Supplementary material

S1. Chemical background in the UTLS

Table S1: Backgrounds expressed as global mass burdens, between 150 and 300 hPa, annually. The black carbon lifetime is written in brackets below the BC burden. It is worth noting that it is derived from the total BC burden, and not only that in the UTLS.

Model	EMAC-NO_x	LMDZ-INCA	MOZART3	OsloCTM3	GEOS-Chem
Period	2014–2018	2014–2018	2014–2018	2014–2017	2019
O_3 (TgO_3)	199	218	231	172	139
NO_y (TgN)	0.318	0.292	0.230	0.317	0.167
NO_x (TgN)	$6.76\ 10^{-2}$	$3.42\ 10^{-2}$	$4.64\ 10^{-2}$	$6.95\ 10^{-2}$	$2.53\ 10^{-2}$
HNO_3 (TgN)	0.152	0.152	0.125	0.224	0.107
OH (Tg)	$8.47\ 10^{-5}$	$7.02\ 10^{-5}$	$7.31\ 10^{-5}$	$8.26\ 10^{-5}$	$5.88\ 10^{-5}$
CH_4 (TgC)	641	744	651	614	546
NH_3 (TgN)	$3.06\ 10^{-2}$	$7.31\ 10^{-3}$	-	$3.09\ 10^{-4}$	$1.22\ 10^{-3}$
SO_2 (TgS)	$2.33\ 10^{-2}$	$4.91\ 10^{-2}$	-	$7.53\ 10^{-3}$	$1.95\ 10^{-2}$
Aerosols	EMAC-aer				
BC (Gg) [lifetime]	3.95 [7.7 days]	38.0 [8.0 days]	-	2.93 [4.6 days]	1.55 [5.1 days]
SO_4 (GgS)	116	473	-	384	59.6
NO_3 (GgN)	56.2	239	-	226	33.6

