Supplementary information of

Impact of aircraft NOx and aerosol emissions on atmospheric composition and associated direct radiative forcing of climate

Terrenoire et al.

Table S1. Total global aircraft emissions corresponding to the baseline REACT4C_2006 and QUANTIFY_2000 inventories and comparison with ACCRI_2006 (AEDT) (Brasseur et al., 2016) and CEDS_2006 (Hoesly et al., 2018) inventories.

Emission	Units	REACT4C_2006	QUANTIFY_2000	ACCRI_2006	CEDS_2006
CO_2	Tg yr^{-1}	560	672	594	715
NO_2	TgN yr^{-1}	0.71	0.84	0.81	0.88
BC	Gg yr^{-1}	4.0	5.0	5.96	6.0
SO_x	GgS yr^{-1}	73	88	113	110

Table S2. Total global aircraft emissions corresponding to 2050 QUANTIFY_A1B, QUANTIFY_B1 and QUANTIFY_B1_ACARE inventories and comparison with ACCRI_2050_Base, ACCRI_2050_S1 (AEDT) (Brasseur et al., 2016) and SSP3.70 and SSP1.26 (Gidden et al., 2019) inventories.

	Units	A1	B1	B1_ACARE	SSP3.70	SSP1.26	ACCRI 2050-Base	ACCRI 2050-S1
CO_2	Tg yr^{-1}	2257	1367	986	1301	421	2852	1625
NO_2	TgN yr^{-1}	3.3	1.0	0.69	1.76	0.87	3.95	1.57
BC	Gg yr^{-1}	16	8.9	6.4	19.7	10.3	29.0	16.6
SO_x	GgS yr^{-1}	289	175	124	257	141	541	308

Table S3. Radiative forcing of ozone (F_{O3}), methane total forcing (F_{CH4}) and total of the two forcings calculated for the different simulations (mW/m^2). The radiative forcing of methane is calculated based on Etminan et al. (2016) (F_{CH4}) or on Myhre et al. (1998) (F_{CH4}^{old}).

Scenario	F_{O3}	F_{CH4}	Total	F_{CH4}^{old}	$Total^{old}$
REACT4C_2006	15.87	-14.69	**1.18**	-12.61	**3.26**
REACT4C_2006 NOx Only	15.90	-14.72	**1.19**	-12.63	**3.27**
QUANTIFY_2000	17.19	-16.69	**0.50**	-14.32	**2.87**
REACT4C_PLUS	17.72	-14.80	**2.92**	-12.71	**5.01**
REACT4C_MINUS	14.28	-14.68	**-0.40**	-12.60	**1.68**
QUANTIFY_A1	70.56	-70.84	**-0.28**	-60.86	**9.70**
QUANTIFY_A1_LowNOx	39.29	-39.45	**-0.16**	-33.91	**5.38**
QUANTIFY_A1_Desulfurized	70.08	-70.65	**-0.57**	-60.69	**9.39**
QUANTIFY_B1	27.57	-26.43	**1.14**	-22.73	**4.84**
QUANTIFY_B1_ACARE	18.74	-17.90	**0.84**	-15.40	**3.34**

Table S4. Factors governing the climate impact of aviation NO_x emissions and comparison with previous factor decompositions. The decomposition of the NO_x forcing F_{NOx}, following the methodology proposed by Holmes et al. (2011), is given by:

$$F = F_{O3} + F_{CH4}$$

where :

$$F_{O3} = \left(\frac{\partial[O_3]}{\partial E}\right)\left(\frac{\partial F}{\partial[O_3]}\right)$$

and

$$F_{CH4} = q_{CH4}\, f \left(\frac{\partial L_{CH4}}{\partial E}\right)\left(\frac{\partial F}{\partial q_{CH4}} + \frac{\partial[O_3]}{\partial q_{CH4}}\frac{\partial F}{\partial[O_3]} + \frac{\partial[H_2O]}{\partial q_{CH4}}\frac{\partial F}{\partial[H_2O]} + \frac{\partial q_{CO2}}{\partial q_{CH4}}\frac{\partial F}{\partial q_{CO2}}\right)$$

and where $[O_3]$ is the tropospheric ozone burden (DU), $[H_2O]$ the stratospheric wator vapor burden (Tg), E the aircraft NO_x emissions (TgN), q_{CH4} the methane mixing ratio (ppmv), q_{CO2} the carbon dioxide mixing ratio (ppmv), and L_{CH4} the methane loss rate through reaction with OH.

