Supplement of

Observational ozone datasets over the global oceans and polar regions version 2024

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Table S1. Methods and uncertainties of CO, NOx, and CN observations associated with O_3 observations from ship cruises.

Label	Cruise	CO, NOx, CN instrumentation	Uncertainty
S1	MR12: MR12-02	Thermo, 48C	3% for CO
S2	MR13: MR13-04, 05, 06, 14-01, 02	Thermo, 48C	3% for CO
S3	MR14: MR14-04, 05, 06	Thermo, 48C	3% for CO
S4	MR15: MR15-03, 04, 05	Thermo, 48C	3% for CO
S5	MR16: MR16-06, 08, 09	Thermo, 48C	3% for CO
S6	MR17: MR17-05C, 08	Thermo, 48C	3% for CO
S7	MR18: MR18-04, 05C, 06	Thermo, 48C	3% for CO
S8	MR19: MR19-03C, 04	Thermo, 48C	3% for CO
S9	MR20: MR20-E01, 05C, E02, 01	Thermo, 48iTLE	3% for CO
S10	MR21: MR21-01, 03, 05C, 06	Thermo, 48iTLE	3% for CO
S11	KH-18-6	Thermo, 48iTLE	3% for CO
S12	NAAMES1	TSI 3010	CO: ±(10 +5%) ppb
S13	NAAMES2	TSI 3010	
S14	NAAMES3	TSI 3010	
S15	NAAMES4	TSI 3010	
S16	ATOMIC	TSI 3010	
S17	DYNAMO	TSI 3010	
S18	WACS	TSI 3010	
S19	VOCALS	TSI 3010	± 2% n/cm3
S20	MAGE92	N/A	
S21	RITS93	TSI 3076	
S22	RITS94	TSI 3076	
S24	ACEASIA	TSI 3760	
S25	NEAQS 2002	NO by NO_2 chemiluminescence (custom instrument) Conversion of NO2 to NO by broadband UV light from 500W Xe lamp	NO ±(4%+0.006 ppb); NO2 ±(7%+0.024 ppb)

S26	NEAQS 2004	CO AeroLaser AL-5002;NO Chemiluminescence instrument; NO_2 Photolysis of NO_2 and NO detection	CO ±(3% + 1 ppbv); NO ±(4.4%); NO2 The total estimated accuracy for NO2 when $NO_2/NO = 3$ is ±(6.5% + 93 pptv), increasing to ±11% when $NO_2/NO = 1$ and ±23% when $NO_2/NO = 0.33$.
S27	TEXAQS 2006	CO AL 5002, NO by ozone-induced Chemiluminescence, NO2 by photolysis, followed by ozone-induced chemiluminescence	CO: ±3%, NO 3.8% + 0.010 ppbv, see NO2_ppbv_var
S28	ICEALOT	CO AL5002, NO is measured directly by ozone-induced chemiluminescence. NO_2 is partially photoyzed and measured as the difference in signal between a photoyzed and unphotolyzed sample., CNC	CO ± 4.1%, see NO_ppbv_unc and NO2_ppbv_unc
S29	CalNex 2010	CO N/A, NO, NO_2: N/A	CO N/A, NO, NO_2 N/A
S60	MOSAiC	CO: Cavity ring-down spectrometer (Picarro model G2401)	manufacturer-specified precisions of 1.0 ppb for 20-s averages, CO 1.5 ppb (5 min)
S62	AEROSOLS99-INDOEX	TSI 3010	N/A

Table S2. Methods and uncertainties of CO, NOx, and CN observations associated with O_3 observations from aircraft campaigns.