S2. Ancillary variables

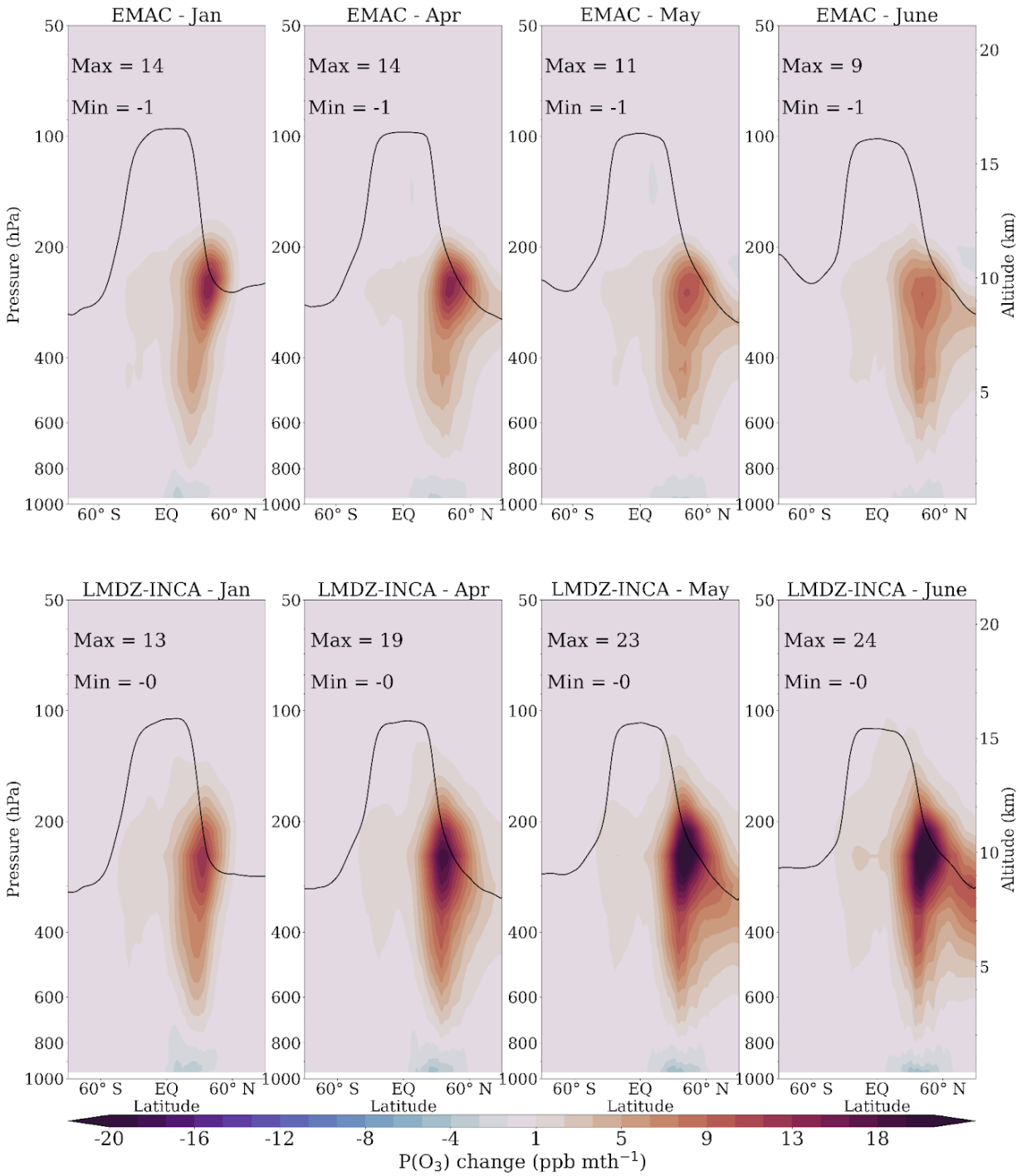
