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Report on Landsat 8 and Sentinel-2B observations of the Nord Stream 2 pipeline methane leak

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Tables S1, S2 and S3 list all the 2-km-side satellite images used in this work. Figures S1 to S7 show all individual fits for sea foam observations in boat trails. Figure S8 shows the effective wind calibration dataset, and Figures S9 and S10 support the calculation of first-order sensitivity indices.

Table S1: Nord Stream 2 (NS2) leak satellite images used in this work

Satellite	**date**	**Latitude**	**Longitude**	**Filters**
Landsat 8	2022-09-29	54.877	15.409	Still sea:
				$s_2 < 0.04$ and $s_1 \leq 1.65\ s_2$
				Clouds: $s_2 \geq 0.04$
				NS2 sea foam:
				$s_2 < 0.04$ and $s_1 > 1.65\ s_2$
Sentinel-2B	2022-09-30	54.877	15.409	Still sea: $s_1 \leq 0.0045$
				NS2 sea foam: $s_1 > 0.0045$
				No cloud filtering required for this S-2B image

Table S2: Landsat 8 ship trail images used in this work

#	Satellite	date	Latitude	Longitude	τ_1	τ_2	c_i
1	Landsat 8	2022-09-02	55.972	11.196	0.0075	0.0400	1.92
2	Landsat 8	2022-09-02	54.598	11.305	0.0050	0.0300	1.86
3	Landsat 8	2022-09-02	54.268	11.699	0.0050	0.0250	1.64
4	Landsat 8	2022-09-06	58.814	18.071	0.0050	0.0300	1.75
5	Landsat 8	2022-09-10	59.847	25.522	0.0035	0.0250	1.58
6	Landsat 8	2022-09-11	54.537	12.220	0.0035	0.0200	1.80
7	Landsat 8	2022-09-11	54.527	12.245	0.0040	0.0400	1.56
8	Landsat 8	2022-09-16	57.619	9.834	0.0080	0.0600	2.19
9	Landsat 8	2022-09-16	57.627	9.851	0.0070	0.0250	1.89
10	Landsat 8	2022-09-16	57.634	9.897	0.0080	0.0300	2.05
11	Landsat 8	2022-09-16	57.682	9.814	0.0085	0.0300	1.76
12	Landsat 8	2022-09-16	56.734	7.976	0.0080	0.0300	2.22
13	Landsat 8	2022-09-25	57.122	10.760	0.0055	0.0300	1.98
14	Landsat 8	2022-09-25	54.131	8.013	0.0065	0.0150	2.43
15	Landsat 8	2022-10-02	57.611	9.921	0.0080	0.0250	1.99
16	Landsat 8	2022-10-02	57.721	8.481	0.0055	0.0200	2.04
17	Landsat 8	2022-10-02	57.574	8.855	0.0075	0.0200	2.25
18	Landsat 8	2022-10-02	57.563	8.884	0.0065	0.0300	1.76
19	Landsat 8	2022-10-04	54.461	10.261	0.0080	0.0150	2.10
20	Landsat 8	2022-10-06	63.508	20.536	0.0065	0.0300	2.05
21	Landsat 8	2022-10-06	54.878	13.070	0.0100	0.0300	1.79
22	Landsat 8	2022-10-10	58.846	21.509	0.0070	0.0300	1.83
23	Landsat 8	2022-10-15	56.613	17.809	0.0115	0.0300	1.88
24	Landsat 8	2022-10-18	57.614	9.918	0.0105	0.0300	2.25
25	Landsat 8	2022-10-18	57.674	9.774	0.0100	0.0500	2.45

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Table S2: Landsat 8 ship trail images used in this work (Continued)

#	Satellite	date	Latitude	Longitude	τ_1	τ_2	c_i
26	Landsat 8	2022-10-20	55.957	11.260	0.0250	0.0350	2.09
27	Landsat 8	2022-10-20	55.169	12.888	0.0070	0.0200	1.79

