

SUPPLEMENTARY MATERIAL

Supplementary Table S1: The seasonal and annual averaged trends calculated for the pre-2000 (1988–2000) and post-2000 (2000–2024) periods using SWOOSH, and the MLS data for period 2005–2024.

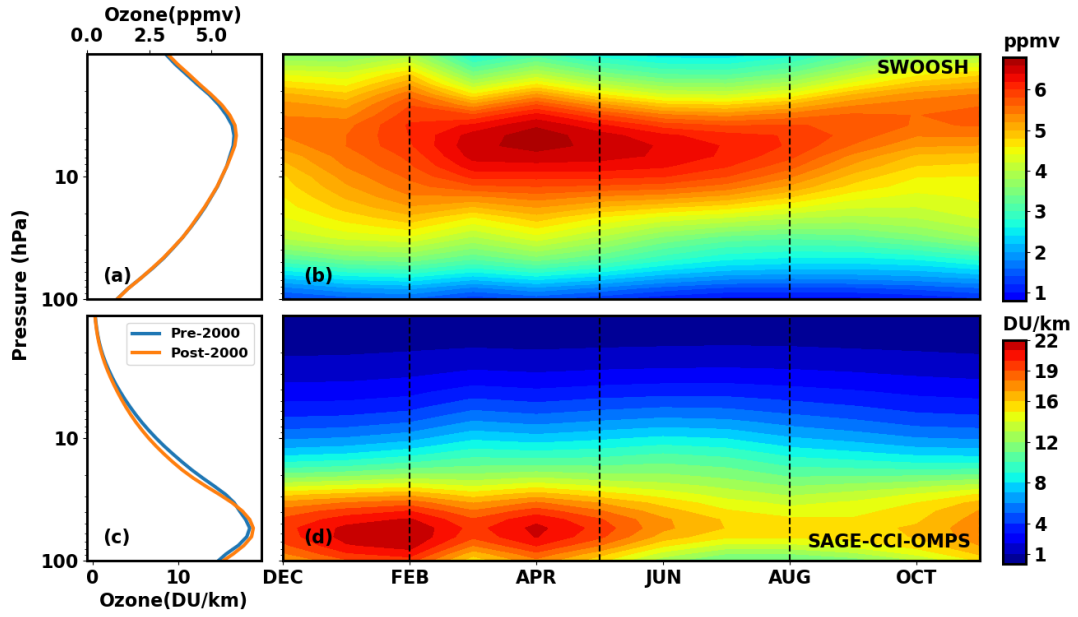
	SWOOSH						MLS		
1988 – 2024	PRE-2000 (ppmv/decade)			POST-2000 (ppmv/decade)			2004–2024 (ppmv/decade)		
	100–30 hPa	30–10 hPa	10–1 hPa	100–30 hPa	30–10 hPa	10–1 hPa	100–30 hPa	30–10 hPa	10–1 hPa
Annual	-0.850±1.051	-0.733±0.977	-1.791±1.348	-0.001±0.536	-0.004±0.379	0.899±0.255	0.343±0.595	0.798±0.503	1.175±0.512
JJA	-0.558±1.315	0.929±0.643	-1.409±1.076	0.505±0.293	-0.673±0.463	0.732±0.420	0.342±0.628	0.933±0.471	1.493±0.357
DJF	-0.386±1.056	-0.488±1.337	-0.829±1.013	-0.45±0.266	-0.214±0.291	0.565±0.262	-0.523±0.401	-0.277±0.175	0.653±0.418
MAM	-0.903±0.851	-0.866±0.754	-2.335±1.248	0.125±0.393	0.263±0.307	0.439±0.280	-0.068±0.533	0.513±0.403	0.315±0.531
SON	0.274±2.079	-0.705±1.13	-0.775±1.204	-0.353±0.421	-0.023±0.299	0.919±0.266	0.446±0.496	0.519±0.284	0.904±0.303

Supplementary Table S2: The seasonal: December-January-February (DJF, Winter), March-April-May (MAM, Spring), June-July-August (JJA, Summer), September-October-November (SON, Autumn) and annual averaged trends calculated for the pre-2000 (1988–2000) and post-2000 (2000–2024) periods using the merged-stations and merged-satellite (TOMS and OMI total column ozone, MSAT) data.

