Pre-industrial to end 21st century projections of tropospheric ozone from the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) – Supplementary Material

P. J. Young, A. T. Archibald, K. W. Bowman, J.-F. Lamarque, V. Naik, D. S. Stevenson, S. Tilmes, A. Voulgarakis, O. Wild, D. Bergmann, P. Cameron-Smith, I. Cionni, W. J. Collins, S. B. Dalsøren, R. M. Doherty, V. Eyring, G. Faluvegi, L. W. Horowitz, B. Josse, Y. H. Lee, I. A. MacKenzie, T. Nagashima, D. A. Plummer, M. Righi, S. T. Rumbold, R. B. Skeie, D. T. Shindell, S. A. Strode, K. Sudo, S. Szopa and G. Zeng

Description

This supplementary material consists of four parts:

(1) Table S1 details the CO, VOC and NOx emissions from each model, as used in the construction of Fig. 1 in the main paper.

(2) Figures S1-S3 show the annual mean ozone for all the models for the Hist 2000 simulation. The figures show the zonal mean ozone concentration (Fig. S1), tropospheric ozone column (Fig. S2) and surface ozone concentration (Fig. S3). These figures relate to Fig. 2 in the main paper.

(3) Figures S4-S6 show the change in annual mean ozone compared to Hist 2000 for all the models, showing the zonal mean ozone concentration change (Fig. S4), tropospheric ozone column change (Fig. S5) and surface ozone concentration change (Fig. S6). These figures relate to Figs. 9-11 in the main paper. Blank panels indicate where a given model did not provide output for the relevant simulation.

(4) Figure S7 shows the multi-model mean change in total column ozone between the Hist 1980 and Hist 2000 simulation. Figure also shows a comparable change in the total ozone column from the Total Ozone Mapping Spectrometer (TOMS) data.

For all figures, the legend on the color bar describes what is plotted.

Table S1a. Yearly total emissions of CO (Tg CO / yr) for each ACCMIP model, for each time slice and scenario. GISS-E2-R-TOMAS emissions same as GISS-E2-R.

Model	Hist			RCP2.6		RCP4.5		RCP6.0		RCP8.5	
	1850	1980	2000	2030	2100	2030	2100	2030	2100	2030	2100
CESM-CAM-superfast	564	1,148	1,248	1,105	790	–	–	1,206	966	1,189	873
CICERO-OsloCTM2	565	1,147	1,248	1,113	750	1,236	689	–	–	1,197	907
CMAM	823	1,375	1,502	–	–	1,424	906	–	–	1,436	1,116
EMAC	497	1,080	1,180	–	–	1,108	589	–	–	–	802
GEOSCCM	527	1,117	1,231	–	–	–	–	–	–	–	–
GFDL-AM3	568	1,146	1,246	1,104	786	1,174	655	1,204	961	1,188	868
GISS-E2-R	387	971	1,070	924	621	989	495	1,029	802	1,005	702
HadGEM2	922	1,483	1,610	–	1,143	–	1,011	–	–	–	1,224
LMDz-OR-INCA	407	991	1,093	944	640	–	–	1,049	821	1,025	722
MIROC-CHEM	384	962	1,064	922	605	–	–	1,024	790	1,006	688
MOCAGE	486	1,068	1,168	1,026	708	–	–	1,126	883	1,110	791
NCAR-CAM3.5	565	1,148	1,248	1,105	787	1,175	656	1,206	962	1,189	870
STOC-HadAM3	492	1,082	1,184	1,040	717	–	–	–	–	1,125	801
UM-CAM	480	1,047	1,148	1,011	700	1,077	570	–	–	1,093	781

Table S1b. As Table S1a, but yearly total emissions of VOCs (Tg C / yr).

Model	Hist			RCP2.6		RCP4.5		RCP6.0		RCP8.5	
	1850	1980	2000	2030	2100	2030	2100	2030	2100	2030	2100
CESM-CAM-superfast	429	429	429	429	429	–	–	429	429	429	429
CICERO-OsloCTM2	411	462	461	462	438	462	438	–	–	462	435
CMAM	–	–	–	–	–	–	–	–	–	–	–
EMAC	697	770	839	–	–	835	869	–	–	–	1020
GEOSCCM	495	578	627	–	–	–	–	–	–	–	–
GFDL-AM3	762	828	830	824	788	830	800	832	808	836	814
GISS-E2-R	721	807	830	851	834	869	885	865	922	876	988
HadGEM2	69	96	106	–	83	–	78	–	–	–	82
LMDz-OR-INCA	565	662	666	654	600	–	–	662	628	671	639
MIROC-CHEM	728	821	833	826	774	–	–	836	808	842	805
MOCAGE	942	1,049	1,059	1,050	990	–	–	1,061	1,024	1,069	1,030
NCAR-CAM3.5	578	665	668	662	616	671	633	673	643	679	651
STOC-HadAM3	573	697	722	771	710	–	–	–	–	794	904
UM-CAM	429	523	535	528	475	532	486	–	–	546	513

Table S1c. As Table S1a, but yearly total emissions of NO_x (Tg N / yr).

Model	Hist			RCP2.6		RCP4.5		RCP6.0		RCP8.5	
	1850	1980	2000	2030	2100	2030	2100	2030	2100	2030	2100
CESM-CAM-superfast	12.1	44.3	50.0	34.3	23.6	–	–	39.5	23.2	48.0	31.7
CICERO-OsloCTM2	18.4	45.4	50.3	43.4	28.9	46.5	28.6	–	–	52.9	35.6
CMAM	18.3	44.1	50.8	–	–	37.2	20.0	–	–	43.6	27.3
EMAC	16.6	44.0	50.0	–	–	46.4	30.4	–	–	–	40.0
GEOSCCM	17.3	41.5	45.0	–	–	–	–	–	–	–	–
GFDL-AM3	13.8	40.9	46.2	39.7	24.5	43.0	27.0	41.2	25.1	49.8	35.8
GISS-E2-R	15.8	43.2	48.6	42.4	27.9	45.3	29.7	43.9	28.5	51.6	39.1
HadGEM2	11.9	39.3	44.8	–	23.4	–	25.7	–	–	–	34.5
LMDz-OR-INCA	–	–	–	–	–	–	–	–	–	–	–
MIROC-CHEM	23.9	51.6	57.3	51.8	36.7	–	–	53.8	39.2	62.4	53.4
MOCAGE	14.8	42.5	47.9	41.3	26.0	–	–	42.8	24.8	51.2	36.9
NCAR-CAM3.5	12.1	44.9	50.7	35.7	23.7	39.0	26.0	40.9	24.3	49.3	35.3
STOC-HadAM3	18.2	46.0	51.6	44.9	29.5	–	–	–	–	55.2	40.9
UM-CAM	17.4	43.9	49.2	44.1	29.2	47.3	31.5	–	–	53.7	40.7

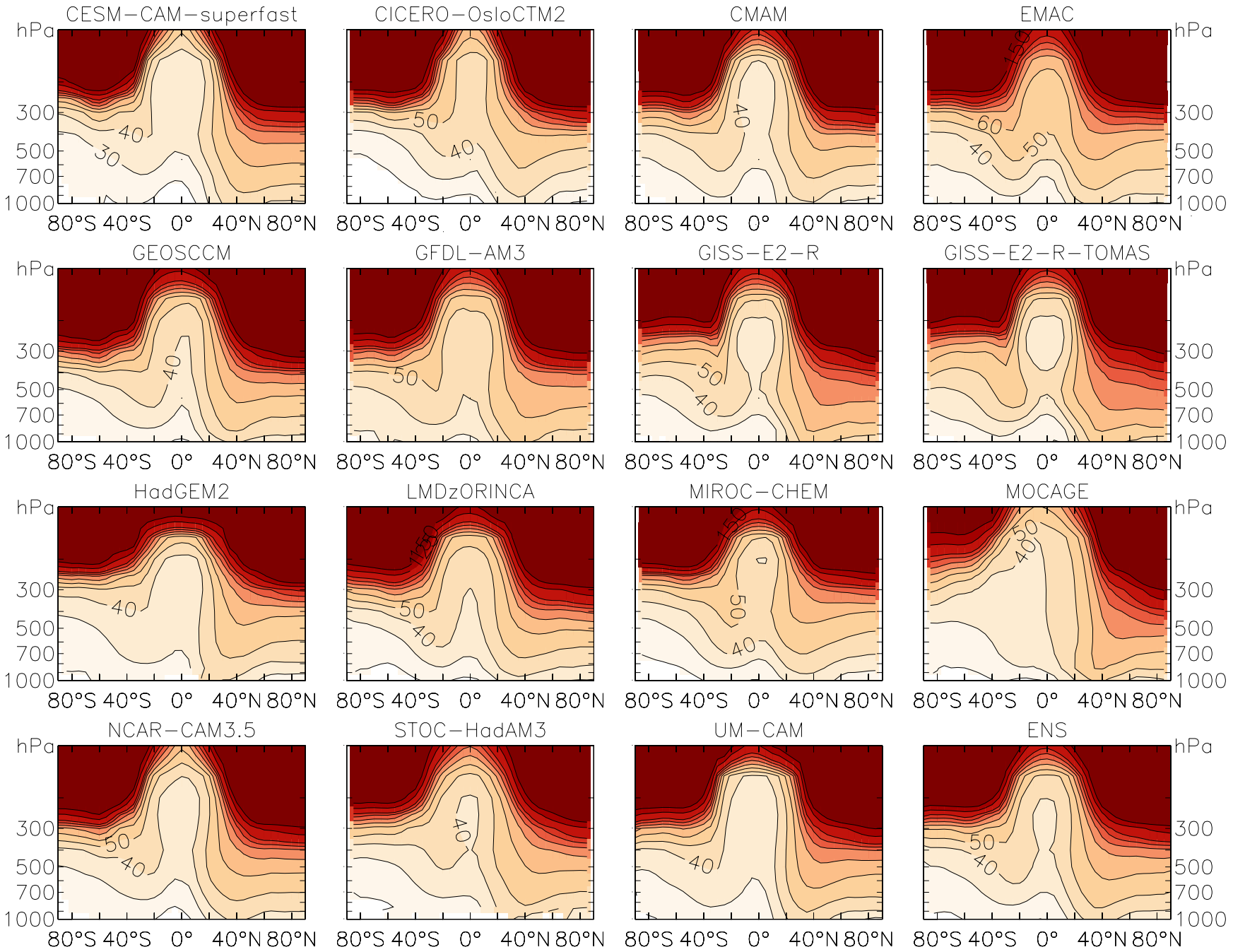


Fig S1. Ann. mean ZM O3 / ppbv (Hist 2000)

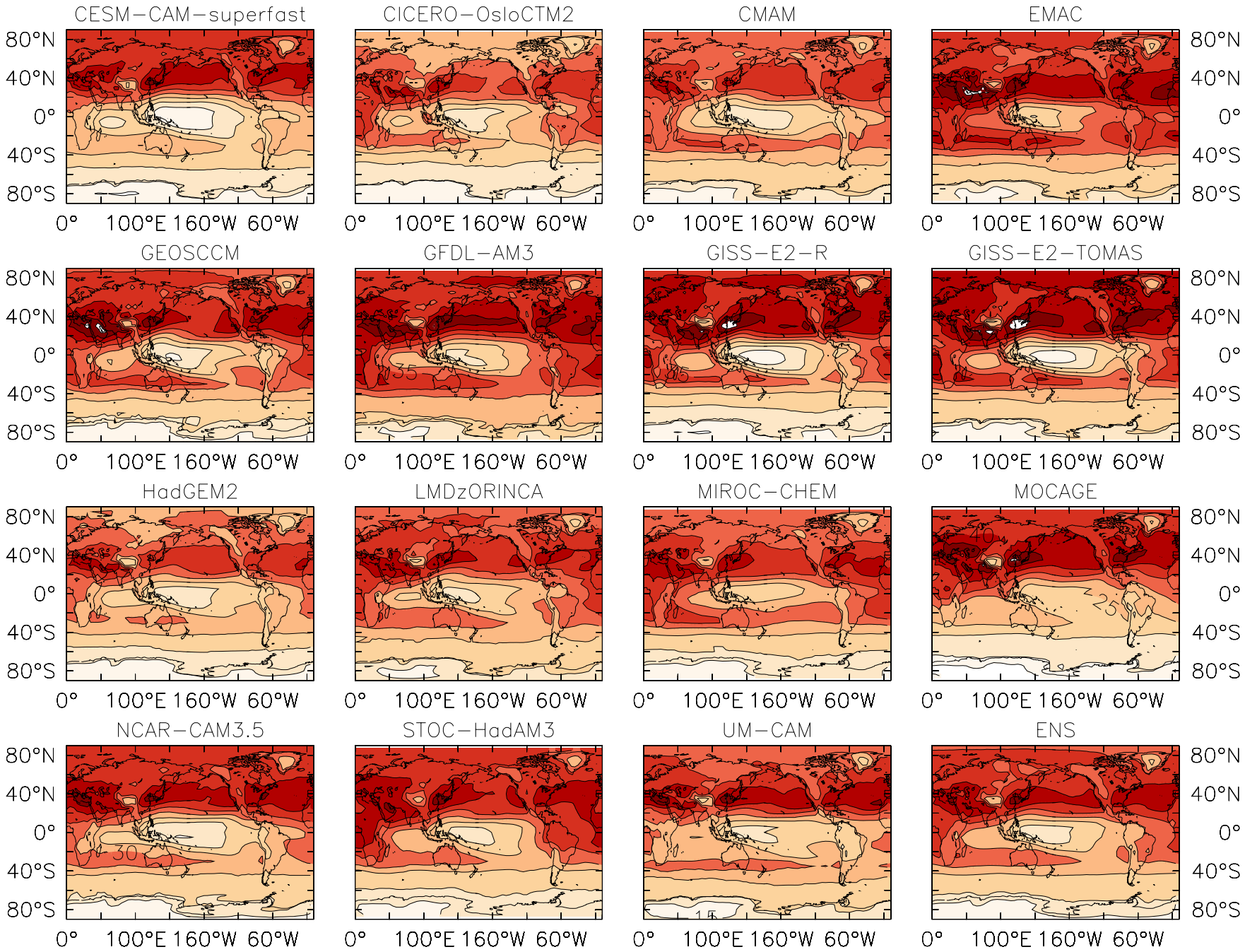


Fig S2. Ann. mean tropospheric col O3 / DU (Hist 2000)

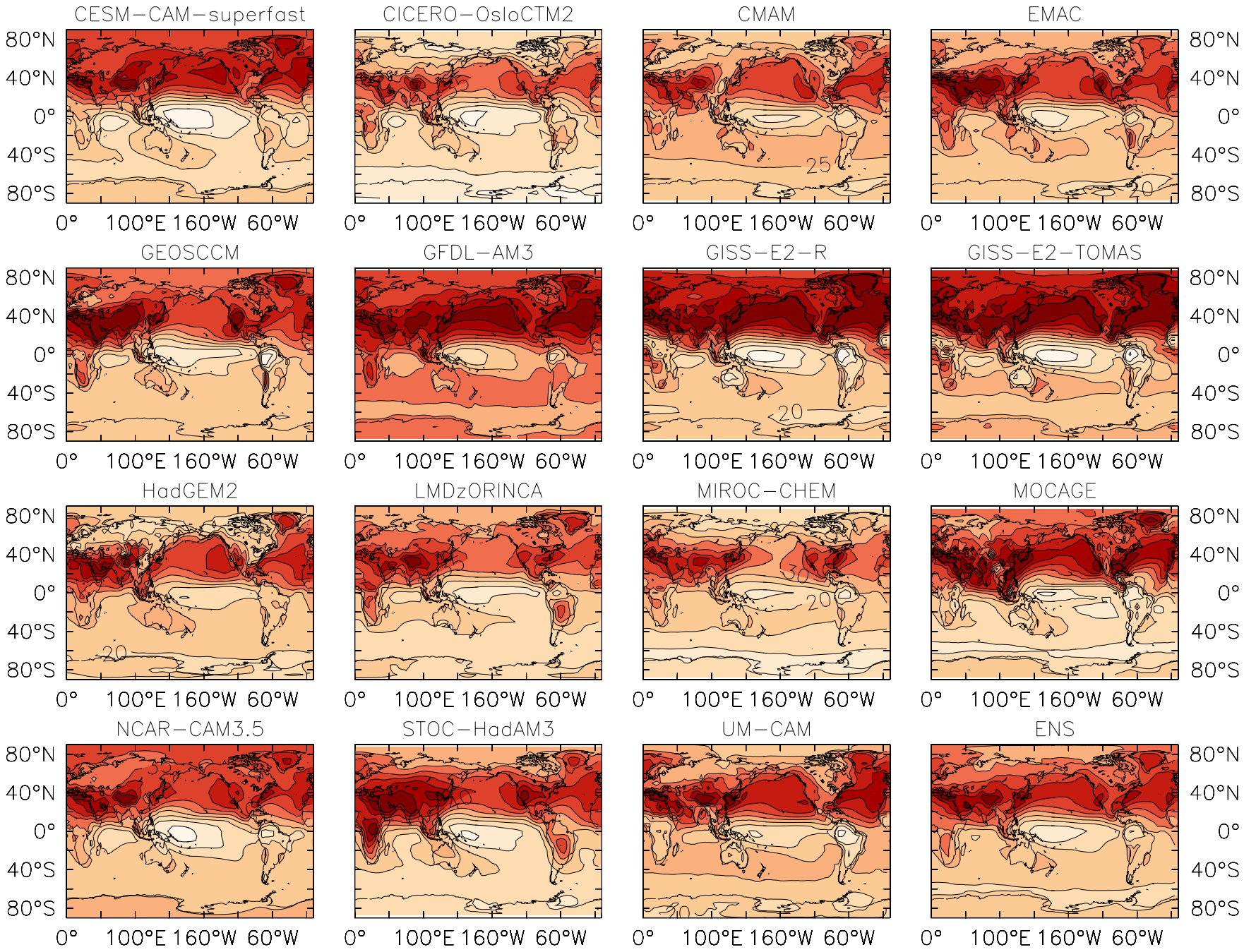


Fig S3. Ann. mean surf O3 / ppbv (Hist 2000)

