

Supplementary information for

Classifying the severity of the annual Antarctic ozone hole

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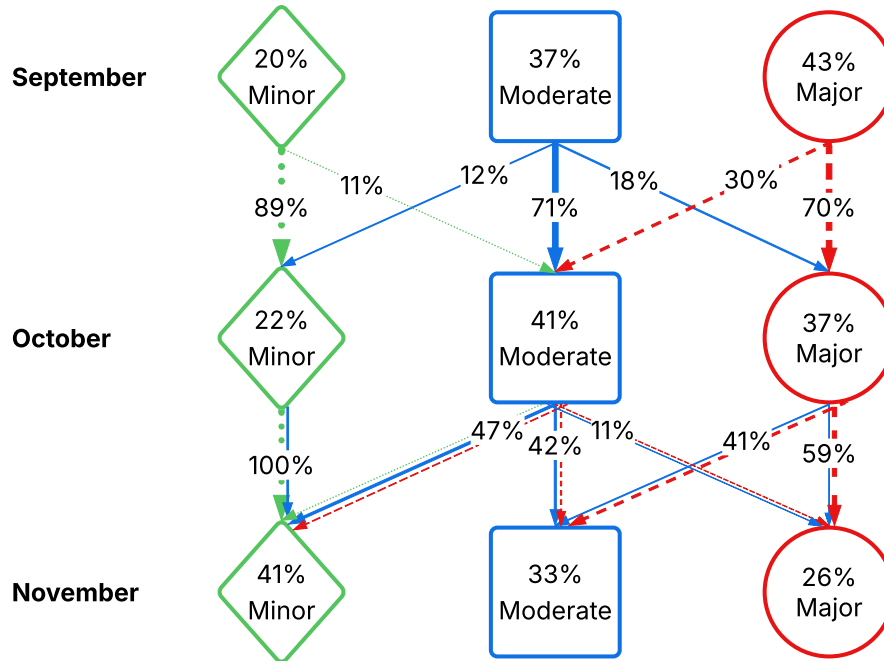
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Supplementary Tables S1 and S2
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Supplementary Table S1: Combined and normalized polar cap total column ozone (*Combined_TCO*) from 1979 to 2025. *SBUV_MOD_TCO*, *C3S_TCO*, and *GEOS_DAS_TCO* datasets are combined to create a single, normalized value for September, October, and November. Results for each month are separated into columns, where high values (> 0) indicate high total column ozone (TCO) and low values (< 0) indicate low TCO relative to other years. Data for September 1994 is missing from all datasets and is omitted.

Year	Sep	Oct	Nov	Year	Sep	Oct	Nov
1979	2.21	2.74	1.90	2003	-1.21	-0.15	0.07
1980	1.61	1.52	1.26	2004	0.00	0.50	-0.06
1981	1.93	1.35	1.43	2005	-0.60	-0.16	0.41
1982	1.35	1.51	0.83	2006	-1.26	-1.03	-1.26
1983	1.12	0.97	1.32	2007	-0.29	0.30	-0.66
1984	0.94	0.80	0.97	2008	-1.05	-0.66	-1.12
1985	0.56	0.04	0.12	2009	-0.91	0.08	-0.33
1986	0.99	0.72	1.21	2010	0.09	-0.31	-1.02
1987	-0.27	-0.86	-1.16	2011	-0.91	-1.15	-0.69
1988	1.31	1.57	1.87	2012	0.19	1.14	1.00
1989	-0.19	-0.36	0.40	2013	-0.06	0.51	0.55
1990	0.14	-0.50	-0.66	2014	-0.13	0.14	0.09
1991	0.12	0.00	0.87	2015	-0.70	-1.72	-1.51
1992	-0.60	0.13	-0.45	2016	0.06	0.03	0.60
1993	-0.85	-0.94	-0.58	2017	0.60	0.50	0.80
1994	–	-0.53	0.24	2018	-0.66	-1.11	-0.47
1995	-0.72	-0.83	-0.66	2019	2.12	1.68	1.36
1996	-0.53	-0.60	-0.75	2020	-0.85	-1.19	-1.69
1997	-0.32	-0.82	-0.30	2021	-0.81	-1.37	-1.32
1998	-1.12	-1.15	-1.10	2022	-0.62	-1.29	-1.23
1999	-1.06	-1.12	-1.12	2023	-0.76	-0.37	-0.92
2000	-1.40	0.26	0.69	2024	0.13	0.19	-0.22
2001	-1.30	-0.80	-0.96	2025	0.59	0.32	0.47
2002	1.52	1.53	1.46				



Supplementary Figure S1: **The seasonal evolution of ozone hole classifications.** Using classifications from 1979 to 2025 (excluding 1994 due to missing data, see Table 1), a state transition diagram schematically represents the typical evolution of ozone hole classifications. The percent distribution of Minor/Moderate/Major ozone holes from the 46-year period is shown for each month. Descending from each classification to the next month, arrows represent the percent of ozone holes which progress to the classification type below. The arrow colours and styles follow the initial September classification (Minor in September = dotted green, Moderate in September = solid blue, and Major in September = dashed red). The size of the arrows reflects the relative percent distributions leaving each intersection.

Supplementary Table S2: Frequency of ozone hole progressions. For each combination of ozone hole classifications (Minor/Moderate/Major for September-October-November), the corresponding occurrence frequency is determined over the historic period from 1979 to 2025 (excluding 1994) using Table 1 and reported as a percent. For progressions that have occurred in more than 10% of past years, the frequency is shown in bold. The years matching each progression type are listed in the rightmost column.

Progression type	Frequency	Years
Major-Major-Major	19.6%	1998, 1999, 2001, 2006, 2008, 2015, 2020, 2021, 2022
Major-Major-Moderate	10.9%	1993, 1995, 1996, 2011, 2018
Major-Major-Minor	-	-
Major-Moderate-Major	2.2%	2023
Major-Moderate-Moderate	6.5%	1992, 2003, 2009
Major-Moderate-Minor	4.3%	2000, 2005
Major-Minor-Minor	-	-
Major-Minor-Moderate	-	-
Major-Minor-Major	-	-
Moderate-Major-Major	2.2%	1987
Moderate-Major-Moderate	4.3%	1990, 1997
Moderate-Major-Minor	-	-
Moderate-Moderate-Major	2.2%	2010
Moderate-Moderate-Moderate	10.9%	1985, 2004, 2007, 2014, 2024
Moderate-Moderate-Minor	13.0%	1989, 1991, 2013, 2016, 2017, 2025
Moderate-Minor-Major	-	-
Moderate-Minor-Moderate	-	-
Moderate-Minor-Minor	4.3%	1984, 2012
Minor-Major-Major	-	-
Minor-Major-Moderate	-	-
Minor-Major-Minor	-	-
Minor-Moderate-Major	-	-
Minor-Moderate-Moderate	-	-
Minor-Moderate-Minor	2.2%	1986
Minor-Minor-Major	-	-
Minor-Minor-Moderate	-	-
Minor-Minor-Minor	17.4%	1979, 1980, 1981, 1982, 1983, 1988, 2002, 2019