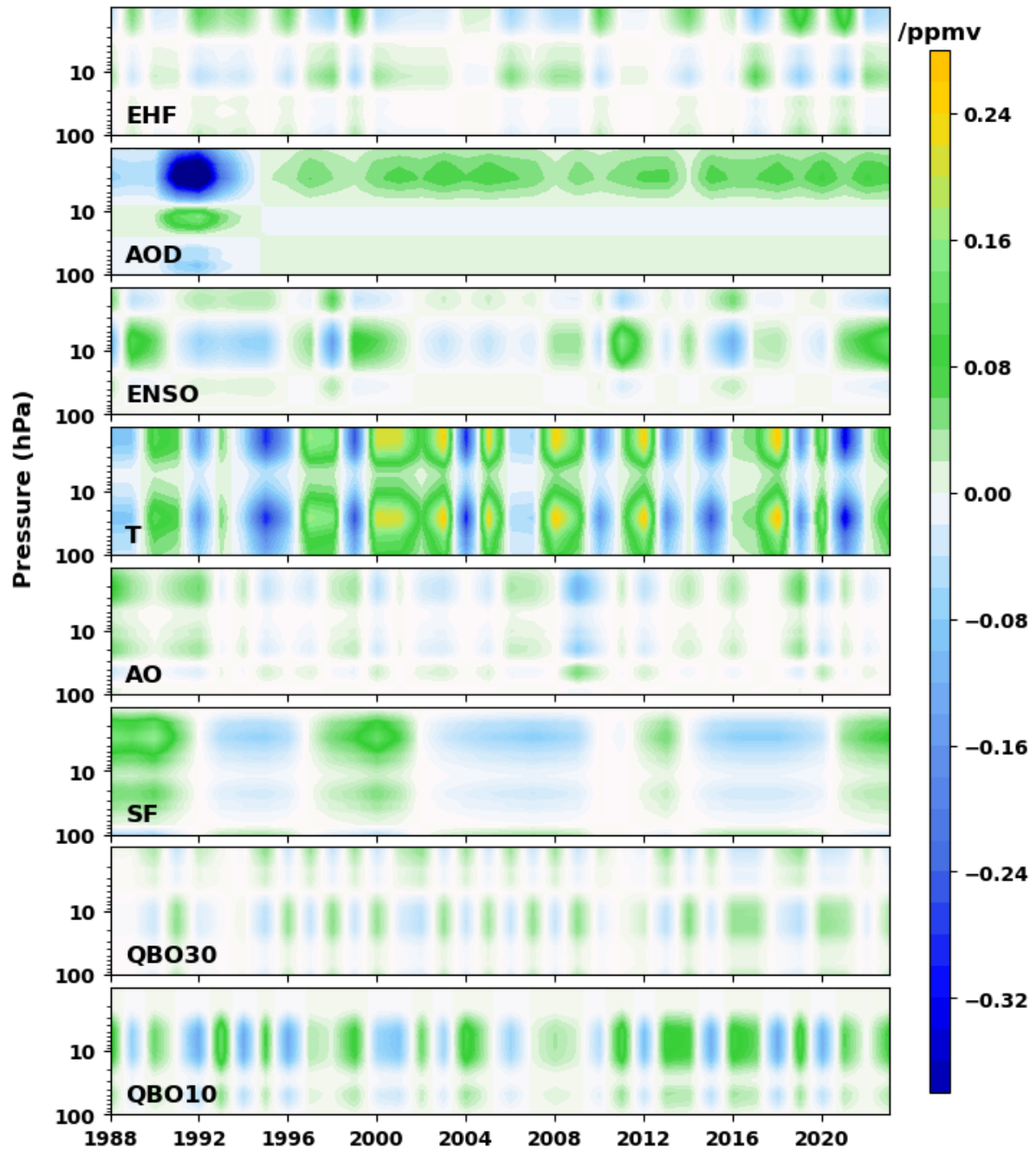
1988–2024	Merged stations (%/dec)		Merged Satellite, MSAT (%/dec)	
	1988–2000	2000–2024	1988–2000	2000–2024
DJF	-10.410 ± 4.02	1.23 ± 2.123	-3.873 ± 5.447	2.280 ± 2.095
MAM	-3.479 ± 5.70	1.89 ± 1.520	-8.158 ± 8.410	2.560 ± 2.094
JJA	-4.190 ± 3.69	1.12 ± 1.104	-2.624 ± 2.604	0.682 ± 0.986
SON	-7.740 ± 3.75	2.92 ± 0.752	-2.251 ± 2.185	1.419 ± 0.936
Annual	-5.720 ± 4.24	1.90 ± 1.058	-4.99 ± 3.910	2.099 ± 1.503