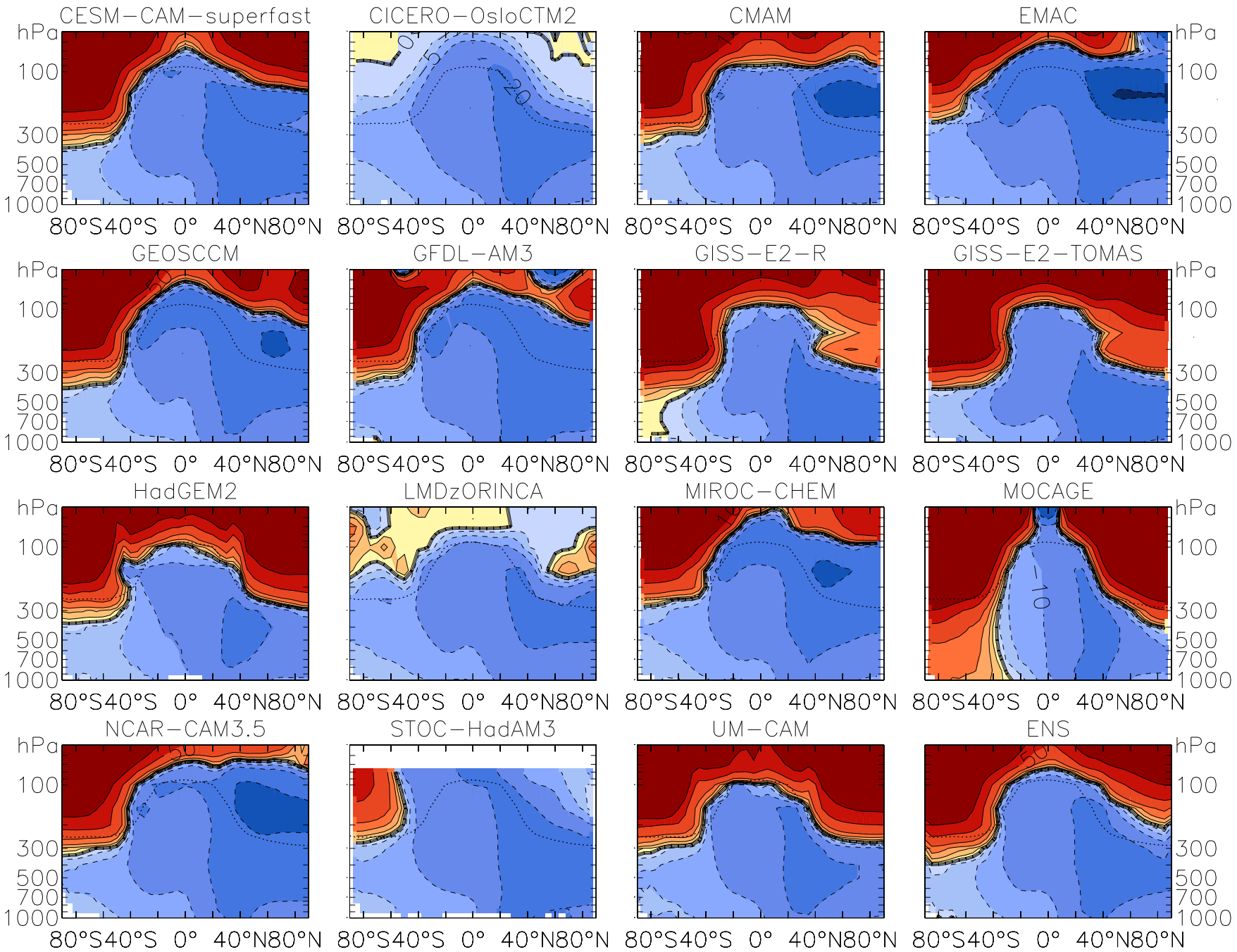


Fig S4. Change in annual zonal mean ozone: Hist 1850 − Hist 2000 / ppbv

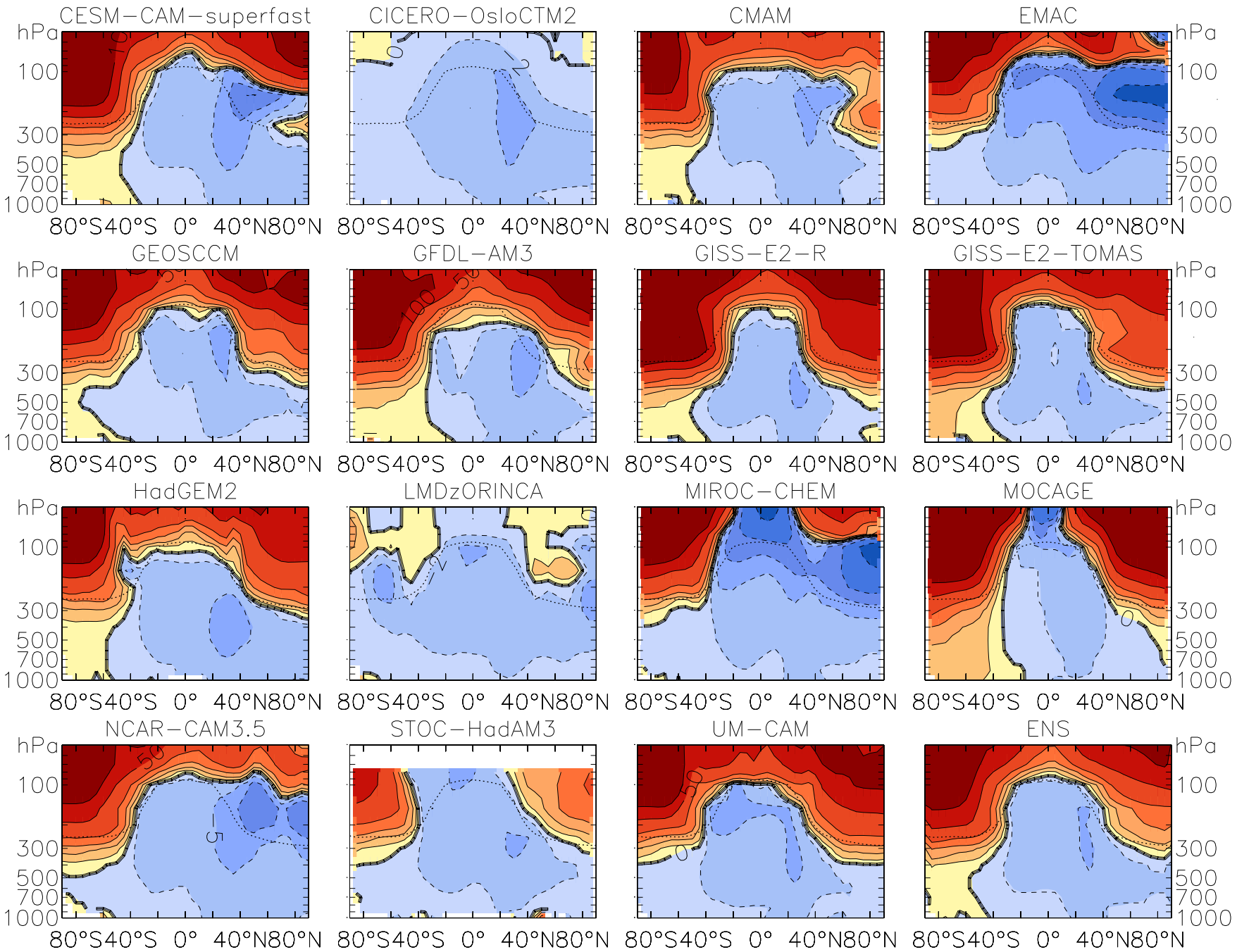


Fig S4 (cont). Change in annual zonal mean ozone: Hist 1980 − Hist 2000 / ppbv

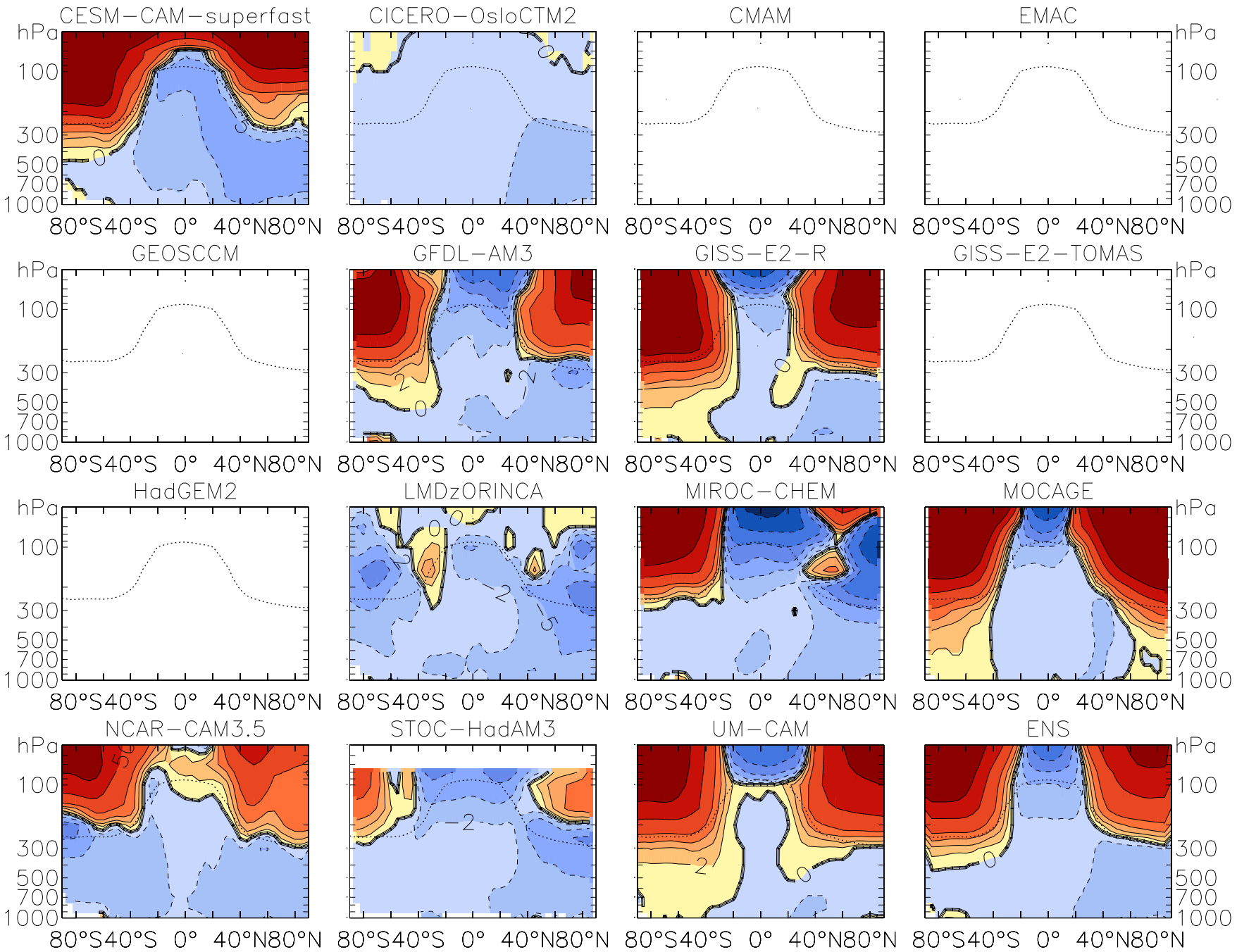


Fig S4 (cont). Change in annual zonal mean ozone: RCP26 2030 − Hist 2000 / ppbv

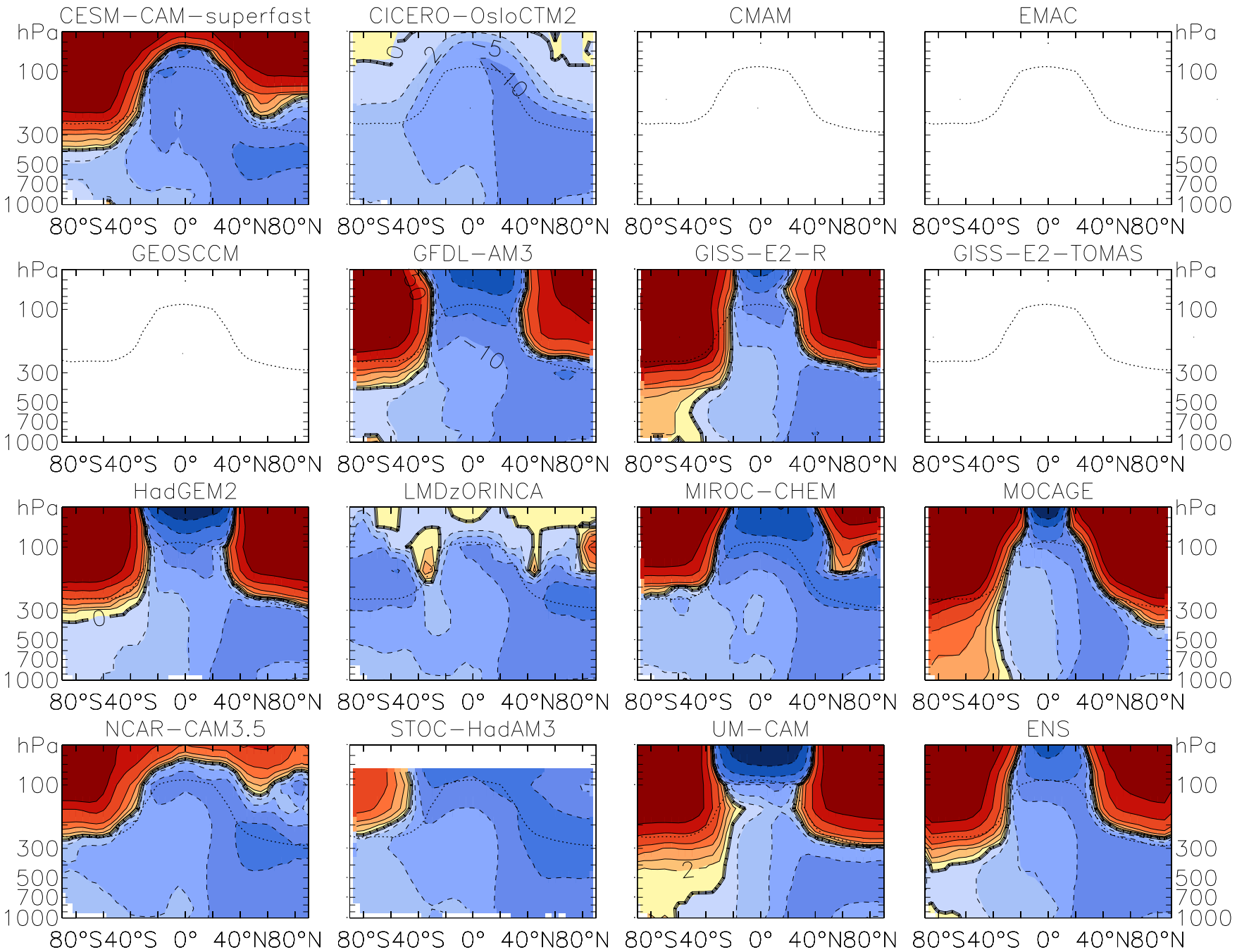


Fig S4 (cont). Change in annual zonal mean ozone: RCP26 2100 − Hist 2000 / ppbv