Label	Campaign	CO, NOx instrumentation	Uncertainty
A5	PEM-West A	TDL, Chemiluminescence, PF/LIF	CO 1%, NO ±18%. NO_2 ±20%
A6	PEM-West B	TDL, LIF	CO 1%, NO ±18%
A8	PEM-Tropics A	TDL, TP-LIF, PF/TP-LIF	CO 1%, NO 63 ppt, NO_2 12 ppt
A9	PEM-Tropics B P3B	differential absorption IR, chemiluminescence	CO ±2%, NO, NO_2: 1.5 ppt
A10	PEM-Tropics B DC8	TDL, TP-LIF, PF/TP-LIF	CO ±2%, NO, NO_2: see original data files
A11	TRACE-P P3B	TDLAS, chemiluminescence	±2% (CO), ±8%(NO), ±20% (NO_2)
A12	TRACE-P DC8	TDLAS, TP-LIF	±2% (CO), ±20-30% (NO, NO_2)
A13	INTEX-NA	TDLAS, LIF	CO (5% or 1 ppb), NO, NO_2 (5 ppt, 10%)
A14	INTEX-B DC8	DACOM, LIF	CO: 5% or 1 ppb, NO, NO_2 5%, 15%
A15	INTEX-B C-130	VUV-fluorescence, chemiluminescence	CO: ± 10%, ±(15+7% of the mixing ratio) pptv for NO, ±(15+10% of the mixing ratio) pptv for NO_2
A16	ARCTAS	TDLAS, chemiluminescence	CO: 2% or 2 ppb, NO: 7%, NO_2: 10%
A17	SEAC4RS DC8	CO: Diode laser spectrometer, NO: chemiluminescence, NO_2:UV-LED photolysis/chemiluminescence	CO: 5% or 5 ppb, NO:0.010 ppbv + 4%, NO_2: 0.030 ppbv + 7%
A18	SEAC4RS ER2	CO: Picarro Cavity Ringdown Spectrometer	CO: 2.5 ppb
A19	DISCOVER-AQ	4ch chemiluminescence	10 pptv + 10% for NO, 20 pptv + 10% for NO_2
A20	KORUS-AQ	4ch chemiluminescence, CO: Diode laser spectrometer	(30 pptv + 20%) for NO, (50 pptv + 30%) for NO_2, 2% or 2 ppbv for CO
A21	ATom1-4	4ch chemiluminescence, PICARRO cavity ringdown spectrometer	NO, NO_2: 5-10 ppt, 3.6 ppb CO (10 s)

A22	HIPPO	VUV fluorescence	CO: 5 ppb
A23	ACSIS FAAM	CO: AERO AL5002 instrument	N/A
A24	ACCACIA FAAM	CO: AERO AL5002 instrument	N/A
A25	CAST FAAM	CO: AERO AL5002 instrument	N/A
A26	CLARIFY FAAM	CO: AERO AL5002 instrument	N/A
A27	ITOP FAAM	CO: AERO AL5002 instrument	N/A
A28	VOCALS FAAM	CO: AERO AL5002 instrument	N/A
A31	TEXAQS2000	CO vacuum ultraviolet fluorescence; NO/O_3 Chemiluminescence; NO_2 via UV photolysis	CO random uncertainty: 2.5%. NO: ±(20 pptv+5%); NO_2: ±(40 pptv+8%);
A32	ITCT2002	CO vacuum ultraviolet fluorescence; NO/O_3 Chemiluminescence; NO_2 via UV photolysis	CO random uncertainty: 2.5%. NO: ±(10 pptv+5%); NO_2: ±(30 pptv+10%)
A33	ITCT2004	CO VUV resonance fluorescence; NO, NO_2: Photolysis & NO/O_3 Chemiluminescence	CO 5%, NO_ppbv ±(0.010 + 5%); NO_2_ppbv ±(0.025 + 8%)
A35	TEXAQS2006	CO VUV resonance fluorescence; NO, NO_2: Photolysis & NO/O_3 Chemiluminescence	CO 5% ±1 ppbv, NO (0.015 ppbv + 5%), NO_2 (0.040 ppbv + 9%)
A36	ARCPAC2008	CO VUV Resonance Fluorescence, NO, NO_2: Photolysis and NO/O_3 Chemiluminescence	CO 3%, NO (0.02 + 8%), NO_2 (0.04 + 10%)
A37	CalNex2010	CO VUV Resonance Fluorescence, NO, NO_2: Photolysis and NO/O_3 Chemiluminescence	CO 5%, NO (0.01 ppbv + 3%), NO_2 (0.03 ppbv + 4%)

A45	ACTIVATE	CO: Picarro Cavity Ringdown Spectrometer	CO ±5 ppb or ±2%
A46	CONTRAST	2-ch chemiluminescence instrument for NO-NO2, CO: Aero-laser AL5002 VUV fluorescence	CO: 3 ppbv ±3%, See error columns in this original file
A47	TORERO	CO: Aero-laser AL5002 VUV fluorescence	CO: 3 ppbv ±3%

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Table S3. List of ozonesonde data contained in the ozonesonde data file.

