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A new version of the CNRM Chemistry-Climate Model, CNRM-CCM : description and improvements from the CCMVal-2 simulations - Supplementary document

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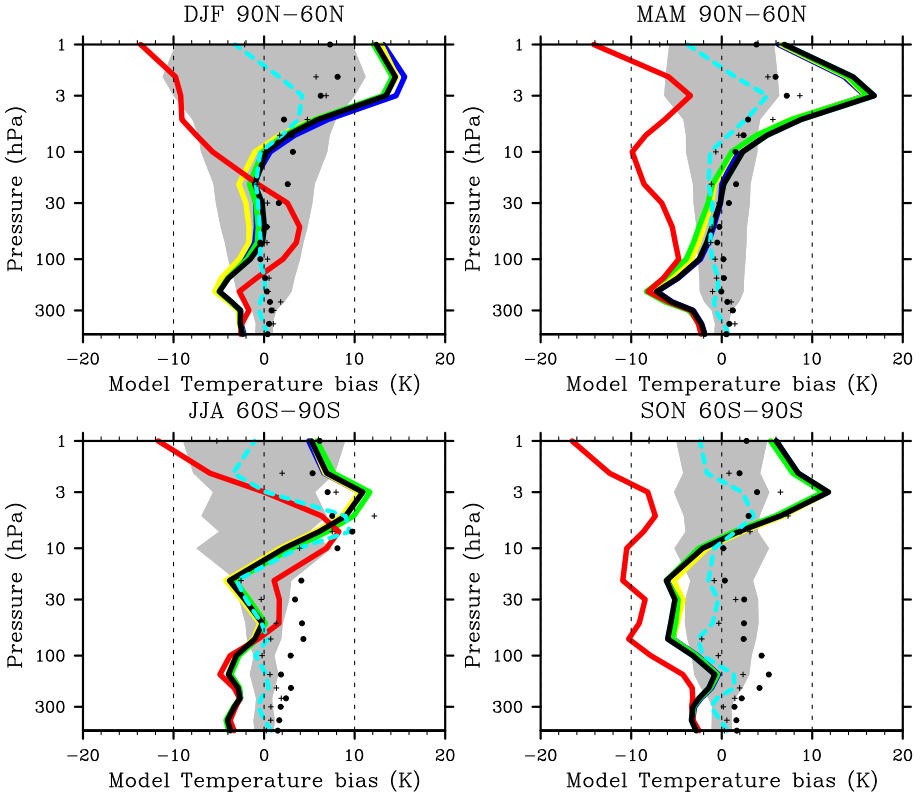
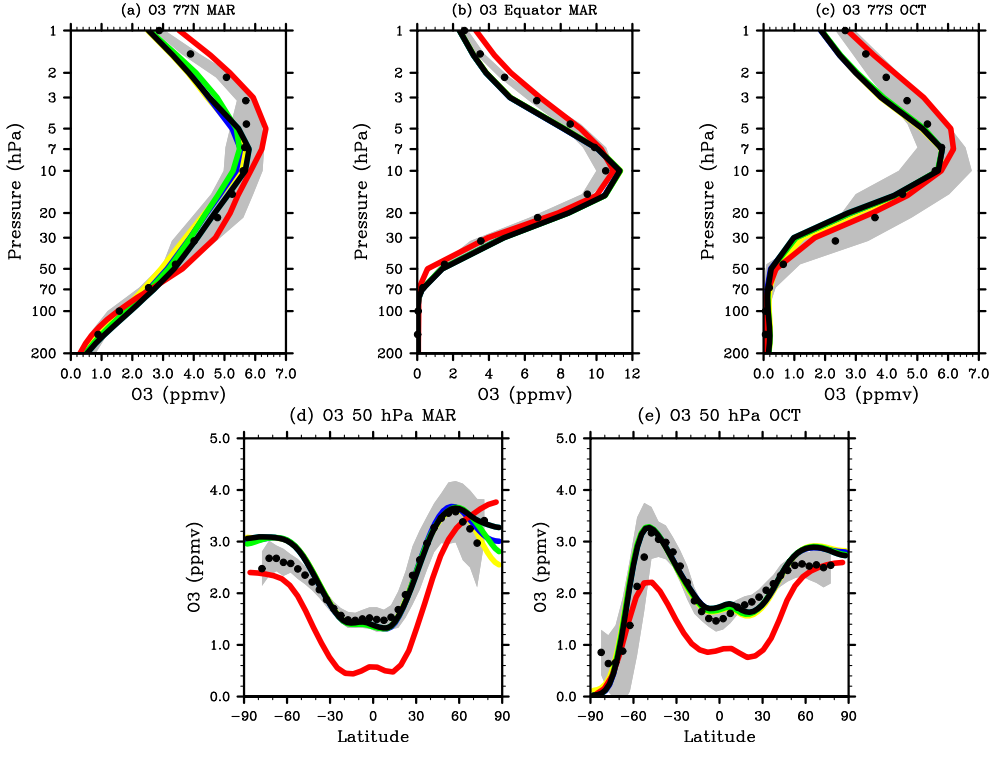
References