Table S3: Sentinel-2B ship trail images used in this work

#	Satellite	date	Latitude	Longitude	τ_1	τ_2	c_i
1	Sentinel-2B	2022-09-02	56.748	7.958	0.0040	0.0400	1.75
2	Sentinel-2B	2022-09-02	56.700	7.823	0.0040	0.0400	1.91
3	Sentinel-2B	2022-09-03	54.369	11.981	0.0050	0.0400	1.64
4	Sentinel-2B	2022-09-03	54.390	11.992	0.0050	0.0400	1.85
5	Sentinel-2B	2022-09-06	56.851	11.812	0.0080	0.0600	1.67
6	Sentinel-2B	2022-09-06	56.856	11.840	0.0090	0.0300	1.77
7	Sentinel-2B	2022-09-06	57.456	11.453	0.0070	0.0300	1.85
8	Sentinel-2B	2022-09-07	54.574	18.878	0.0045	0.0400	1.69
9	Sentinel-2B	2022-09-09	55.789	10.741	0.0115	0.0350	1.77
10	Sentinel-2B	2022-09-13	54.530	11.427	0.0090	0.0200	1.67
11	Sentinel-2B	2022-09-13	54.541	11.410	0.0080	0.0150	1.63
12	Sentinel-2B	2022-09-13	54.315	11.833	0.0070	0.0400	1.80
13	Sentinel-2B	2022-09-16	56.032	10.737	0.0200	0.0375	2.46
14	Sentinel-2B	2022-09-19	57.676	9.673	0.0070	0.0400	1.95
15	Sentinel-2B	2022-09-19	57.464	10.935	0.0120	0.0300	2.04
16	Sentinel-2B	2022-09-19	57.472	8.615	0.0045	0.0500	1.76
17	Sentinel-2B	2022-09-30	54.982	18.303	0.0050	0.0500	1.97
18	Sentinel-2B	2022-09-30	54.876	17.373	0.0040	0.0350	1.59
19	Sentinel-2B	2022-09-30	54.830	13.773	0.0070	0.0300	2.09
20	Sentinel-2B	2022-09-30	54.304	13.980	0.0060	0.0400	1.82
21	Sentinel-2B	2022-10-02	57.681	9.873	0.0160	0.0350	2.22
22	Sentinel-2B	2022-10-02	57.794	9.230	0.0070	0.0410	2.12
23	Sentinel-2B	2022-10-03	54.613	11.309	0.0115	0.0400	2.09
24	Sentinel-2B	2022-10-03	54.629	11.311	0.0100	0.0500	2.07
25	Sentinel-2B	2022-10-06	54.448	12.055	0.0110	0.0400	1.58

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Table S3: Sentinel-2B ship trail images used in this work (Continued)

#	Satellite	date	Latitude	Longitude	τ_1	τ_2	c_i
26	Sentinel-2B	2022-10-06	54.442	12.008	0.0110	0.0400	1.69
27	Sentinel-2B	2022-10-07	54.880	19.232	0.0110	0.0200	1.76
28	Sentinel-2B	2022-10-10	55.528	15.159	0.0110	0.0300	1.82
29	Sentinel-2B	2022-10-12	57.679	9.650	0.0110	0.0400	2.10
30	Sentinel-2B	2022-10-12	57.621	9.932	0.0080	0.0400	2.09
31	Sentinel-2B	2022-10-16	54.292	12.024	0.0070	0.0300	1.72
32	Sentinel-2B	2022-10-16	54.568	11.278	0.0105	0.0400	2.31
33	Sentinel-2B	2022-10-16	54.580	11.277	0.0090	0.0300	2.16
34	Sentinel-2B	2022-10-19	57.673	9.715	0.0045	0.0300	2.19
35	Sentinel-2B	2022-10-19	57.788	10.140	0.0050	0.0300	2.13
36	Sentinel-2B	2022-10-20	54.800	13.774	0.0200	0.0300	2.16
37	Sentinel-2B	2022-10-30	56.678	17.251	0.0070	0.0400	1.75
38	Sentinel-2B	2022-10-30	55.284	14.162	0.0210	0.0400	1.81