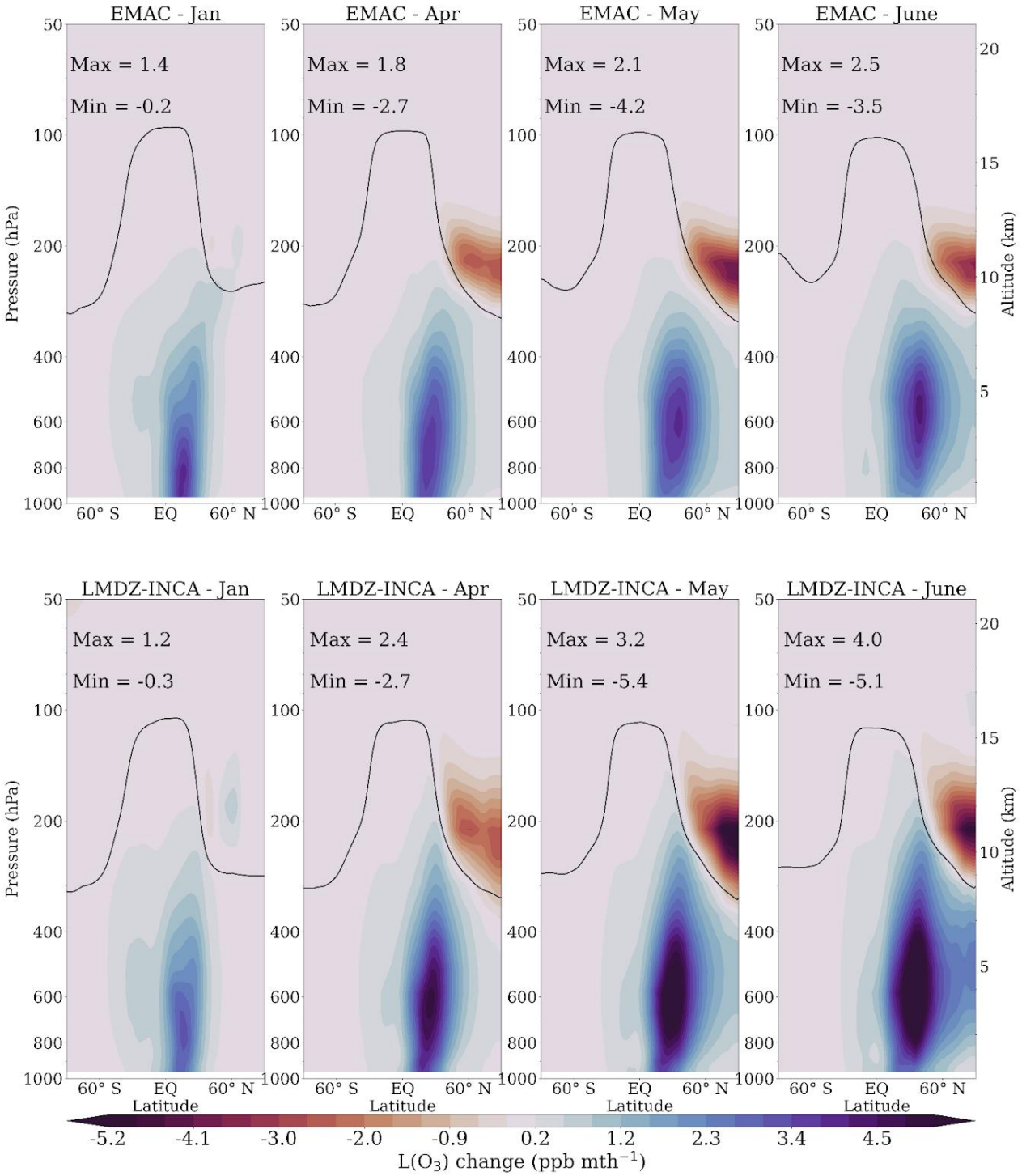


