Quantifying uncertainties of climate signals related to the 11 year solar cycle. Part I: Annual mean response in Heating Rates, Temperature and Ozone

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Supplementary material

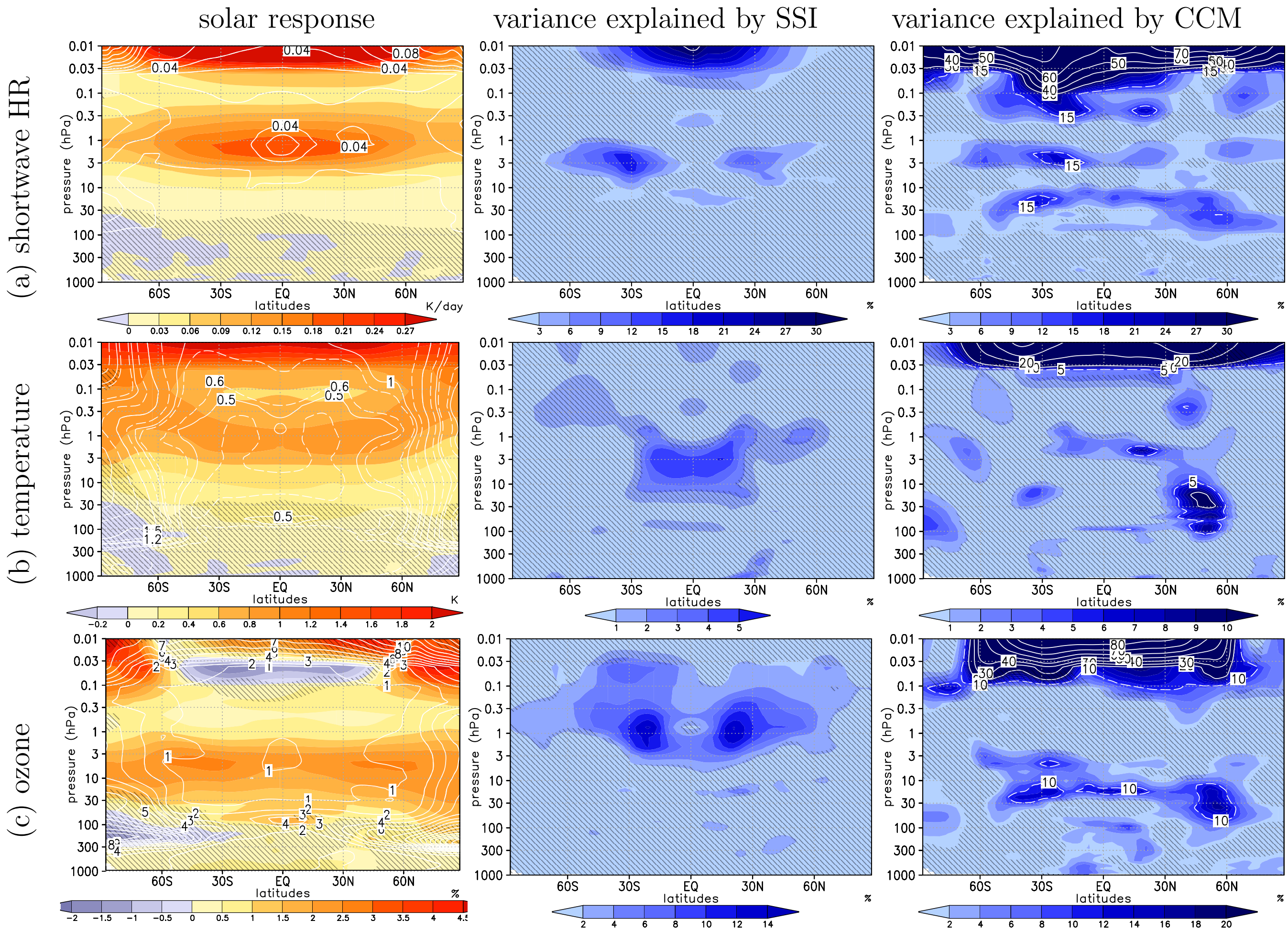

Figure S1: As Figure 1 in the main text, but without the simulations using the SATIRE-T SSI data set. Left column: Annual mean 11–year solar cycle response (shaded) and signal variance (white contours) in terms of the solar response annual standard deviation for shortwave heating-rates (top), temperature (middle), and ozone mixing ratios (bottom). Solar signal derived as ensemble mean over both models using NRLSSI1, NRLSSI2, SATIRE-S, and CMIP6 SSI data sets; solar minimum SSI based on ATLAS3 reference state. Middle column: Percentage of signal variance (square of white contours of left figures) explained by systematic differences between forcing data sets (blue shading). The white contours indicate levels of explained variance larger than the range of shading. Right column: as middle column but for systematic differences between CCMs. The grey hatching masks areas where signal or ratio of explained variance does not pass a test for statistical significance ($p > 5$ %).