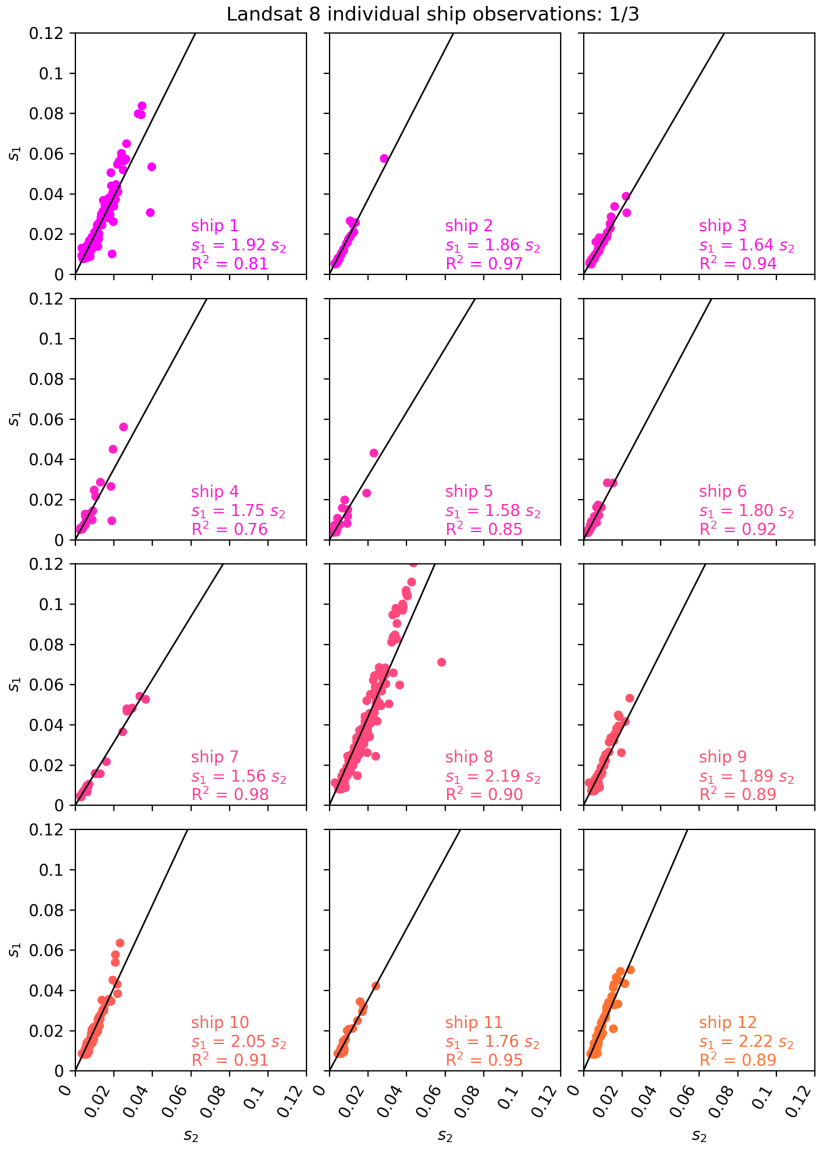

Figure S1. Individual Landsat 8 sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (1/3).

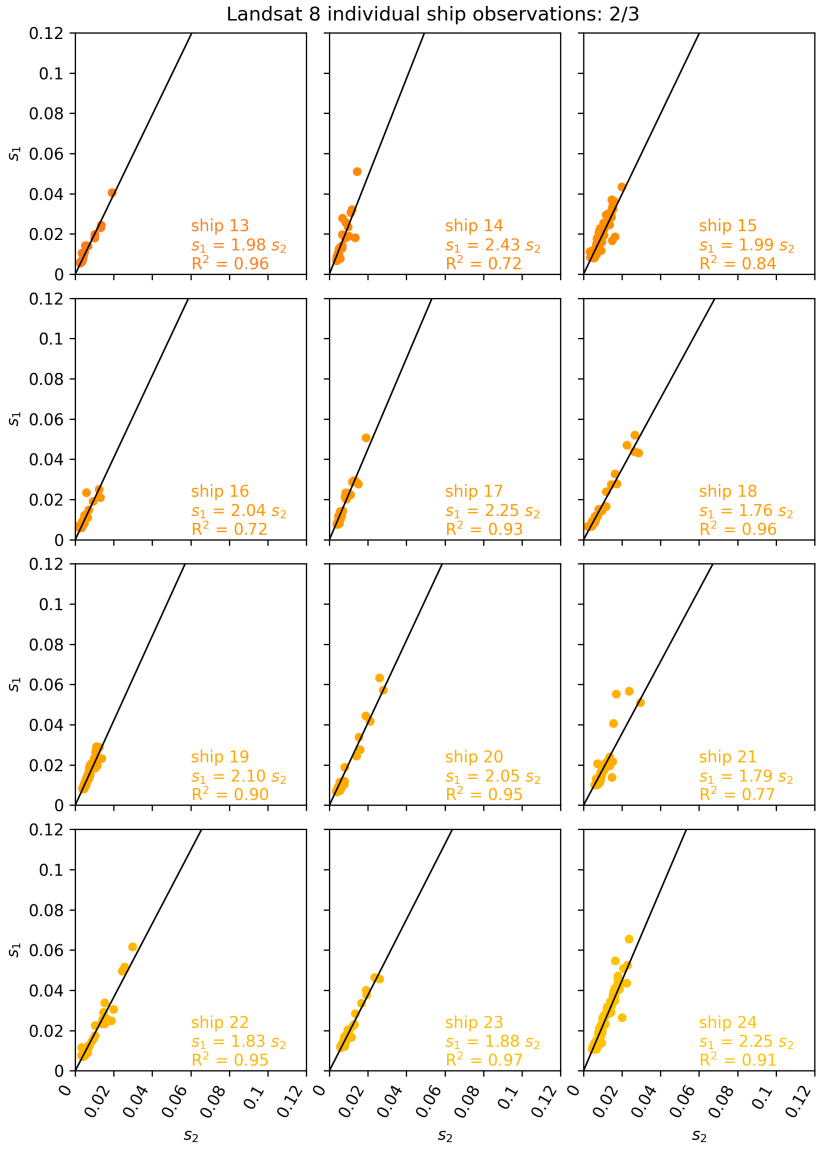

Figure S2. Individual Landsat 8 sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (2/3).