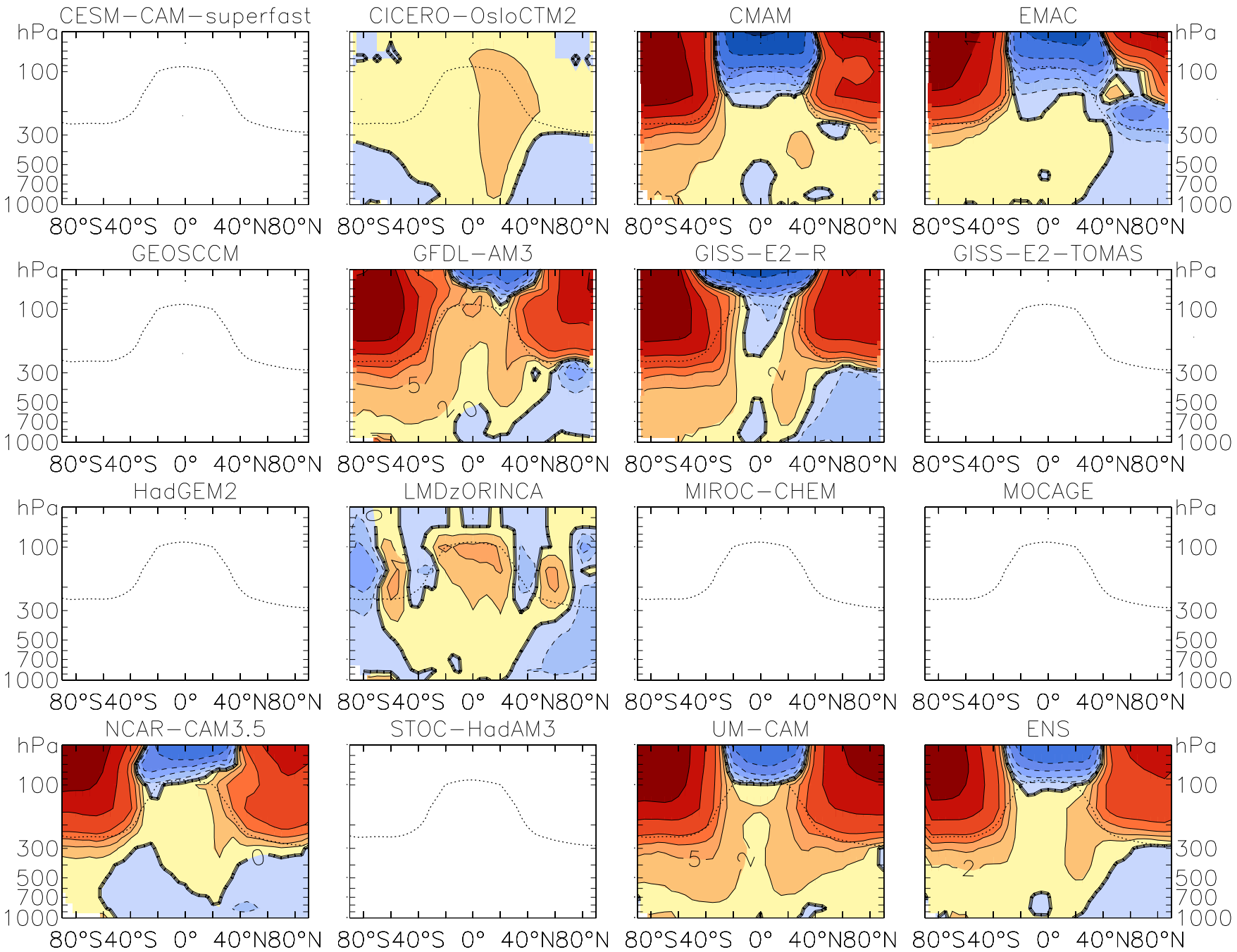


Fig S4 (cont). Change in annual zonal mean ozone: RCP45 2030 − Hist 2000 / ppbv

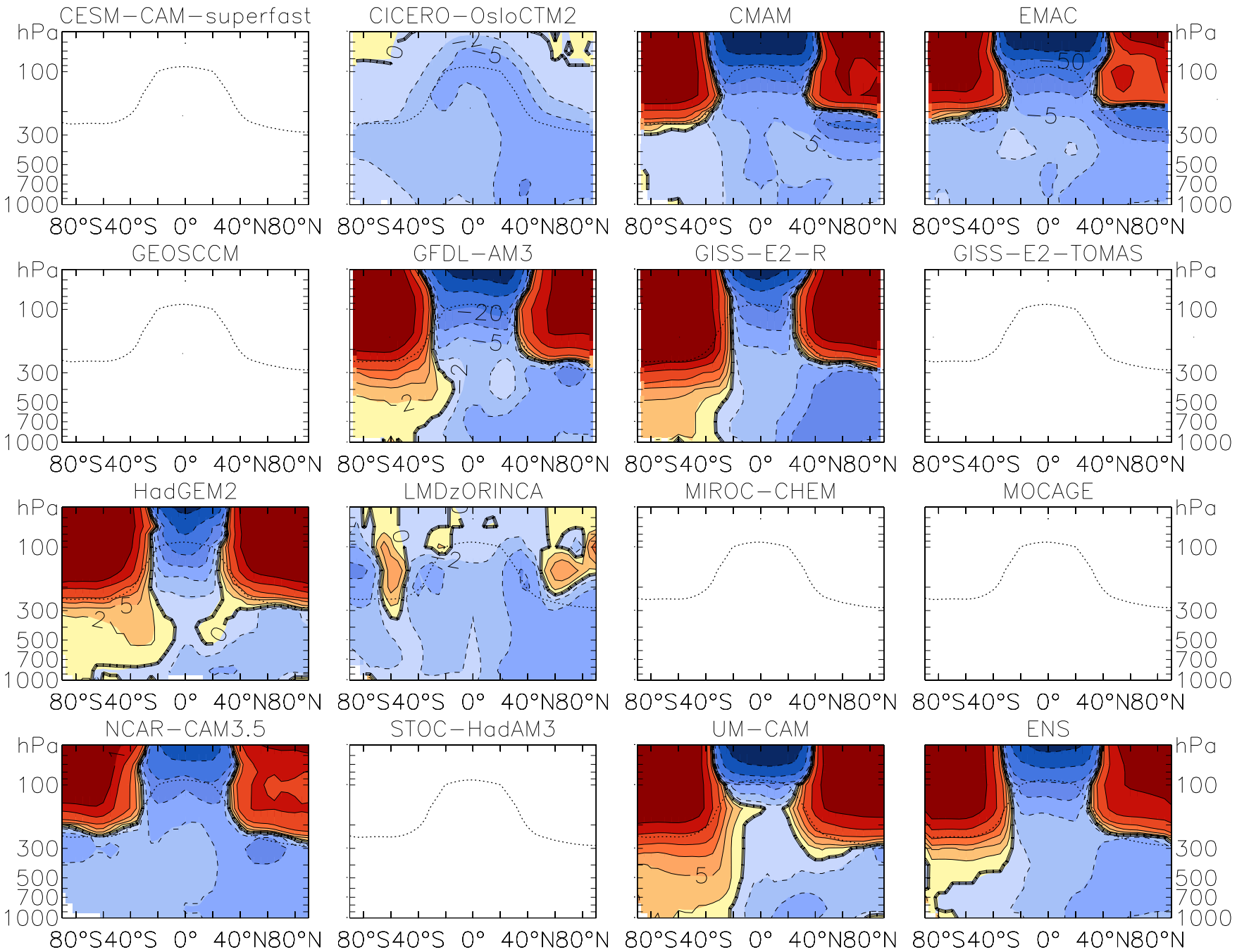


Fig S4 (cont). Change in annual zonal mean ozone: RCP45 2100 − Hist 2000 / ppbv

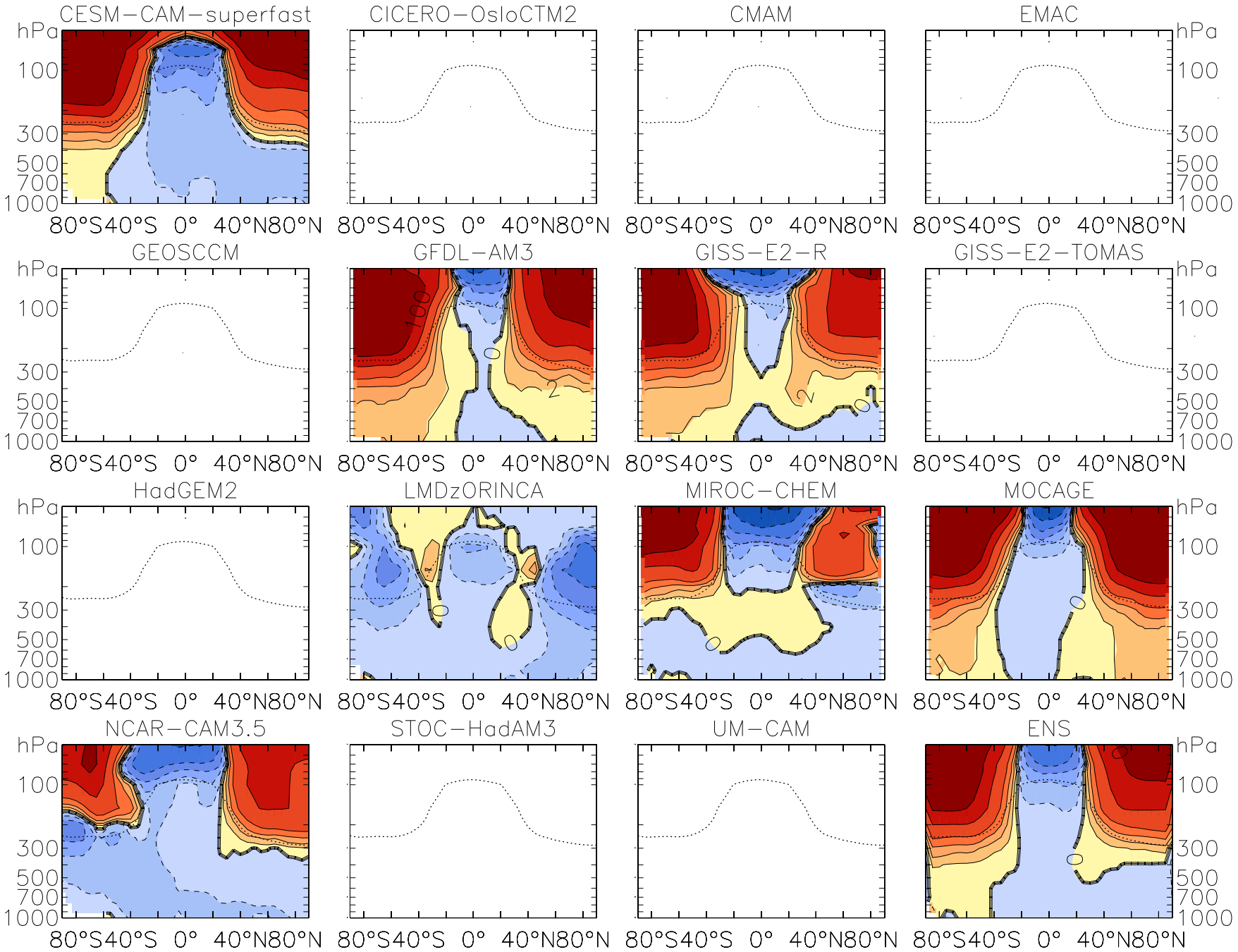


Fig S4 (cont). Change in annual zonal mean ozone: RCP60 2030 − Hist 2000 / ppbv

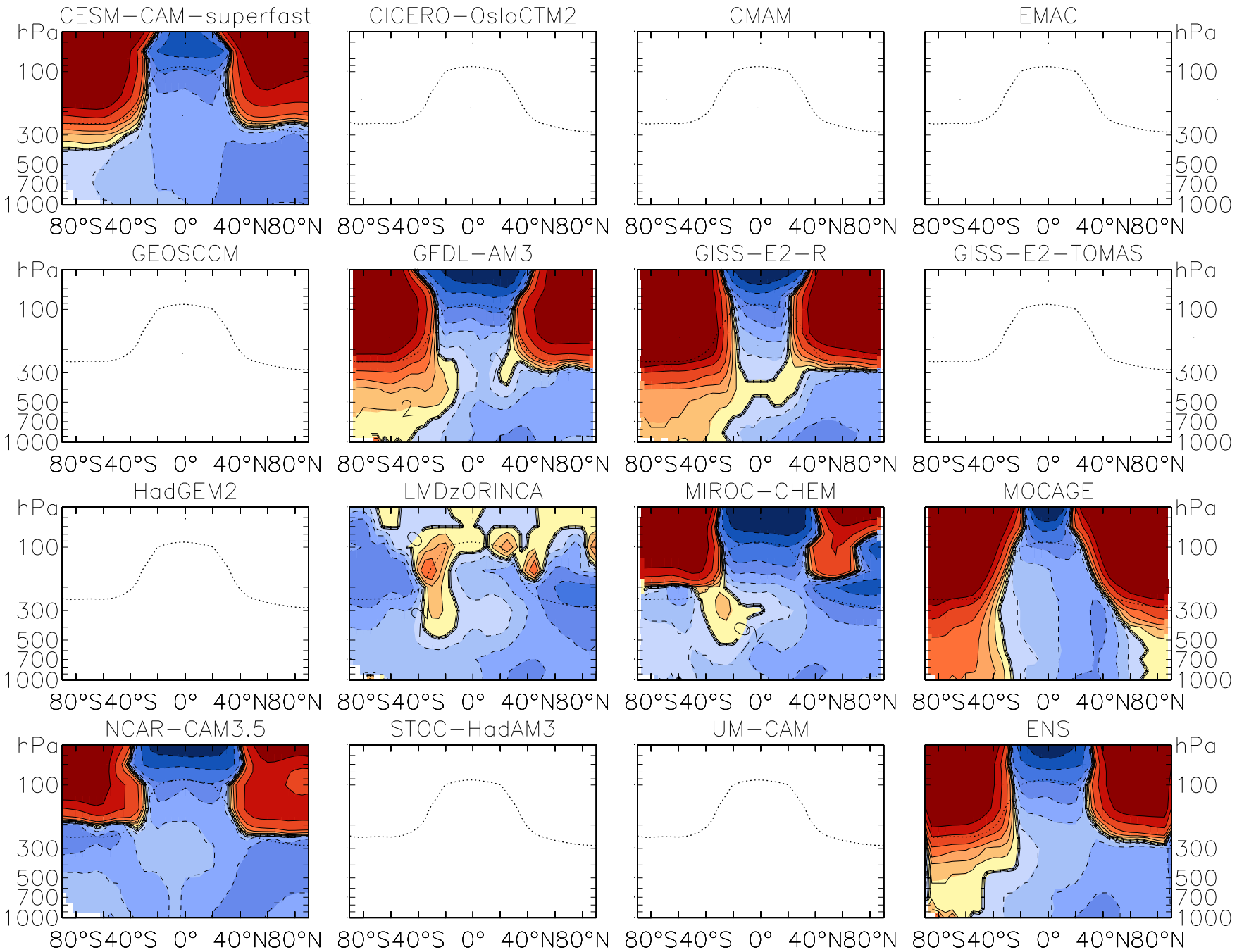


Fig S4 (cont). Change in annual zonal mean ozone: RCP60 2100 − Hist 2000 / ppbv