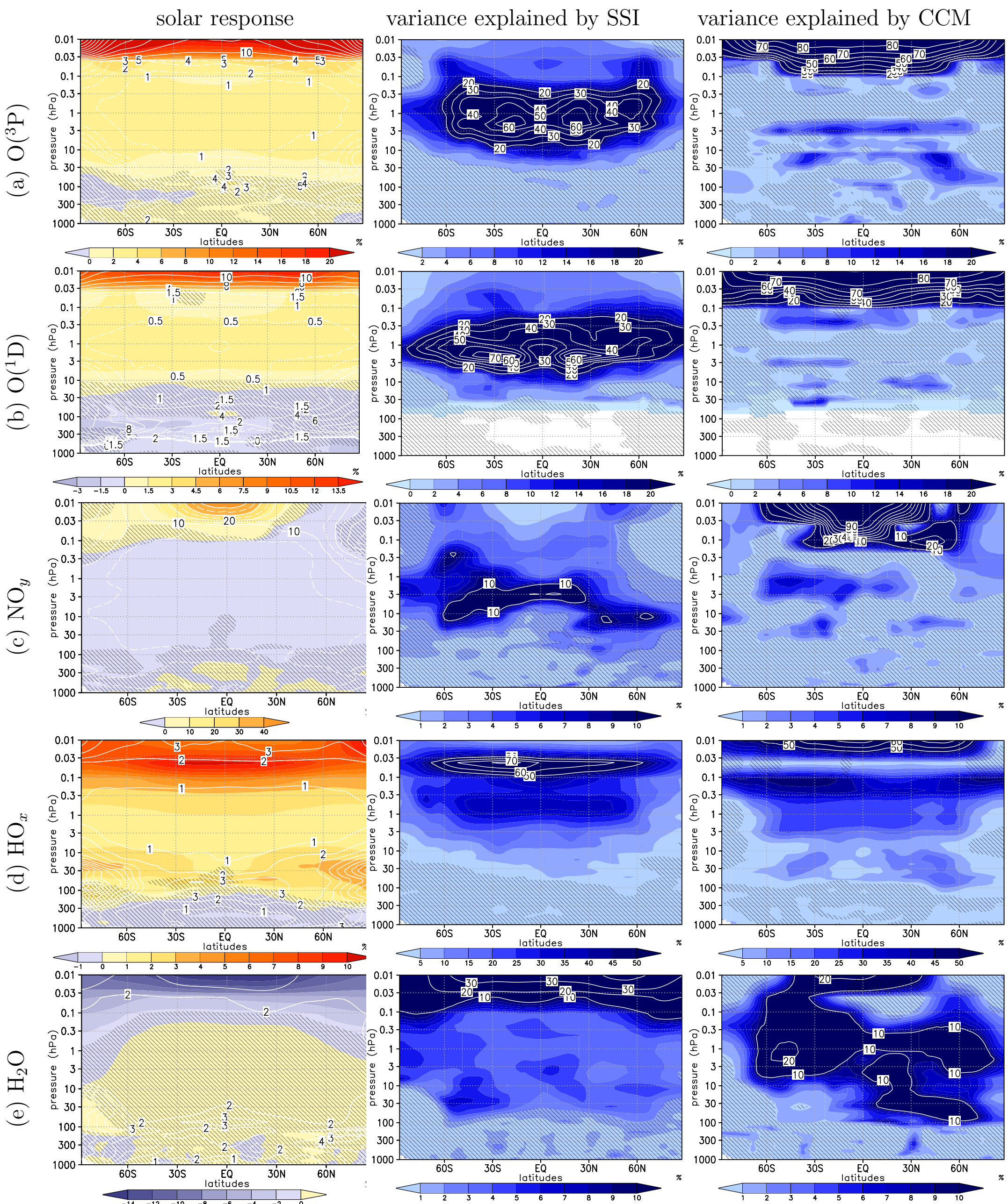

Figure S2: Left column: Annual mean 11–year solar cycle response (shaded) and signal variance (white contours) in terms of the solar response annual standard deviation for (a) $O(^3P)$, (b) $O(^1D)$, (c) NO_y, (d) HO_x, and (e) H_2O mixing ratios. Solar signal derived as ensemble mean over both models and all SSI data sets; solar minimum SSI based on ATLAS3 reference state. Middle column: Percentage of signal variance (square of white contours of left figures) explained by systematic differences between forcing data sets (blue shading). The white contours indicate levels of explained variance larger than the range of shading. Right column: as middle column but for systematic differences between CCMs. The grey hatching masks areas where signal or ratio of explained variance does not pass a test for statistical significance ($p > 5$ %).