Label	Station	Latitude	Longitude	Year begin	Year end	Data number	Wind directions for oceanic air masses (see footnote)	Regions	Literature	Data source
O1	Alert	82.50	-62.33	2000	2020	23211	all wind directions	R10		HEGIFTOM_homogenized
O2	Eureka	79.99	-85.94	2000	2021	33473	all wind directions	R10		HEGIFTOM_homogenized
O3	Resolute	74.71	-94.97	2000	2021	19146	all wind directions	R10		HEGIFTOM_homogenized
O4	Scoresbysund	70.48	-21.95	1989	2022	38362	all wind directions	R10		HEGIFTOM_homogenized
O5	Sodankyla	67.36	26.62	1994	2022	35893	all wind directions	R10		HEGIFTOM_homogenized
O6	Trinidad Head	41.06	-124.15	1997	2021	31441	5, 6 or 7	R1		HEGIFTOM_homogenized
O7	Wallops Island	37.90	-75.70	1995	2020	36700	2, 3 or 4	R7	Witte et al., (2019)	HEGIFTOM_homogenized
O8	Izana	28.46	-16.26	1995	2022	35025	all wind directions	R7		HEGIFTOM_homogenized
O9	Hanoi	21.02	105.80	2004	2018	6537		R2		HEGIFTOM_homogenized
O10	Hilo	19.72	-155.05	1982	2021	39389	all wind directions	R2		HEGIFTOM_homogenized
O11	Costa Rica	9.98	-84.21	2005	2020	10920		R8		HEGIFTOM_homogenized
O12	Paramaribo	5.81	-55.21	1999	2021	20597	0, 1, 2, 5, 6 or 7	R8		HEGIFTOM_homogenized
O13	Kuala Lumpur	2.73	101.70	1998	2019	10985		R2		HEGIFTOM_homogenized
O14	San Cristobal	-0.92	-89.60	1998	2016	10405	all wind directions	R2		HEGIFTOM_homogenized
O15	Natal	-5.40	-35.40	1998	2019	17505	all wind directions	R8		HEGIFTOM_homogenized
O16	Watukosek	-7.60	112.70	1998	2013	8404		R2		HEGIFTOM_homogenized
O17	Ascension Island	-7.56	-14.22	1998	2020	18238	all wind directions	R8		HEGIFTOM_homogenized
O18	Samoa	-14.33	-170.71	1986	2021	25066	all wind directions	R2		HEGIFTOM_homogenized

O19	Suva_Fiji	-18.15	178.45	1997	2021	11779	all wind directions	R2		HEGIFTOM_ homogenized
O20	Reunion	-21.10	55.50	1998	2020	18470	all wind directions	R5		HEGIFTOM_ homogenized
O21	McMurdo	-78.85	166.67	1986	2010	20440	all wind directions	R11		HEGIFTOM_ homogenized
O22	South Pole	-90.00	-169.00	1967	2021	24122	all wind directions	R11		HEGIFTOM_ homogenized
O23	Isabela-San Cristobal	-0.96, -0.92	-90.97, -89.6	2011	2011	400	all wind directions	R2	Gómez Martín et al. (2016)	Campaign (ECC)
O24	Lauder	-45.04	169.68	1986	2021	44796		R3		HEGIFTOM_ homogenized
O25	Ny Ålesund	78.93	11.95	1992	2022	63633	all wind directions	R10		HEGIFTOM_ homogenized
O26	Shoyomaru	variable, see data	variable, see data	1999	1999	350	all wind directions	R2	Shiotani et al. (2002), Fujiwara et al. (2003)	Campaign (ECC)
O27	Marambio	-64.23	-56.62	1988	2019	28057	all wind directions	R11		WOUDC (ECC)
O28	Davis	-68.58	77.97	2006	2023	16201	all wind directions	R11		WOUDC (ECC)
O29	Syowa	-69.01	39.58	2010	2023	16925	all wind directions	R11		WOUDC (ECC only)

Note: wind direction codes are [0=N, 1=NE, 2=E, …, and 7=NW]. Recommendations for Trinidad Head, Wallops Island, and Paramaribo was provisionally included.

Table S4. List of non-polar ground-based observations contained in the coastal sites dataset.