Cionni I., V. Eyring, J. F. Lamarque, W. J. Randel, D. S. Stevenson, F. Wu, G. E. Bodeker, T. G. Shepherd, D. T. Shindell, and D. W. Waugh, Ozone database in support of CMIP5 simulations: results and corresponding radiative forcing, Atmos. Chem. Phys. Discuss., 11, 10875-10933, 2011, www.atmos-chem-phys-discuss.net/11/10875/2011/ doi:10.5194/acpd-11-10875-2011

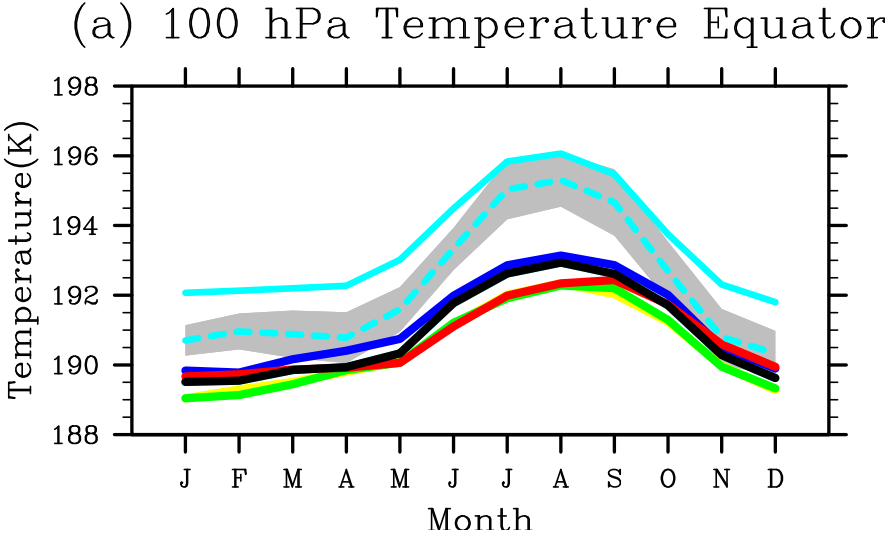
Taylor, K. E., Summarizing multiple aspects of model performance in a single diagram, *J. Geophys. Res.*, 106(D7), 7183-7192, 2001.



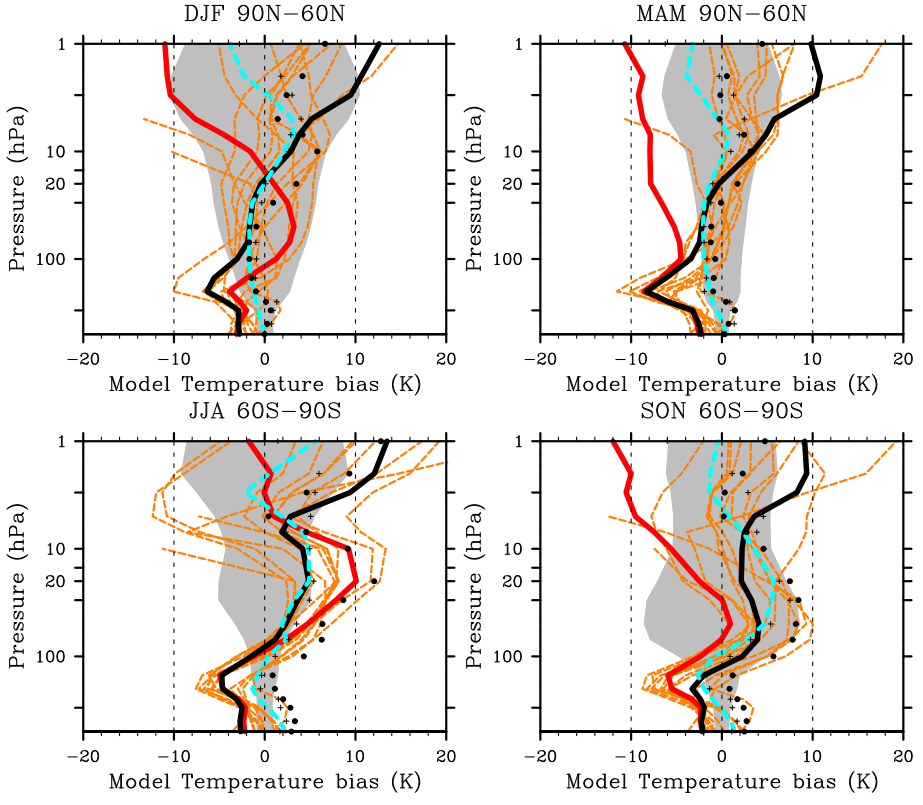
S 1. Temperature biases over two latitude ranges, 90° N–60° N (first row) and 60° S–90° S (second row), and two seasons, winter (left column) and spring (right column). Biases are relative to the ERA-40 1980–2001 monthly reanalysis, for CNRM-ACM (red line), and for five different "versions" of CNRM-CCM (see text, all other full lines, noting that two versions produced non separable lines), and for ERA-Interim (dashed cyan line). The grey area shows ERA-40 ± 1 standard deviation.