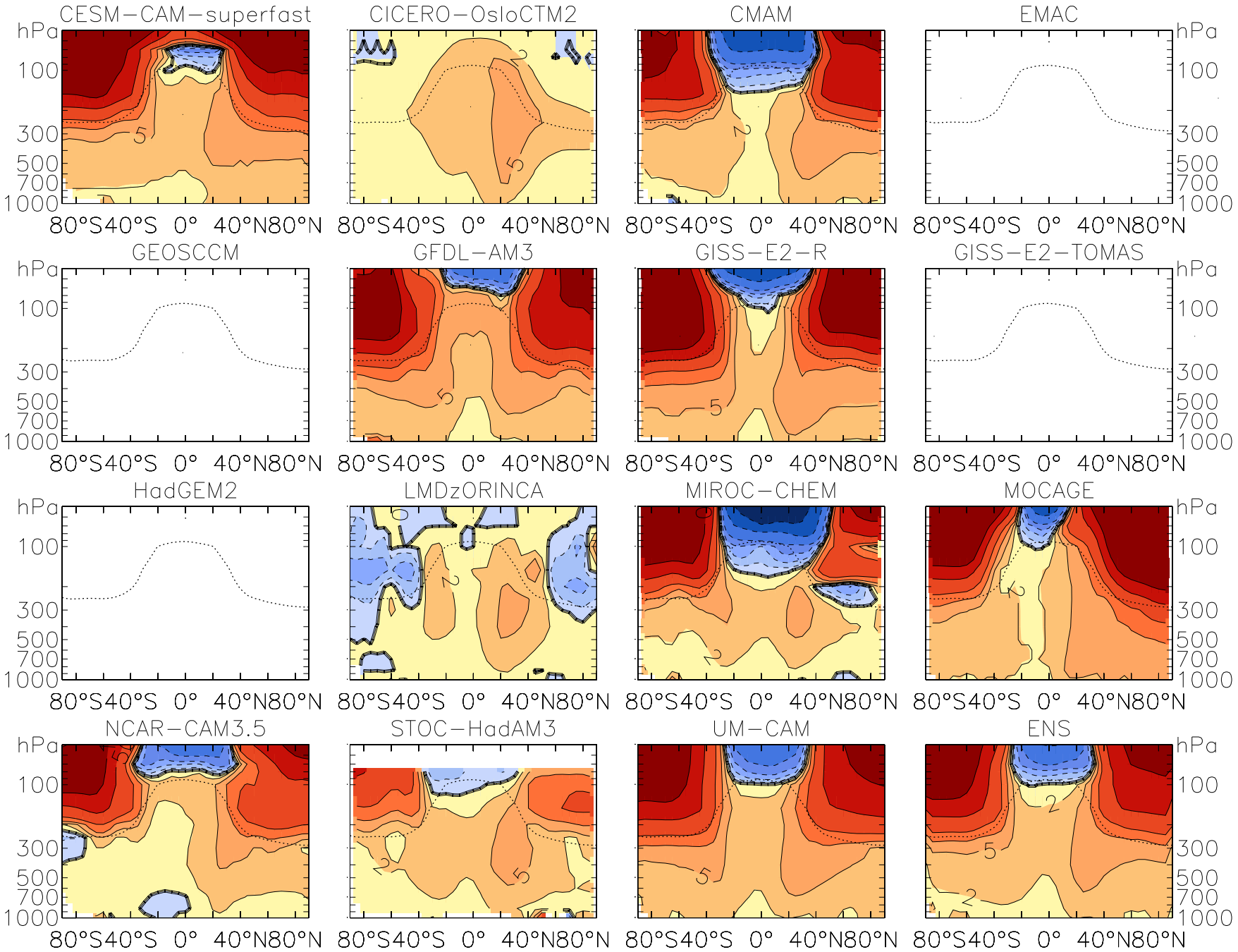


Fig S4 (cont). Change in annual zonal mean ozone: RCP85 2030 − Hist 2000 / ppbv

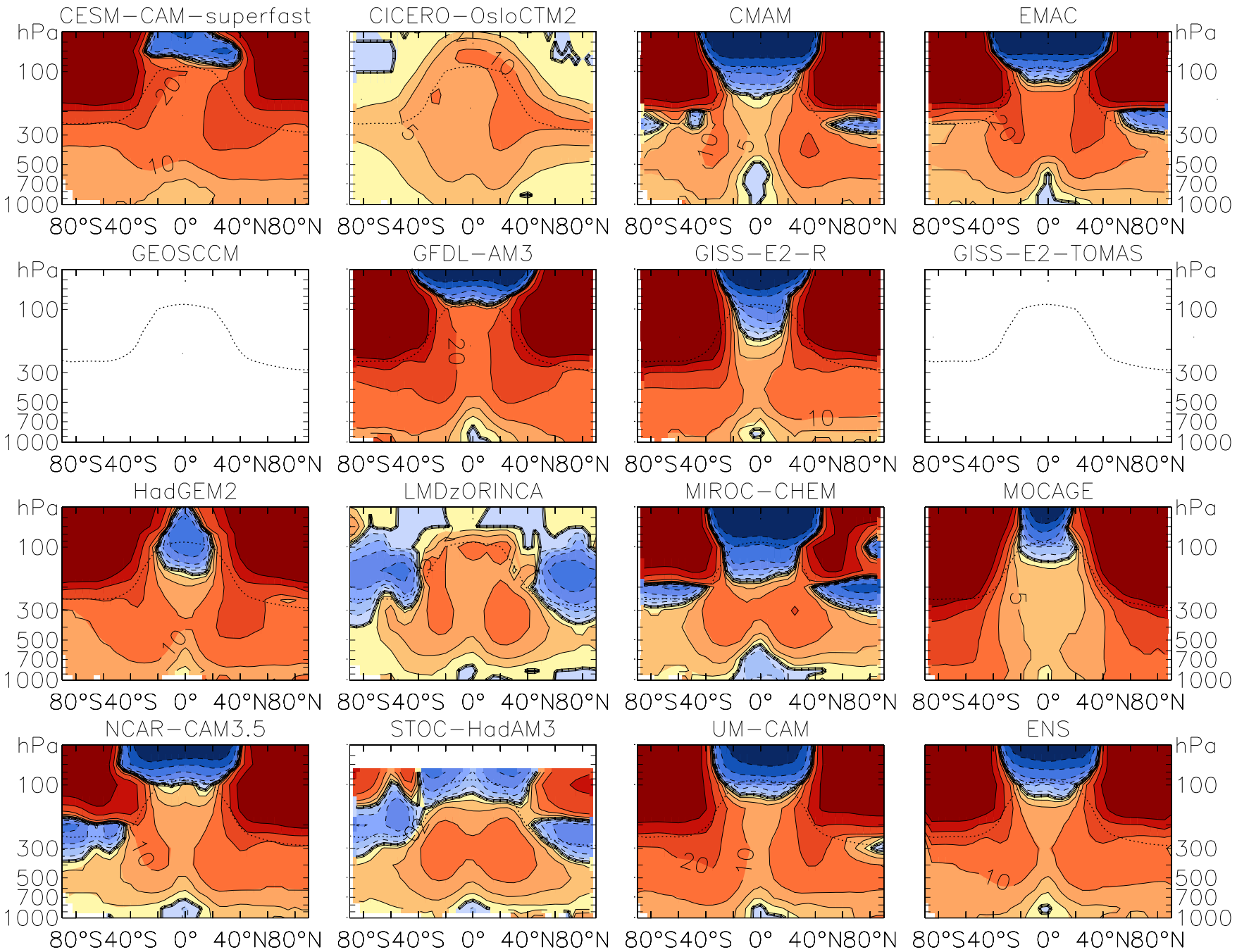


Fig S4 (cont). Change in annual zonal mean ozone: RCP85 2100 − Hist 2000 / ppbv

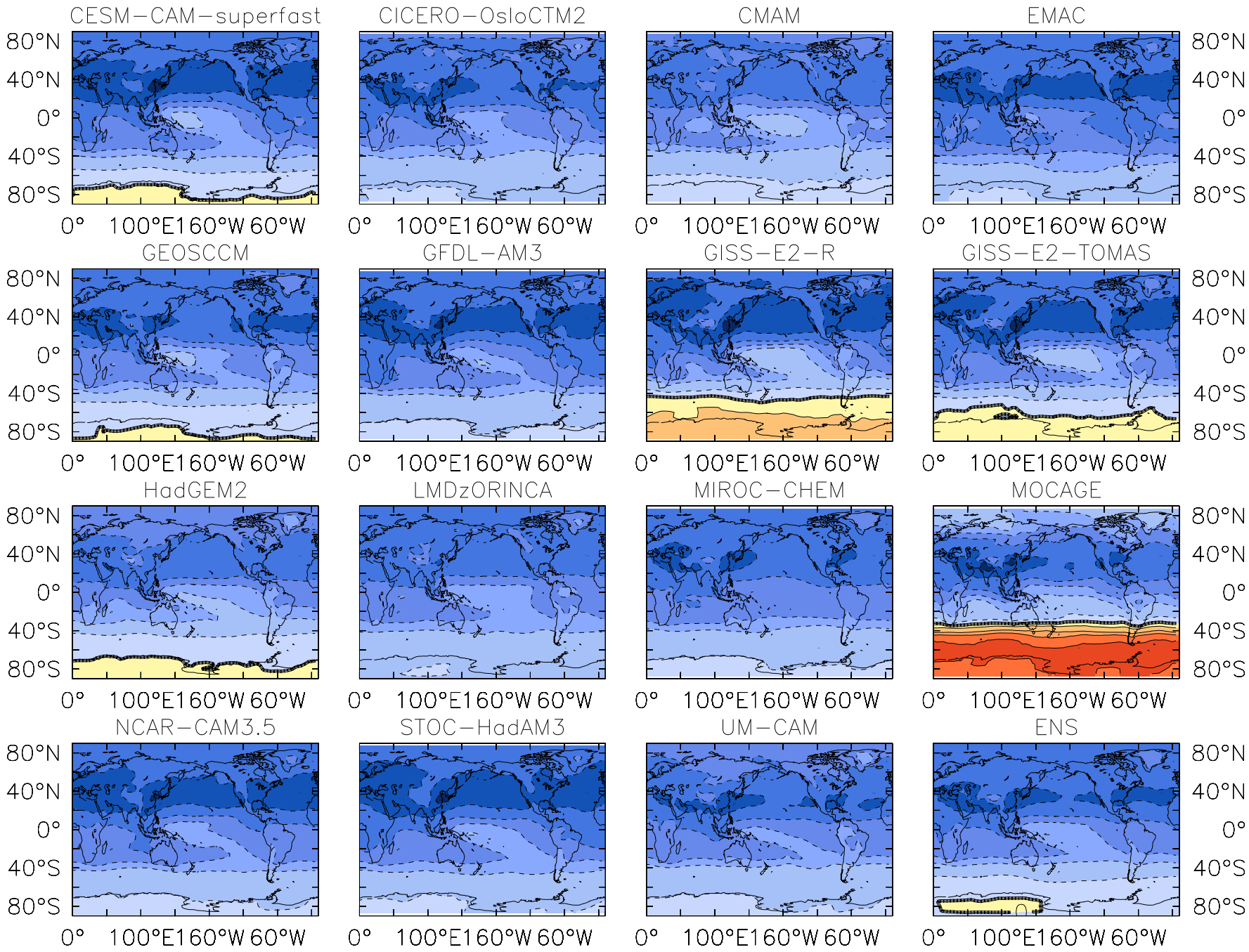


Fig S5. Change in annual mean tropospheric ozone column: Hist 1850 − Hist 2000 / DU

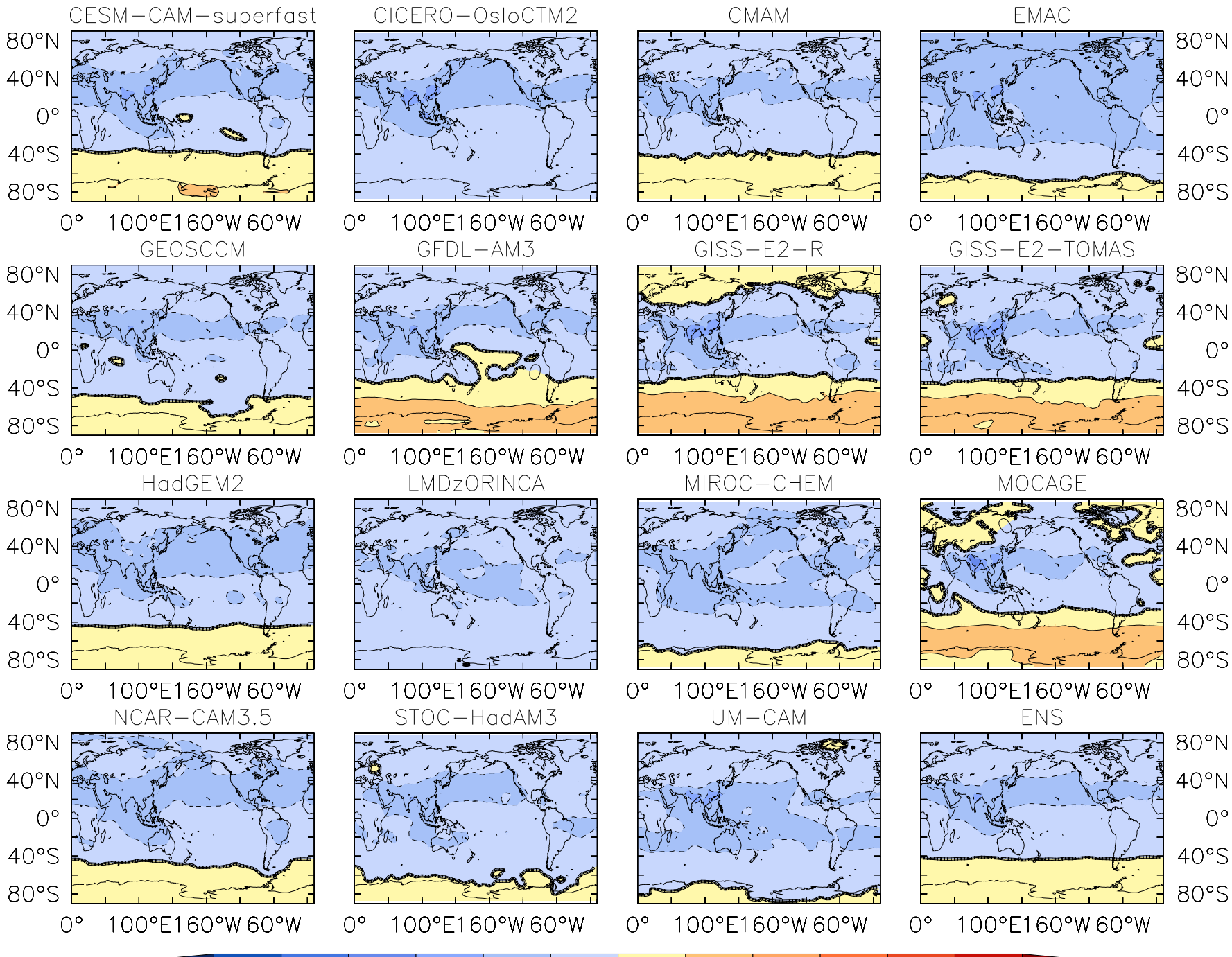


Fig S5 (cont). Change in annual mean tropospheric ozone column: Hist 1980 − Hist 2000 / DU