Supplementary Table S3: The seasonal: December-January-February (DJF, Winter), March-April-May (MAM, Spring), June-July-August (JJA, Summer), September (SON, Autumn) and annual averaged trends calculated for the pre-2000 (1988–2000) and post-2000 (2000–2024) periods using the ERA5 reanalysis data.

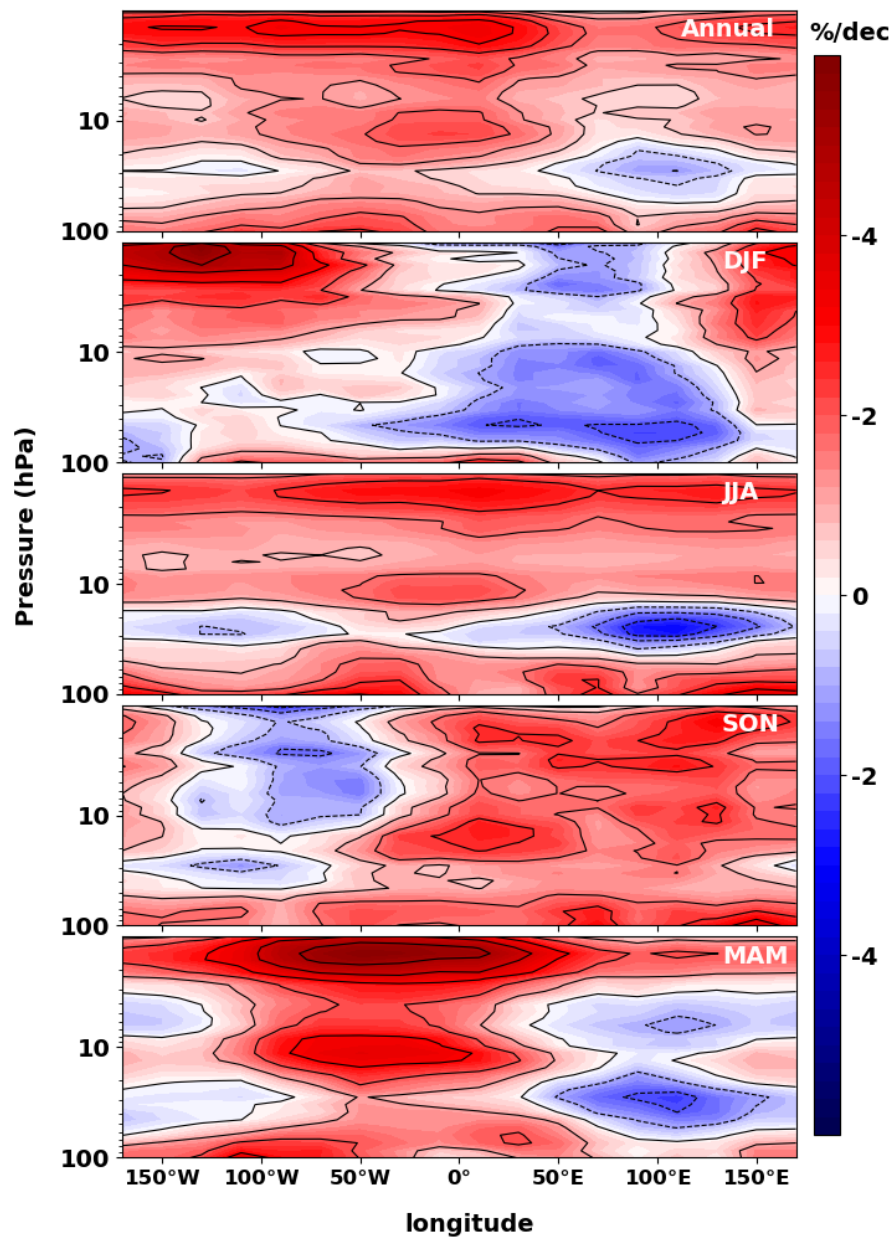
1988–2024	ERA5 (DU/dec)	
	PRE-2000	POST-2000
DJF	6.26 ± 16.63	-2.57 ± 4.31
MAM	-14.46 ± 13.89	7.89 ± 7.71
JJA	-6.76 ± 10.13	5.63 ± 4.85
SON	-0.03 ± 4.96	4.89 ± 1.77
Annual	-4.21 ± 6.79	5.04 ± 4.67