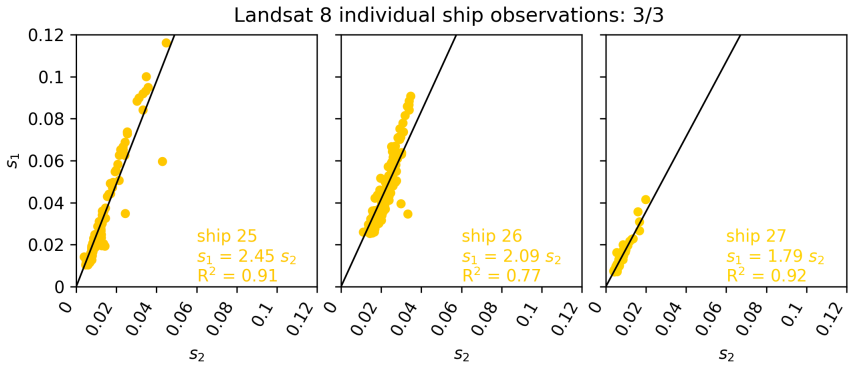

Figure S3. Individual Landsat 8 sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (3/3).

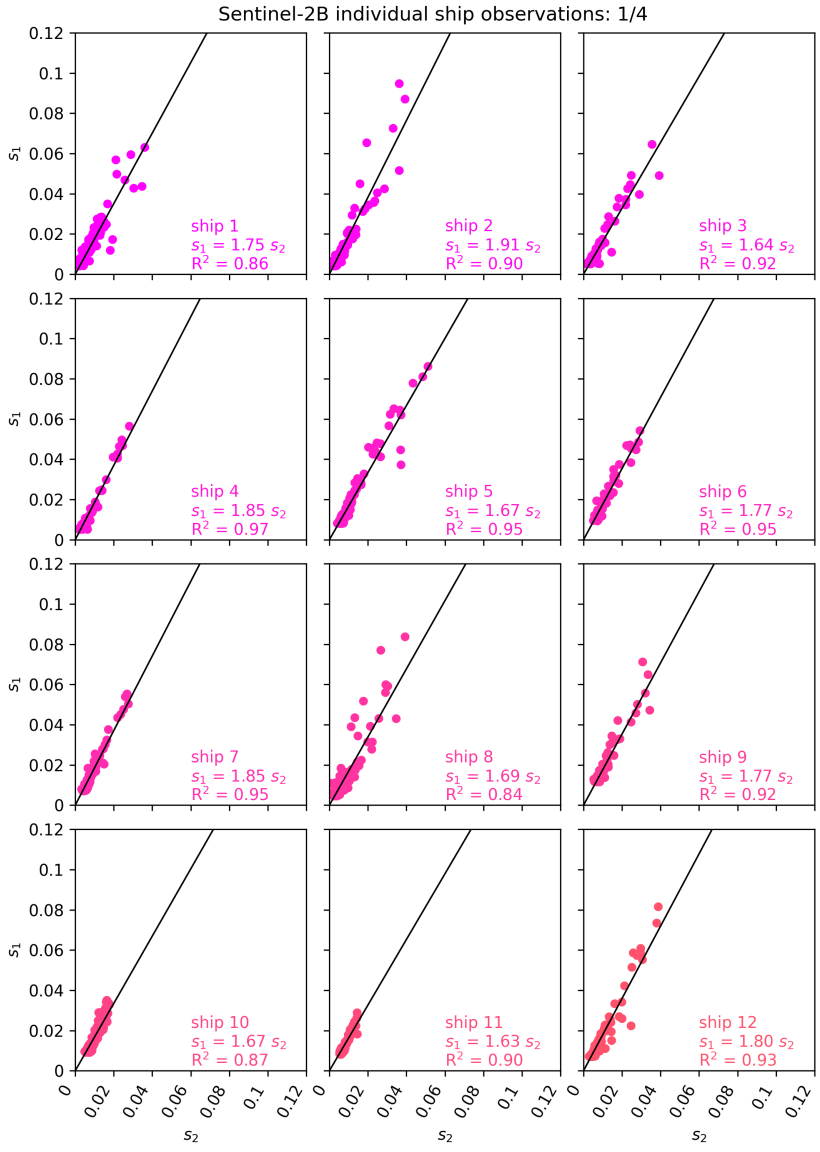

Figure S4. Individual Sentinel-2B sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (1/4).