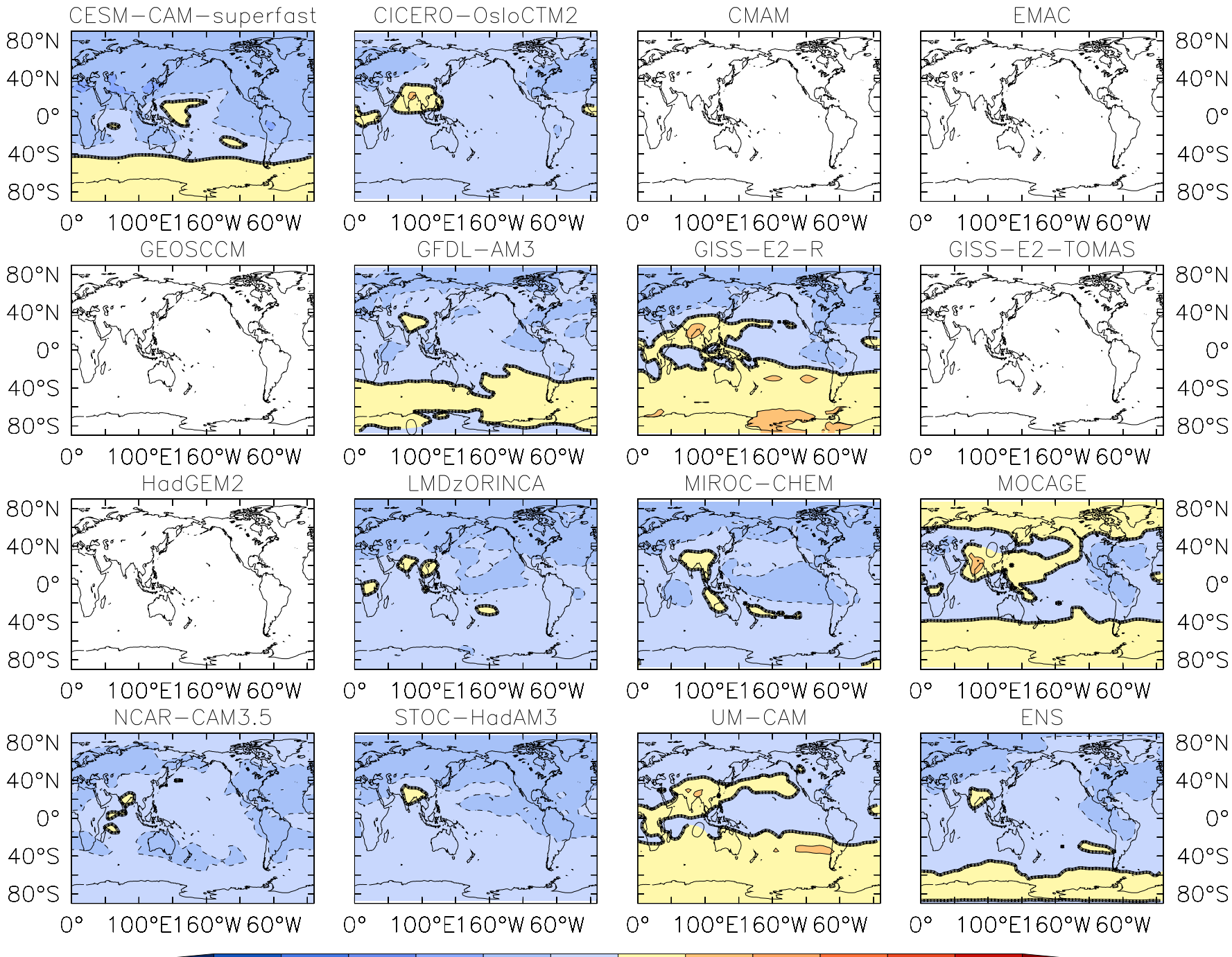


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP26 2030 − Hist 2000 / DU

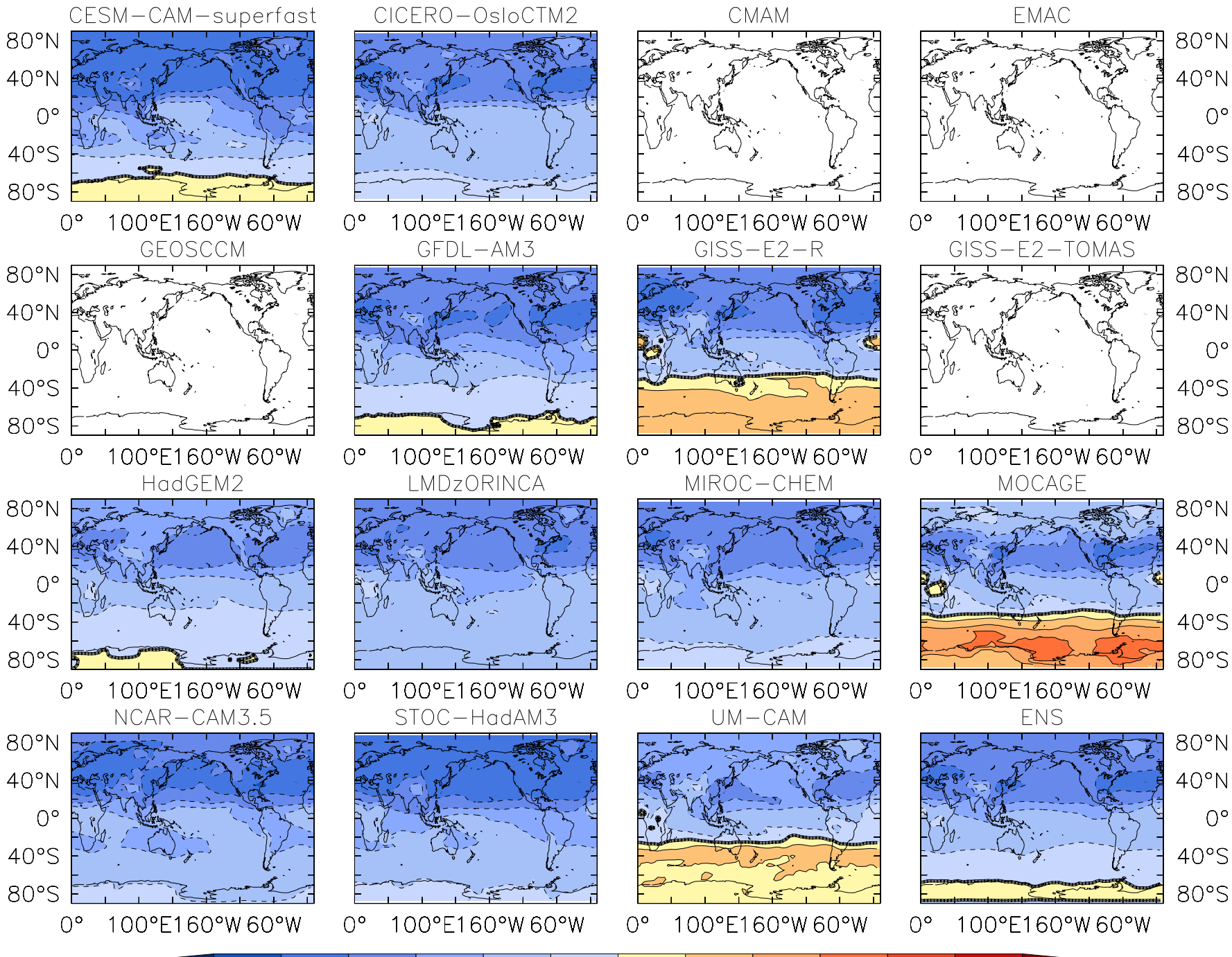


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP26 2100 − Hist 2000 / DU

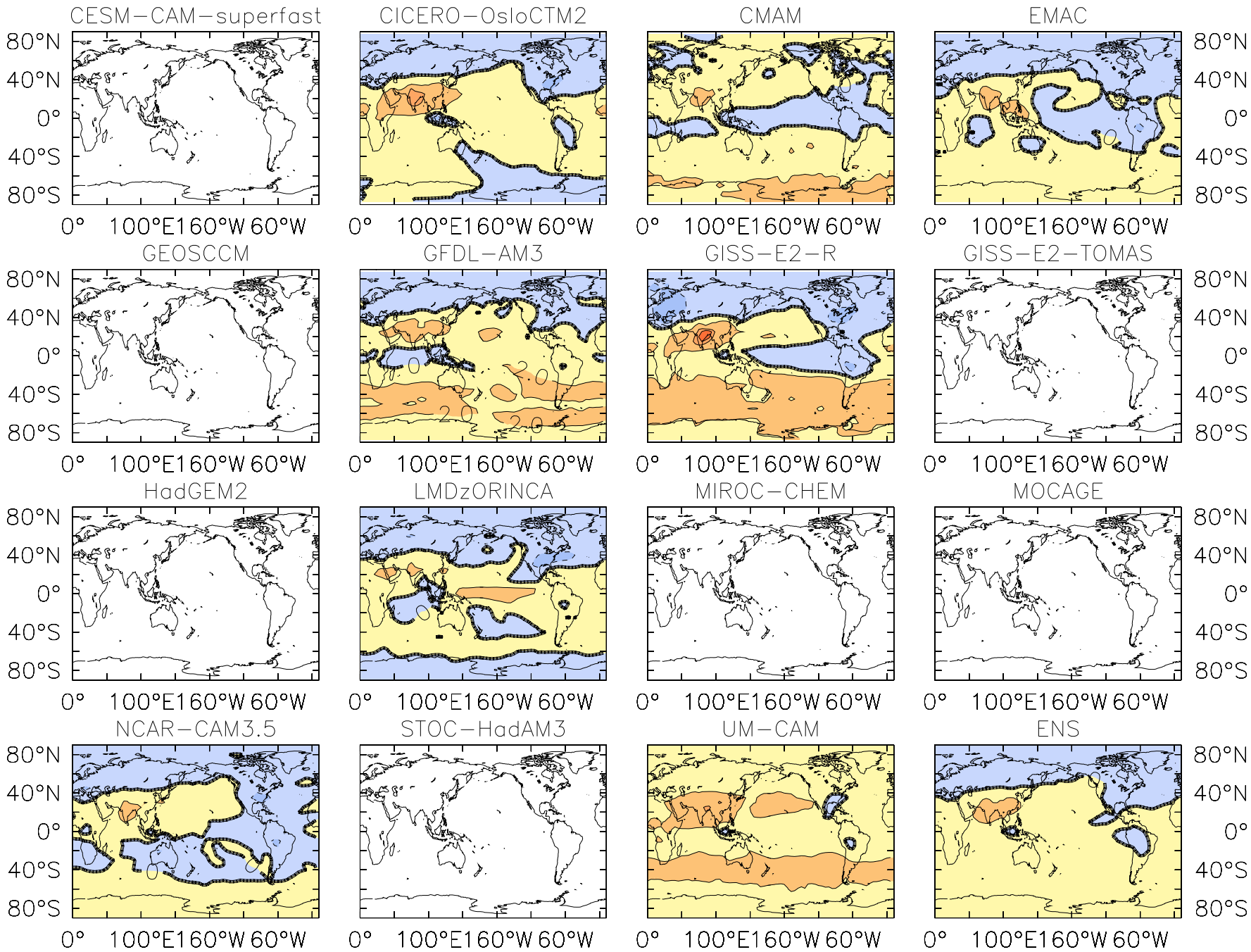


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP45 2030 − Hist 2000 / DU

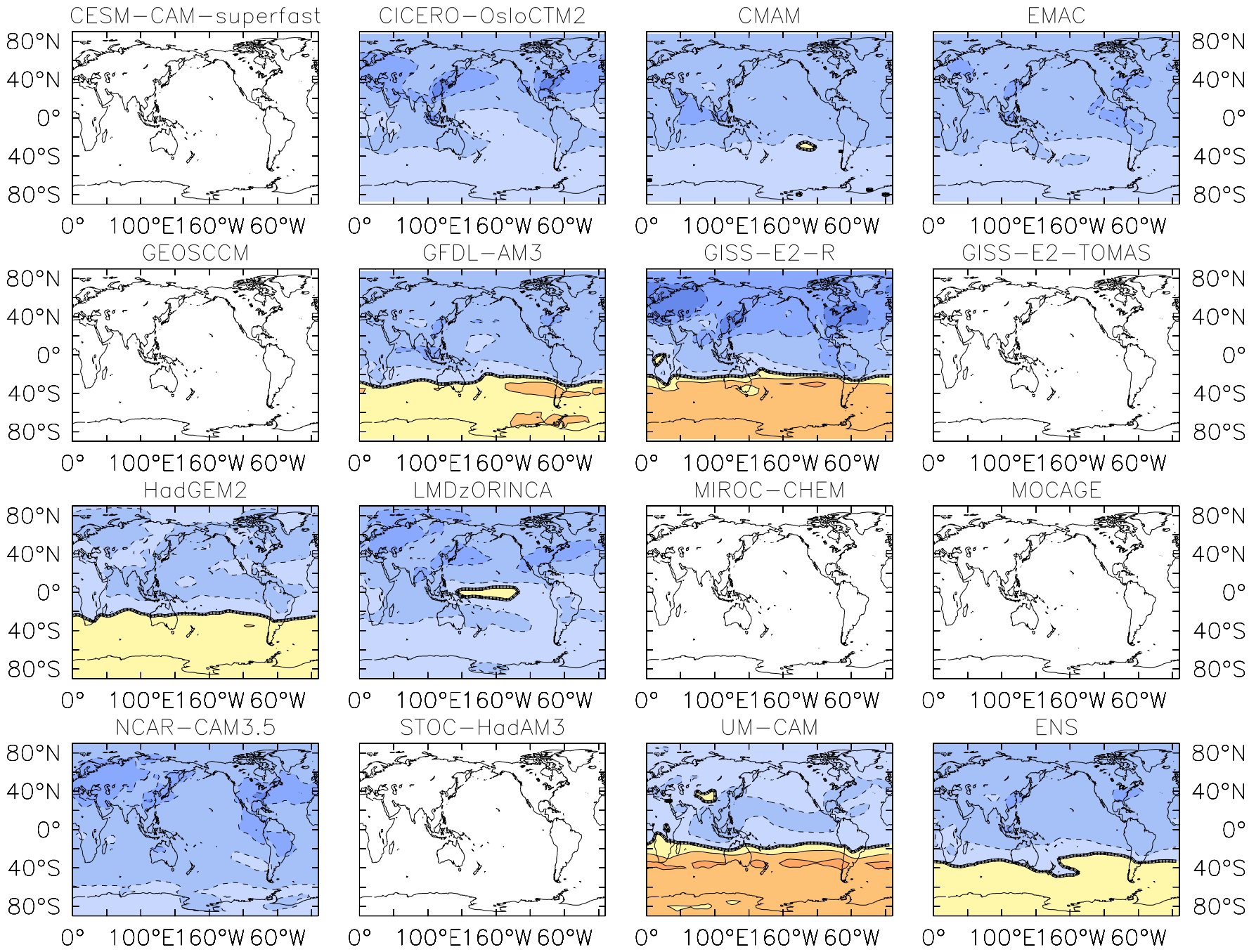


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP45 2100 − Hist 2000 / DU

