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Supplement of

Balloon-borne stratospheric vertical profiling of carbonyl sulfide and evaluation of ozone scrubbing materials

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S1 LISA and BigLISA sampling pressures, altitudes and collected sample volumes

Table S1: pressure, altitudes and estimated sampled volumes at standard temperature and pressure (STP) conditions of the BigLISA (BL) and LISA (L) samples.

Flight code and sample code	Minimum ambient p (hPa)	Maximum ambient p (hPa)	Minimum altitude (km)	Maximum altitude (km)	Final bag pressure absolute (hPa)	Estimated sampled volume (mL STP)
KRN – BL1	10.7	18.8	27.0	30.7	48.8	200
KRN – BL2	19.3	36.0	22.8	26.8	101.0	400
KRN – BL8	27.1	48.8	20.8	24.6	99.3	400
KRN – BL3	37.2	54.4	20.1	22.5	186.9	750
KRN – BL9	56.2	75.2	18.0	19.0	166.6	670
KRN – BL4	65.1	78.9	17.7	19.0	275.7	1100
KRN – BL5	97.8	105.9	15.9	16.4	303.5	1210
KRN – BL6	126.1	131.4	14.5	14.7	252.2	1010
SOD2 – L1	132.3	143.6	14.1	14.7	258.0	650
SOD2 – L2	80.0	95.2	16.8	18.0	236.4	590
SOD2 – L3	39.2	46.5	21.5	22.7	89.9	230
SOD3 – L1	133.7	141.8	14.2	14.6	262.5	660
SOD3 – L2	82.1	93.8	17.0	17.9	257.3	640
SOD3 – L3	35.0	46.5	21.6	23.5	170.4	430
SOD4 – L1	130.2	141.0	14.3	14.6	261.0	650
SOD4 – L2	79.6	94.3	17.0	18.0	242.2	610
SOD4 – L4	18.6	28.7	24.8	27.7	76.5	190

S2 p-values from ANOVA test on stratospheric-mimicking gas mixture

Figures S1-S4 and their relative Table S4-S7 illustrate the results of the ANOVA tests on the other tracers measured by the QCLS. CO, similarly to COS, seem to be produced during the O_3 generation. The other tracers seem to be affected by O_3 and by squalene only marginally, with their ANOVA tests resulting in non-significant differences.

Table S8 and S9 report the p-values related to the ANOVA tests depicted in Fig. 3 and 4 in the main text, respectively.

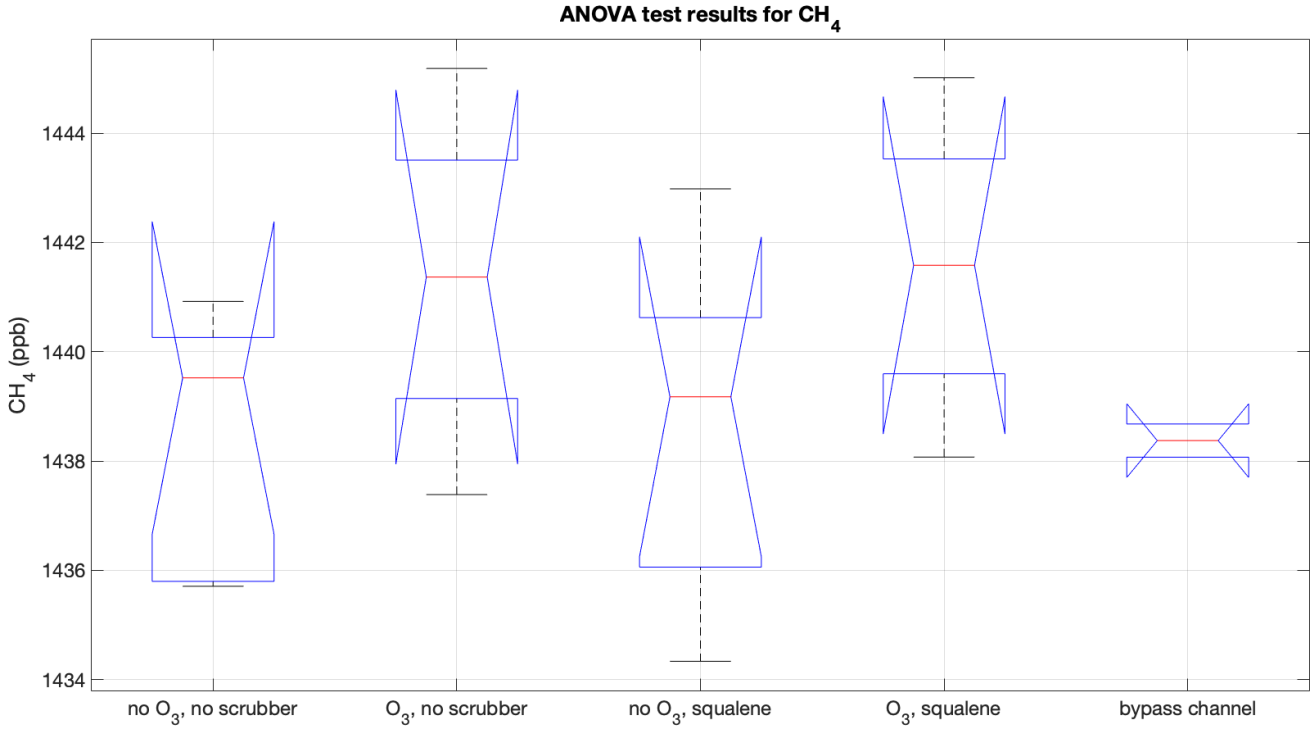

Figure S1: ANOVA test representation for CH_4.

Table S2: p-values resulting from the ANOVA test for CH_4 molar fractions.

CH_4	No O_3, no scrubber	O_3 generation, no scrubber	No O_3, squalene	O_3 generation, squalene	Bypass channel
No O_3, no scrubber		0.155378193	0.949217256	0.108066673	0.88969152
O_3 generation, no scrubber	0.155378193		0.236982215	0.915871475	0.288201694

No O_3, squalene	0.949217256	0.236982215		0.184145628	0.885169195
O_3 generation, squalene	0.108066673	0.915871475	0.184145628		0.212687552
Bypass channel	0.88969152	0.288201694	0.885169195	0.212687552	