Figure S1: Zonal cross sections in the perturbation of ozone production $P(O_3)$, for the EMAC and LMDZ-INCA models (top and bottom), during January, April, May, and June (from left to right).



15 **Figure S2: Same as Fig. S1 for ozone chemical loss L(O_3). Note that the colors are reversed.**

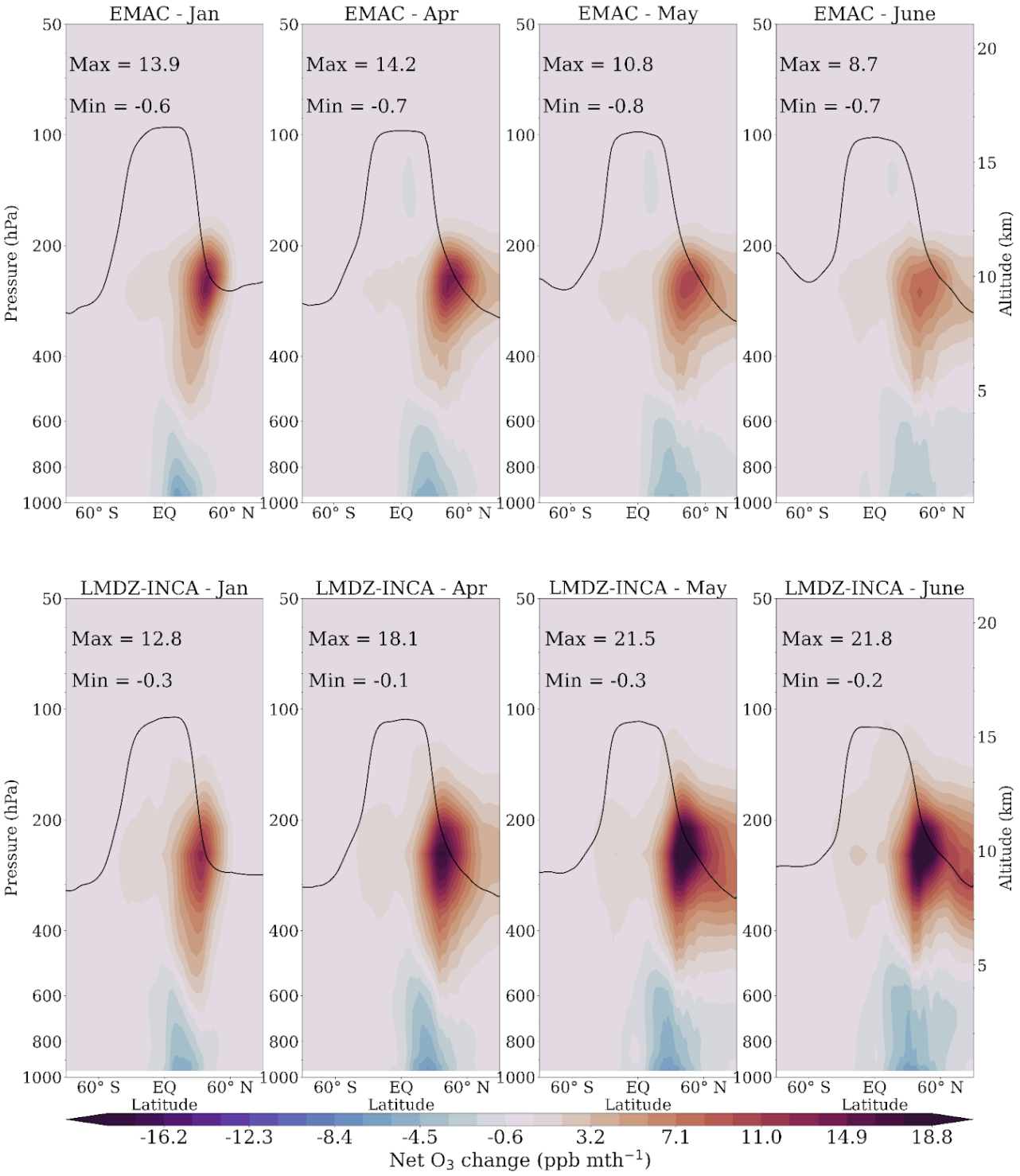


Figure S3: Same as Fig. S1 for net ozone production $P(O_3)$ - $L(O_3)$.