Label	Station	Latitude	Longitude	Altitude (m)	Year begin	Year end	Data number	Ancillary data	Data source	Region	Literature
C1	American Samoa	-14.25	-170.56	77	1975	2015	296716	N/A	TOAR-II DB	R2	
C2	Trinidad Head	41.05	-124.15	107	2002	2021	144515	N/A	TOAR-II DB	R1	
C3	Tudor Hills	32.27	-64.88	30	1988	2021	205951	N/A	TOAR-II DB	R7	
C4	Ragged Point	13.17	-59.43	45	1989	2017	121400	N/A	TOAR-II DB	R8	
C5	Minamitorishima	24.29	153.98	7	1994	2020	227252	N/A	TOAR-II DB	R1	
C6	Cape Hedo	26.87	128.25	68	2000	2021	182731	N/A	EANET, https://monitoring.eanet.asia/document/signin/index	R1	
C7	Ogasawara	27.09	142.22	212	2000	2021	175470	N/A	EANET, https://monitoring.eanet.asia/document/signin/index	R1	
C8	Kennaook-Cape Grim	-40.68	144.69	94	1981	2020	301842	N/A	CSIRO	R3	Galbally et al. (2000)
C9	Mace Head	53.33	-9.9	8	1988	2021	286705	N/A	TOAR-II DB	R7	
C10	Cabo Verde	16.86	-24.87	10	2006	2022	134538	CO	TOAR-II DB	R8	
C11	Cape Point	-34.35	18.49	230	2015	2021	40613	N/A	TOAR-II DB	R9	
C12	Ushuaia	-54.85	-68.31	18	1994	2022	202431	N/A	TOAR-II DB	R9	
C13	Baring Head	-41.41	174.87	85	1991	2021	211900	N/A	TOAR-II DB	R3	
C14	Mauna Loa	19.54	-155.58	3397	1957	2021	412530	N/A	TOAR-II DB	R2	
C15	Sable Island	43.93	-59.9	8	2003	2014	78813	NO, NO_2, NOx	TOAR-II DB	R7	
C16	Izana	28.31	-16.5	2373	1987	2022	300331	N/A	TOAR-II DB	R7	
C17	Faial	38.61	-28.63	310	2007	2020	98546	NO, NO_2, NOx	TOAR-II DB	R7	
C18	Cheeka Peak	48.3	-124.62	466	2006	2022	113646	CO	TOAR-II DB	R1	
C19	Bukit Kototabang	-0.2	100.32	864	2007	2021	93431	N/A	TOAR-II DB	R2	
C20	SanCristobal_Galapagos	-0.9	-89.61	14	2000	2012	16477	N/A	campaign	R2	Gómez Martín et al. (2016)
C21	Isabela_Island	-0.96	-90.97	5	2010	2011	4419	NO_2	campaign	R2	Gómez Martín et al. (2016)

Table S5. List of polar ground-based observations contained in the polar sites dataset.

Label	Station	Latitude	Longitude	Altitude (m)	Year begin	Year end	Data number	Ancillary data	Data source	Region
P1	Barrow	71.32	-156.61	11	1973	2021	399426	N/A	TOAR-II DB	R10
P2	South Pole	-90.0	-24.8	2841	1975	2021	383899	N/A	TOAR-II DB	R11
P3	Syowa	-69.01	39.59	16	1997	2022	208564	N/A	TOAR-II DB	R11
P4	Alert	82.45	-62.51	210	1992	2022	228231	N/A	Canadian data site https://data-donnees.az.ec.gc.ca/data/air/monitor/national-air-pollution-surveillance-naps-program/Data-Donnees/?lang=en	R10
P5	Arrival Heights	-77.83	166.66	184	1996	2021	204240	N/A	TOAR-II DB	R11
P6	Villum	81.6	-16.67	20	2001	2021	106839	N/A	TOAR-II DB	R10
P7	Pallas	67.97	24.12	565	1995	2020	216419	NO_2	TOAR-II DB	R10
P8	Neumayer	-70.67	-8.27	42	1995	2021	203827	N/A	TOAR-II DB	R11
P9	Zeppelin mountain	78.91	11.89	474	1989	2022	219504	CO	TOAR-II DB	R10
P10	Karasjok	69.47	25.22	333	1997	2010	109445	N/A	TOAR-II DB	R10
P11	Concordia	-75.1	23.33	3233	2006	2022	91958	N/A	TOAR-II DB	R11
P12	Halley	-75.62	-26.18	30	2007	2022	88916	N/A	TOAR-II DB	R11
P13	Esrange	67.88	21.07	475	1990	2021	267012	N/A	TOAR-II DB	R10
P14	Tiksi	71.59	128.92	8	2010	2018	51107	N/A	TOAR-II DB	R10
P15	Tustervatn	65.83	13.91	439	1989	2022	275764	N/A	TOAR-II DB	R10
P16	Summit	72.58	-38.48	3238	2000	2021	169281	N/A	TOAR-II DB	R10
P17	Belgrano	-77.87	-34.62	256	2007	2023	138284	N/A	INTA	R11

Table S6. Statistics on the number of observation days per region and season.