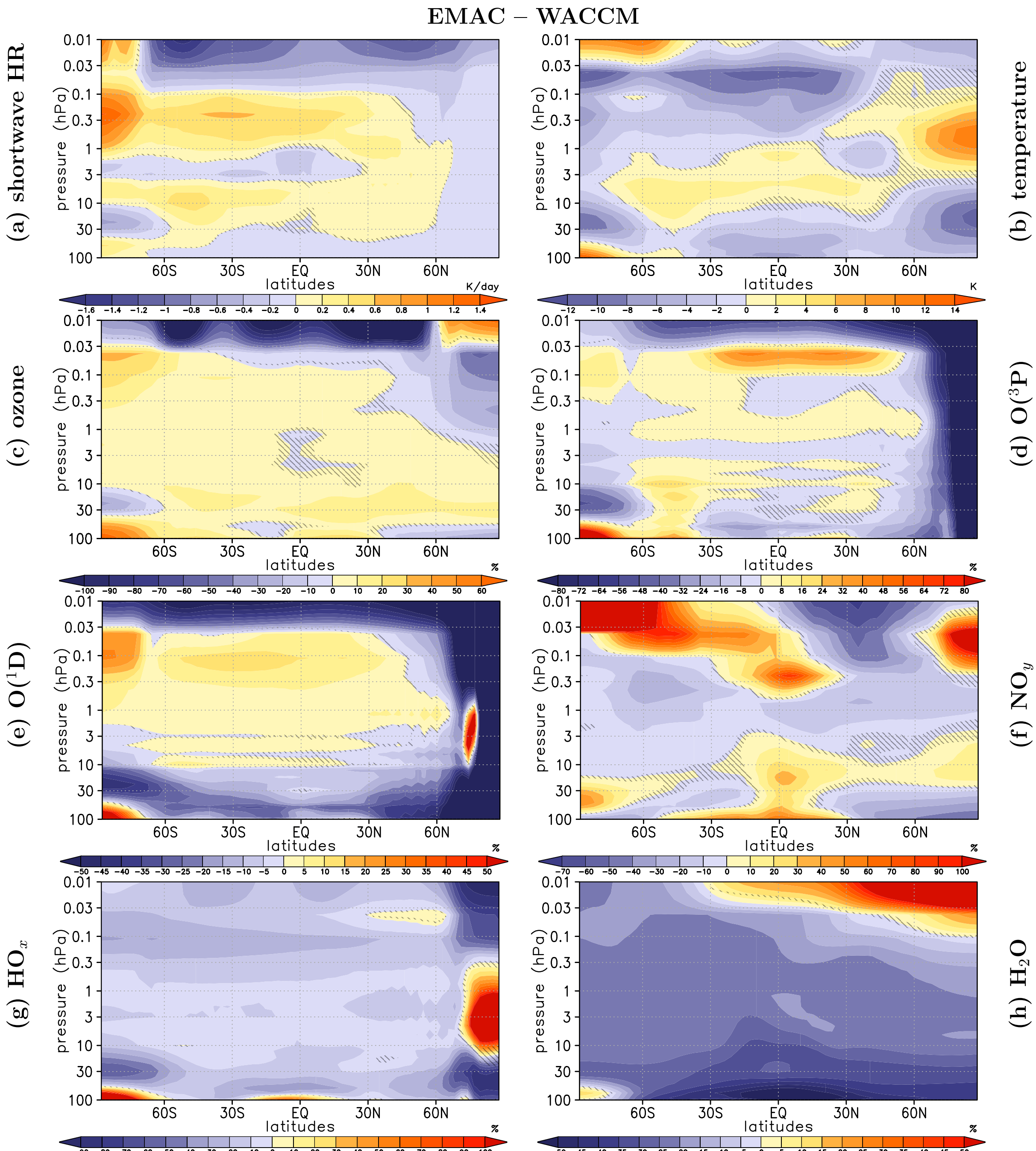

Figure S3: January mean differences for EMAC (ensemble mean) minus WACCM (ensemble mean) (shaded) of (a) shortwave heating rates, (b) temperature, (c) ozone mixing ratios, (d) atomic oxygen (O(^{3}P)), (e) HO$_x$, and (f) NO$_y$. The ensemble mean for both CCMs consists of the solar minimum reference simulation (included 5 times in the ensemble mean) and the 5 simulations for the solar maximum. Grey hatching masks areas where differences does not pass a test for statistical significance ($p > 5$ %).