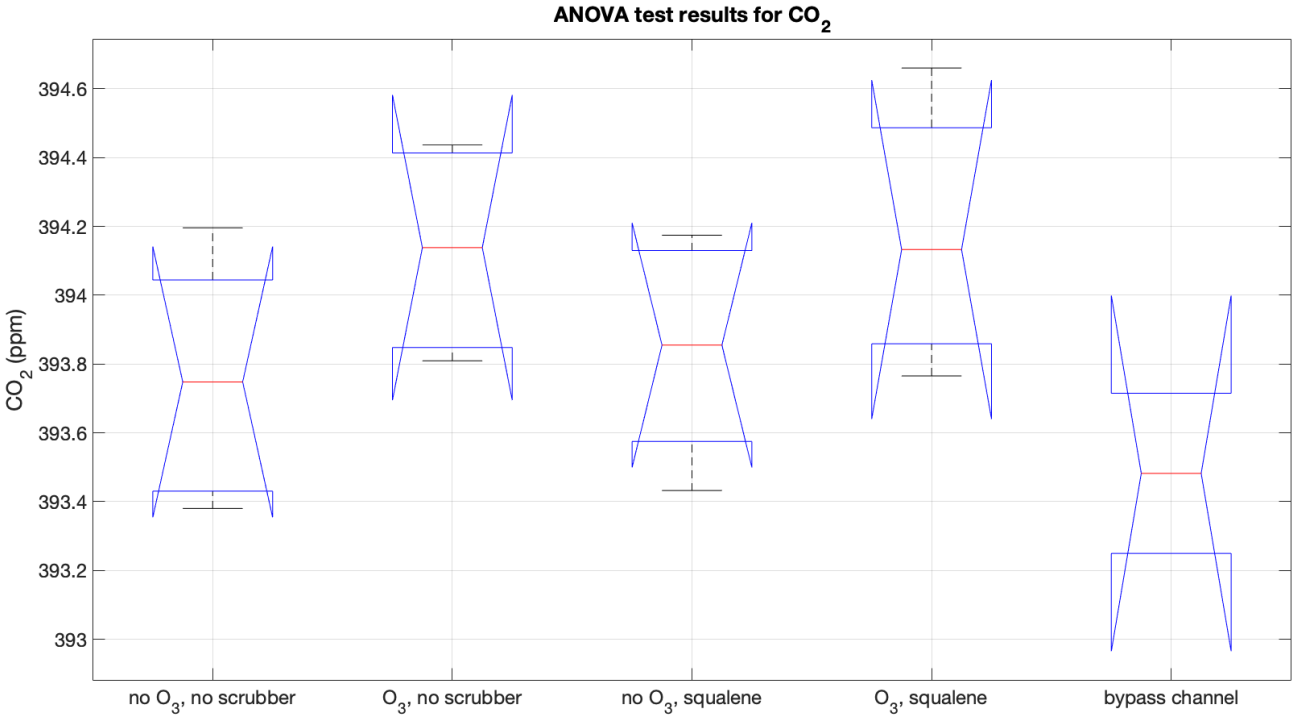

Figure S2: ANOVA test representation for CO_2.

Table S3: p-values resulting from the ANOVA test for CO_2 molar fractions.

CO_2	**No O_3, no scrubber**	**O_3 generation, no scrubber**	**No O_3, squalene**	**O_3 generation, squalene**	**Bypass channel**
No O_3, no scrubber		0.120593543	0.674240248	0.111410702	0.351443899
O_3 generation, no scrubber	0.120593543		0.178580774	0.875554317	0.084883879
No O_3, squalene	0.674240248	0.178580774		0.161549618	0.200493163
O_3 generation, squalene	0.111410702	0.875554317	0.161549618		0.104353378
Bypass channel	0.351443899	0.084883879	0.200493163	0.104353378	

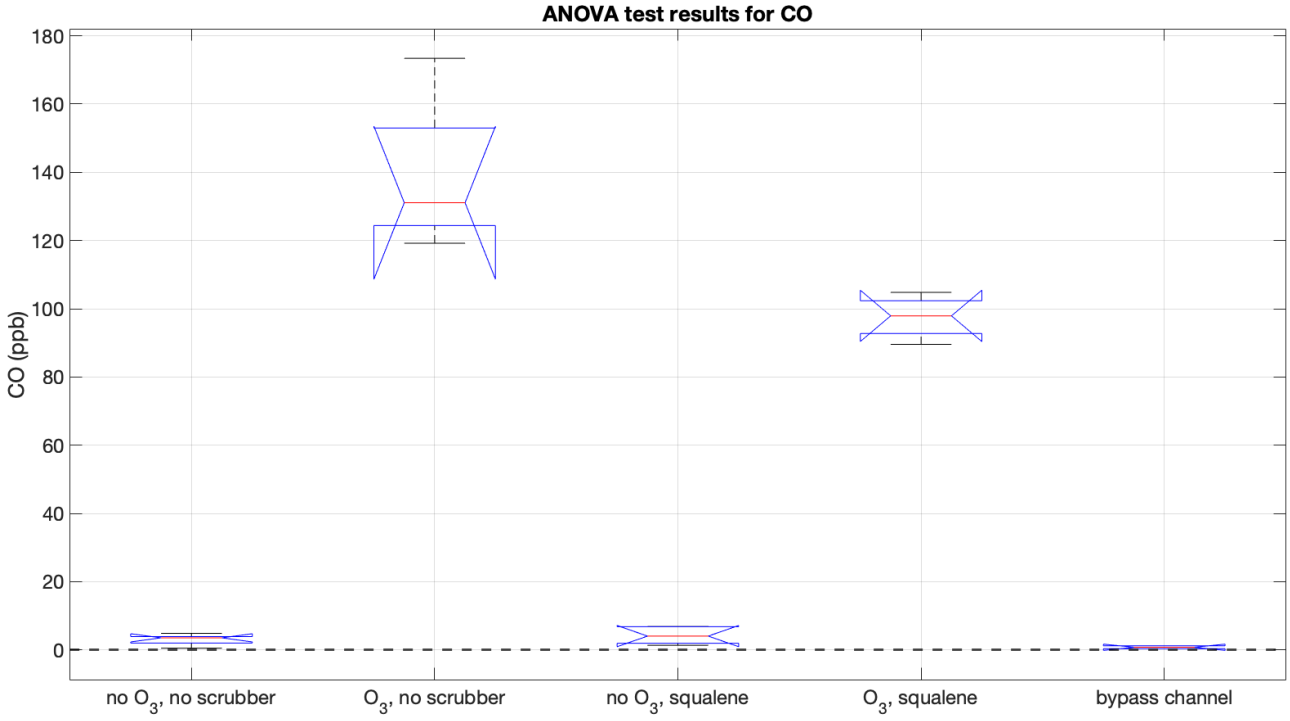

Figure S3: ANOVA test representation for CO.

Table S4: p-values resulting from the ANOVA test for CO molar fractions.

CO	No O_3, no scrubber	O_3 generation, no scrubber	No O_3, squalene	O_3 generation, squalene	Bypass channel
No O_3, no scrubber		5.44265E-07	0.382133147	4.43905E-10	0.100030491
O_3 generation, no scrubber	5.44265E-07		6.06495E-07	0.015757839	0.001519548
No O_3, squalene	0.382133147	6.06495E-07		8.38815E-10	0.123950163
O_3 generation, squalene	4.43905E-10	0.015757839	8.38815E-10		3.69703E-05
Bypass channel	0.100030491	0.001519548	0.123950163	3.69703E-05	

Figure S4: ANOVA test representation for N_2O.

Table S5: p-values resulting from the ANOVA test for N_2O molar fractions.

N_2O	No O_3, no scrubber	O_3 generation, no scrubber	No O_3, squalene	O_3 generation, squalene	Bypass channel
No O_3, no scrubber		0.359325384	0.217409312	0.277689103	0.377699683
O_3 generation, no scrubber	0.359325384		0.112412874	0.137165062	0.289831556
No O_3, squalene	0.217409312	0.112412874		0.761757143	0.972574391
O_3 generation, squalene	0.277689103	0.137165062	0.761757143		0.843816095
Bypass channel	0.377699683	0.289831556	0.972574391	0.843816095	

Table S6: p-values resulting from the ANOVA test for COS molar fractions (see Fig. A2 in the main text).