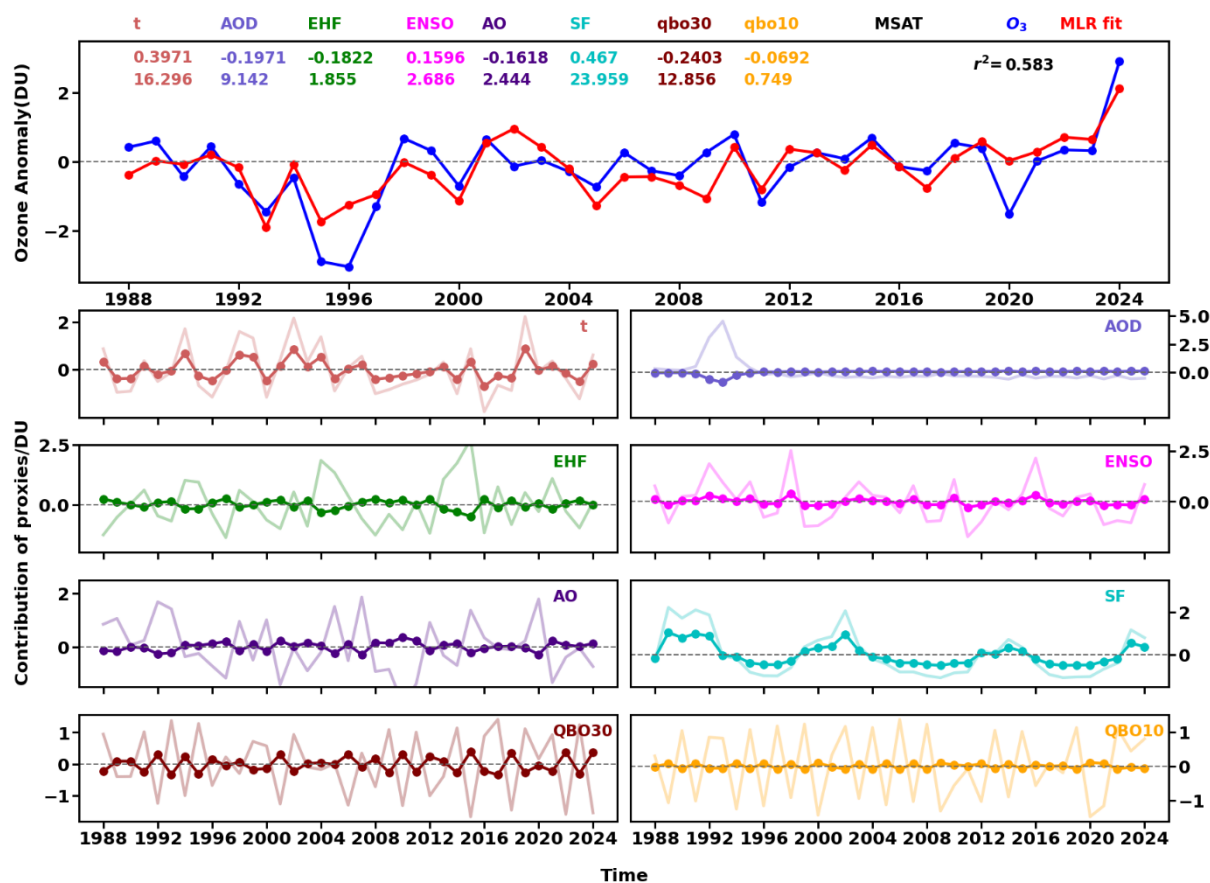
Supplementary Fig. S1: Monthly ozone concentration and mixing ratio for the period 1988–2024 (a) Stratospheric ozone mixing ratio at 100–1 hPa for the 1988–2000 (blue) and 2000–2024 (orange) periods as analysed from the SWOOSH ozone data. (b) The monthly average ozone mixing ratio at different pressure levels averaged for the period 1988–2024 using the SWOOSH data. (c) Averaged vertical distribution of ozone concentration for the pre-2000 (blue) and post-2000 (orange) periods using SAGE-CCI-OMPS measurements. (d) The monthly averaged ozone concentration from SAGE-CCI-OMPS averaged for the period 1988–2024 at 100–1 hPa.