	Ship/buoy				Airborne				Ozonesonde			
	DJF	**MAM**	**JJA**	**SON**	**DJF**	**MAM**	**JJA**	**SON**	**DJF**	**MAM**	**JJA**	**SON**
R1	97	293	241	218	159	204	49	26	262	372	370	270
R2	231	116	102	97	57	65	9	51	1149	1187	1251	1257
R3	131	159	24	140	12	15	13	21	455	462	464	583
R4	76	27	17	109	0	0	0	0	0	0	0	0
R5	179	73	24	41	0	0	0	1	182	206	160	200
R6	0	0	0	0	0	0	0	0	0	0	0	0
R7	220	521	415	350	19	52	93	77	695	690	773	678
R8	348	334	133	284	10	5	16	24	685	718	762	733
R9	319	228	98	214	0	0	0	2	0	0	0	0
R10	560	962	1156	1292	3	44	44	2	2840	2418	1596	1668
R11	567	166	108	113	1	1	0	2	925	784	1349	2427

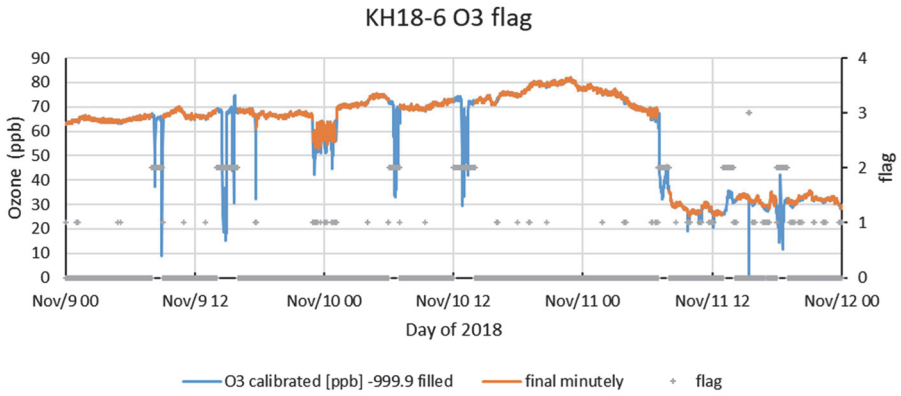

Figure S1. Removal of ozone data affected by ship exhaust and instability (blue). Flags (grey, in the right axis) 1: 1-minute based data removed (as lower than hourly average - 1σ), 2: hours with large variability, and 3: no data. The data after removal (orange) are used to calculate the hourly averages.