COS	No O_3, no scrubber	O_3 generation, no scrubber	No O_3, squalene	O_3 generation, squalene	Bypass channel
No O_3, no scrubber		0.00096097	0.38152	0.0048316	0.16598
O_3 generation,	0.00096097		0.0090425	0.028935	0.028613

no scrubber					
No O_3, squalene	0.38152	0.0090425		0.11413	0.92189
O_3 generation, squalene	0.0048316	0.028935	0.11413		0.0080331
Bypass channel	0.16598	0.028613	0.92189	0.0080331	

Table S7: p-values resulting from the ANOVA tests for O_3 molar fractions (see Fig. A2 in the main text).

O_3	**No O_3, no scrubber**	**O_3 generation, no scrubber**	**No O_3, squalene**	**O_3 generation, squalene**	**Bypass channel**
No ozone, no scrubber		1.0201E-09	0.55868	0.56586	0.89317
O_3 generation, no scrubber	1.0201E-09		3.0293E-10	8.3646E-08	3.3303E-05
No O_3, squalene	0.55868	3.0293E-10		0.89497	0.72736
O_3 generation, squalene	0.56586	8.3646E-08	0.89497		0.68112
Bypass channel	0.89317	3.3303E-05	0.72736	0.68112	

S3 ANOVA test results on gas species removal due to O_3 scrubbers

Table S8: p-values resulting from the ANOVA test for COS molar fractions in the tracer removal tests (see Fig. A3 in the main text). The p-values = 0 are due to a comparison between single measurements, therefore no standard deviation can be computed.

COS	**Bypass channel**	**No O_3, squalene**	**No O_3, cotton**	**O_3 generation, squalene**	**O_3 generation, cotton**
Bypass channel		0.792997793	0.192430962	0.036612983	0.0353083
No O_3, squalene	0.792997793		0.199969975	0.053576395	0.050245879
No O_3, cotton	0.192430962	0.199969975		0.193251053	0.184500858
O_3 generation, squalene	0.036612983	0.053576395	0.193251053		0
O_3 generation, cotton	0.0353083	0.050245879	0.184500858	0	

Table S9: p-values resulting from the ANOVA test for O_3 molar fractions in the tracer removal tests (see Fig. A4 in the main text). The p-values = 0 are due to a comparison between single measurements, therefore no standard deviation can be computed.

O_3	**Bypass channel**	**No O_3, squalene**	**No O_3, cotton**	**O_3 generation, squalene**	**O_3 generation, cotton**
Bypass channel		0.691559115	0.588818228	0.768190602	0.021501555
No O_3, squalene	0.691559115		0.510877137	0.510592973	5.93333E-05
No O_3, cotton	0.588818228	0.510877137		0.936761332	0.015074124

O_3 generation, squalene	0.768190602	0.510592973	0.936761332		0
O_3 generation, cotton	0.021501555	5.93333E-05	0.015074124	0	

S4 Tropopause heights of the presented flights

Figures S7 – S15 show lapse rate and relative humidity for all flights. The tropopause height was identified following the thermal tropopause height definition by WMO (1957). For TRN1, no temperature or relative humidity data was available, therefore the tropopause height could not be identified. SOD5 (Fig. S11) shows a particularly weak tropopause, with H_2O injections up to almost 15 km of altitude.

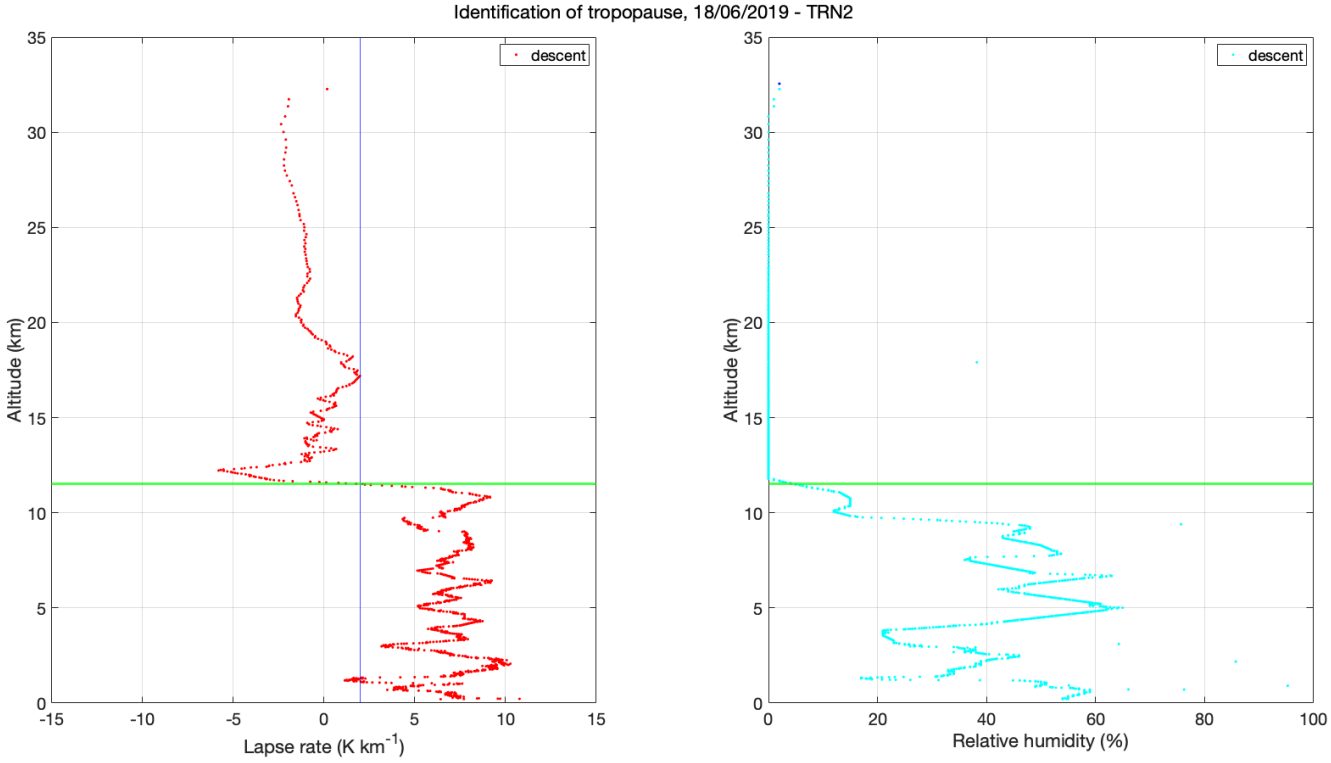

Figure S5: identification of the tropopause height for TRN2 (green line, 11.54 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