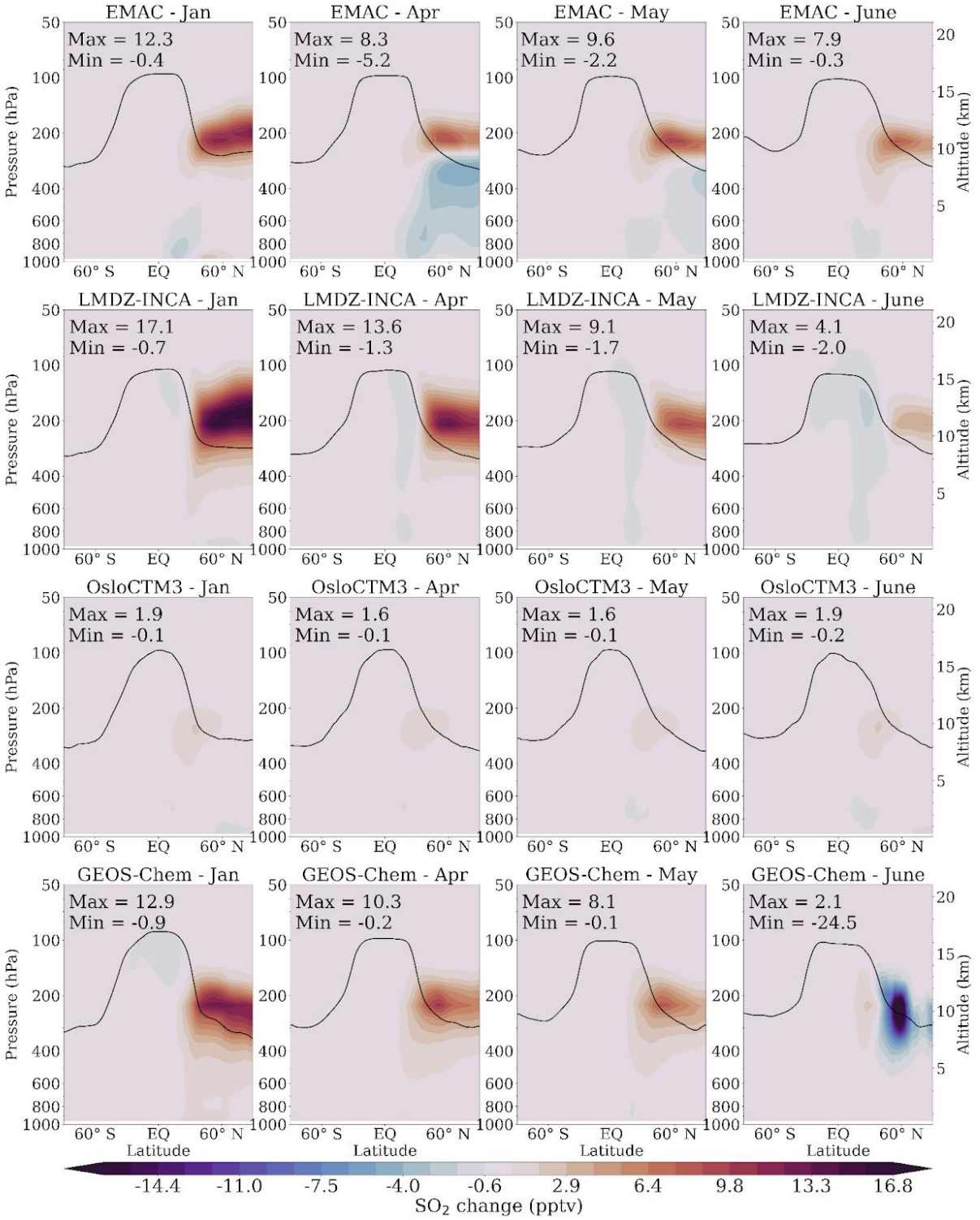


Figure S4: Zonal cross sections in the perturbation sulfate dioxide (SO_2), for the EMAC and LMDZ-INCA models (top and bottom), during January, April, May, and June (from left to right).