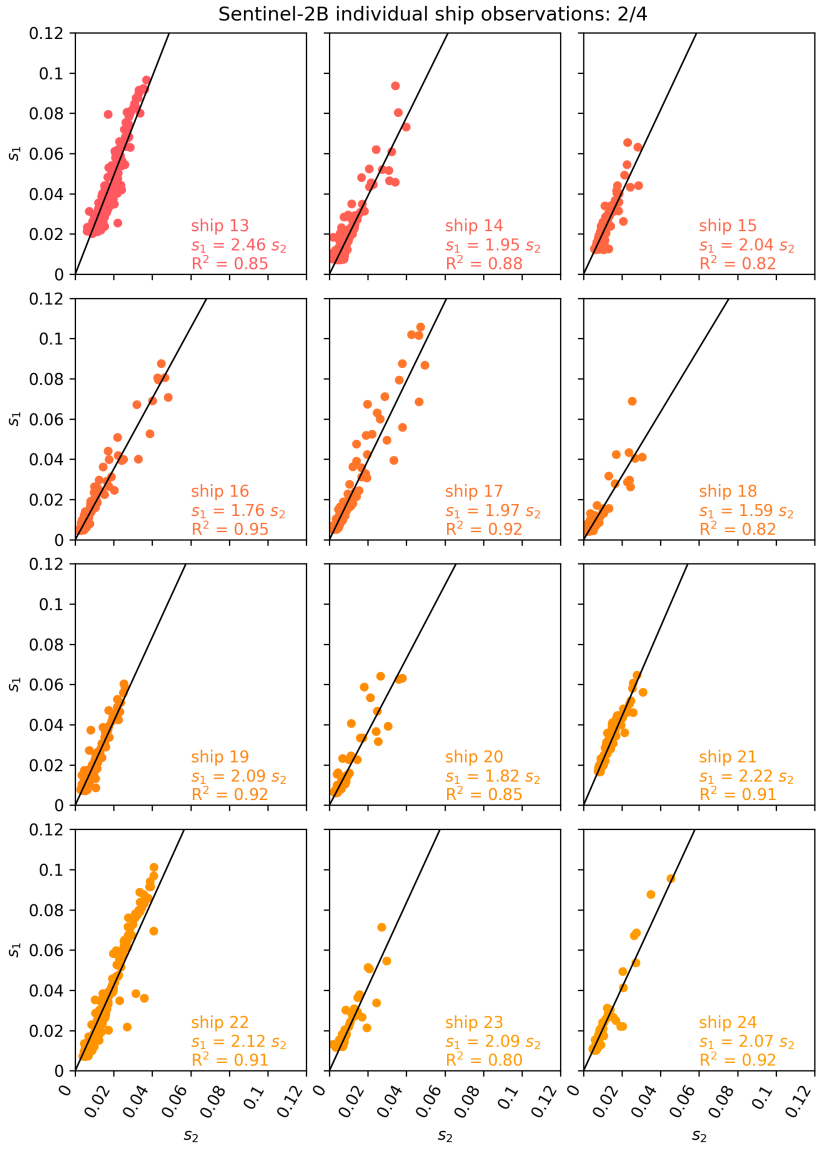

Figure S5. Individual Sentinel-2B sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (2/4).