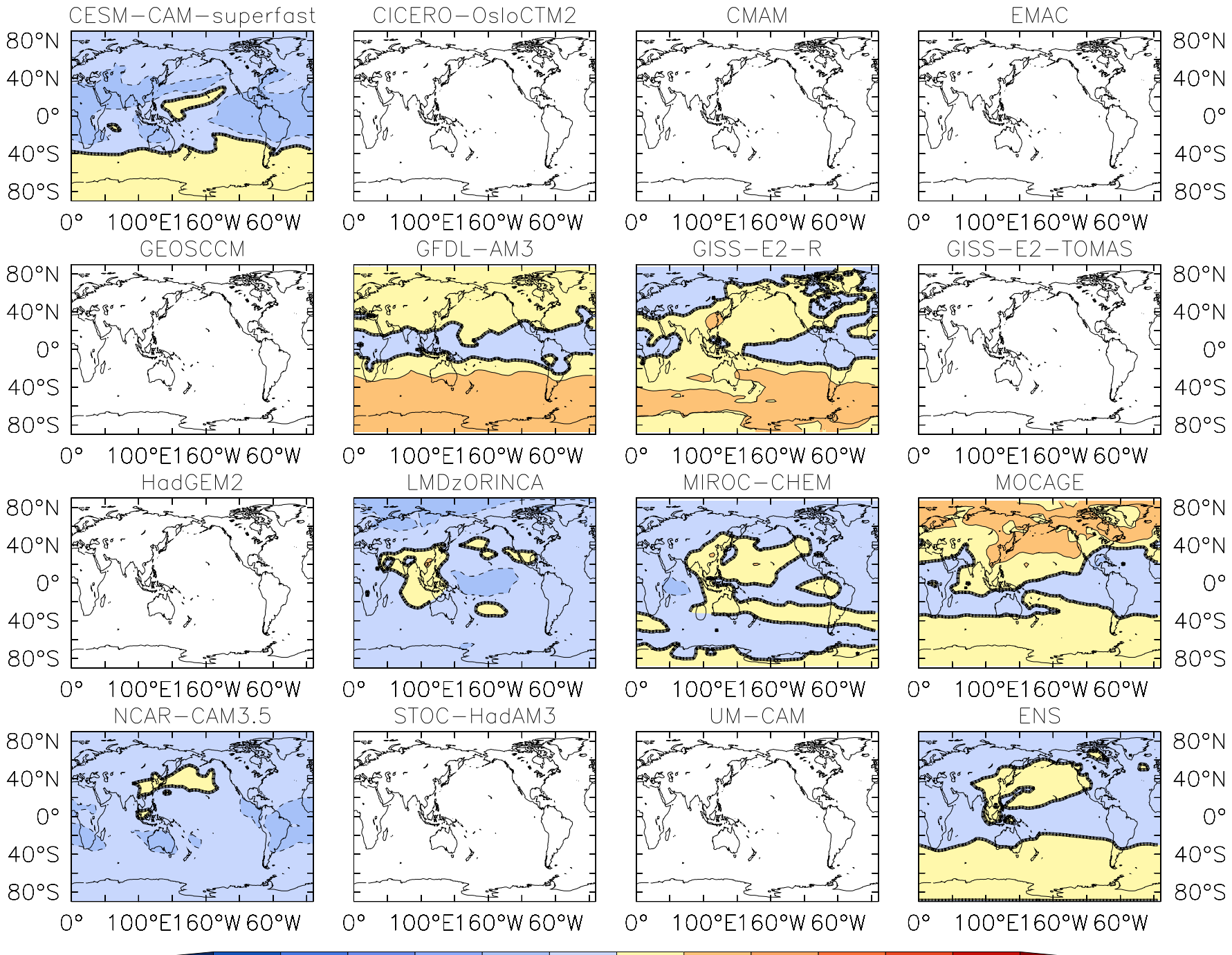


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP60 2030 − Hist 2000 / DU

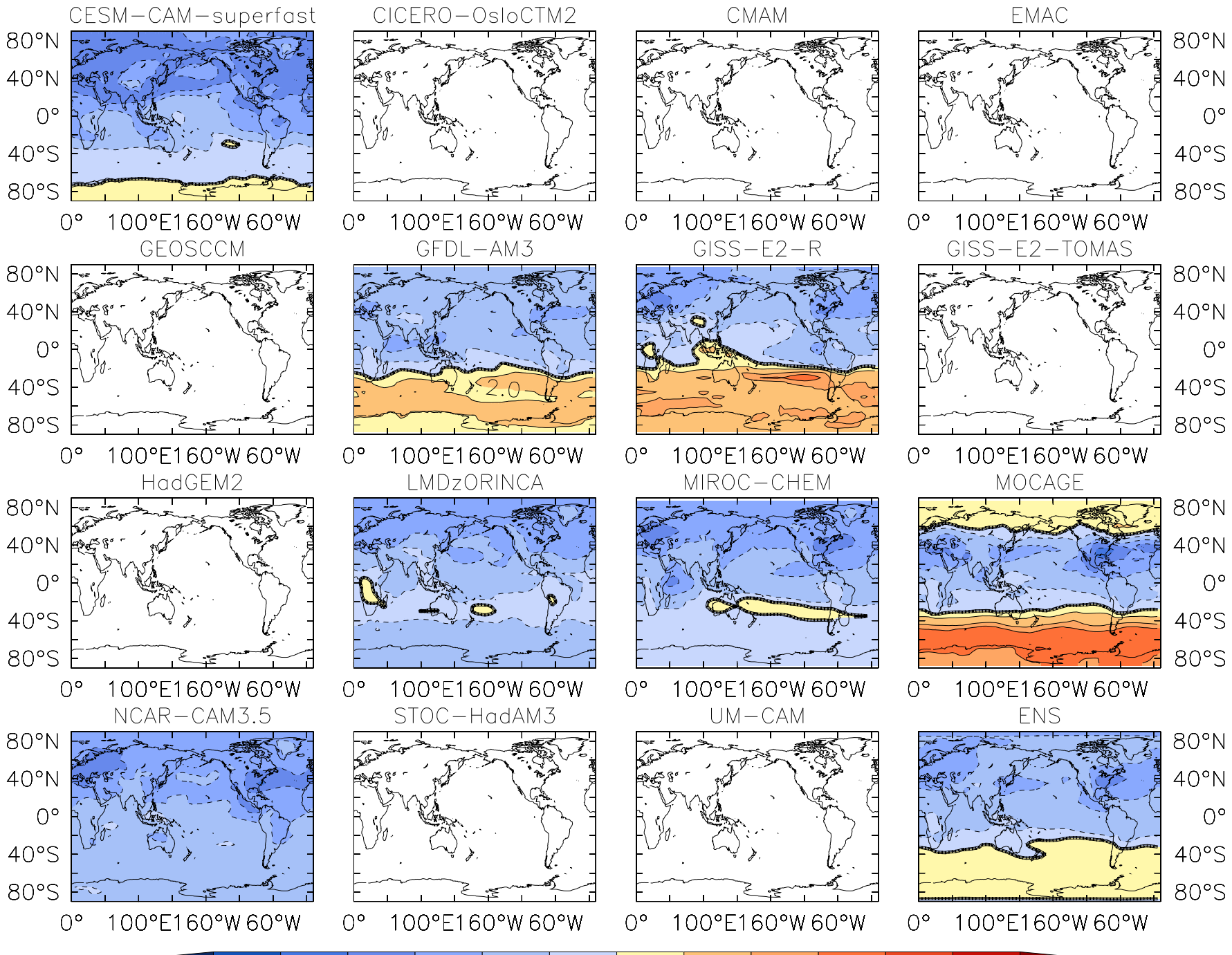
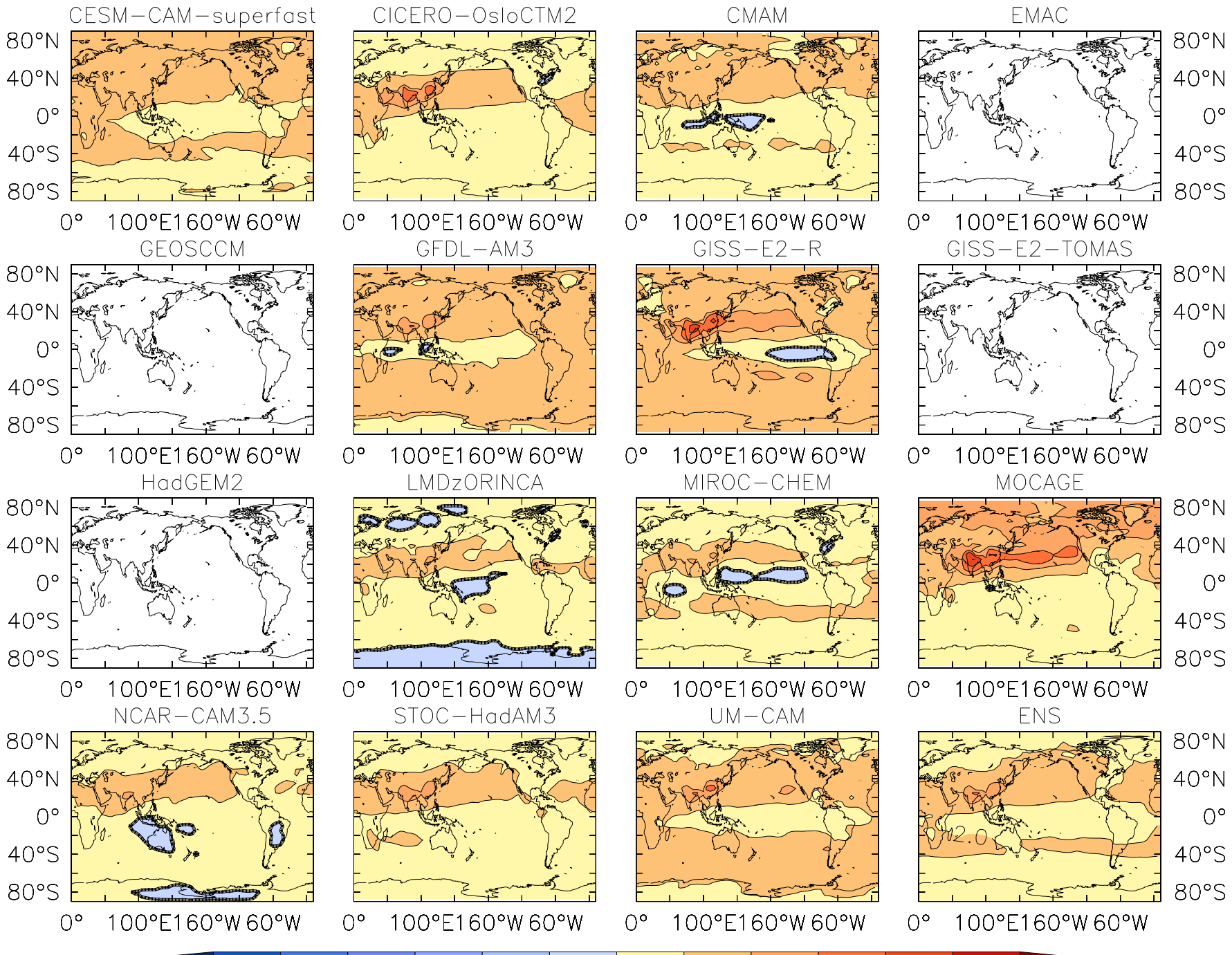


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP60 2100 − Hist 2000 / DU



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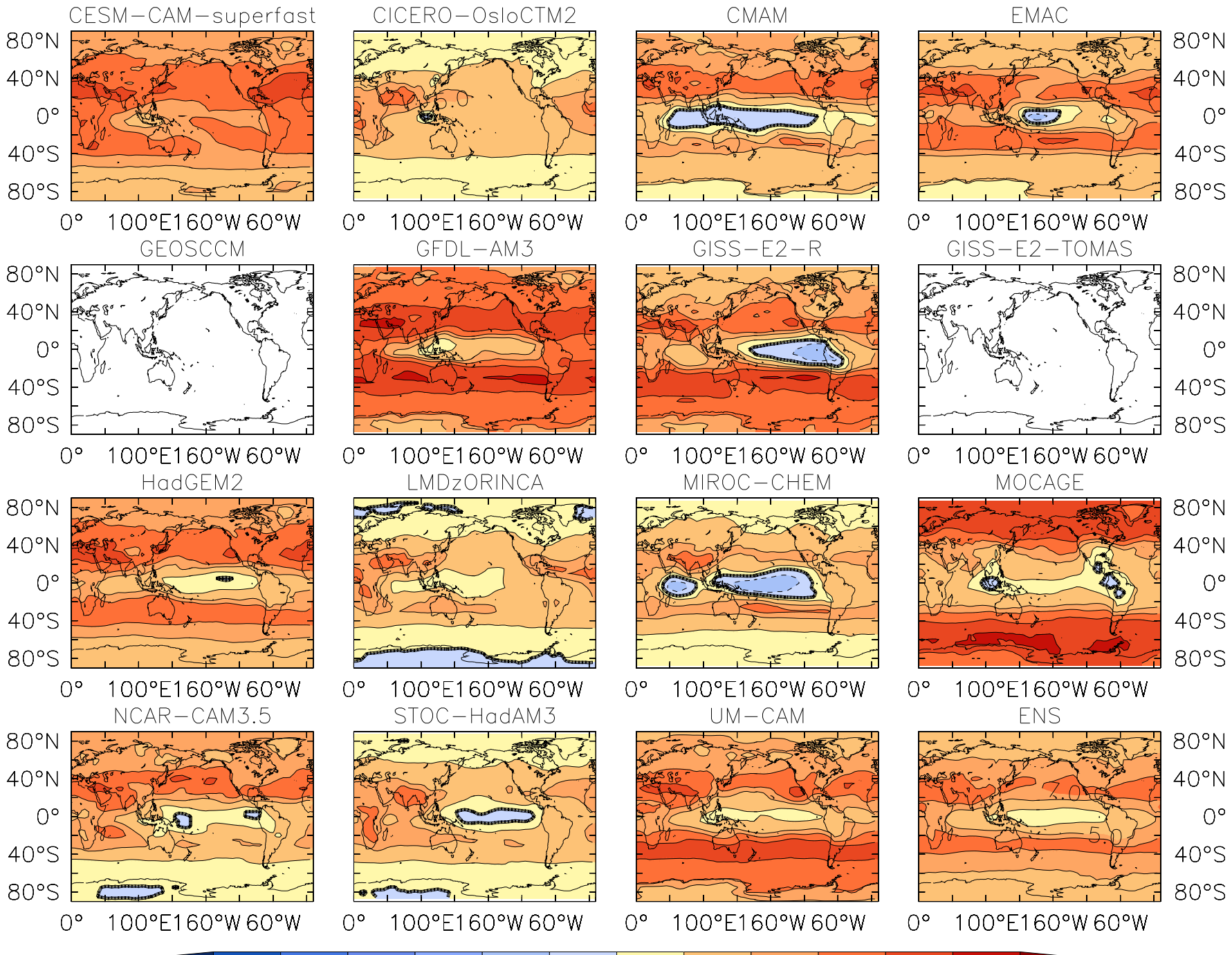


Fig S5 (cont). Change in annual mean tropospheric ozone column: RCP85 2100 − Hist 2000 / DU