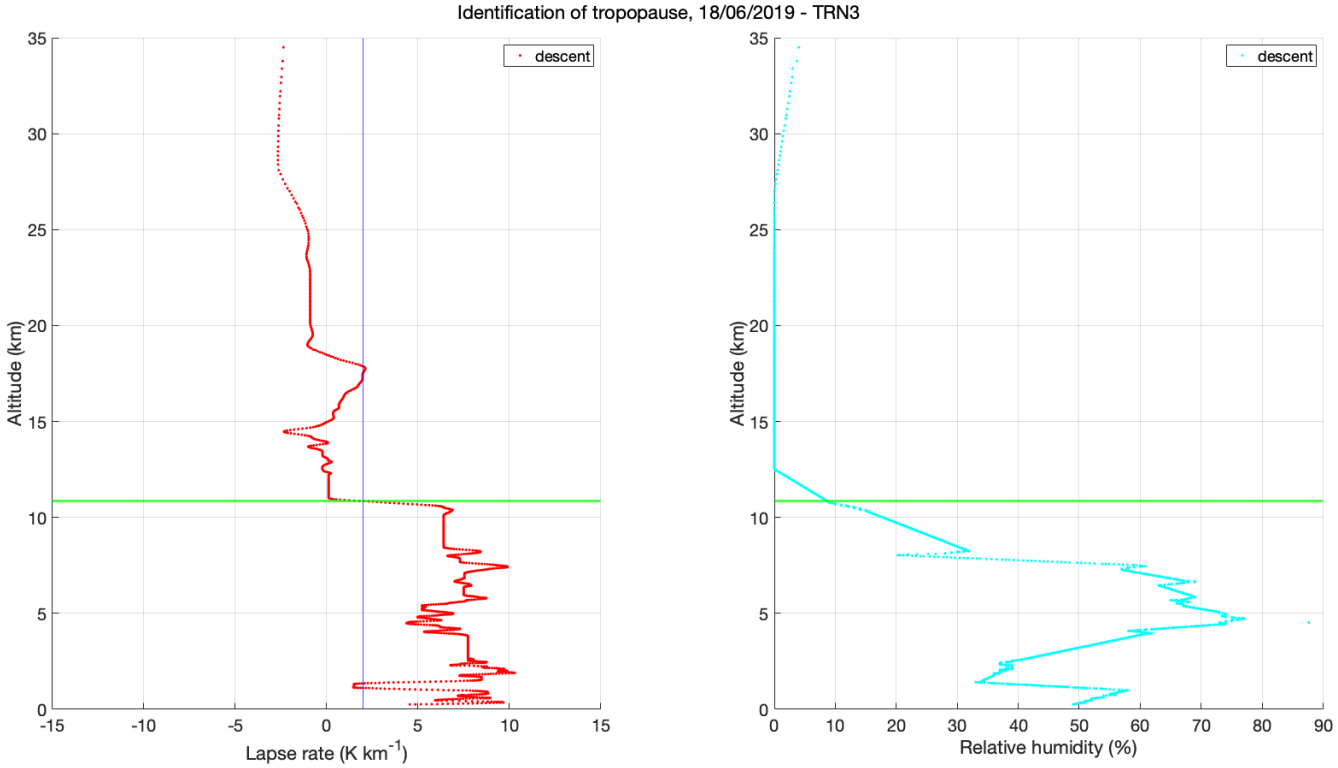

Figure S6: identification of the tropopause height for TRN3 (green line, 10.79 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

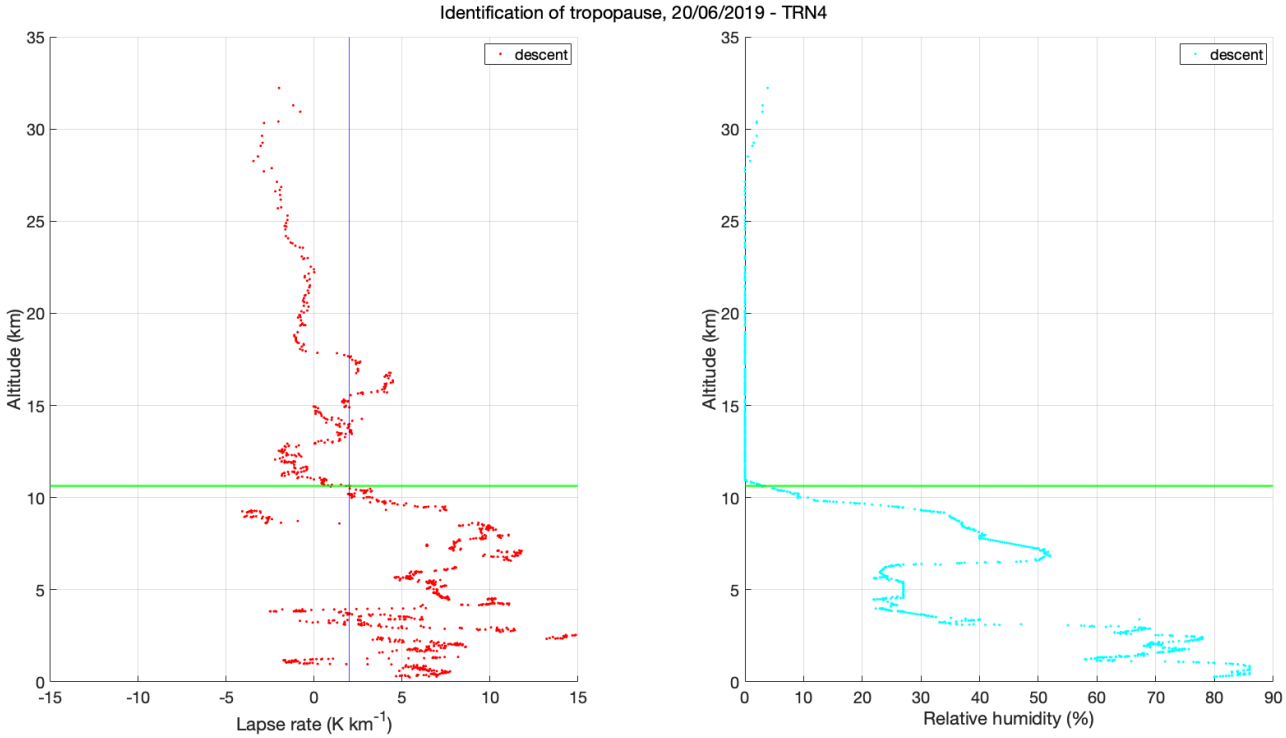

Figure S7: identification of the tropopause height for TRN4 (green line, 10.69 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