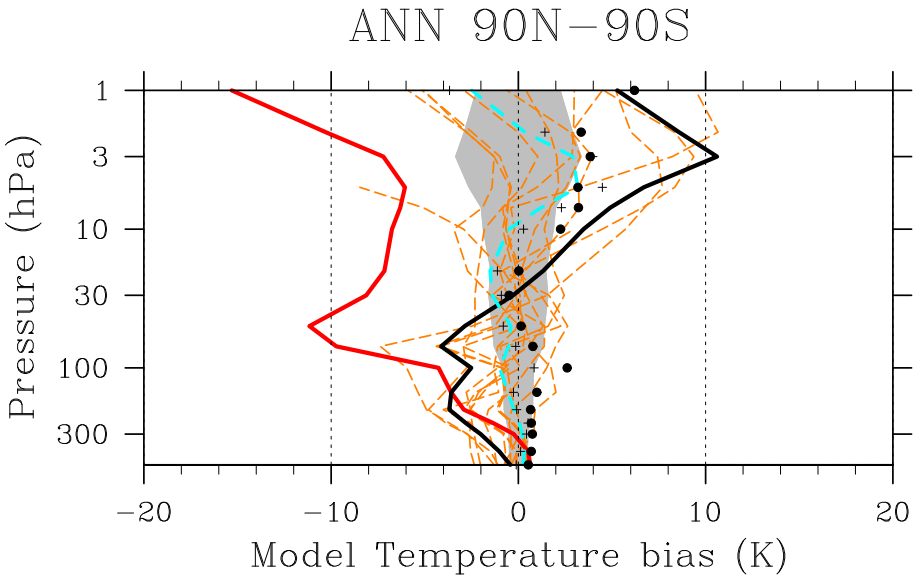
S 2. Climatological (1992–2001) zonal-mean O_3 mixing (ppmv), for HALOE observations (black dots, with grey area showing $\pm$ 1σ), CNRM-ACM (red line), and for five different "versions" of CNRM-CCM (all other full lines, noting that two versions produced non separable lines). Vertical profiles at **(a)** 77° N in March, **(b)** 0° N in March, and **(c)** 77° S in October. Zonal-means at 50 hPa in **(d)** March and **(e)** October.



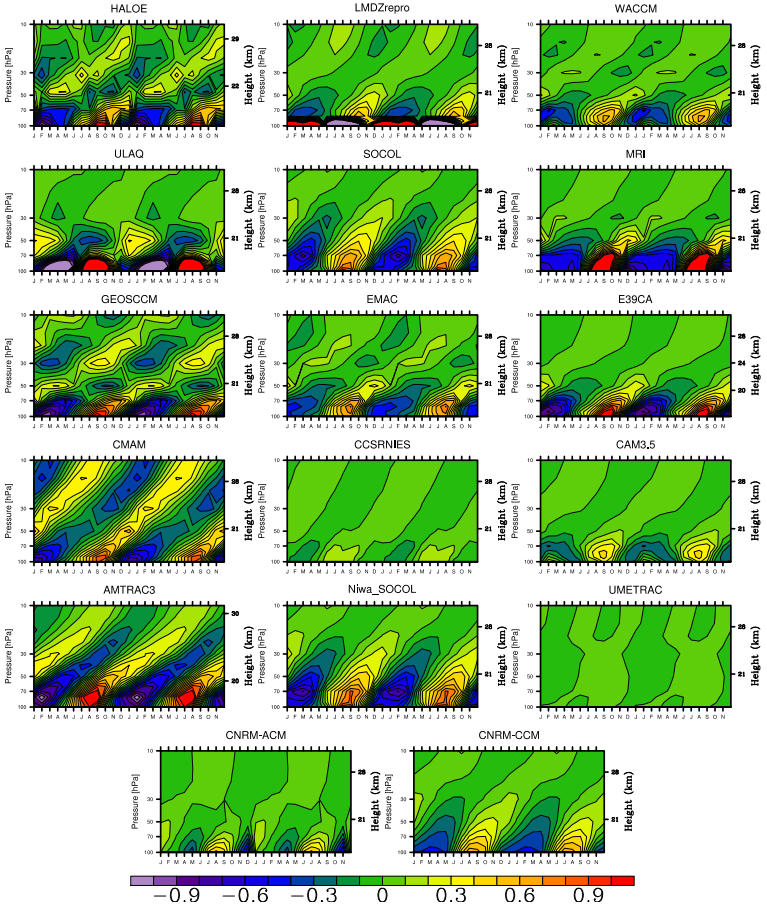
S 3. Zonal tropical climatologies of the temperature at Equator 100 hPa with "observations", ERA-40 (cyan line), ERA-Interim (dashed cyan line, $\pm 1\sigma$ 1989–2001). Models are also shown, CNRM-ACM (red line), and five different "versions" of CNRM-CCM (all other full lines, noting that two versions produced non separable lines).