The NO_x forcing is extended in order to include the forcings involving aerosols:

$$F = F_{O3} + F_{CH4\text{-}OH} + F_{CH4\text{-}O3} + F_{CH4\text{-}SWV} + F_{CH4\text{-}CO2} + F_{SO4} + F_{NO3}$$

where $F_{CH4\text{-}OH}$, $F_{CH4\text{-}O3}$, $F_{CH4\text{-}SWV}$, and $F_{CH4\text{-}CO2}$ are the methane forcing individual components, F_{SO4} the forcing associated with sulfate particles and F_{NO3} the forcing associated with nitrate particles. The NO_x forcing components, normalized by the NO_x emissions, for the REACT4C_2006_NOx_Only simulation and based on **Table 3** are also provided in the Table. The methane forcing $F_{CH4\text{-}OH}$ is calculated based on Etminan et al. (2016) or on Myhre et al. (1998) (under parenthesis).

	Holmes et al. (2011)	**Lee et al. (2021)**	**This work**
∂[O3]/ ∂E [DU/TgN]	0.6±0.15		0.60
∂F/∂[O3] [mW/m^2/DU]	36±8		37.3
$\partial L_{CH4}/\partial E$ [%/TgN]	-1.7±0.35		-1.4
∂[O3]/∂q_{CH4} [DU/ppmv]	3.5±1.0		3.5
∂[H2O]/∂q_{CH4} [Tg/ppmv]			87.6
$\partial q_{CO2}/\partial q_{CH4}$ [ppmv/ppmv]			0.6
∂F/∂q_{CH4} [mW/m^2/ppmv]	370		454.1 (368.3)
∂F/∂[O3] [mW/m^2/DU]	36±8		33.2
∂F/∂[H2O] [mW/m^2/Tg]			0.26
∂F/∂q_{CO2} [mW/m^2/ppmv]			13.7
F_{O3} (mW/m^2/TgN)	21.6±7.2	25.1±7.2	22.3
$F_{CH4\text{-}OH}$ (mW/m^2/TgN)	-15.7±3.6	-13.4±4.5	-15.5 (-12.6)
$F_{CH4\text{-}O3}$ (mW/m^2/TgN)	-5.3±2.2	-6.7±2.3	-3.98
$F_{CH4\text{-}swv}$ (mW/m^2/TgN)	-	-2.0±0.7	-0.92
$F_{CH4\text{-}CO2}$ (mW/m^2/TgN)	-	-	-0.28
F_{SO4} (mW/m^2/TgN)	-	-	-2.81
F_{NO3} (mW/m^2/TgN)	-	-	-0.17
Total ($F_{O3} + F_{CH4\text{-}OH} + F_{CH4\text{-}O3}$)	0.6±8.3	5.0±8.8	2.9 (2.0)
Total ($F_{O3} + F_{CH4\text{-}OH} + F_{CH4\text{-}O3} + F_{CH4\text{-}swv}$)	-	4.0±5.8	1.9 (4.9)
Total (all)	-	-	-1.3 (1.6)

Table S5. Radiative forcing of ozone (F_{O3}), methane total forcing (F_{CH4}) and total of the two forcings calculated for the different simulations (mW/m^2). The radiative forcing of methane is calculated without (F_{CH4}) or with a transient correction factor (F_{CH4}^{tr}).

Scenario	**F_{O3}**	**F_{CH4}**	**Total**	**F_{CH4}^{tr}**	**Total^{tr}**
REACT4C_2006	15.87	-14.69	**1.18**	-11.02	**4.85**
REACT4C_2006 NOx Only	15.90	-14.72	**1.19**	-11.04	**4.86**
QUANTIFY_2000	17.19	-16.69	**0.50**	-12.18	**5.01**
REACT4C_PLUS	17.72	-14.80	**2.92**	-11.10	**6.62**
REACT4C_MINUS	14.28	-14.68	**-0.40**	-11.01	**3.27**
QUANTIFY_A1	70.56	-70.84	**-0.28**	-52.42	**18.14**
QUANTIFY_A1_LowNOx	39.29	-39.45	**-0.16**	-29.16	**10.10**
QUANTIFY_A1_Desulfurized	70.08	-70.65	**-0.57**	-52.28	**17.80**
QUANTIFY_B1	27.57	-26.43	**1.14**	-26.43	**1.14**
QUANTIFY_B1_ACARE	18.74	-17.90	**0.84**	-20.58	**-1.84**