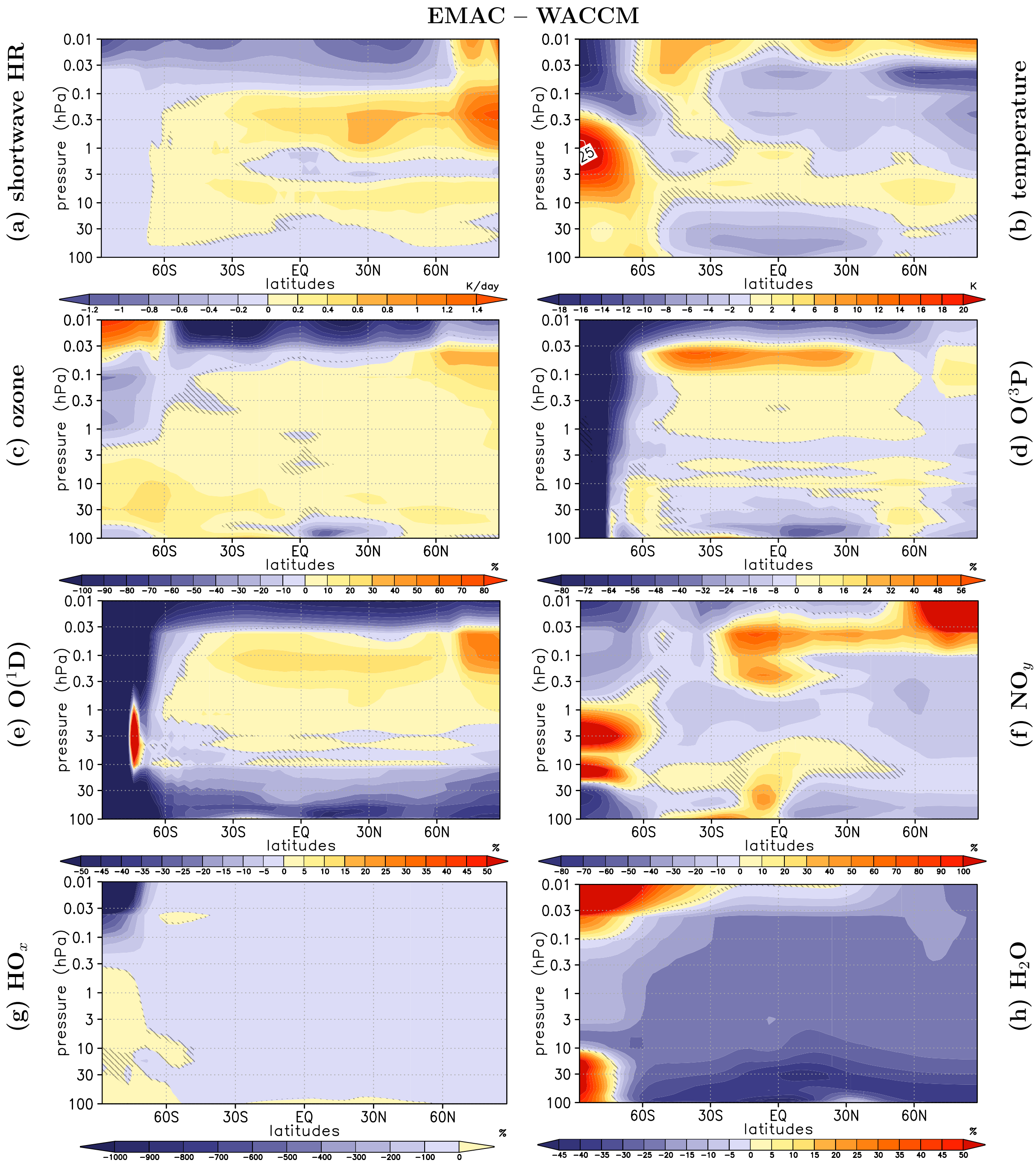

Figure S4: July mean differences for EMAC (ensemble mean) minus WACCM (ensemble mean) (shaded) of (a) shortwave heating rates, (b) temperature, (c) ozone mixing ratios, (d) atomic oxygen ($\mathrm{O(^3P)}$), (e) $\mathrm{HO_x}$, and (f) $\mathrm{NO_y}$. The ensemble mean for both CCMs consists of the solar minimum reference simulation (included 5 times in the ensemble mean) and the 5 simulations for the solar maximum. Grey hatching masks areas where differences does not pass a test for statistical significance ($p > 5$ %).

Figure S5: Correlation of polar region (70°N–90°N) anomalies (solar maximum – solar minimum) of total column ozone (TCO) and the layer thickness from 100 to 10 hPa. TCO change in DU per 100 m geopotential height change and the 95% confidence interval.

		EMAC		WACCM	