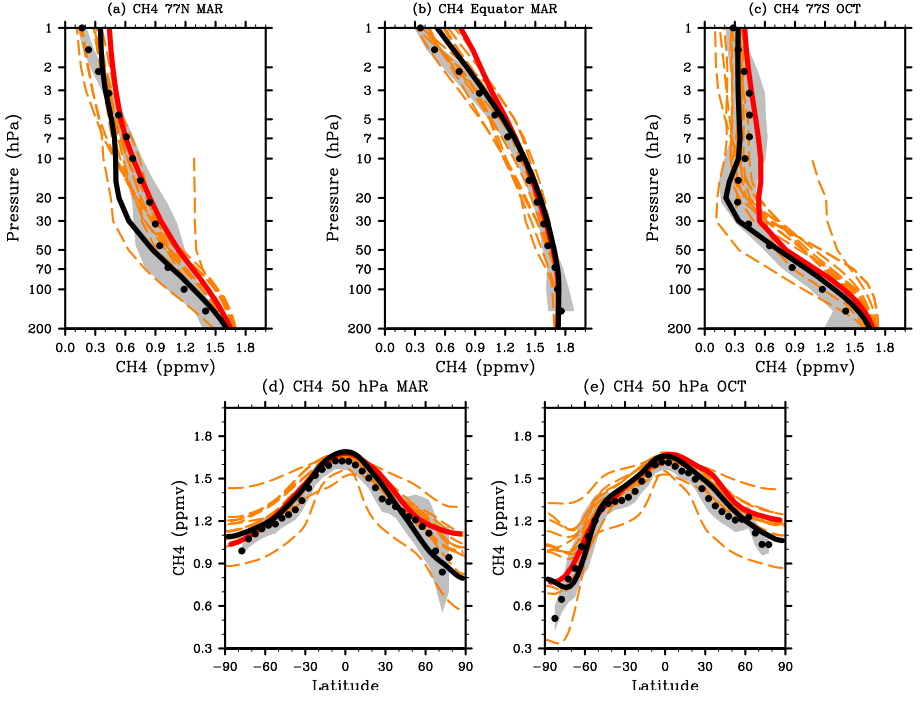
S 4. Temperature biases over two latitude ranges, 90N-60N (first row) and 60S-90S (second row), and two seasons, winter (left column) and spring (right column). Biases are relative to the ERA-40 1960-1980 monthly reanalysis, for CNRM-ACM (red line), CNRM-CCM (black line) and CCMVal-2 REF-B1 models (dashed orange lines), and for ERA-Interim (dashed cyan line), NCEP (dots), and UKMO (crosses) reanalyses. The grey area shows ERA-40 $\pm$ 1 standard deviation.