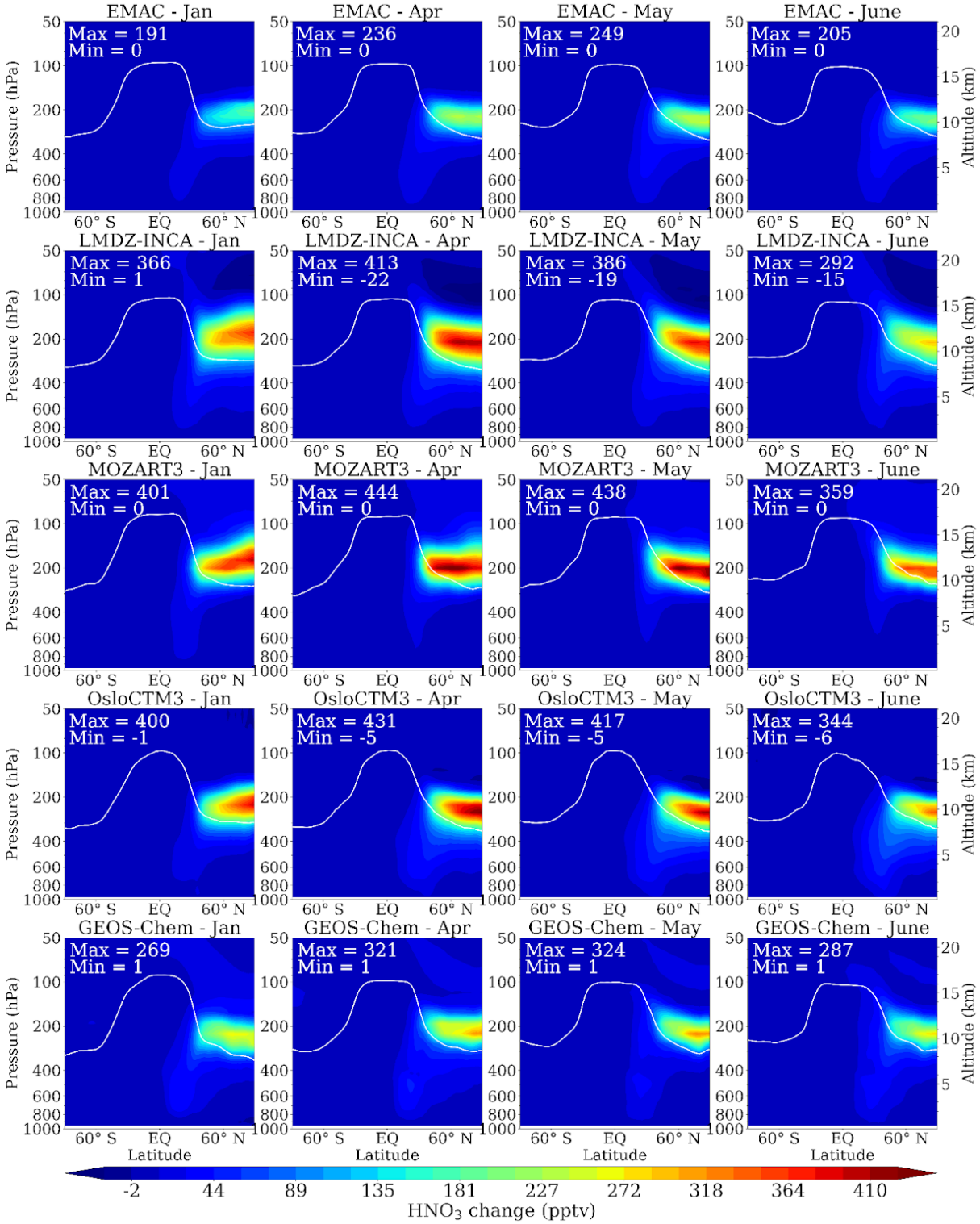


Figure S5: Same as Fig. S4 for nitric acid (HNO_3).