Hemisphere	Season	Correlation	ΔTCO/100 m	Correlation	ΔTCO/100 m
		CMIP6			
NH	Anm	0.82	6.08±0.37	0.68	6.11±0.57
	JFM	0.89	6.79±1.05	0.70	5.49±1.72
SH	Anm	0.81	7.49±0.47	0.77	6.06±0.43
	SON	0.92	8.95±1.14	0.95	5.74±0.61
		SATIRE-T			
NH	Anm	0.81	5.91±0.37	0.69	6.03±0.55
	JFM	0.88	6.14±1.02	0.87	6.29±1.12
SH	Anm	0.82	8.02±0.48	0.76	5.38±0.40
	SON	0.95	9.79±1.02	0.91	5.13±0.73
		SATIRE-S			
NH	Anm	0.83	6.20±0.36	0.71	5.91±0.51
	JFM	0.89	6.75±1.05	0.76	6.31±1.67
SH	Anm	0.81	7.72±0.48	0.69	5.09±0.46
	SON	0.95	9.30±0.89	0.88	4.66±0.78
		NRLSSI1			
NH	Anm	0.84	5.95±0.34	0.70	6.25±0.55
	JFM	0.90	6.00±0.92	0.81	6.96±1.55
SH	Anm	0.82	7.26±0.44	0.76	5.94±0.44
	SON	0.91	8.95±1.24	0.92	5.35±0.70
		NRLSSI2			
NH	Anm	0.82	6.39±0.38	0.66	5.84±0.57
	JFM	0.94	6.48±0.75	0.80	6.81±1.58
SH	Anm	0.83	7.81±0.45	0.76	5.54±0.41
	SON	0.94	9.63±1.10	0.94	5.42±0.61