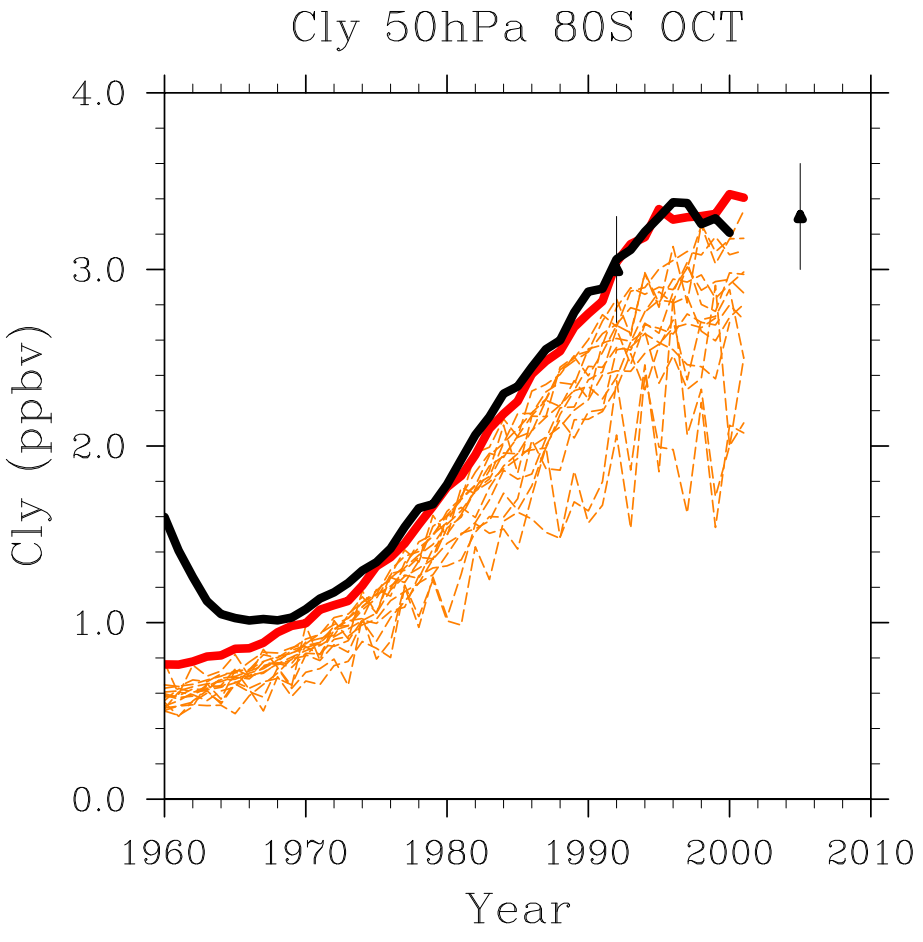
S 5. Annual temperature biases over 90N-90S. Biases are relative to the ERA-40 1980-1999 monthly reanalysis, for CNRM-ACM (red line), CNRM-CCM (black line) and CCMVal-2 REF-B1 models (dashed orange lines), and for ERA-Interim (dashed cyan line), NCEP (dots), and UKMO (crosses) reanalyses. The grey area shows ERA-40 $\pm$ 1 standard deviation.



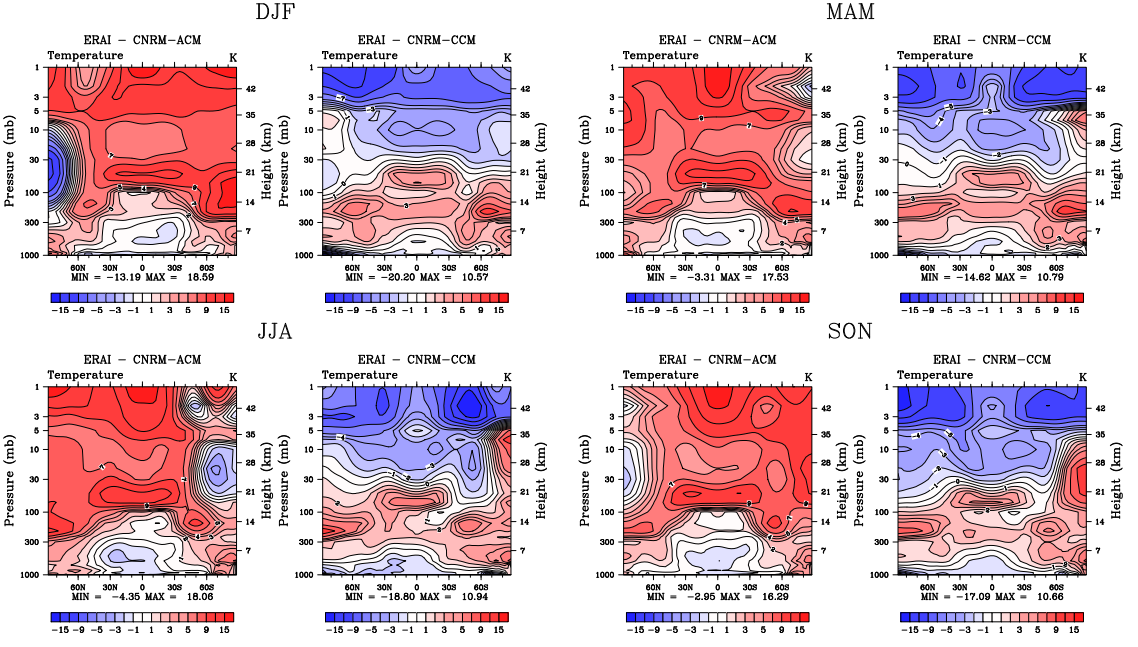
S 6. Deviations of the climatological monthly mean water vapor mixing ratio from the time mean ratio (1992-2001, averaged between 10S and 10N, ppmv), for HALOE observations and CCMVal-2 REF-B1 model simulations. CNRM-ACM and CNRM-CCM appear in the last row. Two identical cycles of the tape recorder are shown.