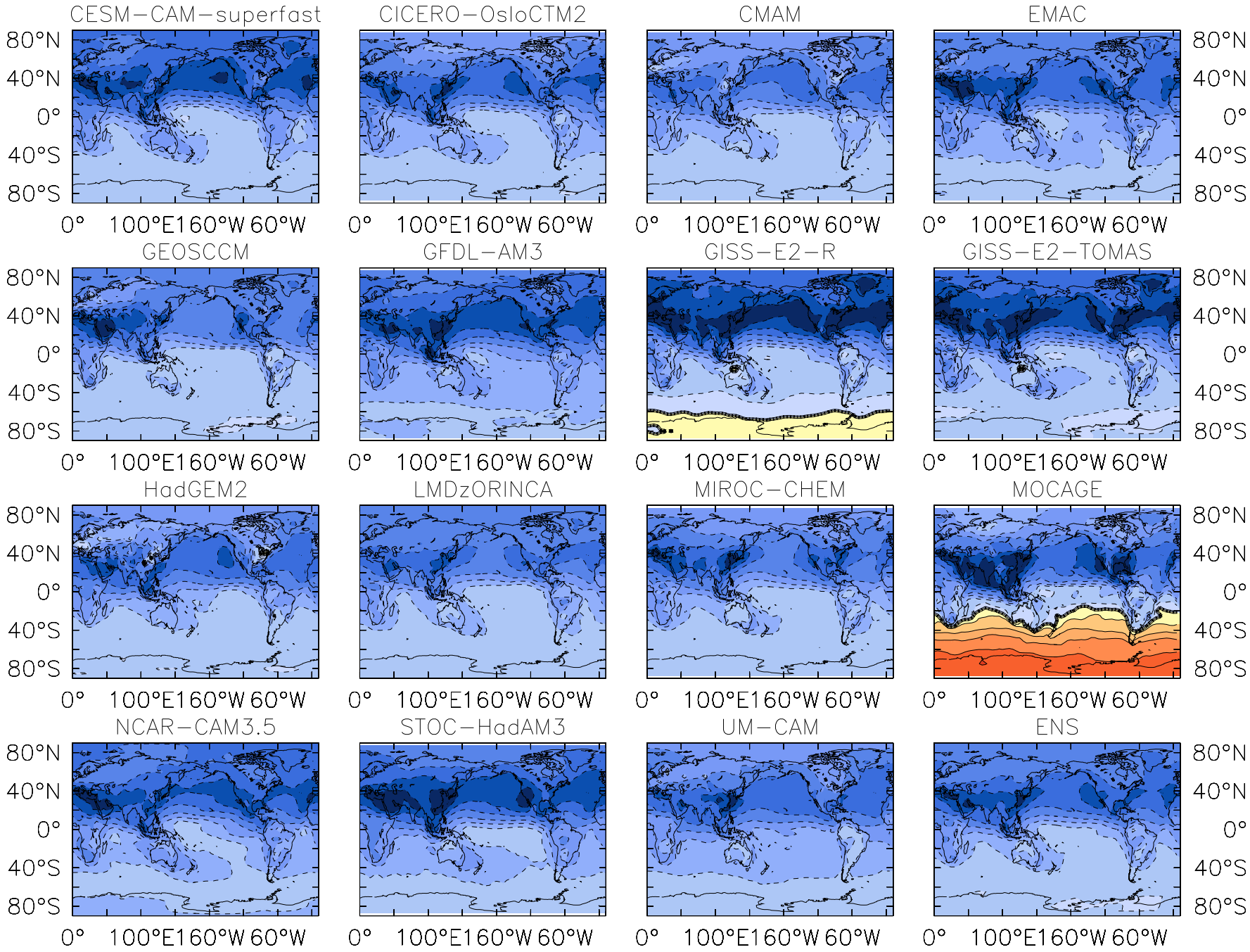


Fig S6. Change in annual mean surf ozone: Hist 1850 − Hist 2000 / ppbv

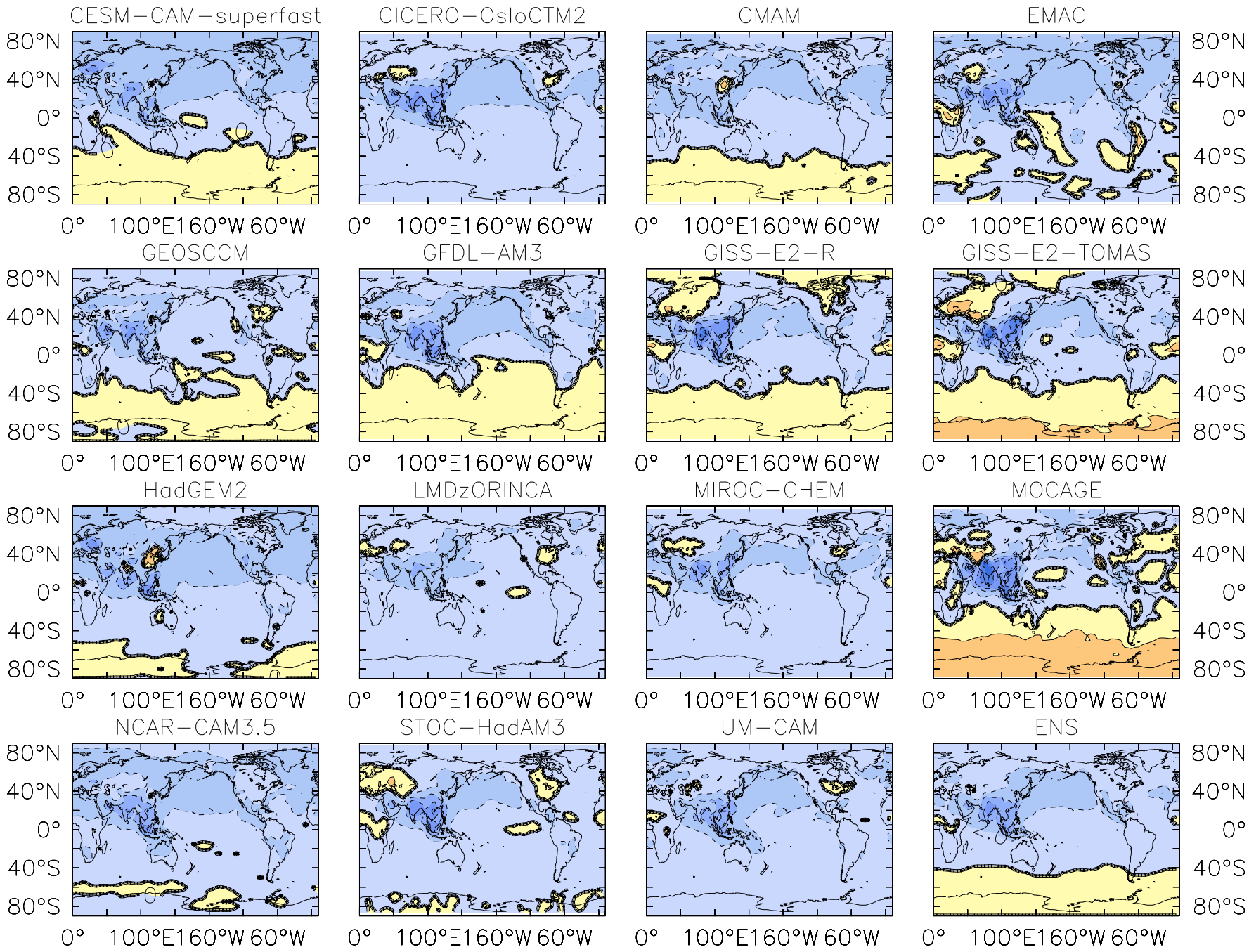


Fig S6 (cont). Change in annual mean surf ozone: Hist 1980 − Hist 2000 / ppbv

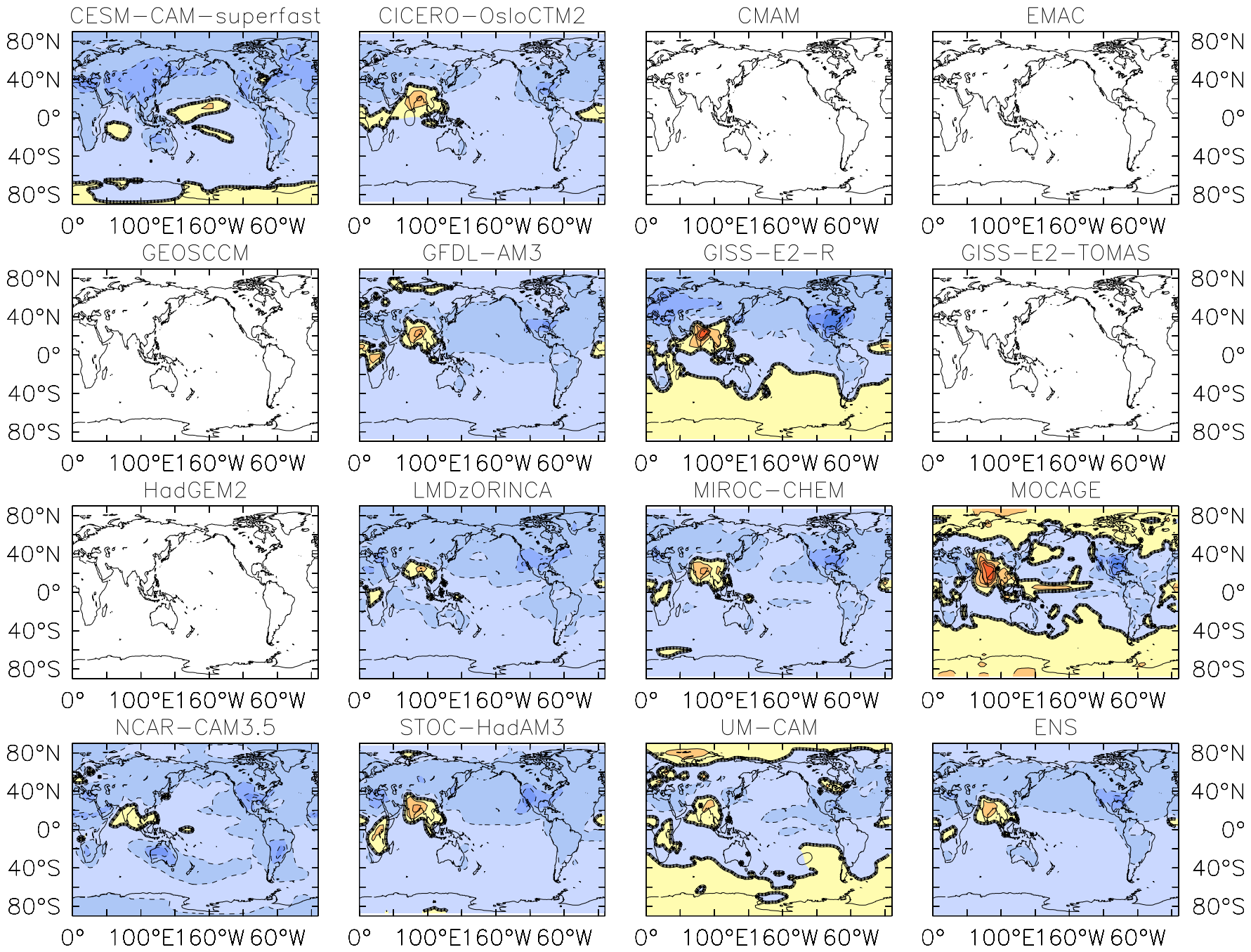


Fig S6 (cont). Change in annual mean surf ozone: RCP26 2030 − Hist 2000 / ppbv

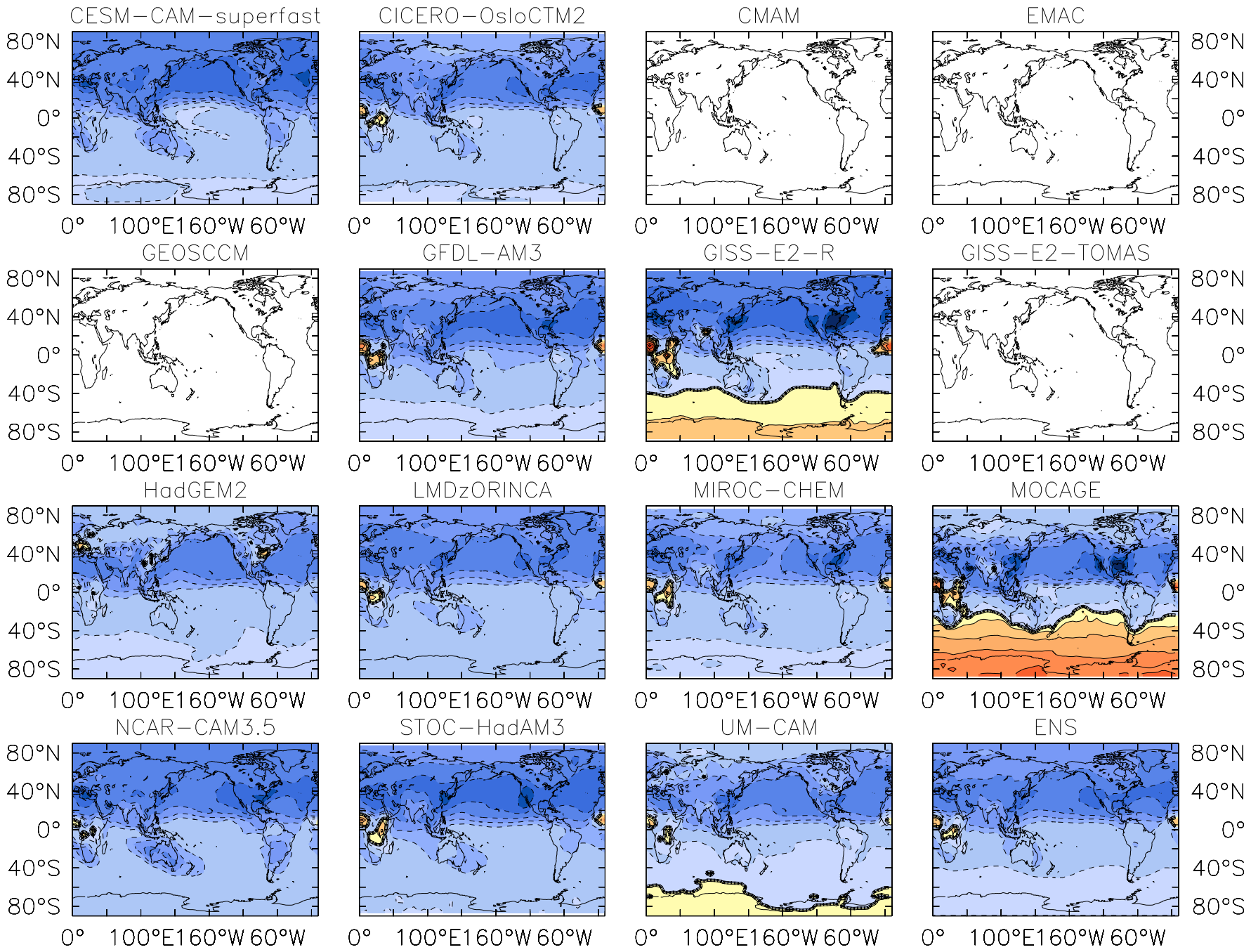
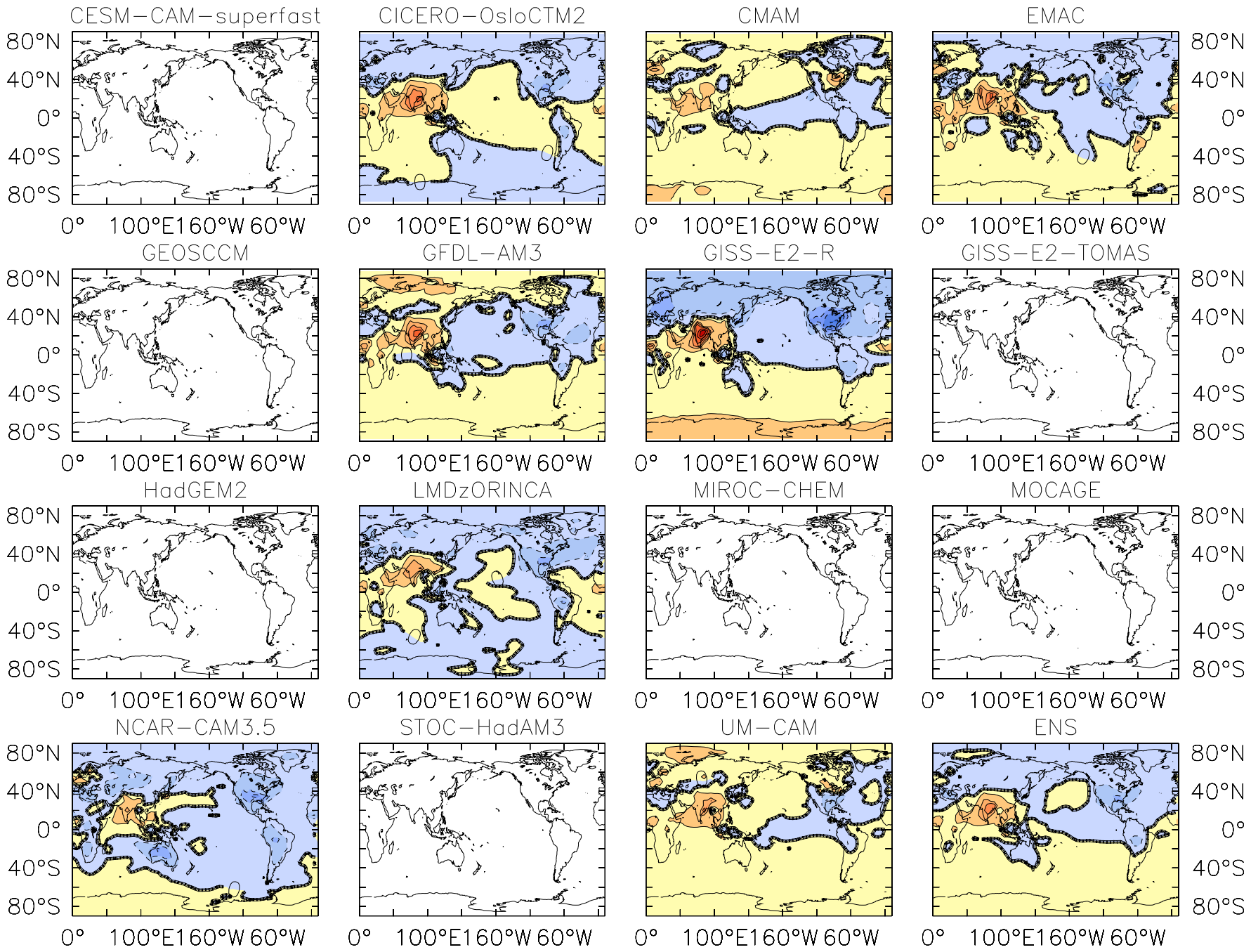


Fig S6 (cont). Change in annual mean surf ozone: RCP26 2100 − Hist 2000 / ppbv



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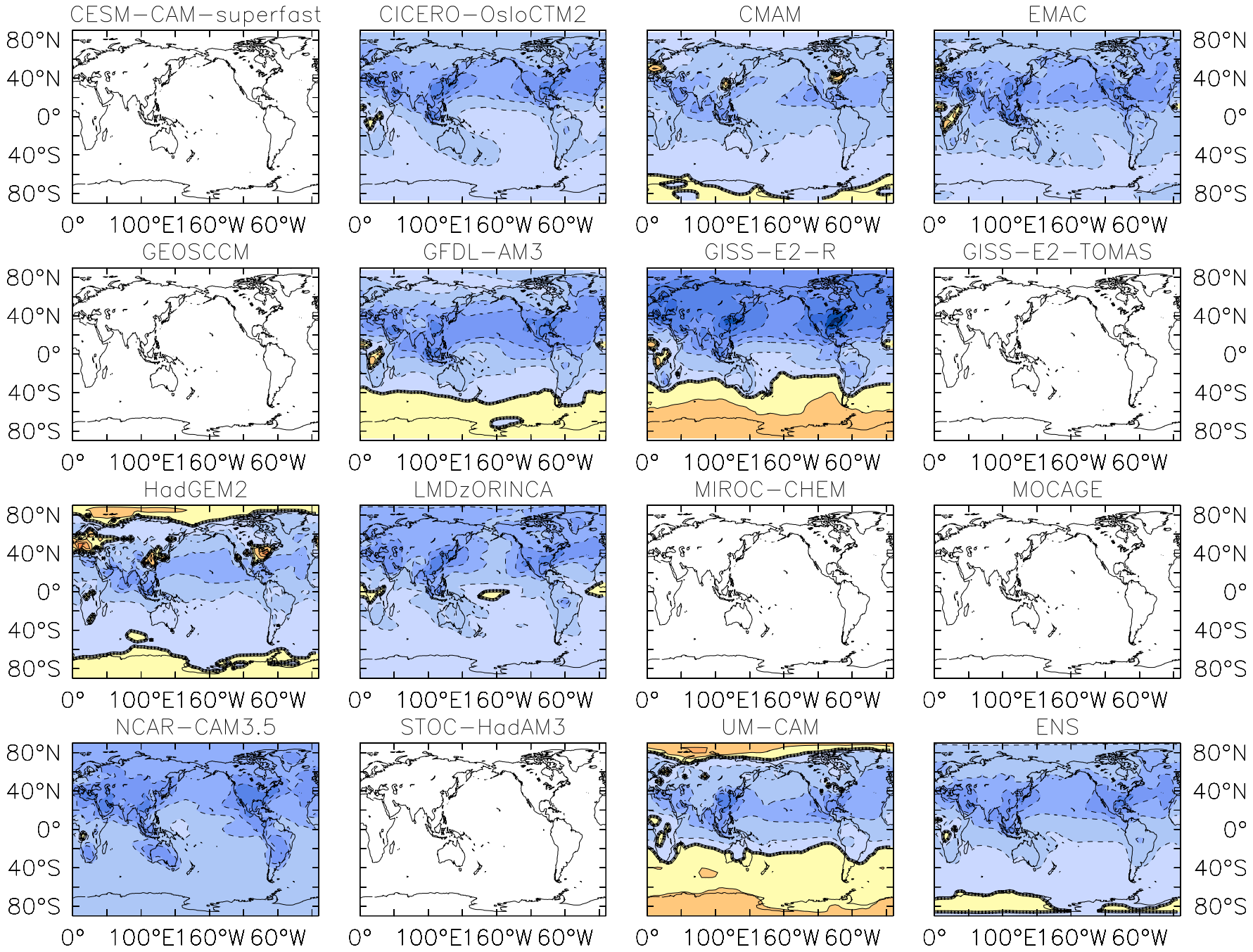
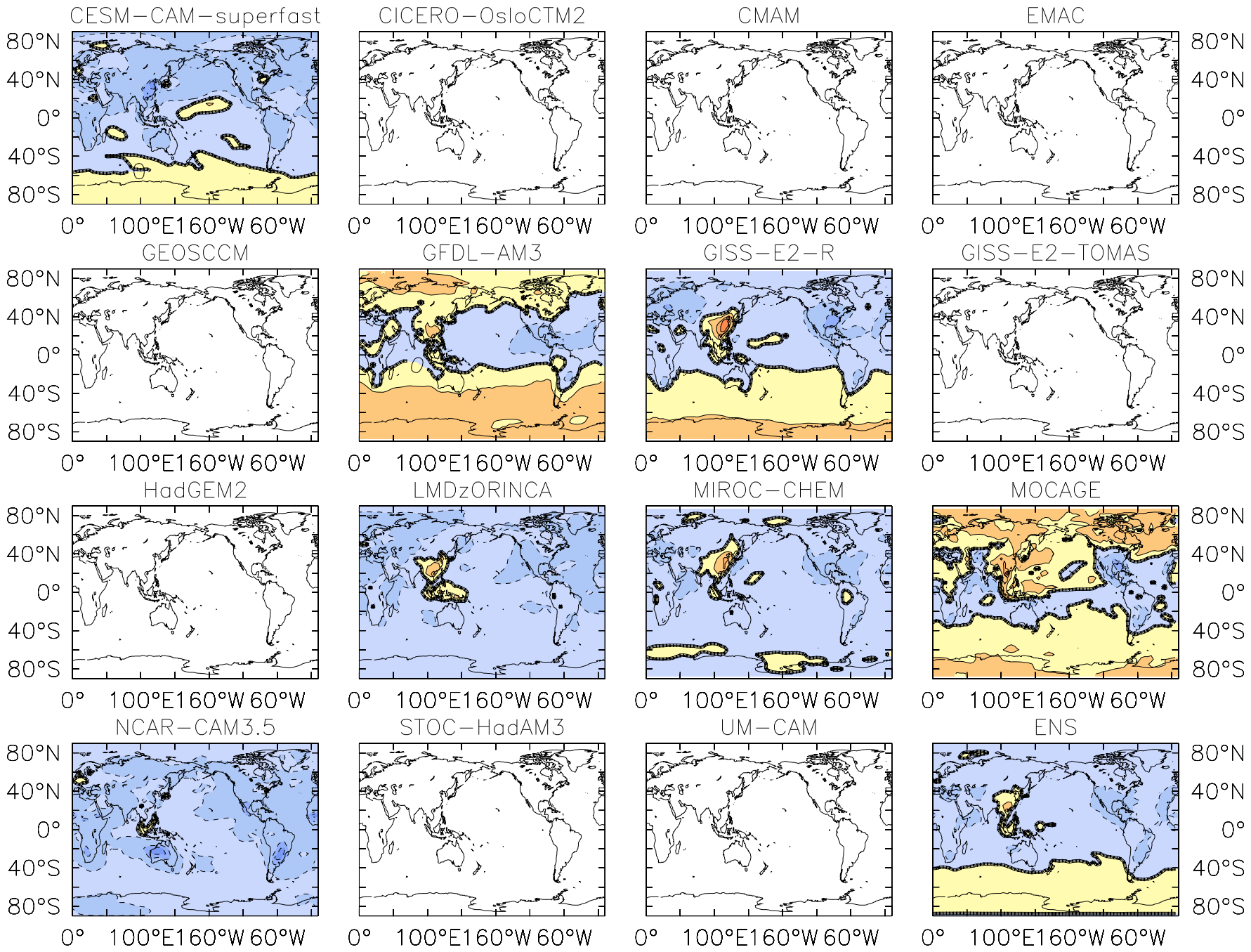