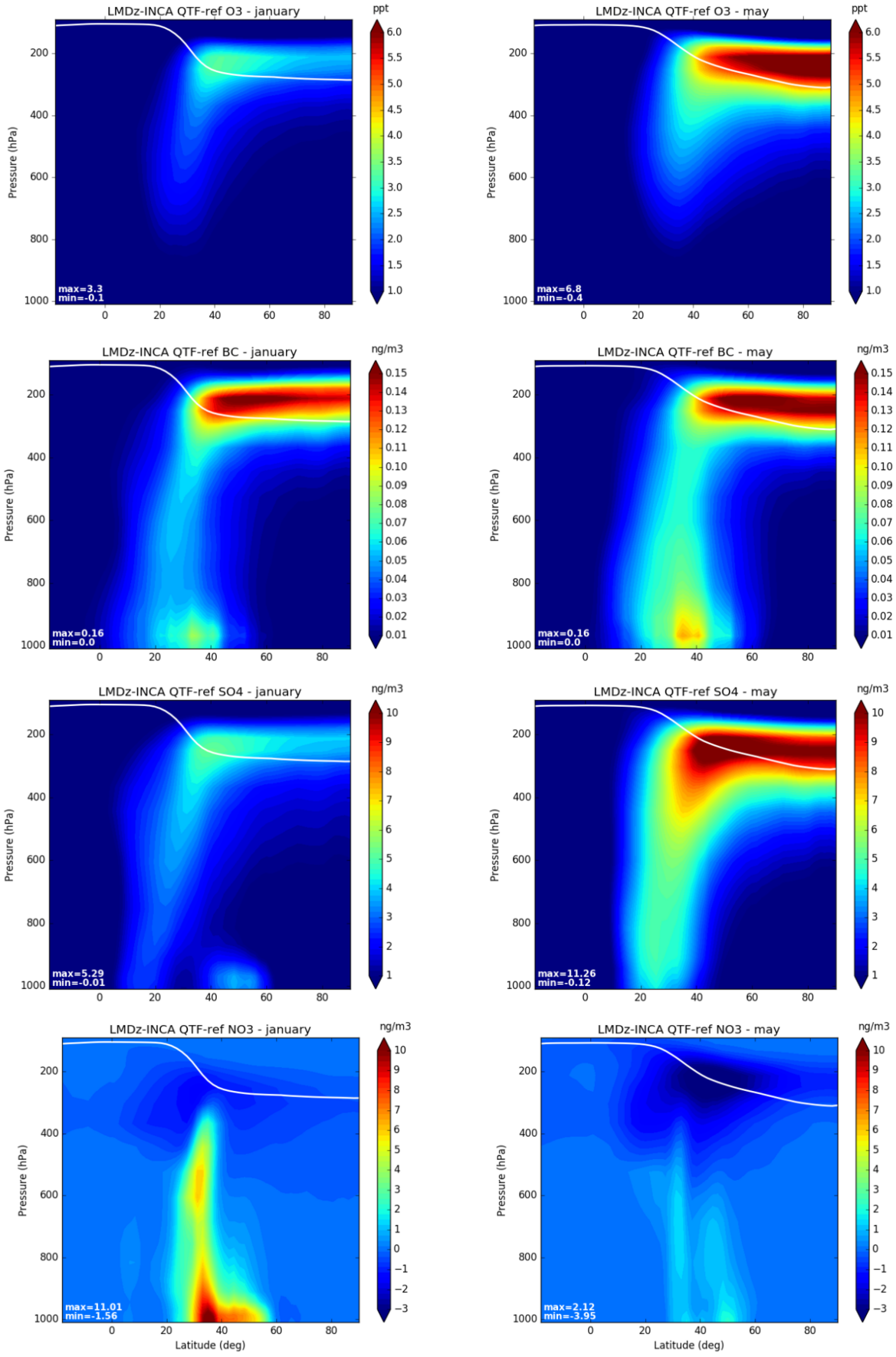

Figure S1. Zonal mean perturbation due to aircraft emissions for January (left) and May (right) of O_3 (ppbv), BC (ng/m^3), SO_4 (ng/m^3) and NO_3 (ng/m^3) for the QUANTIFY_2000 inventory. The solid line represents the tropopause pressure.