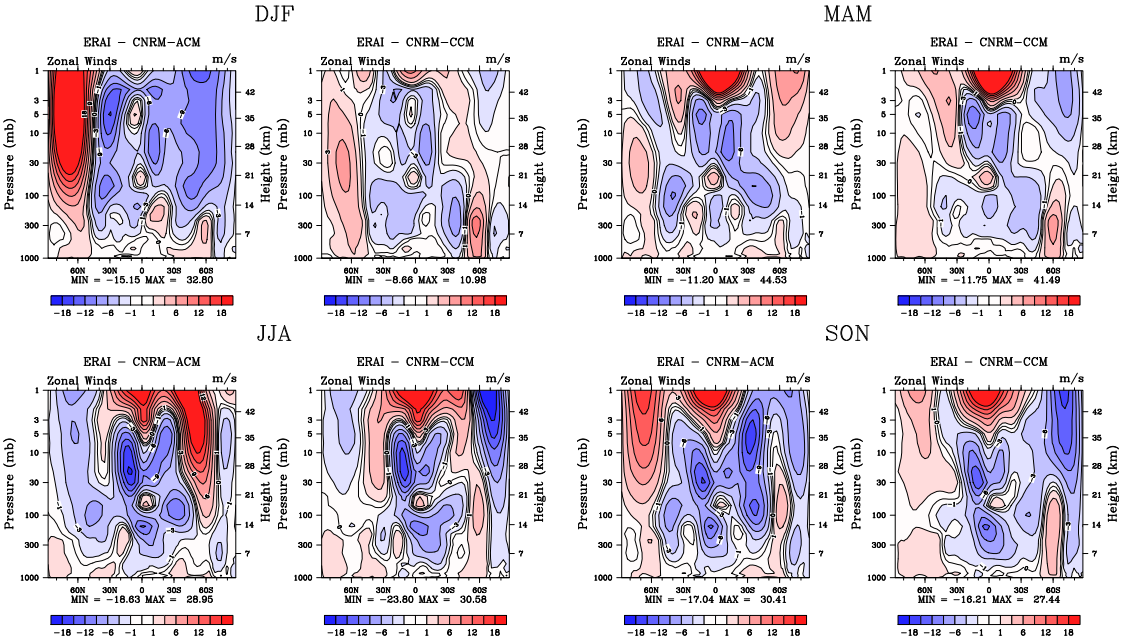
S 7. Climatological (1992–2001) zonal-mean CH_4 mixing ratio (ppmv), for HALOE observations (black dots, with grey area showing $\pm\ 1\sigma$), CNRM-ACM (red line), CNRM-CCM (black line), and CCMVal-2 REF-B1 models (dashed orange lines). Vertical profiles at **(a)** 77° N in March, **(b)** 0° N in March, and **(c)** 72° S in October. Zonal-means at 50 hPa in **(d)** March and **(e)** October.



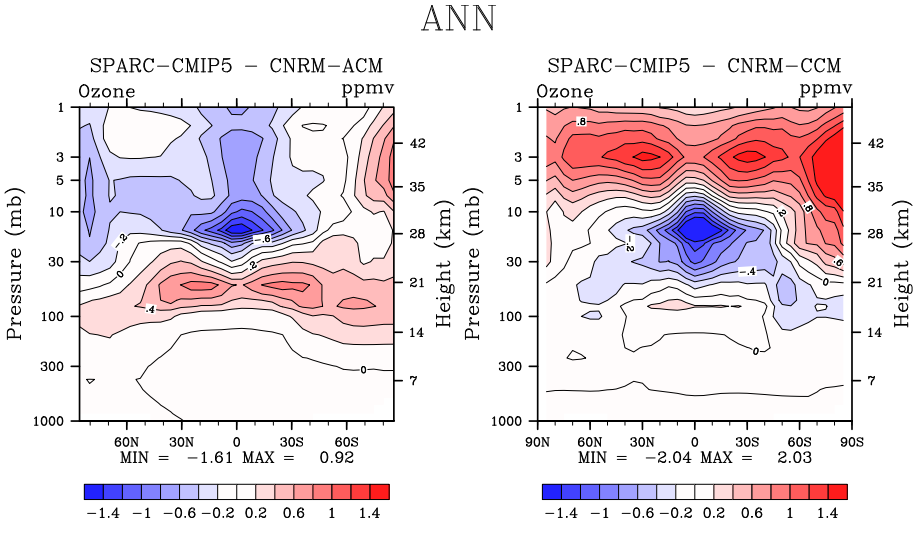
S 8. Time series of Cl_y mixing ratios (ppbv) at 50 hPa, 80S in October over the REF-B1 period, with observations (diamonds, $\pm$ 1σ), CNRM-ACM (red line), CNRM-CCM (black line), and CCMVal-2 models outputs (orange dashed lines).