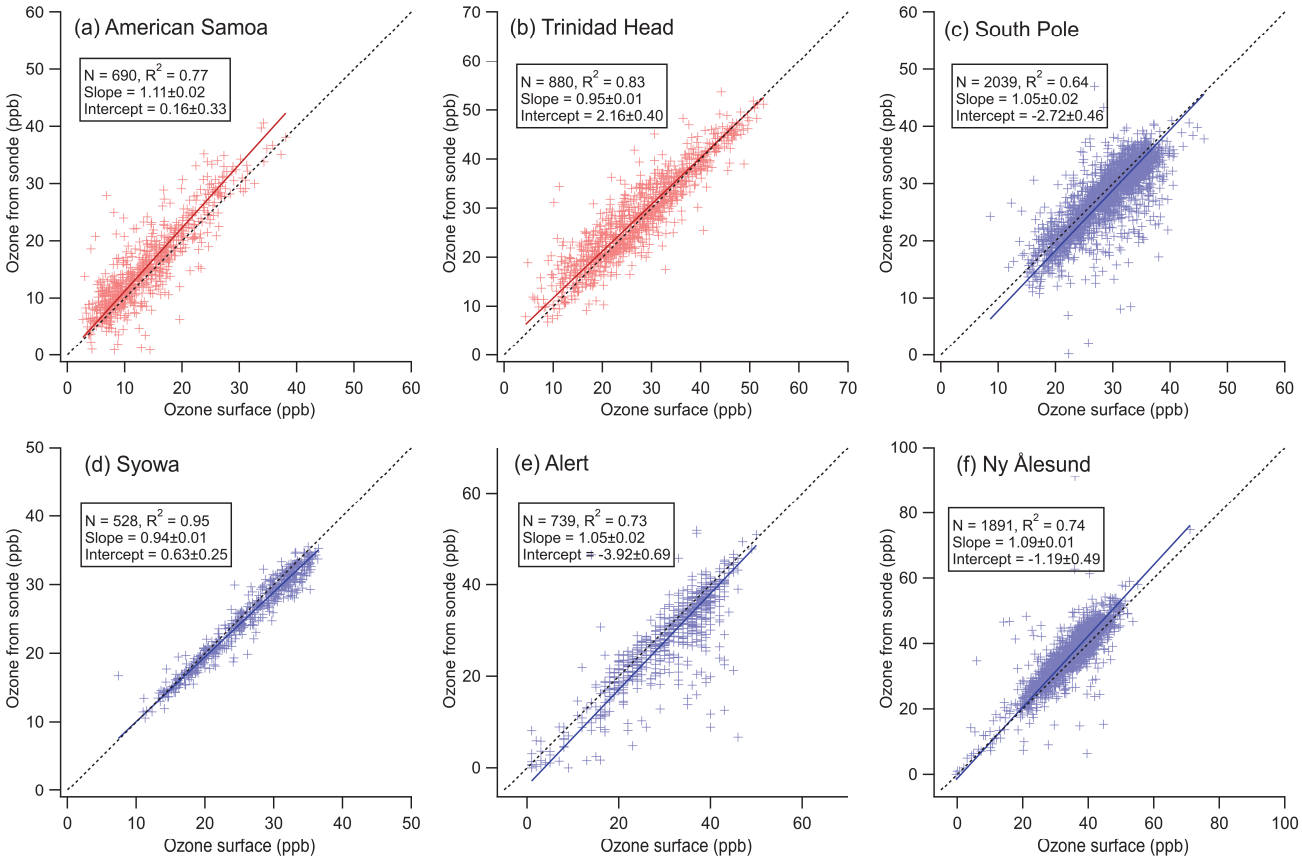

Figure S2. Scatterplots between ozonesonde data at the lowest level (~200 m) and surface data at 6 sites with co-located observations. Two sites (red) are from non-polar regions and the other four sites (blue) are from polar regions. The colored lines are the bivariate linear fits. The dashed black lines represent y = x.

Appendix A

Table S-A1. List of acronyms and abbreviations.

Acronym	Definition
ACCACIA	Aerosol-Cloud Coupling and Climate Interactions in the Arctic
ACE-Asia	Aerosol Characterization Experiment – Asia
ACSIS	Atmospheric Chemistry and Climate of the Southern Indian Ocean
ACTIVATE	Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment
AEROSOLS99-INDOEX	Indian Ocean Experiment 1999
ARCPAC	Aerosol, Radiation, and Cloud Processes affecting Arctic Climate
ARCTAS	Arctic Research of the Composition of the Troposphere from Aircraft and Satellites
ATom	Atmospheric Tomography Mission
ATOMIC	Atlantic Tradewind Ocean–Atmosphere Mesoscale Interaction Campaign
CalNex	California Nexus
CAST	Coordinated Airborne Studies in the Tropics
CLARIFY	Cloud-Aerosol-Radiation Interactions and Forcing: Year 2017
CONTRAST	Convective Transport of Active Species in the Tropics
DISCOVER-AQ	Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DYNAMO	Dynamics of the Madden-Julian Oscillation
HIPPO	HIAPER Pole-to-Pole Observations
ICEALOT	International Chemistry Experiment in the Arctic LOwer Troposphere
INTEX-B	Intercontinental Chemical Transport Experiment-B
INTEX-NA	Intercontinental Chemical Transport Experiment-North America
ITCT	Intercontinental Transport and Chemical Transformation
ITOP	Intercontinental Transport of Ozone and Precursors
KORUS-AQ	Korea-United States Air Quality Study
MAGE	Marine Aerosol and Gas Exchange
MOSAiC	Multidisciplinary drifting Observatory for the Study of Arctic Climate
NAAMES	North Atlantic Aerosols and Marine Ecosystems Study
NEAQS	New England Air Quality Study
PEM-Tropics	Pacific Exploratory Mission-Tropics
PEM-West	Pacific Exploratory Mission-West
RITS	Research in the Tropics
SEAC4RS	Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys
TEXAQS	Texas Air Quality Study
TORERO	Tropical Ocean tRoposphere Exchange of Reactive halogen species and Oxygenated VOC
TRACE-P	Transport and Chemical Evolution over the Pacific
VOCALS	VAMOS Ocean-Cloud-Atmosphere-Land Study
WACS	Western Atlantic Climate Study

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