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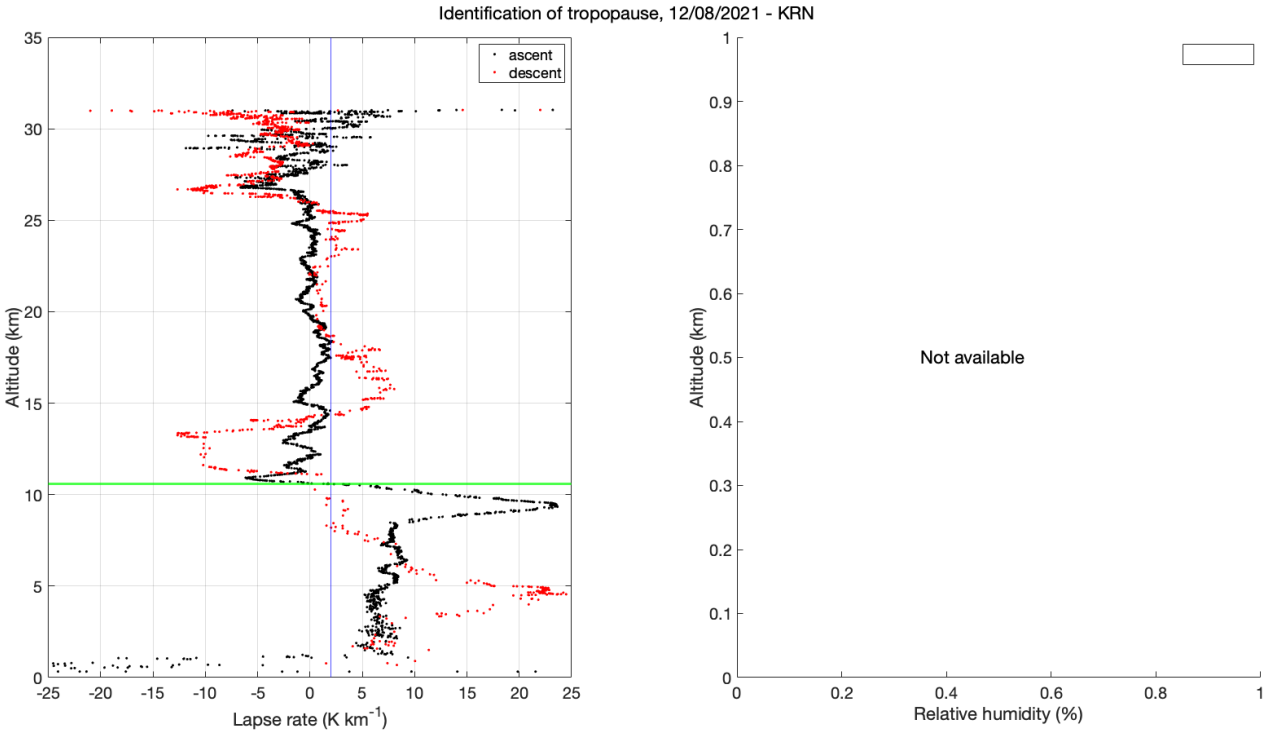

Figure S8: identification of the tropopause height for KRN (green line, 10.93 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

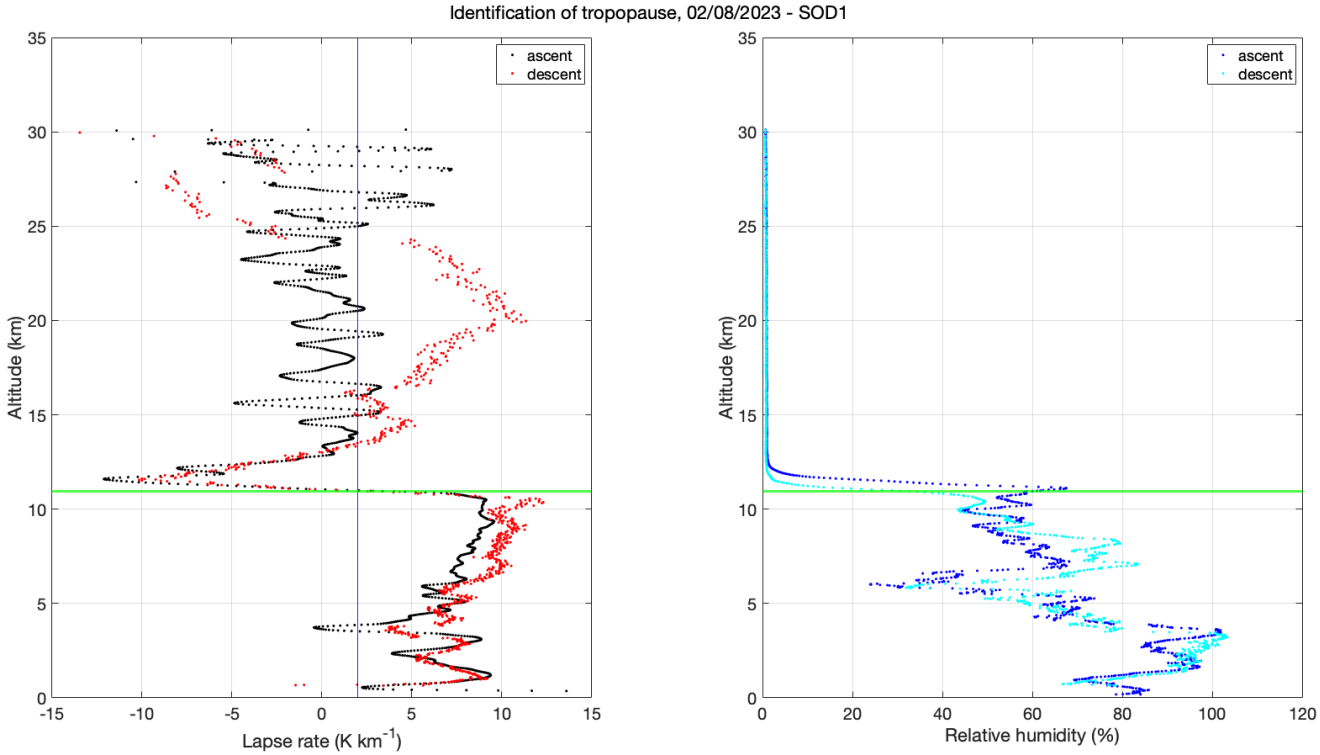

Figure S9: identification of the tropopause height for SOD1 (green line, 10.94 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