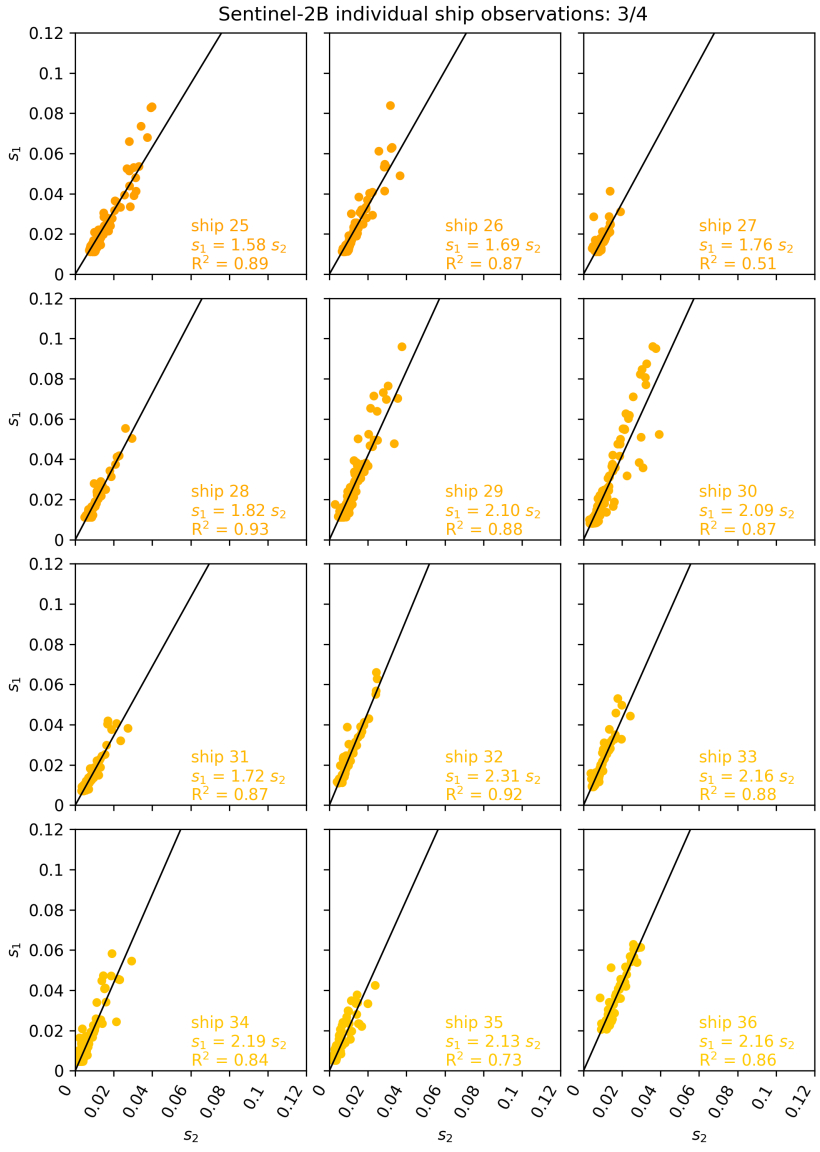

Figure S6. Individual Sentinel-2B sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (3/4).

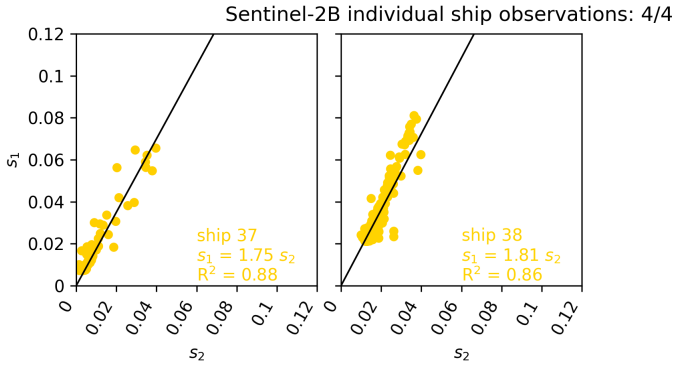

Figure S7. Individual Sentinel-2B sea foam observations in ship trails and least-squares linear regression lines with intercepts forced to zero (4/4).

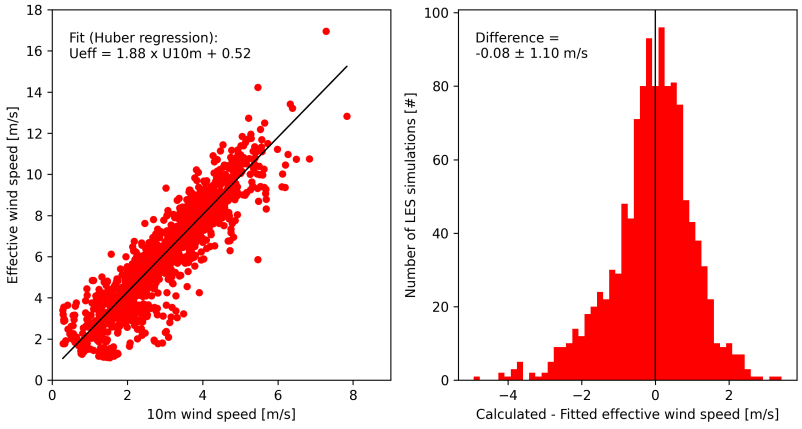

Figure S8. Calibration of IME effective wind speed against 10-m wind speed on the set of Large Eddy Simulation (LES) outputs from Maasakkers et al. (2022) for a 275×275 m^2 source area and sampled only over that same area (left). The distribution of calculated $-$ fitted mismatches used in the Monte Carlo ensembles of Sect. 2.4 is given as well (right).