S3. NO_x emissions

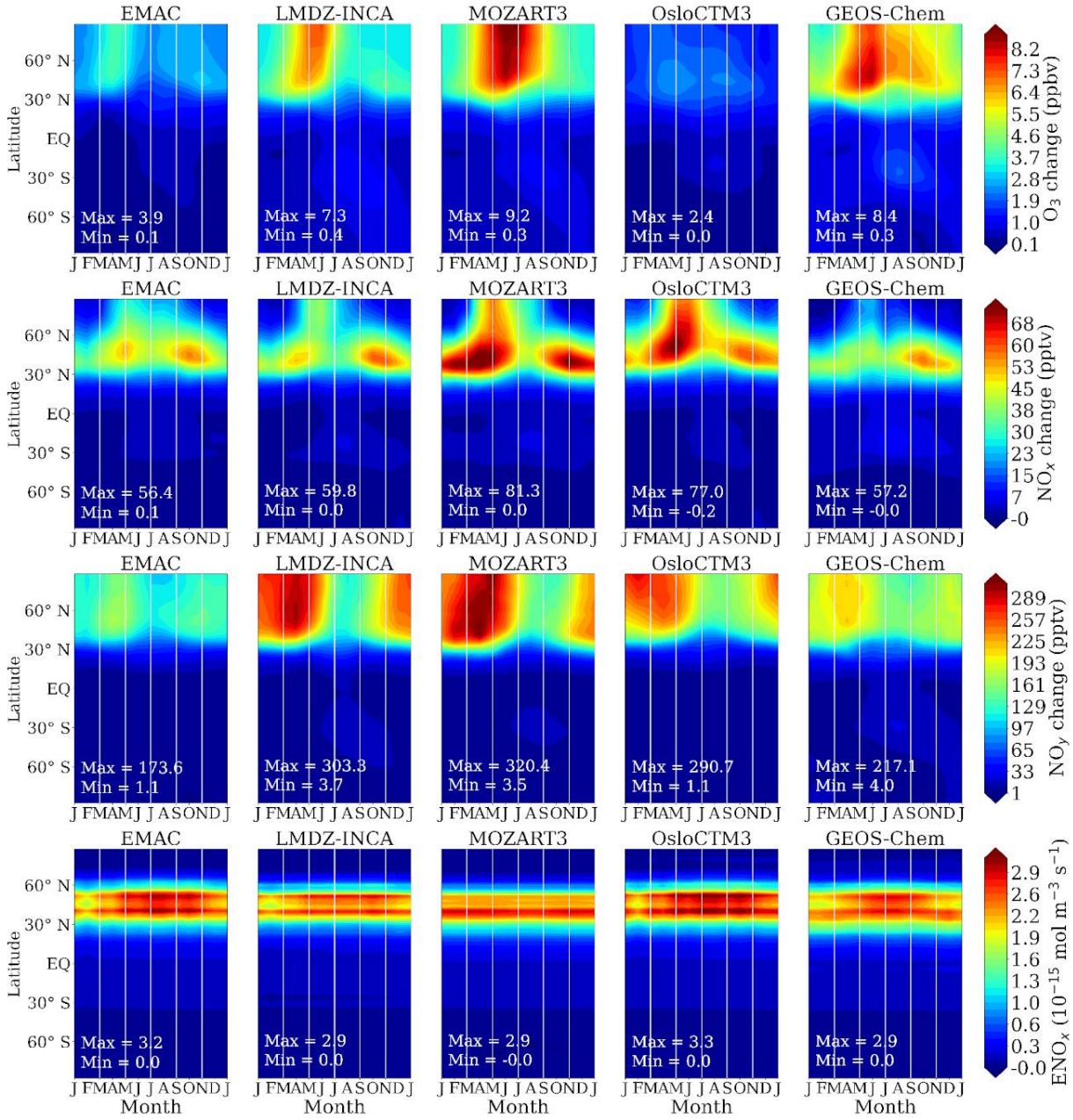


Figure S6: Hovmöller diagrams in NO_x emissions for each model, between 150 and 350 hPa.