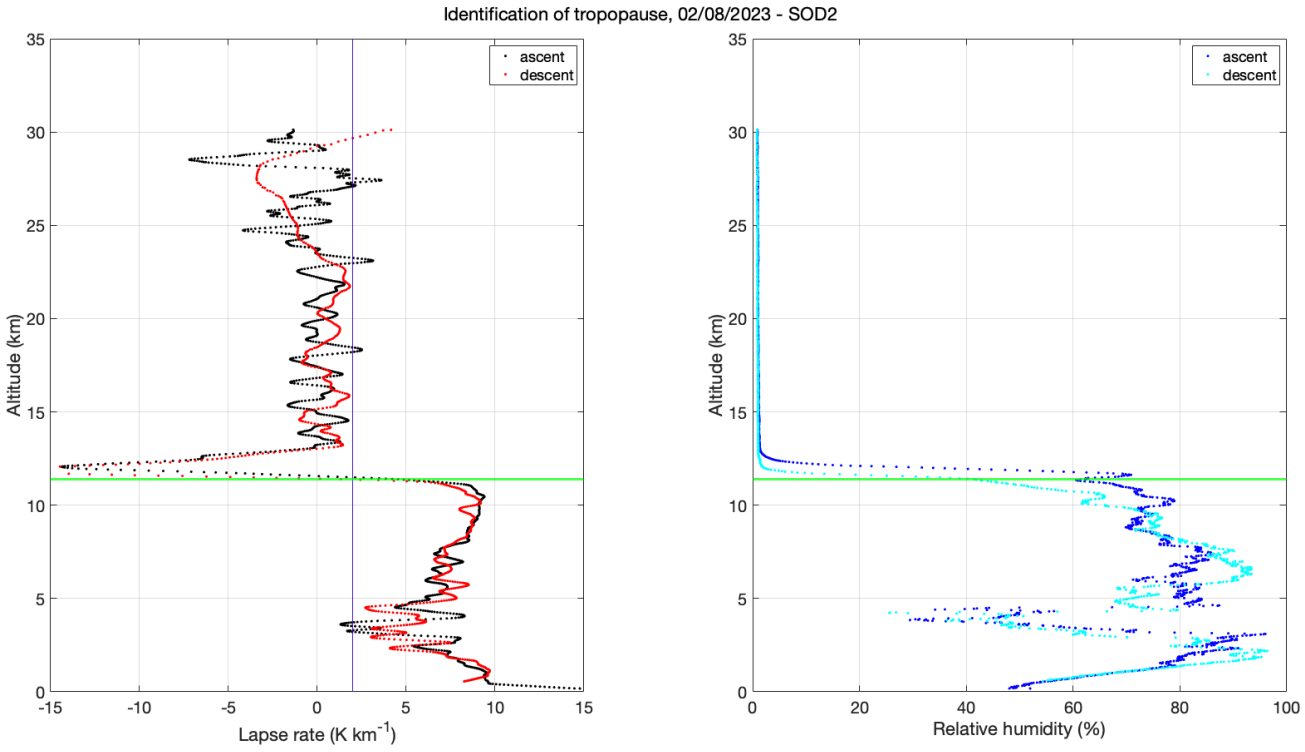

Figure S10: identification of the tropopause height for SOD2 (green line, 11.37 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

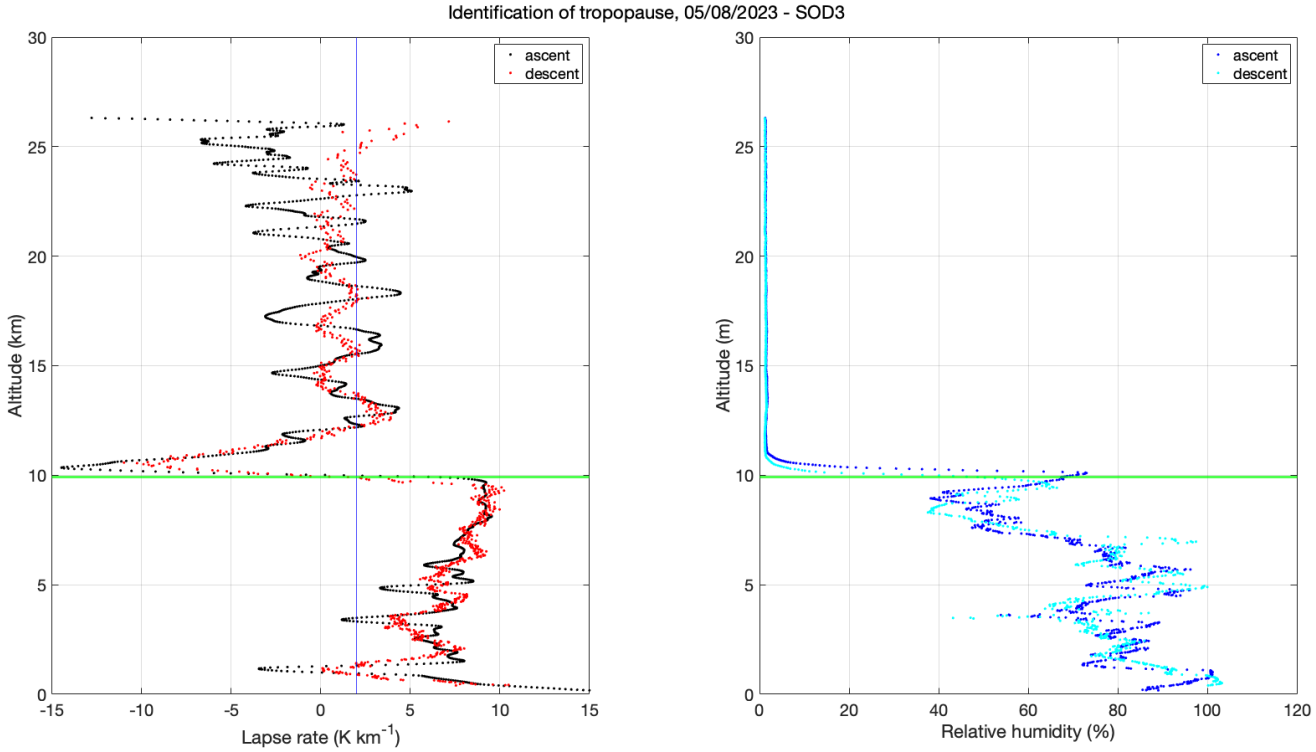

Figure S11: identification of the tropopause height for SOD3 (green line, 9.92 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