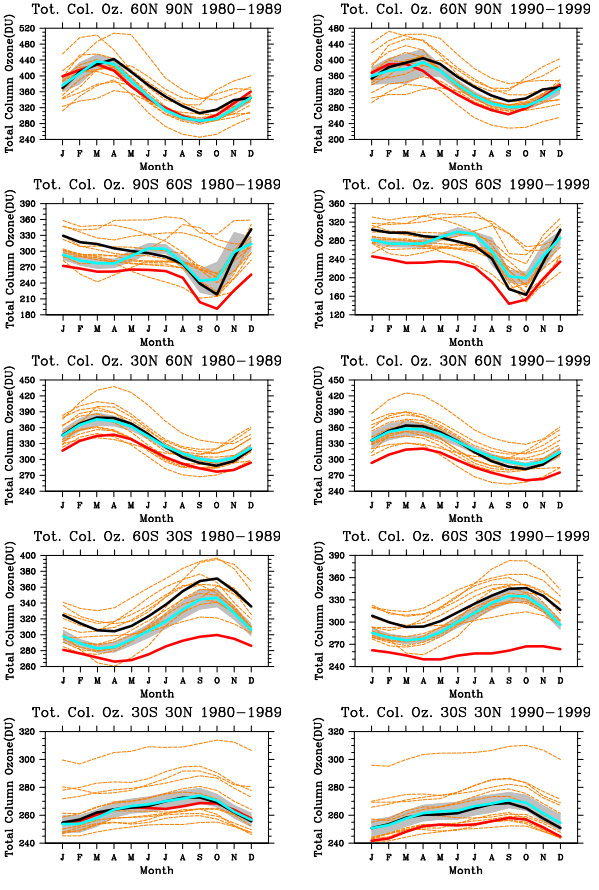
S 9. Latitude-pressure cross-sections of differences in temperature between ERA-Interim and CNRM-ACM (first and third columns), and between ERA-Interim and CNRM-CCM (second and fourth columns), for DJF and MAM (first row), and for JJA and SON (second row) (1989-2000 period).



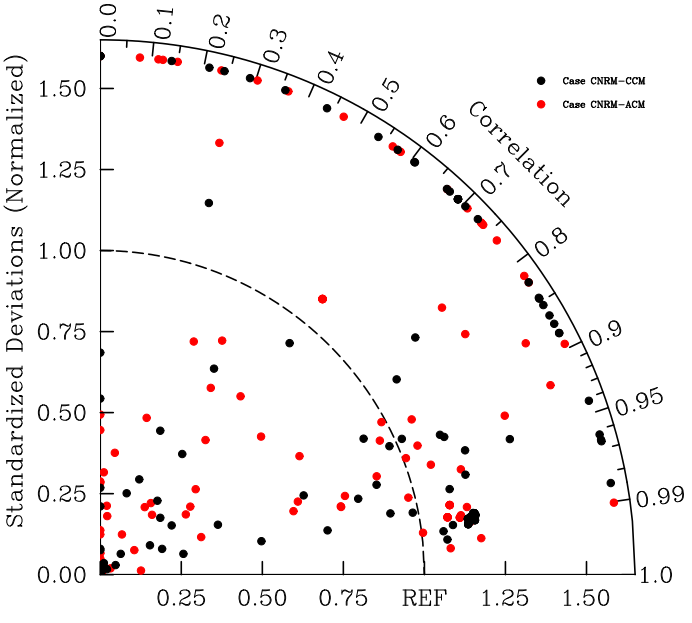
S 10. Latitude-pressure cross-sections of differences in zonal wind between ERA-Interim and CNRM-ACM (first and third columns), and between ERA-Interim and CNRM-CCM (second and fourth columns), for DJF and MAM (first row), and for JJA and SON (second row) (1989-2000 period).



S 11. Latitude-pressure cross-section of differences in ozone (ppmv) between the AC&C SPARC CMIP5 dataset (see Cionni et al. (2011)) and CNRM-ACM (left), or CNRM-CCM (right) (annual mean over 1990-1999).