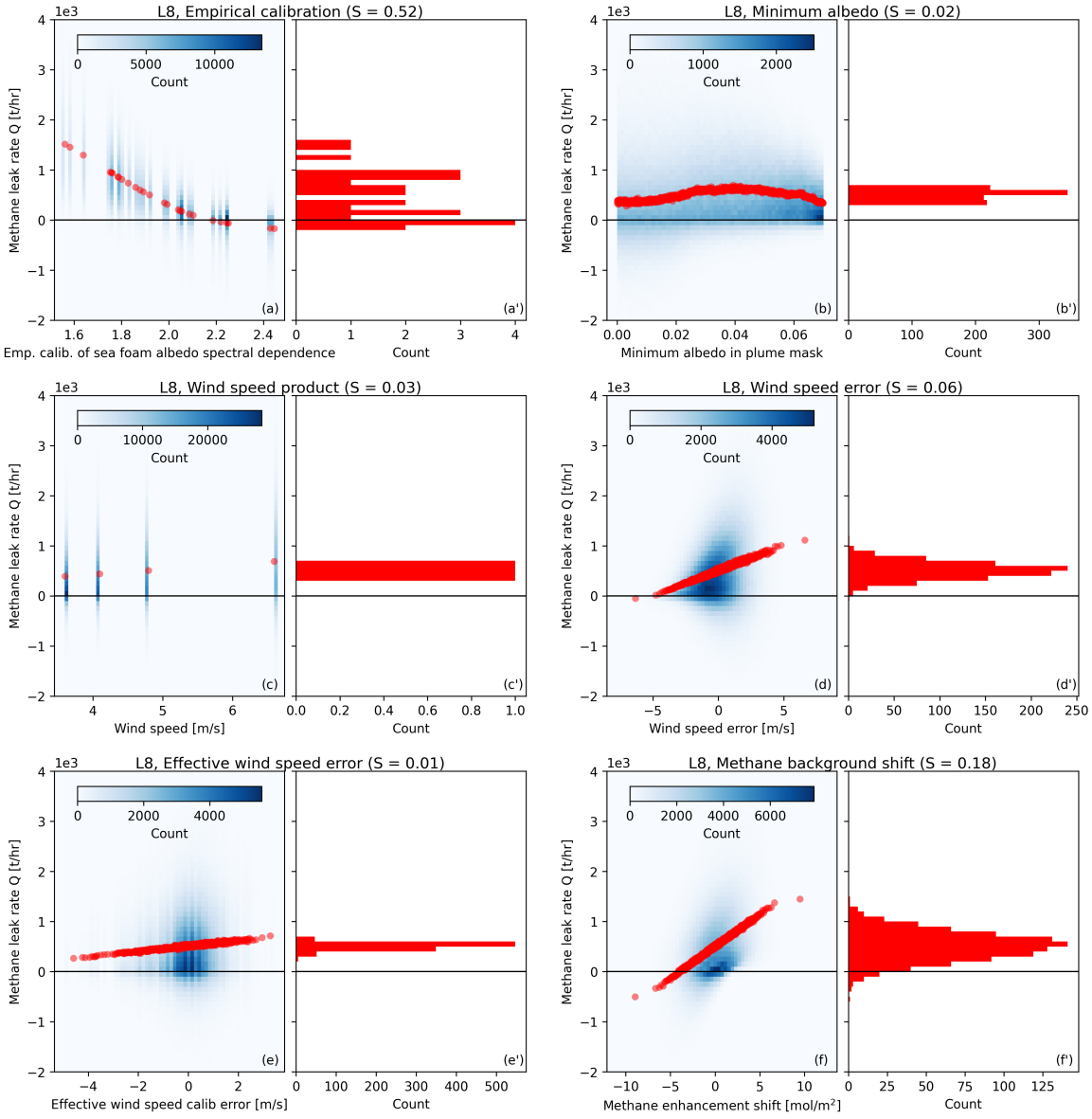

Figure S9. Two-dimensional histograms of Monte Carlo ensemble members showing the computed Landsat 8 methane leak rate Q against: (a) the empirical sea foam albedo spectral dependence, (b) the minimum albedo for pixels to be considered in the plume mask, (c) the wind speed product choice, (d) the wind speed error, (e) the effective wind speed calibration error, and (f) the methane background shift. Smoothed methane leak rate results $E_{\sim X_i}(Q|X_i)$ are shown for all parameters with red points, and their respective distributions are shown in panels next to the two-dimensional histograms (a',b',c',d',e' and f', respectively). Titles include satellite and parameter names, along with the first-order sensitivity index S associated to each parameter.