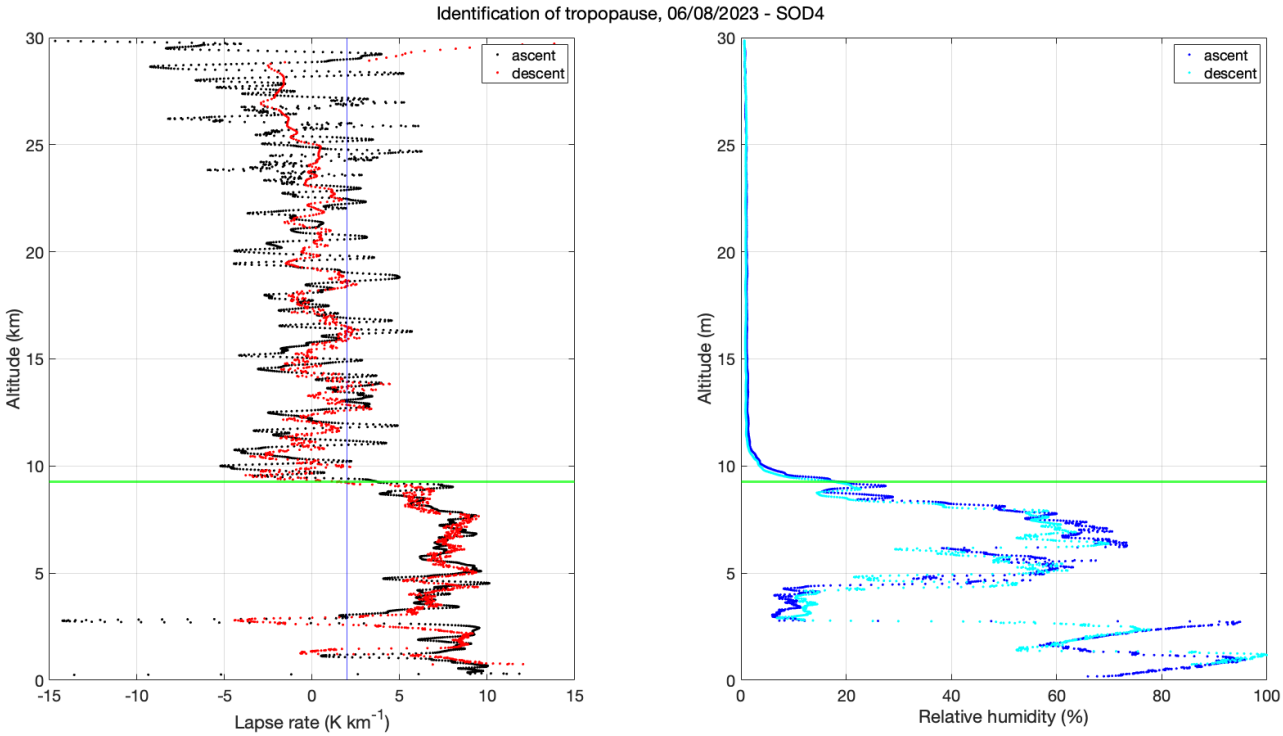

Figure S12: identification of the tropopause height for SOD4 (green line, 9.25 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

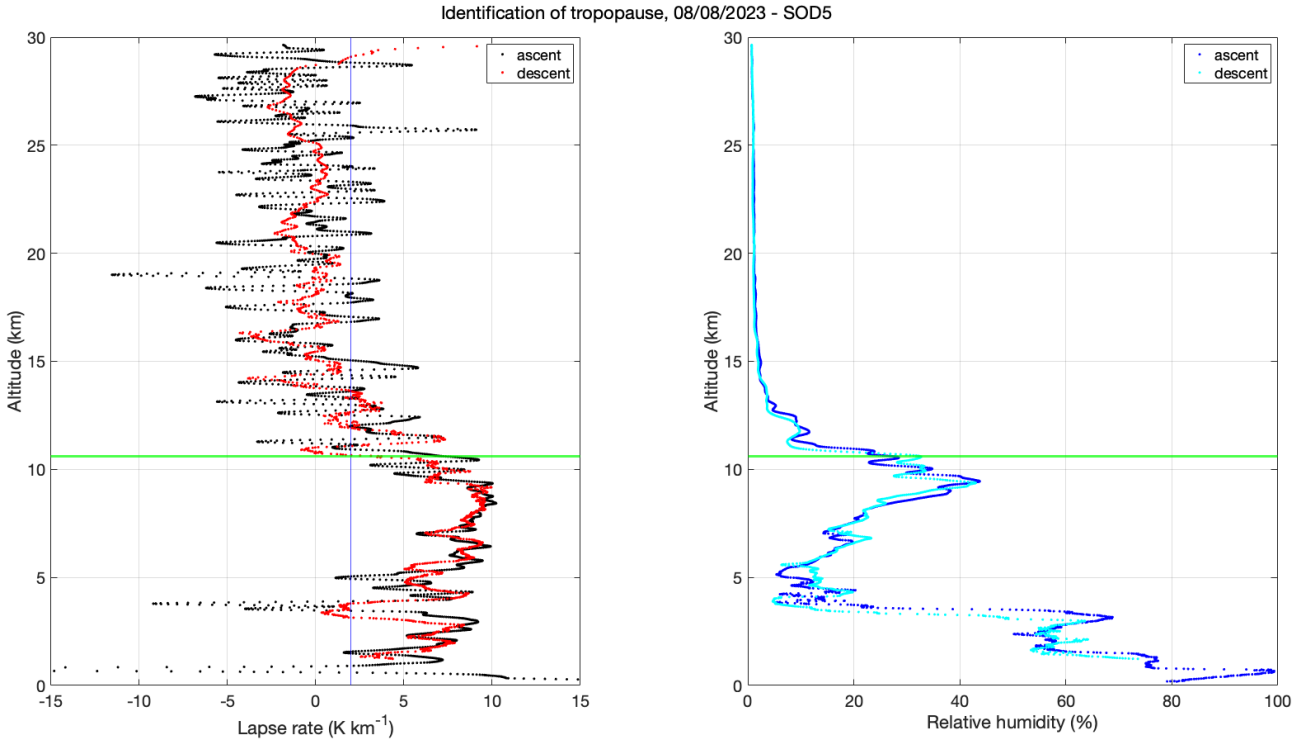

Figure S13: identification of the tropopause height for SOD5 (green line, 10.59 km). The blue line corresponds to a lapse rate of 2 K km^{-1}.

S5 Correlation between CH_4 and N_2O in the observed profiles

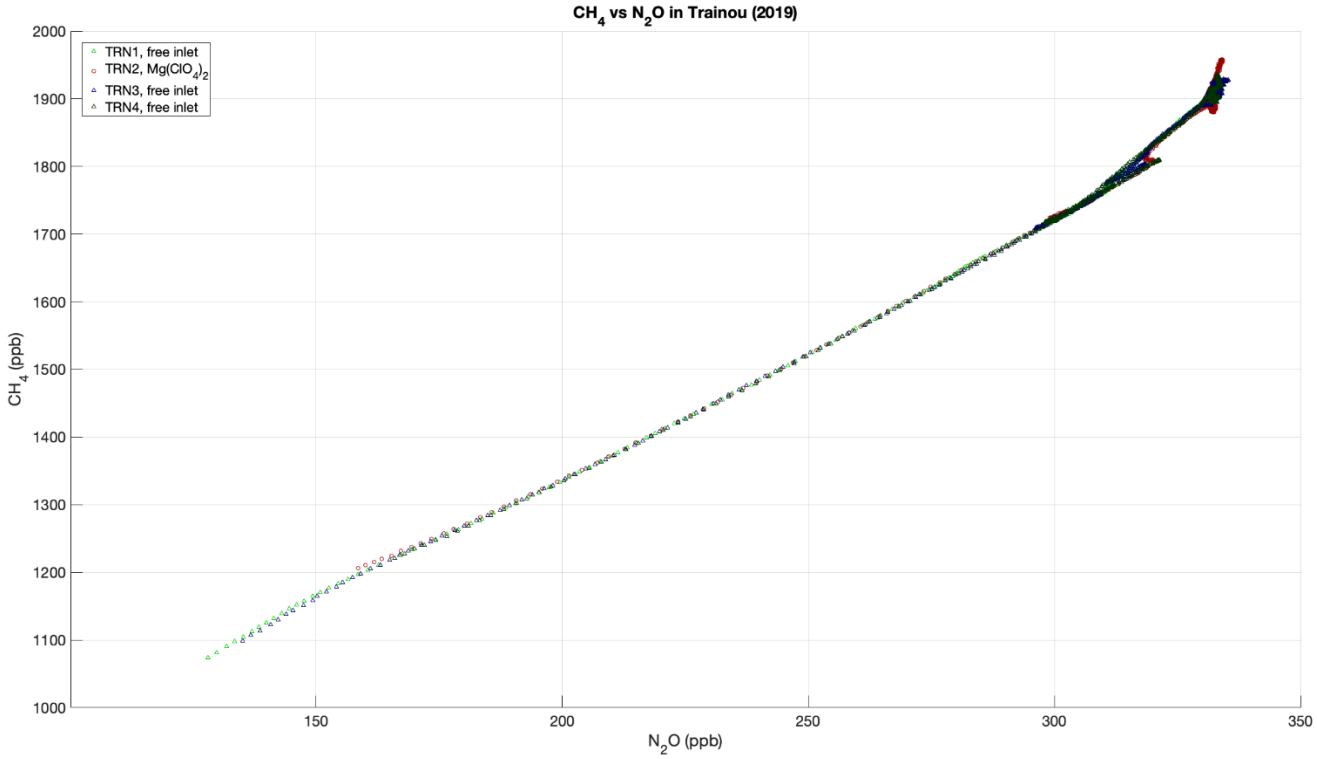

Figure S14: correlation between CH_4 and N_2O in the Trainou campaign (2019).