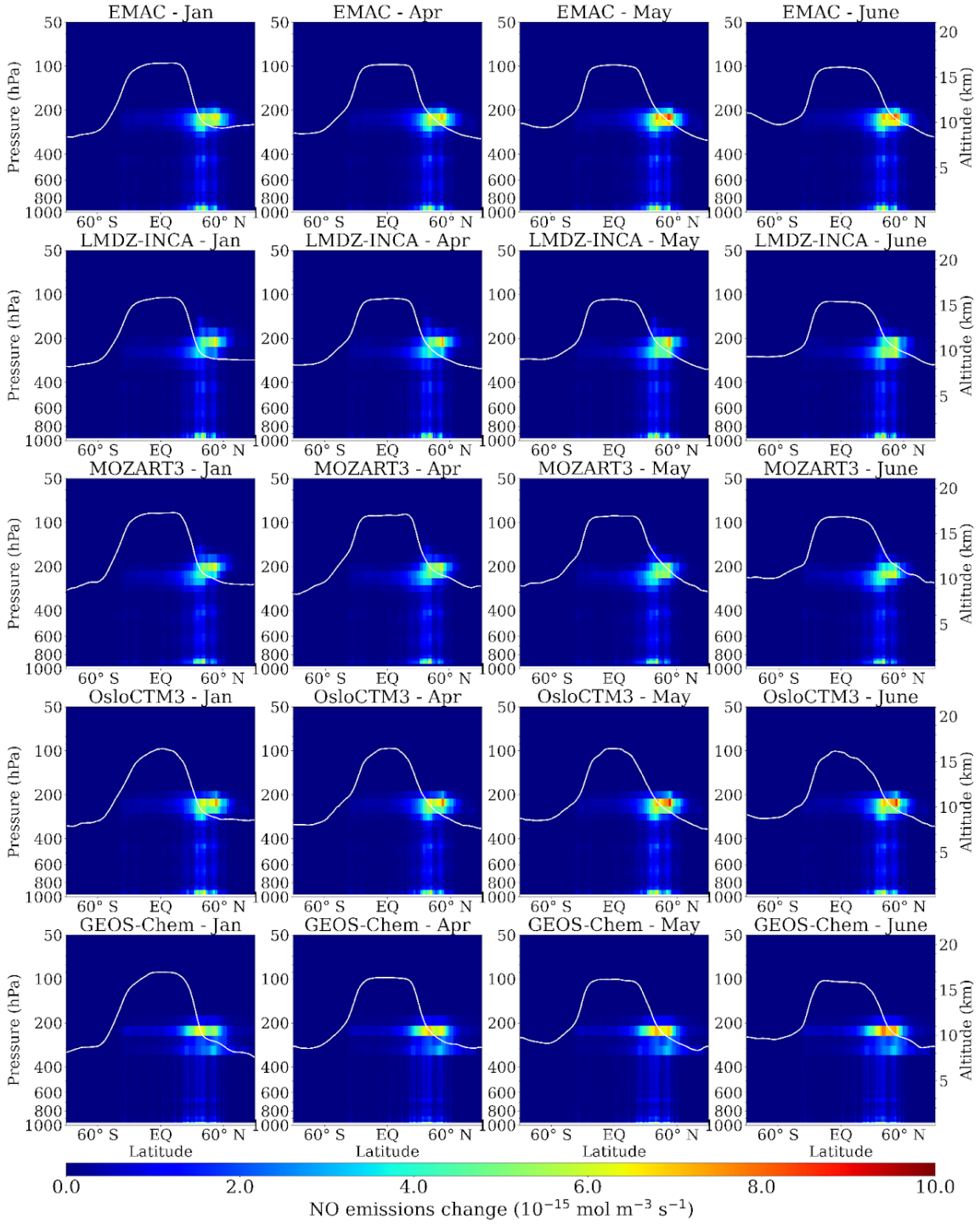


Figure S7: Zonal cross sections in NO_x emissions for each model (from top to bottom) during Jan, April, May, and June (from left to right).

S4. Linearity of the responses with respect to NO_x emissions

Table S2: Ratio between the 100% perturbation and the 20% perturbation rescaled up to 100%, for each model (columns) and gaseous species (row). TCH_4 refers to methane lifetime.

Ratio 100% / 20%	LMDZ-INCA	MOZART3	OsloCTM3
O_3	1.13	1.18	1.09
NO_y	1.08	0.97	1.04
NO_x	0.94	0.92	1.04
HNO_3	1.00	0.97	1.03
PAN	1.12	1.11	1.14
CO	1.10	1.12	1.08
TCH_4	1.09	1.09	1.05
OH	1.11	1.14	1.08

S5. Radiative forcing terms

Table S3: Effective radiative forcings from the different terms linked to NO_x emissions, as in Fig. 12a. The value in bracket shown for the short-term ozone forcing in LMDZ-INCA is calculated from an offline version of the LMDZ GCM radiative code, as described in Terrenoire et al. (2022).

ERF (mW m^{-2})	EMAC-NO_x	LMDZ-INCA	MOZART3	OsloCTM3	GEOS-Chem
Short-term ozone	27.7	43.0 [40.6]	42.0	34.0	56.0
CH_4 direct effect	-13.2	-17.1	-12.9	-12.9	-24.8
Long-term ozone	-5.37	-6.96	-5.24	-5.24	-10.1
Stratospheric H_2O	-1.74	-2.25	-1.70	-1.70	-3.26
Total CH_4	-20.4	-26.4	-19.9	-19.9	-38.2
Total	7.37	16.7	22.2	14.1	17.9

Table S4: Effective direct radiative forcings of the different aerosol species, as in Fig. 12b.

Aerosol-radiation interactions (mW m^{-2})	EMAC-aer (2015)	LMDZ-INCA (2014–2018)	OsloCTM3 (2014–2017)	GEOS-Chem (2019)
BC	6.37	2.08	0.82	2.65
OC	-1.16	-0.09	-0.05	-0.19
SO_4	-11.2	-6.85	-5.10	-8.09
NO_3	-3.82	-1.62	-13.5	-6.36
Total Aerosol	-10.2	-6.47	-17.8	-12.0