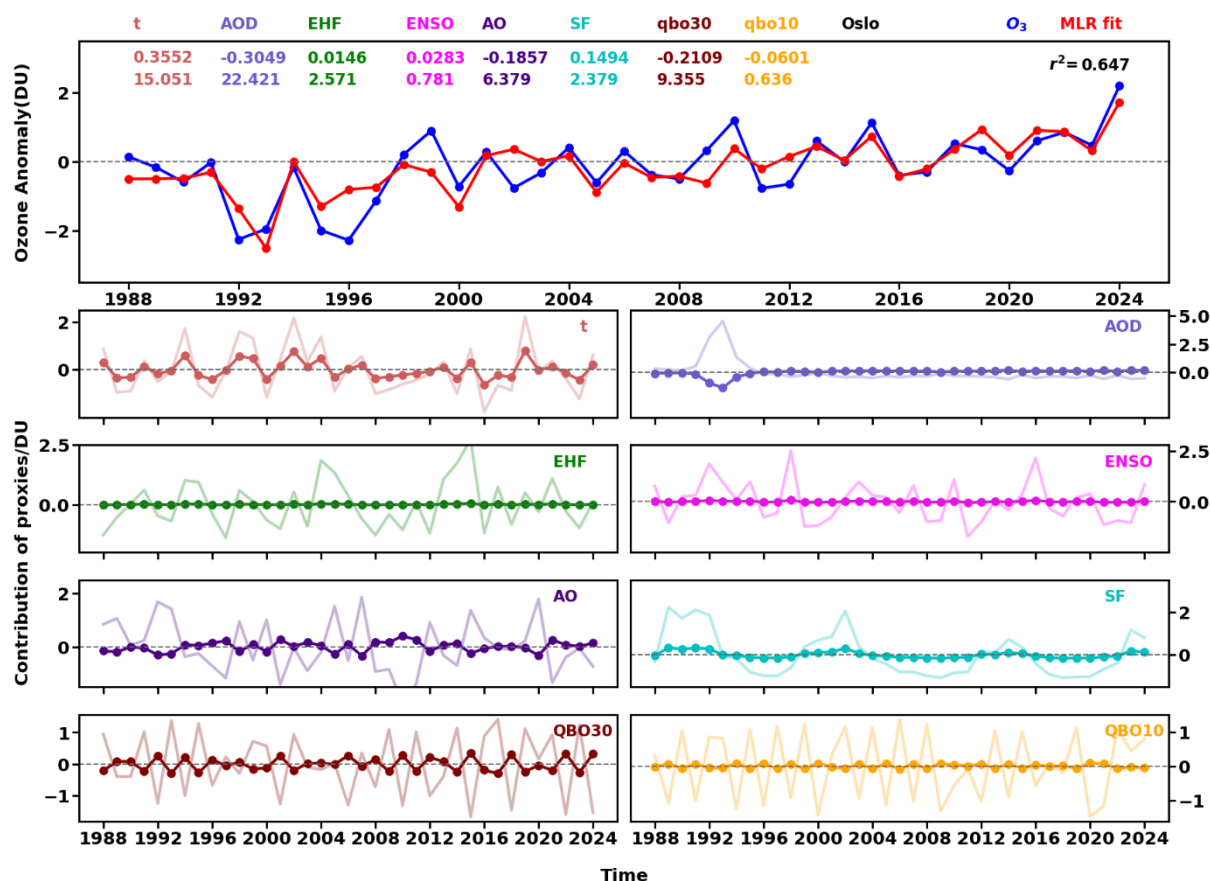
Supplementary Fig. S2: Vertical contribution of different meteorological parameter in ozone changes. Contribution of eddy heat flux (EHF), aerosol optical depth (AOD), El Nino Southern Oscillation (ENSO), temperature (T), Arctic Oscillation (AO), Solar Flux (SF) and Quasi-Biennial Oscillation (QBO30 and QBO10) to ozone change at different altitudes, as analysed with the SWOOSH data for the December, January and February (DJF) period in 1988–2024. QBO and ENSO with a 6-month lag are used here.