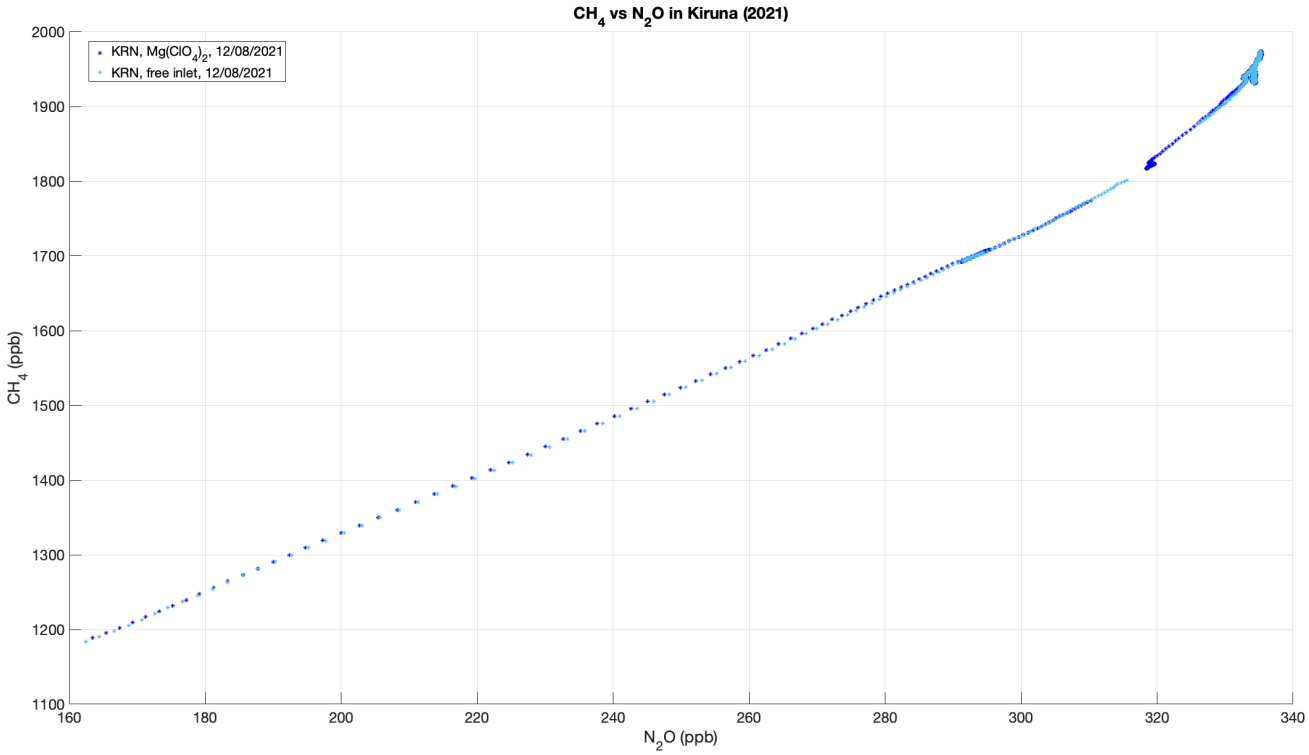

Figure S15: correlation between CH4 and N2O in the Kiruna campaign (2021).

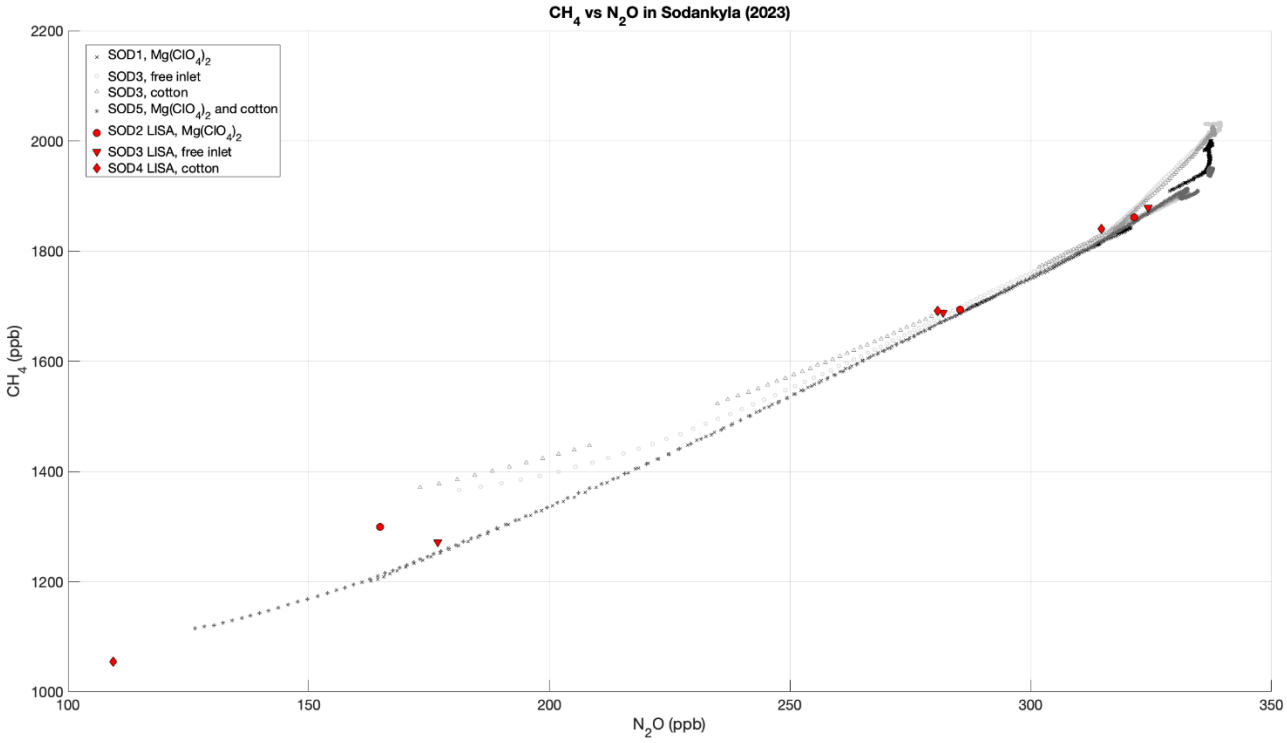

Figure S16: correlation between CH4 and N2O in the Sodankylä campaign (2023).