S 12. Zonal climatological (1980-1989 left column, 1990-1999 right column) total column ozone (DU) in various latitude bands, 60N-90N, 90S-60S, 30N-60N, 60S-30S and 30S-30N, for NIWA BSv2.7 observations (cyan line) $\pm$ 1σ (grey shading), CNRM-ACM (red line), CNRM-CCM (black line) and CCMVal-2 REB-B1 simulations (orange dashed lines).



S 13. Taylor diagram (*Taylor*, 2001) of the diagnostics presented in the various paragraphs of the paper, red dots for CNRM-ACM, black dots for CNRM-CCM.

Table 1. Results of the t-Tests conducted on each month of the annual cycle of a given chemical compound, hn1: 30° N–60° N at 1 hPa, hs1: 30° S–60° S at 1 hPa, hn50: 30° N–60° N at 50 hPa, hs50: 30° S–60° S at 50 hPa, trop1: 30° S–30° N at 1 hPa, trop50: 30° S–30° N at 50 hPa. A ✓ indicates where a significant difference ($p < 0.05$) has been found.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BrO-hn1				✓	✓	✓	✓	✓				
BrO-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
BrO-hs1	✓	✓					✓			✓	✓	✓
BrO-hs50	✓	✓	✓	✓		✓	✓	✓				✓
BrO-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BrO-trop50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4-trop50	✓	✓	✓	✓	✓	✓					✓	✓
CH4-trop50	✓	✓	✓	✓	✓	✓					✓	✓
ClONO2-hn1	✓			✓	✓	✓	✓	✓	✓		✓	✓
ClONO2-hn50	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
ClONO2-hs1	✓	✓			✓	✓			✓	✓	✓	✓
ClONO2-hs50	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
ClONO2-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ClONO2-trop50	✓	✓	✓								✓	✓

Table 2. Same as Table 1, with hn100: 40° N–60° N at 100 hPa, hs100: 40° S–60° S at 100 hPa, hn200: 40° N–60° N at 200 hPa, hs200: 40° S–60° S at 200 hPa.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CO-hn1	✓	✓						✓	✓	✓	✓	✓
CO-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO-hs1	✓	✓	✓	✓		✓	✓			✓		
CO-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO-trop50												
H2O Eq 100hPa												
H2O 20S20N 80hPa												
H2O-hn100		✓	✓	✓								
H2O-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2O-hn200	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
H2O-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2O-hs100												
H2O-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2O-hs200	✓	✓	✓	✓	✓					✓	✓	✓
H2O-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2O-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H2O-trop50												
HCl-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HCl-hn50	✓	✓			✓	✓	✓	✓	✓	✓	✓	
HCl-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HCl-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HCl-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HCl-trop50												
O3 20S20N 80hPa	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Temp Eq 100hPa												

Table 3. Same as Tables 1 and 2.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HNO3-hn100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HNO3-hn1	✓							✓	✓		✓	✓
HNO3-hn200					✓	✓	✓					
HNO3-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HNO3-hs100									✓	✓		
HNO3-hs1	✓	✓		✓	✓	✓				✓		✓
HNO3-hs200	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HNO3-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HNO3-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HNO3-trop50	✓	✓	✓	✓	✓	✓						✓
N2O5-hn1	✓	✓	✓	✓				✓	✓	✓	✓	✓
N2O5-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N2O5-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
N2O5-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N2O5-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N2O5-trop50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NO2-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NO2-hn50	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
NO2-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NO2-hs50			✓	✓	✓		✓	✓				
NO2-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NO2-trop50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hn100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hn1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hn200	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hn50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hs100	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hs1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hs200	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-hs50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-trop1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3-trop50	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 4. Results of the t-Tests conducted on each level of the vertical profiles of a given chemical compound, for the months and latitudes of the diagnostics (see text and figures of the paper). A ✓ indicates where a significant difference ($p < 0.05$) has been found.

Diag/Level (hPa)	1	2	3	5	7	10	20	30	50	70	100	200
CH4 Equa MAR	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
CH4 77S OCT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH4 77N MAR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
H20 Equa MAR	✓	✓	✓	✓	✓	✓						✓
H2O 77S OCT	✓	✓	✓	✓	✓	✓	✓				✓	✓
H2O 77N MAR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
HCl Equa APR	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
HCl 72S NOV		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
HCl 77N APR		✓	✓	✓			✓	✓			✓	✓
O3 Equa MAR	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
O3 77S OCT	✓	✓	✓	✓	✓		✓	✓			✓	✓
O3 77N MAR	✓	✓	✓	✓	✓		✓	✓			✓	✓