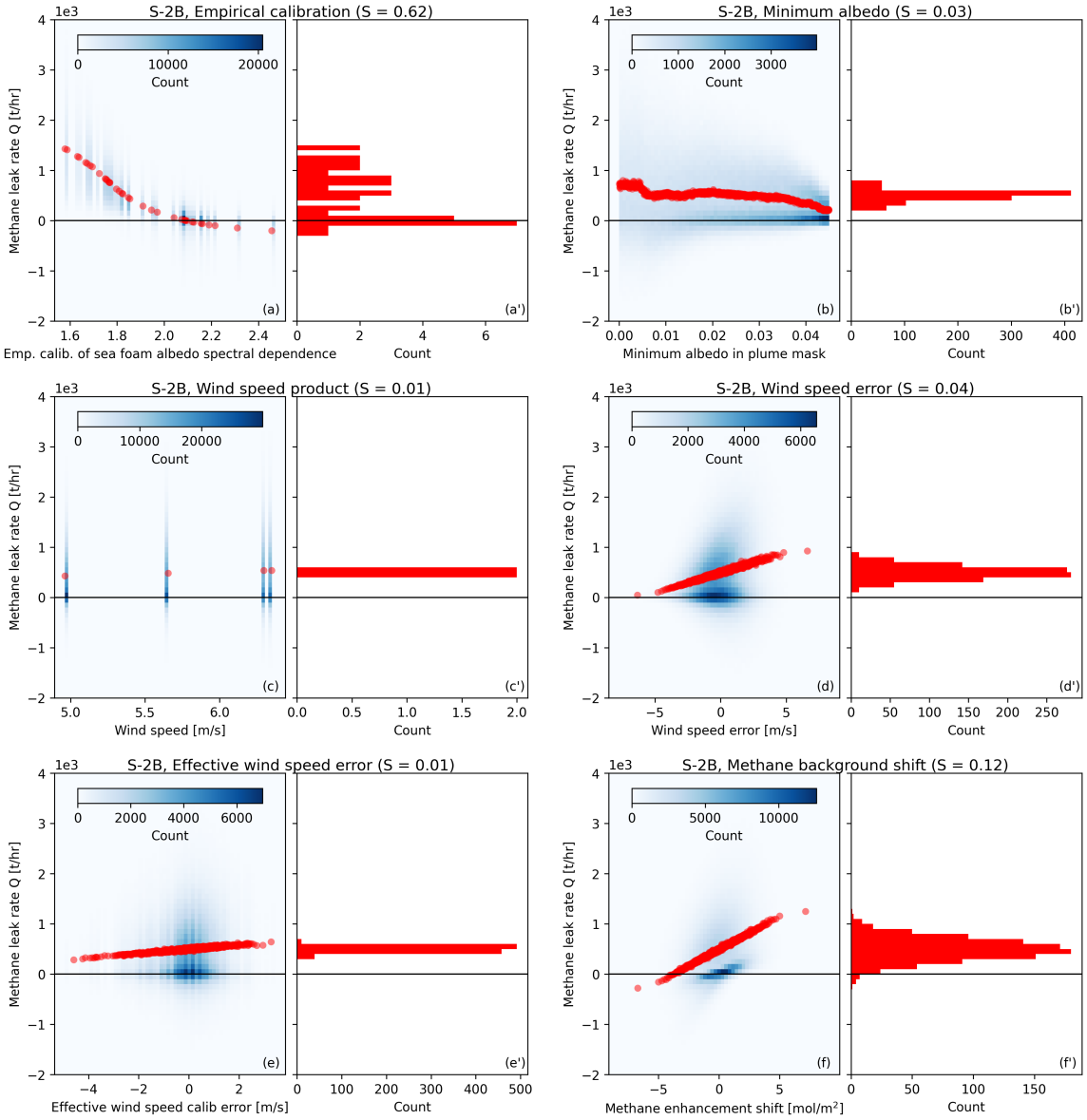

Figure S10. Two-dimensional histograms of Monte Carlo ensemble members showing the computed Sentinel-2B methane leak rate Q against: (a) the empirical sea foam albedo spectral dependence, (b) the minimum albedo for pixels to be considered in the plume mask, (c) the wind speed product choice, (d) the wind speed error, (e) the effective wind speed calibration error, and (f) the methane background shift. Smoothed methane leak rate results $E_{\sim X_i}(Q|X_i)$ are shown for all parameters with red points, and their respective distributions are shown in panels next to the two-dimensional histograms (a',b',c',d',e' and f', respectively). Titles include satellite and parameter names, along with the first-order sensitivity index S associated to each parameter.