TOA}	-3.9	111.5	92.5	141.6	-274.2
	ΔL^N_{TOA}	-6.2	104.8	85.6	134.4	-259.9
	ΔS^N_{TOA}	2.3	6.7	6.9	7.2	-14.3
	$\Delta L{\downarrow}_S$	25.9	158.5	117.4	161.6	-297.3
	$\Delta S{\downarrow}_S$	1.2	-77.6	-58.3	-80.7	194.7
Land	ΔR^N_{TOA}	-9.0	85.6	73.6	100.9	-272.0
	ΔL^N_{TOA}	-9.4	58.6	57.5	84.6	-206.4
	ΔS^N_{TOA}	0.4	27.0	16.1	16.3	-65.6
	$\Delta L{\downarrow}_S$	26.5	137.0	111.3	127.2	-320.6
	$\Delta S{\downarrow}_S$	-2.7	-53.7	-45.2	-54.3	159.3

Sea	ΔR^{N}_{TOA}	-4.1	126.4	80.2	152.9	-279.1
	ΔL^{N}_{TOA}	-6.3	117.8	76.4	146.9	-269.3
	ΔS^{N}_{TOA}	2.2	8.6	3.8	6.0	-9.8
	$\Delta L\downarrow_{S}$	19.1	147.9	104.1	156.4	-266.5
	$\Delta S\downarrow_{S}$	1.3	-80.2	-60.0	-84.2	188.6

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