Fig S6 (cont). Change in annual mean surf ozone: RCP45 2100 − Hist 2000 / ppbv



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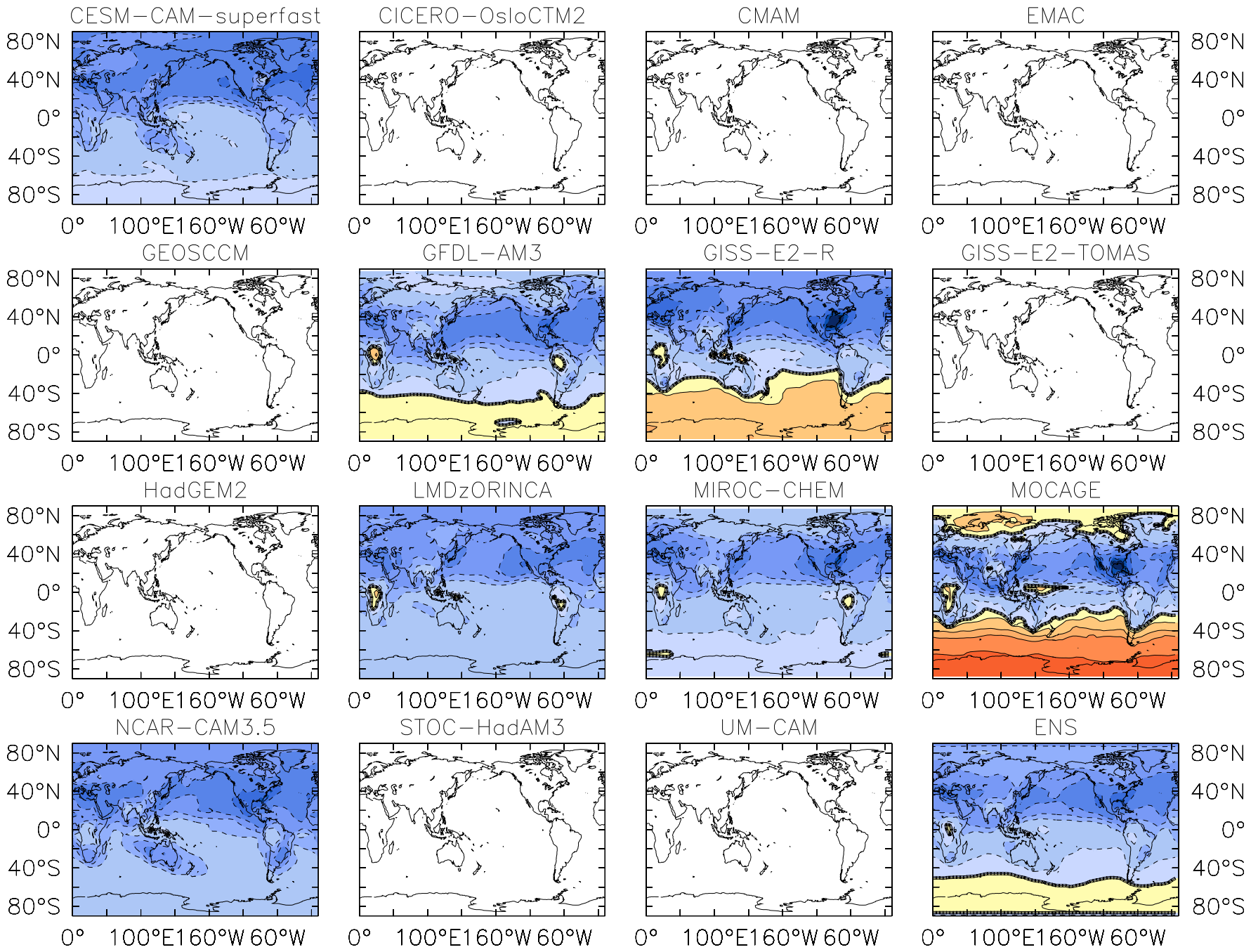

Fig S6 (cont). Change in annual mean surf ozone: RCP60 2100 − Hist 2000 / ppbv

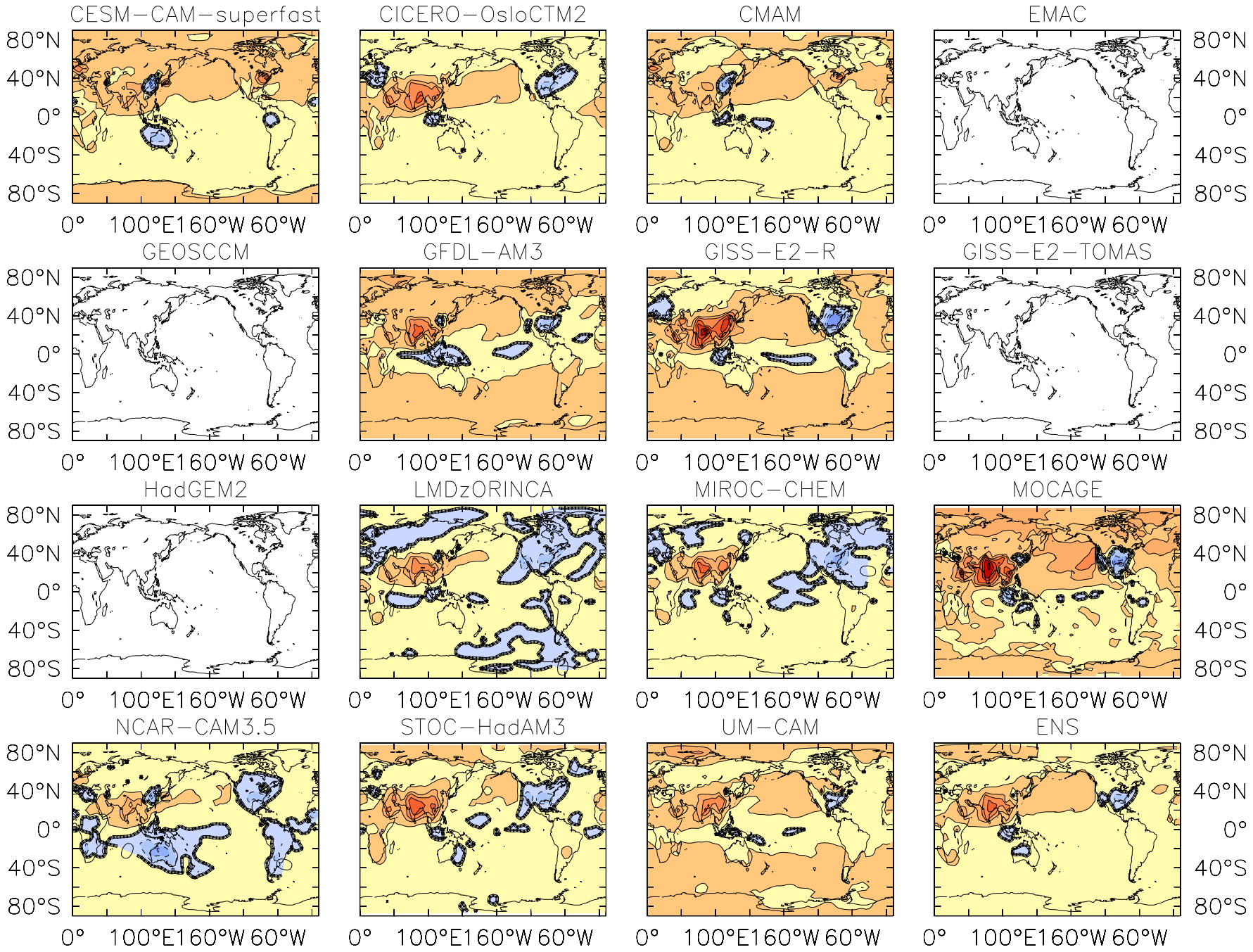

Fig S6 (cont). Change in annual mean surf ozone: RCP85 2030 − Hist 2000 / ppbv

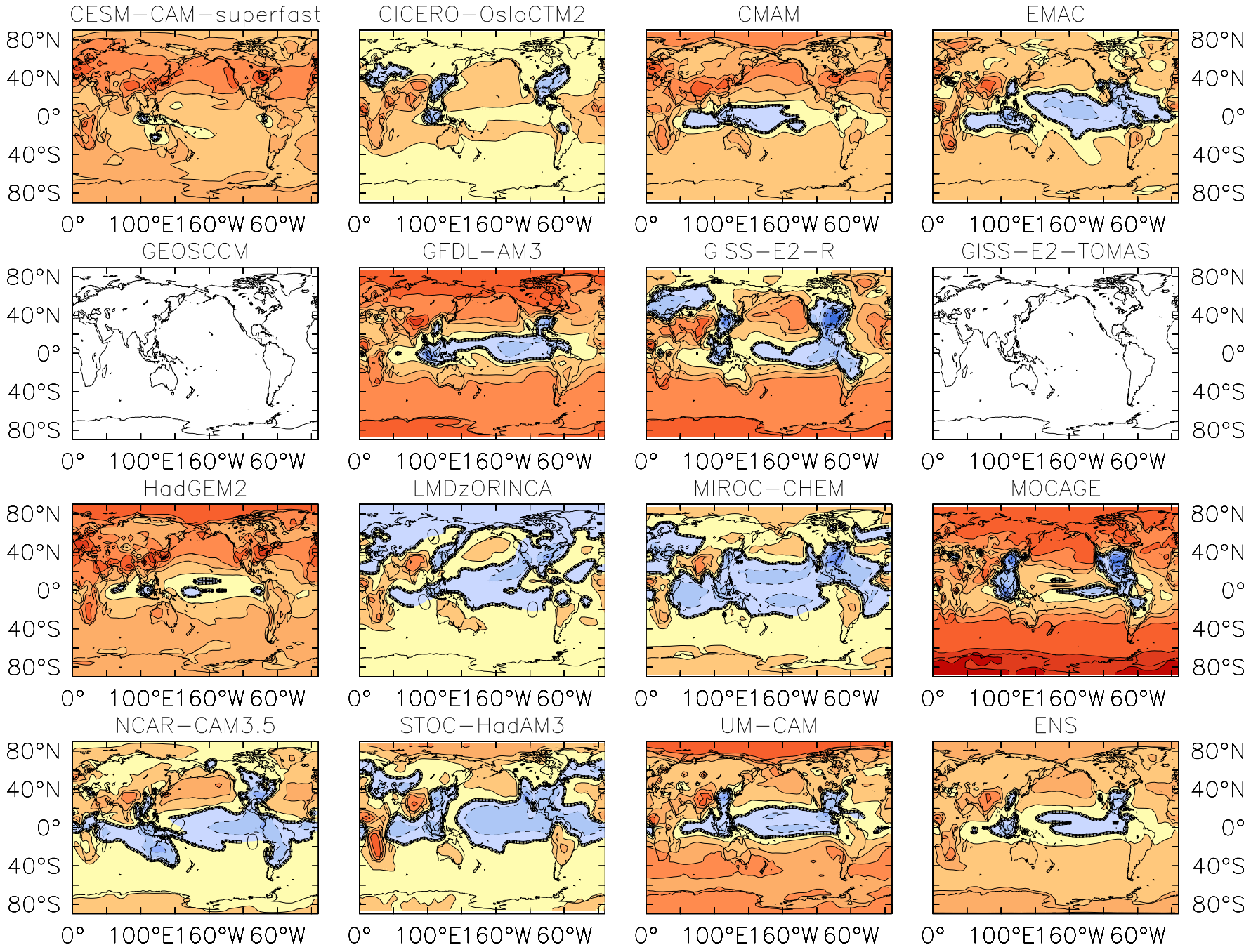

Fig S6 (cont). Change in annual mean surf ozone: RCP85 2100 − Hist 2000 / ppbv

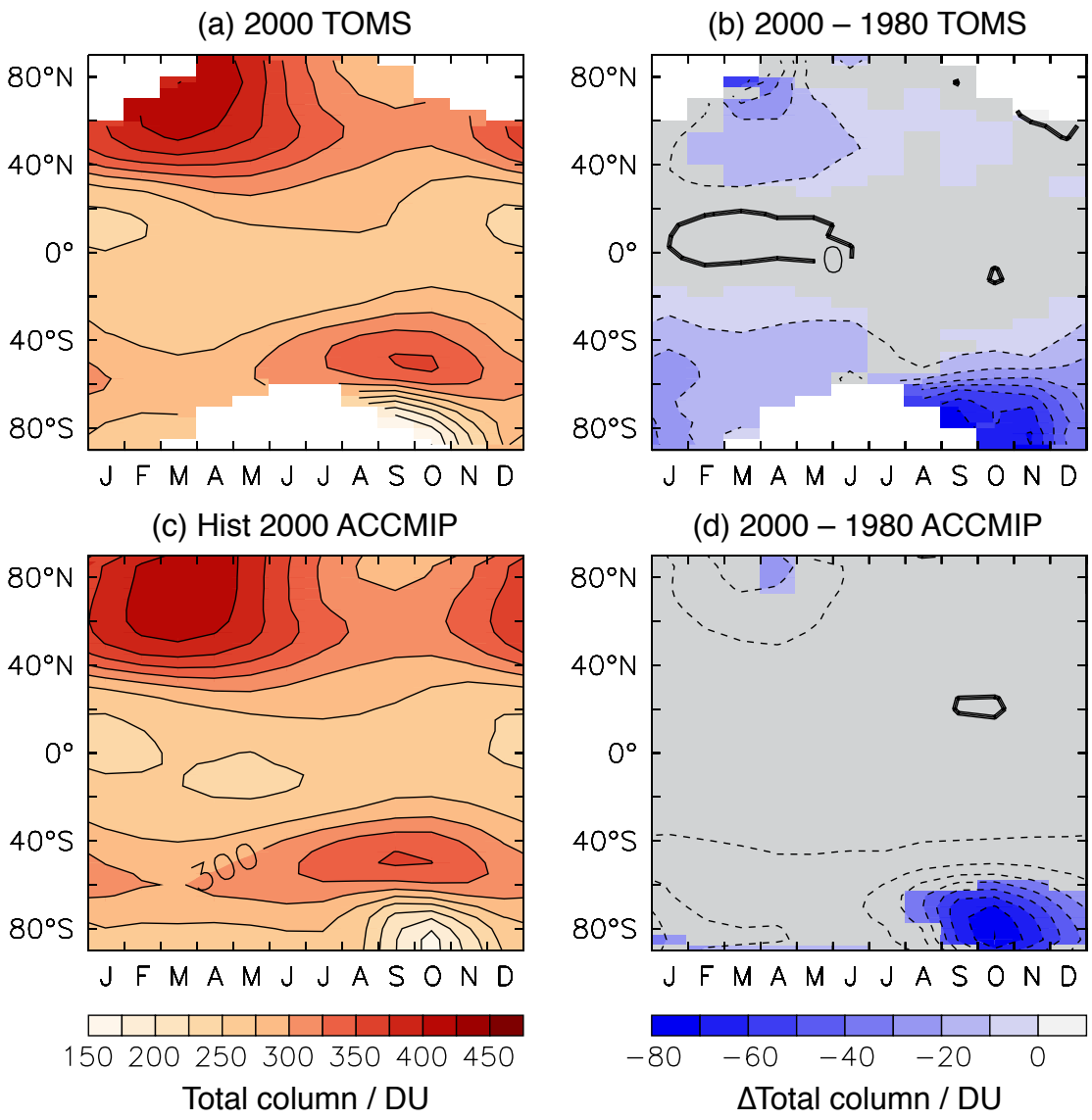

Fig. S7. Annual cycle in total column ozone from (a) the Total Ozone Mapping Spectrometer (TOMS) (1996-2005 average) and (c) the Hist 2000 time slice from the ACCMIP multi-model mean. Late 20th century change in the total ozone column for (b) TOMS (1996-2005 average minus 1979-1985 average) and (d) ACCMIP multi-model mean (Hist 2000 minus Hist 1980). Grey shading in (b) is where the column change is less than 1 standard deviation, calculated from the interannual variability in the 1979-2005 TOMS data. Grey shading in (d) is where the change is less than 1 standard deviation, calculated from the spread in the individual model results.