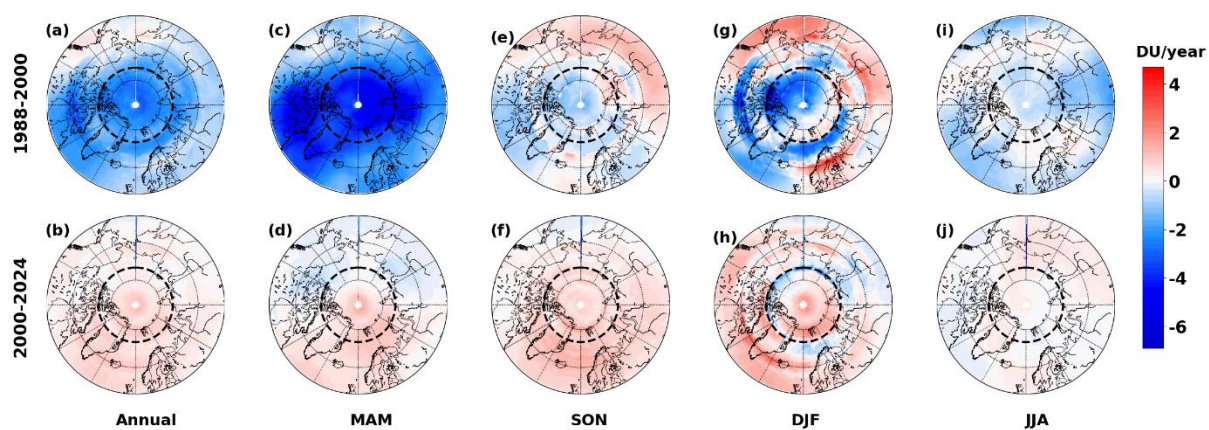
Supplementary Fig. S3: The longitudinally resolved MEGRIDOP annual and seasonal trends.



Supplementary Fig. S4: (Top panel) Regression result based on the normalized TCO over the Arctic region for the period 1988–2024. Annual averaged total column (TCO) data (Blue) from MSAT and the regressed ozone values (red) for the period 1988–2024 are represented. **(Bottom panels)** The thick line represents the contribution of each predictor for the period 1988–2024 with the MSAT data. The thin lines in the background show normalized distribution of the predictors used.



Supplementary Fig. S5: (Top panel) Regression result based on the normalized TCO over the Arctic region for 1988–2024. Annual averaged total column (TCO) data (Blue) from Oslo station and the regressed ozone values (red) for the period 1988–2024 are represented. **(Bottom panels)** The thick line represents the contribution of each predictor for the period 1988–2024 with the TCO data at Oslo. The thin light lines in the background show the normalized distribution of predictors used.



Supplementary Fig. S6: The MSAT total column ozone (TCO) linear trend in the Arctic (55° N – 90° N) in annual and different seasons for the periods 1988–2000 (Upper panel) and 2000–2024 (Lower panel).